The XENON100 experiment: status and results

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Outline

Indications from astronomy and particle candidates

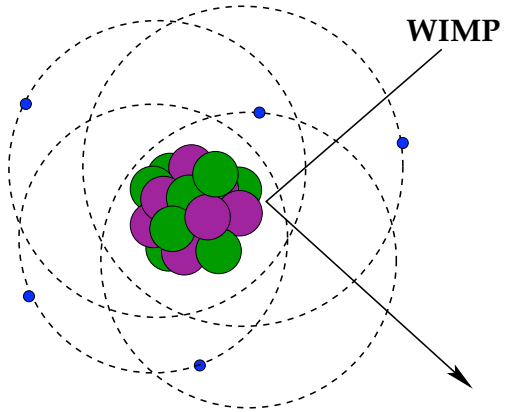
CMB: 24% of the Universe is made of Dark Matter

- Star rotation curves
- Gravitational lensing
- Galaxy clusters

Most general theoretical approach:

WIMP

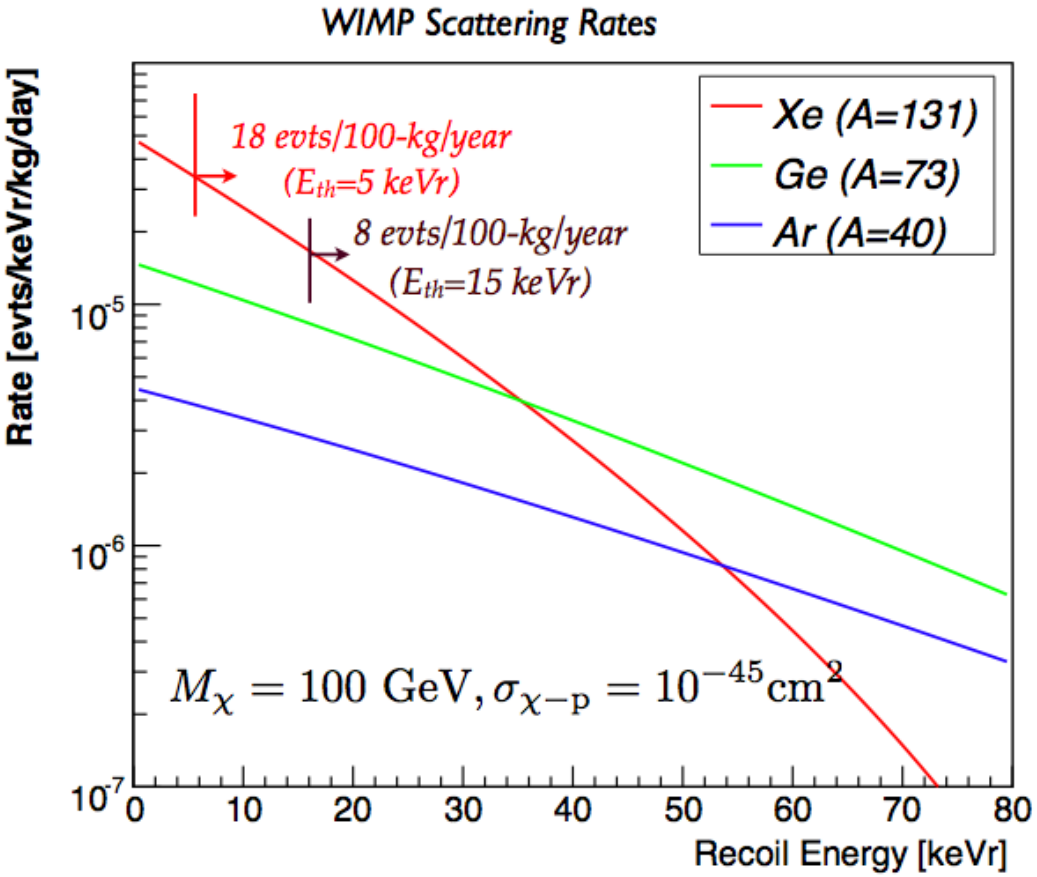
(**W**eak **I**nteracting **M**assive **P**article)



Example: SUSY particles

- Neutralino χ
- CMSSM predictions around $10^{-44\pm2}\,\mathrm{cm}^{-2}$

Xenon as detection medium



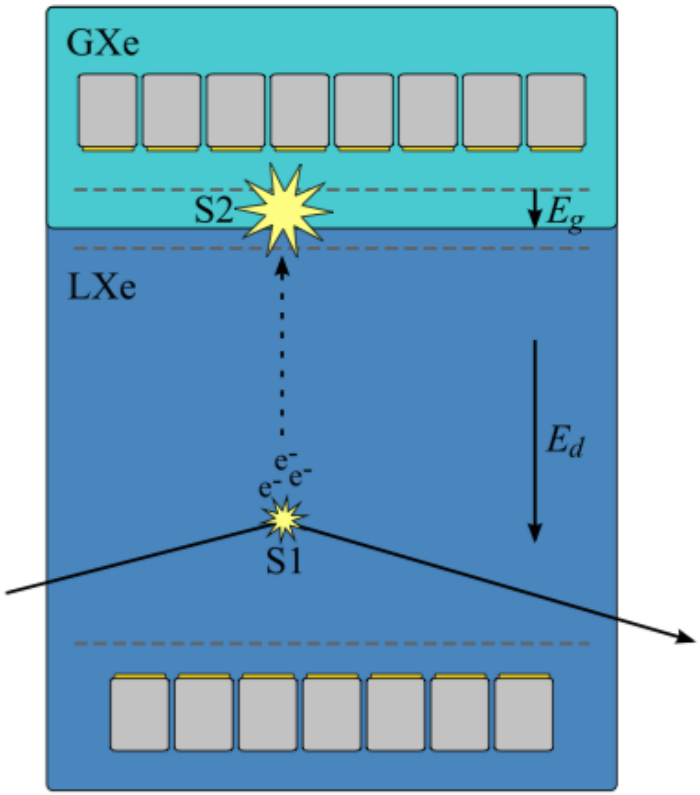
Detection via scatter off nuclei

⟶ Plenary talk tomorrow:
U. Oberlack (PV VII)

