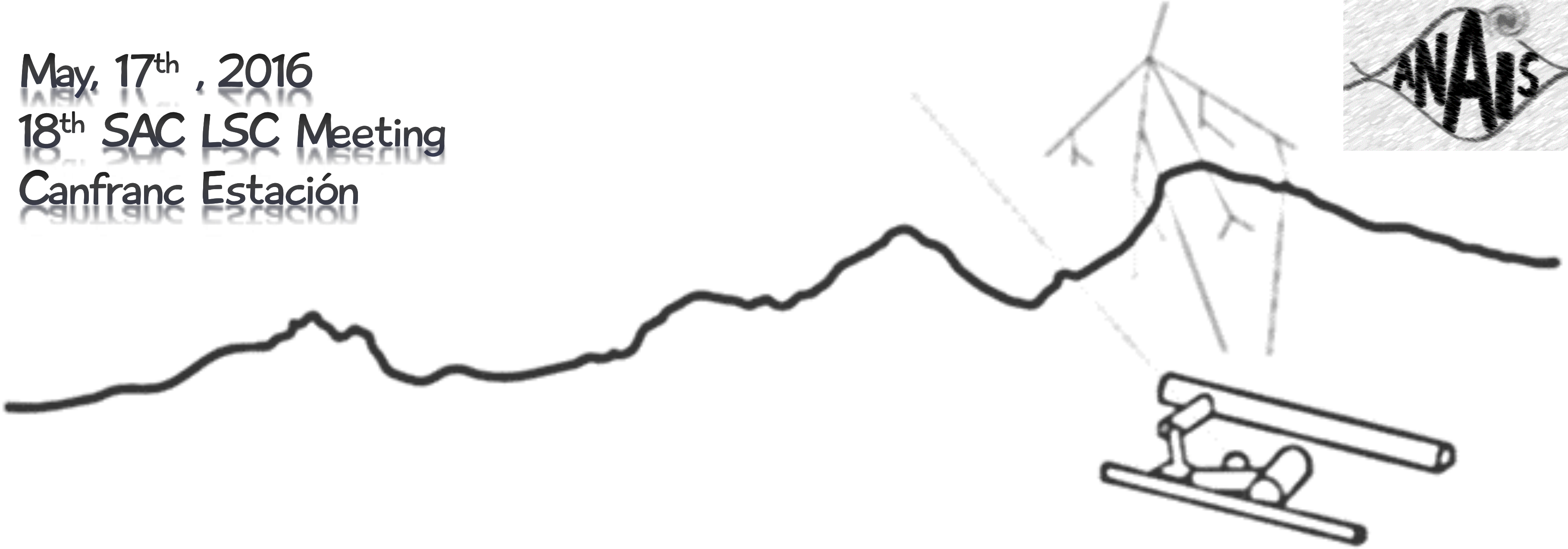
PROGRESS REPORT OF ANAIS (EXP-01-2008)

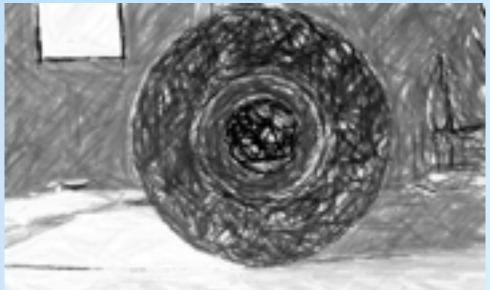
May, 17th , 2016
18th SAC LSC Meeting
Canfranc Estación

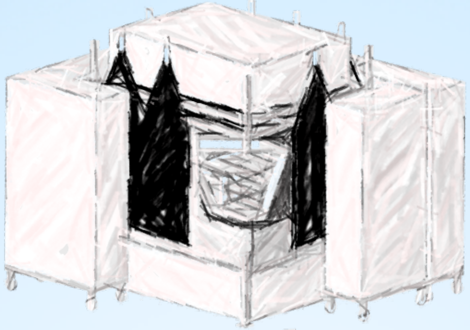


LSC
Laboratorio Subterráneo de Canfranc

Universidad Zaragoza

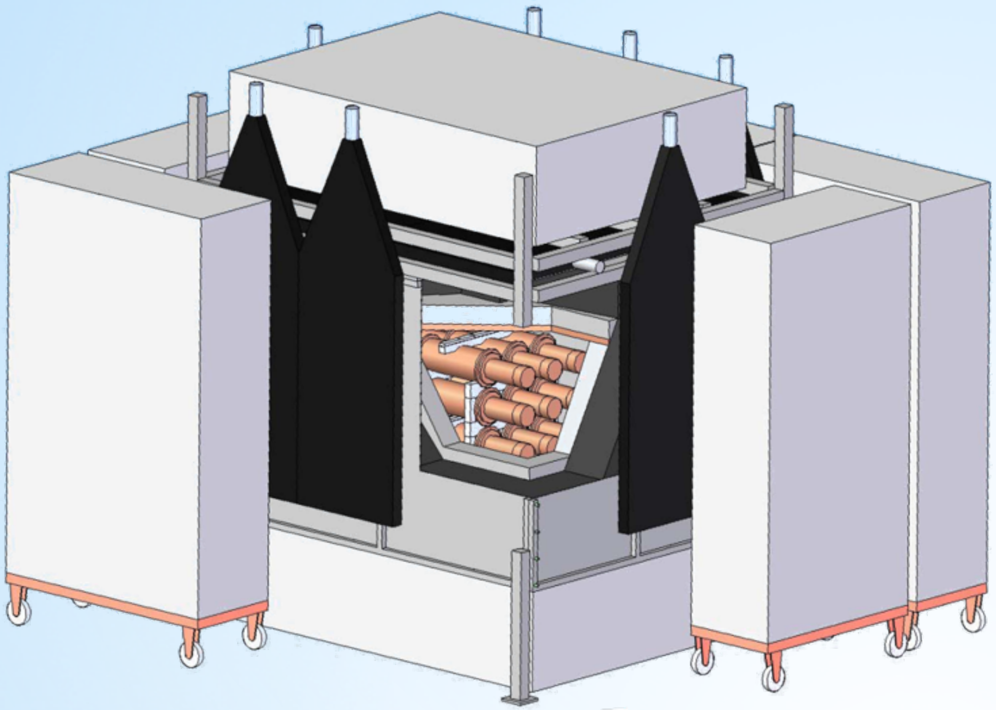
MultiDark
Multimessenger Approach for Dark Matter Detection





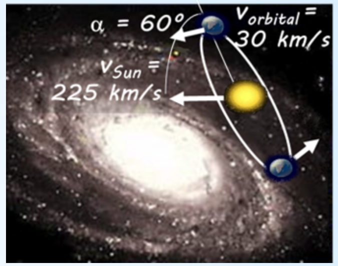
Outline

- Preliminary Data Analysis of A37D3 set-up
  - Radiopurity of D3 module
  - Performance of D3 module
- Mounting and Preliminary Results from the measurements of 1kg AS samples
- Update on the Simulation of a Liquid Scintillator Veto
- Progresses in the ANAIS Background Model
- Status of the Detector Purchase and ANAIS Experimental Planning
- Contacts for Collaboration with International Partners



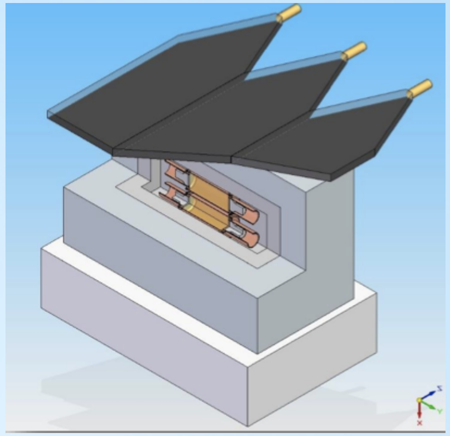
ANAIS Goals

Annual modulation with NAI Scintillators

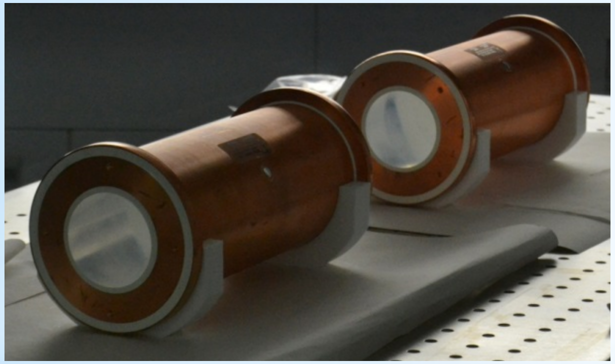


- Confirmation of DAMA-LIBRA modulation signal -> **same target and technique** / **different** experimental approach / **different** environmental conditions affecting **systematics**
- At Canfranc Underground Laboratory, @ **SPAIN** (under **2450 m.w.e**)
- 3x3 matrix of 12.5 kg modules = **112.5 kg** of active mass

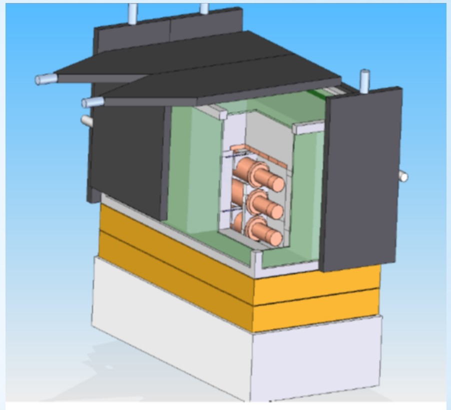
ANAIS D0, D1, D2

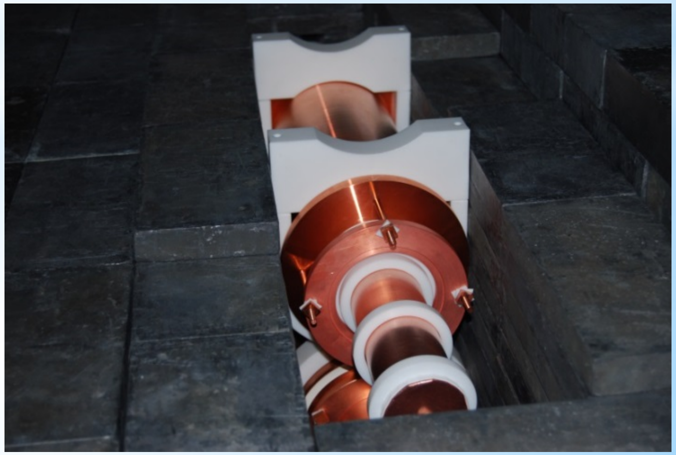


- 12.5 kg cylindrical NaI(Tl) detectors built @ AS
- **ANAIS25 set-up (D0+D1)** data taking @ LSC from Dec 2012 – March 2015
- **ANAIS37 set-up (D0+D2+D1)** data taking since **March 2015**



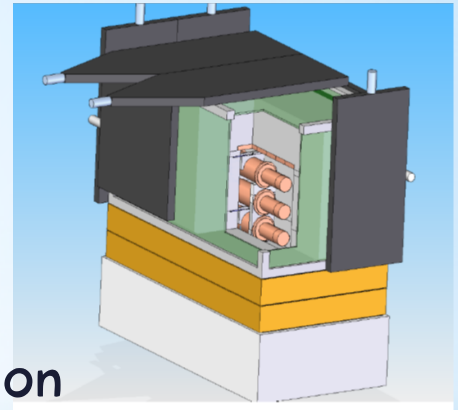
- **Mylar window** allowing LE calibration
- **HE PMT Ham** R12669SEL2
- **WIMPScint-II powder ->D2**



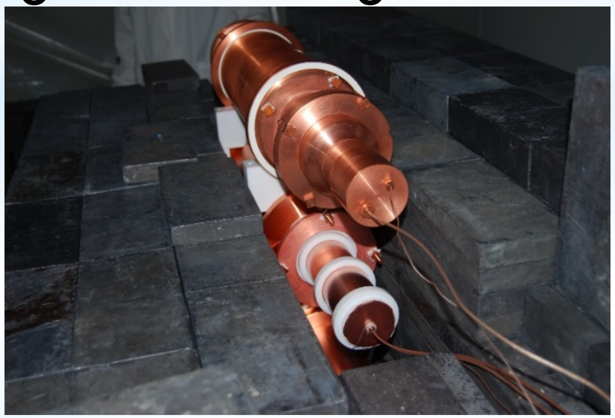


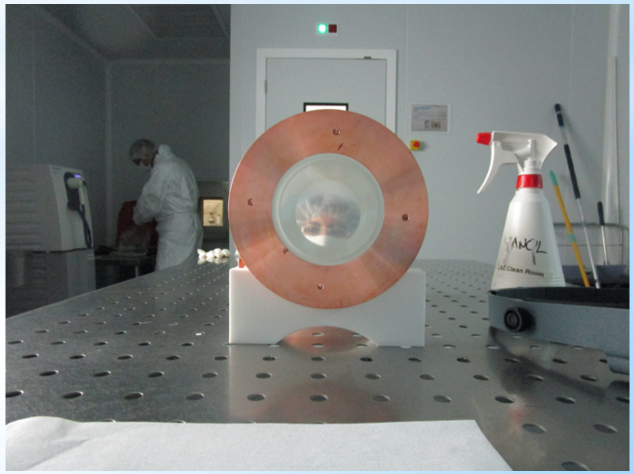
ANAIS D3

- 12.5 kg cylindrical NaI(Tl) detectors built @ AS
- **ANAIS25 set-up (D0+D1)** data taking @ LSC from Dec 2012 – March 2015
- **ANAIS37 set-up (D0+D2+D1)** data taking since **March 2015**



- **A37D3 set-up (D0+D3+D2)** data taking since **March 2016**
    - **WIMPScint-III powder ->D3**
    - D3 showed excellent optical quality by eye inspection
    - Very fast mounting and starting data taking





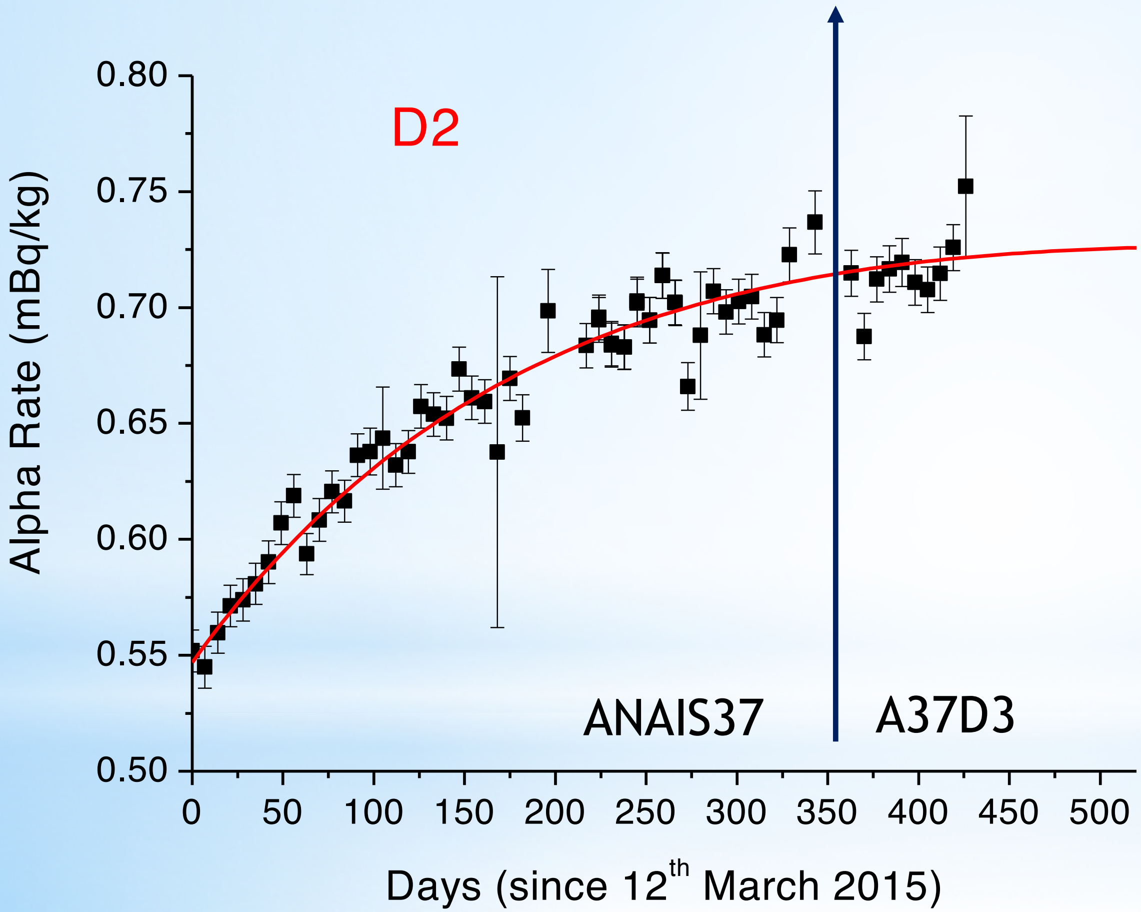
A37D3 Light Collection

- **Excellent light collection in all AS modules and set-ups**

Detector	PMT/set-up	Total Light Collection (phe/keV)
D0	Ham R6956 / ANAIS25	15.6 ± 0.2
	Ham R6956 / ANAIS37	15.3 ± 0.1
	Ham R6956 / A37D3	15.1 ± 0.1
D1	Ham R11065 / ANAIS25	12.6 ± 0.1
	Ham R6956 / ANAIS25-III	15.2 ± 0.1
	Ham R6956 / ANAIS37	14.4 ± 0.1
D2	Ham R6956 / ANAIS37	15.4 ± 0.1
D3	Ham R6956 / A37D3	15.2 ± 0.5

A37D3 Background Features

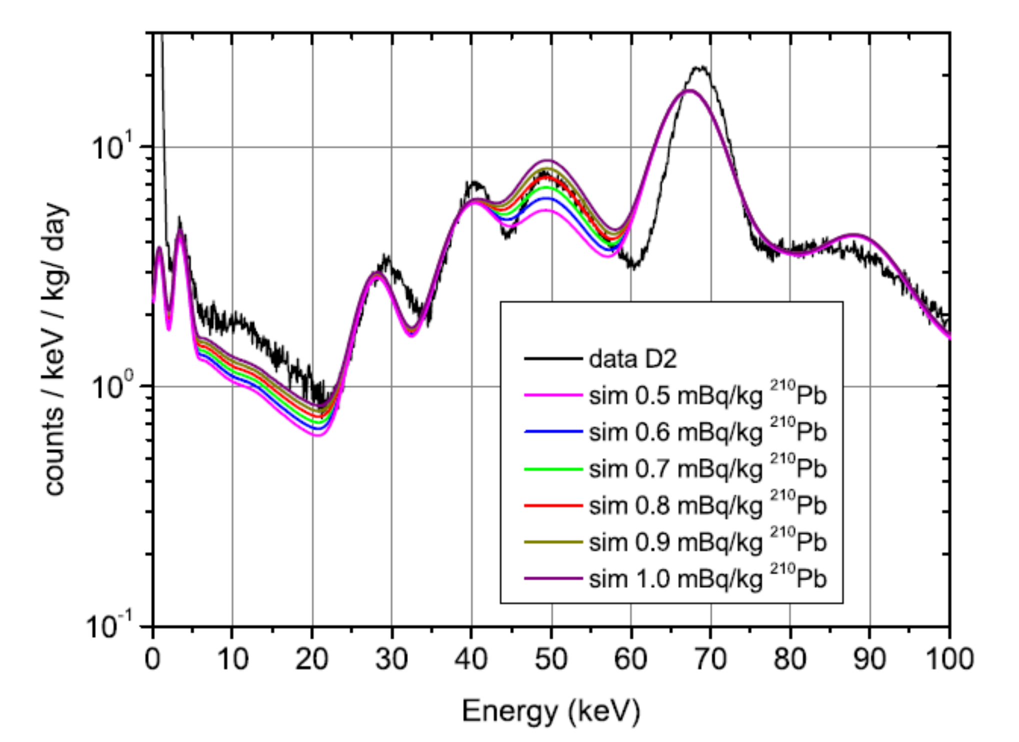
- **Total Alpha Rate in D2**



- ^{210}Pb crystal content at the level of **0.72 mBq/kg**
- Effective reduction of Rn entrance achieved in **WIMPScint-II powder** production / D2 building procedures
- Further improvement was expected for **WIMPScint-III** powder (according to AS)

