COUPP

Jeter Hall

Fermi National Accelerator Laboratory

COUPP Bubble Chamber Program

- Take long runs with smaller chambers to understand backgrounds, operations, and for research and development, while developing and commissioning a larger chamber

Test tube
(U Chicago)

Science **319**:933-936 (2008)

COUPP 2kg

PRL **106** 021303 (2011)
New results from SNOLAB

COUPP 4kg

Now moving to SNOLAB

Ton Scale?

COUPP 60kg

The Chicagoland Observatory for Underground Particle Physics

University of Chicago

Juan Collar (PI, spokesperson), C. Eric Dahl, Drew Fustin, Alan Robinson, Matthew Szydagis

Indiana University South Bend

Ed Behnke, Joshua Behnke, Tonya Benjamin, Austin Conner, Emily Grace, Adam Grandison, Cale Harnish, Ilan Levine (PI), Thomas Nania, Tim Raymond

Fermilab

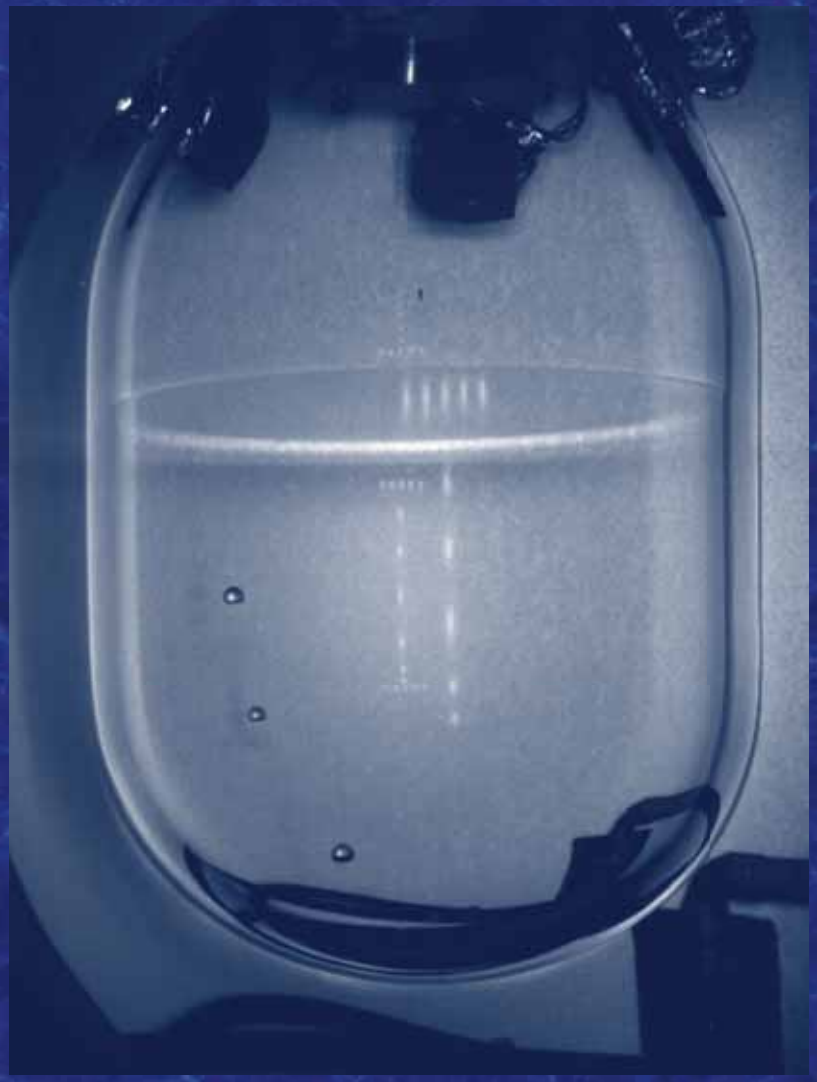
Steve Brice, Dan Broemmelsiek, Peter Cooper, Mike Crisler, Jeter Hall, Martin Hu, Hugh Lippincott, Erik Ramberg, Andrew Sonnenschein, Fermilab Engineers and Technicians

SNOLAB

Eric Vazquez Jauregui

Continuously Sensitive Bubble Chambers

- Superheated CF_3I target
- Depositions of enough energy ($>E_T$) in a small enough volume ($<R_c$) create bubbles
  - F. Seitz, Phys. Fluids **1**, 2 (1958)
- Cameras watch and issue a trigger
- Re-liquefy the target with 60 second compression



COUPP 4 at SNOLAB

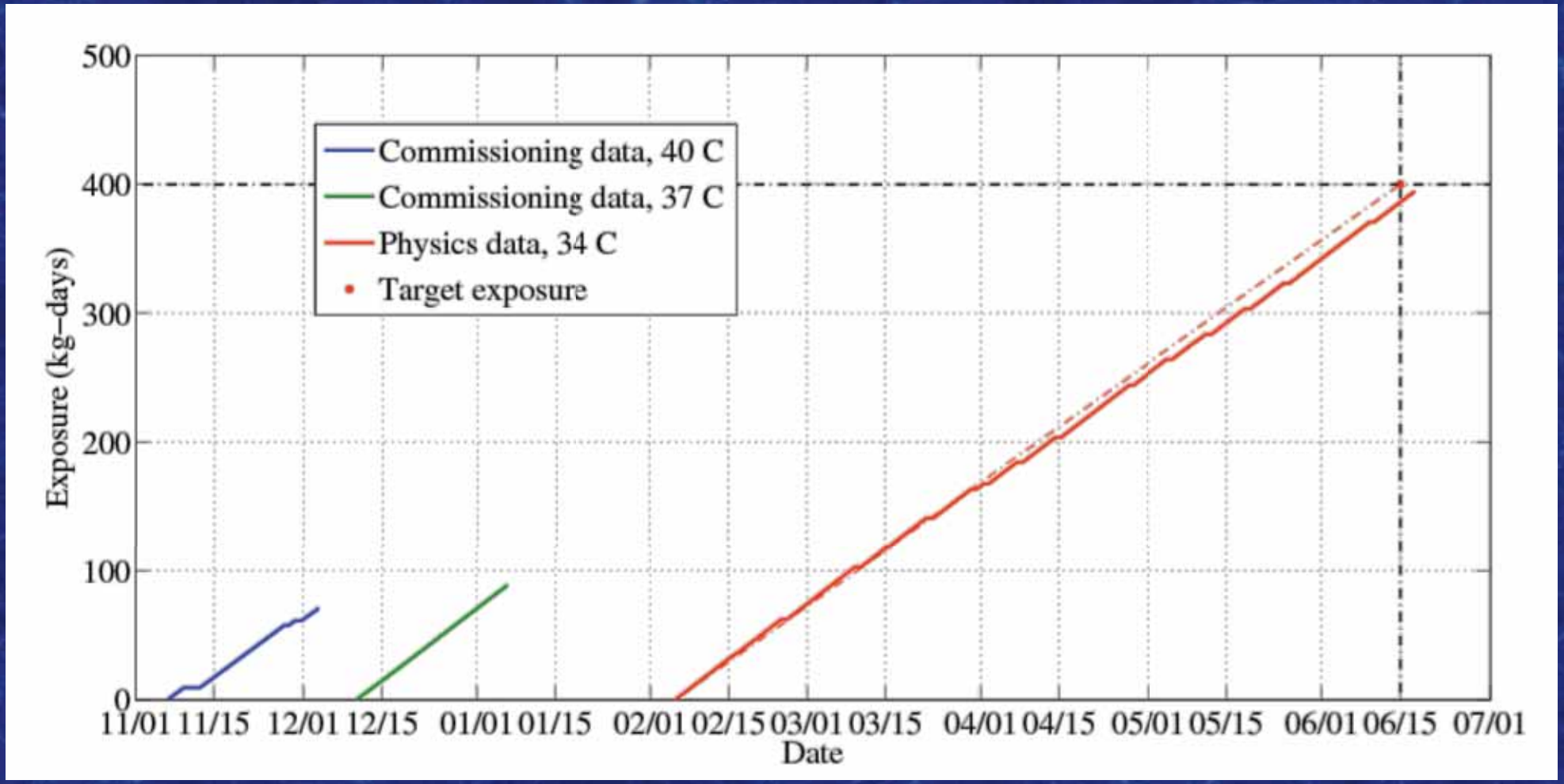
- 2009 results obtained in the MINOS near detector tunnel at FNAL (300 mwe) limited by backgrounds from cosmic radiation
- In 2010 we initiated a move of our 2 liter bubble chamber to SNOLAB (6000 mwe)

