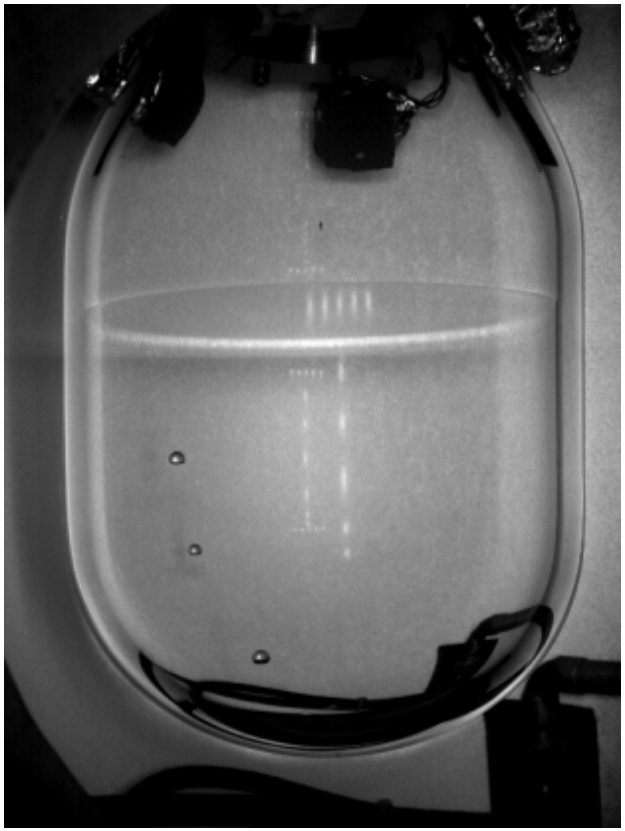
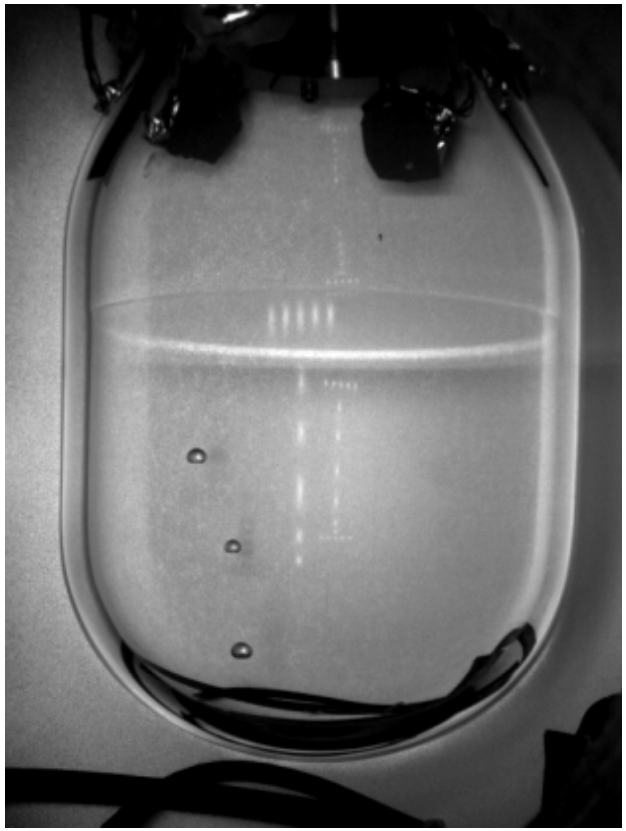
COUPP Bubble Chamber Dark Matter Search





COUPP Collaboration

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Kavli Institute
for Cosmological Physics
AT THE UNIVERSITY OF CHICAGO

COUPP 4kg

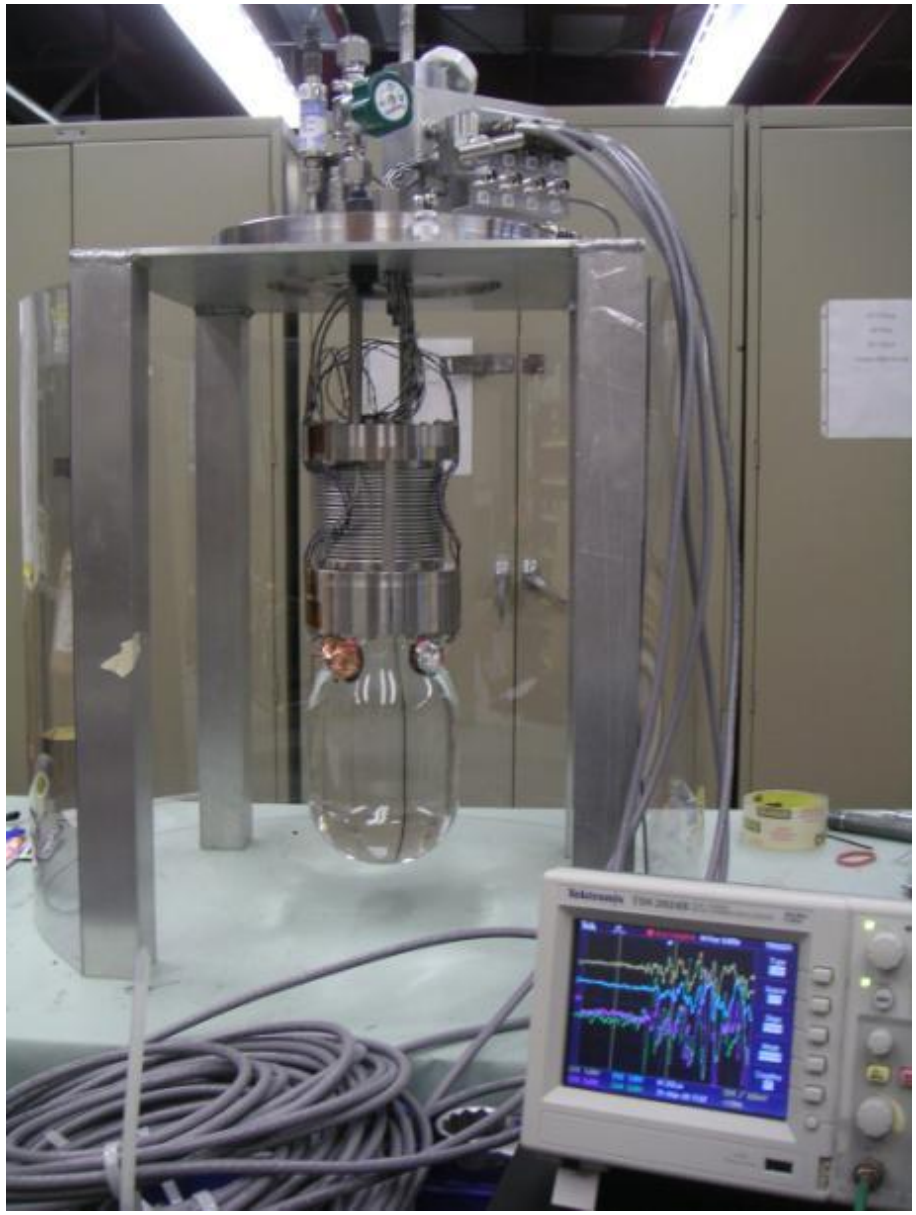
- T945-A2

- Ran Aug 19 – Dec 18 2009 in MINOS Near Detector Hall
  - 300 mwe underground
  - Over 300 kg-days unattended operation at 20 keV threshold

