PICASSO / COUPP

By Tony Noble

Queen’s University

Motivation

- Supplement the talk by Andrew Sonnenschein highlighting the progress PICASSO has made to date, and how that will strengthen the joint collaboration of PICASSO and COUPP

- Provide feedback to some relevant questions posed by the committee where the PICASSO experience has something to add beyond what will be presented by Andrew on behalf of the joint collaboration.

- Provide an overview of the R&D and engineering design program currently foreseen.

Current Status of PICASSO

Physics Run

- We are currently operational underground at SNOLAB, with 32 “pristine” detectors, optimized electronics and upgraded electronics. Over the past year we have been operational but at the same time we have been tweaking the electronics and DAQ to have optimal particle discrimination (alpha/neutron) and gradually replacing detectors that didn’t have the lowest radioactive backgrounds possible. We have now settled into a long run with this configuration – a total mass of about 2.7 Kg C_4F_{10}.

- Our last analysis produced then world leading results in the spin-dependent sector: 114 Kg days, threshold 1.7 keVnr which lead to limits:

  - $\sigma_p^{SD} < 0.032$ pb @ 20 GeV/c^2

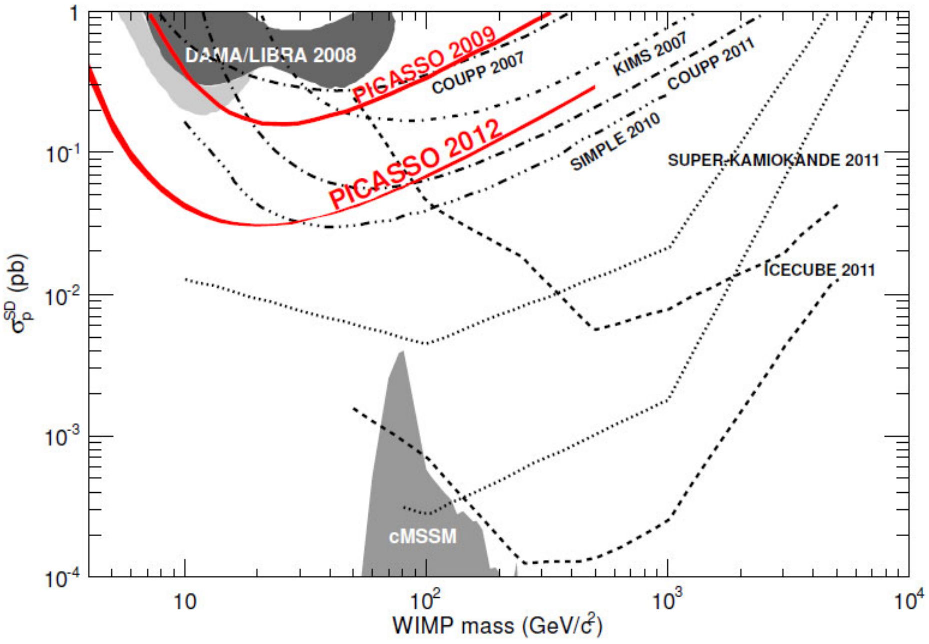
    Including leading sensitivity below 10 GeV/c^2

