

# Rare processes and precision measurements

[frontier calendar](#)

Instrumentation needs

*Frontier conveners [Marina Artuso](#), Bob Bernstein and Alexey Petrov*

Interface slack channel [#rare\\_precision\\_frontier\\_instrumentation](#)

# Reference material

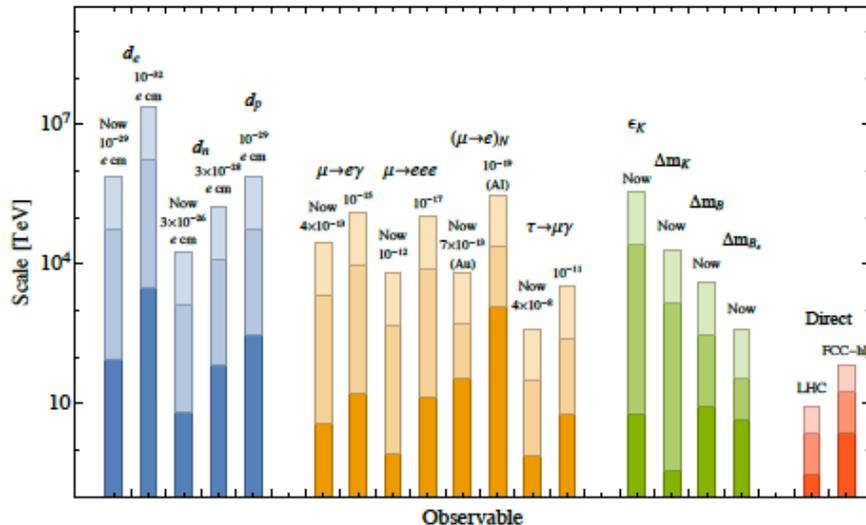
- ❑ DOE BRN Study on HEP Detector Research and Development commissioned by DOE HEP [co-Chairs Bonnie Fleming and Ian Shipsey] Report will become public at the time of its presentation by the co-Chairs at the HEPAP Meeting July 10, 2020, more information at <https://science.osti.gov/hep/hepap/Meetings>
- ❑ Lucie Lissen [Detector challenges for future HEP experiments](#) at Granada ESPPU symposium, May 14th 2019
- ❑ CPAD Report: [New technologies for discovery](#)

# Topical groups

- ❑ Weak Decays of b and c quarks: [Angelo Di Canto/Stefan Meinel]
- ❑ Weak Decays of strange and light Quarks: [Evgueni Goudzovski/Emilie Passemar]
- ❑ Fundamental Physics in Small Experiments [Peter Winter/Tom Blum]
- ❑ Baryon and Lepton Number Violation [Pavel Fileviez Perez/Andrea Pocar]
- ❑ Charged Lepton Flavor Violation [Bertrand Echenard/Sacha Davidson]
- ❑ Dark Sector at High Intensities [Mike Williams/Stefania Gori]

# Some remarks

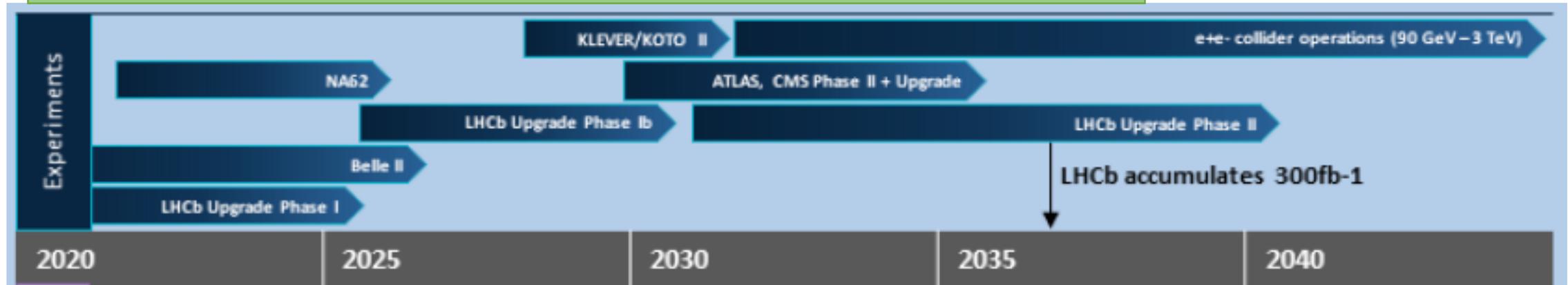
From BRN DOE BRN Study on  
HEP Detector Research and  
Development Report



- ❑ Topical groups organized by physics line of inquiry, unified by the common goal of pursuing a broad-based exploration that might reveal clues towards extensions of the Standard Model.
- ❑ Unifying feature is the accessibility of mass scales that cannot be probed with direct searches.
- ❑ Diverse community with a variety of technological challenges, current compendium illustrative rather than comprehensive, search for some broad themes
- ❑ We are at the beginning of our exercise, these considerations to be considered as a starting point

