Novel Neutron Detector Developments

Three Detectors for Neutron Science

Deutsche Neutronenstreutagung 2024 - Aachen

17.09.2024

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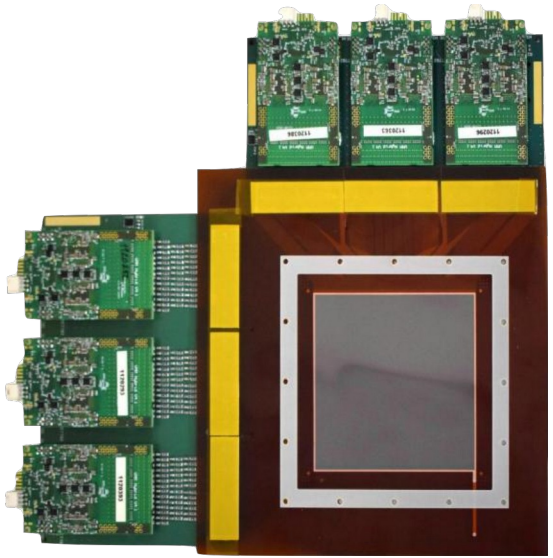
[2]Ruprecht-Karls-Universität Heidelberg
[3]StyX Neutronica GmbH, Mannheim

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Detector Developments at University of Bonn

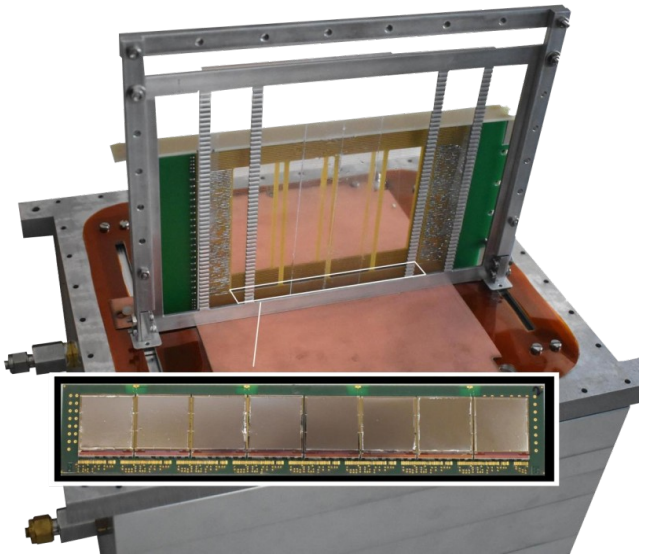
UNIVERSITÄT BONN

Boron lined GEM &
Multichannel Readout



Neutron sensitive
Microchannel Plate &
Timepix3 readout

Neutron Time
Projection Chamber



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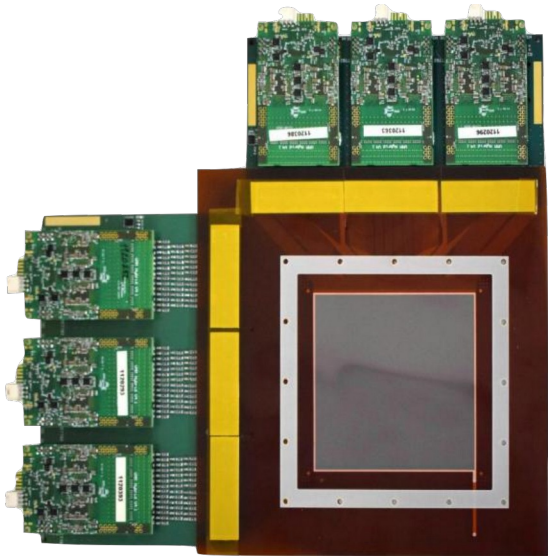
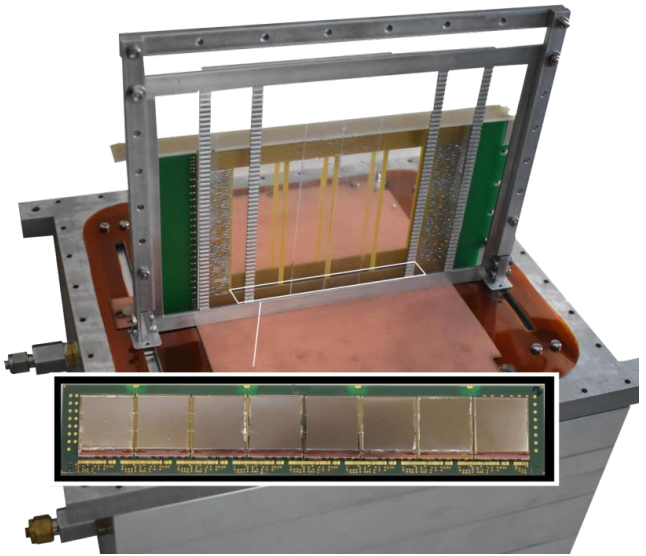


CASCADE – like detector
(patent EP 00 122 360.1)

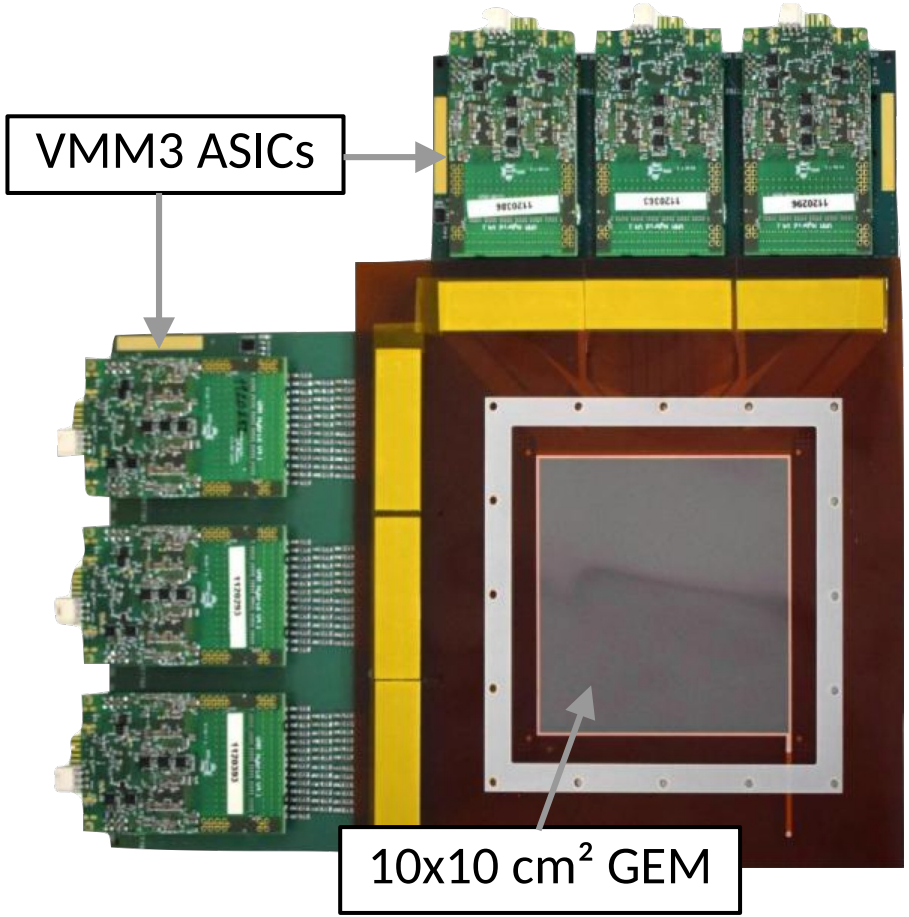
Neutron sensitive Microchannel Plate & Timepix3 readout

Upgrade of neutron senstive MCP/Timepix detector,
K. Watanabe et al. (2017)

Neutron Time Projection Chamber



Boron bAsed MultiSTAge TRacking Detector (BASTARD)



Readout	2 x 3 VMM3a Hybrid ASIC
Hit Rate	10 MHz
Conversion via	Boron-lined GEM
Active Area	10 x 10 cm²
Resolution	~ 100 µm

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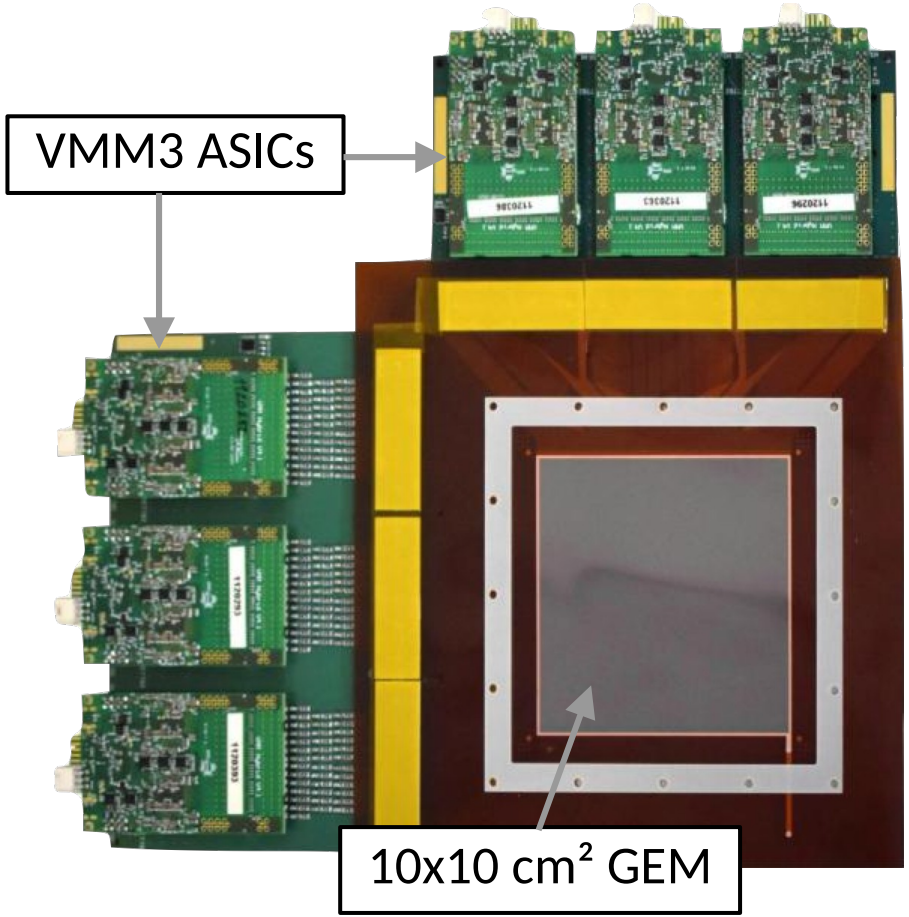

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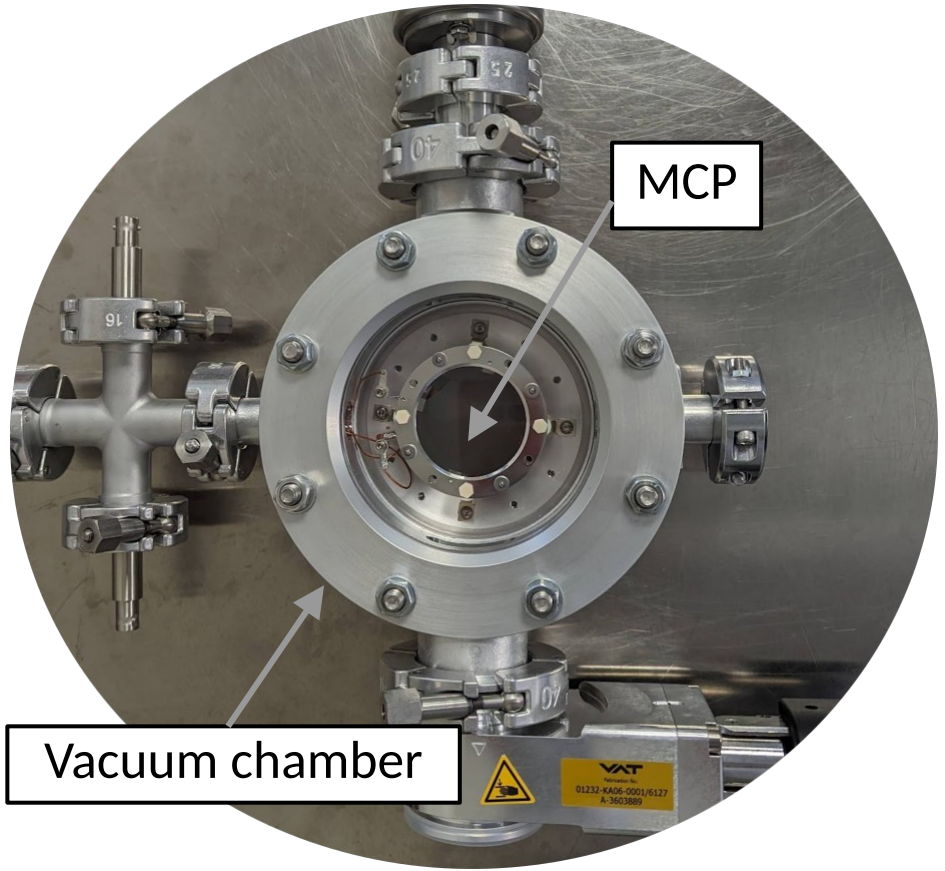
More infos:

See poster by

Jan Glowacz

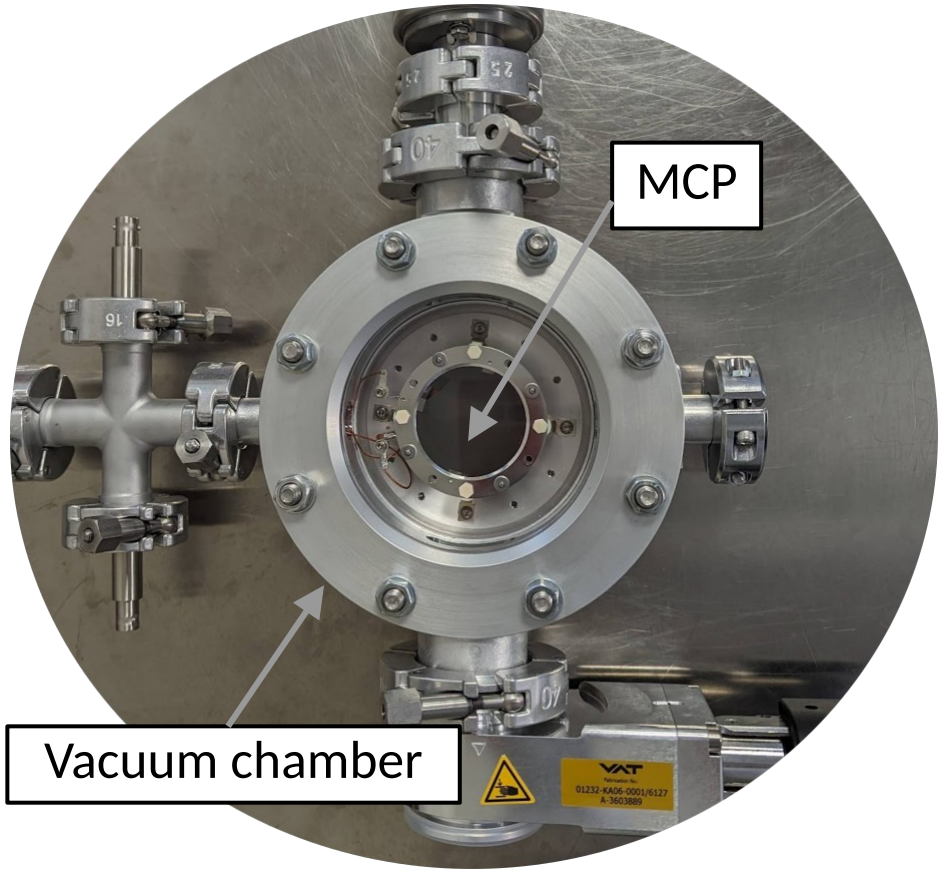
contribution #84

Neutron Microchannel Plate (nMCP)