COUPP 4kg

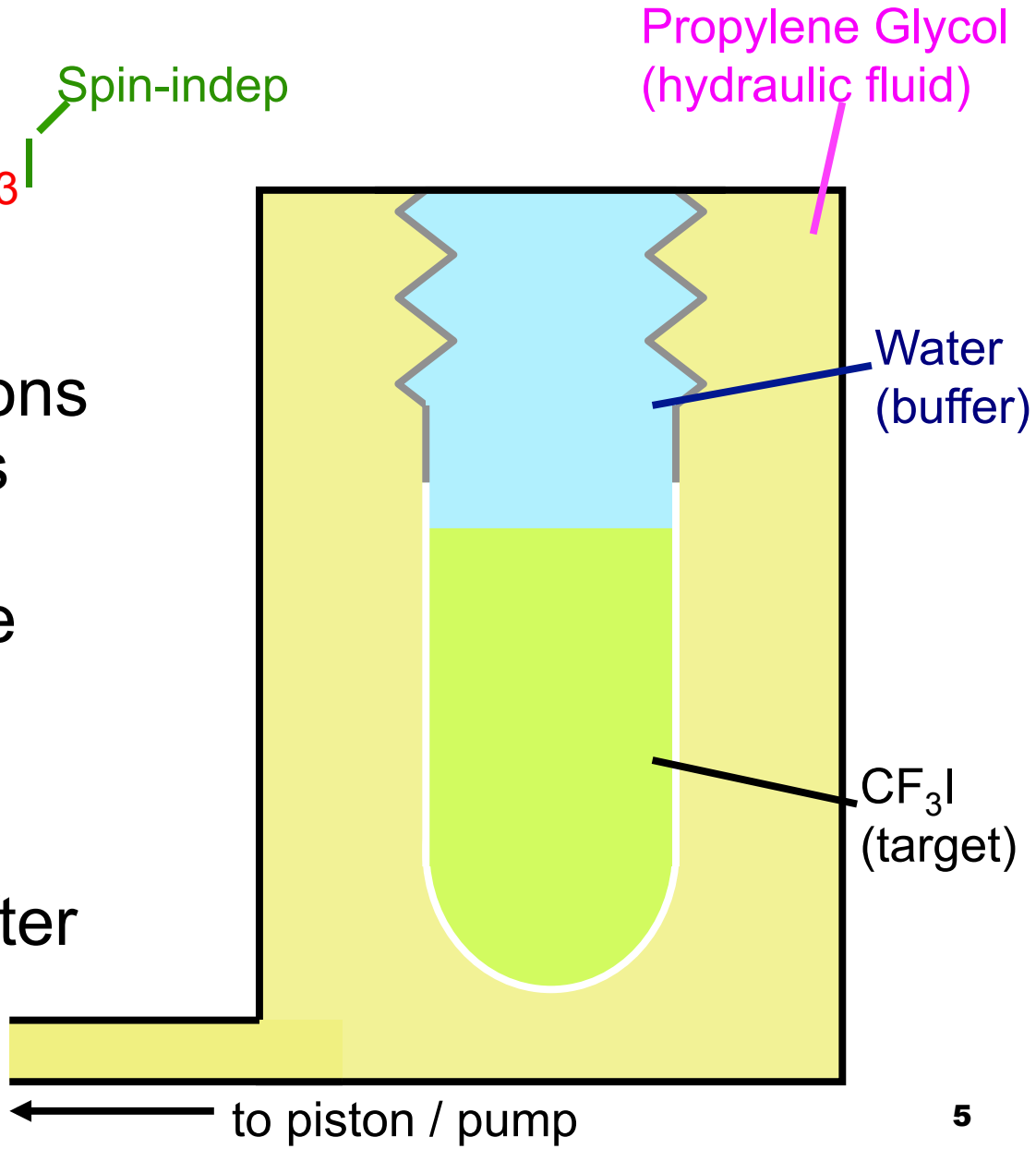
- T945-A2 goals:
  - Test Synthetic Quartz
    - Eliminate wall events
  - Improved Fluid Handling
    - Reduce bulk alpha rate
- New veto/shielding design
- Improved DAQ/Controls
- Added goal:
  - Look for acoustic alpha discrimination reported by PICASSO*

**PICASSO (Aubin et al., arXiv:0807.1536)*



Review

- Superheated CF_3I target (Spin-indep, Spin-dep)
- Particle interactions nucleate bubbles
- Cameras capture bubbles
- Chamber recompresses after each event



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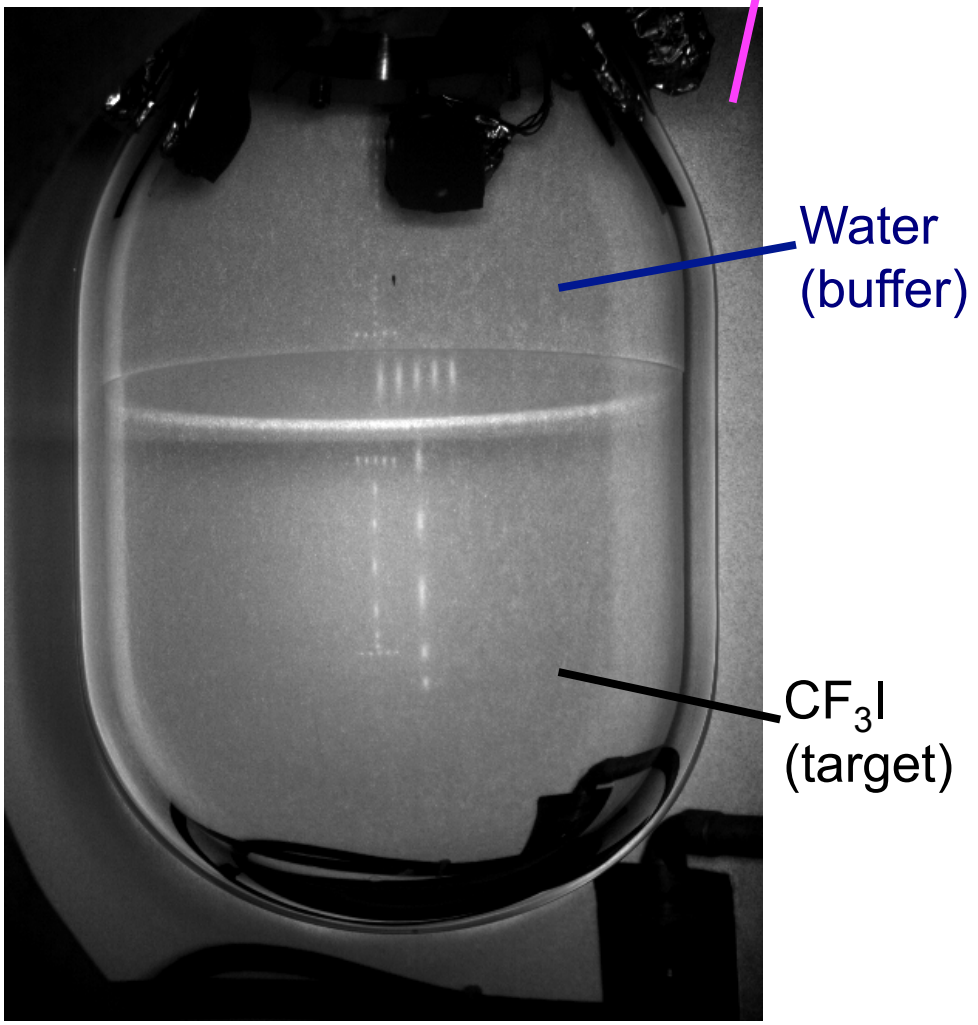

