Time resolved single event imaging (x, y, t) with MCP detectors

and its potential for DIRCs

Outline:

- **Why this talk ?**
- **Who is ProxiVision ?**
- **What is our experience with high rate x,y,t readouts?**
- **How can DIRCs benefit from that?**

Why this talk?

Why this talk ?

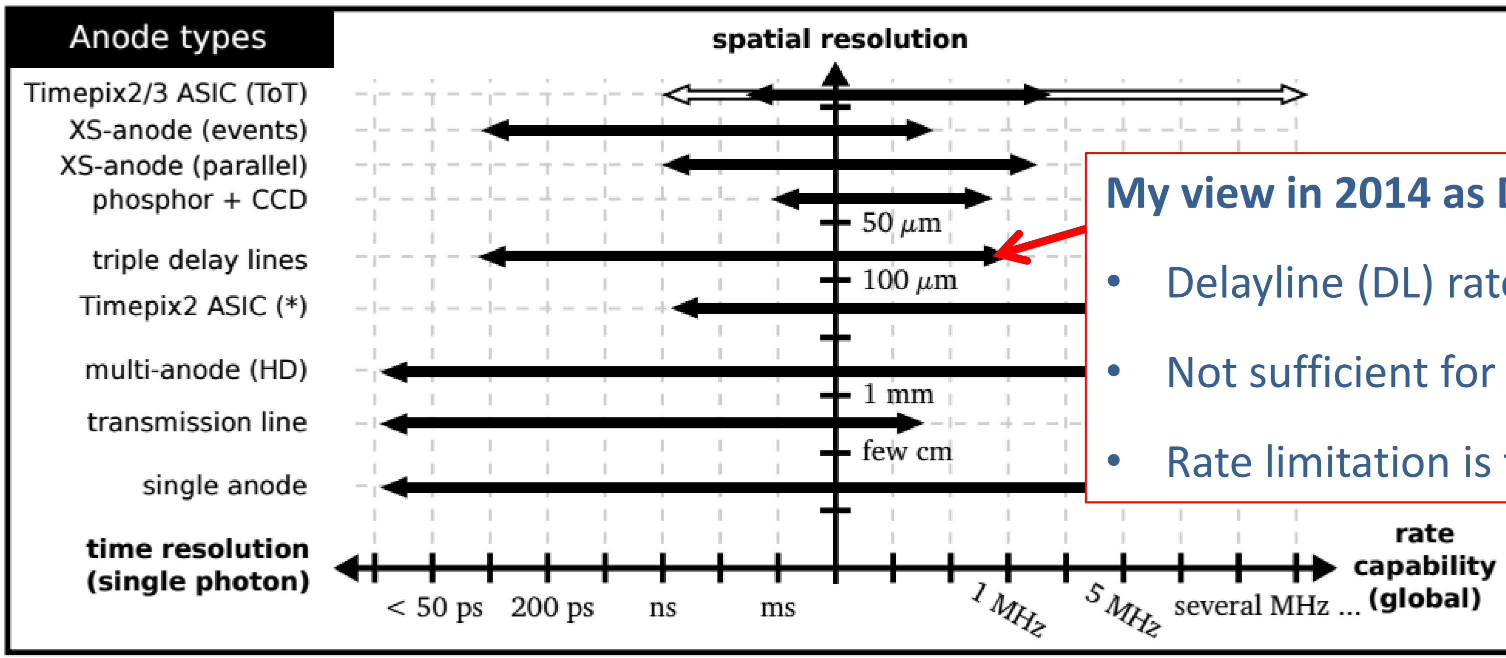
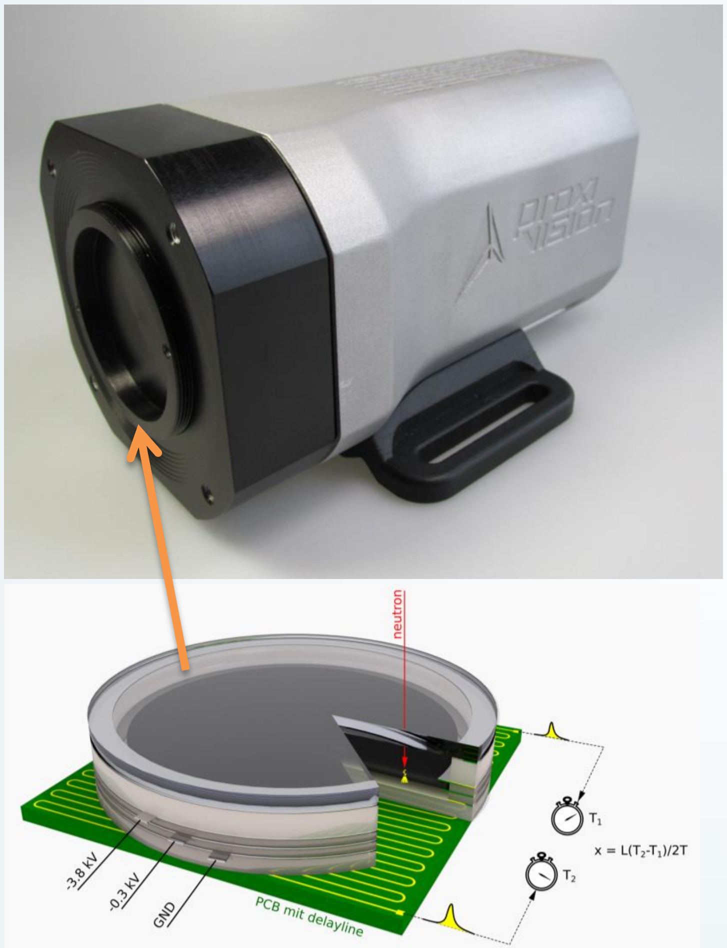


Figure 5.36.: Comparison of selected anode designs discussed in this section. The

My view in 2014 as DIRC researcher:

- Delayline (DL) rate limit: **1 MHz**
- Not sufficient for „Endcap DIRC“
- Rate limitation is the only hurdle.

Why this talk ?



My experience today:

- Delayline (DL) system with > **5 MHz proven!**
- 10 MHz per Delayline feasible.
- Would be sufficient for detectors like the Endcap DIRC (3 x DL/tube => 30 MHz/tube)
- Advantages can be:
  - Low number of channels (2 per DL)
  - High spatial resolution < 100 µm
  - Fast single event timing: ~50 ps @ MCP / 150 ps @ anode
  - Flexible anode design outside the tube

Who is ProxiVision?

ProxiVision:

- **Main products:**
  - (UV) Image Intensifiers
  - PMTs
  - related detector systems
- **Location:** Bensheim, DE
- **Roots**: Bosch Fernseh GmbH
- **Size**: SME, ~65 employees
- **New facility since 2016**: 2300 m² production area, 700 m² admin. area, on 8000 m² property.

