# Evaluation of hybrid contacts a-Si:H detectors with X-ray beams

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# Outline:

- HASPIDE project
- Why a-Si:H
- Production techniques
- Devices
- Samples characterization
- X-ray sensitivity and preliminary results for transmission measurements

# HASPIDE project:

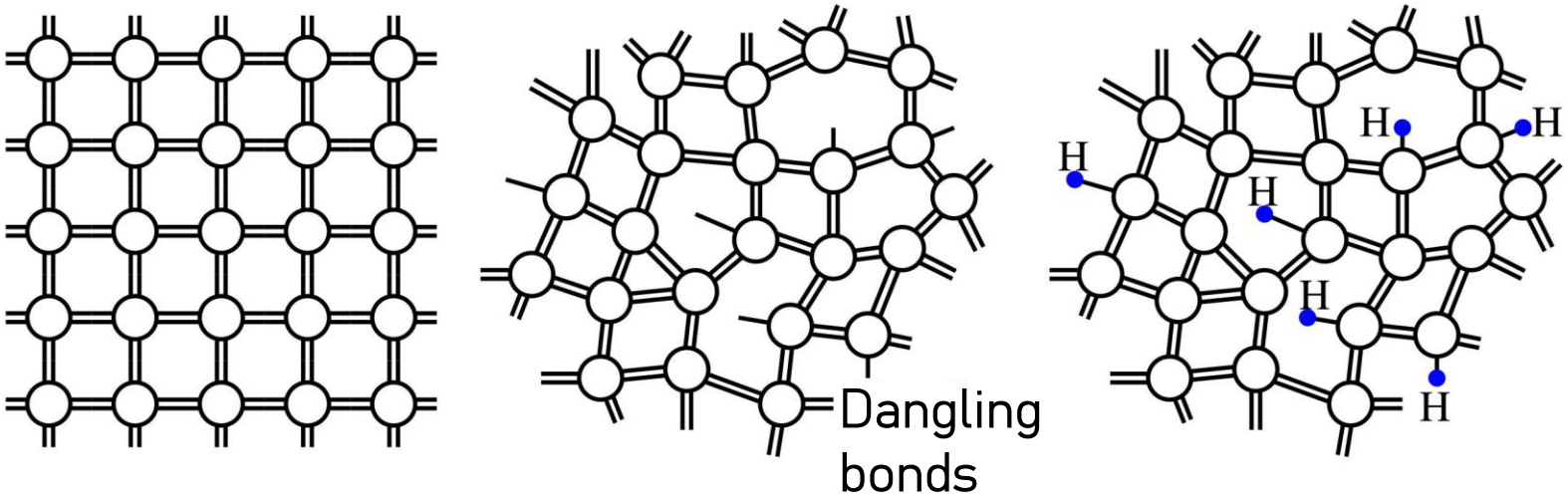
The objective of the INFN HASPIDE project is to investigate the potential use of hydrogenated amorphous silicon (a-Si:H) as a material for the detection of ionizing radiation, with a focus on:

- Monitoring of clinical and non-clinical radiation
- Beams detection of cosmic radiation in space
- Neutron detection

**Talk focus**

From detector electrical characterization to first transmission measurements with Kapton and complete detector stacks.

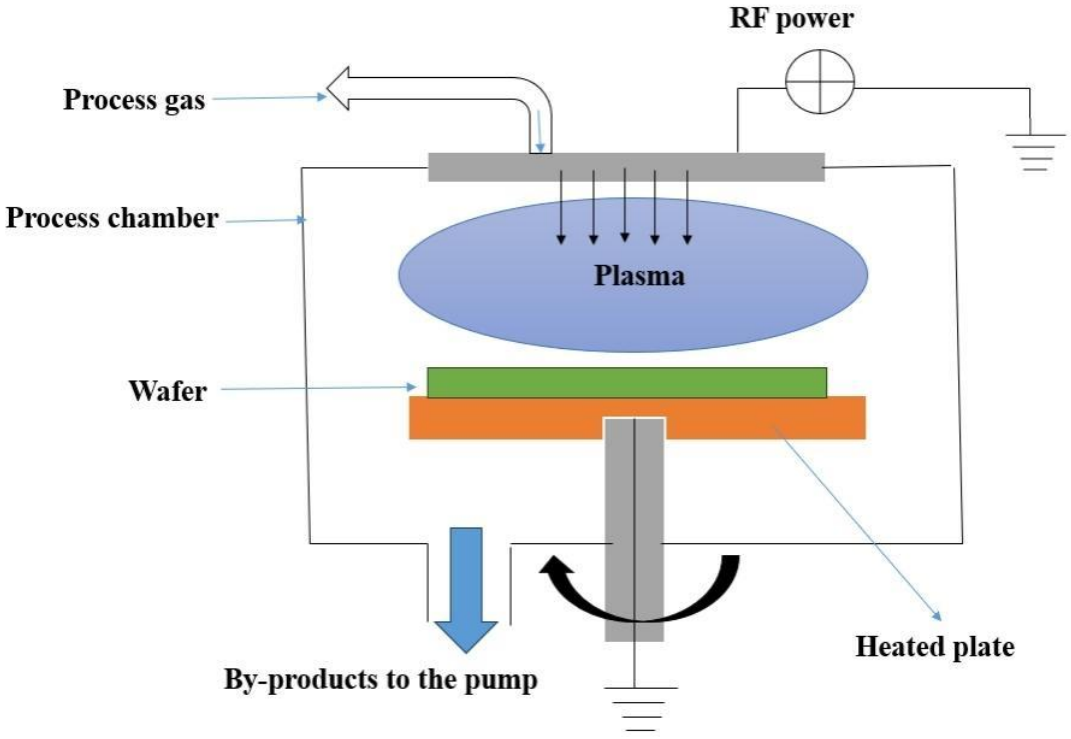
# Why a-Si:H?