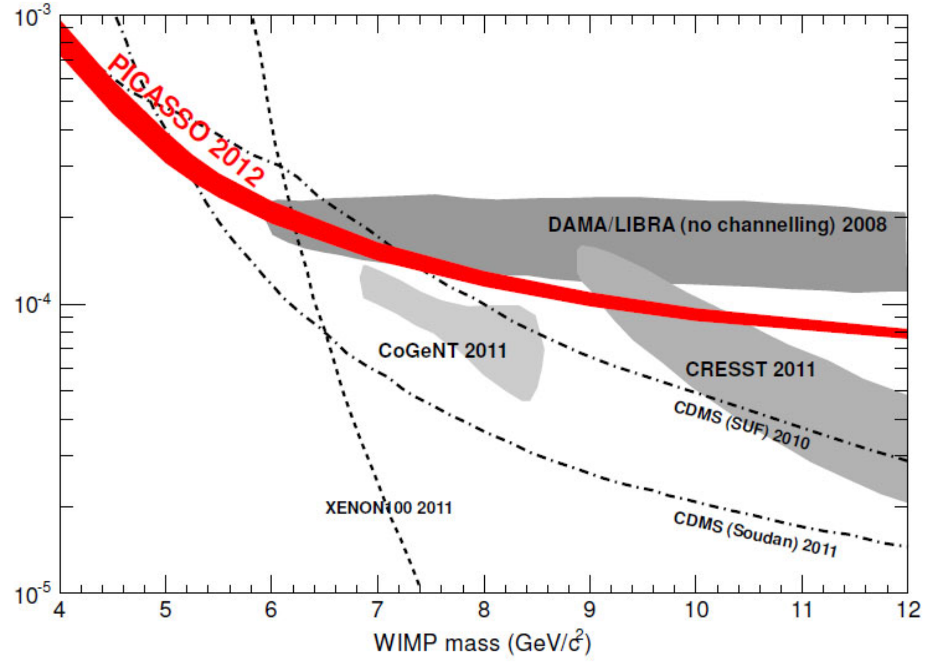
  - $\sigma_p^{SI} < 1.4\times10^{-4}$ pb in region of 7 GeV/c^2

    PICASSO contributes to SI sensitivity below 10 GeV/c^2

Current Status of PICASSO

<u>Most Recent Published Results (2012)</u>





Since eclipsed by COUPP and others….but new data coming!

Future Plans

PICASSO

COUPP

PICASSO/COUPP

Complete PICASSO-32 and publish (Running)

Test COUPP-4Lite with C3F8 or C4F10 (Underway)

Complete COUPP 4 data analysis. Publish. (Data collected)

Develop 100 kg Geyser prototype (underway)

COUPP 60 Kg Detector (Nearly operational)

PICASSO/COUPP **500 Kg** scale Bubble Chamber or Geyser

Condensation Bubble Chamber

Geyser? What's That?

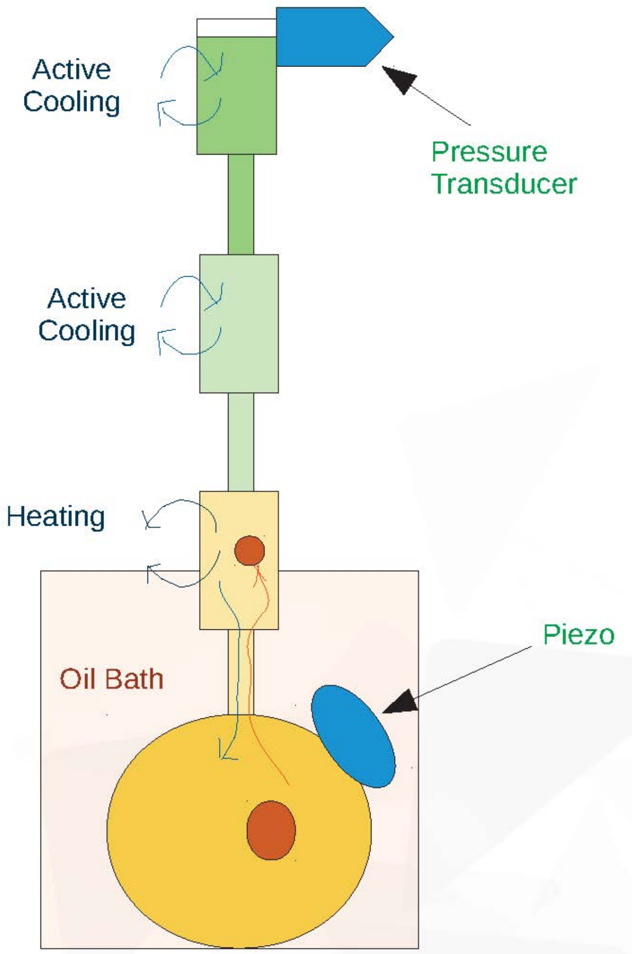
- A variant of the Bubble Chamber that is self regulating and does not require external pressurization.

