Status of the ANAIS Dark Matter project

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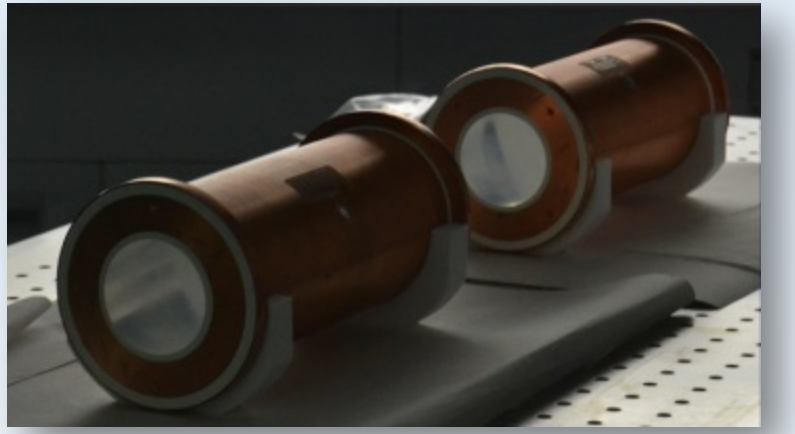
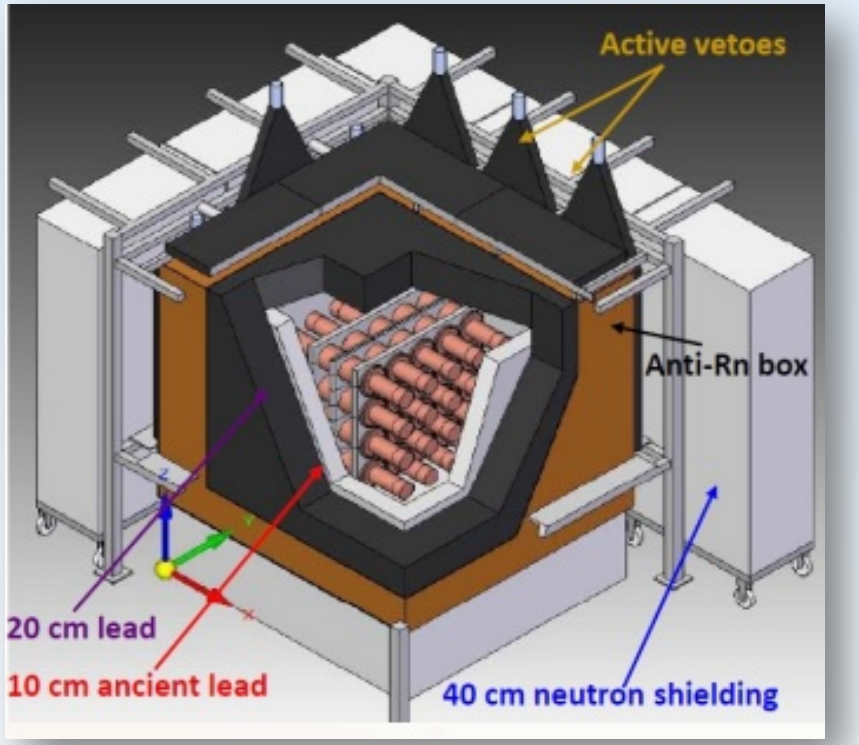
Outline

- The ANAIS experiment
- ANAIS prototypes
  - ANAIS-0
  - ANAIS-25
- ANAIS-25
  - ^{40}K content
  - Trigger efficiency
  - Energy resolution
  - Light collection efficiency
  - Background analysis
  - Background model for ANAIS-25 set-up
- ANAIS-250: Background model
- ANAIS summary and prospects



The ANAIS project



ANAIS
Annual modulation with NaI Scintillators

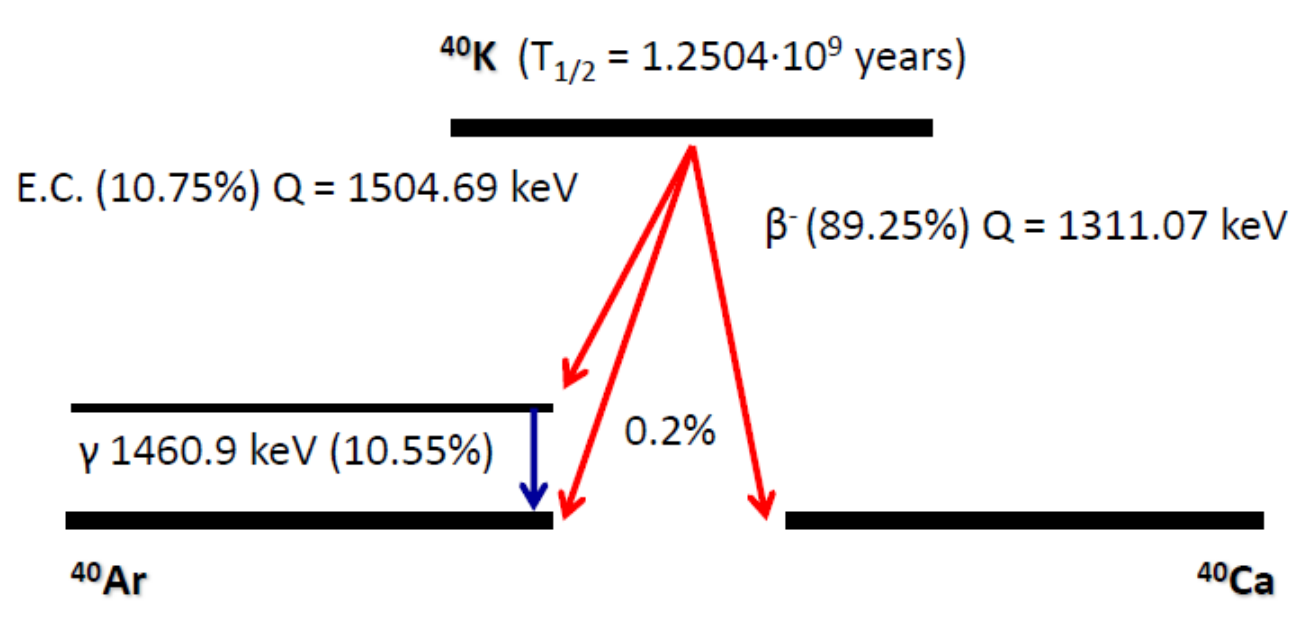
250 kg of ultrapure NaI(Tl) detectors at the Canfranc Underground Laboratory (LSC)

Threshold goal < 2keVee
Background goal < 2 counts/(keV kg day)

SAME TARGET AND TECHNIQUE AS DAMA/LIBRA

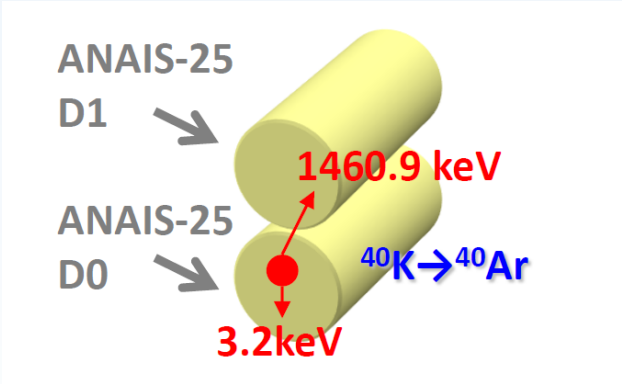
The ANAIS project

^{40}K in crystals



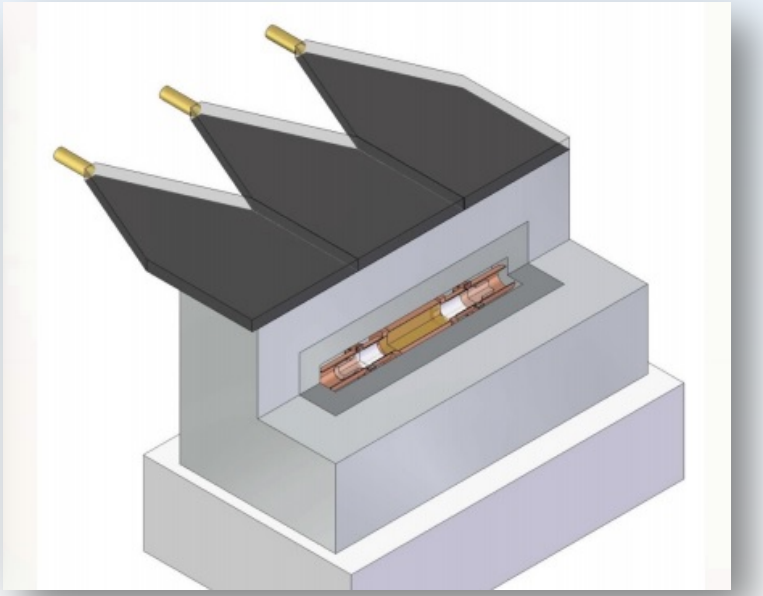
3.2 keV energy deposition
Region of interest for ANAIS!!

