PICO_analysis techniques

Dark Matter search with PICO

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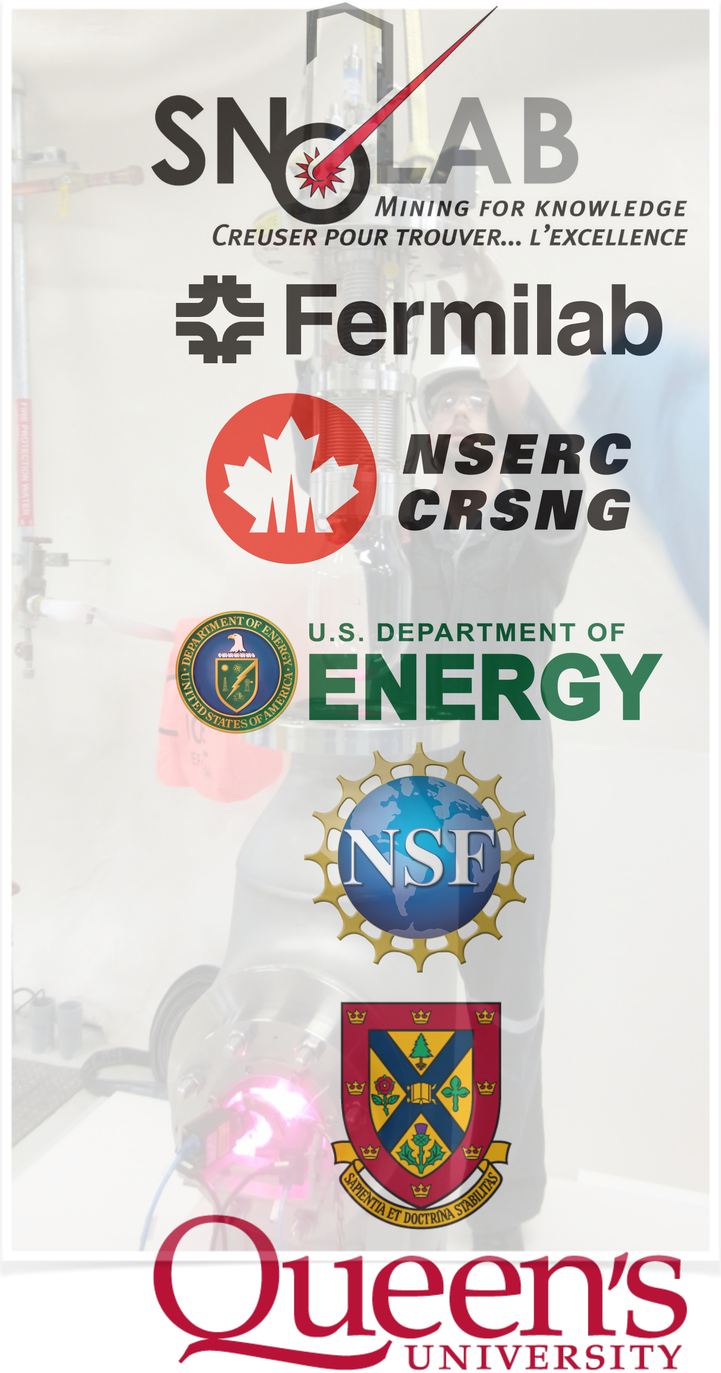
- on behalf of the PICO collaboration.

19th June, 2014

Queen's UNIVERSITY

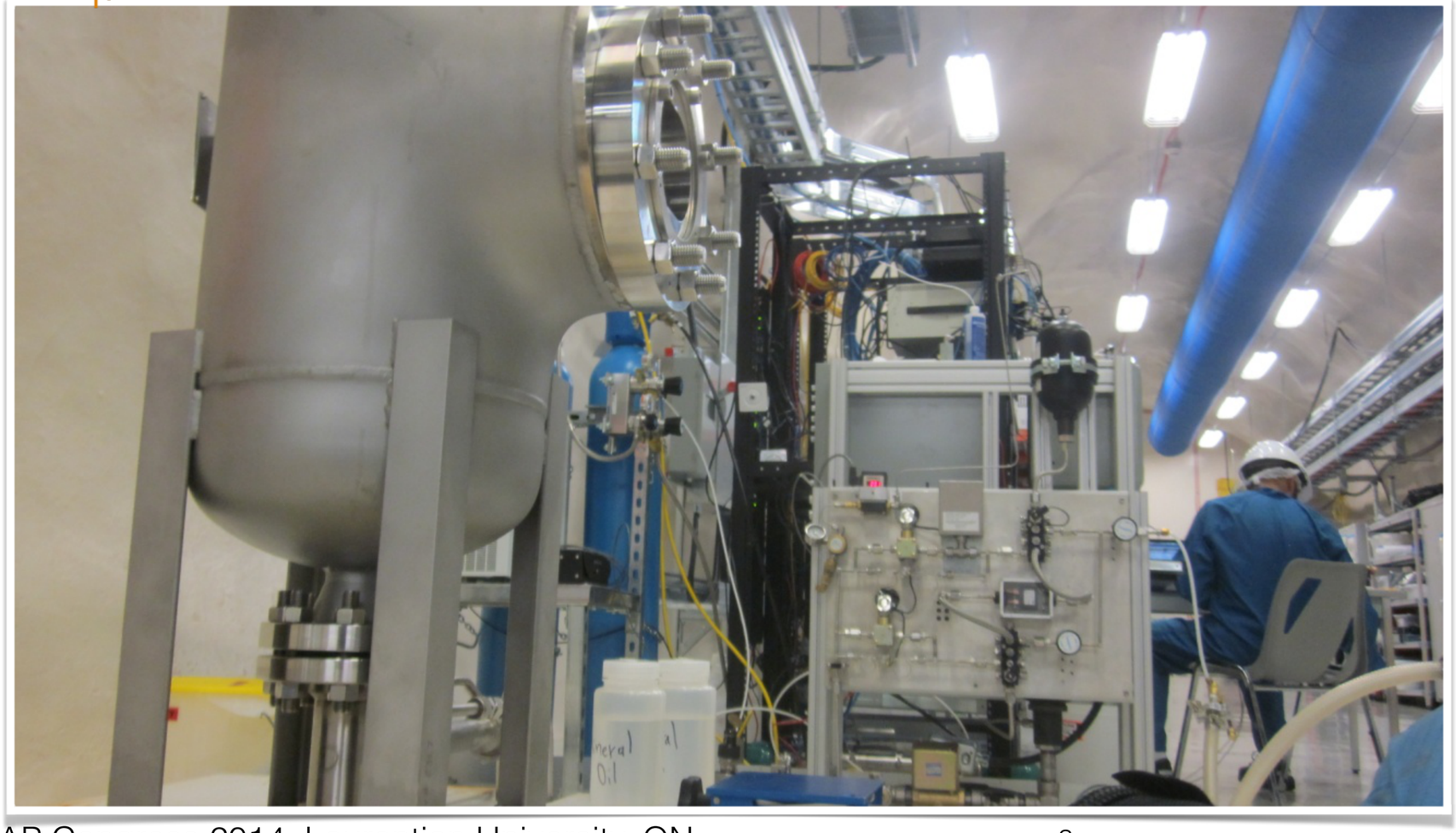
CAP Congress 2014, Laurentian University, ON.

