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

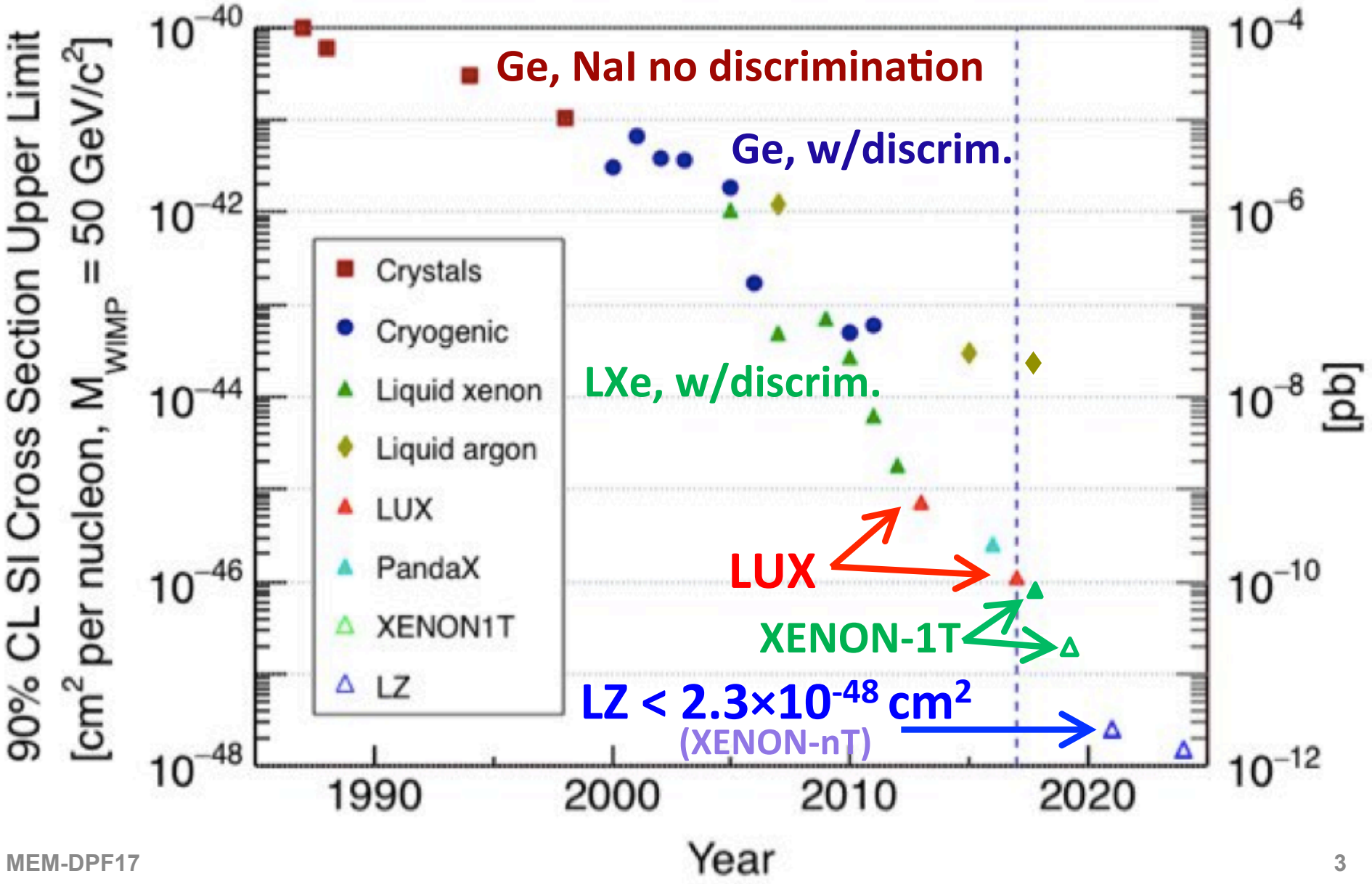
LZ = LUX + ZEPLIN

LZ collaboration:

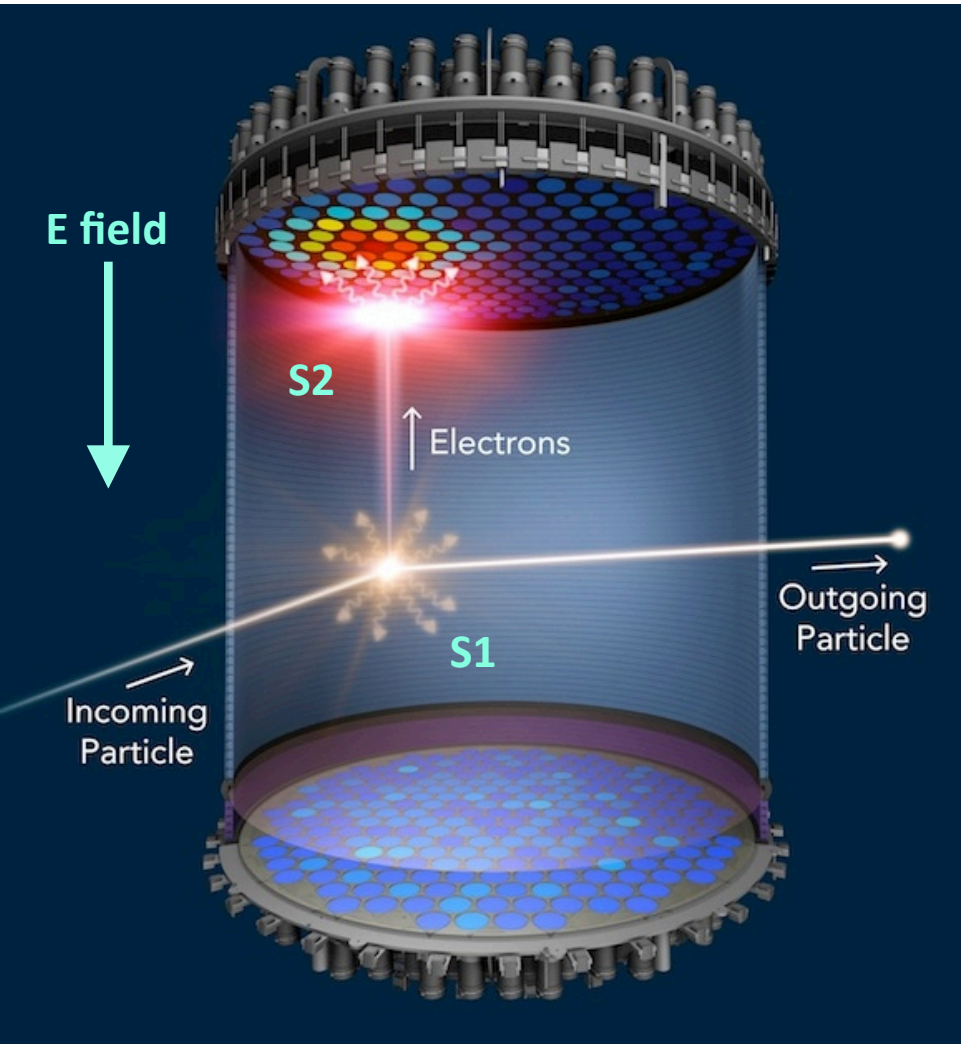
- 38 institutions (USA, UK, Portugal, Russia, South Korea)
- 250+ scientists, engineers, and technicians

