The LZ WIMP dark matter search

Carter Hall, University of Maryland

August 7, 2015

DPF 2015, Ann Arbor, MI

LZ = LUX + ZEPLIN

31 institutions currently
About 180 people
Continuing to expand collaboration

LIP Coimbra (Portugal)
MEPhI (Russia)
Edinburgh University (UK)
University of Liverpool (UK)
Imperial College London (UK)
University College London (UK)
University of Oxford (UK)
STFC Rutherford Appleton Laboratories (UK)
University of Sheffield (UK)

University of Alabama
University at Albany SUNY
Berkeley Lab (LBNL)
University of California, Berkeley
Brookhaven National Laboratory
Brown University
University of California, Davis
Fermi National Accelerator Laboratory
Kavli Institute for Particle Astrophysics & Cosmology
Lawrence Livermore National Laboratory
University of Maryland
University of Michigan
Northwestern University
University of Rochester
University of California, Santa Barbara
University of South Dakota
South Dakota School of Mines & Technology
South Dakota Science and Technology Authority
SLAC National Accelerator Laboratory
Texas A&M
Washington University
University of Wisconsin
Yale University

Scale-up LUX fiducial mass by 50

LZ:

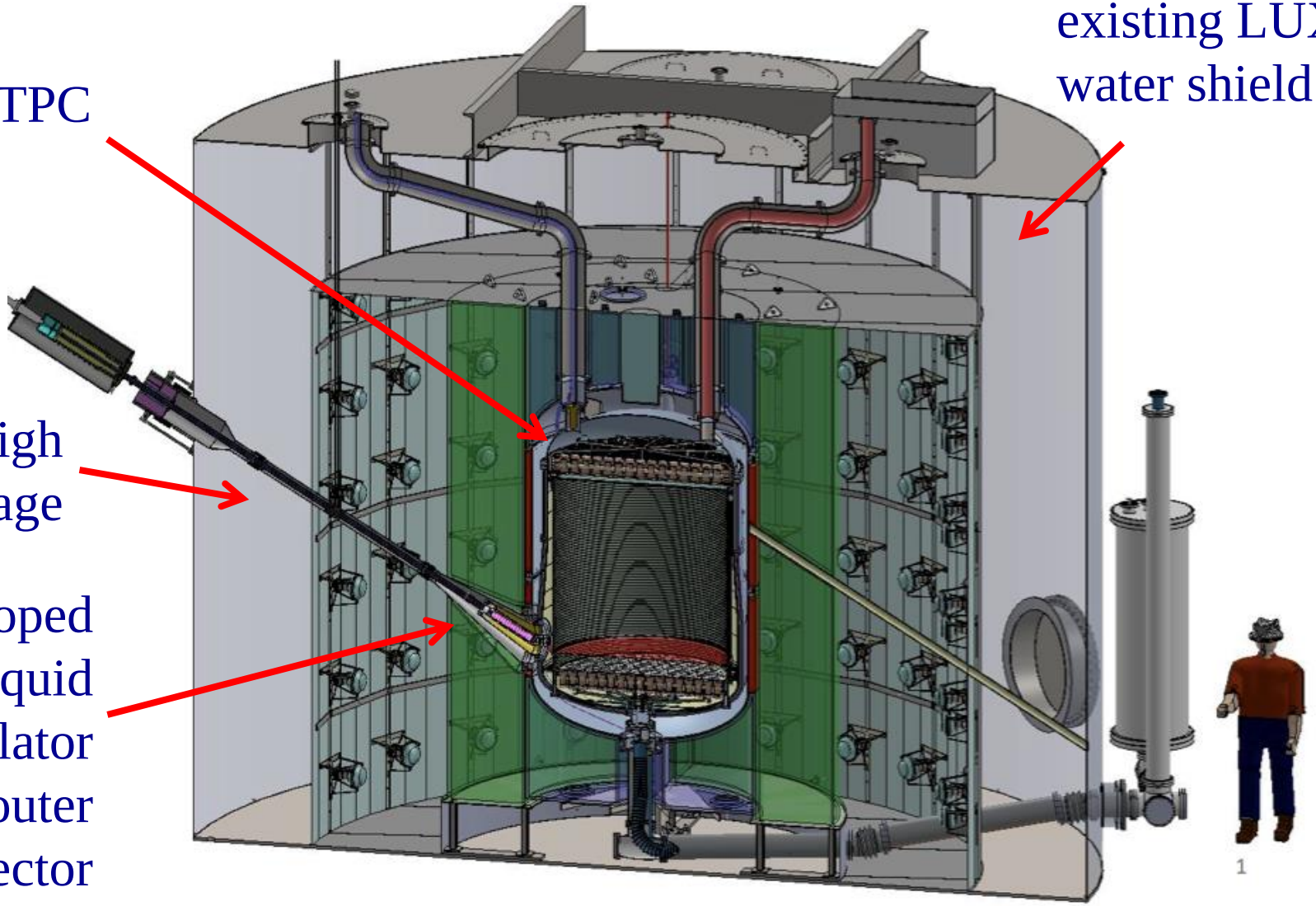
Total Xe - 10 Ton

Active Xe – 7 Ton

Fiducial Xe – 5.6 Ton

LUX

LZ Overview

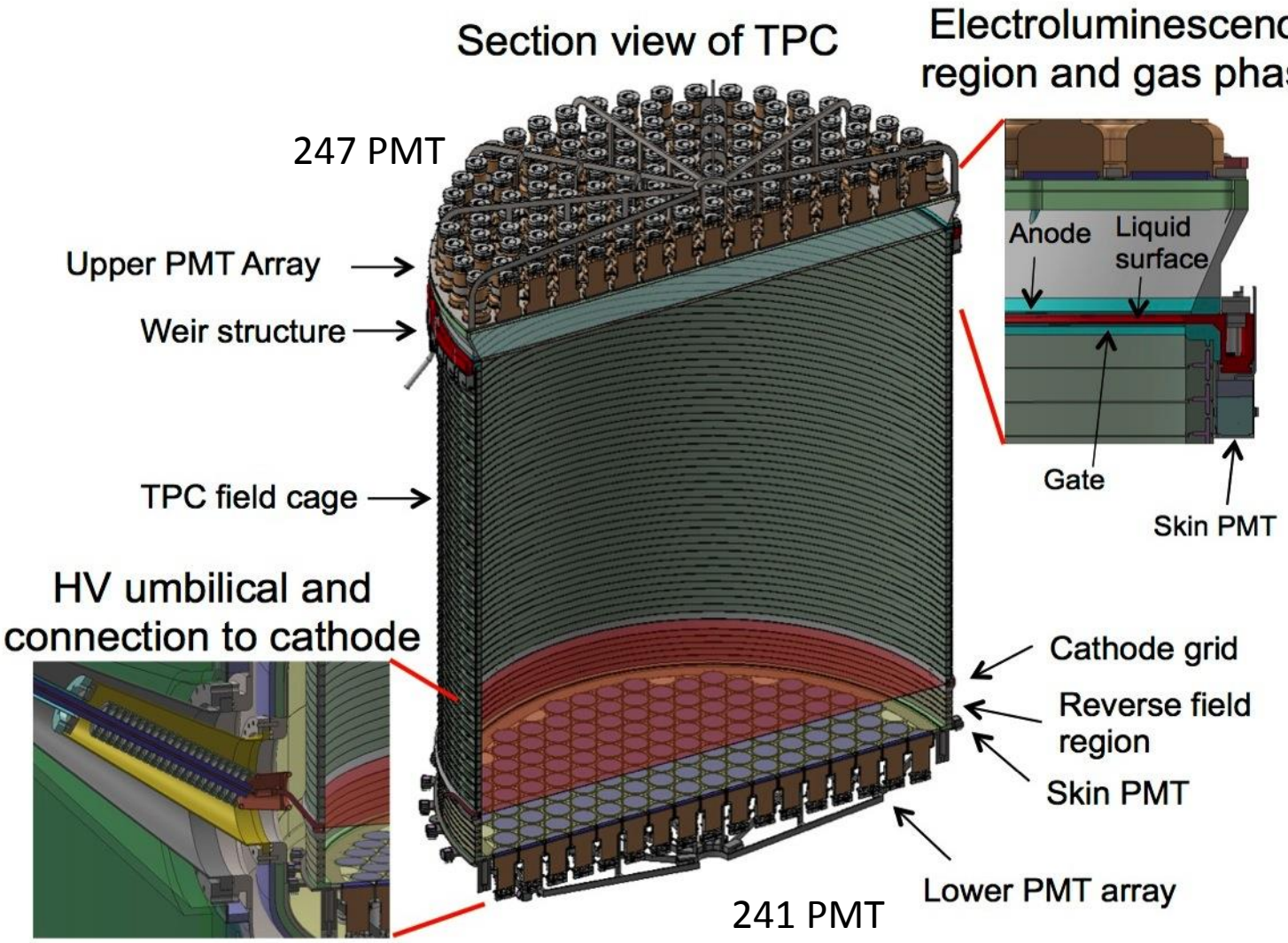

Xe TPC
existing LUX water shield
100 kV high voltage
Gd-doped liquid scintillator outer detector