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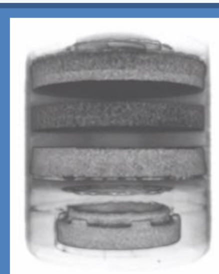
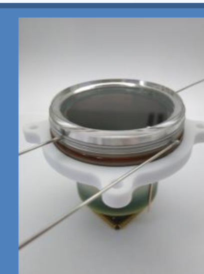
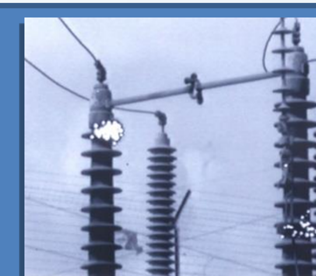
Product range in a nutshell

- **Vacuum Tubes**: Image Intensifiers and Photomultipliers
- **Camera systems**: Gated iCCD, X-Ray, Neutron
- **Electronics**: Power supply, readout electronics
- **Components**: Open-MCP, Phosphor screens (also > 10x10 cm²)

- **Plus customized detectors and cameras.**

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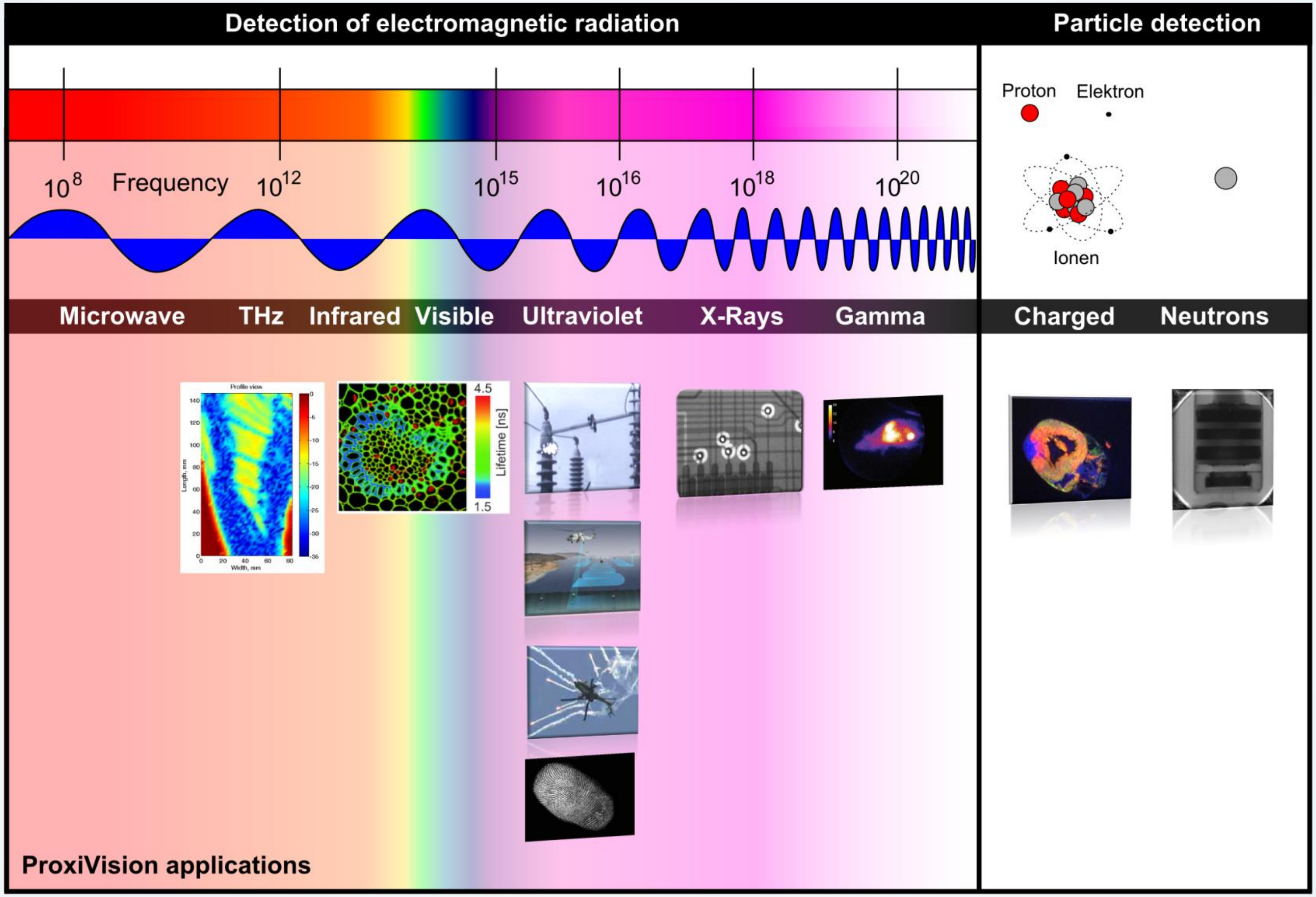
Reveal the *invisible*



ProxiVision's working horse: Solar Blind Image Intensifier.

- Fast, low-noise detection of single UV-C photons
- UV-C source: hot rocket plumes
- No natural UV-C sources => clutter free detection
- Ruggedized design is used on vehicles and aircraft to trigger countermeasures.

