SPC discussion on the Council question concerning the CERN involvement in high energy frontier machines and related R&D
-Stats Report-

On behalf of SPC

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e) Complementary Higgs precision study by an e^+e^- collider (for the ILC, "*Europe looks forward to a proposal from Japan to discuss a possible participation*")

NB: d) is for the neutrino activities

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- No compelling indication of beyond the Standard Model predictions in any other precision measurements.

Energy frontier projects now…

- LHC exploitation:
  - High Lumi LHC is in progress and integrated in the MTP
  - High Energy LHC is part of FCC-hh studies and an interesting "short term" option as a direct discovery machine depending on the 13(4) TeV data outcomes
- Lepton colliders as a direct discovery machine
  - ILC: **Sensitivities** up to ~250 GeV (with ~500 GeV potential)
  - CLIC: **Sensitivities** up to ~1 TeV
  - Muon Collider: not considered by the ESG
    Sensitivities up to multi TeV

  with decreasing technical maturity
- Hadron collider at $\sqrt{s} = O(100\ \text{TeV})$ as a direct search machine
  - FCC-hh
  - SPPC

  Sensitivities beyond $O(10\ \text{TeV})$

Energy frontier projects now…

- Lepton colliders as a Higgs factory
  - ILC: from ZH^0 ($\sqrt{s}\approx250$ GeV) to $\bar{t}tH^0$ ($\sqrt{s}\approx500$ GeV) (including $\bar{t}t$)
  - CLIC: not yet optimized for low energies (foreseen by the time of CDR)
  - FCC-ee: from Z to ZH^0 up to $t\bar{t}$ threshold ($\sqrt{s}\approx350$ GeV)
  - CEPC: emerged after ES-update, basically similar to FCC-ee
  - Muon Collider: *s*-channel H^0 production ($\sqrt{s}\approx125$ GeV)

Observations

- Circular e^+e^- colliders
  - The highest luminosity machine at ZH^0, provide $O(10^{12})$
  - Z for precise electroweak test (for this alone, rings can be smaller).
  - Energy limited to ~$t\bar{t}$ threshold without expandability.
- Linear e^+e^- colliders
  - Provide adequate number of H^0 for meaningful Higgs precision studies to search for new physics indirectly.
  - New technology able to extend energies reflecting the physics needs.

Observations

- ILC is technically at the most advanced stage, ready to proceed as a construction project, if approved.
- CLIC is preparing for the TDR for the next Strategy Update in ~2018 with a cost estimate. The currently foreseen resources in the MTP is sufficient for this goal
  - Key R&D: high gradient and efficient acceleration
- FCC is preparing for the CDR for the next Strategy Update in ~2018 with a cost estimate. The currently foreseen resources in the MTP is sufficient for this goal
  - Key R&D: high field magnet for basic technology, mass production and cost reduction issues
  - Another important issue: civil enginerring cost

Observations

- Muon collider
  - Particularly interesting window of opportunity in the multi TeV (beyond CLIC) **sensitivity** range
  - As a Higgs factory, superior measurements for the mass and coupling to the muons, while other measurements are less good than e^+e^- colliders due to statistics.
  - Simulation studies show its feasibility. Little hardware effort made so far. R&D on the full chain, e.g. source, cooling, rapid acceleration, storage ring with high background due to the muon decays, etc., still needed.
  - Muon collider activities in the US is ramping down

Info. (P5 recommendations)

- Re-align activities in accelerator R&D, which is critical to enabling future discoveries, based on new physics information and long-term needs (see below, Enabling R&D recommendations). Specifically, reassess the Muon Accelerator Program (MAP), incorporating into the general accelerator R&D program those activities that are of broad importance to accelerator R&D, and consult with international partners on the early termination of Muon Ionization Cooling Experiment (MICE). In addition, in the general accelerator R&D program, focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid- and far-term accelerators.

Reflections

- The European Strategy still provides a valid guideline. Thus, preparation for the next Strategy update inline with the Strategy should be the CERN's highest priority:
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  i.e. TDR for CLIC and CDR for FCC
- Muon collider becomes interesting if new physics emerges in a region of several TeV. Rigorous R&D plan with well defined timeline supported by European groups together with international partners will be welcome.
- Development in China (CEPC and SPPC) and Japan (ILC) should be carefully followed