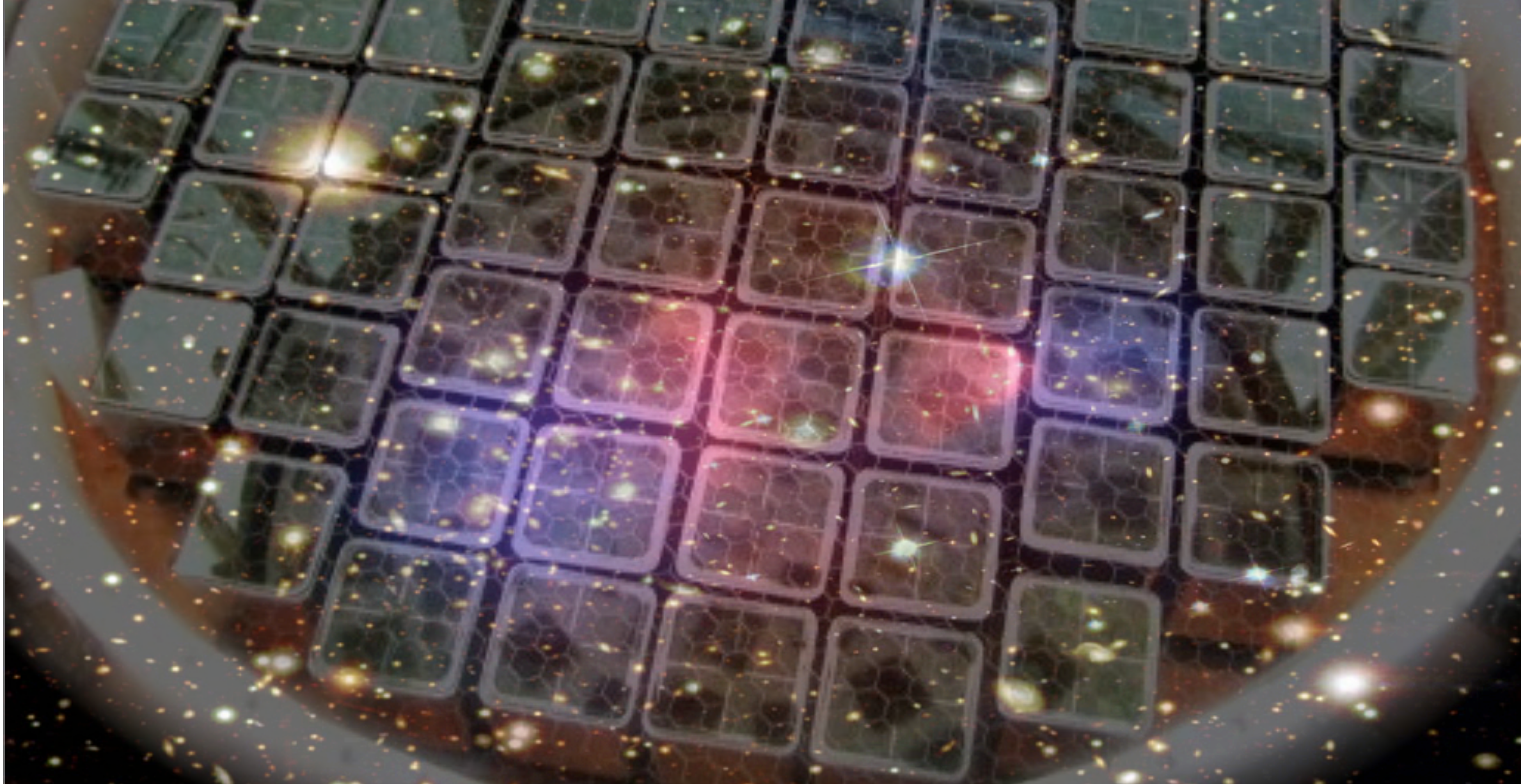


The XENON100 Experiment

Kyungeun E. Lim (on behalf of the XENON collaboration)

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

May. 13th, 2013 IceCube Particle Astrophysics Symposium , Madison, WI

The XENON Dark Matter Search

XENON:
A phased WIMP search program using a LXe TPC

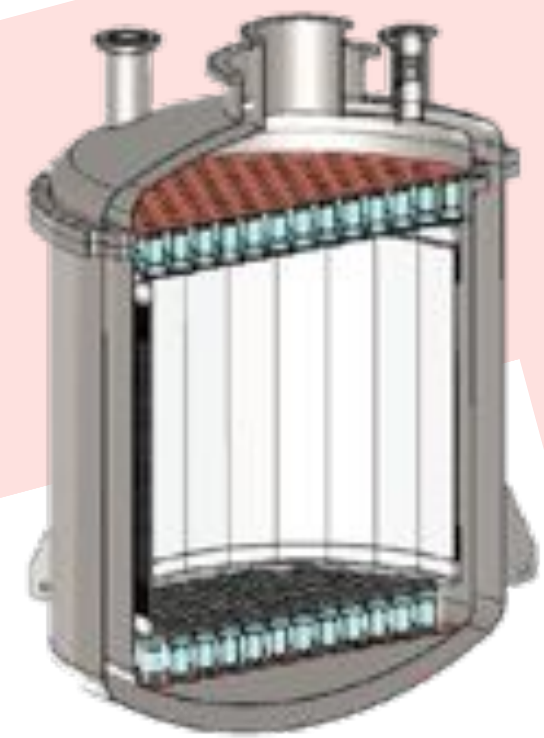
XENON10
(2005-2007)

Achieved (2007)
$\sigma_{SI} = 8.8 \times 10^{-44}\ \mathrm{cm}^2$

XENON100
(2008-2013)

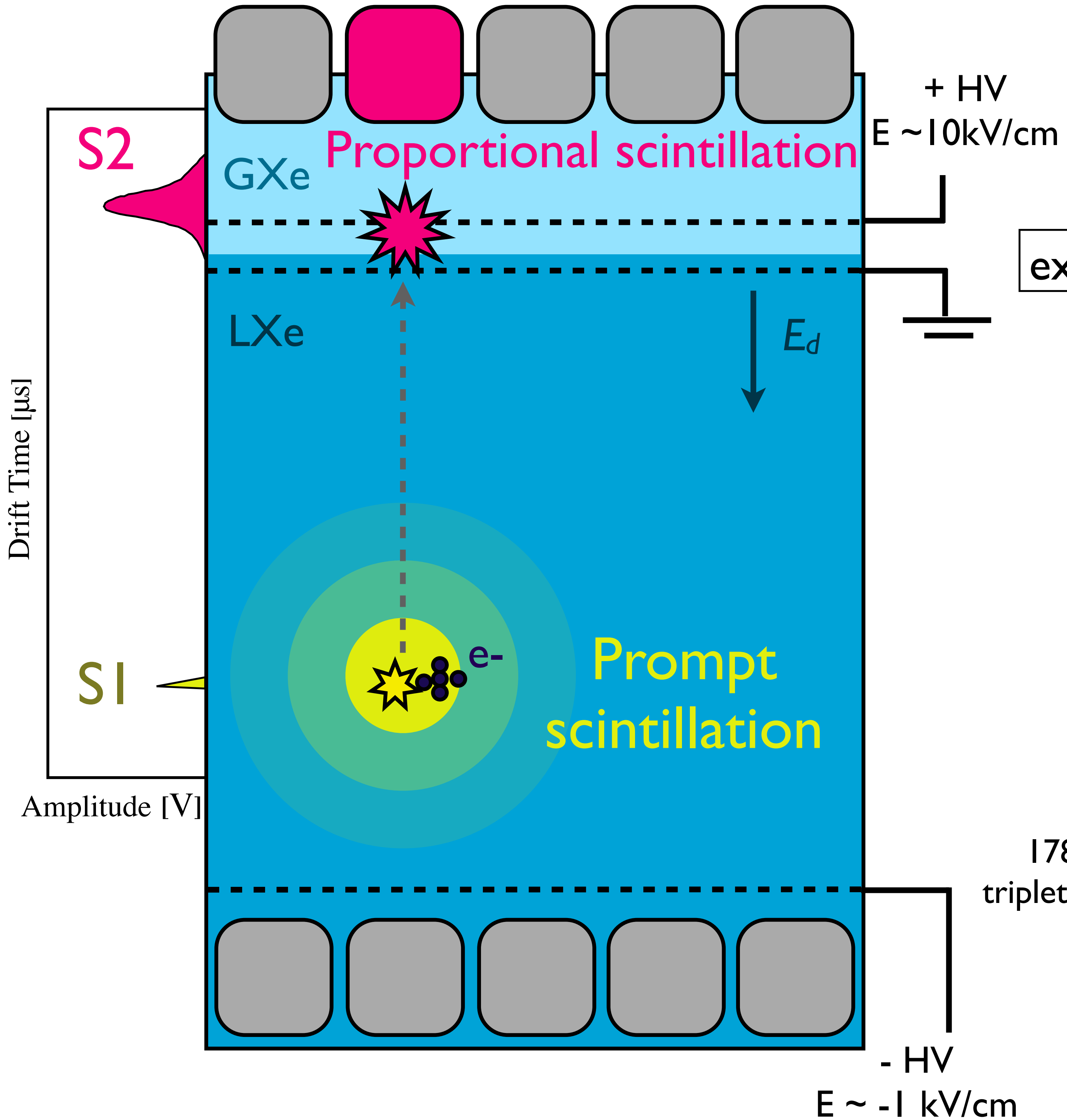
Achieved (2012)
$\sigma_{SI} = 2.0 \times 10^{-45}\mathrm{cm}^2$

