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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Current European Strategy

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d) Preparation to propose the next energy frontier machine for the next strategy update (~2018), with the full energy LHC results in hand (pp and e⁺e⁻ colliders for direct and indirect search for new physics)
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d) Preparation to propose the next energy frontier machine for the next strategy update (~2018), with the full energy LHC results in hand (pp and $e^+e^-$ colliders for direct and indirect search for new physics)

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 $\sim 250$ GeV (with $\sim 500$ GeV potential)
  – CLIC: **Sensitivities** up to $\sim 1$ TeV
  – Muon Collider: not considered by the ESG
    **Sensitivities** up to multi TeV
    with decreasing technical maturity

• Hadron collider at $\sqrt{s} = O(100$ TeV) as a direct search machine
  – FCC-hh
  – SPPC
    **Sensitivities** beyond $O(10$ TeV)
Energy frontier projects now...

- Lepton colliders as a Higgs factory
  - **ILC**: from $ZH^0$ ($\sqrt{s} \approx 250$ GeV) to $\bar{t}tH^0$ ($\sqrt{s} \approx 500$ 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 $\bar{t}t$ threshold ($\sqrt{s} \approx 350$ GeV)
  - **CEPC**: emerged after ES-update, basically similar to FCC-ee
  - **Muon Collider**: $s$-channel $H^0$ production ($\sqrt{s} \approx 125$ 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 $\sim t\bar{t}$ 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 engineering 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

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• Development in China (CEPC and SPPC) and Japan (ILC) should be carefully followed