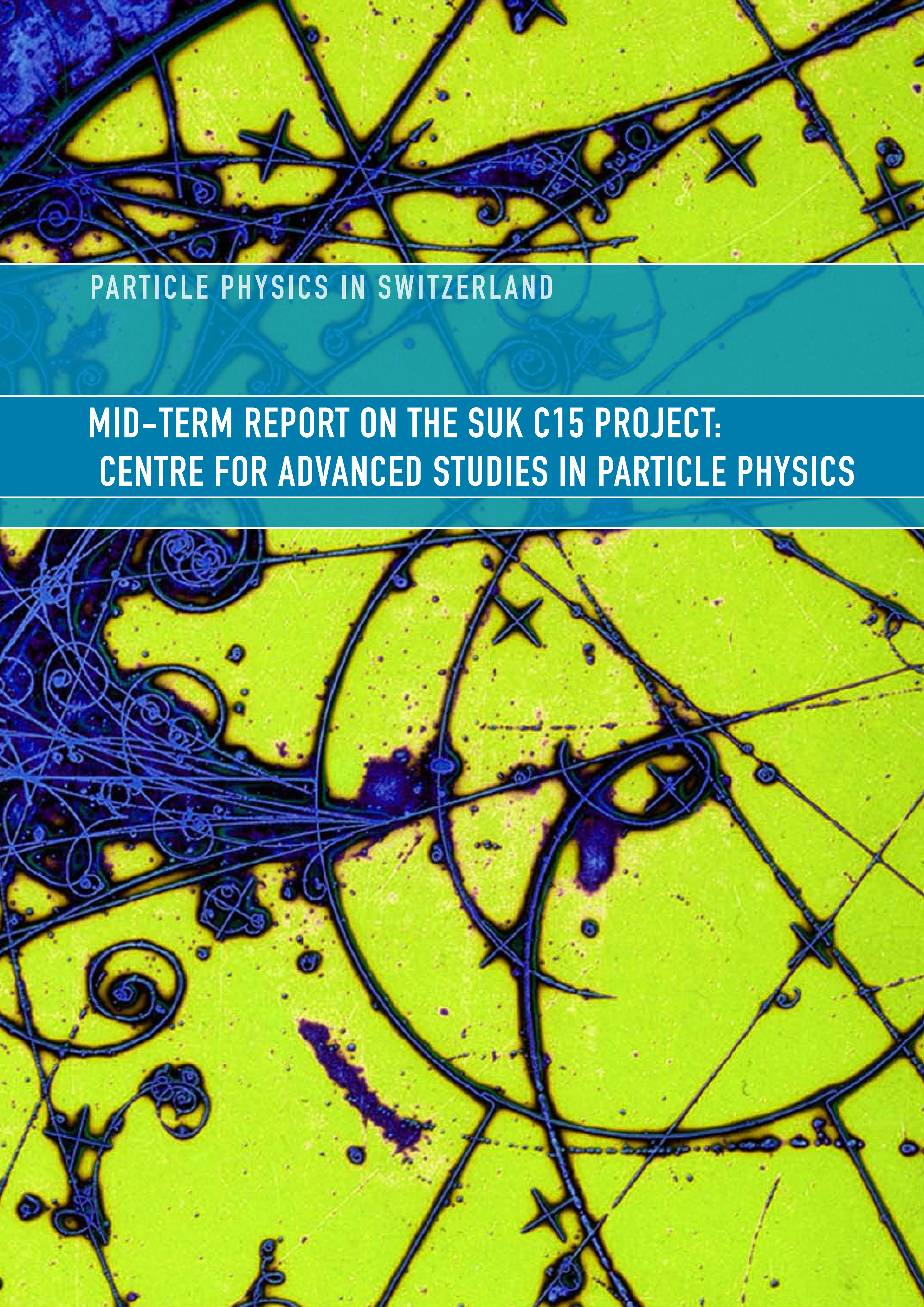
PARTICLE PHYSICS IN SWITZERLAND

MID-TERM REPORT ON THE SUK C15 PROJECT: CENTRE FOR ADVANCED STUDIES IN PARTICLE PHYSICS



Swiss Institute of Particle Physics
an Association according to Swiss law

CHIPP IN A NUTSHELL:

CHIPP is an Association according to Swiss law and – since 2012 – a member society of the Swiss Academy of Natural Sciences SCNAT.

The purpose of the CHIPP Association is to strengthen particle, astroparticle and nuclear physics in Switzerland by being active in particular in the following fields:

a. To help towards a successful participation of Swiss groups in projects;
b. To advise the Universities/ETHs on vacant professorships and academic strategies, and
c. To ensure a proper Swiss representation in relevant national and international bodies.
d. To promote public awareness on particle, astroparticle and nuclear physics.

The CHIPP Association is organized as a two-level system:

- the strategic level comprises the Plenary meeting – the supreme body of the Association – and the Board, where all Professors active in particle, astroparticle and nuclear physics assemble. Subcommittees are dealing with specific issues.
- the operational level, where the day-to-day business of the Association is handled by the Executive Board composed of the Chairman and up to three Vice-Chairs.

Members of the CHIPP Association are the particle, astroparticle and nuclear physicists holding a Master in physics and working for a Swiss institution, as well as the Swiss PhD nationals working at CERN.

For further and more detailed information see www.chipp.ch.

IMPRESSUM

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February 2012

MID-TERM REPORT ON THE SUK C15 PROJECT: CENTRE FOR ADVANCED STUDIES IN PARTICLE PHYSICS

Swiss Institute of Particle Physics

WORKSHOP ON LHC ACTIVITIES IN SWITZERLAND
28/29 JULY 2011, UNIVERSITÄT ZÜRICH-IRCHEL

Mid-Term results:
Presentation of the achievements of the PostDocs working for and funded by the 'Centre for Advanced Studies in Particle Physics in the LHC Era' as well as the ProDoc students associated with the 'Centre's' work and funded by the ProDoc graduate school of the Schweizerische Nationalfonds SNF.

CONTENTS

INTRODUCTION

Prof. Ulrich Straumann,
Project leader of the C15 project.

The Workshop, hosted by the Physik-Institut of the University of Zurich-Irchel was dedicated to the LHC[1] activities of Swiss research groups. It was organised by CHIPP[2] and the 'Swiss Centre for Advanced Studies in Particle Physics in the LHC Era'. In 2007, the promoters had proposed to create such a Centre, which would – among other activities – create scholarships of highest international reputation aiming to attract the best young scientists worldwide to study in Switzerland. The proposal had been accepted by the SUK (Schweizerische Universitätskonferenz) and the ETH-Rat under the label 'C15'.

The purpose of this Workshop was to bring together the achievements of the C15 PostDocs working for and funded by the Centre[3] as well as the PhD student students associated with the Centre's work and funded by SNF's ProDoc graduate school programme. After 2/3 of the period covered by the SUK/ETH-Rat funds has elapsed, it seemed the right time take stock of the achievements and results of the people involved.

CHIPP was (and still is) convinced that the combined effort of all involved Swiss universities[4] is essential to maintain a high quality of education for graduate and post-graduates students in a cost efficient way. Therefore, the PostDocs and PhD students have been assigned to the existing research groups for their research work. For their daily scientific work, the PostDocs follow the guidelines of their individual university group leader. In addition to their own work, they supervise the activities of the PhD students who are assigned to him/her. Further, PostDocs contribute to the education programme of the school by teaching (on specific topics) and by leading exercise sessions.

Seen under this angle, the six PostDocs and six PhD students presented in this workshop a very interesting and representative sample of the Swiss universities' work associated with the LHC. Their work covered all LHC detectors with Swiss participation (ATLAS, CMS, LHCb) as well as Theory, but did not – as it is usually the case – show in a very equilibrated way the work of a whole collaboration but focussed on the speakers' own contributions during the past few years, covering all aspects including detector operation, maintenance and performance, analysis achievements and computing service experience. In this way, the individual activities of each of the beneficiaries of the Centre's funds became very visible and it was a very rewarding moment to see that the Centre's goals and aims had worked out so well.

In more detail the analysis results show the importance of:

– well understanding the functioning of the triggers to increase their efficiency but at the same time choosing the right one to filter out the dominating multijet background without loosing in parallel also the interesting supersymmetry events decaying in many jets. In order to achieve this goal, several updates had been introduced to the ATLAS triggering system in 2010 (Ancu [PostDoc], Agustoni [PhD student], both ATLAS);

[1] Large Hadron Collider, the collider operating at present at the CERN in Geneva.

[2] Swiss Institute of Particle Physics (www.chipp.ch)

[3] The Centre's funds come from the SUK (Schweizerische Universitätskonferenz) and the ETH-Rat and amount to 3.3 MCHF for the period 2008–2012

[4] The term Universities is used according to the Swiss Law on promoting the Swiss law for the promotion and coordination of higher education institutions and comprises the Cantonal Universities as well as the Federal Institutes of Technology.

– the alignment of the LHCb detector and more specifically of its tracker elements. A new procedure using data recorded without magnetic field has been developed and introduced for this unusual geometrical arrangement of the LHCb spectrometer (Dupertuis [PhD student], LHCb);

– simulating standard model physics events in large samples thereby cooperating closely with the Swiss CSCS Computing Centre and the German cloud computing grid (Goulette [PostDoc], ATLAS and computing);

– measuring the inelastic proton-proton collision cross section, in particular the so called strangeness production. This offers also a probe for testing the production models and some sensitivity to new physics (Muresan [PostDoc], LHCb);

– deepening the understanding of the diffractive processes in proton-proton collision, which leave a large part of the detector without particle deposition. The detailed study underway discriminating experimentally between diffractive and non-diffractive interactions will deepen the understanding of these processes, which lack a precise description in theory and in simulations (Sanchez [PhD student], CMS);

– disposing of suitable discriminators to filter signal-like events out from the background. A kinematical variable based solution has been developed for the search of supersymmetry particle produced in proton-proton collision recorded with CMS (Nef [PhD student], CMS);

– reconstructing electrons for both the precise measurement of known particles and for the search for new ones. Measurement methods had been developed and extensively used to establish the efficiency with which electrons have been identified by the ATLAS detector and to identify the production rate of electrons from the decay of hadrons (Pásztor [PostDoc], ATLAS);

– looking in detail into specific methods of the vast supersymmetry search programme of the CMS. A novel method – the so called jet-Z balance – was first used in the 2011 run of the LHC in final states. No signs of supersymmetry particles have been found yet, but these methods were shown to be very sensitive for such searches (Ronga [PostDoc], CMS);

– being able to accurately identify jets containing b quarks. The characteristic properties of b-hadron decays were exploited and excellent agreement found with the detector simulation. The performance of the b-tagging algorithms has now been measured to a precision of better than 10 % (Schmidt [PostDoc], CMS);

– disposing of precise theoretical predictions for the relevant observables used for the LHC data analysis. To deeper understand the electroweak sector of the Standard Model of particle physics, work has started to calculate the production rate of a pair of vector bosons (Tancredi [PhD student], Theory);

Furthermore operation experience with the highly sophisticated detector elements was reported:

– knowing the performance of the detector elements, like the Silicon Tracker at LHCb, where the data collected in 2010 has been used to determine the optimal time and spatial alignment of the detectors, the intrinsic efficiency and resolution, and of the radiation damage (Tobin [PostDoc], LHCb).

– understanding the aging process of the commercially produced near-infrared lasers used for the optical fibres that link the detection modules with the off-detector data acquisition unit. When studying the power spectra of lasers in different conditions, humidity was identified as an important degrading factor (Rosbach [PhD student], ATLAS);

The presentations explained many details of the immensely complicated detector operation and analysis activities. They triggered lively discussions and resulted in a very good atmosphere of communication. It has certainly been rewarding for the young scientist to present and highlight their achievements in the Centre's PostDoc and PhD programme. It will be discussed at the CHIPP Board if the Swiss PostDocs and PhD students should be brought together regularly in this kind of events. This would contribute to establishing transversal structures between the main directions of existing and future research efforts in Switzerland.

sign. Ulrich Straumann

PROGRAMME

Swiss Institute of Particle Physics

CENTRE OF ADVANCED STUDIES IN PARTICLE PHYSICS WORKSHOP ON MID-TERM RESULTS

rev 3 (29 July 2011)

28/29 July 2011, Physik-Institut, Universität Zürich-Irchel, Raum 16 G 15

Presentation of the results and achievements of the PostDocs and PhD students working for the 'Centre of Advanced Studies in Particle Physics in the LHC Era' (C15).

Thursday, 28 July 2011

14:00–14:10	Opening remarks	Ulrich Straumann
14:10–14:35	SUSY searches in di-lepton events at CMS	Frédéric Ronga
14:35–15:00	Searches for supersymmetry in hadronic final states with the CMS detector	Pascal Nef
15:00–15:25	Jet triggers studies for Supersymmetry searches in the ATLAS experiment at LHC	Marco Agustoni
15:25–15:50	Performance of the LHCb Silicon Tracker	Marc Tobin
15:50–16:15	Y Alignment of the LHCb Tracker	Frédéric Dupertuis
16:15–16:40	Diffraction at CMS	Ann-Karin Sanchez
16:40–17:15	*Coffee break*	
17:15–17:45	X-ray Phase Contrast Imaging by Grating Interferometry	Vincent Revol[5]

Friday 29 July 2011

09:00–09:25	Contribution to the ATLAS experiment, CERN and the UniGE	Marc Goulette
09:25–09:50	Study of TX-VCSEL failures in the SCT subdetector at ATLAS	Kilian Rosbach
09:50–10:15	Towards two-loop corrections for vector boson pair production	Lorenzo Tancredi
10:15–10:45	*Coffee break*	
10:45–11:10	Strangeness production studies at LHCb	Raluca Muresan
11:10–11:35	Electron performance and inclusive electron cross-section measurements with the ATLAS detector	Gabriella Pasztor
11:35–12:00	Jet Triggering at ATLAS	Lucian Ancu
12:00–12:10	Concluding remarks	Ulrich Straumann

[5] Vincent Revol's thesis defence was not part of the Centre's activities, but included for organisational reasons. No further details are provided in this brochure.

LAY SUMMARIES

Frédéric Ronga (PostDoc), ETH Zurich
SUSY searches in di-lepton events at CMS
One of the aims of the LHC is to shed light on the shortcomings of the current theory that describes particle physics phenomena, known as the “standard model” (SM). One of the most popular candidate theories that goes beyond the SM is called supersymmetry (SUSY). This theory answers many of the open questions of the SM, and predicts a rich spectrum of new particles that could potentially be seen at the LHC. SUSY searches are, therefore, one of the main focuses of the LHC experiments. In this talk, we present the SUSY search programme of the CMS experiment and put in perspective one of the searches, in a particular final state. This search uses a novel method that was first applied on CMS data in 2011. No sign of SUSY is found yet, but prospects for the future are promising.

Pascal Nef (PhD student), ETH Zurich
Searches for supersymmetry in hadronic final states with the CMS detector
Supersymmetry is one of the most popular extensions of the Standard Model (SM) of particle physics: the theory that summarizes our current understanding of the fundamental particles and their interactions. The CMS experiment at the Large Hadron Collider is well suited to probe physics beyond the SM, including supersymmetry. In this talk, a search for supersymmetric particles produced in proton-proton collisions recorded with the CMS experiment is presented. This search is based on a kinematic variable suitable to discriminate signal-like events from the large SM backgrounds. The search strategies as well as the data-driven methods to predict the Standard Model backgrounds are discussed.

Marco Agustoni (PhD student), University of Bern
Jet triggers studies for Supersymmetry searches in the ATLAS experiment at LHC
This talk focuses on selecting interesting events with the Atlas Experiment at the Large Hadron Collider. Because of the high frequency of interaction between the protons producing about 40 million events per second, it is impossible to record all of them without a filter called “trigger”. A special type of trigger, which combines the energy information of multiple jets (which are bunches of particles flying roughly in the same direction) is particularly suitable for searches for supersymmetry which predicts the existence of new particles. The results of studies I made using the new LHC collisions recorded in 2011 are shown.

Mark Tobin (PostDocs), University of Zurich
Performance of the LHCb Silicon Tracker
The LHCb experiment is one of four major experiments at CERN’s Large Hadron Collider (LHC). It aims to understand the differences between matter and anti-matter that are observed in our (matter dominated) universe. This is done by using the LHC to recreate the conditions that existed when the universe was a hundredth of a billionth of a second old. Beams of protons are accelerated to almost the speed of light and then smashed into each other to produce new particles, for example, b and anti-b quarks. These particles rapidly decay to a range of other particles which then pass through the different parts of the LHCb detector. Each of these particles leaves a characteristic signature in the different materials of the various LHCb sub-systems and these signatures can be used to reconstruct the path of the particles analogous to the way that high flying aeroplanes can be traced by the trail of water vapour they leave behind.

The talk shows the performance of the one of the sub-detectors – the LHCb Silicon Tracker – which is used to reconstruct the trajectory of charged particles as they pass through the detector. These trajectories together with signals from other sub-detectors are ultimately combined to reconstruct the original particles produced in each collision.

Frédéric Dupertuis (PhD student), EPF Lausanne

Y Alignment of the LHCb Tracker

The LHCb experiment is designed to perform high-precision measurements of the so-called CP violation (which indicates that the laws of physics must have acted differently for matter and antimatter) and of rare decays of B hadrons at the Large Hadron Collider. The current LHCb alignment procedure is not able to retrieve correctly and accurately the vertical position of the LHCb tracker elements. A new procedure has been found to deal with vertical alignment using track extrapolation using data recorded without magnetic field. The method and selected results are presented.

Ann-Karin Sanchez (PhD student), ETH Zurich

Diffraction at CMS

A considerable fraction of the proton-proton collisions at the LHC can be ascribed to so-called diffractive processes. These processes have the particular characteristic of leaving a large part of one of the detector hemispheres without particle deposition. This very clear signature serves as an experimental handle to discriminate between diffractive and non-diffractive interactions. A detailed study of such collisions can be used to deepen the understanding of these processes which so far lack a precise description as much in theory as in simulations.

Marc Goulette (PostDoc), University of Geneva

Contribution to the ATLAS experiment, CERN and the University of Geneva

The talk focuses on the production of some important standard physics processes using a specific particle generator. In addition, tests and checks of the availability, performances and general status of the Swiss Tier2 Computing node at the CSCS in Lugano are presented and the link between CERN, the computing grid in Germany 'Cloud' and the University of Geneva are described. Thirdly, the 2011 geometry and materials changes for one detector of the ATLAS experiment are explained.

Kilian Rosbach (PhD student), University of Geneva

Study of TX-VCSEL failures in the SCT sub-detector at ATLAS

The semi conductor tracker (SCT), part of the ATLAS inner detector, consists of four concentric cylinders of 1.5 m length and up to about 1 m in diameter, as well as nine disks at each side of the cylinders. Inner and outer surfaces are covered with 4088 rectangular modules, each comprising 768 silicon strips which detect passing charged particles. Communication between modules and off-detector data acquisition is done via optical fibres. The near-infrared lasers that are generating the optical signals fail at an increasing rate, frequent replacements are necessary. Power spectra of lasers in different conditions were studied, and the aging process was characterized. Humidity was identified as an important degrading factor. Possible solutions are under discussion.

Lorenzo Tancredi (PhD student), University of Zurich

Towards two-loop corrections for vector boson pair production

One of the most outstanding tasks at the LHC is achieving a deeper understanding of the electroweak sector of the Standard Model of Particle Physics, and in particular of the so called Spontaneous Symmetry Breaking mechanism, which seems to provide all the known particles with their masses. Now, almost three years after the official start of the LHC physics programme, a huge amount of experimental data has already been collected and is under analysis. To allow a sensible comparison between such precise experimental results and the underlying theory, we need now more than ever precise theoretical predictions for the relevant observables. In this framework, the aim of my PhD project is the calculation of the production rate of a pair of vector bosons, which are the particles that mediate the electroweak interaction.

Raluca Muresan (PostDoc), EPF Lausanne

Strangeness production studies at LHCb

The Standard Model (SM) explains the particle physics in terms of properties and interactions of a small number of particles: quarks, leptons and gauge bosons. Although the SM was proved to have to have a high predictive power there are few open points that hint that new physics and/or new particles are still to be discovered. A thorough knowledge of the basic properties of inelastic proton-proton (pp) collisions plays a key role in all New Physics searches for all the LHC experiments, and the study of strangeness production offers one of the best probes for testing the production models. In particular LHCb as the one and only LHC experiment fully instrumented in the forward direction has an important contribution to the pp collision production models. The strangeness production results presented here offer a very interesting insight on the baryon number transport, on the baryon suppression and for the production models in general.

Gabriella Pásztor (PostDoc), University of Geneva

Electron performance and inclusive electron cross-section measurements with the ATLAS detector

The ATLAS detector was designed to measure precisely proton-proton collision events at the Large Hadron Collider LHC at CERN. Electrons can be produced by the decay of heavier particles, such as the W and Z bosons transmitting the electroweak interaction or the sought-for Higgs boson presumably responsible for giving mass to the elementary particles. The reconstruction of electrons is, therefore, essential both for the precise measurement of known processes and for searches for new physics. Using the data collected during 2010, we measured the efficiency with which electrons are identified by the ATLAS detector using the decays of well-known particles, such as the W and Z bosons and the J/ψ meson. We also measured the production rate of electrons from the decay of hadrons containing a, b or c quark providing a test of Quantum Chromodynamics (QCD), the theory describing the strong force.

Lucian Ancu (PostDoc), University of Berne

Jet Triggering at ATLAS

While the LHC accelerator is designed to deliver collisions to the ATLAS experiment at 40 MHz (that is 40 million collisions/second) not all the collisions are of interest to be recorded by physicists. In order to reduce this rate ATLAS uses a three layer trigger system that selects interesting physics objects in an event (i.e. electrons, muons, jets, missing transverse energy). Jets are the most copious produced physics objects in the final state at LHC and hence one should understand very well their triggering. The talk focuses on a series of updates to the ATLAS jet triggering system that have been introduced in the last year of LHC running in order that the efficiency of triggering on jets is increased. These updates include: transition to the offline reconstruction algorithm in full scan of the calorimeter at the high level trigger, inclusion of early rejection of some of the jets due to noise in the calorimeter.

Alexander Schmidt (PostDoc)[6]*,*
University of Zurich
b-jet tagging in CMS
The unprecedented collision energies at the Large Hadron Collider (LHC) might produce a multitude of so far undiscovered resonances and particles such as the Higgs Boson or supersymmetric particles. Many of these particles are expected to decay into b-quarks immediately after their production. Thus it is of great interest to identify ("tag") the presence of b-quarks in the collision debris. A b-quark gives rise to a collimated "jet" of particles containing a B-hadron. To discriminate these b-jets from other jets, the characteristic properties of B-hadron decays are exploited. The most important of these is that, during its lifetime of about 1.5 pico-seconds, the B-hadron moves a noticeable distance before it decays, creating a secondary vertex which is displaced from the primary vertex of the original proton-proton collision. The CMS experiment at the LHC managed to commission algorithms using these properties for the identification of b-jets. The excellent agreement with the detector simulation can be considered to be a major success. The performance of the b-Jet tagging algorithms has now been measured to a precision of better than 10 %.

[6] Alexander Schmidt did not present his research, because he fell sick the day before the Workshop. For completeness, his work is included at least in the compilations.

PRESENTATIONS

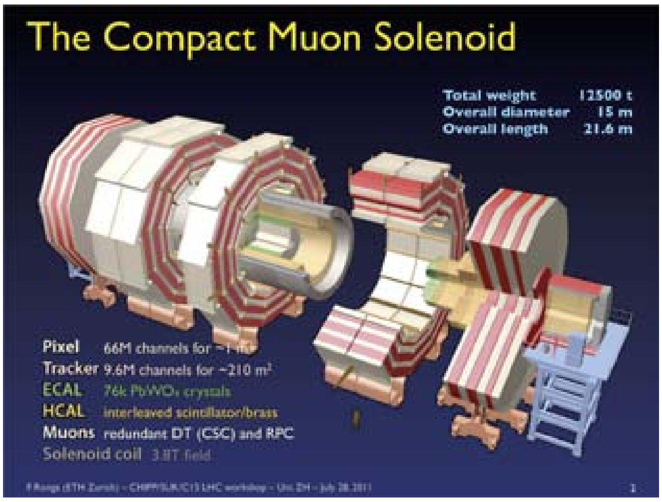
Frédéric Ronga – ETH Zurich
(PostDoc)

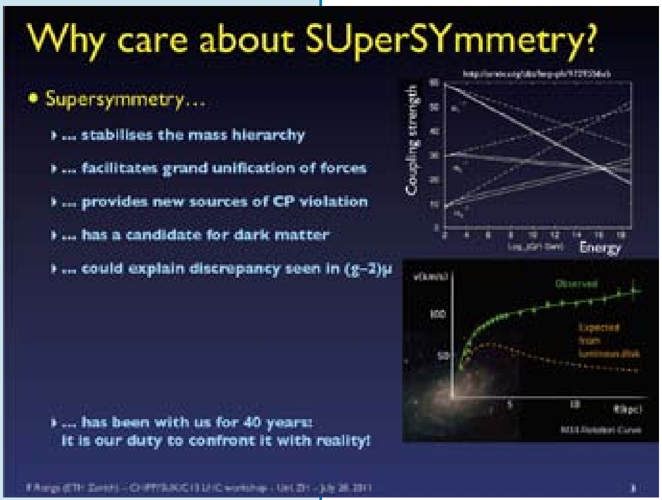
SUSY searches in di-lepton events at CMS

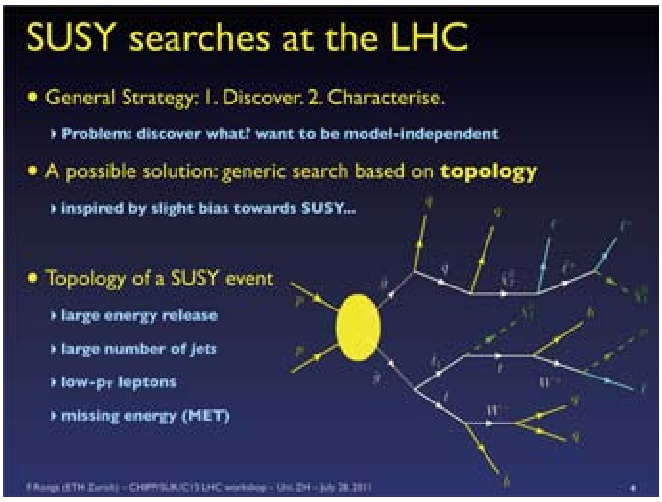
Scientific Abstract:

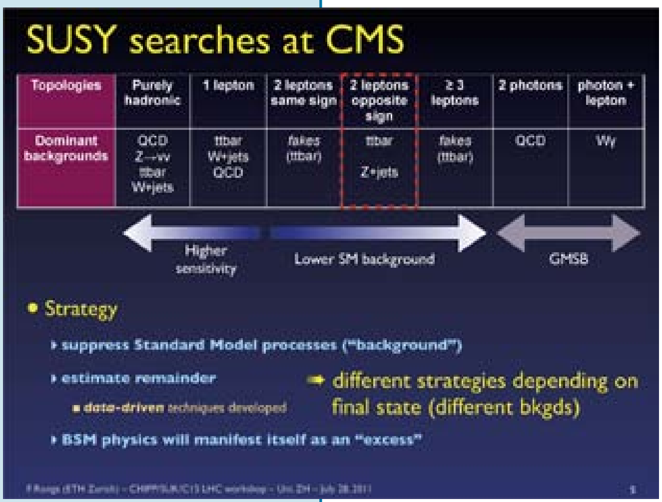
Events with two leptons in the final state, together with jets and missing energy, offer an excellent playground to the search for physics beyond the standard model. First, the supersymmetry search programme of CMS is summarised and the use of leptons in the final state is motivated. We then illustrate these searches with recent results obtained in the first 2011 run of the LHC in final states including a Z boson, using the novel "jet-Z balance" method. In the absence of any signal, exclusion limits are reported.

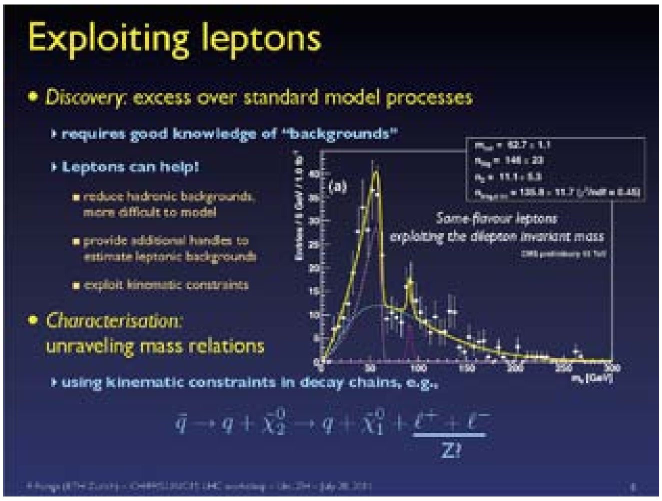

CMS
SUSY searches
in dilepton events
at CMS
Φ
Frédéric Ronga (ETH Zurich)
CHIPP/SUK/C15 LHC workshop – Uni. ZH – July 28, 2011


The Compact Muon Solenoid
Total weight 12500 t
Overall diameter 15 m
Overall length 21.6 m
Pixel 66M channels for ~1 m²
Tracker 9.6M channels for ~210 m²
ECAL 76k PbWO₄ crystals
HCAL interleaved scintillator/brass
Muons redundant DT (CSC) and RPC
Solenoid coil 3.8T field


Why care about SUperSYmmetry?
• Supersymmetry…
… stabilises the mass hierarchy
… facilitates grand unification of forces
… provides new sources of CP violation
… has a candidate for dark matter
… could explain discrepancy seen in (g–2)μ
… has been with us for 40 years:
it is our duty to confront it with reality!
Coupling strength
Energy
Observed
Expected from luminous disk


SUSY searches at the LHC
• General Strategy: 1. Discover. 2. Characterise.
Problem: discover what? want to be model-independent
• A possible solution: generic search based on topology
inspired by slight bias towards SUSY…
• Topology of a SUSY event
large energy release
large number of jets
low-pT leptons
missing energy (MET)


SUSY searches at CMS
Topologies | Purely hadronic | 1 lepton | 2 leptons same sign | 2 leptons opposite sign | ≥ 3 leptons | 2 photons | photon + lepton
Dominant backgrounds | QCD Z→νν ttbar W+jets | ttbar W+jets QCD | fakes (ttbar) | ttbar Z+jets | fakes (ttbar) | QCD | Wγ
Higher sensitivity
Lower SM background
GMSB
• Strategy
suppress Standard Model processes ("background")
estimate remainder
data-driven techniques developed
→ different strategies depending on final state (different bkgds)
BSM physics will manifest itself as an "excess"


Exploiting leptons
• Discovery: excess over standard model processes
requires good knowledge of "backgrounds"
Leptons can help!
reduce hadronic backgrounds, more difficult to model
provide additional handles to estimate leptonic backgrounds
exploit kinematic constraints
• Characterisation: unraveling mass relations
using kinematic constraints in decay chains, e.g.,
Same-flavour leptons exploiting the dilepton invariant mass
$\tilde{q} \to q + \tilde{\chi}_2^0 \to q + \tilde{\chi}_1^0 + \ell^+ + \ell^-$
Z!

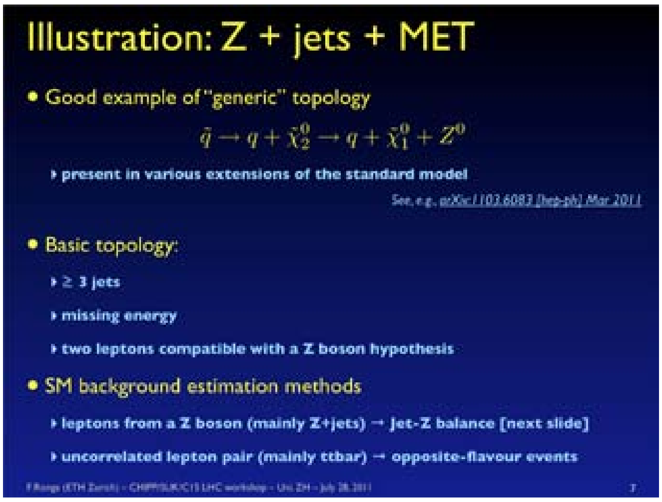
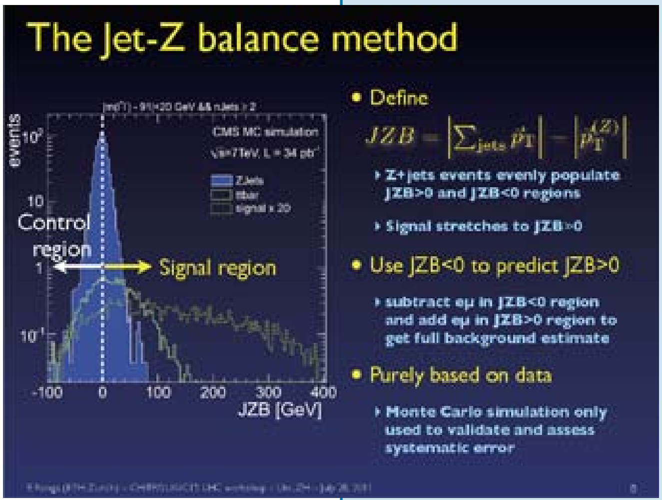
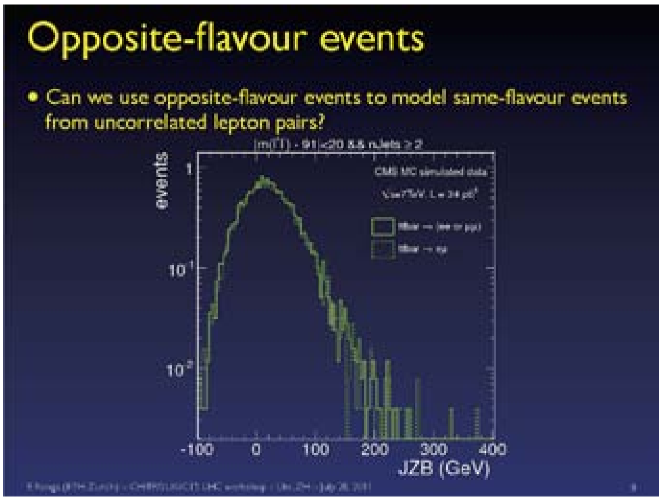
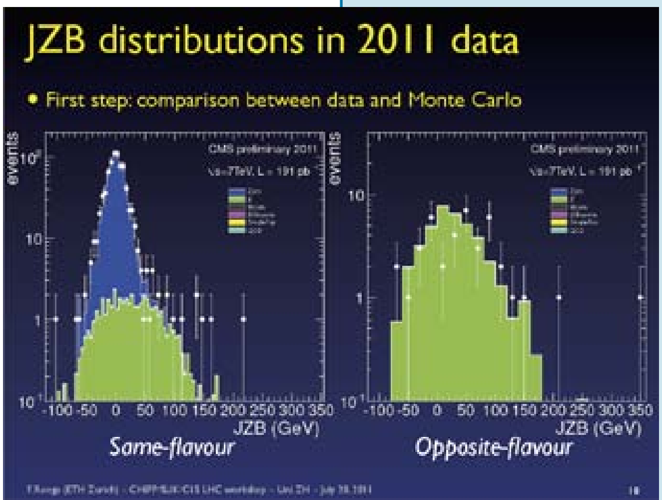
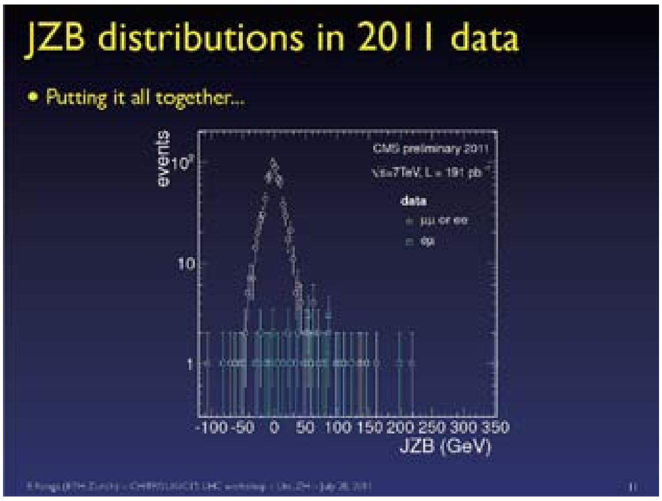


