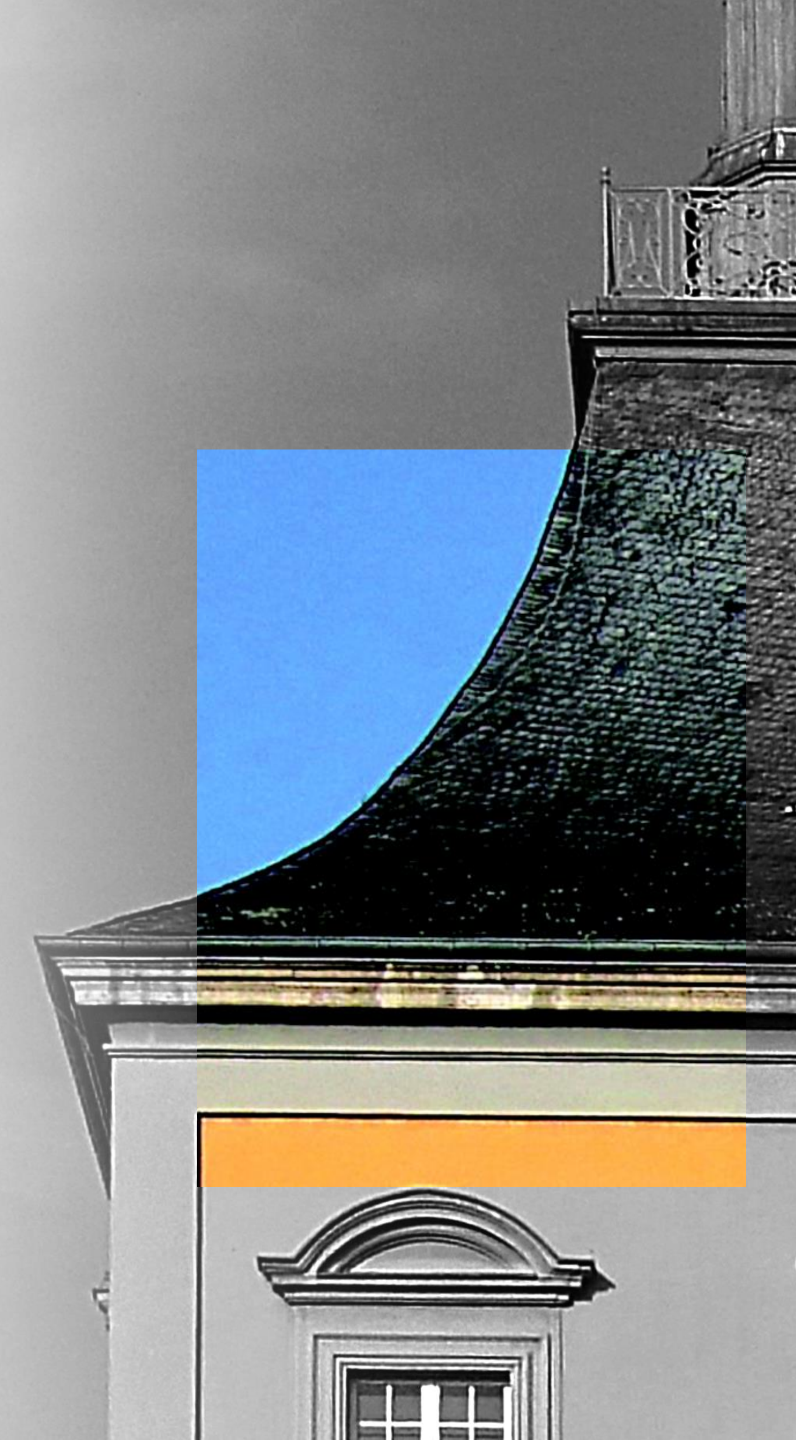
GRIDPIX DETECTOR DEVELOPMENTS FOR BABYIAXO

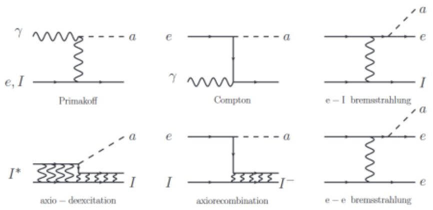
Johanna von Oy

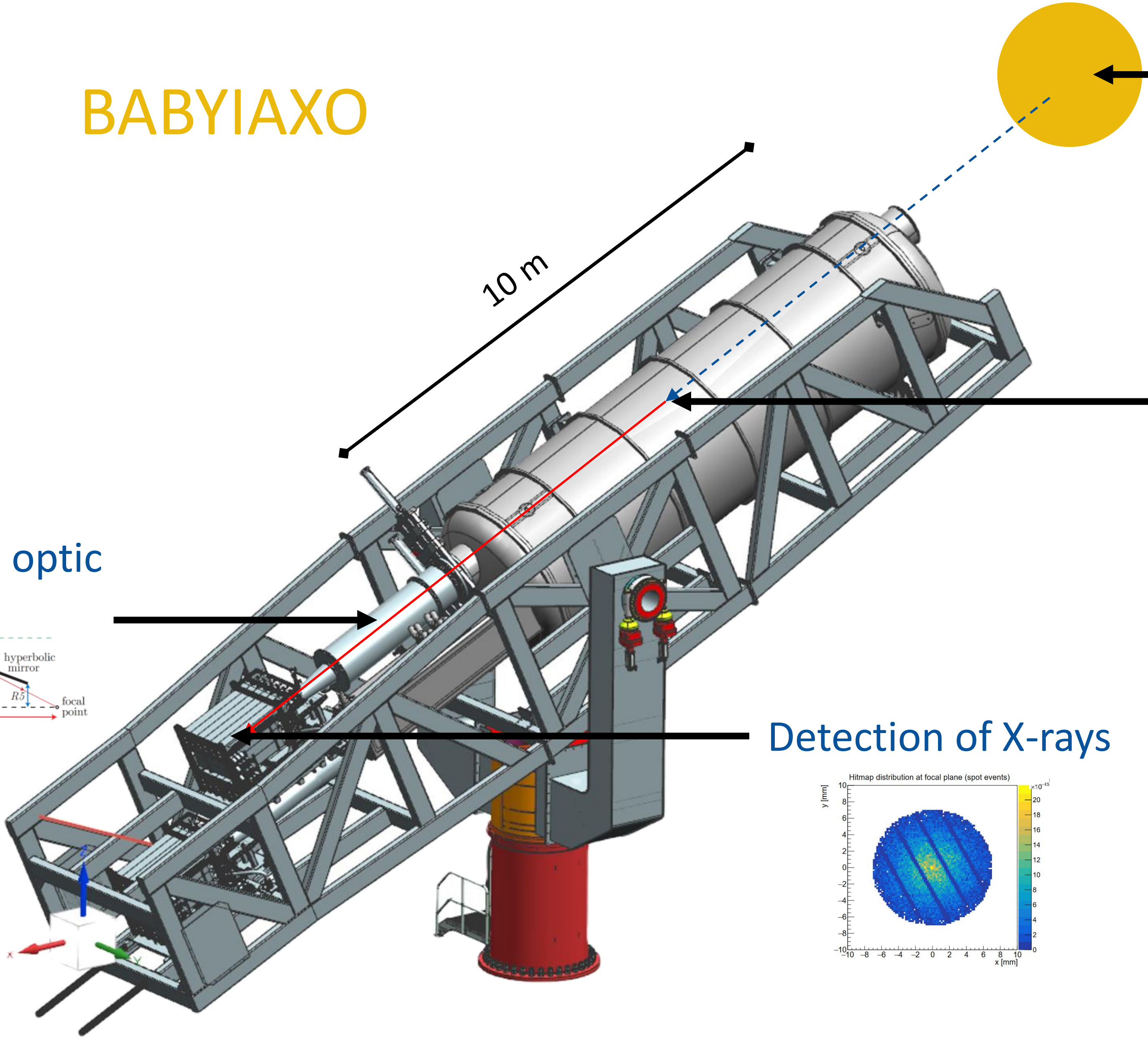
X-ray **DE**tector Technologies for **P**hysics Workshop



