Overview of Future LBNL-led small experiments

Introduction

Examples of small experiments follow to define by example what we're talking about

I'll go over them quickly- no details (each could be a standalone seminar)

Panel follows

Most contact names on the examples are in the panel, so this intro also introduces the panel

Jump right into discussion as fast as possible

EOS: few-ton WbLS prototype detector

Contact: Gabriel D. Orebi Gann

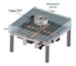
Data-driven demonstration

- ✓ *Demonstrate Cher+scint reconstruction*
- ✓ *Demonstrate Cher+scint particle ID*
- ✓ Enable broad, world-leading physics + nonpro program

Demonstration of next-generation detector capabilities

Develop **R&D infrastructure** — testbed for future programs

CHESS
200mL
LBNL LDRD
(FY13-14)



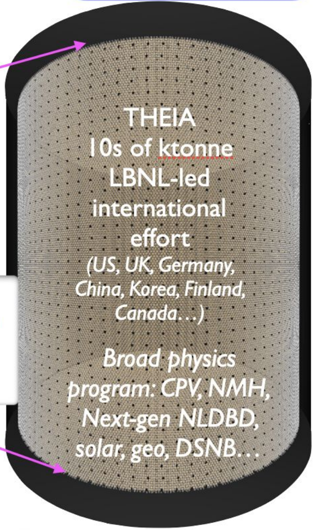
First demonstration of Cherenkov light detection from high yield liquid scintillators

Critical few-ton scale demonstration of detector performance capabilities

Importance for programs in NNSA + ONP, OHEP, & international partners

ANNIE: high-energy ν, neutrons

EOS: low-energy β,γ,α, event reconstruction and PID



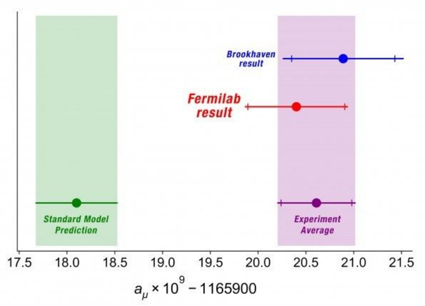
Goals:
Low-energy event reconstruction
Directionality in scintillator
Off-site deployment for possible physics applications

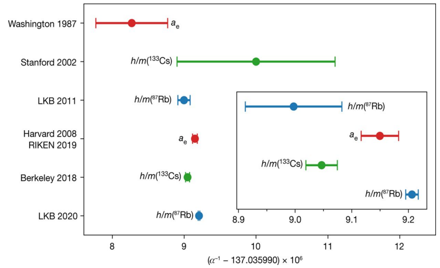
LBNL interest:
Dave Brown (PD)
Richie Bonventre (PD)
Bethany Goldblum (NSD)
Others welcome!

Project Alpha

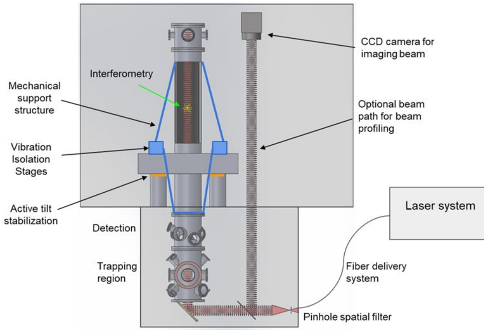
Contact: David Brown, Holger Mueller

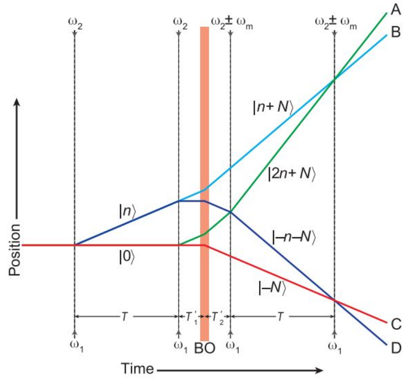
- **Funded and construction in progress!**
- Aim: most accurate measurement of $\alpha \approx$ **1/137.035999046(27)**, improving our previous one
    - Homogeneity of the laser beam
    - New Atom Interferometers to cancel systematics
- Test Standard Model at 0.02 ppb precision
- Search for new physics, such as dark matter candidates
- Methods to extend coherence in quantum information processing





Resolving famous mysteries in lepton magnetic moments...