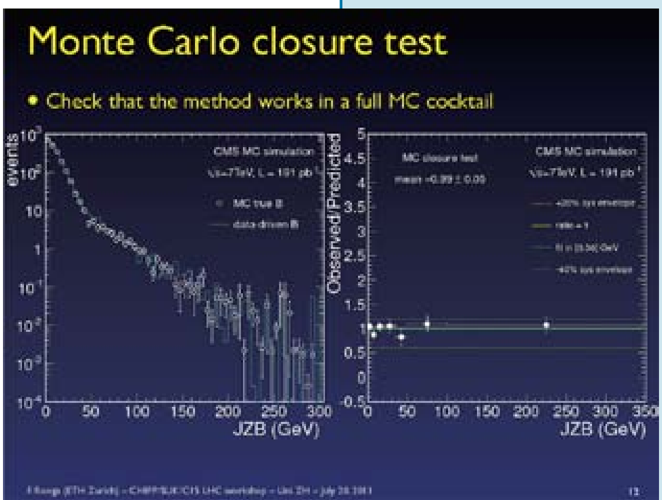
Illustration: Z + jets + MET
• Good example of "generic" topology
$\tilde{q} \rightarrow q + \tilde{\chi}_2^0 \rightarrow q + \tilde{\chi}_1^0 + Z^0$
present in various extensions of the standard model
See, e.g., arXiv:1103.6083 [hep-ph] Mar 2011
• Basic topology:
≥ 3 jets
missing energy
two leptons compatible with a Z boson hypothesis
• SM background estimation methods
leptons from a Z boson (mainly Z+jets) → Jet-Z balance [next slide]
uncorrelated lepton pair (mainly ttbar) → opposite-flavour events

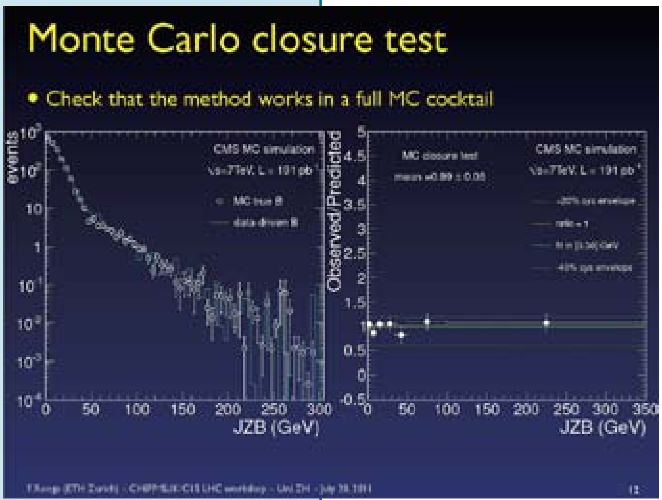

The Jet-Z balance method
events
Control region
Signal region
JZB [GeV]
• Define
$JZB = \left|\sum_{\text{jets}} \vec{p}_T\right| - \left|\vec{p}_T^{(Z)}\right|$
Z+jets events evenly populate JZB>0 and JZB<0 regions
Signal stretches to JZB>0
• Use JZB<0 to predict JZB>0
subtract eμ in JZB<0 region and add eμ in JZB>0 region to get full background estimate
• Purely based on data
Monte Carlo simulation only used to validate and assess systematic error

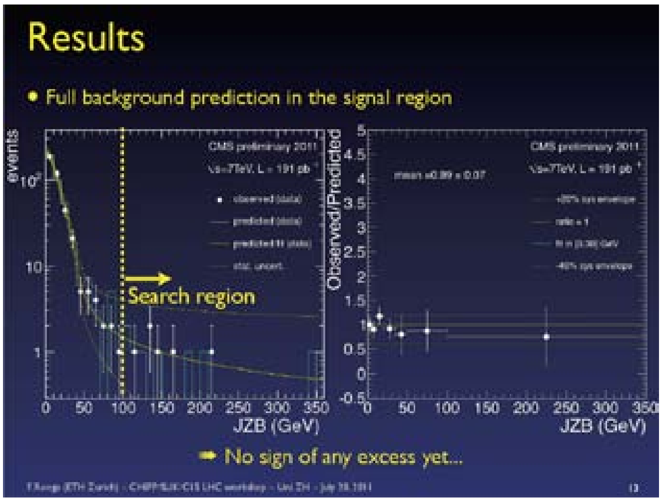

Opposite-flavour events
• Can we use opposite-flavour events to model same-flavour events from uncorrelated lepton pairs?
events
JZB (GeV)

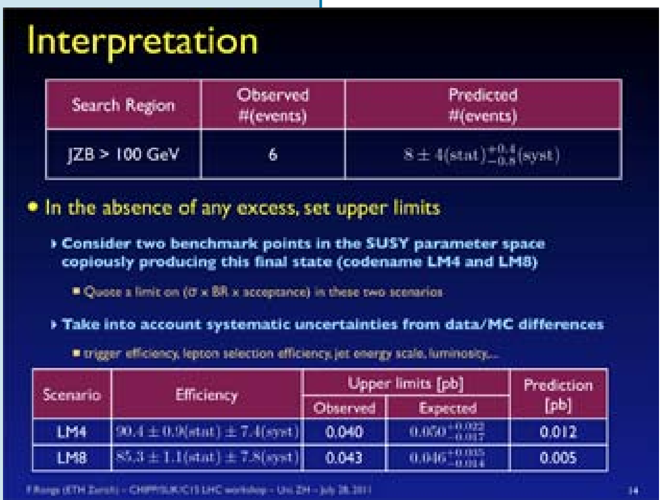

JZB distributions in 2011 data
• First step: comparison between data and Monte Carlo
events
JZB (GeV)
Same-flavour
Opposite-flavour

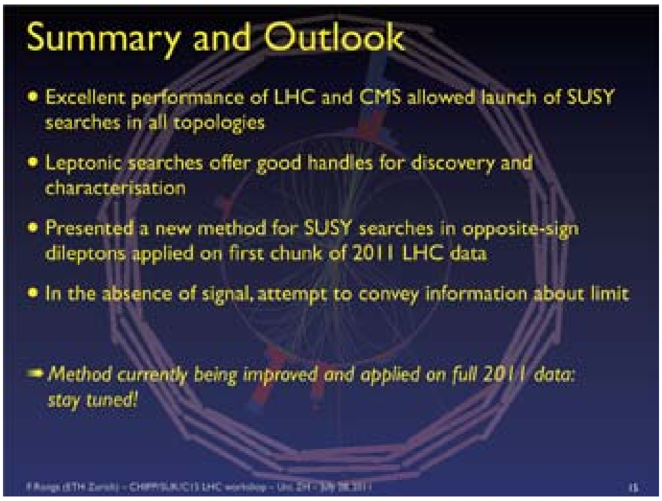

JZB distributions in 2011 data
• Putting it all together...
events
JZB (GeV)


Monte Carlo closure test
• Check that the method works in a full MC cocktail
events
Observed/Predicted
JZB (GeV)


Monte Carlo closure test
Check that the method works in a full MC cocktail
events
CMS MC simulation
√s=7TeV, L = 191 pb⁻¹
MC true B
data driven B
JZB (GeV)
Observed/Predicted
MC closure test
mean = 0.99 ± 0.05
JZB (GeV)


Results
Full background prediction in the signal region
events
CMS preliminary 2011
√s=7TeV, L = 191 pb⁻¹
observed (data)
predicted (data)
Search region
JZB (GeV)
Observed/Predicted
JZB (GeV)
No sign of any excess yet...


Interpretation
Search Region | Observed #(events) | Predicted #(events)
JZB > 100 GeV | 6 | $8 \pm 4(\text{stat})^{+0.4}_{-0.8}(\text{syst})$
In the absence of any excess, set upper limits
Consider two benchmark points in the SUSY parameter space copiously producing this final state (codename LM4 and LM8)
Quote a limit on (σ × BR × acceptance) in these two scenarios
Take into account systematic uncertainties from data/MC differences
trigger efficiency, lepton selection efficiency, jet energy scale, luminosity,...
Scenario | Efficiency | Upper limits [pb] Observed | Expected | Prediction [pb]
LM4 | $90.4 \pm 0.9(\text{stat}) \pm 7.4(\text{syst})$ | 0.040 | $0.050^{+0.022}_{-0.017}$ | 0.012
LM8 | $85.3 \pm 1.1(\text{stat}) \pm 7.8(\text{syst})$ | 0.043 | $0.046^{+0.035}_{-0.014}$ | 0.005


Summary and Outlook
Excellent performance of LHC and CMS allowed launch of SUSY searches in all topologies
Leptonic searches offer good handles for discovery and characterisation
Presented a new method for SUSY searches in opposite-sign dileptons applied on first chunk of 2011 LHC data
In the absence of signal, attempt to convey information about limit
Method currently being improved and applied on full 2011 data: stay tuned!

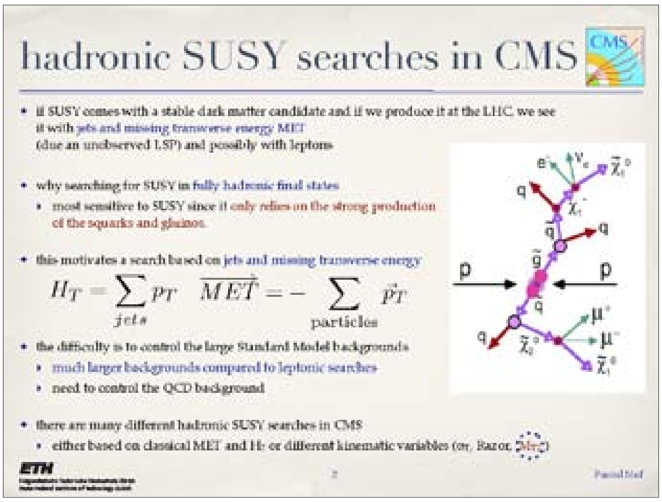
Pascal Nef – ETH Zurich
(PhD student)

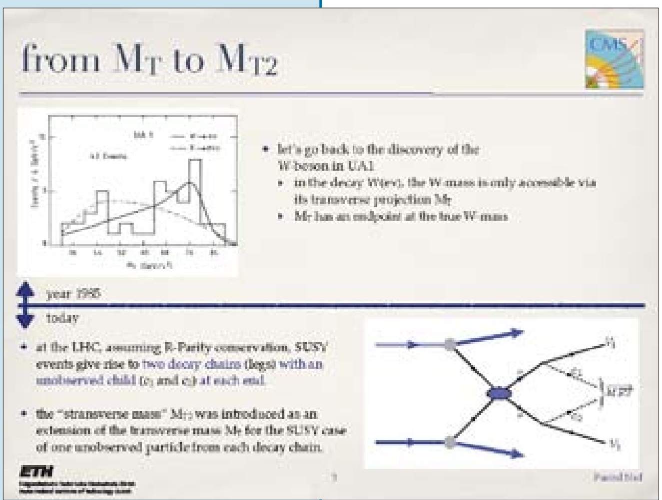
Searches for supersymmetry in hadronic final states with the CMS detector

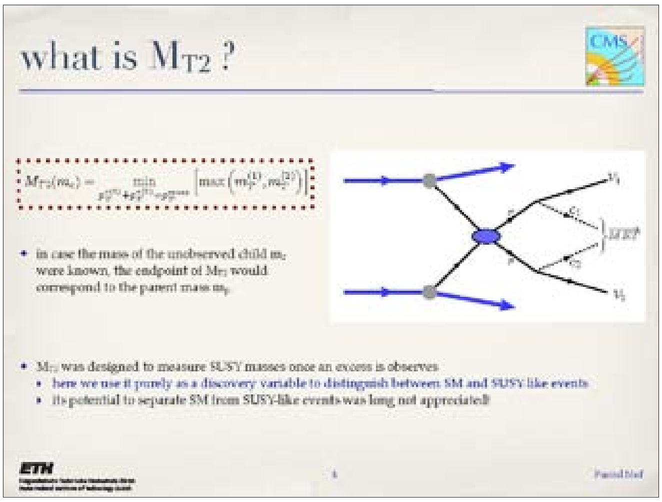
Scientific Abstract:

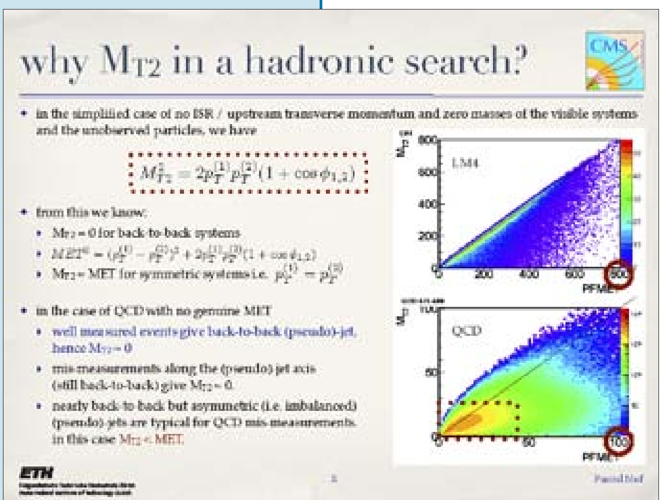
A search for supersymmetry or similar new physics in fully hadronic final states using pp collision data collected by the CMS experiment at the Large Hadron Collider is presented. This search is based on the transverse mass variable MT2, which allows to discriminate Standard Model back-grounds from signal-like events. Two complementary analyses are performed targeting regions of parameter space with medium to high squark and gluino masses as well as regions with a light gluino but heavy squarks. The search strategy as well as the data-driven methods to predict the Standard Model backgrounds are discussed.

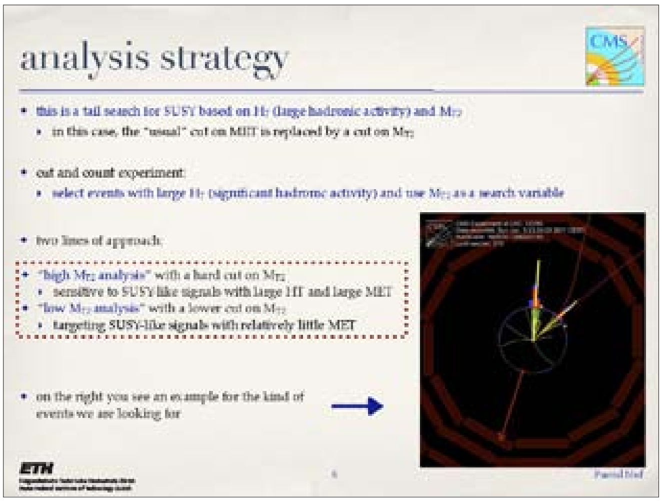

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
CMS
Search for supersymmetry in hadronic final states using MT2 with the CMS detector
Pascal Nef
Centre Of Advanced Studies In Particle Physics
Workshop On Mid-Term Results
Universität Zürich-Irchel, July 13th 2011

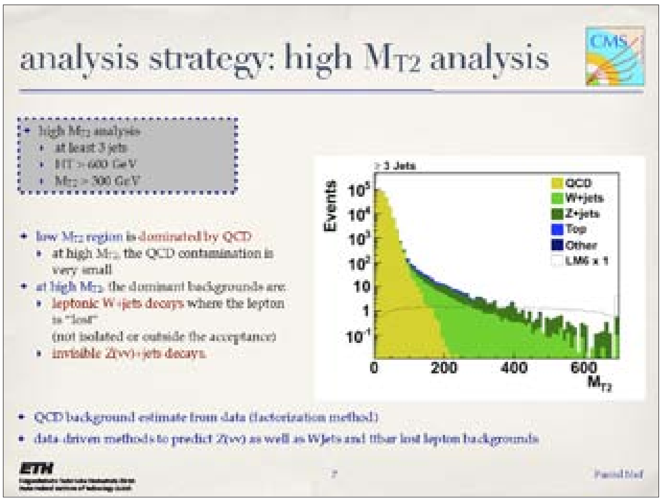

hadronic SUSY searches in CMS
if SUSY comes with a stable dark matter candidate and if we produce it at the LHC, we see it with jets and missing transverse energy MET (due an unobserved LSP) and possibly with leptons
why searching for SUSY in fully hadronic final states
most sensitive to SUSY since it only relies on the strong production of the squarks and gluinos
this motivates a search based on jets and missing transverse energy
$H_T = \sum_{jets} p_T \quad \overrightarrow{MET} = - \sum_{particles} \vec{p}_T$
the difficulty is to control the large Standard Model backgrounds
much larger backgrounds compared to leptonic searches
need to control the QCD background
there are many different hadronic SUSY searches in CMS
either based on classical MET and HT or different kinematic variables (αT, Razor, MT2)
Pascal Nef

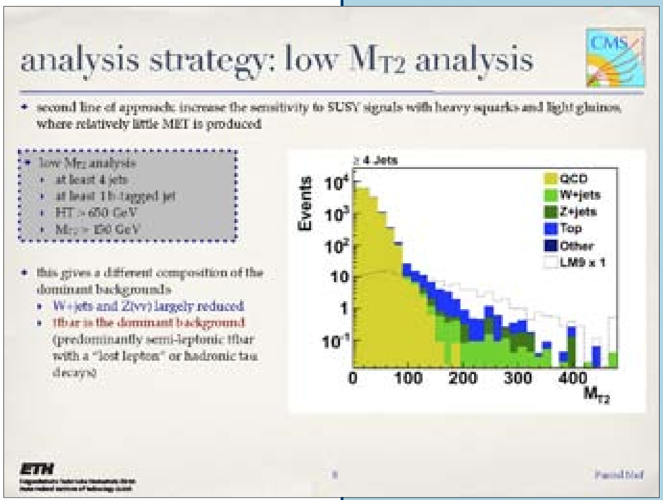

from MT to MT2
let's go back to the discovery of the W-boson in UA1
in the decay W(eν), the W-mass is only accessible via its transverse projection MT
MT has an endpoint at the true W-mass
year 1983
today
at the LHC, assuming R-Parity conservation, SUSY events give rise to two decay chains (legs) with an unobserved child (c1 and c2) at each end.
the "stransverse mass" MT2 was introduced as an extension of the transverse mass MT for the SUSY case of one unobserved particle from each decay chain.
Pascal Nef

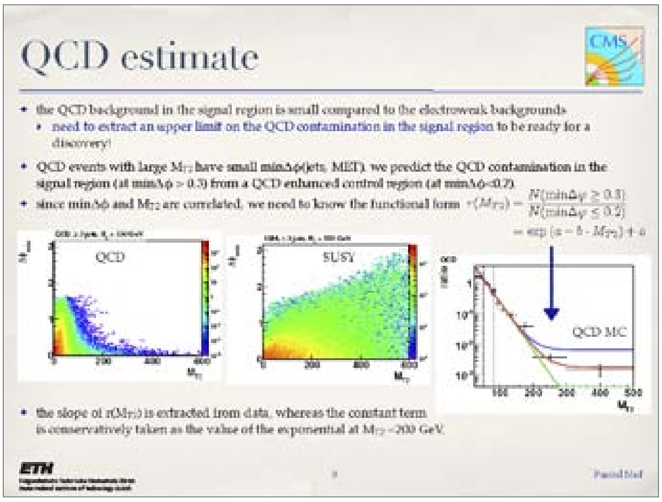

what is MT2 ?
in case the mass of the unobserved child mc were known, the endpoint of MT2 would correspond to the parent mass mp
MT2 was designed to measure SUSY masses once an excess is observes
here we use it purely as a discovery variable to distinguish between SM and SUSY like events
its potential to separate SM from SUSY-like events was long not appreciated!
Pascal Nef

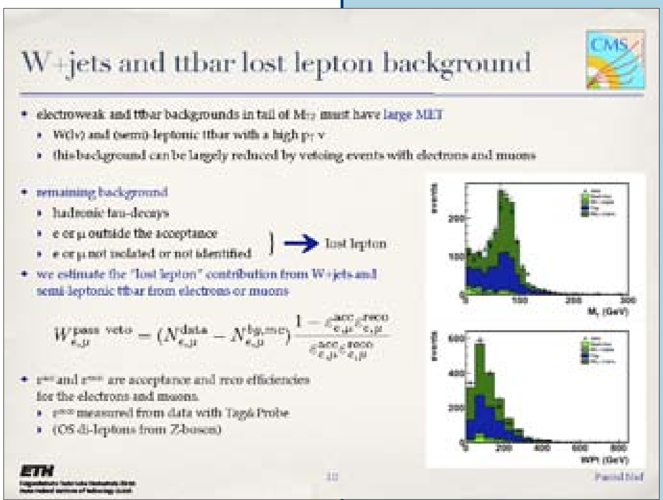

why MT2 in a hadronic search?
in the simplified case of no ISR / upstream transverse momentum and zero masses of the visible systems and the unobserved particles, we have
$M_{T2}^2 = 2p_T^{(1)}p_T^{(2)}(1+\cos\phi_{1,2})$
from this we know:
MT2 = 0 for back-to-back systems
MT2 = MET for symmetric systems i.e. $p_T^{(1)} = p_T^{(2)}$
in the case of QCD with no genuine MET
well measured events give back-to-back (pseudo)-jet, hence MT2 = 0
mis-measurements along the (pseudo) jet axis (still back-to-back) give MT2 = 0.
nearly back-to-back but asymmetric (i.e. imbalanced) (pseudo)-jets are typical for QCD mis-measurements. in this case MT2 < MET.
LM4
QCD
PFMET
Pascal Nef

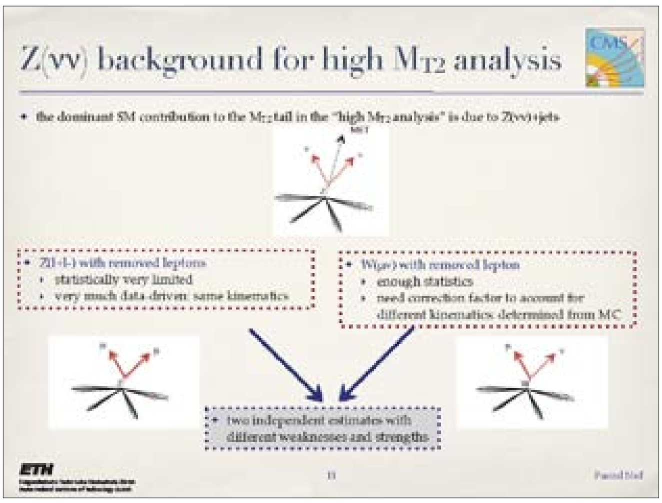

analysis strategy
this is a tail search for SUSY based on HT (large hadronic activity) and MT2
in this case, the "usual" cut on MET is replaced by a cut on MT2
cut and count experiment:
select events with large HT (significant hadronic activity) and use MT2 as a search variable
two lines of approach:
"high MT2 analysis" with a hard cut on MT2
sensitive to SUSY-like signals with large HT and large MET
"low MT2 analysis" with a lower cut on MT2
targeting SUSY-like signals with relatively little MET
on the right you see an example for the kind of events we are looking for
Pascal Nef

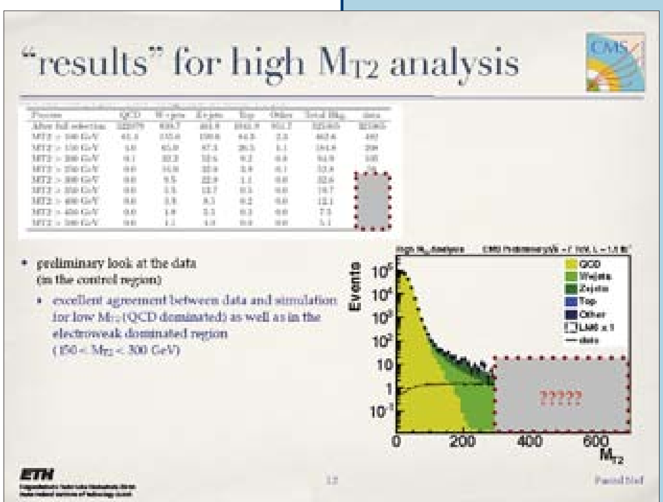

analysis strategy: high MT2 analysis
high MT2 analysis
at least 3 jets
HT > 600 GeV
MT2 > 300 GeV
low MT2 region is dominated by QCD
at high MT2, the QCD contamination is very small
at high MT2, the dominant backgrounds are:
leptonic W+jets decays where the lepton is "lost"
(not isolated or outside the acceptance)
invisible Z(νν)+jets decays.
≥ 3 Jets
Events
QCD
W+jets
Z+jets
Top
Other
LM6 x 1
MT2
QCD background estimate from data (factorization method)
data-driven methods to predict Z(νν) as well as W-jets and ttbar lost lepton backgrounds
ETH

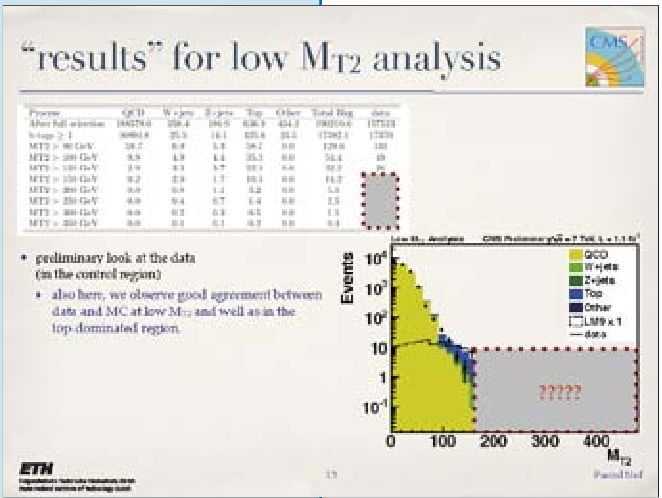

analysis strategy: low MT2 analysis
second line of approach: increase the sensitivity to SUSY signals with heavy squarks and light gluinos, where relatively little MET is produced
low MT2 analysis
at least 4 jets
at least 1 b-tagged jet
HT > 650 GeV
MT2 > 150 GeV
this gives a different composition of the dominant backgrounds
W+jets and Z(νν) largely reduced
ttbar is the dominant background
(predominantly semi-leptonic ttbar with a "lost lepton" or hadronic tau decays)
≥ 4 Jets
Events
QCD
W+jets
Z+jets
Top
Other
LM9 x 1
MT2
ETH

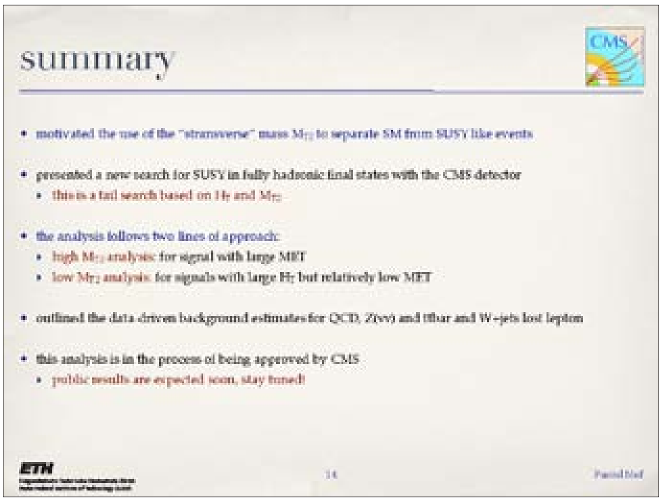

QCD estimate
the QCD background in the signal region is small compared to the electroweak backgrounds
need to extract an upper limit on the QCD contamination in the signal region to be ready for a discovery!
QCD events with large MT2 have small minΔφ(jets, MET). we predict the QCD contamination in the signal region (at minΔφ > 0.3) from a QCD enhanced control region (at minΔφ<0.2).
since minΔφ and MT2 are correlated, we need to know the functional form
QCD
SUSY
QCD MC
the slope of r(MT2) is extracted from data, whereas the constant term is conservatively taken as the value of the exponential at MT2 =200 GeV.
ETH


W+jets and ttbar lost lepton background
electroweak and ttbar backgrounds in tail of MT2 must have large MET
W(lν) and (semi)-leptonic ttbar with a high pT ν
this background can be largely reduced by vetoing events with electrons and muons
remaining background
hadronic tau-decays
e or μ outside the acceptance
e or μ not isolated or not identified
lost lepton
we estimate the "lost lepton" contribution from W+jets and semi-leptonic ttbar from electrons or muons
ε^acc and ε^reco are acceptance and reco efficiencies for the electrons and muons
ε^reco measured from data with Tag&Probe
(OS di-leptons from Z-boson)
ETH


Z(νν) background for high MT2 analysis
the dominant SM contribution to the MT2 tail in the "high MT2 analysis" is due to Z(νν)+jets
MET
Z(l+l-) with removed leptons
statistically very limited
very much data-driven: same kinematics
W(μν) with removed lepton
enough statistics
need correction factor to account for different kinematics determined from MC
two independent estimates with different weaknesses and strengths
ETH


"results" for high MT2 analysis
preliminary look at the data
(in the control region)
excellent agreement between data and simulation for low MT2 (QCD dominated) as well as in the electroweak dominated region
(150 < MT2 < 300 GeV)
Events
QCD
Z+jets
Top
Other
LM6 x 1
data
?????
MT2
ETH


"results" for low MT2 analysis
Process
QCD
W+jets
Z+jets
Top
Other
Total Bkg
data
preliminary look at the data
(in the control region)
also here, we observe good agreement between data and MC at low MT2 and well as in the top-dominated region
Events
QCD
W+jets
Z+jets
Top
Other
LM9 x 1
data
?????
0
100
200
300
400
MT2
ETH
13
Pascal Nef


summary
motivated the use of the "stransverse" mass MT2 to separate SM from SUSY like events
presented a new search for SUSY in fully hadronic final states with the CMS detector
this is a tail search based on HT and MT2
the analysis follows two lines of approach:
high MT2 analysis: for signal with large MET
low MT2 analysis: for signals with large HT but relatively low MET
outlined the data driven background estimates for QCD, Z(νν) and ttbar and W+jets lost lepton
this analysis is in the process of being approved by CMS
public results are expected soon, stay tuned!
ETH
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Pascal Nef

Marco Agustoni – University of Bern
(PhD student)

Jet triggers studies for Supersymmetry searches in the ATLAS experiment at LHC

Scientific Abstract:

At the ATLAS experiment at the LHC, the trigger system has to filter out about 300 of the about 40 million events per second coming from proton-proton interactions. Because of the high mass of the short-lived super-symmetry particles, their decay products carry high momenta. The online selection of supersymmetry events can therefore be done by requiring decay products with high transverse momenta.

This talk focuses on a special type of jet trigger, which combines the energy information of multiple jets. This type of trigger is designed to have good acceptance for supersymmetry events decaying in many jets. At the same time it rejects well the Standard Model multijet background which is dominating at the LHC.

CHIPP Workshop Zurich, July 28. 2011

Studies of Jet Energy sum Triggers in the ATLAS Experiment

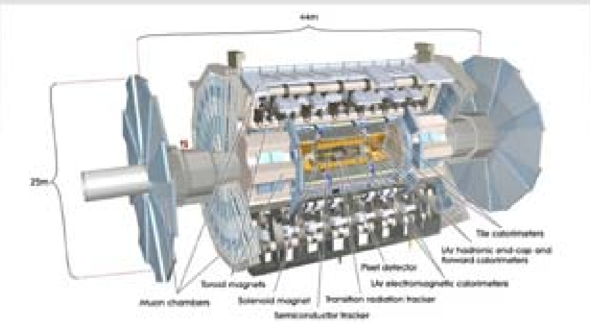
Marco Agustoni

LHEP University of Berne

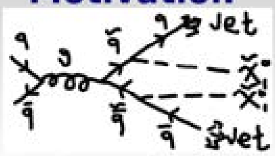
Outline

- The ATLAS detector
- Motivation
- Jet algorithm reconstruction
- ATLAS Trigger
- Data results
- Summary

The ATLAS Detector



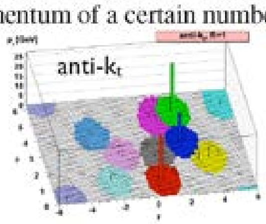
Motivation



- SUSY suggests the existence of massive new particles
  → high hadronic activity!
  → multiple high energy jets
- Trigger on sum of the jet energy (JE Trigger)
  - Avoid a threshold for each jet
  - More selective than sum cells energies (noise)

Jet algorithm reconstruction

- Jets are bunch of hadrons (originate from quarks fragmentation and gluons) flying roughly in the same direction
- Jet algorithm: Sum the momenta of final state particles into momentum of a certain number of jets



Jet Cleaning

- Jets reconstructed in the trigger are further cleaned offline, to separate real and fakes jets
- Jets are classified in 3 categories: good, bad, ugly
  - Bad jets are jets not associated to in-time real energy deposits in the calorimeters (sources: hardware problems, beam conditions, cosmic rays,...)
  - Ugly jets correspond to real energy depositions in region where the energy measurement is not accurate (transition regions barrel/end-cap, problematic calorimeter regions)
  - Good jets are not bad & not ugly jets

Triggering

- LHC bunch crossing rate: 40 MHz (now 20 MHz)
- It corresponds to the event rate (~6 interaction/crossing in average)
  → Impossible to record all events!
- The trigger is an on-line selection of interesting events
- The Trigger consists of three levels of event selection

Level 1 Level 2 Event Filter

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Jet selection: Level 1 (L1)

- L1 decision must reach the front-end electronics within *2.5 μs* after the bunch crossing
- L1 Trigger is based on a sliding-window algorithm that selects high energy depositions in a square size of Δ• •• •• •
- L1 Trigger searches for signatures from high p_T Jets or can make a sum of energies

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Jet selection: Level 2 (L2)

- L2 Trigger has an average events processing time of approximately *40 ms*
- Software based on a computer cluster
- L2 Trigger is based on simplified version of a cone clustering algorithm, on calorimeter clusters with full granularity
- L2 Trigger is seeded by Regions-of-Interest (RoI's), which are regions of detector where L1 trigger has identified possible trigger objects within the event → limit the amount of data to the readout

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Jet selection: Event Filter (EF)

- EF has an average event processing time of order of *4 s*
- It has the full event information
- EF uses offline analysis procedures on built events to further select down to a rate which can be recorded for subsequent offline analysis
- The anti-k_t algorithm is used, like offline

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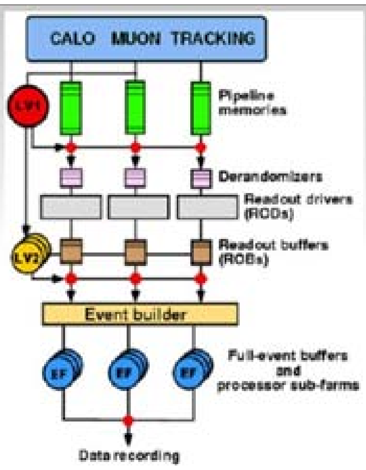

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Results: JetEtSum Trigger

- At L1 : weighted sum of the eight L1 multiplicities, L1 jet $|\eta| < 3.2$
- At L2 : sum of all L2 jet in an event with $jetE_T > 15GeV$ (EM scale) and $|\eta| < 3.2$
- Threshold used:
  - L1 JE100 → L2_je195

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Producing a Turn-on-curve

- Trigger efficiency: fraction of jets of a certain process that fire the trigger:

$$\frac{jets\ that\ fired\ the\ trigger}{all\ \ jets}(p_T)$$

- Independent Trigger (here muons) to have an unbiased measurement of the fired and the other jets

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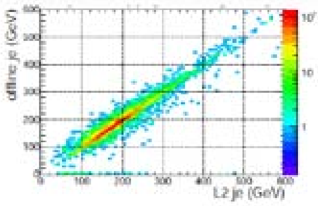
Correlation: offline je to L1|L2

- The good efficiency reached for a turn-on-curve depends also on the correlation between offline and L1|L2 jets energy sum



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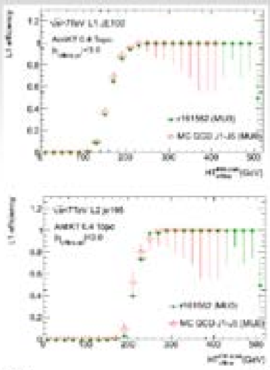
Turn-on-curves



- Offline plots for energy deposited in the calorimeter with the chain: L1 JE100 → L2_je195
- Good agreement between data and simulation with Monte Carlo for the trigger efficiency

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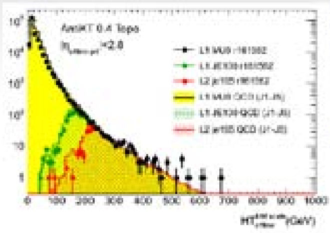
Effect of the Trigger



- With this chain ~10^3 Background events are cut away!
- Good selection for SUSY searches

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Summary

- JE Triggers are good to select SUSY events
- Several trigger chains implemented in ATLAS
- Data and simulation agree in turn-on-curves
- More studies to come with new data

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Marc Tobin – University of Zurich
(PostDoc)

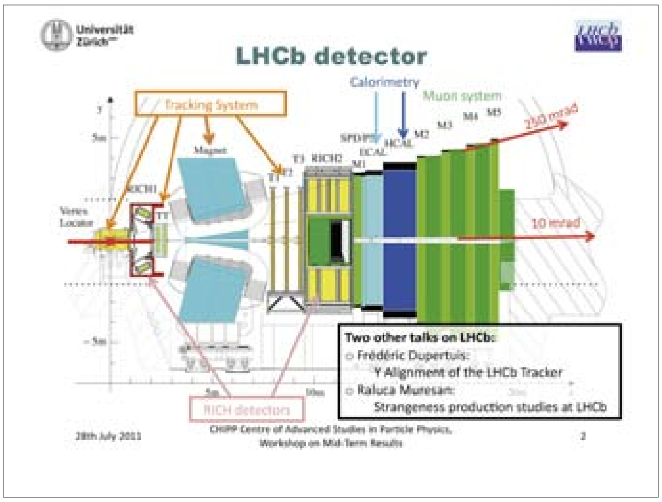
Performance of the LHCb Silicon Tracker

Scientific Abstract:

The LHCb detector is designed to study the decays of B-mesons in proton-proton collisions at the Large Hadron Collider (LHC). The detector is a single arm forward spectrometer with excellent tracking and particle identification capabilities. The Silicon Tracker consists of two detectors both of which are constructed from silicon micro-strip detectors which cover the region with highest occupancy around the beam axis. The first operational experience will be shown together with problems encountered during the commissioning and running of the detector.