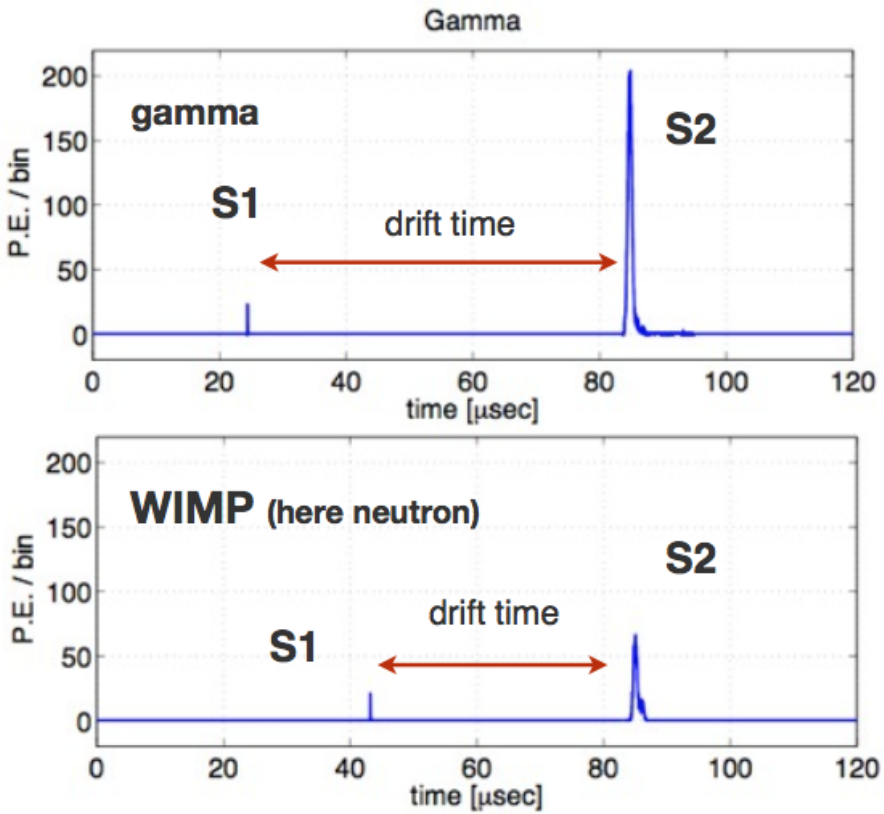
Xe

- Self-shielding
  ⟶ High stopping power
- 178 nm UV photons
  ⟶ No wavelength-shifter
- Simple cryogenics
  $\sim$ 180 K = -93°
- High atomic mass A$\sim$ 131
  ⟶ spin-indep. interactions
- ^{129}Xe and ^{131}Xe
  ⟶ spin-dep. interactions

Two phase noble gas TPC



- Scintillation signal (S1)
- Charges drift to the liquid-gas surface
- Proportional signal (S2)



Electron recombination is stronger for nuclear recoils

→ Electron- / nuclear recoil discrimination

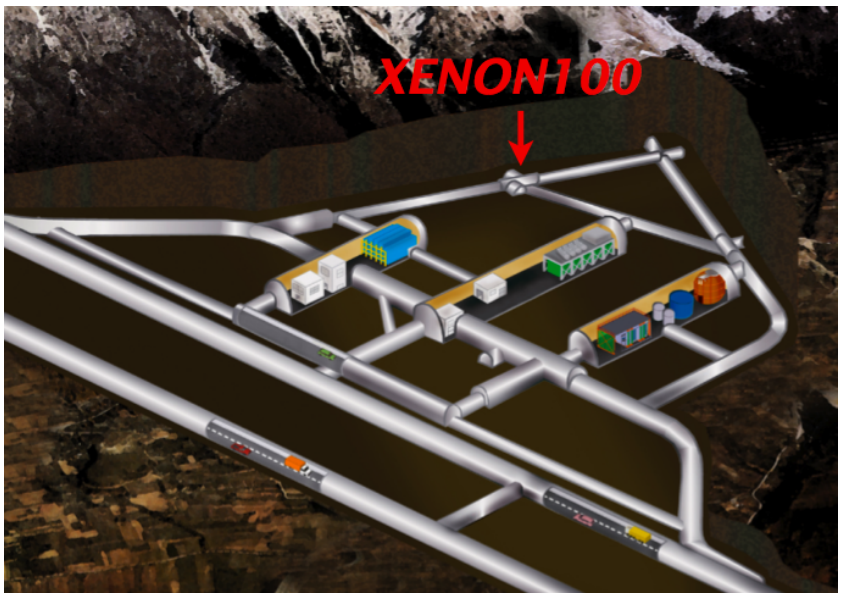
XENON experiment

- Laboratori Nazionali del Gran Sasso (Italy)
- $\sim$ 3 650 m.w.e. shielding

- XENON10: 15 kg active volume
  - Finished: No evidence for DM
- XENON100: 62 kg active volume

E. Aprile *et al.*, Phys. Rev. Lett. 105, 131302 (2010)
E. Aprile *et al.*, arXiv:1101.3866 (2011)
E. Aprile *et al.*, arXiv:1103.0303 (2011)

  - Currently running



XENON100 Collaboration


Columbia


Rice


UCLA


Zürich


Coimbra


LNGS


SJTU


Mainz


Bologna


Subatech


Münster


Nikhef

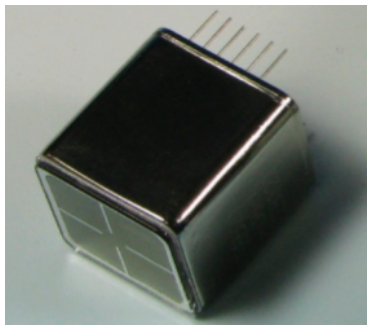

Heidelberg


Weizman

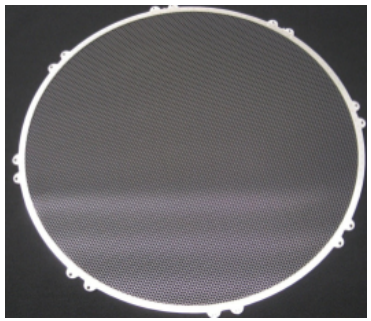
US, Switzerland, Portugal, Italy, China, Germany, Holland, France and Israel

XENON100 detector

- 30 cm drift length and 30 cm ∅
- 161 kg total (30-50 kg fiducial volume)
- ∼ 100x less background than XENON10
- Improved shielding
- Material screening and selection
- Cooling (PTR) outside the shield
- Active liquid xenon veto



