

2025/10/03

# Summary from ENT<sub>1/2</sub>ENTE

Matthew Stukel (he/him)

Research Scientist, SNOLAB

NNN25



# ENTENTE

**en·tente (noun): an international understanding providing for a common course of action**

**Origin: 1830–45; < *French*: understanding**

# ENTENTE Goals



Extreme Nuclear Half-Life Efforts: New Theories and Experiments

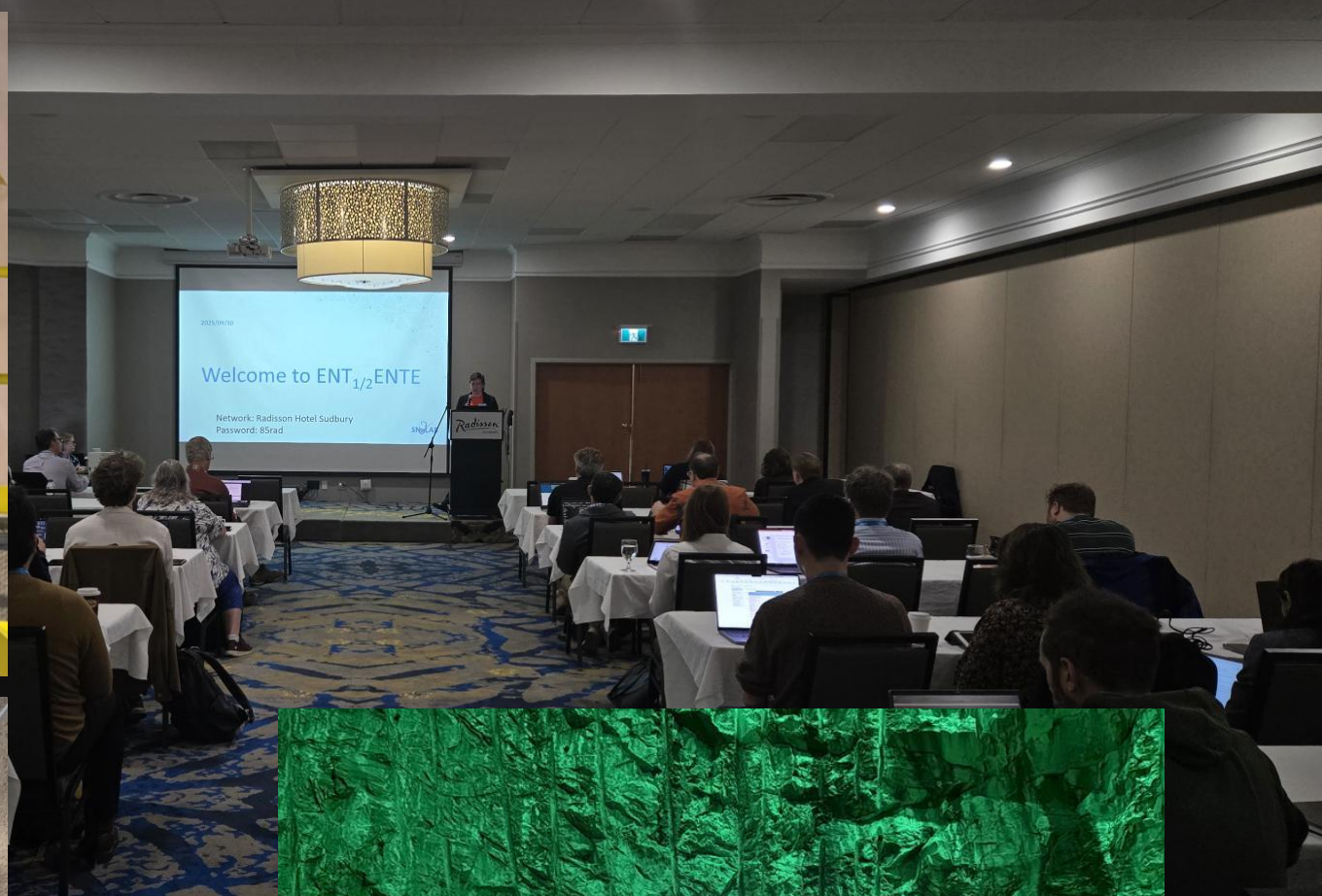
- Focused workshop on extremely long-half lives
- Opportunity for theory and experiment to connect
- Next-generation probing the normal-ordering hierarchy
- New low background techniques
- Link: [ENTENTE \(29-September 30, 2025\): Overview · Indico](#)

# ENTENTE: Stats



- Location: Radisson Hotel Sudbury
- Over 70 people in attendance
- 1 underground lab tour of SNOLAB + a Dynamic Earth visit with its own underground tour
- 8 talks over 10+ hours of discussion







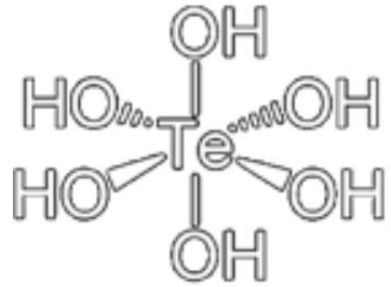
# Lots of talk about Te

Matt's Opinion: They should consider adding Helium  
It would be very funny: TeHe!