Sanford Underground Research Facility

Davis Cavern 1480 m
(4200 mwe)
LZ in LUX Water Tank
South Dakota USA

LUX removed
by early 2017
Water tank kept

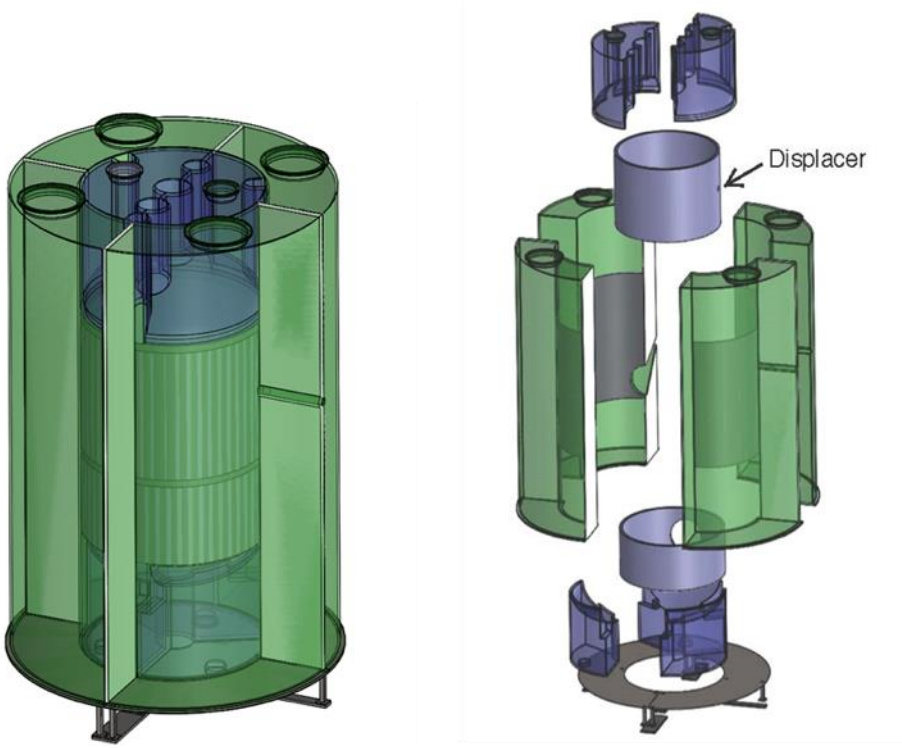
Dual-phase liquid xenon TPC



180 total Skin PMT

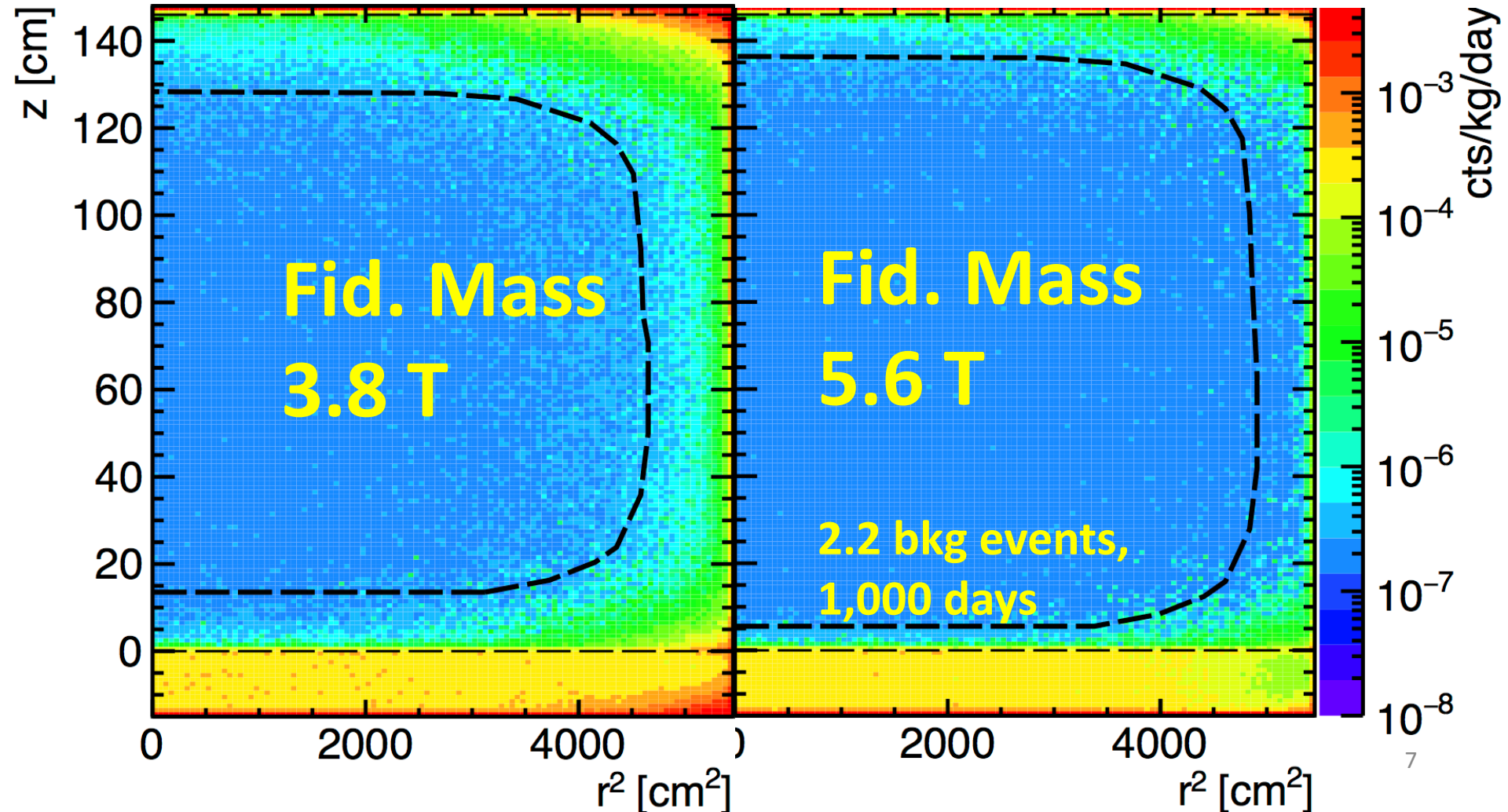
Outer Detector

- Essential to utilize most Xe, maximize fiducial volume
- Segmented tanks – installation constraints (shaft, water tank)
- Gadolinium - loaded scintillator, LAB, OK underground
- Daya Bay legacy, scintillator & tanks (and people)
- Advanced conceptual design



Layout of the LZ outer detector system, which consists of nine acrylic tanks. The largest are the four quarter-tanks on the sides. Two tanks cover the top, and three the bottom. The exploded view on the right shows the displacer cylinders placed between the acrylic vessels and the cryostat.

