Recent Results from the XENON Experiment

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on behalf of the XENON collaboration

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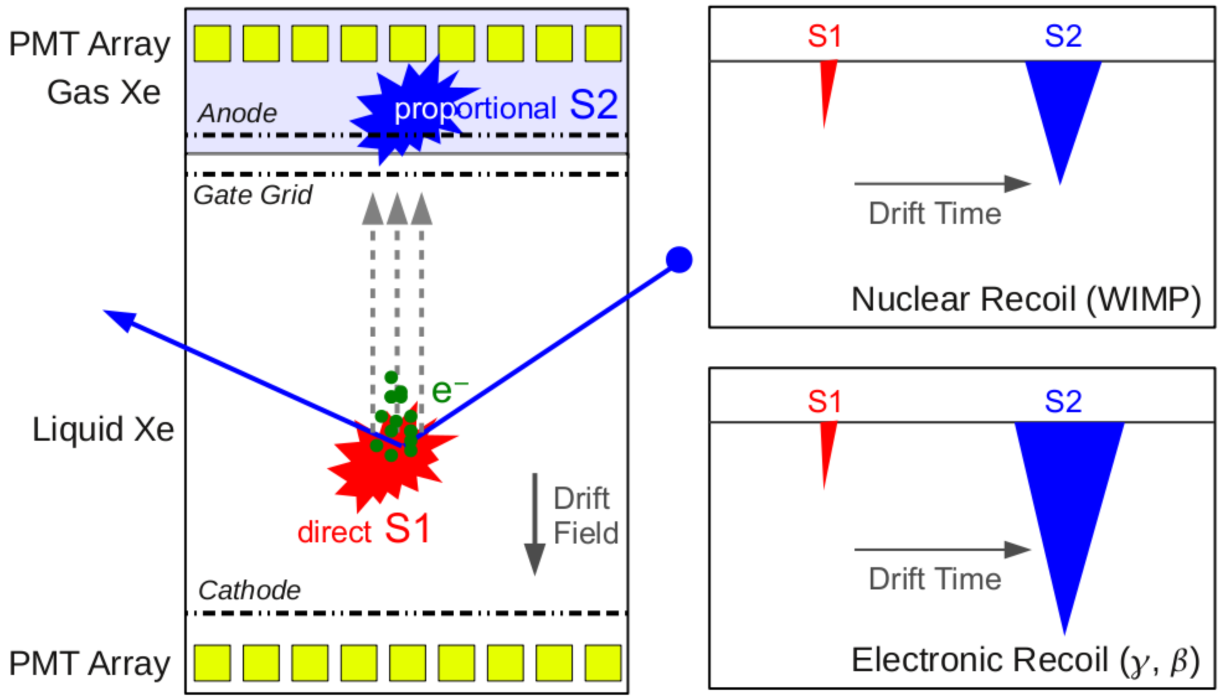
The XENON100 Collaboration