The performance of the detectors in high energy collisions at the LHC is presented. The data collected in 2010 and 2011 has been used to determine the optimal time and spatial alignment of the detectors. A detailed study has also been made of the intrinsic detector efficiency and resolution. First measurements of the observed radiation damage are also shown.


Universität Zürich
Performance of the LHCb Silicon Tracker
Mark Tobin
Physik-Institut der Universität Zürich
28th July 2011
CHIPP Centre of Advanced Studies in Particle Physics, Workshop on Mid-Term Results
1


Universität Zürich
LHCb detector
Tracking System
Calorimetry
Muon system
250 mrad
10 mrad
Vertex Locator
RICH1
Magnet
RICH2
ECAL
HCAL
M1
M2
M3
M4
M5
RICH detectors
Two other talks on LHCb:
Frédéric Dupertuis:
Y Alignment of the LHCb Tracker
Raluca Muresan:
Strangeness production studies at LHCb
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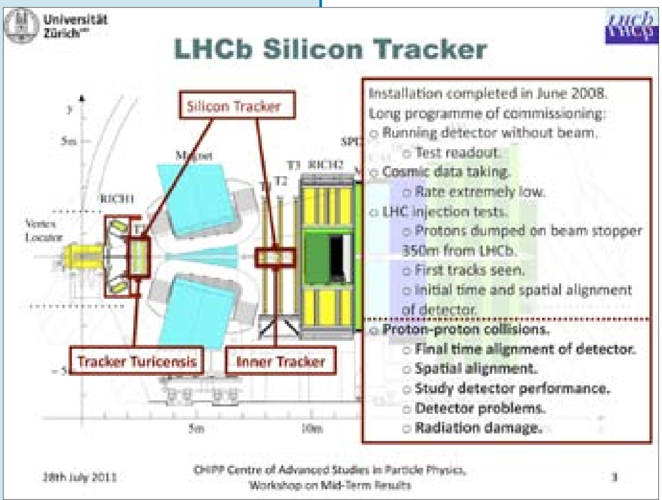
Universität Zürich
LHCb Silicon Tracker
Silicon Tracker
Tracker Turicensis
Inner Tracker
Installation completed in June 2008.
Long programme of commissioning:
Running detector without beam.
Test readout.
Cosmic data taking.
Rate extremely low.
LHC injection tests.
Protons dumped on beam stopper 350m from LHCb.
First tracks seen.
Initial time and spatial alignment of detector.
Proton-proton collisions.
Final time alignment of detector.
Spatial alignment.
Study detector performance.
Detector problems.
Radiation damage.
28th July 2011
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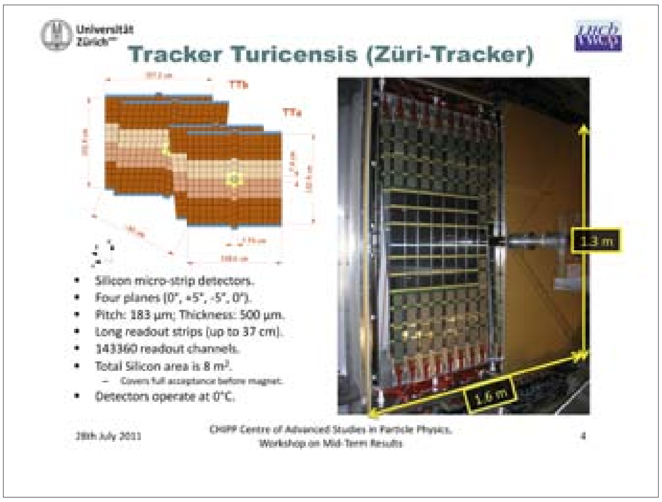
3


Universität Zürich
Tracker Turicensis (Züri-Tracker)
TTb
TTa
1.3 m
1.6 m
Silicon micro-strip detectors.
Four planes (0°, +5°, -5°, 0°).
Pitch: 183 µm; Thickness: 500 µm.
Long readout strips (up to 37 cm).
143360 readout channels.
Total Silicon area is 8 m².
Covers full acceptance before magnet.
Detectors operate at 0°C.
28th July 2011
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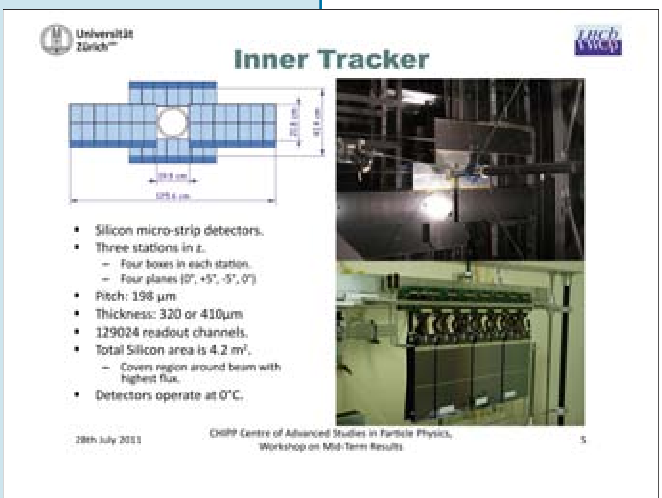
4


Universität Zürich
Inner Tracker
Silicon micro-strip detectors.
Three stations in z.
Four boxes in each station.
Four planes (0°, +5°, -5°, 0°)
Pitch: 198 µm
Thickness: 320 or 410µm
129024 readout channels.
Total Silicon area is 4.2 m².
Covers region around beam with highest flux.
Detectors operate at 0°C.
28th July 2011
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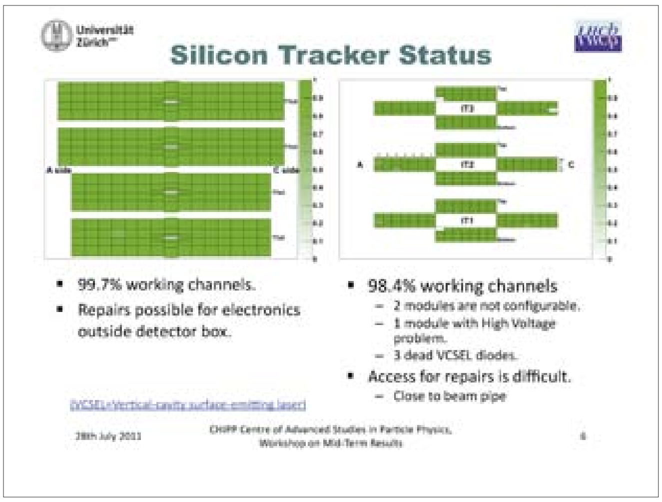
5


Universität Zürich
Silicon Tracker Status
A side
C side
IT3
IT2
IT1
99.7% working channels.
Repairs possible for electronics outside detector box.
98.4% working channels
2 modules are not configurable.
1 module with High Voltage problem.
3 dead VCSEL diodes.
Access for repairs is difficult.
Close to beam pipe
(VCSEL=Vertical-cavity surface-emitting laser)
28th July 2011
CHIPP Centre of Advanced Studies in Particle Physics, Workshop on Mid-Term Results
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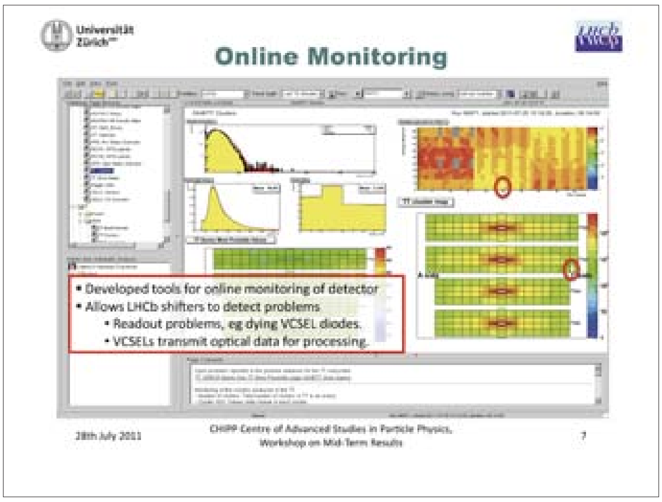
Universität Zürich
Online Monitoring
• Developed tools for online monitoring of detector
• Allows LHCb shifters to detect problems
• Readout problems, eg dying VCSEL diodes.
• VCSELs transmit optical data for processing.
28th July 2011
CHIPP Centre of Advanced Studies in Particle Physics, Workshop on Mid-Term Results
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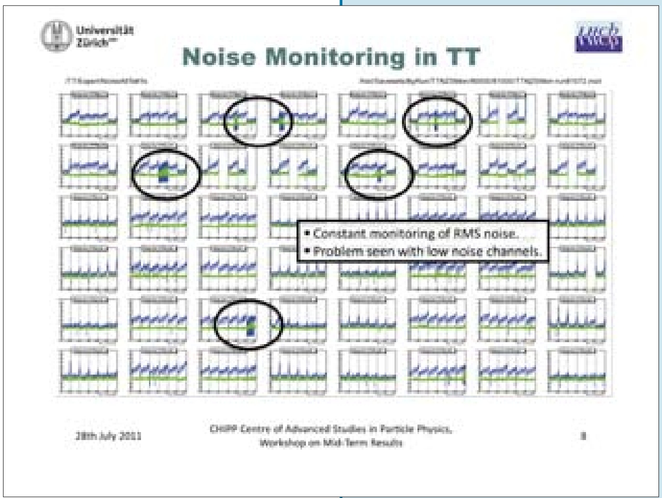
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Noise Monitoring in TT
• Constant monitoring of RMS noise.
• Problem seen with low noise channels.
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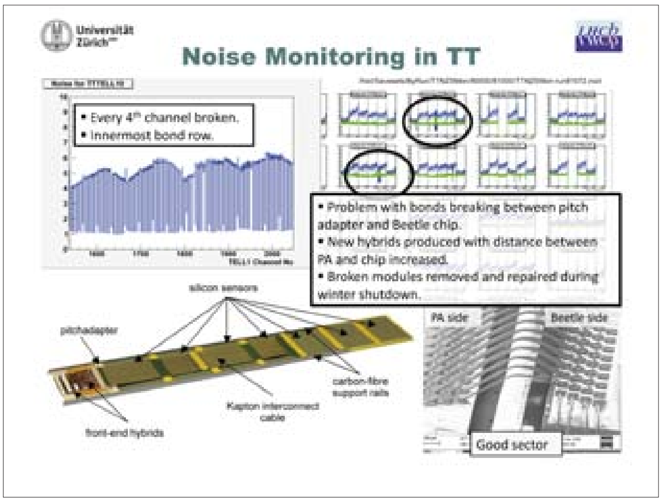
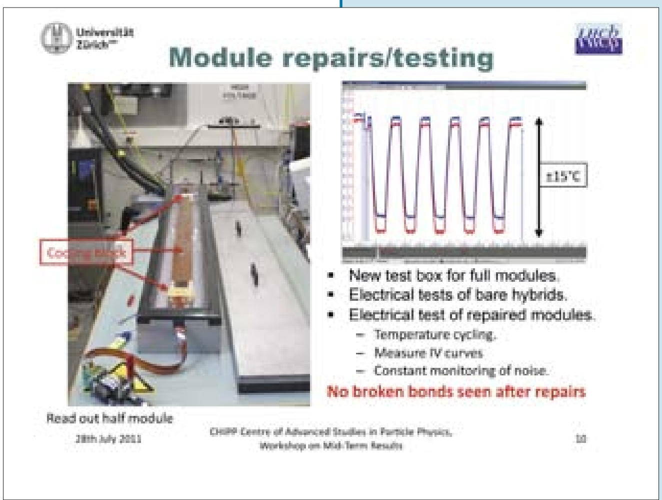

Universität Zürich
Noise Monitoring in TT
• Every 4th channel broken.
• Innermost bond row.
• Problem with bonds breaking between pitch adapter and Beetle chip.
• New hybrids produced with distance between PA and chip increased.
• Broken modules removed and repaired during winter shutdown.
silicon sensors
pitchadapter
carbon-fibre support rails
Kapton interconnect cable
front-end hybrids
PA side
Beetle side
Good sector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Module repairs/testing
±15°C
Cooling block
• New test box for full modules.
• Electrical tests of bare hybrids.
• Electrical test of repaired modules.
– Temperature cycling.
– Measure IV curves
– Constant monitoring of noise.
No broken bonds seen after repairs
Read out half module
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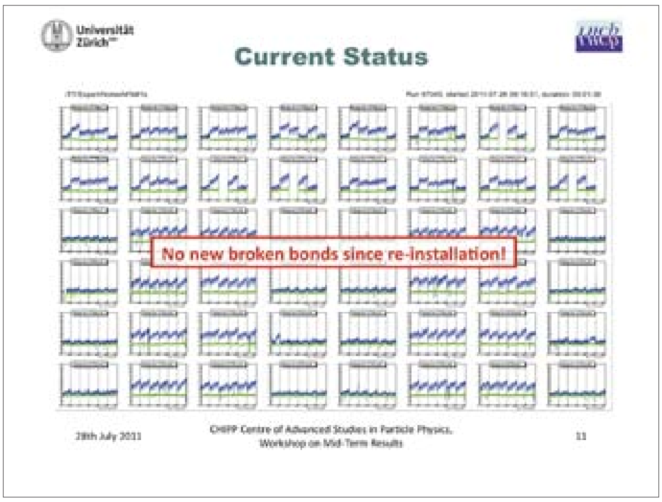
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Current Status
No new broken bonds since re-installation!
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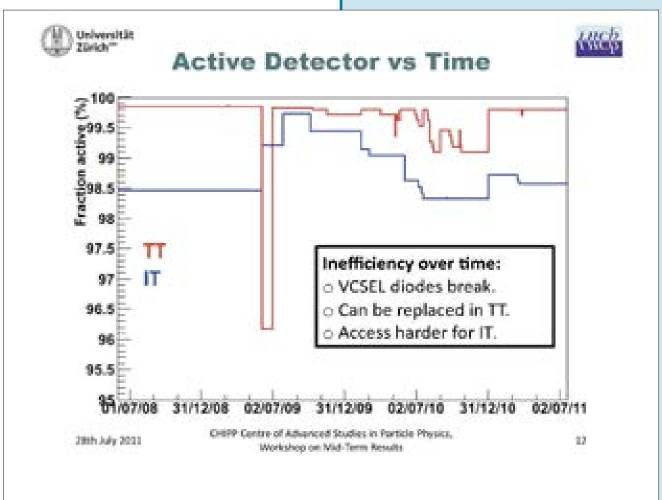
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Active Detector vs Time
Fraction active (%)
100
99.5
99
98.5
98
97.5
97
96.5
96
95.5
95
TT
IT
Inefficiency over time:
○ VCSEL diodes break.
○ Can be replaced in TT.
○ Access harder for IT.
01/07/08
31/12/08
02/07/09
31/12/09
02/07/10
31/12/10
02/07/11
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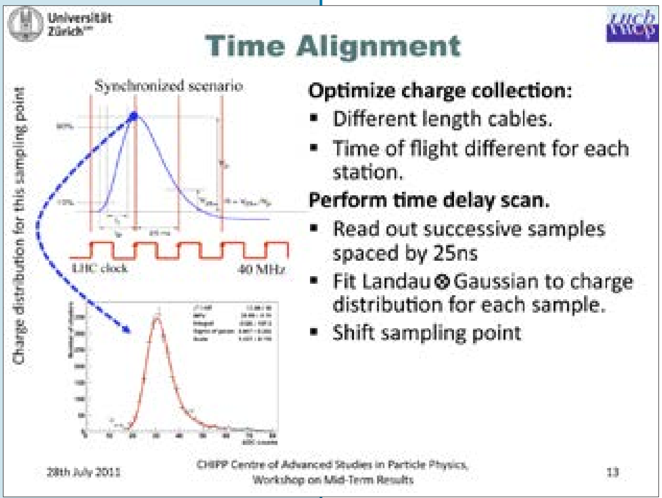
Universität Zürich
Time Alignment
Synchronized scenario
LHC clock
40 MHz
Charge distribution for this sampling point
Optimize charge collection:
Different length cables.
Time of flight different for each station.
Perform time delay scan.
Read out successive samples spaced by 25ns
Fit Landau ⊗ Gaussian to charge distribution for each sample.
Shift sampling point
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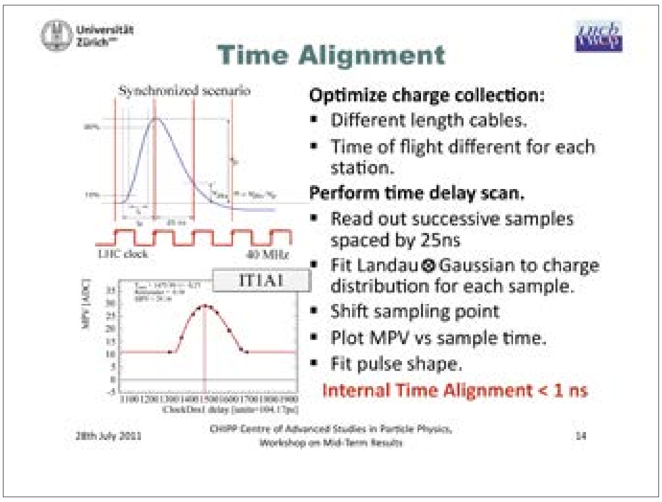
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Time Alignment
Synchronized scenario
LHC clock
40 MHz
IT1A1
MPV [ADC]
Optimize charge collection:
Different length cables.
Time of flight different for each station.
Perform time delay scan.
Read out successive samples spaced by 25ns
Fit Landau ⊗ Gaussian to charge distribution for each sample.
Shift sampling point
Plot MPV vs sample time.
Fit pulse shape.
Internal Time Alignment < 1 ns
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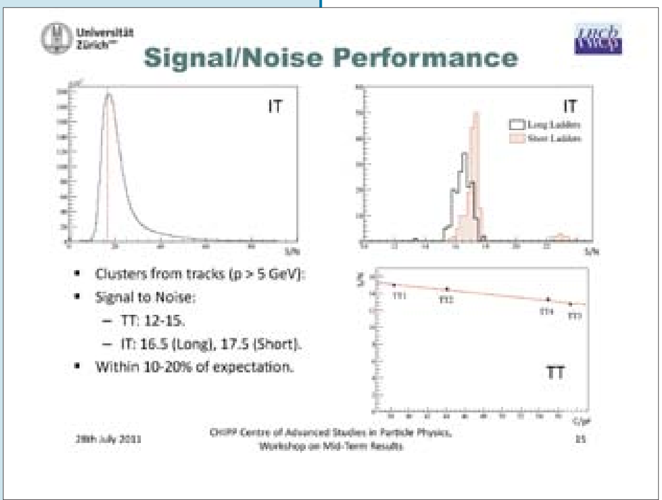
Universität Zürich
Signal/Noise Performance
IT
IT
Long Ladders
Short Ladders
TT
Clusters from tracks (p > 5 GeV):
Signal to Noise:
TT: 12-15.
IT: 16.5 (Long), 17.5 (Short).
Within 10-20% of expectation.
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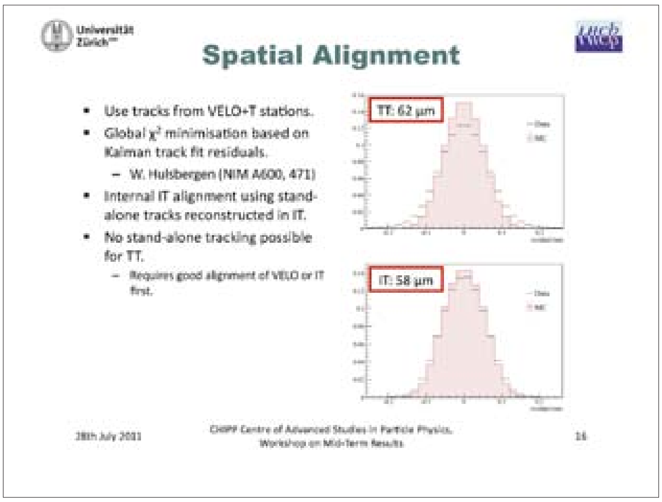
Universität Zürich
Spatial Alignment
Use tracks from VELO+T stations.
Global χ² minimisation based on Kalman track fit residuals.
W. Hulsbergen (NIM A600, 471)
Internal IT alignment using stand-alone tracks reconstructed in IT.
No stand-alone tracking possible for TT.
Requires good alignment of VELO or IT first.
TT: 62 µm
IT: 58 µm
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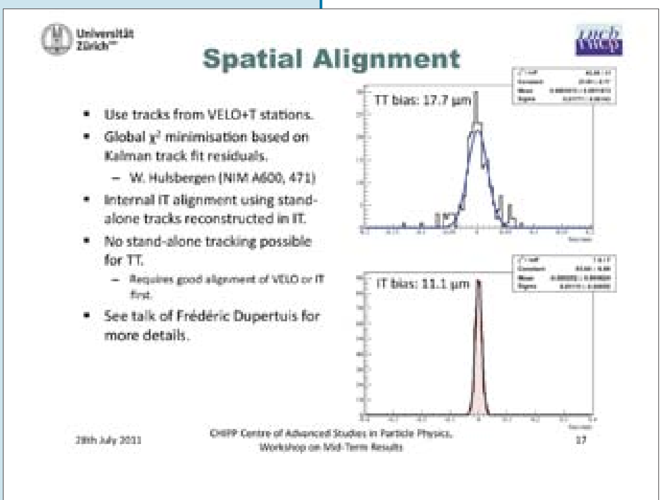
Universität Zürich
Spatial Alignment
Use tracks from VELO+T stations.
Global χ² minimisation based on Kalman track fit residuals.
W. Hulsbergen (NIM A600, 471)
Internal IT alignment using stand-alone tracks reconstructed in IT.
No stand-alone tracking possible for TT.
Requires good alignment of VELO or IT first.
See talk of Frédéric Dupertuis for more details.
TT bias: 17.7 µm
IT bias: 11.1 µm
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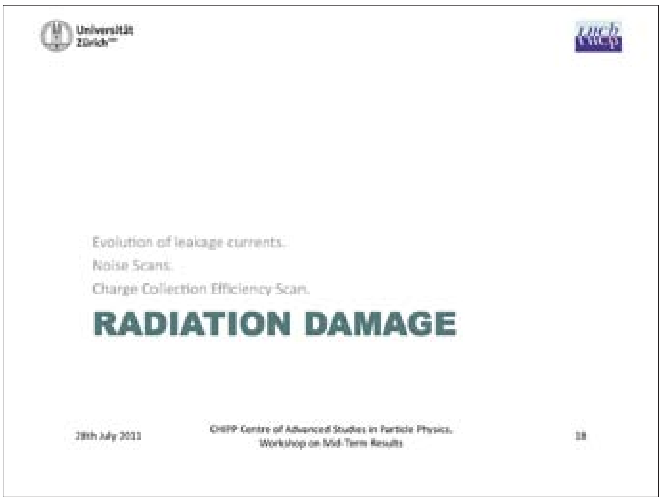
Universität Zürich
Evolution of leakage currents.
Noise Scans.
Charge Collection Efficiency Scan.
RADIATION DAMAGE
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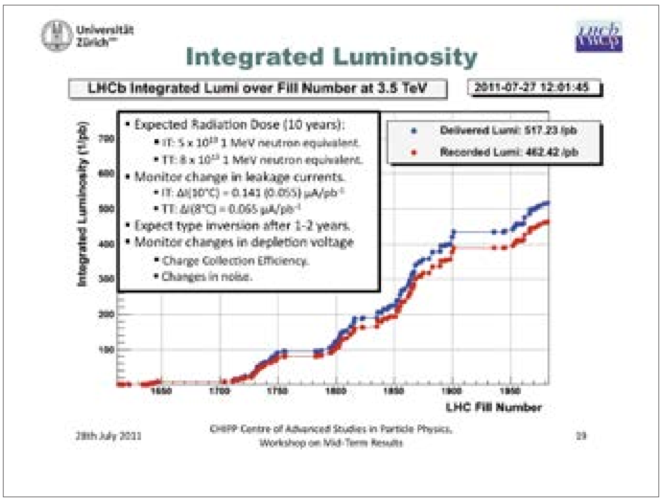
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Integrated Luminosity
LHCb Integrated Lumi over Fill Number at 3.5 TeV
2011-07-27 12:01:45
• Expected Radiation Dose (10 years):
• IT: 5 x 10^13 1 MeV neutron equivalent.
• TT: 8 x 10^13 1 MeV neutron equivalent.
• Monitor change in leakage currents.
• IT: ΔI(10°C) = 0.141 (0.055) μA/pb^-1
• TT: ΔI(8°C) = 0.065 μA/pb^-1
• Expect type inversion after 1-2 years.
• Monitor changes in depletion voltage
• Charge Collection Efficiency.
• Changes in noise.
Delivered Lumi: 517.23 /pb
Recorded Lumi: 462.42 /pb
Integrated Luminosity (1/pb)
LHC Fill Number
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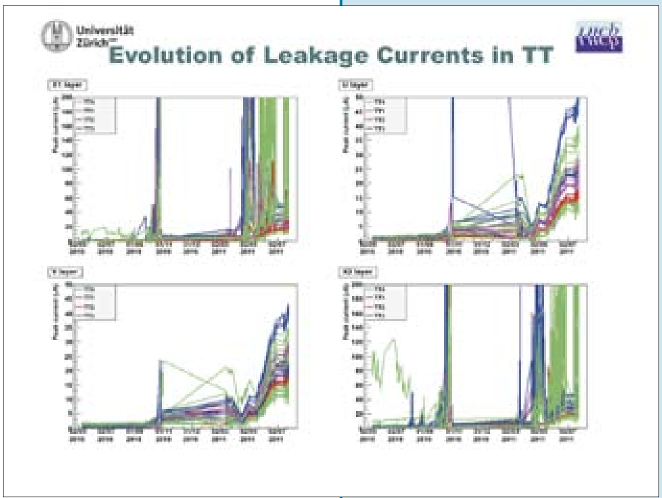
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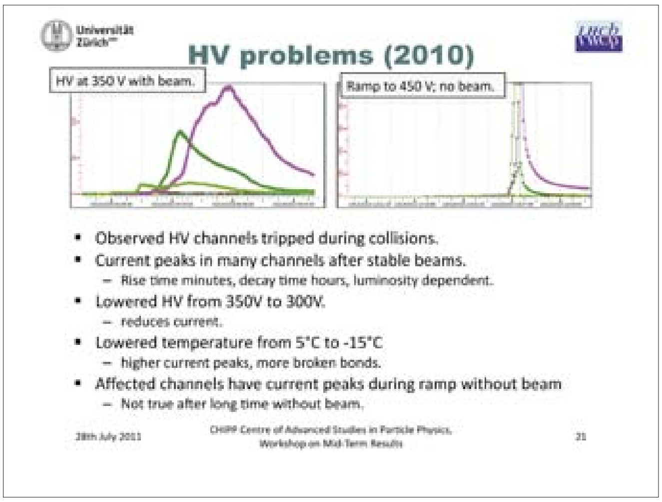
Evolution of Leakage Currents in TT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HV problems (2010)
HV at 350 V with beam.
Ramp to 450 V; no beam.
• Observed HV channels tripped during collisions.
• Current peaks in many channels after stable beams.
– Rise time minutes, decay time hours, luminosity dependent.
• Lowered HV from 350V to 300V.
– reduces current.
• Lowered temperature from 5°C to -15°C
– higher current peaks, more broken bonds.
• Affected channels have current peaks during ramp without beam
– Not true after long time without beam.
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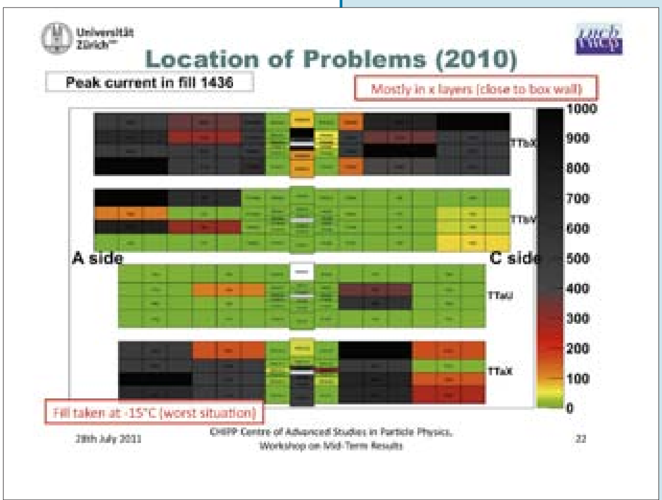
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Location of Problems (2010)
Peak current in fill 1436
Mostly in x layers (close to box wall)
TTbX
TTbV
TTaU
TTaX
A side
C side
1000
900
800
700
600
500
400
300
200
100
0
Fill taken at -15°C (worst situation)
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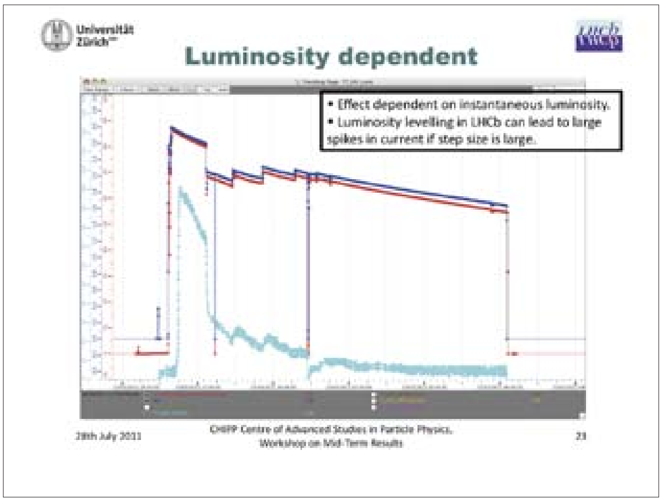
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Luminosity dependent
• Effect dependent on instantaneous luminosity.
• Luminosity levelling in LHCb can lead to large spikes in current if step size is large.
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Installation of Kapton foil
• Installed kapton foil on wall of TT box during last technical stop (10/5).
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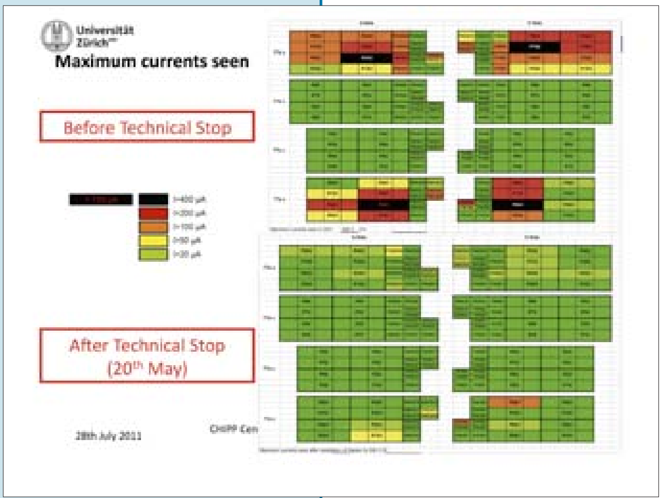
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Maximum currents seen
Before Technical Stop
After Technical Stop (20th May)
28th July 2011
CHIPP Cen


Universität Zürich
We didn't make things worse!
☺
28th July 2011
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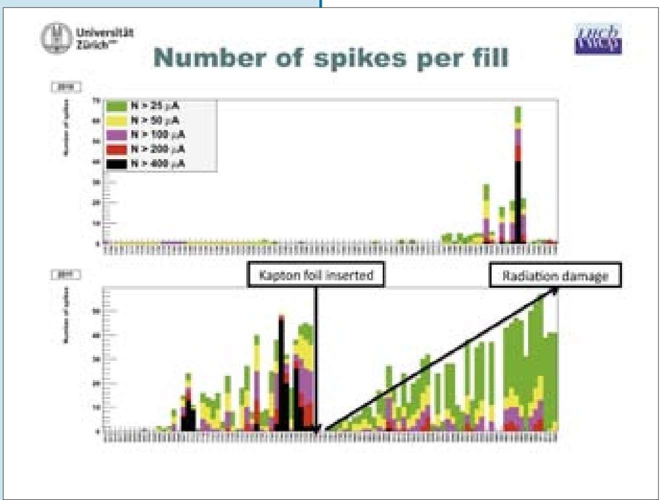
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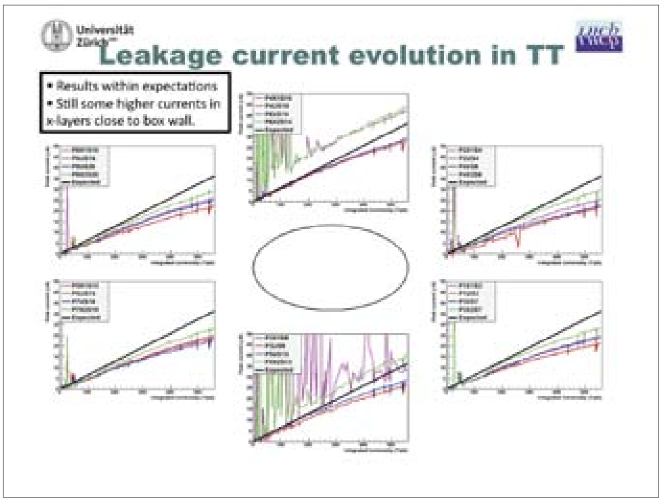
Number of spikes per fill
N > 25 µA
N > 50 µA
N > 100 µA
N > 200 µA
N > 400 µA
Kapton foil inserted
Radiation damage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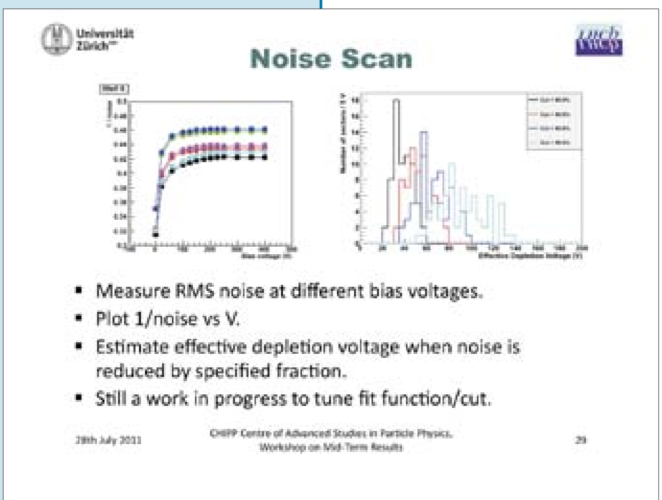
Leakage current evolution in TT
• Results within expectations
• Still some higher currents in x-layers close to box wall.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Noise Scan
• Measure RMS noise at different bias voltages.
• Plot 1/noise vs V.
• Estimate effective depletion voltage when noise is reduced by specified fraction.
• Still a work in progress to tune fit function/cut.
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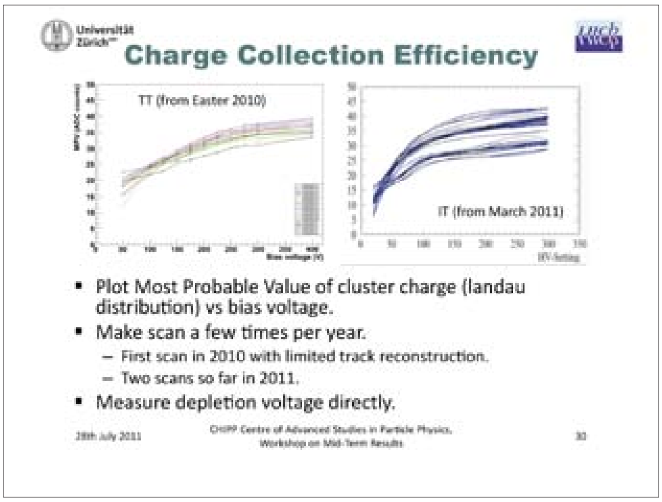
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Charge Collection Efficiency
TT (from Easter 2010)
IT (from March 2011)
• Plot Most Probable Value of cluster charge (landau distribution) vs bias voltage.
• Make scan a few times per year.
– First scan in 2010 with limited track reconstruction.
– Two scans so far in 2011.
• Measure depletion voltage directly.
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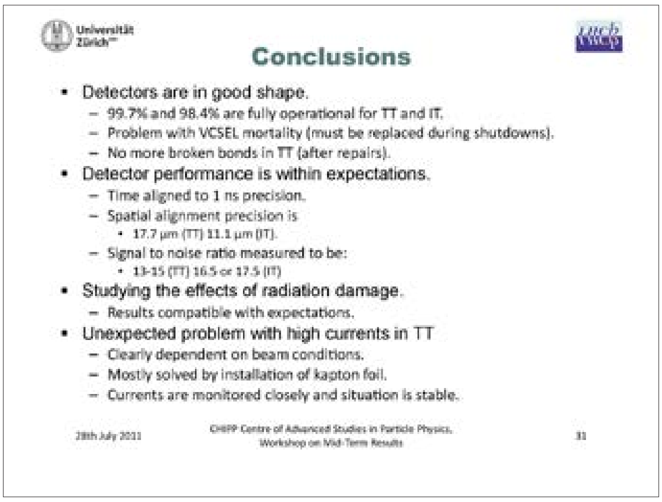
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Conclusions
• Detectors are in good shape.
– 99.7% and 98.4% are fully operational for TT and IT.
– Problem with VCSEL mortality (must be replaced during shutdowns).
– No more broken bonds in TT (after repairs).
• Detector performance is within expectations.
– Time aligned to 1 ns precision.
– Spatial alignment precision is
• 17.7 μm (TT) 11.1 μm (IT).
– Signal to noise ratio measured to be:
• 13-15 (TT) 16.5 or 17.5 (IT)
• Studying the effects of radiation damage.
– Results compatible with expectations.
• Unexpected problem with high currents in TT
– Clearly dependent on beam conditions.
– Mostly solved by installation of kapton foil.
– Currents are monitored closely and situation is stable.
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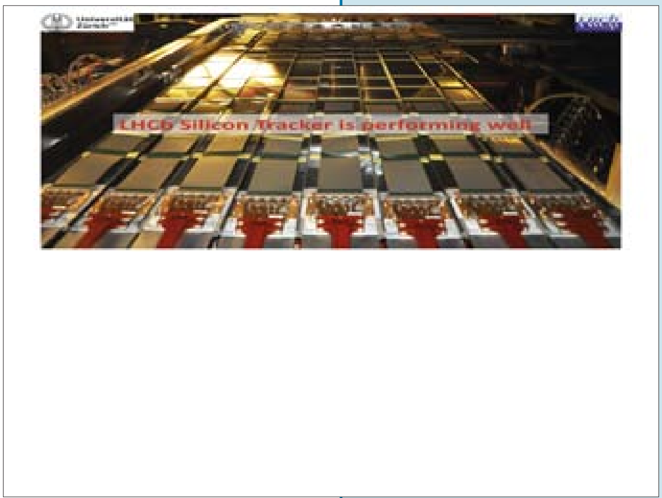

