European Strategy for Particle Physics
Agreed Draft by the CERN Council

https://europeanstrategygroup.web.cern.ch/EuropeanStrategyGroup/

Institute of Physics annual Joint Meeting of High Energy and Astro Particle Physics

Liverpool, UK, 8-10 April 2013

T. Nakada

EPFL-LPHE
Lausanne, Switzerland

Scientific Secretary for Strategy Session of CERN Council
Chair of Strategy Group and Preparatory Group

In 2006 first European Strategy

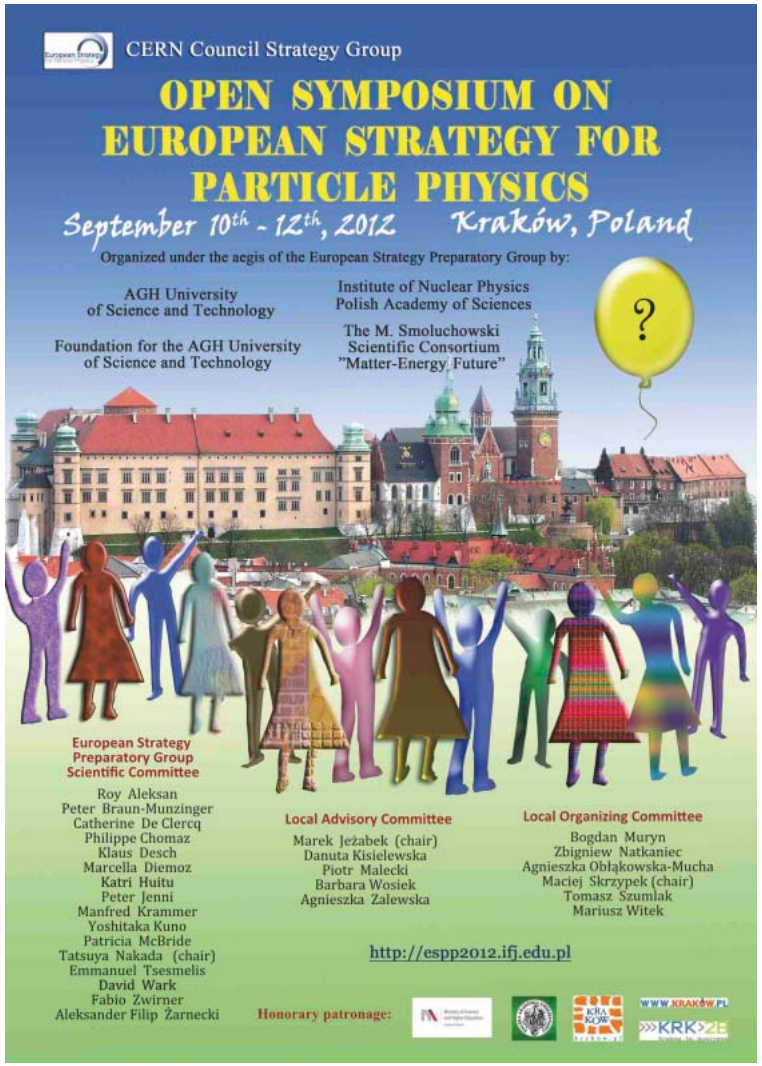
- LHC was still under construction.
- ILC baseline design completed under the guidance of GDE. The next steps were, the Reference Design Report and finally the Technical Design Report
- HERA, PEP-II, KEKB and Tevatron were still operating.
- Several neutrino experiments, accelerator based and reactor based were under construction.
- Higgs mass prediction from the electroweak fits, but no direct observation of the Higgs particle.
- No convincing sign (neither direct nor indirect) of new physics (except the neutrino masses).
- The third neutrino mixing angle, θ_{13}, not measured.

Timeline of this Update

- Preparation of the update started in 2011 by setting up Strategy Group and Preparatory Group by the Council
- September 2012: Open Symposium
  Organised by the Preparatory Group
  scientific input from the community
- December 2012: Scientific Briefing Book
  by the Preparatory Group based on the community input (Open Symposium + written submissions)
- January 2013: Strategy Group drafting session
  Draft of updated European Strategy made, submitted to the Council and made **available to the community**
- March 2013: Council discussion on the draft, reached agreement on the text to be adopted formally in May
- May 2013: The Council formally adopting the Strategy

