phenoPET

A PET Scanner for Plants

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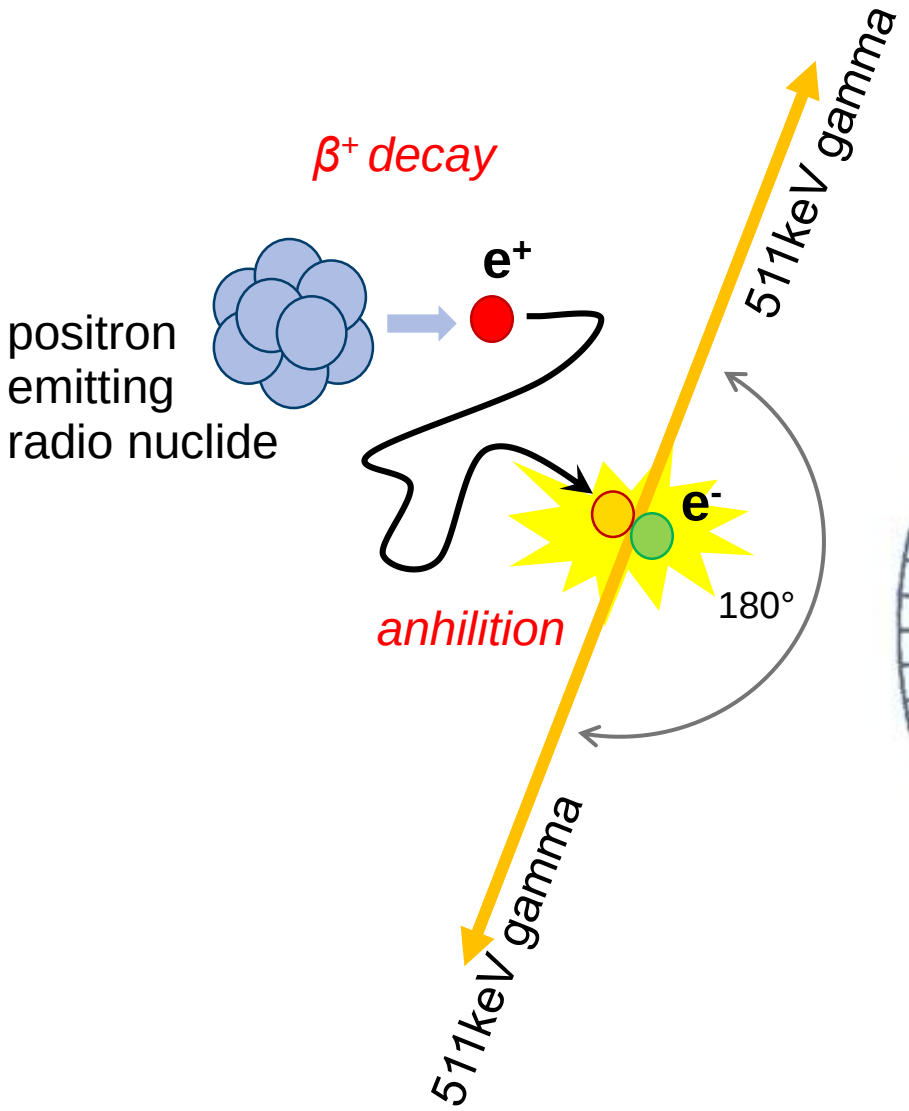
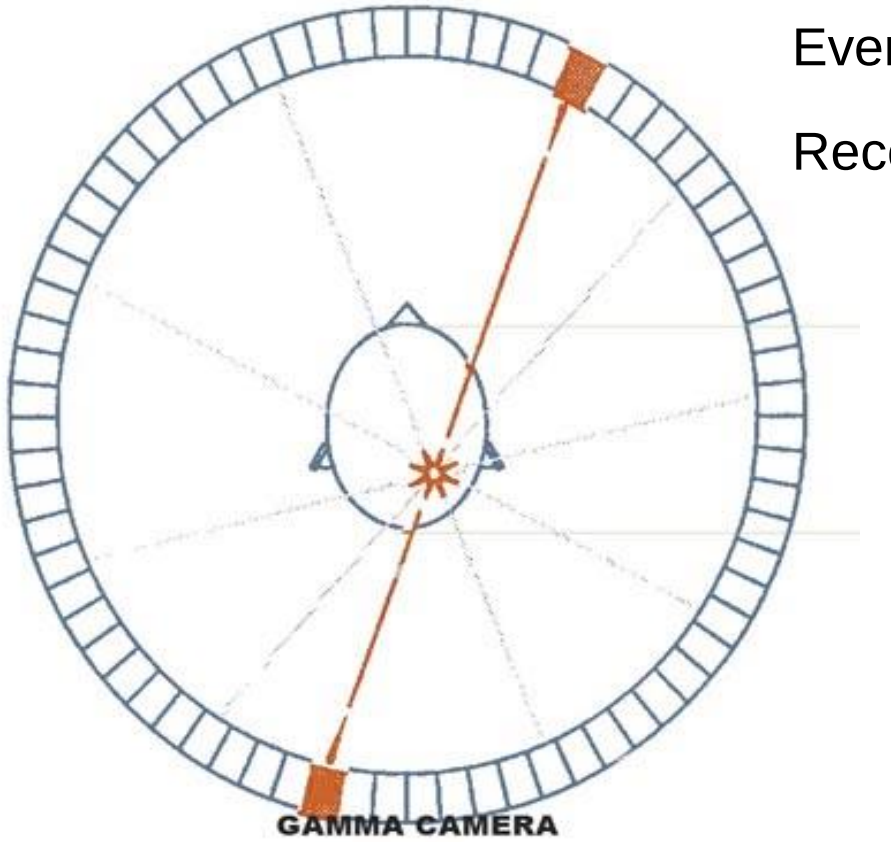
Development within the Frame of the German Plant Phenotyping Network (DPPN)

Positron Emission Tomography (PET)



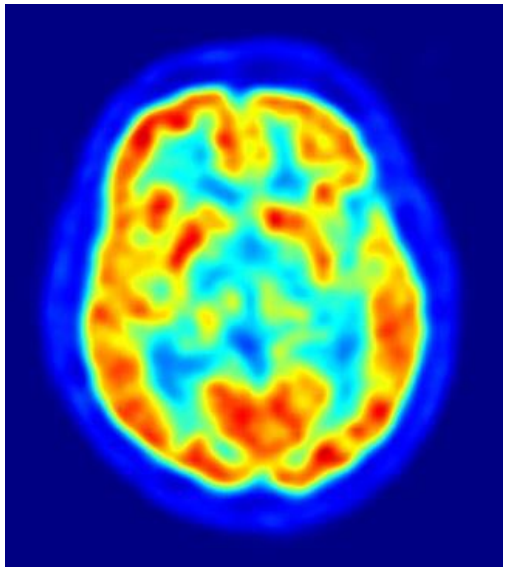


Two correlated gammas at 180°.

Detection in coincidence.

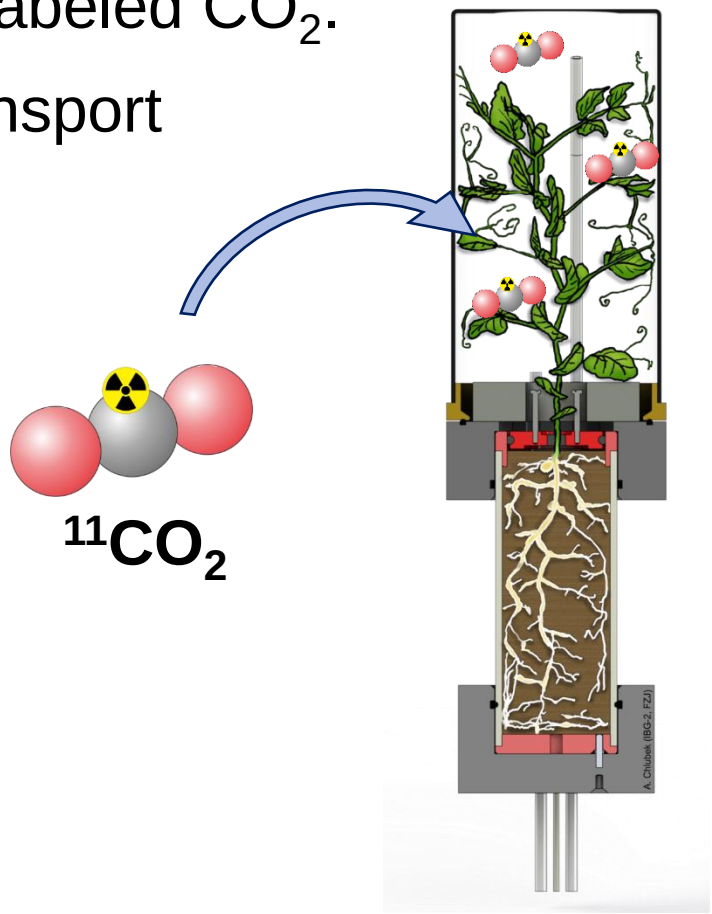
Event on connecting line.

Reconstruction of density map.

