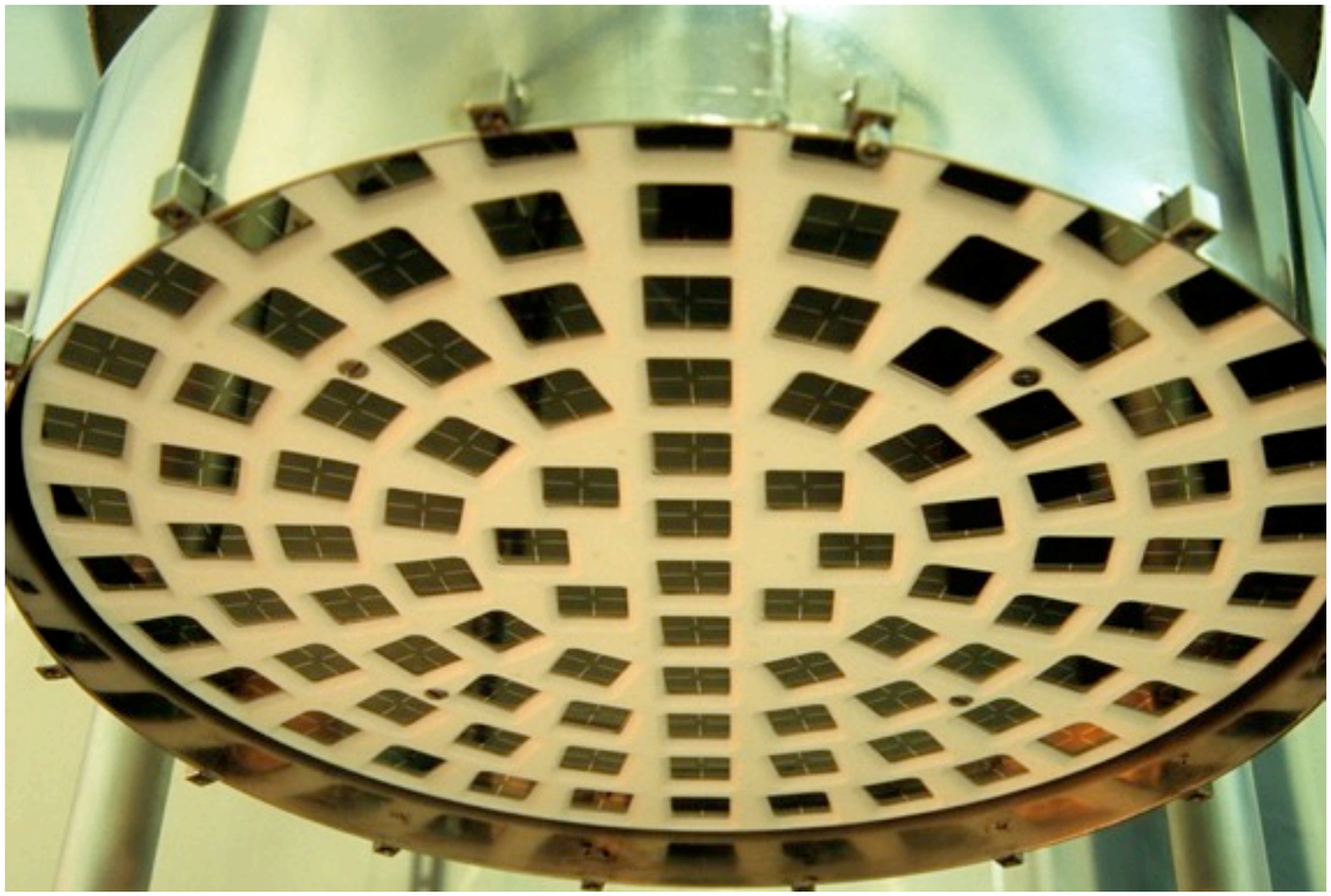

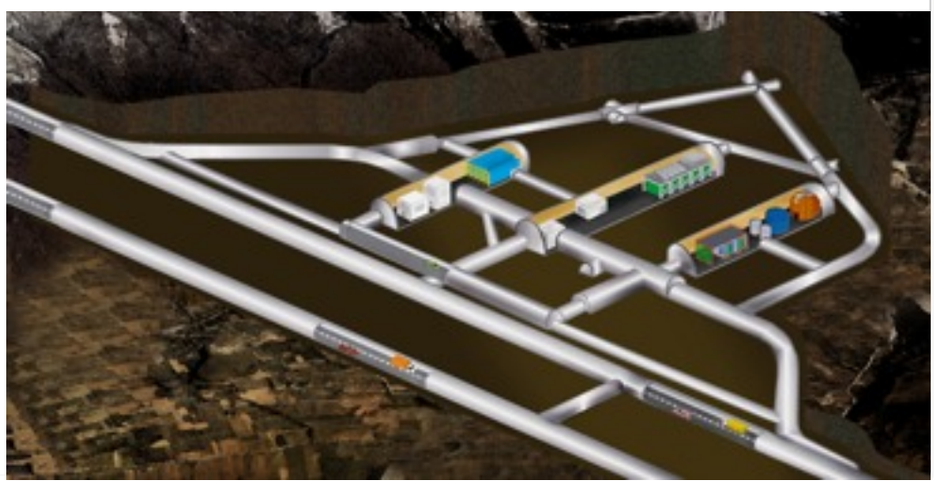

Liquid Xenon for Dark Matter

performance of the XENON100 detector

Kaixuan Ni
Shanghai Jiao Tong University

Calor2010, IHEP, Beijing, May 12, 2010

XENON100 Collaboration

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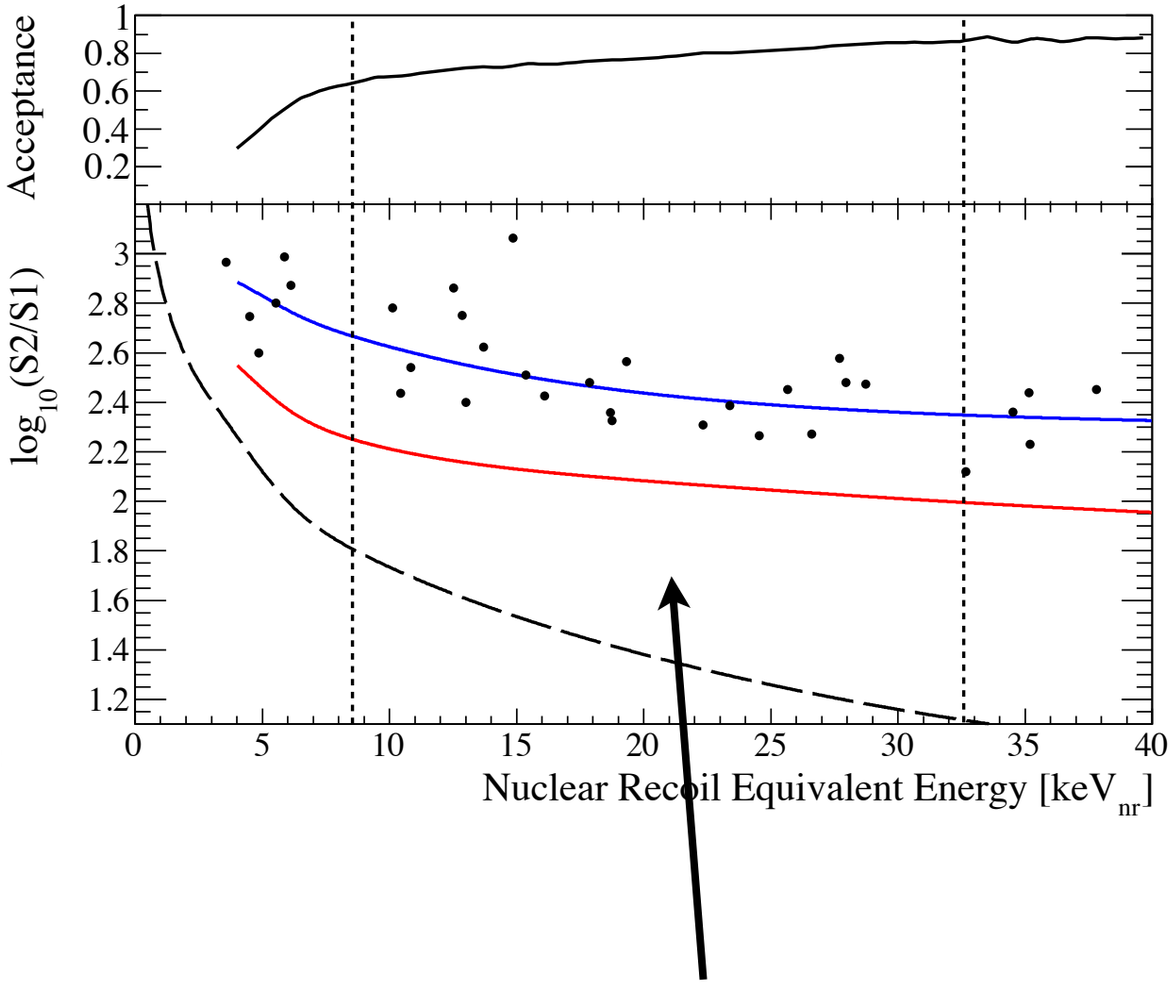
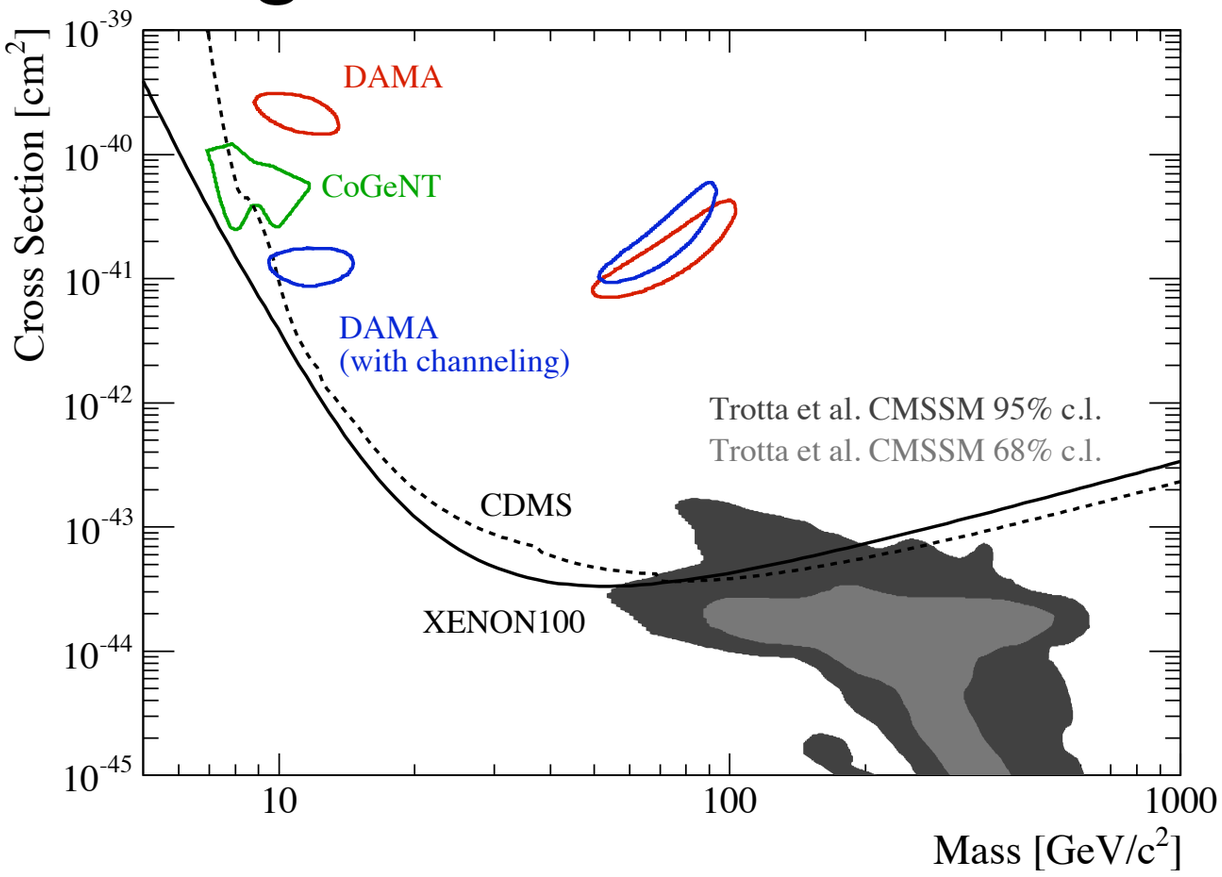
The first dark matter search results from XENON100

