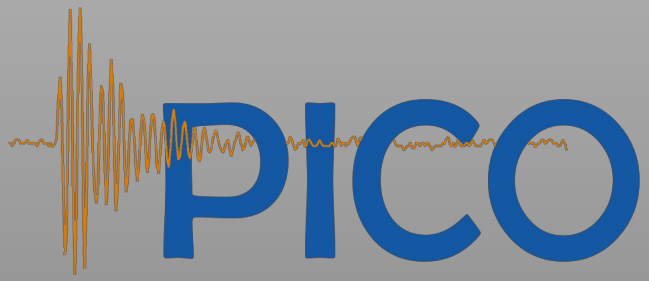
Towards and Beyond Ton-Scale Bubble Chambers



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IF8, August 2020

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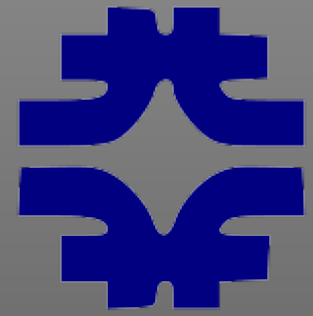
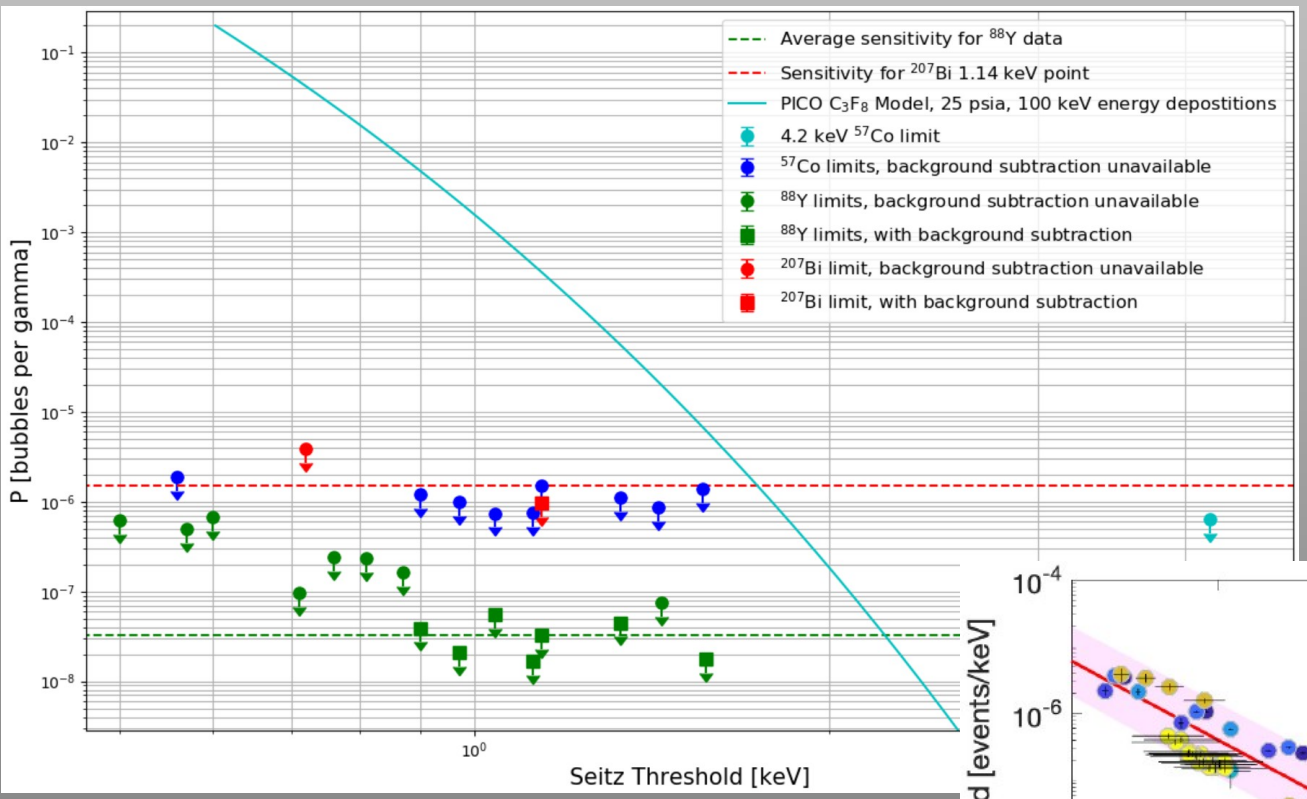
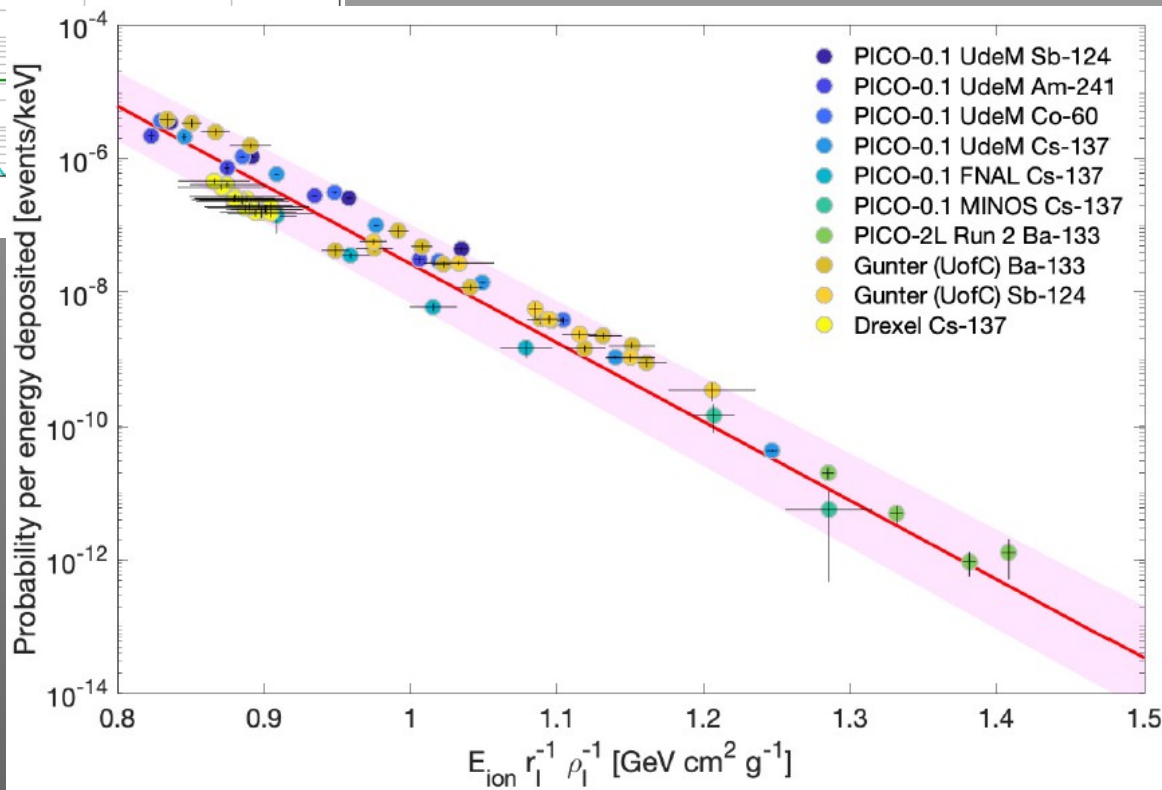