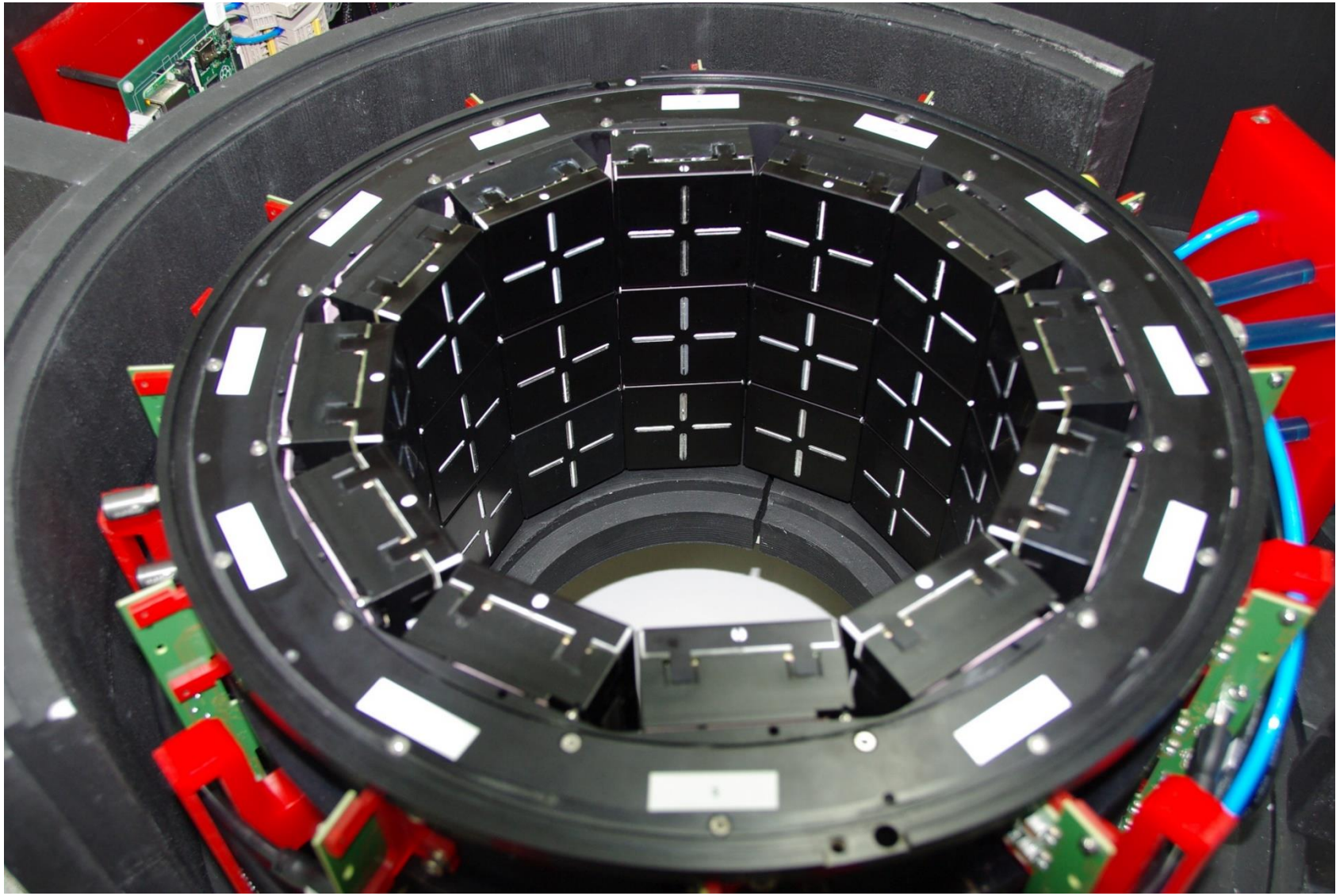


Why PET for Plants?

The plant absorbs C-11 labeled CO_2.
PET can observe the transport
of the photo assimilates,
particularly in the
root system.

