Test of Amorphous Silicon Detectors on the Trento Proton Beam Line

L. Servoli on behalf of HASPIDE Collaboratiom

Goal of the HASPIDE project

Creation of thin a-Si:H (1 - 10 μm) ionizing radiation detectors deposited over thin plastic substrate to be used for:

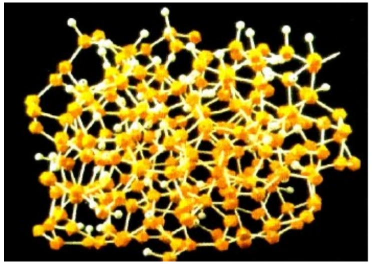
- → beam monitoring of medical LINACs and other types of accelerators
- → detection of radiation bursts in space, for example Solar Energetic Particles events;
- → neutron detection via ^{10}B deposition over an a-Si:H layer to detect α produced by neutron conversion.

Why a-Si:H as detection material?

→ Highly disordered material → radiation damage resistant;

→ ***Thin film deposition with several techniques (PECVD most used)***

→ High level of industrial production for standard applications (solar cells, flat panel for X-ray imaging)



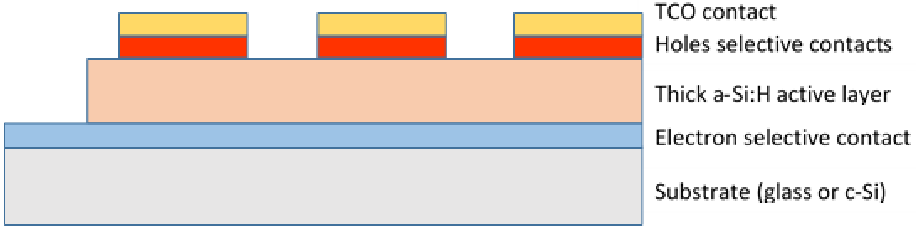
→ ***Easy deposition at moderate (PECVD) and low (PLD) temperature on flexible surfaces like kapton***

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

→ Already used in beam monitoring at CNAO.

Status of device production

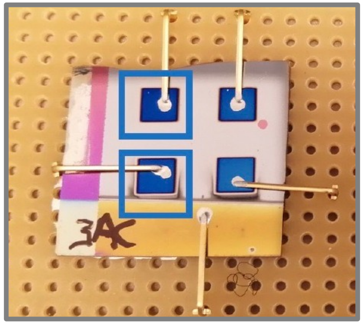
Several batches of a-Si:H depositions on polymmide has been produced (PECVD).



2x2 mm² and 5x5 mm² devices (p-i-n) are available for cutting and testing.

Thickness: 2.5 μm.

