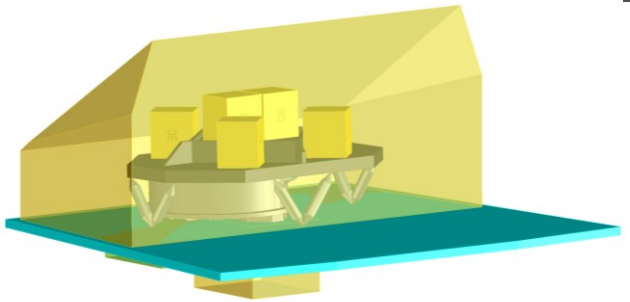
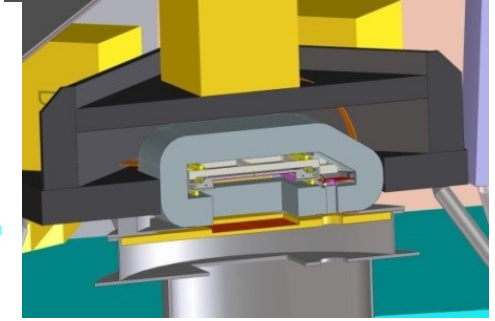
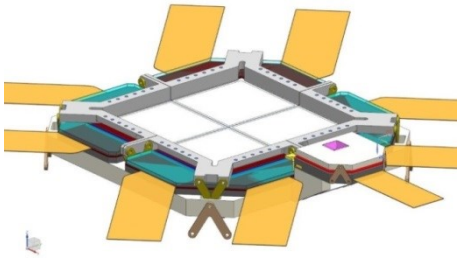
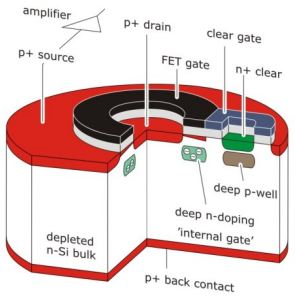




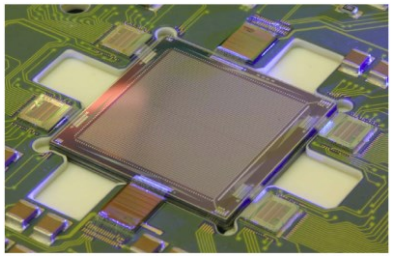
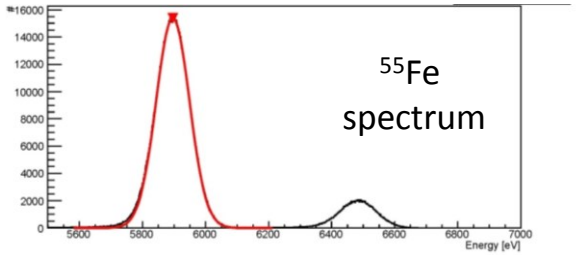

Exploring the Hot and Energetic Universe:
The first scientific conference dedicated to the Athena X-ray observatory

