BODELAIRE:
A TPC for Neutron Science

DPG Spring Meeting Karlsruhe 2024

08.03.24 – T 116.1

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Neutron science

Using thermal neutron beams as a non-evasive probe

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Study atomic and magnetic structure and dynamics of condensed matter

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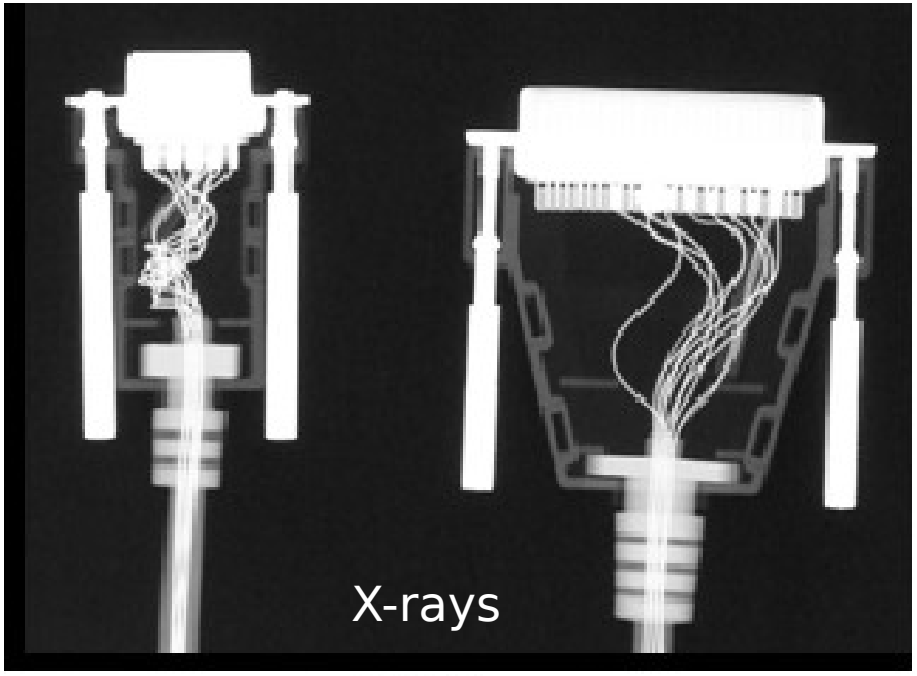
Study atomic and magnetic structure and dynamics of condensed matter

Advantages over X-rays: Cross section for thermal neutrons irregular

→ Higher contrast between isotopes and elements with similar Z

Neutron science – Example: Imaging

RS-232 connector



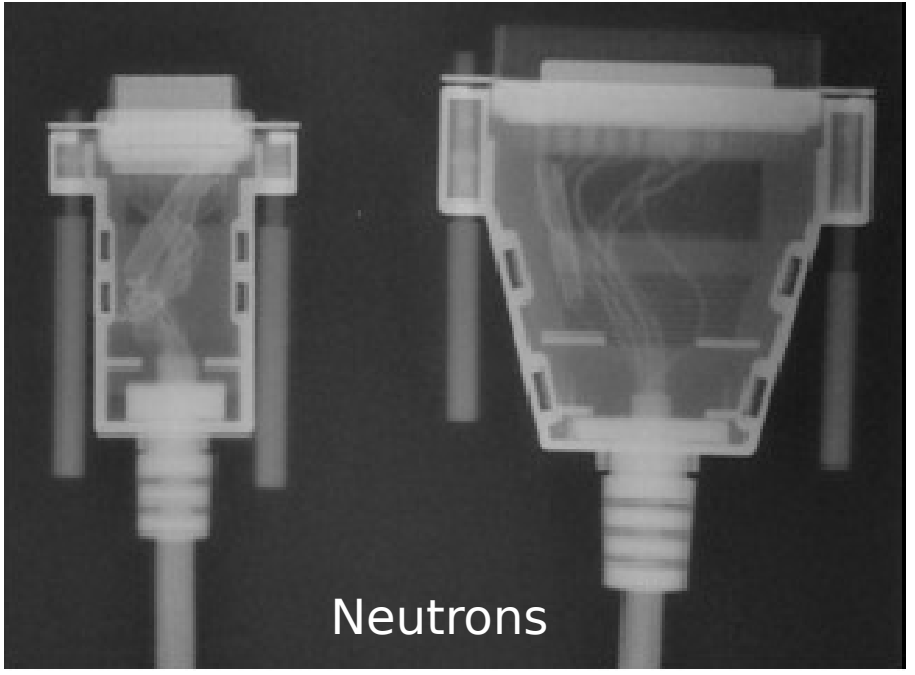
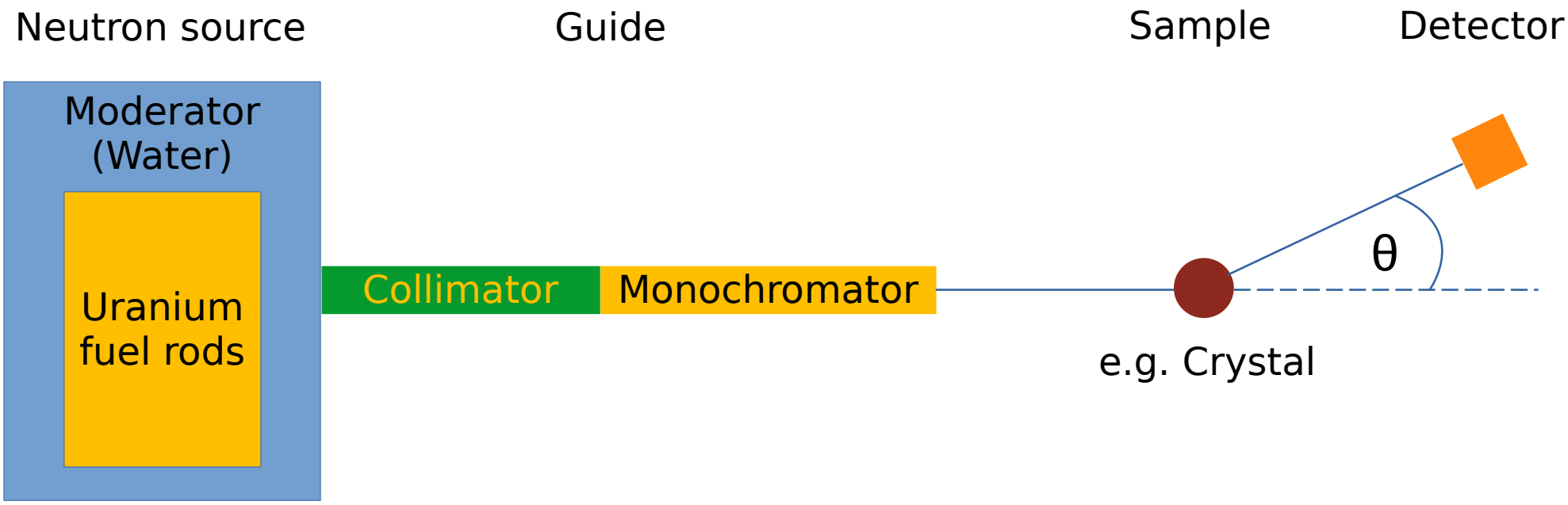


Image source: DOI:10.5772/35650

Neutron science – Basic setup



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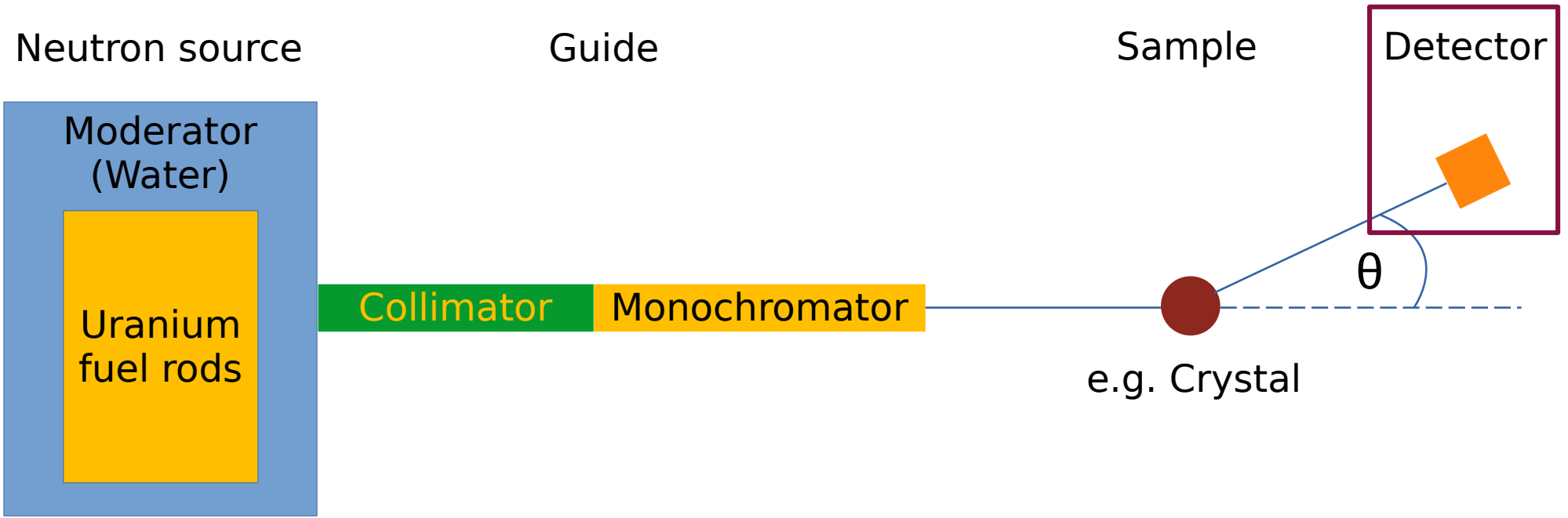

Neutron science – What is the problem?

^{3}He heavily used as a neutron converter

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But: Increasing demand, i.e. **exploding costs**, of He-3

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But: Increasing demand, i.e. **exploding costs**, of He-3

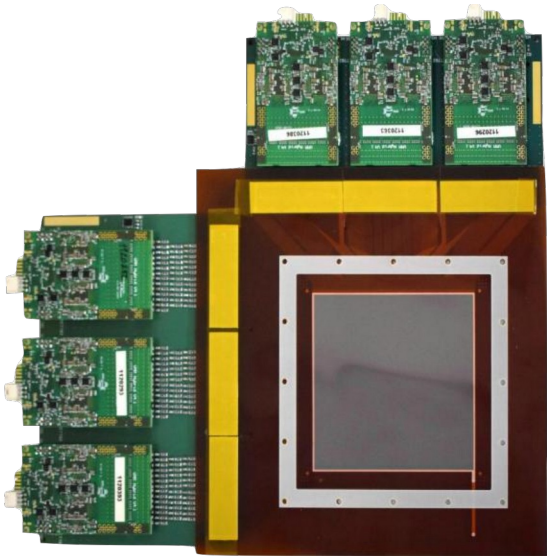
Need an **alternative**: We want **solid converters** with

- **high** absorption cross section for thermal neutrons
- **easy** to handle and process

^{10}B is our choice!