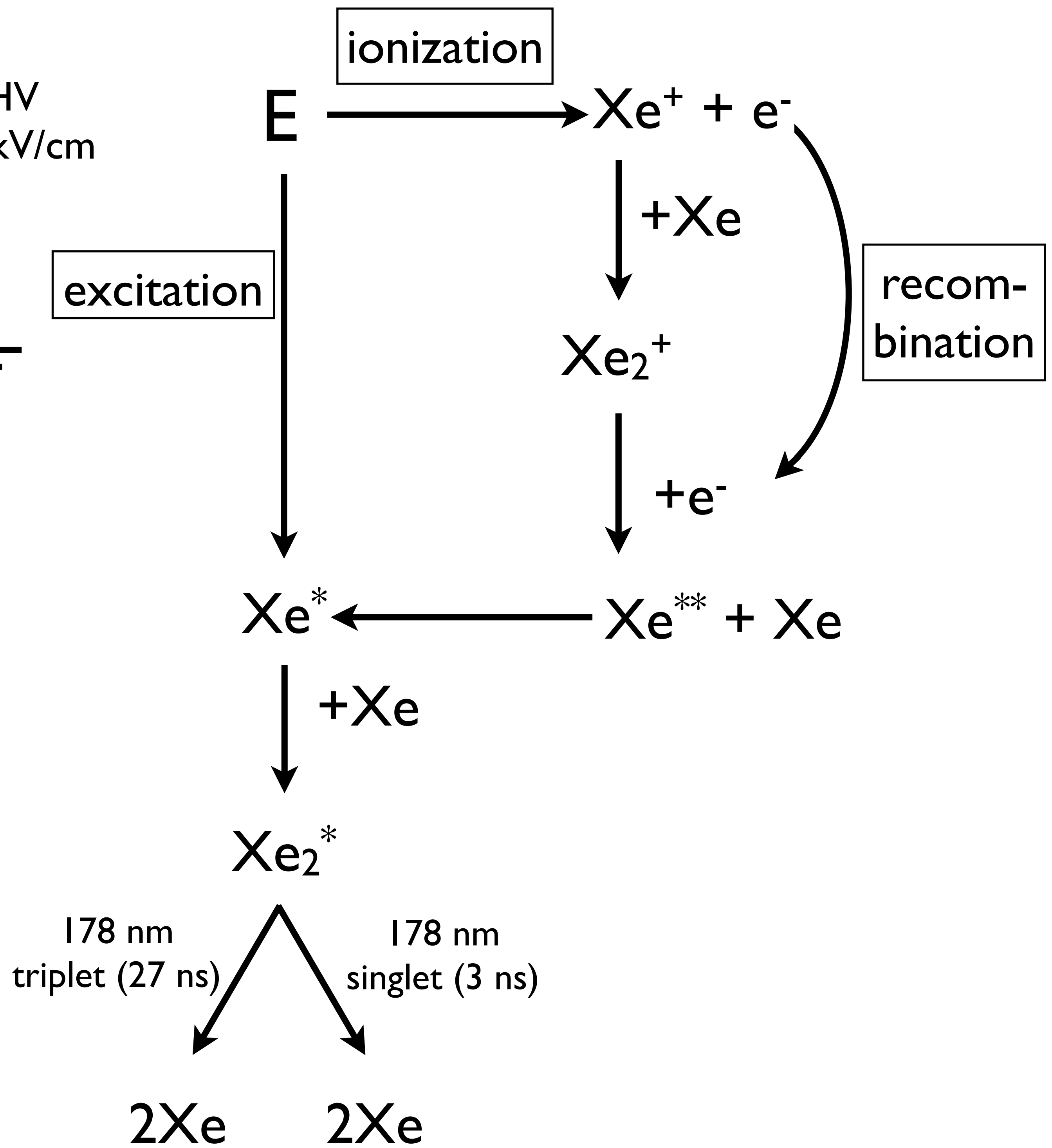
XENON1T
(2012-2017)



Projected (2015)
$\sigma_{SI} = 2.0 \times 10^{-47}\mathrm{cm}^2$

Dual-phase (Liquid-gas) LXe TPC





The XENON Collaboration

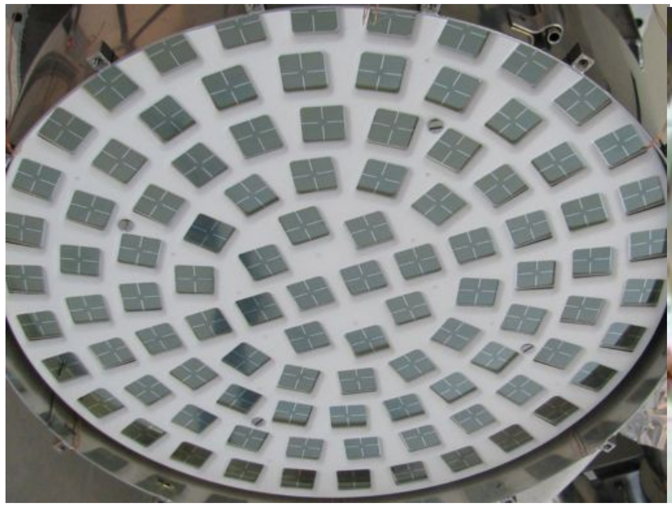
Columbia Rice UCLA Zürich Coimbra LNGS INFN Purdue

Bologna Subatech Münster Heidelberg Nikhef Weizmann Mainz Bern

The XENON100 Detector

- Designed to be x100 less background and x10 fiducial target compared to XENON10
- Cryocooler and FTs outside shield
- Materials screened for low activity
- 30 cm drift x 30 cm diameter TPC
- 162 kg ultra-pure LXe (target+veto)
- Multilayer passive shield
- For details, see Aprile *et al.*, Astropart. Phys. 35, 573, 2012

- Active veto all around the target
- 242 PMTs: 1 mBq (U/Th) w/ 30% QE



XENON100 at LNGS

Xe XENON Dark Matter Project

Nuclear Recoil (NR) Equivalent Energy

- Nuclear recoil equivalent energy (E_{nr}) is obtained from S1 signal.

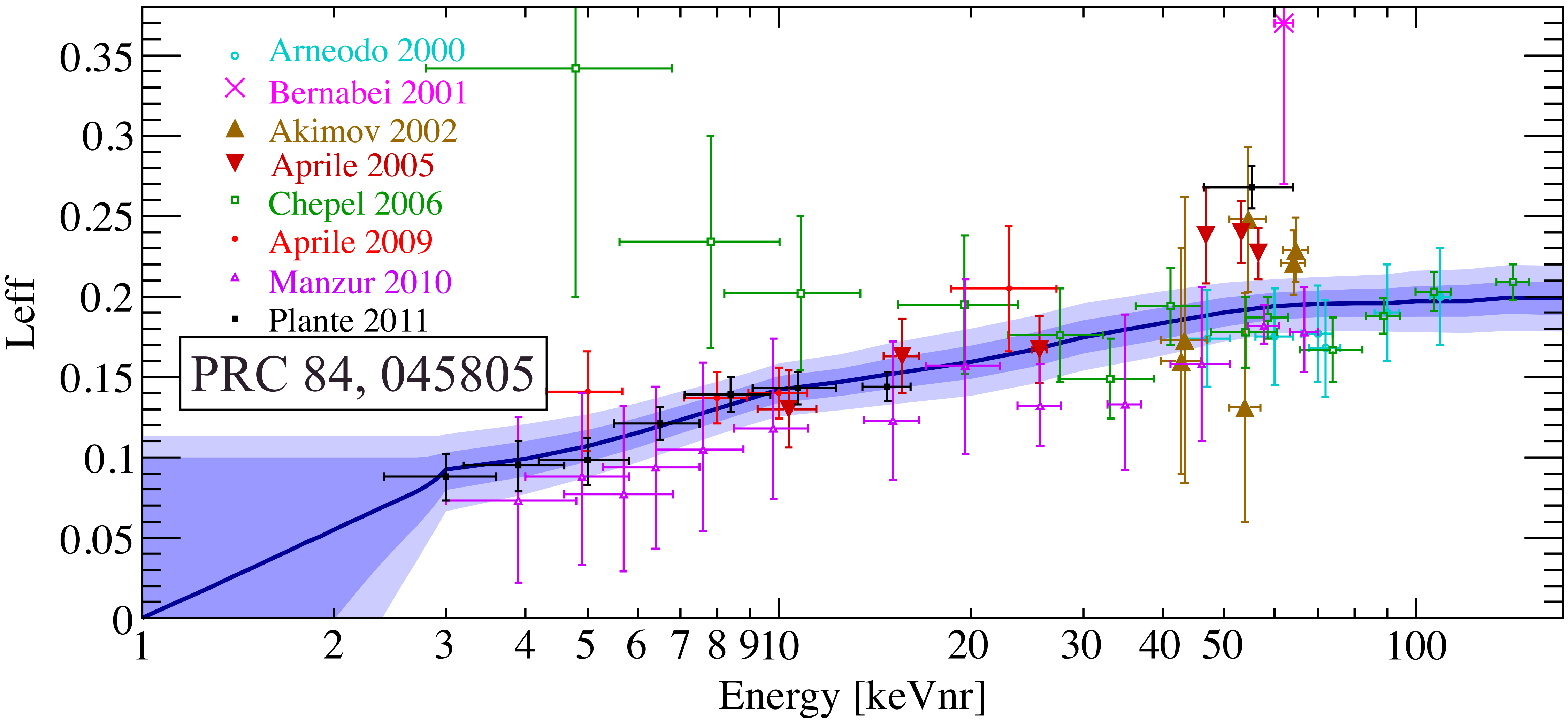
$$E_{\rm nr} = \frac{S1}{L_y}\frac{1}{\mathcal{L}_{\rm eff}}\frac{S_e}{S_r}$$

Field Quenching

122 keV γ-ray light yield

- $\mathcal{L}_{\rm eff}$, Relative Scintillation Efficiency

$$\mathcal{L}_{\rm eff}(E_{\rm nr}) = \frac{L_{y,\rm nr}(E_{\rm nr})}{L_{y,\rm er}(E_{\rm ee} = 122\ {\rm keV})}$$

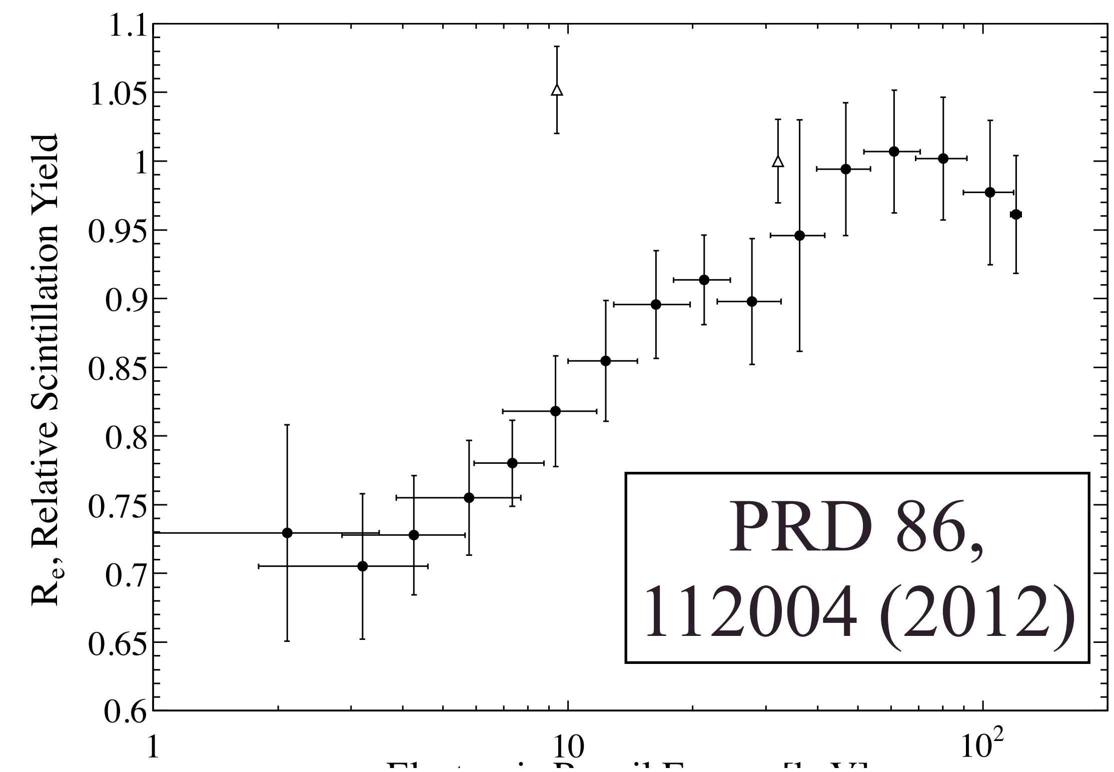


Electronic Recoil (ER) Equivalent Energy

- Electronic recoil equivalent energy (E_{er}) can be obtained in a similar manner to E_{nr}.