LZ collaboration meeting, SURF, July 19 2017

Moore's Law of Direct Detection



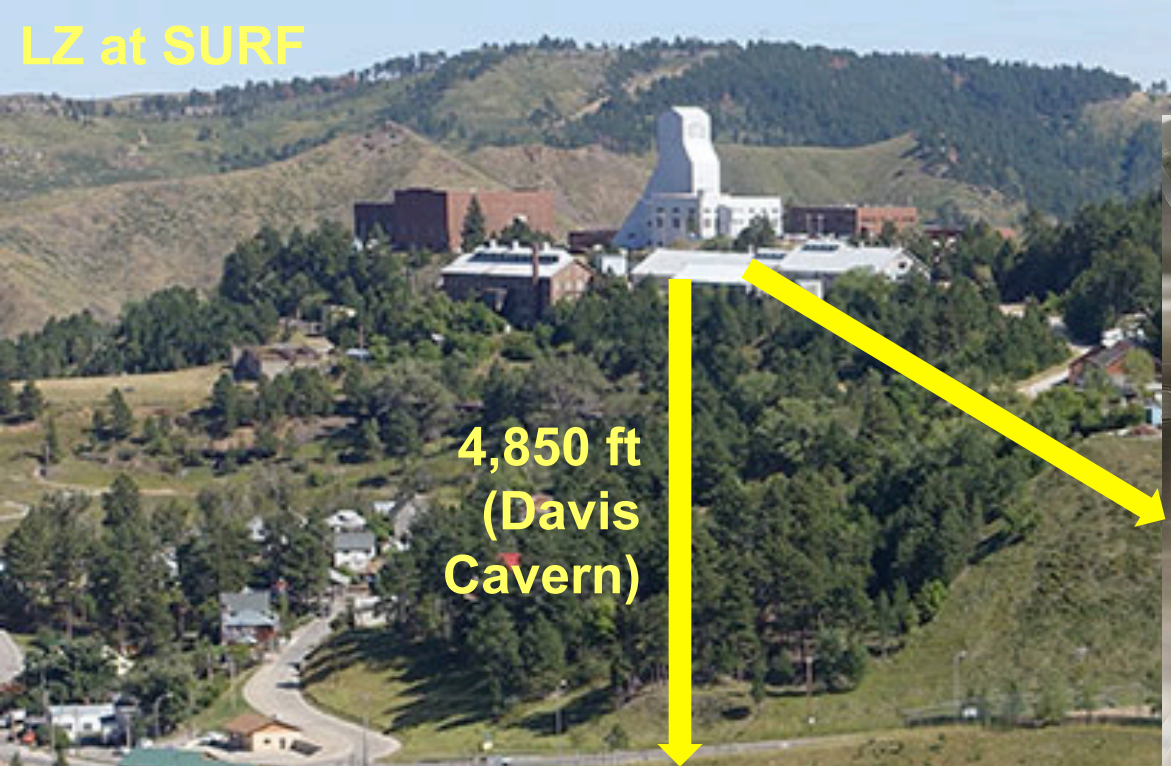
Noble Liquid TPCs for WIMP Detection



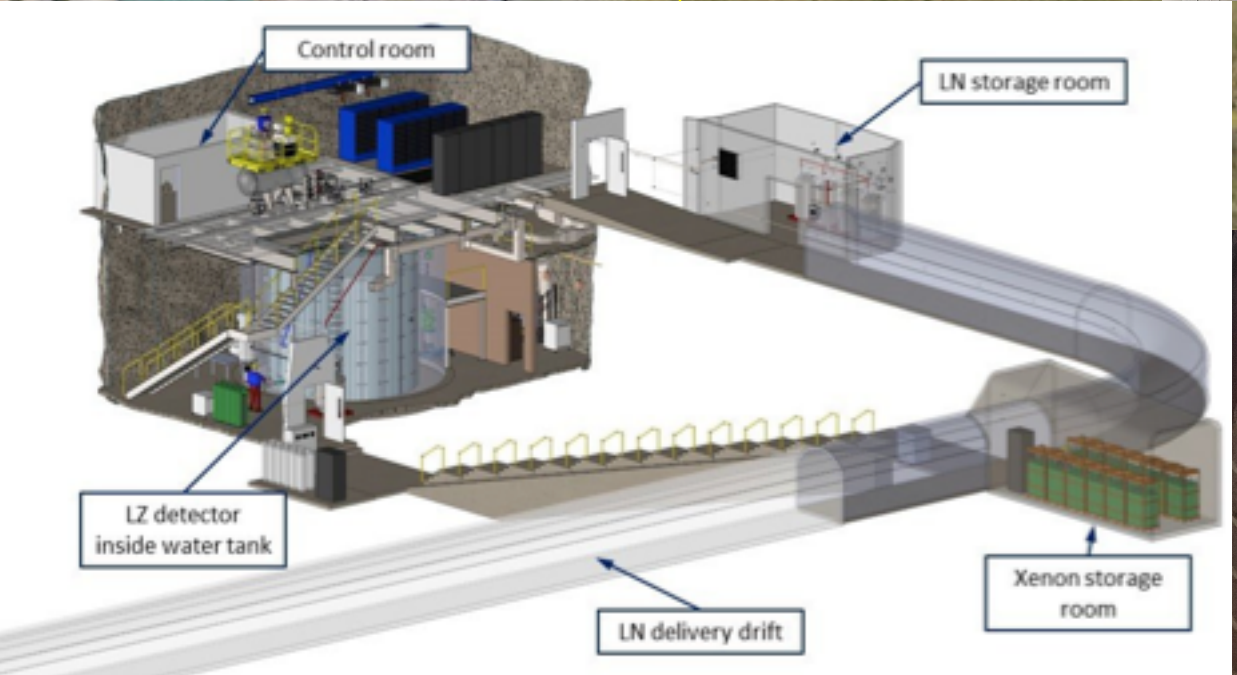
- **WIMP-induced nuclear recoils: ~ few keV energy**
  - **S1, S2 → event energy**
  - **S2 image → xy coordinate**
  - **S1-S2 timing → z coord.**
  - **S2/S1 (Xe) → recoil type**
  - **S1 PSD (Ar) → recoil type**

