Snowmass 2021

AF1: Beam Physics and Accelerator Education Summary Report

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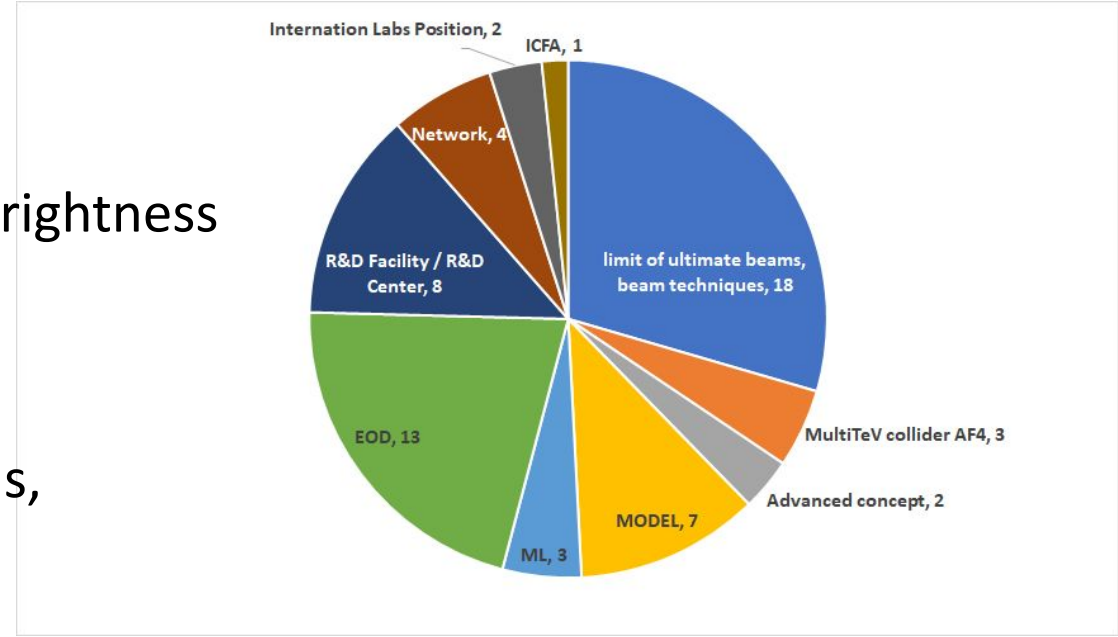
AF1: Beam Physics and Accelerator Education

- A total of 61 LoI received at the beginning of Snowmass
  - Education, Outreach, Diversity (EOD)
    - research facility/center/program for general research/training
  - International research organizations' plan and interests
    - INFN, Dubna
  - ICFA panel on sustainability and energy management of accelerators
  - Modeling and ML
  - Extreme beams
    - intensity, energy, brightness
  - Multi TeV colliders
  - Advance concepts
    - laser plasma
    - beam cooling, elens,
  - ERL, etc



AF1: Beam Physics and Accelerator Education

Snowmass 2021

01: Education, Diversity and Outreach

Dedicated meeting (workshop)

- Invite all LoI contributors
- Discuss issues and propose steps

Date: Target October

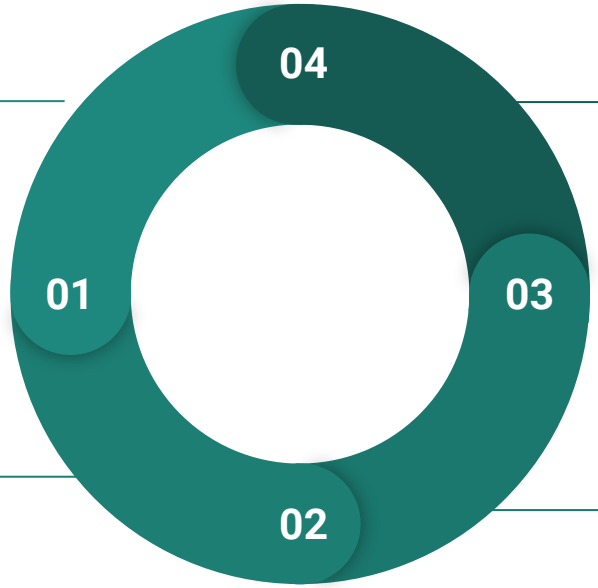
Venue: online

02: Research Center/Facility

Discussion forum to clarify needs of test/R&D facilities to support concept R&D, training, and educational needs.

