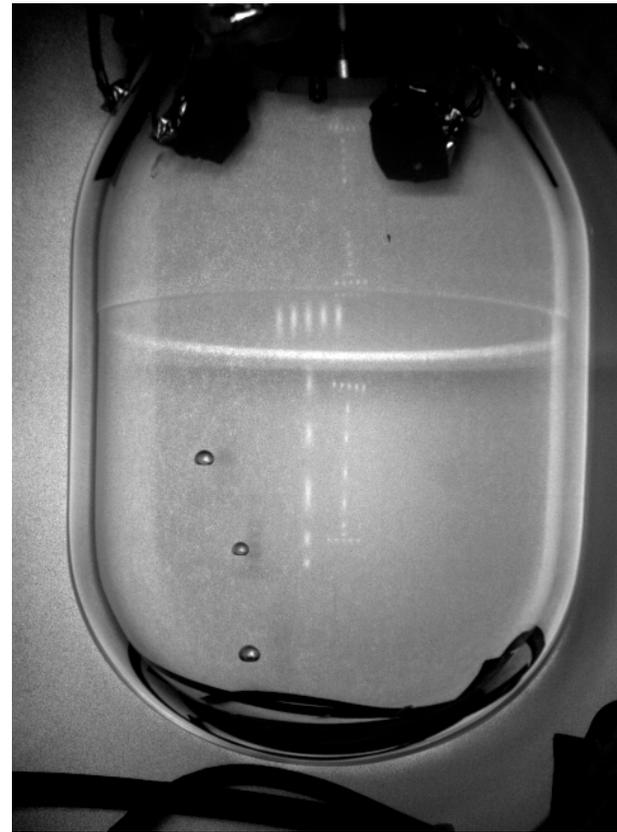
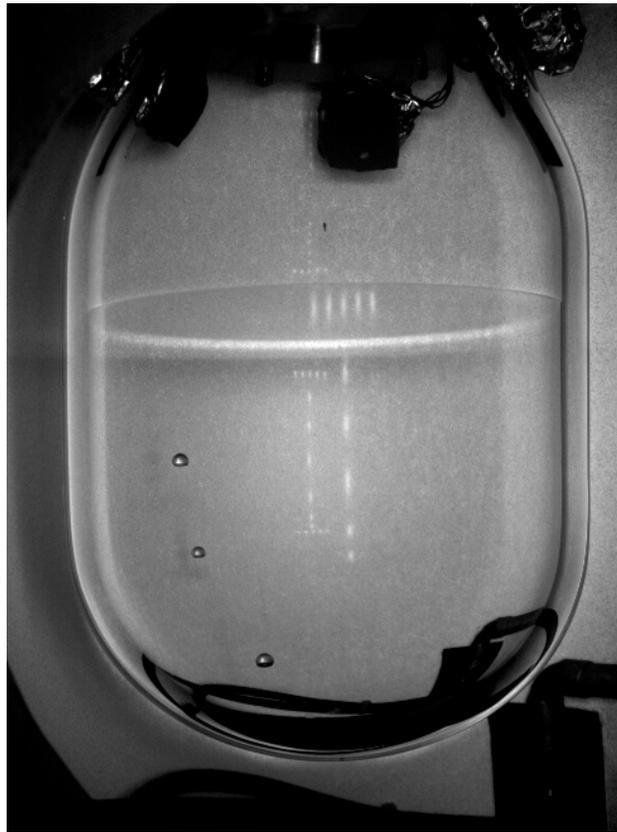


# COUPP Progress Report

## Results from the 4kg Test Chamber



# The COUPP Collaboration

## University of Chicago

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## Fermilab

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Jeter Hall, Martin Hu, Erik Ramberg, Andrew Sonnenschein,  
Fermilab Engineers and Technicians

