First Results of the XENON100 dark matter search

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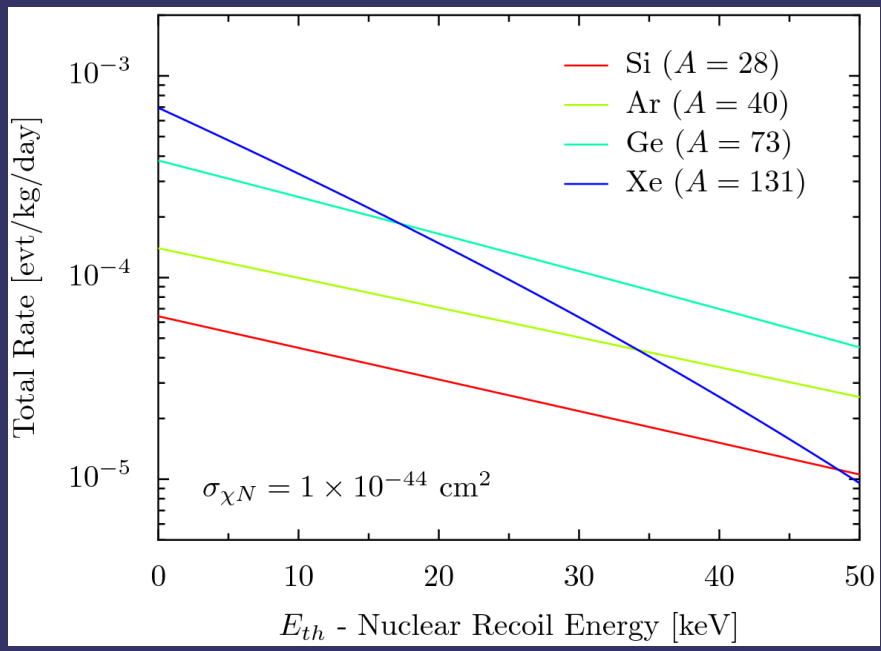
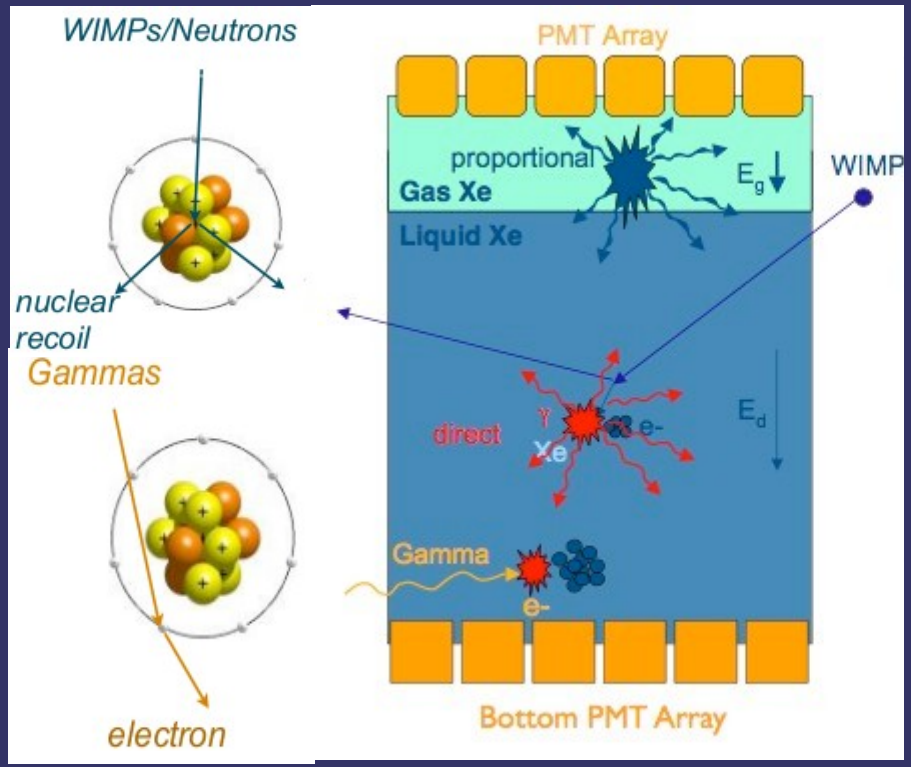
on behalf of the
XENON100 Collaboration

Why using Xe for dark matter searches

- Large Mass number A (~131): high rate for SI if energy threshold for NR is low
- 50% of odd isotopes (^{129}Xe, ^{131}Xe): sensitive to SD interactions
- High stopping power (Z=54, ρ=3g·cm^{-3}): self-shielding capability
- Efficient scintillation (~80% of NaI) and ionization
- Intrinsically pure: No long lived isotopes and Kr/Xe reduction to ppt levels
- NR discrimination by simultaneous measurement of light and charge signals
- Scalability: relatively inexpensive for very large detectors



