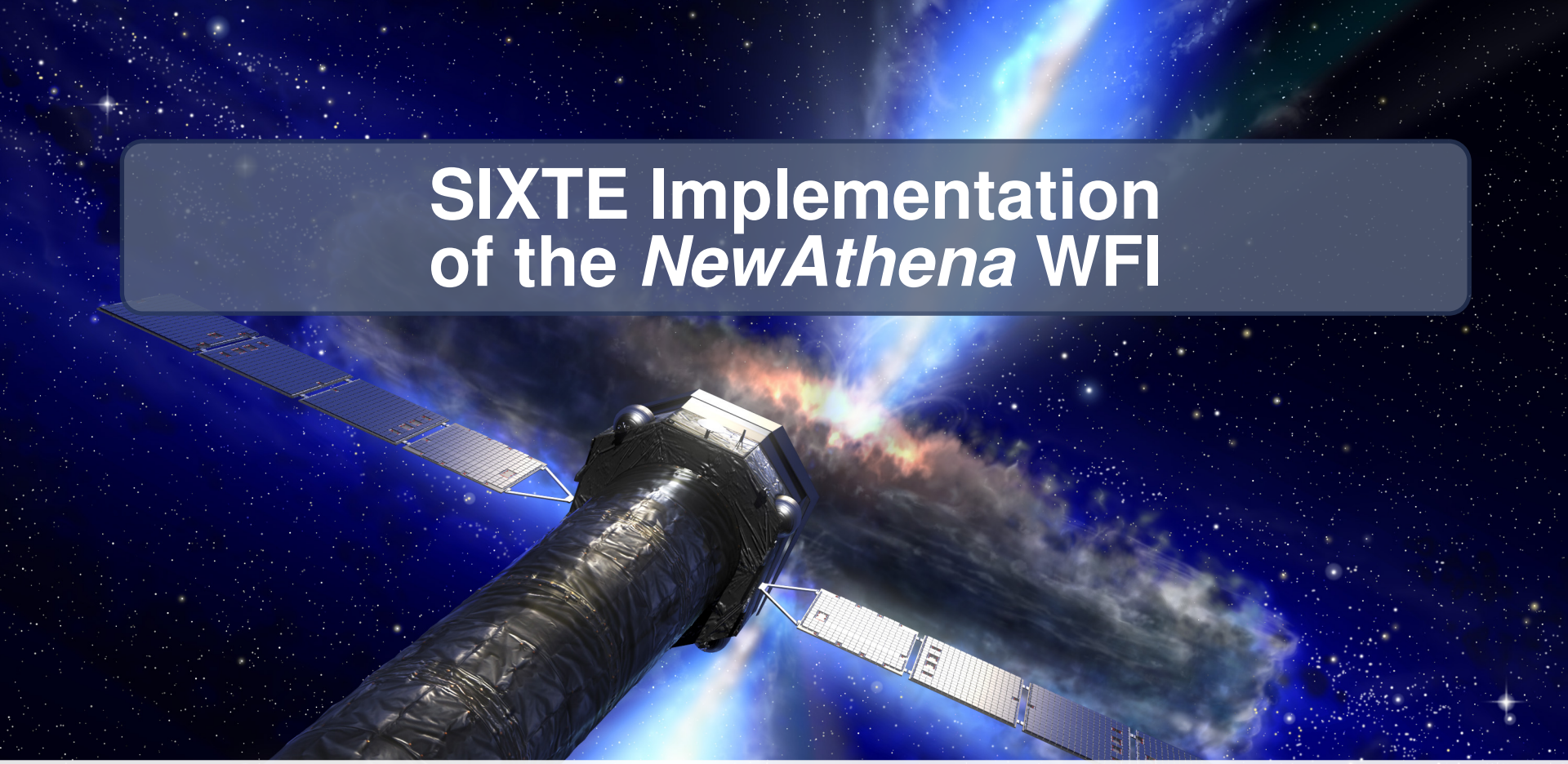
SIXTE Implementation of the *NewAthena* WFI



Maximilian Lorenz

Remeis Observatory & ECAP
on behalf of the SIXTE team

SIXTE Workshop 2024

FRIEDRICH-ALEXANDER
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ERLANGEN-NÜRNBERG

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

WFI
ATHENA

IFU
ATHENA X-ray Integral Field Unit

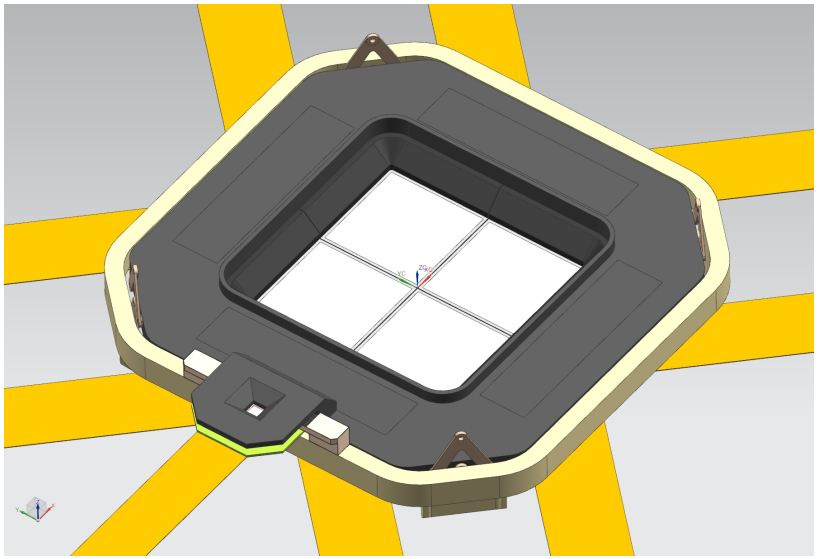
The *NewAthena* X-ray Observatory

- To be **launched to L1 in 2037** as the second ESA L-class mission.
- Science theme: **The Hot and Energetic Universe**
- **12 m focal length**, mirror based on **Silicon Pore Optics** technology.
- **Two instruments**:
  - Wide Field Imager (WFI)
  - X-ray Integral Field Unit (X-IFU)

The *NewAthena* Instruments

WFI (Imager)

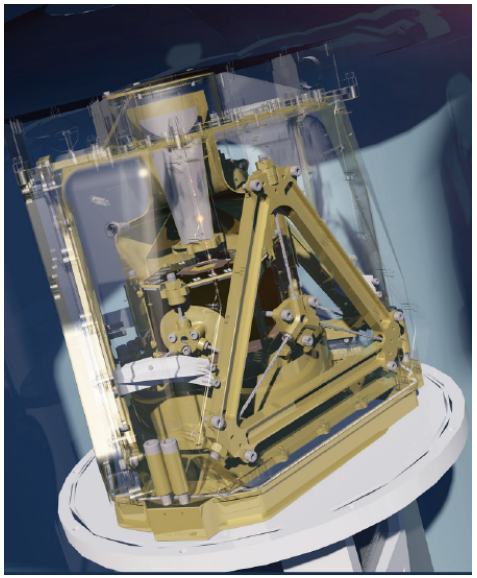
- For **imaging and spectroscopy over large field of view** ($40' \times 40'$ FoV, 160 eV @ 7 keV)
- High count-rate capabilities



Credit: MPE

X-IFU (Calorimeter)

