Beyond ton-scale 0νββ experiments — Scalability

Yuan Mei[a]

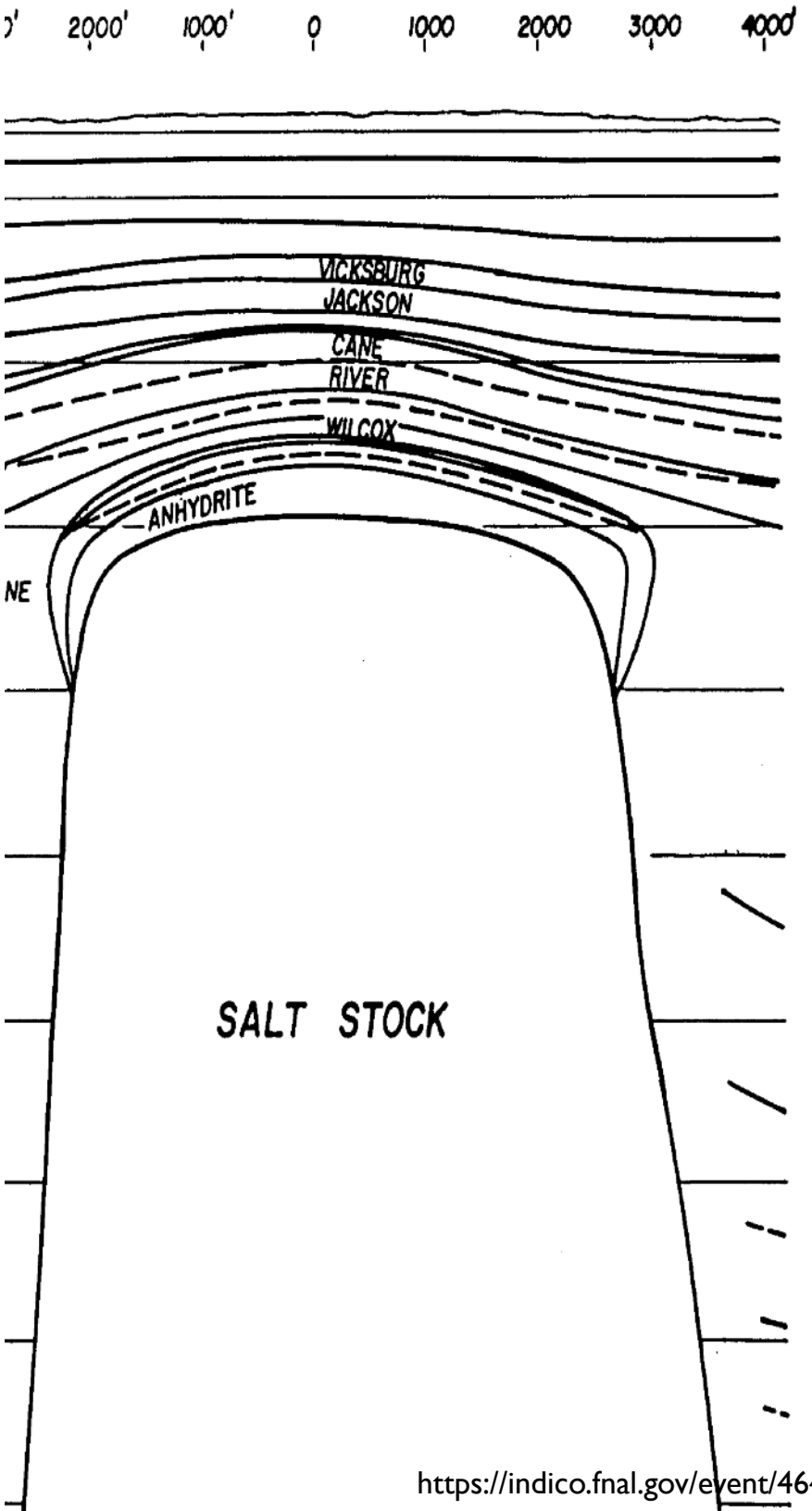
[a]NSD, LBNL

Beyond ton-scale

- Make detector big and cheap
  - Lower the cost means things happen faster
- Economy of scale: utilize industrial processes to lower the cost (ref: LArPix in DUNE)
- Get to the required detector mass scale early
  - Improvement on details later
  - If large-scale is made sufficiently cheap, isotopic enrichment may not be necessary

