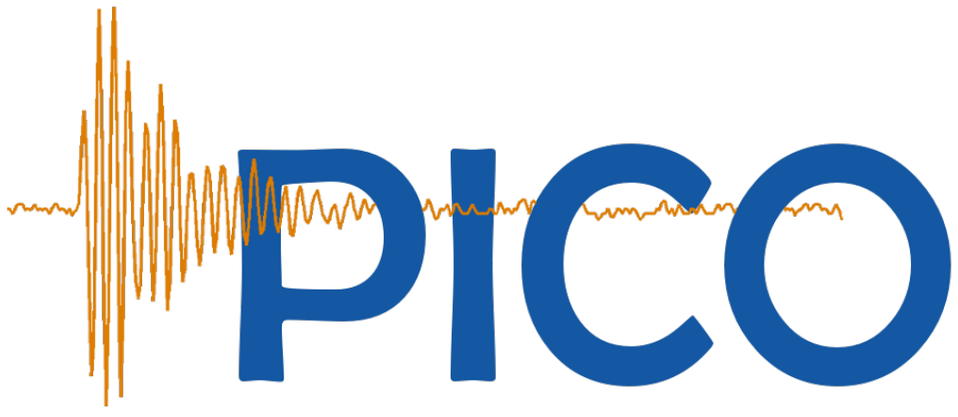


Carsten B. Krauss for the PICO collaboration

June 26 2014, Amsterdam

PICO

SNOLAB
Mining for knowledge
Creuser pour trouver... l'excellence
I. Lawson, E. Vázquez Jáuregui

Universitat Politècnica de València
M. Ardid, M. Bou-Cabo, I. Felis

Northwestern University
D. Baxter, C.E. Dahl, M. Jin, J. Zhang

P. Bhattacharjee. M. Das, S. Seth

Czech Technical University in Prague
R. Filgas, S. Pospisil, I. Stekl

Indiana University South Bend
E. Behnke, H. Borsodi, O. Harris, I. Levine, E. Mann, J. Wells

Fermilab
S.J. Brice, D. Broemmelsiek, P.S. Cooper, M. Crisler, W.H. Lippincott, M.K. Ruschman, A. Sonnenschein

Université de Montréal
F. Debris, M. Fines-Neuschild, C.M. Jackson, M. Lafrenière, M. Laurin, L. Lessard, J.-P. Martin, M.-C. Piro, A. Plante, O. Scallon, N. Starinski, V. Zacek

Kavli Institute for Cosmological Physics at the University of Chicago
J.I. Collar, R. Neilson, A.E. Robinson

Virginia Tech
D. Maurya, S. Priya

Queen's University
C. Amole, M. Besnier, G. Caria, G. Giroux, A. Kamaha, A. Noble

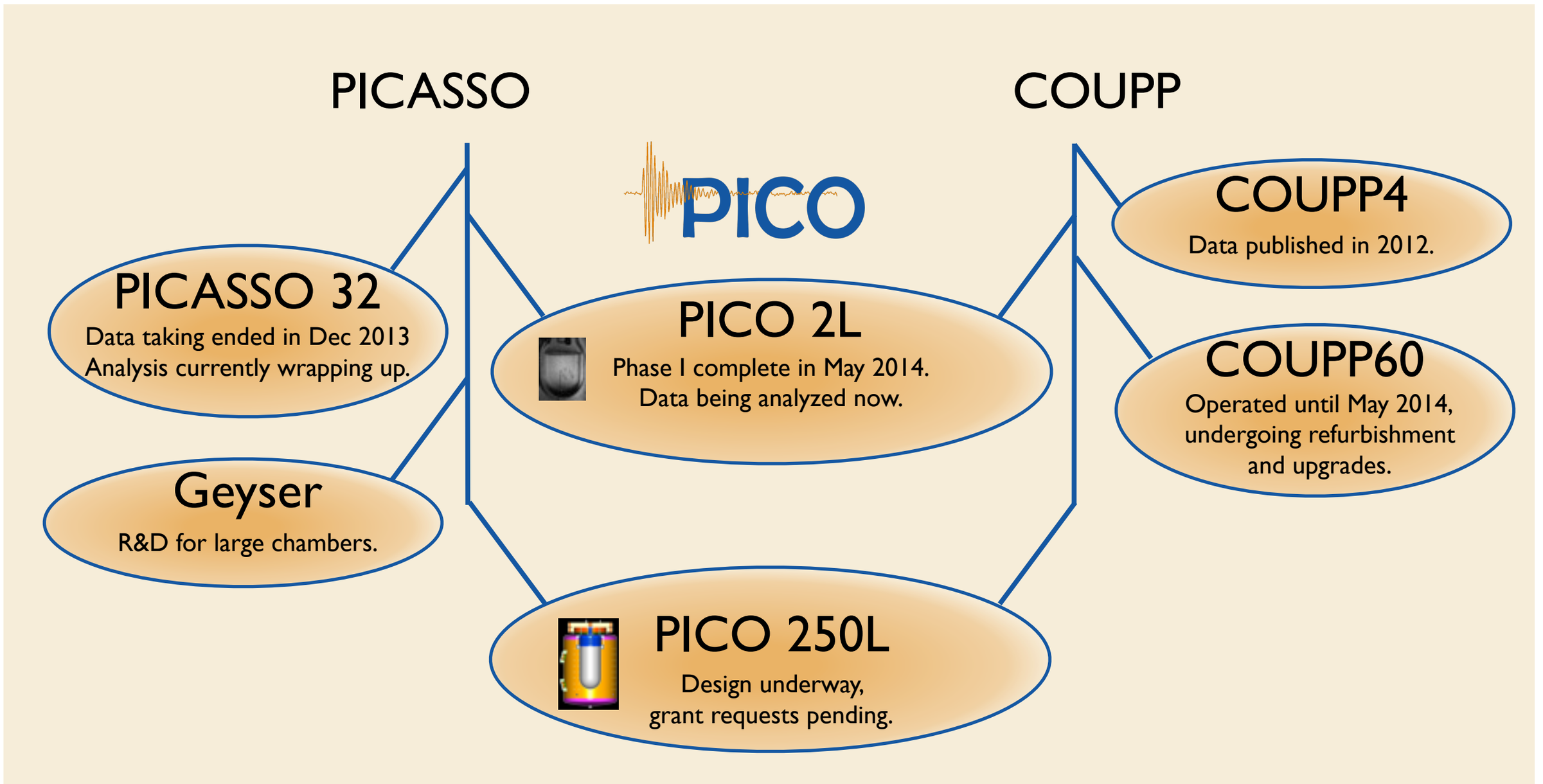
Pacific Northwest National Laboratory
D.M. Asner, J. Hall

University of Alberta
S. Gagnebin, C. Krauss, D. Marlisov, P. Mitra

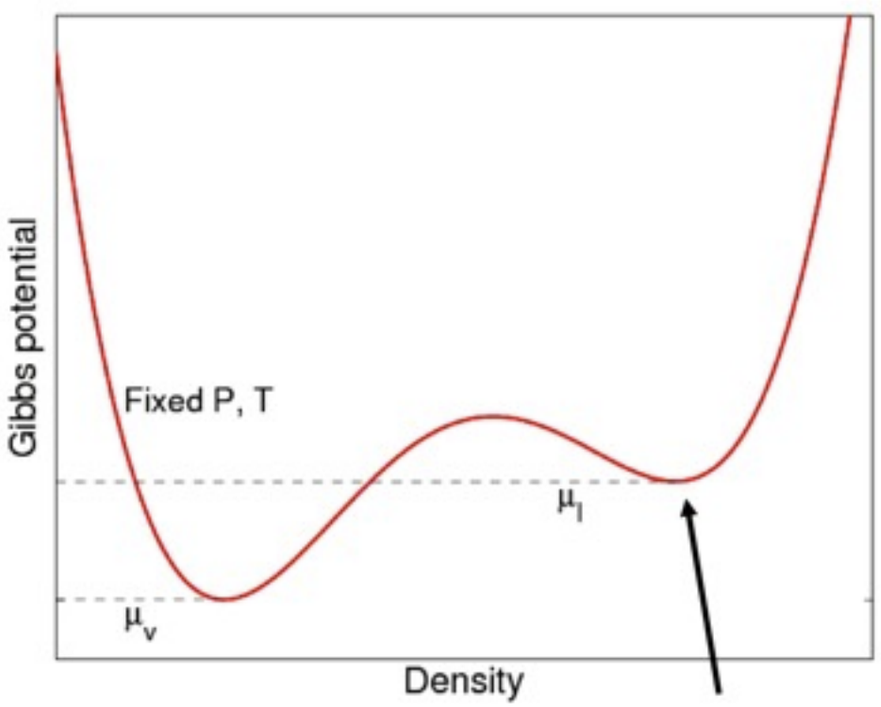
University of Toronto
K. Clark

Laurentian University / Université Laurentienne
N. Dhungana, J. Farine, R. Podviyanuk, U. Wichoski

