U.S. Engagement in an Off-shore Higgs Factory

Discussion

P5 Recommendation 2c.

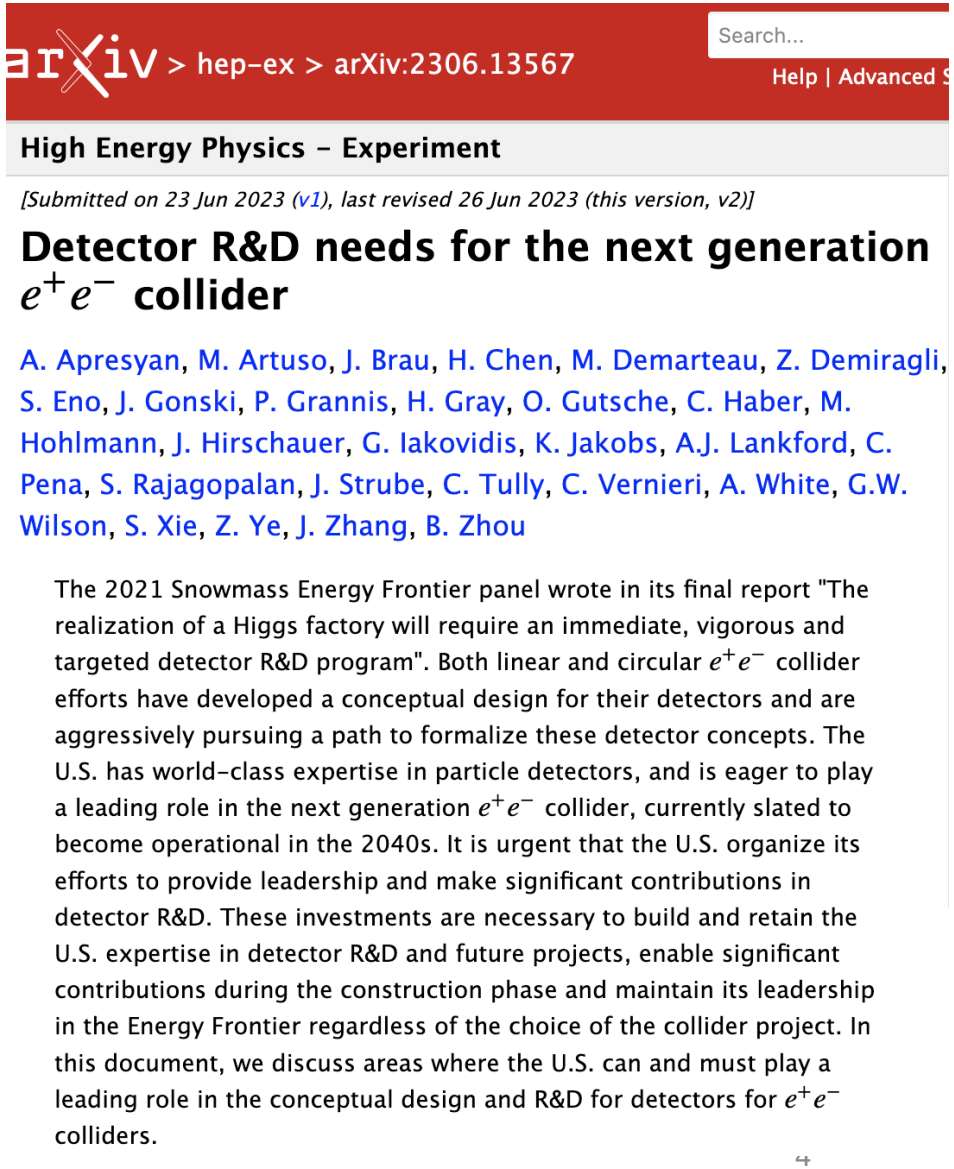
[Plan and start] an off-shore Higgs factory, realized in collaboration with international partners, in order to reveal the secrets of the Higgs boson. The current designs of FCC-ee and ILC meet our scientific requirements. **The US should actively engage** in feasibility and design studies. Once a specific 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).

