The LUX-Zeplin Dark Matter Search: detector design and sensitivity

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on behalf of the LZ Collaboration

SLAC NATIONAL ACCELERATOR LABORATORY

DPF FNAL, July 31 2017

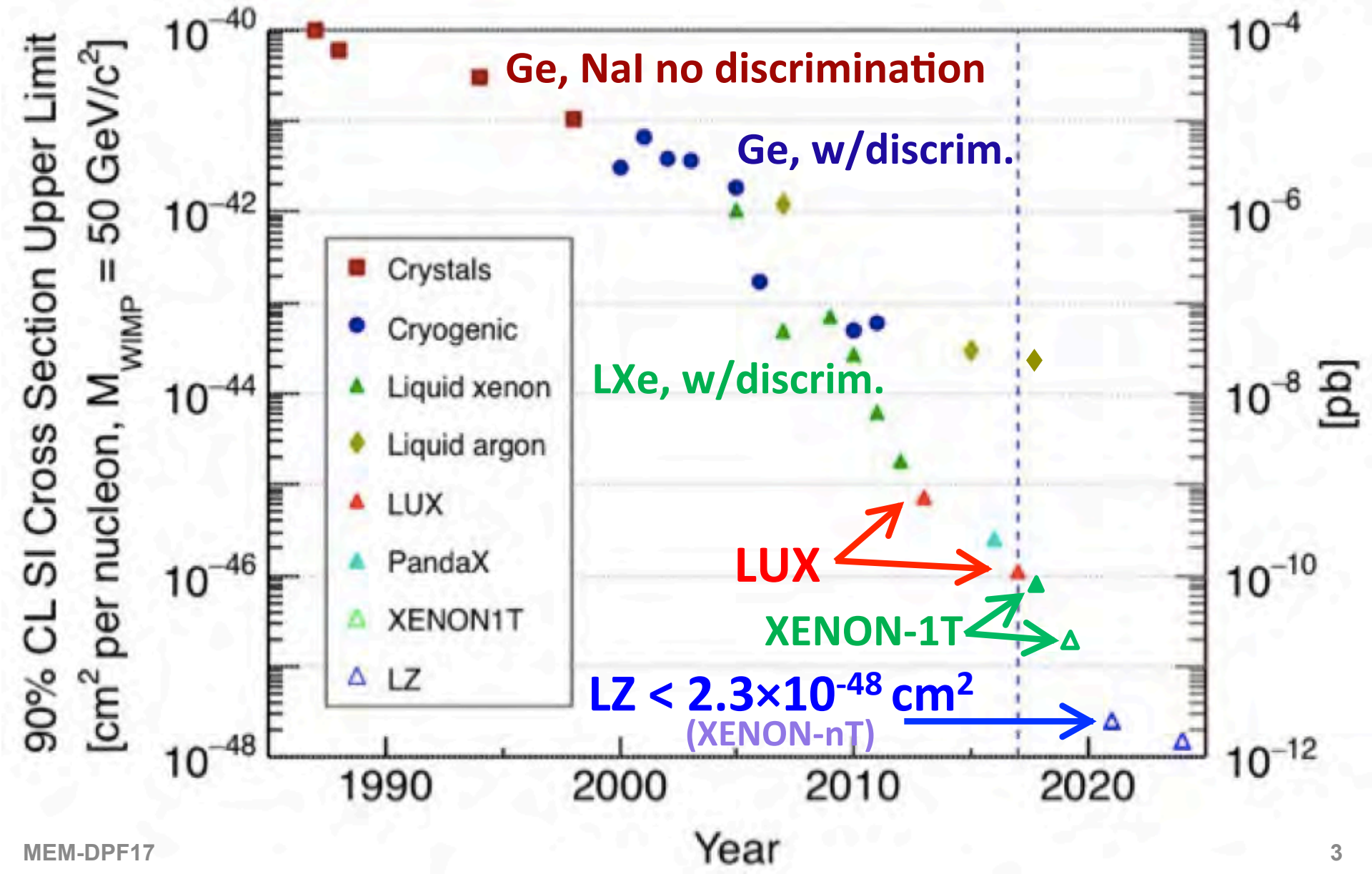
LZ = LUX + ZEPLIN

LZ collaboration:

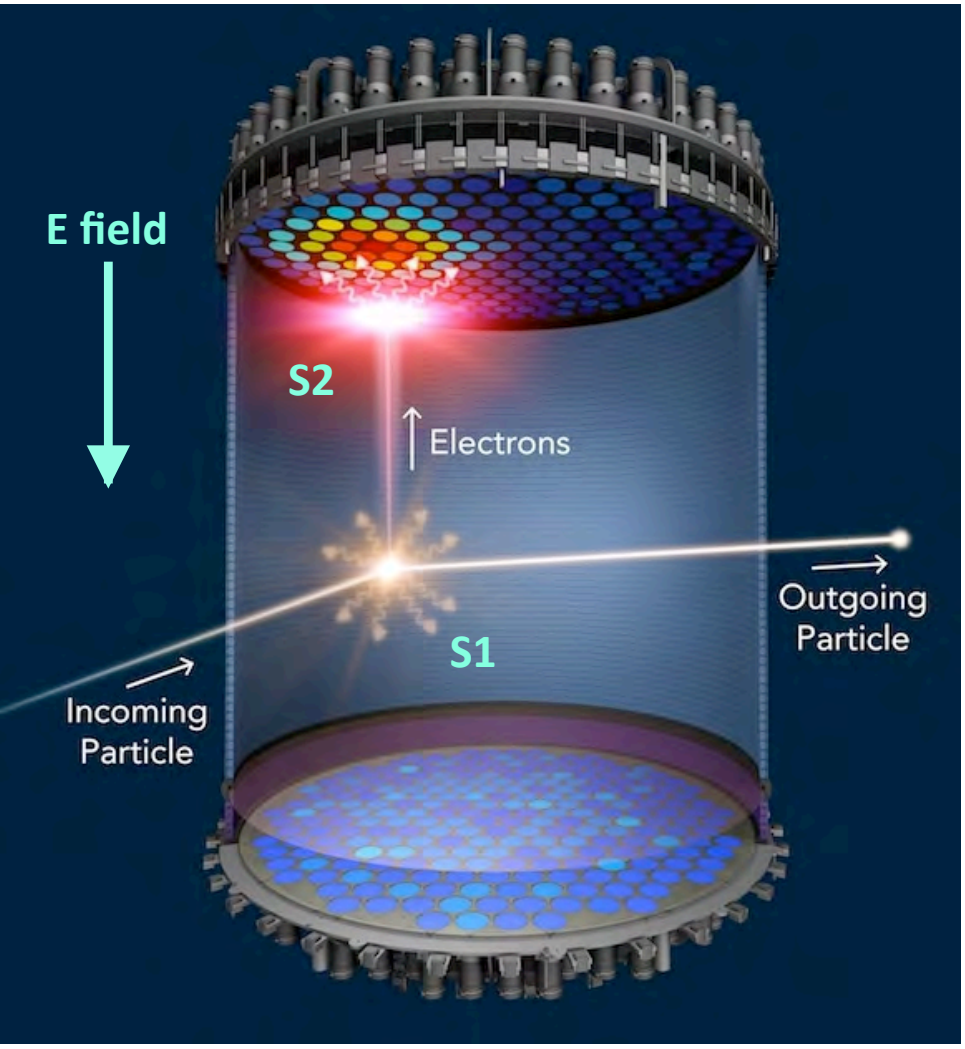
- 38 institutions (USA, UK, Portugal, Russia, South Korea)
- 250+ scientists, engineers, and technicians