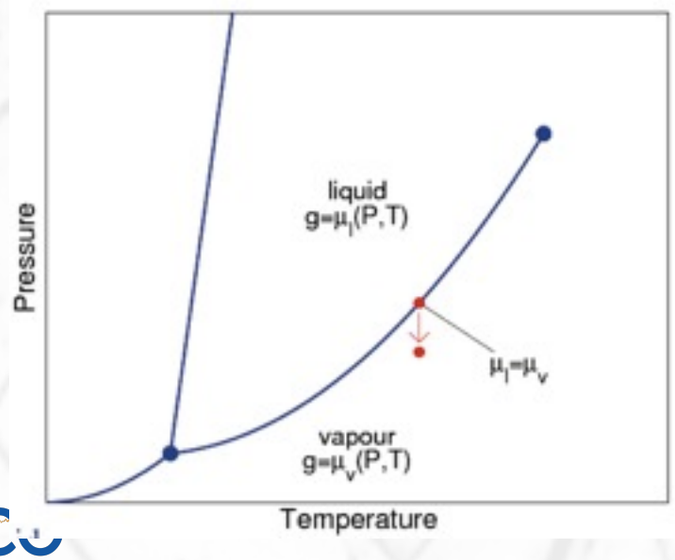
PICO Family Tree



Superheated liquids



Metastable superheated liquid



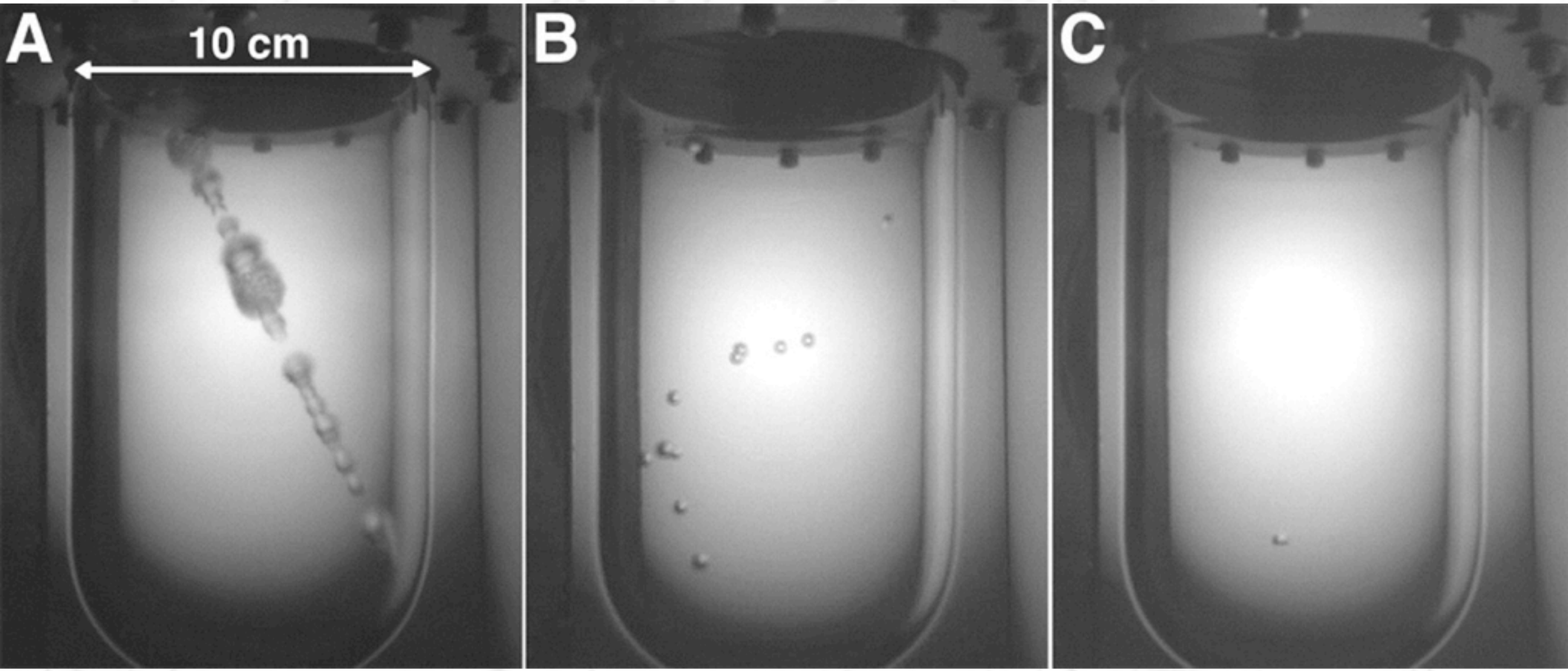
- A small energy deposition leads to a nucleation and release of large amounts of energy.
- Due to the hump, only energy depositions larger than E_c and within critical radius r_c cause boiling.
  This can be understood as a requirement to overcome the surface tension term $\propto 1/r$.
- A change in operating temperature and pressure allows adjustment of the energy threshold.

Carsten B Krauss, Astroparticle Physics 2014

History: PICASSO and COUPP

- PICASSO pioneered superheated liquid for dark matter search using droplet detectors.
  - PICASSO discovered acoustic discrimination of alpha background events.
- COUPP established bulk superheated liquid detectors in a low background bubble chamber.

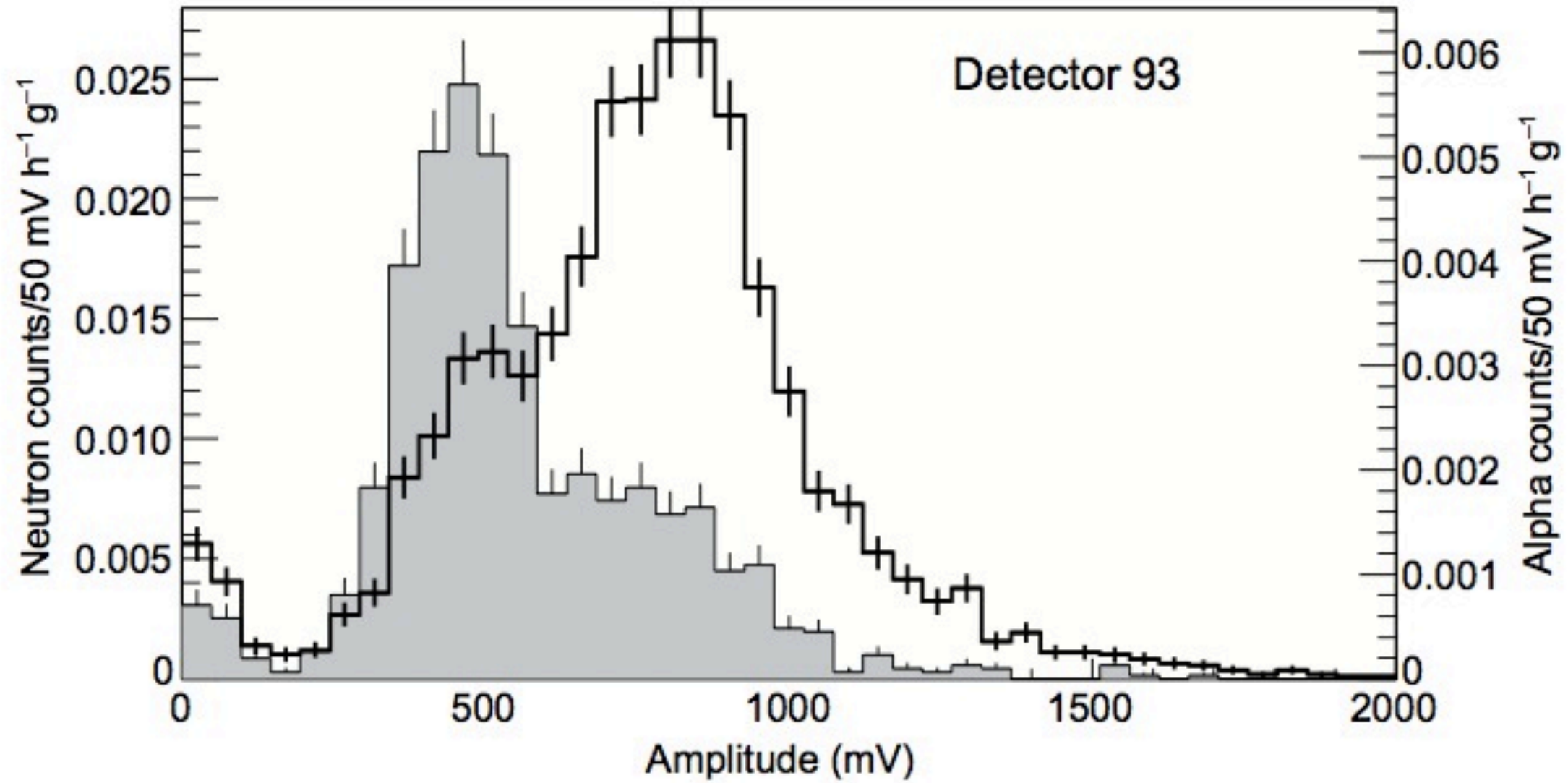
History: PICASSO and COUPP



Acoustic Discrimination

- In 2008 PICASSO discovered that the acoustic signal contains information about the particle interaction.
- Alpha (background) events are louder than recoil (signal) events!