Possible Pro's:

- Less material required with no hydraulic pressurization system (radiopurity issue)
- Vessel likely comprised of ultra-pure acrylic (with C_4F_{10} or similar)
- Dead time per event appears to be a few seconds before fully reset.
- Good particle ID discrimination

Possible Con's:

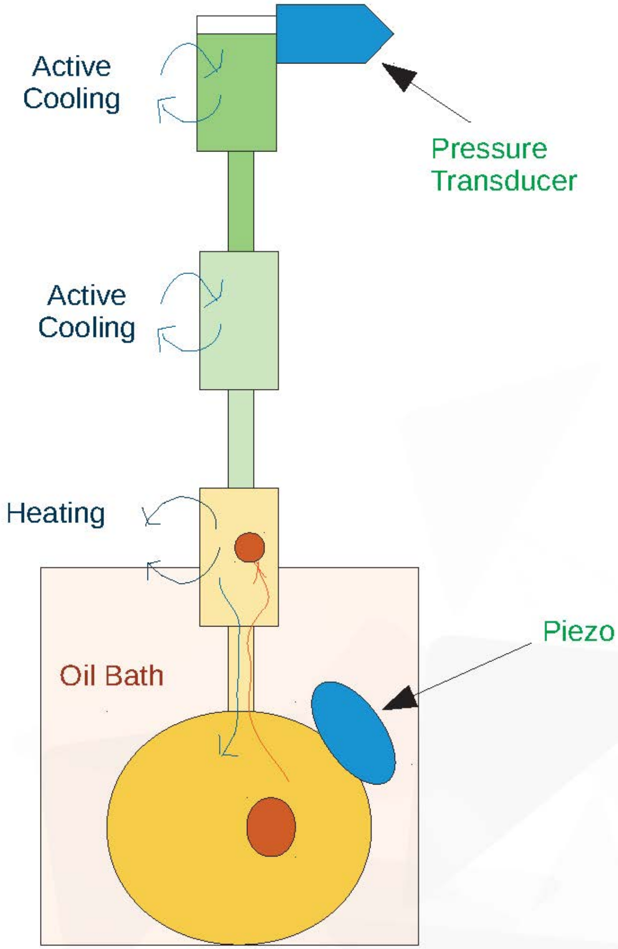
- Need to demonstrate stable operation at high superheat (to reach low thresholds) with no wall boiling. Understand convection

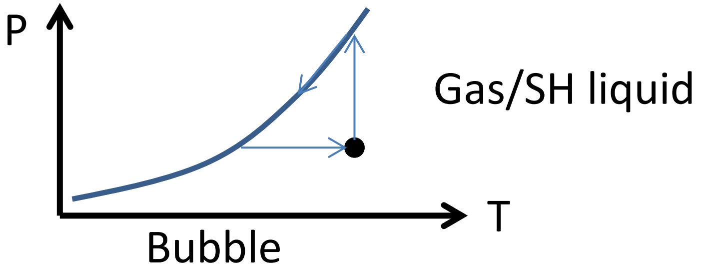


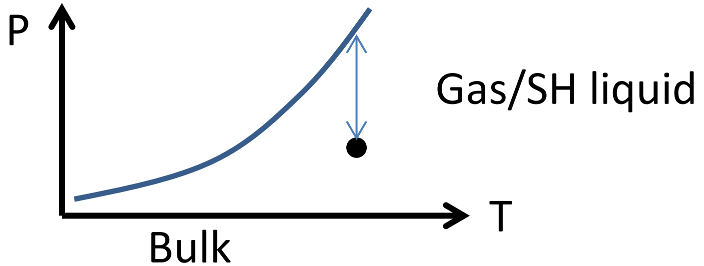
Crude schematic of Alberta Geyser

Principle of Operation

- When a massively ionizing particle interacts in the bulk superheated liquid, the energy deposition creates a localized bubble from evaporation.
- The system is sealed, so as the gas bubble rises, the pressure increases.
- Pressure increase stops evaporation, and bulk is no longer in superheated state. (On saturation curve)
- Cooling in the neck condenses gas bubble.
- The small condensed bubble quickly attains temperature of bulk fluid and pressure in neck drops, re-establishing the superheated state.