LZ collaboration meeting, SURF, July 19 2017

Moore's Law of Direct Detection

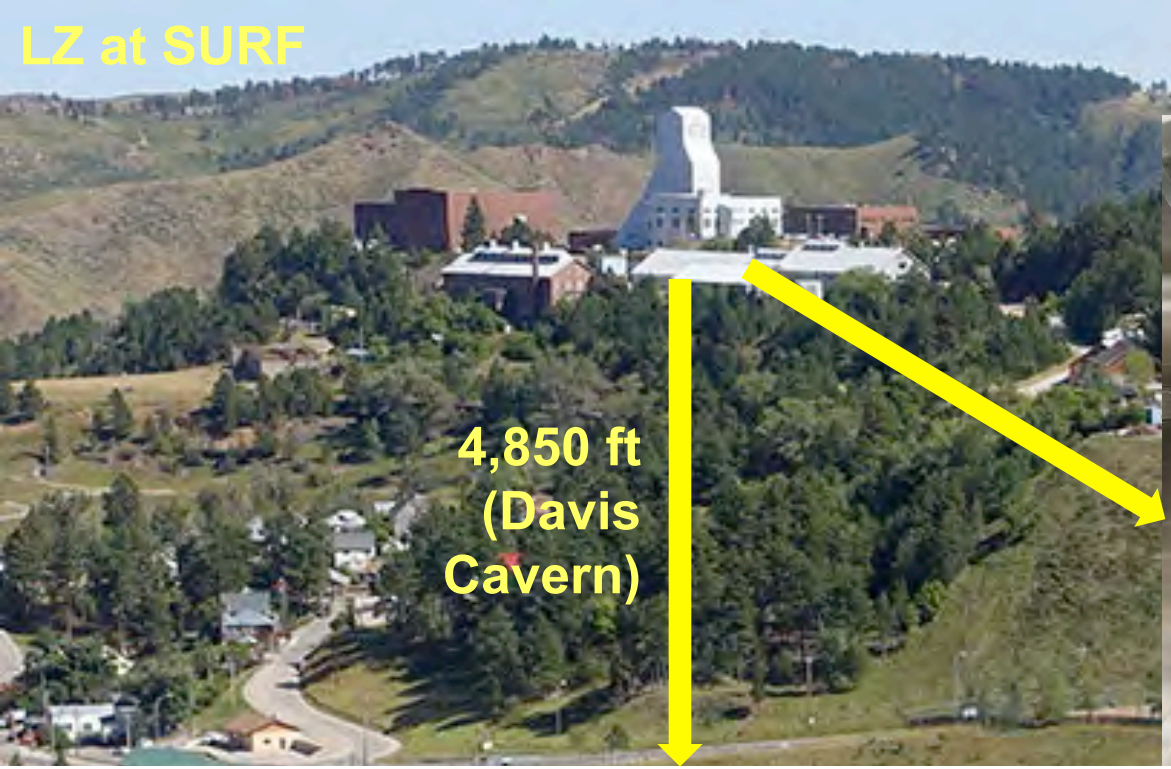


Noble Liquid TPCs for WIMP Detection

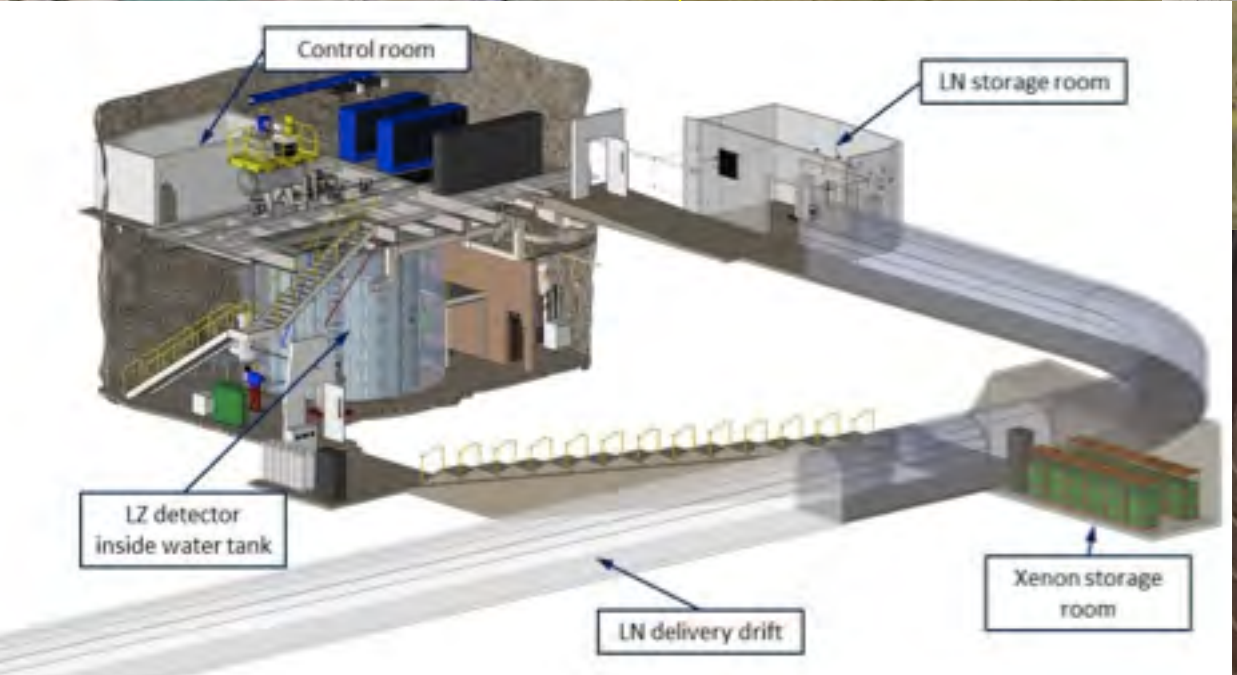


- **WIMP-induced nuclear recoils: ~ few keV energy**
  - **S1, S2 → event energy**
  - **S2 image → xy coordinate**
  - **S1-S2 timing → z coord.**
  - **S2/S1 (Xe) → recoil type**
  - **S1 PSD (Ar) → recoil type**

