Comments on US Efforts and Plans in the P5 Context

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Recommendation 4 & MC Activities

4a) 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 [see sections 3.2, 5.1, 6.5, and also Recommendation 6]

4c) Expand the General Accelerator R&D (GARD) program within HEP, including stewardship [see section 6.4]

4d) 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… [see sections 3.1, 3.2, 4.2, 5.1, 5.2, and 6.3]

4g) 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 [see section 6.6]

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Recommendation 6

We can (and must) be ready for key decisions within the next decade!

Convene a targeted panel with broad membership across particle physics later this decade that makes decisions on the US accelerator-based program at the time when major decisions concerning an off-shore Higgs factory are expected, and/or significant adjustments within the accelerator-based R&D portfolio are likely to be needed. A plan for the Fermilab accelerator complex consistent with the long-term vision in this report should also be reviewed.

The panel would consider the following:

1. The level and nature of **US contribution in a specific Higgs factory** including an evaluation of the associated schedule, budget, and risks once crucial information becomes available.
2. Mid- and large-scale **test and demonstrator facilities** in the accelerator and collider R&D portfolios.
3. A plan for the evolution of the **Fermilab accelerator complex** consistent with the longterm vision in this report, which may commence construction in the event of a more favorable budget situation.

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2.5 International and Inter-Agency Partnerships

Stability of the program requires implementing the framework for our international partnerships!

In the case of the Higgs factory, crucial decisions must be made in consultation with potential international partners. The FCC-ee feasibility study is expected to be completed by 2025 and will be followed by a European Strategy Group update and a CERN council decision on the 2028 timescale. The ILC design is technically ready and awaiting a formulation as a global project. **A dedicated panel should review the plan for a specific Higgs factory once it is deemed feasible and well-defined;** evaluate the schedule, budget and risks of US participation; and give recommendations to the US funding agencies later this decade (Recommendation 6). **When a clear choice for a specific Higgs factory emerges, US efforts will focus on that project, and R&D related to other Higgs factory projects would ramp down.**

Parallel to the R&D for a Higgs factory, **the US R&D effort should develop a 10 TeV pCM collider (design and technology)**, such as a muon collider, a proton collider, or possibly an electron-positron collider based on wakefield technology. **The US should participate in the International Muon Collider Collaboration (IMCC) and take a leading role in defining a reference design.** We note that there are many synergies between muon and proton colliders, especially in the area of development of high-field magnets. R&D efforts in the next 5-year timescale will define the scope of test facilities for later in the decade, paving the way for initiating **demonstrator facilities within a 10-year timescale** (Recommendation 6).

Next Steps for the US Program

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P5 “Ask” from the US MC Community

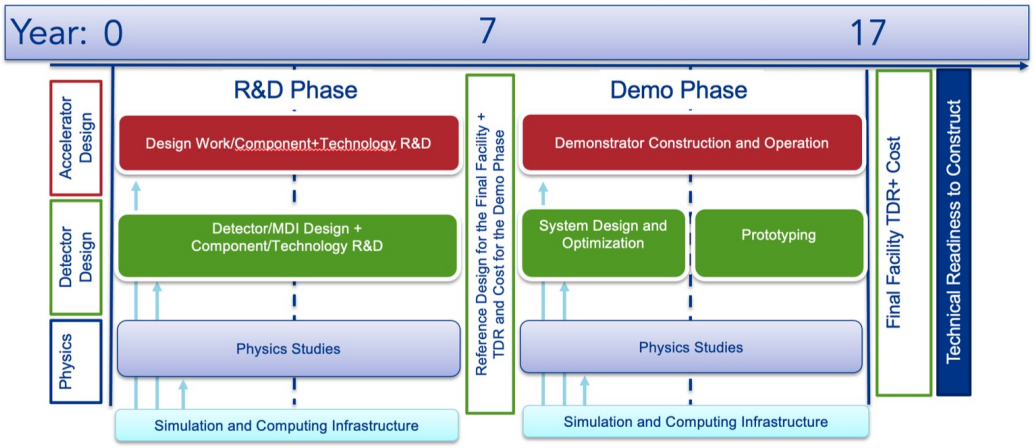

Figure 1: A sketch of the proposed muon collider R&D timeline, along with high-level activities, milestones, and deliverables.

S. Jindariani, D. Stratakis, Sridhara Dasu et al.

- Aims for the US to be a co-equal partner with Europe in an International Effort
- Timeline trails the European “technically-limited” roadmap somewhat

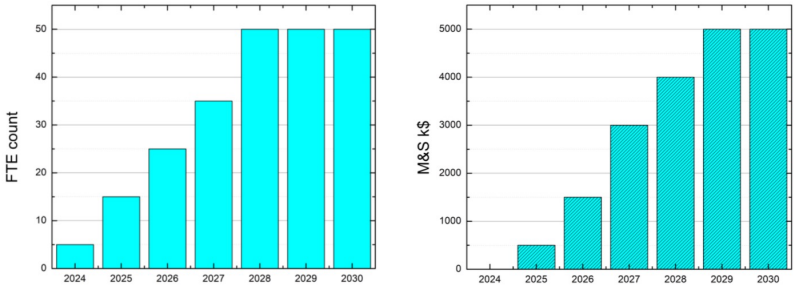

Figure 2: FTE and M&S profiles for accelerator R&D corresponding to the first phase of the program. We assume here that funding can start in 2024. The M&S is in FY23 dollars and escalation is not included in these estimates.

