WFI

ATHENA

The Wide Field Imager

Arne Rau (MPE)

Exploring the Hot and Energetic Universe: The 2nd scientific conference dedicated to the Athena X-ray observatory, Palermo, Sep 24-27, 2018

CONSORTIUM

AT CH DE DK FR GB GR IT PL PT US

WFI ATHENA

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

UNIVERSITÀ DEGLI STUDI DI PALERMO

The Open University

DE LA RECHERCHE À L'INDUSTRIE cea

DTU Technical University of Denmark

UNIVERSITÉ DE GENÈVE

MPE Max-Planck-Institut für extraterrestrische Physik

Observatoire astronomique de Strasbourg

ia instituto de astrofísica e ciências do espaço

Smithsonian

CBK PAN

universität wien

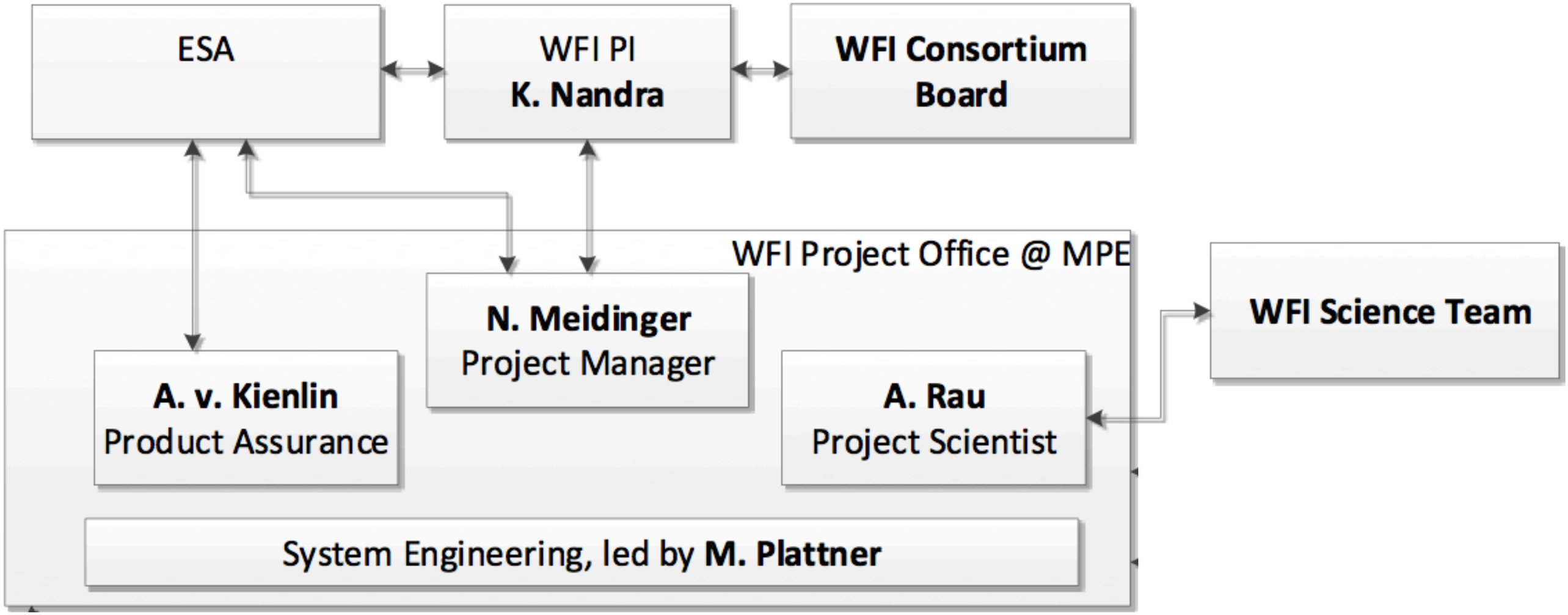
IWF

SLAC NATIONAL ACCELERATOR LABORATORY

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

University of Leicester

Massachusetts Institute of Technology

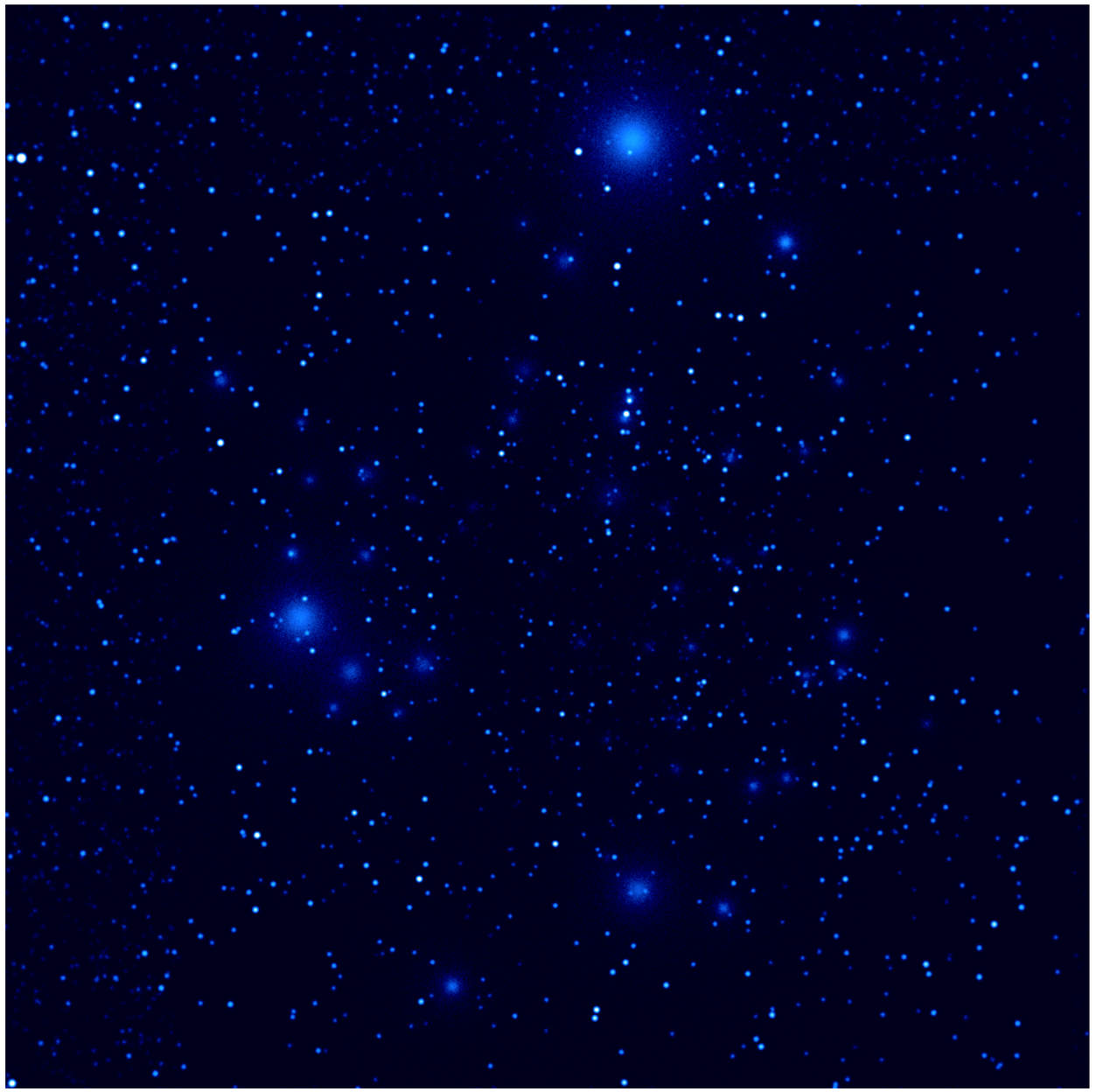


Science Team:

A. Rau (chair), J. Afonso, J. Aird, A. Comastri, D. Della Monica Ferreira, D. Eckert, A. Fabian, A. Georgakakis, M. Güdel, A. Hornschemeier, A. Merloni, S. Paltani, G. Pratt, J. Sanders, T. Reiprich, A. Rozanska, M. Sasaki, J. Wilms