PICO_collaboration



PICO_ 2L experiment

SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE



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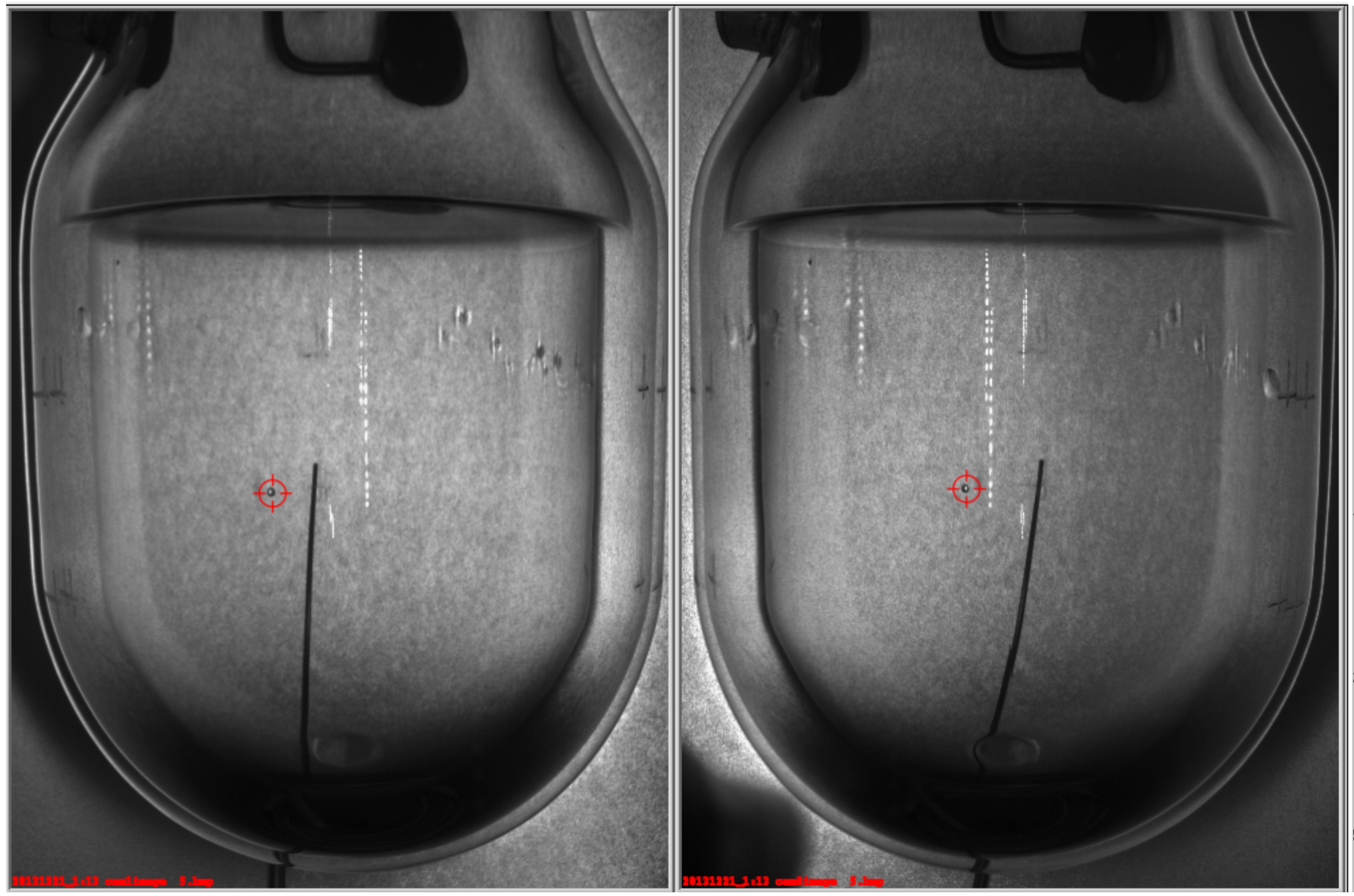
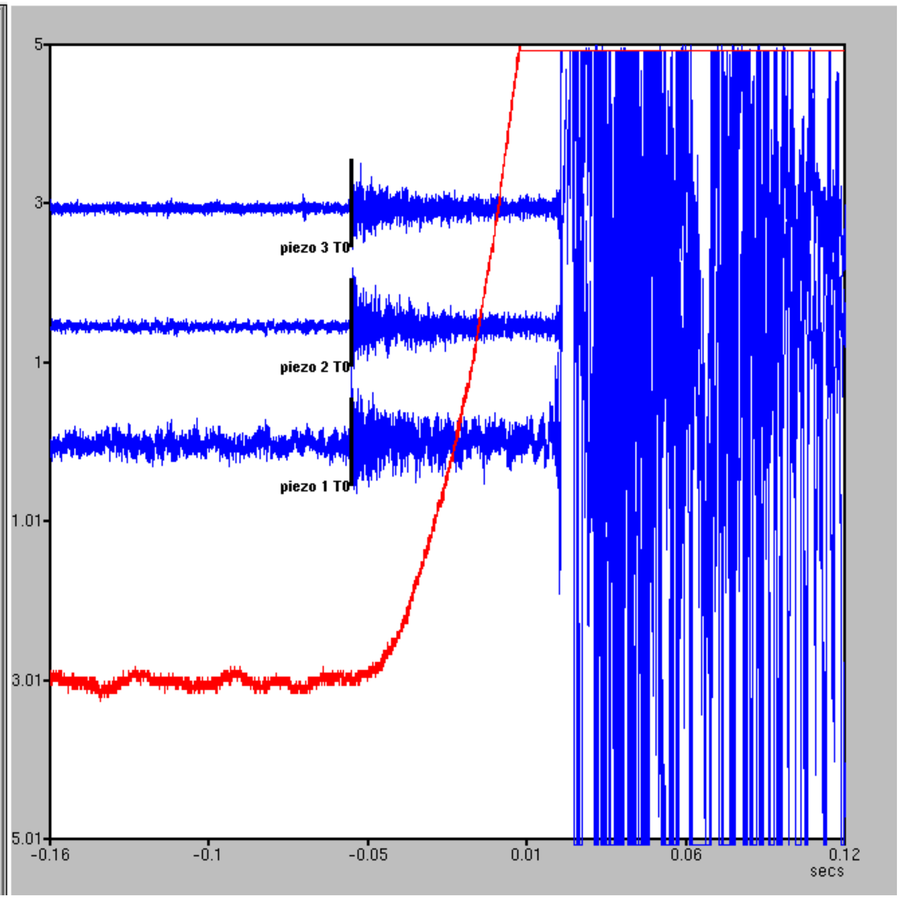
PICO_instruments

