USE a:Si-H AS A DETECTION MATERIAL FOR IONIZING RADIATION FOR MEDICAL AND SPACE APPLICATION

# INTERNATIONAL AND INDUSTRIAL PH.D PROGRAM IN PHYSICS

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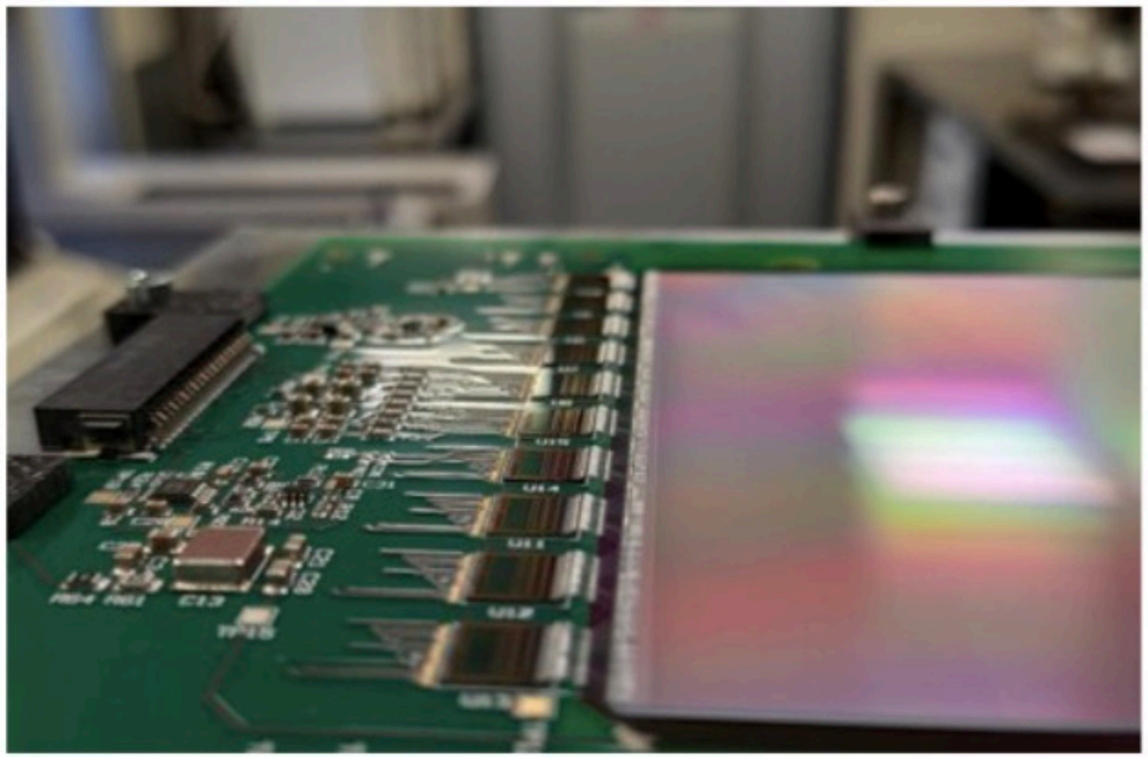
13/12/2021