Columbia Rice UCLA Zürich Coimbra LNGS INFN SJTU Purdue

Bologna Subatech Münster Heidelberg Nikhef Weizmann Mainz Bern

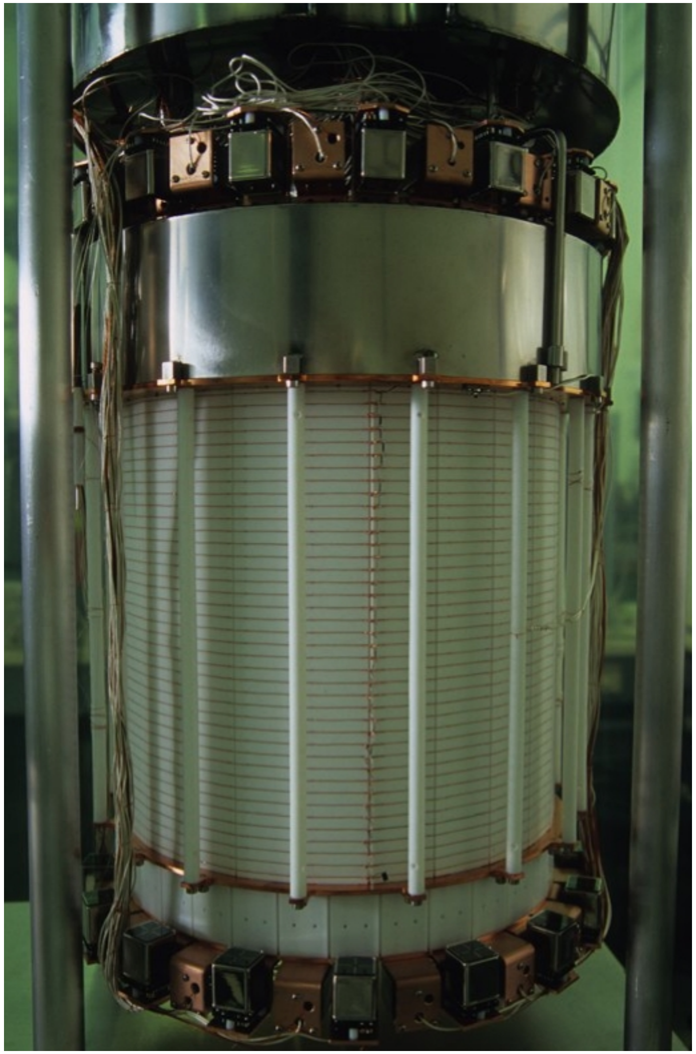
The XENON Detection Principle



- 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

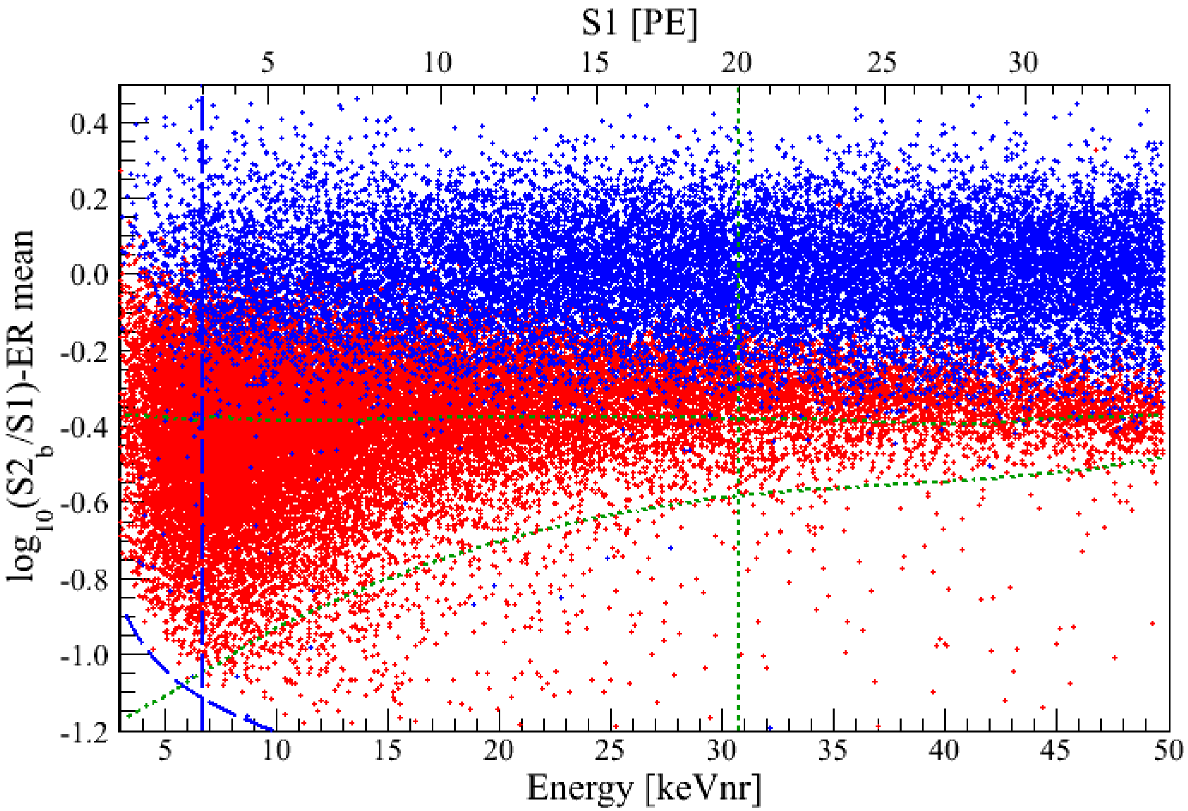
XENON100



- 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.)

Astropart. Phys. 35, 573-590 (2012)