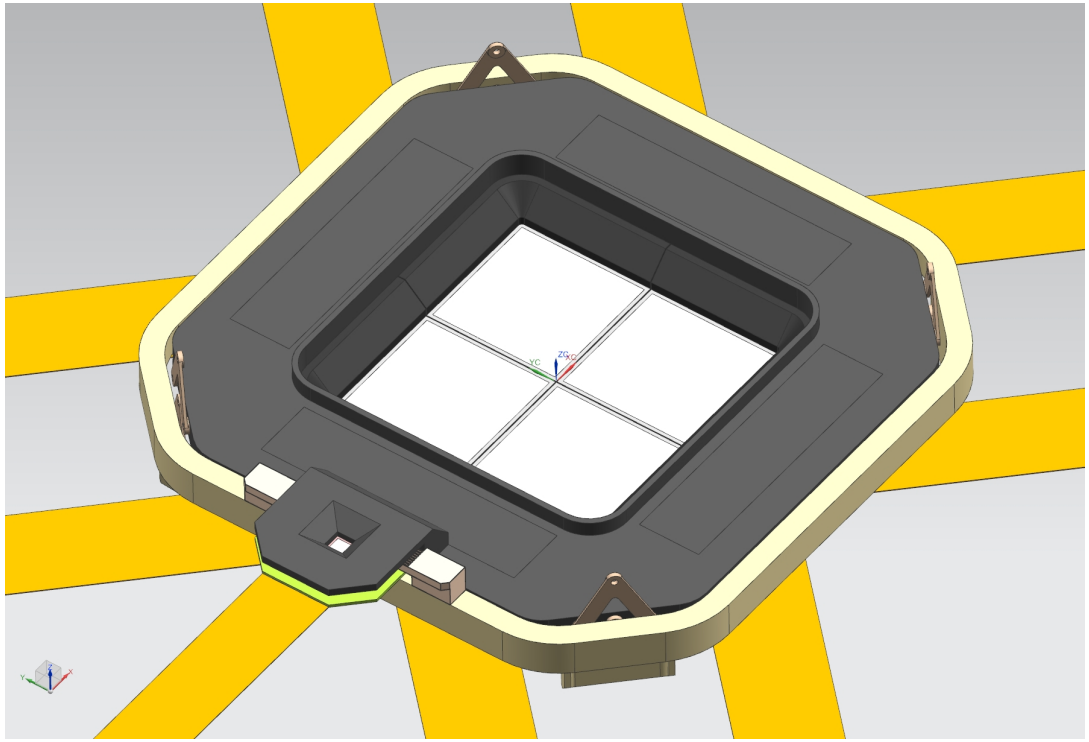
- For **high spectral resolution imaging** ($4'$ FoV, 4 eV up to 7 keV)
- Calorimeter operating at 50 mK



Credit: X-IFU Consortium

The Wide Field Imager (WFI)

Large Detector Array (LDA) and **Fast Detector** (FD, 35 mm defocused)