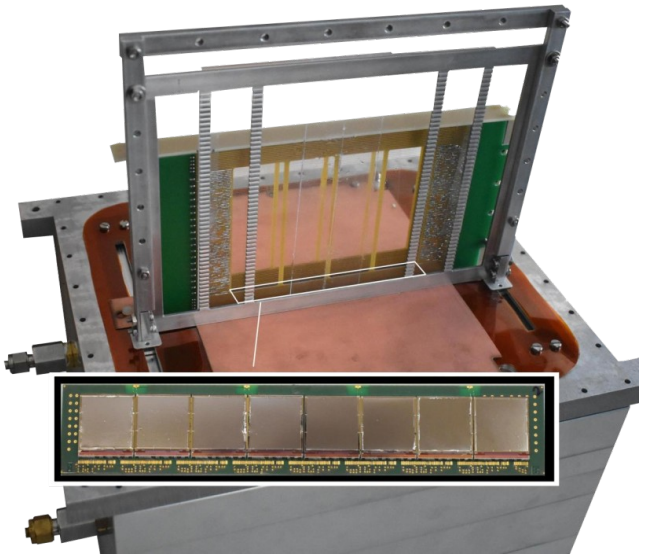
Neutron detectors in GasDet group

Boron lined
GEM-VMM Hybrid



Neutron sensitive
Microchannel Plate

Neutron Time
Projection Chamber



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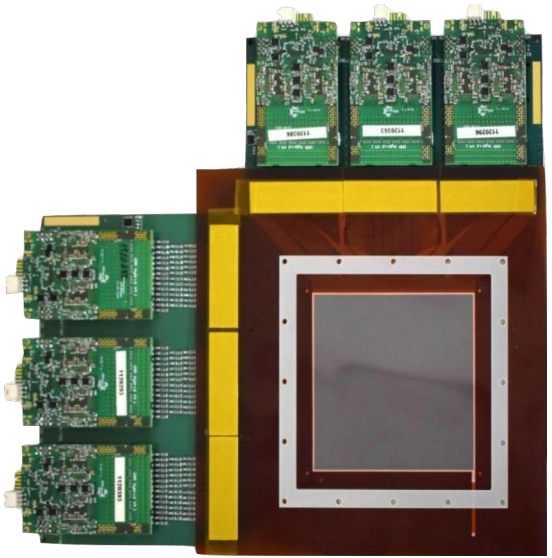

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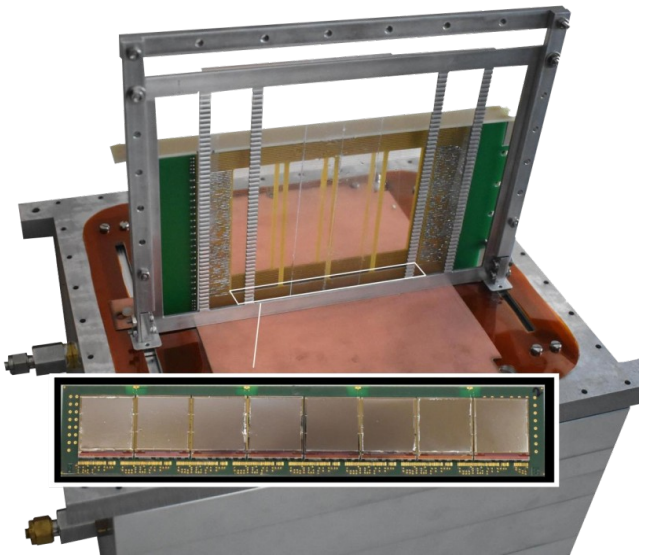

Detector concept – Neutron TPC

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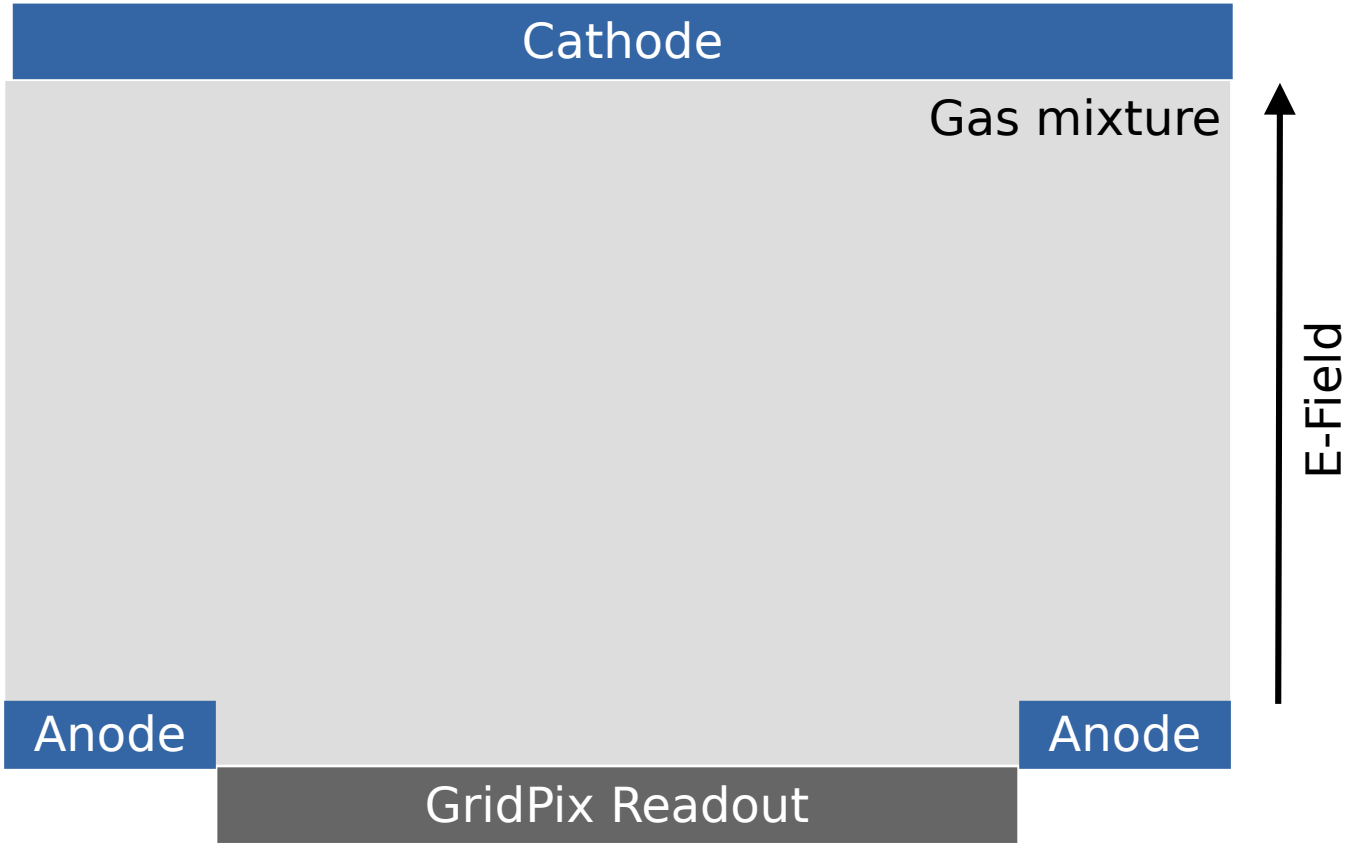

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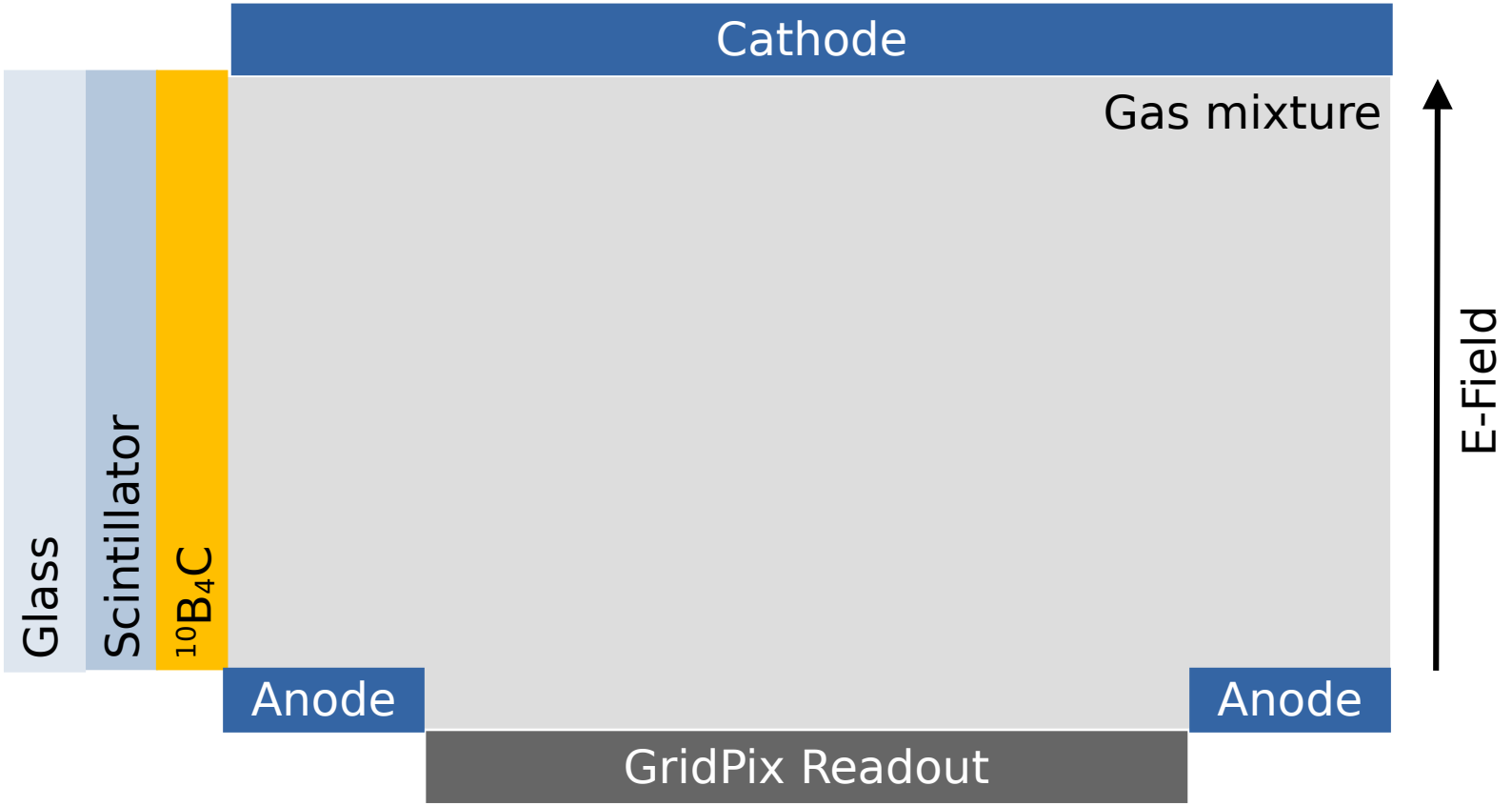