Wide Field Imager for Athena

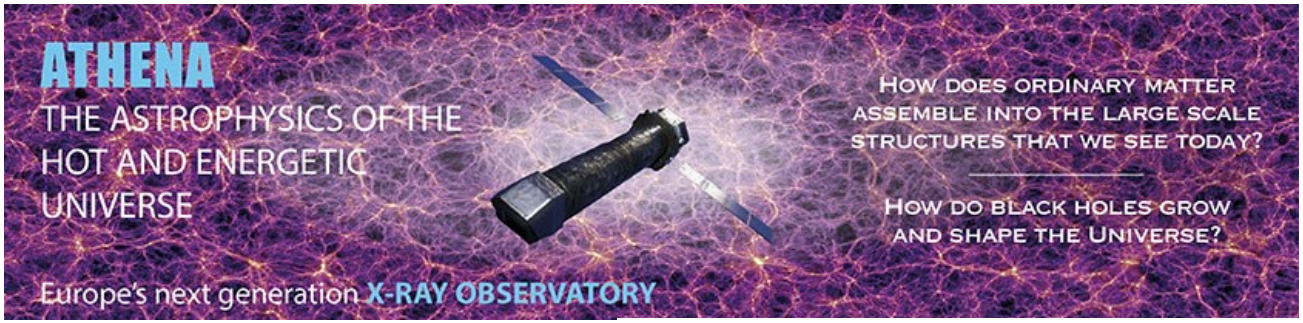
Norbert Meidinger

on behalf of the WFI proto-consortium

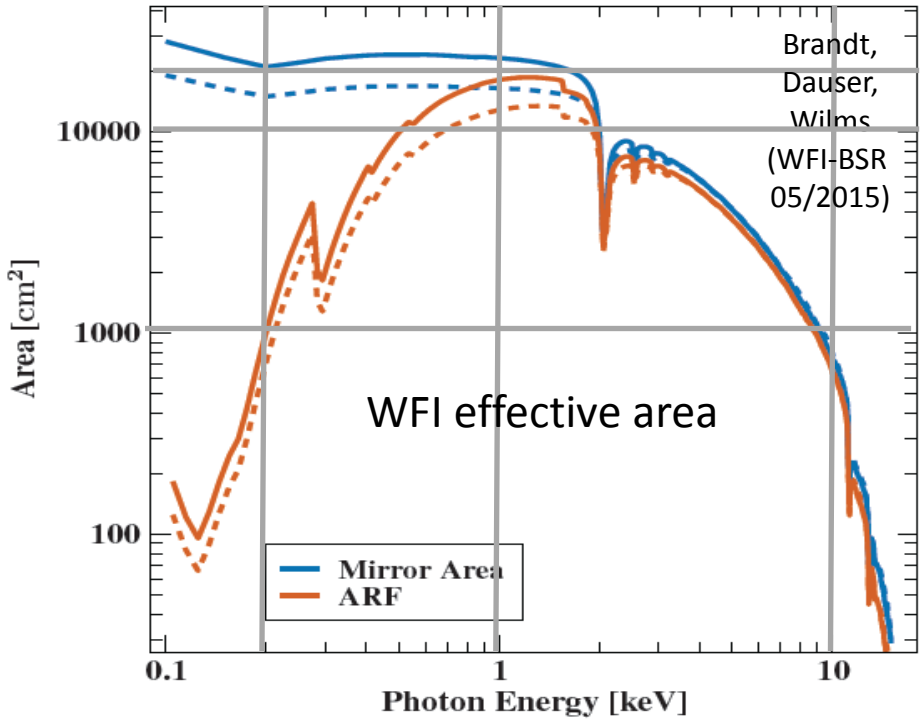



Introduction

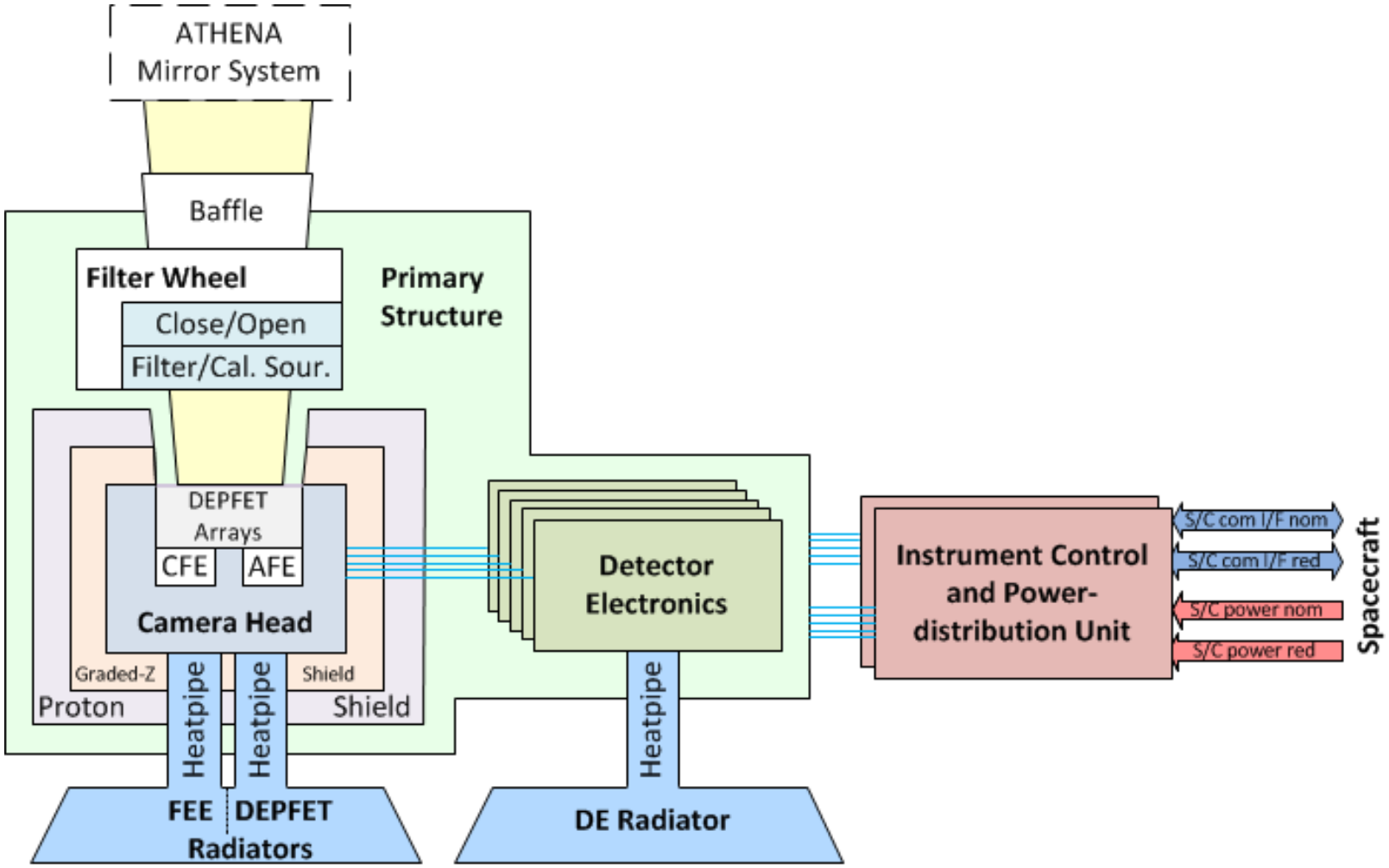


- Single **mirror system** focal plane cameras: **X-IFU** and **WFI**

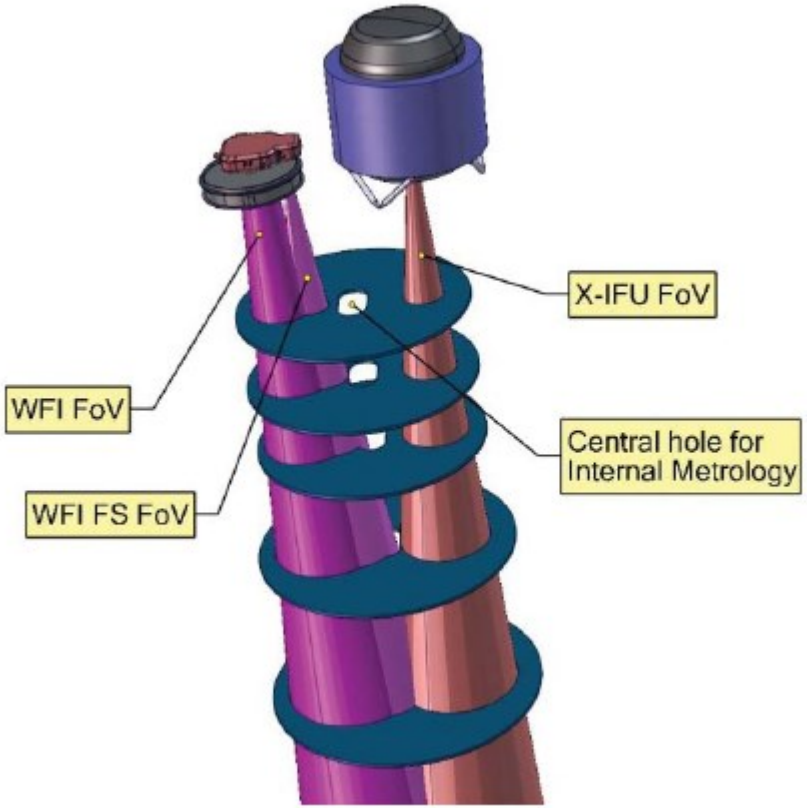
- **WFI**:
  - unprecedented survey power through large FoV (40` x 40`)
  - excellent count-rate capability (≥ 1 Crab)

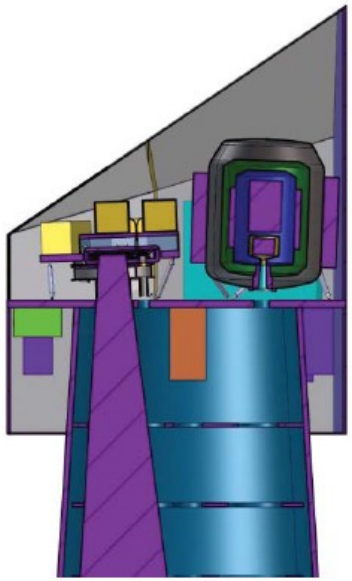


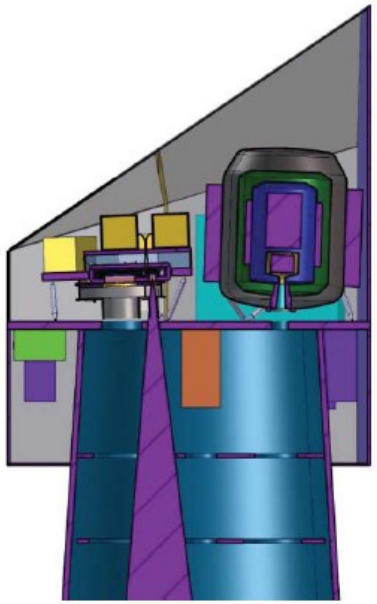
WFI Functional Block Diagram

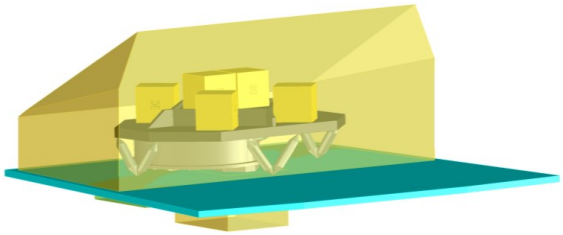


Field of View (CDF study)

