status of xenon

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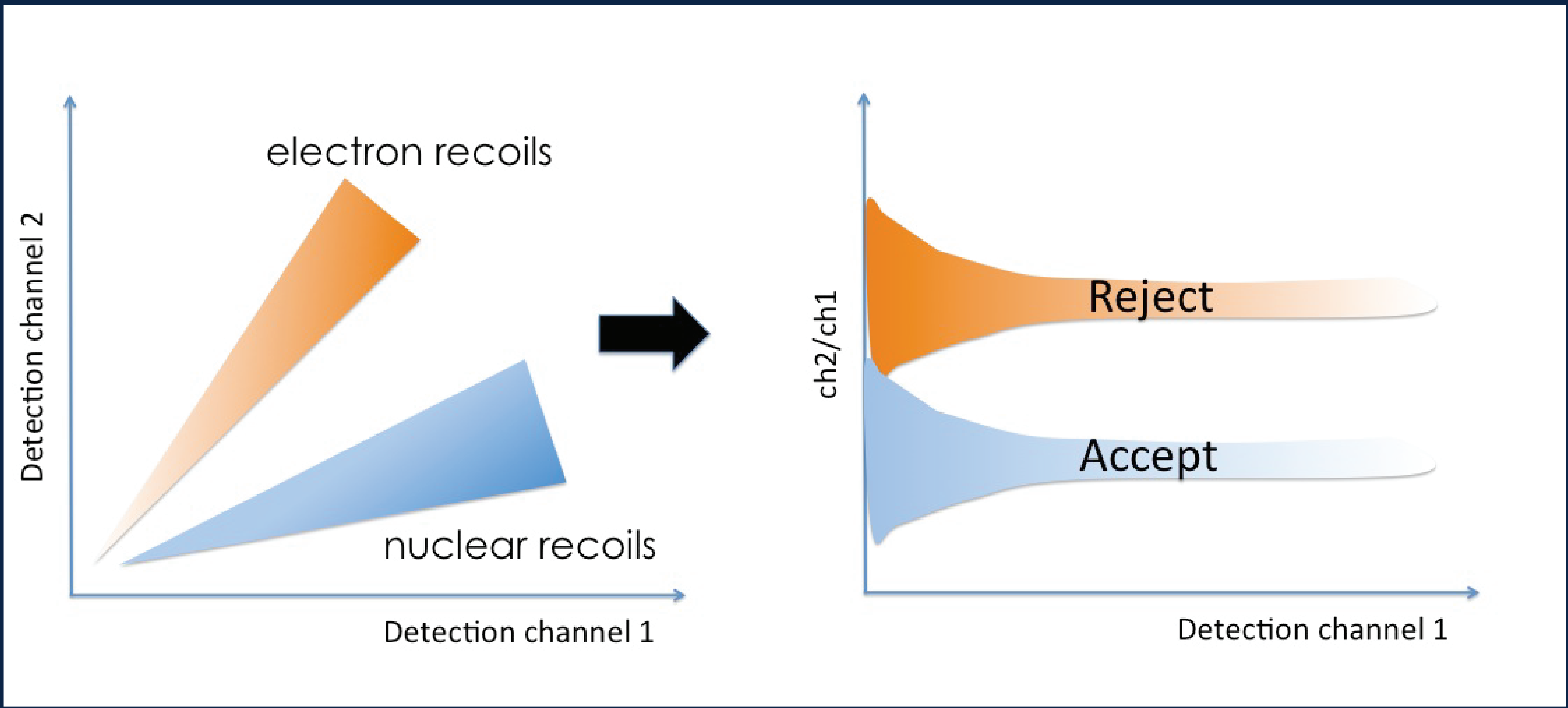
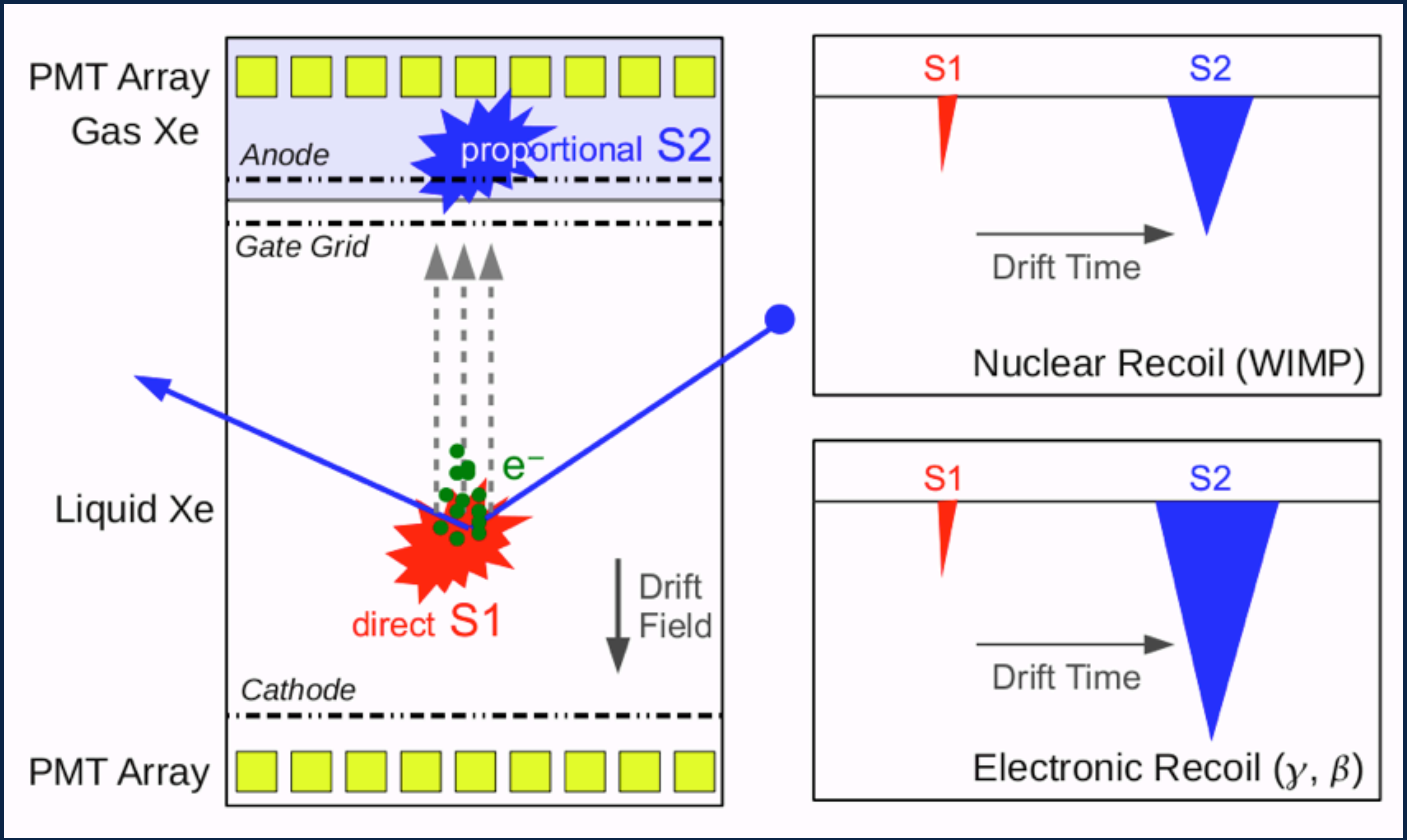
for the xenon collaboration
new york university - abu dhabi
&
LNGS-INFN