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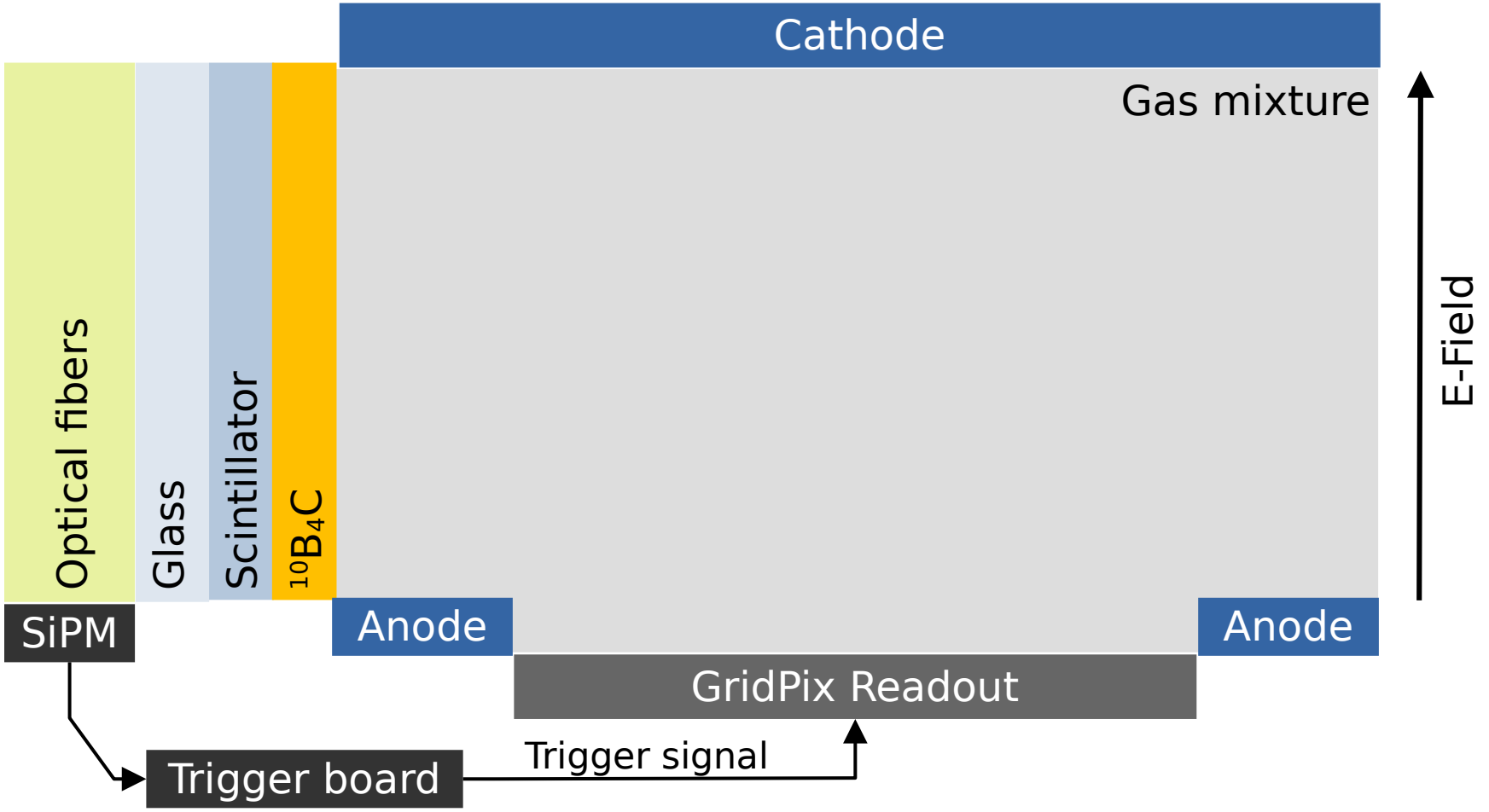

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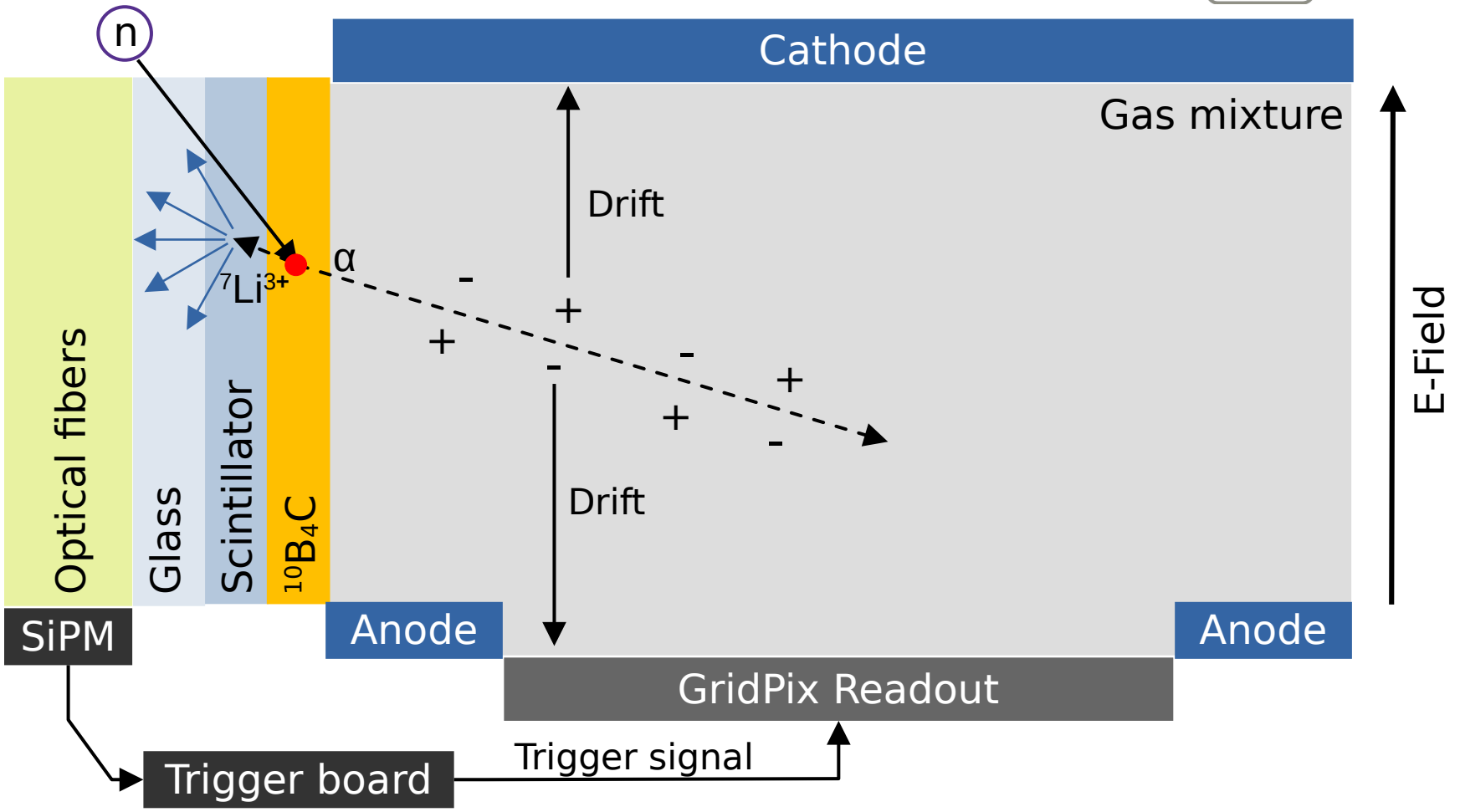
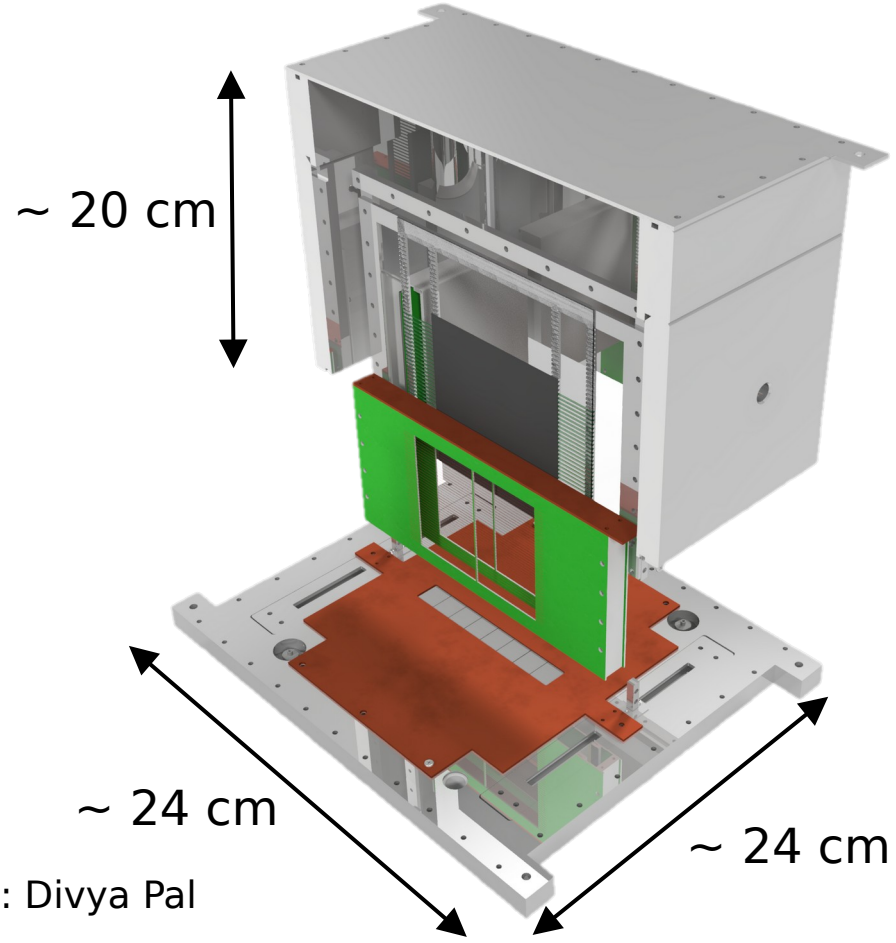


Current detector design



Credit: Divya Pal

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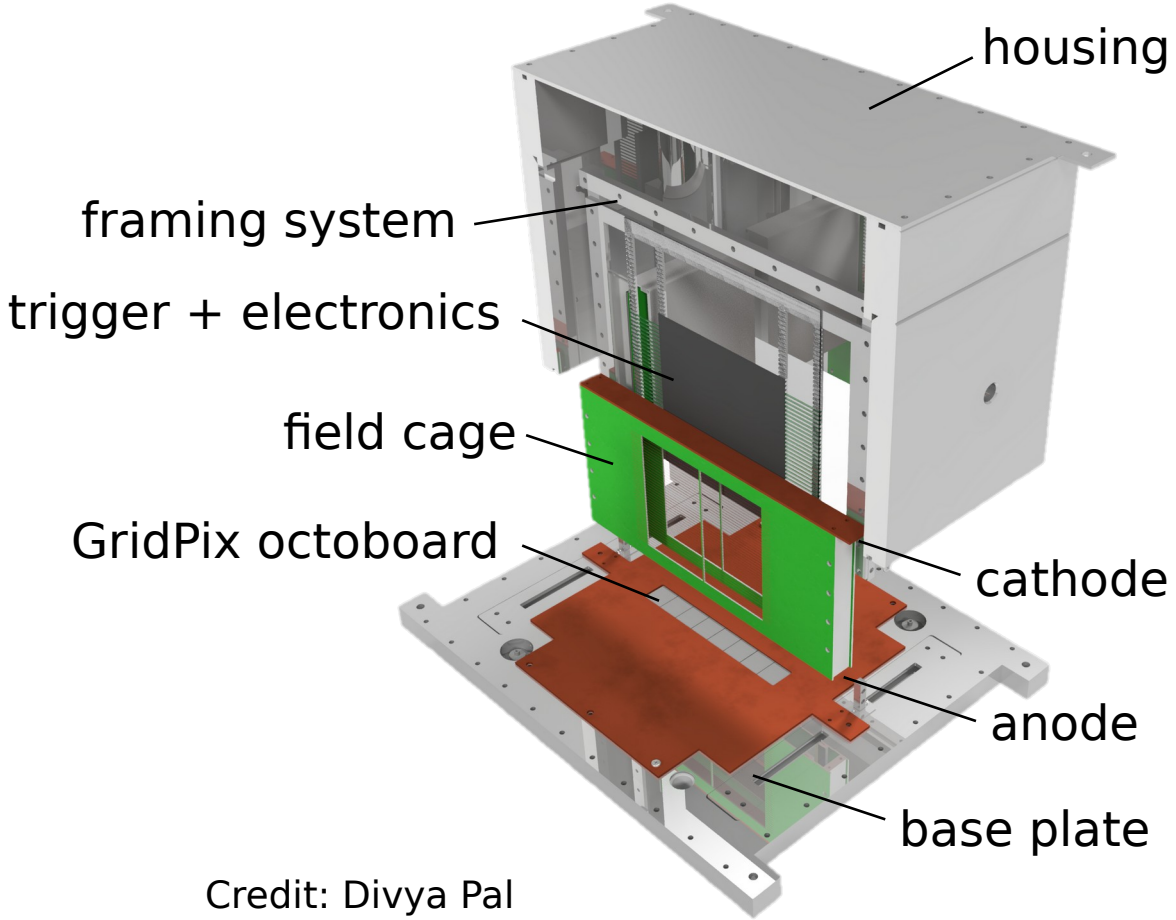