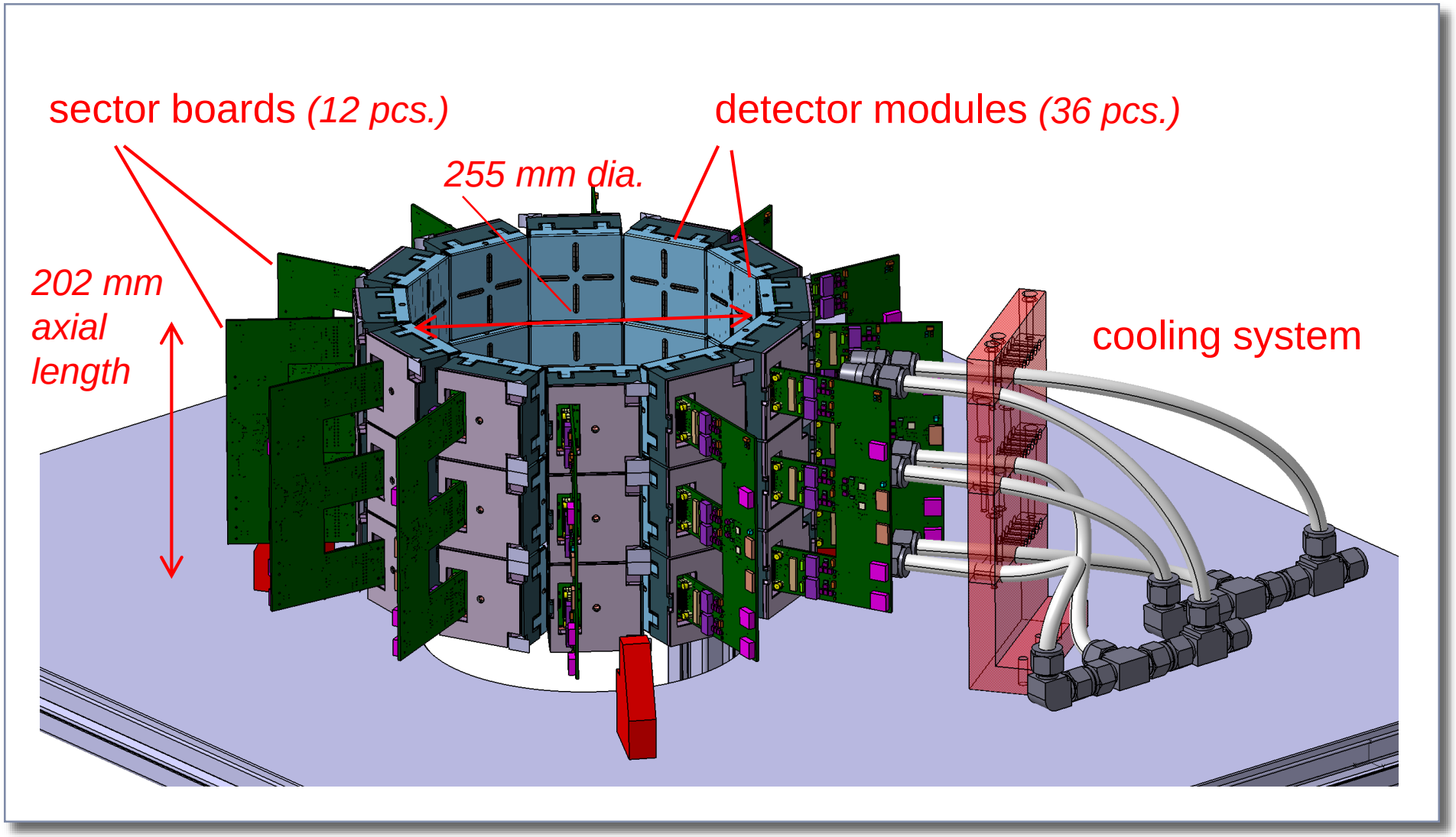


Plant Scanner *phenoPET*

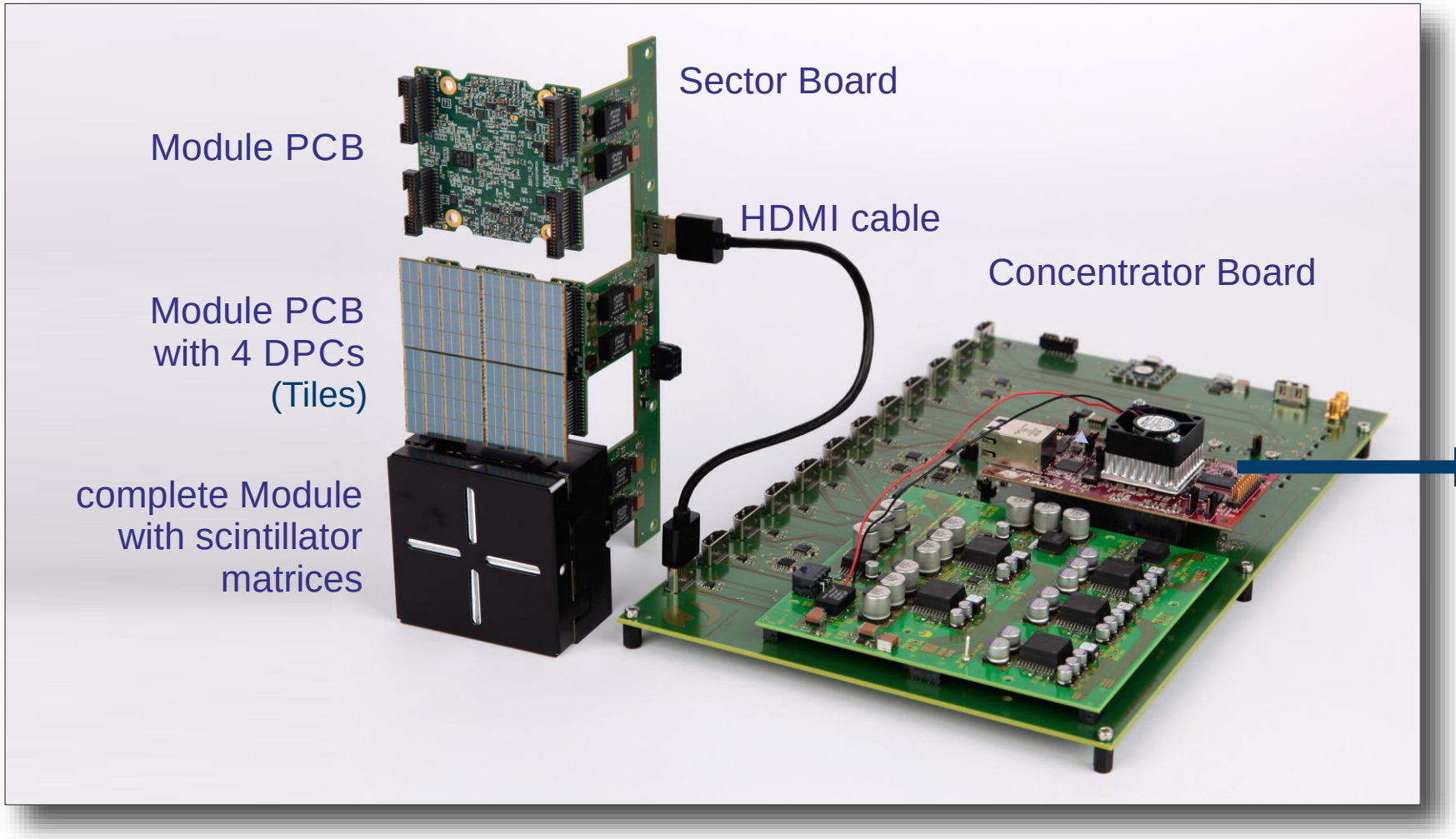


- Field of View:
  ∅180mm×200mm
- Scintillation Detectors with
  - LYSO crystals and
  - Digital SiPM (Philips DPCs)