active background discrimination with 2 channels



The wonders of double phase TPCs

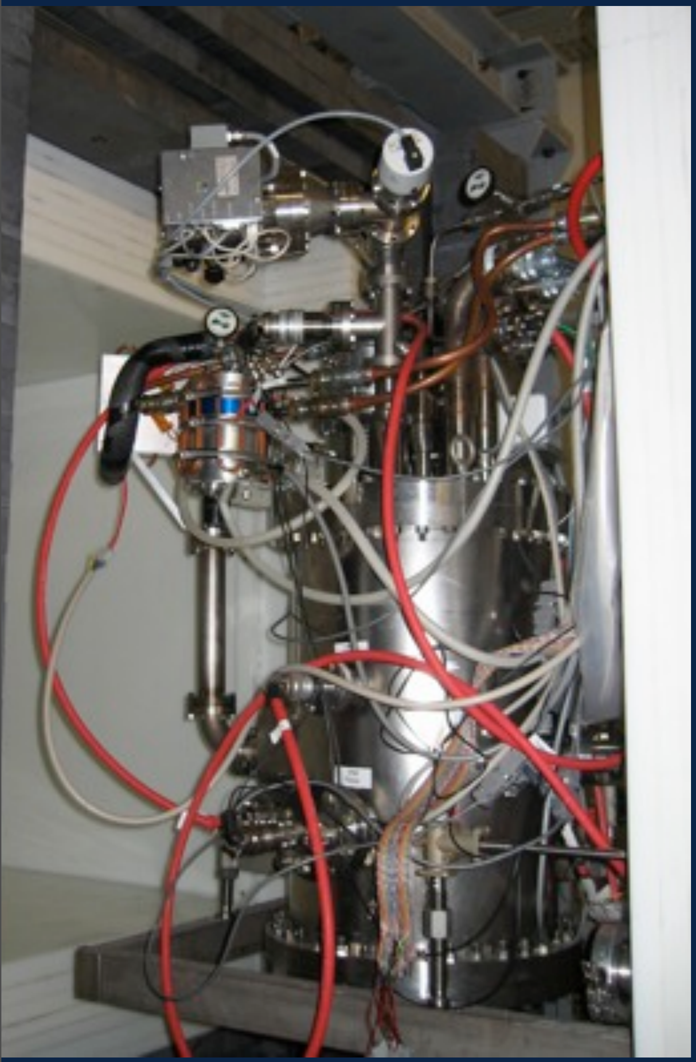


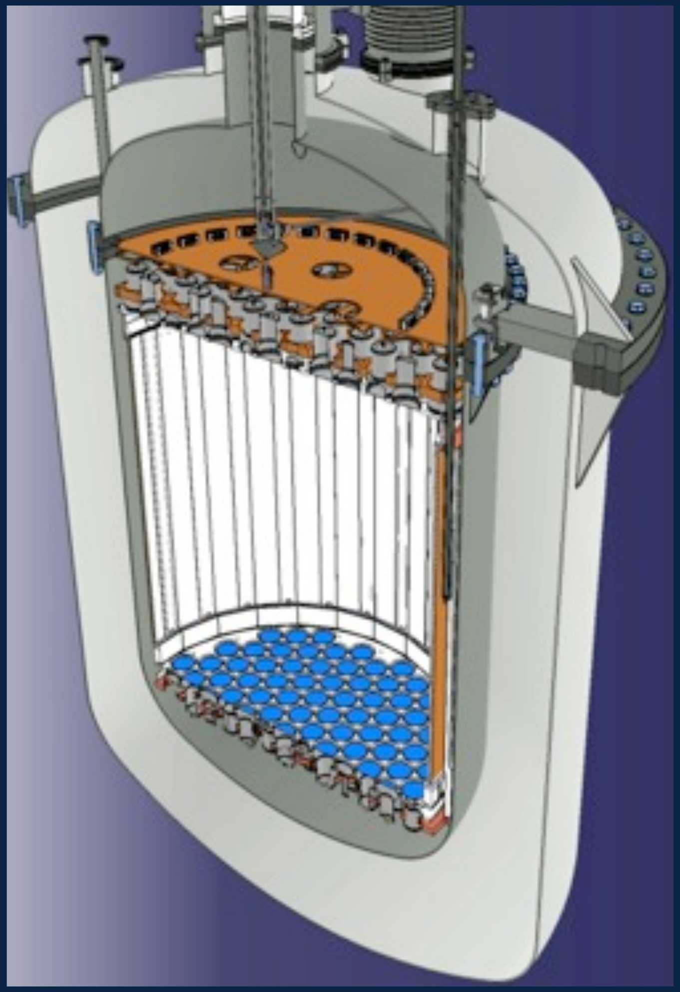
The XENON Dark Matter Program

past
(2005 - 2007)

current
(2008-2013)

future
(2014....)