Key Science Drivers

The Energetic Universe



Formation and growth of earliest SMBHs

Understanding the build-up of SMBHs

Close environments of SMBHs

The physics of accretion

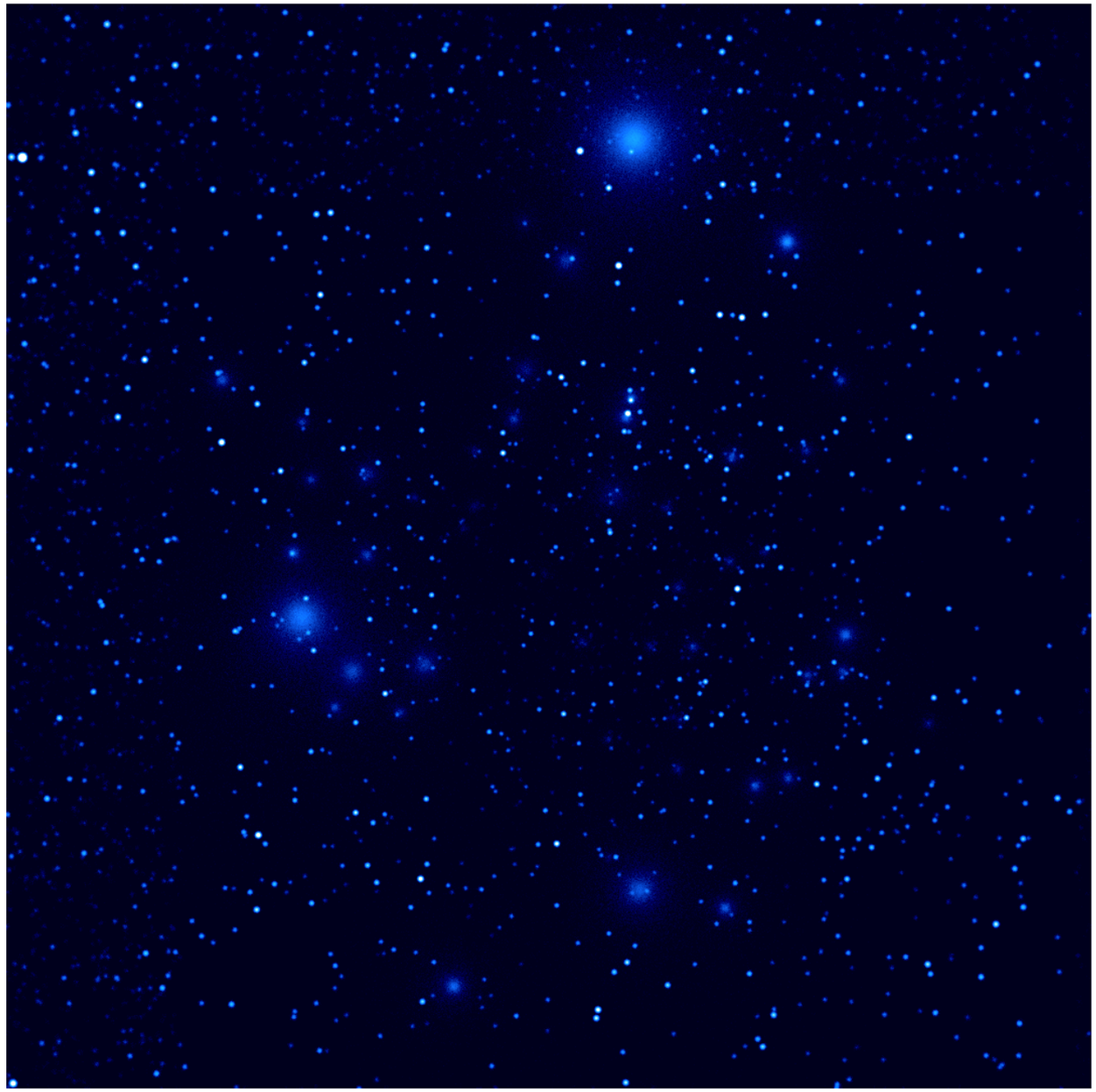
Luminous extragalactic transients

The Hot Universe

The evolution of galaxy groups and clusters

The astrophysics of galaxy groups and clusters

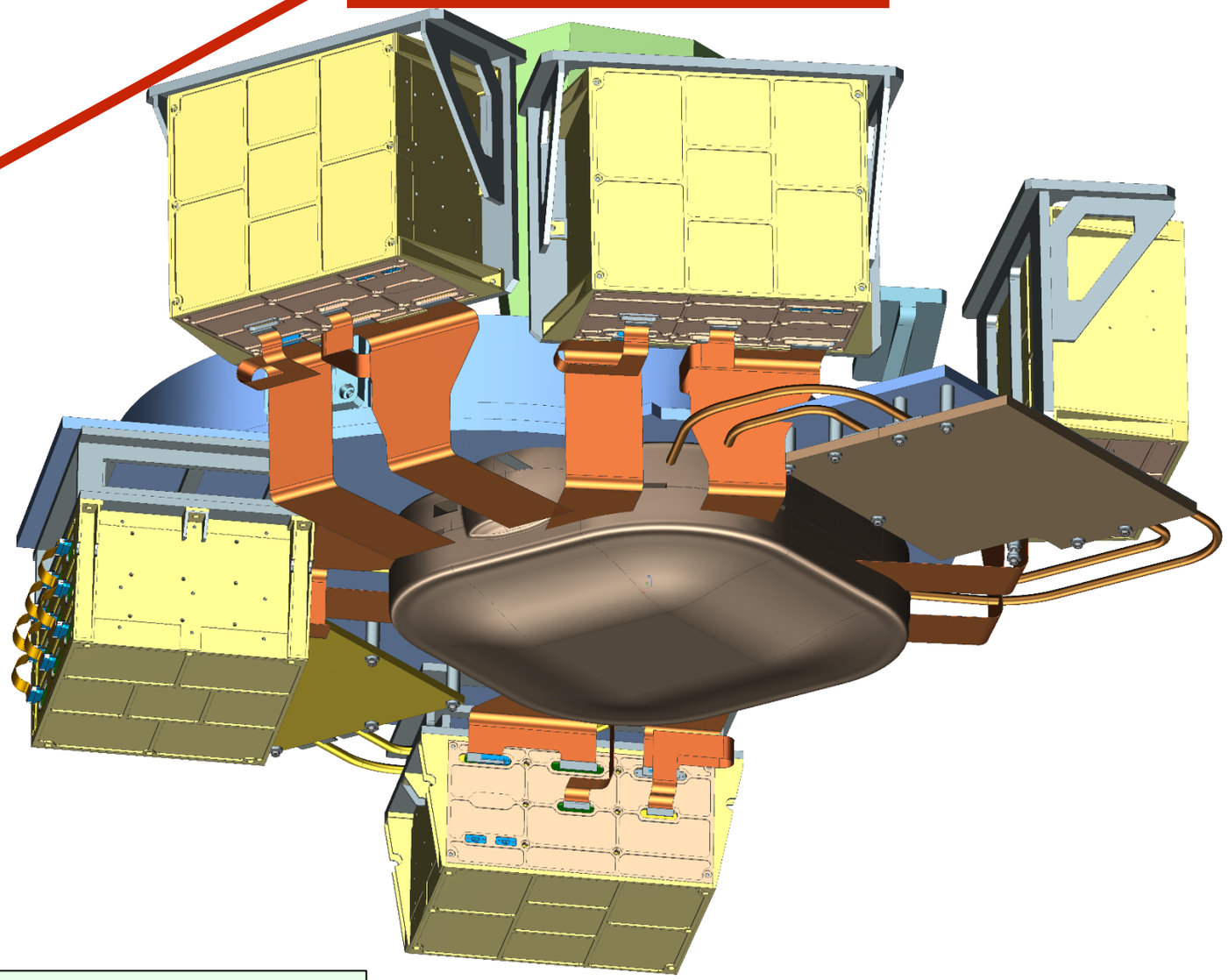
AGN feedback in galaxy groups and clusters



Parameter	Requirement			
Energy Range	0.2-15keV			
Point Source Sensitivity (0.5-2keV)	≤2.4 x 10^{-17} erg/cm^2/s (450ks)			
Surface Brightness Sensitivity (5-7keV)	≤6.2 x 10^{-16} erg/cm^2/s/arcmin^2 (100ks; 5' circle)			
	0.2keV	**1keV**	**7keV**	**10keV**
Effective Area (on-axis)	≥0.069m^2	≥1.25m^2	≥0.15m^2	≥0.034m^2
Grasp		≥0.268 m^2/deg^2	≥0.014 m^2/deg^2	
Energy Resolution		≤80eV	≤170eV	
Field of View (LDA)	40' x 40'			
PSF Sampling	130µm x 130µm pixels (i.e. 2.24" x 2.24")			
Positional Accuracy	≤1" (99.7% confidence)			
Frame time	LDA: ≤5ms		FD: ≤80µs	
FD Count Rate Capability	1Crab: ≤1% pile-up, ≥80% throughput			
Instrumental Background Level	≤5x10^{-3} cnt/s/cm^2/keV (2-7keV)			
Instrumental Background Knowledge	≤2% (2-7keV)			
Absolute flux calibration uncertainty	≤12%			

Instrument and Technology Development

ATHENA Mirrors



ATHENA
Mirror System

Baffle

Primary Structure

Filter Wheel

Close/Open

Filter/Cal. Sour.