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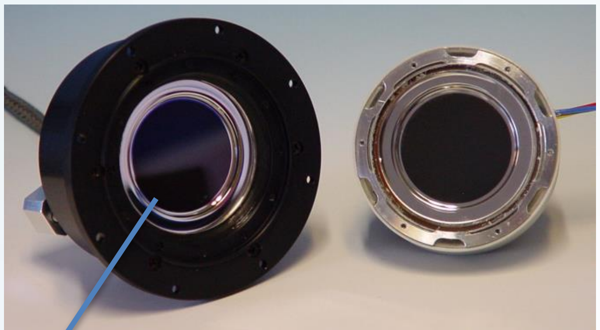
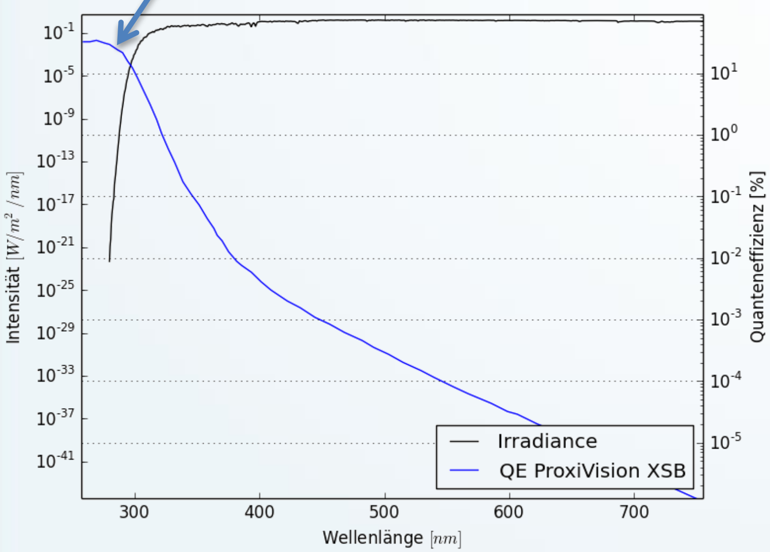
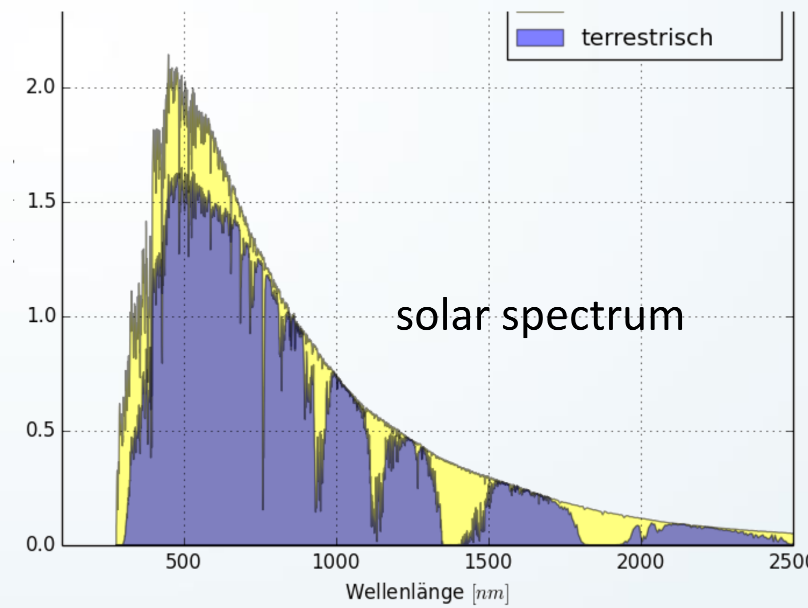
ProxiVision's working horse: Solar Blind Image Intensifier.

- Ozone-layer acts as filter for solar UV-C
- => all UV-C sources below are artificial !
- Sensor requirements: UV-C sensitive **and** as insensitive as possible > 280 nm.







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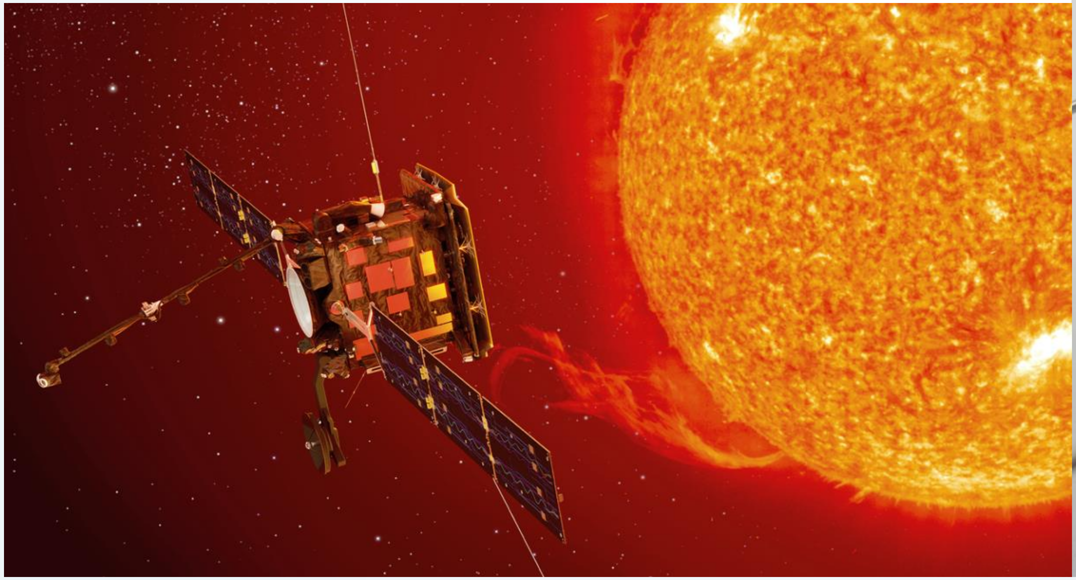
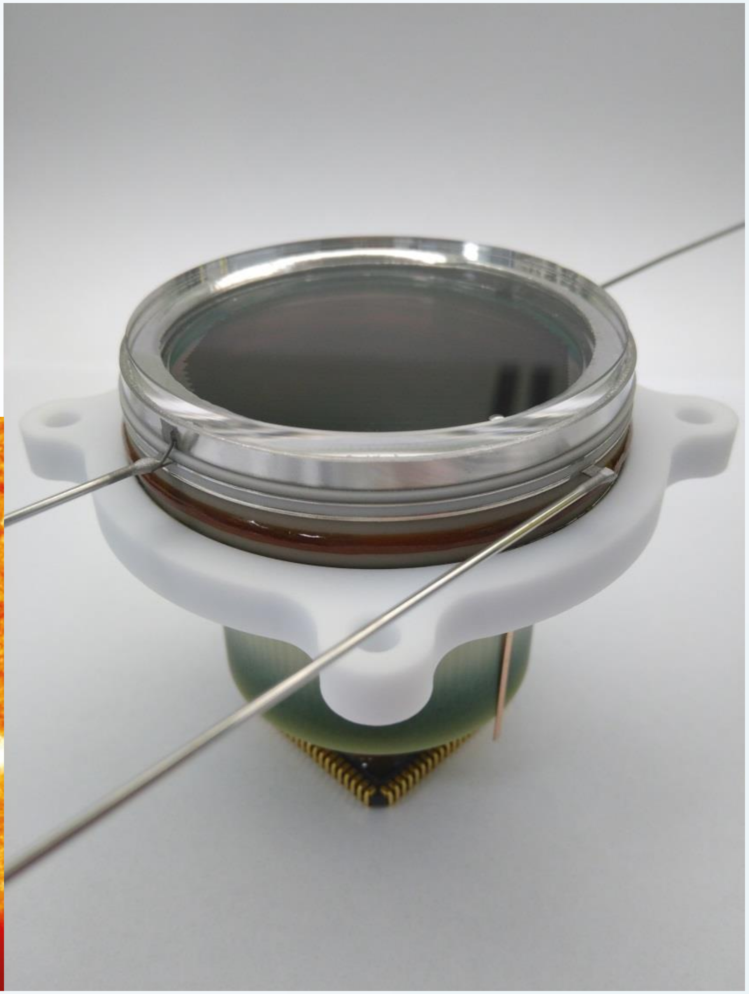
FUV Detection in Space

- FUV detector for the METIS instrument on the Solar Orbiter mission (ESA)
- Goal: FUV imaging at Lyman-α lines of H und He in the solar corona.
- Enables the study of solar plasma dynamics.