XENON10

Achieved (2007) σ_{SI}=8.8 x10^{-44} cm^2

XENON100

Achieved (2010) σ_{SI}=2.4 x10^{-44} cm^2

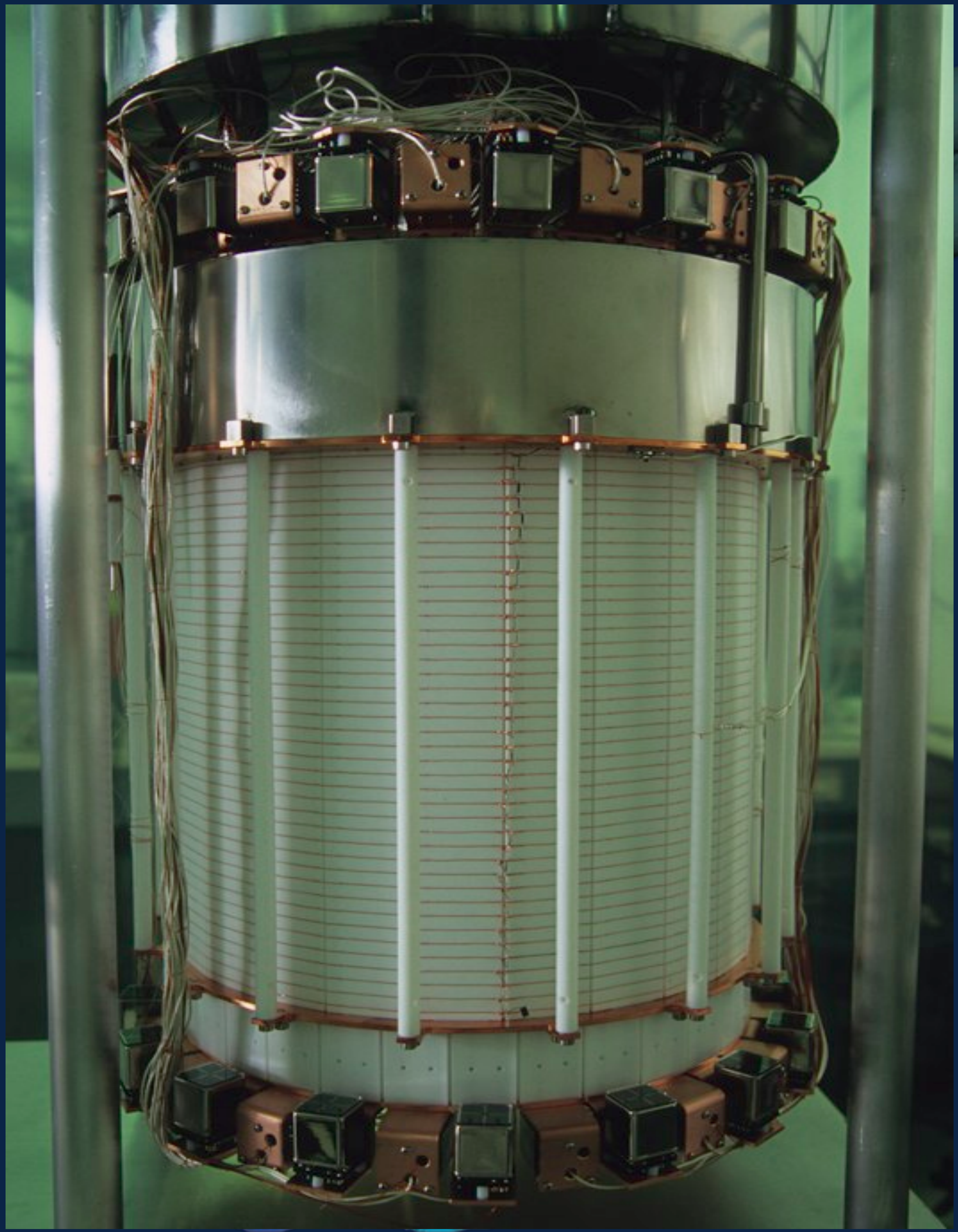
Achieved (2011) σ_{SI}~2x10^{-45} cm^2

XENON1T

Projected (2015) σ_{SI} ~10^{-47} cm^2

XENON100 @LNGS

the xenon 100 Detector

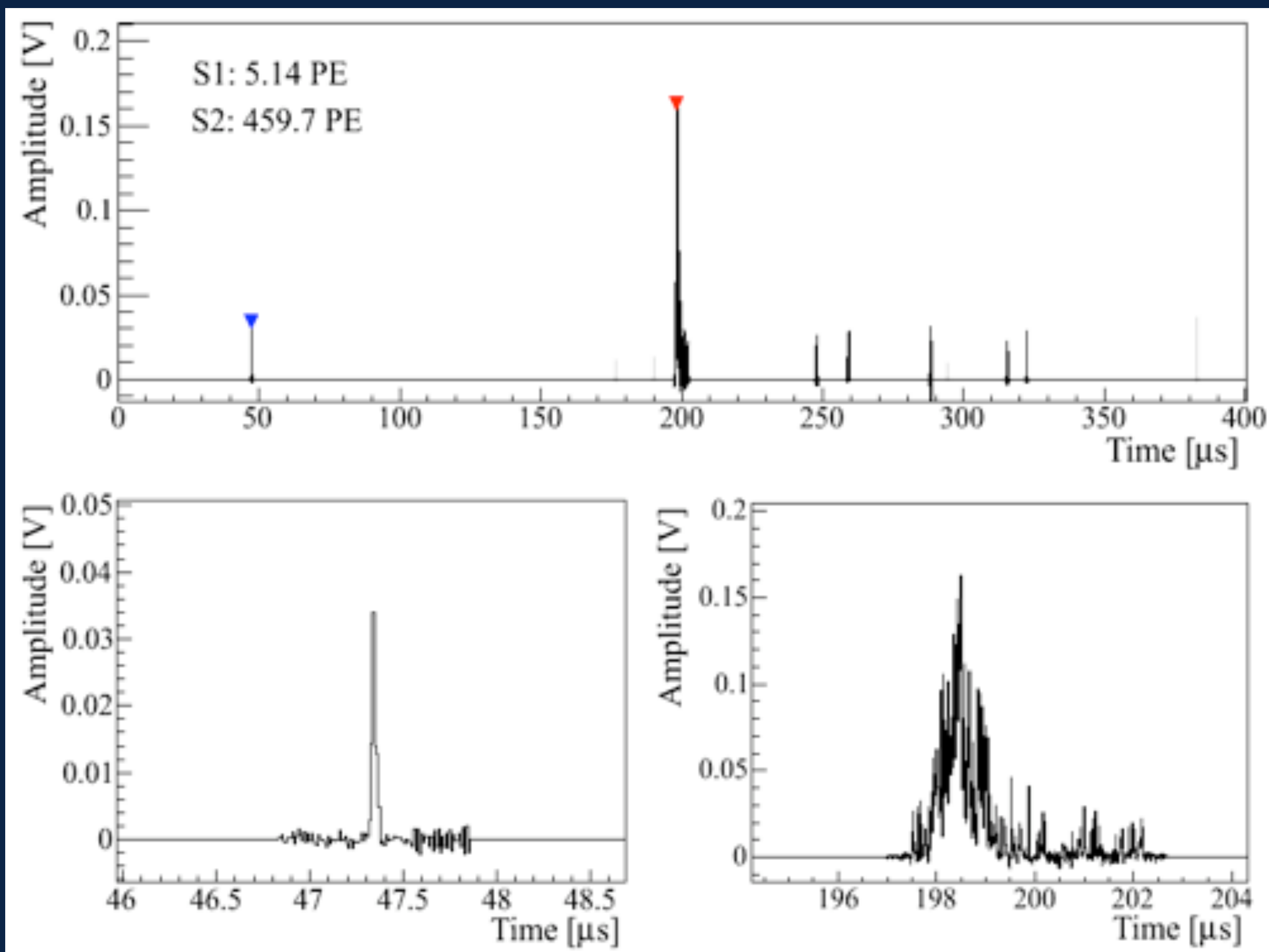


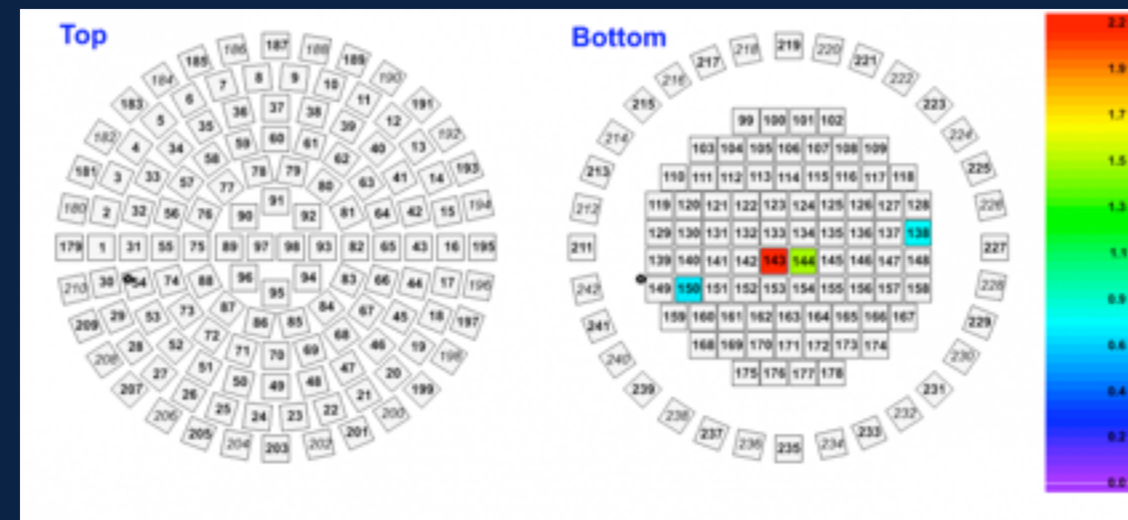
- 161 kg of LXe.
- TPC: 30 cm height x 30 cm diameter.
- Active veto: 4 cm thick.
- 242 PMTs 1-inch x 1-inch.
  - Top array, QE~23%. Bottom array, QE~33%.
- Electric field: E_{drift} = 0.53 kV/cm. E_{extr} = ~12 kV/cm.
- Shielding: 5 cm Cu, 10 cm Poly, 15 + 5 cm Pb, 20 cm H_2O.
- Radio-pure detector materials. Cryocooler, FT outsid
- Kr distillation column