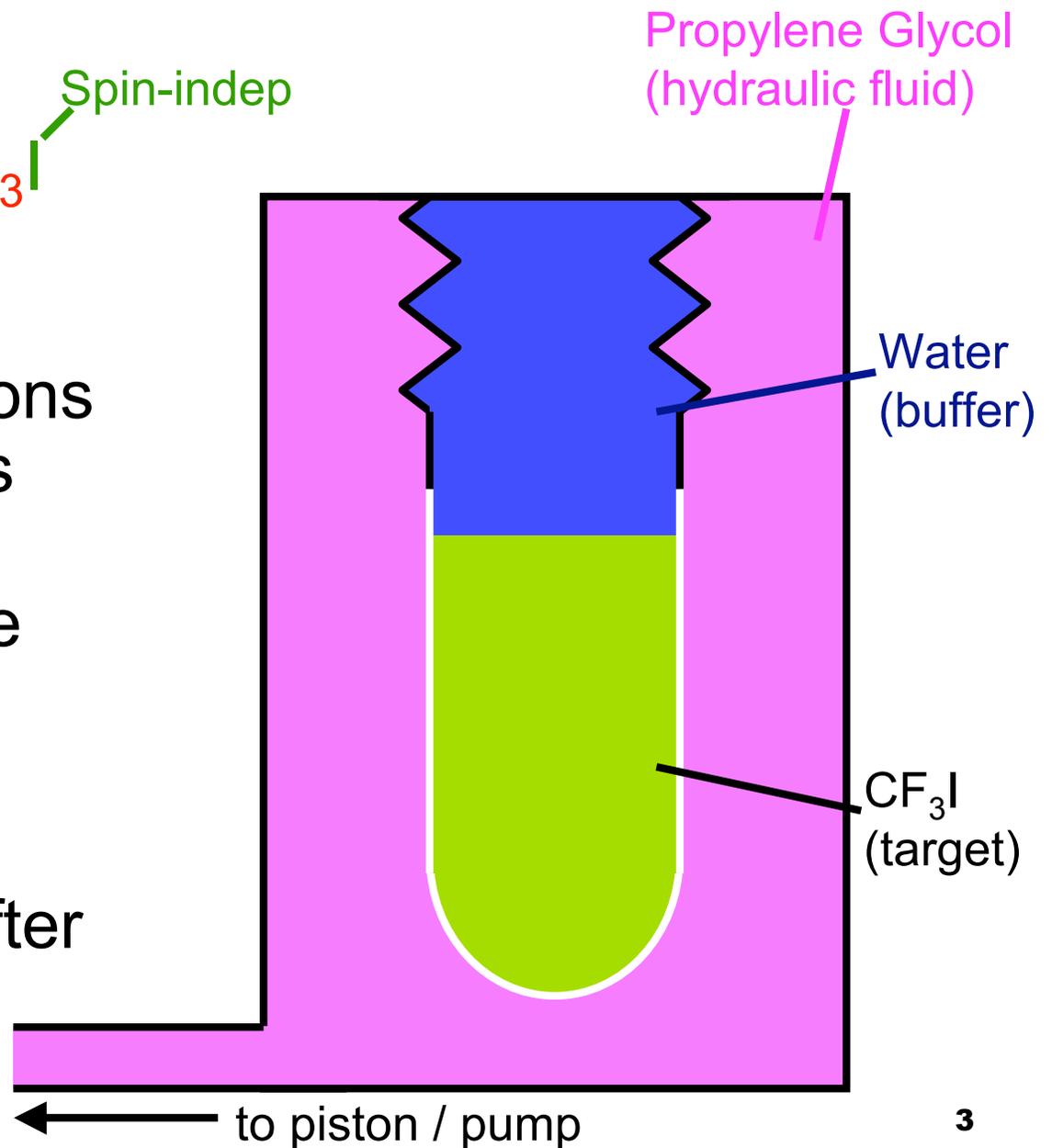


**Kavli Institute**  
for Cosmological Physics  
AT THE UNIVERSITY OF CHICAGO



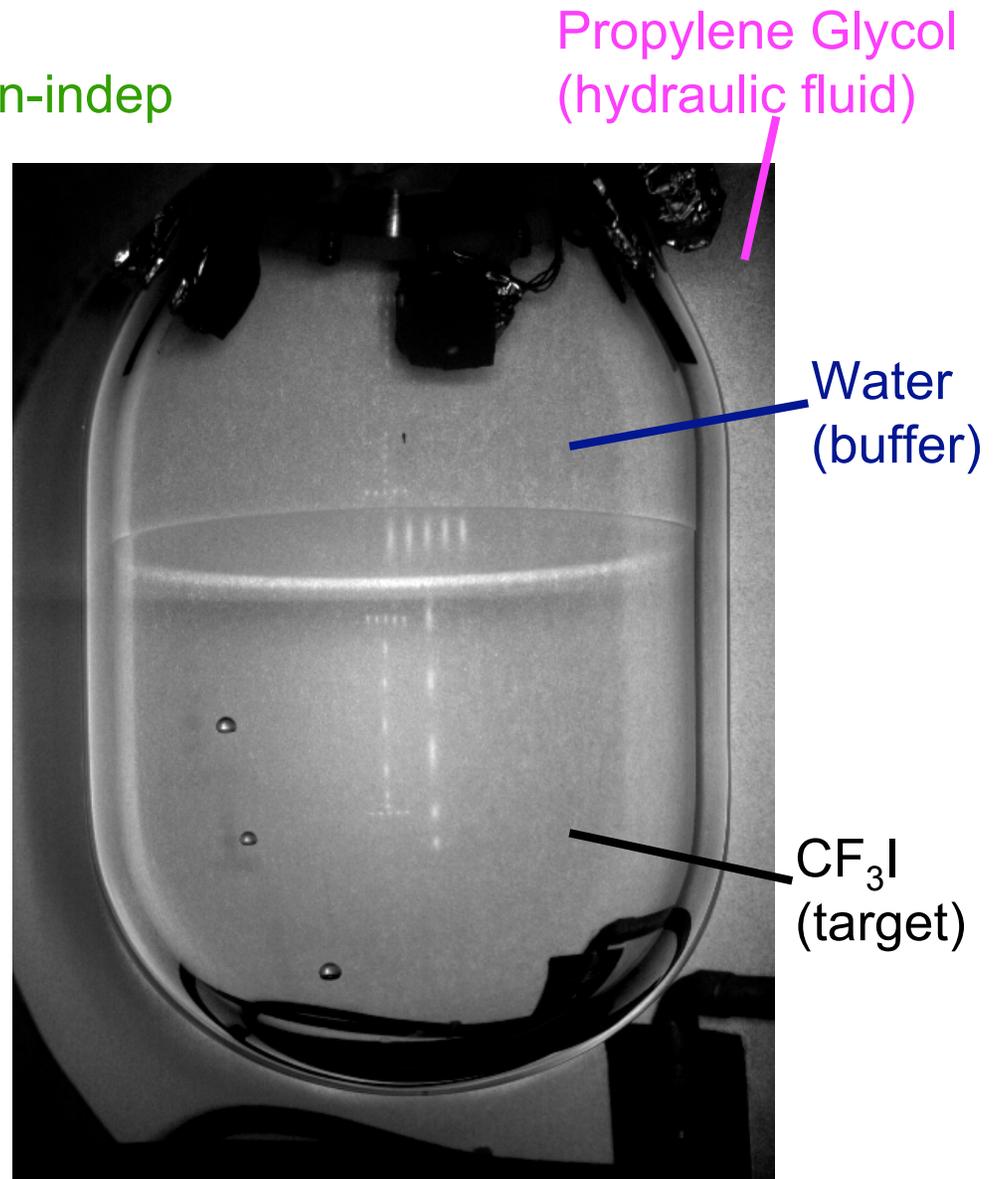
# Review

- Superheated  $\text{CF}_3\text{I}$  target  
Spin-dep
- Particle interactions nucleate bubbles
- Cameras capture bubbles
- Chamber recompresses after each event



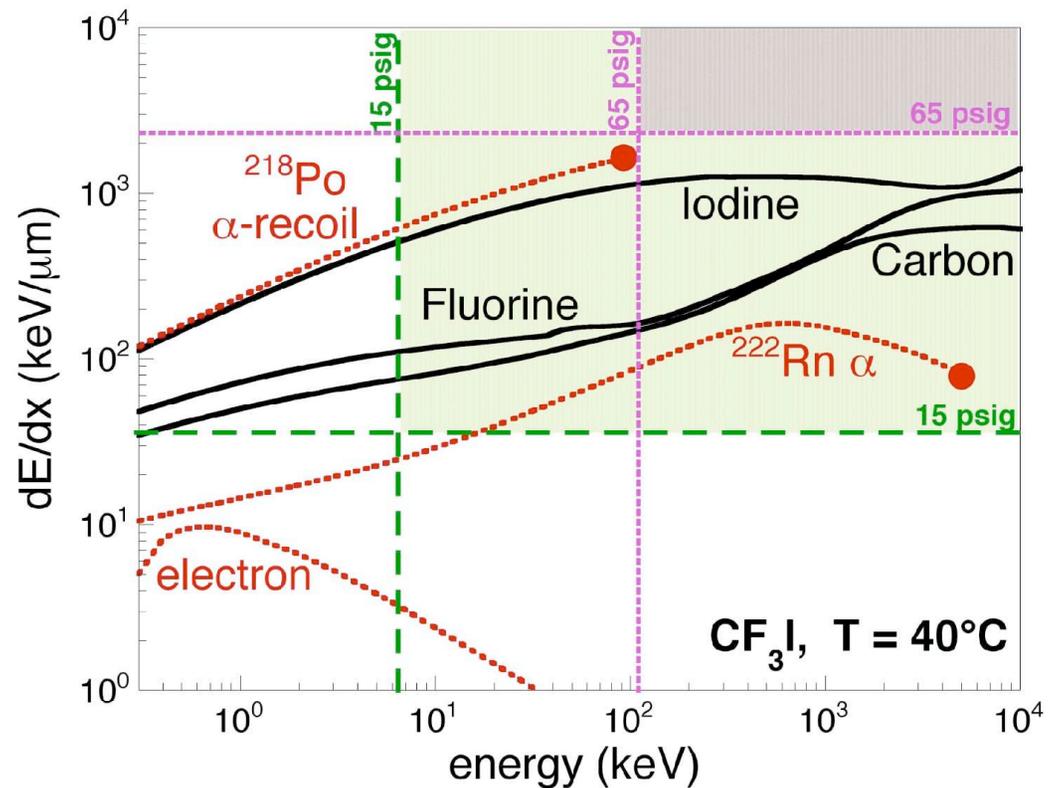
# Review

- Superheated  $\text{CF}_3\text{I}$  target Spin-indep  
Spin-dep
- Particle interactions nucleate bubbles
- Cameras capture bubbles
- Chamber recompresses after each event



# Review

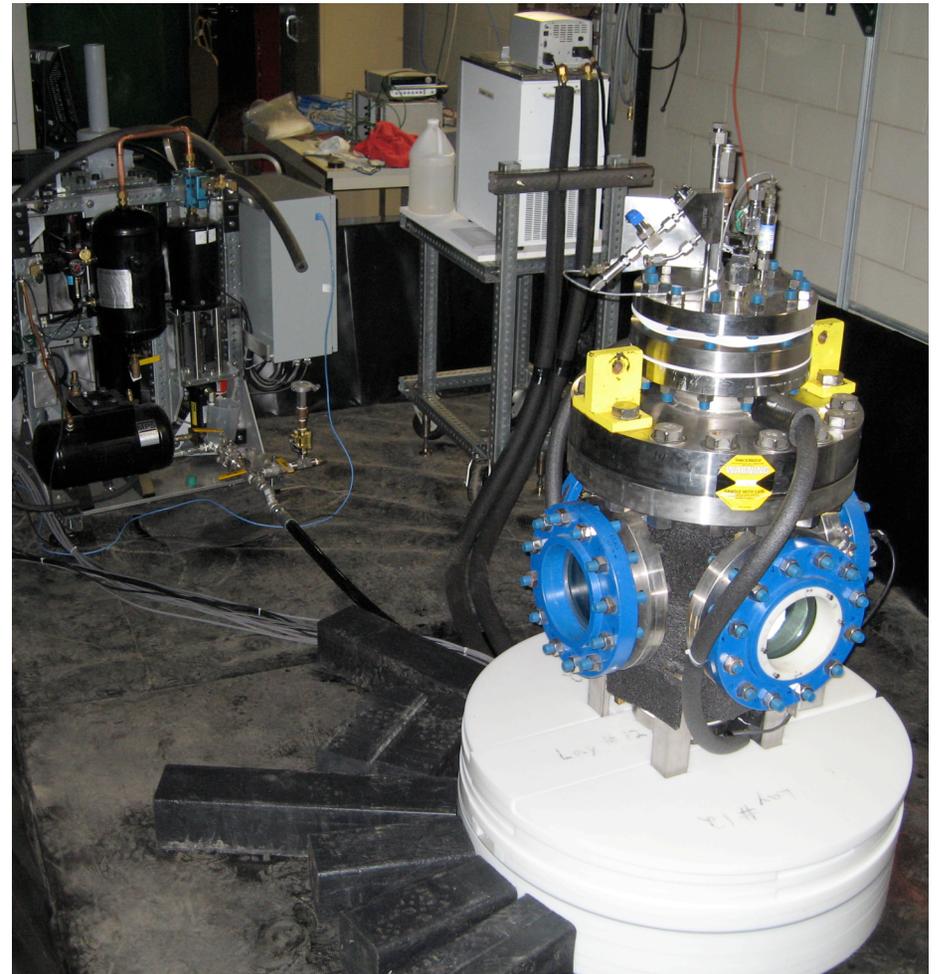
- Only proto-bubbles with  $r > r_{\text{crit}}$  grow to be macroscopic
- Critical proto-bubble requires minimum  $dE$  within minimum volume
- Recoil must be over thresholds in both  $E$  and  $dE/dx$



No sensitivity to  $\gamma$ 's or  $\beta$ 's,  
but  $\alpha$ 's do make bubbles

