Response of XENON10 to Neutrons: Comparison of MonteCarlo and data

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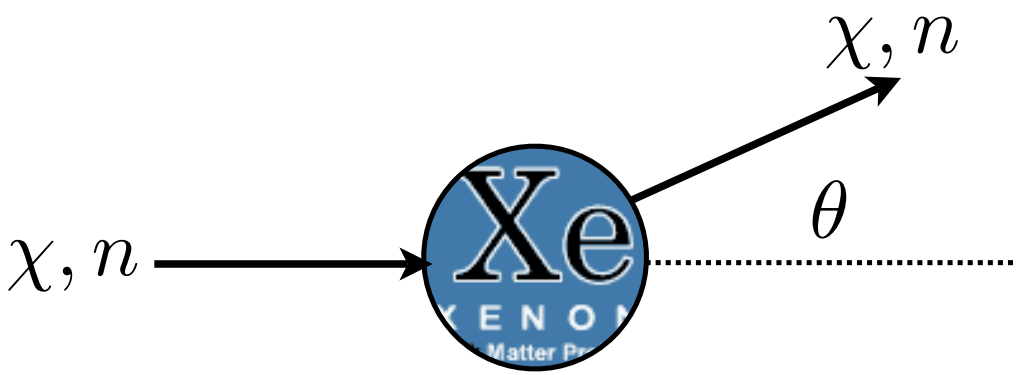
XENON Collaboration