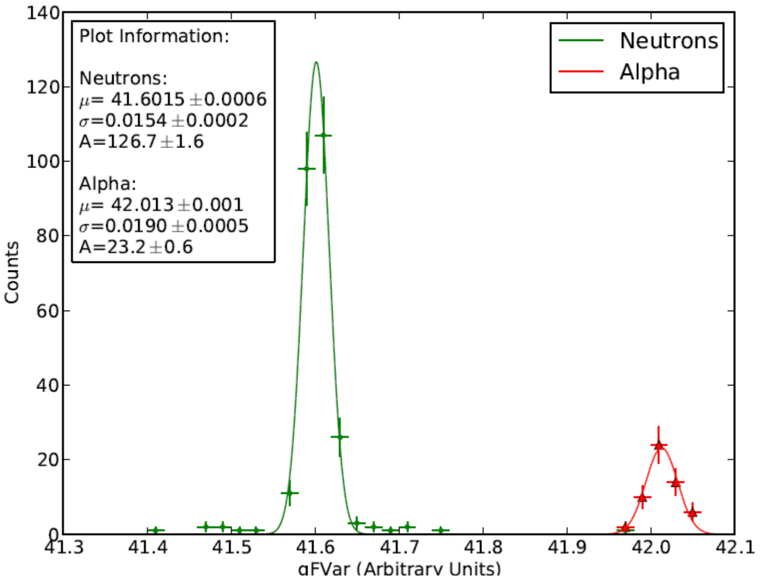


4. Detector Discrimination

Discrimination:

- PICASSO first discovered ability to discriminate between alpha and recoil nucleus by measuring acoustic power. This is now used in COUPP and SIMPLE as well.

- Very preliminary results with one of our Geysers demonstrates that a high superheat and good particle ID discrimination can be achieved



- Discrimination in droplet detectors works best when contamination is inside active material rather than the gel. PICASSO is becoming limited by this

