

Rare and Precision Frontier Snowmass Day

<https://snowmass21.org/rare/start>

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Four Questions

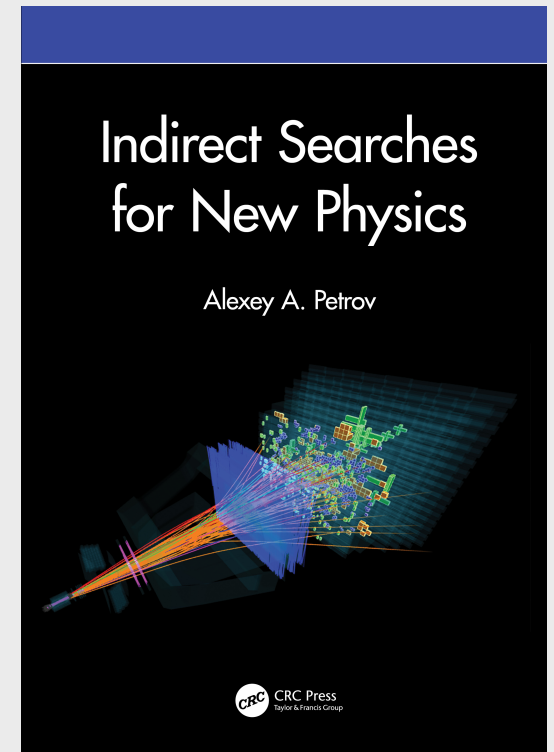
- What is the physics of the topical group?
- What are the specific P5 Drivers?
- What is required for progress?
- What do we want P5 to do?

and we'll give you
upcoming plans:
all Frontier workshop
Cincinnati May 2022



Unifying Theme

- This frontier is about probing New Physics with precision measurements from as many directions as possible
- Indirect:
 - targeted experiments looking for specific signatures
 - studying low-energy operators to connect to high-scale Lagrangian
- Direct:
 - searches in Dark Sector



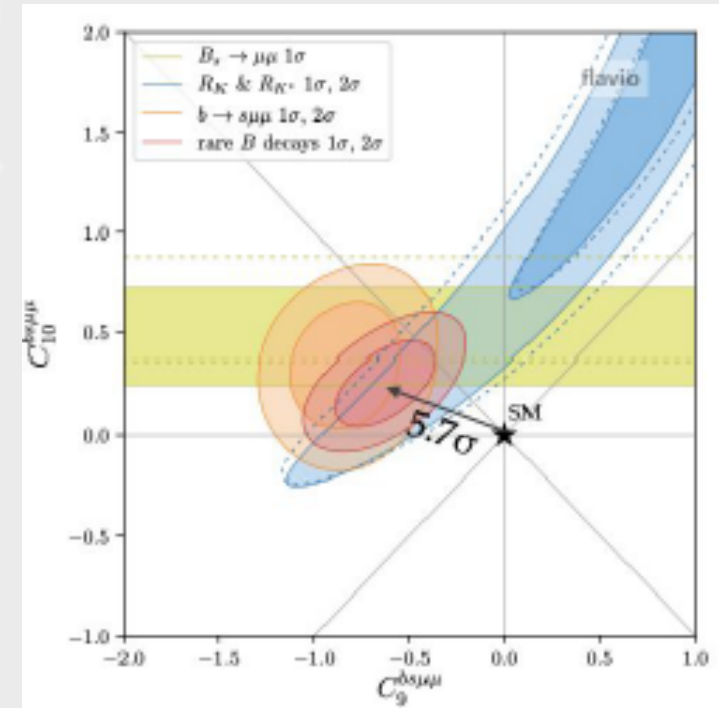
Standard Disclaimer

- In 10 min I can't cover every experiment, facility, etc. Too many terrific ideas to do them justice.
- This overview is about themes and ideas, some I heard for the first time this week
- So I apologize and come to the parallel session!

RF1: Weak Decays of b and c

- **Physics:** Diverse and model-independent probes for new physics and high precision tests of the Standard Model; weak decays of heavy quarks can provide early hints/directions of discoveries at the energy frontier (anomalies in $b \rightarrow sl\ell$ and $b \rightarrow c\tau\nu_\tau$).
- **Drivers:** explore the unknown
- **Progress:** LHCb Phase II upgrades and LHC upgrades; support for BELLE program; BES-III; FCCee
- **P5:** explicit recognition of importance of this physics and prioritization of support. Endorse a strong heavy flavor program during HL-LHC and beyond
- **Plans:** find editors of ~4 summary whitepapers covering the main physics areas

https://indico.fnal.gov/event/50820/contributions/223201/attachments/146990/188073/RPF_convener_meeting_2021_09_08_RF1.pdf