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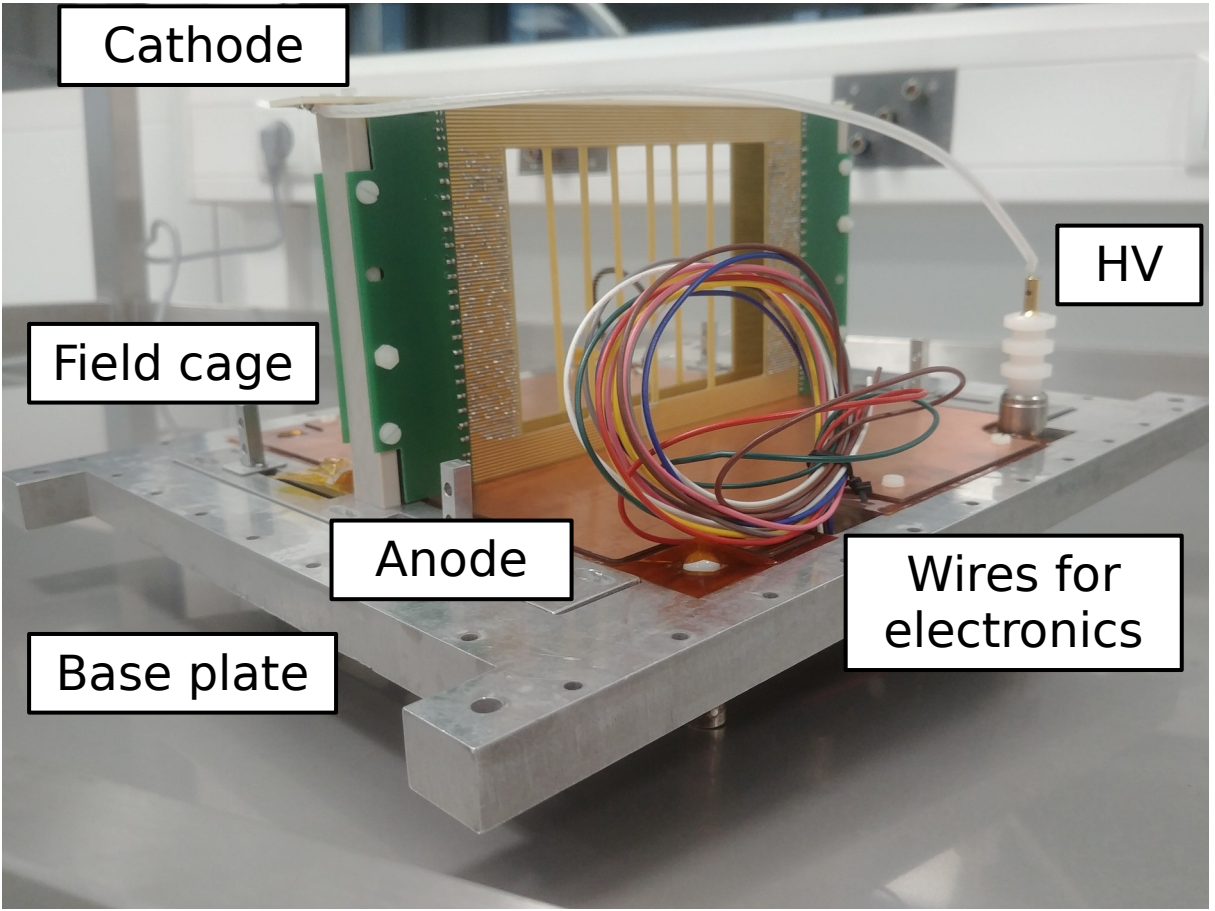

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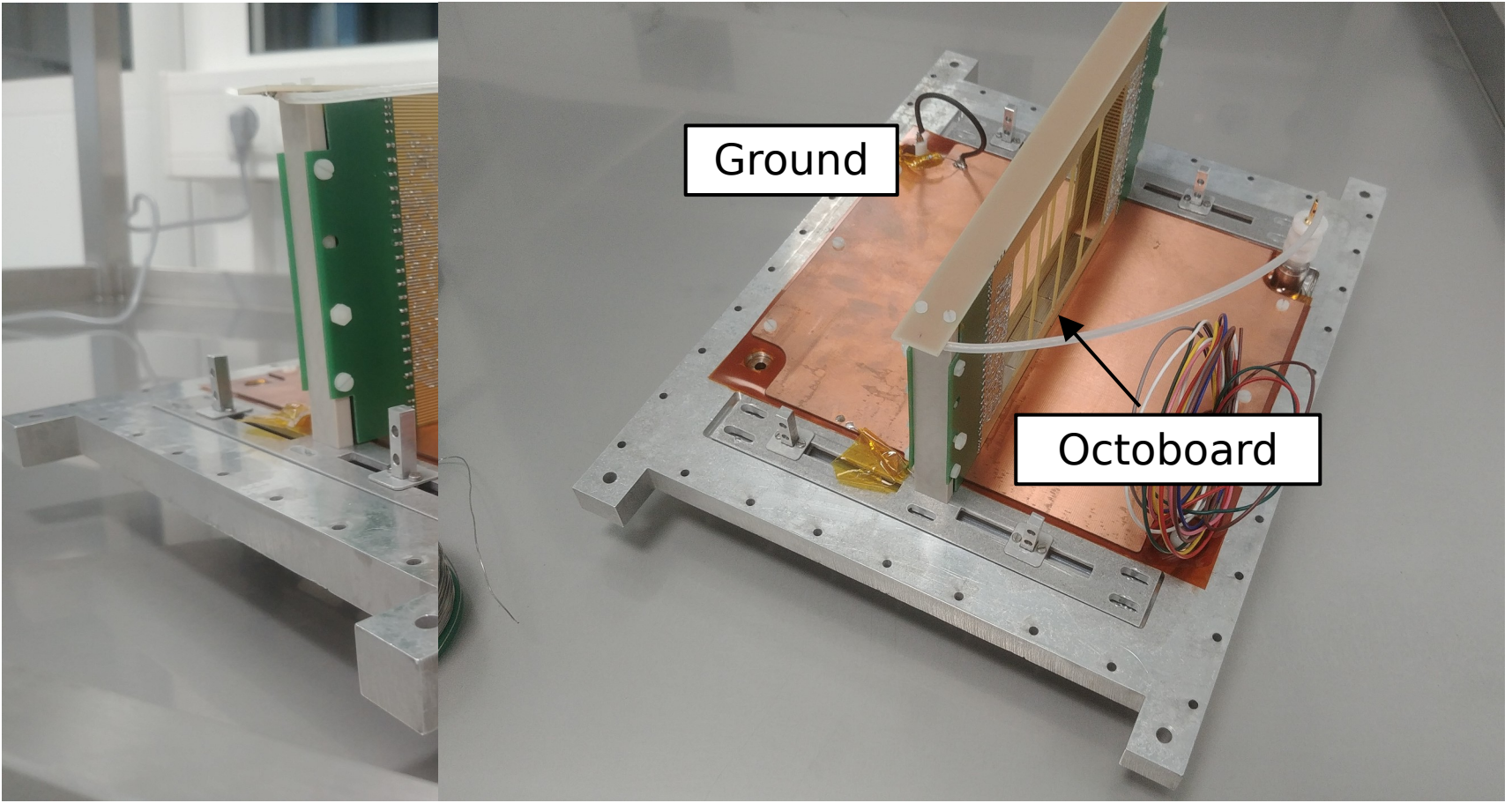

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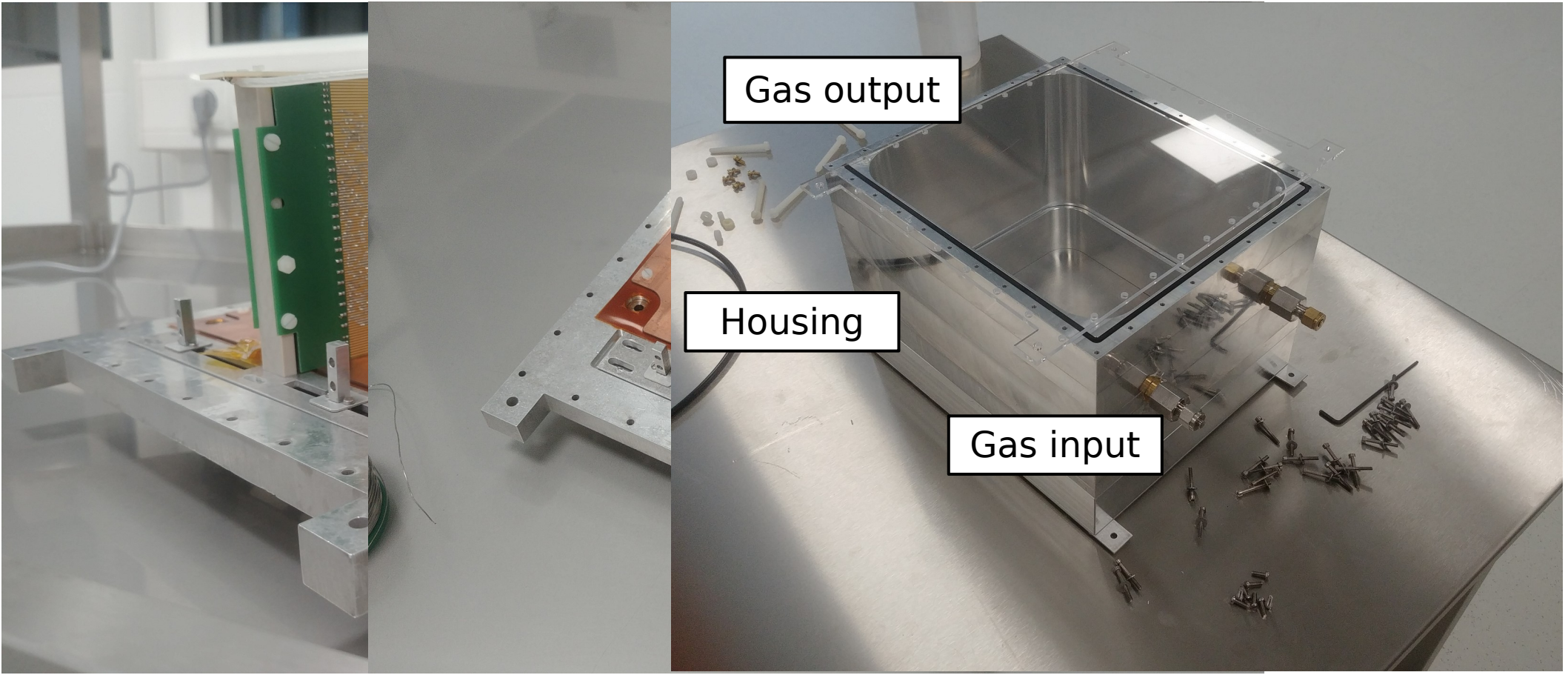

