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Upcoming Results from the PICO-60 Dark Matter Search

Dan Baxter

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PICO



E. Vázquez-Jáuregui



C. Amole, G. Giroux,
A. Noble, S. Olson



Pacific Northwest
NATIONAL LABORATORY
D.M. Asner, J. Hall



K. Clark, I. Lawson



UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA

M. Ardid, M. Bou-Cabo, I. Felis



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



P. Bhattacharjee,
M. Das, S. Seth



INDIANA UNIVERSITY
SOUTH BEND

E. Behnke, H. Borsodi, O.
Harris, A. LeClair, I. Levine, A.
Roeder



R. Neilson



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



S. Fallows, C. Krauss,
P. Mitra



CZECH TECHNICAL
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IN PRAGUE

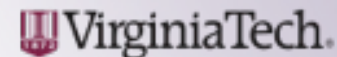
R. Filgas, I. Stekl



J.I. Collar,
A. Ortega



F. Debris, M. Fines-
Neuschild, C.M. Jackson,
M. Lafrenière, M. Laurin, J.-
P. Martin, A. Plante,
N. Starinski, V. Zacek



D. Maurya, S. Priya

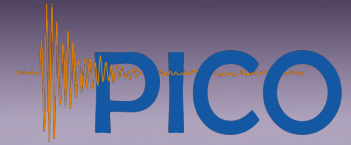


J. Farine, F. Girard,
A. Le Blanc, R. Podvyanuk,
O. Scallon, U. Wichoski



Bubble Chambers

located in SNOLAB



PICO-2L

100 kg-day exposures

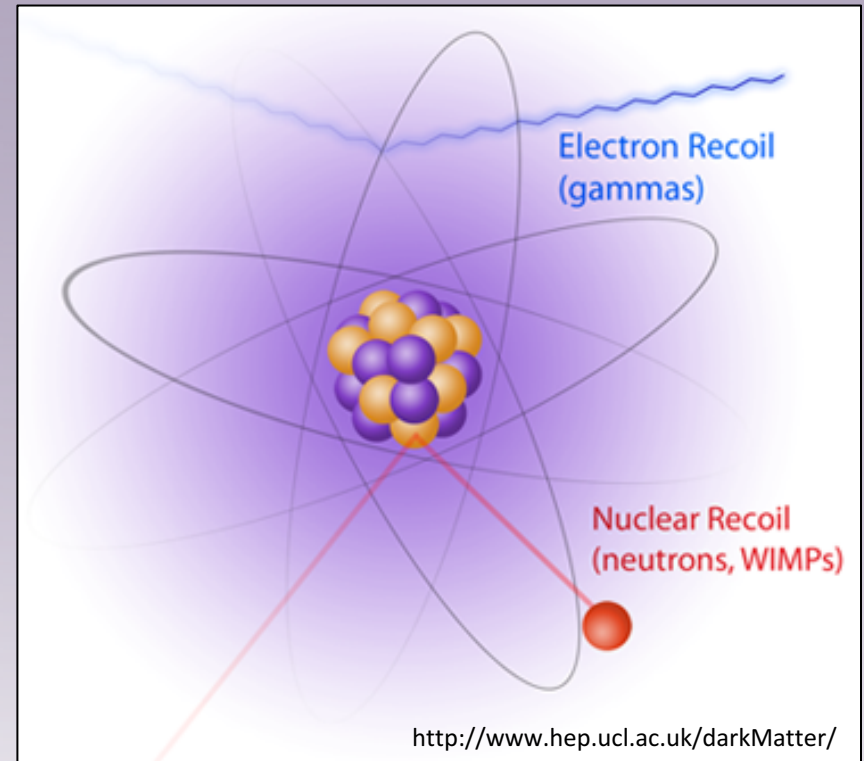
PICO-60
ton-day exposures





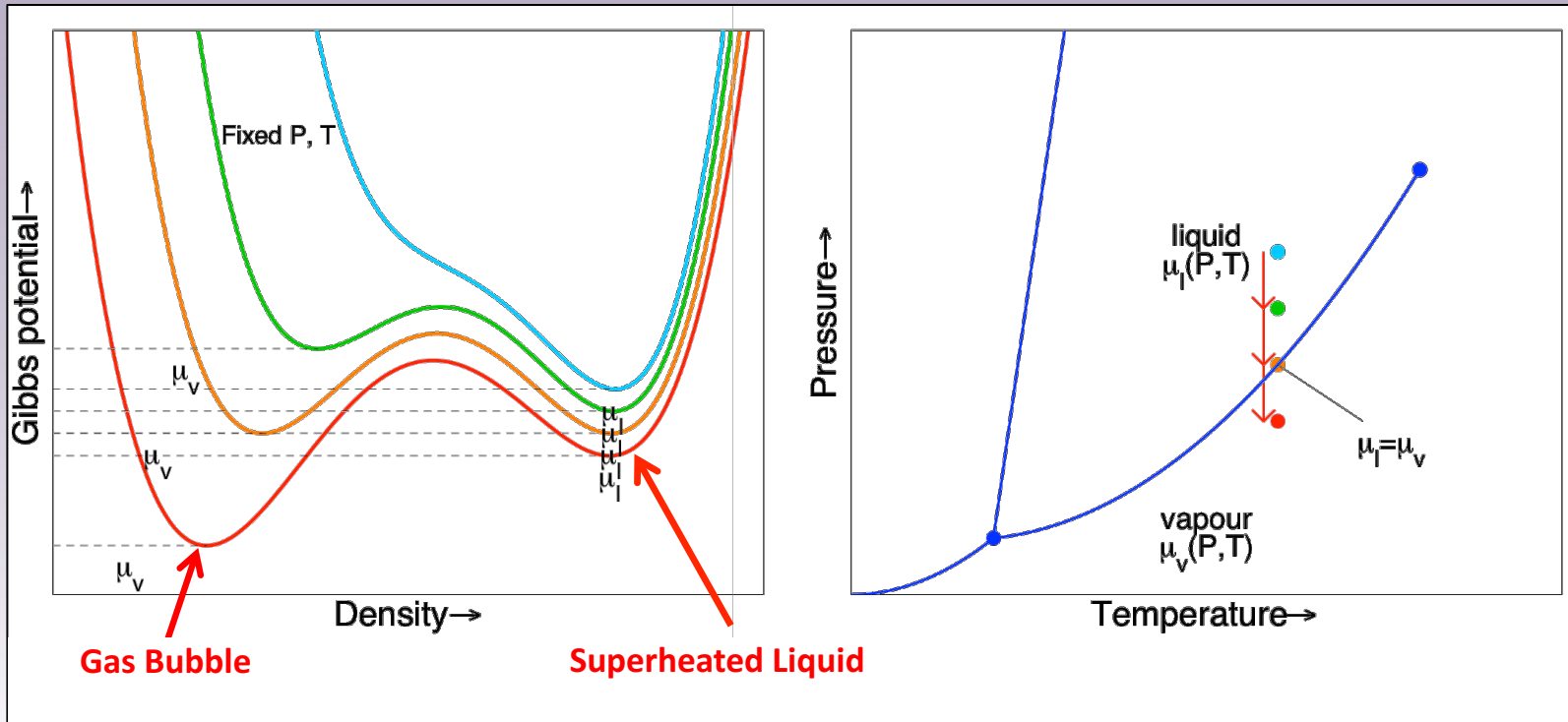
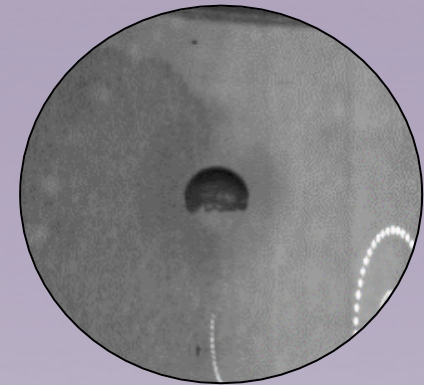
Dark Matter Detection