ER/NR Calibration



ER calibration data

- ^{60}Co and ^{232}Th
- > 35x statistics of background

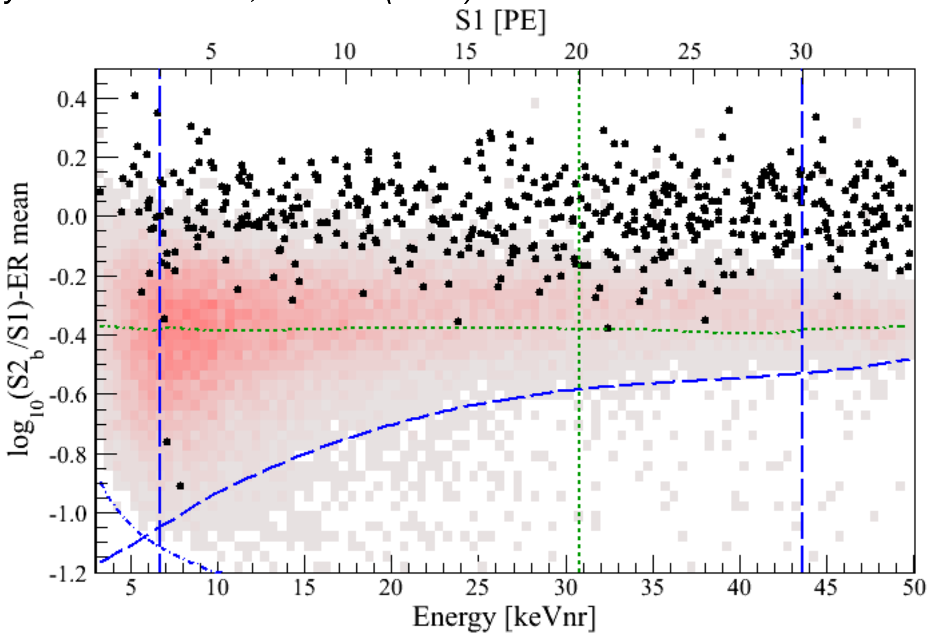
NR calibration data

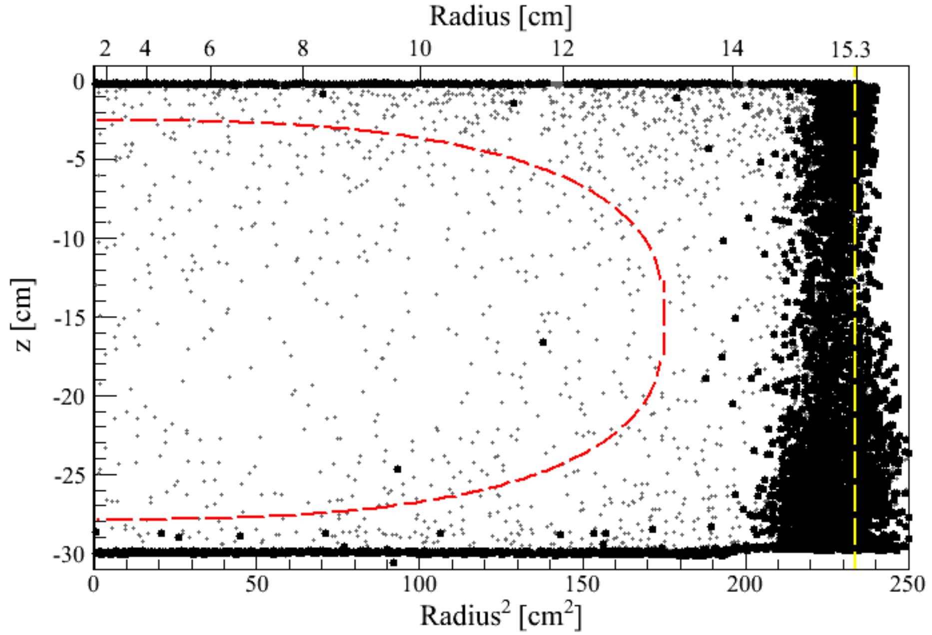
- AmBe
- Calibration at beginning and end of the run

At 50 % NR acceptance ~99.5 % ER rejection

Results from 225 Live Days

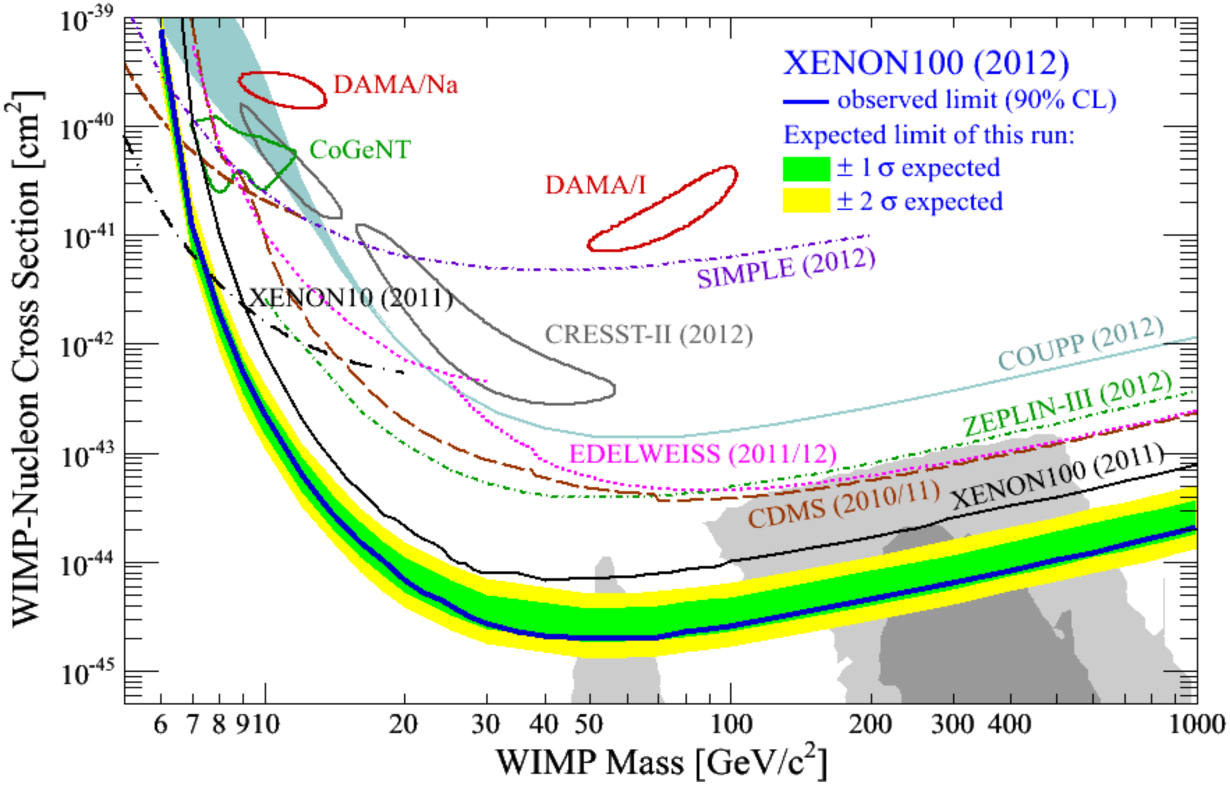
Phys. Rev. Lett. 109, 181301 (2012)