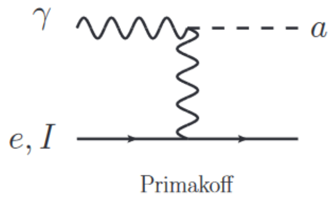
BABYIAXO

Axion production in the sun

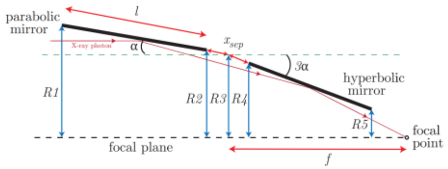




Axions couple to photons in magnetic field



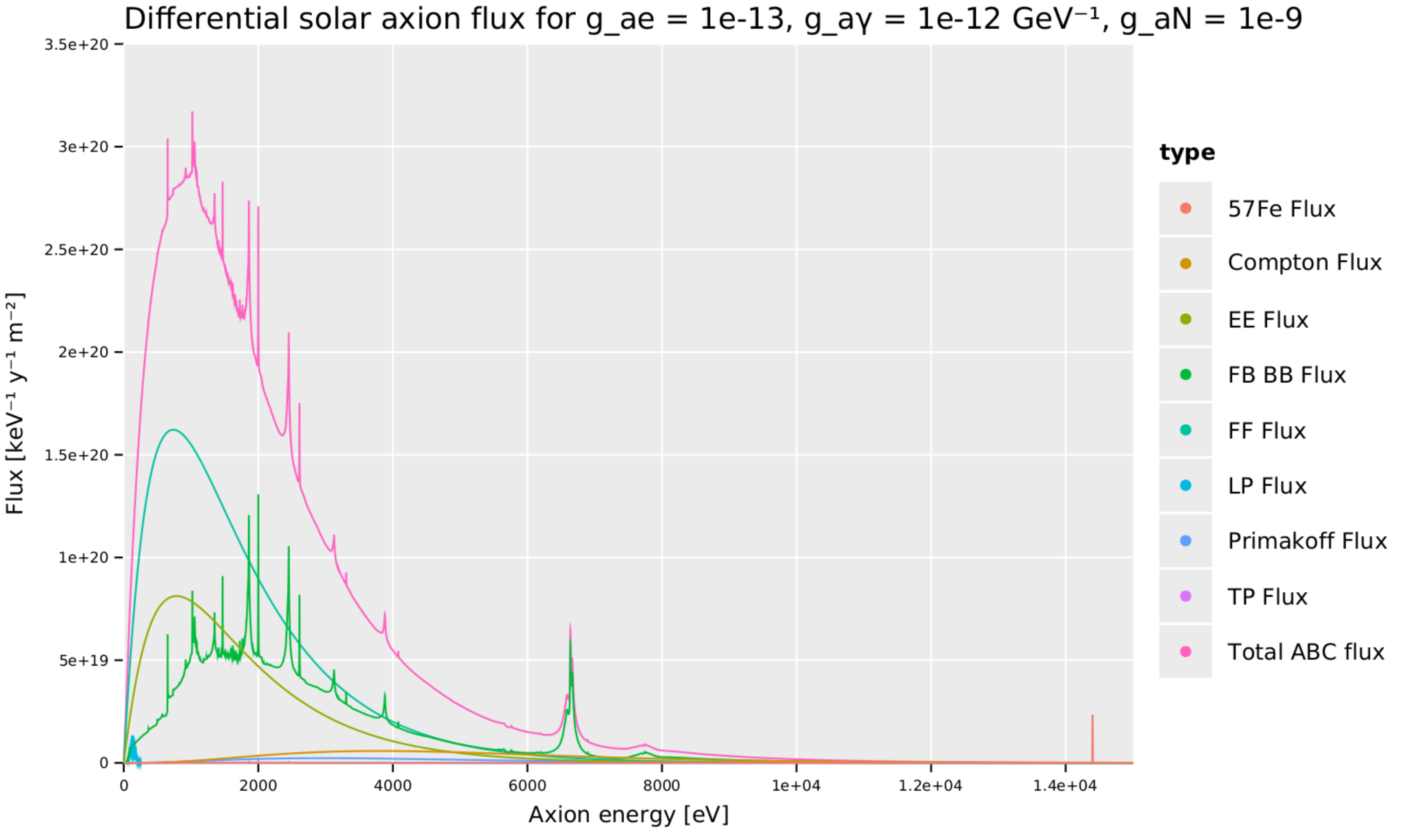
Focus of X-rays in optic



Detection of X-rays

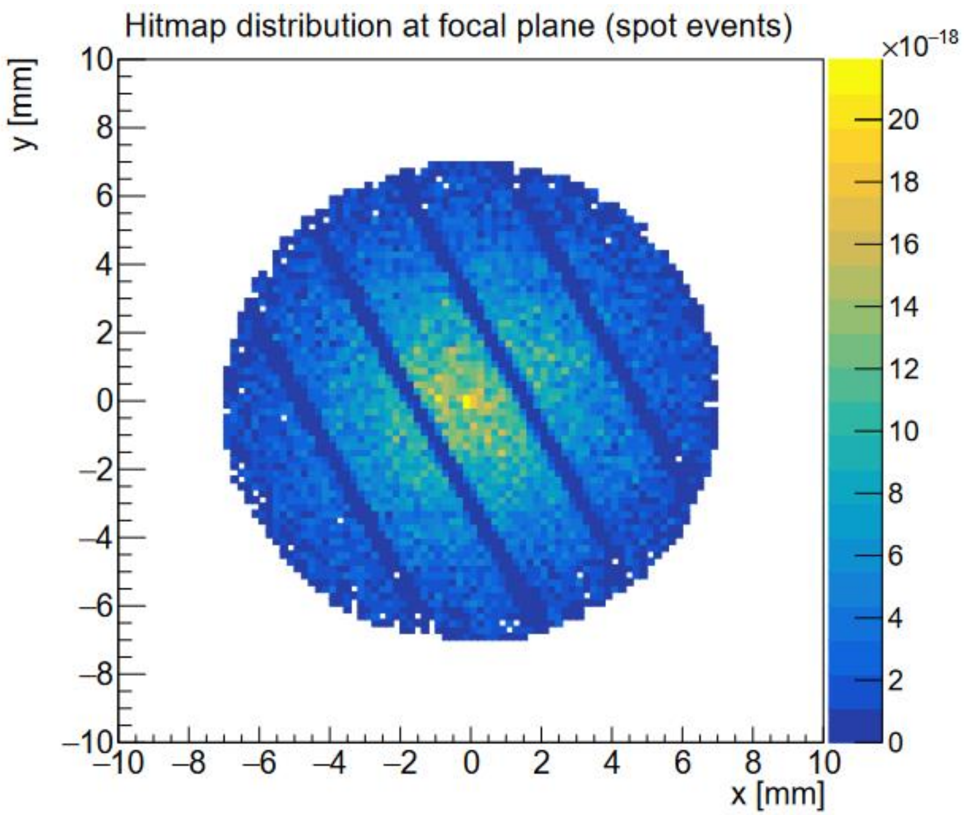
DETECTOR GOAL

Low energy X-rays



DFSZ axion model

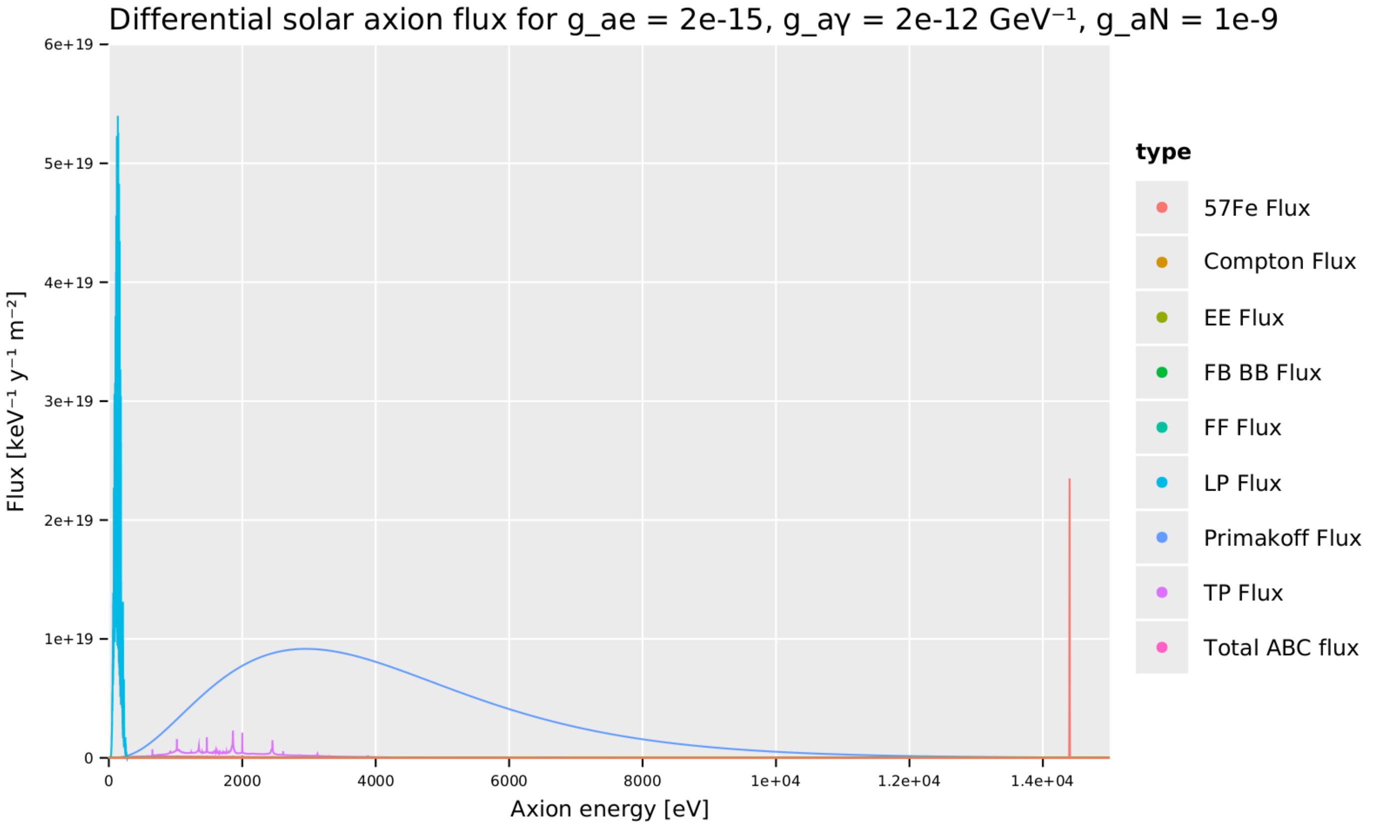
Low signal count



100000 events ≈ 10.5 ns

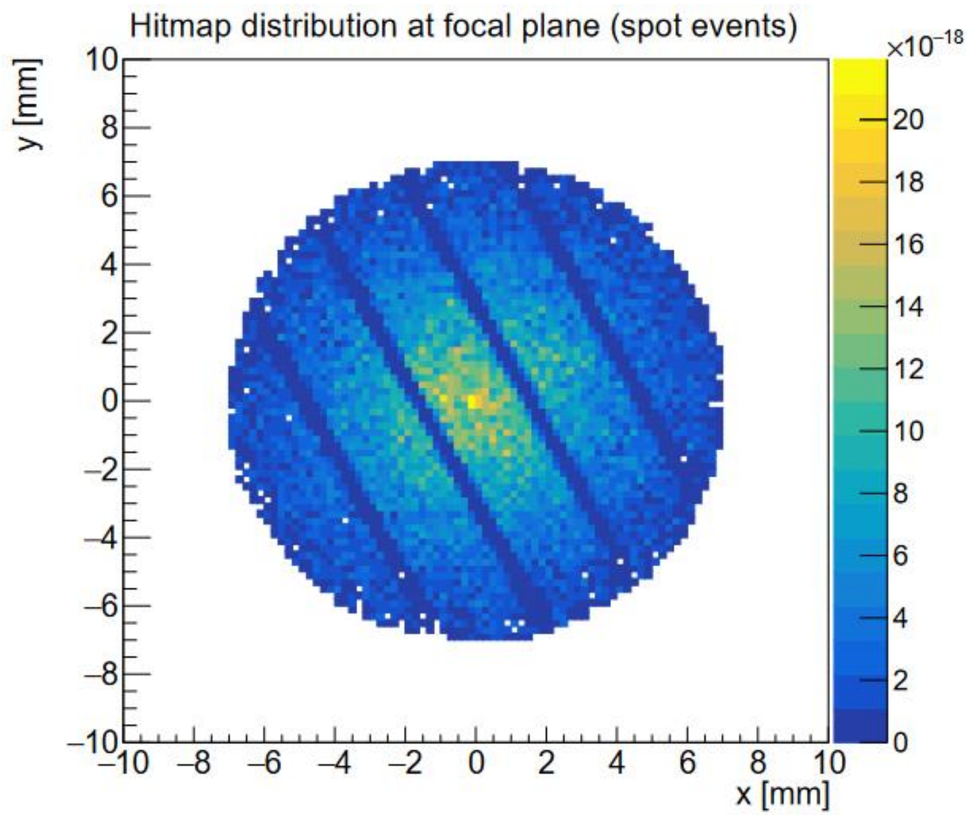
DETECTOR GOAL

Low energy X-rays



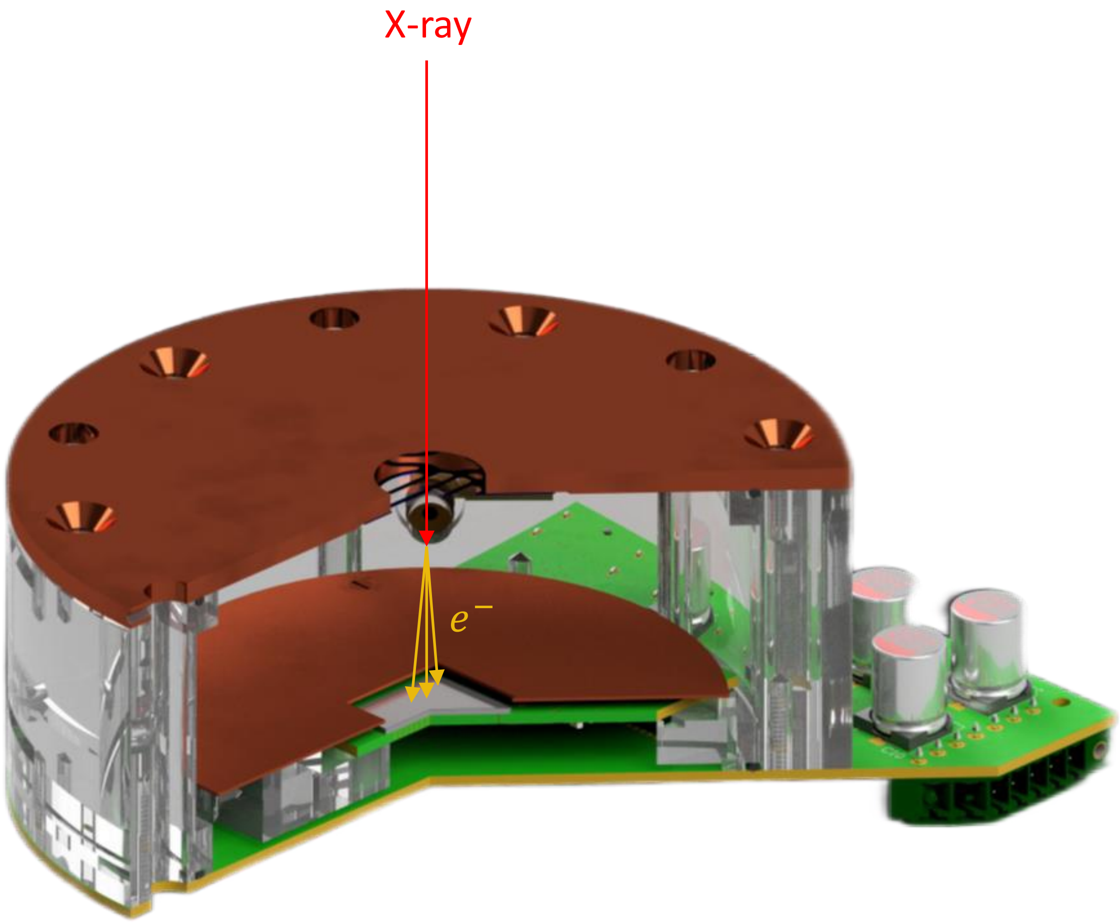
KSVZ axion model

Low signal count



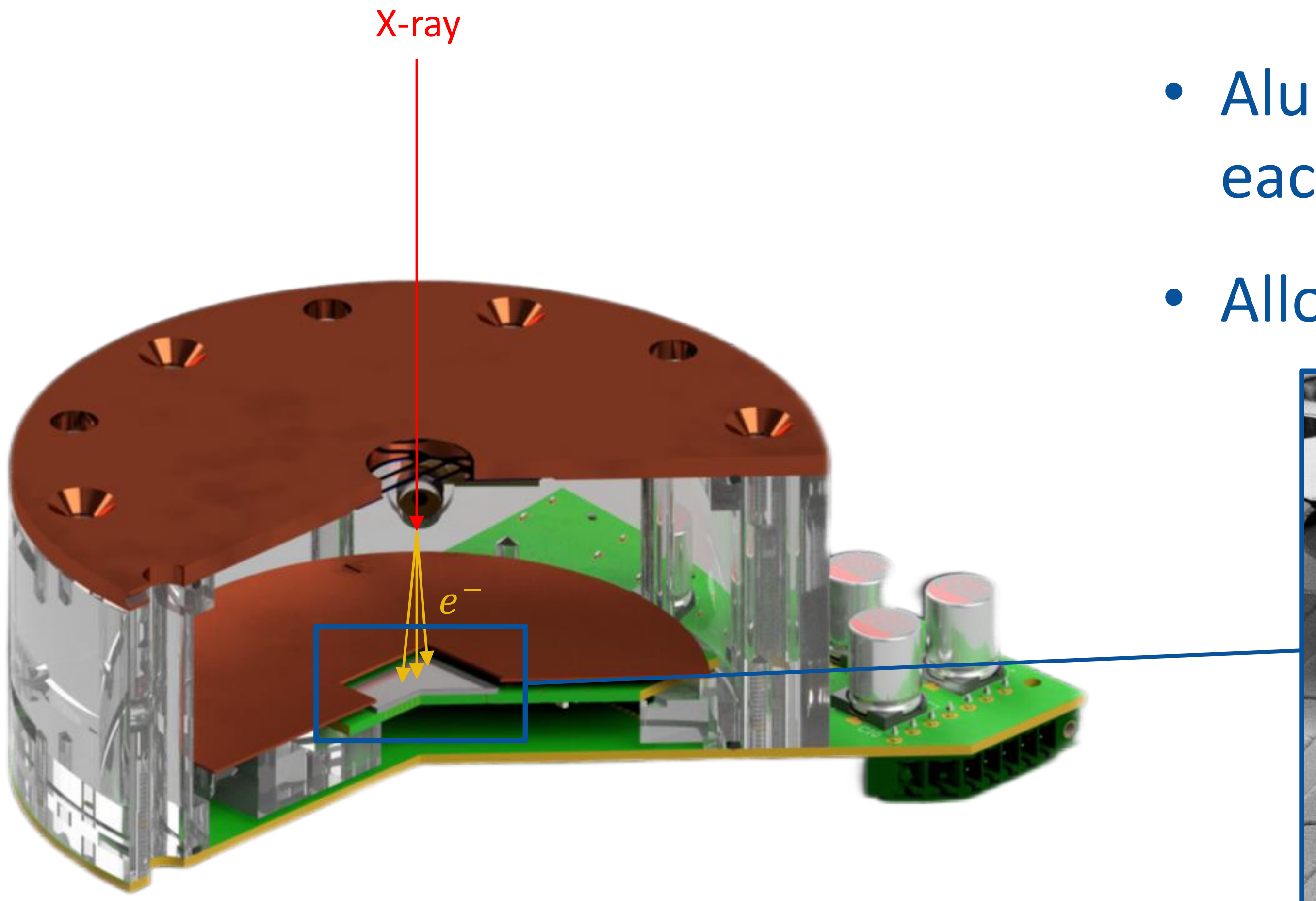
100000 events ≈ 10.5 ns