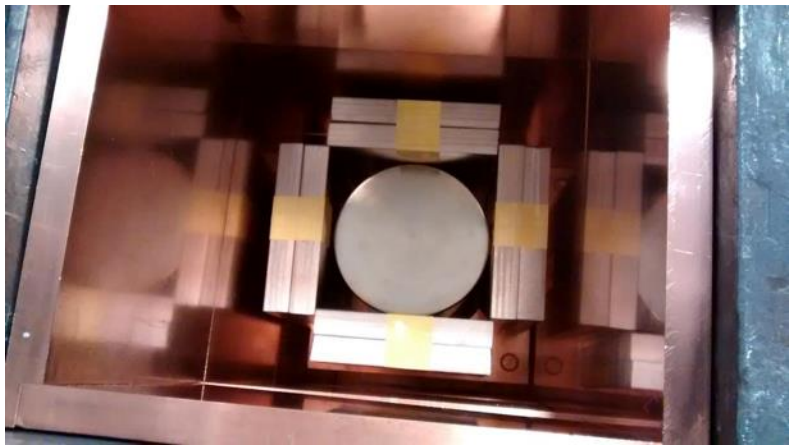
Backgrounds with and without outer detector

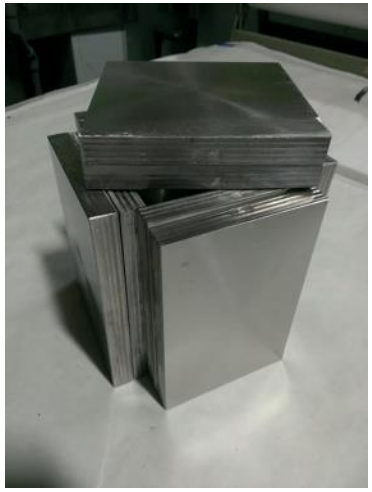


Cryostat Vessels

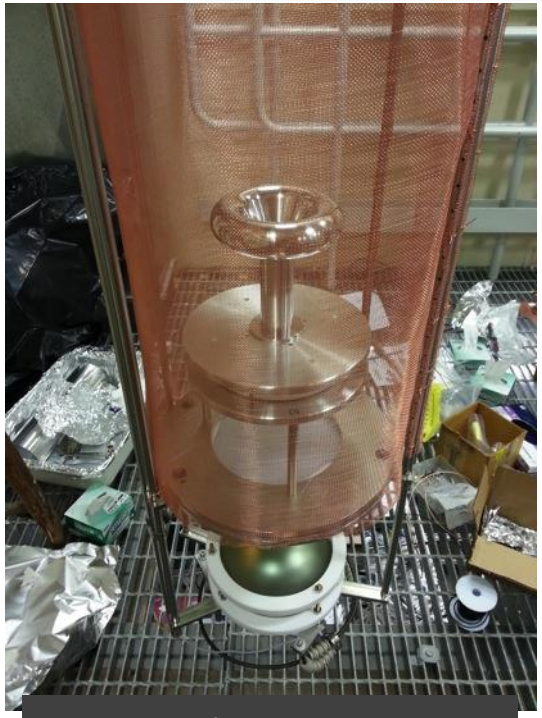
- UK responsibility
- Low background titanium chosen direction

  SS alternative advanced as backup
- Ti slab for all vessels(and other parts) received and assayed
- Contributes < 0.05 NR+ER counts in fiducial volume in 1,000 days after cuts

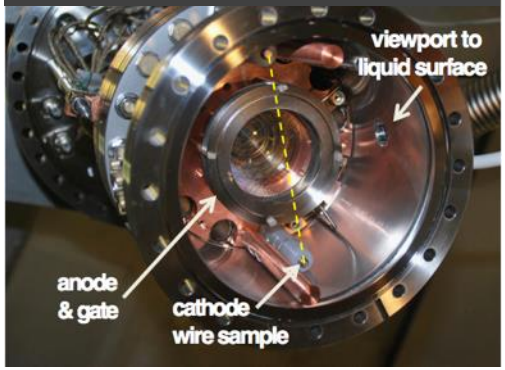


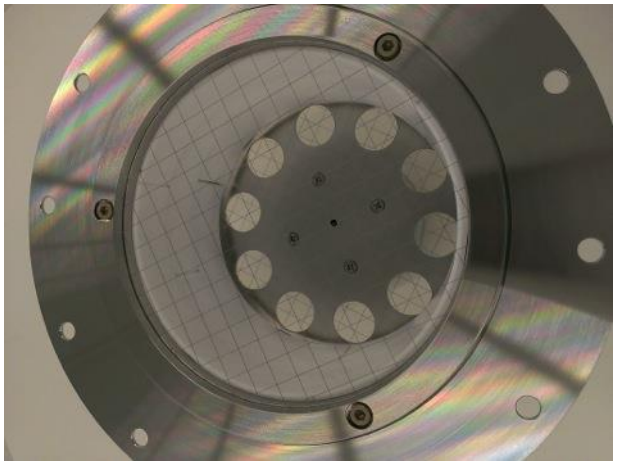


High Voltage Studies



Wire grid tests ongoing



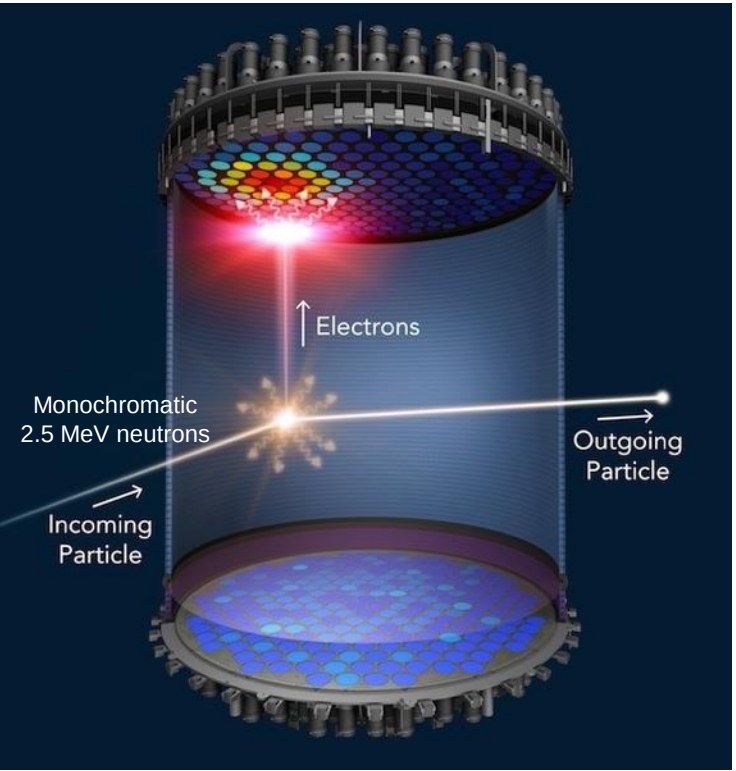


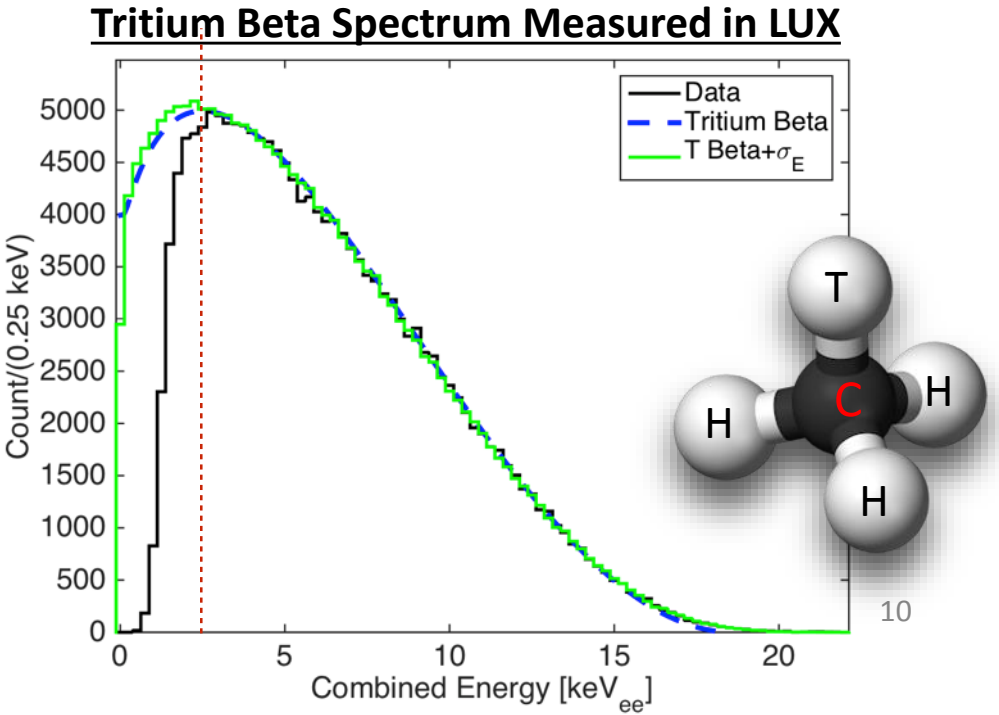
Prototype of highest E-field region tested in LAr

