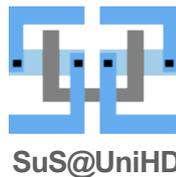


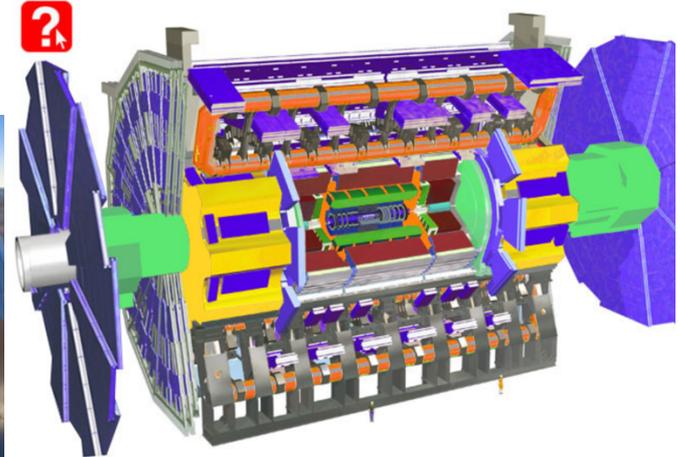
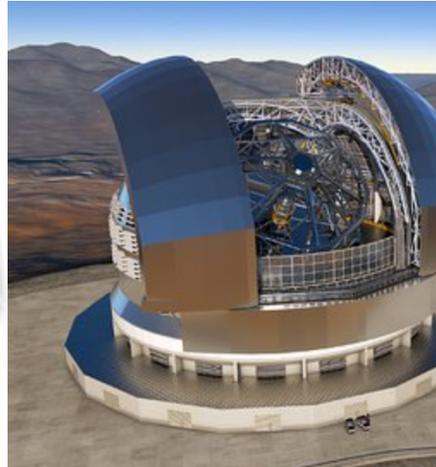
# Von Chips...

AG Schaltungstechnik und Simulation

Peter Fischer



- Wissenschaft braucht
  - Forscherinnen und Forscher mit neuen Ideen
  - Neue Instrumente!



- Wissenschaftlicher Fortschritt **ERFORDERT** neue Methoden und Geräte!

# Eine Analogie...



„To win the race, you need the best car!“

## WANTED

- Beschleunigung
- Geschwindigkeit
- Gewicht
- Verbrauch
- ...

© DRUCKEREI BCT/DE



Ein großes Team! Am Ende bekommt der Fahrer den Champagner...



# Beispiel 1: Röntgenkamera

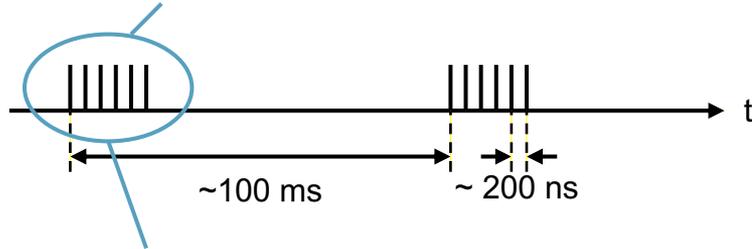
# European XFEL in Hamburg



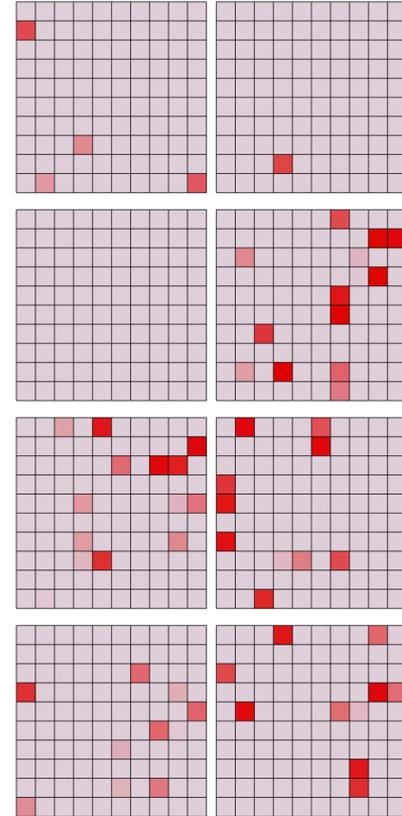
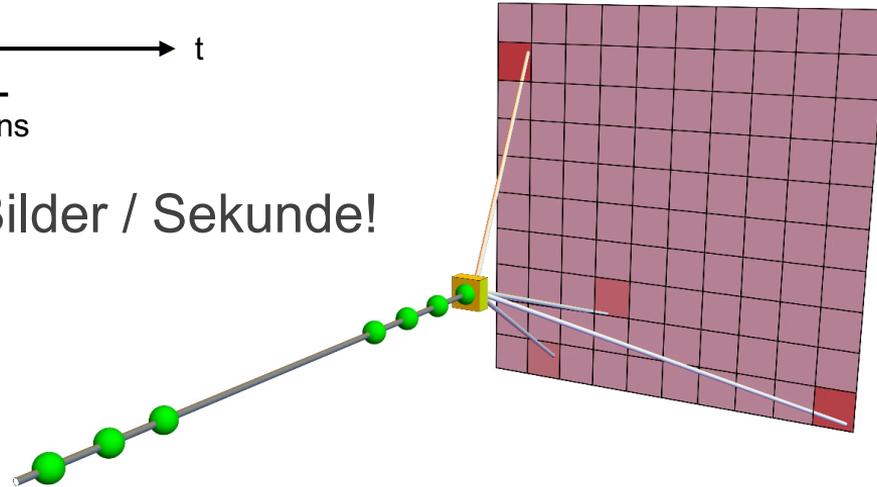
## Ziele:

- Messung der Struktur von (Bio) Molekülen
- Verständnis chemischer Prozesse
- Optische, elektrische, magnetische Eigenschaften

- 10 Bursts / s mit je  $\sim 3000$  Xray Pulsen (viele Xrays / Puls!)



- Im Burst: 5.000.000 Bilder / Sekunde!



- Burst Datenrate:  $\sim 200$  Gbit/s pro Chip ... zu viel ...  
→ Bilder speichern und in den Pausen auslesen...