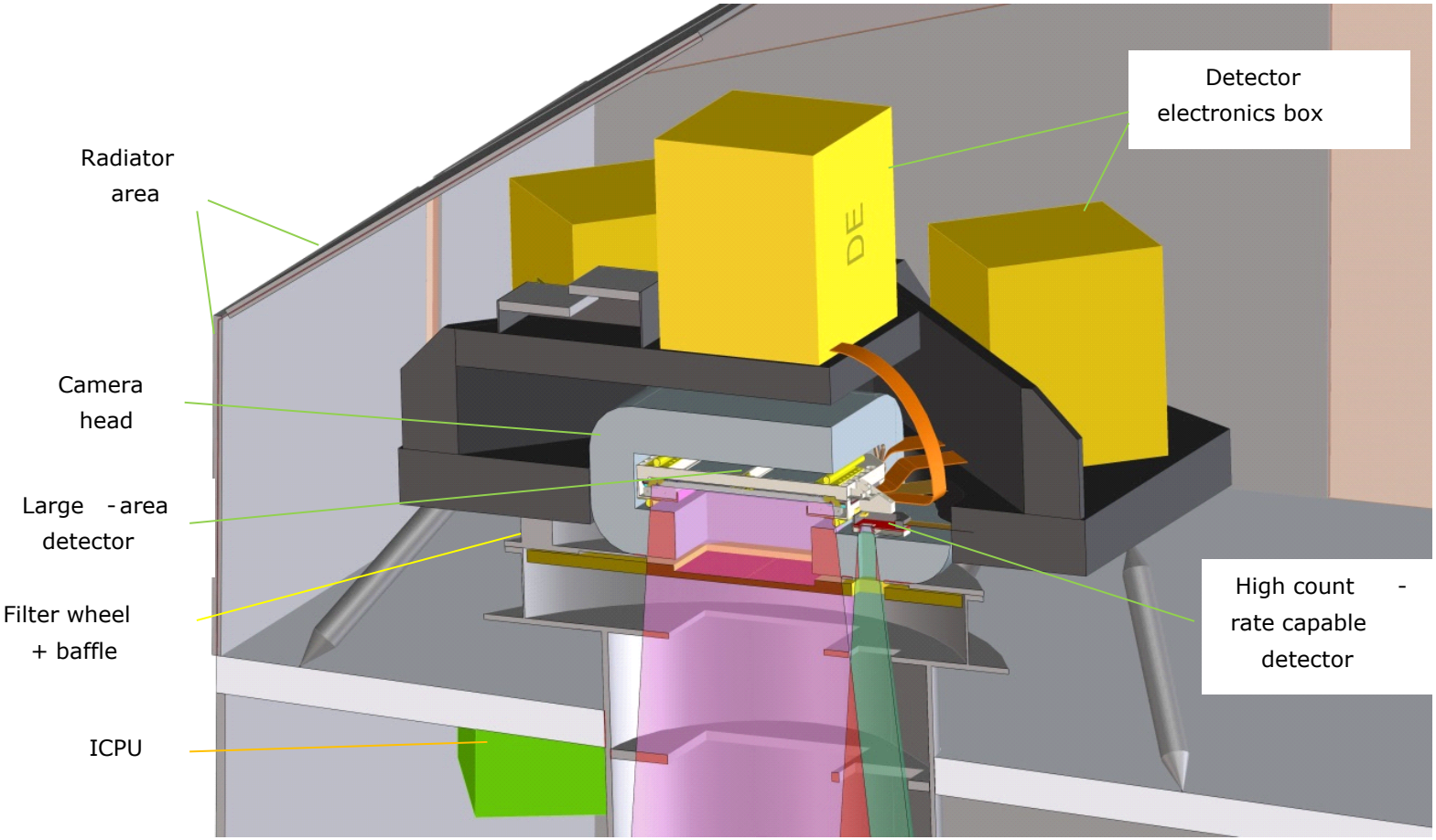








WFI conceptual design

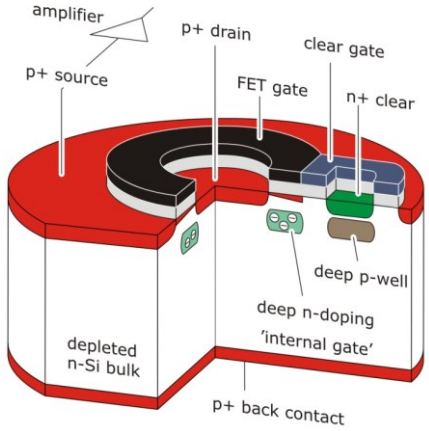


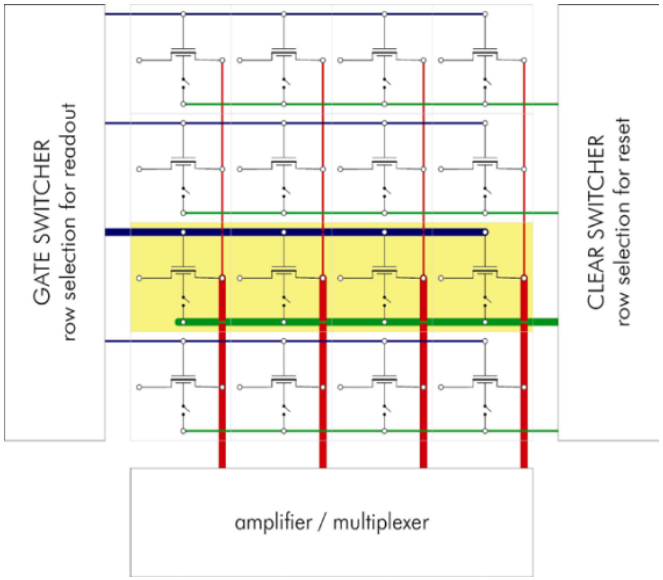
Focal plane layout

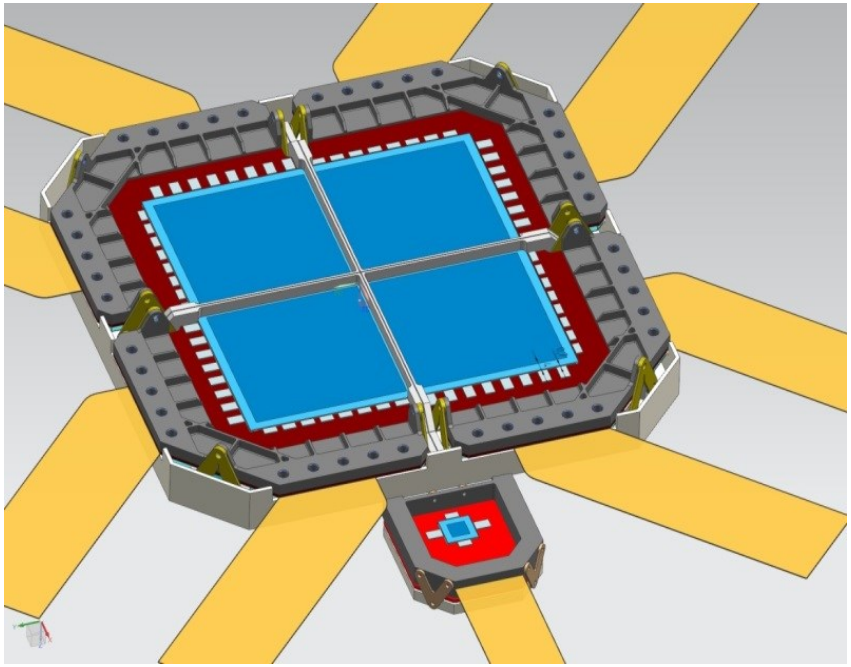
Observation: **large** or **fast** WFI

- **Rolling shutter mode**
- Pixel size **130 µm x 130 µm**

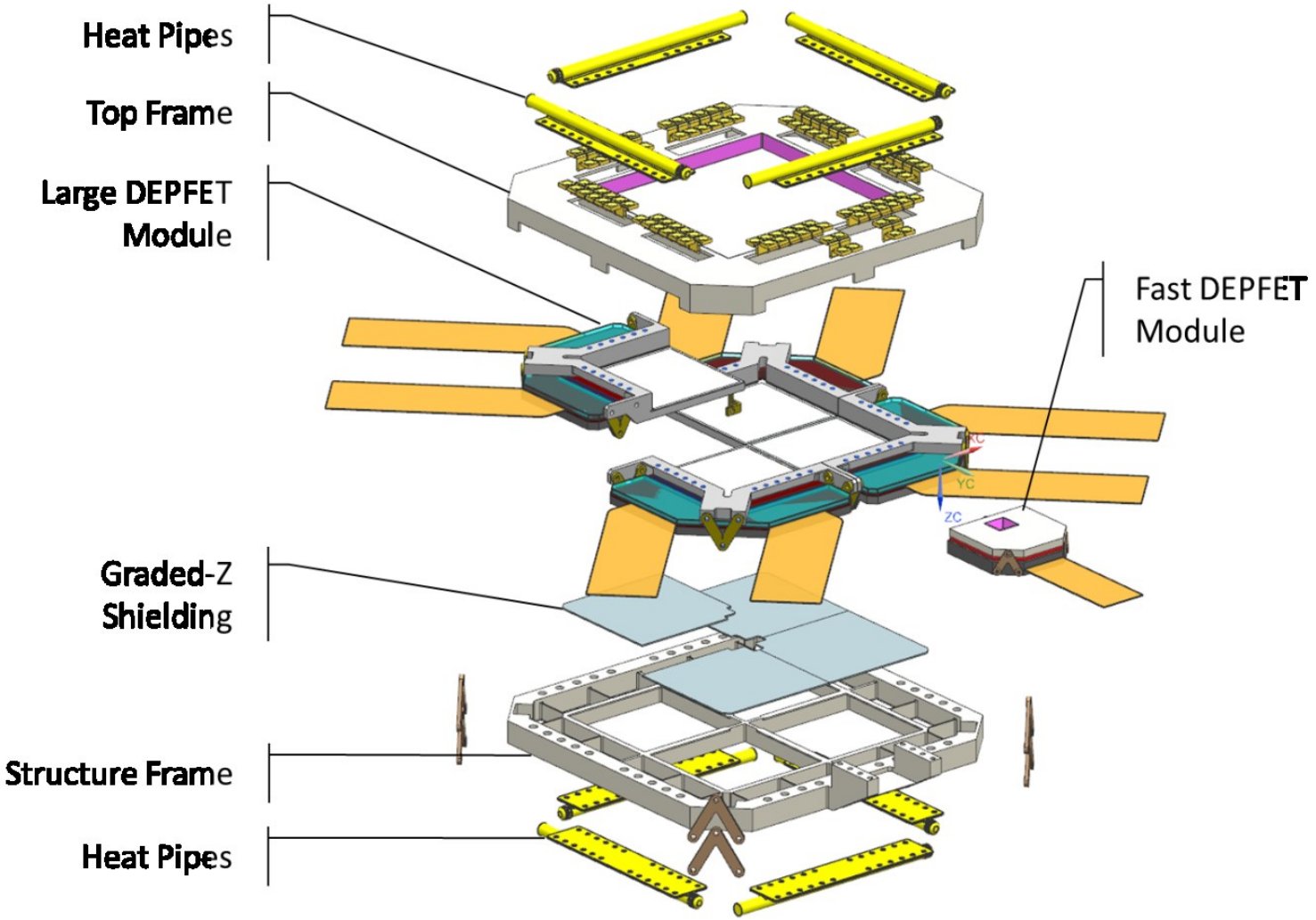
  ⇒ accurate source position reconstruction (splits!)