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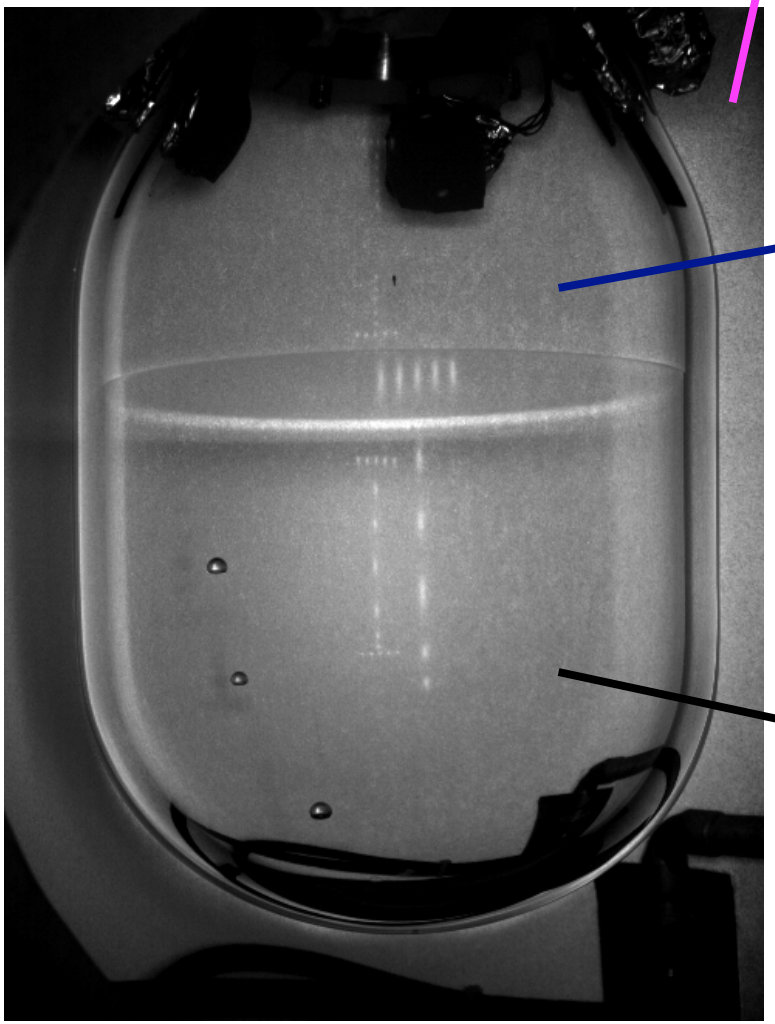
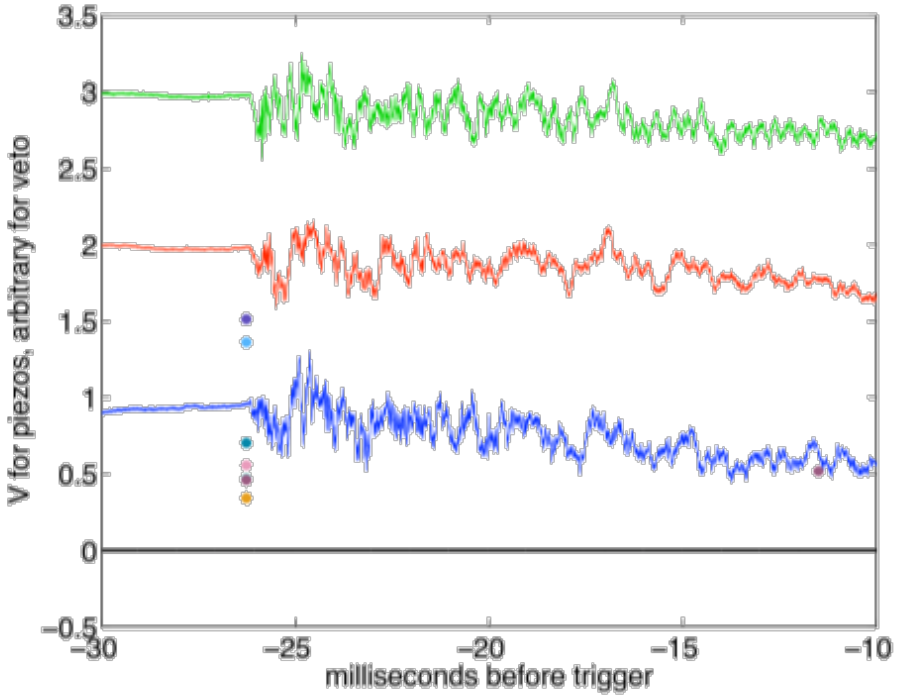
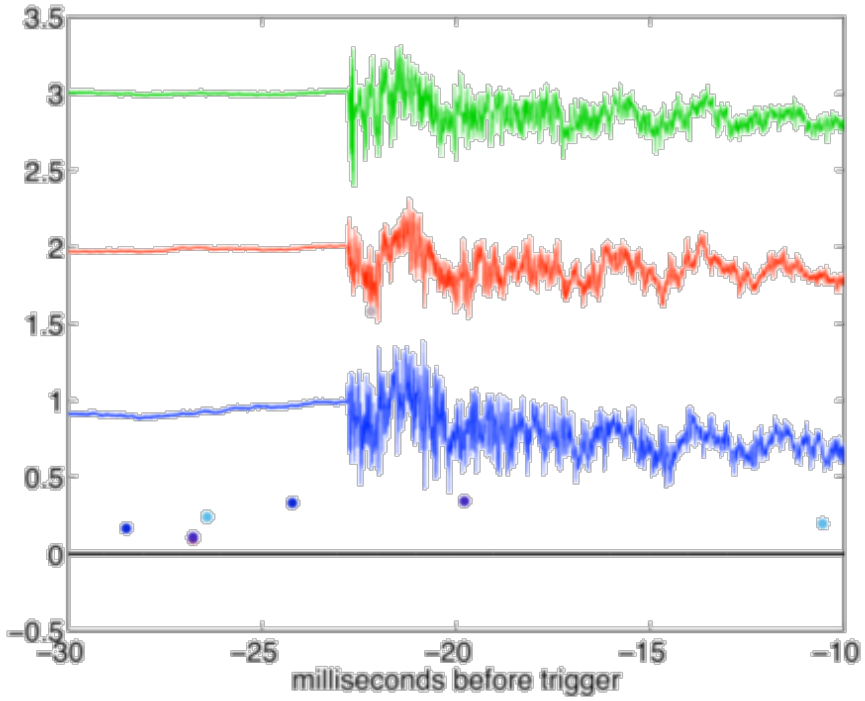