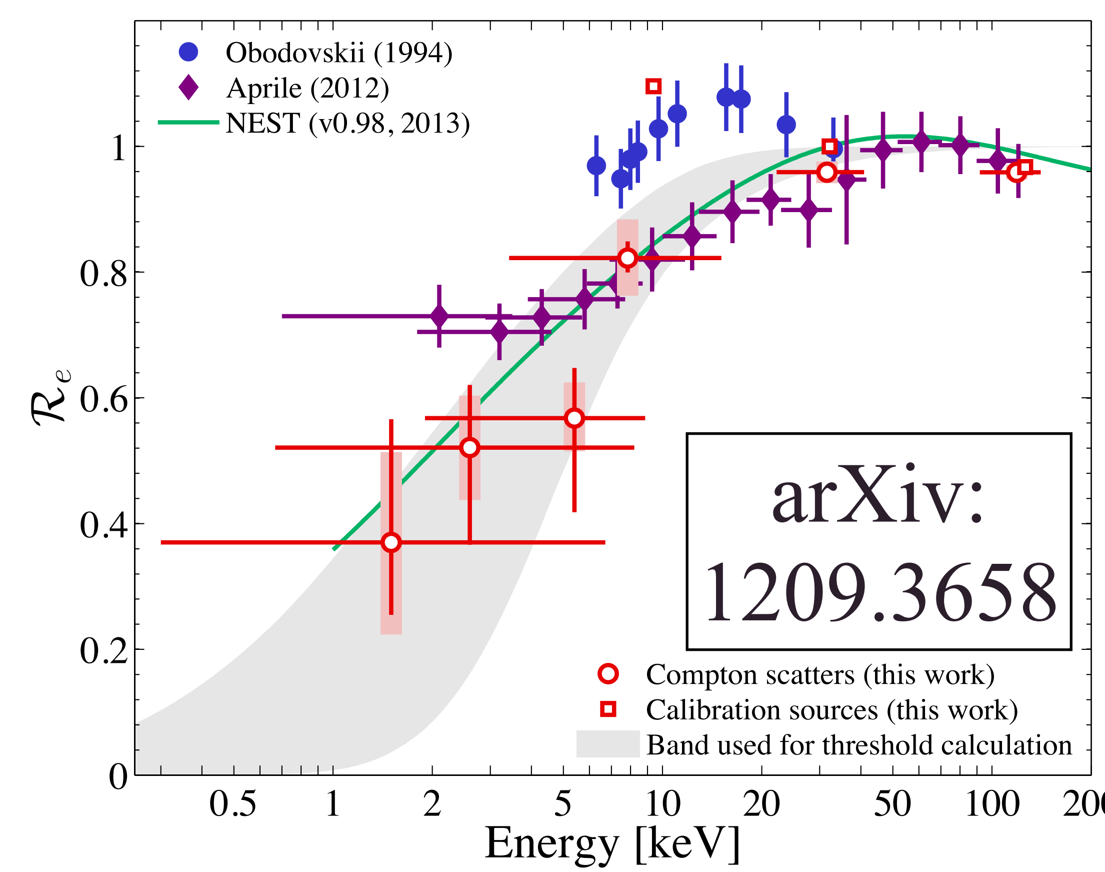
- $\mathcal{R}_e$, Relative Scintillation Efficiency

$$\mathcal{R}_e(E_{\rm er}) = \frac{L_{y,{\rm er}}(E_{\rm er})}{L_{y,{\rm er}}(E_{\rm ee} = 32.1\ {\rm keV})}$$

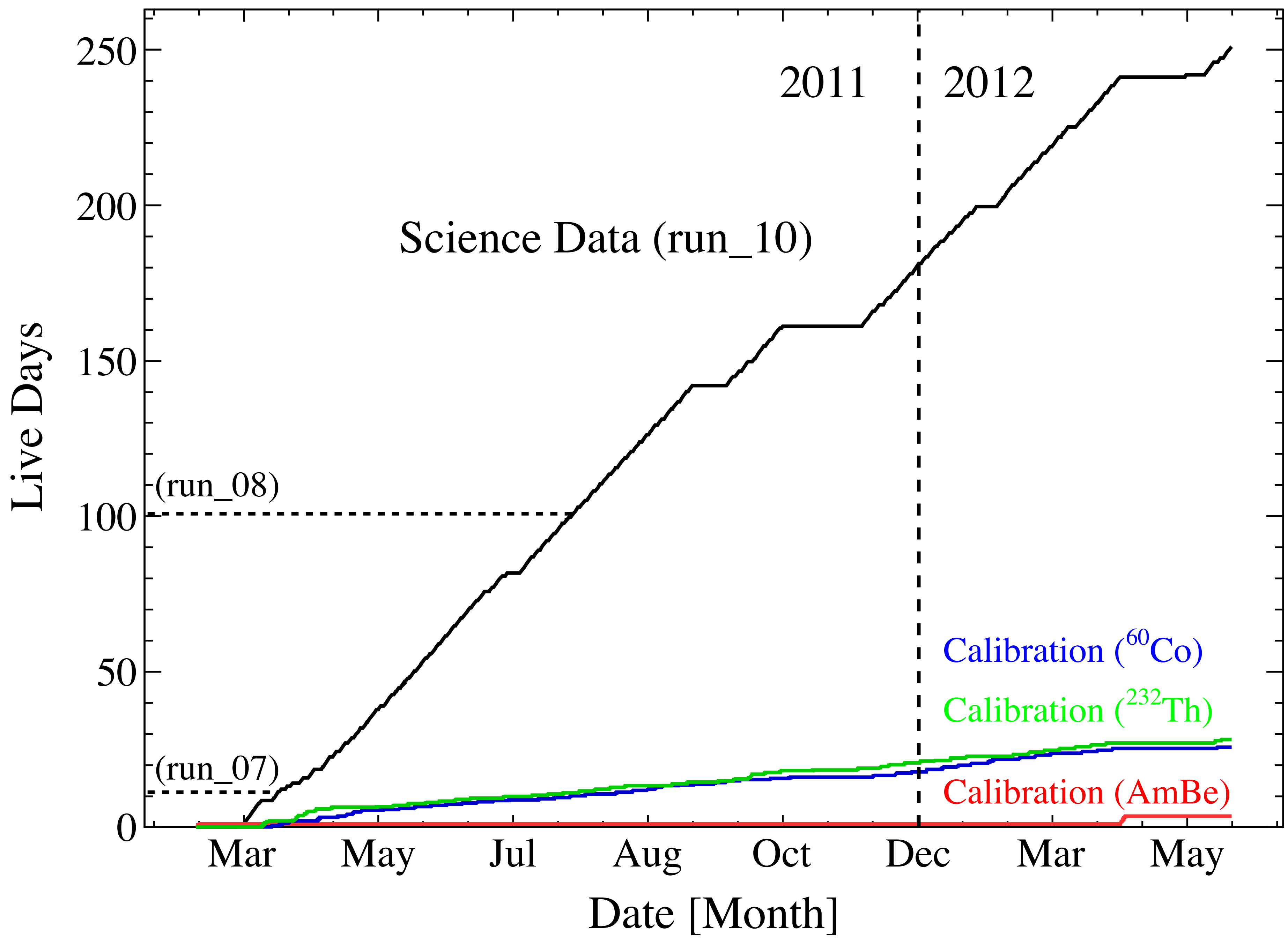


- It is important not only to estimate ER background but also for the annual modulation studies.

- Measurements with 450V/cm is available and the measurements with different electric fields are planned and ongoing.