Find a cavern
Place a isotope-filled balloon
Instrument it

Gaseous TPC
<1% FWHM energy resolution
Extended charge tracks
Decay-daughter identification



Benjamin Monreal's idea:

Storage cavern used by oil industry

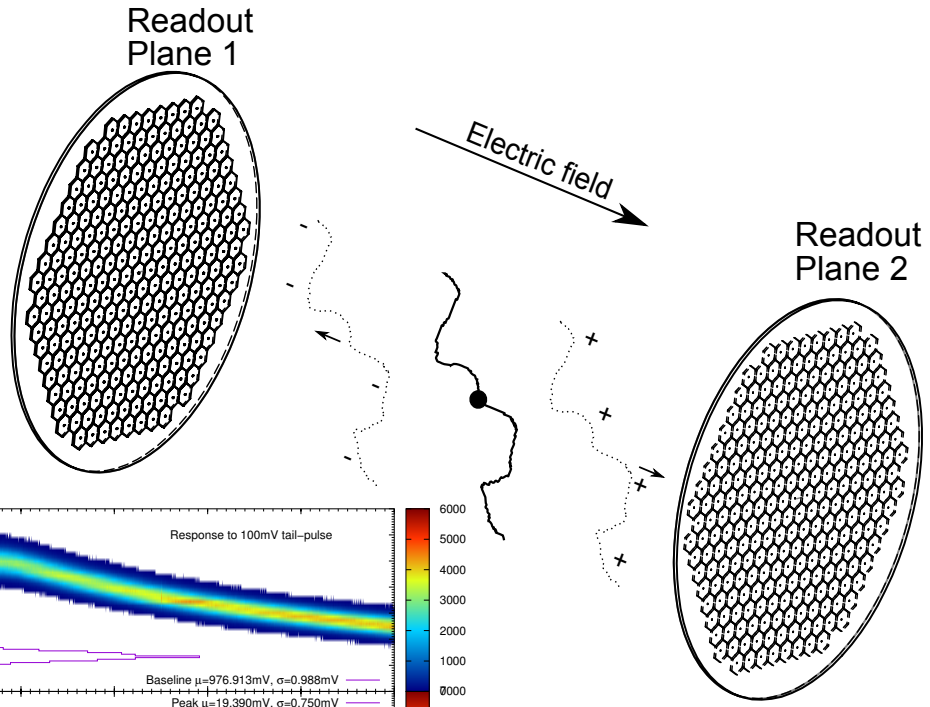
Put an `inflatable' detector in the cavern via a small shaft

May allow the use of toxic gas

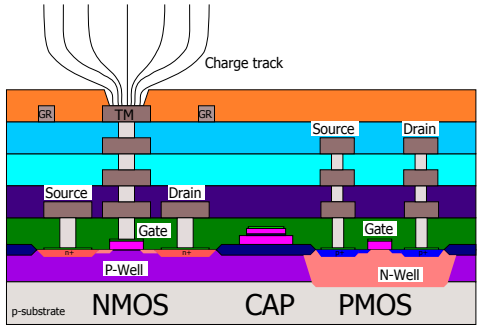
https://indico.fnal.gov/event/46424/contributions/202839/attachments/138331/173165/snowmass_0vbb.pdf

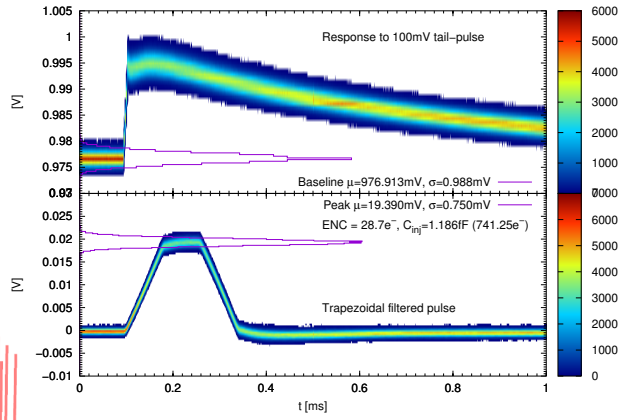
Gaseous TPC with CMOS array charge readout

