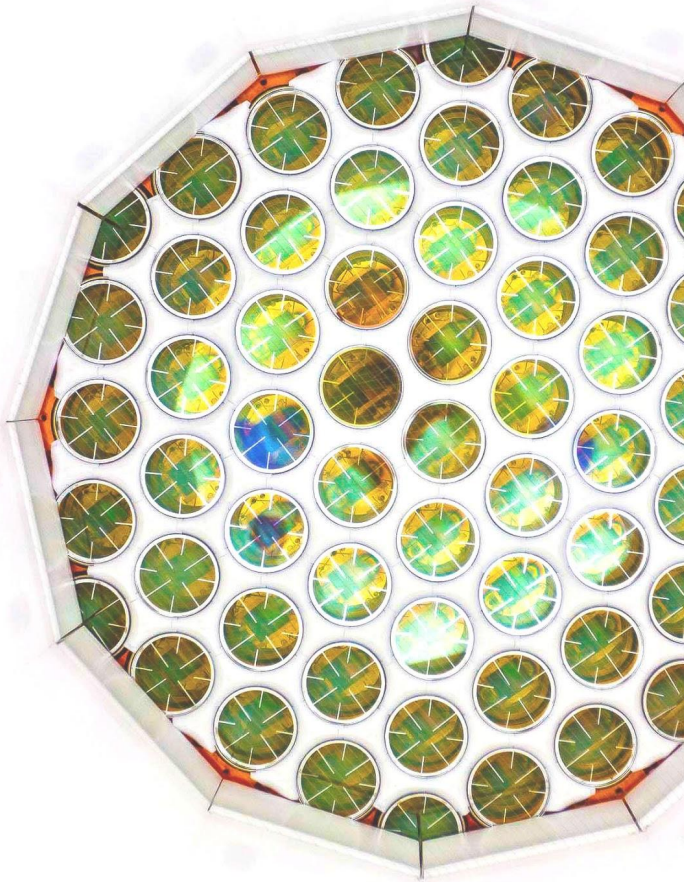

Updated analysis of the 2013 LUX dataset

Alastair Currie, Imperial College London

for the LUX collaboration

TAUP 2015-09-07

Imperial College London

The LUX Collaboration

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Evan Pease	Graduate Student
Brian Tennyson	Graduate Student
Lucie Tvrznikova	Graduate Student

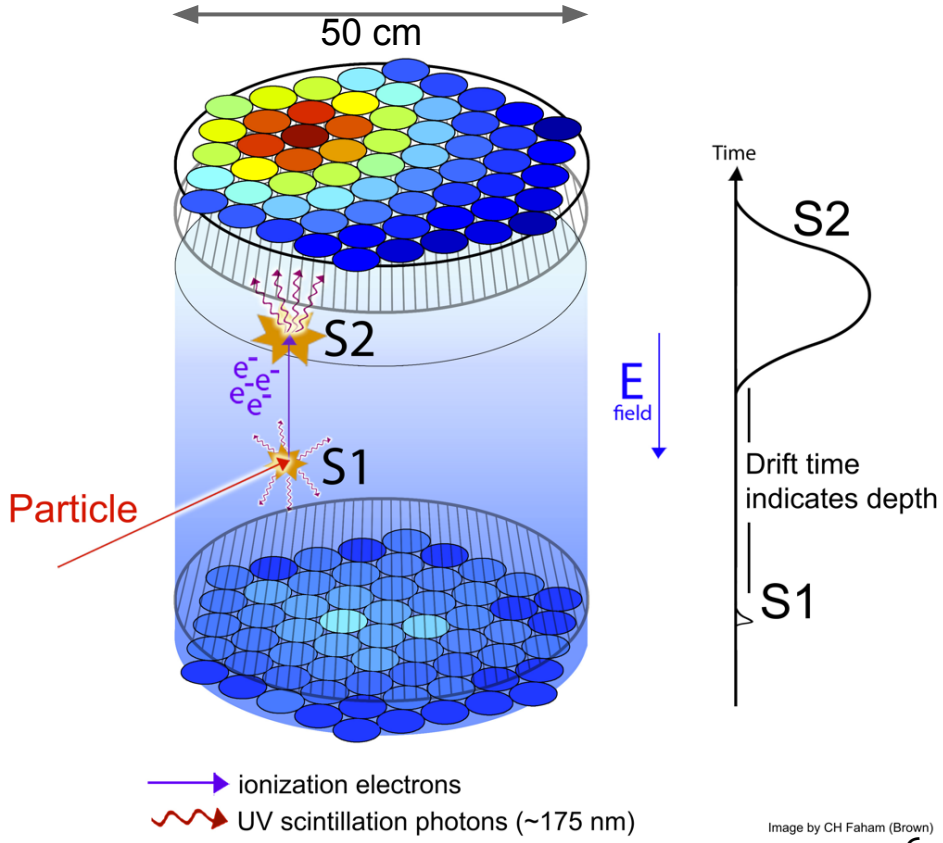
Contents

- LUX: signal, backgrounds and first results
- Updates in the new analysis
  - Estimators of light and charge
  - Calibrated event populations and thresholds
- Search data for the reanalysis, and status.