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# Opportunities with Te



- Loading Method (TeA plant, Butandiol distillation, DDA distillation):
  - LAB-soluble Tellurium-Diol complexes
  - Long-term chemical stability
  - Long-term optical stability
  - Chemical compatibility
- Sufficient optimization could give 500 kg of Telluric Acid per week.
- Future detector technology needs more refined simulations and engineering work

- All Plastic

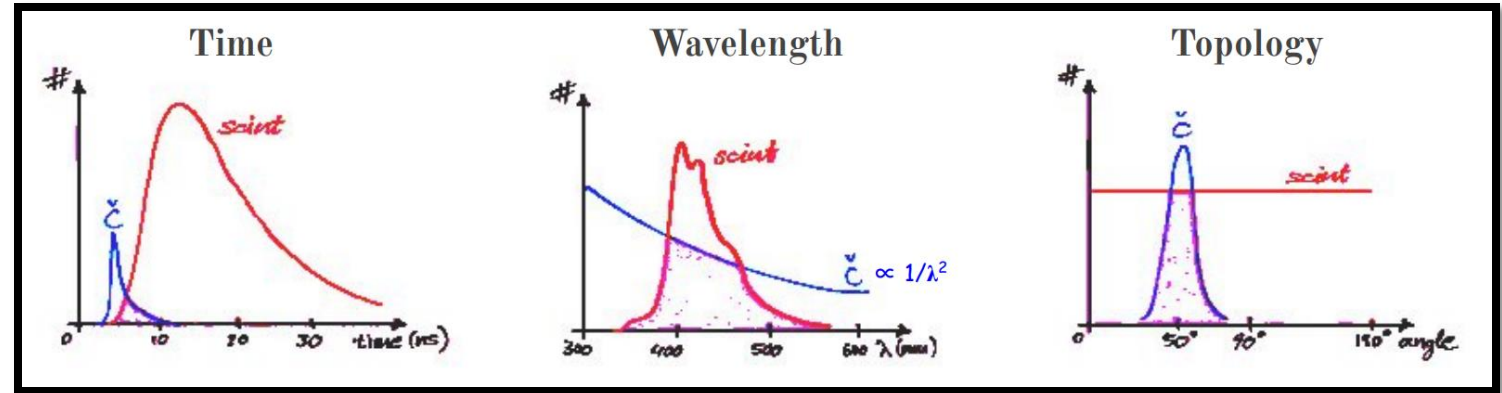
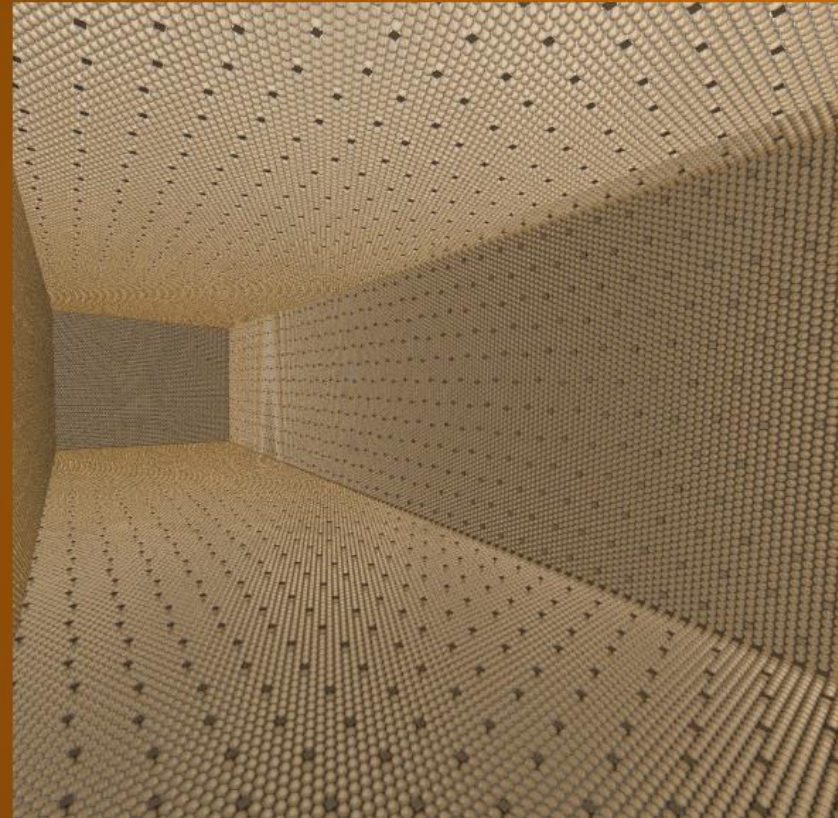


# $0\nu\beta\beta$ into the normal ordering with Theia



- Novel Scintillators, Fast Photosensors, Spectral Sorting

## 25 kt Box



Primary physics goal	Reach	Context
Nucleon decay $p \rightarrow \nu K^+ (\rightarrow 3\nu)$	$T > 1.1 \times 10^{34}$ yrs ( $T > 1.2 \times 10^{32}$ yrs)	Complementary to DUNE, HK, JUNO (sensitive to different modes)
Supernova burst	$2^\circ$ pointing, 5k events (10 kpc)	Complementary to DUNE ( $\nu$ vs. anti- $\nu$ ) Improved flavour separation via Cher/scint
Diffuse supernova neutrino background	$5\sigma$ in 5 yrs	Beyond SK / JUNO due to low threshold, bkg tagging
MSW transition	$5\sigma$	Unique handle on bkg rejection via directionality
CNO neutrinos	$< 12\%$ (2%) Wb(LS)	No concurrent competition
Geoneutrinos	$< 5\%$ (2% stat.)	First high-stats measurement in North America
$0\nu\beta\beta$	$T_{1/2} > 1.1 \times 10^{28}$ yrs (90% C.L.)	Beyond ton-scale (further optimization possible)