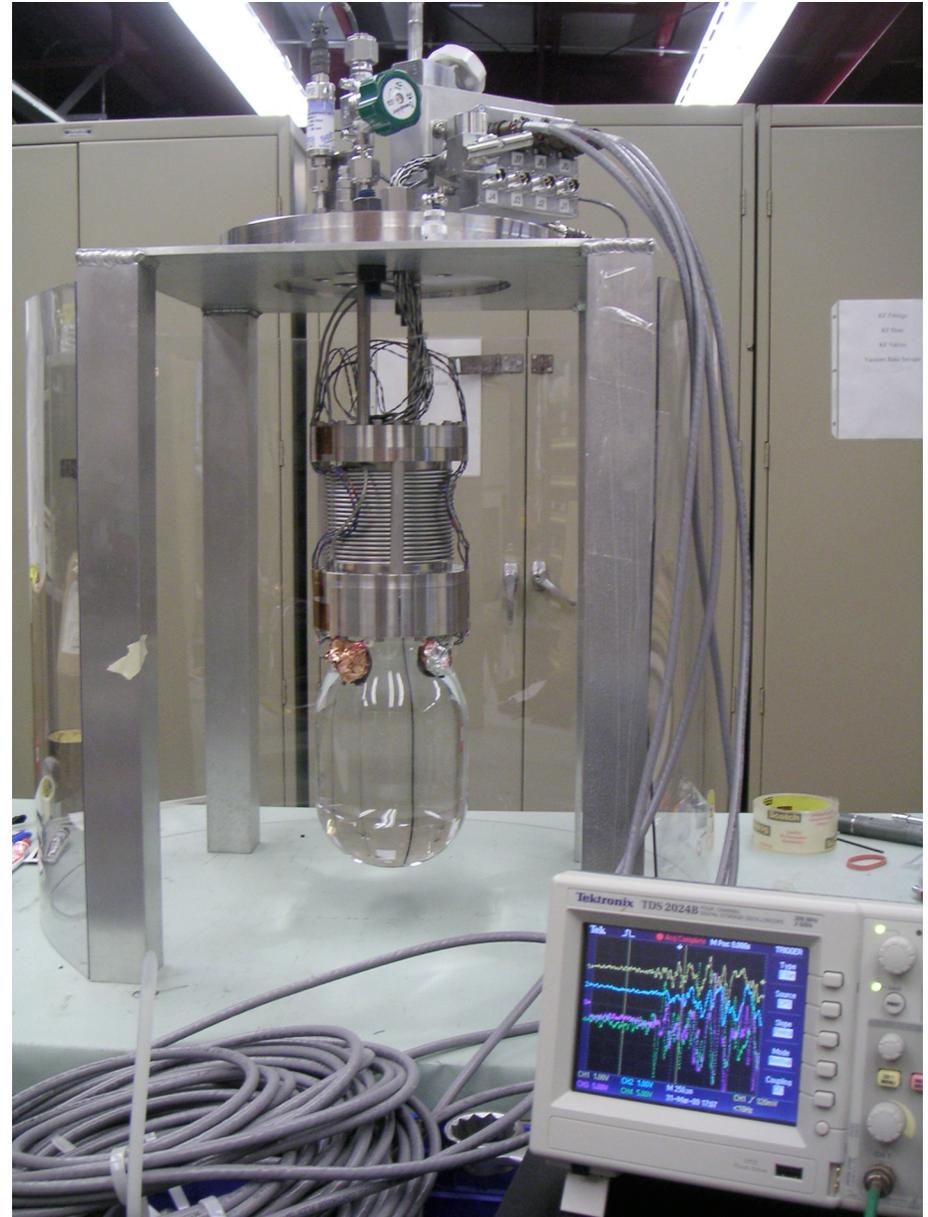
# COUPP 4kg

- Ran Aug 19 – Dec 18 in NuMI tunnel at Fermilab
  - 300 mwe underground
  - Over 300 kg-days unattended operation at 20 keV threshold



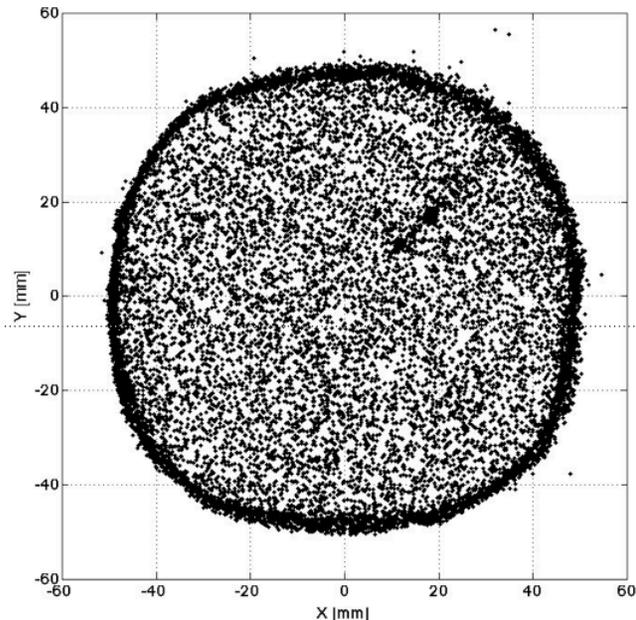
# COUPP 4kg

- 3 stated goals
  - Reduce wall rate
  - Reduce bulk alpha rate
  - Commission new veto
- Added goal:
  - Look for acoustic alpha discrimination reported by PICASSO



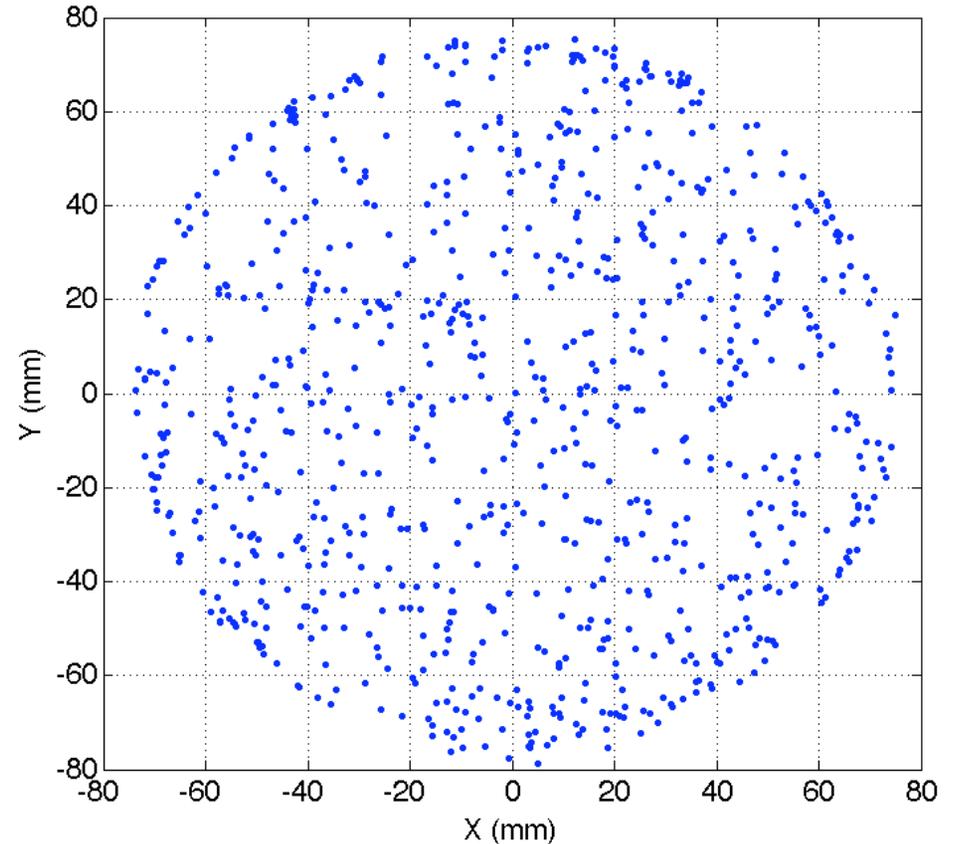
# Goal #1: Wall rate reduction

Natural Quartz:  $0.8/\text{day}/\text{cm}^2$



~40 live-days  
(2007-08)

Synthetic Silica:  $\leq 1e-3/\text{day}/\text{cm}^2$

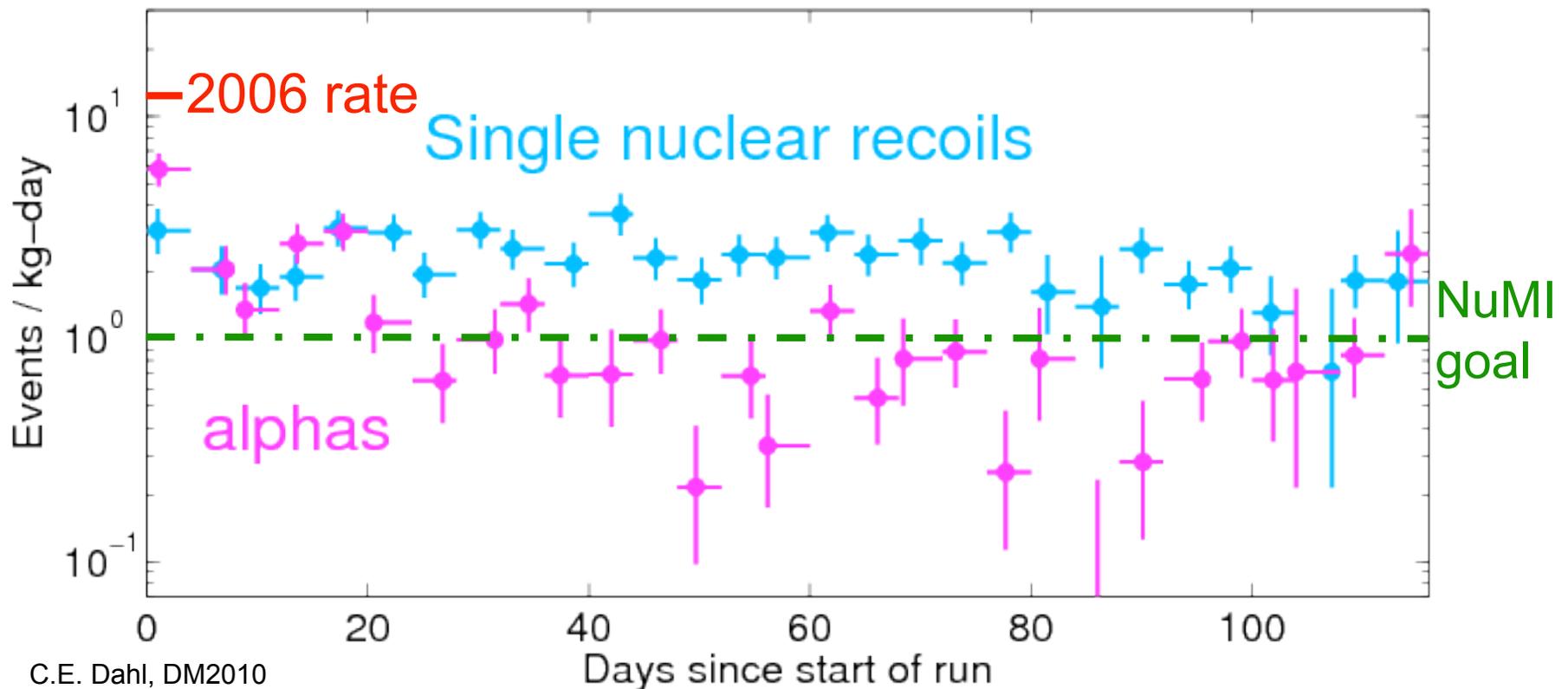


64 live-days (2009)