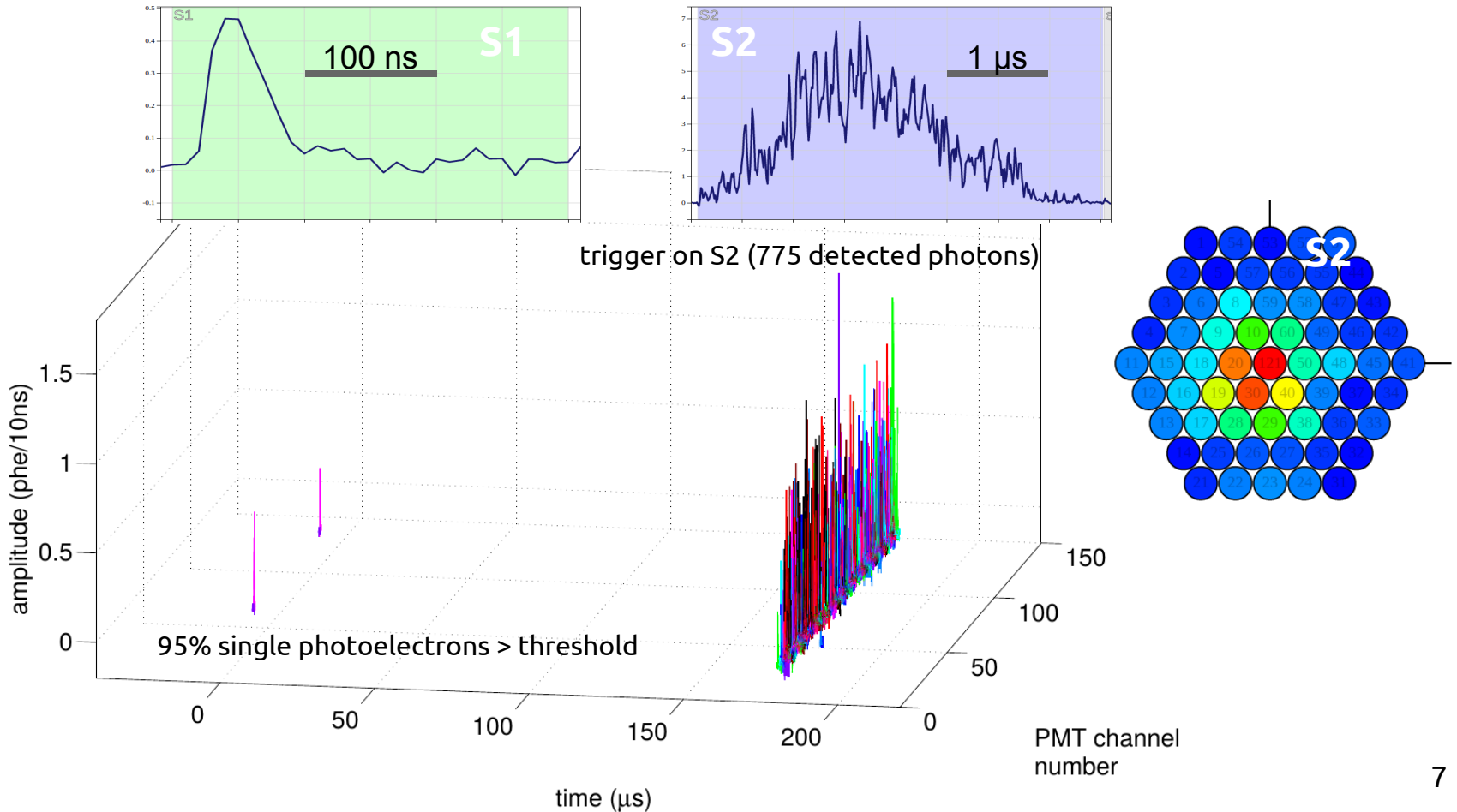
LUX

LUX, a two-phase Xe TPC

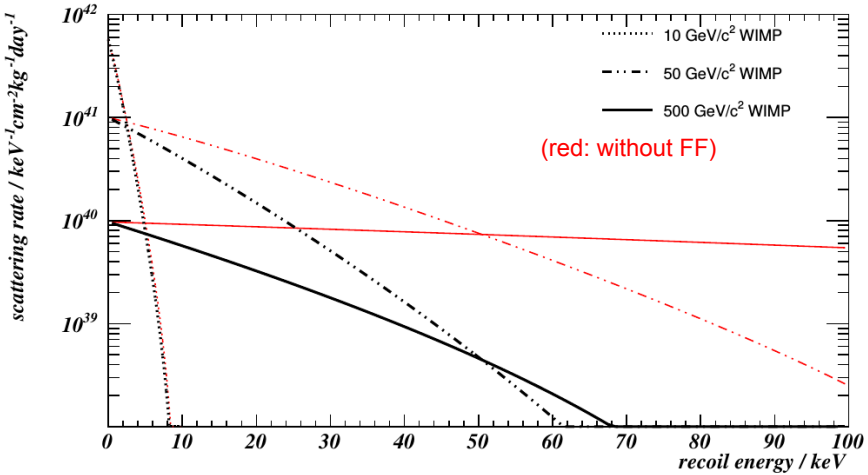
- Energy loss to atomic electrons (also thermal motion, not measured)
- S1 (scintillation) and S2 (ionisation)
- Single detected quanta are obvious
- Event variables are light, charge and position

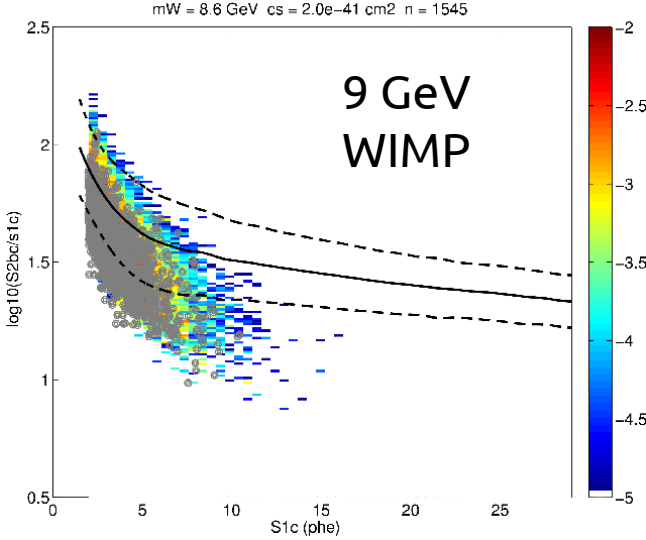


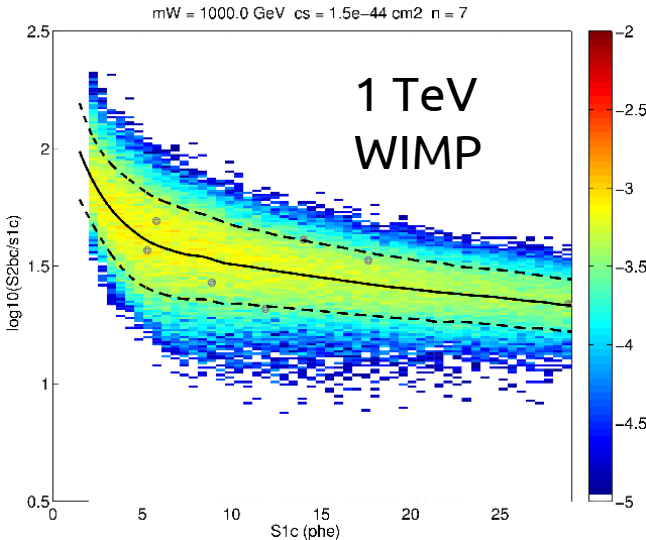
Near threshold: 1.5 keV electron recoil



WIMP signal, round numbers







- What's kinematically accessible with Xe?

  $m_{min}[GeV] \approx 3 \cdot (E_{min}[keV])^{1/2}$

- Recoil spectrum ~ $\exp(-E/rE_0)$

  DM mass m_D ; $v_0^2 \approx 5e\text{-}7c^2$

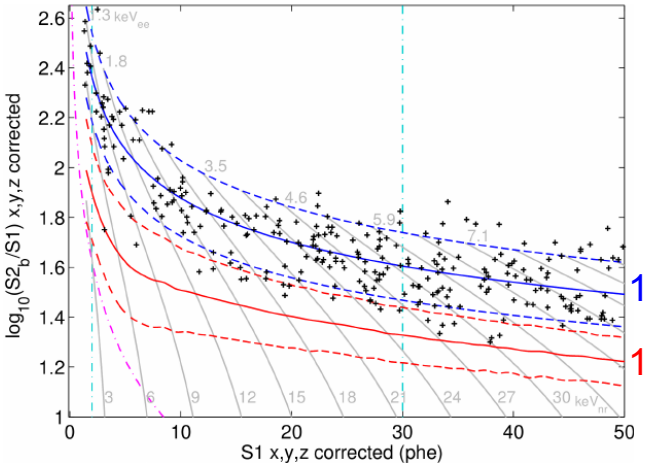
  $r = 4 \cdot \mu_{XeD}/(m_{Xe}+m_D)$; $E_0 = \frac{1}{2} m_D \cdot v_0^2$