- ✦Cathode voltage design goal: 200 kV (provides margin)
- ✦LZ nominal operating goal: 100 kV (~700 V/cm)
- ✦Feedthrough prototype tested to 200 kV
- ✦Prototype TPC for 100 kg LXe system fabrication starting
- ✦HV prototyping expanding at Berkeley

Calibrations

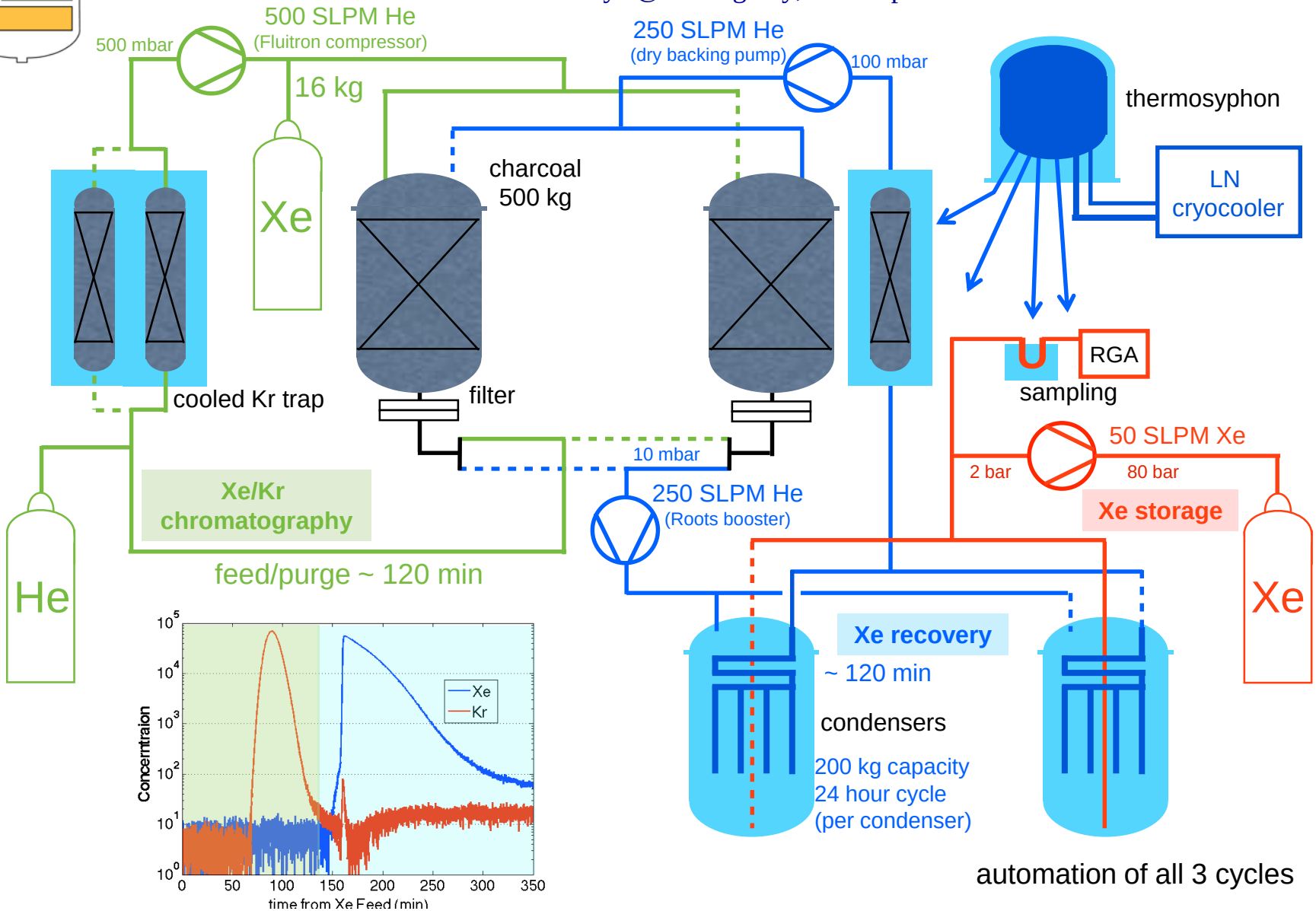
- Demonstrated in LUX.
- DD Neutron Generator (Nuclear Recoils)
- Tritiated Methane (Electron Recoils)
- Additional Sources e.g. YBe Source for low energy (Nuclear Recoils)





Kr removal via chromatography

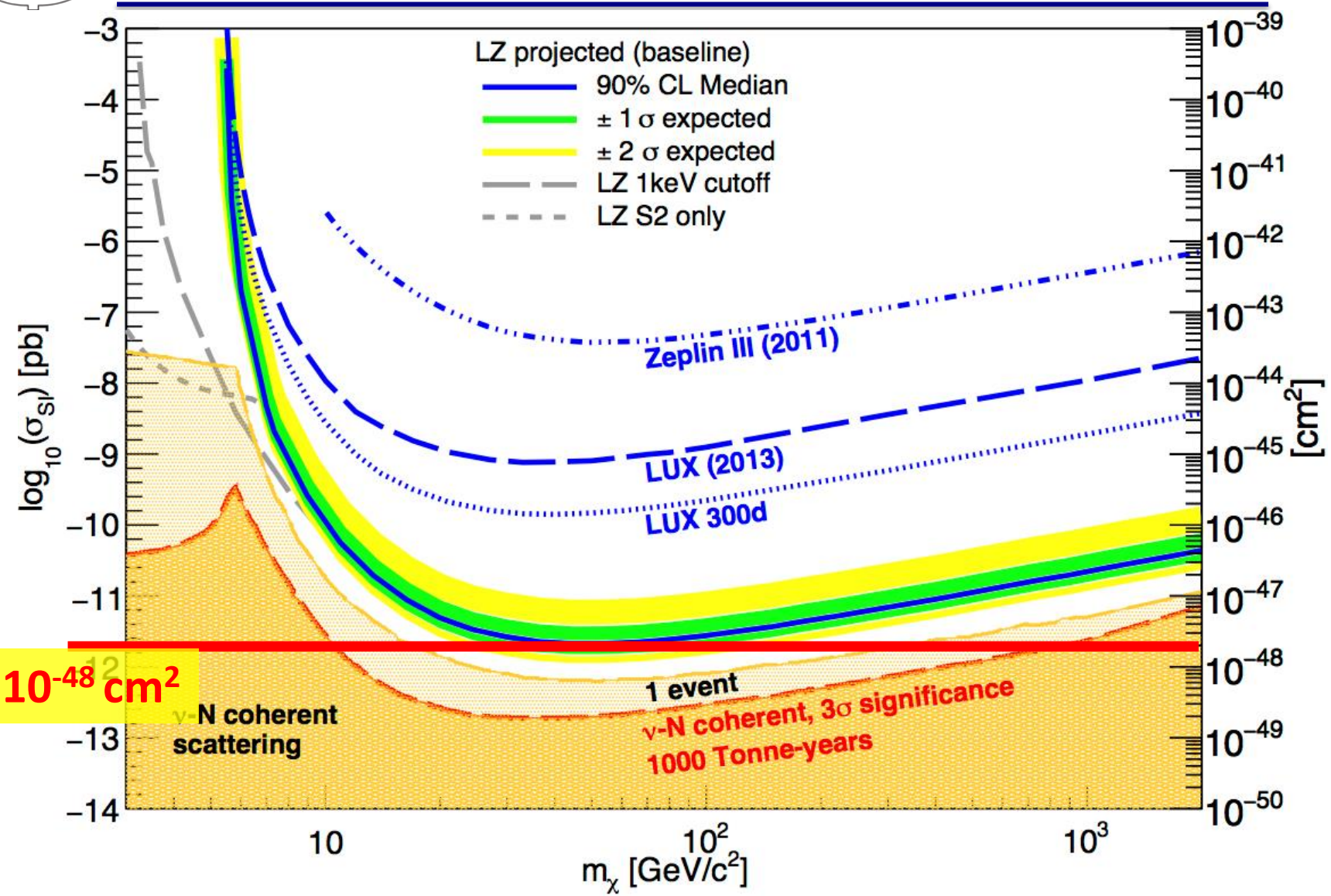
10 tons / 60 days @ 200 kg/day; 85% uptime