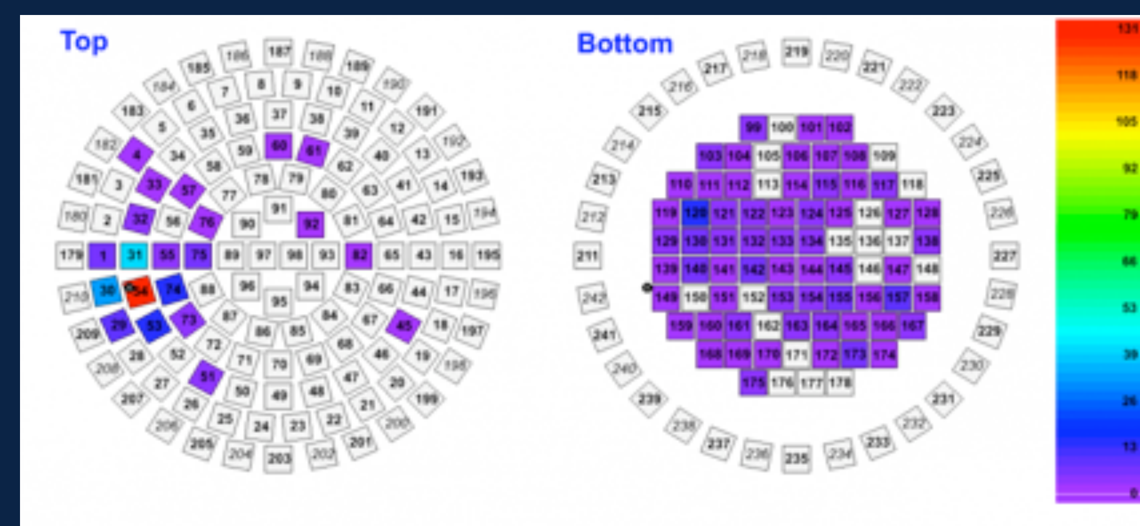
Astropart. Phys. 35: 43-49, 2011

xenon100 at lngs

typical low energy event





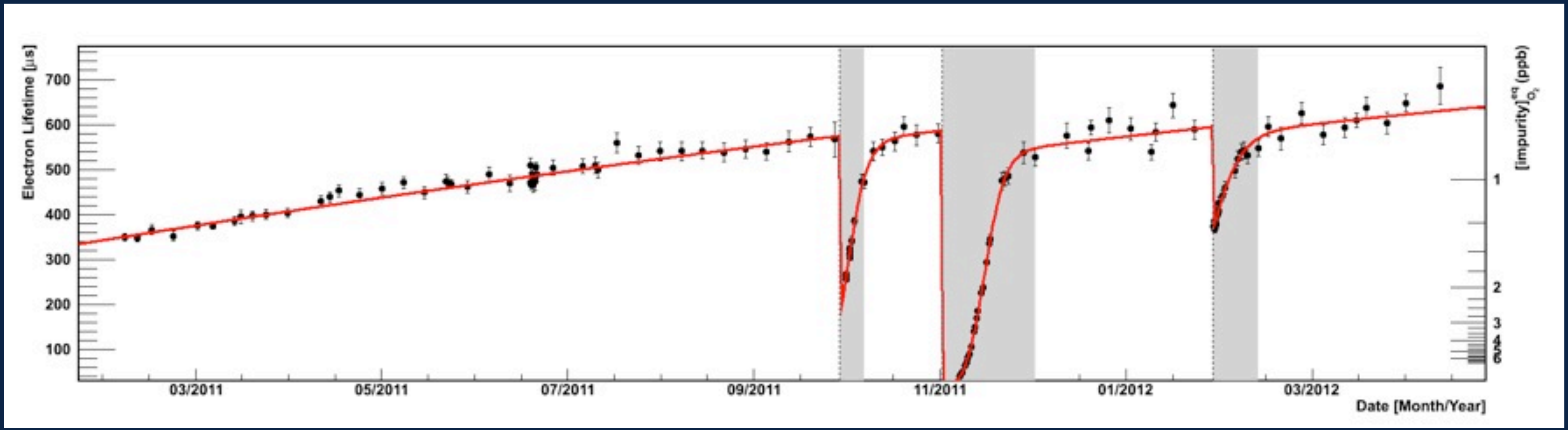


see The XENON100 dark matter experiment. Astroparticle Physics 35 (2012) 573–590

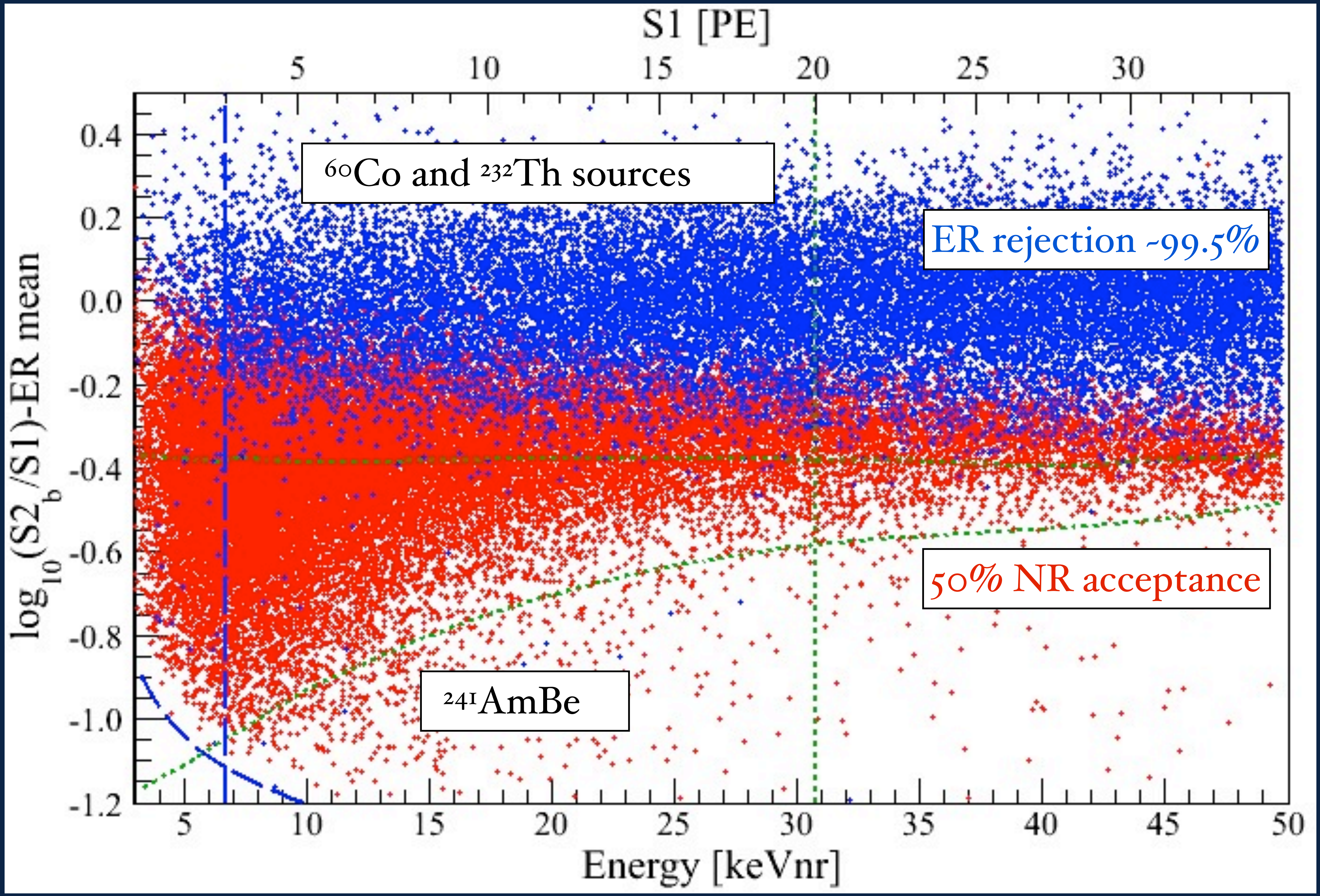
the 2011 run

- 225 days
- Threshold for the analysis:

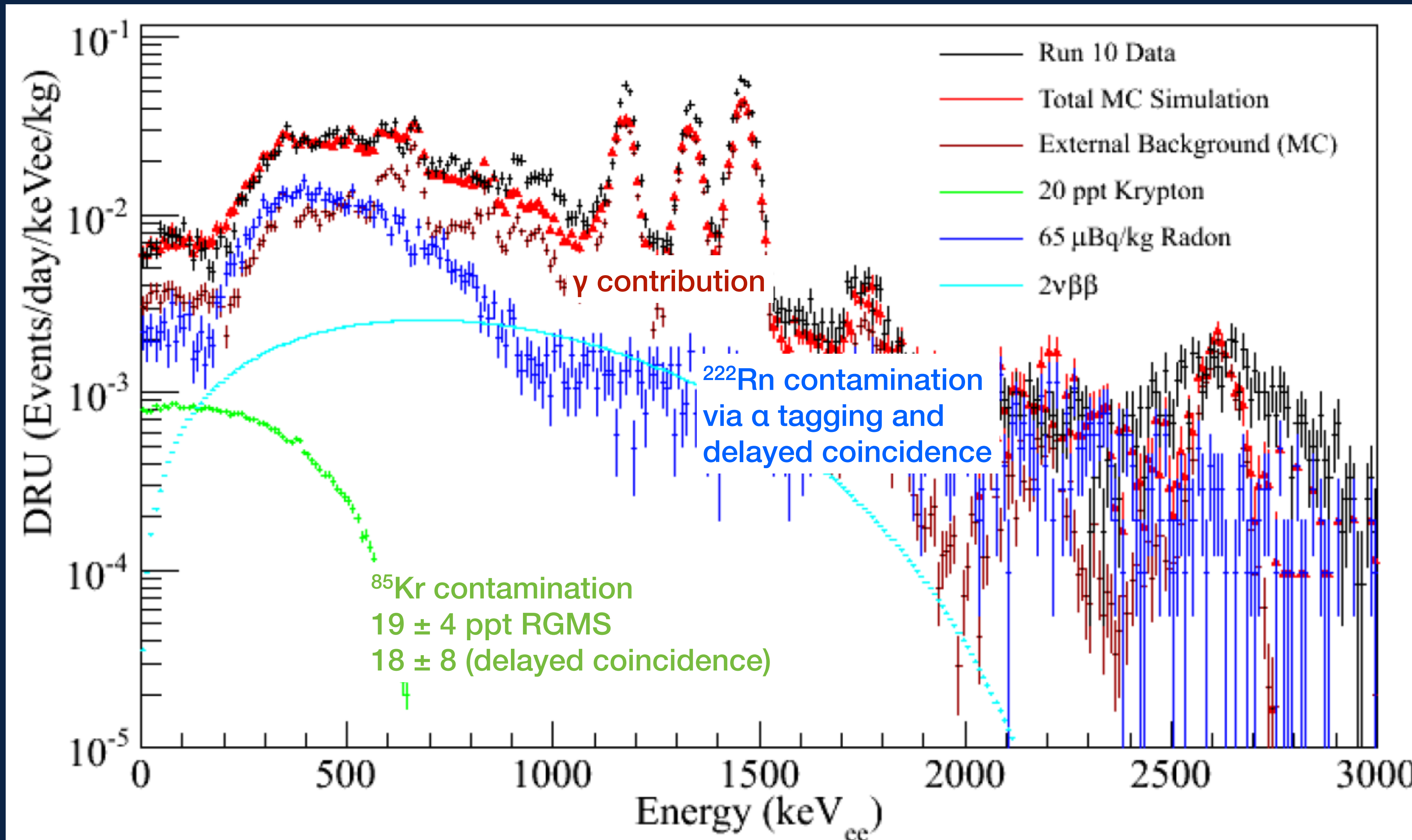
  S2 > 150 pe and S1 > 3 pe (6.6 keVnr)
- Dedicated cuts to identify/reject "noisy" events
- Very small Kr contamination (19 ppt)
- Electron lifetime monitored with ^{137}Cs source increasing from 375 to 610 μs