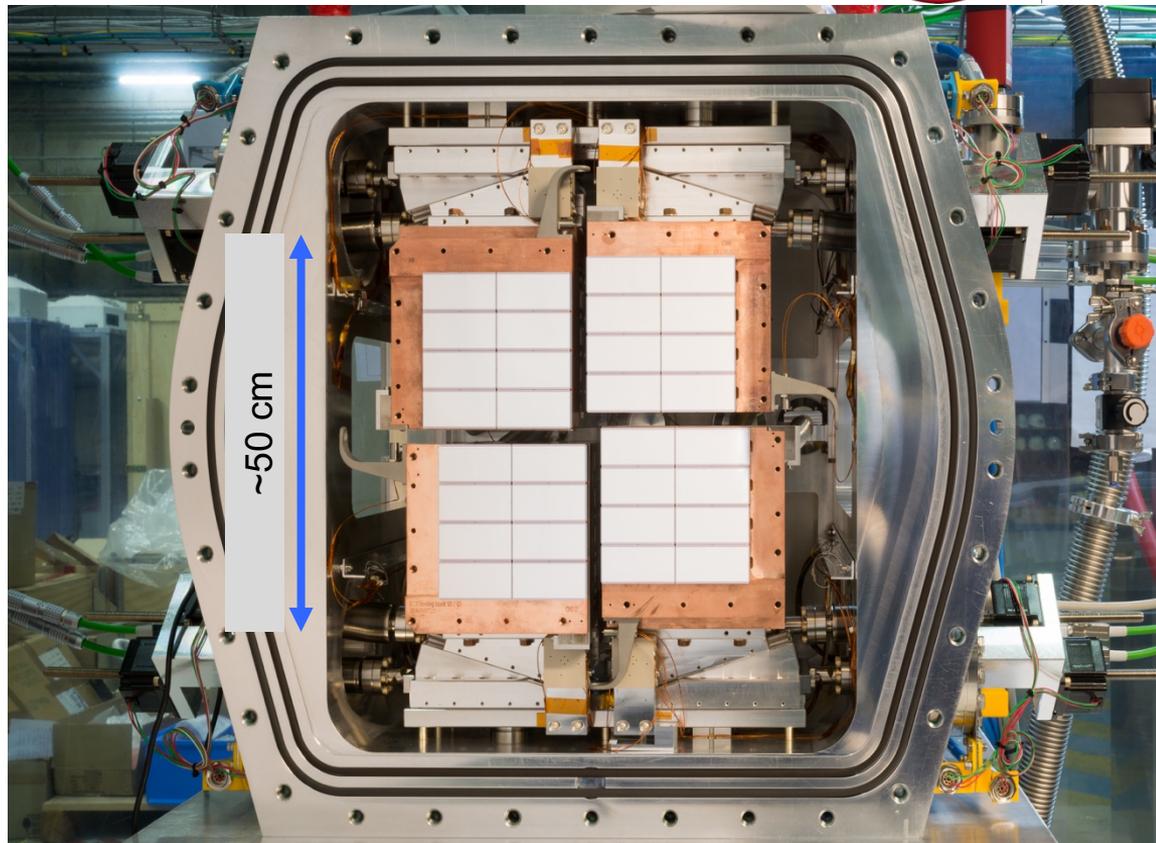
# Gesucht: Der ‚perfekte‘ Detektor



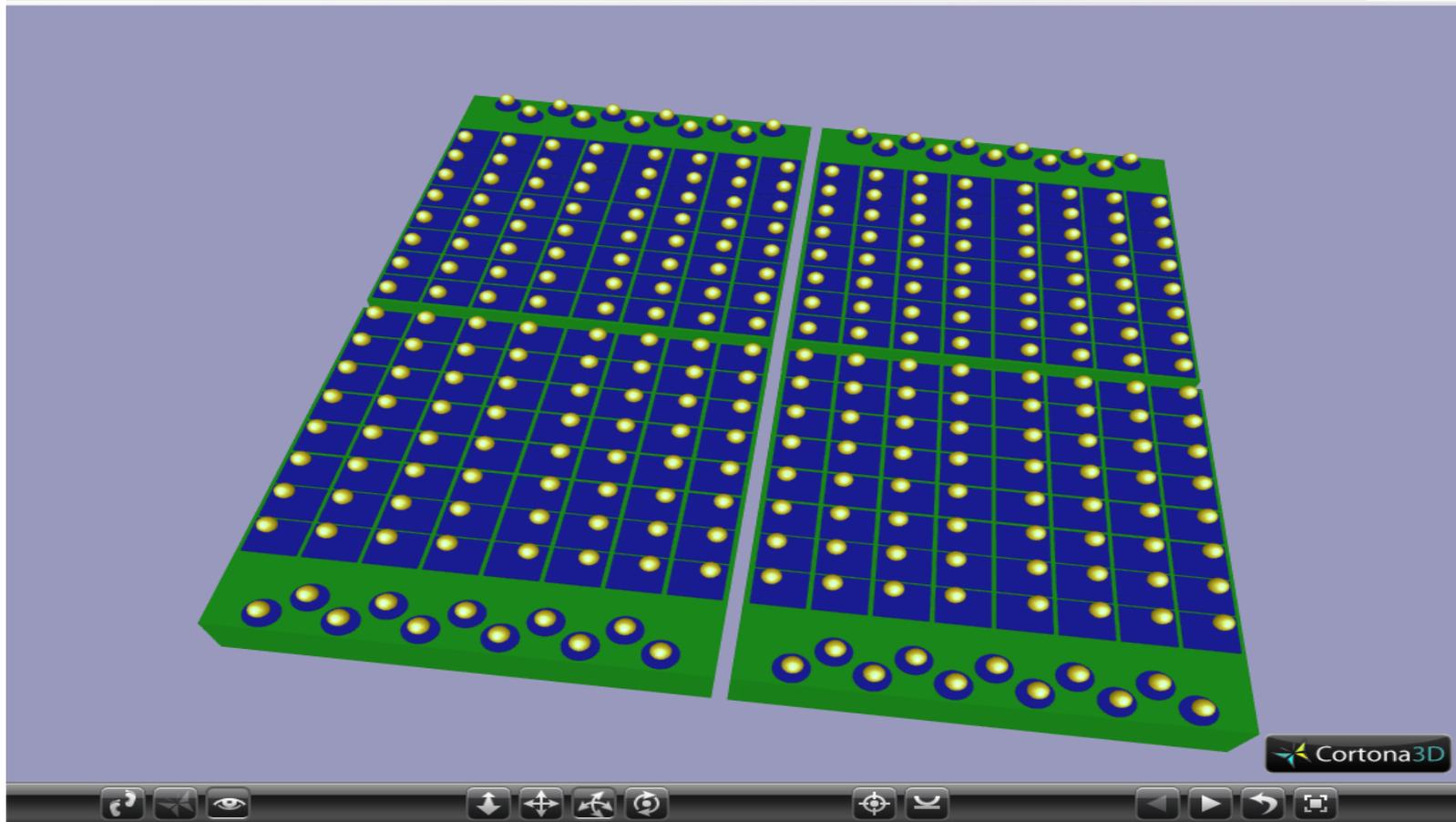
## WANTED

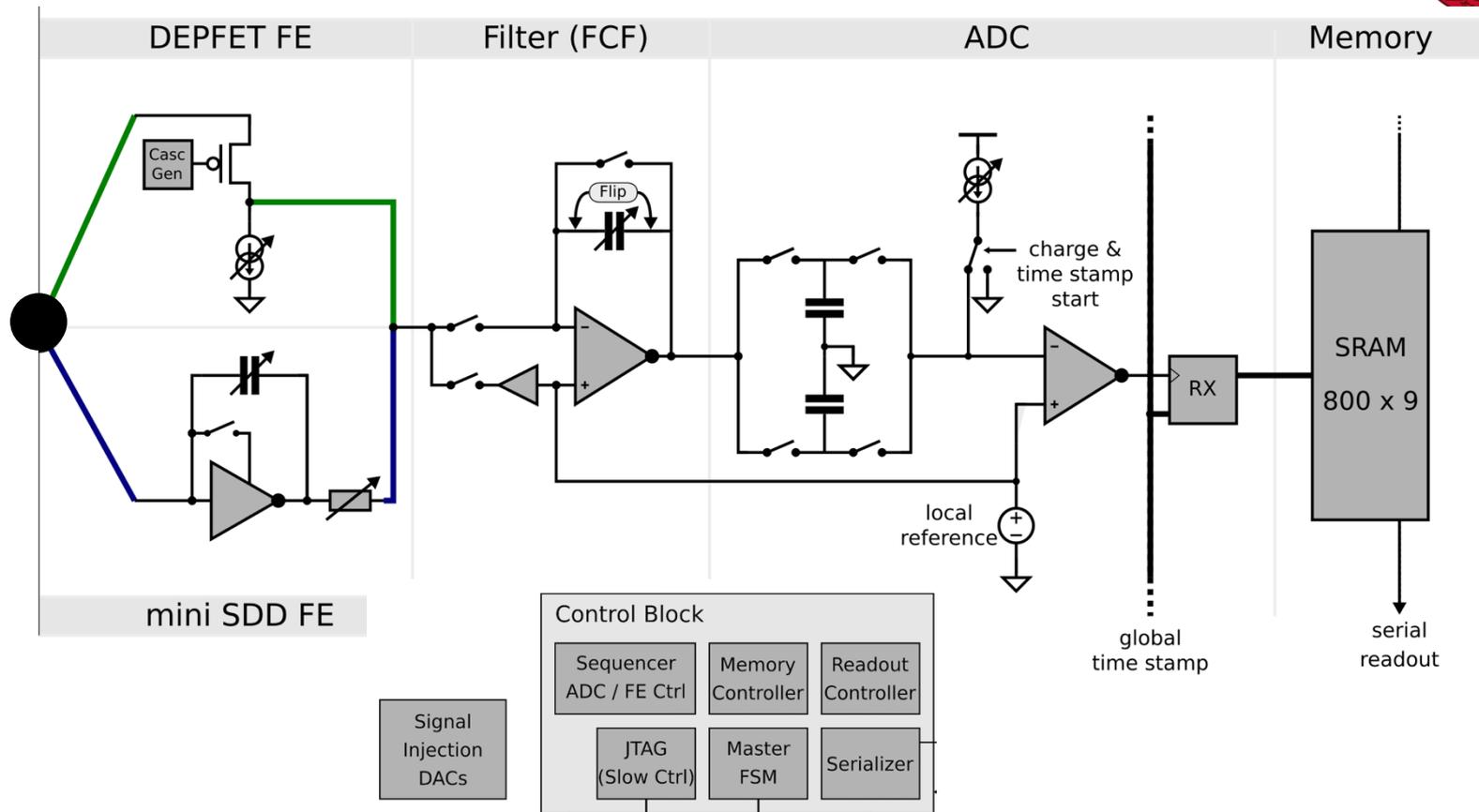
- Kann auch schwache X-Rays sehen
- Winziges Rauschen
- 4M Bilder / Sekunde
- $\geq 800$  Bilder / Paket
- Hoher dyn. Bereich
- 1M Pixel
- Betrieb im Vakuum
- ...