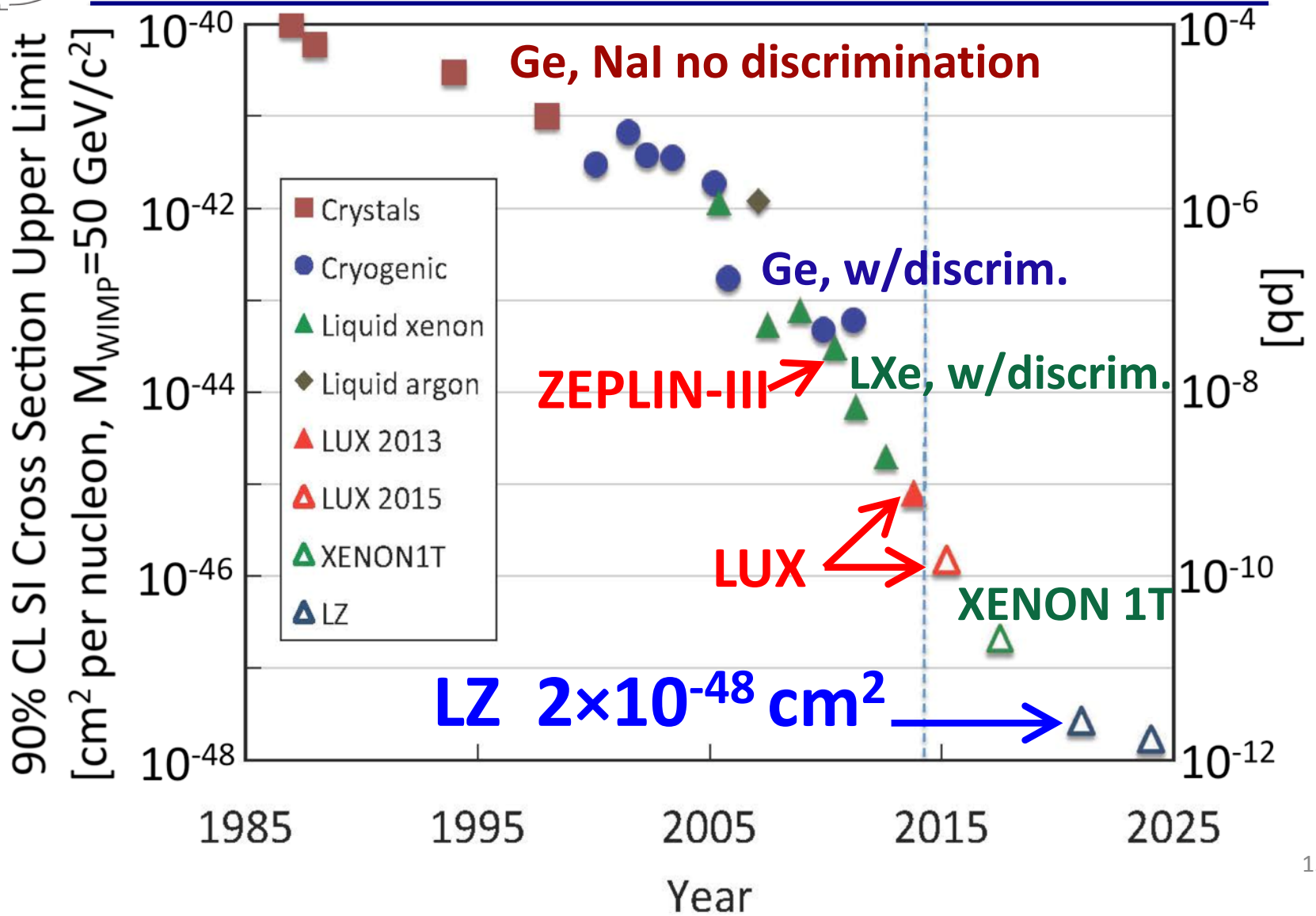
automation of all 3 cycles

LZ Sensitivity

(5.6 Tonnes, 1000 live days)