acoustic transducer x 3

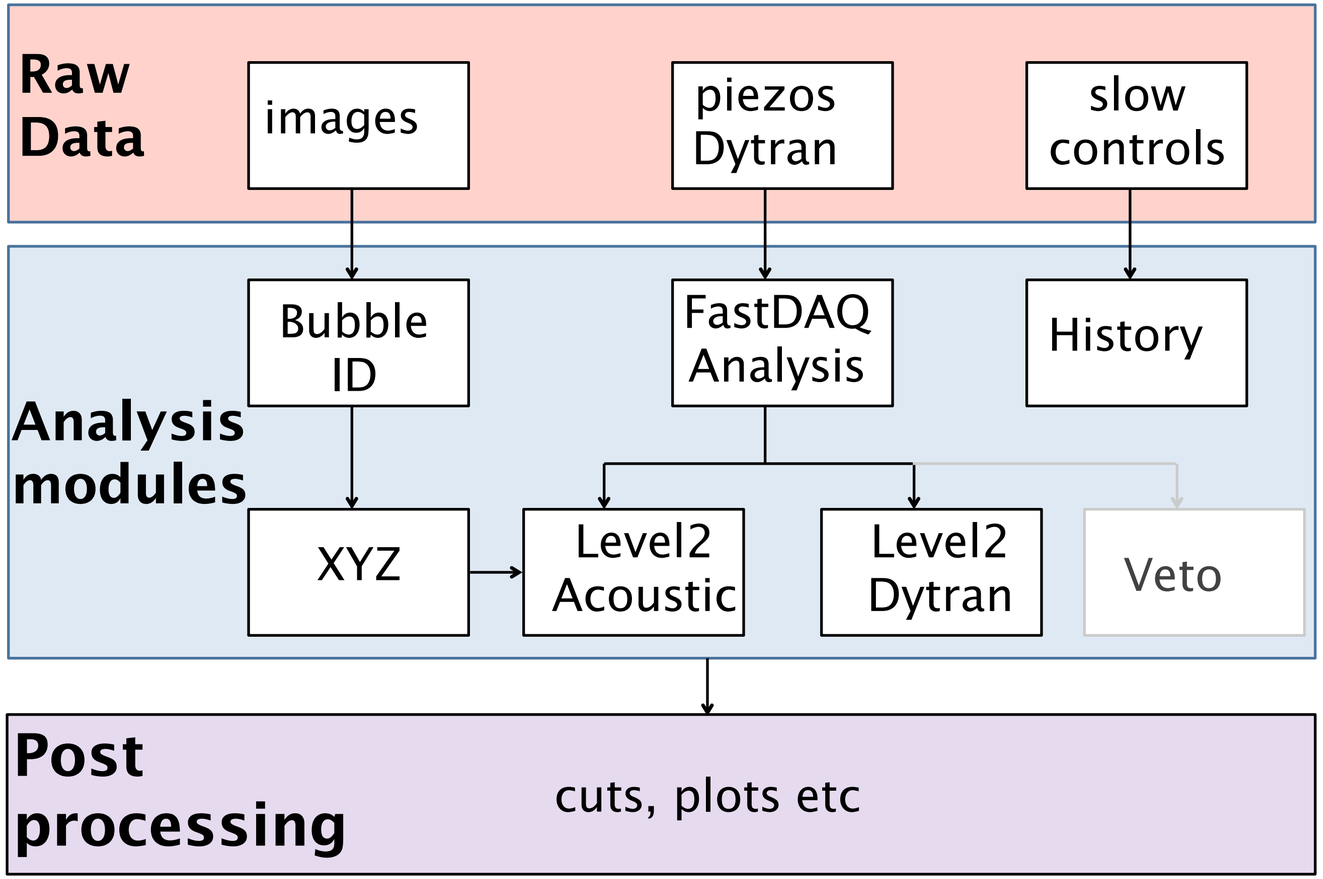




stereo vision with 100 fps cameras

fast pressure transducer

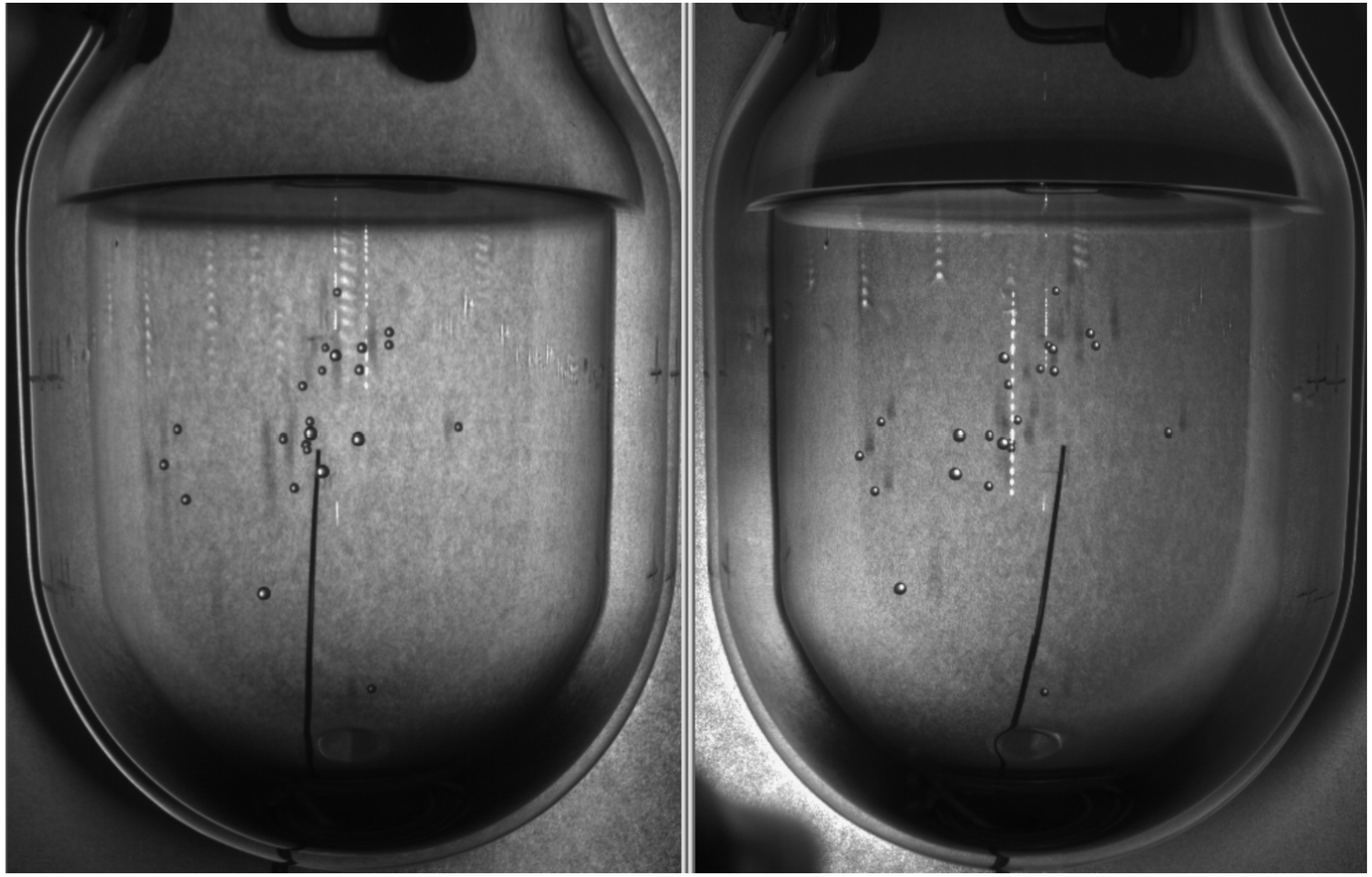
PICO_analysis chain



- **Cameras:**
  # of bubbles and their location.
- **Acoustic signal and pressure trace:**
  time of bubble's birth.

- **Position correction in acoustics:**
  level2 acoustic analysis
  (Alpha discrimination)
- **Pressure trace fit:**
  level2 Dytran analysis
  (event validity and confirmation on multiplicity)

PICO_neutrons



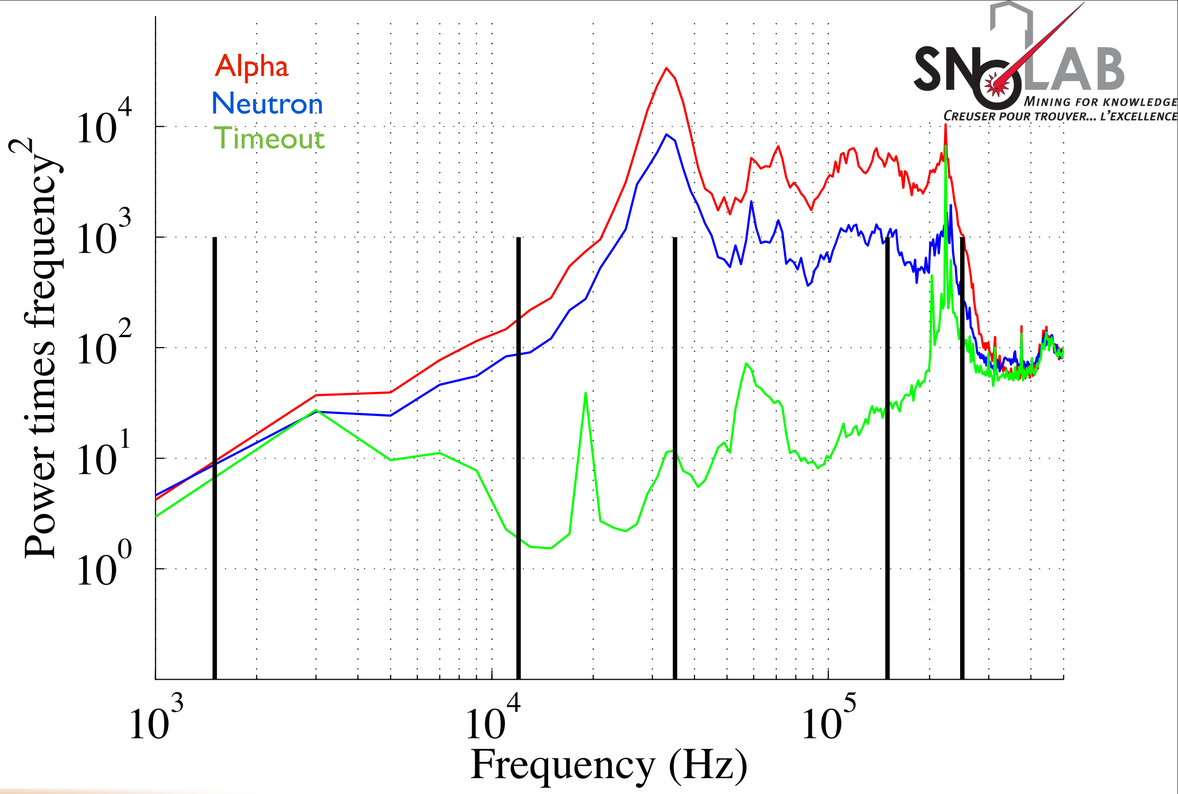
23 bubble AmBe neutron event:

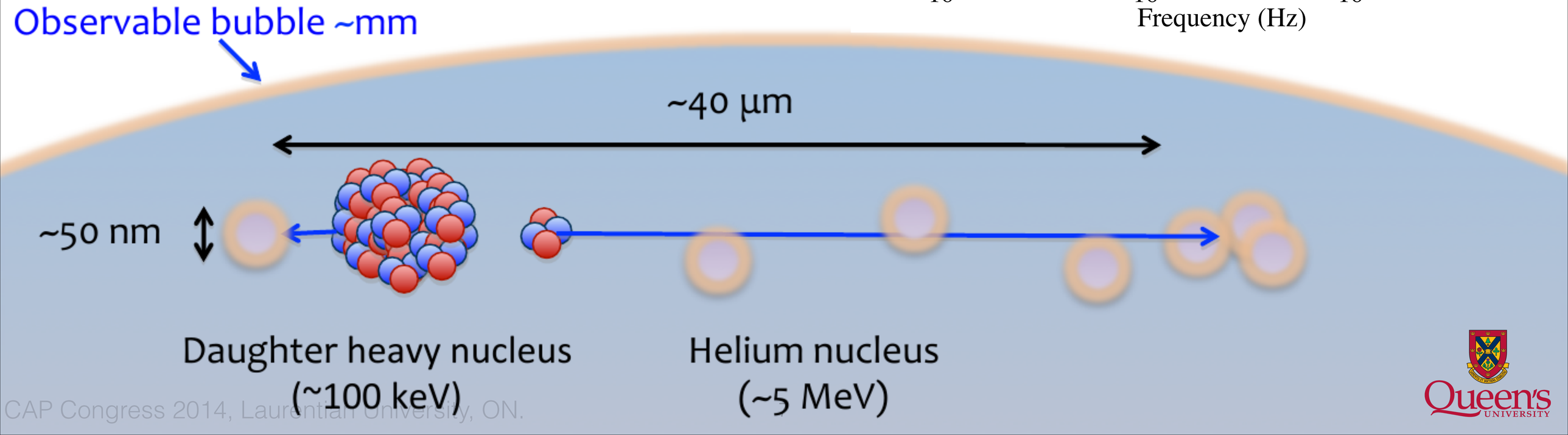
- C_3F_8 offers high bubble nucleation efficiency.
- 60% neutron events have multiple bubbles.
- SNOLAB + Water shielding.
- Currently, no multiples seen in the background data.