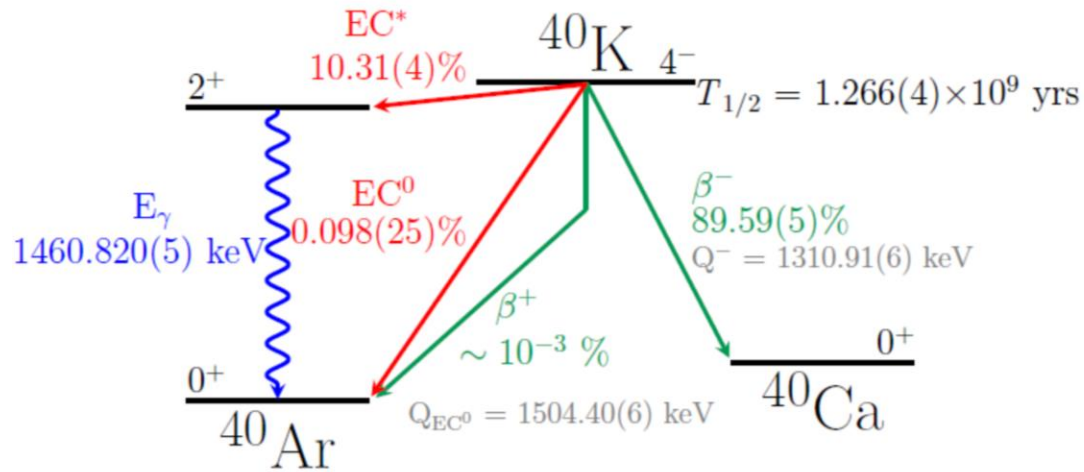
# Nuclear Physics: Rare-event searches

Matt's Opinion: They were quite radiating!