Detector concept – GridPix chip

GridPix =
Timepix ASIC +
Integrated Micromegas grid
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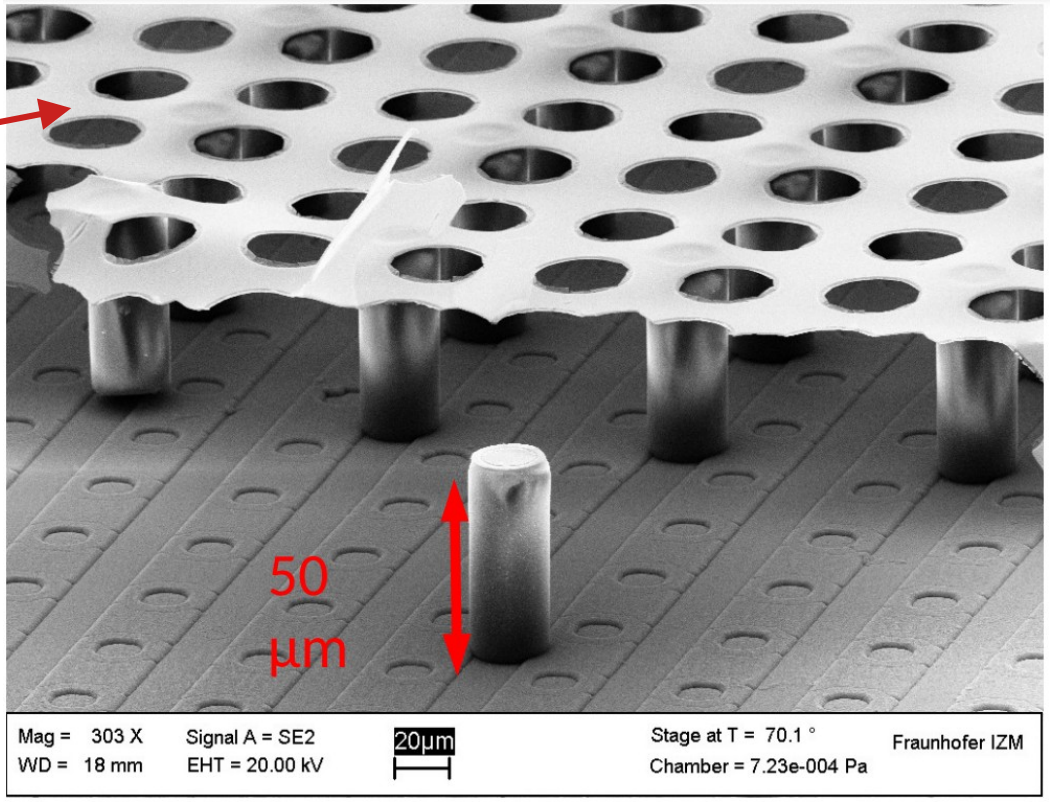

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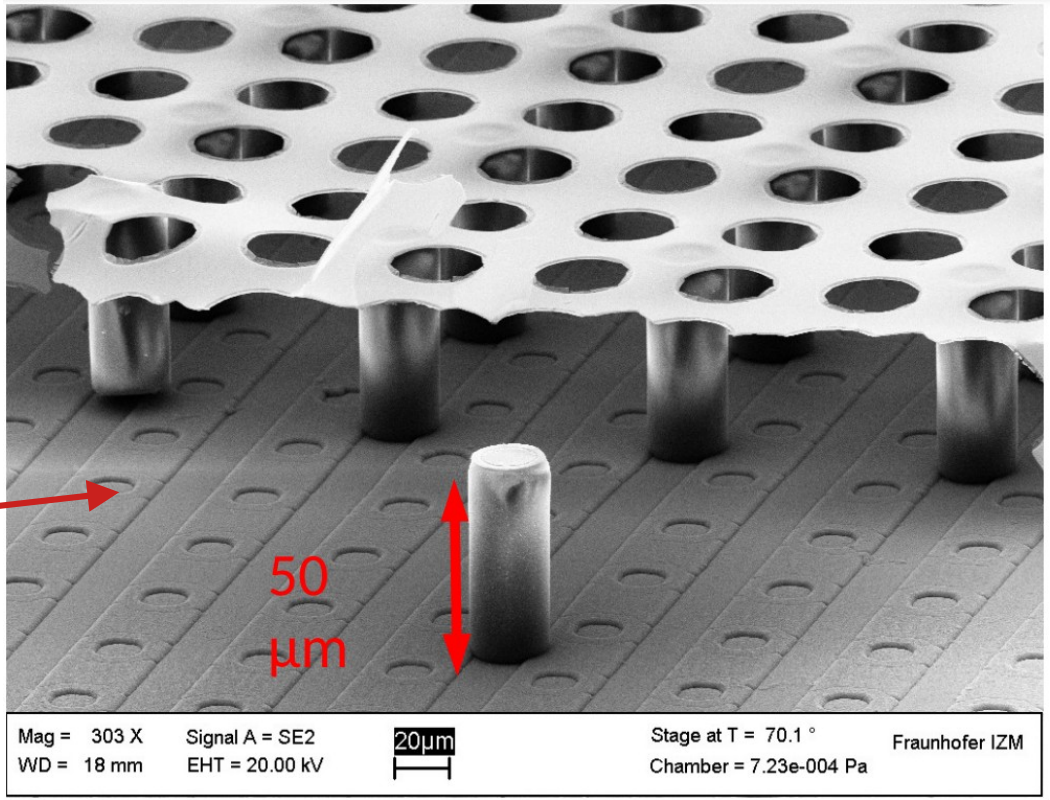
256 x 256 pixels

Pitch: 55 µm

ToT and ToA

Clock frequency: 40/80 MHz



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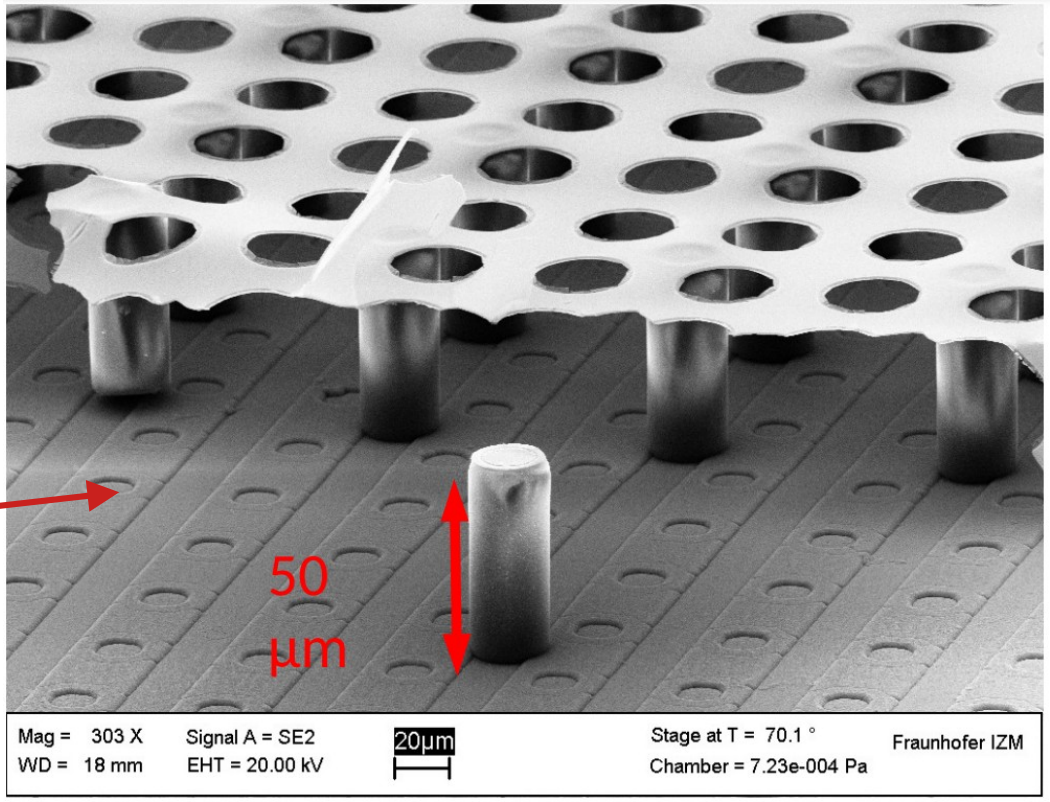
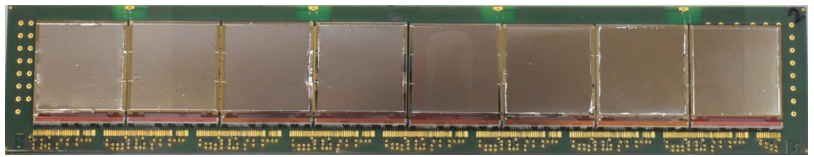


How to produce: Sabine Hartung (T 93.3)

Detector concept – GridPix readout chain

GridPix Octoboard



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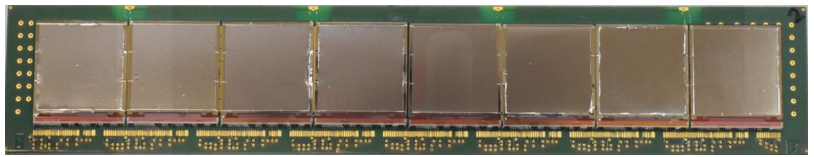
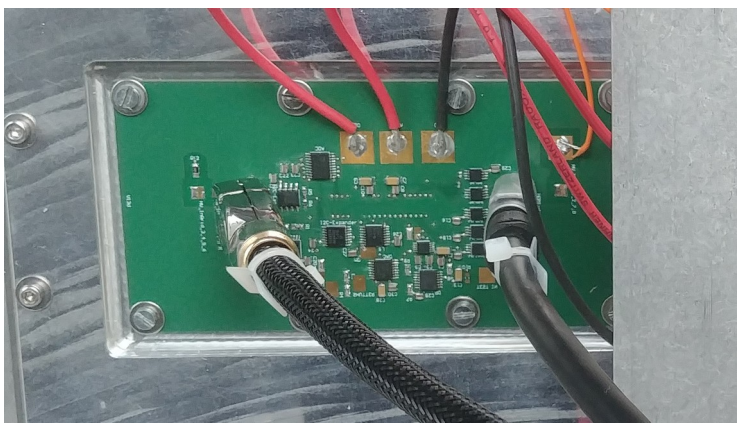


Intermediate board



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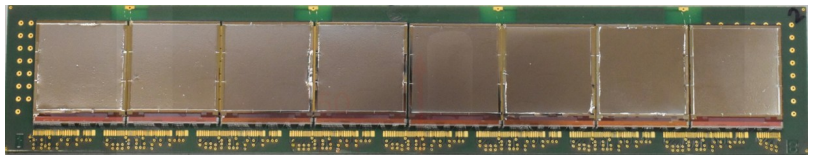

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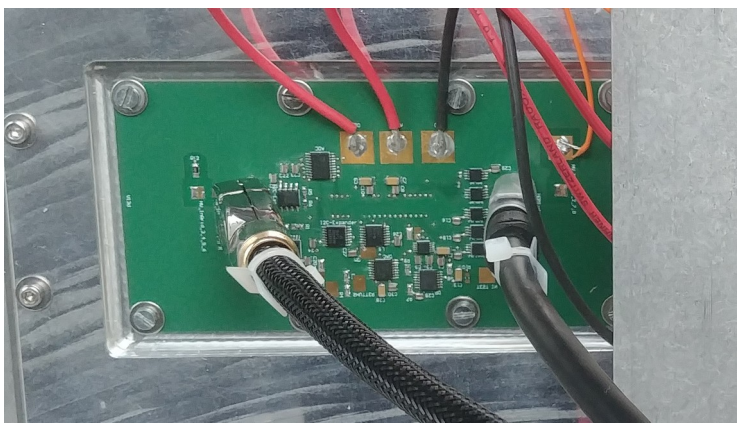