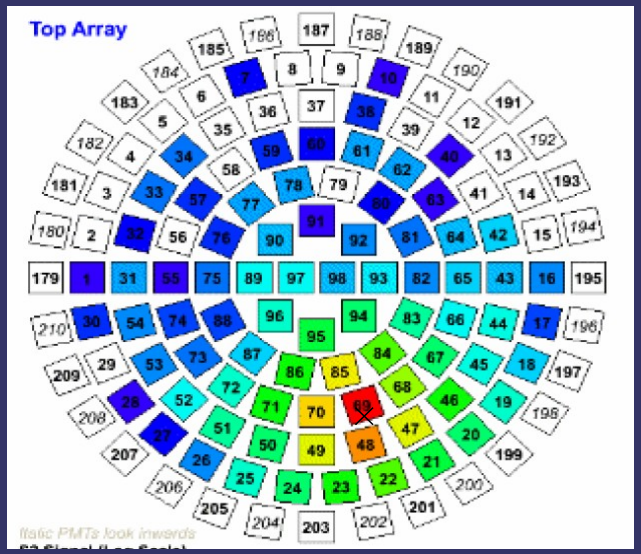
WIMP detection with a Xenon TPC

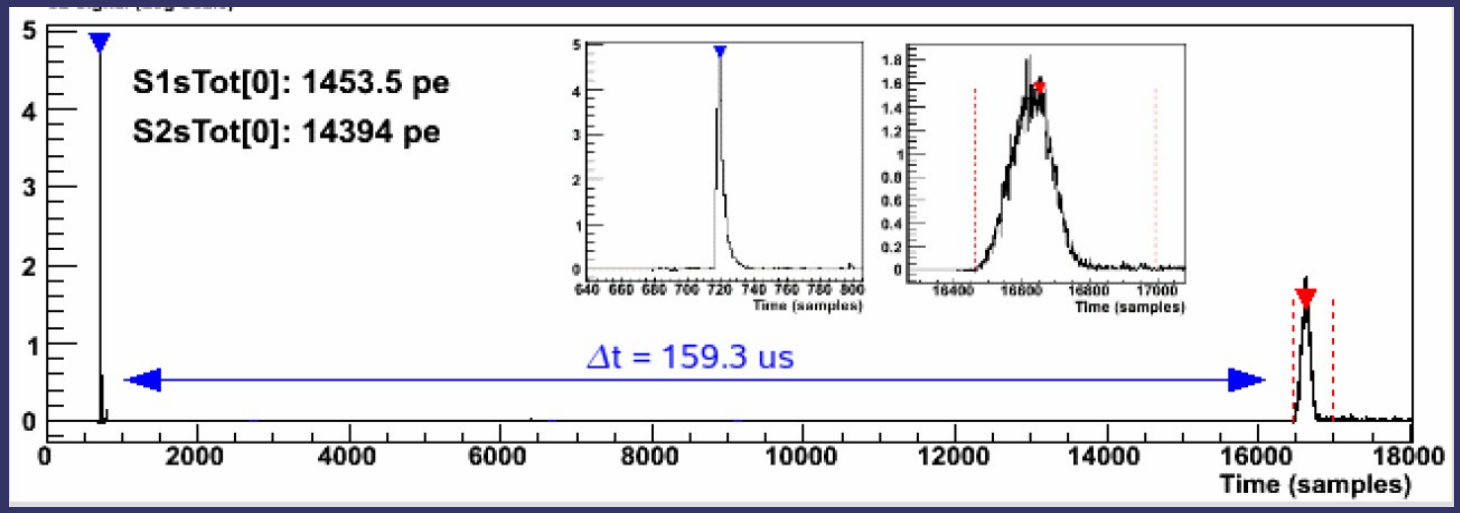


- Interactions in the detector produce scintillation and ionization
- Scintillation signal is recorded by two arrays of PMTs in the bottom and top of the detector
- Free electrons are drifted with an Electric Field and produce proportional scintillation in the gas gap below the anode, which is detected by the photosensors
- Different ionization/scintillation ratio allows for discrimination of nuclear recoils against electron recoils

WIMP detection with a Xenon TPC

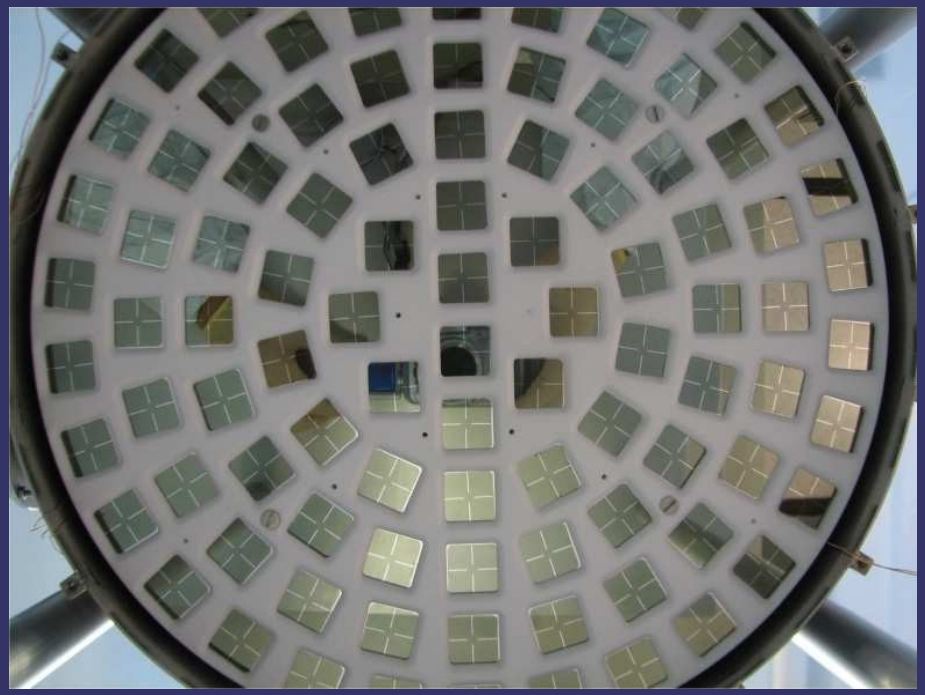
- The time difference between the primary and proportional scintillation allows for reconstruction of the depth of the interaction
- The PMT pattern of the proportional scintillation gives information about the XY position of the interaction