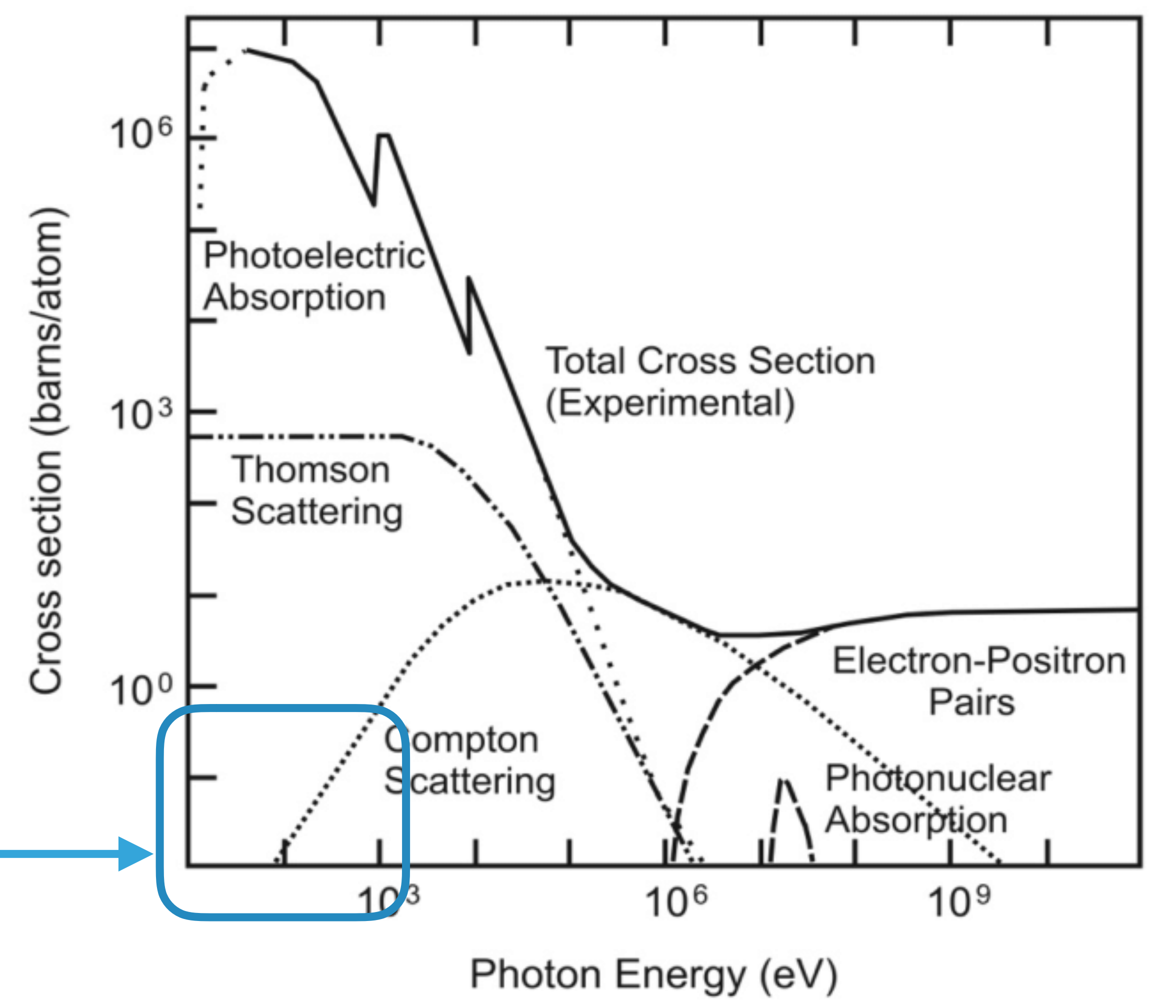
# TEST OF PROTOTYPE SILICON MICRO STRIP DETECTOR FOR THE FOOT EXPERIMENT



During my master's thesis work I investigated a new method for the calibration of silicon micro strip detector which is part of the FOOT tracking system.

I used a monochromatic photon source, as an alternative to standard calibration with charged particles. We chose photons with the right energy to interact via photoelectric effect, to be able to reconstruct all the original signal.

