Imperial College London

LZ
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MINING FOR DARK MATTER

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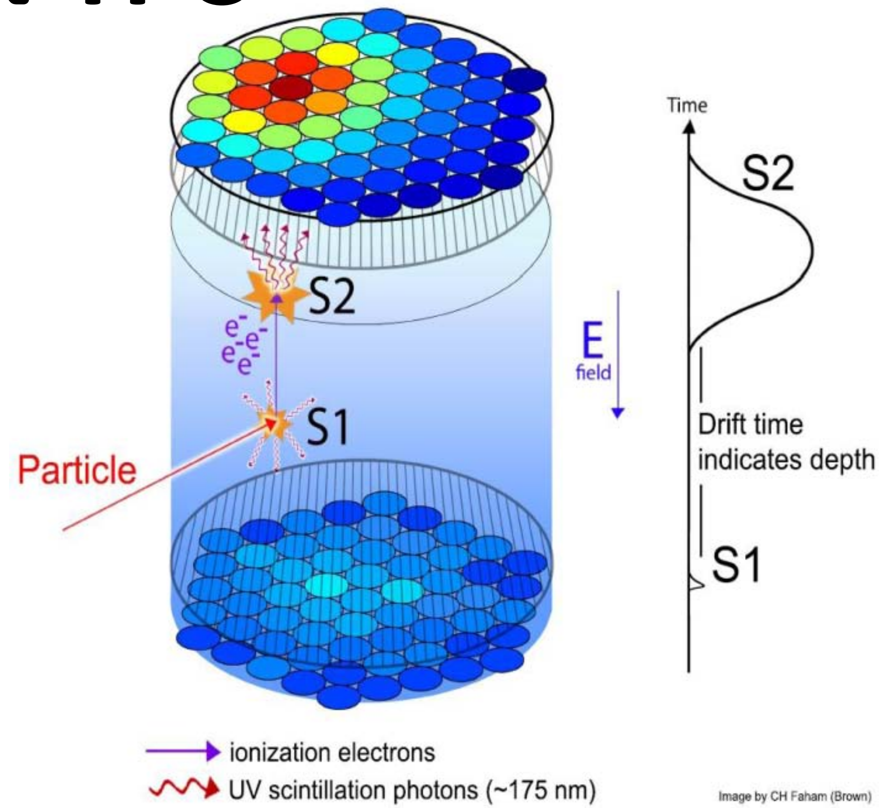
On behalf of the
LUX-ZEPLIN Collaboration

HEPP/APP IOP Meeting, 7-9 APR 2014, RHUL

TWO-PHASE XENON TPC



S1: prompt scintillation signal

- Light yield: ~60 ph/keV (ER, 0 field)
- Scintillation light: 178 nm (VUV)
- **Nuclear recoil threshold ~5 keV**

S2: delayed ionisation signal

- Electroluminescence in vapour phase
- Sensitive to single ionisation electrons
- **Nuclear recoil threshold ~1 keV**

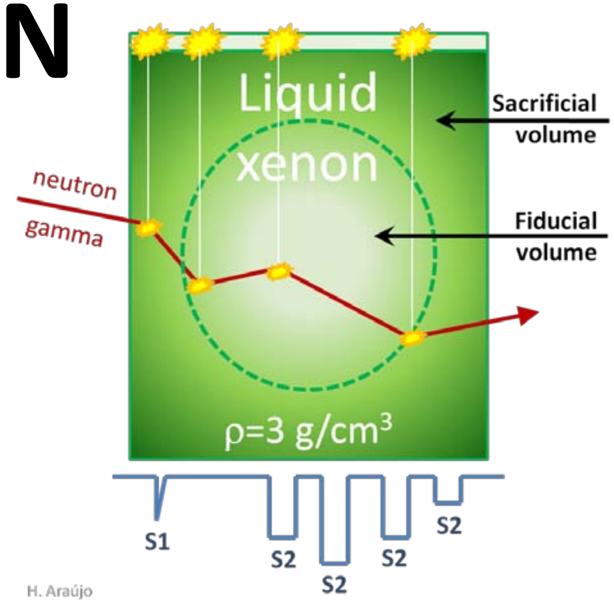
S1+S2 event by event

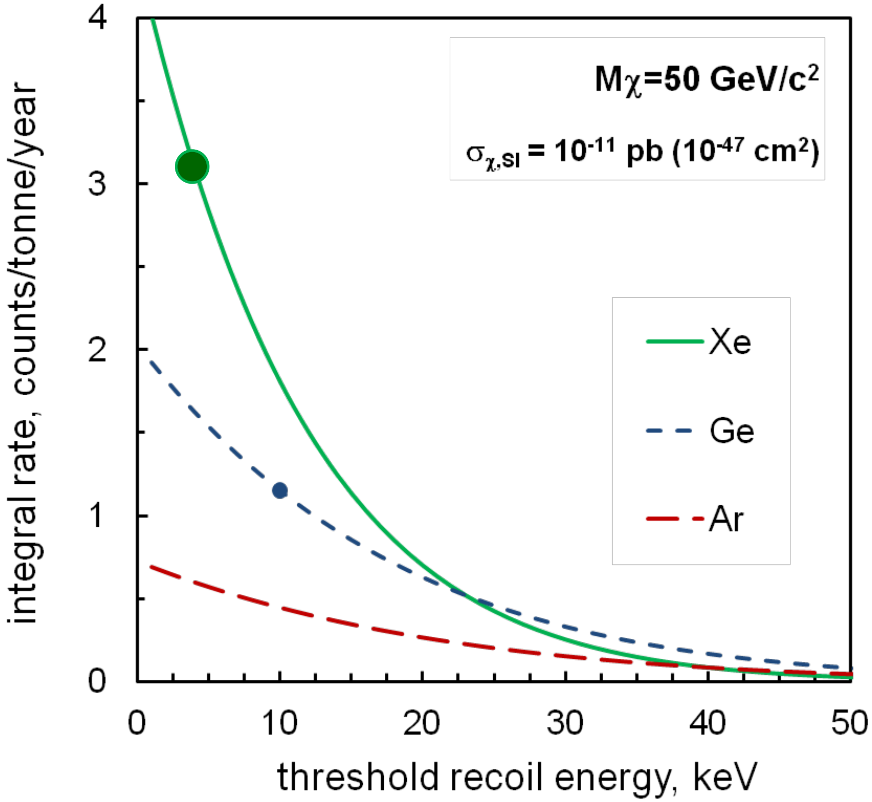
- ER/NR discrimination (>99.5% rejection)
- mm vertex resolution + high density: *self-shielding* of radioactivity backgrounds

