Swiss Institute of Particle Physics
an Association according to Swiss law

Cost-intensive Infrastructures: Particle and Astroparticle Physics

Report addressed to the Rectors' Conference of the Swiss Universities CRUS

7 September 2012

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.

TABLE OF CONTENT

1. Preface

In 2011, the Swiss Institute of Particle Physics CHIPP has been asked by CRUS to produce an analysis regarding the infrastructures needed in particle and astroparticle physics and to submit it to CRUS in summer 2012. The CRUS mandate has been addressed to the CHIPP Chair, at that time Prof. Martin Pohl, who has been asked by the CHIPP Executive Board to take the lead in this task.

The request is part of CRUS' preparatory work in view of the forthcoming new university[1] legislation (*Bundesgesetz über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich* [HFKG]). Based on Article 63a of the Swiss Constitution[2] this law contains in its Article 3h[3] the goal of a Swiss wide coordination of and task-sharing within the particularly cost-intensive research fields. In order to be able to propose useful coordinative measures once the legislation comes into force, CRUS has decided to identify the research fields, for which such coordination is necessary and where such measures would possibly be most beneficial.

CHIPP shares the position of CRUS that each and every expensive research domain is not necessarily a cost-intensive domain which would benefit from coordination. Therefore, each individual field should be assessed in detail rather than inventing a rigid coordination framework. In addition, it supports the SWTR's opinion that the categorisation resulting from such an assessment depends to a certain extent on individual judgements and priorities.

This report assesses the situation in particle and astroparticle physics[4]. It takes account of the special situation of this field of research, which has been the first to use transnational and international cooperation. For this purpose, several tools were developed (like Peer Review, the world wide web, the computing grid) and at national level the actors got together – from 1974 onwards in informal meetings, between 1988 and 2003 in the Forum der schweizerischen Hochenergiephysiker, and since then as CHIPP (transformed into an association under Swiss law in 2011). Furthermore, particle physics took advantage of the fact that Switzerland is one of the CERN host states.

[1] In the law – as well as in this report – the term ‚university' encompasses the Cantonal Universities as well as the Federal Institutes of Technology
[2] Annex C1
[3] Annex C2
[4] With the exception of AMS, particle and astroparticle physics projects in space are not included in this study, since they are in general directly and fully financed by the Confederation.

2. Executive Summary

The analysis of particle and astroparticle physics in Switzerland under the aspect of 'cost-intensive infrastructures' summarizes the existing collaboration (section 4), lists and categorizes the existing and planned international projects with Swiss participation (section 5), and sketches the possible development of the collaboration in this field (section 6). Section 7 gives a short assessment regarding the advantages and drawbacks of being considered 'cost-intensive'. Future funding models and the consequences on the institutions' strategies are outlined in sections 8 and 9.

The central findings of the analysis of the existing inter-university cooperation in particle physics in Switzerland and its prospects for the future are:

- Particle and astroparticle physics require costly research infrastructures of two kinds: accelerators and detectors. Both are costly only when their total construction and maintenance cost is considered. However, these costs are typically taken over by the Government in the form of its annual contributions to international organisations like CERN, ESA, or ESO. Participation in a project, however, stays affordable for single research groups in Swiss universities because of the high degree of collaboration and self-organisation in the field. This self-organisation exists since the 1950's in account of the intellectual and technological challenges inherent in particle physics, not only because of their high cost (→ sections 4 and 5.1).
- Accelerator infrastructure requires large national laboratories, like PSI in Switzerland, and regional centres like CERN in Europe, where coordination is in the focus from the start. These laboratories are run by governmental organisations like the ETH Rat or the CERN Council. In the future, the sheer size of the next generation of accelerator projects will likely require worldwide organisation (→ section 3.1).
- Particle detectors can vary in size and complexity by two orders of magnitude. The size of collaborations to construct and operate them varies commensurately, but reaches essentially always beyond the national level. However, this does not mean that national coordination is irrelevant. On the contrary, the degree of inter-university coordination is essential in determining the weight of the participants in a multinational project. Particle and astroparticle physics are willing to make a step further and to explore the sketched 'purchasing cooperation' at local level and for smaller infrastructure projects (→ sections 3.1 and 6).
- Due to the long-term nature of the activities in particle physics, a consistent and reliable funding policy is essential. In Switzerland this is implemented via the long-term strategy of the SNF on one hand, federal funding lines on the other hand, like FORCE in the past, FLARE (comprising FORCE, FOLIS and FINES) in the future. The existence of these mechanisms has led to a sustainable leading role of Swiss researchers in the field. It is suggested that the SNF reviews its policy of long-term funding of large infrastructure projects and that the direct federal funding is sustained at least at the present level, if not increased to face the newly emerging projects (→ sections 8 and 9).
- The self-organisation in particle and astroparticle physics is based on a bottom-up structure, ranging from inter-university collaboration inside a country on a single project to multinational consortia proposing, building and operating research infrastructure. Its organisational principles are peer review and consensus. In this context it is also essential to underline the benefits of free access to national infrastructures, subject only to scientific criteria (→ sections 6 and 8).
- National coordinating bodies like CHIPP play an essential role in finding consensus and defending its conclusions when competing with other costly fields of research. The mechanisms for finding consensus are well established in Switzerland as far as single disciplines inside particle and astroparticle physics are concerned. The most important ones in Switzerland are: Physics at the frontier of the highest energies and ultimate precision, neutrino physics and astroparticle physics (→ sections 4 and 6).

- Cooperation is very strong inside these three domains, much less developed between them. Competition exists between them, moderated to some extent by CHIPP. Priorities are decided by the competent funding agencies, scientific and political bodies (→ section 6).
- The collaboration between the domains inside particle and astroparticle physics on the one hand and between experimental and theoretical particle physics on the other hand will have to be strengthened and intensified to answer the fundamental questions that are the subject of our field. In addition, a large amount of input from neighbouring field like high-energy astrophysics and cosmology is required. The NCCR Universe has been proposed as a large step forward to strengthen these transversal collaborations (→ section 6).
- The proliferation of actors – political, scientific and financial; local, cantonal and federal – is inherent in the Swiss system and all can usually work together successfully. However, it regularly leads to problems in the approval mechanism of large international projects and the commitment of sustainable funding. A first step to improve the situation has been made with the "Round Table International Infrastructures" initiated by CHIPP, which regularly assembles representatives of all relevant actors to discuss these issues and to feed back recommendations to the authorities. We propose a more formal structure for this process with the aim of
  - enhancing the function of the Round Table to serve as a Think Tank that designates also the signatories of collaboration MoUs and appoints the Swiss representative(s) in international projects, and
  - transforming the Lenkungsausschuss FLARE to a recognized body for recommending project participation to the Research Council of SNF (→ section 6).