- Radiation resistant
- Can be deposited in thin layers (~1-100 µm) and on flexible substrates like Mylar and Kapton
- Band gap slightly higher than c-Si (1.12 eV): 1.7-1.9 eV
- Deposition possible on wide areas
- Hydrogen passivates structural defects

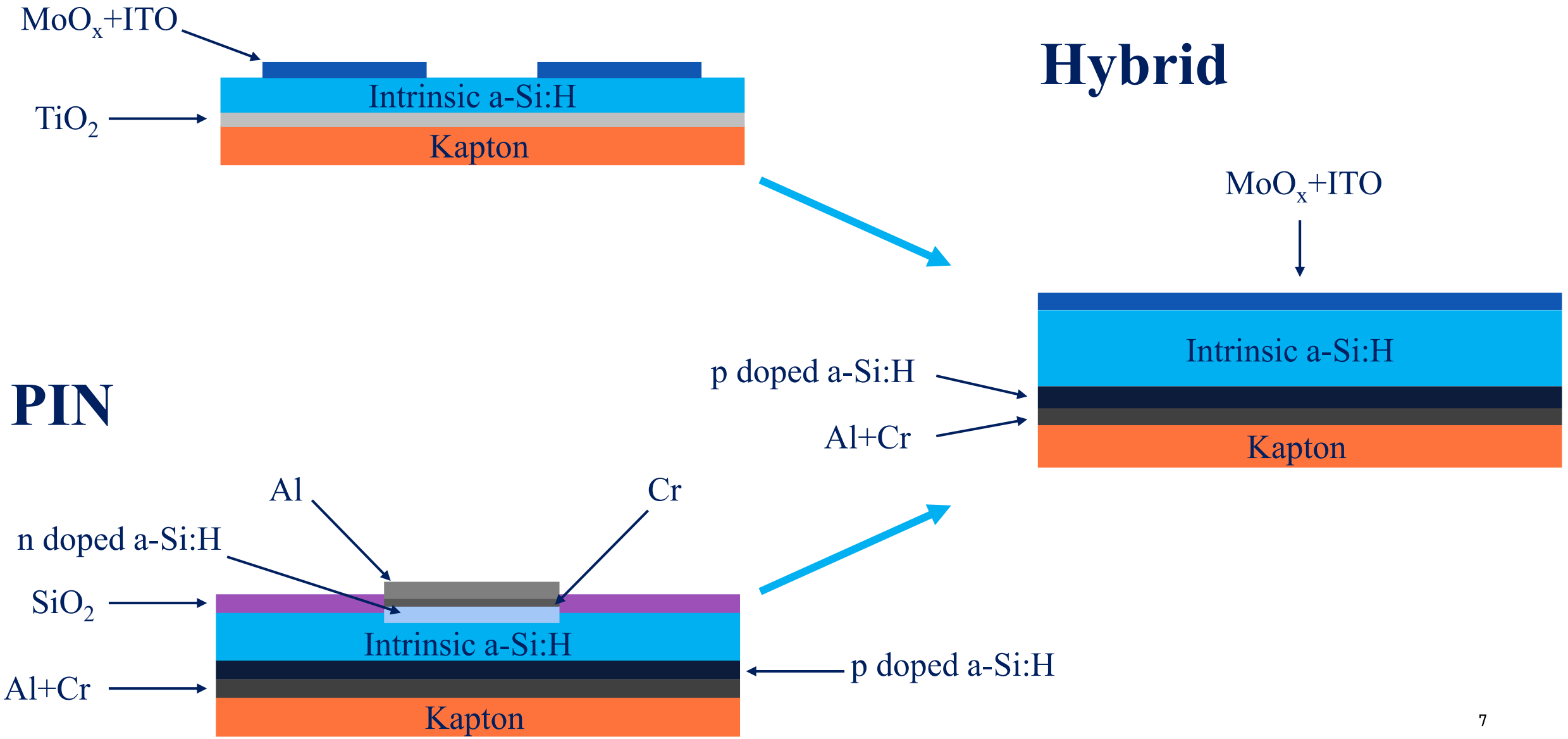
# Production techniques:

- PECVD (Plasma-Enhanced Chemical Vapor Deposition): mixture of silane ($SIH_4$) and hydrogen
- Radio-Frequency PECVD (RF-PECVD): operates at a frequency of 13.56 MHz.
- Very-High-Frequency PECVD (VHF-PECVD): operates at frequencies between 27 and 150 MHz.