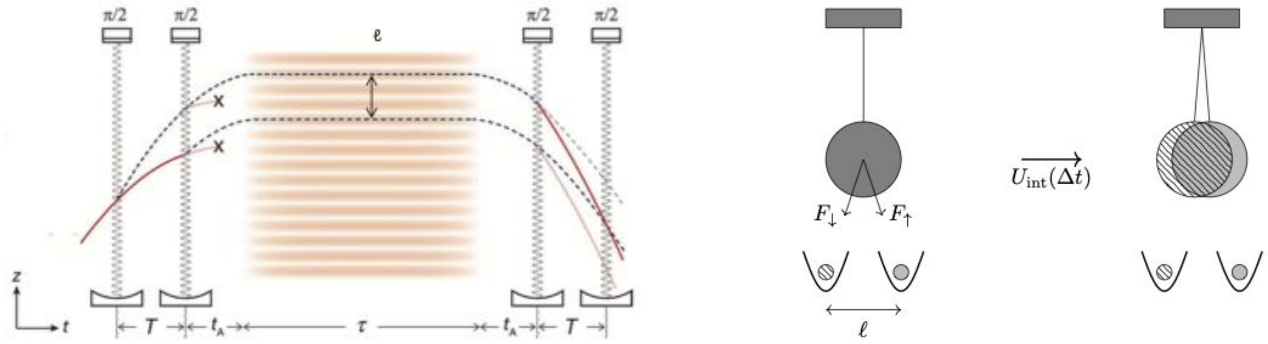


Left: Setup. Right: Trajectories of matter - waves for measuring h/m_{Cs}

Test of quantum gravity

Contact: Holger Mueller, Dan Carney

Experiment w/ atom interferometer: demonstrate communication of quantum information via pure gravity



Proposal: DC, HM, J. Taylor, PRX Quantum (2101.11629), see also DC 2108.06320 and DC, P. Stamp, J. Taylor CQG (1807.11494), general snowmass LOI on quantum grav experiments

LBNL press: https://newscenter.lbl.gov/2021/09/07/is-gravity-a-quantum-force/

Proposal for gravitational direct detection of dark matter

Contact: Dan Carney

Can we use optomechanics (~LIGO) to do direct detection of heavy (~m_planck) DM via gravity?

Nascent experimental effort “Windchime” collaboration (http://windchimeproject.org/), funded by DOE QSC and a QuantISED grant at Purdue/ORNL/FNAL/…, plus some other non-collab groups

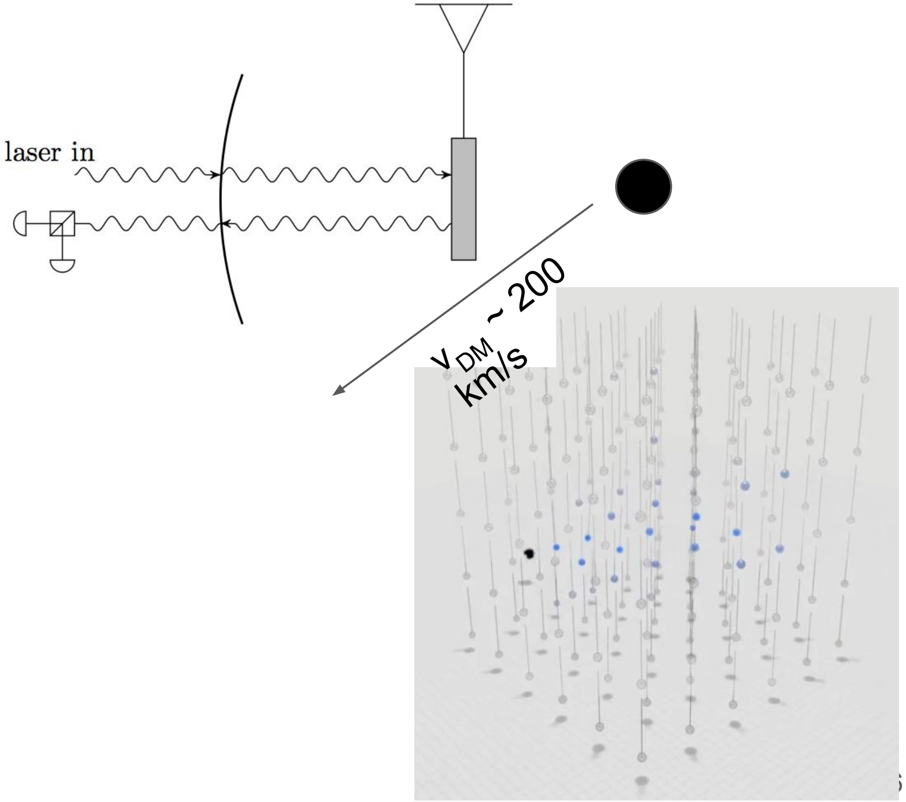
Proposal: DC, Ghosh, Krnjaic, Taylor 1903.00492