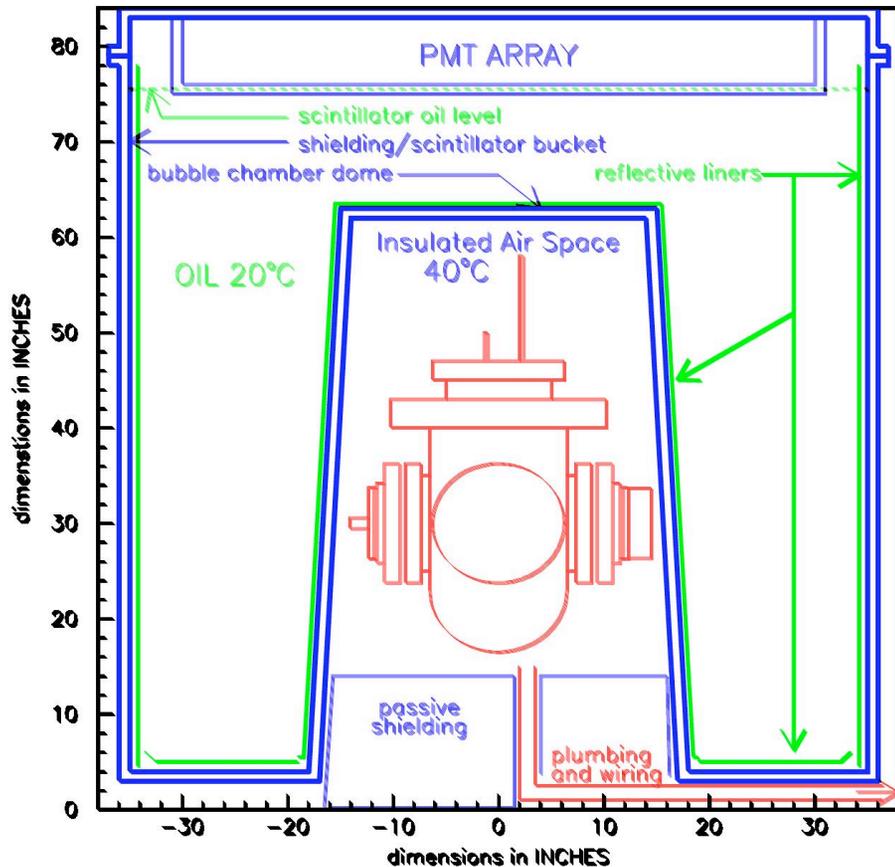
# Goal #2: Bulk alpha reduction

## ■ Targeting radon

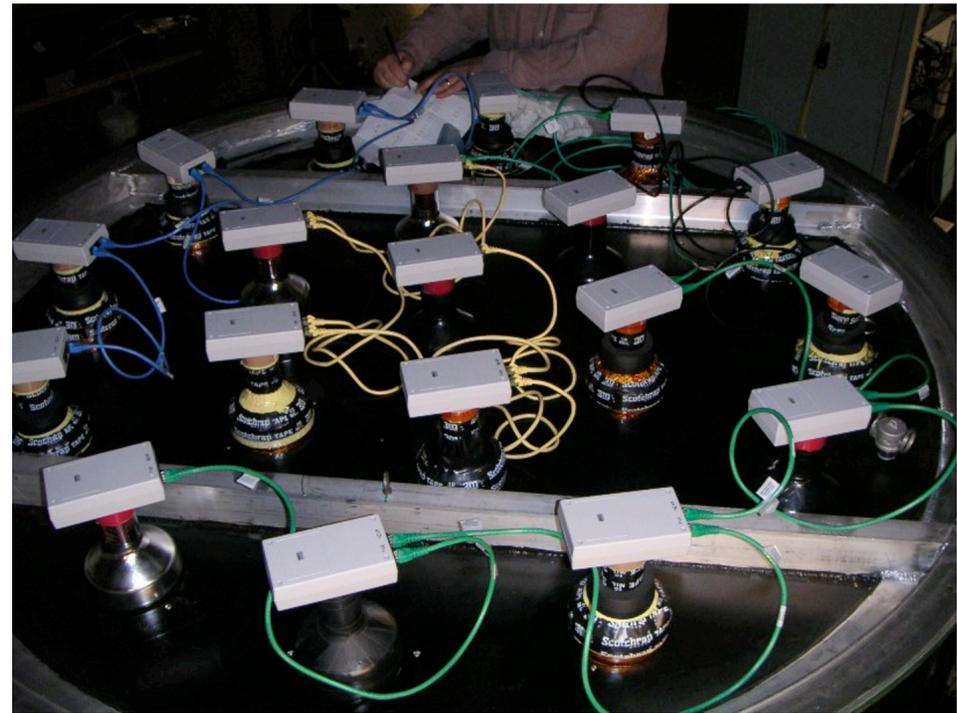
- Materials known to emanate radon removed
- No steps taken to purify  $\text{CF}_3\text{I}$ , remove  $^{210}\text{Pb}$ , etc



# Goal #3: New muon veto



Liquid Scintillator “Bundt Cake”

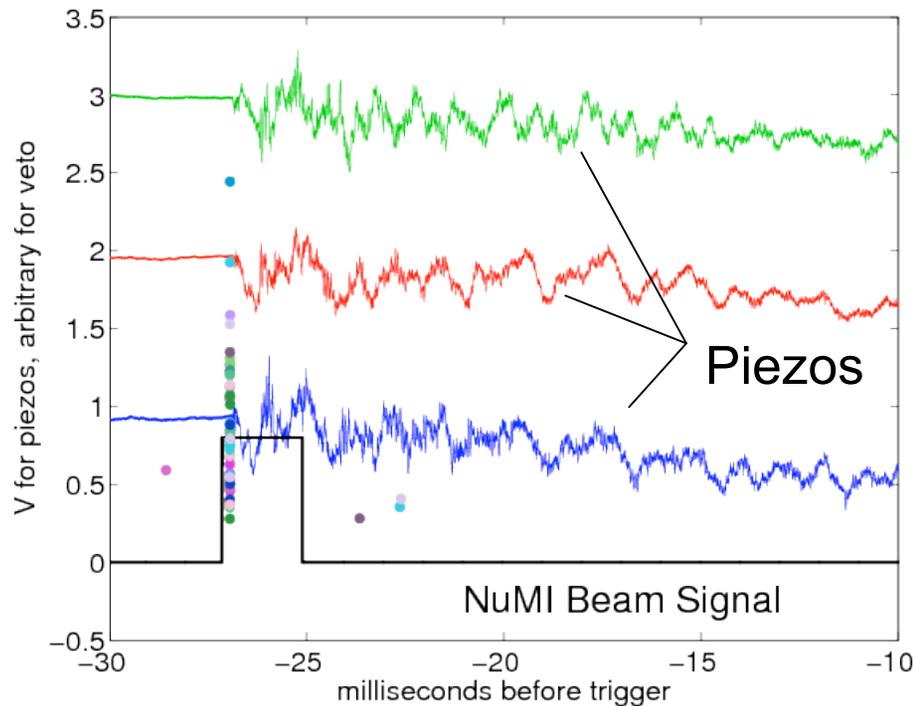


## PMT Bases feature:

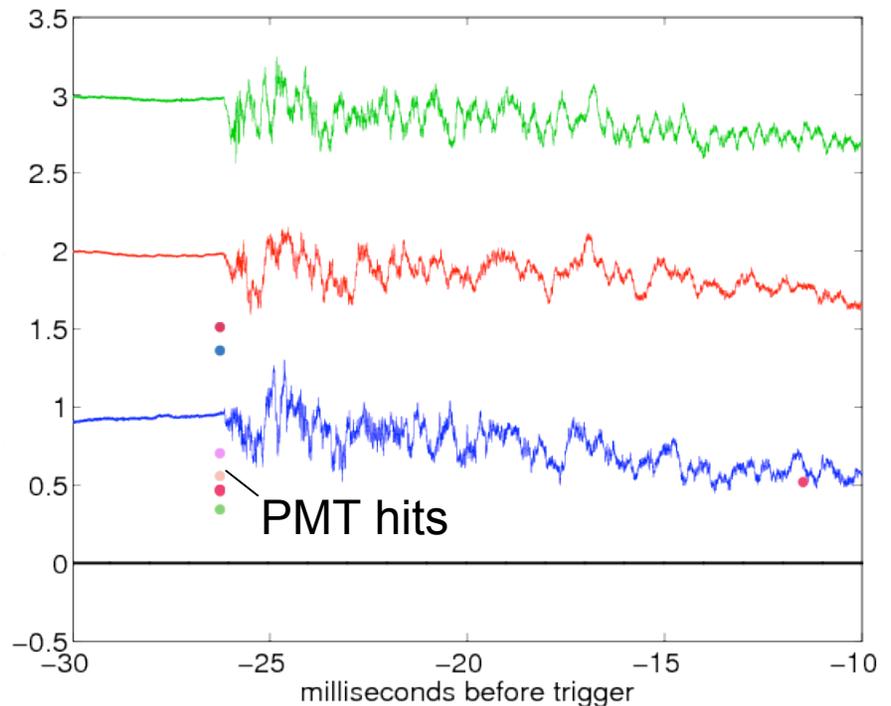
- On board digitizers
- Cockcroft-Walton HV
- Power and data over ethernet

# Goal #3: New muon veto

## Beam Event



## Cosmic Event



- Require:
- 300 ns coincidence between PMTs
  - 500  $\mu$ s coincidence with piezos