DETECTOR PRINCIPLE

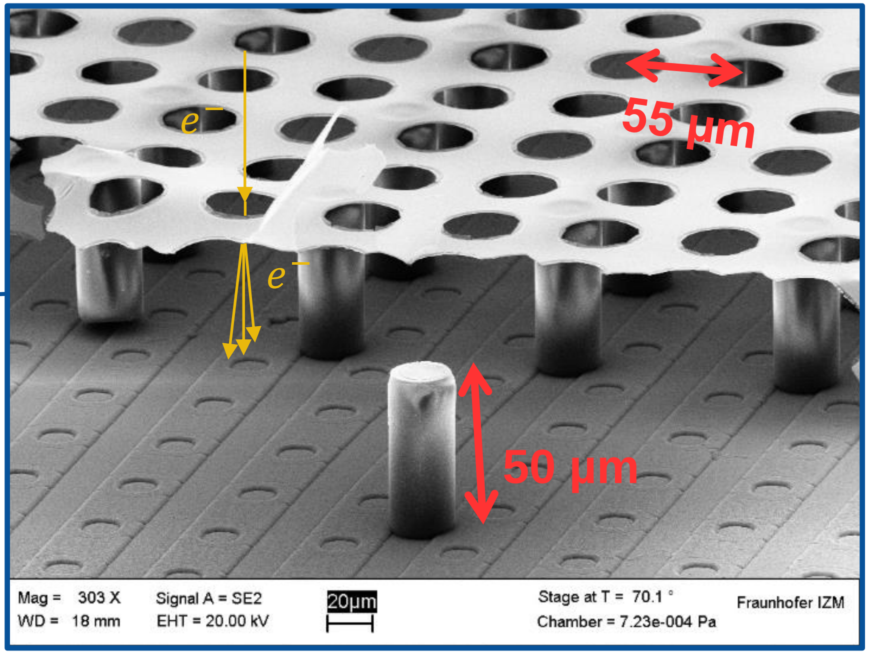


- X-rays travel through vacuum tight window
- Ionize atoms in argon isobutane mixture
- Electrons are accelerated in electric field towards detection chip

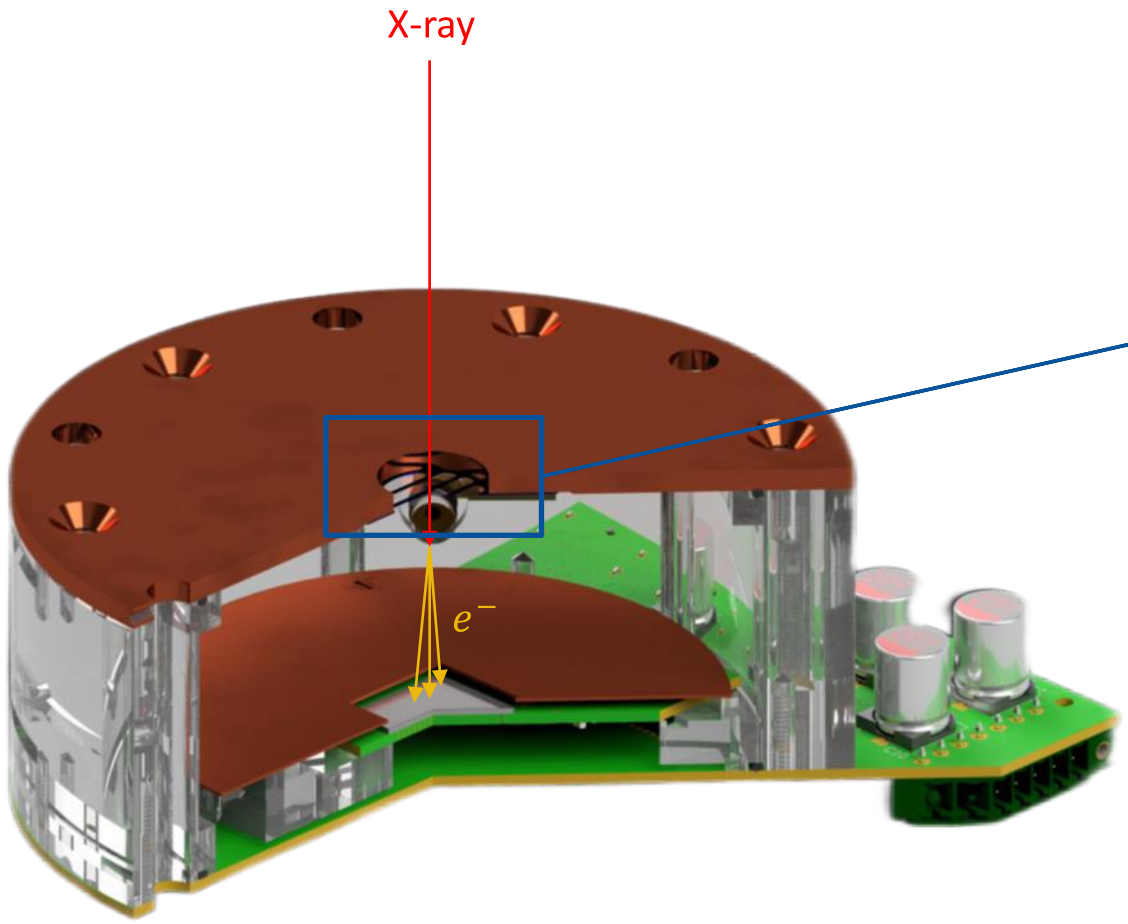
DETECTOR PRINCIPLE

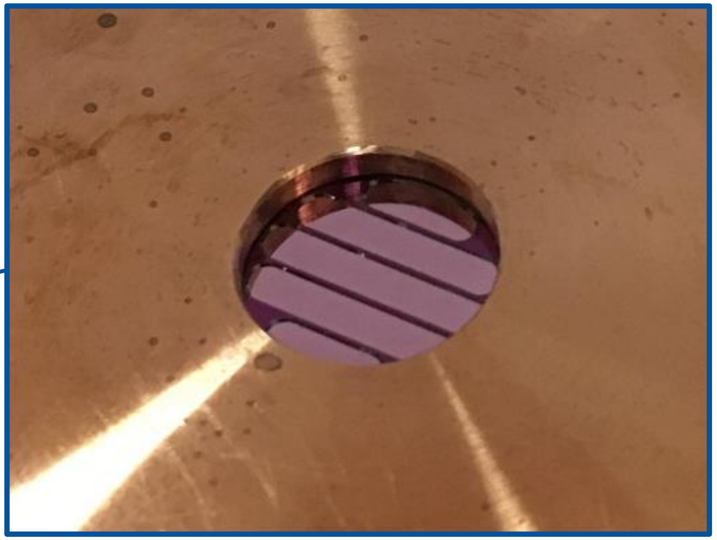


- Aluminium grid with one hole above each pixel of the Timepix3 chip
- Allows single electron detection



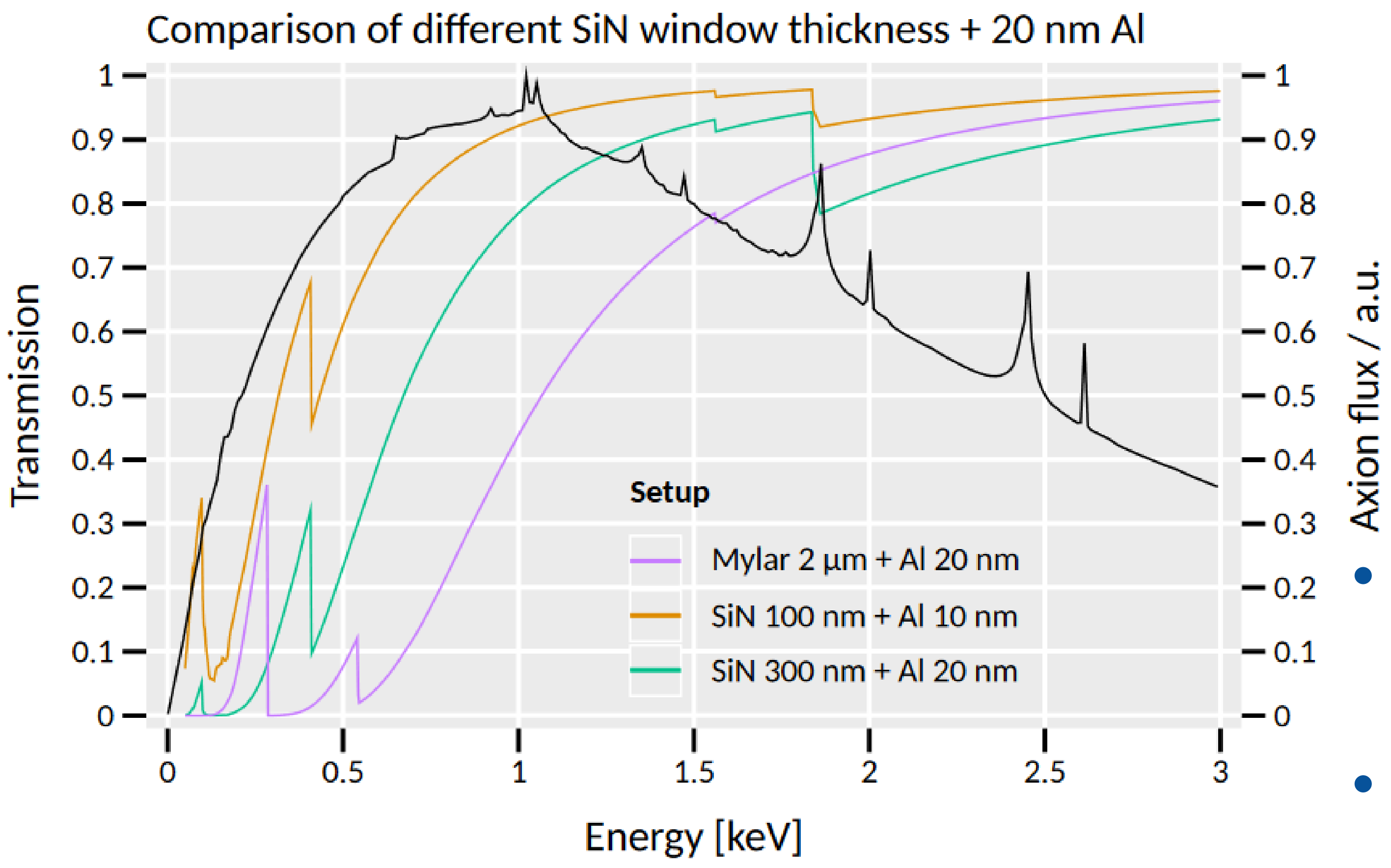
DETECTOR PRINCIPLE - VACUUM TIGHT WINDOWS

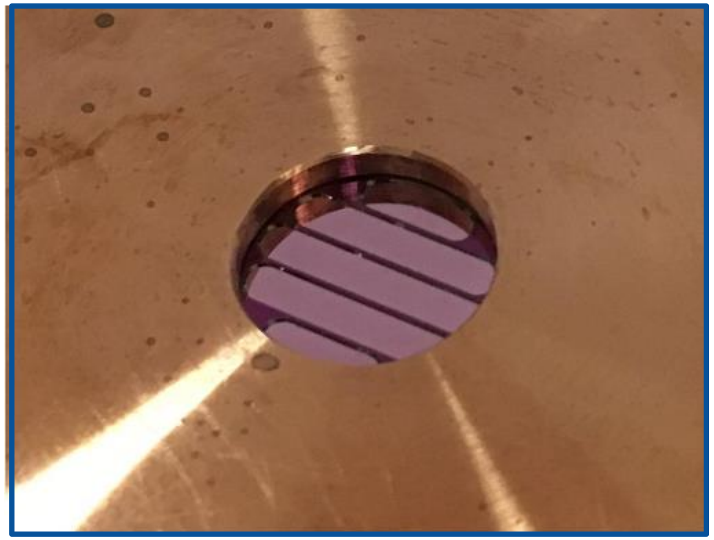




- Silicon nitride window supported by silicon strips
- Withstands a pressure difference of up to 1.5 bar