- Galactic dark matter may scatter with ordinary nuclei
- Interaction is rare
 - $\sigma < 10^{-40} \text{ cm}^2$
- Energy transfer is small
 - 1-100 keV
- Exact interaction is unknown
- Need to reject radioactive backgrounds



Bubble Chambers

- Superheat a fluid by lowering pressure under constant temperature
- Metastable state awaits energy deposition
- Interaction nucleates small gas pocket that grows
- Trigger on bubble with cameras
- Detector expanded 80% of the time

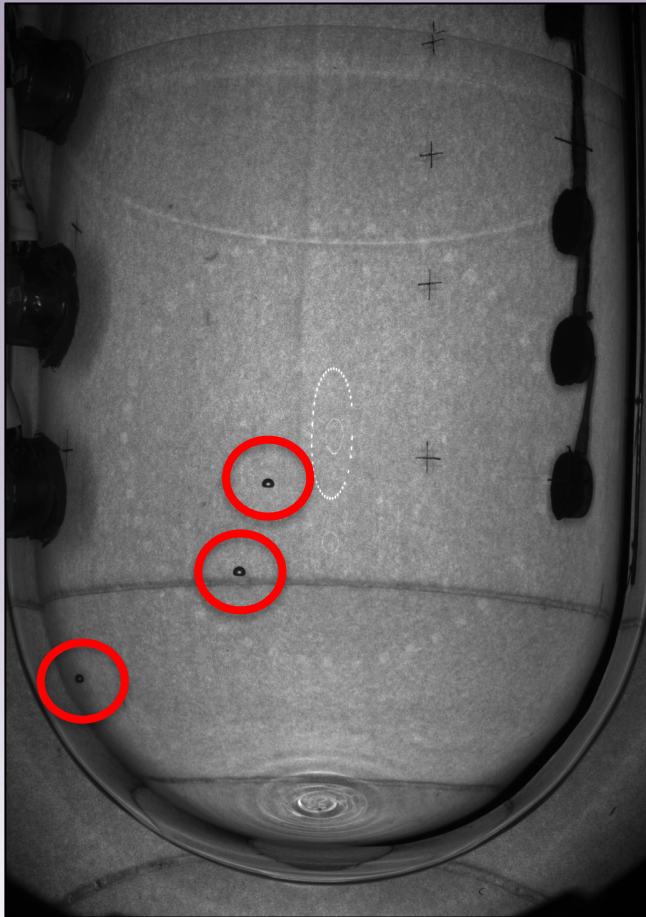




Detector Backgrounds

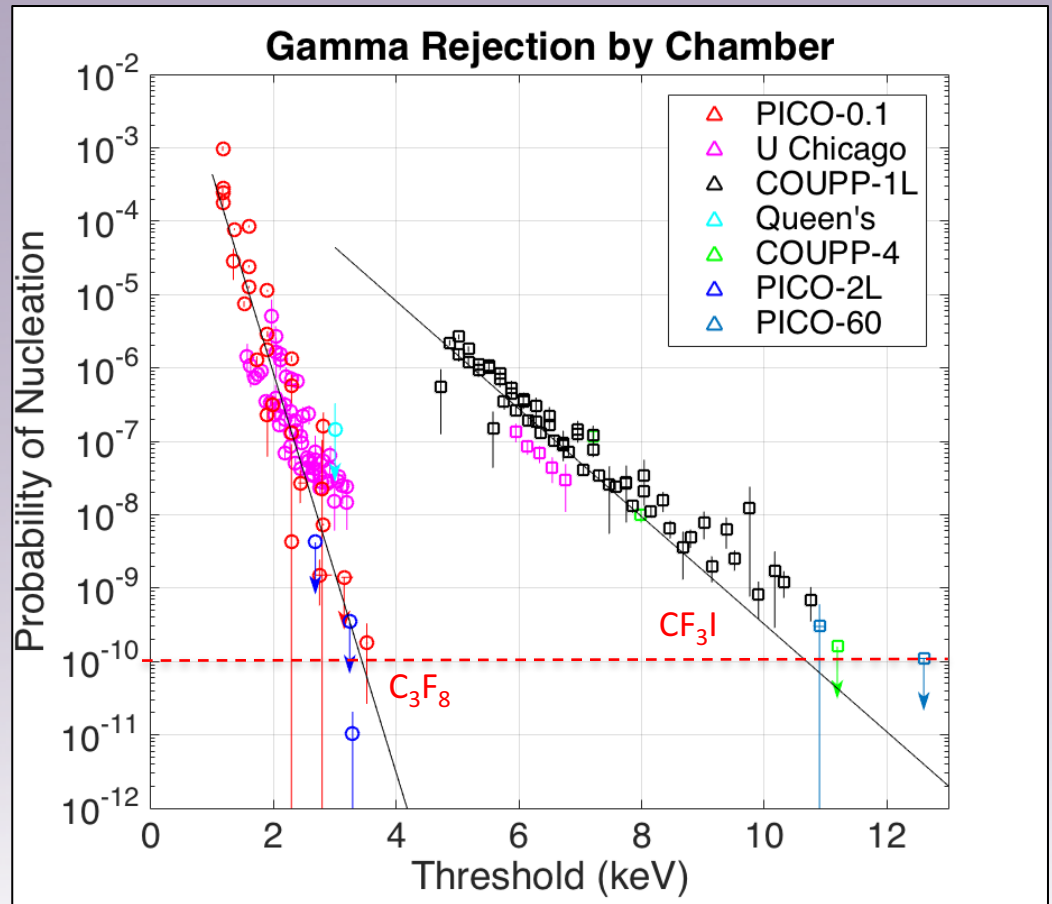
Neutrons

Rate Measured by multiple bubble events



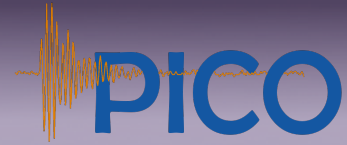
Electron Recoils

Tune threshold such that they do not make bubbles

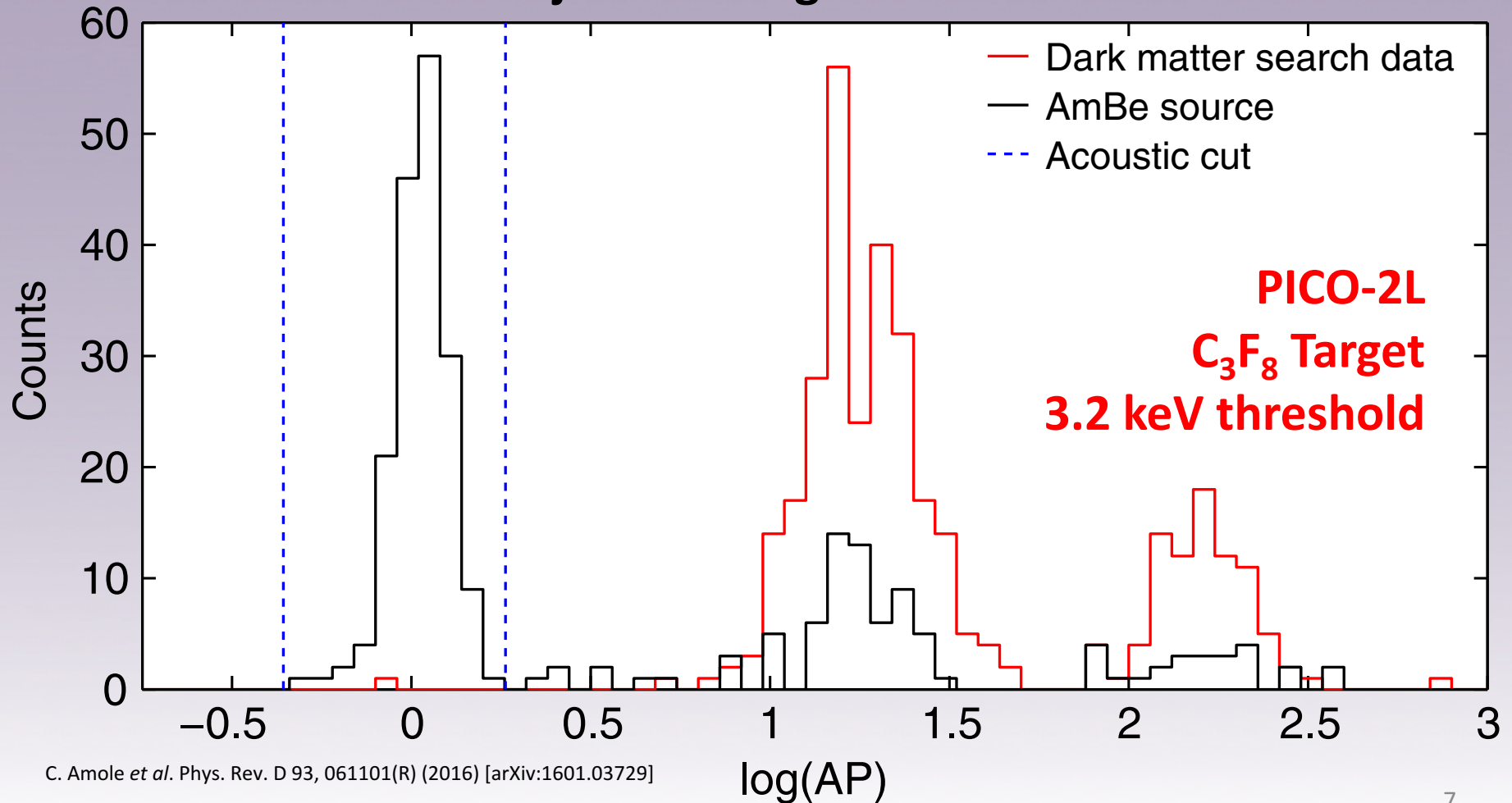




Alpha Background Discrimination

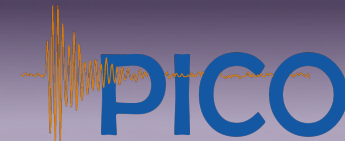


Rejected Using Acoustics

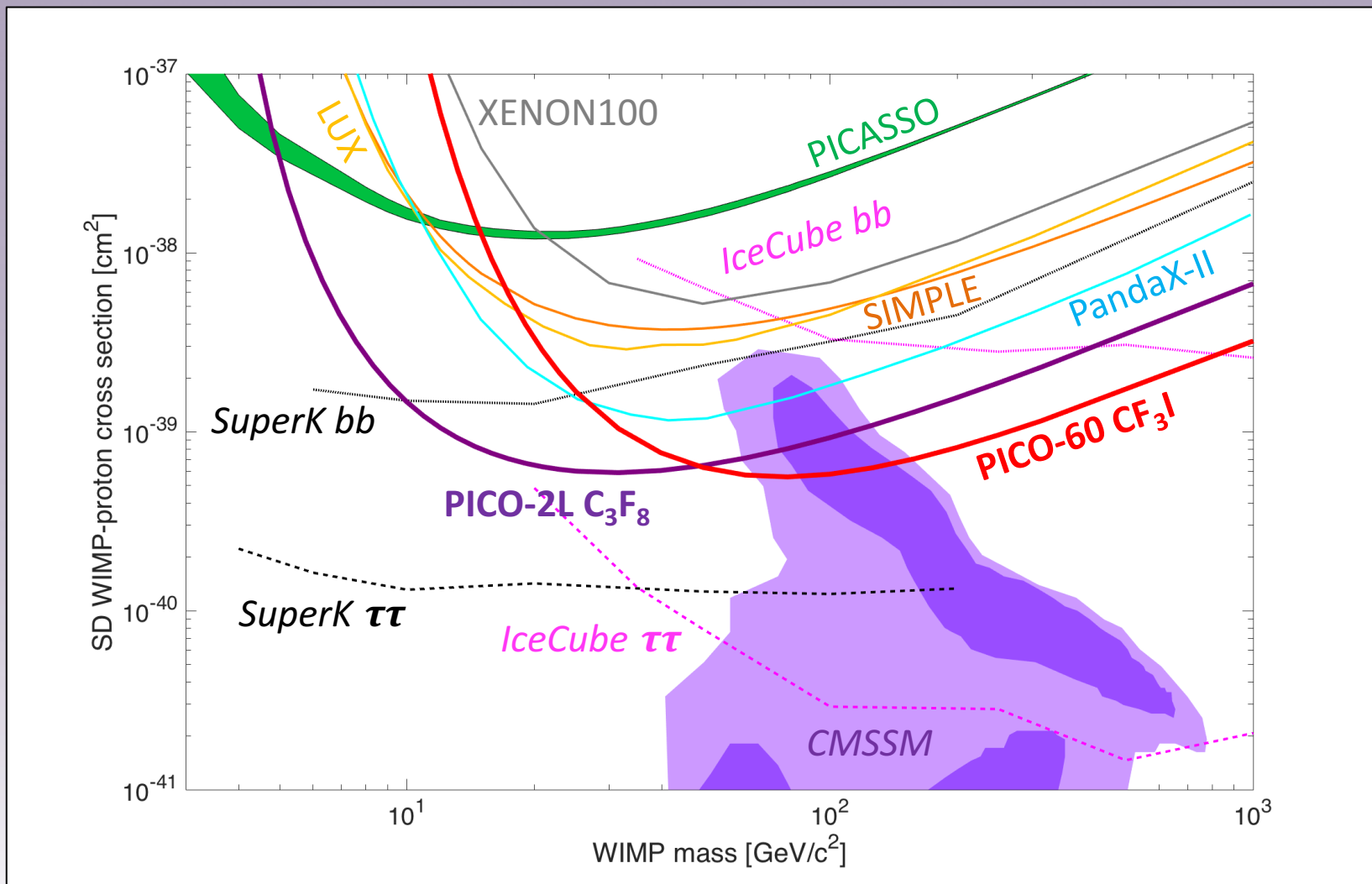




Previous Results