Two major meetings

Cracow Open Symposium and Erice Drafting Session



Groups

- European Strategy Group: Members and invitees
  - Working Groups of ESG
    - Working Group 1:
      Organisational structure for the Council for the European Strategy and its implementation
    - Working Group 2:
      Organisational structure for European participation in global projects. Role and definition of the National Laboratories and the CERN Laboratory in the European Strategy
    - Working Group 3:
      Relations with external bodies, in particular EU-related
    - Working Group 4:
      Knowledge and technology transfer, and relations with industry
    - Working Group 5:
      Communication, outreach and education
- Preparatory Group: Scientific input to ESG

European Strategy Group (ESG)

Members

Member States Representatives

Austria	Prof. A. H. Hogang
Belgium	Prof. W. Van Doninck
Bulgaria	Prof. L. Litov
Czech Republic	Prof. J. Chyla
Denmark	Prof. J.J. Gaardhoje
Finland	Prof. P. Eerola
France	Prof. J. Martino
Germany	Prof. S. Bethke
Greece	Dr P. Rapidis
Hungary	Prof. P. Levai
Italy	Prof. F. Ferroni
Netherlands	Prof. S. De Jong
Norway	Prof. A. Read
Poland	Prof. J. Krolikowski
Portugal	Prof. G. Barreira
Slovakia	Dr L. Sandor
Spain	Prof. F. del Aguila
Sweden	Prof. B. Asman
Switzerland	Prof. K. Kirch
United-Kingdom	Prof. J. Butterworth

CERN - Director-General Prof. R. Heuer

Major European National Labs

CIEMAT	Dr C. Lopez
DESY	Prof. J. Mnich
IRFU	Dr Ph.Chomaz
LAL	Dr A. Stocchi
NIKHEF	Prof. F. Linde
LNF	Dr U. Dosselli
LNGS	Prof. S. Ragazzi
PSI	Dr L. Rivkin
STFC-RAL	Dr J. Womersley

Strategy Secretariat Members

Prof. T. Nakada	Scientific Secretary (Chair)
Prof. F. Zwirner	SPC Chair
Dr M. Krammer	ECFA Chair
Dr Ph. Chomaz	Repres. EU Lab. Directors
Prof. E. Tsesmelis	Scientific Assistant

Invited - President of Council Prof. A. Zalewska

Invitees

Candidate for Accession and Associate Member States

Israel	Prof. E. Rabinovici
Romania	Dr S. Dita
Serbia	H. E. Amb. U. Zvekic

Observer States

India	Prof. T. Aziz
Japan	Prof. Sh. Asai
Russian Federation	Prof. A. Bondar
Turkey	Prof. Dr M. Zeyrek
United-States	Prof. M. Shochet

EU	Dr R. Lecbychova
ApPEC	Dr S. Katsanevas
Chairman FALC	Prof. Y. Okaka
Chairman ESFRI	Dr B. Vierkorn-Rudolph
Chairman NuPECC	Prof. A. Bracco
JINR, Dubna	Prof. V. Matveev

Also invited to the Open Session, Preparatory Group Members

The European Strategy Preparatory Group (ESPG) Members

Strategy Secretariat Members

Prof. T. Nakada	Scientific Secretary (Chair)
Prof. F. Zwirner	SPC Chair
Dr M. Krammer	ECFA Chair
Dr Ph. Chomaz	Repres. EU Lab. Directors
Prof. E. Tsesmelis	Scientific Assistant

SPC
Prof. R. Aleksan (FR)
Prof. P. Braun-Munzinger (DE)
Prof. M. Diemoz (IT)
Prof. D. Wark (UK)

ECFA
Prof. K. Desch (DE)
Prof. K. Huitu (FI)
Prof. A. P. Zarnecki (PL)
Prof. C. De Clercq (BE)

CERN
Dr P. Jenni

ASIA/AMERICAS
Prof. Y. Kuno (Asia)
Prof. P. McBride (Americas)

Erice Meeting

- Monday
  - Briefing Book summaries and update
    - by Preparatory Group members and Research Director
  - SPC and ECFA inputs
    - by SPC and ECFA chairs
  - Brief statements
    - Member, Candidate for Accession to Membership, Associate Member States and two Observer States (US and Japan)
- Tuesday
  - Discussion on the scientific issues
- Wednesday
  - Reports by the Working Groups followed by the discussion
- Thursday morning
  - morning, Discussion on the scientific issues
- Followed by Thursday afternoon and Friday
  - Strategy drafting

Drafting process

- Draft was made by the Strategy Secretariat + editorial help
- First draft (produced over Wednesday-Thursday)

Composition

Prof. Tatsuya Nakada, Scientific Secretary

Prof. Fabio Zwirner, SPC Chair

Dr Manfred Krammer, ECFA Chair

Dr Ph. Chomaz, Representative of the European Laboratory Directors' meeting

+ Emmanuel Tsesmelis and John Pym

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- First discussion Thursday afternoon

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- First discussion Thursday afternoon
- Second draft (Thursday-Friday night)
- Second discussion Friday morning

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- Second draft (Thursday-Friday night)
- Second discussion Friday morning
- Third draft (Friday lunch time)
- Third discussion Friday afternoon
- Fourth draft (Friday afternoon coffee break)

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- Third draft (Friday lunch time)
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- Fourth draft (Friday afternoon coffee break)
- Fourth discussion Friday evening
  line by line reading, real time editing and real time endorsement, item by item.