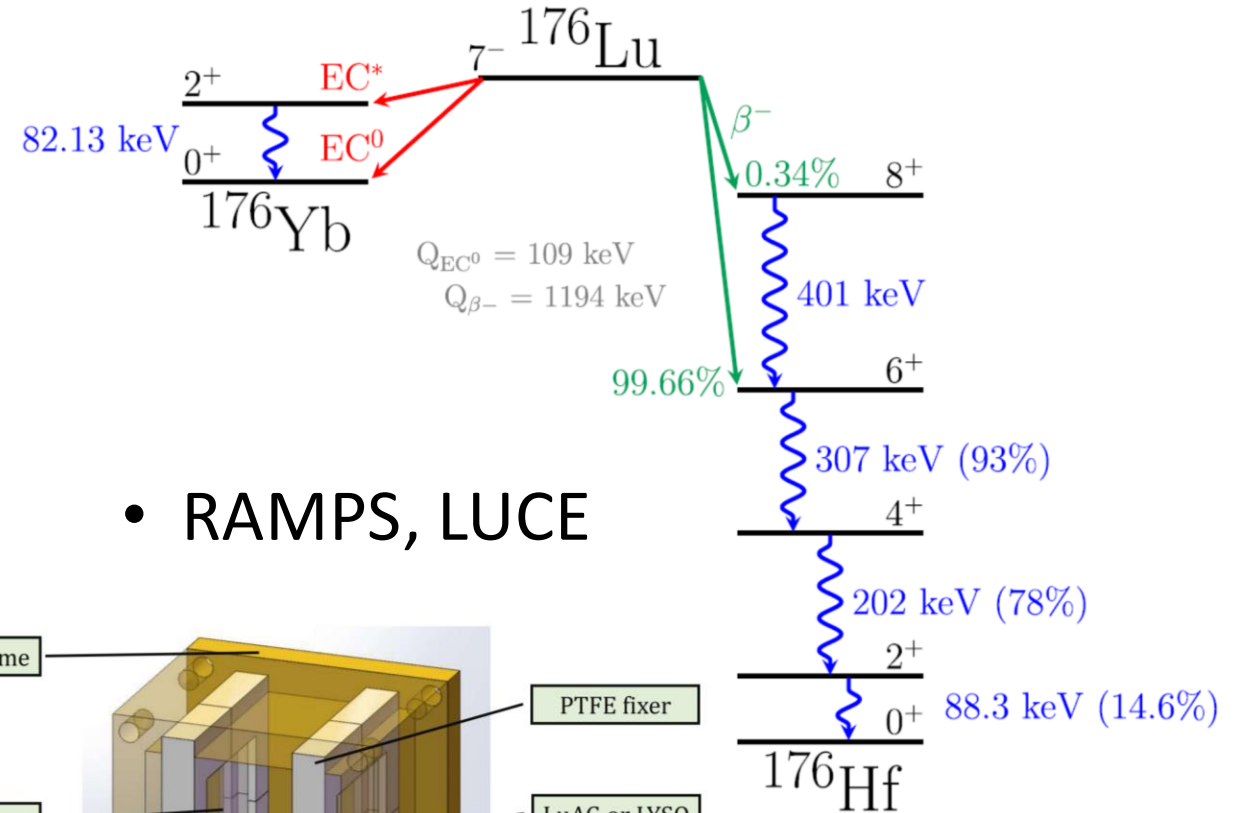


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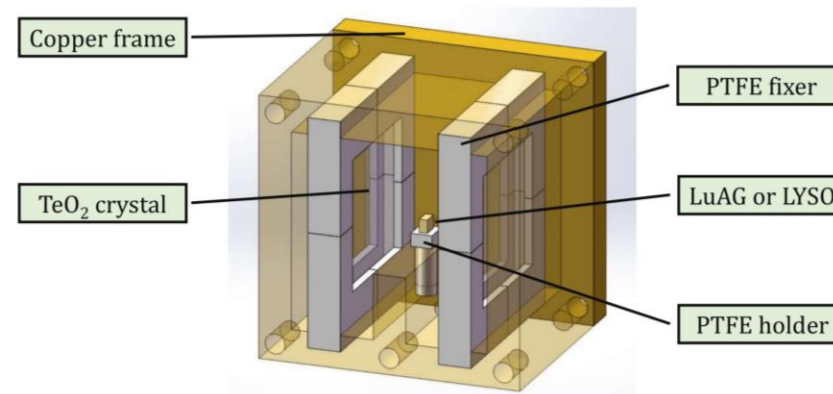
# Rare-forbidden nuclear decays



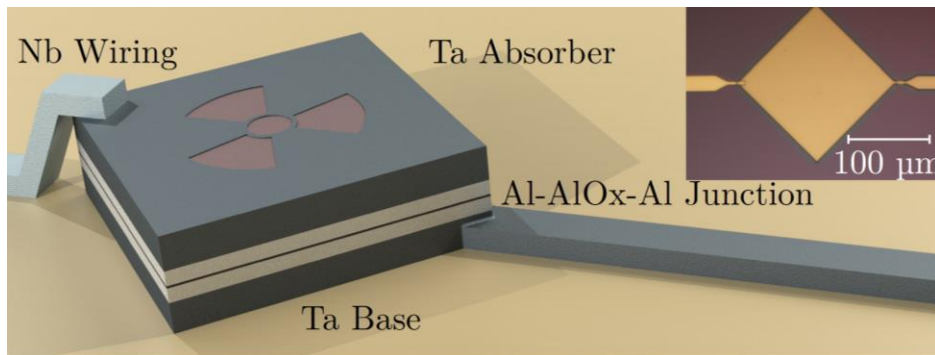
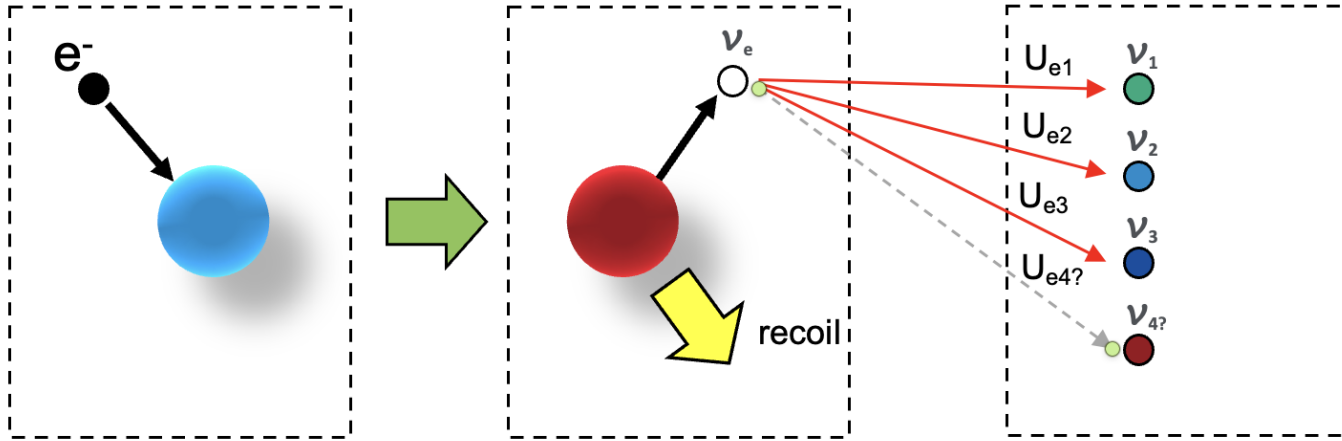
- KDK, KDK+