$$^{241}_{95}Am \rightarrow ^{237}_{93}Np + ^{4}_{2}He + \gamma$$



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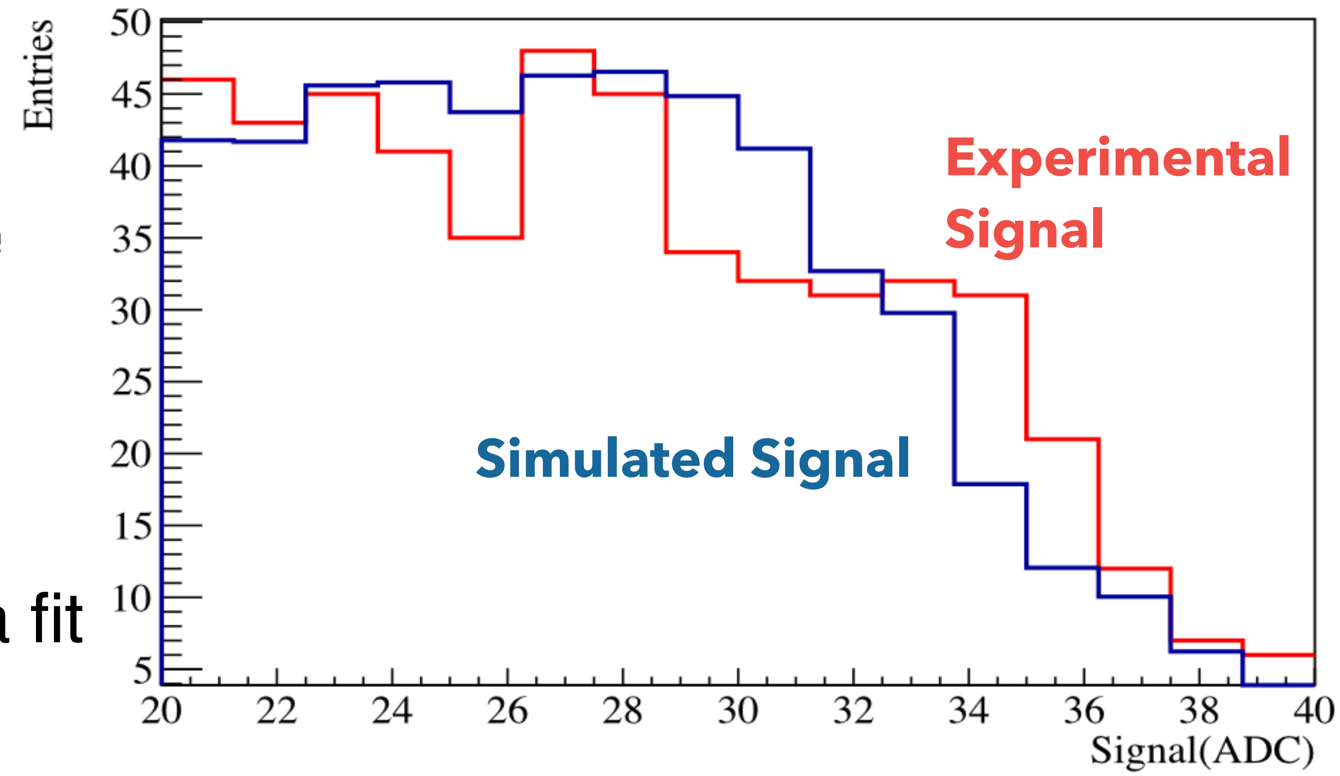
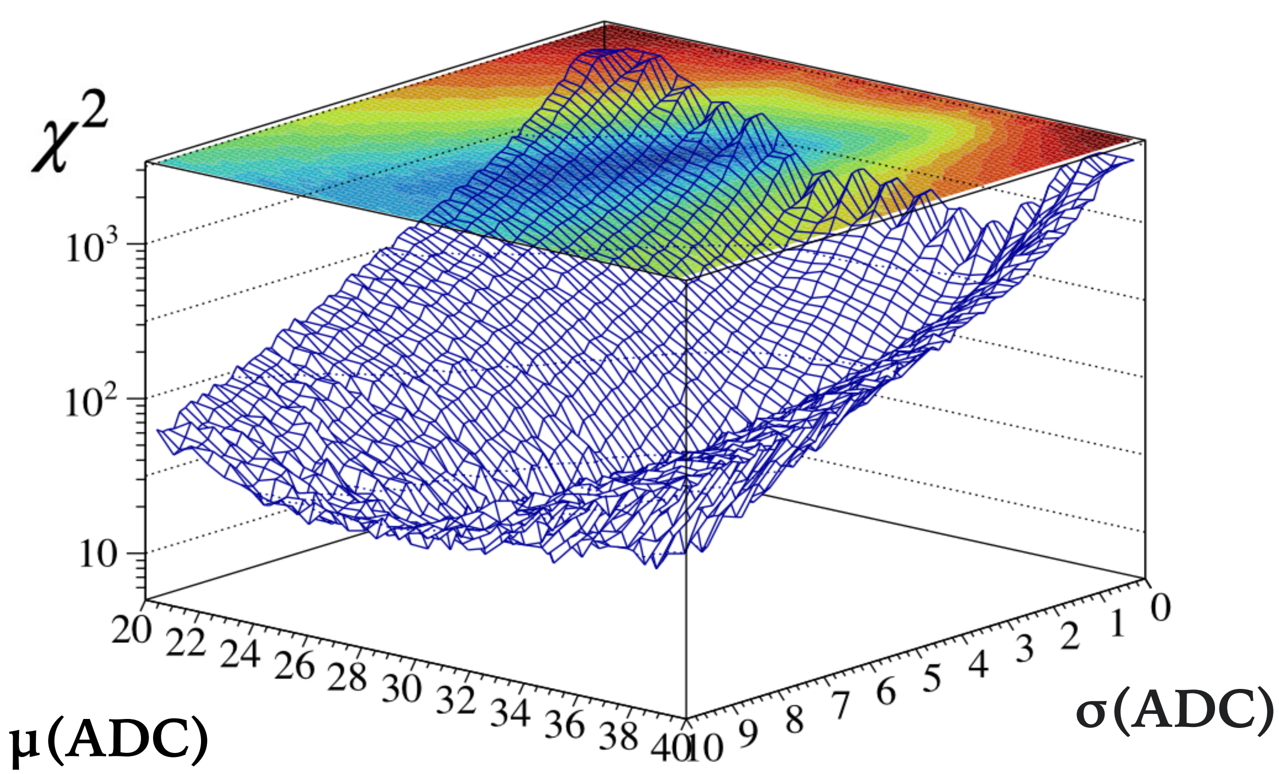