The XENON100 detector

- 161 kg of LXe divided in:
  - 62 kg fiducial region: 30cm heightx30cm diameter cylinder seen by two PMT arrays (178 PMTs total)
  - 99 kg active veto covering top, sides and bottom seen by 64 PMTs
- Multiple strategies for background reduction:
  - Passive shield: 5 cm Cu+20cm Poly+20 cm Pb +20 cm Water
  - Careful selection and screening of materials
  - Placement of all cryogenics outside the shield
  - Distillation column to reduce the Kr/Xe content

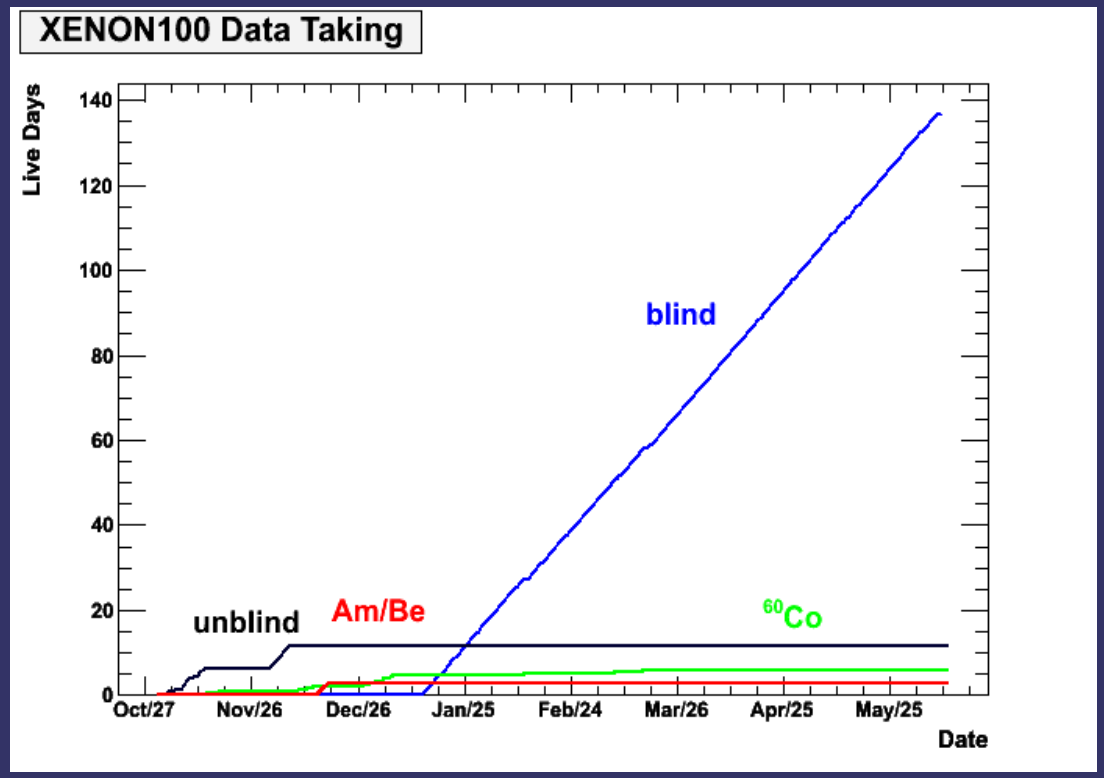


Backgrounds: gammas from detector components

- Careful selection and screening of the detector materials in a dedicated facility with HPGe detectors (GATOR)
- Kr is present in commercial Xenon at ppb level. A distillation column is used it to reduce this concentration. After processing delayed coincidence analysis gives ~150ppt