- RAMPS, LUCE

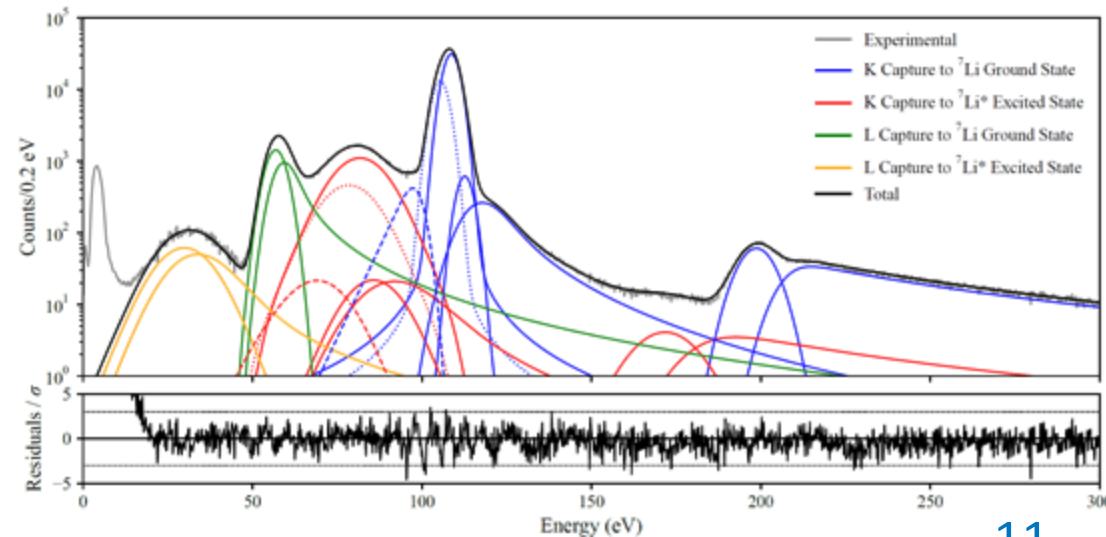
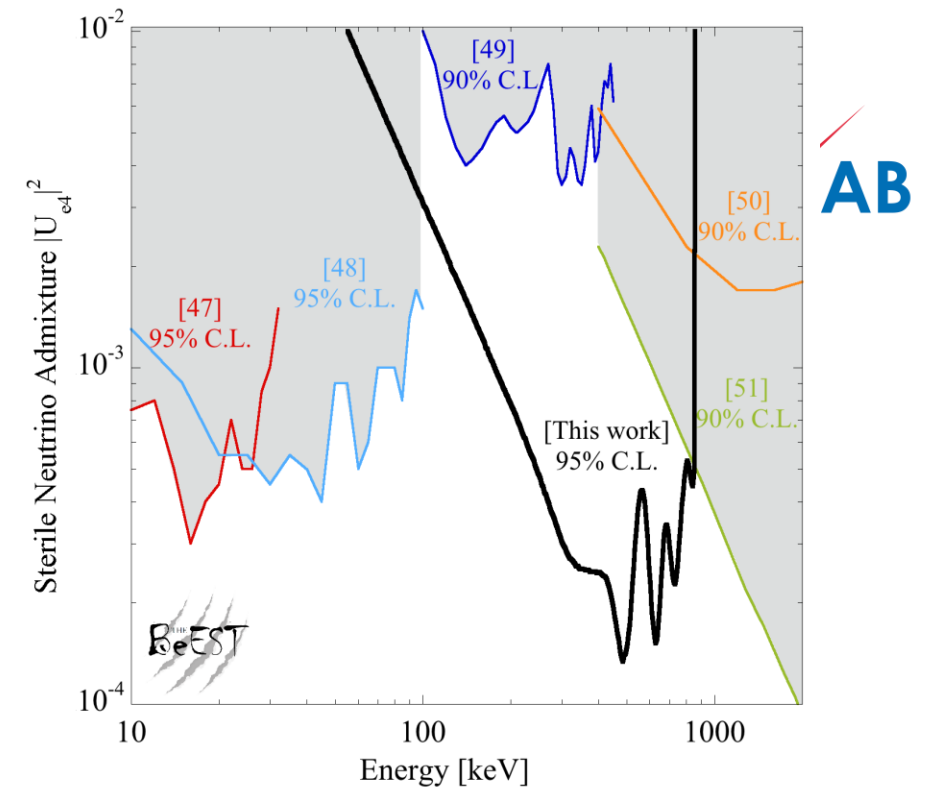


# BeEST and SALER



THE BeEST

- Weak-nuclear decays are a probe for BSM physics
- BeEST (Beryllium Electron capture in Superconducting Tunnel junctions)



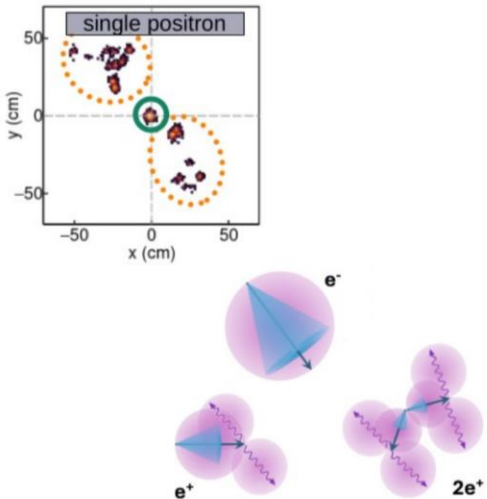
Photos adapted from slides by: Annika Lennarz



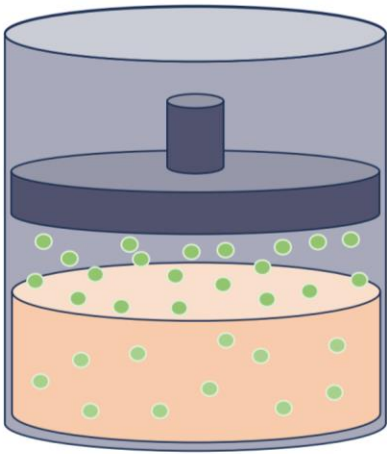
# Exploring Double Beta Plus Decays with NuDoubt++