Source: ESA



CEM based PMTs

- Typical active ∅ [mm]: 5, 9, 15
- Required HV: 2-3 kV
- Low dark count, down to 10 Hz/cm²
  (Low-noise Bialkali 160-670 nm)
- Available spectral range: 115 nm – 900 nm
- TTS ~ 2 ns

- Modules with internal HV-Supply
- Gain control via 0..5 V reference.
- Analog and TTL out

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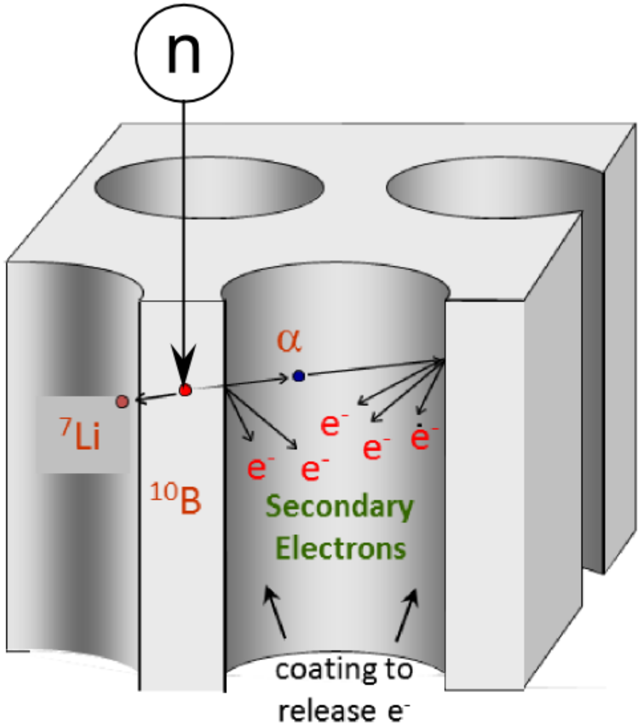
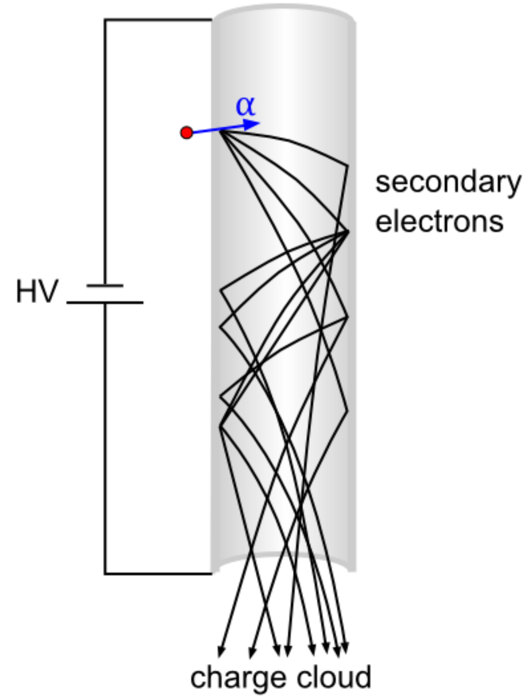
What is our experience with high rate x,y,t readouts?

Neutron sensitive MCP

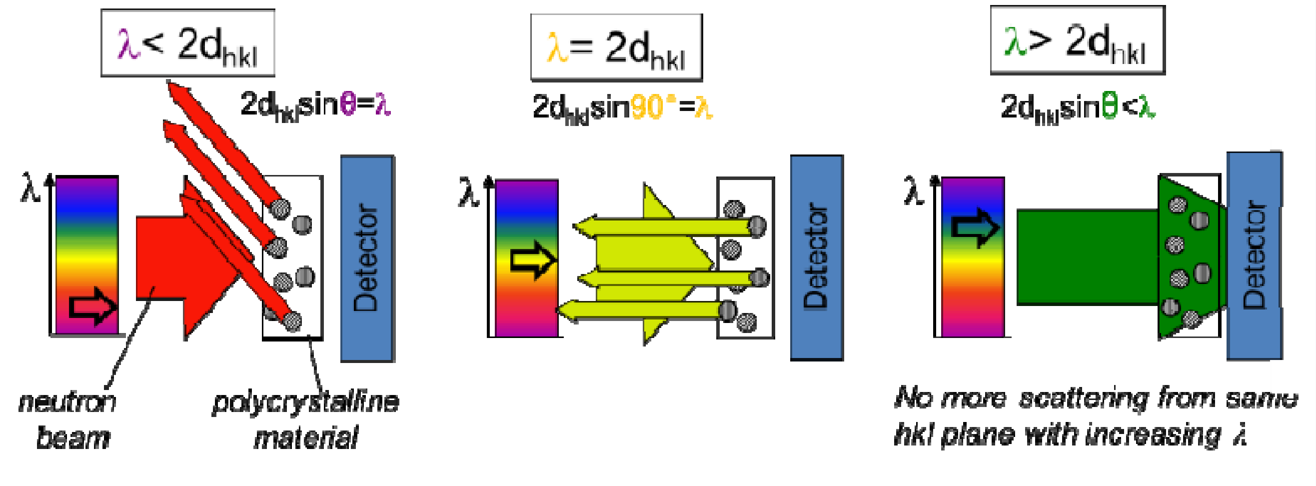




Neutron detection in boron-doped MCP

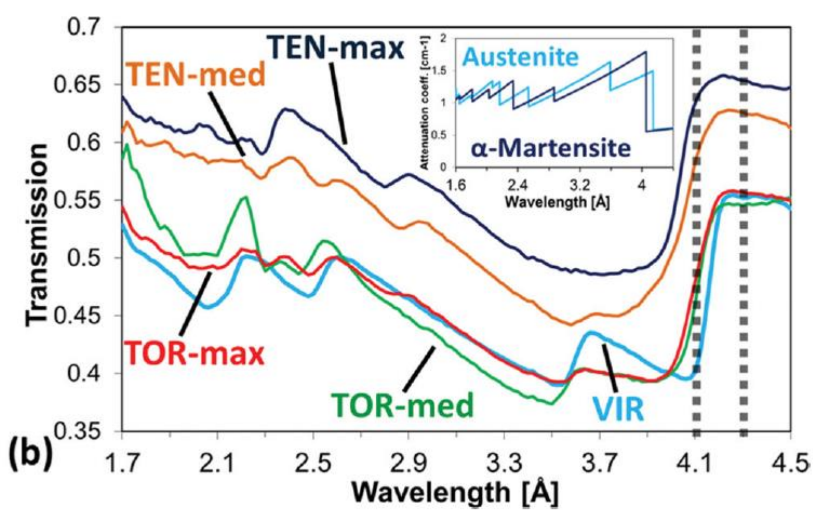
Charge amplification triggered by ions from bulk glass

Applications?