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- Second discu
- Third draft (F
- Third discuss
- Fourth draft (ak)
- Fourth discus
  line by line re l real time
  endorsement

- Meeting concluded at 18:50 with fifth draft unanimously endorsed by the ESG members. Only then, singing and dancing!

Deliberation Paper

- Deliberation Paper by the ESG is to provide
  - rationale behind the scientific issues
    ⇒ partly in this presentation
  - recommendations of the ESG Working Groups on the non-scientific issues
    ⇒ Council may consider taking up for future consideration

will be finalised by the May Council session.

Preamble

- Since the adoption of the European Strategy for Particle Physics in 2006, the field has made impressive progress in the pursuit of its core mission, elucidating the laws of nature at the most fundamental level. A giant leap, the discovery of the Higgs boson, has been accompanied by many experimental results confirming the Standard Model beyond the previously explored energy scales. These results raise further questions on the origin of elementary particle masses and on the role of the Higgs boson in the more fundamental theory underlying the Standard Model, which may involve additional particles to be discovered around the TeV scale. Significant progress is being made towards solving long-standing puzzles such as the matter-antimatter asymmetry of the Universe and the nature of the mysterious dark matter. The observation of a new type of neutrino oscillation has opened the way for future investigations of matter-antimatter asymmetry in the neutrino sector. Intriguing prospects are emerging for experiments at the overlap with astroparticle physics and cosmology. Against the backdrop of dramatic developments in our understanding of the science landscape, Europe is updating its Strategy for Particle Physics in order to define the community's direction for the coming years and to prepare for the long-term future of the field.

General issues

a) The success of the LHC is proof of the effectiveness of the European organisational model for particle physics, founded on the sustained long-term commitment of the CERN Member States and of the national institutes, laboratories and universities closely collaborating with CERN. *Europe should preserve this model in order to keep its leading role, sustaining the success of particle physics and the benefits it brings to the wider society.*

b) The scale of the facilities required by particle physics is resulting in the globalisation of the field. *The European Strategy takes into account the worldwide particle physics landscape and developments in related fields and should continue to do so.*

Scientific activities

- Balance between setting priory vs maintaining diversity
  - Large scale projects with priority: regional to global
  - Competitive small to medium scale projects: national to regional
- Large scale projects
  - Not all large scale projects can be done in Europe (at the same time) even with a good scientific case
  - Current physics situation: Higgs and neutrino θ_{13}
  - Full exploitation of large investment already made
  - Required versus available resources
  - International landscape: America and Asia
  - LHC, LC, LHeC, LEP3, TLEP, γ-γ Colliders, muon colliders, …

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High-priority large-scale scientific activities 1

After careful analysis of many possible large-scale scientific activities requiring significant resources, sizeable collaborations and sustained commitment, the following four activities have been identified as carrying the highest priority.

At the energy frontier

- Higgs study is becoming a precision study to investigate its property in detail: eventually look for deviations from the Standard Model predictions
  ⇒ High statistics with excellent detectors
- Direct search for new particles is far from completed

LHC is currently the only machine for these studies.

- LHC is a versatile facility used by heavy flavour and heavy ion communities as well
- For a post-LHC machine in Europe
  - Further physics input, in particular results at 14 TeV, is needed for the decision, i.e. for the next Strategy update
  - European ambition is to stay at the forefront of the highest energies needs rigorous R&D.