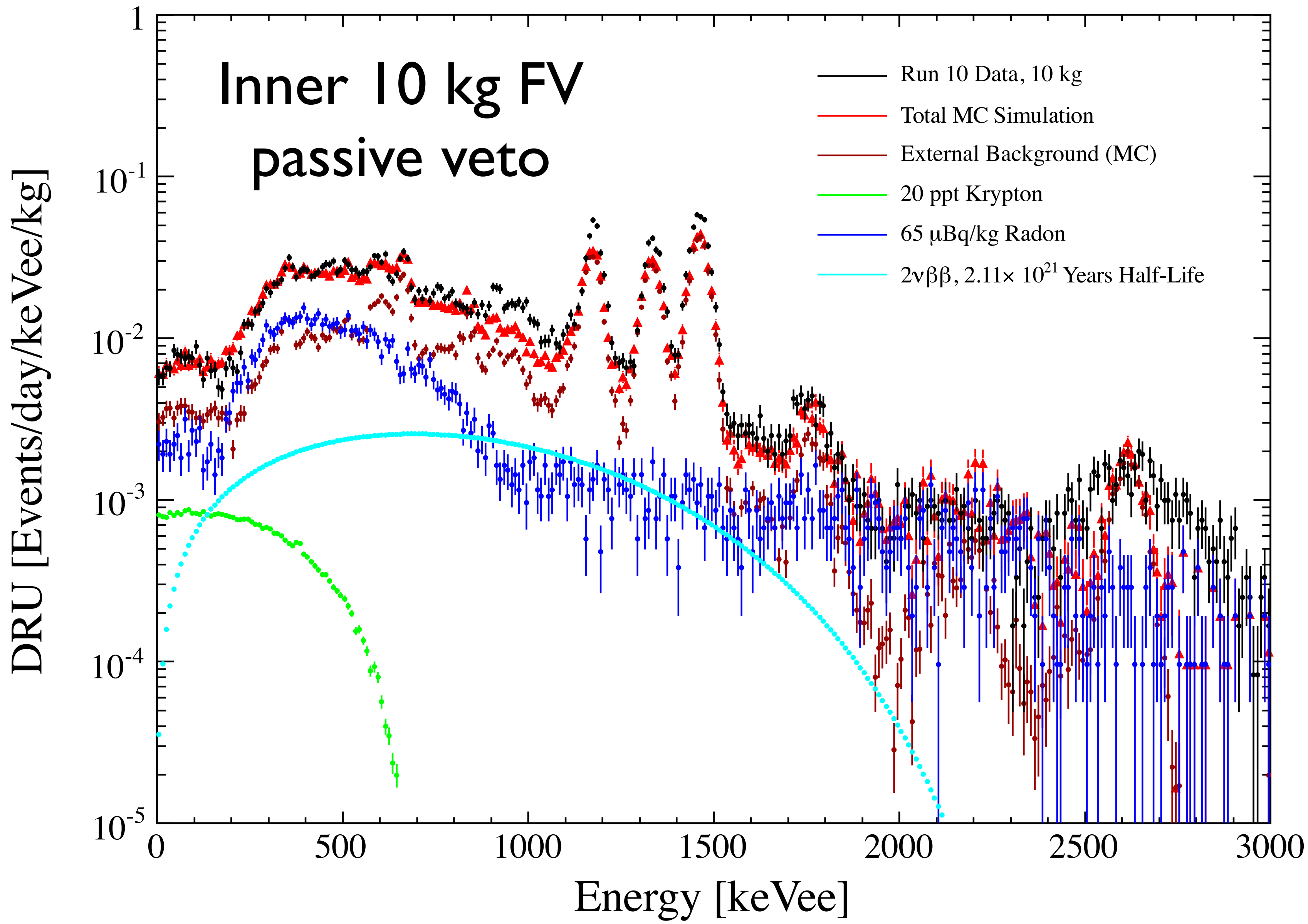


New Results of 2012: Data Taking



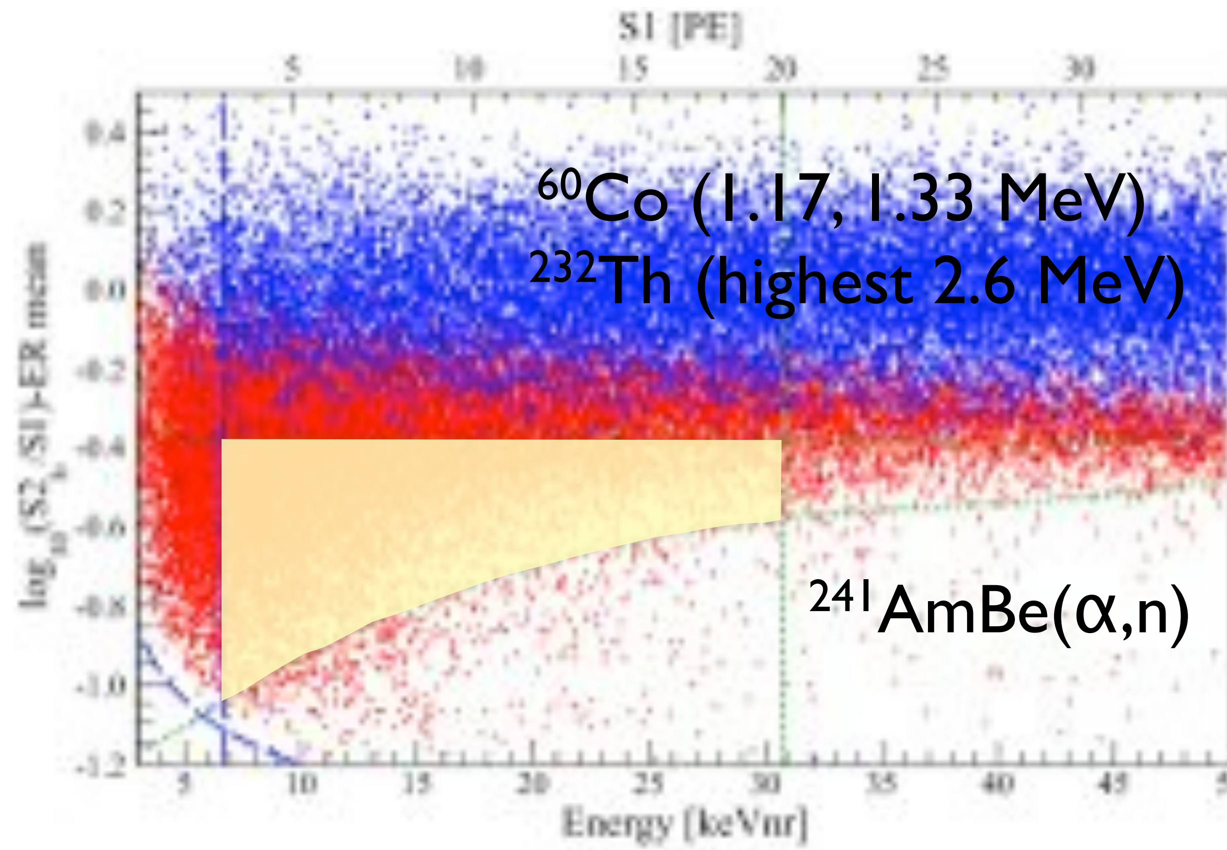
Data taking over 13 months: full annual cycle (224.6 live days)