- Background expectation in benchmark region: 1.0 ± 0.2
- 2 events observed → 26.4 % probability of background fluctuation
- Exclusion limit derived using profile likelihood analysis

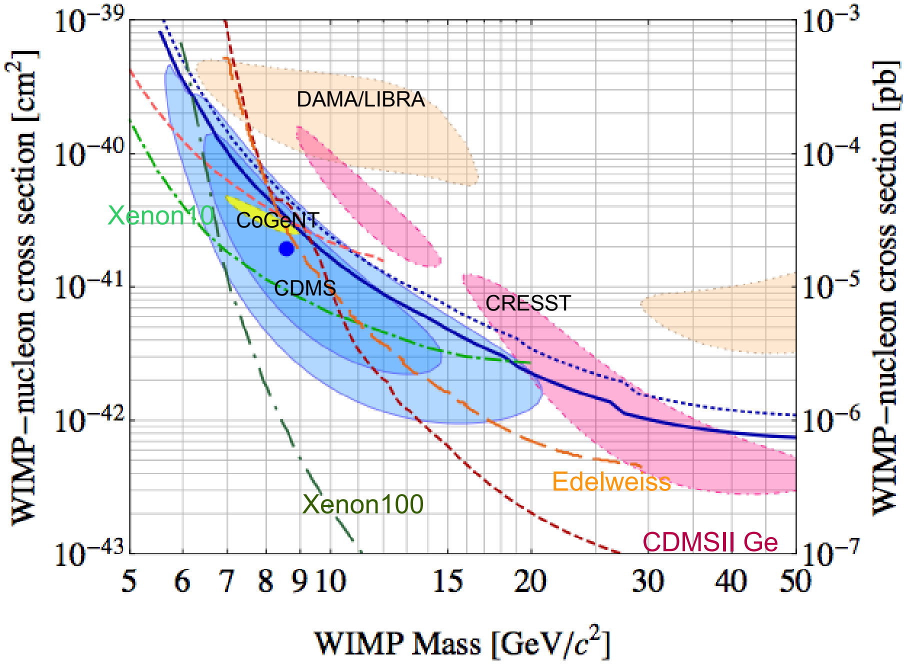
Results from 225 Live Days

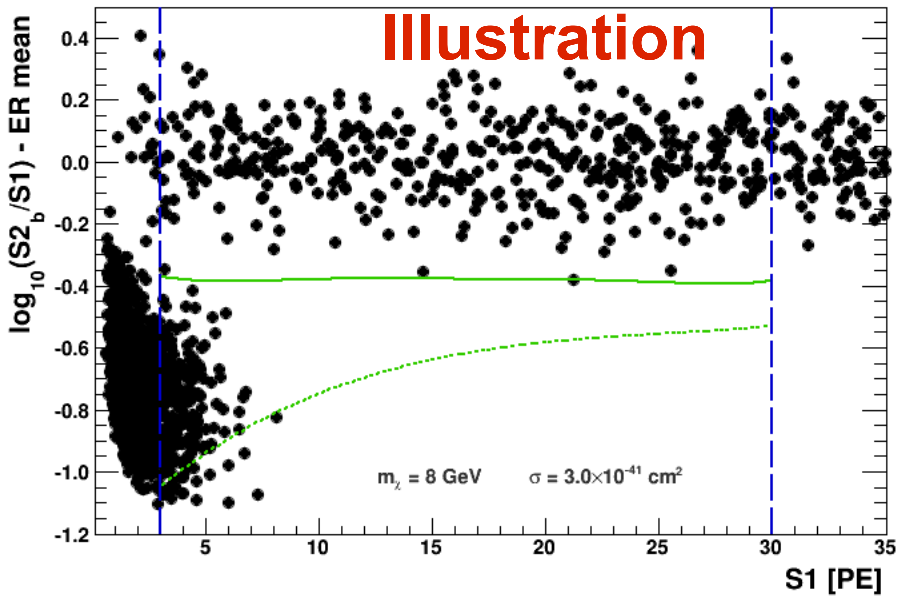


- Most stringent exclusion limit for WIMP masses > 8 GeV
- $\sigma = 2 \times 10^{-45} cm^2$ at 55 GeV WIMP mass at 90 % CL