Acoustic Discrimination



Aubin, F., et al. (2008, July 10)..New Journal of Physics 10 (2008) 103017

Acoustic Discrimination

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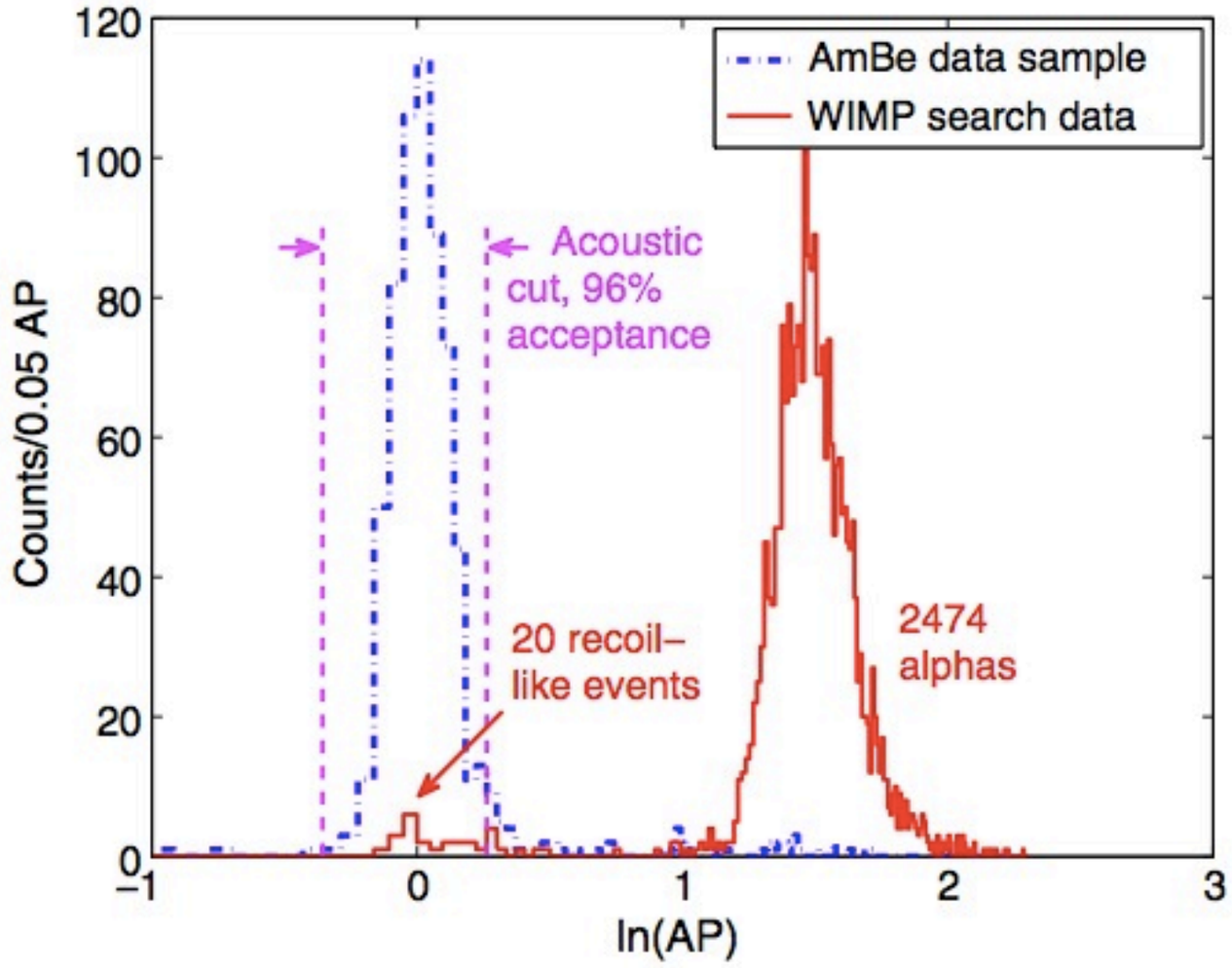
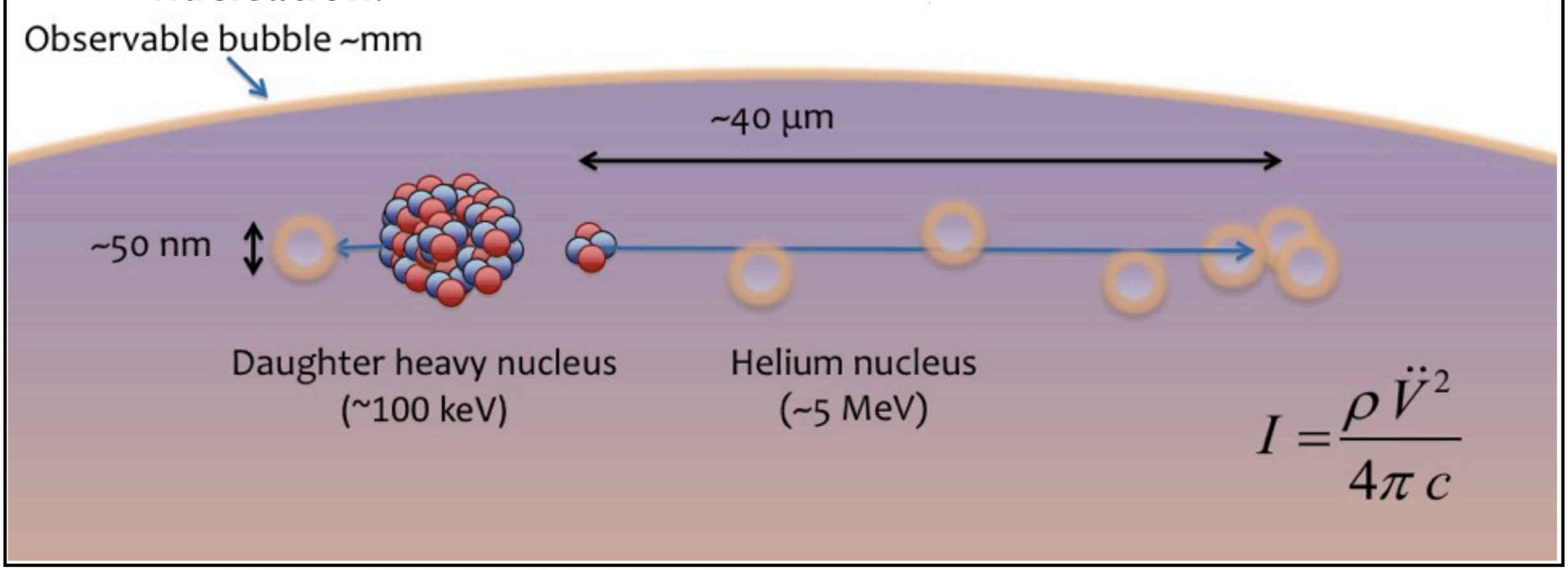


Behnke, E., , et al. (2012).. *Physical Review D*, *86*(5), 052001.

Aubin, F., et al. (2008, July 10)..New Journal of Physics 10 (2008) 103017

Acoustic Discrimination

- An alpha particle deposits energy along its (long) path causing multiple nucleations along the way.
- A recoil has a sub μm path lenght causing only a single nucleation.



Behnke, E., , et al. (2012).. *Physical Review D*, *86*(5), 052001.

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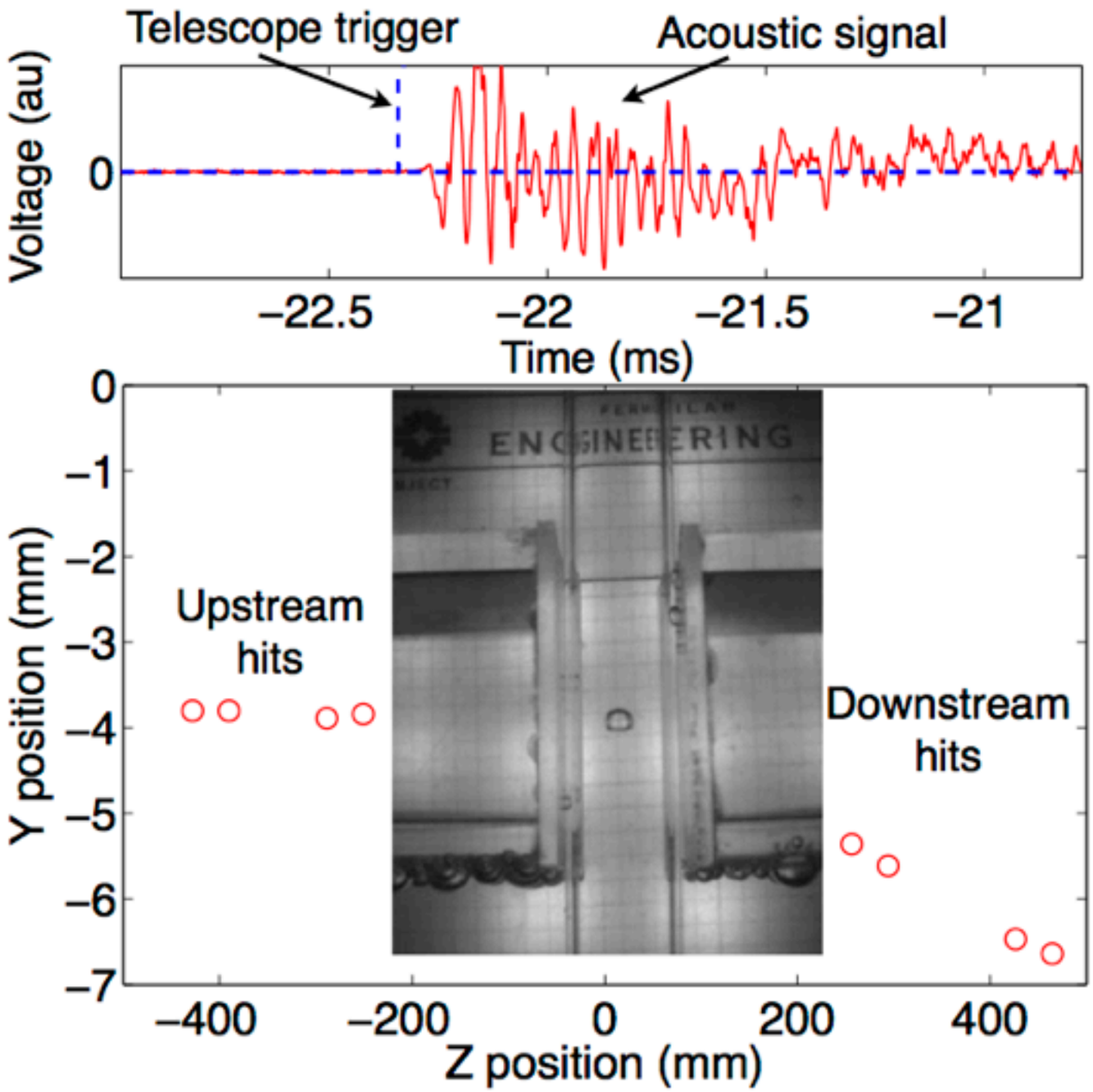
Calibration activities

