Measurements of the low-energy response of liquid xenon

Aaron Manalaysay
Universität Zürich

Universität Zürich[UZH]

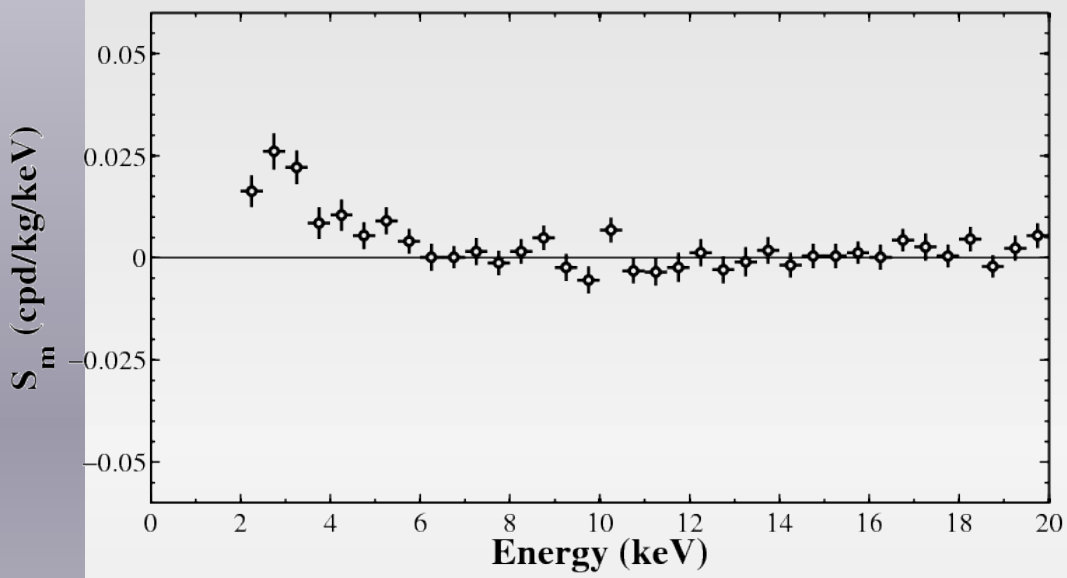
Annual Meeting of the Swiss Physical Society

with L. Baudis, A. James, A. Kish, C. Geis, T. Marrodán Undagoitia, M. Schumann

⟨S|P|S⟩ swiss physical society

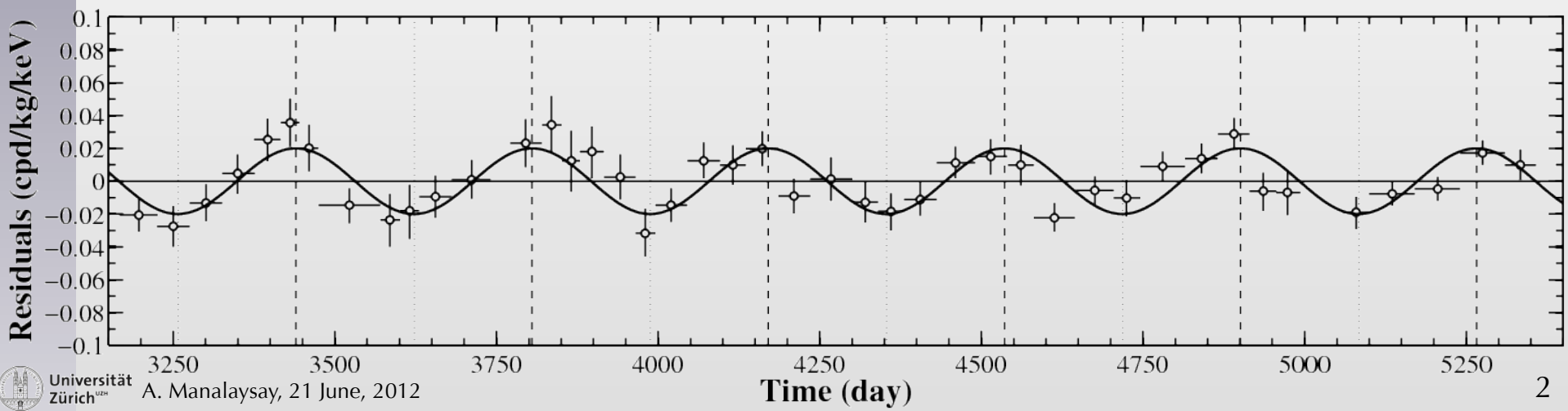
ETH Zürich
21 June, 2012

The context of these measurements

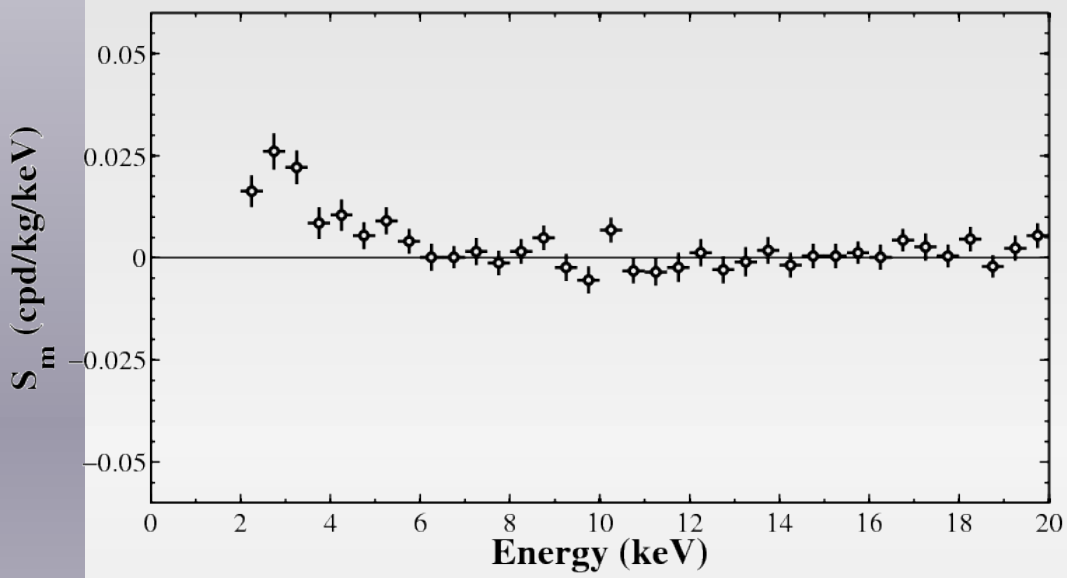


The DAMA modulation, if dark matter, can be interpreted as:

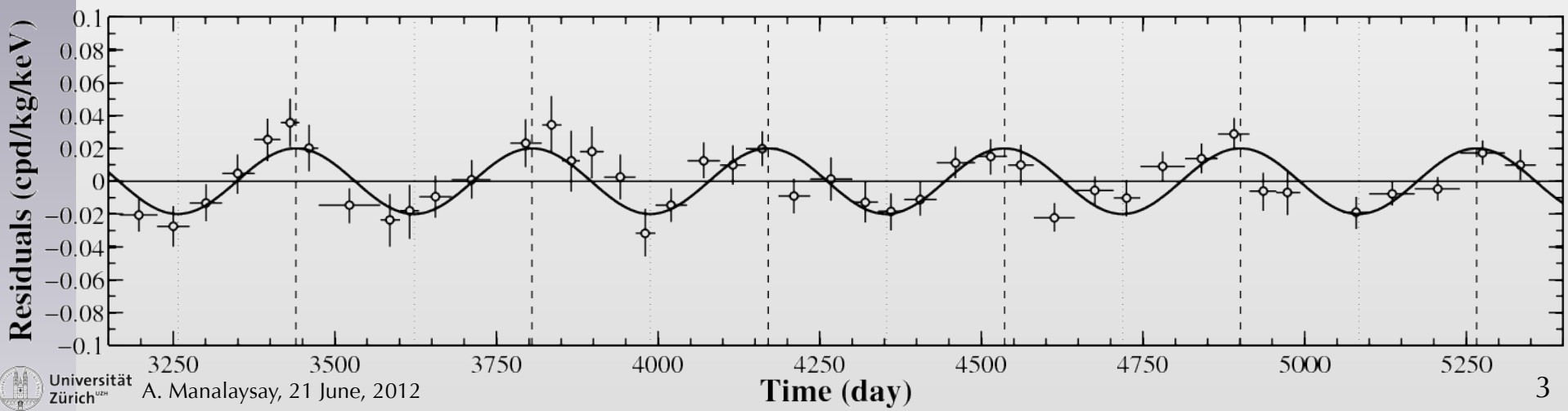
- DM recoils with iodine nuclei
- DM recoils with sodium nuclei
- DM recoils with thallium nuclei
- Electronic recoils (e.g. axio-electric, sub-GeV, etc.)



The context of these measurements



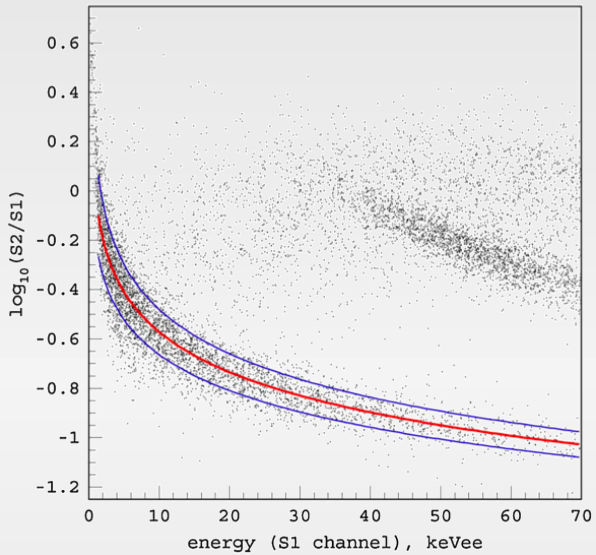
Normally we worry about sensitivity to nuclear recoils in this energy range, but can LXe probe such low-energy electronic recoils?
(i.e. 2-3 keV)



What can liquid xenon say?

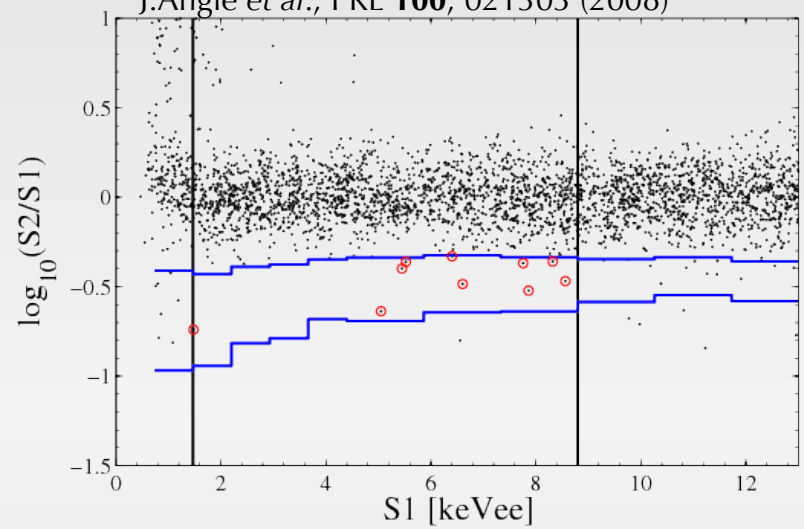
Zeplin-III WS data

V.N.Lebedenko *et al.*, PRD **80**, 052010 (2009)



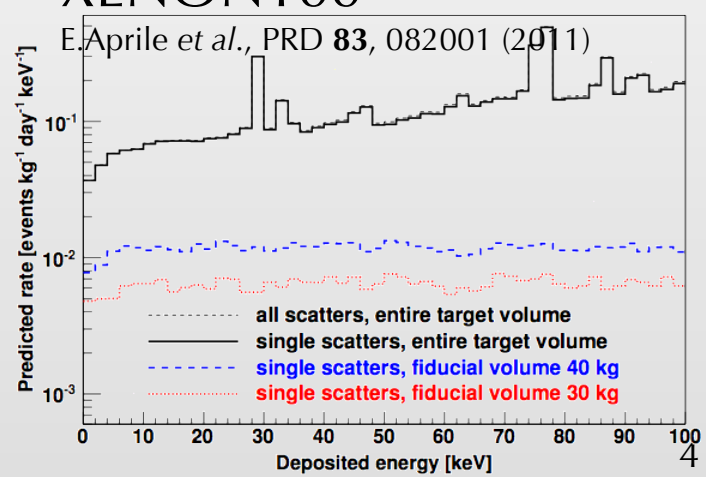
XENON10 WS data

J.Angle *et al.*, PRL **100**, 021303 (2008)



XENON100

E.Aprile *et al.*, PRD **83**, 082001 (2011)



All scales here are given as "electron-equivalent energy". These thresholds are low enough, but they are based on inferred energy scales. There have been no calibrations at these energies.