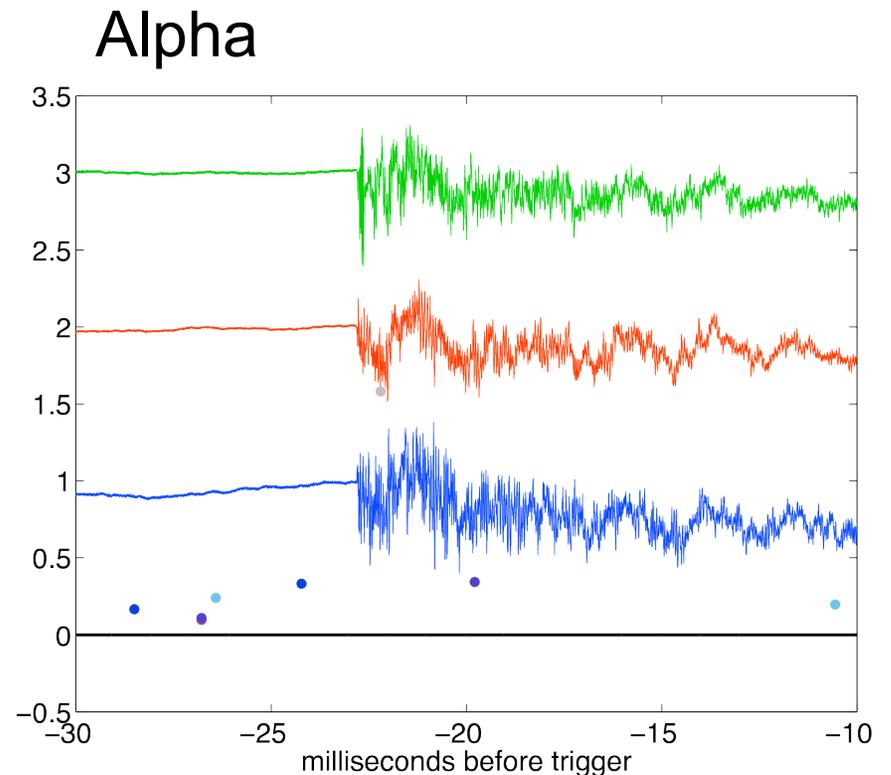
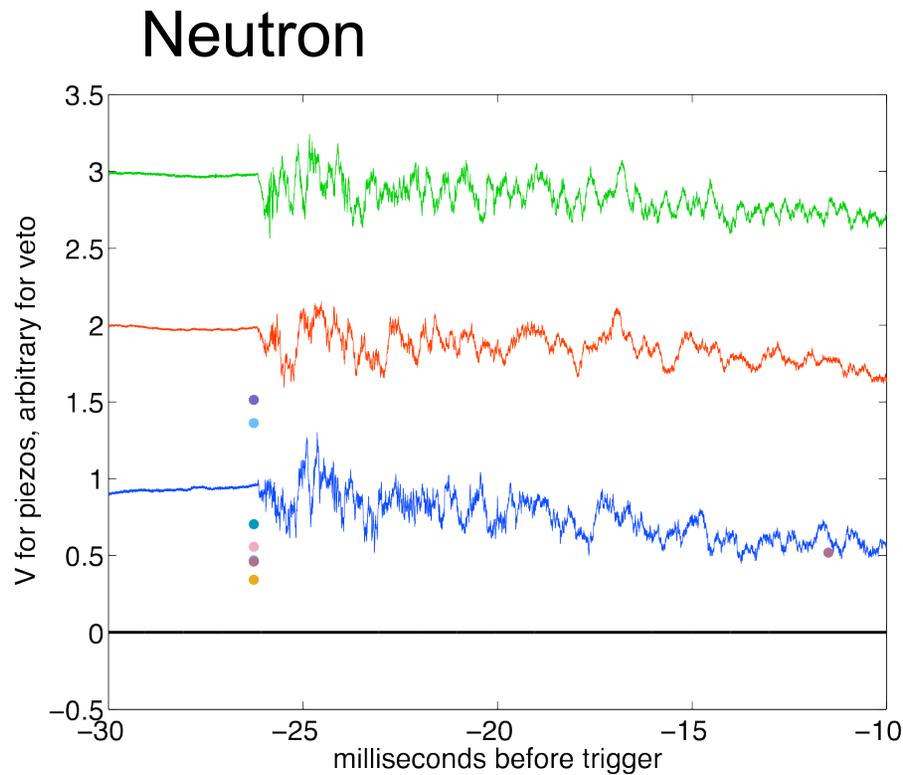


# Bonus: Acoustic Discrimination

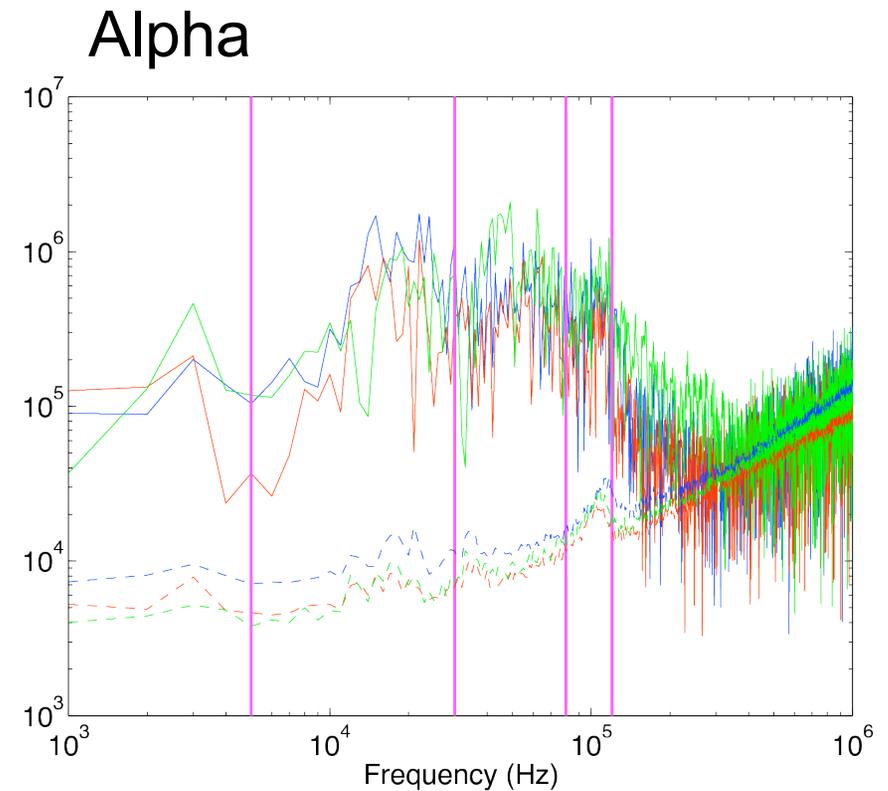
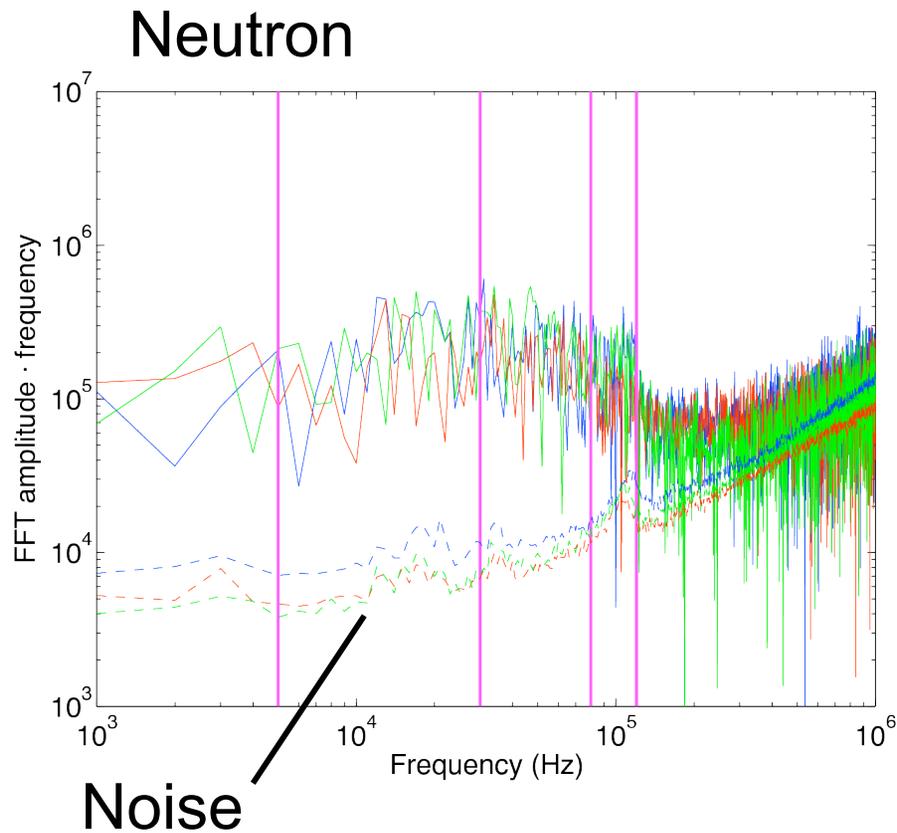
PICASSO (Aubin et al., arXiv:0807.1536)

- Nuclear recoil: 1 proto-bubble
- Bulk  $\alpha$ -decay: 2+ proto-bubbles
  - 1 proto-bubble from  $\alpha$ -recoil
  - 1+ proto-bubbles from alpha
- Alpha's should be louder...