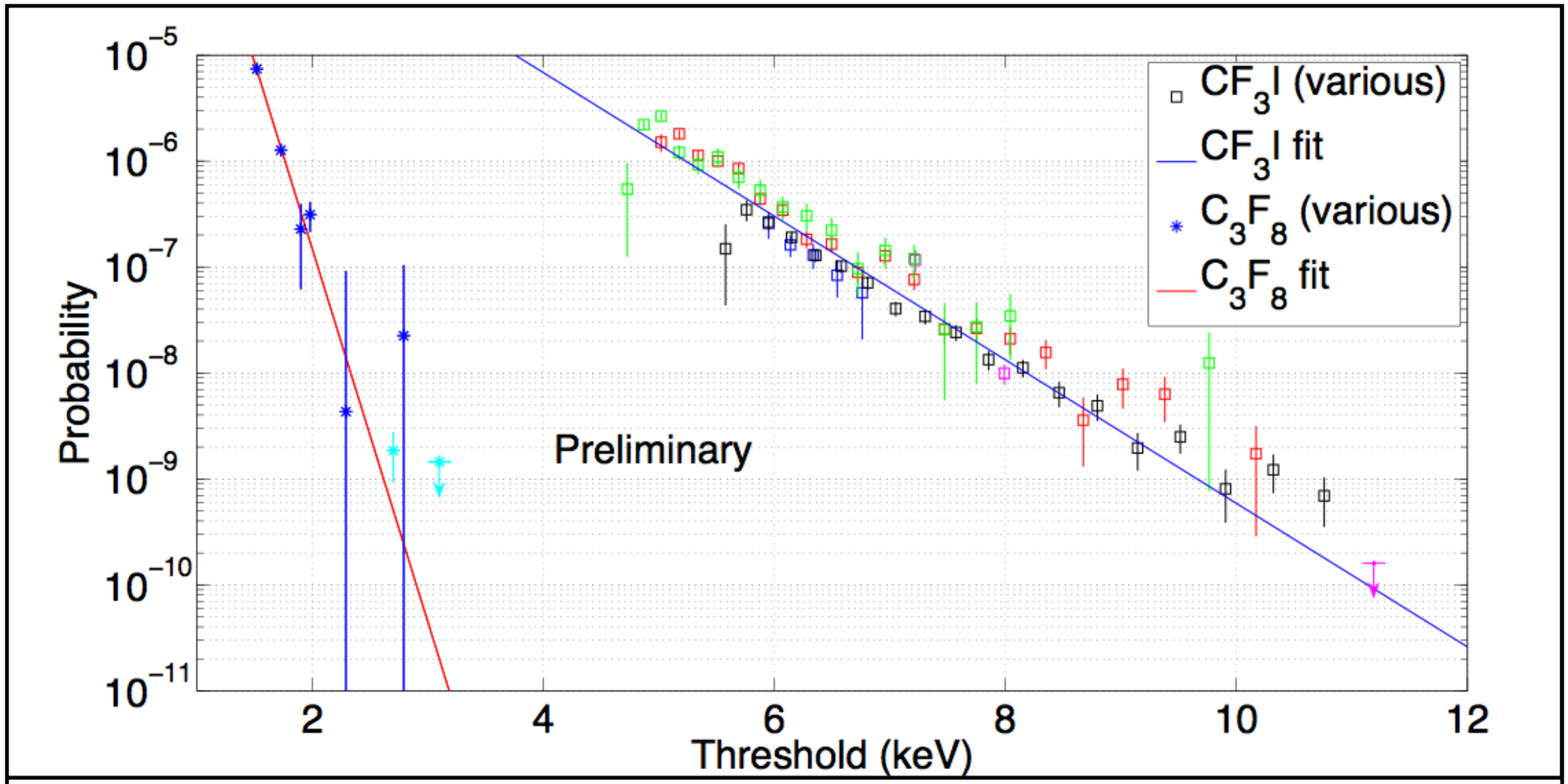
- Beam and gamma measurements confirm that our understanding of bubble nucleations is accurate.
- Detailed measurements of threshold behaviour with mono-energetic neutron sources and test beam measurements.
- Montreal test beam is now used with a bubble chamber and C_3F_8, further improving the understanding of the bubble nucleations from nuclear recoils.

Calibration activities



Beam tests at Fermilab with a CF_3I filled chamber to determine threshold efficiency.

Calibration activities



Gamma background suppression

Calibration activities

- Beam and gamma measurements confirm that our understanding of bubble nucleations is accurate.
- Detailed measurements of threshold behaviour with mono-energetic neutron sources and test beam measurements.
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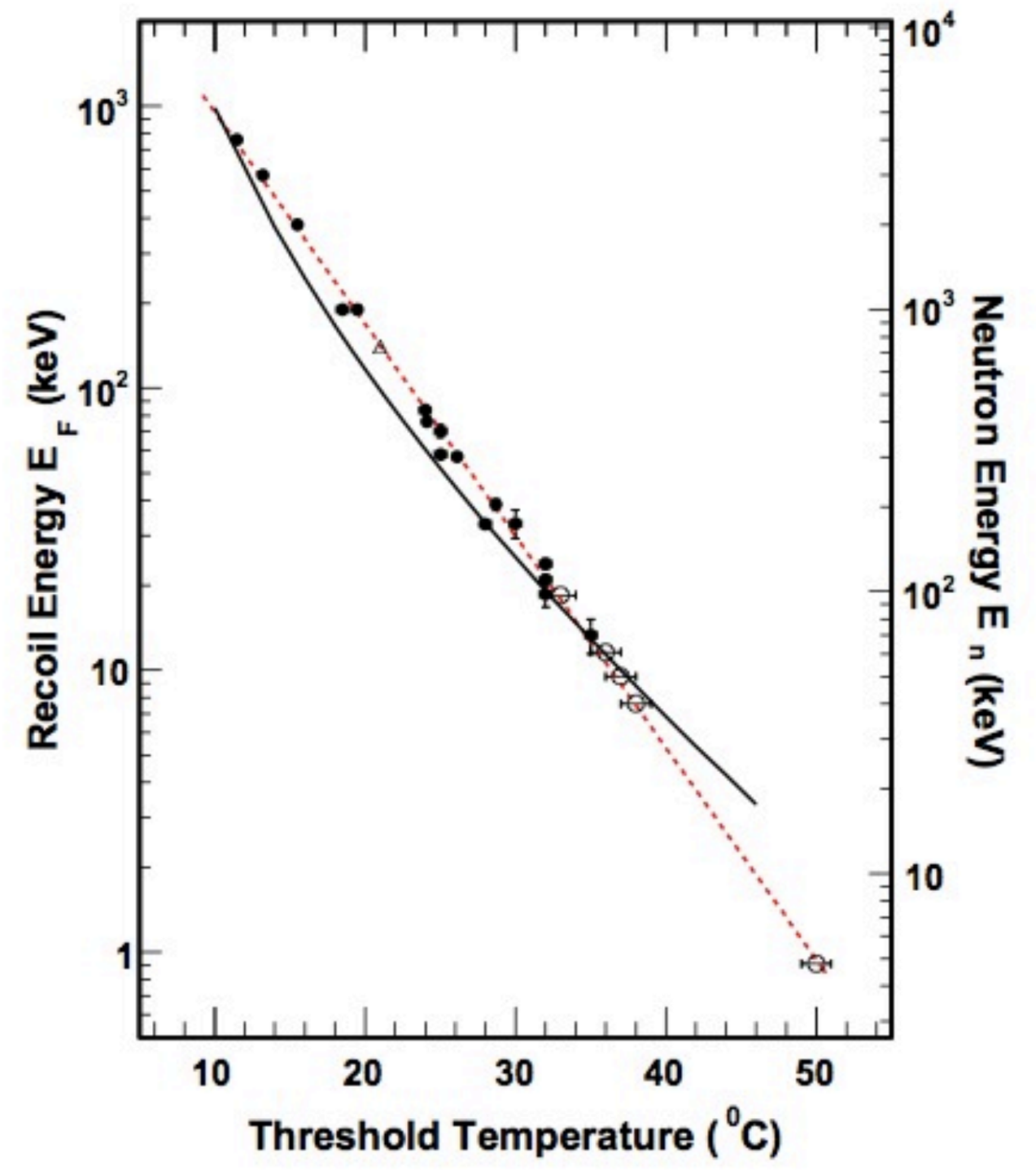


- Threshold Calibration with mono energetic neutrons at Montreal beam line.
- Shown for C_4F_{10}, calibration measurements and analysis using C_3F_8 is ongoing.