- **No long-lived isotopes (Xe)**
- **Self-shielding**
- **Recoil discrimination**

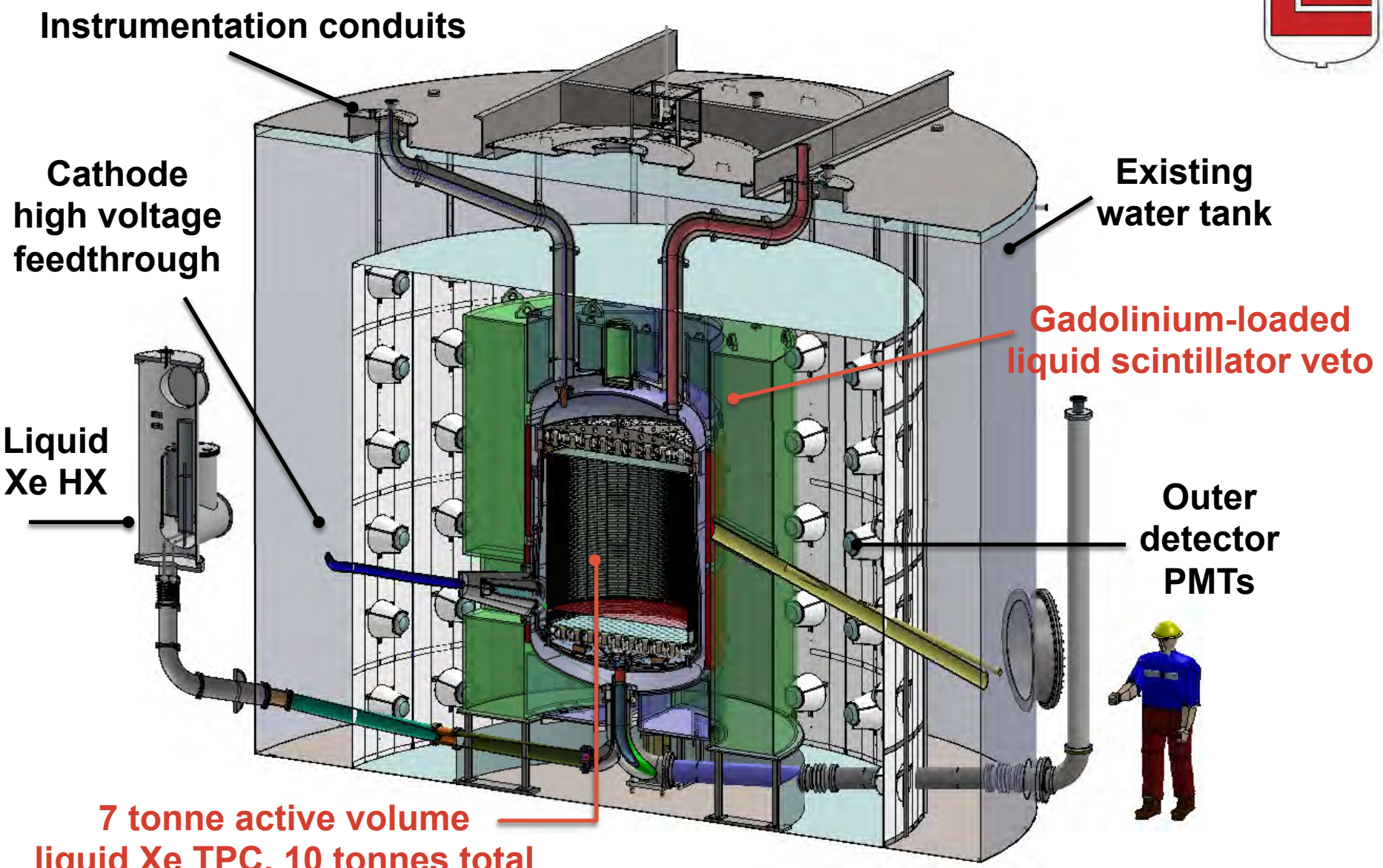

LZ at SURF
4,850 ft
(Davis
Cavern)