ER & NR calibration data



electronic recoil background

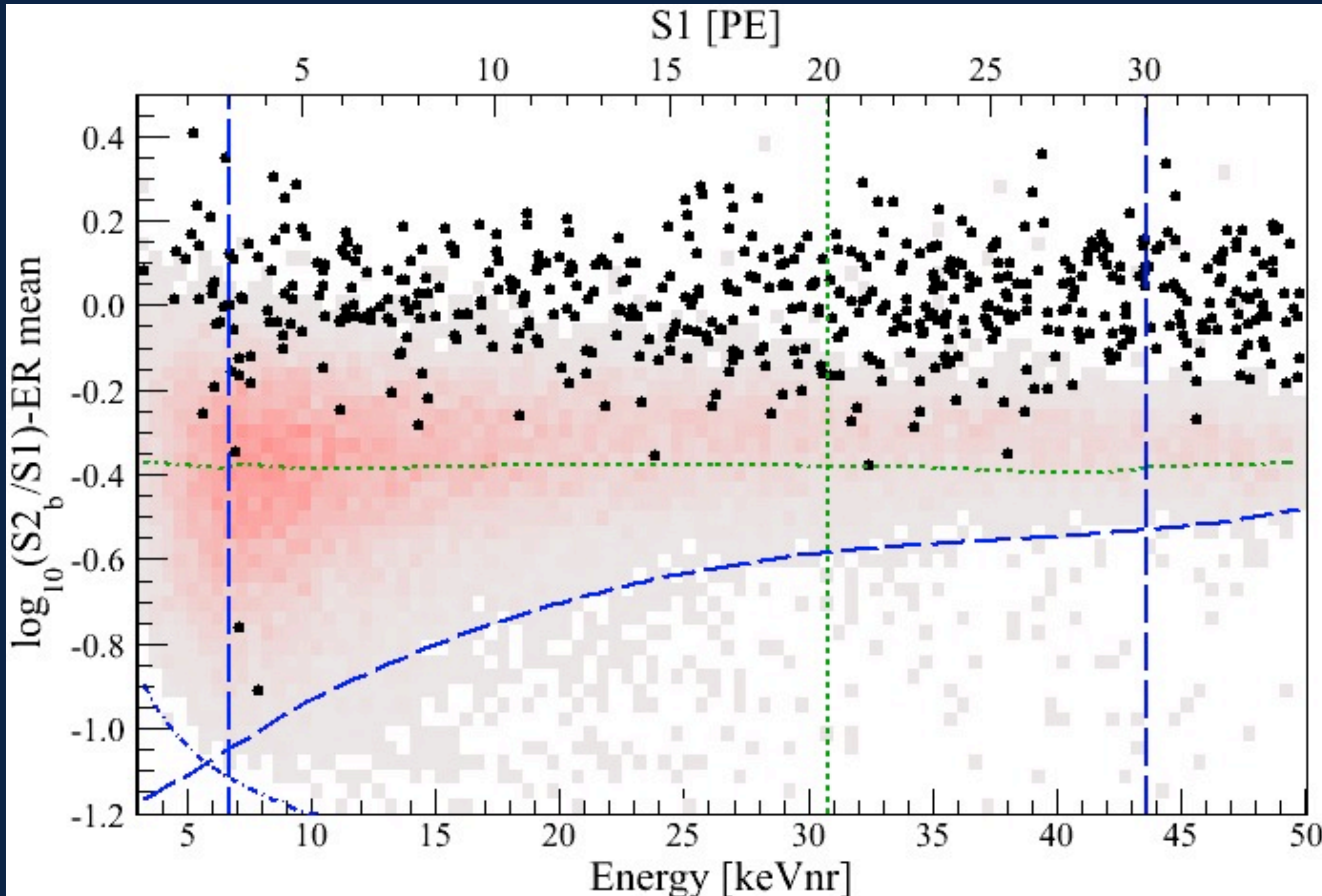


ER background:
10 kg FV, no veto cut

Background level @ 34 kg = (5.3 ± 0.6) x 10^{-3} DRU
(active veto no S2/S1 discrimination)

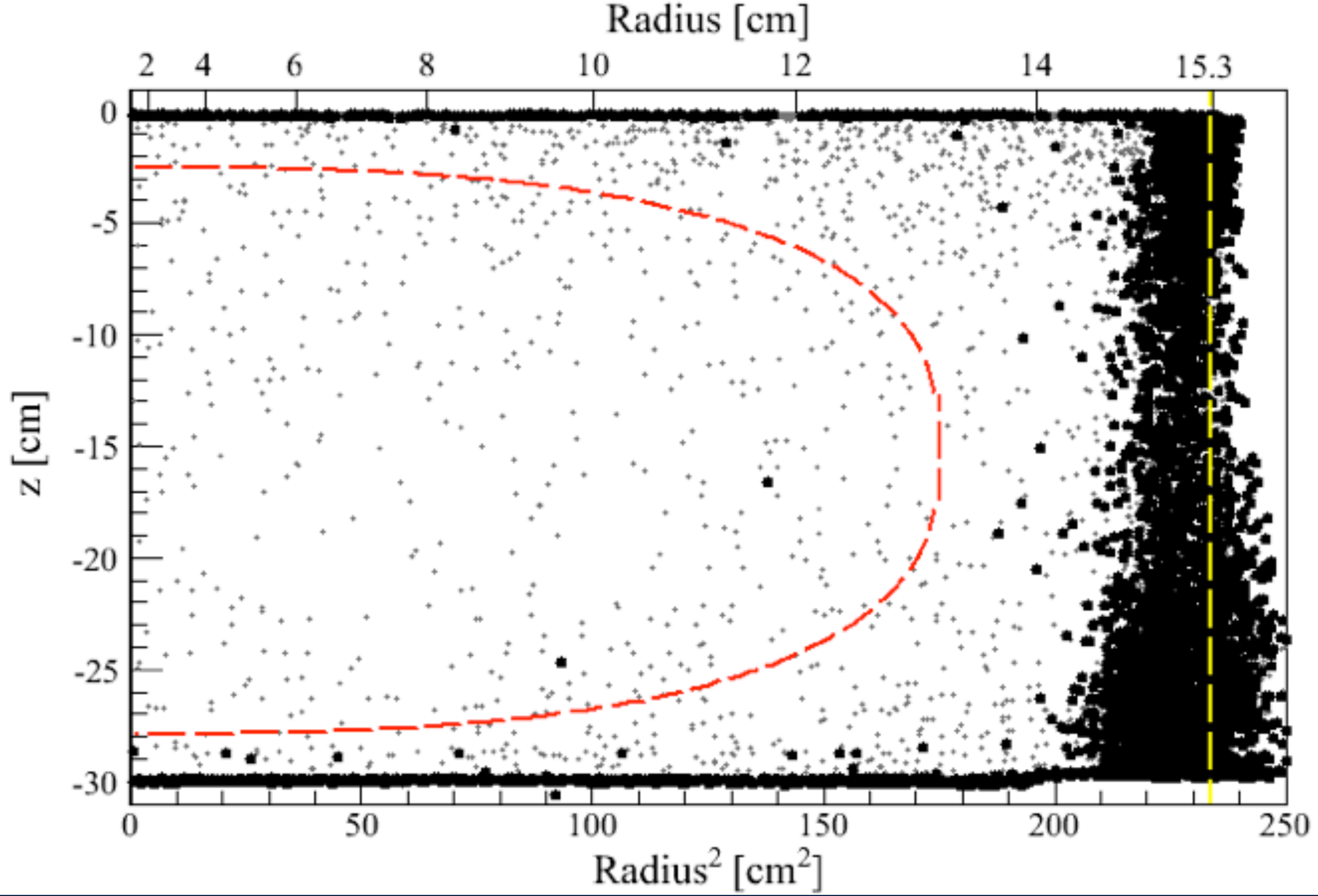
1 **dru** = 1 event/kg/day/keV

2012 xenon100 unblinding results



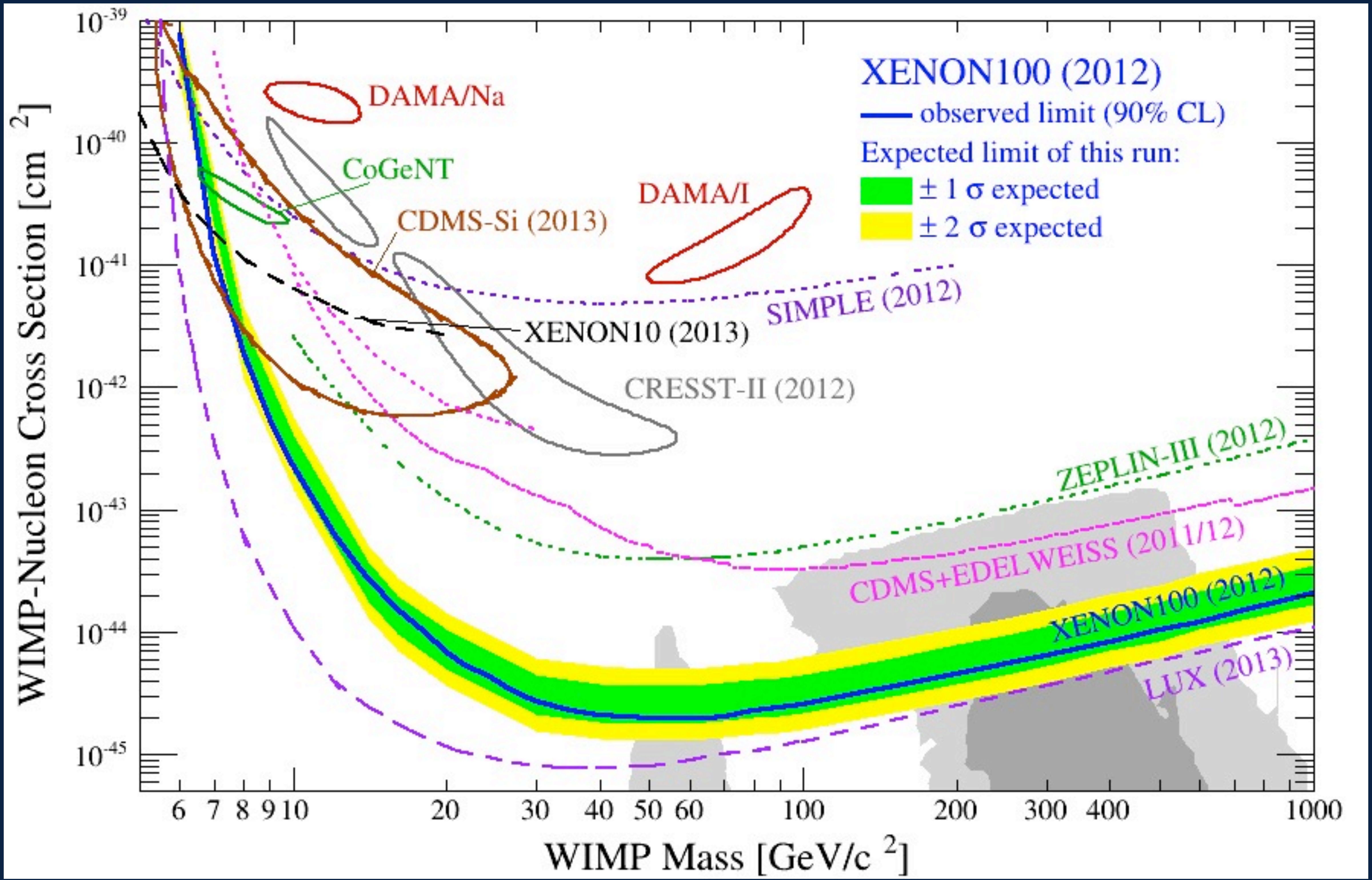
2 events observed in the signal region with (1±0.2) expected
No events below the signal threshold