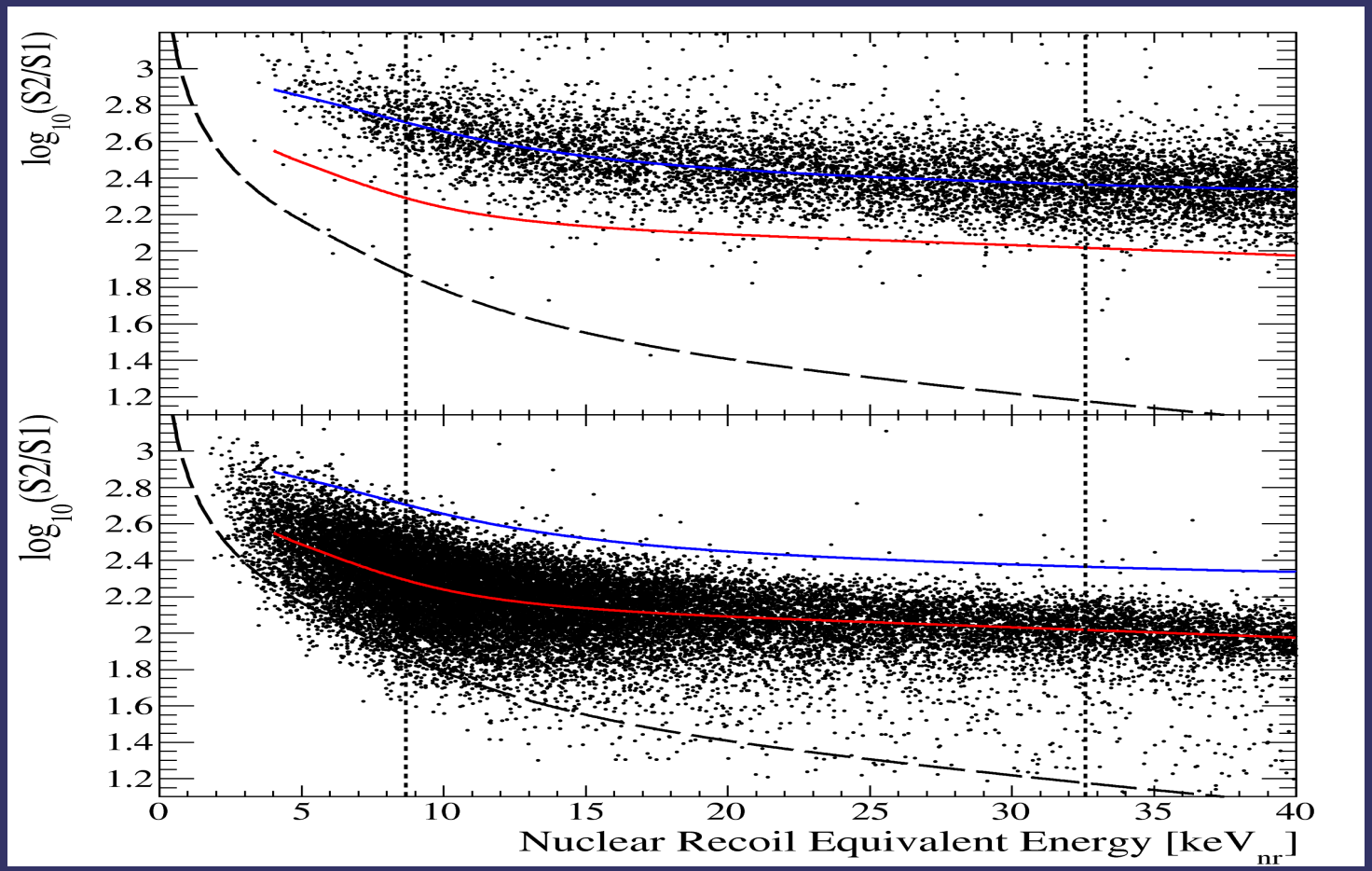
Current status of the XENON100 detector

- The detector is installed in the LNGS (Italy) since summer 2008
- Succesful calibration of the detector has been achieved during 2009
- Dark matter data taking started at the beginning of 2010. More than 8 tons·day have been already acquired



Electron/nuclear recoil discrimination

- It is possible to distinguish between nuclear recoils and electron recoils due to their different charge/light ratio
- The rejection efficiency is > 99% in the range from 4 to 20 pe



Energy scale for low energy NR

Measured signal

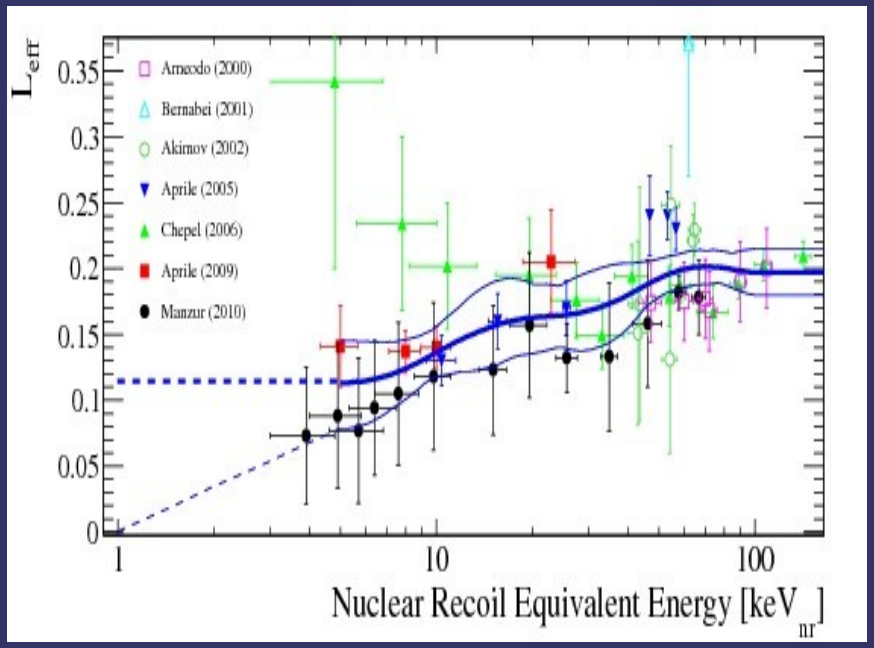
Light quenching due to electric field for gammas @122keV