Overview of optomech for DM: DC+32, 2008.06074

Snowmass LOI “mechanical particle detectors”

I am supposed to organize a solicited CF community white paper on heavy (m > TeV) DM, detection + theory, if anyone wants to get involved please reach out

Lots of press, see list @ my site

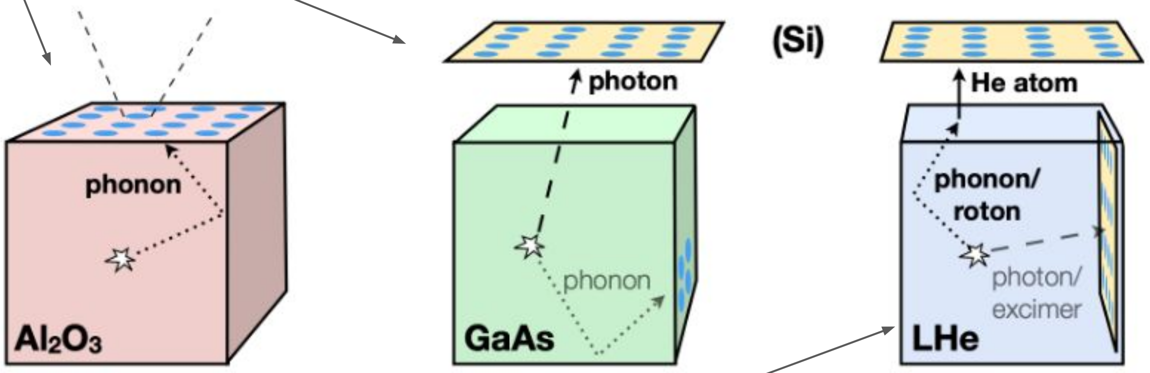


SPICE-HeRALD

Contact: Dan McKinsey, Matt Pyle
Snowmass LOI

Partly funded through the TESSERACT award. Plan TDR in 2 years

1)SPICE: **S**ub-ev **P**olar **I**nteractions **C**ryogenic **E**xperiment 1712.06598



Same detector, cryostat, shielding, etc.
3 complementary targets NR, ER, and coherent modes.

10KeV to 100MeV DM mass range

3)HeRALD: **He**lium **R**oton **A**pparatus for **L**ight **D**ark matter 1810.06283

Crystallize

Contact: Peter Sorensen

See DM session

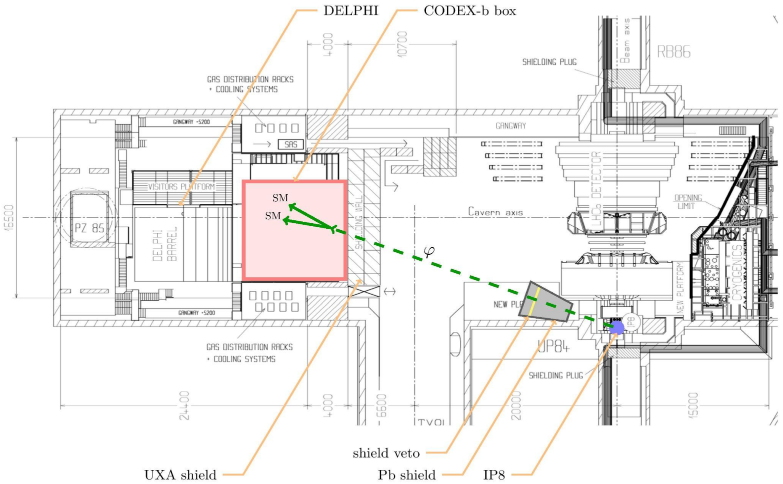
Snowmass LOI

CODEX-b

Contact: Dean Robinson, Ben Nachman

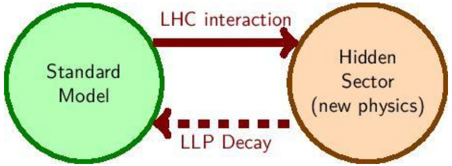
COmpact Detector
for EXotics at LHCb

Original proposal: [1708.09395]
Expression of Interest: [1911.00481]

