



Final Remarks and Thanks from DPF and Snowmass Program Committee

Joel Butler, Fermilab
Chairperson, Division of Particles and Fields,
Presented at the Snowmass Community Summer Study
Seattle, Washington
July 26, 2022



Reminder: Goal of Snowmass 2021



- This Snowmass Community Planning exercise is organized by the Division of Particles and Fields (DPF) of the American Physical Society (APS) as a ~ year-long “Science” study
- **Goal: To identify the most important questions in HEP and the tools and infrastructure required to address them**
 - To achieve a broader and deeper understanding of the science in our field and its connection to other research areas.
 - To engage junior scientists and foster our community development
 - **To reach a compelling, shared scientific vision** for the field moving forward for the US in alignment with its international partners
 - **Provide input to the “Particle Physics Project Prioritization Panel” (P5) process**, expected to begin its work in the late fall of 2022 and produce a report in the spring of 2023.

This Community Summer Study and Workshop is the final large meeting of this exercise and is the ***primary*** place where cross-frontier input is received. **Did we achieve the goals?**

"P5" Drivers

- **From P5 report:** "Snowmass, the yearlong community-wide study, preceded the formation of our new P5. A vast number of scientific opportunities were investigated, discussed, and summarized in Snowmass reports. **We distilled those essential inputs into five intertwined science Drivers for the field:**
 - Use the **Higgs boson** as a new tool for discovery
 - Pursue the physics associated with **neutrino mass**
 - Identify the new physics of **dark matter**
 - Understand cosmic acceleration: **dark energy** and inflation
 - Explore the unknown: **new particles, interactions, and physical principles**"

Flavor as a sixth driver?



Some Very High-Level Comments



- HEP is healthy but not without challenges
- The CSS was a success although individual experiences varied
- Issues relating to our scientists and how to become a more equitable, diverse, and inclusive moved to center stage
 - It may not be a project but it must become a priority and some entity in HEP must take ownership and some organization, perhaps HEPAP, has to watch over it
- The new frontiers lived up to their responsibilities and gained by having this new status

Will Snowmass 2022 have as big an impact on the outcome of P5 as Snowmass 2013?



- The main recommendations - LHC/HL-LHC, neutrinos - are the ones everyone remembers and were part of the vision of Snowmass, but there were 29 recommendations in all, leading to a strong, diverse program that will be discussed in talks later in this session.
- Only time will tell but I know that we will give them excellent input
 - Remember, the outcome depends greatly on the budget scenarios they are asked to consider

Organization of Snowmass 2021 in Ten "Frontiers" -I



Accelerator



Steve Gourlay
(LBNL)



Tor Raubenheimer
(SLAC)



Vladimir Shiltsev
(FNAL)

Cosmic



Aaron Chou
(Fermilab)



Marcelle Soares-Santos
(U.Michigan)



Tim Tait
(UC Irvine)

Community Engagement



Kétévi Assamagan
(BNL)

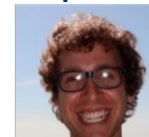


Breese Quinn
(Mississippi)

Computing



Steven Gottlieb
(Indiana U.)



Ben Nachman
(LBNL)



Daniel Elvira
(FNAL)

Energy



Meenakshi Narain
(Brown U)

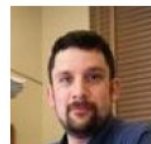


Laura Reina
(FSU)



Alessandro Tricoli
(BNL)

Instrumentation



Phil Barbeau
(Duke)



Petra Merkel
(FNAL)



Jinlong Zhang
(ANL)

Organization of Snowmass 2021 in Ten "Frontiers" - II



Neutrino



Patrick Huber
Virginia Tech



Kate Scholberg
Duke University



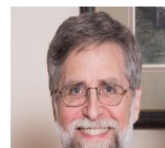
Elizabeth Worcester
BNL



Marina Artuso
(Syracuse U.)



Alexey Petrov
(Wayne State U.)



Bob Bernstein
(FNAL)

Rare Processes & Precision Measurements

Theory



Nathaniel Craig
(UCSB)



Csaba Csaki
(Cornell)



Aida El-Khadra
(UIUC)

Underground Facilities and Infrastructure



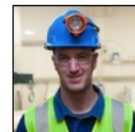
Laura Baudis (U. Zurich)



Jeter Hall (SNOLAB)



Kevin Lesko (LBNL)



John Orrell (PNNL)

All frontiers have topical subgroups, 80 in all (details on Twiki)

Accelerator:	7	Instrumentation:	10
Cosmic:	7	Neutrino:	10
Community Engagement:	7	Rare Processes:	7
Computing:	7	Theory:	11
Energy:	10	Underground:	6

More than 1500 people participated in the Snowmass process!