Signal, background, telling the difference

Source	Spectrum	Charge-to-light ratio	Location
WIMPs	c. exponential	low (NR)	uniform
Compton scatters from materials γs	**c. flat**	**high (ER)**	**peripheral**
internal βs from Kr-85, Rn impurities	**c. flat**	**high (ER)**	uniform
X-rays from Xe-127 (**λ=36.4 d**)	**1, 5 keV lines**	**high (ER)**	**peripheral**
decays on walls	**c. flat**	low, variable (NR and ER with charge loss)	**high-radius**

Recall: first result

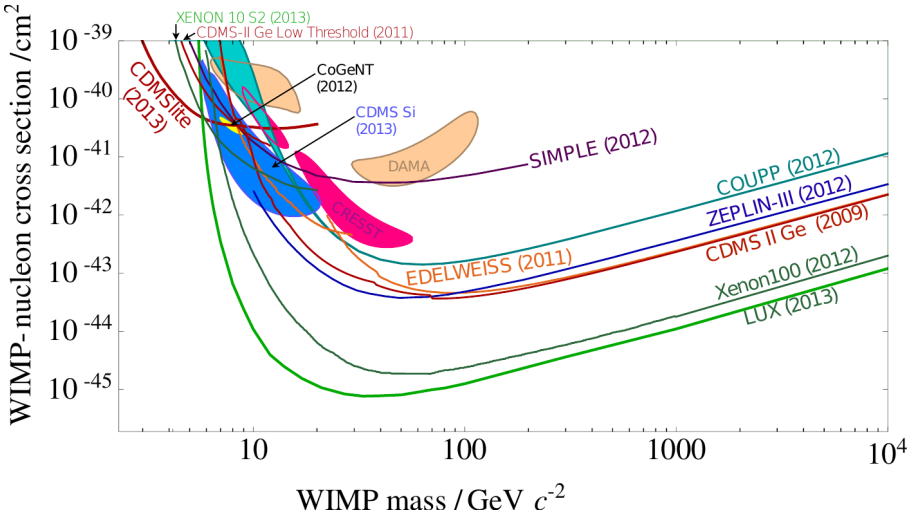
- 85.3 net days
- 118 kg fiducial (r<18 cm)
- 2–30 phe $S1_c$
- $S2_{raw}$>200 phe
- conservative 3 keV signal cutoff →5.2 GeV m_{min}
- 90% UL
  - 2.4–5.3 WIMP counts
  - min. cross section 8×10^{-46}cm^2



PRL **112**, 091303 (2014)

10,50,90% flat-in-*E* ER

10,50,90% flat-in-*E* NR

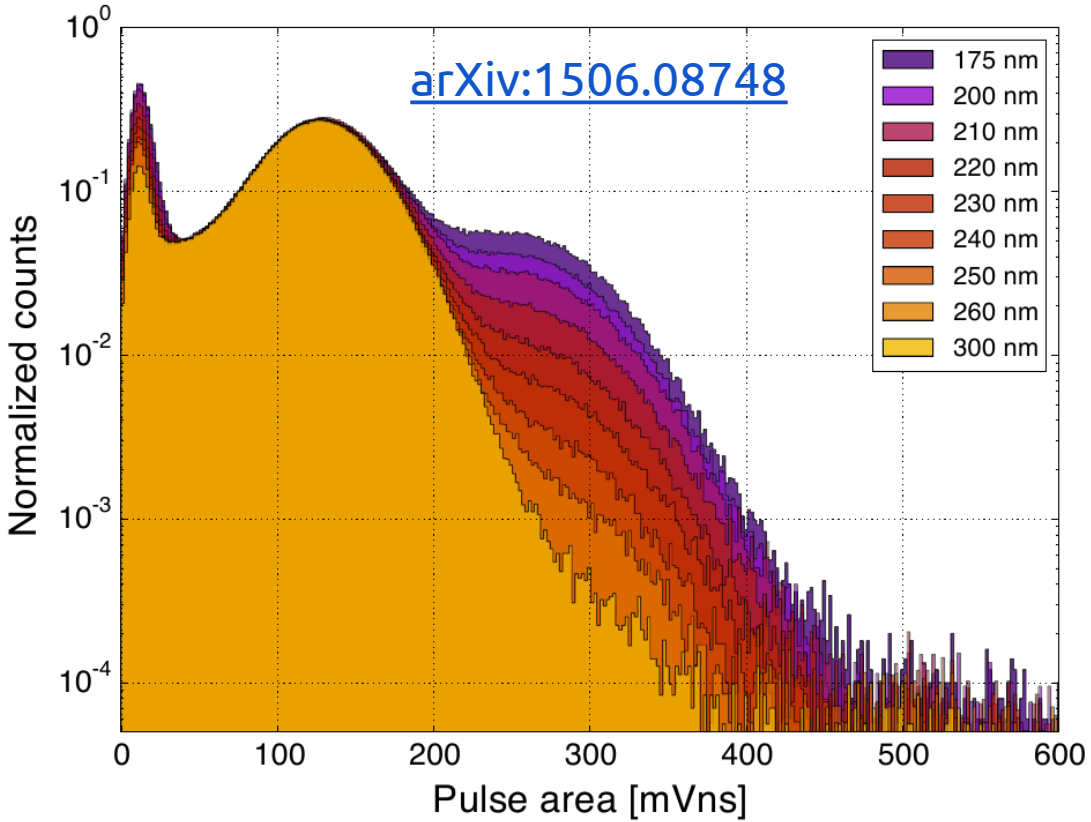


The reanalysis

Measuring light

Better estimators for detected photons:

- Removed a bias in baselines
- **Photon response calibrated in the VUV (2 phe from 1 photon)**
- Digital counting of photons in PMT waveforms