11.2 live-day x 40 kg data



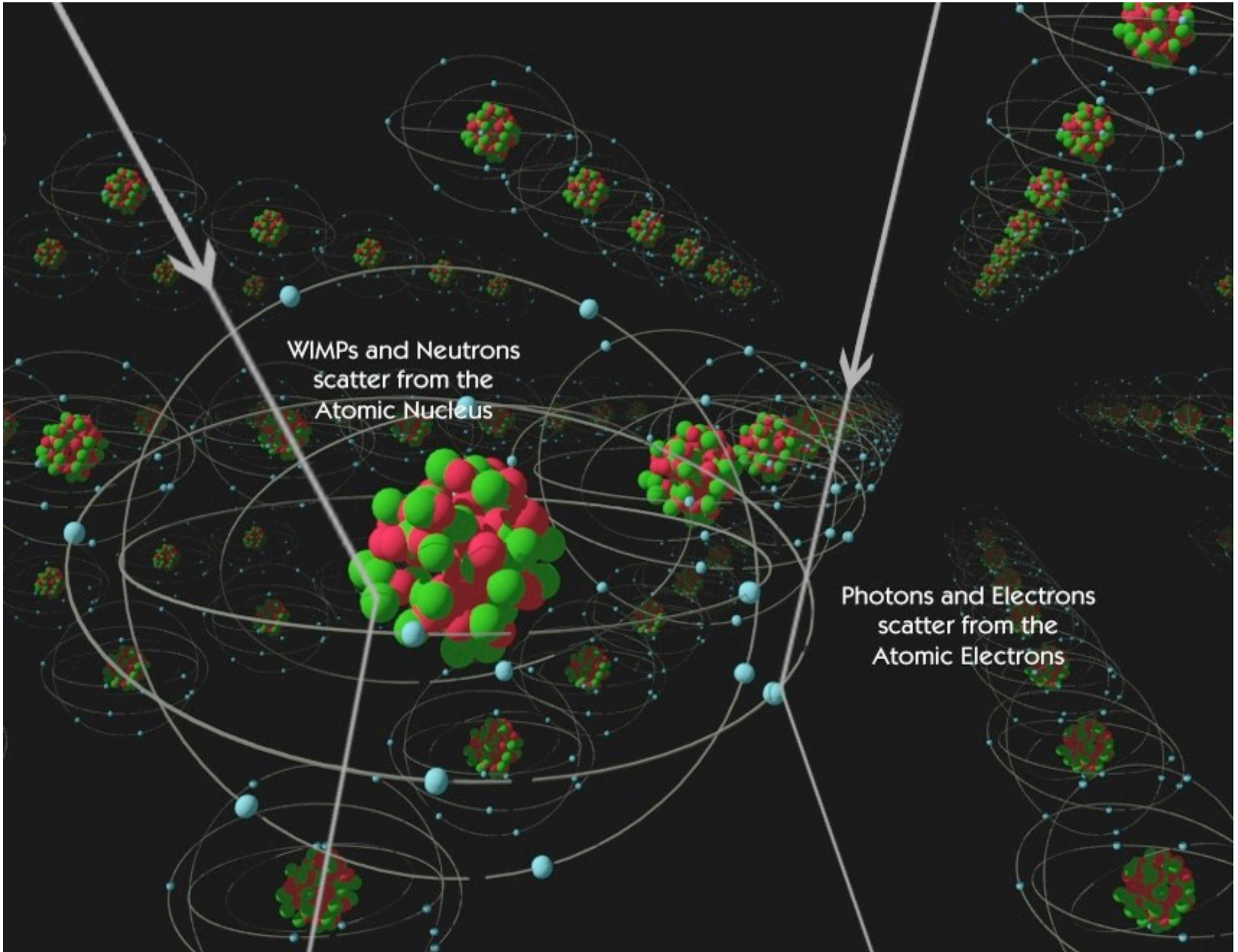


no candidate events
in the search window

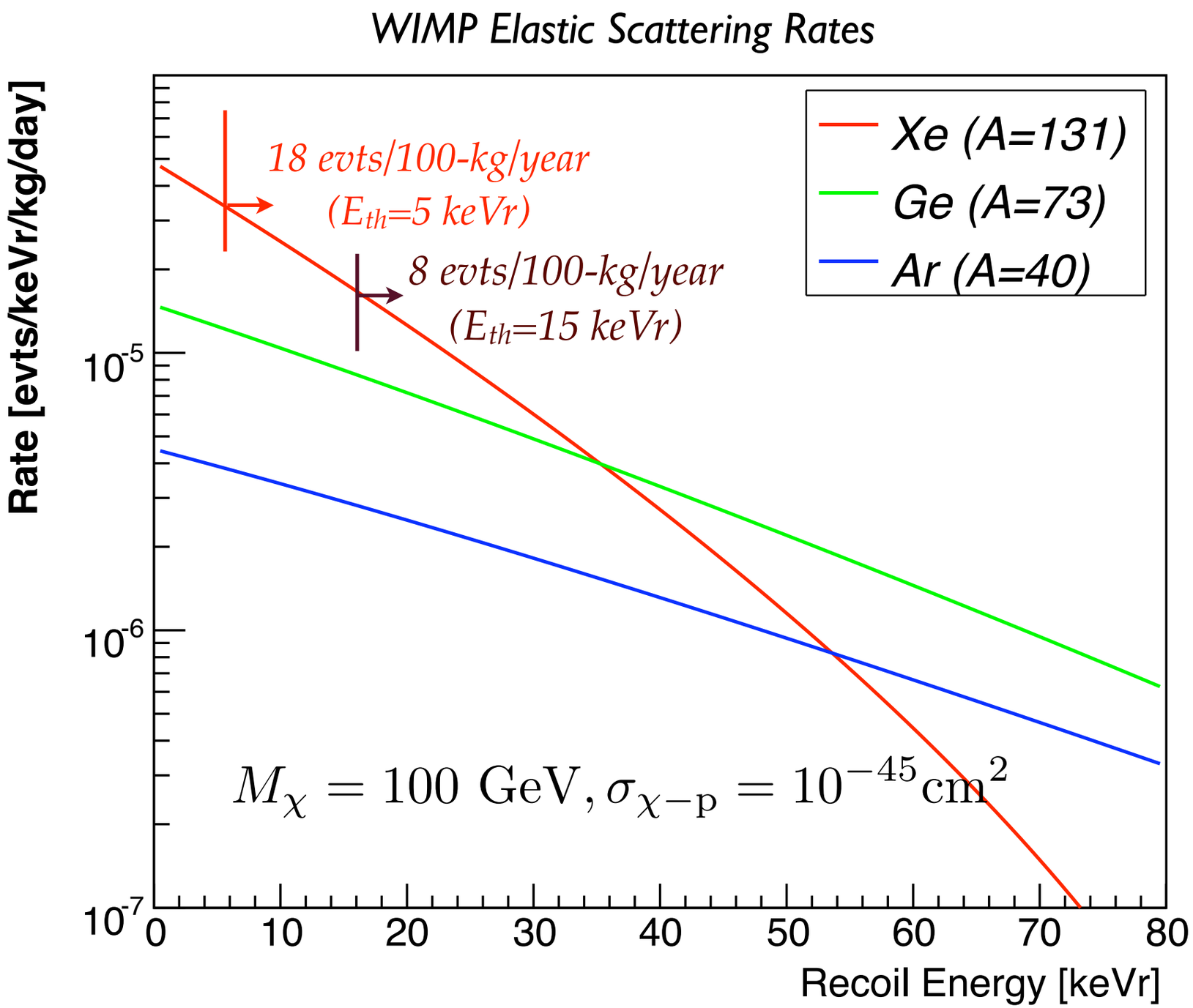
improving upper limits to
exclude more parameter space

arXiv:1005.0380

Direct Dark Matter Detection



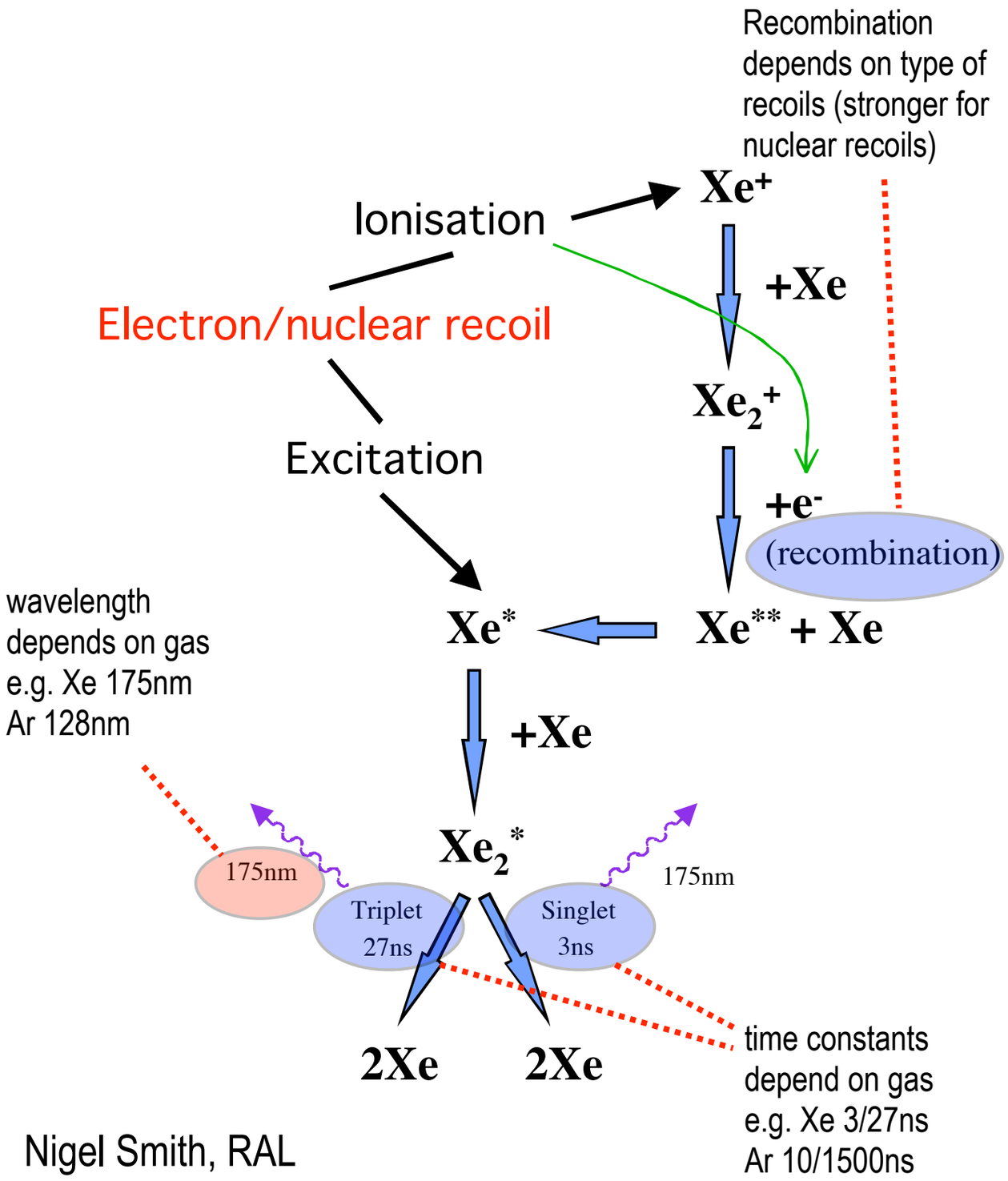
Requirements for Direct DM Detection



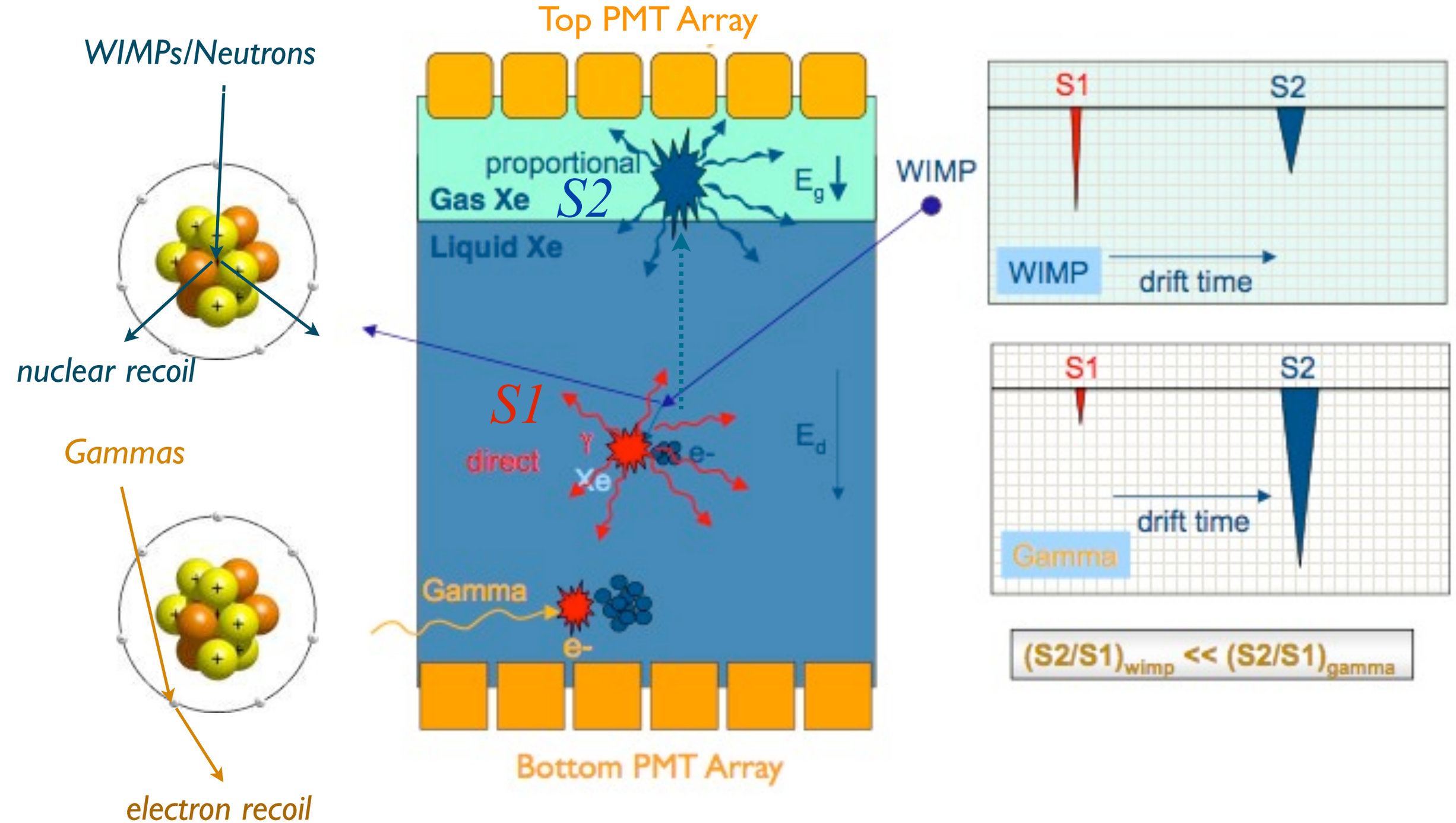
Large target mass & *low threshold* & *ultra-low background*

Liquid Xenon for Dark Matter Search

- High scintillation yield (50,000 photon/ MeV), relative easy detection of the 175 nm light, almost intrinsic transparent → low energy threshold
- Available in large quantity ($1000/kg) and scalability → large mass
- ”Kr-free” Xe available commercially and can be further removed by purification → intrinsic background free
- discrimination between background (mostly electron recoils) and signal (nuclear recoils) events → more than 99.5% background events are removed
- self-shielding → further bkg reduction