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

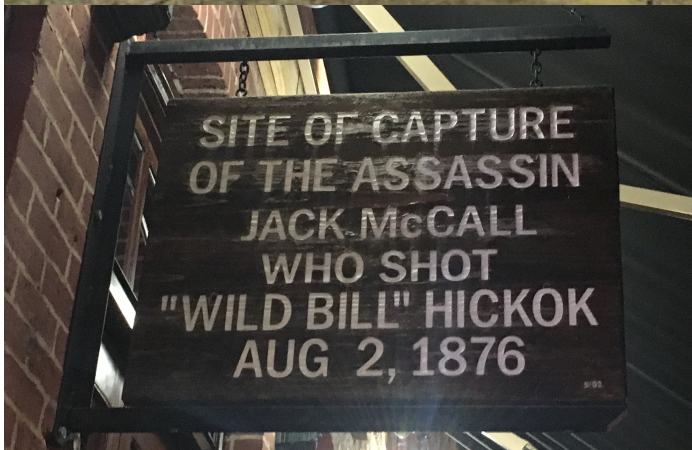
LZ at SURF



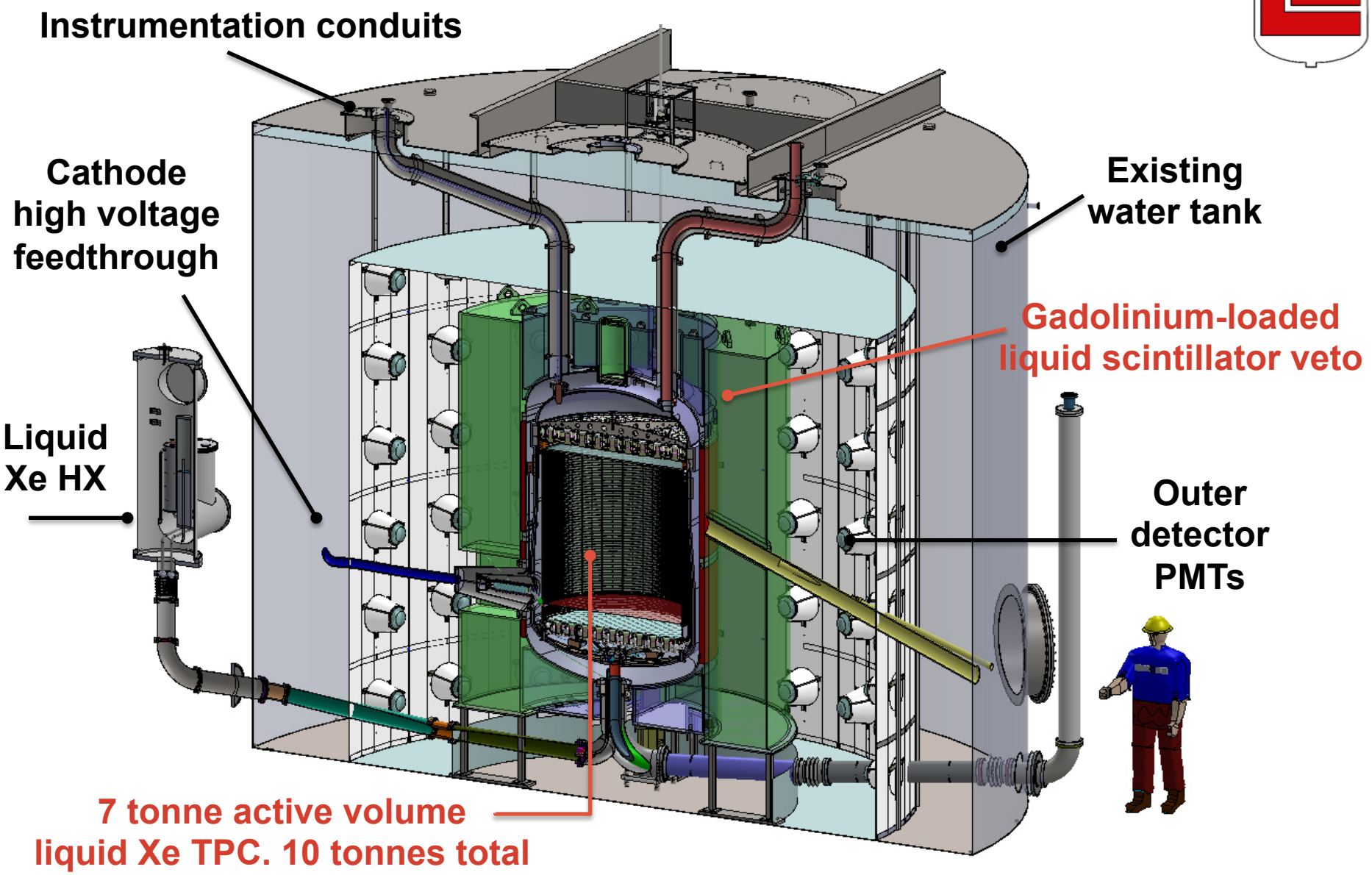
Rn-reduced cleanroom



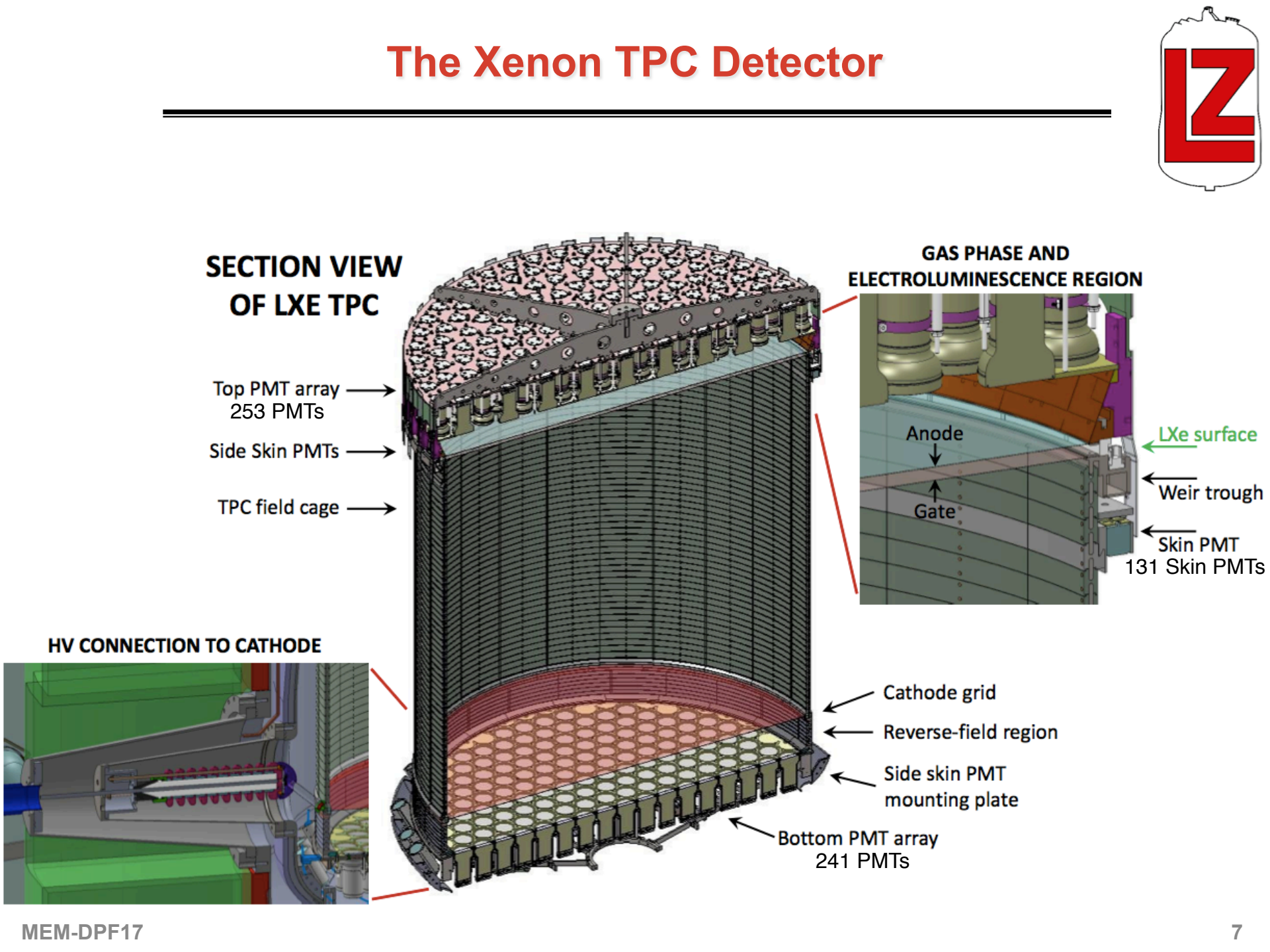
South Dakota folklore...