In summary, particle and astroparticle physics is thus to be considered a cost-intensive branch of basic science. Its actors have, however, made successful efforts already to coordinate their activities, to avoid double investments, and to optimize efficiency in the usage of funds by a well-established bottom-up cooperation system. As a matter of fact, they already apply and implement since long the coordination efforts required by the new HFKG. The benefit to be expected from additional coordination through CRUS is thus deemed marginal within particle physics itself. However, the existing intensive coordination comes at a cost. We call upon the members of CRUS

- to recognize the work of CHIPP acting in the future on the basis of a mandate by CRUS and
- to support the CHIPP operating cost, thereby ensuring its sustained functioning (→ section 7).

Value will be added to existing structures if the field of coordination is enlarged, strengthened and intensified to transversal cooperation, between e.g. different directions in experimental particle physics, astroparticle physics, high-energy astrophysics, particle theory and cosmology. We call upon the members of CRUS to support local efforts in transversal integration, like e.g. the AEC in Berne and CAP in Geneva. We also draw the attention of CRUS to the national effort in transversal integration represented by the proposed NCCR Universe, embedded into the ongoing European strategy process initiated by the CERN Council (→ sections 6 and 9).

The report leads to a number of conclusions, focussing on coordination, funding and funding policy, as well as on transversal collaboration and access policy (→ section 10).

3. Introduction and Definitions

3.1. Introduction

When assessing large research infrastructures, often an international or national organisation or laboratory like CERN, ESA or PSI, one must obviously distinguish the cost of construction from the usage cost. One must also distinguish the cost covered by the institutional (mostly governmental or semi-governmental) support of the infrastructure, from the cost contributed to and spent by the individual university research group or their national network.

It seems important to underline the fact that international organisations or laboratories (like CERN) are politically supported, based on an intergovernmental agreement. They receive their funding directly from the government in the same way as university institutes receive their infrastructure funds directly from their mother institution. In this sense there is no competition on funds and the level of coordination in the field is irrelevant. On the national level, the Swiss particle physics laboratory PSI, as part of the ETH domain, is again directly supported at the federal level. It serves as one of the focal points of experimental particle physics activities in Switzerland, using its first class accelerator.

It thus becomes obvious that particle accelerators belong to the infrastructure centrally supplied by laboratories like CERN or PSI. Coordination is thus ensured automatically by this centralization. Experimental hard- and software, on the other hand, can to a large extent be procured or constructed by individual research groups, often with the help of local industry. Coordination here is ensured by the experimental collaborations themselves, who internally attribute construction projects to research groups.

It is also useful to consider in the latter context EU wide infrastructure measures for particle physics, like EUDET, AIDA, ASPERA, and LAGUNA etc. Since Switzerland is a full member of the EU framework programs directed towards fundamental research, it benefits from the bottom-up part of FP6 and FP7 programs in a major way. These projects cover generic long-term R&D for detectors as well as governance issues, with often very wide scope. Coordination is required to be at the multinational level, since the impact of these issues it at that level.

One should be aware that there are huge differences at the level of the individual research projects: a cost factor of 100 exists e.g. between a project like the ATLAS detector at CERN (600 MCHF) and typical PSI projects (5 MCHF). This shows clearly that it is not the size of the project that matters, but the level of participation of the individual group of researchers. Here, questions about the affordability in terms of financial, technical and human resources are essential during the construction phase, but play sometimes an even more important role during operation and use (how much resources are blocked in the long-term?).

As far as usage cost is concerned, one should distinguish between observatory-type infrastructures (like CTA and most space infrastructures), where usage projects compete with each other for data generation, and PI-driven infrastructure (like the LHC, PSI experiments, IceCube or MAGIC), where intellectual competition determines the impact of an individual research group on the analysis of common data.

3.2. Definitions (used in this report)

3.2.1. Cost-intensive

CHIPP takes the position that a cost-intensive domain – seen individually by a university – either requires a large, expensive infrastructure, or shows very high annual operating costs, or both. It is suggested to use the following numbers:

- investments (per university) > 1.5 MCHF
- annual operating costs (per university) > 0.5 MCHF (salaries of the staff concerned and pro-rata to their effective (end exclusive) work for operating the facility; and operations cost).

3.2.2. Infrastructure

In this report, the term infrastructure is used for a research facility, which is used by several research groups. Such facilities can range from very large international research laboratories (like CERN) to relatively small single purpose experiments (like AMS). The facility has either been built by the research community itself or by industry contracted by the research community or the facility management.

4. Existing Collaboration in Particle and Astroparticle Physics

Particle and astroparticle physics has been the first field of research, which has used extensively transnational and international cooperation. This need was triggered by the fact that research projects in this domain were (and still are) usually large undertakings, representing an important intellectual and technological challenge and requiring a large amount of human and financial resources. Therefore, it goes without saying that they cannot be carried out locally at the level of an individual university by individual groups but require national, regional or global collaboration. For this purpose, particle and astroparticle physics developed or adopted several tools (like peer review, the World Wide Web, and the computing grid). Also at national level, the success of Swiss particle and astroparticle physics is based on small, large and extremely large collaborations, mostly across the Swiss border. Many of them occur naturally – between groups working in the same field or requiring the same type of infrastructure – or are coordinated bottom-up by CHIPP. Such collaborations may be carried out at an informal level and are sometimes not even noted at the level of the home institution. In addition, experiments in particle and astroparticle physics usually involve research facilities, which again are the result of national, regional and global collaboration. For this reason, it is not possible in this report to clearly separate research collaboration from collaboration in the context of large infrastructures.