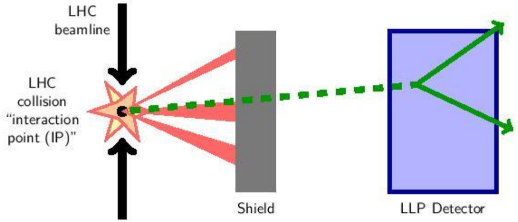


Search for long-lived particles beyond SM through displaced decays in flight at LHC

Physics paradigm:



Search paradigm:



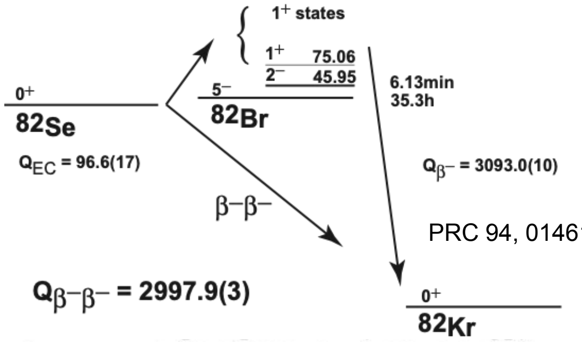
Snowmass LOI
https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF9_EF0-RF6_RF0-034.pdf

CMOS imaging detector for $0\nu\beta\beta$ in ^{82}Se and solar neutrino

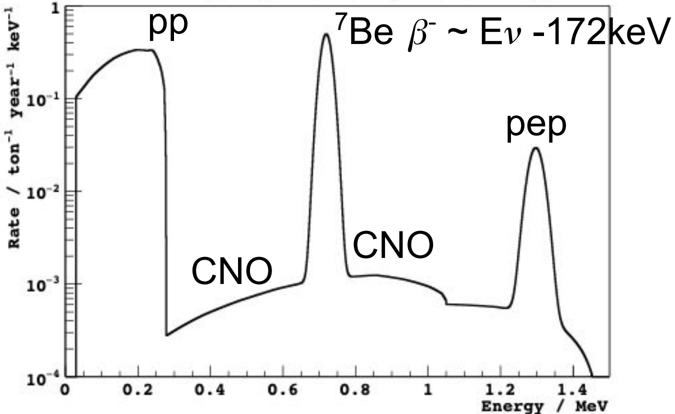
Contact: Xinran Li, Yuan Mei

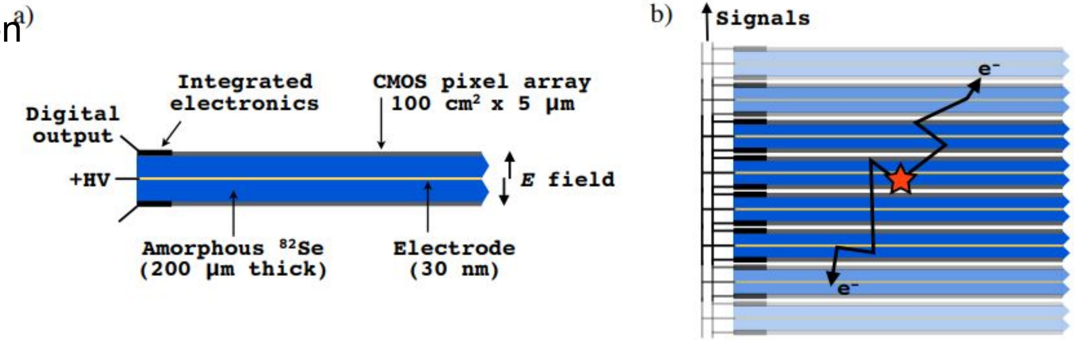
Collaboration: U. Washington, Princeton

- Imaging beta tracks with μm-level precision in amorphous ^{82}Se
- Prompt events for solar ν spectroscopy



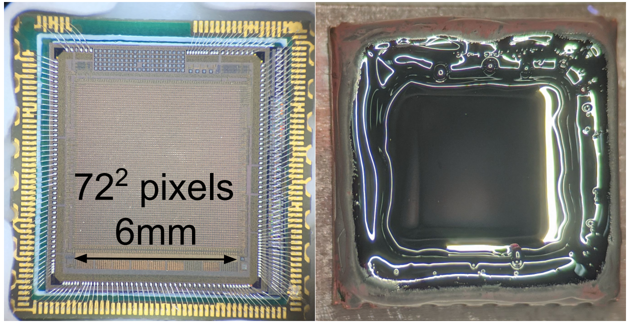
PRC 94, 014614 (2016)