APS 2007

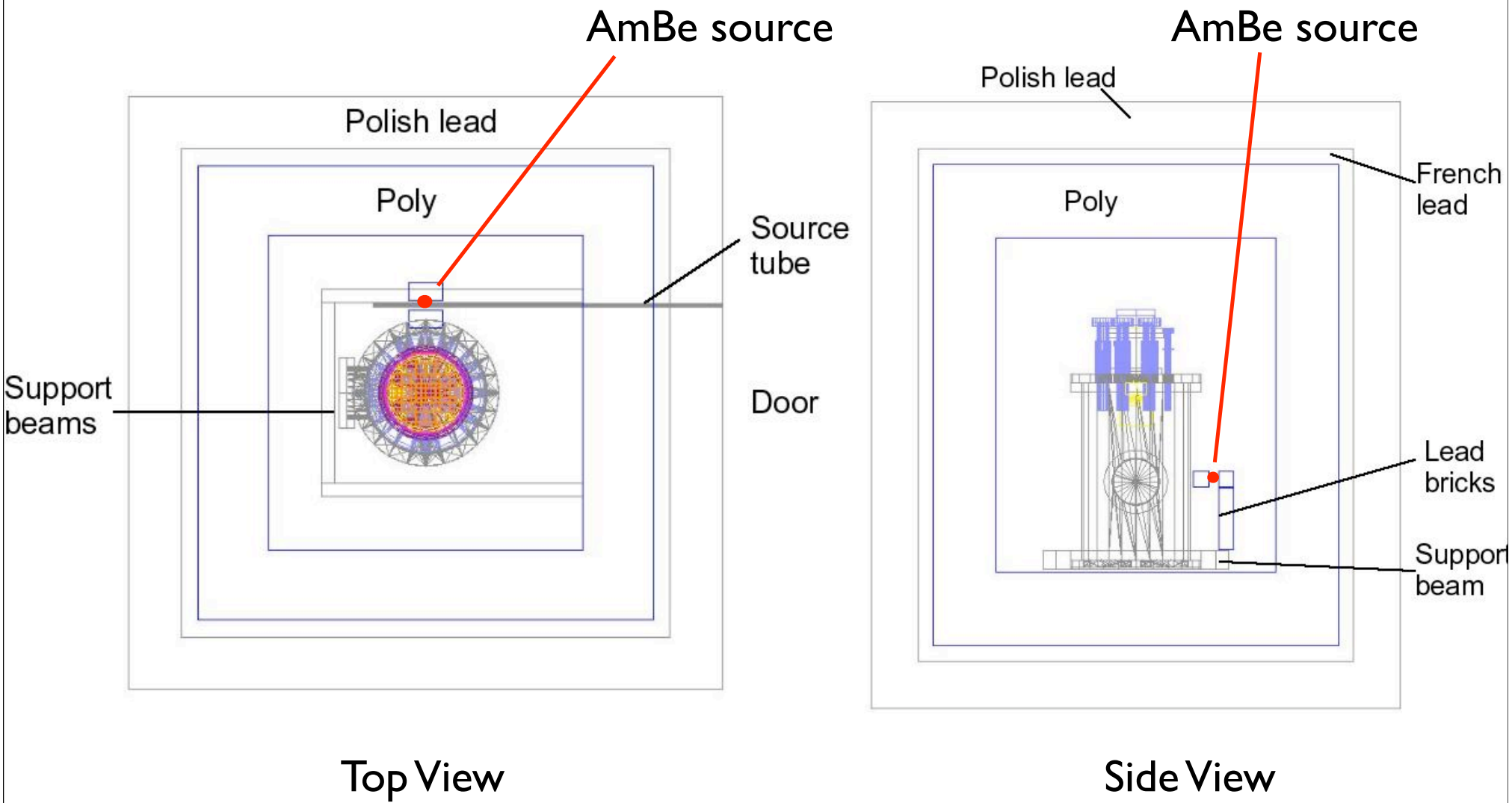
Xe10 Dark Matter Detector

$$E_r \sim 10 - 100\ keV_r$$

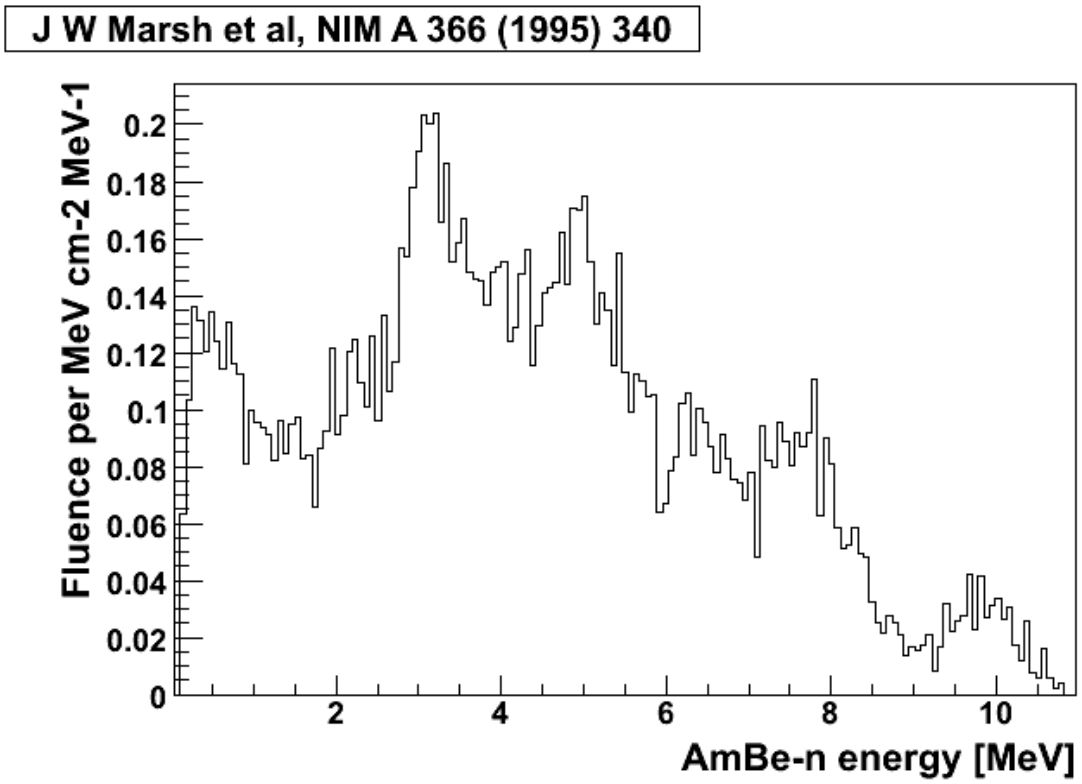


$$E_r \approx E_n \frac{2 m_n M_{Xe}}{(m_n + M_{Xe})^2} (1 - \cos\theta)$$

Xe10: Neutron run setup



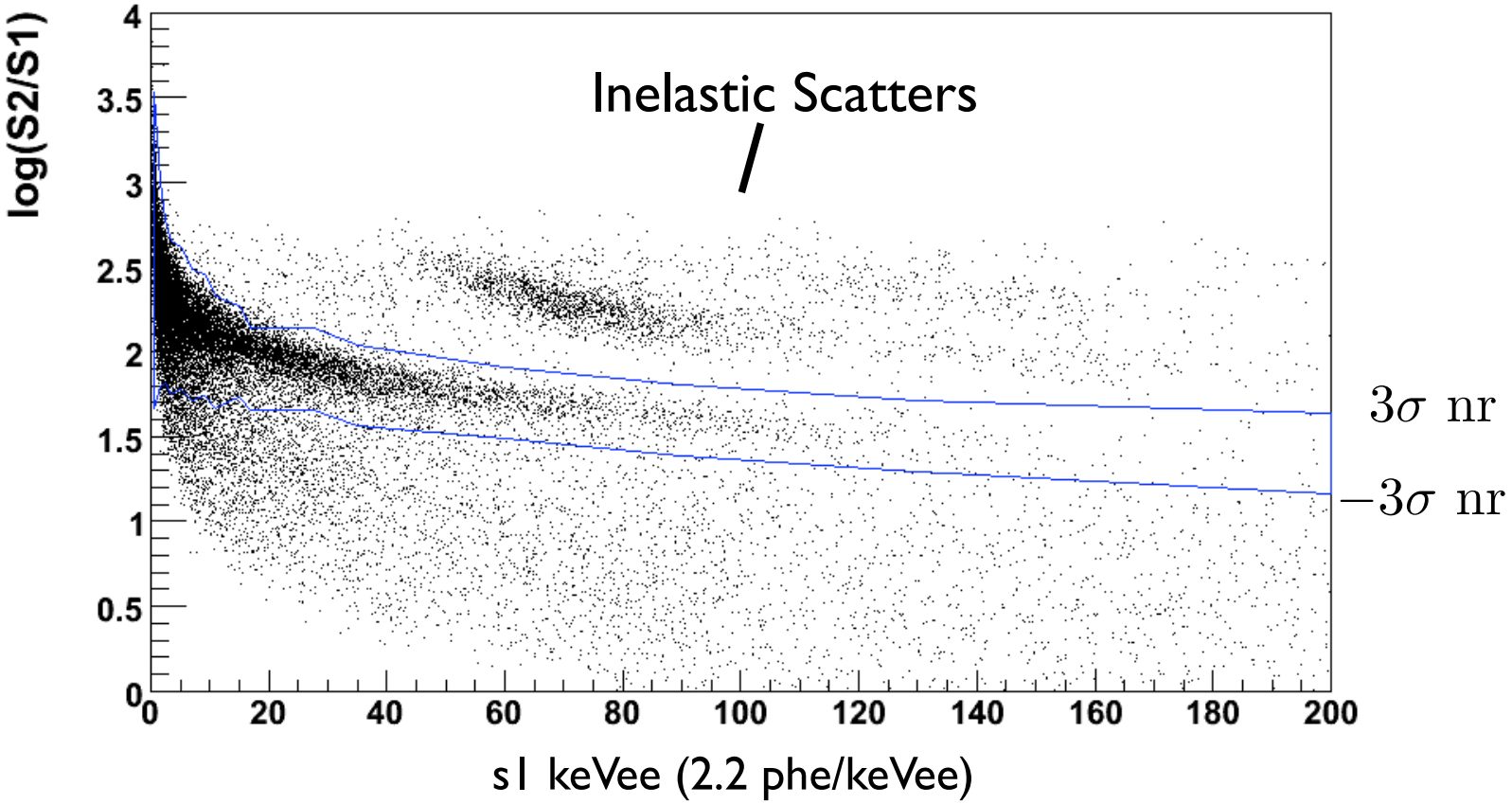
AmBe source



Neutron spectrum

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

AmBe run



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)
- Neutron spectrum taken from Marsh, NIM A (366) (1995) 340
- 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 $\Delta z < 3\ mm$
- 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

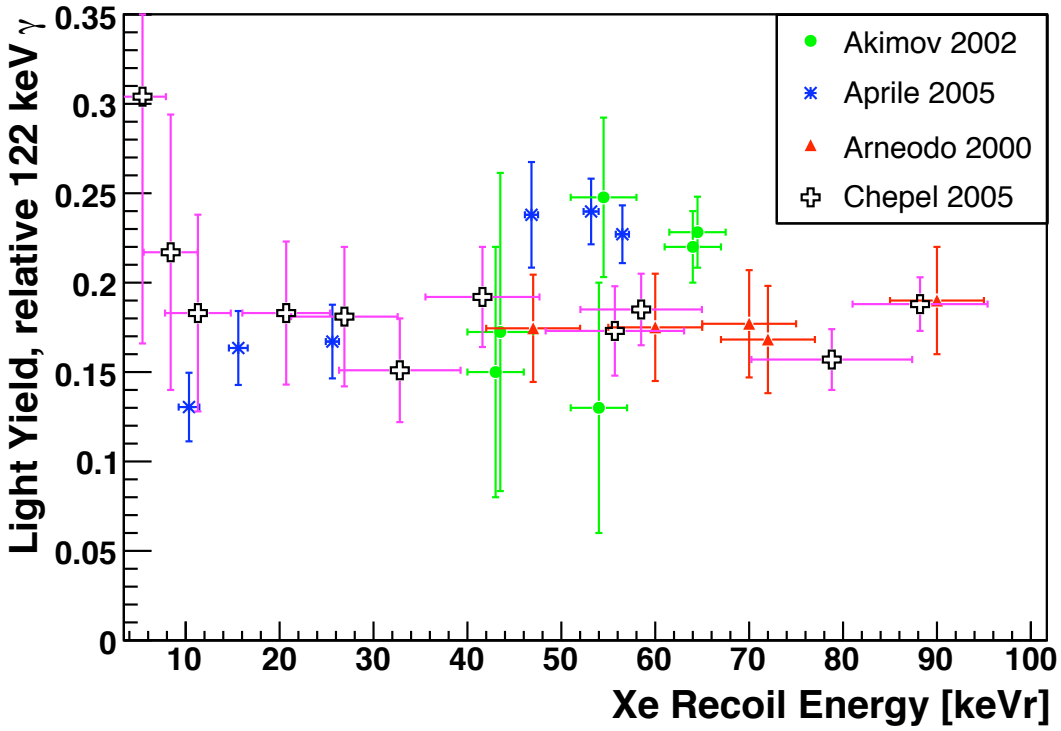
Relative scintillation efficiency of NR to 122 gammas at zero field