Coordination in Swiss High Energy Physics dates back to 1974 when the physicists involved in CERN experiments decided to organize regular meetings to present and discuss their research projects. The Forum of Swiss High Energy Physicists was then founded in 1988 by the "Sous-commission de physique nucléaire et corpusculaire" of the "3ème Cycle de la Physique en Suisse Romande", with the purpose of coordinating large projects at CERN. This body was instrumental in the coordination of Swiss research at the Large Electron Positron Collider LEP, in advising the Swiss authorities on a participation in the Large Hadron Collider LHC programme and, more recently, on the FORCE programme (Fonds pour la recherché au CERN)[5]. Initially restricted to universities in the Romandie, it was soon extended to all Swiss groups working in particle, astroparticle and nuclear physics. Physicists holding a PhD working in these fields for a Swiss research institution and Swiss nationals employed by CERN were members of the Forum, which – among others – elected its representatives to international committees like ECFA and discussed items of common interest.

Following suggestions of the Committee for Future Accelerators ECFA (March 2002) and of the Swiss State Secretary for Science and Research, Charles Kleiber, the Forum decided in June of the same year to transform itself into something more ambitious, aiming at coordinating the participation of Swiss physicists in international research projects in particle, astroparticle and nuclear physics, ensuring an optimum use of resources, and promoting the education and public awareness in these fields at the national level.

After intense discussions the "Arbeitsgruppe Teilchenphysik" of the ETH-Council[6] formulated a proposal for creating a virtual Swiss institute 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 coordinate teaching activities;
c. To ensure a proper Swiss representation in relevant national and international bodies;
d. To promote public awareness on particle, astroparticle and nuclear physics.

After its creation on 2-3 October 2003[7] the Swiss Institute for Particle Physics CHIPP set up the tools for the dialogue with the funding agencies (State Secretariat for Education and Research SER, Swiss National Science Foundation SNF) and commissioned a Roadmap entitled 'Particle Physics in Switzer-

5 see Brochure published by the SNF "FORCE – 10 Years of Funding Research at CERN" http://www.snf.ch/SiteCollectionDocuments/Web-News/news_080922_Force_Broschuere.pdf
6 Vorschlag zur Errichtung eines virtuellen Schweizerischen Instituts für Teilchen- und Astroteilchenphysik, 25. Juni 2002.
7 see http://www.chipp.ch/documents/CHIPP_constitution.pdf

land – Status and Outlook of Research and Education'[8]. Recently, an implementation document "Achievements and Status of Particle Physics in Switzerland: Implementation of the Road Map (2005-2010) and Outlook"[9] has been worked out.

Between 2008 and 2012, the Universities of Berne, Geneva and Zurich as well as the two ETHs and PSI increased their cooperation in the analysis of the LHC data and their physics interpretation: a SUK and ETH-Rat funded project allowed nine scholarships for PostDocs of highest international reputation. In this way, the large multi-year investment of almost 600 MCHF made by the Swiss Confederation, the Cantons and the physics institutes by supporting the construction of the LHC and its detectors at CERN was further validated. In addition to the increase of the scientific output, the coordination of inter-institutional cooperation among the institutes concerned and the modernization of research and teaching was supported. In this way, two to three topical workshops per year and a 'School of Particle Physics' are held. Further, a monitoring framework for resources and funding needed for existing and future participation in international projects, serving as valuable planning tool for the SER (CHIPP tables) has been created and is updated annually. The intensive cooperation between the Swiss universities active in the field of particle and astroparticle physics is also demonstrated by the fact that the five institutes involved in CERN LHC activities submit each year joint requests to SNF in the fields of 'Maintenance and Operations Cost of the LHC' and 'LHC Computing Grid'. Recently, the joint efforts of the Swiss research groups assembled in the CHIPP Outreach Group have led to the submission of an Agora request to the SNF, which will be resubmitted in 2012 in a revised and improved version.

The successful self-organization of the Swiss particle physics community with the CHIPP body and its initiatives has also been recognized in 2009 by the Schweizerische Wissenschafts- und Technologierat SWTR in its analysis on «Besonders kostenintensive Bereiche und deren wissenschaftliche Koordination auf nationaler Ebene»[10]:

> ***Schlussfolgerungen betreffend Kosten der Teilchenphysik***
>
> *Obwohl Teilchenphysik auf der Ebene von Experimenten wie das LHC „besonders kostenintensiv" erscheint und obwohl der Schweizer Mitgliederbeitrag zum CERN signifikant ist, muss Teilchenphysik auf der Ebene der Hochschulen nicht notwendigerweise als „besonders kostenintensiv" betrachtet werden. Zudem generieren die in die Teilchenphysik-Forschung investierten Beträge neben dem wissenschaftlichen Fortschritt[5] auch ökonomische Vorteile. Durch den Standortvorteil des CERN in Genf wird geschätzt, dass ungefähr zweimal der Betrag, der von der Schweiz investiert wird, in die Volkswirtschaft des Landes zurückfliesst[6]. Im Rahmen der Zusammenarbeit der Schweiz am internationalen CERN ist eine gegenseitige Stärkung von Lehre, Forschung und Innovation festzustellen, die es den jeweiligen Studierenden ermöglicht, an Spitzenforschung im Rahmen ihrer Ausbildung teilzunehmen.*

In summary, it can be said that the field of particle and astroparticle physics enjoys an extensive collaboration as well at the level of research as at the level of infrastructure. The recent decision of the community to submit a proposal for a NCCR[11] is just the logical next step on this road.

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[8] see: http://www.chipp.ch/documents/roadmap.pdf
[9] see: http://www.chipp.ch/documents/Achievements_RoadMap2005-2010.pdf
[10] see: http://archiv.swtr.ch/wp-content/uploads/SWTR_Empfehlung_Kooperation_kostenintensiver_Bereiche_2009.pdf
[11] The Universe – Constituents, Forces, Space-Time (in print; publication pending)

5. Infrastructure in Particle and Astroparticle Physics

5.1. Existing Infrastructure

In a survey organised by CRUS in April 2010, the universities indicated 35 infrastructure facilities that had been bought or built in cooperation[12]. Interestingly enough, no facility in the field of particle and astroparticle physics is listed. This reflects very well the fact that for this field, infrastructure facilities needed for research are usually international undertakings.