A37D3 Background Features

- ^{210}Pb contamination from alpha rate and LE spectrum in D2



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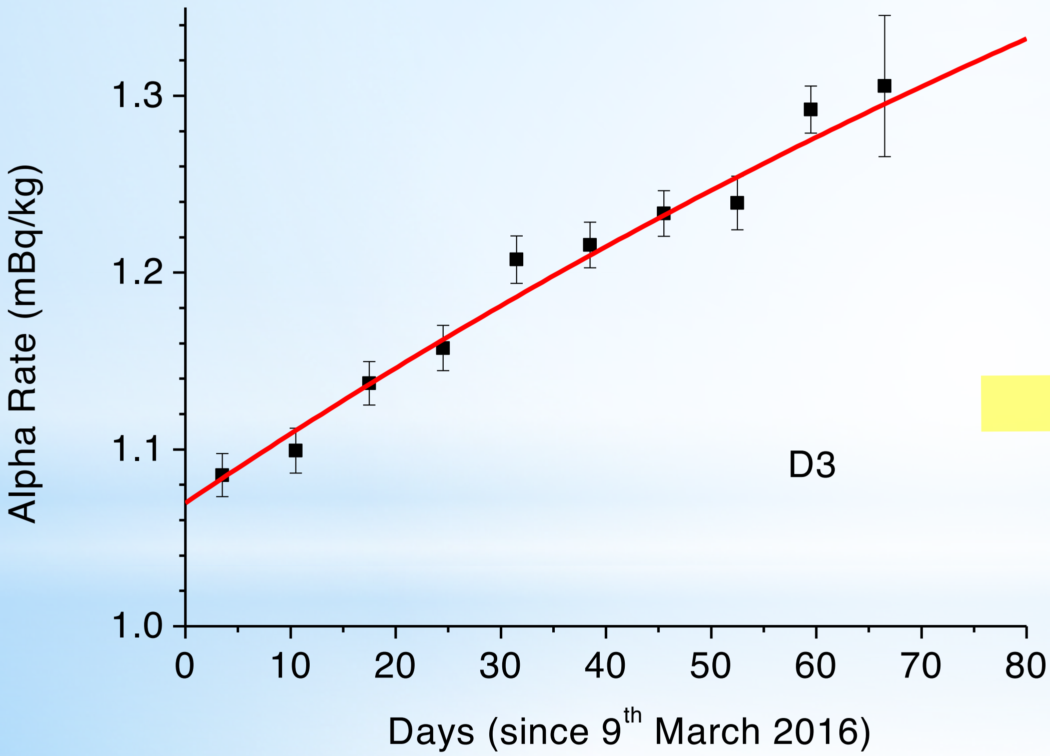
- Effective reduction of Rn entrance achieved in **WIMPScint-II powder** production / D2 building procedures
- Further improvement was expected for **WIMPScint-III** powder (according to AS)

~0.7-0.8 mBq/kg ^{210}Pb is compatible with LE data (50 keV)

A37D3 Background Features

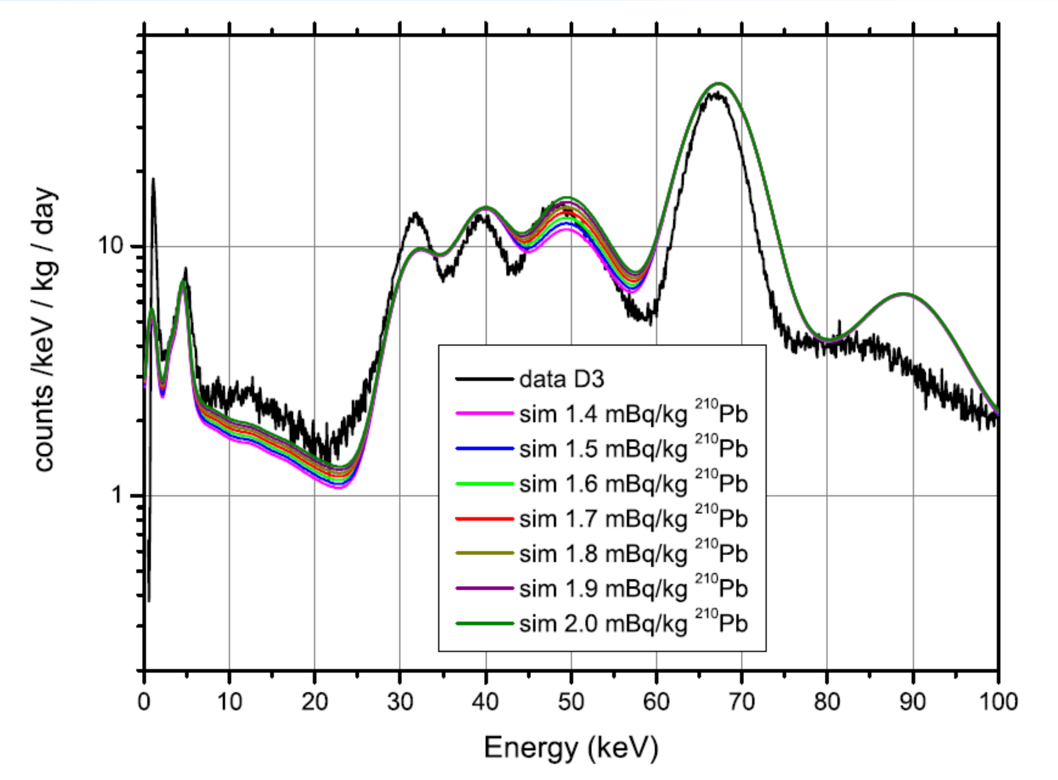
- Total Alpha Rate in D3



- Still building ^{210}Po activity at high rate
- ^{210}Pb crystal content at the level of **1.3 mBq/kg** , probably still increasing up to 1.6-1.8 mBq/kg
- WORSENING of ^{210}Pb levels observed in **WIMPScint-III** powder (being discussed with AS) – more information later on

A37D3 Background Features

- ^{210}Pb contamination from alpha rate and LE spectrum in D3



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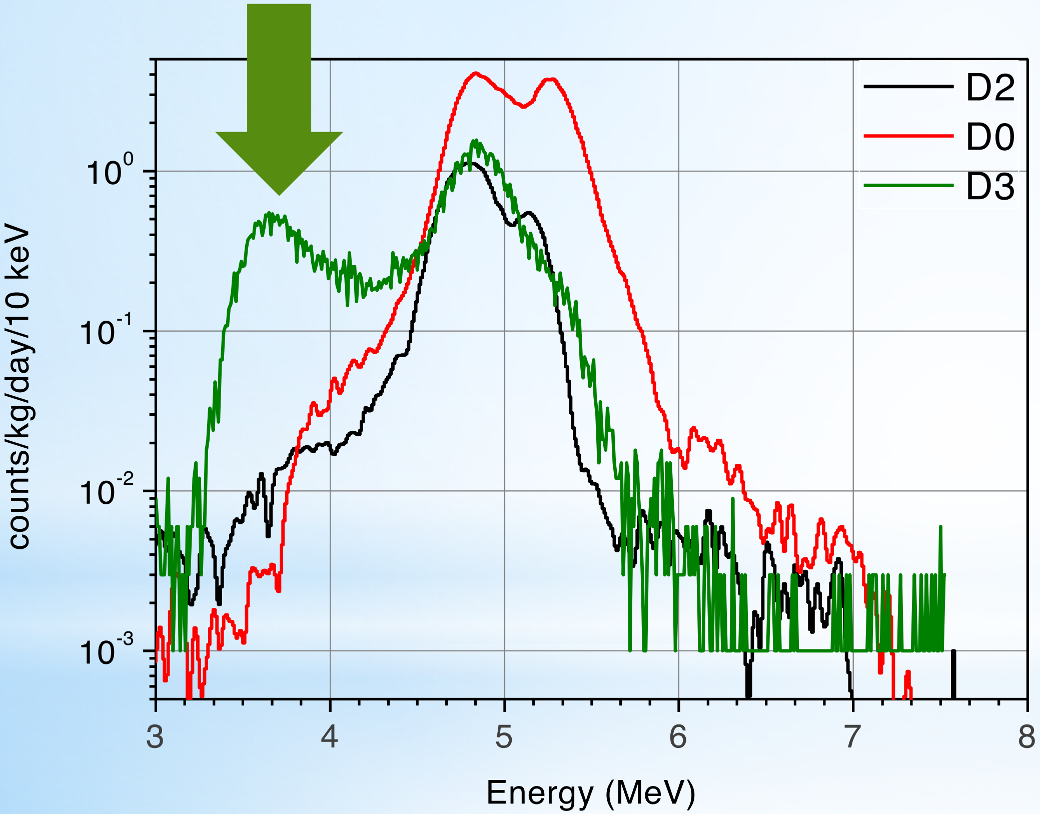
~1.8 mBq/kg ^{210}Pb is compatible with LE data (50 keV)

A37D3 Background Features

- **Total Alpha Rate in D3**

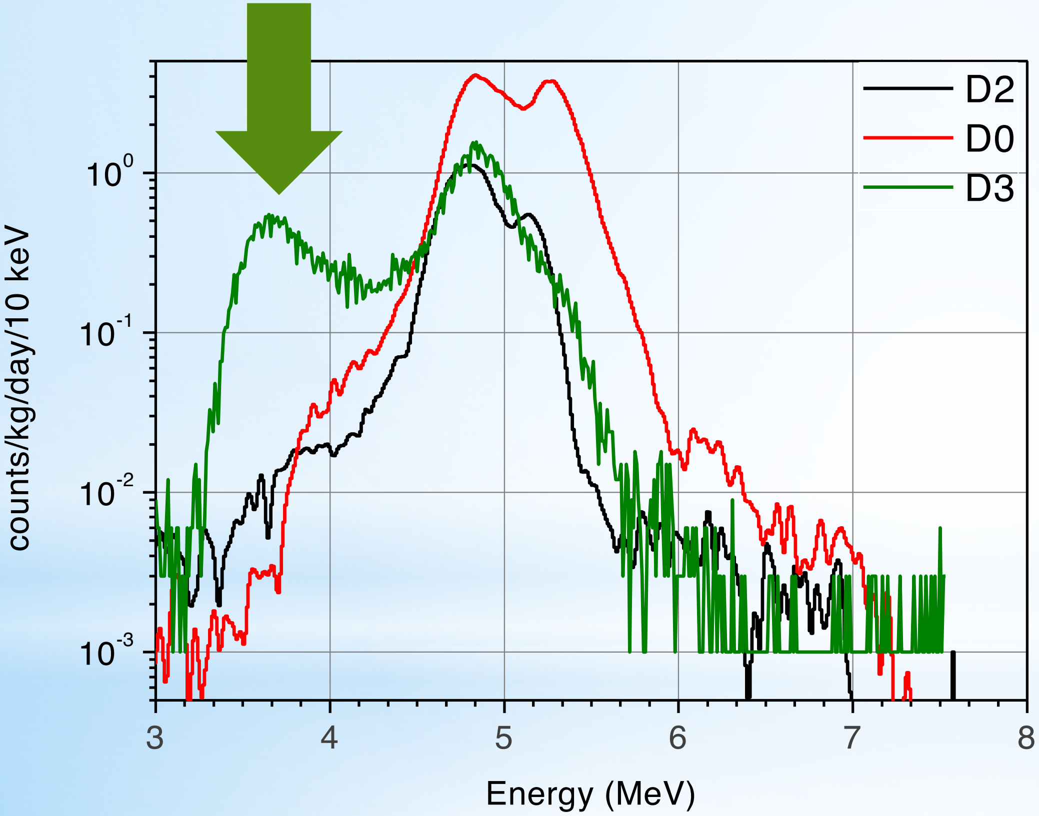


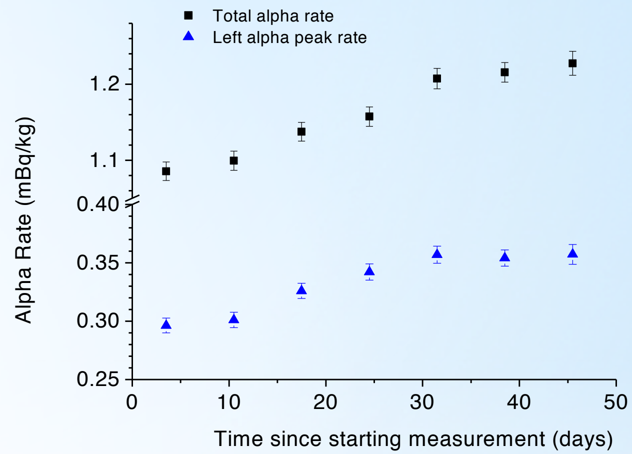
- Very different alpha spectrum (working with AS to understand the origin)
  - Surface contaminations?

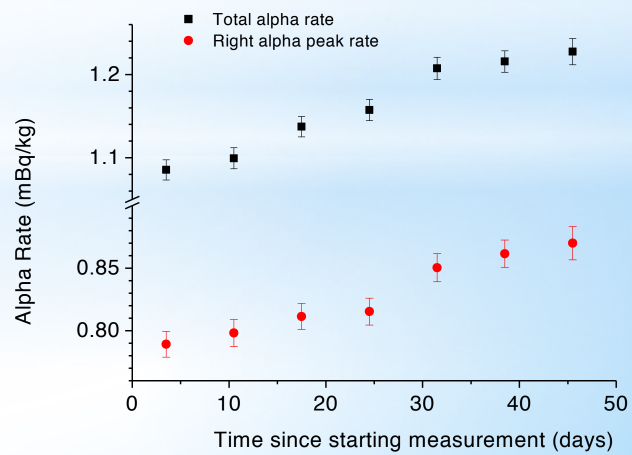
- Study of Rn-Po alpha-alpha sequences in D3 point to similar content in ^{232}Th chain than D2

A37D3 Background Features

- Total Alpha Rate in D3: left and right peaks show similar time evolution



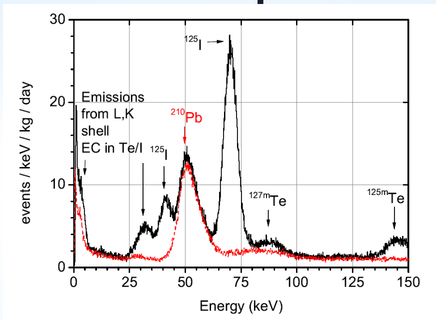


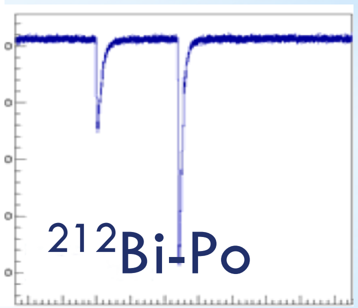


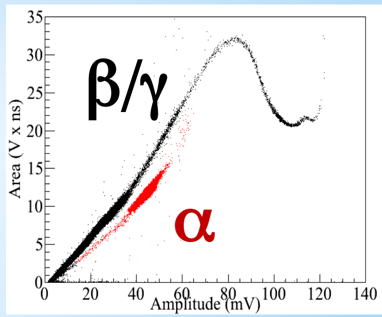
A37D3 Background Features

	^{40}K	^{238}U	^{210}Pb	^{232}Th
D0		9 µBq/kg	3.15 mBq/kg	5 µBq/kg (^{220}Rn-^{216}Po) 3 µBq/kg (^{212}Bi-Po)
D1		9 µBq/kg	3.15 mBq/kg	4 µBq/kg (^{220}Rn-^{216}Po)
D2		2.7 µBq/kg	0.70 mBq/kg	≈1 µBq/kg (^{220}Rn-^{216}Po) ≈1 µBq/kg (^{212}Bi-Po)
D3		~4 µBq/kg	>1.3 mBq/kg	≈0,6 µBq/kg (^{220}Rn-^{216}Po) ≈0,6 µBq/kg (^{212}Bi-Po)

Determined by alpha rate and Bi/Po & Rn/Po sequences. Verified by simulations

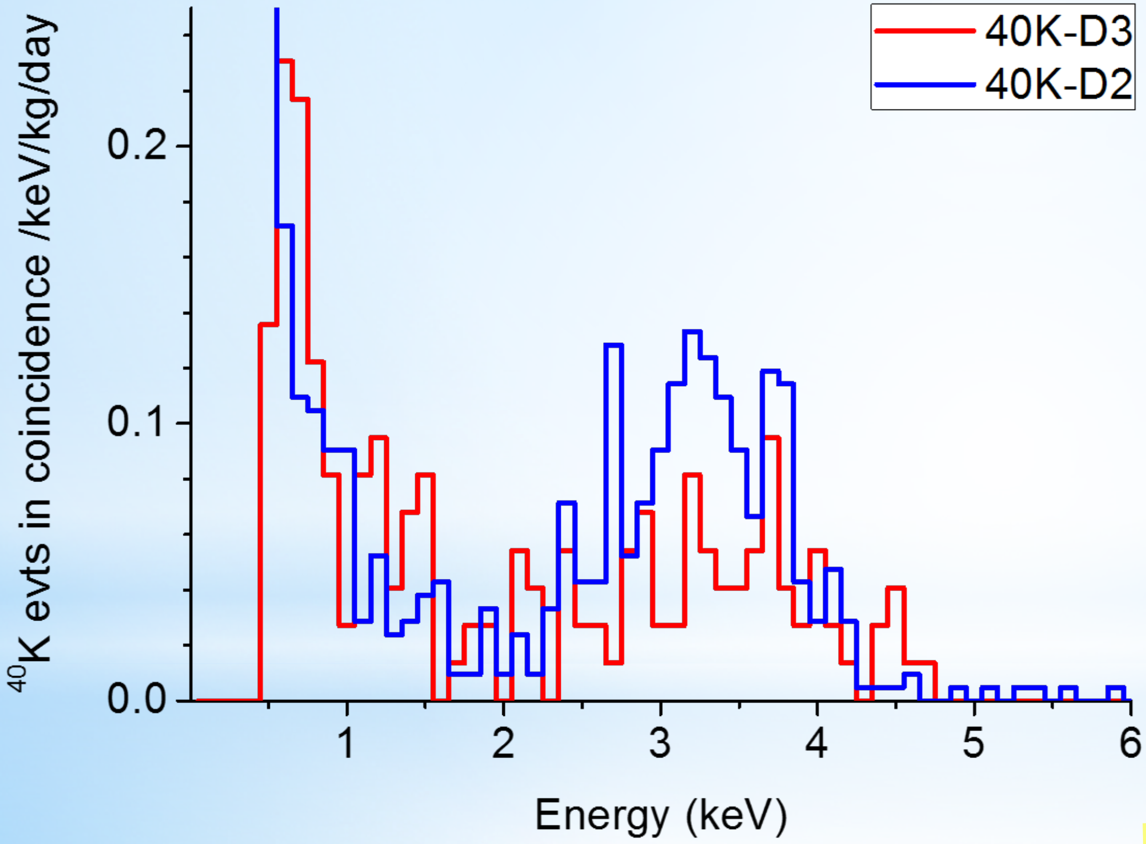


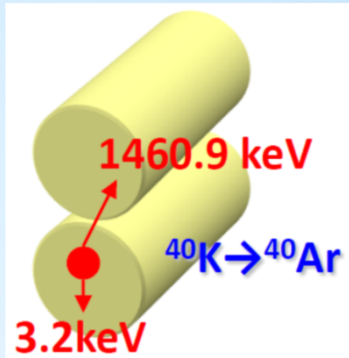




A37D3 Background Features

- Potassium content in D3: 58,95 days live time





Determined by coincidence analysis

- Very high efficiency for the coincidence
- Potassium content has clearly improved in WIMPScint-III powder, present estimate is: 22±4 ppb

A37D3 Background Features

	^{40}K	^{238}U	^{210}Pb	^{232}Th
D0	1.4 mBq/kg (45 ppb K)	9 μBq/kg	3.15 mBq/kg	5 μBq/kg (^{220}Rn-^{216}Po) 3 μBq/kg (^{212}Bi-Po)
D1	1.1 mBq/kg (34 ppb K)	9 μBq/kg	3.15 mBq/kg	4 μBq/kg (^{220}Rn-^{216}Po)
D2	1.1 mBq/kg (34 ppb K)	2.7 μBq/kg	0.70 mBq/kg	≈1 μBq/kg (^{220}Rn-^{216}Po) ≈1 μBq/kg (^{212}Bi-Po)
D3	0.65 mBq/kg (22 ppb K)	~4 μBq/kg	>1.3 mBq/kg	≈0,6 μBq/kg (^{220}Rn-^{216}Po) ≈0,6 μBq/kg (^{212}Bi-Po)

Other Background Features

- **Cosmogenic ^{22}Na determination**

After initial application of D2-background model, high energy events rate pointed at a lower ^{22}Na content with respect to D0 and D1 modules. We have checked this is true with the A37Blank data, after most of the other cosmogenic isotopes decayed