PICO_alphas

- Discovery of acoustic discrimination against alphas
  (Aubin et al., New J. Phys.10:103017, 2008)

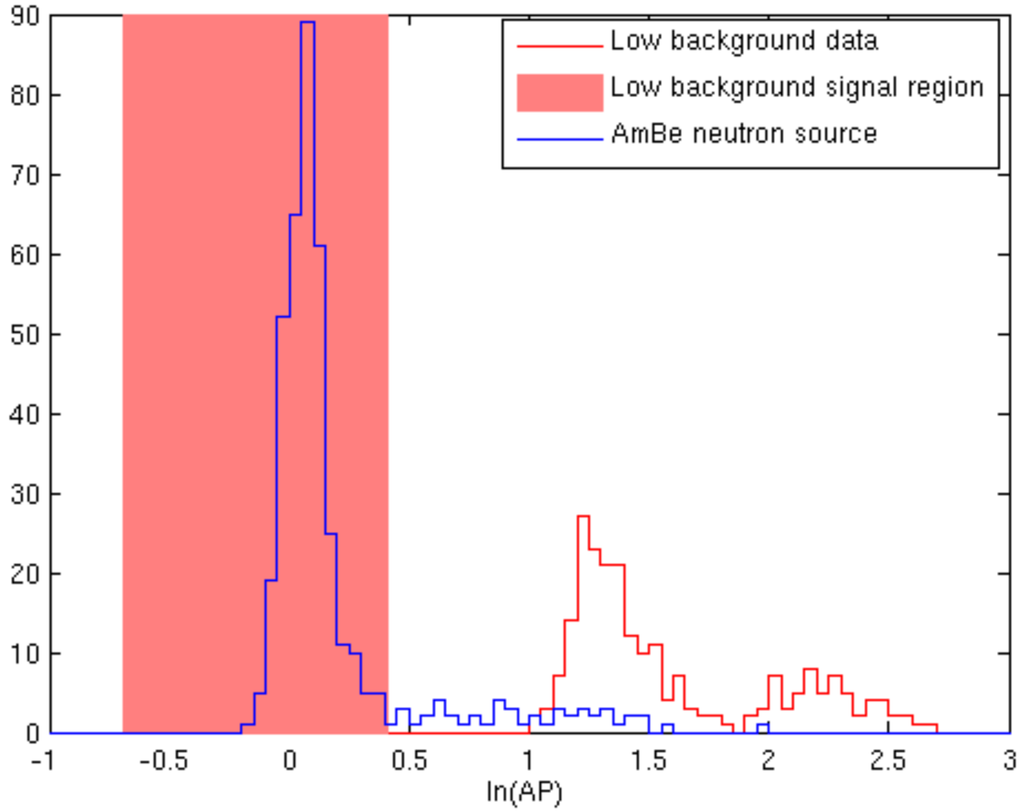
- Alphas deposit their energy in a few tens of micrometers where as nuclear recoils energy is over tens of nanometers

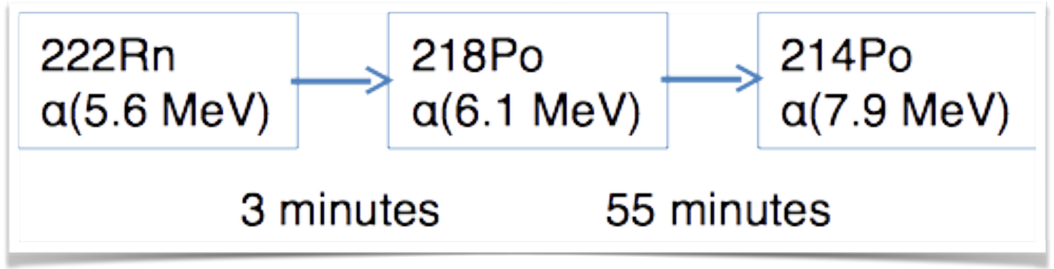


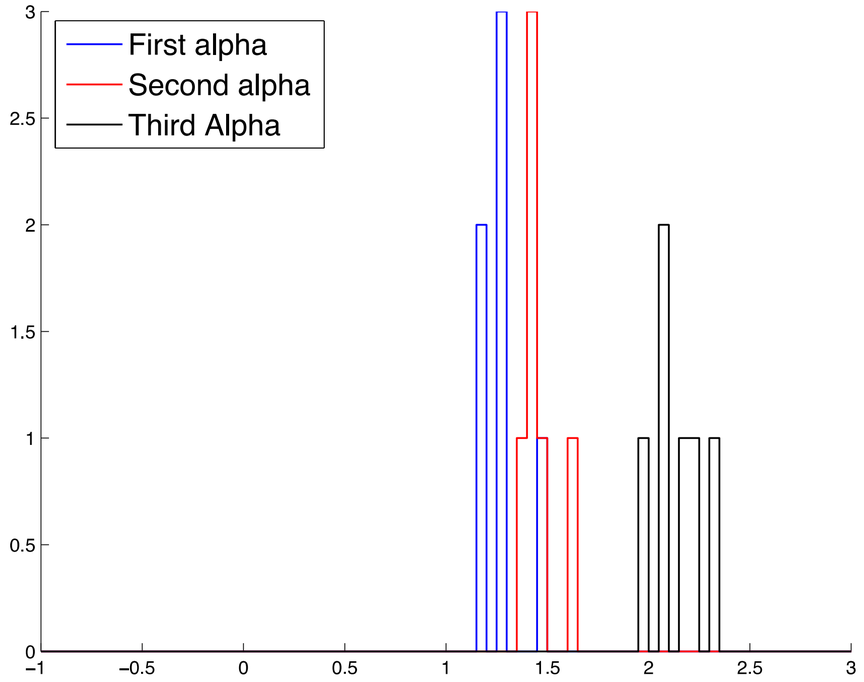


PICO_alphas

- > 99.4% rejections of alphas
- Timing of high AP events consistent with radon chain alphas.
- Separate peaks indicate higher energy alphas being louder.