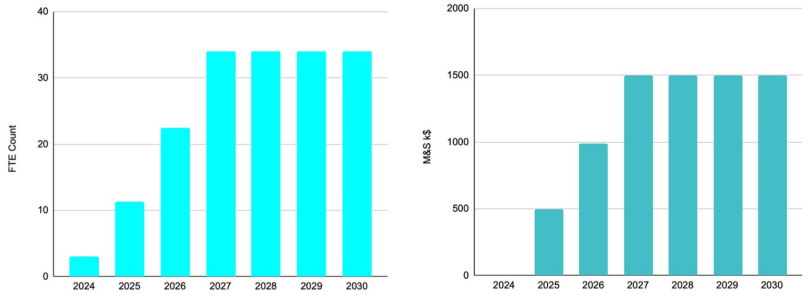

Figure 3: FTE and M&S profiles for detector R&D corresponding to the first phase of the program. We assume here that funding can start in 2024. The M&S is in FY23 dollars and escalation is not included in these estimates.

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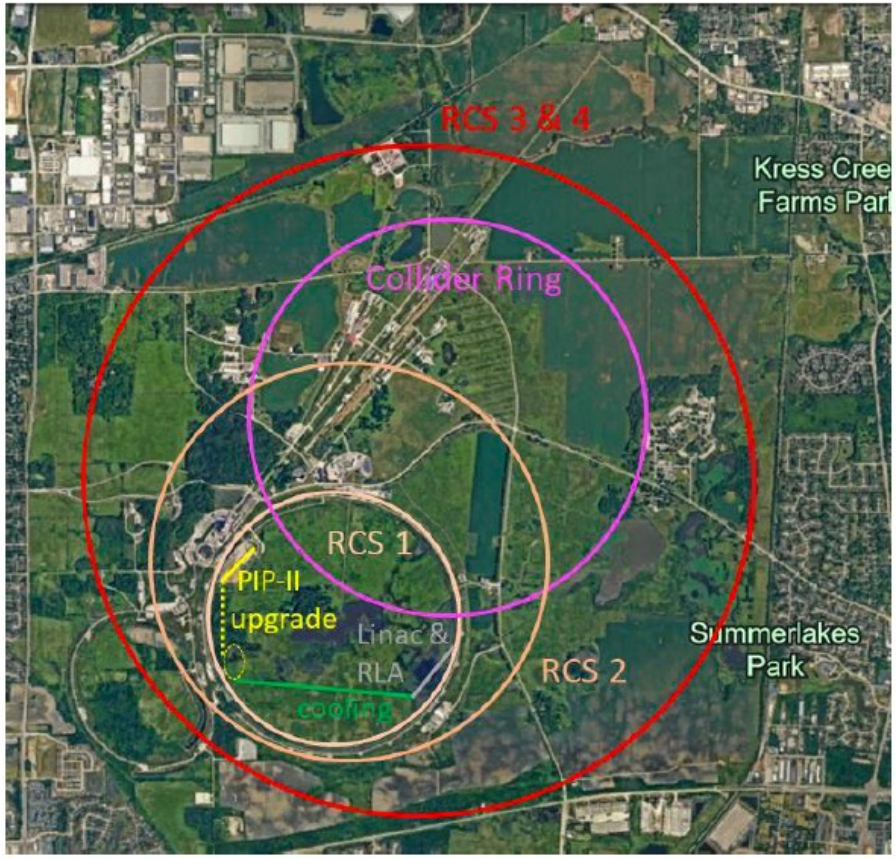
Formal funding start for Collider R&D Program no earlier than US FY26

Muon Collider at Fermilab

- **10 TeV MuC** concept is in place
- Proton source
  - Post-ACE driver -> Target
- Ionization cooling channel
- Acceleration (4 stages)
  - Linac + RLA → **173 GeV**
  - RCS #1 → **450 GeV (Tevatron size)**
  - RCS #2 → **1.7 TeV (col. ring size)**
  - RCS #3, 4 → **5 TeV (site fillers)**
- Collider ring, 10.5 km long
  - Could be combined with RCS #2



- In the next years we like to have a baseline design including a neutrino flux mitigation system

Courtesy D. Stratakis

Key Steps Forward

- The US Particle Physics Community is ready to engage with Detector and Physics efforts to deliver the necessary concepts for a 10 TeV pCM capability
- Accelerator expertise exists for all parts of the envisioned machine
  - Must engage strongly with the international effort to achieve a technically limited timeline
    - *It cannot be overstated as to how critical it will be to achieve timely progress!!*
  - Options for early engagement are being explored
    - *US budgetary headwinds present a challenge*
    - *The GARD program can provide some basic technology development support*
    - *Individual laboratories have some flexibility*
    - *We hope for (and must advocate for) some rebalancing within existing US program*
  - Options for US siting are closely tied to the Fermilab ACE planning effort
- We anticipate that US MC activities will eventually be part of a DOE-HEP targeted US Collider R&D Program