Adapter and concentrator card

Detector concept – GridPix readout chain

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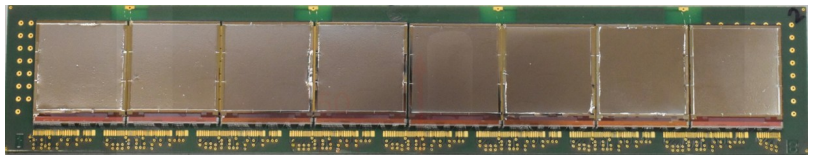

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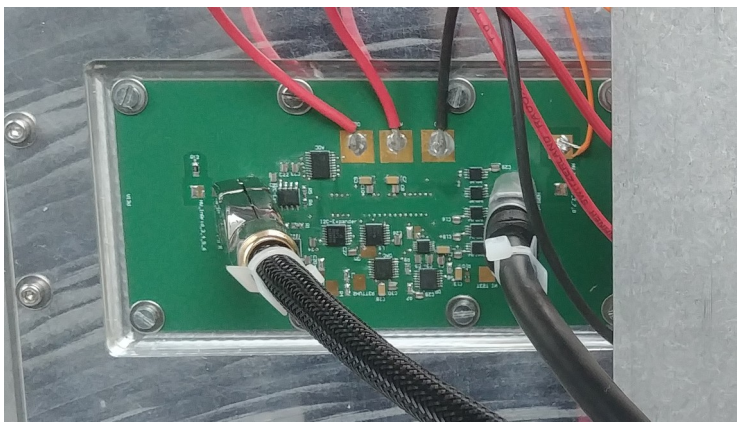
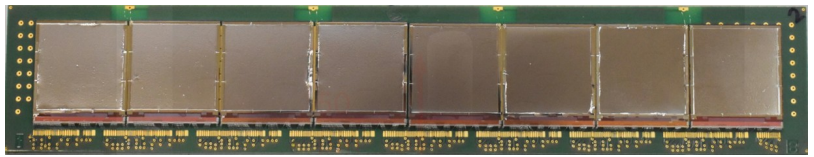


Adapter and concentrator card

PC

Detector concept – GridPix readout chain

GridPix Octoboard



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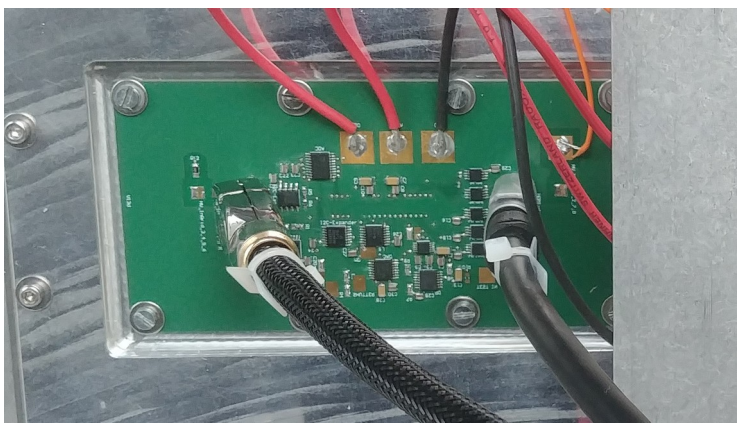

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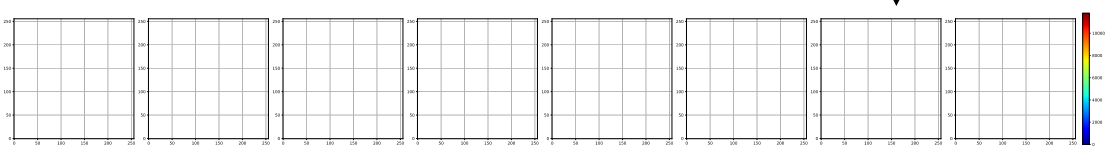
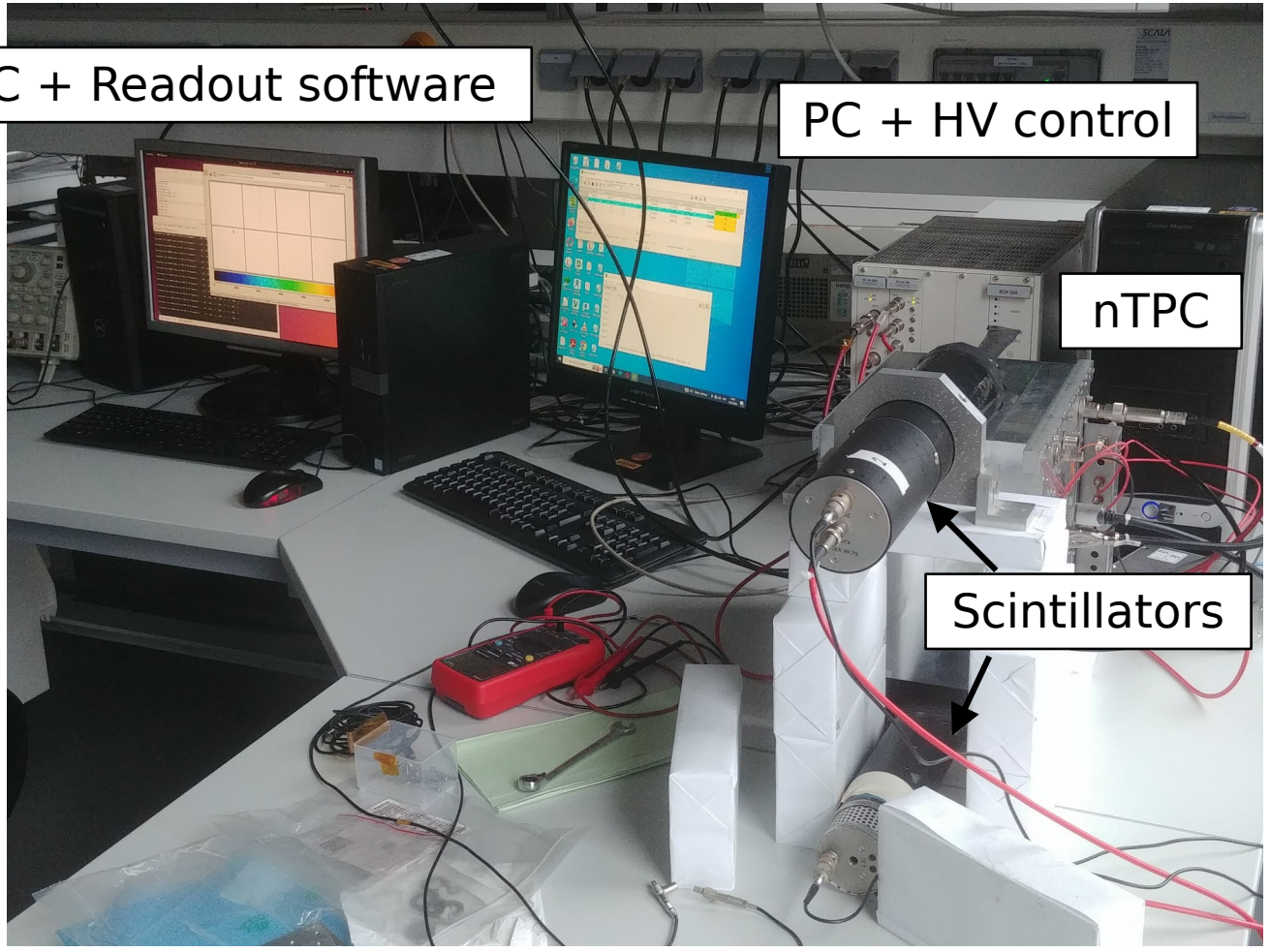
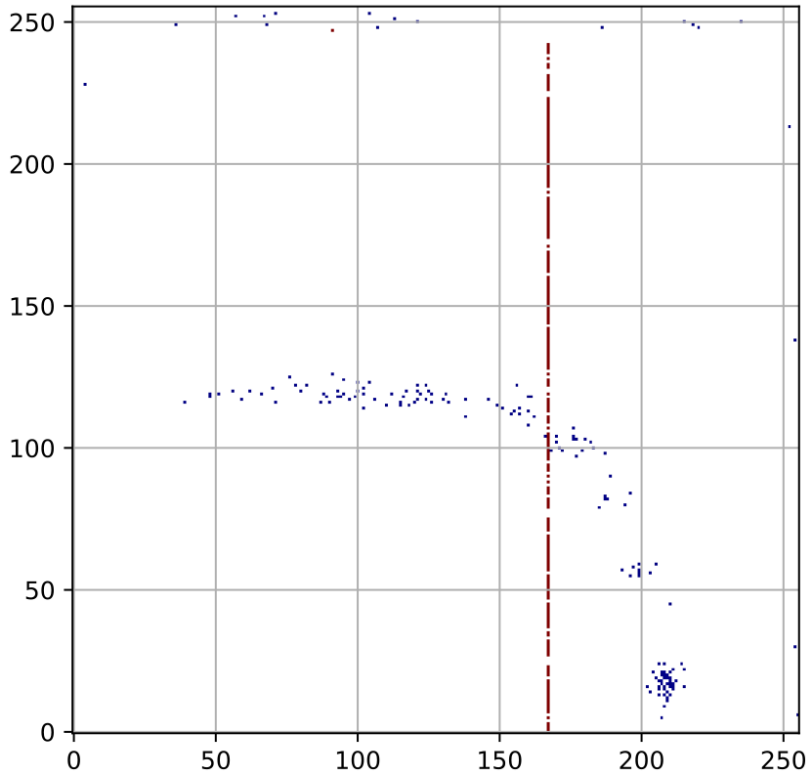