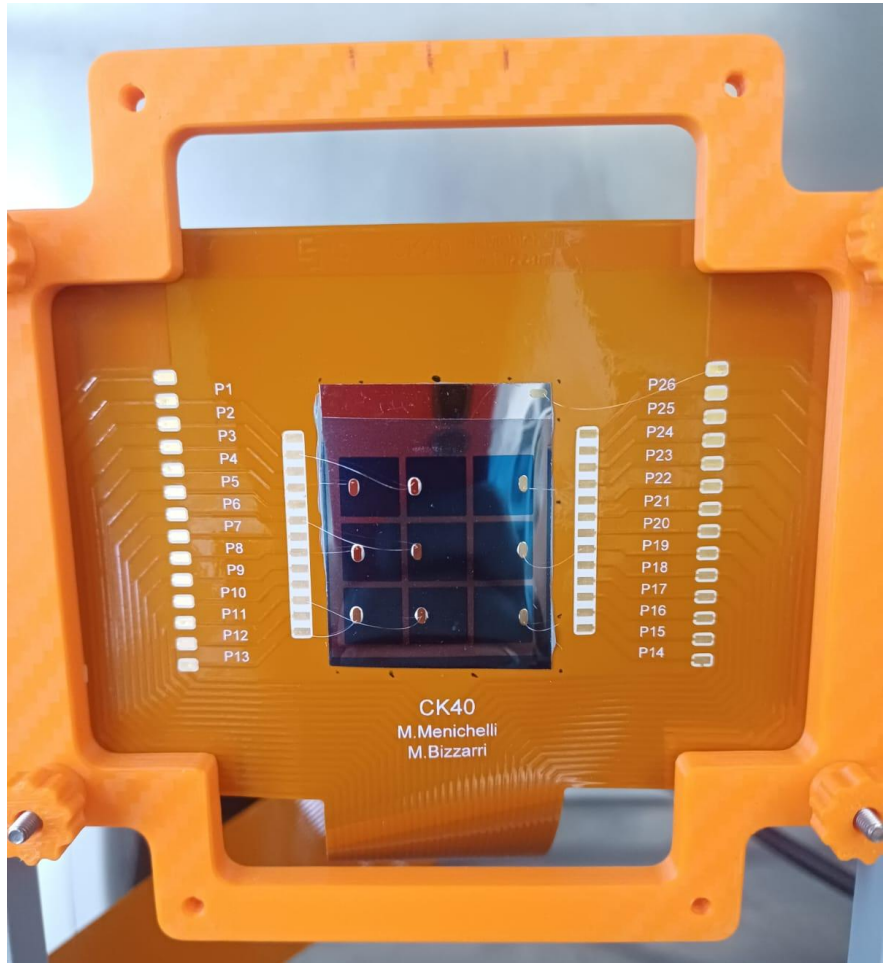


# Devices

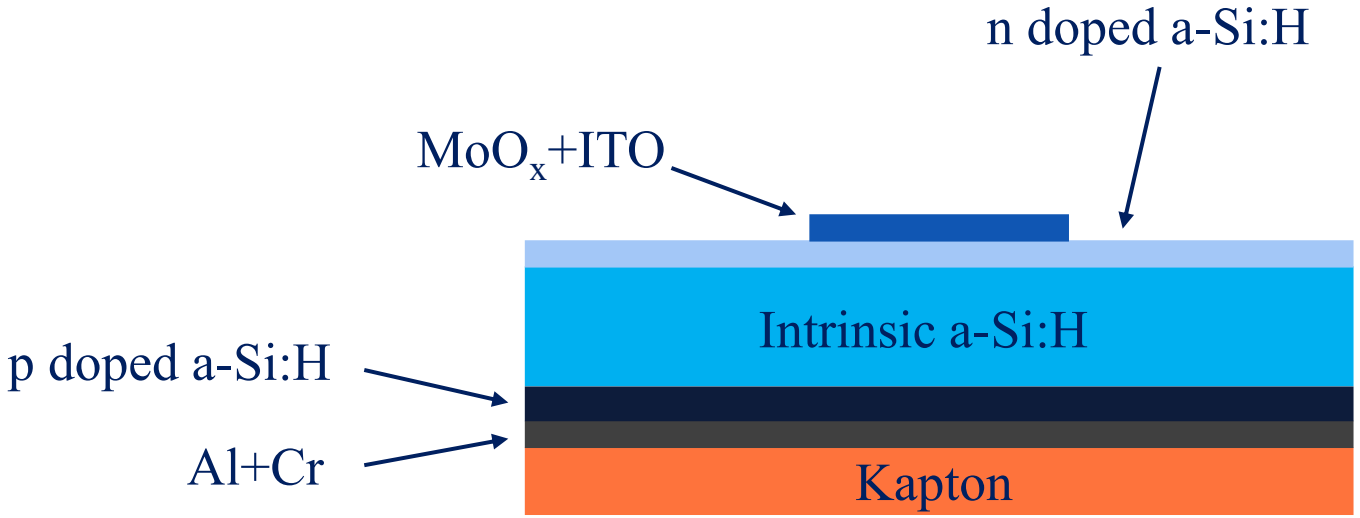
# Charge Selective Contacts



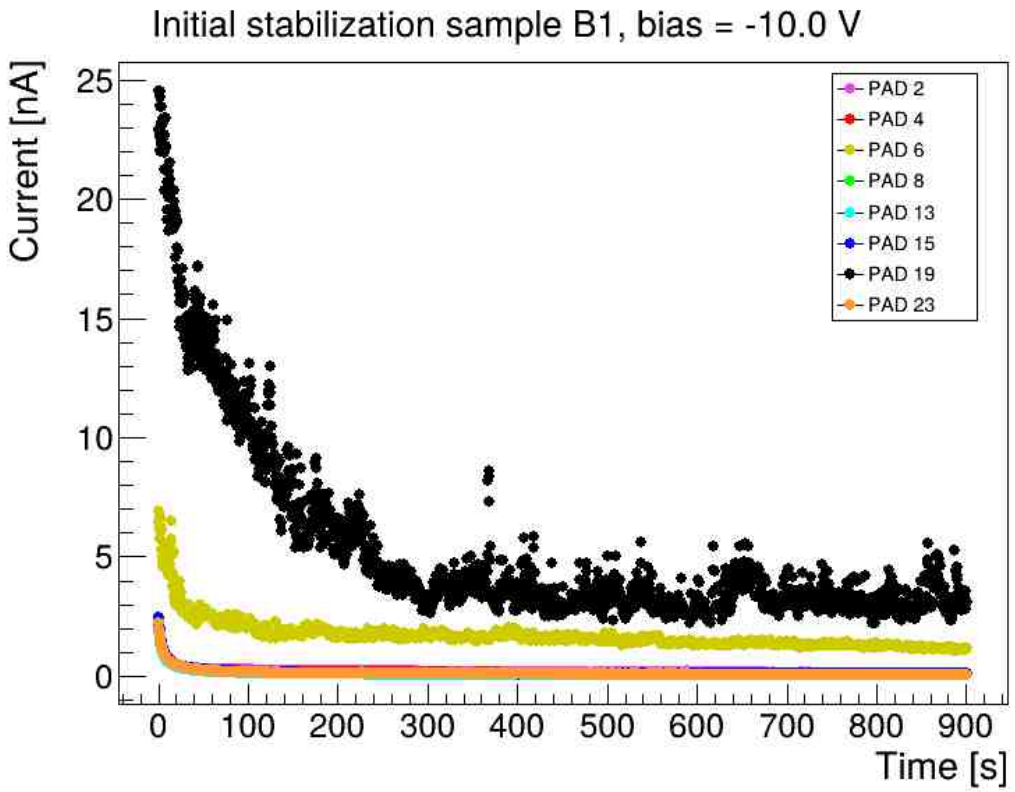
# Characterization


P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P26
P25
P24
P23
P22
P21
P20
P19
P18
P17
P16
P15
P14
CK40
M.Menichelli
M.Bizzarri