Readout	2 x 2 Timepix3 ASIC
Hit Rate	Max. 40 Mhits/cm²/s
Conversion via	^{10}B & $^{155/157}$Ga doped MCP
Active Area	2.8 x 2.8 cm²
Resolution	< 50 µm

Neutron Microchannel Plate (nMCP)



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More infos:

See poster by Saime Gürbüz contribution #87

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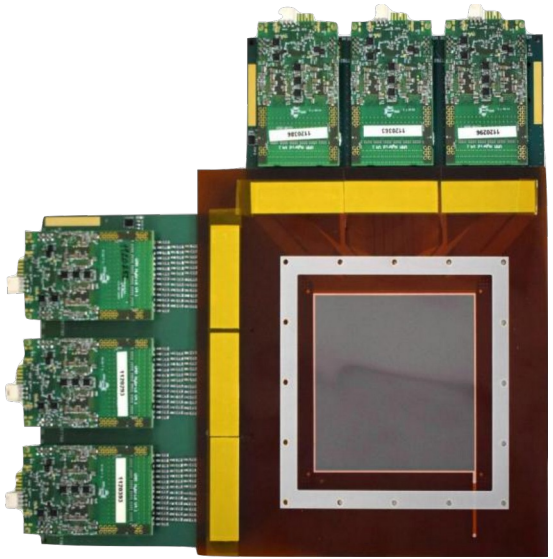

Neutron sensitive
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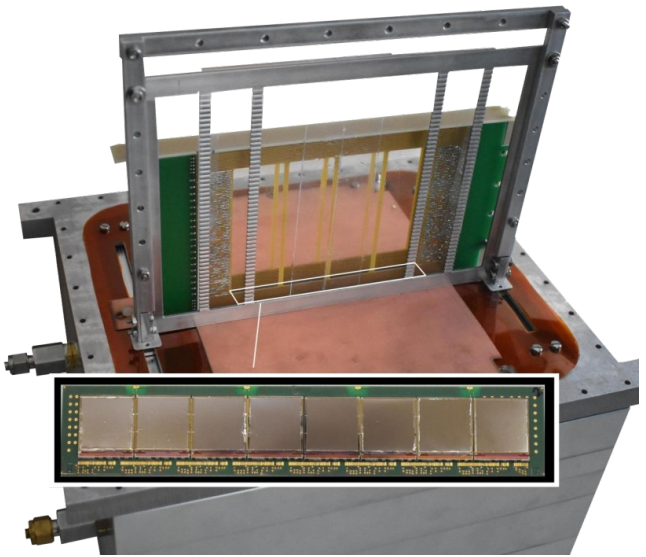
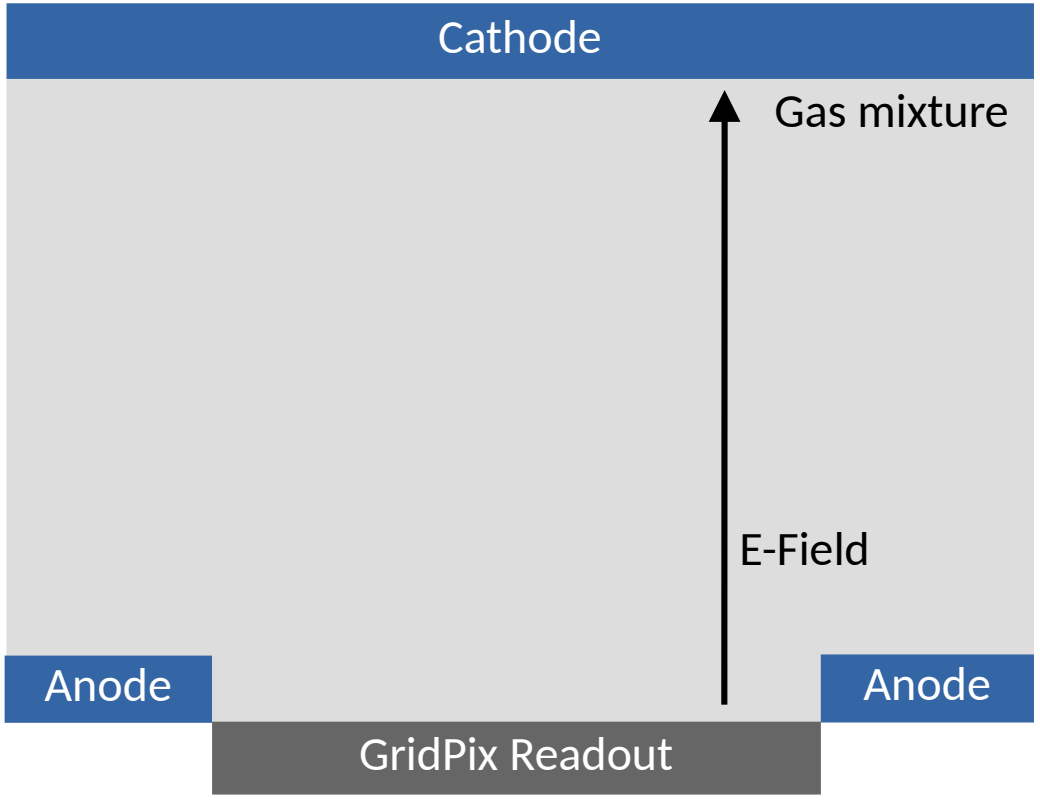


Detector Concept



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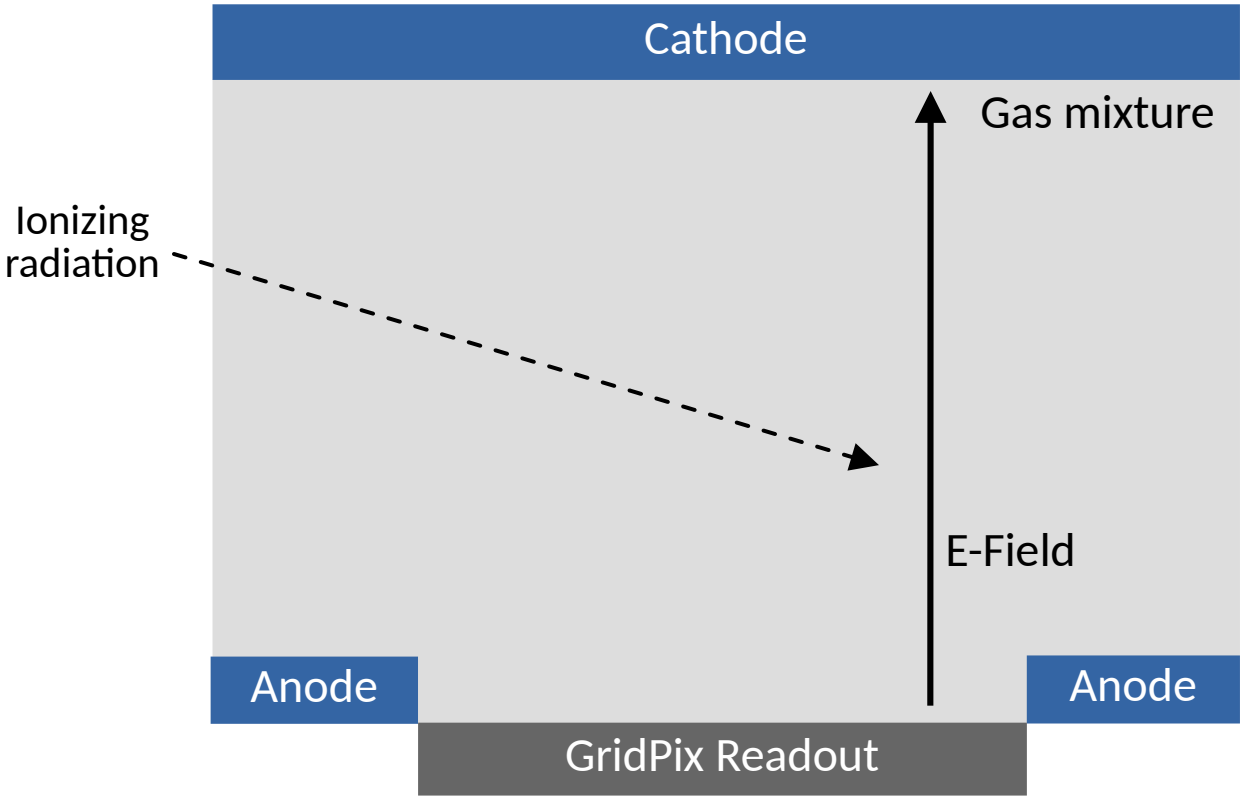

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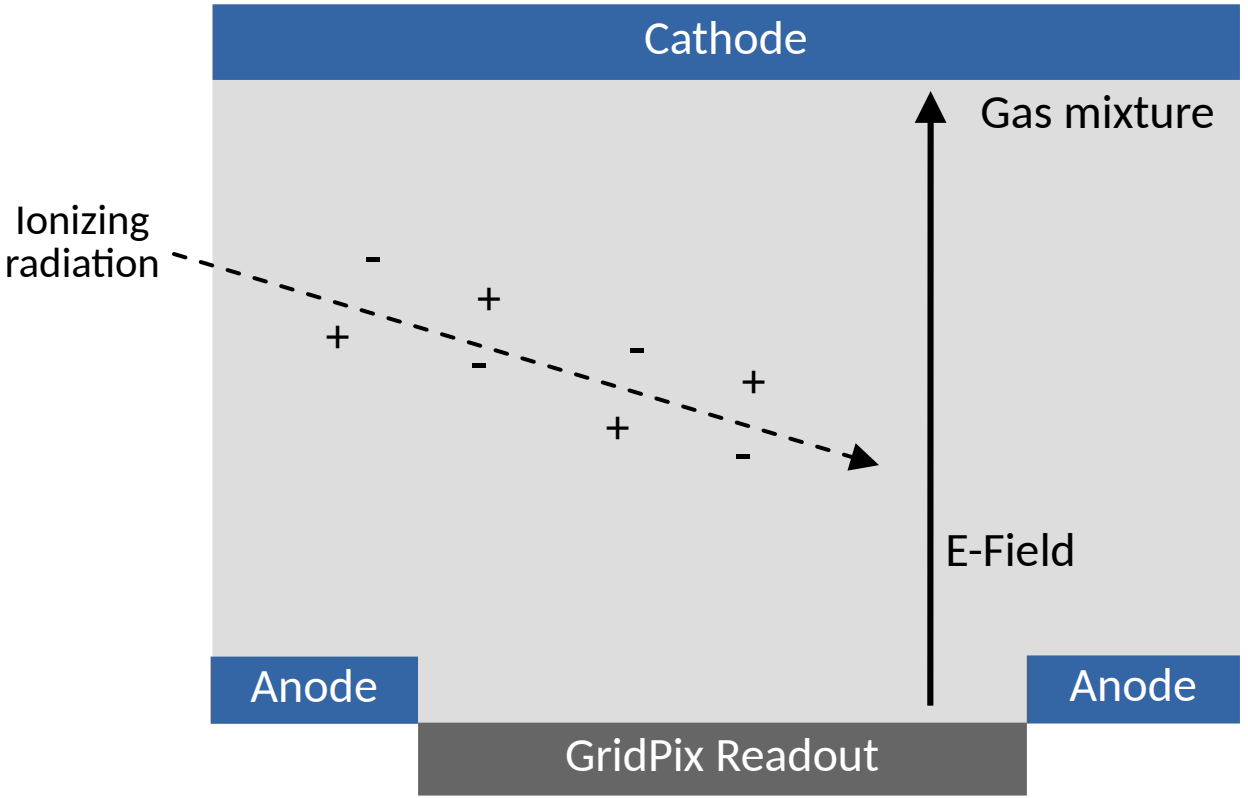
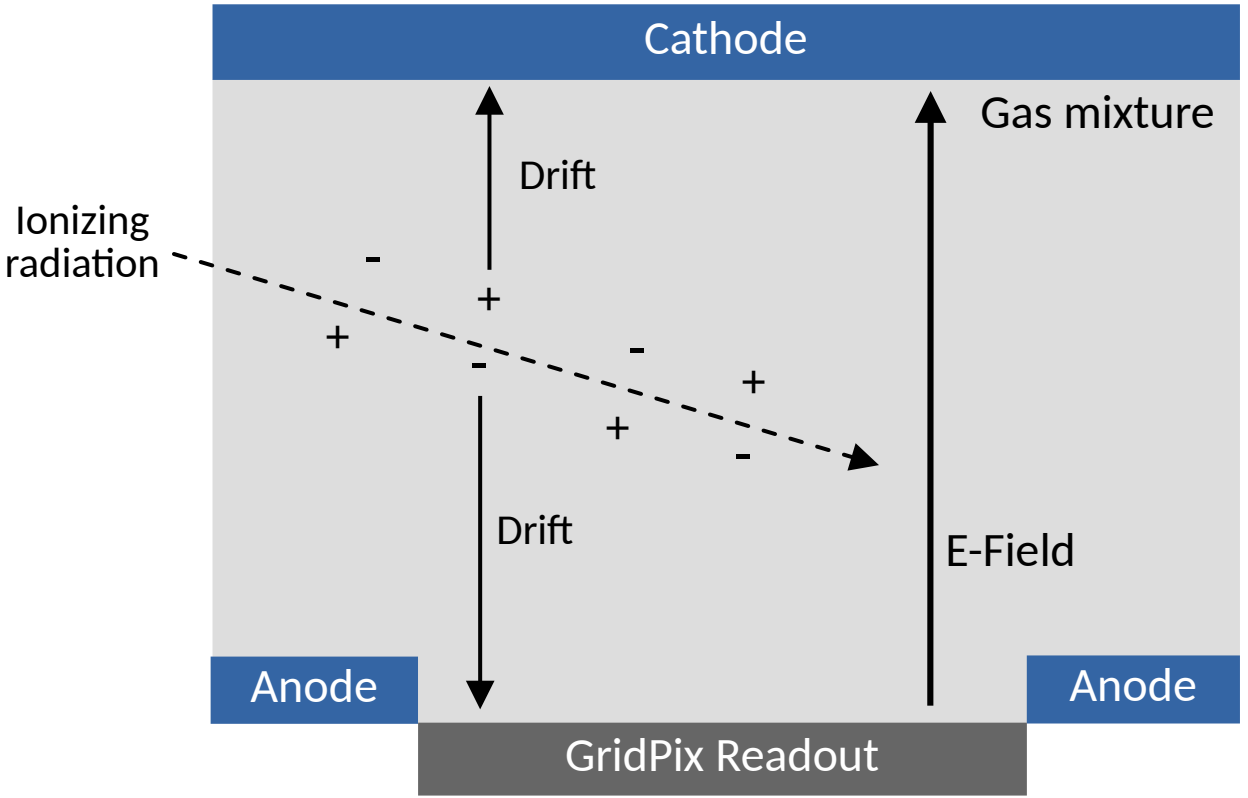
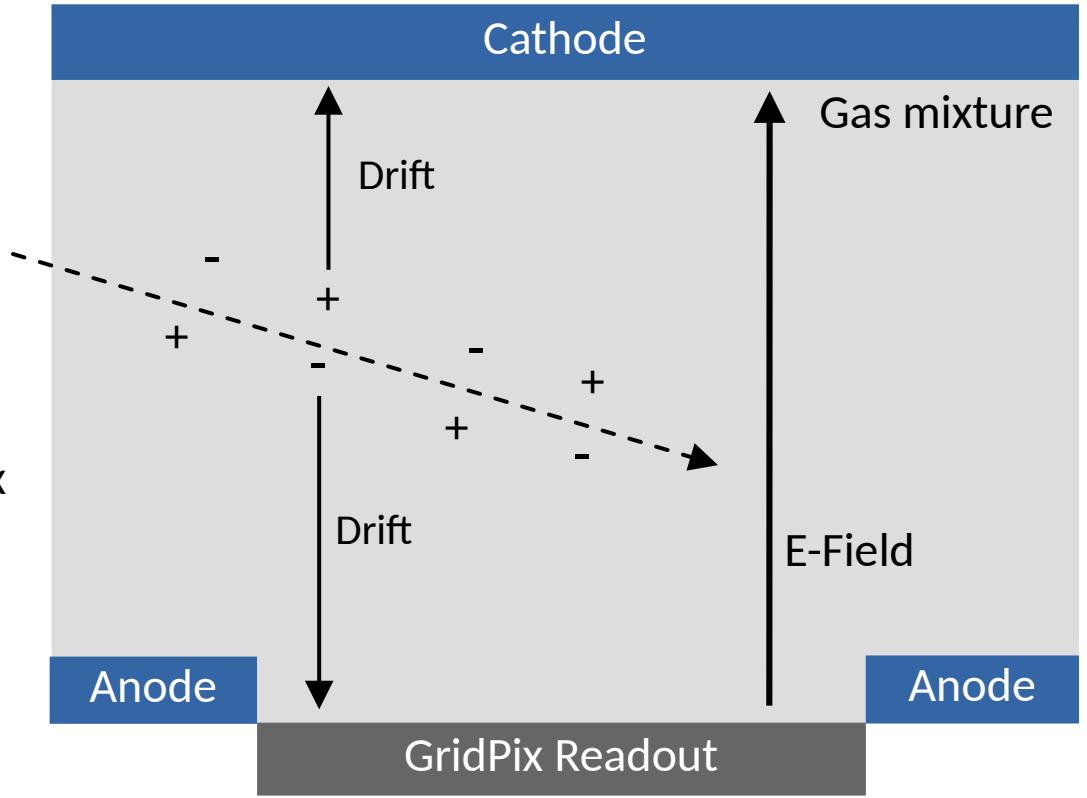