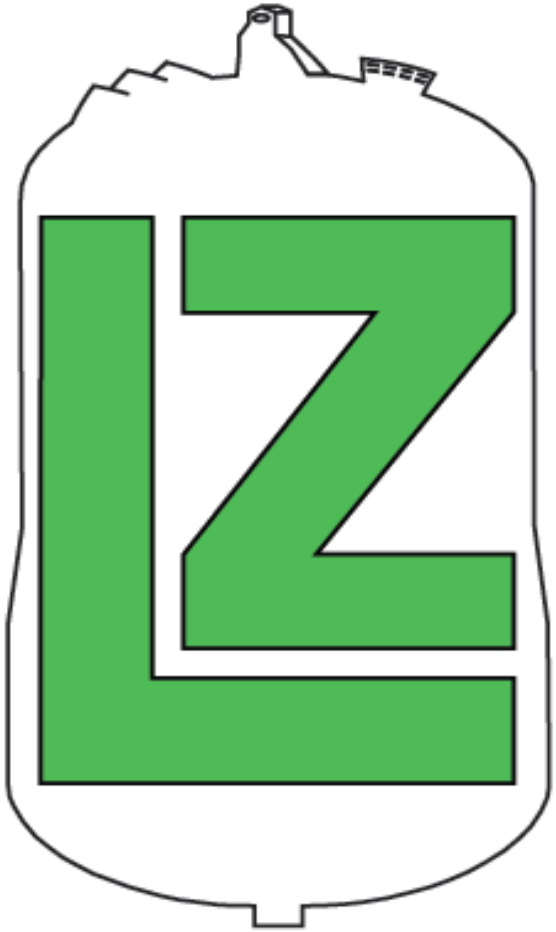


Time Evolution



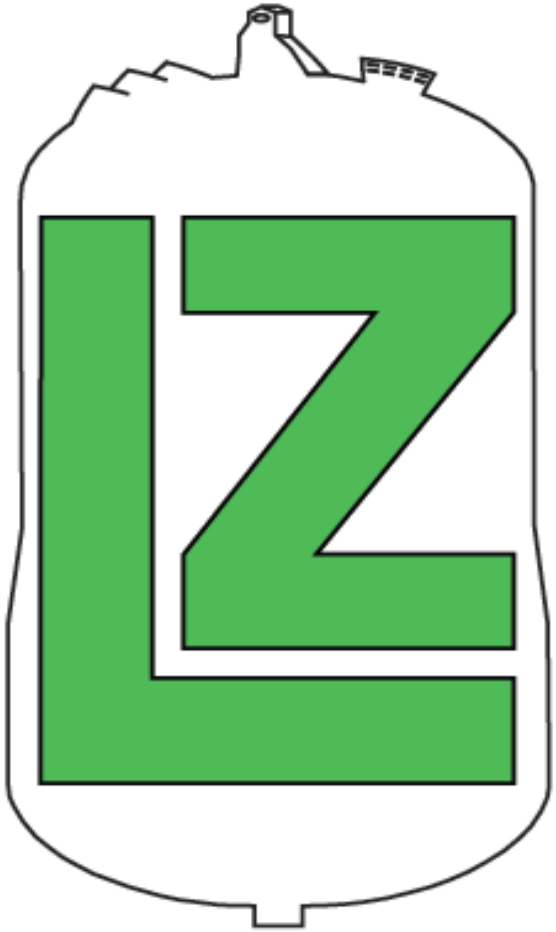
Timeline

Year	Month	Activity
2012	March	LZ (LUX-ZEPLIN) collaboration formed
	May	First Collaboration Meeting
	September	DOE CD-0 for G2 dark matter experiments
2013	November	LZ R&D report submitted
2014	July	LZ Project selected in US and UK
2015	April	DOE CD-1/3a approval, similar in UK
		Begin long-lead procurements(Xe, PMT, cryostat)
2016	April	DOE CD-2/3b approval, baseline, all fab starts
2017	June	Begin preparations for surface assembly @ SURF
2018	July	Begin underground installation
2019	Feb	Begin commissioning



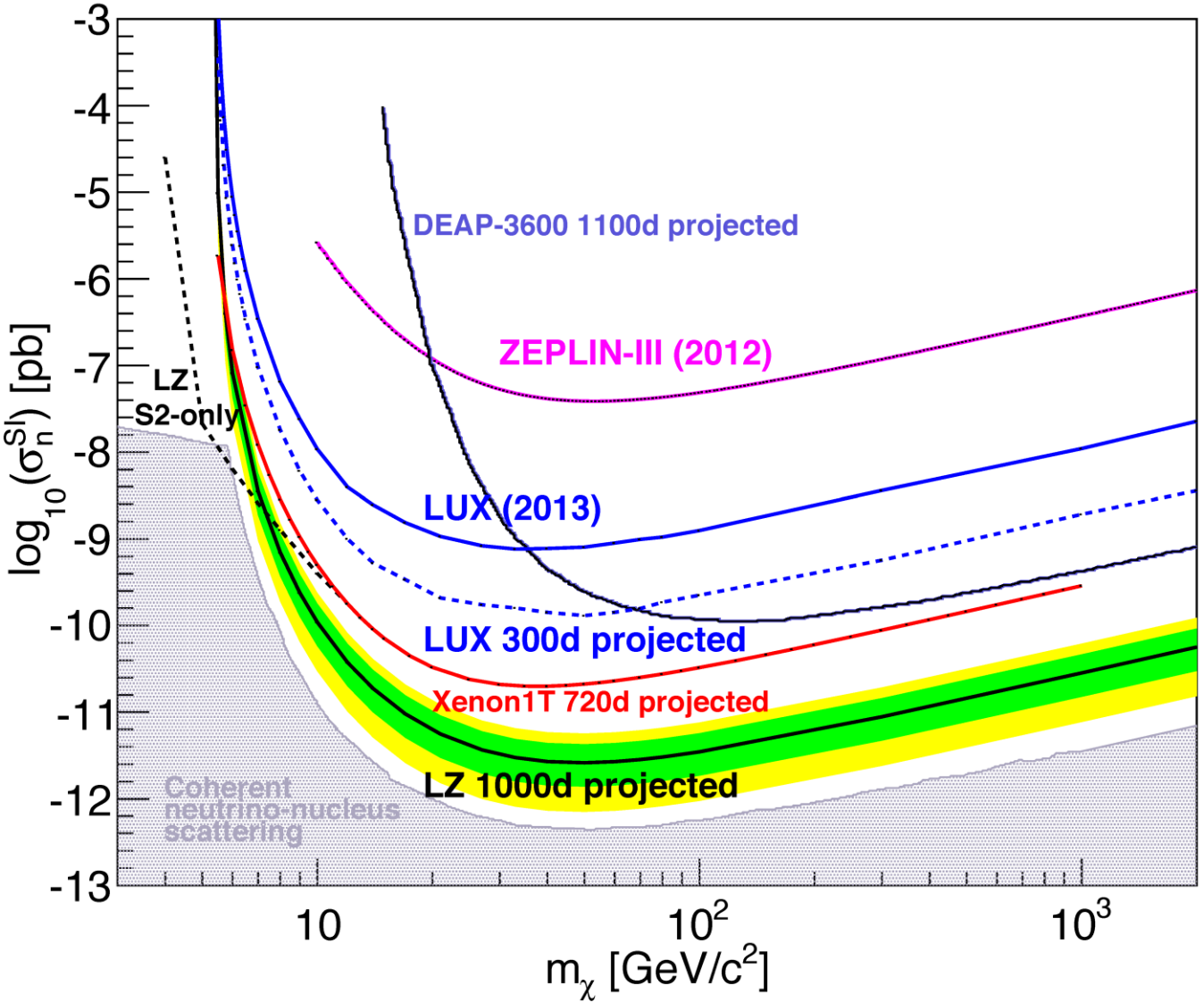
Summary

- LZ Project well underway, with procurement of Xe, PMTs and cryostat vessels started
- Extensive prototype program underway
- LZ benefits from the excellent LUX calibration techniques and understanding of background