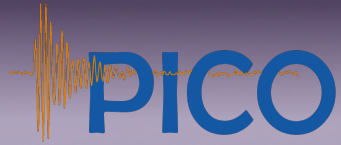


Spin-dependent WIMP-proton coupling

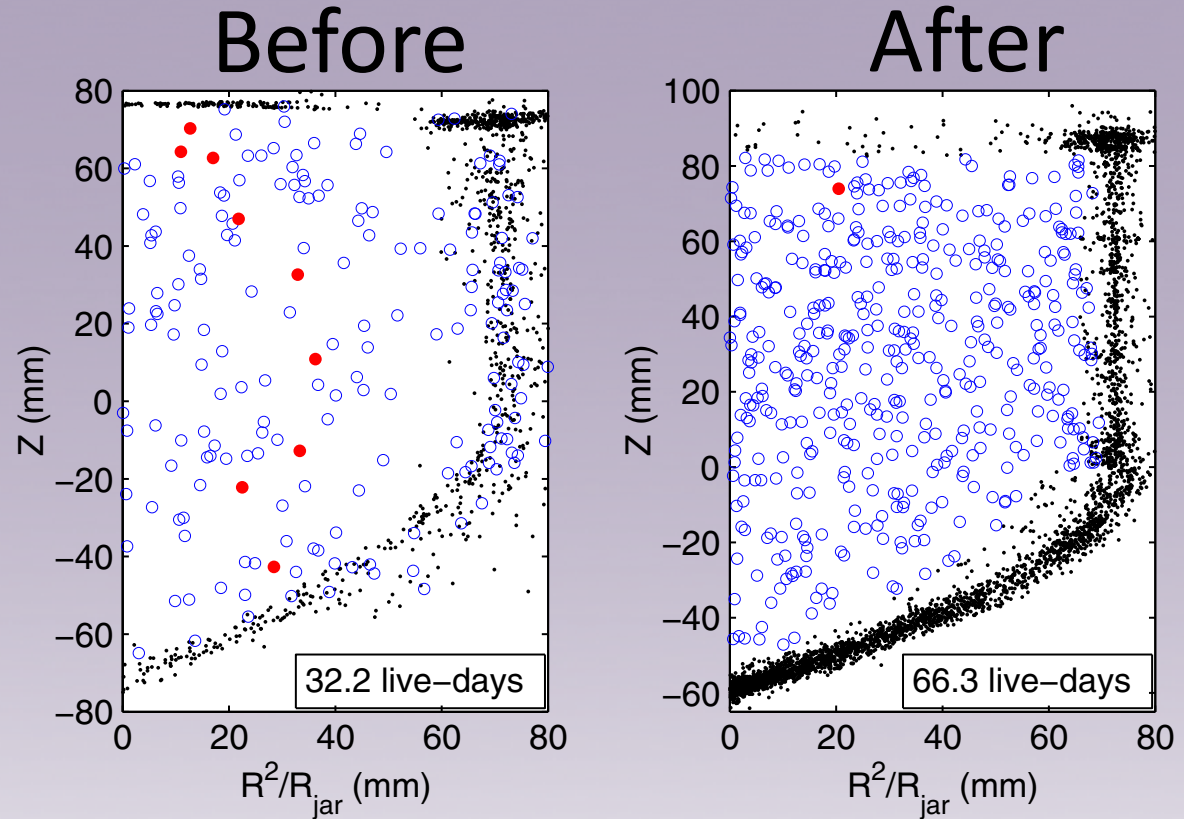




Anomalous Background



- PICO-2L Run1
 - 9 candidate events in 32 live-days at 3.2keV
 - Inconsistent with known radioactive backgrounds
- PICO-2L Run2
 - 1 candidate event in 66 live-days at 3.2keV
 - Consistent with neutron expectations
- Between runs, the detector was cleaned of particulate contamination
- First run of PICO-60 was also background limited