Detector Concept



Detector Concept

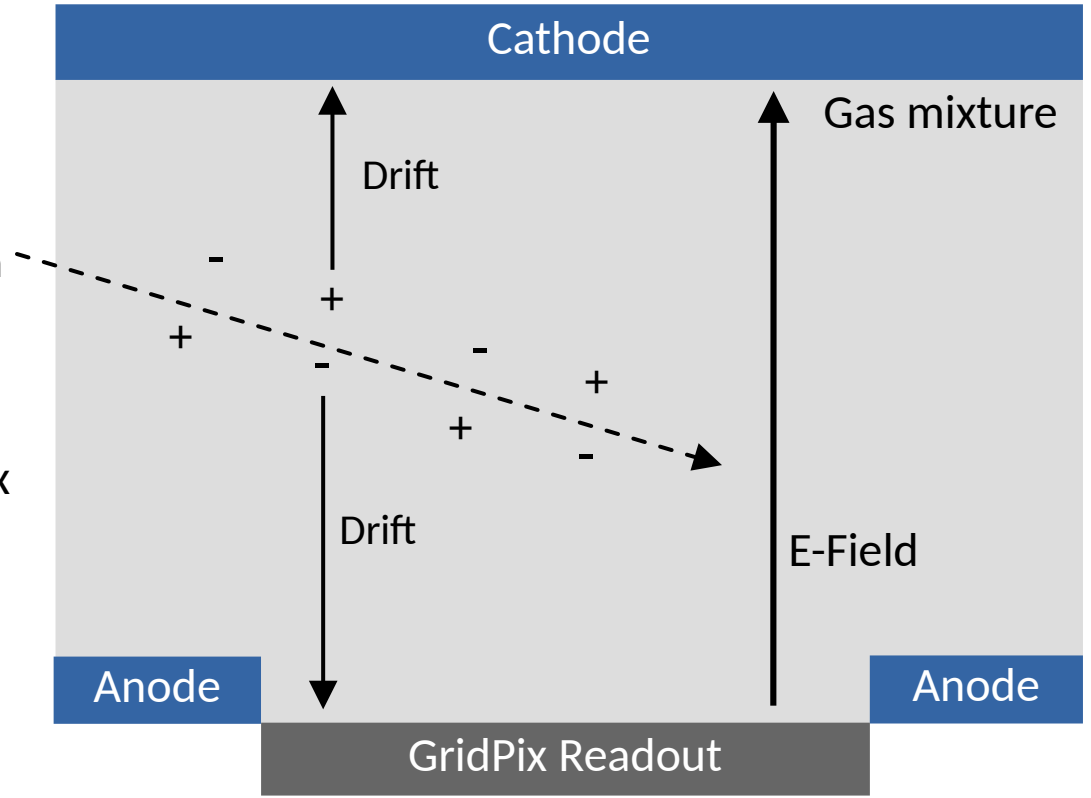


Detector Concept

x-y-coordinates:

pixel positions on chip matrix

$$z = v_{drift} \cdot t_{drift}$$



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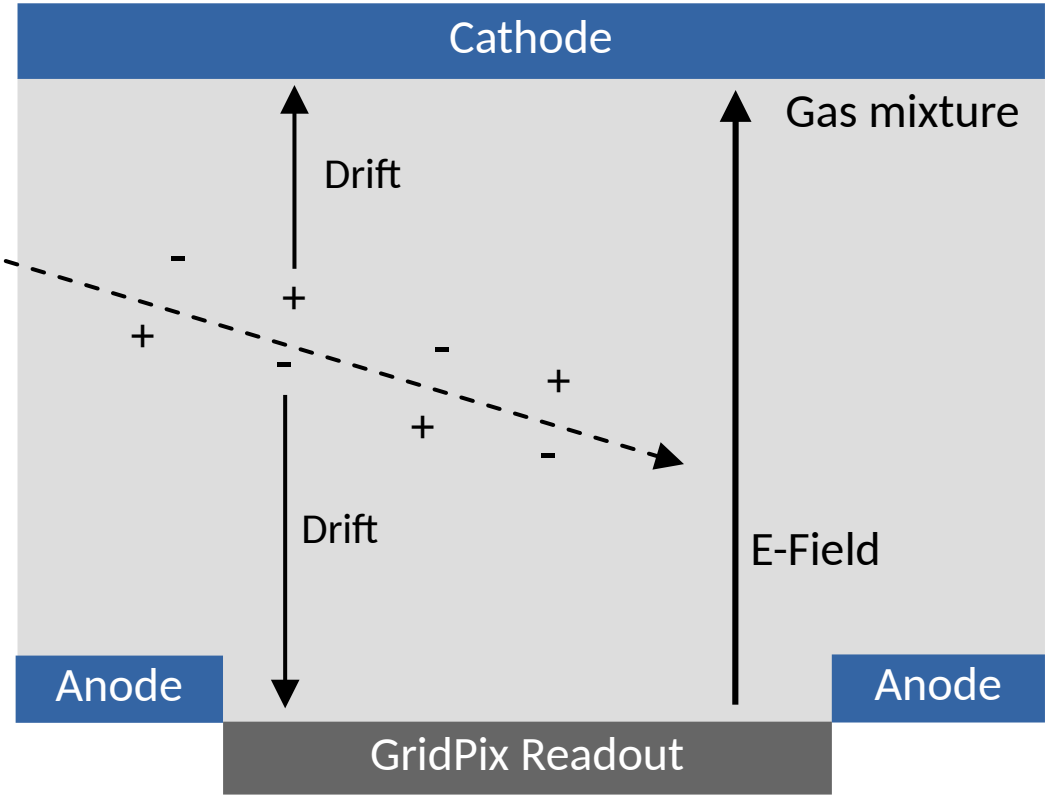


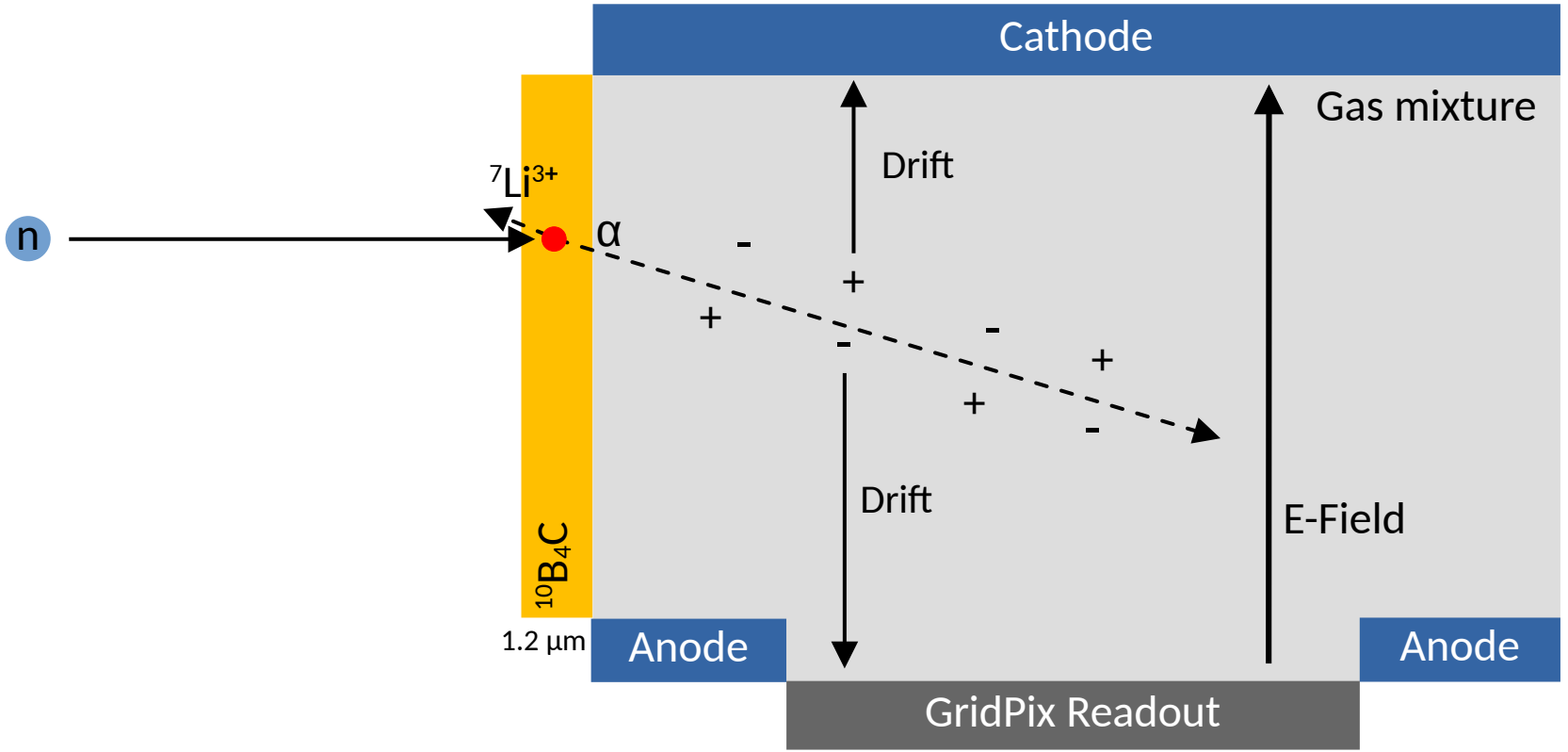
x-y-coordinates:

pixel positions on chip matrix

$$z = v_{drift} \cdot t_{drift}$$

Time-of-Arrival

Detector Concept



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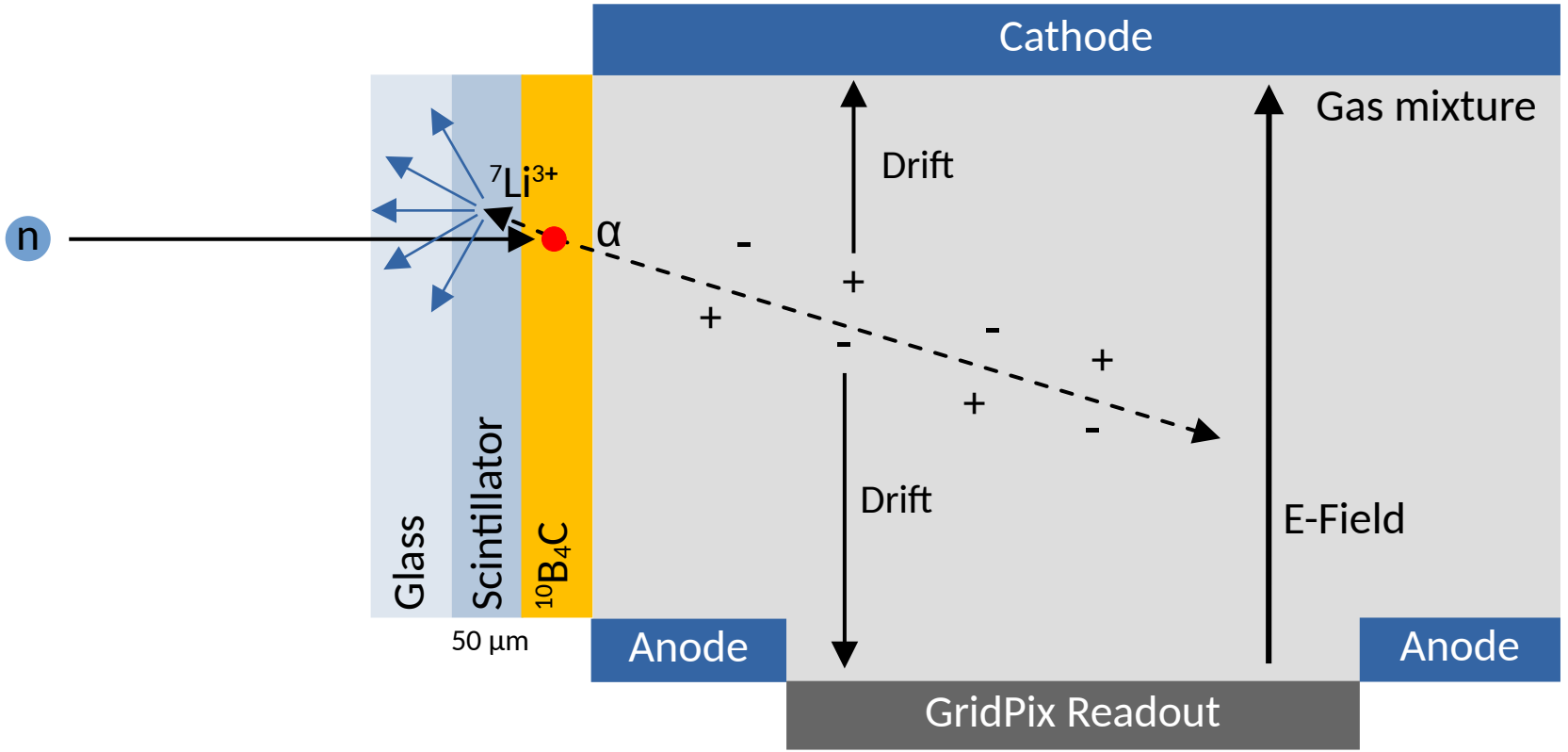

