European Strategy for Particle Physics Update Process Status

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

ESG meeting

CERN, Geneva, 11 December 2012

T. Nakada

EPFL-LPHE

Lausanne, Switzerland

Scientific Secretary for Strategy Session of CERN Council

Chair of Strategy Group and Preparatory Group

Strategy Update where are we?

- Physics Briefing Book, pre-public version submitted to the Strategy Group for their drafting session of European Strategy Update on 8 December 2012 (also to SPC)
- Polished and updated version for printing will be released before the Erice meeting in January 2013
- Strategy drafting session by the Strategy Group 21-25 January 2013
- March Council week (18-22 March 2013) for discussion on the draft
- Special session of Council for adoption on 23 May 2013

Some issues from Briefing Book

- Introduction
  - Major scientific changes since 2006
    - Experience in LHC operation, both by the machine and experiments in p·p, Pb·Pb, p·Pb collisions
    - Discovery of Higgs like particle
    - Compelling sign of physics beyond the Standard Model neither from the direct search at high energy nor precision experiments so far
    - Third angle, θ_{13}, in the neutrino mixing found to be $\neq 0$
  - Major items where decisions are required (in random order)
    - LHC upgrade for 0.3 → 1 or 3 ab^{-1}
    - Short and long baseline neutrino facilities and experiments
    - Toward ILC under discussion in Japan
    - Needs for preparing for the decision process of the next large machine in Europe

Some issues from Briefing Book

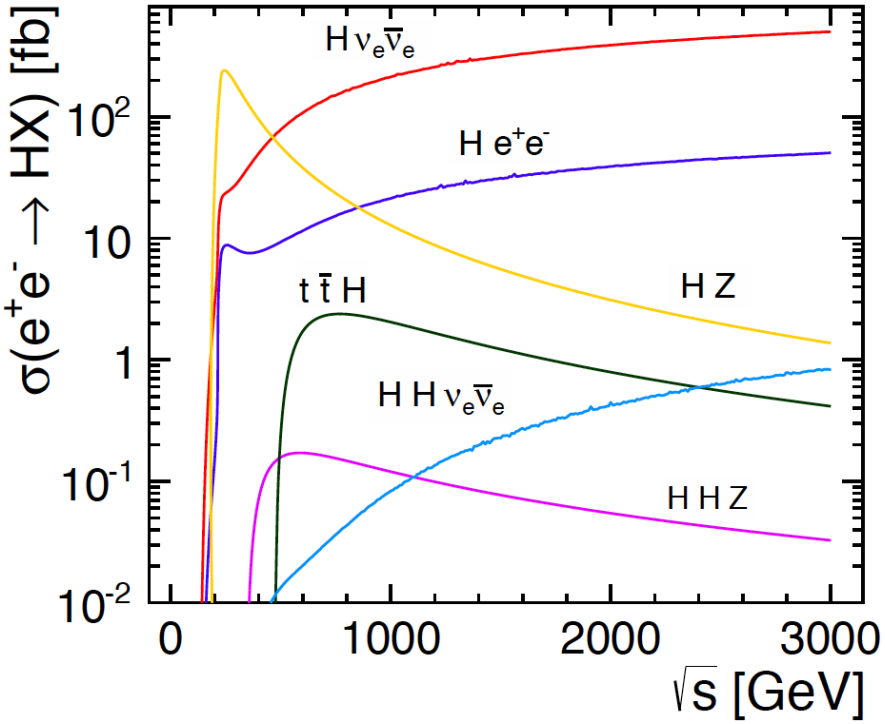
- High Energy Frontier (I)
  - ATLAS and CMS achievement
    - Standard Model Physics: QCD, top, W, and Z
    - Higgs studies: production and decays
    - Search for particles beyond the Standard Model
  - ATLAS and CMS prospects for short ($\int L dt = 0.3$ ab^{-1}) and longer term (1 to 3 ab^{-1})
    - Higgs studies and New Physics search
  - Achieving higher energies with 16 to 20 T dipoles
    - with the LHC tunnel: 26 to 33 TeV (HE-LHC)
    - New 80 Km circumference tunnel: 42 to 100 TeV (VHELHC)