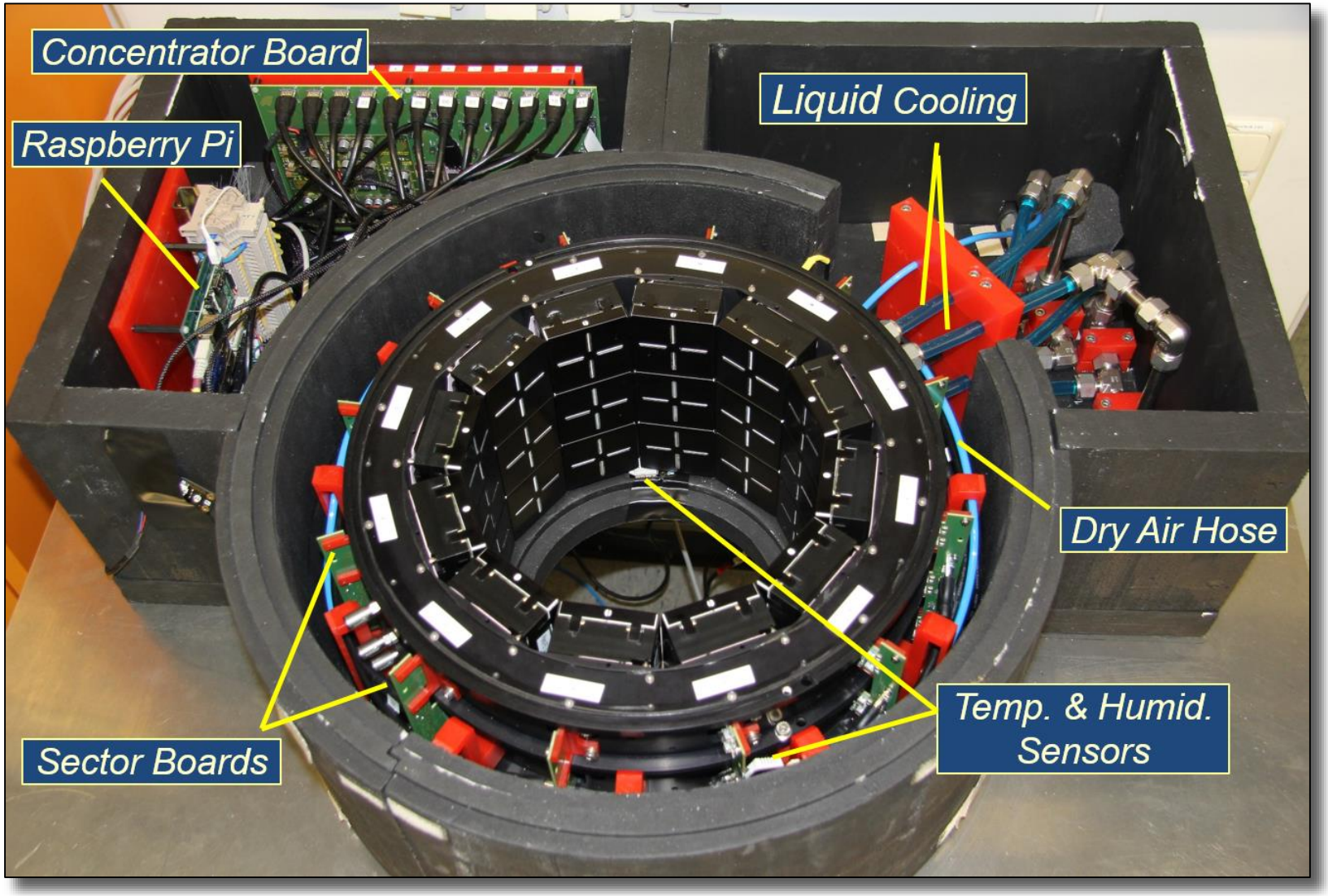
phenoPET Design



Electronic Hardware



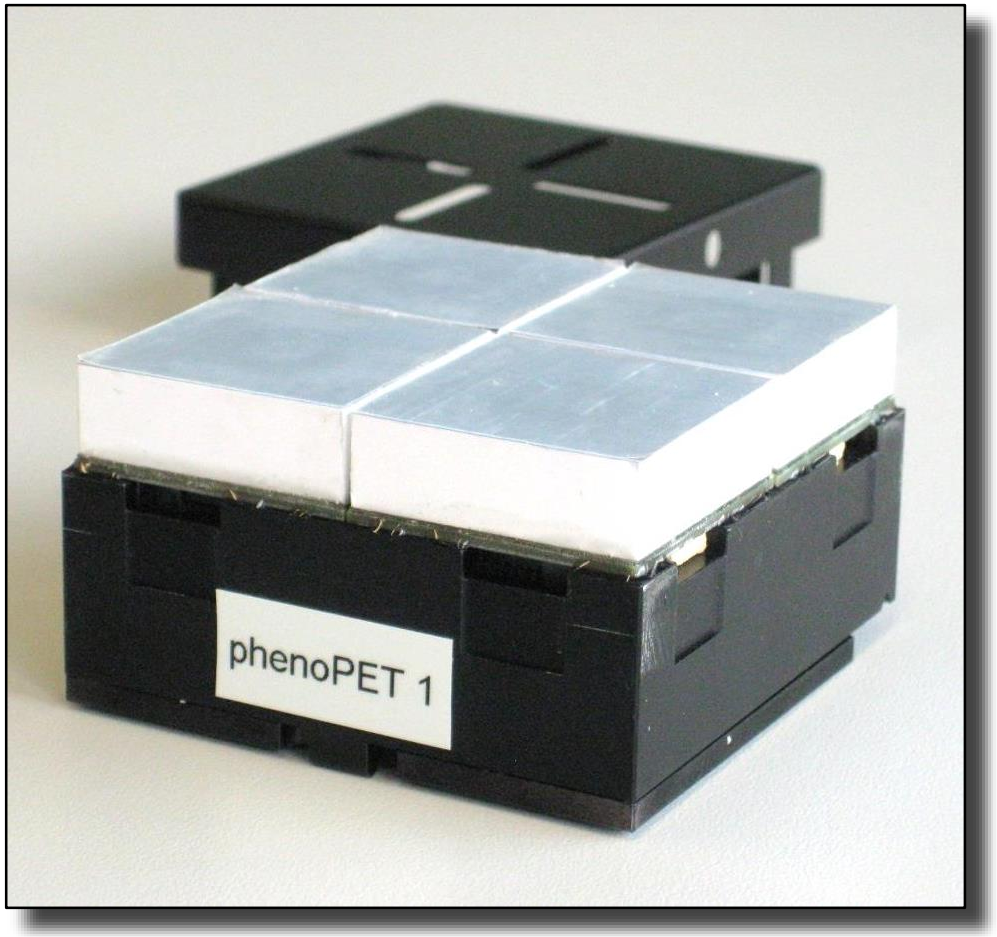
Assembled System



The Detector Module

provides 4 dSiPM-‘Tiles‘ with Scintillator Matrices

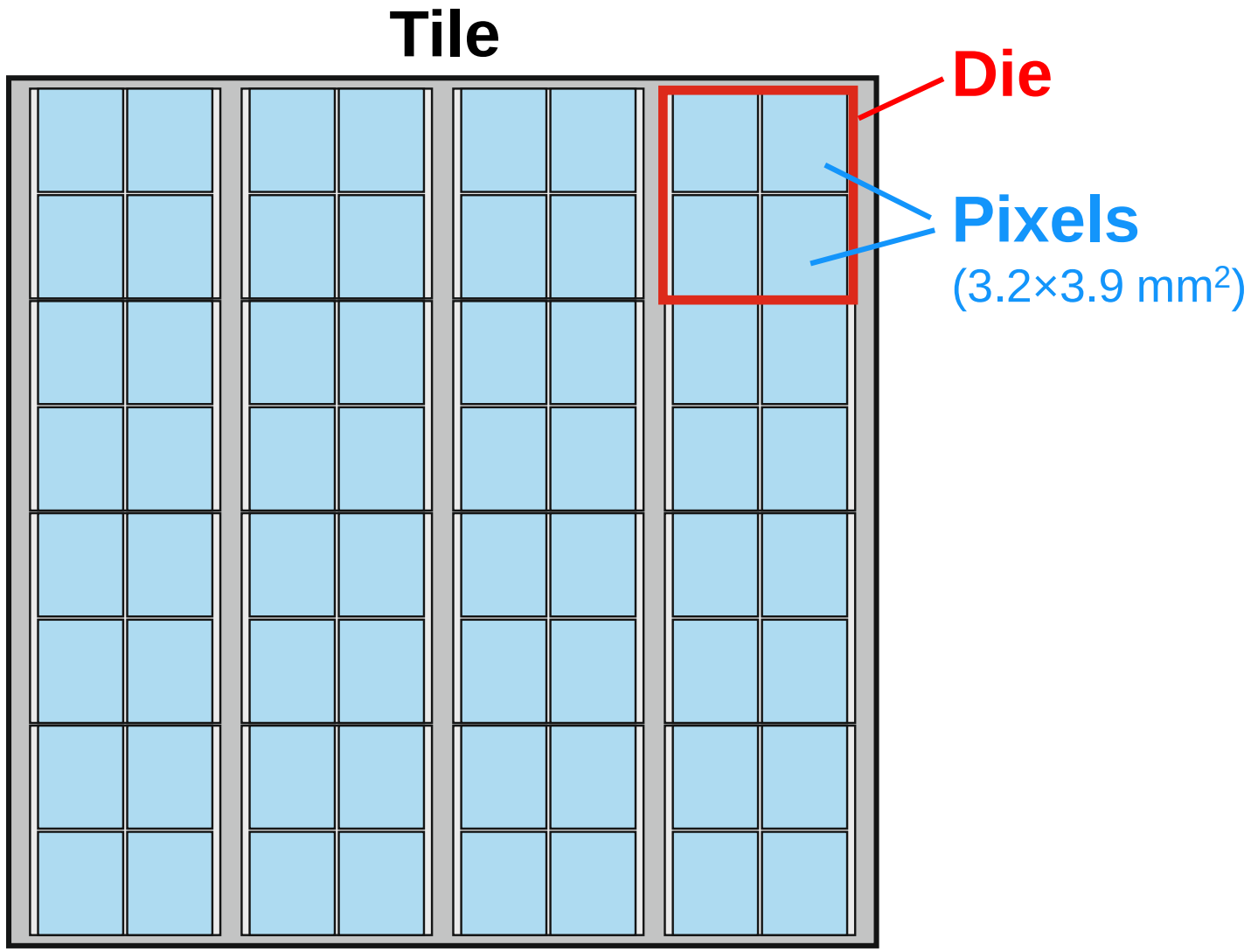
Module with cap



Module without cap

8x8 Pixel Detector Tile

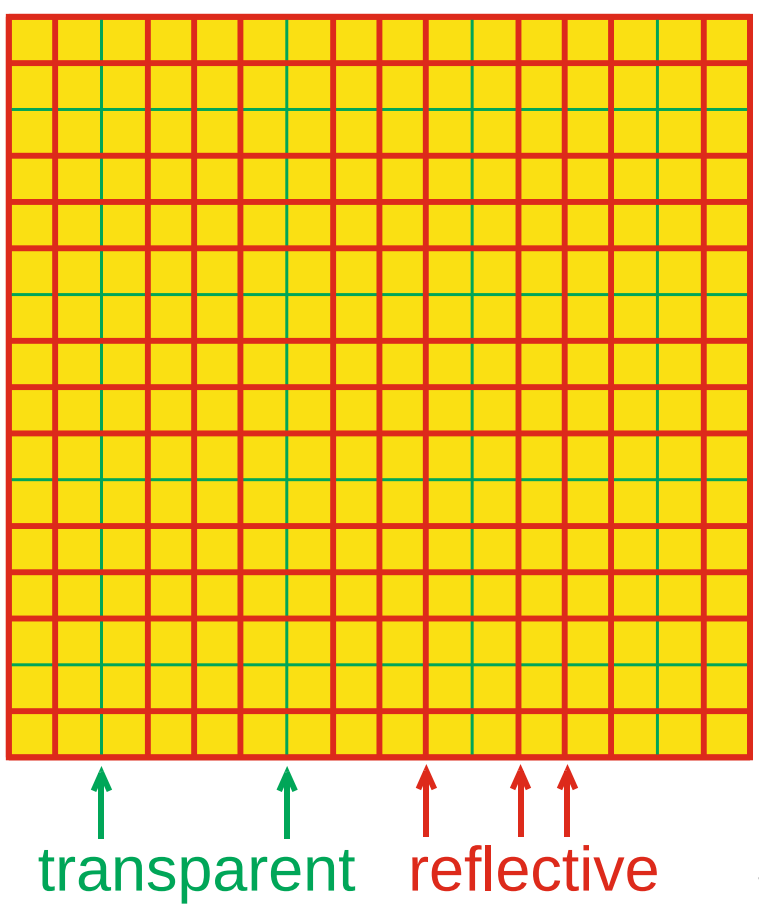
- One “Tile“ holds 16 Dies.
- One Die has 2x2 pixels.
- Each Die triggers indivdually.
- Trigger generates data with
  - timestamp
  - photon count on each of the 4 pixels