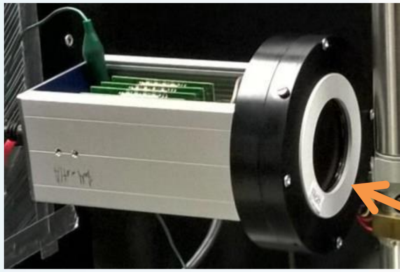
Woracek et al.,
Physics Procedia
69 (2015) 227 – 236

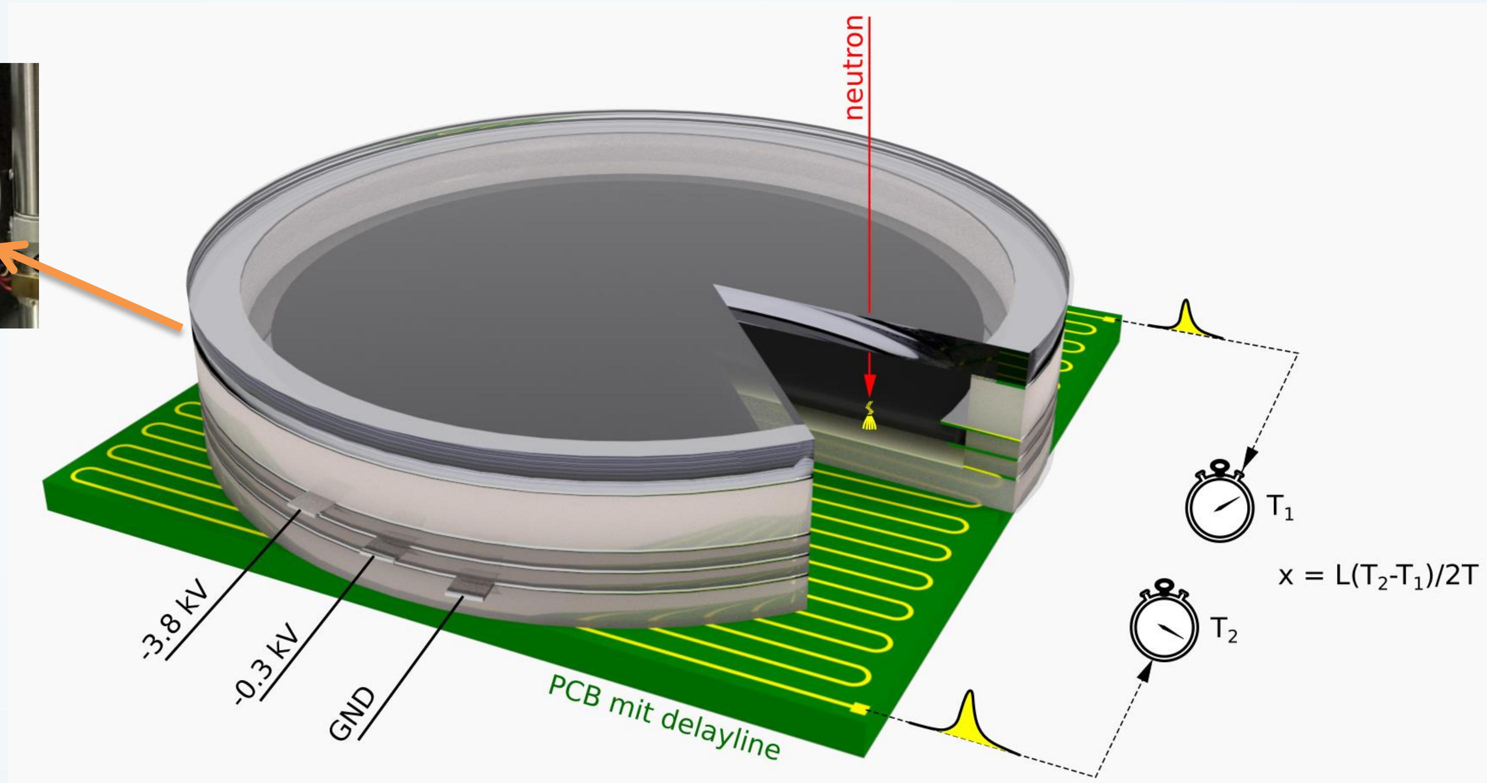
Adv. Mater.
2014, *26*, 4069–4073



- Neutron de Broglie wavelength is determined by the time of flight.
- ToF camera delivers „hyperspectral“ neutron image
- „Bragg edge“ (top picture) allows to measure bulk material properties like phase distribution (left).

Capacitively coupled delayline

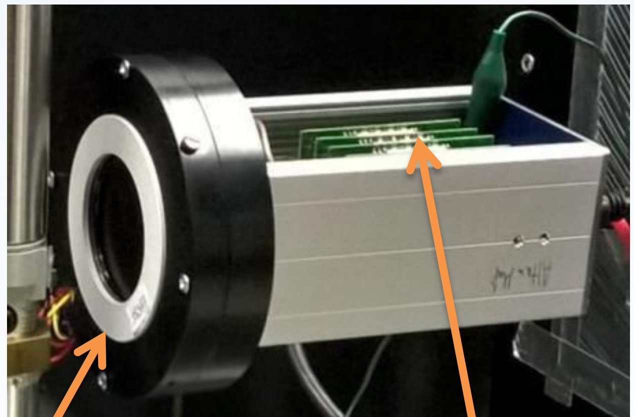


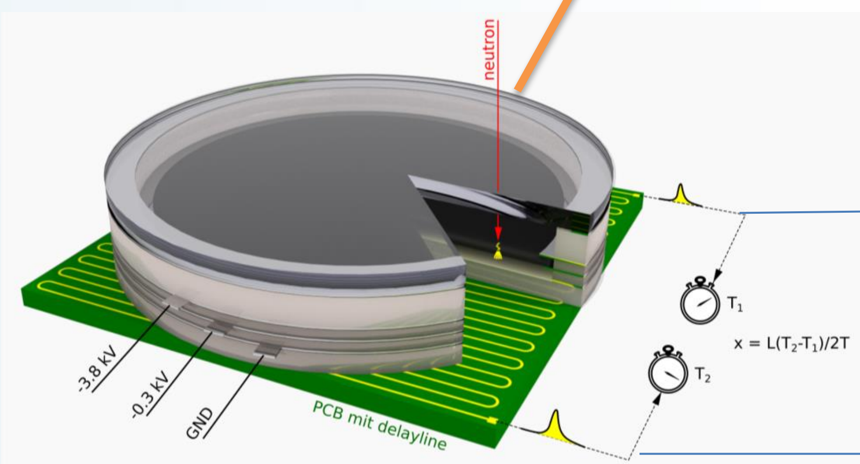


Neutron imaging by spatially resolved detection of single neutrons at high rate.