LZ Detector Overview



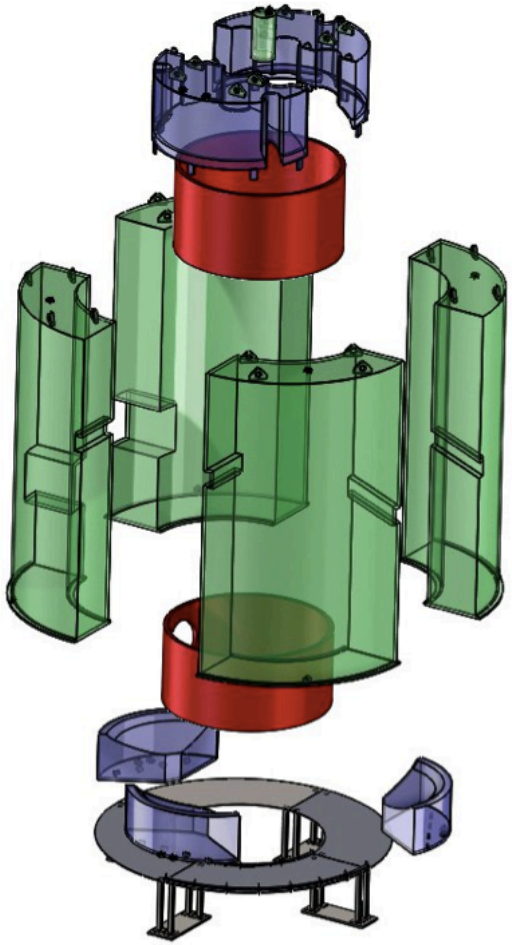
The Xenon TPC Detector



LZ as a Discovery Instrument

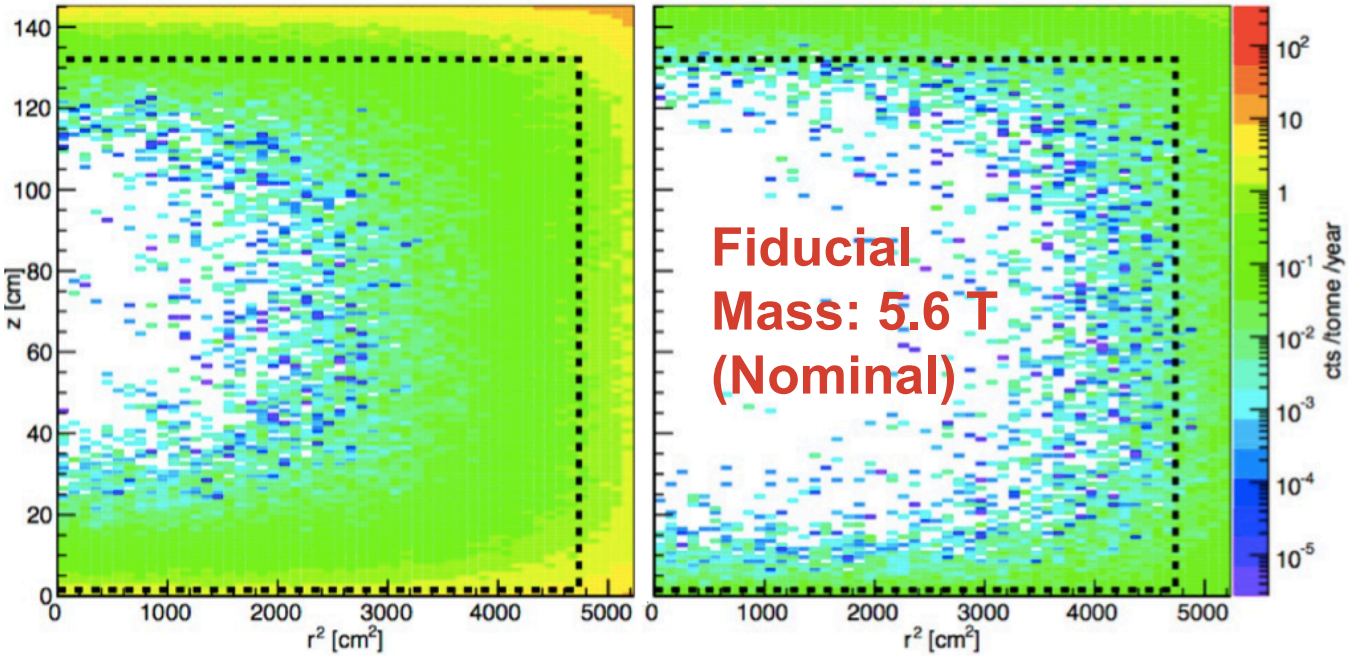
- 0.61 m thick Gd-loaded scintillator
- instrumented Xenon “skin”
- we can tag neutrons and gammas

} In-situ monitoring of residual backgrounds



ROI + Single Scatter

ROI + S.S. + Vetoes



Screening + Simulations: the background table

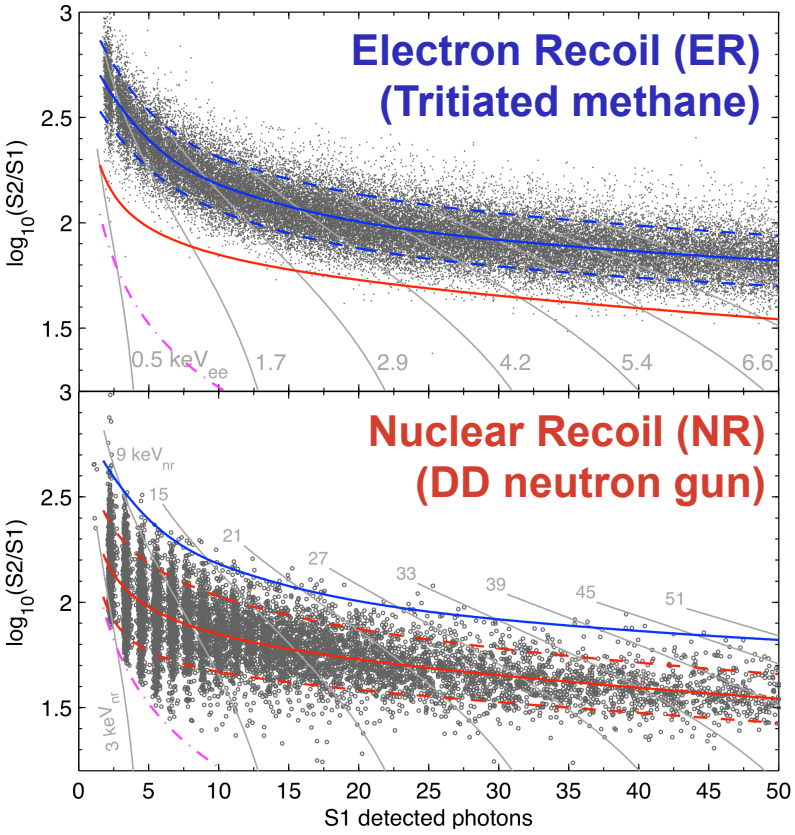
Expected counts in 1,000 live days in an indicative 5.6-tonne fiducial mass in [1.5-6.5] keV_{ee} (ER) and [6-30] keV (NR):