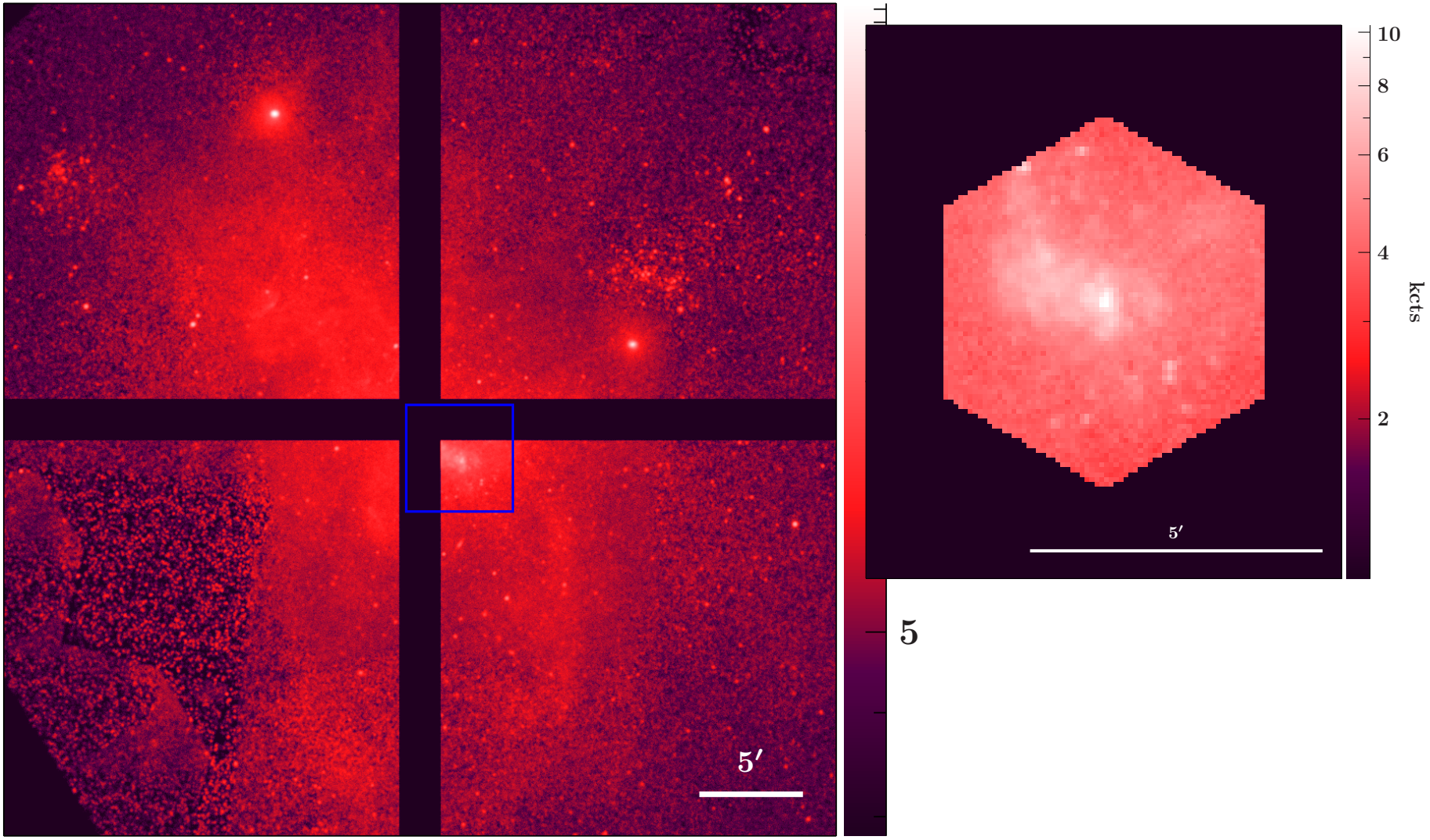


Credit: MPE

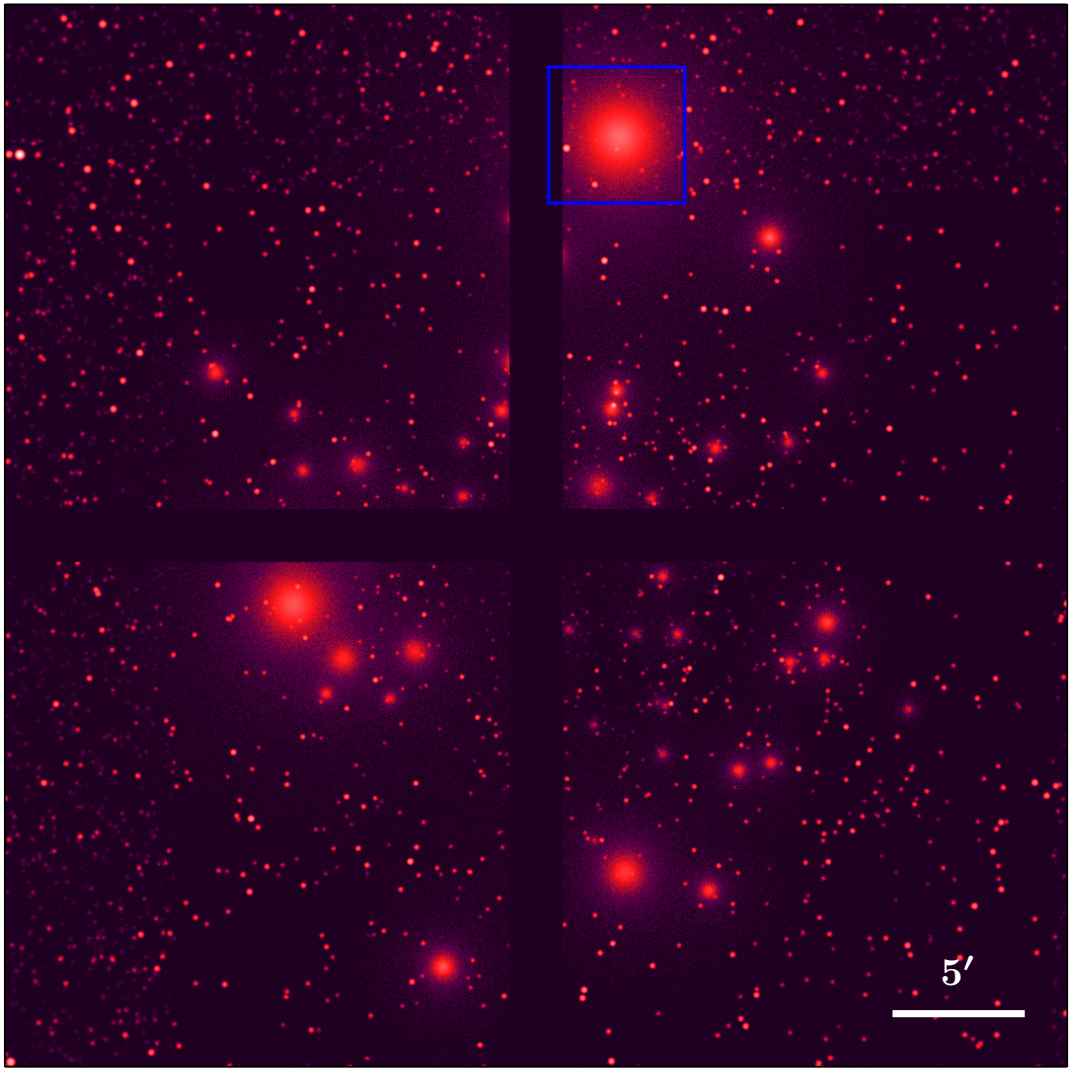
- DePFET active pixel technology (similar to CCD with line-by-line readout)
- Energy resolution: $\leq$ 160 eV @ 7 keV
- Large FOV: $40' \times 40'$
- High count-rate capabilities (10 Crab)

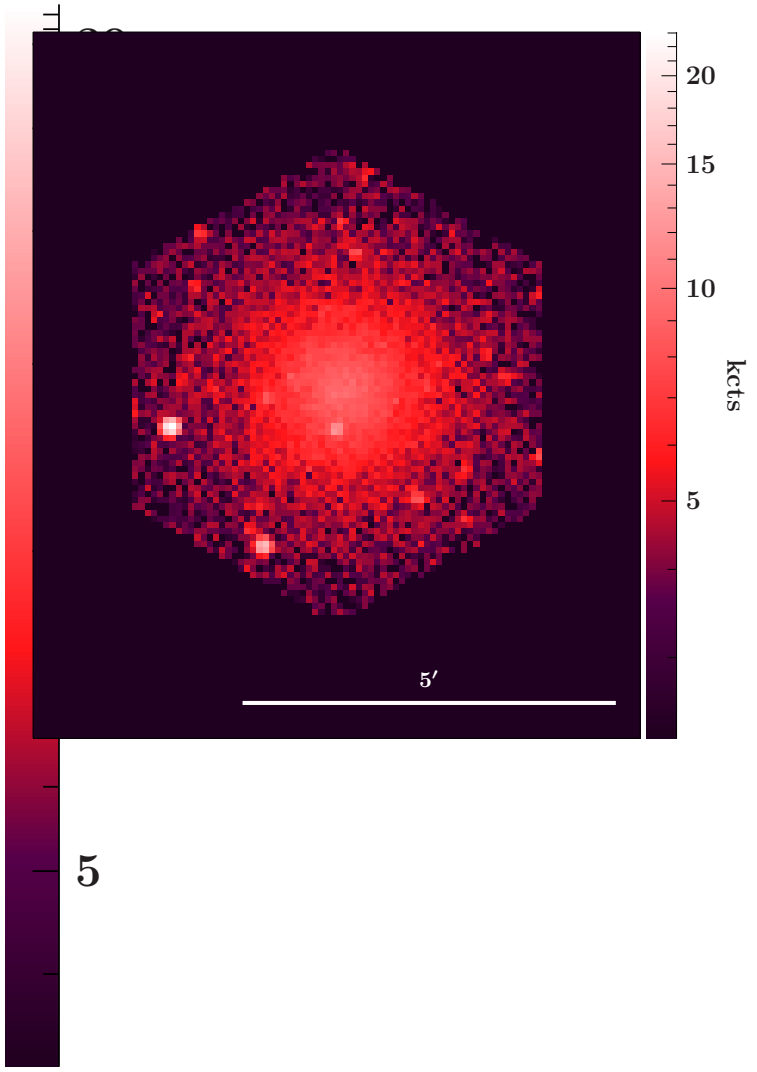
Meidinger et al. (2020)