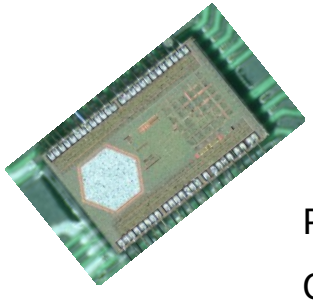
- Scaling up to larger size while keeping spatial resolution means drastic increase in channel number
- With or without charge multiplication, or SiPM array
- Fill the plane with CMOS sensor
- Use bonding pad for charge collection
- Amplify and digitize on the spot
- CMOS sensors talk to neighbors to form a network
- In-chip regulation of power, eliminating external components (reduce radioactivity)
- Economy of scale: leverage standard industrial processes

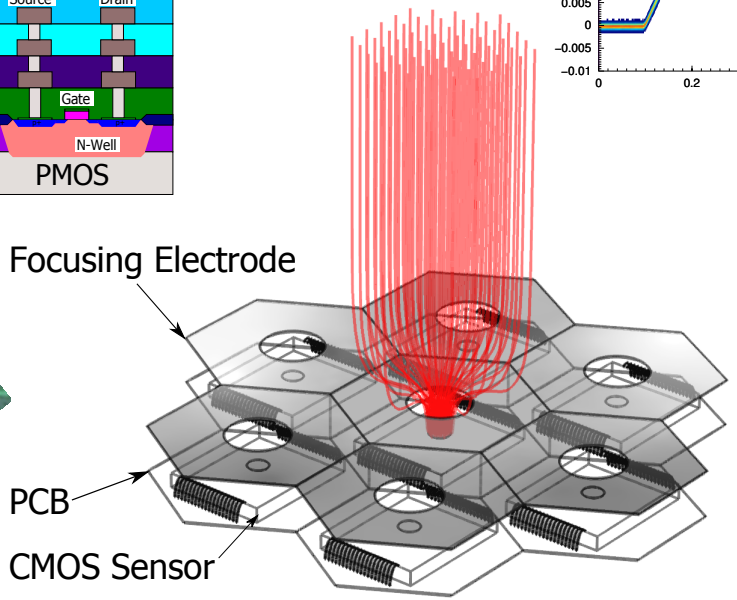


Topmetal sensor project(s)