- **10 µm**
- **7x7 mm²**

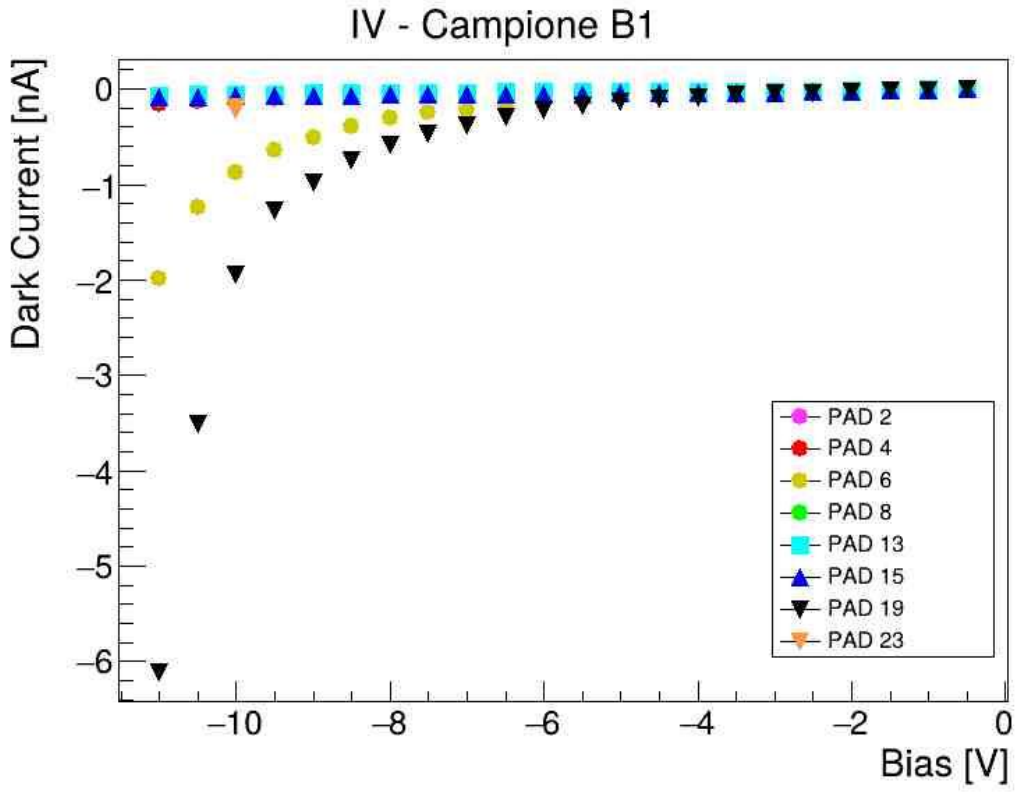

n doped a-Si:H
MoOx+ITO
Intrinsic a-Si:H
p doped a-Si:H
Al+Cr
Kapton

# Stabilization




Mean value = 0.59 nA

# IV



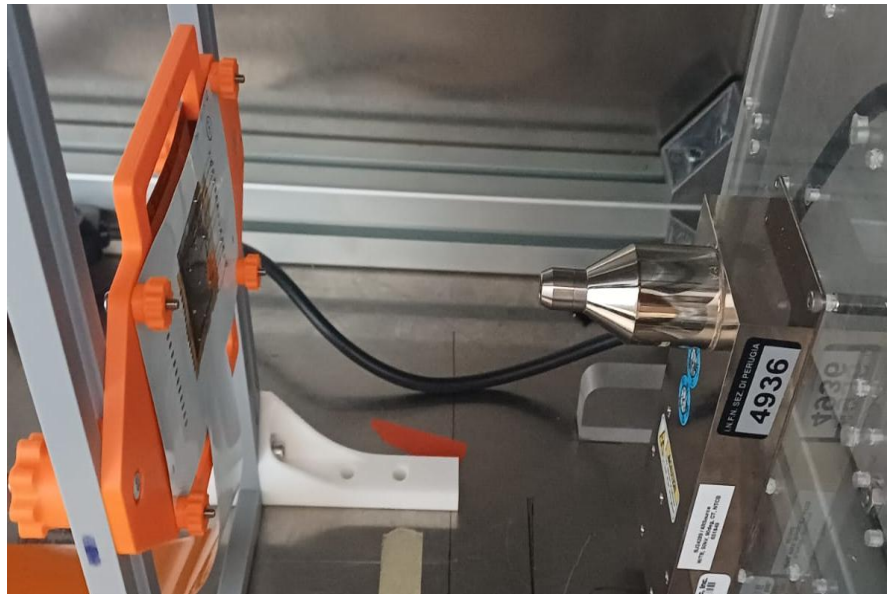
# Sensitivity and transmission

# X-ray response characterization

After dark-current stabilization, the detector response is evaluated in two controlled scans.

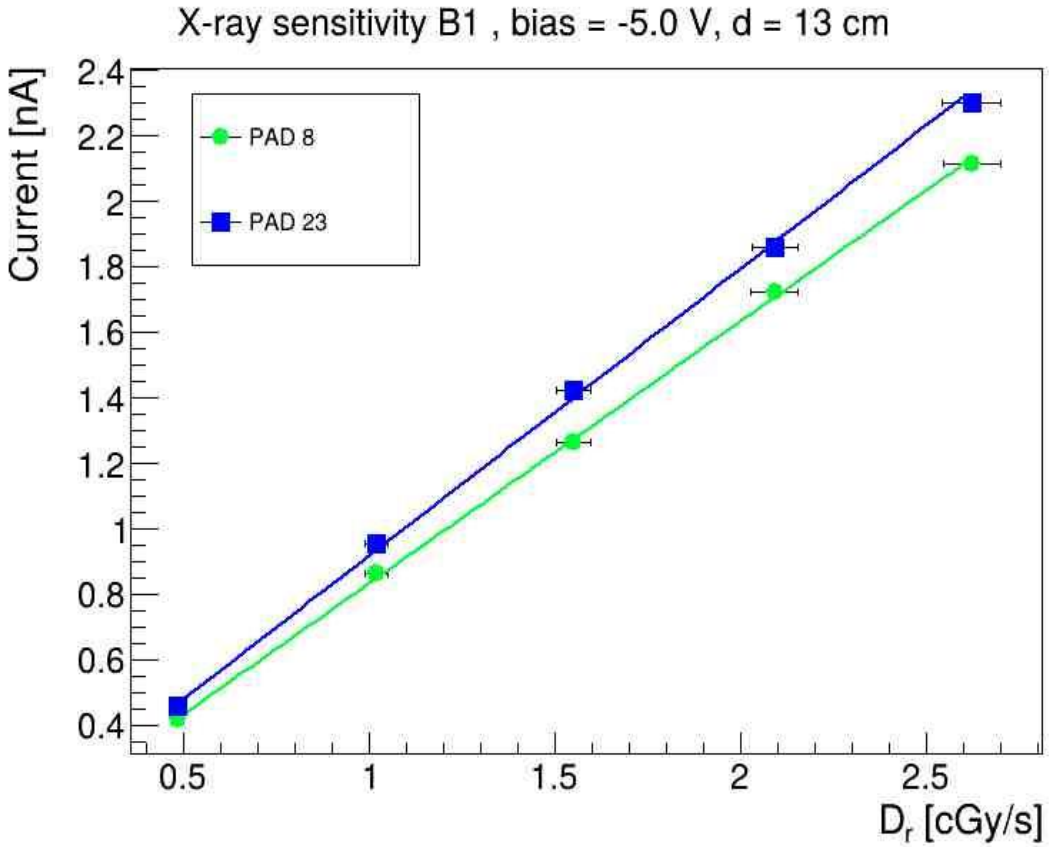
**Tube current / dose-rate scan**
Bias and geometry fixed.
The current signal is expected to increase linearly with dose rate.