Total Electronic Recoil Background

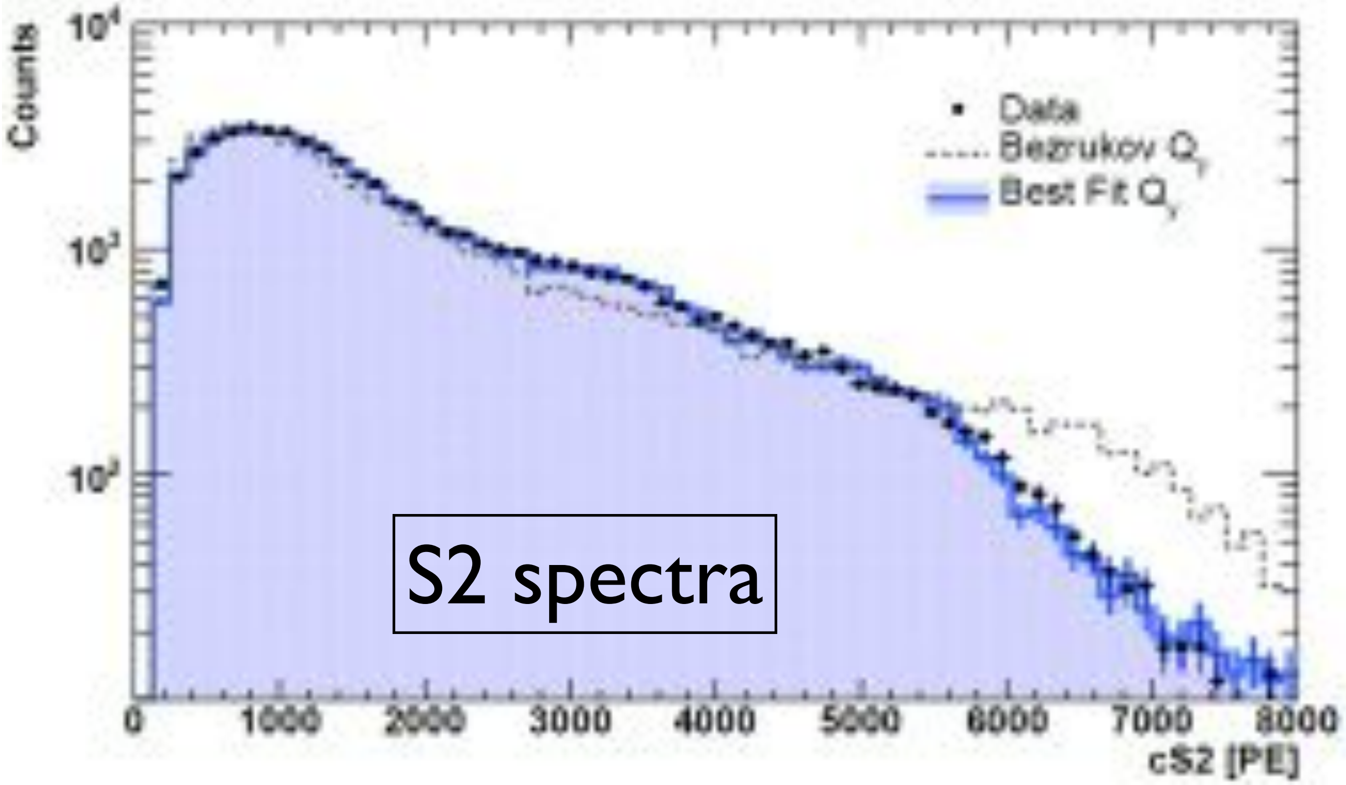


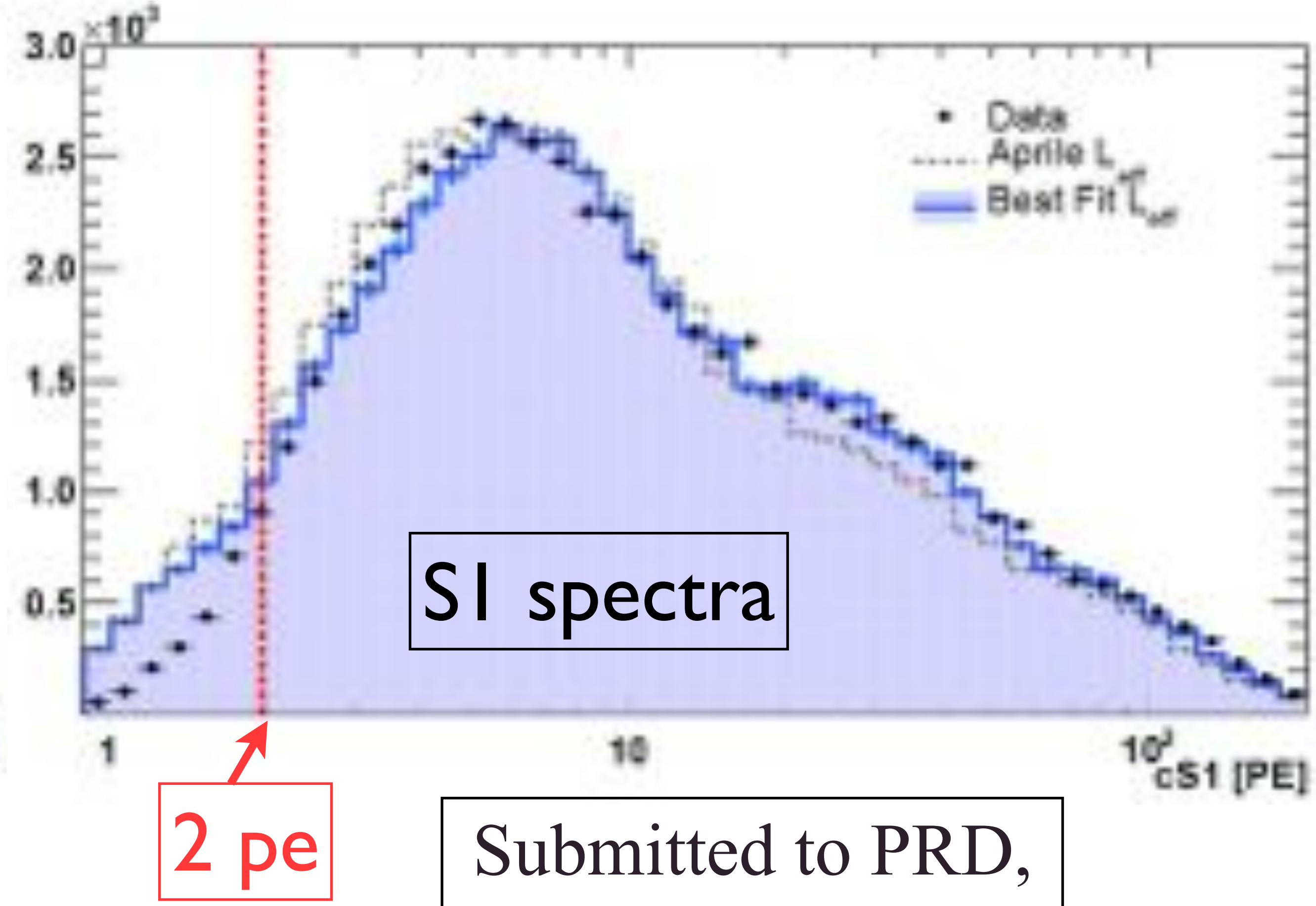
- Good agreement btw MC and Data (no tuning).
- (5.3 ± 0.6) x 10^{-3} evts/keV/kg/day w/ active veto before discrimination.
- For the details on ER MC, see Aprile *et al.*, Phys. Rev. D 83, 082001 (2011).

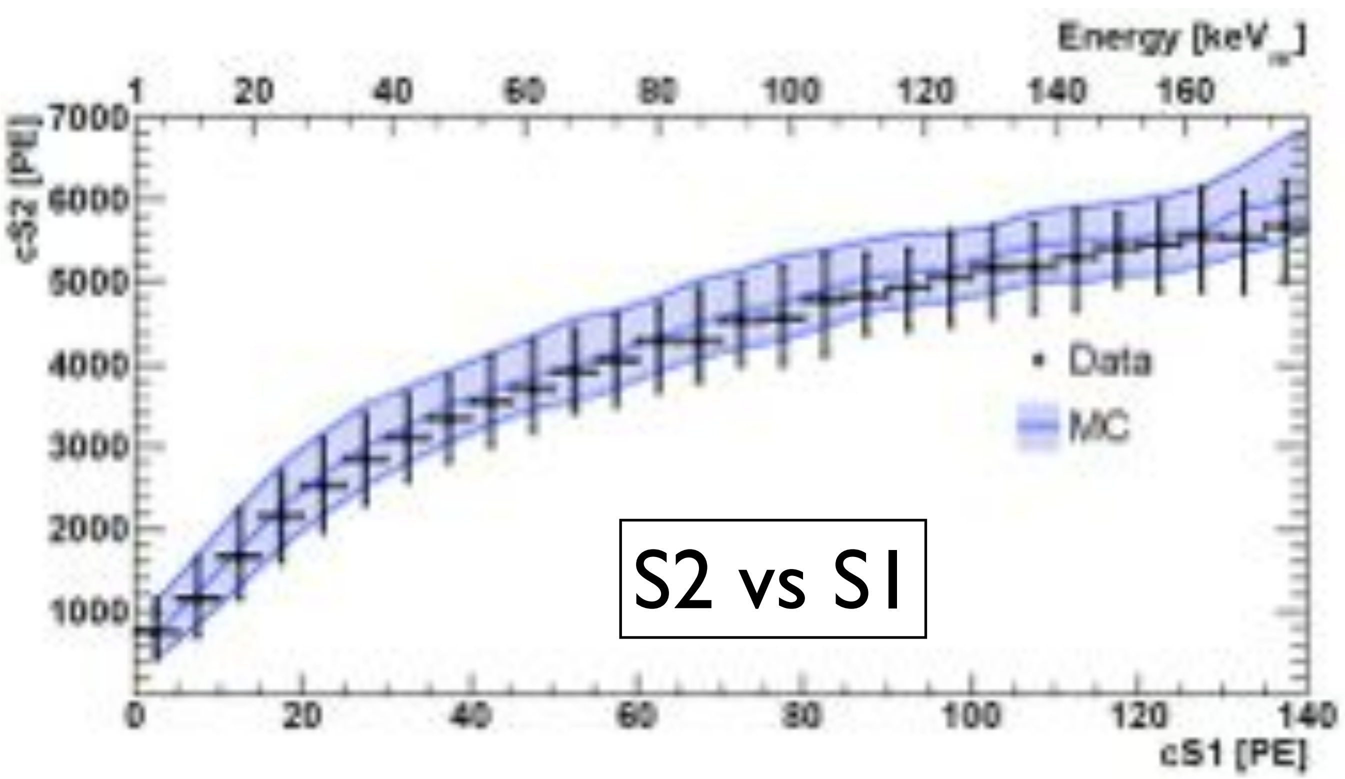
- Electronic recoil band calibration is performed w/ high energy γ rays from ^{60}Co and ^{232}Th.
- Background in the region of interest is due to low energy Compton scatters from high energy γ rays or β decays.



- Nuclear recoil band calibration is performed w/ 160 +/- 4 n/s ^{241}AmBe neutron source.
- Benchmark signal region for the cut-based analysis was chosen 99.75% of ER band rejection and S1 btw 3 pe and 20 pe.
- The FV and the benchmark signal region are adjusted simultaneously to maximize the sensitivity (34 kg was chosen).







Submitted to PRD, arXiv: 1304.1427

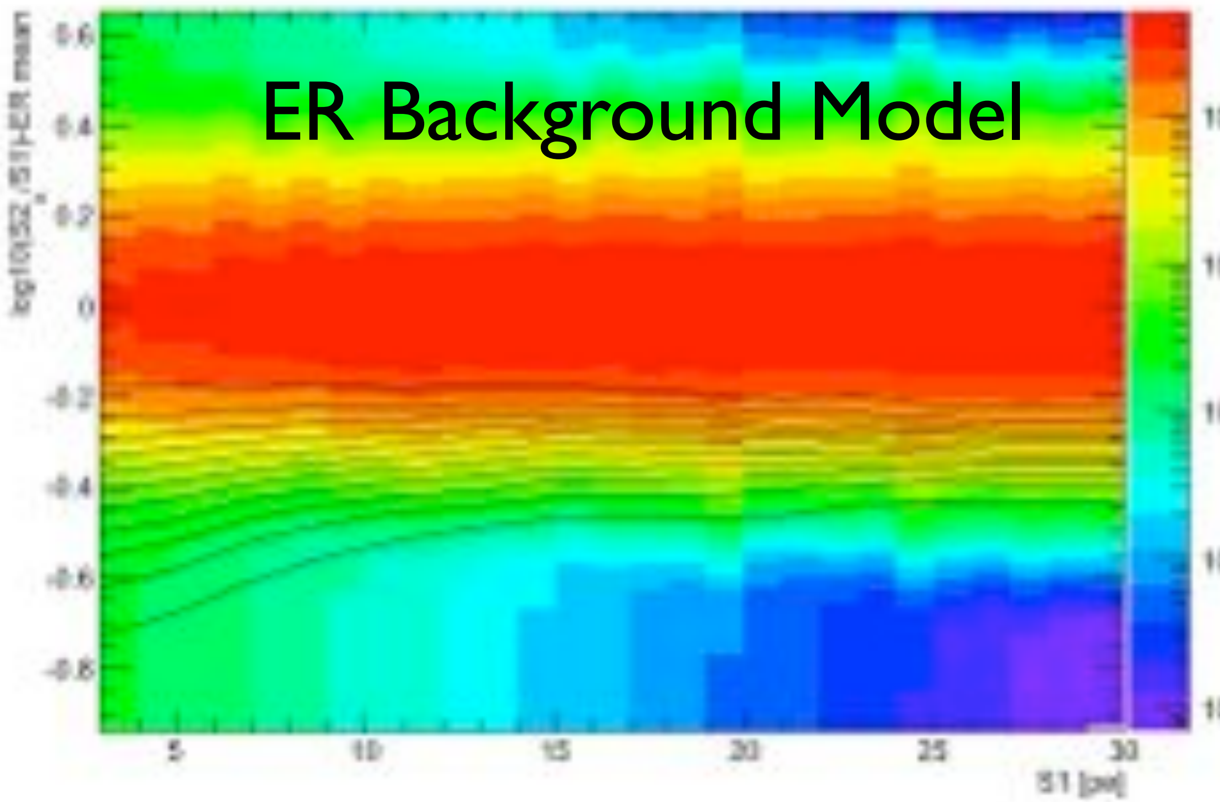
- Absolute matching btw data and MC has been achieved (the nuclear response of XENON100 is very well understood).
- S2-S1 simultaneous matching provides robust consistency.