DPF Oversight and Coordination: Snowmass Steering Group



DPF:

Joel Butler (chair, Fermilab)

Sekhar Chivukula (chair-elect,
University of California,
San Diego)

Andre de Gouvea (vice chair,
Northwestern University)

Tao Han (past chair, University
of Pittsburgh)

Young-Kee Kim (recent chair,
University of Chicago)

Priscilla Cushman (recent chair,
University of Minnesota)

APS Divisions with strong cross-disciplinary links:

Particle Beams: Sergei Nagaitsev (FNAL)

Nuclear Physics: Yury Kolomensky (University
of California, Berkeley)

Astrophysics: Glennys Farrar (New York
University)

Gravitational Physics: Nicolas Yunes
(University of Illinois, Urbana-
Champaign)

The Steering Group Ensures a multi- and cross- disciplinary focus.
Each frontier also has a liaisons to all other associated frontiers

DPF Oversight and Coordination: Snowmass Advisory Group (2021)



- **Chair (Joel Butler)**
- **The Snowmass Steering group**
- **Additional DPF Executive Committee members:**
 - Secretary/Treasurer: Tulika Bose, University of Wisconsin
 - Councilor: Bob Bernstein, FNAL
 - Member-at-Large: Kendall Mahn
 - Member-at-Large: Heather Gray
 - Member-at-Large: Mary Raafat Mikhail Bishai, BNL
 - Member-at-Large: Lauren Tompkins, Stanford University
 - Member-at-Large: Mayly Sanchez, Iowa State University
 - Member-at-Large: Gordon Watts, University of Washington - Seattle
 - Early Career Member-at-Large: Julia Gonski, Columbia University
- **Representatives of the International Community**
 - Claudio Dib, Universidad Tecnica Federico Santa Maria, Chile
 - Val Gibson, Cavendish Laboratory, UK
 - Berrie Giebels, CNRS, France
 - Atsuko Ichikawa, Kyoto University, Japan
 - Heather Logan, Carleton University, Canada
 - Xinchou Lou, IHEP, China
 - Michelangelo Mangano, CERN
 - Azwinndini Muronga, Nelson Mandela University, South Africa
- **Editor**
 - Michael Peskin, SLAC National Laboratory
- **Communications Liaison**
 - Robert Bernstein, Fermilab
- **Technical Liaison**
 - Sergei Chekanov, Argonne National Laboratory

The Advisory Group ensures awareness of international plans and opportunities for collaboration

Snowmass Early Career (SEC)



- Early Career physicists have been formally represented at Snowmass since at least 2001 and gained even more formal recognition in 2013 and now in 2021/22
- This Snowmass they were treated as a full frontier
 - Many problems have been exposed and HEP will have to develop the means to make progress faster
 - The EC physicists will be given an opportunity to contribute to the Snowmass book
- The issues addressed by the Community Engagement frontier and the SEC are now at the forefront of our agenda and those of the DOE and NSF

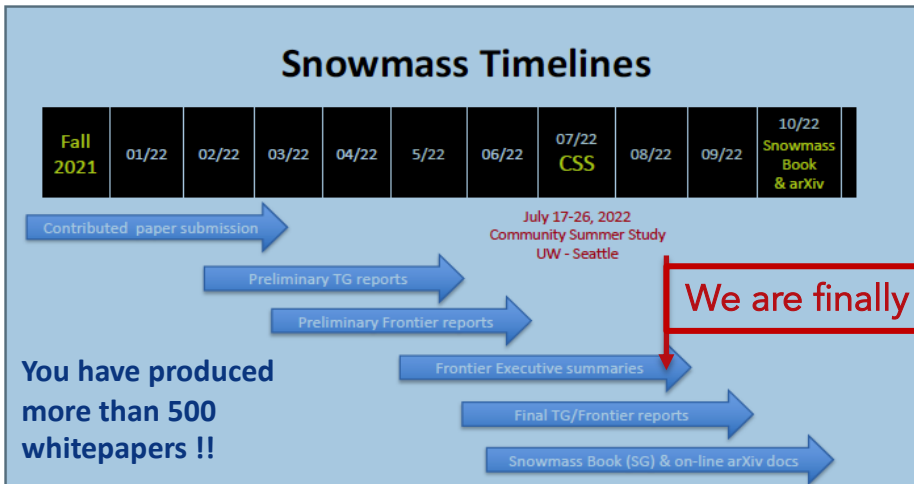
COVID at this meeting



- The infection rate is increasing again
- **Respect all UW and Snowmass rules and guidelines!**
 - **Masking when in close quarters is crucial**
- **We truly thank the members of this community who almost without exception wore masks in indoor areas and minimized the amount of time in close proximity to others when masking was impractical, such as when eating.**

We honor and appreciate the hard work and resilience shown by the community to work through the COVID pandemic period.