High-priority large-scale scientific activities 2

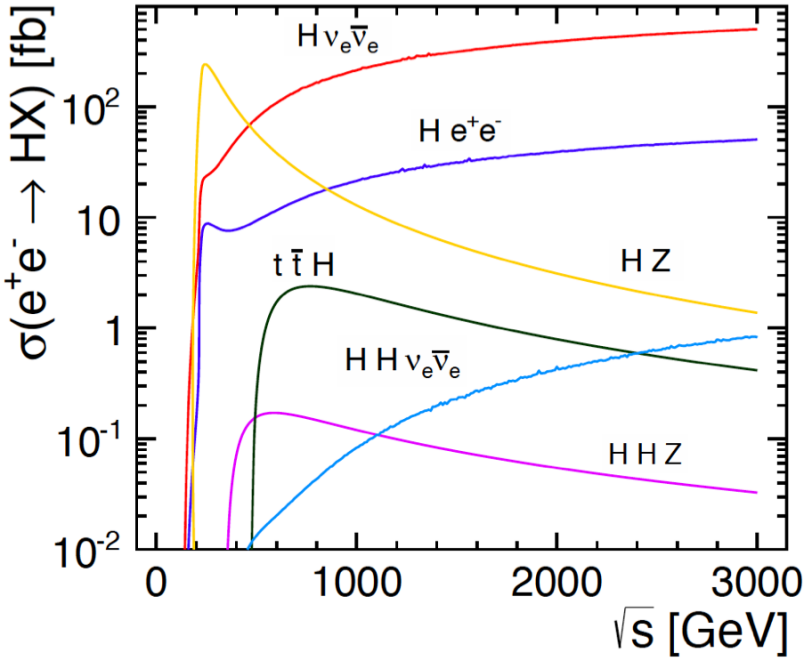
c) The discovery of the Higgs boson is the start of a major programme of work to measure this particle's properties with the highest possible precision for testing the validity of the Standard Model and to search for further new physics at the energy frontier. The LHC is in a unique position to pursue this programme. *Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma*.

High-priority large-scale scientific activities 3

d) To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14 TeV will be available. *CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide.*

e^+e^- machines

- Higgs studies at "High" energy lepton colliders
  - total decay width (including invisible decay modes)
  - absolute branching fractions
  - final states not easily accessible by the LHC
  - etc. …complementary to LHC, + top mass
- e^+e^- colliders < 1 TeV could be realised, reasonably soon. Important parameters are energy AND luminosities!



High-priority large-scale scientific activities 4

e) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. *Europe looks forward to a proposal from Japan to discuss a possible participation*.

ILC in Japan, if realised, would be an opportunity for particle physics worldwide.

Neutrinos

- Since θ_{13} is now known, one can make a reasonable estimate for expected performance of long baseline neutrino experiments with a conventional accelerator neutrino beam for the mass hierarchy and oscillation parameters measurements including CP violation, and it looks promising!
- Mass hierarchy can also be studied with non-accelerator neutrinos (⇒NB: domain of ApPEC)
- CP violation studies require a long baseline project:
  - LAGUNA-LBNO in Europe
  - LBNE-FNAL in US
  - HyperK-JPARC in Japan
- European groups are at the forefront of detector R&D
- Overall scale of the project may be too large for Europe to do everything?

High-priority large-scale scientific activities 5

f) Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. *CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*

Other scientific activities essential to the particle physics programme 1

g) Theory is a strong driver of particle physics and provides essential input to experiments, witness the major role played by theory in the recent discovery of the Higgs boson, from the foundations of the Standard Model to detailed calculations guiding the experimental searches. *Europe should support a diverse, vibrant theoretical physics programme, ranging from abstract to applied topics, in close collaboration with experiments and extending to neighbouring fields such as astroparticle physics and cosmology. Such support should extend also to high-performance computing and software development.*

Importance undisputed.
Wide range of support needed for theoretical physics.
Their contribution is essential for the next Strategy update!!!

Physics of Flavour and Symmetries

- Precision experiments are complementary to those at high energies in the search for new physics
- Proven track records for establishing the Standard Model
- Broad opportunities, current examples are
  - CERN, KEK: b, c, τ
  - IHEP (Beijing): c, τ
  - CERN, FNAL, JPARC, INFN-LNF: s
  - PSI, FNAL, JPARC: μ
  - CERN: $\bar{p}$

National Laboratories

Other scientific activities essential to the particle physics programme 2

h) Experiments studying quark flavour physics, investigating dipole moments, searching for charged-lepton flavour violation and performing other precision measurements at lower energies, such as those with neutrons, muons and antiprotons, may give access to higher energy scales than direct particle production or put fundamental symmetries to the test. They can be based in national laboratories, with a moderate cost and smaller collaborations. *Experiments in Europe with unique reach should be supported, as well as participation in experiments in other regions of the world.*

Other scientific activities essential to the particle physics programme 3

i) The success of particle physics experiments, such as those required for the high-luminosity LHC, relies on innovative instrumentation, state-of-the-art infrastructures and large-scale data-intensive computing. *Detector R&D programmes should be supported strongly at CERN, national institutes, laboratories and universities. Infrastructure and engineering capabilities for the R&D programme and construction of large detectors, as well as infrastructures for data analysis, data preservation and distributed data-intensive computing should be maintained and further developed.*

Ability to construct large detectors is non trivial.
Computing is added as a crucial item for the infrastructure.