Venue: online

Co-Org with AF4, AF6, etc



04: Physics Limits of Ultimate Beams

Dedicated workshop (joint with AF4, AF6, and Aries) to discuss ultimate beam parameters such as energy, intensity, brilliance, beam power on-target allowed by the fundamental laws of physics. Discuss practical limits from engineering and technology.

Venue: online

Co-Org with: AF4, AF6, & Aries

03: Computational Tools & Machine Learning

Propose joint with Computational Frontier to cover tools extending modeling capabilities, potential ML impacts, education, and more efficient use of resources.

Co-Org with: Comp Frontier

Community wide discussions

- Regular AF1 conveners meeting for the last 2+ years
- Physics Limits of Ultimate Beams seminar series
  - A total of five zoom workshop sessions (joint with AF4 and AF6) was held between Dec. 3, 2020 and April 6, 2021 (https://indico.fnal.gov/category/1120/)
    - Fundamental ultimate beams for various physics goals. In particular, for colliders, we wanted to understand the required luminosity scaling with energy. Other scaling laws for other quantities were welcome to be discussed.
    - Potential and feasibility of advanced concepts towards the ultimate physics limits, such as PeV beams yet low luminosity etc.

PLUB Workshop Series

- A total of five zoom workshop sessions (joint with AF4 and AF6) were held between Dec. 3, 2020 and April 6, 2021. (https://indico.fnal.gov/category/1120/)

Michael Peskin: Discovery **physics of e+e- and gamma-gamma colliders**
Allen Caldwell: Physics potentials with **low luminosity super high energy colliders**
Liantao Wang: **desired ultimate beams for probing BSM physics at colliders: scale of required lumi vs. energy**
Thomas Roser: Wishes from **Acc Implementation task force:** required inputs for your task
Vladimir Shiltsev: Overview of the **achieved collider performance and scaling rules**
Swapan Chattopadhyay: **Ultimate beams** and physics/accelerator technologies beyond colliders
Pisin Chen: **Quantum Luminosity**
Valery Telnov: Perspective of **gamma-gamma colliders,** physics potentials and limits
Tao Han: Physics opportunity with **muon collider**
Daniel Schulte/Mark Palmer: **Muon Collider status and outlook**

Summary

- The exploration of new physics calls for future colliders in beyond 1 TeV lepton colliders, and 100 TeV hadron colliders. Both cases require luminosity in the range of $10^{30} cm^{-2} s^{-1} \sim 10^{36} cm^{-2} s^{-1}$
- The conventional RF acceleration-based beams so far are not yet at the quantum limit, but are facing a lot of challenges that require substantial R&Ds
- The ongoing plasma wake field acceleration or other disruptive acceleration technology could have the potential to reach the ultimate beams at the quantum limit
- Continue the technology exploration
  - **Need test facilities**
  - **Need people**

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- AF1 held sessions in Snowmass Community Planning Meeting (October 2020) to discuss LOI submitted
- AF1 community hybrid meeting @SLAC (November 2021) to discuss white papers