Timeline for Snowmass Book



- **March 15: Contributed papers (a.k.a. White Papers)**
- **May 31: Preliminary Topical Group Reports**
- **June 30: Preliminary Frontier Reports**
- **July 17 – 26: Converge on reports for all the frontiers and produce executive summaries representing the views of their communities and providing the basic input needed for P5**
- **September: draft Executive Summary and Report Summary**
- **October- November: Snowmass Book finalized and ready for submission**

- Cover from Snowmass 2013 report, ~ 350 pages
- The new report will be ~500 pages
- All Contributed Papers will remain part of the permanent record of Snowmass

Summary and Outlook



- This Seattle meeting was a hybrid meeting with a large in-person, >700, presence and a large remote participation, ~500.
- Despite all the challenges, an amazing amount of outstanding work is being done and, as we begin end this July meeting, we have the basic input to the Snowmass Book and P5 in hand
 - I am in awe of the commitment of this community, which succeeded in the face of such great challenges
- We still have work on the Snowmass document, which will be coordinated by the Steering Committee
- We plan to give P5 a thorough picture of the most important physics opportunities, and the capabilities needed to achieve them
 - As we began to summarize this work, discussions and debate intensified, as they should!
- We continue to expect that we will emerge from this 2022/2023 Snowmass/P5 with a program that will enable us to do great physics and will have the same or a higher level of community support than we achieved in 2013/2014!

Before I turn the meeting over to Gordon, let me wish



Thanks to everyone in HEP and associated disciplines, in the US and other nations, who are helping us produce a great result!

Thank you for your attention and for joining us in Seattle, in-person or remotely! Before I turn the meeting over to Gordon, have a safe trip home or to your next destination

7/26/22

Local Organizing Committee



- The CSS could not have happened without Gordon, Shih-Chieh, and their outstanding team!

Backup Slides

DPF Oversight and Coordination



- Snowmass includes all aspects of high energy physics and takes an interdisciplinary and international approach
 - **Snowmass Steering Group [meets weekly]**
 - DPF Chair line + representatives of four closely associated APS Divisions: Astrophysics, Nuclear Physics, Gravitational Physics, Physics of Beams
 - **Snowmass Advisory Group [meets monthly]**
 - DPF Executive Committee + representatives of major regional and international organizations
 - **Snowmass All-Conveners Group [meets monthly]**
 - DPF chair line, 30 frontier conveners, the UW chair and deputy chairs of the CSS
 - **Community Summer Study (CSS) Program Committee**
 - One convener chosen by each frontier, Steering Committee, Early Career scientist representatives, UW chairs of CSS
 - **CSS Local Organizing Committee**