Two-phase Xenon Detectors for Dark Matter Detection



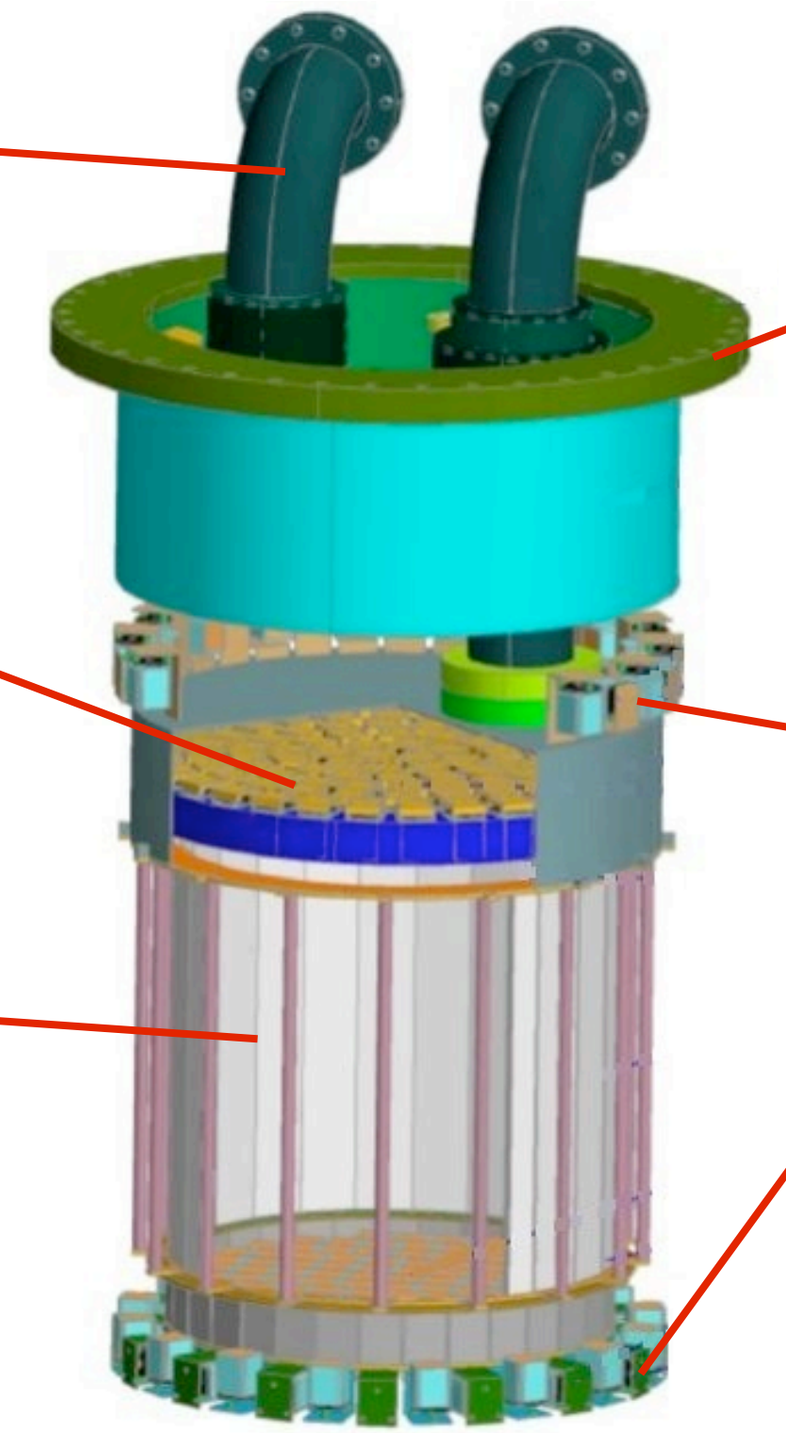
XENON100 Detector Design

Heavy flanges & cooling tower moved outside the shield

242 ultra-low radioactive & high QE PMTs

170 kg LXe total
60 kg in target

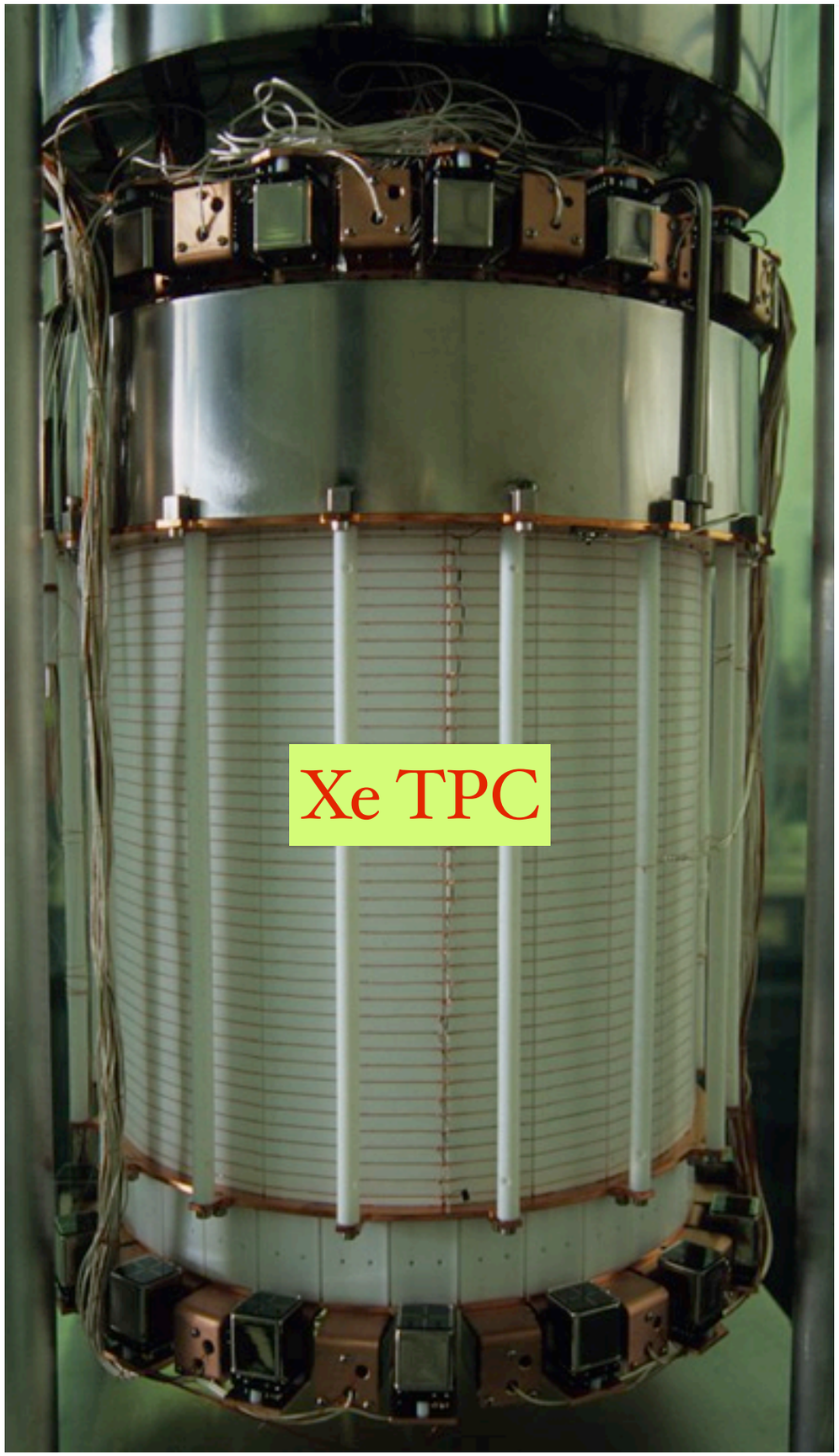
Improved cryogenics

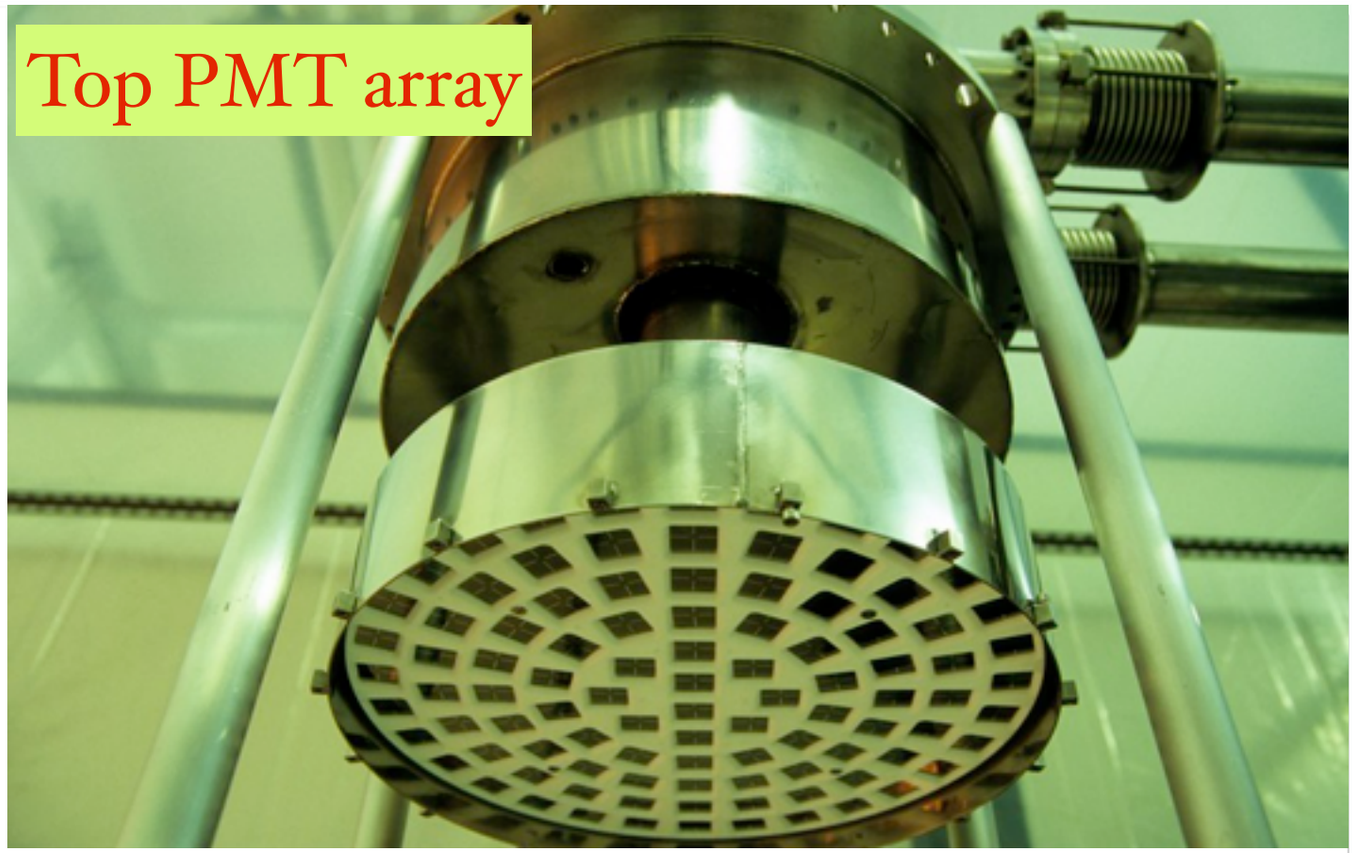


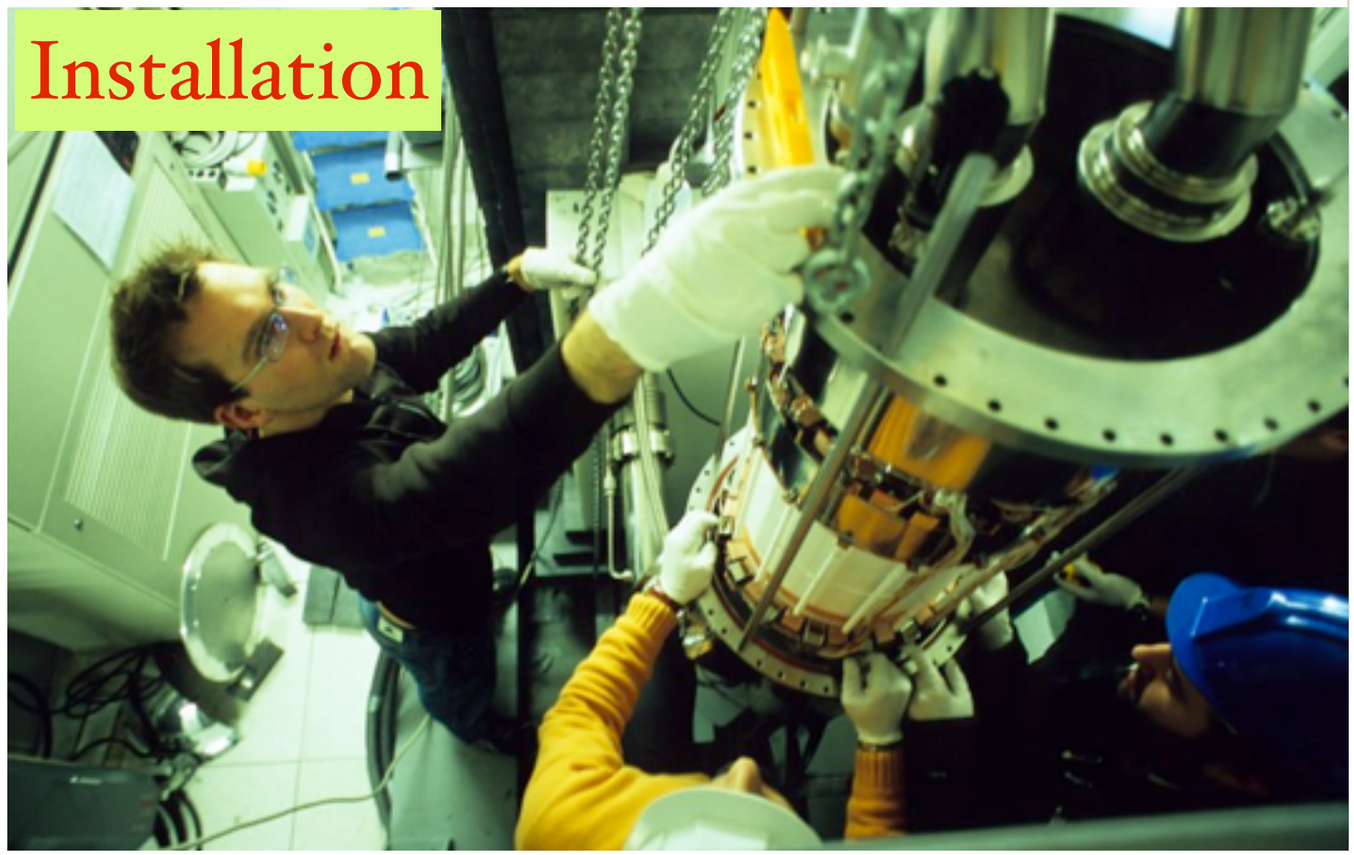
Minimum weight of low-background SS

Active veto

Improved passive shielding


Xe TPC


Top PMT array


Installation

more detector photos at:
http://xenon.astro.columbia.edu/

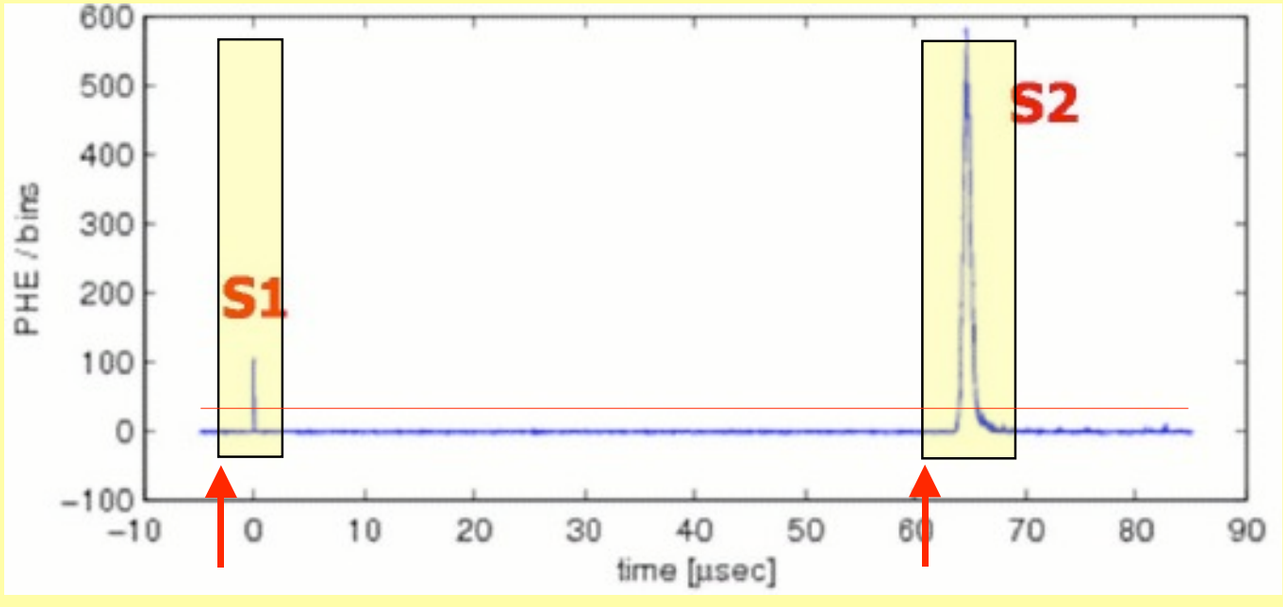
Data Acquisition System

Requirements:

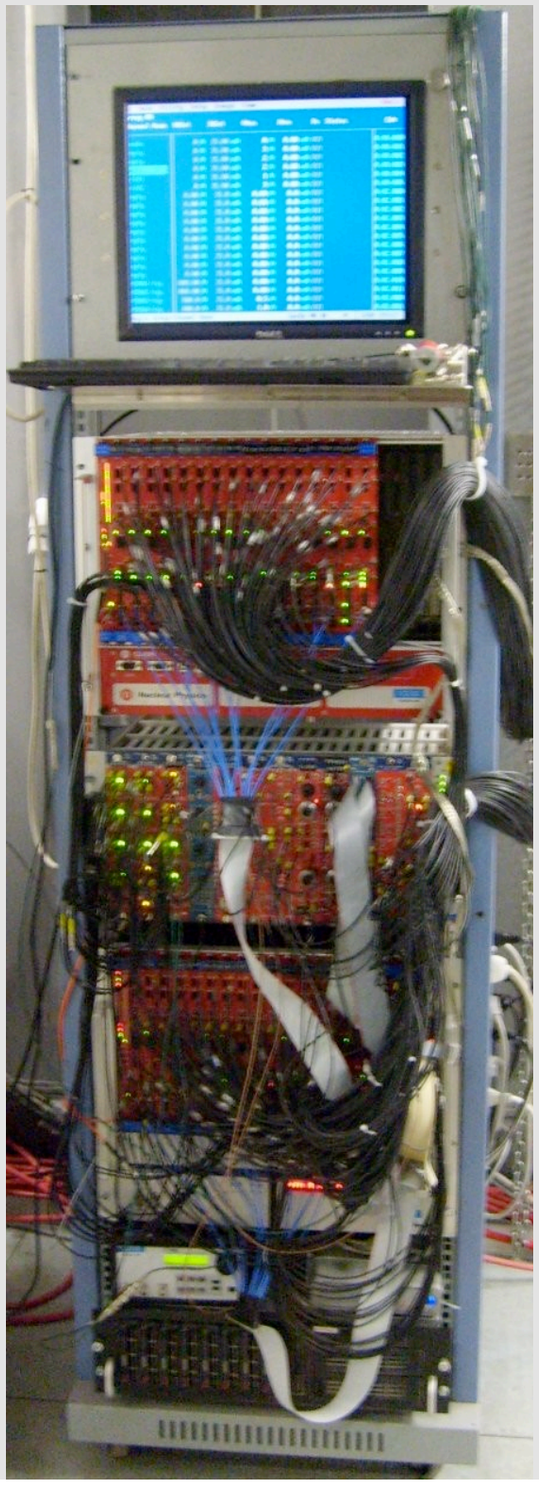
- digitize full waveform (320µs) of 242 PMTs
- no deadtime
- high rate capability for calibration

CAEN V1724 Flash ADC: 14bit, 100MHz

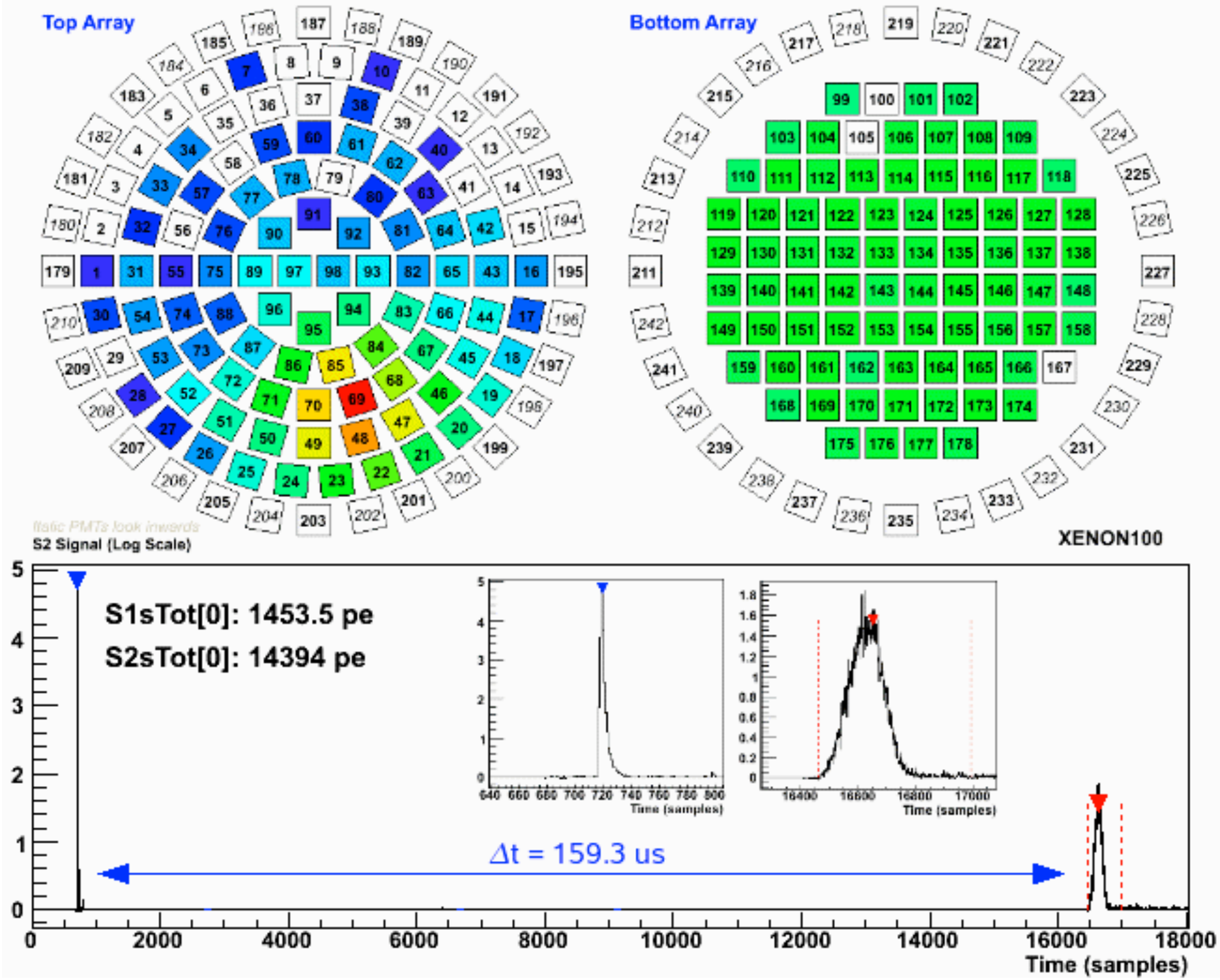
- circular buffer → no deadtime
- on board FPGA: *Zero Length Encoding*