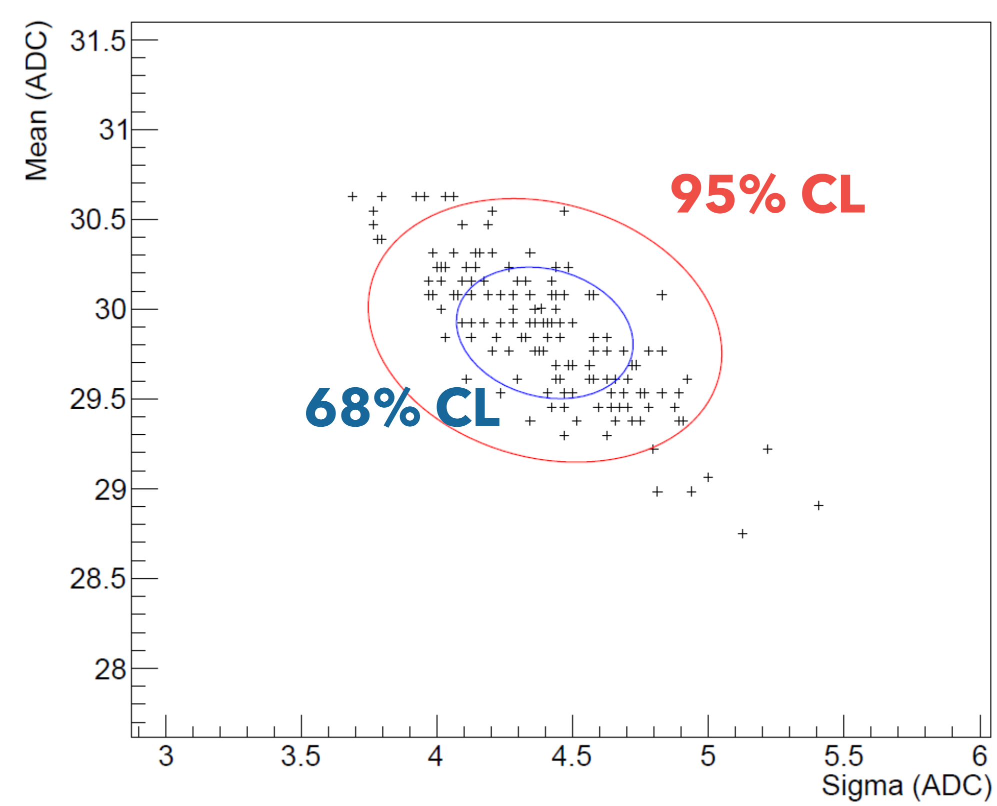
To find signal parameters and a match between counts ADC and keV I used a Monte Carlo simulation to reproduce the shape of the experimental signal.