# Acoustic Signatures, time domain



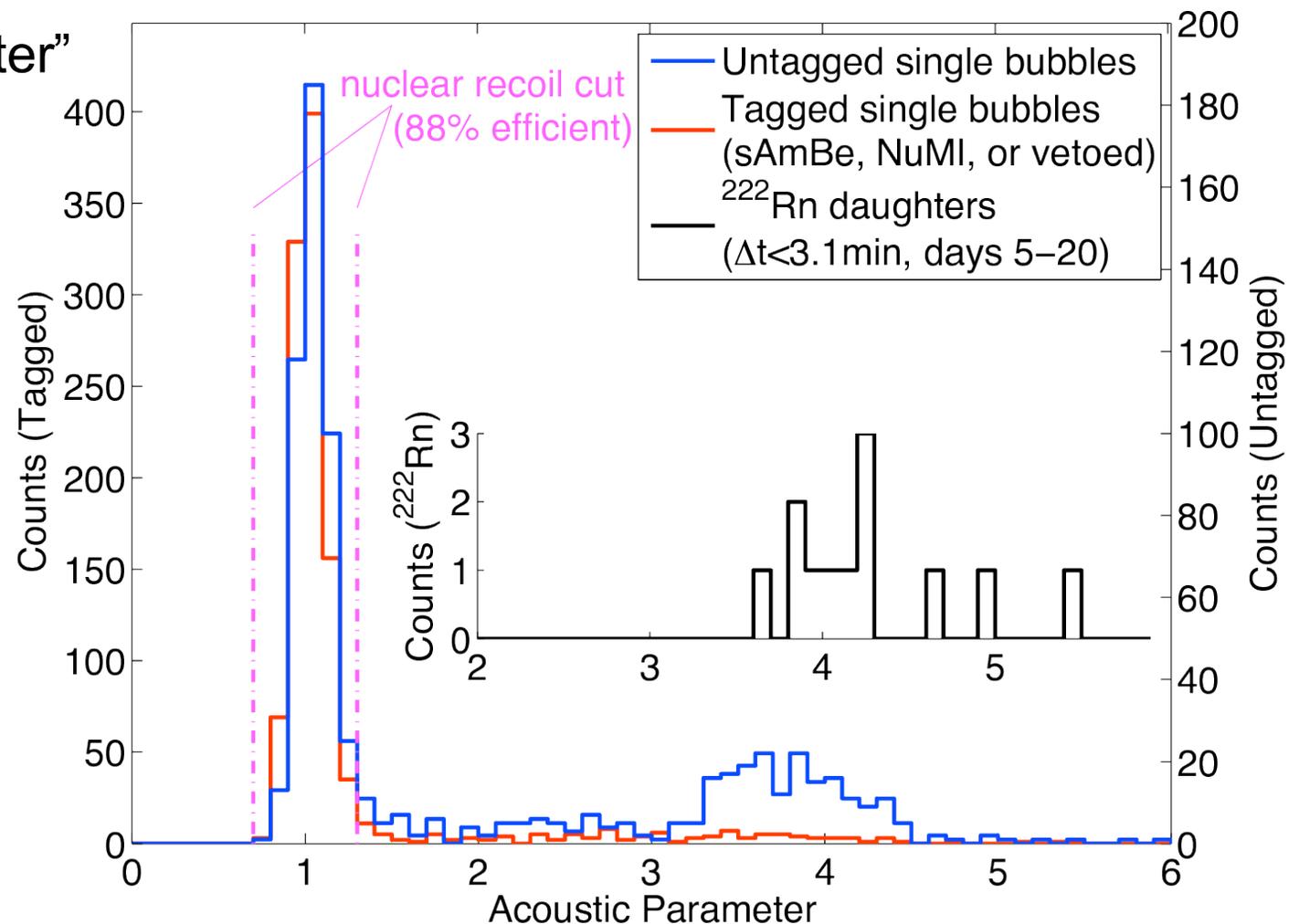
# Acoustic Signatures, freq domain



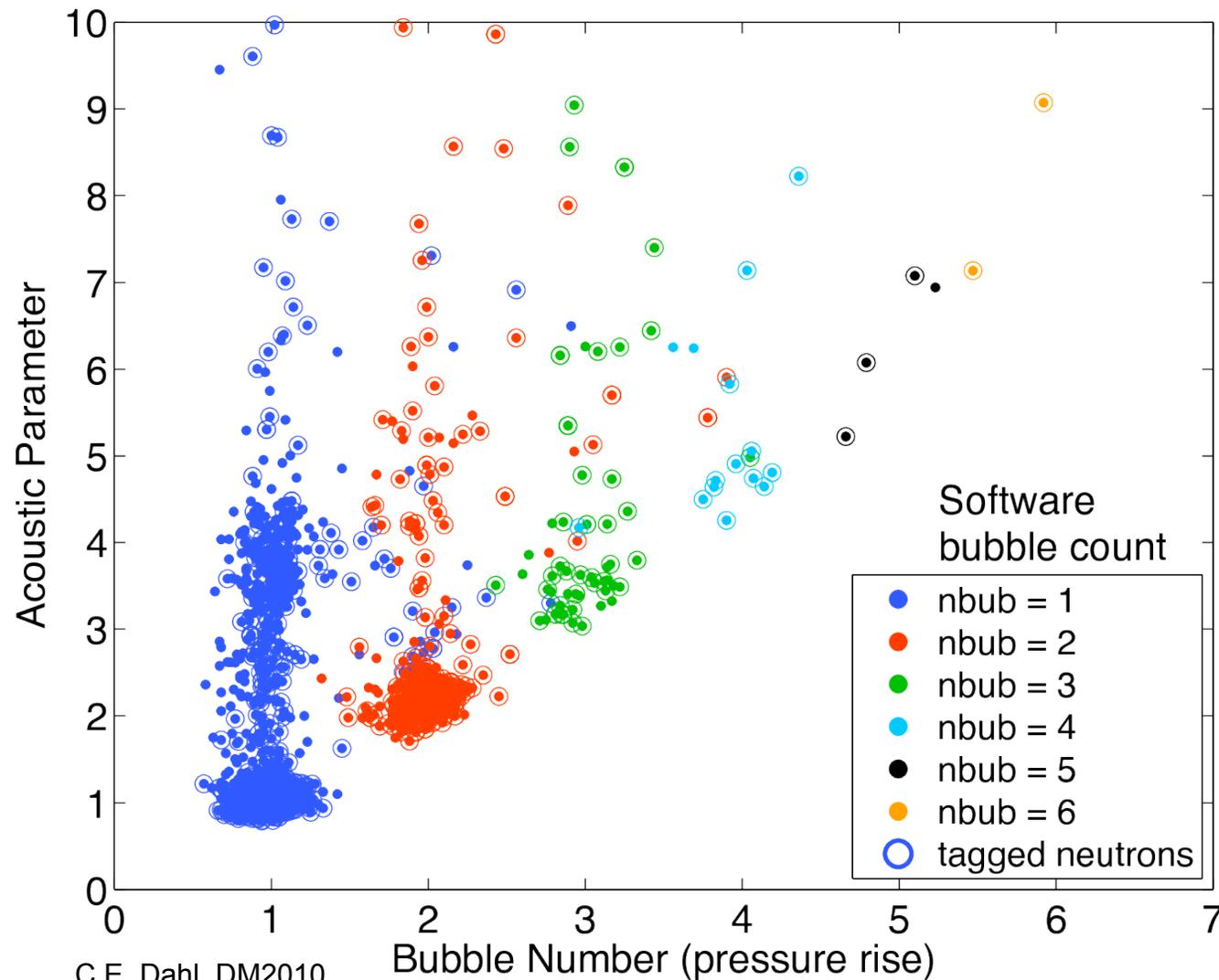
# Acoustic Discrimination

## “Acoustic Parameter”

- $(\text{Amp} \cdot \omega)^2$   
(Normalized and position-corrected for each freq-bin)
- Measure of acoustic energy deposited in chamber