⇒ calibration rates >50 Hz possible

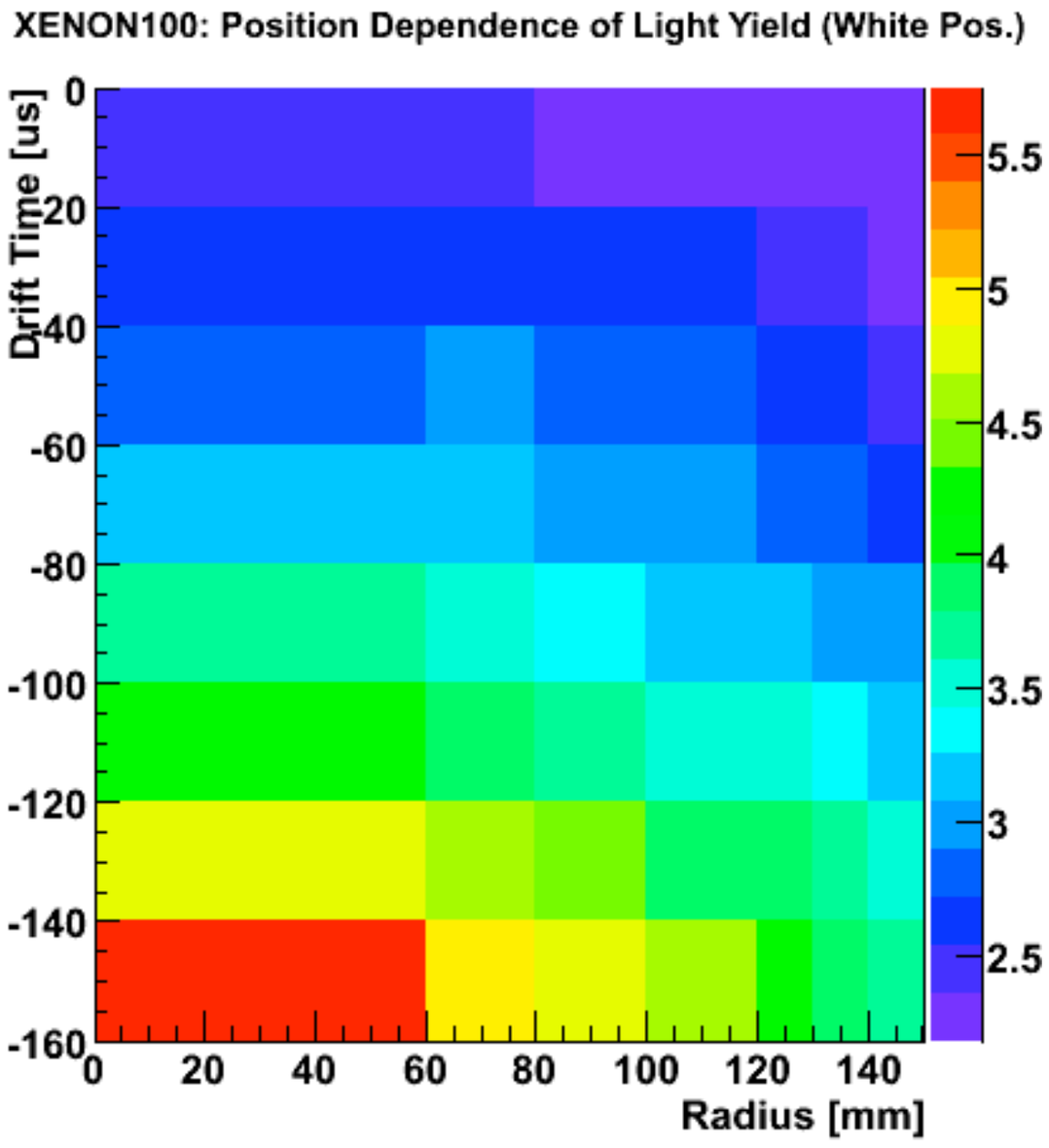


A typical event from XENON100



position dependence of signals

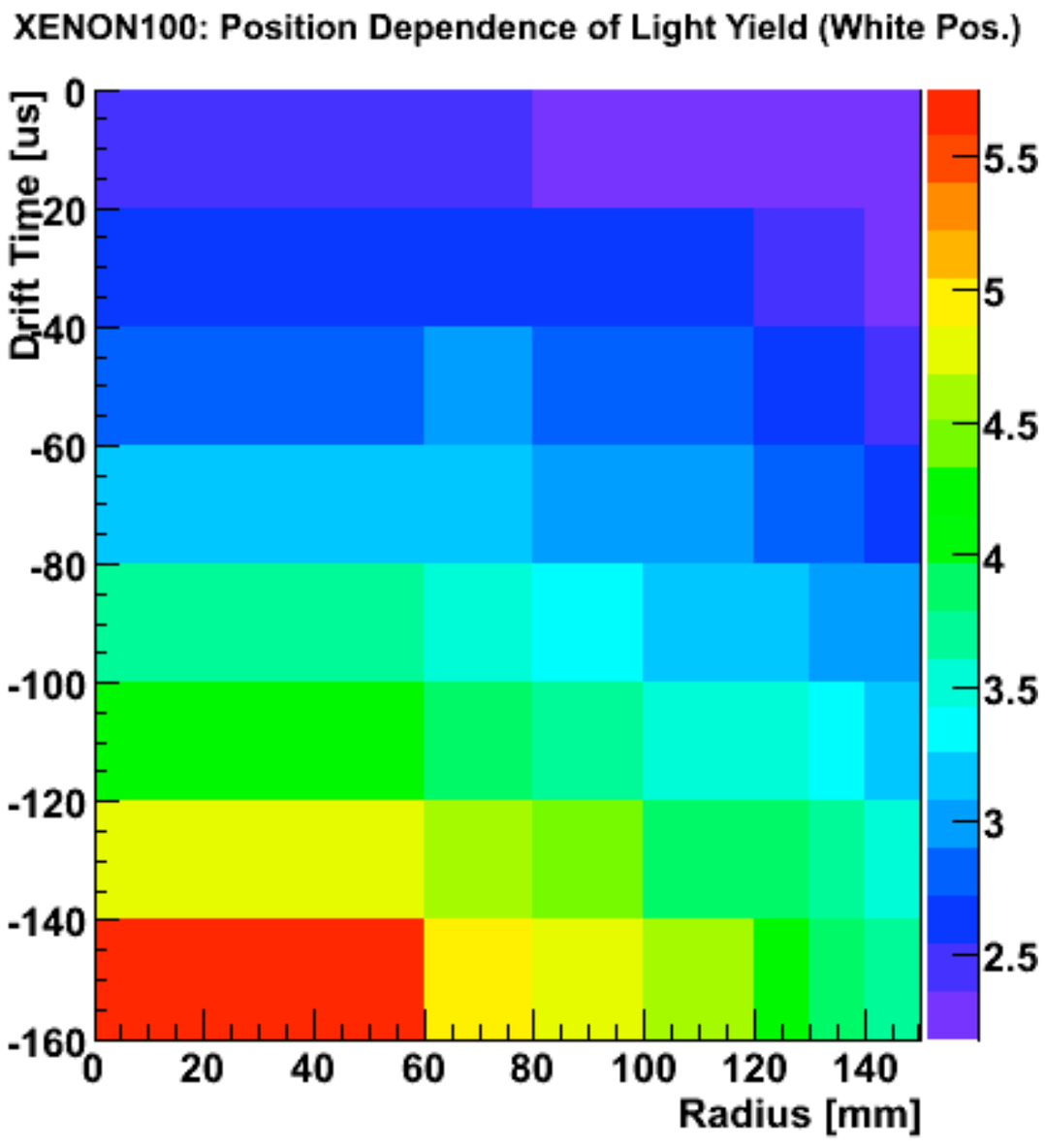
S1

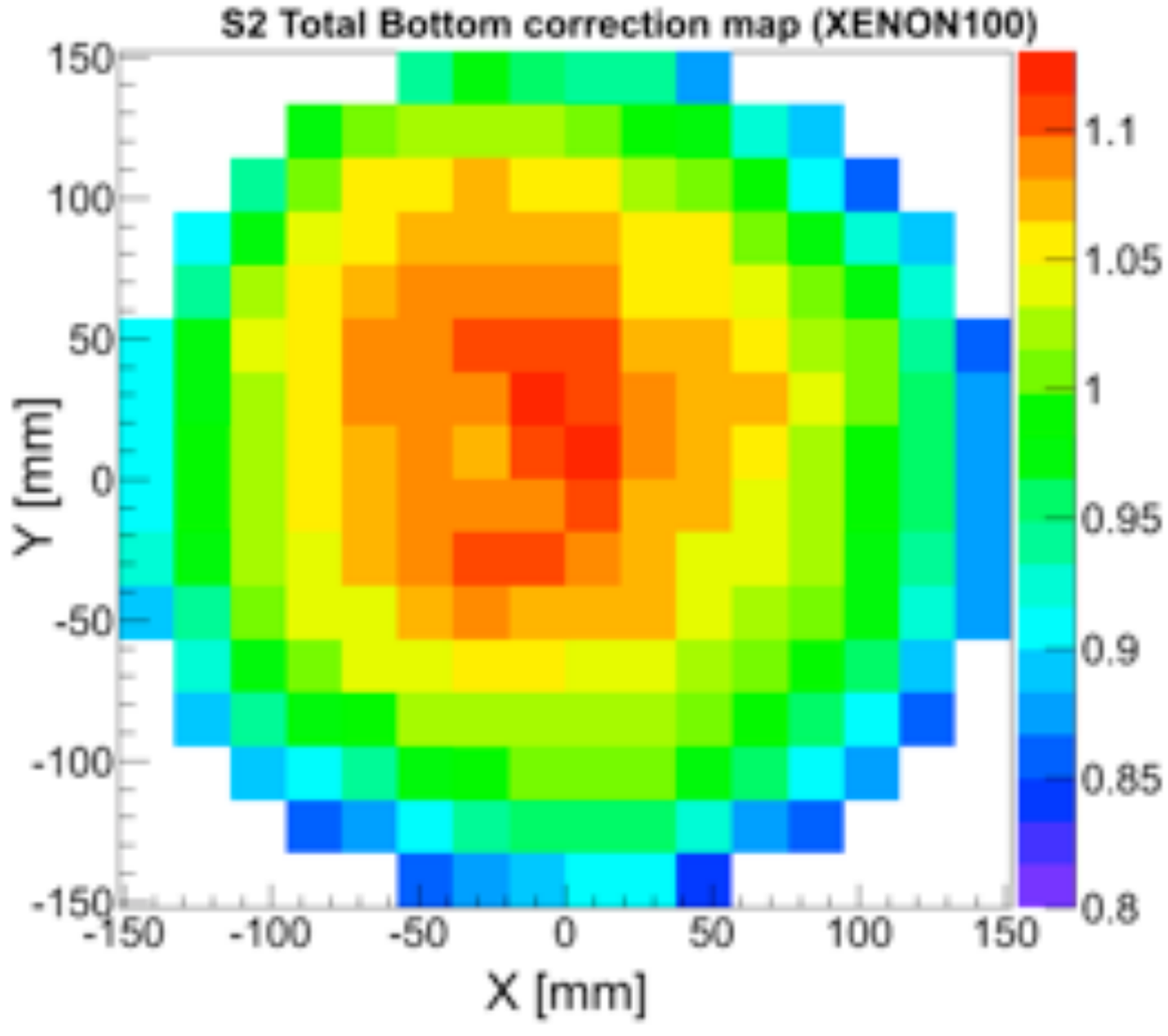


position dependence of signals

S1

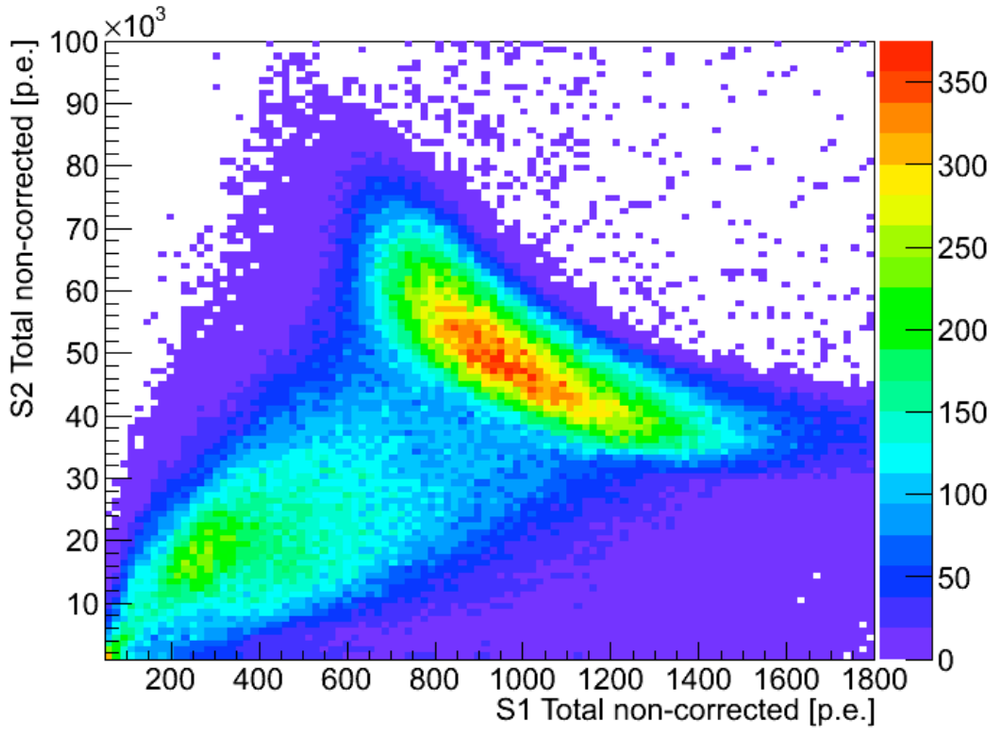
S2



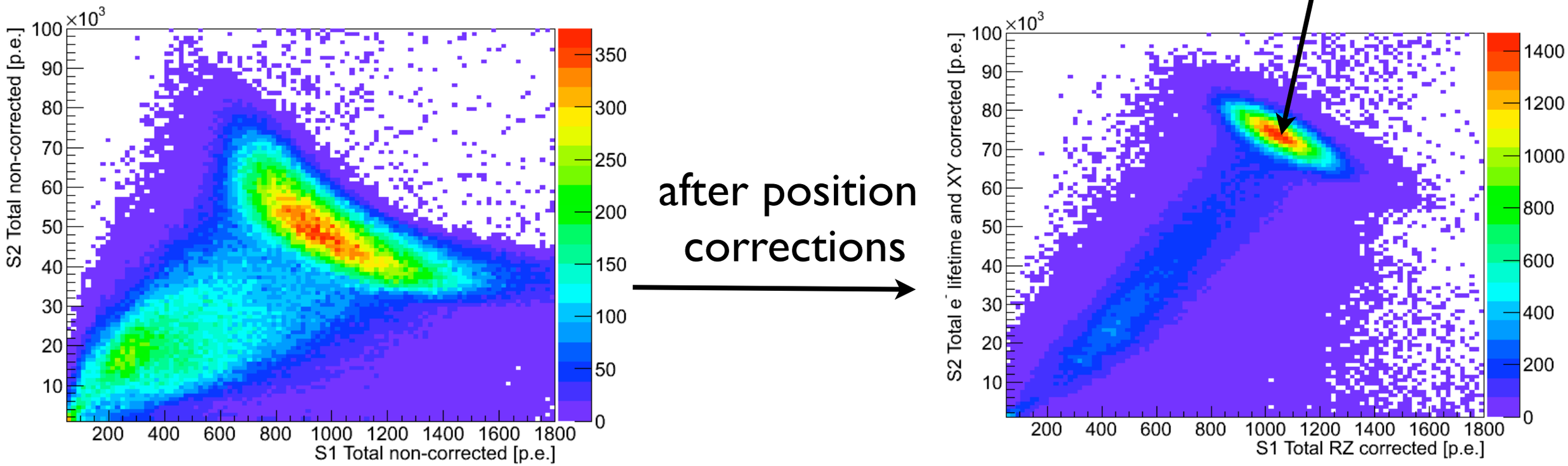


position corrections

Cs137 (662 keV)

