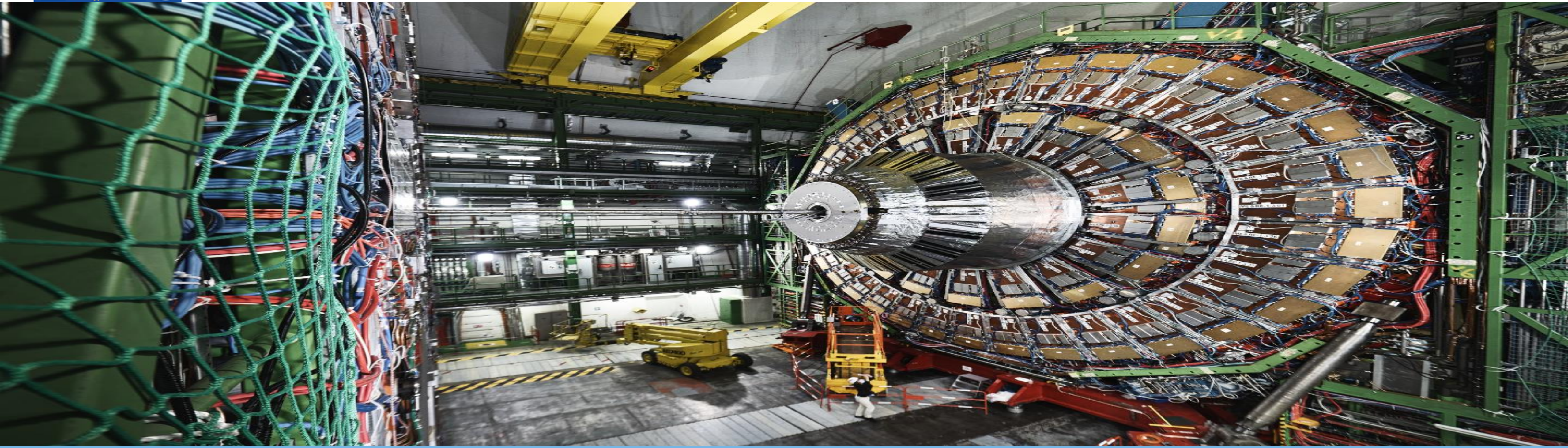


JRA8 – ASTRA Advanced ultra-fast solid STate detectors for high precision RAdiation spectroscopy

Johann Zmeskal, SMI

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

JRA8 / WP26 Objectives

Development of advanced detector systems, from sensors and read-out electronics, to DAQ and controls, using large-area CdZnTe detectors to perform high precision photon energy measurements in the range from 10-1000 keV.

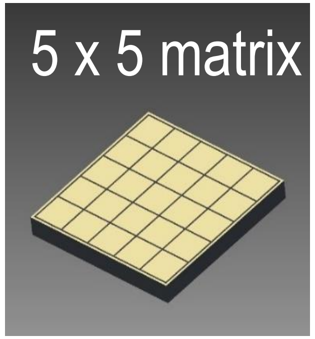
Special focus on

- **Task1:** Low energy detection region - energy range: 10 – 100 keV
- **Task2:** High energy detection region - energy range: 50 – 1000 keV

Aim: Compact modular room temperature detector systems with excellent energy resolution: FWHM ~ 3% at 60keV and 1% at 662keV.

1. Progress made during the year towards the objectives

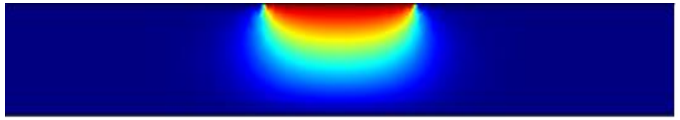
Low energy detector



A possible detector design was simulated consisting of a 5×5 matrix with a pitch of 1.9 mm (1850 μm pixel + 50 μm gap), performed by CNR-IMEM to obtain the best detector performances.

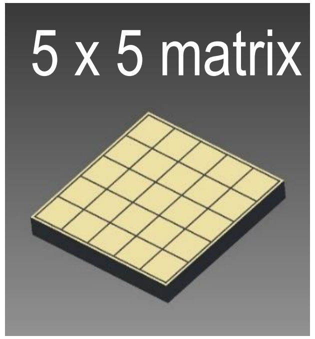
Advantage

- The weighting potential is focused in a small region under the pixel.