DEPFET
Large Sensor Array
Fast Sensor

Graded-Z Shield

CFE

AFE

Detector Board

Proton

Shield

Camera Head

DEPFET Heatpipe

FEE Heatpipe

Detector Electronics

Frame Processor

Power Conditioner

Instrument Control and Power-distribution Unit

Centra Processing Module

Power Distribution Unit

Analog Interface Board

Science Products Module

S/C com I/F nom

S/C com I/F red

S/C power nom

S/C power red

Spacecraft

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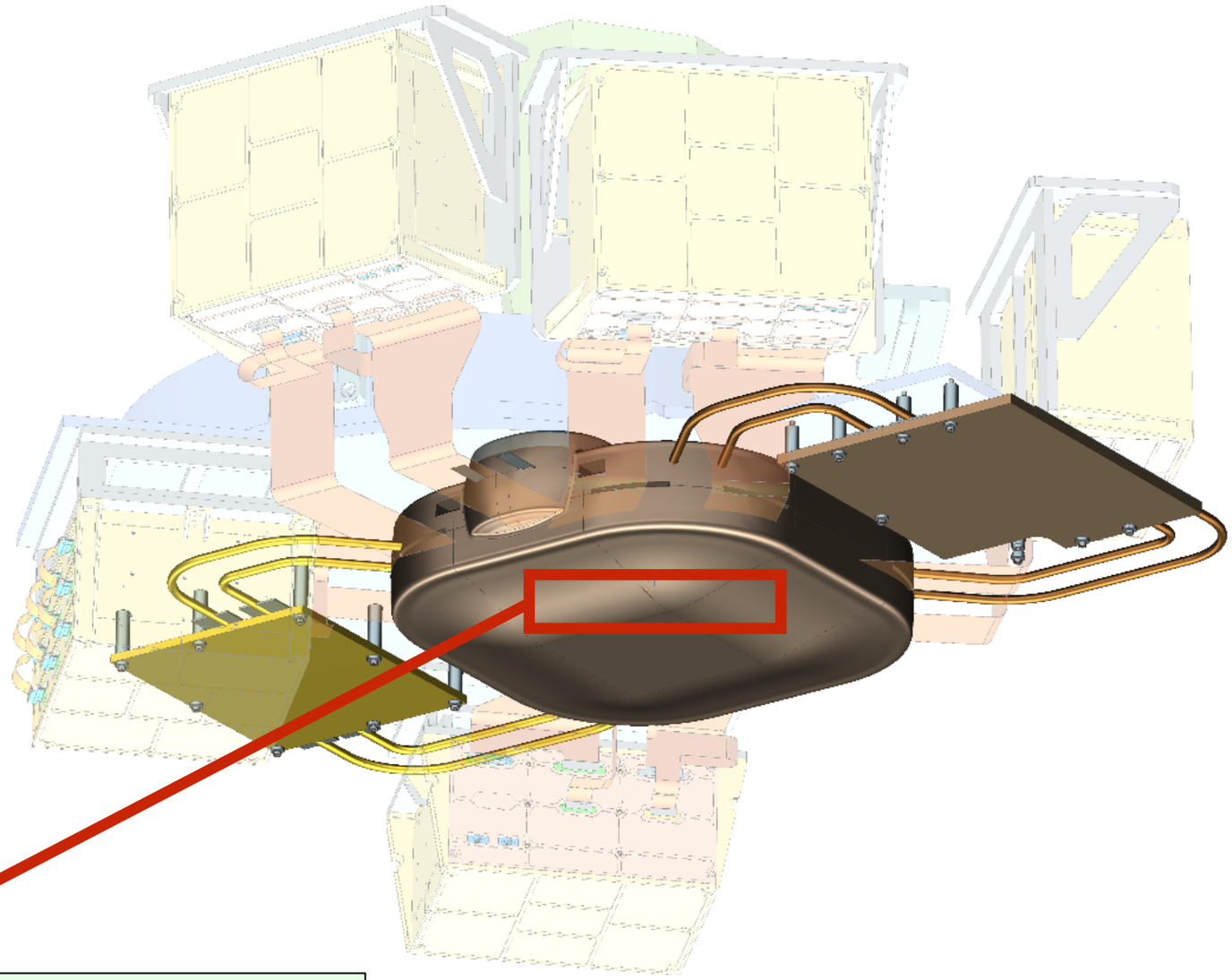

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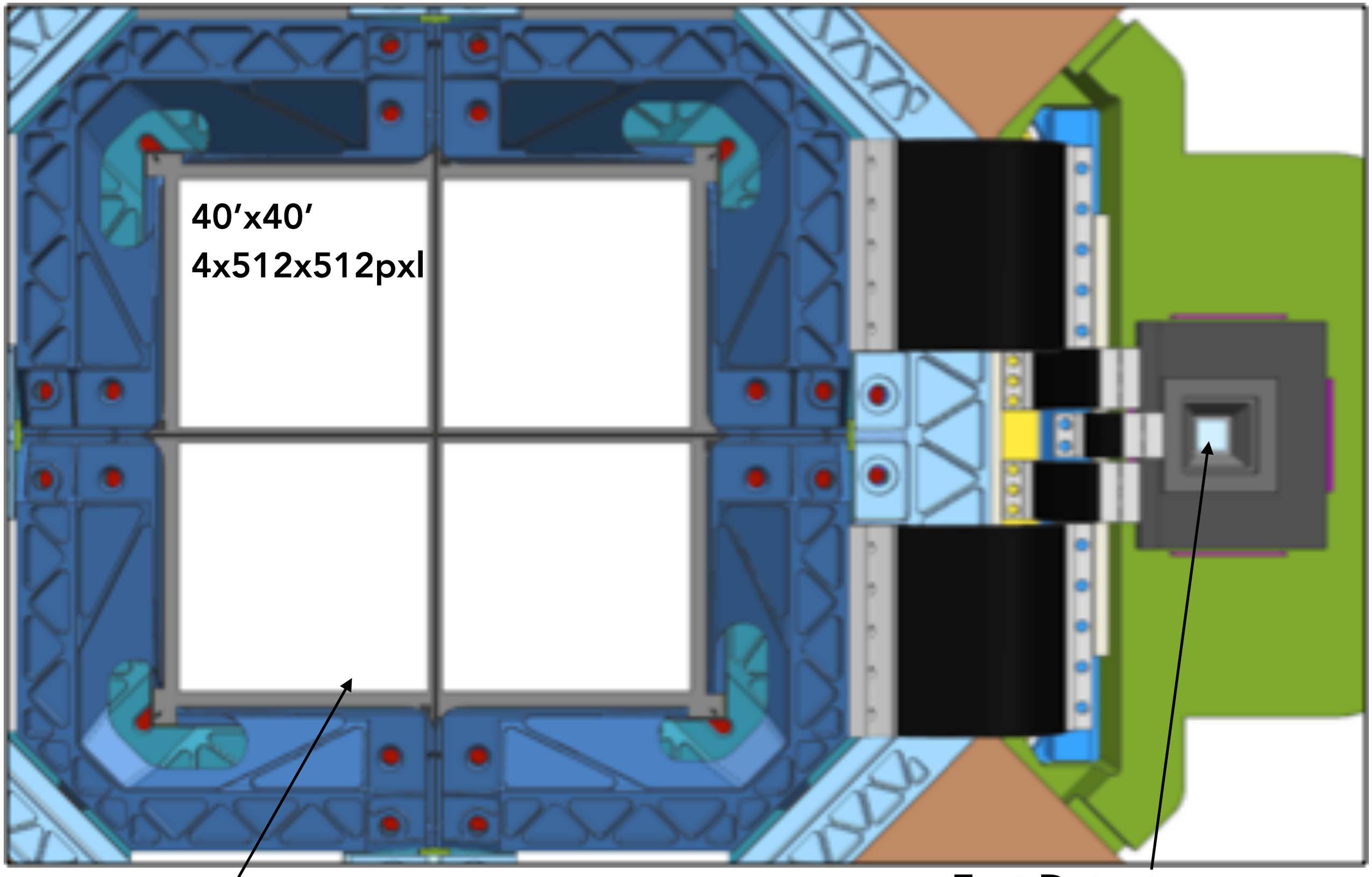
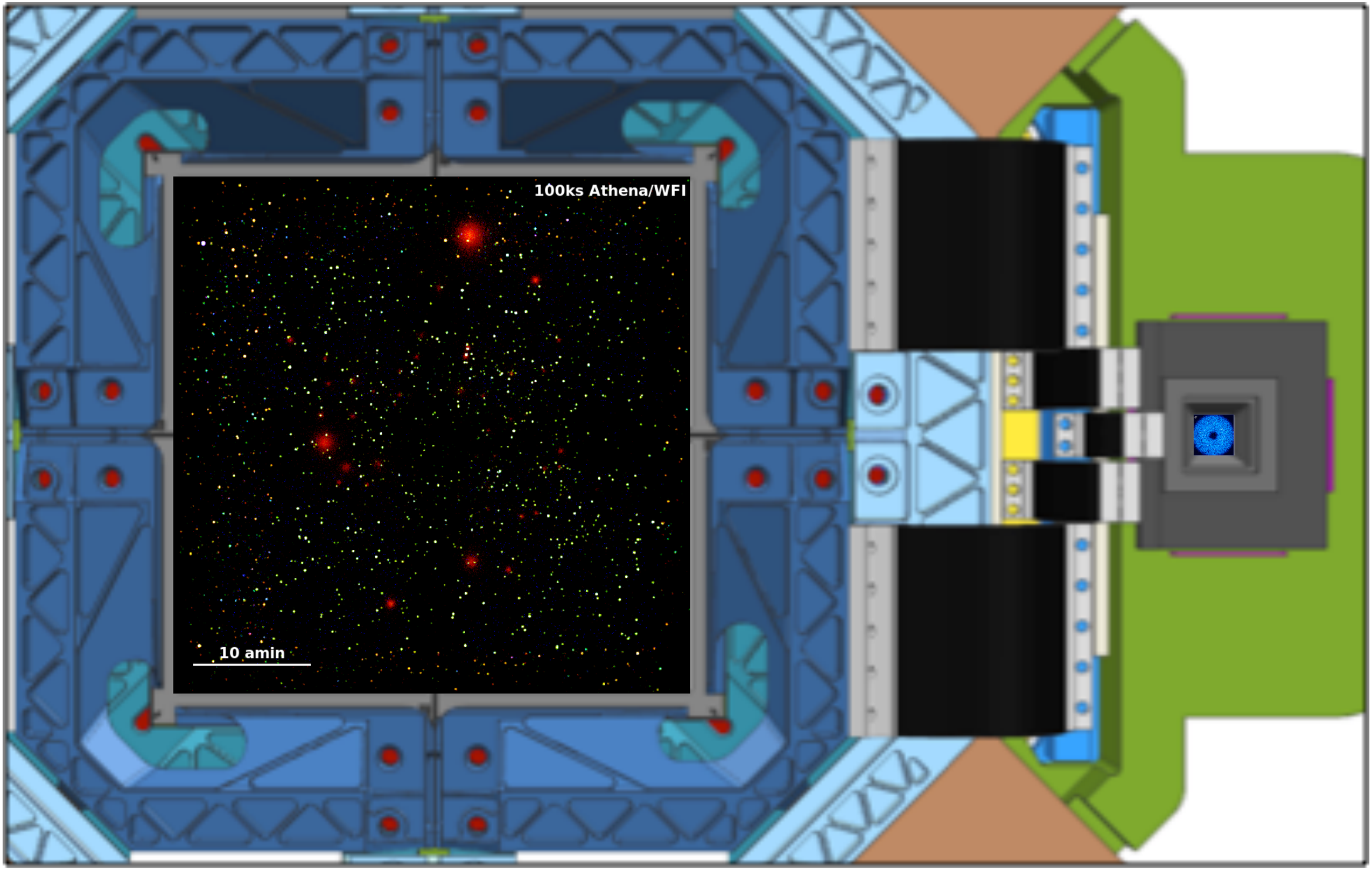