PICO Family Tree

PICASSO

COUPP

PICO

PICASSO 32

Data taking ended in Dec 2013
Analysis currently wrapping up.

Geyser

R&D for large chambers.

PICO 2L

Phase I complete in May 2014.
Data being analyzed now.

PICO 250L

Design underway,
grant requests pending.

COUPP4

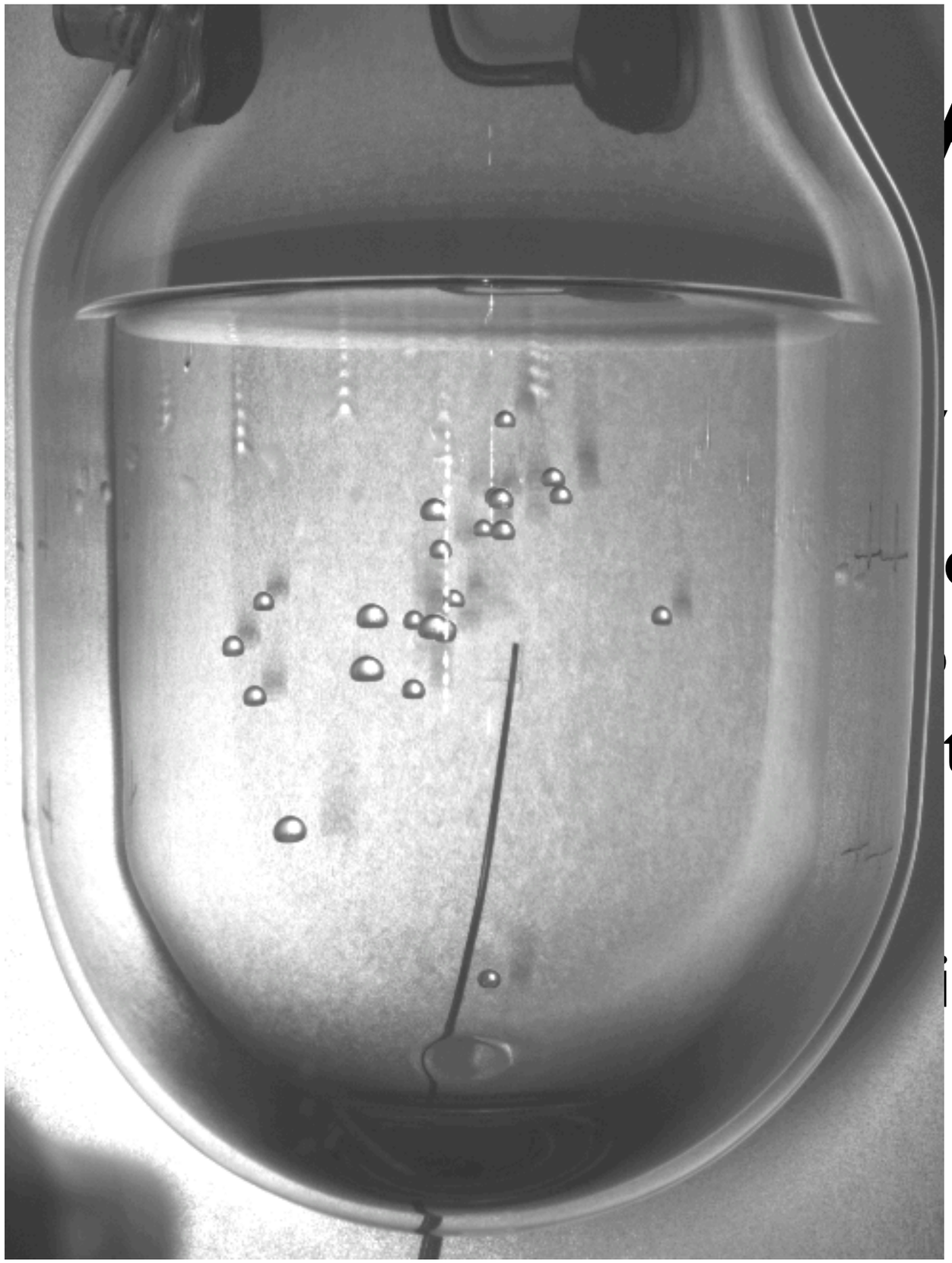
Data published in 2012.

COUPP60

Operated until May 2014,
undergoing refurbishment
and upgrades.

PICO 2L Activities

- First run successfully established that
  - C_3F_8 is a suitable liquid for bubble chambers. Threshold can be set as low as 3 keV. The sensitivity for recoil events is very high.
  - The acoustic discrimination works well in C_3F_8.



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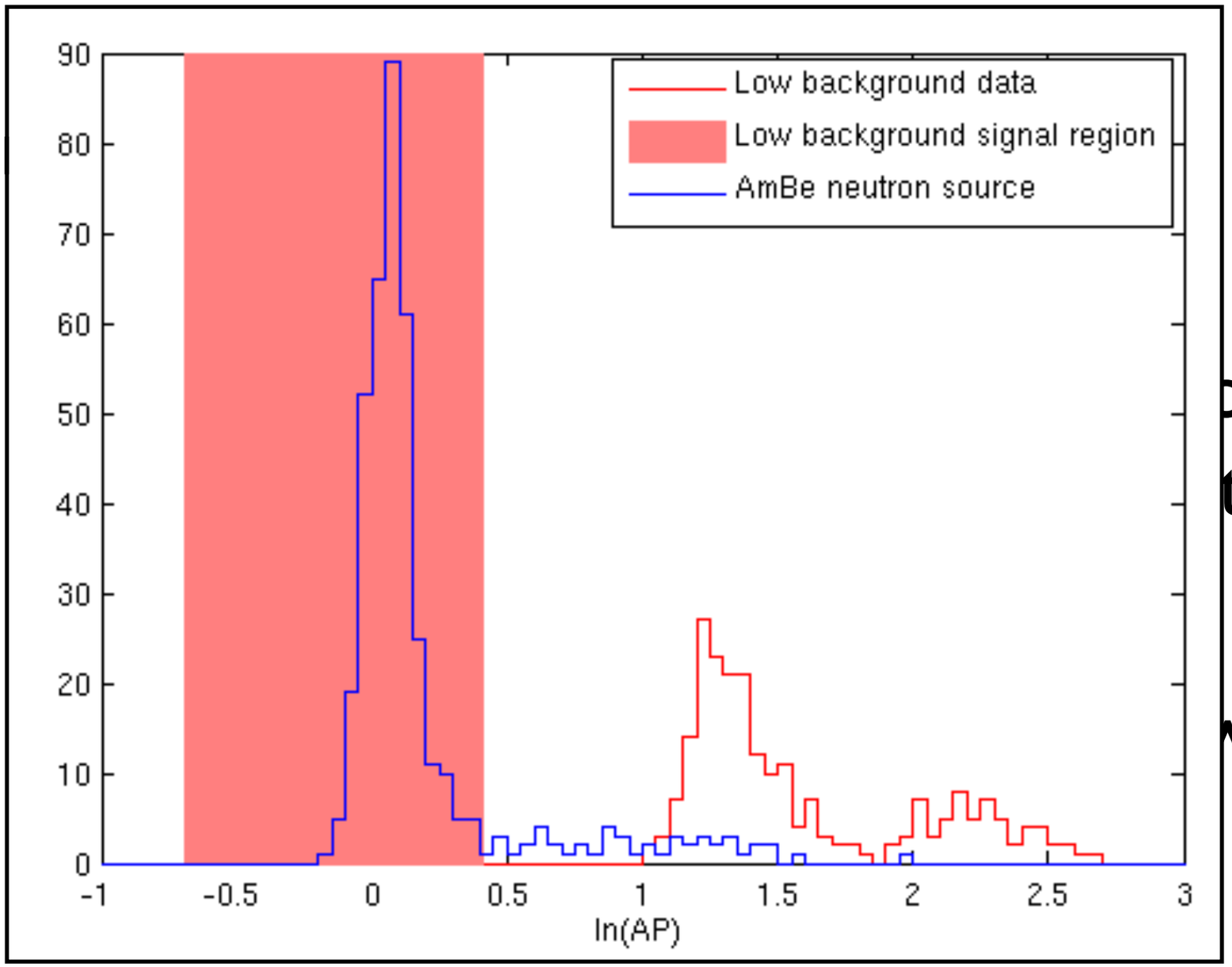

PICO 2L Status

- The chamber just finished the first run. The data is of high quality and is expected to produce very competitive results.
- The chamber was contaminated in October 2013 during filling. Therefore some radon like events remained in the chamber as background, partially appearing as nuclear recoil events.
- Currently the system is being assayed and refurbished for a second run to exploit the full SD dark matter sensitivity.

PIC tus

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Data published in 2012.