After having simulated the signal, the parameters (mean and sigma) of the signal distribution were extracted, from a fit of the $\chi^2$ distribution.



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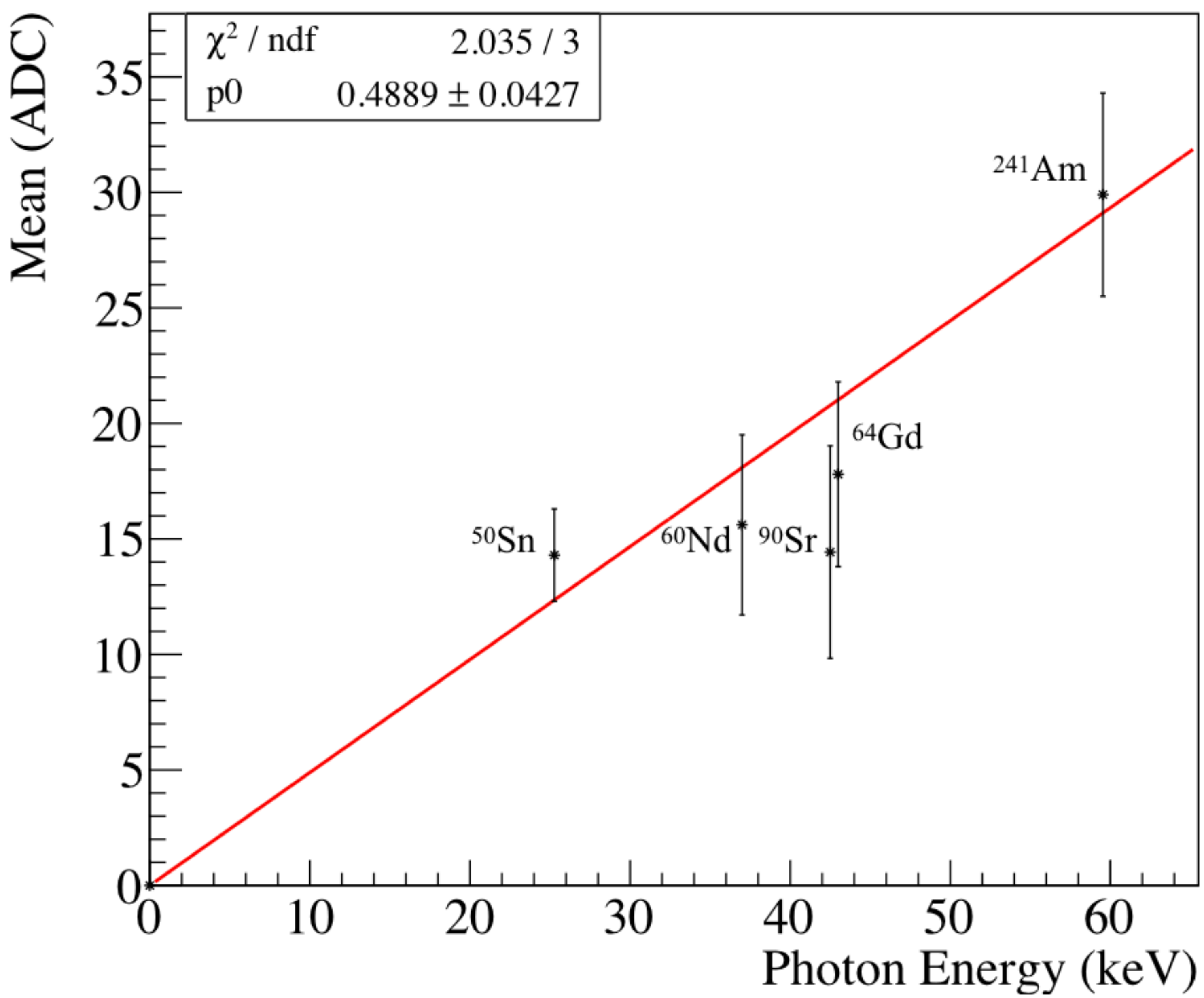
I then plotted the calibration line after repeating the analysis for different photon sources.




I have therefore obtained a value of K in accordance with the standard method (with electrons) but with a smaller error: we have achieved an accuracy of 5% against 34%.

$$K_{e^-} = 2.9 \pm 1.0 \frac{keV}{ADC}$$

$$K_{\gamma} = 2.1 \pm 0.1 \frac{keV}{ADC}$$

# HASPIDE PROJECT: STATE OF THE ART

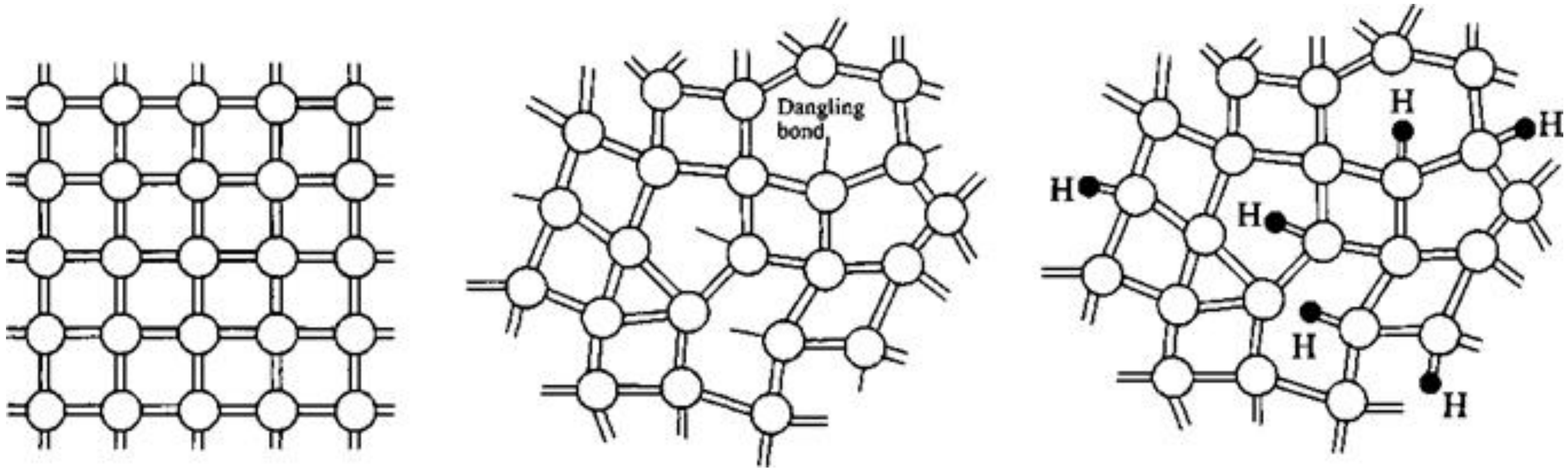
The **HASPIDE** collaboration *(6 INFN and Italian Universities, 2 foreign institutions EPFL Neuchatel and University of Wollongong, about 40 researchers)* wants to explore the possibility to use **a:Si-H** as a detection material for ionizing radiation of different types.