Example: Galactic Center with *NewAthena*



Example: Chandra Deep Field South with *NewAathena*





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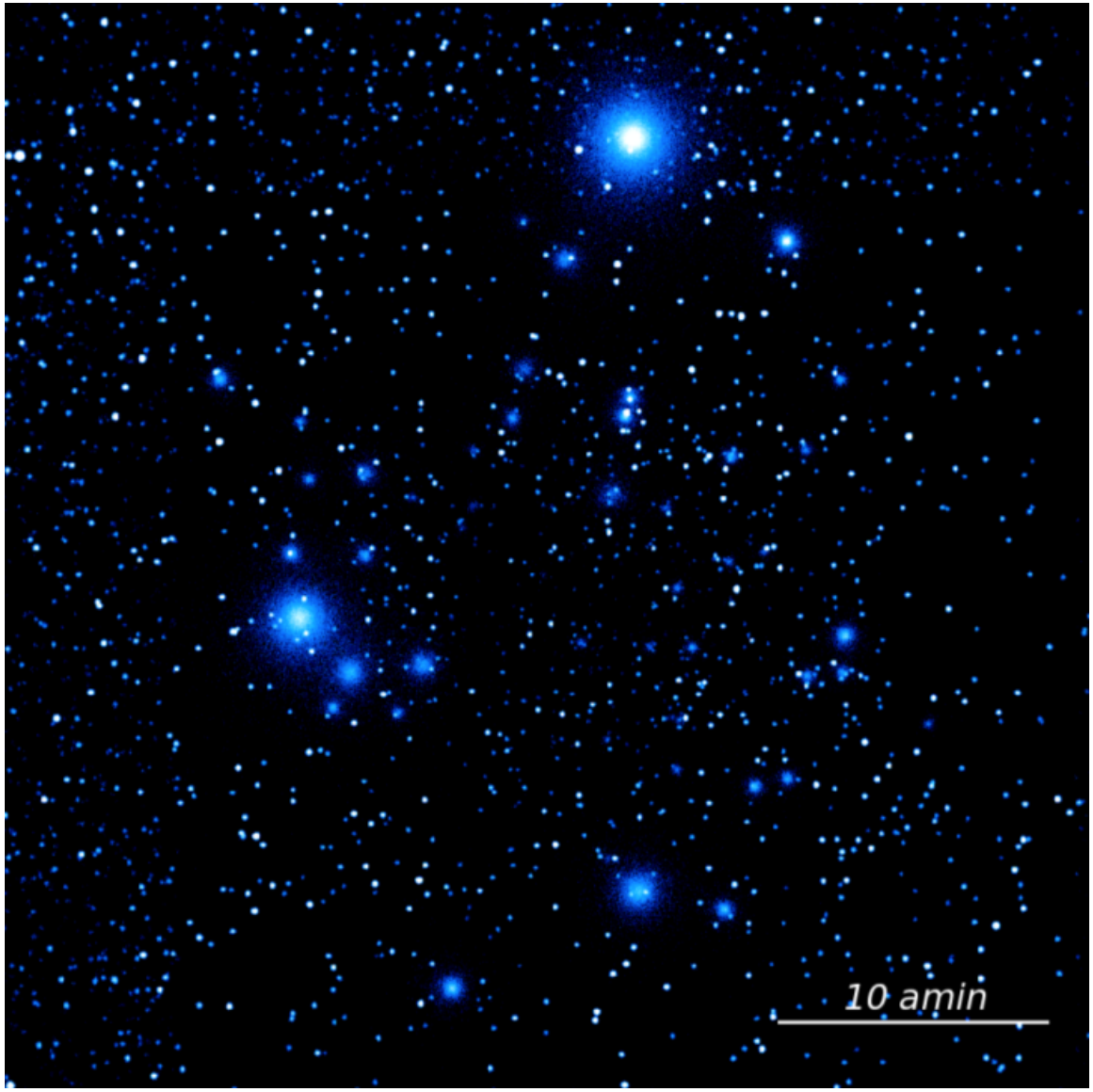
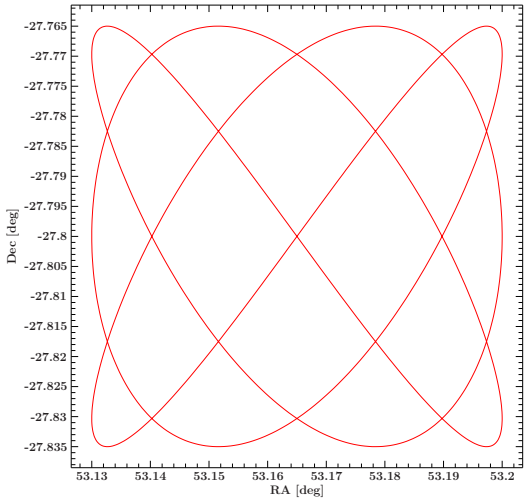
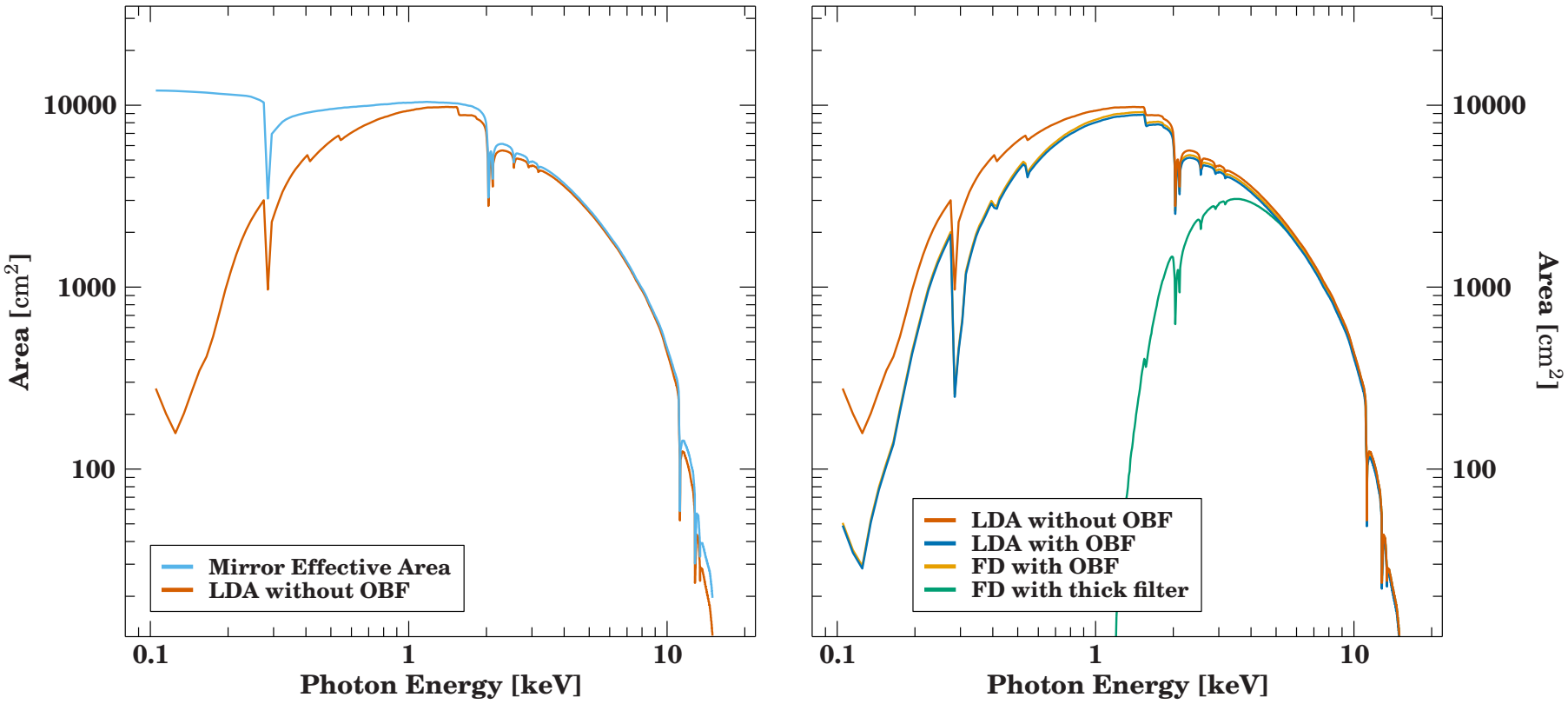