© DRUCKSELBST.DE

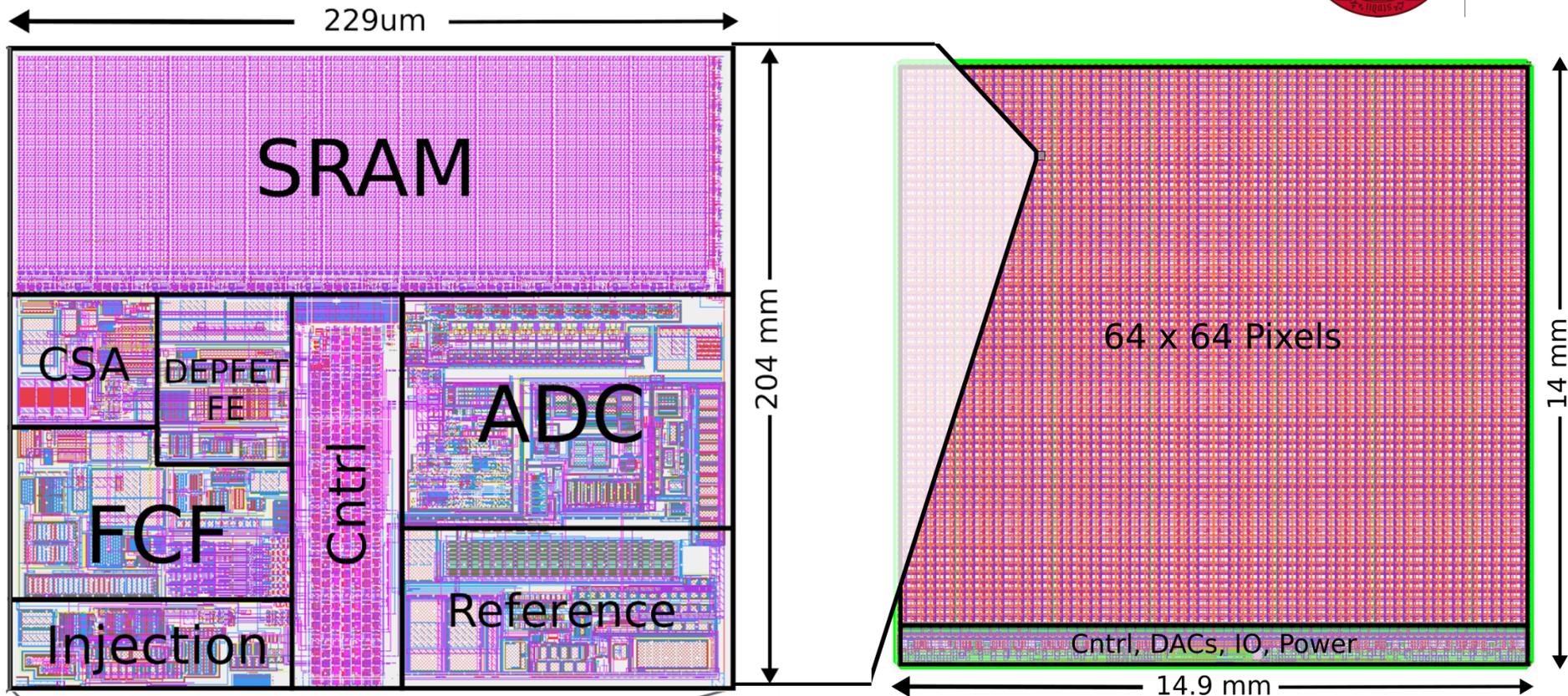


# Hybrider Pixeldetektor: Sensor und Chip





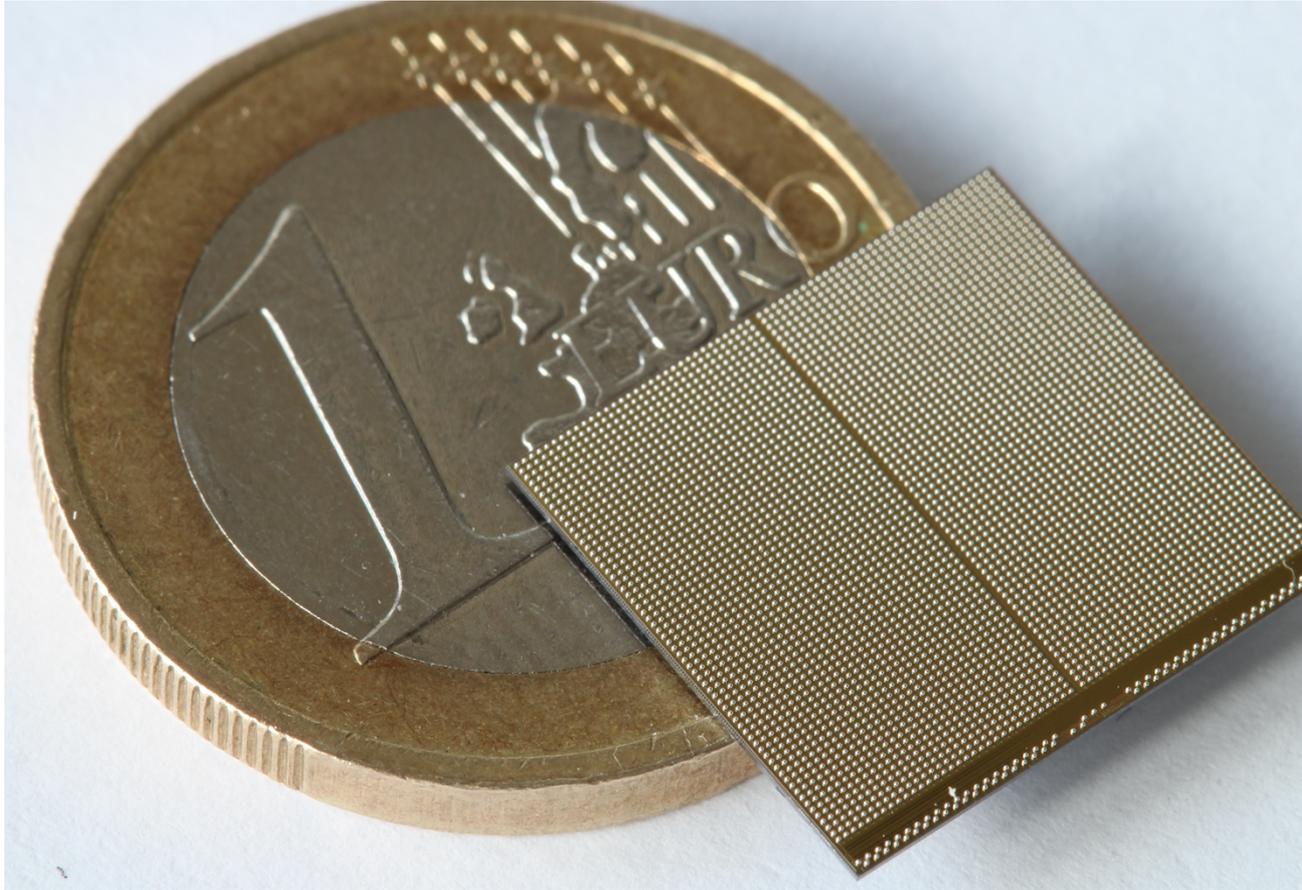
# Pixel Layout



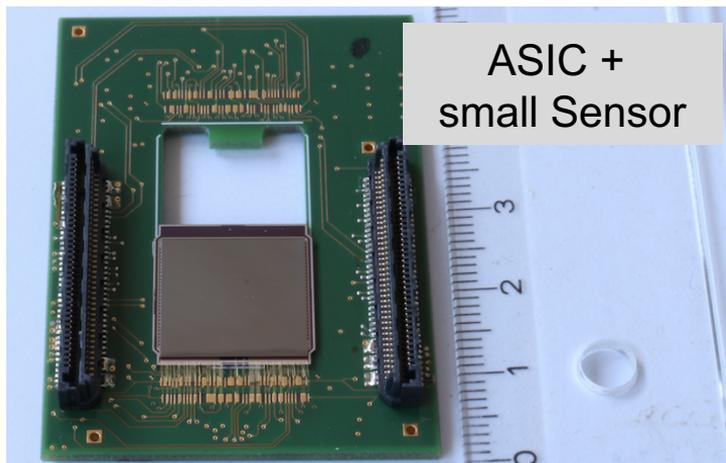
# Der Chip



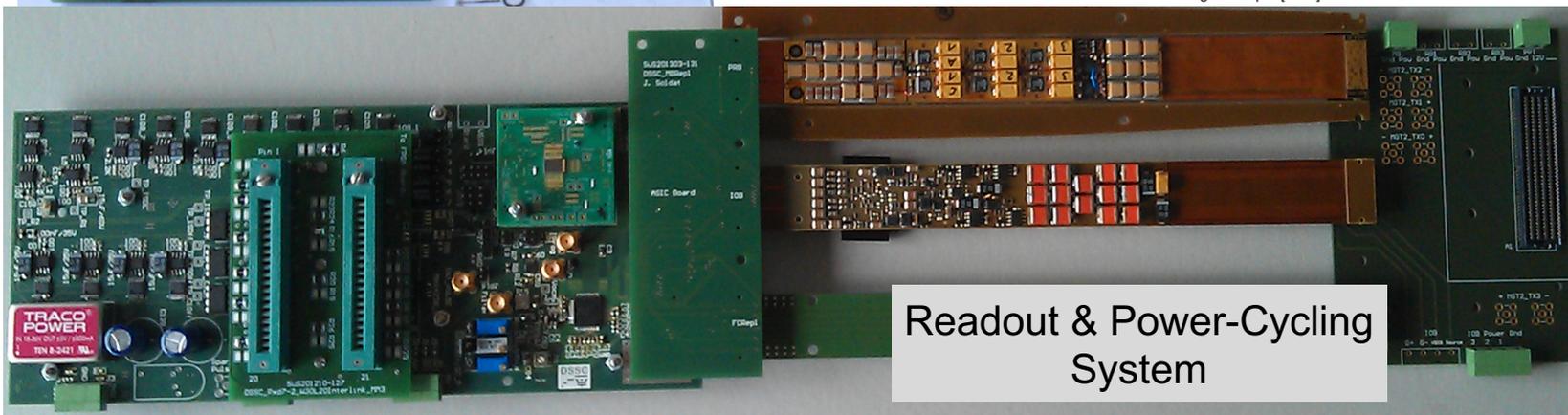
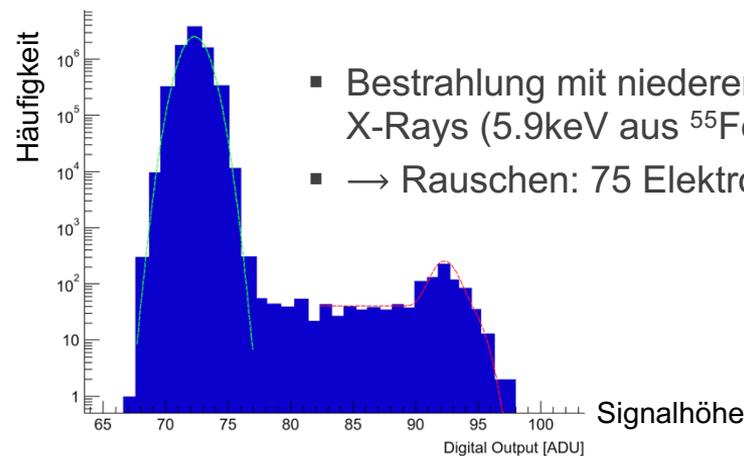
UNIVERSITÄT  
HEIDELBERG  
ZUKUNFT  
SEIT 1386



# Chip + Sensor: Rausch-Messung



ASIC +  
small Sensor



Readout & Power-Cycling  
System



Deutsches Elektronen-Synchrotron DESY  
A Research Centre of the Helmholtz Association

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NEWS SEARCH

## Fastest soft X-ray camera in the world installed at the European XFEL

BACKGROUNDERS

International consortium develops tailor-made detector for European X-ray laser

EVENTS

LECTURE SERIES

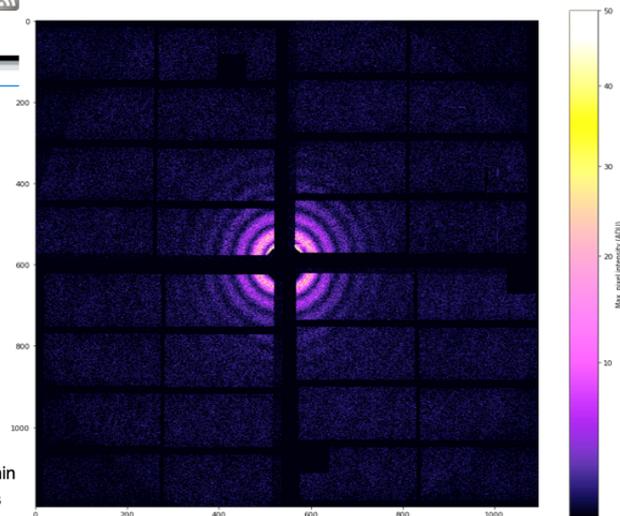
An international consortium has built the world's fastest soft X-ray camera. Tailor-made for the X-ray laser European XFEL, the DSSC detector shoots 800 images in just under 200 millionths of a second and can detect single X-ray photons. With its incredible speed, the detector can keep up with the rapid pace of X-ray flashes of the European XFEL that researchers use to analyse a wide variety of material samples with atomic accuracy.

- empfindlichste Kamera
- niedrigstes Rauschen
- die meisten Bilder
- ....
- die teuerste Entwicklung
- das längste Projekt
- ...



The European XFEL delivers 27,000 X-ray flashes per second. They come in ten packets, called pulse trains, with 2700 flashes each. Within the pulse trains, the flashes repeat every 220 nanoseconds (billionths of a second). Detectors that shoot images at this speed are not available off-the-shelf. Ten years ago, therefore, international institutions joined forces to develop a tailor-made X-ray camera. Partners in the consortium are the University of Heidelberg, the Politecnico di Milano, the University of Bergamo, European XFEL and DESY, where central electronic components and the detector housing have been developed.