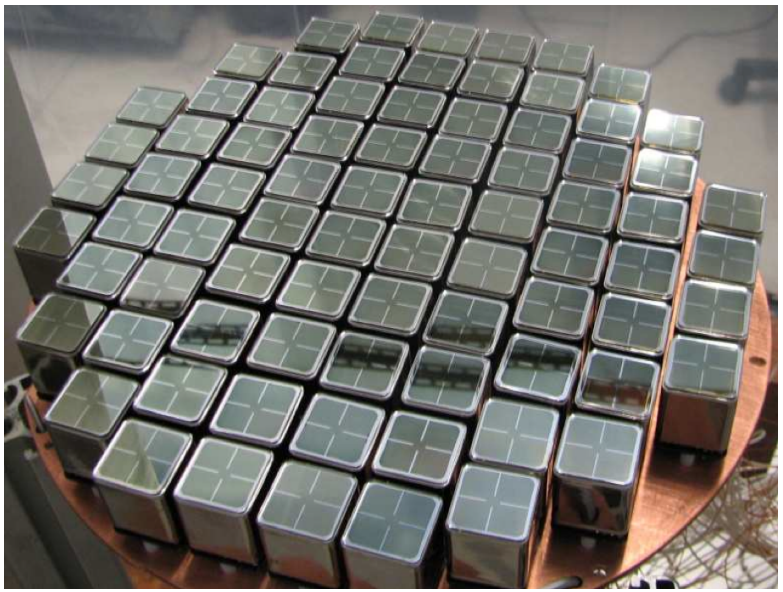
1 inch PMTs



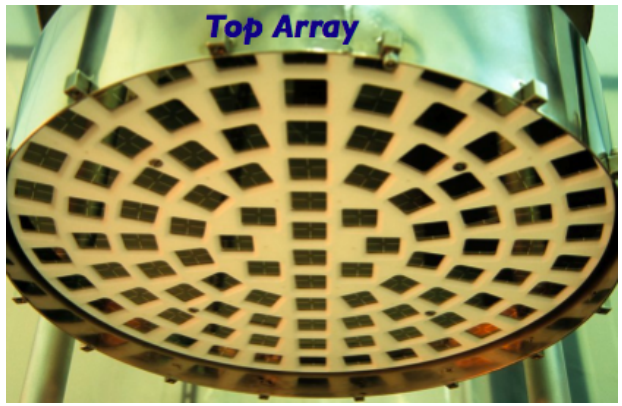
30 cm ∅ meshes

Light and charge read out

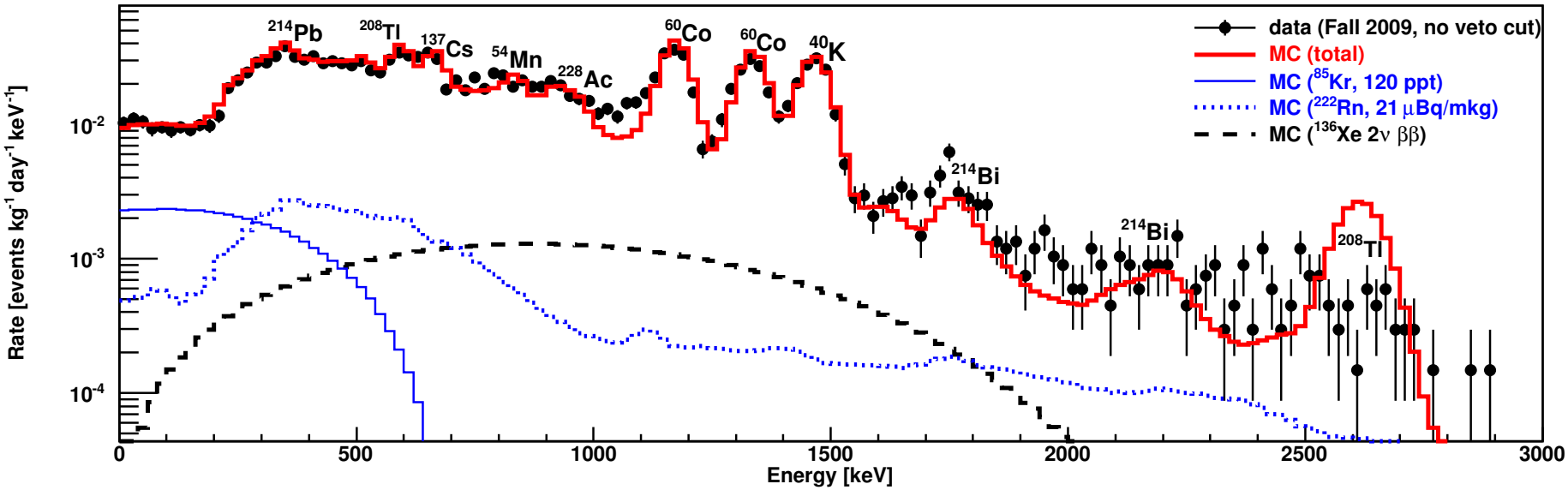
- Bottom PMTs: high quantum efficiency (on average >30% @178 nm)



- 3 Dim. position reconstruction
  - XY from light pattern in the PMTs
  - Z from the drift time
- 3 mm resolution in XY and 2 mm in Z



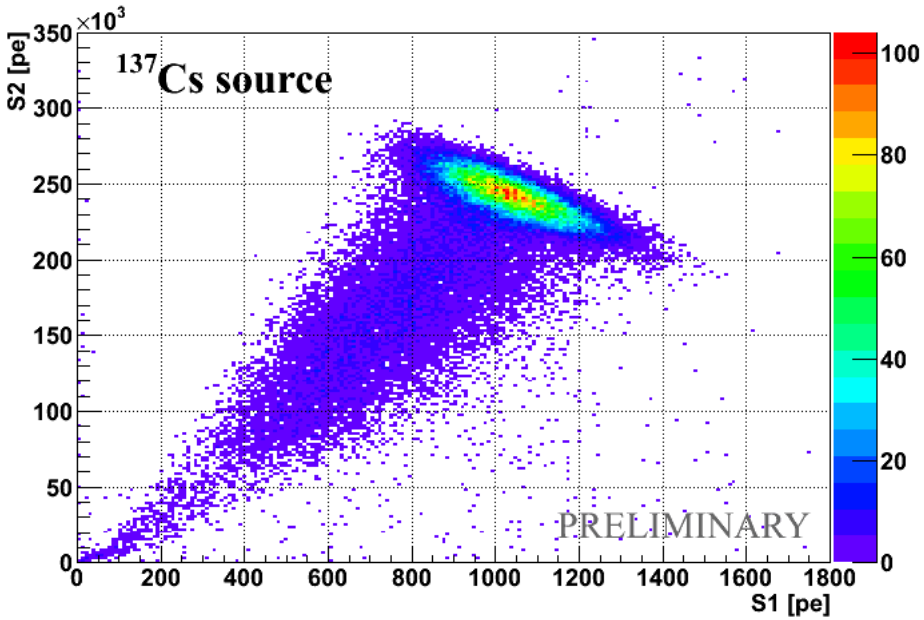
Measured background spectrum

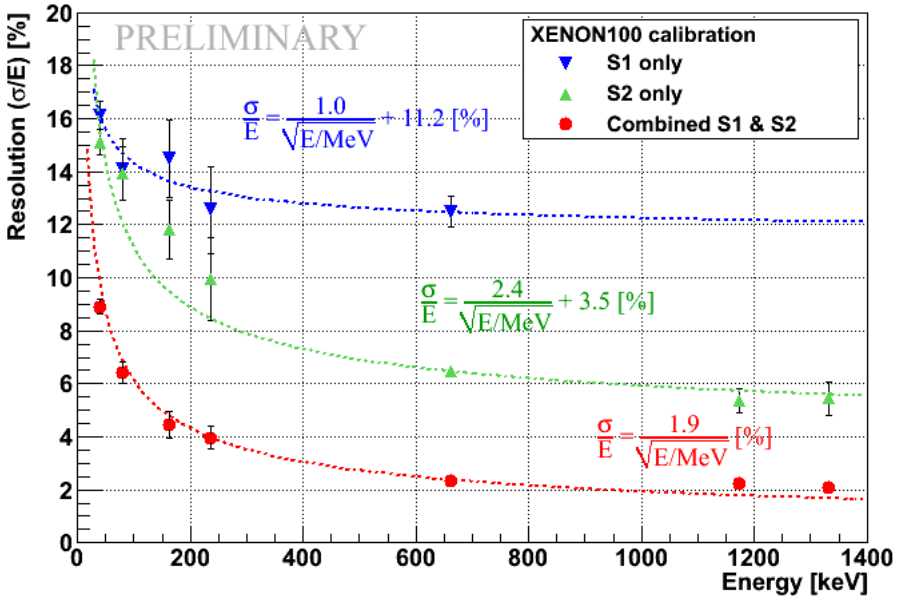


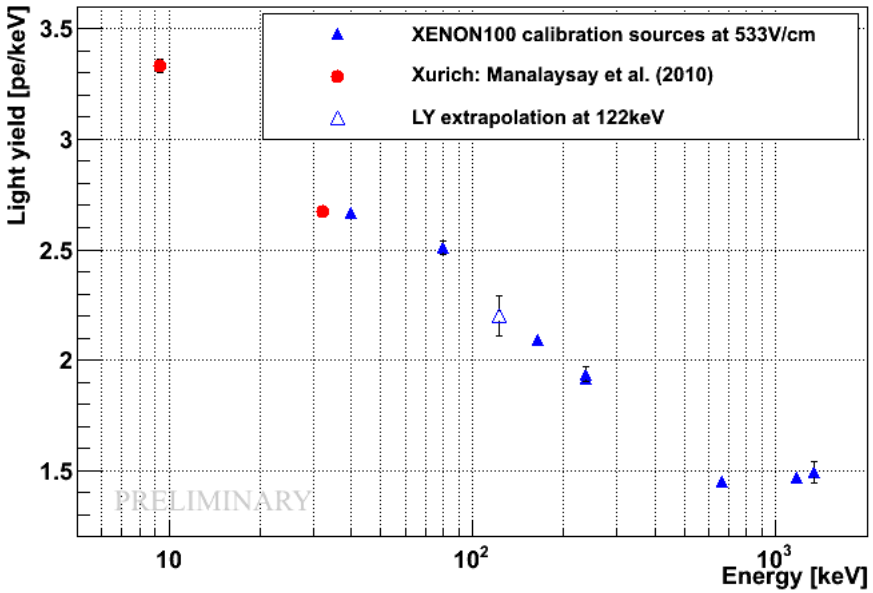
- Background at the level of the predictions
- The measured single scatter rate below 100 keV is $5 \cdot 10^{-3}$ evts/kg/keV/d after applying the veto cut
- Factor 100 less than in XENON10 achieved!!

