Snowmass process and contributed papers

Frontier for Rare Processes and Precision Measurements

Alexey A. Petrov
Wayne State University

Snowmass 2021: Frontiers

Energy Frontier


Meenakshi Narain (Brown U)


Laura Reina (FSU)


Alessandro Tricoli (BNL)

Frontier in Neutrino Physics


Patrick Huber (Virginia Tech)


Kate Scholberg (Duke University)


Elizabeth Worcester (BNL)

Frontier for Rare Processes & Precision Measurements


Marina Artuso (Syracuse U.)


Alexey Petrov (Wayne State U.)


Bob Bernstein (FNAL)

Cosmic Frontier


Aaron Chou (Fermilab)


Marcelle Soares-Santos (Brandeis)


Tim Tait (UC Irvine)

Theory Frontier


Nathaniel Craig (UCSB)


Csaba Csaki (Cornell)


Aida El-Khadra (UIUC)

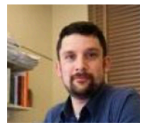
Accelerator Frontier


Steve Gourlay (LBNL)


Tor Raubenheimer (SLAC)


Vladimir Shiltsev (FNAL)

Instrumentation Frontier


Phil Barbeau (Duke)


Petra Merkel (FNAL)


Jinlong Zhang (ANL)

Computational Frontier


Steven Gottlieb (Indiana U)


Ben Nachman (LBNL)


Oliver Gutsche (FNAL)

Underground Facilities & Infrastructure Frontier


Laura Baudis (U. Zurich)


Jeter Hall (SNOLAB)


Kevin Lesko (LBNL)


John Orrell (PNNL)

Community Engagement Frontier


Kétévi A. Assamagan (BNL)


Breese Quinn (Mississippi)

Frontier for Rare Processes and Precision Measurements

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- SNOWMASS CALENDAR
- ETHICS GUIDELINES
- SNOWMASS REPORT

- Organization

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- SNOWMASS STEERING GROUP
- FRONTIER CONVENERS
- APS DPF SNOWMASS PAGE
- SNOWMASS EARLY CAREER

- Snowmass Frontiers

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- ACCELERATOR FRONTIER
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- UNDERGROUND FACILITIES

RARE PROCESSES AND PRECISION MEASUREMENTS

Frontier Conveners

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Name	Institution	email
Marina Artuso	Syracuse University	martuso[at]syr.edu
Bob Bernstein	Fermi National Accelerator Lab	rhbob[at]fnal.gov
Alexey A Petrov	Wayne State University	apetrov[at]wayne.edu

Description

The Frontier for Rare Processes and Precision Measurements explores fundamental physics with intense sources and ultra-sensitive detectors. It encompasses seeking tiny deviations from Standard Model expectations in properties and transitions of elementary particle and searches for extremely rare processes. The Frontier for Rare Processes and Precision Measurements experiments use precision measurements to probe quantum effects and employ sophisticated theoretical techniques for their interpretations. These experiments typically investigate new laws of physics that manifest themselves at higher energies or weaker interactions than those directly accessible at high-energy particle accelerators. These experiments require the greatest possible beam intensities of electrons, muons, photons or hadrons, as well as large detectors, which provide an opportunity for substantial new discoveries complementary to other Frontier experiments.

https://snowmass21.org/rare/start

Frontier for Rare Processes and Precision Measurements

Topical groups

- RF1: Weak decays of b and c quarks (Angelo Di Canto/Stefan Meinel)
- RF2: Weak decays of strange and light quarks (Evgueni Goudzovski/Emilie Passemar)
- RF3: Fundamental Physics in Small Experiments (Tom Blum/Peter Winter)
- RF4: Baryon and Lepton Number Violating Processes (Pavel Fileviez Perez/Andrea Pocar)
- RF5: Charged Lepton Flavor Violation (electrons, muons and taus) (Bertrand Echenard/Sacha Davidson)
- RF6: Dark Sector Studies at High Intensities (Mike Williams/Stefania Gori)
- RF7: Hadron Spectroscopy (Tomasz Skwarnicki/Richard Lebed)

Liaisons with other frontiers:

- Energy Frontier: Angelo Di Canto
- Neutrino Frontier: Bob Bernstein
- Cosmic Frontier: Susan Gardner
- Theory Frontier: Alexey Petrov
- Accelerator Frontier: Bob Bernstein
- Instrumentation Frontier: Marina Artuso
- Computational Frontier: Stefan Meinel
- Community Engagement Frontier: Sophie Middleton