Very difficult to track in powder



ANAIS-0 (2009 - 2012)

9,6 kg NaI(Tl) crystal made by Saint Gobain
4"x 4"x 10"
Encapsulated at the UZ



Goals

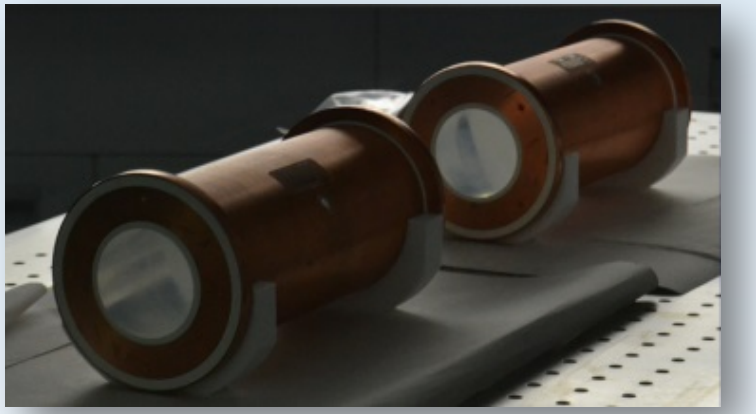
Understand bulk crystal background

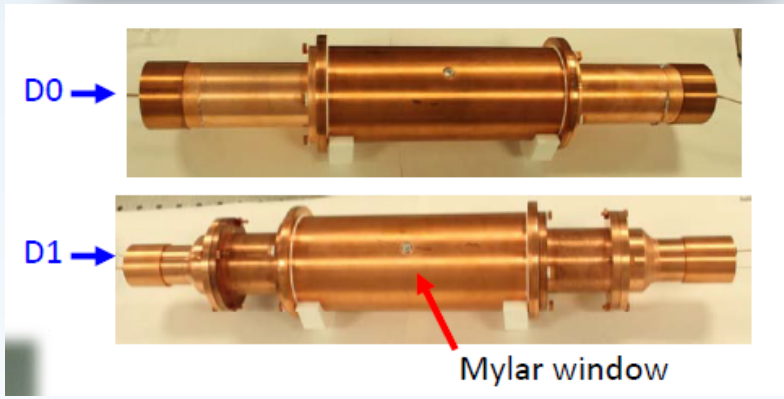
Tune-up electronics and acquisition system

Filtering protocols at low energy

➡ Astropart. Phys. 37 (2012) 60-69

ANAIS prototypes





- Coupled to Hamamatsu PMTs at LSC clean room

- No light guides

ANAIS-25

ANAIS-25 (2012 -)

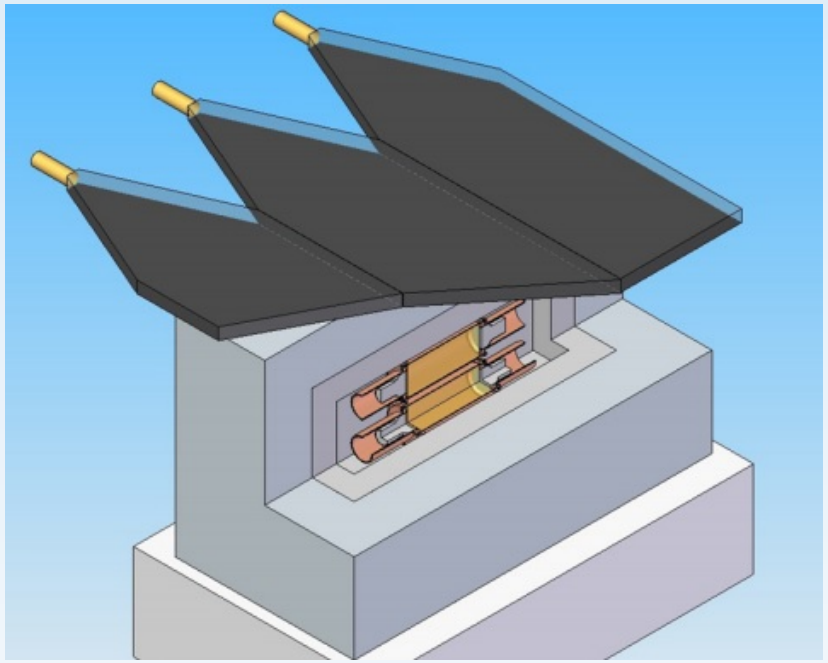
12,5 kg NaI(Tl) crystal made by Alpha Spectra

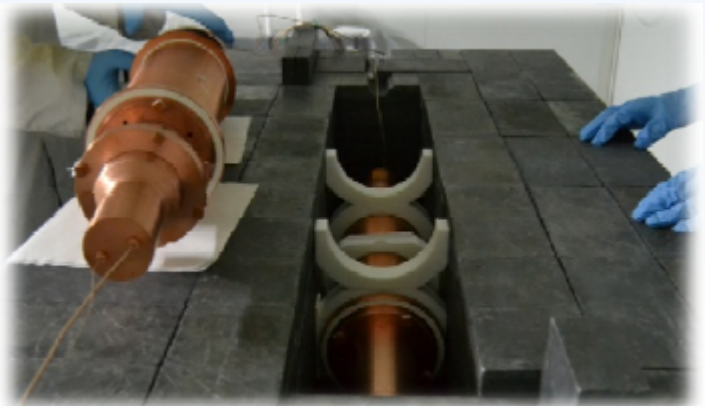
4.75"x 11.75" cylinder

Main goals:

Determine potassium content

General performance assessment

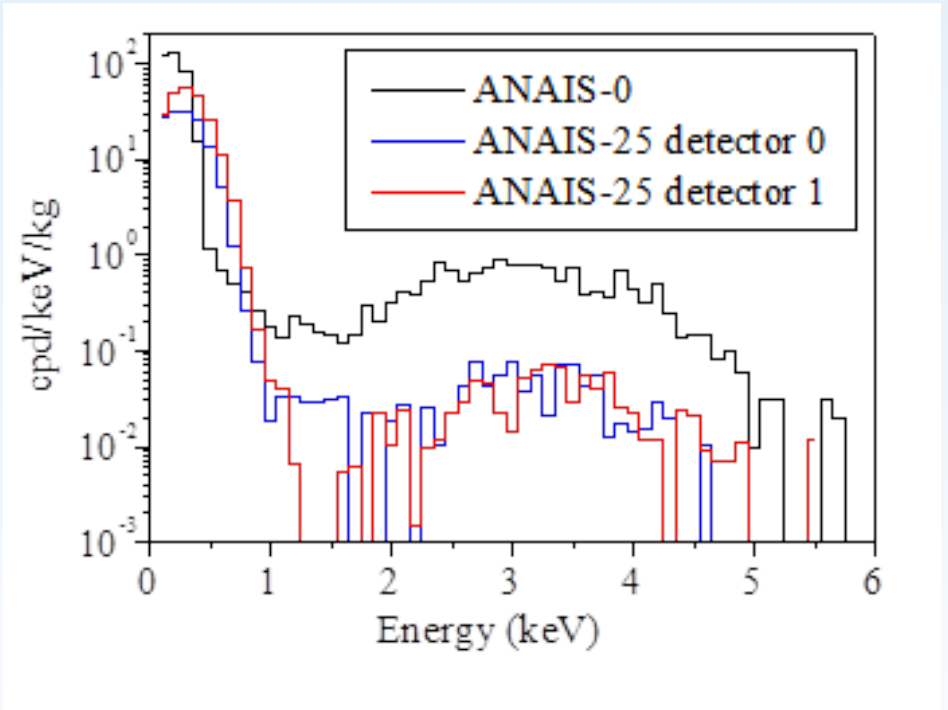




ANAIS-25

^{40}K content in ANAIS-25

	Potassium	^{238}U	^{232}Th
AS – selected powder	*< 90 ppb*	*<0.055 ppb*	*<0.13 ppb*
ANAIS-25 crystals	***41.7 ± 3.7 ppb***	0,81 ± *0,16* ppt	0,5 ± *0,2* ppt



ANAIS goal is 20 ppb!!

