

XENON1T

First Results from the First Multi-Ton Liquid Xenon Detector

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Dark Matter Detection with LXe TPCs

- Earth-based detector → direct scattering between WIMPs and target (liquid Xe)
- Immediate scintillation light S1
- **Ionization electrons** drift to the top of the TPC
- Strong field extracts electrons to gas phase
 - proportional amplification → charge signal S2
- X, Y position → S2 hit pattern
- Z position → electron drift time
- Energy \rightarrow S1, S2 integral
- Electronic/Nuclear recoil discrimination → S2/S1
 - WIMPs (NR), background (mostly ER)





Example XENON1T Event



The XENON1T TPC





See: XENON Collaboration (E. Aprile et al.). Mar 26, 2015. 10 pp. Eur. Phys. J. C75 (2015) 11, 546

TPC Design

- Located at LNGS, Italy (3600mwe)
- 3.2t (total) 2.0t (target) mass
- Entire inner volume (except PMTs) covered in high-reflectivity PTFE
- Dimensions 1x1 meters

248 Hamamatsu R11410, 3" PMTs

- Low radioactive background
 - Developed with Hamamatsu
- QE ~34% @ 175 nm
- Avg. gain ~5 x 10⁶ @ 1.5 kV



First Science Run

- 34 days dark matter exposure (deadtime corrected)
- Nuclear and electronic recoil calibration data
- Interrupted by a magnitude 5.5 earthquake
 - Plus one meter snow. Access to lab restricted.
 - Detector survived. Once safe for staff, operations continued
 - Now over 100 days exposure and counting!





In this plot: total exposure (no deadtime corrections)

Deadtime science run 0: ~12%

Deadtime science run 1: ~1%

Calibrations



Nuclear Recoils: AmBe

- External source (source belt)
- low energy ER band
- Upgraded to neutron generator
 - Commissioned May 2017
 - Time needed to calibrate:
 weeks → days





Calibrations

Energy Response

- Linear from keV to MeV using known calibration sources
- **g1** = 0.1442 ± 0.0068 (sys) PE/photon
 - light detection efficiency (12.5 ± 0.6)%
 - MC predicted 12.1%
- g2= ~100% charge extraction



^{83m}Kr Calibration

- Internal Source (injected into LXe)
 - Homogenous coverage
- 32.2 keV and 9 keV emissions separated by 152ns
- Used for several corrections
 - Position dependent light collection
 - Position dependent S2 amplification
 - Electric field distortion
 - Electron lifetime cross-check
 - Light/charge yield stability





Data Selection

Note: Signal region **blinded** until selection fixed!

- Single-scatter
 - Only one S2 (>200 pe) per event
- General event quality
 - Event can't directly follow a high energy event \rightarrow single e-tails
 - Reject noise (uncorrelated signals) before main S2
- Peak Quality
 - Drift time and width of S2 signal must be consistent
 - S1 and S2 hit patterns must be consistent with reconstructed position
 - Ratio of light seen by top/bottom array consistent with event in liquid
- Fiducial Volume \rightarrow Cylindrical, 1 ton

Cut	Events Remaining
All events (cS1 < 200 PE)	128144
Data quality, selection	48955
Fiducial volume	180
S1 Range (3 < cS1 < 70 PE)	63



Backgrounds ER

- Online Krypton distillation
 - ⁸⁵Kr background ^{nat}Kr/Xe < 0.048·10⁻¹² (<48 ppq)
 - ER background now radon dominated
- ²²²Rn chain
 - Emanation from detector materials
 - Extensive screening program
 - Lowest possible emanation materials chosen
 - Surface treatments for internal components
 - 10 μ Bq/kg target concentration reached
 - Further reduction possible (XENONnT)
 - Rn distillation in XENON100 \rightarrow 27x decrease
 - See: arxiv:1702.06942
 - First tests in XENON1T promising



Total Background



Search Results

See: arXiv:1705.06655



- No post-unblinding changes to event selection
- Unbinned profile likelihood analysis
- ER/NR shape largely determined from calibration fits

The XENON (to DARWIN) Project







XENON100 Total Xe: 162 kg Target: 62 kg Fiducial: 34/48 kg Limit: ~10⁻⁴⁵



XENON1T Total Xe: 3.2 ton Target: 2 ton Fiducial: 1 ton Limit: ~10⁻⁴⁷



XENONnT Total Xe: ~8 ton Target: ~6.5 ton Fiducial: ~5 ton Limit: ~10⁻⁴⁸



DARWIN Total Xe: 50 ton Target: 40 ton Fiducial: 30 ton Limit: ~10⁻⁴⁹



Outlook

- XENON1T leads the world in sensitivity
 - 34 live days published
 - >100 live days on disk and running!
- XENONnT will provide a fast upgrade with x10 sensitivity
 - Re-use most infrastructure
 - Upgrade planned from beginning
 - cryogenic plant planned for >8T Xe
 - Signal cables already in pipe
 - Outer cryostat large enough to accommodate larger detector



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