Profile Likelihood Method (PL)

- Instead of applying hard cut, take into account of the background distribution in $\text{Log}_{10}(S2/S1)$ vs S1.
- Test both discovery and exclusion at the same time w/o flip-flop.
- Systematic uncertainties are incorporated in a consistent manner.
- Construct the likelihood function

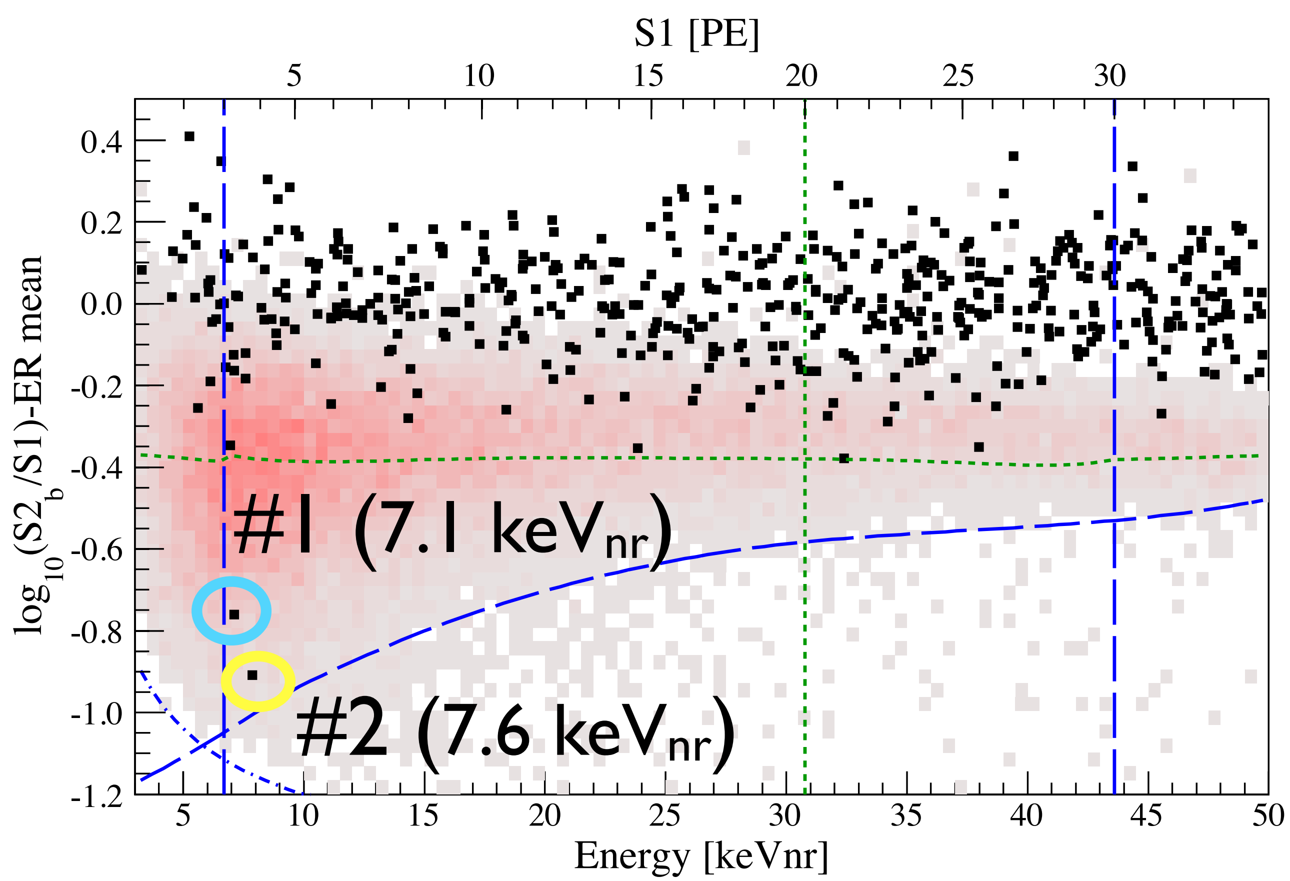
$$\mathcal{L} = \mathcal{L}_1(\sigma, N_b, \epsilon_s, \epsilon_b, \mathcal{L}_{\text{eff}}; m_\chi) \times \mathcal{L}_2(\epsilon_s) \times \mathcal{L}_3(\epsilon_b) \times \mathcal{L}_4(\mathcal{L}_{\text{eff}})$$

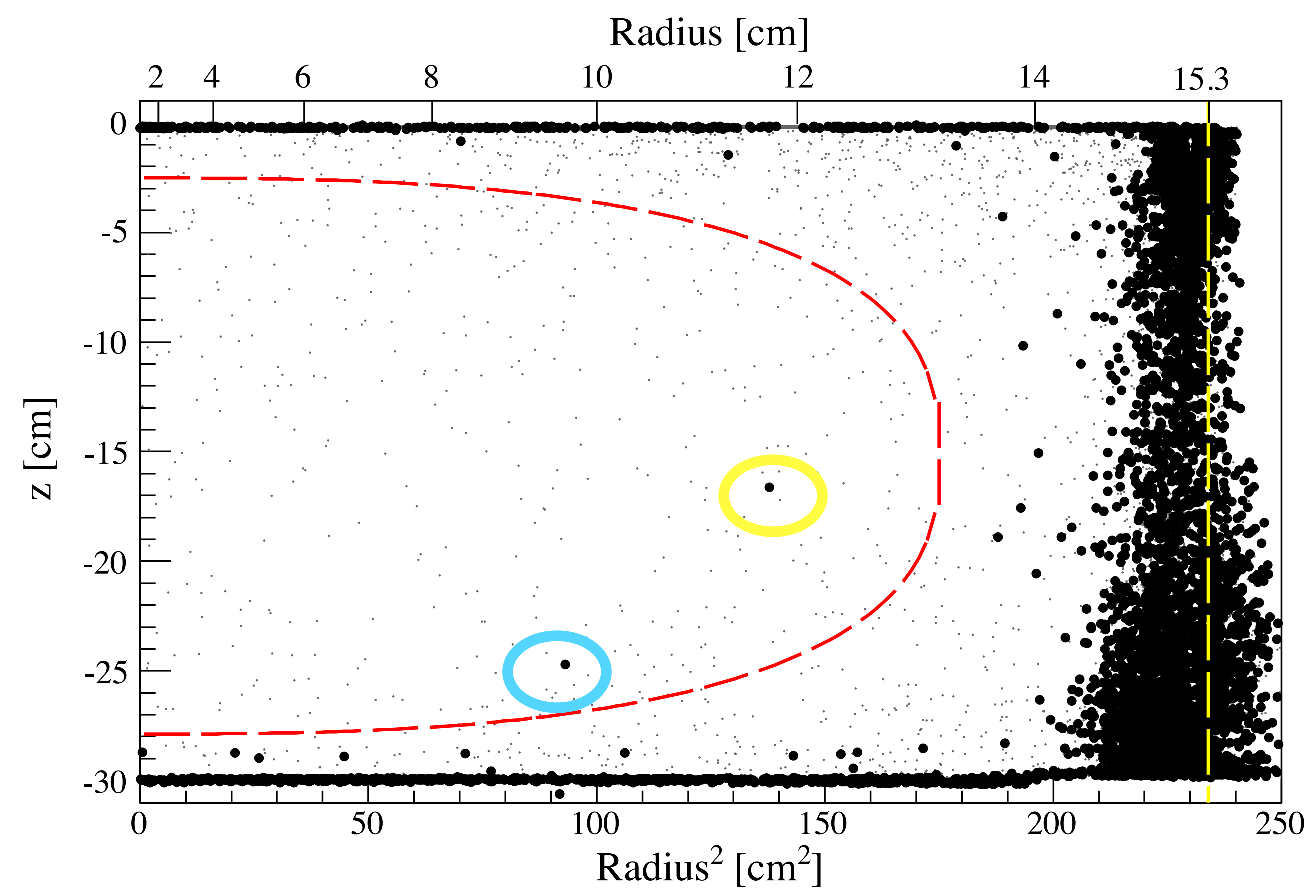
- Main term contains only one parameter of interest, σ, other parameters are nuisance parameters and profiled out.



- Use the same data input as cut based analysis.
- PL method was used to report the dark matter results.
- For the details, see Aprile *et al.*, Phys. Rev. D 84, 052003, 2011

Results After Unblinding

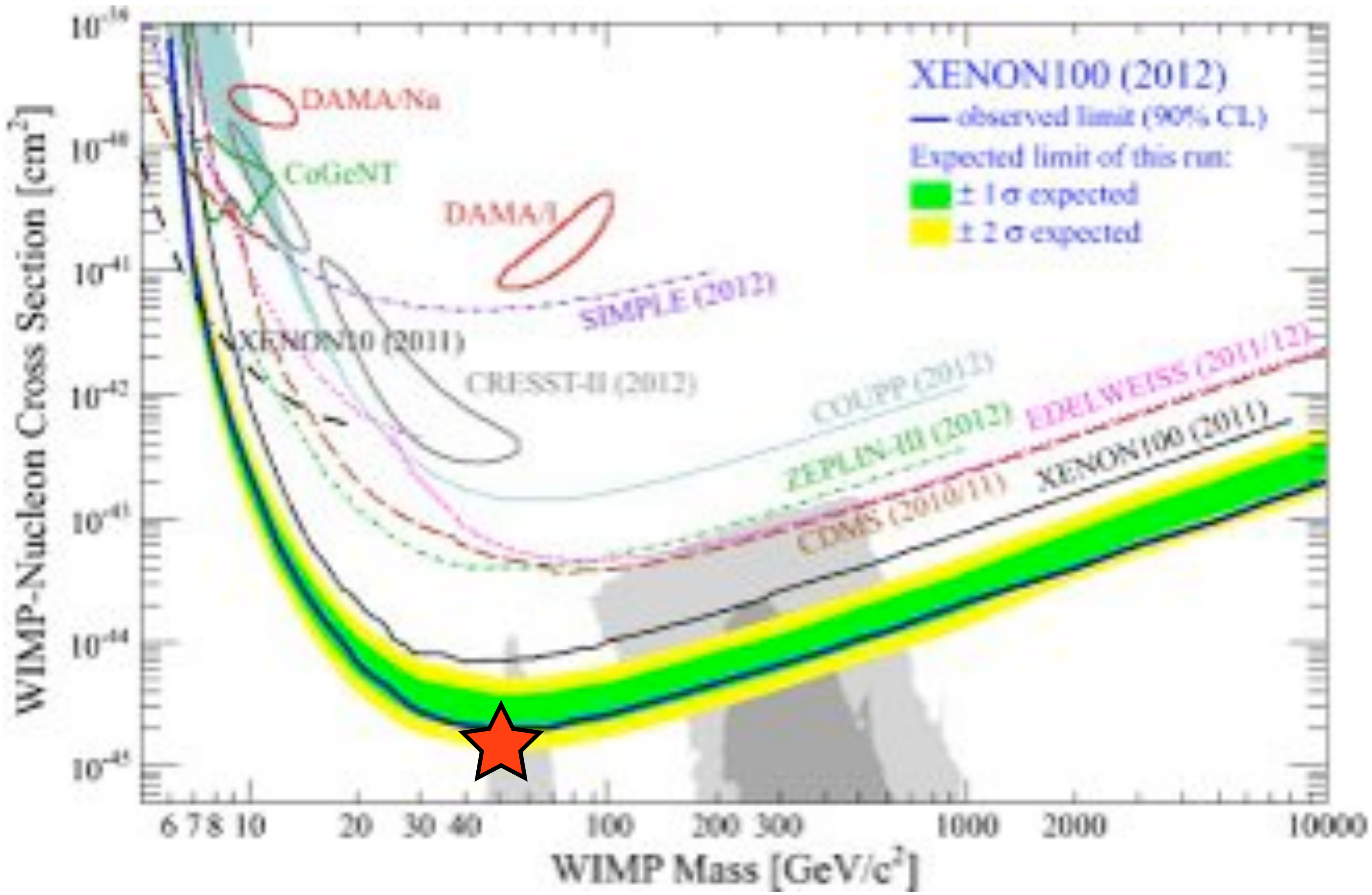




- Profile Likelihood analysis cannot reject the background-only hypothesis (p-value: > 0.05 for all WIMP masses).
- 2 evts observed w/ 1 evt of background prediction from cut-based analysis (26.4% probability that background fluctuates > 1 evt)