The material in itself is very radiation-resistant, could be deposited as a thin layer of few micrometres over many substrates, including flexible ones like Kapton, that potentially opens up the way toward many important applications:

- Beam monitoring of clinical and non-clinical accelerators;
- Detection of cosmic radiation in space;
- Neutron detection. → With the deposition of $^{10}B$ films on a-Si:H layers to convert neutrons to alfa.

The project's foundation is the capability already demonstrated by several research groups and by some of the proponents to use this material to build several devices, such as a detector of ion beam at CNAO.

# WHY THE A-SI:H?




Highly disorder material → radiation damage resistant

High level of industrial production for standard applications

Easy deposition at moderate (PECVD) and low (PLD) temperature on flexible surfaces

Wide area deposition is possible at lower costs than for corresponding crystalline silicon deposition.

A:Si-H sensor has already been used to monitor therapeutic beam at CNAO, and we have already carried out some preliminary studies, results look encouraging.

# GOALS

In order to reach the goals of the project, several steps need to be accomplished:

- Fabrication and optimization of detectors

  We foresee a Prototyping Phase, where sensors will be fabricated using different deposition technologies to characterize their basic performances

  Pulsed Laser Deposition (PLD)

  Plasma enhanced chemical vapor deposition (PECVD)

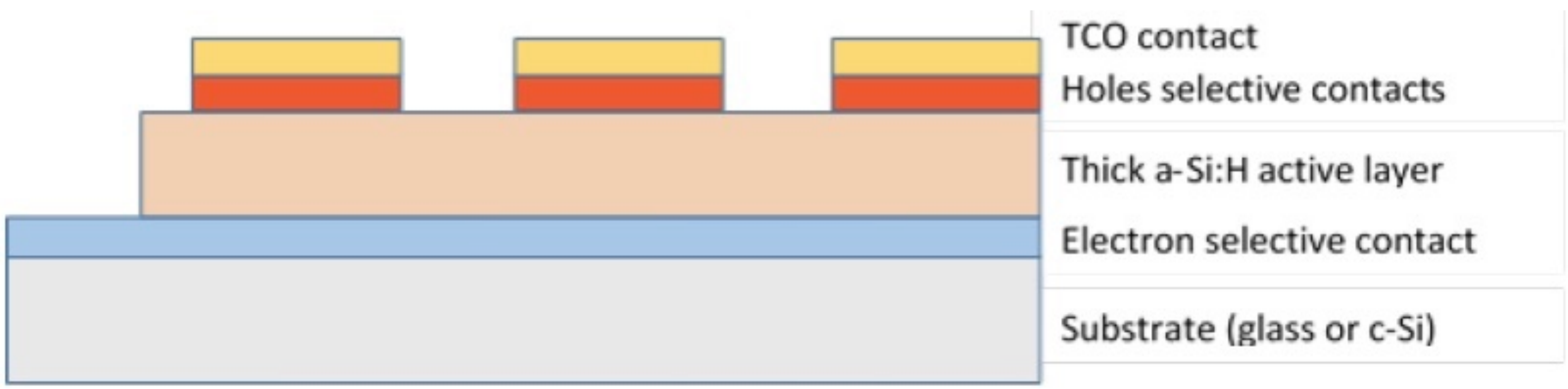
- Performance and quality testing

  After prototype fabrication, performance and quality testing will be performed. The basic tests on each prototype will include:

  - I/V measurements;
  - Radiation damage measurements;
  - X-ray dosimetric calibrations;

# CONTACTS: CHARGE SELECTIVE CONTACTS

Different contacts type will be explored: p-doped and n-doped layers, charge selective contacts




Contacts are realized with thin layers (< 100 nm) with asymmetric charge carriers mobility to create a gradient inside the device.