LHCb Silicon Tracker is performing well

Frédéric Dupertuis – EPF Lausanne
(PhD student)

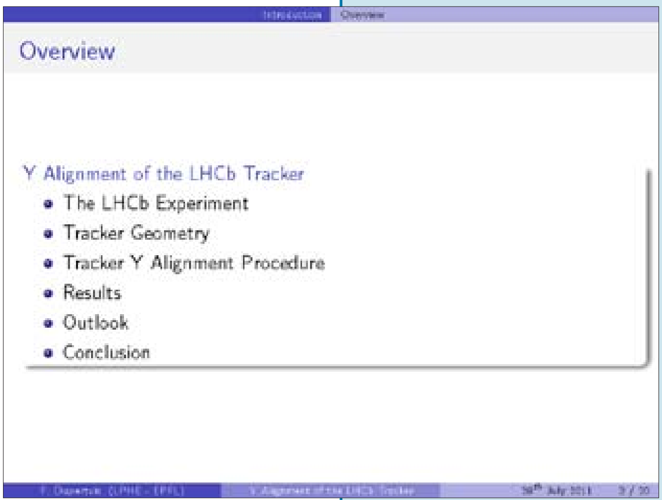
Performance of the LHCb Silicon Tracker

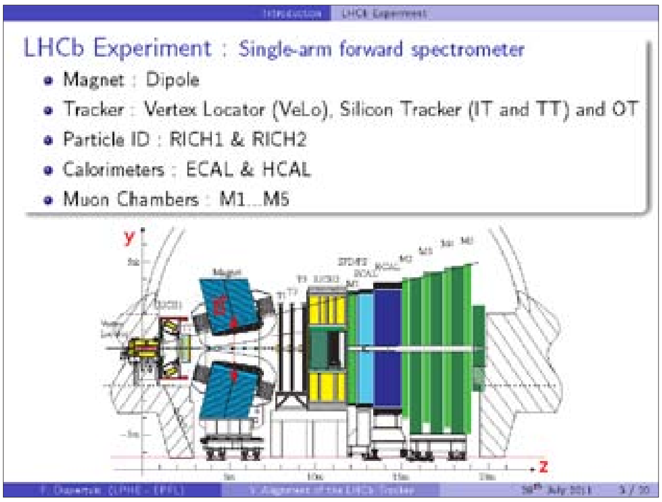
Scientific Abstract:

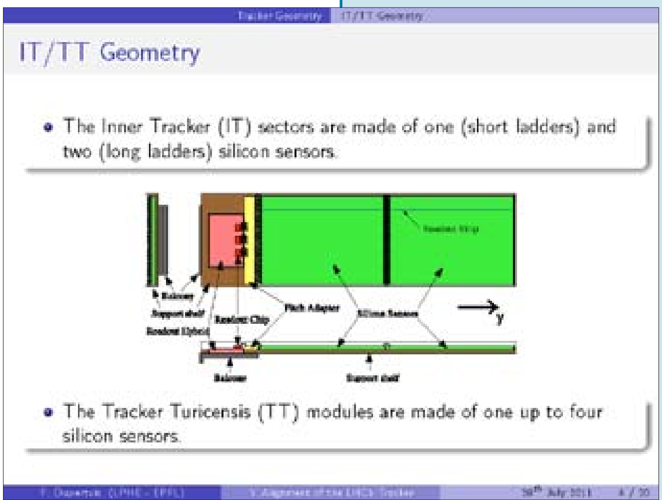
The LHCb experiment is a single-arm spectrometer located along the LHC collider ring. The tracking system is composed of a vertex detector called VErtex LOcator (VELO), the Tracker Turicensis (TT) and three T stations (T1... T3) which include the Inner Tracker (IT) and Outer Tracker (OT). The tracking system is distributed on both sides of a dipole magnet to measure charged particle momenta. All the tracking system is made of silicon micro-strips except for the OT which is made of gaseous straw-tube based detectors.

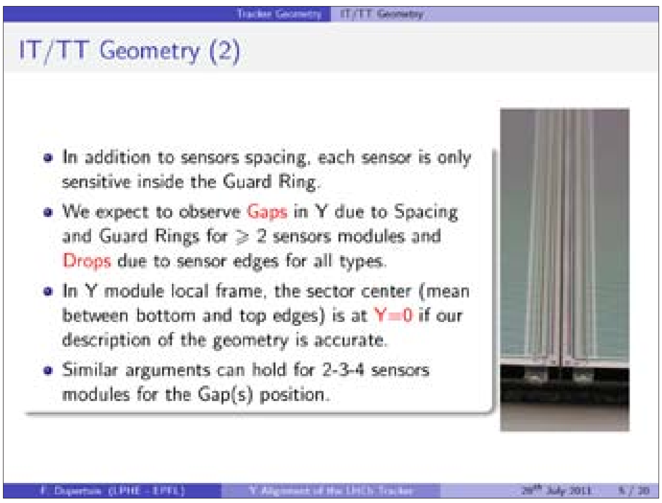
The alignment performed with default magnet-on collision data relies strongly on the LHCb magnetic field map quality since there is no tracking system inside the magnet. This can be studied by using magnet-off data. In addition, the track vertical (Y) position is retrieved for IT, TT, OT subdetectors by the combination of a vertically oriented and a 5° Stereo module. This induces a "weak" mode when aligning for Y coordinate between Y and relative horizontal (X) translation of X-Stereo elements. A solution has been found using magnet-off data and extrapolating VELO tracks to the IT, TT, OT modules. By computing residuals between found and expected hits position, a direct X misalignment measurement can be obtained. This leads to a strong validation of magnet-on versus -off for a given VELO alignment. The misalignment of the Y coordinate can be measured directly by adding knowledge of insensitive part of the detector perpendicular to the Y axis and looking for shifts of gaps or/and edges with respect to their expected positions in the track's Y distribution.

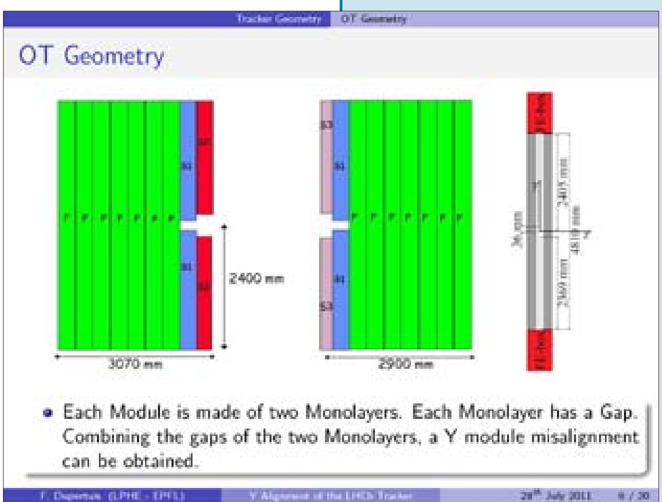

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
LHCb
LPHE
CHIPP Workshop 'C15 Mid-Term Results'
Y Alignment of the LHCb Tracker
Frédéric Dupertuis
Laboratoire de Physique des Hautes Energies - EPFL
28th July 2011

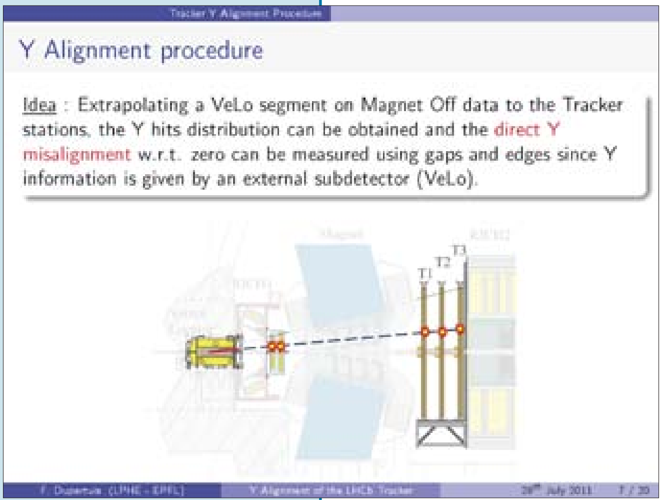

Overview
Y Alignment of the LHCb Tracker
The LHCb Experiment
Tracker Geometry
Tracker Y Alignment Procedure
Results
Outlook
Conclusion


LHCb Experiment : Single-arm forward spectrometer
Magnet : Dipole
Tracker : Vertex Locator (VeLo), Silicon Tracker (IT and TT) and OT
Particle ID : RICH1 & RICH2
Calorimeters : ECAL & HCAL
Muon Chambers : M1...M5
y
z


IT/TT Geometry
The Inner Tracker (IT) sectors are made of one (short ladders) and two (long ladders) silicon sensors.
The Tracker Turicensis (TT) modules are made of one up to four silicon sensors.


IT/TT Geometry (2)
In addition to sensors spacing, each sensor is only sensitive inside the Guard Ring.
We expect to observe Gaps in Y due to Spacing and Guard Rings for ⩾ 2 sensors modules and Drops due to sensor edges for all types.
In Y module local frame, the sector center (mean between bottom and top edges) is at Y=0 if our description of the geometry is accurate.
Similar arguments can hold for 2-3-4 sensors modules for the Gap(s) position.


OT Geometry
2400 mm
3070 mm
2900 mm
Each Module is made of two Monolayers. Each Monolayer has a Gap. Combining the gaps of the two Monolayers, a Y module misalignment can be obtained.


Tracker Y Alignment Procedure
Y Alignment procedure
Idea : Extrapolating a VeLo segment on Magnet Off data to the Tracker stations, the Y hits distribution can be obtained and the direct Y misalignment w.r.t. zero can be measured using gaps and edges since Y information is given by an external subdetector (VeLo).
T1
T2
T3
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
28th July 2011
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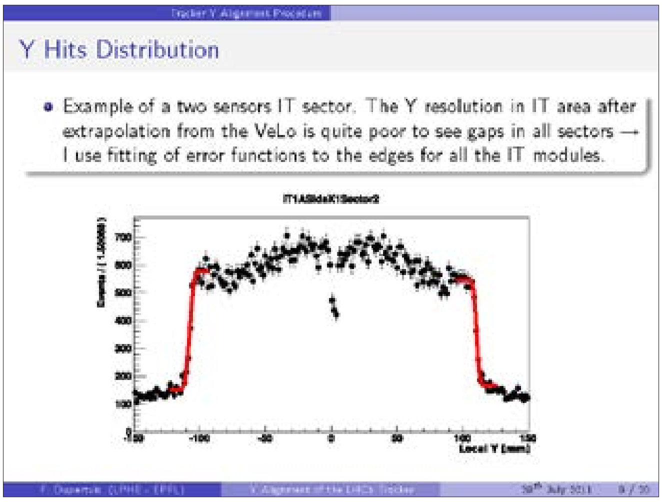
Tracker Y Alignment Procedure
Y Hits Distribution
Example of a two sensors IT sector. The Y resolution in IT area after extrapolation from the VeLo is quite poor to see gaps in all sectors → I use fitting of error functions to the edges for all the IT modules.
IT1ASideX1Sector2
Local Y [mm]
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
28th July 2011
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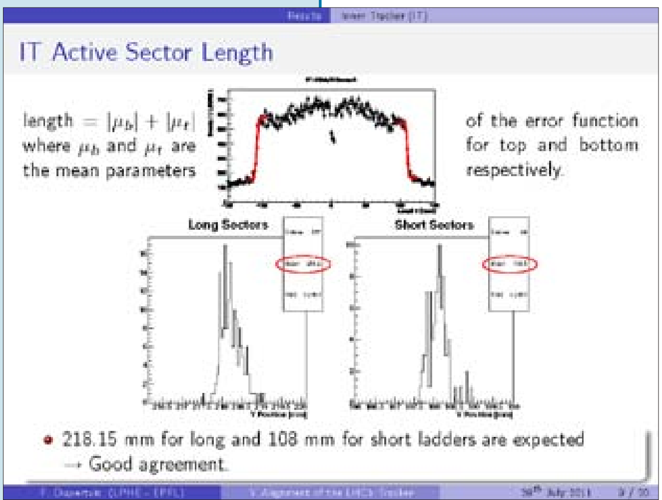
Results Inner Tracker (IT)
IT Active Sector Length
length = $|\mu_b| + |\mu_t|$ where μ_b and μ_t are the mean parameters
of the error function for top and bottom respectively.
Long Sectors
Short Sectors
218.15 mm for long and 108 mm for short ladders are expected → Good agreement.
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
28th July 2011
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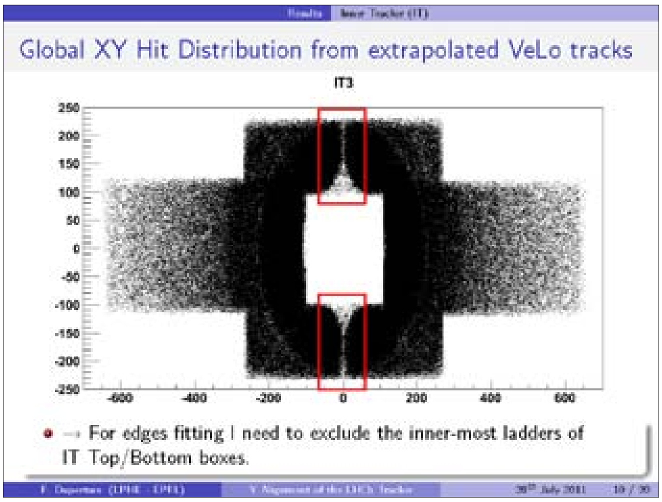
Results Inner Tracker (IT)
Global XY Hit Distribution from extrapolated VeLo tracks
IT3
→ For edges fitting I need to exclude the inner-most ladders of IT Top/Bottom boxes.
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
28th July 2011
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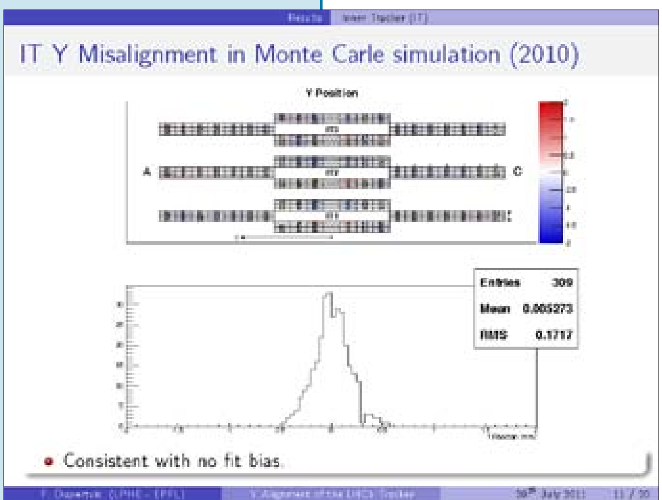
Results Inner Tracker (IT)
IT Y Misalignment in Monte Carlo simulation (2010)
Y Position
A
C
Entries 309
Mean 0.005273
RMS 0.1717
Consistent with no fit bias.
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
28th July 2011
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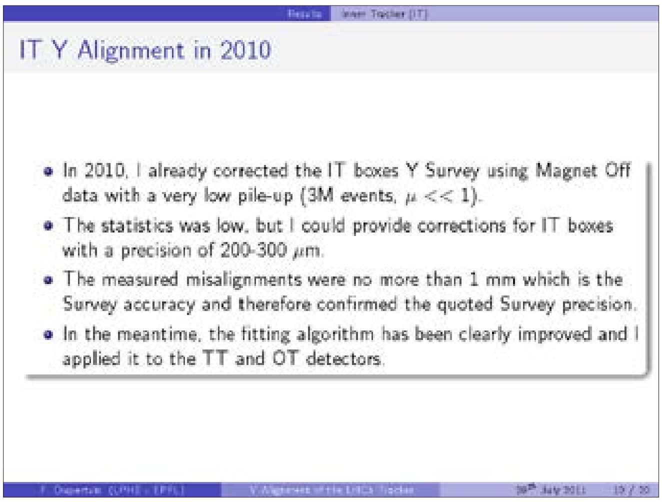
Results Inner Tracker (IT)
IT Y Alignment in 2010
In 2010, I already corrected the IT boxes Y Survey using Magnet Off data with a very low pile-up (3M events, $\mu << 1$).
The statistics was low, but I could provide corrections for IT boxes with a precision of 200-300 μm.
The measured misalignments were no more than 1 mm which is the Survey accuracy and therefore confirmed the quoted Survey precision.
In the meantime, the fitting algorithm has been clearly improved and I applied it to the TT and OT detectors.
F. Dupertuis (LPHE - EPFL)
Y Alignment of the LHCb Tracker
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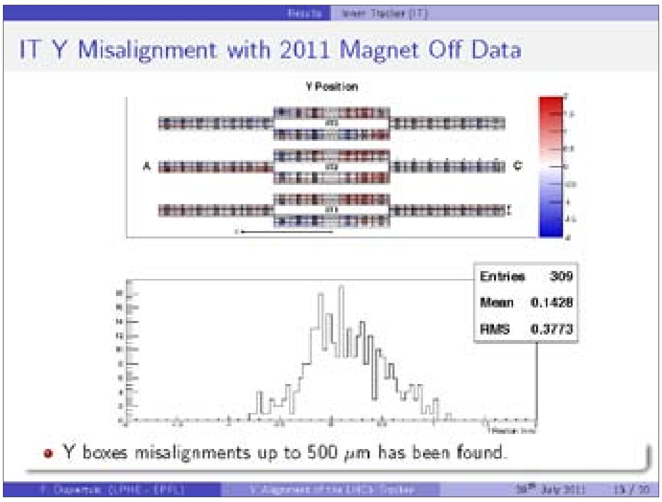
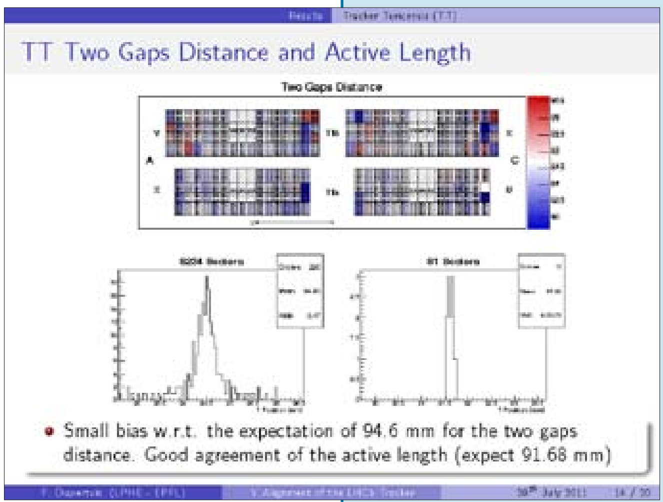
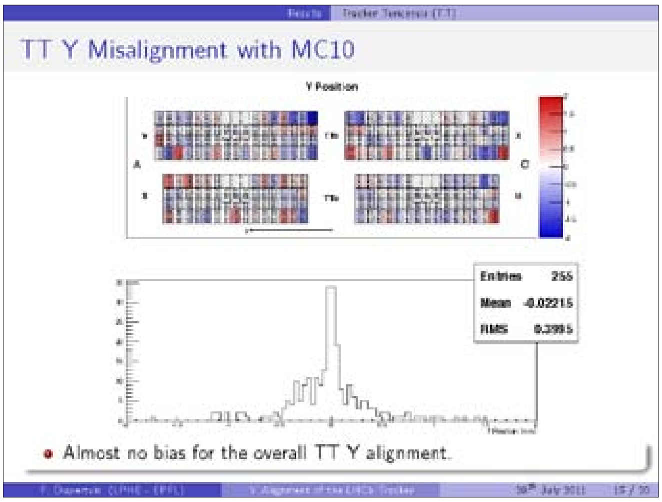
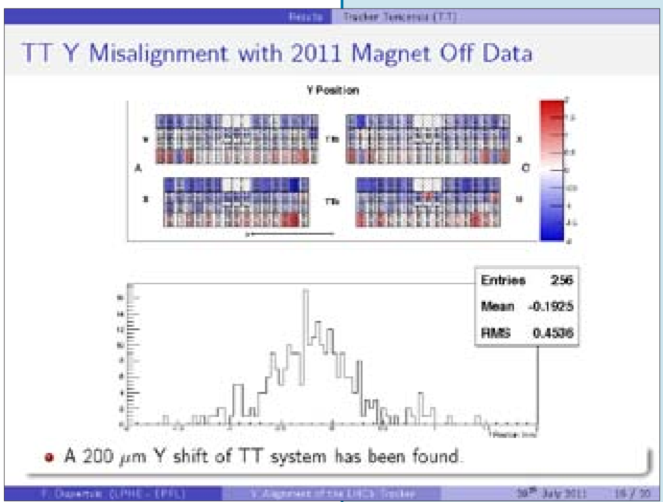
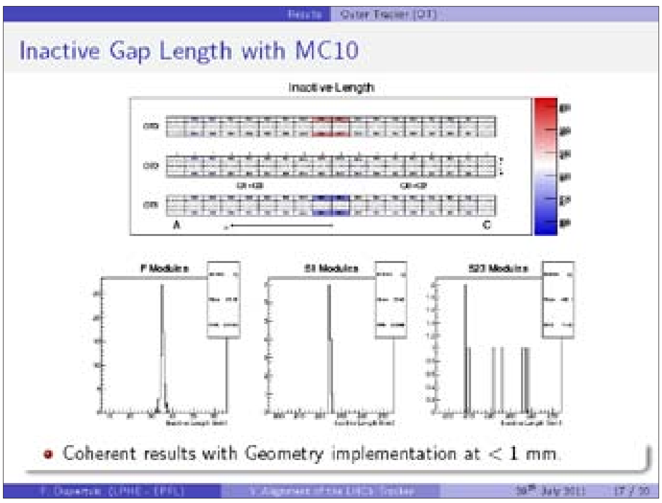
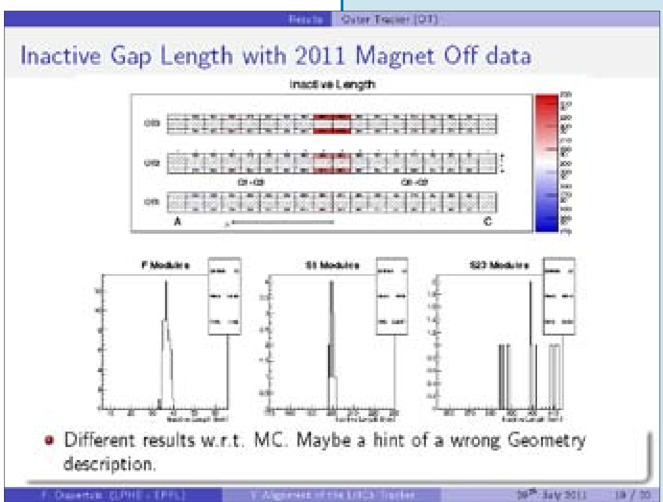

IT Y Misalignment with 2011 Magnet Off Data
Y Position
A
C
Entries 309
Mean 0.1428
RMS 0.3773
Y boxes misalignments up to 500 μm has been found.

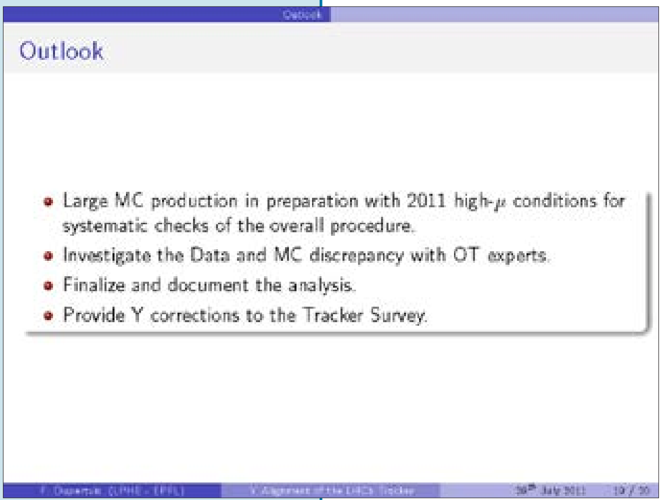

TT Two Gaps Distance and Active Length
Two Gaps Distance
A
C
Small bias w.r.t. the expectation of 94.6 mm for the two gaps distance. Good agreement of the active length (expect 91.68 mm)

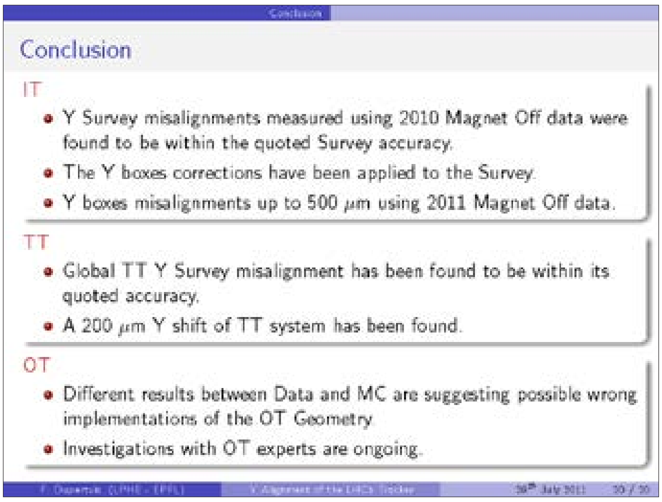

TT Y Misalignment with MC10
Y Position
A
C
Entries 255
Mean -0.02215
RMS 0.3995
Almost no bias for the overall TT Y alignment.


TT Y Misalignment with 2011 Magnet Off Data
Y Position
A
C
Entries 256
Mean -0.1925
RMS 0.4536
A 200 μm Y shift of TT system has been found.


Inactive Gap Length with MC10
Inactive Length
A
C
F Modules
S1 Modules
S23 Modules
Coherent results with Geometry implementation at < 1 mm.


Inactive Gap Length with 2011 Magnet Off data
Inactive Length
A
C
F Modules
S1 Modules
S23 Modules
Different results w.r.t. MC. Maybe a hint of a wrong Geometry description.


Outlook
Large MC production in preparation with 2011 high-μ conditions for systematic checks of the overall procedure.
Investigate the Data and MC discrepancy with OT experts.
Finalize and document the analysis.
Provide Y corrections to the Tracker Survey.

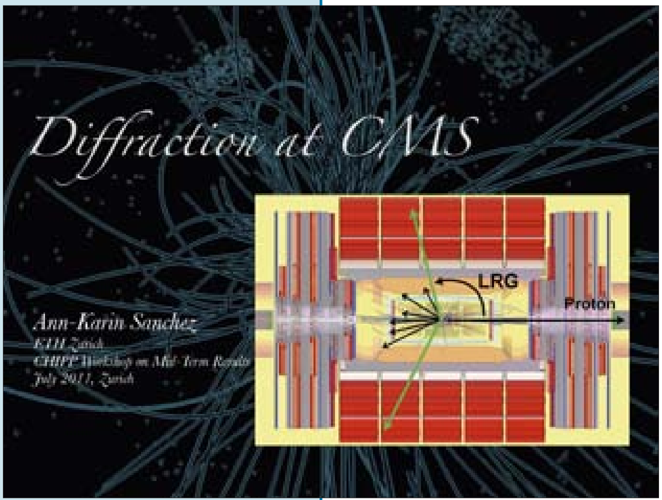

Conclusion
IT
Y Survey misalignments measured using 2010 Magnet Off data were found to be within the quoted Survey accuracy.
The Y boxes corrections have been applied to the Survey.
Y boxes misalignments up to 500 μm using 2011 Magnet Off data.
TT
Global TT Y Survey misalignment has been found to be within its quoted accuracy.
A 200 μm Y shift of TT system has been found.
OT
Different results between Data and MC are suggesting possible wrong implementations of the OT Geometry.
Investigations with OT experts are ongoing.

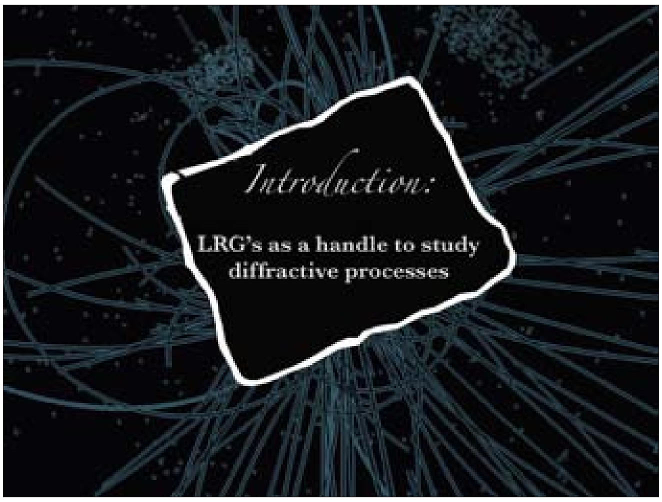
Ann-Karin Sanchez – ETH Zurich
(PhD student)

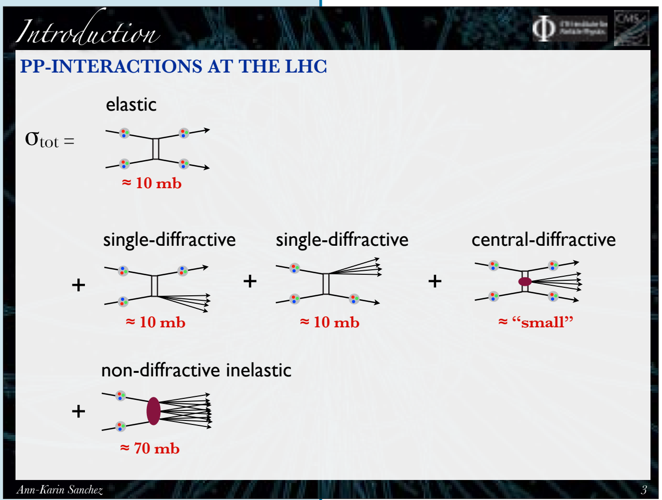
Diffraction at CMS

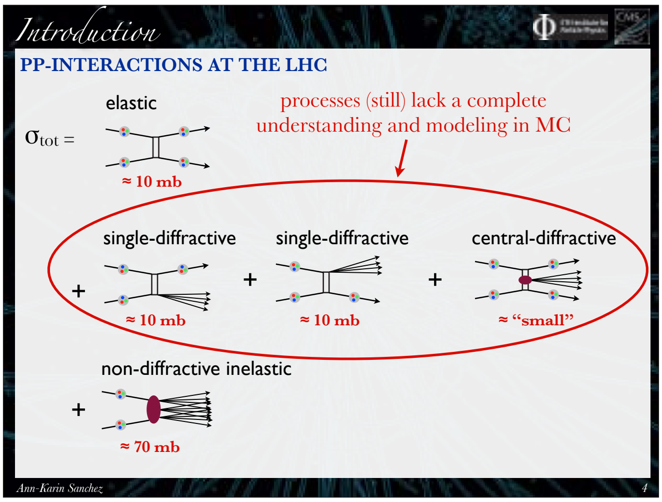
Scientific Abstract:

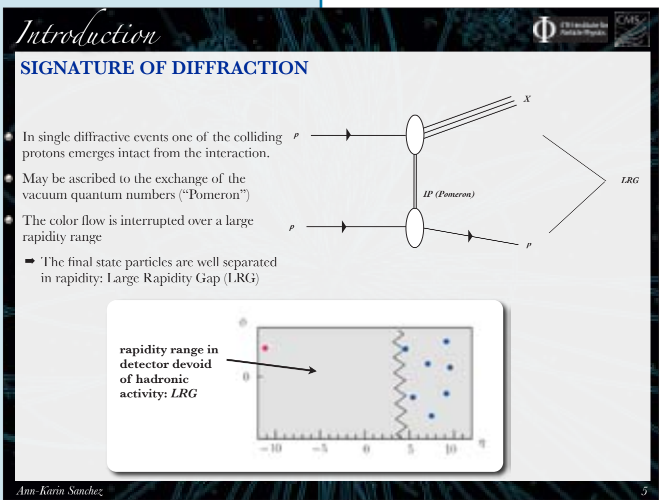
The observation of the production of W and Z bosons at the LHC in pp collision events with a large rapidity gap is presented. Using data collected by the CMS experiment in 2010, corresponding to an integrated luminosity of 36 pb-1, a detailed study of the event structure and the energy distribution in the forward region of W and Z events is presented. These contain also event samples which are dominated by diffractive interactions.