Large Detector Array:
5ms/frame (200fps)

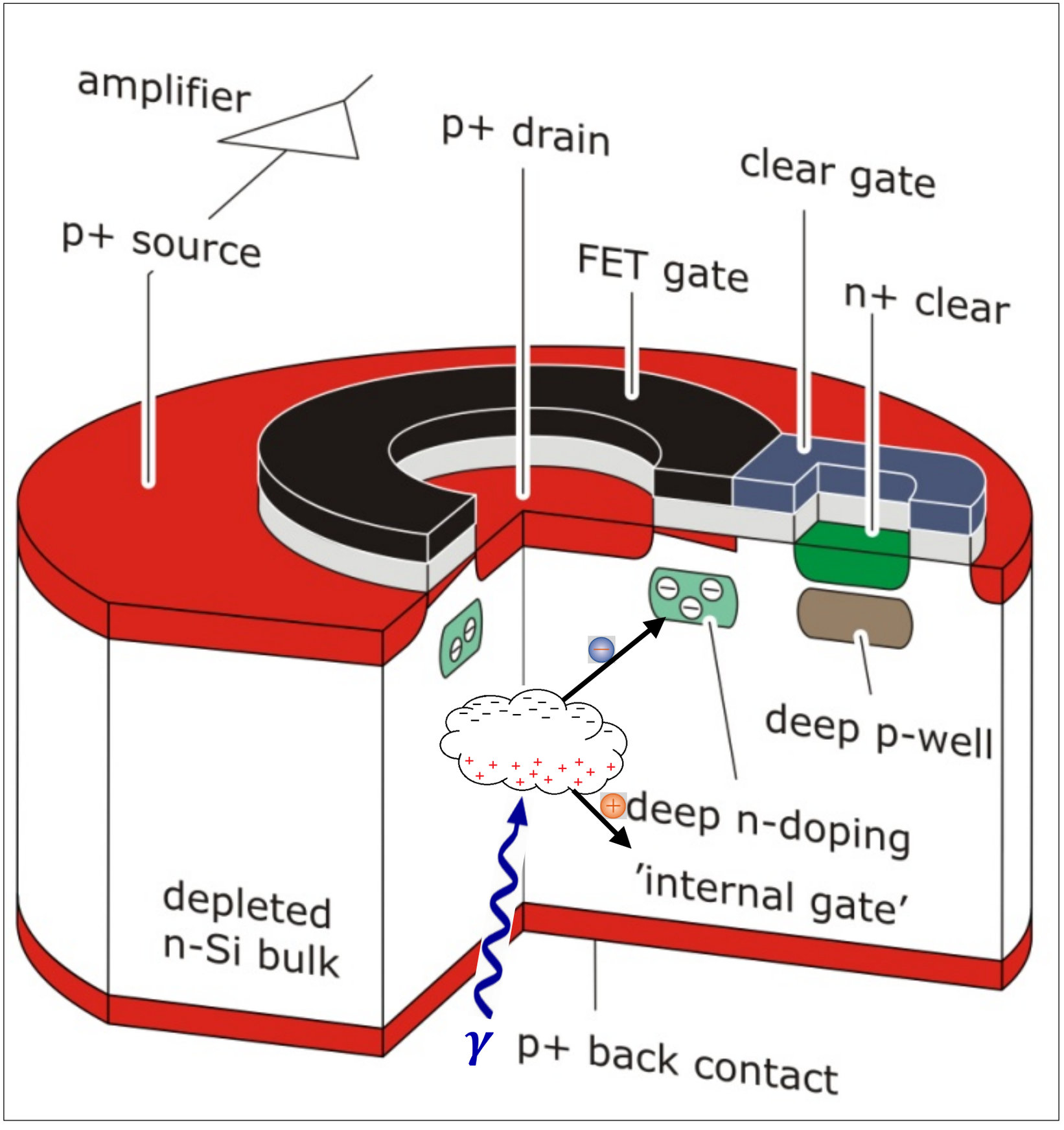
Both:
130µmx130µm DEPFETs

Fast Detector:
80µs/frame (12500fps)
defocussed

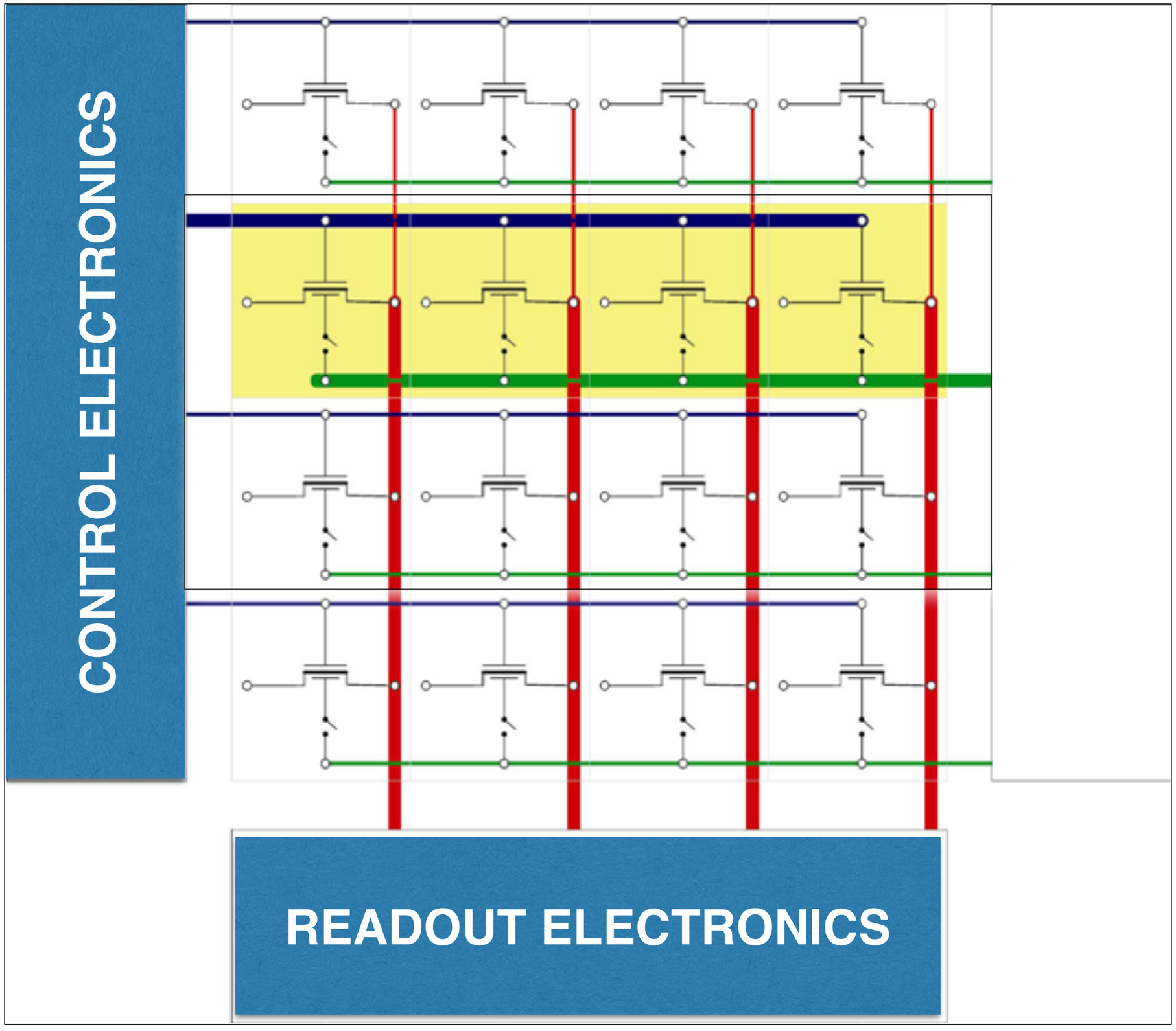


(SIXTE end-to-end simulations)

The WFI uses matrices of DEPFET active pixel sensors.