CDMS Signal Indication

CDMS, arXiv: 1304.4279

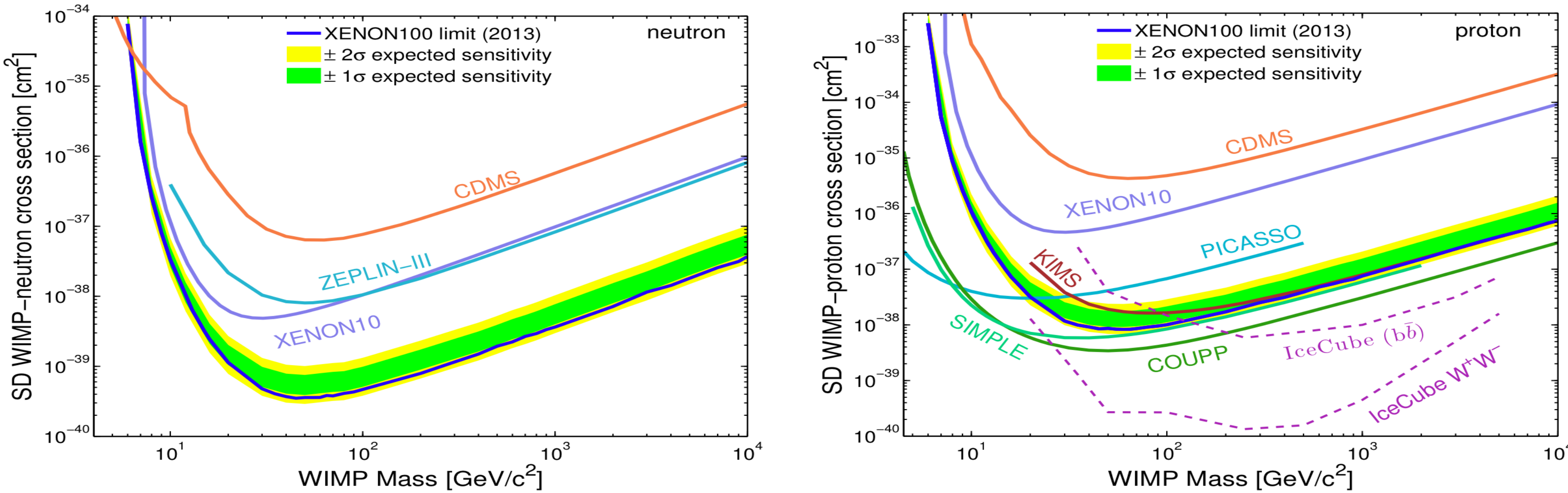




- Recent signal indication by CDMS for WIMP with σ = 1.9 x 10 $^{-41}$cm^2 at 8.6 GeV
- In XENON100, >200 events in signal region would be expected for such a WIMP

Spin-Dependent Results

Phys. Rev. Lett. 111, 021301 (2013)



- 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))*
- $\sigma = 3.5 \times 10^{-40}$ 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

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

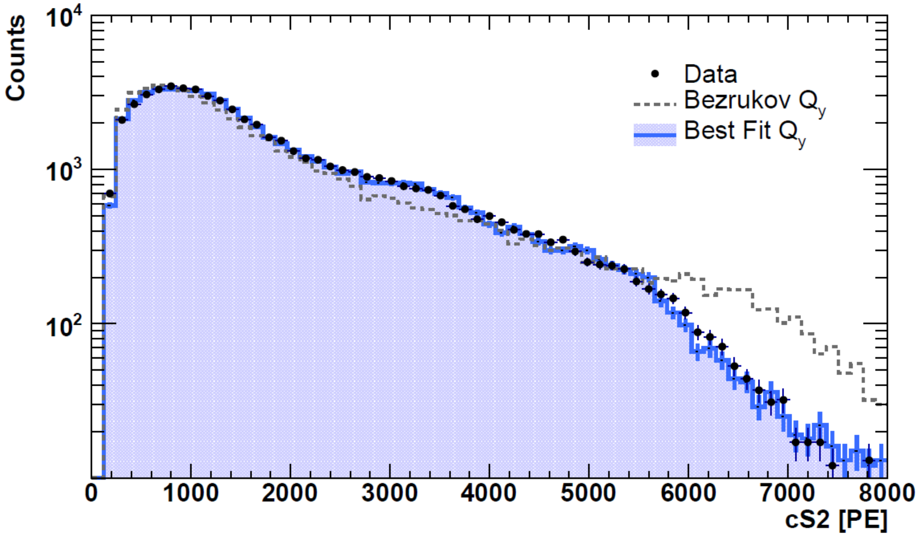
- Nuclear recoil energy is connected to S2 signal via