COUPP 4 at SNOLAB

Physics Operations
Nov 3, 2010

COUPP 4 at SNOLAB

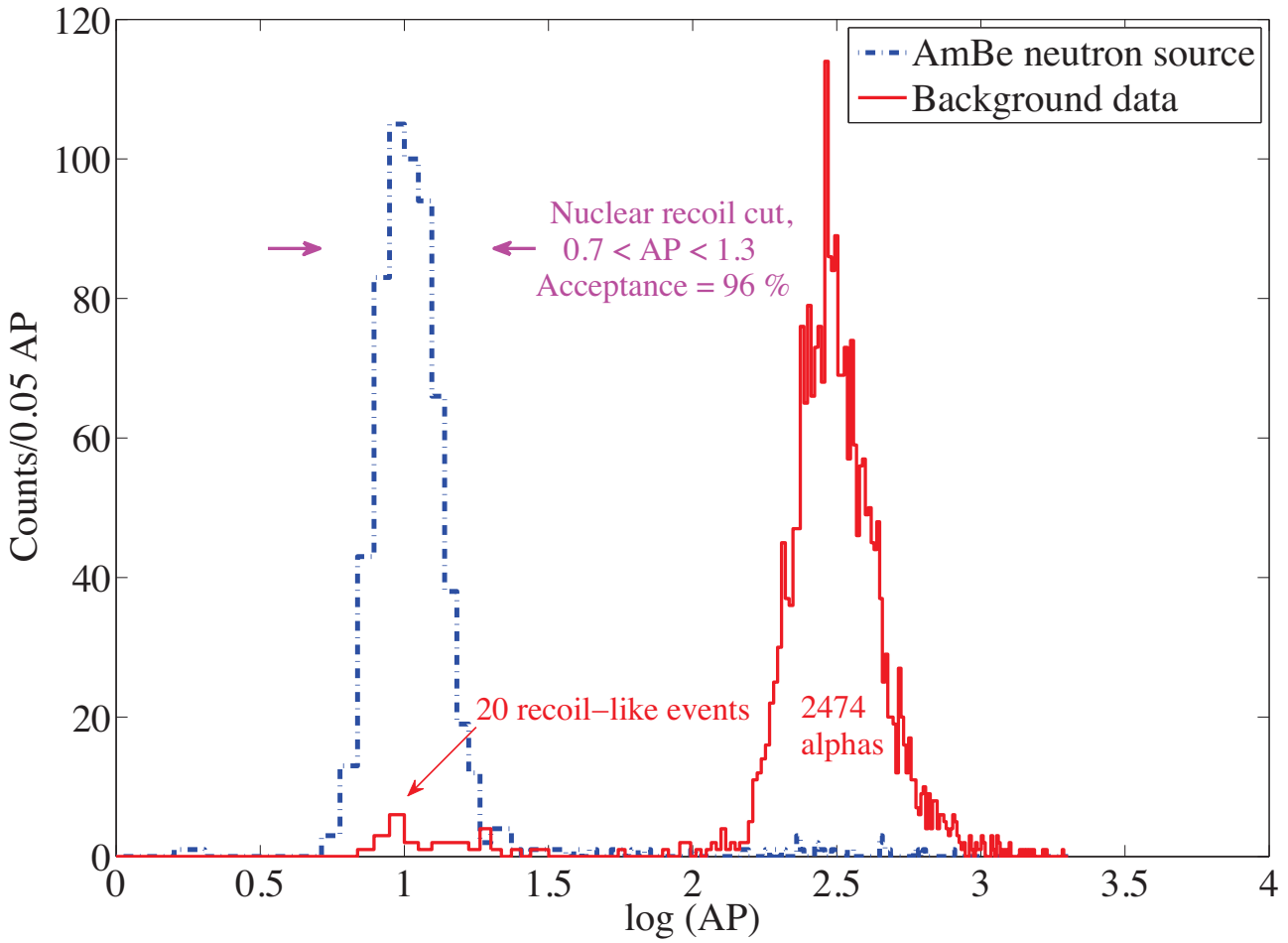
COUPP2L SNOLAB Exposure



- 17.4, 21.9, 97.3 live-days at 8, 10, 15 keV thresholds finished Summer 2011
- 4.048 kg CF_3I, 79% efficiency for nuclear recoils
  - 90% quality cuts, 92% fiducial volume, 96% acoustic cut

COUPP2L SNOLAB Results

- >99.3% alpha rejection (15 keV threshold)
- 20 WIMP candidates
  - (0.11,0.09,0.03) ev/kg/day above (8, 11, 16) keV
  - Expect ~0.01 ev/kg/day from identified neutron sources

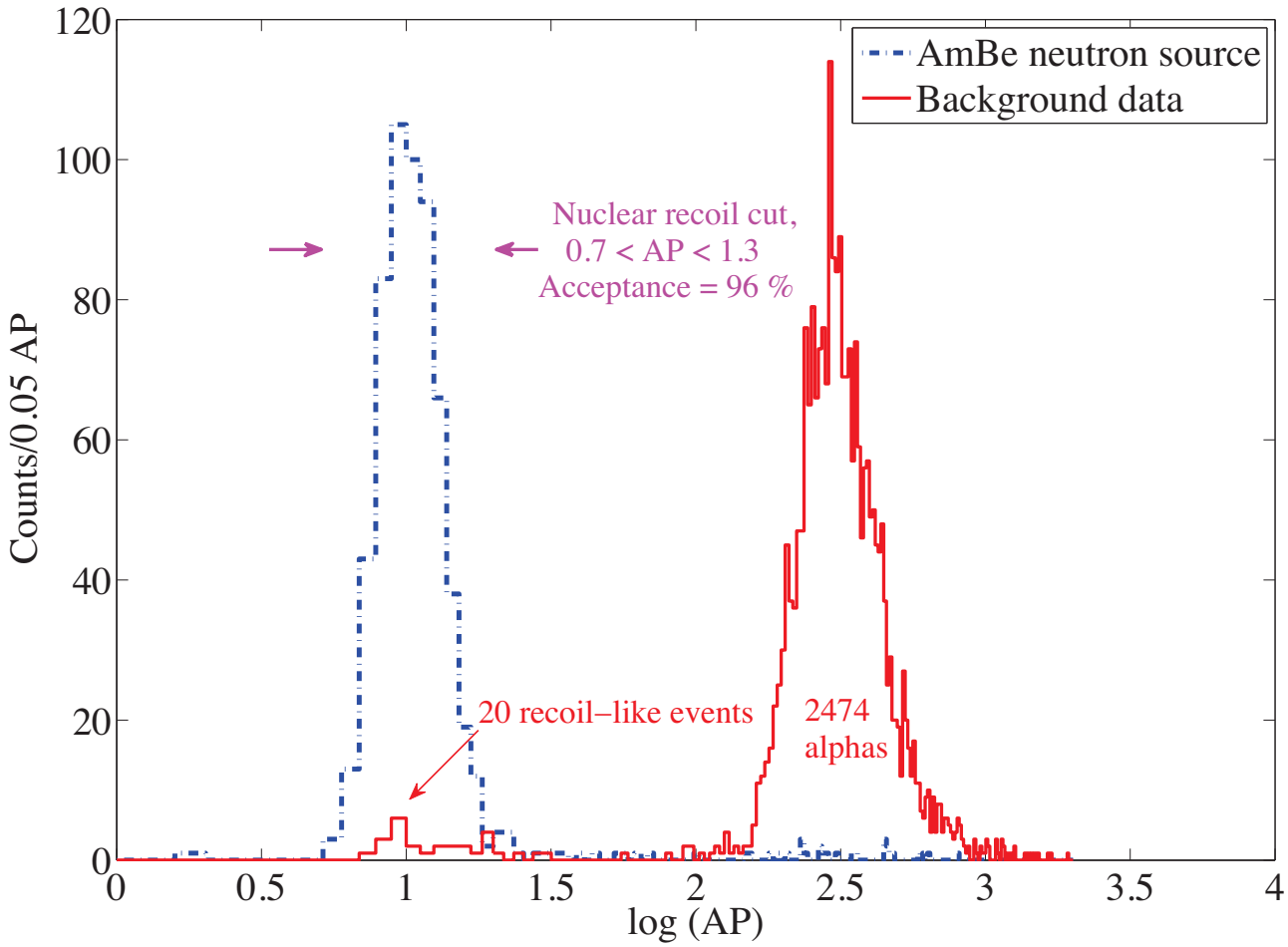


$$AP = A(T)\sum_{j} G_j \sum_{n} C_n(x) \sum_{f} f \times psd_f^j$$

- **AP** is a measure of acoustic energy
- **A(T)** temperature correction
- G_j gain correction for j^{th} acoustic sensor
- $C_n(x)$ position correction for n^{th} frequency range
- **psd** power spectral density with bin center frequency **f**