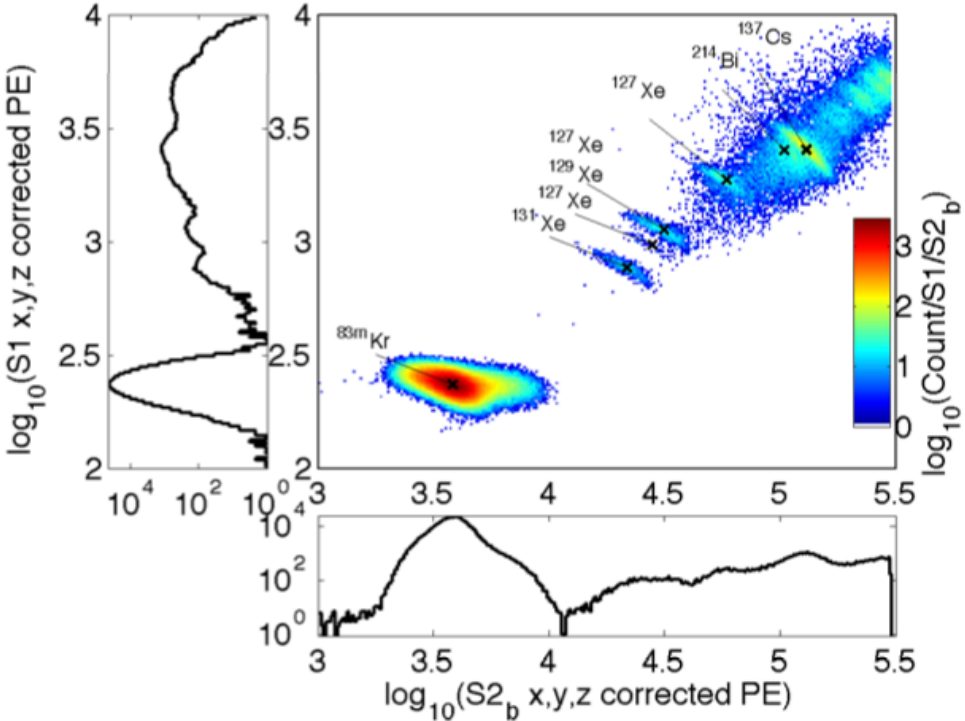


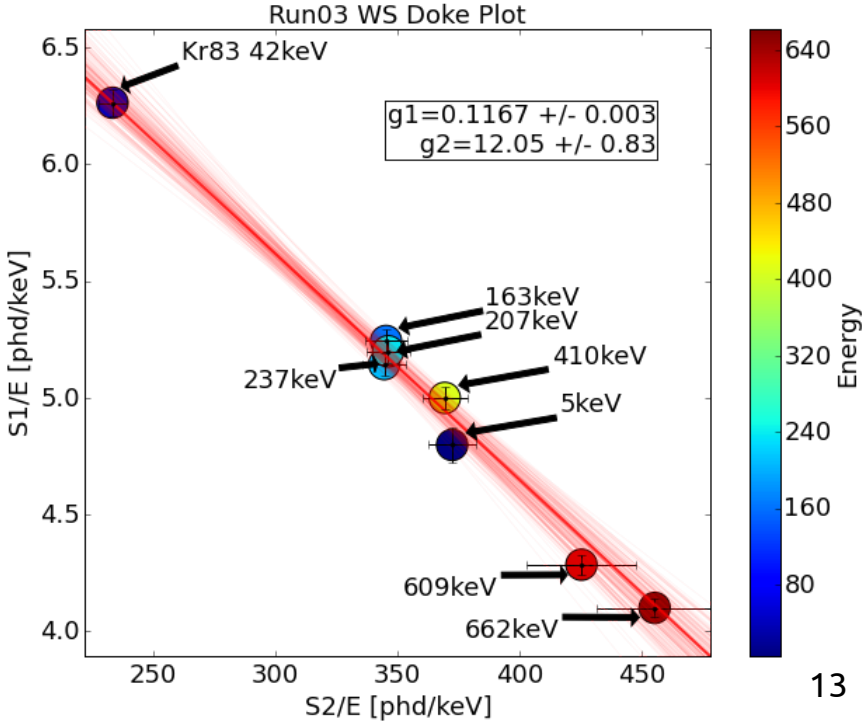
ER ‘Doke plot’ (5–662 keV)

Monoenergetic sources in the mean-yields plane.

Line fit and $W = 13.7$ eV give **absolute quanta**:

$$\langle S_{1c}[\text{phd}] \rangle = 0.12 \cdot n_{\text{phot}} \,, \langle S_{2c}[\text{phd}] \rangle = 12 \cdot n_{\text{elec}}$$

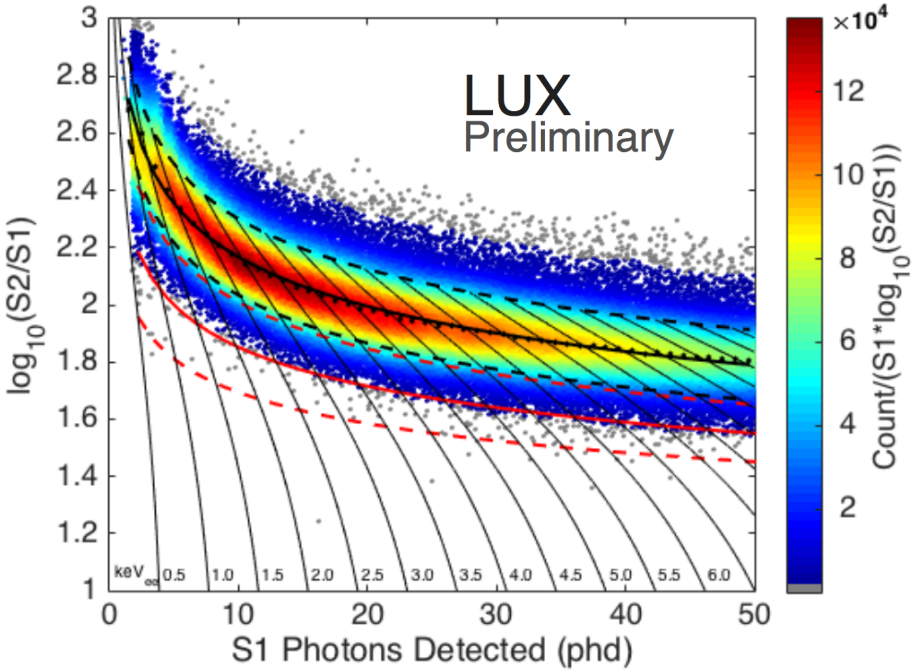


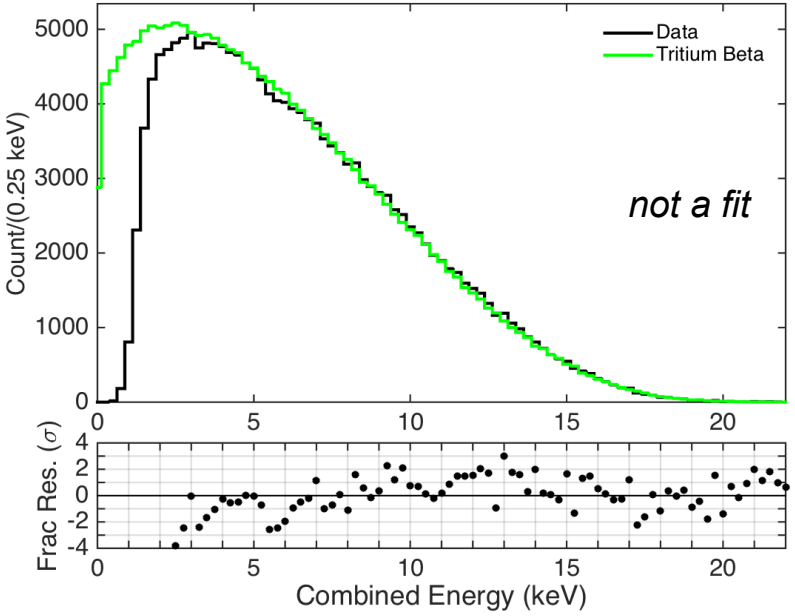


ER calibration with tritium (0–18 keV)

