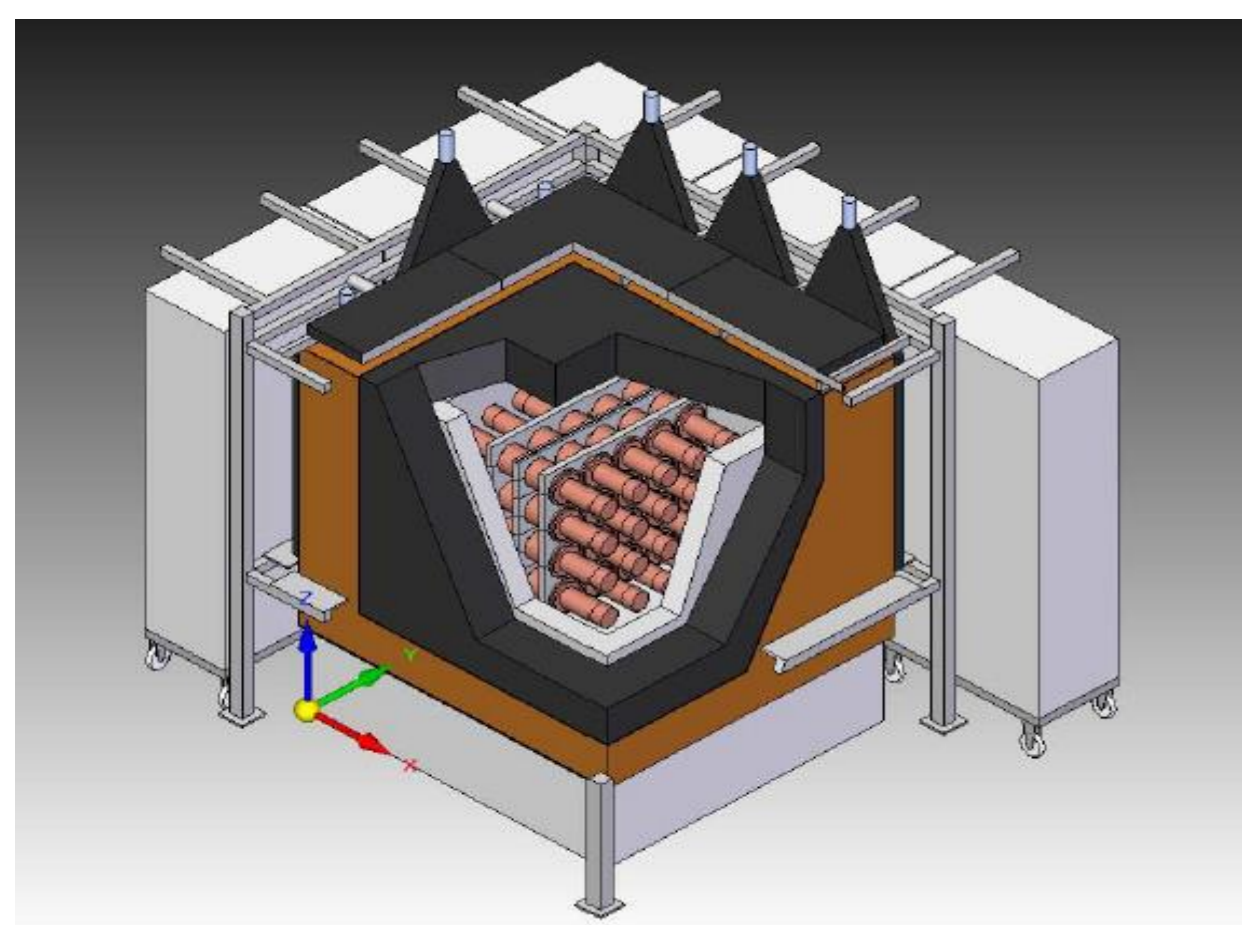


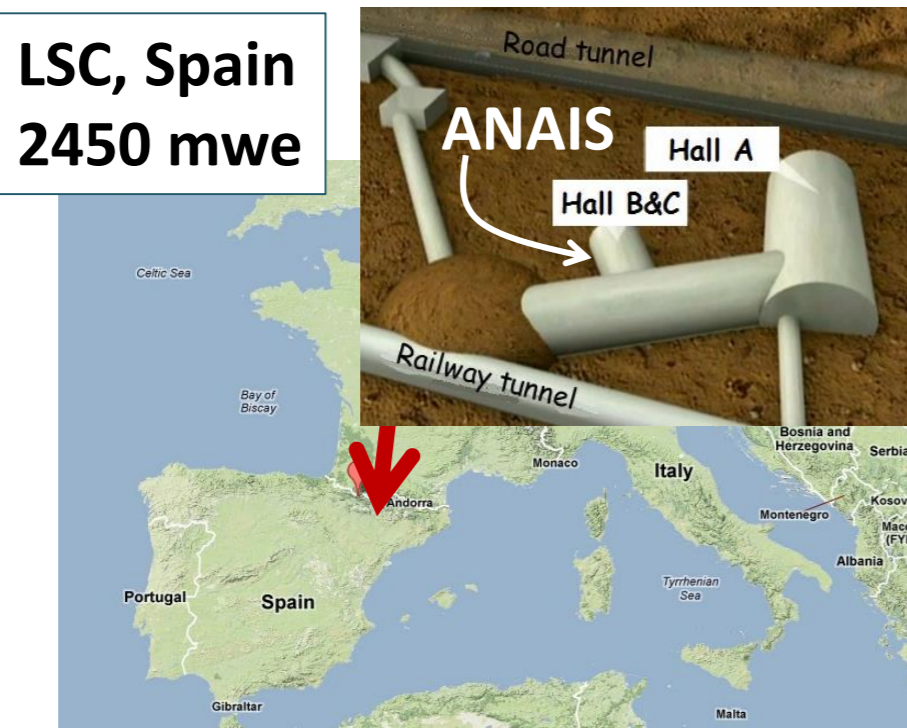
J. Amaré, S. Cebrián, C. Cuesta, E. García, C. Ginestra, M. Martínez, M.A. Oliván,
Y. Ortigoza, A. Ortiz de Solórzano, C. Pobes, J. Puimedón, M.L. Sarsa, J.A. Villar, P. Villar