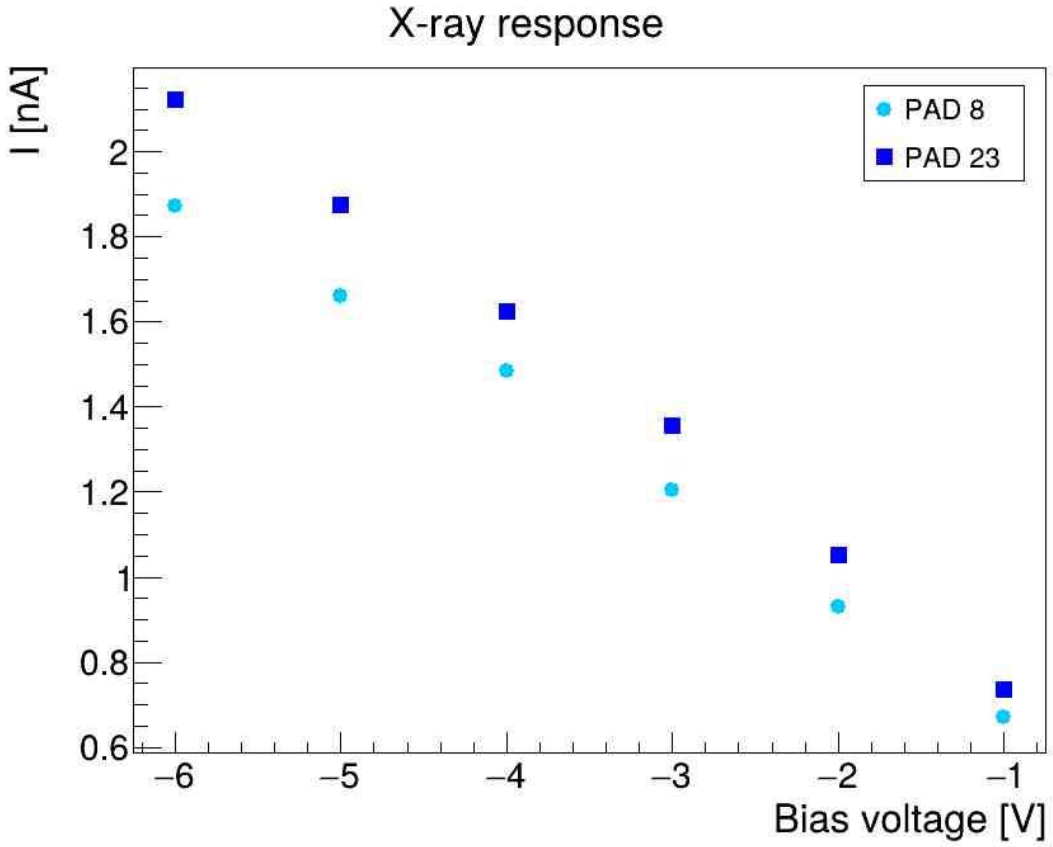
**Bias-voltage scan**
Tube settings and geometry fixed.
The signal increases with reverse bias due to improved charge collection.




**Key point**
These measurements characterize the detector itself before using the device as a passive object in the transmission setup.

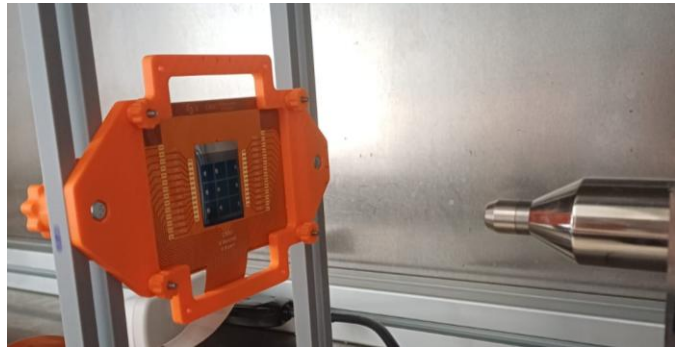
# Sensitivity



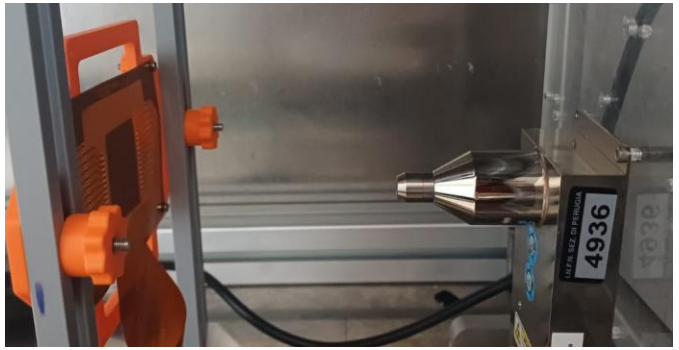

Linear response
Sensitivity of pad 8 = 0.82 nA/(Cy/s)
Sensitivity of pad 23 = 0.87 nA/(Cy/s)

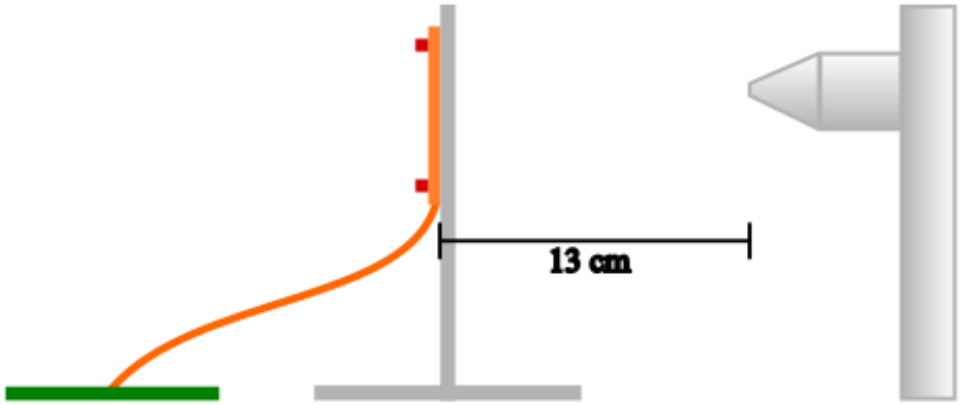
The signal increases with reverse bias, as expected from improved charge collection.