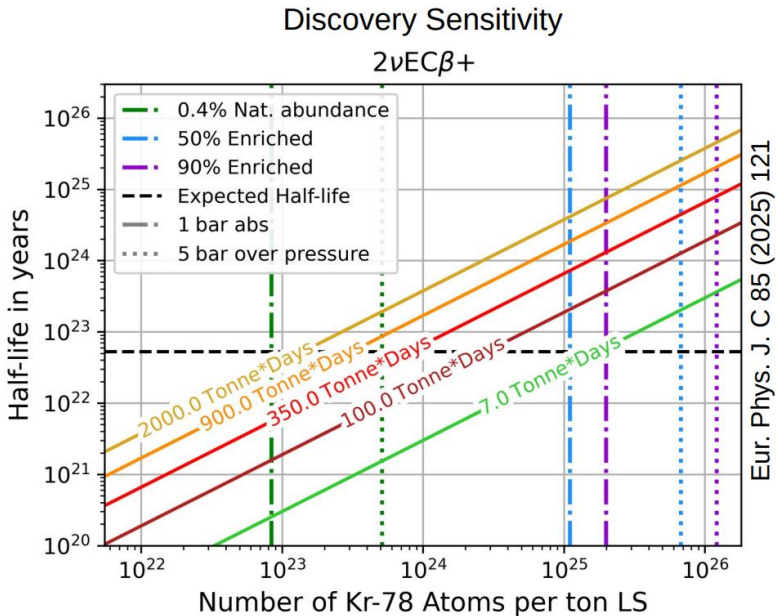
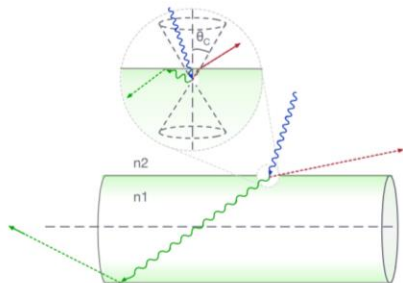
✔ strong background suppression



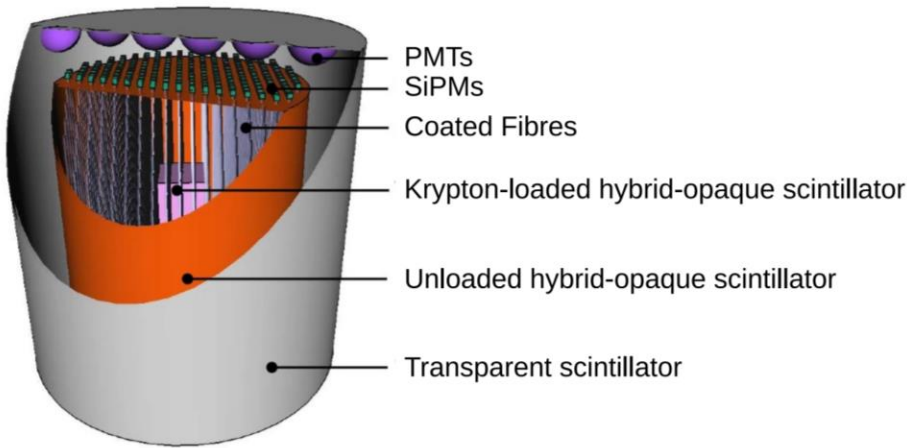
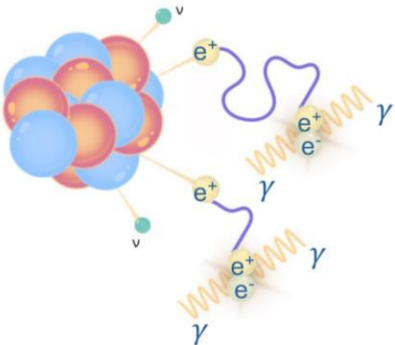
✔ high signal rate



✔ good energy resolution



	$2\nu$	$0\nu$
$2\beta^+$	✗	?
$EC\beta^+$	✗	?
$2EC$	✔	?



# The search for $\beta\beta$ decays begins

Matt's Opinion: I don't have a double entendre for this one.