  for PSF = 5'' (goal: 3'') HEW
- DEPFETs thermally decoupled from FEE





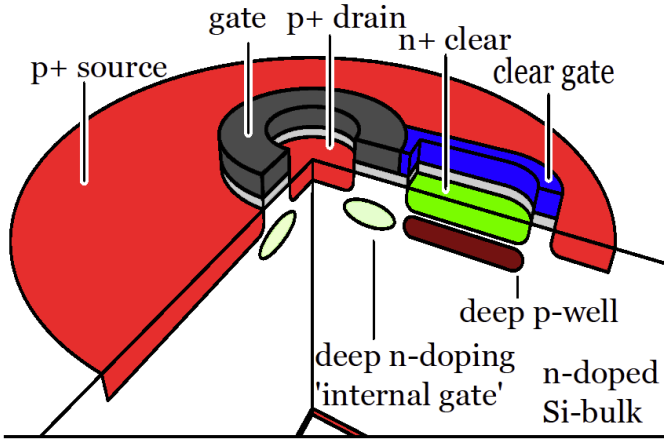


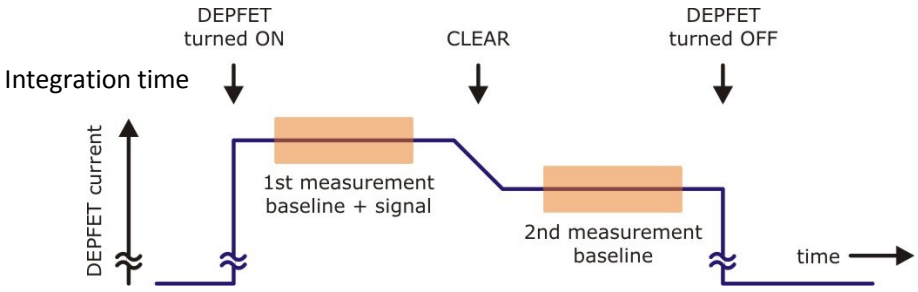
WFI detector assembly

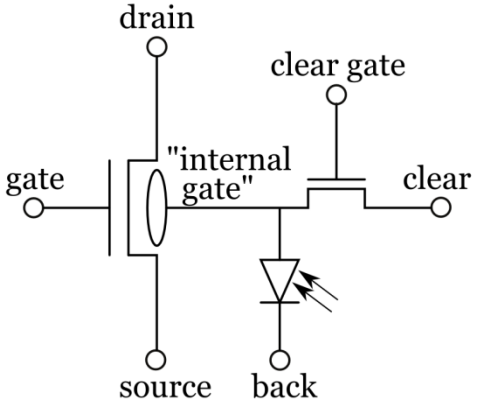


DEPFET APS Detectors: Concept

- p-FET on depleted n-bulk
  - ↳ back-side illuminated
  - ↳ signal charge collected in **"internal gate"**
  - ↳ reset via ClearFET