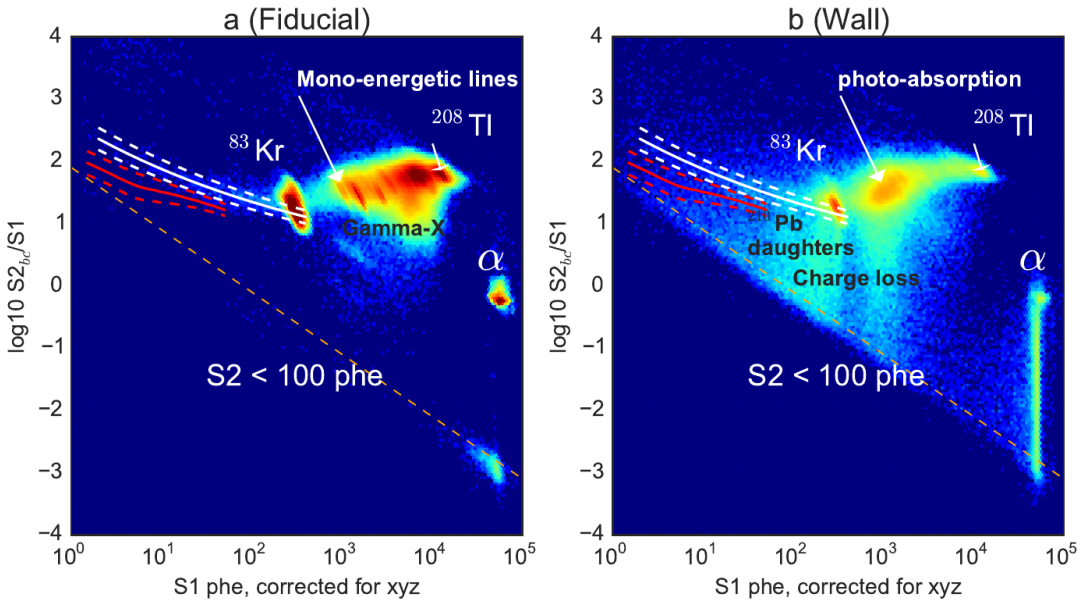
2nd campaign of CH_3T calibration, Dec 2013

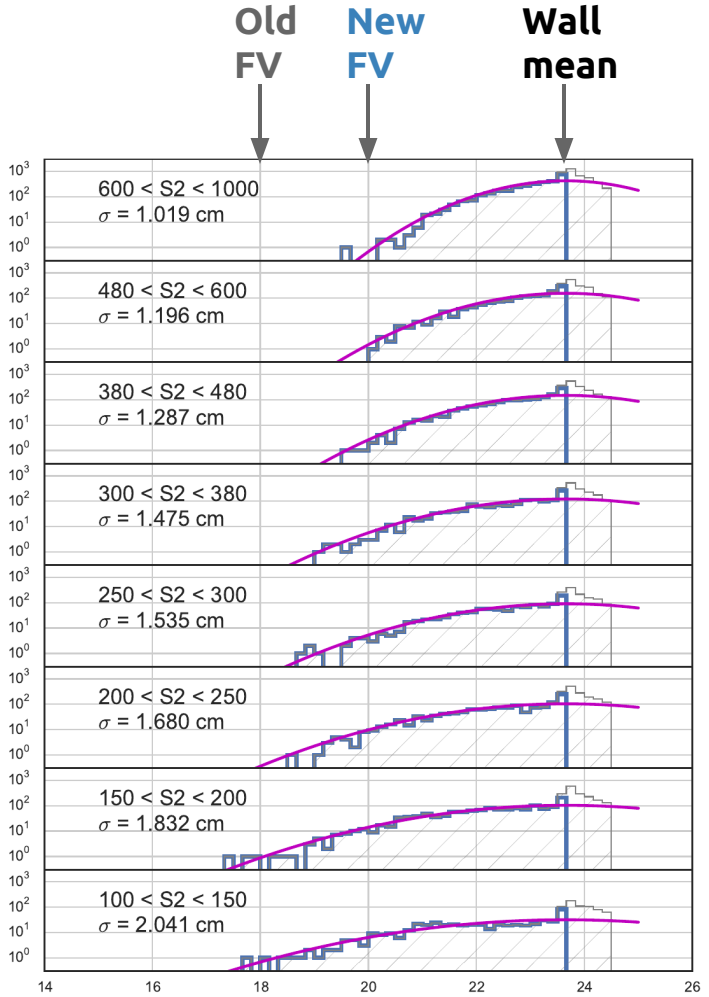
- **180 000 events**
- Reconstruct spectrum with Doke result
- Constrain threshold, yields, fluctuations





Calibration of decays on the wall



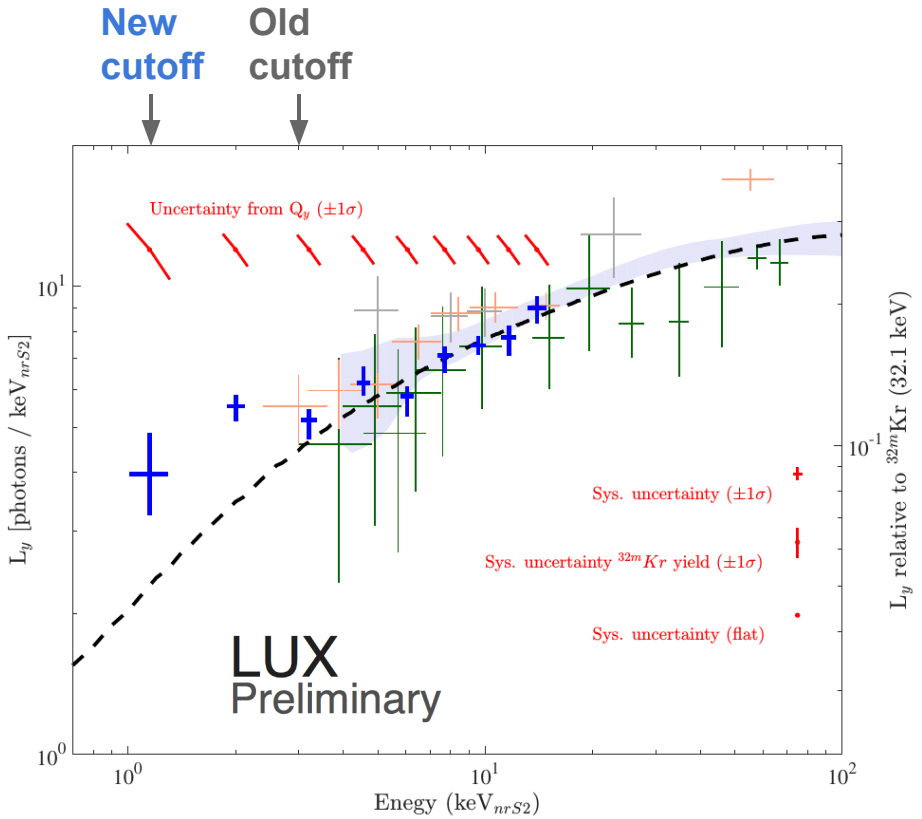


C. Lee Ph.D. thesis, CWRU, 2015

NR calibration with kinematically-constrained neutron scatters

See D. Huang talk Thursday

- S2 v absolute energy to 0.7 keV
- S1 yield measured to 1.2 keV via single scatters
- Lowers assumed cutoff (same conservative criterion)
- **Kinematic reach now 3.3 GeV WIMP mass**