Established calibration sources

^{60}Co - 1.1 MeV, 1.3 MeV

^{137}Cs - 662 keV

^{133}Ba - 81 keV, 303 keV, 356 keV

^{57}Co - 122 keV, 136 keV

^{129m}Xe - 197 keV, 40 keV (summed)

^{131m}Xe - 164 keV

^{83m}Kr - 9.4 keV, 32 keV

almost low enough, but not quite

Established calibration sources

60

137

133

57

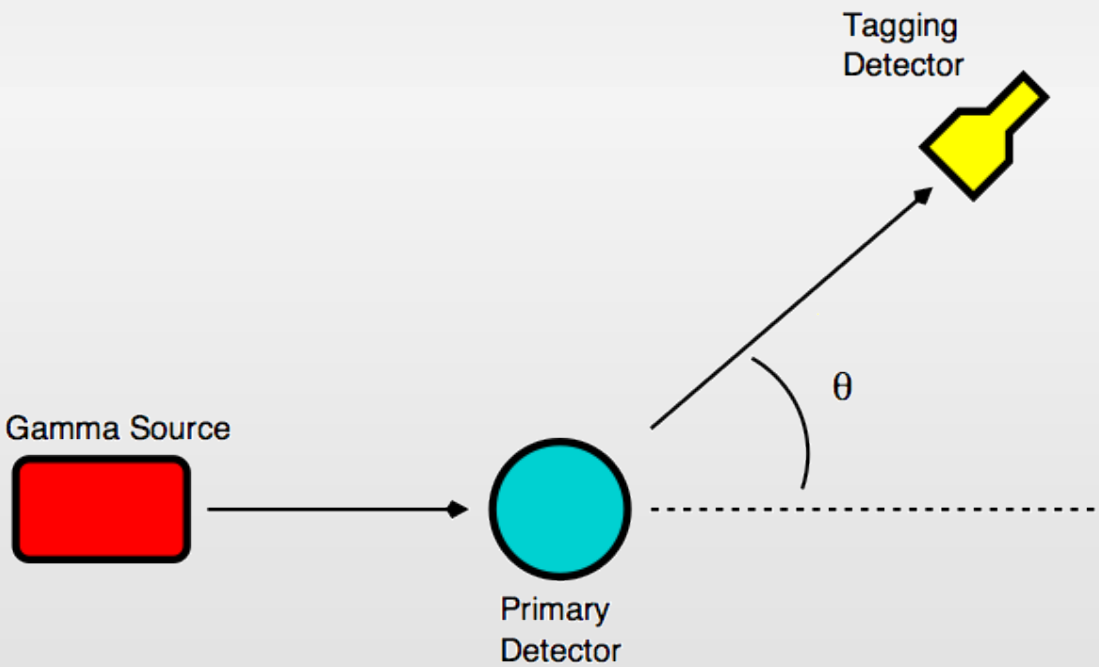
129m

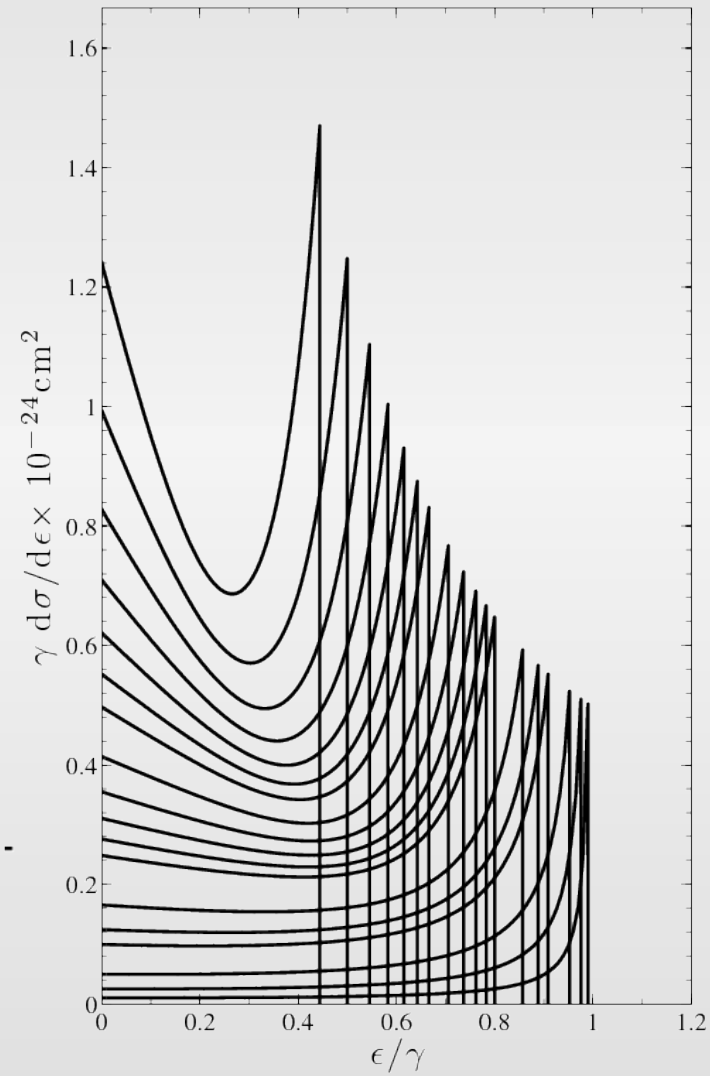
131m

83m

Must we use a decay line?