Some issues from Briefing Book

- High Energy Frontier (II)
  - e^+e^- colliders
    - Higgs studies at $\sqrt{s} \approx 250$ GeV ($e^+e^- \rightarrow HZ$)
    - Higgs studies at much higher energies ($e^+e^- \rightarrow H\tau\tau$, HHZ, HH$\nu\nu$, …)
    - Trilinear and quartic gauge coupling
    - Top physics (mass in particular)
    - Search for weakly coupling SUSY particles
    - Linear colliders versus circular colliders
      - at lower energies, $L_{\text{circular}} > L_{\text{linear}}$
      - $\sqrt{s}$: circular limited to 350 GeV, linear > 500 GeV
      - many machines built for circular, only one for linear
      - paper/software studies for circular, TDR/CDR stages for linear
      - expandability: circular TLEP→VHELHC, linear 250→500→?
      - $\gamma\gamma$ collider: 2×125 GeV e^- + laser, limited to $\gamma\gamma \rightarrow H$

Some issues from Briefing Book

- High Energy Frontier (III)
  - Accessibility on Higgs physics by the e^+e^- machines depends on the energy



  - At LHC, all the processes are in principle accessible but some are limited by the statistics and background; e.g. coupling to c or H.

Some issues from Briefing Book

- High Energy Frontier (IV)
  - CDR for LHeC
    - LHC p/ion, + 60 GeV e from re-circulating lineac,
      L_{target} ($e^{-}p$) = 10^{33} $cm^{2}s^{-1}$
      running together with LHC from > 2025
    - PDF of p for the LHC relevant range
    - search for new particles (e.g. leptoquark)
  - Muon collider
    - multi TeV lepton collider with a “reasonable” size
    - neutrino factory as a possible intermediate stage

Some issues from Briefing Book

- Flavour and Precision Physics (I)
  - Look for Physics Beyond the Standard Model for quark and leptons via
    - Qualitative studies
      - search for forbidden processes in the SM, e.g. lepton number violation decays
      - search for processes at a well above the rate predicted by SM, e.g. neutron dipole moment
    - Quantitative studies
      - measure the SM parameters with an extremely high precision and look for a deviation, e.g. $\mu(g-2)$
    - Global studies
      - to measure same quantities with a good precision but in many different ways and test a consistency, e.g. CKM parameter studies
  - Potentially sensitive to energy scales much higher then direct searches.

Some issues from Briefing Book

- Flavour and Precision Physics (II)
  - Done at different energies with different facilities for
    - With existing facilities, e.g. LHC
    - With dedicated facilities, e.g. (Super) B factories
    - With high intensity beams at high energies, e.g. NA62
    - With high intensity beams at low energies, e.g. MEG
  - Results on B_s and D from LHCb do not show any compelling evidence for new physics.
  - Future requirements are (usually); clean measurements with high intensities→ accelerator and beam lines, detector and clever ideas
  - Interesting measurements can still be done with small to medium size investments → effort at national laboratories are also possible and on going

Some issues from Briefing Book

- Neutrino Physics (I)
  - Different neutrino sources have been used and contributed to the current results
    - cosmic (solar and atmospheric)
    - reactor
    - accelerator

    (and radioactive sources)
  - Recent highlight
    - $\theta_{13} \neq 0$ and appear to be the larger side, ≈ 0.1, major contribution by the reactor experiments

    allows a better definition for the next step

Some issues from Briefing Book

- Neutrino Physics (II)
  - Major remaining questions
    - mass hierarchy
    - CP violation in the neutrino oscillation
    - number of ν families 3?
    - m_ν Dirac or Majorana?
    - absolute mass scale of ν
    - and others…
  - New accelerator based facilities proposed in Europe to address the first three questions:
    - SBL and ICARUS+NESSIE at CERN
    - LBL at CERN and LAGUNA in Finish mine
      Other LBL ideas: source at ESS or IHEP (Protovino)

Some issues from Briefing Book

- Neutrino Physics (III)
  - Delicate questions are:
    - Competitions with ν's from cosmic, reactor and radioactive source
    - Competitions and collaborations with the Japan and US projects
      - Japan: Hyper K and JPARC upgrade
      - US: LBNE for long baseline
        Short base line programme
        νSTORM
      - HyperK the best CP, LBNO best mass hierarchy, LBNE needs to go underground and to build near detector then becomes competitive with LBNO.
    - Neutrino factory needed for systematic precision measurements of the mixing parameters (not just a qualitative discovery)