- Possible effects due to crystal inhomogeneity can be corrected with dedicated electronics.

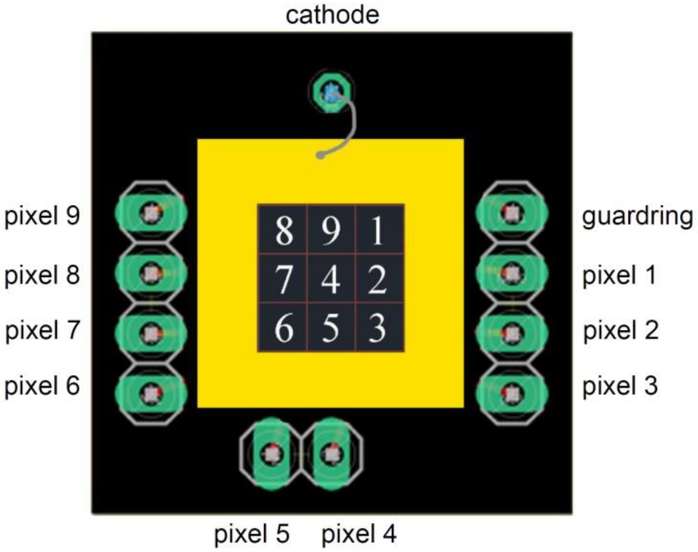
➢ **First low energy detector prototype**



Low energy detector - prototype

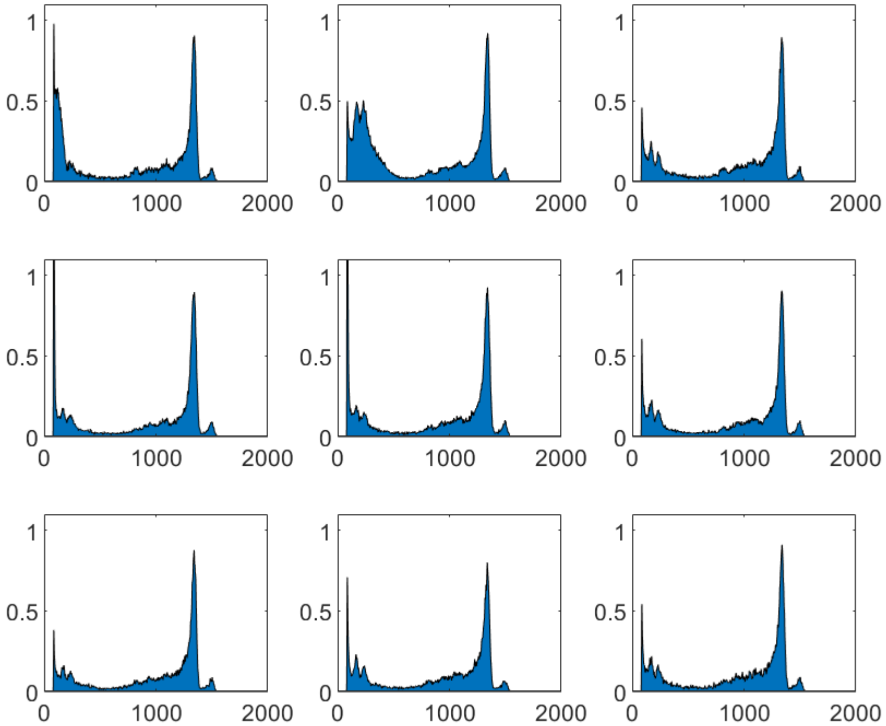
Fabrication:

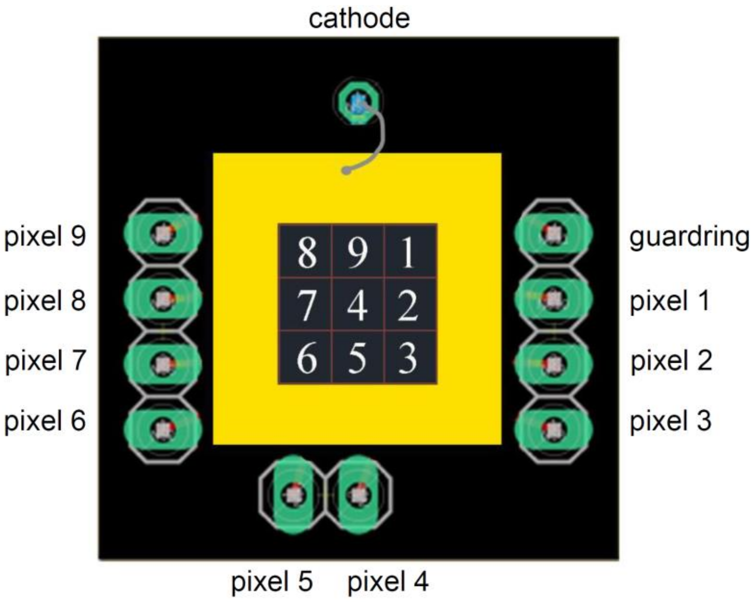
- A 10x10x10 mm^3 Redlen crystal was cut in dimensions of 10x10x1.5 mm^3
- Contact faces were lapped and polished
- Au contacts were deposited using a methanol solution of $AuCl_3$
- Anode pattern was realized using a photolithographic process, etching the gold contacts with Br2
- Pixel sizes are 1.85x1.85 mm^2 with gaps in-between of 50 μm
- The final detector thickness is 1.25 mm
- The CZT was bonded on a dedicated Diclad PCB



Low energy detector - spectroscopy

Spectroscopic performance, with Co57:
of a 3x3 matrix with pixel sizes of 1.85x1.85 mm^2 and a thickness of 1.25 mm





FWHM at 122 keV with Co57

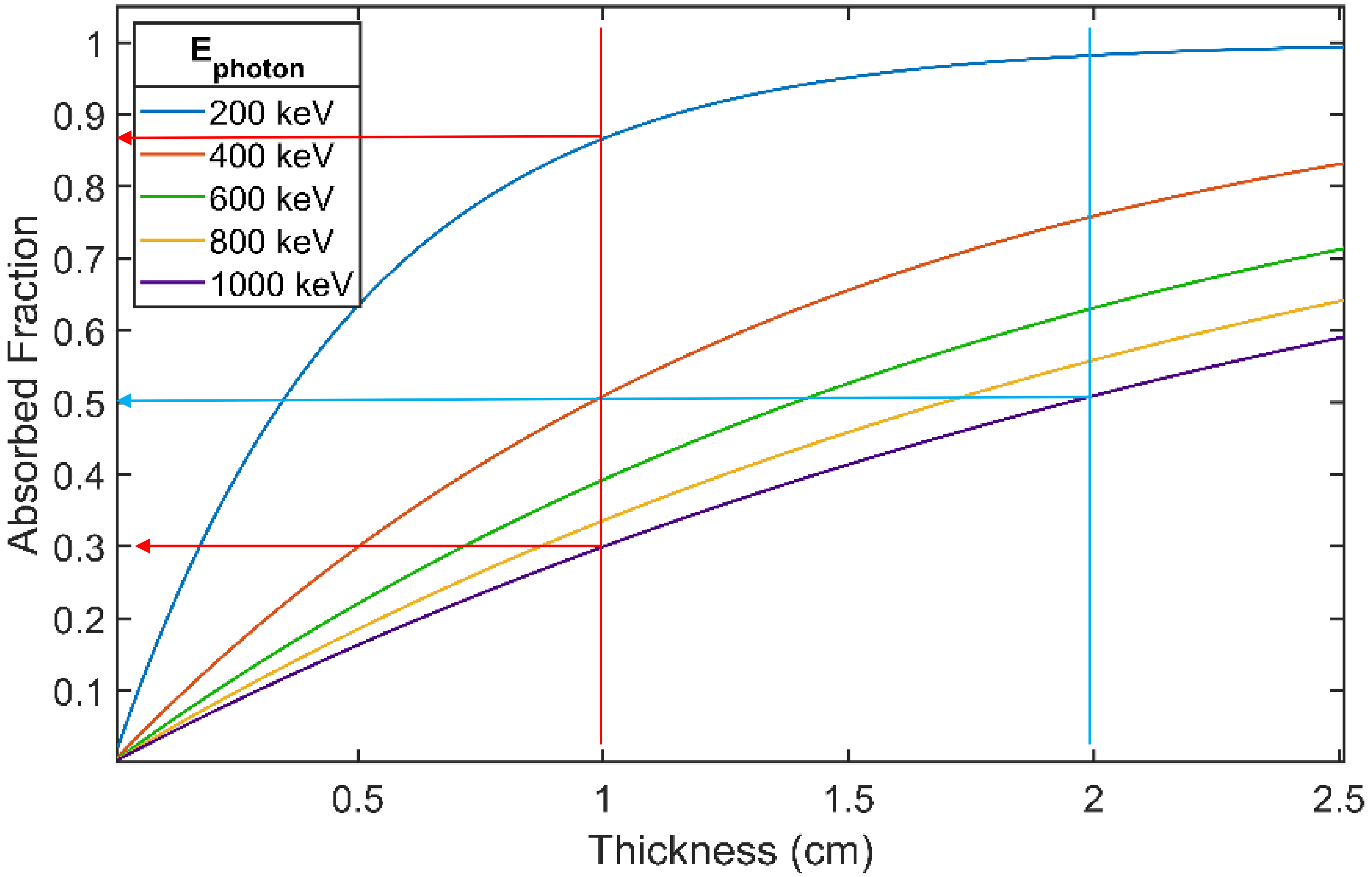
3.6%	3.8%	4.3%
4.2%	4.4%	3.8%
3.6%	4.5%	3.6%