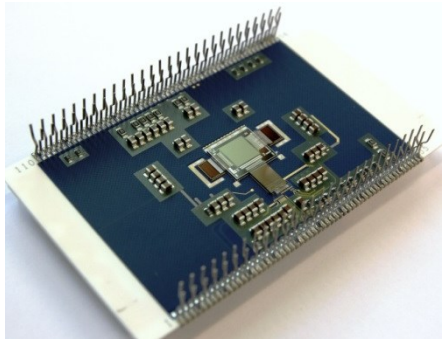




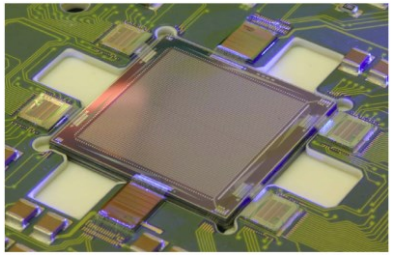


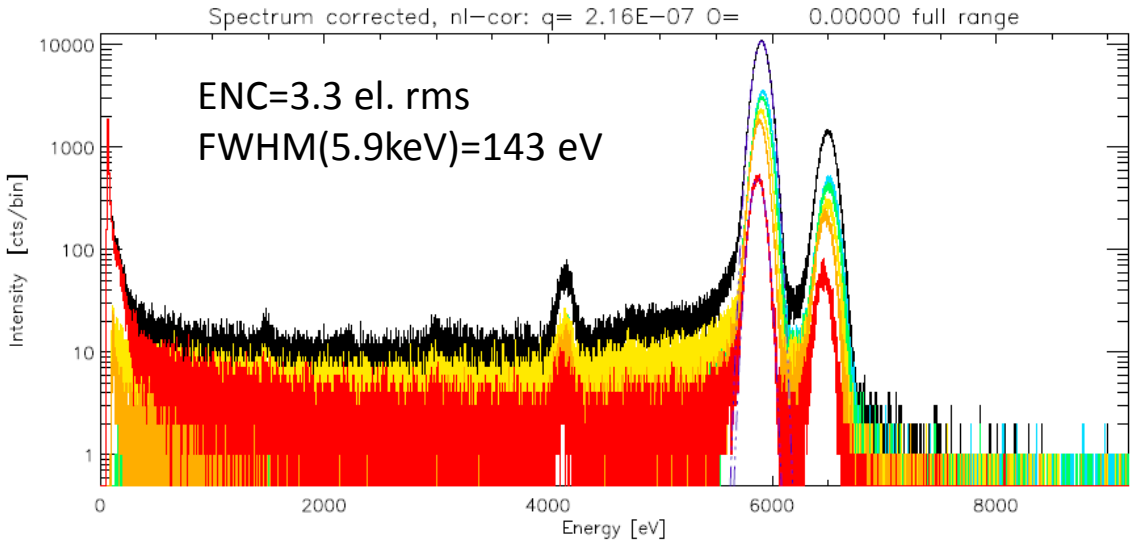
DEPFET Detector: Energy resolution

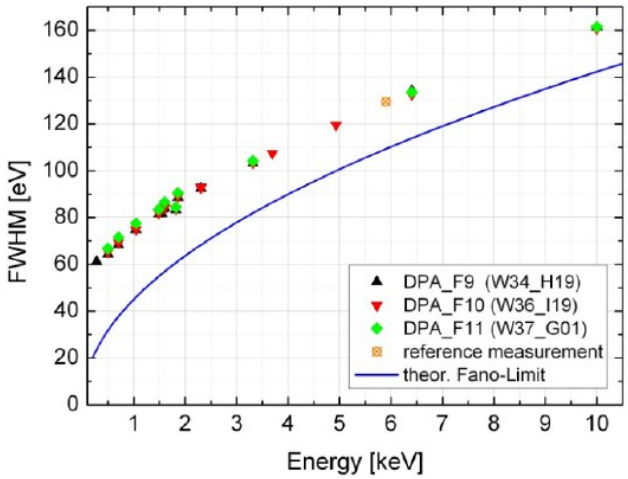
Standard DEPFET
pxd5, 64x64 pixel
Asteroid (→ VERITAS2)



Heritage:
MIXS DEPFET detectors on BepiColombo

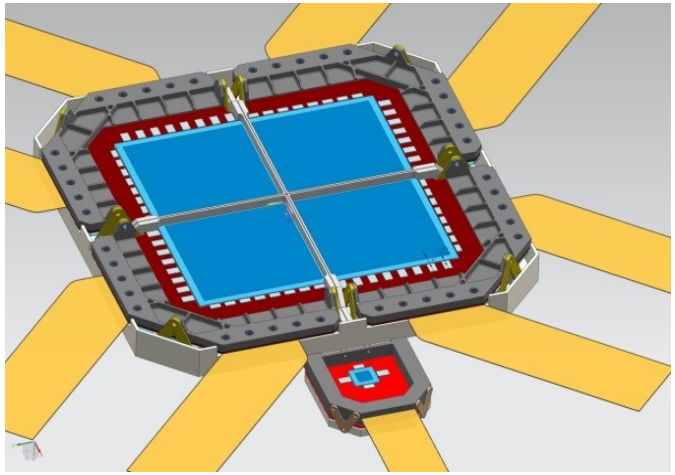






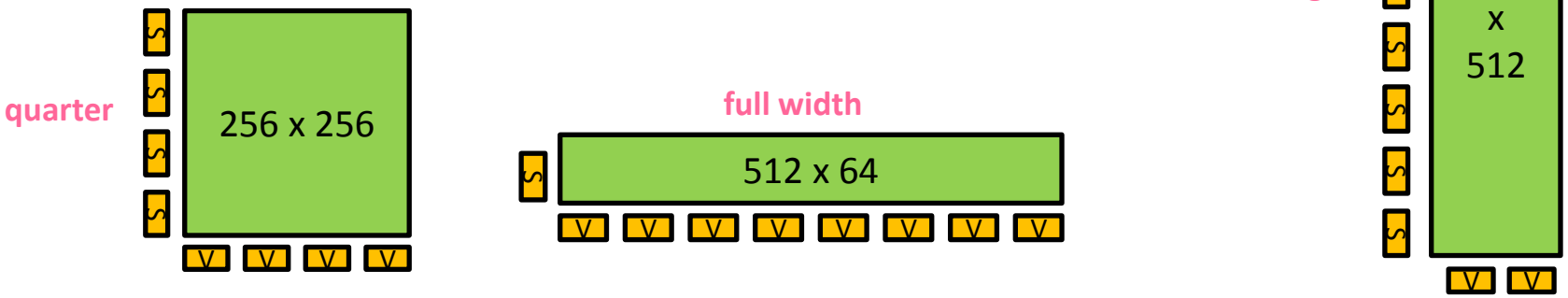
Aim: **512 x 512** matrix
+ 2x **faster** readout