COUPP2L SNOLAB Results

- 20 WIMP candidates
  - (0.11,0.09,0.03) ev/kg/day above (8, 11, 16) keV
  - Expect ~0.01 ev/kg/day from identified neutron sources
- Are these WIMPs?
- Events at 8 keV threshold indicate that this is unlikely
  - Events are not consistent with the neutron AP distribution
  - If we include higher AP events, see clustering in time (3 in 3 hour period, 4 in 9 hour period in a ~1 month exposure with 6+4 events total)
  - Events are correlated with events at the CF_3I, H_20, SiO_2 boundary



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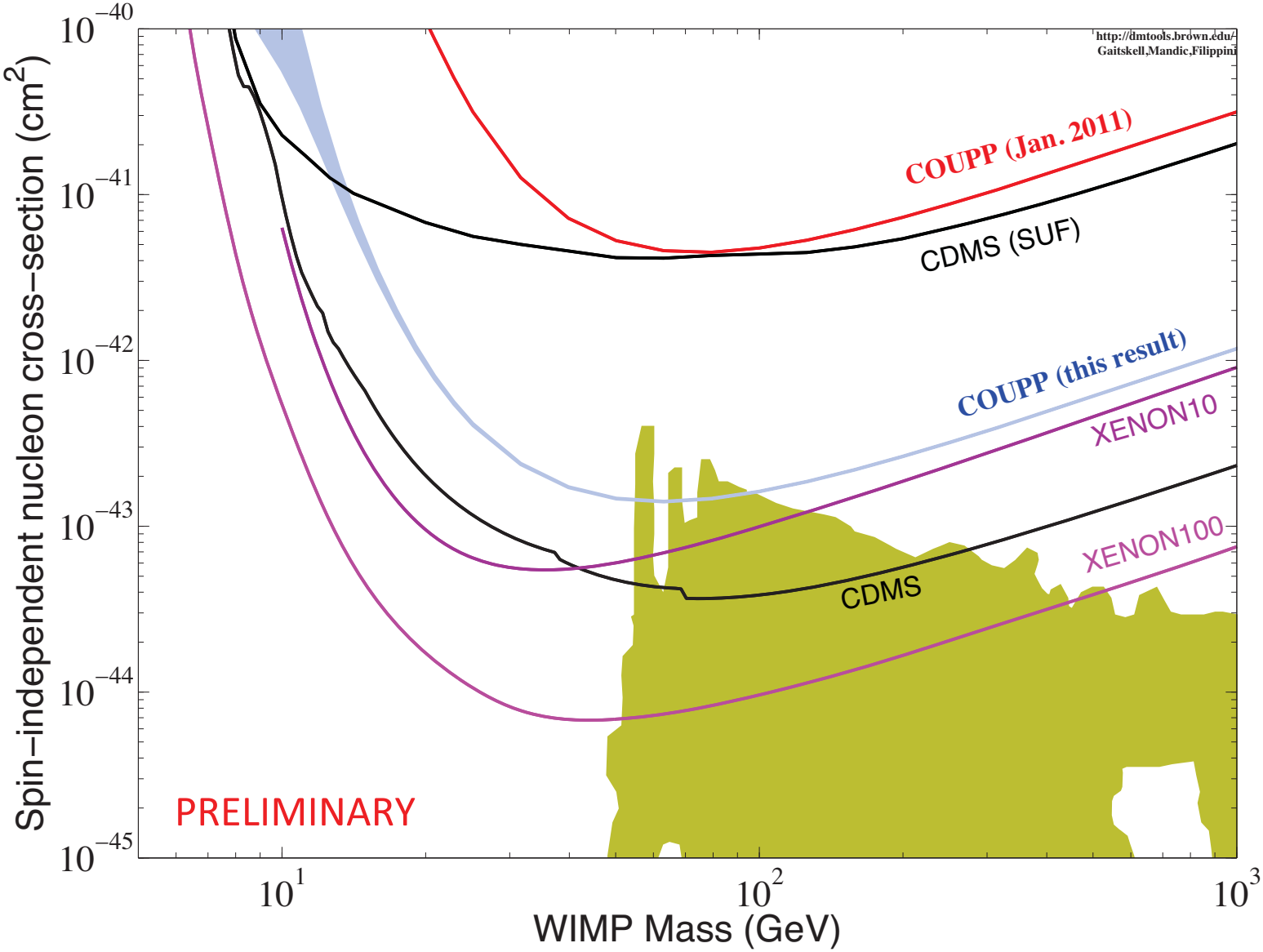

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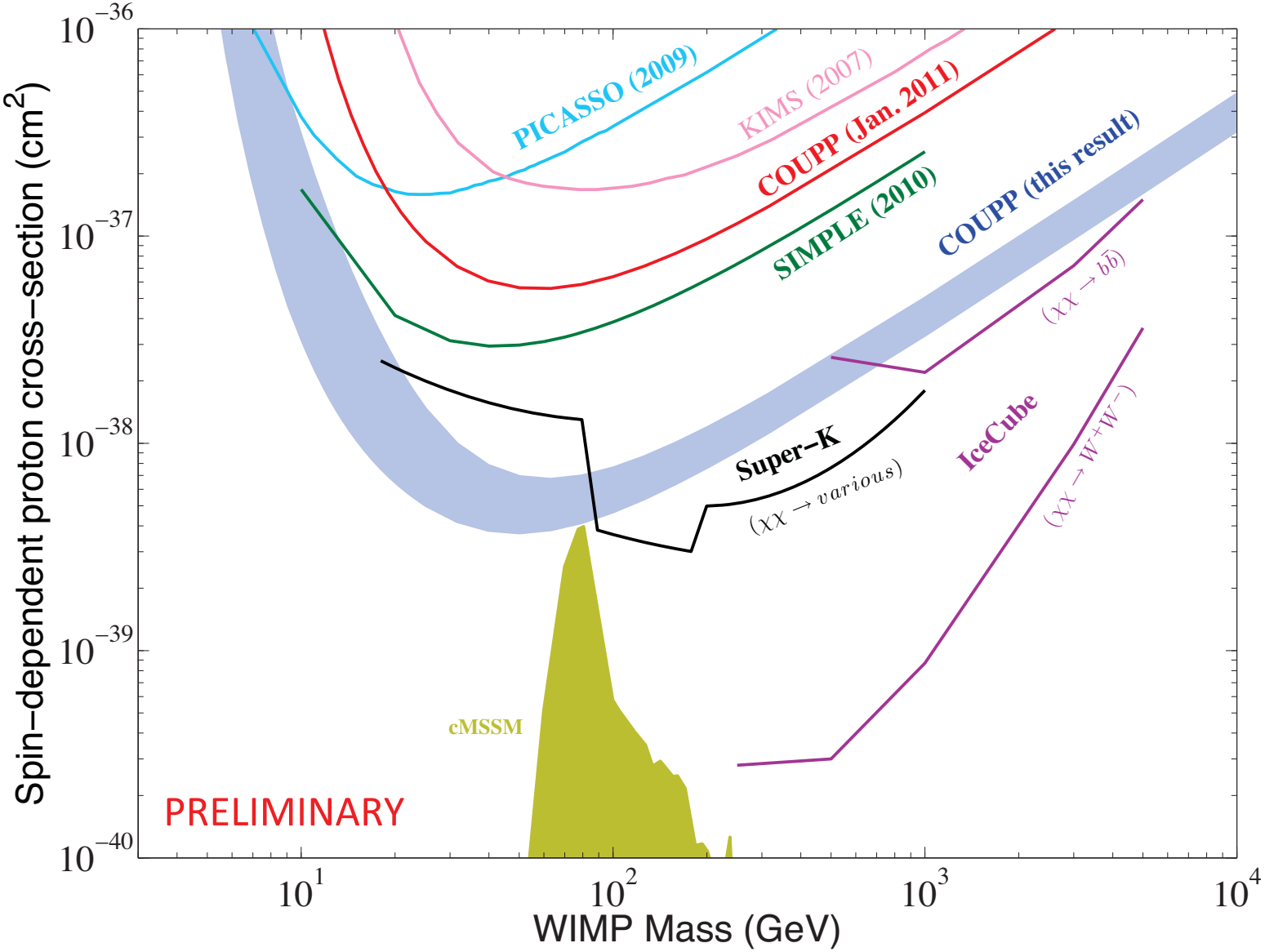
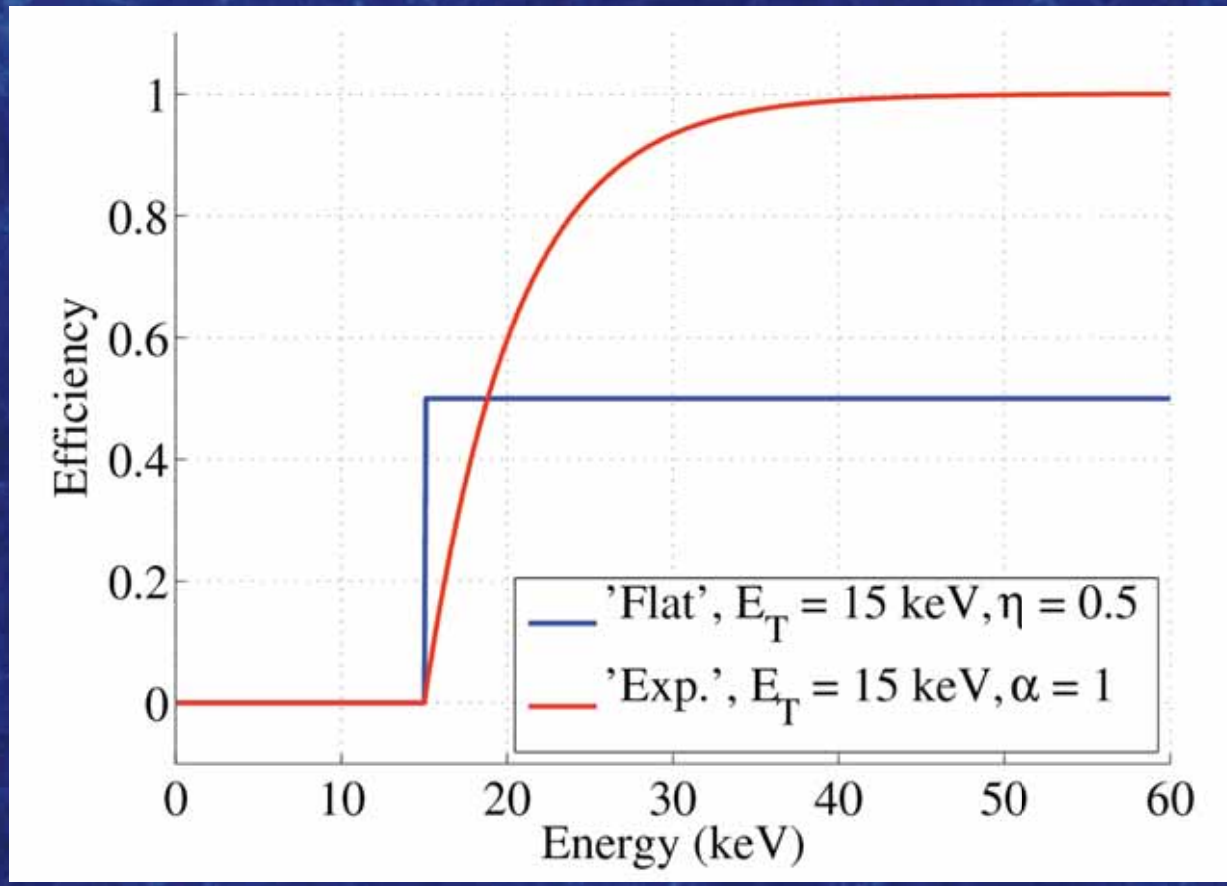