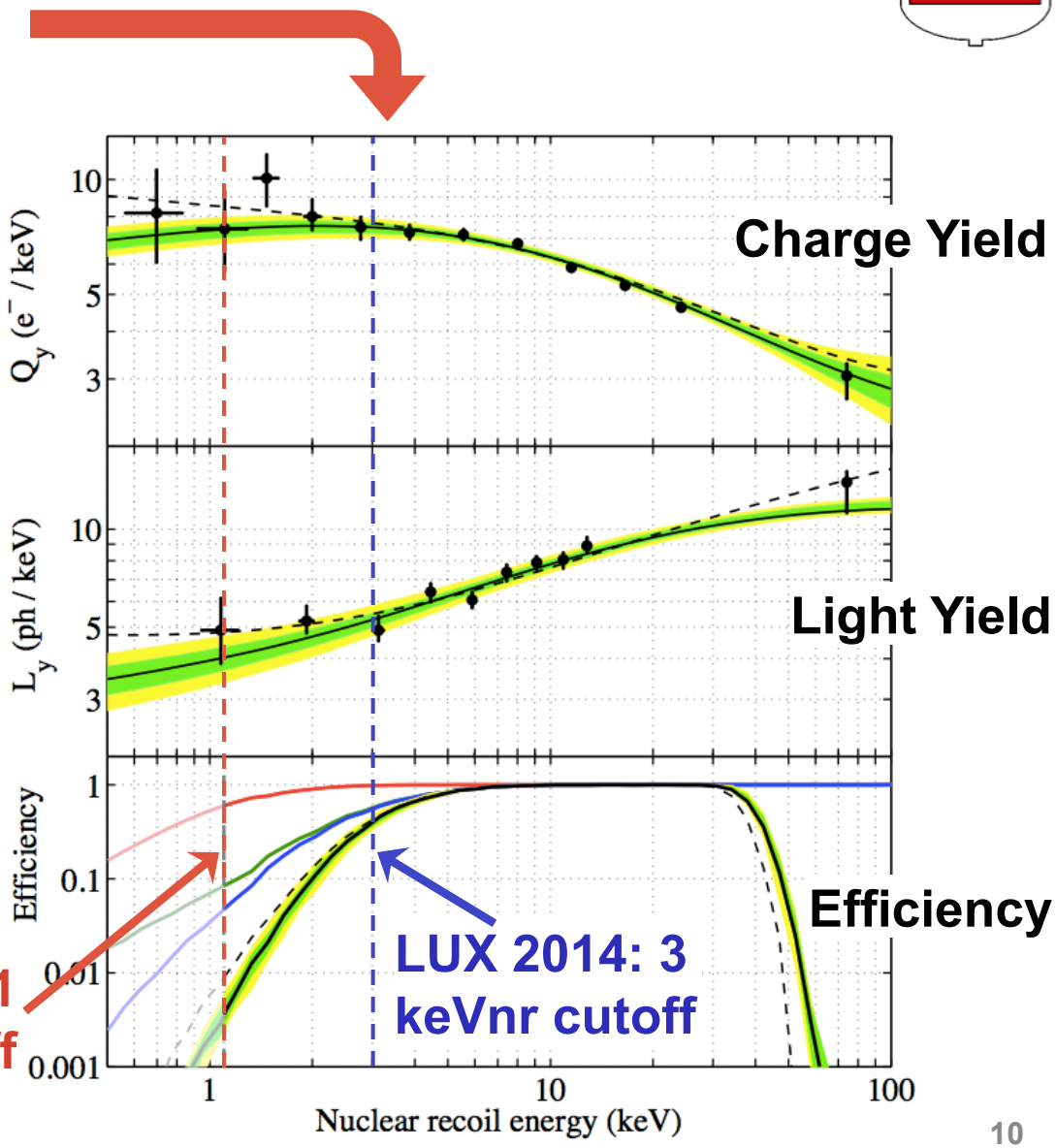
Item	ER cts	NR cts
Detector Componenents	6.2	0.07
Dispersed radionuclides (Rn, Kr, Ar)	911	-
Laboratory and cosmogenic	4.3	0.06
Fixed surface contamination	0.19	0.37
^{136}Xe $2\nu\beta\beta$	67	-
Neutrinos (ν-e, ν-A)	255	0.72
Total	1244	1.22
Total (with 99.5% ER discrimination, 50% NR efficiency)	6.22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