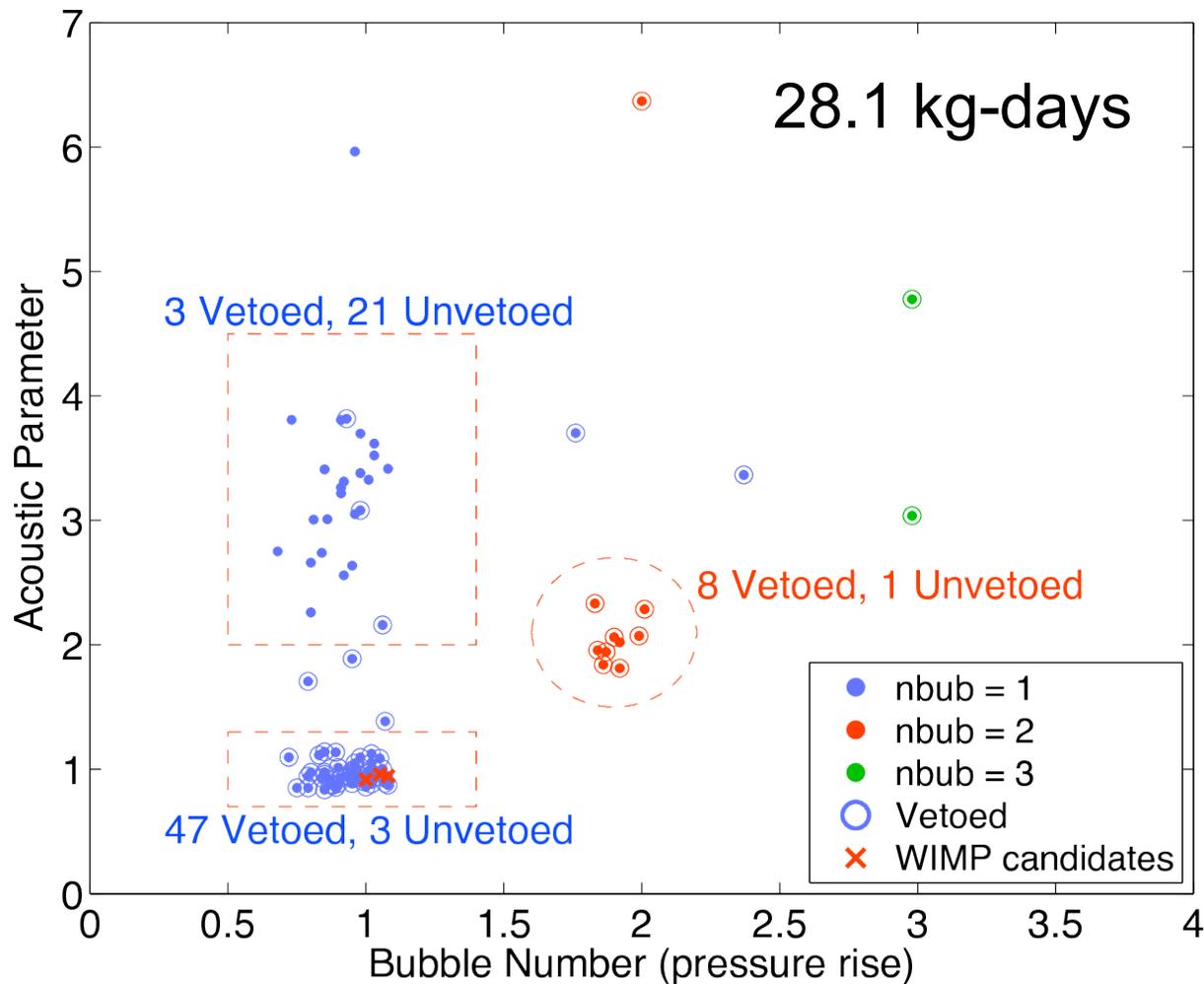


# Acoustic Discrimination



- 291 kg-days, mostly before veto installation
- Acoustic Parameter (AP) scales with # of bubbles
- No tails at low AP
- All bubble numbers have tail at high AP

# Acoustic Discrimination

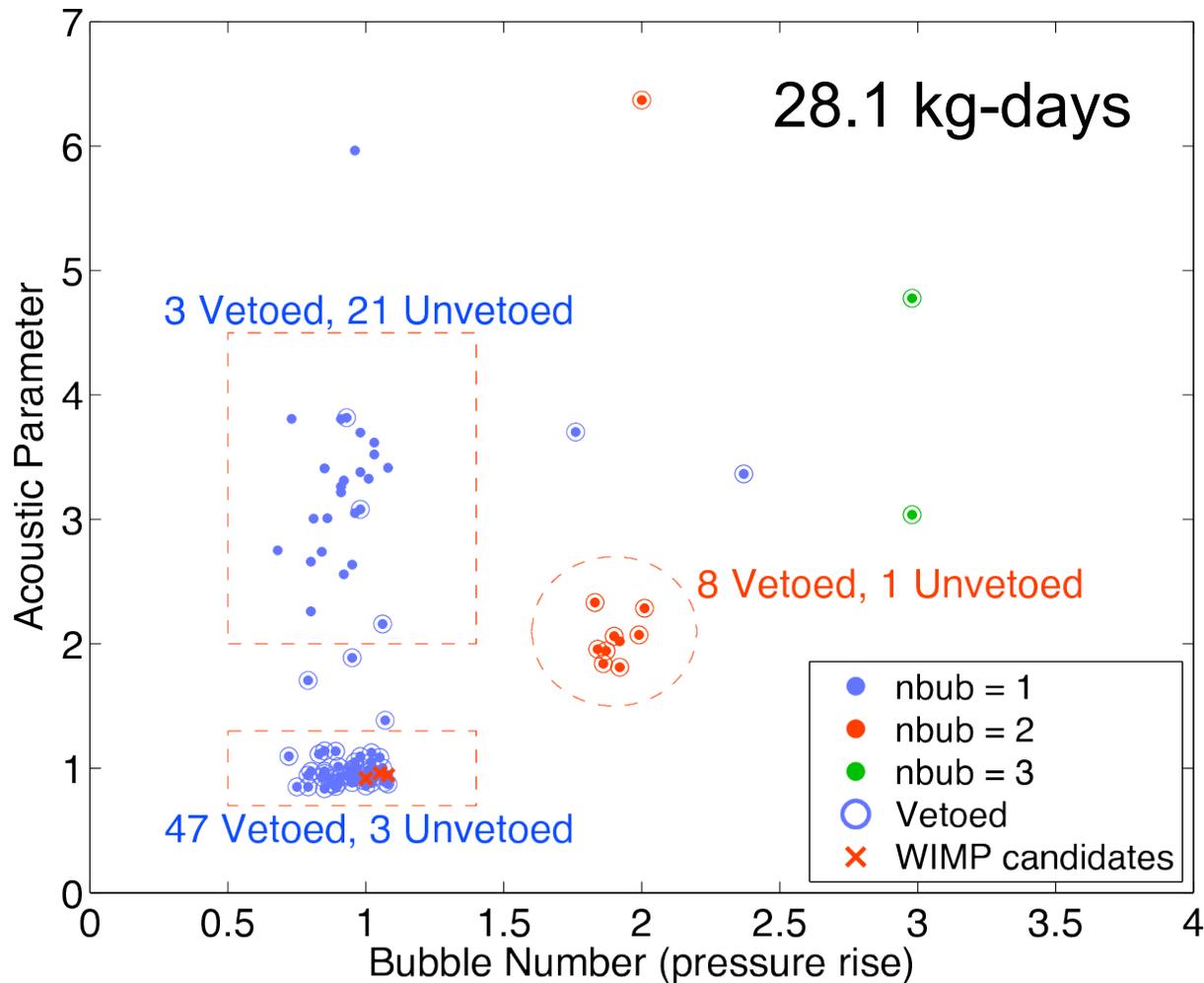


- 3 “WIMP candidates” could be

- alphas
- neutrons
- WIMPs

- Note un-vetoed 2-bubble event...

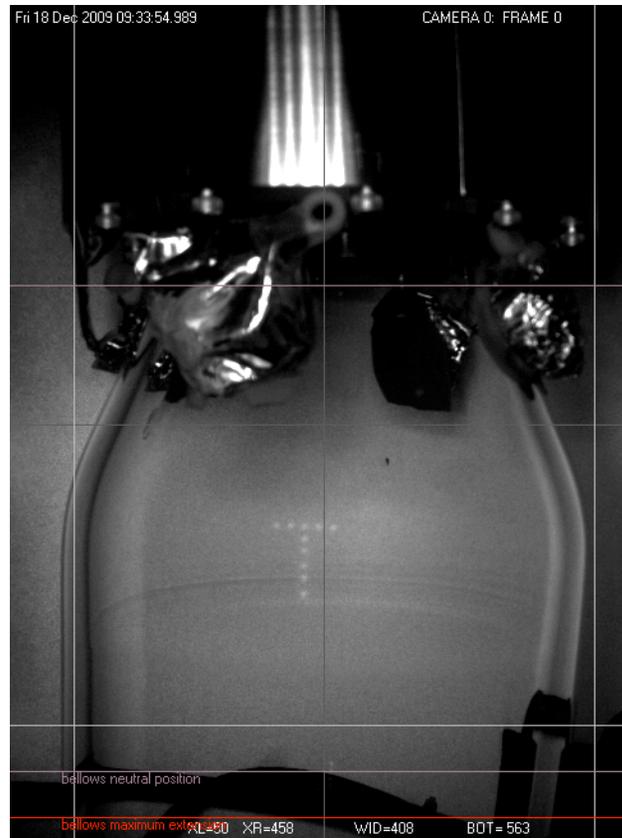
# Acoustic Discrimination

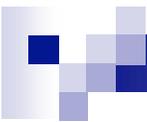


- Counting WIMP candidates as possible alphas...
- $^{222}\text{Rn}$  and un-vetoed singles give >80% alpha rejection at 88% nuclear recoil acceptance, with 90% CL

# COUPP 4kg: WIMP Limits

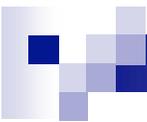
- Clear opportunity for dark matter physics with 4kg chamber, but...





# COUPP 4kg: WIMP Limits

- Clear opportunity for dark matter physics with 4kg chamber, but...
- Run ended prematurely due to technical failure
  - Failure understood
  - Chamber operational but compromised
  - Decision to end run and make repairs
- What can we do with data in hand?