COUPP Thresholds

- Width in limit plots indicates two efficiency models for C,F to characterize our threshold systematics
  - Flat 100% efficiency used for Iodine
- Both models fit our calibration data
  - Neutron count rates ~50% of those predicted by simulations
  - Alpha data indicates ~100% efficiency for heavy nuclear recoils above the Seitz threshold



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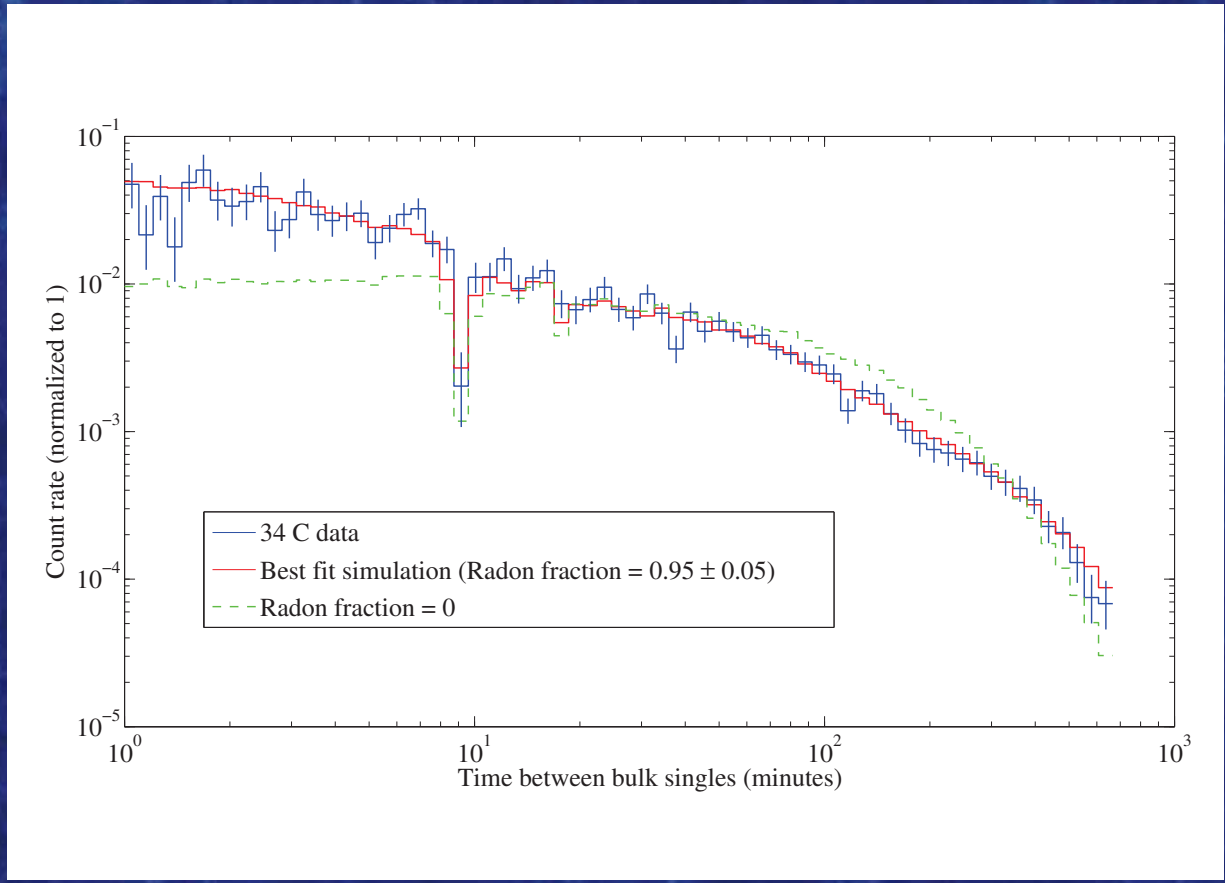