Acoustic Signatures

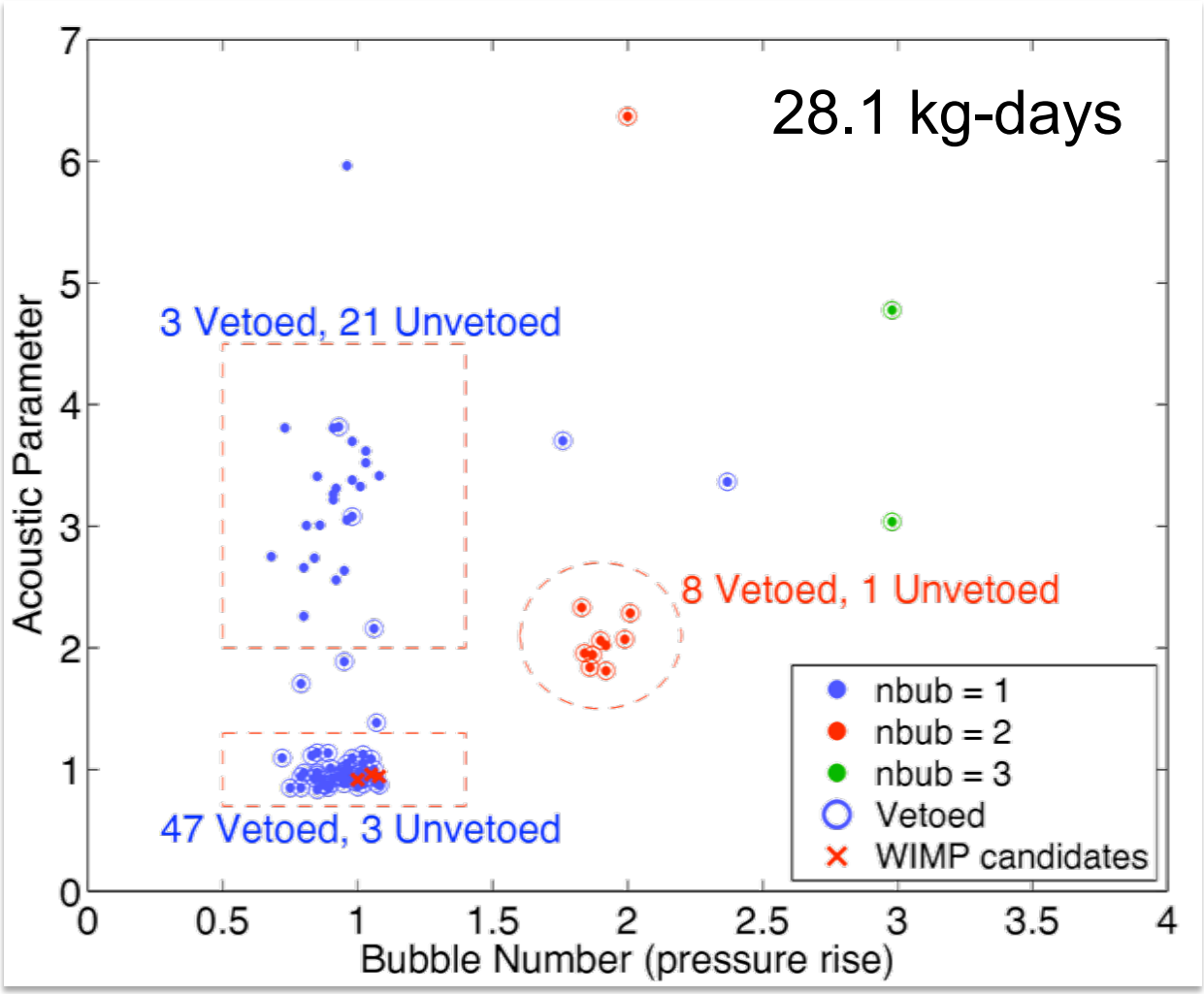
"Neutron" (Neutron source on…)



"Alpha" (Neutron source off…)