# Heavy flavor

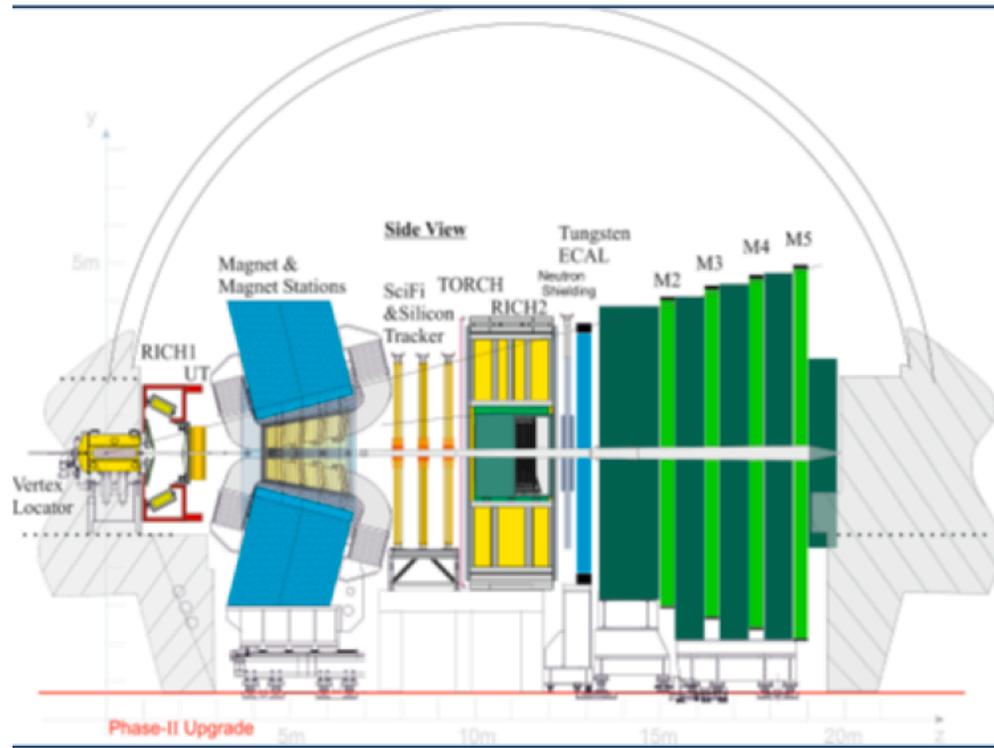
From BRN DOE BRN Study on HEP Detector Research and Development Report



- ❑ This timeline encapsulates RF1 and RF2 (at least the K program)
- ❑ Synergy with HE frontier (most prominently heavy hadron decays with leptons in the final state)
- ❑ Belle II started operation, upgrade of machine/detector being considered

# Experimental requirements – heavy flavors

LOI US LHCb group



- ❑ Timing added to tracking [10-30 ps/hit] and calorimetry [10-30 ps/track]
- ❑ Higher granularity tracking
- ❑ Radiation hardness [up to  $5 \times 10^{16}$   $n_{eq}/cm^2$ ] for LHCb upgrade 2.
- ❑ New calorimeter concept (5D, higher segmentation)
- ❑ Next generation of ASIC [data rate/preprocessing]
- ❑ Rad hard optical links
- ❑ Real time data flow/software trigger

High  
luminosity  
(x7.5)

# Charge leptons

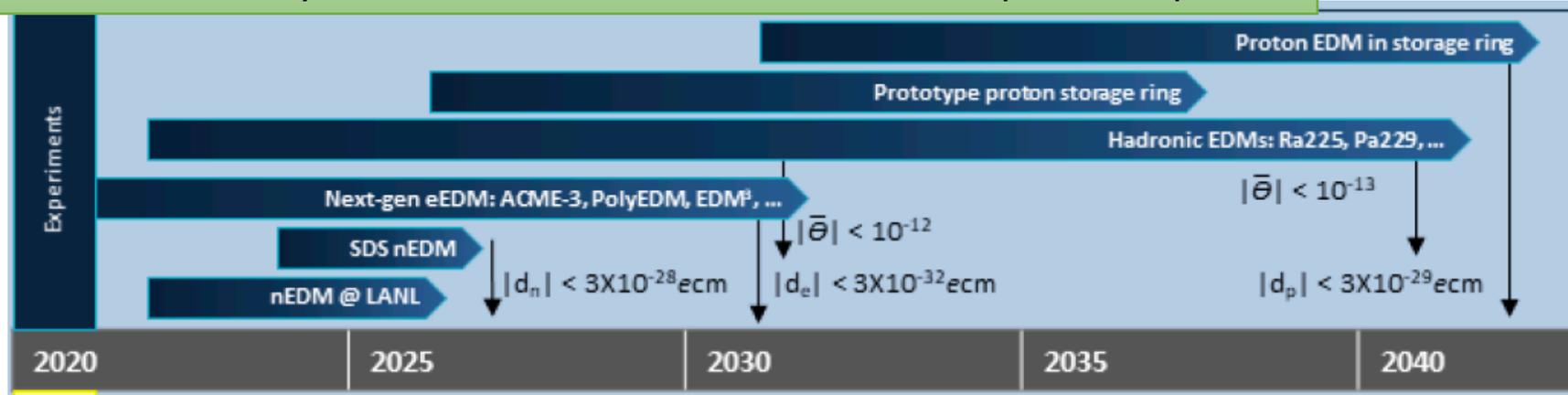
From BRN DOE BRN Study on HEP Detector Research and Development Report