It is important to care about avoiding activation while building the detectors

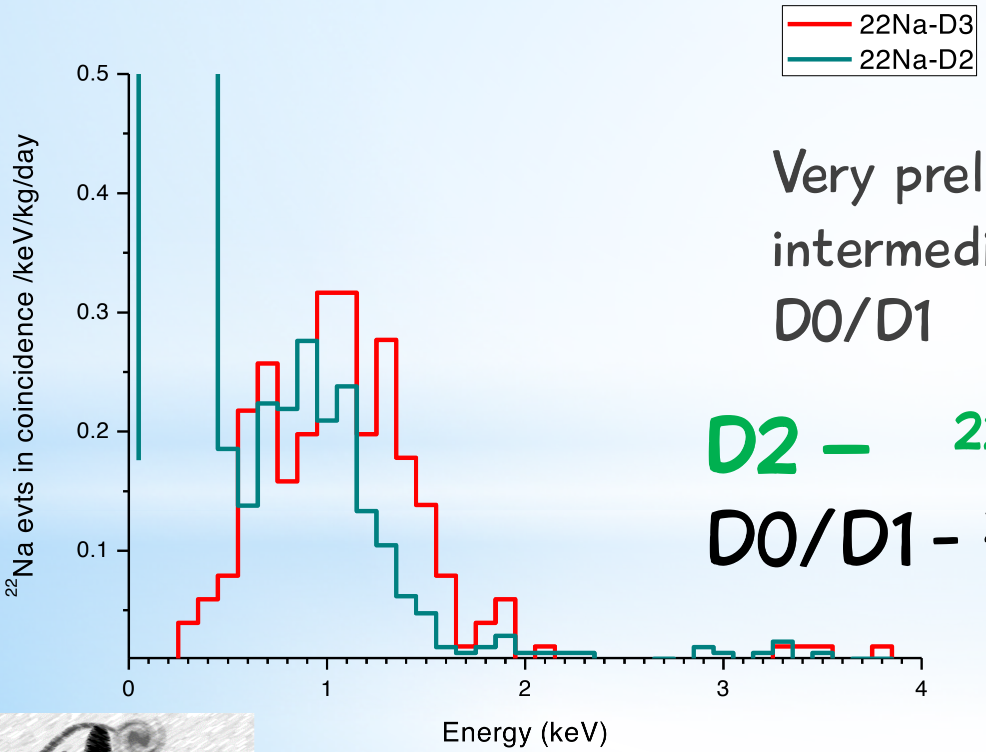
D2 – ^{22}Na $A_0 = 70 \pm 4\ kg^{-1}\ d^{-1}$

D0/D1 - ^{22}Na $A_0 = 160 \pm 5\ kg^{-1}\ d^{-1}$

Other Background Features

- **Cosmogenic ^{22}Na determination**

In the case of D3, we should determine ^{22}Na content after the decay of most of the other short-lived cosmogenics

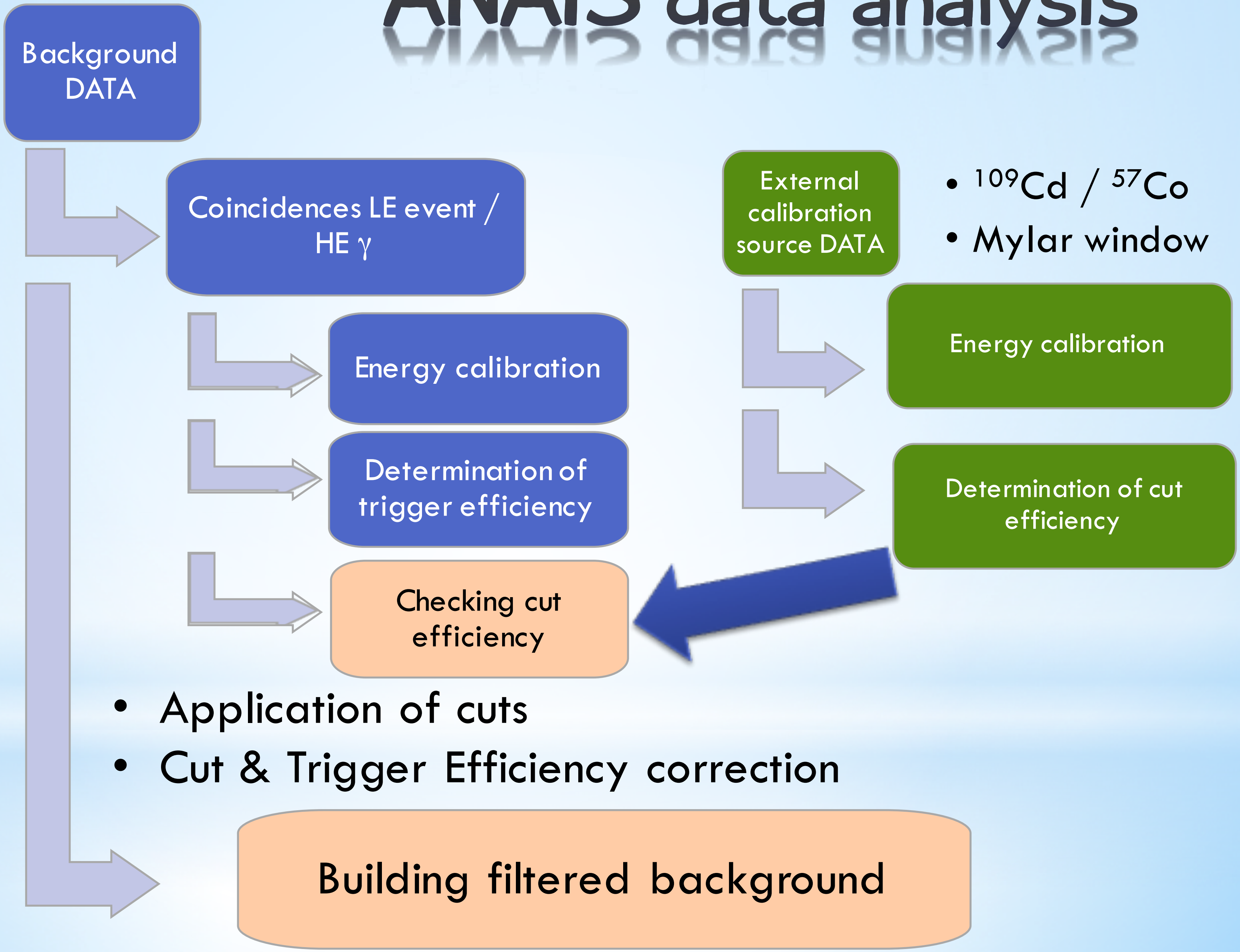


Very preliminary estimates point at an intermediate ^{22}Na content in D3 vs D2 and D0/D1

D2 – ^{22}Na $A_0 = 70 \pm 4$ kg^{-1} d^{-1}

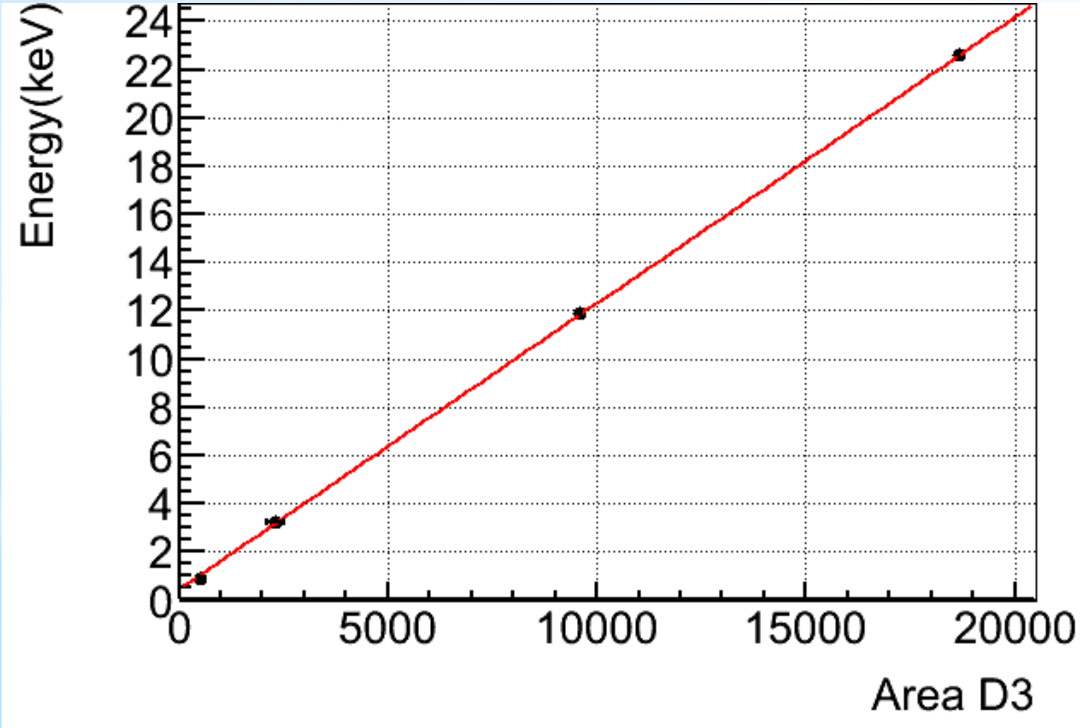
D0/D1 - ^{22}Na $A_0 = 160 \pm 5$ kg^{-1} d^{-1}

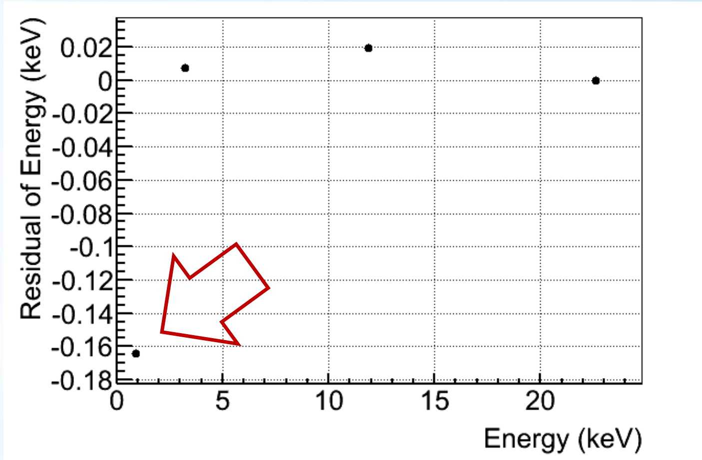
ANAIS data analysis



D3 calibration @ very low energy

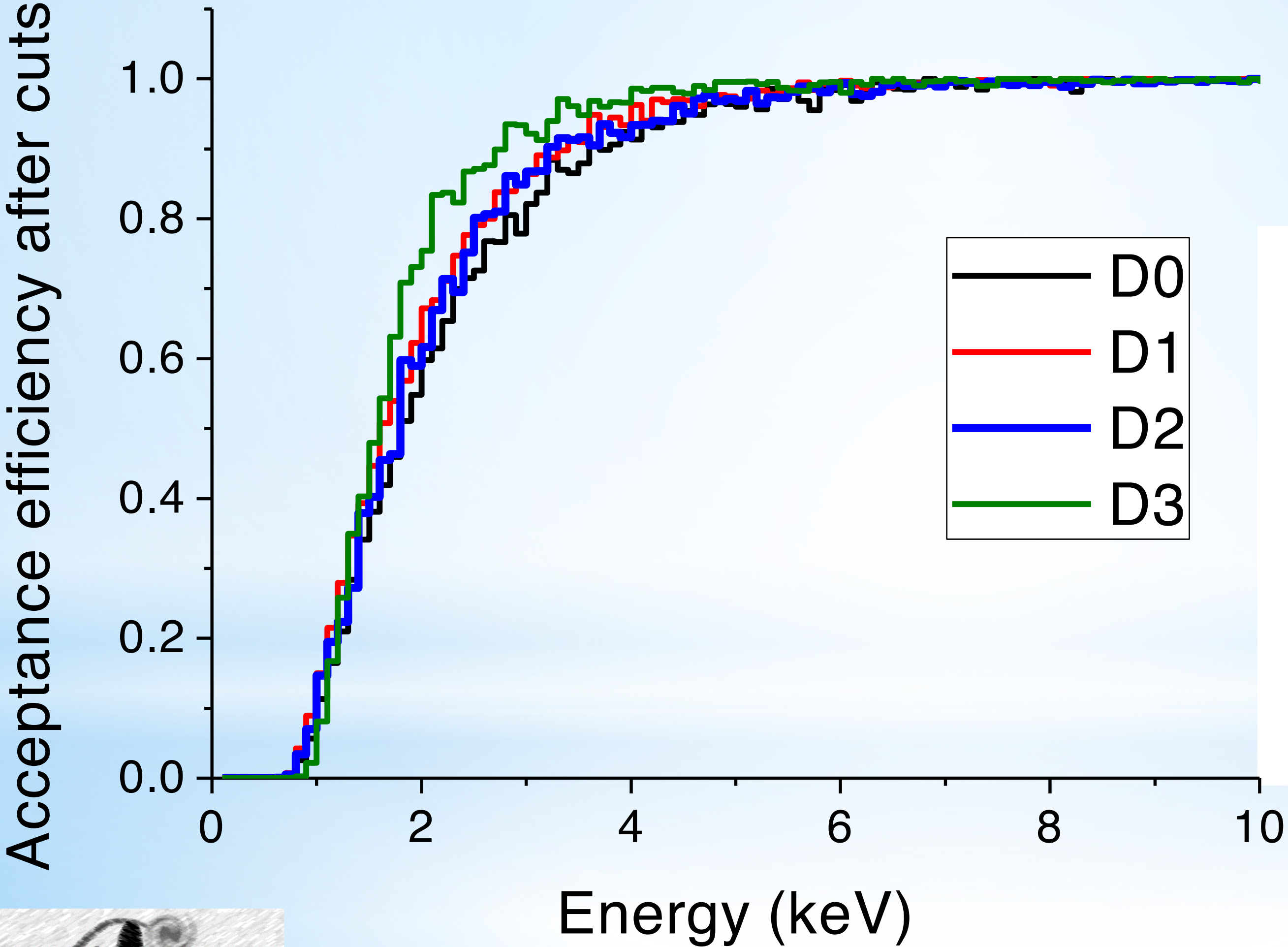
- Good calibration down to threshold:
  - External source ^{109}Cd
  - 3.2 keV and 0.9 keV lines (still few number of events)



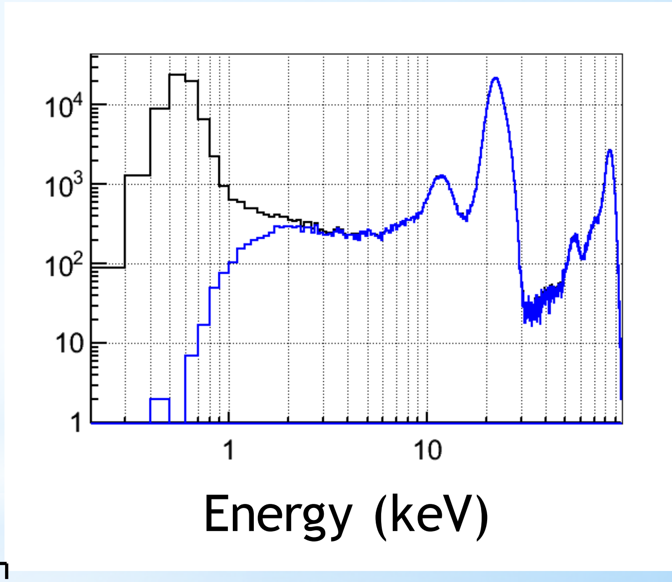


ANAIS data analysis

- **FILTERING PROCEDURE**



^{109}Cd calibration – D3



ANA

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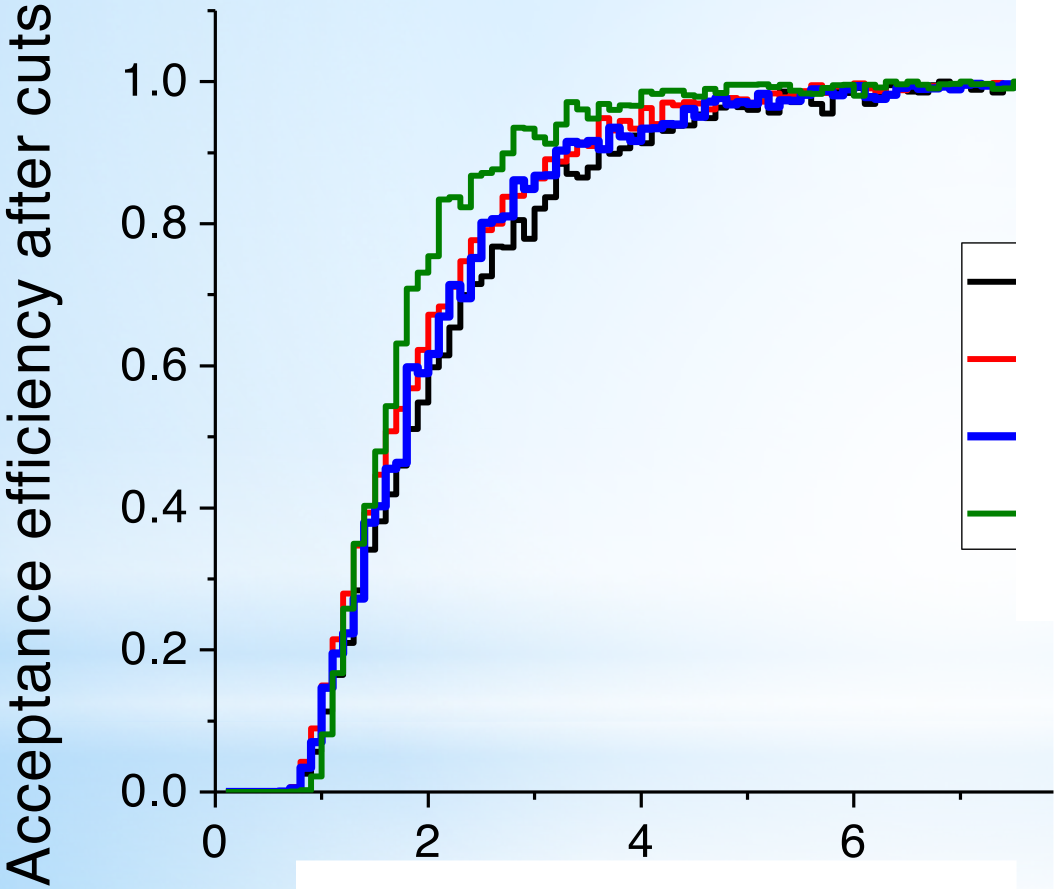
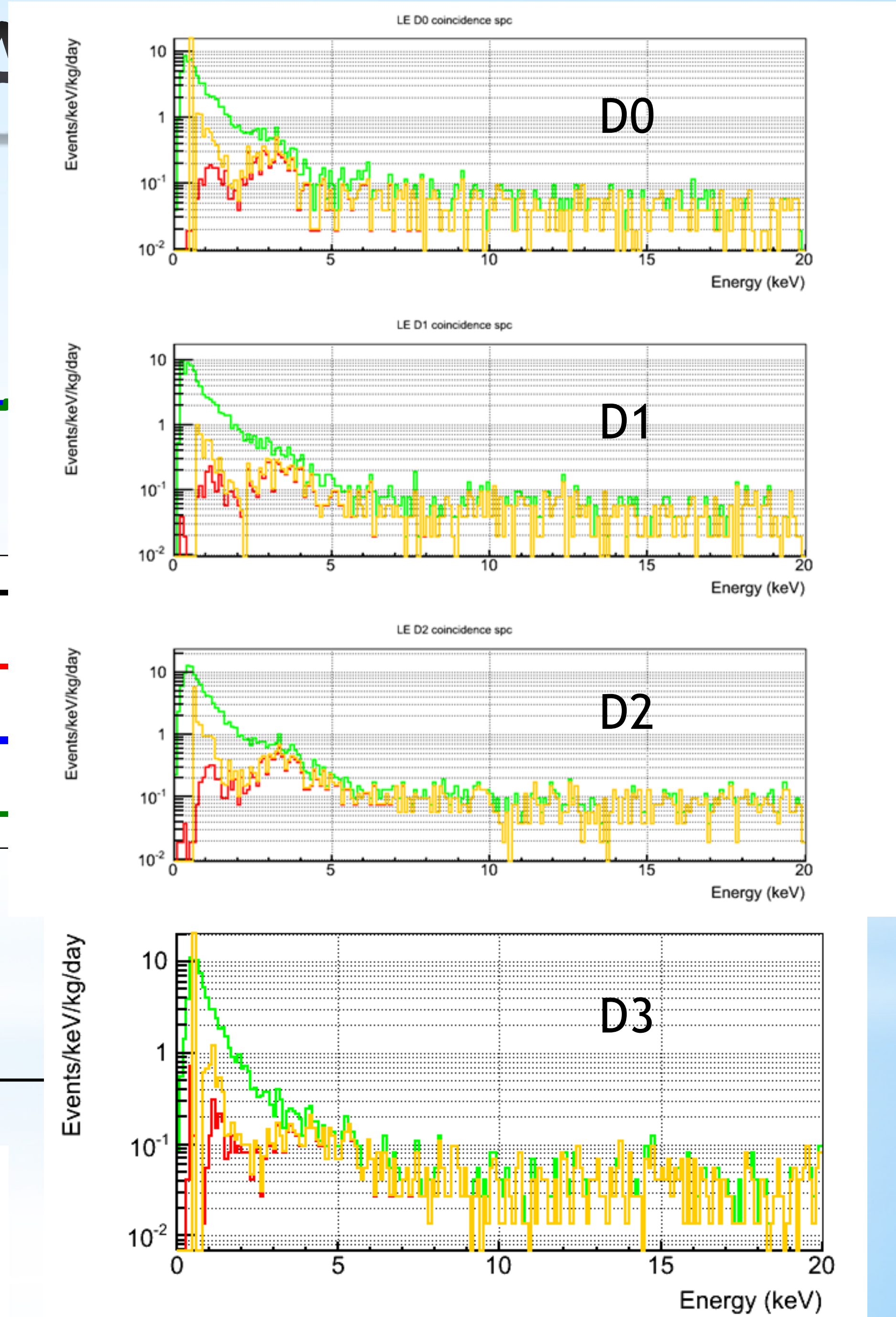
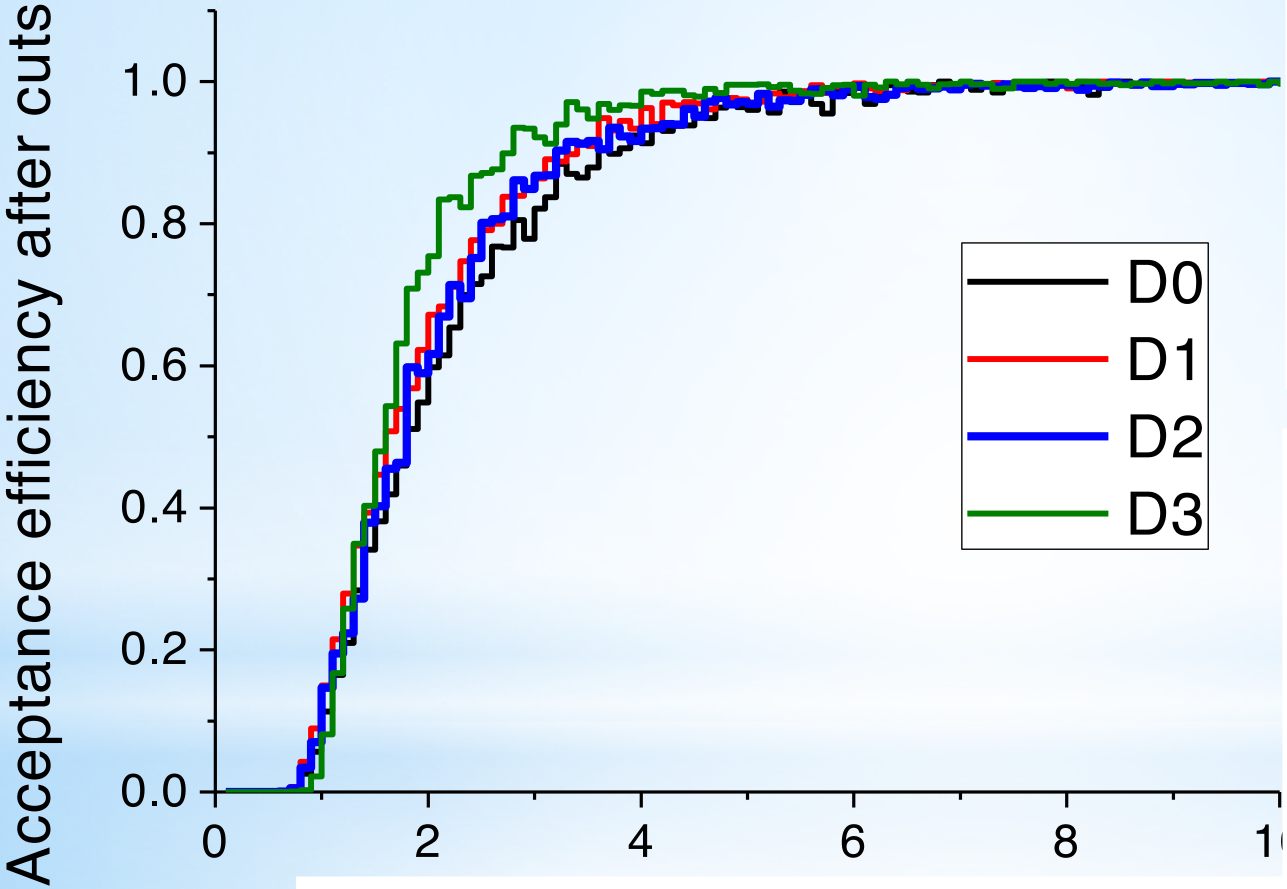