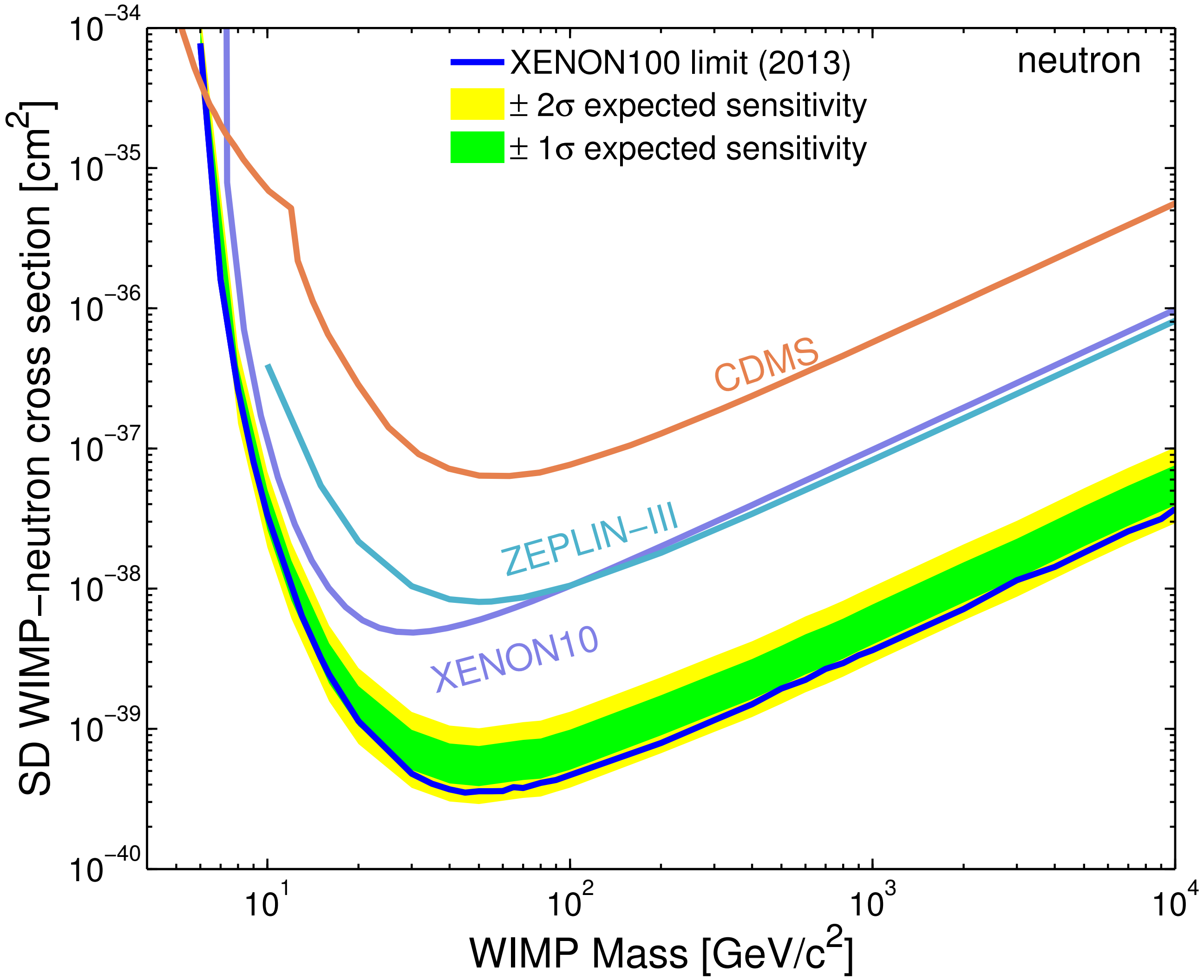
No significant excess due to a signal seen in XENON100 data.

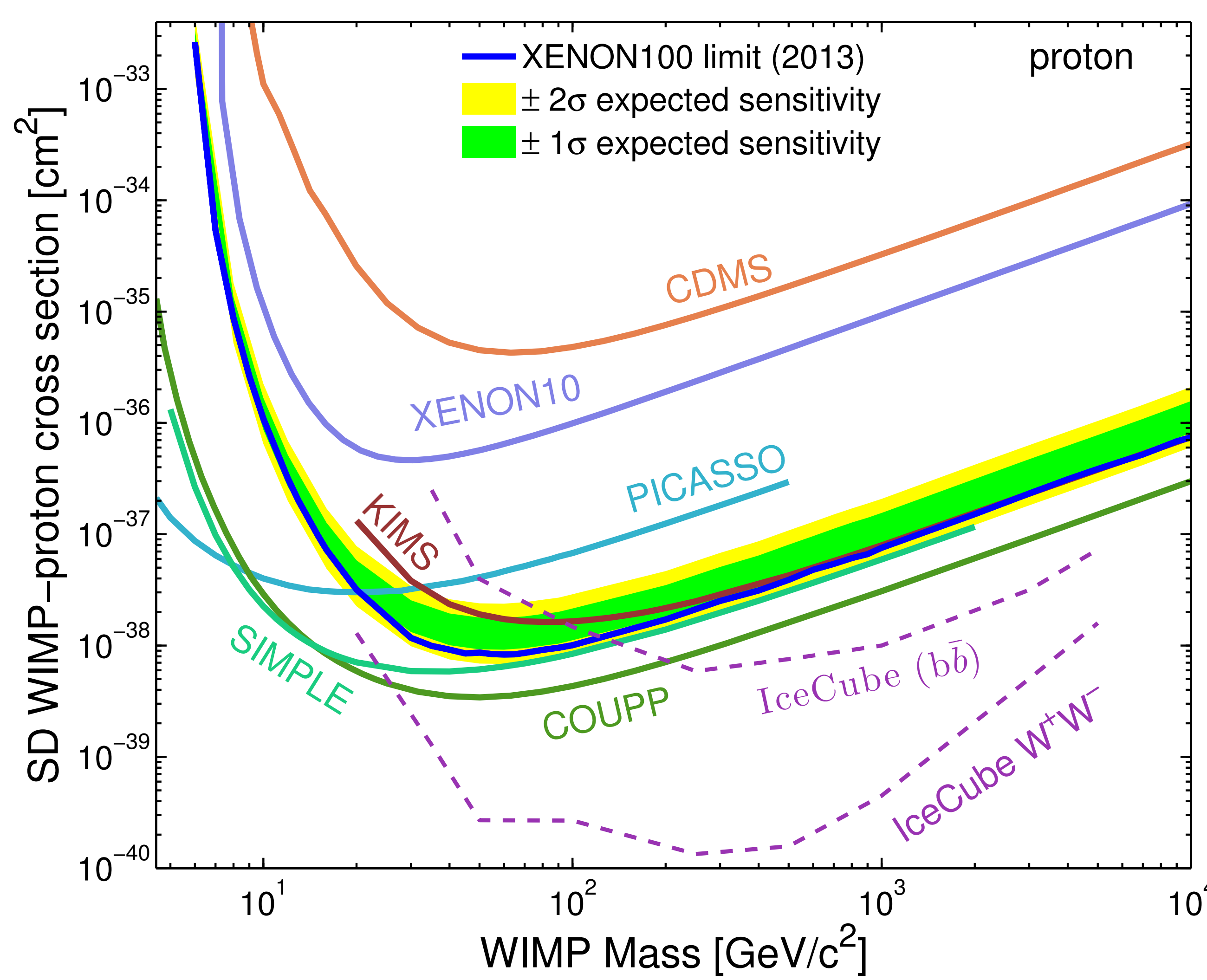
The XENON100 SI Limit



- Strongest limit to date over a large WIMP mass range (2 x 10^{-45} cm^2 @ 50 GeV), keep challenging the interpretation of CoGeNT and DAMA signals being due to low mass WIMPs.
- Results published (Aprile *et al.*, Phys. Rev. Lett. 109, 181301 (2012)).