Rn-reduced cleanroom

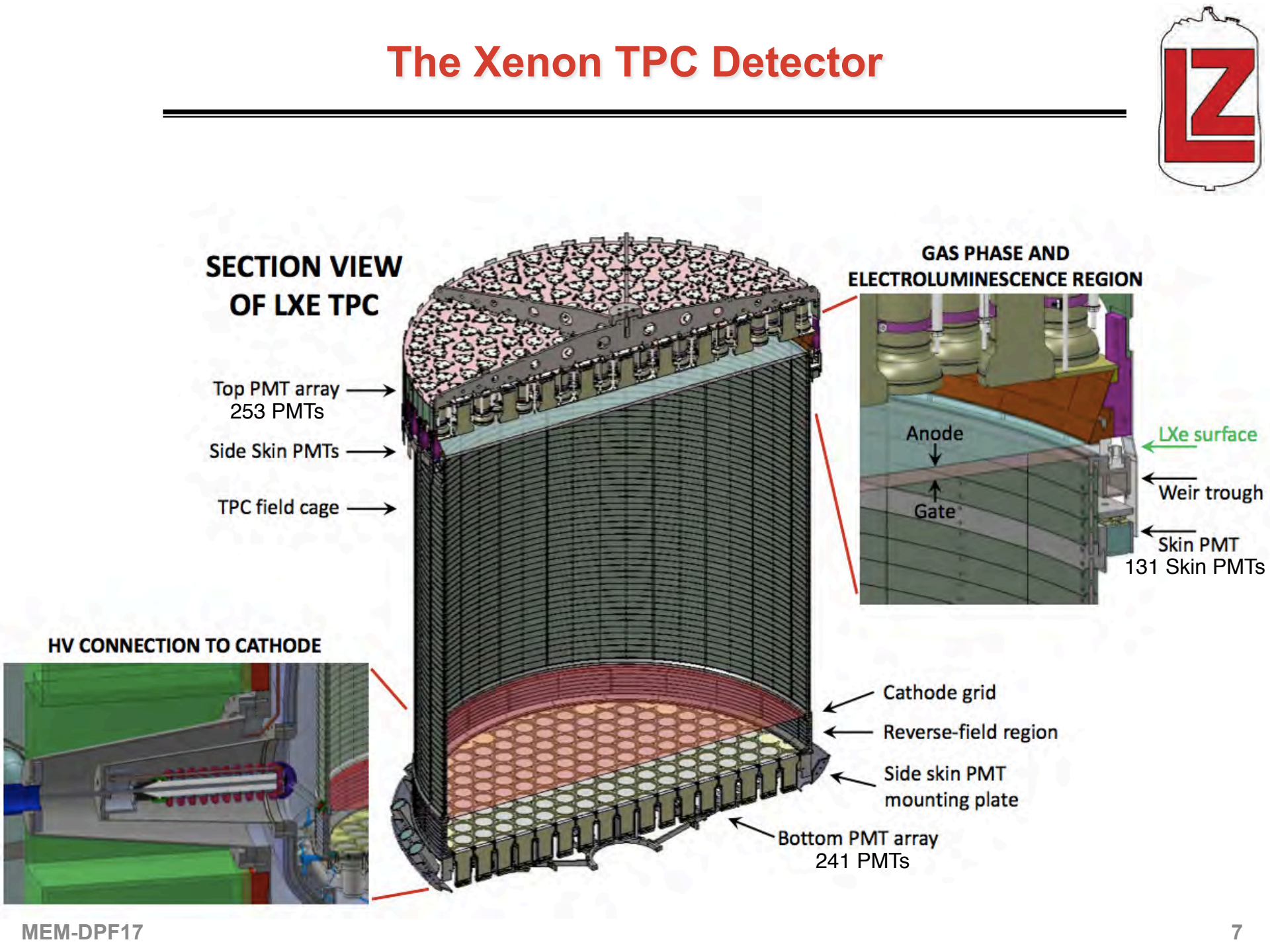

Control room
LN storage room
LZ detector
inside water tank
LN delivery drift
Xenon storage
room


South Dakota folklore...
SITE OF CAPTURE
OF THE ASSASSIN
JACK McCALL
WHO SHOT
"WILD BILL" HICKOK
AUG 2, 1876

LZ Detector Overview



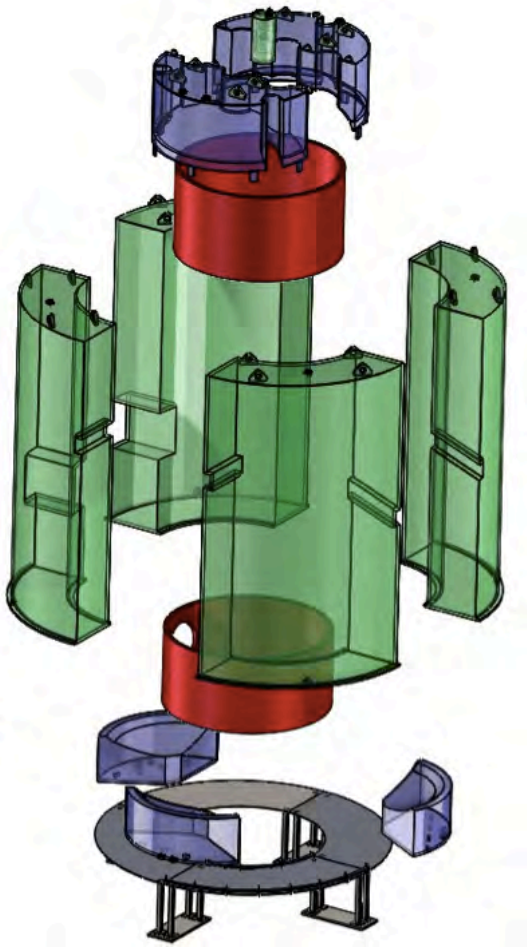
The Xenon TPC Detector



LZ as a Discovery Instrument

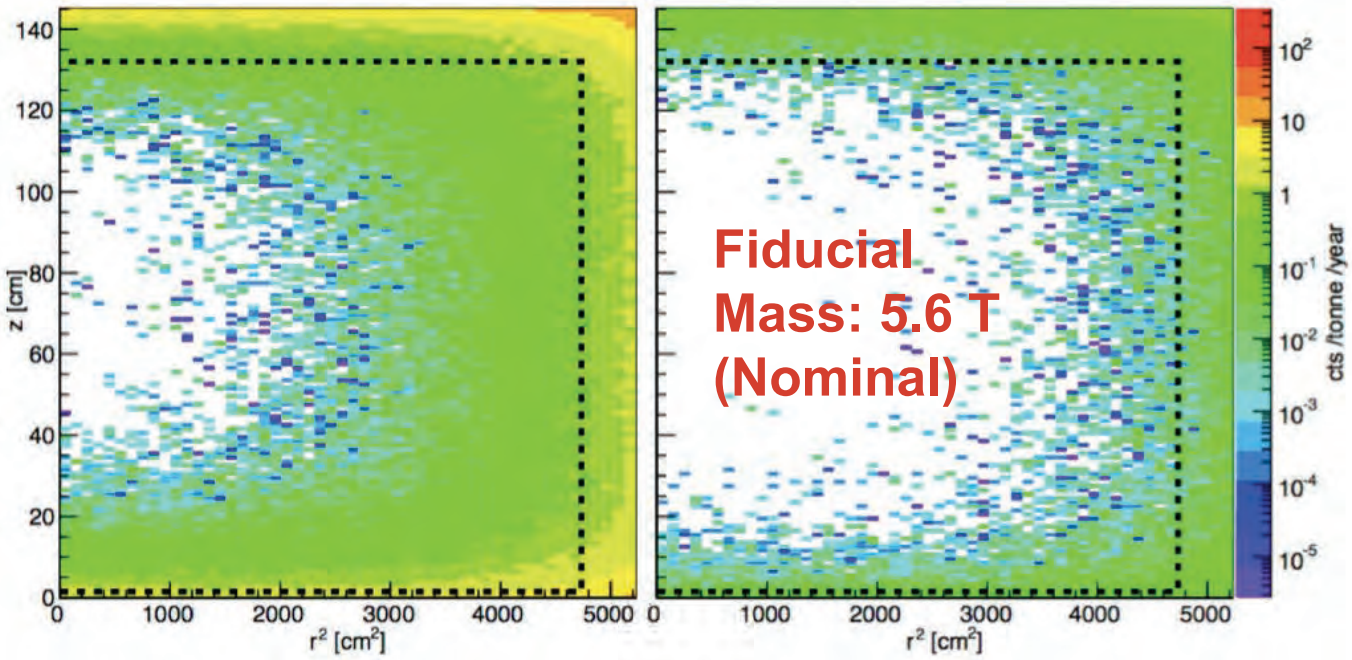
- 0.61 m thick Gd-loaded scintillator
- instrumented Xenon “skin”
- we can tag neutrons and gammas

