

CERN ATS seminar on 14/12/2023: <https://indico.cern.ch/event/1355457/>

**The 2020-2023 US HEP Planning Process: from Snowmass to P5
(Accelerator Frontier Aspects) by Vladimir Shiltsev (FNAL)**

Number of participants: 35 persons in 6/2-024 - BE Auditorium Meyrin (CERN) + ?? people connected through Webcast

- Snowmass'21 AF Conveners: Vladimir Shiltsev (FNAL), Stephen Gourlay (LBNL/FNAL) and Tor Raubenheimer (SLAC)
- Vladimir started with a special thanks to CERN (Mike Lamont, Gianluigi Arduini, etc.) for all the work done (topical group conveners, speakers/fora/ITF, P5 member and contributors with Letter of Interest, White Papers, etc.)
- Reminder that "Snowmass is a particle physics community study" => Snowmass provides input to P5 (Particle Physics Project Prioritization Panel) which develops a 10-20 years strategy for the US HEP program
- Vladimir reminded first what was recommended after the previous (2013/2014) Snowmass/P5 process and that everything was done or is ongoing, except the item linked to ILC in Japan as the situation is unclear. Then, he showed few examples linked to
 - Facilities / Programs
 - (Under construction) AUP LHC Nb3Sn IR quads for HI-LHC
 - (Construction started) PIP-II 800 MeV proton SRF linac @FNAL
 - (Completed) ILC@Fermilab 1 st 1.3GHz full CM with beam => FAST facility
 - (Ongoing) muon beams for g-2 and mu2e experiments => FNAL
 - Accelerator R&D
 - Record 14.5T Dipole (at FNAL, part of the US MDP)
 - MAP/MICE: Ionization cooling of muons (140 MeV/c, RAL, UK)
 - FACET-II User facility (SLAC), BELLA: PWFA records (LBNL)
 - IOTA Ring/Optical Stochastic cooling e- (100 MeV, FNAL)
- Coming back to the last, Snowmass'2021, process, it started in 2020 and due to the COVID it finished in 2022 (with last report at the beginning of 2023)
 - ~ 3000 people including international one
 - Snowmass CSS workshop in Seattle (July 2022) with ~ 1400 people
 - 10 Frontiers discussed: Energy, Theory, Cosmic, ..., Accelerator
 - Key questions for the Accelerator Frontier
 - 1) What is needed to advance the physics?

- 2) What is currently available (state of the art) around the world?
- 3) What new accelerator facilities could be available on the next decade (or next next decade)?
- 4) What R&D would enable these future opportunities?
- 5) What are the time and cost scales of the R&D and associated test facilities as well as the time and cost scale of the facilities?
- Reminder about the pre-Seattle huge activity
 - 257 Letters-Of-Interest
 - 114 White Papers
 - > 30 Topical Workshops
 - 8 Cross-Frontiers Agoras
 - Special Cross-Frontier Groups
- Accelerator Frontier Summary
 - Draft Report => Finalised in Seattle => Final Report
 - Below, only few topics will be briefly covered
 - Accelerators for Neutrinos => Multi-MW neutrino Beams for DUNE
 - By 2032 (LBNF/DUNE Project Phase I): 1.2 MW proton beam (120 GeV) on target
 - By 2038 (LBNF/DUNE Project Phase II): ~ 2.4 MW proton beam (120 GeV) on target
 - Accelerators for Rare Processes/DM Searches
 - > 20 Proposed Experiments For Rare Processes (most via Snowmass White Papers)
 - Started LESA Beamline for LDMX @ SLAC
 - Proposed PIP-II Accumulator Ring (PAR)
 - Future Colliders
 - 8 proposals of Higgs/EW factories
 - 17 (!) High Energy Collider concepts / proposals
 - (New!) LC-Higgs Factories on FNAL Site => Must fit ~ 7 km including the BDS
 - FNAL Siting – O(10 TeV) Muon Collider
 - Implementation Task Force (ITF) charged with developing metrics and processes to facilitate a comparison between collider projects
 - 10 international experts => Philippe Lebrun from CERN
 - 2 Snowmass young people

