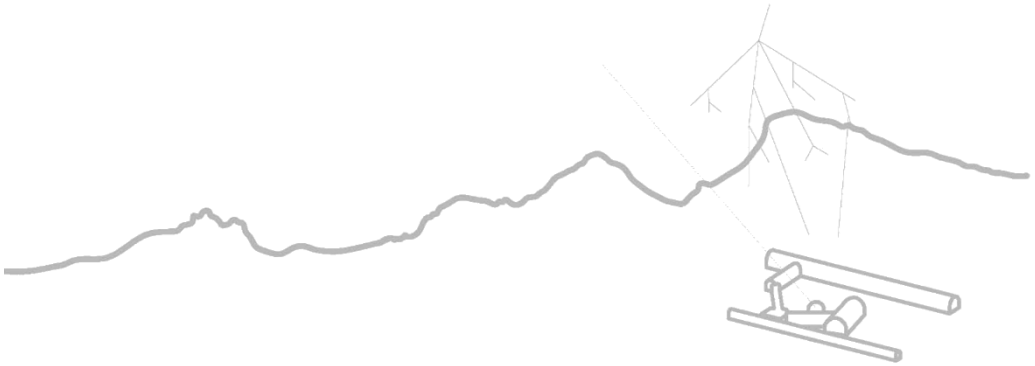
Background analysis and status of the ANAIS dark matter project.



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 , P. Villar and J. A. Villar.

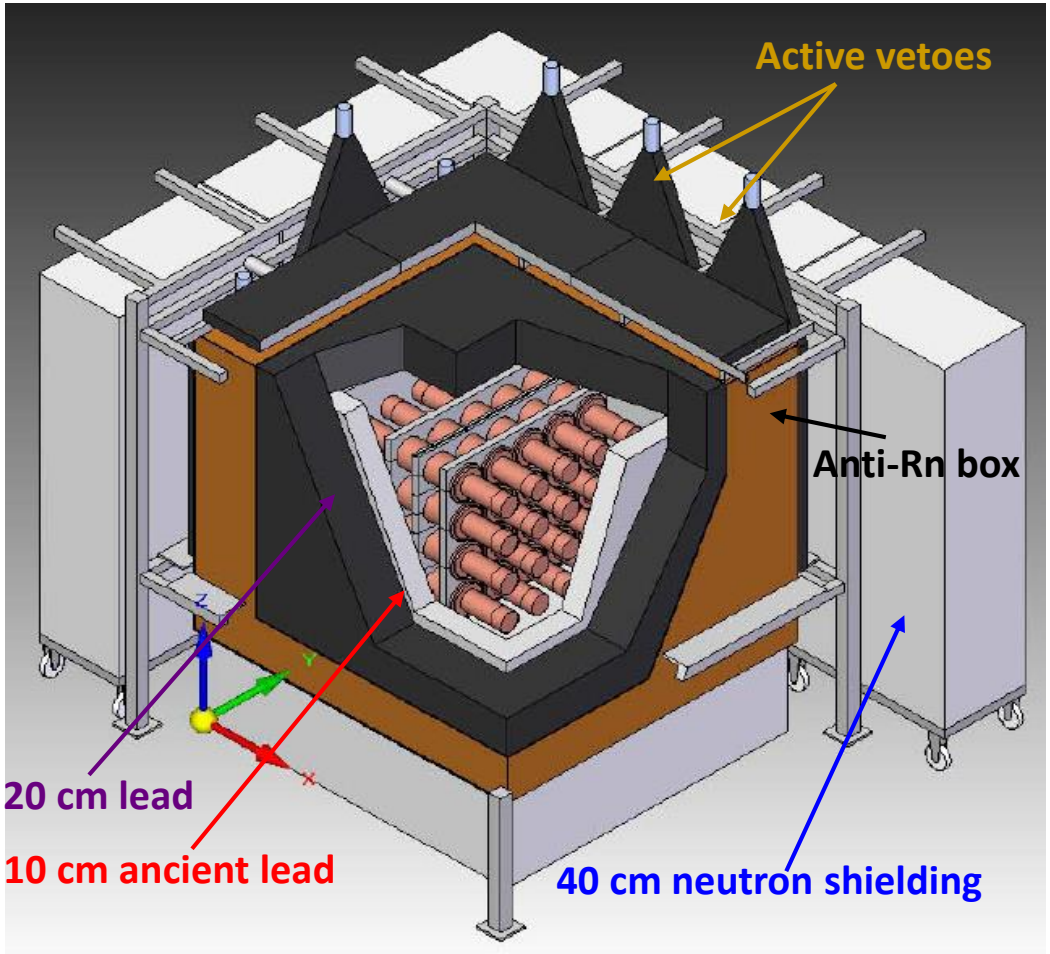
Universidad Zaragoza 1542

LSC Laboratorio Subterráneo de Canfranc

MultiDark Multimessenger Approach for Dark Matter Detection

ANAIS EXPERIMENT

ANAIS is a project aiming to set up, at the new facilities of the Canfranc Underground Laboratory (Spain), a 250 kg potassium-purified NaI(Tl) experiment to look for dark matter.



Motivation

Study of the annual modulation DAMA/LIBRA positive signal.

Technical aspects:

- 20 NaI(Tl) crystals of 12.5 kg.
- Coupled each one to 2 PMTs.
- Shielded from external radiation.

Experimental goals:

- Energy threshold < 2 keVee.
- Background at low energy as low as possible.
- Very stable operation conditions.