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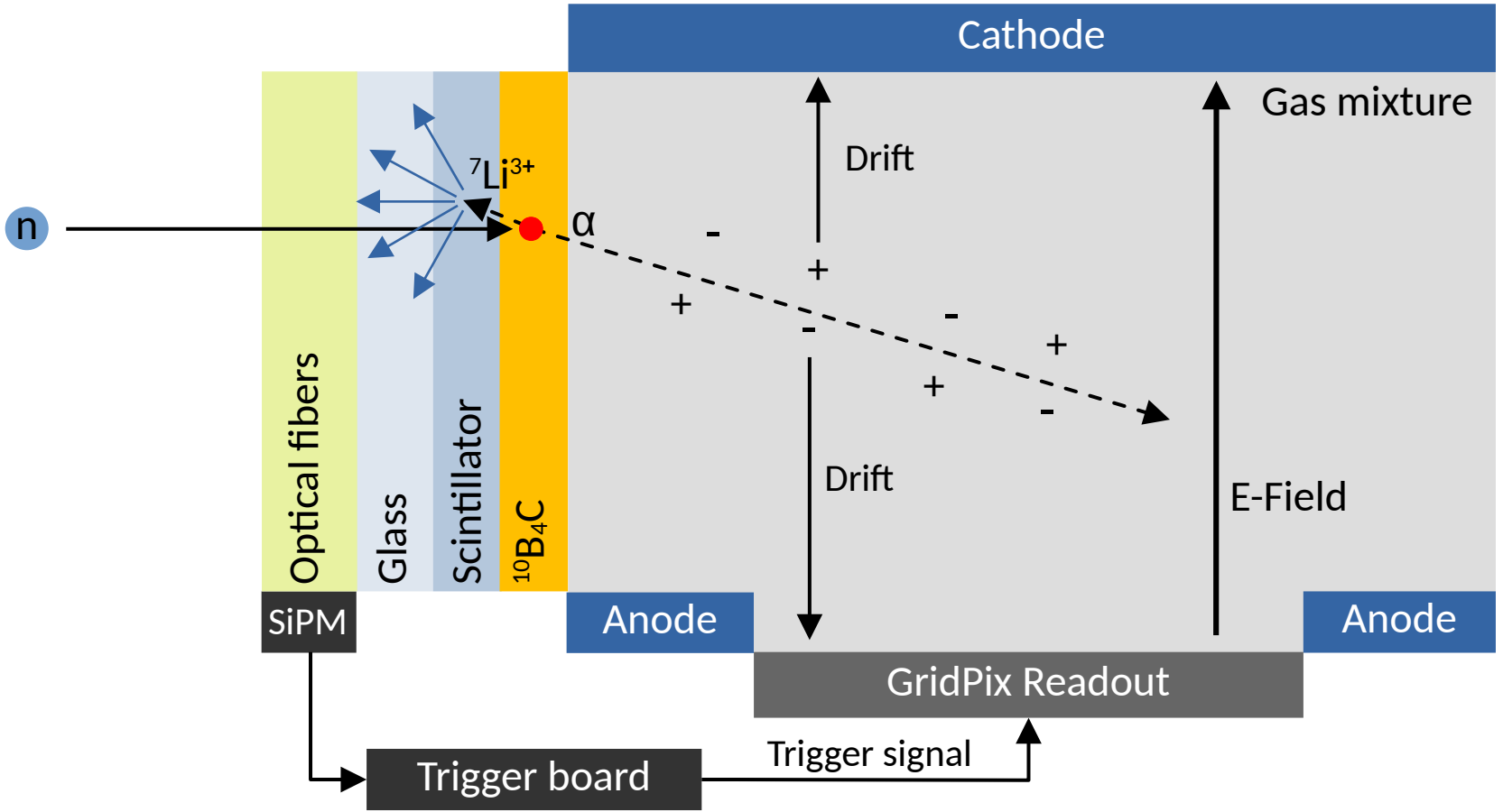

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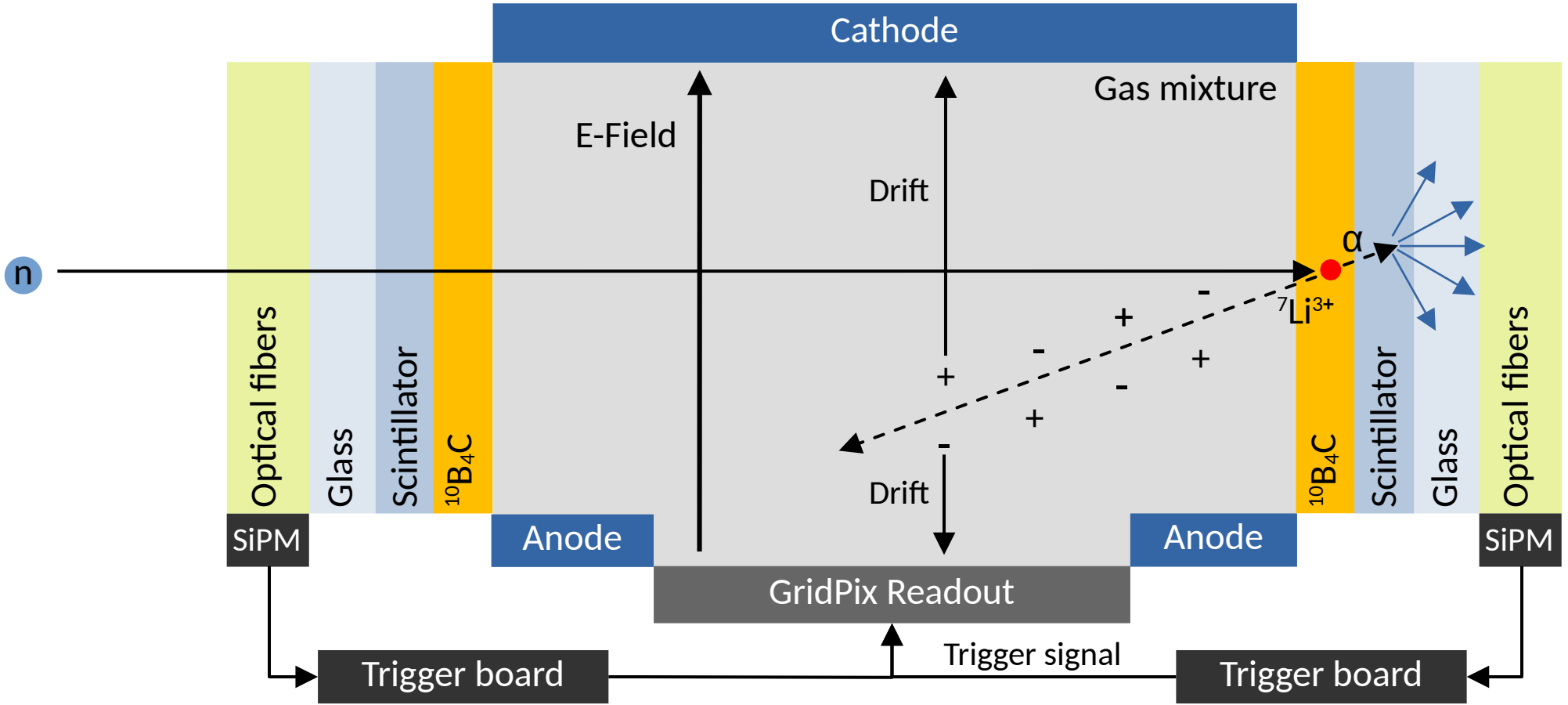
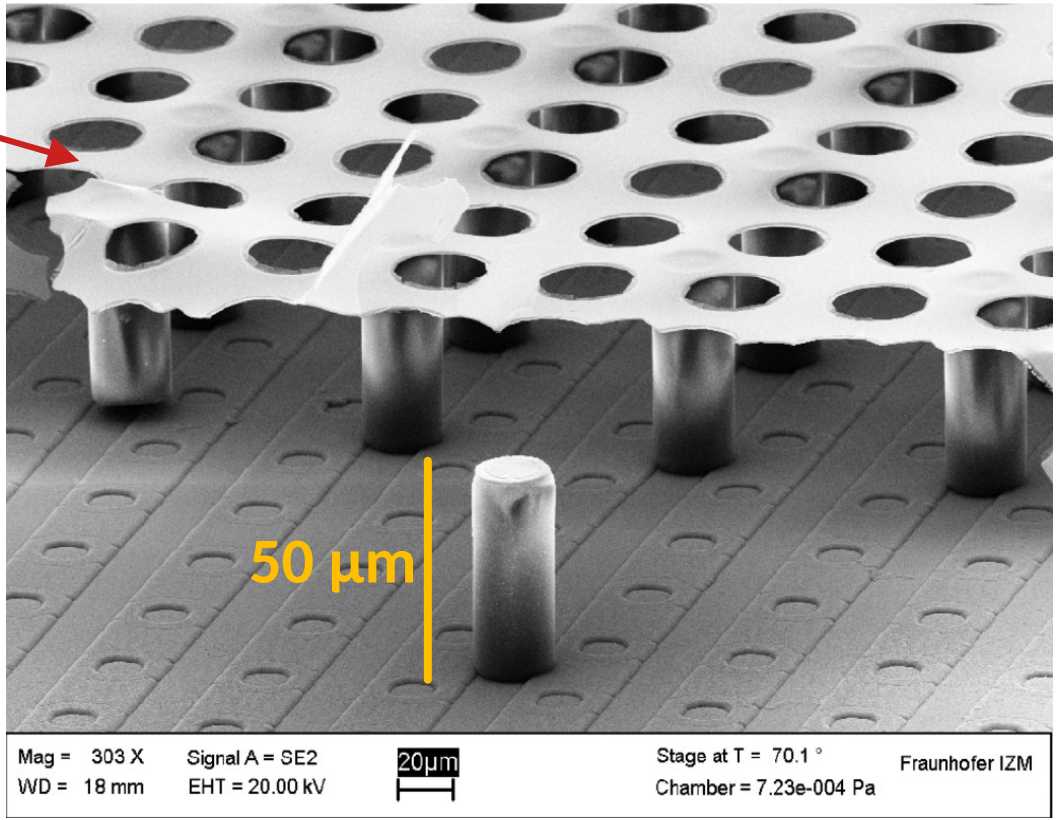


Detector Readout – GridPix Chip

GridPix =
Integrated Micromegas Grid (InGrid)
+
Timepix ASIC



Detector Readout – GridPix Chip

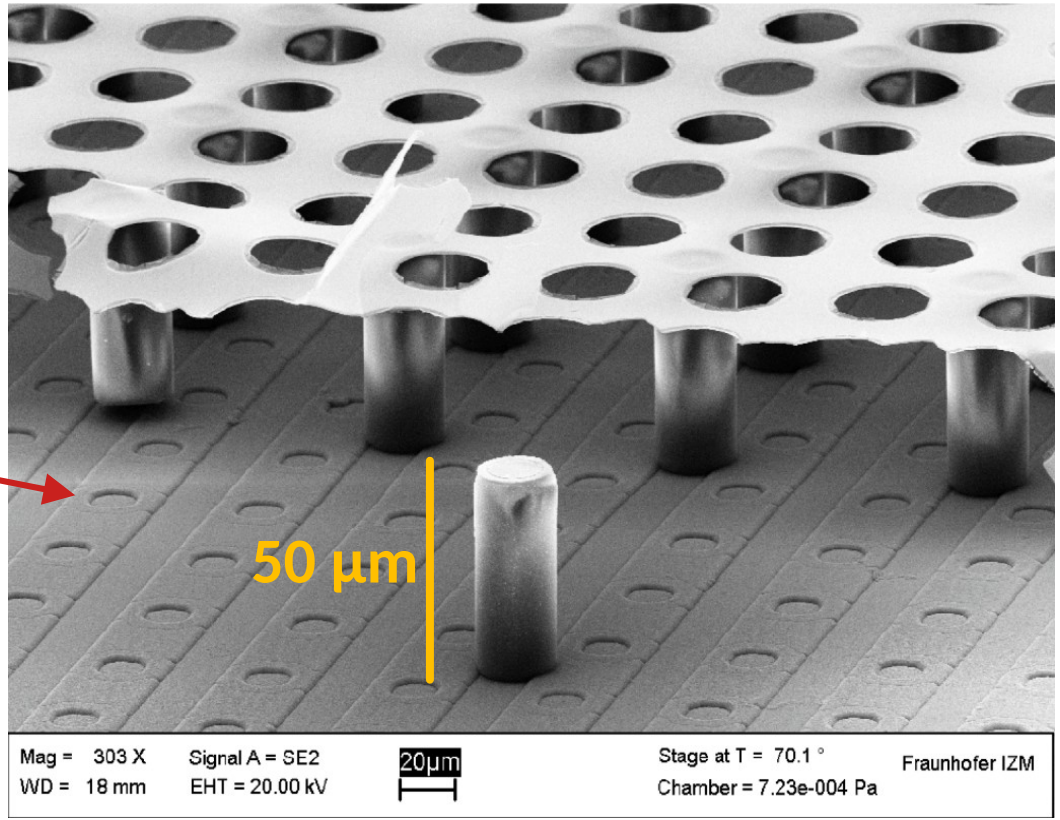
GridPix =
Integrated Micromegas Grid (InGrid)
+
Timepix ASIC

256 x 256 pixels

Pitch: 55 µm

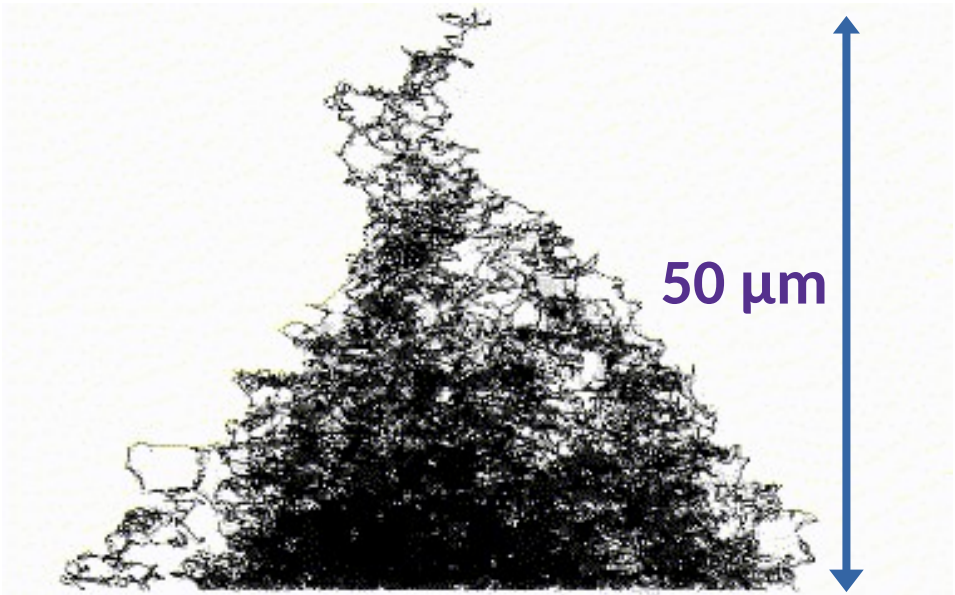
ToT (charge) or ToA (time)