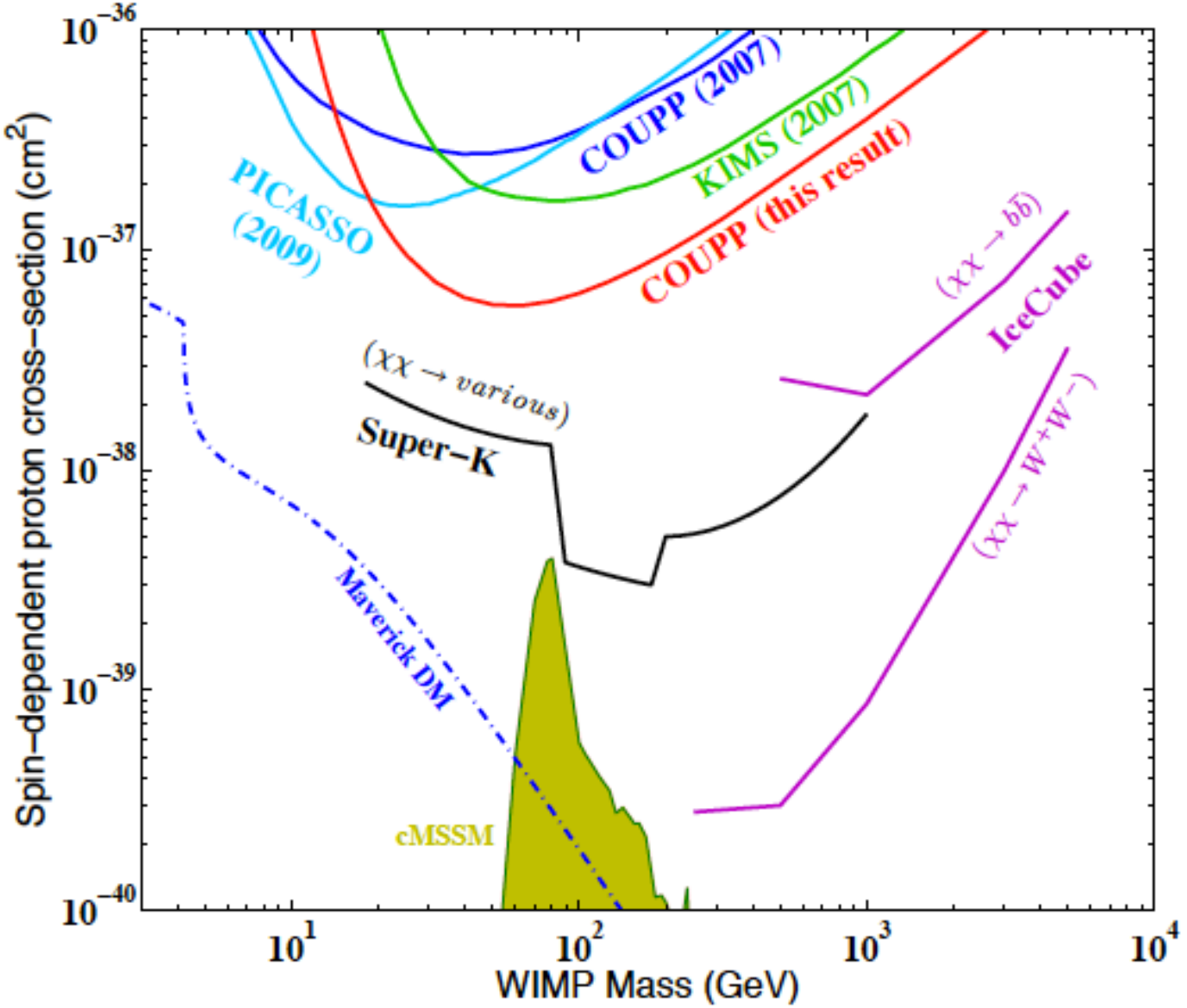


Candidate Events



- Taking the 3 unvetoed events as alphas
- Alpha rejection >80% at 90% confidence level
- Consistent with >99% alpha rejection

Improved Limits on Spin-Dependent WIMP-Proton Interactions from a Two Liter CF_3I Bubble Chamber http://arxiv.org/abs/1008.3518v1, accepted for PRL

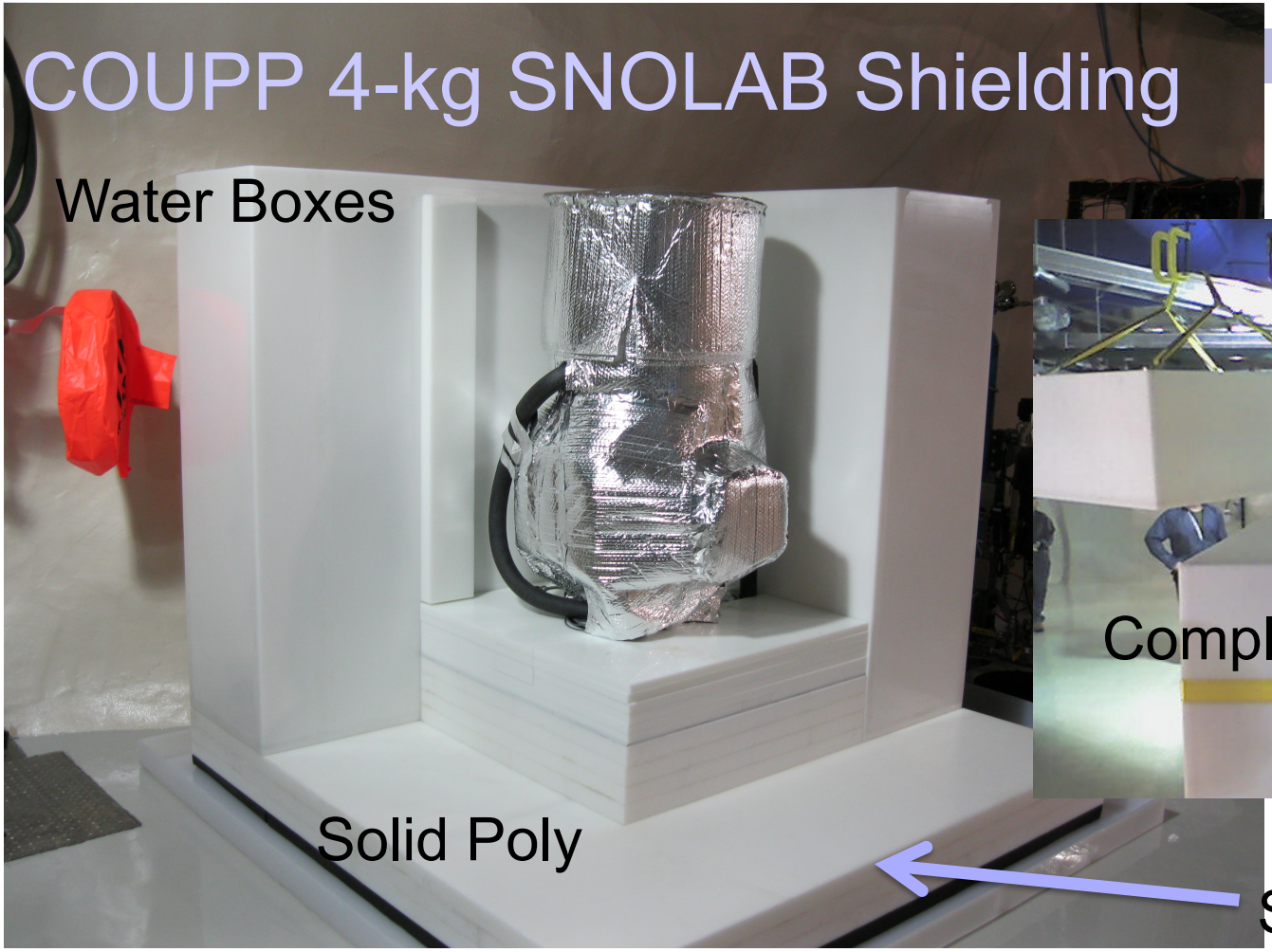


This result limited by residual cosmic background in NUMI

The COUPP 4-kg experiment has been reassembled in the new Ladder Lab area at SNOLAB (6800')