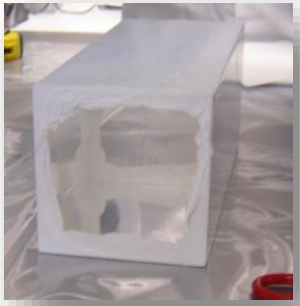
APPROACH

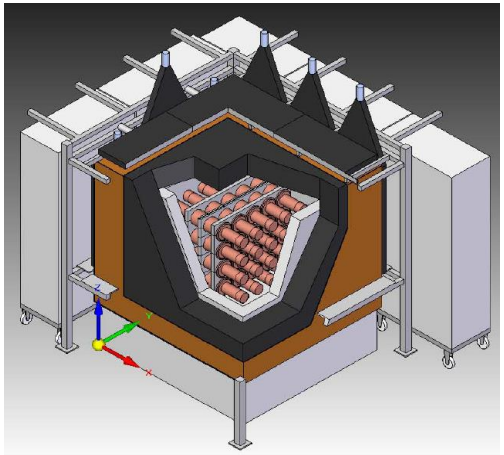
ANAIS-250

ANAIS-37

ANAIS-25

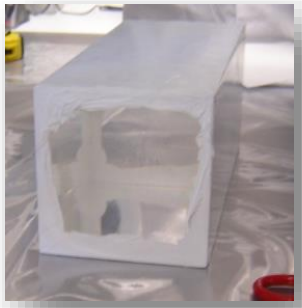
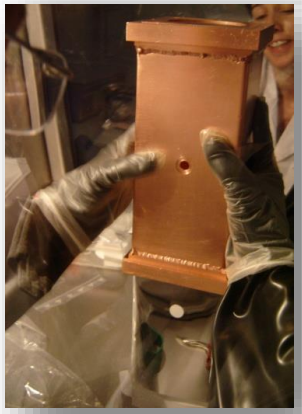
ANAIS-0





ANAIS-0

- 9.6 kg NaI(Tl) crystal made by Saint Gobain.
- Encapsulated at the UZ.
- Data taking 2009 – 2012.
- Goals:
  - Characterize ANAIS background.
  - Optimize events selection.
  - Design the calibration method.
  - Test the acquisition code and electronics.
  - Determine the optimum configuration of PMTs and light guides.
- Most relevant results:

Bulk NaI(Tl) scintillation low energy events selection with the ANAIS-0 module. C. Cuesta et al., *EPJ C 74 (2014) 3150.*

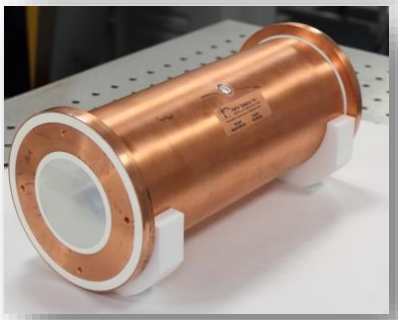
Analysis of the ^{40}K contamination in NaI(Tl) crystals from different providers in the frame of the ANAIS project. C. Cuesta et al., *Int. J. Mod. Phys. A. 29 (2014) 1443010.*

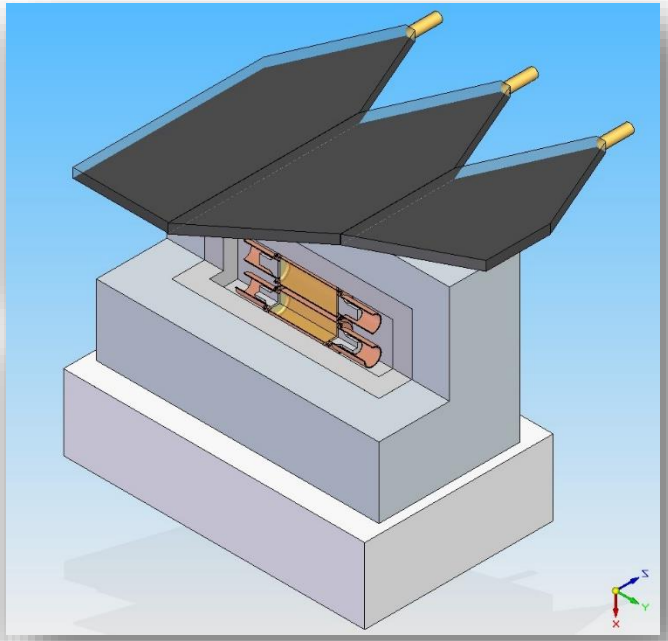
Slow scintillation time constants in NaI(Tl) for different interacting particles. C. Cuesta et al., *Opt. Mat. 36 (2013) 316.*

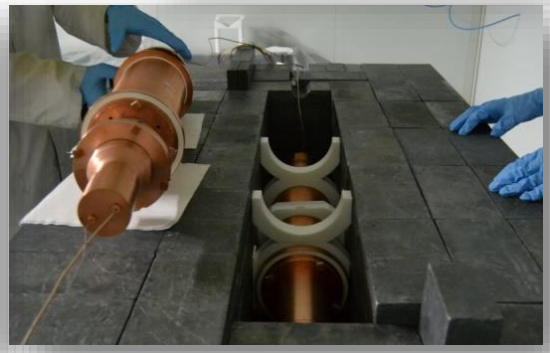
Background model for a NaI(Tl) detector devoted to dark matter searches. S. Cebrián et al., *Astrop. Phys. (2012) 60.*

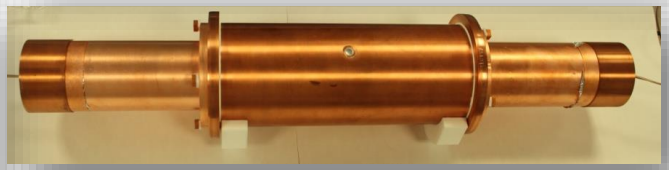
ANAIS-25

- 2 ultrapure NaI(Tl) (12.5 kg) crystals made by Alpha Spectra.
- Data taking 2012 – 2015.
- Coupled to Hamamatsu PMTs at LSC clean room - No light guides.
- Goals:
  - Determine their bulk contamination.
  - General performance assessment.