Clock frequency: 40/80 MHz

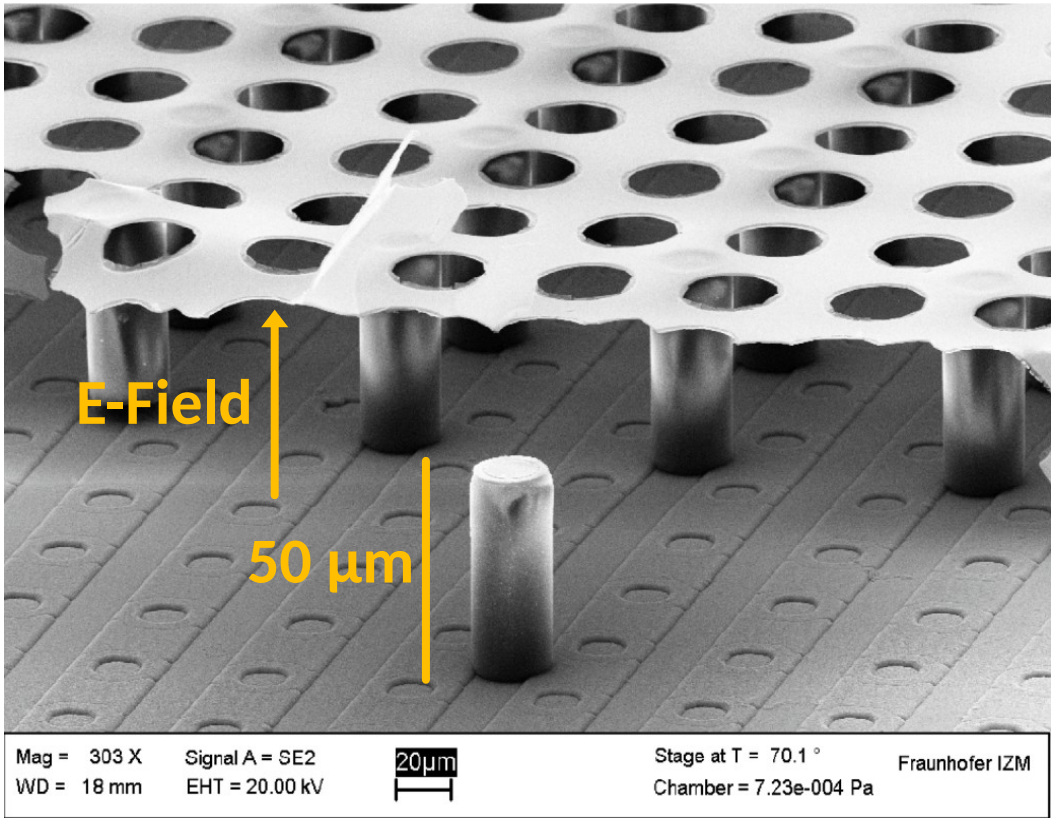


Detector Readout – GridPix Chip

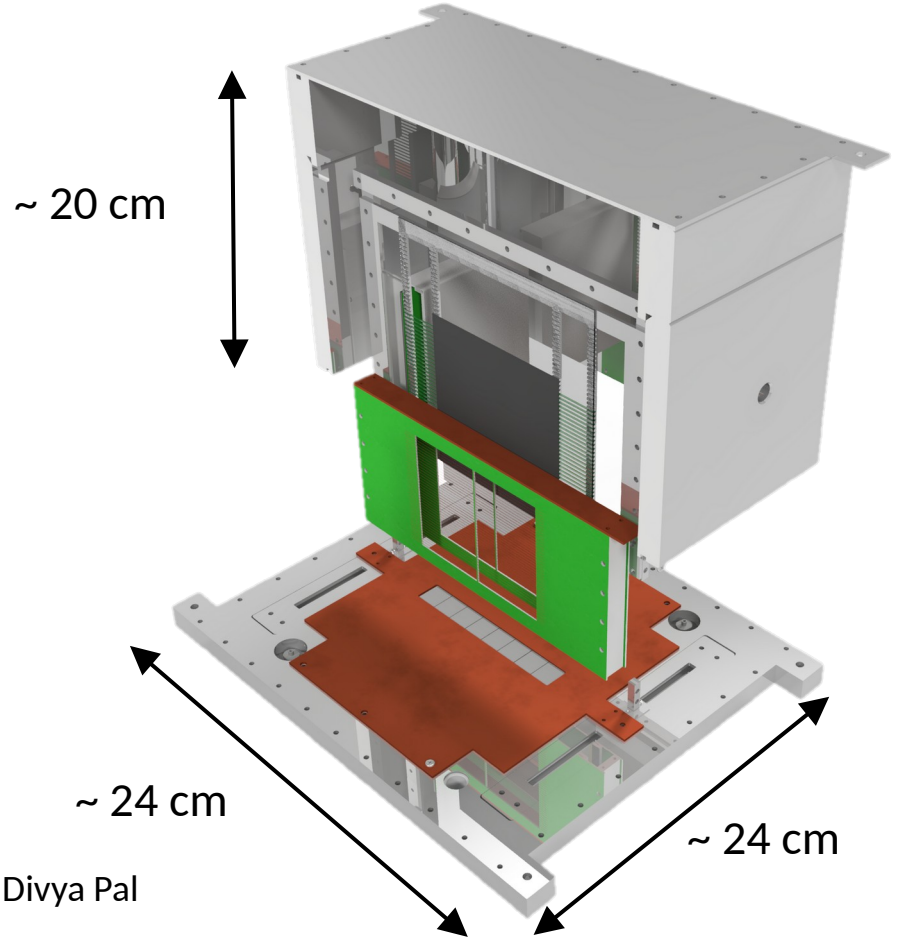
Gas Amplification of a single Electron
Simulation with Garfield++



Credit: Markus Gruber, University of Bonn



Current Detector Design



Credit: Divya Pal

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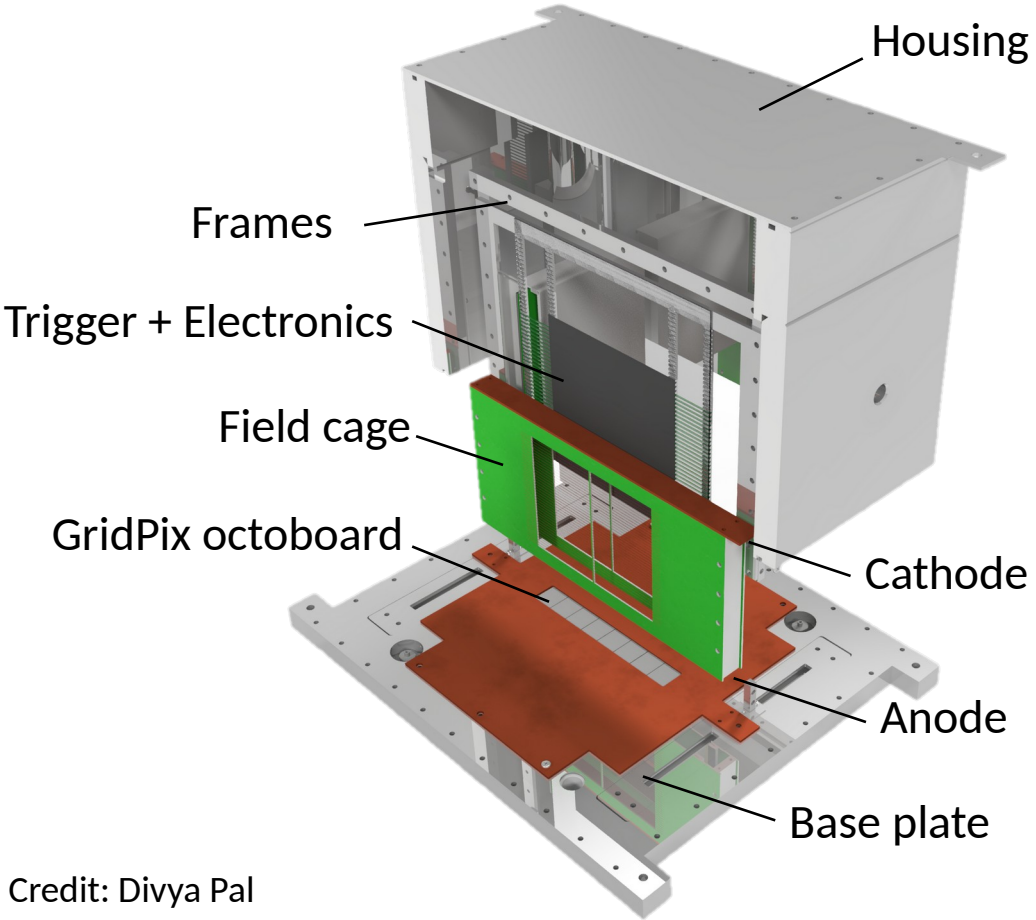

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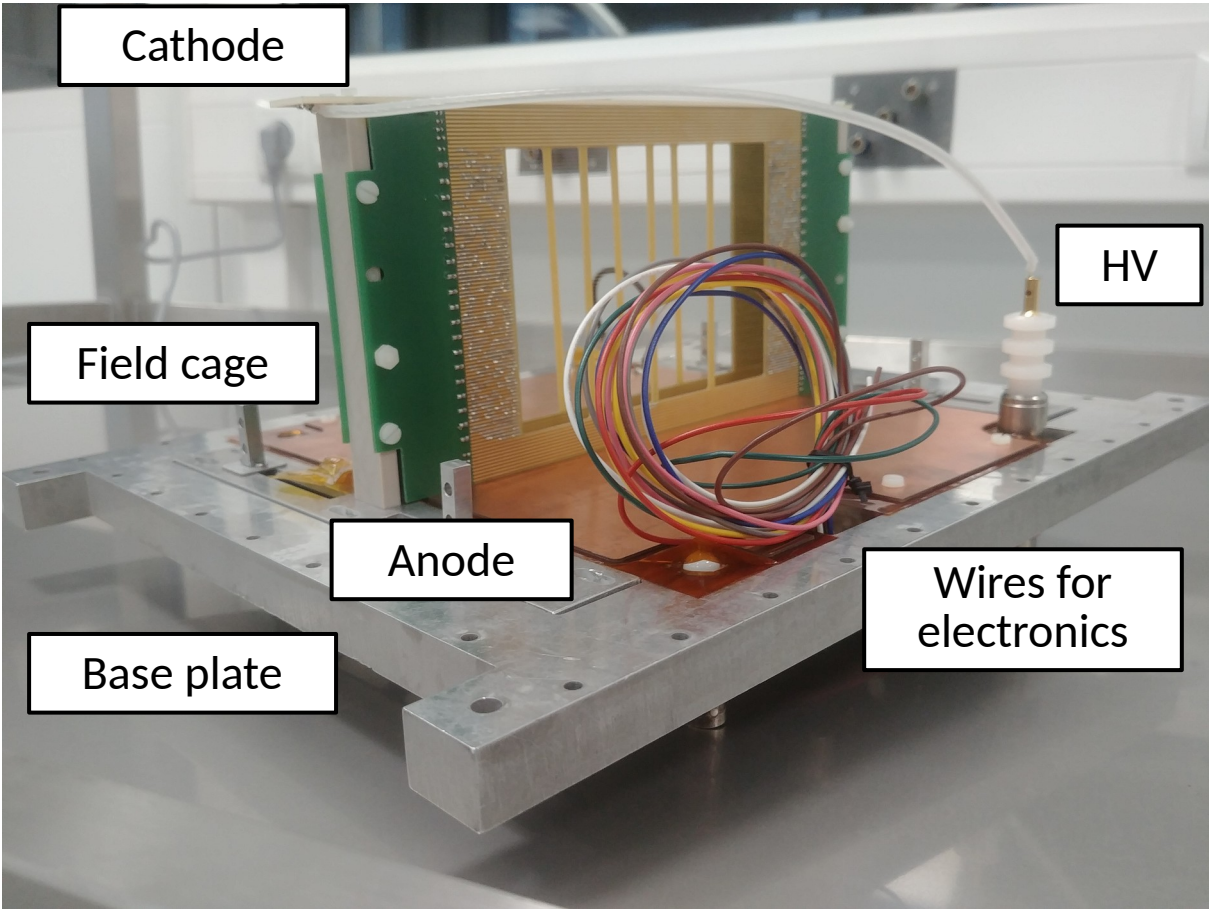
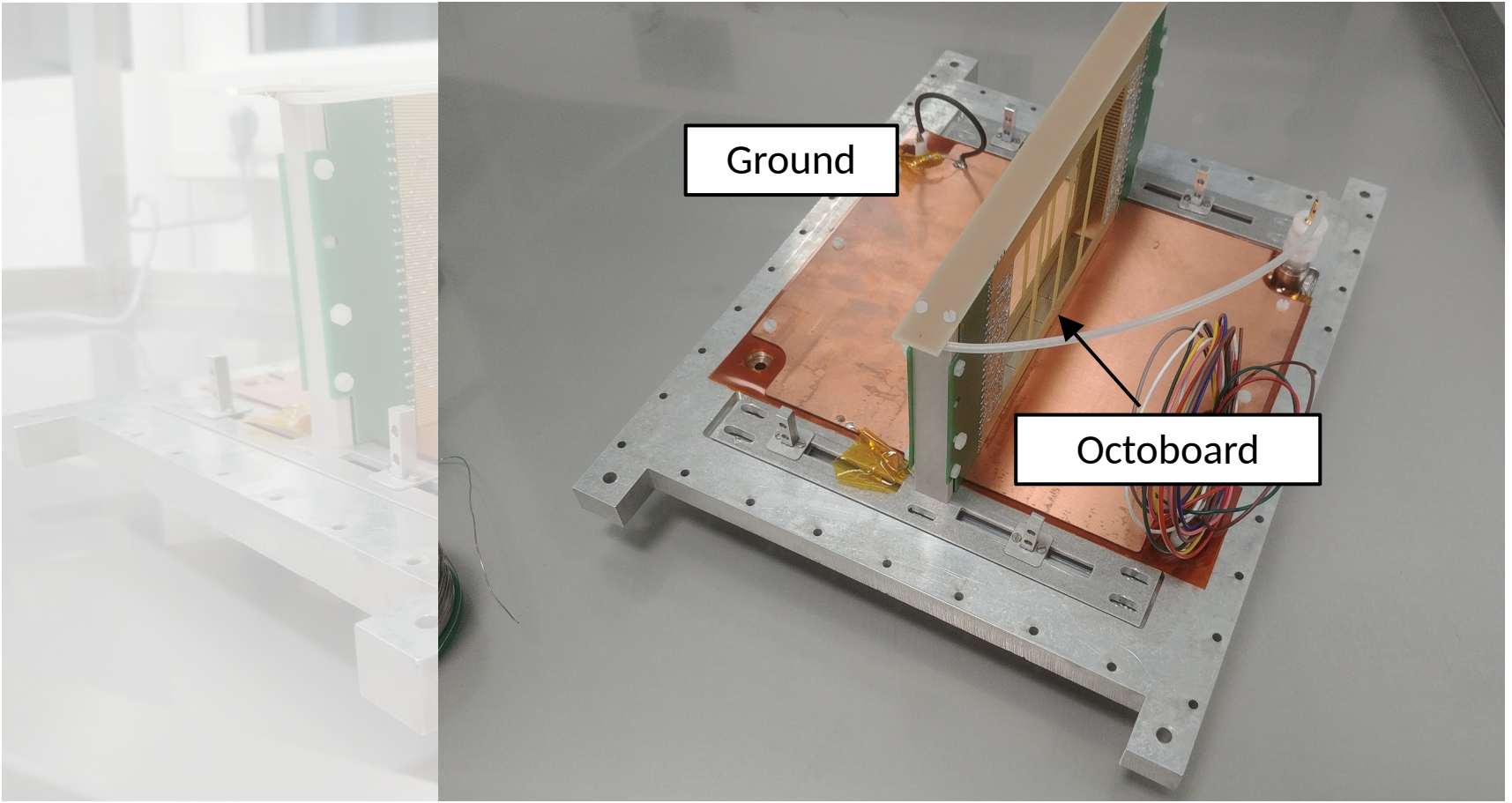
Current Detector Design, Time Projection Chamber