} In-situ monitoring of residual backgrounds



ROI + Single Scatter

ROI + S.S. + Vetoes



Screening + Simulations: the background table

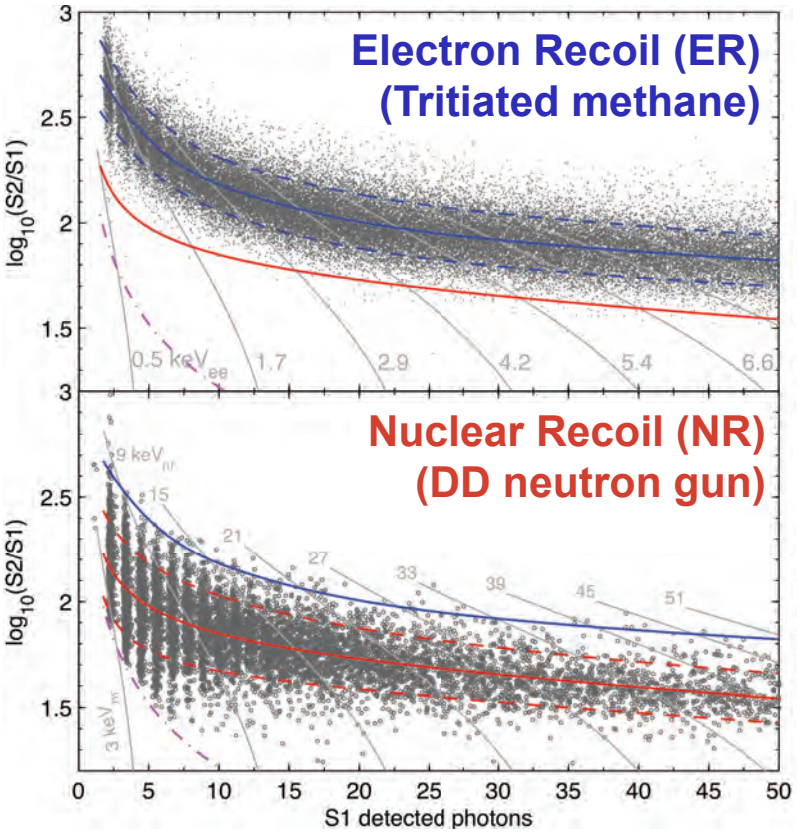
Expected counts in 1,000 live days in an indicative 5.6-tonne fiducial mass in [1.5-6.5] keV_{ee} (ER) and [6-30] keV (NR):

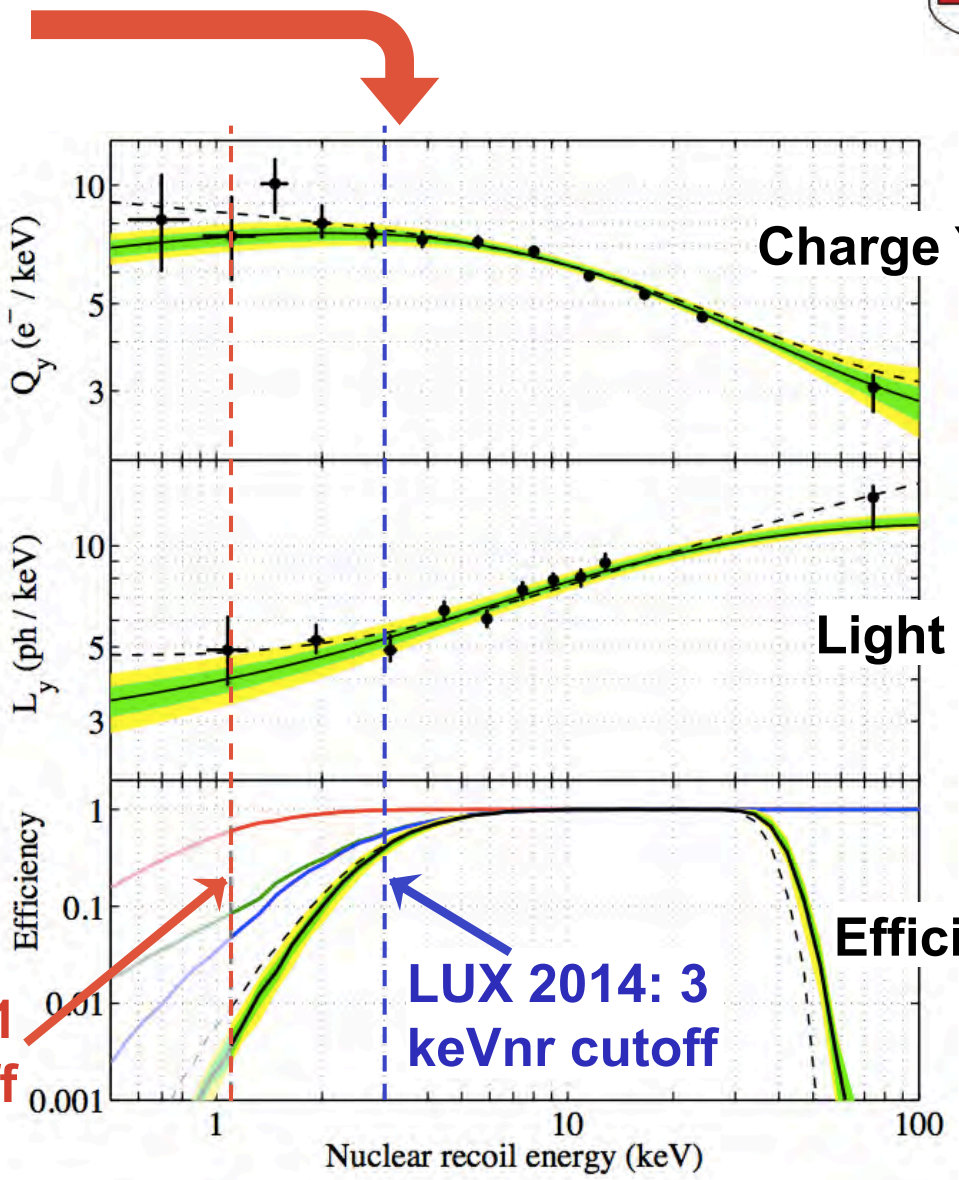
Item	ER cts	NR cts
Detector Componenents	6.2	0.07
Dispersed radionuclides (Rn, Kr, Ar)	911	-
Laboratory and cosmogenic	4.3	0.06
Fixed surface contamination	0.19	0.37
^{136}Xe $2\nu\beta\beta$	67	-
Neutrinos (ν-e, ν-A)	255	0.72
Total	1244	1.22
Total (with 99.5% ER discrimination, 50% NR efficiency)	6.22	0.61
Total ER+NR background events	6.83	

See Amy Cottle's talk

- **ER/NR rejection is crucial to the success of the experiment**
- **PLR analysis: very powerful at rejecting residual ER counts**