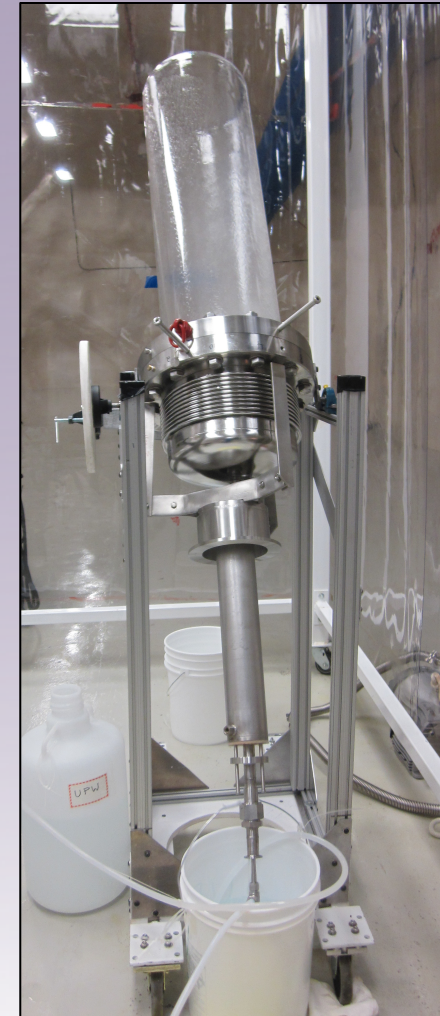
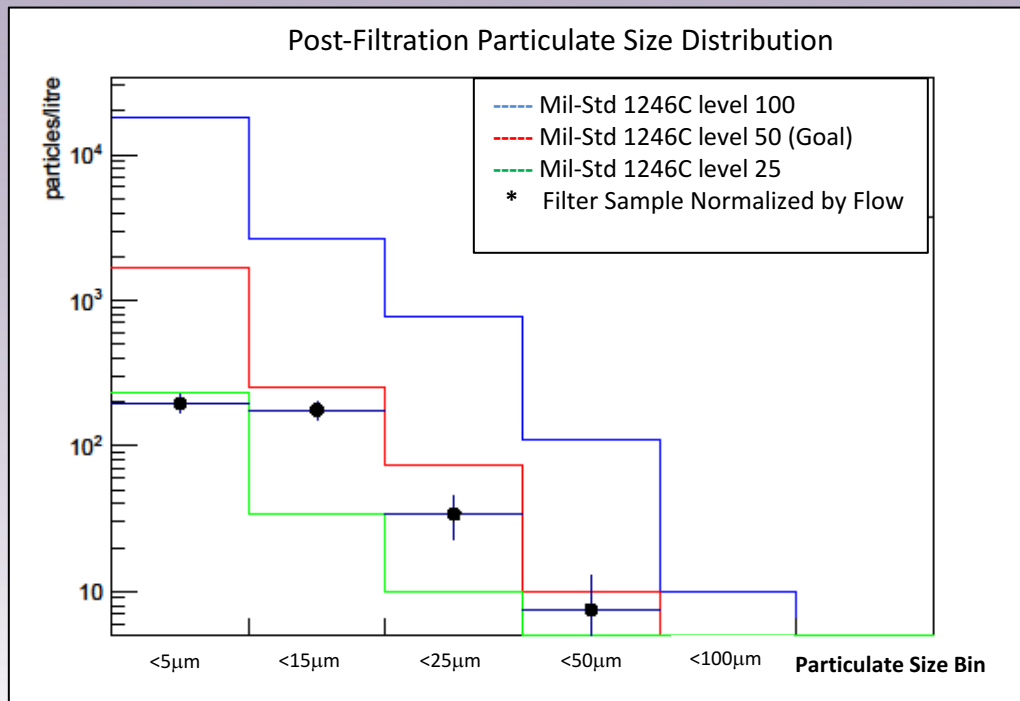


C. Amole *et al.* Phys. Rev. D 93, 061101(R) (2016) [arXiv:1601.03729]

Hypothesis: combination of particulate matter and water leads to anomalous nucleation mechanism

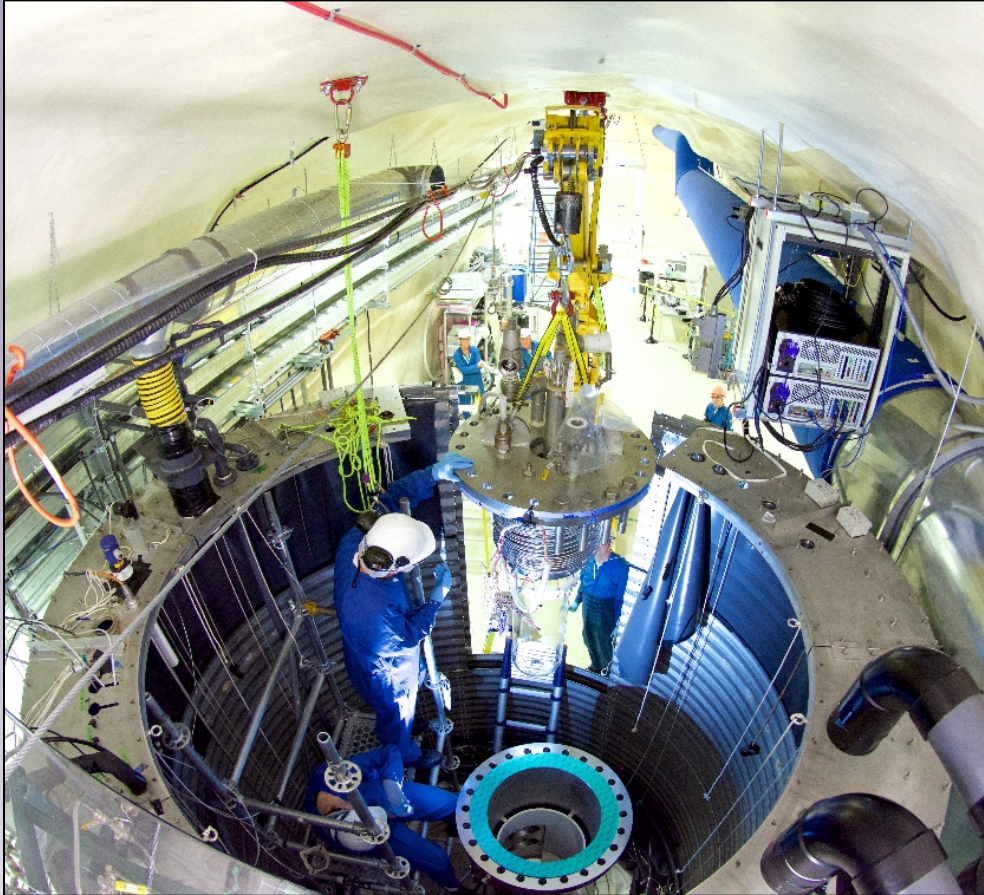
PICO-60 Recommissioning

- Every component touching the inner volume was cleaned against MIL-STD-1246C level 50