Laboratorio de Física Nuclear y Astropartículas, Universidad de Zaragoza, Calle Pedro Cerbuna 12, 50009 Zaragoza, Spain
Laboratorio Subterráneo de Canfranc, Paseo de los Ayerbe s/n, 22880 Canfranc Estación, Huesca, Spain

1. The ANAIS experiment

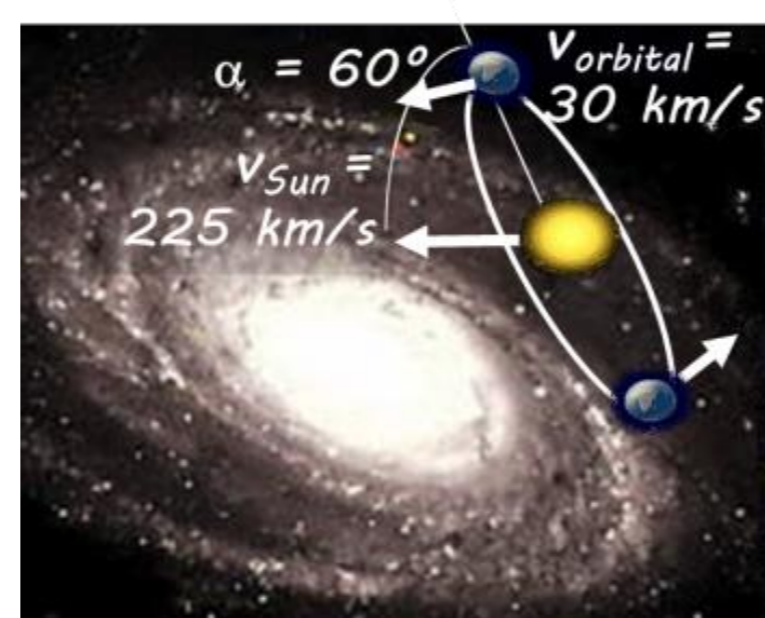


250 kg NaI(Tl) scintillators to look for Dark Matter (DM) annual modulation at Canfranc Underground Laboratory (LSC)



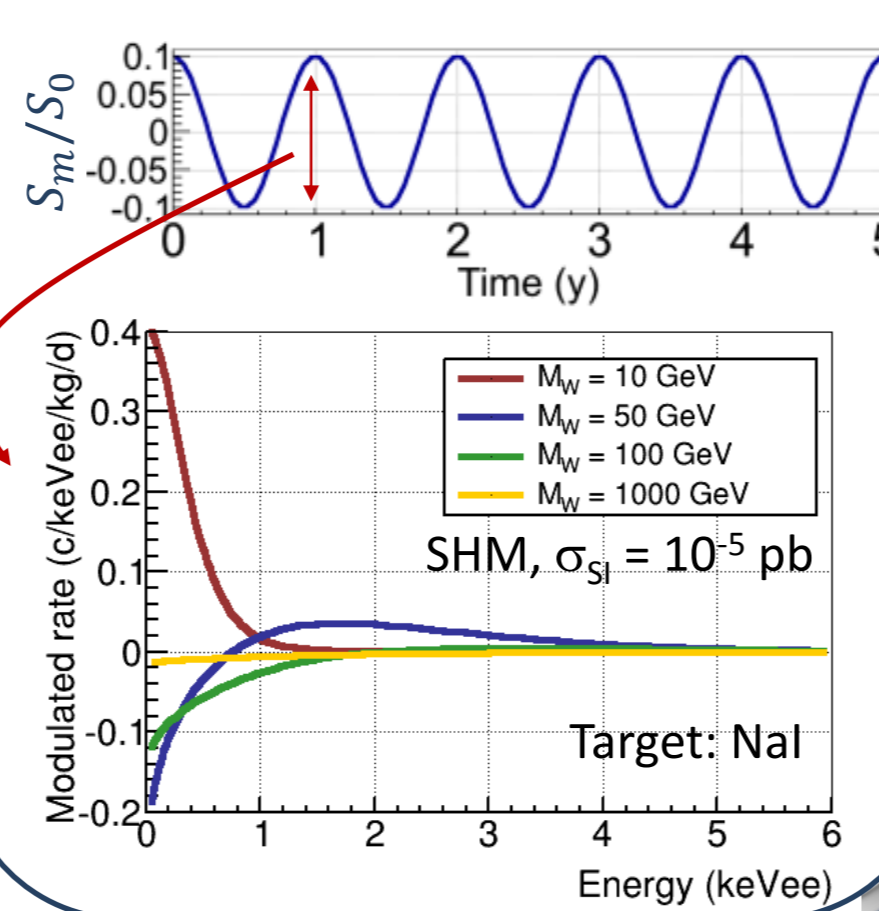
LSC, Spain
2450 mwe

DM ANNUAL MODULATION SIGNATURE



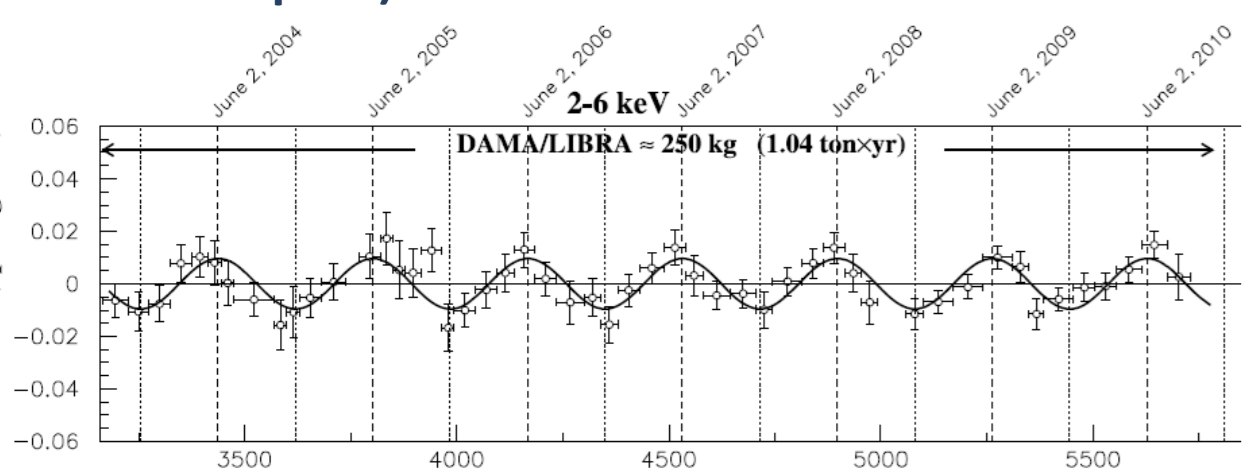
The movement of the Earth around the Sun induces an annual modulation in the expected DM rate in the detector:

$$Rate = S_0 + S_m \cos(\omega(t - t_0))$$



GOAL:

Confirmation of the DAMA/LIBRA positive annual modulation signal in a model-independent way (using the same target and technique)

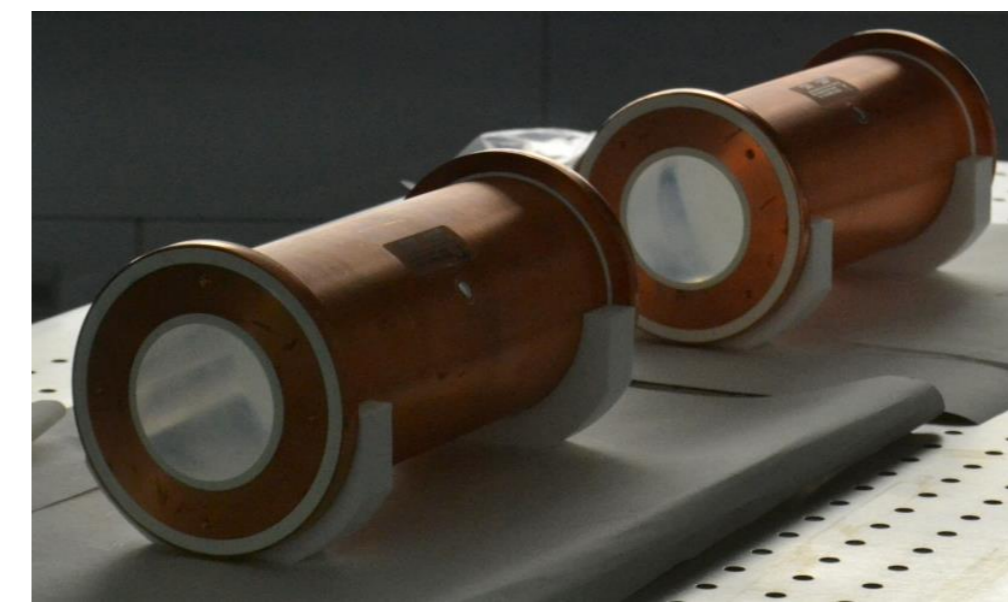


"Evidence (9.3 σ C.L.) of an annual modulation in the single-hit events in the (2-6) keV energy region satisfying all the requests of a DM component in the galactic halo"
Eur. Phys. J. C (2013) 73

EXPERIMENTAL "MUSTS":

- Energy threshold at or below 2 keV
- Background near threshold at or below 2 c/keV/kg/day

2. The prototypes (ANAIS-25)



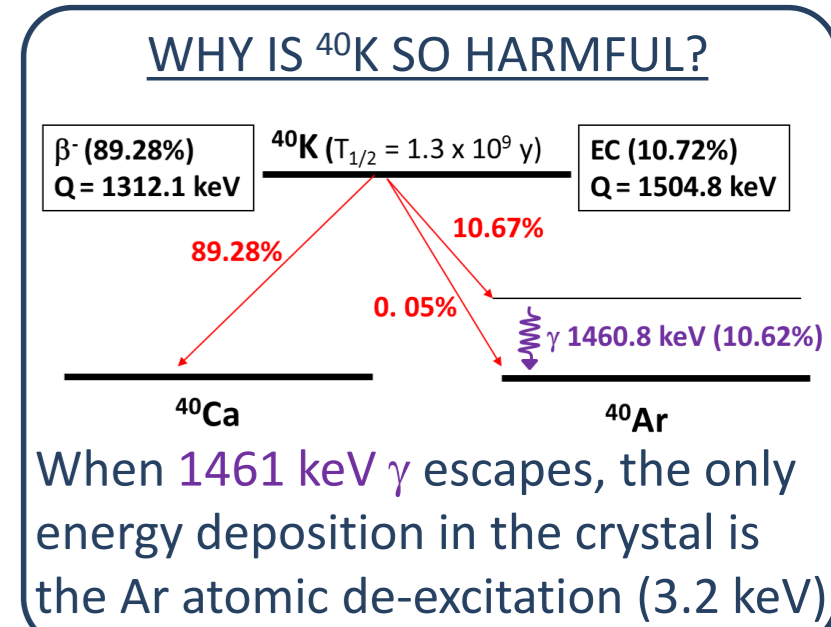
THE DETECTORS:

- 2 x 12.5 kg NaI(Tl) crystals made by Alpha Spectra (AS)
- Cylindrical shape (4.75" ϕ x 11.75" length)
- Every module is coupled (quartz window, no light guides!) to two Hamamatsu PMTs (R12669SEL2 & R11065SEL models)
- Mylar window for low energy calibrations

Taking data @ LSC since Dec 2012

GOALS:

- Detector performance assessment
- Crystals radiopurity screening (in particular ^{40}K content)
- Tuning DAQ & analysis tools



RESULTS:

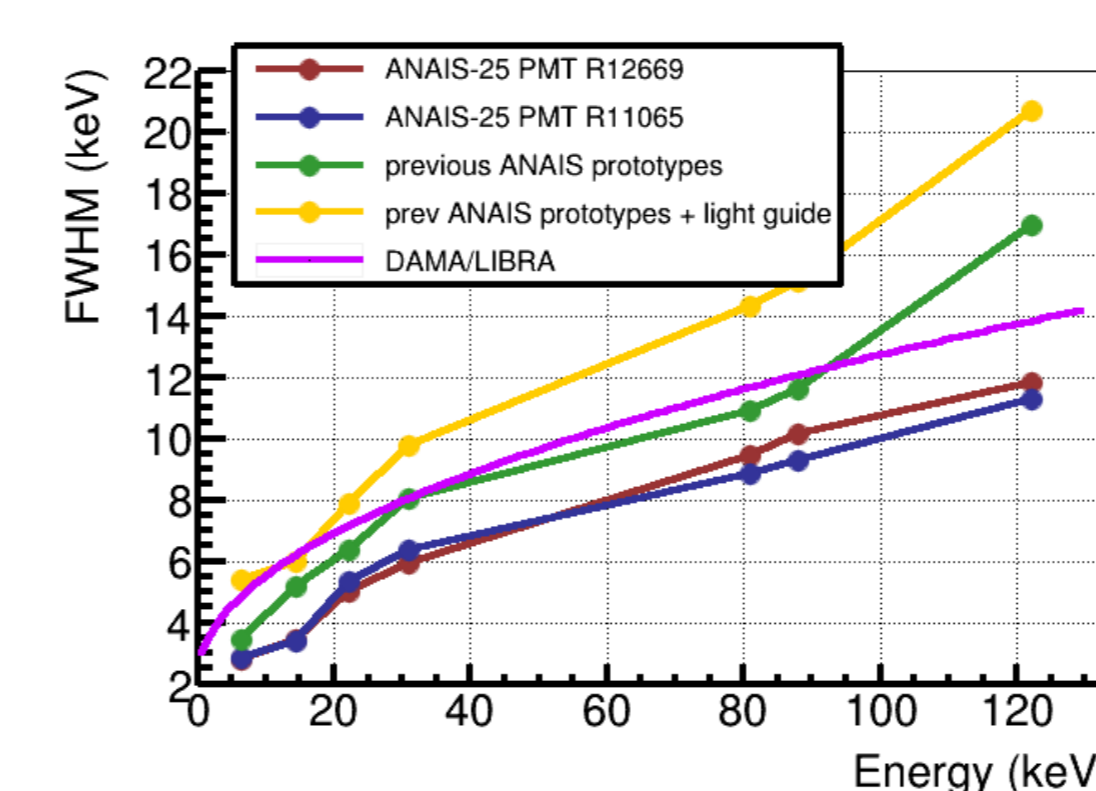
2.1 LIGHT COLLECTION EFFICIENCY:

PMT model	Phe ⁻ /keV
Ham R12669SEL2	16.13 ± 0.66
Ham R11065SEL	12.58 ± 0.13

With the higher quantum efficiency PMTs **excellent light collection efficiency**

⇒ Clear improvement in:

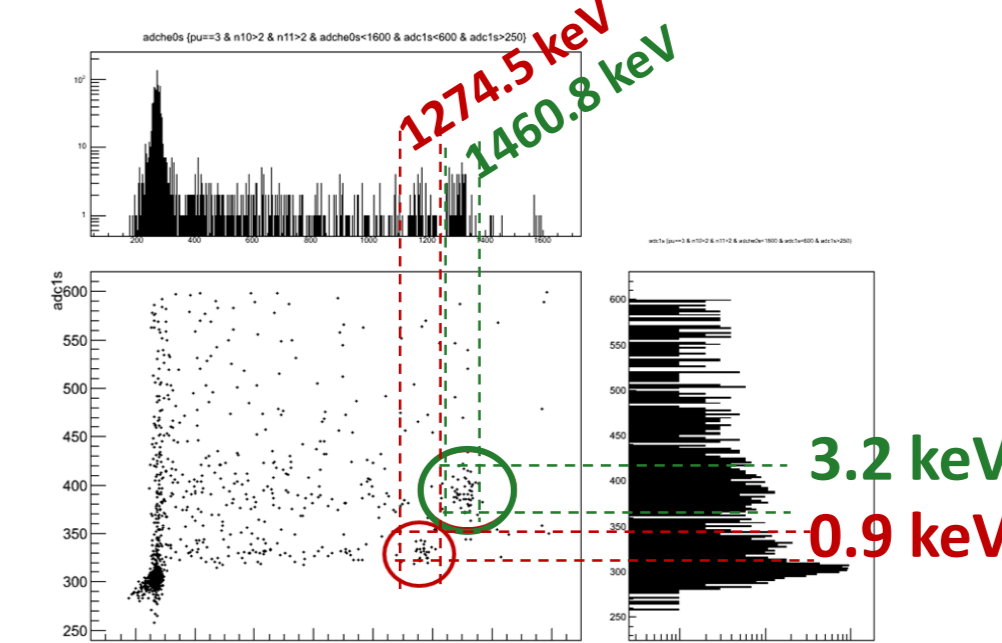
ENERGY RESOLUTION:



1.2 keV FWHM @ 3.2 keV

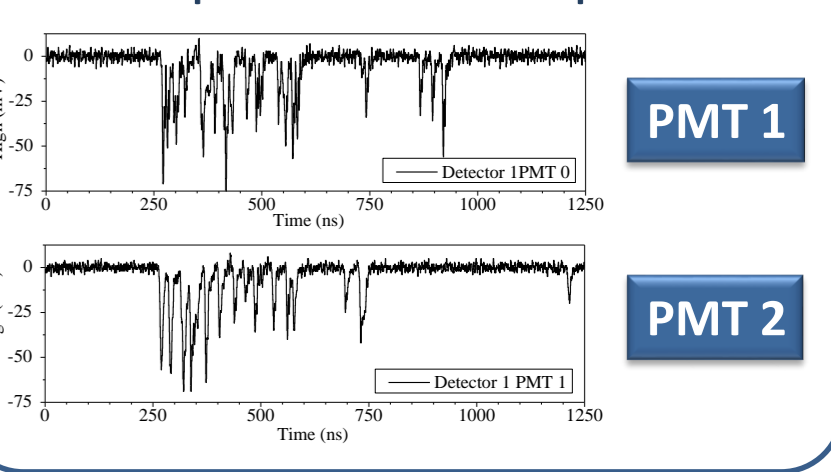
ENERGY THRESHOLD:

Study of very low energy depositions: atomic de-excitation after ^{40}K and ^{22}Na EC decays in coincidence with γ -ray in another crystal:

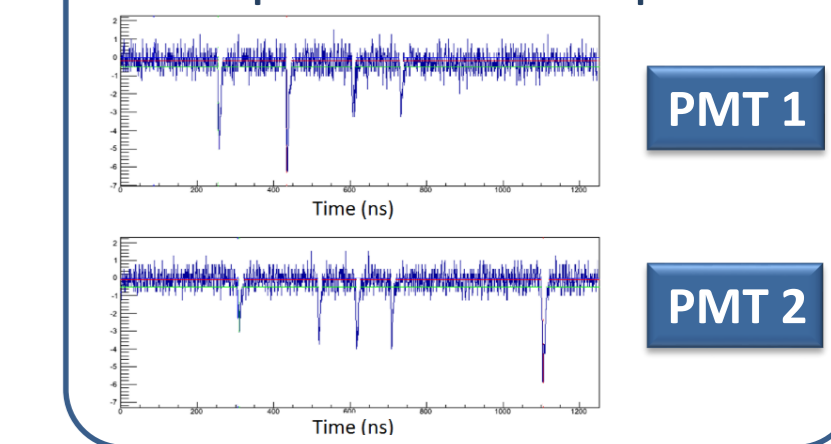


≤ 1 keV energy threshold achievable

Example of 4.7 keV pulses:

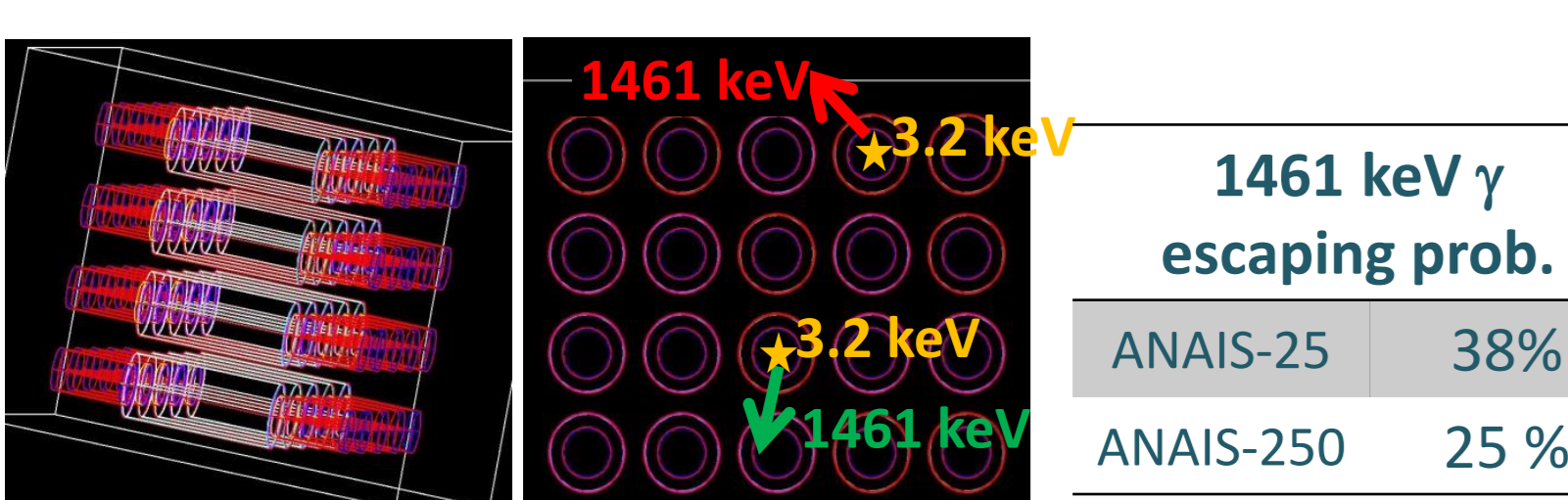


Example of 0.9 keV pulses:



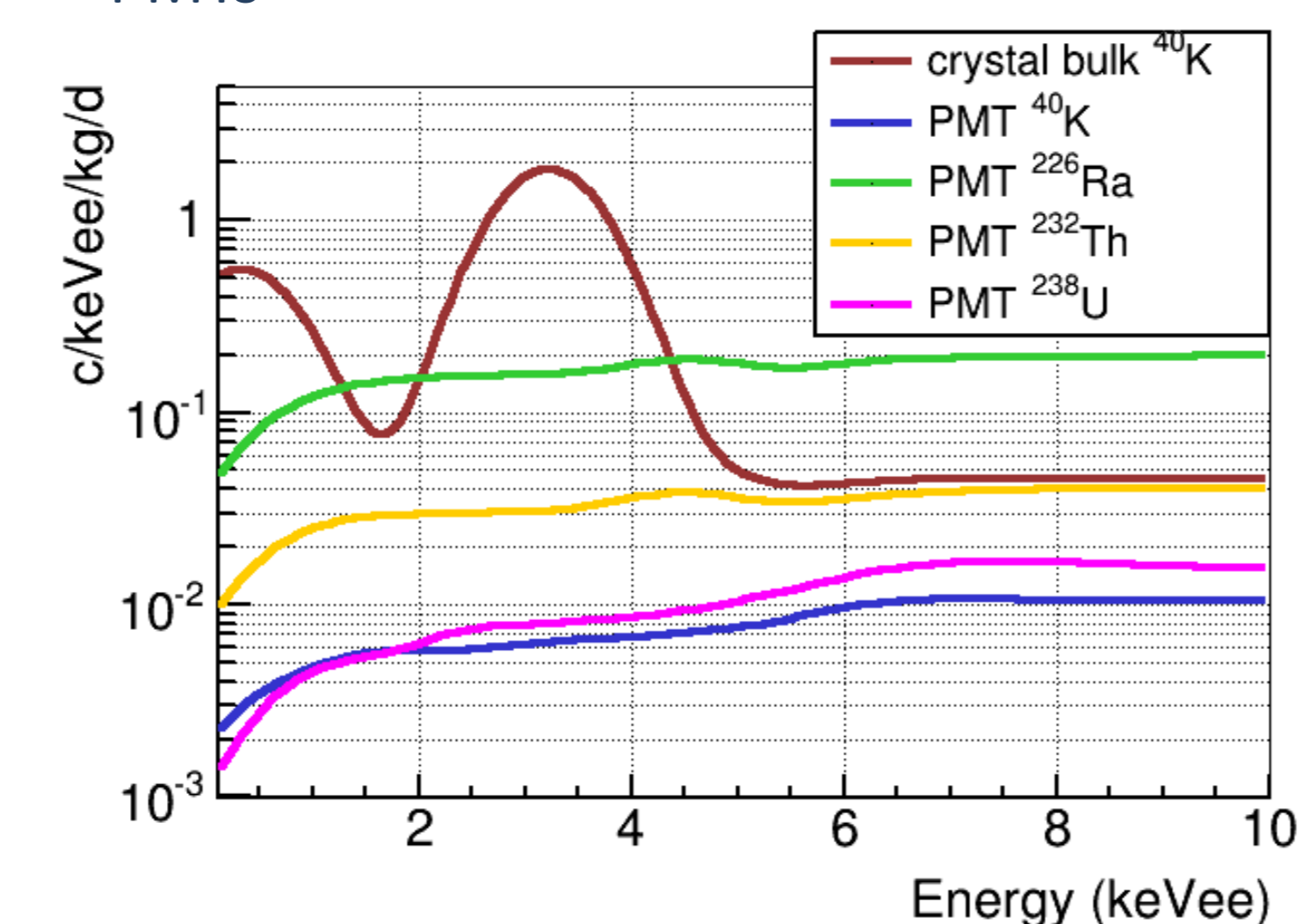
3. ANAIS-250 background model

In the complete experiment (ANAIS-250), thanks to the closed-packed configuration the 3.2 keV peak can be considerably reduced by rejecting multiple hit events. The escaping probability of the 1461 keV γ has been calculated by MC simulations:

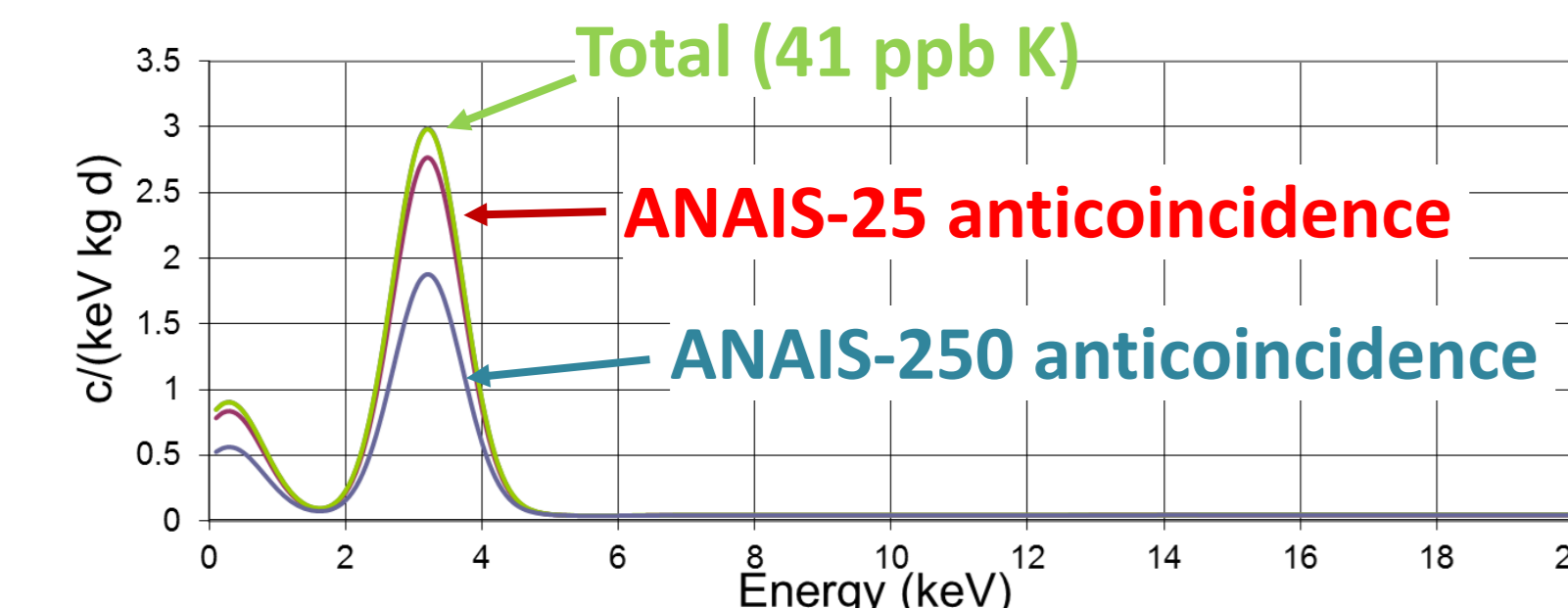


Main background contributions at low energy:

- crystal internal ^{40}K contamination
- PMTs



Even at ~40 ppb potassium level we could reach a background in the region of interest below 2 c/keV/kg/d