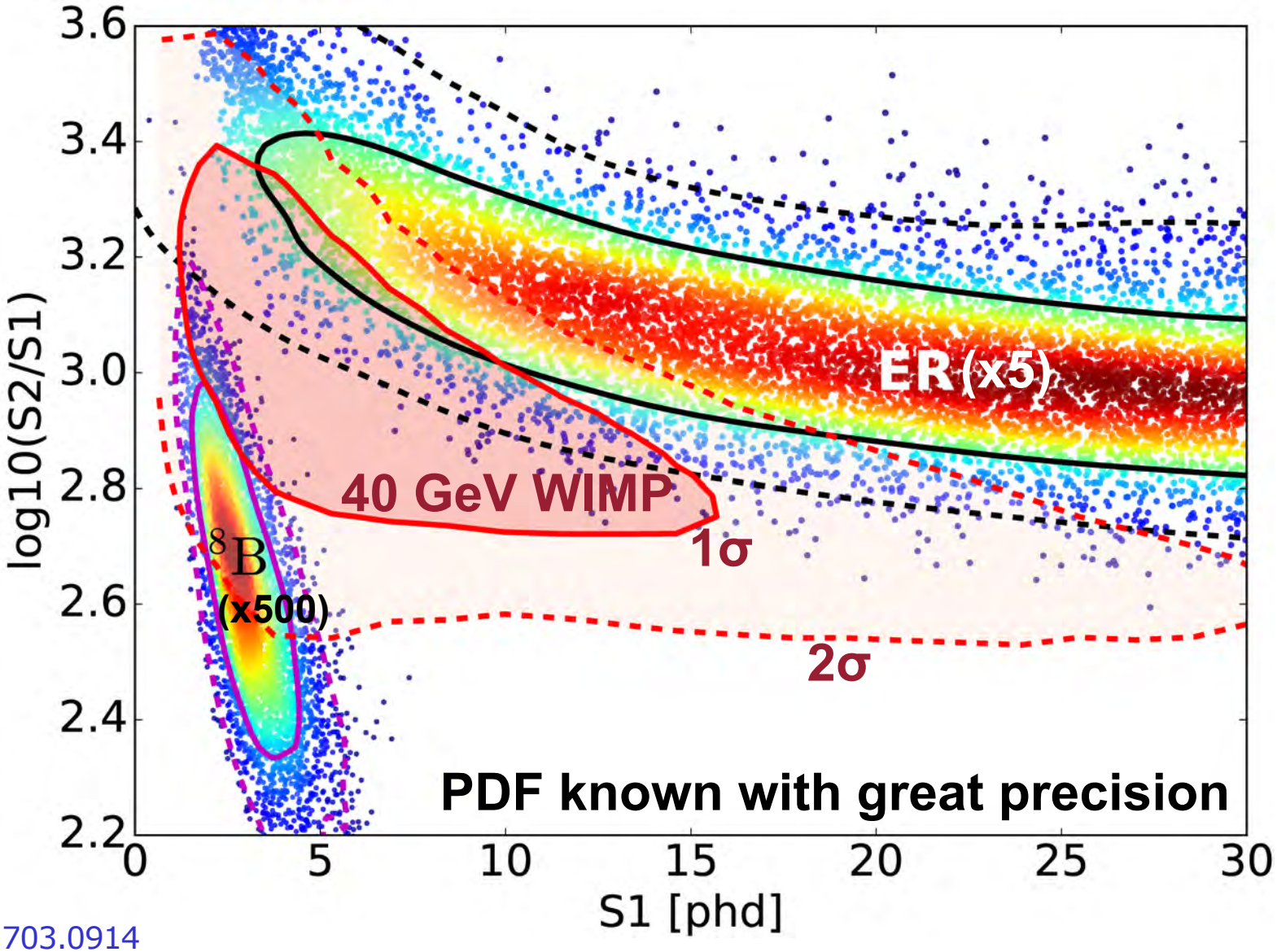
High Statistics Calibrations in LUX





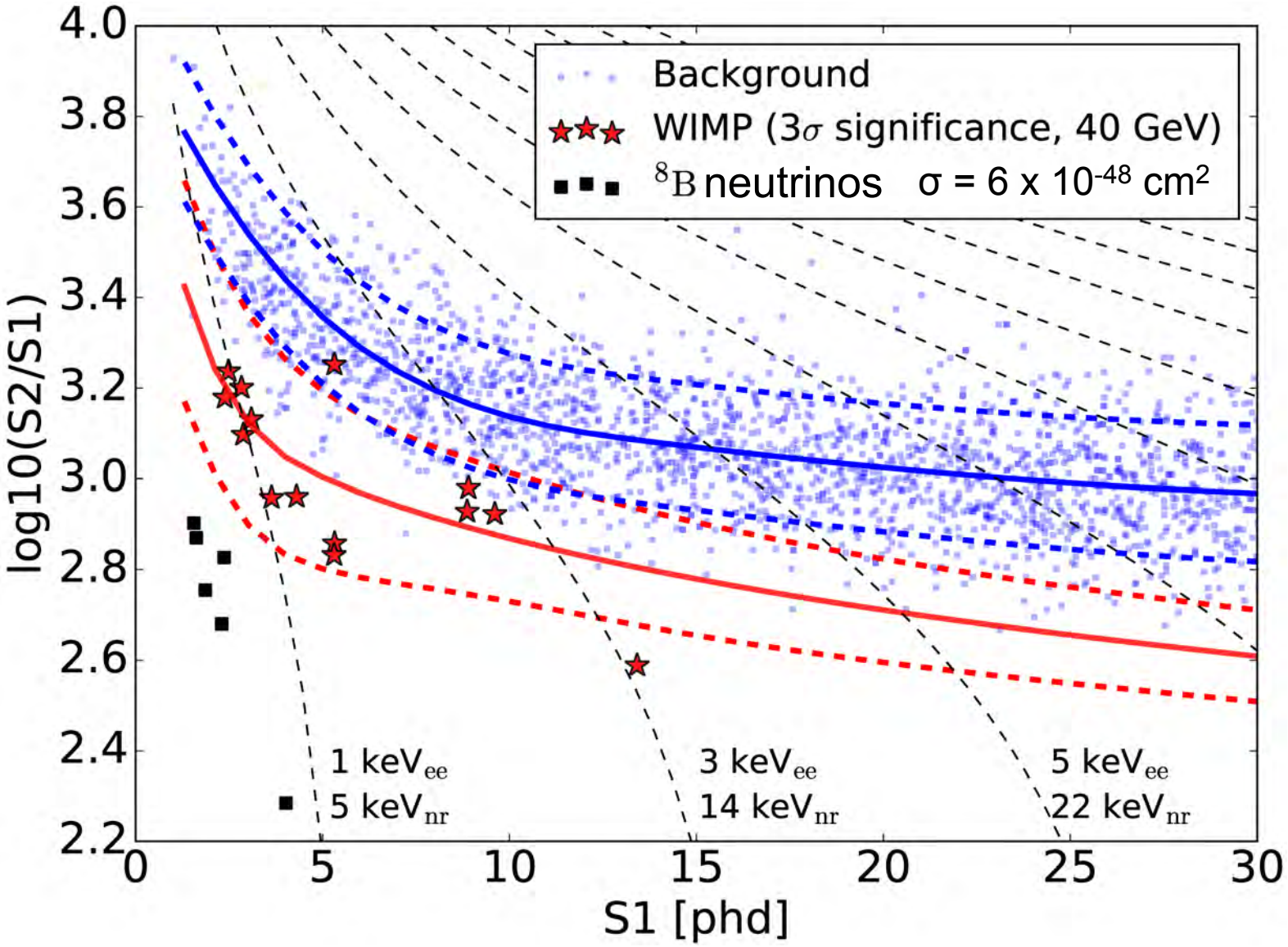