SNOWMASS-RP-FRONTIER@fnal.gov

1. SNOWMASS-RPF-01-HEAVY-QUARKS@FNAL.GOV
2. SNOWMASS-RPF-02-LIGHT-QUARKS@FNAL.GOV
3. SNOWMASS-RPF-03-FUNDAMENTL-SMALL@FNAL.GOV
4. SNOWMASS-RPF-04-BLNV@FNAL.GOV
5. SNOWMASS-RPF-05-CLFV@FNAL.GOV
6. SNOWMASS-RPF-06-DARK-SECTOR@FNAL.GOV
7. SNOWMASS-RPF-07-HADR-SPECT@FNAL.GOV

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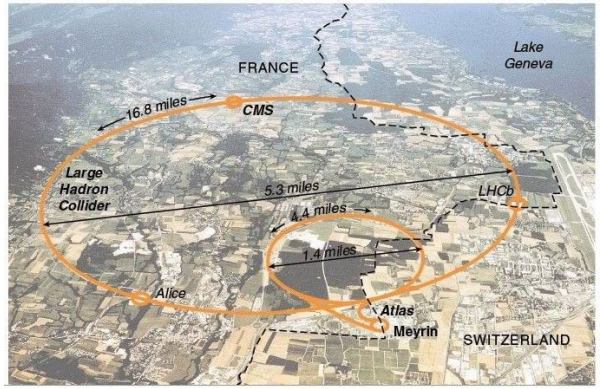
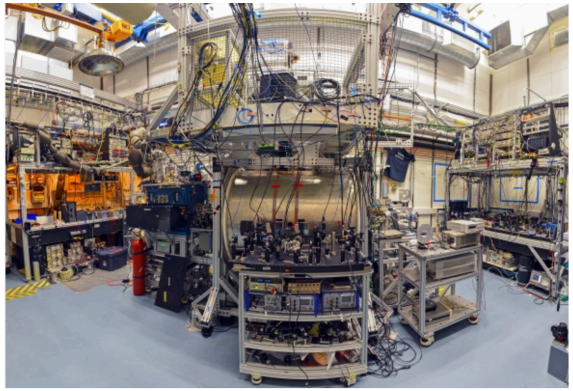


Accelerator-based experiments



"Table-top" experiments

Frontier summary: searches for new (rare) phenomena with precision measurements

Community input

Letters of Interest (submission period: April 1, 2020 – August 31, 2020)

Letters of interest allow Snowmass conveners to see what proposals to expect and to encourage the community to begin studying them. They helped conveners to prepare the Snowmass Planning Meeting that took place on October 5 - 8, 2020 ~~at Fermilab~~ on Zoom. Letters should give brief descriptions of the proposal and cite the relevant papers to study. Instructions for submitting letters are available at https://snowmass21.org/loi. Authors of the letters are encouraged to submit a full writeup for their work as a contributed paper.

Contributed Papers (submission period: April 1, 2020 – March 15, 2022)