→ XENON100 Collaboration, arXiv: 1101.3866, accepted in PRD

Calibration with gamma sources



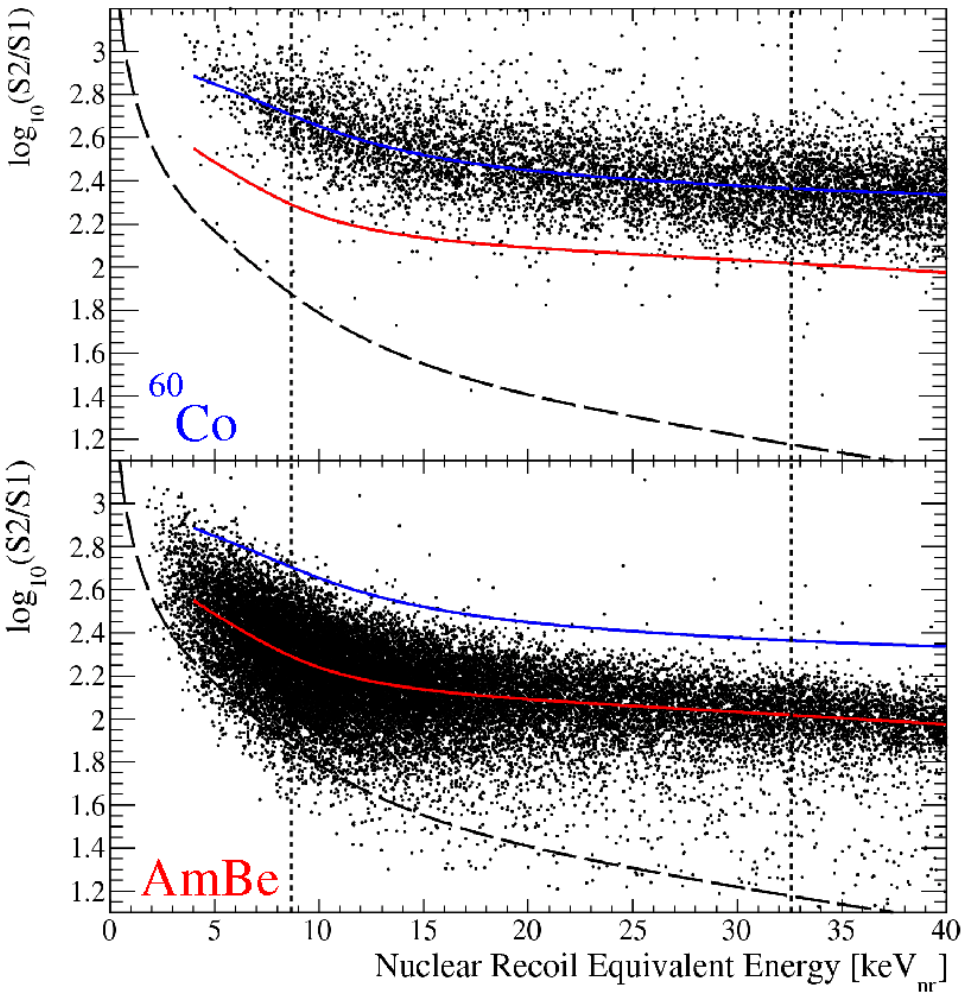




- Energy dependence of resolution for light (S1), charge (S2) and CES signals
- CES: combined energy scale

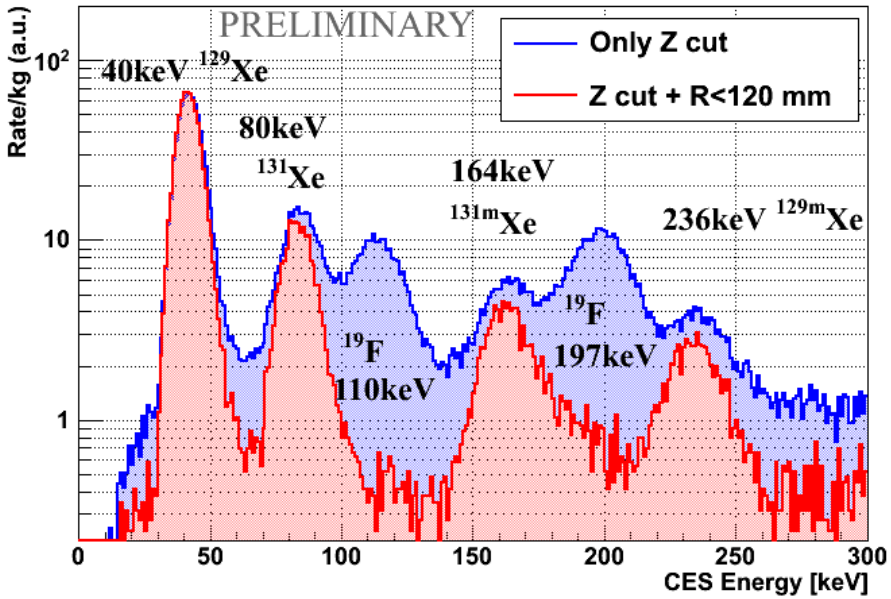
→ using anticorrelation between S1 and S2 signals