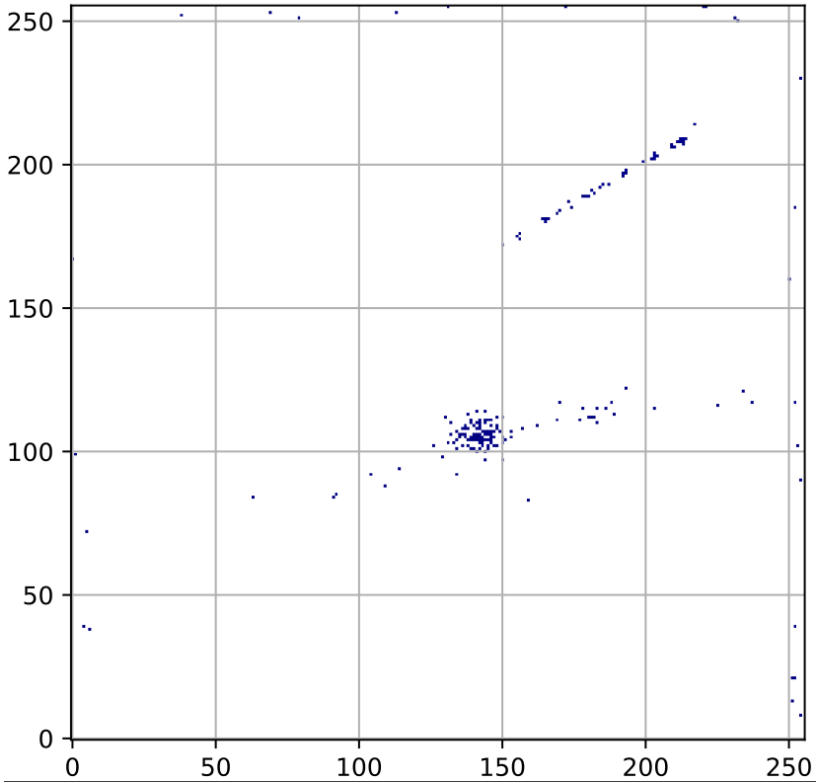
Current setup



Untriggered events - signatures

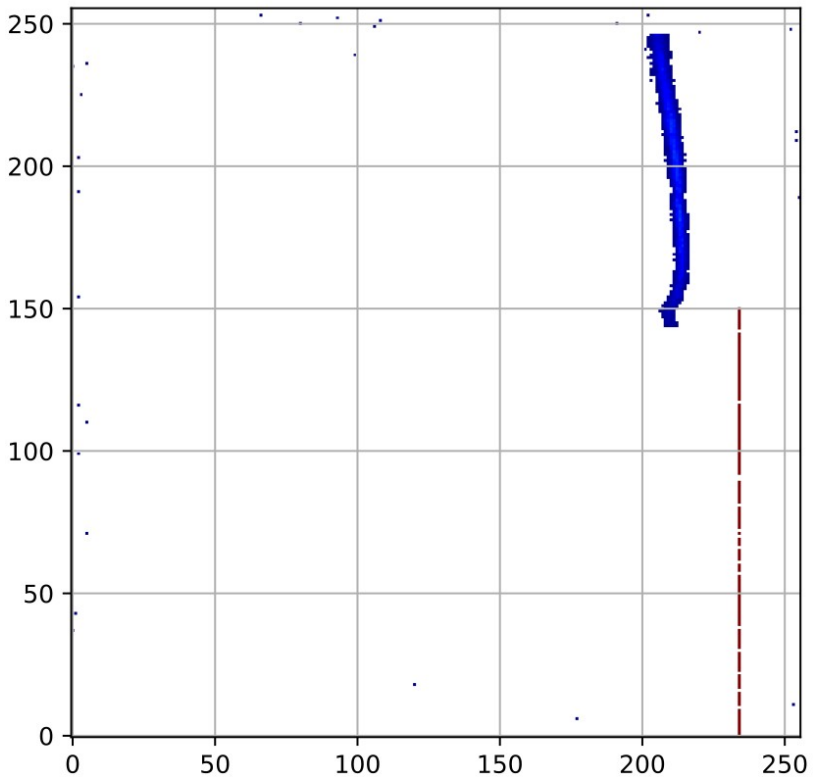
Lightly ionizing particles + Bragg peak

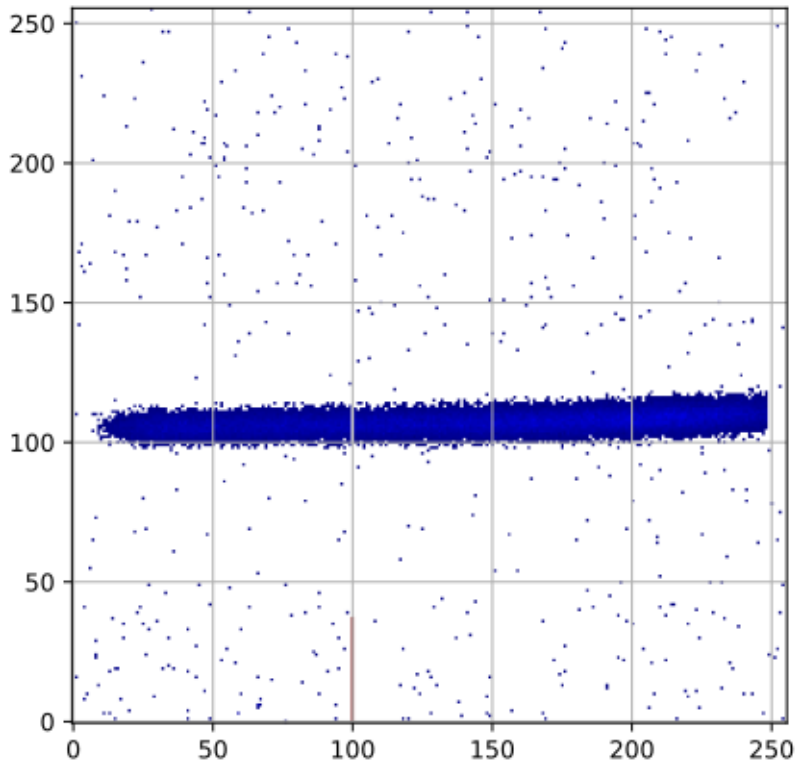




Untriggered events - signatures

Strongly ionizing particles





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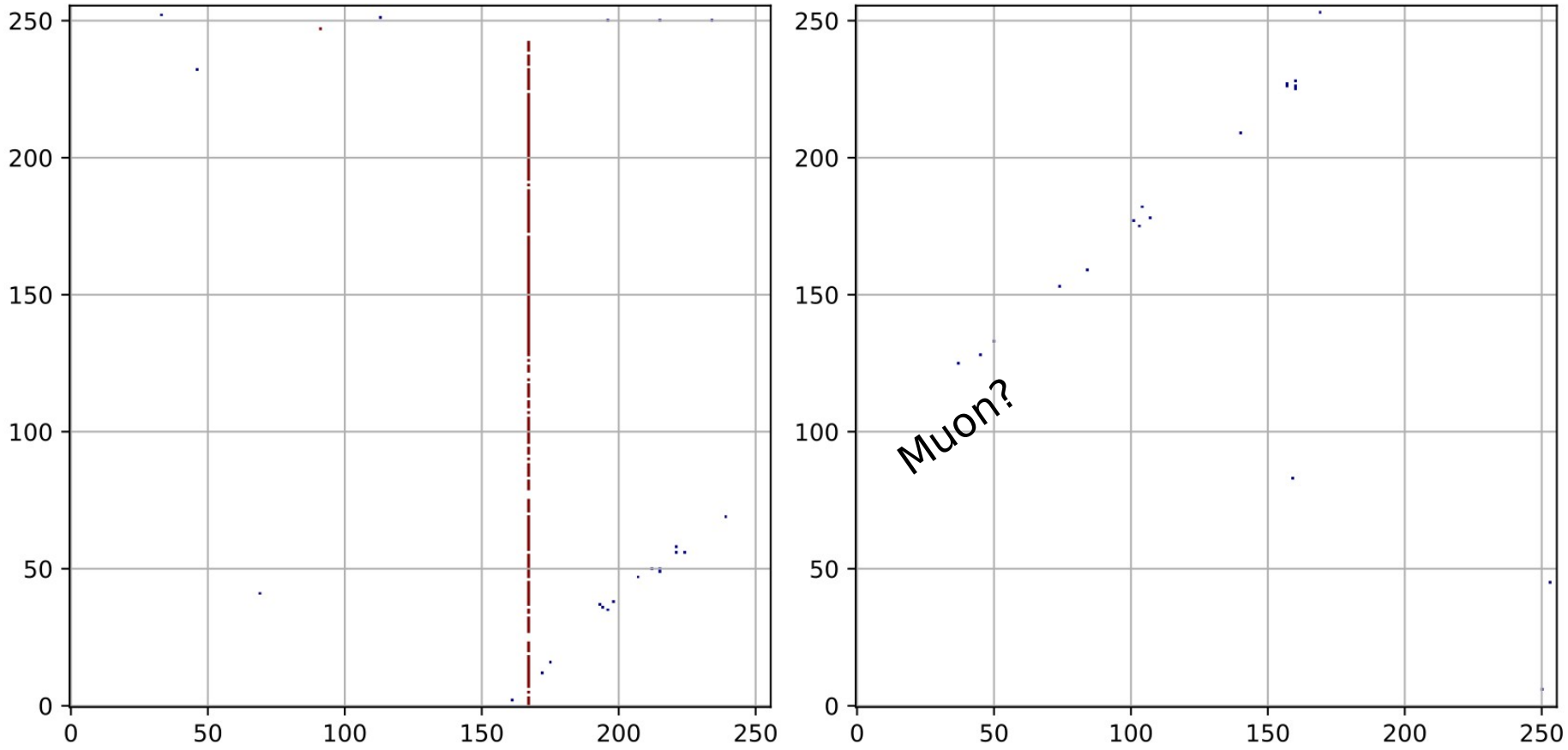


Next steps

Mounting trigger system + Boron converter inside the detector

Beam time! Proof of principle, characterization

Backup

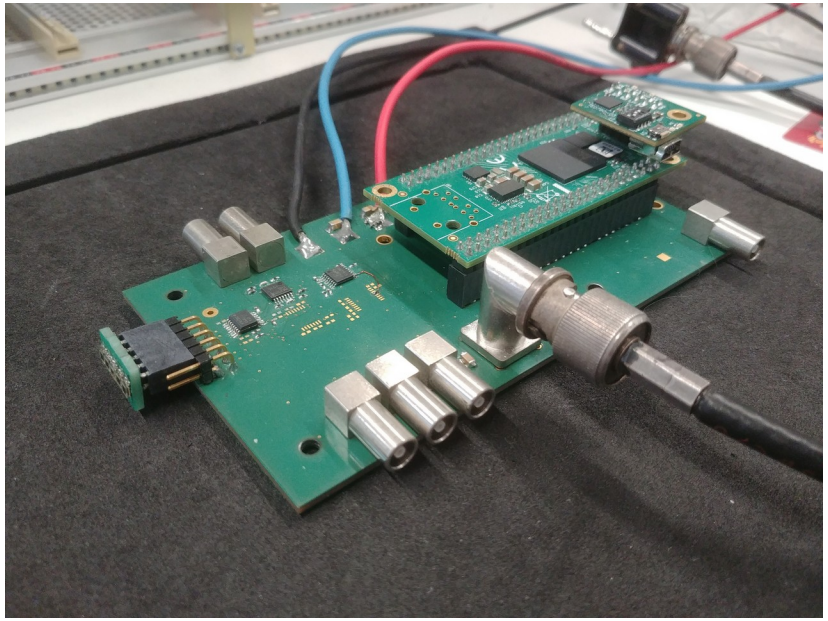
Backup – Name Clarification

BODELAIRE stands for:

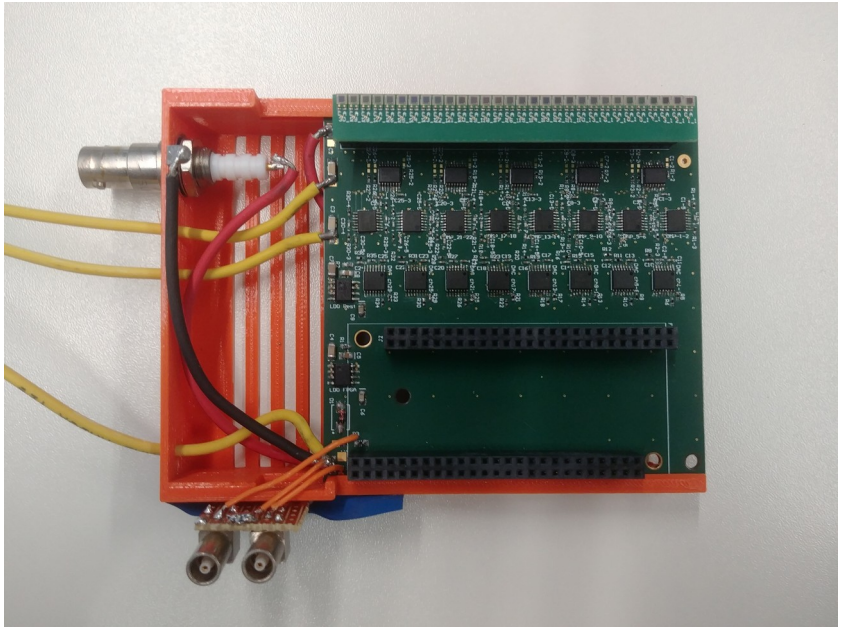
Boron **De**tector with **L**ight **a**nd **I**onization R**e**construction

