

SNOWMASS'21 ACCELERATOR FRONTIER*

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Abstract

The Particle Physics Community Planning Exercise (a.k.a. “Snowmass”) is the form of organization of regular, every 6 to 8 years, discussions among the entire particle physics community to develop a scientific vision for the future of particle physics in the U.S. and its international partners. The Snowmass'21 *Accelerator Frontier* activities include discussions on high-energy hadron and lepton colliders, high-intensity beams for neutrino research and for the “Physics Beyond Colliders”, accelerator technologies, science, education and outreach as well as the progress of core accelerator technology, including RF, magnets, targets and sources.

SNOWMASS'21

The “Snowmass'21” study (the name is historical, originally held in Snowmass, Colorado) is organized by the Divisions of Particles and Fields (DPF), Beam Physics (DPB), Nuclear Physics (DNP), Astrophysics (DAP) and Gravitation (DGRAV) of the American Physical Society [1]. The Snowmass'21 is a scientific study to define the most important questions for the field and to identify promising opportunities to address them, see [1]. It provides an opportunity for the entire particle physics community to come together to identify and document a scientific vision for the future of particle physics in the U.S. and its international partners. The P5, Particle Physics Project Prioritization Panel, will take the scientific input from the Snowmass'21 and develop a strategic plan for U.S. particle physics that can be executed over a 10 year timescale, in the context of a 20-year global vision for the field.

Snowmass'21 activities are managed along the lines of ten “Frontiers”:

- Energy Frontier,
- Neutrino Physics Frontier,
- Rare Processes and Precision,
- Cosmic Frontier,
- Theory Frontier,
- Accelerator Frontier,
- Instrumentation Frontier,
- Computational Frontier,

- Underground Facilities,
- Community Engagement Frontier.

The Frontiers are led by Frontier Conveners who have been nominated by the community and selected by the Snowmass'21 Steering Committee. The Frontier conveners have invited topical group conveners, drawing heavily from the original list of community-proposed nominations. This process was developed in order to provide a diverse and representative leadership including junior and senior researchers, theorists and experimentalists, and balance regarding gender, geographical distribution, and background. Snowmass'21 community-wide meetings and workshops include *Snowmass Kick-off Town-Hall meeting* (virtual, April 18, 2020), *Snowmass Community Planning Meeting* (virtual, October 5-8, 2020), and *Snowmass Summer Study* (July 2022 at UW Seattle).

ACCELERATOR FRONTIER

The Accelerator Frontier (AF) conveners are Stephen Gourlay (LBNL), Tor Raubenheimer (SLAC), and Vladimir Shiltsev (FNAL). The AF activities include discussions on high-energy hadron and lepton colliders, high-intensity beams for neutrino research, beams for “Physics Beyond Colliders”, accelerator technologies, science, education and outreach, as well as the progress of core accelerator technology, including RF, magnets, targets and sources. The AF participants have submitted Letters-of-Interest, contributed papers, are taking part in corresponding workshops and events, and will contribute to writing summaries and take part in the general Snowmass'21 events.

Topical Groups

There are 7 AF topical groups led by internationally recognized researchers:

- AF1 “Beam Physics and Accelerator Education” - Mei Bai (GSI/SLAC), Zhirong Huang (SLAC), Stephen Lund (MSU);
- AF2 “Accelerators for Neutrinos” - John Galambos (ORNL), Robert Zwaska (FNAL), Gianluigi Arduini (CERN);
- AF3 “Accelerators for EW/Higgs” - Georg Hoffstaetter (Cornell), Qing Qin (ESRF), Marc Ross (SLAC);
- AF4 “Multi-TeV Colliders” - Mark Palmer (BNL), Nadia Pastrone (INFN), Jingyu Tang (IHEP), Alexander Valishev (FNAL);

