Summary of ECFA-wide event and next steps

Future colliders for early-career researchers in Belgium and the Netherlands

Armin Ilg (University of Zürich)
On behalf of the
ECFA Early-Career Researchers Panel

2020 Update of the European Strategy for Particle Physics (ESPP)

Year-long process, 20 strategy statements

3.a: 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:

7.b: Particle physics, with its fundamental questions and technological innovations, attracts bright young minds. Their **education and training** are crucial for the needs of the field and of society at large. For **early-career researchers** to thrive, the particle physics community should place strong emphasis on their **supervision and training**. Additional measures should be taken in large collaborations to **increase the recognition of individuals developing and maintaining experiments, computing and software**. The particle physics community commits to placing the principles of **equality, diversity and inclusion** at the heart of all its activities.

Short history of ECFA ECR

The ECFA ECR panel was created as a follow-up to the ECFA Early-Career Researchers response to the 2020 Update of the European Strategy for Particle Physics (rather ad-hoc, not a panel)

*The objective of the ECFA Early-Career Researchers (ECR) Panel is for its members to discuss **all aspects** that contribute in a broad sense to the **future of the research field of particle physics**. In its advisory role to ECFA, the panel reports to ECFA on a regular basis. An annual report of the ECFA ECR Panel is added as a standing item to the agenda of Plenary ECFA meetings.*

→ The ECFA ECR panel is tightly linked with the Update of the European Strategy → We'll be in the loop from the beginning next time!

Future colliders WG

Goal: Inform ECRs about future collider options and development, enabling them to shape their own vision on future colliders

***Future colliders for early-career researchers*, 27th of September 2023**

Short presentations on prospects, lots of time for discussions. Can serve as reference information for ECRs.

→ Almost one hundred in-person participants, > 100 on Zoom

Summary of CERN event

https://arxiv.org/abs/2407.01852

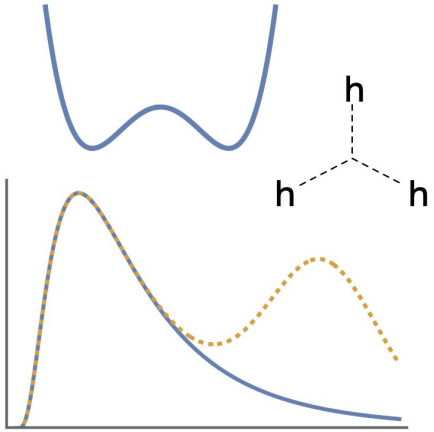
Key message 1: Communicating need for future colliders

Summary

Exciting times ahead if a future collider is built!

- Guaranteed deliverables:
  - Precision measurements
  - Higgs self-coupling
- Potential direct discoveries

Anke Biekoetter



There are guaranteed discoveries!

- Learn how to communicate importance of precision

Future colliders are worth it

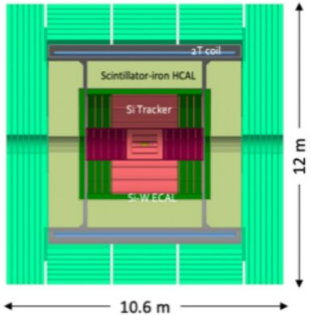
- For science and society

See sustainability not as a concern but as a challenge

- To develop technologies relevant for society

Key message 2: Knowledge transfer and collaboration

CLD



https://arxiv.org/abs/1911.12230 and FCC CDS vol. 2

Well established design
- ILC -> CLIC detector -> CLD

Full Si vtx + tracker; CALICE-like calorimetry; large coil, muon system

Engineering and R&D needed for
- reduction of tracker material budget
- operation with continous beam (no power pulsing: cooling of Si sensors for tracking + calorimetry)

Possible detector optimizations
- Improved σ_p/p, σ_E/E
- PID: timing and/or RICH?

- Had participants from all future collider communities at our workshop
  - Open and creative exchange of ideas beyond various borders
- Future collider R&D is highly transferable from one collider proposal to another (and beyond)
  - Good ideas will survive a collider or two…

Good reasons for everyone to work on future colliders!