Fermilab

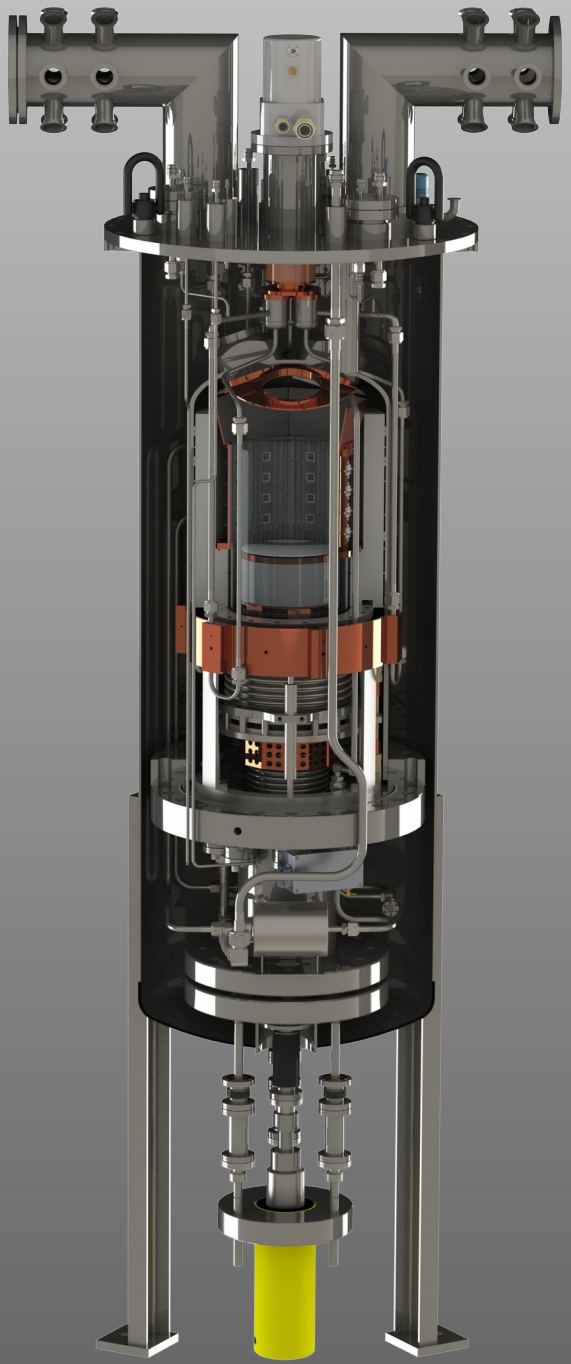
Why Bubble Chambers

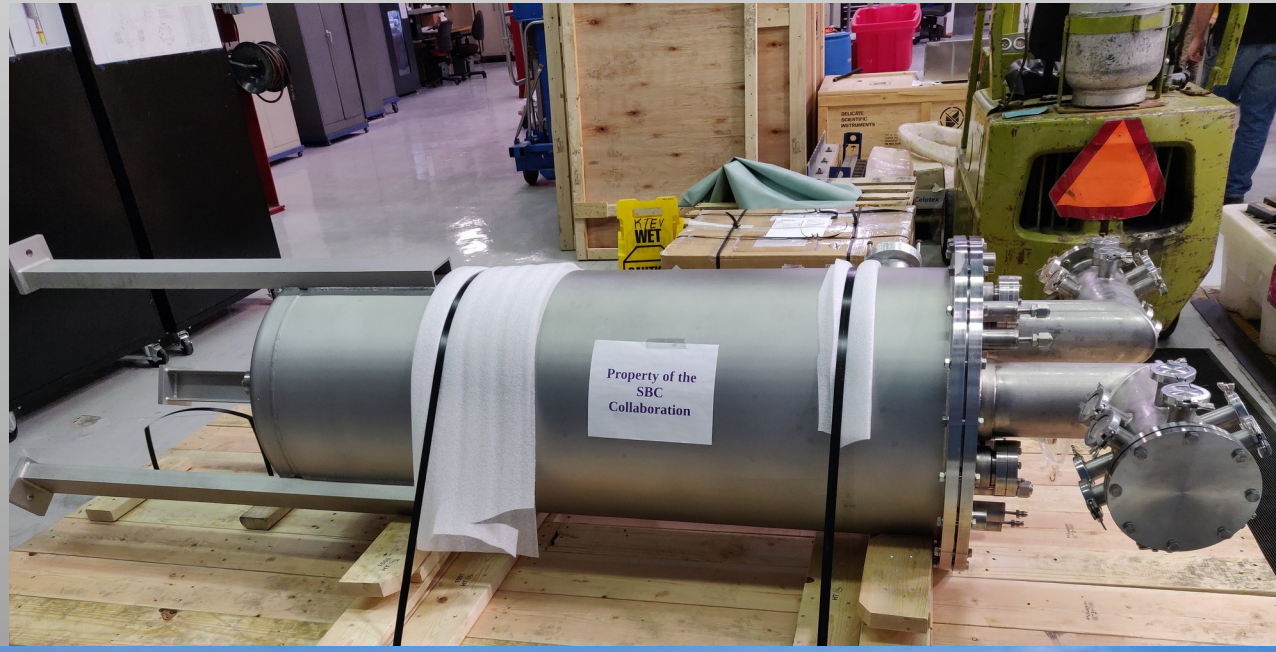