The XENON100 SD Limit

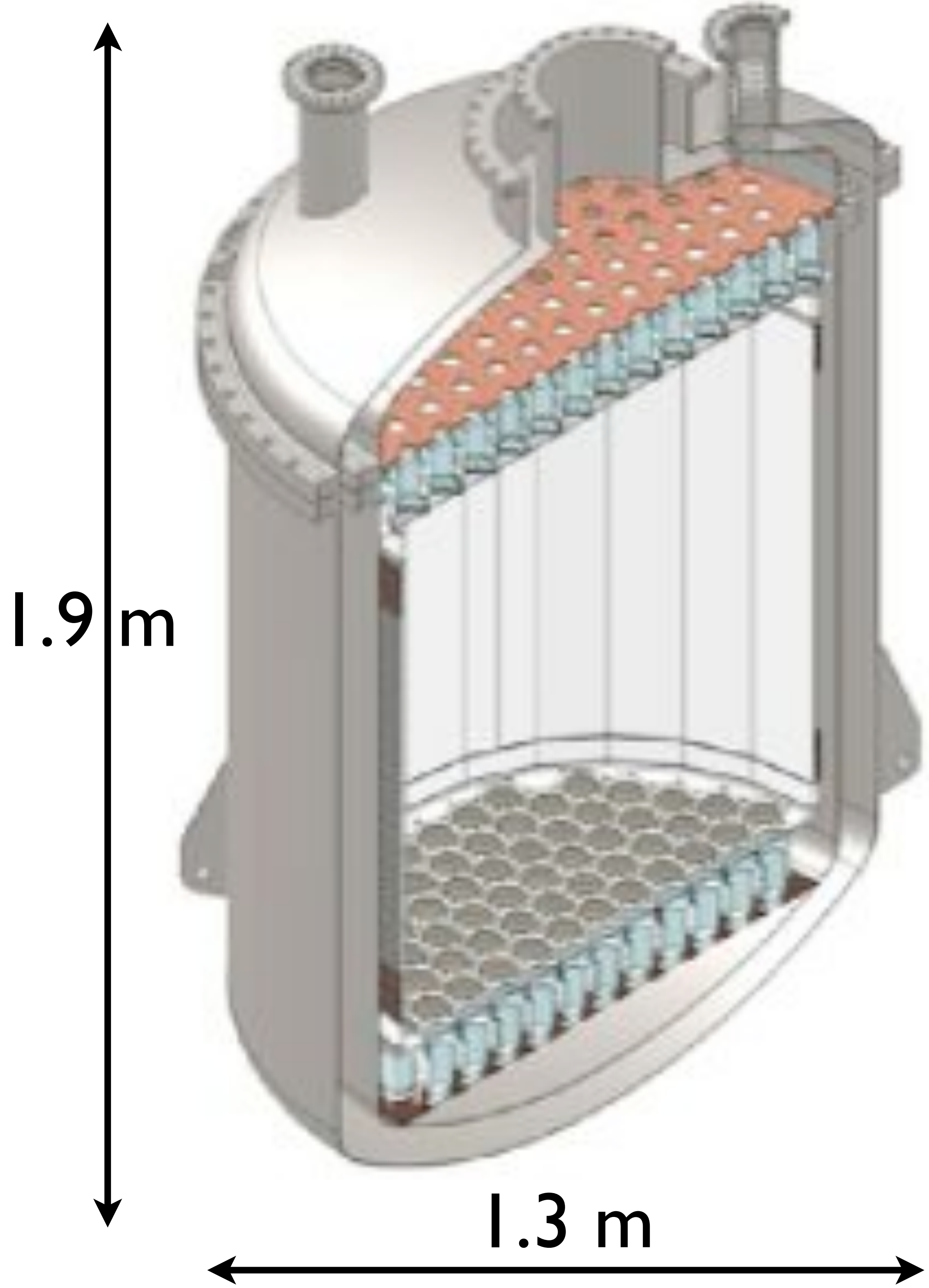


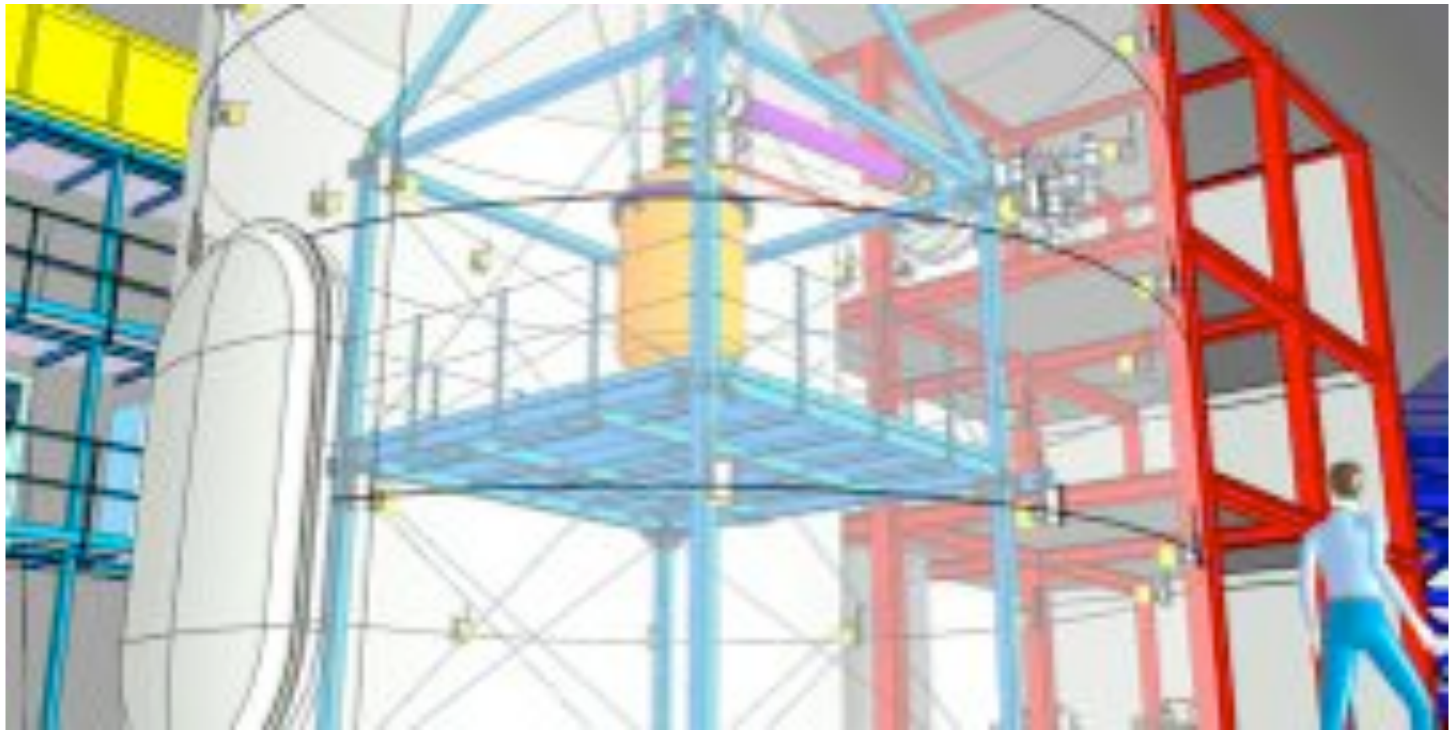


- Strongest WIMP-neutron limit to date over above 6 GeV WIMP masses (3.5 x 10^{-40} cm^2 @ 45 GeV).
- Results have been submitted to PRL and available at arXiv:1301.6620.

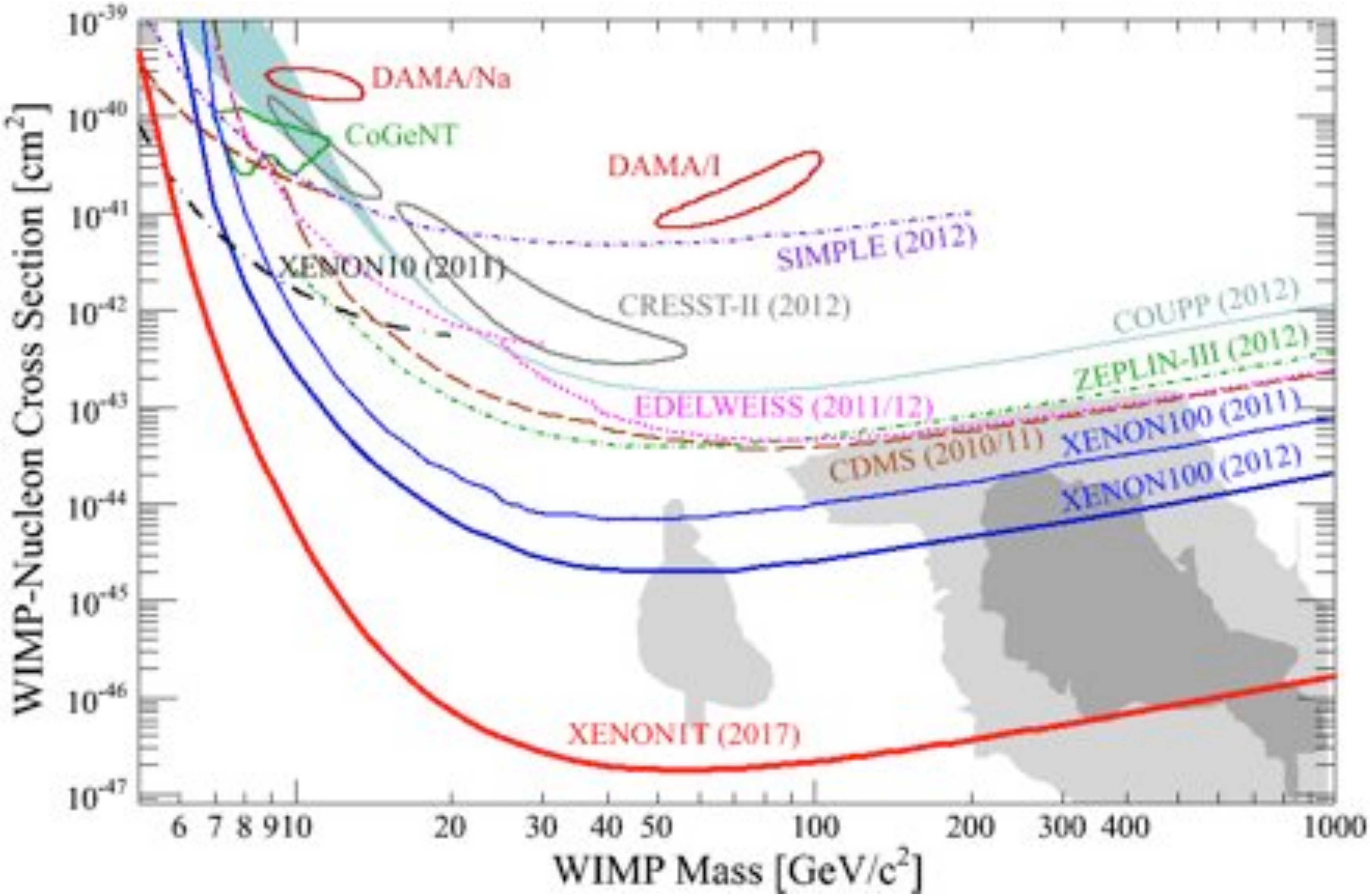
XENON1T: Future

- 1m^3 TPC, 3t LXe, 1t fiducial mass
- x100 less BG compared to XENON100
- Low radioactivity photosensors
- 9.6 m diameter water shield
- Approved for construction in HallB at LNGS





XENON1T Projected Sensitivity



Summary

- The XENON100 direct WIMP search detector has been operated since 2008, using LXe as a target/detection medium.
- The new dark matter results from 225 live days of XENON100 data show no significant signal excess due to WIMPs.
- Set the most stringent limit on the WIMP-nucleon spin-independent cross section above 8 GeV/c^2 WIMP masses (2×10^{-45} cm^2 @ 50 GeV).
- Set the most stringent limit on the WIMP-neutron spin-dependent cross section above 6 GeV/c^2 WIMP masses (3.5×10^{-45} cm^2 @ 45 GeV).
- Excellent AmBe MC and data matching has been achieved.
- XENON100 is still taking science data.