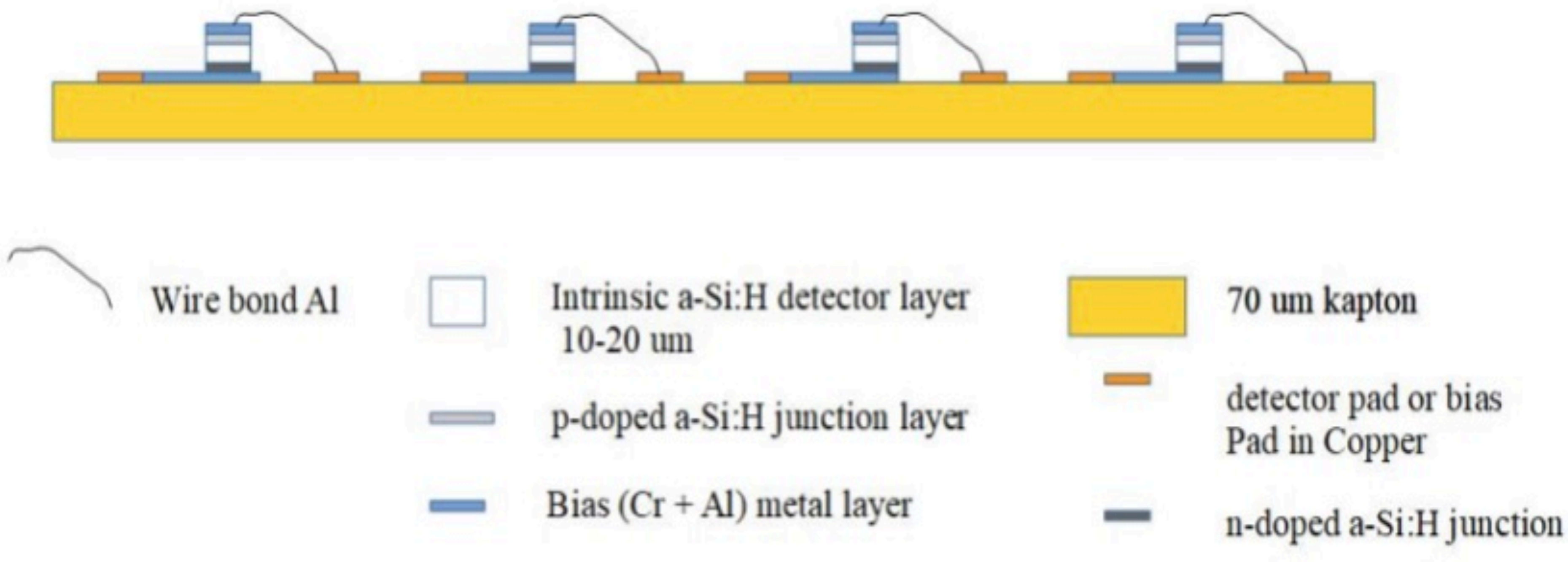
First prototypes:

**electron selective contacts: ZnO:Al or $TiO_2$**

**hole selective contacts: $MoO_x$**

# CONTACTS: DOPED LAYERS

Contacts are realized via deposition of doped layers: p-doped and n-doped, plus a metal contact on both sides to allow polarization and signal extraction.




State of the art: much research performed on Charge selective layers in thin layers (100 nm) for solar cell application. Never for radiation detection.