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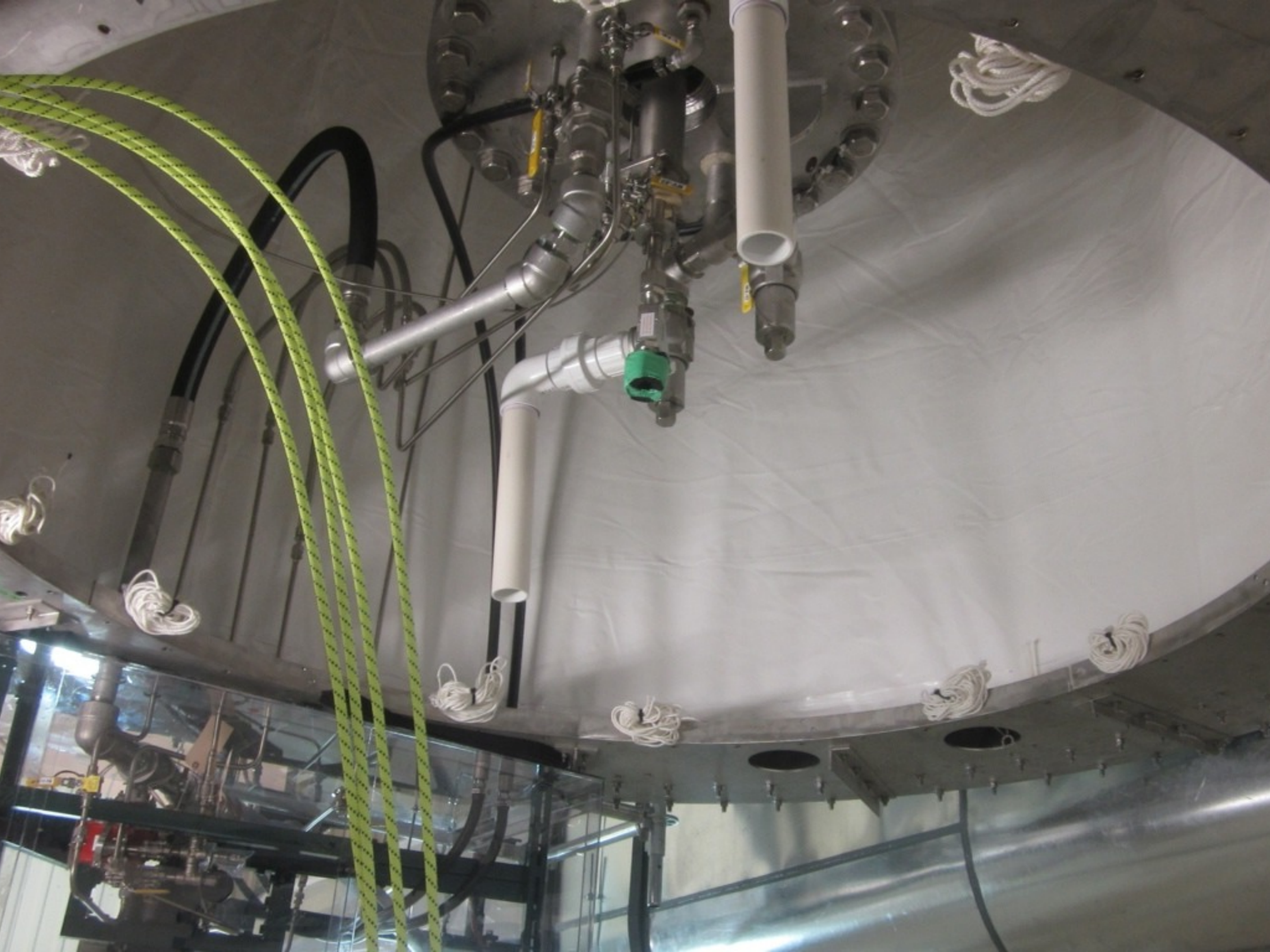
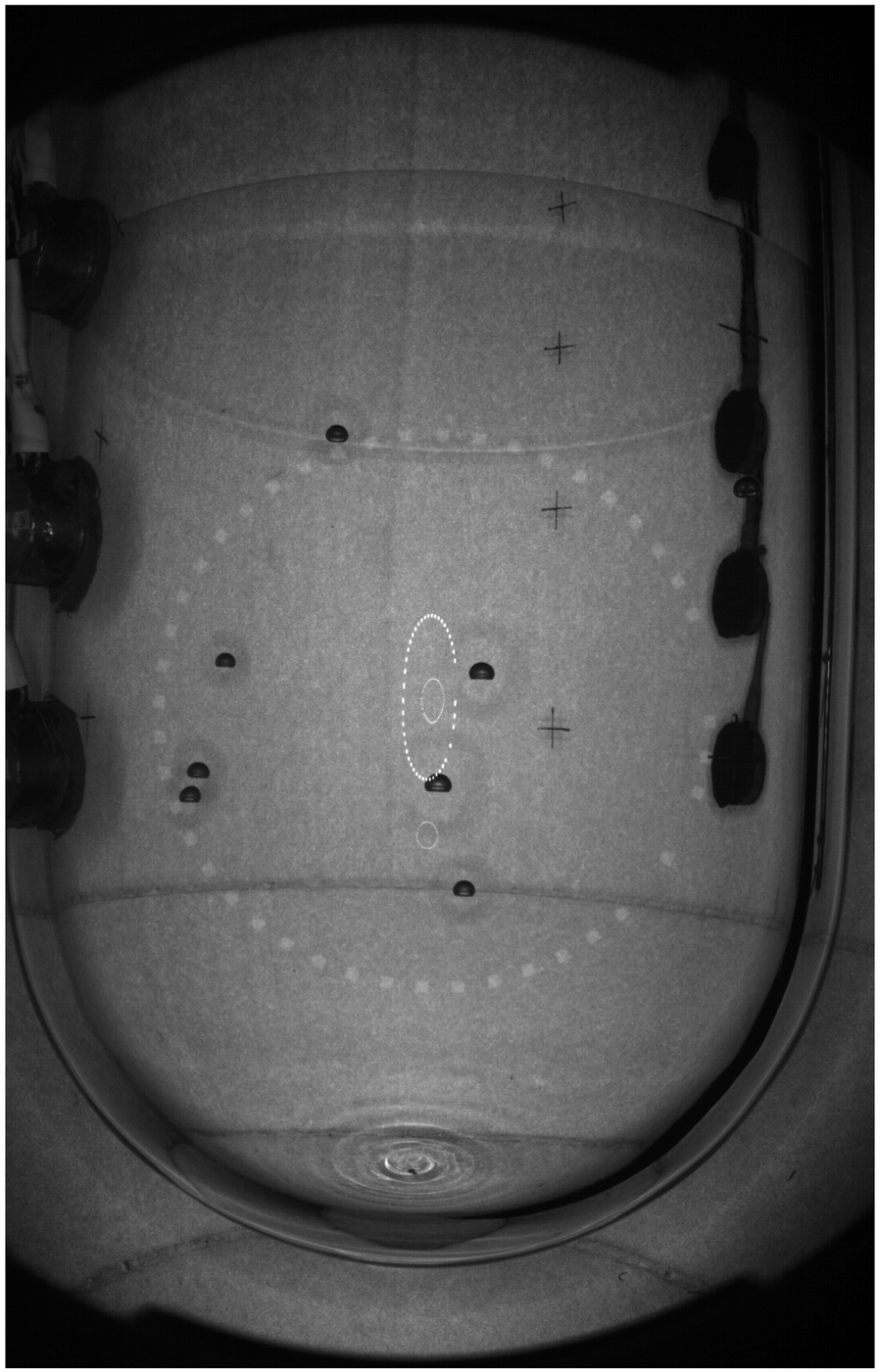
Operated until May 2014,
undergoing refurbishment
and upgrades.

COUPP 60 activities

- The experiment was put together and funded 100% by the US collaborators, therefore the COUPP 60 name remains in place.
- The system operates very well, with good optical reconstruction and excellent live time.
- The chamber has a background that is thought to originate from particulate matter containing uranium chain elements. We believe to have found the mechanism of contamination, but need to verify our suspicion by measurements. This background has different acoustic properties from neutron recoil events - we did not find WIMPs.
- A second run is planned when the system is cleaned up.