All pixels in one active row are read out simultaneously.



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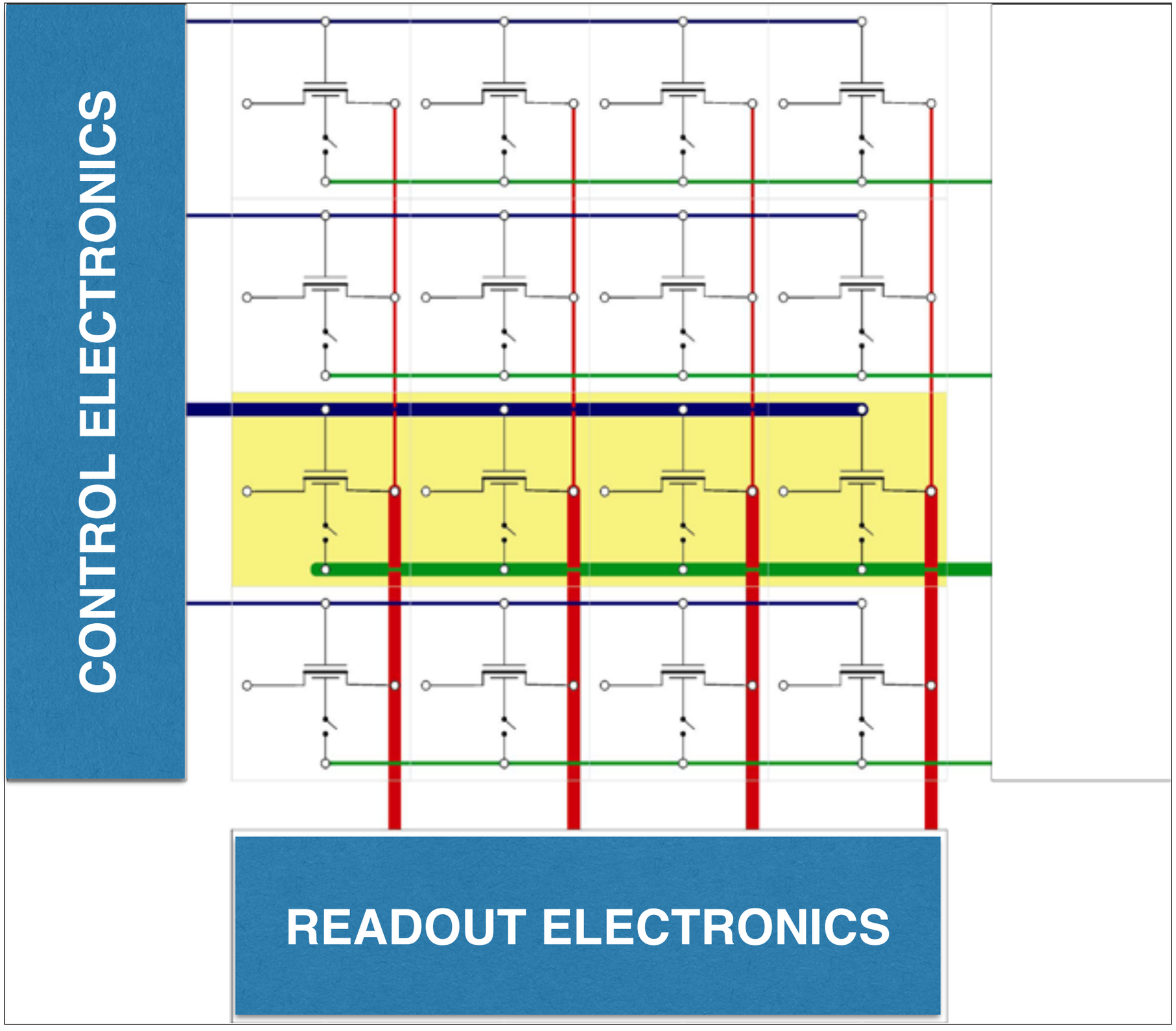

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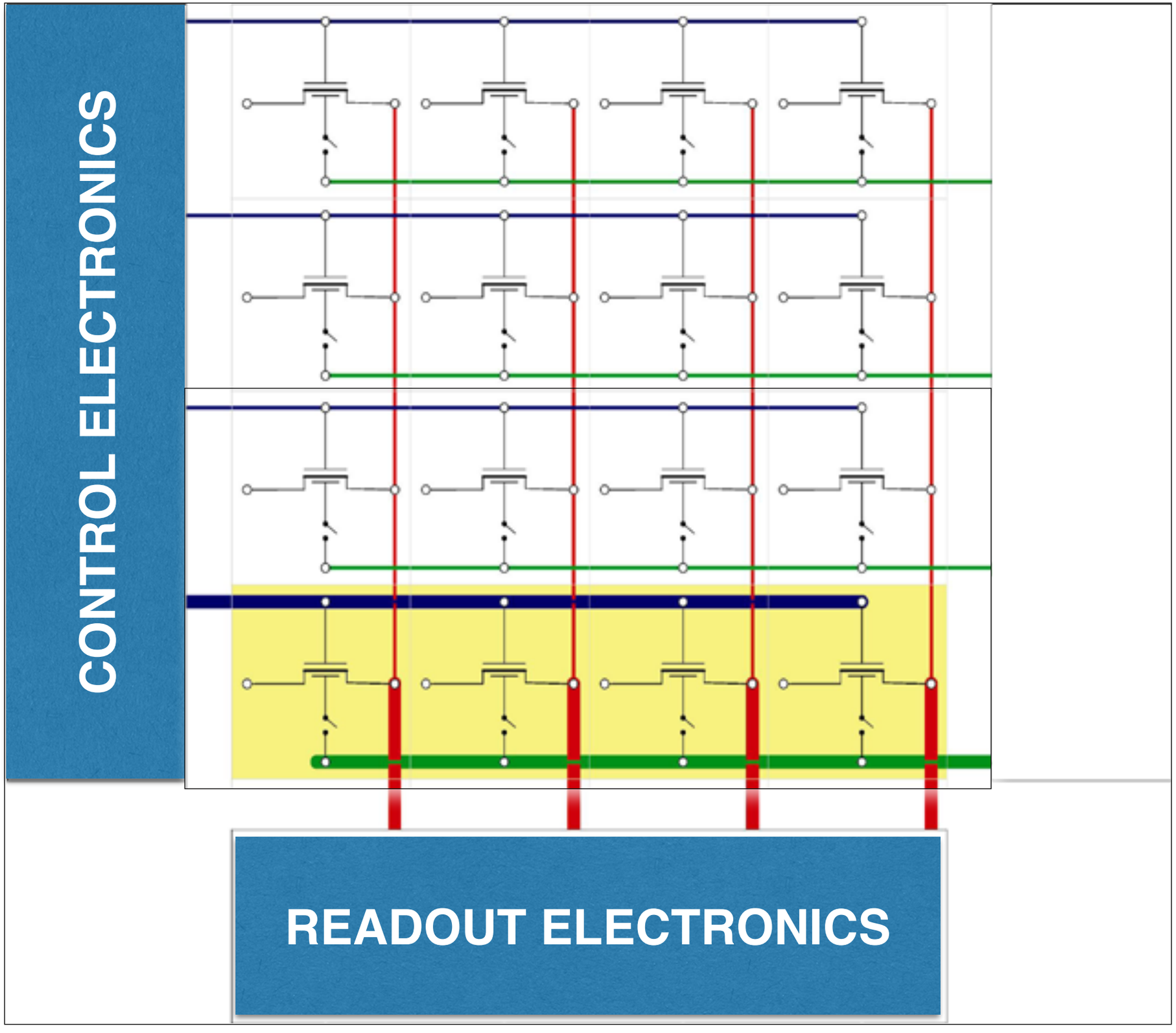
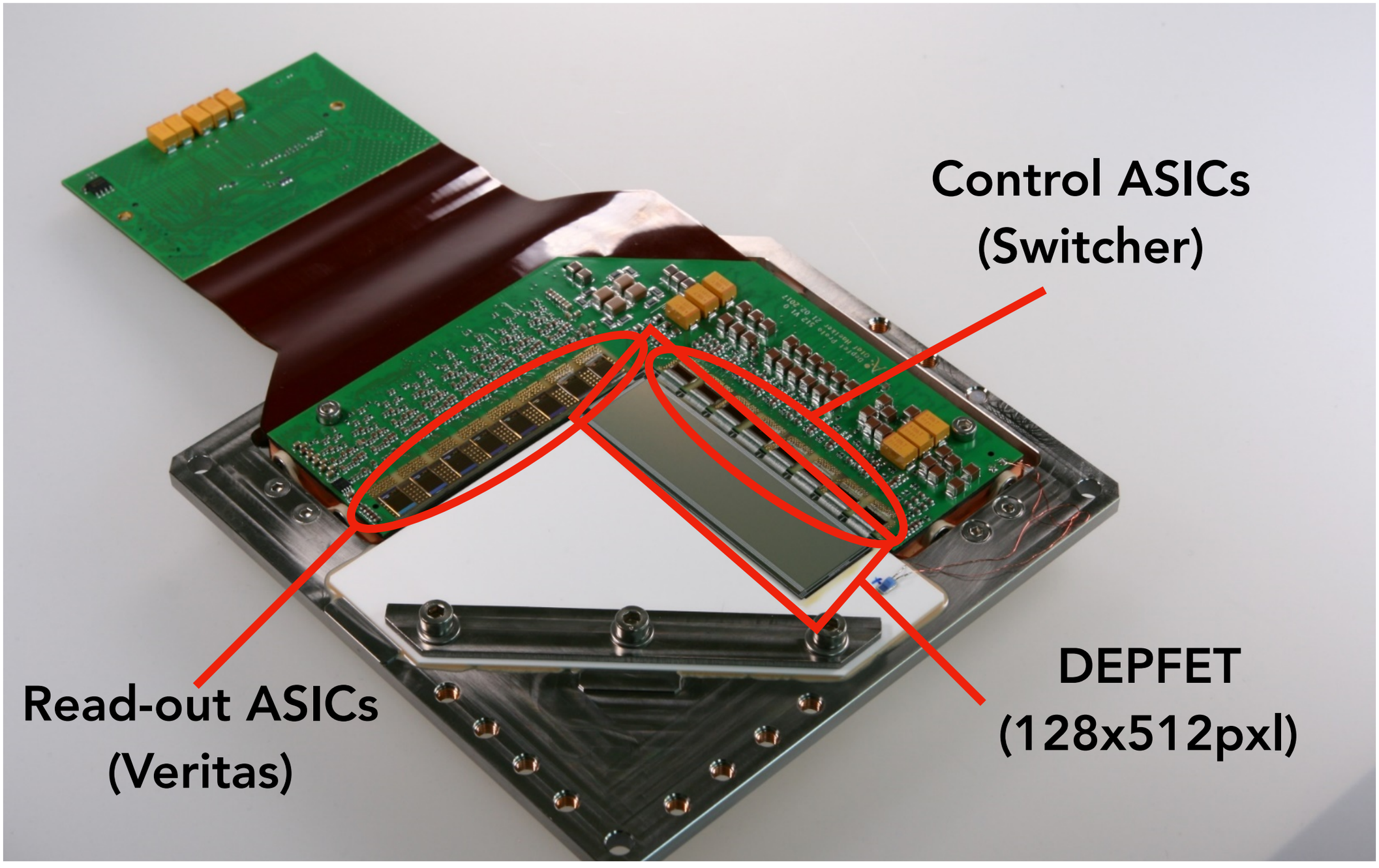