The power of self shielding



XENON100 unblinding, 2012

Present scenario



recent work

- Observation and applications of single-electron charge signals in the XENON100 experiment, arXiv:1311.1088, J. Phys. G: Nucl. Part. Phys. 41 (2014) 035201.

- 2013-12-13: Analysis of the XENON100 Dark Matter Search Data, E. Aprile et al. (XENON100), Astropart.Phys. 54 (2014) 11-24.

- The neutron background of the XENON100 dark matter search experiment, arXiv:1306.2303, J. Phys. G: Nucl. Part. Phys. 40, 115201 (2013)

- Response of the XENON100 dark matter detector to nuclear recoils, arXiv:1304.1427, Phys. Rev. D 88, 012006 (2013)

- Limits on spin-dependent WIMP-nucleon cross sections from 225 live days of XENON100 data, Phys. Rev. Lett. 111, 021301 (2013)

- The distributed Slow Control System of the XENON100 Experiment, JINST 7 T12001 (2012), arXiv:1211.0836.

spin-dependent interaction

PRL 111, 021301 (2013)

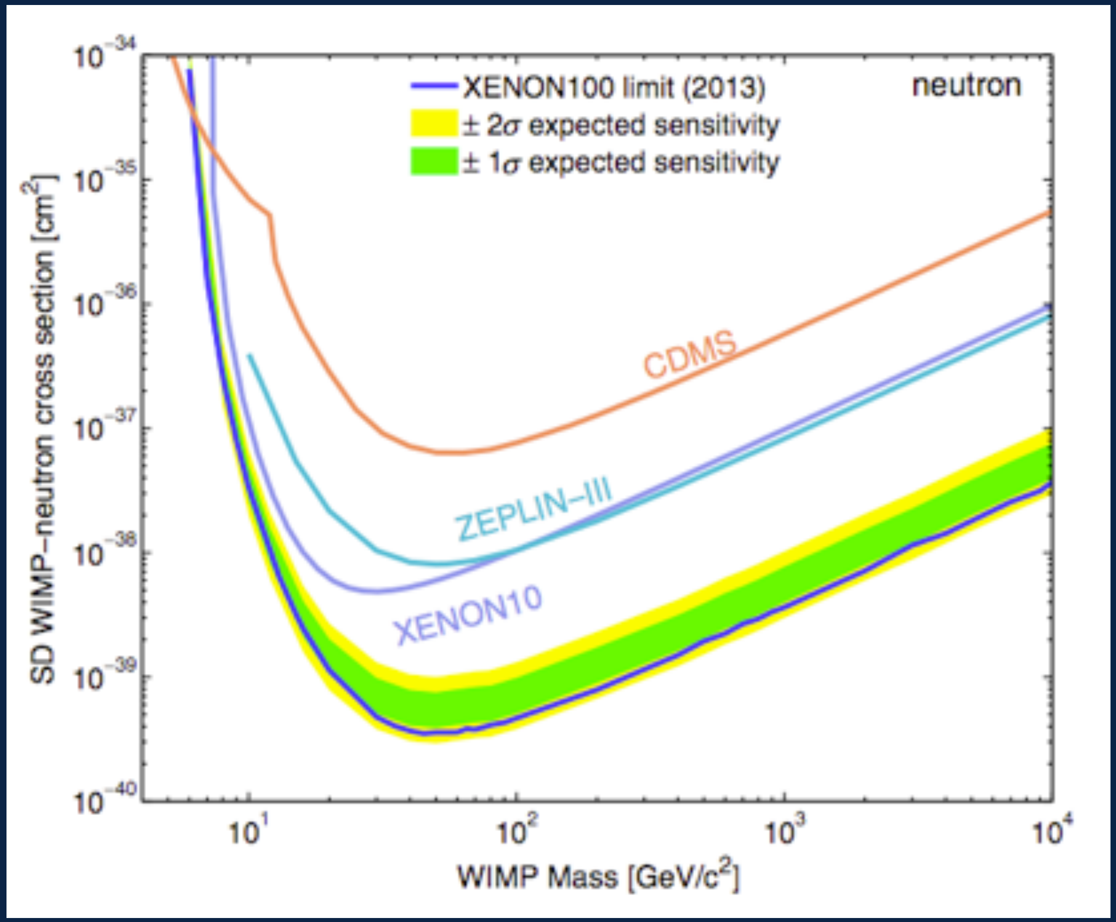
$$\sigma_{p,n}(q) = \frac{3}{4}\frac{\mu_{p,n}^2}{\mu_A^2}\frac{2J+1}{\pi}\frac{\sigma_{\mathrm{SD}}(q)}{S_A^{a_0=\pm a_1}(q)},$$