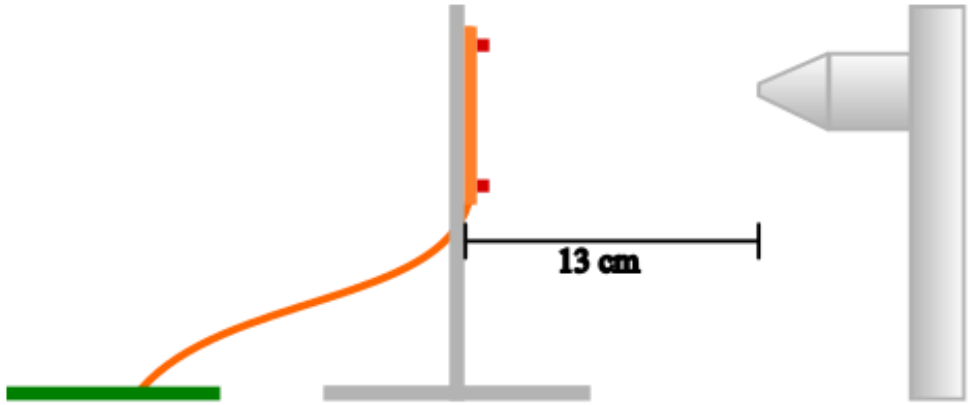


**X-ray tube**

Anode: W
Voltage:10–50 kV
Current: 5–100 µA
Max Power: 4 W



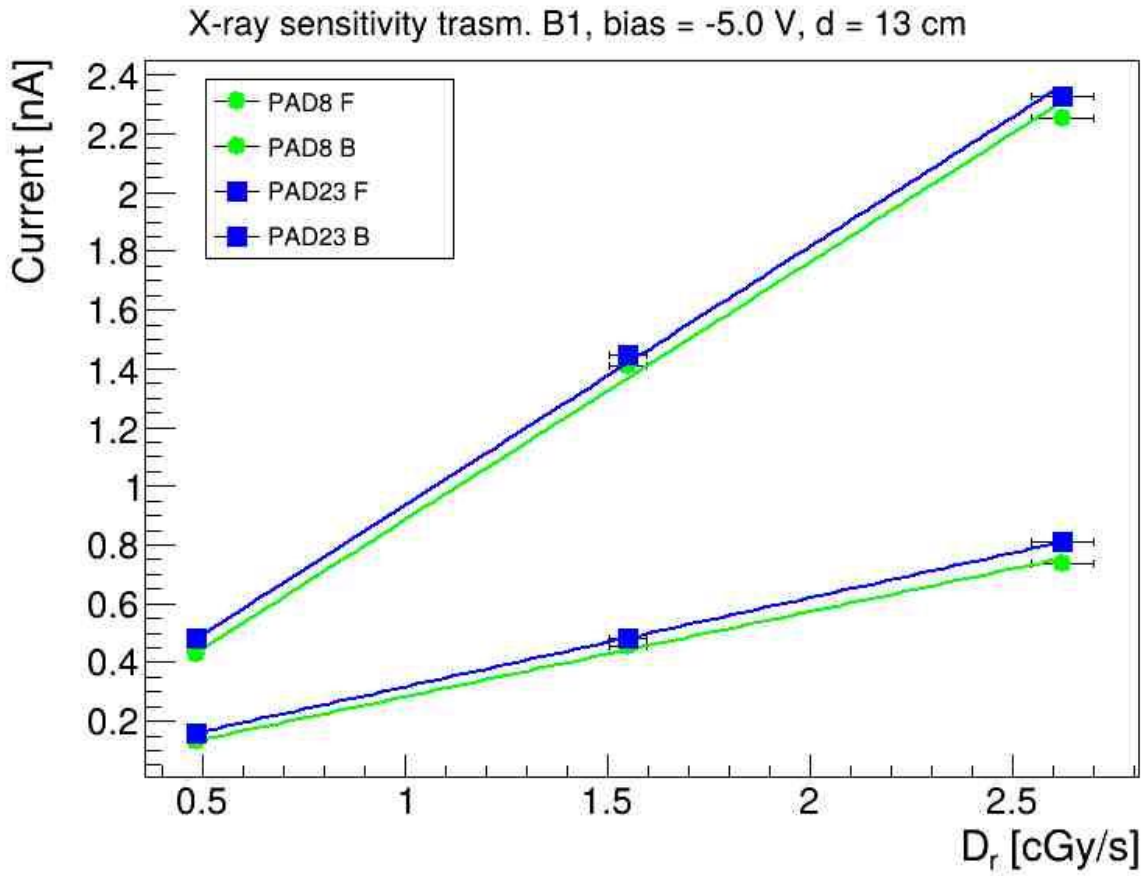




Detector directly read out while the front side faces the X-ray tube.

Same distance and readout conditions; detector rotated by 180°.