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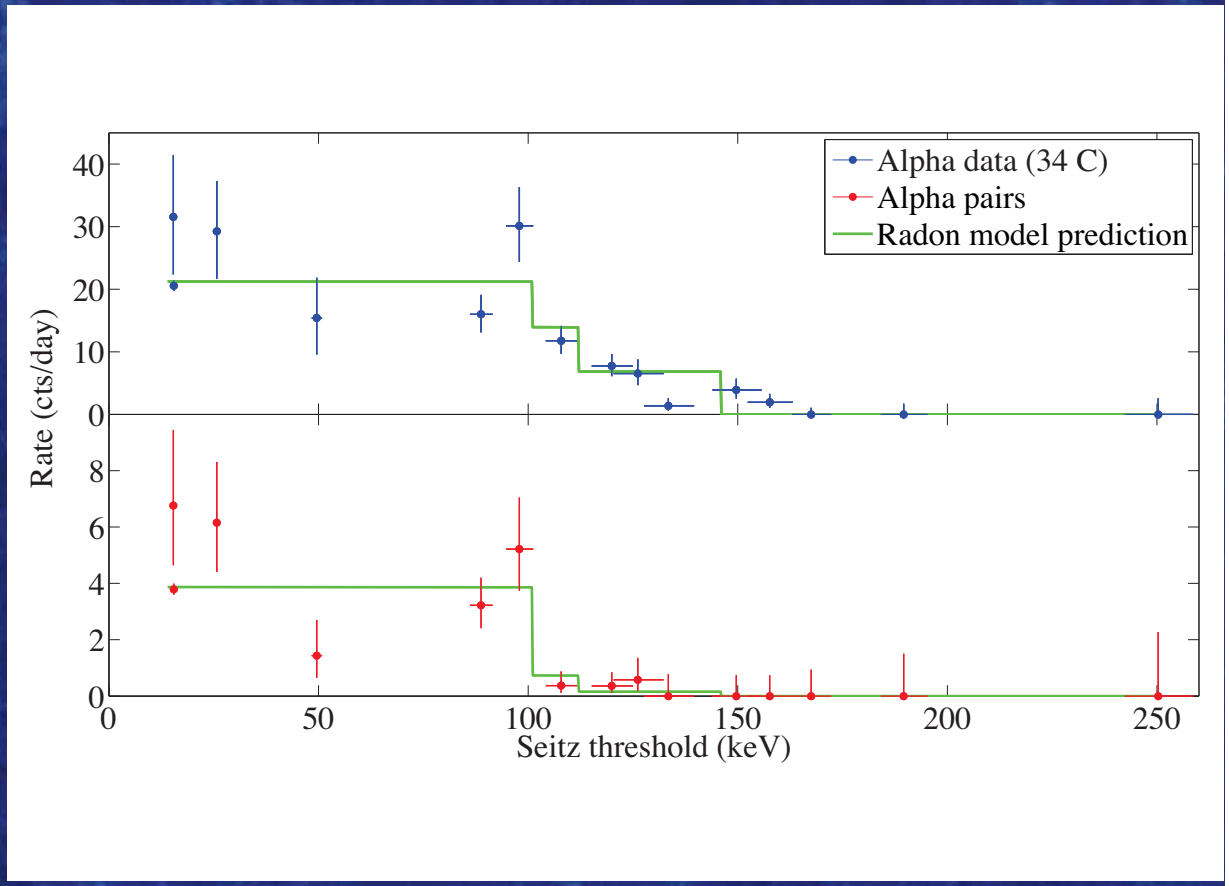

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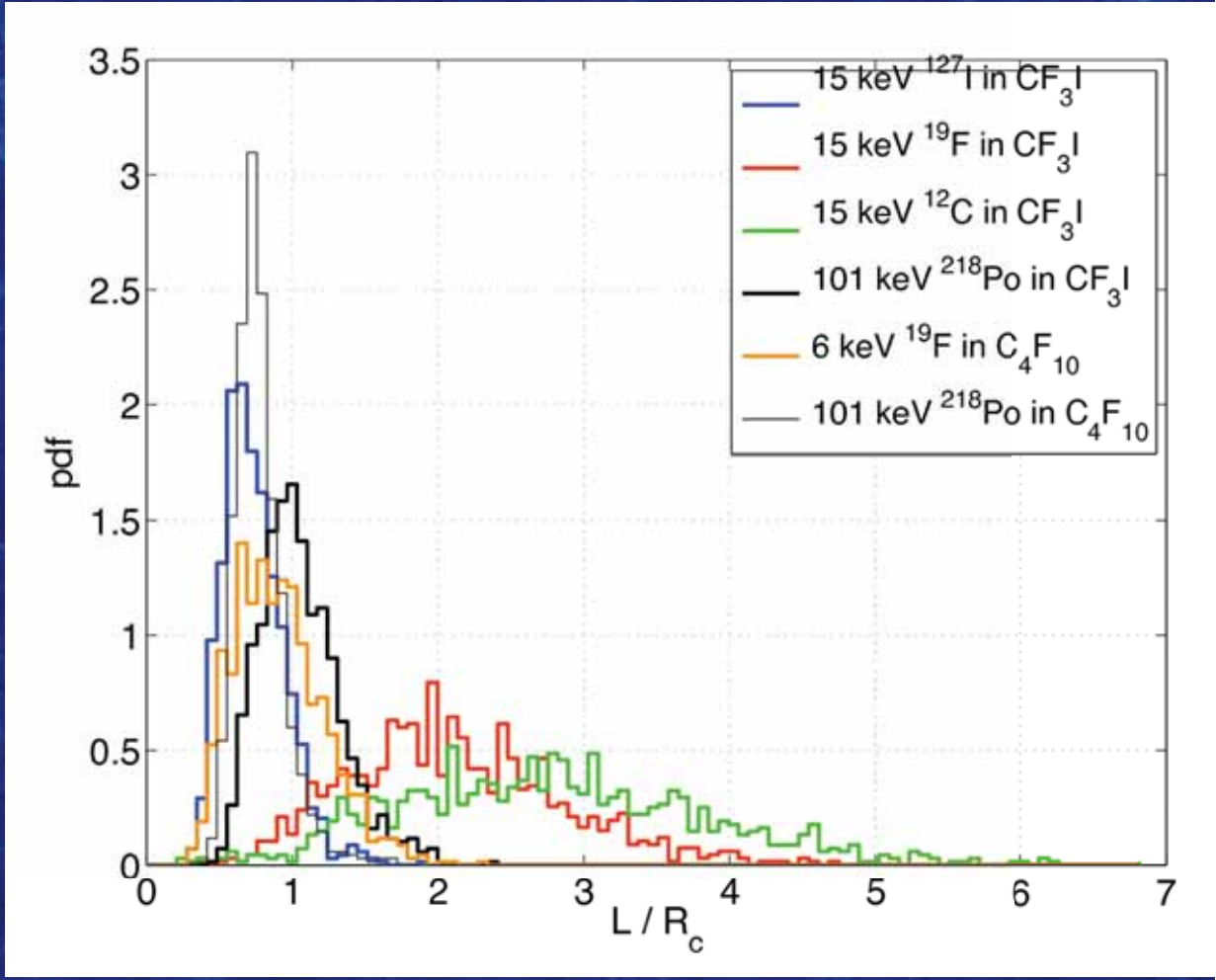
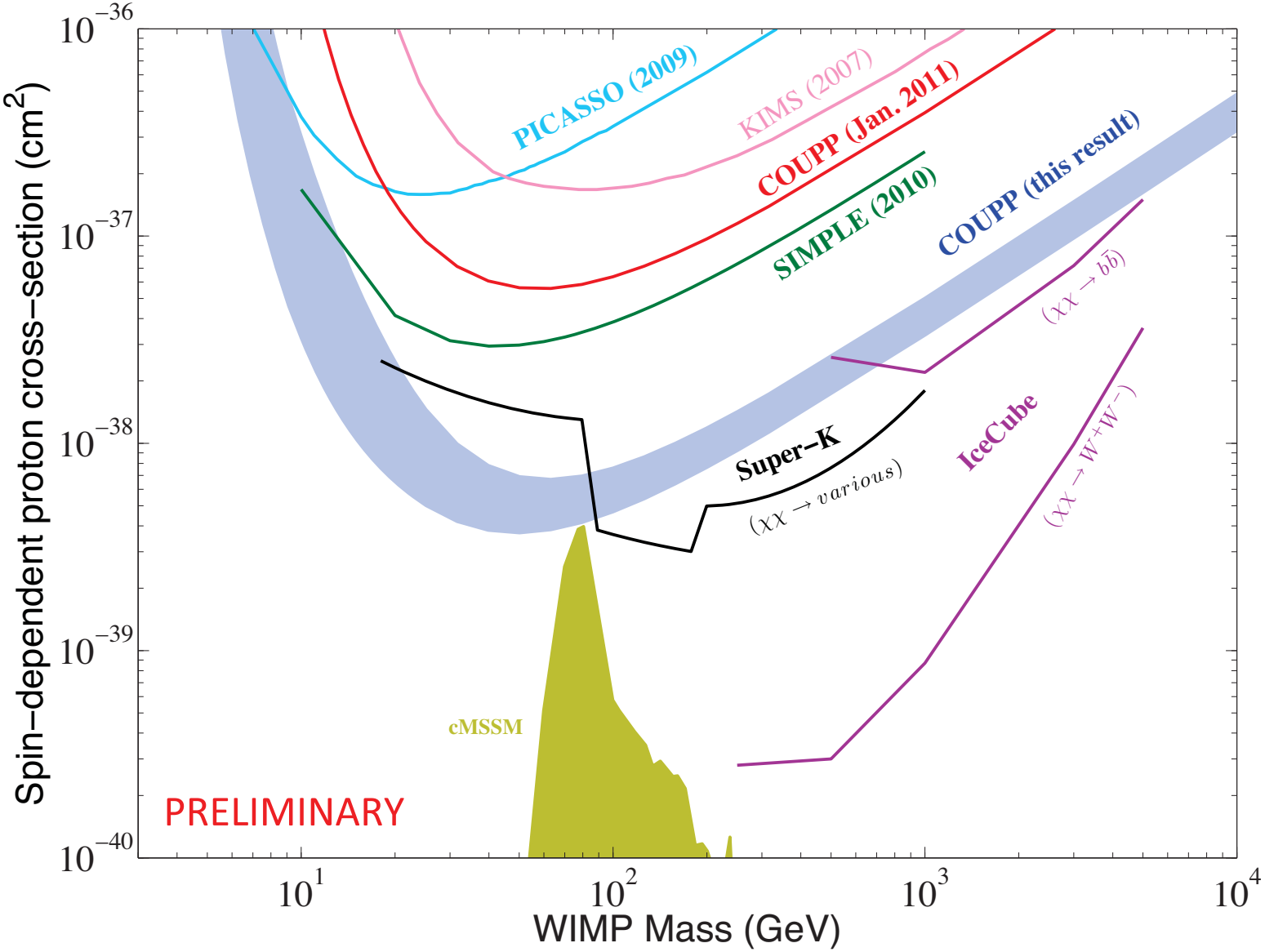