In such co-operations, two funding models are in use for construction:

1 In case of an intergovernmental organisation hosting the research facility or in an international undertaking based on agreements at ministerial level, the funding – usually in proportion to the Swiss GDP relative to the sum of the GDPs of all participating countries (i.e. approx. 3-4%) – is provided by the Swiss Confederation. Such participations are in line with the declared goal of the Swiss Government to facilitate the access of the Swiss researchers to international research facilities, as can be seen also in the most recent Bill on Education, Research and Innovation to Parliament[13]. It contains a number of new participations and the corresponding funding, based on a Roadmap compiled by the SER[14]. Such governmental participation is usually complemented by in-kind contributions from the universities (see under 2 below).

2 In case of a research collaboration not involving the governments or of a research collaboration complementing a governmental participation, the researchers contribute in-kind to the experiment or the facility with their own resources. Such in-kind contributions can be
   a. specific components or sub-systems, which are developed by the group and made available to the facility,
   b. specific know-how shared with the facility,
   c. workshops, computing power or skills in data analysis put at the disposal of the facility, or
   d. a mixture of two or more of the above.

   The funds for such cooperation stem from the universities' research budget and from SNF funds and rarely involve large new infrastructures at local or national level. Also here, a typical participation rate lies between 2 and 4 percent.

Regarding the operations costs, the situation is less clear-cut. Whereas the operations costs for large laboratories like CERN are covered by the contributions from the Member States, problems exist at the level of the experiments, where the SNF and the SER would qualify in principle as funding agencies. The SNF describes itself as *"a central agency for state-funded research … based on the principle of scientific self-governance; its activities focus primarily on funding investigator-driven research and promoting junior scientists"*. This translates, as shown at several occasions, into a SNF not being keen at all to pay for operations. At the governmental level, membership fees are directed towards the international undertaking and it has been very rare that the SER has provided funds to cover operations costs for individual experiments. In this situation, the creation of the FORCE instrument was a real blessing for the particle physics community, since it is defined as an accompanying fund covering the use of infrastructure funded by the government[15]. Over the 13 years of its existence, FORCE has provided more than 50 MCHF to CERN related experiment support in the particle physics and astroparticle physics community. Starting in 2015, the fund will be enlarged to international infrastructure facilities beyond CERN. Nevertheless, up to now, the operations costs created by participation of research groups in international undertakings are dominated by personnel costs and have been covered by the home institutes of the groups.

[12] The report „Zwischenbericht: Vorschlag zum Vorgehen der CRUS bei der Bestimmung von kostenintensiven Bereichen has been presented to the CRUS Plenum on 5/6 May 2011

[13] Botschaft über die Förderung von Bildung, Forschung und Innovation in den Jahren 2013–2016; http://www.admin.ch/ch/d/ff/2012/3099.pdf

[14] Schweizer Roadmap für Forschungsinfrastrukturen (CH-Roadmap), SBF 2011, http://www.sbf.admin.ch/htm/dokumentation/publikationen/forschung/Roadmap_2012_de.pdf

[15] Similar accompanying funds exist at the SER for astronomy (for ESO) and for space research (for ESA).

Covering both aspects, the investment and operations costs, the following table gives the categorisation of the projects with Swiss involvement as well as a qualitative impression of the cost sharing between government, universities and SNF for those experiments in particle and astroparticle physics, which are either running or under construction.

The following colour key is used:

		cost-intensive		not cost-intensive	
Colour key:	Investment:	> 1.5 M		< 1.5 M	
	Operations:	> 0.5 M/year		< 0.5 M/year	

Facility, experiment	Construction, extension			Operations**			Max. costs for an individual university	
	Government*	University	SNF	Government*	University	SNF	Invest.	Ops.
CERN accelerators	X			X			--	--
CERN LHC Detectors	X	X	X	X	X	X		
LHC Swiss Tier2 Computing	X	X	X	X	X	X		
European Grid	X	X	X					
CERN NA61		X	X	X	X			
CLOUD	X	X	X	X	X	X		
OPERA	X	X	X	X	X	X		
T2K		X	X		X	X		
EXO		X	X		X	X		
AMS		X	X		X	X		
IceCube		X	X		X	X		
ArDM°	X	X	X		X	X		
AIDA	X	X		X	X			
UCN/nEDM	X	X	X	X	X	X		
MEG	X	X	X	X	X	X		
MICE	X	X	X			X		

* = Government includes FORCE support
** = Operations cost sometimes include infrastructure items like electricity and building maintenance, sometimes not.

It is obvious from the table that in addition to the CERN detectors and the operations of the European Computing Grid only very few facilities qualify as 'cost-intensive' (using the definition from section 3) for individual universities. All the projects listed are based on international cooperation and coordination with Switzerland contributing certain sub-components and knowhow. Reducing the resulting Swiss cost would inevitable mean that the Swiss activities as such would have to be reduced by cutting specific participations. Thanks to the high degree of self-organisation and self-coordination in the field, the potential for achieving economies through further and increased coordination is marginal.

Up to this point, infrastructure has always referred to international projects and facilities. However, one should not forget to mention the substantial support of particle and astroparticle physics coming from the universities. It consists mainly of the regular funds for salaries of the professors and staff (which have been included in the table above when taking stock of the operations cost), operations funds and project money. In addition, there are also national infrastructures financed from the university's investment budget or through SNF grants (either in the context of a research project or via the R'Equip programme). Several large scale facilities for Swiss and international users are located at the Paul Scherrer Institute PSI in Villigen: The high power proton accelerator (HiPA) serves several communities with about 25 beamlines and instruments, among them the neutron scattering community at SINQ, the muon spin rotation community at SmuS and particle physics. Particle physics at PSI can presently be served by 3 pion and muon beamlines, the ultracold neutron facility and the proton irradiation facility (PIF). For science proposals which have been reviewed and approved by the Particle Physics Advisory Committee beam time is usually granted for free. With an average cost for operation of 10kCHF/day/beamline (or facility) for the 200-250 days long beam periods per year and taking into account their use for other disciplines, the particle physics community is supported by about 8MCHF/year. In addition, PSI provides support for approved experimental projects: technical services, crane operation, express workshop service, cryogenic fluids like liquid helium and nitrogen, either free of charge or at much reduced rates. Projects are also granted access to laboratories and clean rooms as requested and as available. One beamline is also made available for advanced student training (ETHZ/UZH) for 1 month/year. The laboratory for particle physics at PSI has a "Chip Design Core Team" which is set up as a know-how pool and connected with the offer to the community to couple in, e.g. with PostDocs, to design and realize their own chips. While the manpower is then coming from the outside, PSI is providing the infrastructure and know-how. A similar construction is chosen for a "Board Design Core Team". PSI develops chips and electronics hardware designed to be versatile and makes them available to the Swiss and international community, e.g. the DRS chip which is widely used at universities and labs.