Submitted Whitepapers

AF01: Beam Physics and Accelerator Education

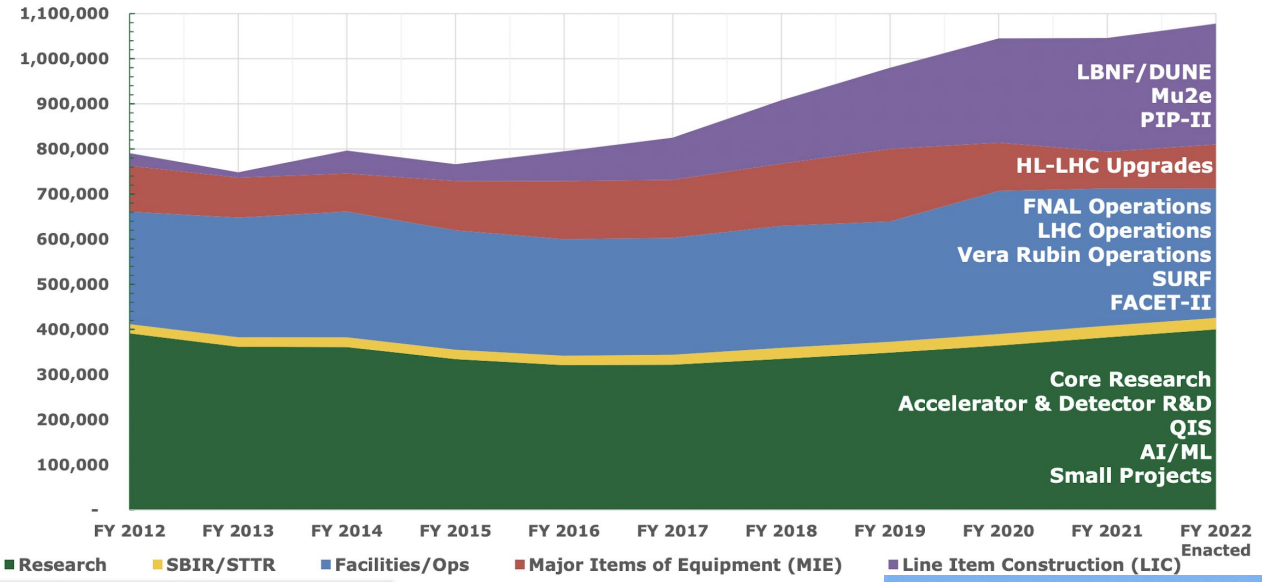
- S. Nagaitsev, V. Shiltsev, A. Valishev, T. Zolkin, J.-L. Vay, M. Bai, et al. "Accelerator and Beam Physics: Grand Challenges and Research Opportunities", arXiv:2203.06816 [physics.acc-ph] (pdf).
- S. Brooks, K. Brown, F. Méot, A. Nomerotski, S. Peggs, M. Palmer, et al. "Ion Coulomb Crystals in Storage Rings for Quantum Information Science", arXiv:2203.06809 [physics.acc-ph] (pdf). (also under TF10, IF01, CompF06)
- M. Bai, W. A. Barletta, D. L. Bruhwiler, S. Chattopadhyay, Y. Hao, S. Holder, et al. "Strategies in Education, Outreach, and Inclusion to Enhance the US Workforce in Accelerator Science and Engineering", arXiv:2203.08919 [physics.acc-ph] (pdf). (also under CommF03)
- Enrique Arce-Lareta, Ketevi Assmamagan, Emanuela Barzi, Uta Bilow, Kenneth Cecire, et al. "The Necessity of International Particle Physics Opportunities for American Education", arXiv:2203.09336 [physics.ed-ph] (pdf). (also under CommF04)
- Emanuela Barzi, S. James Gates Jr., Roxanne Springer. "In Search of Excellence and Equity in Physics", arXiv:2203.10393 [physics.soc-ph] (pdf). (also under EF0, NF0, RF0, CF0, TF0, IF0, CompF0, UF0, CommF0)
- John Power, Christine Clarke, Michael Downer, Eric Esarey, Cameron Geddes, et al. "Beam Test Facilities for R&D in Accelerator Science and Technologies", arXiv:2203.11290 [physics.acc-ph] (pdf).