Current Detector Design, Time Projection Chamber



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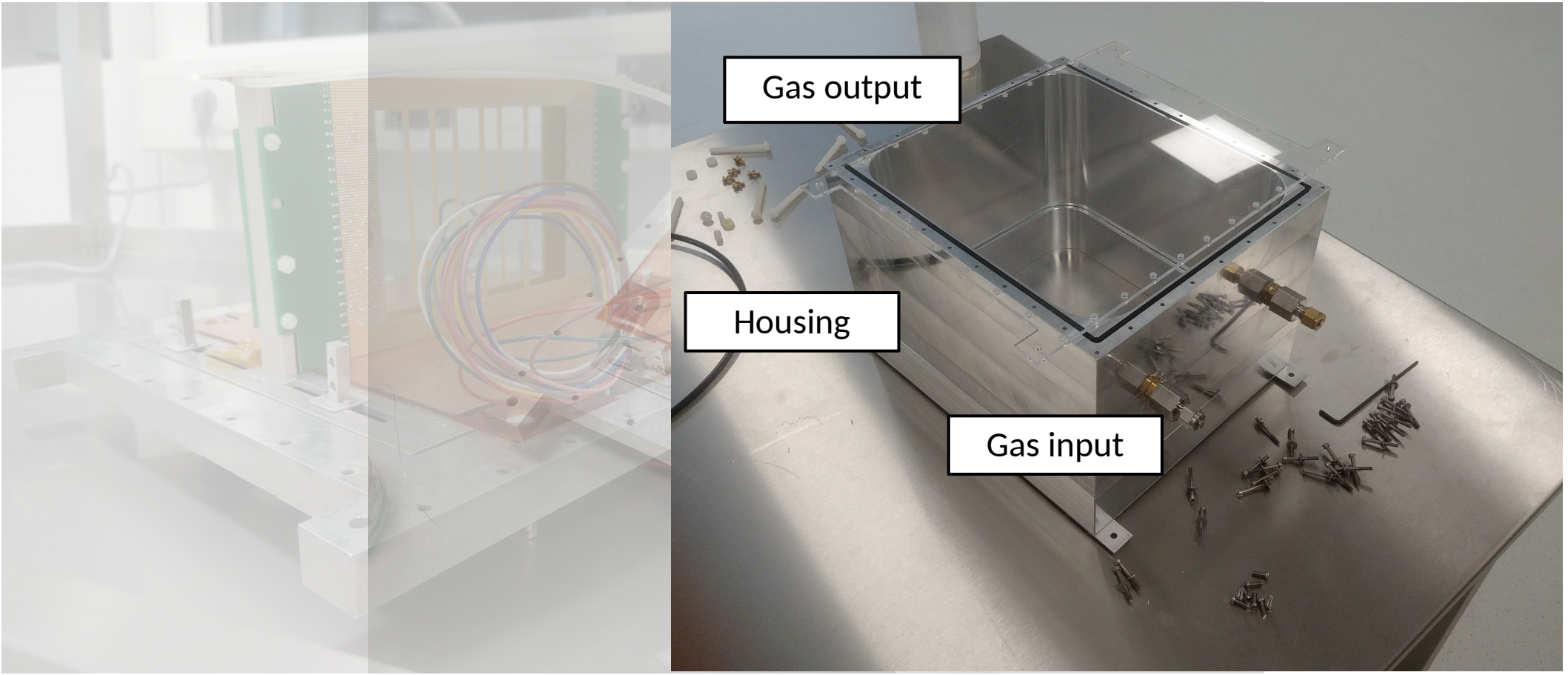
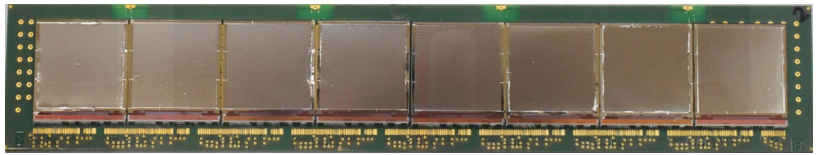
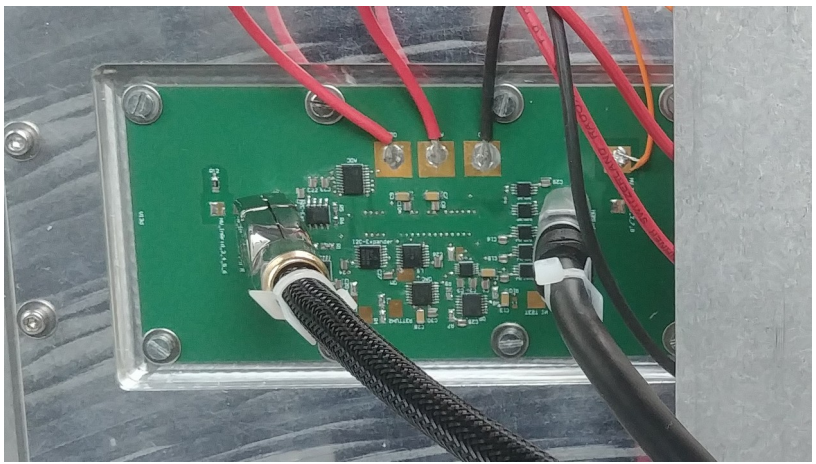


Detector concept – GridPix Readout Chain

GridPix Octoboard

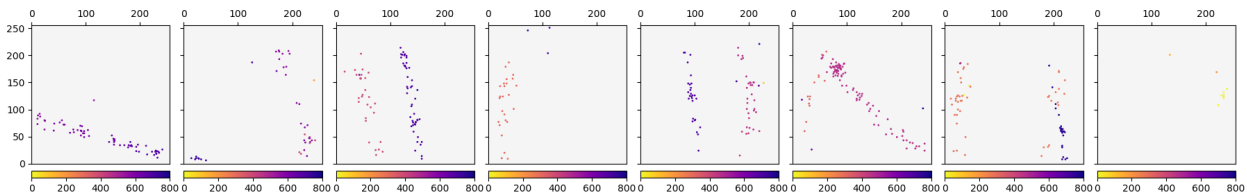


Intermediate board

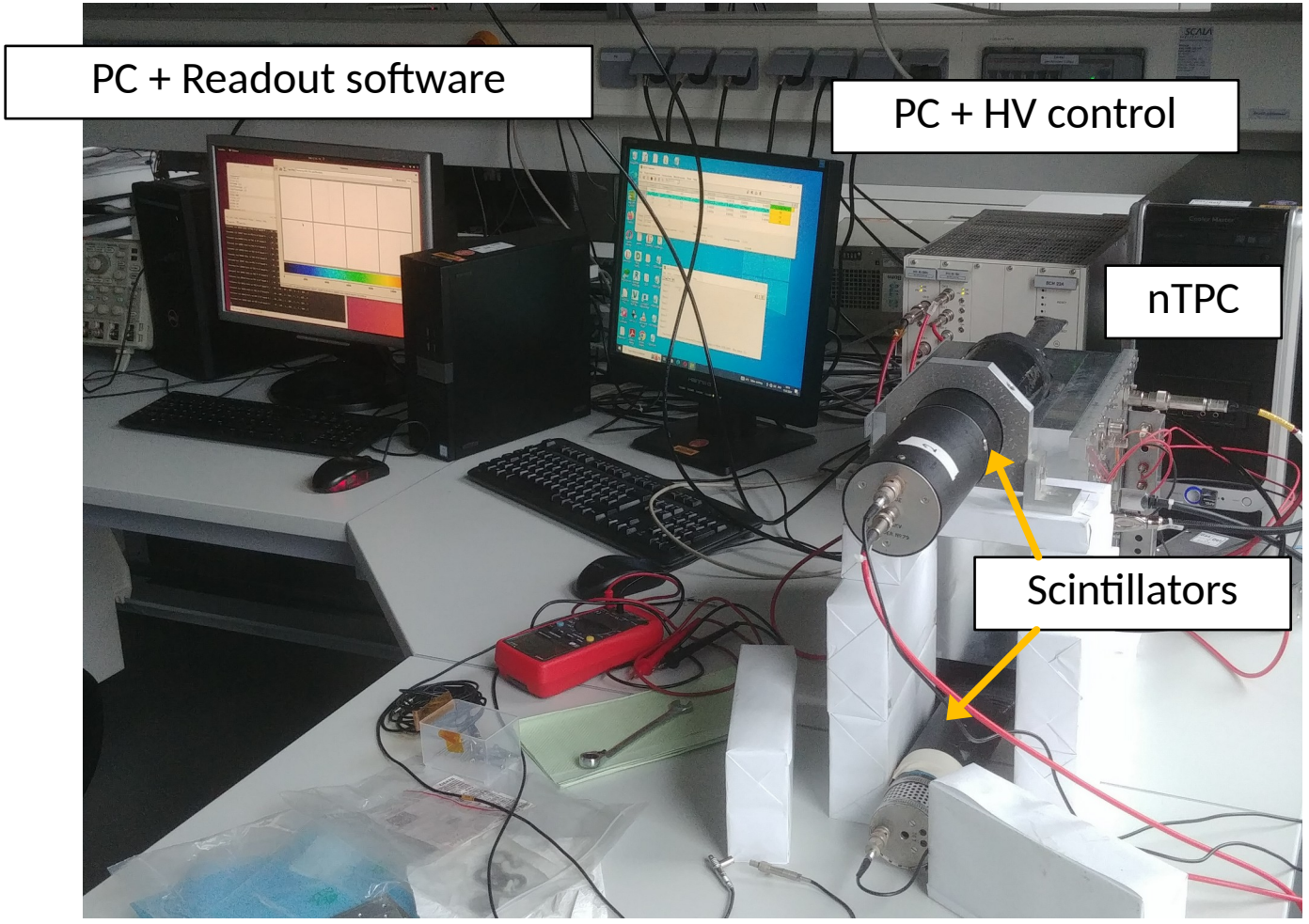


Adapter and concentrator card

Computer



Testing TPC and Readout with Cosmic Muons



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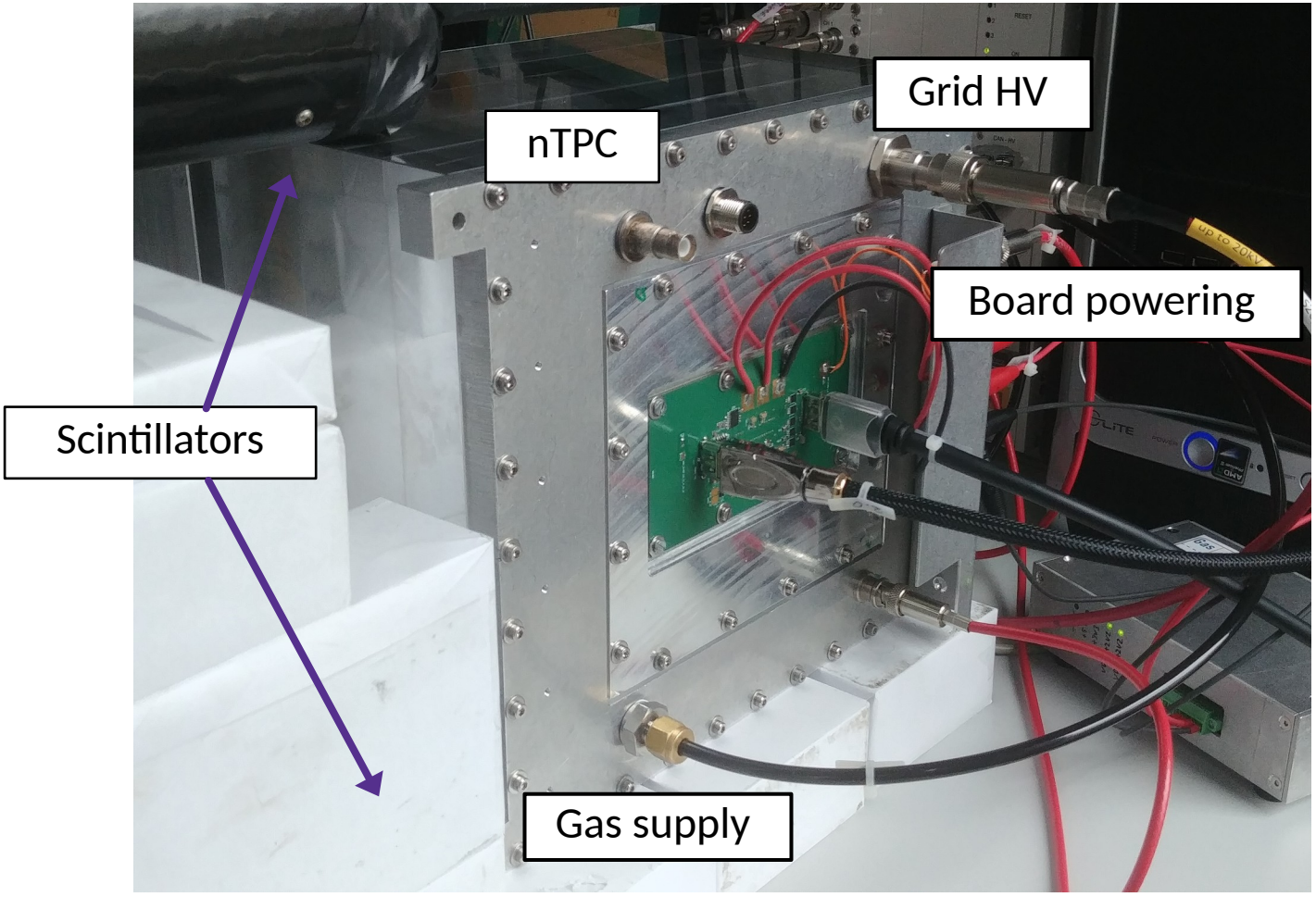