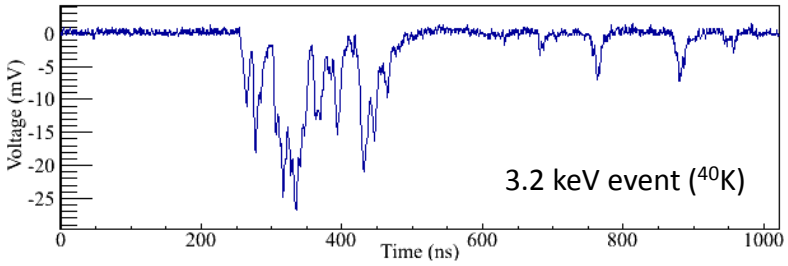




ANAIS-25

Light collection efficiency:

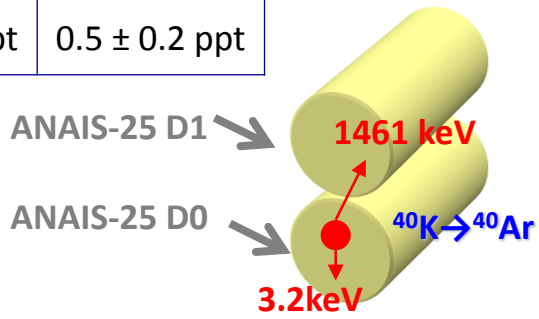
Detector	PMT	Phe⁻/keV
D0	Ham R6956 MOD SEL	16.13 ± 0.66
D1	Ham R11065SEL	12.58 ± 0.13
D1	Ham R6956 MOD SEL	15.47 ± 0.24

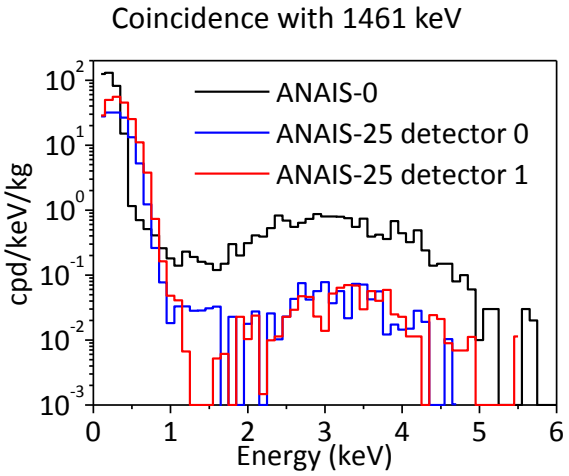


Bulk activity results:

K	^{238}U	^{232}Th
41.7 ± 3.7 ppb	0.81 ± 0.16 ppt	0.5 ± 0.2 ppt

^{40}K Measurement in coincidence:

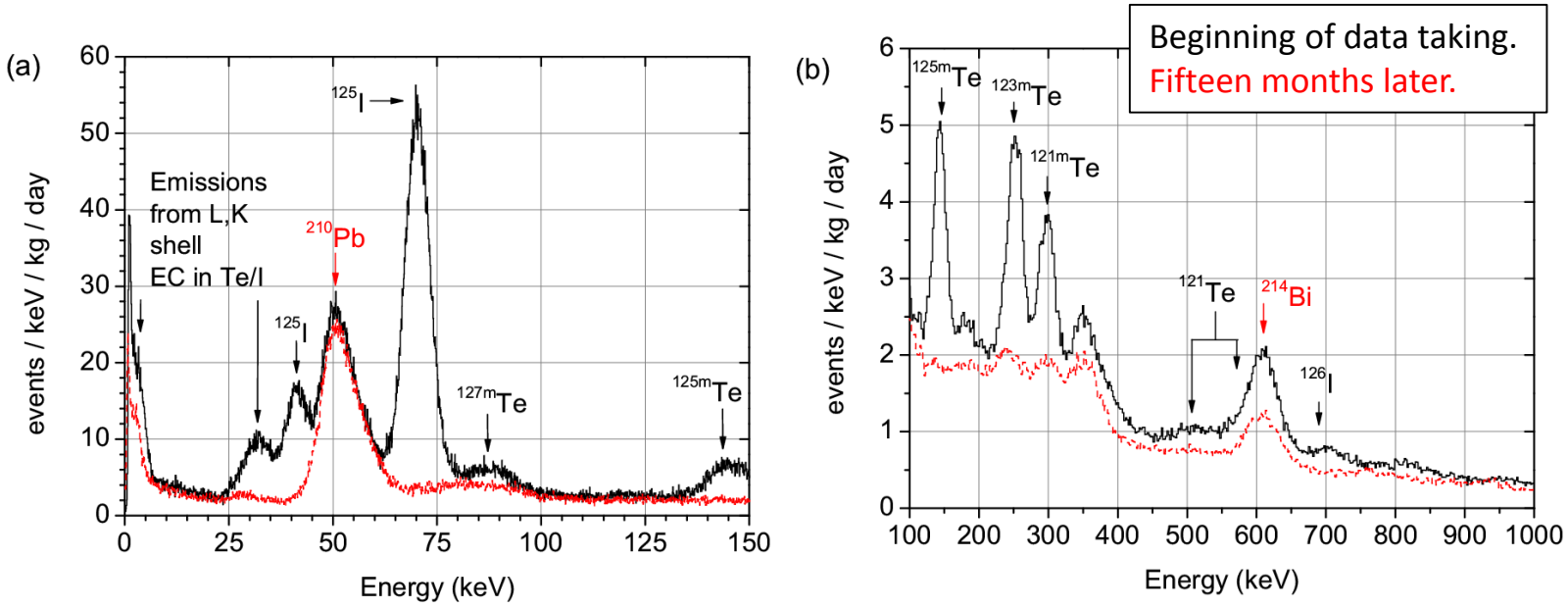




Preliminary results of ANAIS-25. J. Amaré et al., *NIM A 742 (2014) 197.*
Analysis of the ^{40}K contamination in NaI(Tl) crystals from different providers in the frame of the ANAIS project. C. Cuesta et al., *Int. J. Mod. Phys. A. 29 (2014) 1443010.*

ANAIS-25

Cosmogenic activation:



Production rates at sea level for Te isotopes, ^{22}Na and I isotopes have been derived from measured activities. Long-life isotopes can be relevant (^{22}Na, H_3).

Cosmogenic radionuclide production in NaI(Tl) crystals. J. Amaré et al., *JCAP 02 (2015) 046.*

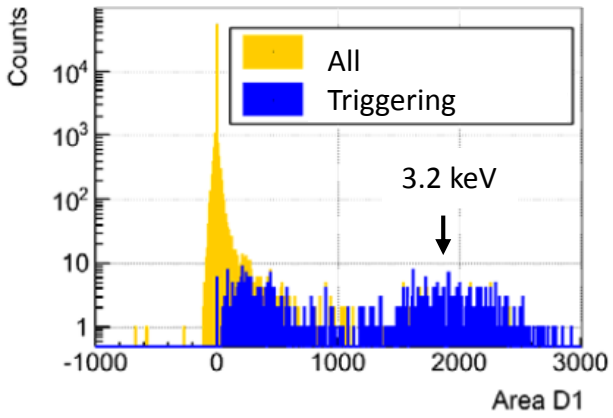
See poster: Production and relevance of cosmogenic radionuclides in NaI(Tl) crystals. (S. Cebrián).