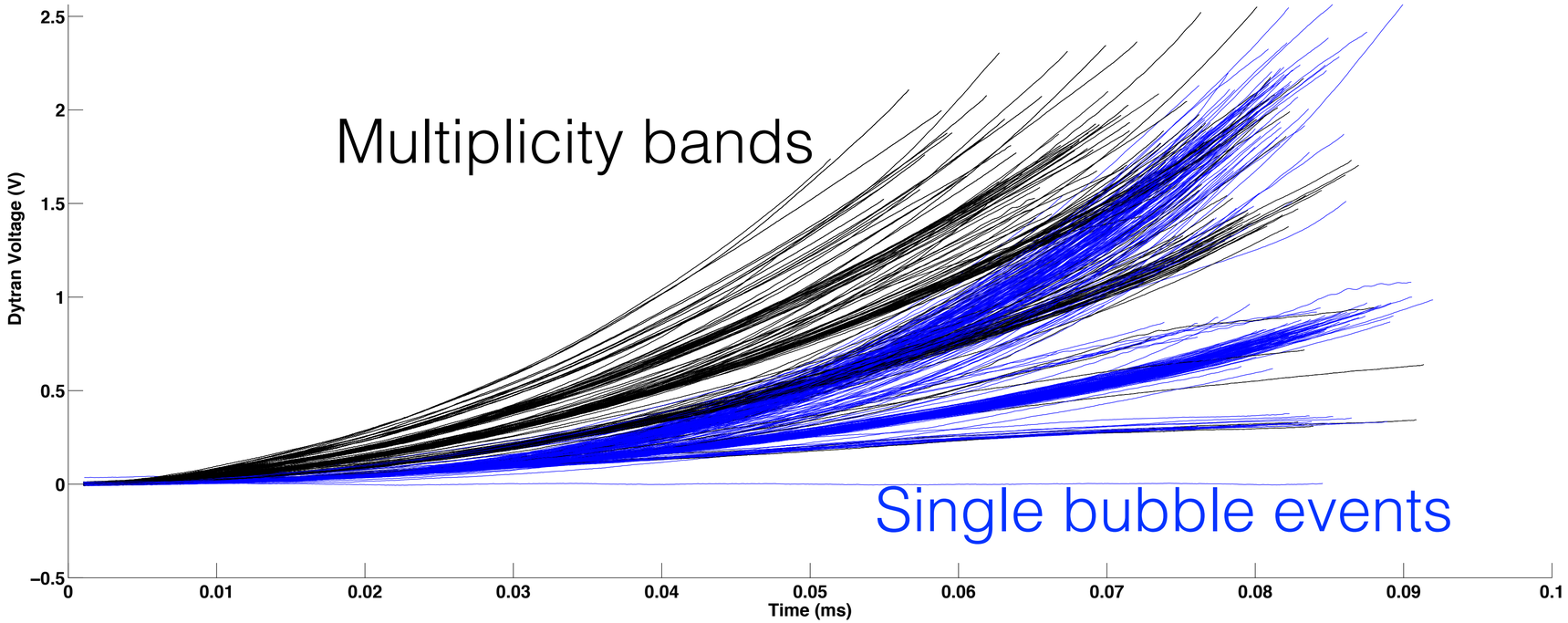


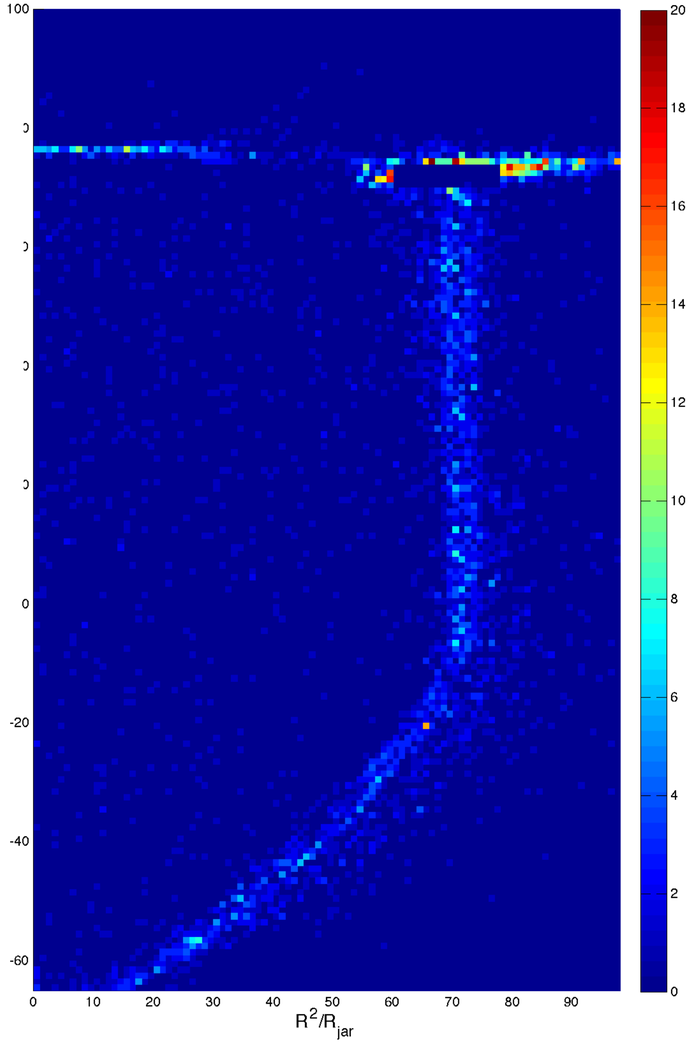




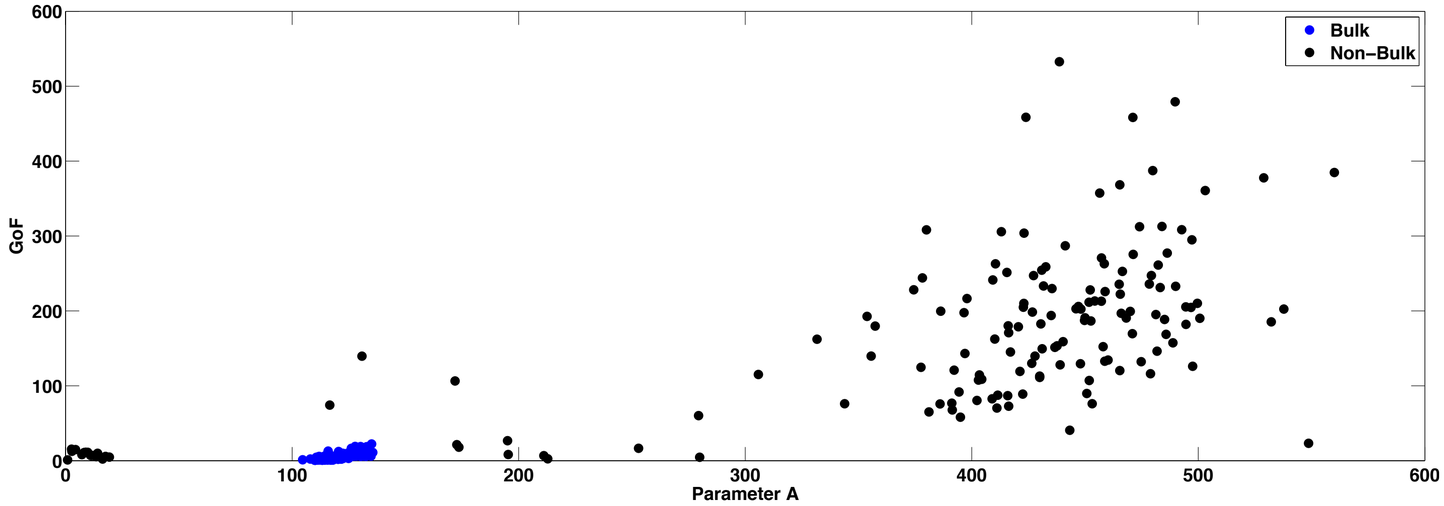
PICO_fiducial volume

- Interfaces provide nucleation sites.
- Pressure change for bubbles on interfaces is different from that in the bulk.
- Multiple bubble events can also be tagged using the pressure change traces

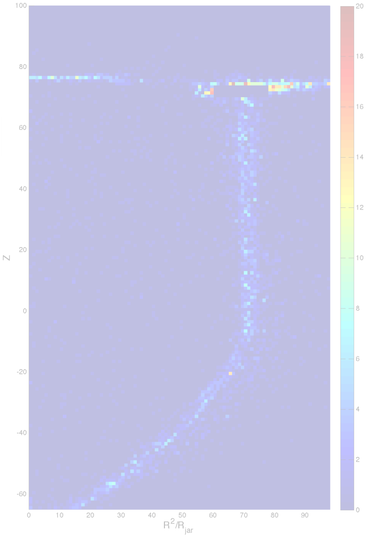




PICO_fiducial volume

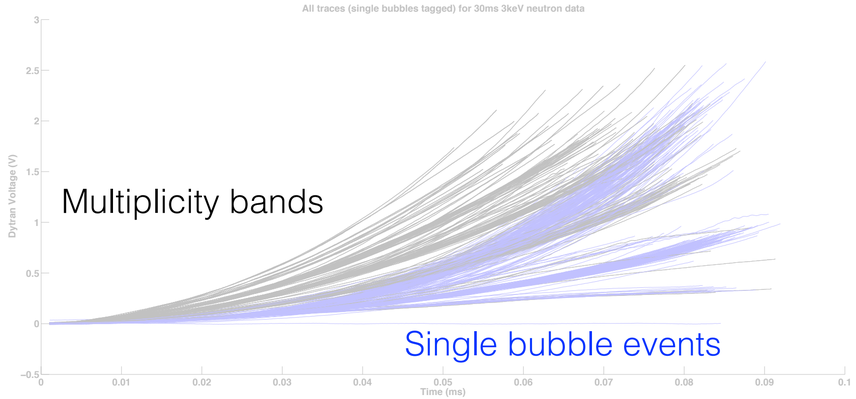


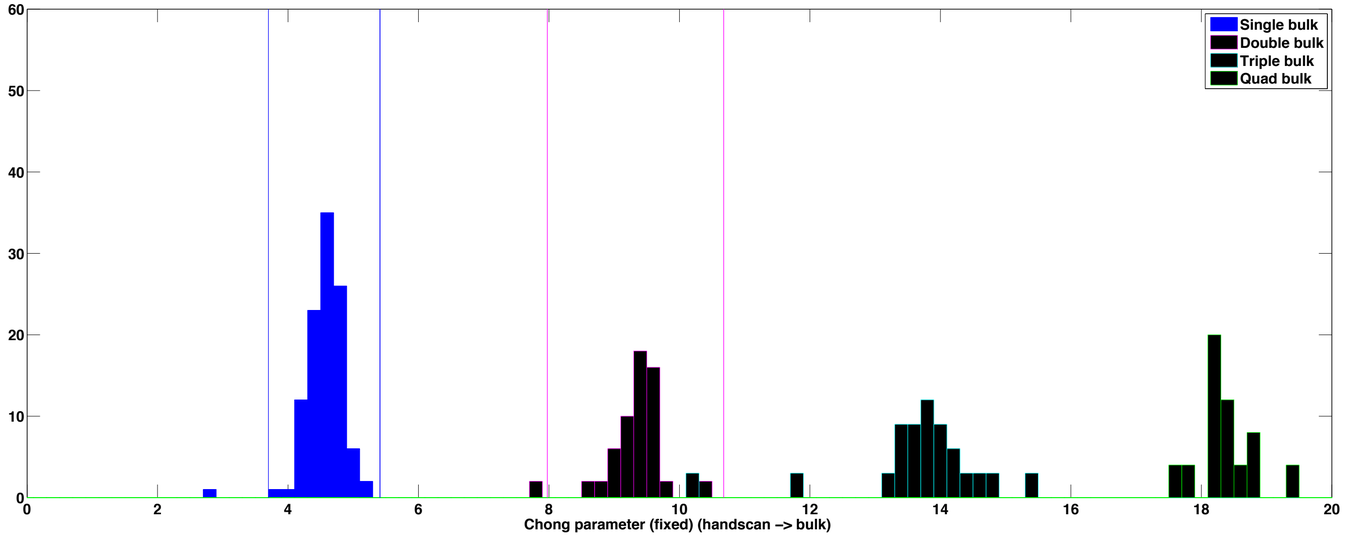
- Pressure traces fit with $\mathbf{A}x^2 + \mathbf{B}x + C = 0$.
- **A** vs GoF used for fiducial information.
- Combination of **A** and **B** used to calculate **A'** which is used for multiplicity.