~100 µm position resolution, ~1 µs time resolution per neutron (limited by neutron ToF jitter)

Time resolved neutron camera





Amp/Disc

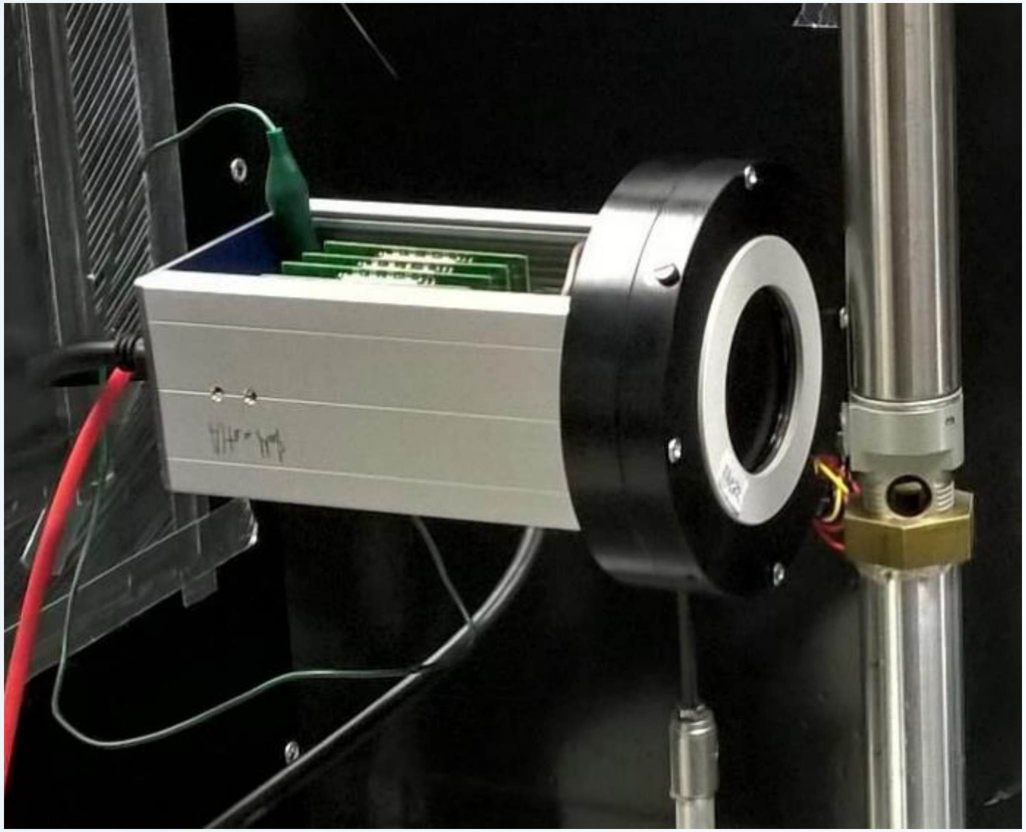
Amp/Disc

5m cable

Trigger / Time Ref.

TDC + Event Processing

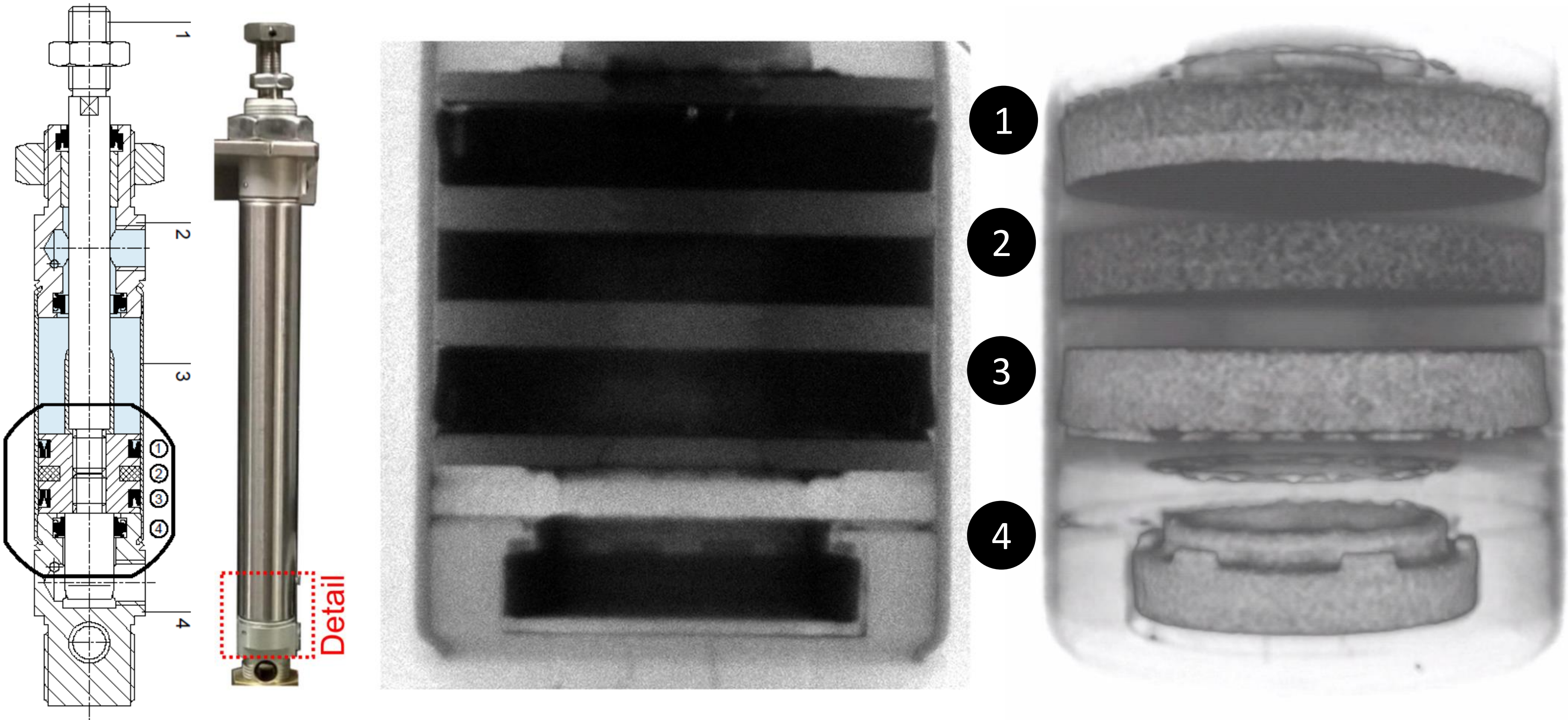
Time resolved neutron camera



Neutron imaging by spatially resolved detection of single neutrons at high rate.