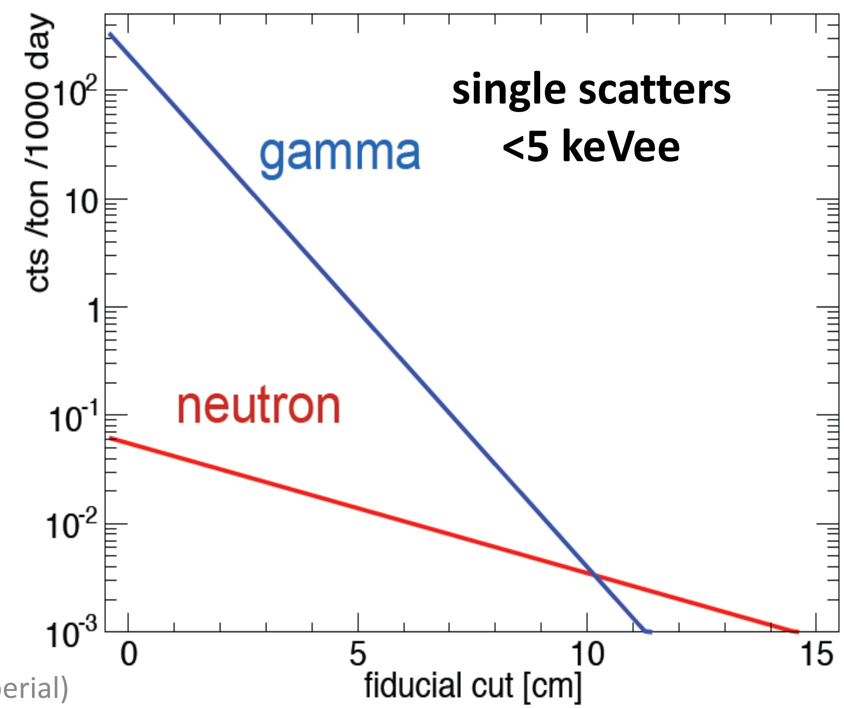
LXe is the leading WIMP target:

- Scalar WIMP-nucleon scattering rate dR/dE~A^2, broad mass coverage >5 GeV
- Odd-neutron isotopes (^{129}Xe, ^{131}Xe) enable SD sensitivity; target exchange
- No damaging intrinsic nasties (^{127}Xe short-lived, ^{85}Kr removable, ^{136}Xe $2\nu\beta\beta$ ok)

THE NOBLE LIQUID XENON



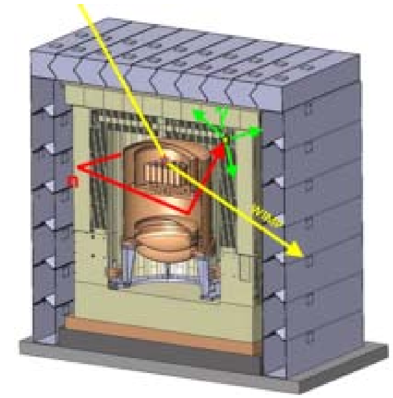




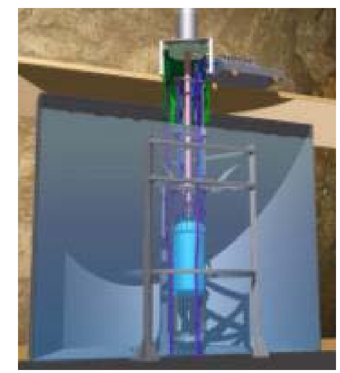
Searches for RARE *and* LOW ENERGY events: a challenging combination

H Araujo (Imperial)

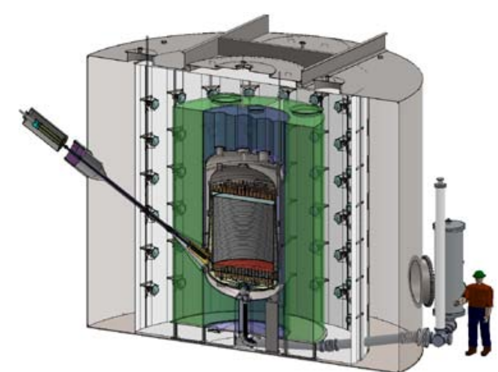
ZEPLIN→ LUX→ LUX-ZEPLIN



- **UK-led ZEPLIN programme at Boulby (2001-2011)**
  - Pioneered two-phase xenon technology
  - World class results from 3 xenon experiments
  - Fiducial mass ~6 kg