In addition, each university runs specialized and general workshops that serve not only the institute they are located in, but are open also to other disciplines and fields of research. Further, several clean rooms and vacuum chambers exist within the Swiss university landscape, which are open to teams from other institutes or universities.

5.2. Future needs for upgraded or new facilities

5.2.1. Facilities to be upgraded

For different reasons, several of the facilities mentioned above will need upgrades in the years to come – or are already in the process of being upgraded. The following table shows the status of August 2012:

Facility, experiment	Nature of upgrade	Task distribution (number of Swiss participants in the collaboration)	Swiss contribution	timetable	Swiss investment costs	Investment cost funding sources (HS/SNF/Gov)*	Swiss annual operations costs**	Operations cost funding sources (HS/SNF/Gov)*
CERN accelerator	Hard- and software	CERN	~3.5%	2013-2014	n.a.	(0/0/100)	n.a.	n.a.
CERN LHC Detectors	Refurbishment, hard- and software	shared within collaborations (6 Swiss institutes)	4 – 9%	2013-2020	30 M	(20/0/80)	1 M/year	(0/0/100)
CERN GRID Computing	Refurbishment, hard- and software	shared within collaborations (6 Swiss institutes)	~1%	2013-2020	4-5 M	(0/0/100)	0.3-0.45 M/year	(15/0/85)
CERN NA61	Hard- and software	shared within collaboration (3 Swiss institutes)	1%	2013-2020	0.25M	(0/0/100)	0.1 M/year	(0/0/100)
MICE	Hard- and software	shared within collaboration (3 Swiss institutes)	~10%	2013-2017	0.5 M	(30/70/0)	0.115 M/year	(35/13/52)

* = HS: Hochschulbereich, SNF: National Science Foundation, Gov: direct contributions from federal and cantonal governments and FORCE funding plus EU support.

** = Operations costs sometimes include infrastructure items like electricity and building maintenance, sometimes not. So they are not easily comparable.

The table shows that not even the upgrade of the CERN Detectors will qualify as 'cost-intensive' (using the definition from section 3) at the level of an individual university (20% of 30 M over 8 years and shared between the 6 institutes concerned) under the assumption that the resulting cost is shared equally among the participating institutes.

5.2.2. New Facilities

Based on the CHIPP monitoring framework for resources and funding, a number of new projects with a potential Swiss participation are already at different stages of planning, R&D or pre-development. A recent meeting of the CHIPP Board has contributed to a great deal to clarifying a number of issues. The table reflects the status, the knowledge and the best estimates of August 2012.

Facility, experiment (number of Swiss institutes involved)	timetable	investment costs	annual operations cost	Swiss investment costs	investment cost funding sources (HS/SNF/Gov)*	Swiss annual operations costs**	operations cost funding sources (HS/SNF/Gov)*
GERDA (1 Swiss institute)	2013-2016	9 M	0.15 M/year	0.3 M	(10/10/80)	0.005 M/year	(10/10/80)
XENON (1 Swiss institute)	2013-2016	11 M	1.5 M/year	1 M	(30/5/65)	0.15 M/year	(10/20/70)
DARWIN (2 Swiss institutes)	2013-2020	50 M	1-1.5 M/year	5.1 M	(5/10/85)	0.1-0.15 M/year	(0/40/60)
LAGUNA-LBNO (3 Swiss institutes)	2012-2020	430 M***	1 M/year	21.5 M	(5/25/70)	0.1 M/year	(0/25/75)
CTA (5 Swiss institutes)	2013-2020	250 M	0.6-19 M/year♦	7.6 M	(20/0/80)	0.07-0.5 M/year♦♦	(10/0/90)
IceCube – PINGU (2 Swiss institutes)	2013-2020	15 M	2 M/year	0.15 M	(20/80/0)	0.12 M/year	(20/80/0)
MAGIC (1 Swiss institute)	2013-2020	2 M	0.4 M/year	0.07 M	(20/0/80)	0.04M/year	(20/0/80)
Mu3e♦♦♦ (1 Swiss institute)	2013-2020	20 MCHF	2 M/year	15 M	(30/30/40)◄	2 M/year	(30/30/40)◄

* = HS: Hochschulbereich, SNF: National Science Foundation, Gov: direct contributions from federal and cantonal governments and FORCE funding.

** = Operations costs sometimes include infrastructure items like electricity and building maintenance, sometimes not. So they are not easily comparable.

*** = contribution from CERN (for accelerator part): ~ 150 MCHF

♦ = increasing from 2013 onwards to reach 19 M in 2018

♦♦ = increasing from 2013 onwards to reach 0.5 M in 2018

♦♦♦ = ongoing feasibility study 2012-14; concrete numbers will depend on its outcome.

◄ = today's best estimate; the detailed plan will come out of the feasibility study, which will be undertaken in 2013/14.

The table shows that possibly not even the very large new projects like CTA (20% of 7.6 M over 8 years and shared between 5 institutes) and LAGUNA-LBNO (5% of 21 M over 8 years and shared between three institutes) will fall into the category 'cost-intensive' (using the definition from section 3), assuming that the share of participation and the number of institutes involved will remain as is.

6. Possible Development of the Collaboration

The international cooperation in infrastructures in the context of participation in an experiment or in a facility is natural for particle and astroparticle physics, and usually precedes national coordination. Infrastructure cooperation and research collaborations form when needed, based on a bottom-up structure, ranging from inter-university collaboration inside a country on a single project to multinational consortia proposing, building and operating research infrastructure. Their organisational principles are peer review and consensus. At national level, using SUK project funds, CHIPP has fostered the increase of the scientific output, the coordination of inter-institutional cooperation and the modernization of research and teaching (collaborations for doctoral courses, joint programmes, workshops in several fields and PhD Schools). The situation will not be much improved with developing a national top-down coordination effort.