S1 signal in # pe

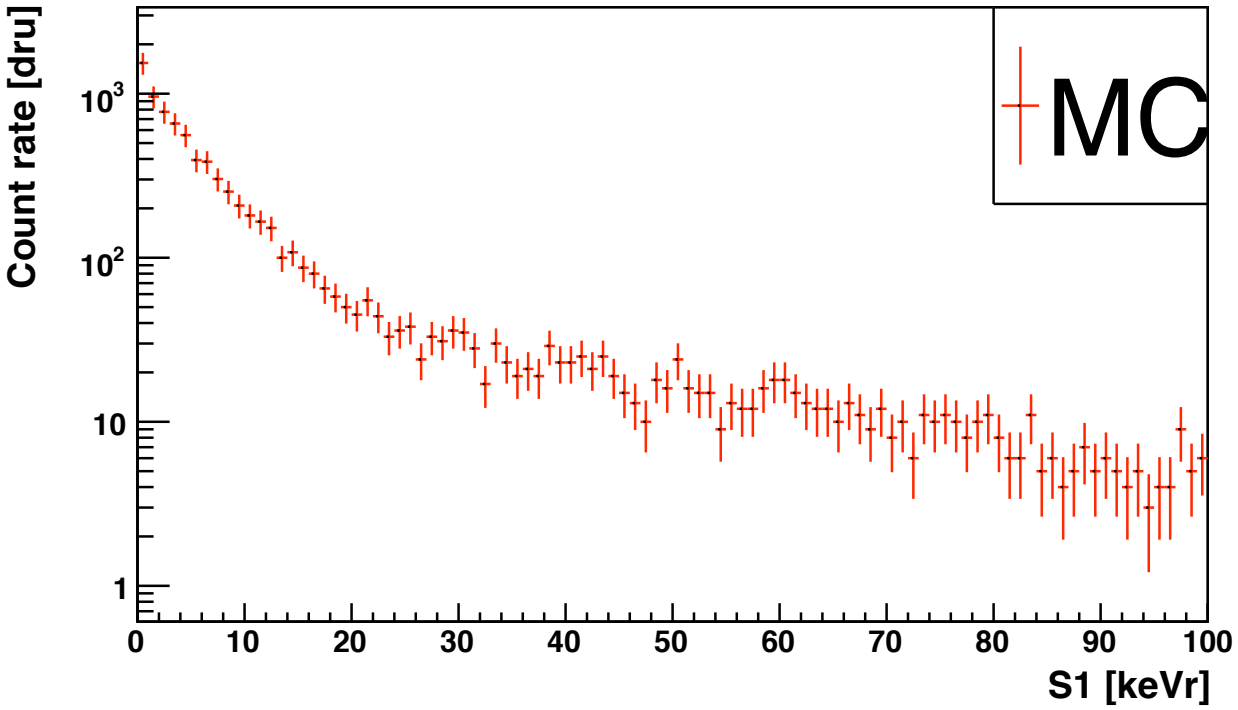
$$E_{nr} = S1/L_y/L_{eff} \times S_{er}/S_{nr}$$

Light Yield for 122 keV in pe/keVee

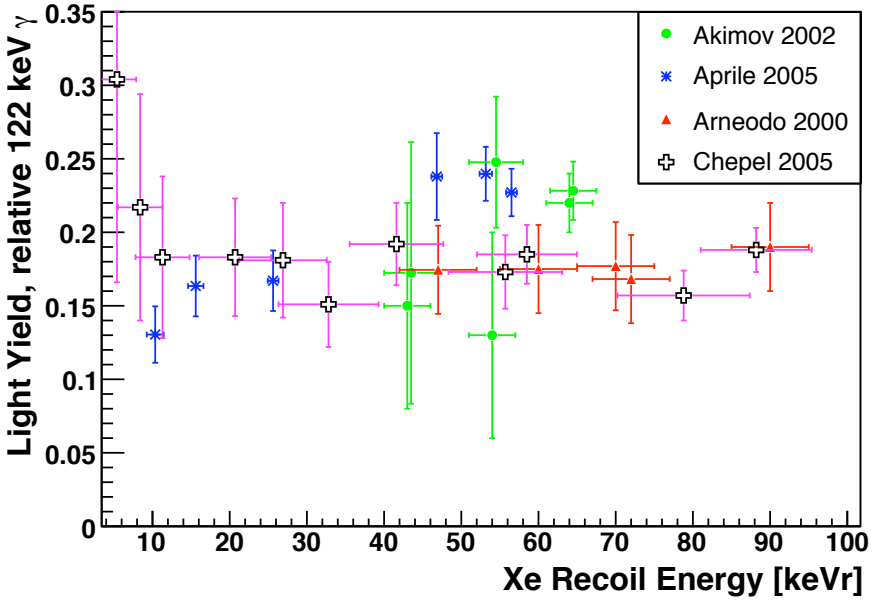
quenching of scintillation yield for gammas and NRs due to drift field



Single nuclear recoils



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



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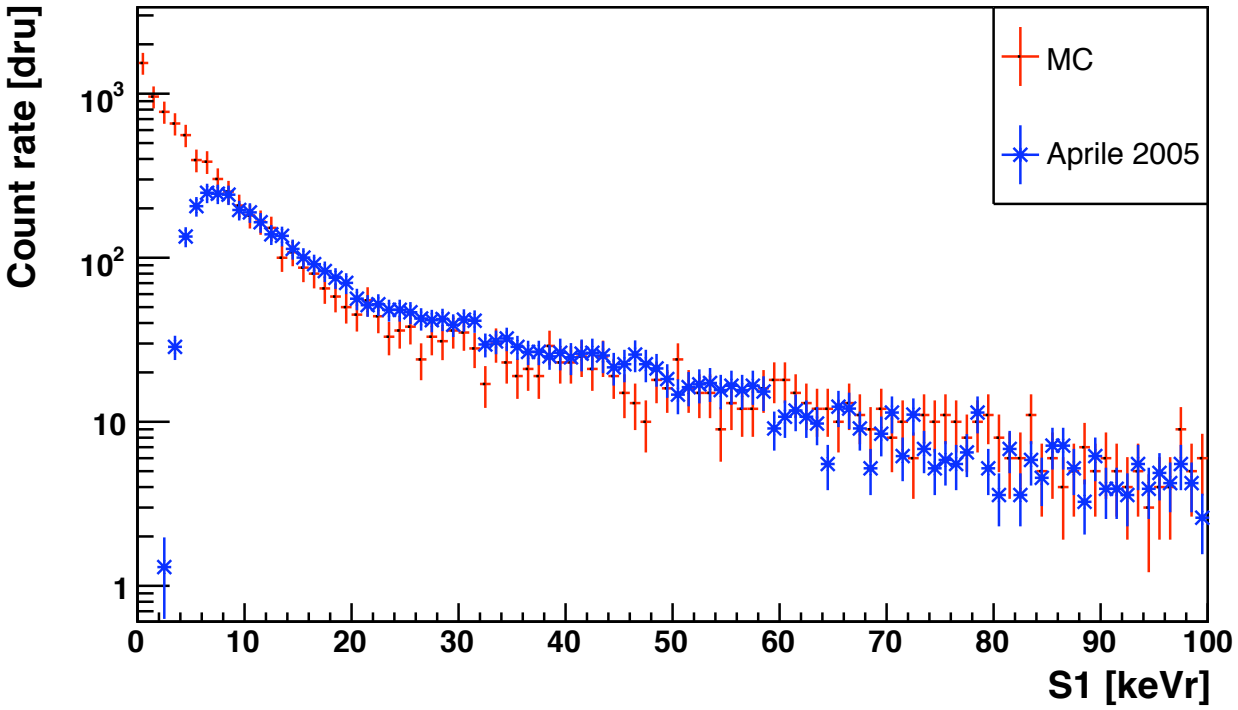