Large FoV detector

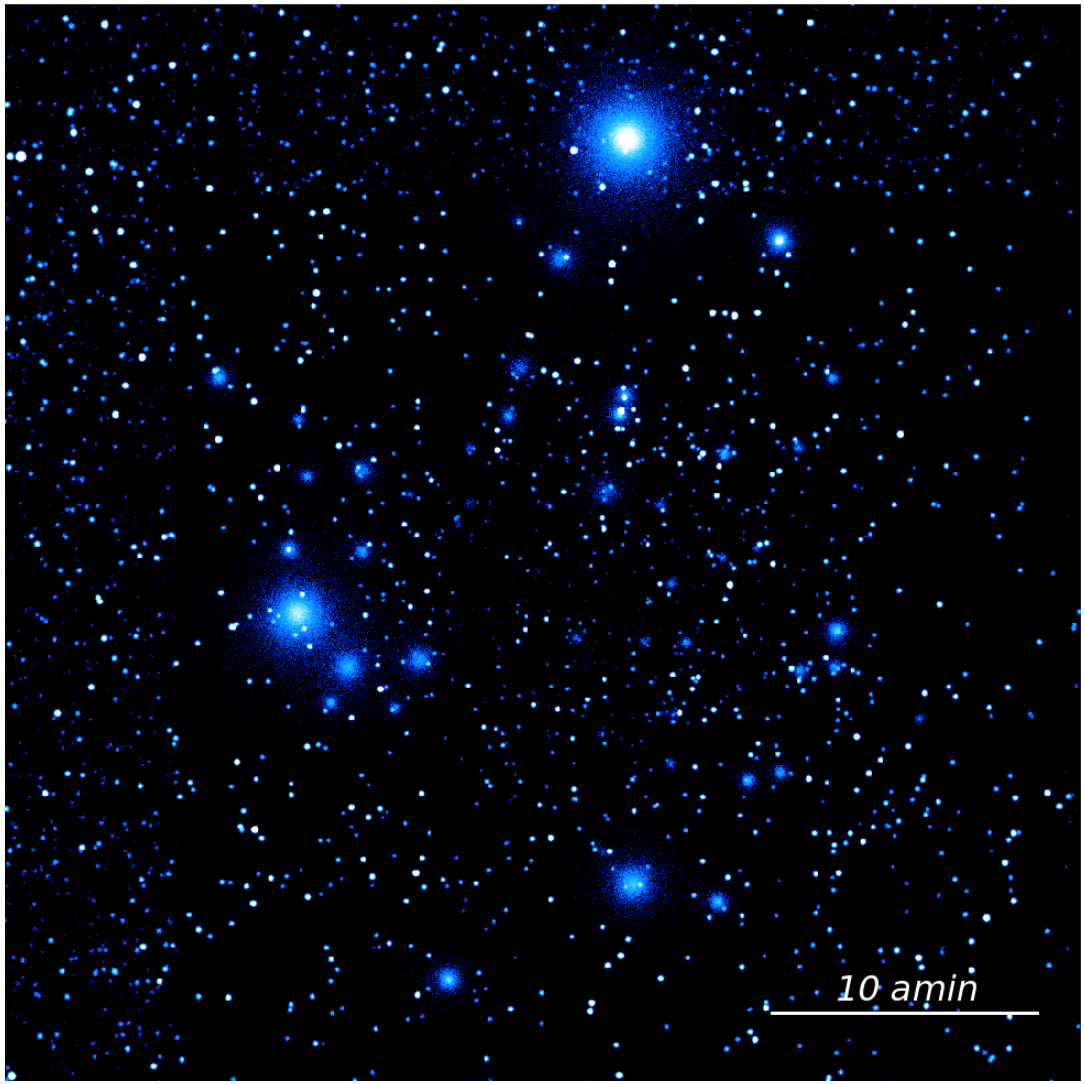


- **40` x 40`** by **1024 x 1024 pixel**
- 4 independent + identical quadrants
- Insensitive regions
  → observation with dither pattern
- 2-side buttable DEPFETs
- Switcher under redesign
- VERITAS-2 under develoment
  2.5 µs/row → **1.3 ms / frame**
- **Prototype large DEPFET**
  designed + currently produced at

MPG HLL HALBLEITERLABOR DER MAX-PLANCK-GESELLSCHAFT

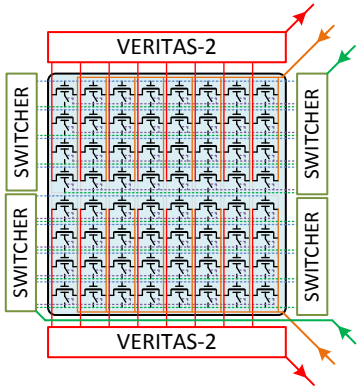


Simulation of **Chandra Deep Field South** (**SIXTE,** 100ks)
Lissajous dither pattern (4 amin amplitude)

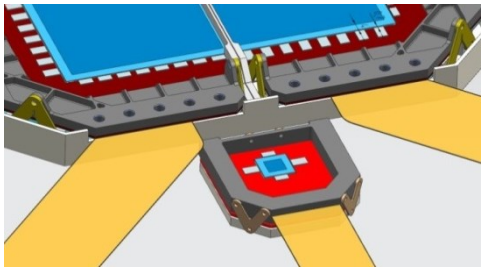


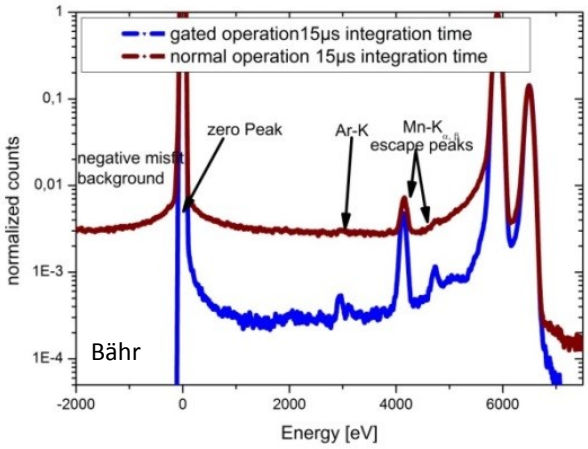
by Rau, Dauser

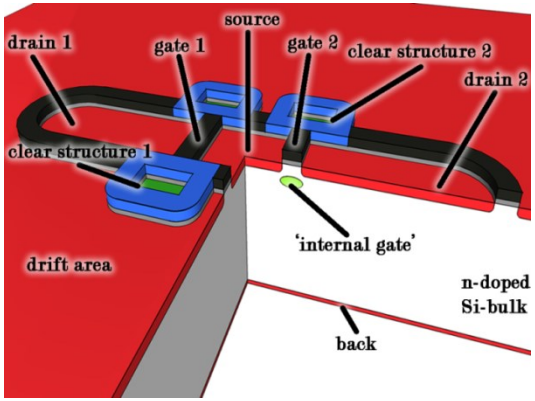
High count-rate capable detector



- **64 x 64** pixel (FoV: 143`` x 143``)
- "split full frame mode" → time resolution: **80 µs**
- **gateable DEPFET with add. signal storage region**
  → **better spectral response**
- Concepts:
  A. 2 DEPFETs per pixel: readout ↔ charge collection
  B. Signal charge transferred to internal gate
  Status: Proof-of-concept DEPFETs successfully produced
  → under test
  → design & production of **prototype fast DEPFET**







High count-rate capability

Rising count-rate

$\Rightarrow$ **throughput drops**

\+ **pile-up increases**

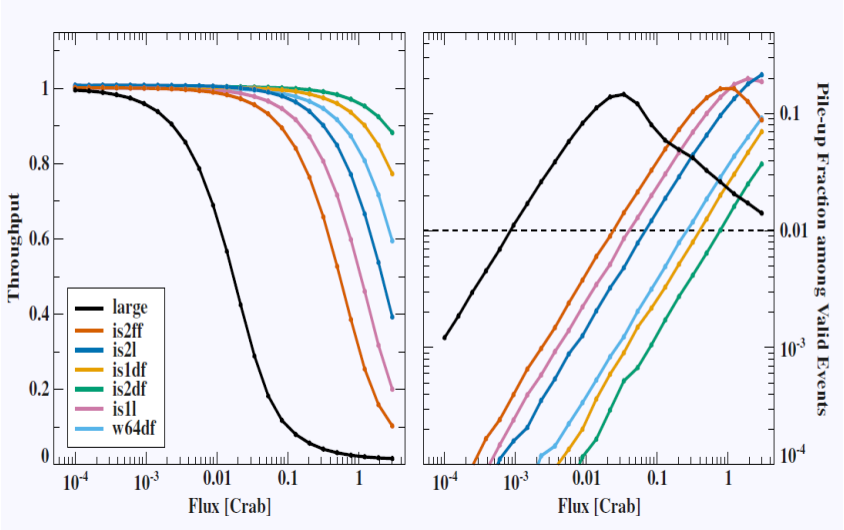
Simulations (SIXTE): fast detector FF mode with **defocused PSF** optimum

Result: if mounted 35mm out-of-focus:

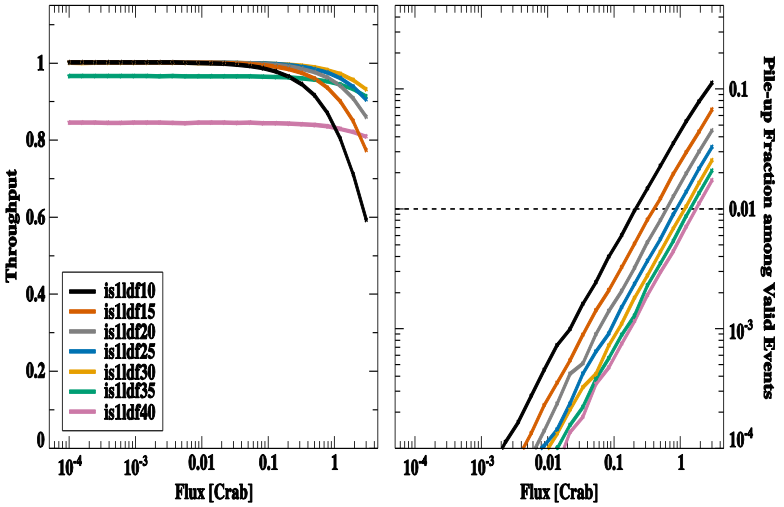
for **1 Crab**: **>90% throughput; <1% pile-up**

→ Poster 12.06 by Dauser et al.

comparison of operating modes



optimum out-of-focus distance



Brand, Dauser, Wilms, Willingale et al.