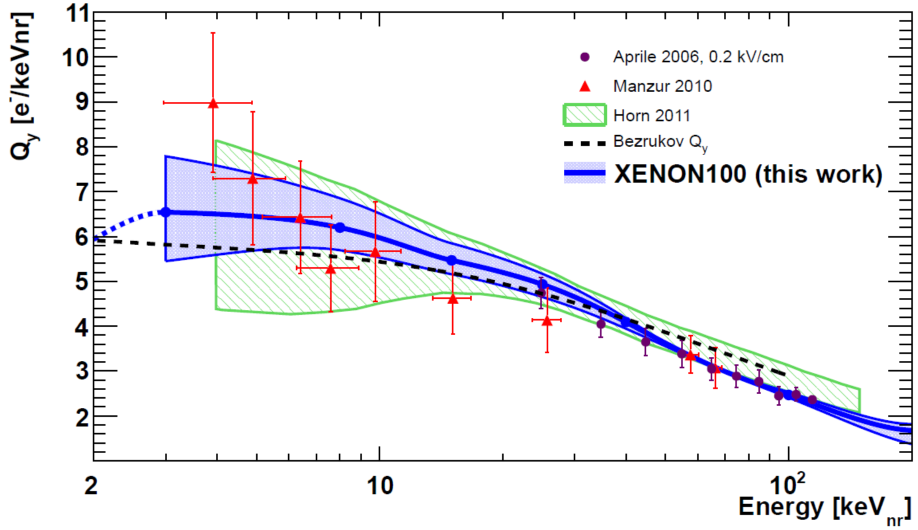
$$S2 = E_{nr} Q_y(E_{nr}) Y$$

- 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

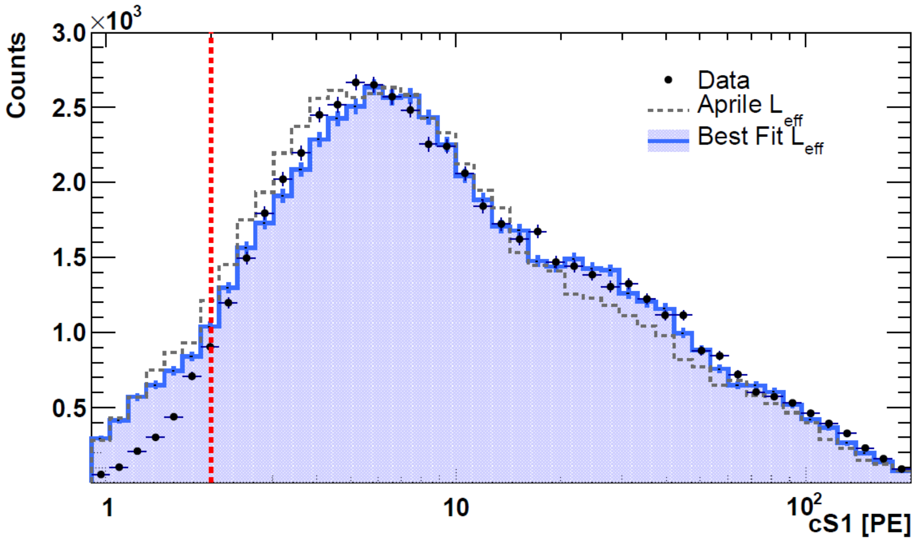
arXiv:1304.1427

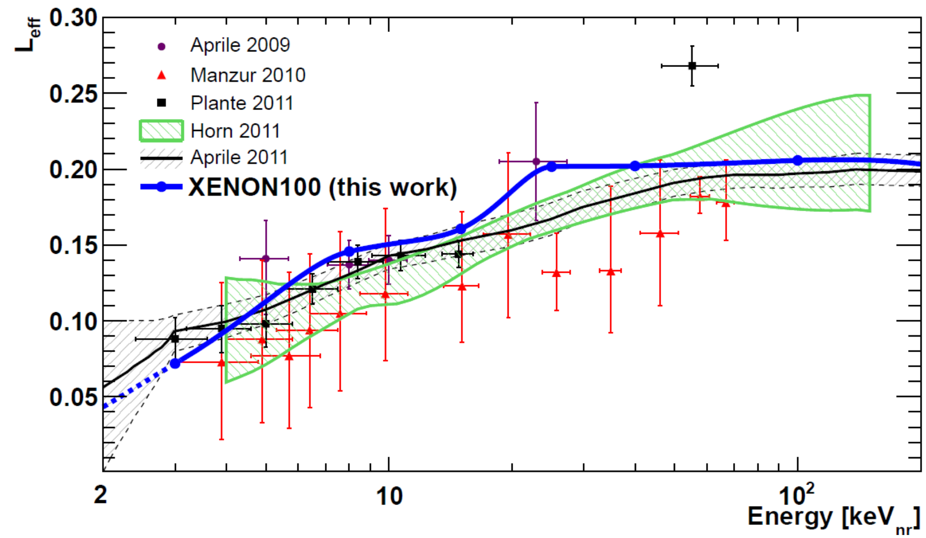




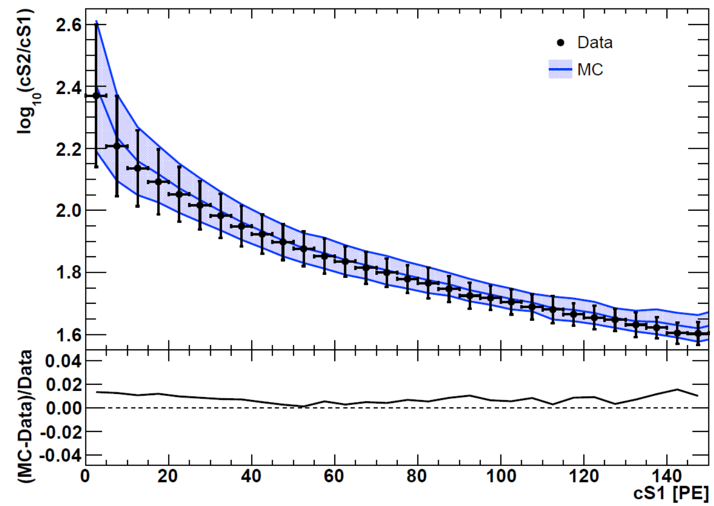
- Absolute matching of Monte Carlo to data from AmBe neutron calibration
- Monte Carlo includes complete description of detector including the shield
- In a first step fit S2, using L_{eff} from direct measurements → Q_y

Nuclear Recoil Energy Scale



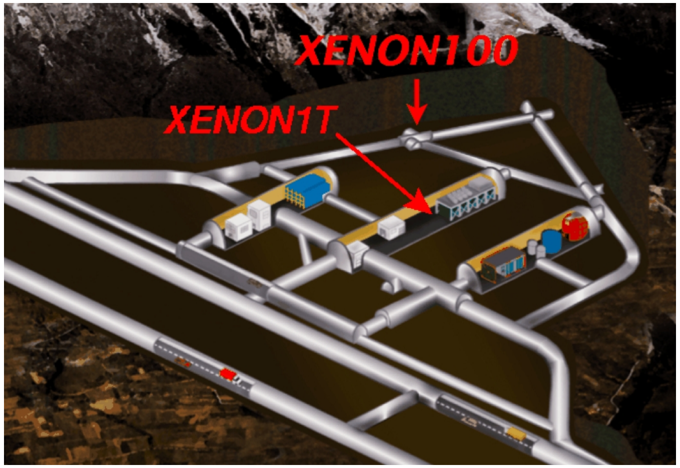


- Using the derived Q_y, fit S1 → L_{eff}
- Good overall agreement down to 3 keV_{nr}
- L_{eff} matches previous measurements
- Detector response well understood down to energies below analysis threshold