But... it is 1 order of magnitude better than our previous prototypes!

Trigger efficiency in ANAIS-25

Looking at events in coincidence with high energy gamma from potassium

→ 3.2 keV population events after ^{40}K decay triggered

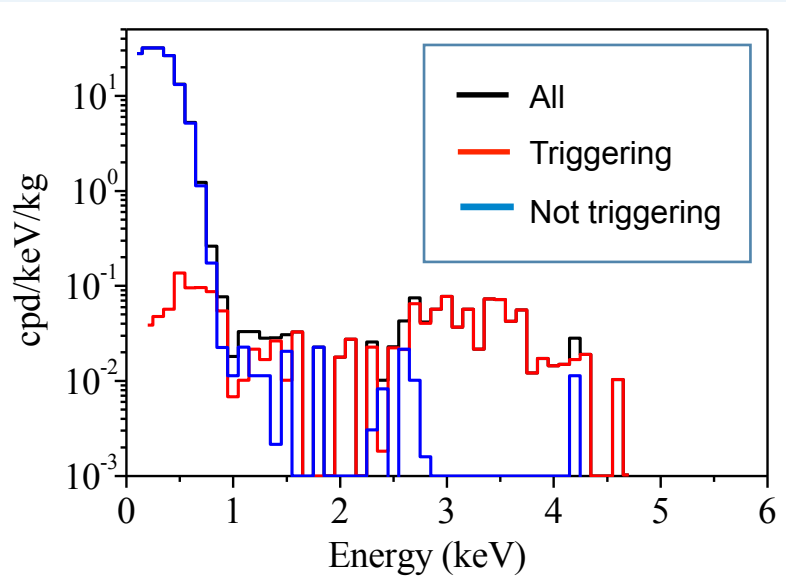
Limits for the trigger efficiency:

~97% of the events above 1.5 keV in D0

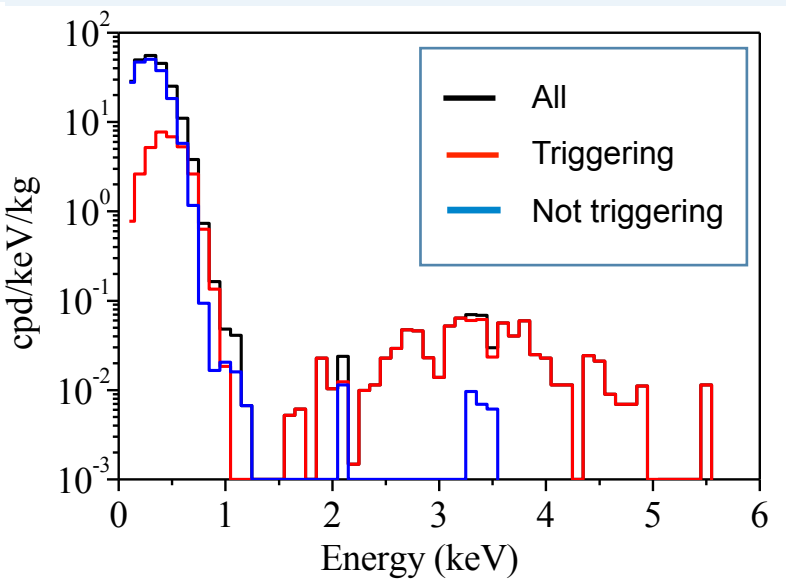
99% of the events above 1.5 keV in D1

Trigger at 1.5 keV achieved
- **with high efficiency**

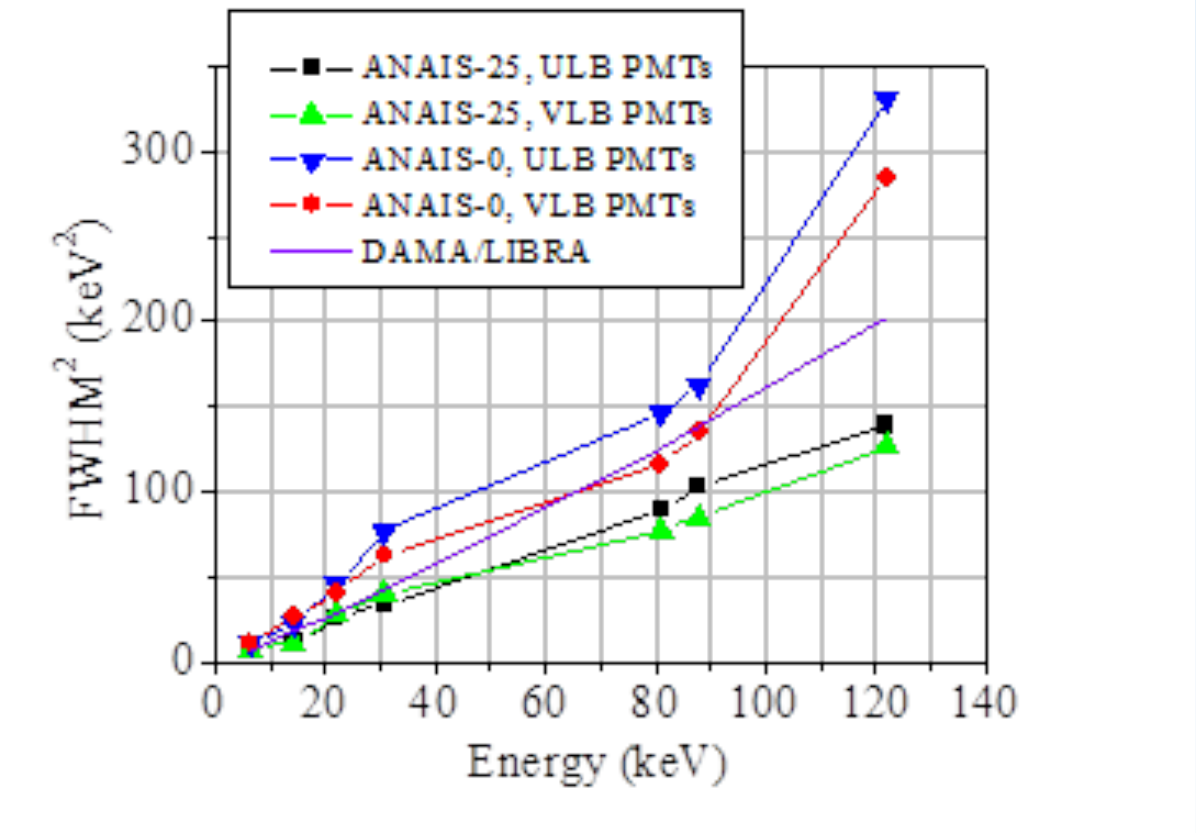
Detector 0



Detector 1



Energy resolution efficiency in ANAIS-25

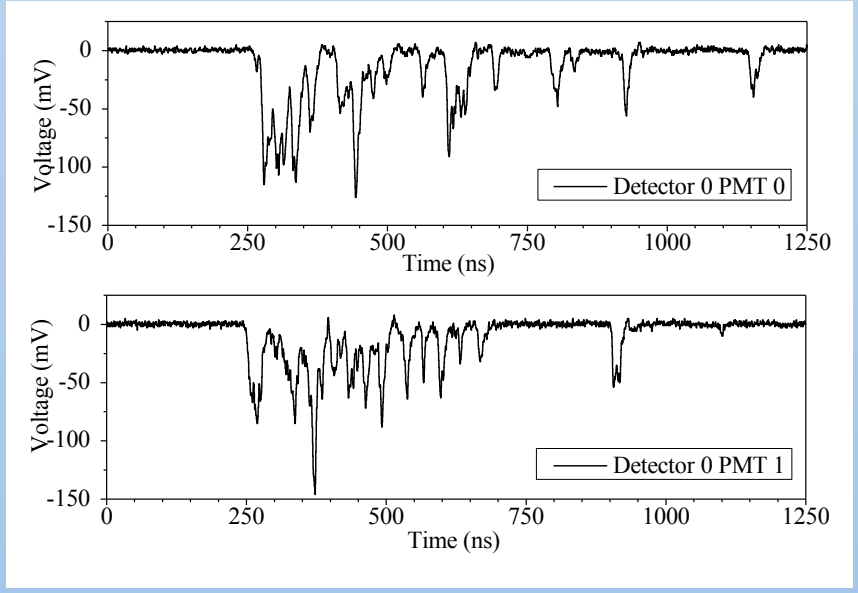


Significant improvement in energy resolution observed in ANAIS-25

Consistent with the improvement in light collection efficiency

ANAIS-25

Measurement of individual photoelectrons



Pulses at 4.7 keV

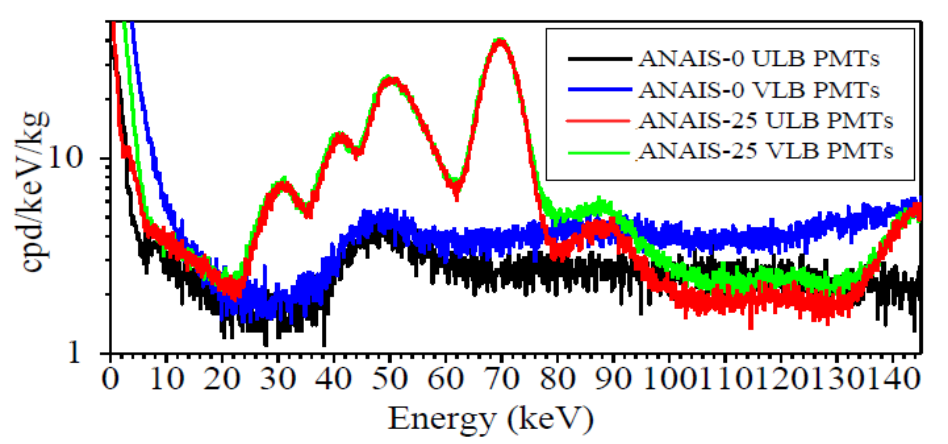
Light collection efficiency in ANAIS-25

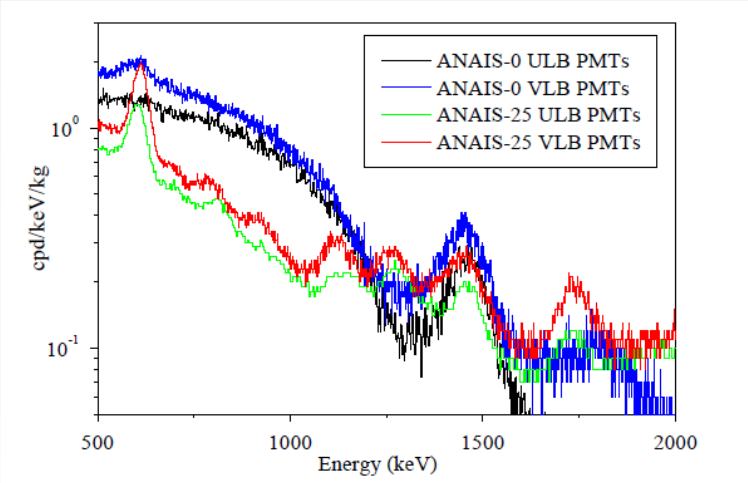
ANAIS Set-up	ph.e./keV at PMT0	ph.e./keV at PMT1	ph.e./keV (total)
ANAIS-0 Set up 4	2.68 ± 0.04	2.66 ± 0.03	5.34 ± 0.05
ANAIS-0 Set up 5	3.66 ± 0.02	3.71 ± 0.07	7.38 ± 0.07
ANAIS-25 D0	7.77 ± 0.04	8.36 ± 0.66	16.13 ± 0.66
ANAIS-25 D1	5.82 ± 0.08	6.76 ± 0.10	12.58 ± 0.13

We are confident we can reduce energy threshold down to 1 keVee

EXCELLENT LIGHT COLLECTION EFFICIENCY CAN BE REPORTED

Background analysis: First month

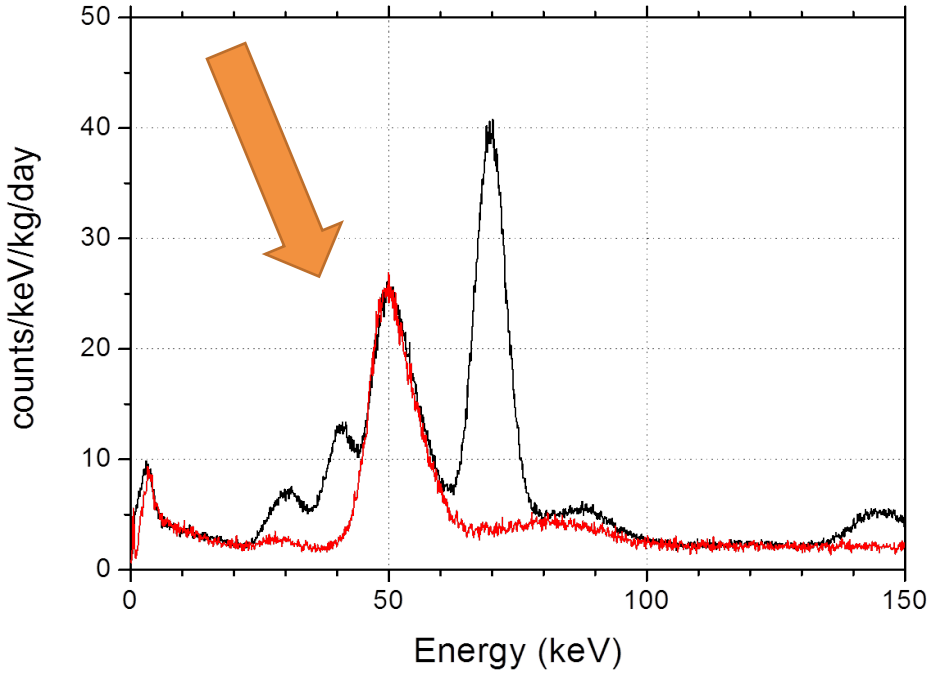




Raw data

- Cosmogenically activated isotopes dominate background at low energy
- Clear reduction of ^{40}K background at high energy in comparison with previous prototypes
- Below 20 keV background is dominated by dark events / PMT events
- Effect of the PMT radiopurity is present above 80 keV

Background analysis



Events at low energy are filtered by selecting number of photoelectrons larger than 2 in both PMTs separately.

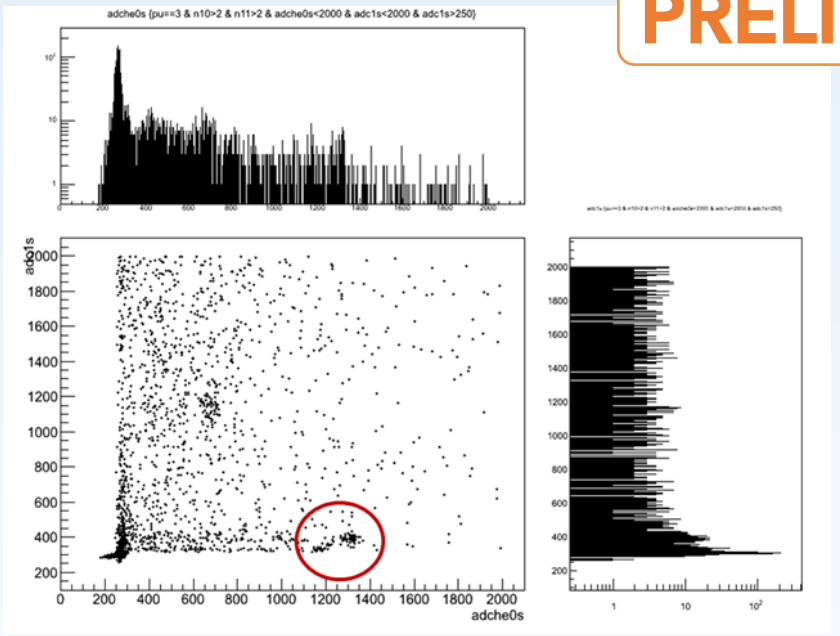
— First month of taking data ⟹ Cosmogenic isotopes contributing