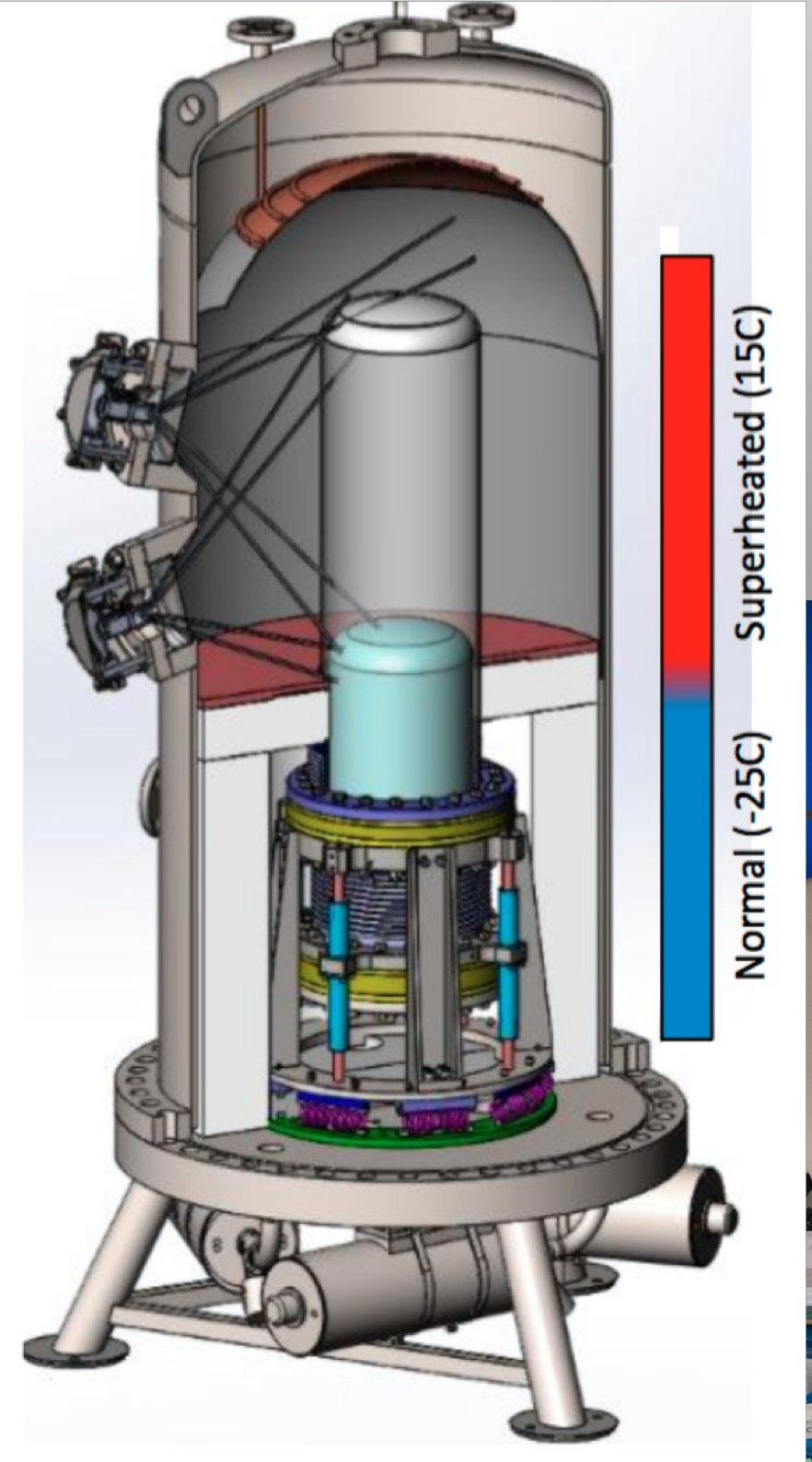
Background free detection of NRs down to 100eV depending on fluid