# Dose-rate dependance




**Front facing the X-ray tube:**

Sensitivity pad 8 = 0.86 nA/(Cy/s)
Sensitivity pad 23 = 0.87 nA/(Cy/s)

**Back facing the X-ray tube:**

Sensitivity pad 8 = 0.29 nA/(Cy/s)
Sensitivity pad 23 = 0.30 nA/(Cy/s)

**Interpretation**
The detector response is orientation-dependent

# Transmission measurement

**Why?**

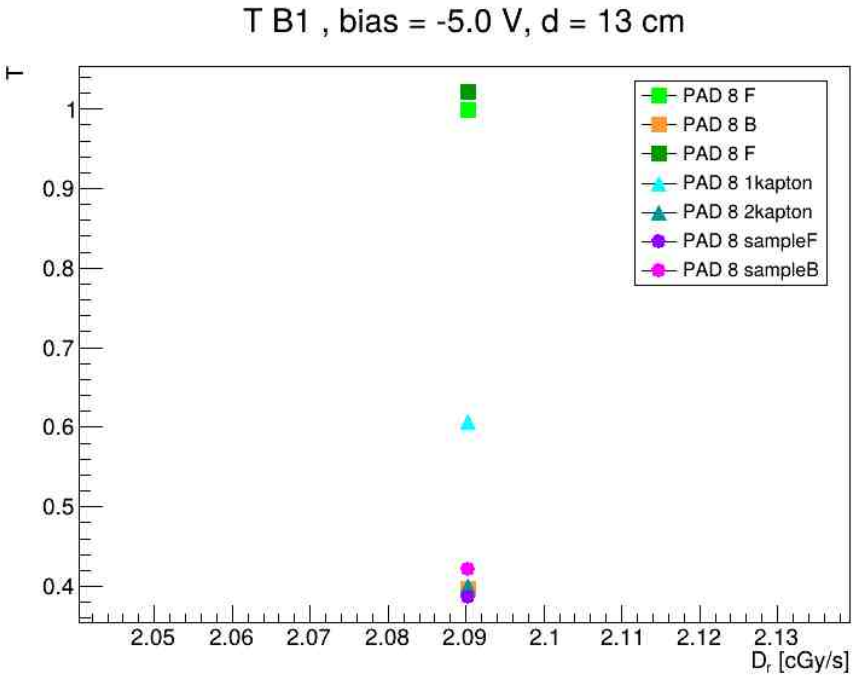
Flexible a-Si:H detectors can be used as ultra-thin devices placed directly in the beam path.
For transmission or in-phantom applications, the detector must measure dose while minimally perturbing the beam.

**Extracted quantity**

$$T = \frac{S\ (\text{with material})}{S\ (\text{reference})}$$

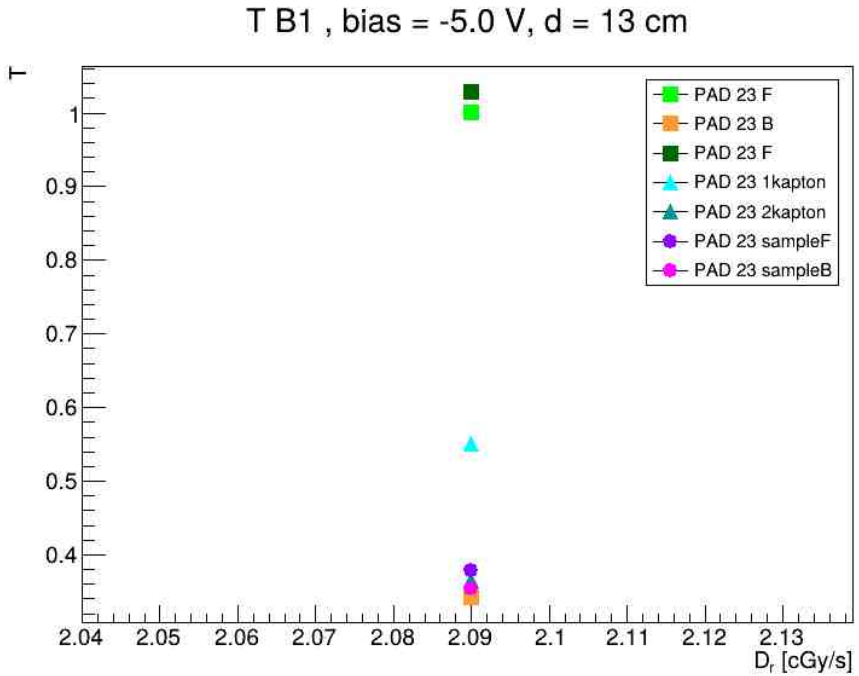
with $S = I_{meas} - I_{dark}$

A lower T indicates stronger beam attenuation.




Variation:

- Back side: 60%
- 1 Kapton: 45%
- 2 Kapton, device: 60%




Reference response:

- Direct irradiation gives the highest signal

→

Kapton contribution:

- One/two Kapton layers reduce the downstream signal.

→

Detector stack:

- Full stack gives additional attenuation.

These preliminary data quantify the perturbation introduced by passive layers in the tested X-ray configuration.

# Conclusions

- Dark-current stabilization and I–V measurements identify the operating behaviour of the hybrid detector pads.
- X-ray sensitivity is linear with dose rate for the selected pads and increases with reverse bias voltage.
- Front/back irradiation shows a clear orientation dependence, consistent with attenuation by passive layers before the active a-Si:H volume.
- Transmission measurements provide a first estimate of the beam perturbation introduced by Kapton layers and by the complete detector stack.

Next steps: repeatability with additional pads, improved uncertainty treatment and comparison of full detector stacks with Kapton-only references.

# Thank you for the attention

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