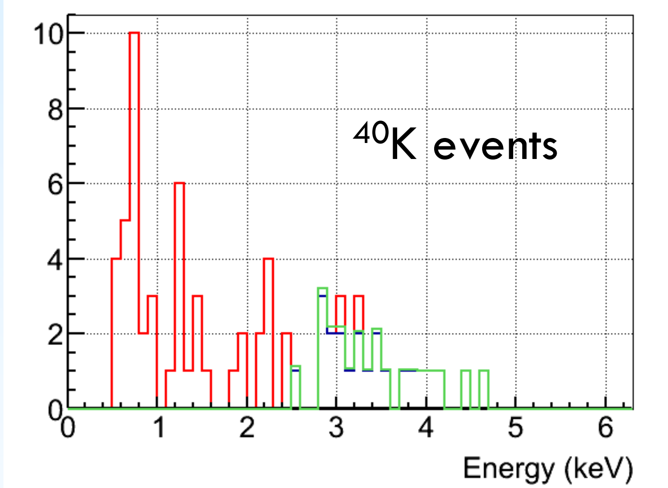


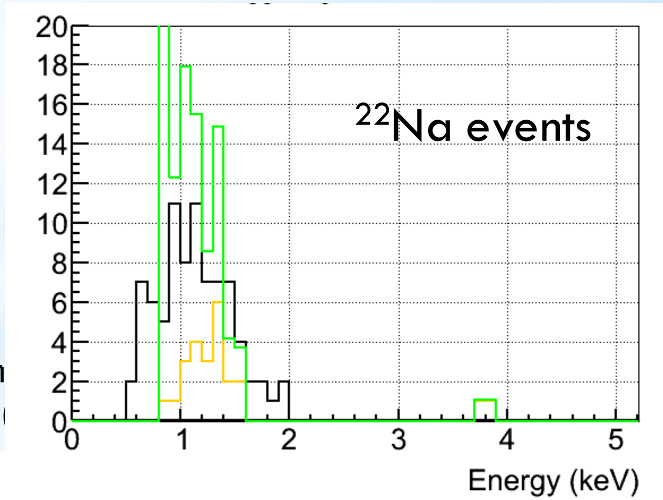
Underestimate of acceptance efficiencies is not clear by the study of coincident events

ANAIS data analysis

- **FILTERING PROCEDURE**



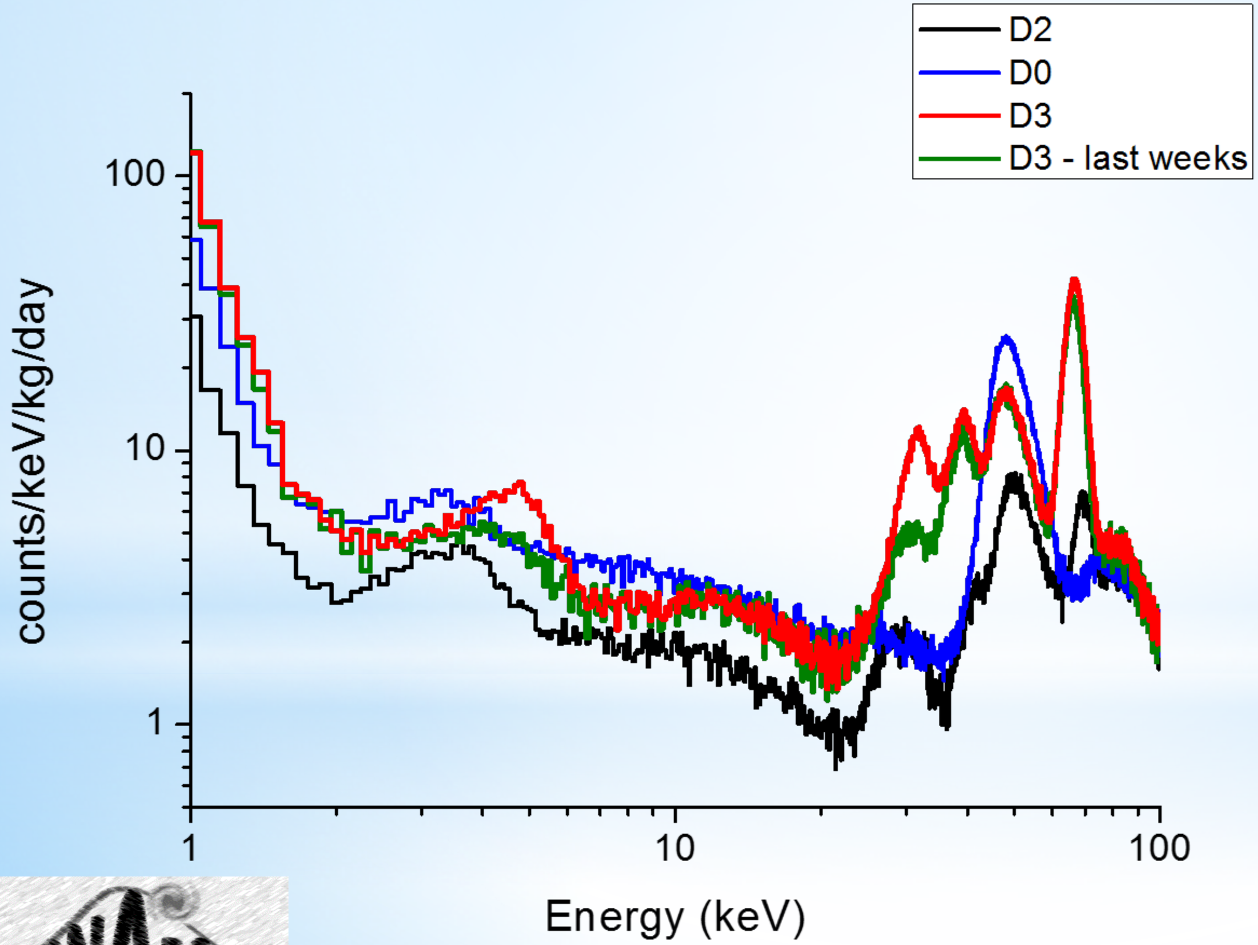




Some underestimate of acceptance efficiency could be indicated by ^{22}Na events (below 2 keVee)

A37D3 Background Features

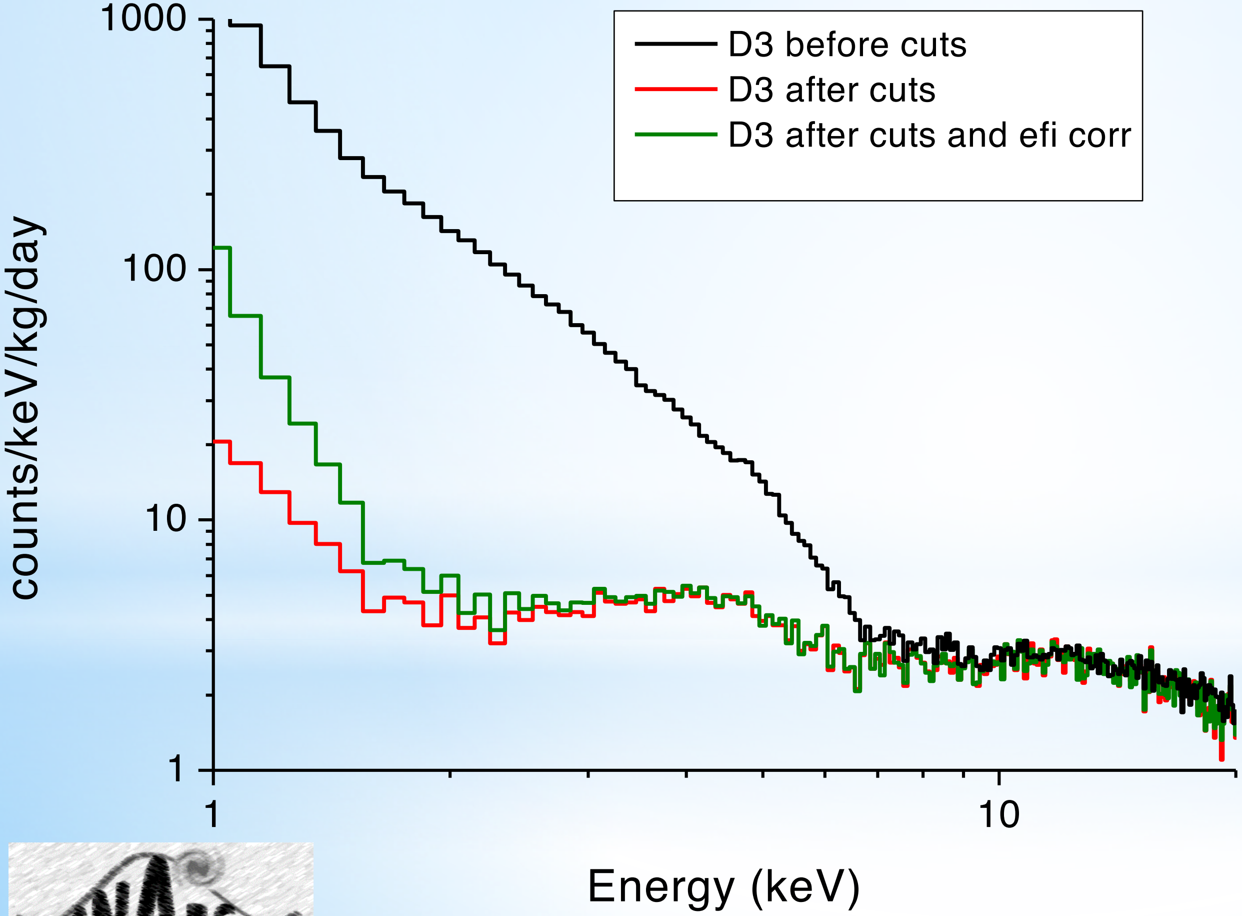
- **Low Energy Background in D3**
  - 60 days of live time / last 20 days



- Still decaying D2/D3 bckg
- Background at 20 keV 2counts/keV/kg/day
- Filtering for D3 not yet optimized
- More aggressive filtering protocols still under study

A37D3 Background Features

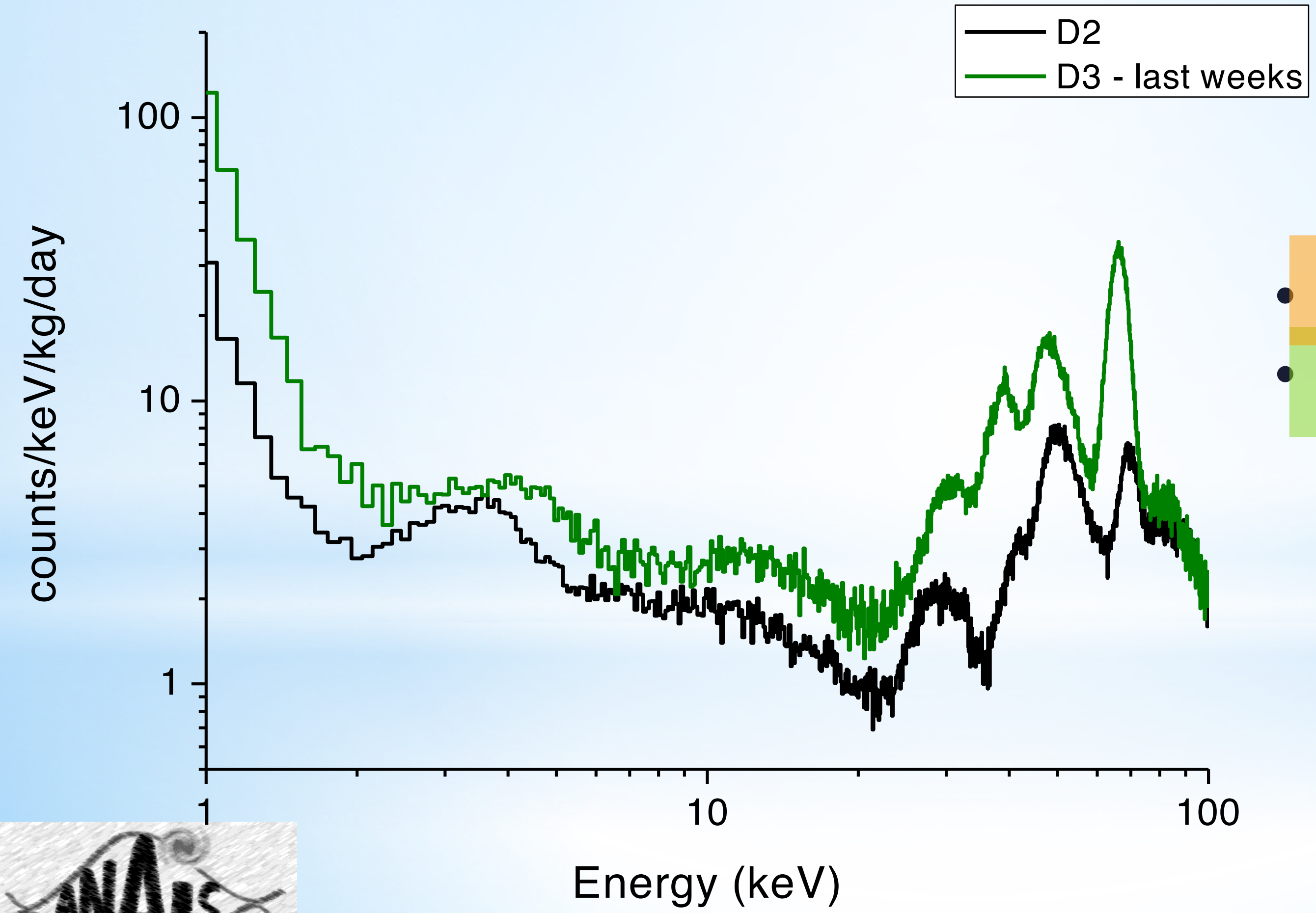
- **Low Energy Background in D3**



- Still decaying D2/D3 bkg
- Background at 20 keV 2counts/keV/kg/day
- Filtering for D3 not yet optimized
- More aggressive filtering protocols still under study

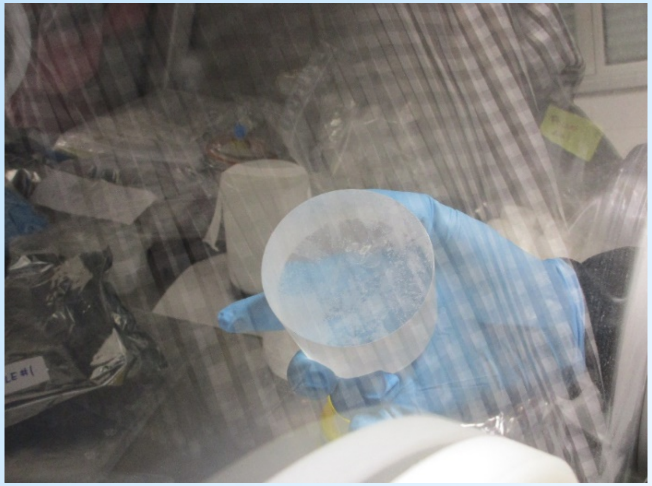
A37D3 Background Features

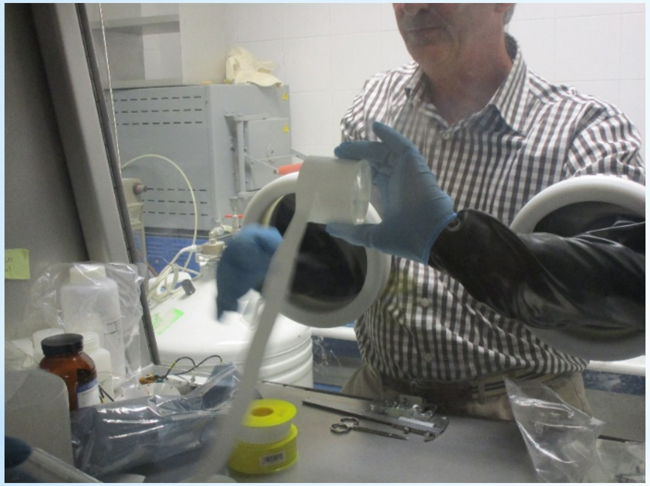
- Low Energy Background in D3 vs Background in D2