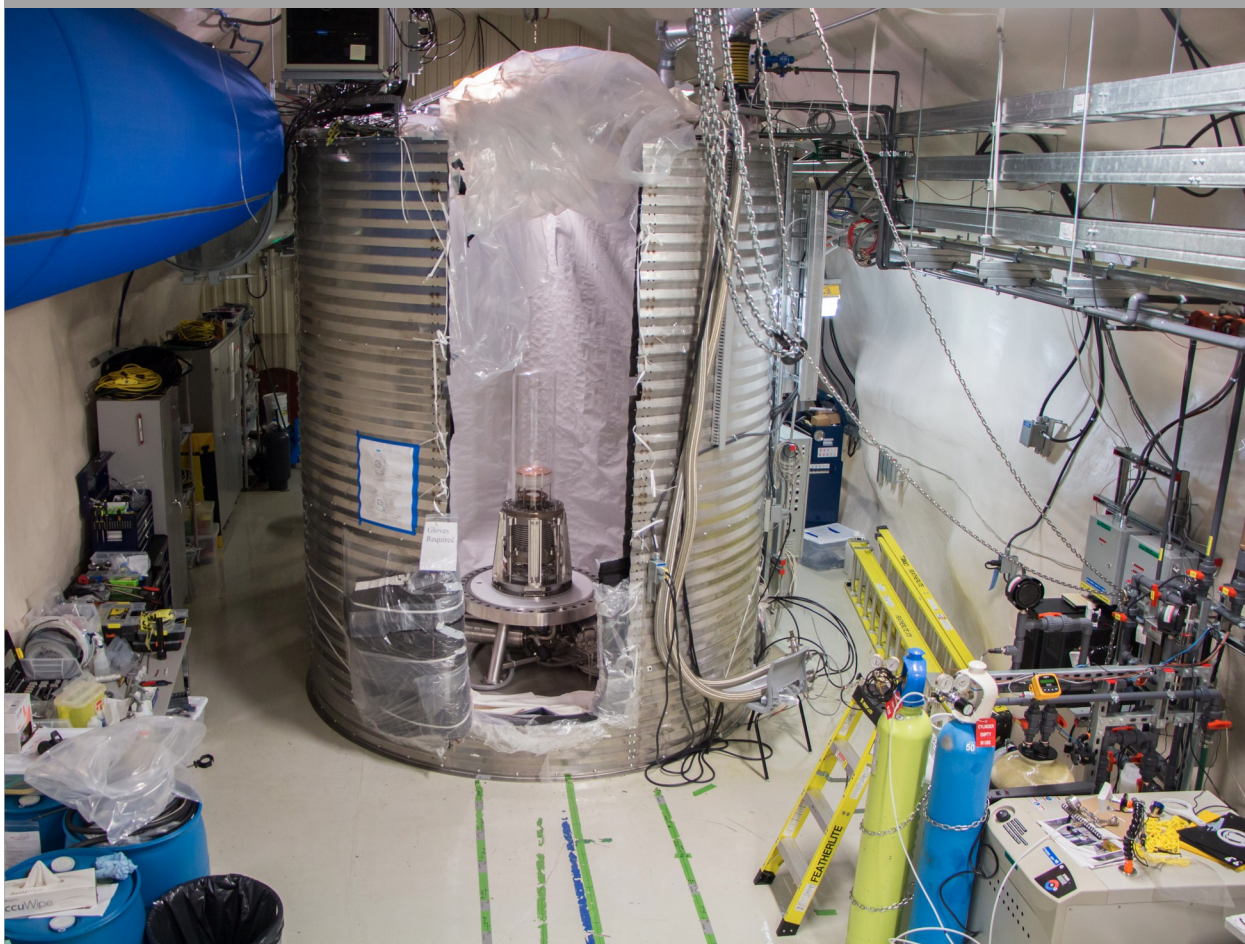
SBC: 10 Kg

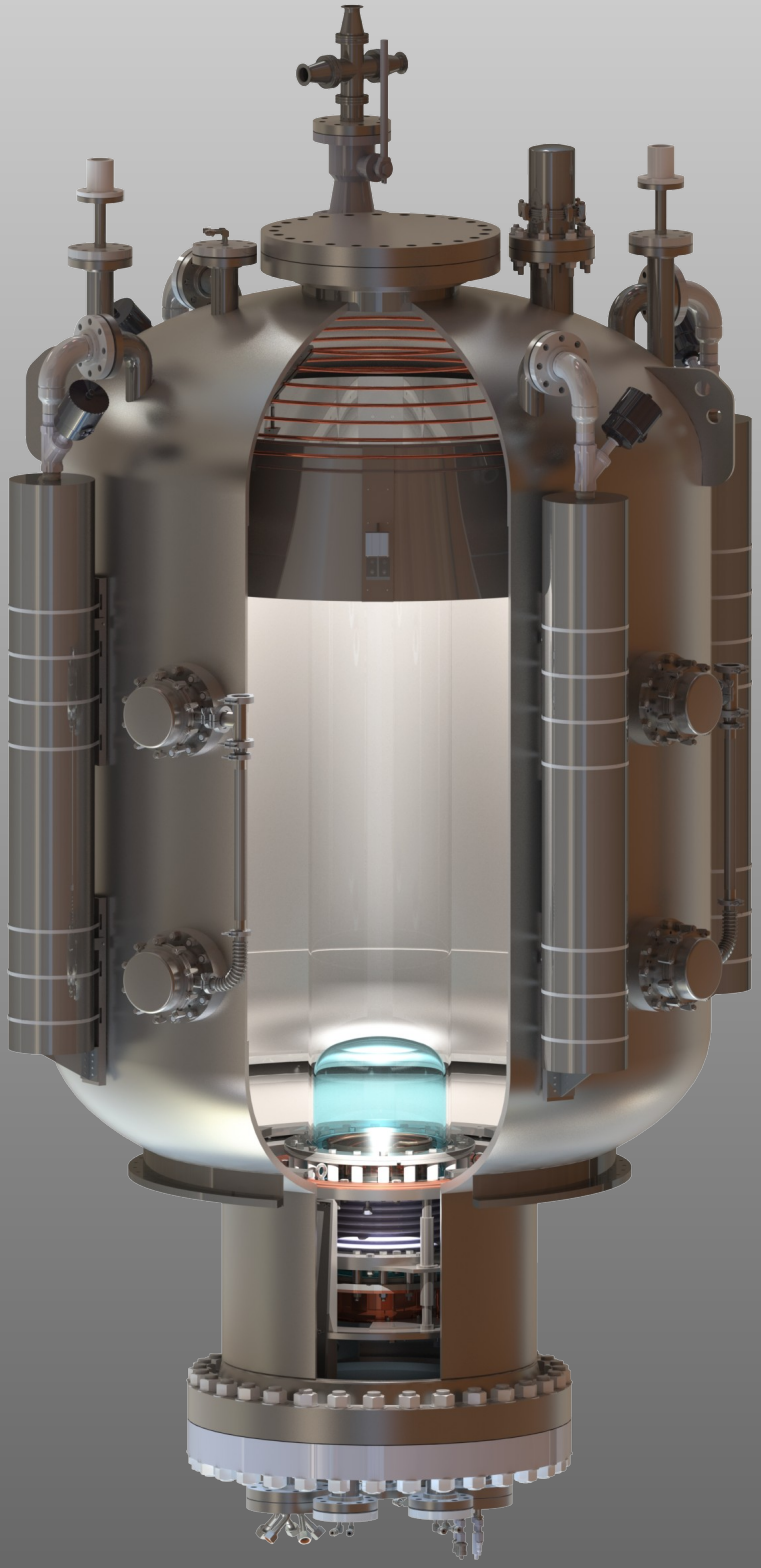






PICO 40L: 40L



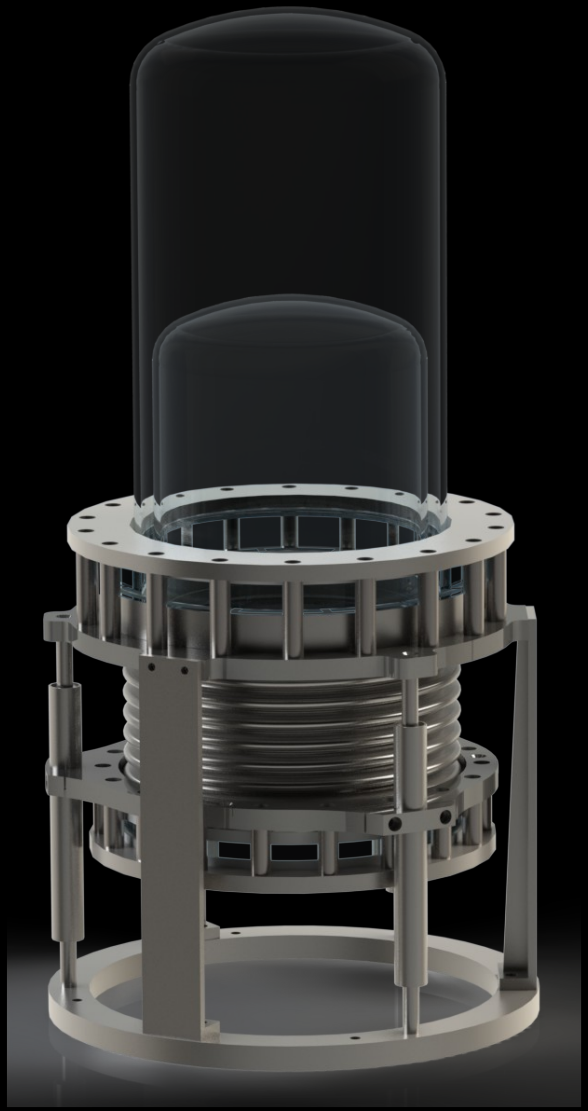


PICO 500: 350L

- Physics out to 100s of tones
- Old chambers ran at 10s of tones

Surface Nucleation

- Fused silica jars
  - Size limited to a few 100L
  - Most fragile and expensive component



- Identity new materials
  - Acrylic
  - Electropolished metals
  - Balloons
- Surface treatments

Radon Emanation & Plateout

- Surface treatments to avoid bubble nucleation by alpha decays
- Neutron from alpha-n on fluids such as CF_4