4. Setting the scene for ANAIS-250

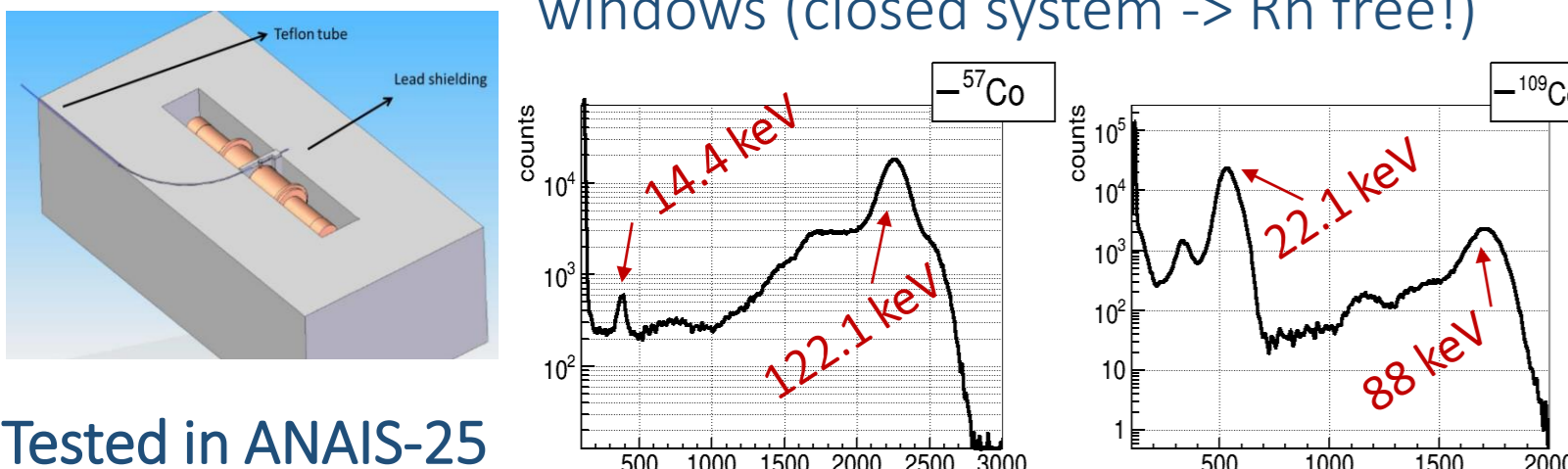
4.1. PMTs



30 units from Hamamatsu R12669 PMT (specially built for ANAIS) have been received at LSC by now (the remaining 10 before Aug 2014) and are being characterized (radiopurity, dark current, gain, quantum efficiency...)

4.2. LOW ENERGY CALIBRATION SYSTEM

^{57}Co and ^{109}Cd sources along flexible wires. During calibrations they are introduced into the shielding and positioned in front of the Mylar windows (closed system → Rn free!)



4.3. DAQ & ANALYSIS TOOLS

- Electronic chain (20 detectors x 2 PMTs = 40 channels) fully commissioned. Every PMT channel is digitized independently at 2 GS/s with high vertical resolution (12 bits)
- Data acquisition software ready
- First level analysis & events selection protocols optimized with previous prototypes

4.4. ACTIVE VETOES



To remove muon-related events, plastic scintillators will cover maximally the ANAIS shielding:

- 12 (100 x 50 x 5 cm³) (lateral faces)
- 4 (75 x 70 x 5 cm³) (top face)

They are being tested in ANAIS-25

4.5. SHIELDING

All the archaeological and low activity lead required for the whole ANAIS shielding is available underground at the LSC, ready for the mounting (+mechanical isolation, polyethylene and anti-radon box)