XENON1T

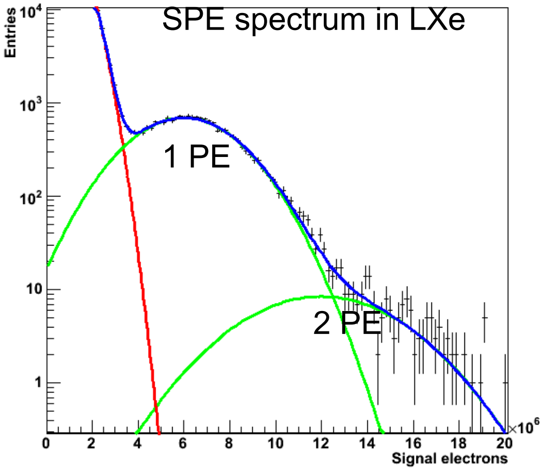
- XENON100: 62 kg target
  - Currently running
- XENON1T: 2.2 t target
  - Construction started June 2013
  - Commissioning by end of 2014

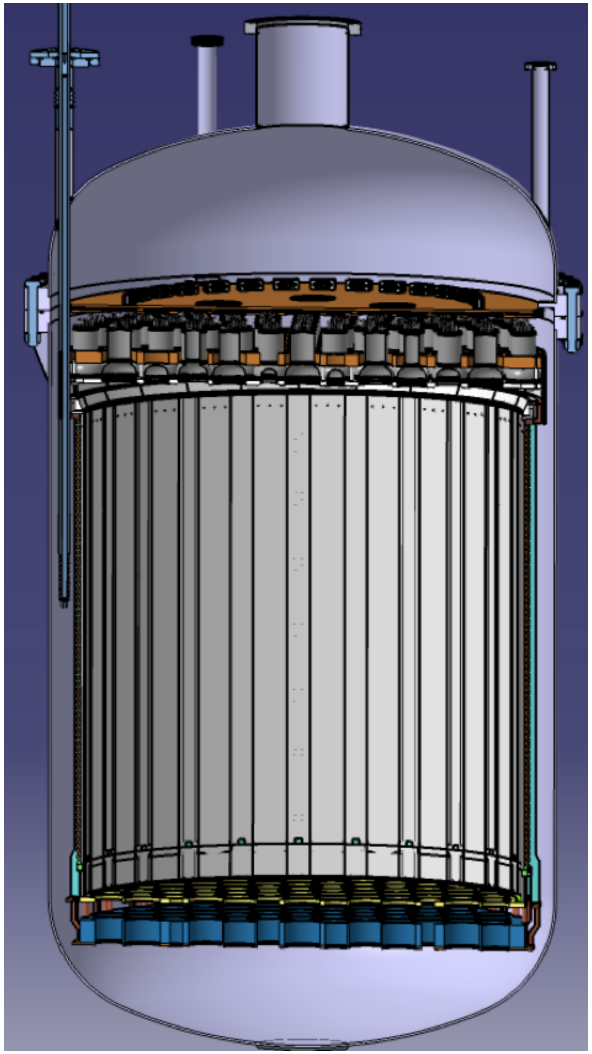


XENON1T

- 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

JINST 8 P04026 (2013)