$$E_{nr} = \frac{S1}{L_y \cdot L_{eff}} \cdot \frac{S_e}{S_r}$$

Light yield for gamma @122 keV

Scintillation eff. for nr at 0 field

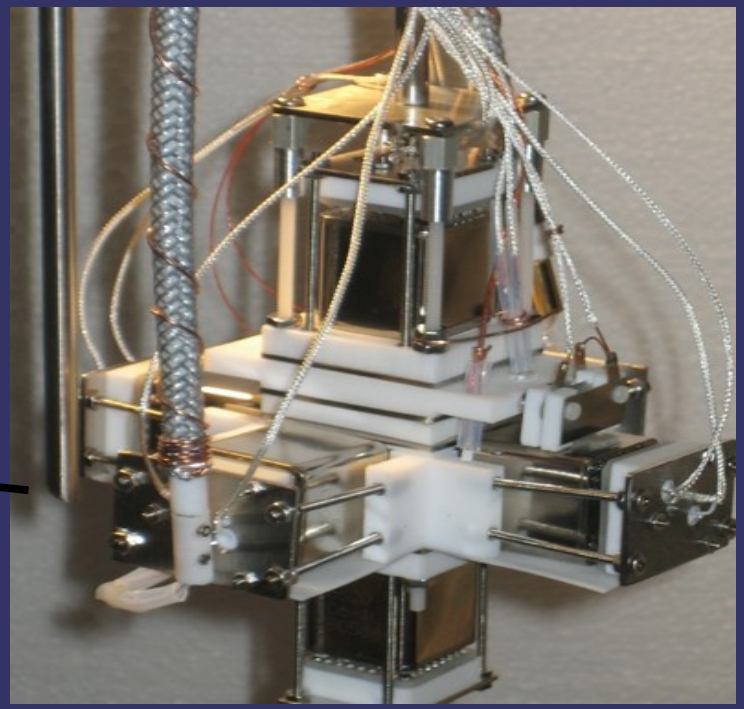
Light quenching due to electric field For nuclear recoils



- Big discrepancies between different measurements of Leff
- We choose not to favor any measurement and consider the result of a global fit with constant extrapolation below 5keVr as suggested by the measurements
- We also consider a pessimistic 90% lower confidence level with logarithmic extrapolation as suggested by Yale points