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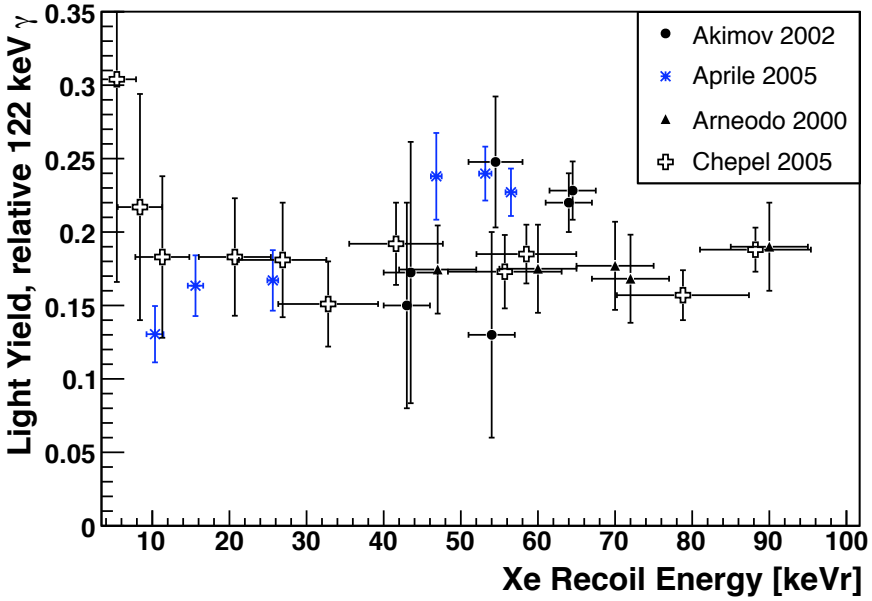

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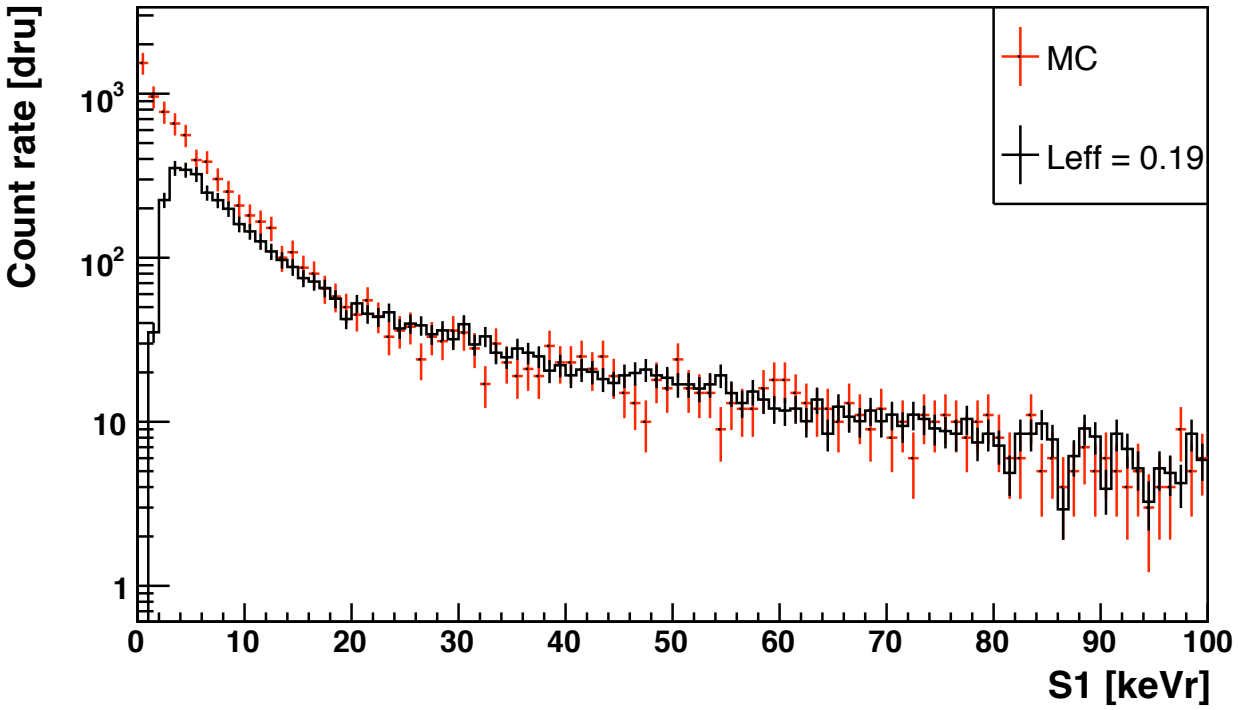

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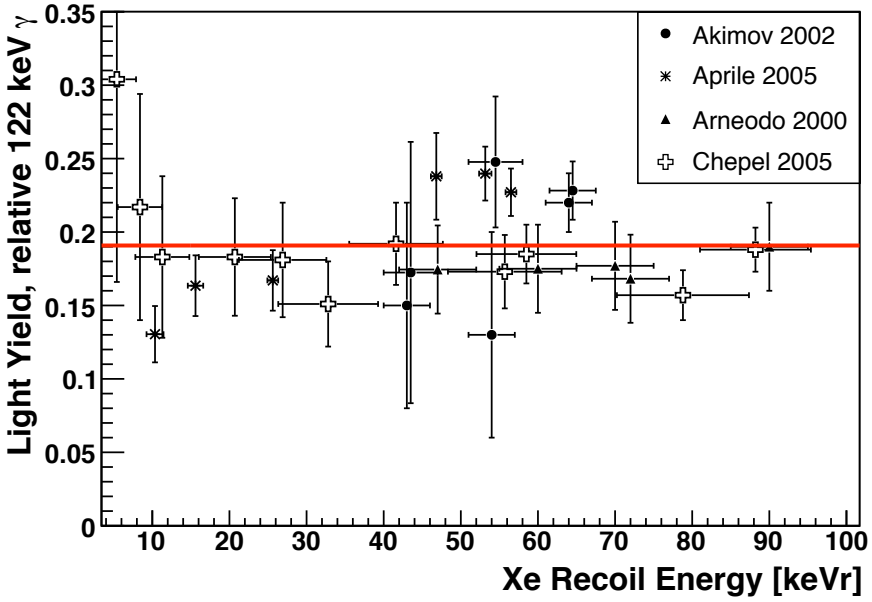