arXiv:1512.03506

WIMP Signal Region in LZ



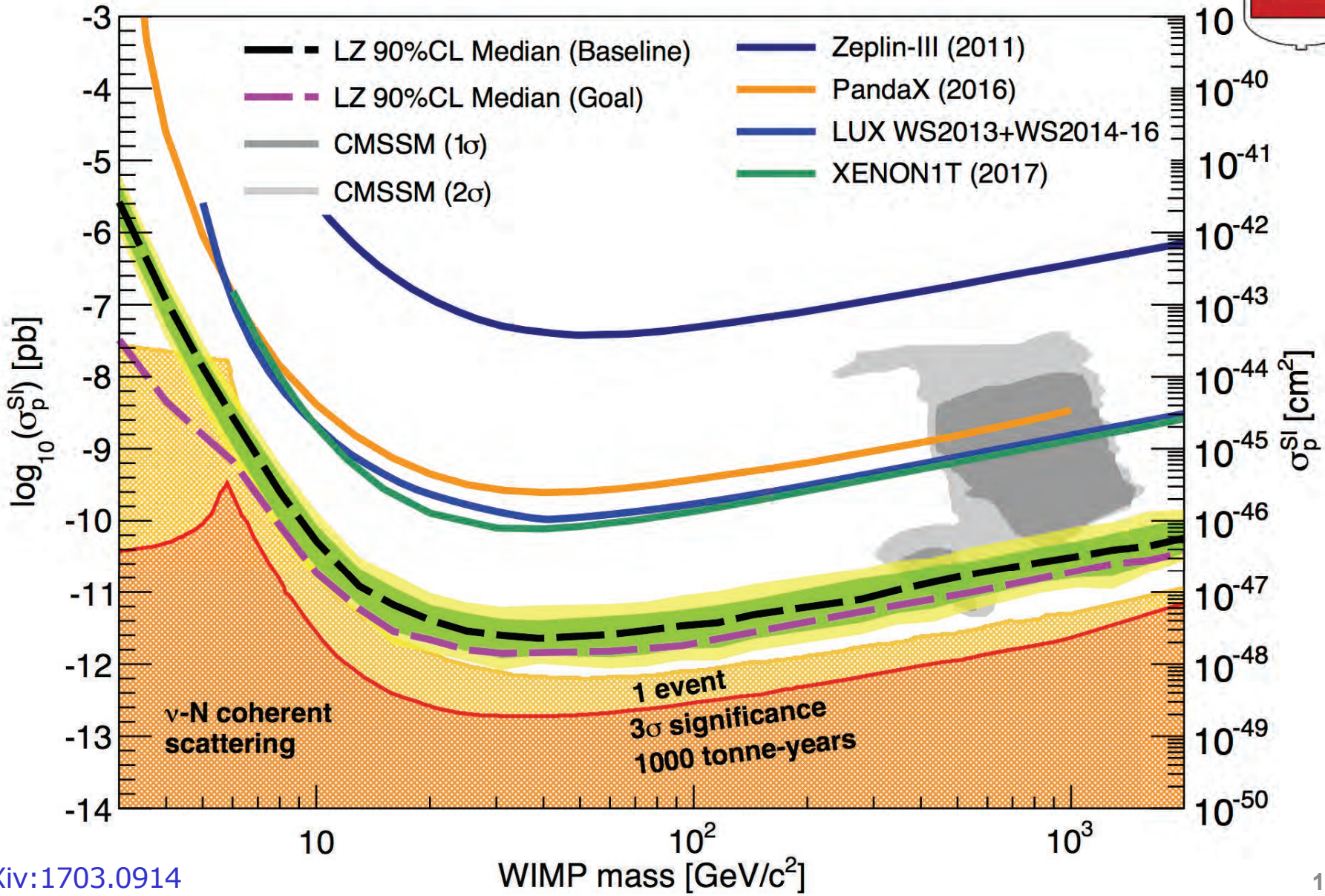
arXiv:1703.0914

1,000 days of simulated LZ (5.6 T)