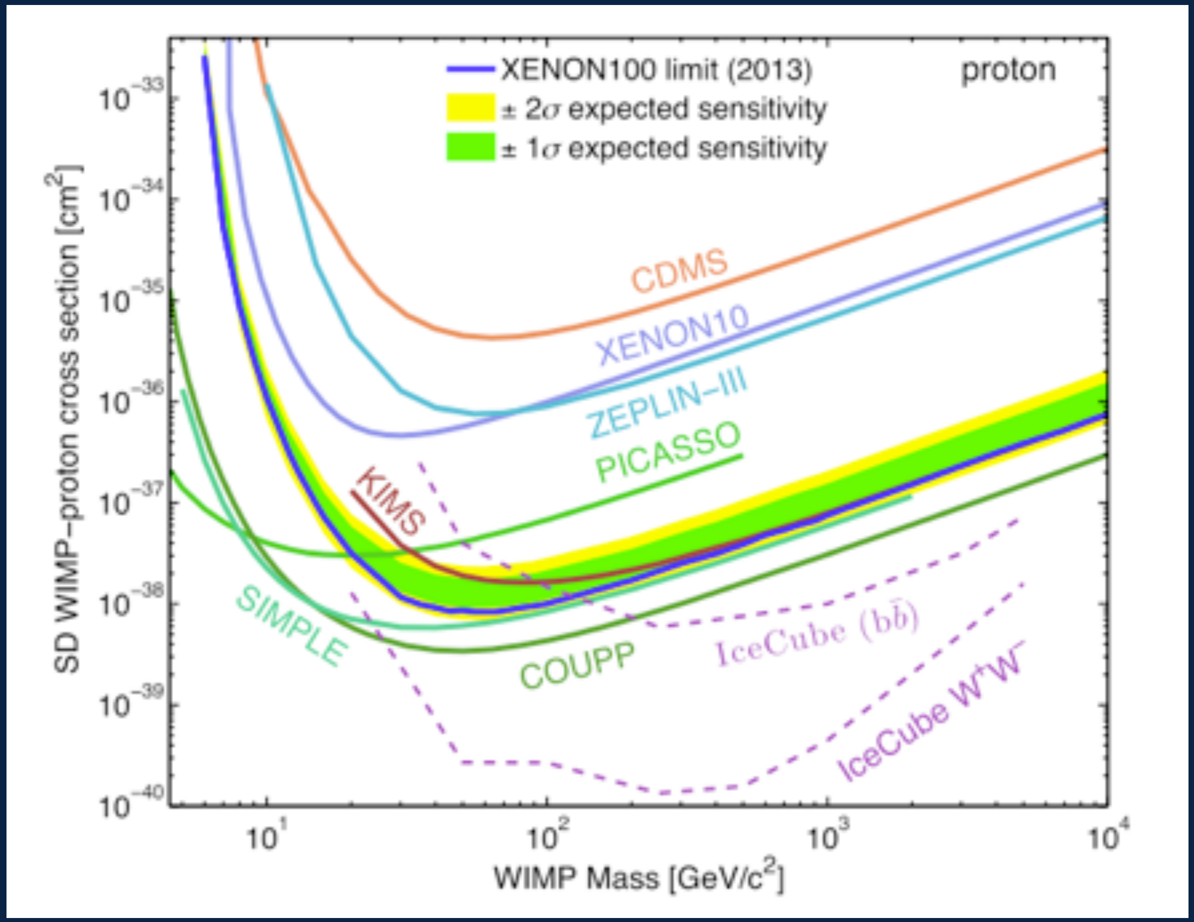
Nuclear structure functions

- Model dependent calculation
  - ✓ Several shell models on the market
  - ✓ The new, dedicated calculations by Menendez et al. yield a far superior agreement between calculated and measured spectra of the ^{129}Xe and ^{131}Xe nuclei, both in energy and in the ordering of the nuclear levels compared to older results.

J. Menendez, D. Gazit, and A. Schwenk, Phys. Rev. D 86,

spin-dependent interactions: limits





SD coupling with neutrons

SD coupling with protons

response to nuclear recoils

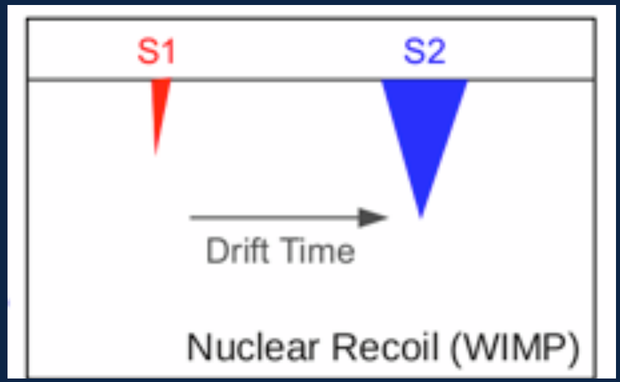
- We have performed dedicated runs with an AmBe source
  - ✓ $^{241}Am \rightarrow ^{237}Np + \alpha(5.6MeV)$
  - ✓ $^{9}Be(a,n)^{12}C$
  - ✓ neutrons are in the 2-10 MeV range
  - ✓ neutrons are used to define the response of the detector to wimps
- the response to nuclear recoils has been accurately simulated (phys. rev. d 88, 012006, 2013)
  - ✓ the scintillation and ionization channels have been assessed independently and simultaneously

response to nuclear recoils: S1

corrected primary signal

electric field suppression factor for e-recoils

$$E_{nr} = \frac{cS_1}{L_y} \frac{1}{\mathcal{L}_{eff}(E)} \frac{S_{ee}}{S_{nr}}$$

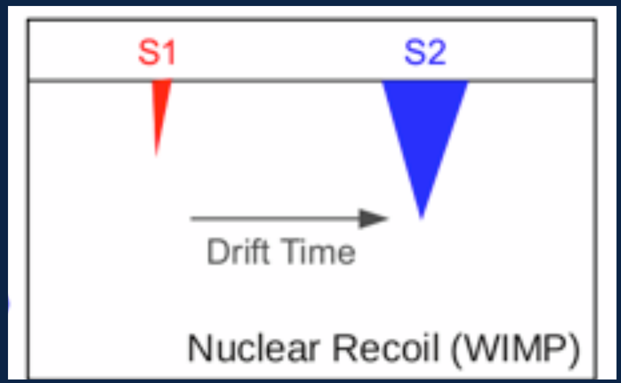


light yield at 122 keV

electric field suppression factor for n-recoils

relative scintillation efficiency for nuclear recoils

response to nuclear recoils: S2



corrected secondary signal

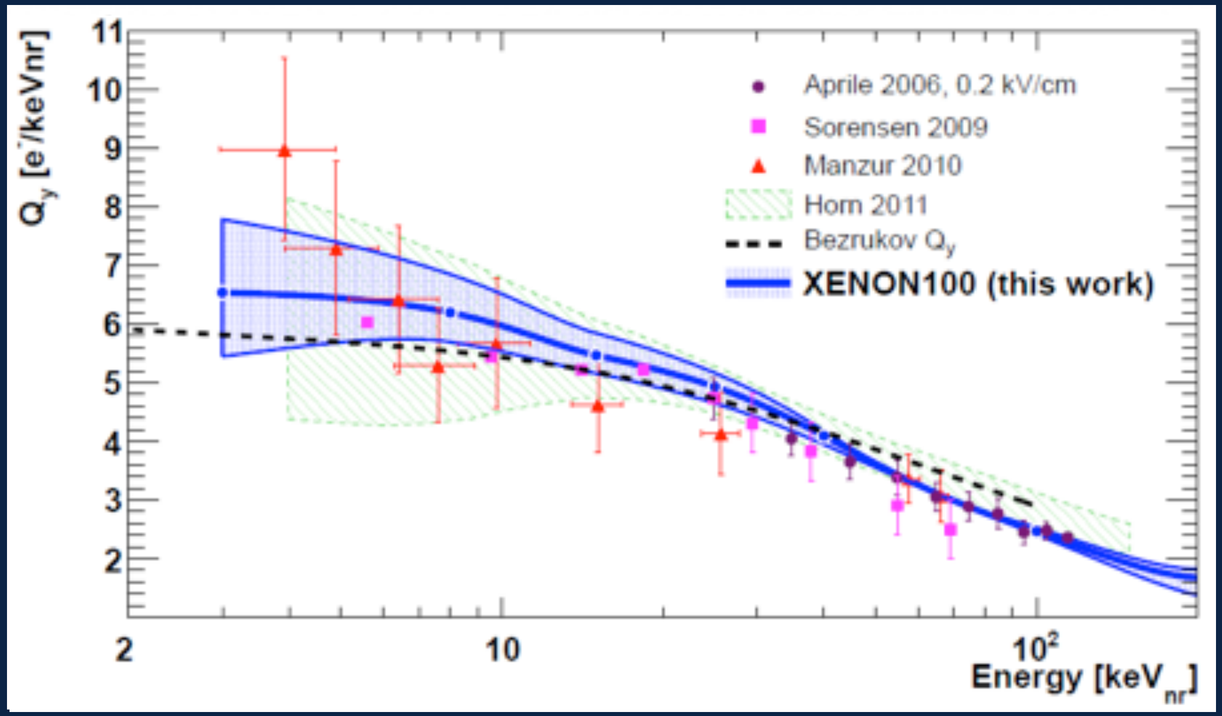
$$E = \frac{cS2}{Y}\frac{1}{Q_y(E)}$$

amplification factor

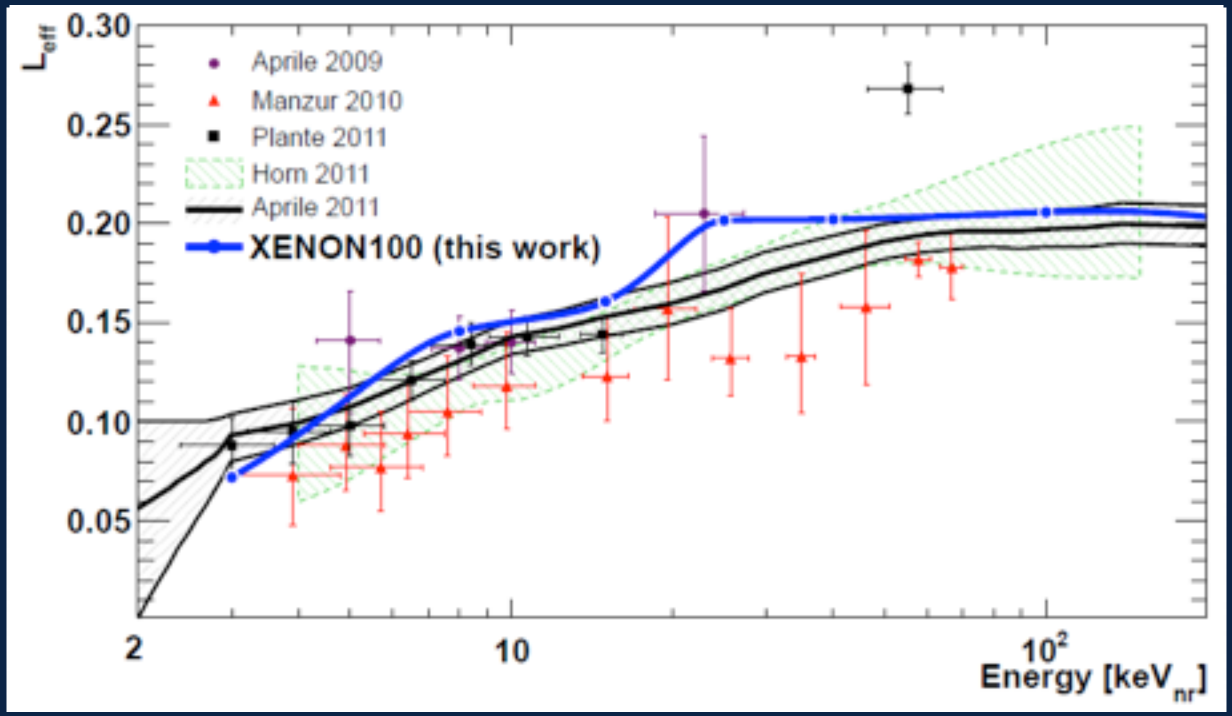
charge yield
(number of free electrons per unit energy)