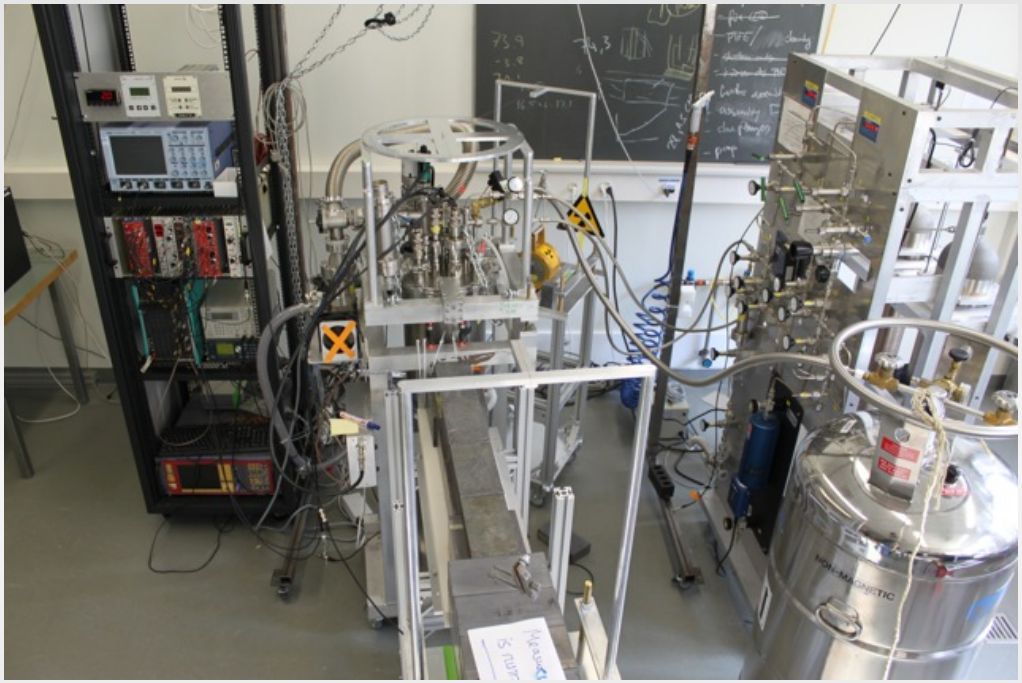
Compton scatters go all the way down to zero...