10 Frontiers	80 Topical Groups
Energy	Higgs Boson properties and couplings, Higgs Boson as a portal to new physics, Heavy flavor and top quark physics, EW Precision Phys. & constraining new phys., Precision QCD, Hadronic structure and forward QCD, Heavy Ions, Model specific explorations, More general explorations, Dark Matter at colliders
Neutrino Physics	Neutrino Oscillations, Sterile Neutrinos, Beyond the SM, Neutrinos from Natural Sources, Neutrino Properties, Neutrino Cross Sections, Nuclear Safeguards and Other Applications, Theory of Neutrino Physics, Artificial Neutrino Sources, Neutrino Detectors
Rare Processes	Weak Decays of b and c, Strange and Light Quarks, Fundamental Physics and Small Experiments. Baryon and Lepton Number Violation, Charged Lepton Flavor Violation, Dark Sector at Low Energies, Hadron spectroscopy
Cosmic	Dark Matter: Particle-like, Dark Matter: Wave-like, Dark Matter: Cosmic Probes, Dark Energy & Cosmic Acceleration: The Modern Universe, Dark Energy & Cosmic Acceleration: Cosmic Dawn & Before, Dark Energy & Cosmic Acceleration: Complementarity of Probes and New Facilities
Theory	String theory, quantum gravity, black holes, Effective field theory techniques, CFT and formal QFT, Scattering amplitudes, Lattice gauge theory, Theory techniques for precision physics, Collider phenomenology, BSM model building, Astro-particle physics and cosmology, Quantum information science, Theory of Neutrino Physics
Accelerator	Beam Physics and Accelerator Education, Accelerators for Neutrinos, Accelerators for Electroweak and Higgs Physics, Multi-TeV Colliders, Accelerators for Physics Beyond Colliders & Rare Processes, Advanced Accelerator Concepts, Accelerator Technology R&D: RF, Magnets, Targets/Sources
Instrumentation	Quantum Sensors, Photon Detectors, Solid State Detectors & Tracking, Trigger and DAQ, Micro Pattern Gas Detectors, Calorimetry, Electronics/ASICS, Noble Elements, Cross Cutting and System Integration, Radio Detection
Computational	Experimental Algorithm Parallelization, Theoretical Calculations and Simulation, Machine Learning, Storage and processing resource access (Facility and Infrastructure R&D), End user analysis
Underground Facilities	Underground Facilities for Neutrinos, Underground Facilities for Cosmic Frontier, Underground Detectors
Community Engagement	Applications & Industry, Career Pipeline & Development, Diversity & Inclusion, Physics Education, Public Education & Outreach, Public Policy & Government Engagement
Snowmass Early Career	Snowmass Early Career to represent early career members and promote

Snowmass 2021



- Why “Snowmass”?

- The name Snowmass is retained since it implies **an outlook or state-of-mind** as to how we pursue our science in US HEP:
 - Community driven and inclusive – all people and ideas are welcome
 - Global - Open to all, including physicists from all over the world, and takes into account the plans in all other regions
 - Interdisciplinary – reaches out to related fields

- Why 2021?

- It started in 2020, but because of the pandemic, it took two years so 2021 is the “average” of the years??



History: US HEP Community Planning Exercise, a.k.a. Snowmass



- Snowmass, the DPF-hosted Community Planning Exercises, started in 1982
 - The then DPF chair Charles Baltay said: "The 1982 DPF Summer Study was the first attempt in recent years to bring together physicists from the whole country to consider the future of our field from the point of view of the best overall national program. The DPF Executive Committee feels that this summer study was sufficiently useful in this last respect to hold similar summer studies at appropriate times in future years."
 - The study lasted several months and culminated in a 3-week-long workshop in Snowmass, Colorado
- **Goal: To identify the most important questions in HEP and the tools and infrastructure required to address them**
 - To achieve a broader and deeper understanding of the science in our field
 - To engage junior scientists and foster our community development
 - To reach a compelling vision for the field moving forward
 - **Provide input to the "Particle Physics Project Prioritization Panel" (P5) process (starting in 2013)**
- In 2013, for reasons external to HEP, the meeting was held outside of Snowmass at the **University of Minnesota , Snowmass on the Mississippi**, and was shortened to ~10 days
 - The shorter meeting requires more discussion and consensus building to be done in advance

Did Snowmass 2013 have an impact on the P5 outcome?



- I would say yes!
- The main recommendations (LHC, neutrinos) may have been somewhat obvious even at the beginning of the process, but needed justification and incorporation into real budgets with timelines
- There were, however, 29 recommendations total, including
 - Maintain a program of projects of all scales, from the largest international projects to mid- and small-scale projects.
 - Increase the budget fraction invested in construction of projects to the 20%–25% range.
 - Provide the flexibility to support new ideas and developments
 - Select and perform in the short term a set of small-scale short-baseline experiments
 - Build DESI and complete LSST,
 - Proceed with G2 Dark Matter programs, support one or more G3 dark Matter Programs
 - Complete Mu2e and muon g-2

I do not believe that all these would have been included without our strong communities developing excellent proposals and explaining them to their colleagues outside their community.

Snowmass 2021/22



- **We must make strong physics cases for near-term, i.e., the HL-LHC, and far term, i.e., new colliders**
 - We have to clearly identify the physics advantages of each and how they differ or overlap
- We should acknowledge the current situation of project readiness and also the demands on funding of ongoing projects which affects timing of new projects
- **The next big decision will be based on what CERN learns about the technical feasibility, siting issues, and cost of the large tunnel and FCC-ee**
 - We need to prepare an R&D program that can support it but also can pursue the most promising directions if it cannot go forward
- We might anticipate a decision point ~ 4years from now, well before the “natural” time for the next P5
 - **We should put in place now what is needed to be ready for that**