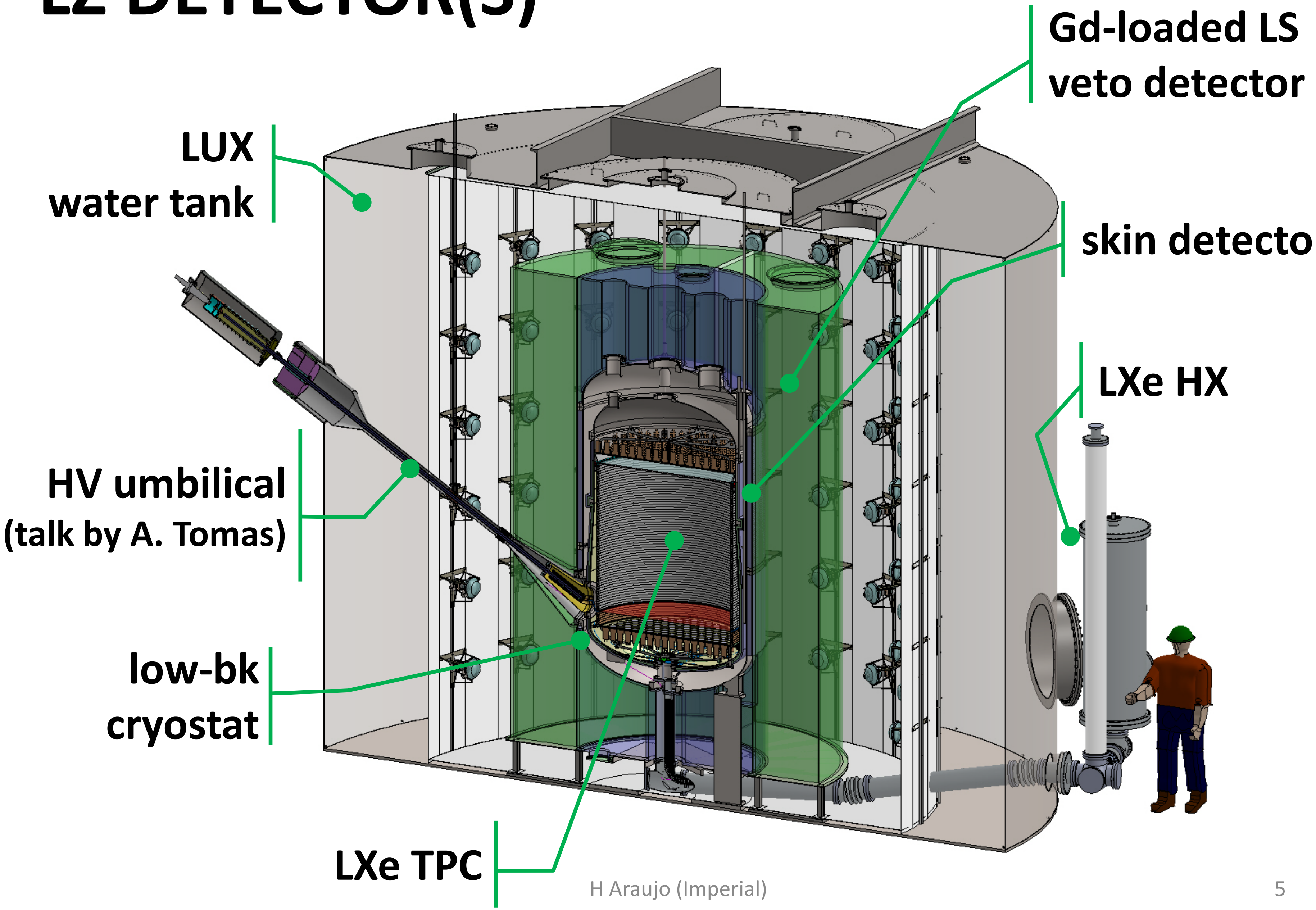
- **LUX operating at Sanford Underground Laboratory**
  - Imperial, Edinburgh and UCL joined after ZEPLIN-III
  - Present world-leading experiment
    (see talks by L. Reichhart and A. Bailey)
  - Fiducial mass ~100 kg