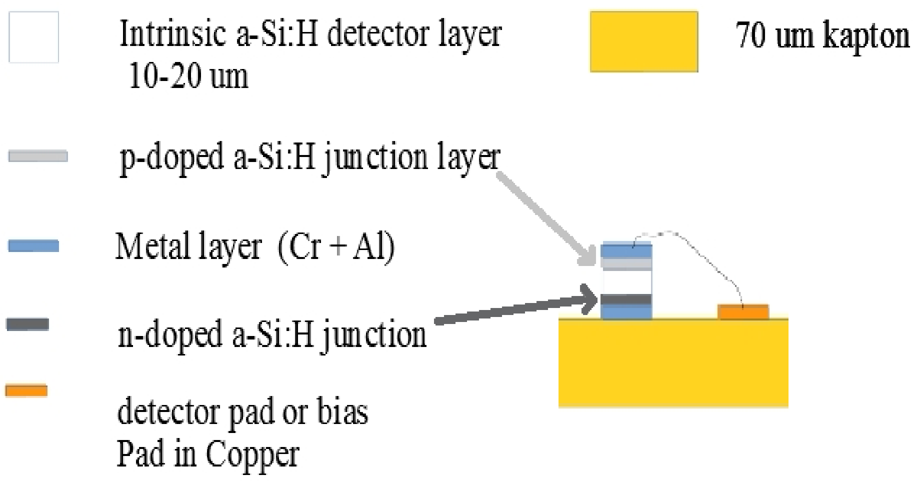
Polymmide thickness: 25 μm



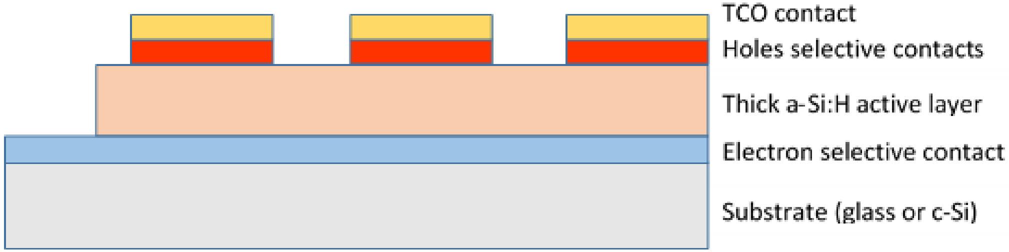
Status of device production

Two different tipe of contacts under study:

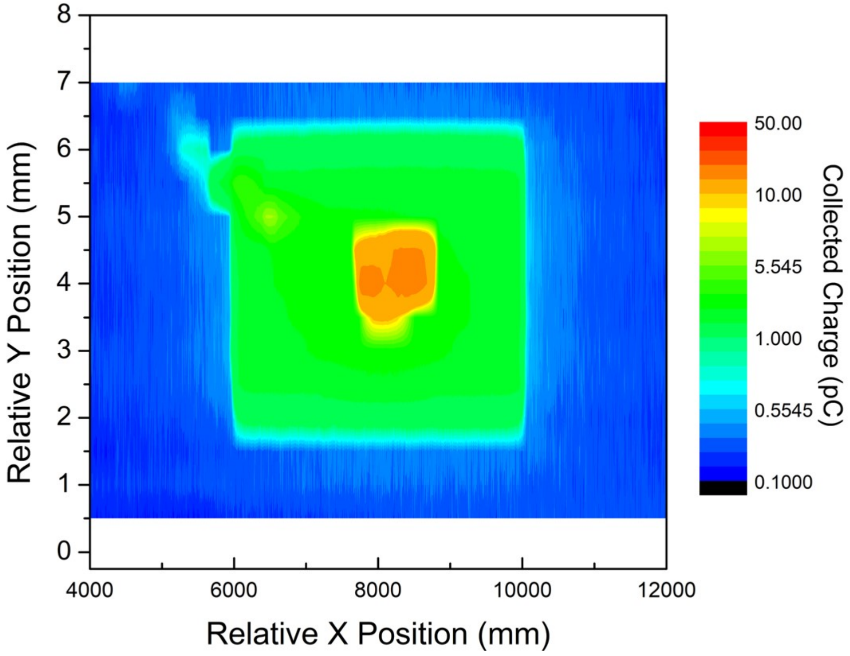
→ *n-i-p devices*

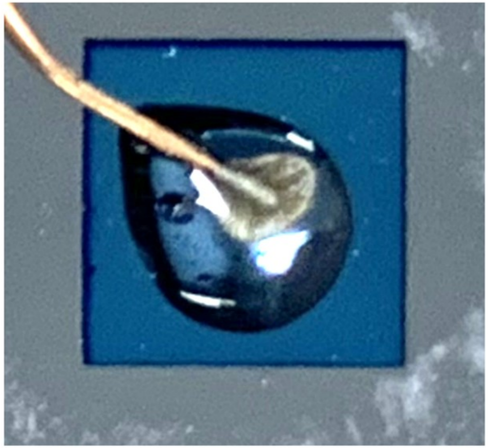


→ *Charge selective contacts*



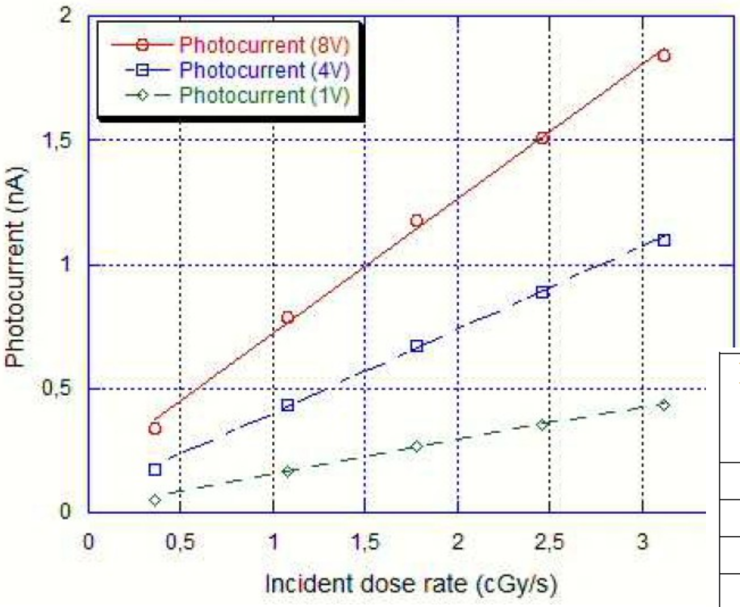
Results: Charge collection only below electrode.