National coordinating bodies like CHIPP play an essential role in finding consensus and defending its conclusions when competing with other costly fields of research and with its international competitors. The mechanisms for finding consensus are well established in Switzerland as far as the three “pillars” identified in the CHIPP roadmap are concerned: physics at the frontier of the highest energies and ultimate precision, neutrino physics and astroparticle physics. Cooperation is very strong inside these three domains, much less developed between them, and even less between experimental and theoretical physics.

Such transversal cooperation will add value to existing structures in the field, involving different directions in experimental particle physics, astroparticle physics, high-energy astrophysics, particle theory and cosmology. Local efforts in transversal integration, like e.g. the AEC in Bern and CAP Genève, should thus be supported by CRUS members. We also draw attention to the national effort in transversal integration represented by the proposed NCCR Universe. If approved, this NCCR will strengthen the Swiss position in the field, embedded into the ongoing European strategy process initiated by the CERN Council.

The proliferation of actors – political, scientific and financial, local, cantonal and federal – is inherent in the Swiss system and all can usually work together successfully. However, it regularly leads to problems in the approval mechanism of large projects and the commitment of sustainable funding. As a first step to improve the situation CHIPP has initiated a ‘Round Table for International Infrastructure’ where the community sits together with the Swiss funding agencies and the institutions relevant for research policy (SNF, SER, CRUS, SCNAT). This body serves as ‘advanced warning system’ for funding agencies regarding potential future financial needs and as a discussion forum for forthcoming projects and the Swiss representatives therein. CHIPP is of the opinion that this body should be further developed to serve as a Think Tank for future international participation. The relation between the Round Table and the new Lenkungsausschuss LA-FLARE (succeeding the LA-FORCE, and now chaired by the SNF) could even be seen as legislative and executive, respectively. For instance, large funding requests for participation in international projects should be accompanied by a positive recommendation of the LA-FLARE, and the Research Council of the SNF should take such recommendations into account when assessing the request at stake. Further, the Round Table should be the body for appointing the Swiss representative(s) to the governing bodies of an international project in a legally binding way and for providing a binding mandate for that representative. To this end, it should also be or designate the signatory of the MoU formalizing Swiss participation.

At local level and for smaller infrastructure projects, there might be room for improvement and development in the sense that universities would join forces by creating purchasing cooperation for laboratory or workshop equipment. A regular exchange of information of new facilities, apparatuses and instruments planned to be bought for particle and astroparticle physics could be circulated among all the institutes concerned. Such a process might reduce the number of similar or identical investments made or at least result in lower prizes and possibly improve contractual conditions.

7. Particularly Cost-intensive – Advantages and Drawbacks

There is little doubt that experimental particle physics as a whole belongs to the category of cost-intensive basic research. However, the mechanisms inside the field for finding consensus and zooming in on a limited number of high priority projects ensures that participation in these projects remains affordable to single university research groups. Indeed, as the size and complexity of projects increases, so does the number of participants and contributing funding agencies. In this way, the obvious advantages of coordination and cooperation are fully preserved:

- The cost of an infrastructure is split among more partners.
- The scientific collaboration is enhanced.
- Upgrade and follow-on development of infrastructures is facilitated.
- Technical know-how is exchanged.
- The project is embedded in the international context.
- The way to possible co-funding from the Swiss Government is open.

Given the embedding of the vast majority of particle physics projects into international consortia and processes, the potential drawbacks of national coordination appear minor:

- The investment process is slowed down in a negligible way, but offers the opportunity to privilege Swiss industry.
- The margin for autonomous decisions is reduced, but this reduction is alleviated by the bottom-up approach.
- Oversupscriptions for using the facilities are handled by peer committees using scientific criteria.

Despite these minor drawbacks, coordination and cooperation is accepted and implemented at Swiss level. The existing coordination by CHIPP thus already implements the coordination effort required by the new HFKG; therefore, no need for additional layers or new instruments of coordination has been identified up to now and in the course of the present analysis.

However, coordination comes at a cost. The annual administrative budget of CHIPP, which is of the order of 120 kCHF, has in the past been covered by an SUK cooperation and innovation grant. Starting in 2012, CHIPP collects membership fees, which should ultimately cover its operations cost. If particle physics is classified into the category of cost-intensive domains, it is proposed that the CRUS members mandate CHIPP to continue coordinating this field on behalf of CRUS, and therefore finance the coordination functions of CHIPP directly through the participating Rectorates. In that case, CRUS will receive an annual financial report as well as an activity report in the same style as delivered to SUK in the past and to the SCNAT at present.

8. Long-Term Funding Models

The current Swiss funding scheme for particle and astroparticle physics is characterized by a rather large number of actors, including the Confederation, Cantonal subventions, the SNF and university funding at the level of each institution. Subventions may intervene directly or be channelled through international organisations or accompanying measures. Most of these subventions result from a competitive process and the attribution to each partner takes into account their strength and competence. More often than not, the SNF is instrumental in providing the peer review expertise to evaluate proposals. This is a sound mechanism, which should by all means be preserved.

The multitude of complementary funding sources is perceived as strength of the Swiss system rather than a drawback. It provides the necessary flexibility to cater for projects of different size and number of partners. It functions in a subsidiary fashion in the sense that funding that can be secured locally is supplemented at higher levels. There is consensus within CHIPP that this system is best suited to sustain support to particle physics projects. However, sustainability of long-term projects is impaired by the inability of the SNF to engage in long-term funding. It would be advisable that SNF considers a change of policy in this respect.

Access to infrastructure, which may be present only in selected places like the PSI, should remain free of charge and subject to scientific criteria only. Infrastructure for which construction has already been centrally funded should generally also be operated via central funds. It is therefore obviously important that such funds are available for important infrastructures. The principle of mutual access to facilities without financial compensation simplifies administration.

Central Swiss funding mechanisms for particle physics infrastructure exist already, in the past with FORCE, in the future with FLARE, which comprises FORCE, FOLIS and FINES. To duplicate these mechanisms by a common infrastructure fund financed by the Universities does not seem advisable as long as direct federal funding is sustained at least at the present level.

Private co-funding is unusual for particle physics projects because of the fundamental nature of this research. However, Swiss industry has largely profited from investments into particle physics and technology transfer from the field. It is recommended to leave university-industry cooperation to established local technology transfer offices and federal mechanisms such as KTI.