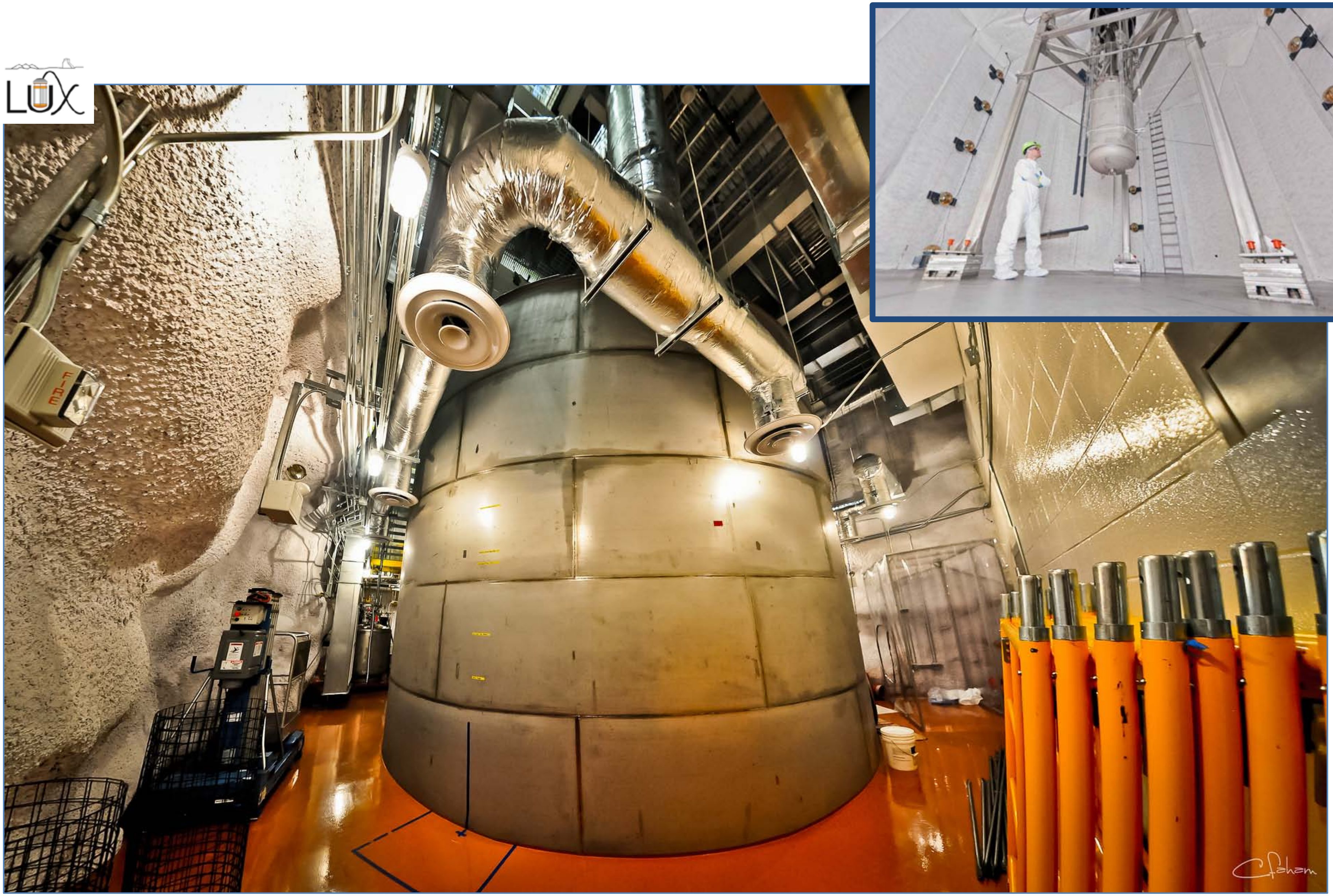


- **LZ: next-generation experiment**
  - LZ formed with MOU between LUX and ZEPLIN-III in 2008
  - Selected by DMUK for construction proposal to STFC
  - Fiducial mass ~6,000 kg (~10^{-48} cm^2 sensitivity)
  - Conceptual design nearly completed, construction f/ 2015

The University of Edinburgh · Imperial College London · University of Oxford · Science & Technology Facilities Council Rutherford Appleton Laboratory · The University Of Sheffield. · UCL

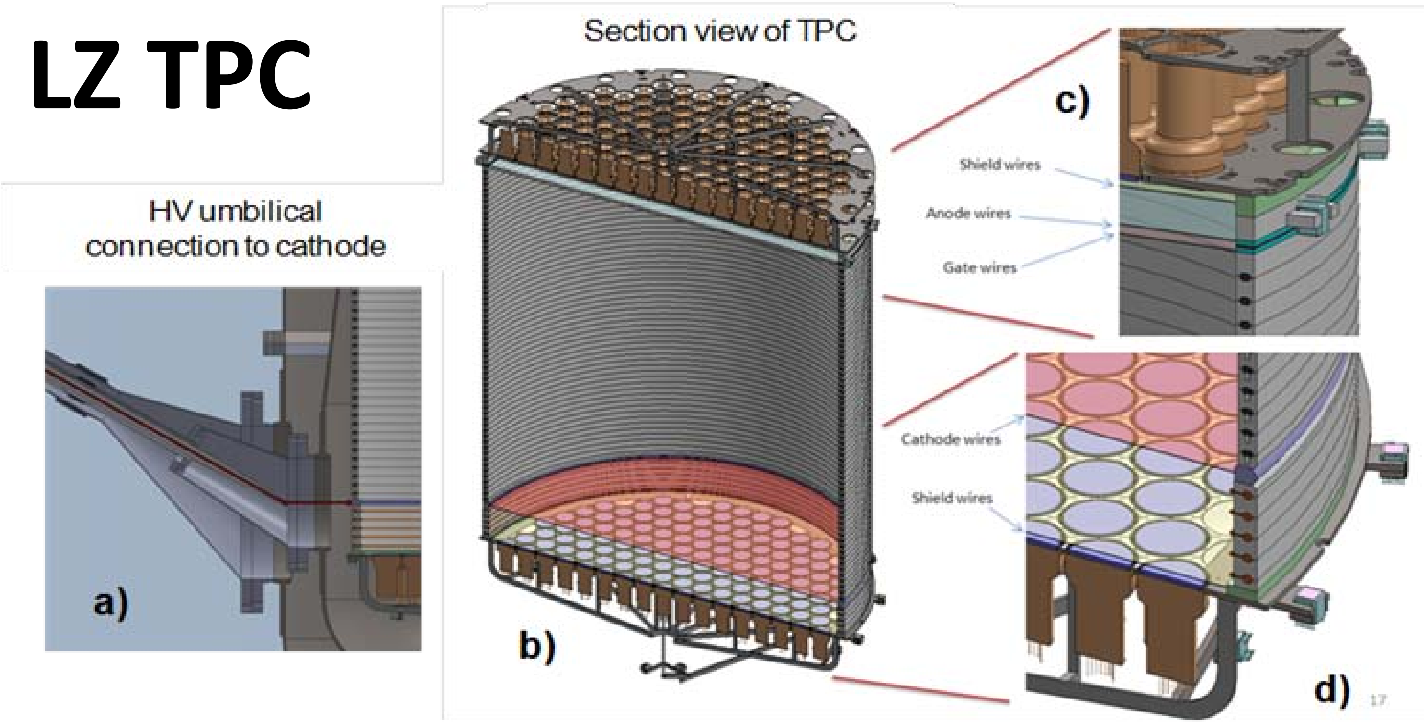
LZ DETECTOR(S)





The 8-m diameter LUX water tank, Davis Campus, 4850-ft u/g level, Sanford Underground Research Facility

THE LZ TPC



- **TPC PARAMETERS**
  - 1.5 m diameter/length (3x LUX)
  - 7 tonne active LXe mass (28x LUX)
  - 2x 241 3-inch PMTs (4x LUX)
  - Highly reflective PTFE field cage
  - 100 kV cathode HV (10x LUX)
  - Electron lifetime 3 ms (3x LUX)

