Characterization of the DTAS detector and first measurements

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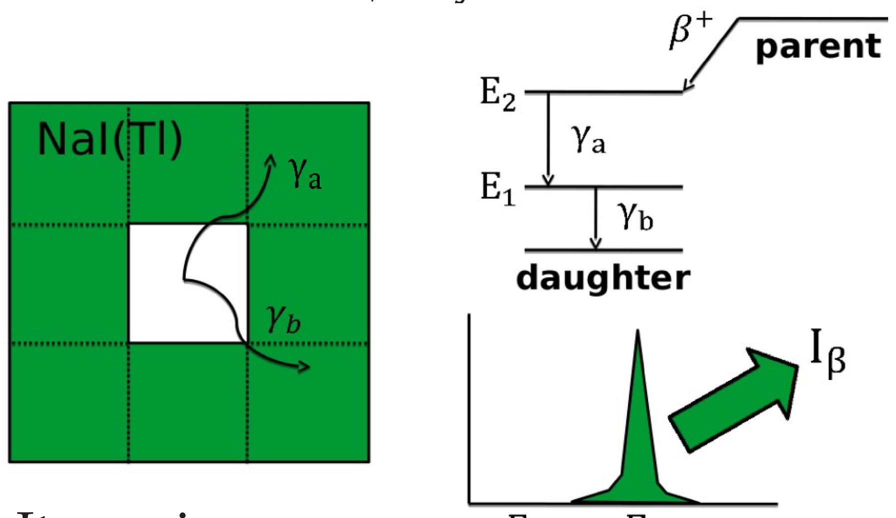
1-TAS technique

- It consists of:

Absorbing the **entire** γ**-cascades** de-exciting the daughter nucleus after the β-decay rather than the individual γ-rays.



- It requires:

Large scintillator crystals covering a solid angle of $\sim 4\pi$ in order to maximize the γ-ray detection **efficiency**.

In order to determine the β**-intensity distribution** from an experimental spectrum, an inverse problem has to be solved [1],[2]:

$$d_i = \sum_j R_{ij} f_j$$

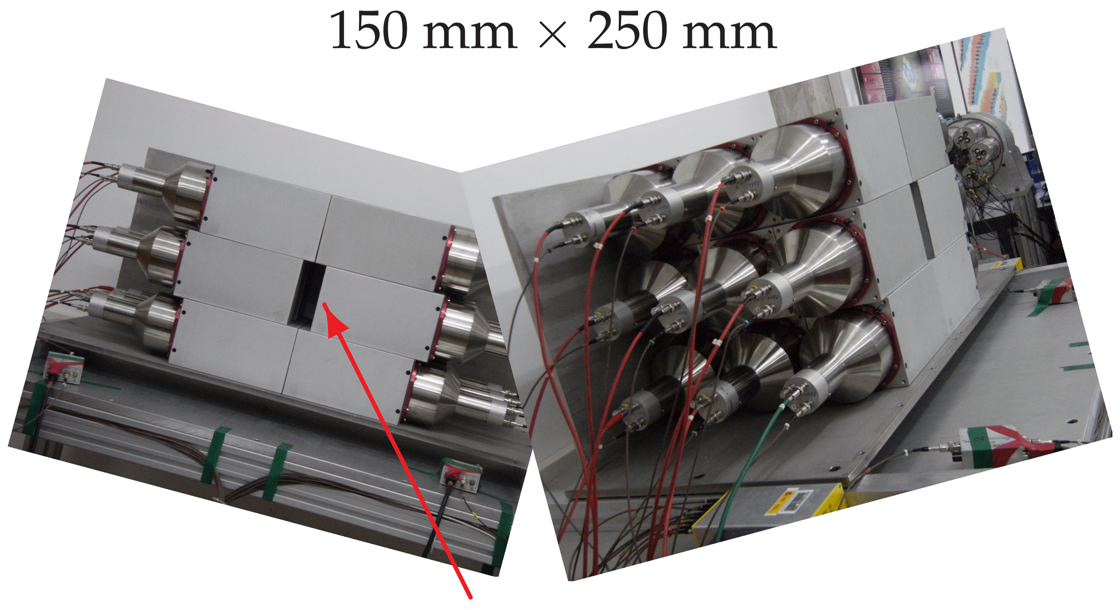
d_i: no. counts in the channel i.
f_j: no. events that fed level j in the daughter.
R_{ij}: response function of the detector.

The **response function** represents the probability that feeding to the level j gives a count in the channel i of the spectrum.

2-The DTAS detector

A **new** segmented **D**ecay **T**otal **A**bsorption Gamma-Ray **S**pectrometer (DTAS) has been developed for the Decay SPECtroscopy (DESPEC) experiment at FAIR [3].