Electronic and nuclear recoil bands



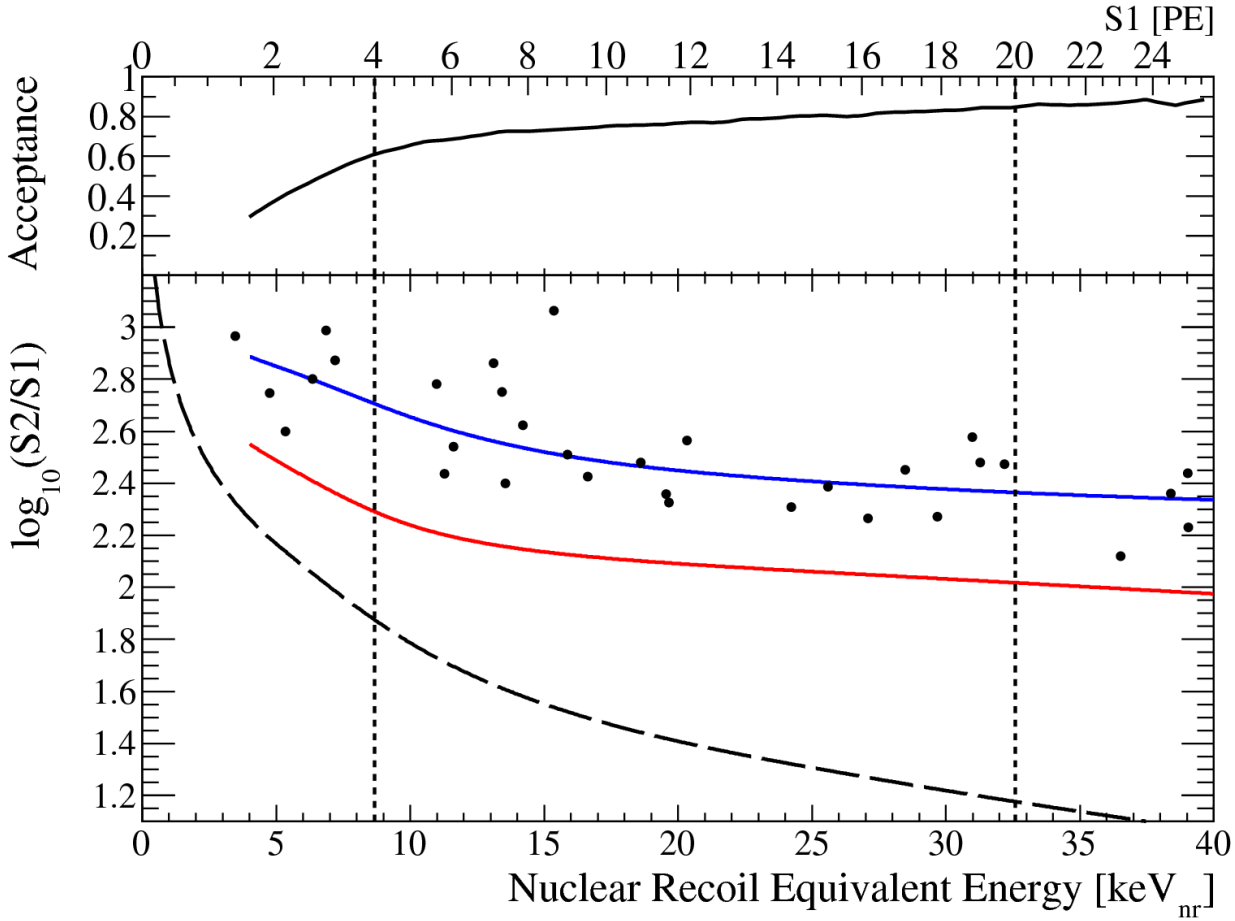
- Electronic recoil band: defined with ^{60}Co source
- Nuclear recoil band: defined with AmBe neutron source

→ ER lines during n-calibration:



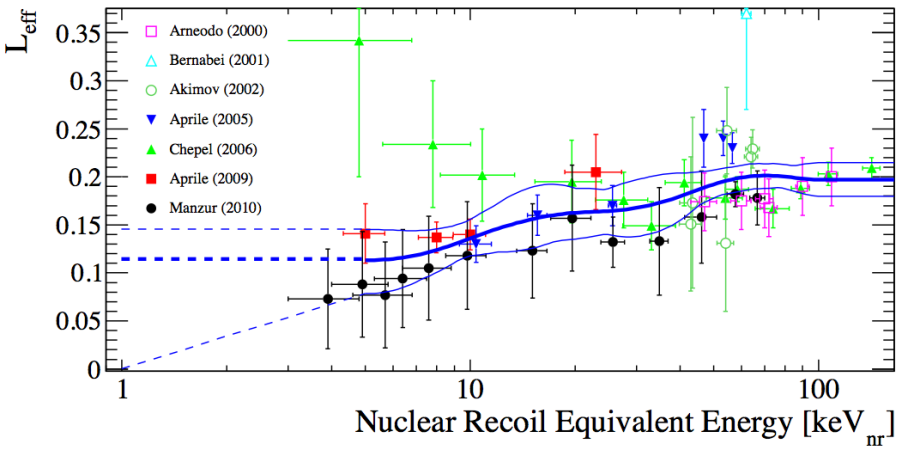
More analysis details: M. Weber (T 106.2)

First results from a commissioning run



- Data sample: 11.17 days in October/November 2009
- 'Background free' after discrimination
- Similar exposure as in XENON10 $\rightarrow$ much cleaner detector

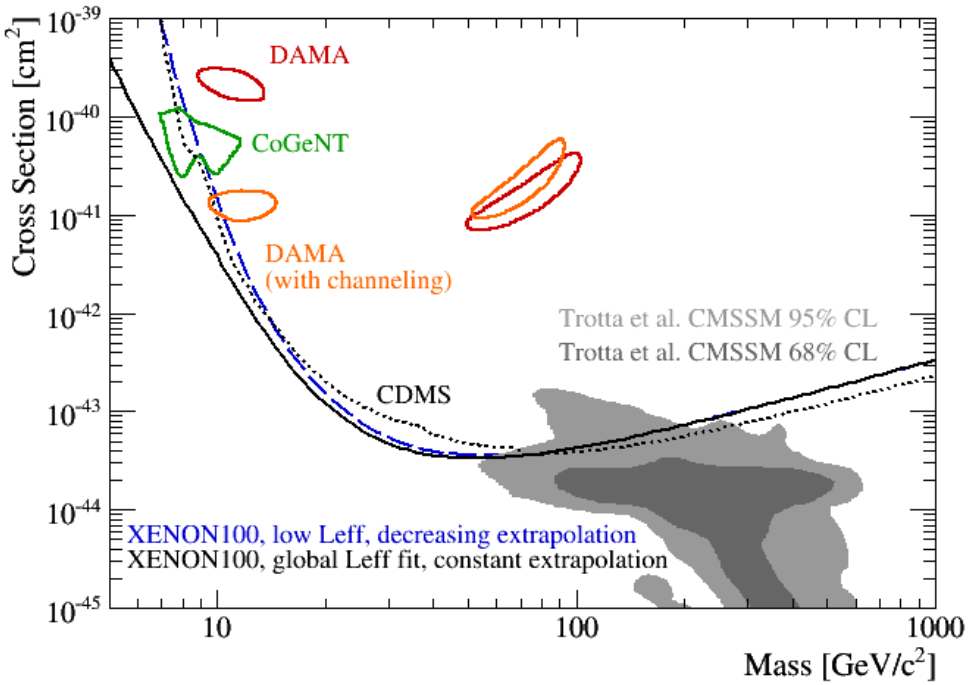
Limit from non-blinded data analysis



- Excellent sensitivity: even for few days of data

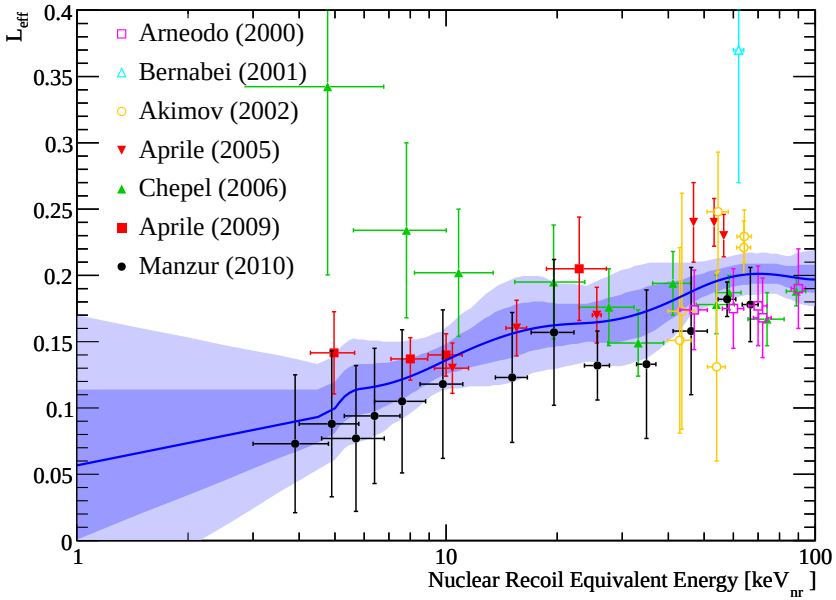
→ Sensitivity to low WIMP masses depends on L_{eff}