DETECTOR PRINCIPLE - VACUUM TIGHT WINDOWS





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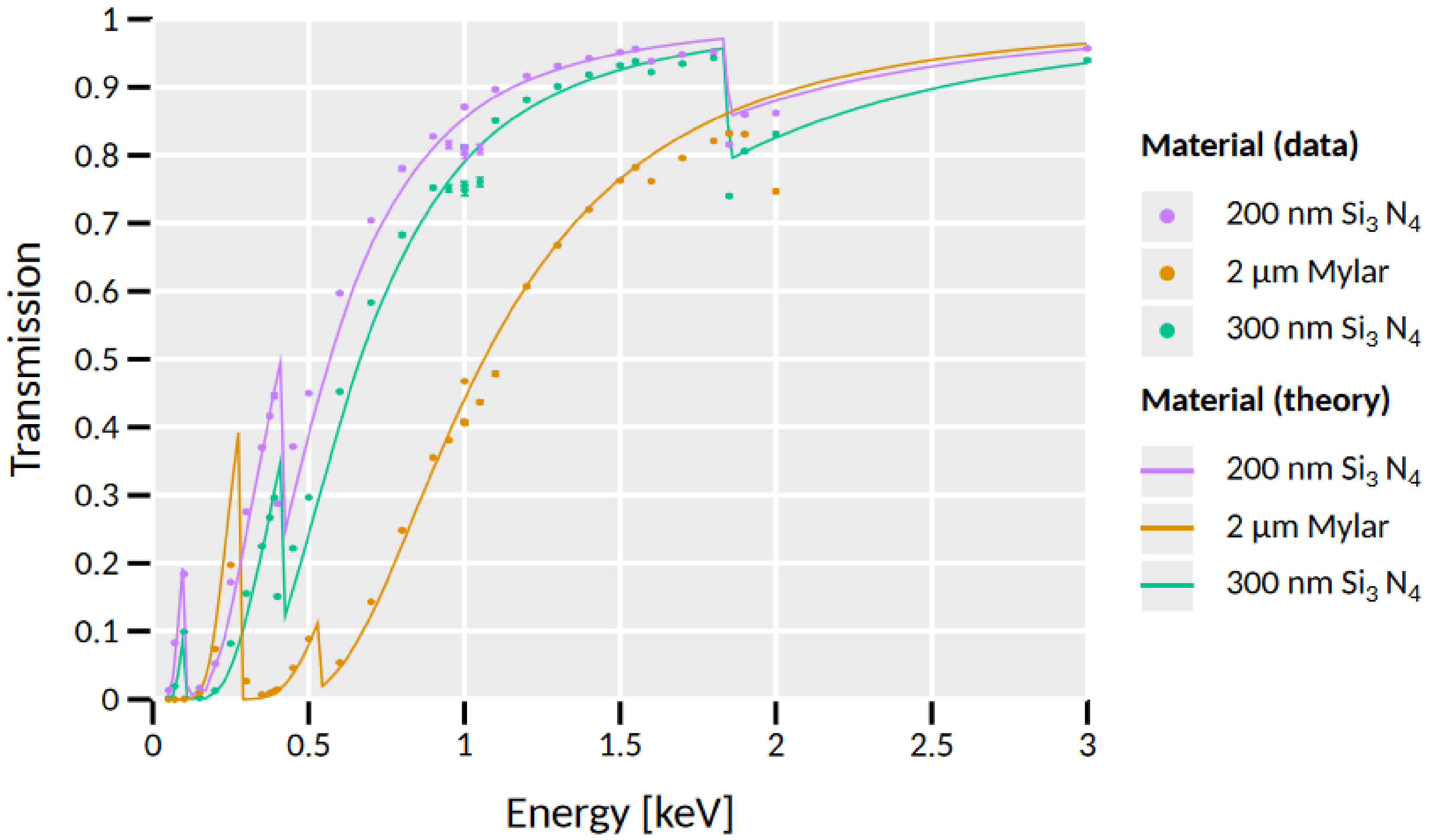
- Withstands a pressure difference of up to 1.5 bar

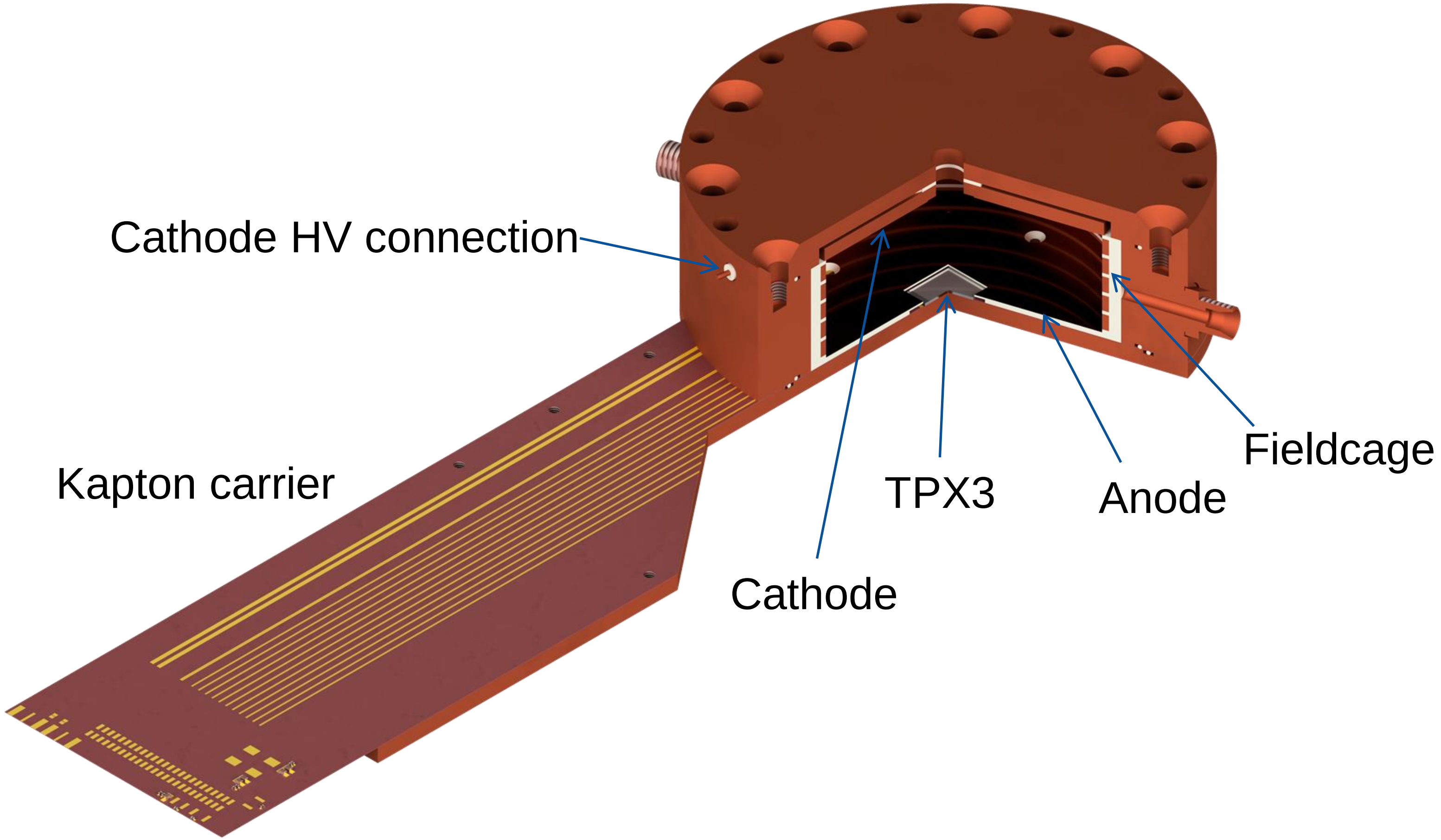
DETECTOR PRINCIPLE - VACUUM TIGHT WINDOWS

Window measurements at SOLEIL



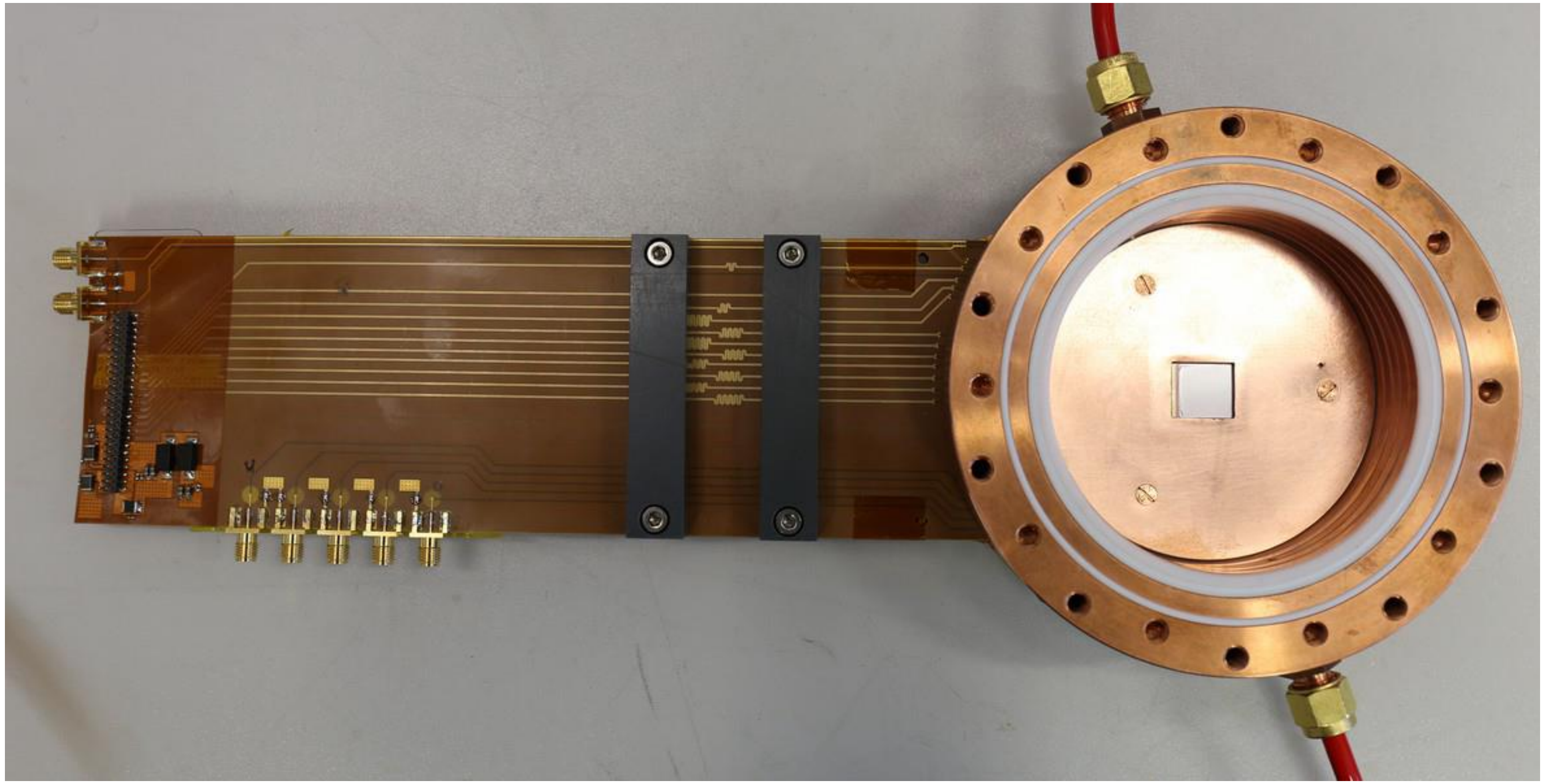
RADIOPURE DETECTOR CONCEPT

- Low signal calls for radiopure materials like lead, copper, teflon or kapton
- Move away as many electronic parts as possible
- No soldering close to chip -> knot copper wires
- Build lead housing setup
- Clean and test all materials



FIRST PROTOTYPE

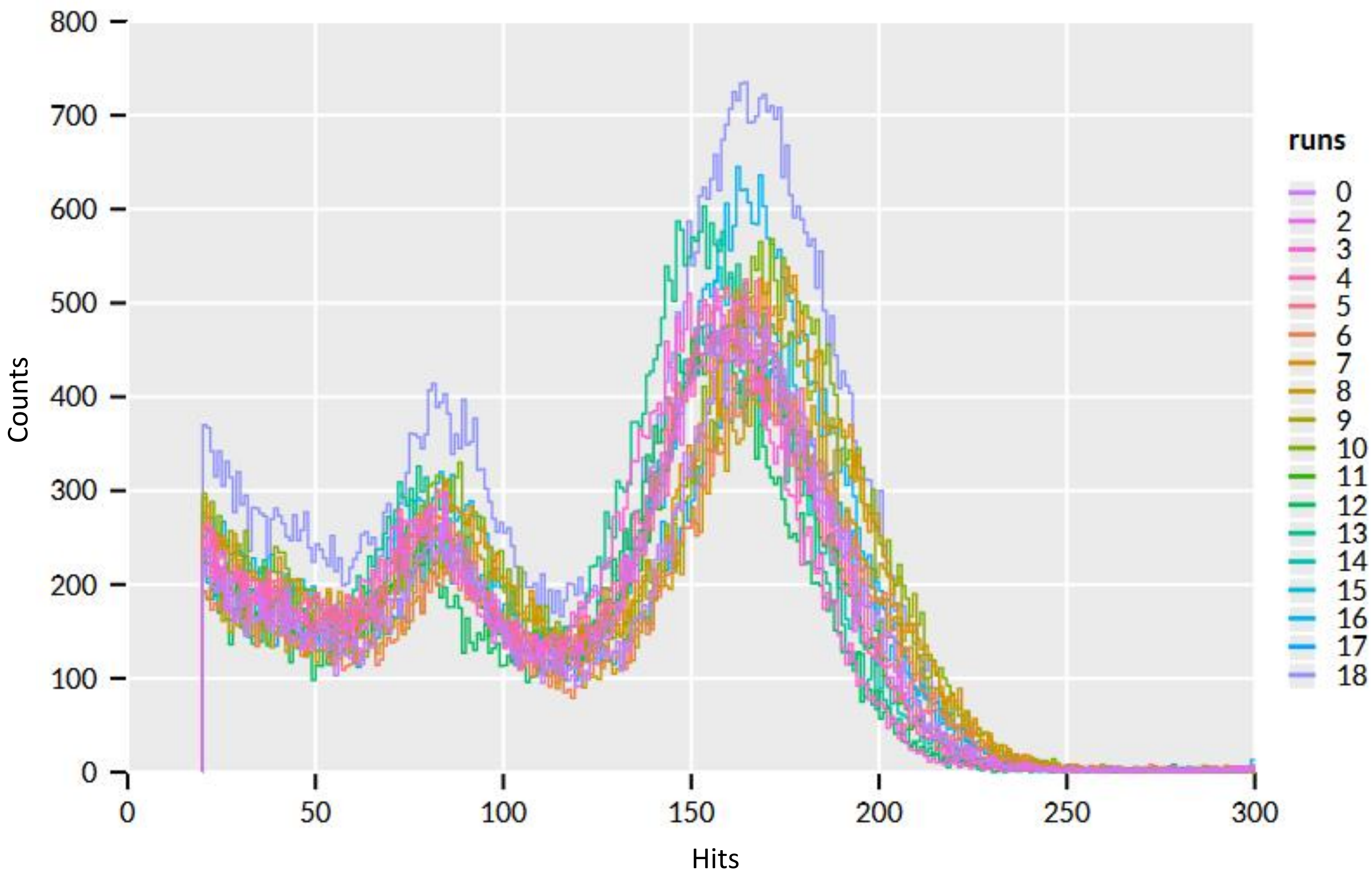
- Low signal calls for radiopure materials like lead, copper, teflon or kapton
- Move away as many electronic parts as possible
- No soldering close to chip -> knot copper wires
- Build lead housing setup
- Clean and test all materials