Commissioning



- Filled with 40L C_3F_8 on June 30, 2016



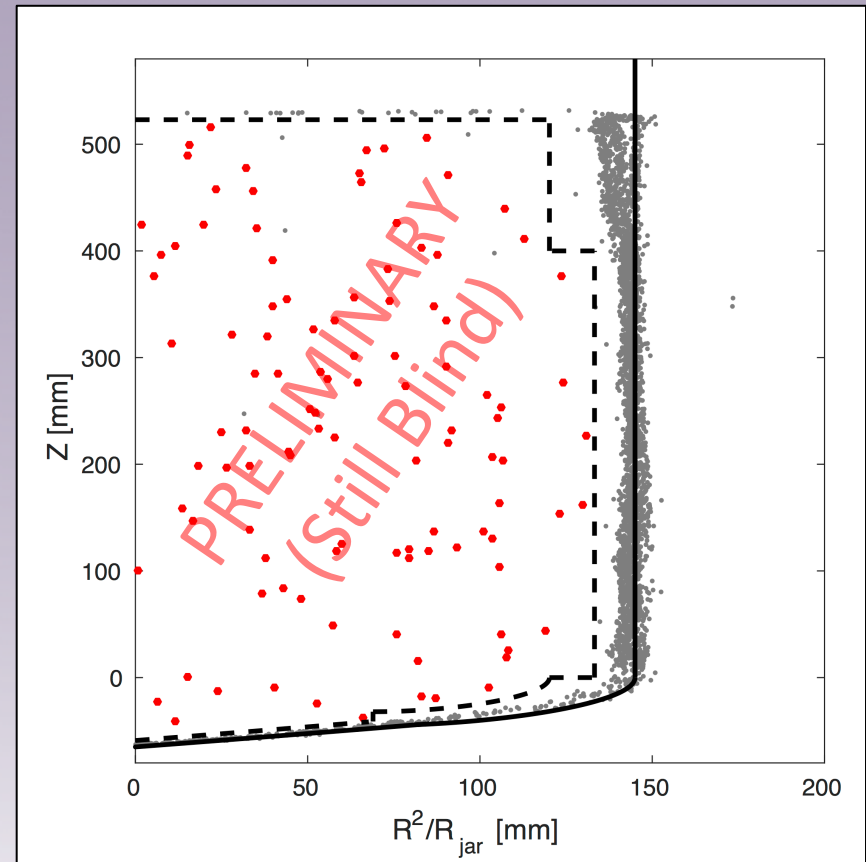
First Run with C3F8

- Physics run: Nov 28, 2016 – Jan 13, 2017
 - *Blinded acoustic analysis*
 - Renders alpha decays (from radon) and WIMP candidates indistinguishable
- Fiducial mass: 45.7 kg
- Total live-time: 30.0 days
- WIMP selection efficiency: 85.1%
 - Dominated by acoustic cuts
- **Final exposure: 1.3 ton-days**
 - Factor of 9 improvement over PICO-2L



Before Opening the Box

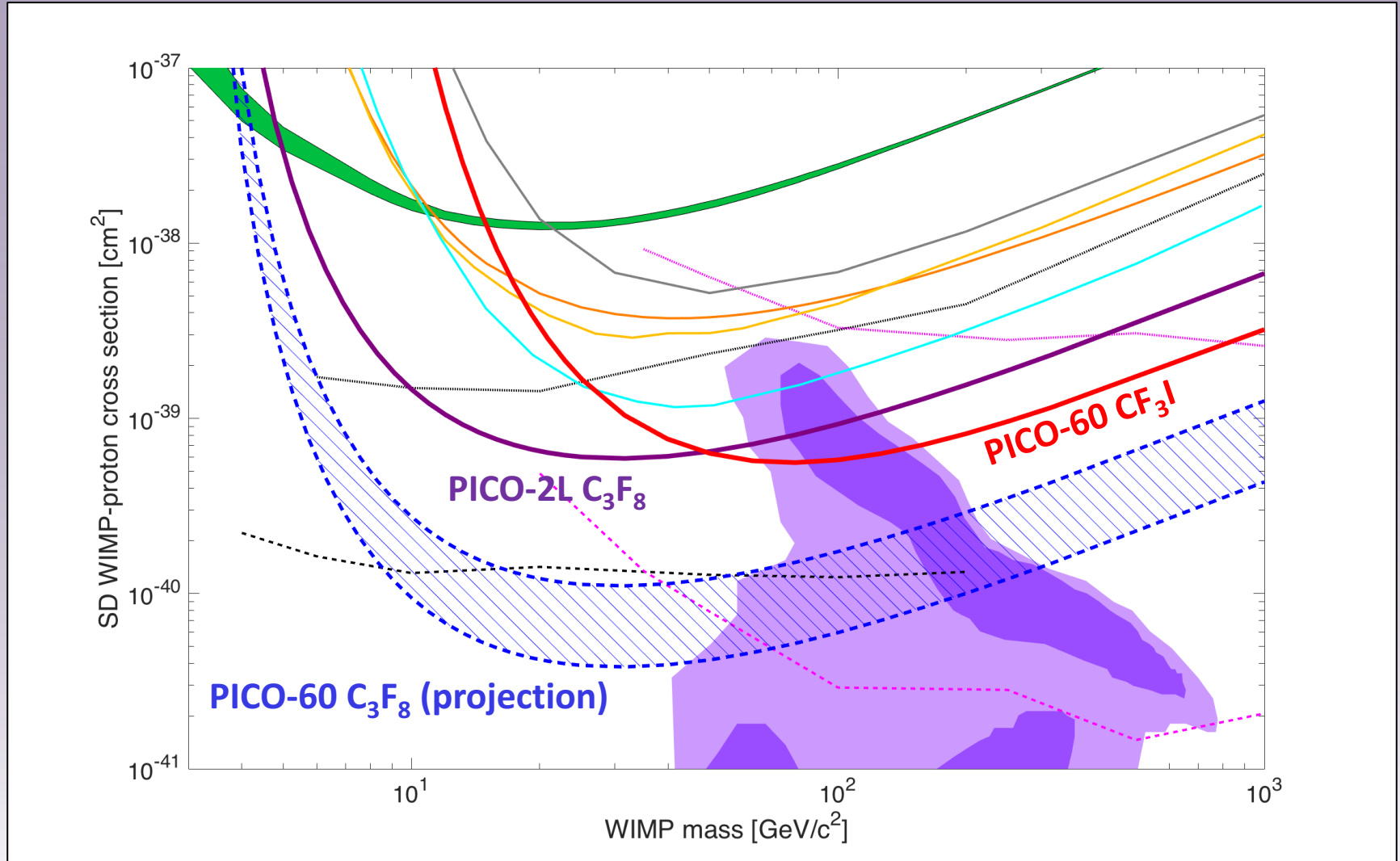
- 106 bulk singles in WIMP search dataset
 - *Acoustics Still Blind*
 - Consistent with Rn decay rate
- Neutron Background
 - Not blinded to multiplicity
 - 3 multiple bubbles in the physics data
 - Multiples to singles ratio is approximately 3:1
- **Conclusion: 0-3 bulk singles would be consistent with neutrons and no anomalous background**