And even muon collider now!

Mogens Dam and Nadia Pastrone

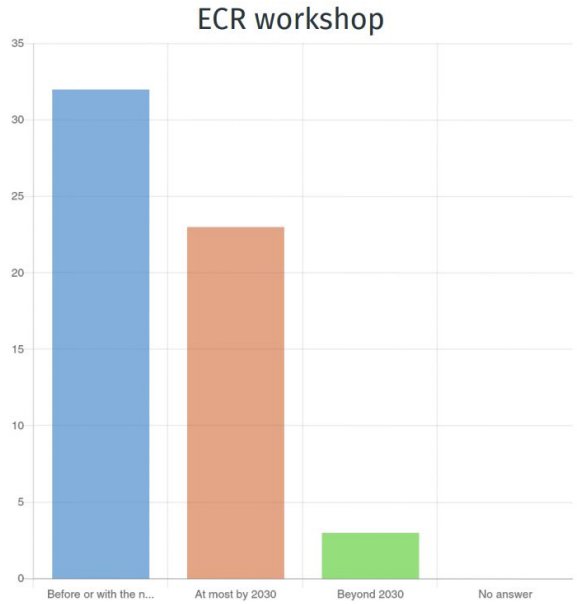
Key message 3: Enabling careers on future colliders

It’s a long time until any future collider is operational

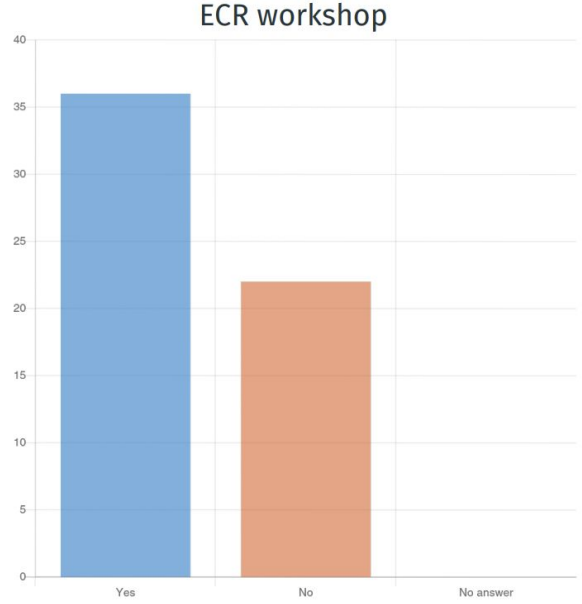
- Take future collider decision as early as possible
  - To give ECRs a concrete goal and timeline
  - To ease applying for grants
- Long-term R&D projects and support for careers in instrumentation
  - DRD Collaborations look very promising!
- Mind the gap!
  - Intermediate projects delivering data before future collide is ready or to complement future collider work

CERN and ECR Workshop survey (full presentation here)

In light of your career prospects, how long do you think it is acceptable to wait before the decision of which machine to build is made



Would you accept to work nearly full time on a project connected to a future collider, while the decision on the next machine is still pending? If yes, under which conditions



CERN event: Conclusions (see report)

Specifically for ECRs, the future HEP machine should emphasize the continuity of the physics program, to bridge the gap to HL-LHC and provide exciting project opportunities to younger scientists. Transferability of skills and knowledge, as well as expertise across the field, should be encouraged both at the scientific and political levels, in connection also to improving the current status of very short-term jobs and positions for young researchers. Moreover, an early, clear, and determined decision regarding which future machine will be built can only have positive effects on the ECRs community as well as on the whole field of particle physics as it will give a strong incentive to work towards a project that has high chances of being realized. … We, therefore, believe that the highest priority and importance has to be given to the choice of the future HEP machine, that this choice has to be made as soon as possible in the most informed way to minimize the negative impacts on ECRs careers and maximize the physics and discovery opportunities, thereby providing a clear direction for the future of our field.