- Higher ^{210}Pb
- Lower ^{40}K

AS 1kg samples mounting

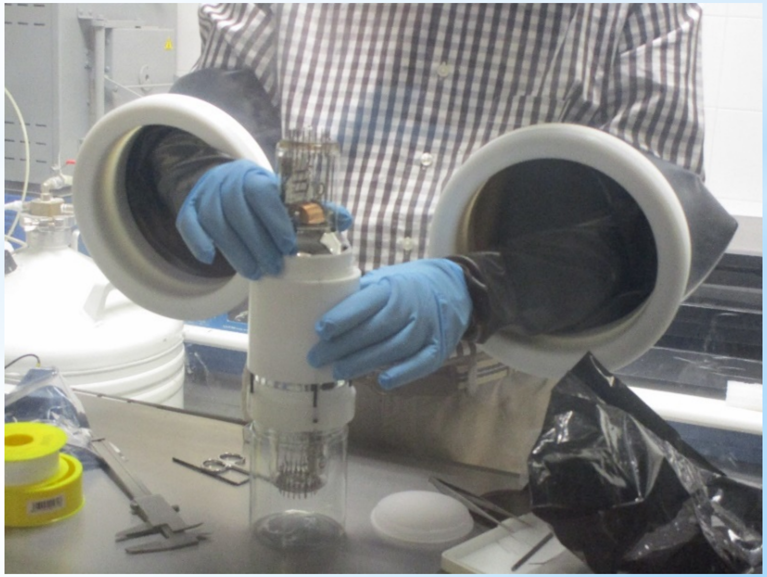




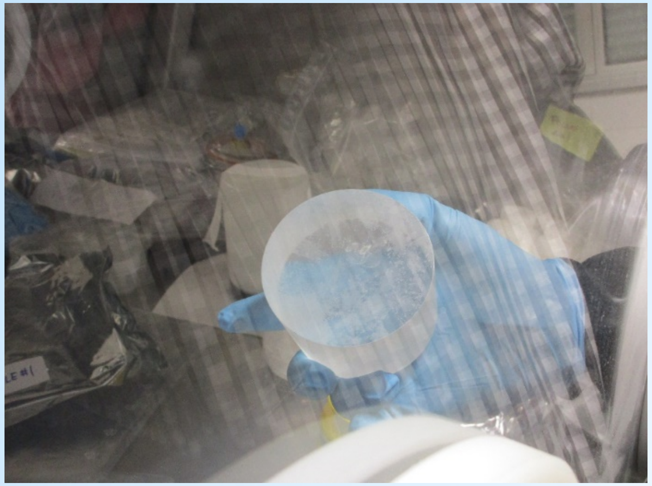
Trying to understand the origin of the ^{210}Pb contamination in D3 module AS prepared two 1kg crystal pieces to be measured at LSC

The goal was to discard surface contamination from the Teflon used in D3

They have been coupled to two PMTs at UZ glove box and measured at LSC (still ongoing)



AS 1kg samples results

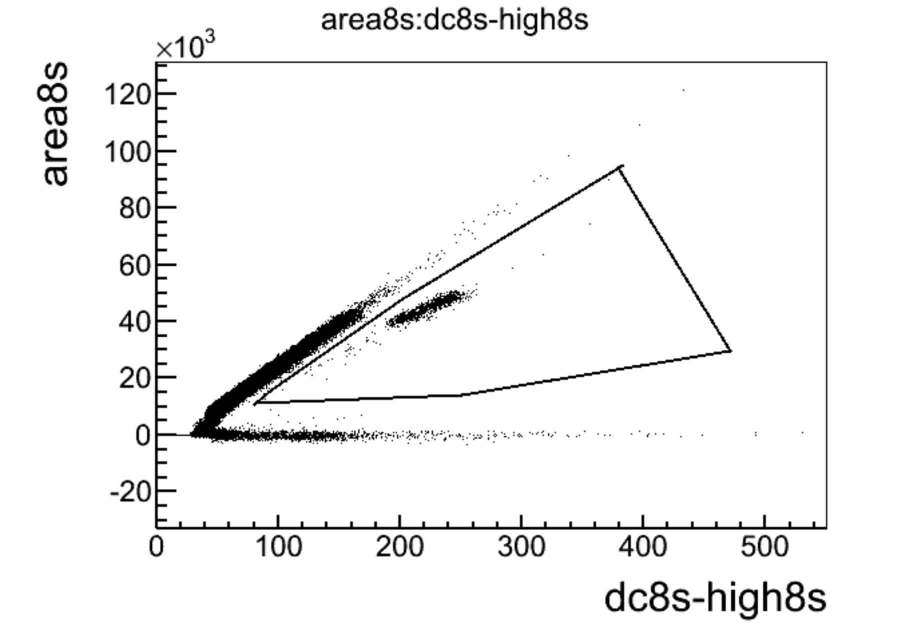


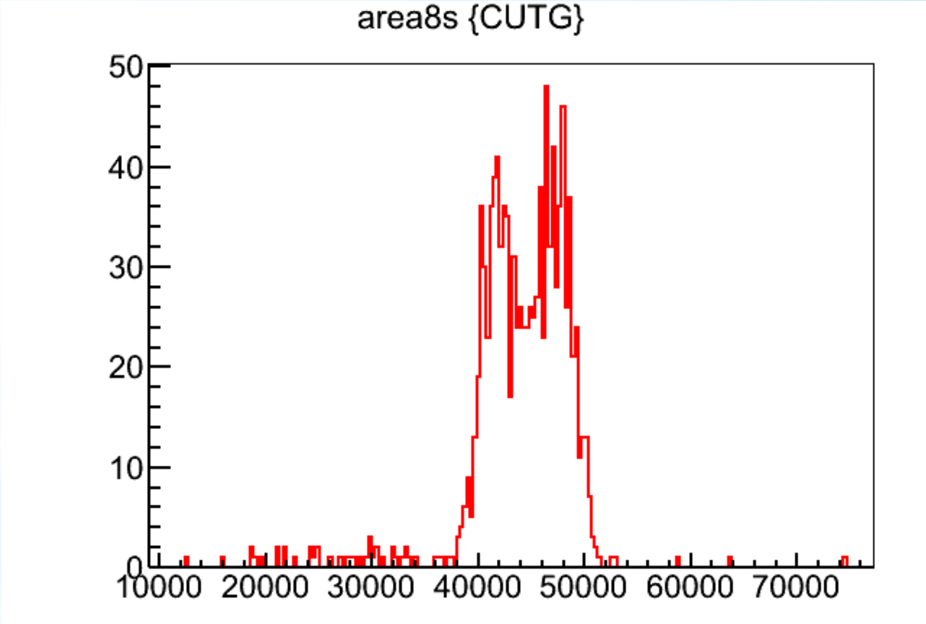
PSA allows easily the identification and quantification of the alpha rate.

Sample #1: 1.3 mBq/kg

Same ingot as D3

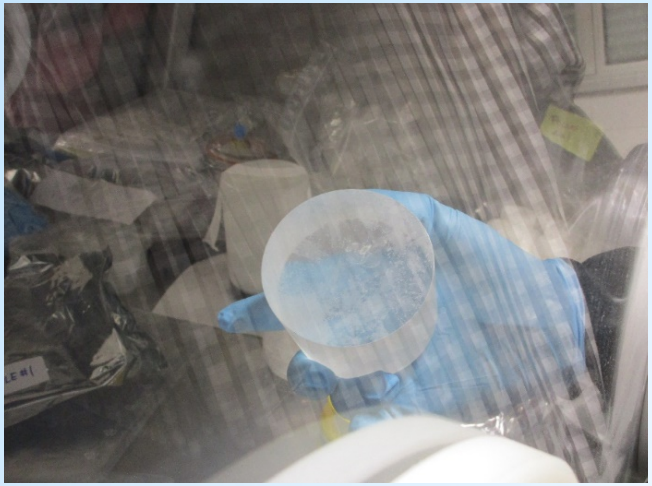
10 days of data





The treatment of the surfaces made at AS is under revision by the company

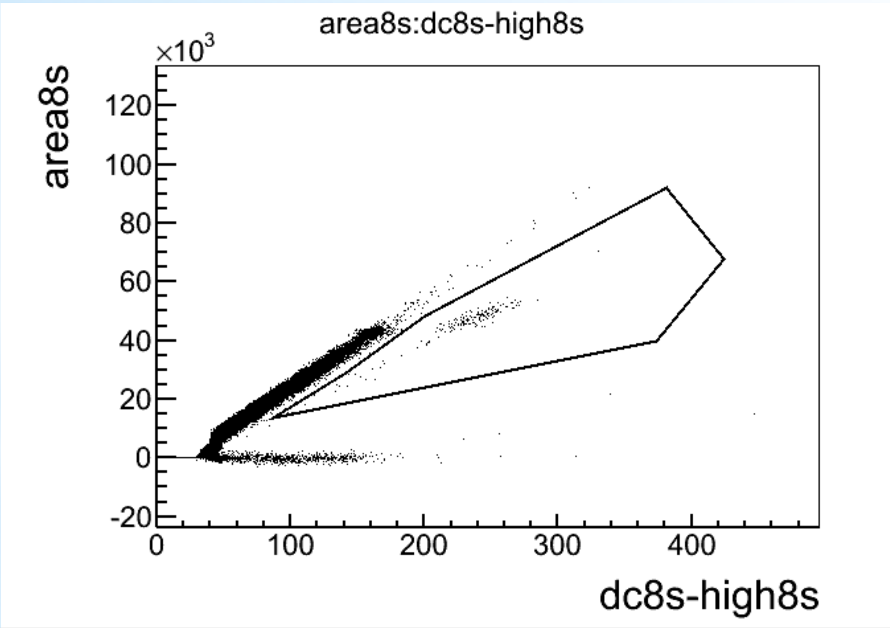
AS 1kg samples results

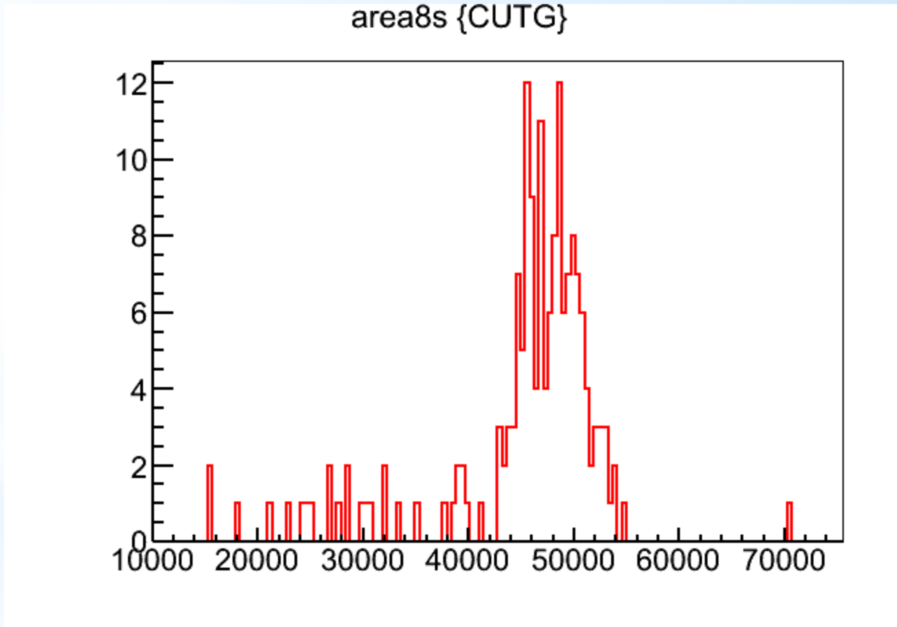


PSA allows easily the identification and quantification of the alpha rate.

Sample #2: 0.6 mBq/kg

6.7 days of data



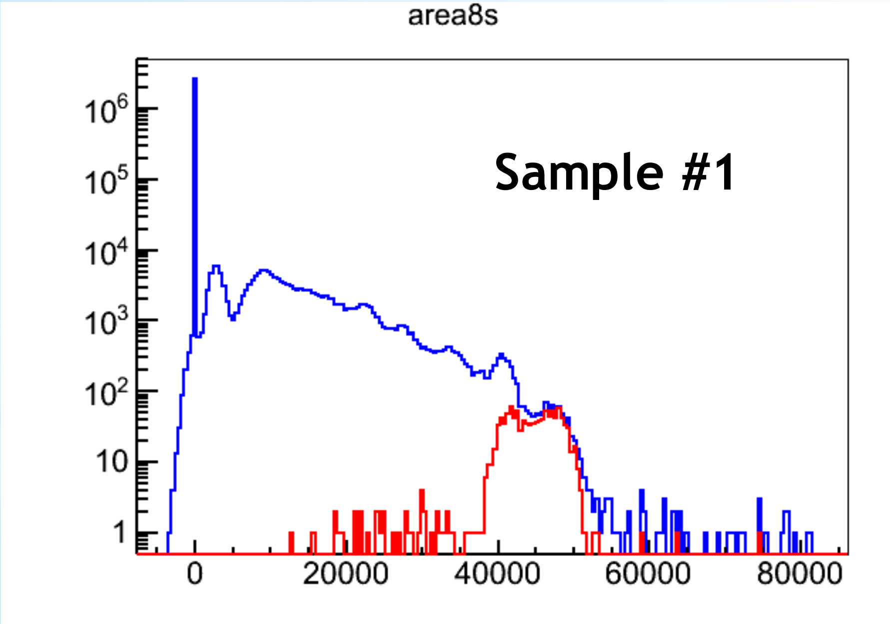


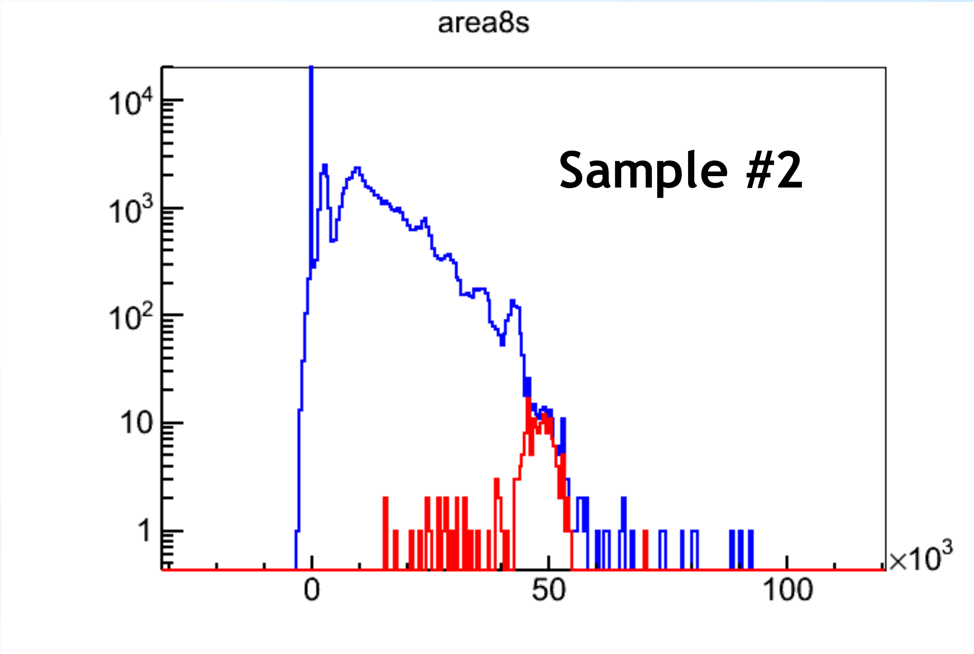
In order to draw conclusions more data about growing dates are required, ^{210}Po activity is still being built

AS 1kg samples results

More data are required to trace back the origin of the contamination in time

Measurements still ONGOING

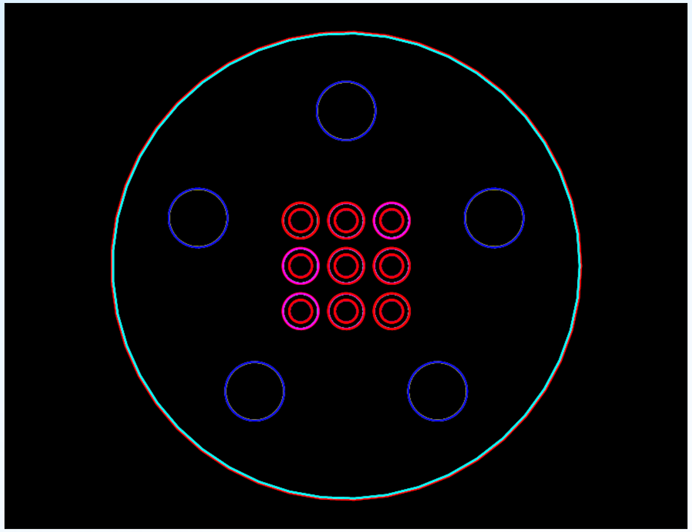


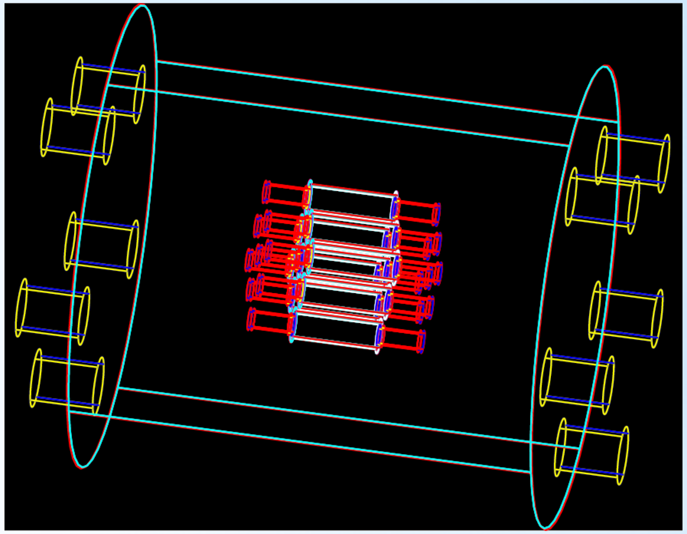


Updated Liquid Scintillator Veto Simulation

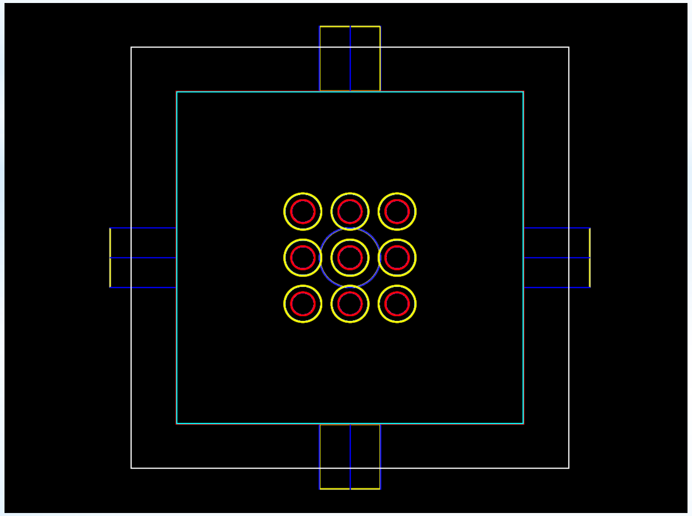
Two different designs have been considered:

