INFN Accelerator studies for the upcoming European Strategy for Particle Physics

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Future Circular Colliders – Expanding our Horizons

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European Strategy for Particle Physics

- INFN key player for the process of the European Strategy for Particle Physics (ESPP), initiated by the CERN Council in 2005, with successive updates in 2013 (Cracow, PL) and 2019 (Granada, ES).
- Next edition of the ESPP expected in 2025/26. This appointment is crucial for the future of High-Energy Physics (HEP), in Europe and in the world.
- As in previous ESPP editions, studies of future accelerators needed to fully exploit the HEP programme of next decades are crucial for deciding about new facilities.
- FCC represents the baseline of the next HEP accelerator at CERN, and its feasibility will be scrutinised in depth in occasion of the next ESPP
- ➔ it is crucial to perform the work needed to meet this goal

2020 Update of the European Strategy for Particle Physics

- The 2020 Update of the European Strategy for Particle Physics is available in two CERN Council documents, CERN-ESU-013 and CERN-ESU-014
- Main points follow
- *An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology*:
  - *the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;*
  - ***Europe**, together with its international partners, **should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage**. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.*
  - *The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.*

2020 Update of the European Strategy for Particle Physics

Halina Abramowicz (Tel Aviv University) Secretary of the Strategy Update 19/06/2020 CERN Council Open Session

Accelerator R&D is crucial to prepare the future collider programme

- The European particle physics community should develop an accelerator R&D roadmap focused on the critical technologies needed for future colliders, maintaining a beneficial link with other communities such as photon or neutron sources and fusion energy
- The roadmap should be established as soon as possible in close coordination between the National Laboratories and CERN
- A focused, mission-style approach should be launched for R&D on high-field magnets (16 T and beyond) including high-temperature superconductor (HTS) option to reach 20 T. CERN's engagement in this process would have a catalysing effect on related work being performed in the National Laboratories and research institutions
- The roadmap should also consider: R&D for an effective breakthrough in plasma acceleration schemes, an international design study for a muon collider and R&D on high-intensity, multi-turn energy-recovery linac (ERL) machines

ECFA Laboratory Detector Group (LDG): we have five R&D areas:

1. **Magnets**
2. **RF**
3. **Laser/Plasma**
4. **Muons**
5. **ERLs**

(see talk by Dave Newbold at the last ECFA Open meeting)

Organizing the INFN effort for the next ESPP - 1

- Many INFN researches are already producing a lot of effort for FCC and other proposed future accelerators; however, in order to be incisive, INFN thought to set a work programme to best prepare the contribution for the next ESPP.
- Around the end of 2021, the INFN Management initiated a process, following a bottom-up approach:
  - to foster contributions to future accelerator studies,
  - to organise and harmonise this work and to maximise synergies
  - to supports with adequate financial and human resources those projects targeting next ESPP
  - and to identify possible collaborations with international research institutes

Organizing the INFN effort for the next ESPP - 2

This plan is developing around the following milestones:

- call a national workshop on FCC inviting in particular interested researchers to meet and to show their interests, the work on-going and the work planned in view of the next ESPP
- Map the on-going efforts, and those proposed, in areas of activity collecting in the same area R&D studies with similar workplan
  - As part of the ESPP, these should include also the Muon Collider studies
  - This helps to tighten collaboration between groups

The FCC Worshop in Rome

- FCC Overviews presented by M. Benedikt and F. Zimmermann
- Reports on FCC-ee and FCC-hh machine studies
  - These includes presentations on RF and SRF Cavities
- Included reports on Detector R&D and Physics simulation studies