ECFA ECR letter to March 2024 CERN Council (see also our report)

Dear CERN Council,

In the 70 years since its founding, CERN has not only established itself as the global centre of particle physics research but as a powerful symbol of international collaboration and scientific excellence. This would never have been possible without the unfaltering support offered by the CERN member states.

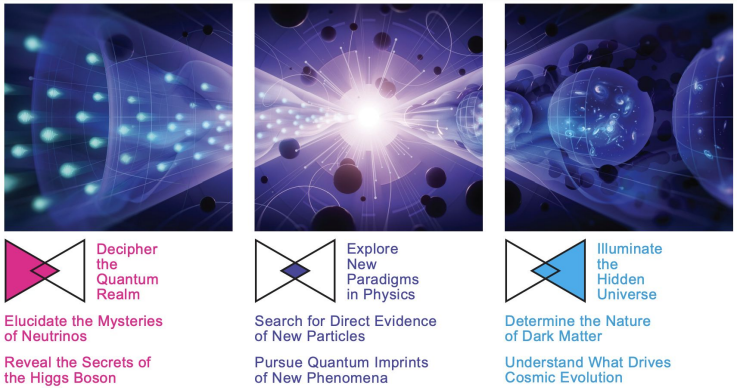
As a community, we feel immense pride and gratitude that we are part of this journey of scientific exploration and opportunity which CERN has pioneered. While the High-Luminosity LHC constitutes a much-anticipated and necessary advance in the LHC program, a clear path beyond it for our future in the field must be cemented with as little delay as possible. For the field to sustain the population, expertise, and enthusiasm required to overcome the challenges of what CERN's next major project/accelerator will present, the ECR community needs certainty without delay that High Energy Physics has an immediate future beyond HL-LHC, and that funding and positions required to realise our future will grow rapidly.

We, the ECFA Early-Career Researchers Panel, on behalf of the ECR community, would like to strongly urge the Council to make every effort to ensure that the process of evaluating, selecting and implementing potential future projects, which will define this century of High Energy Physics for Europe and the World, proceed with as quick a pace as possible, accelerating its time frame to start the European strategy process as early as possible and conclude by early 2026. This will go some way in helping further secure CERN's unique position in science, technology and international cooperation for the next 70 years and beyond.

Kind regards,

The ECFA Early-Career Researchers panel

What happened since CERN event



- Dec. 2023: US strategy culminating in P5 report
  - *… an off-shore Higgs factory … The current designs of the FCC-ee and ILC meet our scientific requirements*
  - *… vigorous R&D towards a cost-effective* 10 TeV pCM collider *… long-term ambition of hosting a major international collider facility in the US …* ***This is our Muon Shot***
- Dec. 2023: CEPC accelerator TDR, strong support from Chinese HEP community
  - What does this mean for FCC-ee? → F. Gianotti in Jan. 2024 meeting to CERN personnel: *Should we change our plans?* ***NO***. Should we accelerate our planning? ***YES***
- Feb. 2024: FCC Feasibility Study mid-term report released (not publicly)
  - Positively received by CERN Council
  - To finish by end of 2024
- April 2024: Joint Statement of Intent between The USA and CERN
  - *… continue to collaborate in the feasibility study of the Future Circular Collider Higgs Factory (FCC-ee) …*
  - *… should the CERN Member States determine the FCC-ee is likely to be CERN's next world-leading research facility following the HL-LHC, the US intends to collaborate on its construction and physics exploitation, subject to appropriate domestic approvals.*

European Particle Physics Strategy Update

European Particle Physics Strategy Update

28th of March, mail by Eliezer Rabinovici, President of CERN Council

On 21 March 2024, the CERN Council decided to launch the process for updating the European Strategy for Particle Physics. I am pleased to announce that the ***deadline for submitting written input*** *has been set for* ***31 March 2025****, with a view to* ***concluding the European Strategy update process in June 2026*** *…*

→ Earlier start and end then what was previously expected!