18 rectangular NaI(Tl) crystals of 150 mm × 150 mm × 250 mm



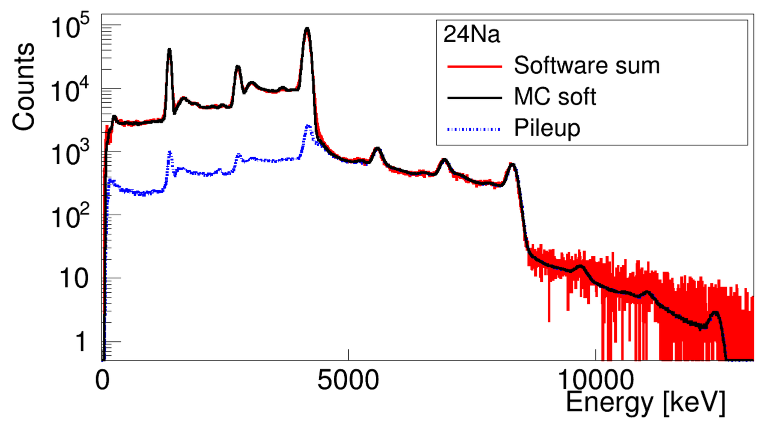
Beam pipe and ancillary detectors

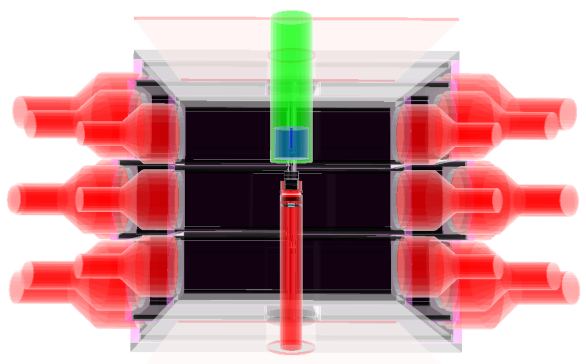
Composition, design and optimal dimensions were chosen with:

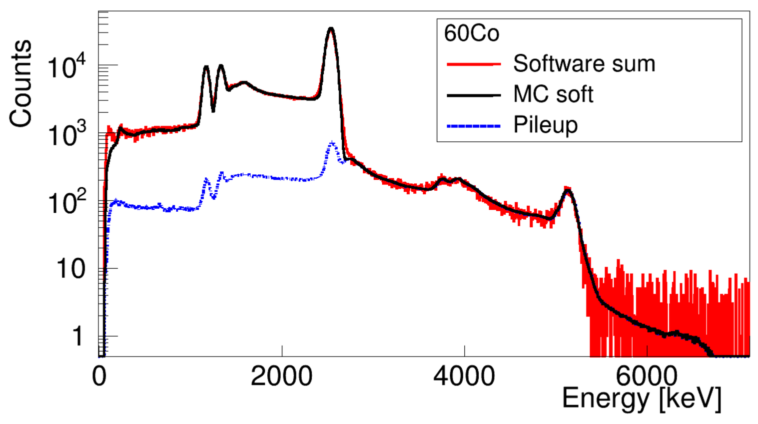
MC simulations + prototypes [4]

3-Characterization

The response function is unique to each detector and each decay scheme → it has to be calculated via MC codes (Geant4 [5]), with the geometry and the physics involved in the detection process. This response in tested by **comparing with calibration sources**:

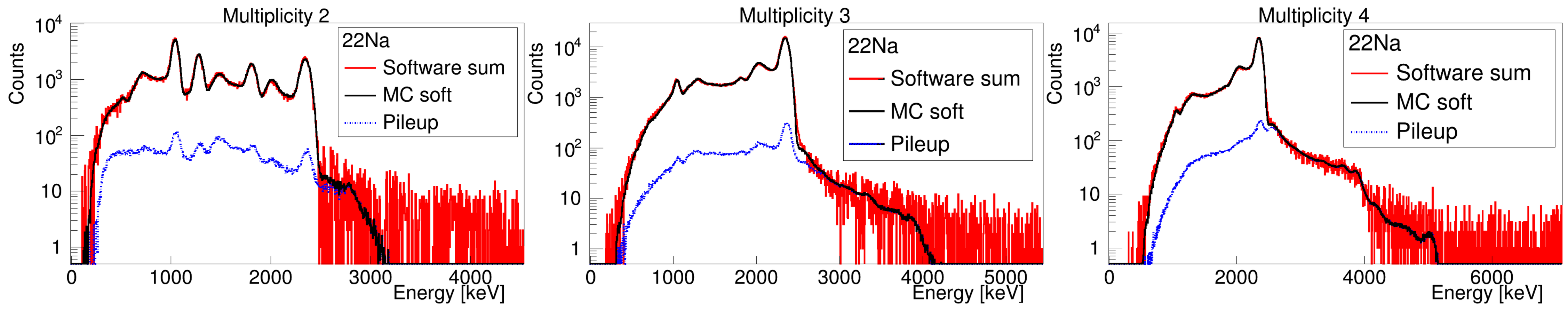






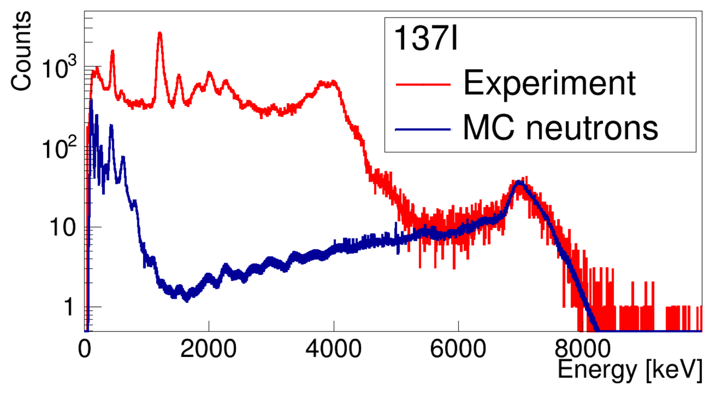
The electronic **pileup** must also be taken into account to reproduce properly the experimental spectra [6]. A **new** method has been developed based on the random superposition of events.

Segmentation can be useful to study different multiplicities:



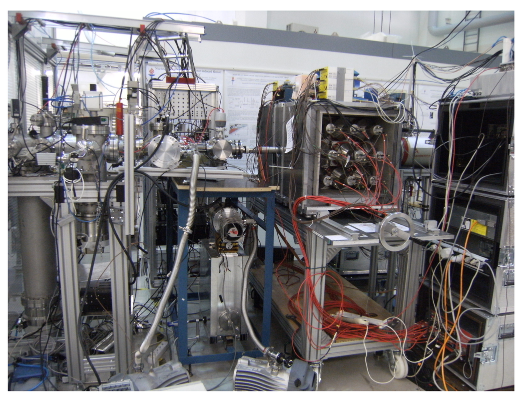
MC simulations of β-delayed **neutron capture** and inelastic interactions in NaI [7] gives:

- A high energy peak for the calibration
- An important background for β-delay neutron emitters

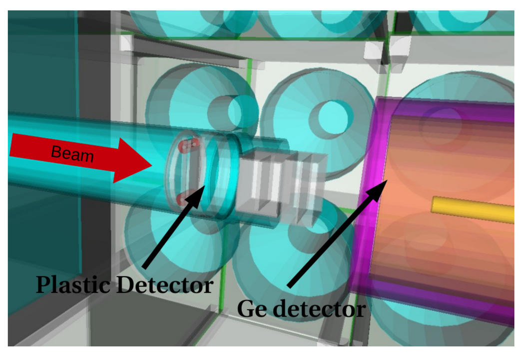


4-First experiments (JYFL)

Around a dozen ^{235}U fission products of interest in **neutrino physics** and **reactor technology** were measured in 2014 at the upgraded IGISOL IV (Jyväskylä, Finland) [8].



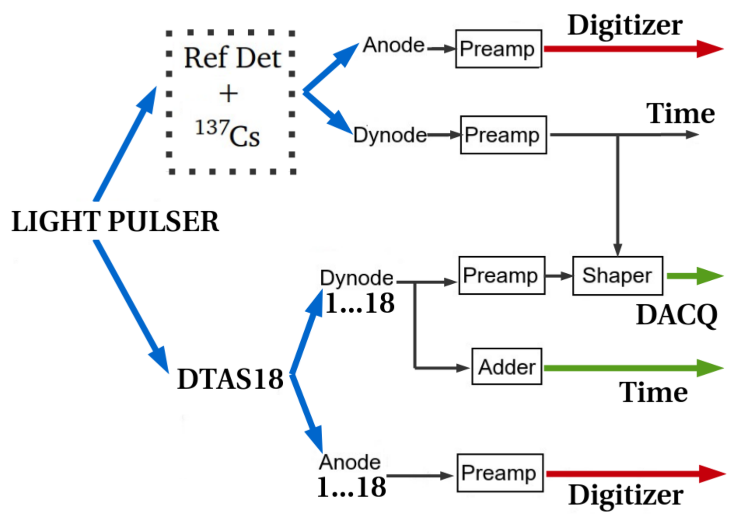
The Penning trap was used to clean the beams produced by IGISOL.