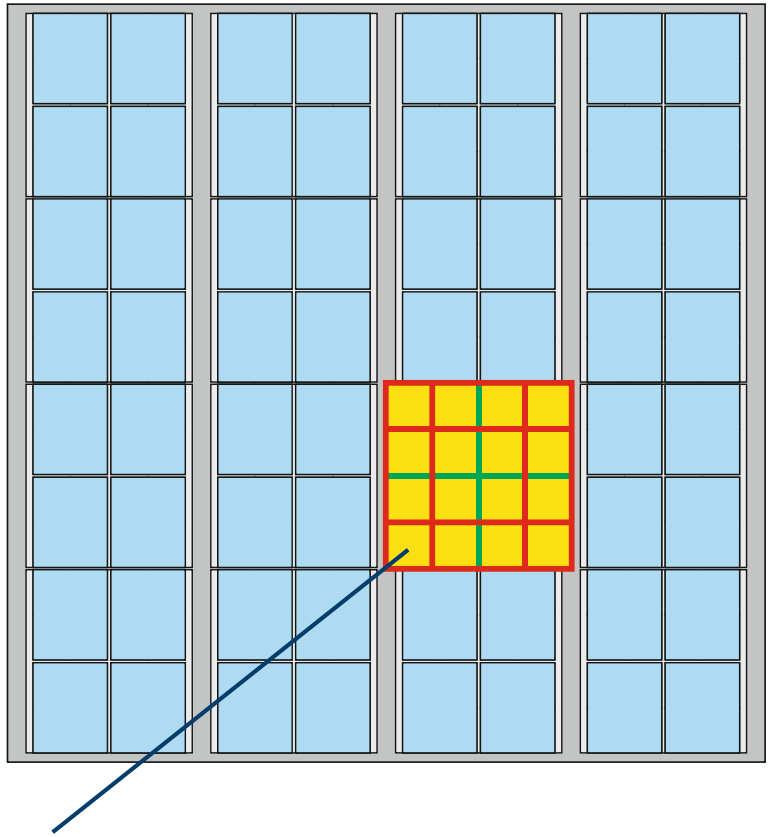


Scintillator Matrix on Tile

16×16 LYSO Crystals
á 1.85×1.85×10 mm^3

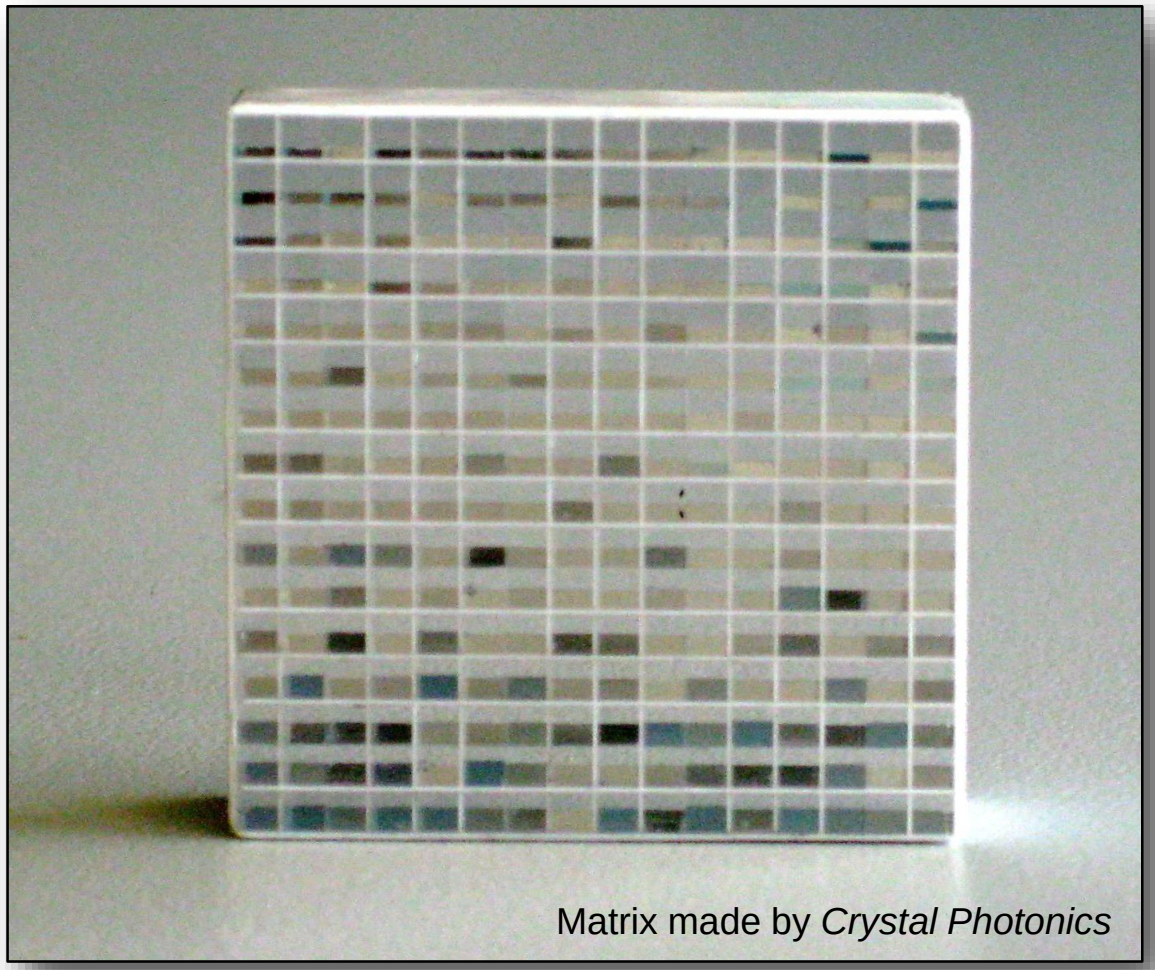
8×8 Pixel dSiPM Tile
á 3.2×3.9 mm^2





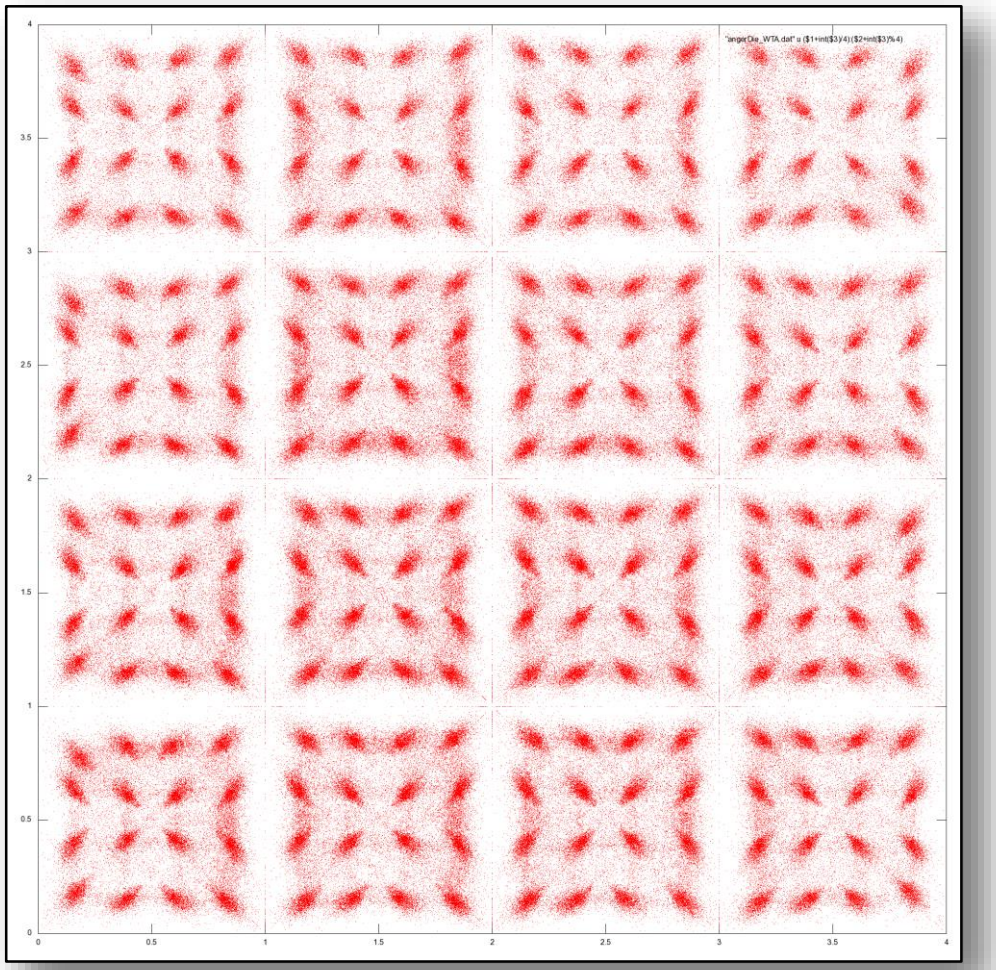
Sketch of scintillator alignment on one Die

Scintillator Matrix



16×16 LYSO Crystals

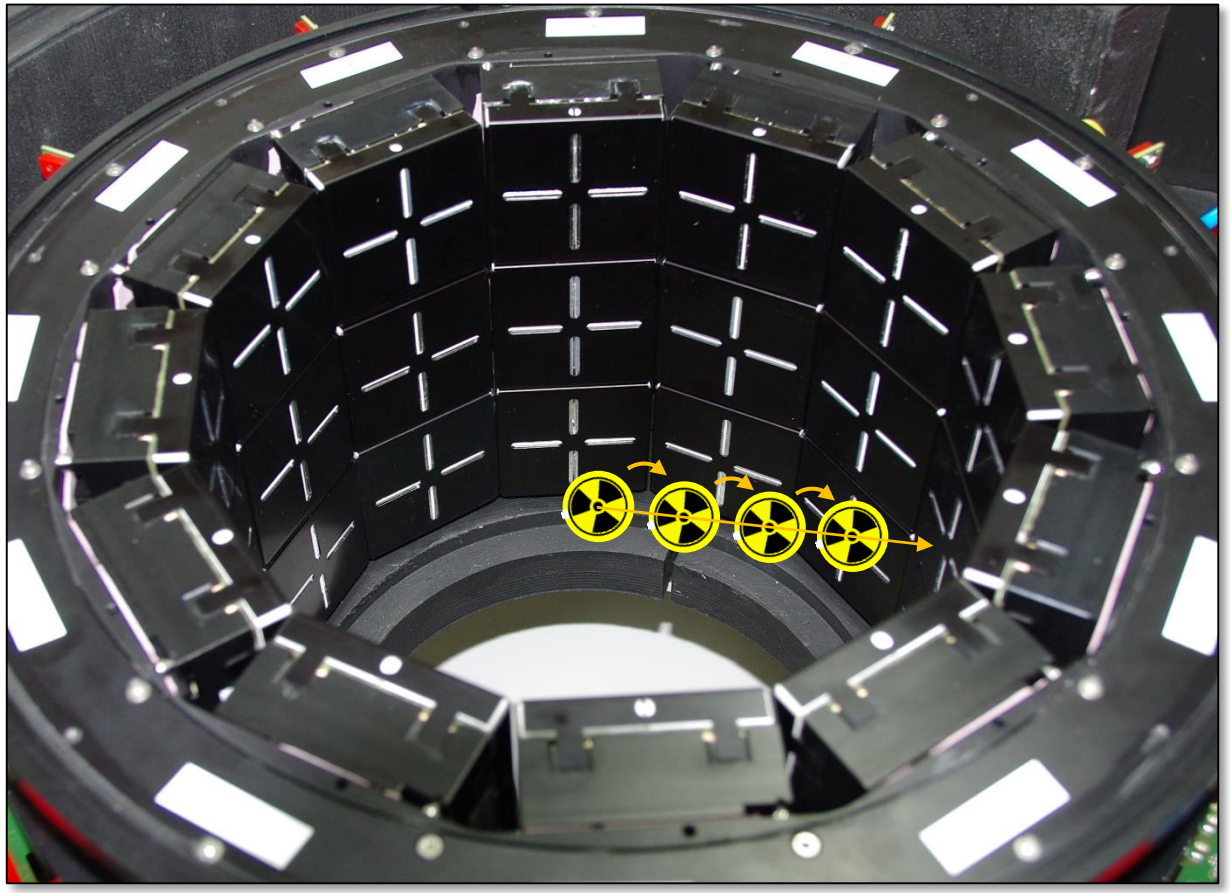
á 1.85×1.85×10 mm³



Floodmap

Sensitivity Measurements

Sensitivity = % of recorded to total number of decays



Point Source placed in defined positions

- Na22 Point Source
  Ø = 0.25mm, $\boldsymbol{A}$ = 300kBq
- > $2 \cdot 10^6$ coincidences per position
- Random Correction:

$$\dot{N}^{True} = \dot{N}^{Prompt} - \dot{N}^{Random}$$

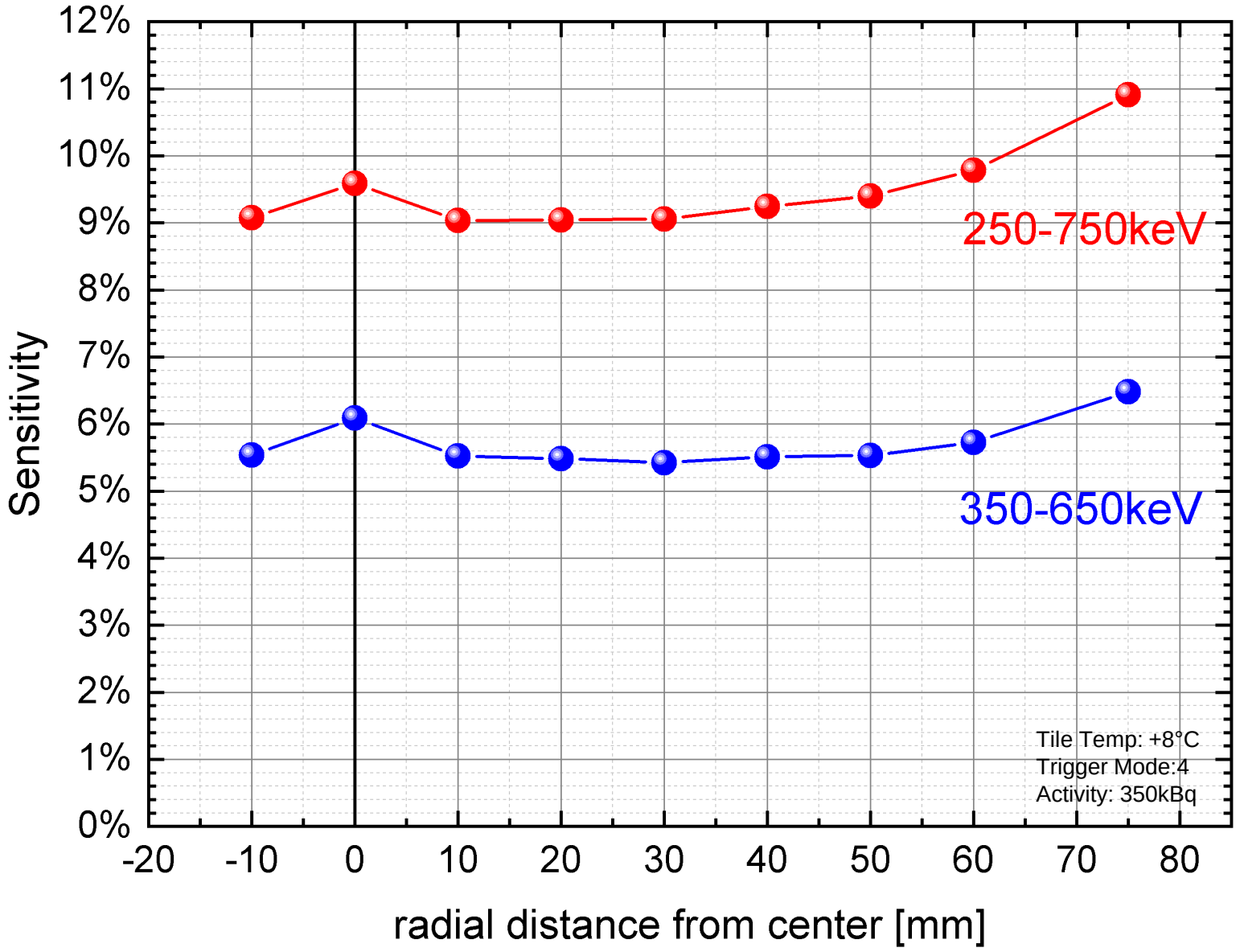
- Background Subtraction:

$$S_i = \frac{\dot{N}^{True}_{Source} - \dot{N}^{True}_{Back}}{A}$$

- Na22 Branching Ratio Correction:

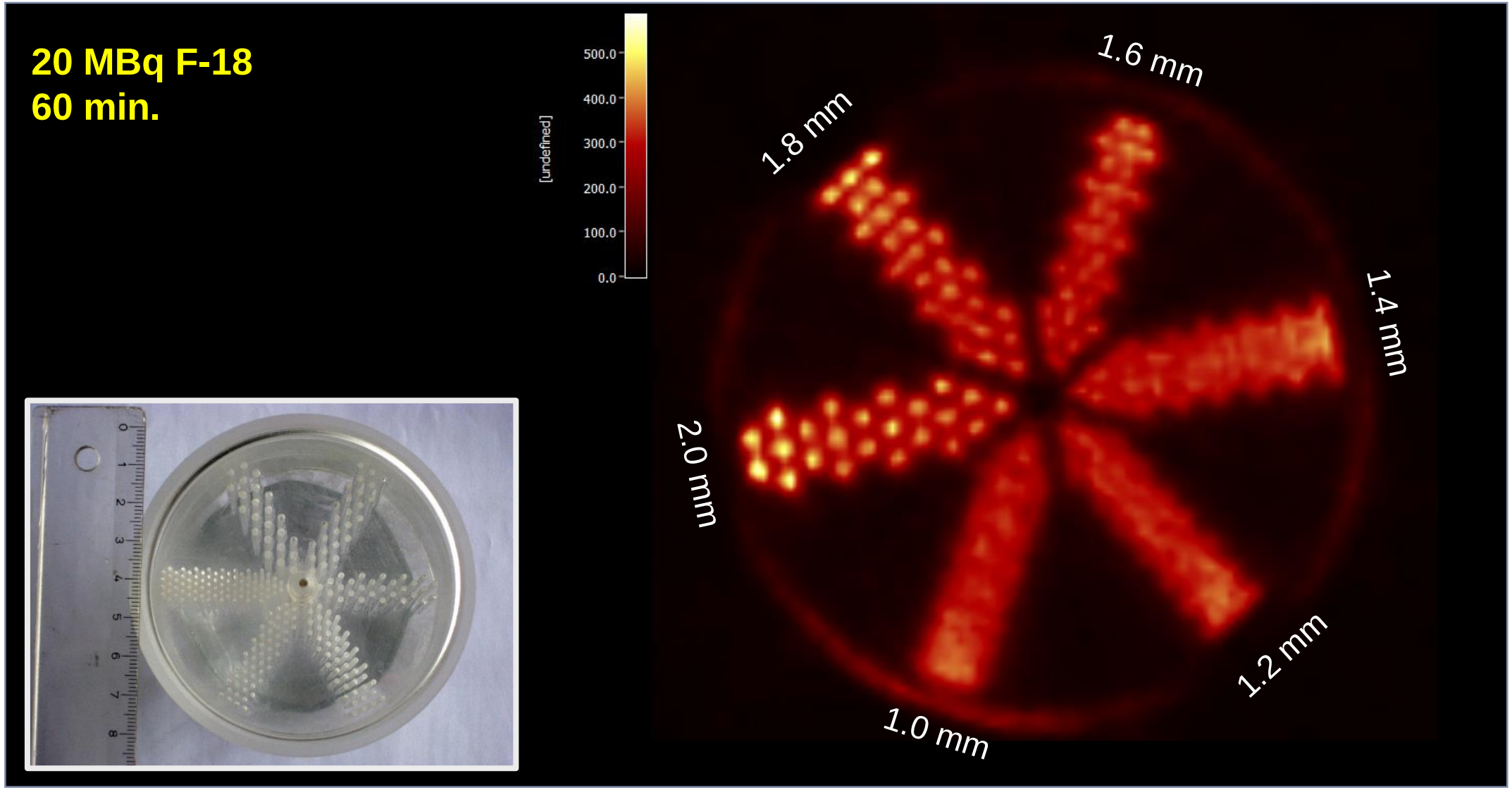
$$S = S_i / 0.906$$

Radial Sensitivity



Spatial Resolution – Hot Rod Phantom

20 MBq F-18
60 min.

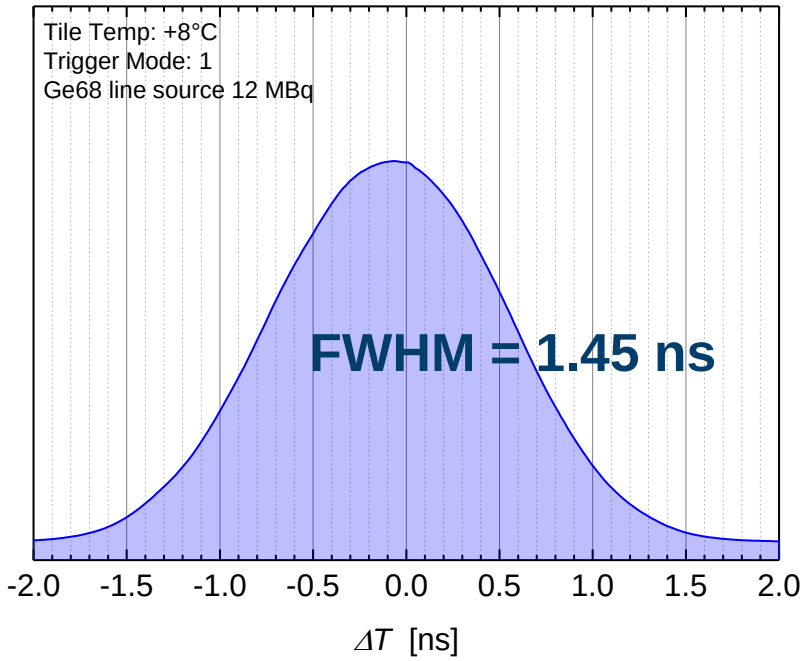


Time Resolution

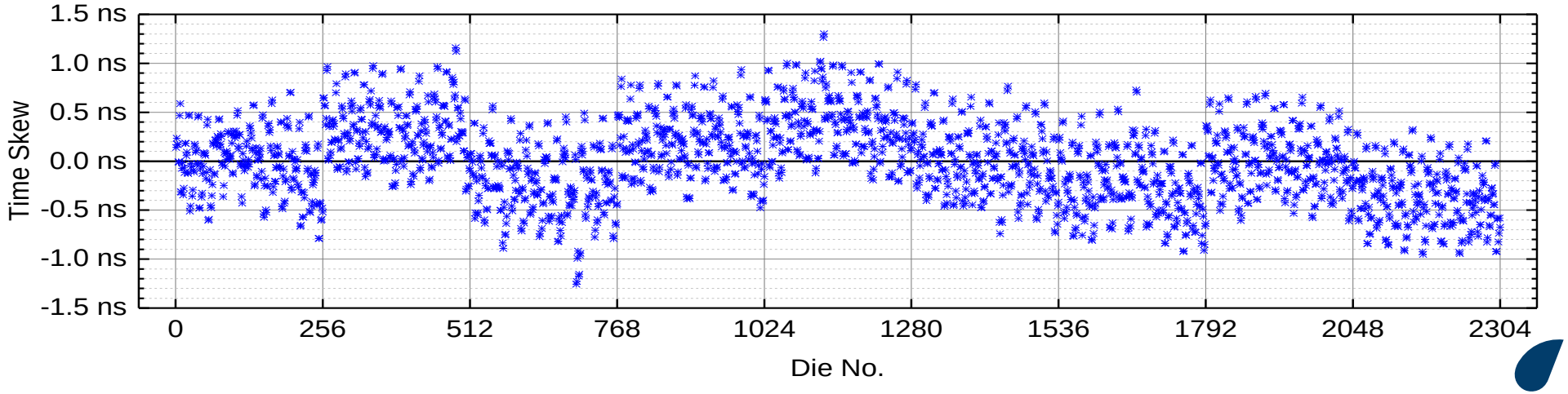
Even triggering on the 1st photon leads to a rather large Coincidence Time Resolution (CRT) of 1.45 ns.

The main reason are the individual timemark offsets (time skew) of the detector dies.

