Measurement of the ^{115}In decay with ACCESS: preliminary results and perspectives

GRAN SASSO SCIENCE INSTITUTE
SCHOOL OF ADVANCED STUDIES
Scuola Universitaria Superiore

INFN LNGS

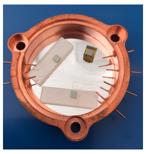
ACCESS (Array of Cryogenic Calorimeters to Evaluate Spectral Shapes)

The ACCESS project aims to establish a novel technique to perform **precision measurements of forbidden β-decays**, which can serve as an important benchmark for **nuclear physics calculations** and represent a significant **background in astroparticle physics experiments**. ACCESS will operate a pilot array of cryogenic calorimeters based on natural and doped crystals containing β-emitting radionuclides. In this way, **natural (^{113}Cd and ^{115}In) and synthetic isotopes (^{99}Tc)** will be simultaneously measured with a common experimental technique. The array will also include further crystals optimised to **disentangle the different background sources**, thus reducing the systematic uncertainty. Here we present an overview of the ACCESS research program, and the preliminary results of ^{115}In.

Overview

Array of cryogenic calorimeters:

- Natural Crystals
  - In_2O_3, InI and ⇒ ^{115}In
  - $CdWO_4$ ⇒ ^{113}Cd
  - $PbWO_4$ ⇒ ^{210}Pb/^{210}Bi
- Doped Crystals
  - TeO_2:^{99}Tc
  - TeO_2:^{151}Sm
  - TeO_2:^{210}Pb
- Undoped Crystals
  - Background assessment



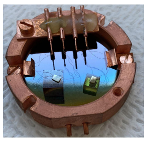


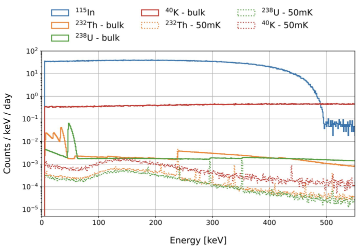
Table 1 List of the isotopes whose β-decay could be measured using the carrier crystal approach proposed by ACCESS (in bold) or natural crystals

Physics case	Isotope	Q_β (keV)	Half-life (year)	Natural abundance or target doping
Nuclear physics	^{99}**Tc**	293.8	2.11×10^5	0.25 ppb
	^{113}Cd	316	7.70×10^{15}	13.47%
	^{115}In	496	4.41×10^{14}	95.7%
	^{90}**Sr**	545.9	28.8	30 ppq
Background in ν-physics and dark matter search	^{39}**Ar**	565	269	0.15 ppt
	^{42}**Ar**	599	32.9	20 ppq
	^{210}Bi	1161.2	0.014	^{238}U decay chain
Cosmic neutrino background detection	^{151}**Sm**	76.4	94.7	0.20 ppt
	^{210}Pb	63.5	22.2	^{238}U decay chain

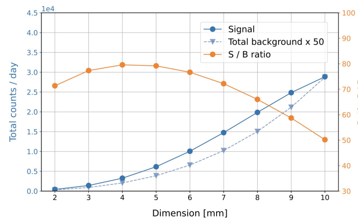
In the rightmost column, we report the isotopic abundance of naturally occurring isotopes, and the target activity of artificial isotopes in doped crystals. ^{210}Pb and ^{210}Bi belong to ^{238}U natural radioactive chain, so that their spectra can be measured with natural $PbWO_4$ exploiting the residual ^{210}Pb contamination

Design study of an InI-based cryogenic calorimeter

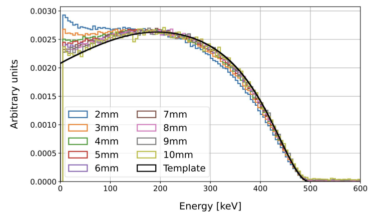
ACCESS HOME
PAPER



Simulated energy spectra of the ^{115}In β-decay (blue), and the different background components for a 7 mm-side InI crystal with NTD readout. As expected, the ^{115}In β-decay is two orders of magnitude higher with respect to the limit on the ^{40}K background (solid red)

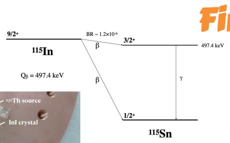


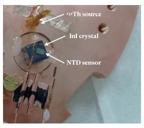
Signal rate (blue solid line), limit on background rate (blue-dashed line), and signal-to-background ratio (orange solid line) as a function of the absorber side.



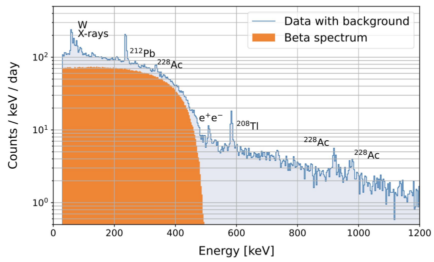
Simulated energy spectra of the ^{115}In β-decay for different dimensions of the absorber (assuming s-NME = 2.0 and gA = 0.9, left). The larger is the crystal the lower is the difference between the template spectrum (black) and the simulated one.

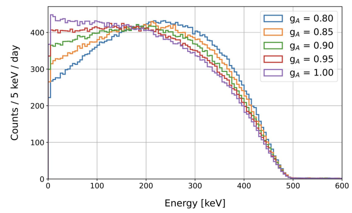
First measurement





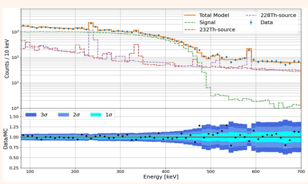
- 7×7×7 cm^3 (1.9 g) indium iodine crystal
- Equipped with a 3×3×1 mm^3 NTD
- Livetime of 300 h
- Permanent ^{232}Th calibration source
- Energy threshold of 17 keV
- Energy resolution of 3.1 keV FWHM at 60 keV



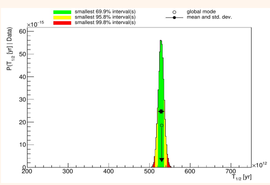


The simulation for the 7 mm side crystal is repeated for five different values of g_A around the chosen reference value).

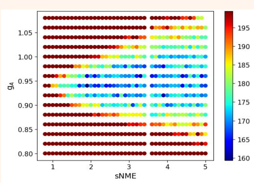
Measurement of the ^{115}In β-decay with a InI-based cryogenic calorimeter



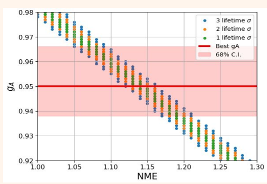
Experimental data and bayesian fit results



Posterior of the ^{115}In half-life



χ^2 value in the g_A/sNME plan



Comparison of the fit result with the theoretical $T_{1/2}$

PRELIMINARY

Best fit results (shell model):

- $T_{1/2} = (5.32 \pm 0.06) \times 10^{14}$ yr
- $g_A = 0.950 \pm 0.016$
- sNME = 2.2 ± 0.5 (FIT)
- sNME = 1.1 - 1.2 (from theoretical $T_{1/2}$ comparison)

TAUP VIENNA 2023

GSSI OPENINGS

Lorenzo Pagnanini & Stefano Ghislandi
on behalf of the ACCESS collaboration

MARIE CURIE ACTIONS