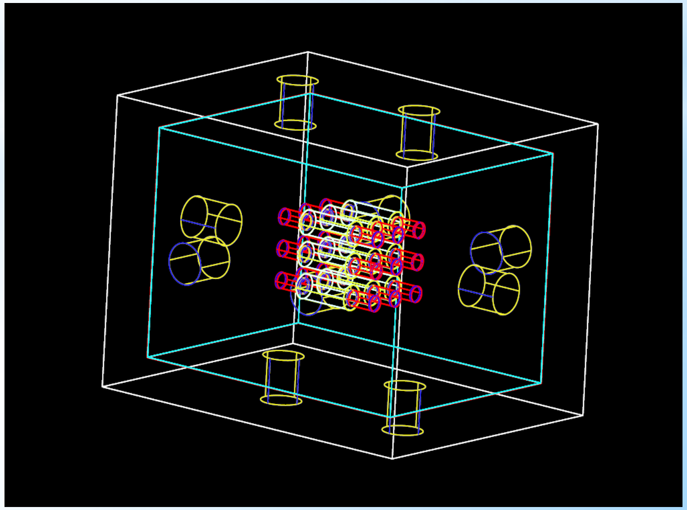
LSVc



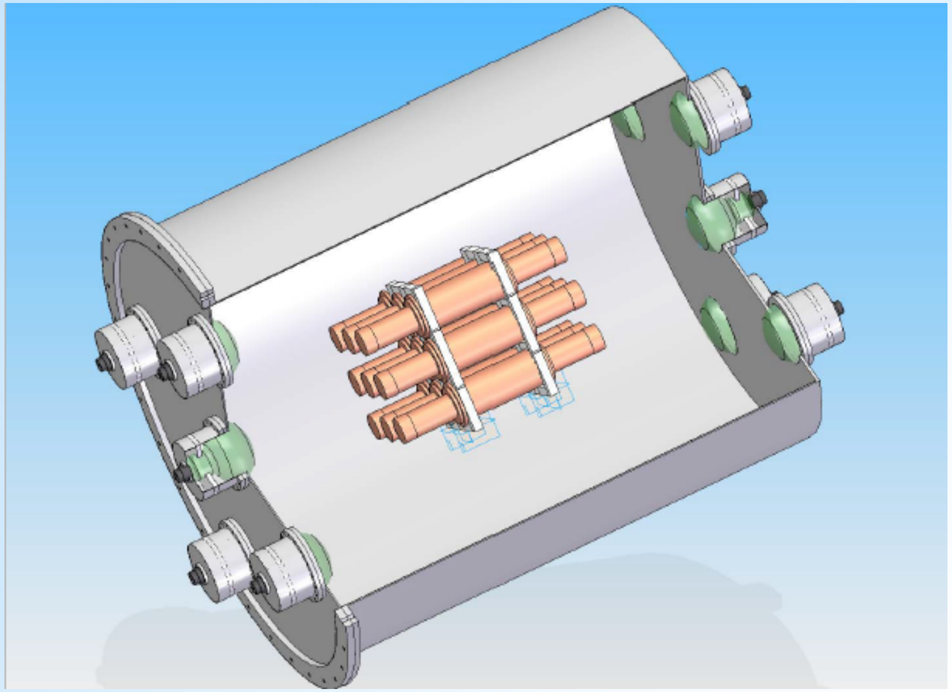


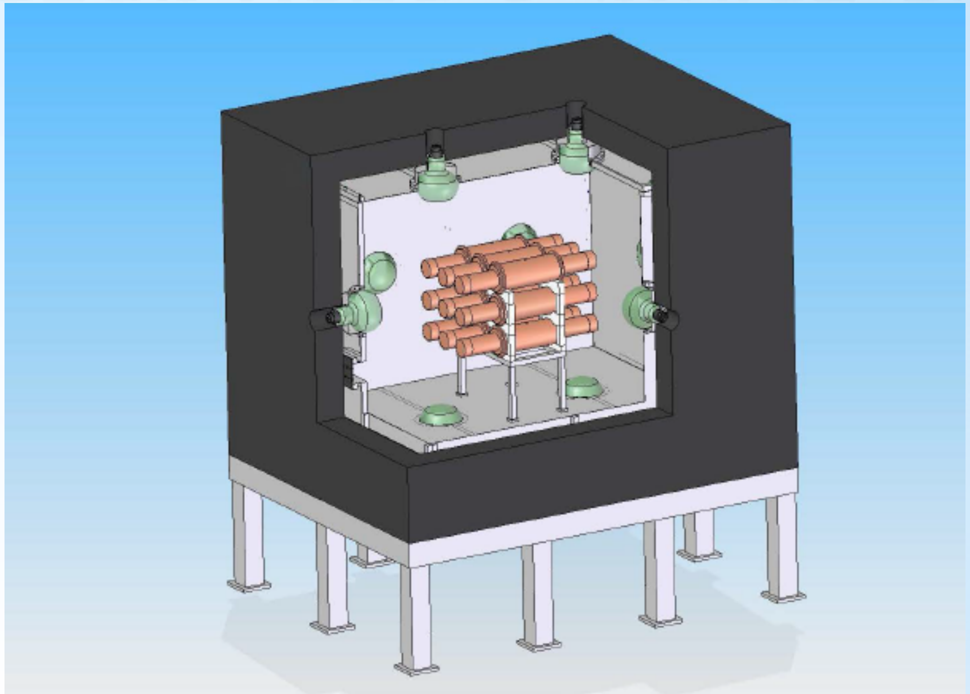
LSVb





Liquid Scintillator Veto Simulation





LSVc consists of a large cylinder for the LS container (and whose preliminary results had been presented already at the previous committee meeting).

LSVb consists of a smaller LS container that could be installed in the same set-up configuration designed for ANAIS-112 (3x3 matrix of crystals), including the external lead shielding (15 cm).

Liquid Scintillator Veto Simulation

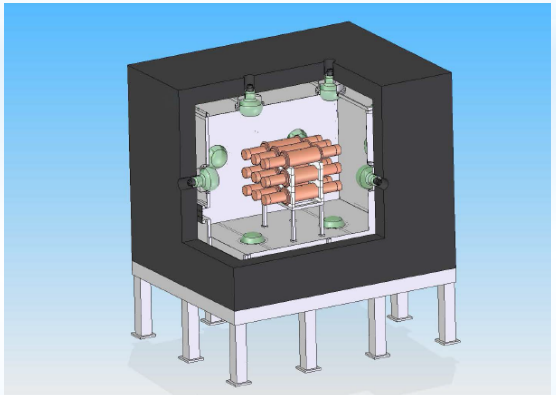
Vessel: For LSVc stainless steel cylinder, 5-mm-thick, 60 cm scintillator thickness. For LSVb, it has been defined as the 1.5 mm thick stainless steel box prepared for the ANAIS-112 set-up, having external dimensions 1150 x 1125 x 1550 mm^3.

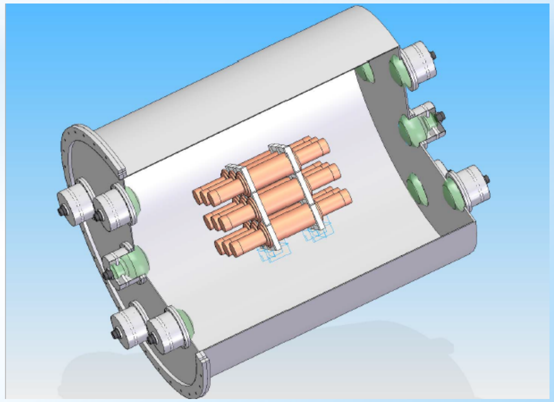
Reflector: 0.5 mm reflector Lumirror.

Liquid scintillator medium: Linear AlkylBenzene (LAB). The total mass of scintillator is estimated to be 3.8 tons for LSVc and 1.7 tons for LSVb. Although it has not been considered in the simulation, 2 g/L 2,5-diphenyloxazole (PPO) will be added to the LAB as wavelength shifter.

Photomultipliers: Hamamatsu R5912, 8" diameter borosilicate glass. For both geometries, ten units are assumed: five PMTs at each end of the cylindrical vessel for LSVc, and one unit at each small face and two units at the four large faces for LSVb.

Shielding: no shielding has been considered for LSVc, but a 15 cm thick layer of lead for LSVb.





Liquid Scintillator Veto Simulation

CONTAMINATIONS CONSIDERED AT NaI CRYSTALS – D2

	Unit	^{40}K	^{232}Th	^{238}U	^{226}Ra	^{210}Pb	^{22}Na	^{3}H
Crystal	mBq/kg	1.25 ± 0.11	$(0.7 \pm 0.1)10^{-3}$	$(2.7 \pm 0.2)10^{-3}$		0.70 ± 0.10	0.81 ± 0.05	0.09
PMTs	mBq/PMT	111 ± 5	20.7 ± 0.5	157 ± 8	82.5 ± 0.8			

CONTAMINATIONS CONSIDERED AT LSV SYSTEM

	Unit	^{40}K	^{232}Th	^{238}U	^{226}Ra	^{60}Co	Ref.
SS container	mBq/kg	<0.96	<0.54	<21	<0.57	2.8 ± 0.8	NEXT
PMTs	mBq/PMT	2150 ± 126	339 ± 11	346 ± 105	652 ± 18	1.3 ± 2.2	SNOlab
LS (LAB)	mBq/kg	0.0031	$4.1\ 10^{-6}$	$1.2\ 10^{-5}$			JUNO

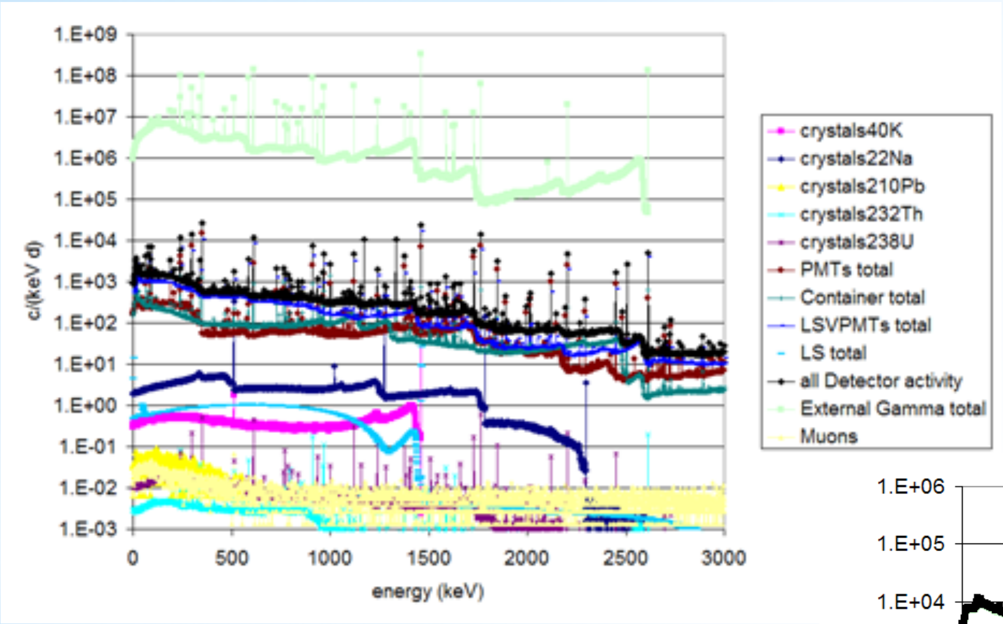
GAMMA AND MUON ENVIRONMENTAL FLUXES:

	Unit	^{40}K	^{232}Th	^{238}U
LSC, Hall B (2006)	$\gamma\ cm^{-2}\ s^{-1}$	0.33 ± 0.01	0.85 ± 0.07	0.71 ± 0.12
LSC, Hall A (2010)	$\gamma\ cm^{-2}\ s^{-1}$	0.15 ± 0.04	0.36 ± 0.23	0.55 ± 0.22

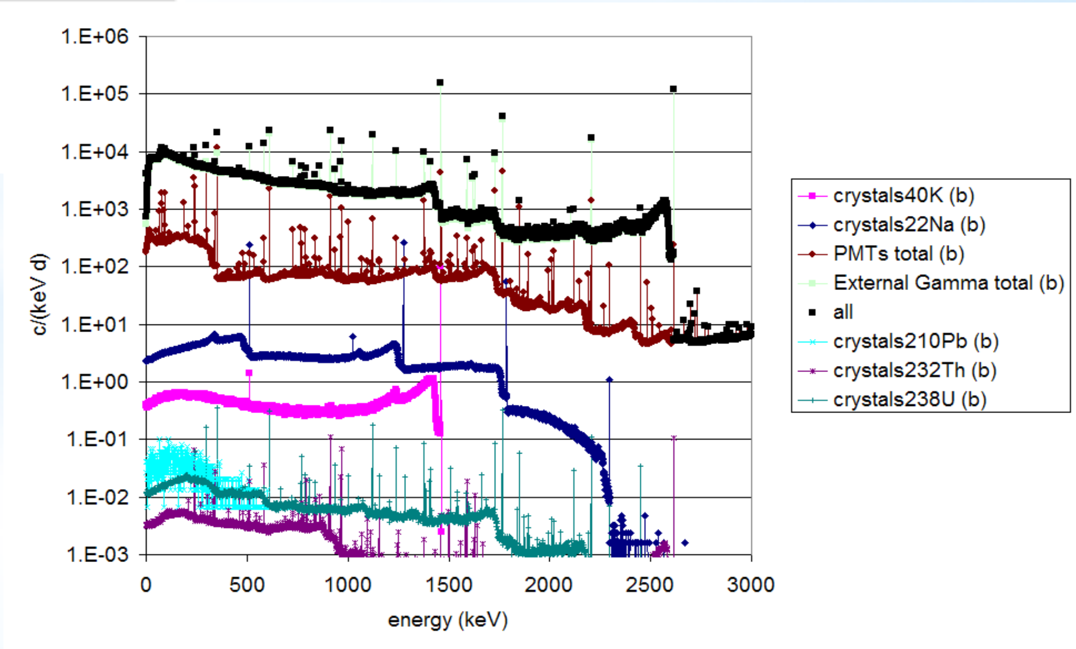
	Unit	Muon
LSC, Hall B	$\mu\ m^{-2}\ s^{-1}$	$(5.04 \pm 0.06\,(stat) \pm 0.25\,(sys))\ 10^{-3}$
LSC, Hall A	$\mu\ m^{-2}\ s^{-1}$	$(4.71 \pm 0.06\,(stat) \pm 0.24\,(sys))\ 10^{-3}$

Liquid Scintillator Veto Simulation

LSVc detection rate is extremely dominated by the external gamma flux contributions, contribution in LSVb design is significantly lower



LSVc



LSVb

Liquid Scintillator Veto Simulation

LSVc detection rate is extremely dominated by the external gamma flux contributions, contribution in LSVb design is significantly lower

The total trigger rate below 3 MeV for the LSV is of the order of 65 kHz in the LSVc (simulated without shielding) while it is below 100 Hz in the LSVb design.

Different energy thresholds for the LS triggering have been considered in the simulation: 500 keV threshold allows to reduce the trigger rate in a factor of 2 for both designs.

Different logic trigger conditions have been considered:

t: total spectra

a: events in anticoincidence among NaI modules

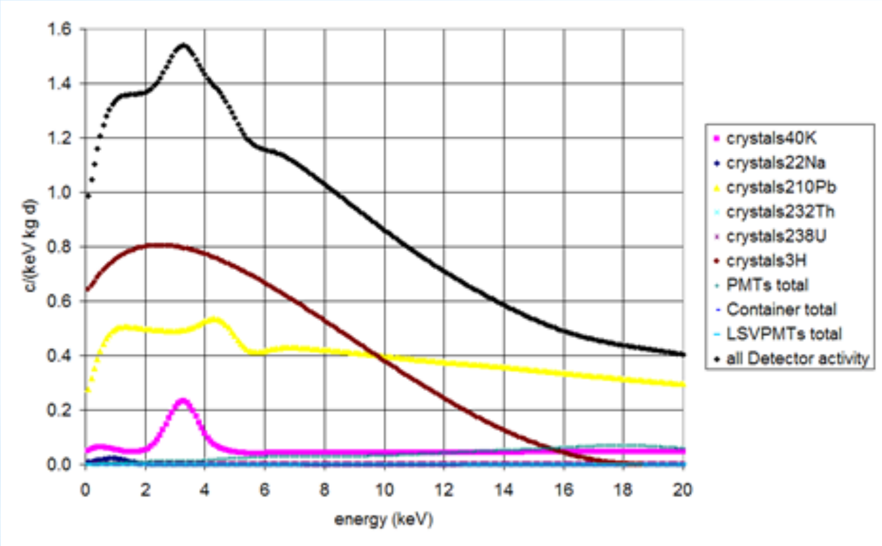
av: events in anticoincidence among NaI modules and LSV

av500: "same" with a 500 keV energy threshold in LSV system

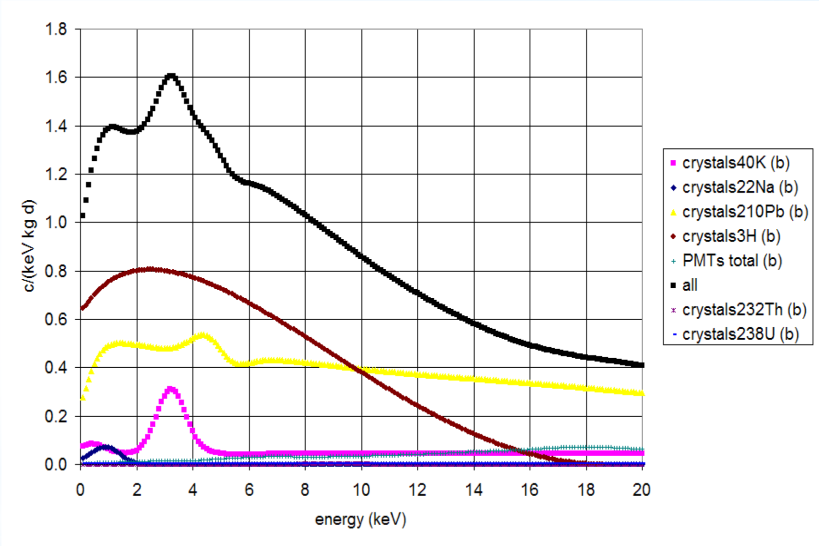
Liquid Scintillator Veto Simulation

Energy Spectra of the NaI(Tl) modules for both designs in av trigger conditions, assuming external gamma backgrounds have been suppressed

LSVc



LSVb



Concerning the contribution at RoI from ^{210}Pb in crystals, it could be higher in case of a surface contamination. Assuming all the ^{210}Pb was on surface at a depth of 30 μm, the increase in the rate in the 1-6 keV region in comparison to a pure bulk contamination would be of a factor 1.6.

Liquid Scintillator Veto Simulation

Total rate in the NaI(Tl) modules for both designs in av trigger conditions in the 1-6 keV region

LSVc

	c/kg/d	% of total
Crystal 40K	4.7E-01	6.83
Crystal 232Th	5.6E-04	0.01
Crystal 238U	2.1E-02	0.31
Crystal 210Pb	2.4E+00	35.72
Crystal 3H	3.8E+00	55.78
Crystal 22Na	1.3E-02	0.19
PMTs	8.0E-02	1.16
LSV PMTs	1.5E-05	0.0002
Container	4.1E-06	0.0001
LS		
Muons		

LSVb

	c/kg/d	%
Crystal 40K	5.7E-01	8.19
Crystal 232Th	5.6E-04	0.01
Crystal 238U	2.1E-02	0.31
Crystal 210Pb	2.4E+00	34.88
Crystal 3H	3.8E+00	54.85
Crystal 22Na	4.2E-02	0.60
PMTs	8.2E-02	1.17
LSV PMTs	not simulated	
Container	not simulated	
LS	not simulated	
Muons	not simulated	
External Gamma	<0.19 (90%CL)	

Concerning the contribution at RoI from ^{210}Pb in crystals, it could be higher in case of a surface contamination. Assuming all the ^{210}Pb was on surface at a depth of 30 μm, the increase in the rate in the 1-6 keV region in comparison to a pure bulk contamination would be of a factor 1.6.