WFI light blocking filter

DEPFET sensitive to **visible light + UV light** ⇒ blocking filter necessary

on-chip: 90 nm Al + 20 nm Si_3N_4 + 30 nm SiO_2

external filter (160 mm x 160 mm): 40 nm Al + 200 nm PI + mesh 95%

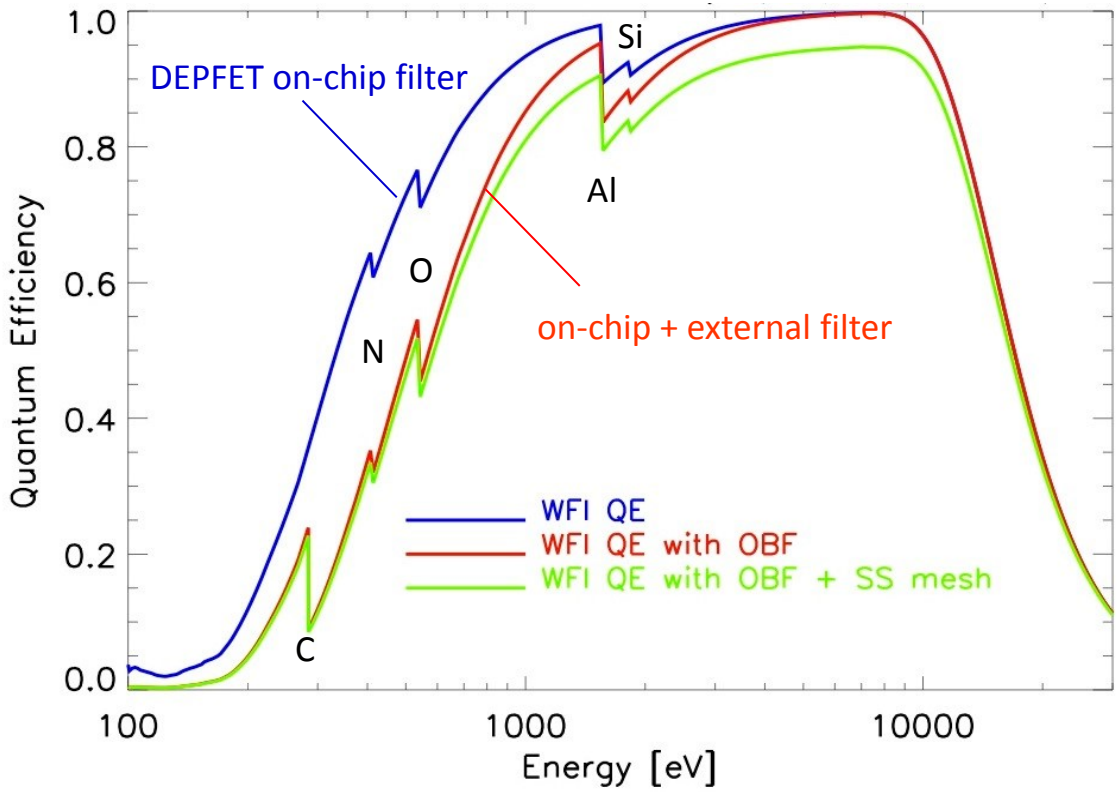
Blocking filter	on-chip filter	external filter	combination
Visible light	$T = 3 \times 10^{-5}$	$T = 10^{-2}$	$T = 3 \times 10^{-7}$
UV light: 643A	$T = 4 \times 10^{-4}$	$T = 6 \times 10^{-7}$	$T = 3 \times 10^{-10}$
UV light: 1932A	$T = 2 \times 10^{-5}$	$T = 9 \times 10^{-6}$	$T = 2 \times 10^{-10}$

Barbera et al. SPIE 2015

→ permits observations of hot stars ($m_v = 2$)

Alternative solution w/o mesh:
Launch filter + detector evacuated like EPIC PN-camera on XMM-Newton
⇒ Vacuum vessel: higher mass for WFI + 'single point failure'-risk