The camera's rapid imaging is only possible because the images are

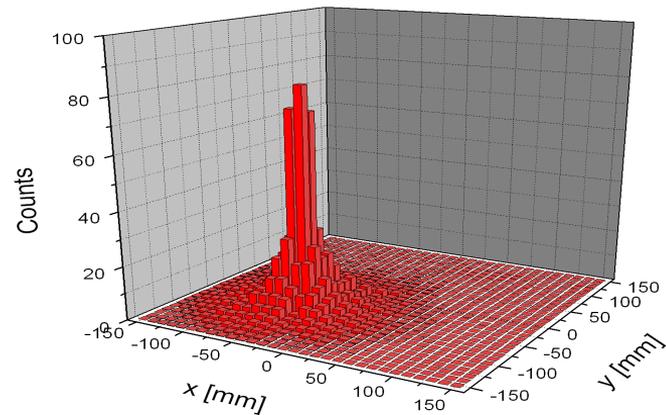
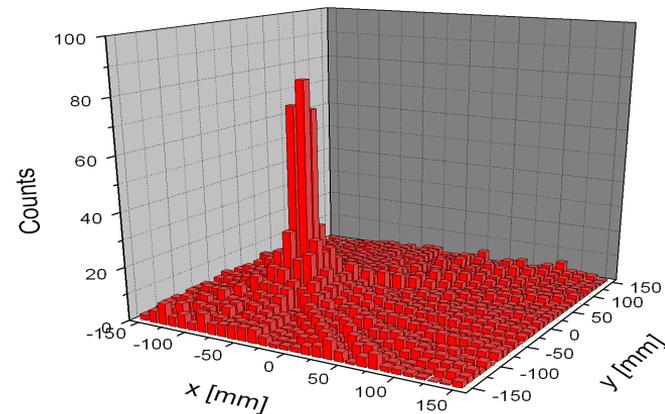
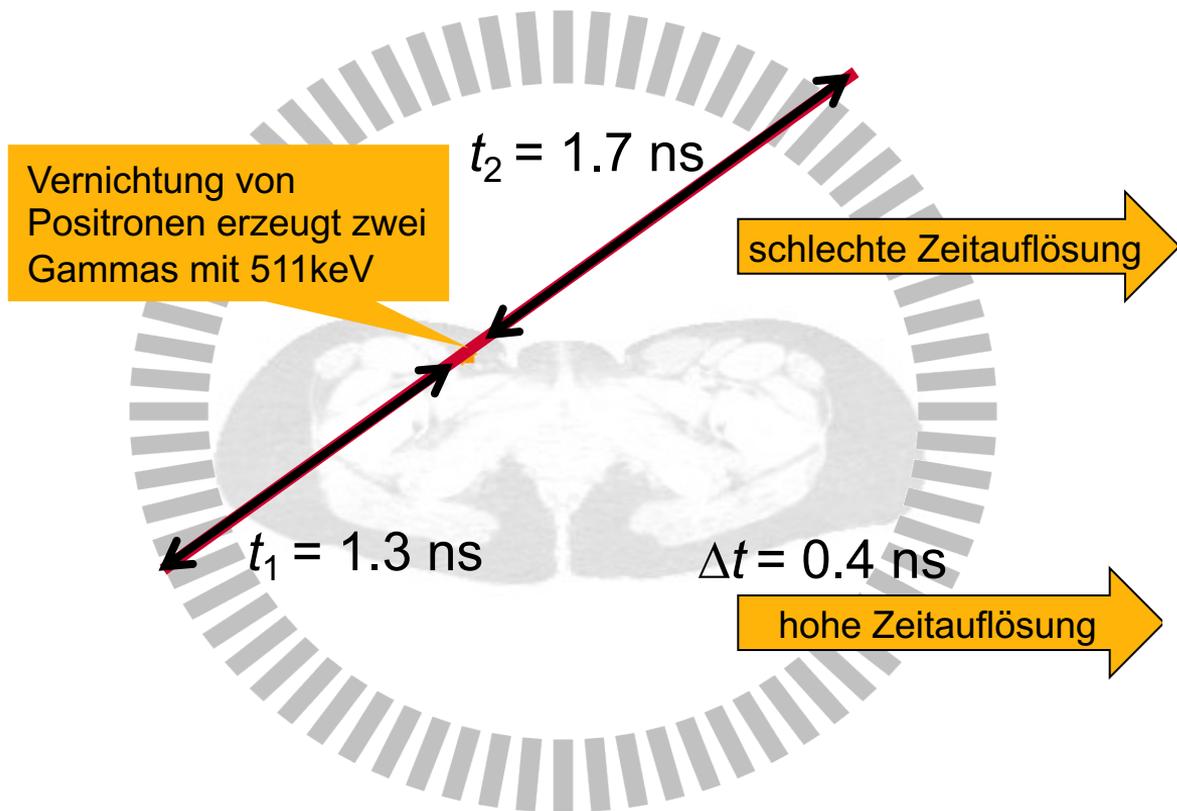


Das erste volle Beugungsbild!



# Beispiel 2: PET

# Positron Emission Tomography (PET)



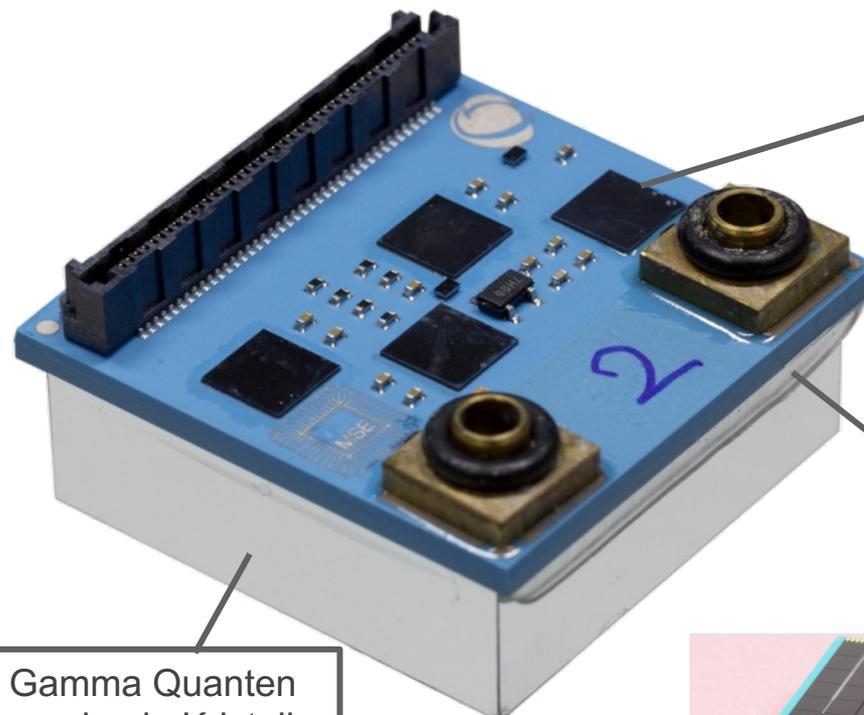
# Gesucht: Der ‚perfekte‘ Detektor



## WANTED

- Effizienter Nachweis von Gamma Quanten mit 511 keV Energie
- Extrem gute Zeitauflösung (100 ps)
- Energiemessung
- Viele Kanäle
- Wenig Power
- ...

