November 28, 2003

Report
of the DESY Extended Scientific Council
on
Scientific Activities at DESY

I. Preamble

Deutsches Elektronen-Synchrotron DESY, established in 1959, has as its mission

- the development, construction and operation of high energy particle accelerators;
- the exploitation of these facilities for particle physics and for synchrotron radiation based research in collaboration with university groups and with other research centres.

DESY fulfills this mission as a world renowned accelerator laboratory for high energy physics and photon science. Apart from very successful collaboration with national and international research institutions, DESY has established and maintained, throughout its history, invaluable relationships with university groups in high energy physics and since 1973 in photon science. Today, over 3000 scientists worldwide access the unique DESY facilities.

The Extended Scientific Council (ESC) of DESY is an external, international advisory committee, consisting of 24 scientists from universities and research centres in the fields of particle physics, astro-particle physics, physics with photons and synchrotron radiation, and accelerator physics. In view of the upcoming review process of the Helmholtz Gemeinschaft (HGF), the ESC decided to prepare a report in which it critically reviews the scientific program and evaluates the future projects of DESY. The ESC formed two sub-committees, each consisting of 5 ESC members plus 2 or 3 renowned scientists from outside the ESC and DESY, who evaluated the field of photon physics as well as the fields of particle and astro-particle physics. In its meeting of November 13 and 14, the ESC discussed the two reports from the sub-committees and, as a result, agreed on the following overall evaluation report on the scientific activities at DESY.

II. Particle Physics and Astro-Particle Physics at DESY

DESY has a long and successful history of accelerator development and application in particle physics, starting with the DESY Synchrotron, and subsequently with the DORIS, PETRA and HERA accelerators and storage rings. The current and the future program is

strongly driven by a large international user community which has agreed that the next international project in particle physics should be a Linear Collider (LC) with centre of mass energy of 500 GeV, upgradable to about 1 TeV, overlapping with the operation of the LHC at CERN. DESY, together with the TESLA collaboration, has successfully developed the technique and demonstrated the feasibilty of the TESLA superconducting technology for a Linear Collider. This technology is also the basis for the development of the XFEL, as well as many other applications in accelerator based science. This development, together with the unique and world recognised results obtained at HERA and at previous accelerator projects, places DESY among the leading laboratories for high energy physics in the world. Especially for the particle physics community in Eastern Europe, DESY has a significant coordinating and focussing role which is envisaged to continue in the future.

II.1. HERA

The ESC recognises that:

- the HERA program has attracted scientists from German universities and from around the world. HERA has provided fundamental results on the structure of protons, such as the strong rise of the structure function F_2 at low parton momentum fraction x, the stunning existence of a significant fraction of rapidity gap events, the precise determination of the strong coupling constant α_s, on the spin structure of the proton, as well as on the unification of the electromagnetic and of the weak interaction. The HERA accelerator has entered a new phase in 2003, HERA2, with significantly increased luminosity, with the demonstrated ability to provide polarised lepton beams for precise tests of the electroweak interaction, and with upgraded and significantly improved particle detectors.

The ESC supports:

- the laboratory plans that the first priority is to provide a total integrated luminosity of approximately one inverse femtobarn to ensure the successful and timely completion of the HERA2 program;

- the priority given to the photon science programs and the preparation of the Linear Collider over the proposed new HERA3 phase of the HERA program beyond 2007, given the limited resources for the present overall program.

II.2. The Linear Collider

The ESC recognises that:

- there is full agreement in the HEP community that the next step is the construction of a Linear Collider which will operate during the LHC exploitation.

The understanding of new physics that we expect beyond the Standard Model will require complementary measurements at both the LHC and the LC;

- in the last 10 years, DESY together with its German university partners and the international TESLA Collaboration has played an outstanding role in the preparation of a Global Linear Collider through highly successful accelerator R&D, physics studies and detector R&D. DESY is today a world leader in Linear Collider research.