What's the scope?

… the Strategy should aim to develop a visionary and concrete plan that greatly advances knowledge in fundamental physics **through the realisation of the next flagship project at CERN**. This plan should attract and value international collaboration and allow Europe to continue to play a leading role in the field.

Regarding a future collider project, the Strategy update should include the **preferred option for the next collider at CERN** and **prioritised alternative options** to be pursued if the preferred plan turns out not to be feasible or competitive.

Timeline and structure

9 WGs:

- EW/Higgs Physics
- Strong Interaction
- Flavor Physics
- BSM
- Neutrino Physics and Cosmic Messengers
- DM and Dark Sector
- Accelerator Science and Technology
- Instrumentation
- Computing

1 ECR scientific secretary for each WG

- Anyone can submit input to the strategy (31st of March)
  - Future collider communities
  - E.g. ECFA countries, collaborations, … → use this chance!
  - And us!

Early-career researcher white paper input

This time we want to give input to the strategy (not respond to its results)

- Open to anyone, beyond our ECFA ECR panel
- First hybrid town-hall meeting at 3rd ECFA Workshop on $e^{\pm}e^{-}$ Higgs/EW/top factories in Paris, 9-11. October 2024
  - Discuss topics to be addressed
  - Work in ad-hoc WGs
- Second hybrid town-hall meeting adjacent to Plenary ECFA meeting 14-15. November 2024 at CERN
- Draft of ECR white paper until ~end of January
  - Endorsement by ECFA ECR panel, upload to arXiv, submission to Strategy

Join us! → Subscribe to esppu-ecr@cern.ch e-group!

Concluding words

Today's ECRs are the leaders of the experiments and theoretical efforts of tomorrow

- Discuss aspects of future colliders especially relevant to ECRs
  - e.g. compatibility with ECR careers

Keep in touch with us

- Our webpage to find your country ECR representative
- ecfa-ecr-organisers@cern.ch
- Subscribe to ecfa-ecr-announcements e-group to get notified about our activities!

Thanks!

What will happen? I don’t know ;-)

ECFA ECR Panel composition and activities

Members are, in general, ***PhD students and postdocs, either with a non-permanent contract or with up to eight years after obtaining the PhD****. Up to* ***three members*** *(+1 for countries with LDG lab), among them at least one PhD student and one postdoc, can be nominated* ***by each ECFA country*** *represented in ECFA for a* ***mandate of two years****,* ***extendable for another two years****. Nominations are to be endorsed by Plenary ECFA. Members act as individuals, but should be able to represent the views of early-career researchers in particle physics in the nominating country.*

- From PhD students to young assistant professors
- Theoreticians, phenomenologists, experimentalists, …
  → Diversity in cultural background, career and research, try to represent the community
- 3 members per country (+1 if LDG lab in country)
  - Belgium: Anna Bennecke, Kirill Skovpen
  - Netherlands: Andrea Garcia Alonso, Andrii Usachov, Zef Wolffs, Lydia Brenner (NIKHEF)
- Organization Committee (Marko Pesut, Jan-Hendrik Arling, Arnau Morancho Tarda)
- 5 delegates in Plenary ECFA (Andrea Garcia Alonso, Lydia Brenner, Patrick Dougan, A.I, Holly Pacey), 1 delegate in Restricted ECFA (Lydia Brenner)
- Actual work is done in **working groups** that are flexible

Role of ECRs for future colliders

The future is ours - Eliezer Rabinovici, President of the CERN Council

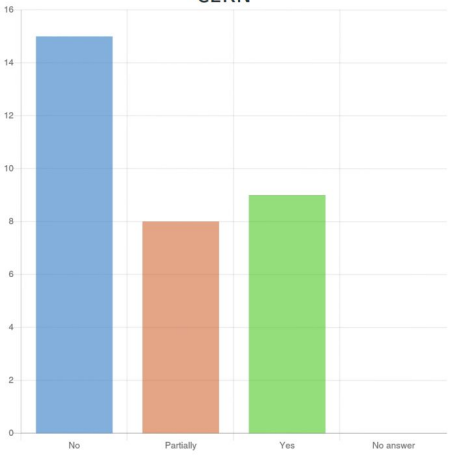
Long time scales of future collider proposals mean that most researchers in charge of decisions now will not be around anymore to build and operate the experiments and analyse their data.