High energy detector

For the high energy detector a complete absorption is not feasible.

The absorbed fraction as a function of the crystal thickness is shown in the figure for photons of different energies.

- ➢ 25 mm can be considered the maximum possible thickness since it represents the state-of-the-art for this class of detector.

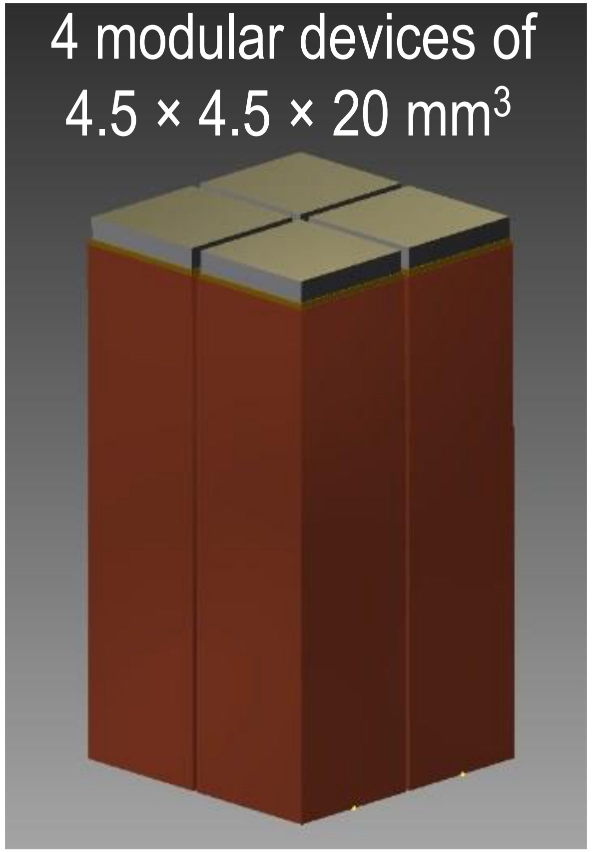


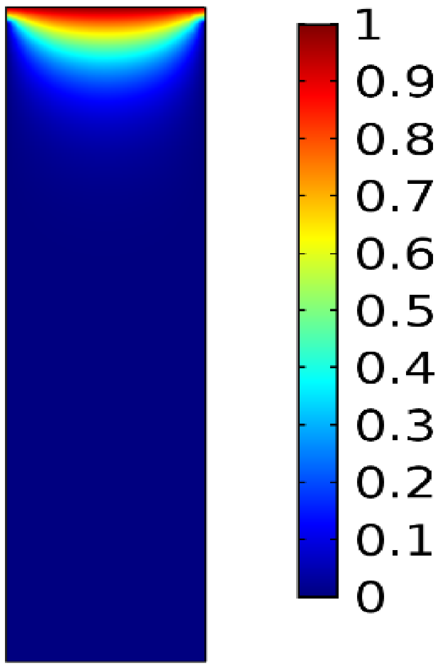
High energy detector - simulation

Frisch-grid configuration

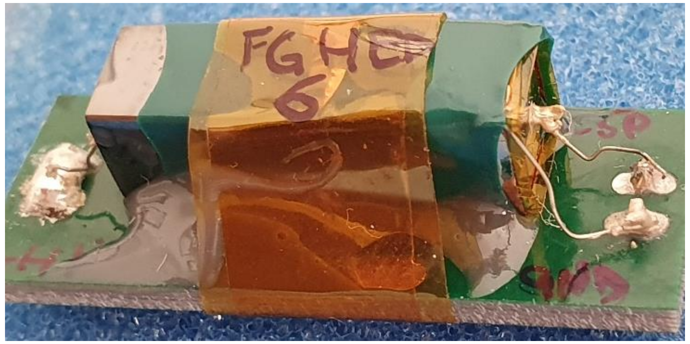
Due to the presence of non-collecting contacts on the lateral surfaces of the crystal, the weighting potential is focused in a small region under the collecting electrode.

The Frisch grid detector has only one collecting electrode, charge sharing is avoided in this type of geometry.