XBIC mapping of the charge collected by a single pixel -10 V bias

Test with photon beams, X-ray.



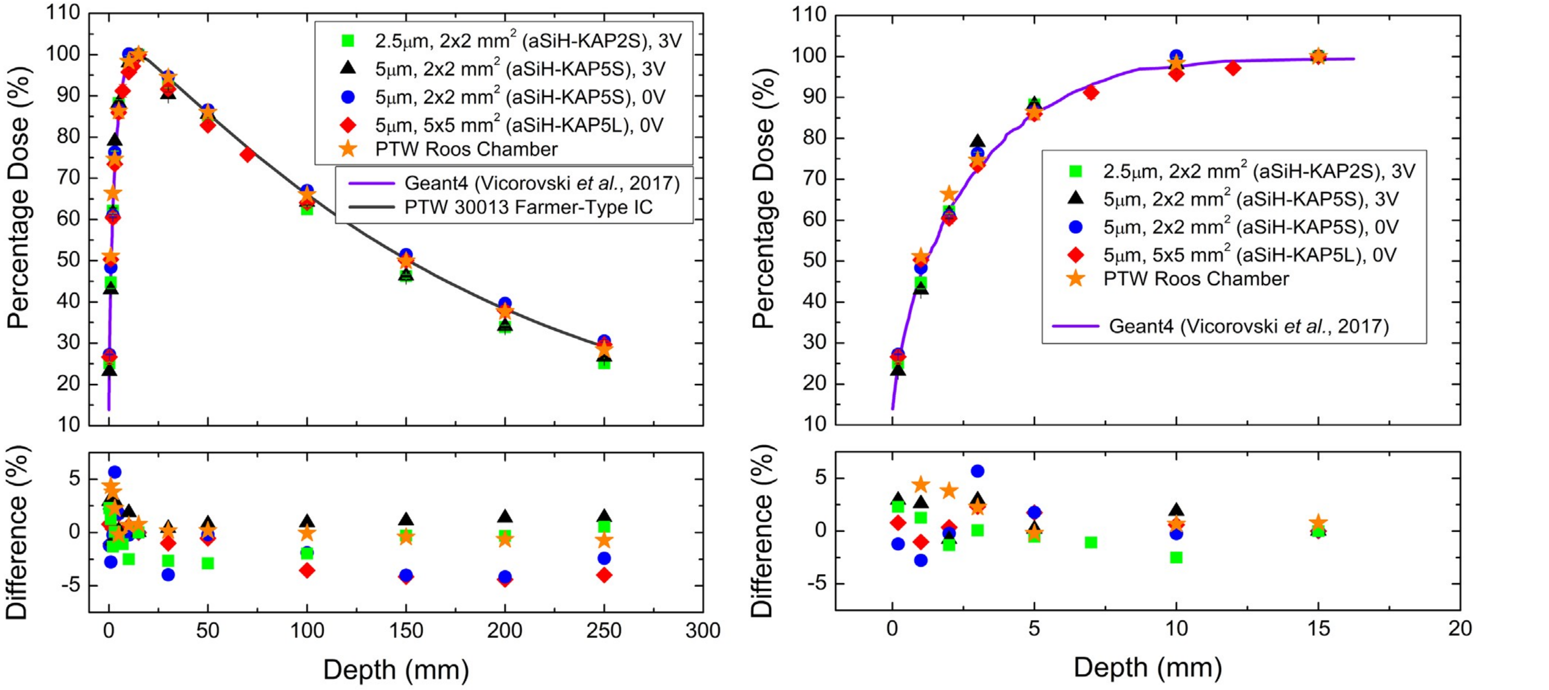
Current vs incident dose-rate (X-ray source) for 2x2 mm device at various bias.

Noise ~ few pA.

Sensitivity for different devices and bias.