COUPP2L SNOLAB Results



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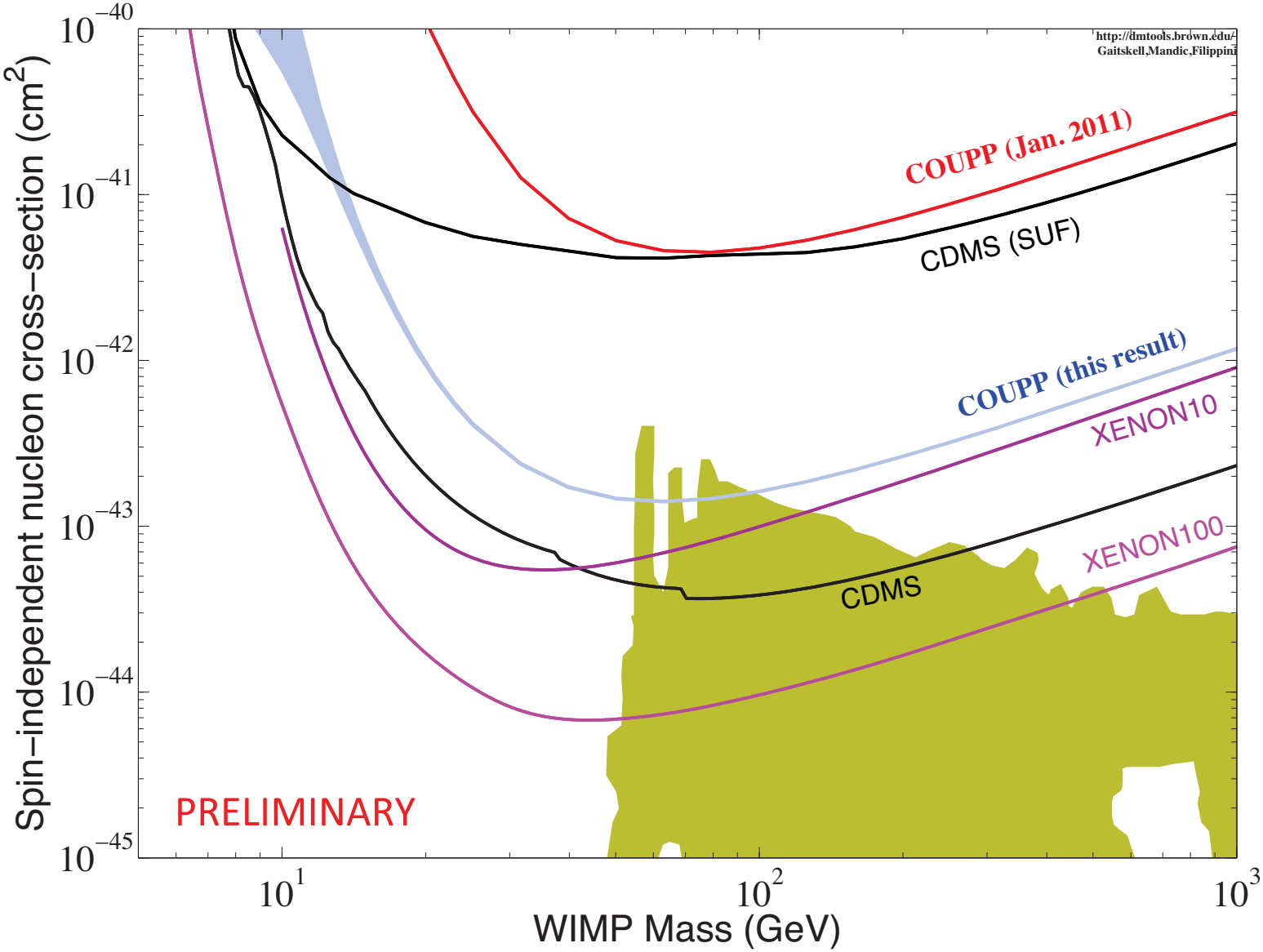
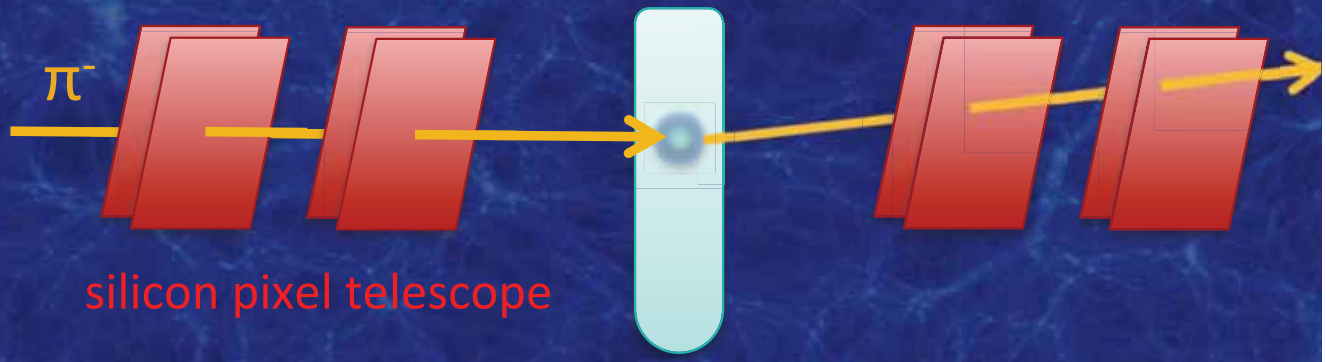
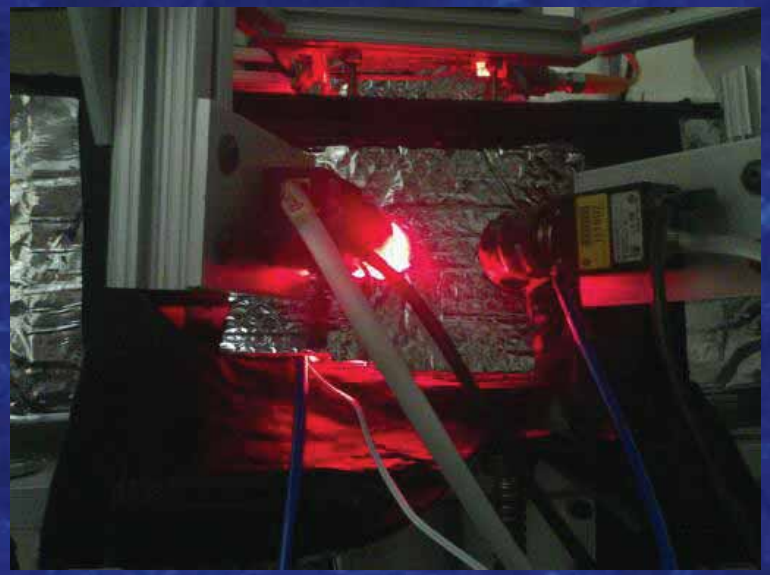