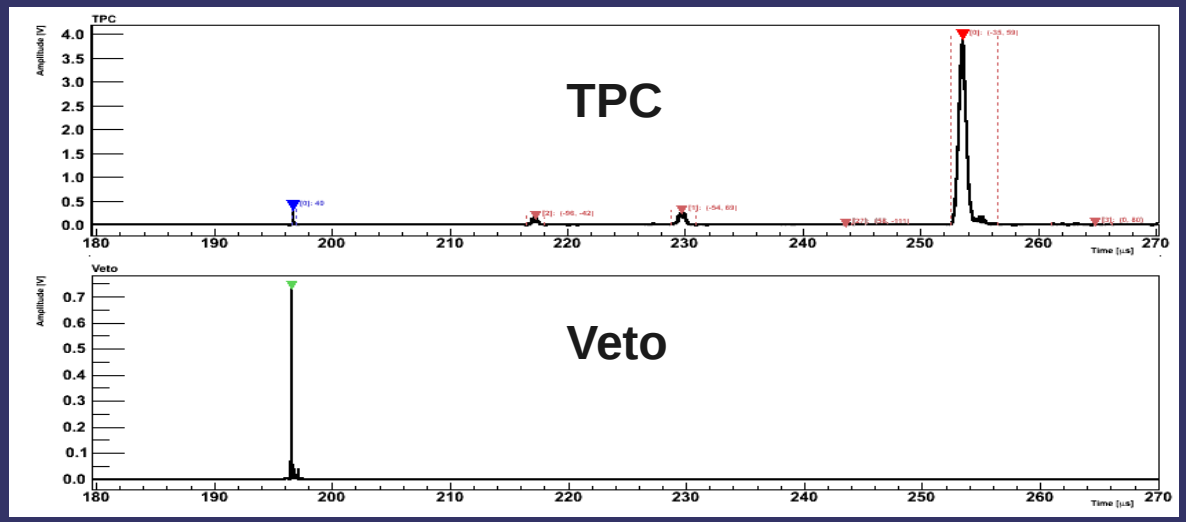
Energy scale for low energy NR

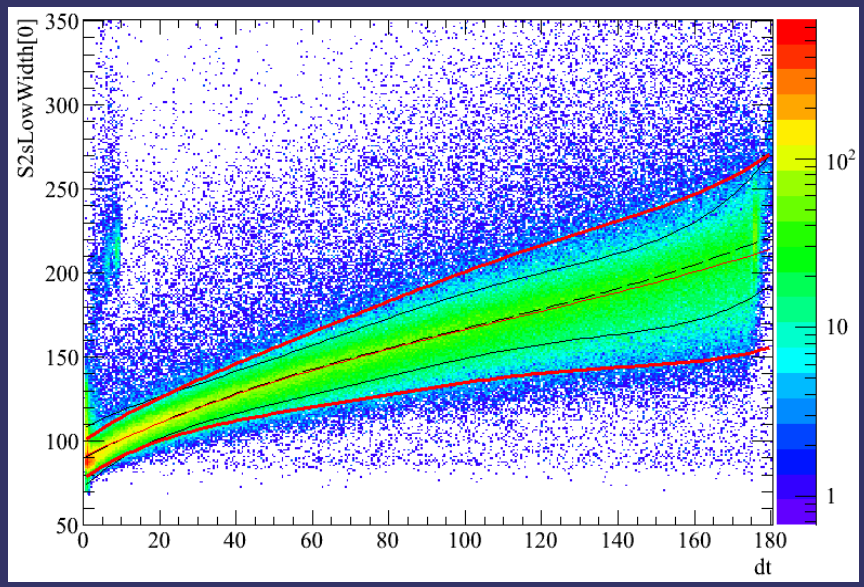
- New measurements of Leff with better precision and lower threshold are needed
- Two independent setups within the collaboration



Background analysis

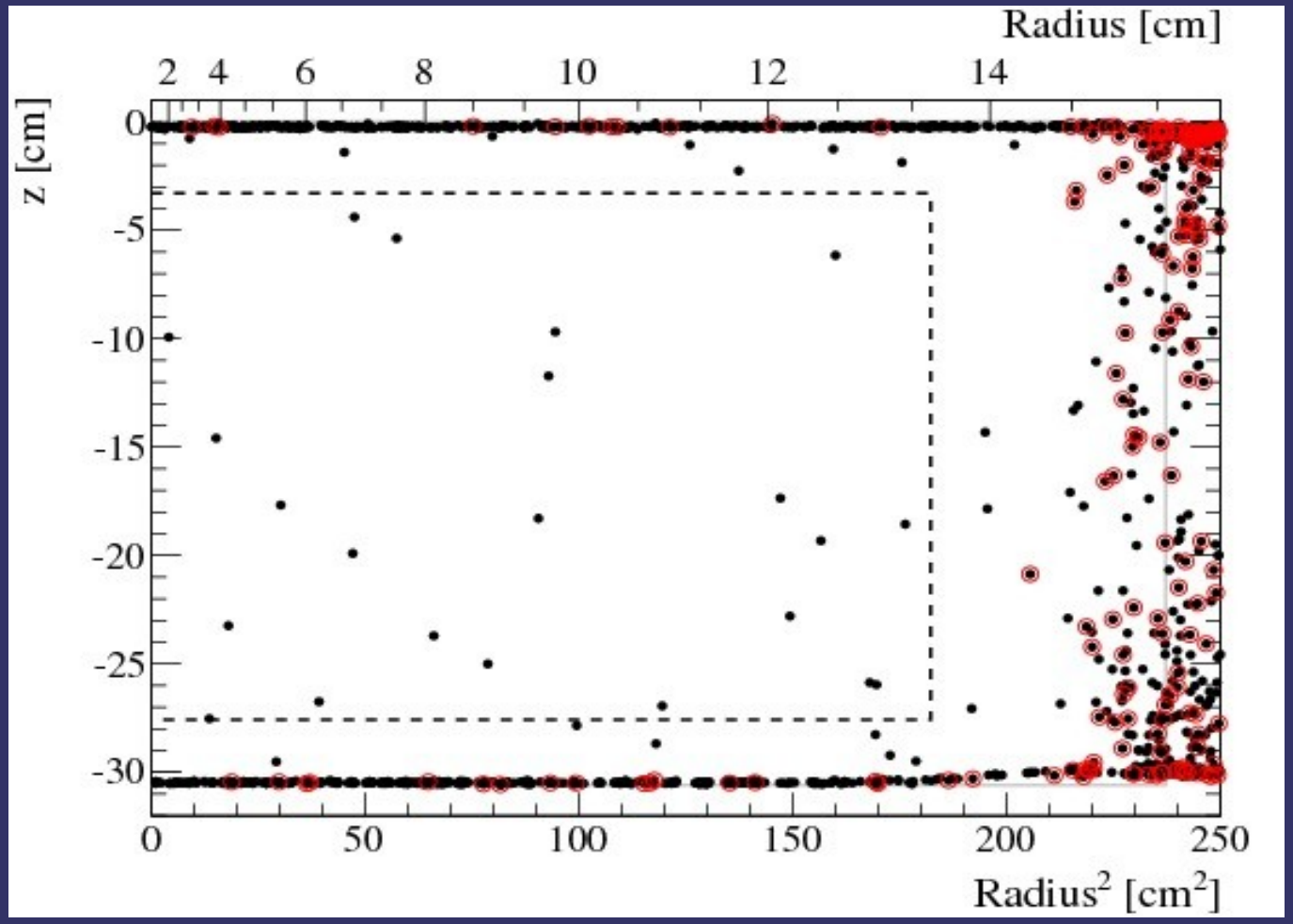
- 11.2 days of non blinded data were taken in the period Oct-Nov 2009
- Applied cuts are only optimized in calibration data
- Only very basic cuts are used:
  - Single scatters
  - Reasonable signal to noise ratio
  - Width and drift time of the event compatible(remove gas events)
  - Veto anticoincidence