COUPP 60 activities



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PICO

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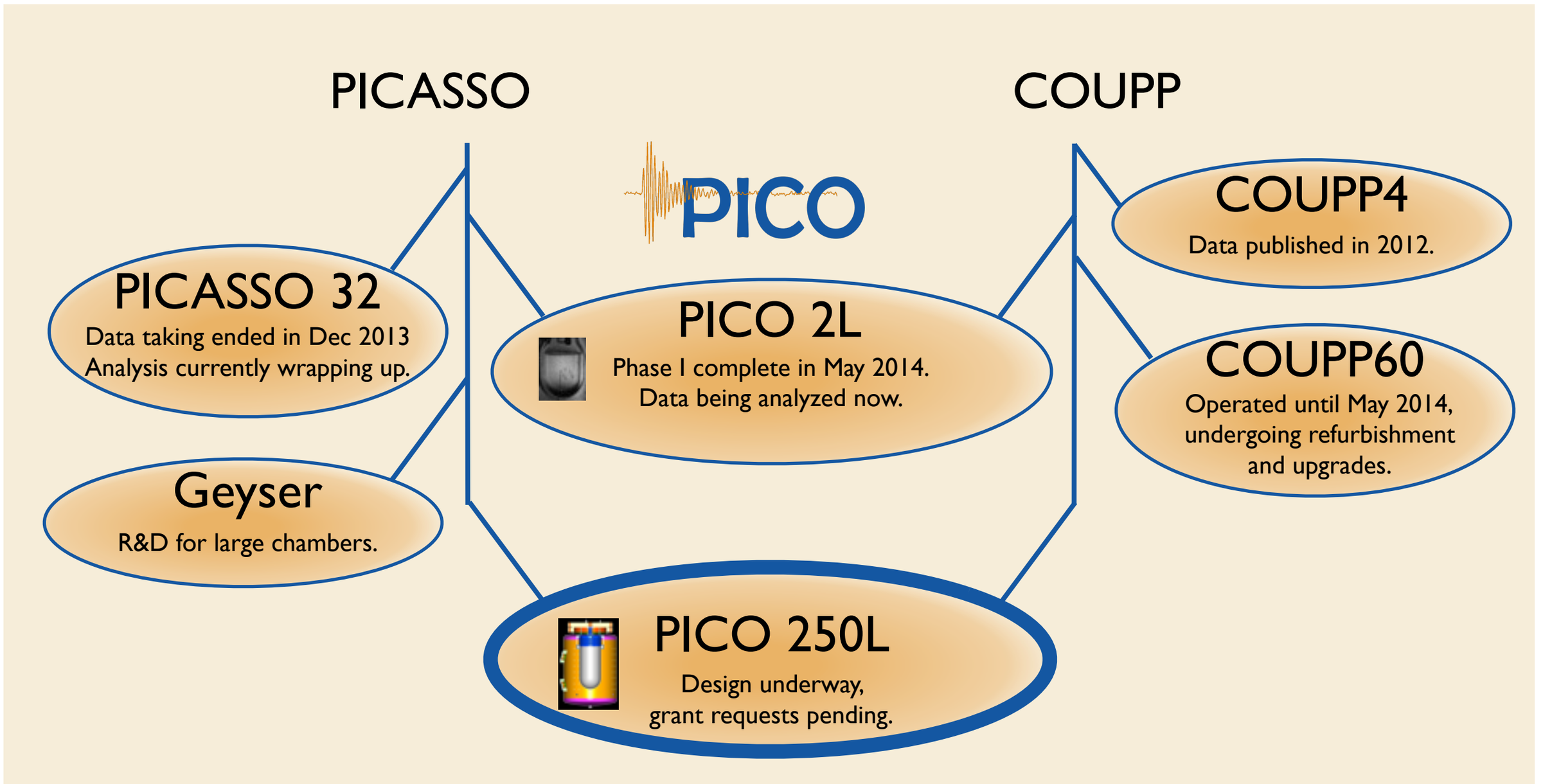
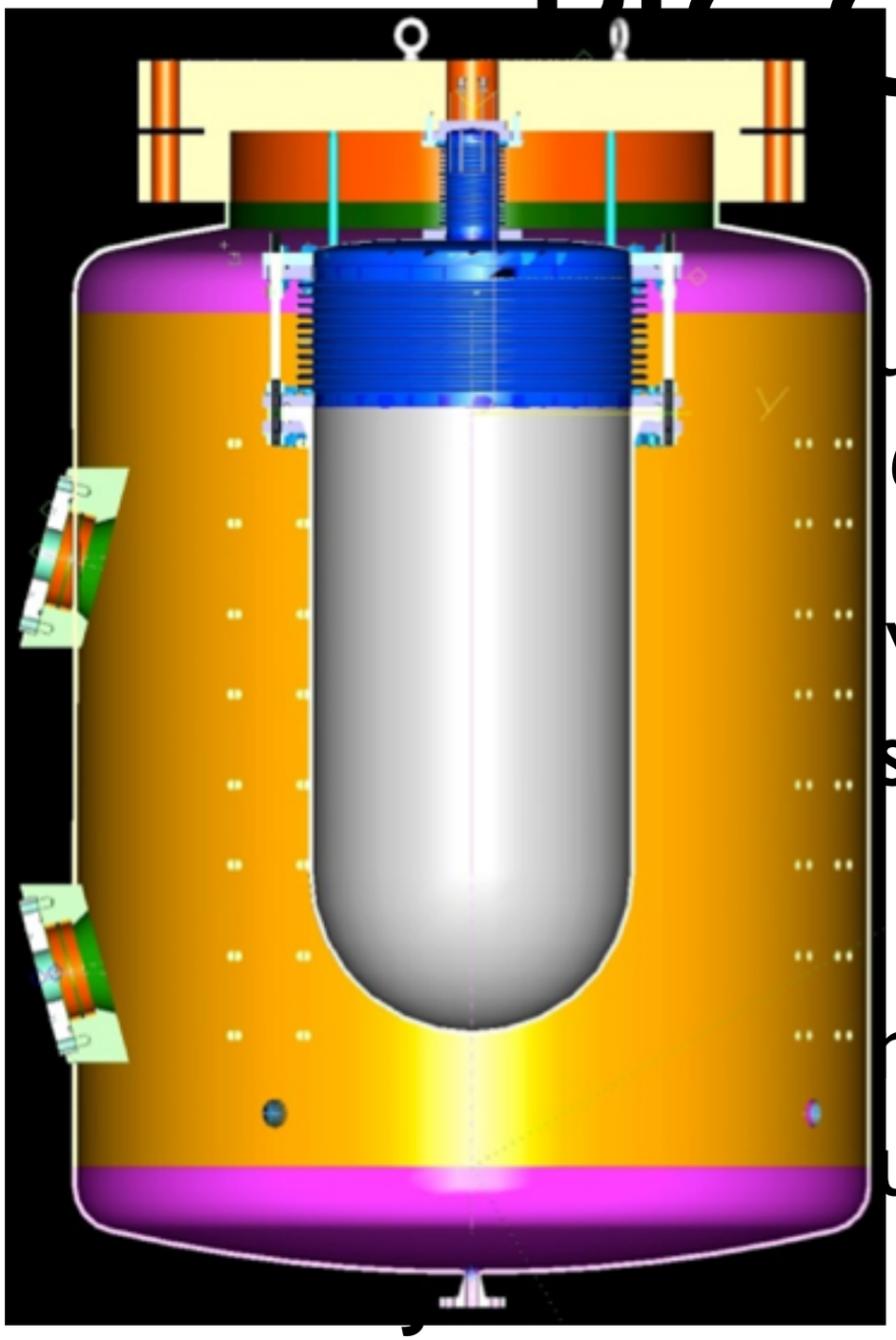
PICO Family Tree



PICO 250

- We plan to construct a 250 litre detector at SNOLAB in 2016/17.
- Design for system with the largest currently possible synthetic quartz vessel is progressing well.
- US funding decision is pending, Canadian funding will be requested in this funding round, June 2014.

PICO 250



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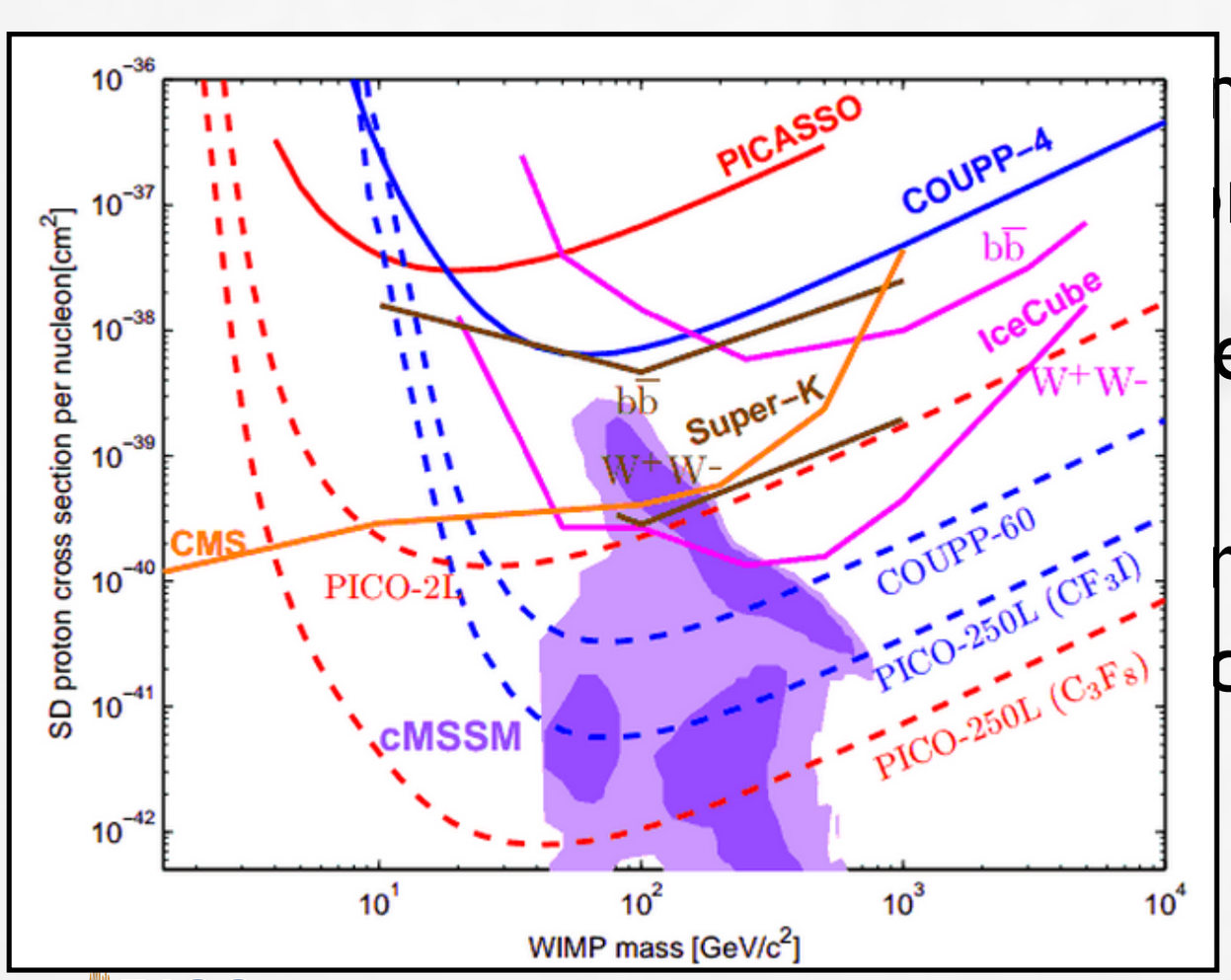
Summary