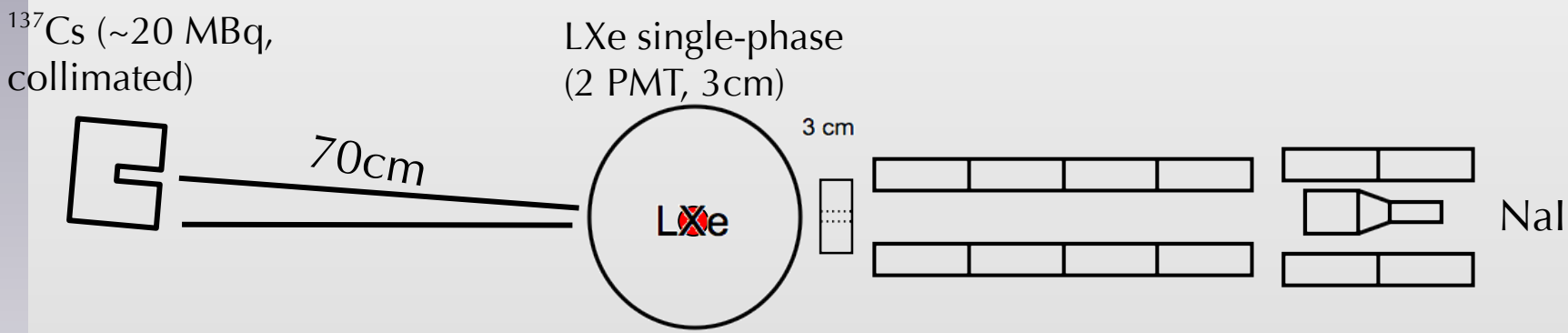




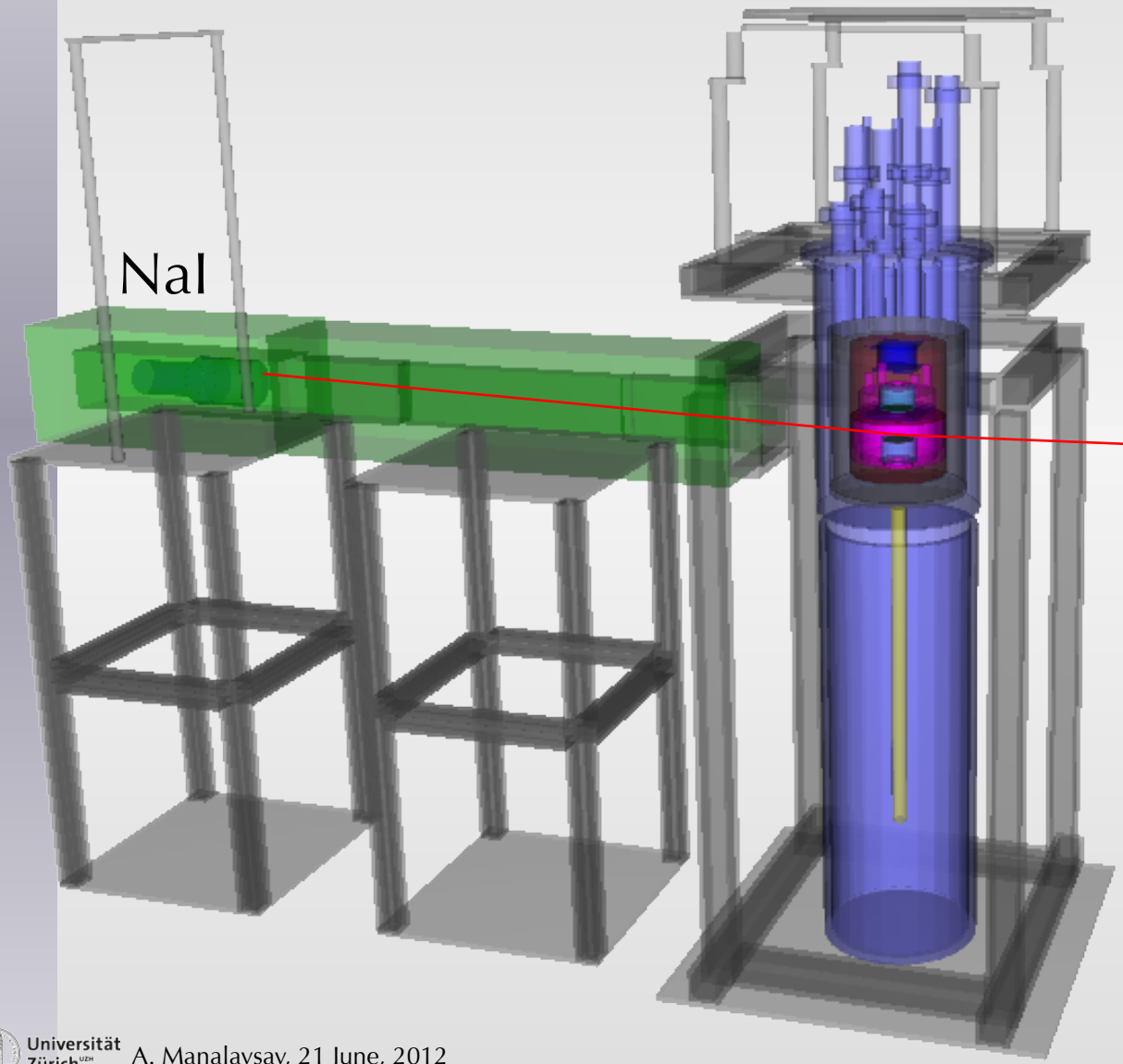
Our setup

- 662 keV γ from ^{137}Cs
- < 9.4 keV means < 8.5°
- 50cm diameter goniometer with 0.25° ticks.
- Collimate both source and scatter γ rays.
- Scattered γ rays tagged with 3″ NaI scintillator crystal
- Data from one angle takes ~1 week to collect.





Monte Carlo

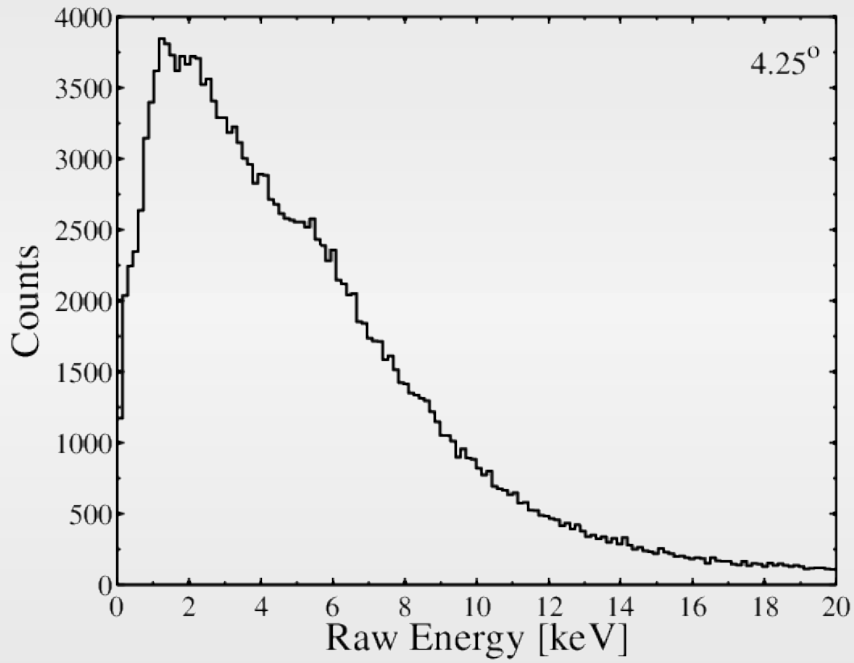


The systematics at such low scattering angles are non-trivial, and must be estimated by Monte Carlo.

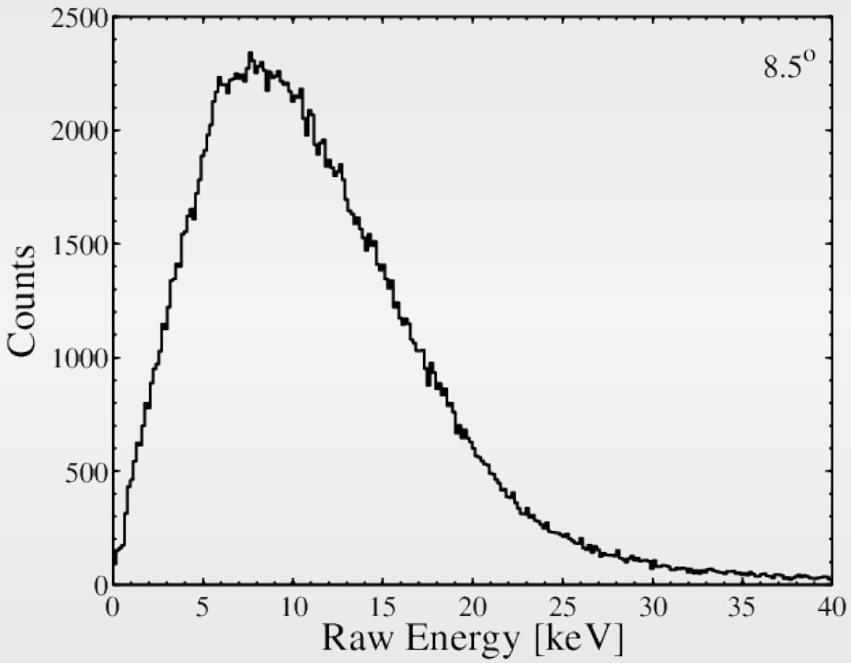
We have constructed a full simulation of all detector components in Geant4. Data are compared with MC to obtain a light yield.