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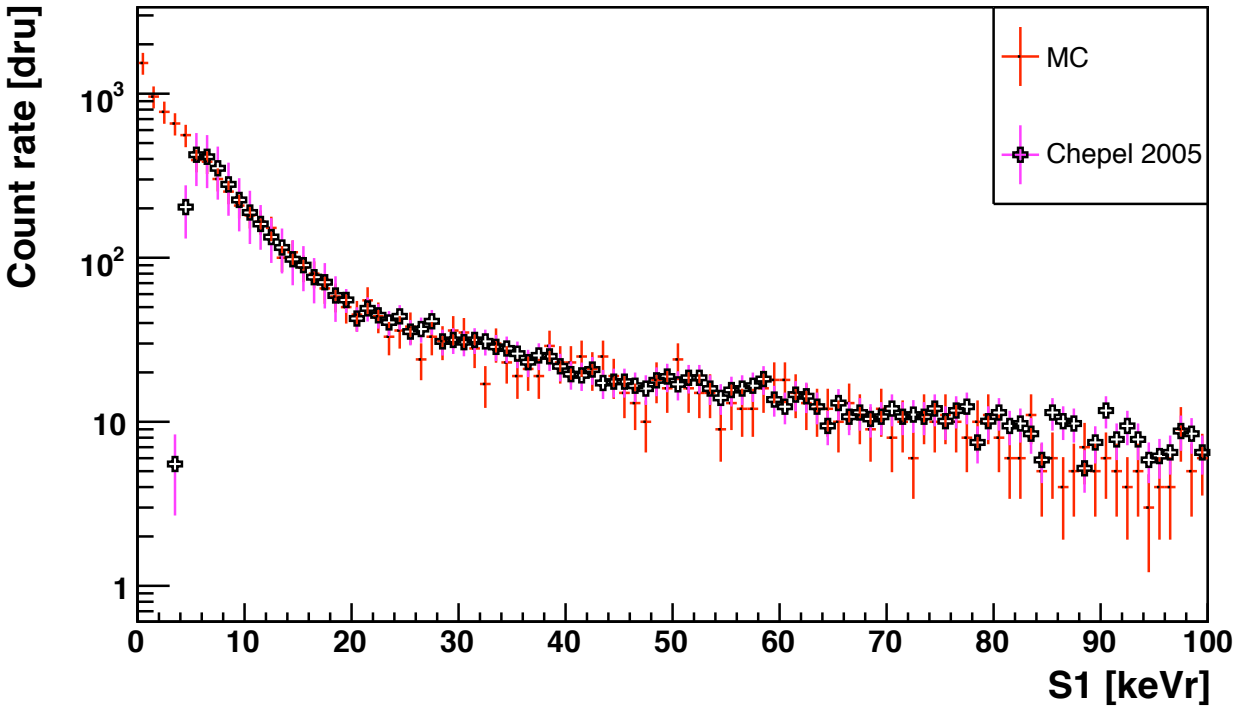

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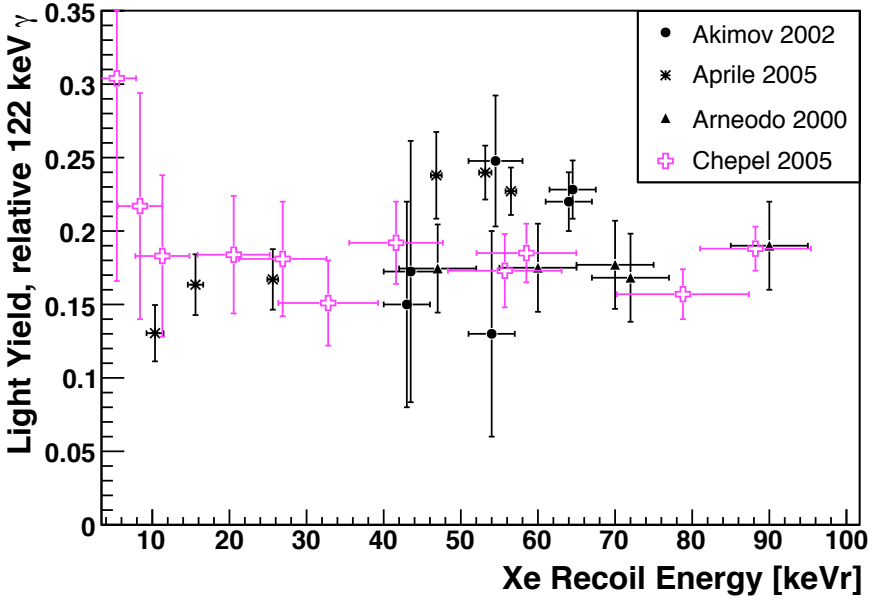
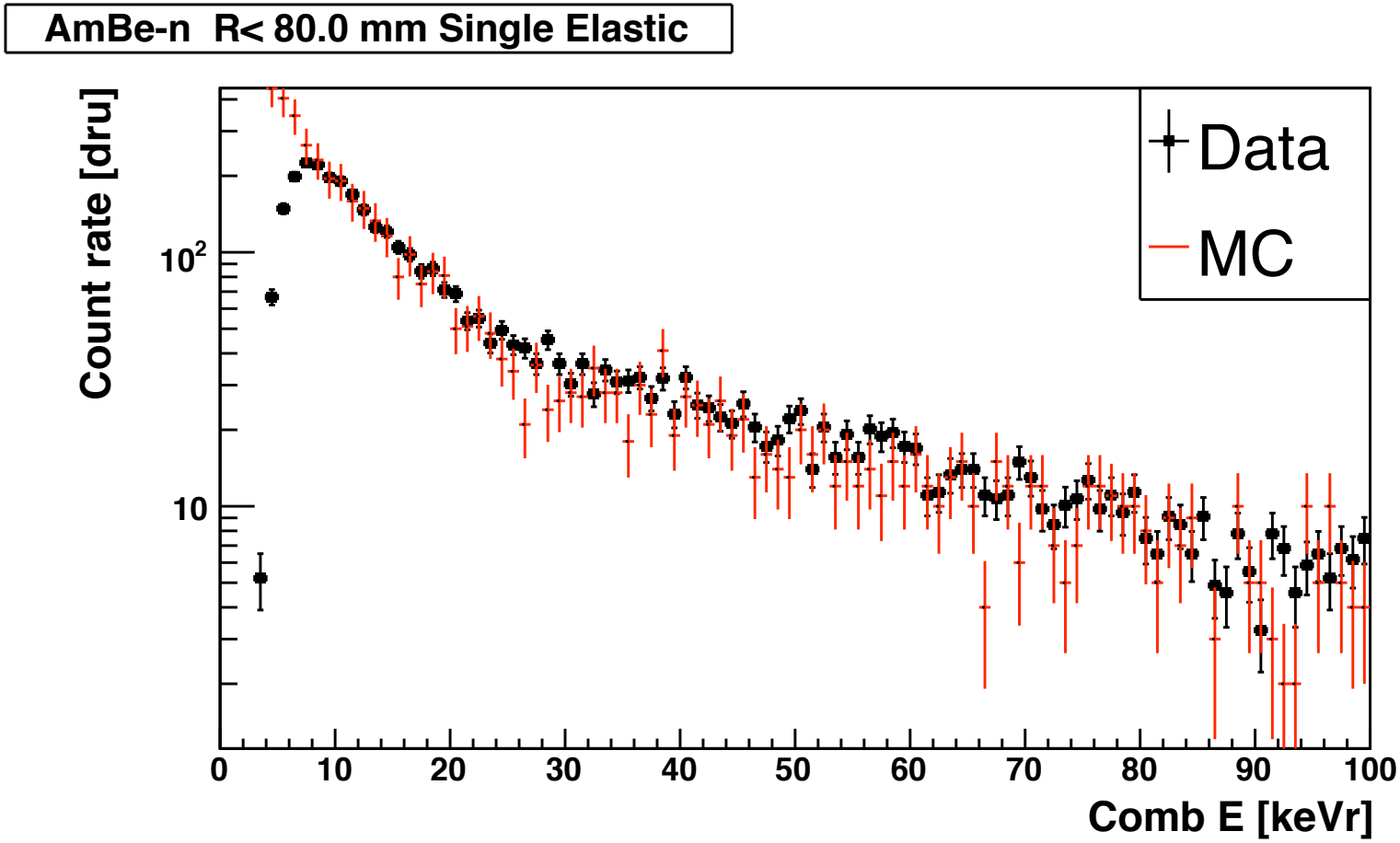