Spin-Dependent Projections

for 0 to 3 events consistent with neutron expectations





Acknowledgements

- Support:

- US Department of Energy Office of Science Graduate Student Research (SCGSR) Award



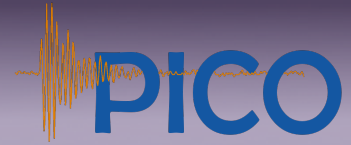
- SNOLAB, the National Sciences and Engineering Research Council of Canada (NSERC), the Canada Foundation for Innovation (CFI), the National Science Foundation (NSF) (Grant 1506337, 1242637 and 1205987), U.S. Department of Energy (DOE) Office of Science, Office of High Energy Physics (under award DE-SC-0012161), the Department of Atomic Energy (DAE), DGAPA-UNAM through grant PAPIIT No. IA100316, CONACyT (Mexico) through grant No. 252167, the Government of India, under the Center of AstroParticle Physics II project (CAPP-II) at SAHA Institute of nuclear Physics (SINP), the Czech Ministry of Education, Youth and Sports (Grant LM2015072) and the the Spanish Ministerio de Economía y Competitividad, Consolider MultiDark (Grant CSD2009-00064), Fermi National Accelerator Laboratory (Contract No. De-AC02-07CH11359), and Pacific Northwest National Laboratory, which is operated by Battelle for the U.S. Department of Energy under Contract No. DE-AC05-76RL01830.

- Papers:

- C. Amole *et al.* (PICO Collaboration), *Dark Matter Search Results from the PICO-60 CF₃I Bubble Chamber*, Phys. Rev. D **93**, 052014, Published: 28 March 2016, [arXiv:1510.07754].
- C. Amole *et al.* (PICO Collaboration), *Improved Dark Matter Search Results from PICO-2L Run-2*, Phys. Rev. D **93**, 061101(R), Published: 21 March 2016, [arXiv:1601.03729].
- C. Amole *et al.* (PICO Collaboration), *Dark Matter Search Results from the PICO-2L C₃F₈ Bubble Chamber*, Phys. Rev. Lett. **114**, 231302, Published: 11 June 2015 [arXiv:1503.00008].



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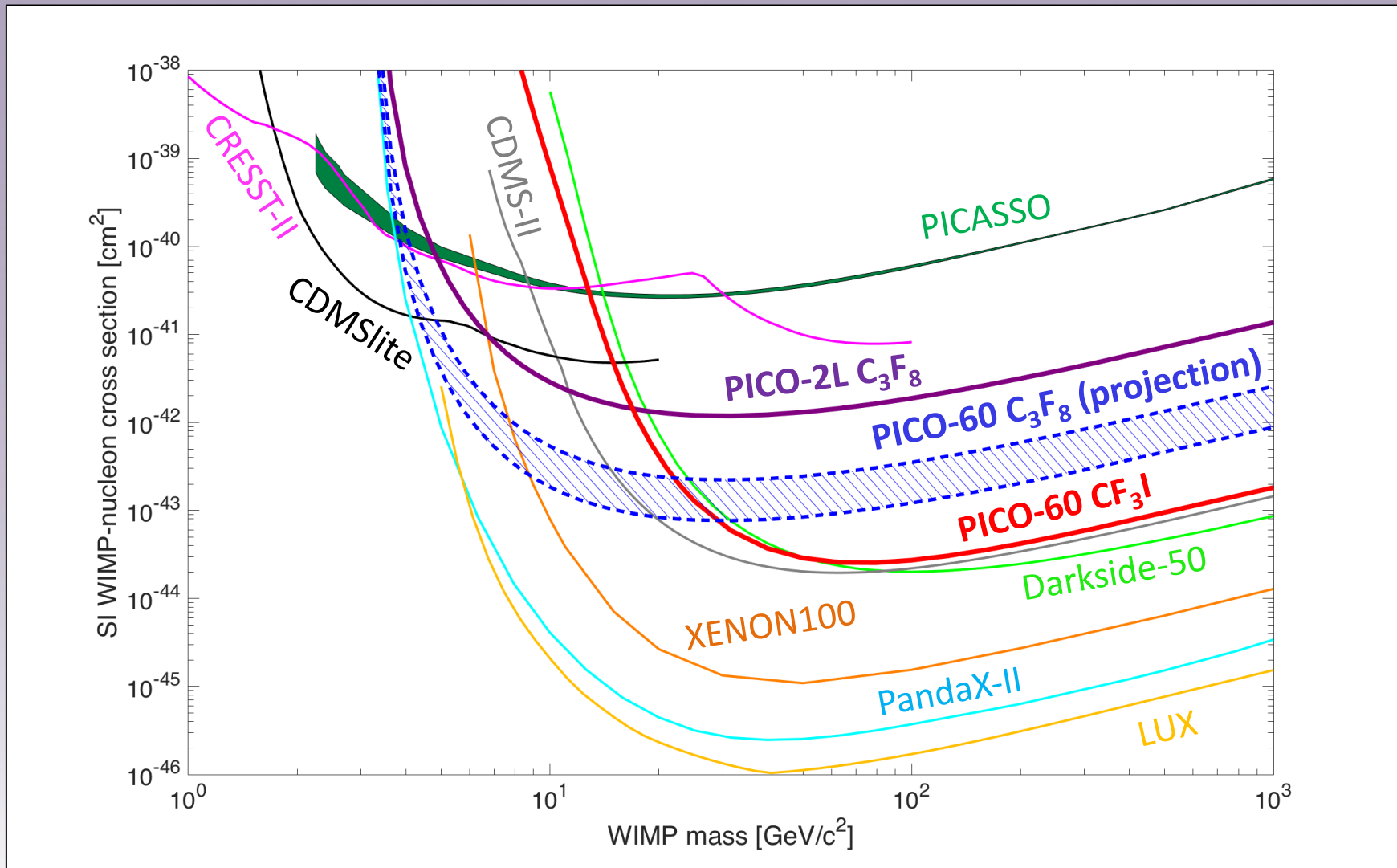