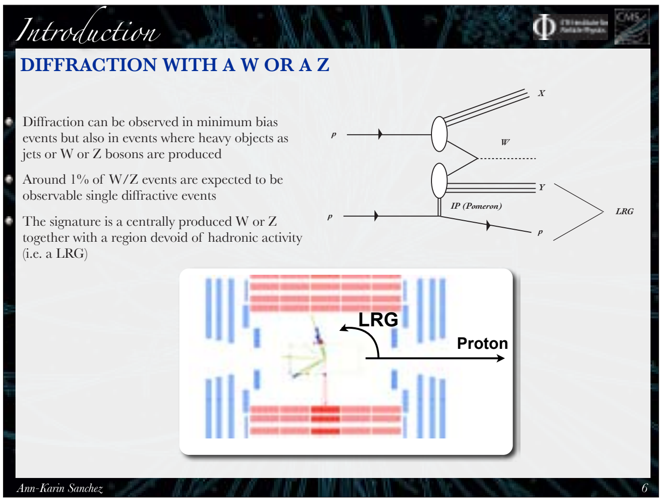

Diffraction at CMS
LRG
Proton
Ann-Karin Sanchez
ETH Zurich
CHIPP Workshop on Mid-Term Results
July 2011, Zurich

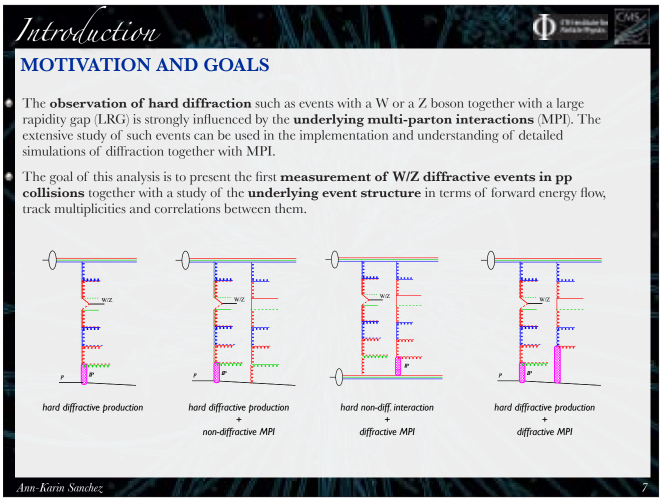

Introduction:
LRG's as a handle to study
diffractive processes


Introduction
PP-INTERACTIONS AT THE LHC
σtot =
elastic
≈ 10 mb
+
single-diffractive
≈ 10 mb
+
single-diffractive
≈ 10 mb
+
central-diffractive
≈ "small"
non-diffractive inelastic
+
≈ 70 mb
Ann-Karin Sanchez
3


Introduction
PP-INTERACTIONS AT THE LHC
σtot =
elastic
≈ 10 mb
processes (still) lack a complete
understanding and modeling in MC
+
single-diffractive
≈ 10 mb
+
single-diffractive
≈ 10 mb
+
central-diffractive
≈ "small"
non-diffractive inelastic
+
≈ 70 mb
Ann-Karin Sanchez
4


Introduction
SIGNATURE OF DIFFRACTION
In single diffractive events one of the colliding protons emerges intact from the interaction.
May be ascribed to the exchange of the vacuum quantum numbers ("Pomeron")
The color flow is interrupted over a large rapidity range
➡ The final state particles are well separated in rapidity: Large Rapidity Gap (LRG)
p
p
X
p
IP (Pomeron)
LRG
rapidity range in
detector devoid
of hadronic
activity: LRG
φ
0
−10
−5
0
5
10
η
Ann-Karin Sanchez
5


Introduction
DIFFRACTION WITH A W OR A Z
Diffraction can be observed in minimum bias events but also in events where heavy objects as jets or W or Z bosons are produced
Around 1% of W/Z events are expected to be observable single diffractive events
The signature is a centrally produced W or Z together with a region devoid of hadronic activity (i.e. a LRG)
p
X
W
Y
IP (Pomeron)
p
p
LRG
LRG
Proton
Ann-Karin Sanchez
6


Introduction
MOTIVATION AND GOALS
The observation of hard diffraction such as events with a W or a Z boson together with a large rapidity gap (LRG) is strongly influenced by the underlying multi-parton interactions (MPI). The extensive study of such events can be used in the implementation and understanding of detailed simulations of diffraction together with MPI.
The goal of this analysis is to present the first measurement of W/Z diffractive events in pp collisions together with a study of the underlying event structure in terms of forward energy flow, track multiplicities and correlations between them.
hard diffractive production
hard diffractive production + non-diffractive MPI
hard non-diff. interaction + diffractive MPI
hard diffractive production + diffractive MPI
Ann-Karin Sanchez
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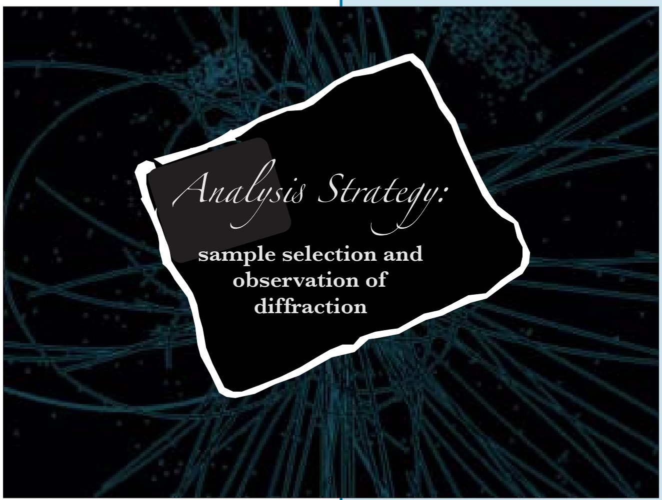
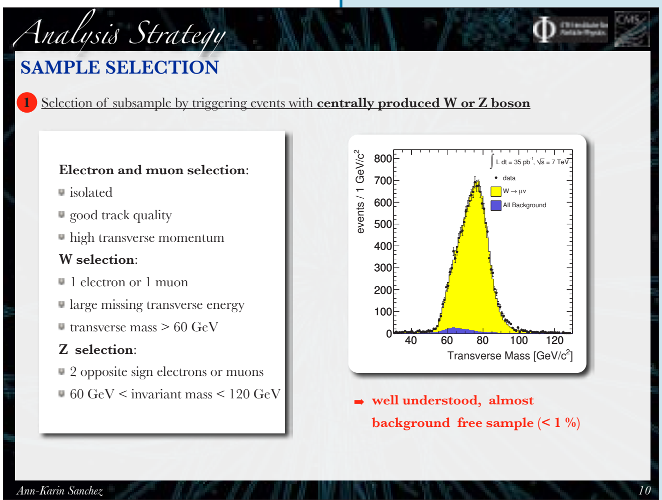

Analysis Strategy:
sample selection and observation of diffraction


The Large Hadron Collider: LHC
Restart of the machine in November 2009
First 7 TeV collisions in March 2010
Integrated luminosity 2010 recorded by CMS: XX pb-1
Integrated luminosity 2011 recorded by CMS: XX pb-1
The Compact Muon Solenoid: CMS
Pixel: 66M channels for ~1m²
Tracker: 9.6M channels for ~210 m²
ECAL: 76k PbWO4 crystals
HCAL: interleaved scintillator/brass
Muons: redundant DT (CSC) and RPC
HF: steel absorbers / quartz fibers
Solenoid coil: 4 T
Total weight: 12'500 t
Overall length: 21.6 m
Overall diameter: 15 m


Analysis Strategy
SAMPLE SELECTION
1 Selection of subsample by triggering events with centrally produced W or Z boson
Electron and muon selection:
isolated
good track quality
high transverse momentum
W selection:
1 electron or 1 muon
large missing transverse energy
transverse mass > 60 GeV
Z selection:
2 opposite sign electrons or muons
60 GeV < invariant mass < 120 GeV
events / 1 GeV/c²
Transverse Mass [GeV/c²]
data
All Background
well understood, almost background free sample (< 1 %)
Ann-Karin Sanchez
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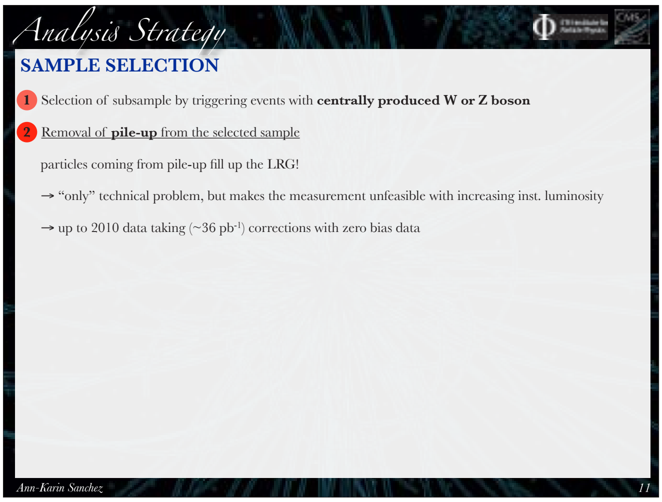
Analysis Strategy
SAMPLE SELECTION
1 Selection of subsample by triggering events with centrally produced W or Z boson
2 Removal of pile-up from the selected sample
particles coming from pile-up fill up the LRG!
→ "only" technical problem, but makes the measurement unfeasible with increasing inst. luminosity
→ up to 2010 data taking (~36 pb-1) corrections with zero bias data
Ann-Karin Sanchez
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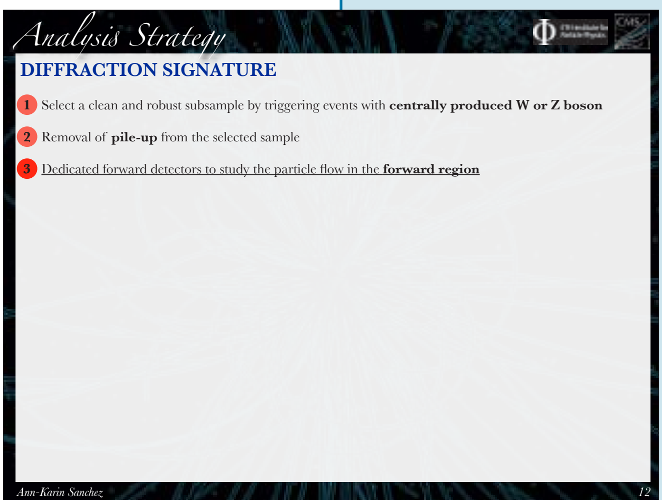
Analysis Strategy
DIFFRACTION SIGNATURE
1 Select a clean and robust subsample by triggering events with centrally produced W or Z boson
2 Removal of pile-up from the selected sample
3 Dedicated forward detectors to study the particle flow in the forward region
Ann-Karin Sanchez
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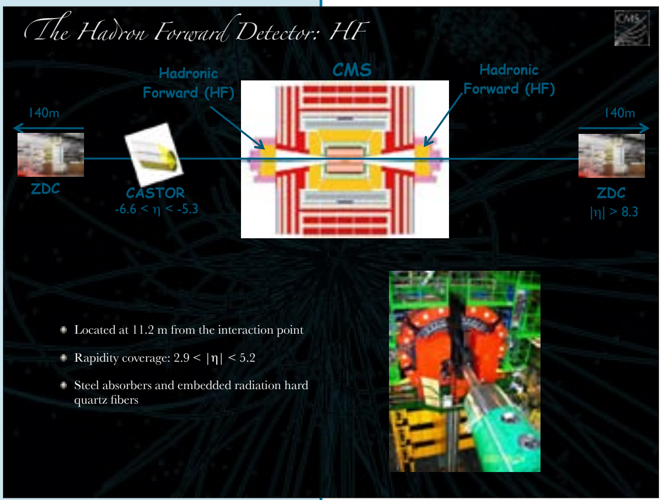
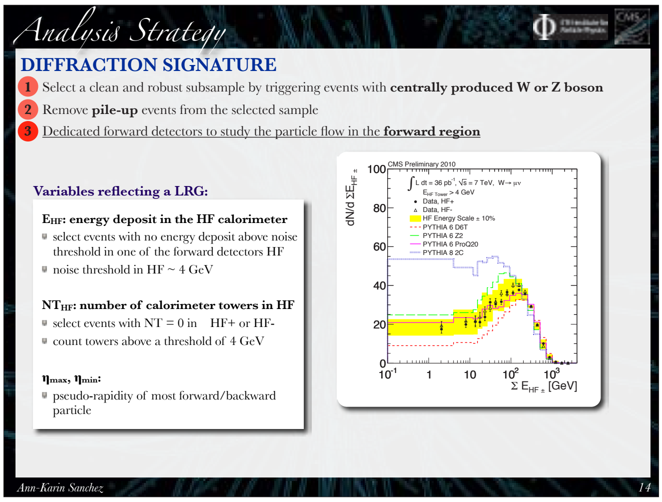

The Hadron Forward Detector: HF
Hadronic Forward (HF)
CMS
Hadronic Forward (HF)
140m
140m
ZDC
CASTOR
-6.6 < η < -5.3
ZDC
|η| > 8.3
Located at 11.2 m from the interaction point
Rapidity coverage: 2.9 < |η| < 5.2
Steel absorbers and embedded radiation hard quartz fibers


Analysis Strategy
DIFFRACTION SIGNATURE
1 Select a clean and robust subsample by triggering events with centrally produced W or Z boson
2 Remove pile-up events from the selected sample
3 Dedicated forward detectors to study the particle flow in the forward region
Variables reflecting a LRG:
E_HF: energy deposit in the HF calorimeter
select events with no energy deposit above noise threshold in one of the forward detectors HF
noise threshold in HF ~ 4 GeV
NT_HF: number of calorimeter towers in HF
select events with NT = 0 in HF+ or HF-
count towers above a threshold of 4 GeV
η_max, η_min:
pseudo-rapidity of most forward/backward particle
CMS Preliminary 2010
Σ E_HF ± [GeV]
Ann-Karin Sanchez
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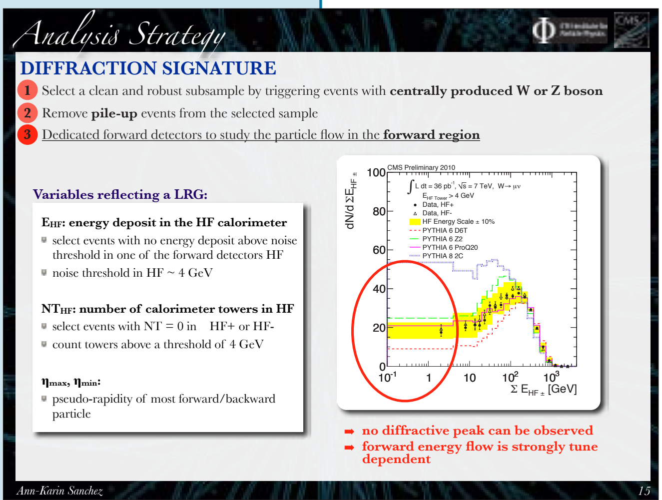
Analysis Strategy
DIFFRACTION SIGNATURE
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select events with NT = 0 in HF+ or HF-
count towers above a threshold of 4 GeV
η_max, η_min:
pseudo-rapidity of most forward/backward particle
CMS Preliminary 2010
Σ E_HF ± [GeV]
➡ no diffractive peak can be observed
➡ forward energy flow is strongly tune dependent
Ann-Karin Sanchez
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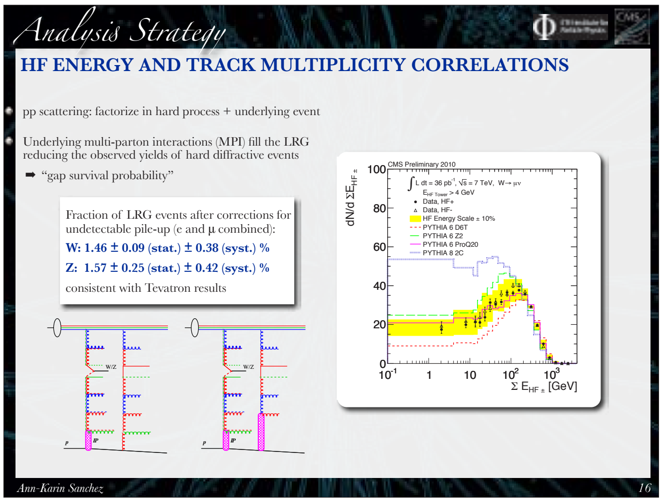
Analysis Strategy
HF ENERGY AND TRACK MULTIPLICITY CORRELATIONS
pp scattering: factorize in hard process + underlying event
Underlying multi-parton interactions (MPI) fill the LRG reducing the observed yields of hard diffractive events
➡ "gap survival probability"
Fraction of LRG events after corrections for undetectable pile-up (e and μ combined):
W: 1.46 ± 0.09 (stat.) ± 0.38 (syst.) %
Z: 1.57 ± 0.25 (stat.) ± 0.42 (syst.) %
consistent with Tevatron results
CMS Preliminary 2010
Σ E_HF ± [GeV]
Ann-Karin Sanchez
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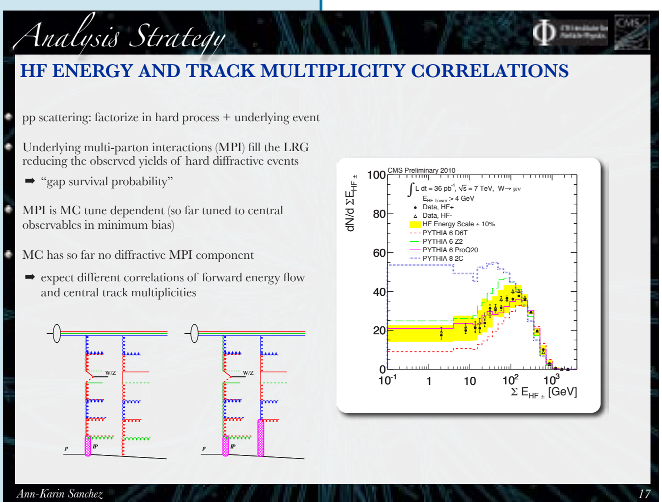
Analysis Strategy
HF ENERGY AND TRACK MULTIPLICITY CORRELATIONS
pp scattering: factorize in hard process + underlying event
Underlying multi-parton interactions (MPI) fill the LRG reducing the observed yields of hard diffractive events
➡ "gap survival probability"
MPI is MC tune dependent (so far tuned to central observables in minimum bias)
MC has so far no diffractive MPI component
➡ expect different correlations of forward energy flow and central track multiplicities
CMS Preliminary 2010
Σ E_HF ± [GeV]
Ann-Karin Sanchez
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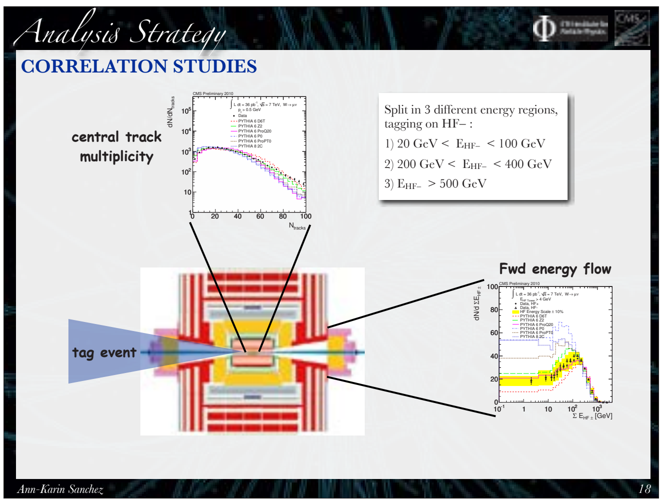
Analysis Strategy
CORRELATION STUDIES
central track multiplicity
Split in 3 different energy regions, tagging on HF- :
1) 20 GeV < E_HF- < 100 GeV
2) 200 GeV < E_HF- < 400 GeV
3) E_HF- > 500 GeV
Fwd energy flow
tag event
Ann-Karin Sanchez
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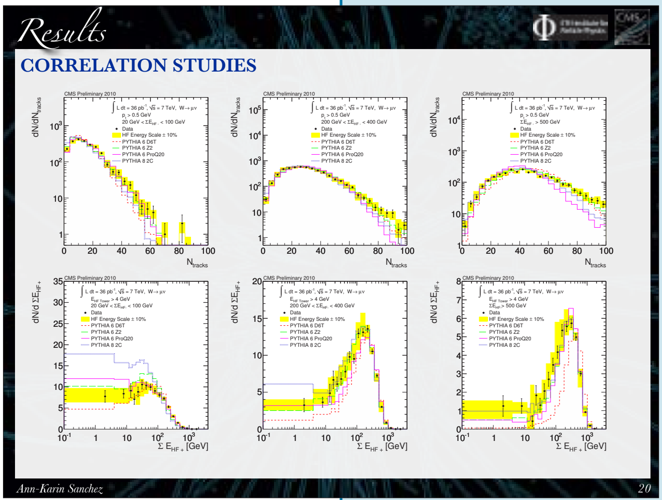
Results:
correlations and
observation of
diffraction


Results
CORRELATION STUDIES
CMS Preliminary 2010
Ann-Karin Sanchez
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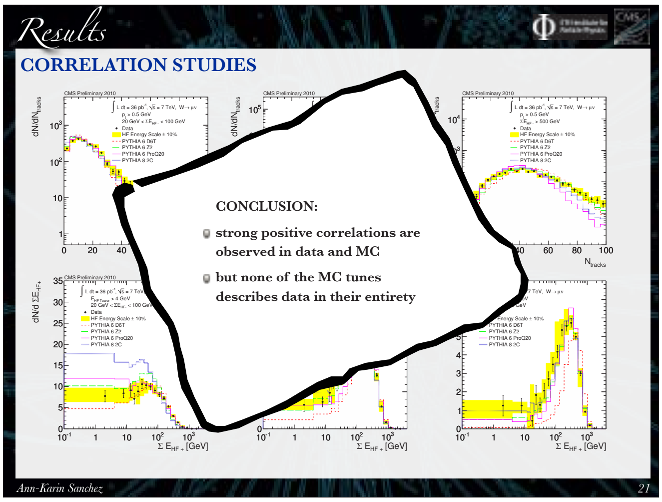
Results
CORRELATION STUDIES
CONCLUSION:
strong positive correlations are observed in data and MC
but none of the MC tunes describes data in their entirety
Ann-Karin Sanchez
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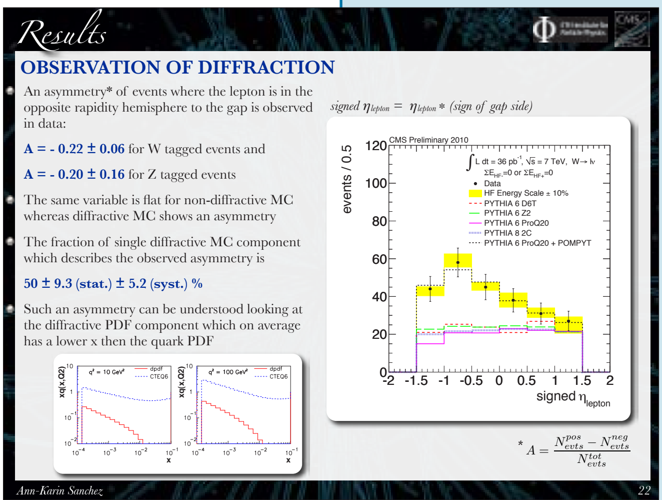
Results
OBSERVATION OF DIFFRACTION
An asymmetry* of events where the lepton is in the opposite rapidity hemisphere to the gap is observed in data:
A = - 0.22 ± 0.06 for W tagged events and
A = - 0.20 ± 0.16 for Z tagged events
The same variable is flat for non-diffractive MC whereas diffractive MC shows an asymmetry
The fraction of single diffractive MC component which describes the observed asymmetry is
50 ± 9.3 (stat.) ± 5.2 (syst.) %
Such an asymmetry can be understood looking at the diffractive PDF component which on average has a lower x then the quark PDF
signed η_lepton = η_lepton * (sign of gap side)
CMS Preliminary 2010
events / 0.5
signed η_lepton
* A = (N_evts^pos − N_evts^neg) / N_evts^tot
Ann-Karin Sanchez
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Conclusions
Hard diffraction with W or Z events has been observed through an asymmetry in data
A 50 % single diffractive component in MC can describe this asymmetry
Forward energy flow, central track multiplicity and their correlations in W and Z events have been studied and it is found that in general the existing Monte Carlo tunes differ significantly from data
These measurements can be used to improve the understanding and tuning of diffractive Monte Carlo models at the hard scale
Ann-Karin Sanchez
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Marc Goulette – University of Geneva
(PostDoc)

Contribution to the ATLAS experiment, CERN and the University of Geneva

Scientific Abstract:

The talk focuses on Monte-Carlo production (MC@NLO), where official W/Z into leptons input files needed for the MC10 and MC11 physics campaigns are produced. Tools needed and the complicated procedure is described and lists of samples and main campaigns are provided. In addition, the tests and check of the availability, performances and general status of the Swiss Tier2 at CSCS in Lugano are shown and the link between CERN, the Grid German Cloud and the University of Geneva is described. Thirdly, the 2011 updates of the TRT detector simulation, including geometry and materials changes is presented.

Contribution to the ATLAS experiment, CERN and the Unige

Marc Goulette (University of Geneva)

Outline

1. MC production
2. Computing
3. Teaching
4. Outreach
5. TRT material simulation

MC production

- Responsible for the production of some official MC@NLO input files for the Standard Model and the Monte-Carlo Generators groups since 1.5 year (MC10 and MC11)

  - Generation of input files, as well as Evgen, and some D3PDs
  - Testing of MC@NLO v. 3.42 patched (bugs seen for some W/Z physics distribution with version 3.41)

  - Resources and privileges:

    - Production role to send jobs to the Grid using Pathena

    - Working space:

    /afs/cern.ch/atlas/groups/WZgroup/scratch0/ (80 GB)
    /afs/cern.ch/atlas/groups/WZgroup/mcatnlo/ (8 GB)

All this work has been rewarded in ATL-COM-PHYS-2010-477 and ATL-COM-PHYS-2010-703 (W&Z cross-sections measurement)

Complicated procedure

- Installation of MC@NLO, lhapdf (Pdf Sets) and Herwig (libs):

  /afs/cern.ch/atlas/groups/WZgroup/mcatnlo
  /afs/cern.ch/atlas/groups/WZgroup/lhapdf
  /afs/cern.ch/atlas/groups/WZgroup/HerwigLIB

- Integration phase (NLO step)

  - User writes ChannelDSNUMBER.MCatNLO.inputs.Integration File in which you specify physics input such as IPROC, M_W, M_Z, E_{CM}, BR's, CKM matrix elements, Pdfs, Seeds, Names, … and runs the main MC@NLO code.

- Generation phase (MC step)
  Using scripts and input files, change of seeds, renaming of files

- Resulting files: *.events and *.dat, stored into some *.tar.gz files

- Then production of the evgen files using the Grid and Pathena….

This looks like that…

List of samples and main campaigns (2010-2011)

In 2010, production of the input files for W/Z into e or muons, with at least two millions of events per sample. In addition production of the evgen and of some D3PDs. Samples are now registered on the grid.

- Main samples used for MC10: (MC@NLO v 3.42, LHAPDF 5.8.2, CTEQ 6.6)

  mc10_7TeV.106087.McAtNloZee_no_filter
  mc10_7TeV.106088.McAtNloZmumu_no_filter
  mc10_7TeV.106081.McAtNloWplusenu_no_filter
  mc10_7TeV.106082.McAtNloWminenu_no_filter
  mc10_7TeV.106083.McAtNloWplusmunu_no_filter
  mc10_7TeV.106084.McAtNloWminmunu_no_filter

- Other requests for special studies:

  group10.phys-sm.valid.HeraPdf60500.106081.McAtNloWplusenu
  group10.phys-sm.valid.HeraPdf60500.106082.McAtNloWminenu
  group10.phys-sm.valid.HeraPdf60500.106088.McAtNloZmumu
  group10.phys-sm.valid.HeraPdf60500.106087.McAtNloZee
  group10.phys-sm.valid.Pdf10550_NoPhotos.106087.McAtNloZee
  group10.phys-sm.valid.HeraPdf60500_NoPhotos.106087.McAtNloZee

List of samples and main campaigns (2010-2011)

Dec. 2010 - Jan. 2011: W/Z into e/muon samples at 8 TeV (not used so far..)

DS106087: Z → ee DS106088: Z → mumu
DS106081: Wplus → enu DS106083: Wplus → munu
DS106082: Wmin → enu DS106084: Wmin → munu

Feb. 2011 - June 2011: "Z" Drell Yan samples

113226.ZeeNoFilter.DY10to60GeV.Cteq66.PdfSet10550.7TeV (40 Millions)
113227.ZmumuNoFilter.DY10to60GeV.Cteq66.PdfSet10550.7TeV (40 M.)
113228.ZtautauNoFilter.DY10to60GeV.Cteq66.PdfSet10550.7TeV (2 billions)

Last request in 2011 (May - in progress): W/Z into leptons for MC11

MC@NLO v 4.02, LHAPDF 5.8.5, HERWIG 6.520, 5 M. events each channel
New Pdfs (CT10), New Electroweak parameters (MC11 recommendations)

DS106087:Z → ee DS106088:Z → mumu DS106062:Z → tautau
DS106081:Wplus → enu DS106083:Wplus → munu DS108328:Wplus → taunu
DS106082:Wmin → enu DS106084:Wmin → munu DS108329:Wmin → taunu

29/07/2011 CHIPP Workshop - Activity report - Marc Goulette 7/11

Computing activity

Contact person for the CSCS site, grid tests and meetings

- Link between CSCS, the DE cloud (Atlas) and the University of Geneva
- Responsibility shared with Gianfranco Sciacca (Bern), Sigve Haug (Bern) and Szymon Gadomski (Geneva). Important to cover full activity.
- Grid tests such as sending jobs to the grid and to the site to see performances and availability…
- CSCS biweekly meeting, CSCS F2F meetings, GridKA monthly meeting, internal, others… (and a lot of mail exchanges…)

Infos and status of the site (within the cloud and in overall Atlas):

- Resources at site are shared between CMS/ATLAS/LHCb (40/50/10 %)
- Good performance in the DE cloud and in overall ATLAS. Recently qualified as a T2D (directly connected to Tier2s and other clouds).
- Pledges: 533 TB online (required 469 TB). 277 TB used (52 %)
- CPU efficiency above 90 % in May and June. Important move in 2012.
- ~ 200 k jobs and 420 k walltime hours in June. Analy/Prod. rate: 47.6 %

Regular ADC@Comp1 shifter: 21 shifts in 2010, 14 done in 2011 (in progress). (In 2009, I did 24 shifts for the TRT detector).

29/07/2011 CHIPP Workshop - Activity report - Marc Goulette 8/11

Teaching activity in Geneva

General physics for 1st year students in Medicine
Team of 7 students + 7 assistants + teacher Michel Decroux
About 600 students this year (about 150 will pass).

From September to March (22 weeks): main courses
April - May (6 weeks): modules (Etudes accompagnées)
Exams: in January, and June (one day each)

Topics: Mécanique, Thermo, Electricité, Magnétisme, Ondes elmg, Ondes sonores, Physique nucléaire (introduction), mécanique des fluides (basics)

→ Provide help to the students, preparation of 2 to 3 series of exercices, preparation of the exams (questions), assistance, and teaching for the module Nuclear physics (3 x 2h)

Meetings on Monday morning, TD on Tuesday, and when needed preparation on Thursday and Friday + reading at home.

⇒ Good team and really good feedback from students and hierarchy

29/07/2011 CHIPP Workshop - Activity report - Marc Goulette 9/11

Teaching and outreach activities

- Supervision of a PhD student: Gauthier Alexandre

Working on excited leptons (mostly electrons, a bit muons), and Z'.
Already has better exclusion regions than the Tevatron with current data.
On the way to publish a note. Should finish his thesis in Autumn 2012

- CERN official guide, in particular for ATLAS

French and English
Different tours: ATLAS open, PS-LEIR-LINAC, SM18, Globe
Different groups of visitors: general public, students, specialists, …
132 visits since July 2009. In average 5 a month (Saturday sometimes…)

- Physicist representative for the project "Dans la peau d'un jeune chercheur"

30 classes from primary schools in France and Switzerland (11-12 y.o)
Work as researchers on a closed box containing different objects
Visit in some classes, welcome at Cern, and final conference (interview)
http://cdsweb.cern.ch/record/1361703

02/09/2010 CHIPP Workshop - ATLAS grid experience - Marc Goulette 10/11

Update of the TRT simulation

Last update done this year between February and May 2011.

- Provide individual information for the inner and outer rails for the TRT barrel and end-caps.
- In addition, give as an input for the simulation the full and detailed list of materials for all defined volumes (previous version only contained the 3 main materials…)
- Work with Grant Gorfine (who left recently), and now this is Oleg Fedin. Update should be included in the Atlas software in the coming months.
- Impact on physics analysis has been noticed in 2010 when looking at some discrepancies between MC and data due to the amount of material present in front of the calorimeter. (https://indico.cern.ch/getFile.py/access?contribId=8&resId=0&materialId=slides&confId=77970)
- Reference documents and update of main tables:
  - Update on the TRT end-cap material weight, ATL-INDET-PUB-2007-002
  - Update on the TRT material weight, ATL-INDET-PUB-2006-008
  - Updated documents on the TRT material and geometry, ATL-IT-ER-0032

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Differencies between MC10 and MC11 tuning (1/2)

Proton PDF

MC10 MC11
CTEQ6.6 (LHAPDF ID=10550) CT10 (LHAPDF ID=10800)
PDG2010 values (except top mass, which is kept at PDG2007 after discussion with Top WG)

W/Z/top masses/widths:

	MC10	MC11
MW	80.403	80.399
MZ	91.1876	91.1876 (i.e. no change)
GammaW	2.141	2.085
GammaZ	2.4952	2.4952 (i.e. no change)

	MC10	MC11
W->lnu BR:	0.111 (MC@NLO), 0.108 (Powheg)	0.108
(W->had BR:	0.333 (MC@NLO), 0.338 (Powheg)	0.338 <--- in Powheg, should be calculated automatically as (1-3*lepBR)/2)

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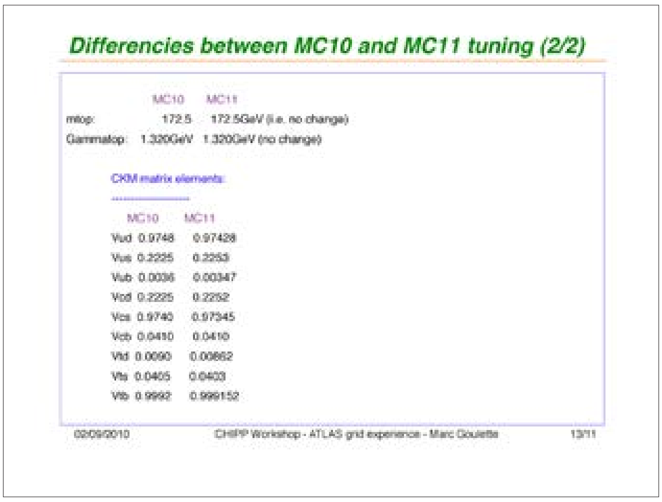
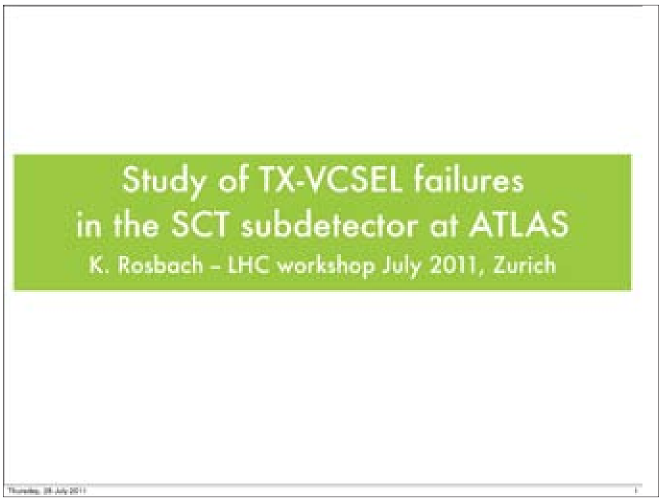

Differencies between MC10 and MC11 tuning (2/2)
MC10 MC11
mtop: 172.5 172.5GeV (i.e. no change)
Gammatop: 1.320GeV 1.320GeV (no change)
CKM matrix elements:
MC10 MC11
Vud 0.9748 0.97428
Vus 0.2225 0.2253
Vub 0.0036 0.00347
Vcd 0.2225 0.2252
Vcs 0.9740 0.97345
Vcb 0.0410 0.0410
Vtd 0.0090 0.00862
Vts 0.0405 0.0403
Vtb 0.9992 0.999152
02/09/2010
CHIPP Workshop - ATLAS grid experience - Marc Goulette
13/11

Kilian Rosbach – University of Geneva
(PhD student)

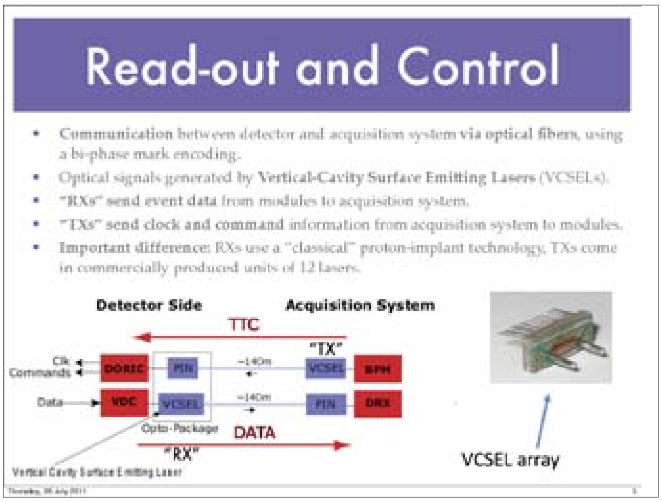
Study of TX-VCSEL failures in the SCT subdetector at ATLAS

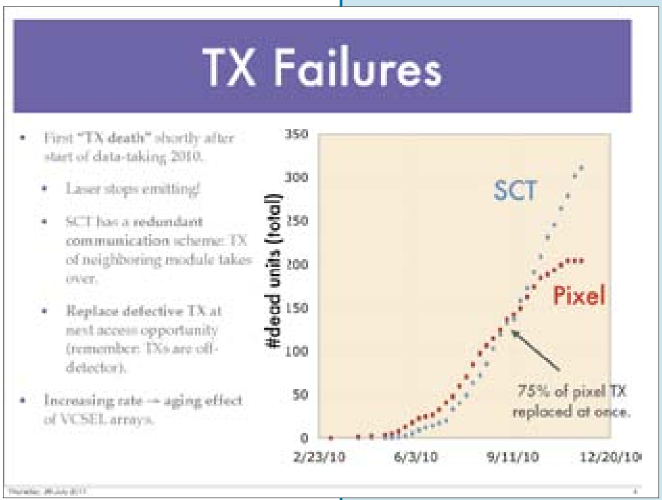
Scientific Abstract:

The semi conductor tracker (SCT), part of the ATLAS inner detector, comprises 4088 silicon modules with 768 strips each, organized in 4 cylindrical barrel layers and 2x9 end-cap disks. Timing and control information is sent to the modules as bi-phase mark encoded near-infrared signals, generated by commercially produced vertical cavity surface emitting lasers (VCSELs). Early into the 2010 data-taking, VCSELs started to fail at an increasing rate. The power spectra of virgin and used lasers were compared with optical spectrum analyzers, showing a significant narrowing of the spectra. Further tests with VCSELs in nitrogen and air revealed humidity as an important degrading factor. The studies are ongoing, possible solutions include replacement of the VCSELs or an improved packaging.