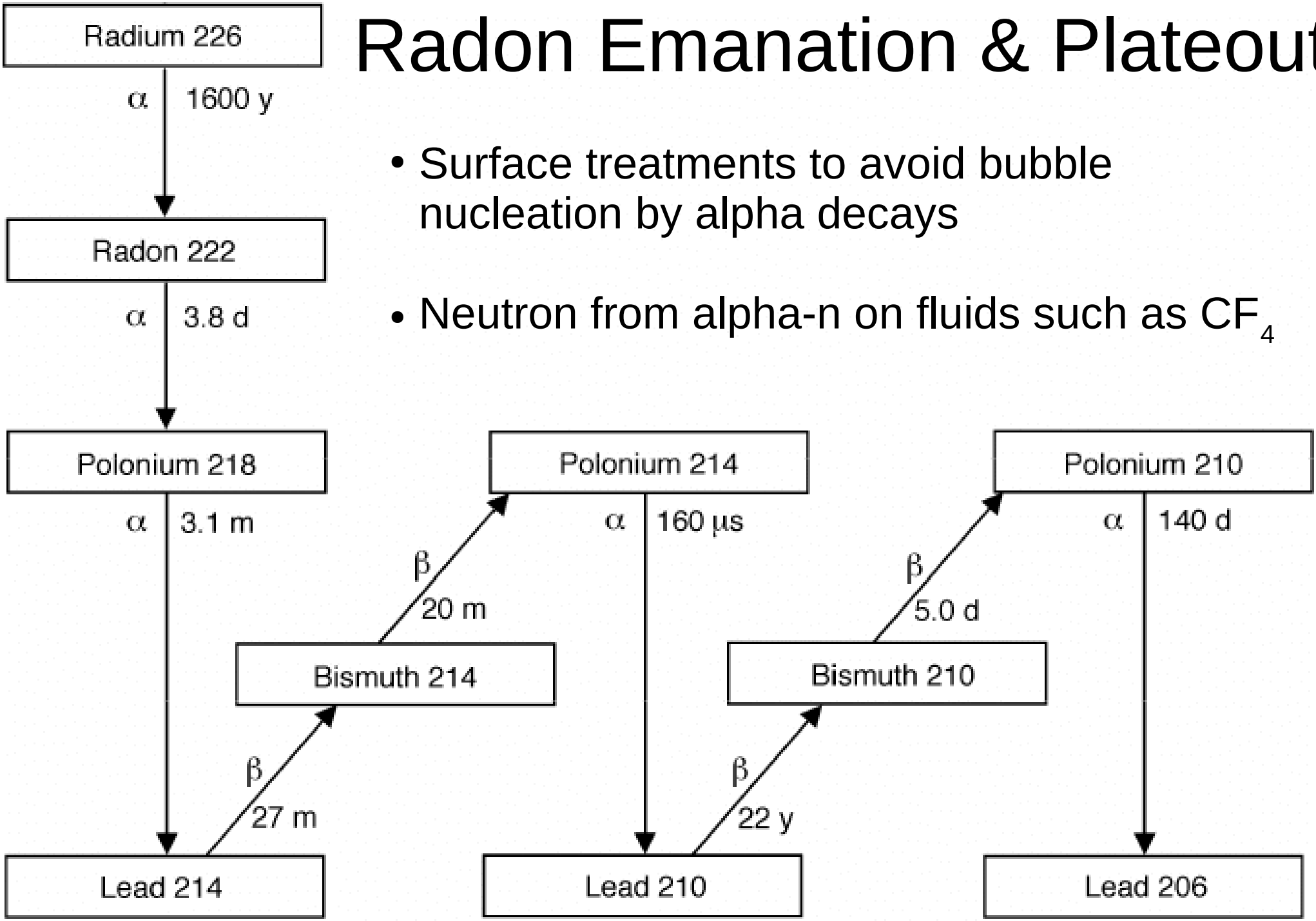
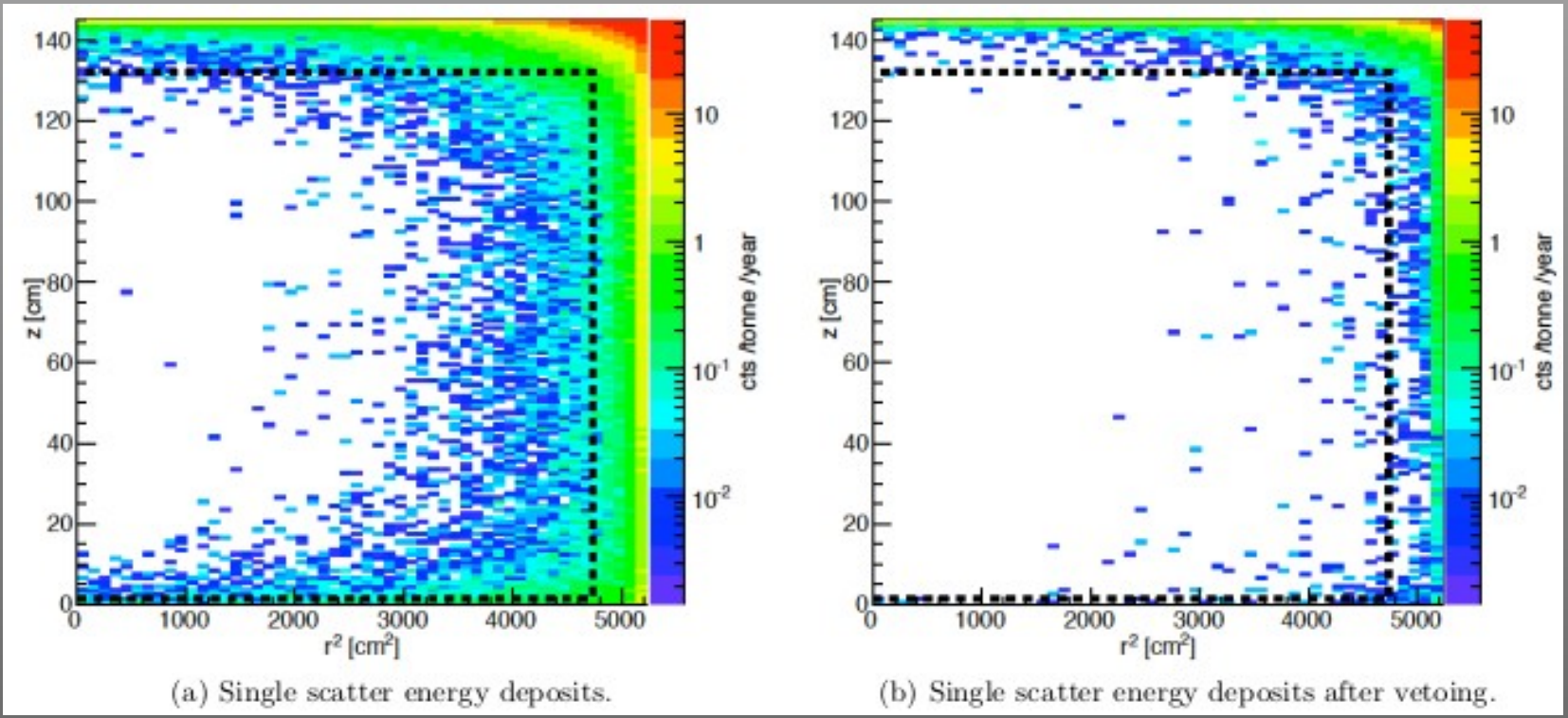


Image from: Gillmore, G. K., Crockett, R., Przylibski T., Nat. Hazards Earth Syst. Sci., 10, 2051–2054, 2010

Active Veto for Neutrons

- Typical hydraulid fluids
  - CF4 (cryogenic)
  - Mineral oil
  - Both good scintillator bases
- Develop and study fluids

- Veto must operate in bubble chamber environment
  - 300K to 77K
  - ~0psi < P < ~1000psi



(a) Single scatter energy deposits.

(b) Single scatter energy deposits after vetoing.