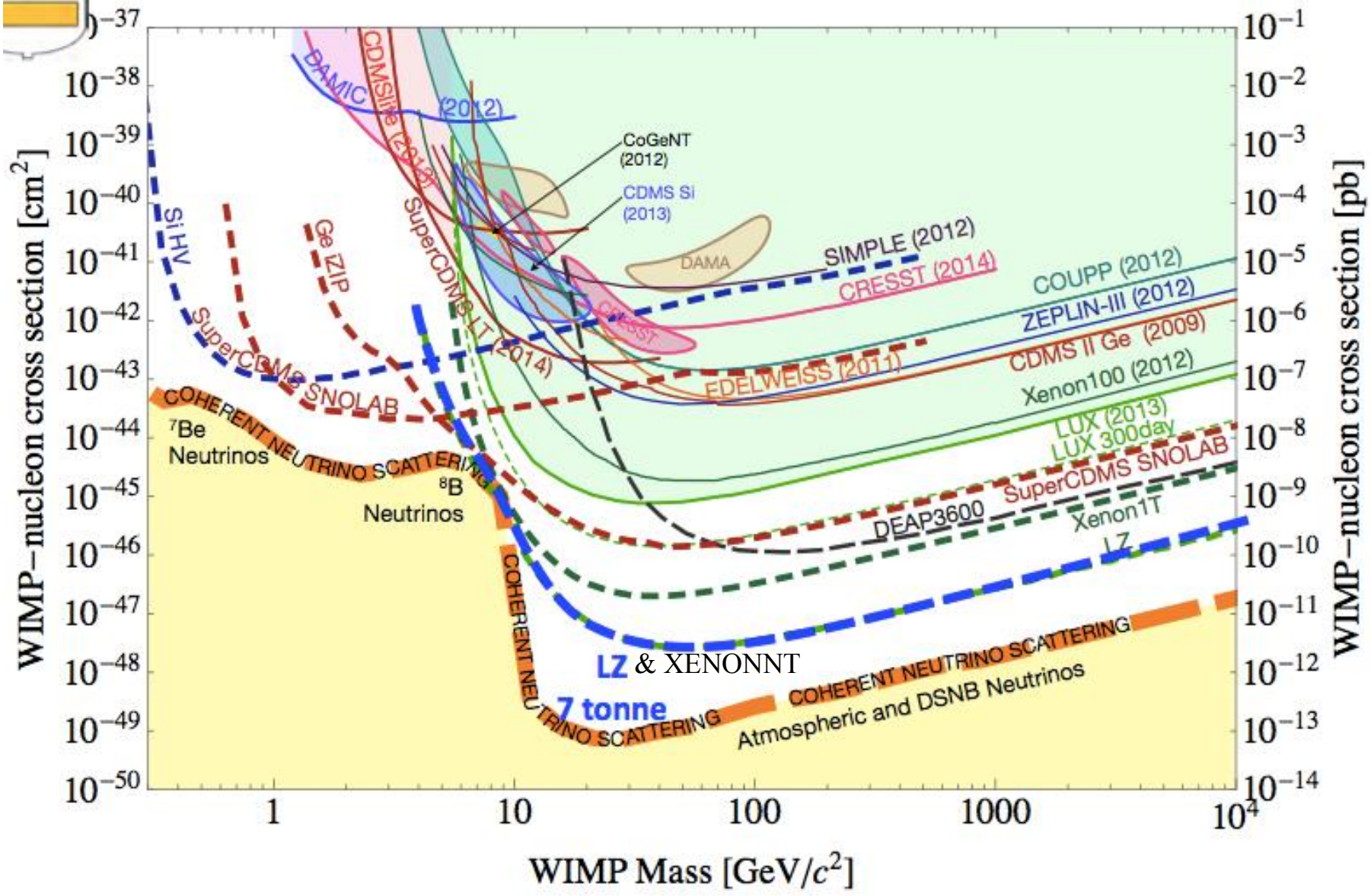


Extra Slides

LZ Sensitivity

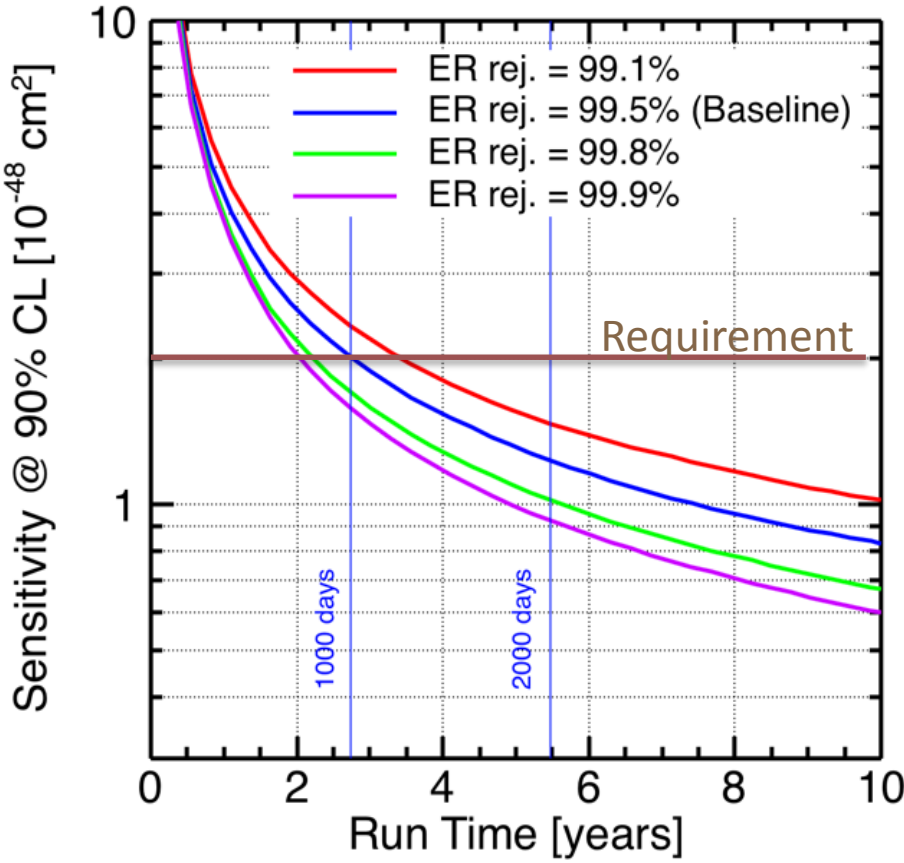


Status and outlook for WIMP detection



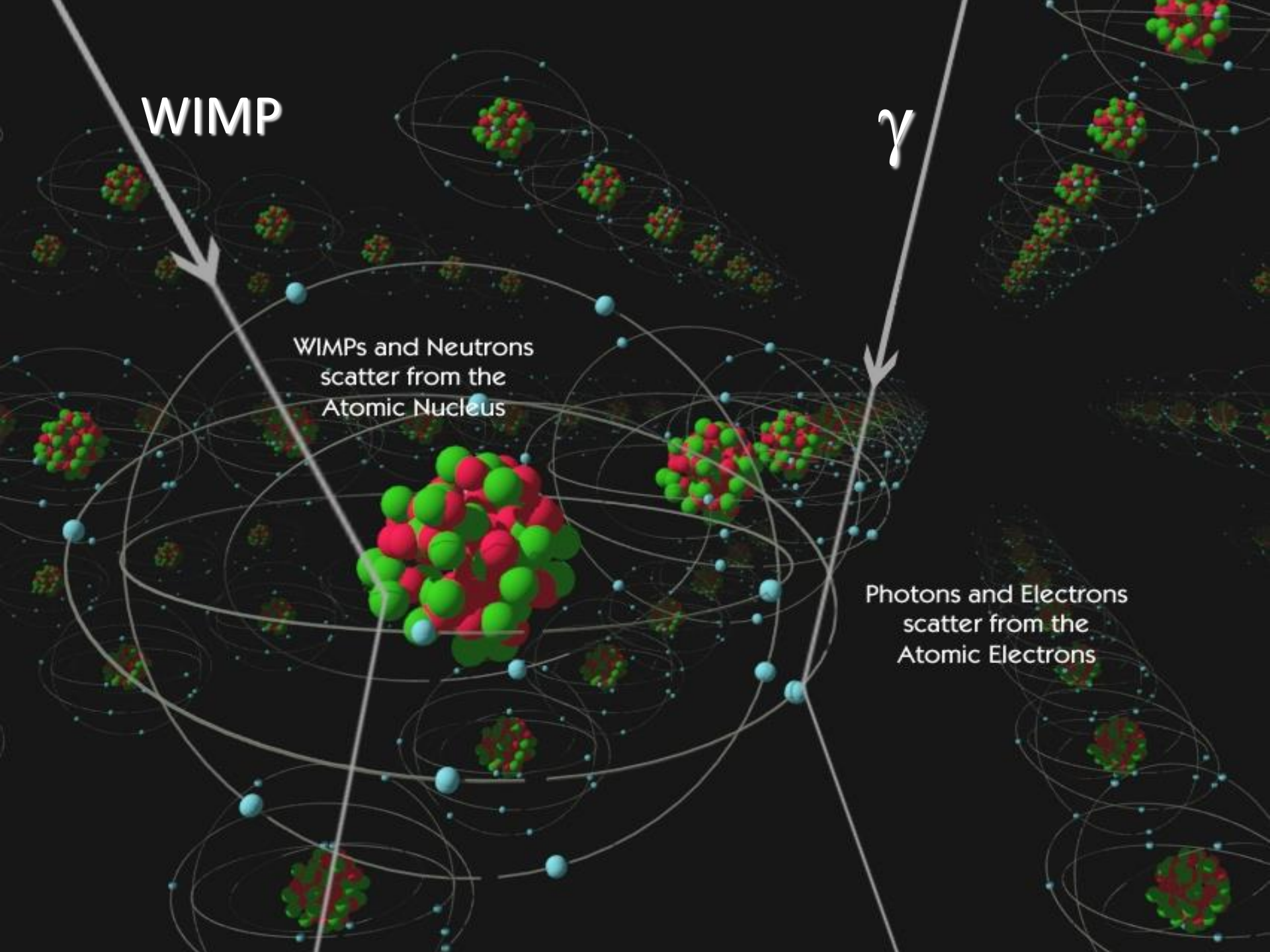
Running Time

- Sensitivity vs. running time.
- 1,000 days is the nominal.
- Baseline backgrounds
- Rapid improvement in sensitivity
- Potential to eventually get to ~ 1 x 10^{-48} cm^2