Other scientific activities essential to the particle physics programme 4

j) A range of important non-accelerator experiments take place at the overlap of particle and astroparticle physics, such as searches for proton decay, neutrinoless double beta decay and dark matter, and the study of high-energy cosmic-rays. These experiments address fundamental questions beyond the Standard Model of particle physics. The exchange of information between CERN and ApPEC has progressed since 2006. *In the coming years, CERN should seek a closer collaboration with ApPEC on detector R&D with a view to maintaining the community's capability for unique projects in this field.*

Non-accelerator particle physics experiments are under astroparticle physics in Europe, including reactor neutrinos.

Other scientific activities essential to the particle physics programme 5

k) A variety of research lines at the boundary between particle and nuclear physics require dedicated experiments. *The CERN Laboratory should maintain its capability to perform unique experiments. CERN should continue to work with NuPECC on topics of mutual interest.*

CERN machines also serve for nuclear physics community
e.g. LHC, SPS, (HIE)ISOLDE, nTOF, …,
and should be continued.

Organisational issues 1

l) Future major facilities in Europe and elsewhere require collaboration on a global scale. *CERN should be the framework within which to organise a global particle physics accelerator project in Europe, and should also be the leading European partner in global particle physics accelerator projects elsewhere. Possible additional contributions to such projects from CERN's Member and Associate Member States in Europe should be coordinated with CERN.*

WG 2

Europe should be ready to participate in a large project taking place outside of Europe, if it happens.

Balance between the coherent European contribution and initiative of individual countries and lab's important.

WG 3

Organisational issues 2

m) A Memorandum of Understanding has been signed by CERN and the European Commission, and various cooperative activities are under way. Communication with the European Strategy Forum on Research Infrastructures (ESFRI) has led to agreement on the participation of CERN in the relevant ESFRI Strategy Working Group. The particle physics community has been actively involved in European Union framework programmes. *CERN and the particle physics community should strengthen their relations with the European Commission in order to participate further in the development of the European Research Area.*

Wider impact of particle physics 1

n) Sharing the excitement of scientific discoveries with the public is part of our duty as researchers. Many groups work enthusiastically in public engagement. They are assisted by a network of communication professionals (EPPCN) and an international outreach group (IPPOG). For example, they helped attract tremendous public attention and interest around the world at the start of the LHC and the discovery of the Higgs boson. *Outreach and communication in particle physics should receive adequate funding and be recognised as a central component of the scientific activity. EPPCN and IPPOG should both report regularly to the Council.*

WG 5

Produced recommendations to be considered by the relevant executive bodies for implementation.

Wider impact of particle physics 2

o) Knowledge and technology developed for particle physics research have made a lasting impact on society. These technologies are also being advanced by others leading to mutual benefits. Knowledge and technology transfer is strongly promoted in most countries. The HEPTech network has been created to coordinate and promote this activity, and to provide benefit to the European industries. *HEPTech should pursue and amplify its efforts and continue reporting regularly to the Council.*

WG 4

Produced recommendations to be considered by the relevant executive bodies for implementation.

Wider impact of particle physics 3

p) Particle physics research requires a wide range of skills and knowledge. Many young physicists, engineers and teachers are trained at CERN, in national laboratories and universities. They subsequently transfer their expertise to society and industry. Education and training in key technologies are also crucial for the needs of the field. *CERN, together with national funding agencies, institutes, laboratories and universities, should continue supporting and further develop coordinated programmes for education and training.*

Special educational aspect in engineering skills.

WG1

- WG1 made recommendations for the organisation and working practice for
  - Updating of the Strategy
  - Council Sessions dealing with the Strategy
  - Implementation and following-up of the Strategy

  based on the past operational experience since 2006.

⇒ The Council may consider putting some consideration.

Concluding recommendations

q) This is the first update of the European Strategy for Particle Physics. It was prepared by the European Strategy Group based on the scientific input from the Preparatory Group with the participation of representatives of the Candidate for Accession to Membership, the Associate Member States, the Observer States and of other organisations. Such periodic updates at intervals of about five years are essential. *Updates should continue to be undertaken according to the principles applied on the present occasion. The organisational framework for the Council Sessions dealing with European Strategy matters and the mechanism for implementation and follow-up of the Strategy should be revisited in the light of the experience gained since 2006.*