Liquid Scintillator Veto Simulation

Reduction factors (R.F.) at the very low energy region

Percentage of background remaining after anticoincidence (or anticoincidence + veto) in the 1-6 keV region

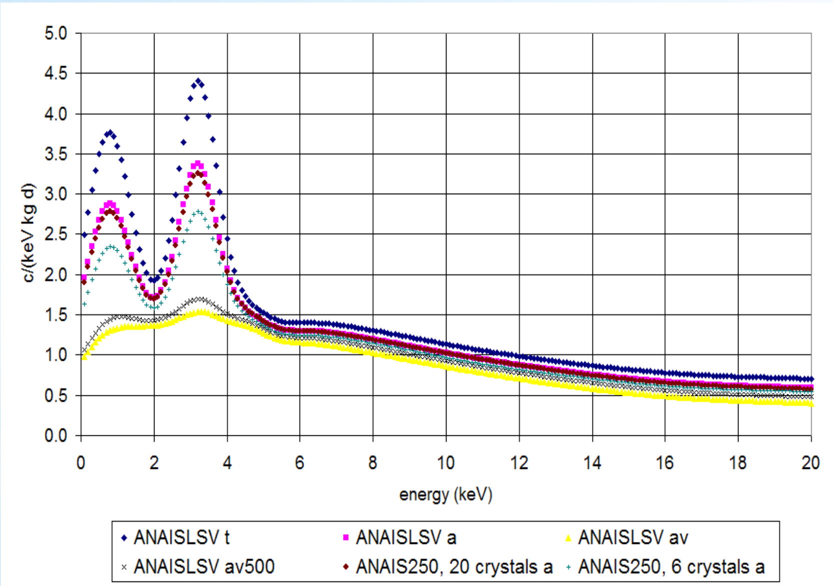
	R.F. (%) ^{40}K from crystals	R.F. (%) ^{22}Na from crystals	R.F. (%) PMTs	R.F. (%) All (but Gammas)	R.F. (%) Gammas
3x3 modules (a)	69.0	62.4	62.3	83.7	68.8 (LSVc) 55.9 (LSVb)
3x3 modules + LSVc (av)	11.9	1.2	7.3	55.6	0
3x3 modules + LSVc (500 keV threshold) (av500)	15.5	5.7	29.3	59.1	5.2
3x3 modules + LSVb (av)	14.5	3.7	7.3	56.6	2.4
3x3 modules + LSVb (500 keV threshold) (av500)	20.5	11.0	31.1	61.3	16.5
4x5 modules (a)	62.7	55.1	45.9	77.9	
4x5 modules (6 inner crystals) (a)	48.6	39.8	32.5	70.3	

For the assumed background model, about 70% of the background obtained in anticoincidence for the 3 × 3 crystals configuration remains even after the vetoing effect of the LSV.
Comparing the reduction for the two veto systems, the loss of effectiveness in the small box veto is more important for ^{22}Na; the ^{40}K contribution is in both systems dominated by the EC decays to the ground state of the daughter, which cannot be vetoed

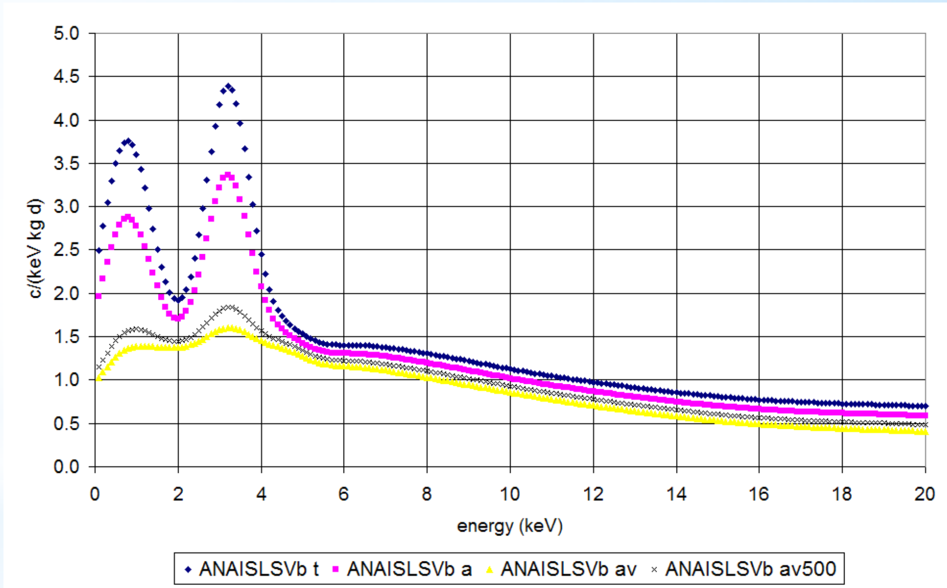
Liquid Scintillator Veto Simulation

Low Energy Spectra of the NaI(Tl) modules for both designs for t, a, av and av500 anticoincidence conditions. Spectra obtained in anticoincidence in the 4x5 modules set-up (ANAIS-250) are also shown

LSVc



LSVb



Liquid Scintillator Veto Simulation

We can conclude:

-Operation of a LSV system without a lead (water) shielding is precluded due to the non-negligible contribution of the environmental gamma background at the region of interest and the high counting rate generated at the LSV. The inclusion of a 15 cm thick lead shielding allows to reduce the environmental gamma background contribution in the 1-6 keV below 0.04 c/(keV kg d) for an ideal LSV and to 0.11 c/(keV kg d) considering a 500 keV threshold for the LSV.

-The increase in the rate at the region of interest when considering a small box instead of a larger cylindrical LSV is not very significant for the dominant background sources and it seems that it could be tolerated. Reduction factors are virtually the same for both LSV systems.

-Assuming the activities of the last characterized detector (D2), for nine crystals with total mass of 112.5 kg the expected background rate is below 2 counts/keV/kg/d above 4 keV and of 2.5 counts/keV/kg/d in the region from 1 to 4 keV, which could be reduced at 1.4 counts/keV/kg/d by using a LSV.

D0/D1/D2 Background Model

- It has been completed and sent for publication to Eur. Phys. Journal C

http://arxiv.org/abs/1604.05587

- We need tritium in the bulk and ^{210}Pb surface contamination to explain the background in the low energy range

Eur. Phys. J. C manuscript No.
(will be inserted by the editor)

arXiv:1604.05587v2 [astro-ph.IM] 26 Apr 2016

Assessment of backgrounds of the ANAIS experiment for dark matter direct detection

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Received: date / Accepted: date

Abstract A large effort has been carried out to characterize the background of sodium iodide crystals within the ANAIS (Annual modulation with NaI Scintillators) project. In this paper, the background models developed for three 12.5-kg NaI(Tl) detectors produced by Alpha Spectra Inc. and operated at the Canfranc Underground Laboratory are presented together with an evaluation of the background prospects for the full experiment. Measured spectra from threshold to high energy in different conditions are well described by the models based on quantified activities. At the region of interest, crystal bulk contamination is the dominant background source. Contributions from ^{210}Pb, ^{40}K, ^{22}Na and ^{3}H are the most relevant. Those from ^{40}K and ^{22}Na could be efficiently suppressed thanks to anticoincidence operation in a crystals matrix or inside a Liquid Scintillator Veto (LSV), while that from ^{210}Pb has been reduced by improving crystal production methods and ^{3}H production could be reduced by shielding against cosmic rays during production. Assuming the activities of the last characterized detector, for nine crystals with a total mass of 112.5 kg the expected background rate is 2.5 counts/keV/kg/d in the region from 1 to 4 keV, which could be reduced at 1.4 counts/keV/kg/d by using a LSV.

1 Introduction

Sodium iodide crystals doped with Tl have been widely used as radiation detectors and, in particular, they have been applied in the direct search of galactic dark matter particles for a long time [1–5]. Among the several experimental approaches using NaI(Tl) detectors, DAMA/LIBRA is the most relevant, having reported the observation of a modulation compatible with that expected for galactic halo WIMPs with a large statistical significance [6]. Results obtained with other target materials and detection techniques (like those from CDMS [7], CRESST [8], EDELWEISS [9], KIMS [10], LUX [11], PICO [12] or XENON [13] collaborations) have been ruling out for years the most plausible compatibility scenarios. The ANAIS (Annual modulation with NaI Scintillators) project [14] is intended to search for dark matter annual modulation with ultrapure NaI(Tl) scintillators at the Canfranc Underground Laboratory (LSC) in Spain; the aim is to provide a model-independent confirmation of the annual modulation positive signal reported by DAMA/LIBRA using the same target and technique, but different experimental conditions affecting systematics. Projects like DM-Ice [15], KIMS [16] and SABRE [17] also envisage the use of large masses of NaI(Tl) for dark matter searches.

ANAIS aims at the study of the annual modulation signal using a NaI(Tl) mass of 112.5 kg at the LSC. To confirm the DAMA/LIBRA results, ANAIS detectors should be comparable to those of DAMA/LIBRA in terms of energy threshold and radioactive background: energy threshold lower than 2 keVee[1] and background at 1-2 counts/keV/kg/day in the region of interest (RoI) below 6 keVee. Several prototypes have been developed and operated at LSC using BICRON and Saint-Gobain crystals; all of them were disregarded due to an unacceptable K content in the crystal at the level of hundreds of ppb. Among them, the so-called ANAIS-0 detector [18–21], a 9.6 kg Saint-Gobain crystal similar to those of DAMA experiment, has to be highlighted because its successful background model [18] has been the

[a]e-mail: scebrian@unizar.es

[1]Electron equivalent energy.

D3 Background Model

- **VERY PRELIMINARY:**

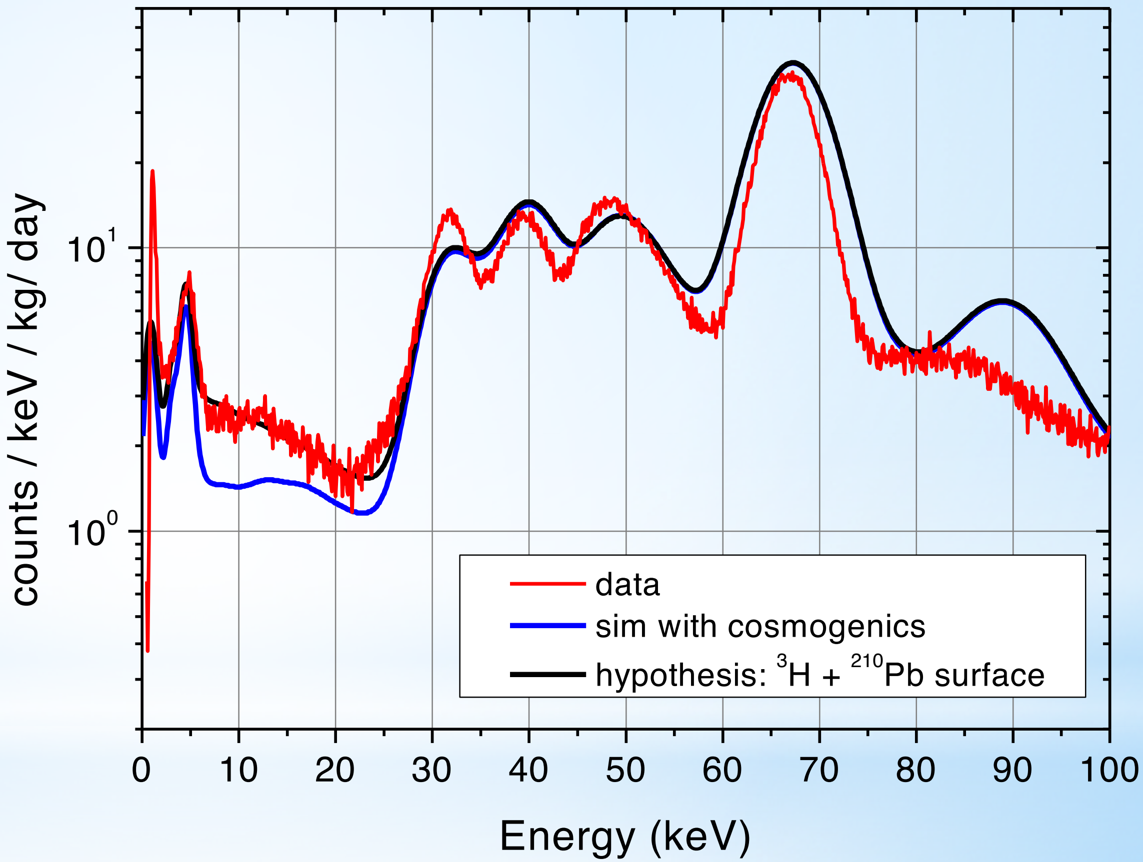
CRYSTAL

1.6 mBq/kg ^{210}Pb
0.7 mBq/kg ^{40}K
0.09 mBq/kg ^{3}H
0.94 mBq/kg ^{129}I
U/Th chains in the NaI bulk
Cosmogenic backgrounds

PMTs

Upper bounds on:

Quartz window
Silicone pads
Copper housing
Residual Radon
Lead shielding



D3 Background Model

- **VERY PRELIMINARY**

CRYSTAL

1.6 mBq/kg ^{210}Pb
0.7 mBq/kg ^{40}K
0.09 mBq/kg ^{3}H
0.94 mBq/kg ^{129}I
U/Th chains in the NaI bulk
Cosmogenic backgrounds

PMTs

Upper bounds on:

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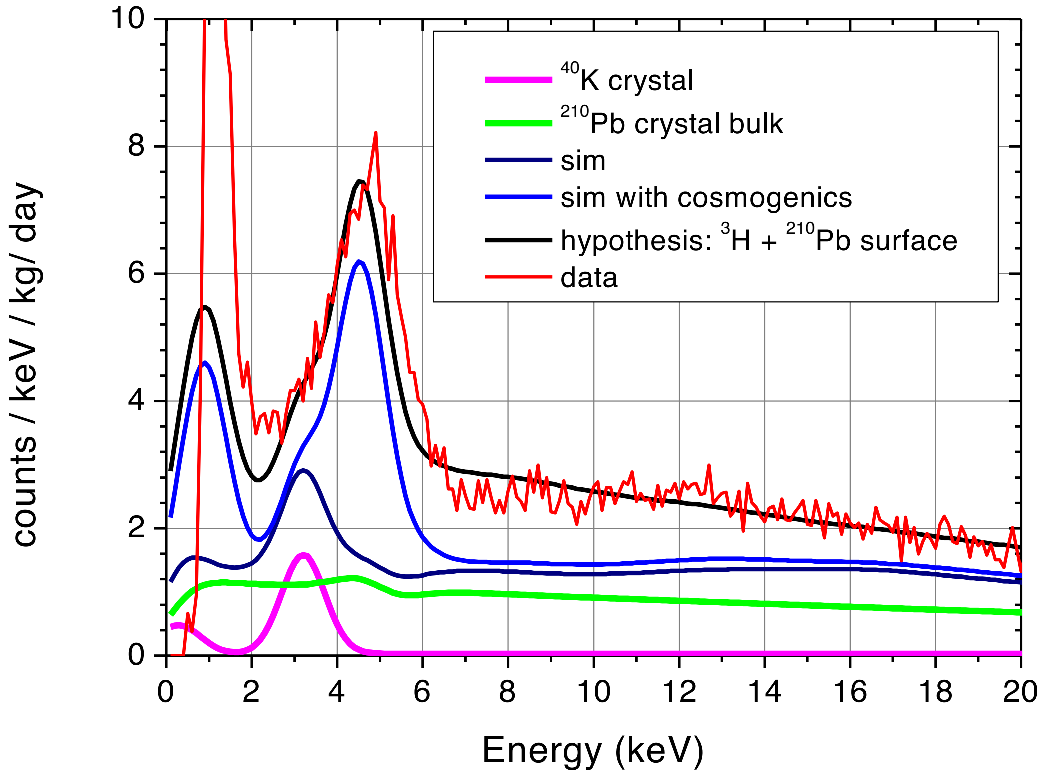
Silicone pads
Copper housing
Residual Radon
Lead shielding



BEST Background Model

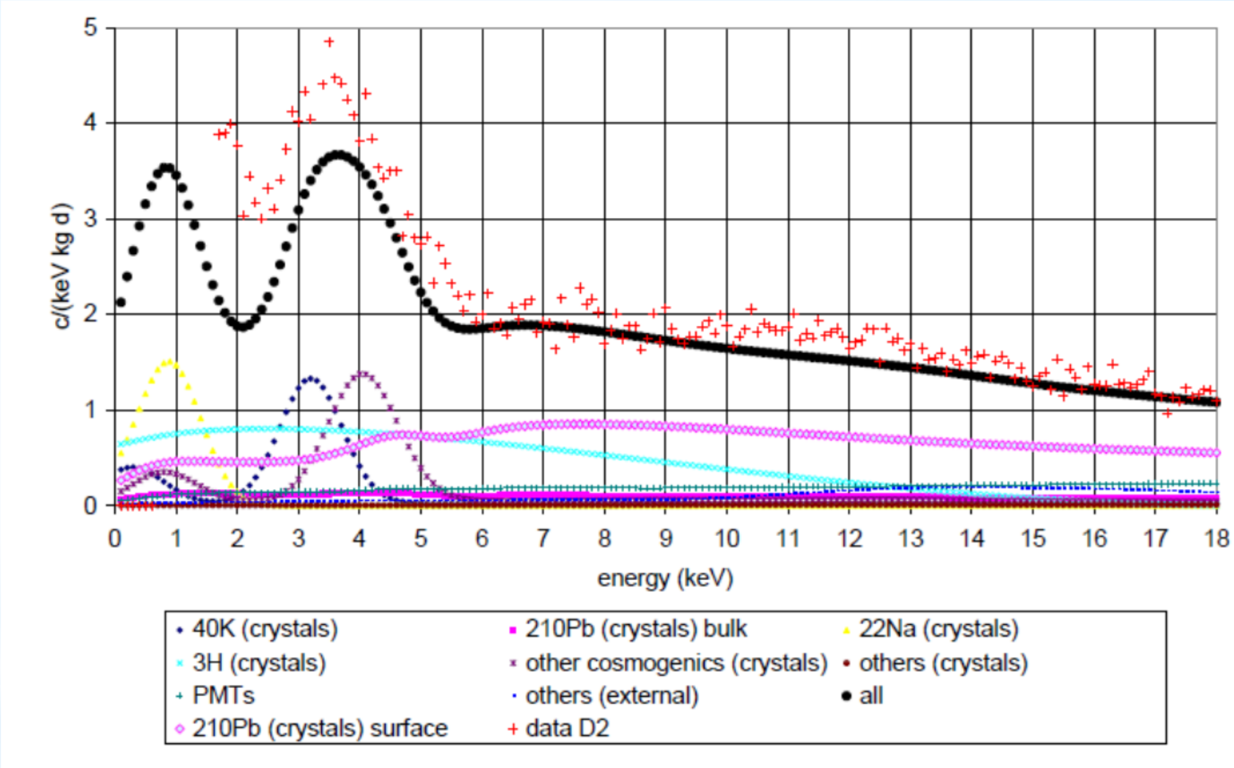
CRYSTAL

- 0.7 mBq/kg ^{210}Pb
- 0.65 mBq/kg ^{40}K
- 0.09 mBq/kg ^{3}H
- 0.94 mBq/kg ^{129}I
- U/Th chains in the NaI bulk
- Cosmogenic backgrounds

PMTs

Upper bounds on:

- Quartz window
- Silicone pads
- Copper housing
- Residual Radon
- Lead shielding



^{210}Pb bulk + surface

^{210}Pb surface contamination is a serious background contribution

BEST Background Model

Anticoincidence Reduction in 3x3 matrix (ANAIS 112 set-up)

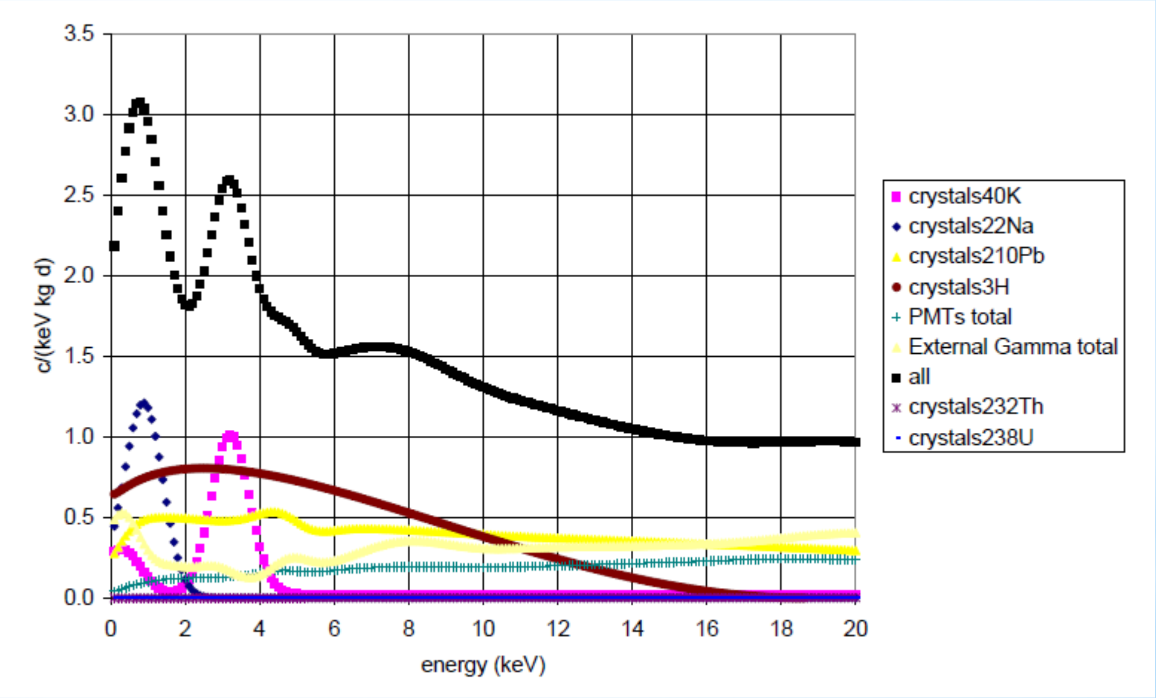
CRYSTAL

- 0.7 mBq/kg ^{210}Pb
- 0.65 mBq/kg ^{40}K
- 0.09 mBq/kg ^{3}H
- 0.94 mBq/kg ^{129}I
- U/Th chains in the NaI bulk
- Cosmogenic backgrounds

PMTs

Upper bounds on:

- Quartz window
- Silicone pads
- Copper housing
- Residual Radon
- Lead shielding



^{210}Pb bulk

Tritium would become very relevant contamination ->exposure to cosmics should be avoided

ANAIS experimental planning

AS is using a **shelter for cosmic rays** that should reduce the activation of the crystals while being at Colorado, but it is small, only a few modules can be stored simultaneously

ANAIS experimental planning

^{210}Pb issue is **UNDER STUDY** in collaboration with AS.

