Directions for particle physics in Europe

Statement by the German Committee for Particle Physics (KET)[1]

March 9, 2006

During the past half century accelerator-based particle physics has made the key discoveries that led to the development of the Standard Model. These discoveries were predominantly made with machines that, at their time, provided the highest energies available worldwide. With its accelerators Europe played a leading role in this endeavour with highlights such as the discovery of the gluon at DESY, of weak neutral currents and the W and Z Bosons at CERN. In addition, experiments at LEP have tested the Standard Model with unprecedented precision. The leading role of European particle physics will be strengthened with the start of the LHC that will reach for the first time the energy regime of several TeV.

We welcome the initiative of the CERN Council to develop a long-term strategy for particle physics in Europe. In 2002, based on extensive discussions in the German community, KET published a report laying out priorities and major strategic directions for particle physics in Germany for the next two decades[2]. We wish to reconfirm the priorities set in this document, with emphasis on key points raised during recent discussions on a strategy for particle physics in Europe.

Many excellent and challenging projects have been discussed at the recent Orsay symposium. They demonstrate the diversity and the wide scope of our field, the liveliness of the research community, and the importance of the questions addressed by particle physics. All proposed experiments have the potential of making important contributions to new physics beyond the Standard Model, albeit with different sensitivity and precision. However, resources will be limited and priorities have to be defined.

The main aims of particle physics today are the exploration of the last missing sector of the Standard Model, responsible for the generation of mass, and the search for solutions to the many puzzles of the Standard Model through the discovery of new phenomena. The best opportunities to discover new effects and to study them in depth are provided by accelerators with the highest energies.

In view of these aims, the infrastructure presently available, and considering the technology

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[1] The Committee for Particle Physics (Komitee für Elementarteilchenphysik, KET) is the elected representation of the community of German particle physicists at universities, DESY, and CERN. Current members are: T. Behnke, F. Eisele, G. Herten, L. Köpke, J. Kühn (deputy chair), T. Lohse, P. Mättig (chair), K. Meier, T. Müller, H. Oberlack, G Quast, R. Rückl, R. Voss. Contact: Peter.Mattig@cern.ch.

options, KET has identified the following priorities for particle physics in Europe.

Priority 1: Timely completion and full exploitation of the LHC

The LHC will be the leading-edge particle accelerator at the highest energy frontier. It will probe the as yet unexplored Higgs mechanism, answer open questions of the Standard Model, and has an enormous potential to discover new and unexpected phenomena.

Full support must be given to the timely completion of the LHC and to a swift start of experimentation with this unique facility. The immediate goal will be to reach the design luminosity and a regime of efficient data taking. This requires a continuous effort by CERN to ensure the reliability of critical accelerator components. The funding agencies must provide continued support to the scientists, to enable them to fully harvest the data taken with the LHC detectors.

We support the preparation of the LHC upgrade to ten times higher luminosity (SLHC) as an efficient way of boosting the discovery reach of the machine. This requires an immediate and substantial R&D effort on accelerator components and detectors.

Priority 2: Construction of an e^+e^- collider

We share the common expectation that the LHC will open up a new chapter in physics. History of particle physics has shown that a complete understanding of the new phenomena requires, in addition to the high energy available at hadron colliders, the high precision that can only be reached at lepton colliders. The proposed International Linear e^+e^- Collider (ILC) will provide a wealth of measurements that are essential for the deeper understanding of the new energy regime. The LHC and the ILC will offer mutually supporting views of the new physics world at the TeV scale.

We emphasise the importance of a substantial period of overlap of measurements at a lepton collider with the LHC. Keeping in mind the significant lead-time to realise such a machine, we consider the early approval and construction of such a machine our next priority. We share the opinion of many young particle physicists who have stressed the importance of a timely approval to maintain the know-how and the attractiveness of our field.

Today, the only proven technology to reach TeV energies in lepton collisions is a linear electron-positron collider based on RF cavities. We welcome the choice of ICFA of superconducting RF cavities, which has led to the International Linear Collider (ILC) concept. The global cooperation for the ILC has developed considerable momentum. We

[2] For the English version, refer to http://www.ketweb.de/ketStudie/ket-study.pdf

urge the European particle physics community to stand united behind a linear collider based on this advanced design.

As pointed out in detailed physics studies and in statements by ECFA, ACFA, and HEPAP, the precision investigation of the TeV energy range is of highest importance and complements LHC physics. Whereas we support an initial energy reach of 500 GeV, we should also prepare for reaching the 1 TeV scale, depending on LHC results.

Independently of where the ILC will be built, it can only be realised as a global project. The host laboratory must provide unrestricted access to collaborating scientists from all regions. Considering the pioneering contributions by European laboratories, in particular by DESY, European particle physics and DESY should continue to play a prominent role in this project. We are pleased that both CERN and DESY are considered as sample sites for building the ILC. We encourage the European particle physics community, the CERN Council, and the funding agencies to work towards the construction of a large e^+e^- collider on our continent.

Priority 3: Advanced accelerator research and development

In the longer term future we expect ever higher energies to be the main key to an increased discovery reach. Such energies require novel accelerator technologies. We emphasise the need for a broad European and global accelerator R&D program. In particular we recommend pursuing accelerator R&D in two complementary directions:

- Lepton colliders in the multi-TeV range;
- Proton colliders in the range of several 10 TeV.