Raw spectra

4.25°

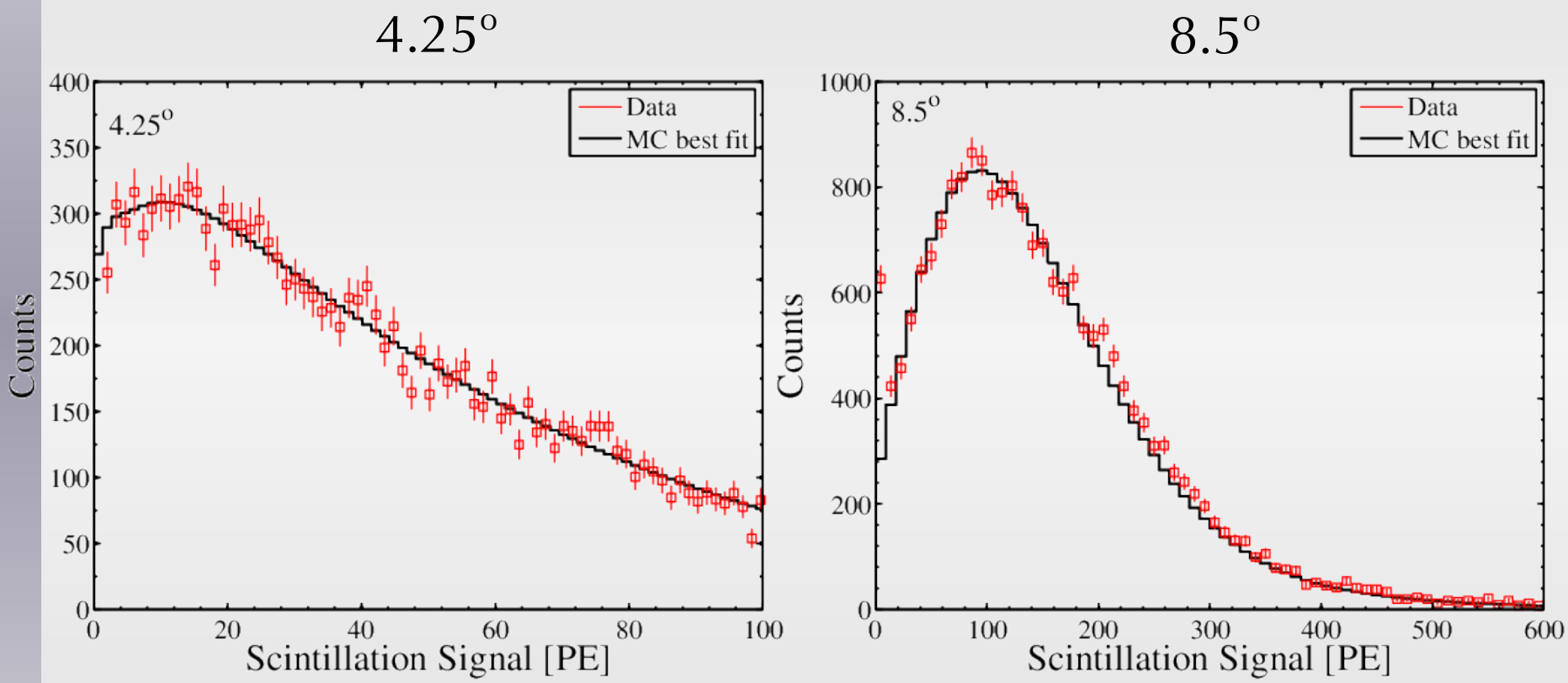


8.5°



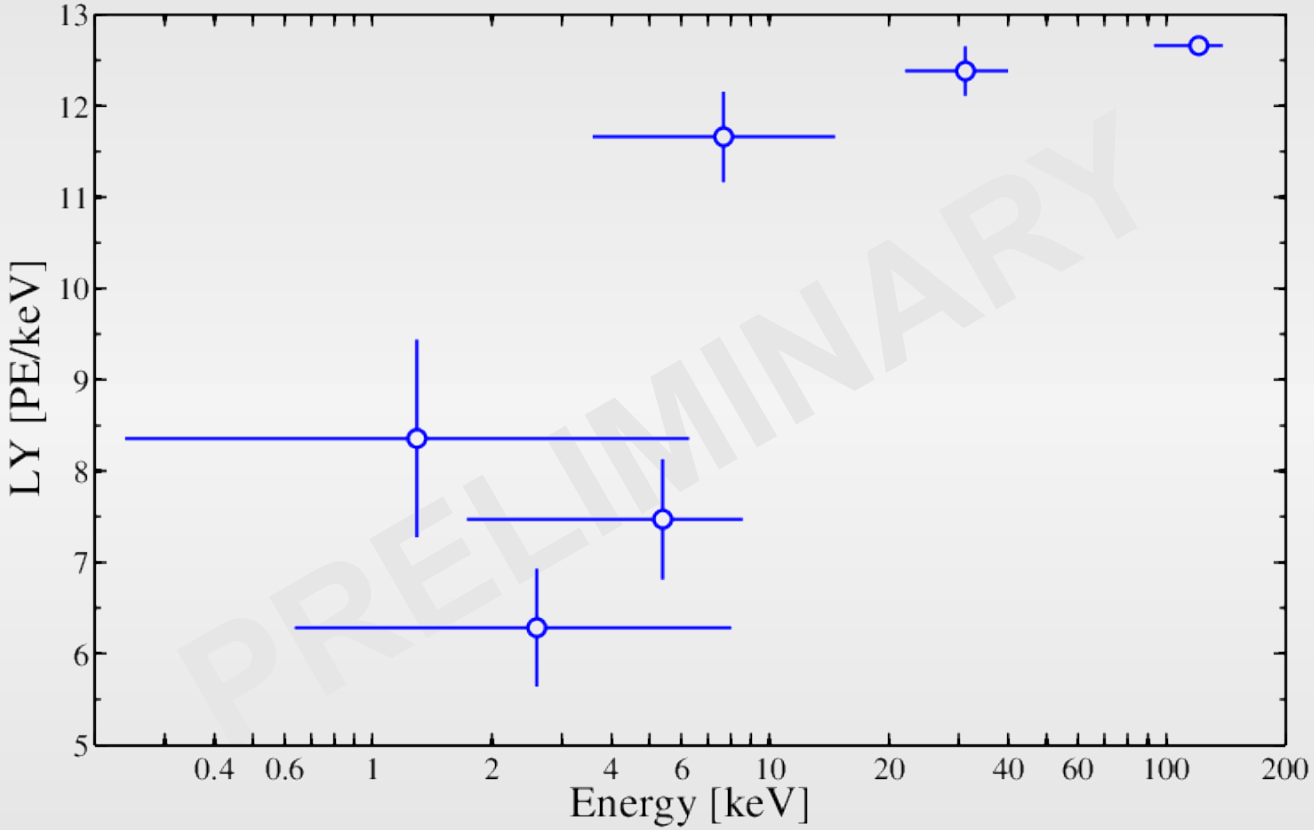
The raw energy distribution (from Monte Carlo) is used as input to a MLE best fit analysis with the observed spectra.