- PICO is a cutting edge dark matter search experiment with a great track record at SNOLAB.
- We are aiming to "own" the SD dark matter search sector in the foreseeable future.
- Superheated liquids are a very well understood target for dark matter searches. Bubble chambers also provide the opportunity to change liquids and explore details of the dark matter interaction.

Summary

- PICO is a cutting edge dark matter search experiment with a great track record at SNOLAB.



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PICO

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Summary

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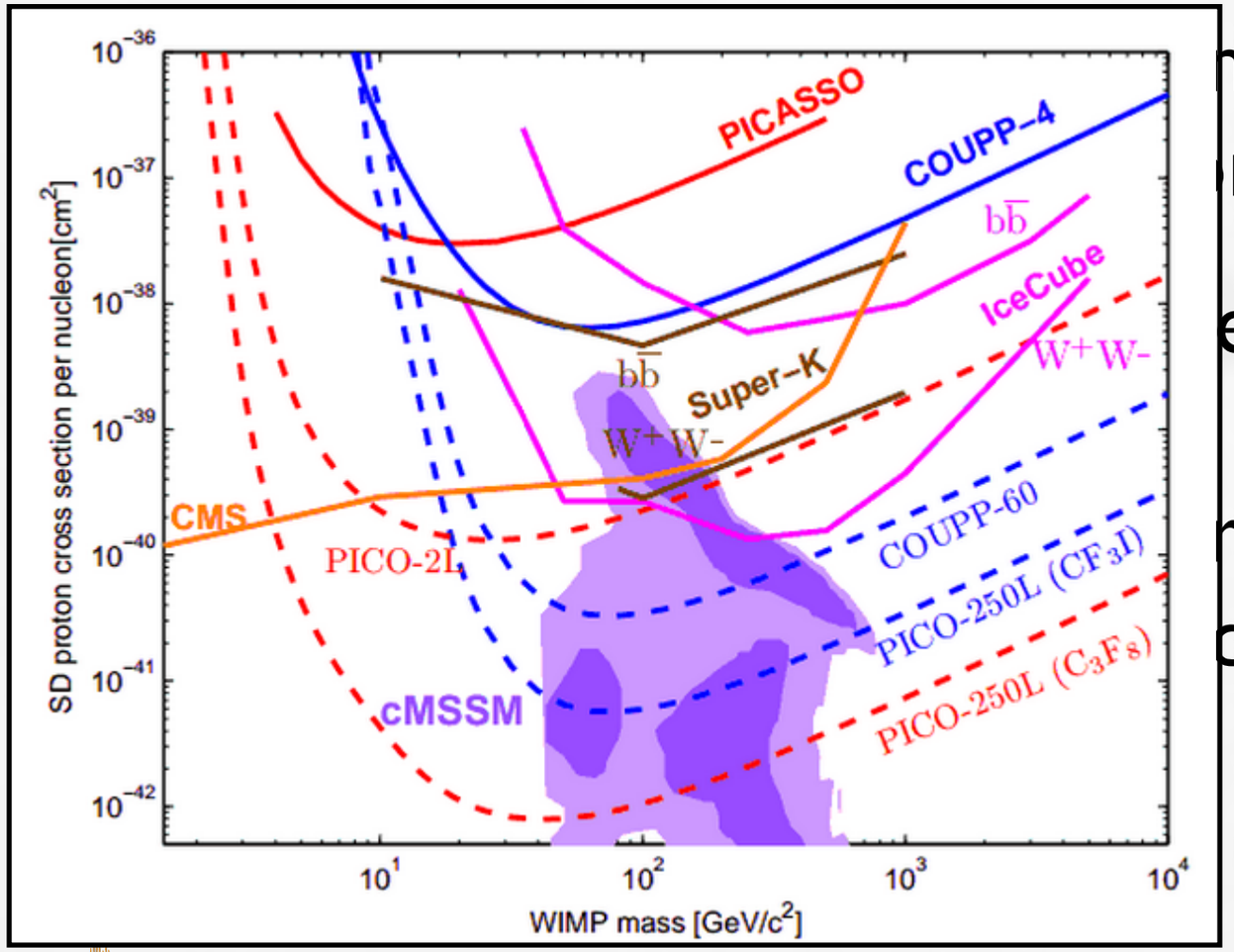

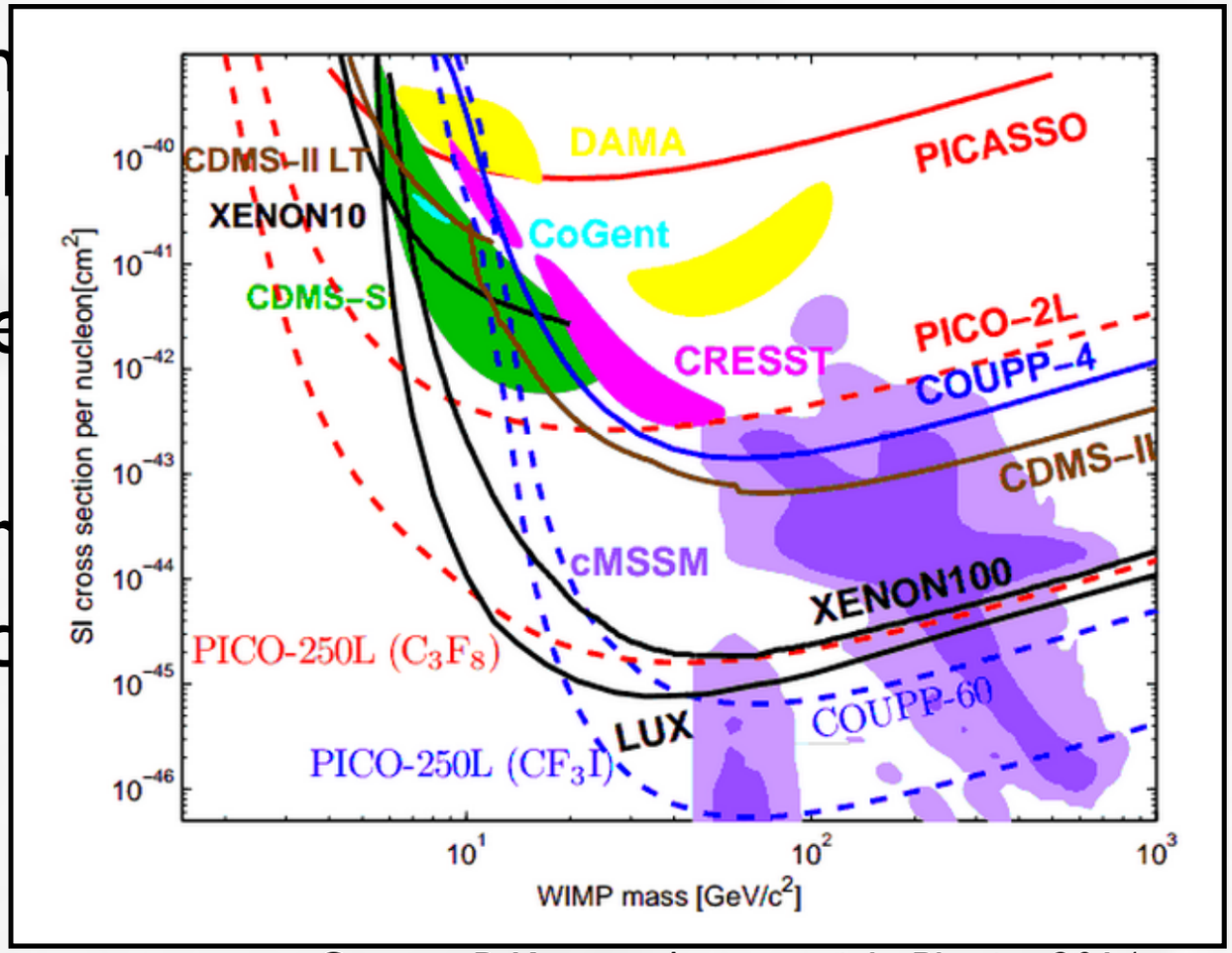

Carsten B Krauss, Astroparticle Physics 2014