Background results: fiducialization and energy range

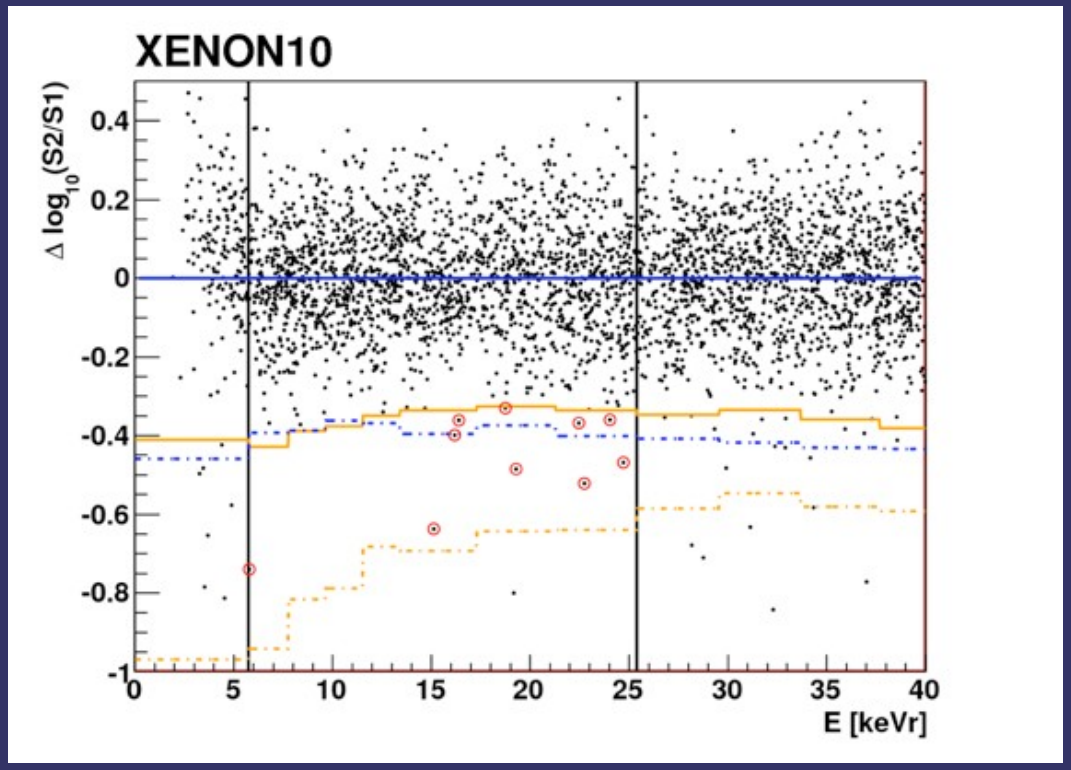
Selection of a 40kg cylindrical fiducial volume + Energy range 9-32 keVr