ECRs have to shape their own vision of the future of our field

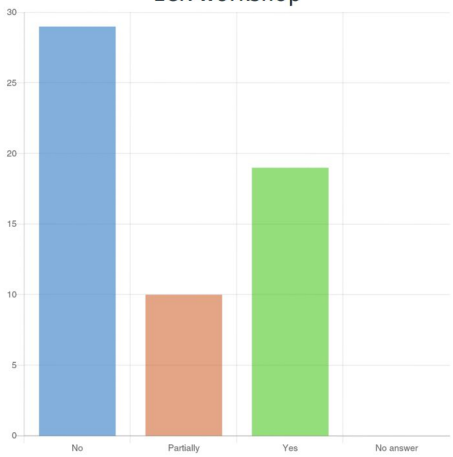
CERN and ECR Workshop survey (full presentation here)

- Are you currently working on projects connected to future colliders?

CERN



ECR workshop

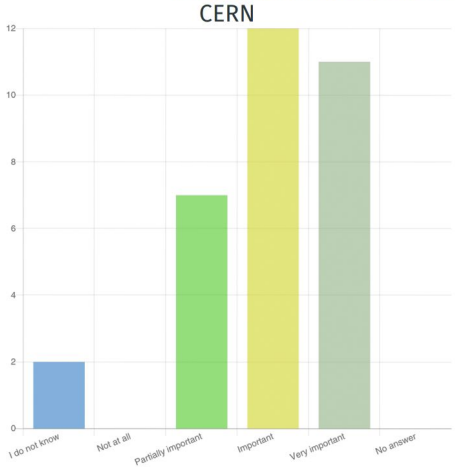


- Majority already working (partially or fully) on future collider projects

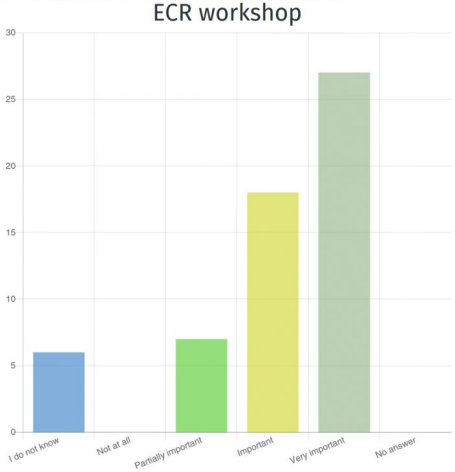
- Majority already working (partially or fully) on future collider projects

- How important is the future collider programme for your career?

CERN



ECR workshop



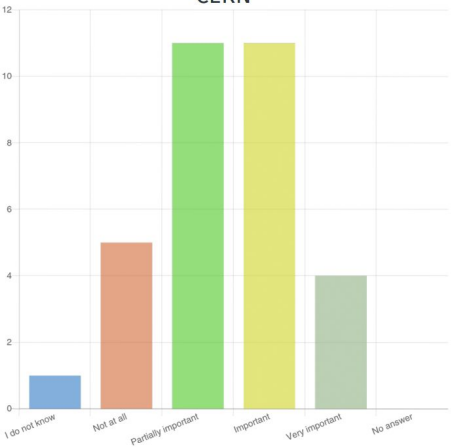
- A future collider program is considered important by (almostt) everyone

- A future collider program is considered important by (almost) everyone

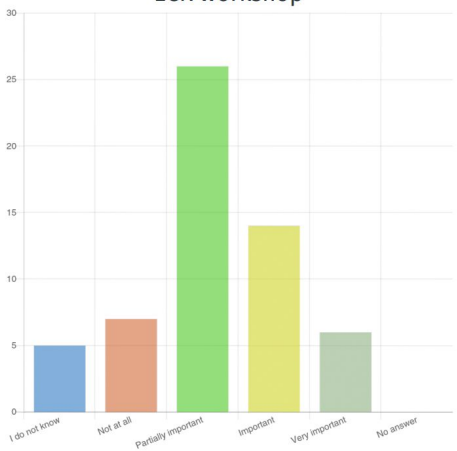
CERN and ECR Workshop survey (full presentation here)

- Is the choice of a specific future collider over another important for your career?