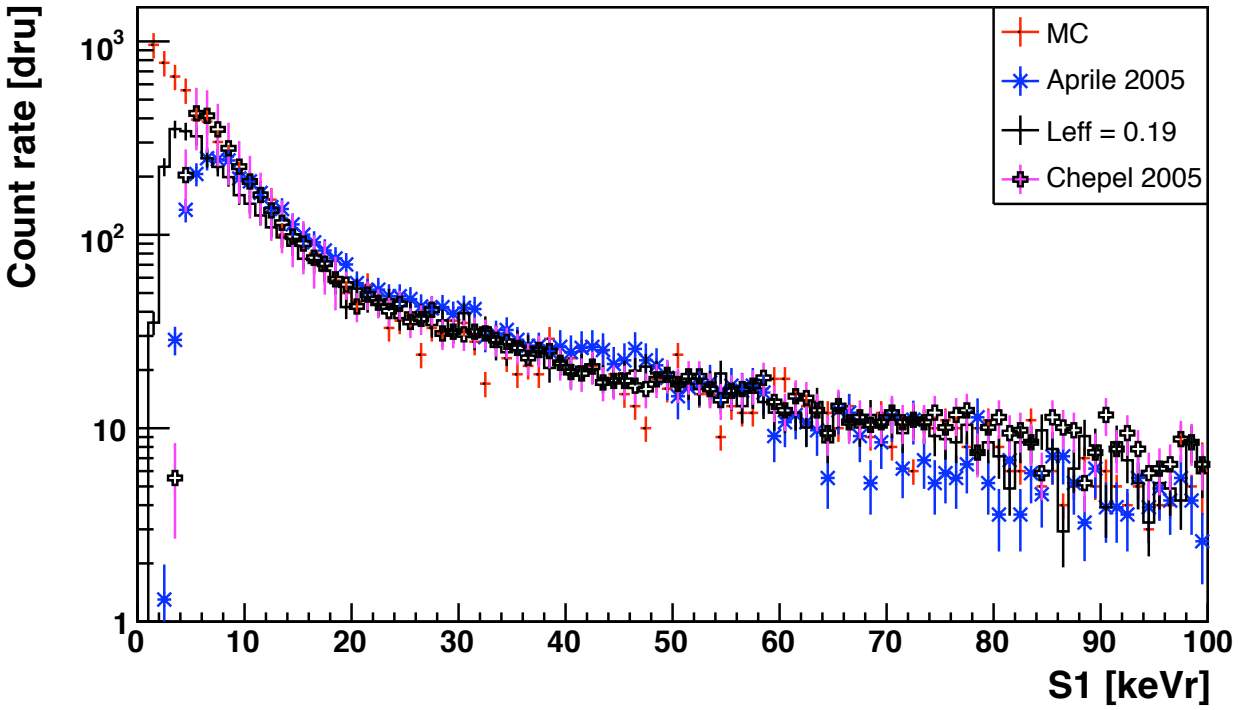
Conclusions

- 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
Count rate [dru]
10^2
10
0
10
20
30
40
50
60
70
80
90
100
Comb E [keVr]
Data
MC

Single nuclear recoils



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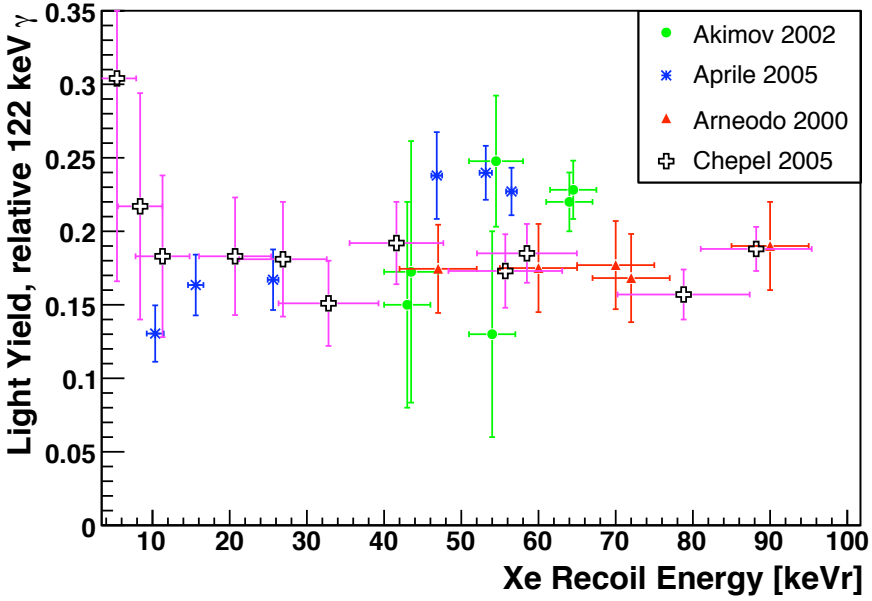

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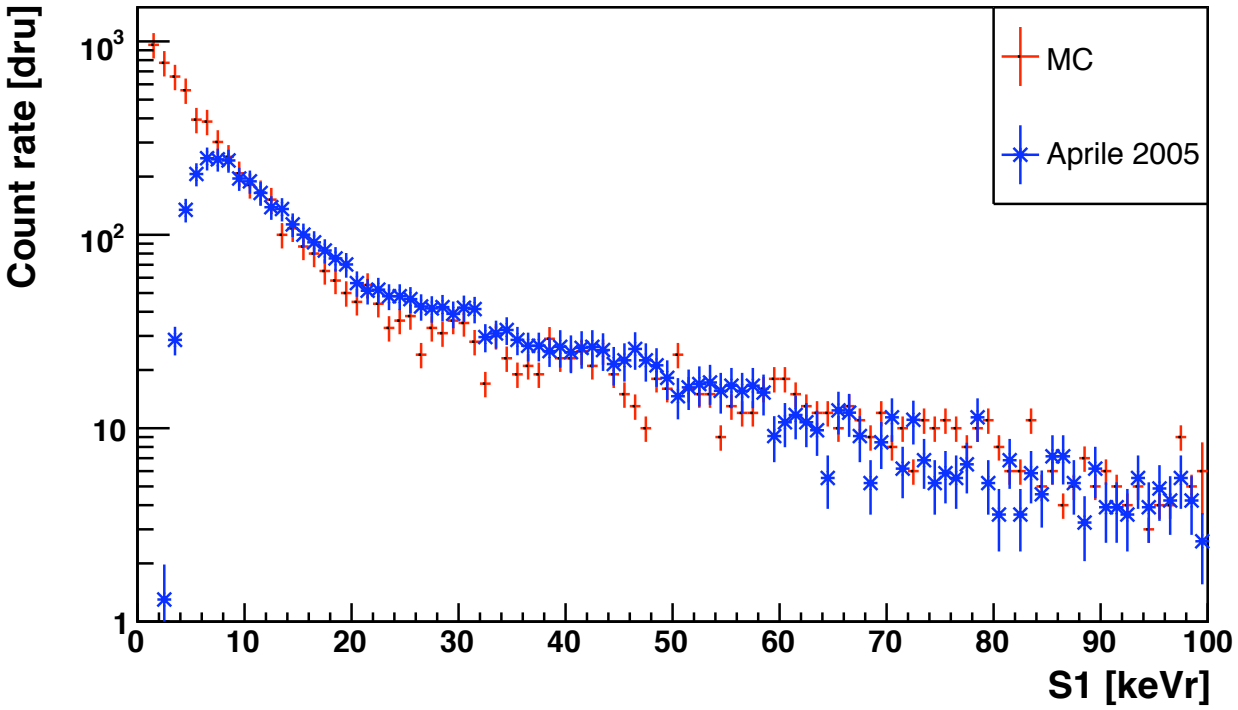