For e^+e^- colliders with a centre-of-mass energy above 1 TeV, the CLIC concept today is the only candidate technology. It is in an advanced state of R&D. We strongly support the continuation and intensification of this R&D effort in an extended international network.

A proton collider in the multi-10 TeV range would require gigantic dimensions if based on present-day technology. Such a scenario could overstrain the global resources for basic science, and could put at risk the long-term future of particle physics. Avoiding this dead end will require substantial time and effort but may have important, beneficial consequences beyond particle physics.

An important step towards multi – 10 TeV proton colliders could be doubling the LHC energy (DLHC). To this end we advocate a timely R&D effort, in particular on a new generation of superconducting magnets that would allow achieving this goal. A decision on the DLHC must be contingent on technological feasibility, cost, and the expected physics yield. These will only become clear after several years of LHC running.

To reach beyond the DLHC we emphasise the need for dedicated R&D in accelerator physics in Europe, embedded in a global effort, to prepare the design of a multi-10 TeV hadron collider based on novel, cost-effective technologies.

Innovative accelerator R&D requires the preservation and expansion of national facilities, and the strengthening of this field at universities. CERN must continue to be the forefront European accelerator laboratory, and must continue to play a key role in promoting accelerator R&D. CERN should team up with other European laboratories and universities to build a strong network embedded in a global framework.

Neutrino physics and flavour physics

With the discovery of neutrino oscillations, the precision study of neutrinos is an emerging field in elementary particle physics. At the proposed new high intensity neutrino beams the fundamental properties of neutrinos can be measured, however, in most cases, the main challenges of the Standard Model will thereby be probed only indirectly. In view of the huge resources required for creating the next generation of accelerator-based neutrino experiments, and in view of our priorities towards LHC and ILC as outlined above, we consider hosting such a facility in Europe lower in priority.

We encourage, however, a participation of European groups in next-generation, accelerator-based neutrino experiments in Japan and the USA. Moreover, we support a global R&D effort towards a neutrino factory with a coordinated European participation. We also support a strong involvement in non-accelerator based neutrino experiments where Europe has substantial expertise, such as neutrinoless double beta decay experiments or the measurement of oscillations of reactor neutrinos.

With respect to heavy flavour physics we consider LHCb as the prime experiment to study the physics of the bottom sector in future years. Super-B-factories based on very high luminosity e^+e^- colliders should be approached on a global basis. Again we consider the realisation of such a project in Europe to be of lower priority.

As a general rule, we discourage the simultaneous construction of similar, major facilities and projects on different continents.

Related fields of research

The European community of astro-particle physics is developing its own roadmap,

complementary to ours. There is a strong overlap of particle physics with parts of this field; maintaining close relations and collaborating on selected projects will be beneficial for both communities. Unlike accelerator-based physics, this research needs not be tied to a central European laboratory, but can largely be supported by universities and national laboratories.

There is also traditional, strong overlap of particle physics with hadron and heavy ion physics, in particular with the aim of understanding collective phenomena in QCD that will be studied e.g. at the planned FAIR facility.

The organisation of European Particle Physics

CERN is the most successful example of the huge potential of Europe-wide cooperation in basic research. It is the world's leading laboratory for particle physics. CERN must maintain its leadership, and further develop its potential.

The leading position of European particle physics has been made possible by a functioning network of central infrastructures, national laboratories, and universities. The continued development of this network is the prerequisite to maintain world class research at CERN and in Europe in general. Therefore, we strongly support an enhanced coordination of particle physics research between universities, national laboratories, and CERN.

To define a coordinated strategy towards the various projects in Elementary Particle Physics, and to secure the required funds, Europe should have a body comprising national funding agencies and scientific representatives. Given the wide range of projects and their global character, which implies also coordinated European activities outside of our continent, such a body should not be tied to one laboratory. Also for projects of global dimensions outside CERN, European particle physics should speak with one voice. Taking into account that national priorities and shares of funds may differ for such projects, the coordinating body should name the European representatives for each of the major projects.

The CERN Council is in a natural position to fulfill this role, but it must take a wider responsibility beyond the oversight of the CERN laboratory. Council may have to be enlarged accordingly. In addition, the role of ECFA in the discussion and planning of European particle physics must be strengthened. For topics, which are relevant for European and worldwide particle physics and which are outside of the scope of the CERN laboratory, ECFA should have a more influential representation in the Council.

Summary

For more than fifty years, particle physics has been a successful international endeavour crossing geographical and political divides. Today, as they grow in size and complexity, particle physics projects become increasingly global. European physicists have strongly participated in the BaBar and Tevatron experiments, and make strong contributions to new projects outside Europe such as T2K. Inversely, physicists from all continents have joined in large numbers the LEP, HERA, and LHC experiments.

Future large particle physics projects and facilities must be coordinated, funded, and built in global collaborations. This implies that Europe cannot play a leading role in all projects, and that we have to set priorities. We advocate that European particle physics continues to focus on projects at the high-energy frontier, and participates at the same time in cutting-edge projects in other areas of the world. Europe can maintain its leadership position in particle physics based on its vast expertise in building accelerators and detectors for the highest energies. For this reason, we must exploit in depth the unique research opportunities offered by the LHC, but should aim, at the same time, at building the next large e^+e^- collider on our continent. Finally, an intensified programme of accelerator R&D will be of highest importance to progress to new energy frontiers.