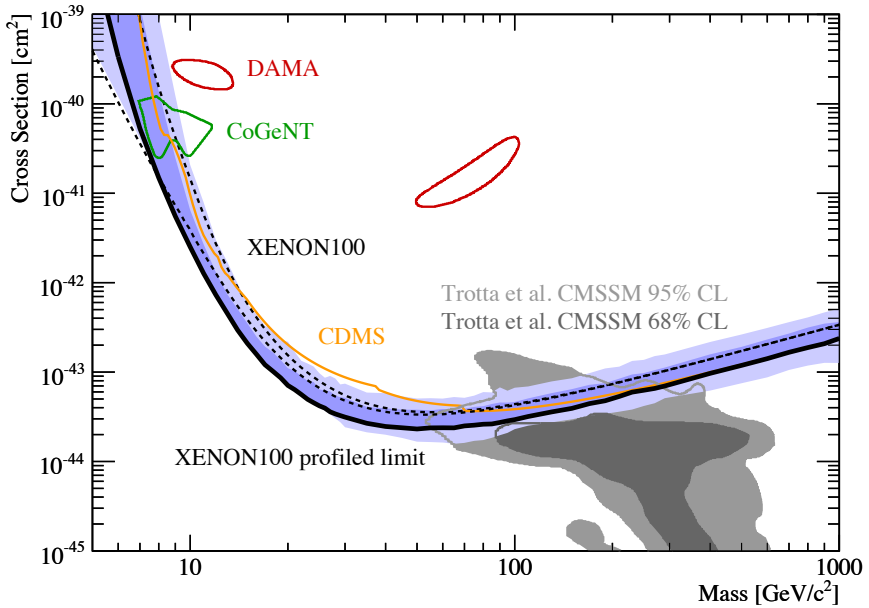
- Spin independent limit: for standard halo parameters



E. Aprile *et al.* (XENON100 Collaboration), Phys. Rev. Lett. 105, 131302 (2010)

Re-analysis using profile Likelihood method

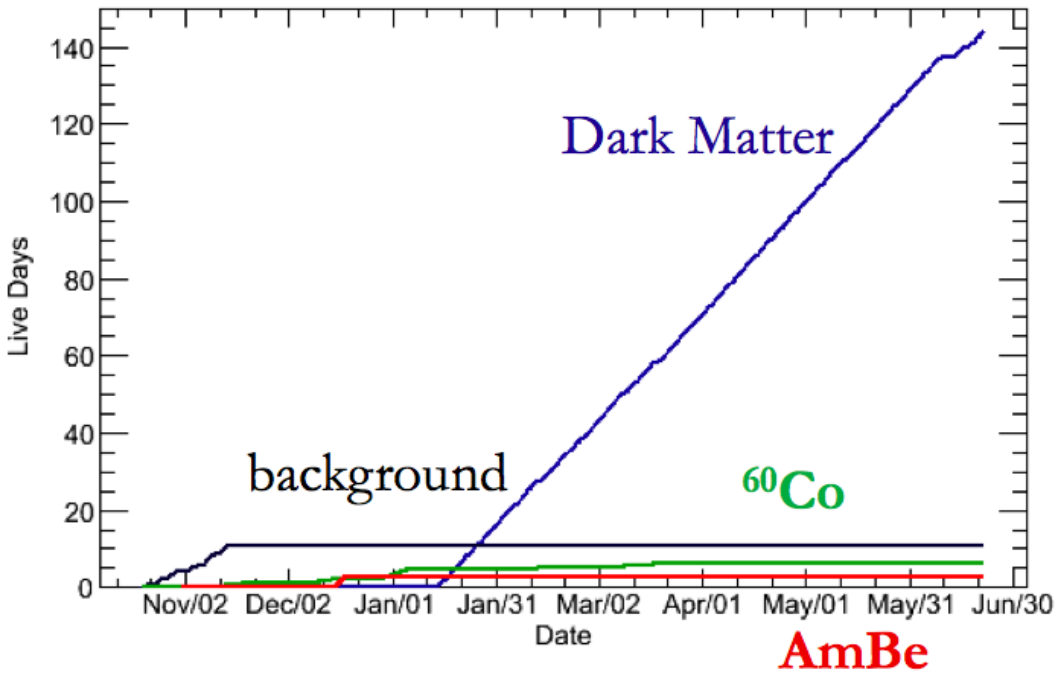




- Uses the whole discrimination parameter space
- Introduces uncertainties: L_{eff} and galactic escape velocity
- Improvement in the limit for the 11.2 d analysis

  → XENON100 Collaboration, arXiv: 1103.0303

Data taking: Overview



→ 11.2 days of non-blinded data analyzed (commissioning run)

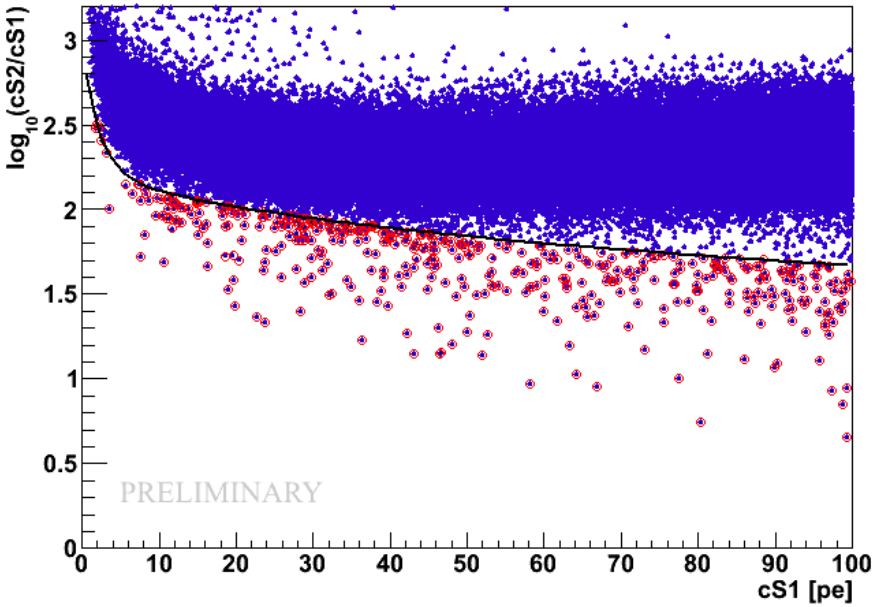
→ New run ∼100 days

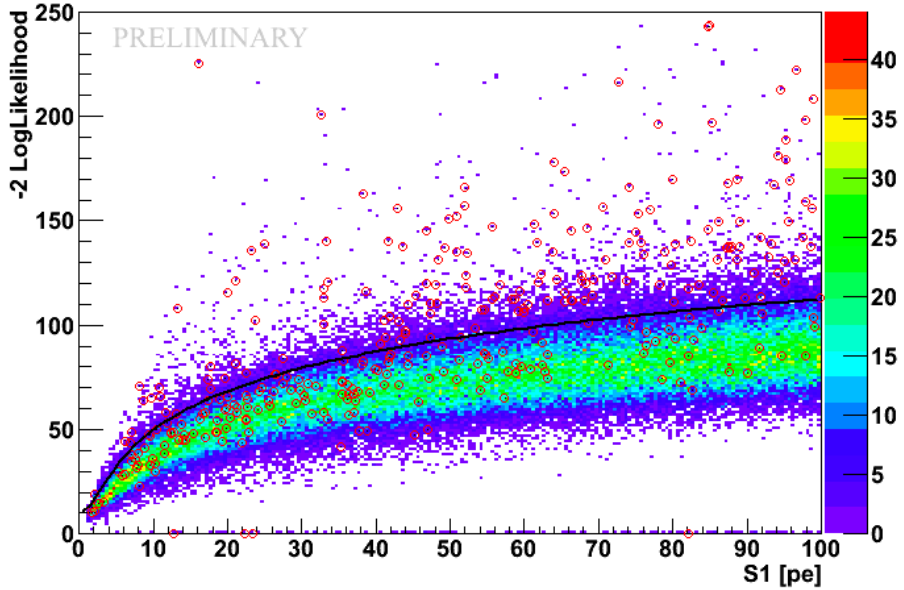
- New likelihood cut for anomalous S1 pattern recognition
- New position reconstruction algorithms
- Improved corrections:

  XY and Z
- New analysis of sensitivity based on likelihood methods

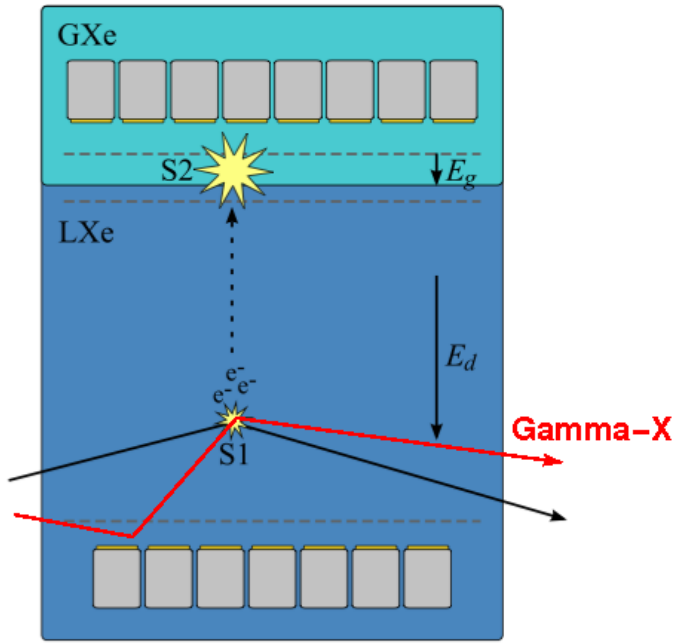
→ Results in the next weeks!

RUN08: Likelihood cut for anomalous S1 patterns





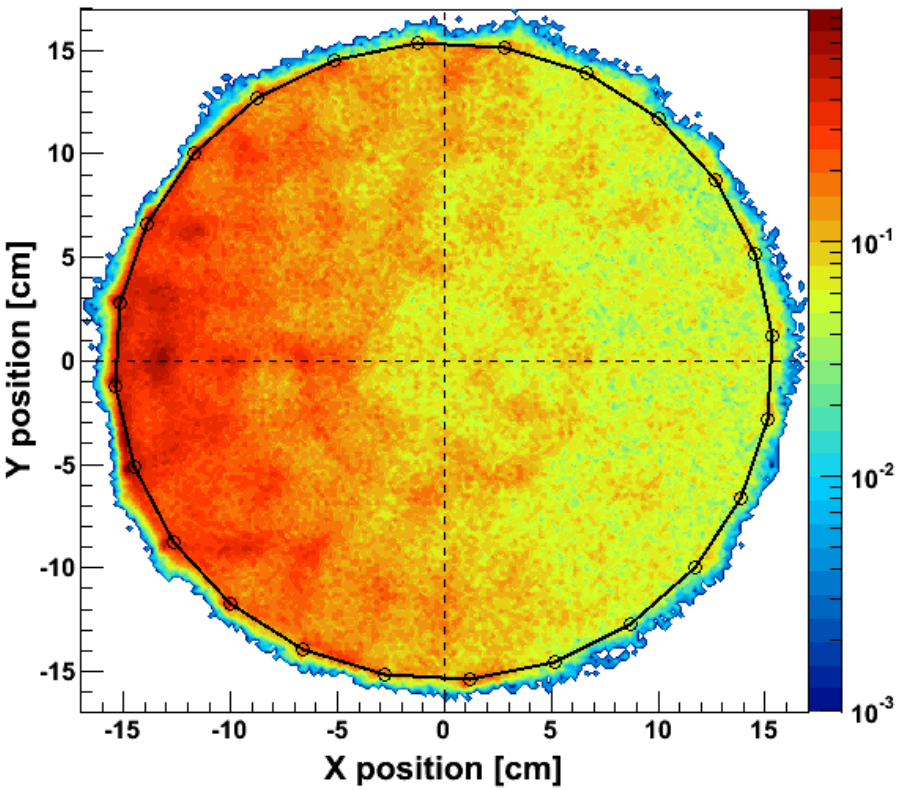
- Gamma-X events: double scatters, one of them in a charge insensitive region



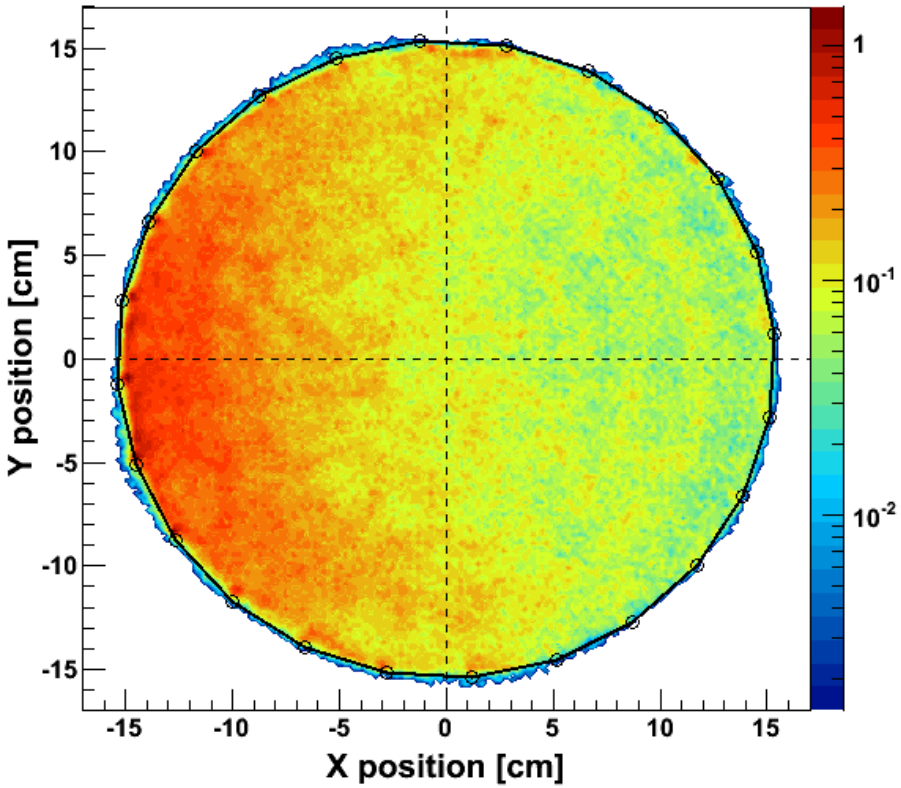
- Likelihood cut removes large fraction of events below NR median while having a high neutron acceptance