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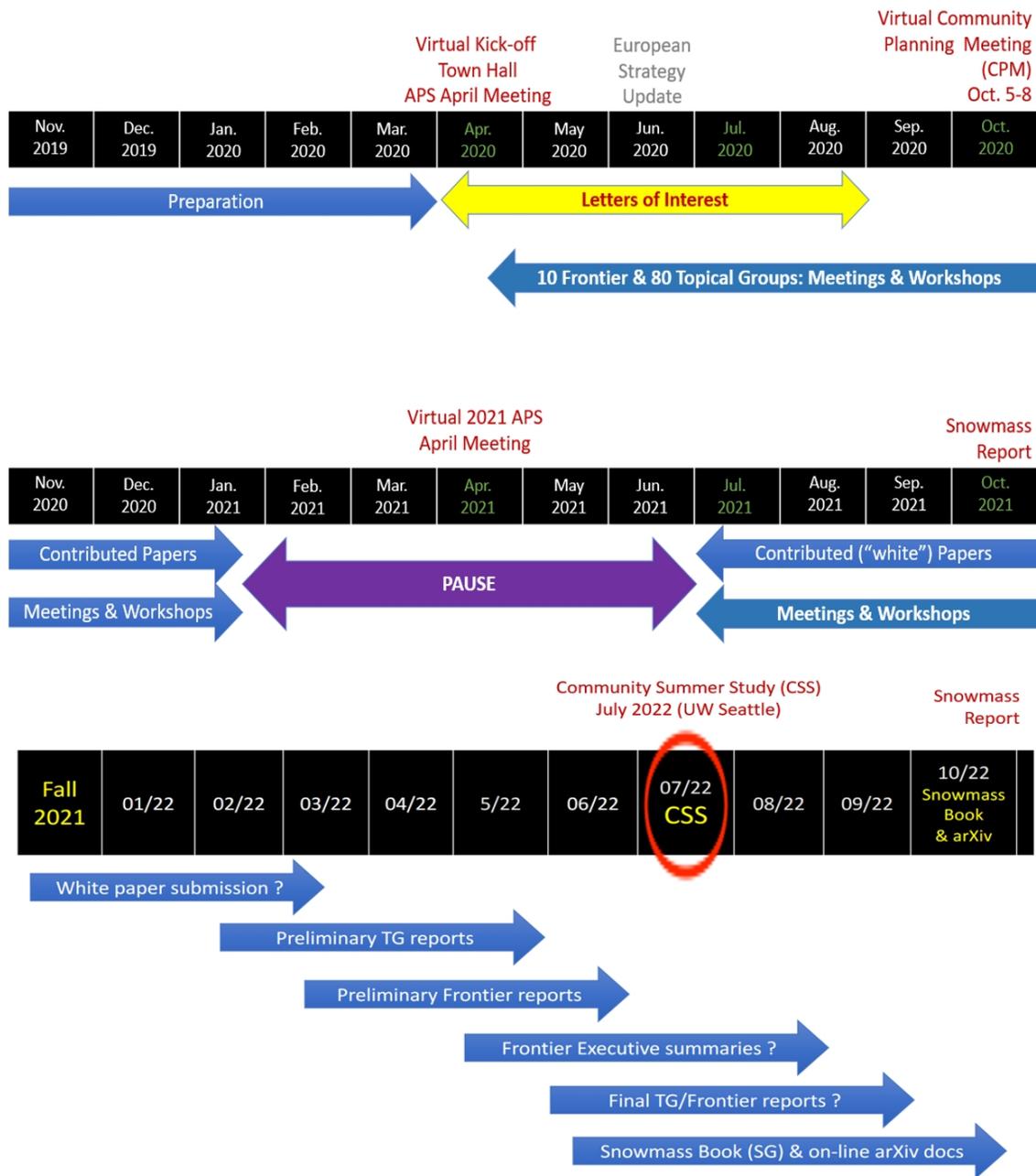


Figure 1: "Snowmass'21" community study timeline (see text).