9. Impact and Consequences on the Institutions' Strategies

Particle and astroparticle physics is a cost-intensive branch of fundamental research, which is well imbedded in the strategic directions of the Swiss universities where it is represented. The analysis of the current situation in particle physics presented in this report indicates that it is not advisable for the Swiss institutions to impose further top-down coordination in this field. Such measures would hinder innovation and discourage the development of new ideas. Rigid new structures would also not allow to keep up with the rapid progress in this field caused by the success of the experiments at LHC, non-accelerator experiments and astroparticle observatories. It would also endanger the excellent Swiss position in international scientific competition. This assessment is shared by the SWTR in its report on this subject[16].

We conclude that institutions should allow, encourage and support existing and future bottom-up coordination. This includes local transversal structures improving coordination among different research lines in particle and astroparticle physics, fostering and further increasing cooperation between theory and experiment, and enlarging coordination to neighbouring fields like high-energy astrophysics and observational cosmology. It also includes promoting national coordinating bodies like CHIPP and the proposed NCCR Universe. All of these efforts must necessarily be imbedded into the European and worldwide strategy elaborated by the competent bodies.

[16] see: http://archiv.swtr.ch/wp-content/uploads/SWTR_Empfehlung_Kooperation_kostenintensiver_Bereiche_2009.pdf

10. Conclusions

Costly infrastructure?

1. Particle and astroparticle physics require costly research infrastructure, which are 'cost-intensive' when their total construction and operations cost is considered.
2. Particle and astroparticle physics at the level of the individual university institute are not cost-intensive in the majority of cases, because these research fields benefit from a well established bottom-up self-organisation, collaboration and cost-sharing, avoiding double investments or parallel activities.

Coordination

3. Accelerator based projects require large national or international laboratories, where coordination is in the focus from the start.
4. At national level, inter-university coordination is well developed and essential in determining the weight of the participants in a multinational project.
5. In the field of particle and astroparticle physics, an additional layer of coordination would not reduce cost.
6. Particle and astroparticle physics are willing to explore the sketched 'purchasing cooperation' at local level and for smaller infrastructure projects, but fears that the cost-benefit ratio would not be to its advantage.
7. CHIPP provides a Swiss national forum for dialogue and coordination as required by the new HFKG; it plays an essential role in finding consensus and defending its conclusions. It is suggested that CRUS mandates CHIPP to continue this coordination on behalf of CRUS and to maintain it at the present level. In return, CRUS would contribute to the operations cost of CHIPP caused by this effort.

Funding and funding policy

8. In particle and astroparticle physics, a consistent and reliable long-term funding policy is essential; it is therefore suggested that the direct federal funding with FLARE is sustained at least at the present level. In fact, the latest projections for funding needs show that the FOLIS part of FLARE could become a much more important funding instrument if it were to be increased to the level of the FORCE part. In addition, we suggest that the SNF reviews its policy of long-term funding of large (and long-lasting) infrastructure projects.
9. The Swiss approval mechanism of large international projects is a cumbersome road. It is suggested to develop a more formal process with the aim of enhancing the 'Round Table International Infrastructures' to a Think Tank for international participation, and the LA-FLARE to a recognized body for recommending project participation to the Research Council of SNF.

Transversal collaboration and access policy

10. The transversal collaboration between the disciplines within particle and astroparticle physics on the one hand and between theoretical and experimental particle and astroparticle physics on the other hand must be further developed and strengthened throughout Switzerland, and the input from neighbouring fields like high-energy astrophysics and cosmology strengthened. The proposed NCCR 'Universe' will allow a large step forward in this matter. It is suggested that the members of CRUS encourage and support local efforts in transversal integration, like e.g. the AEC in Berne and the CAP in Geneva.

11. Access to national infrastructure should remain free of charge and subject to scientific criteria only. The principle of mutual access to facilities without financial compensation simplifies administration.

Annexes

Annex A: *Abbreviations*

- AEC: Albert Einstein Centre for Fundamental Physics, Berne
- AIDA: Advanced European Infrastructures for Detectors at Accelerators
- AMS: Alpha Magnetic Spectrometer
- ArDM: Argon Dark Matter
- CAP: Centre for Astroparticle Physics, Geneva
- CERN: Organisation européenne pour la recherche nucléaire; Laboratoire européen pour la physique des particules (European Organization for Nuclear Research ; European Laboratory for Particle Physics)
- CHIPP: Swiss Institute of Particle Physics
- CLOUD: Cosmics Leaving OUtdoor Droplets
- CRUS: Conférence des Recteurs des Universités Suisses (Rectors’ Conference of the Swiss Universities)
- CTA: Cherenkov Telescope Array
- DARWIN: DARk matter WImp search in Noble liquids
- ESA: European Space Agency
- ESO: European Southern Observatory
- EXO: Enriched Xenon Observatory
- FINES: Fonds pour infrastructure au sein de l’ESO
- FLARE: Fund for Large Research Infrastructures
- FORCE: Fonds pour la Recherche au CERN
- GERDA: GERmanium Detector Array
- Grid Computing: a worldwide network of computers working on a ‘single’ problem
- HFKG: Hochschulförderungs- und Koordinationsgesetz (Swiss Federal Law on the Promotion of the Swiss Universities and on their Coordination)
- HiMB: High Intensity Muon Beam
- IceCube – PINGU: South Pole Neutrino Observatory – Precision IceCube Next-Generation Upgrade
- LAGUNA – LBNO: Large Apparatus for Grand Unification and Neutrino Astrophysics – Long BaseLine Neutrino Observatory
- LHC: Large Hadron Collider
- MAGIC: Major Atmospheric Gamma-Ray Imaging Cherenkov
- MEG: lepton-flavor violating decay of a positive muon into one positron and one photon
- MICE: Muon Ionisation Cooling Experiment
- Mu3e: lepton-flavour violating decay of a positive muon into two positrons and one electron
- NA61: Study of Hadron Production in Collisions of Protons and Nuclei at the CERN SPS
- Neutrino Factory (MICE): Muon Ionisation Cooling Experiment
- OPERA: Oscillation Project with Emulsion tRacking Apparatus
- PhD: Doctor of Philosophy
- POLAR: Gamma Ray Burst Polarimetry onboard the ISS
- PP: Particle Physics
- PSI: Paul Scherrer Institute Villigen
- SCNAT: Swiss Academy of Natural Sciences
- SER: State Secretariat for Education and Research
- SNF: Schweizerischer Nationalfonds (Swiss National Science Foundation)
- SWTR: Schweizerischer Wissenschafts- und Technologierat (Swiss Science and Technology Council)
- Swiss Tier2: Third Layer of the Worldwide LHC Computing Grid (Swiss LHC Computing Centre at Manno)
- T2K: Tokai to Kamioka
- UCN/nEDM: Ultra Cold Neutron source at PSI / neutron electric dipole moment experiment
- XENON: The Xenon Dark Matter Project