CERN



ECR workshop

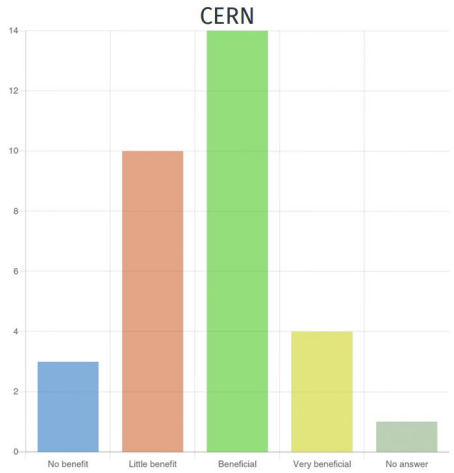


- The choice of the collider seems to matter, in part or completely

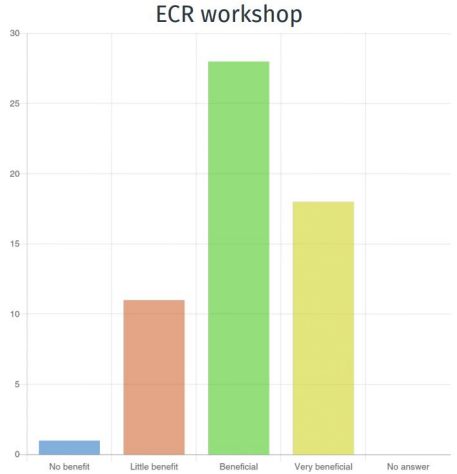
- The choice of the collider seems to matter, in part or completely

- Do you consider including future-collider related projects in your activities as beneficial to your career?

CERN



ECR workshop



- Sizable 'little benefit' choice

- More positive outlook

From ECFA to the national communities

- Follow-up the ECFA-wide event with national, in-person events on future colliders, directing discussions into the ECFA countries as some issues are country dependent
  - Also inspired by UK Future Collider town-hall
- Came up with blueprint for national Future Colliders for Early-Career Researchers events
  - Nordic countries, Austria, Czech Republic, Czech Republic+Slovakia, Germany, Italy,
  - Belgium+Netherlands!

CEPC

Current plans
- ❑ TDR release: Dec 2023
- ❑ Engineering Design Report: 2024-2027
- ❑ Application for 5-year funding: 2025
- ❑ Construction: 2027-2035
- ❑ Start of operation: 2036

- CEPC Accelerator TDR released end of December 2023
- What does this mean for other future colliders? -> F. Gianotti in Jan. to CERN personnel

1) Only a new European Strategy can modify the plans of a previous one, taking into account Europe's ambitions within the global context (e.g. P5/US support for an off-shore Higgs factory, CEPC in China, etc.)

2) Recommendation of 2020 European Strategy for future colliders:
"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."
Note: the Strategy does not state that a Higgs factory should be built in Europe. However, a Higgs factory is the highest priority for the European community → wherever it will be built, it should allow for significant participation from Europe

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Should we change our plans ? NO

Should we accelerate our planning ? YES
→ CERN Directorate will discuss these matters with the CERN Council in the coming months

C

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Exploring the Quantum Universe

Recommendation 2

Rank-Ordered

a. **CMB-S4**, which looks back at the earliest moments of the universe to probe physics at the highest energy scales. It is critical to install telescopes at and observe from both the South Pole and Chile sites to achieve the science goals (section 4.2).