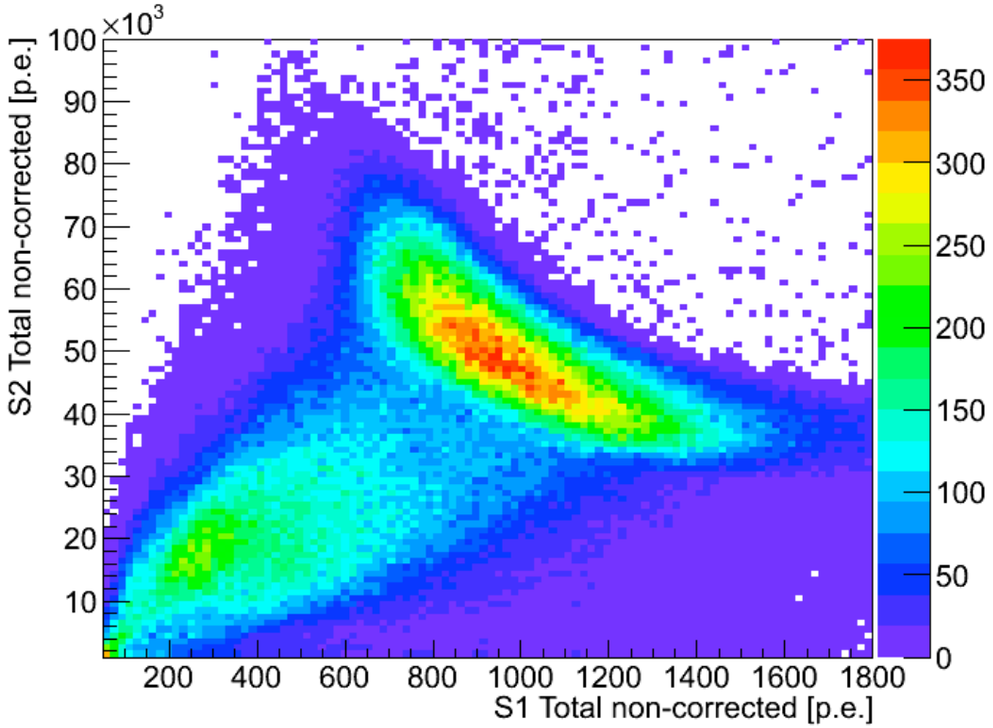


position corrections

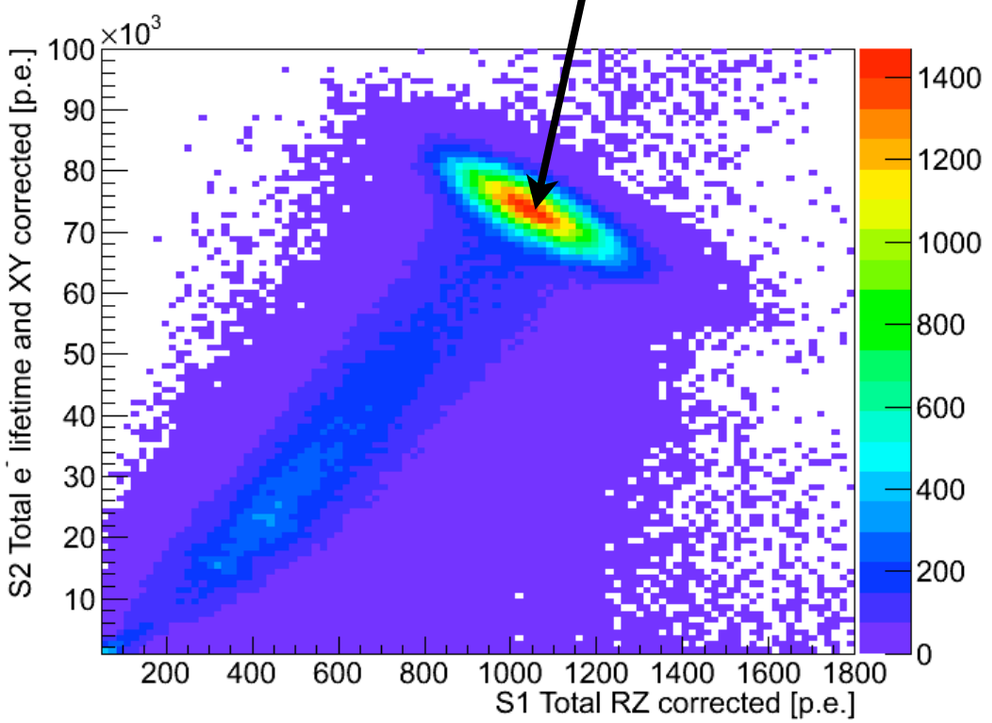


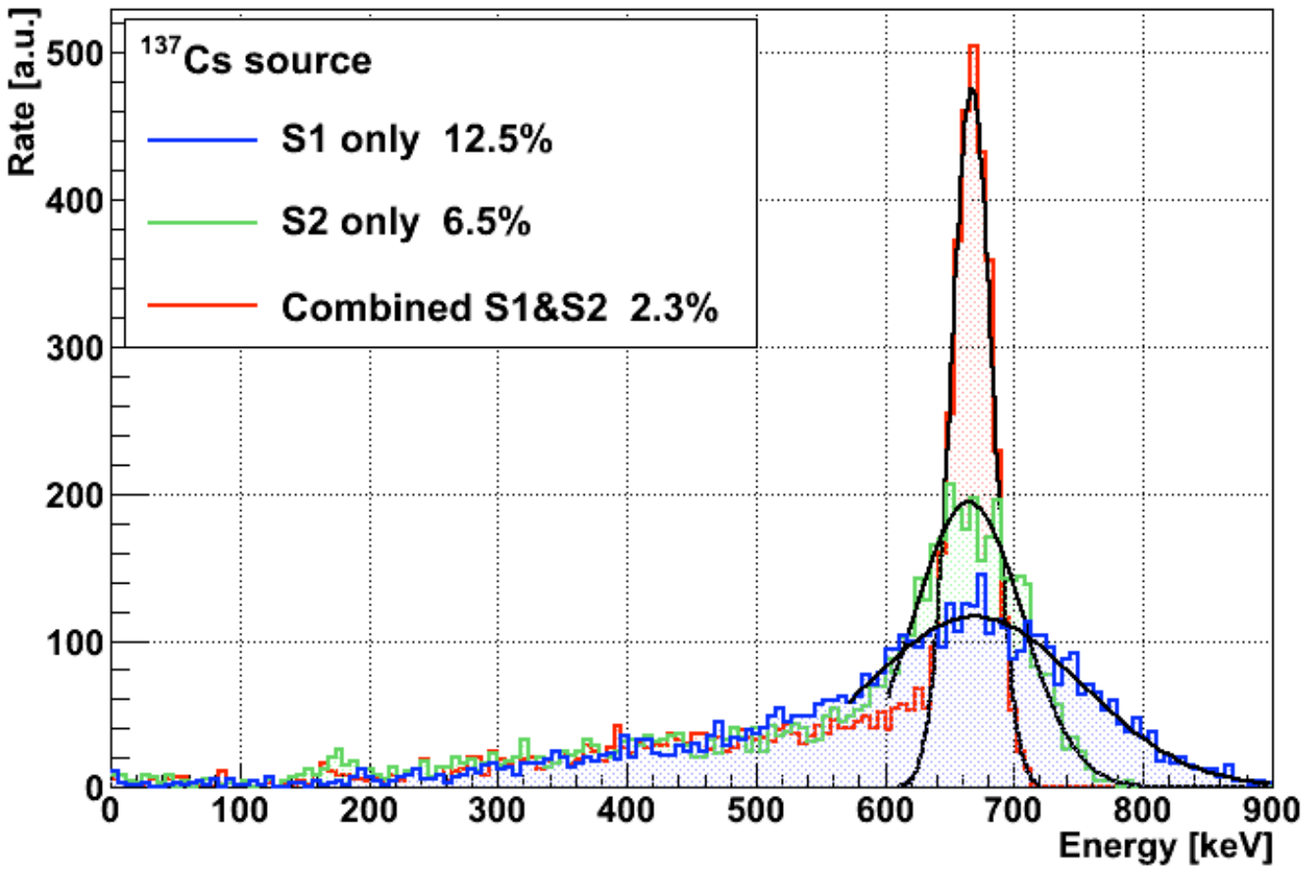
position corrections

Cs137 (662 keV)