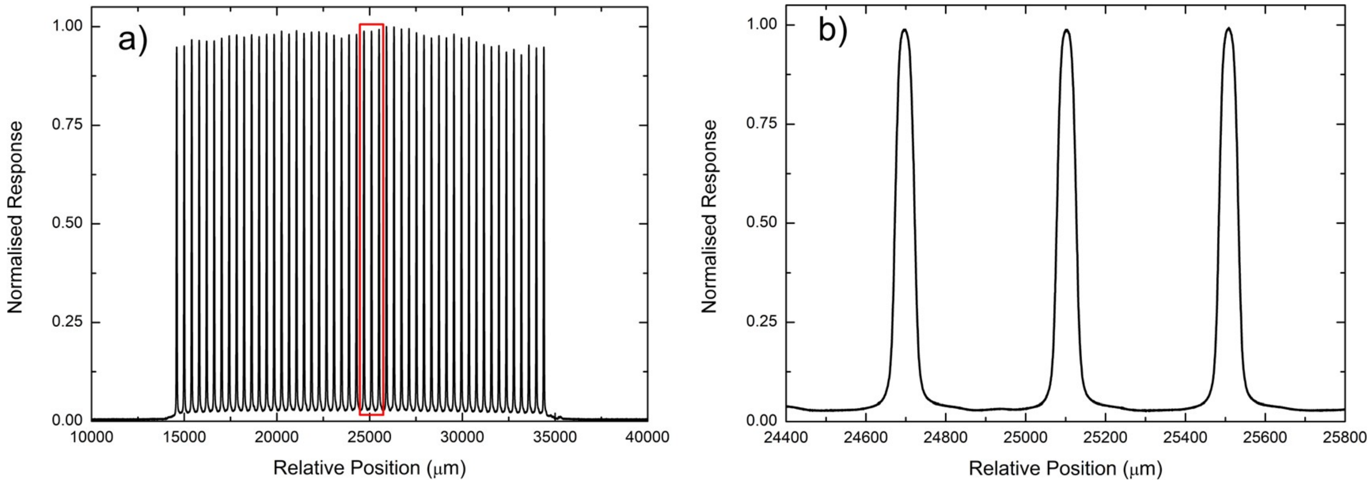
Device Area (mm^2)	Bias Voltage	Dosimetric sensitivity (nC/cGy)	Regression coefficient R
5 x 5	0V	0.367	0.99999
	2V	1.283	0.99991
	4V	1.900	0.99975
	6V	2.505	0.99972
	8V	3.027	0.99926
2 x 2	1V	0.137	0.99878
	4V	0.335	0.99961
	8V	0.540	0.99881

Test with photon beams: clinical MV beams.



Very good results, comparable with reference dosimetry

Test with photon beams: microbeam profile.



Using 0.8 μm thick device edge-on wrt beam spatial reconstruction of microbeams 50 μm wide could be obtained.

Tests done on proton beam at APSS

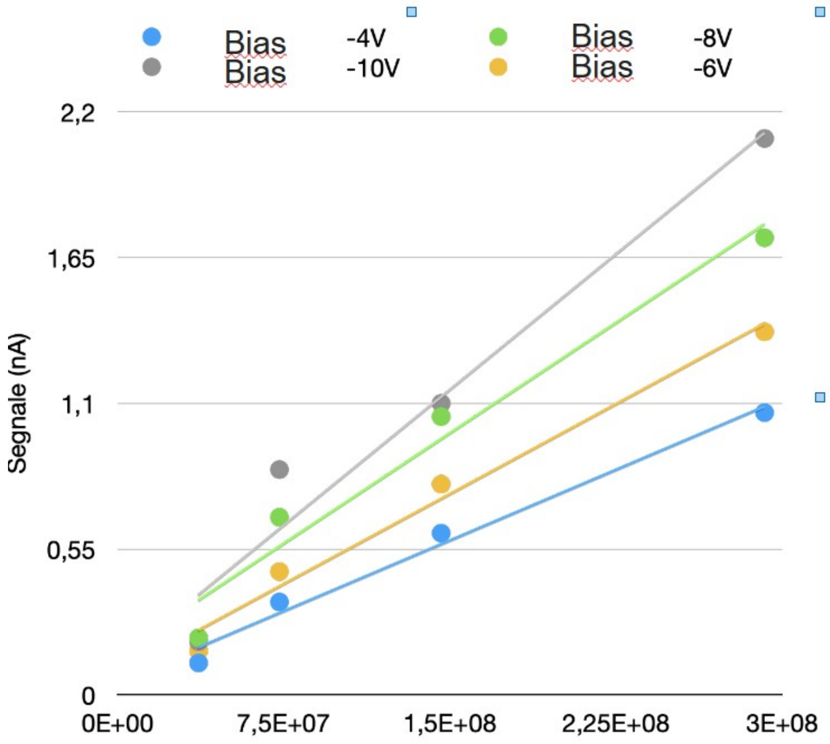
HASPIDE need to test devices also on charged particle beams.