RUN08: Improved position reconstruction

SVM position reconstruction used for 11.2 d analysis

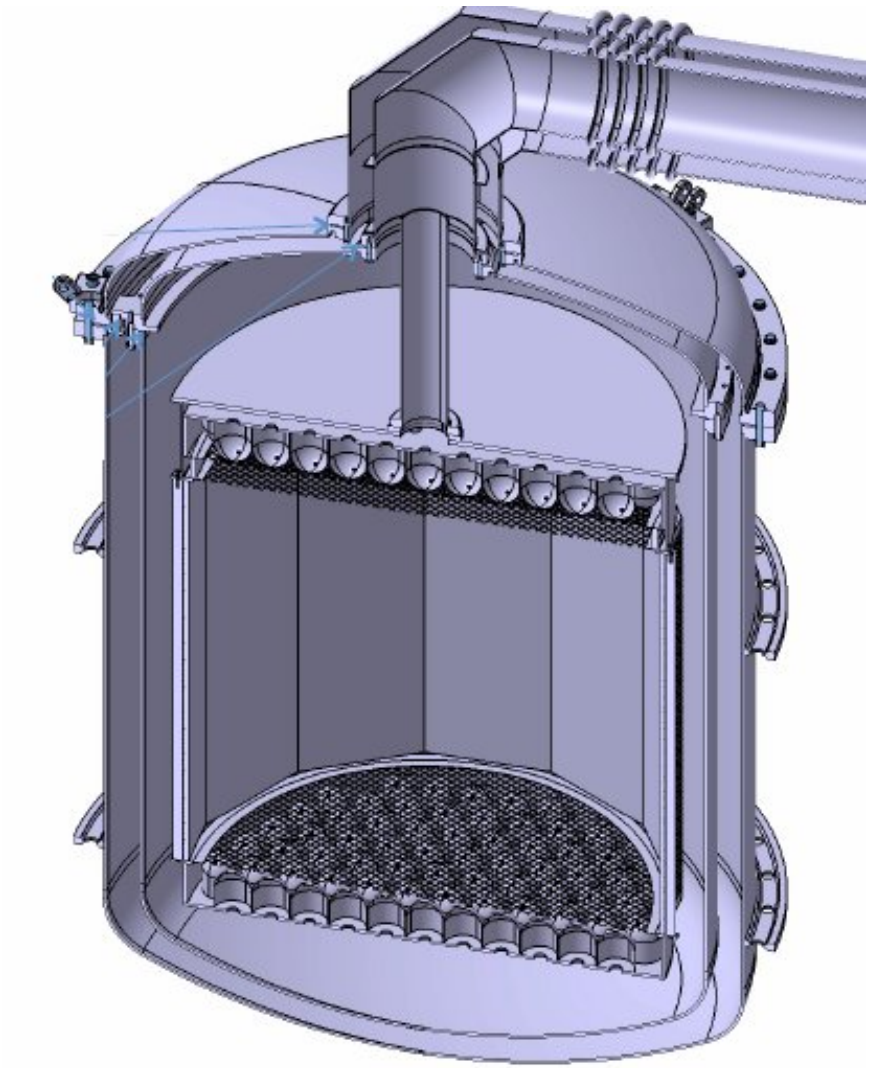


Improved NN position reconstruction



→ Also new raw data processor, new S1/S2 spatial corrections, new electric field correction, new MC for background predictions ...

Future: XENON1T

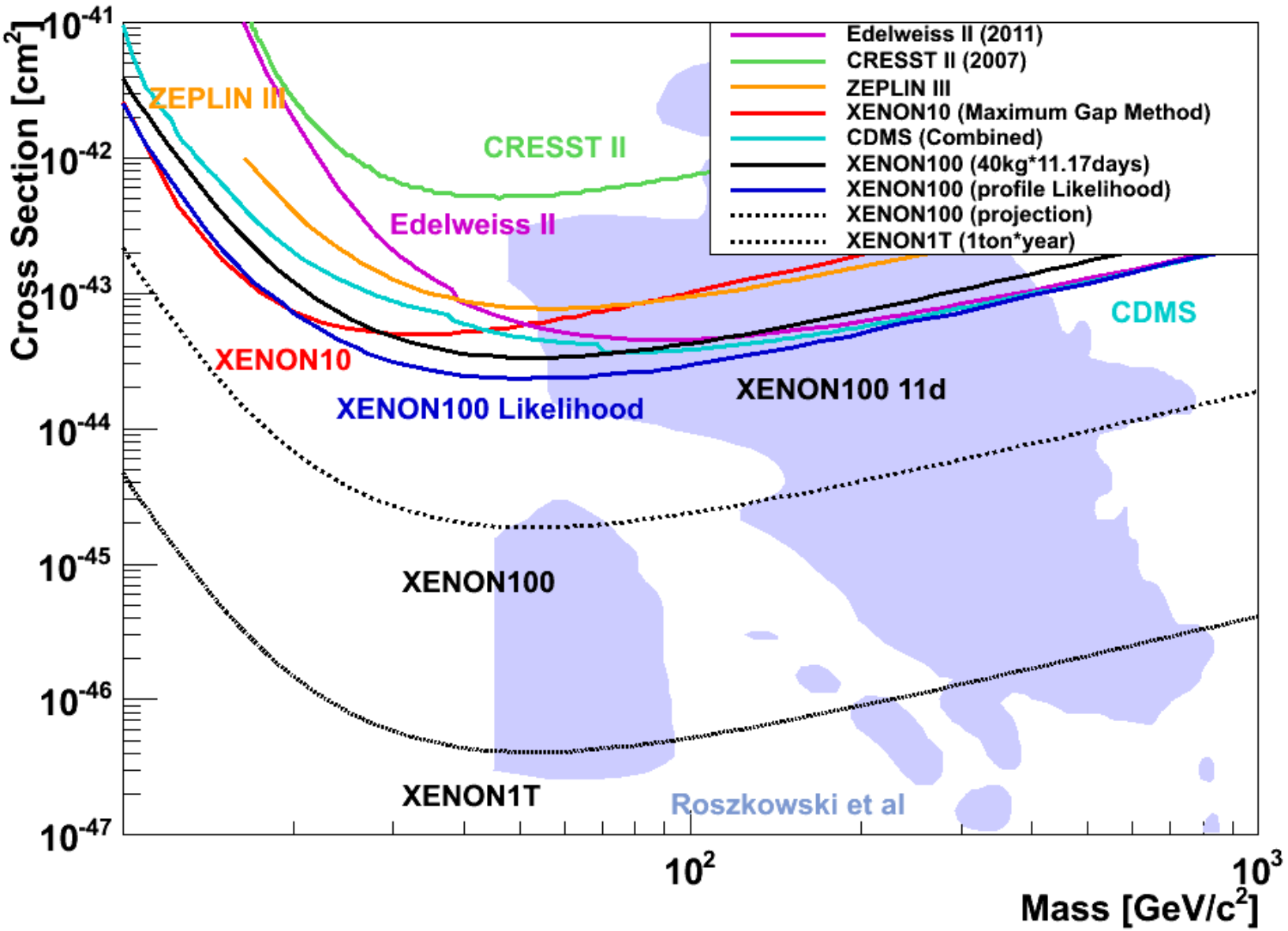


- 1 ton fiducial mass
  (total of 2.4 ton LXe)
- Drift length = $\sim$ 90 cm
- 100x background reduction
- Muon veto: 5 m water around the detector
- Titanium cryostat
- Low radioactivity photosensors

- Large international collaboration
- Timeline: 2011 - 2015

More information: S. Lindemann (T 106.3)

XENON sensitivity



Summary

- Liquid xenon is a promising target material to discover dark matter
  - Large nucleus (A^2 enhancement on σ)
  - Dual-phase: particle discrimination
  - Self-shielding (large detectors)
- XENON100 is taking dark matter data
  - Design background level achieved
  - Results from first data published
  - Re-analysis using profiled Likelihood recently submitted
  - Unblinding of $\sim$100 days of data coming soon!
- XENON1T currently under design