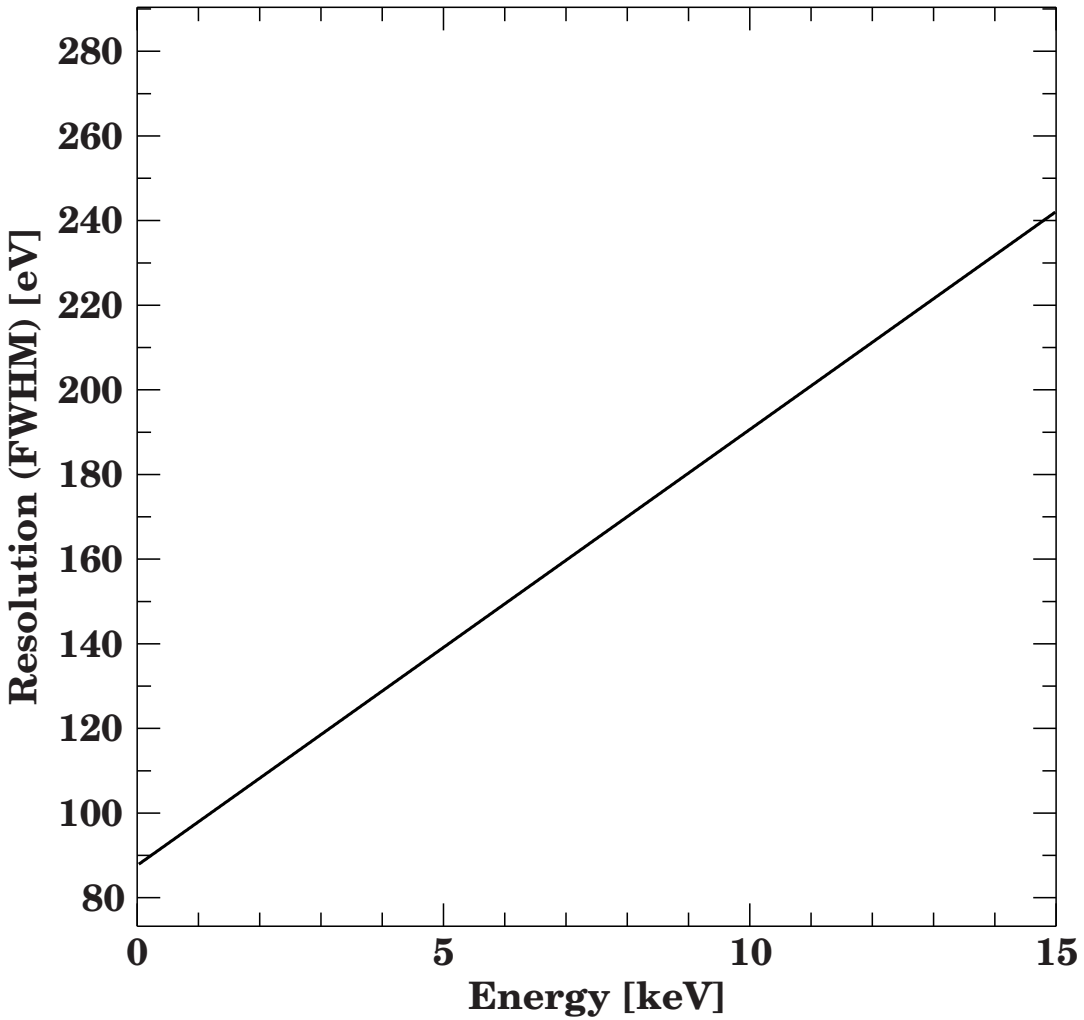
Dithering efficiently removes gaps between the chips.

WFI Mirror Area and Ancillary Response File (ARF)



Thick filter $\Rightarrow$ removes photons below 2 keV

WFI Redistribution Matrix File (RMF)

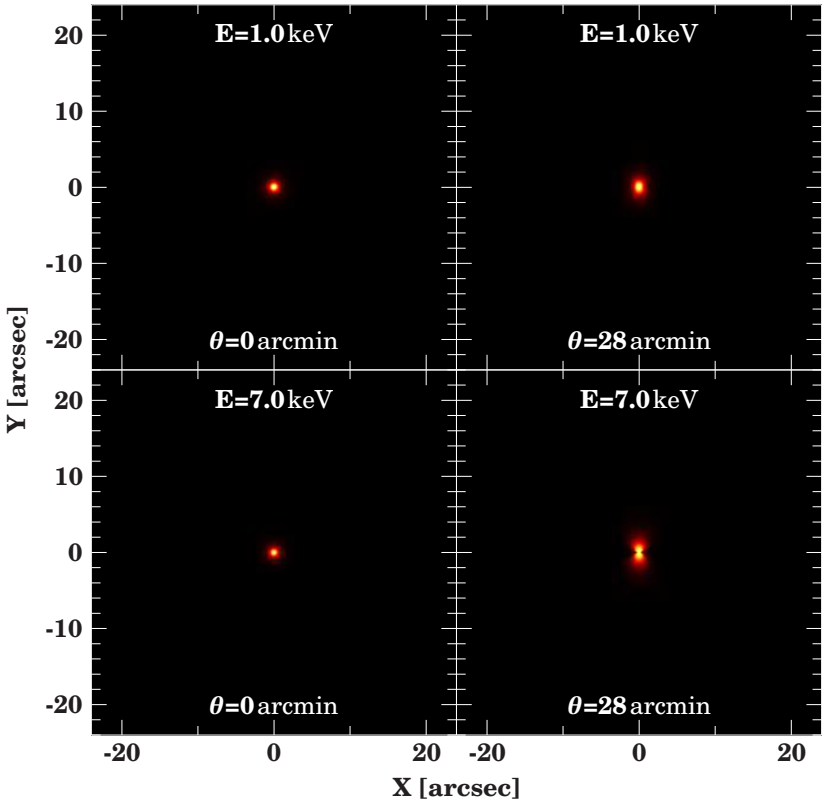


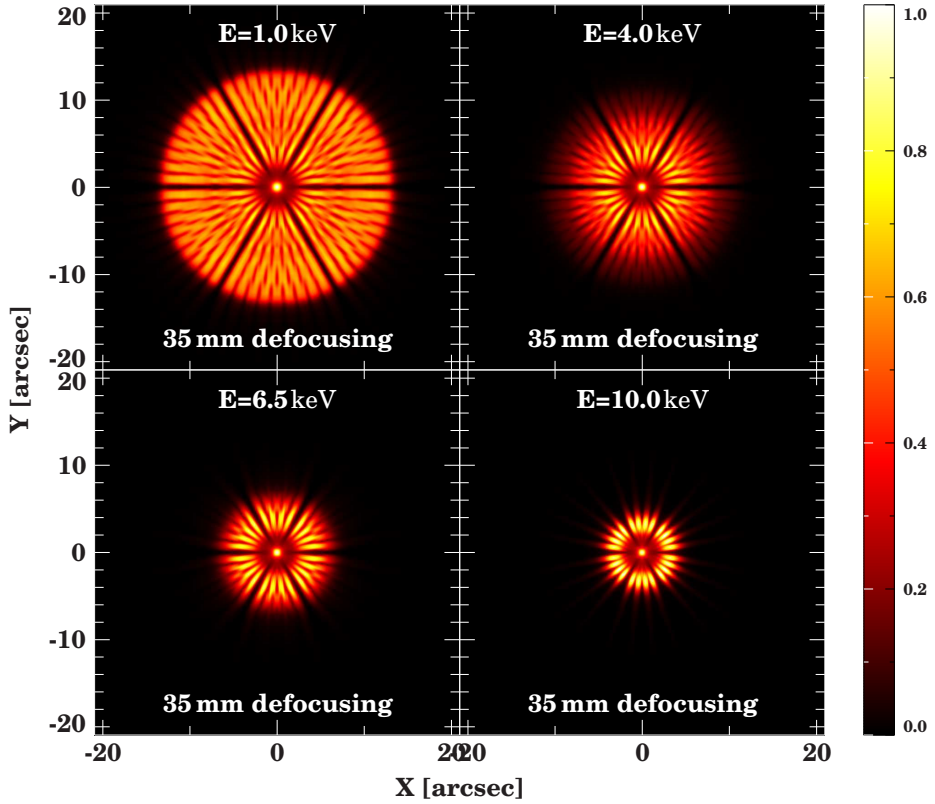
RMF composed of Gaussian with a width fit to lab measurements.