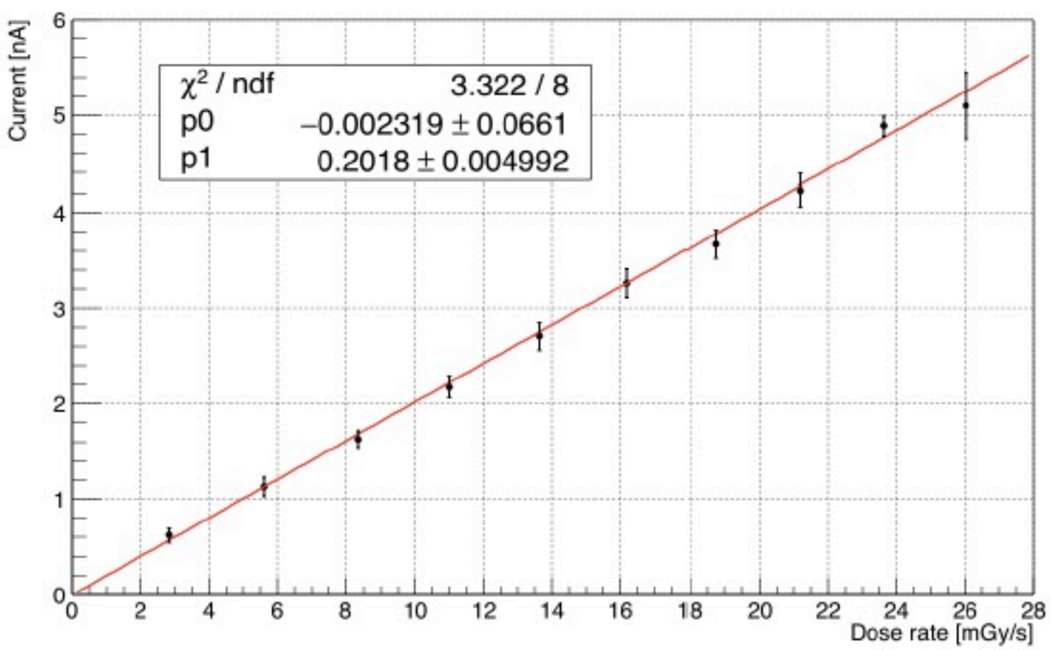
**Thicker devices (1- 10 mm) and their contacts are a new game.**

# CONTACTS

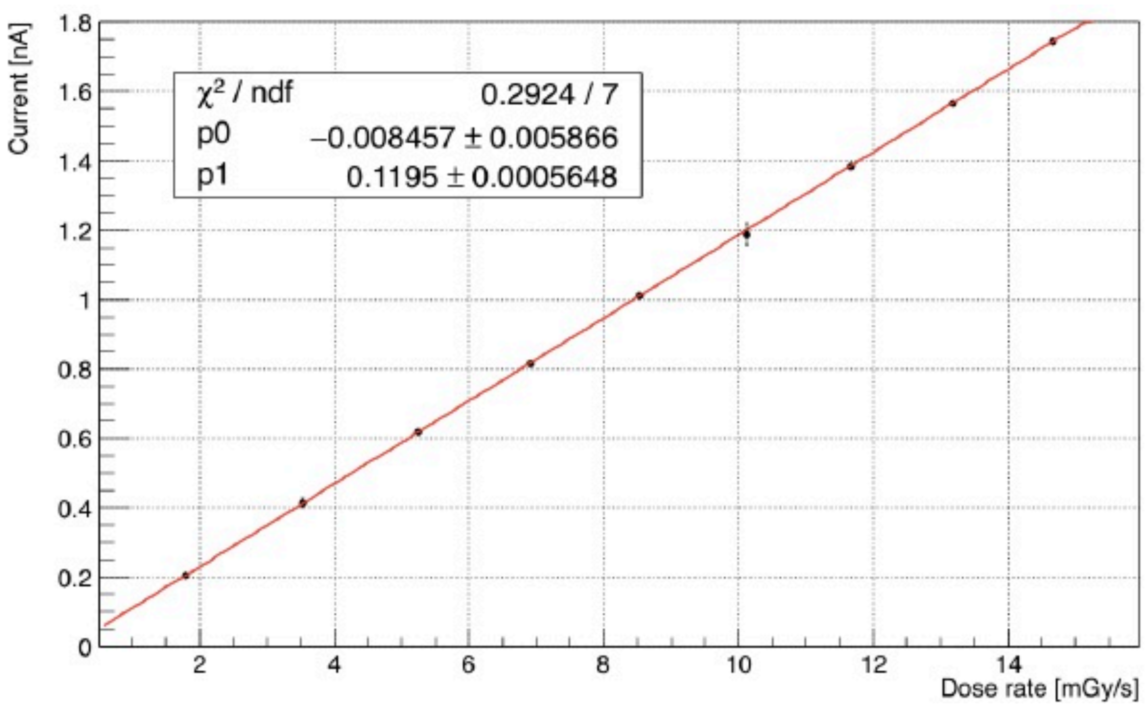
The prototypes must be characterized also from the aspect of the quality of the material, for example through spectroscopic techniques to study their electrical and transport properties.

The final tests must therefore be carried out using different sources of ionizing radiation, most of which are located in hospitals or specialized research centers.

## Doped layers vs charge selective contacts




Vertical diode structure




Charge selective contacts