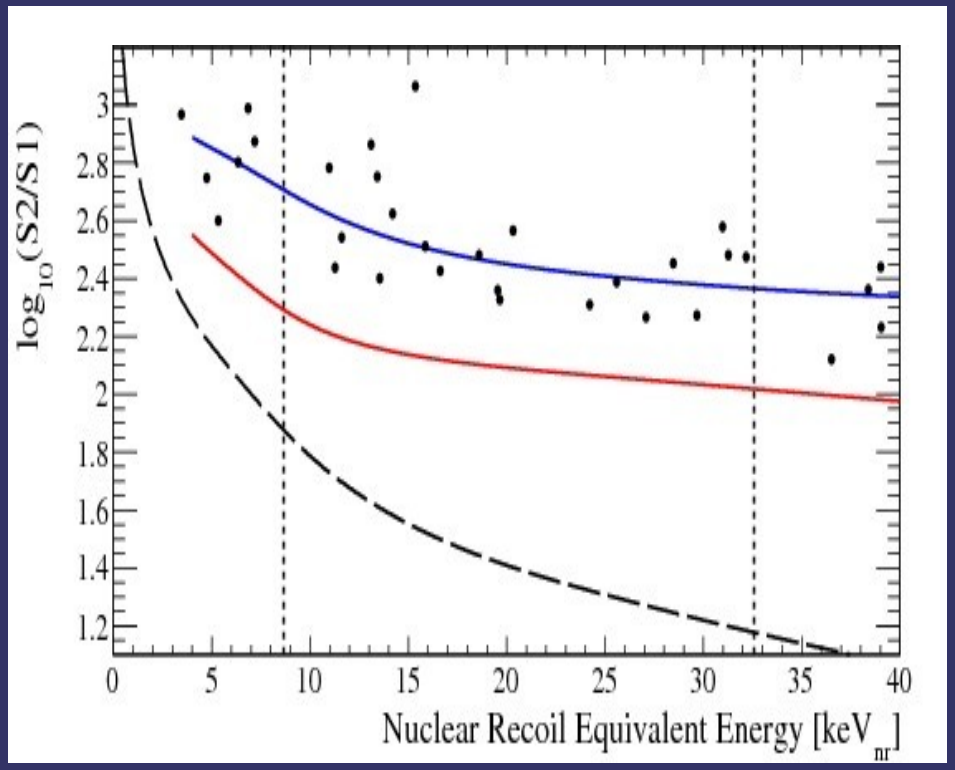


Background results after discrimination

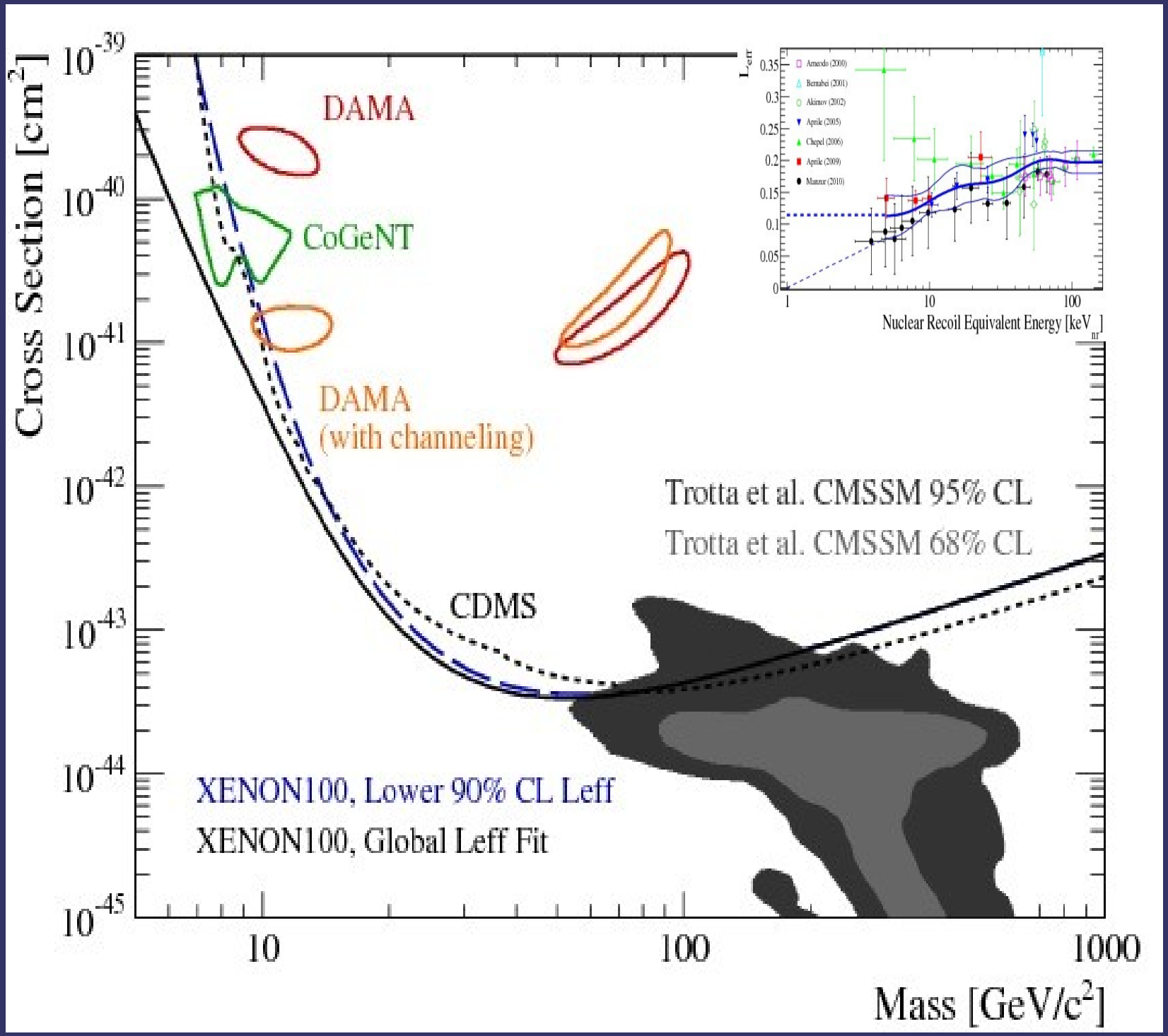
XENON10 PRL 100, 021303 (2008)
136 kg-days Exposure =
58.6 live days x 5.4 kg x 0.86 (ε) x 0.50 (50% NR)
(data collected between Oct.2006 and Feb.2007)

XENON100 submitted to PRL
172 kg · days acceptance-corrected exposure weighted by the spectrum of a 100GeV/c^2 WIMP
(data collected between Oct.2009 and Nov.2009)





0 backgrounds with a bigger exposure than XENON10!!


Cross Section [cm^2]
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
DAMA
CoGeNT
DAMA
(with channeling)
Trotta et al. CMSSM 95% CL
Trotta et al. CMSSM 68% CL
CDMS
XENON100, Lower 90% CL Leff
XENON100, Global Leff Fit
10
100
1000
Mass [GeV/c^2]
L_{eff}
Arneodo (2000)
Bernabei (2001)
Akimov (2002)
Aprile (2005)
Chepel (2006)
Aprile (2009)
Manzur (2010)
Nuclear Recoil Equivalent Energy [keV$_{nr}$]


The End