Fitting the MC to the data



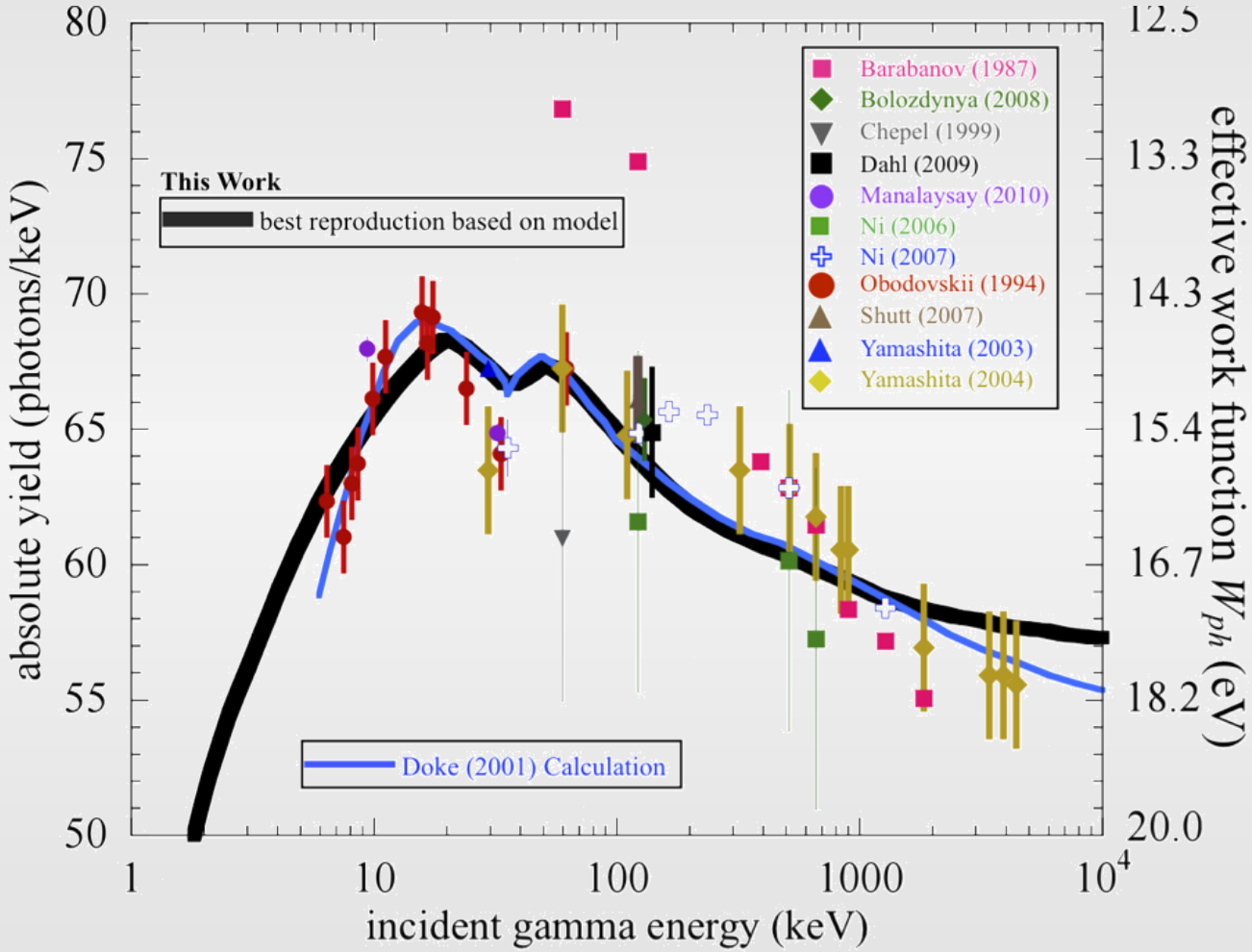
MC events are converted to a scintillation signal, and smeared to account for Poisson and PMT fluctuations.

Light yield versus energy



The light yield (LY) is defined as the average number of photoelectrons collected per keV.