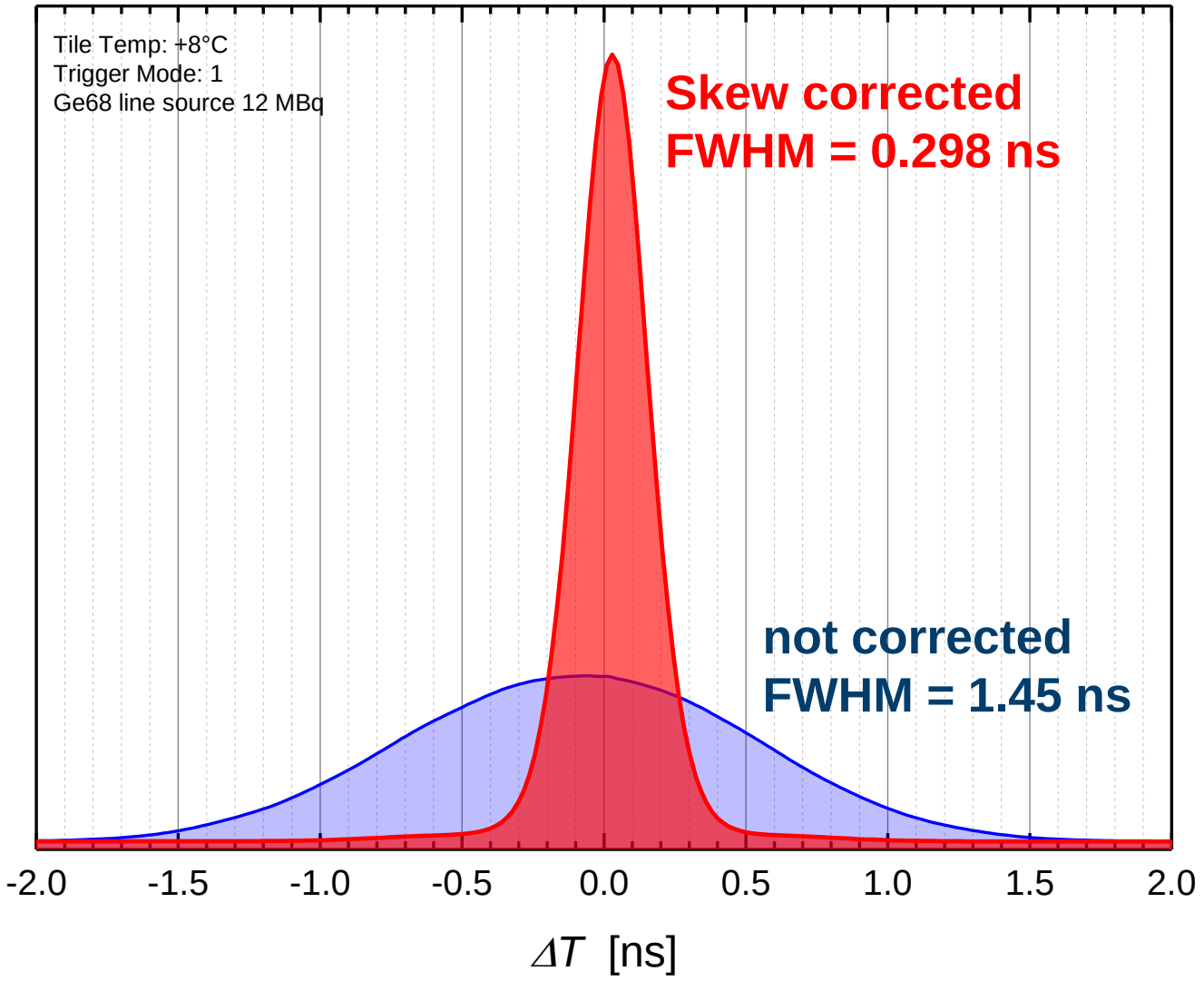
Coincidence Peak



Time Skew per Die

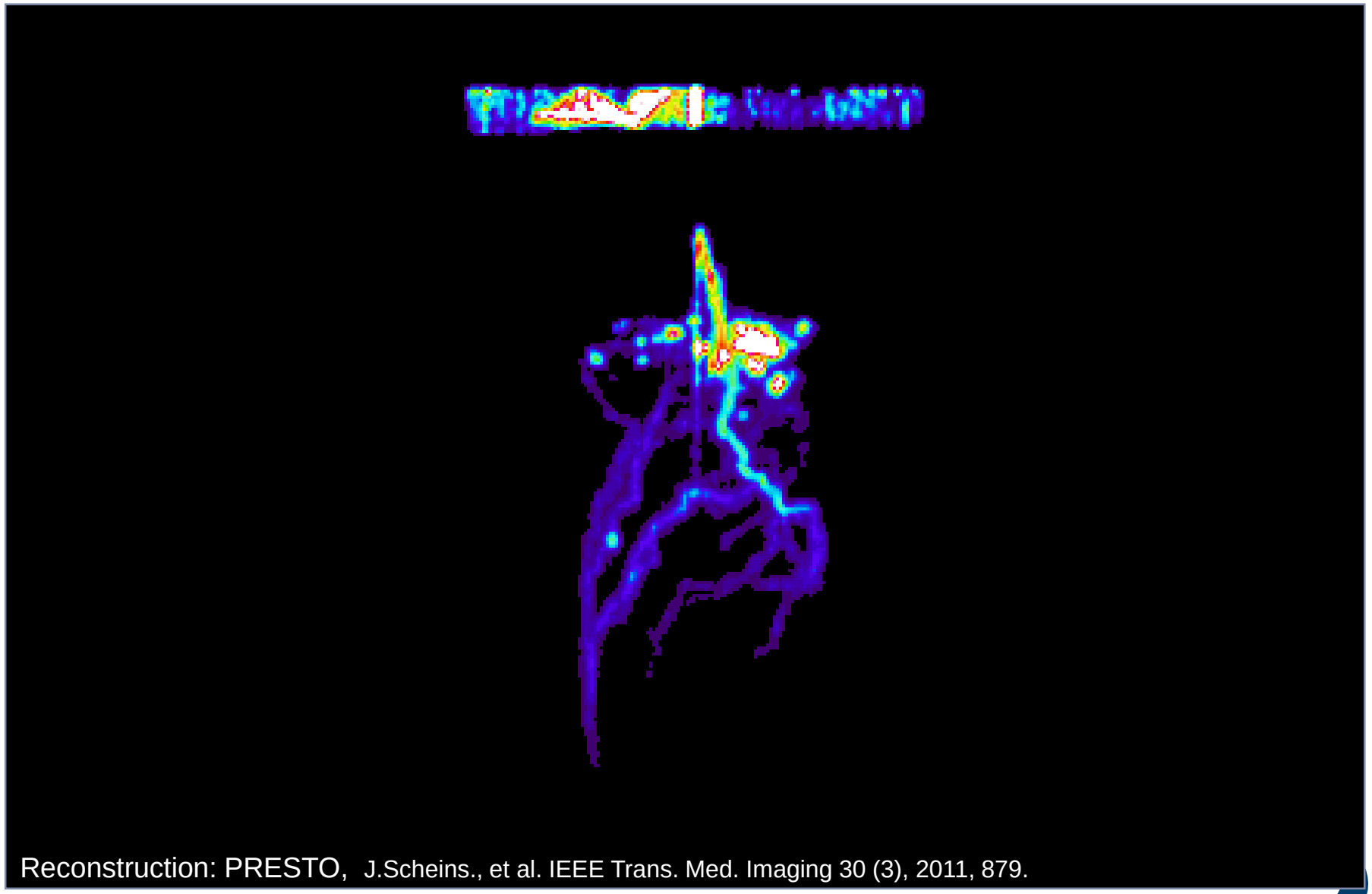


Time Res. with Skew Correction



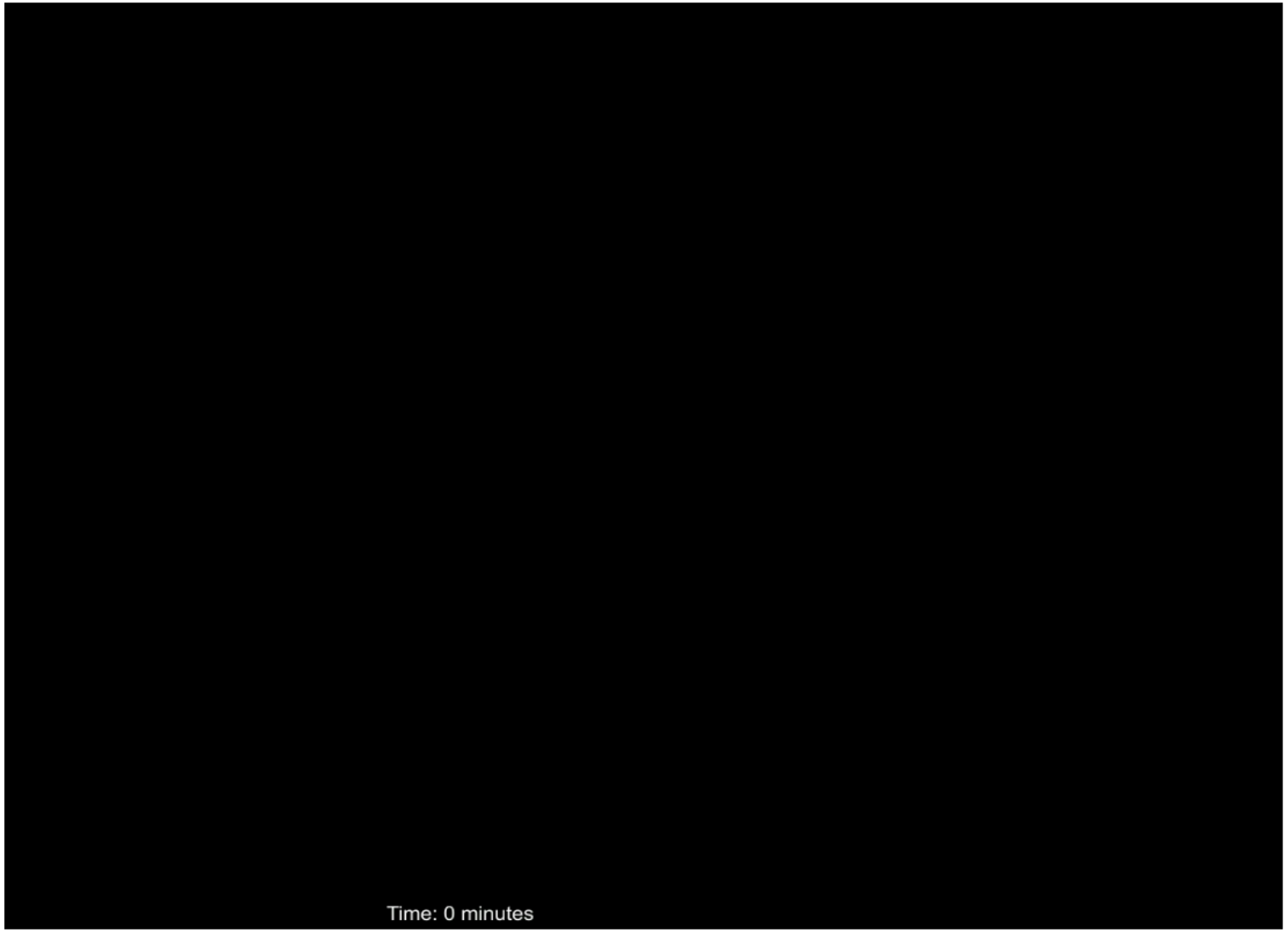
The individual time skews can be determined and used for correction giving a much better CRT.

First Plant Image: Pea Plant



Reconstruction: PRESTO, J.Scheins., et al. IEEE Trans. Med. Imaging 30 (3), 2011, 879.

Carbon Uptake of a Pea Root



Summary & Outlook

- *pheno*PET is a PET scanner with digital SiPMs
  - 18 x 20 cm FoV
  - **298 ps** CRT
  - **9.6%** peak sensitivity (ΔE=250-750keV)
  - **1.6 mm** resolution in center FoV
- High Quality Dynamic Measurements with ≤1 min frames
- Data Transfer Rate 380 MB/s (USB3.0)
- *Next Steps*: USB3.0 is still bottleneck, we‘re replacing it by 10 GBit Connection for higher dynamic range

Thank You!

Antonia Chlubek
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Ulrich Schurr
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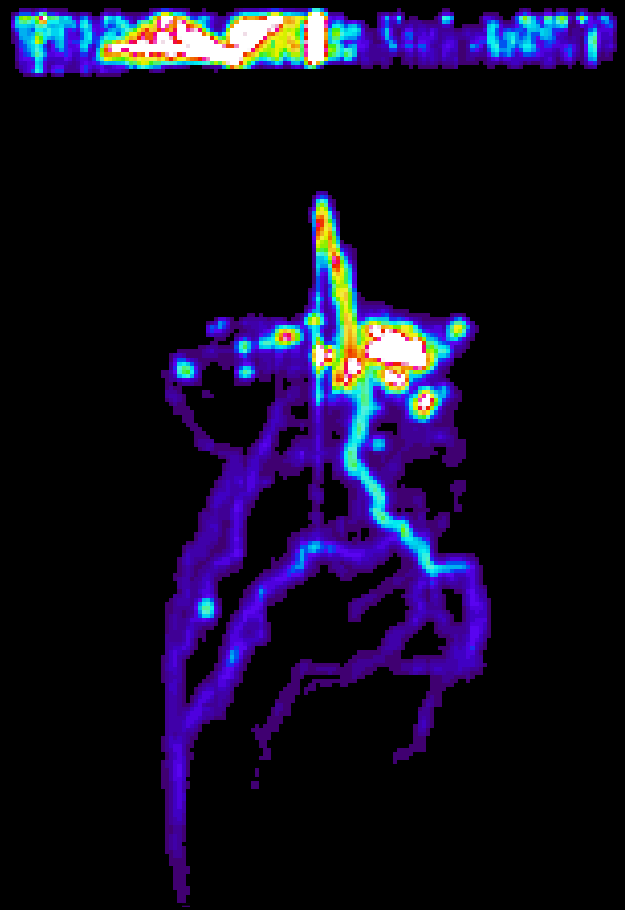

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