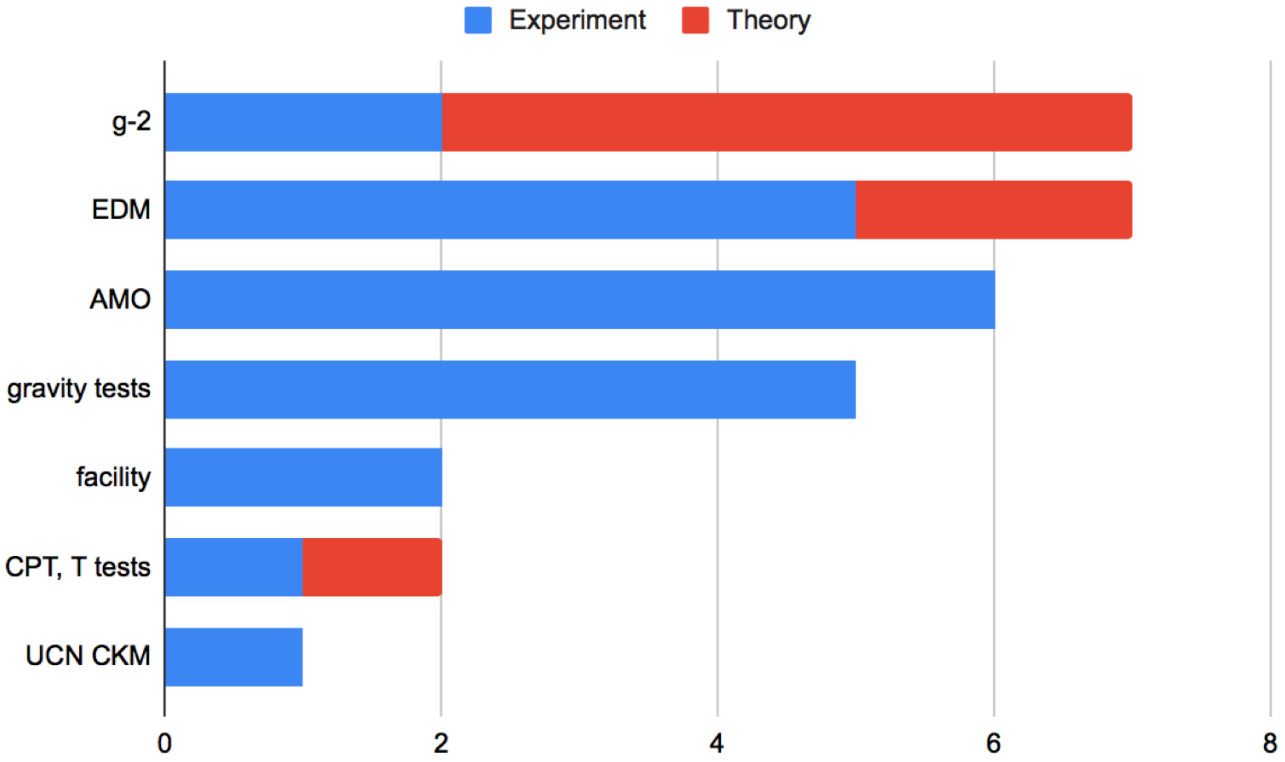
Contributed papers will be part of the Snowmass proceedings. They may include white papers on specific scientific areas, technical articles presenting new results on relevant physics topics, and reasoned expressions of physics priorities, including those related to community involvement. These papers and discussions throughout the Snowmass process will help shape the long-term strategy of particle physics in the U.S. Contributed papers will remain part of the permanent record of Snowmass 2021. Instructions for submitting contributed papers are available at https://snowmass21.org/submissions/ (both solicited and non-solicited)

Final Product: Snowmass Report (submission: 30 September 2022)

The Town Hall meeting was held in response to Letters of Interest (LOIs) submitted to our Frontier. It offered the submitters of LOIs a chance to make presentations on the topic of their LOIs.

Letters of Interest (LOIs)

- 214 LOIs submitted to RPF
  - physics, devices/experiments, facilities
  - example distribution for RF3-5:



  - wide variety of LOIs -> “on-point” Contributed Papers

Snowmass 2021: timeline

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Welcome to Snowmass 2021

The Particle Physics Community Planning Exercise (a.k.a. "Snowmass") is organized by the Division of Particles and Fields (DPF) of the American Physical Society. Snowmass is a scientific study. 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

- Timeline:

  31 August 2020: Submission of Letters of Interest (LOIs)
  15 March 2022: Submission of Contributed Papers to arXiv
  30 June 2022: Preliminary reports of the Frontiers
  July 2022: Community Summer Study meeting (UW Seattle)
  30 September 2022: Final Reports

- Currently on hiatus until June 2021 (COVID)

Sincerely,

Young-Kee Kim (DPF Chair), Tao Han (DPF Chair-Elect), Joel Butler (DPF Vice-Chair), Priscilla Cushman (DPF Past Chair)

Glennys Farrar (DAP Rep), Gabriela Gonzales (DGRAV Rep), Yury Kolomensky (DNP Rep), Sergei Nagaitsev (DPB Rep)

DPF Community Planning Process

https://snowmass21.org/start

The Way: idea ➡ LOI ➡ Contributed Paper

- Theoretical Letter of Intent

Physics of muonium and muonium oscillations

Alexey A. Petrov[1]

[1]*Department of Physics and Astronomy*
Wayne State University, Detroit, MI 48201, USA

Precision studies of a muonium, the bound state of a muon and an electron, provide access to physics beyond the Standard Model. We propose that extensive theoretical and experimental studies of atomic physics of a muonium, its decays and muonium-antimuonium oscillations could provide an impact on indirect searches for new physics.