~100 µm position resolution, ~1 µs time resolution per neutron (limited by neutron ToF jitter)

Tomography recorded in „overnight run“



Radiography and tomography of a pneumatic cylinder (CONRAD@BER2)
Lightweight organic materials in metal cylinder generate strong contrast

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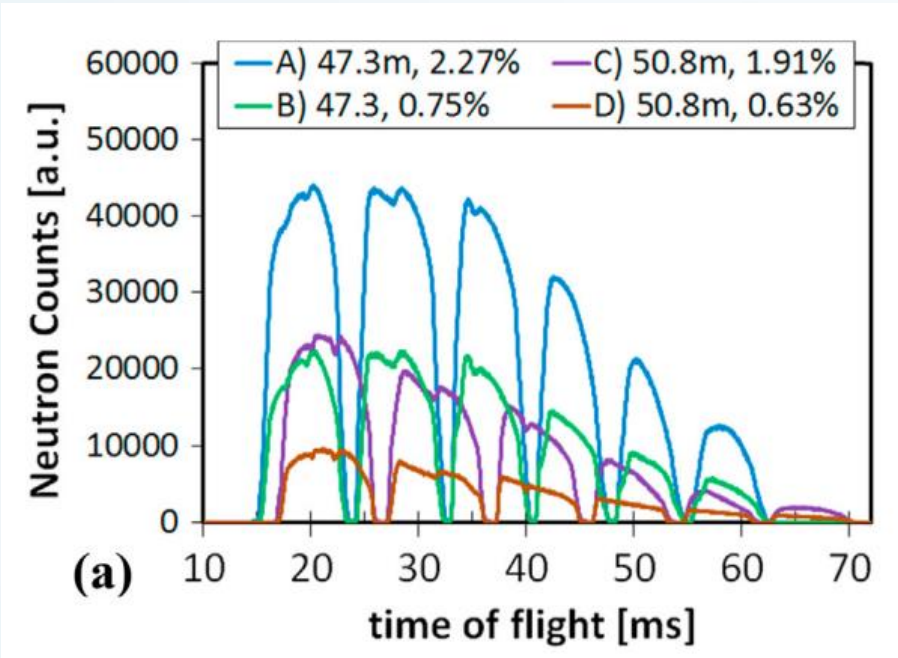
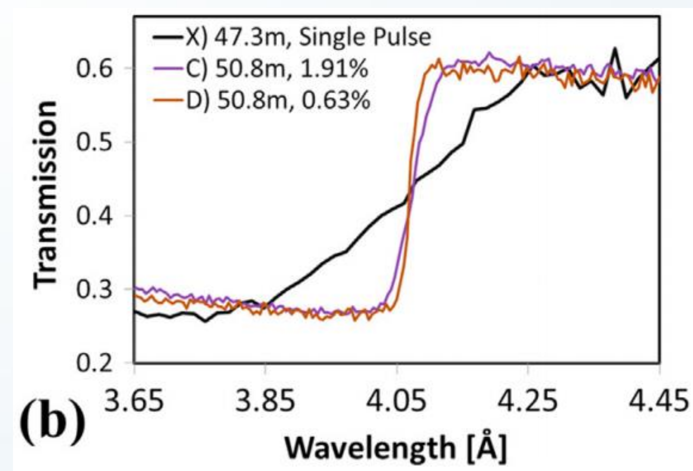
Measurements @ESS Test Beamline (BER2)

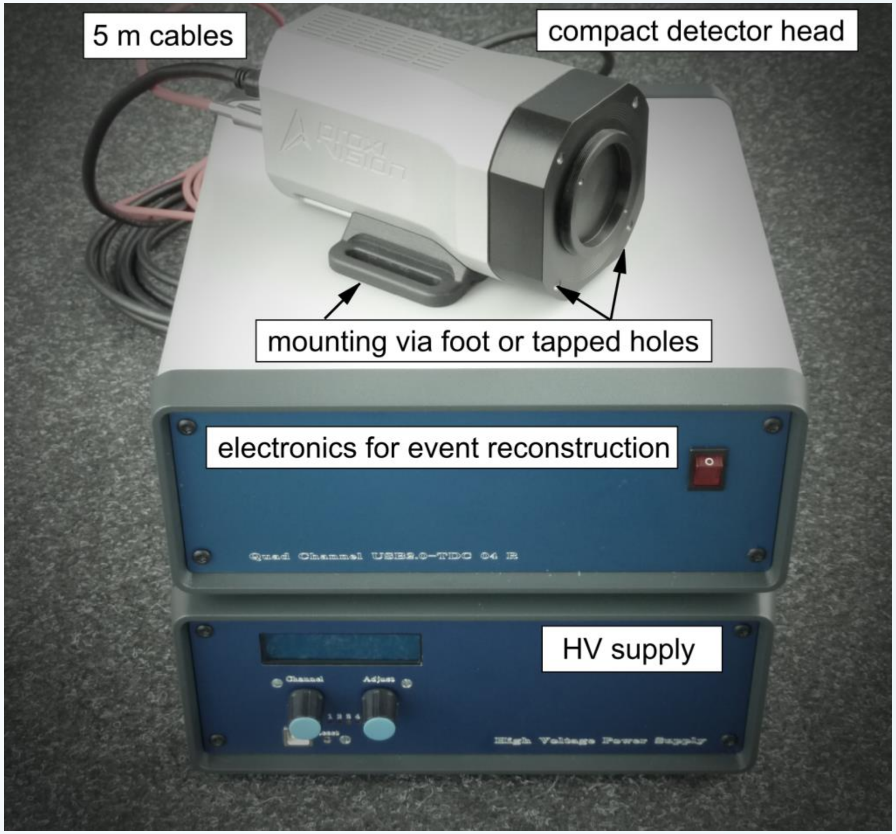


Robin Woracek, NIMA 839 (2016) 102–116

- List data =>
  Time-of-flight spectra can be plotted for arbitrary regions/pixels
- „Hyperspectral neutron imaging"
  (Time ⇔ Wavelength @ pulsed src.)