Challenge: verification of function and performance

- DEPFET Proto-type production completed in 2016.
- Different shapes and sizes produced with different layout and technology.



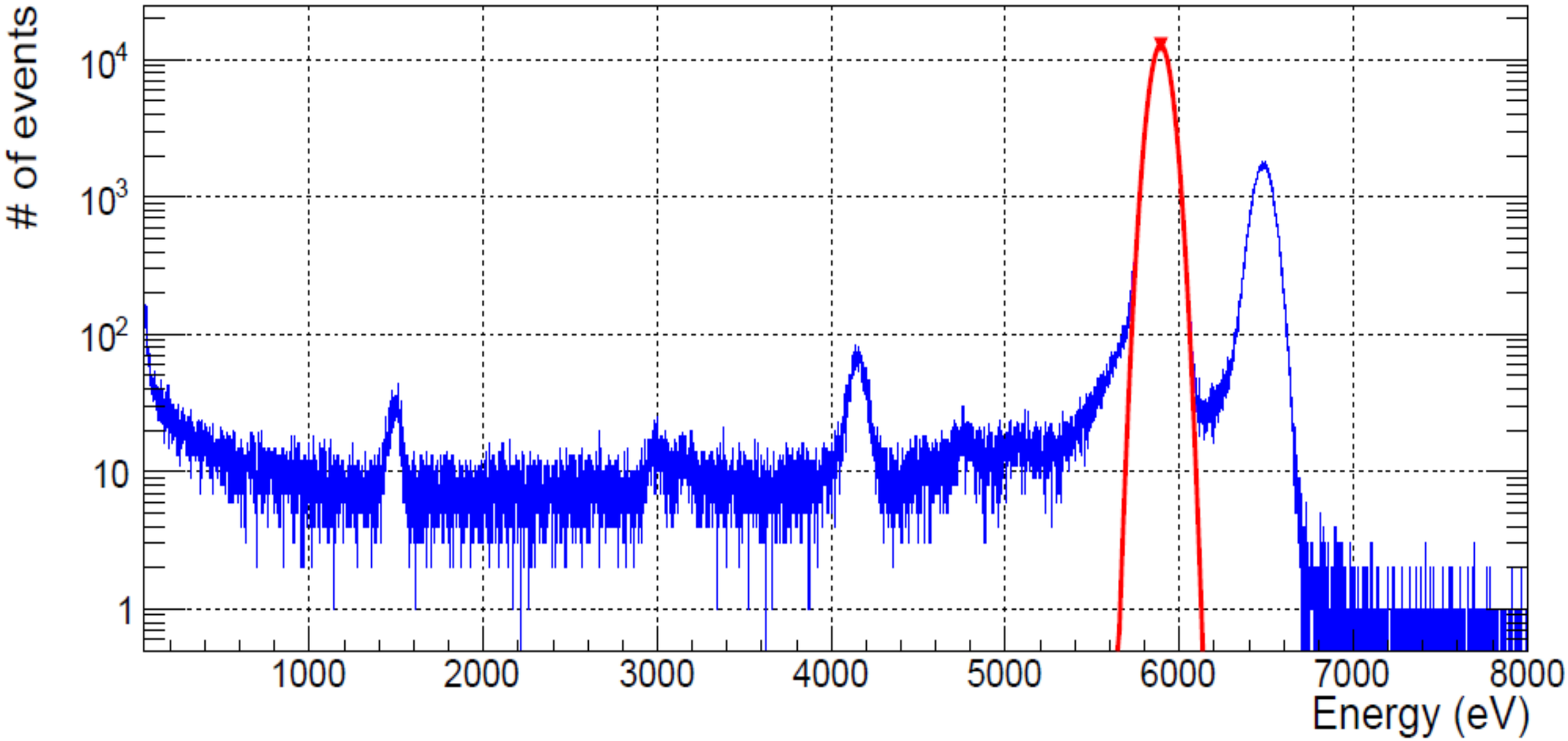
DETECTOR DEVELOPMENT

64x64 pxl (FD):

- σ ≈ 2.0 - 2.5 el. rms + FWHM(5.9keV)≈130eV for 2.5 µs/row

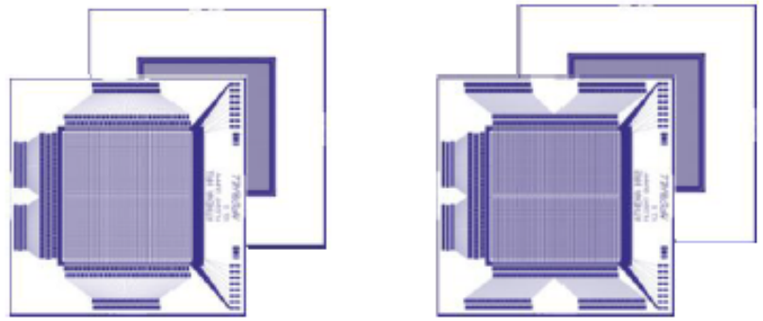
256x256 pxl (1/2 LD):