- ❑ Synergistic with  $e^+e^-$  b-factories, LHCb Upgrade, HE Frontier [e.g. FCC-ee] ( $\tau \rightarrow e\gamma$ ,  $\tau \rightarrow 3\mu$ )
- ❑ Instrumentation needs:
  - ❑ Low cost calorimeter with good energy resolution, excellent pointing capabilities and timing resolution longer term goals.
  - ❑ 20 ps track-level timing with low-mass tracker and excellent momentum resolution
  - ❑ Ultimate goal transparent tracker with excellent resolution

# Electric Dipole Moments of particles

From BRN DOE BRN Study on HEP Detector Research and Development Report



Instrumentation needs:

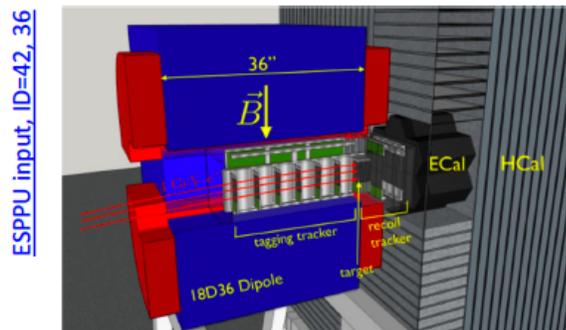
- Controlled preparation of many coherent particles
- Laser refinements
- Characterization of target atoms

# Baryon and lepton number violation

- ❑ searches for baryon and lepton number violation address, among other things, the fundamental question of the matter abundance in the universe
- ❑ Proton decay and neutrinoless double  $\beta$  decay require “passive” detectors of increasing size, with numerous instrumentation issues
  - ❑ light/charge collection
  - ❑ radio-purity, isotope enrichment, ...
- ❑ BLV searches at accelerators require pushing PID and reconstruction at accelerators, possibly dedicated beams [this is for the accelerator frontier]
- ❑ neutrinoless double  $\beta$  beyond the tonne-scale is exploring new avenues traditionally not in the HEP portfolio (e.g. Barium tagging)
- ❑  $n-\bar{n}$  oscillations requires development of a tools of its own

# Dark sector (two examples)

## LDMX, SPS

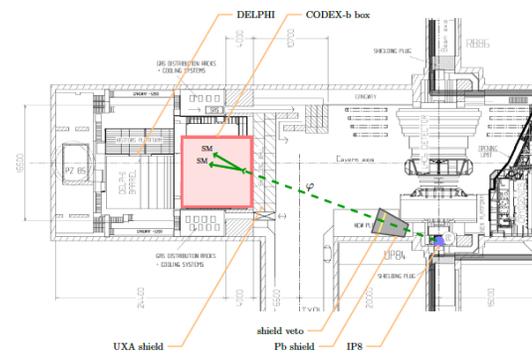


Light Dark Matter experiment at  $\sim 16$  GeV beam  
Goal: measurement of soft recoiling electron with large

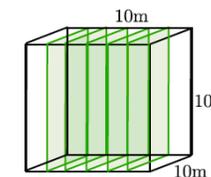
$p_T$

- ❑ High precision strip tracker
- ❑ High granularity ECAL  $\sim 50$  ps time resolution per calorimeter cluster
- ❑ HCAL scintillator bars with SiPM readout

## CODEX-B LHC



(a) Location in the cavern



(b) Detector geometry

Hermetic detector with RPCs featuring precision timing + large scale calorimeter, cost optimization

# Concluding remarks

- ❑ RP frontier encompasses a wide portfolio of instrumentation needs that will allow key measurements that will help us in answering fundamental questions
- ❑ Broad synergies with other fields:
  - ❑ Precision tracking with state-of-the-art timing
  - ❑ 5D calorimetry
  - ❑ Cost-effective and radiation hard photon detectors
  - ❑ ASICs for specific goals
  - ❑ Fast DAQ and processing of increasing data volumes
  - ❑ ...