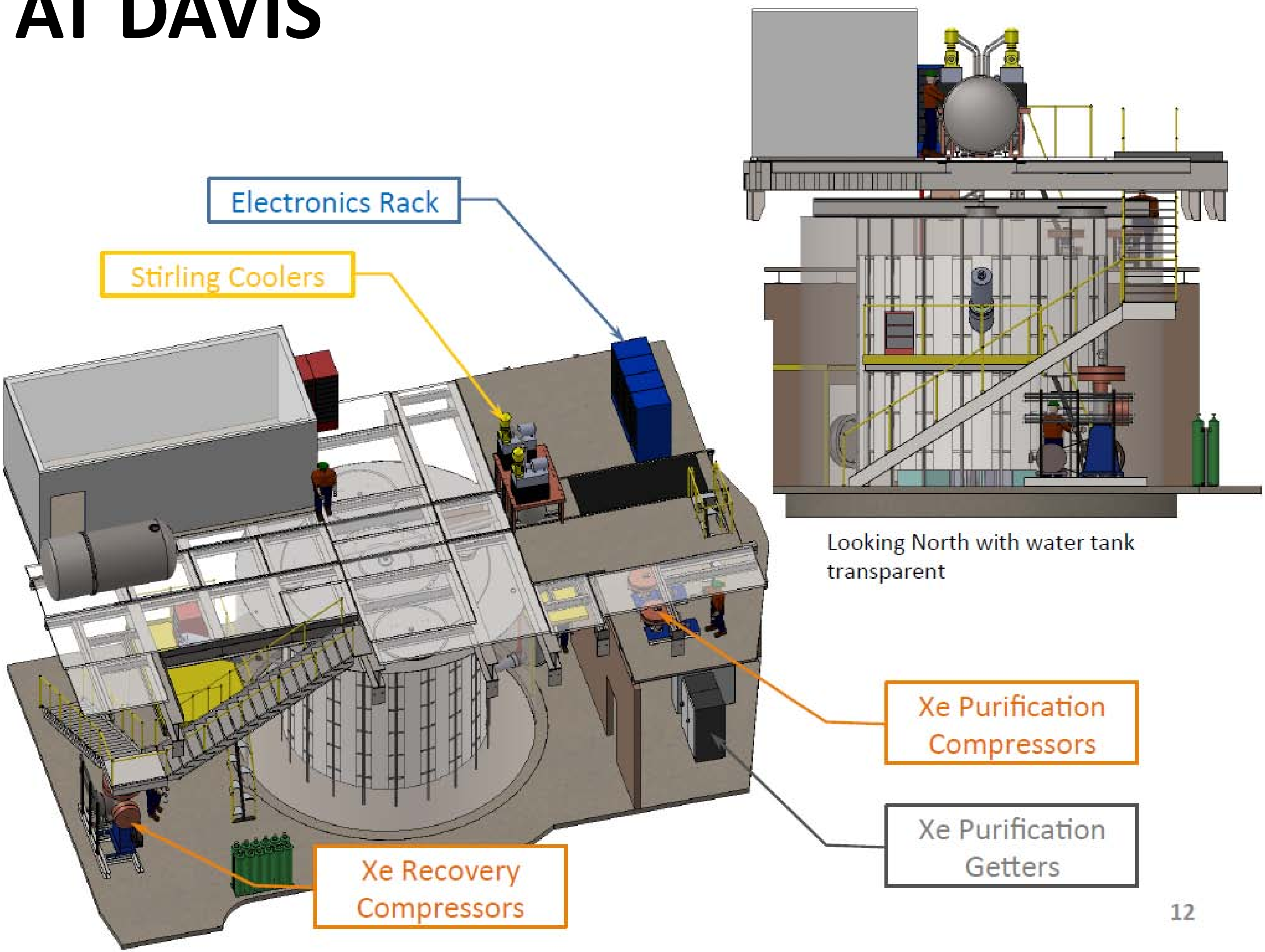
PHYSICS PARAMETERS

- 5.8 keVr S1 threshold (4.5 keVr LUX)
- 0.7 kV/cm drift field, 99.5% ER/NR disc. (already surpassed in LUX at 0.2 kV/cm)