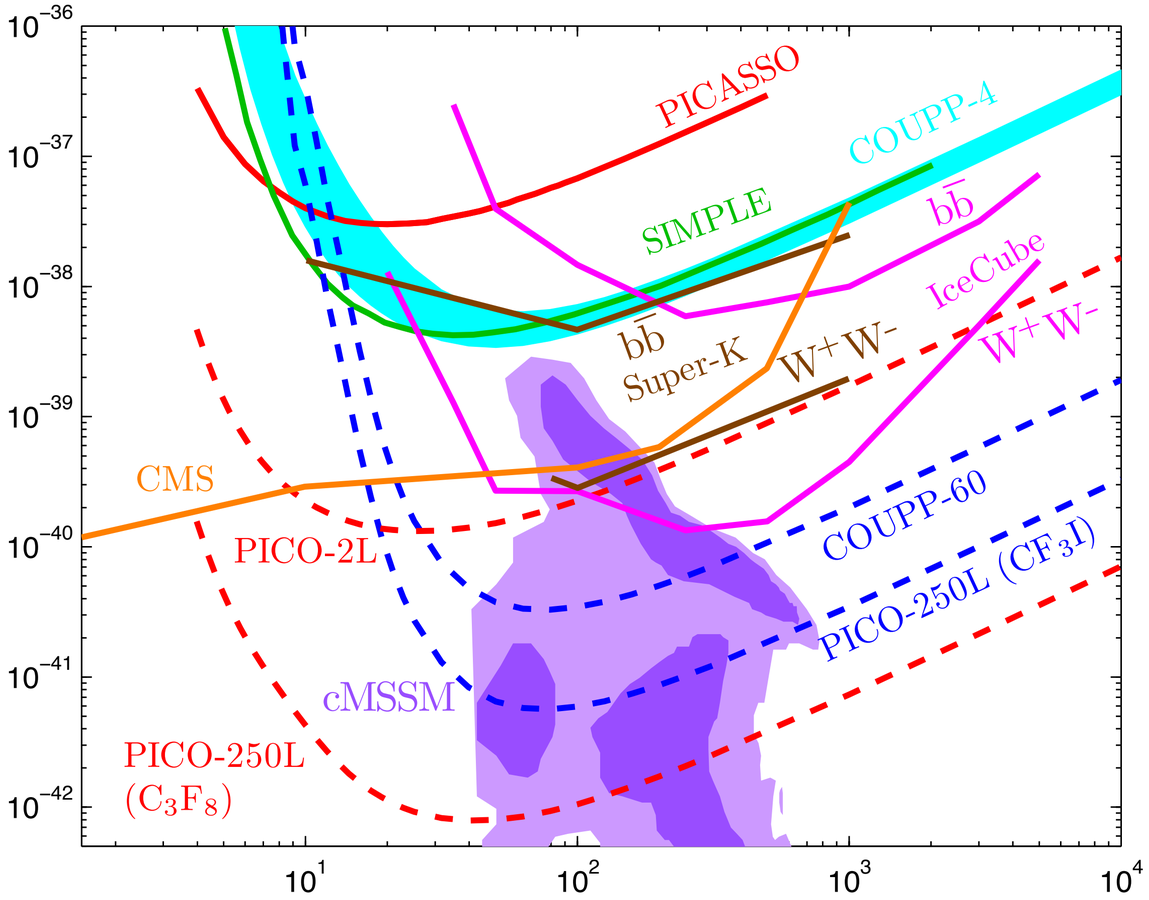
> 97.5% fiducial volume

> 99.5% acceptance for multiplicity

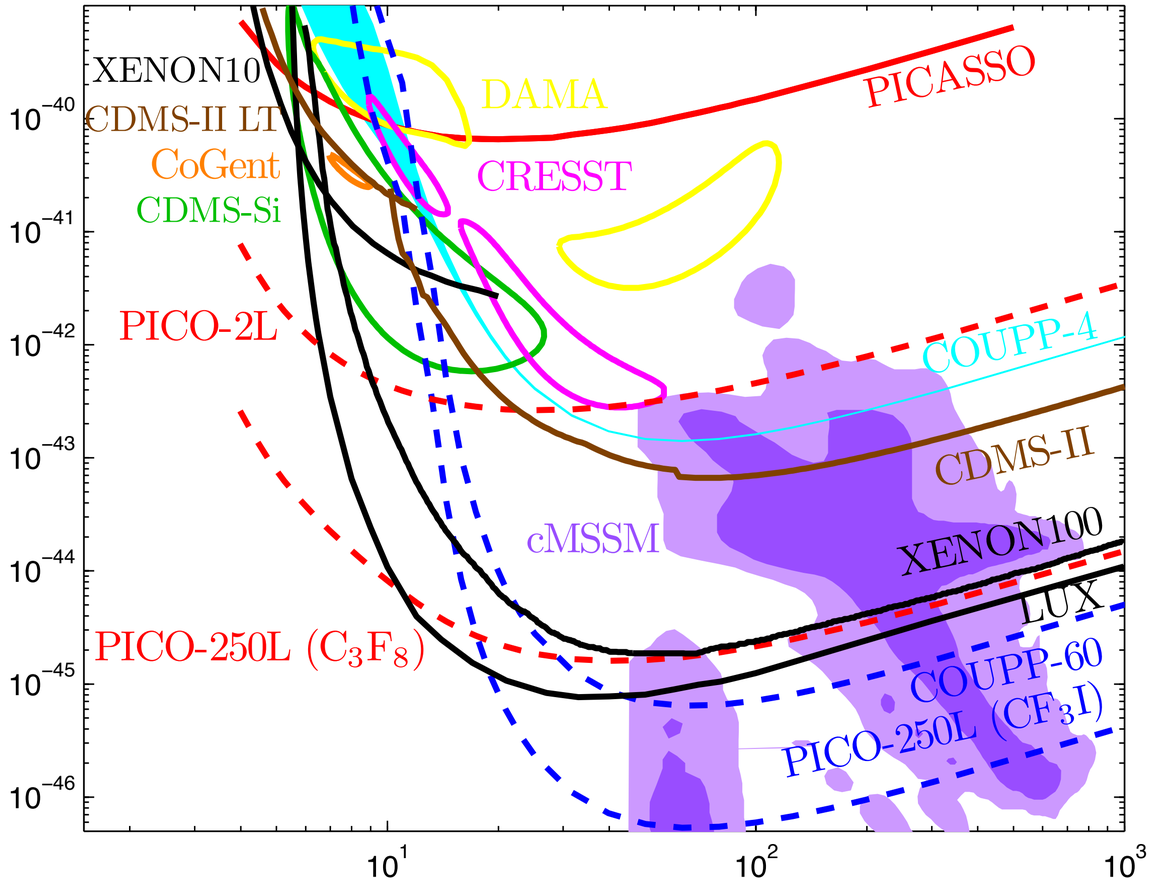




PICO_projected limits

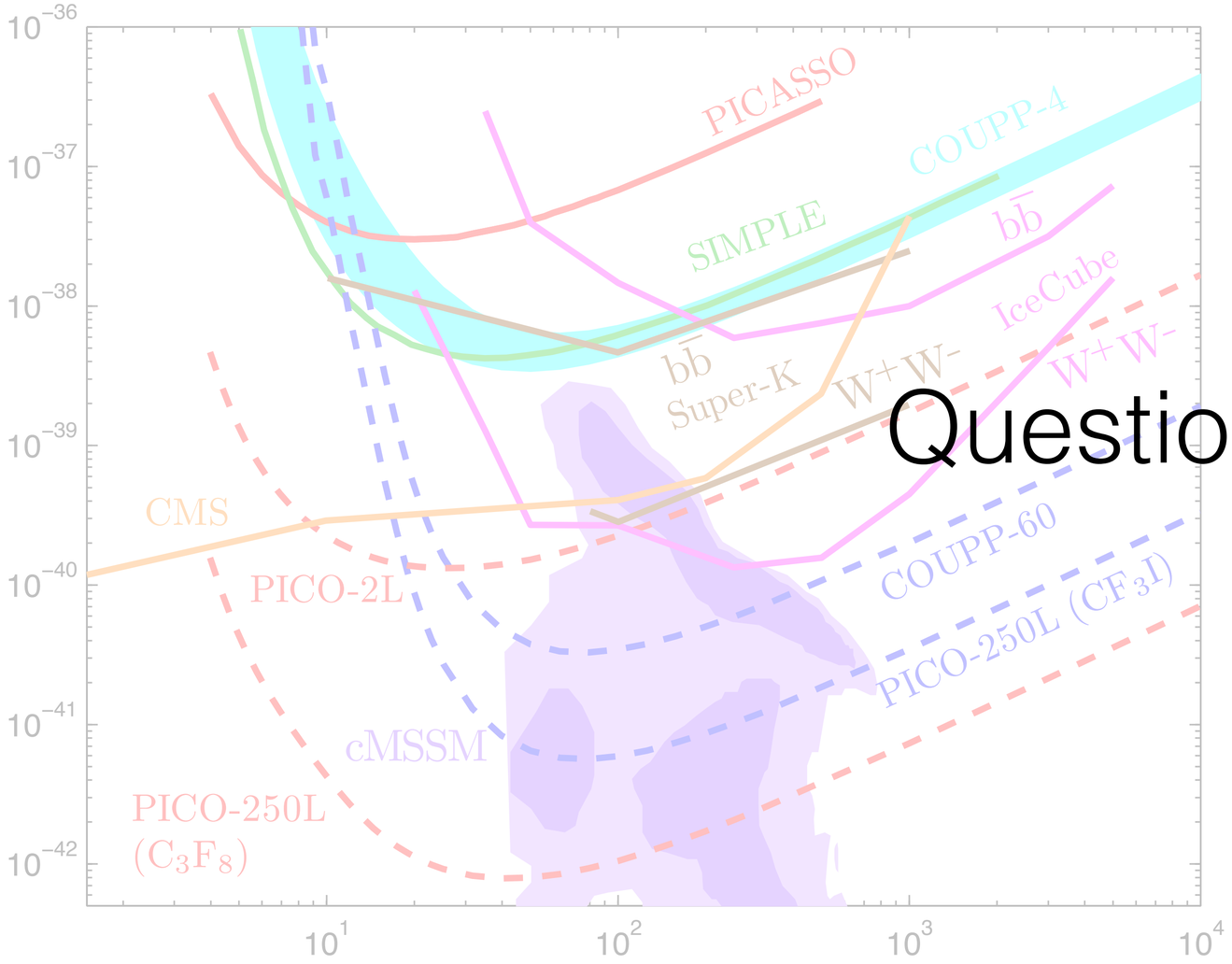


Spin dependent

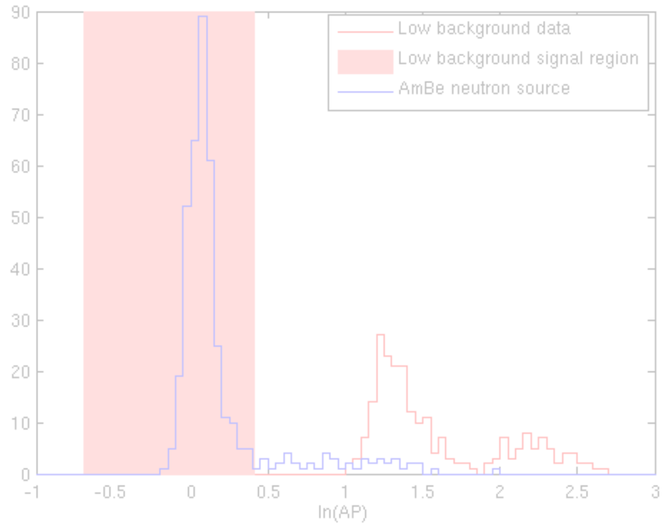


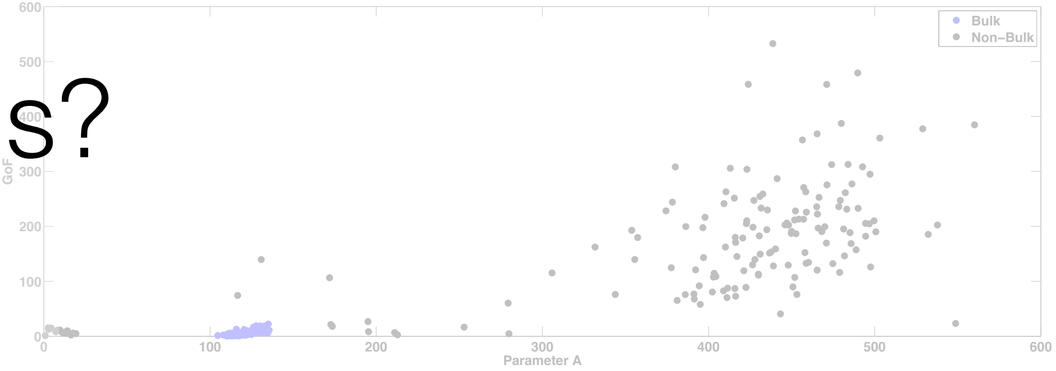
Spin independent

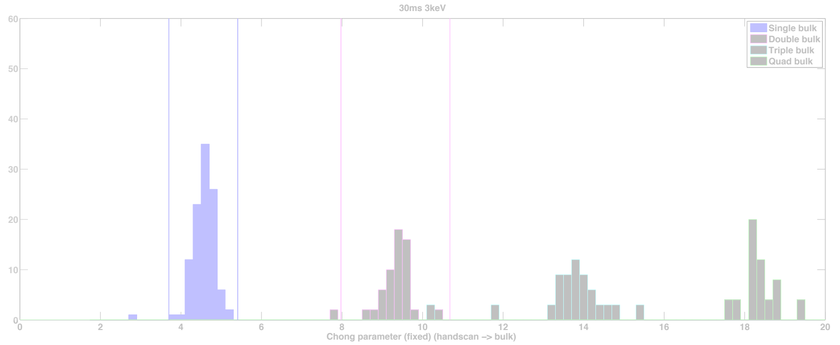
PICO_thanks.



Questions?