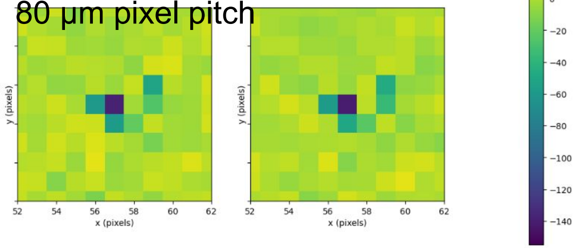


Stack of large 2D aSe-CMOS imaging detectors for 0vbb search.
(A.E. Chavarria *et al* 2017 *JINST* 12 P03022)

Synergy with collider physics (EIC): wafer-sized stitched pixel tracker

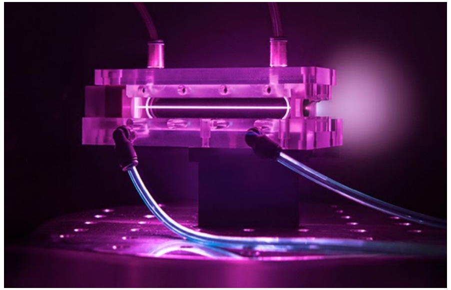


Ongoing R&D: aSe on Topmetal-II$^-$
Single β tracks from ^{90}Sr source.
80 μm pixel pitch



40 GeV laser accelerator collider

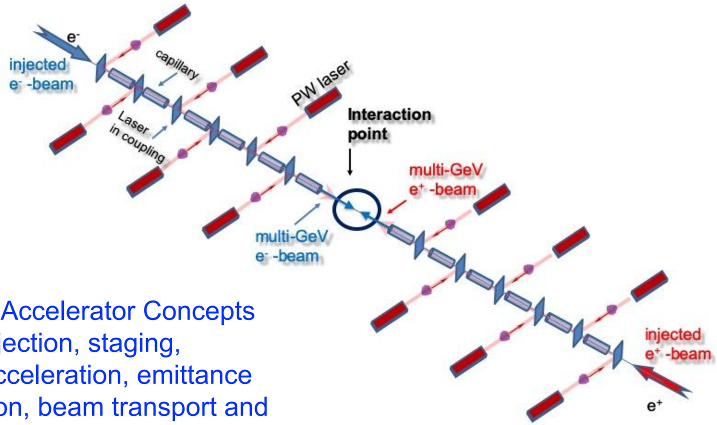
Contact: Jeroen van Tilborg, Stepan Bulanov

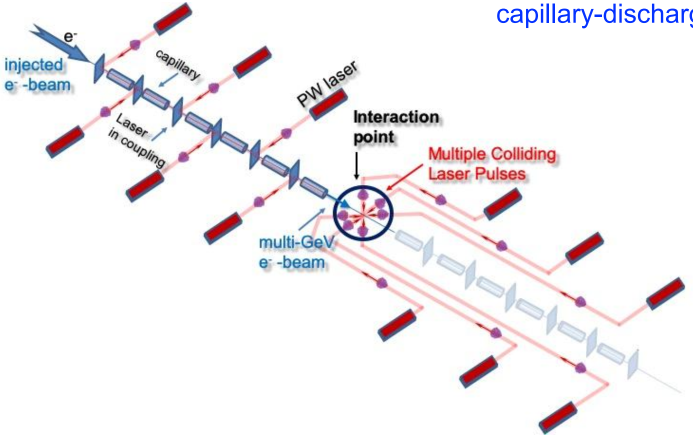


Next initiative: kBELLA facility will demonstrate scaling to/beyond kHz rates for luminosity

Plasma based collider can be made multi-purpose with minimal adjustments to its configuration

Key technologies: all-optical or capillary-discharge waveguides





Advanced Accelerator Concepts studies: injection, staging, positron acceleration, emittance preservation, beam transport and focusing.

Strong Field QED phenomena such as high-multiplicity cascades, spin-polarized high energy lepton beams, high energy photon sources, and prototype γγ colliders.

E. Esarey, W. P. Leemans, Physics Today, 2009

P. Zhang, S. S. Bulanov, D. Seipt, A. V. Arefiev, and A. G. R. Thomas, Phys. Plasmas 27, 050601 (2020)