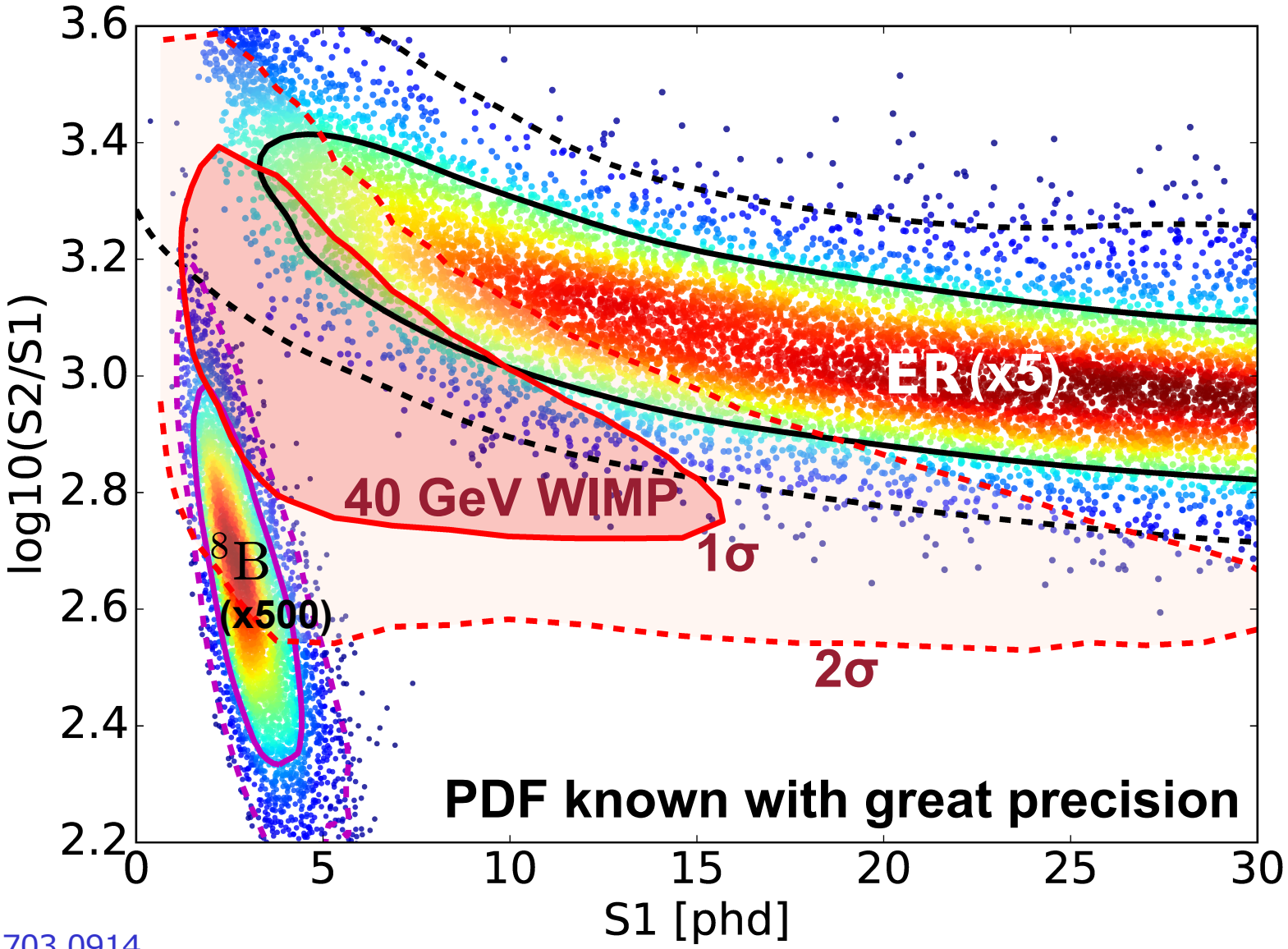
High Statistics Calibrations in LUX





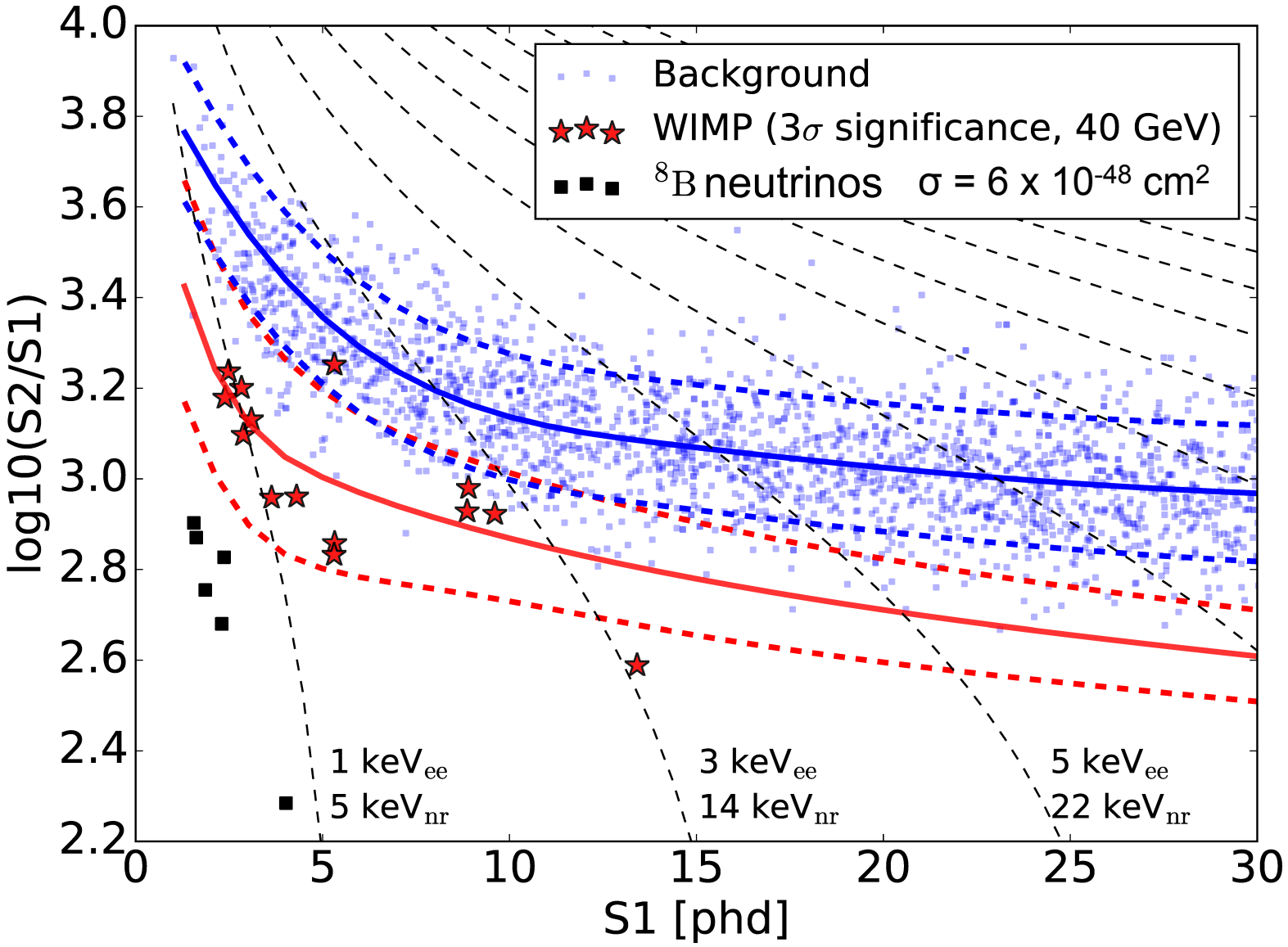
arXiv:1512.03506

WIMP Signal Region in LZ



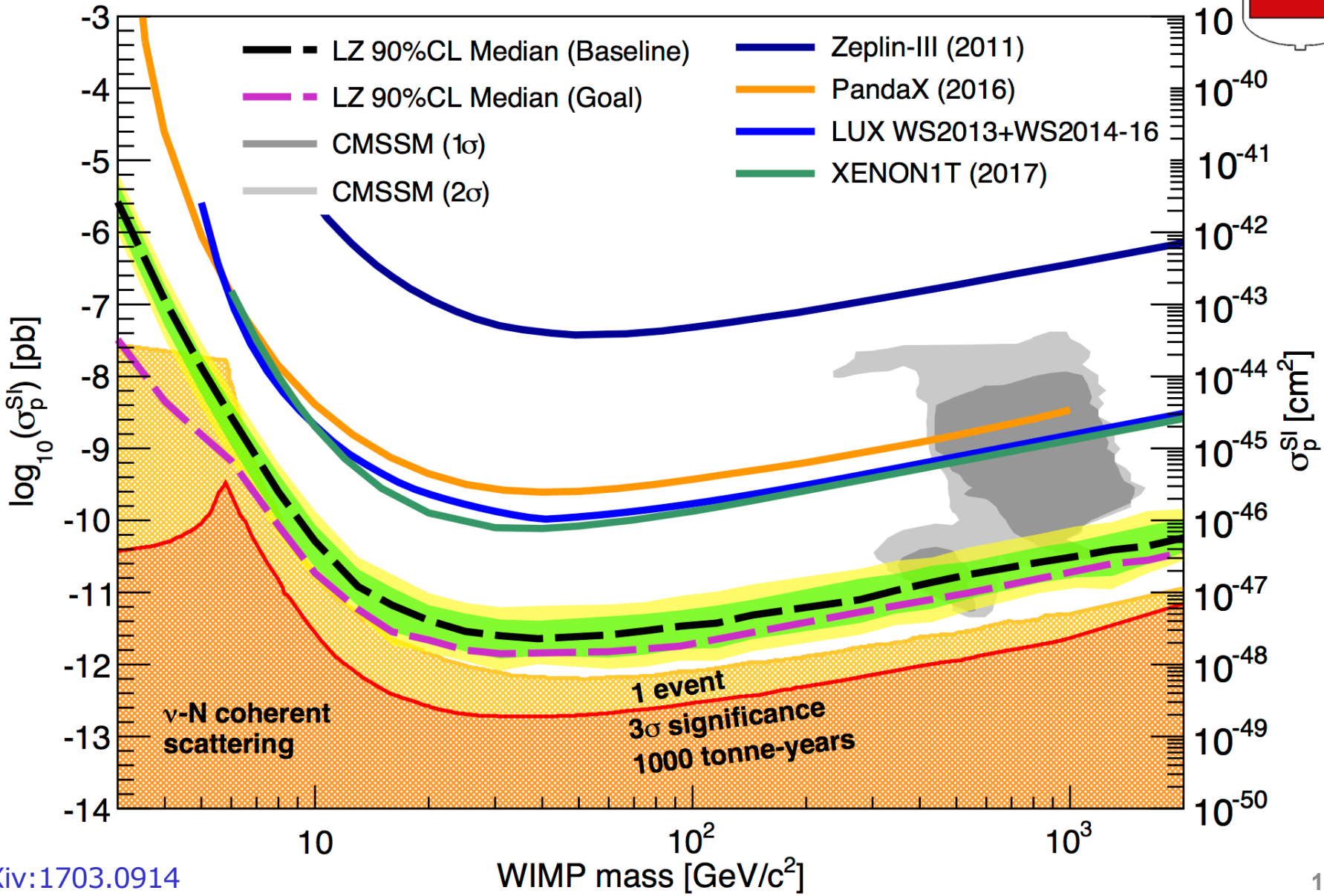
arXiv:1703.0914

1,000 days of simulated LZ (5.6 T)