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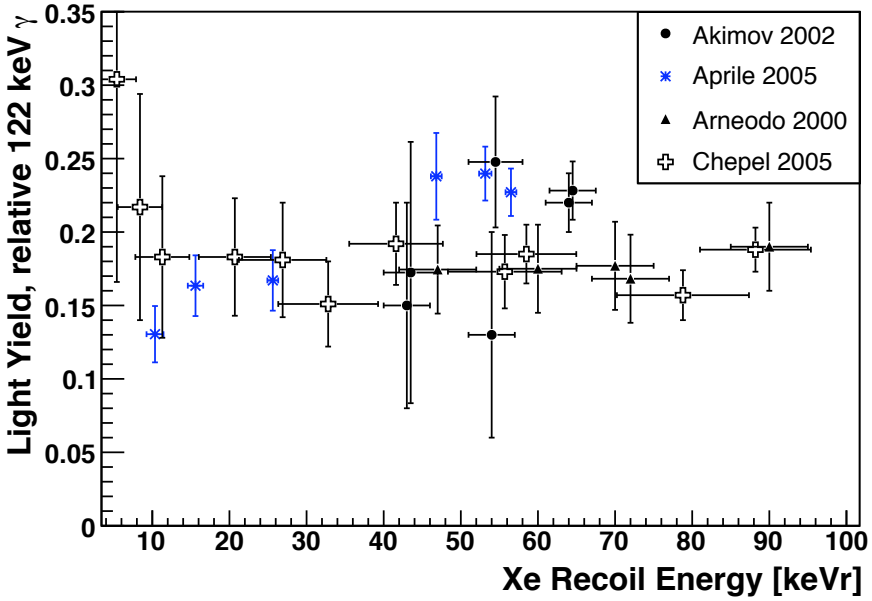

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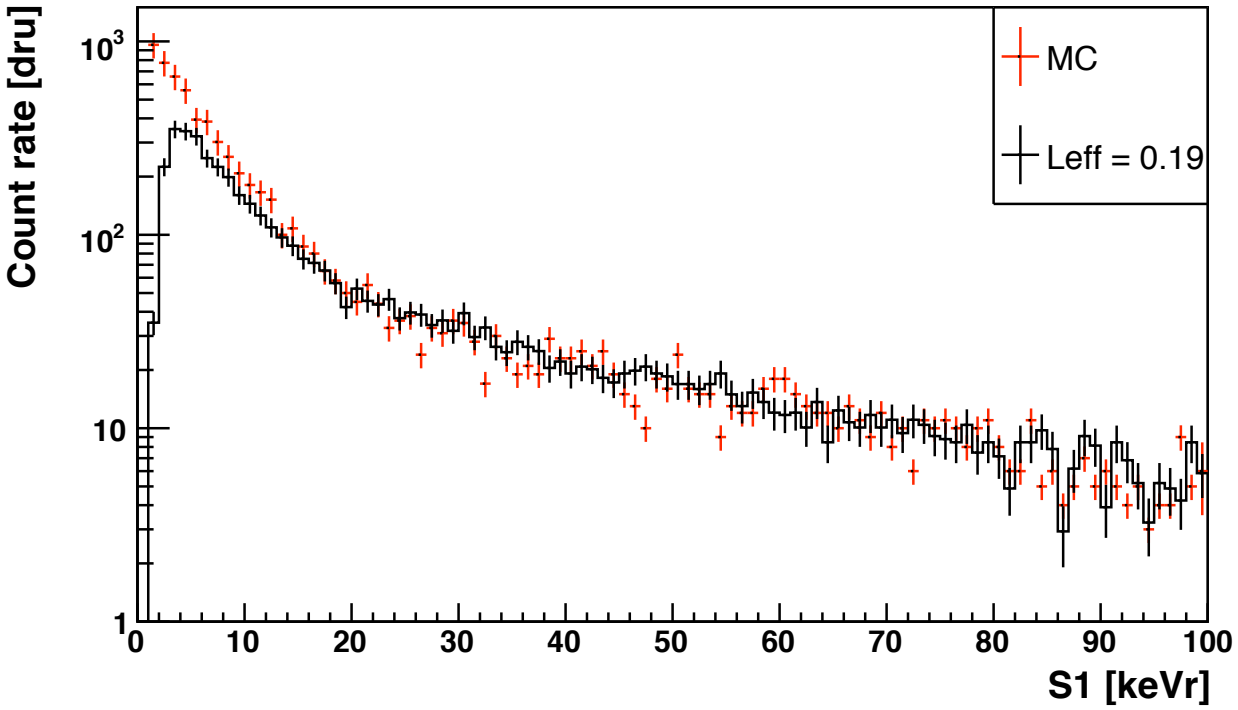

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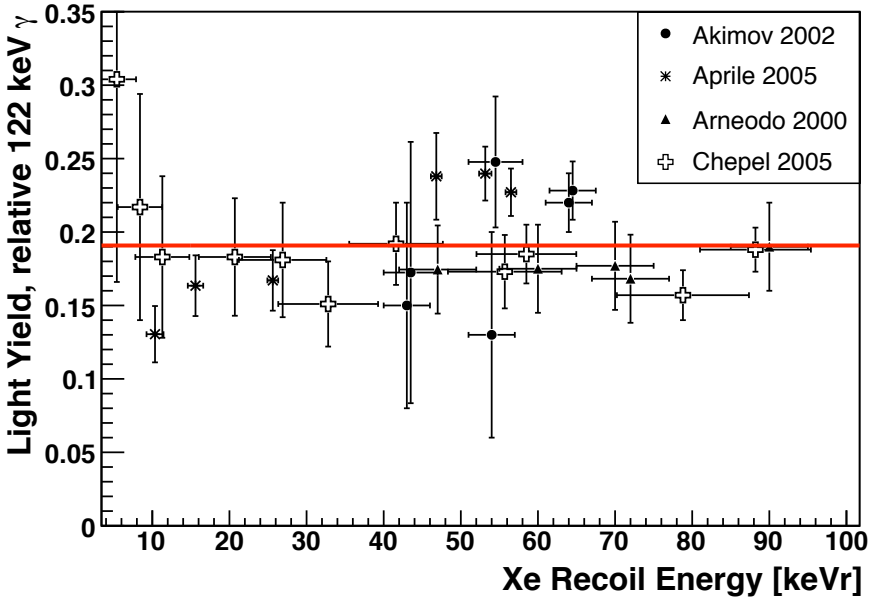

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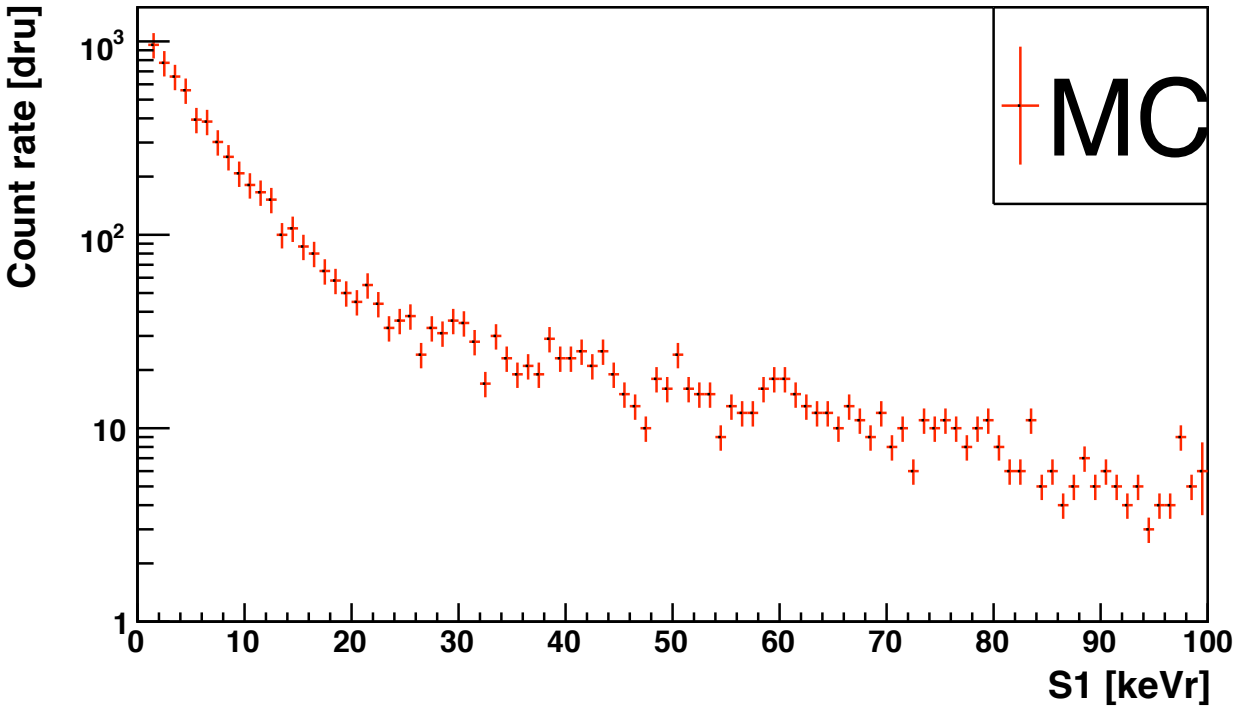