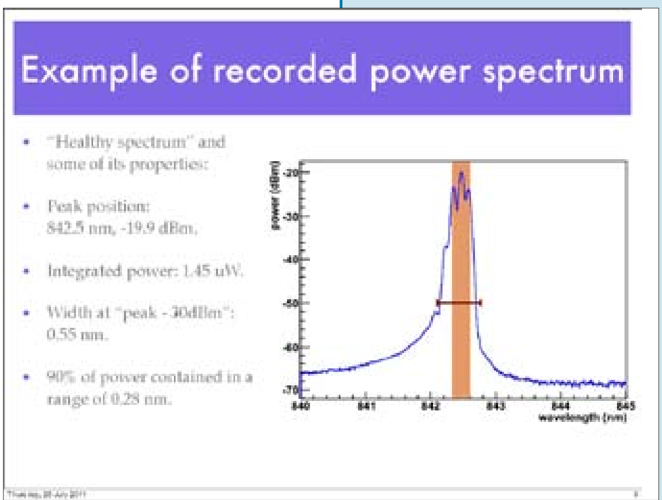

Study of TX-VCSEL failures
in the SCT subdetector at ATLAS
K. Rosbach – LHC workshop July 2011, Zurich

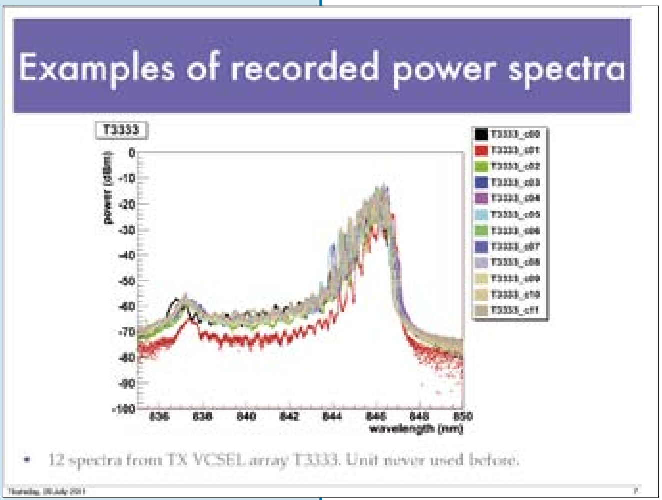

Semi-Conductor Tracker
SCT: part of the ATLAS inner detector.
4 barrel cylinders and 9 end-cap discs on both ends. Detector surface 63 m².
~4088 modules, 768 sensor strips each.
Modules arranged in pairs on each side of each layer → intrinsic noise suppression by requiring hits on both sides.
Pairs are slightly tilted against each other (~0.2 mrad) → reconstruct space points.
figures: Atlas Detector Paper 2008 JINST 3 S08003

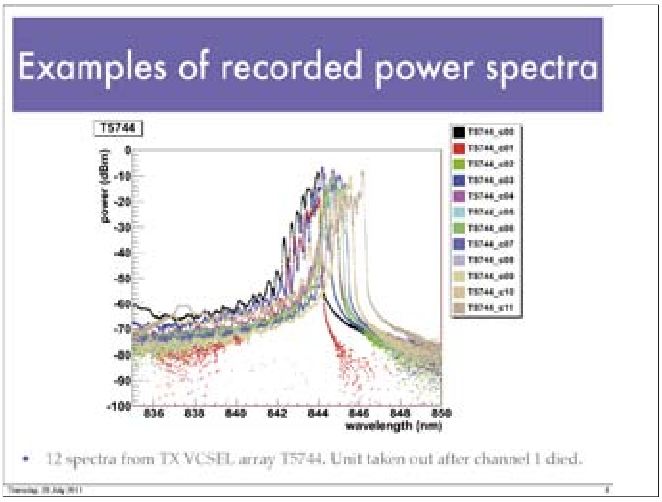

Read-out and Control
Communication between detector and acquisition system via optical fibers, using a bi-phase mark encoding.
Optical signals generated by Vertical-Cavity Surface Emitting Lasers (VCSELs).
"RXs" send event data from modules to acquisition system.
"TXs" send clock and command information from acquisition system to modules.
Important difference: RXs use a "classical" proton-implant technology, TXs come in commercially produced units of 12 lasers.
Detector Side
Acquisition System
TTC
"TX"
Clk
Commands
DORIC
PIN
~140m
VCSEL
BPM
Data
VDC
VCSEL
~140m
PIN
DRX
Opto-Package
DATA
"RX"
Vertical Cavity Surface Emitting Laser
VCSEL array

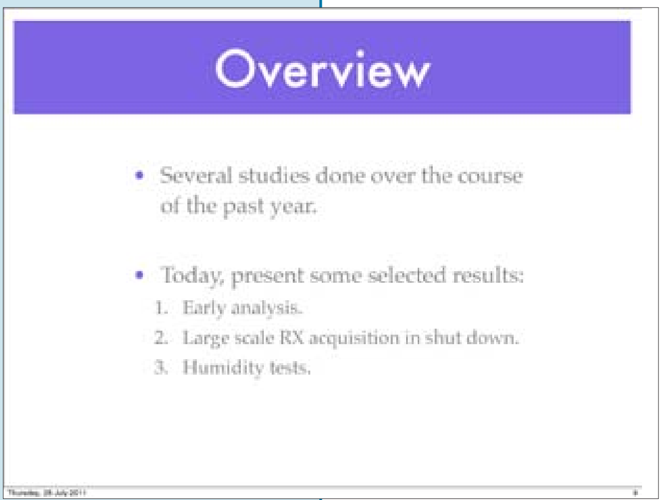

TX Failures
First "TX death" shortly after start of data-taking 2010.
Laser stops emitting!
SCT has a redundant communication scheme: TX of neighboring module takes over.
Replace defective TX at next access opportunity (remember: TXs are off-detector).
Increasing rate → aging effect of VCSEL arrays.
#dead units (total)
350
300
250
200
150
100
50
0
2/23/10
6/3/10
9/11/10
12/20/10
SCT
Pixel
75% of pixel TX replaced at once.

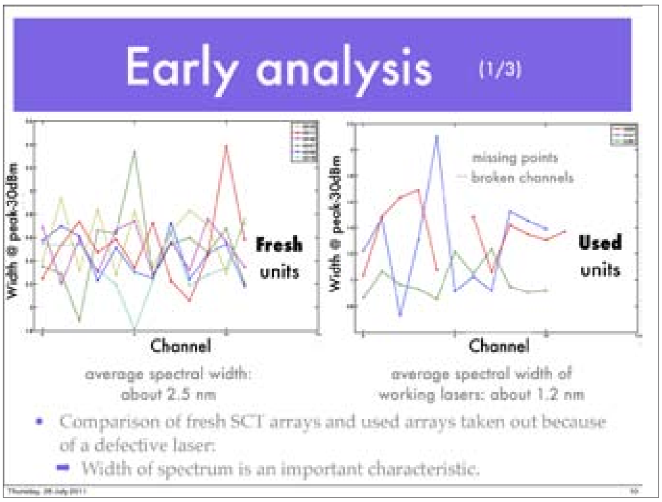

Hardware
Optical Spectrum Analyser (OSA).
Operated at –70 dB sensitivity, and ~50 pm resolutions.
Sweep over range of interest (830 nm-855 nm) takes about 10s.
VCSEL fibers arrive in ribbons of 12 and are separated in an optical switch (Leoni).
Yokogawa AQ6370B
Agilent 86146B
photos from manufacturer websites.

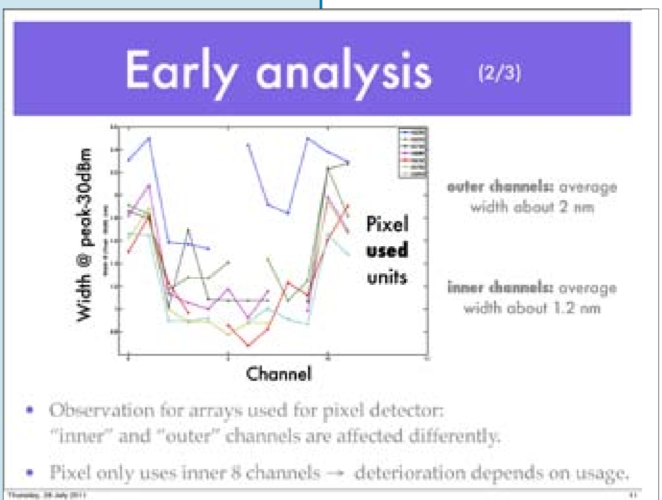

Example of recorded power spectrum
"Healthy spectrum" and some of its properties:
Peak position: 842.5 nm, -19.9 dBm.
Integrated power: 1.45 uW.
Width at "peak - 30dBm": 0.55 nm.
90% of power contained in a range of 0.28 nm.
power (dBm)
-20
-30
-40
-50
-60
-70
840
841
842
843
844
845
wavelength (nm)

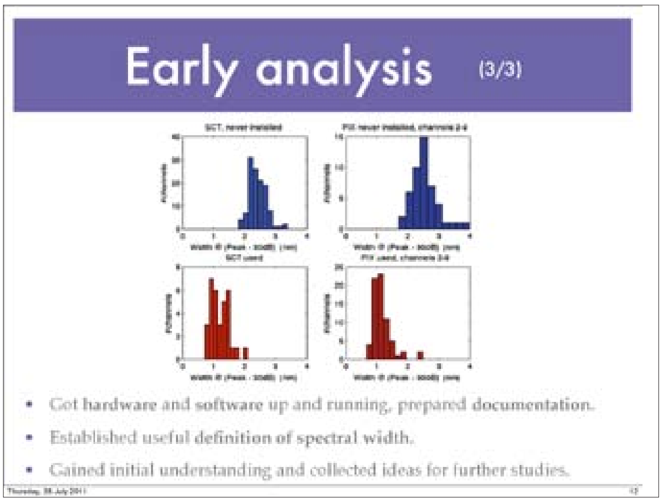

Examples of recorded power spectra
T3333
power (dBm)
wavelength (nm)
• 12 spectra from TX VCSEL array T3333. Unit never used before.

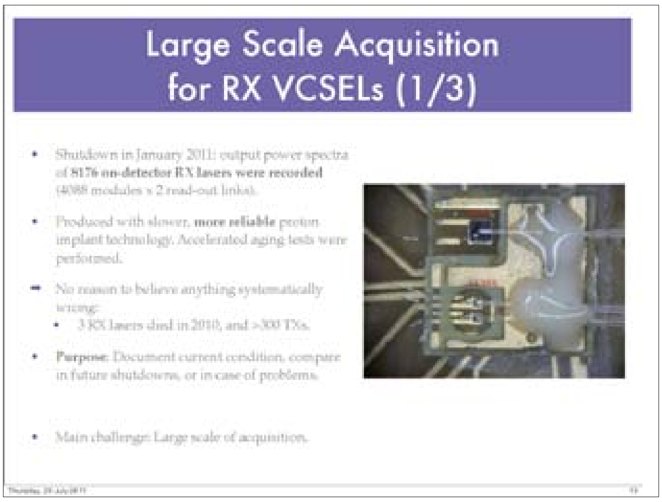

Examples of recorded power spectra
T5744
power (dBm)
wavelength (nm)
• 12 spectra from TX VCSEL array T5744. Unit taken out after channel 1 died.

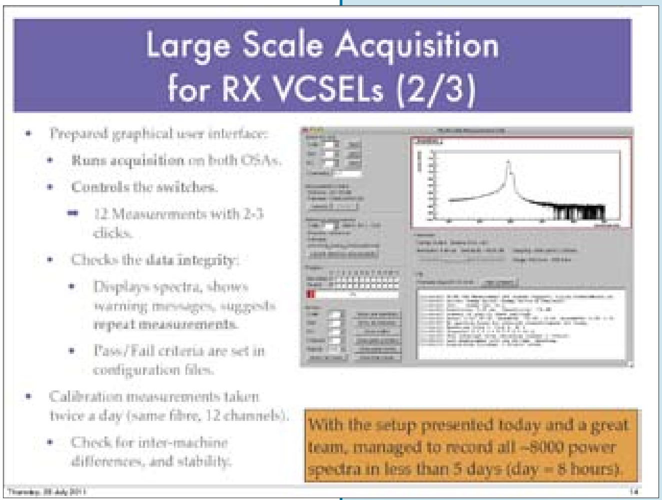

Overview
• Several studies done over the course of the past year.
• Today, present some selected results:
1. Early analysis.
2. Large scale RX acquisition in shut down.
3. Humidity tests.

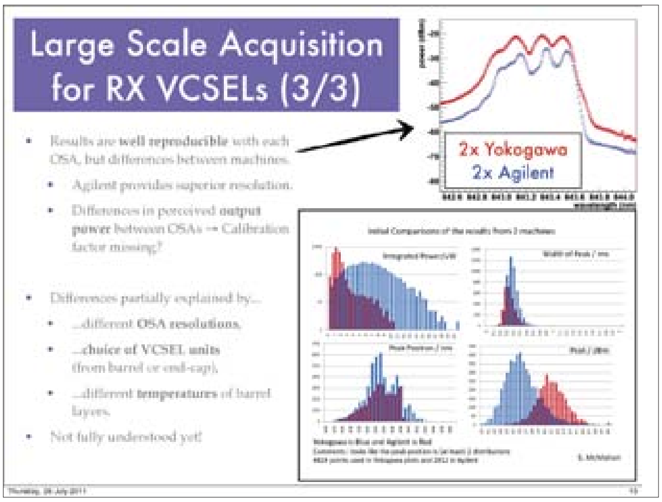

Early analysis (1/3)
Width @ peak-30dBm
Fresh units
Channel
average spectral width: about 2.5 nm
missing points
broken channels
Used units
Channel
average spectral width of working lasers: about 1.2 nm
• Comparison of fresh SCT arrays and used arrays taken out because of a defective laser:
➡ Width of spectrum is an important characteristic.

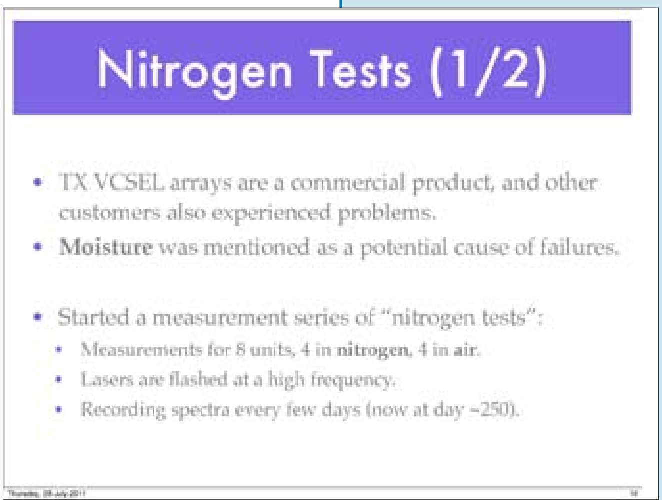

Early analysis (2/3)
Width @ peak-30dBm
Pixel used units
Channel
outer channels: average width about 2 nm
inner channels: average width about 1.2 nm
• Observation for arrays used for pixel detector: "inner" and "outer" channels are affected differently.
• Pixel only uses inner 8 channels → deterioration depends on usage.

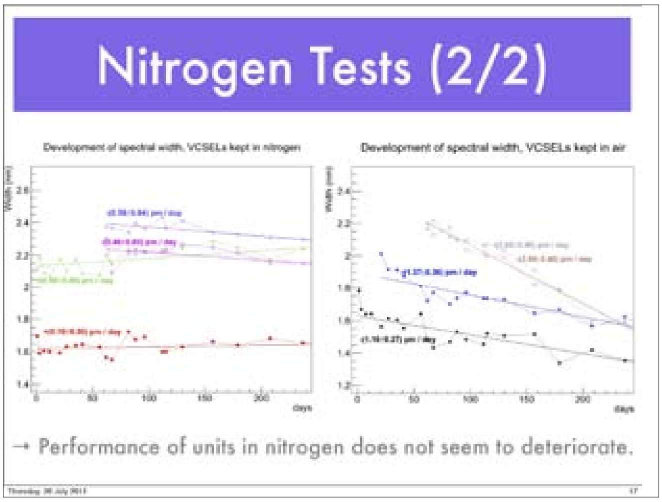

Early analysis (3/3)
SCT, never installed
PIX never installed, channels 2-9
SCT used
PIX used, channels 2-9
• Got hardware and software up and running, prepared documentation.
• Established useful definition of spectral width.
• Gained initial understanding and collected ideas for further studies.

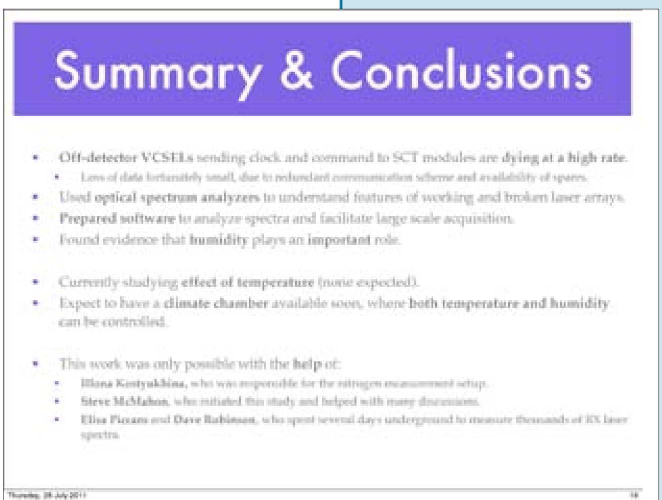

Large Scale Acquisition for RX VCSELs (1/3)
Shutdown in January 2011: output power spectra of 8176 on-detector RX lasers were recorded (4088 modules x 2 read-out links).
Produced with slower, more reliable proton implant technology. Accelerated aging tests were performed.
No reason to believe anything systematically wrong:
3 RX lasers died in 2010, and >300 TXs.
Purpose: Document current condition, compare in future shutdowns, or in case of problems.
Main challenge: Large scale of acquisition.


Large Scale Acquisition for RX VCSELs (2/3)
Prepared graphical user interface:
Runs acquisition on both OSAs.
Controls the switches.
12 Measurements with 2-3 clicks.
Checks the data integrity:
Displays spectra, shows warning messages, suggests repeat measurements.
Pass/Fail criteria are set in configuration files.
Calibration measurements taken twice a day (same fibre, 12 channels).
Check for inter-machine differences, and stability.
With the setup presented today and a great team, managed to record all ~8000 power spectra in less than 5 days (day = 8 hours).


Large Scale Acquisition for RX VCSELs (3/3)
Results are well reproducible with each OSA, but differences between machines.
Agilent provides superior resolution.
Differences in perceived output power between OSAs → Calibration factor missing?
Differences partially explained by...
...different OSA resolutions.
...choice of VCSEL units (from barrel or end-cap).
...different temperatures of barrel layers.
Not fully understood yet!
2x Yokogawa
2x Agilent


Nitrogen Tests (1/2)
TX VCSEL arrays are a commercial product, and other customers also experienced problems.
Moisture was mentioned as a potential cause of failures.
Started a measurement series of "nitrogen tests":
Measurements for 8 units, 4 in nitrogen, 4 in air.
Lasers are flashed at a high frequency.
Recording spectra every few days (now at day ~250).


Nitrogen Tests (2/2)
Development of spectral width, VCSELs kept in nitrogen
Development of spectral width, VCSELs kept in air
days
→ Performance of units in nitrogen does not seem to deteriorate.


Summary & Conclusions
Off-detector VCSELs sending clock and command to SCT modules are dying at a high rate.
Loss of data fortunately small, due to redundant communication scheme and availability of spares.
Used optical spectrum analyzers to understand features of working and broken laser arrays.
Prepared software to analyze spectra and facilitate large scale acquisition.
Found evidence that humidity plays an important role.
Currently studying effect of temperature (none expected).
Expect to have a climate chamber available soon, where both temperature and humidity can be controlled.
This work was only possible with the help of:
Iliona Kostyukhina, who was responsible for the nitrogen measurement setup.
Steve McMahon, who initiated this study and helped with many discussions.
Elisa Piccaro and Dave Robinson, who spent several days underground to measure thousands of RX laser spectra.

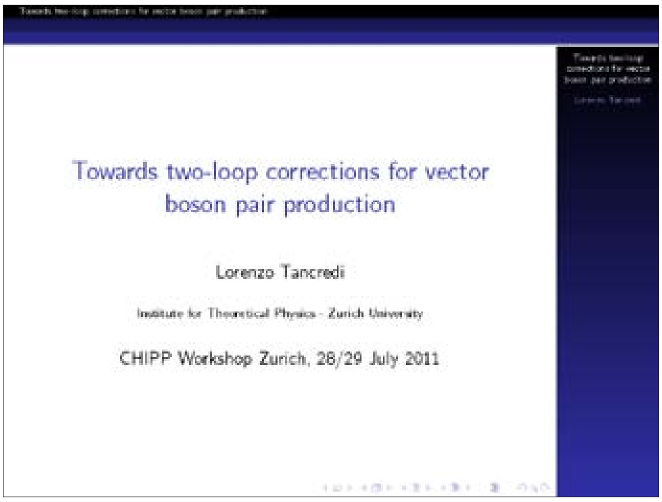
Lorenzo Tancredi – University of Zurich
(PhD student)

Towards two-loop corrections for vector boson pair production

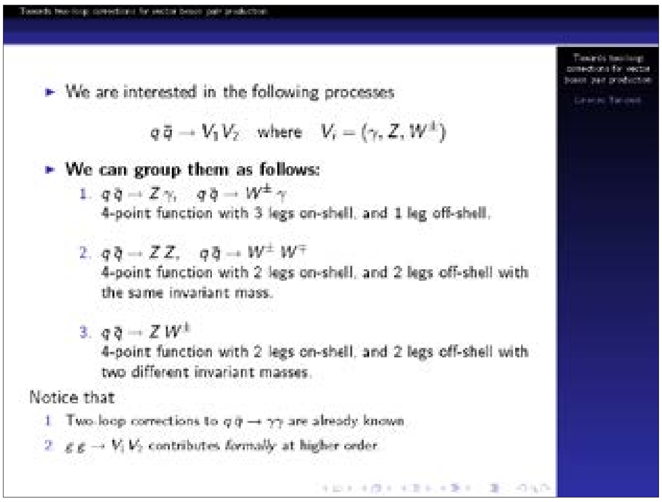
Scientific Abstract:

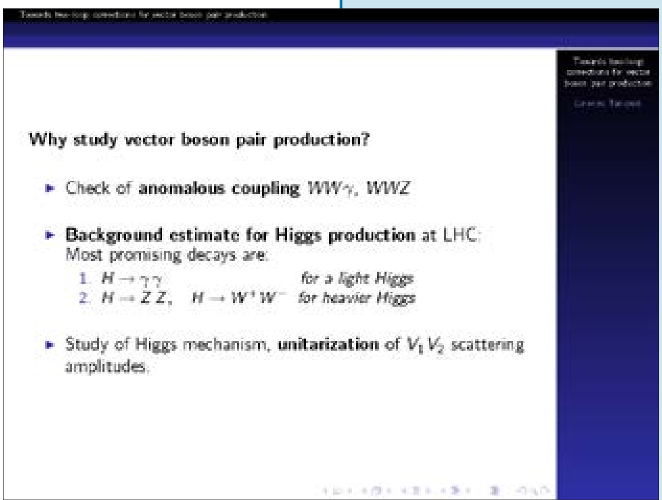
One of the most outstanding tasks at the LHC is probing the electroweak sector of the standard model and testing the spontaneous symmetry breaking mechanism. In particular, a precise estimate of the background in the Higgs search, both for heavy and light invariant masses, requires a very precise theoretical knowledge of the production rate of vector boson pairs, whose main contribution is given by QCD. To this aim, during the first year of my PhD I focussed my attention on the evaluation of the two-loop helicity amplitudes for the W photon and Z photon production.

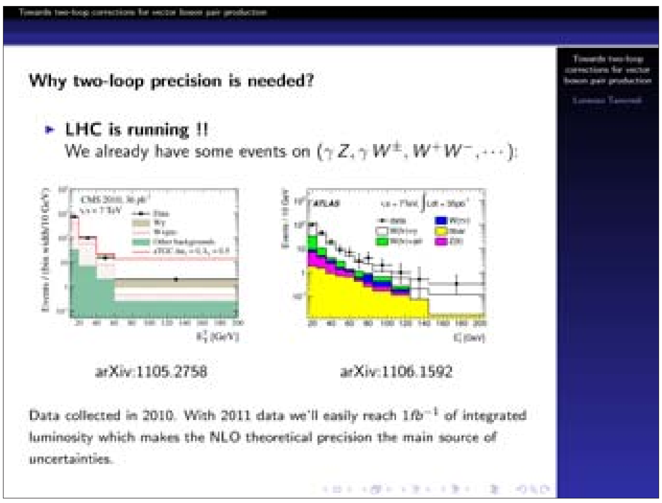
The helicity amplitudes have been evaluated analytically in terms of Harmonic Polylogarithms, the UV divergences have been renormalized in the modified minimal subtraction scheme, and the IR poles have been subtracted using Catani's formula.

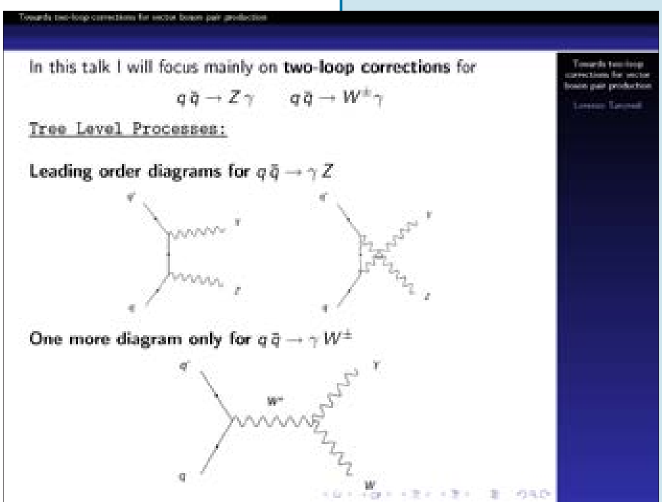

Towards two-loop corrections for vector boson pair production
Towards two-loop corrections for vector boson pair production
Lorenzo Tancredi
Institute for Theoretical Physics - Zurich University
CHIPP Workshop Zurich, 28/29 July 2011


Towards two-loop corrections for vector boson pair production
Plan of the talk
Introduction - why two-loop corrections?
Tecnical issues and tools
Results obtained up to date
Further developments


Towards two-loop corrections for vector boson pair production
We are interested in the following processes
$q\,\bar{q} \to V_1 V_2$ where $V_i = (\gamma, Z, W^{\pm})$
We can group them as follows:
1. $q\,\bar{q} \to Z\,\gamma$, $q\,\bar{q} \to W^{\pm}\,\gamma$
4-point function with 3 legs on-shell, and 1 leg off-shell.
2. $q\,\bar{q} \to Z\,Z$, $q\,\bar{q} \to W^{\pm}\,W^{\mp}$
4-point function with 2 legs on-shell, and 2 legs off-shell with the same invariant mass.
3. $q\,\bar{q} \to Z\,W^{\pm}$
4-point function with 2 legs on-shell, and 2 legs off-shell with two different invariant masses.
Notice that
1. Two-loop corrections to $q\,\bar{q} \to \gamma\gamma$ are already known
2. $g\,g \to V_1 V_2$ contributes *formally* at higher order

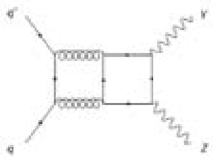

Towards two-loop corrections for vector boson pair production
Why study vector boson pair production?
Check of anomalous coupling $WW\gamma$, WWZ
Background estimate for Higgs production at LHC:
Most promising decays are:
1. $H \to \gamma\gamma$ for a light Higgs
2. $H \to Z\,Z$, $H \to W^+W^-$ for heavier Higgs
Study of Higgs mechanism, unitarization of $V_1 V_2$ scattering amplitudes.


Towards two-loop corrections for vector boson pair production
Why two-loop precision is needed?
LHC is running !!
We already have some events on $(\gamma\,Z, \gamma\,W^{\pm}, W^+W^-, \cdots)$:
CMS 2010
ATLAS
arXiv:1105.2758
arXiv:1106.1592
Data collected in 2010. With 2011 data we'll easily reach $1 fb^{-1}$ of integrated luminosity which makes the NLO theoretical precision the main source of uncertainties.


Towards two-loop corrections for vector boson pair production
In this talk I will focus mainly on two-loop corrections for
$q\,\bar{q} \to Z\,\gamma$ $q\,\bar{q} \to W^{\pm}\gamma$
Tree Level Processes:
Leading order diagrams for $q\,\bar{q} \to \gamma\,Z$
One more diagram only for $q\,\bar{q} \to \gamma\,W^{\pm}$

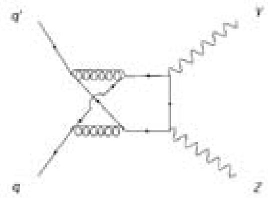
Main task in two loop calculations is the **evaluation of the loop-integrals**.

Tipical two-loop **Planar** Feynman graph for $q\,\bar{q} \to \gamma\, Z/W^{\pm}$



$$\int_k \int_l \frac{\mathcal{N}_i}{k^2 l^2 (k-l)^2 (k-p_1)^2 (k-p_1-p_2)^2 (l-p_1-p_2)^2 (l-p_1-p_2+p_3)^2}$$

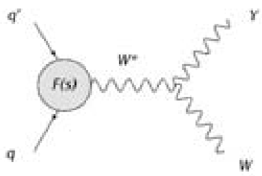
Tipical two-loop **Non-Planar** Feynman graph for $q\,\bar{q} \to \gamma\, Z/W^{\pm}$



$$\int_k \int_l \frac{\mathcal{N}_i}{k^2 (k-l)^2 (k-l+p_1)^2 (l-p_1)^2 (k-p_{12})^2 (l-p_{12})^2 (k-p_{12}+p_3)^2}$$

with $p_{12} = p_1 + p_2$

To obtain two-loop corrections for $q\,\bar{q} \to \gamma\, W^{\pm}$ one has to add also the contributions from another class of diagrams:



Where $F(s)$ is the **Quark Form Factor** at two-loop in QCD.

(This is "trivially" done since $F(s)$ is know up to three-loop in QCD)

`Tecnical Issues:`

- In general a Two-Loop calculation requires the evaluation of hundred or thousands of different **Scalar Integrals**.
  For Example: For the case $q\,\bar{q} \to \gamma\, Z$ we had
  1. 143 Feynman Diagrams
  2. 1051 *PLANAR* Integrals
  3. 933 *NON-PLANAR* Integrals
- In general integrals are affected by both **UV** and **IR divergences**.
- Two-Loop integrals can also be very complicated to evaluate **analytically** by direct integration.
- Many tools have developed in the last fifteen years to deal with such huge calculations.

`Tools:`

- **Dimensional Regularization (DR)**:
  1. We use dimensional regularization to regularize both UV and IR divergences, which manifest as poles in

$$\epsilon = (4-d)/2 \quad \text{as} \quad d \to 4$$

- Working in **Massless QCD** brings huge simplifications.
- **Helicity Amplitudes (HA)**:
  1. The couplings of vector bosons to fermions are spin-dependent → Helicity Methods `[Dixon]`.
  2. HA also are especially convenient in Massless QCD.

- **Reduction to Master Integrals (MI)**:
  1. In a general calculation one finds thousands of scalar integrals of the general form

$$I = \int \Pi_i d^d k_i \, \frac{S_1^{i_1} \cdots S_m^{i_m}}{D_1^{j_1} \cdots D_n^{j_n}}$$

  2. Exploiting *Integration By Parts Identities* (IBPs)

$$\int \Pi_i d^d k_i \left(\frac{\partial}{\partial k_i^{\mu}} v_{\mu} \frac{S_1^{i_1} \cdots S_m^{i_m}}{D_1^{j_1} \cdots D_n^{j_n}} \right) = 0$$

  (with v_μ any external or internal momenta)
  one can express all these thousands of integrals as linear combination of tens of *irreducible* Master Integrals (MIs)

- **Evaluation of the Master Integrals:**
  - At the moment there is no unique method for the evaluation of the MIs.
  - We make use of the Differential Equation (DE) method. [F.V.Tkachov, E.Remiddi, T.Gehrmann]
  - Exploiting the IBPs one can derive DE for the MIs in the external invariants (i.e. $s_{ij} = (p_i + p_j)^2$)

1. PRO: No explicit integration has to be performed.
2. CONTRA: The MI are evaluated *analytically* matching the solution of the DE with an appropriate **boundary condition**. This can be very difficult to determine.

Results up to date:

- $\mathbf{q\,\bar{q} \to \gamma\, Z}$, $\mathbf{q\,\bar{q} \to \gamma\, W^{\pm}}$
  - Reduction to Masters: Known.
  - Master Integrals: Known

(from the process $\gamma^* \to q\,\bar{q}\,g$, hep-ph/0101124, hep-ph/0008287)

What has been done so far:

1. The diagrams have been generated with **QGRAF**
2. The reduction to MI has been performed with **Reduze** [C.Studerus, A.Von Manteuffel]
   Change of Basis from Reduze basis → Known Basis.
3. The **HA** have been obtained diagram by diagram in function of MIs, then the diagrams have been summed.
4. **UV div.** have been renormalized, **IR poles** have been subtracted using **Catani Ansatz** (hep-ph/9802439)
5. For all the algebraic manipulations I used **FORM.**

- **Tensor Structure** for $q(p_1) + \bar{q}(p_2) \to \gamma(p_3) + V(p_4)$
  - We start from the general tensor structure for $\gamma^* \to q\,\bar{q}\,\gamma$:

$$S_\mu(q;\gamma;\bar{q}) = A_{11}\,T_{11\mu} + A_{12}\,T_{12\mu} + A_{13}\,T_{13\mu} + A_{21}\,T_{21\mu} + A_{22}\,T_{22\mu} + A_{23}\,T_{23\mu} + B\,T_\mu.$$

  - Where the tensors are defined as:

$$T_{1j\mu} = \bar{u}(p_2)\left[\not{p}_3\,\epsilon_3\cdot p_1\,p_{j\mu} - \frac{s_{13}}{2}\not{\epsilon}_3\,p_{j\mu} + \frac{s_{j4}}{4}\not{\epsilon}_3\not{p}_3\gamma_\mu\right]v(p_1)$$

$$T_{2j\mu} = \bar{u}(p_2)\left[\not{p}_3\,\epsilon_3\cdot p_2\,p_{j\mu} - \frac{s_{23}}{2}\not{\epsilon}_3\,p_{j\mu} + \frac{s_{j4}}{4}\gamma_\mu\not{p}_3\not{\epsilon}_3\right]v(p_1)$$

$$T_\mu = \bar{u}(p_2)\left[s_{23}\left(\gamma_\mu\epsilon_3\cdot p_1 + \frac{1}{2}\not{\epsilon}_3\not{p}_3\gamma_\mu\right) s_{13}\left(\gamma_\mu\epsilon_3\cdot p_2 + \frac{1}{2}\gamma_\mu\not{p}_3\not{\epsilon}_3\right)\right]v(p_1)$$

- Using the techniques listed above we obtained an explicit expression for the coefficients A_{ij} and B, expressed in terms of 1- and 2-dim **Harmonic Polylogarithms (HPLs)**, up to weight 4.
- An Example of **Finite** result for $q\,\bar{q} \to \gamma\,Z$ reads:

$$A_{11}(u,v) = N^2\frac{u}{u+v}\left(\frac{\pi}{4} + \frac{i}{4}H(0,v) - \frac{i}{4}G(0,u)\right) + \cdots + (\approx 2500 \text{ lines})$$

where

$$u = -\frac{y}{x} \qquad v = \frac{1}{x}$$

and

$$x = \frac{s_{12}}{s_{123}}, \quad y = \frac{s_{13}}{s_{123}}, \quad z = \frac{s_{23}}{s_{123}}, \quad s_{ij} = (p_i + p_j)^2$$

Future Developments and Goals for next 12 months:

- $q\,\bar{q} \to \gamma\, Z$, $q\,\bar{q} \to \gamma\, W^{\pm}$
  1. Implementing **NNLO cross section.**
- $q\,\bar{q} \to Z\,Z$, $q\,\bar{q} \to W\,W$
  1. Reduction to MI has been performed some months ago with Reduze 2.
  2. Classification of the MI for 4-point functions with 2 legs off-shell with equal masses.
  3. Development and Automation of the Differential-Equation method for the MI.
- $q\,\bar{q} \to W^{\pm}Z$
  1. Perform the Reduction for the 2 legs off-shell case, with two different masses.
  2. ...