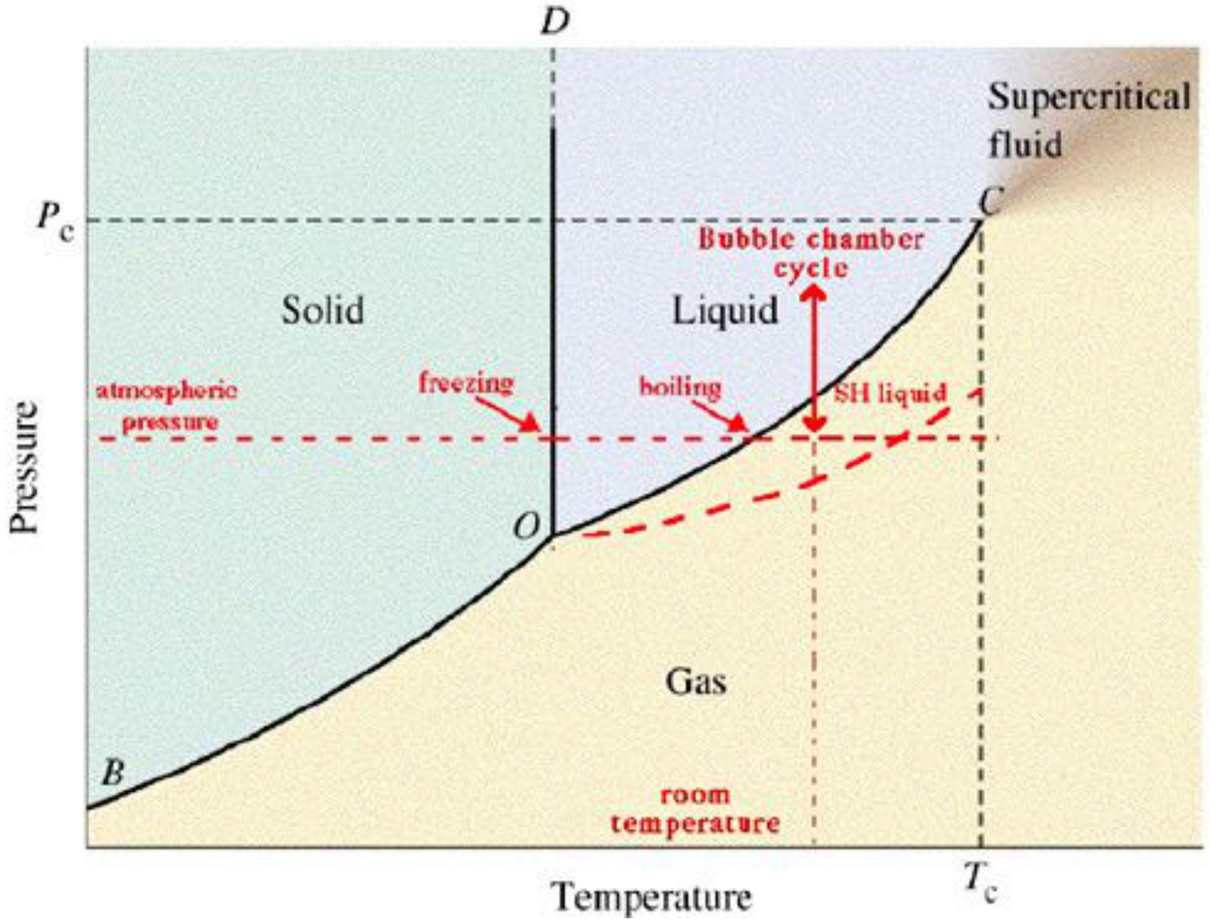


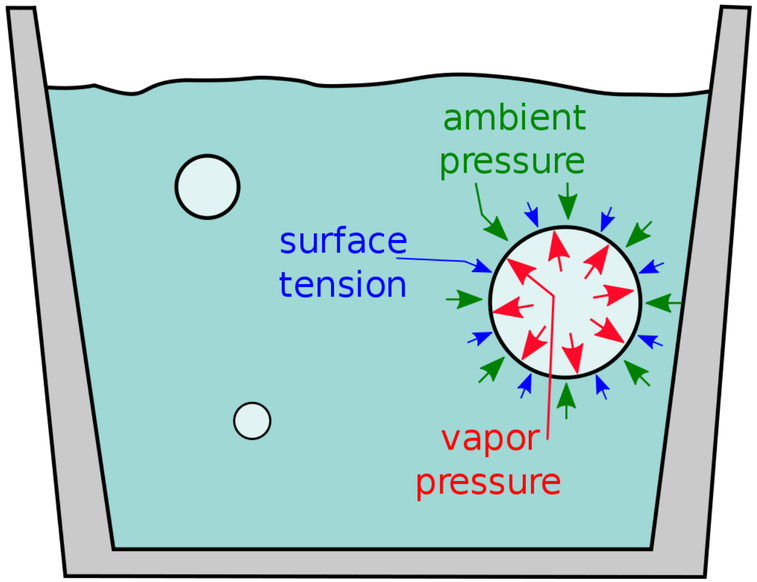


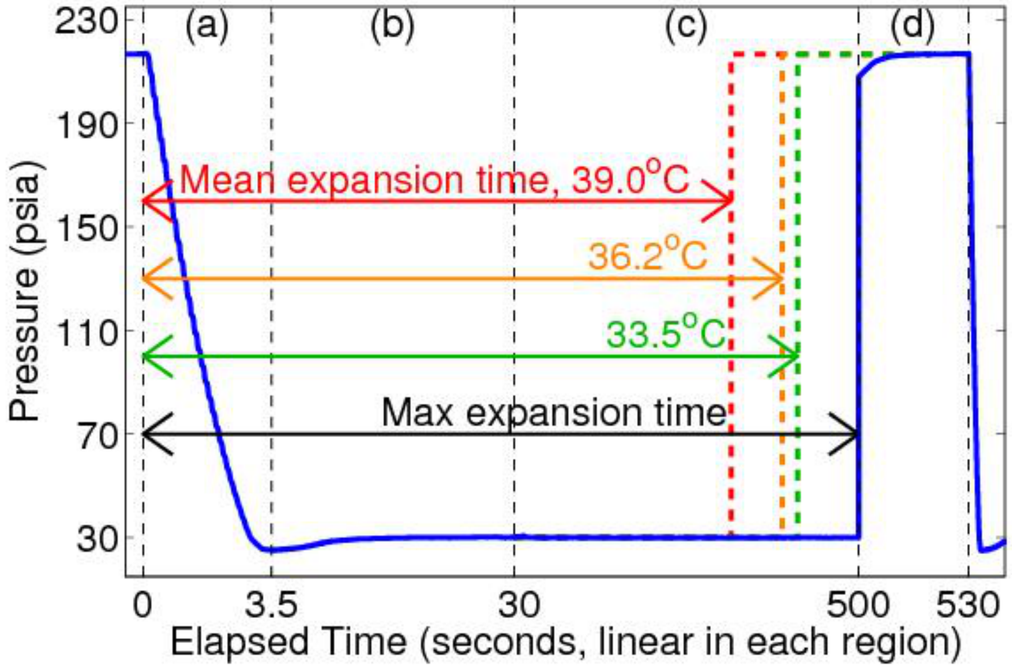


PICO_extra slides

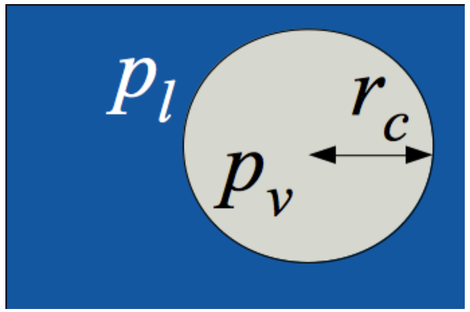
PICO_bubble chamber







PICO_sensitivity



$$p_v - p_l = \frac{2\sigma}{r_c}$$

$$E_{th} = 4\pi r_c^2 \left(\sigma - T\frac{\partial\sigma}{\partial T}\right) + \frac{4}{3}\pi r_c^3 \rho_v h$$

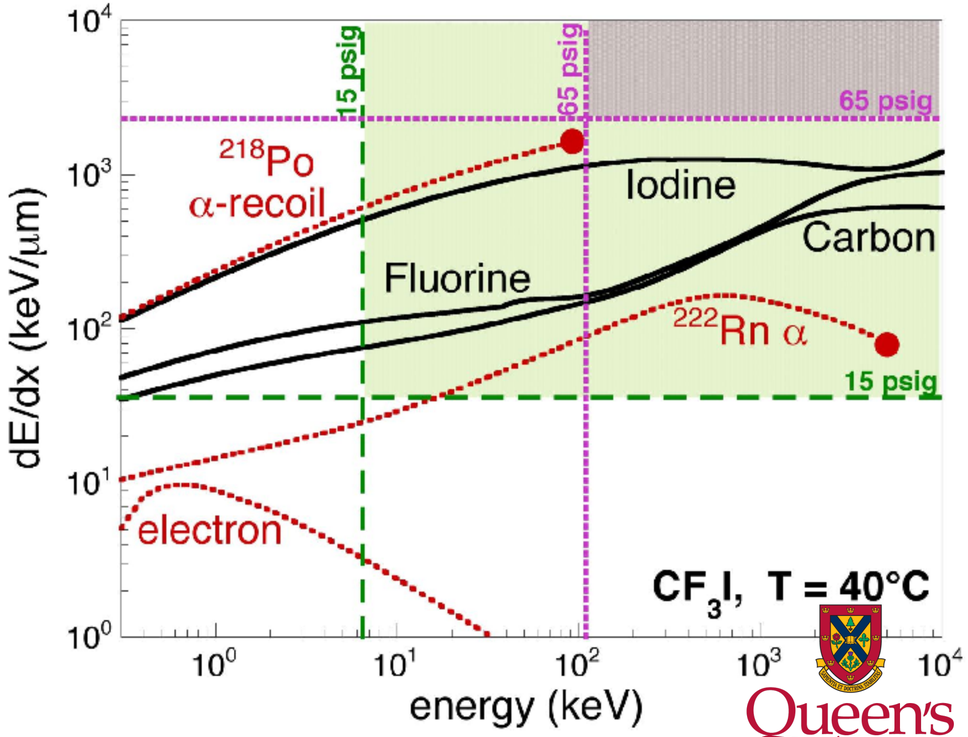
surface energy **latent heat**