COUPP Thresholds – CIRTE at FNAL

- Better threshold and efficiency measurements are needed for COUPP chambers
- **C**OUPP **I**odine **R**ecoil **T**hreshold **E**xperiment pion scattering in the Fermilab test beam has been initiated





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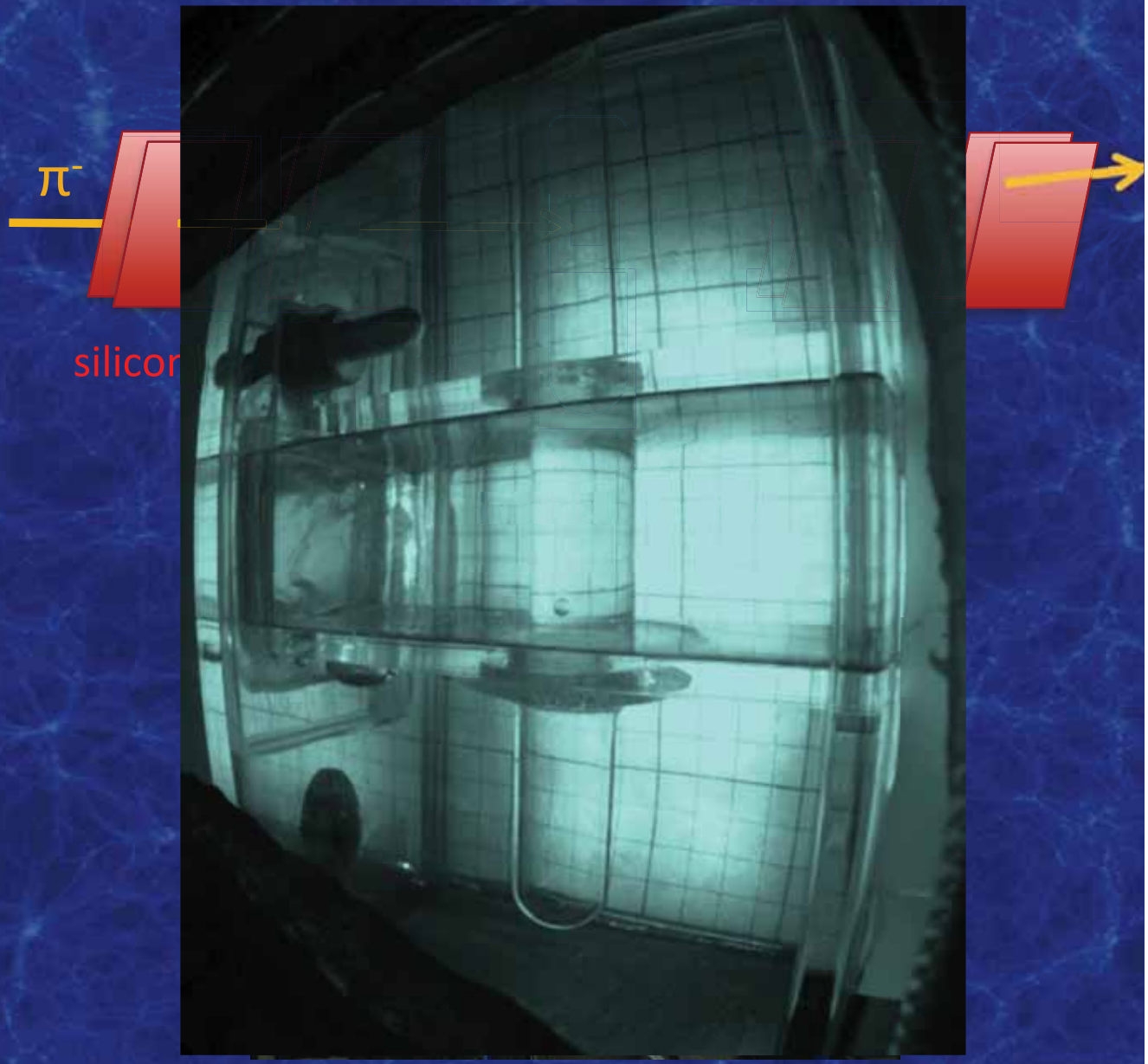
- **C**OUPP **I**odine **R**ecoil **T**hreshold **E**xperiment pion scattering in the Fermilab test beam has been initiated
- Initial 2 days of data with full silicon pixel telescope and 10 mm bubble chamber in 12 GeV pion beam
- 2 weeks beam time scheduled for March 14-27, 2012



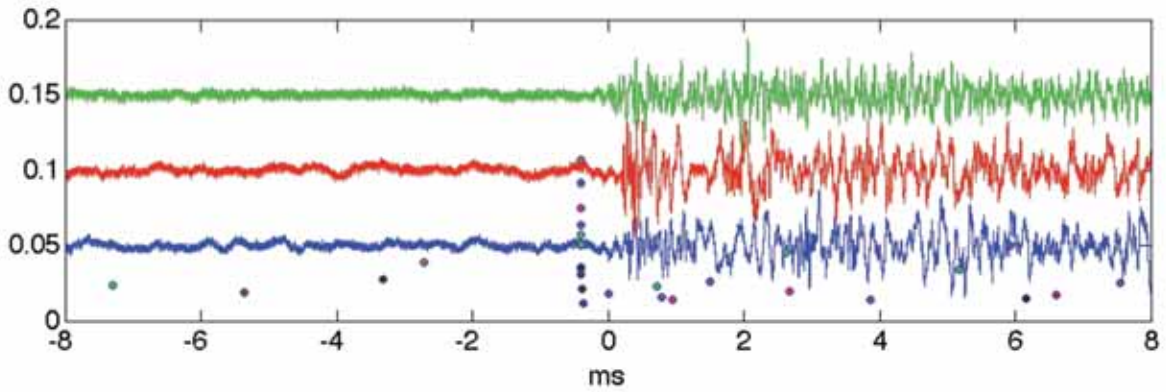
COUPP Future

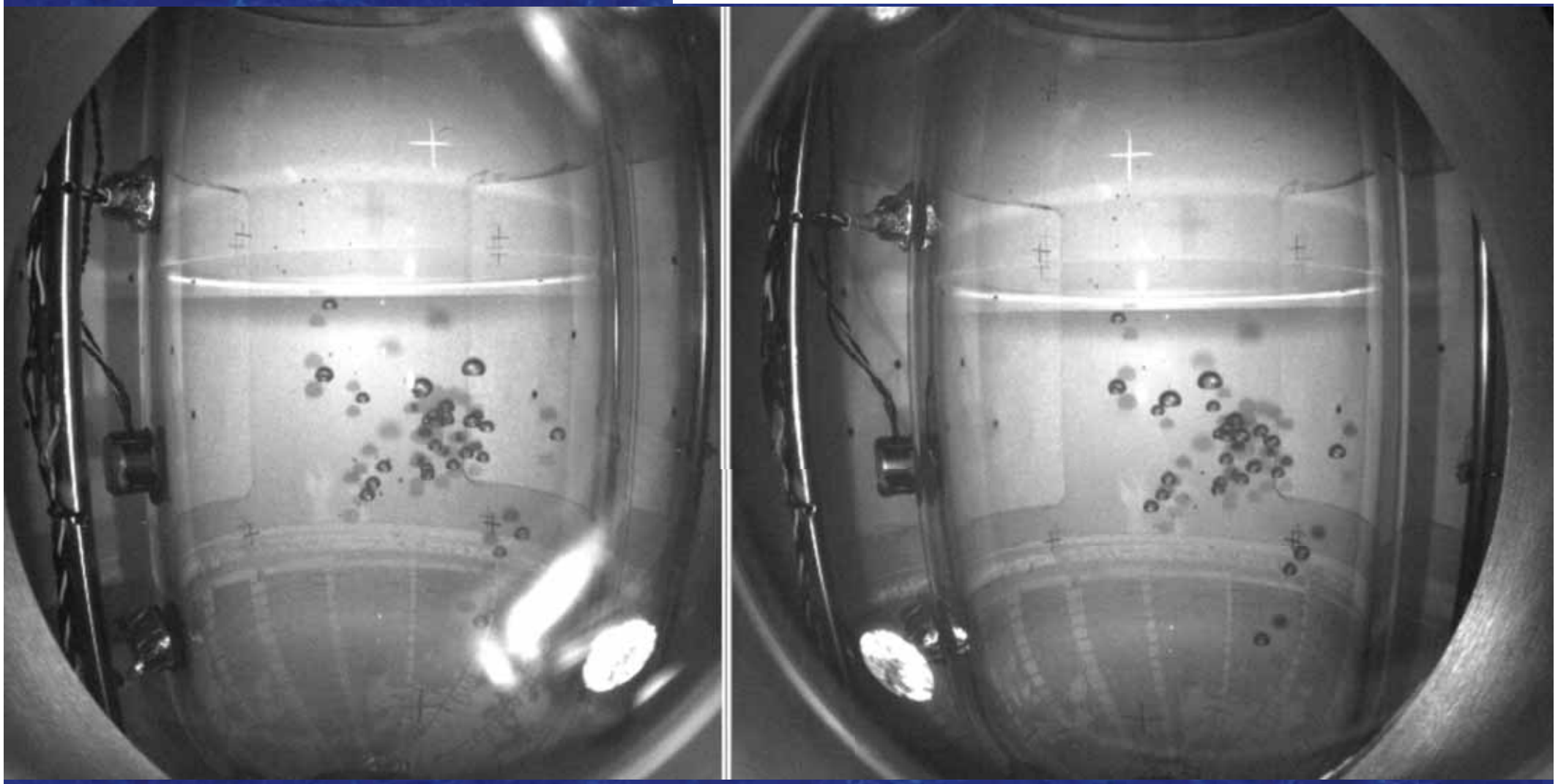
- The 4 kg vessel is being refurbished
- Known neutron sources removed
  - New piezos
  - New viewport
- CF_3I purity improved
- Run planned to start April 2012