EXTRA SLIDES



Spin-Independent Projections

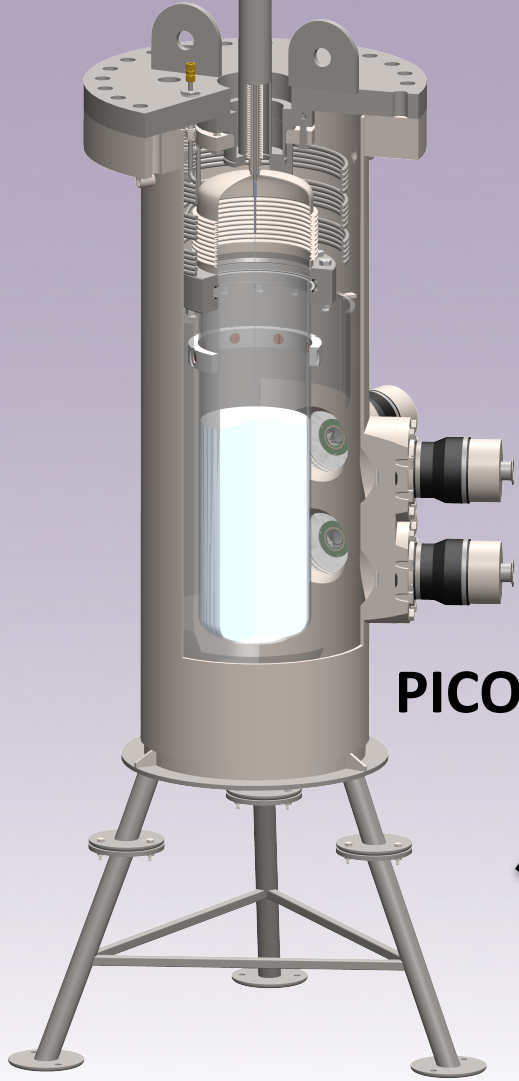
for 0 to 3 events consistent with neutron expectations





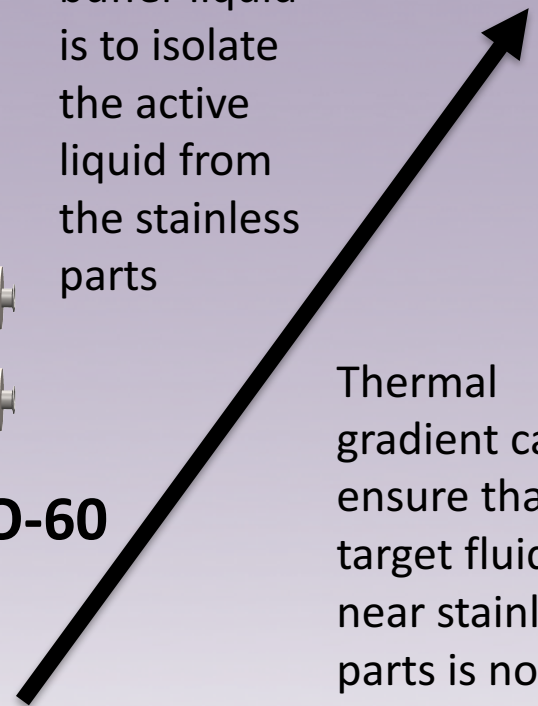
Future Detectors

Eliminate buffer fluid



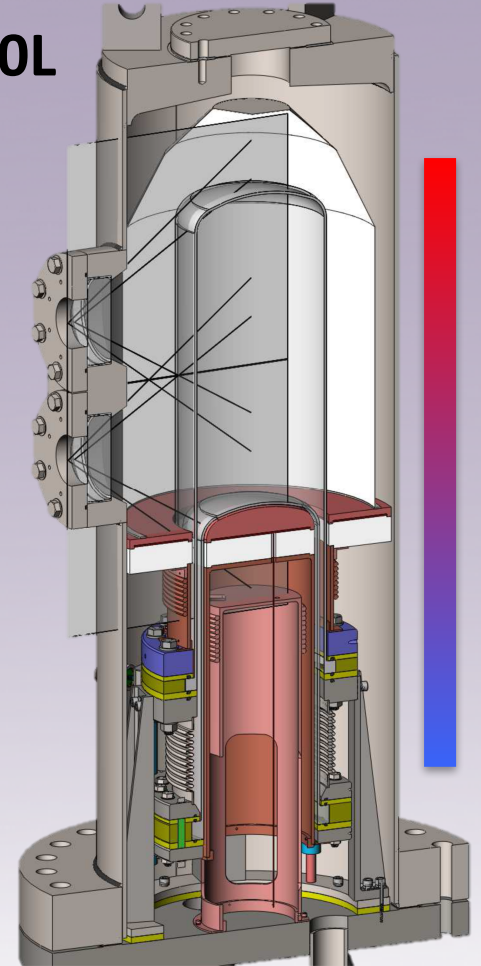
PICO-60

Purpose of buffer liquid is to isolate the active liquid from the stainless parts



PICO-40L

Thermal gradient can ensure that target fluid near stainless parts is not active



Thermal Gradient



Spin-Dependent Reach