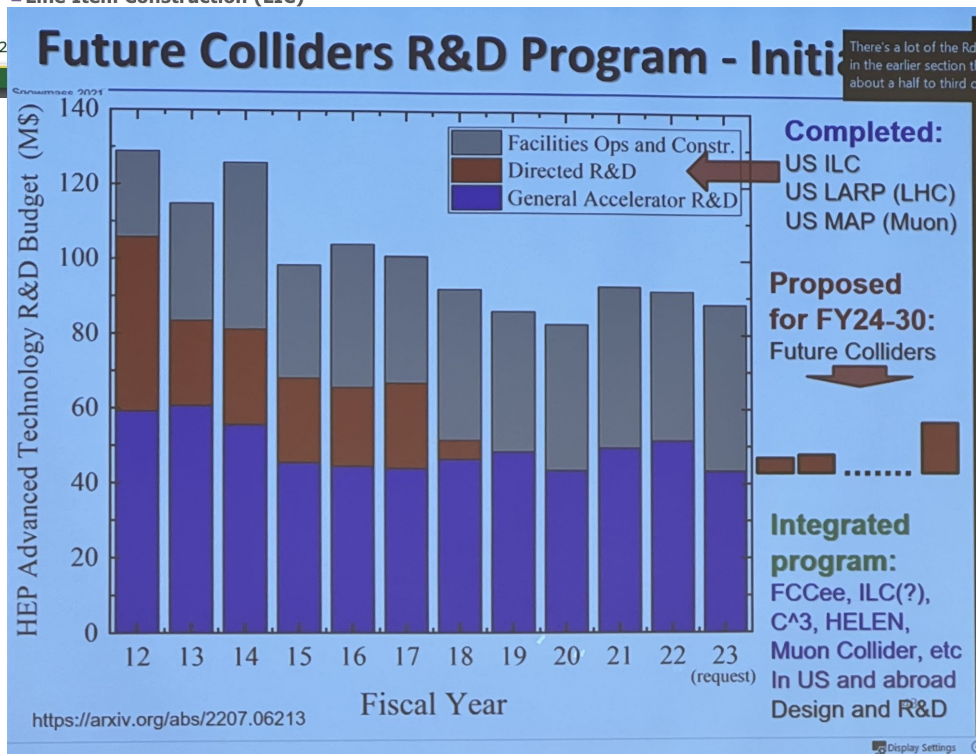
AF1 Findings and Observations

- ABP cross-cuts through multiple accelerator based scientific fields. Non-HEP applications drive significant fraction of ABP near-term goals.
- The HEP frontiers have been pushing the accelerator performance towards ultimate beams. Four grand challenges identified during the previous two GARD ABP workshops are the outstanding long-term goals of ABP.
- R&D at universities has tremendous scientific and education value. By making accelerator research visible to undergraduates and graduate students, it creates a pipeline into the field.
- The funding for ABP in GARD has been in decline, and NSF has cancelled its accelerator science program. These desire stronger funding support to maintain and expand current R&Ds -- NSF funding, GARD, etc

HEP Budget ($k) FY 2012-2022

Research, Operations, Projects: (Construction and MIEs)





AF1 Recommendations

- Establish a decadal road map of accelerator and beam physics research in the DOE OHEP General Accelerator R&D (GARD) to address the four ABP ”grand challenges”

- Re-establish a program of beam physics research on general collider related topics, in particular, towards future e +e − colliders and muon colliders

- Strengthen and expand capabilities of the US accelerator beam test facilities to maintain their competitiveness w.r.t. worldwide capabilities.

AF1 Recs: Education, Outreach & Diversity

- **Education:**
  - **USPAS:** +1 FTE Enhance Effort to: Run national undergrad recruit class; Gather community statistics on jobs, needs, diversity, etc; IT enhancements for community resources; Long-range planning
  - **Universities:** More research grants and programs to involve faculties and students in DOE lab facilities & projects
  - **DOE Traineeships:** Clear expectations on labs to support placement of traineeship students; Relax severe cap limits per student; Allow international students to participate
- **Outreach:**
  - Yearly national undergrad-oriented recruiting class to draw in talent (USPAS run?)
  - Lab programs and expectations to deliver colloquia at universities
- **Diversity Equity & Inclusion:**
  - Enhance support to national undergrad recruiting class to bring in women & URM talent
  - Lab Programs to Address: Quality of life issues & family support; Tone of professional discourse