4.6. SLOW CONTROL

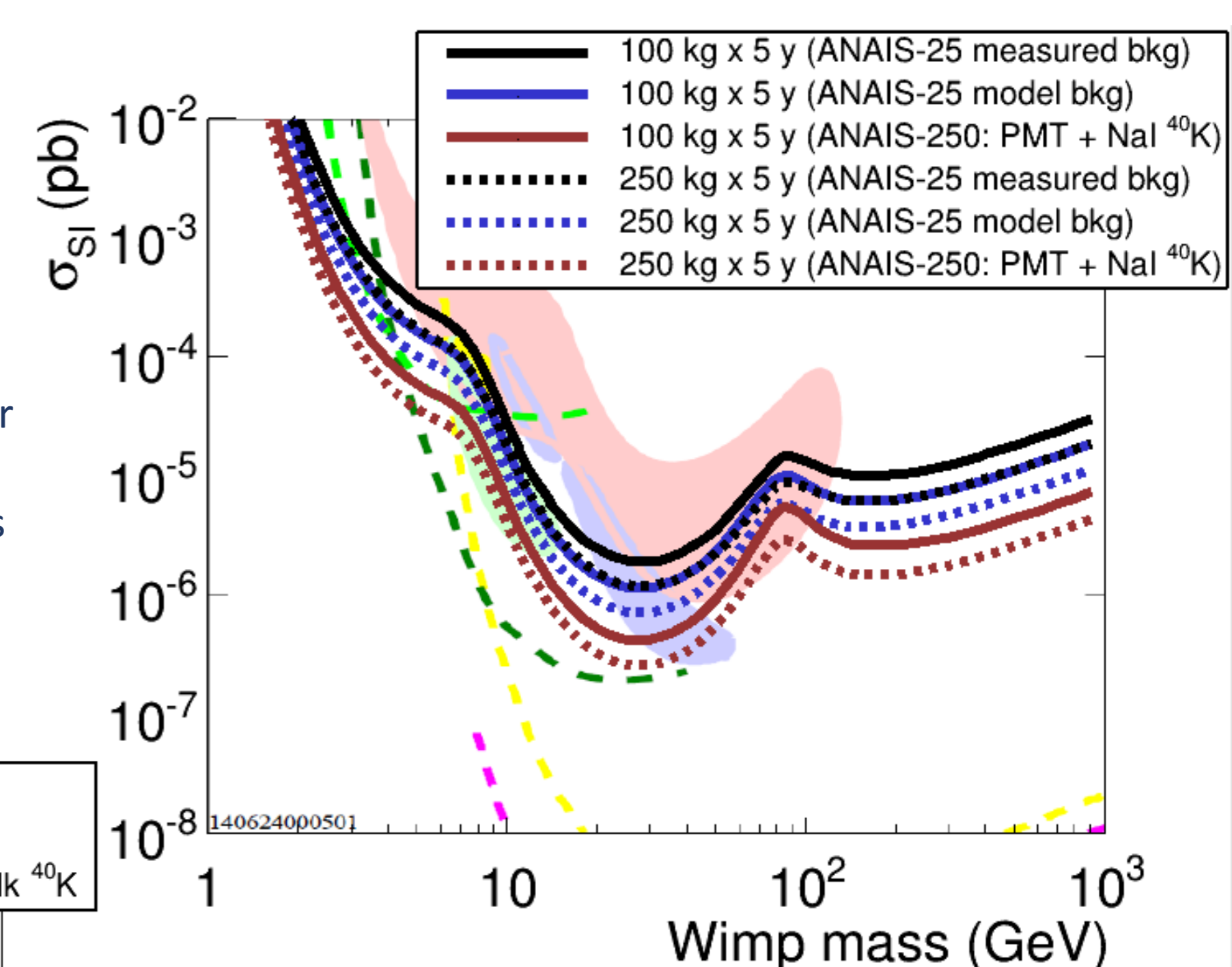
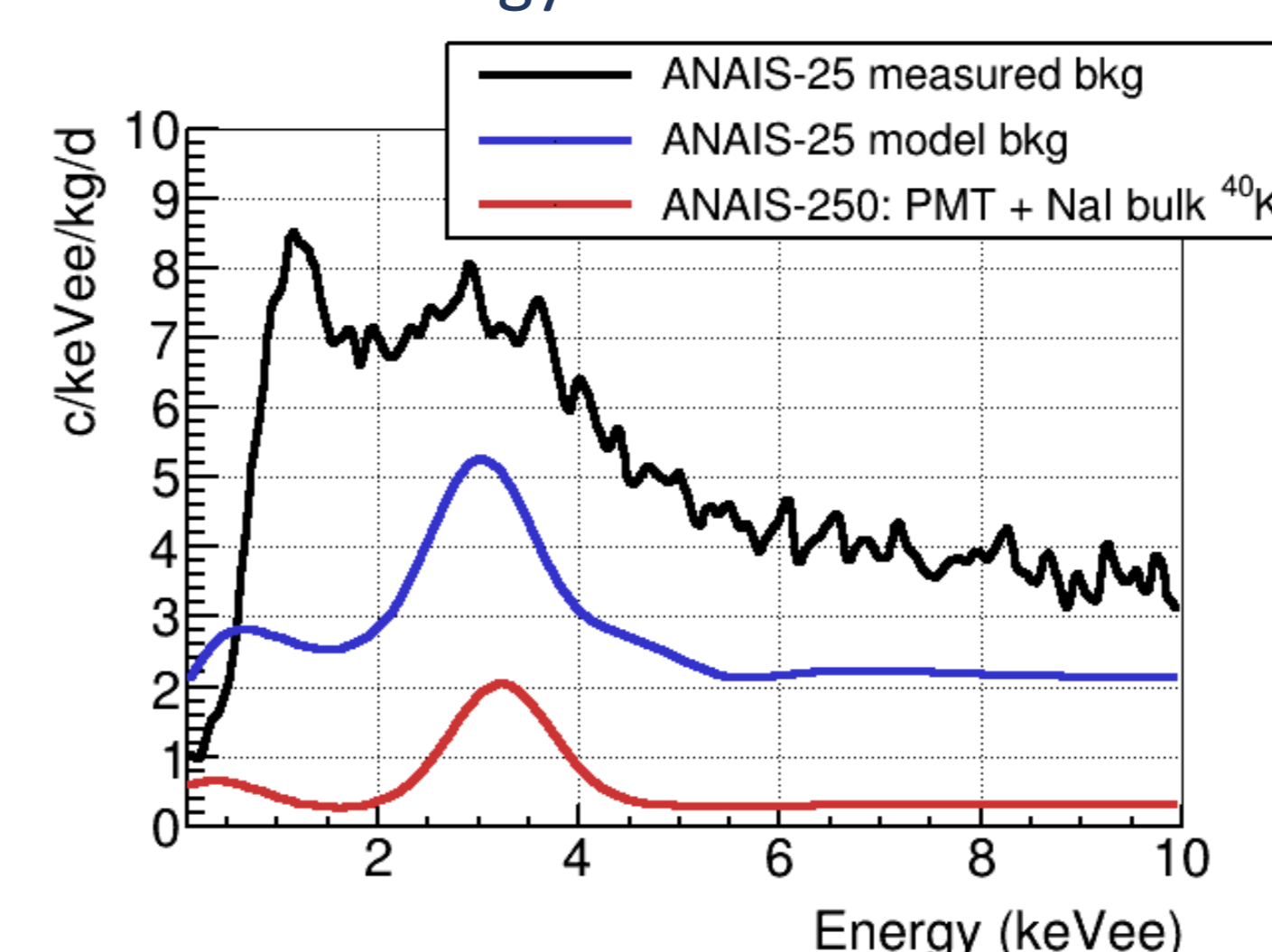
A slow control system is installed, currently monitoring:

- Temperature
- Radon concentration (Hut/electronics/Hall B) @ Hall B
- N₂ flux
- HV supply
- Baseline noise
- Muon rate
- ...

5. ANAIS projected sensitivity

Projected ANAIS sensitivity to annual modulation supposing:

- 3 different background models
 - Measured bkg in ANAIS-25.
 - Model for ANAIS-25 considering PMTs, copper encapsulation, optical windows, lead shielding, radon in the inner volume air & NaI bulk contaminations.
 - Main contributions from ANAIS-250 (PMTs + 40 ppb K in NaI bulk).
- 100 / 250 kg total mass x 5 years.
- 1-3 keV energy window.



http://cedar.Berkeley.edu/plotter

- CoGeNT Annual Modulation Search, PRL 107 (2011), ROI
- CDMSlite Soudan, Run 1 (2013)
- CDMS-II (Soudan Silicon SI Result, R125-128, contour, 68% C.L.)
- DAMA/LIBRA 2008 5sigma, no ion channeling
- CRESST-II 1-Sigma Allowed Region, 730k-days data
- SuperCDMS Soudan LT (2014), 90% C.L.
- XENON 100 Results from 225 live days of data presented at IDM
- LUX (2013) 90% U.L.