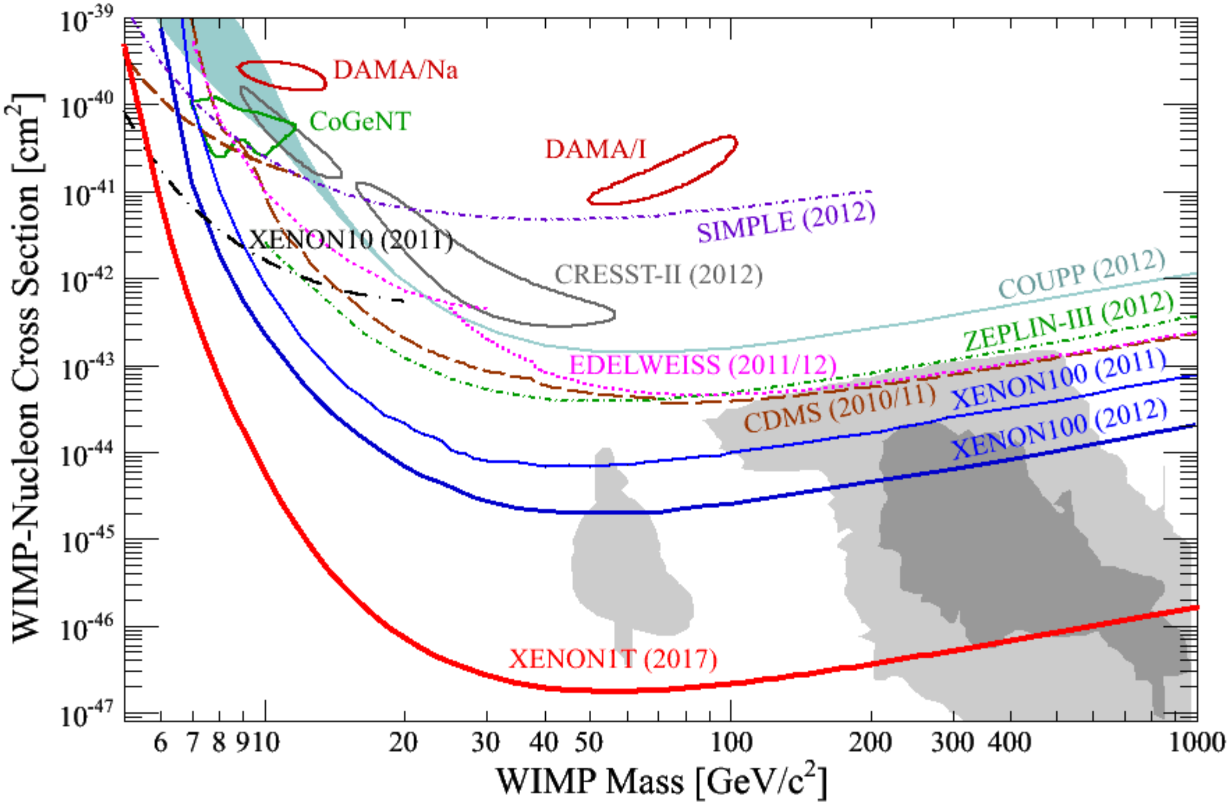




XENON1T

- 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

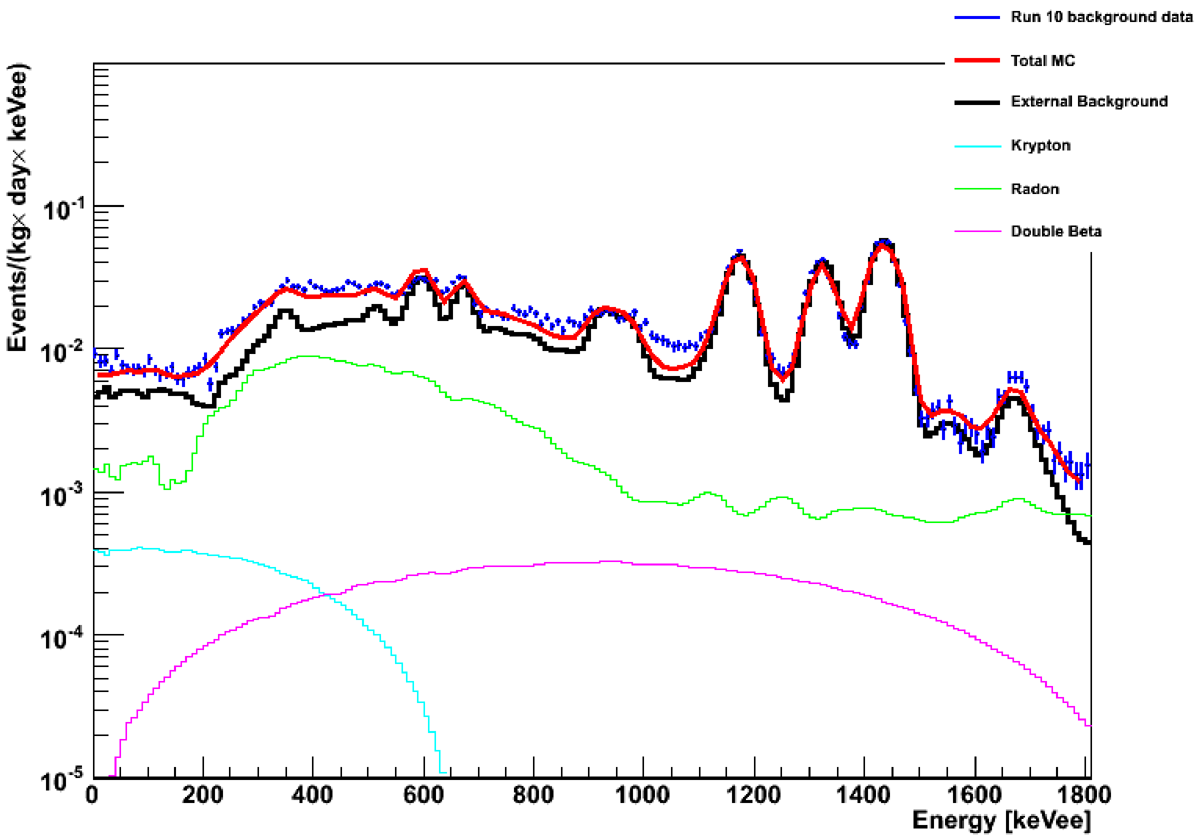
XENON1T



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}Kr concentration:
  19 ± 4 ppt (RGMS)
  18 ± 8 ppt (delayed coincidence)
- ^{222}Rn concentration:
  62.8 ± 0.4 μBq/kg

Total background level:

(5.3 ± 0.6) $\cdot 10^{-3}$ events/(keV kg day) in 34 kg

Background Prediction

- Electronic recoil background: 0.79 ± 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 ± 0.2 events in benchmark region in 225 d

L_{eff} Direct Measurement

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

$$E_{nr}=\frac{S1}{L_y}\frac{1}{L_{eff}(E)}\frac{S_{ee}}{S_{nr}}$$