Polished System



Detection of thermal and cold neutrons with high spatial and time resolution.

Time-of-flight => de Broglie wavelength (**<u>wavelength resolved imaging</u>**)

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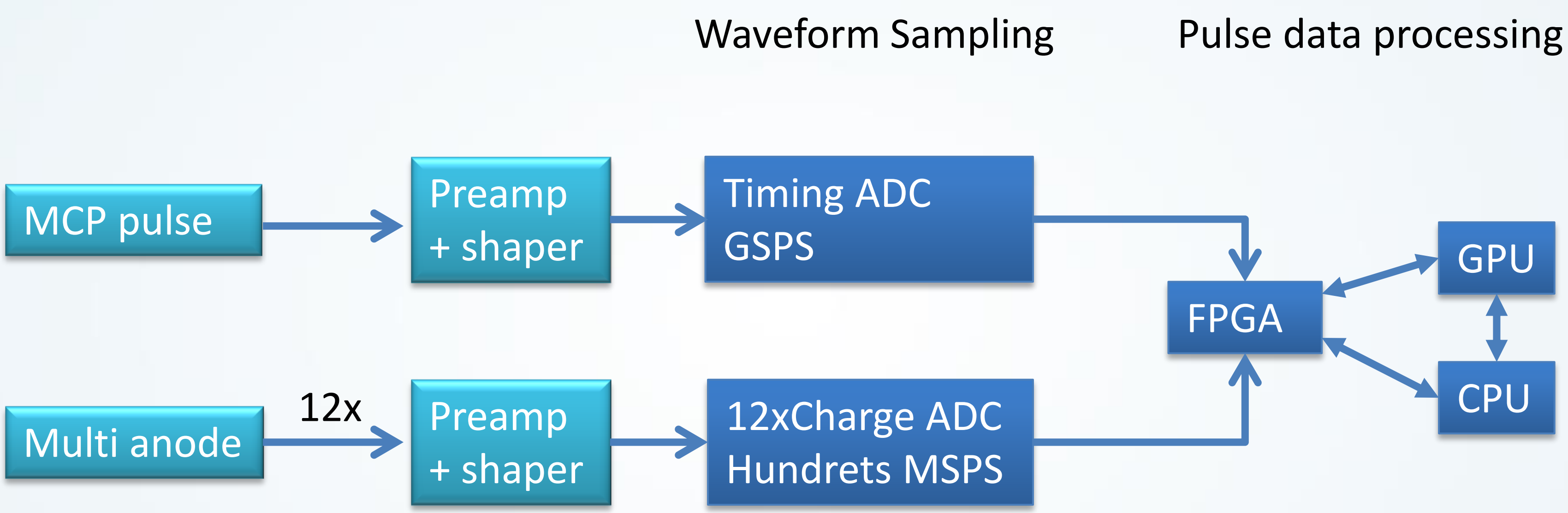
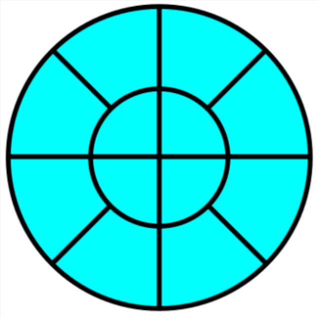
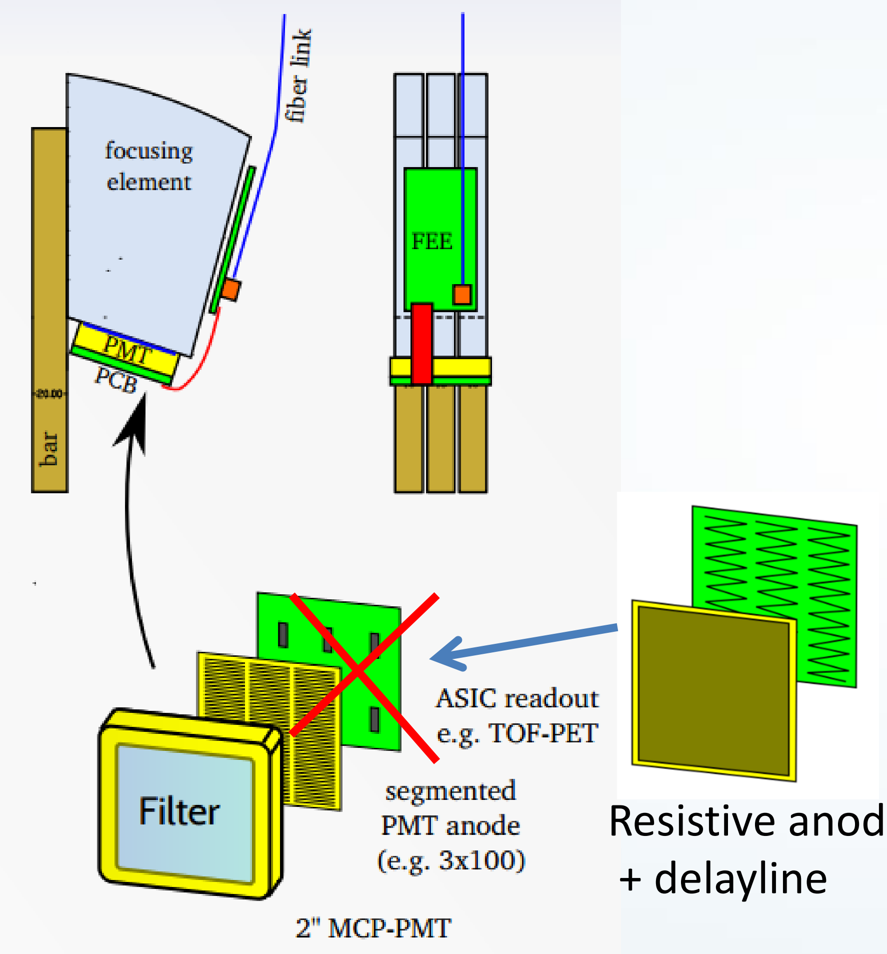
More capacitively readouts …





- Charge sharing due to capacitive coupling for position => ~50µm
- ~5 MHz with online pile-up correction
- Massive parallel processing required (GPU)

Potential DIRC usage:



Resistive anode + delayline

- 1D Strips for focusing designs
  - high spatial resolution ~100 µm
  - Fast timing ~150 ps
  - Low channel count
  - TDCs can be up to ~5 m away from analog FEE.
  - >>5 MHz per Strip
  - Works with Chevron
- Even 2d Imaging possible.
- In the example to the left:
  - 6 instead of 300 channels
  - 1 instead of 300 anode pins
  - PCBs can still be in vincinity.

Questions …

contact Oliver.Merle@proxivision.de