Recent Results from the XENON Experiment

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The XENON100 Collaboration
The XENON Detection Principle

- Background mostly at the edges, high self-shielding of liquid xenon
- Full 3d position reconstruction → Volume cut to decrease background

- Detection of direct scintillation light (S1) and charge via proportional scintillation (S2)
- S2/S1 ratio → Discrimination between nuclear and electronic recoils
XENON100

- TPC with 30 cm drift length and 30 cm diameter
- 161 kg of xenon, 62 kg target
- 30 – 50 kg fiducial volume
- 242 1 inch high QE PMTs
- Located at LNGS, Italy
- 1400 m of rock (~ 3600 m w.e.)
ER/NR Calibration

At 50 % NR acceptance ~99.5 % ER rejection

ER calibration data
- $^{60}$Co and $^{232}$Th
- > 35x statistics of background

NR calibration data
- AmBe
- Calibration at beginning and end of the run

ER/NR Calibration data
- $S_1$ [PE]
- $\log_{10}(S_2/S_1)$-ER mean
- Energy [keVnr]
Results from 225 Live Days


- Background expectation in benchmark region: $1.0 \pm 0.2$
- 2 events observed $\rightarrow$ 26.4 % probability of background fluctuation
- Exclusion limit derived using profile likelihood analysis
Results from 225 Live Days

- Most stringent exclusion limit for WIMP masses $> 8$ GeV
- $\sigma = 2 \times 10^{-45}$ cm$^2$ at 55 GeV WIMP mass at 90 % CL
CDMS Signal Indication

- Recent signal indication by CDMS for WIMP with $\sigma = 1.9 \times 10^{-41} \text{cm}^2$ at 8.6 GeV
- In XENON100, >200 events in signal region would be expected for such a WIMP
Spin-Dependent Results


- Two isotopes with nonzero spin: $^{129}$Xe (26.2 %) and $^{131}$Xe (21.8 %)
- Using nuclear model by Menendez et al. (Phys. Rev. D86, 103511 (2012))
- $\sigma = 3.5 \times 10^{-40}\text{cm}^2$ at 45 GeV WIMP mass for neutron coupling at 90 % CL
Nuclear Recoil Energy Scale

- Nuclear recoil energy is connected to S1 signal via

\[ S1 = E_{nr} L_y L_{eff}(E_{nr}) \frac{S_{nr}}{S_{ee}} \]

- Nuclear recoil energy is connected to S2 signal via

\[ S2 = E_{nr} Q_y(E_{nr}) Y \]

- Using S1 and S2 simultaneously both \( Q_y(E) \) and \( L_{eff}(E) \) can be determined by matching calibration data to Monte Carlo
Nuclear Recoil Energy Scale

- Absolute matching of Monte Carlo to data from AmBe neutron calibration
- Monte Carlo includes complete description of detector including the shield
- In a first step fit S2, using $L_{\text{eff}}$ from direct measurements $\rightarrow Q_y$
Nuclear Recoil Energy Scale

- Using the derived $Q_y$, fit $S1 \rightarrow L_{\text{eff}}$
- Good overall agreement down to 3 keV$_{nr}$
- $L_{\text{eff}}$ matches previous measurements
- Detector response well understood down to energies below analysis threshold
XENON1T

• XENON100: 62 kg target
  • Currently running

• XENON1T: 2.2 t target
  • Construction started June 2013
  • Commissioning by end of 2014
XENON1T

- TPC 1 m height, 1 m diameter
- 2.2 t target mass → 1 t with 10 cm fiducial volume cut
- Drift field 1 kV/cm
- 250 3 inch Hamamatsu R11410 PMTs
XENON1T

- 100 x lower background than in XENON100
- Goal: < 1 background event in 2 t·y exposure
- Reduce external background from detector materials
- Reduce intrinsic background from xenon contamination with $^{85}$Kr and Rn
- Use distillation column for Kr removal, adsorption tower for Rn removal
- 10m high, 9.6 m diameter water tank equipped with 84 high QE PMTs for muon veto
Goal: $\sigma = 2 \times 10^{-47} \text{cm}^2$ at 50 GeV WIMP mass by 2017
(XENON100: $\sigma = 2 \times 10^{-45} \text{cm}^2$ at 55 GeV WIMP mass)
ER Background

- $^{85}\text{Kr}$ concentration: 
  \[19 \pm 4 \text{ ppt (RGMS)}\]
  \[18 \pm 8 \text{ ppt (delayed coincidence)}\]
- $^{222}\text{Rn}$ concentration: 
  \[62.8 \pm 0.4 \mu\text{Bq/kg}\]

Total background level:

\[(5.3 \pm 0.6) \cdot 10^{-3} \text{ events/(keV kg day)} \text{ in 34 kg}\]
Background Prediction

- Electronic recoil background: $0.79 \pm 0.16$ events
  - Determined by comparison of non-blinded background data to calibration data with $^{60}$Co and $^{232}$Th
- Neutron background: $0.17^{+0.12}_{-0.07}$ events
  - Determined by MC using screening data and muon rate at LNGS
  - 70% muon-induced neutrons
- Total background: $1.0 \pm 0.2$ events in benchmark region in 225 d
Direct Measurement

From elastic scattering of monoenergetic neutrons on liquid xenon at fixed angles

\[ E_{nr} = \frac{S_I}{L_y} \frac{1}{L_{\text{eff}}(E)} \frac{S_{ee}}{S_{nr}} \]