- Experimental Letter of Intent

Search for Muonium to Antimuonium Conversion

RF Topical Groups: (check all that apply ☐/■)

☐ (RF1) Weak decays of b and c quarks
☐ (RF2) Weak decays of strange and light quarks
☐ (RF3) Fundamental Physics in Small Experiments
☐ (RF4) Baryon and Lepton Number Violating Processes
■ (RF5) Charged Lepton Flavor Violation (electrons, muons and taus)
☐ (RF6) Dark Sector Studies at High Intensities
☐ (RF7) Hadron Spectroscopy
☐ (Other) *[Please specify frontier/topical group(s)]*

Contact Information:(authors listed after the text)
Name and Institution: Jian Tang/Sun Yat-sen University
Collaboration: MACE working group
Contact Email: tangjian5@mail.sysu.edu.cn

Abstract: It is puzzling whether there is any charged lepton flavor violation phenomenon beyond standard model. The upcoming Muonium (bound state of μ^+e^-) to Antimuonium (μ^-e^+) Conversion Experiment (MACE) will serve as a complementary experiment to search for charged lepton flavor violation processes, compared with other on-going experiments like Mu3e ($\mu^+ \to e^+e^-e^-$), MEG-II ($\mu^+ \to e^+\gamma$) and Mu2e/COMET ($\mu^-N \to e^-N$). MACE aims at a sensitivity of P($\mu^+e^- \to \mu^-e^+$) $\sim \mathcal{O}(10^{-13})$, about three orders of magnitude better than the best limit published two decades ago. It is desirable to optimize the slow and ultra-pure μ^+ beam, select high-efficiency muonium formation materials, develop Monte-Carlo simulation tools and design a new magnetic spectrometer to increase S/B.

Things to take home: mechanics of CP submission

- Step 0: LOI submission
  - if submitted: good!
  - if NOT submitted: also good!
- Step 1: Contributed paper (CP) decision
  - inform Frontier/Topical Group conveners that you are interested
  - project consolidation: if possible (conveners provide contacts)
  - CPs based on physics (if possible): trying to avoid multitude of similar CPs
- Step 2: Contributed paper submission
  - please submit your paper here: https://snowmass21.org/submissions/
  - submit your paper to arXiv


The Evening Herald
EXTRA!

LOI Breakdown

"Fundamental" Physics	
Dedicated Experiment Exploring Gravitational Effects on CP Violation	Gravity-generated / connected CPV
Strong CP and Neutrino Masses: A Common Origin of Two Small Scales	neutron EDM <-> neutrino masses (cross-frontier)
Searches for Exotic Short-range Gravity and Weakly Coupled Spin-Dependent Interactions using Slow Neutrons	Gravity tests with neutrons
Lorentz and CPT Tests with Low-Energy Precision Experiments	L / CPT tests (overview of many opportunities)
NOPTREX:	T violation with neutrons
Muonium Gravity Experiment	Gravity test (antimatter)
Facilities	
Upgraded Low-Energy Muon Facility at Fermilab	Facility (cross-group)
Potential storage ring and Muon Campus experiments	Muon campus / facility use
Dipole Moments	
Using lattice QCD for the hadronic contributions to the muon g – 2	Lattice QCD - HVP
Calculations of nucleon electric dipole moments on a lattice with chiral fermions	Lattice QCD - nucleon EDM
Hadronic contributions to the anomalous magnetic moment of the muon	Lattice QCD - HVP & HLbL
Opportunities and New Physics Implications for (g – 2)e,μ	electron and muon MDM: Theory model (cross frontier)
The Proton Storage Ring EDM Experiment	EDMs (CPV) and axion DM
Test of the Standard Model and Search for Physics Beyond∗ Opportunities for Fundamental Physics using Small-scale Storage Ring Experiments	EDMs storage ring (see other LOI in AF5)

AMO	
Atomic/nuclear clocks and precision spectroscopy measurements for dark matter	Precision clocks and spectroscopy/DM
Optically levitated sensors for precision tests of fundamental physics	Gravity tests (micron-scale) with nanospheres, axion DM
Probing fundamental physics with highly-coherent nuclear spins	EDM (CPV) and axion DM
Th-229 Nuclear Clock	Precision clocks
Mechanical tests of the gravity-quantum interface	Gravity (-quantum) tests
Doped Cryocrystals for Ultrasensitive EDM Measurements: Snowmass LOI	EDMs, facility for cryo-crystals
Searches for new sources of CP violation using molecules as quantum sensors	EDMs (CPV) with molecules

R. Bernstein (FNAL)