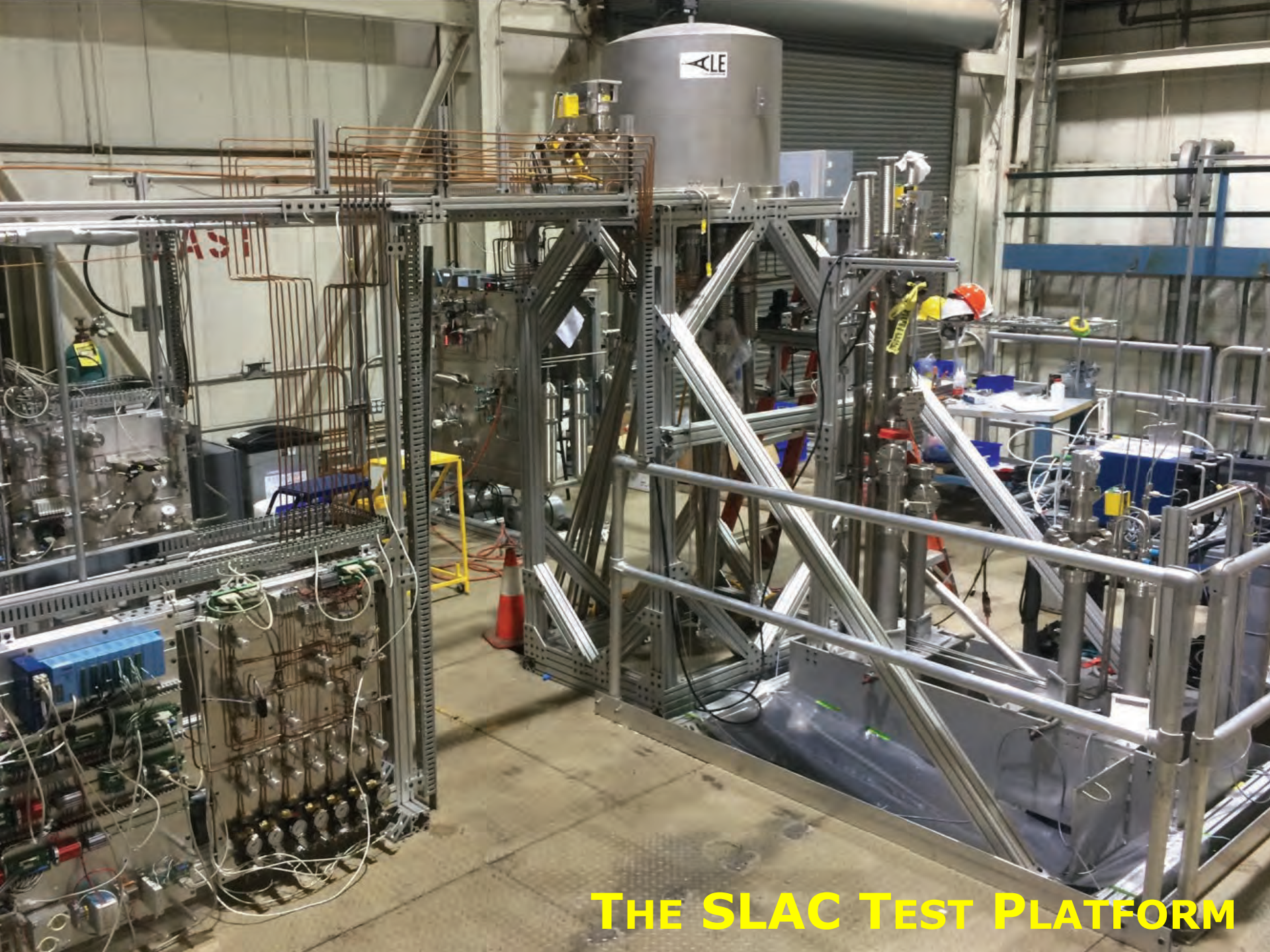


arXiv:1703.0914

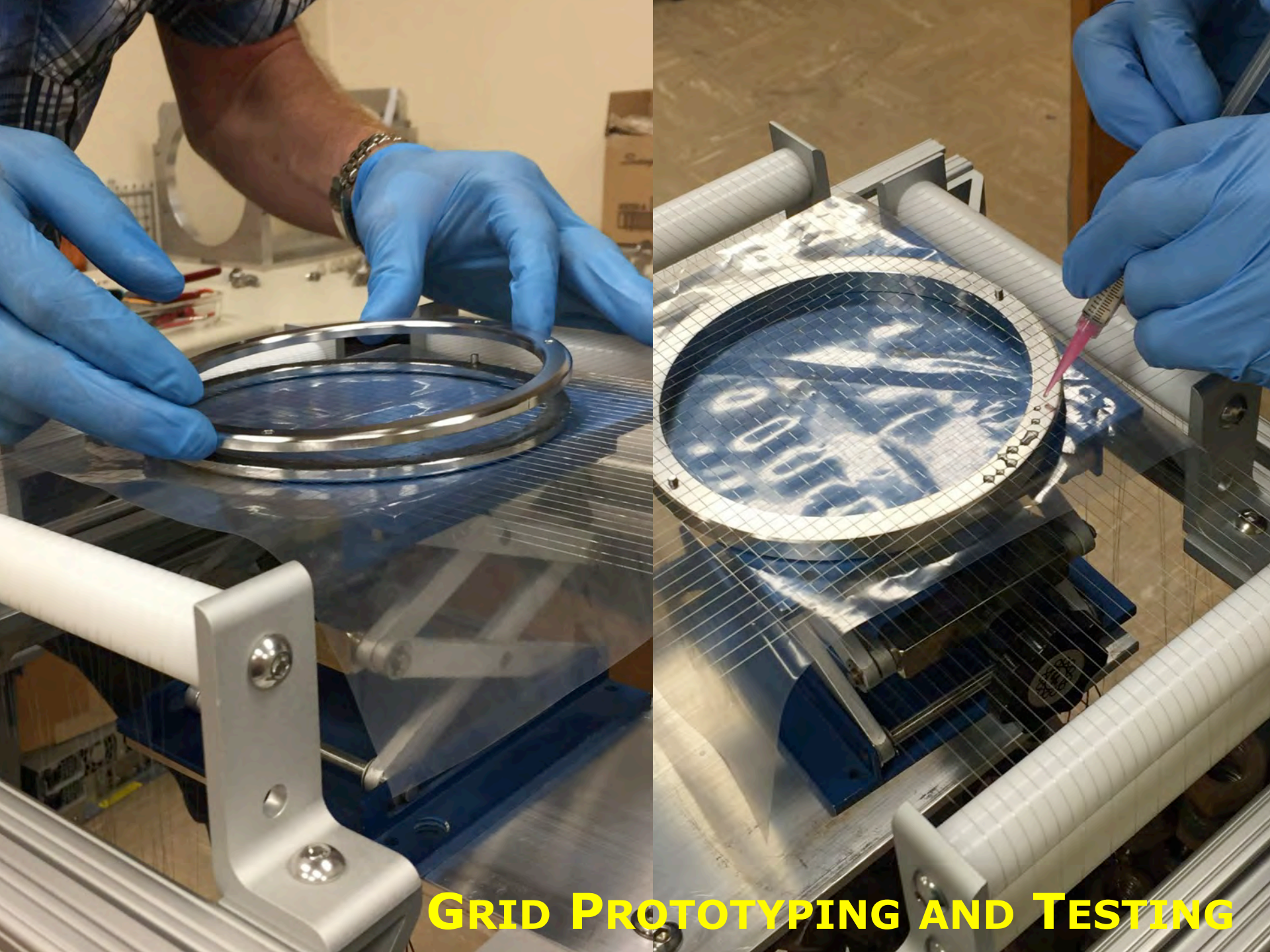
LZ Projected Sensitivity: Spin Independent



arXiv:1703.0914



The SLAC Test Platform



Grid Prototyping and Testing

Phase I Test Detector


Full-Scale Grid Loom at SLAC

Summary and Outlook

- **LZ achieved CD-3 milestone on 02/09/17:**
  - **2016: LUX removed from Davis campus**
  - **July 2017: surface assembly preparation**
  - **July 2018: underground installation**
  - **2020: begin LZ commissioning**
- **Long lead-time procurements underway**
- **Quality assurance and testing for hardware underway; material screening program busy**
- **LZ benefits from excellent LUX calibrations and understanding of backgrounds**
- **LZ science run to start in 2021:**
  - **1000 live days, 5.6 tons fiducial mass**
  - **Spin-Indep. sensitivity: 2.3×10^{-48} cm^2**
  - **Start probing the neutrino floor**