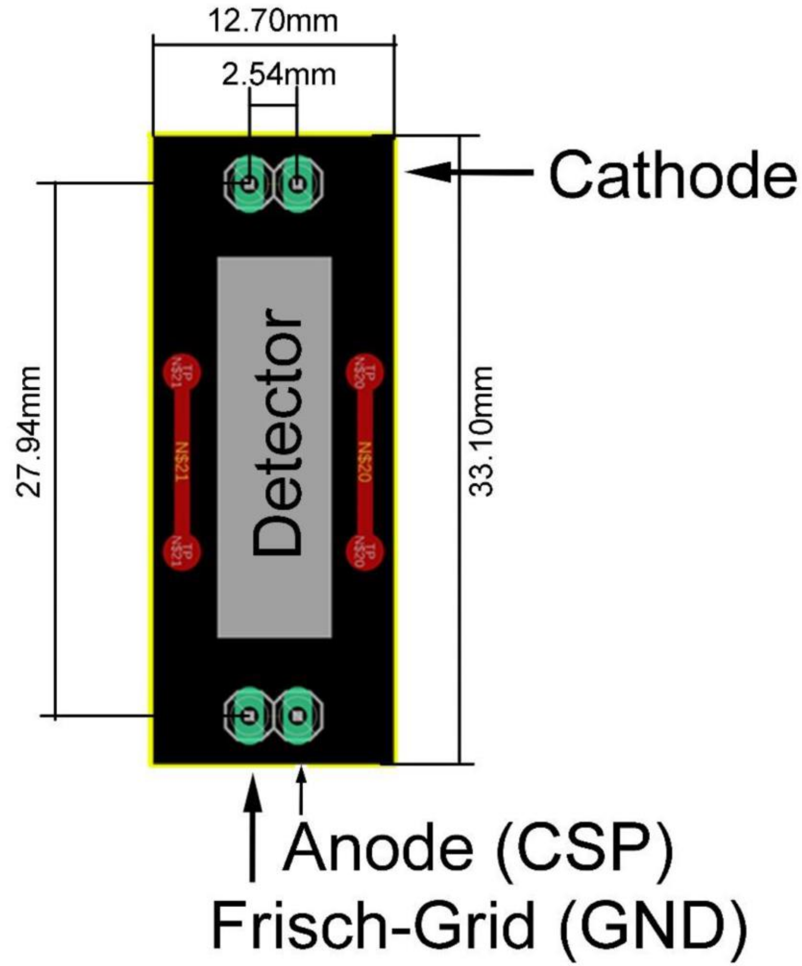


High energy detector - prototype



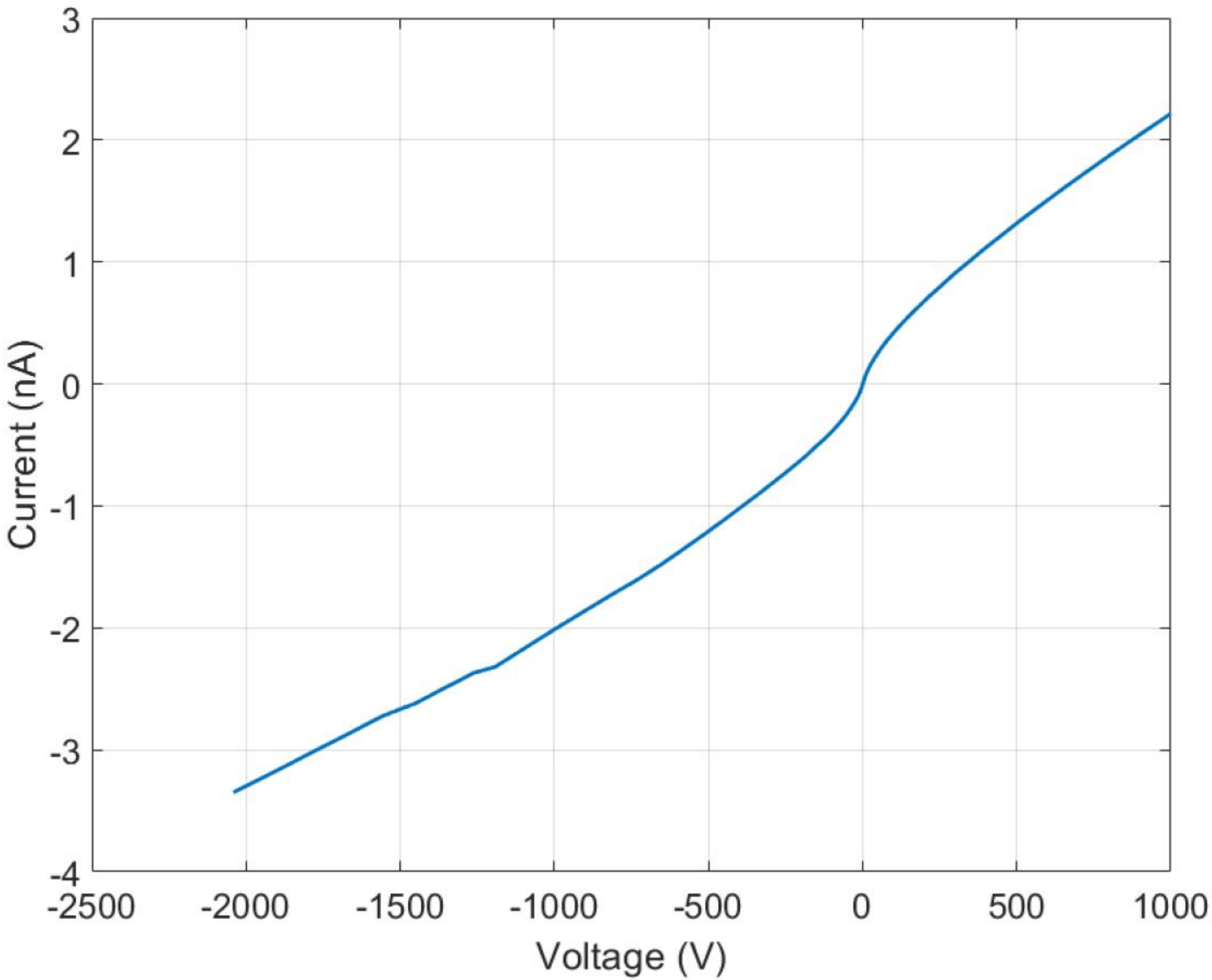
Fabrication:

- A 19.4x19.4x6 mm^3 Redlen crystal was cut in dimensions of 6x6x19.4 mm^3
- Contact faces were lapped and polished
- Au contacts were deposited using a methanol solution of $AuCl_3$
- Lateral surfaces of sample were covered with Kapton foils and, at the anode side, a 5mm Cu tape was coiled around the samples (Frisch-grid).
- The CZT was bonded on a dedicated Diclad PCB