ANAIS-25

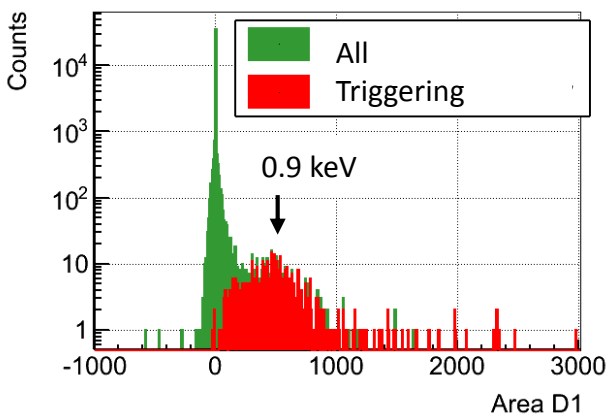
PRELIMINARY

Trigger efficiency:

Coincidence with 1461 keV (^{40}K)



Coincidence with 1274 keV (^{22}Na)



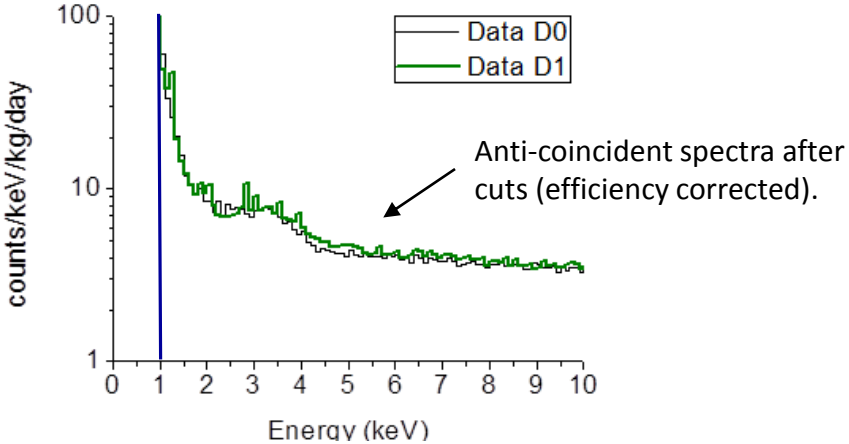
Energy 0.9 keV – 3 keV:
- D0 > 75%
- D1 > 90%

Energy > 3 keV:
- DO & D1 > 90%

Low energy:

- Anomalous high rate not considered.
- NaI(Tl) scintillation events selected through:
  - number of photoelectrons (n > 2 per PMT).
  - p1 timing parameter.
  - Asymmetric events.

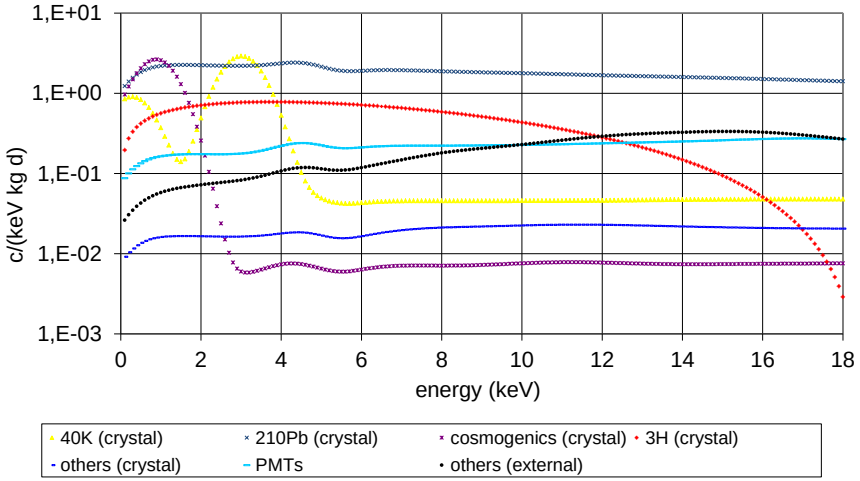
Efficiency checked with calibrations down to 1 keV.

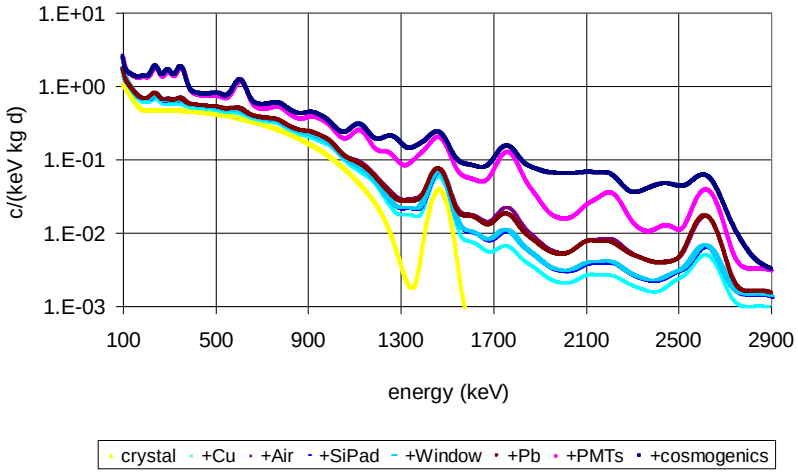


PRELIMINARY

Simulations

- Bulk contaminations in NaI(Tl) crystal of: ^{40}K , ^{232}Th, ^{238}U, ^{210}Pb, ^{129}I, and present cosmogenic activation.
- Photomultipliers contaminations.
- Upper limits for quartz windows, copper, roman lead and silicone pads contaminations.
- Radon upper limit content in the air filling the inner volume of the shielding.