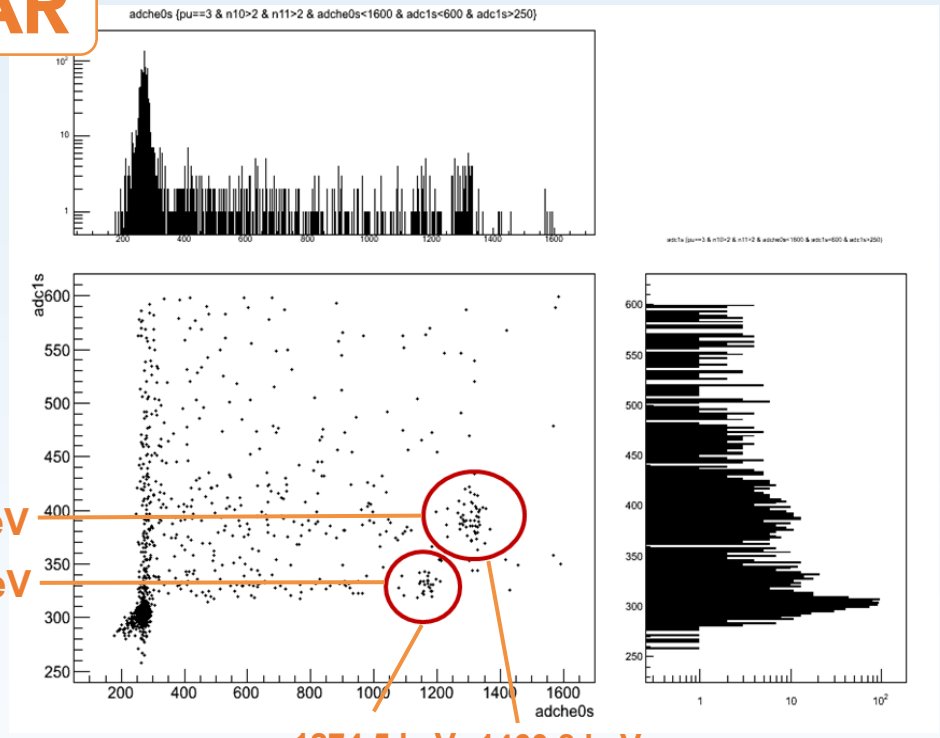
— After fifteen months underground ⟹ Still high contribution at about 50 keV!!

Study of coincidences between modules:

Background analysis

PRELIMINAR





Peaks corresponding to ^{40}K and ^{22}Na identified

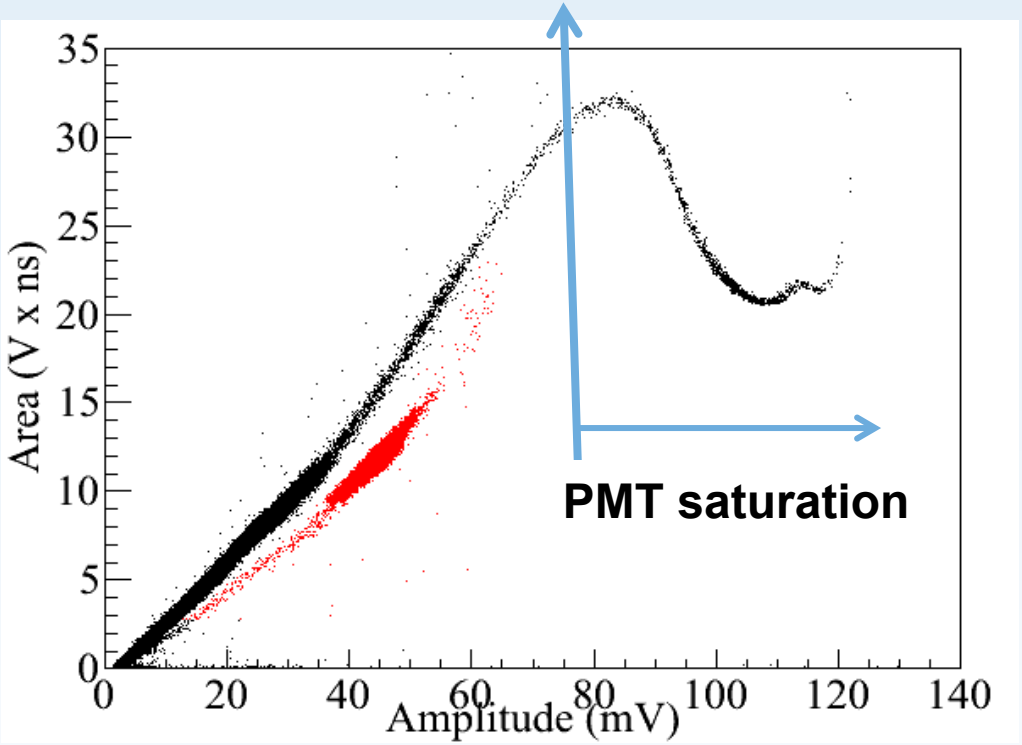
Background analysis

Alpha events identified by PSA

Total alpha rate in both modules

280 kg^{-1} day^{-1} (3.15 mBq/kg)

Much higher than that of ANAIS-0 prototype !!



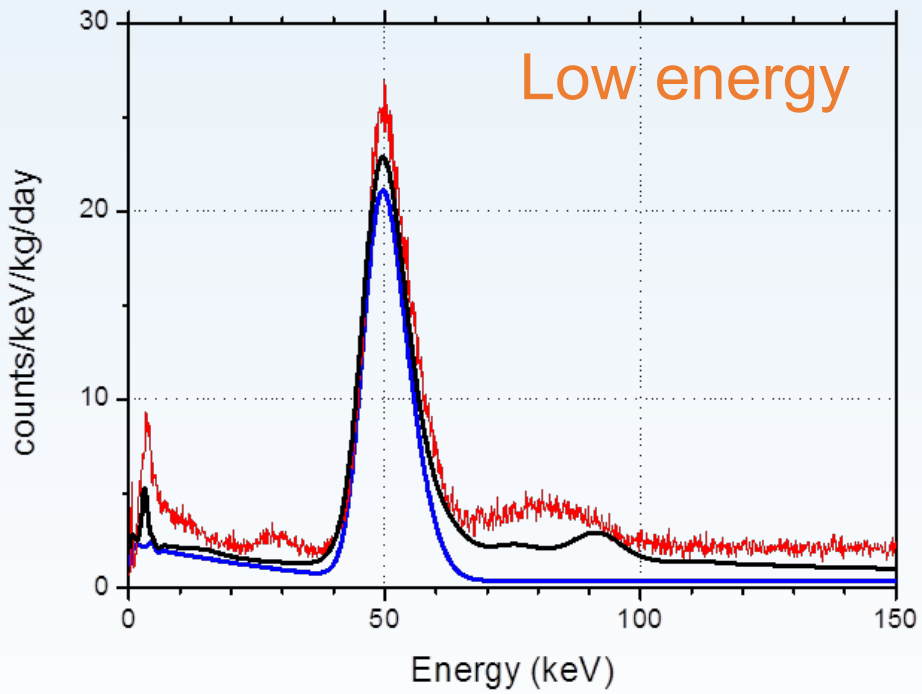
Could be mostly attributed to ^{210}Po coming from the ^{210}Pb decay

⟹ Explanation also to line at about 50 keV at low energy

Background model for ANAIS-25 set-up

Geant 4 simulation of the ANAIS-25 setup:

Contribution from PMTs, copper encapsulation, optical windows, lead shielding and radon in the inner volume air, and some internal contaminations in the NaI(Tl) crystal, distributed homogeneously in the bulk:



- **1.25 mBq/kg of ^{40}K (corresponding to 40 ppb K)**
- **0.94 mBq/kg of ^{129}I**
- **10 μBq/kg of ^{238}U**
- **3.15 mBq/kg of ^{210}Pb (out of equilibrium)**
- **3 μBq/kg of ^{232}Th**

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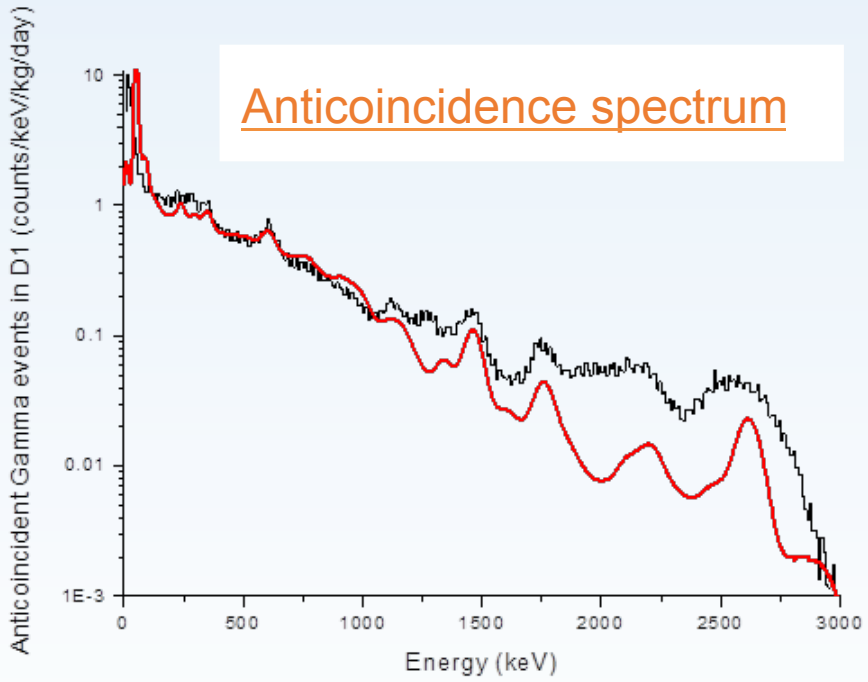