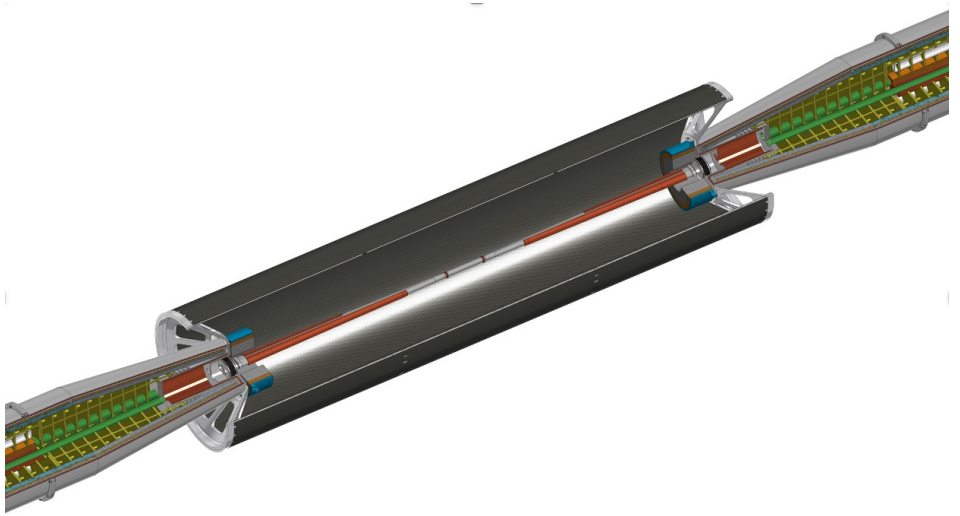
Areas of interest

- Machine Detector Interface (MDI) and Beam Injector studies for FCC-ee
  - Agreements between INFN and CERN on MDI studies and the beam injector for FCC-ee
  - Proceed now with studies made with a mock-up

  INFN divisions involved: LNF, GE, LNL, RM1, MI, PI, PD
- MDI + final cooling studies for the Muon Collider

  INFN divisions involved: MI, TO, RM1, LNL, LNS, PD
- Studies of RF Cavities, normal and superconducting
  - Activity on SRF cavities High-Q/High-G, 1.3 GHz monocell → multicell, required by many future colliders, including FCC-ee, Muon Collider, ILC,
  - Normal Conductive RF cavities for the Muon Collider

  INFN divisions involved: Milano, LASA, LNL



Muon collider (to be defined):

- **E_{goal} = 30 MV/m**, 1.3 GHz, pulsed op., high average beam current (**2 X 20 mA**), HOM issue

ILC:

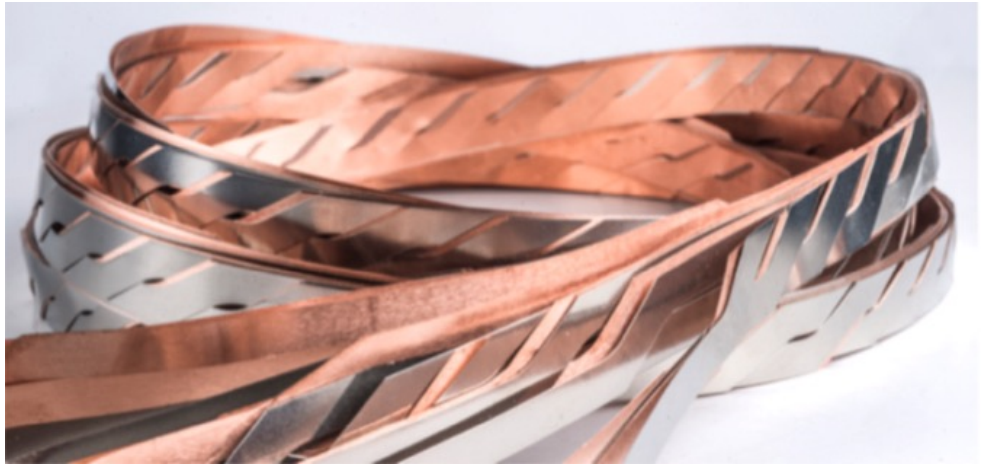
- **E_{goal} = 35 MV/m @ Q0 ≥ 0.8 e10** (E_{goal} = 38.5 MV/m @ Q0 ≥ 1.6 e10 for cost red.), 1.3 GHz, pulsed op.

➔ **Important synergy between FCC, Muon Collider and ILC R&D studies**

Areas of interest

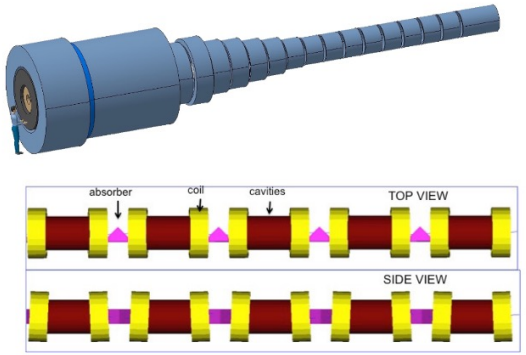
- Studies of Low-Field and High-Field Magnets with HTS technologies; relevant for FCC-hh but also for the Muon Collider
  - It is emerging a very interesting synergy with the Muon Collider activity and it may boost HTS studies, essential for FCC-hh
  - Agreement between INFN and CERN on the construction in Italy of demonstrator/model cos(theta) dipole able to reach 14 T (FalconD; using the Rutheford Nb_3Sn cable)
  - Italian research programme IRIS (funded with EU funds, *European Recovery Plan*) also important for the study of HTS cables