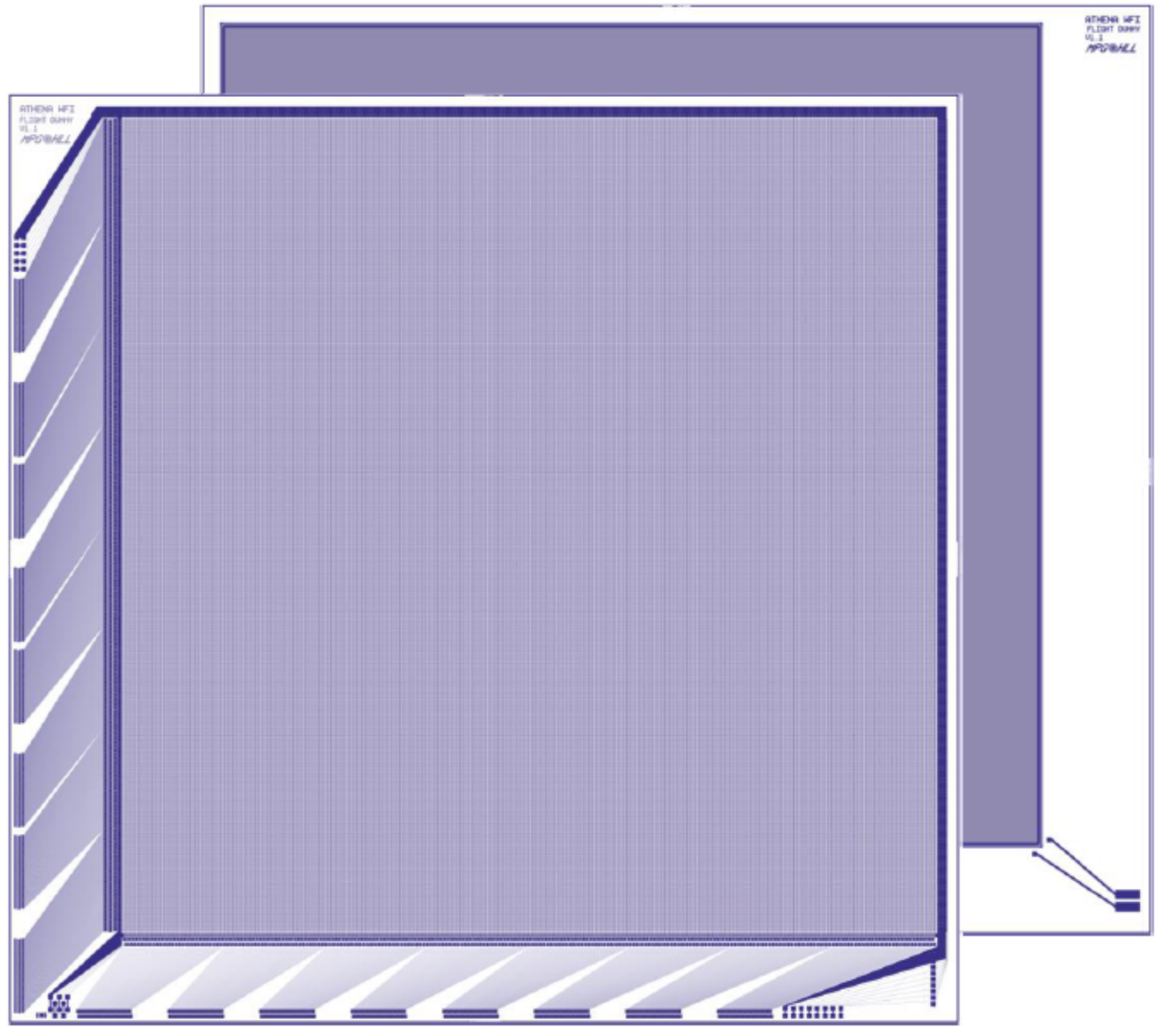
- σ ≈ 2.5 el. rms + FWHM(5.9keV)≈134eV for 8.7 µs/row



DEPFET Pre-flight production started in 2017.

EM Quality in form/fit/function/ performance and similar to flight devices





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Large Sensor Array
Fast Sensor

Graded-Z Shield

CFE

AFE

Detector Board

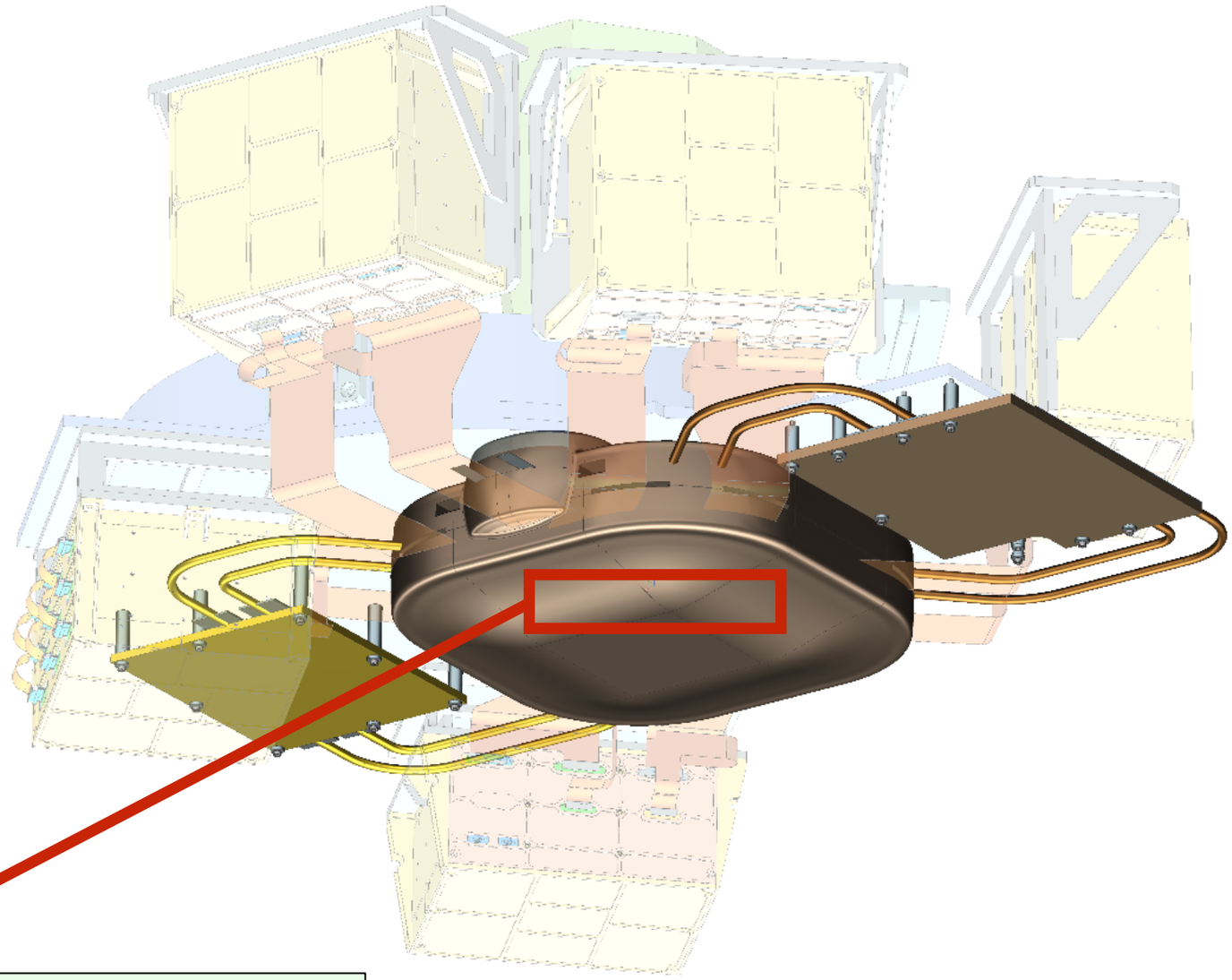
Proton

Shield

Camera Head

DEPFET Heatpipe

FEE Heatpipe



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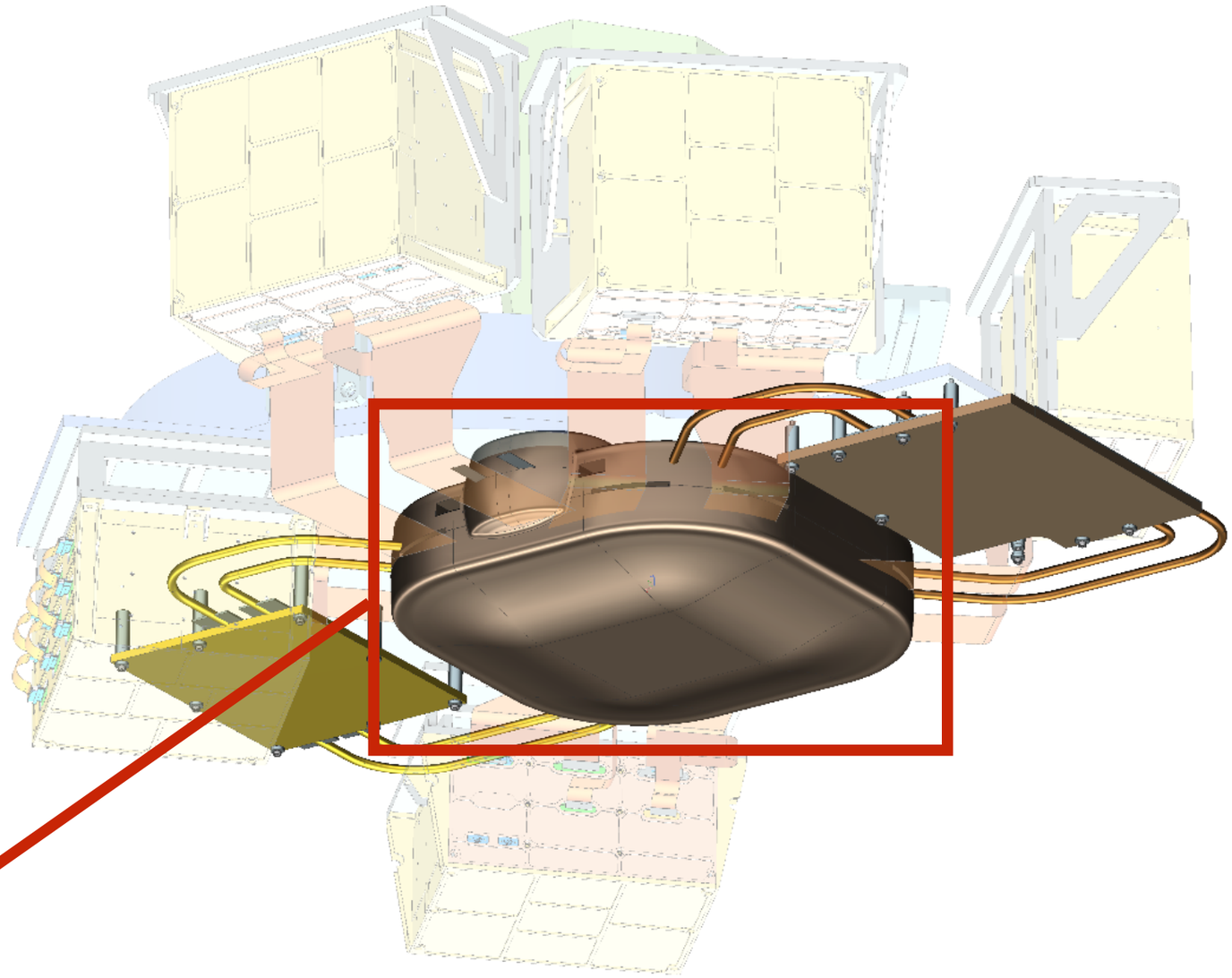