The ESC recommends:

- in the situation where the TESLA technology is chosen, DESY should maintain its unique leadership. This requires the timely provision of additional financial and human resources;

- if the normal conductive technology is chosen, DESY should identify areas of contribution to maintain a leading role in the global Linear Collider project. Additional resources will also be required in this case;

- irrespective of the choice of LC technology, DESY should maintain its strong role in LC physics studies and in detector R&D.

The ESC is, however, particularly worried about the potential consequences of a progressive delay of the decision on the Linear Collider that could open a larger time gap in the experimental HEP program of the laboratory.

II.3. External Accelerator Experiment

The ESC recommends:

- DESY should identify and participate with adequate resources in an outstanding particle physics program at an external accelerator in the period between the completion of the HERA program and the start of the Linear Collider.

II.4. Theory

The ESC recognises that:

- the DESY theory group is one of the leading particle theory centres in Europe, with a well balanced program and with strong links to German universities;

- DESY is a centre of excellence in Lattice Field Theory, and, together with collaborators in France and Italy, is participating in the design of the apeNEXT

machines. The ESC is pleased to note that DESY will procure a 3 TFlops apeNEXT machine for the theory group, with a possible extension to 15 Tflops.

The ESC supports:

- the Laboratory's plans to maintain the group's important role in particle theory;
- the proposed coordination role of the DESY group in the Lattice Forum.

II.5. Astroparticle Physics

The ESC recognises that:

- DESY has a strong and highly visible position in the field of astroparticle physics, in particular through the development of the most advanced neutrino telescopes. DESY's important contributions to the successful Lake Baikal telescope and the successful Amanda detector in the icecap of the South Pole, place the laboratory in an excellent position to participate in all aspects of the next stage, the IceCube project at the South Pole, and to remain a leader in the field.

The ESC supports:

- the Laboratory's plans to maintain the group's important role in the Amanda / IceCube projects.

III. Photon Science Activity at DESY

DESY has over its history demonstrated the flexibility to adapt to the changing scientific landscape and in its plans for the next five years is concentrating significant resources towards developments related to photon science. Apart from unique relationships with university groups within Germany, the cooperation also includes various laboratories. The synergy that exists at DESY between the various disciplines has lead to a plan for photon science composed of:

(1) the continued exploitation of DORIS III,
(2) the construction of a new storage ring based dedicated light source, PETRA III,
(3) the increase of the energy of the VUV-FEL to be operated as a user facility,
(4) a low emittance electron gun development in the context of the SASE FEL project, and
(5) the start of construction of the European XFEL Laboratory.

These plans will impact the synchrotron radiation community with new outstanding science opportunities in an evolutionary way by adding PETRA III. In contrast, the X-ray laser holds the potential to revolutionise scientific research utilising photons with Angstrom wavelengths.

III.1. DORIS III

The ESC recognises:

- impressive science highlights (electrochemistry, nano-particles, atomic clusters, protein structures, materials catalysis etc.). The success of this research is based on strong participation of university groups which also operate instruments serving more than half of the user community;

- instrumentation efforts focused on the high power load issues associated with the wiggler sources. They led to the development of crystal cooling schemes that have been adopted at other facilities;

- the reliability and stability of DORIS III beams obtained through maintenance and upgrade of critical components. This provided 5800 hours of excellent delivered beam during last year.

The ESC recommends:

- DORIS III should be kept fully operational at least until 2009. DORIS supports a user community numbering more than 2000 scientists with strong and successful programs. It is critical that HASYLAB ensures that this community will not be dispersed during the construction and commissioning phase of PETRA III.

III.2. PETRA III

The ESC recognises that:

- the construction of a dedicated 3rd generation SR source, PETRA III, represents a substantial increase in hard X-ray undulator based photon science in Europe. By utilising the existing significant infrastructure and experience in accelerator science and photon science on the DESY site this will be accomplished in a very cost-effective way;

- the project has several unique features compared to the European Synchrotron Radiation Facility (ESRF). Improved emittance is obtained through the use of damping wigglers, and the bunch structure is better suited to time resolved experiments. In addition, PETRA has a tremendous potential for future expansion in the number of beamlines.