4-kg Inner Vessel awaiting installation at SNOLAB

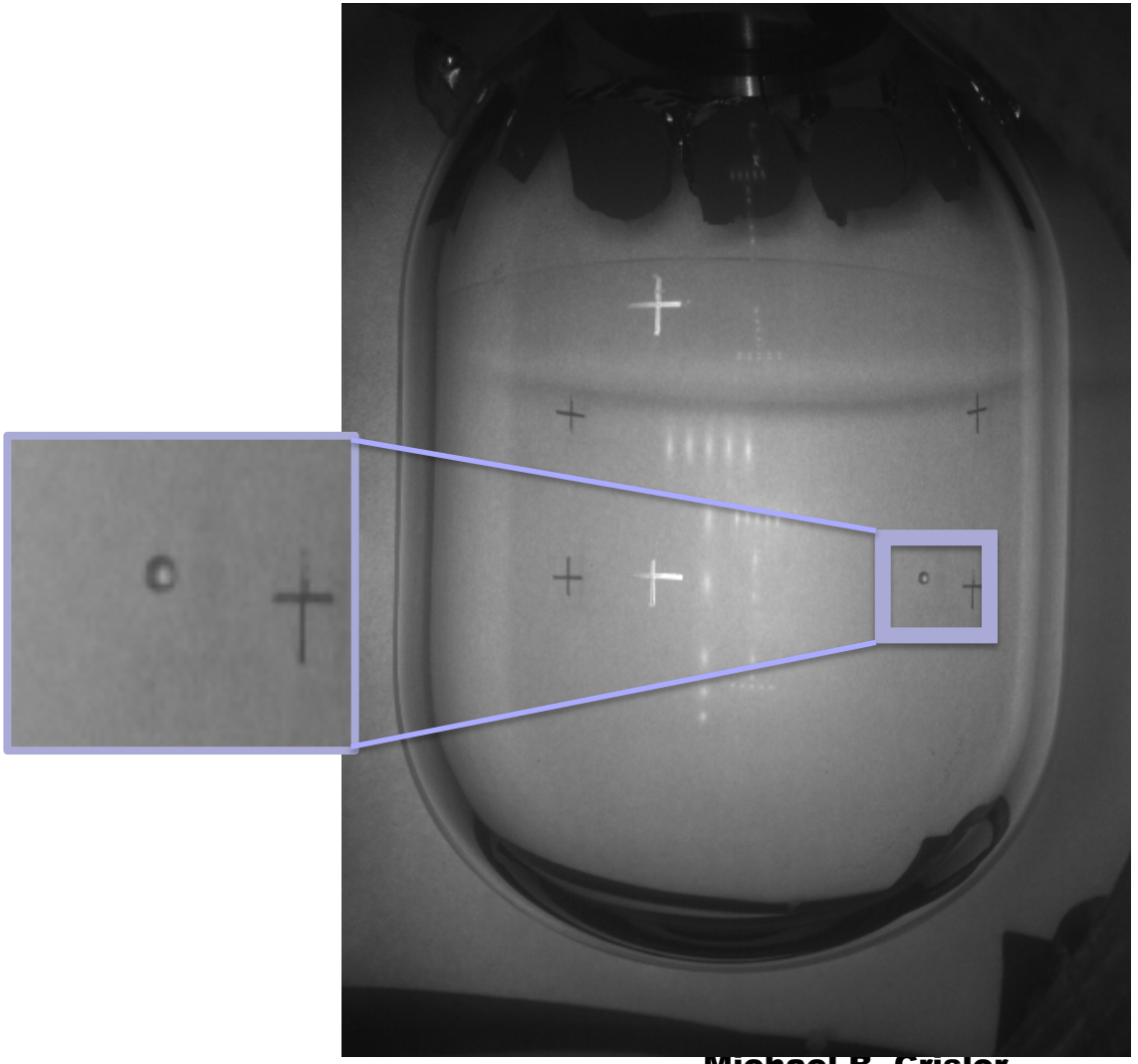
COUPP 4-kg SNOLAB Shielding



- 20 inch thick boxes made with 1” thick HDPE
- Filled with SNOLAB high purity water

4-kg Physics Run at SNOLAB

- 4.048 kg CF3I distilled on September 2nd
- First bubble on the next day
- >75 kg-days accumulated to date



COUPP-60 Commissioning

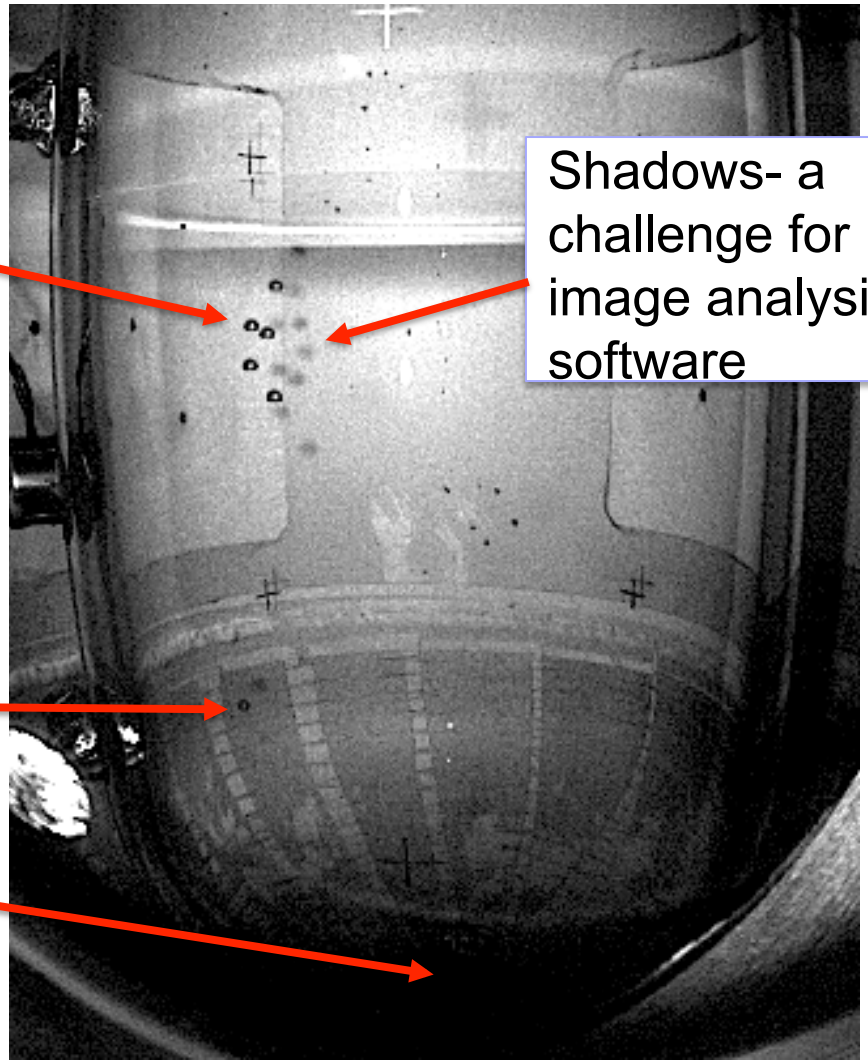
- Ran from July 28 to August 30 in MINOS Near Detector Hall
- Goal: Test fully operating detector before moving to Snolab
  - Stability of mechanical systems, DAQ, photography
  - Backgrounds due to internal radioactivity
    - Analysis in progress, rates appear to be low.
  - Acoustic alpha/ nuclear recoil discrimination
- Run ended Aug. 30, 2010 due to a combination of problems that will be discussed in following slides.
- Bottom line: some of the problems are quite serious– significant work needed before move to SNOLAB.