© DRUCKSELBST.DE

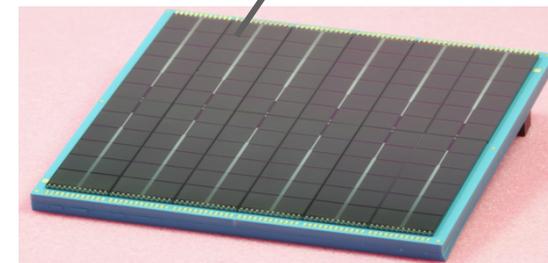


Chips messen die schwachen Signale

Photo Sensoren verwandeln Licht in elektrisches Signal

Gamma Quanten werden in Kristallen absorbiert und erzeugen Licht

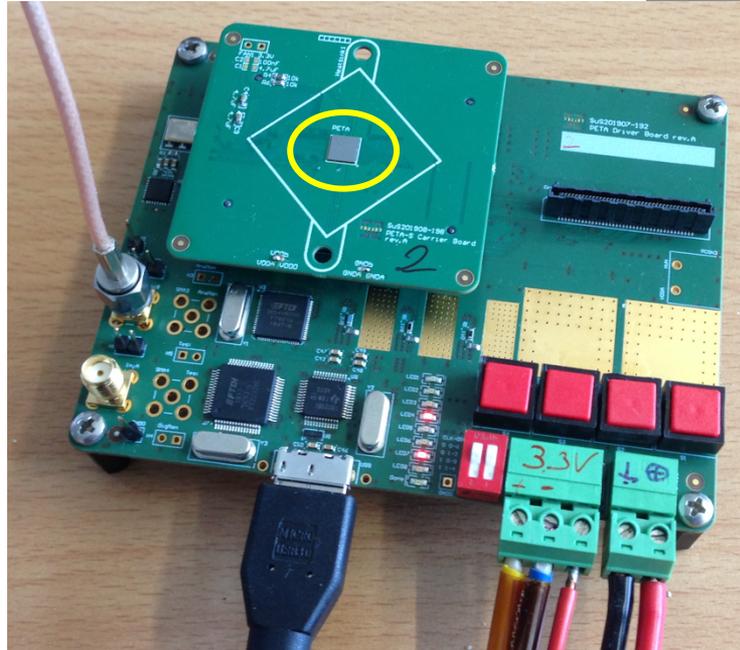
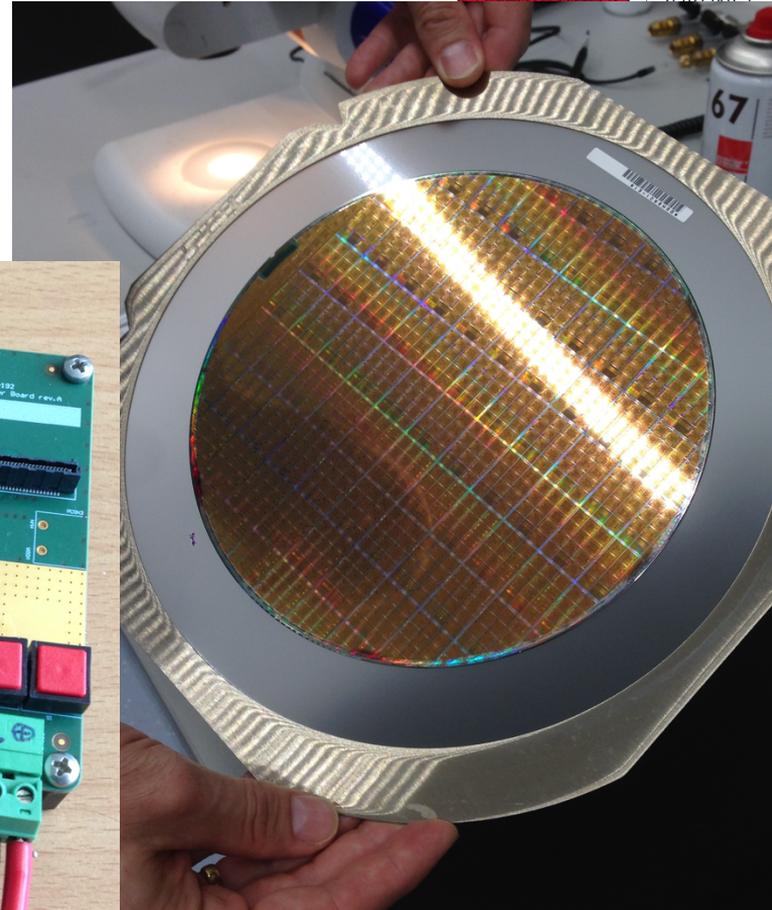
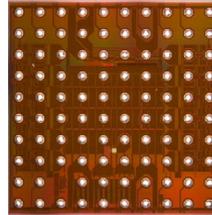
$\gamma$  (511 keV)



# Unser Chip



- 5 x 5 mm<sup>2</sup>
- Bumps Verbindungen
- 32 Kanäle
- Zeitmessung  
in 50ps Schritten
- Schneller ADC
- Nachbarschafts-  
trigger
- ...



- PET Ring für Kleintiere
- State-of-the Art Zeitauflösung (200ps!)
- *Gleichzeitige* Messung eines MRT Bildes!

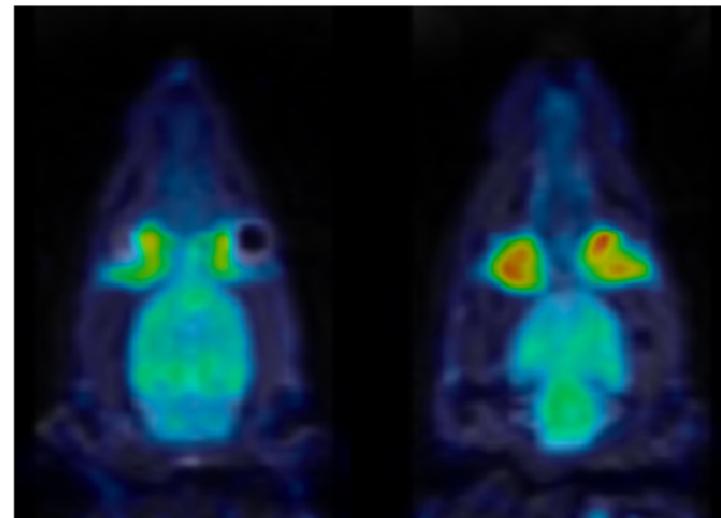
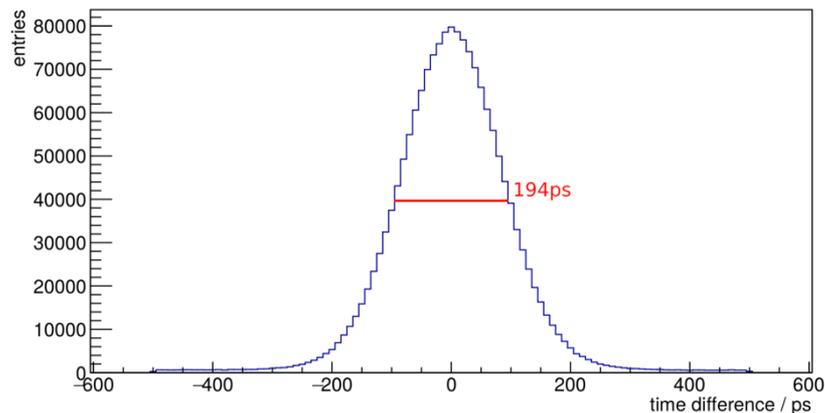


Figure 10: Two slices of an ex-vivo rat brain PET-MR image, consisting of two PET images from consecutive bed positions and one MR image.

