Report from the “Exploring the Unknown” Science Driver Session

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Brief Introduction

- **Science Drivers:**
  - **Broad set of precision measurements searching for small deviations from Standard Model processes**
  - **Indirectly probe beyond-the-Standard-Model physics occurring at high energy scales; study flavor physics**
- **Structure of parallel session:**
  - **Kaons at CERN (NA62, $K^+ \to \pi^+ \nu \bar{\nu}$), *H. Danielsson***
  - **Charged lepton flavor violation:**
    - **MEG, Mu3e, (*μ->eγ*, *μ->eee*), *F. Grancagnolo***
    - ***μ->e* in muonic atoms, *H. Natori***
  - **Muon *g*-2 and EDM, *J. Tojo***
  - **Precision searches for EDMs (*n*, e^-, nuclei), *L. Yang***
  - **Direct neutrino mass measurements, *B. Monreal***
  - **Neutrinoless double beta decay, *A. Pocar***

Findings

- Active and diverse precision measurements community includes a wide variety of experiments and technologies
- Experiments are complementary to energy frontier and can indirectly probe mass scales above reach of colliders; comparisons among experiments pin down models and help determine couplings: not just the mass scale, but the flavor structure
- Detector technologies from many areas of HEP, NP, and elsewhere are needed to enable the many different searches
- Benefit from advances in tracking, photodetectors, fast timing, low background techniques, calorimeters

Comments

- Most of these searches represent ongoing efforts continually improved with each new generation of detector
- Many people showed Moore's-law like improvements in previous years that have been driven by technology
- For mature searches, continuing to maintain this pace of improvement is challenging
- Many "grand" challenges already met, but technologies for next-generation experiments are even more demanding

Recommendations

- Pursue R&D in the following areas:
- Thin Straws in Vacuum:
  - Precision Kaon physics provides clean channel to search for BSM physics. NA62 will reach 10% precision on branching ratio. Upgrades will require less mass in trackers.
  - cLFV experiments coming on line. Next generation will need at least x2 thinner straws, 7μm or less with low leak rates.
- Low-mass, high-resolution pixel sensors for both Kaon and cLFV muon experiments
- Radiation hard, fast scintillating crystal calorimetry for upgraded muon experiments (talk by D. Hitlin)

Recommendations (cont'd)

- Upcoming muon g-2 experiments are aiming for 0.1 ppm sensitivity.
  - Challenging experiments will require continued development of new muon beam technologies, calorimetry and timing (talk by J. Kaspar)
- Studying cLFV signals will also require new techniques
  - Need to characterize muon beams (10^{11} muons/sec, well below typical technologies for proton beams)
  - Rad-hard SiPMs needed for cLFV background rejection (talk by R. Ruchti)
  - Rad hard Ge X-ray detectors (normalization in cLFV)

Recommendations (cont'd)

- Substantial overlap in technology (and physics) between NP-led precision searches and HEP, both programs would benefit from following technology advances:
  - Cryogenic nEDM shares several challenges with liquid noble TPC development (high voltage, VUV photon detectors)
  - Next-gen direct neutrino mass measurements require advanced superconducting μCalorimeters (CMB, DM), RF antenna arrays, correlators (21cm cosmology)
  - NLDBD searches: superconducting photon detectors (CMB, DM), low-background materials (DM), large liquid scintillator detectors (LAPPDs, neutrinos), liquid noble TPCs (DM, neutrinos), low mass tracking calorimeters

Possible Grand Challenge Ideas

- Muon and Kaon experiments: not new grand challenges, but focused applications:
  - Thin straws, fast calorimetry, NP/HEP partnerships to study few hundred keV to 100 MeV processes
- Challenge which can enable both dark matter and precision neutrino searches:
  - 100 ton scale low-background detector with ~keV scale energy resolution (NLDBD, DM)