WFI Point Spread Function (PSF)

PSF at different energies and off-axis angles

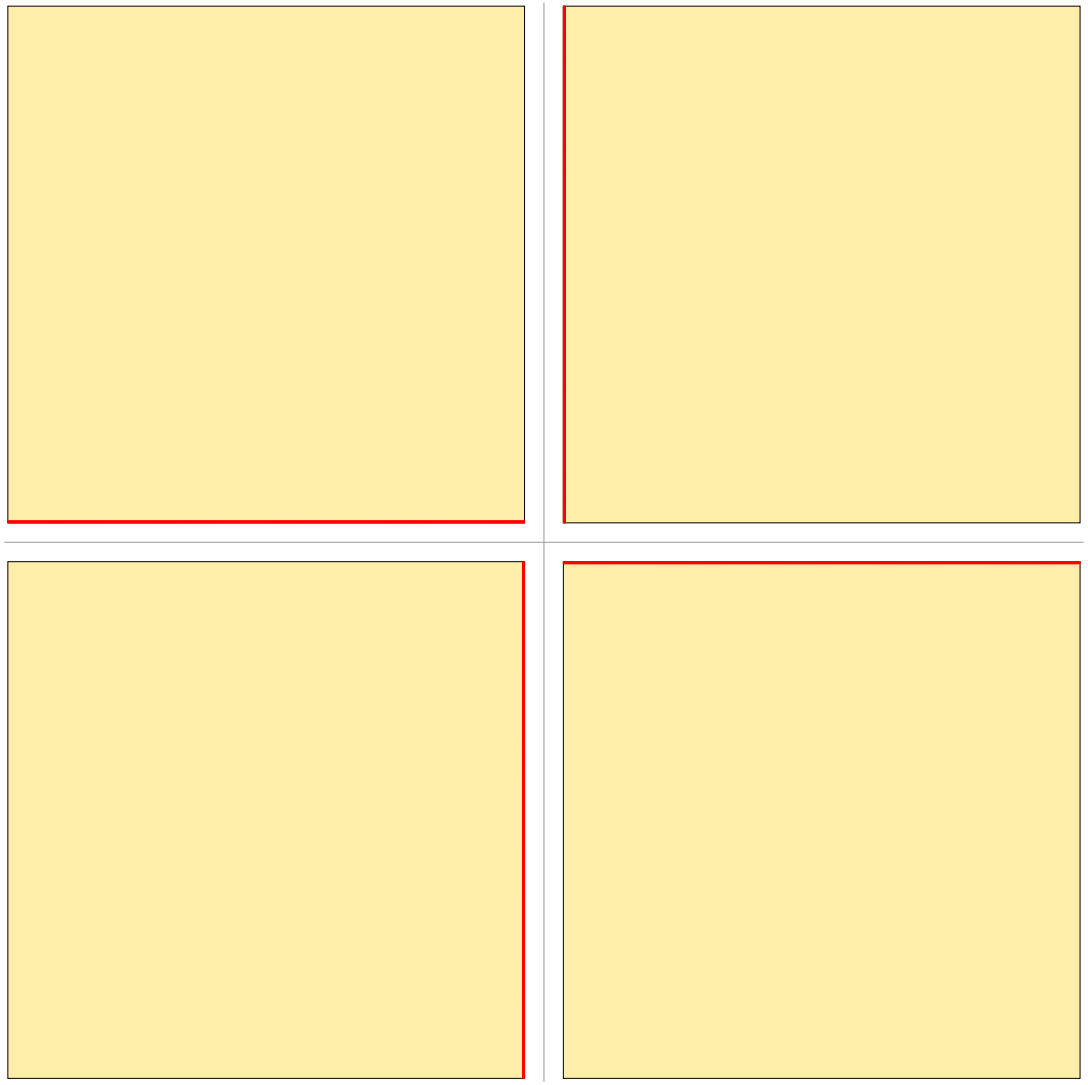
Defocused PSF (35 mm)





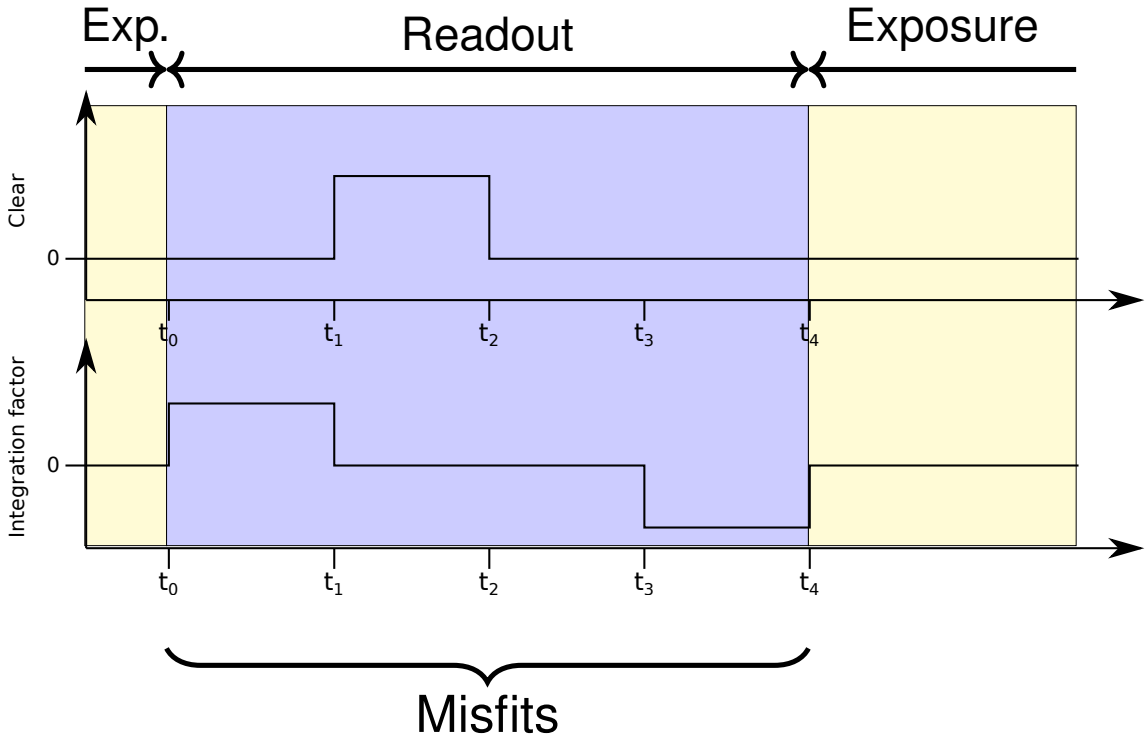
⇒ Defocusing distributes photons over larger area

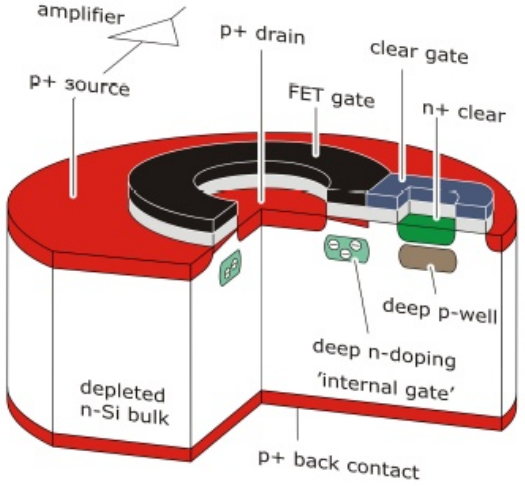
LDA Chip Geometry



- Aim point at LDA center.
- 5 mm gap between chips.