PSMR2019: Initial Characterisation of the SAFIR Dual-Ring-Prototype



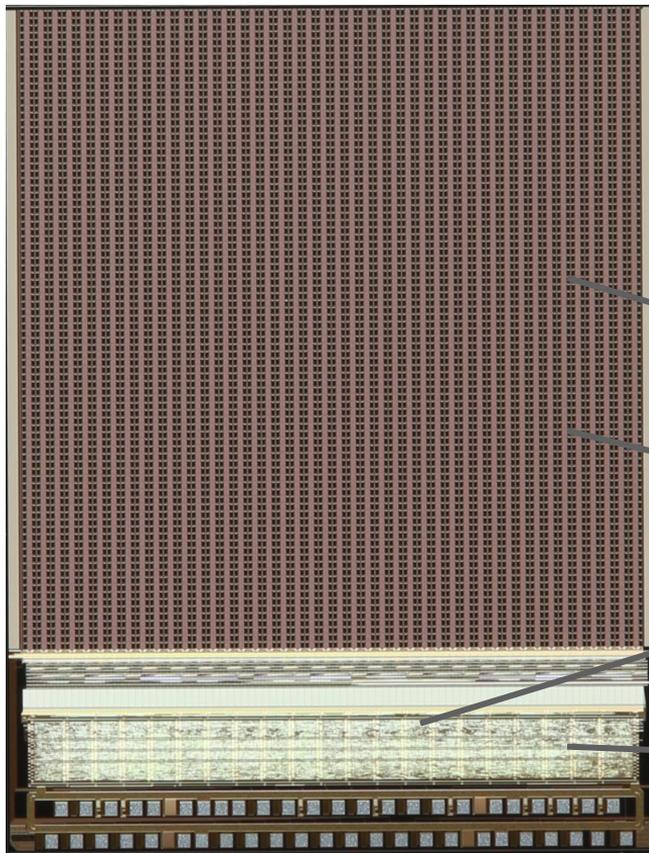
# Beispiel 3: Detektoren für **einzelne** Photonen



## WANTED

- Nachweis einzelner Photonen
- Photonen Zählen
- Zeit genau messen
- Hohe Bildrate
- Rauschunterdrückung
- ....

© DRUCKSELBST.DE



Aktive Fläche  
~ 5 × 5 mm<sup>2</sup>

88 × 88 Pixel  
56.44 × 56.44 μm<sup>2</sup>

Hit-OR, Multiplicity

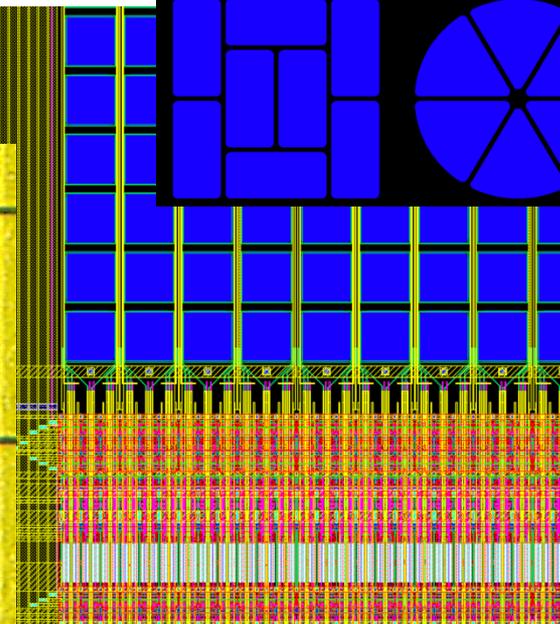
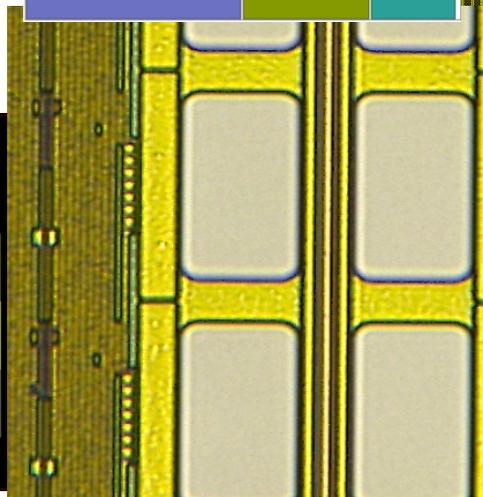
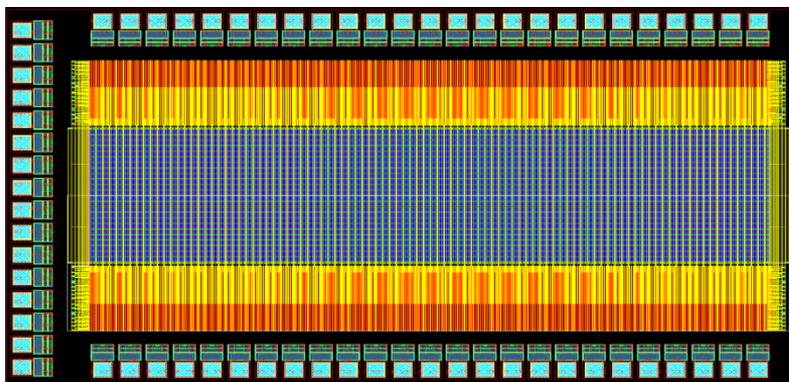
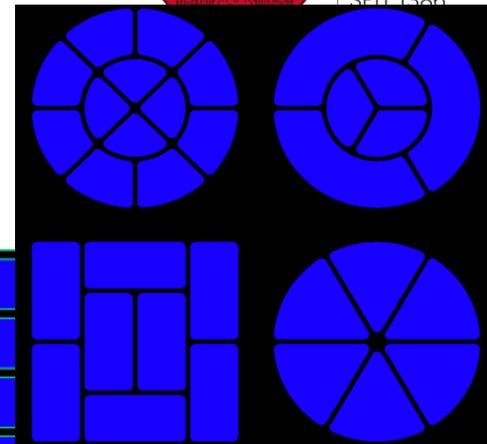
Schnelle Auslese

# Viele Architekturen / Viele Anwendungen



- PET
- Suche nach Dunkler Materie
- Kalorimetrie
- 3D Kameras
- Fluoreszenz-Mikroskopie
- ...

SCI42 9700 x 3000	SPARE 5700 x 3000	TEST 3800 x 3000
XY 9700 x 6100	DARWIN 5700 x 6100	TPC 3800 x 6100
IDP 9700 x 9700	TDC 5700 x 9700	SCI56 3800 x 9700



Wir entwickeln Chips / Sensoren / Systeme  
für  
Grundlagenforschung und Medizin

Nur mit hoch spezialisierten  
Instrumenten mit optimaler  
Performanz kann man  
,ganz vorne mit dabei' sein!





Vielen Dank für Ihre Aufmerksamkeit!