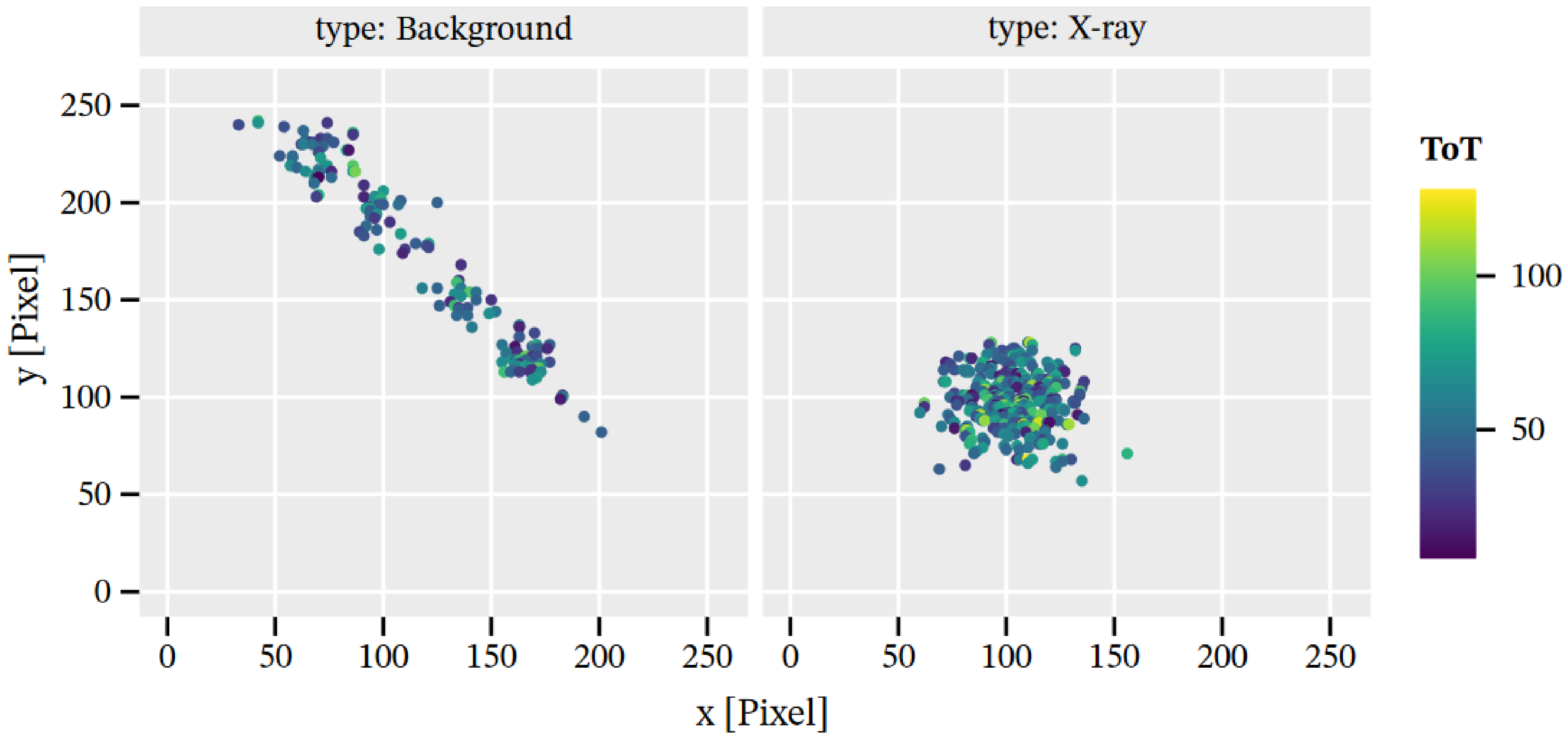
First prototype, non-radiopure

DETECTOR CALIBRATION WITH ^{55}FE

- Data taking for about 750 h
- 18 calibration runs with ^{55}Fe and no shielding
- Shows iron peak at expected around 220 pixels per event



BACKGROUND REDUCTION THROUGH SHAPE



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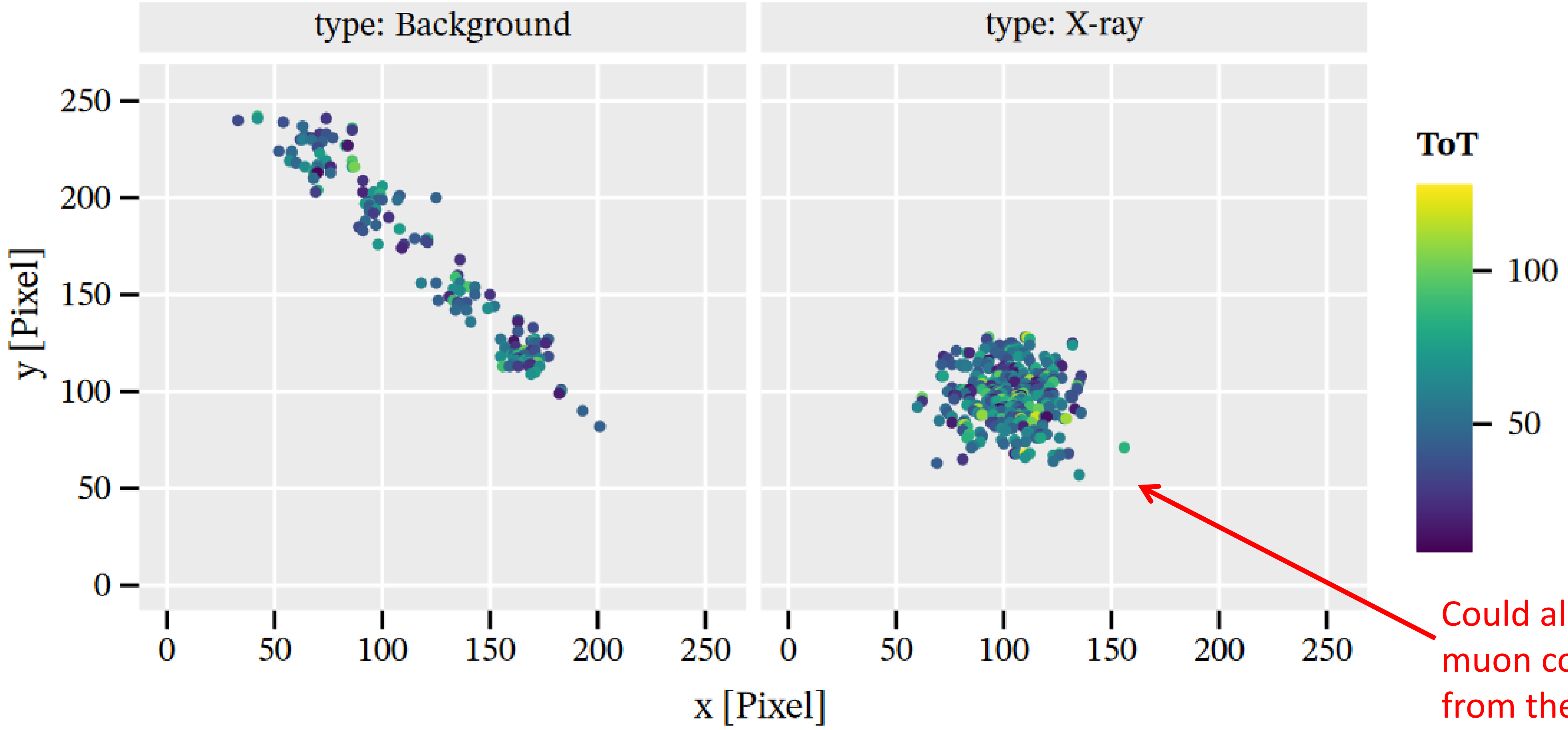
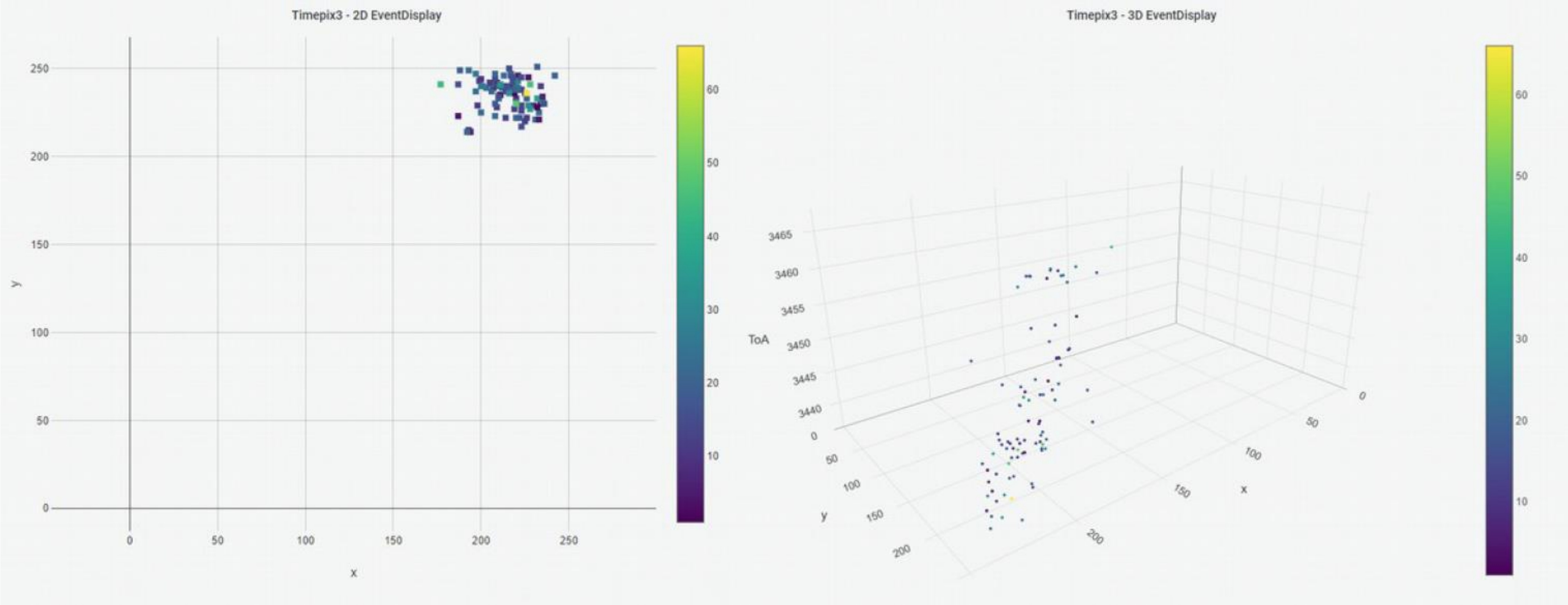


Could also be a muon coming from the window side

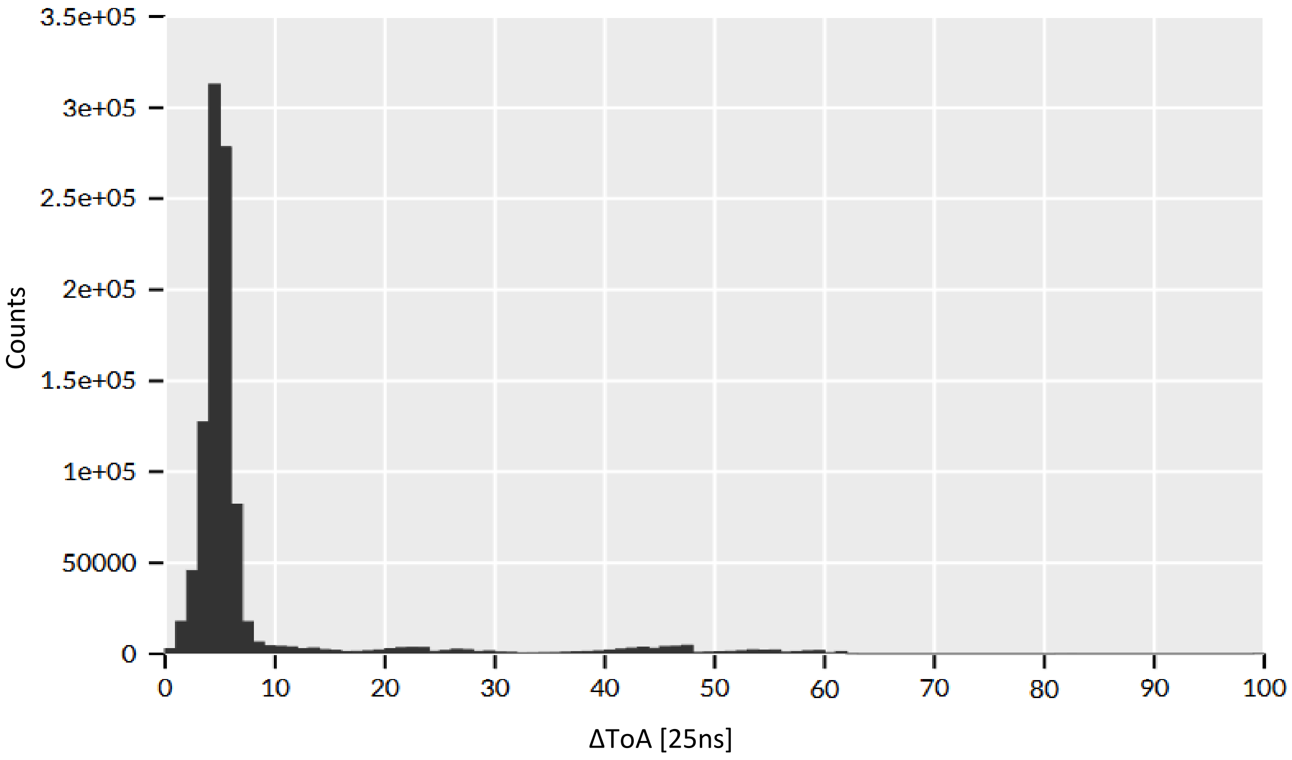
TOA FOR BACKGROUND REDUCTION

New background reduction with Timepix3:
→ ToA (Time of Arrival) is more spread out for muon events