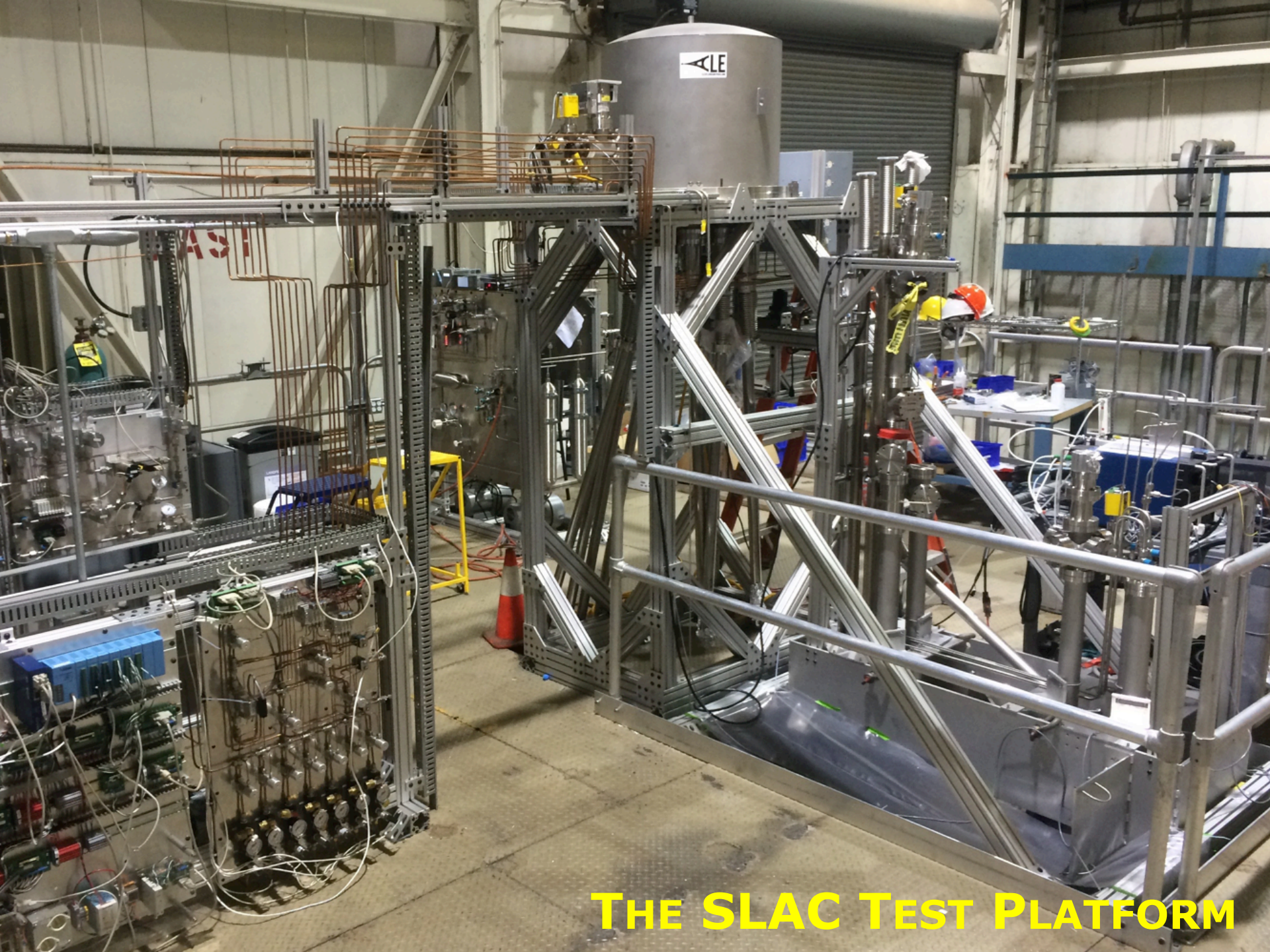


arXiv:1703.0914

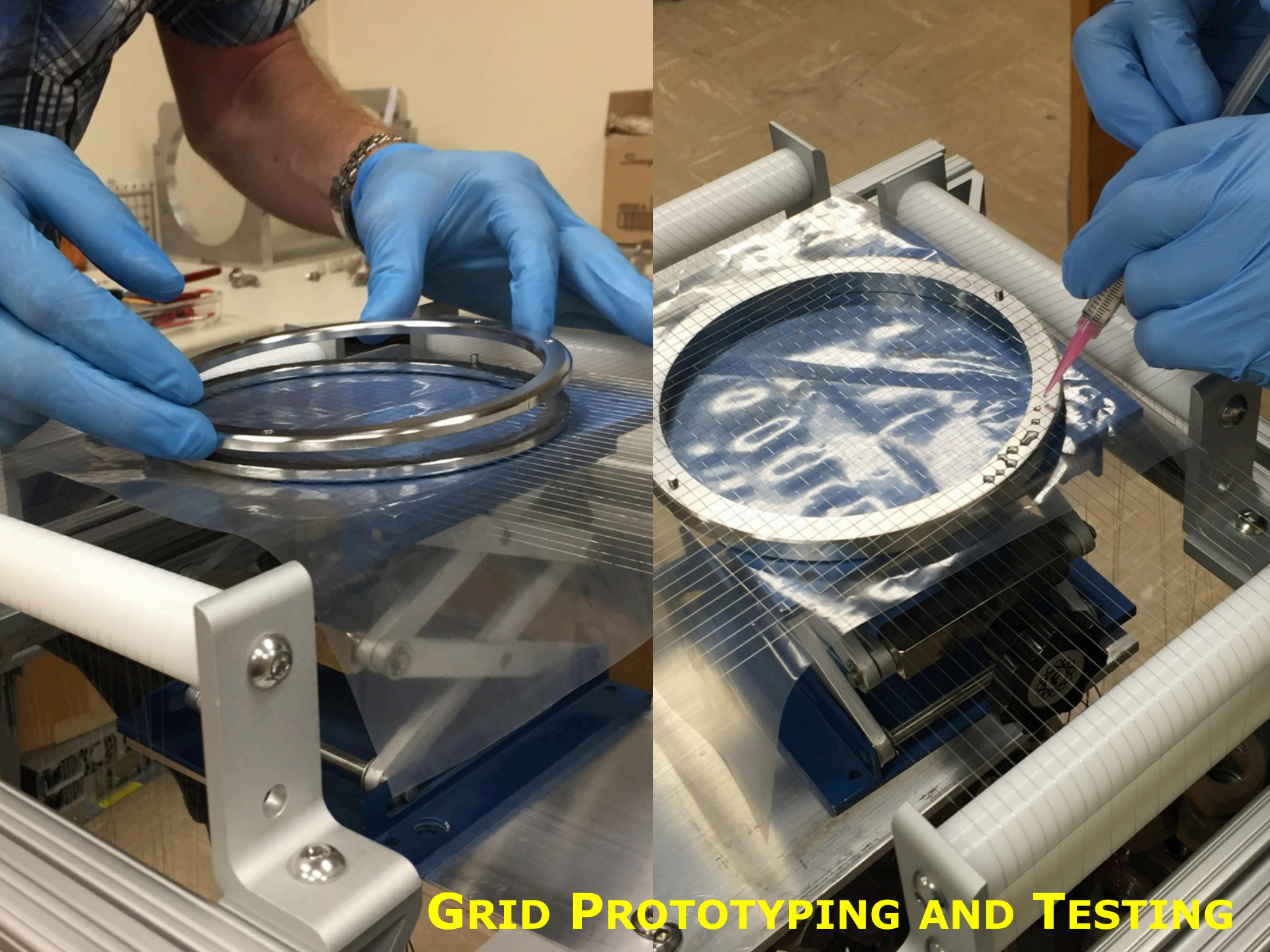
LZ Projected Sensitivity: Spin Independent