Outliers

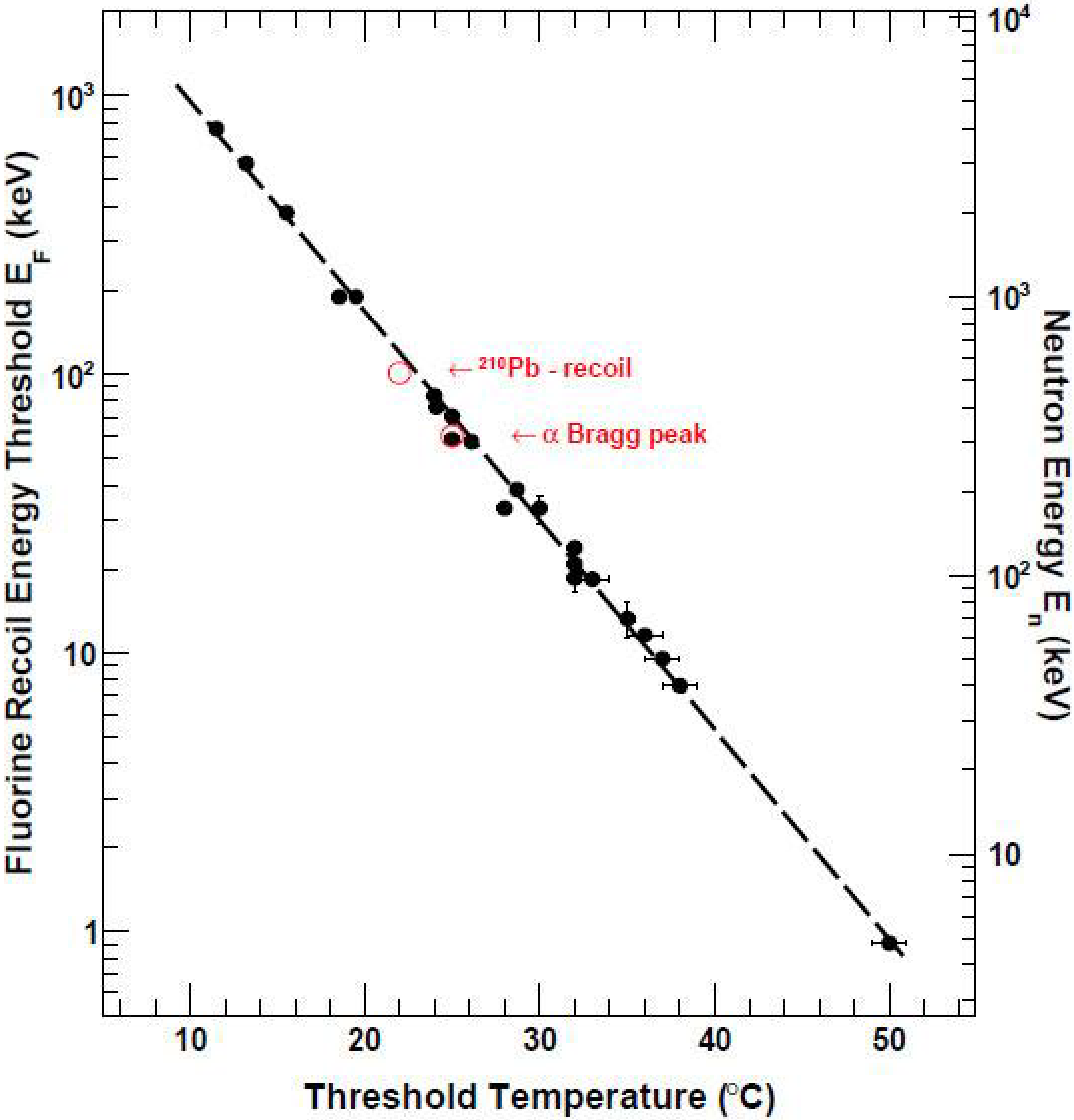
- Class of events with odd timing structure. Appear at high temperature. Thought to be secondary vaporizations in vicinity of progenitor bubble. Discrimination works well at this scale. Likely related to gel so not a concern for bubble chambers.

5. Energy Thresholds

- PICASSO uses mono-energetic neutrons produced with the Montreal Van de Graff to calibrate detectors, in particular to measure the threshold behaviour. A consequence of these studies is that we confidence in our threshold determination.

- Droplet detectors are ideal for these measurements as they can record thousands of events before having to recompress.

- This technology can be used for suite of gasses proposed for PICASSO/COUPP.



7. Experimental Challenges

As successful as the droplet detectors have been, a 500 kg detector requires a bubble chamber or Geyser technology, building on the understanding of the fluid dynamics, discrimination, acoustic readout, of the droplet detector era.

Geyser Challenges

- To reach a very low threshold, the detectors need to be operated as close to their critical point as possible, without wall boiling or the generation of spontaneous nucleations. This requires highly smooth surfaces and careful attention to wetting techniques.

- We are exploring acrylic as the vessel, as we believe it could be made cleaner, but the robustness under operating conditions (pressure/temperature) needs to be proven.

9. Unique Capabilities

PICASSO will add about 30 collaboration members, plus students to the combined PICASSO/COUPP Initiative. The combined collaboration is very strong scientifically, is funded, and has good engineering and technical support. SNOLAB is very supportive of this initiative. These all help create the conditions for success. In addition, there are some unique capabilities of both the detector and the resources…

- Superheated Detectors blind to many “conventional” backgrounds…e.g. gammas and mips.
- Low WIMP-mass sensitivity in both Spin-Dependent and Spin-Independent searches. Thresholds as low as 1.5 keVnr have been achieved with PICASSO
- Can exchange fluid rather easily to help confirm a signal when it is observed.
- Liquids can be loaded as droplet detectors for calibration with beams of mono-energetic neutrons. Threshold behavior well understood. No issues with quenching at low energies…
- Good access to SNOLAB resources including research scientists, engineering and technical personnel.