Response of XENON10 to Neutrons: Comparison of MonteCarlo and data

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Xe10 Dark Matter Detector

\[ E_r \sim 10 - 100 \text{ keV}_r \]

\[ E_r \approx E_n \frac{2m_n M_{Xe}}{(m_n + M_{Xe})^2} (1 - \cos \theta) \]
Xe10: Neutron run setup

Top View

- AmBe source
- Polish lead
- Poly
- Source tube
- Support beams
- Door

Side View

- AmBe source
- Polish lead
- French lead
- Lead bricks
- Support beam
AmBe source

- AmBe source. 3.7 MBq (220 n/sec) ±15%
- 5 cm of lead between the detector and the source to stop the γ
- 12 hour run at trigger rate ~14 Hz

Neutron spectrum
Nuclear recoils are selected from NR band after applying quality and fiducial cuts.
Xe10 Monte Carlo Simulation

- Geant4 simulation toolkit version 4.8.2.
- Used high precision physics lists for neutrons (<20MeV) and E&M processes. (Valid from 250 eV to ~100 GeV).
- G4NDL data bases for elastic and inelastic cross sections. Data taken from: ENDF/B, Jef, EFF, JENDL, FENDL, CENDL, ENSDF, Brond, MENDL
- Simulated a total of 5 hours (220 n/s)
- Only neutron spectrum was simulated.
Xenon10 Detector Geometry in Monte Carlo simulation.

- Shield
  - 20 cm lead.
  - 20 cm polyethylene
  - Stainless steal support beams
  - Lead bricks outside the cryostat.
- Stainless steal tube that contains the source.
- Outer cryostat
  - PTR
  - Signal and HV feed-throughs
- Inner can
- Connections to the outer cryostat (signal feedthroughs and PTR)
  - 89 PMTs (window, cathode & body)
  - 4 grids (cathode, anode and 2 grids)
- Teflon spacers, including grooves and holes for cableing.
- Several teflon and copper pieces holding everything together
- Gas and liquid Xe.
- Shrinking
Nuclear recoil events from MC

- Nuclear recoils are selected. Information about type of interaction is stored.
- Multiple hits are considered a single if $\Delta z < 3 \text{ mm}$
- Same fiducial volume as the data.
- 15.1% resolution for nuclear recoils, based on S1 resolution at 122 keVee line from Co57 run.
Nuclear recoil energy

Relative scintillation efficiency of NR to 122 keV gammas at zero field

\[ E_{nr} = \frac{S1}{L_y/L_{eff}} \times \frac{S_{er}}{S_{nr}} \]

Light Yield for 122 keV in pe/keVee

quenching of scintillation yield for gammas and NRs due to drift field

Akimov 2002
Aprile 2005
Arneodo 2000
Chepel 2005
\[ E_{nr} = \frac{S1}{L_y \cdot L_{eff} \cdot S_{nr}} \]
\[ E_{nr} = \frac{S1}{L_y L_{eff} S_{nr}} \]
\[ E_{nr} = \frac{S1}{L_y L_{eff}} \frac{1}{S_{er}} \frac{S_{nr}}{S_{er}} \]
Single nuclear recoils

\[ E_{nr} = \frac{S1}{L_y L_{eff}} \frac{1}{S_{nr}} S_{er} \]

Count rate [dru]

Xe Recoil Energy [keVr]

Light Yield, relative 122 keV

Akimov 2002
Aprile 2005
Arneodo 2000
Chepel 2005

Chepel 2005
Single nuclear recoils
Conclusions

• Overall agreement between MC and data.
• A more precise measurement is needed for the relative scintillation efficiency at E<10 keVr, with and without field?
• Current work is being done to understand double scatters.
Extra slides
AmBe-n $R < 80.0$ mm Single Elastic

- Data
- MC
Single nuclear recoils

\[ E_{nr} = \frac{S_1 \frac{1}{L_y L_{eff}}}{S_{er} S_{nr}} \]

![Graph showing single nuclear recoils](image)
\[ E_{nr} = \frac{S1}{L_y L_{eff}} \frac{1}{S_{er}} \frac{S_{nr}}{S_{nr}} \]
Single nuclear recoils

\[ E_{nr} = \frac{S1}{L_y \cdot L_{eff}} \cdot \frac{1}{S_{er}} \cdot S_{nr} \]
\[ E_{nr} = \frac{S1}{L_y L_{eff} S_{nr}} \]
$E_{nr} = \frac{S1}{L_y L_{eff}} \frac{1}{S_{er}} \frac{S_{nr}}{S_{nr}}$
Multiple Scatters

XY distance

- Data
- MC

XY1-XY2 [mm]

Z distance

- Data
- MC

Z1-Z2 [mm]