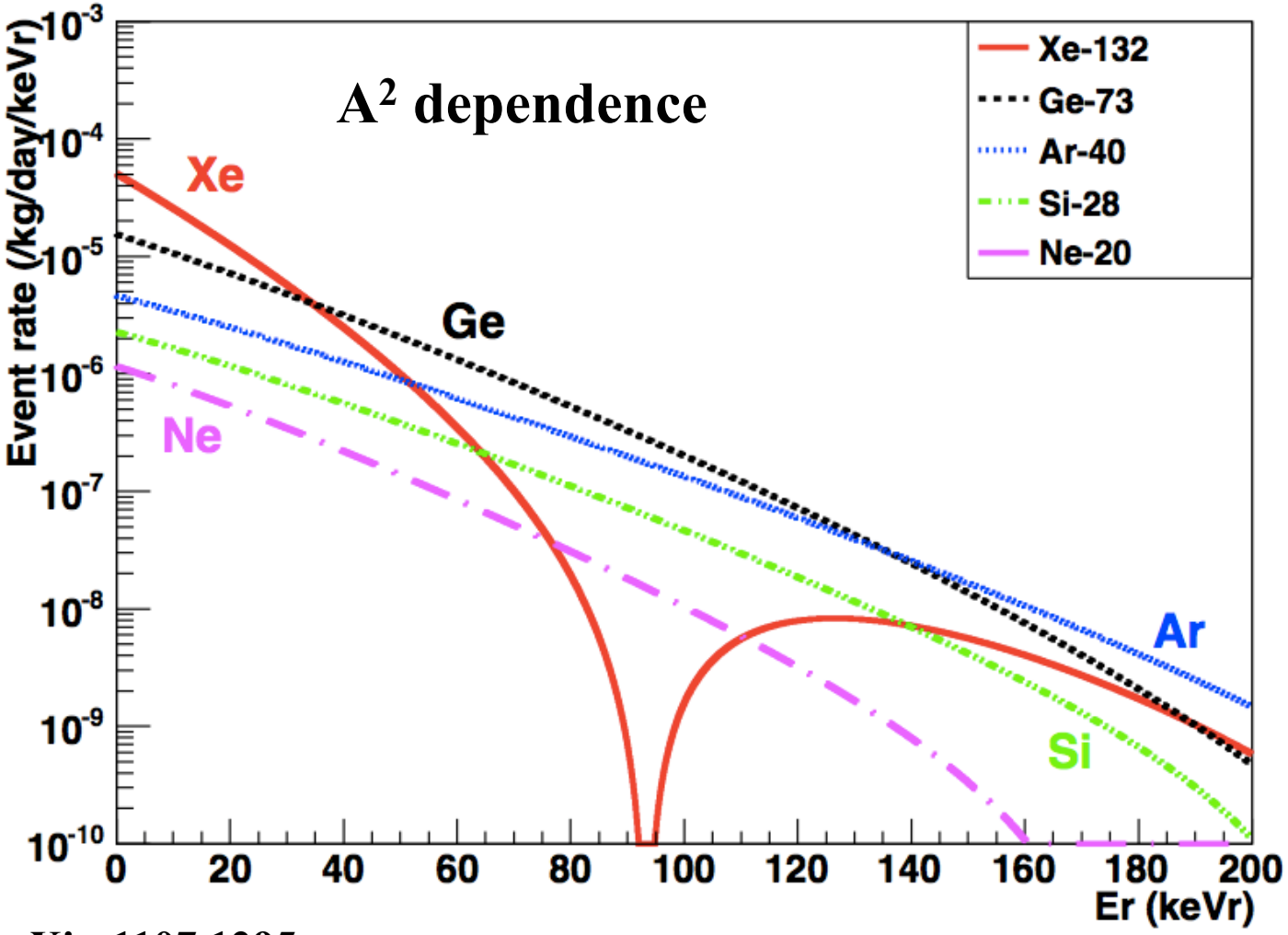


Integrated Xe purity screening via mass spectrometry

- Have a sampling program to instantly assay the Kr removal at SLAC and continuously assay in situ during physics running at SURF.
- Sensitivity Kr, Ar, O_2, N_2, He, CH4 in real time.

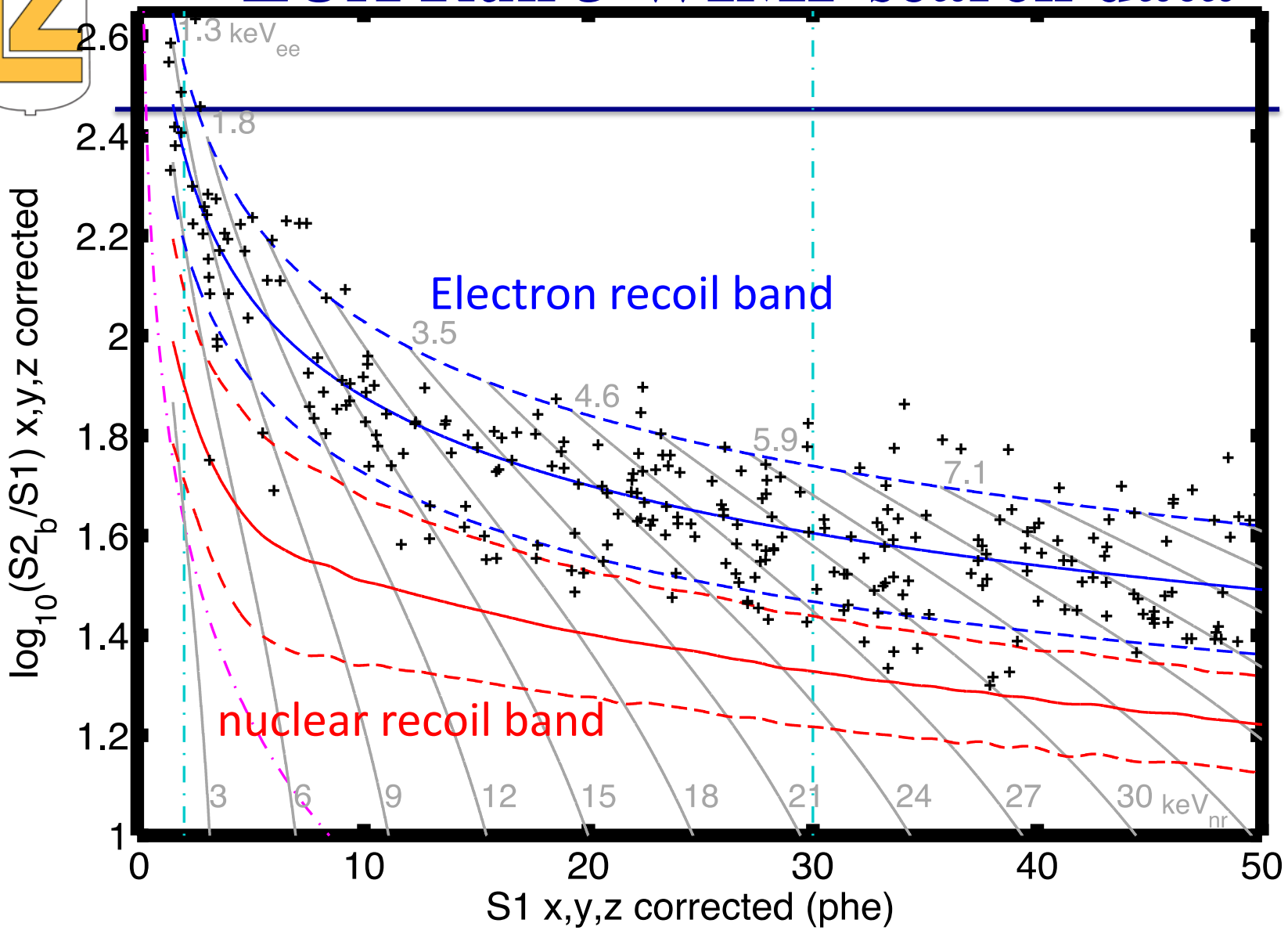

WIMP
γ
WIMPs and Neutrons
scatter from the
Atomic Nucleus
Photons and Electrons
scatter from the
Atomic Electrons

Nuclear recoil spectra



From: arXiv:1107.1295

LUX Run 3 WIMP search data



Phys. Rev. Lett 112 (2014) 091303