Collider Options

- FCC-ee (CERN) is well advanced in its planning.
  - Mid-term Review of the FCC Feasibility Study completed in December 2023 and approved by CERN Council in February 2024.
    - https://indico.cern.ch/event/1379648/
  - Feasibility study expected to be completed before mid 2025 → accelerated schedule
    - Projected cost $12B for baseline option, but endorsement by Council for 4 detectors.
  - Council Approval in ~2026 (1 year ahead, accelerated schedule agreed in 3/24 Council meeting).
  - Planned operation: ~2045 – 2060
- ILC, described as shovel ready (published TDR), but a host has not been identified.
  - Detector R&D has significant synergies with FCC-ee, and these efforts must be coordinated.
- CEPC recently published its TDR, awaiting approval from CAS.
  - Geopolitical challenges prevent us from collaborating even if CEPC moves forward.
- Uncertainty over the next few years.
  - U.S. must position itself to engage and lead in an off-shore Higgs Factory as recommended by P5.
  - Synergies in detector technologies across collider options allow for constructive collaboration.

P5 Organization

- During the P5 process, the Linear and Circular collider communities worked together to submit a common proposal defining a unified and prioritized scope/ask.
  - A bottom-up community driven process (https://arxiv.org/abs/2306.13567)
  - Addressing eight technological areas including software development, each led by 2-3 L2 coordinators selected from across the community.
  - Coordination group included L2 coordinators + additional advisors/ex-officio's.
  - Focus on targeted detector R&D toward detectors for e+e- colliders
  - This team interfaced, as appropriate, with DOE, CERN FCC Feasibility Study team, ECFA-DRD, CPAD and P5 leadership.
- Similar efforts for accelerator R&D.



arXiv > hep-ex > arXiv:2306.13567

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High Energy Physics – Experiment

[Submitted on 23 Jun 2023 (v1), last revised 26 Jun 2023 (this version, v2)]

Detector R&D needs for the next generation e^+e^- collider

A. Apresyan, M. Artuso, J. Brau, H. Chen, M. Demarteau, Z. Demiragli, S. Eno, J. Gonski, P. Grannis, H. Gray, O. Gutsche, C. Haber, M. Hohlmann, J. Hirschauer, G. Iakovidis, K. Jakobs, A.J. Lankford, C. Pena, S. Rajagopalan, J. Strube, C. Tully, C. Vernieri, A. White, G.W. Wilson, S. Xie, Z. Ye, J. Zhang, B. Zhou

The 2021 Snowmass Energy Frontier panel wrote in its final report "The realization of a Higgs factory will require an immediate, vigorous and targeted detector R&D program". Both linear and circular e^+e^- collider efforts have developed a conceptual design for their detectors and are aggressively pursuing a path to formalize these detector concepts. The U.S. has world-class expertise in particle detectors, and is eager to play a leading role in the next generation e^+e^- collider, currently slated to become operational in the 2040s. It is urgent that the U.S. organize its efforts to provide leadership and make significant contributions in detector R&D. These investments are necessary to build and retain the U.S. expertise in detector R&D and future projects, enable significant contributions during the construction phase and maintain its leadership in the Energy Frontier regardless of the choice of the collider project. In this document, we discuss areas where the U.S. can and must play a leading role in the conceptual design and R&D for detectors for e^+e^- colliders.

Reminder: Coordination body during P5 process

- A joint Linear/Circular collider coordinators responsible for engaging the community to construct a prioritized scope/ask for P5 consideration.
  - Solid State: A. Apresyan, C. Haber, C. Vernieri
  - Calorimeter: H. Chen, C. Tully, A. White
  - Gaseous Detectors: M. Hohlmann, G. Iakovidis, B. Zhou
  - ASIC/Electronics: J. Hirschauer, J. Gonski
  - Particle ID: M. Artuso, G. Wilson, Z. Ye
  - Quantum: M. Demarteau, C. Pena, S. Xie
  - Software: H. Gray, O. Gutsche, J. Strube
  - Trigger/DAQ: Z. Demiragli, J. Zhang
  - ex-officio: from ALCC, US-FCC, CPAD, ECFA, DOE and other stakeholders.
  - Chair: S. Rajagopalan