WFI DePFET read-out implementation in SIXTE





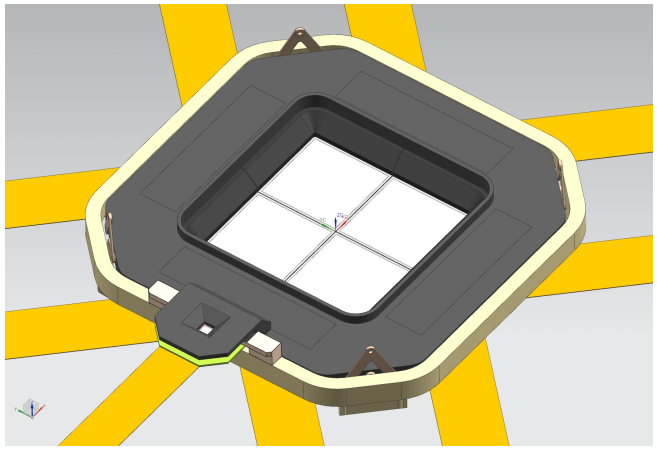
If photon hits during the read-out: measured charge is affected
$\Rightarrow$ Wrong energy (“Misfit”)

this is most relevant for window modes or the fast detector

Different modes of the WFI (in SIXTE)

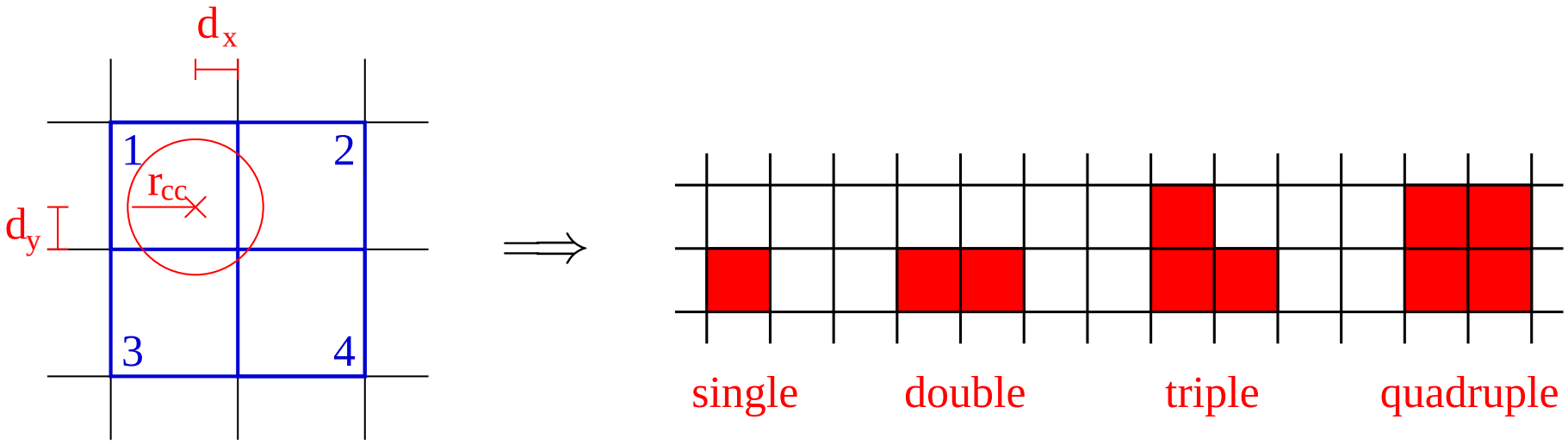
Name	Filename	Size (rows × columns)	Time Resolution	Defocusing	Filter
full	ld_wfi_ff_all_chips.xml	$(4\times)\,512 \times 512$	5018 μs	—	wo/w
single	ld_wfi_ff_chip[0,1,2,3].xml	512×512	5018 μs	—	wo/w
large	ld_wfi_ff_large.xml	512×512	5018 μs	—	wo/w
w128	ld_wfi_w128.xml	128×512	1254 μs	—	wo/w
w256	ld_wfi_w256.xml	256×512	2509 μs	—	wo/w
fast	fd_wfi_df35mm.xml	64×64	80 μs	35 mm	w
fastThickFilter	fd_wfi_df35mm_thick_filter.xml	64×64	80 μs	35 mm	w

- Large Detector Array configurations available w/wo optical blocking filter.
- Fast Detector defocused by default.
- Option for a thick filter.



Example: CCD Effects – Patterns and Pileup

SIXTE includes charge cloud model, event patterns, and pileup.



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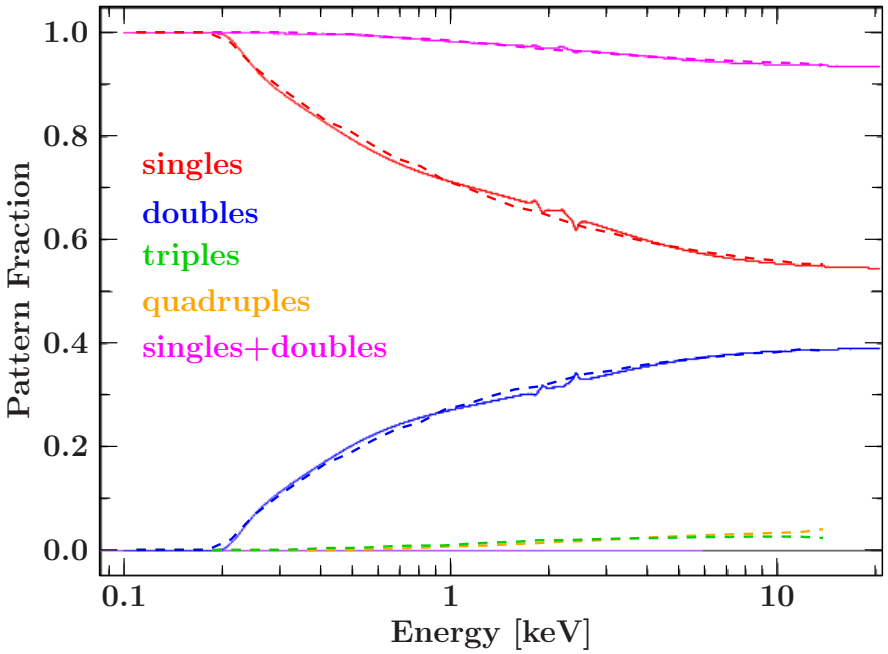
Pattern fractions *XMM Newton*



⇒ Simulated distribution matches very well

Dauser et al. (2019)