The 1kg samples will continue being measured to understand the evolution of the rate and, if possible, trace back the contamination origin

We are discussing with AS possible surface etching or polishing treatment to be applied to this 1 kg pieces of NaI(Tl) in order to redo the alpha measurement at LSC

This could be done in about one month.

ANAIS experimental planning

Building of D4, D5, and D6 modules (ordered already in 2015) is in pause.

The crystals are already grown, but the modules have not been assembled. In the case the contamination could be removed from the surface, the reception of this three modules at LSC could suffer from only a few weeks' delay.

MULTIDARK project, funding these three crystals, has been extended till June 2017

ANAIS experimental planning

We are finishing the estimate of the potassium content of the crystal D3 to decide if we return it back to Colorado for an upgrading of the detector (still to be discussed with AS) or the background in the Region of Interest could allow fulfilling the ANAIS background goals.

Reduction of potassium content would improve really the background below 6 keV, and if it is confirmed, a re-analysis of the limits allowed for other contaminants should be carried out. We need at least one month more of data to confirm potassium level in D3.

ANAIS experimental planning

Since the last committee meeting, the Spanish call for research projects was open.

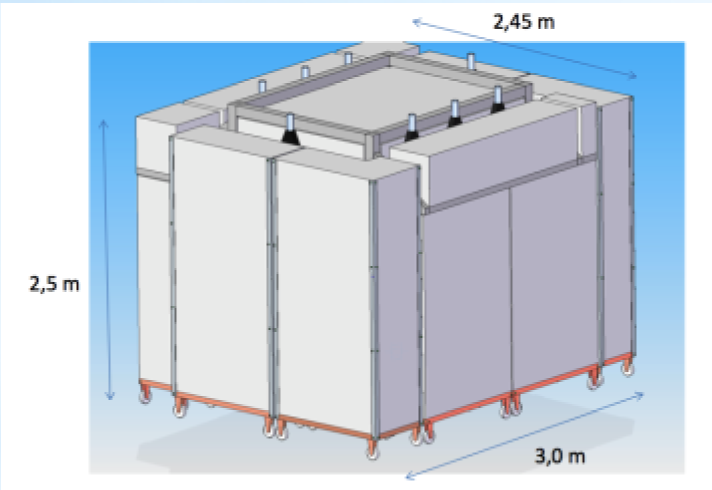
ANAIS included in his application the funds to design and install a LSV system for ANAIS.

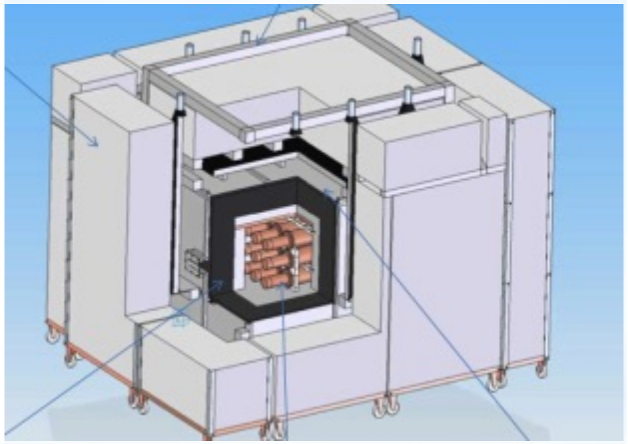
We have also included in this application funding to carry out measurements of the Relative Efficiency Factor for scintillation in AS crystals in collaboration with P.S. Barbeau (Duke University).

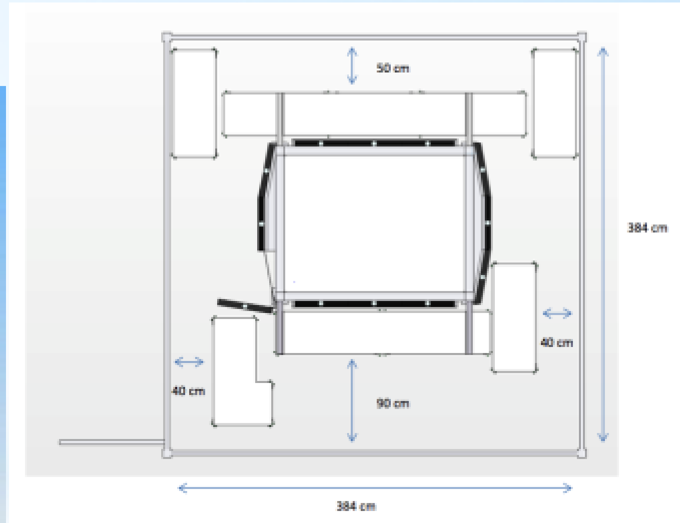
This call should be resolved in the second half of 2016.

ANAIS experimental planning.

The building of the **Radon-free box and neutron shielding** is ongoing.



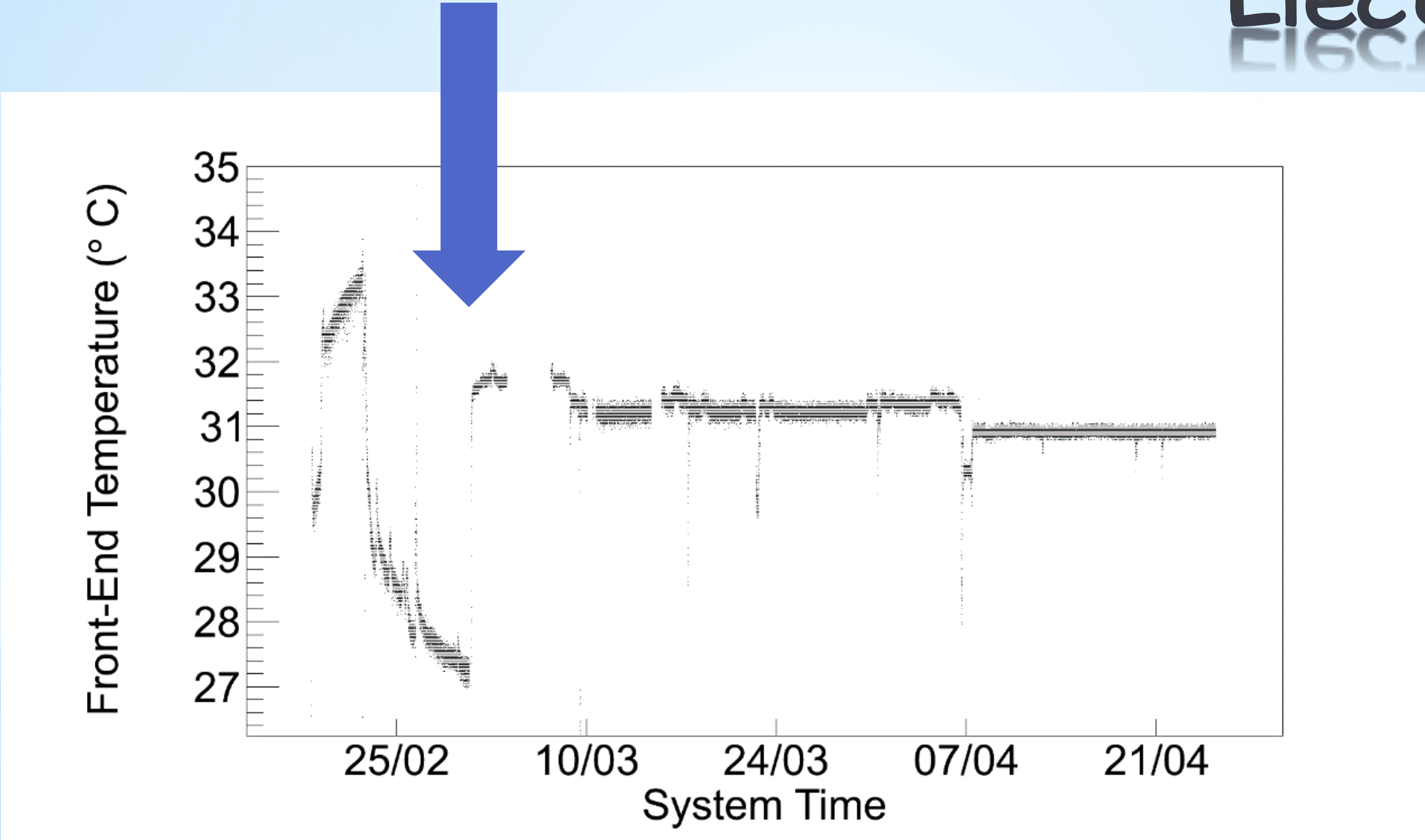




New Temperature Control @ ANAIS Electronics

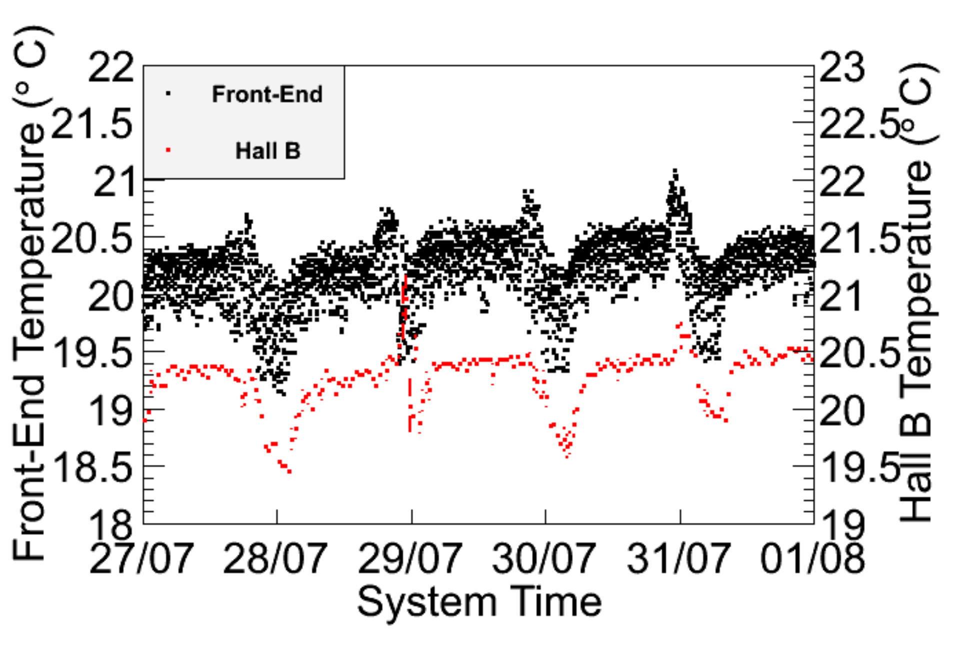
Conditioned Room behind ANAIS hut for ANAIS Electronics

New Temperature Control @ ANAIS Electronics



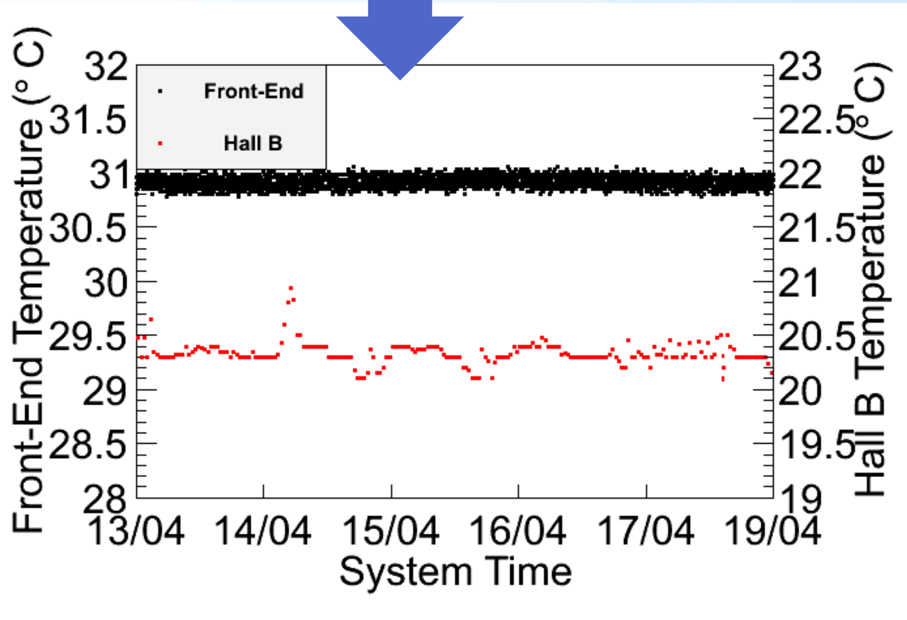
Temperature at ANAIS electronics is not following the Hall B temperature fluctuations

New Temperature Control @ ANAIS Electronics



BEFORE

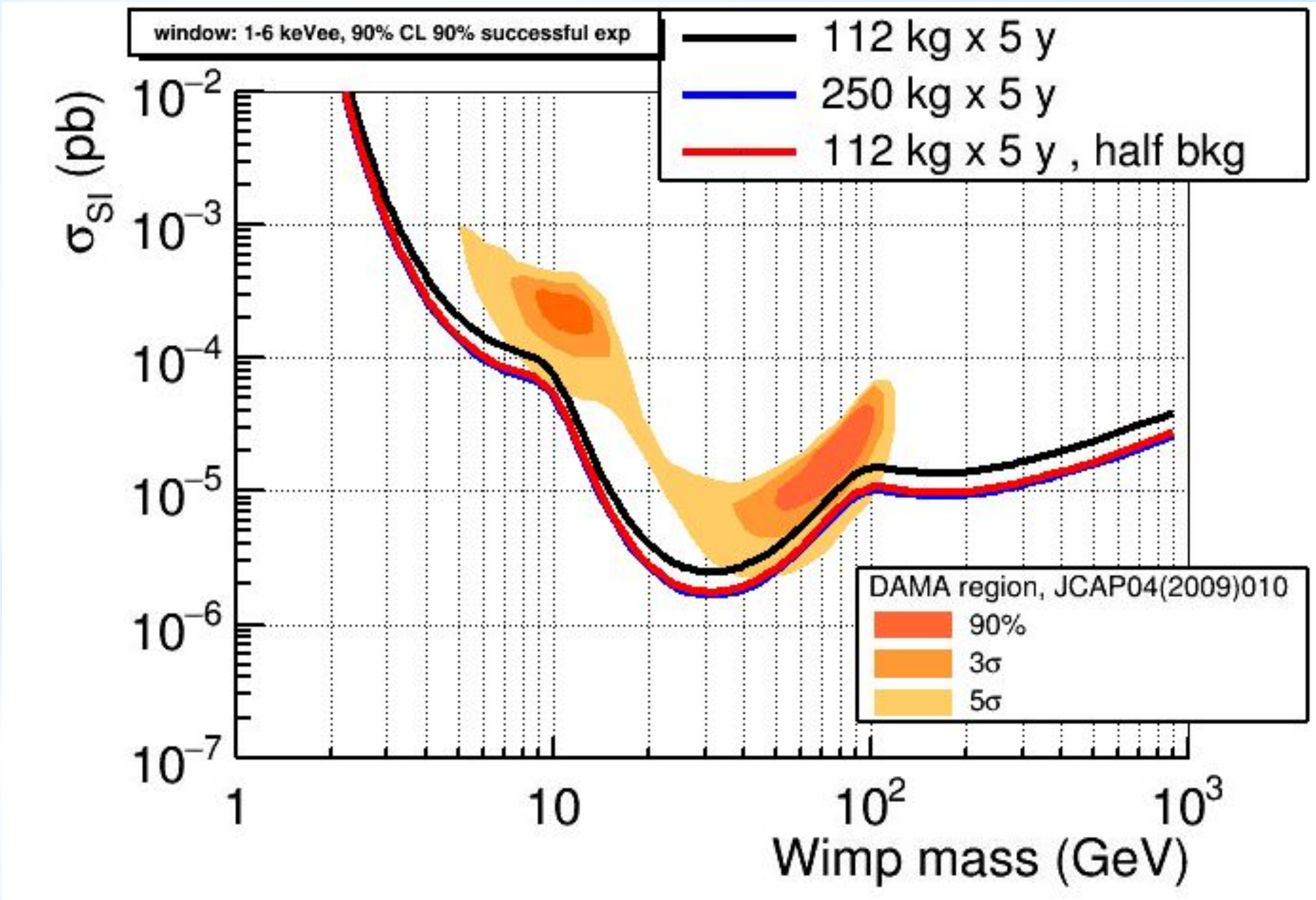
AFTER



Temperature at ANAIS electronics is not following the Hall B temperature fluctuations

ANAIS SENSITIVITY PROSPECTS

- **1-6 keVee region / 5 years**
- **90% C.L. signal in 90% of the carried out experiments**
  (Following S. Cebrián et al., Astroparticle Physics 14, 2001, 339)
- **D2 present background level**

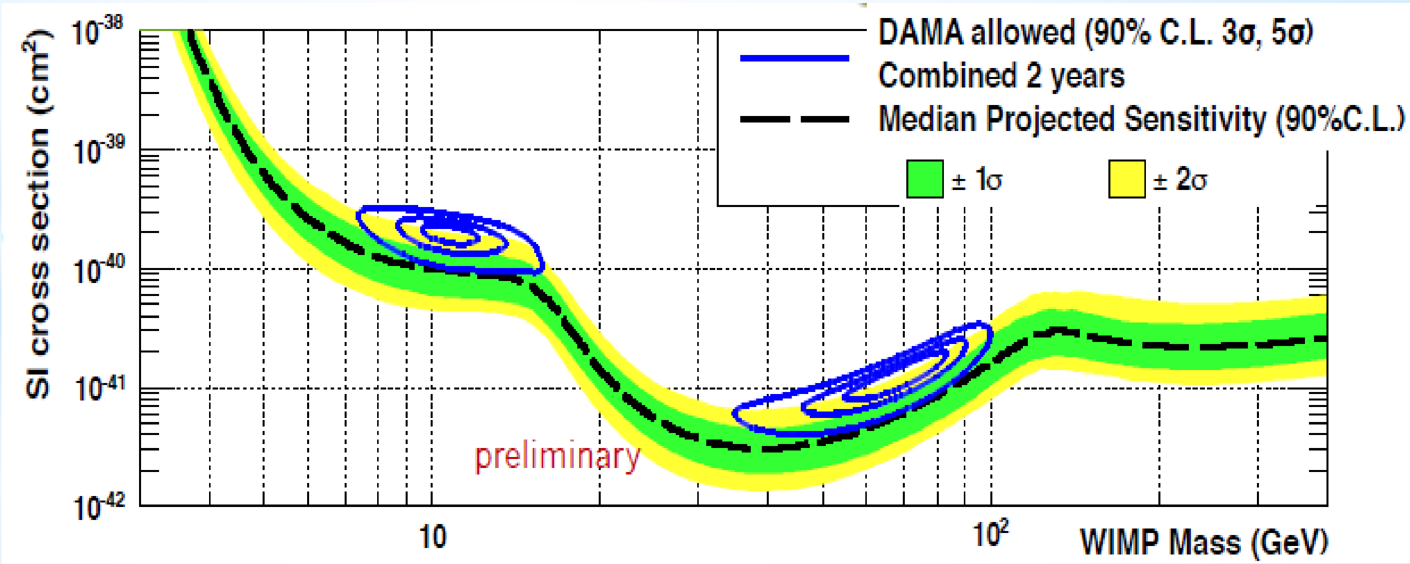


International contacts

JOINT DATA ANALYSIS among **KIMS, DM-Ice and ANAIS** has been discussed

DM-Ice crystals will be installed at Yang-Yang laboratory, together with those of KIMS, amounting to 107 kg, along 2016.

Added to the 112.5 kg from ANAIS at LSC, a total mass of 220 kg would be available, allowing for a better sensitivity for the annual modulation



SUMMARY

- ANAIS experimental schedule:
  - 112.5 kg (3×3 crystal matrix) of NaI taking data along 2016 (not by June)
  - Shielding, electronic front-end, DAQ and software, slow control ready for the full experiment

- Good quality NaI detectors from Alpha Spectra in terms of light collection, but background problems remain:
  - Outstanding light collection improving energy resolution and triggering at or even below 1 keVee, still working on acceptance efficiencies to confirm 1 keVee threshold
  - **Potassium seems to have been reduced significantly in WIMPScint-III** powder, **but ^{210}Pb contaminations are not under control by AS**
  - Additional 5 modules (funded by LSC and MultiDark) are waiting to be mounted till solving ^{210}Pb issue