Annex B: *Mandate of the CRUS*

Mandats d'analyse pour domaines d'infrastructures

Physique des particules

Contexte
En prévision de l'entrée en vigueur de la Loi sur l'encouragement aux hautes écoles et la coopération dans le domaine des hautes écoles (LEHE), la CRUS explore les possibilités d'indentifier et de définir les *Domaines particulièrement onéreux* (selon l'alinéa 5 de l'article 63a de la Constitution fédérale) sur la base de la collaboration en matière d'infrastructures. Ses réflexions ont conduit au rapport intermédiaire *Vorschlag zum Vorgehen der CRUS bei der Bestimmung von kostenintensiven Bereichen* (voir annexe). Sur proposition de la CPC-CRUS, le Plénum de la CRUS a décidé de poursuivre la réflexion par des analyses approffondies de 4 domaines d'infrastructure, la physique des particules, l'imagerie biomédicale, le calcul à haute performance et l'accès à l'information scientifique. Ces domaines ont été choisis à titre d'exemples, afin de couvrir suffisament de situations différentes.

Mandat
La CPC-CRUS prie le **Prof. Dr. Martin Pohl**, avec le Comité exécutif de CHIPP de soumettre pour l'été 2012 un rapport sur le domaine de la **physique des particules** comprenant :

1. un état de la collaboration actuelle dans le domaine,
2. un bilan de l'infrastructure existante et des besoins en termes d'acquisition et de renouvellement,
3. une analyse de la volonté de développer la collaboration dans ce domaine
4. une analyse des avantages et inconvénients, pour ce domaine, d'être défini comme particulièrement onéreux,
5. des modèles de financement à long terme (répartition des charges équitable, tarification) et
6. une analyse de l'impact et des conséquences sur les stratégies des institutions concernées.

Mandat approuvé par la CPC-CRUS le 30 septembre 2011.

Annex C: *Legal Basis*

Annex C1. Swiss Federal Constitution

3. Titel: Bund, Kantone und Gemeinden
2. Kapitel: Zuständigkeiten
3. Abschnitt: Bildung, Forschung und Kultur
< **Art. 63** Berufsbildung
> **Art. 64** Forschung

Art. 63*a*[1] Hochschulen

[1] Der Bund betreibt die Eidgenössischen Technischen Hochschulen. Er kann weitere Hochschulen und andere Institutionen des Hochschulbereichs errichten, übernehmen oder betreiben.

[2] Er unterstützt die kantonalen Hochschulen und kann an weitere von ihm anerkannte Institutionen des Hochschulbereichs Beiträge entrichten.

[3] Bund und Kantone sorgen gemeinsam für die Koordination und für die Gewährleistung der Qualitätssicherung im schweizerischen Hochschulwesen. Sie nehmen dabei Rücksicht auf die Autonomie der Hochschulen und ihre unterschiedlichen Trägerschaften und achten auf die Gleichbehandlung von Institutionen mit gleichen Aufgaben.

[4] Zur Erfüllung ihrer Aufgaben schliessen Bund und Kantone Verträge ab und übertragen bestimmte Befugnisse an gemeinsame Organe. Das Gesetz regelt die Zuständigkeiten, die diesen übertragen werden können, und legt die Grundsätze von Organisation und Verfahren der Koordination fest.

[5] Erreichen Bund und Kantone auf dem Weg der Koordination die gemeinsamen Ziele nicht, so erlässt der Bund Vorschriften über die Studienstufen und deren Übergänge, über die Weiterbildung und über die Anerkennung von Institutionen und Abschlüssen. Zudem kann der Bund die Unterstützung der Hochschulen an einheitliche Finanzierungsgrundsätze binden und von der Aufgabenteilung zwischen den Hochschulen in besonders kostenintensiven Bereichen abhängig machen.

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[1] Angenommen in der Volksabstimmung vom 21. Mai 2006 (BB vom 16. Dez. 2005, BRB vom 27. Juli 2006 – AS **2006** 3033; BBl **2005** 5479 5547 7273, **2006** 6725).

Stand am 1. Januar 2011

Annex C2. Swiss Federal Law on the promotion of the Swiss Universities and on their coordination

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Bundesgesetz über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich

(Hochschulförderungs- und -koordinationsgesetz, HFKG)

vom 30. September 2011

Auszug

Art. 3 Ziele

Der Bund verfolgt im Rahmen der Zusammenarbeit im Hochschulbereich insbesondere die folgenden Ziele:

a. Schaffung günstiger Rahmenbedingungen für eine Lehre und Forschung von hoher Qualität;

b. Schaffung eines Hochschulraums mit gleichwertigen, aber andersartigen Hochschultypen;

c. Förderung der Profilbildung der Hochschulen und des Wettbewerbs, insbesondere im Forschungsbereich;

d. Gestaltung einer kohärenten schweizerischen Hochschulpolitik in Abstimmung mit der Forschungs- und Innovationsförderungspolitik des Bundes;

e. Durchlässigkeit und Mobilität zwischen den Hochschulen;

f. Vereinheitlichung der Studienstrukturen, der Studienstufen und ihrer Übergänge sowie gegenseitige Anerkennung der Abschlüsse;

g. Finanzierung der Hochschulen nach einheitlichen und leistungsorientierten Grundsätzen;

h. gesamtschweizerische hochschulpolitische Koordination und Aufgabenteilung in besonders kostenintensiven Bereichen;

i. Vermeidung von Wettbewerbsverzerrungen bei Dienstleistungen und Angeboten im Weiterbildungsbereich von Institutionen des Hochschulbereichs gegenüber Anbietern der höheren Berufsbildung.