Image from: Akerib, D.S. et. al., 2017, Astroparticle Physics, 96, 1-10

Acoustic Bubble Imaging

- Determining bubble position critical, how to achieve without transparent jars
- Significantly simplified design
- Increased list of materials

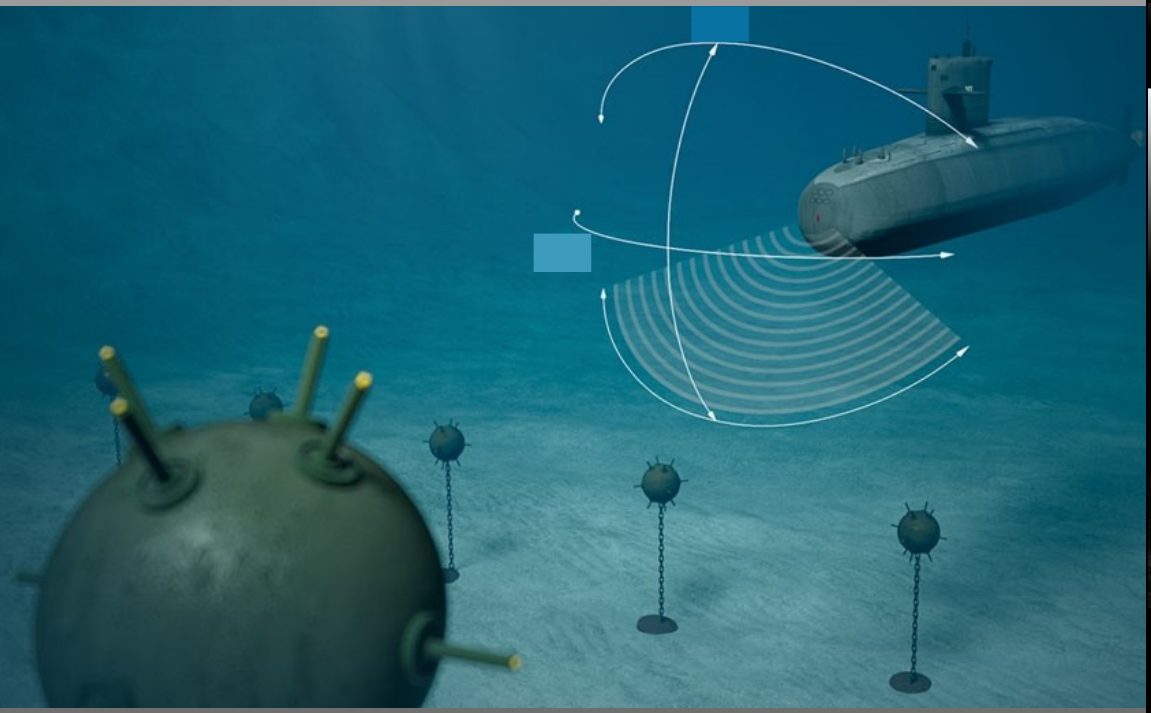


Image from: https://www.kongsberg.com/

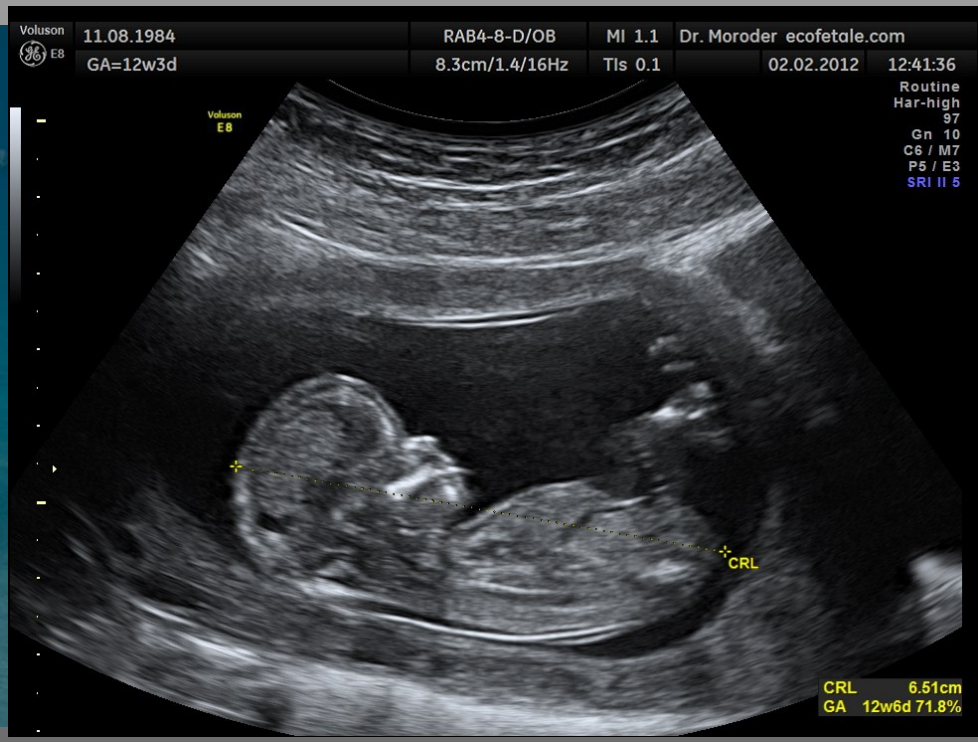


Image by Wolfgang Moroder

Recap

- **Why bubble chambers?**
  - Background free detection of NRs down to 100eV depending on fluid
- **Goal**
  - Existing detectors of ~100Kg
  - Physics out to 100s of tones
- **R&D**
  - Low surface nucleation materials
  - Radon control
  - Active vetos for neutrons
  - Acoustic bubble imaging