RF2: Weak Decays of Strange and Light Quarks

- **Physics:** goals: searches for new physics in ultra-rare processes; CP violation measurements; CKM unitarity, lepton universality and LN/LF conservation and fundamental symmetry tests; searches for light hidden sectors.
- **Drivers:** explore the unknown
- **Progress:** construction and operation of high-intensity kaon beam facilities at CERN and J-PARC and new-generation rare pion and η decay experiments; progress in lattice QCD computations.
- **P5:** recognition of importance of this physics; support of dedicated kaon, pion, and η decay experiments
- **Plans:** a number of community papers are in preparation

RF3: Fundamental Physics in Small Experiments

- **Physics:** EDMs, precision measurements of universality, fundamental symmetry violations
- **Drivers:** explore the unknown. Help identify the new physics of dark matter
- **Progress:** requires upgrades and new experiments, tightly coupled to CLFV, DM (RF5 & RF6)
 - proton storage ring for EDM
- **P5:** robust support for small precision experiments on fundamental symmetries
 - very interesting connections to AMO. What should be US HEP role?
- **Plans:** coordinate 6—7 white papers. Group related LOIs, assign editors, encourage writers

RF4: B and L Violating Processes

- **Physics:** B and L violation in colliders, proton decay, $0\nu 2\beta$, $n\bar{n}$ oscillations, exotic processes, and connections to cosmology (baryogenesis). Strong theory component and overlap with several other Frontiers:
- **Drivers:** explore the unknown; nature of neutrinos and matter-antimatter asymmetry.
- **Progress:** requires upgrades of existing facilities and will exploit next-generation detectors. An important component is the development and refinement of theoretical calculation tools (lattice, EFT, ab-initio many-body)
Instrumentation: existing and future neutron facilities, large neutrino detectors
- **P5:** strong support for this physics
- **Plans:** BL white paper with summary discussion of LOIs, white papers and others

RF5: Charged Lepton Flavor Violation

- **Physics:** μ, τ CLFV ($\mu N \rightarrow e N$; $\mu, \tau \rightarrow e \gamma$ or $3e$) muonium-antimuonium; meson and baryon LFV; Higgs CLFV; light to heavy CLFV ($e N \rightarrow \tau N$)
- **Drivers:** explore the unknown. CLFV is closely related to the physics of neutrino mass, not emphasized in first P5
- **Progress:** requires upgrades and new experiments
 - R&D overlaps with muon collider and AF issues. FCCee can contribute.
- **P5:** call for design studies for a new high-intensity muon facility using PIP-II
 - this is a significant new effort that reaches outside RF5
 - US could lead the field and P5 needs to prioritize it
- **Plans:** coordinate white papers. Work with other frontiers, especially AF

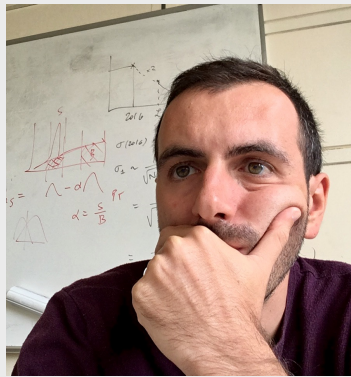
RF6: Dark Sector at High Intensities

- **Physics:** dark sector studies at high intensities, including the production of dark matter and unstable dark particles
- **Drivers:** identify the physics of dark matter; explore the unknown
- **Progress:** To explore the landscape of viable dark-sector theories requires in-progress and future upgraded proton and lepton colliders, fixed-target and beam-dump experiments, meson factories, neutrino experiments, long-lived particle detectors, along with novel experimental ideas. Strong theory efforts are required to better explore and define this landscape.
- **P5:** recognize the importance of these efforts; endorse parasitic exploration at multi-purpose experiments; and prioritize support for smaller-scale dedicated experiments and for theory.
- **Plans:** Coordinating 4 solicited white papers on (a) dark matter production and detection; (b) production and detection of unstable mediators; (c) rich dark sectors; (d) experiments / facilities and tools. In addition, expecting many contributed white papers focused on specific efforts.

RF7: Hadron Spectroscopy

- **Physics:** Our understanding of full bound-state spectrum of QCD is woefully incomplete. Tetra- and pentaquarks now seen, other exotics likely. How are they bound?
- **Drivers:** explore the unknown.
- **Progress:** theoretical tools (phenomenology and lattice QCD) lag behind experiment. Increased support for theorists doing this work
- **P5:** no explicit mention in last report
 - support experiments and groups addressing key questions
 - endorsement of theory efforts
- **Plans:** white papers; final workshop on Oct 25, summarizing experimental discoveries made during pause!

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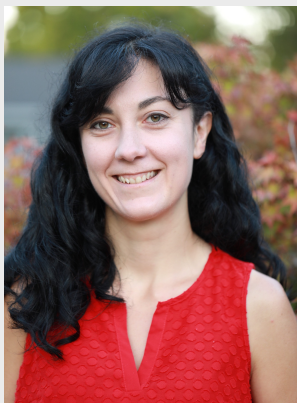
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