b. **Re-envisioned second phase of DUNE** with an early implementation of an enhanced 2.1 MW beam—ACE-MIRT—a third far detector, and an upgraded near-detector complex as the definitive long-baseline neutrino oscillation experiment of its kind (section 3.1).

c. **An off-shore Higgs factory**, realized in collaboration with international partners, in order to reveal the secrets of the Higgs boson. The current designs of FCC-ee and ILC meet our scientific requirements. The US should actively engage in feasibility and design studies. Once a specific project is deemed feasible and well-defined (see also Recommendation 6), the US should aim for a contribution at funding levels commensurate to that of the US involvement in the LHC and HL-LHC, while maintaining a healthy US on-shore program in particle physics (section 3.2).

d. **An ultimate Generation 3 (G3) dark matter direct detection experiment** reaching the neutrino fog, in coordination with international partners and preferably sited in the US (section 4.1).

e. **IceCube-Gen2** for study of neutrino properties using non-beam neutrinos complementary to DUNE and for indirect detection of dark matter covering higher mass ranges using neutrinos as a tool (section 4.1).

Exploring the Quantum Universe

Recommendation 4

Not Rank-Ordered

a. Support **vigorous R&D toward a cost-effective 10 TeV pCM collider** based on proton, muon, or possible wakefield technologies, including an evaluation of options for US siting of such a machine, with a goal of being ready to build **major test facilities and demonstrator facilities within the next 10 years** (sections 3.2, 5.1, 6.5, and Recommendation 6).
b. Enhance research in **theory** to propel innovation, maximize scientific impact of investments in experiments, and expand our understanding of the universe (section 6.1).
c. Expand the **General Accelerator R&D (GARD)** program within HEP, including stewardship (section 6.4).
d. Invest in R&D in **instrumentation** to develop innovative scientific tools (section 6.3).
e. Conduct **R&D** efforts to define and enable new projects in the next decade, including detectors for an e^+e^- Higgs factory and 10 TeV pCM collider, Spec-S5, DUNE FD4, Mu2e-II, Advanced Muon Facility, and line intensity mapping (sections 3.1, 3.2, 4.2, 5.1, 5.2, and 6.3).
f. Support key **cyberinfrastructure** components such as shared software tools and a sustained R&D effort in computing, to fully exploit emerging technologies for projects. Prioritize **computing and novel data analysis techniques** for maximizing science across the entire field (section 6.7).
g. Develop plans for improving the **Fermilab accelerator complex** that are consistent with the long-term vision of this report, including neutrinos, flavor, and a 10 TeV pCM collider (section 6.6).

We recommend specific budget levels for enhanced support of these efforts and their justifications as **Area Recommendations** in section 6.

Exploring the Quantum Universe

2.3 The Path to a 10 TeV pCM

Realization of a future collider will require resources at a global scale and will be built through a world-wide collaborative effort where decisions will be taken collectively from the outset by the partners. This differs from current and past international projects in particle physics, where individual laboratories started projects that were later joined by other laboratories. The proposed program aligns with **the long-term ambition of hosting a major international collider facility in the US, leading the global effort** to understand the fundamental nature of the universe.

…

In particular, a muon collider presents an attractive option both for technological innovation and for bringing energy frontier colliders back to the US. The footprint of **a 10 TeV pCM muon collider is almost exactly the size of the Fermilab campus**. A muon collider would rely on a powerful multi-megawatt proton driver delivering very intense and short beam pulses to a target, resulting in the production of pions, which in turn decay into muons. This cloud of muons needs to be captured and cooled before the bulk of the muons have decayed. Once cooled into a beam, fast acceleration is required to further suppress decay losses.

…

Although **we do not know if a muon collider is ultimately feasible**, the road toward it leads from current Fermilab strengths and capabilities to **a series of proton beam improvements and neutrino beam facilities**, each producing world-class science while performing critical R&D towards a muon collider. At the end of the path is an unparalleled global facility on US soil. **This is our Muon Shot.**