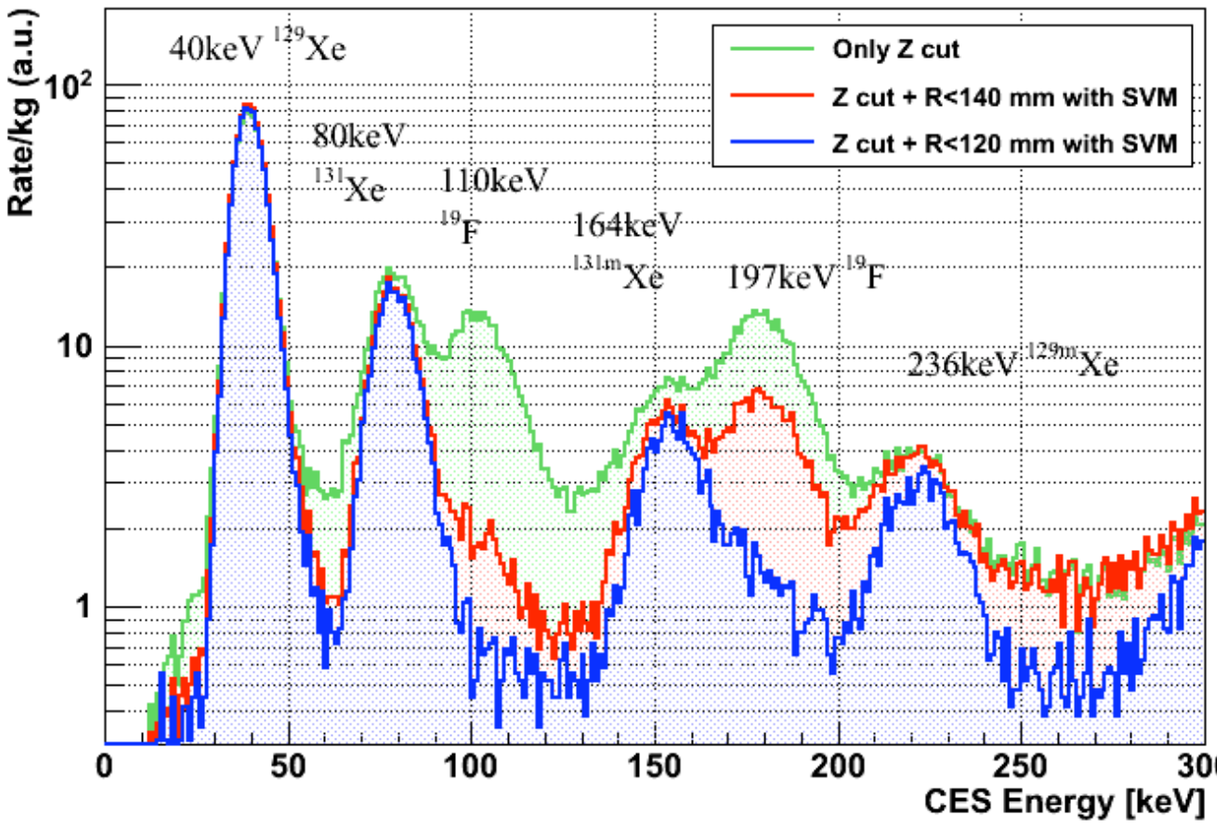


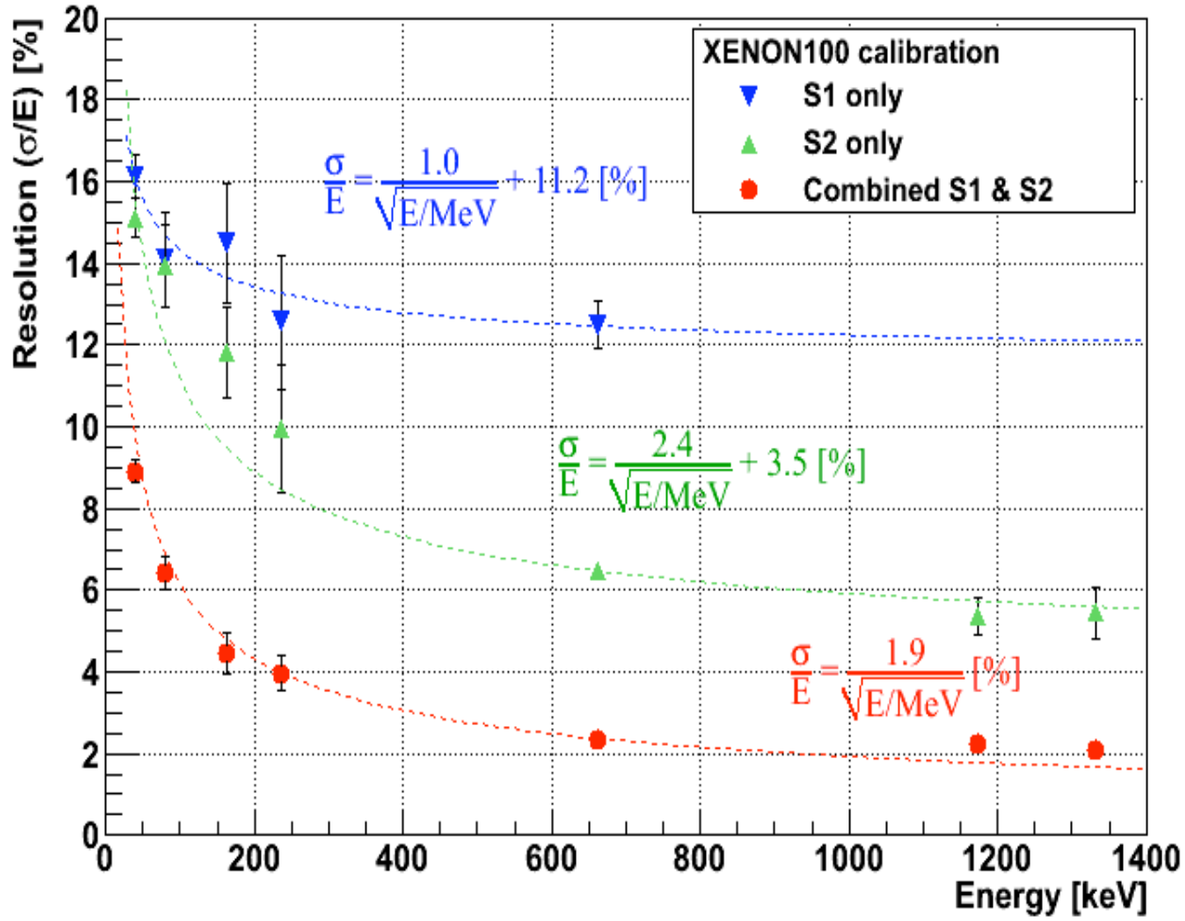
after position corrections





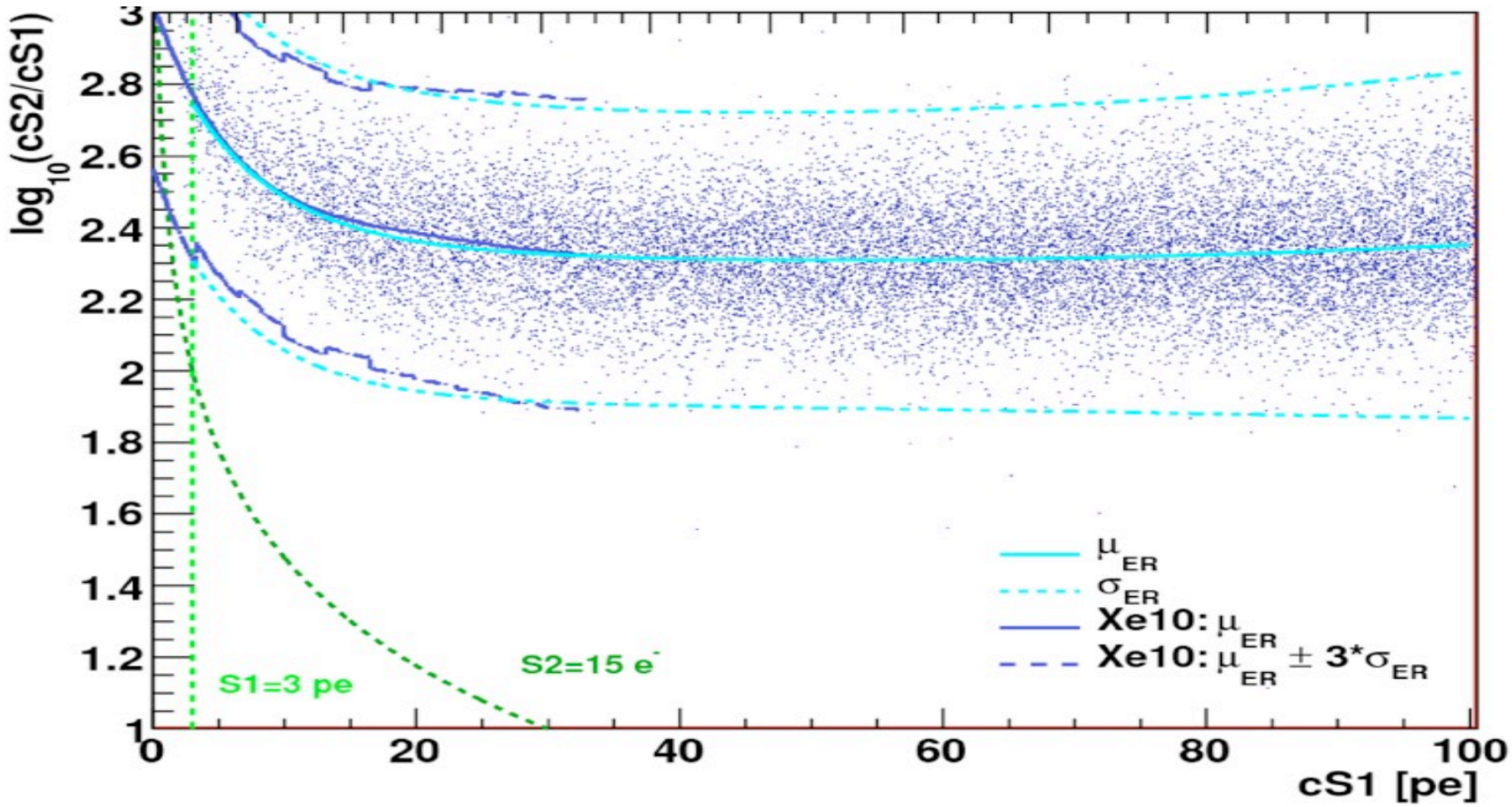
Response to different energy gammas



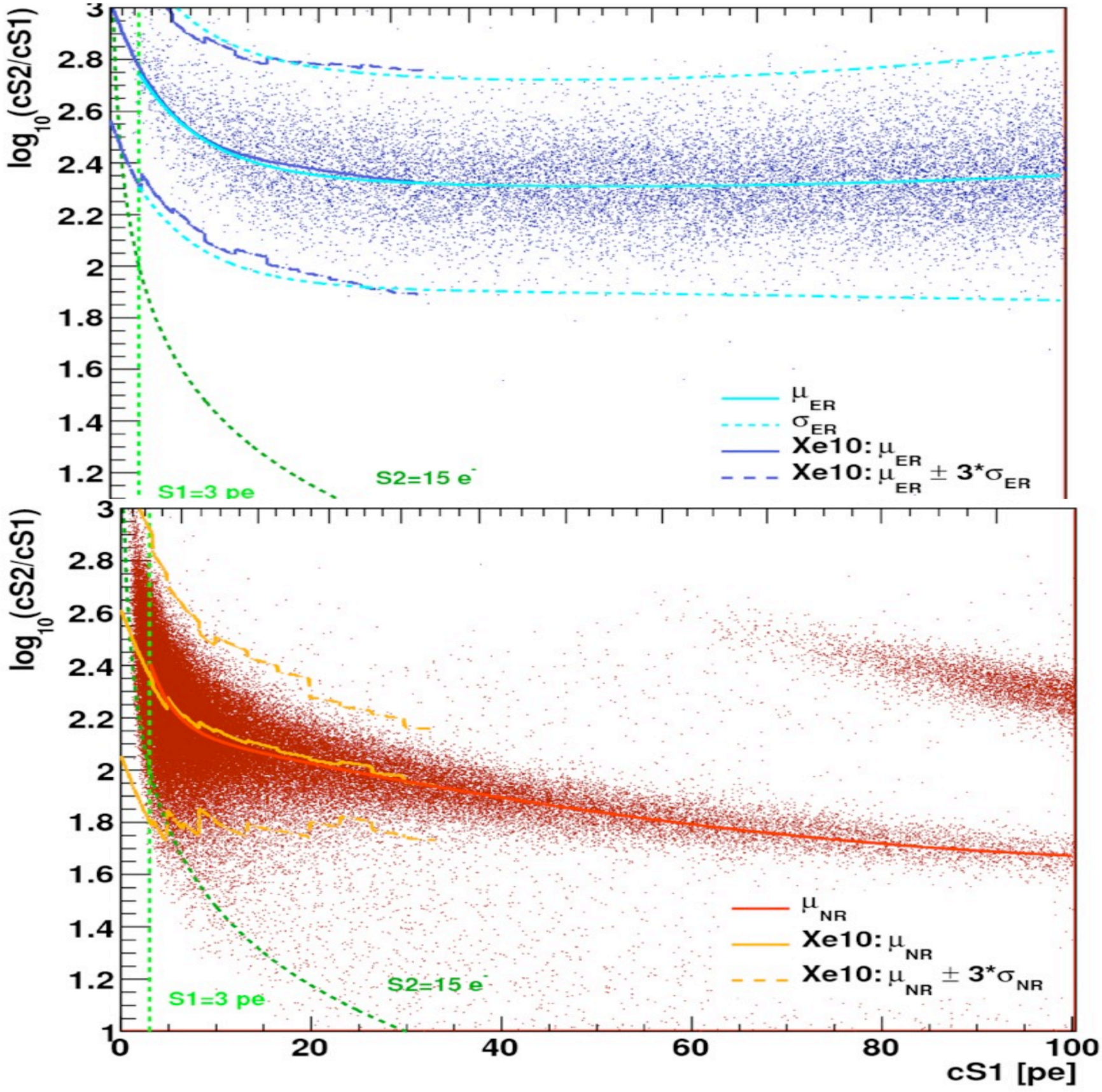


the improvement of energy resolution in LXe makes it an interesting medium for other physics: neutrinoless