Uneven lighting, hard shadows

5 bubbles (neutron multiple scatter)

6th bubble- harder to see due to uneven lighting

Dark region at bottom, poor photography, poor triggering

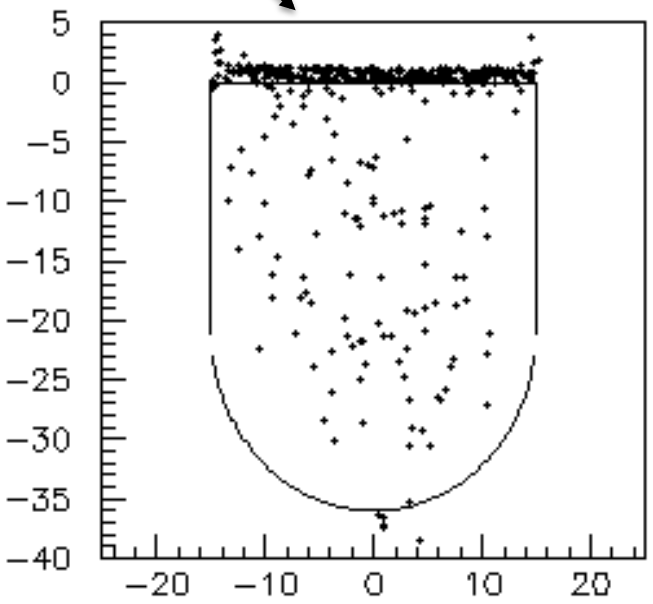


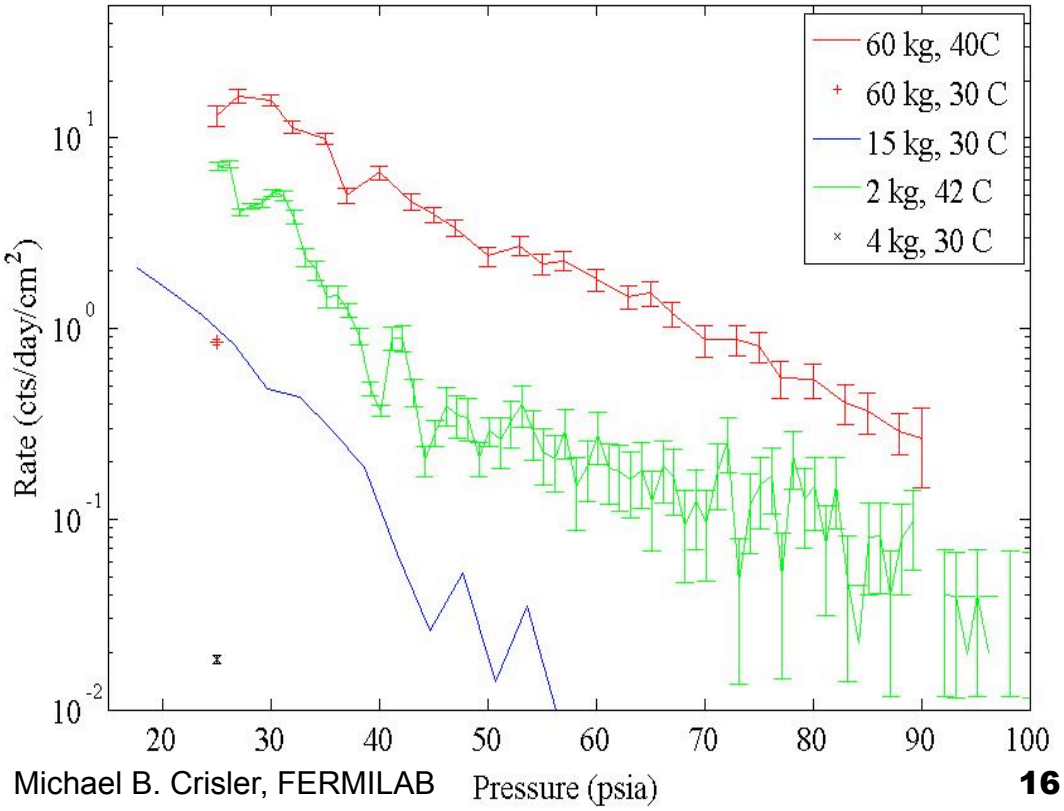
Shadows- a challenge for image analysis software

Excess Bubbling at Water/ CF_3I Interface

- Problem has existed at some level in all COUPP chambers, but COUPP-60 is the worst.
- Cause is unknown.
- Ideas: Dissolved gas in water or particulate floating on interface.
- Consequence is reduction in live time fraction due to 30-60 second compression cycle after each detected bubble. Live fraction reduced to 25% at 40 degrees C.