Some issues from Briefing Book

- Strong Interaction Physics
  - Parton Density Functions
    - At small and large x, and Q^2 evolution
      → Is LHeC needed for the future LHC data analysis?
      No clear conclusion reached.
    - Spin contents
      →Extracted beam from LHC?
  - Perturbative QCD
    - extensively studied at LHC and necessary for understanding of background for new particle search
  - Relativistic heavy ion physics
    - ALICE has now upgrade plan, with an experimental programme>2025 to increase substantially statistics for both soft and hard probs.

Some issues from Briefing Book

- Other topics covered are,
  - Astroparticle Physics relevant for particle physics,
  - Theoretical Physics in more organizational issues,
  - Accelerator Science identifying the challenges for the future machines and indicating needs of coordinated effort and networking on R&D
  - Instrumentation, computing and infrastructure addressing the future needs.

Preparation for the Updates

- Draft comes out after the Erice session should reflect the view of the member countries/council delegates, i.e. not be orthogonal to the view by the delegates.
- Country representatives of the Strategy Group should consult the government before the Erice meeting.
  ⇒ important for the March Council discussion
- Update should start from the current strategy statements: update and modify.

Current Strategy Statements

- General Issues
  - European particle physics is founded on strong national institutes, universities and laboratories and the CERN Organization; ***Europe should maintain and strengthen its central position in particle physics.***
  - Increased globalization, concentration and scale of particle physics make a well coordinated strategy in Europe paramount; ***this strategy will be defined and updated by CERN Council as outlined below***

Not much change needed…

Strategy Statements

- Scientific Issues
  - The LHC will be the energy frontier machine for the foreseeable future, maintaining European leadership in the field; ***the highest priority is to fully exploit the physics potential of the LHC, resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance. A subsequent major luminosity upgrade (SLHC), motivated by physics results and operation experience, will be enabled by focused R&D; to this end, R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.***

→LHC is running now and the base programme is up to ~300 fb^{-1}. Do we have scientific justification already now to upgrade machine and experiments for 1 to 3 ab^{-1}?

Strategy Statements

- Scientific Issues (continue)
  - In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; ***a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.***

→LHC results at ~13 TeV needed for the decision on the next large accelerator in Europe.

Strategy Statements

- Scientific Issues (continue)
  - It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; ***there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.***

→Japanese HEP community sees a window of opportunity for the next couple of years to host ILC. What is the European position toward this initiative? Is this an opportunity for a new worldwide facility, complementing a possible future machine at CERN without jeopardizing it?

Strategy Statements

- Scientific Issues (continue)
  - Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; ***Council will play an active role in promoting a coordinated European participation in a global neutrino programme***

→Now θ_{13} is measured. The necessary short term neutrino facilities and experiments are well defined and proposed. Should Europe build its own facilities (they are in principle within the European scope), or participate in those in other regions, i.e. in Japan (HyperK), and in US (LBNE and Short Baseline beams) to make them better?

Strategy Statements

- Scientific Issues (continue)
  - A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena; ***Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest.***

→Some concrete steps?

Strategy Statements

- Scientific Issues (continue)
  - Flavour physics and precision measurements at the high-luminosity frontier at lower energies complement our understanding of particle physics and allow for a more accurate interpretation of the results at the high-energy frontier; ***these should be led by national or regional collaborations, and the participation of European laboratories and institutes should be promoted.***

    →Need to be more explicit? e.g. exploitation of existing facilities, smaller scale experiments in lepton flavour violation, any new facilities required?

Strategy Statements

- Scientific Issues (continue)
  - A variety of important research lines are at the interface between particle and nuclear physics requiring dedicated experiments; ***Council will seek to work with NuPECC in areas of mutual interest, and maintain the capability to perform fixed target experiments at CERN.***

→Some concrete steps?

Strategy Statements

- Scientific Issues (continue)
  - European theoretical physics has played a crucial role in shaping and consolidating the Standard Model and in formulating possible scenarios for future discoveries. Strong theoretical research and close collaboration with experimentalists are essential to the advancement of particle physics and to take full advantage of experimental progress; ***the forthcoming LHC results will open new opportunities for theoretical developments, and create new needs for theoretical calculations, which should be widely supported.***

    →Some coordination needed for the area require resources, i.e. computing?