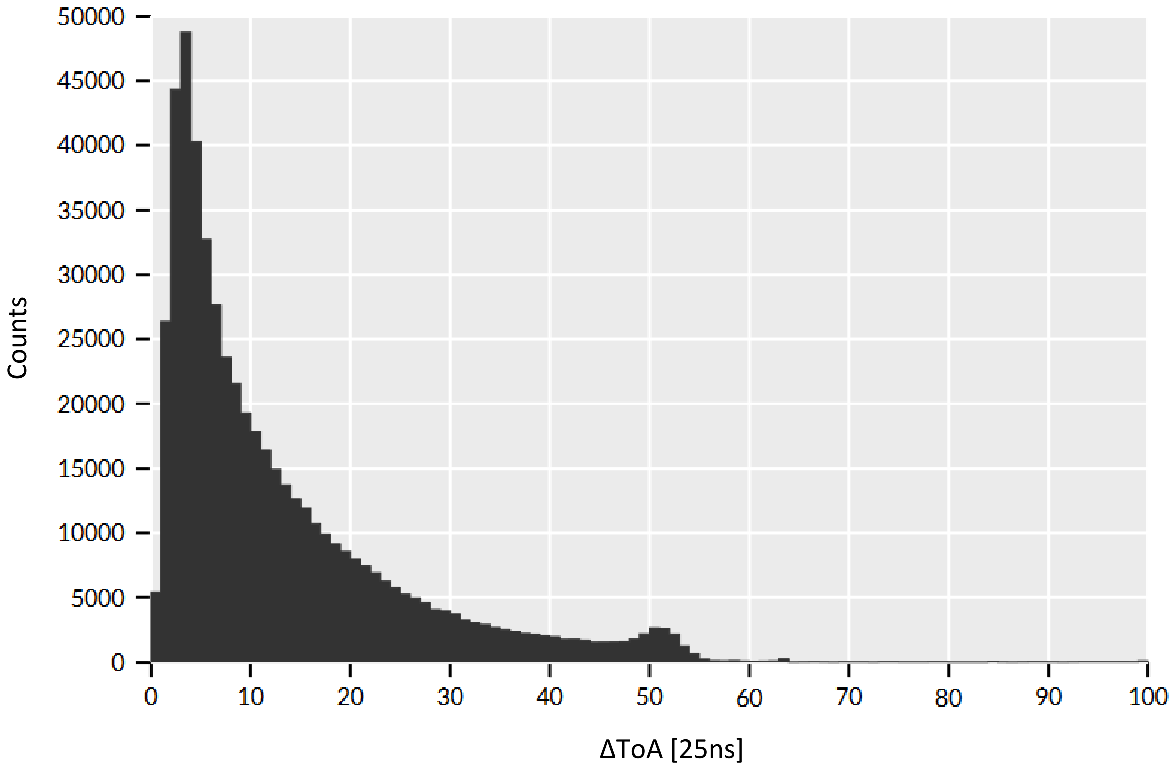


ΔTOA OF ^{55}FE EVENTS VS BACKGROUND

^{55}Fe

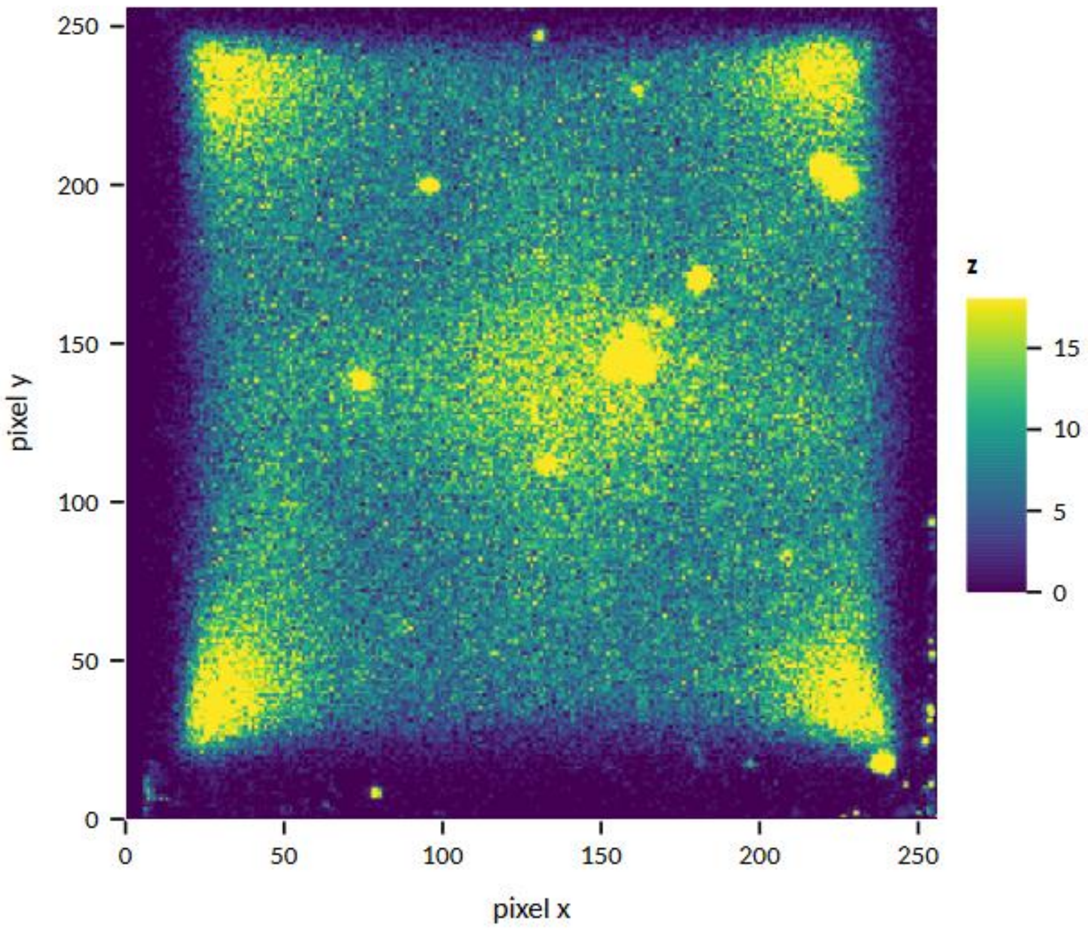


Background



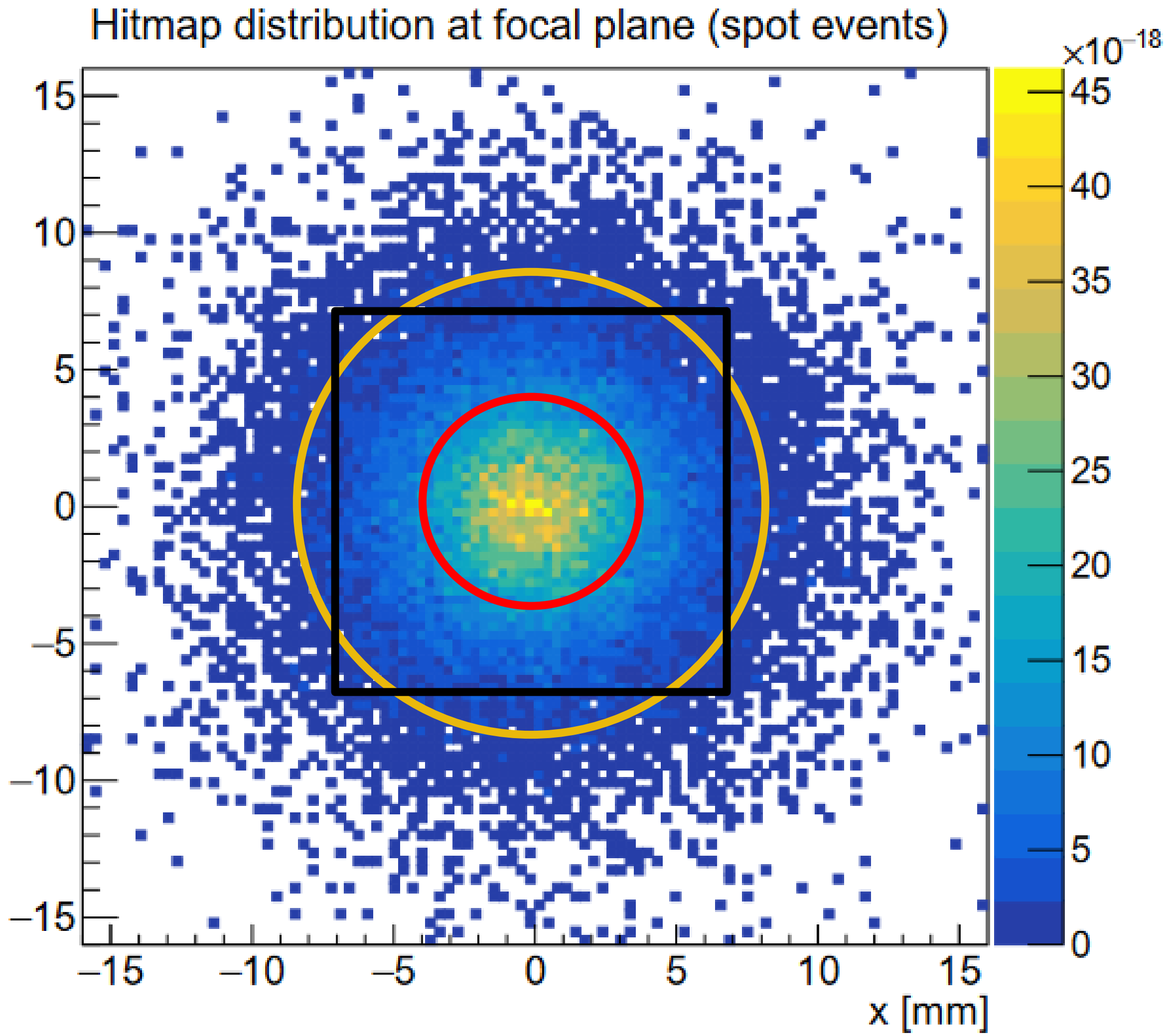
BACKGROUND RUN SPATIAL RESOLUTION

- Centers of round events displayed on the chip dimensions
- Already cut non-round background events
- Defects visible



FOCAL DISTRIBUTION BEFORE WINDOW

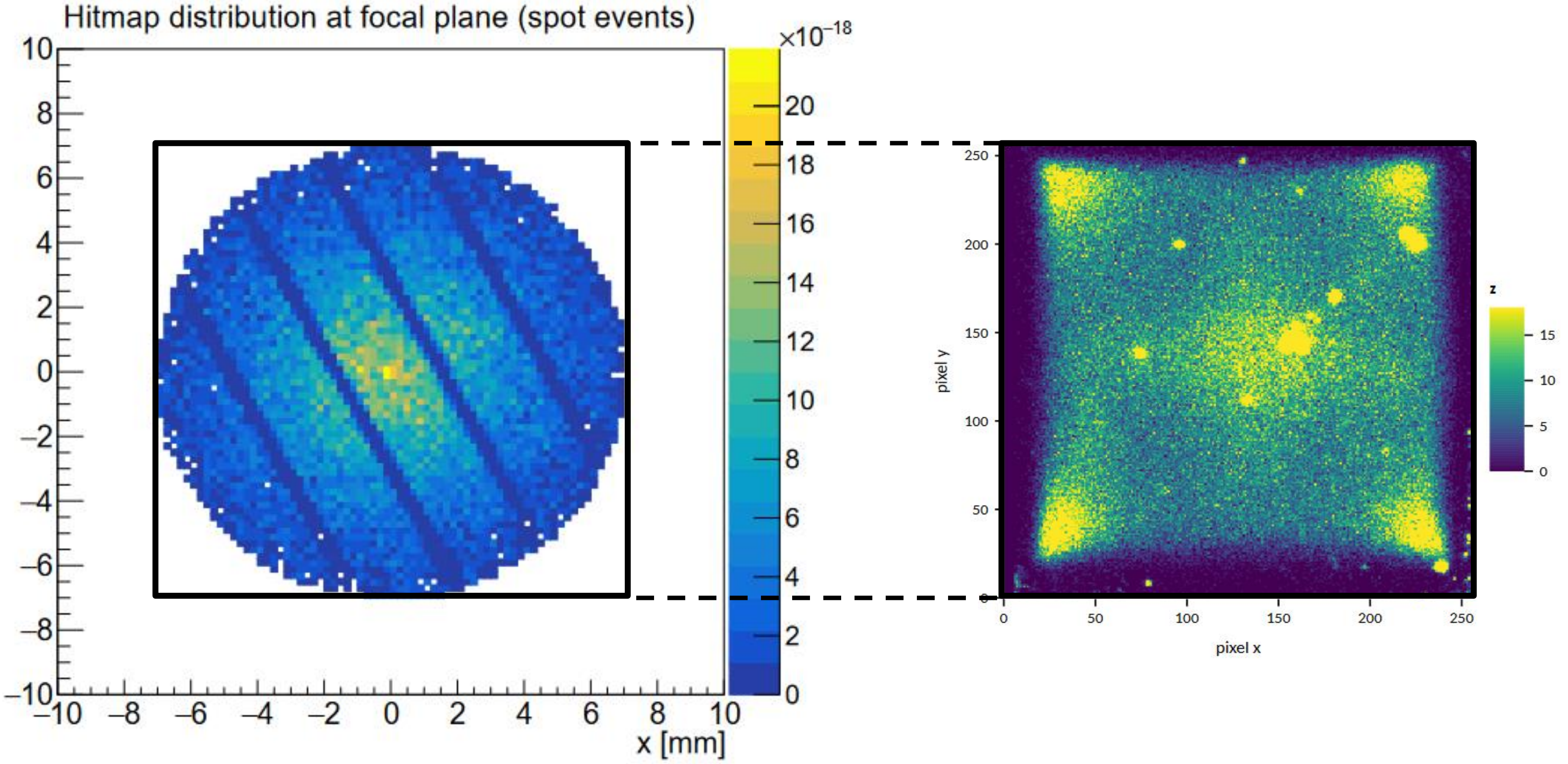
Simulation: Primakoff, XMM with REST v2.4.1