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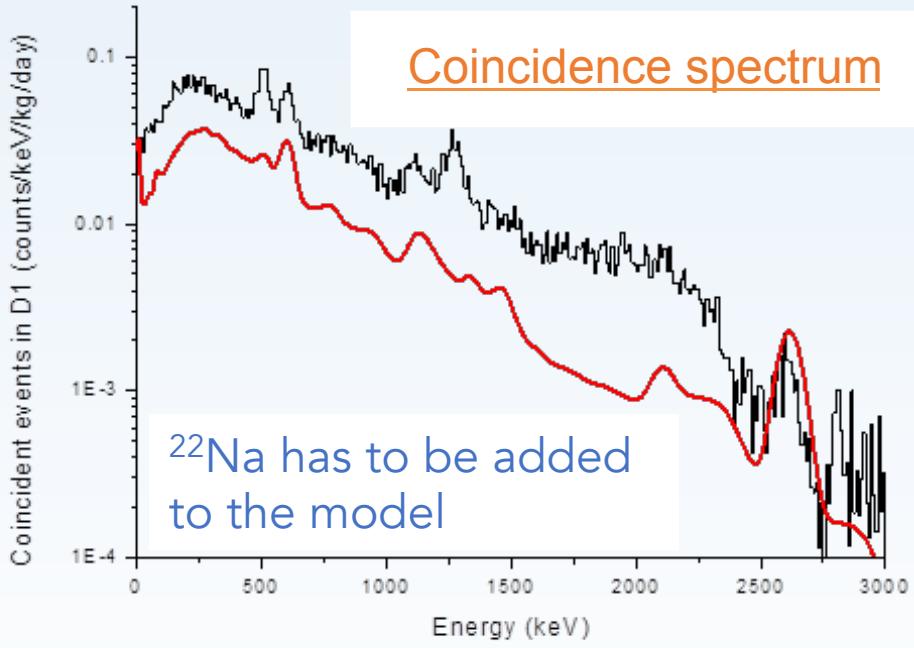

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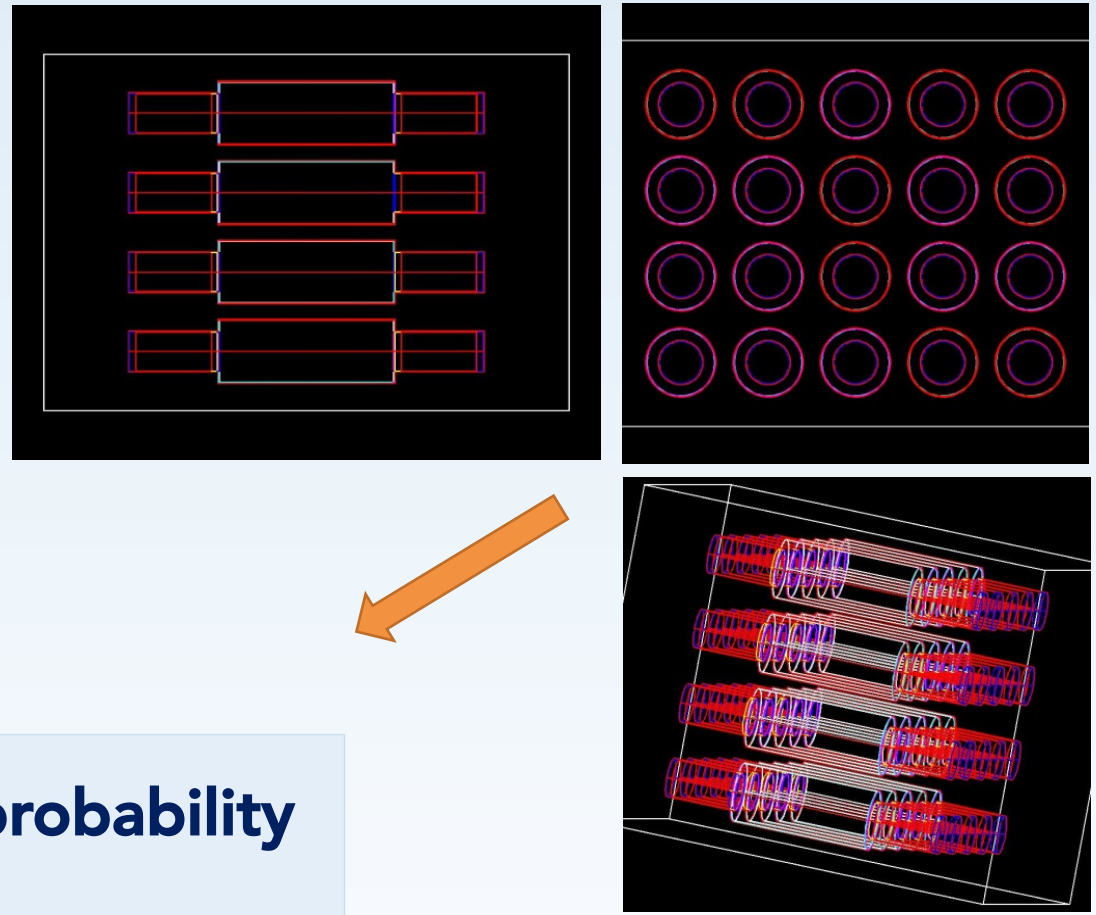
ANAIS-250: Background model

20 NaI(Tl) detectors
12,5 kg each
Configuration: 4 x 5 matrix



First goal of global rejection capability is to estimate the ^{40}K events rejection factor in different experimental configurations.