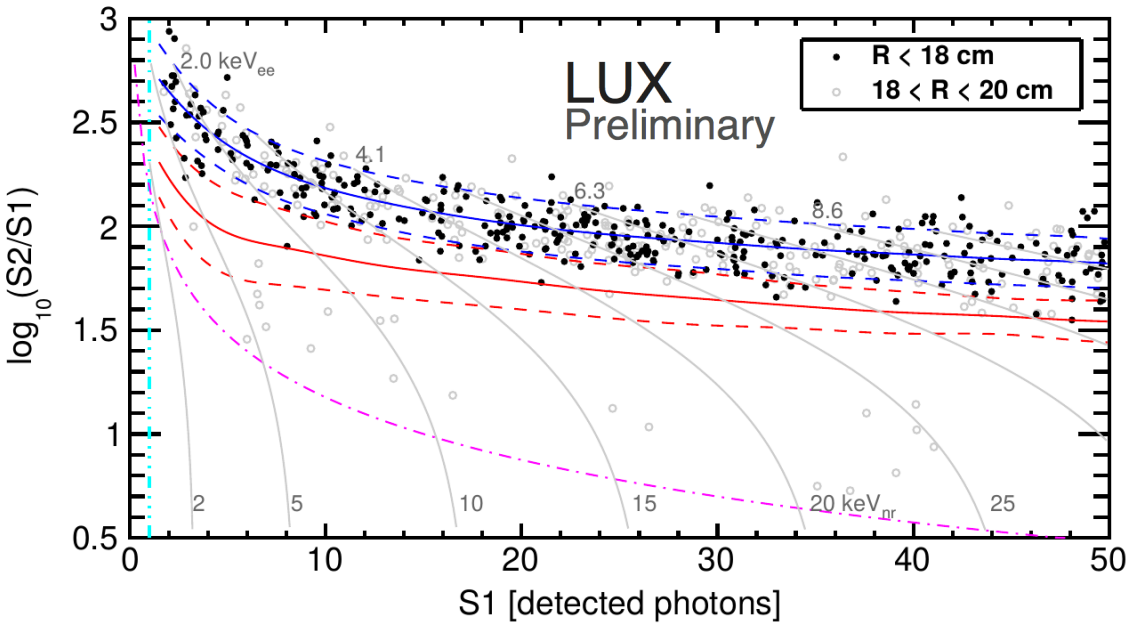


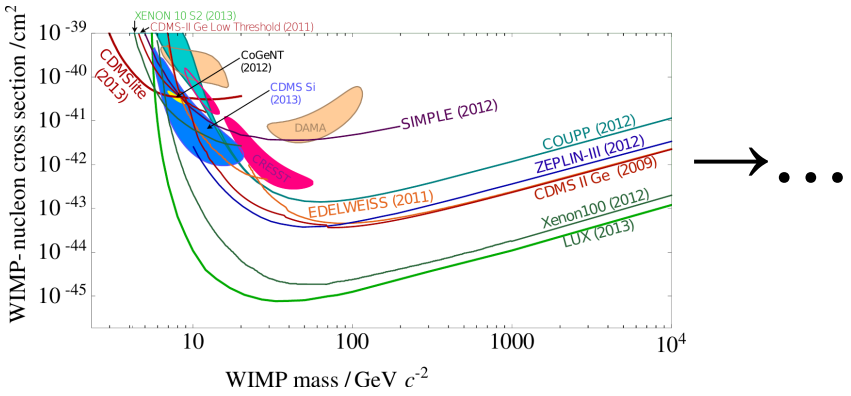
LUX Measured Ly; reported at 180 V/cm (absolute *E* scale)
Manzur 2010; 0 V/cm (absolute *E* scale)
Horn Combined Zeplin III FSR/SSR band; 3.6 kV/cm, rescaled to 0 V/cm (*E* scale from best fit MC)
Plante 2011; 0 V/cm (absolute *E* scale)
Aprile 2009 (absolute *E* scale)
----- Sydagis et al. (NEST) predicted yield at 181 V/cm

Search data, reanalysed

Onwards and downwards:

- **95 days** net (previously 85 d)
- **145 kg** fiducial (118 kg)
- **1–50 phd** $S1_c$,>2 raw photons (2–30 phe)
- $S2_{raw}$>**165 phd** (200 phe)
- conservative **1.2 keV** signal cutoff →**3.3 GeV** m_{min} (3.0 keV, 5.2 GeV)
- Limits on the way…





→…

Conclusions

Since the 2013 search analysis:

- New understanding of PMT response in VUV.
- Lower analysis thresholds
- ER calibration
  - Doke plot
  - 180k tritium events 0–18 keV
- Empirical wall model: more FV
- S1 yield to 1.2 keV recoil energy with DD generator

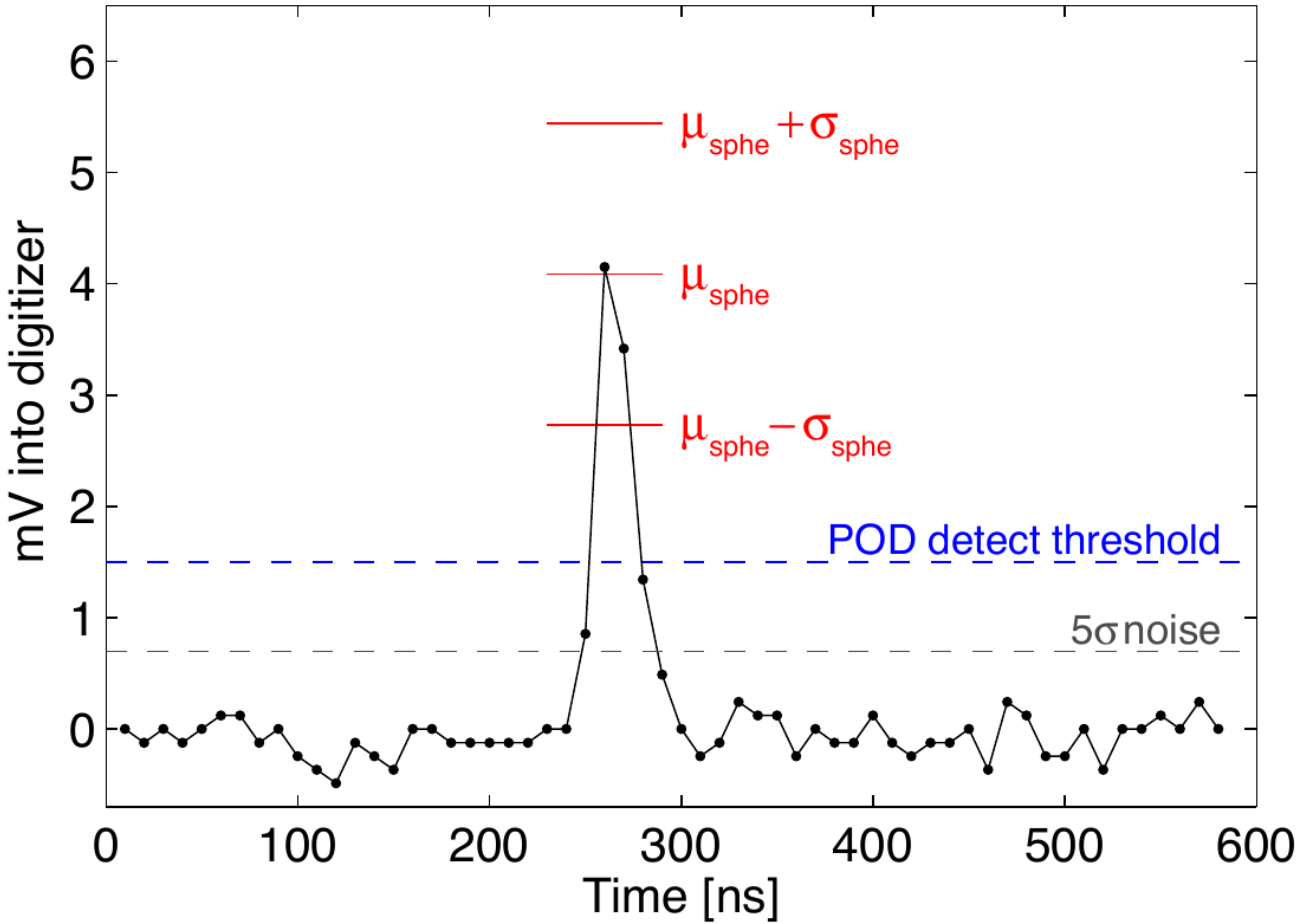
Current status:

- Background model from new calibrations ✓
- Search dataset ✓
- DD calibration and signal models: **final checks**.