TPC CALIBRATION

- ER: Dispersed sources: Kr-83m, CH3T
- NR: AmBe, YBe, D-D generator

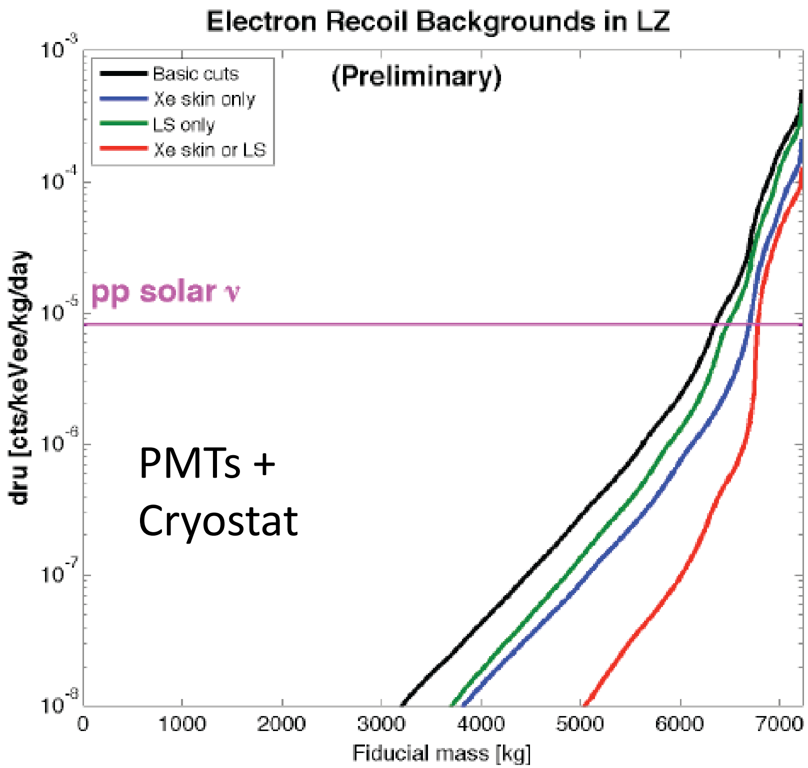
LZ AT DAVIS

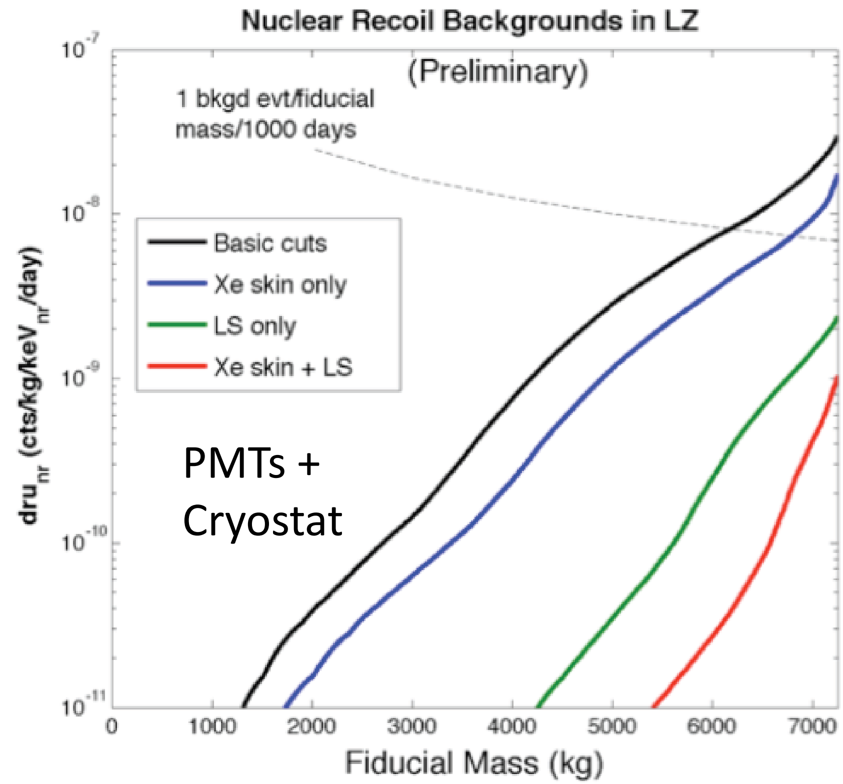


Electronics Rack
Stirling Coolers
Xe Purification Compressors
Xe Purification Getters
Xe Recovery Compressors
Looking North with water tank transparent
12