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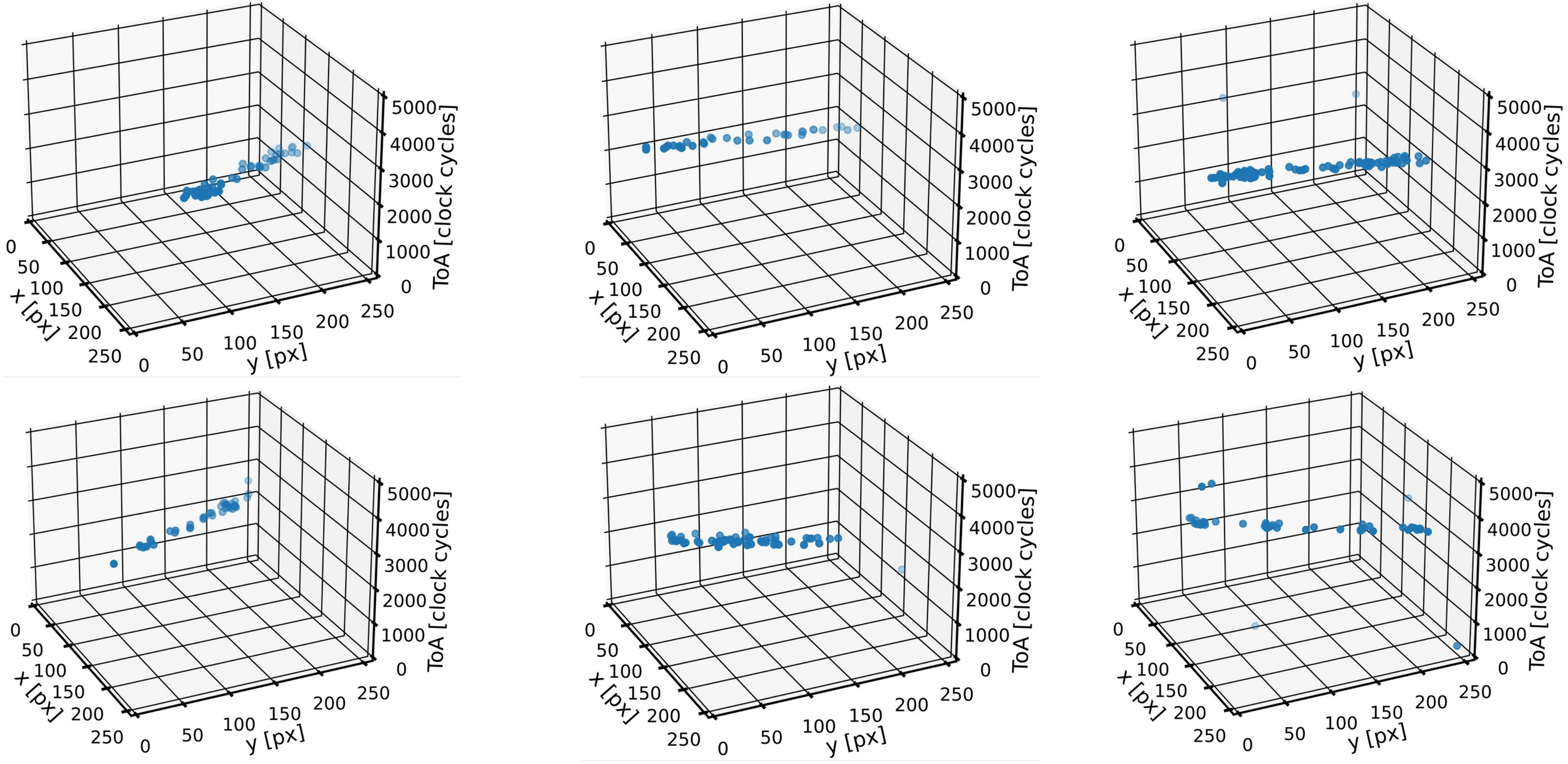
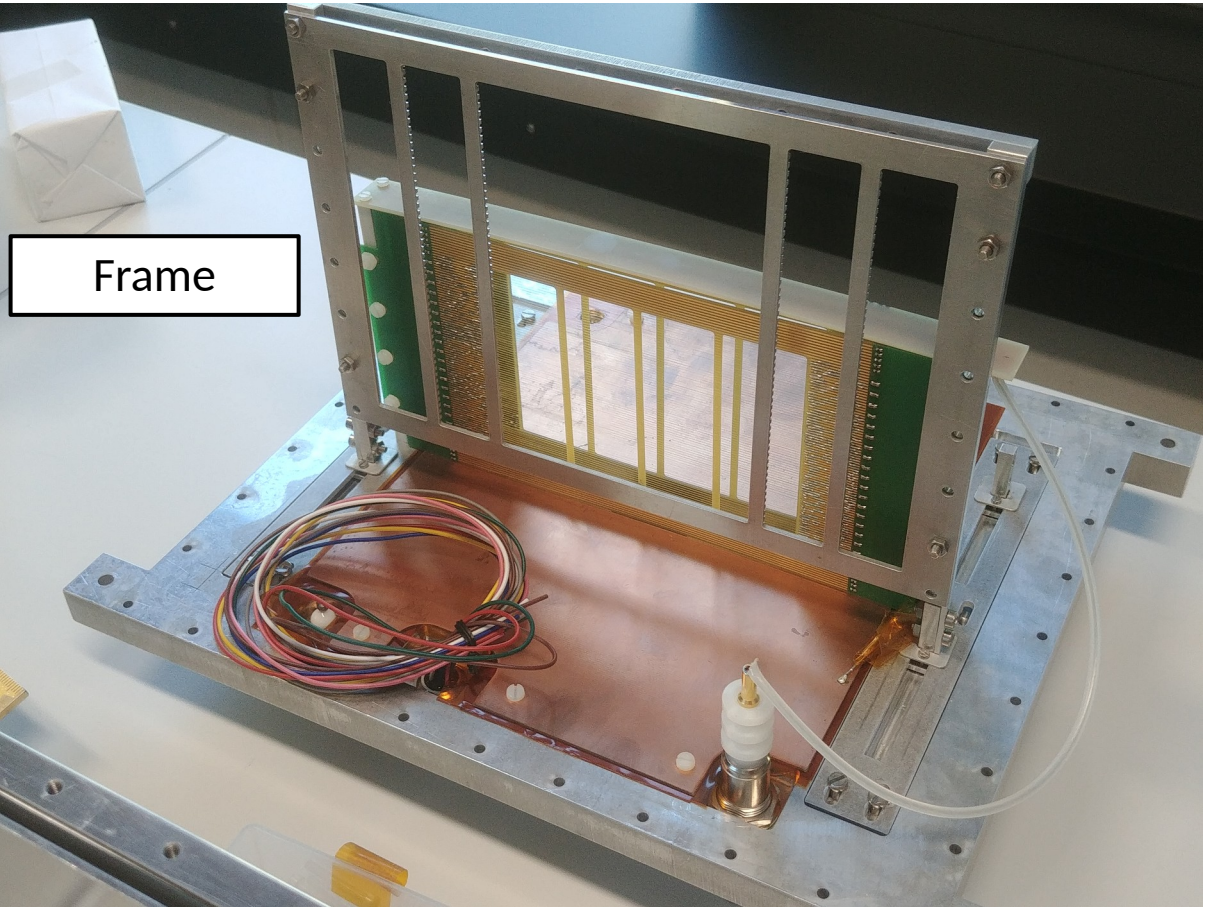


Current Detector Design, Trigger



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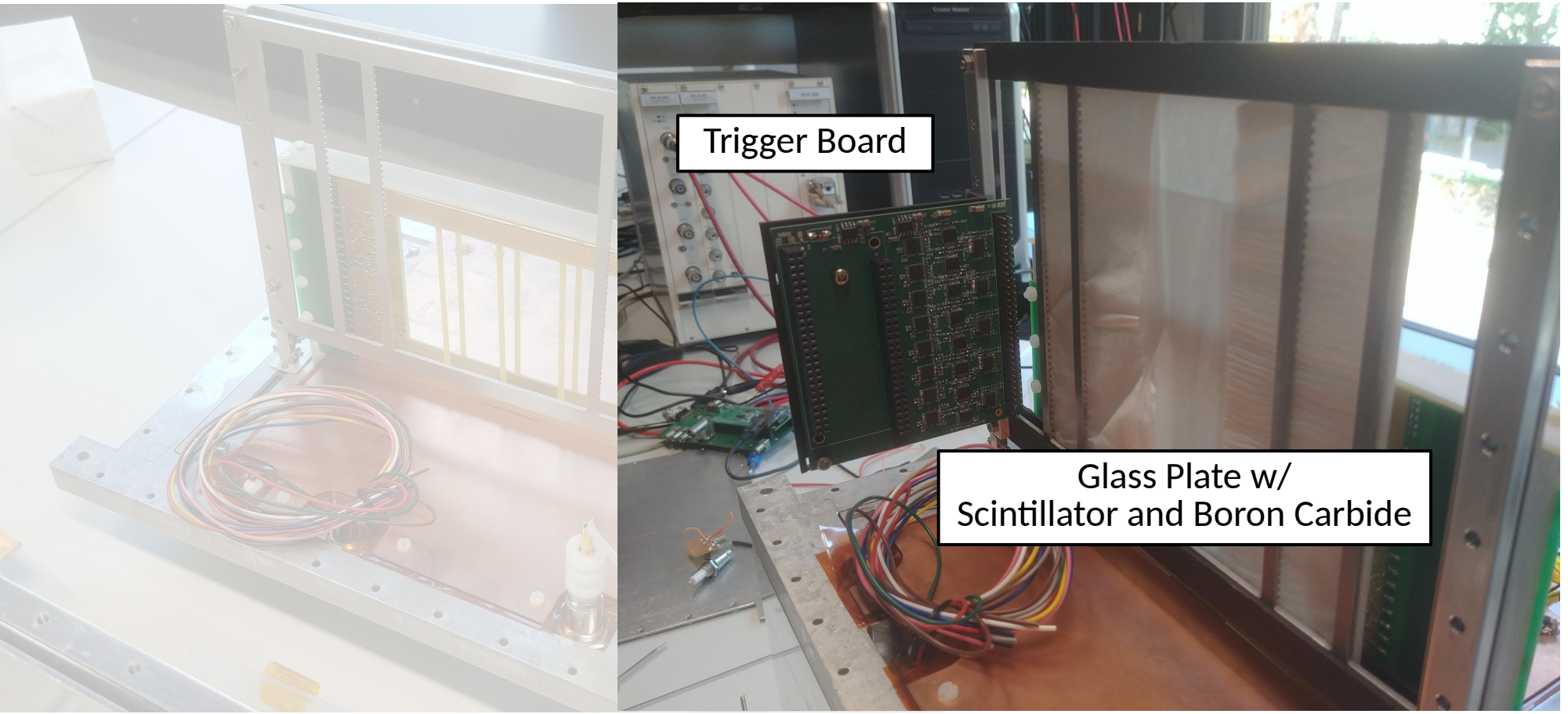

Trigger Board

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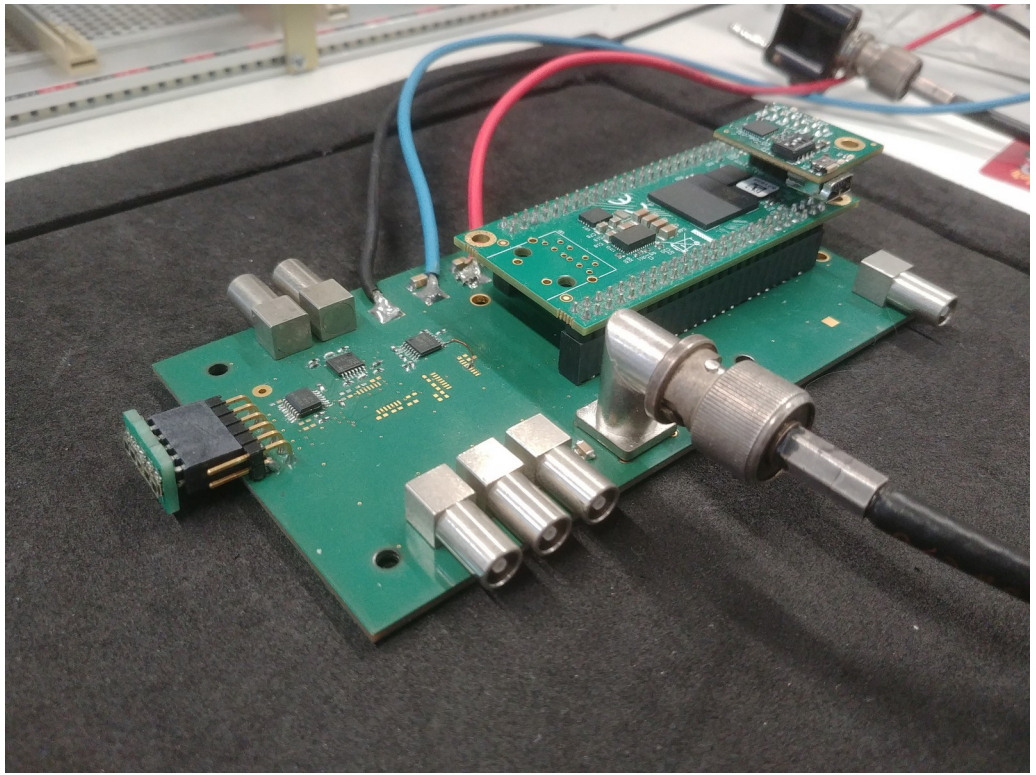
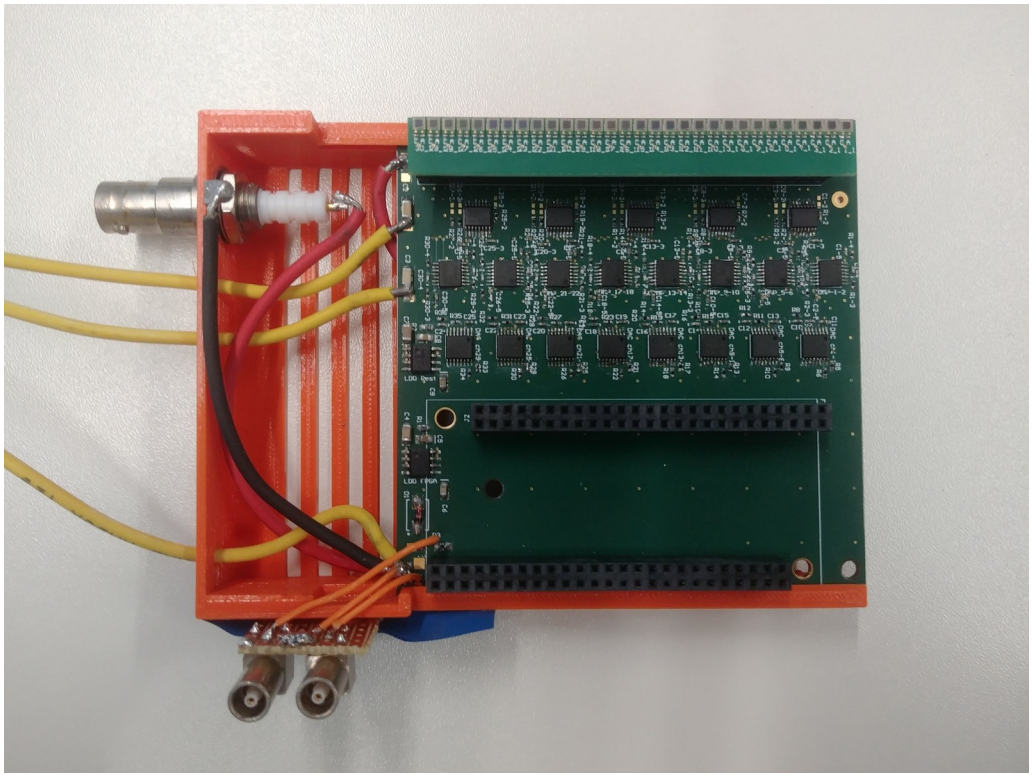
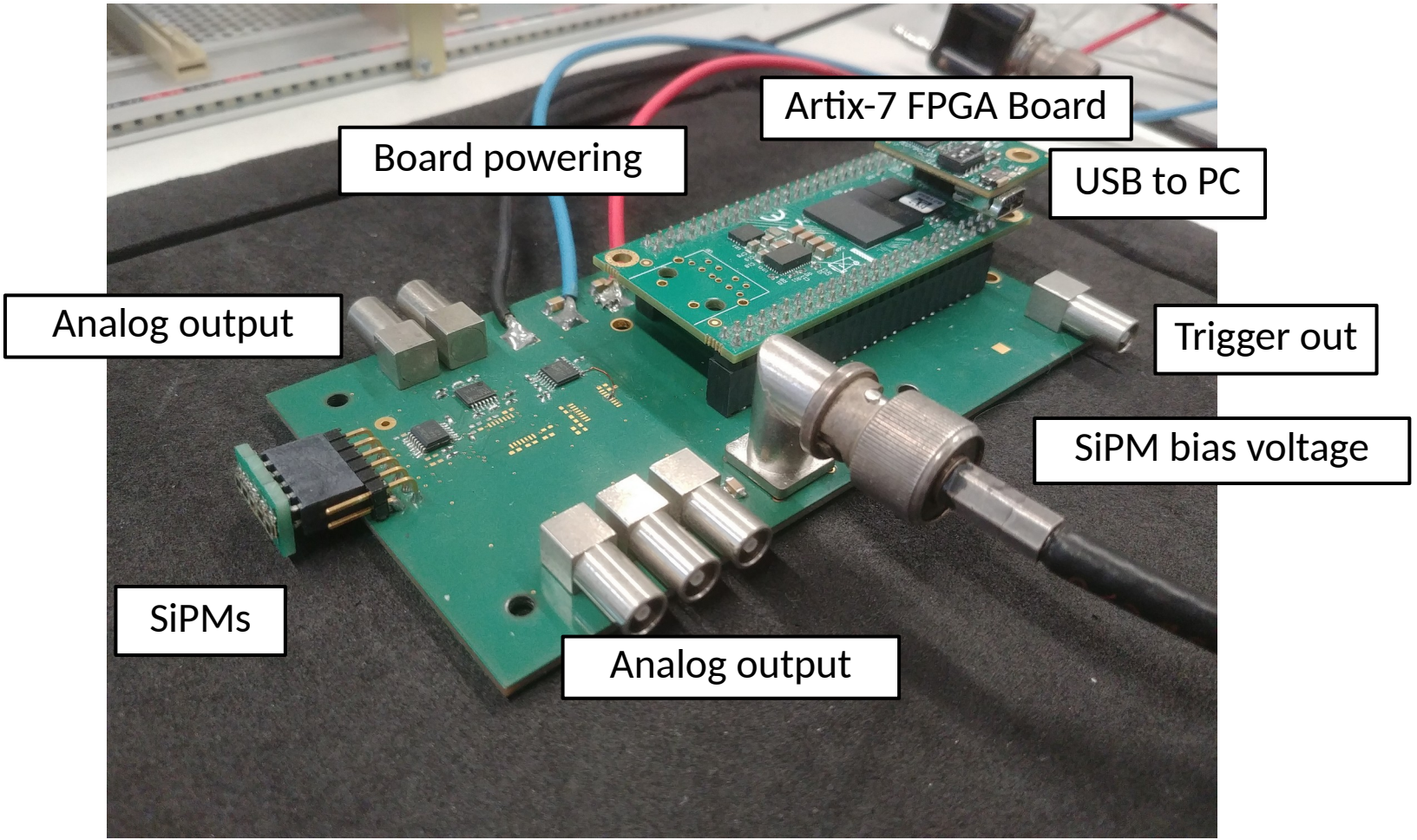
4 channels