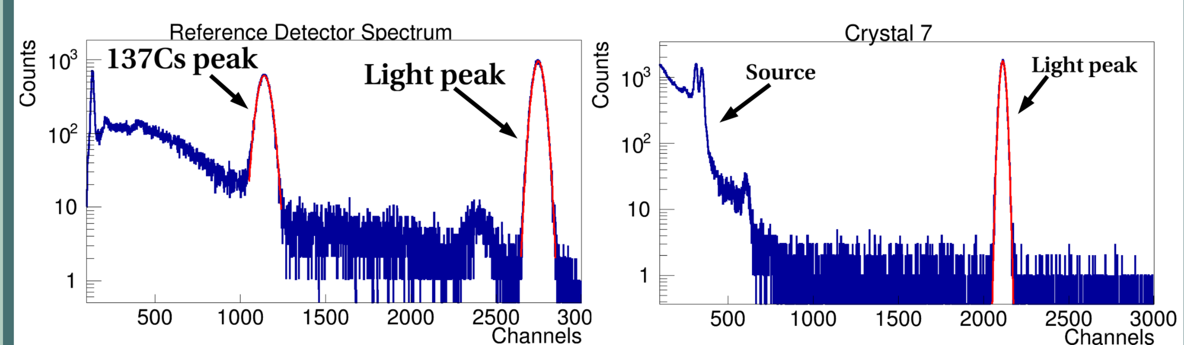
The nuclei were implanted on a tape placed in vacuum at the centre of the DTAS and in front of a plastic beta detector.

5-Gain correction system

▶ **Objective:** correct off-line possible gain changes of the PMTS.



▶ **How?** light pulser (6010 BNC 490nm) + bundle of optical fibers connected to each NaI crystal and to an external reference NaI(Tl) Well detector + ^{137}Cs weak source.



A gain correction is calculated for each detector module every ~ 250 s.

References

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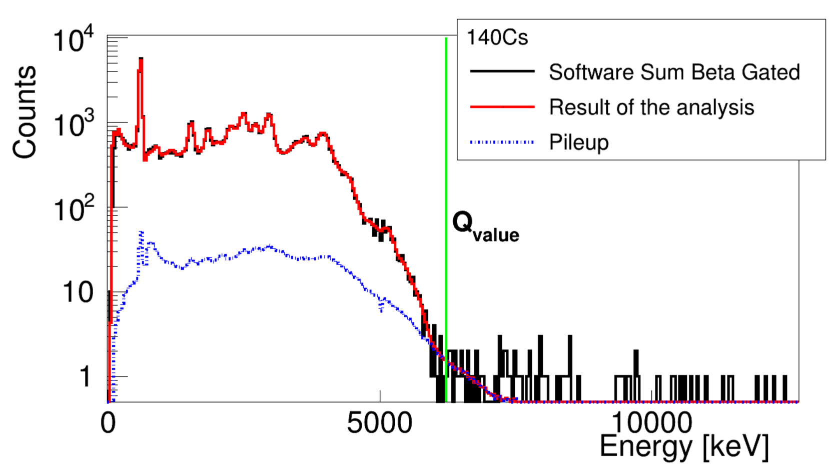
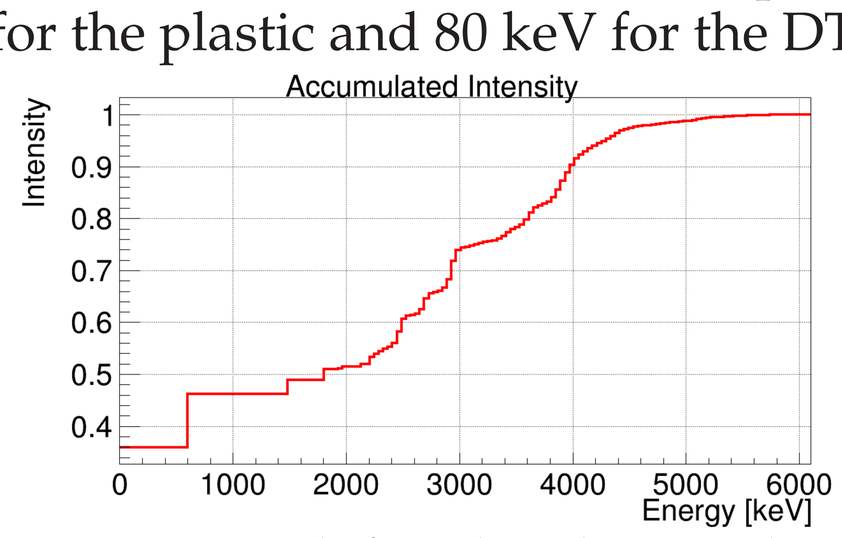
6-First analysis

The software sum of the 18-crystal was reconstructed off-line and β-γ **coincidences** were required to obtain a clean spectrum. The timing coincidence between DTAS and plastic was done with signals above the threshold (around 60 keV for the plastic and 80 keV for the DTAS).





An **Expectation-Maximisation (EM)** algorithm was used for the deconvolution of the β-intensity distribution [1].