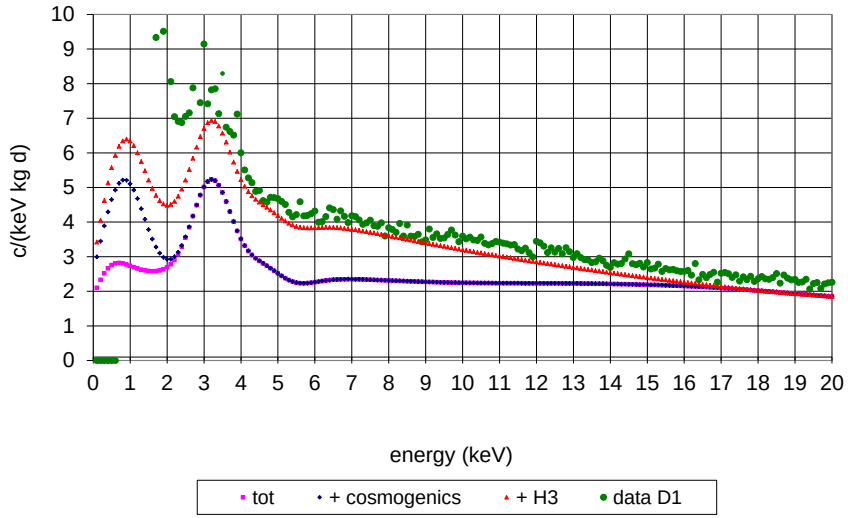


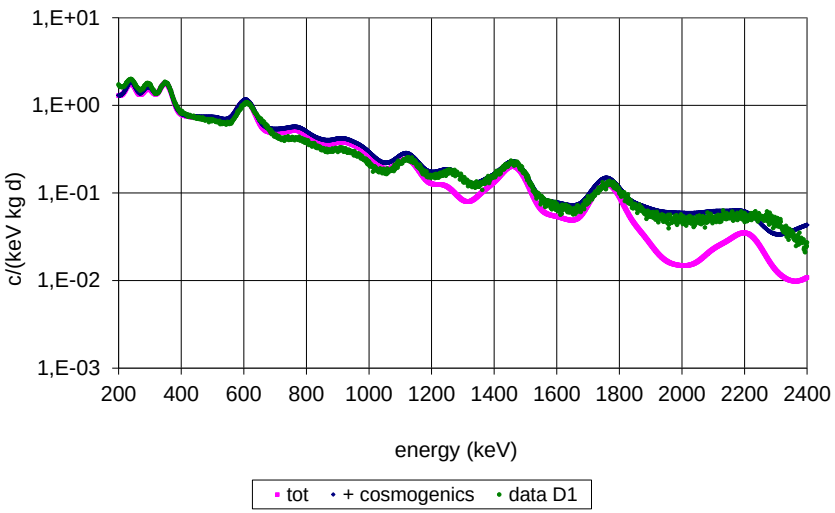


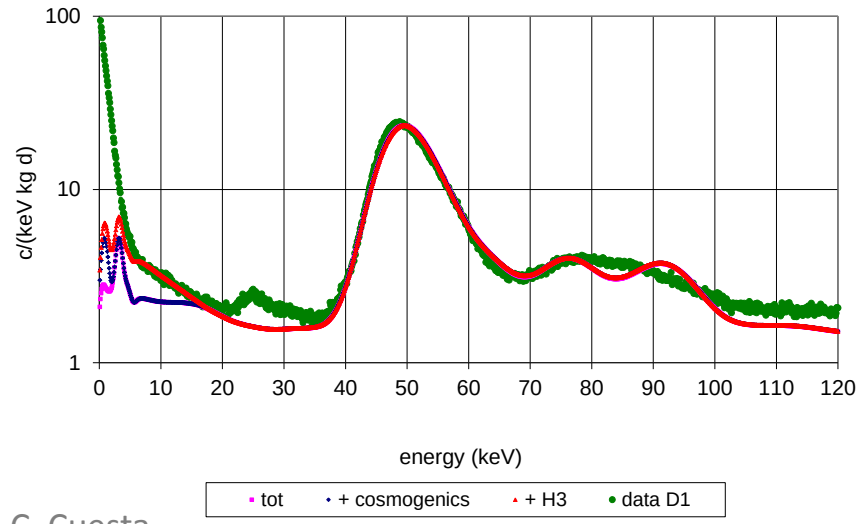
ANAIS-25

PRELIMINARY

Simulations vs experimental data







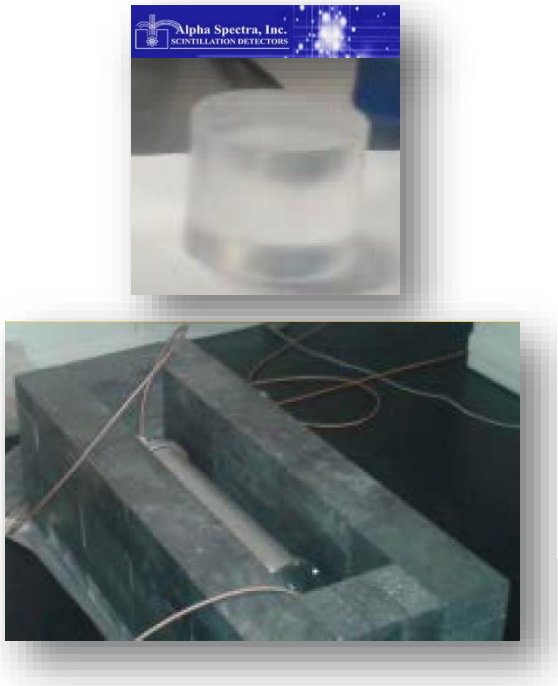
^{210}Pb contamination

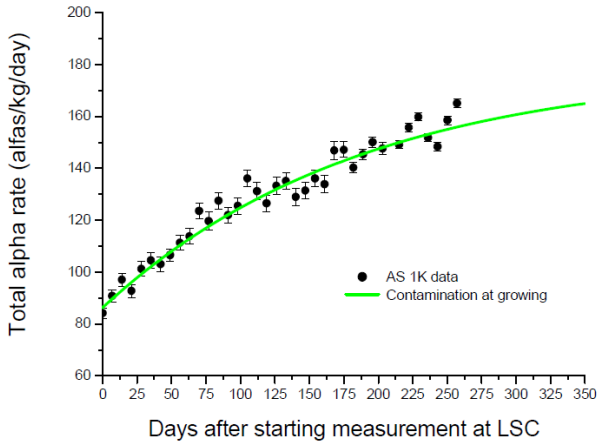
Total alpha rate in both modules: 3.15 mBq/kg.