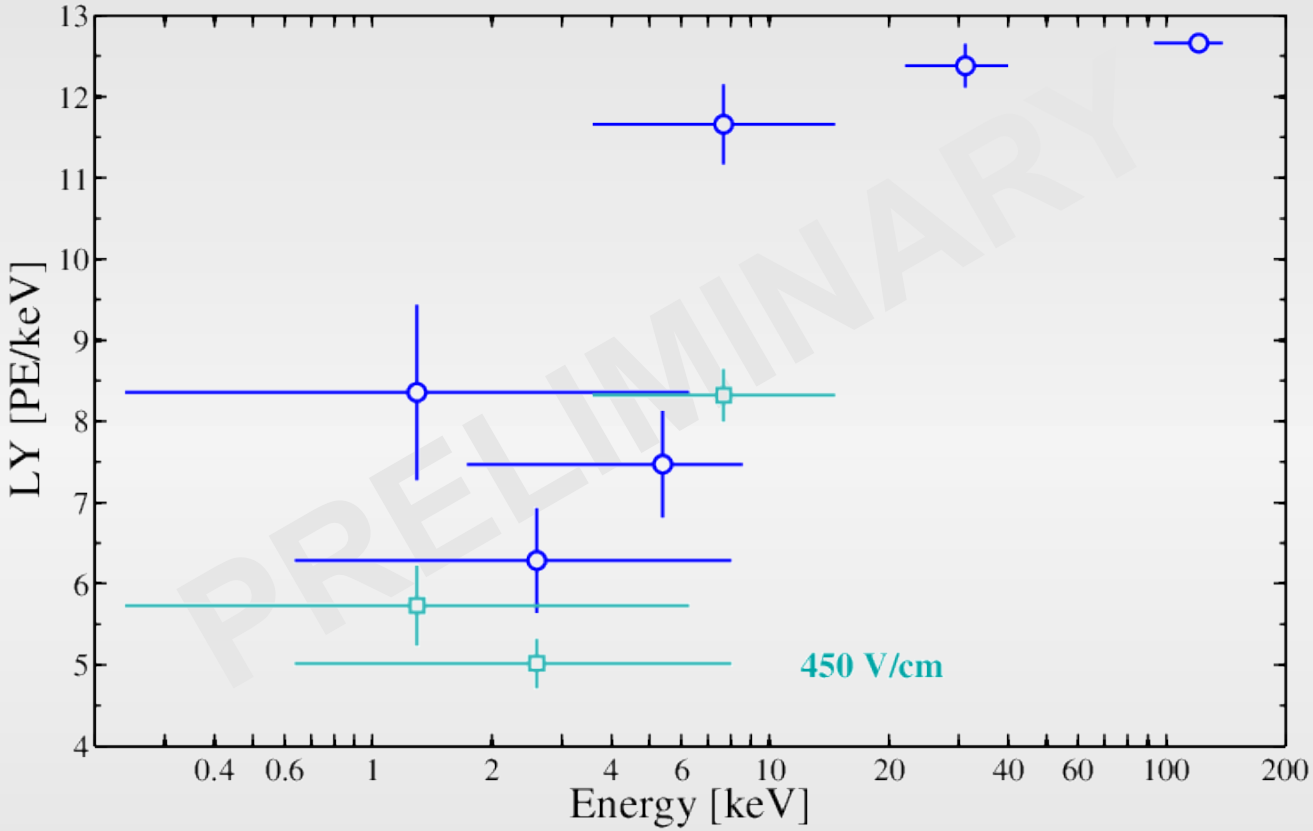
Expectations



M.Szydagis *et al*. JINST **6** P10002 (2011)

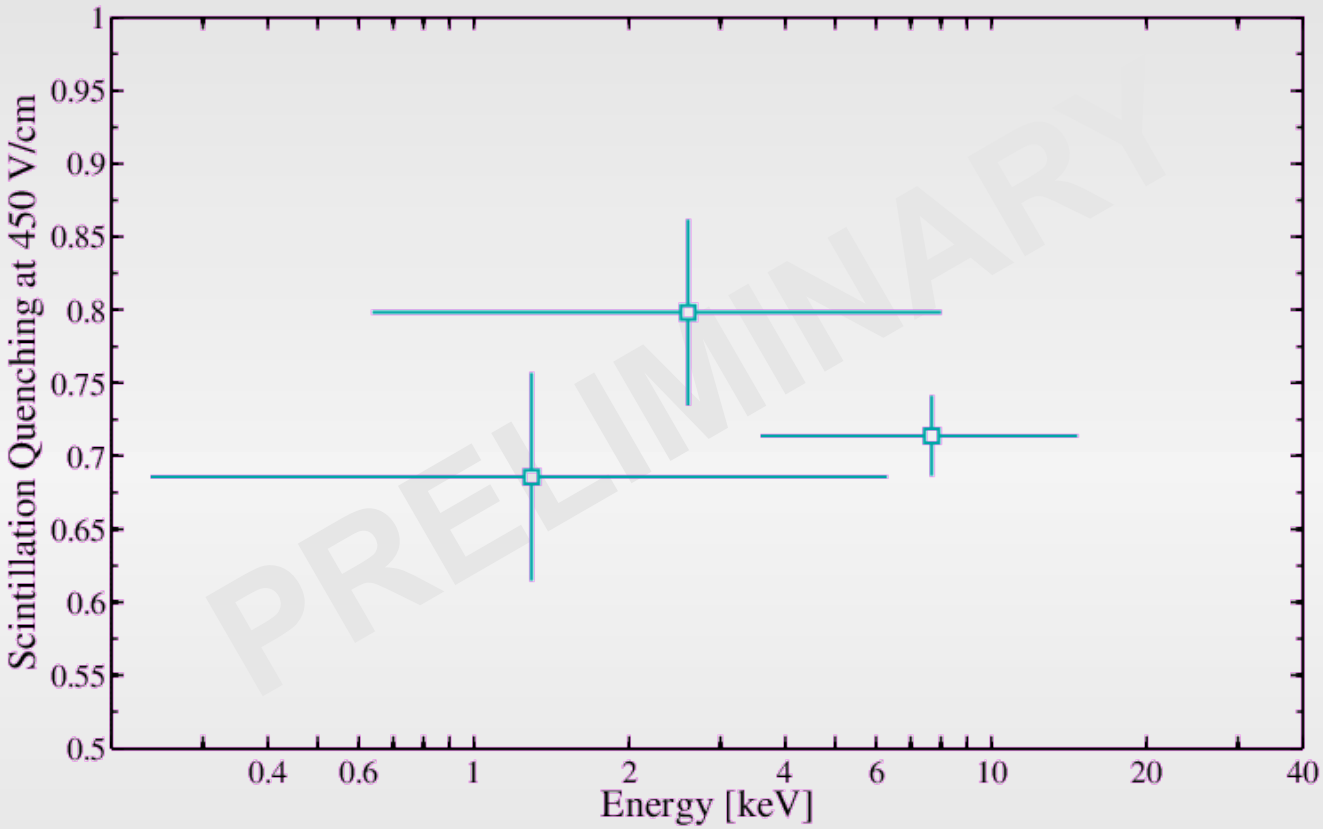
Thanks for your attention!

Electric field quenching



An applied static electric field prevents some free electrons from recombining with the parent ions, and therefore "quenches" the observed signal.

Electric field quenching



The numerical value of quenching is simply the LY with field divided by the LY at zero field.