Agency

- Following the release of the 2023 P5 report, ongoing deliberations within both DOE and NSF to set the long-term strategy for our field, including the U.S. strategy to collaborate in an off-shore Higgs Factory.
  - The agencies are working through the P5 report and developing their implementation plan; given available fiscal budget, considering recommendations in a prioritized manner.
  - DOE & NSF have stated it will take another couple of months to provide any concrete guidance.
  - Expect further guidance from DOE and NSF during the May HEPAP meeting and further clarification on the U.S. strategy by the time of FCC Week in San Francisco (June 2024).
  - Discussions on FCC cooperation are ongoing between DOE, NSF, and CERN.
- As a community, we should use this occasion to discuss and collect input on the best approach forward.
  - Today's panel discussion serves as one of those opportunities to collect community feedback.
  - It would help us with our discussions with the agencies as they work with the community to develop the long-term strategy.

Organization

- Many feel that we must continue to work together as a united community.
  - Synergies and the common interests and expertise in detector R&D require us to collaborate to develop a cost-effective and a targeted U.S. effort toward a future off-shore e+e- collider.
  - U.S. will have a bigger impact in an international project if we combine resources/expertise.
  - Increased credibility with DOE/NSF → $$$.
  - **We welcome the panel and community input on this matter.**
- We propose that the joint coordination body setup during the P5 process, addressing various technological areas, continues to drive the effort while we wait for further agency guidance.
  - Coordination body with all L2 coordinators + ex-officio and stakeholders.
  - Note that the agencies would need to approve any organization structure!
- To facilitate this, we have initiated a U.S. Higgs Factory steering committee to:
  - Provide strategic direction for the U.S. community to enable strong and leading U.S. engagement in an off-shore Higgs Factory.
  - Cross-prioritize efforts across technological areas and allocate funding for targeted R&D.

Next steps.

- The U.S. Higgs Factory steering committee has been initiated following initial discussions with DOE and NSF.
  - Members are the current U.S.-FCC and ALCC leadership + major stakeholders
  - Organization & membership will evolve and adapt with further guidance from both community and agencies.
  - A. Canepa, M. Demarteau, S. Eno, R. Patterson, S. Rajagopalan
  - Note that the broader Higgs Factory coordination body will include all L2 coordinators + stakeholders and report to the steering committee.
- Minimal seed funding available from DOE to pursue urgent and critical tasks in FY 2024, while the agency continues to develop a long-term strategy.
  - Primarily to support travel and engaging key professionals required during the early phase.
  - Allocation of funds primarily based on the prioritization made during the P5 process, which was a joint bottom-up community driven process, with the aim of maintaining key U.S. engagement.
  - Additional information collected during the EOI session on Wednesday will further aid the prioritization and subsequent allocation of funds.

Expression of Interests (short-term)

- We have reached out to all institutes to express their interests in detector R&D. incl. software and physics studies:
  - What is the area of expertise within the group?
  - Where can the institute contribute over the next two years?
  - What are the available resources at the institute that can be committed to the above R&D effort without impacting ongoing work on LHC physics, operations, and HL-LHC upgrades?
- Focus is short-term, to pursue an R&D toward realizing an off-shore e+e- Higgs Factory.
  - Need to be realistic of limited resources and funding given other higher priority efforts (e.g., HL-LHC upgrades).
  - Need to consolidate the available resources/expertise to launch a targeted R&D effort where the U.S. can make a near-term impact.
  - The goal is to ensure that the U.S. is engaged coherent in targeted detector R&D and related efforts required to assume a leadership role in an off-shore Higgs Factory in the years to come.
- Wednesday session of this MIT workshop would allow us to collect that input.
  - Note that the EOI discussion this week is the start of the process to help construct a prioritized U.S. scope. There will be more opportunities to engage the community.
  - We would like to engage anyone interested in software/detector R&D for e+e- colliders to contribute to the EOI process.

Panel Discussion

- We seek to engage the community to gather your input on how best to move forward:
  - Is the proposed coordination and steering groups the right approach?
    - If yes, how should it further evolve to address the needs of the community?
  - Panel Discussion today is one of the vehicles to gather that input.
  - We should continue to discuss and prepare our strategy that will serve to strengthen the U.S. efforts, aligned with any international efforts, and also assist the agencies to develop their long-term strategy.
- We also seek input from our international partners in our panel.