- 3 liaisons to Energy and Theory Frontiers
- ITF report has been published in JINST: T.Roser, et al, JINST 18 P05018 (2023) => Direct access: <https://iopscience.iop.org/article/10.1088/1748-0221/18/05/P05018/pdf>.
- Vladimir discussed the main results (comparison between the different colliders) on slides 21 to 25
- Key Accelerator R&D
 - Multi-MW targets:
 - 2.4MW PIP-III
 - 4-8 MW for muon collider
 - Magnets for colliders and RCSs
 - 16T dipoles
 - 30T solenoids
 - 1000 T/s fast cycling ones coordinate with US MDP
 - Advanced
 - Collider quality beams
 - Efficient drivers
 - Close coordination with Int'l (Euro Roadmap, EUPRAXIA,..)
 - SC/NC RF
 - 72-120 MV/m C3
 - 72 MV/m TW SRF
 - New materials, high Q0
 - Efficient power sources
- Post Snowmass'21, NAS EPP and P5
 - All Snowmass reports published
 - HEPAP International Benchmarking Panel (Nov 2, 2023)
 - P5 committee (H. Murayama, see below)
 - Parallel effort @ National Academy of Sciences:
- P5 report (Dec. 7, 2023) => <https://www.usparticlephysics.org/2023-p5-report/>
 - Several budget scenarios considered => Baseline scenario starts with ~ \$1.2B in 2023 and reaches ~ \$2B in 2035
 - **P5 recommendations (or relevance to AF and in the baseline scenario): 6 in total**
 - **#1 => Highest priority**

- HL-LHC
- First Phase of LBNF/DUNE and PIP-II
- **#2**
 - ... 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 onshore program in particle physics
- **#3**
 - (Belle II upgrade among others)...contributions towards the SuperKEKB accelerator
- **#4 => R&D programs**
 - Support vigorous R&D toward a cost-effective 10 TeV **pCM (= parton Centre-of-Mass)** 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
 - Expand the General Accelerator R&D (GARD) program within HEP, including stewardship
 - 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
- **#5**
 - Workforce development
- **#6 => Targeted Panel**
 - 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.
- Among 20 "Area Recommendations"
 - General Accelerator R&D: increase annual funding to the General Accelerator R&D program by \$10M per year
 - Collider R&D: investment in collider detector R&D funding at the level of \$20M per year and collider accelerator R&D at the level of \$35M per year
- Other notable messages

- The GARD program is critical in supporting a broad range of AS&T for DOE SC
- [there is] ...The long-term ambition of hosting a major international collider facility in the US
- 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
- Although we do not know if a muon collider is ultimately feasible, the road toward it leads from current Fermilab strengths and capabilities... At the end of the path is an unparalleled global facility on US soil. **This is our Muon Shot** => Reference to the past "Moon Shot" (<https://www.jfklibrary.org/visit-museum/exhibits/past-exhibits/moon-shot-jfk-and-space-exploration>)

Q&A session / discussion

- P. Muggli was surprised to see that there wasn't much about plasma wake field accelerators.
- Following a question from O. Bruning, Vladimir mentioned that in the US the concept of sustainability for the future projects was considered by some (at the Snowmass discussions) to be less critical than in Europe. The P5 report has a section 6.9 about it and corresponding Area recommendation #20. Elias mentioned that T. Roser will give a talk on "Sustainable Accelerator Concepts and Technologies" at the IPAC'24 conference (see https://ipac24.org/wp-content/uploads/2023/11/20231108_IPAC24-Synoptic-Table.pdf).
- Young generations tend to prefer FCC-ee or Muon Collider, to be able to see them during their life. FCC-hh (in ~ 2070) is not attractive at the moment.
- There was some discussion about the time required for CLIC vs. ILC to become operational.
- Elias mentioned that today (from 13 to 15/12/23) there is the 1st International Workshop on TeV Muon-Ion Colliders (see <https://indico.cern.ch/event/1276216/>): was it discussed at Snowmass'21? Vladimir answered that the proponents had not submitted their input to the Snowmass ITF (so, such collider was not considered).
- Following a question from Michele about the estimated cost for FCC-hh (between 30 and 50 B\$), Vladimir emphasised that all projects in the tables are considered independently (for sake of comparison).
- Question from Alessandro: with respect to your slide 21 where you rank the diverse collider projects following common figures of merit, do you think that the technology transfer and consequent IMPACT ON SOCIETY possibly coming from the design and construction of these colliders should be taken into account as an additional figure of merit? In your opinion, is that aspect relevant to contribute in steering the strategy for the future? Vladimir mentioned that it is indeed an important aspect which is discussed in the report.
- Following a question from Elias, Vladimir confirmed that indeed the main physics with a ~ 10 TeV muon collider is compatible with a ~ 100 TeV pp collider, hence the new term of "**10 TeV pCM**".

Alessandro, Elias, Michele, Thierry (and Vladimir)