Thanks !!

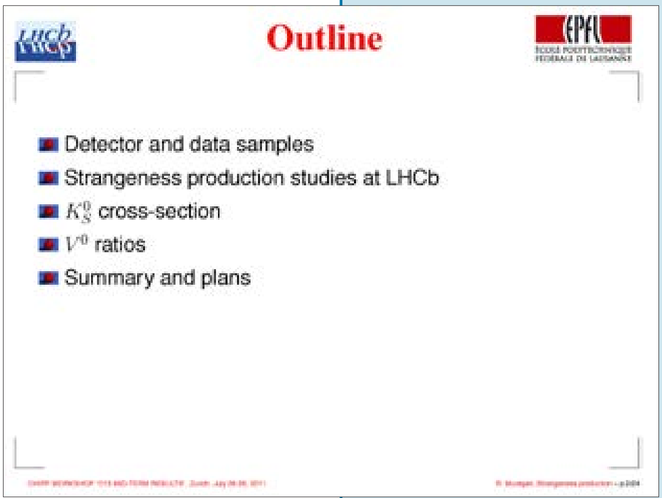
Raluca Muresan – EPF Lausanne
(PostDoc)

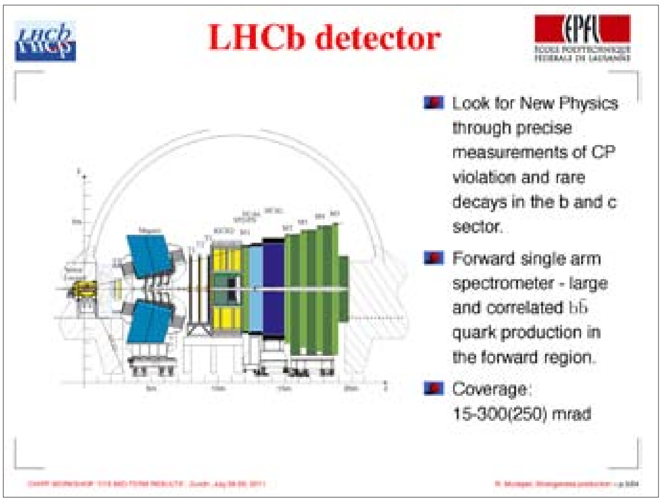
Strangeness production studies at LHCb

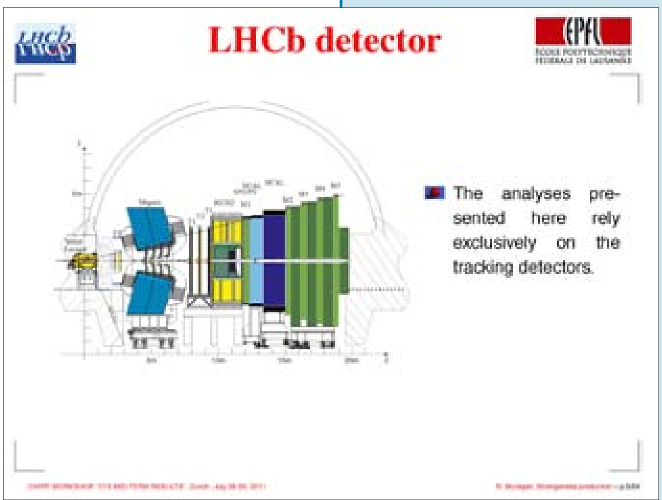
Scientific Abstract:

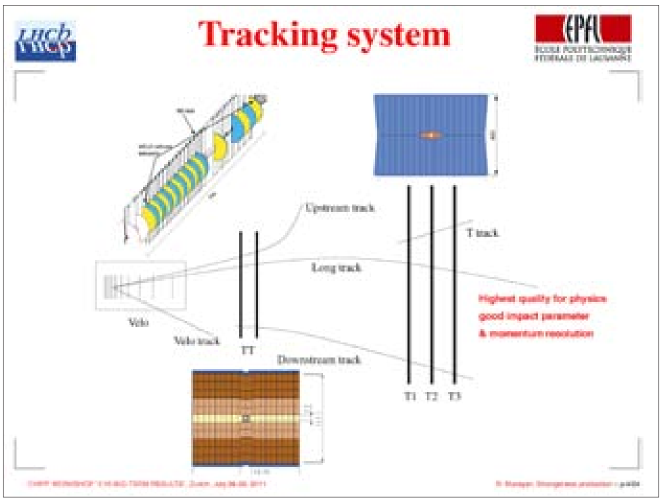
The LHCb experiment, designed to look for New Physics through precise measurements of CP violation and rare decays in the b- and c-hadrons, has also an interesting soft-QCD physics program. Due to the unique pseudo-rapidity coverage of the detector and to the possibility of extending the measurements to low transverse momenta, the 2009-2010 LHCb data gave an insight in the strangeness production mechanisms in a kinematical range where QCD models are divergent. Measurements of the production cross section of K0S at 0.9 TeV will be presented together with results on the production ratios of anti-Λ/Λ and anti-Λ/K0S at 0.9 and 7 TeV.

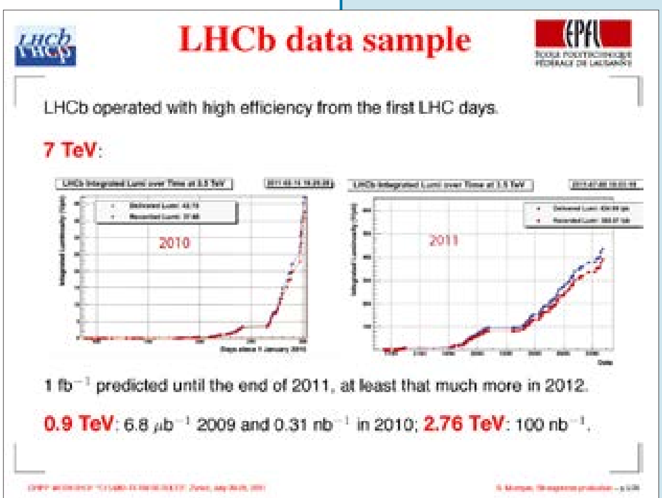

Strangeness production studies at LHCb
CHIPP WORKSHOP "C15 MID-TERM RESULTS"
Zürich
Raluca Mureşan
Ecole Polytechnique Fédérale de Lausanne (EPFL)

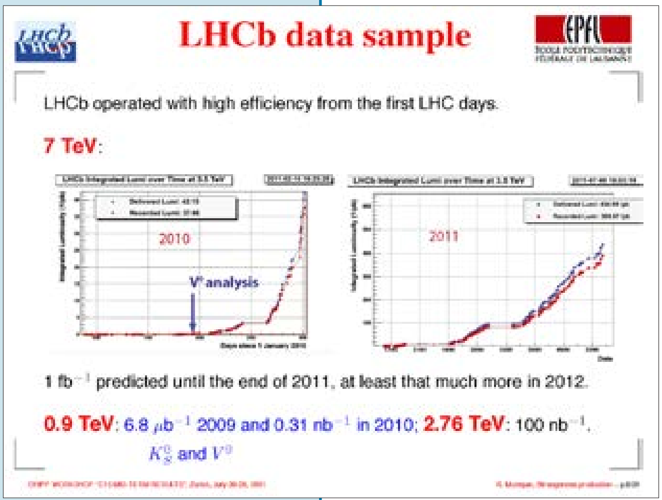

Outline
Detector and data samples
Strangeness production studies at LHCb
K^0_S cross-section
V^0 ratios
Summary and plans

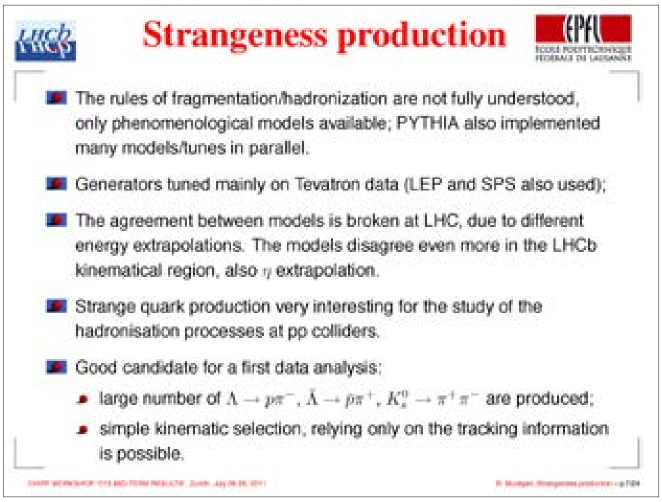

LHCb detector
Look for New Physics through precise measurements of CP violation and rare decays in the b and c sector.
Forward single arm spectrometer - large and correlated $b\bar{b}$ quark production in the forward region.
Coverage: 15-300(250) mrad

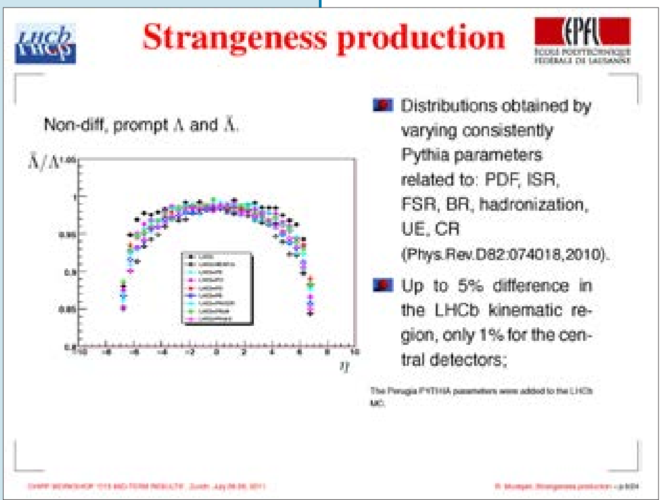

LHCb detector
The analyses presented here rely exclusively on the tracking detectors.

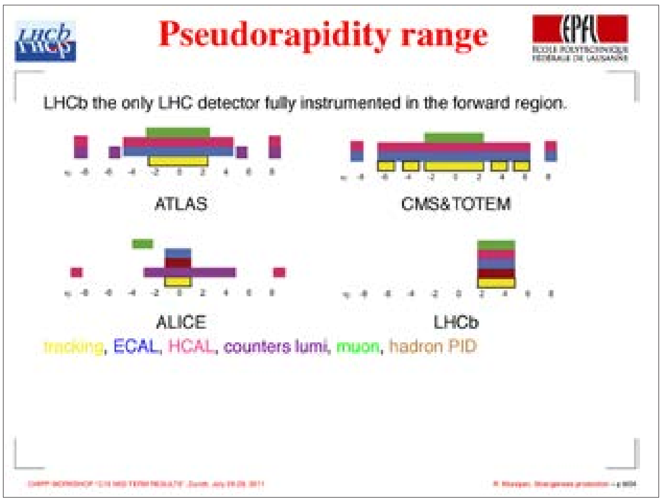

Tracking system
Upstream track
T track
Long track
Velo
Velo track
TT
Downstream track
T1 T2 T3
Highest quality for physics
good impact parameter
& momentum resolution

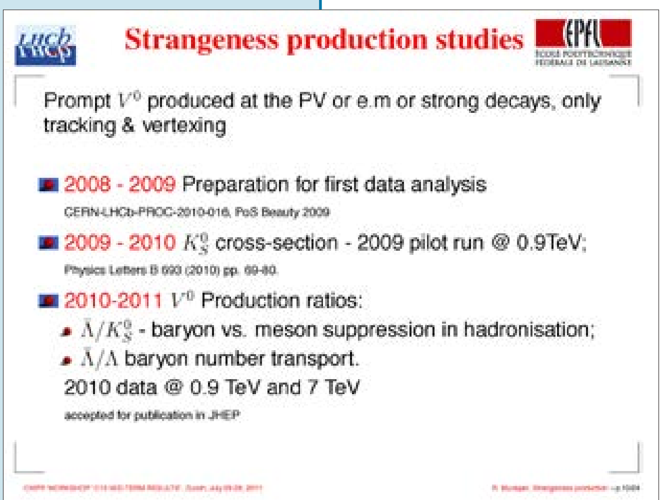

LHCb data sample
LHCb operated with high efficiency from the first LHC days.
7 TeV:
2010
2011
1 fb^{-1} predicted until the end of 2011, at least that much more in 2012.
0.9 TeV: 6.8 $\mu\mathrm{b}^{-1}$ 2009 and 0.31 nb^{-1} in 2010; 2.76 TeV: 100 nb^{-1}.

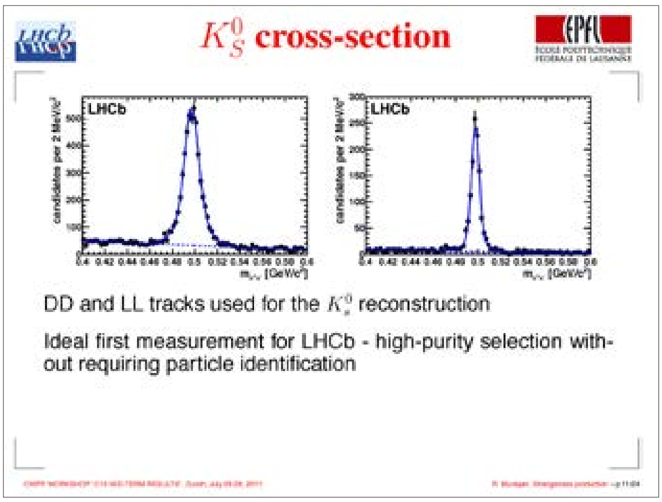

LHCb data sample
LHCb operated with high efficiency from the first LHC days.
7 TeV:
2010
V⁰ analysis
2011
1 fb⁻¹ predicted until the end of 2011, at least that much more in 2012.
0.9 TeV: 6.8 μb⁻¹ 2009 and 0.31 nb⁻¹ in 2010; 2.76 TeV: 100 nb⁻¹.
K^0_S and V^0

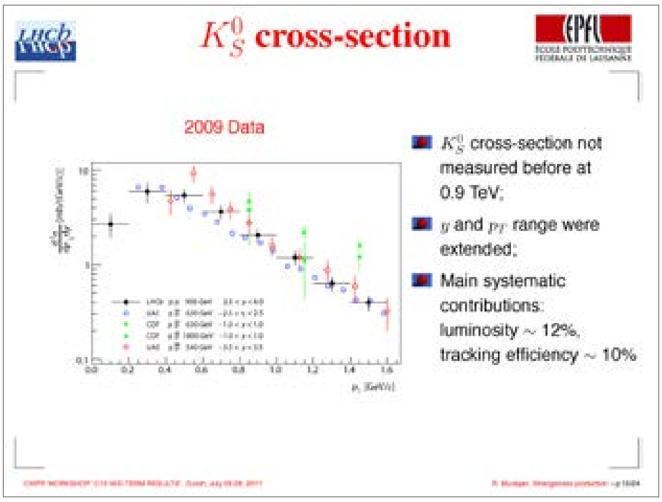

Strangeness production
The rules of fragmentation/hadronization are not fully understood, only phenomenological models available; PYTHIA also implemented many models/tunes in parallel.
Generators tuned mainly on Tevatron data (LEP and SPS also used);
The agreement between models is broken at LHC, due to different energy extrapolations. The models disagree even more in the LHCb kinematical region, also η extrapolation.
Strange quark production very interesting for the study of the hadronisation processes at pp colliders.
Good candidate for a first data analysis:
large number of $\Lambda \to p\pi^-$, $\bar{\Lambda} \to \bar{p}\pi^+$, $K^0_s \to \pi^+\pi^-$ are produced;
simple kinematic selection, relying only on the tracking information is possible.

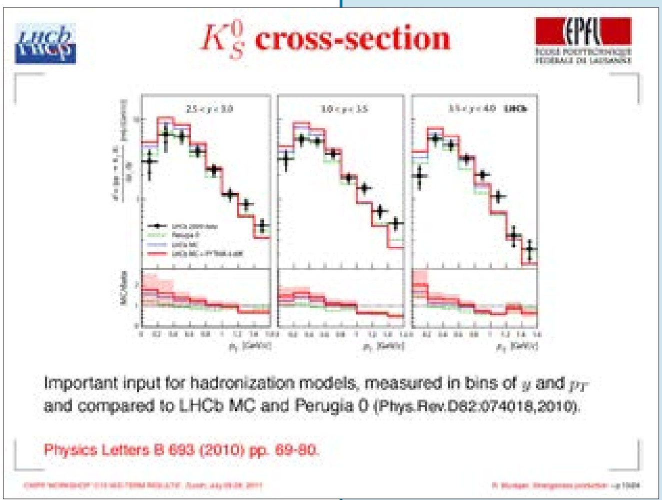

Strangeness production
Non-diff, prompt Λ and $\bar{\Lambda}$.
$\bar{\Lambda}/\Lambda$
η
Distributions obtained by varying consistently Pythia parameters related to: PDF, ISR, FSR, BR, hadronization, UE, CR (Phys.Rev.D82:074018,2010).
Up to 5% difference in the LHCb kinematic region, only 1% for the central detectors;
The Perugia PYTHIA parameters were added to the LHCb MC.

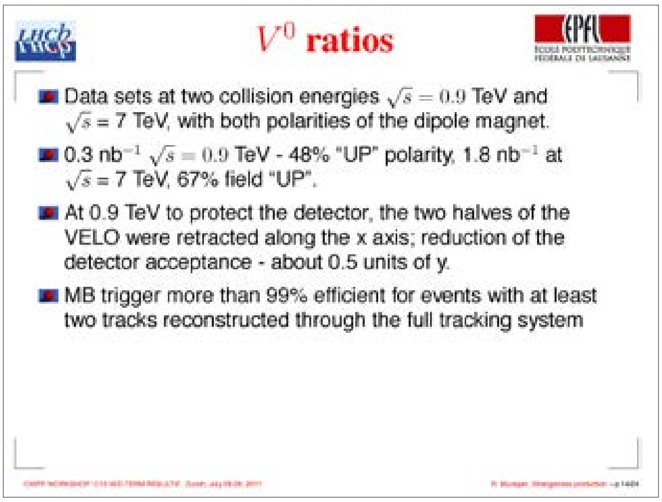

Pseudorapidity range
LHCb the only LHC detector fully instrumented in the forward region.
ATLAS
CMS&TOTEM
ALICE
LHCb
tracking, ECAL, HCAL, counters lumi, muon, hadron PID

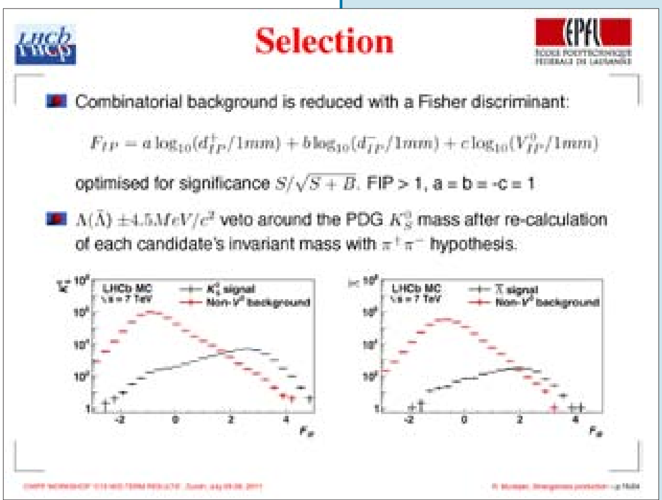

Strangeness production studies
Prompt V^0 produced at the PV or e.m or strong decays, only tracking & vertexing
2008 - 2009 Preparation for first data analysis
CERN-LHCb-PROC-2010-016, PoS Beauty 2009
2009 - 2010 K^0_S cross-section - 2009 pilot run @ 0.9TeV;
Physics Letters B 693 (2010) pp. 69-80.
2010-2011 V^0 Production ratios:
$\bar{\Lambda}/K^0_S$ - baryon vs. meson suppression in hadronisation;
$\bar{\Lambda}/\Lambda$ baryon number transport.
2010 data @ 0.9 TeV and 7 TeV
accepted for publication in JHEP

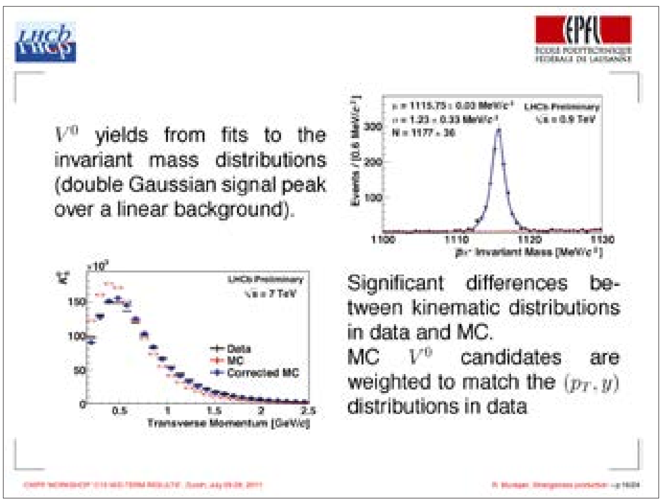

K^0_S cross-section
LHCb
LHCb
DD and LL tracks used for the K^0_s reconstruction
Ideal first measurement for LHCb - high-purity selection without requiring particle identification

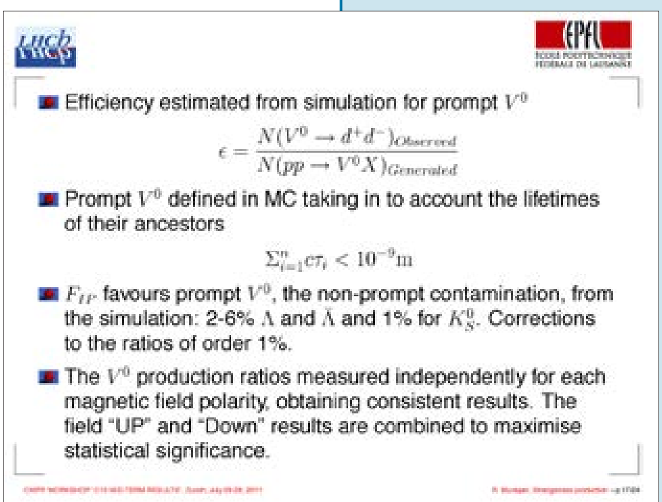

K^0_S cross-section
2009 Data
K^0_S cross-section not measured before at 0.9 TeV;
y and p_T range were extended;
Main systematic contributions: luminosity ~ 12%, tracking efficiency ~ 10%


K^0_S cross-section
Important input for hadronization models, measured in bins of y and p_T and compared to LHCb MC and Perugia 0 (Phys.Rev.D82:074018,2010).
Physics Letters B 693 (2010) pp. 69-80.


V^0 ratios
Data sets at two collision energies $\sqrt{s} = 0.9$ TeV and $\sqrt{s}$ = 7 TeV, with both polarities of the dipole magnet.
0.3 nb^{-1} $\sqrt{s} = 0.9$ TeV - 48% "UP" polarity, 1.8 nb^{-1} at $\sqrt{s}$ = 7 TeV, 67% field "UP".
At 0.9 TeV to protect the detector, the two halves of the VELO were retracted along the x axis; reduction of the detector acceptance - about 0.5 units of y.
MB trigger more than 99% efficient for events with at least two tracks reconstructed through the full tracking system


Selection
Combinatorial background is reduced with a Fisher discriminant:
$F_{IP} = a\log_{10}(d^+_{IP}/1mm) + b\log_{10}(d^-_{IP}/1mm) + c\log_{10}(V^0_{IP}/1mm)$
optimised for significance $S/\sqrt{S+B}$. FIP > 1, a = b = -c = 1
$\Lambda(\bar{\Lambda})$ $\pm 4.5 MeV/c^2$ veto around the PDG K^0_S mass after re-calculation of each candidate's invariant mass with $\pi^+\pi^-$ hypothesis.
LHCb MC
K^0_S signal
Non-V^0 background
$\bar{\Lambda}$ signal

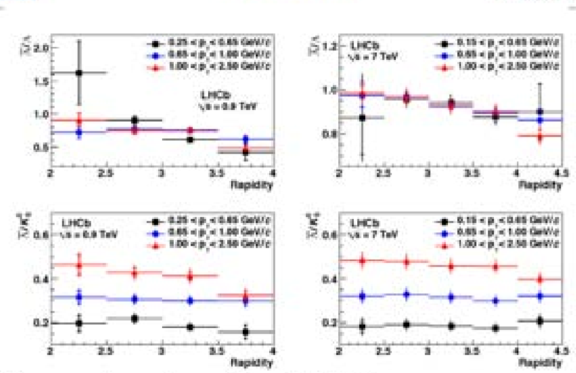

V^0 yields from fits to the invariant mass distributions (double Gaussian signal peak over a linear background).
LHCb Preliminary
Invariant Mass [MeV/c²]
Transverse Momentum [GeV/c]
Data
MC
Corrected MC
Significant differences between kinematic distributions in data and MC.
MC V^0 candidates are weighted to match the (p_T, y) distributions in data


Efficiency estimated from simulation for prompt V^0
$\epsilon = \frac{N(V^0 \to d^+d^-)_{Observed}}{N(pp \to V^0X)_{Generated}}$
Prompt V^0 defined in MC taking in to account the lifetimes of their ancestors
$\Sigma^n_{i=1} c\tau_i < 10^{-9}$m
F_{IP} favours prompt V^0, the non-prompt contamination, from the simulation: 2-6% Λ and $\bar{\Lambda}$ and 1% for K^0_S. Corrections to the ratios of order 1%.
The V^0 production ratios measured independently for each magnetic field polarity, obtaining consistent results. The field "UP" and "Down" results are combined to maximise statistical significance.

- Due to the primary vertex requirement, only $\sim$ 3% of the selected V^0 are produced in diffractive events (PYTHIA 6 and PYTHIA 8).
- Complete removal of diffractive events only produces a change of 0.01-0.02 in the ratios across the measurement range.
- Minimal requirements for PV reconstruction can be approximated in MC by requiring at least 3 charged particles from the collision with lifetime $c\tau > 10^{-6}$ mm, momentum p > 0.3 GeV/c, polar angle 15 < θ [mrad] < 460.

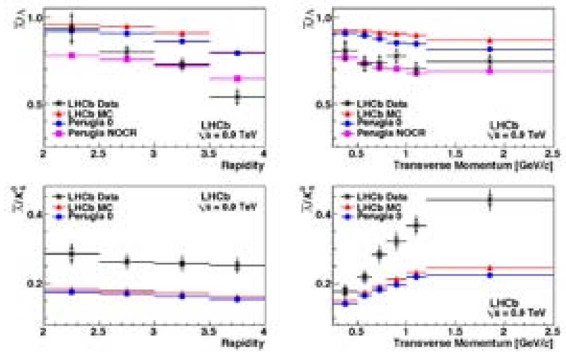
Sources of systematic uncertainty	$\bar{\Lambda}/\Lambda$	$\bar{\Lambda}/K^0_S$
Correlated between field Up and Down:		
Material interactions	0.02	0.02
Diffractive event fraction	$0.01-0.02$	$0.01-0.02$
Primary vertex finding	< 0.02	< 0.01
Non-prompt fraction	< 0.01	< 0.01
Track finding	negligible	0.01
Uncorrelated:		
Kinematic correction	$0.01-0.05$	< 0.03
Signal extraction from fit	0.001	0.001
Total	$0.02-0.06$	$0.02-0.03$

Results

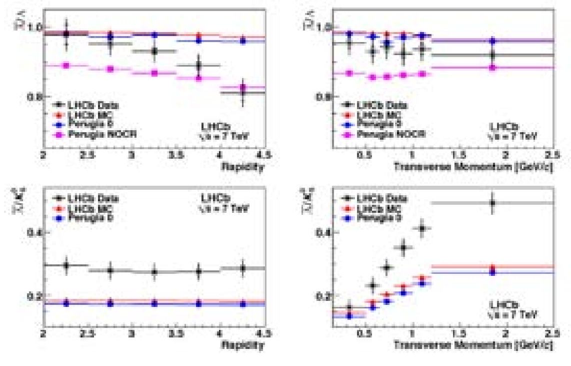


Strong p_T dependence of the ratio Λ/K^0_s.

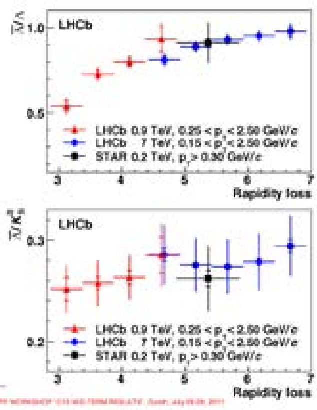
LHCb vs. MC - 0.9 TeV



LHCb vs. MC - 7 TeV

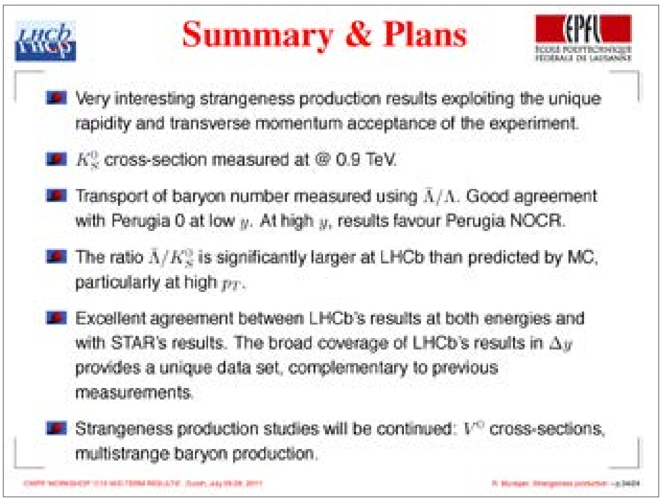


Rapidity loss



$\Delta y = y_{beam} - y$

Excellent agreement between the two energies and STAR result.


Summary & Plans
Very interesting strangeness production results exploiting the unique rapidity and transverse momentum acceptance of the experiment.
K^0_S cross-section measured at @ 0.9 TeV.
Transport of baryon number measured using $\bar{\Lambda}/\Lambda$. Good agreement with Perugia 0 at low y. At high y, results favour Perugia NOCR.
The ratio $\bar{\Lambda}/K^0_S$ is significantly larger at LHCb than predicted by MC, particularly at high p_T.
Excellent agreement between LHCb's results at both energies and with STAR's results. The broad coverage of LHCb's results in Δy provides a unique data set, complementary to previous measurements.
Strangeness production studies will be continued: V^0 cross-sections, multistrange baryon production.

Gabriella Pásztor – University of Geneva
(PostDoc)

Electron performance and inclusive electron cross-section measurements with the ATLAS detector

Scientific Abstract:

The first measurements of the electron identification efficiency of the ATLAS detector at the LHC using the decays of the Z, W and J/ψ particles observed in the data collected in 2010 at $\sqrt{s}$ = 7 TeV, corresponding to an integrated luminosity of almost 40 pb-1, were performed. A fraction of the data collected by an unbiased electromagnetic trigger and amounting to 1.3 pb-1 was used to measure the differential cross-section for inclusive electron production from the decay of heavy flavour hadrons as a function of the electron transverse energy in the range 7 < ET < 26 GeV and |η| < 2 excluding 1.37 < |η| < 1.52. The results are found to be in good agreement with the theoretical prediction using a Fixed Order NLO calculation with high-pT resummation.

Electron performance and inclusive electron cross-section measurements with the ATLAS detector

Gabriella Pásztor
University of Geneva

CHIPP workshop on mid-term results
Zurich, 28-29 July, 2011

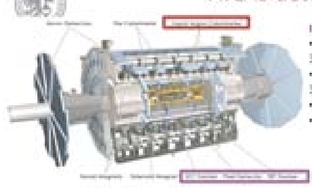
Outline

- Electron reconstruction and identification in ATLAS
- In-situ efficiency measurements
- Inclusive electron production cross-section
- Comparison to theoretical predictions

Introduction

- Understanding electron performance is a prerequisite of any physics measurement (SM or beyond) using electron final states
- Electron production from Heavy Flavour hadron, W and Z decays is a major background to searches for new physics (Higgs, SUSY,...)
- Theoretical calculations of HF prediction have large uncertainties
- Monte Carlo predictions (even when based on the same matrix element) vary significantly
- Need a precise HF cross-section measurement to test QCD in the new energy regime

ATLAS detector



Inner Tracking Detector
- Silicon pixel & strip tracking: $|\eta|<2.5$
3 pixel, 8 SCT measurements in barrel
- Transition Radiation Tracker: $|\eta|<2.0$
36 measurements @ $\eta = 0$
- Axial magnetic field: 2T
- $\sigma(p_T)/p_T = 0.05\%/pT \oplus 1\%$

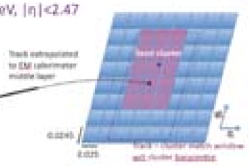
LAr EM Calorimeter
- Fine lateral segmentation
- 3 or 4 longitudinal layers
- EM energy resolution:

$$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$

a=10%, b=170 MeV, c=0.7%

Electron reconstruction

- Seeded by EM clusters with E_T>2.5 GeV, $|\eta|$<2.47
- Track matched within $\Delta\eta$<0.05, $\Delta\phi_{\eta\ corr}$<0.05 (0.1)
- If several tracks:
  - priority of tracks with Si hits
  - closest match in ΔR
- Rebuild cluster from 3x7 (5x5) longitudinal towers in barrel (endcap)



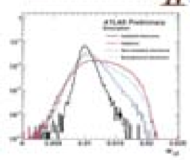
- $E_{electron}(E_{PS}, E_1, E_2, E_3, \eta, \phi) = E_{before\ calo} + E_{cluster} + E_{lateral\ leakage} + E_{longitudinal\ leakage}$
- In-situ electron energy scale calibration using Z→ee events relying on the well-known Z lineshape, cross-checked by J/ψ→ee (m_{ee}) and W→eν (E/p) calibration
- Electron direction from track

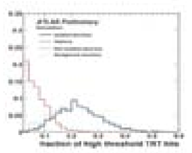
Electron identification

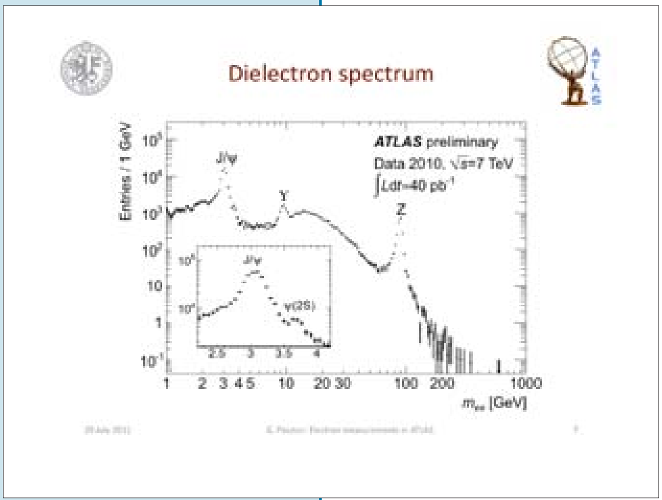
Loose level (typical jet rejection: 1/500)
- Hadronic leakage
- EM calorimeter shower shapes in middle layer

Medium level (typical jet rejection: 1/5000)
- EM calorimeter shower shapes in front layer
- Track pixel and SCT hits
- Transverse impact parameter (d_0)
- Track – cluster match in η

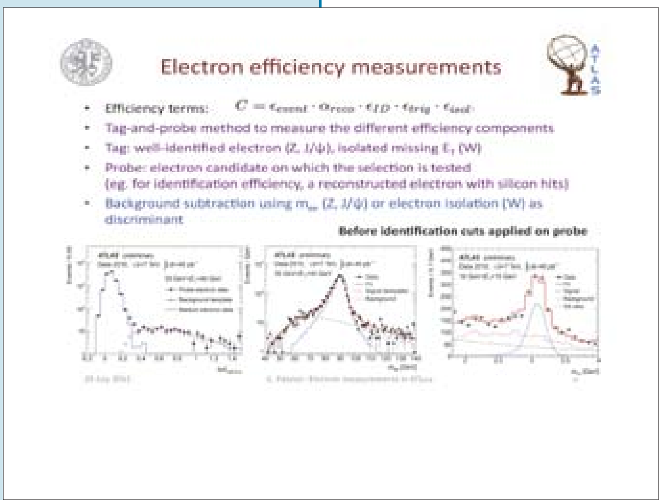
Tight level (typical rejection: 1/50 000)
- More stringent d_0
- Track cluster match (Δη, Δφ, E/p)
- TRT electron – hadron discrimination
- Photon conversion veto