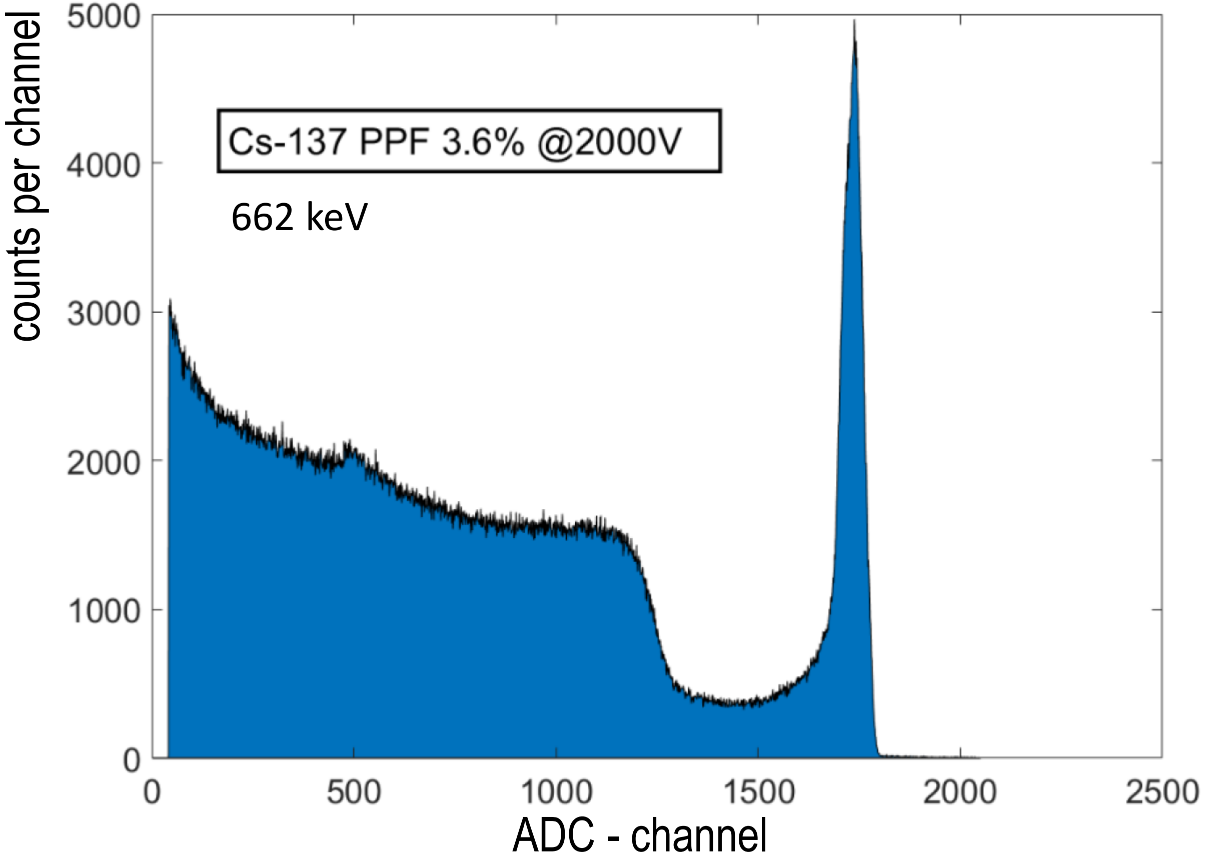


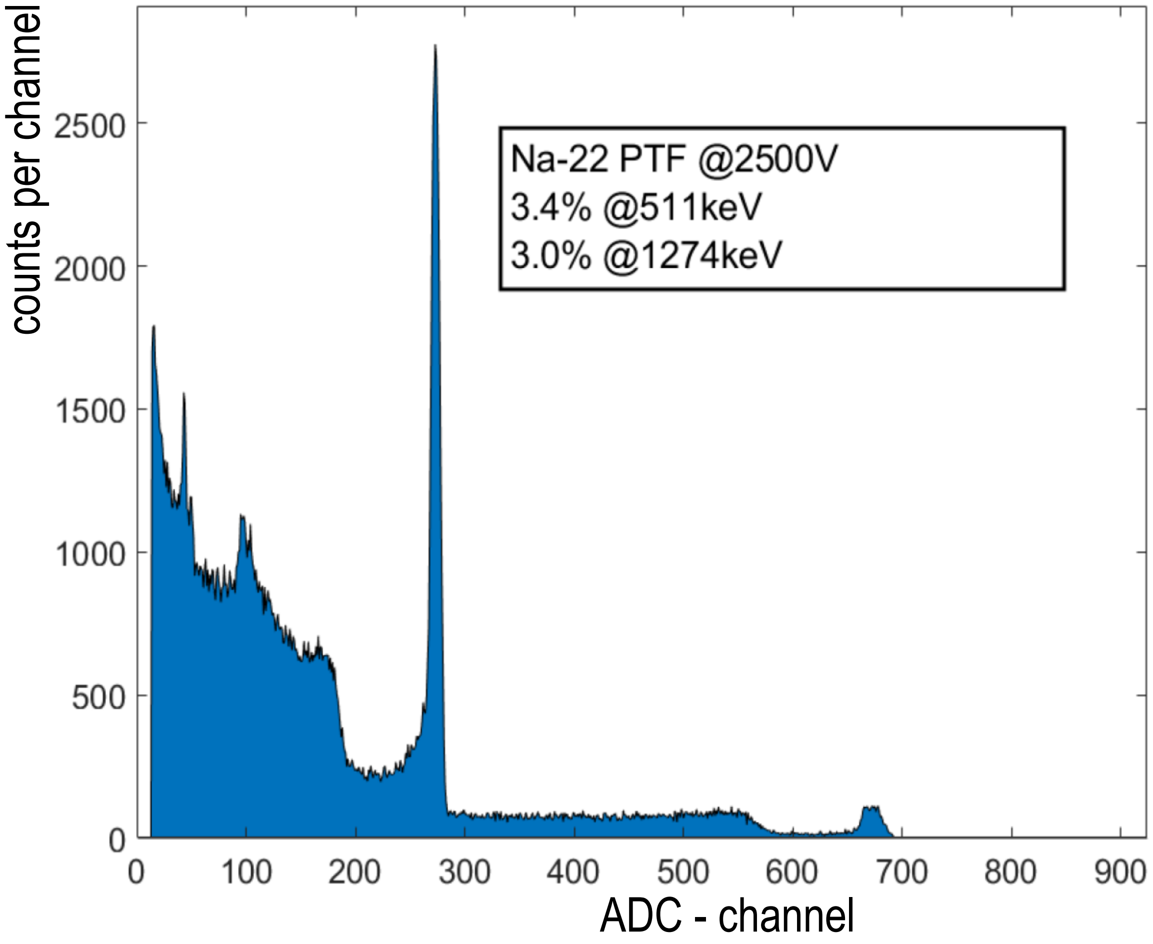
I-V curve

The very low leakage current is remarkable: about 3.2nA at 2000V



High energy detector - spectroscopy





High energy detector - comments

- IV characteristic shows that the leakage current is low also at high bias voltages
- The spectra are already very good considering that measurements were carried out reading only the anode signal and no signal post-processing correction was used.
- The digital readout of both anode and cathode signals and the signal post-processing will strongly improve the spectroscopic performances of the detectors $\rightarrow$ factor 2-3.

2. Deviations from planned objectives and tasks, and their impact on the progress of the Work Package

- Up to now there are only small deviations with respect to the objectives and tasks

3. Deliverables and milestones

no deliverables in the reporting period

Milestones

Milestone number	Milestone name	Lead beneficiary	Delivery month from Annex I	Delivered (yes/no)	Comments
MS57	CdTe* prototype device	2 - OEAW	26	yes	measurement
MS59	CdZnTe prototype device	2 - OEAW	26	yes**	measurement

* Due to improvements in CdZnTe crystal production, also for low energy devices CdZnTe are used

** delivered with two month delay

Summary

- ❑ Despite of the working restrictions caused by Covid19, the ASTRA project is going very well.
- ❑ MS59 could be successfully finished mid of July 2021, while MS57 was roughly two month in delay due to Covid-19.

- ➢ Simulation were performed by CNR-IMEM to obtain best detector performances (Task1 and 2).
- ➢ First **CZT** prototypes are produced (Task1 and 2) tested and characterized at CNR-IMEM and SMI.
  - ➢ Master thesis at SMI was finished spring 2021
  - ➢ Master thesis at SMI started summer 2021

- ➢ Readout electronic with further optimisation on preamplifier and DAQ are ongoing, by POLIMI, LNF, UZ and UJ