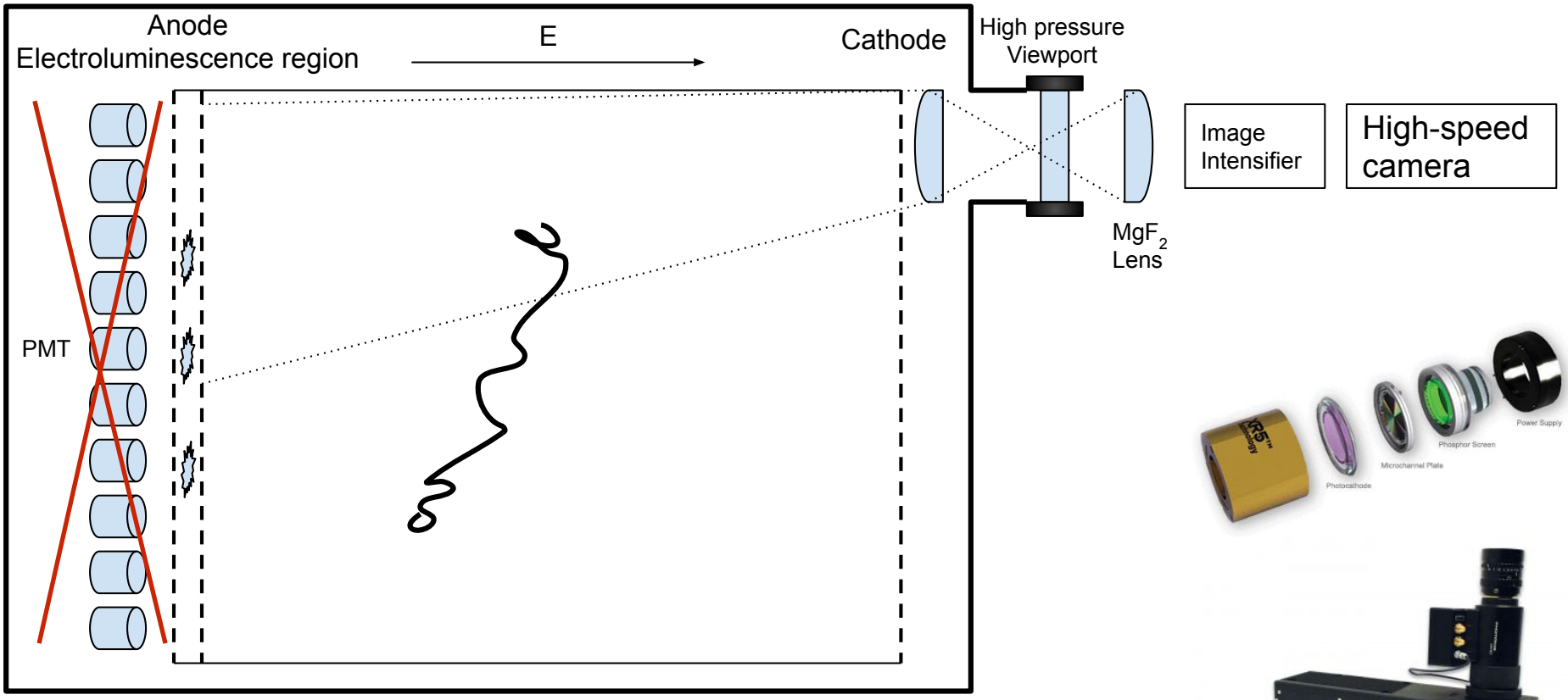


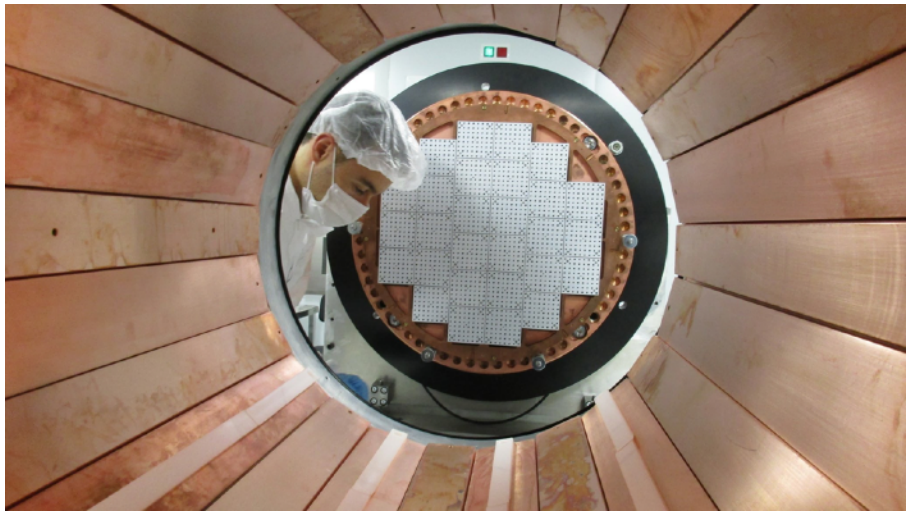
- LBNL LDRD funded (FY16,17)
- <30e- noise per pixel (CMOS electrical test)
- Should reach 1% FWHM without charge multiplication
- In-gas validation in (slow) progress
- Can detect drifting ions directly. May enable $^{82}SeF_6$ as a detector medium

D.R. Nygren 2007 J. Phys.: Conf. Ser. 65 012021
M. An et al 2016 NIMA 810, 144
D.R. Nygren et al 2018 JINST 13 P03015
Y. Mei et al arXiv:2010.09226