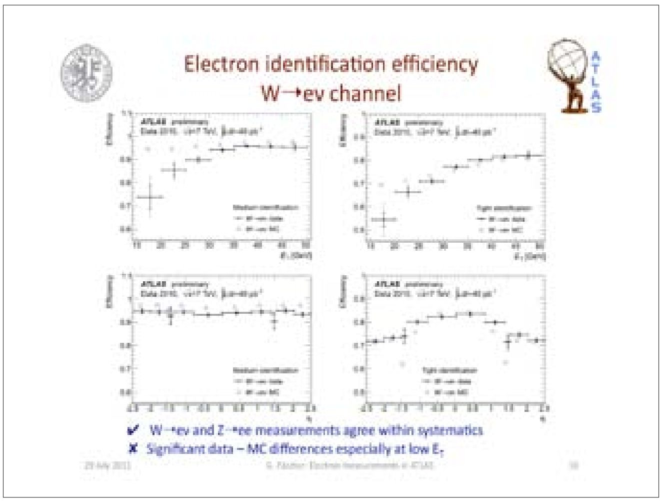


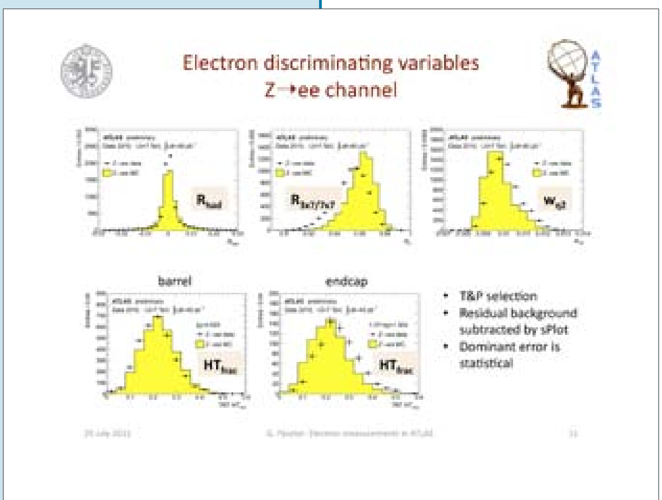


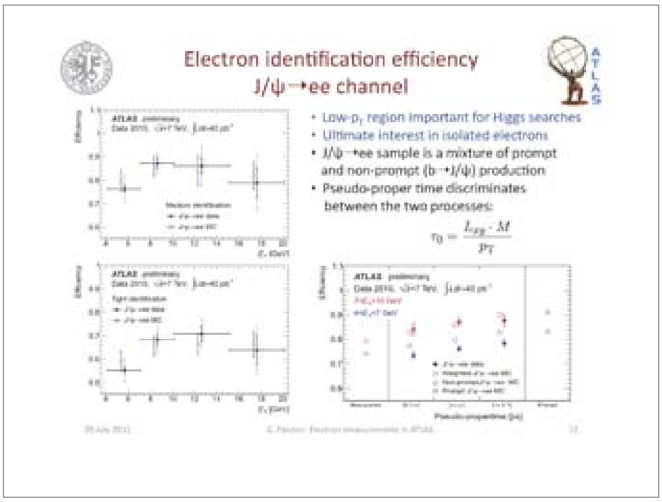

Dielectron spectrum
ATLAS preliminary
Data 2010, √s=7 TeV
∫Ldt=40 pb⁻¹
J/ψ
Υ
Z
ψ(2S)
Entries / 1 GeV
m_ee [GeV]

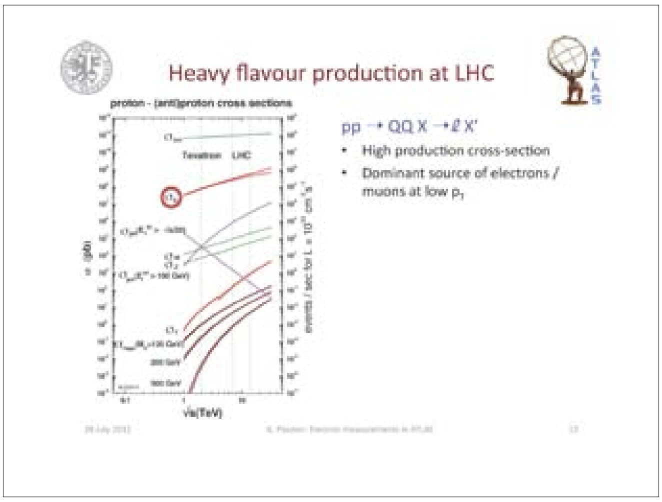

J/ψ → ee candidate
e⁺: E_T = 7.52 GeV, η = 0.080, ϕ = -0.835
e⁻: E_T = 12.44 GeV, η = 0.400, ϕ = -0.767
J/ψ candidate: m_ee = 3.17 GeV, p_T = 19.96 GeV
ATLAS EXPERIMENT

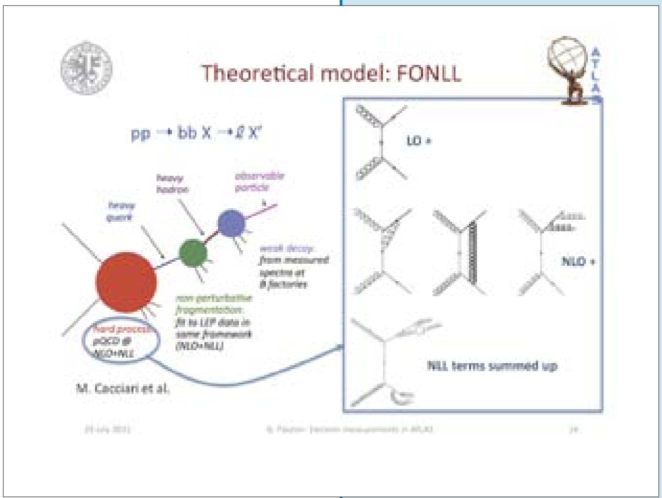

Electron efficiency measurements
Efficiency terms: C = ε_event · α_reco · ε_ID · ε_trig · ε_isol
Tag-and-probe method to measure the different efficiency components
Tag: well-identified electron (Z, J/ψ), isolated missing E_T (W)
Probe: electron candidate on which the selection is tested
(eg. for identification efficiency, a reconstructed electron with silicon hits)
Background subtraction using m_ee (Z, J/ψ) or electron isolation (W) as discriminant
Before identification cuts applied on probe

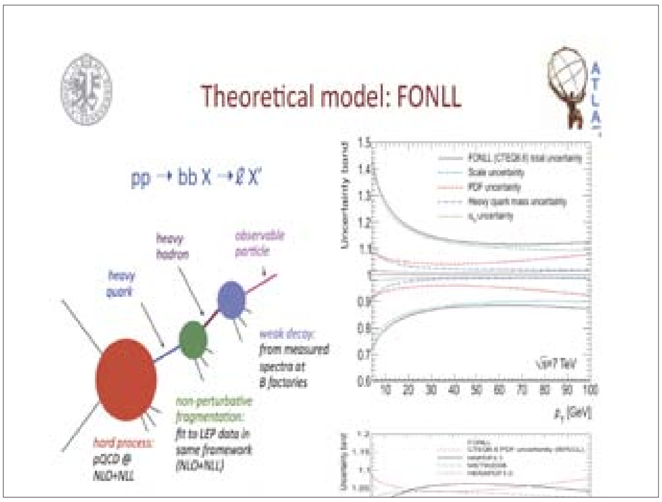

Electron identification efficiency
W→eν channel
W→eν and Z→ee measurements agree within systematics
Significant data – MC differences especially at low E_T


Electron discriminating variables
Z→ee channel
R_had
R_3x7/7x7
W_η2
barrel
endcap
HT_frac
T&P selection
Residual background subtracted by sPlot
Dominant error is statistical


Electron identification efficiency
J/ψ→ee channel
Low-p_T region important for Higgs searches
Ultimate interest in isolated electrons
J/ψ→ee sample is a mixture of prompt and non-prompt (b→J/ψ) production
Pseudo-proper time discriminates between the two processes:
τ_0 = L_xy · M / p_T


Heavy flavour production at LHC
proton - (anti)proton cross sections
Tevatron LHC
√s (TeV)
pp → QQ X → ℓ X'
High production cross-section
Dominant source of electrons / muons at low p_T


Theoretical model: FONLL
pp → bb X → ℓ X'
heavy quark
heavy hadron
observable particle
weak decay: from measured spectra at B factories
non perturbative fragmentation: fit to LEP data in same framework (NLO+NLL)
hard process: pQCD @ NLO+NLL
M. Cacciari et al.
LO +
NLO +
NLL terms summed up


Theoretical model: FONLL
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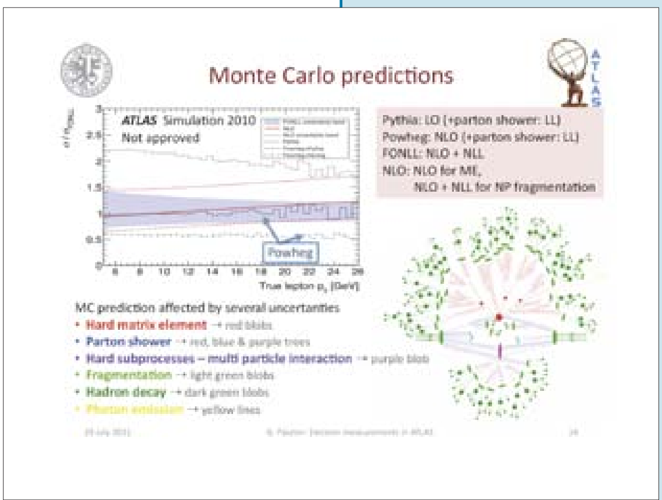
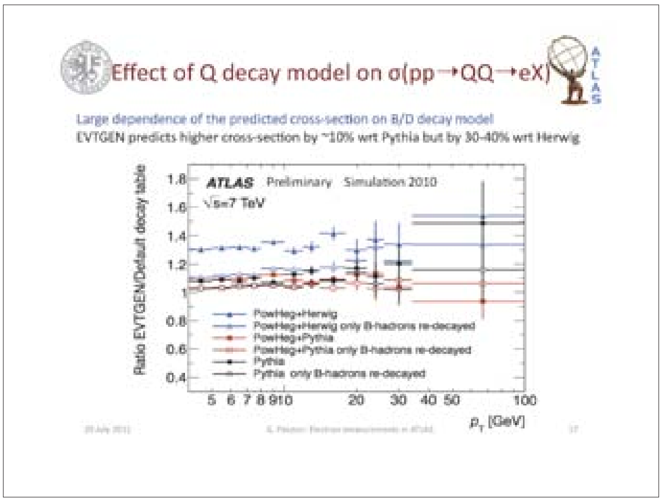
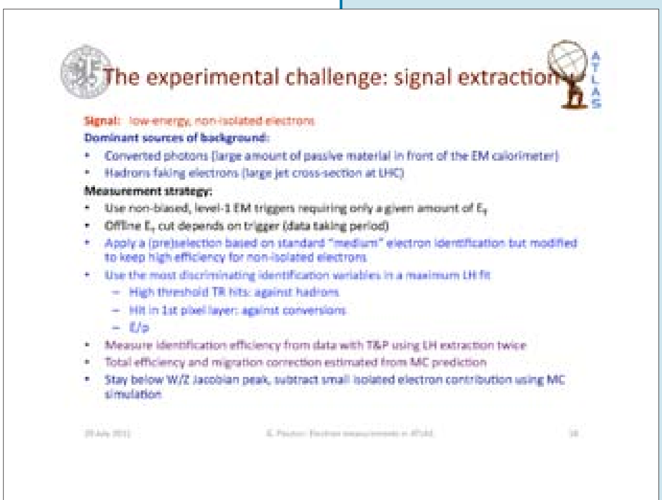
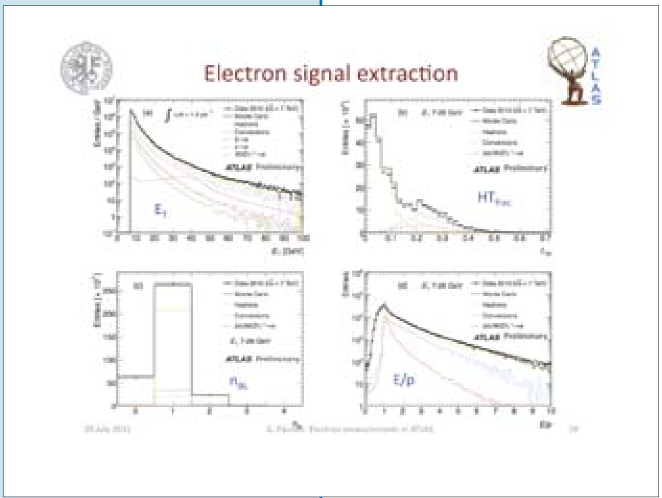
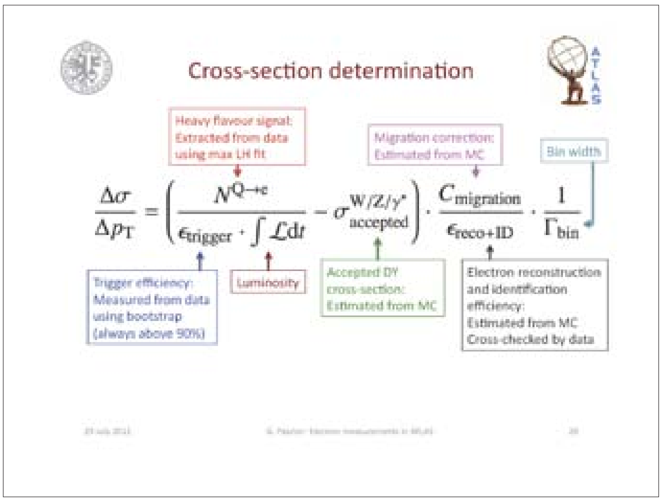
hard process: pQCD @ NLO+NLL
Uncertainty band
√s=7 TeV
p_T [GeV]

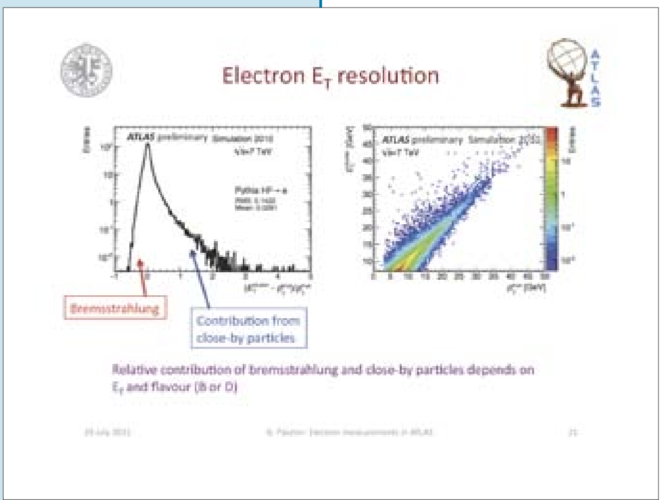

Monte Carlo predictions
ATLAS Simulation 2010
Not approved
Powheg
True lepton p_T [GeV]
Pythia: LO (+parton shower: LL)
Powheg: NLO (+parton shower: LL)
FONLL: NLO + NLL
NLO: NLO for ME,
NLO + NLL for NP fragmentation
MC prediction affected by several uncertainties
Hard matrix element → red blobs
Parton shower → red, blue & purple trees
Hard subprocesses – multi particle interaction → purple blob
Fragmentation → light green blobs
Hadron decay → dark green blobs
Photon emission → yellow lines

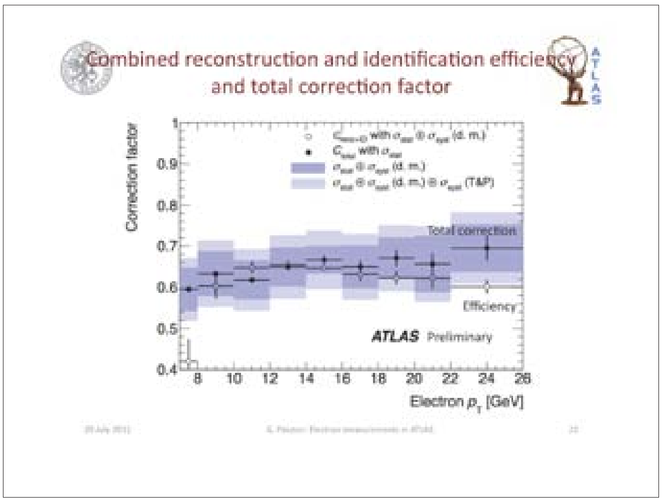

Effect of Q decay model on σ(pp→QQ→eX)
Large dependence of the predicted cross-section on B/D decay model
EVTGEN predicts higher cross-section by ~10% wrt Pythia but by 30-40% wrt Herwig
ATLAS Preliminary Simulation 2010
√s=7 TeV
Ratio EVTGEN/Default decay table
PowHeg+Herwig
PowHeg+Herwig only B-hadrons re-decayed
PowHeg+Pythia
PowHeg+Pythia only B-hadrons re-decayed
Pythia
Pythia only B-hadrons re-decayed
p_T [GeV]

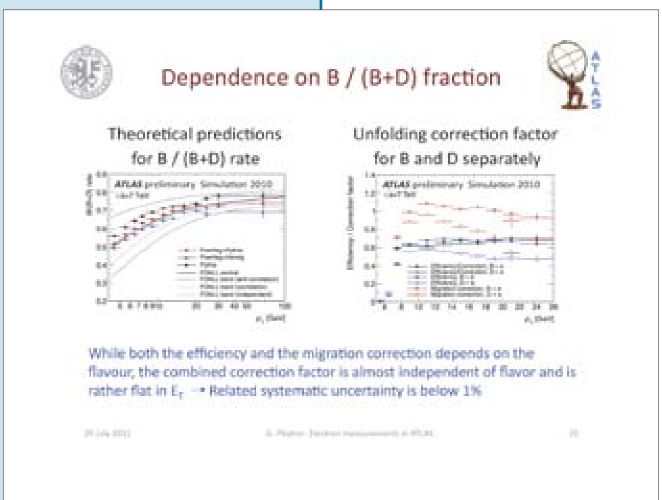

The experimental challenge: signal extraction
Signal: low-energy, non-isolated electrons
Dominant sources of background:
Converted photons (large amount of passive material in front of the EM calorimeter)
Hadrons faking electrons (large jet cross-section at LHC)
Measurement strategy:
Use non-biased, level-1 EM triggers requiring only a given amount of E_T
Offline E_T cut depends on trigger (data taking period)
Apply a (pre)selection based on standard "medium" electron identification but modified to keep high efficiency for non-isolated electrons
Use the most discriminating identification variables in a maximum LH fit
High threshold TR hits: against hadrons
Hit in 1st pixel layer: against conversions
E/p
Measure identification efficiency from data with T&P using LH extraction twice
Total efficiency and migration correction estimated from MC prediction
Stay below W/Z Jacobian peak, subtract small isolated electron contribution using MC simulation

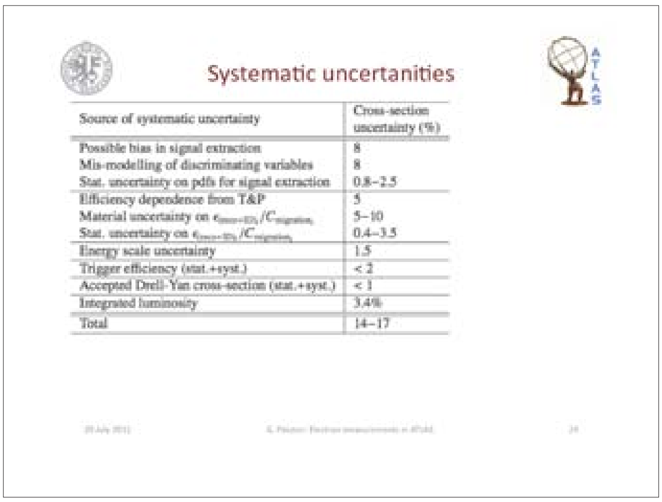




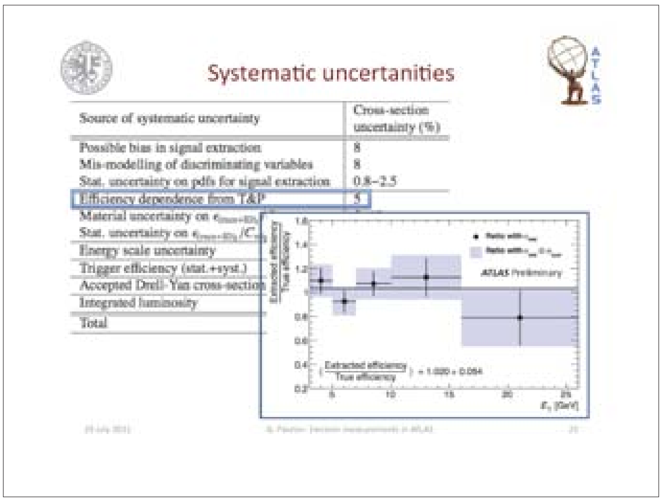


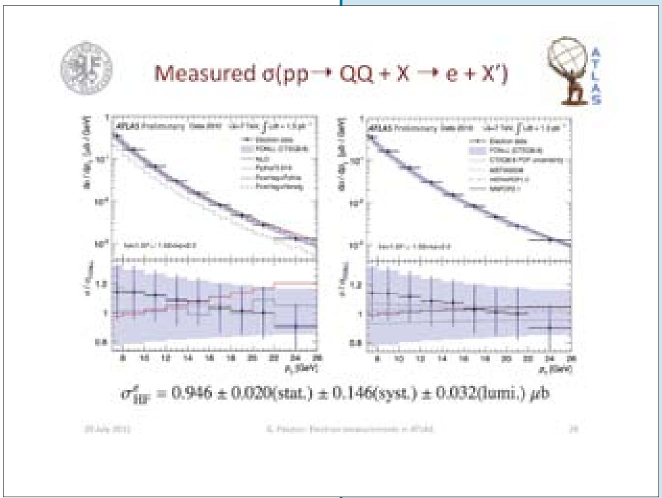


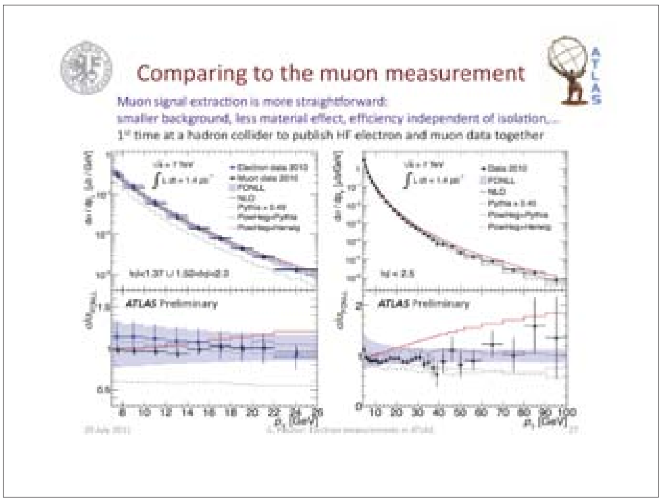


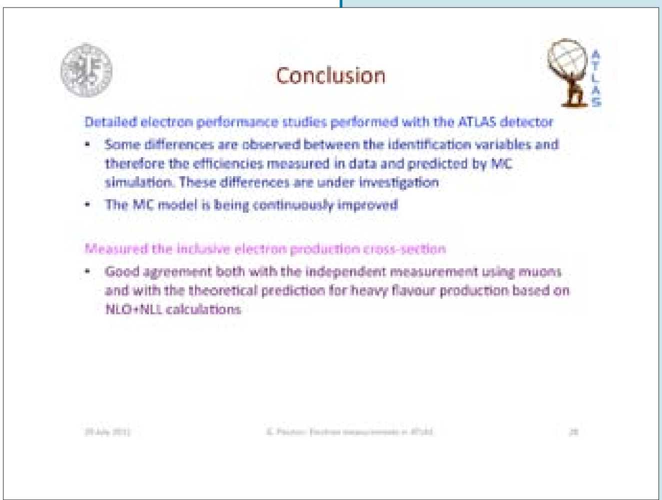


Source of systematic uncertainty	Cross-section uncertainty (%)
Possible bias in signal extraction	8
Mis-modelling of discriminating variables	8
Stat. uncertainty on pdfs for signal extraction	0.8–2.5
Efficiency dependence from T&P	5
Material uncertainty on $\epsilon_{(reco+ID)_i}/C_{migration_i}$	5–10
Stat. uncertainty on $\epsilon_{(reco+ID)_i}/C_{migration_i}$	0.4–3.5
Energy scale uncertainty	1.5
Trigger efficiency (stat.+syst.)	< 2
Accepted Drell-Yan cross-section (stat.+syst.)	< 1
Integrated luminosity	3.4%
Total	14–17


Systematic uncertanities
Source of systematic uncertainty
Cross-section uncertainty (%)
Possible bias in signal extraction 8
Mis-modelling of discriminating variables 8
Stat. uncertainty on pdfs for signal extraction 0.8–2.5
Efficiency dependence from T&P 5
Material uncertainty on
Stat. uncertainty on
Energy scale uncertainty
Trigger efficiency (stat.+syst.)
Accepted Drell-Yan cross-section
Integrated luminosity
Total
ATLAS Preliminary
Extracted efficiency / True efficiency
Extracted efficiency / True efficiency = 1.020 ± 0.054
E_T [GeV]


Measured σ(pp→ QQ + X → e + X')
ATLAS Preliminary
p_T [GeV]
$\sigma^e_{HF} = 0.946 \pm 0.020(\text{stat.}) \pm 0.146(\text{syst.}) \pm 0.032(\text{lumi.})\ \mu b$


Comparing to the muon measurement
Muon signal extraction is more straightforward:
smaller background, less material effect, efficiency independent of isolation,…
1st time at a hadron collider to publish HF electron and muon data together
Electron data 2010
Muon data 2010
FONLL
NLO
Data 2010
ATLAS Preliminary
p_T [GeV]


Conclusion
Detailed electron performance studies performed with the ATLAS detector
• Some differences are observed between the identification variables and therefore the efficiencies measured in data and predicted by MC simulation. These differences are under investigation
• The MC model is being continuously improved
Measured the inclusive electron production cross-section
• Good agreement both with the independent measurement using muons and with the theoretical prediction for heavy flavour production based on NLO+NLL calculations

Lucian Ancu – University of Berne
(PostDoc)

Jet Triggering at ATLAS

Scientific Abstract:

Jets are fundamental physics objects for many analyses at the LHC and hence the jet triggering system of ATLAS is fundamental for such analysis. I will present the performance of the jet triggering system in 2010 and 2011 data with special emphasis on changes that were recently implemented in the system. These changes include transition to the anti-kT algorithm, transitioning to a full scan of the calorimeter and applying online jet cleaning at the event filter level of the trigger system.

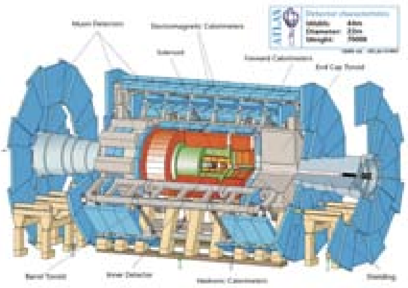
Jet triggering in ATLAS

Lucian Ancu
LHEP, University of Bern

Overview

- ATLAS detector
- Jets
- Setting the scene
- Jet triggers
- Cleaning at trigger level
- Outlook

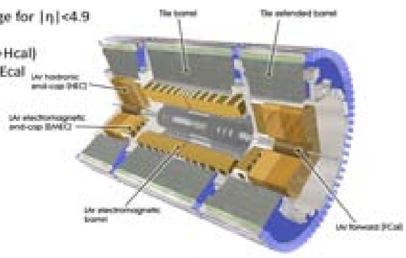
The ATLAS Detector



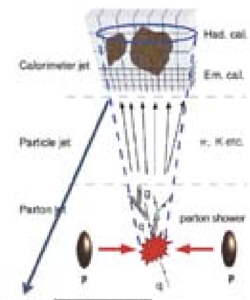
The ATLAS Detector

Hermetic coverage for |η|<4.9

~220k cells (Ecal+Hcal)
-0.025x0.025 in Ecal
-0.1x0.1 in Hcal

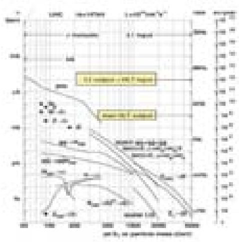


What is a jet?

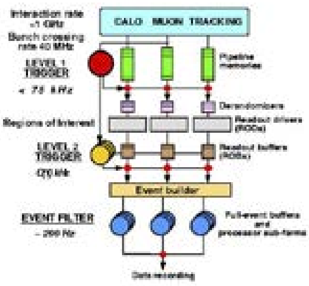


$$R \le \sqrt{\Delta\eta^2 + \Delta\phi^2}$$

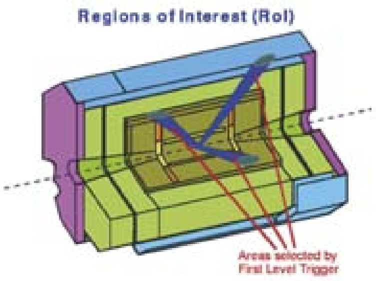
Depends on the algorithm used….



Three layer trigger



RoI concept

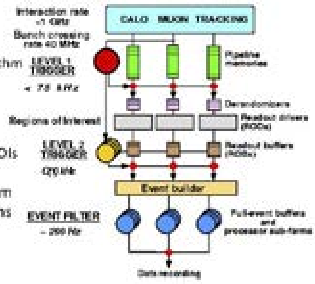


Three layer trigger jets

Hardware based:
- 0.2x0.2 granularity
- sliding window algorithm
- determining ROI's

Software based :
- looking just around ROIs
- window 1.4x1.4
- running cone algorithm
- limited nb of iterations

Software based :
- close to offline



2010 status

- EF
  - Cone 0.7 jets
  - Reconstructed from trigger towers
  - ROI based
  - Looking in a window 1.6x1.6 around ROI

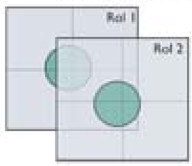
$$R \le \sqrt{\Delta\eta^2 + \Delta\phi^2}$$

- Offline:
  - AntiKT D=0.4 jets
  - Reconstructed from clusters
  - Full calorimeter

$$d_{ij} = \min\left(\frac{1}{p_{Ti}}, \frac{1}{p_{Tj}}\right)\frac{\Delta_{ij}^2}{D^2}$$

$$d_i = \frac{1}{p_{Ti}}$$

Limitations of RoI approach



- Not unusual for several RoIs to overlap
- increase of time with number of RoIs
- Duplication of same jet in different RoIs
- Can lead to false multi-jet signatures

Solution: move to a "full scan"* approach

*) limitation in backtracking trigger chains

2011 status

- EF
  - AntiKT D=0.4 jets
  - Reconstructed from clusters
  - Full scan approach

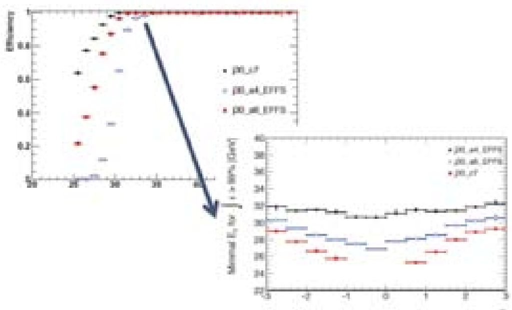
With these changes EF is similar to Offline

- Offline:
  - AntiKT D=0.4 jets
  - Reconstructed from clusters
  - Full calorimeter

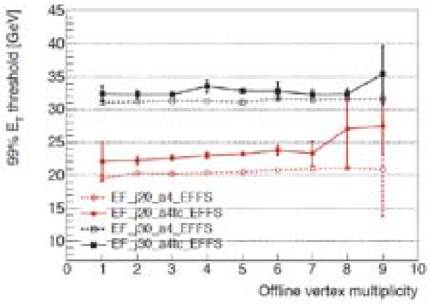
$$d_{ij} = \min\left(\frac{1}{p_{Ti}}, \frac{1}{p_{Tj}}\right)\frac{\Delta_{ij}^2}{D^2}$$

$$d_i = \frac{1}{p_{Ti}}$$

Cone vs AntiKT efficiencies

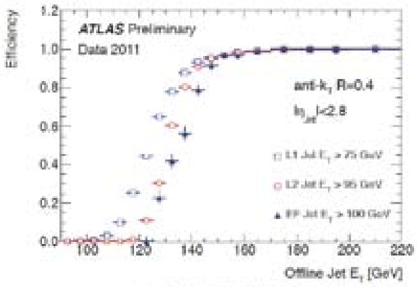


Towers, clusters and pileup



Full chain

- L1 → L2 → EF



Tobias Kruker

Jet Cleaning @ L2

- Fake jets produced by:
  - Hardware problems
  - Beam conditions
  - Cosmic rays showers,..
- These jets are offline cleaned (discarded) based on:
  - N90 – cells accounting for 90% of jet energy
  - Fraction of energy in HEC or EM
  - Timing
- Include this directly at L2

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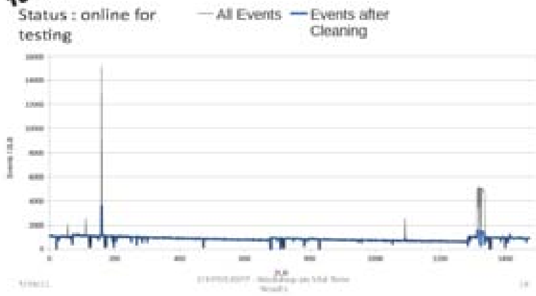
Tobias Kruker

Jet Cleaning @L2

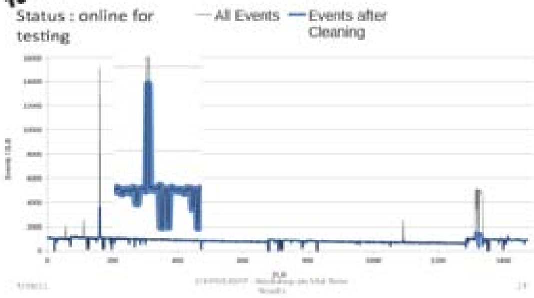
Status : online for testing



Tobias Kruker

Jet Cleaning @L2

Status : online for testing



Tobias Kruker

Jet Cleaning @L2

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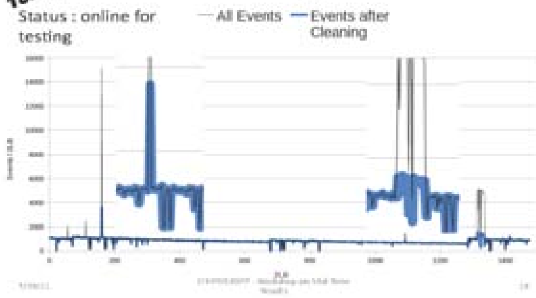


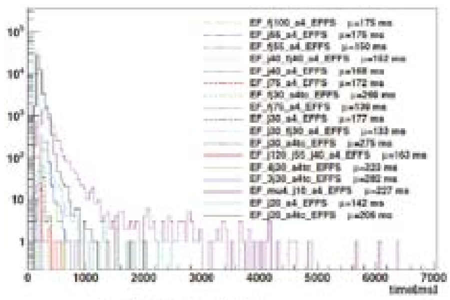
Improvements in the pipeline

- Implemented and/or awaiting deployment:
  - Noise suppression
  - Pileup subtraction
  - L2 full scan
  - Offline energy calibration at trigger level

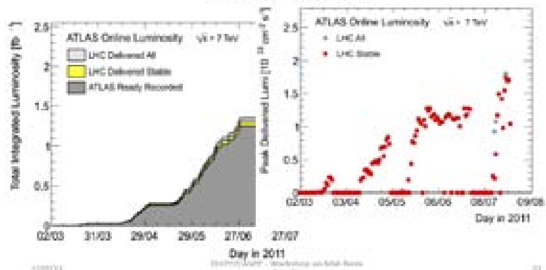
Conclusions/Outlook

- Transition to AntiKT and full scan successful
- Jet Trigger performing really good
- Trigger is moving closer and closer to the offline objects

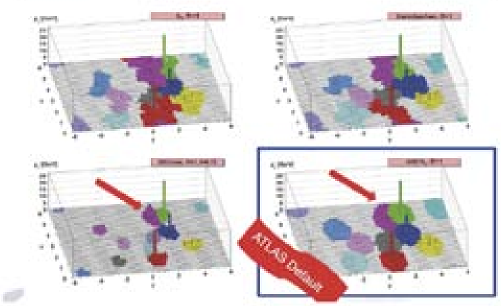
EF Timing



Luminosity



Algorithm Boundaries



Alexander Schmidt – University of Zurich
(PostDoc)

b-jet tagging in CMS

Scientific Abstract:

The first 7 TeV proton-proton collisions delivered by the LHC and recorded by the CMS experiment have been used for the commissioning and calibration of the detector in the beginning of 2010. One of the most important tools which were commissioned in that period is b-jet tagging. Jets that arise from b-quark hadronisation and decay are present in a wide range of physics processes of interest, such as the decay of top quark, Higgs bosons, and various supersymmetric processes. The ability to accurately identify b-jets is vital in reducing the otherwise overwhelming background to these channels. The excellent agreement of the most important observables (such as the impact parameter) with the detector simulation can be considered to be a major success. The performance of the b-jet tagging algorithms in terms of efficiency and misidentification rate has now been measured to a precision of better than 10 %.

(presentation not available)