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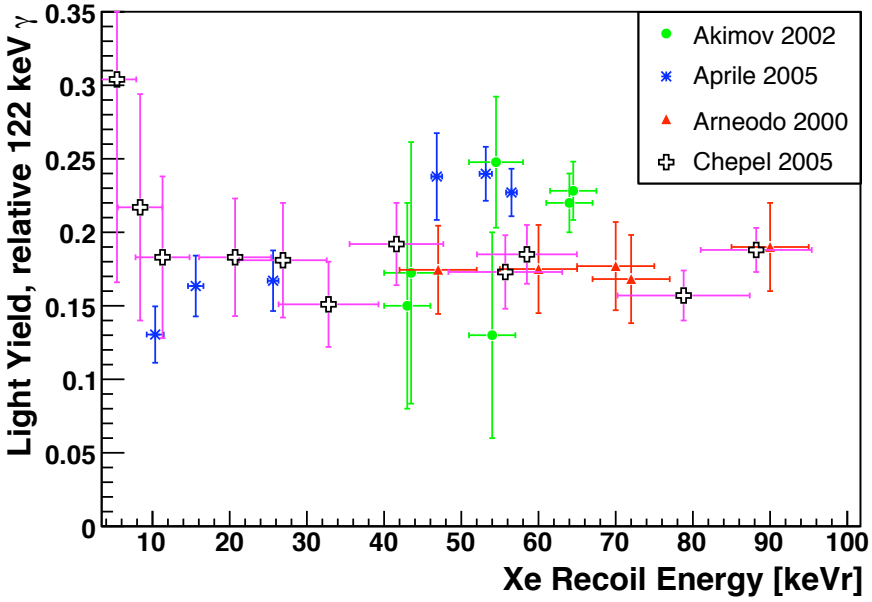

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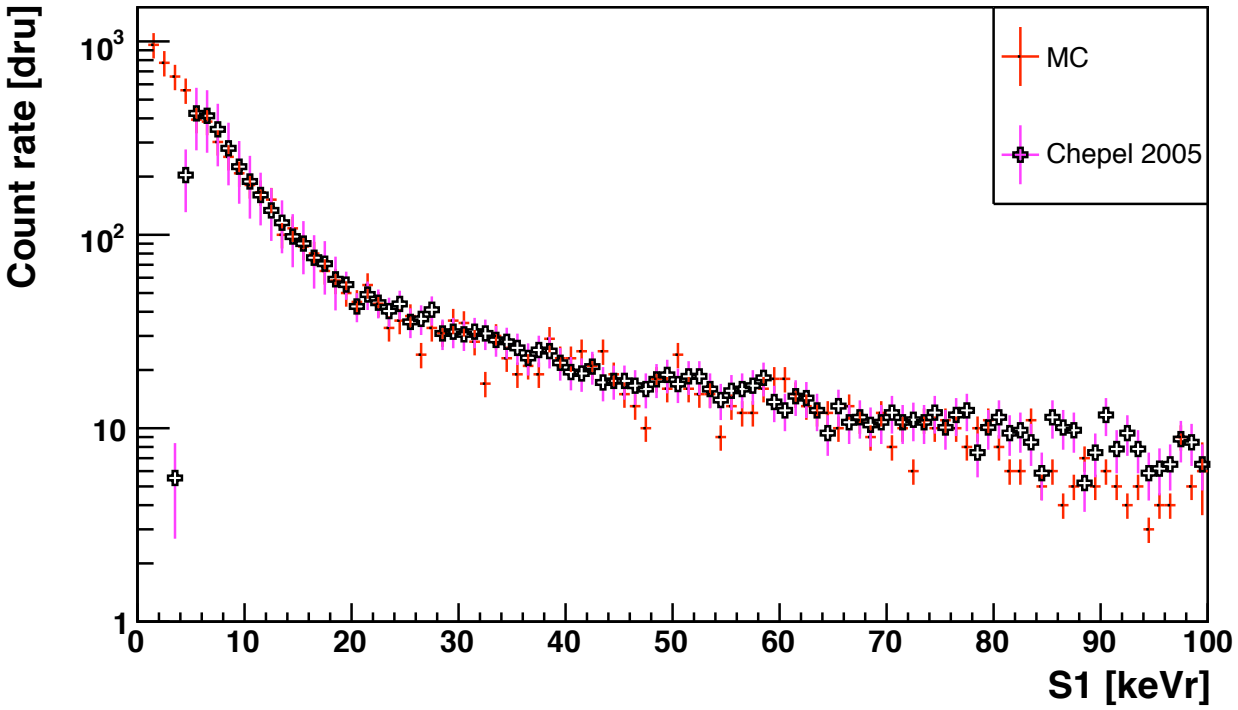

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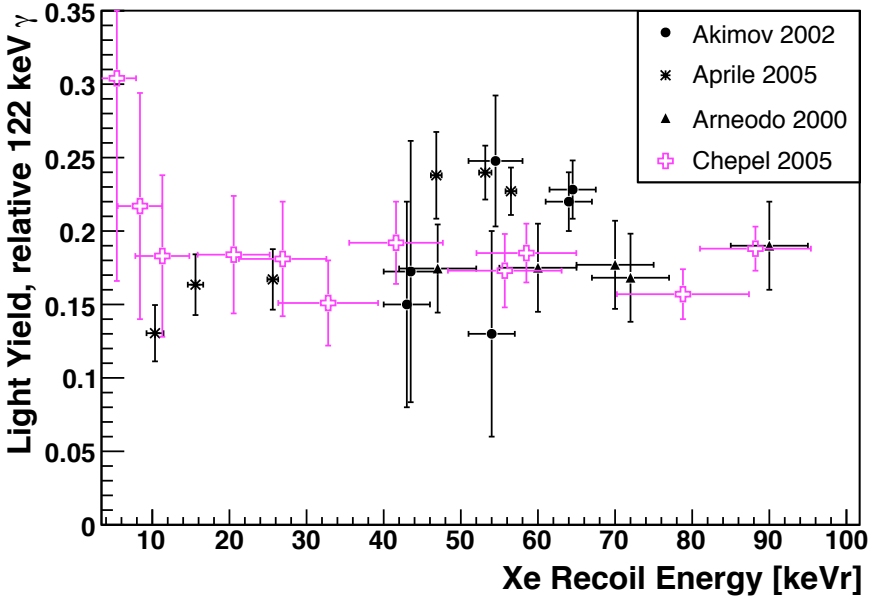

Multiple Scatters