Work is in progress

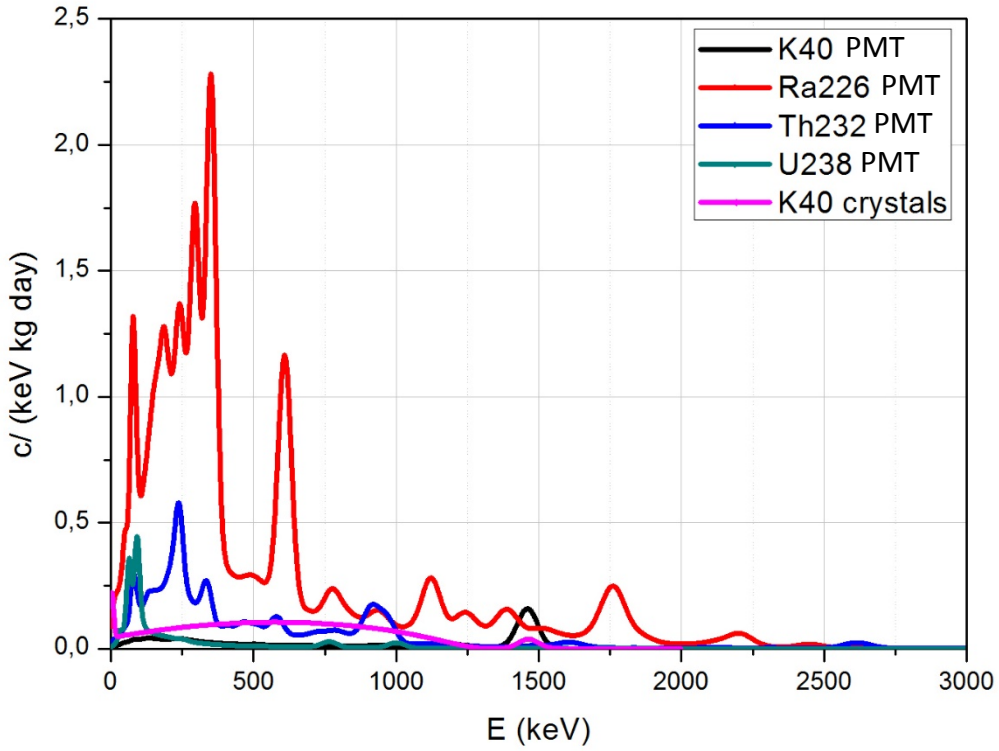
1460.8 keV gamma escaping probability

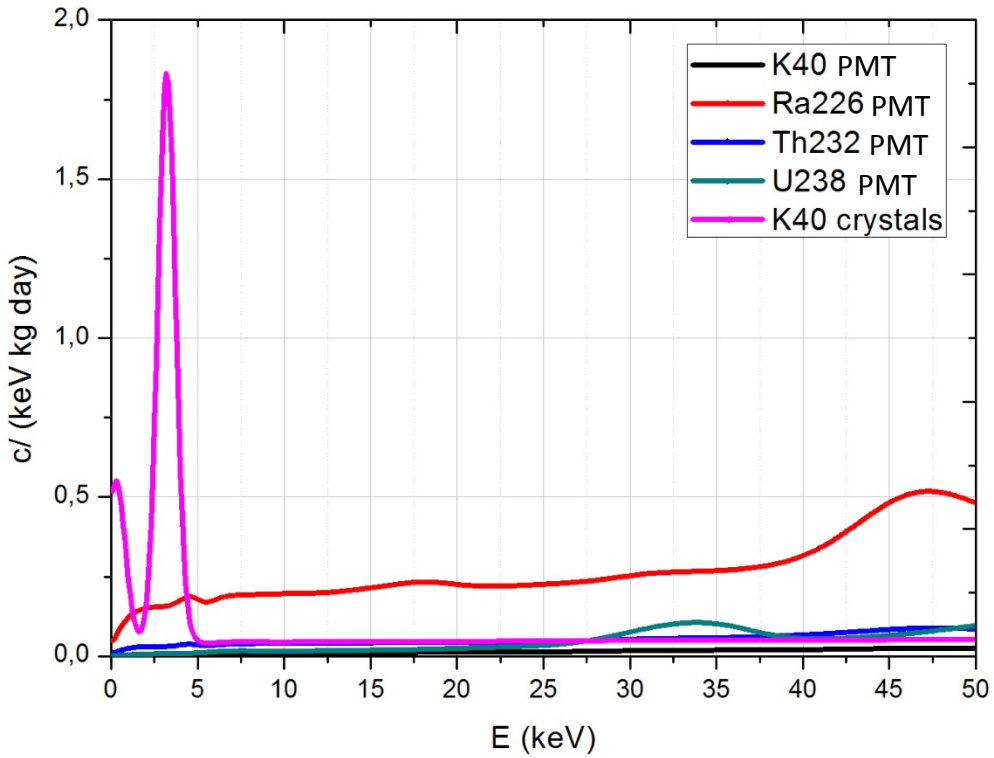
ANAIS-25 ~38%

ANAIS-250 ~25%

ANAIS-250: Background model

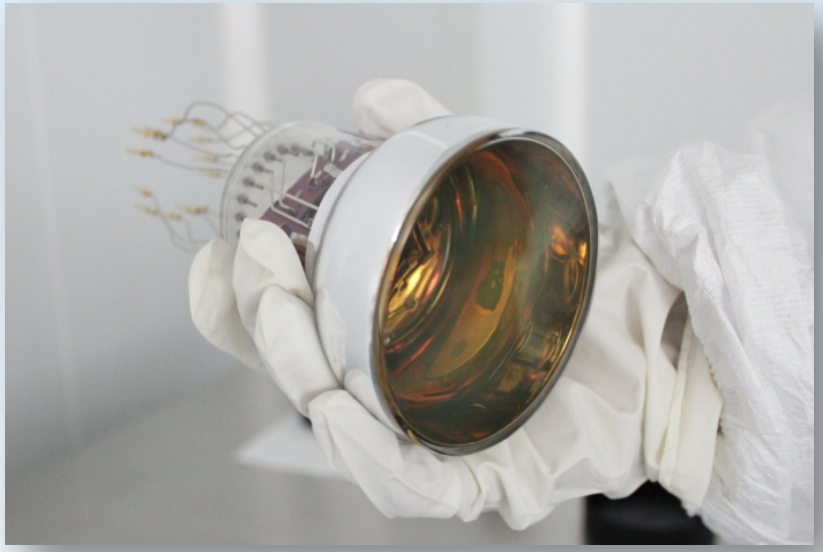
^{40}K contamination in the crystals (40 ppb) vs ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U contamination in PMTs





Anticoincidence spectrum

ANAIS Status



Photomultipliers

First 30 units from Hamamatsu R12669 PMT (specially built for ANAIS) received at LSC by now

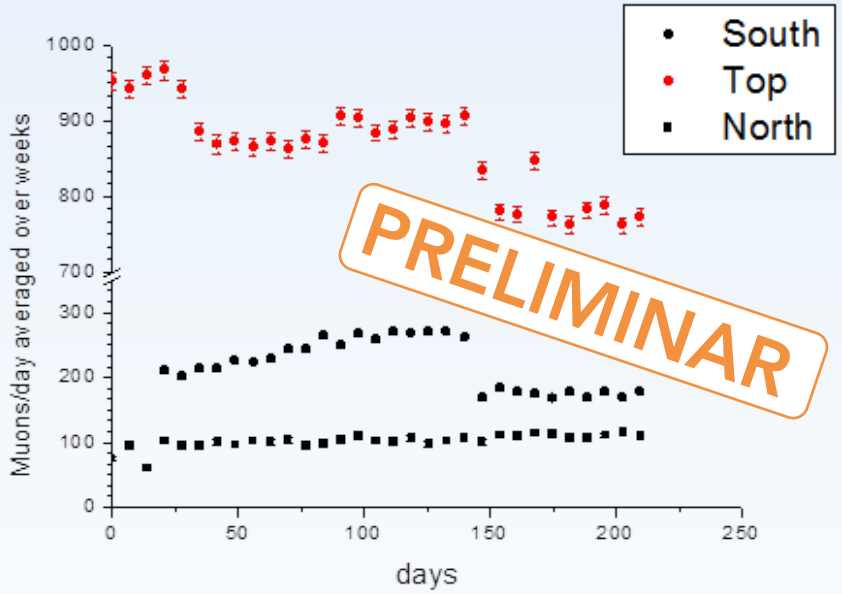
Screening and testing started immediately after reception and still ongoing