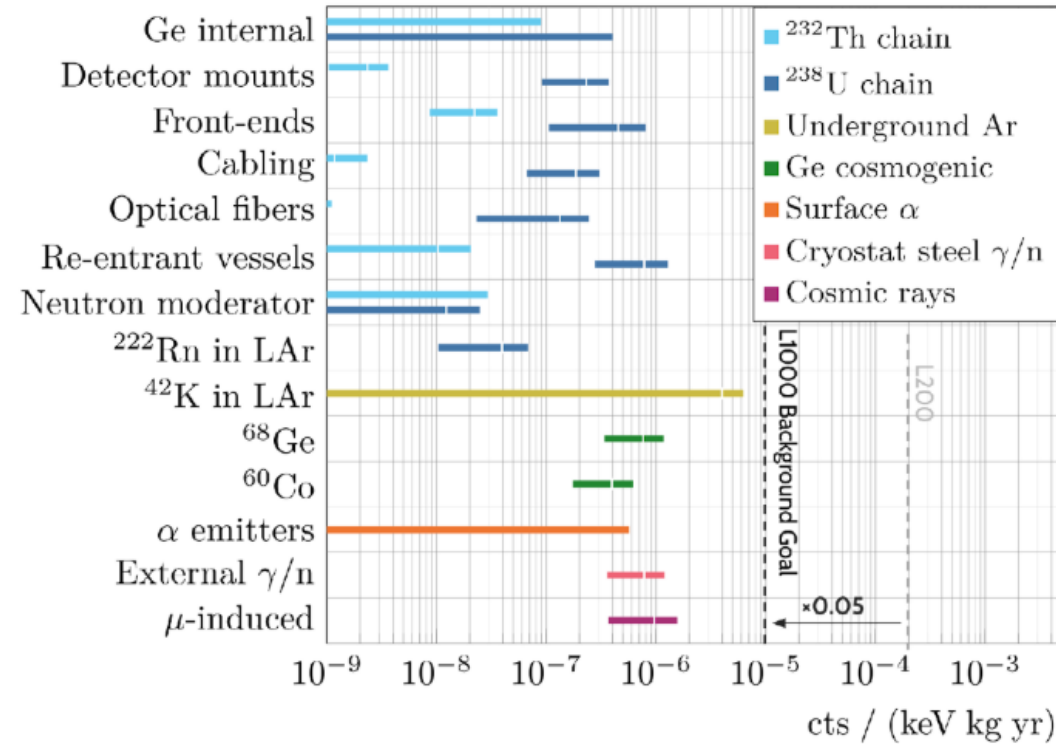
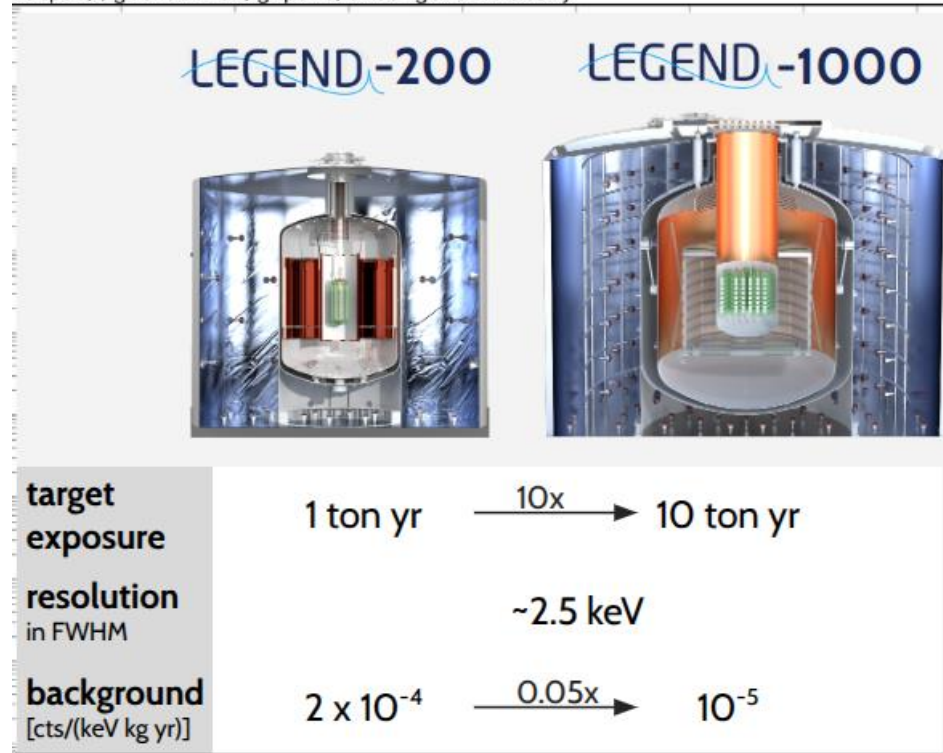


*We're good with this one.*

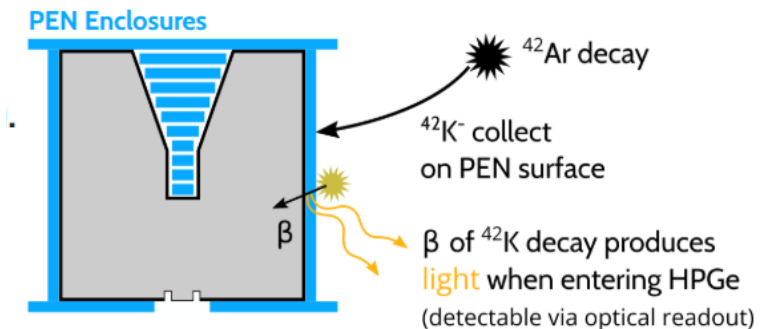
# The Quest for No Neutrinos: Advancing the Search with LEGEND-1000



<https://github.com/gipert/vbb-ge76-history>



- Background Strategy:
  - Clean active material
  - K-42 made from cosmogenically activated Ar-42
  - Delayed muon induced background