The ESC recommends:

- to fully utilise the capabilities of PETRA III, top up injection should be included from day 1;

- the final choice of day 1-beamlines should be determined in 2004;

- the beamline staffing plan should be developed in a timely fashion, and should be comparable in size to that for ESRF beamlines. When possible, this plan should draw upon university and other external groups;

- proper infrastructure and personnel should be established for optics, sample environment, detectors and computing to properly support the beam line operation and upgrades.

III.3. VUV-FEL

The ESC recognises that:

- the VUV-FEL at the Tesla Test Facility Phase1 (TTF I), based on developments in superconducting RF technology achieved by the TESLA collaboration, has demonstrated saturation of the SASE process at wavelengths down to 80 nm. TTF I establishes the technical basis for the planned European X-Ray Free Electron Laser (XFEL) and the Linear Collider for High Energy Physics;

- the discovery potential of these qualitatively new X-ray sources has been demonstrated by the unexpected observation of highly charged ions from multiphoton Coulomb explosion of Xe atom clusters.

The ESC recommends:

- a timely start of the user program on the VUV-FEL TTF2:

- to continue to put emphasis on issues of bunch length measurement and pump-probe timing jitter.

III.4. RF cathode gun

The ESC recognises that:

- at X-ray wavelengths, the RF gun performance becomes the key component for the realization of the SASE process;

- DESY has established a successful Photo Injector Test facility at Zeuthen (PITZ). This facility has already developed a gun that satisfies the requirements for TTF II and, in collaboration with the Max Born Institute in Berlin, is developing a laser

system that will provide the necessary transverse and longitudinal pulse profiles needed for the XFEL.

The ESC recommends:

- a timely R&D effort should be pursued to reach the gun parameters required for the functioning of a 0.1 nm XFEL.

III.5. European XFEL

The ESC recognises that:

- the fully dedicated European X-ray source proposed by DESY will have a revolutionary impact on science, ranging from structural biology to the physics of atoms. The XFEL will take full advantage of the synergy between particle- and accelerator-physics and photon science expertise existing at the DESY site. The realisation of this ambitious project relies on a solid foundation of user workshops addressing the scientific opportunities, developments in accelerator technology, theory and simulations of FEL physics;

- DESY and SLAC have entered into a MoU for the mutual development of accelerator technology, FEL physics and photon science. The X-ray FEL project at SLAC at Stanford has a time schedule that is particularly fruitful for collaboration.

The ESC recommends:

- since almost all technical components of key importance for the XFEL can be tested at the TESLA Test Facility and the VUV FEL, accelerator and beamline R&D, including the study of advanced FEL concepts and simulation of electron beam dynamics, should be strongly supported;

- additional funding through other European countries should be assured. A European working group dealing with scientific and technical aspects of the proposed European XFEL Laboratory should be established in due time, in preparation of an MoU defining the international collaboration.

IV. Summary

In view of the outstanding scientific and technological achievements and of the inspiring and challenging future developments of particle accelerators and their respective application in the fields of particle physics and photon science, the ESC emphasises that a continuation of the successful collaboration and synergy between these fields at DESY be pursued in the future. The projects discussed and recommended above will continue to enable DESY to fulfill its mission. Efficient and flexible use of the available

infrastructure, the resources and the experience will guarantee continued scientific success at the highest level.

The assignment of DESY resources to the projects recommended above will depend critically on the development of European and international agreements and collaboration. The ESC sees the danger that the projected level of resources will not be sufficient to maintain the world leading role of DESY in the most demanding future developments, the XFEL and the Linear Collider. The ESC therefore strongly emphasises the need for an appropriate and well balanced funding, particularly for the preparatory phases of those projects.