- Energy greater than E_{th} deposited in radius less than r_c is necessary to overcome the surface tension to form a bubble.

- Lower dE/dx results in smaller bubbles that collapse immediately.

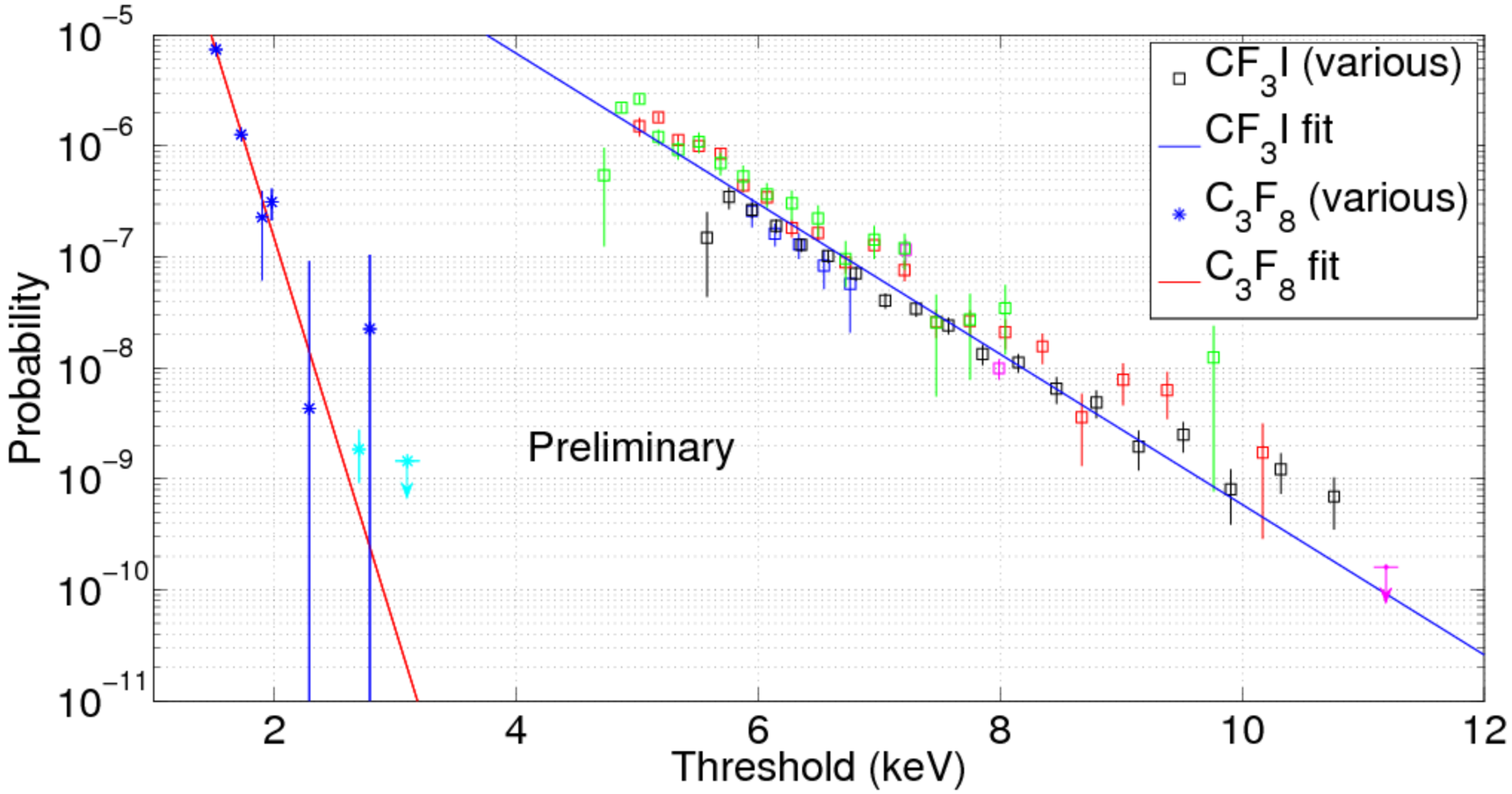
- Energy threshold (measure of superheat) can be adjusted to control the sensitivity.

- Superheated liquid can be chosen such that it is not sensitive to electron recoils at the working threshold.



PICO_gammas

C_3F_8 as active fluid



~10^{-10} probability of bubble nucleation per interaction for gammas @ ~ 3 keV threshold.