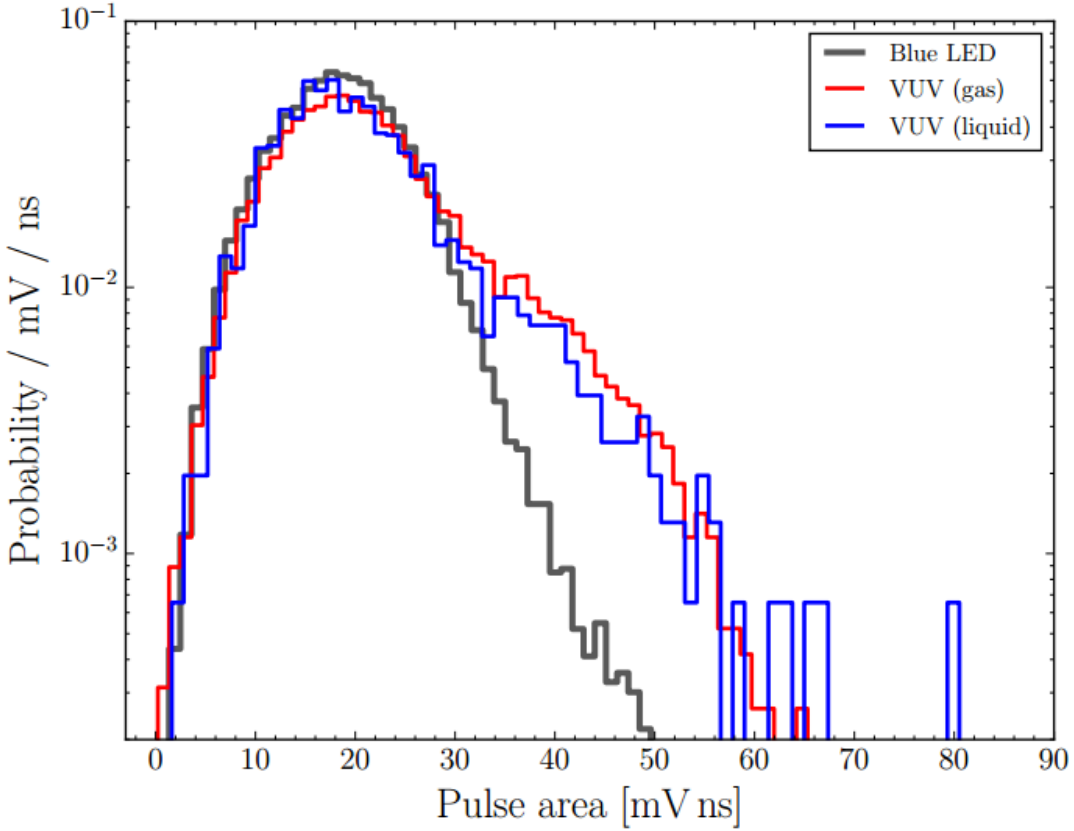
Also: Run 4 ongoing with higher fields, acquired livetime greater than Run 3.