double beta decay searches, or practical applications..

n/gamma discriminations

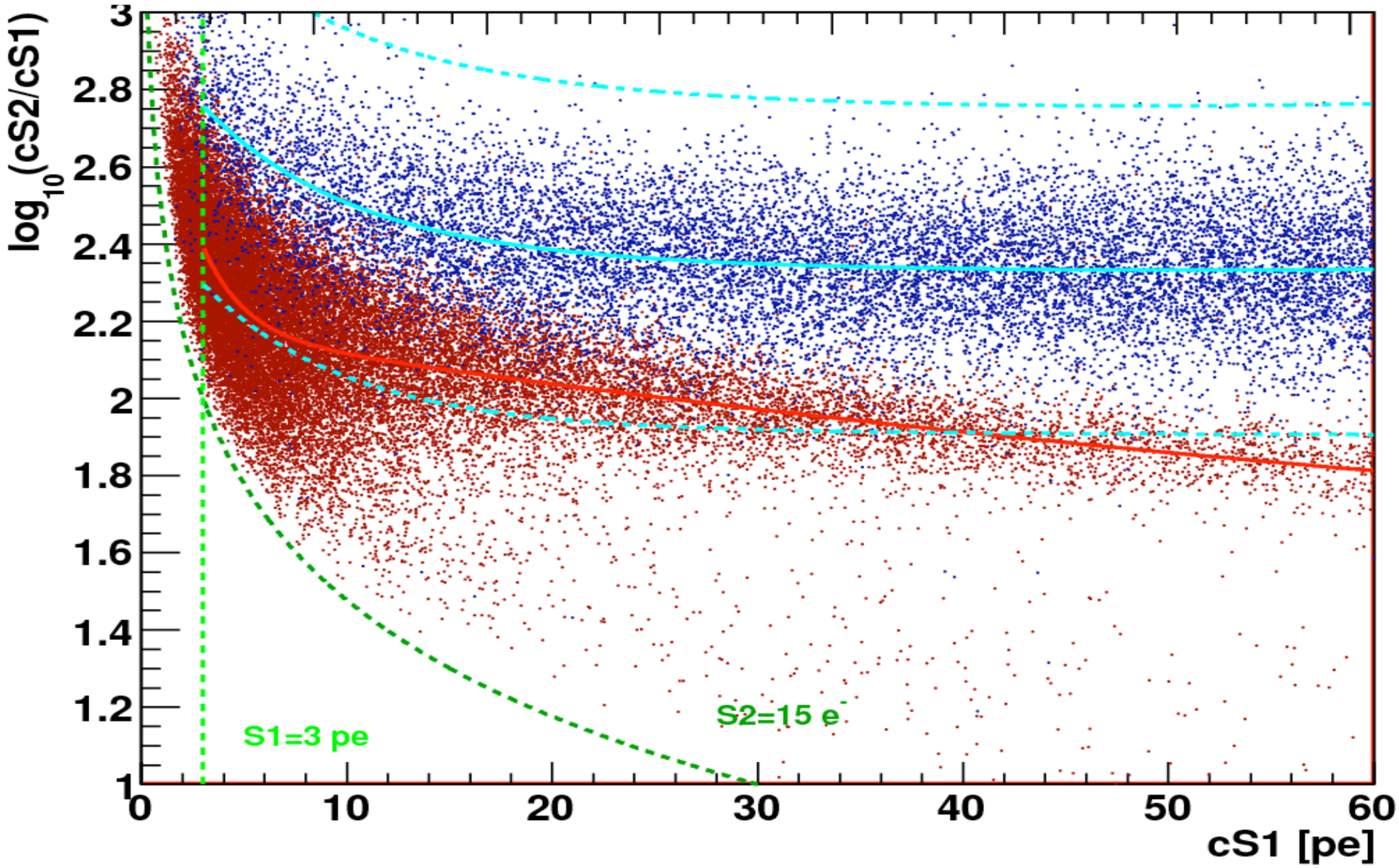


n/gamma discriminations



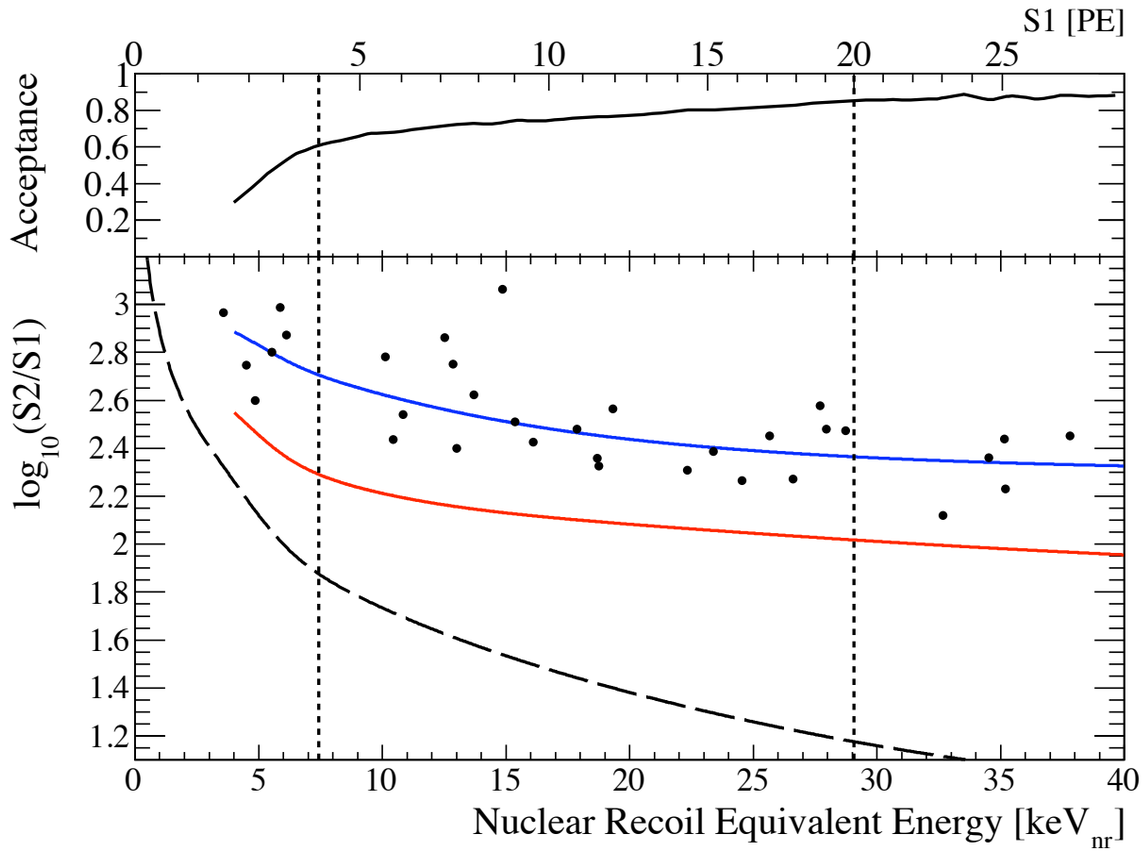
K. Ni (SJTU)

gamma rejection



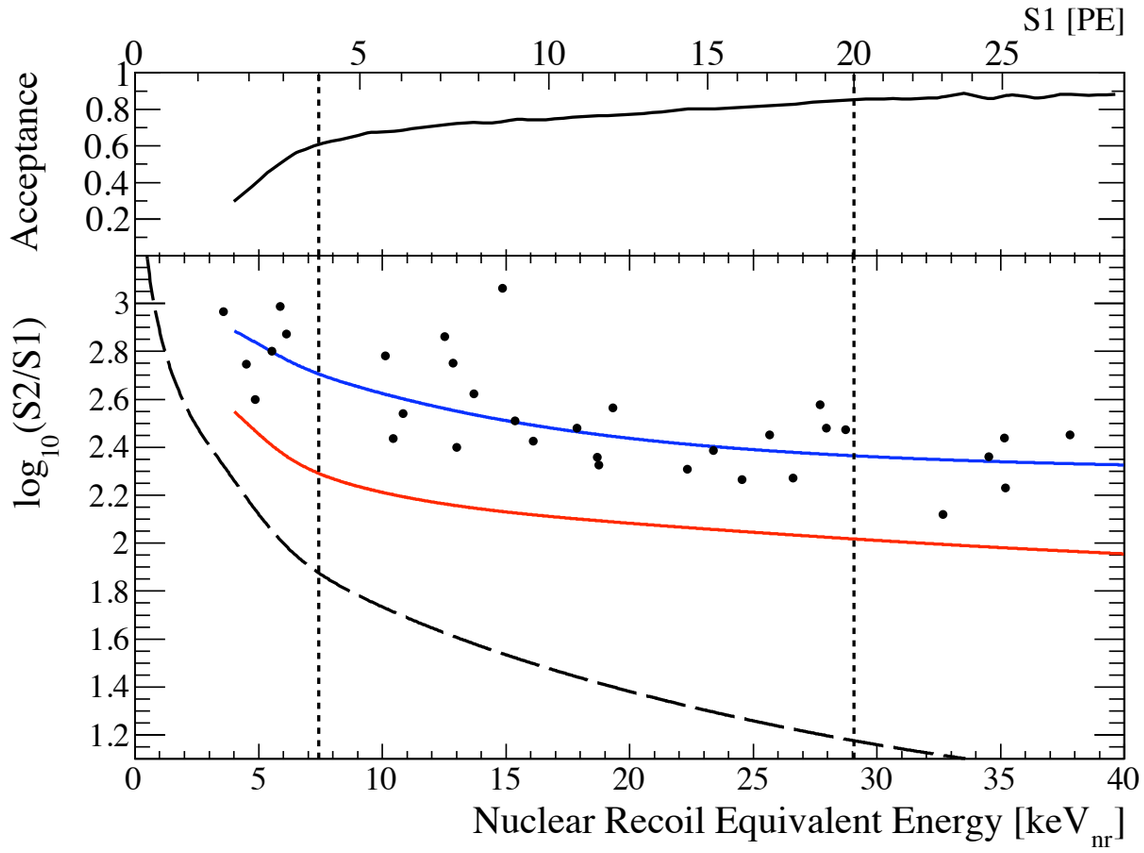
more than 99% gamma events are rejected, while keeping ~50% of nuclear recoil events