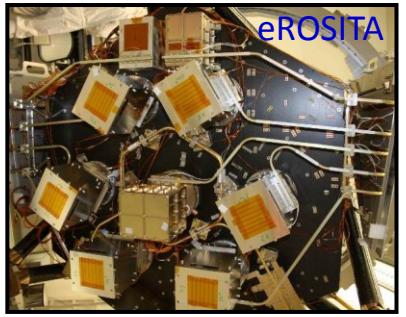
WFI Quantum Efficiency



Barbera, Meidinger, et al. SPIE 2015

Back-illuminated DEPFET chip; **450 µm** thickness fully depleted

Thermal design

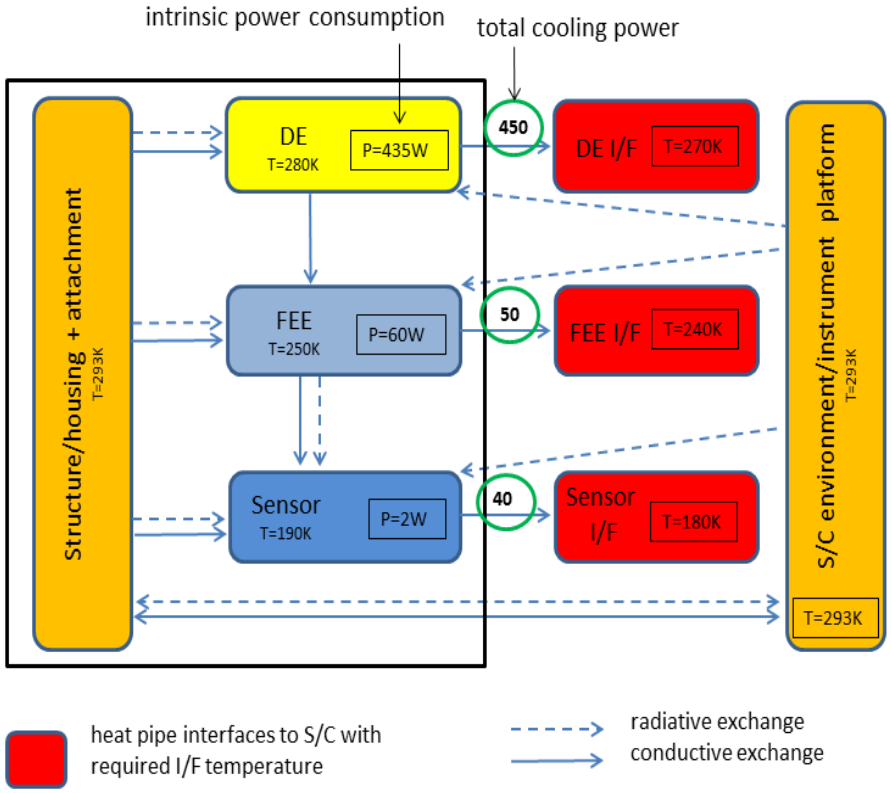


Passive cooling with heat pipes and radiators
→ **no limited lifetime**

- **Focal plane sensors @ T=190K**
- **FEE @ T=250K**
- **DE and ICPU @ T=280K**

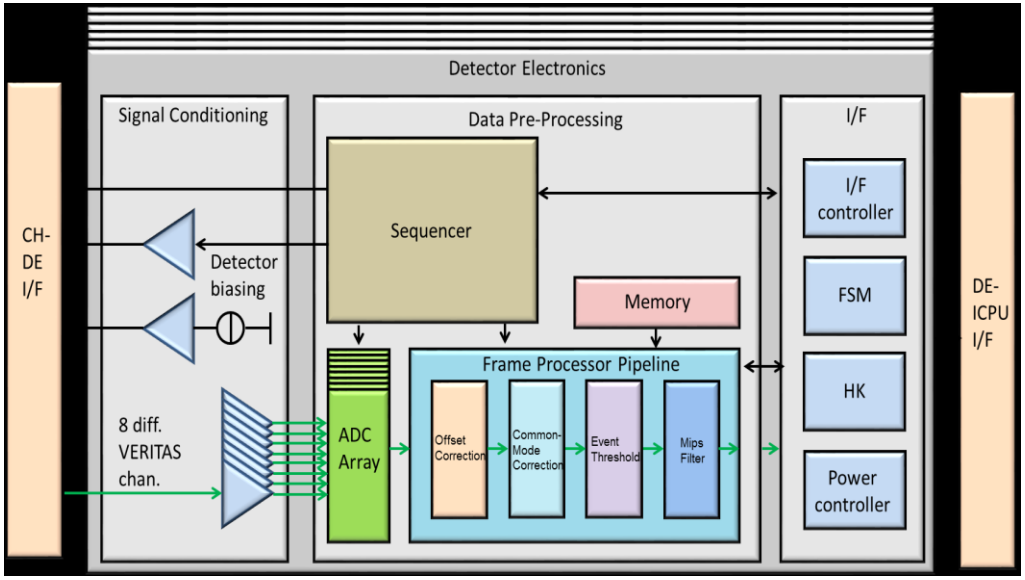
Heat pipes:
- standard **ammonia** heat pipes for FEE + DE + ICPU
- **ethane** heat pipes for sensor cooling

⇒ WFI radiator area: **3 m²**



Detector electronics

- **Power conditioning** for DEPFET + FEE ASICs
- **Data processing**:
  - Realtime pre-processing: **205 Mpixel/s** per quadrant !!!



WFI model philosophy

BB model (- 2018) → TRL5 for DEPFET, frame processor, OBF

EM, **STM**, **EFM** (2019-2021)

QM (2022-2024)

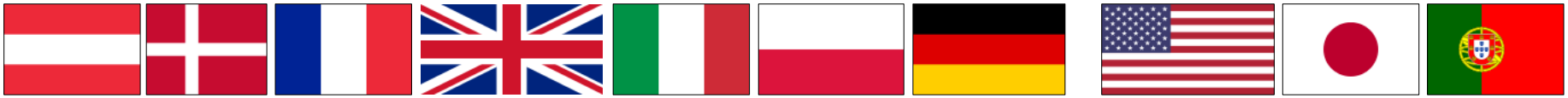
FM (2025-2026)

FS of critical components/subsystems

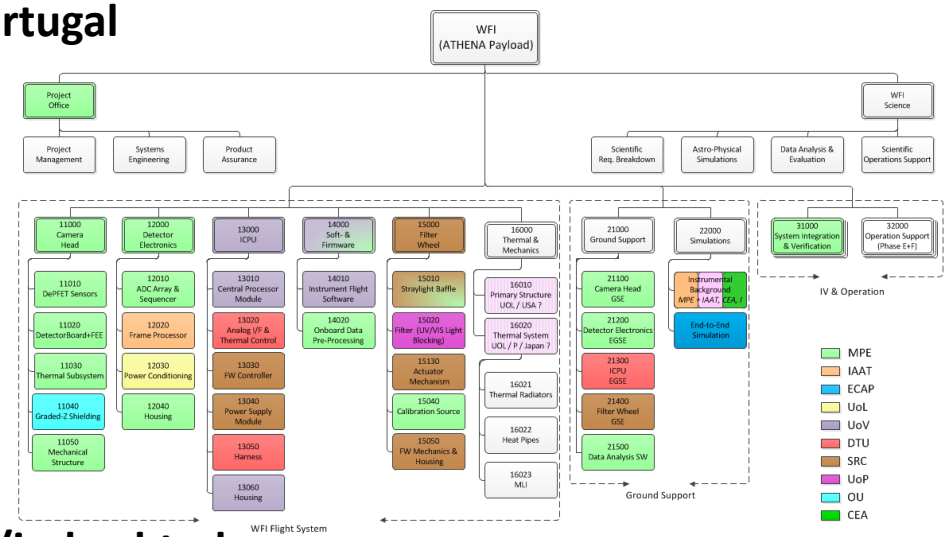
Main technical budgets	
Power (incl. 20% margin)	**570 W (684 W)**
Mass (incl. 20% margin) w/o radiators + heat pipes	**190 kg (228 kg)** **227 kg (273 kg) if vacuum vessel option**
Size (w/o radiator) L x W x H	**1.2 m x 0.8 m x 1.0 m**
Data rate	**Science**: 10 kbit/s – 2 Mbit/s **HK**: 3 kbit/s

Project organization

Milestones:
MCR: 05/2016
Instrument AO: late summer 2016
WFI TDA: till 2018
Mission adoption envisaged for 2020



WFI proto-consortium:
Austria, Denmark, France, Great Britain, Italy, Poland, and Germany
+ potential partners: **USA, Japan, and Portugal**
WFI lead institute: **MPE**
PI: **Kirpal Nandra**
PM: Norbert Meidinger
SI: Markus Plattner
PS: Arne Rau

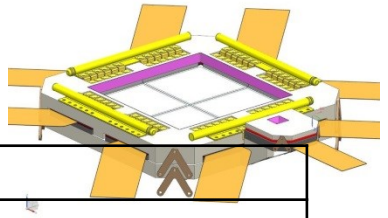


WFI consortium board

WFI science team

http://www.mpe.mpg.de/ATHENA-WFI/index.html

Main WFI Requirements + Characteristics



Parameter	Value
Energy range	≈ 0.1 keV - 15 keV
Pixel size	130 µm x 130 µm pixel size (corr. to 2.2`` x 2.2``)
Operating time	nonstop
Operating mode	rolling shutter
Large FoV detector	FoV: 40` x 40` → 1024 x 1024 pixel (4 quadrants) readout: full frame mode; optional: window mode non-gateable DEPFET type time resolution: 1.3 ms
High count-rate capable detector	64 x 64 pixel → FoV: 143`` x 143`` readout: split full frame gateable DEPFET type with add. signal storage region time resolution: 80 µs 1 Crab: >90% throughput; <1% pile-up (PSF defocused)
Quantum efficiency incl. ext. filter	>20% @ 277 eV >80% @ 1 keV >90% @ 10 keV
Transmission	visible light: T = 3 x 10^{-7} UV light (643 A - 1932 A): T < 10^{-9}
Non X-ray background (L2 orbit)	< 5 × 10^{-3} cts cm^{-2} s^{-1} keV^{-1}
Energy resolution	FWHM(5.9 keV) ≤ 150 eV