Reserve

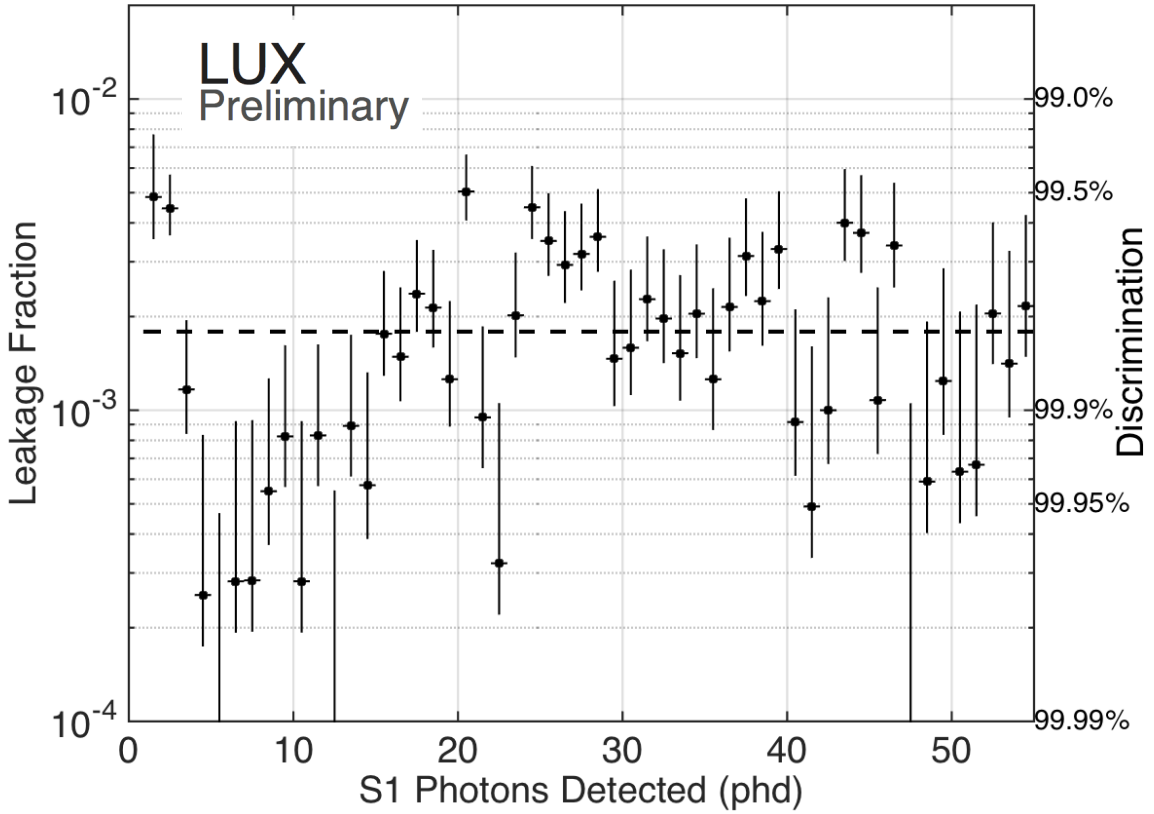
Zero-suppression threshold



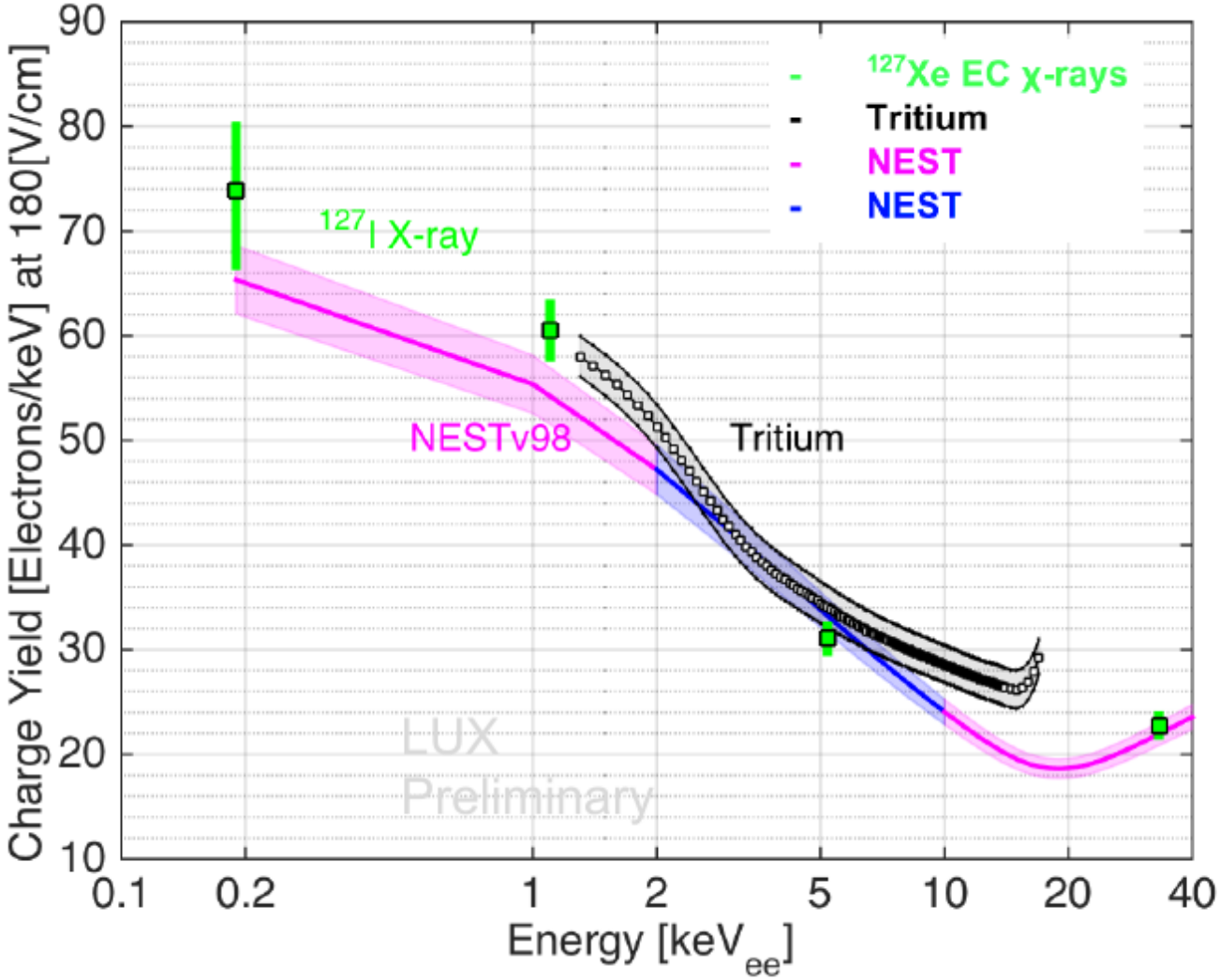
In situ calibration of VUV photons



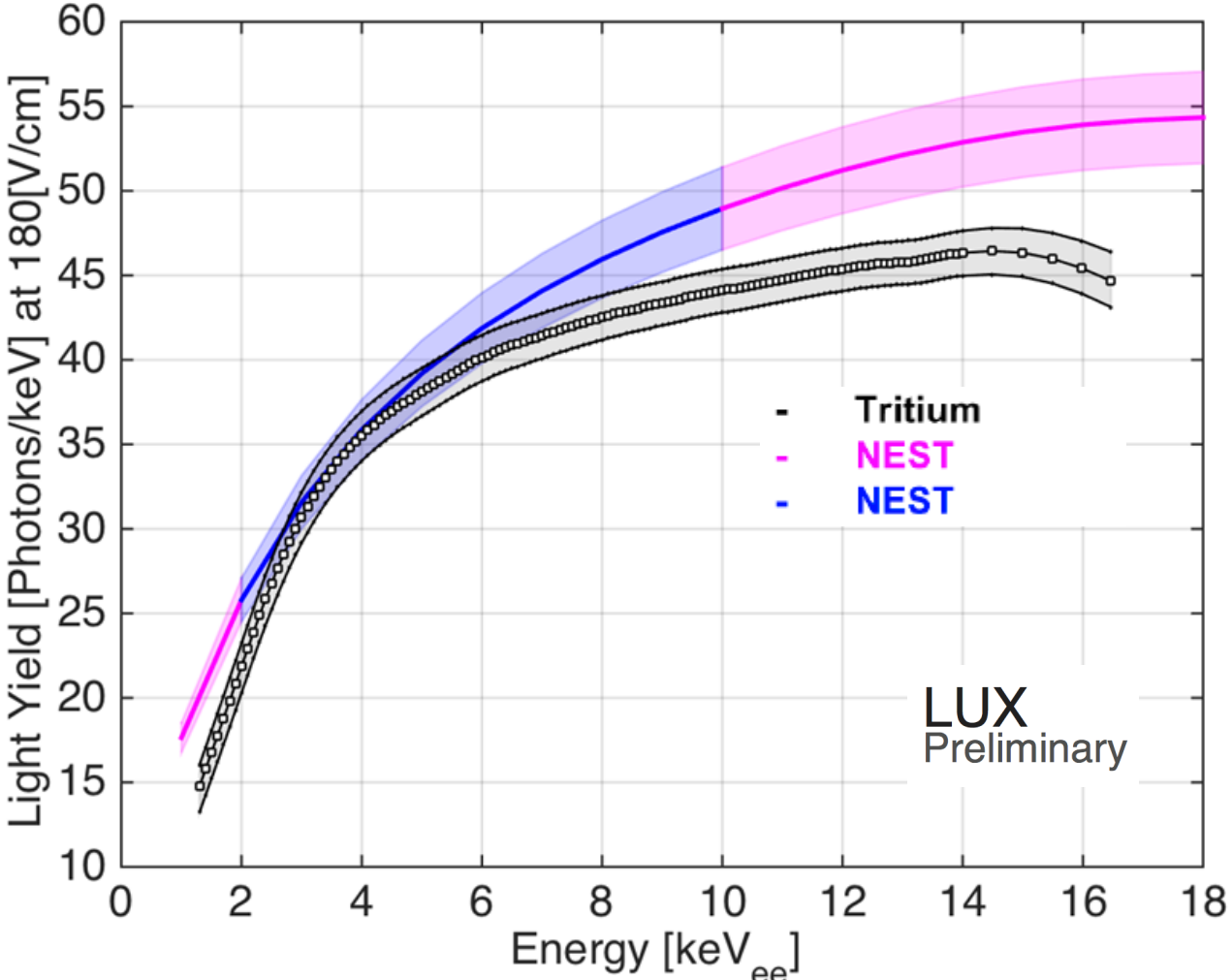
Tritium events below NR median S2|S1



ER charge yield



ER light yield



ER efficiency from tritium (Doke g1,g2)