INFN divisions involved: Milano, LASA, Genova



Solenoid zoo for Muon Collider

- Target solenoid
  1.5 m 20 T 2MW
- Muon cooling
  1km 2 T to14 T
- Final cooling
  8.5 m – 40 T or 60 T



➔ **Important synergy between FCC and Muon Collider ILC R&D studies**

What we have done so far

- Put together these groups, we met with them, discussed their projects
- Performed an initial “screening” of these projects, discussed their goals and their timeline, to plan for results on time for the next ESPP

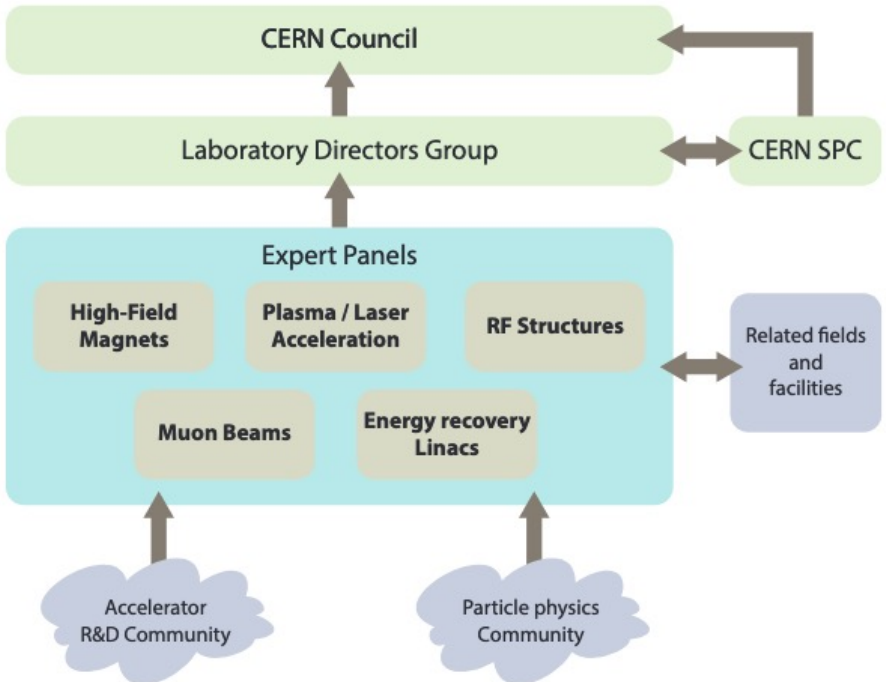
Next steps

- We’re about to ask document from each group for an internal review (by a Review Panel) to analyse the project proposed, the available resources, the requested resources and the international collaborations proposed
- Perform the internal review and assign human and financial resources following the recommendation of the Review Panel
- … then do the work!

backup

Motivation and Scope

- European Strategy contains clear recommendations on accelerator R&D:
  - *The particle physics community should ramp up its R&D effort focused on advanced accelerator technologies.*
  - *The European particle physics community must intensify accelerator R&D and sustain it with adequate resources; a roadmap should prioritise the technology.*
  - *Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.*



- Key messages
  - Implementation is now under way
  - Need to maintain focus on delivery of the future facilities for PP
    - Inlcuding any intermediate benefits of new technologies
  - Ongoing engagement of the wider PP community is key

Coordination Panel Leadership

- HFM
  - Mike Lamont (CERN)
  - Pierre Vedrine (IRFU)
- RF
  - Giovanni Bisoffi (INFN Padova)
  - Peter Mcintosh (DL)
- LPA
  - Wim Leemans (DESY)
  - Rajeev Pattahill (RAL)
- Muons
  - Steinar Stapnes (CERN)
  - Daniel Schulte (CERN)
- ERL
  - Jorgen D'Hondt (VUB)
  - Max Klein (U. Liverpool)

- Nominations invited from laboratories and funding agencies
  - Sought to identify strong technical leadership, with a proper national balance
  - Where a formal collaboration was already in place, names were drawn from the leadership bodies of the collaboration
- These people are now all in place and working (hard)
  - Please feel free to address comments / questions / inputs directly to them