simulation of the AmBe source

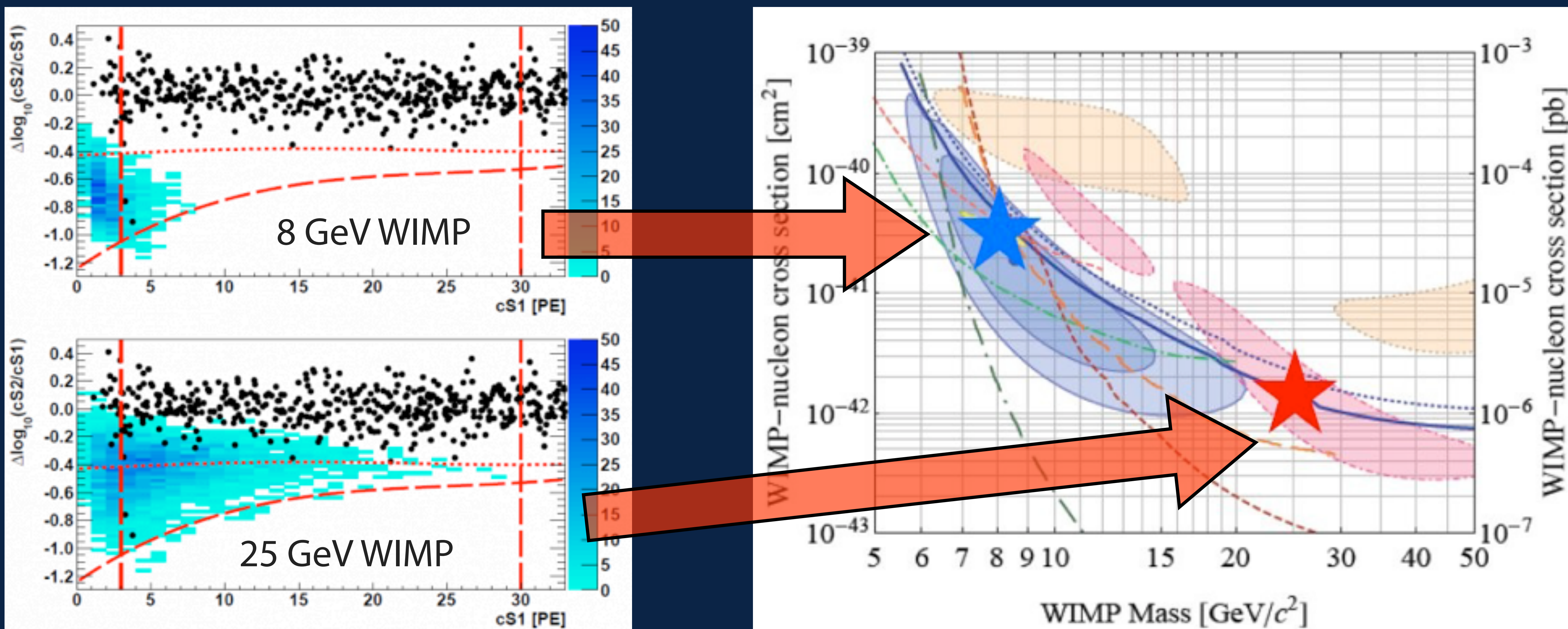
- The detector has been simulated with GEANT
- Energy and data quality cuts applied as done with real data
- χ^2 minimization to find the best match
- Step 1: fix L_{eff} and parametrize Q_y
- Step 2: use Q_y fit and get L_{eff}



- Results:
  - ✓Excellent agreement between MC and data
  - ✓reconstructed activity of the source of 159 n/s (measured: 161 ± 4 n/s)
  - ✓Important consistency check of all cuts and systematics
  - ✓Leff measured with the same detector

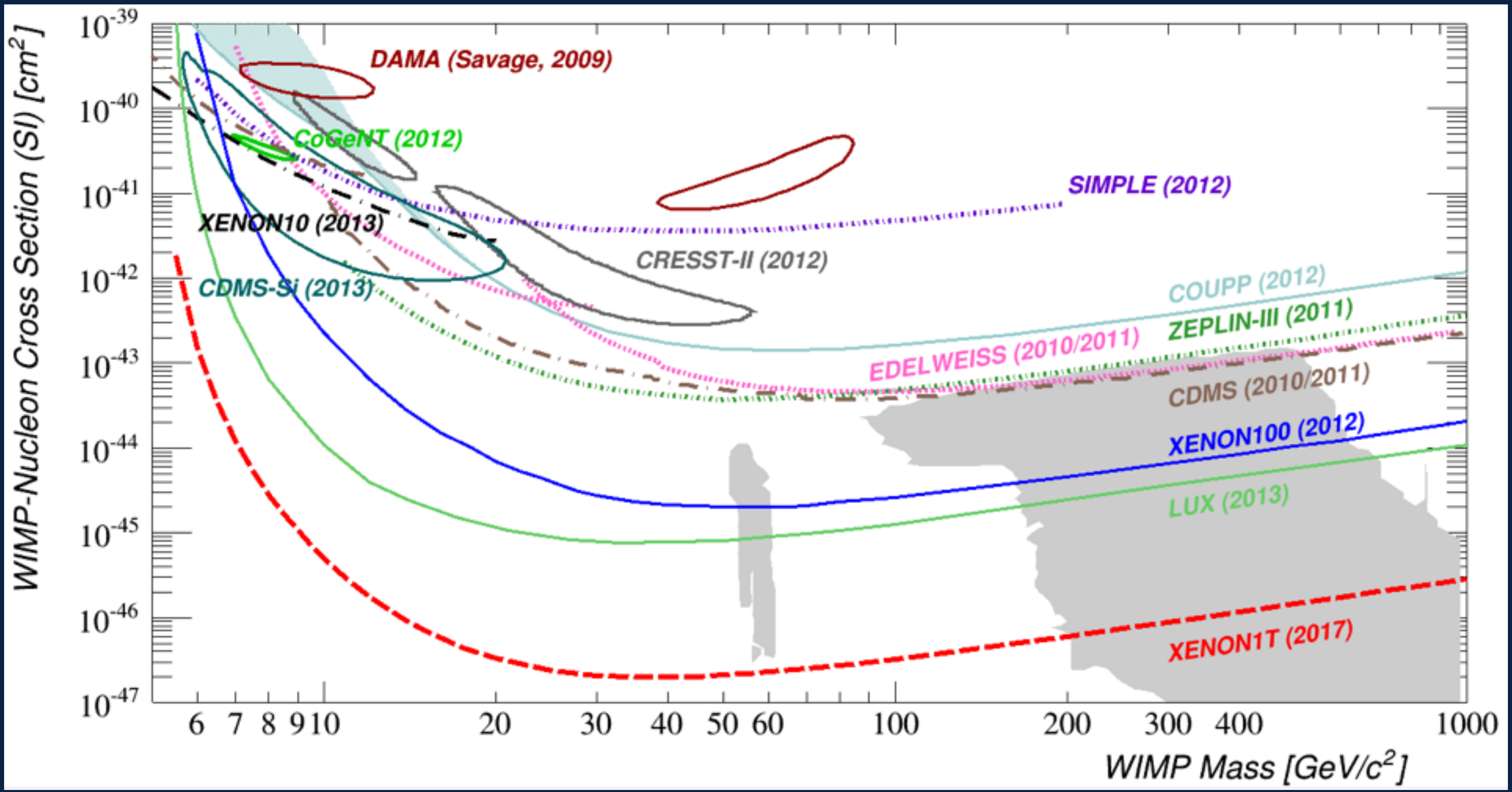


simulated wimp distributions



xenon1t

xenon1t physics reach



Main technical challenges

	XENON100	XENON1T
• liquid xenon	161 kg	~3500 kg
• background	$5{\cdot}10^{-3}$ dru	$5{\cdot}10^{-5}$ dru
• krypton/xenon	(19±4) ppt	<0.5 ppt
• radon/xenon	~65 µBq/kg	~1 µBq/kg
• electron drift	30 cm	1 m
• cathode	-16 kV	-100 kV