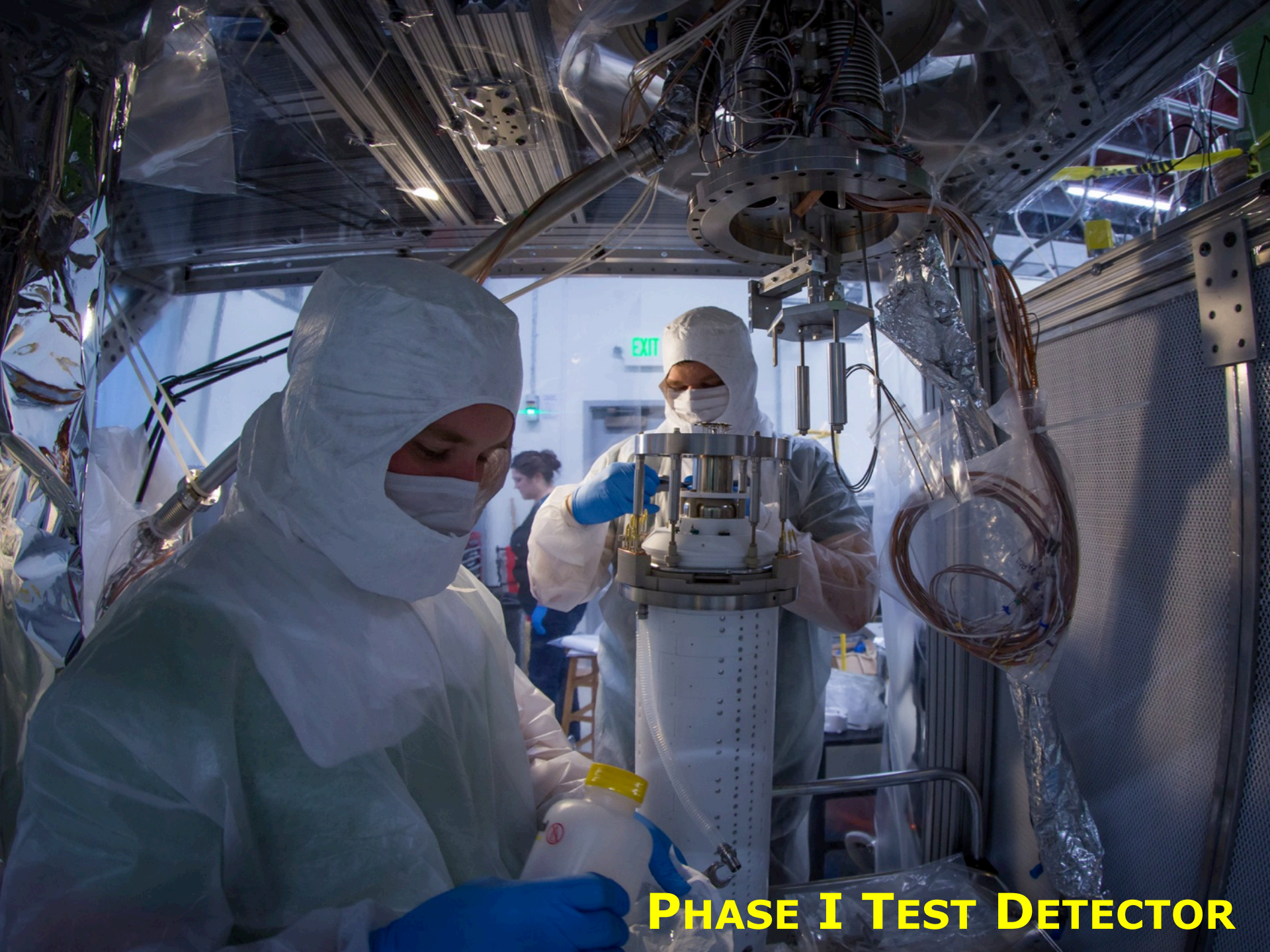
arXiv:1703.0914



The SLAC Test Platform



Grid Prototyping and Testing


EXIT
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**