IMPORTANT BACKGROUNDS

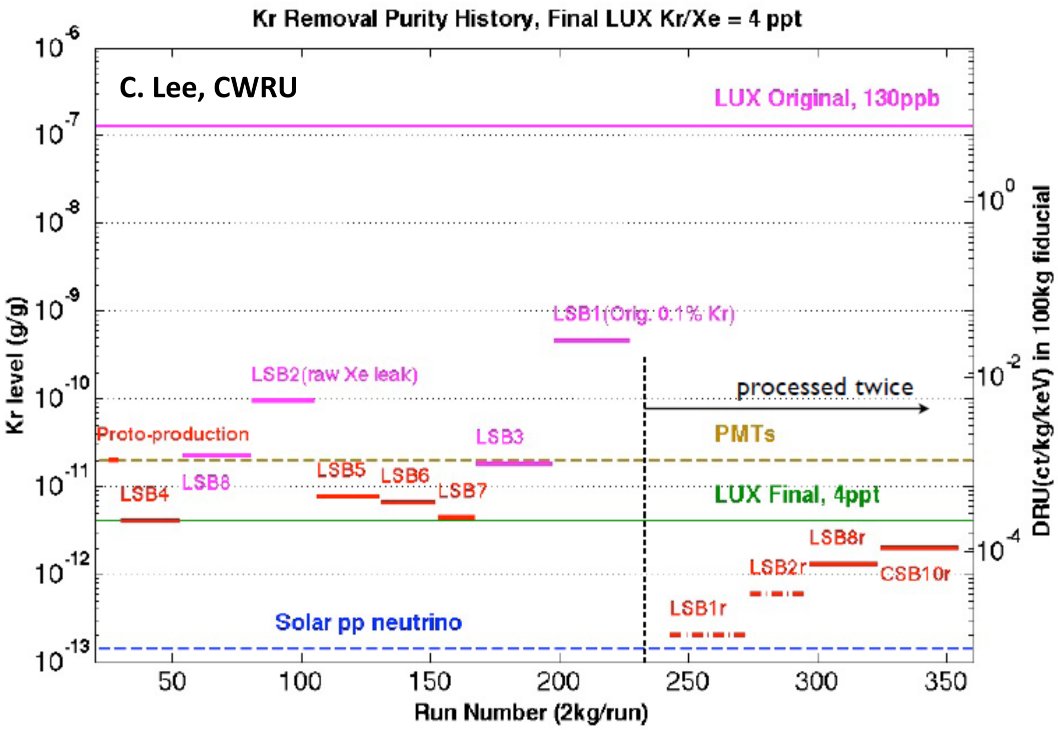
See talk by C. Ghag

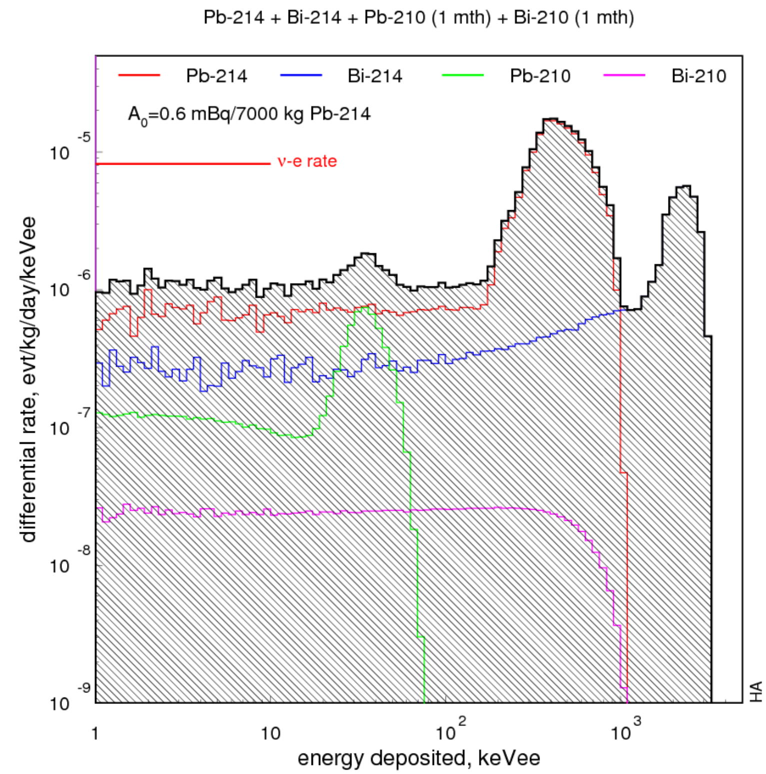




- **Neutrons and gamma-rays from internal radioactivity**
  - Die out very quickly into xenon target, leaving ~6-tonne fiducial
  - Layered, near-hermetic detector strategy plus self-shielding and accurate 3D position reconstruction are extremely effective

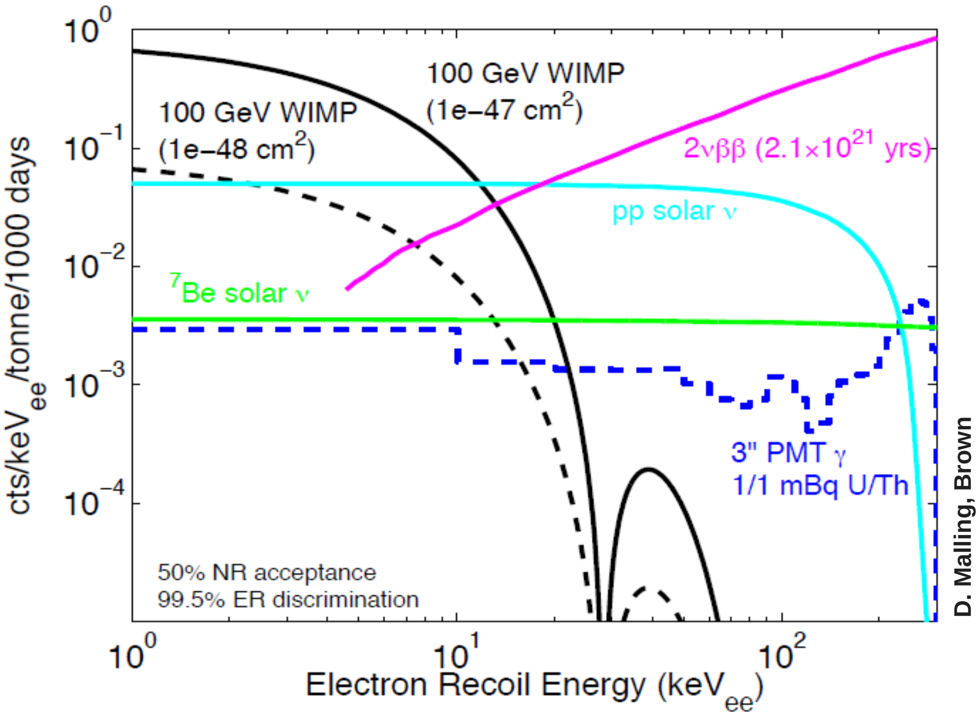
INTRINSIC BACKGROUNDS

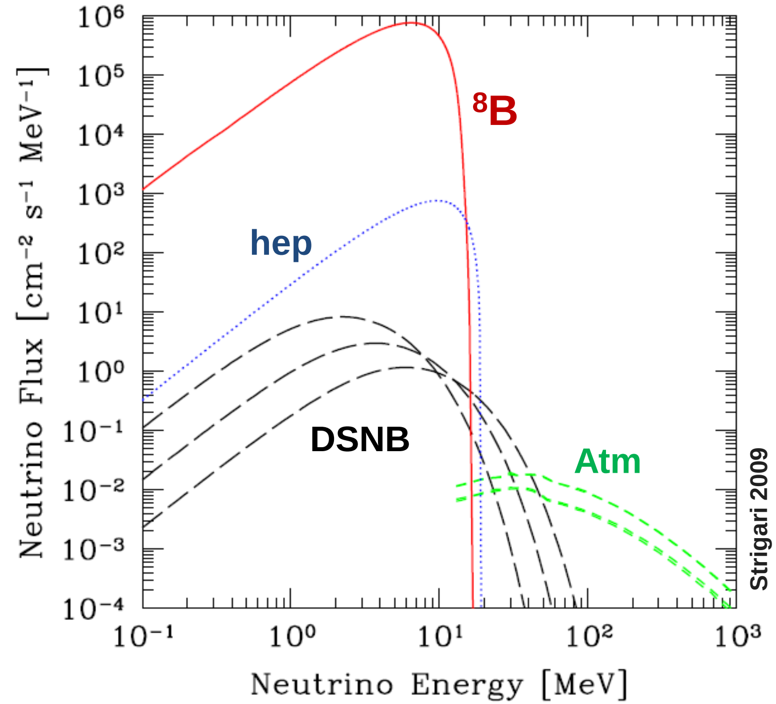




- **Intrinsic electron backgrounds**
  - Controlled with modest discrimination (99.5%) – already achieved in LUX
  - **^{85}Kr:** require <0.02 ppt Kr (best LUX production batch ~0.2 ppt)
  - **^{214}Pb**: require <0.6 mBq radon in active volume (cf. ~μBq in Borexino, SNO)
  - **2νββ from ^{136}Xe** dominates only >20 keVee (signal acceptance <6 keVee)