Line at about 50 keV consistent with equilibrium between ^{210}Po coming from the ^{210}Pb decay.

AS1K

1 kg crystal from Alpha Spectra dedicated to further study the alpha contamination.





$3.8\,d$	^{222}Rn
	$\downarrow \alpha$
$3.10\,m$	^{218}Po
	$\downarrow \alpha$
$26.8\,m$	^{214}Pb
	$\downarrow \beta$
$19.9\,m$	^{214}Bi
	$\downarrow \beta$
$164.3\mu\,s(*)$	^{214}Po
	$\downarrow \alpha$
$22.3\,y$	^{210}Pb
	$\downarrow \beta$
$5.01\,d$	^{210}Bi
	$\downarrow \beta$
$138.4\,d$	^{210}Po
	$\downarrow \alpha$
Stable	^{206}Pb

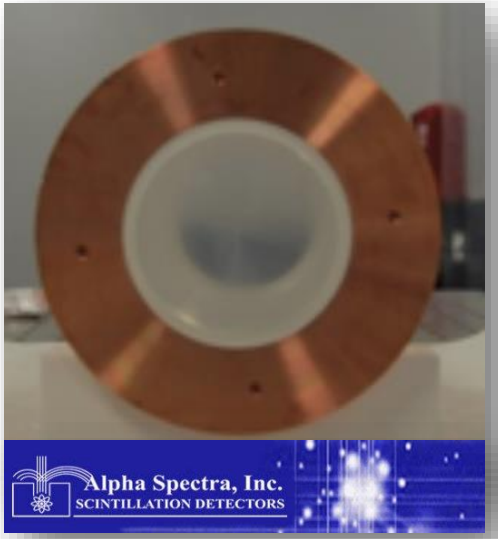
→ ANAIS identified broken equilibrium in ^{210}Pb – ^{210}Bi – ^{210}Po.

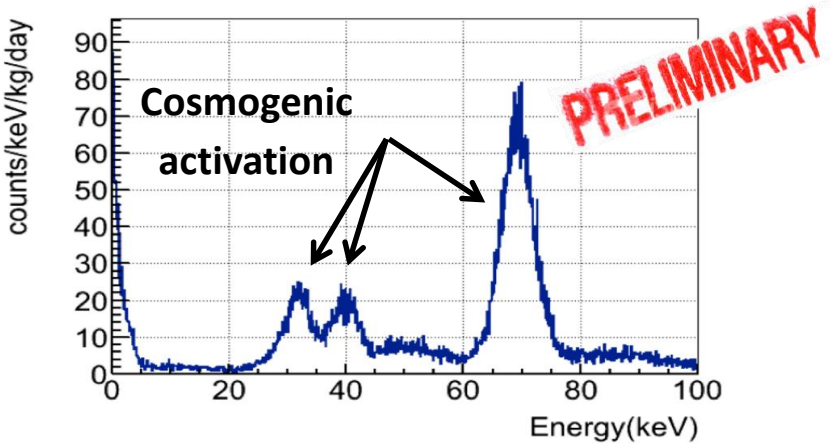
→ ^{222}Rn contamination in growing procedure could be responsible.

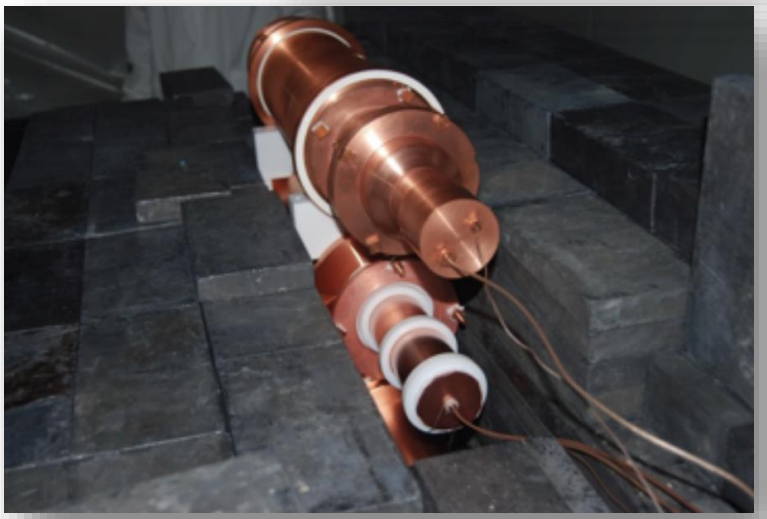
→ Growing procedures in Alpha Spectra improved → **ANAIS-37**.

ANAIS-37

- ANAIS-25 + ultrapure NaI(Tl) (12.5 kg) crystal made by Alpha Spectra with improvements in the growing procedures.
- Received at LSC 03/06/2015.
- Ham PMTs coupled at LSC clean room 03/09/2015.
- Installed in the shielding at LSC Hall B 03/10/2015 together to ANAIS-25 modules.
- Started data taking 03/11/2015.
- Goal: Determine the bulk contamination.
  Very preliminary results (LiveTime = 6.77 days):
  Alpha rate 0.55 ± 0.01 mBq/kg.

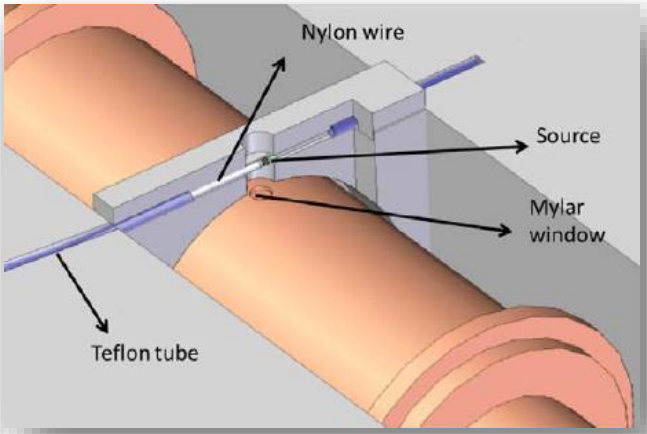






ANAIS-250

- Crystals: To be ordered in view of ANAIS-37 results.
- PMTs: 42 on-site and being characterized.
- Calibration system: ^{57}Co and ^{109}Cd sources along flexible wires positioned in front of the Mylar windows. On-site and in use.
- Shielding: On-site, and partially in use.
  - 10 cm roman lead + 20 cm lead.
  - Active vetoes anti-muons (characterized).
  - Anti-radon box.
  - Neutron shielding.
- VME electronics and final acquisition software and hardware on-site and partially in use.
- Control room: already operative at LSC Hall B.