The rest of the PMT units
August 2014

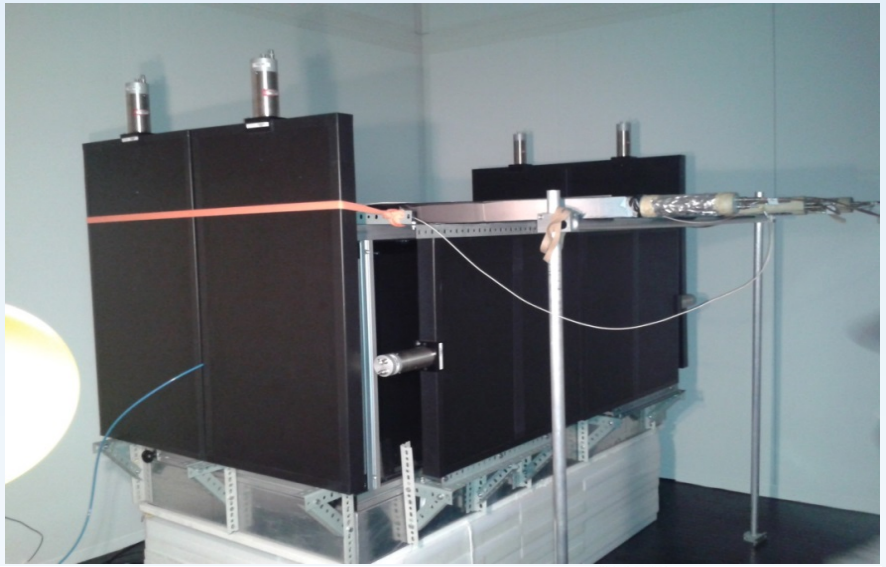
ANAIS Status

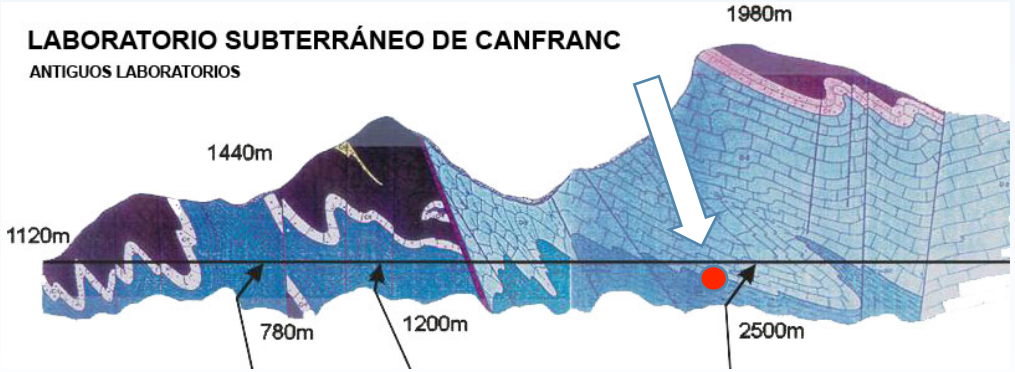
Vetoes

New scintillator vetoes installed in Summer 2013 → Rejection of muons



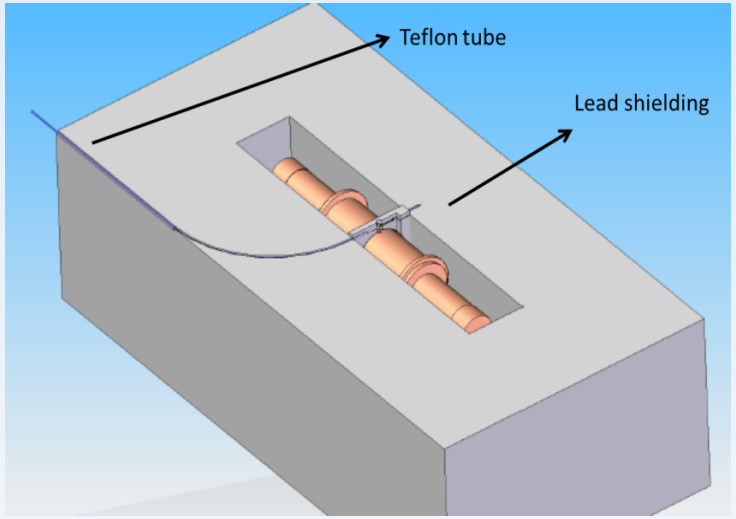
Muon flux asymmetry & study of possible modulations

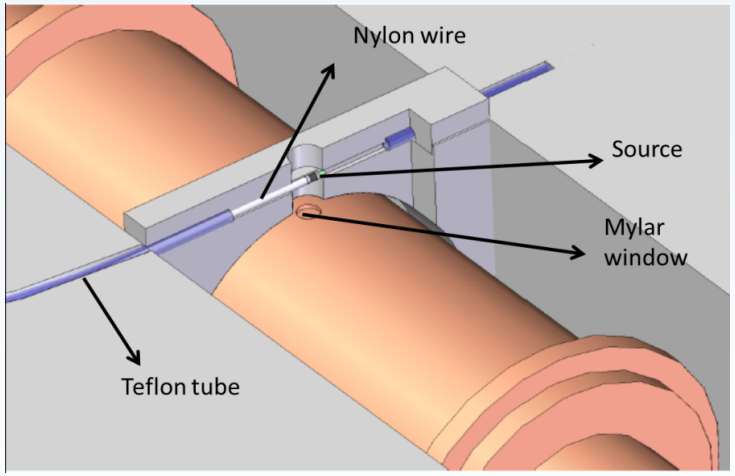




ANAIS Status

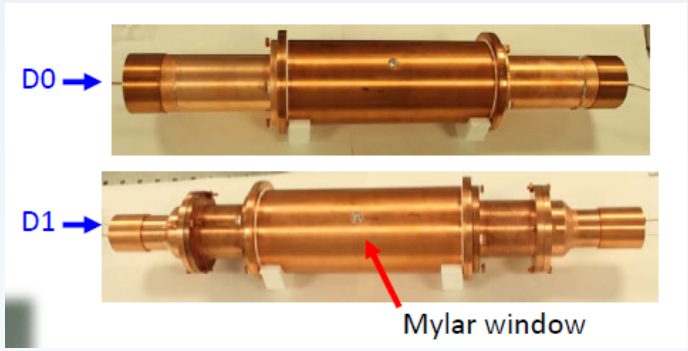
Energy calibration





Calibration system for ANAIS-250 designed

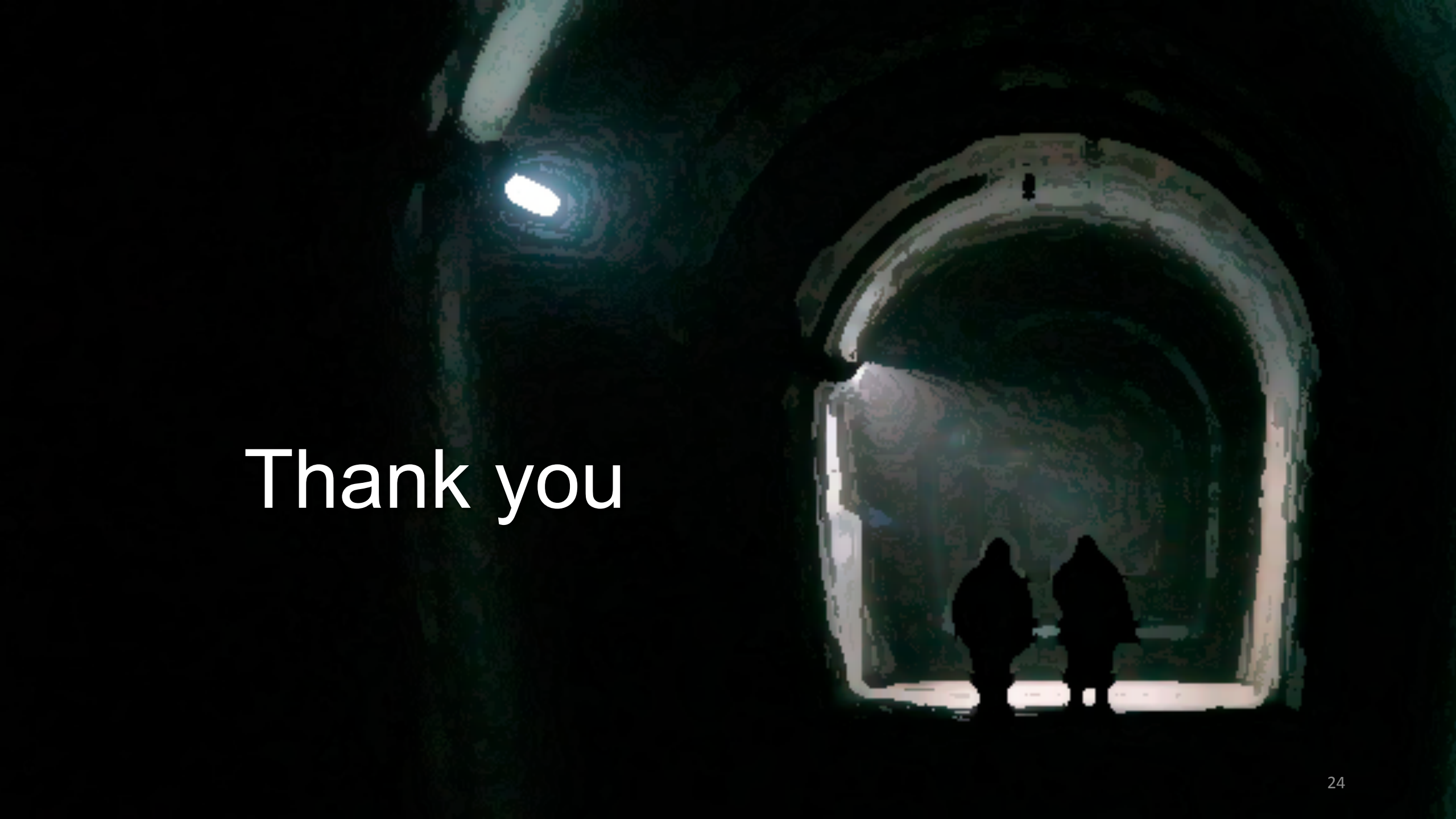
→ Being tested in ANAIS-25



^{57}Co and ^{109}Cd sources along a flexible wire

ANAIS summary and prospects

- Electronics and shielding are prepared for the installation of ANAIS-250 at Canfranc
- Detectors have shown to be really good:
  - Very low energy threshold
  - Excellent light collection
  - Low energy calibration
  - Energy resolution
- We keep trying to further understand our low energy background
- ^{210}Pb contamination issue could have been solved at AS and further purification in K has been attempted. New material by AS could be ready very soon (first grown large mass crystal could be ready by September to be checked at LSC for radiopurity)
- We are discussing the terms of agreement for 250kg NaI(Tl)


Thank you