→ *verify the radiation flux measurement capabilities for different types of radiation.*

→ *measure the sensitivity to small proton fluxes for Space Weather use.*

→ *First test done in 2023. Second one ongoing this week.*

Tests done on proton beam at APSS



Preliminary results:

Sensor K2_P3 : n-i-p, area 5x5 mm^2

thickness 2.5 μm.

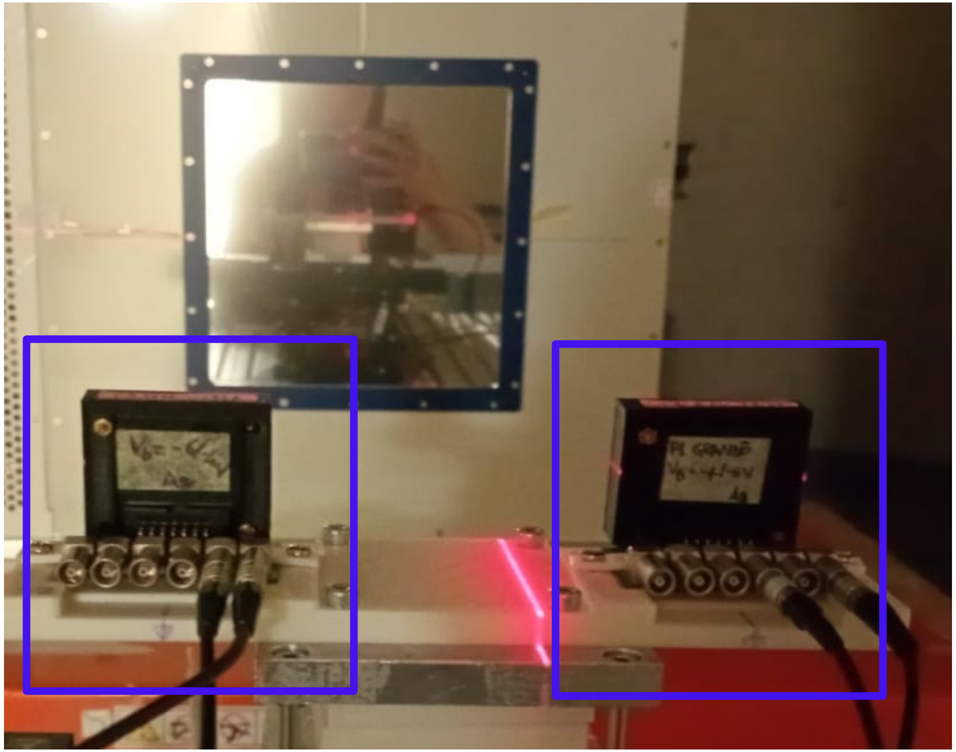
Proton energy: 148 MeV.

charge collection efficiency ~ 24% for 0.8 10^7 p/s

Tests ongoing at APSS proton beam

2 series of devices under test:
both 2x2 and 5x5 mm^2 area, 2.5 μm thickness:

→ n-i-p contacts
→ CSC contacts



Tests ongoing at APSS proton beam

Goals:

1) compare the two different contact technologies

2) verify linearity of response vs flux for different proton energies

3) verify response vs bias to study Charge Collection Efficiency

Tests ongoing at APSS proton beam

Goals:

1) compare the two different contact technologies

2) verify linearity of response vs flux for different proton energies

3) verify response vs bias to study Charge Collection Efficiency

What we would like to have….

→ an independent method to measure the protons/s for lower fluxes, ideally 10^5 protons/s or lower.
This is relevant for the Space Weather application where we need to detect 400 MeV protons after they have been degraded to an energy of few MeV.

→ Access to the APSS proton FLASH mode to test our devices.
Up to know we have done test at the Australian Synchrotron for photon beams.
We are starting tests at Electron FLASH accelerator in Pisa.