DOMINANT BACKGROUNDS

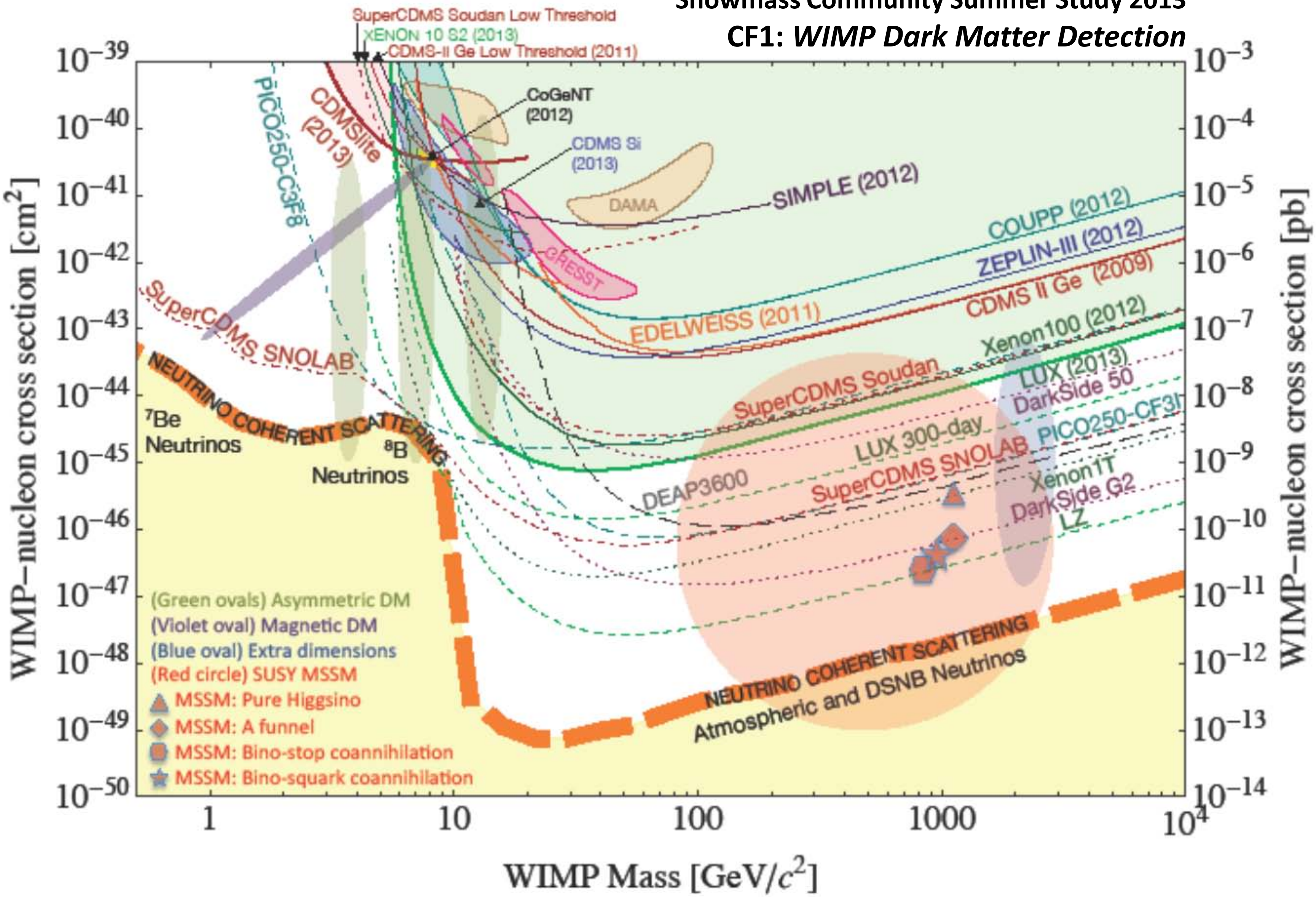




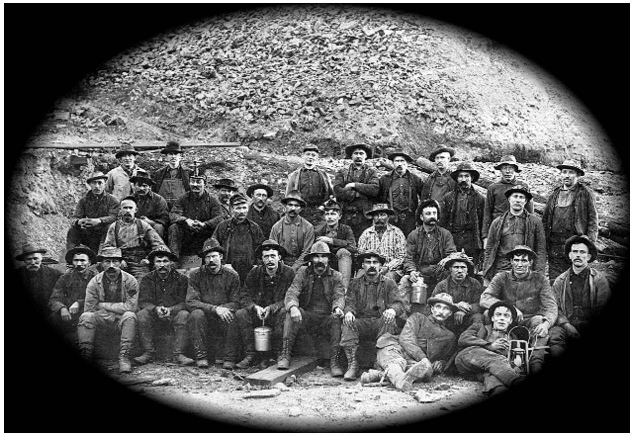
- **Solar pp ν-e elastic scattering is dominant e-recoil background**
  - **1.46 events in 1,000 live days x 6,000 kg (99.5% discrimination, 50% acceptance)**
- **CNS is dominant nuclear recoil background**
  - ^{8}B solar neutrinos: significant number of events, but ~0 above 6 keVr threshold
  - Small background from atmospheric and diffuse supernova neutrinos
  - **0.26 events in 1,000 live days x 6,000 kg (50% acceptance)**

LZ SENSITIVITY

Snowmass Community Summer Study 2013
CF1: *WIMP Dark Matter Detection*



See talk by P. Beltrame for axion sensitivity



LZ COLLABORATION

US (17) + UK (7) + PT (1) + RU (1)

- University of Alabama
- Brown University
- University of California, Berkeley
- University of California, Davis
- University of California, Santa Barbara
- Case Western Reserve University
- Daresbury Laboratory
- Edinburgh University
- Imperial College London
- MEPHI-Moscow, Russia
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- LIP-Coimbra, Portugal
- University of Maryland
- University of Oxford
- Rutherford Appleton Laboratory
- University of Rochester
- Sheffield University
- SLAC National Accelerator Laboratory
- SD School of Mines & Technology
- University of South Dakota
- Texas A&M University
- University College London
- Washington University
- University of Wisconsin
- Yale University