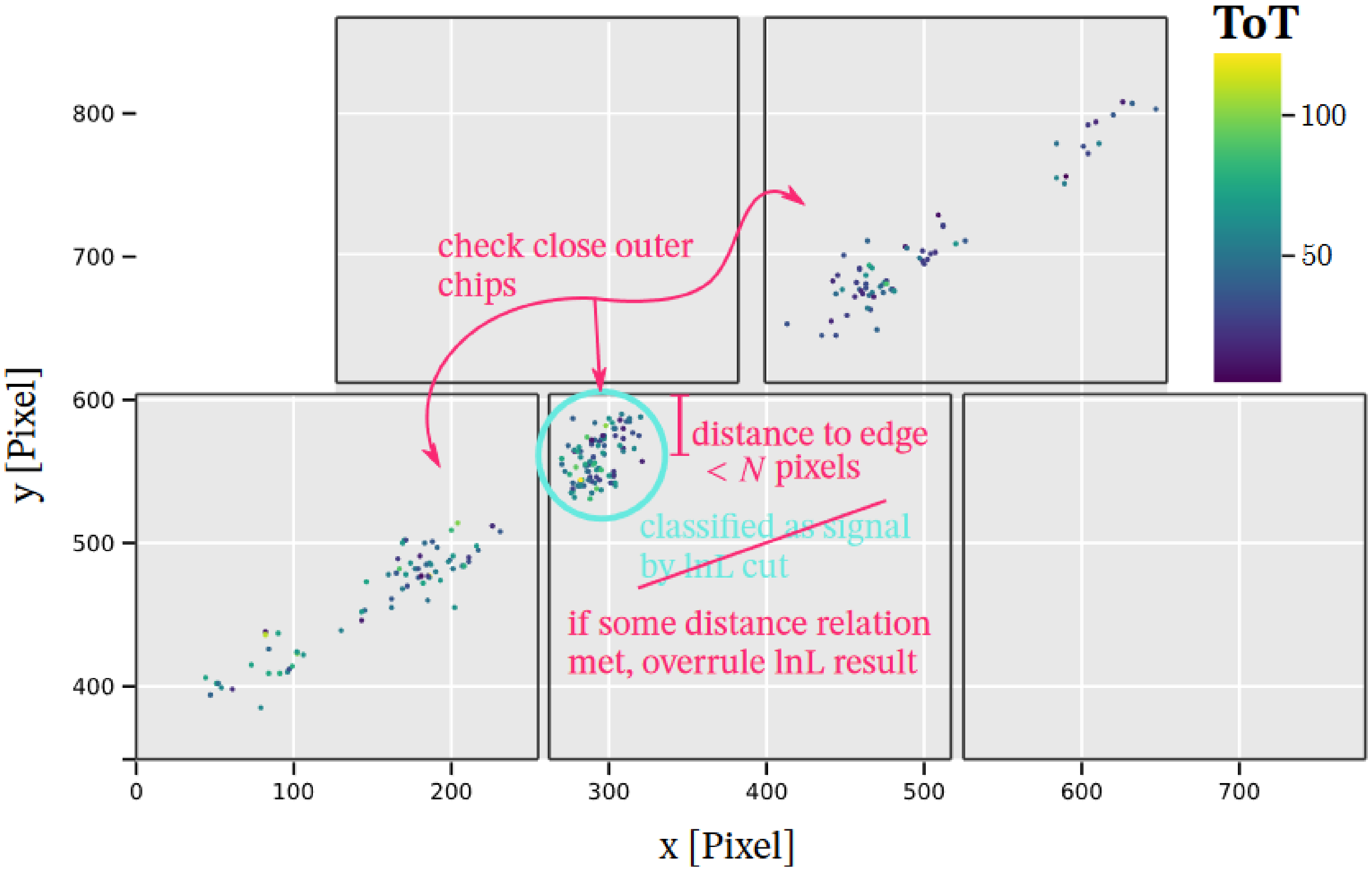
- Red: HEW=7.83mm
- Yellow: W90=16.83mm
- Black: Timepix3 chip size

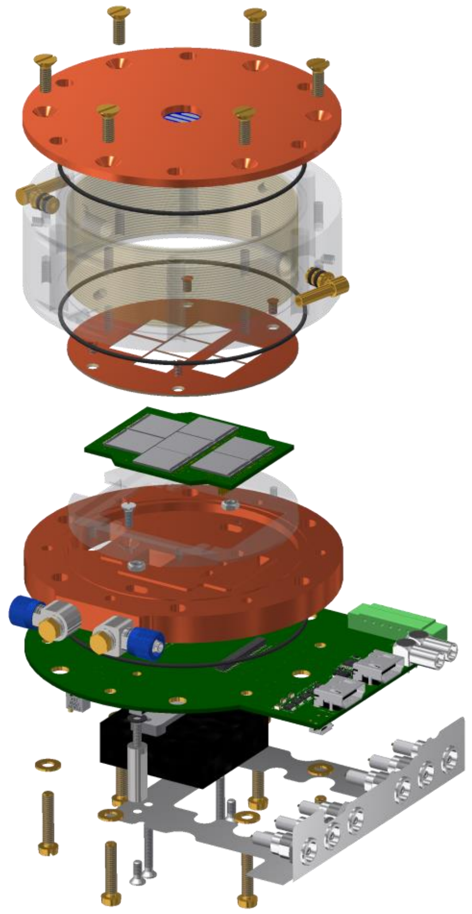
BACKGROUND RUN SPATIAL RESOLUTION

Simulation: Primakoff, XMM, GridPix with REST v2.4.1



BACKGROUND REDUCTION THROUGH 7 CHIPS

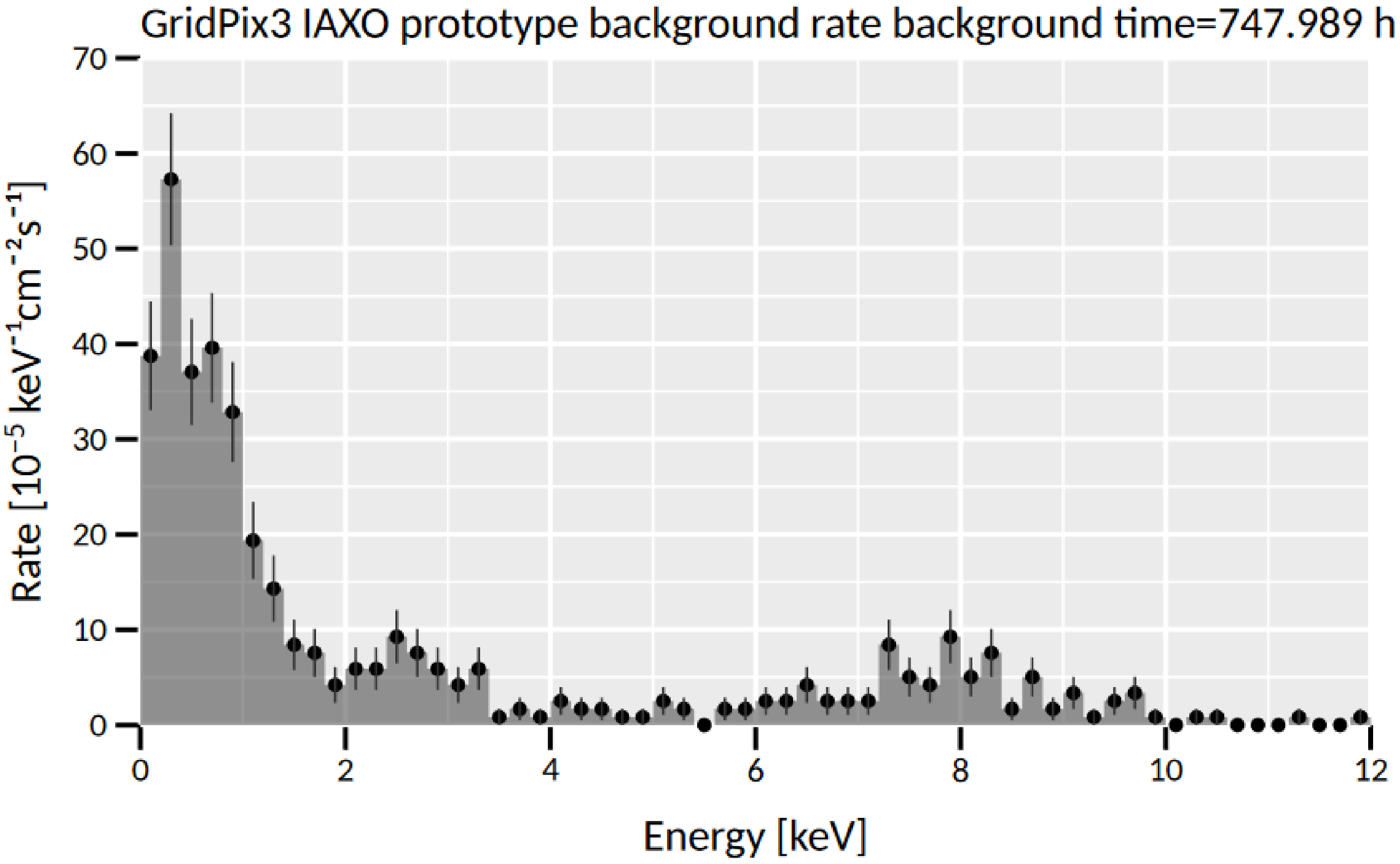




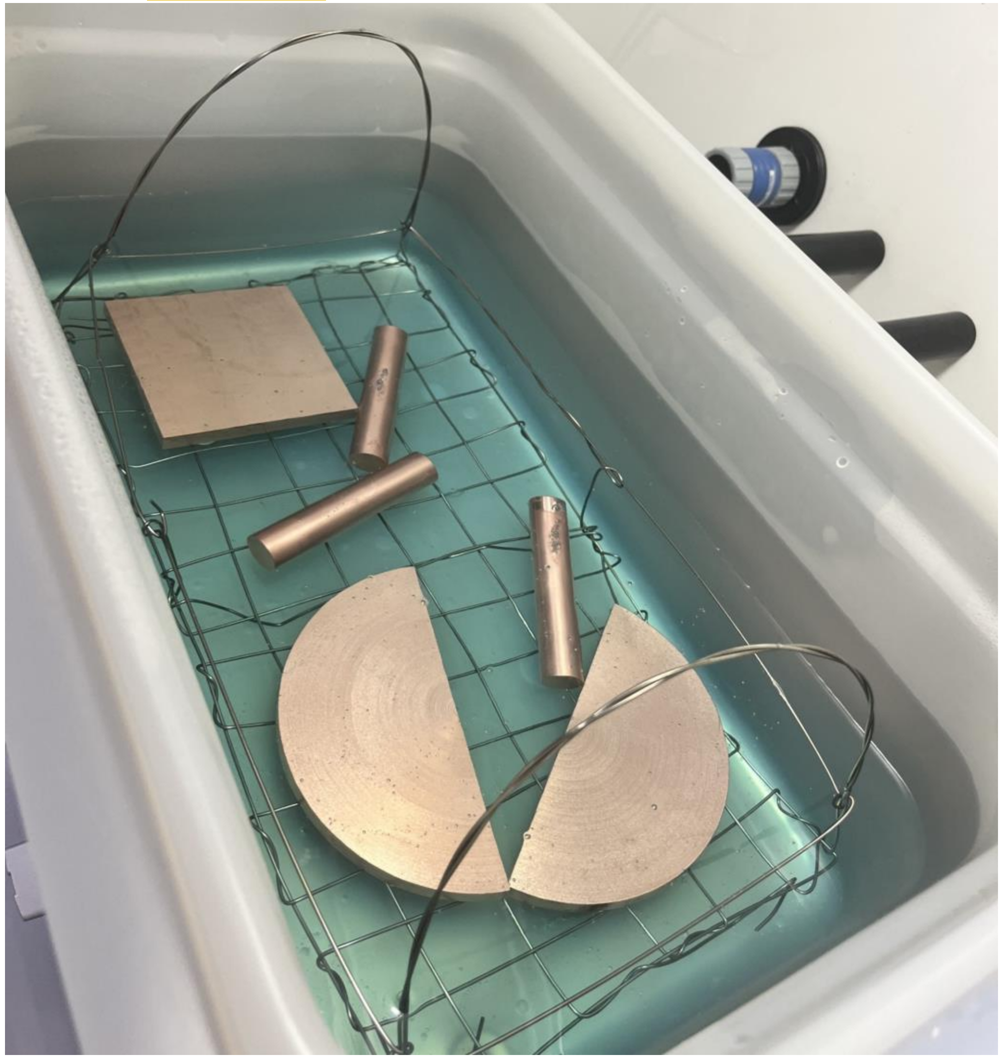
7 chip GridPix detector

BACKGROUND RATE

- Peak in front is under investigation, probably due to the bad chip
- Rate for the rest looks fine
- No radiopure material here, no shielding