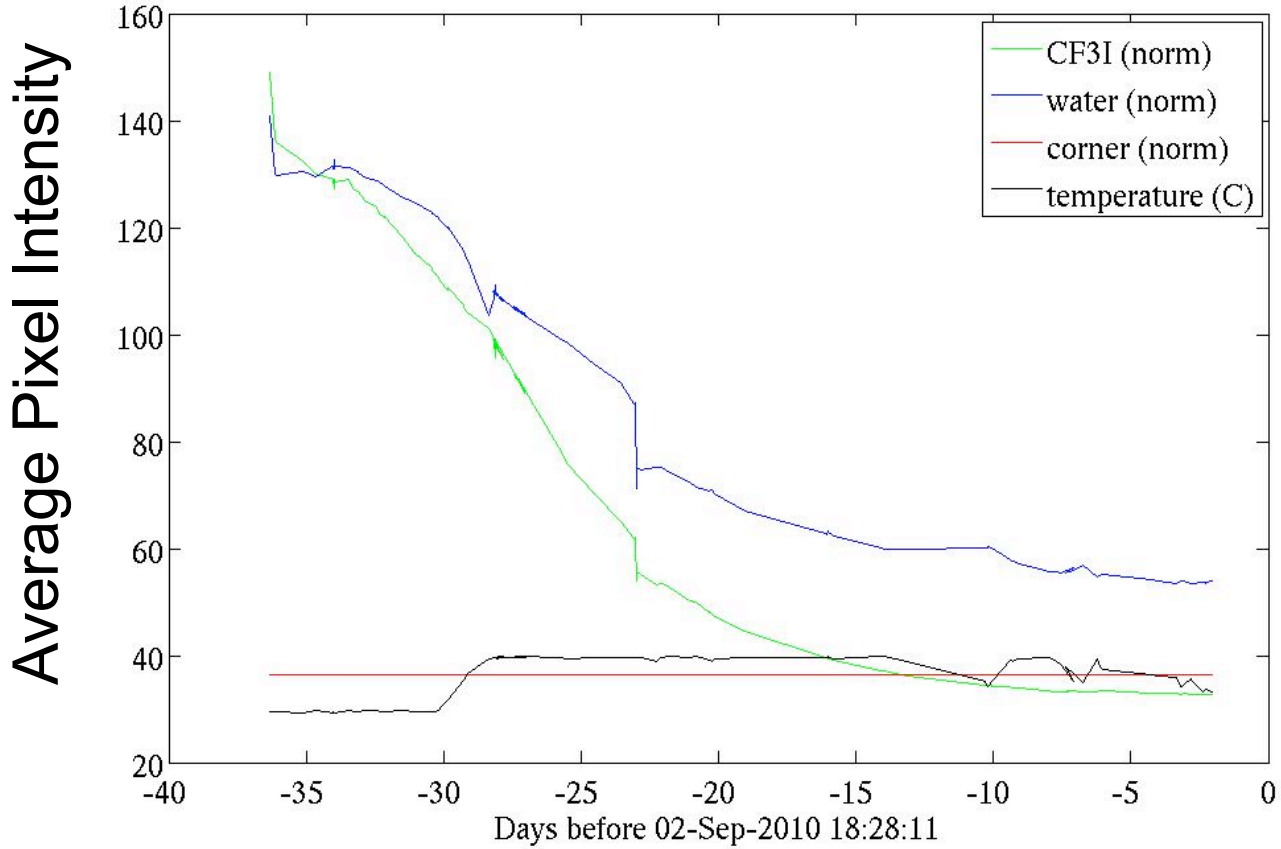
CF3I/ water interface





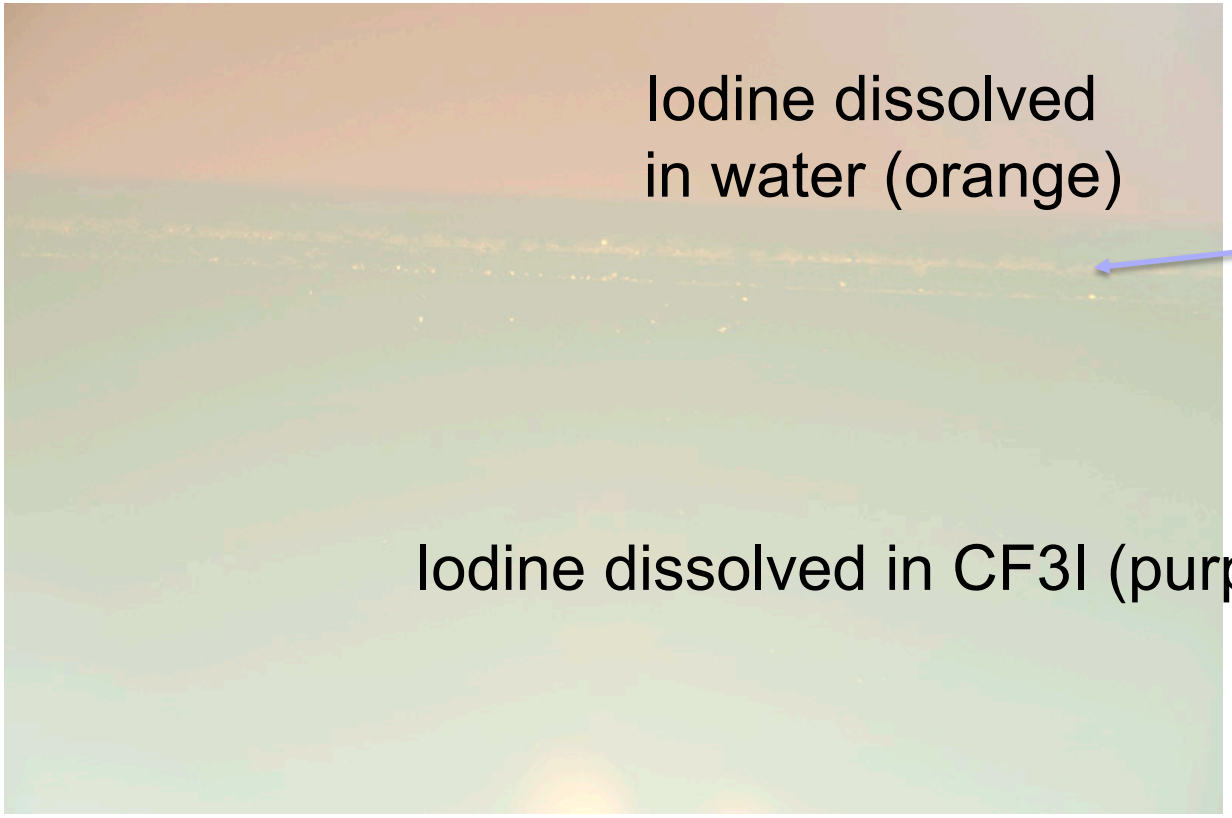
Darkening of Video Images

- Progressive from beginning of run.
- Eventually made data taking impossible
- Cause was a mystery until we viewed the chamber with white light…



CF_3I Is Decomposing and Changing Color

Color change indicates the presence of free iodine (I_2) dissolved in chamber liquids.



"ring around the collar" near water/ CF3I interface. Solid material? Bubbles?

Could be cause of surface boiling?

Photo by Raidar Hahn

Next Steps for COUPP-60

- PPD has formed a COUPP-60 Task Force to help us call on appropriate resources.
  - Working groups: Optics/Illumination, Chemistry, Mechanical/Operations. Core group from collaboration will be supplemented as necessary by outside experts.
- Key issue is access to chemistry expertise, which is in short supply at Fermilab. Collaborators at Indiana University are analyzing samples by GC/MS. Argonne has expertise in Chemical Sciences and Engineering Division which we have started to tap.
- We are recovering samples of gases and fluids from bubble chamber. Analysis of decomposition products may suggest mechanism.
- Will attempt to reproduce the problem in a test tube.
  If this is a light exposure problem, we should know soon.
- In parallel, we can make progress on better understood optics and mechanical issues.