S2/S1 rejection

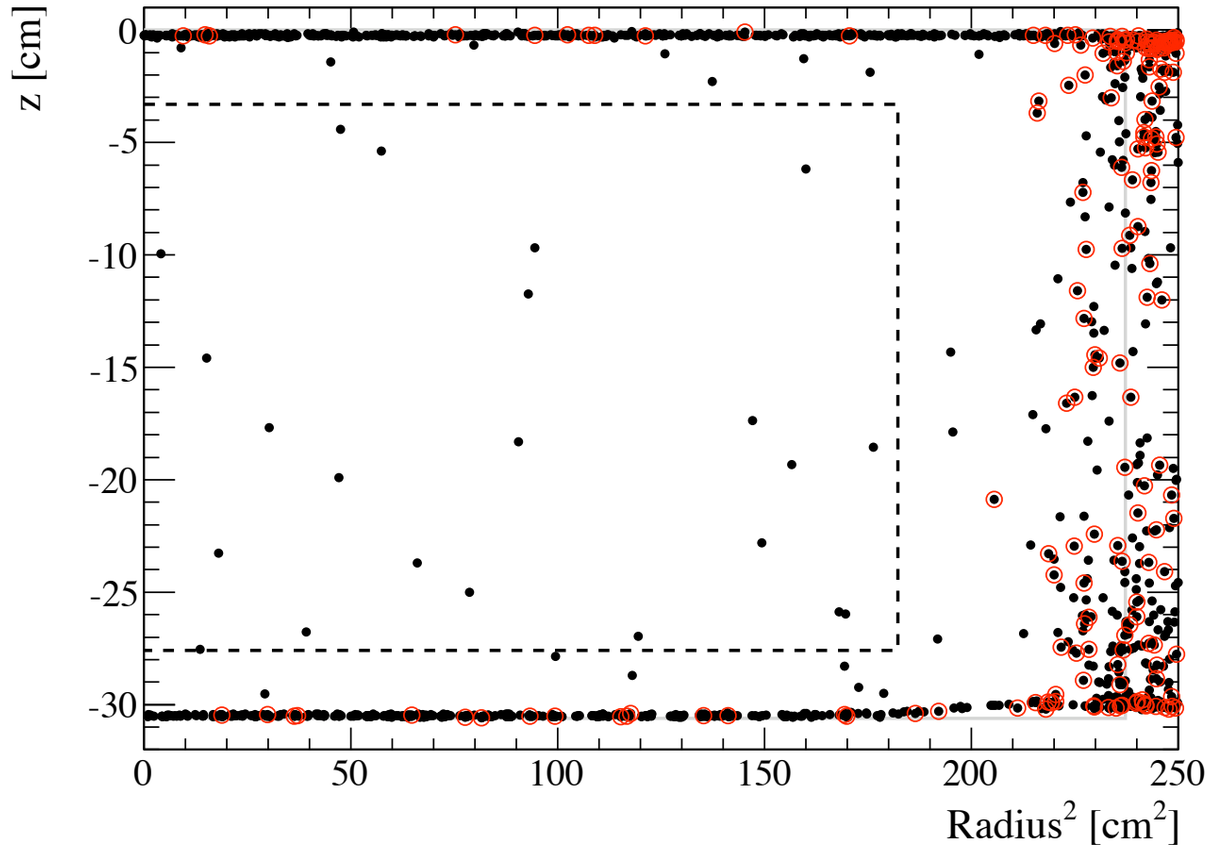


background rejection in the WIMP search run

S2/S1 rejection

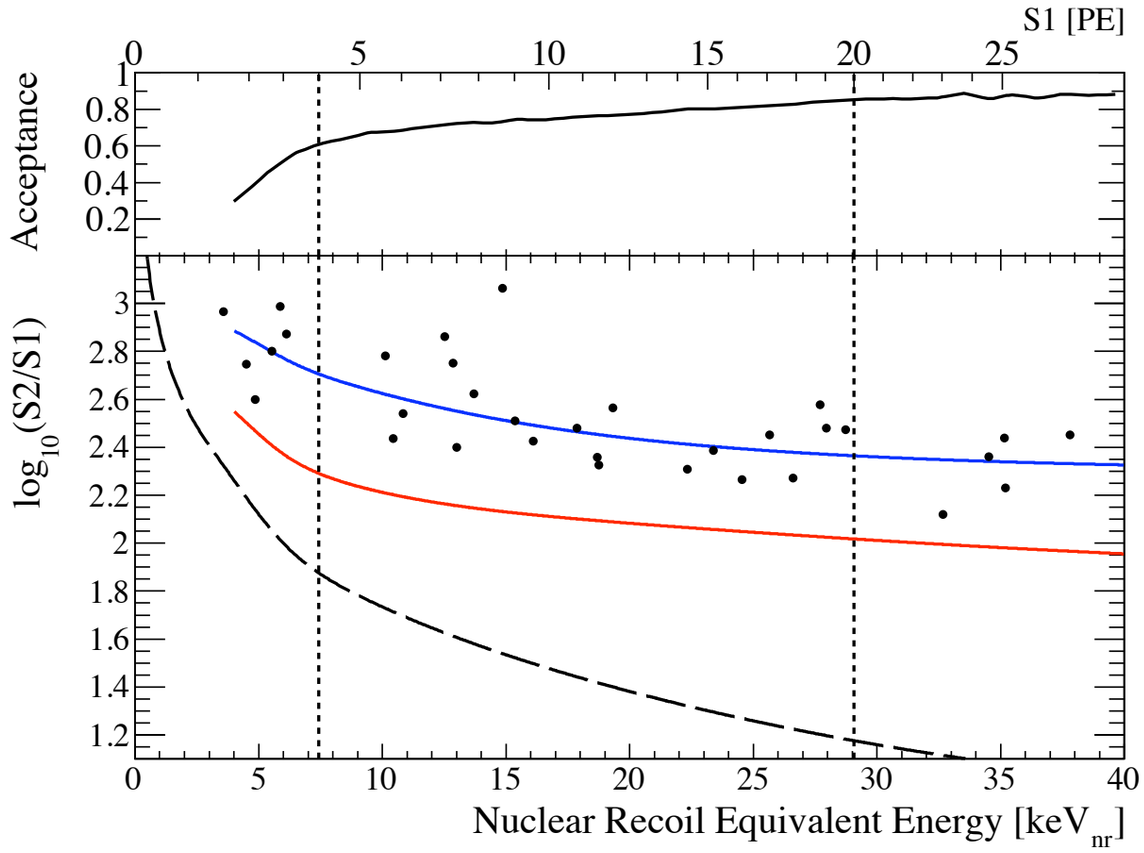


fiducial cut

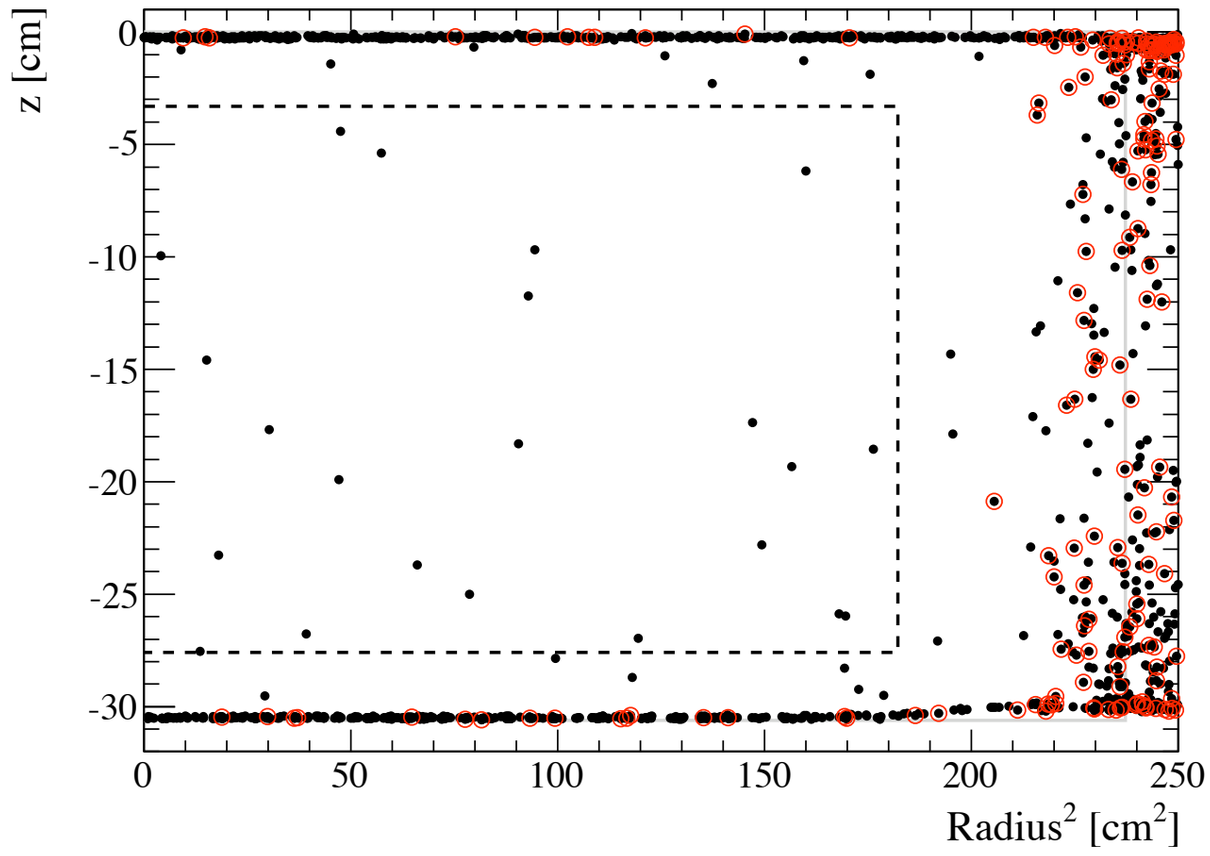


background rejection in the WIMP search run

S2/S1 rejection



fiducial cut



The power of 3D position sensitivity + S2/S1 gamma rejection make XENON100 one of the most sensitive dark matter experiments.

Energy Calibration: determine the energy of nuclear recoils

energy of nuclear recoils (NRs)

measured signal in # of pe

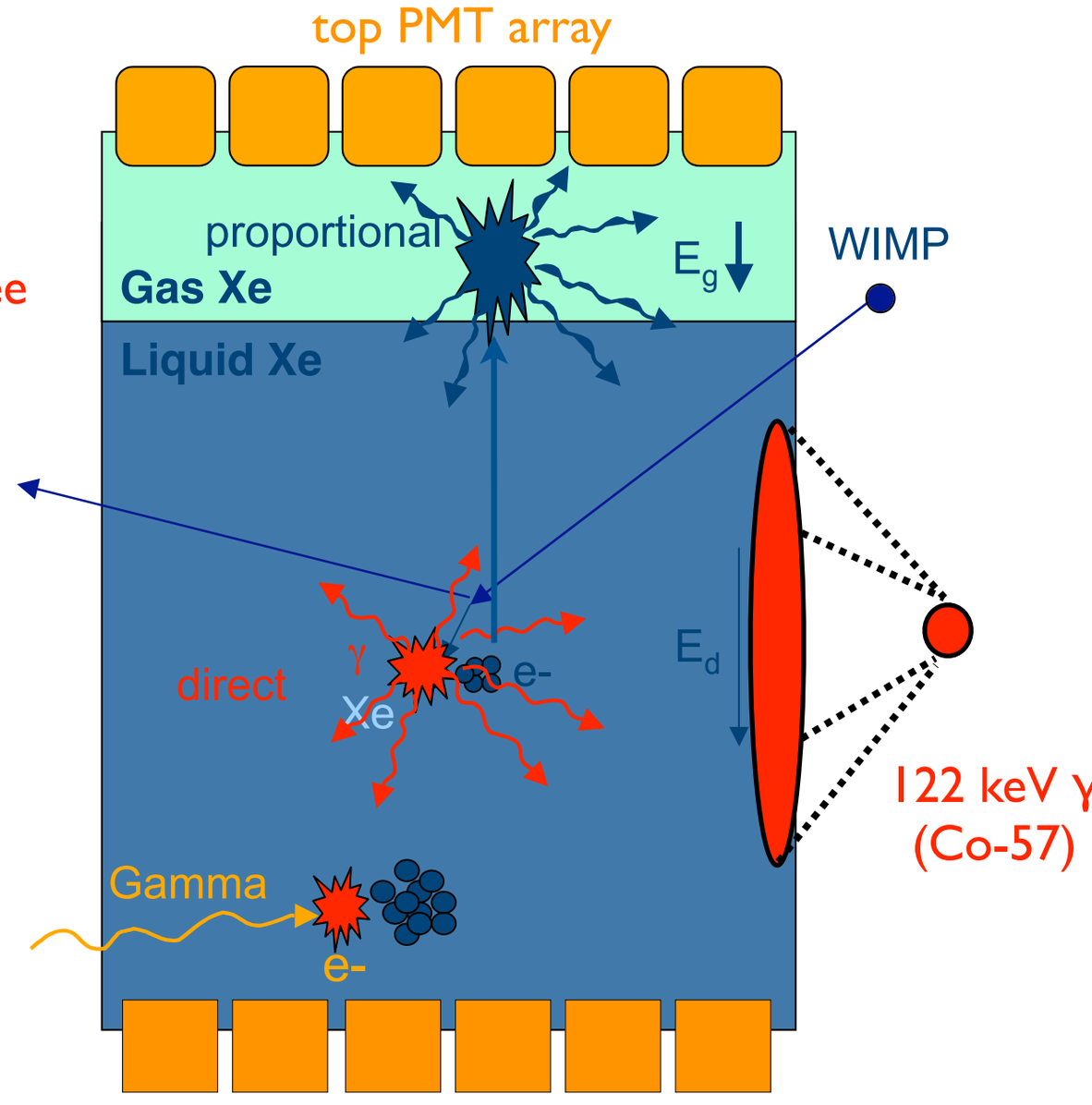
light yield for 122 keV γ in pe/keVee

$$E_{nr} = S1/L_y/\mathcal{L}_{eff} \cdot S_{er}/S_{nr}$$

relative scintillation efficiency of NRs to 122 keV γ's at zero field

quenching of scintillation yield for 122 keV γ's due to drift field

quenching of scintillation yield for NRs due to drift field



Global fit of Leff measurements