- AF5 "Accelerators for Physics Beyond Colliders and Rare Processes" - Mike Lamont (CERN), Richard Milner (MIT), Eric Prebys (UC Davis);
- AF6 "Advanced Accelerator Concepts" - Ralph Assmann (DESY), Cameron Geddes (LBNL), Mark Hogan (SLAC), Pietro Musumeci (UCLA);
- AF7 "Accelerator Technology - RF" Emilio Nanni (SLAC), Sergey Belomestnykh (FNAL), Hans Weise (DESY); "Magnets" - Susana Bermudez (CERN), Gianluca Sabbi (LBNL), Alexander Zlobin (FNAL); "Targets/Sources" - Charlotte Barbier (ORNL), Frederique Pellemoine (FNAL), Yin-E Sun (ANL).

The key AF questions include:

- What is needed to advance the physics?
- What is currently available (state of the art) around the world?
- What new accelerator facilities could be available in the next decade (or next next decade)?
- What R&D would enable these future opportunities?
- 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?

By the time of the Snowmass Community Planning Meeting, 329 Letters-of-Interest (LoI) had been submitted to all seven topical groups of the Accelerator Frontier. For example, 61 LoIs submitted to AF1 (Beam Physics) covered several main themes and directions of the study, including physics of Multi-TeV colliders and ultimate beams (intensity, energy, brightness); fundamental beam physics (space-charge, plasma, beam cooling, electron lenses, ERL, instabilities, etc); modeling, AI and machine learning; education, outreach, diversity - centers/programs for general research/training; and sustainability and energy management of accelerators.

Accelerator Frontier Events

As part of the Snowmass'21 community discussion, AF1 (Accelerator Science, Education, Outreach), AF4 (Multi-TeV Colliders) and AF6 (Advanced Accelerator Concepts) have launched a series of joint workshops on the topic of *Physics Limits of Ultimate Beams*. The main scope of this series is to engage the community to explore fundamental ultimate beams for various physics goals, to understand the required luminosity scaling with energy and to evaluate the potential and feasibility of advanced concepts towards the ultimate physics limits, such as PeV beams yet low luminosity etc. See past and planned workshops at [2–5]. Status and plans of other AF topical group activities can be found at [6].

Implementation Task Force

One of the key questions for the Snowmass'21 Accelerator Frontier is "...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 facility?". It was quickly realized that there is a very large number of accelerator projects under active discussion by the HEP community: ILC, Muon Collider, gamma-gamma and ERL options, large circumference electron rings, and large circumference hadron rings, amongst others.

The AF Implementation Task Force (ITF) has been organized and charged with developing metrics and processes to facilitate a comparison between projects. The ITF is chaired by Thomas Roser (BNL) and comprises 10 world-renowned accelerator experts from Asia, Europe and the US and two representatives of the *Snowmass Young* (the Snowmass'21 organization of early career researchers).

SNOWMASS TIMELINE

Because of the COVID-19 pandemic, the Snowmass'21 Report and the Community Summer Study meeting (CSS) - originally planned for the Summer of 2021 - will be delayed by one year until July 2022 (see Fig.1. Correspondingly shifted are the timelines: the White Paper submissions will take place by March 15, 2022; preliminary reports by the Topical Groups due May 31, 2022; preliminary reports by the Frontiers due June 30, 2022; all final reports by Topical Groups and Frontiers due September 30, 2022; the Snowmass'21 Book and the on-line archive documents due October 31, 2022.

REFERENCES

- [1] Snowmass'21, <https://snowmass21.org/>
- [2] Physics Limits of Ultimate Beams, event 46645, <https://indico.fnal.gov/event/46645/>.
- [3] Physics Limits of Ultimate Beams, event 46742, <https://indico.fnal.gov/event/46742/>.
- [4] Physics Limits of Ultimate Beams, event 47217, <https://indico.fnal.gov/event/47217/>.
- [5] Physics Limits of Ultimate Beams, event 47819, <https://indico.fnal.gov/event/47819/>.
- [6] Snowmass'21, Accelerator Frontier, <https://snowmass21.org/accelerator/>.