Backup – Trigger boards

4 channels



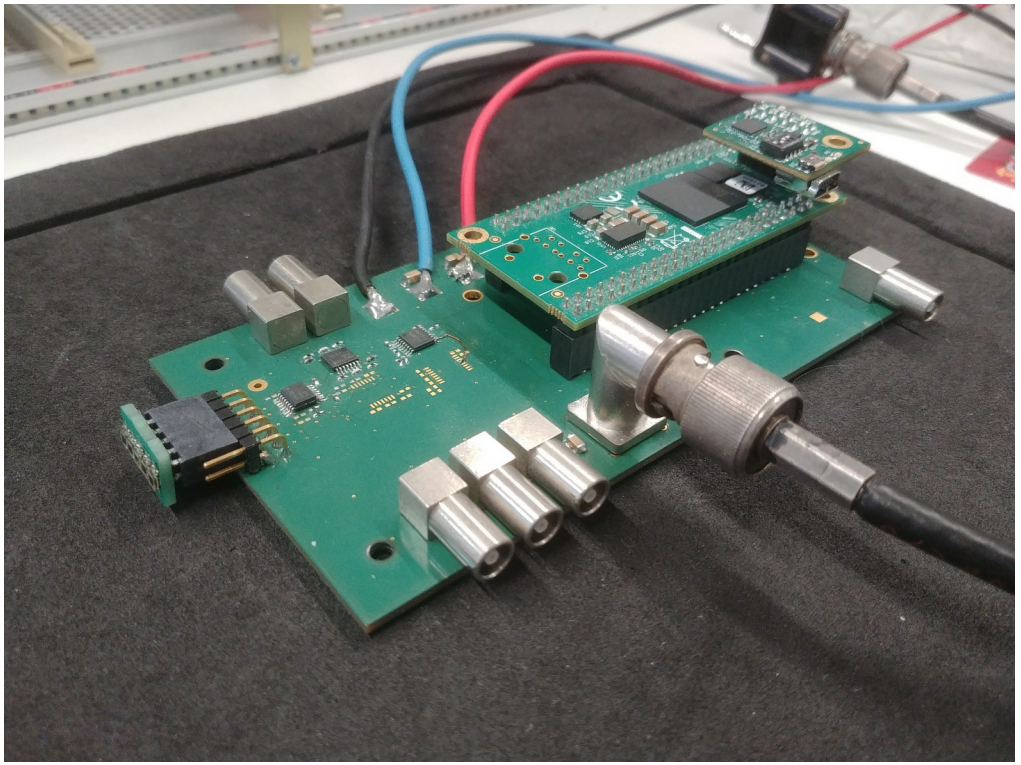
30 channels



Backup – 4ch Trigger board

Board powering

Artix-7
FPGA Board



Amplifier output

SiPMs

USB to PC

Trigger out

SiPM bias voltage

Backup – Trigger board control

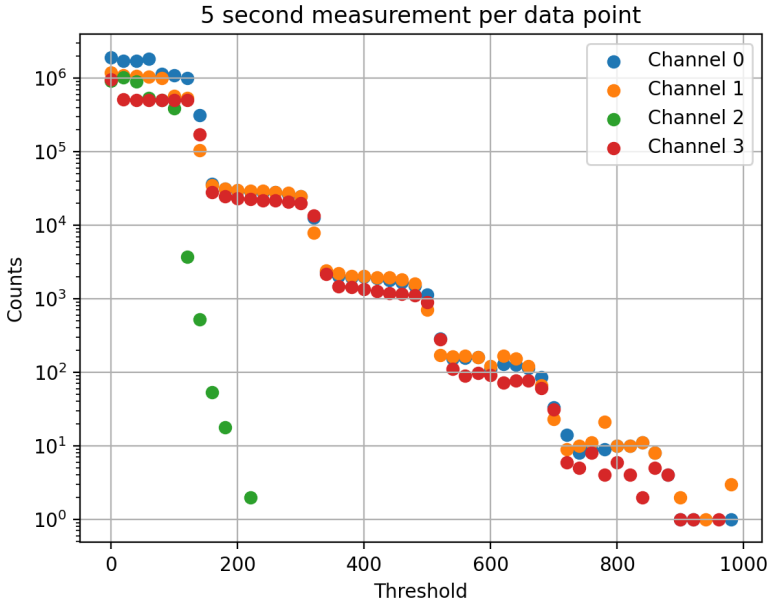
Python script

```
tpc@tpc09: ~/nTPC/Trigger/FPGA codes/SiPM_...
Menu
[ ] - Initialize board
[ ] - Start trigger
[ ] - Stop trigger
[ ] - Set DAC register values
[ ] - Start a threshold scan
[ ] - Quit the application
```

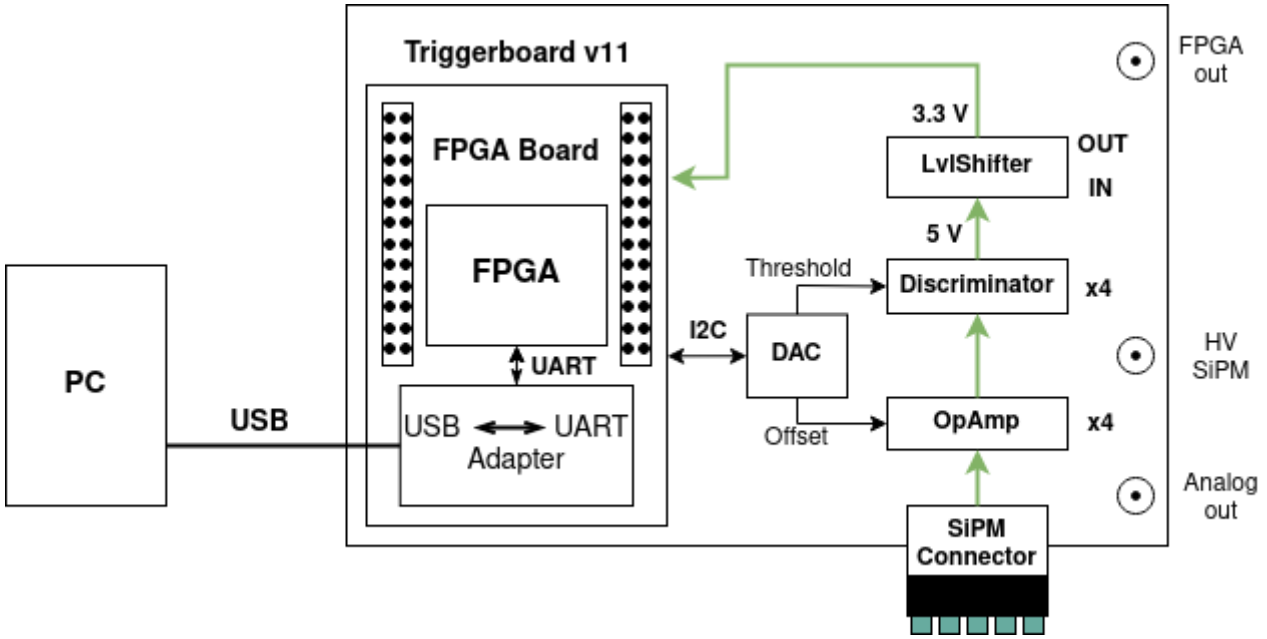
```
tpc@tpc09: ~/nTPC/Trigger/FPGA codes/SiPM_...
Here you can set values for different DAC registers

   Channel   Value    New
=        1      25  [     ]
T        2      28  [124  ]
h        3      22  [     ]
r        4      85  [     ]
=
============================
=        1      13  [     ]
O        2      32  [     ]
f        3      43  [     ]
f        4      20  [     ]
=

          << 1/1 >>

     [ ] save to file
     [ ] load from file
     [ ] exit
```

```
tpc@tpc09: ~/nTPC/Trigger/FPGA codes/SiPM_...
Start a threshold scan

Start   0       [     ]
Stop    4095    [     ]
Step    1       [     ]

          [ ] start

          [ ] exit
```

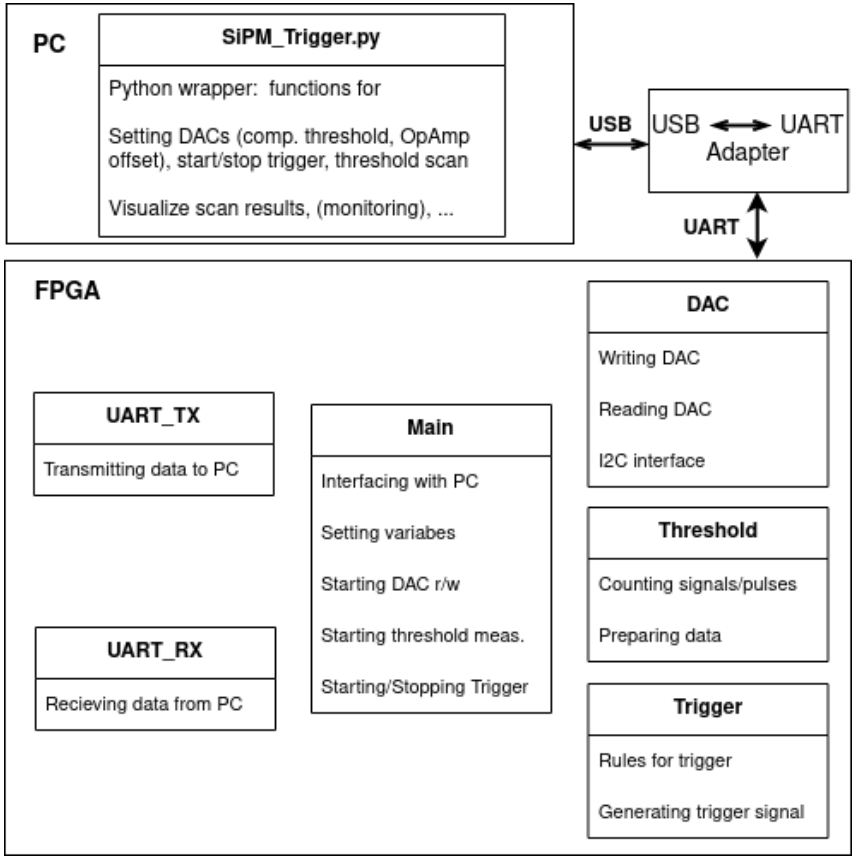
Threshold scan with dark counts



Backup – Trigger board schematic

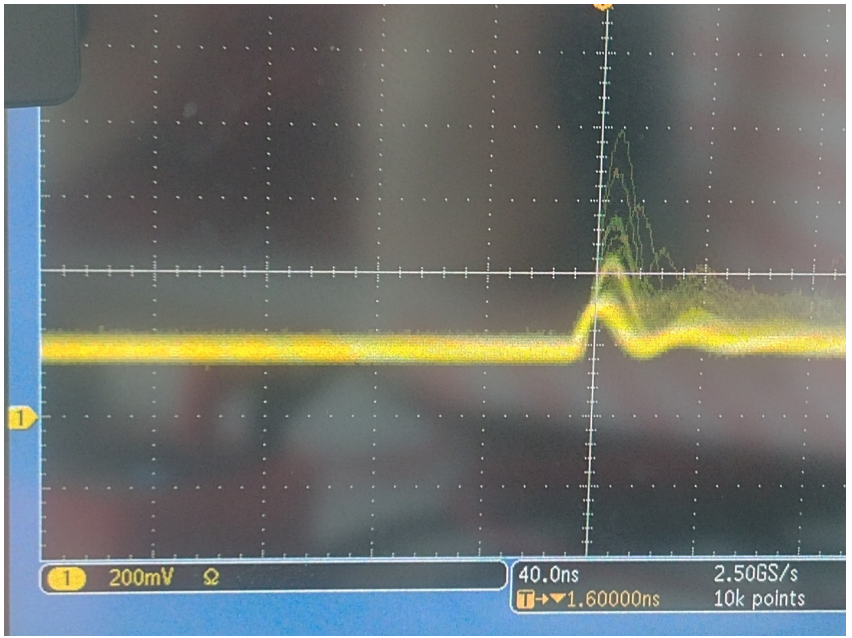


Backup – FPGA firmware + Interface



Backup – SiPM amplifier output

cross talk and afterpulses



threshold scan with dark counts