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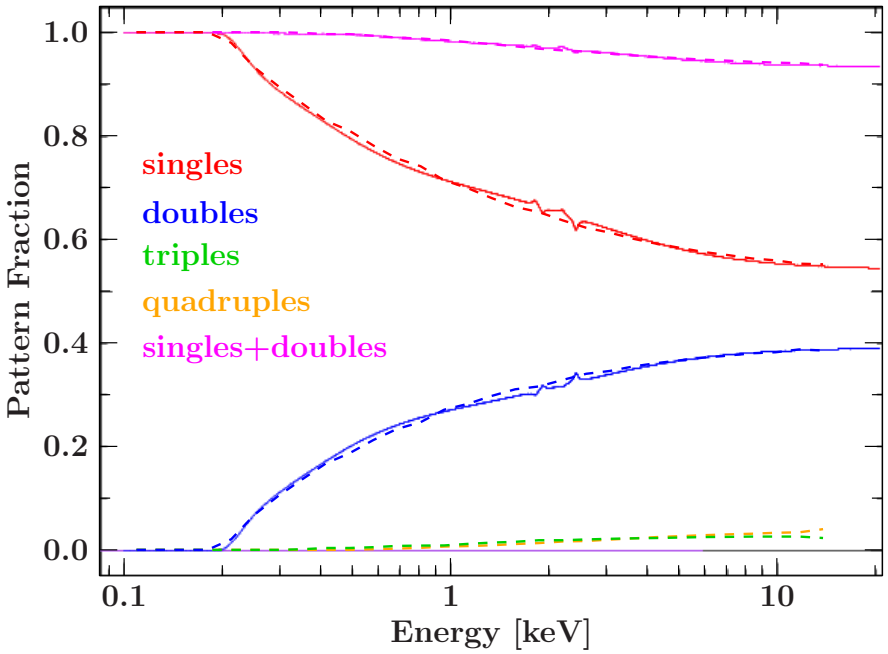
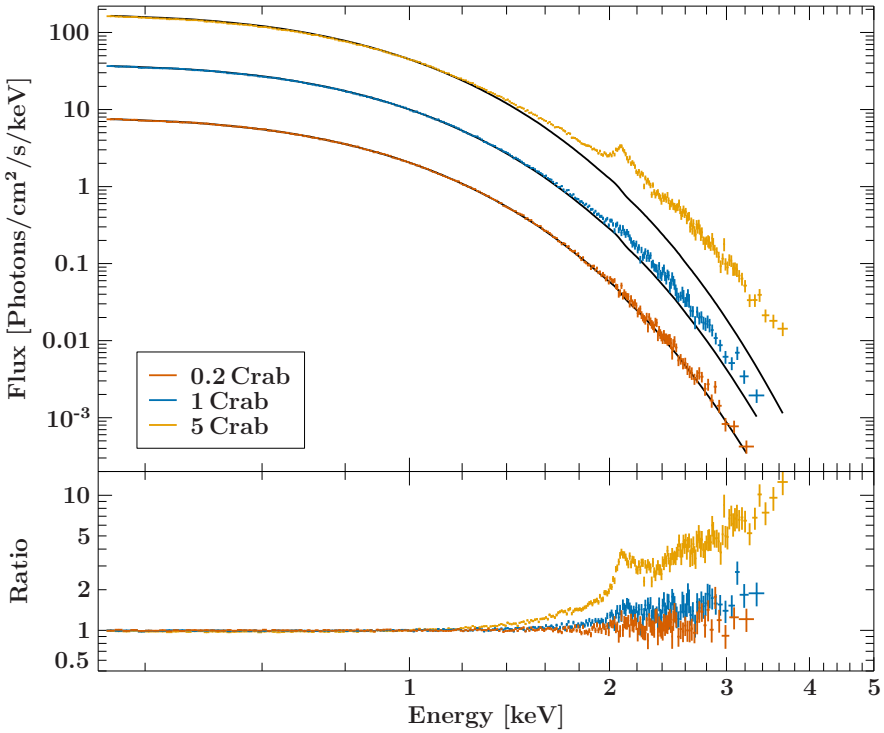


Pileup *NewAthena* WFI



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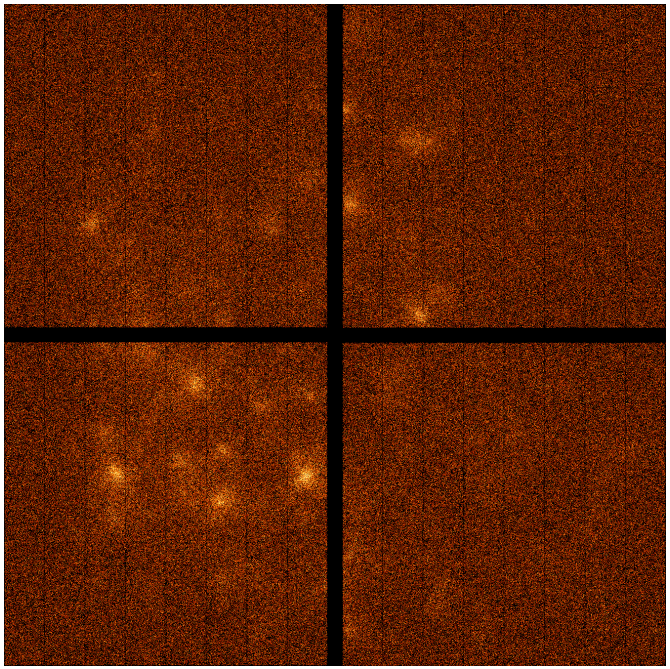
Example: Chandra Deep Field South with XRISM Xtend

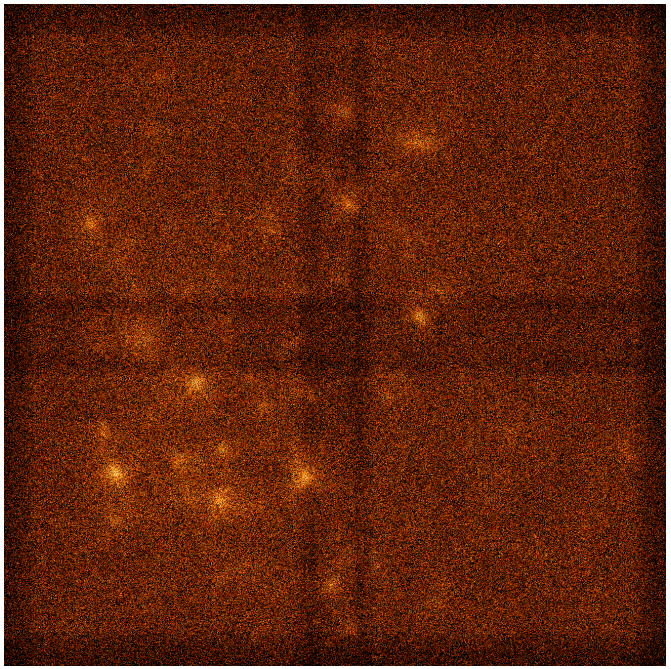
XRISM

- JAXA/NASA X-ray observatory, launched in 2023
- Two instruments: Xtend & Resolve

$\Rightarrow$ Use same SIMPUT, just switch the instrument files!



Without dithering



With dithering

Summary: The WFI with SIXTE

- **DePFET** technology: active pixels, no line shifts $\rightarrow$ **misfits** if pixel is hit during read-out
- Observations possible up to a few Crab, plus a thick filter for even brighter sources.
- Large 40' FoV made of 4 chips $\rightarrow$ requires **dithering**
- Simulations possible for the full 4 chip LDA, or only a single chip (LD, or the 35 mm defocused FD).

References

- N. Meidinger, et al., "Development status of the wide field imager instrument for Athena," Proc. SPIE 11444, Space Telescopes and Instrumentation 2020: Ultraviolet to Gamma Ray, 114440T (13 December 2020); https://doi.org/10.1117/12.2560507