30 channels



4-channel Trigger Board



Trigger Board Control

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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
```

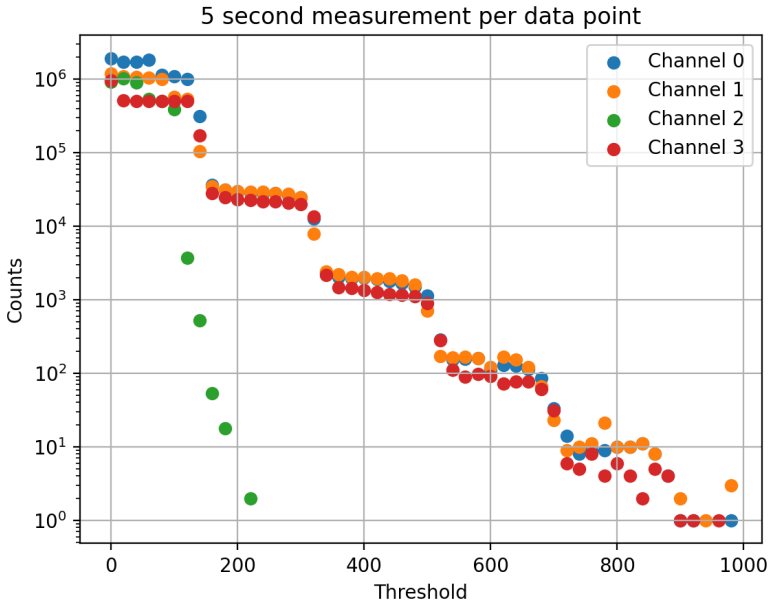
```
tpc@tpc09: ~/nTPC/Trigger/FPGA codes/SiPM_...
Start a threshold scan

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

        [ ] start

        [ ] exit
```

Threshold scan with SiPM dark counts



Summary & Outlook

Time-Projection-Chamber successfully built and tested

- Testing and installation of trigger ongoing
- **Proof-of-Concept**: measurement with sample in neutron beam

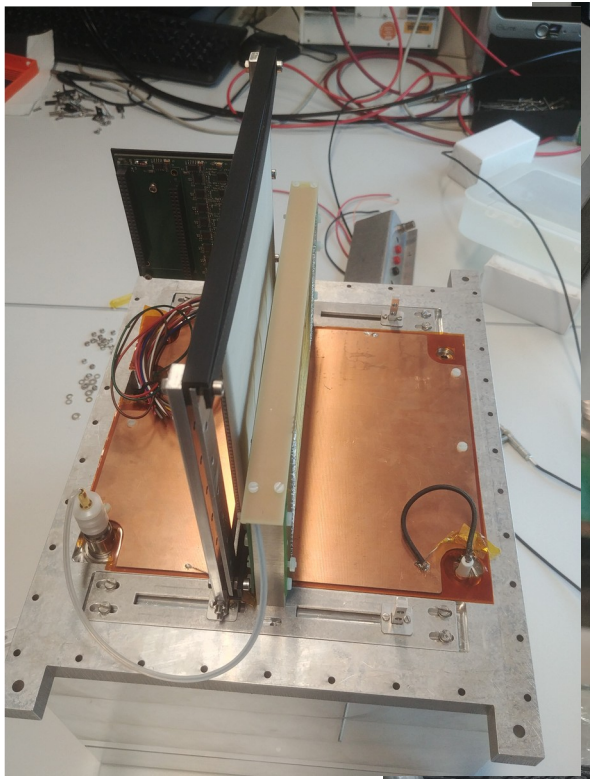
Data Analysis:

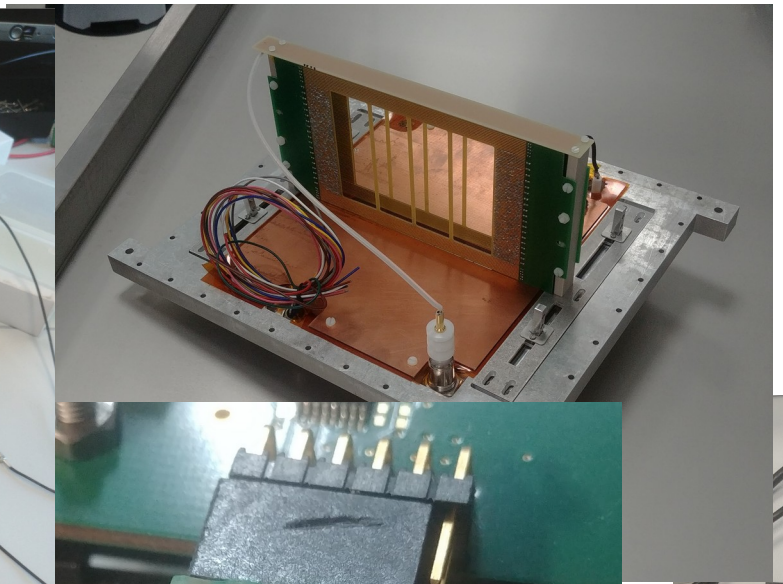
- Implementation of track-finder &
- Reconstruction of sample image in development

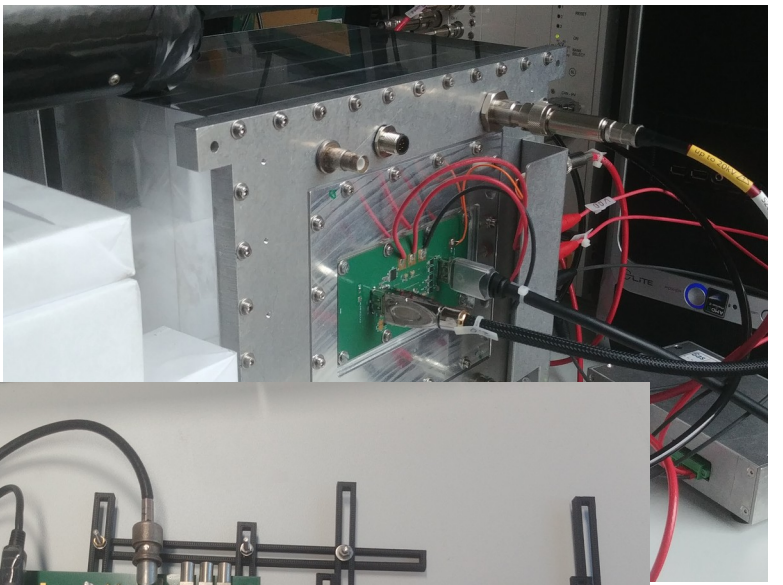
Upgrade readout:

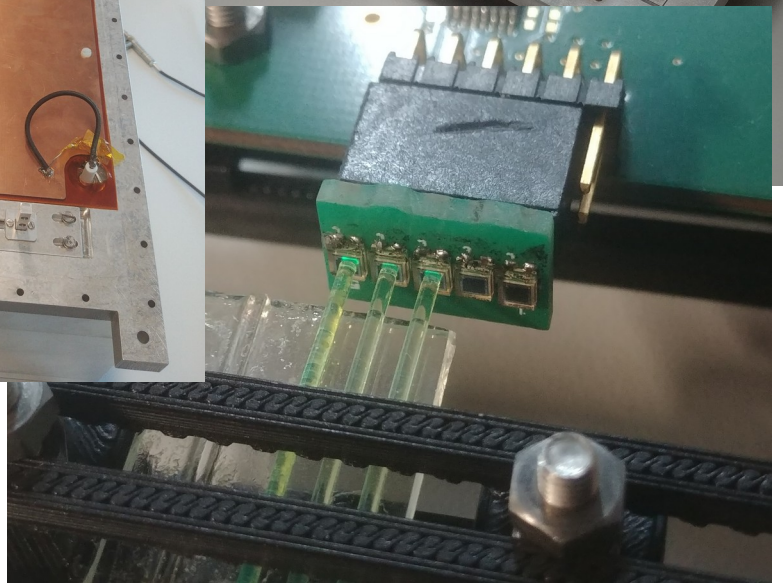
- Timepix3/GridPix3 for higher readout rate
- Multi-stage conversion for enhanced neutron acceptance

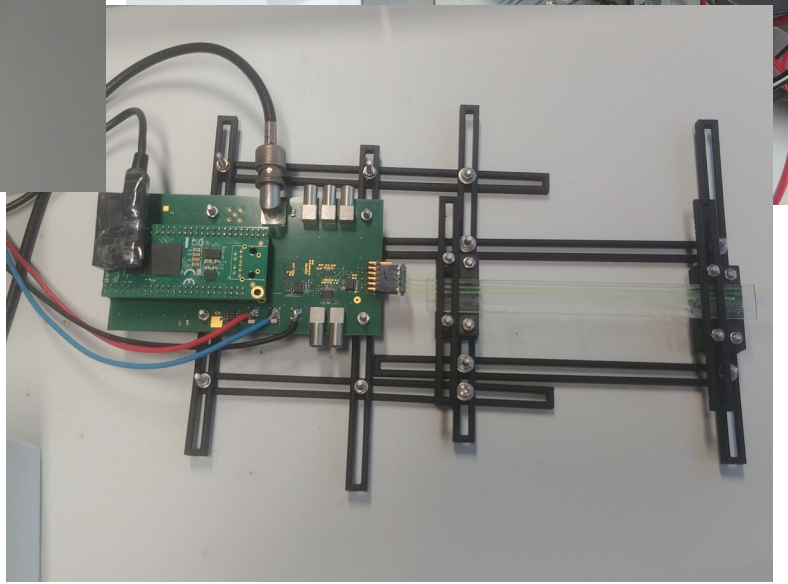
Thank you!



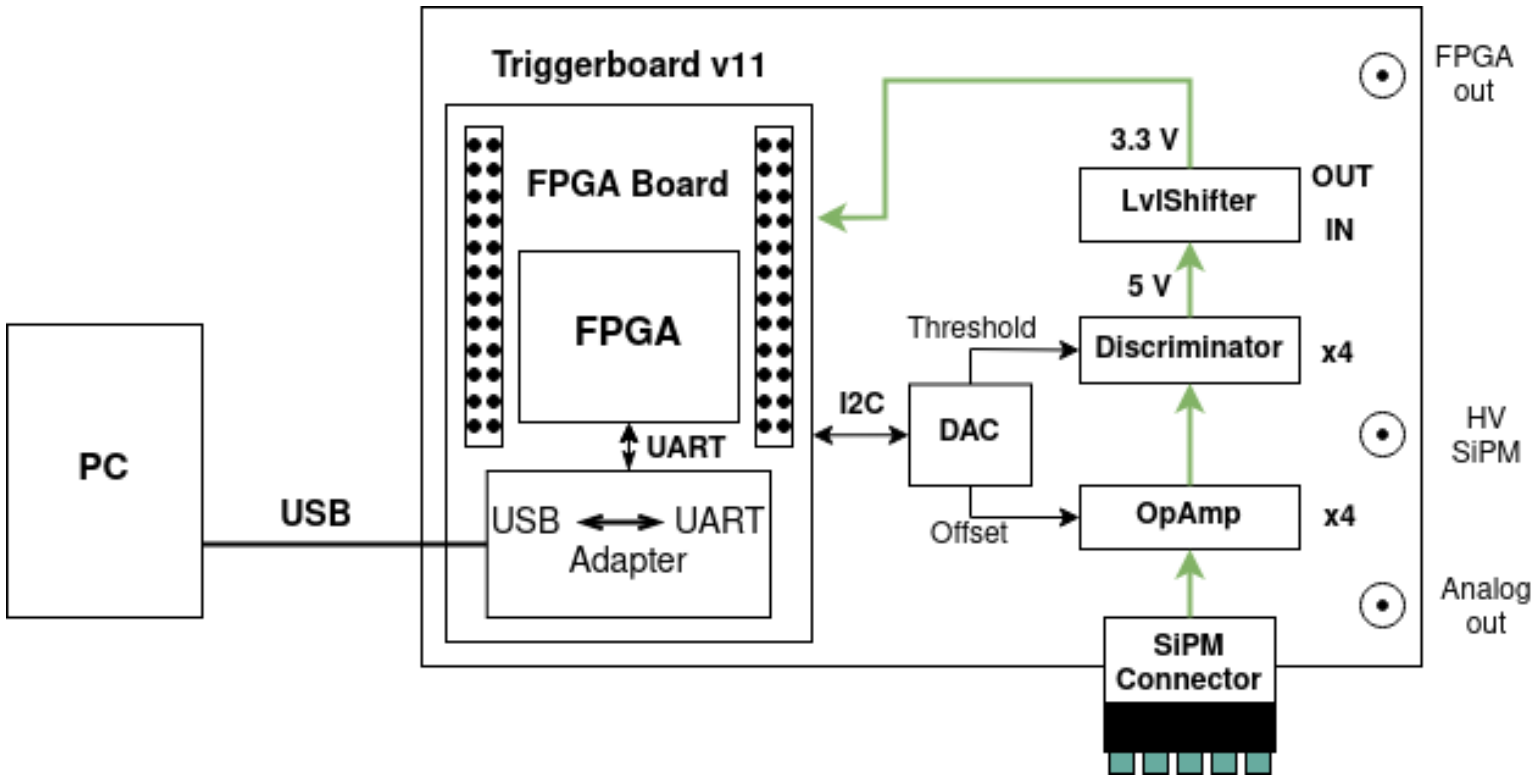




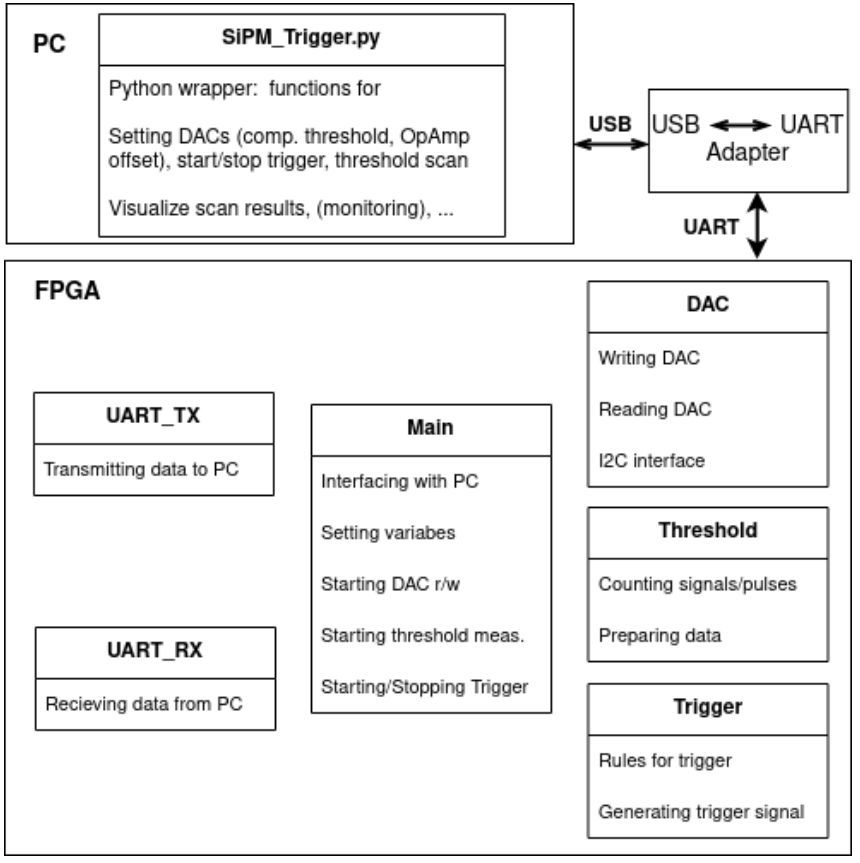




Backup - Trigger Board Schematic



Backup – FPGA Firmware + Interface



Backup – SiPM Amplifier Output