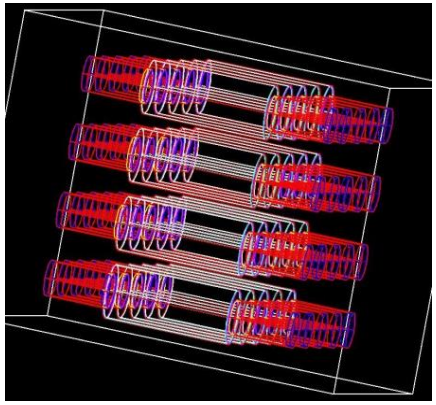


ANAIS-250

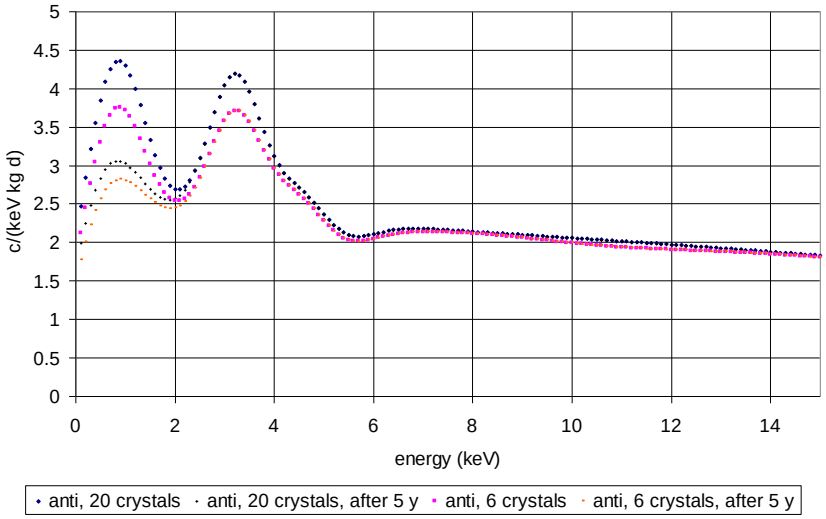
PRELIMINARY

Simulations: Background reduction by anticoincidence.

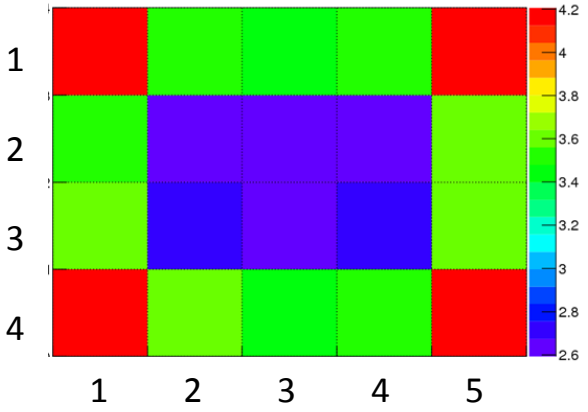
- Bulk contaminations in NaI(Tl) crystal of: ^{40}K, ^{232}Th, ^{238}U, ^{210}Pb, ^{22}Na.
  Same as in ANAIS-25 after ~500 days of underground storing.
- Photomultipliers contaminations.
- More contaminations to be included.