# COUPP 4kg: WIMP Limits

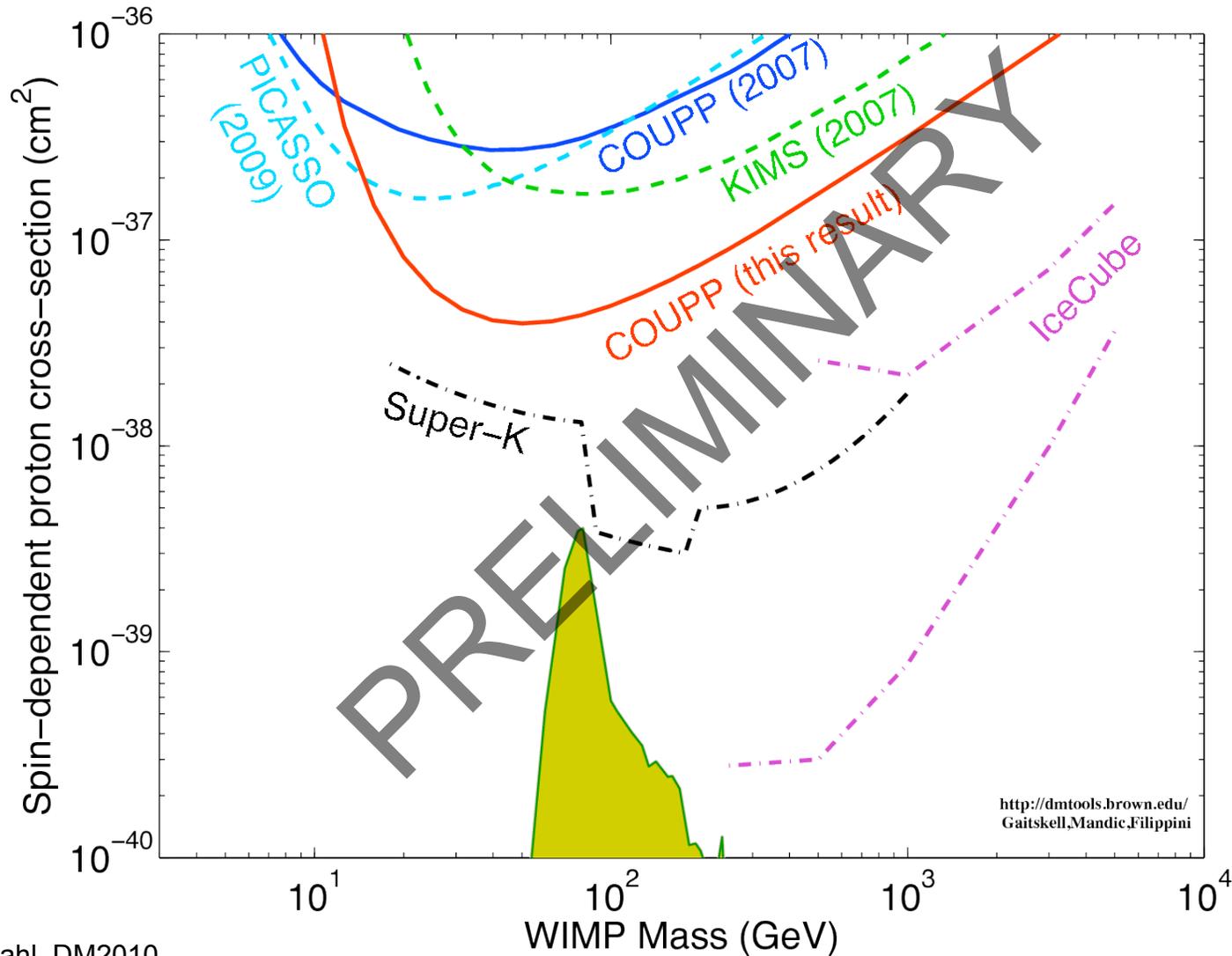
## ■ Be aware:

- Temperature and pressure not ideal for dark matter physics
- Vetting of threshold, efficiency ongoing
- No true blind analysis
- We expect to surpass these limits in the near future

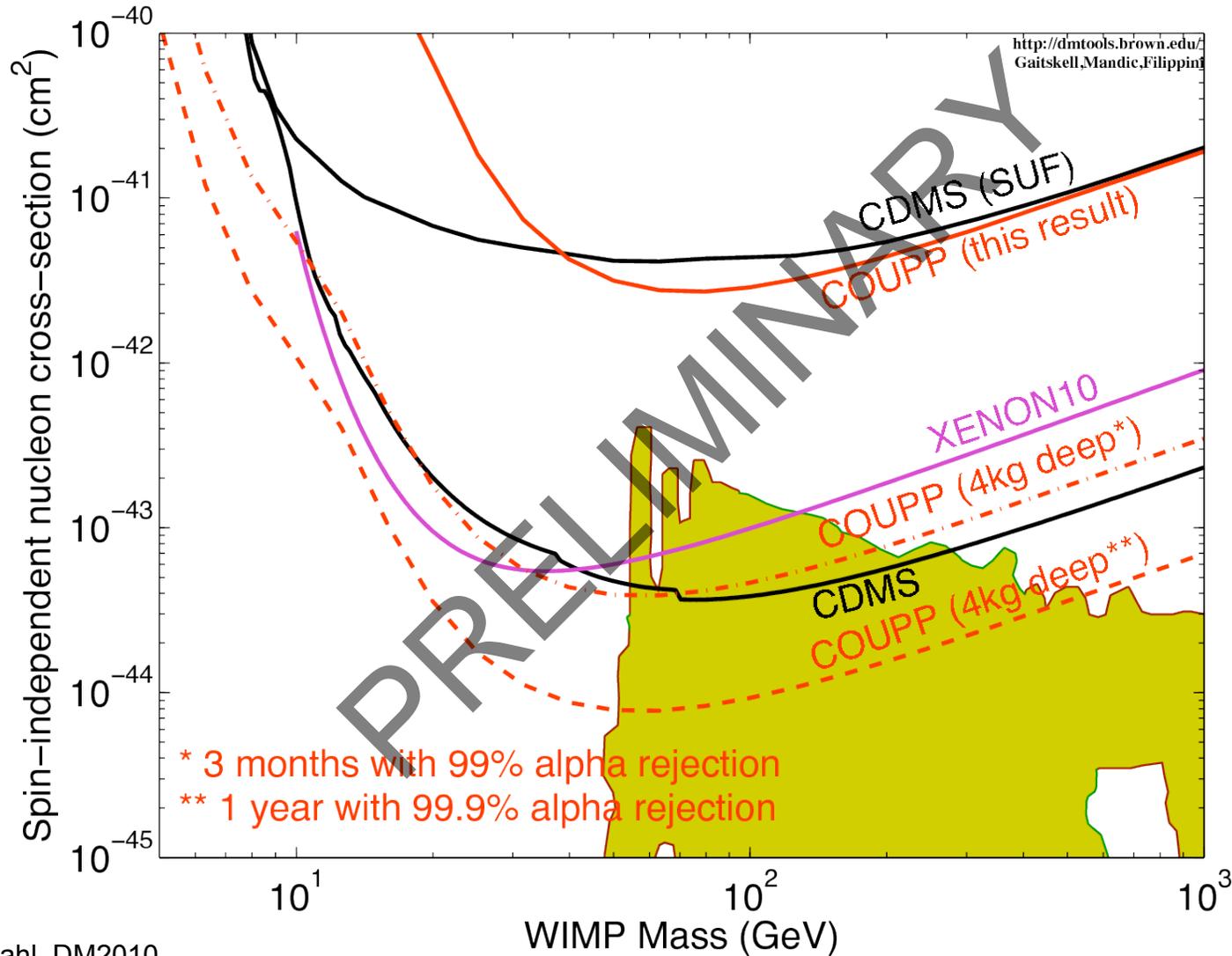
## ■ The following 90% CL limits take

- 3 events, with no background subtraction
- 28.1 kg-days after cut efficiencies
- 20 keV recoil threshold
- 65% bubble nucleation efficiency (preliminary)

# COUPP 4kg: WIMP Limits, SD-p

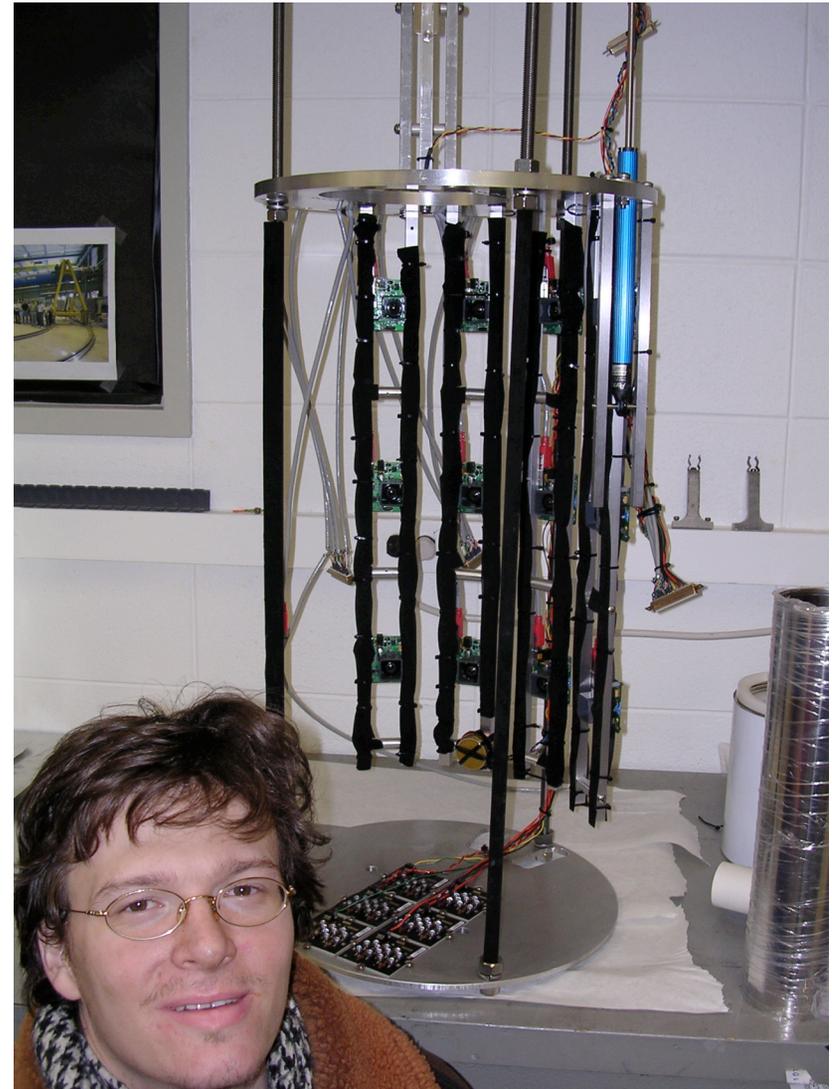


# COUPP 4kg: WIMP Limits, SI



# Coming Soon:

- 20kg chamber (TARP)
  - Now taking physics data
  - Will reach similar limit if similar acoustic discrimination is seen



# Coming Soon:

- 60kg chamber
  - Engineering runs with prototype last fall
  - High-purity assembly completed
  - Installation in NuMI tunnel in March
  - SNOLAB soon...



# Summary

- Wall rate reduced  $<10^{-3}$  evts/cm<sup>2</sup>/day
- Bulk rate reduced  $<1$  evt/kg/day
- New muon veto  
Installed on 4kg  
and 60kg detectors
- Acoustic  
discrimination  
 $>80\%$  rejection at  
 $88\%$  acceptance
- Chamber in a deep  
site soon