Strategy Statements

- Organisational Issues
  - There is a fundamental need for an ongoing process to define and update the European strategy for particle physics; ***Council, under Article II-2(b) of the CERN Convention, shall assume this responsibility, acting as a council for European particle physics, holding a special session at least once each year for this purpose. Council will define and update the strategy based on proposals and observations from a dedicated scientific body that it shall establish for this purpose.***

    →Not much change needed. Some details in the Deliberation Book.

Strategy Statements

- Organisational Issues (continue)
  - Future major facilities in Europe and elsewhere require collaborations on a global scale; ***Council, drawing on the European experience in the successful construction and operation of large-scale facilities, will prepare a framework for Europe to engage with the other regions of the world with the goal of optimizing the particle physics output through the best shared use of resources while maintaining European capabilities.***

→Not much change needed. Some details in the Deliberation Book.

Strategy Statements

- Organisational Issues (continue)
  - Through its programmes, the European Union establishes in a broad sense the European Research Area with European particle physics having its own established structures and organizations*; **there is a need to strengthen this relationship for communicating issues related to the strategy.***

→Update reflecting the current cooperation.

Strategy Statements

- Organisational Issues (continue)
  - Particle physicists in the non-Member States benefit from, and add to, the research programme funded by the CERN Member States; ***Council will establish how the non-Member States should be involved in defining the strategy***

→Update reflecting the modification of the current status.

Strategy Statements

- Complementary Issues
  - Fundamental physics impacts both scientific and philosophical thinking, influencing the way we perceive the universe and our role in it. It is an integral part of particle physics research to share the wonders of our discoveries with the public and the youth in particular. Outreach should be implemented with adequate resources from the start of any major project; ***Council will establish a network of closely cooperating professional communication officers from each Member state, which would incorporate existing activities, propose, implement and monitor a European particle physics communication and education strategy, and report on a regular basis to Council.***

    →Add "Communication"

Strategy Statements

- Complementary Issues (continue)
  - Technology developed for nuclear and particle physics research has made and is making a lasting impact on society in areas such as material sciences and biology (e.g. synchrotron radiation facilities), communication and information technology (e.g. the web and grid computing), health (e.g. the PET scanner and hadron therapy facilities); ***to further promote the impact of the spin-offs of particle physics research, the relevant technology transfer representatives at CERN and in Member states should create a technology transfer forum to analyse the keys to the success in technology transfer projects in general, make proposals for improving its effectiveness, promoting knowledge transfer through mobility of scientists and engineers between industry and research.***
    →No real change needed.

Strategy Statements

- Complementary Issues (continue)
  - The technical advances necessary for particle physics both benefit from, and stimulate, the technological competences available in European industry; ***Council will consolidate and reinforce this connection, by ensuring that future engagement with industry takes account of current best practices, and continuously profits from the accumulated experience.***

    →No real change needed.

Outline of Erice agenda

- Monday, 21
  - 9:00-13:00
    - welcome
    - last minutes physics updates (S. Bertolucci)
    - comments from SPC (F. Zwirner)
    - comments from the community via ECFA (M. Krammer)
    - work plan for the week
  - 15:00-19:00
    - discussion on scientific issues
- Tuesday, 22
  - 9:00-19:00
    - Working groups activities on organisation, governance, external relation, knowledge transfer, communication and outreach.

Outline of Erice genda

- Wednesday 23
  - 9:00 - 13:00
    - discussion on the contents of the deliberation document for organization, governance, external relation, knowledge transfer, communication and outreach matters
  - afternoon
    - free time to explore Erice
- Thursday 24
  - 9:00 - 19:00
    - Discussion on the rational for the scientific strategy choices
- Friday 25
  - 9:00 - <24:00
    - Drafting of the strategy statements

Very Important Point

- Strategy statements needs to be adopted by the Council in May in a ceremonial way, after the discussion in March
  - Country representatives of the Strategy Group are expected to reflect on the views by the government and community of their countries.
  - Please consult the relevant bodies to gather and to distil opinions before coming to Erice so that your contributions to the strategy discussion will be inline with the view of the country.