5x4 crystal array

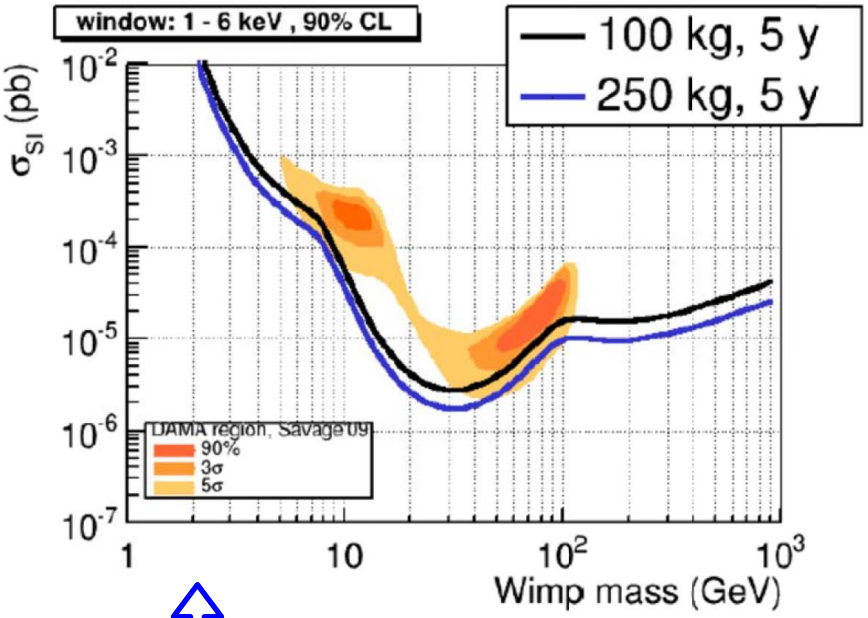


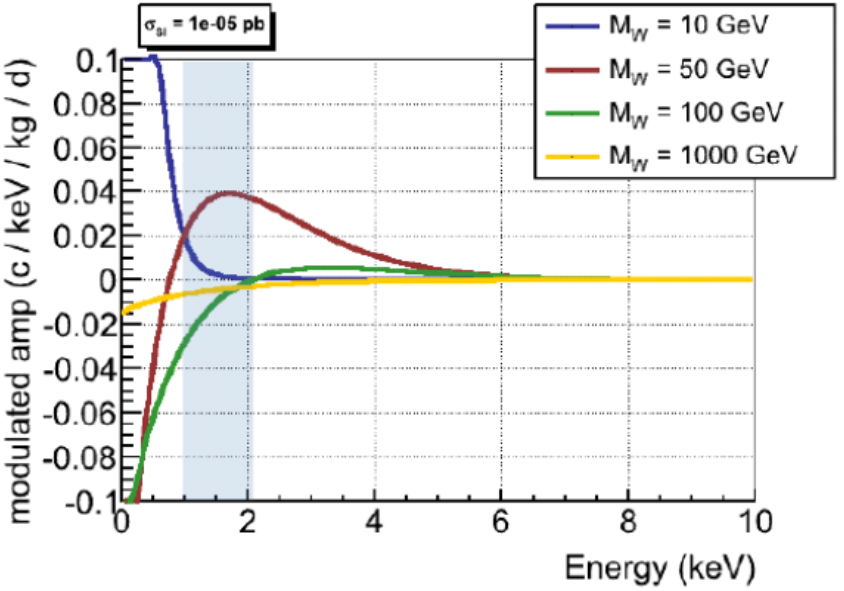
^{40}K activity (cpd/kg) in E <10 keV

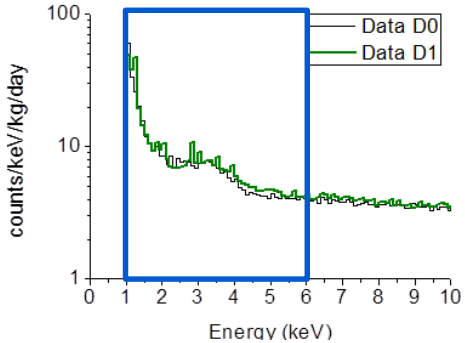


ANAIS-250

Prospects

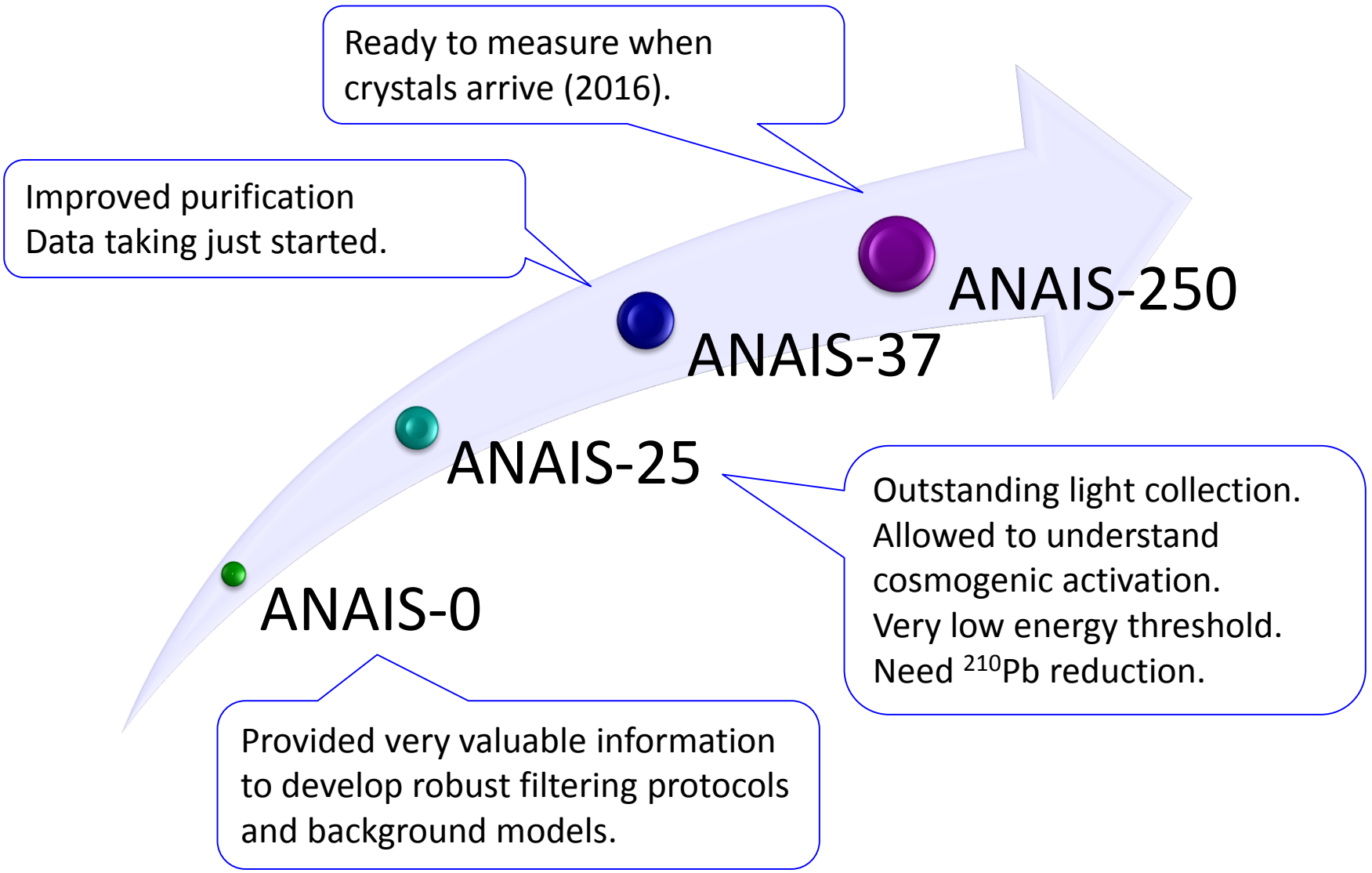






ANAIS-25 experimental spectrum considered. Improvement foreseen with anticoincidence reduction and new crystals background reduction.

SUMMARY


Ready to measure when crystals arrive (2016).
Improved purification
Data taking just started.
ANAIS-250
ANAIS-37
ANAIS-25
ANAIS-0
Outstanding light collection.
Allowed to understand cosmogenic activation.
Very low energy threshold.
Need ^{210}Pb reduction.
Provided very valuable information to develop robust filtering protocols and background models.