COUPP60 Status

- 2 runs at shallow MINOS site at FNAL (300 mwe)
- System understood and shipping to SNOLAB
- Lessons learned from COUPP4 impacting the pressure vessel, acoustic sensors, and viewports
- Installation planned for Summer 2012

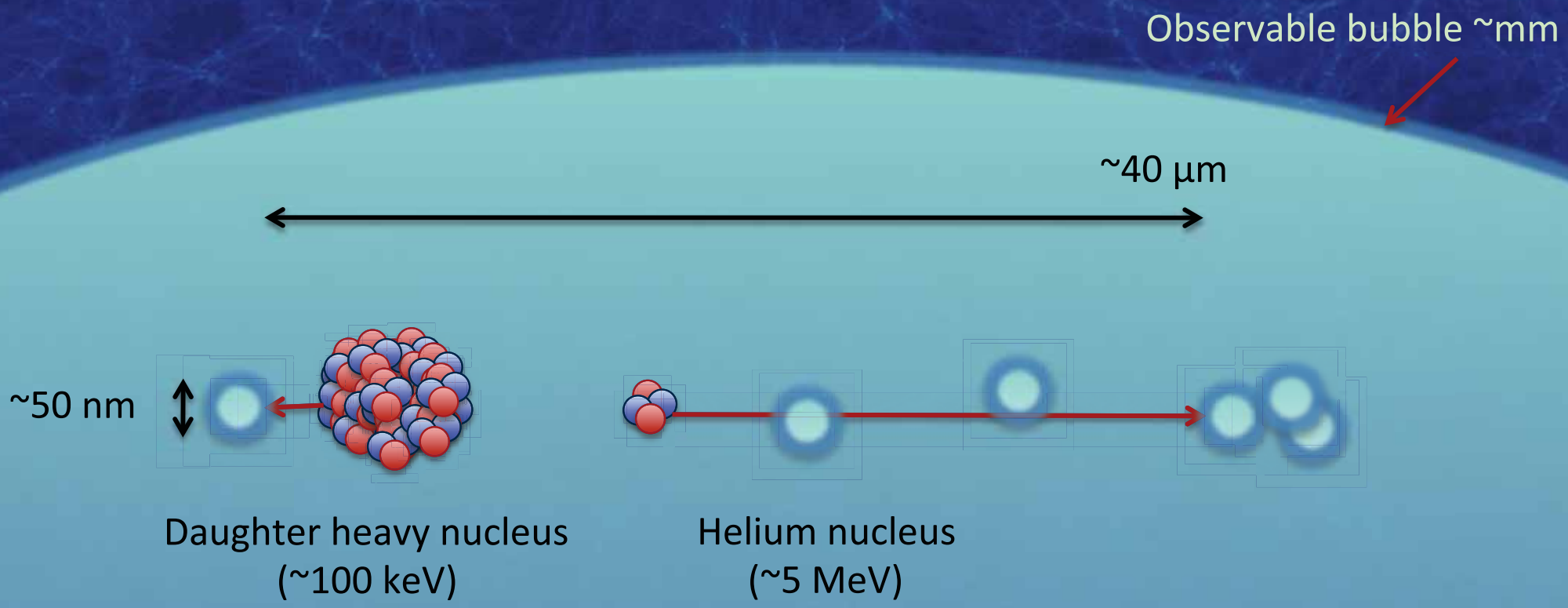
The End





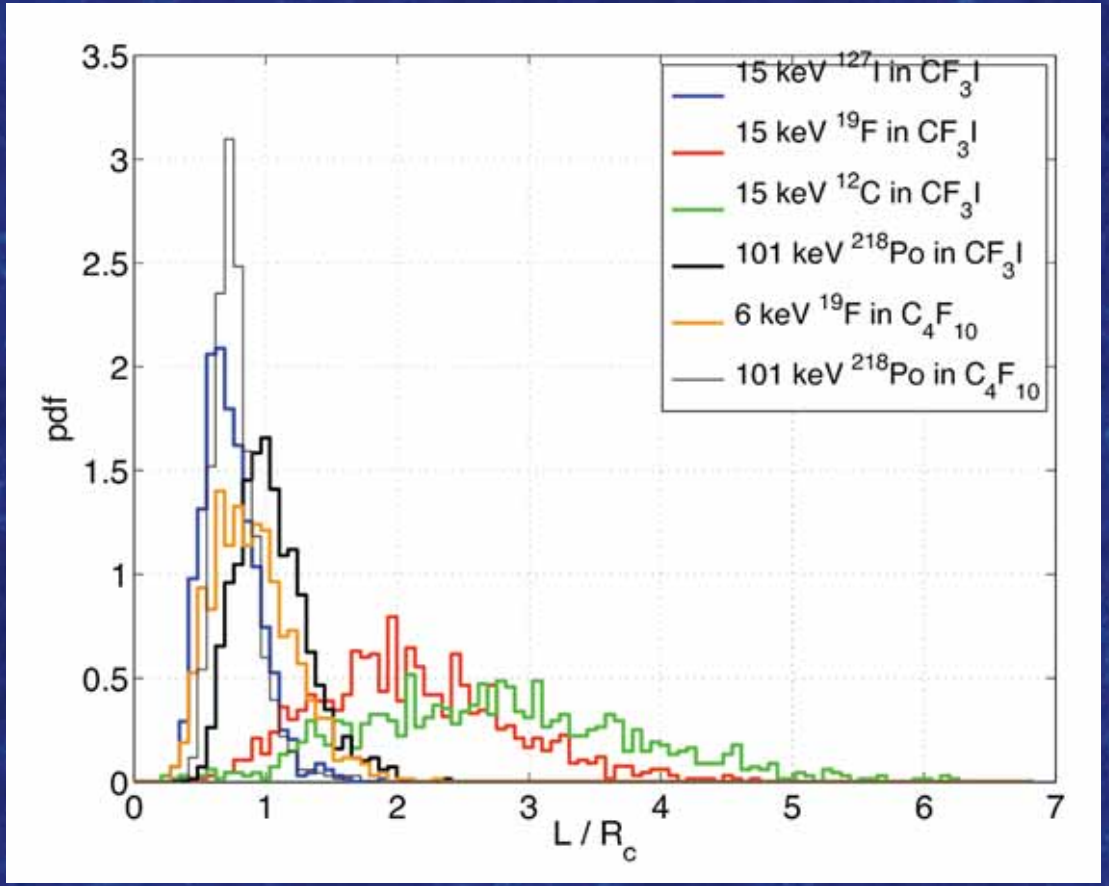
Acoustic Discrimination

- Alpha/Nuclear recoil discrimination based on acoustic power demonstrated at 10:1 level in 2011



COUPP Thresholds

- Track lengths for C,F are significantly larger than the critical radius for bubble nucleation in CF_3I
- I, Po in CF_3I have track lengths smaller than the critical radius
- F in C_4F_{10} also have track lengths shorter than the critical radius



COUPP60 Darkening

Significant darkening after 25 days

No significant darkening after 50days

- Optical photons can destroy the C-I bond leading to a red solute in COUPP chambers
- We observed no significant darkening in a two month run of COUPP60