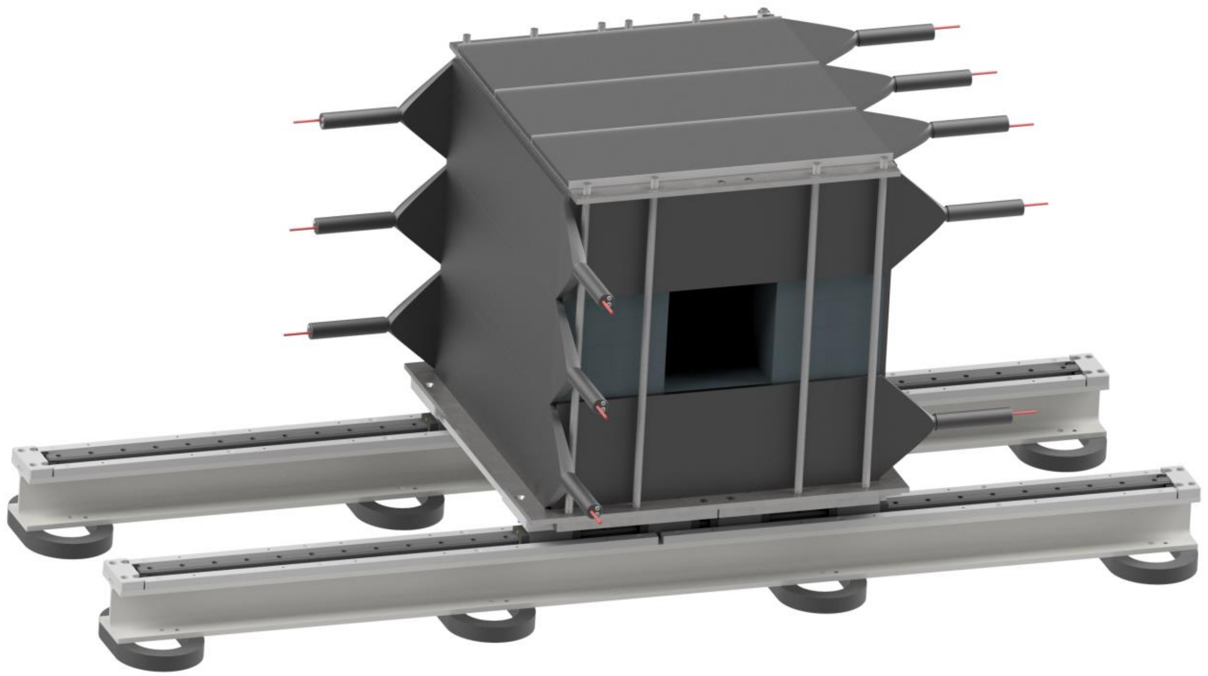
CLEANING THE RADIOPURE PARTS



- Cleaning the radiopure materials to get rid of:
  - ^{40}K from human contact
  - ^{210}Pb from ^{222}Rn from surfaces
  - Oxidation of copper
- Storage in sealed or N_2 flushed areas

MUON VETO TEST STAND

- Test stand for GridPix tests will be built in underground lab
- Movable lead shielding for easy access
- Muon veto scintillators covering the sides and top



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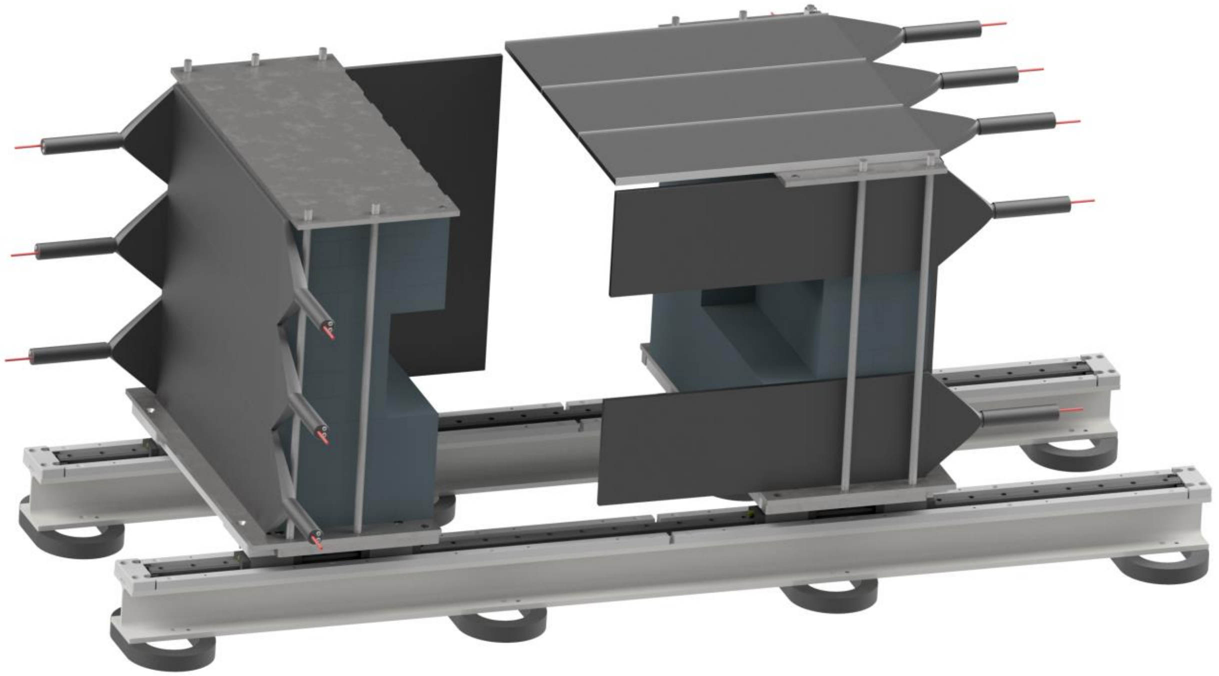
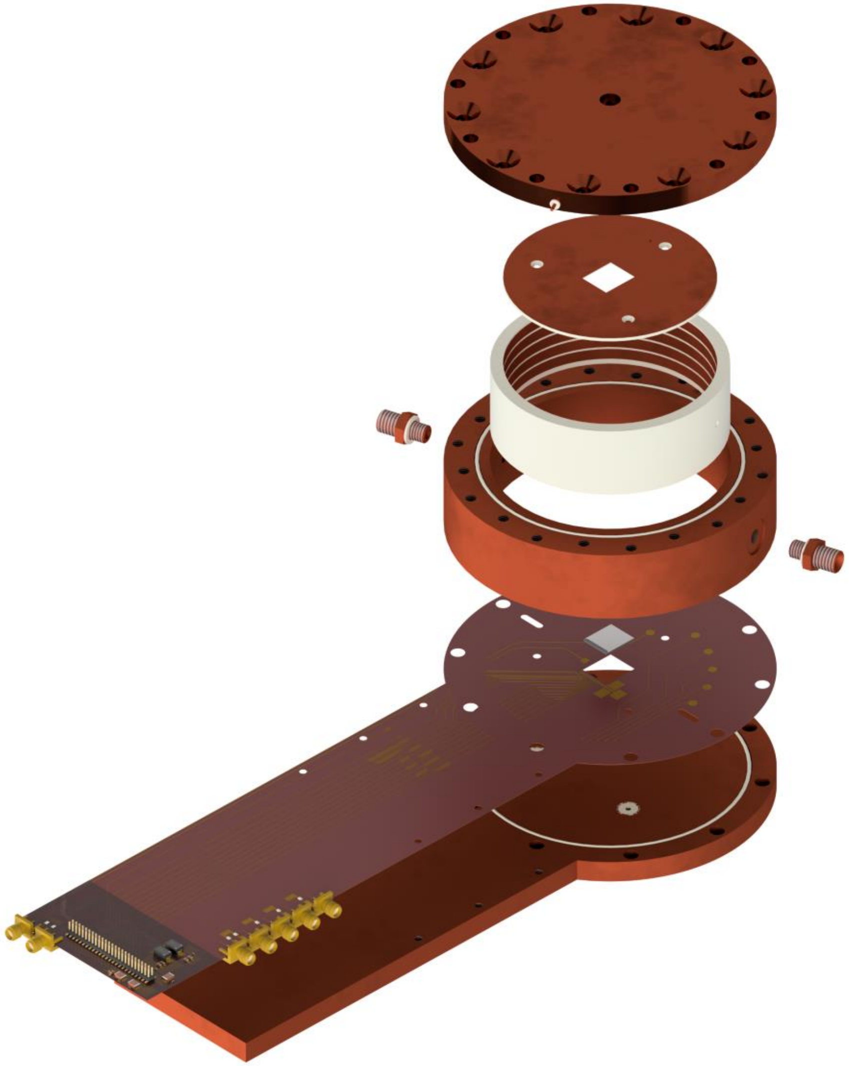


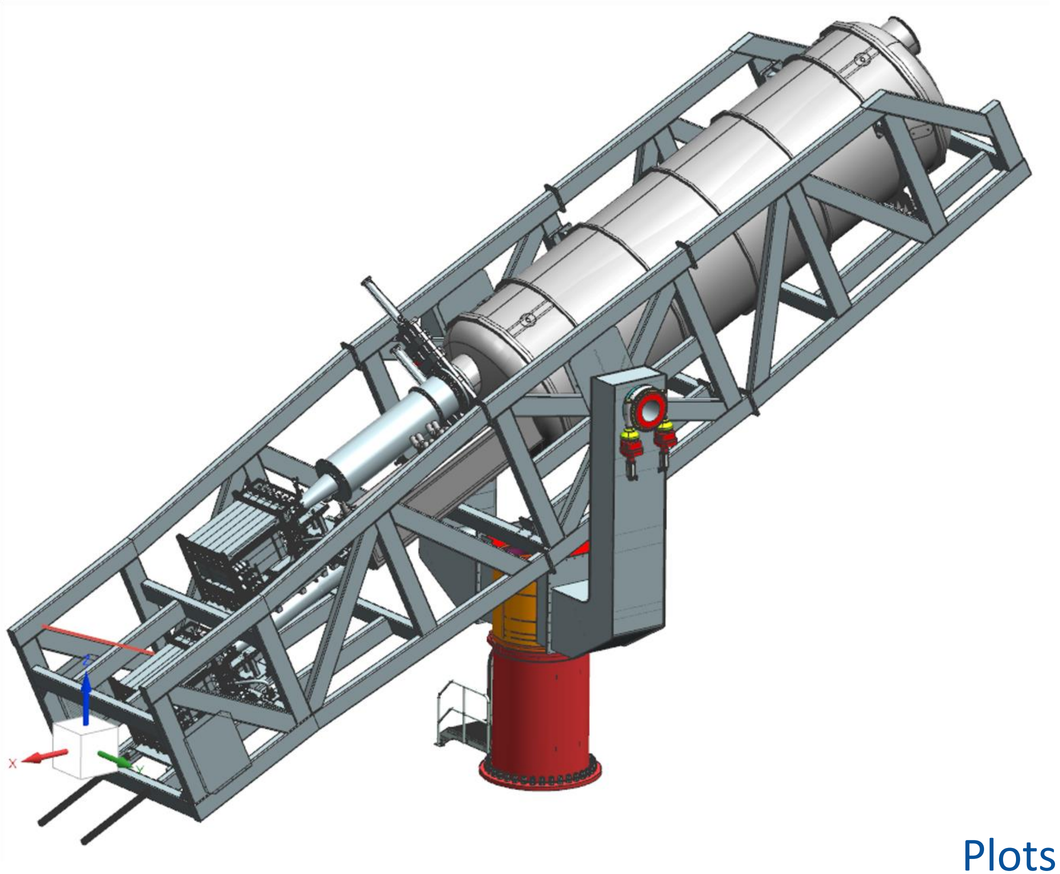
CONCLUSION AND OUTLOOK

- Axion detection challenges approached with a GridPix detector with:
  - Radiopure materials
  - Ultra thin windows
- First runs with first prototype detector successful
- ToA as newly accessible feature of Timepix3 helps reduce the background
- Build second prototype from radiopure Cu-OFE and PTFE



BACKUP

Sun



Plots and CAD models in collaboration with Sebastian Schmidt and Tobias Schiffer

CLEANING COPPER

Following the cleaning protocol from Zaragoza:

1. Brush with an **abrasive scouring pad** (portable grinding machine if possible)
2. Etch in a solution of 0.5 Molar super-pure **Nitric Acid** in ultrasonic bath for 30 min at 40°C
3. Rinse in **distilled water**
4. Passivate with a solution of 10% **citric acid** ($C_6H_8O_7$) for 1 hour at 60°C
5. Rinse in **distilled water**
6. Dry ideally by a N_2 flush (or hairdryer)

CLEANING A TEST PIECE OF RADIOPURE COPPER

UNIVERSITÄT BONN

BEFORE AND AFTER

BACKGROUND RUN SPATIAL RESOLUTION

Simulation: Primakoff, XMM, GridPix with REST v2.4.1