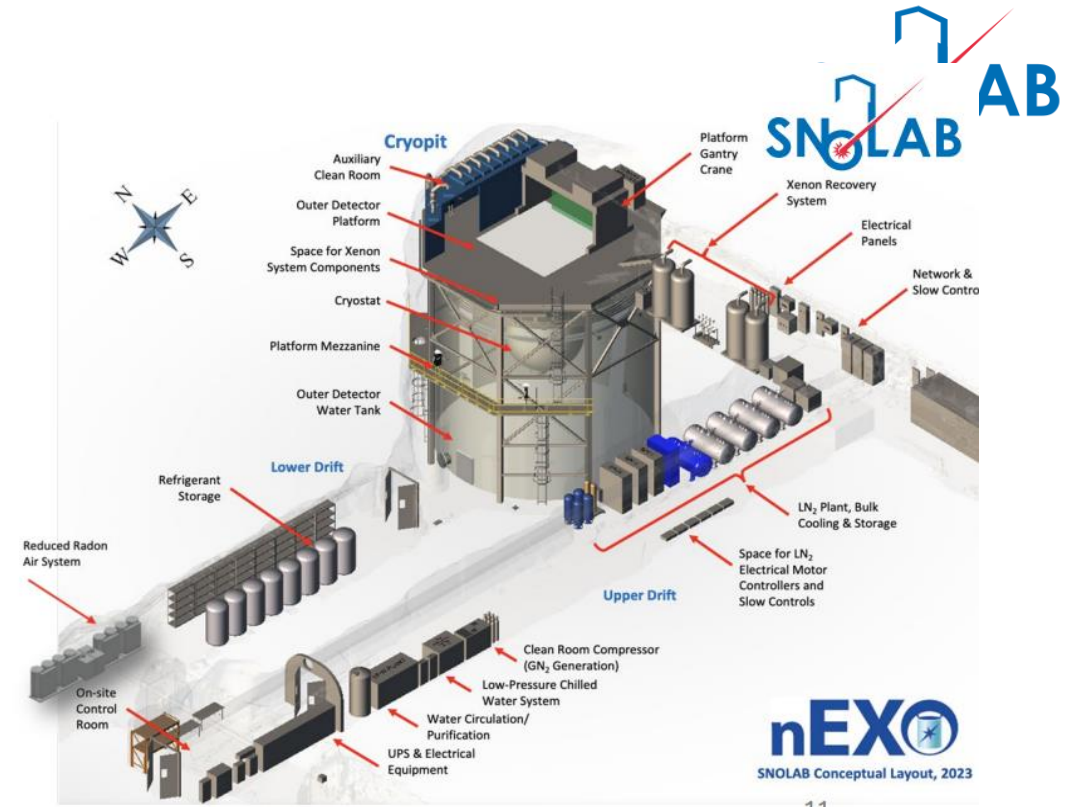
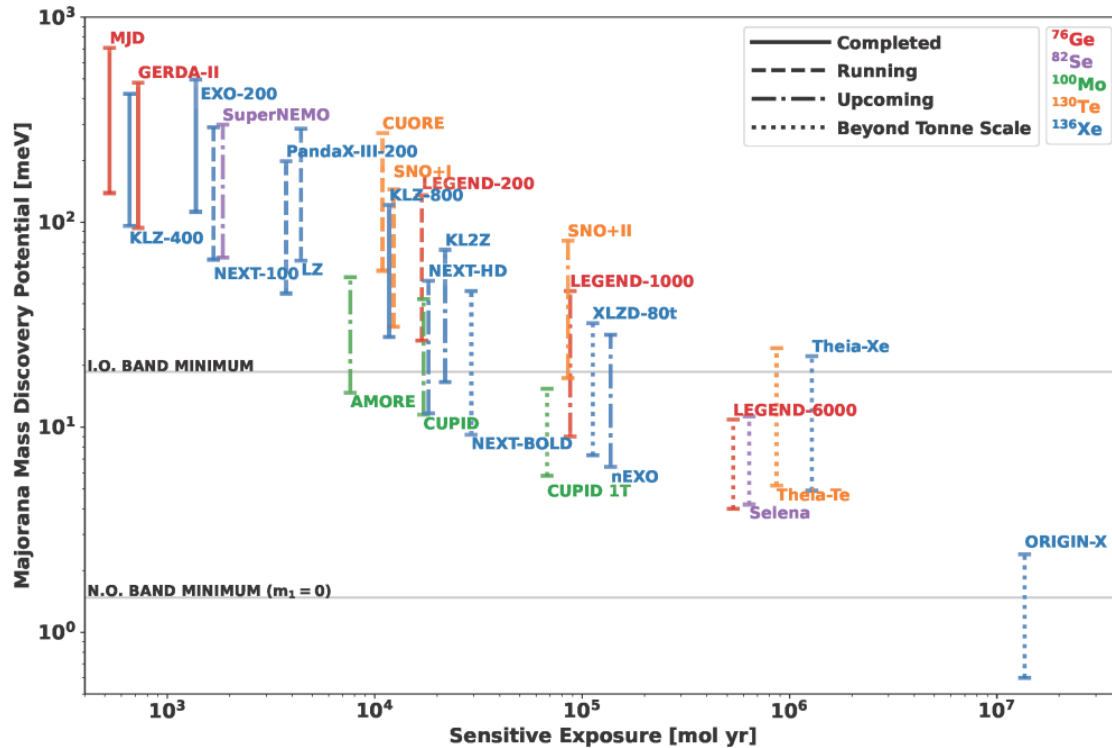


# Techniques to reach the Normal Hierarchy of Double Beta Decay using Liquid Xenon



- Novel Ideas:
  - Add few ppm of TEA to Xe, converts 80% of photons to electrons, efficiency goes from 15%→80%
  - Developments in pixelated detectors, improvement of spatial resolution
  - Individual Event reconstruction
- Sociology:
  - Procurement of Xe is a challenge. Cannot have competition
  - World should get together to do this
  - Design could be modular, each lab hosting a module, shared data

# Challenges and Opportunities with Xenon



- Proposed next generation Xenon-based experiments:
  - NEXT (GXe TPC, event topology), nEXO (LXe TPC, Xe enriched to 90% Xe-136), nEXO 2.0 (phased loading), PandaX (LXe TPC, 20T → 43T), XLZD (LXe DM+0 $\nu\beta\beta$ , 60T)
- Proposed next-generation experiments will require ~200 t of natXe by ~2035 (**HARD!!!**)
- Challenging funding opportunities, heavy competition
- Neutrinoless double beta decay search in Xe –next- generation experiment workshop:

<https://nyx.physics.mcgill.ca/event/538/>

# Takeaways



- The study of long-half lives (BSM, forbidden decays,  $0\nu\beta\beta$ ,  $2\beta^+$ ,  $EC\beta^+$  etc..) is leading to some
- Success is more likely to be guaranteed when shared
- The size/scale of next-generation experiments needs world-wide co-operation
- Reaching the NO seems achievable!!!!