Electroluminescence imaging with camera

1 Meg frames/sec VUV(ƛ=175nm) imaging



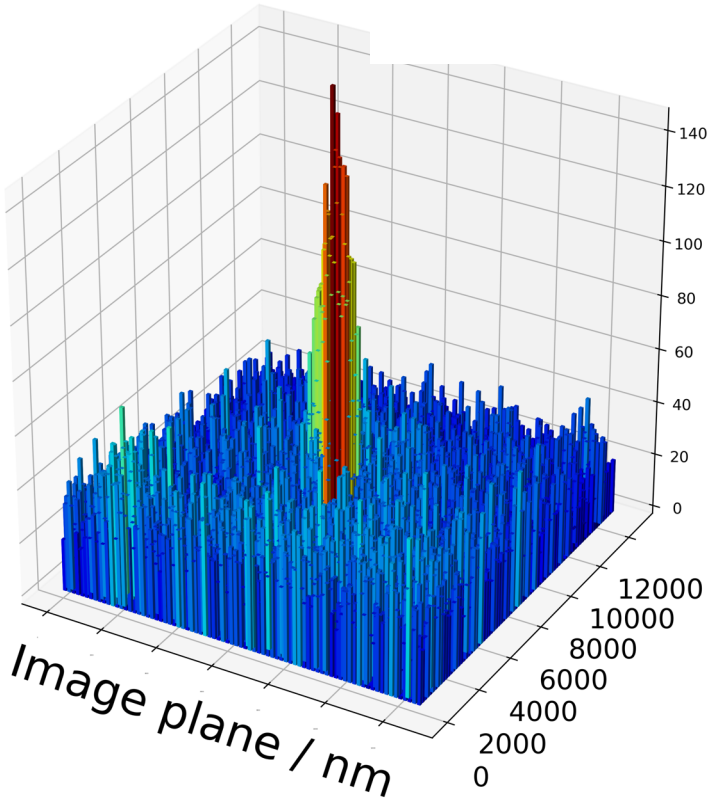


Photonis II and Mantis Timepix3-based photon counting camera

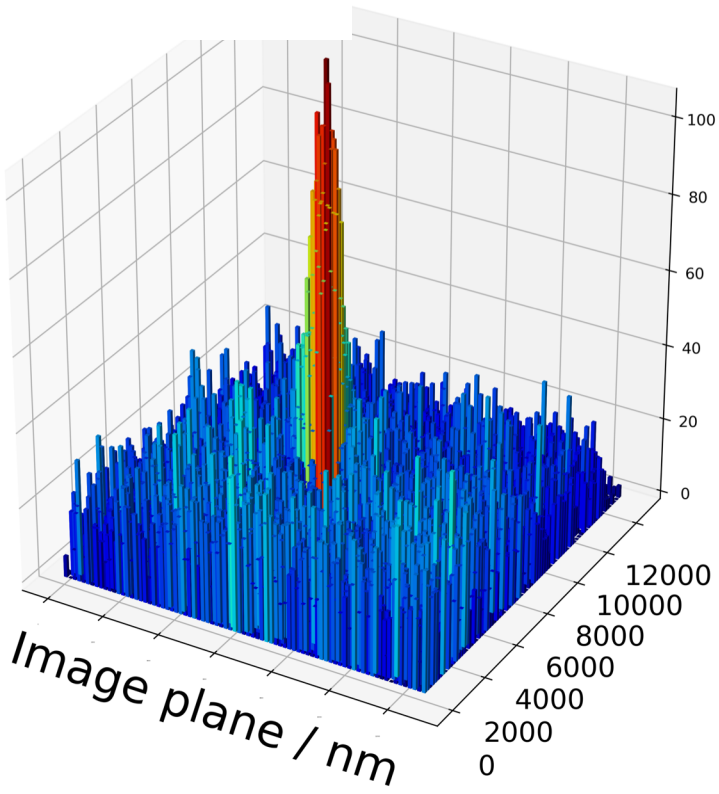
D.R. Nygren, B. Jones, Y. Mei *et. al.*

First ever single molecule images in high pressure gas

single Barium ions in 10 bar argon and xenon



Ba^{++} ion / 10 bar xenon



Ba^{++} ion / 10 bar argon