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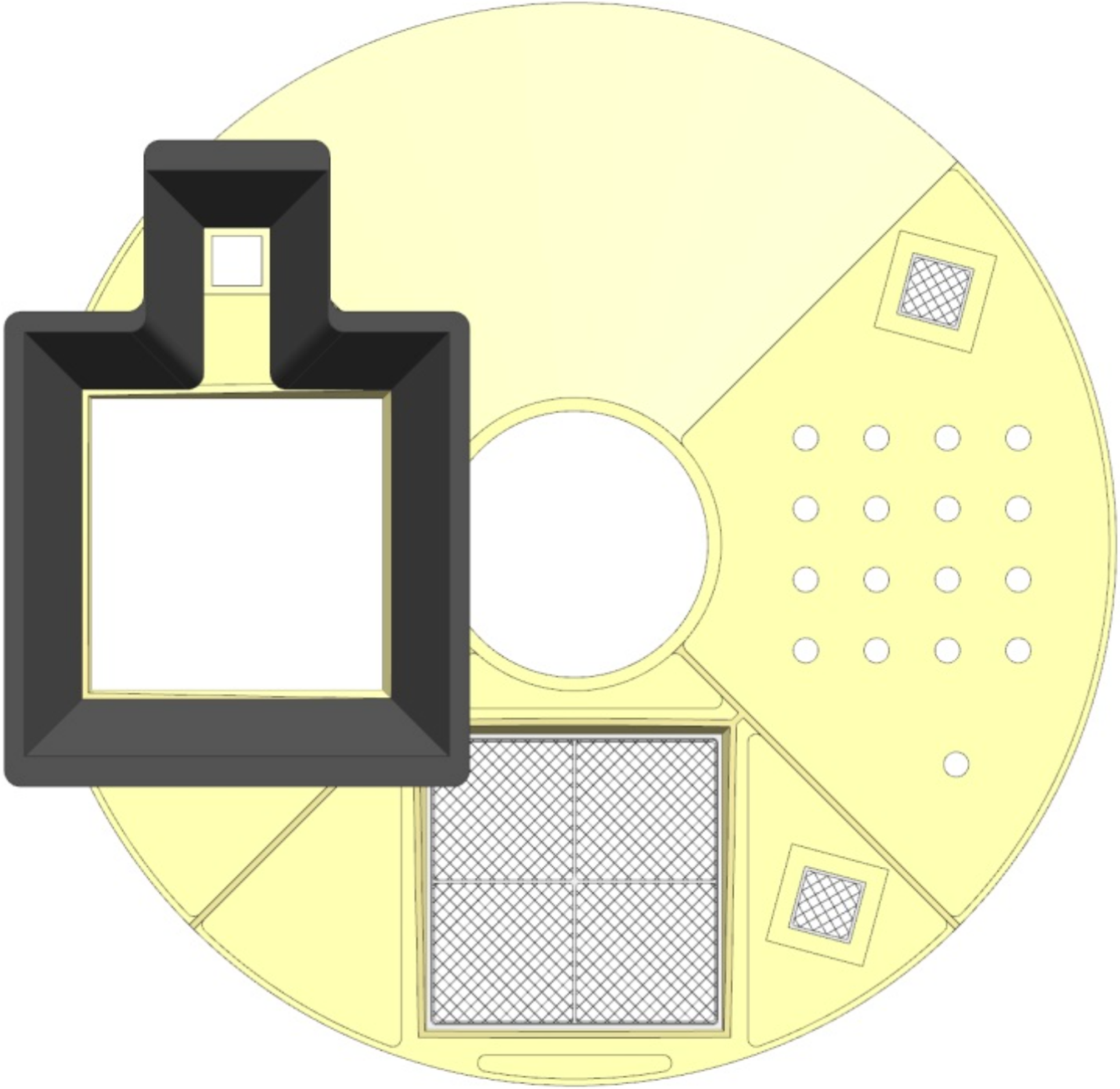
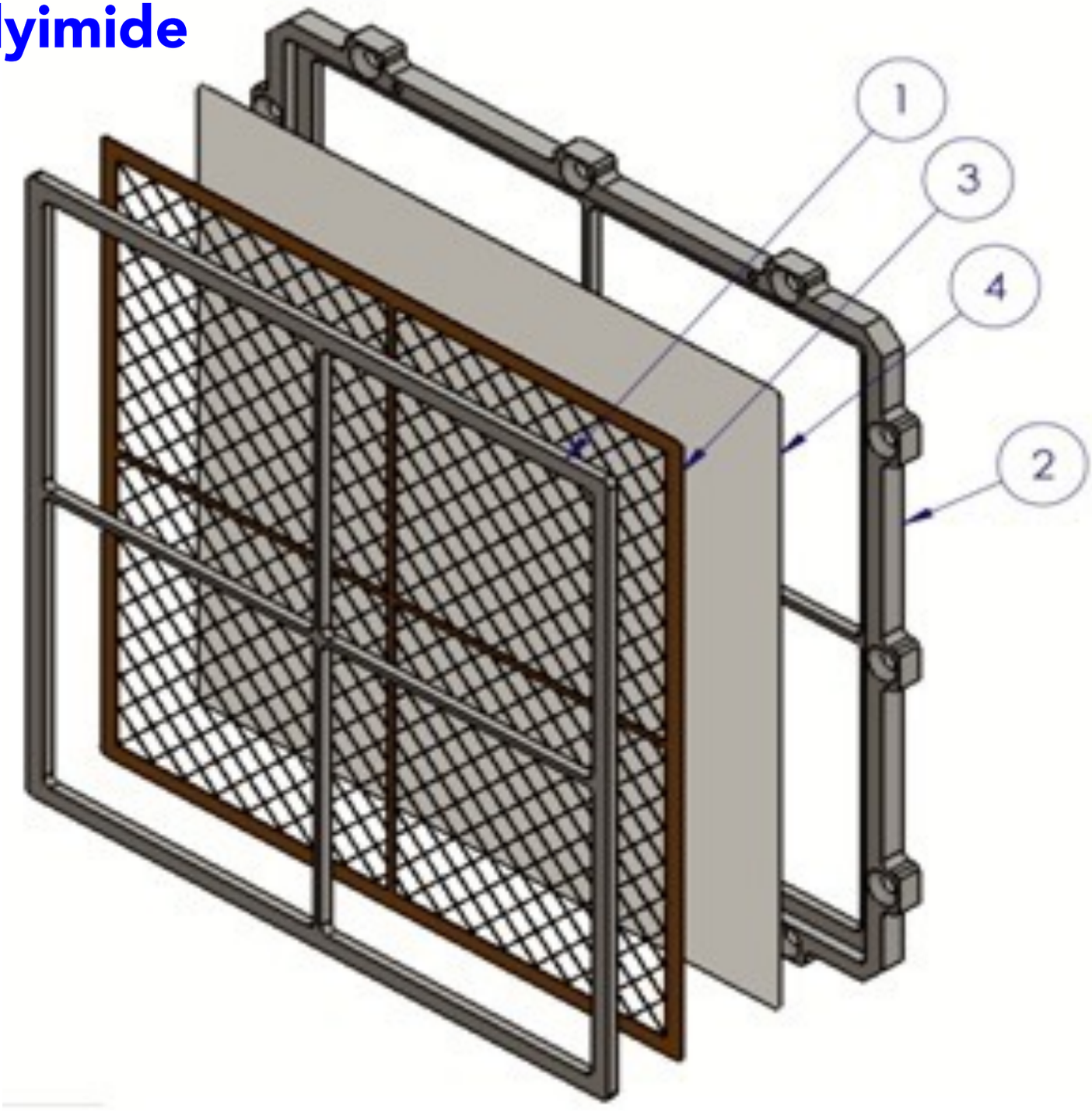


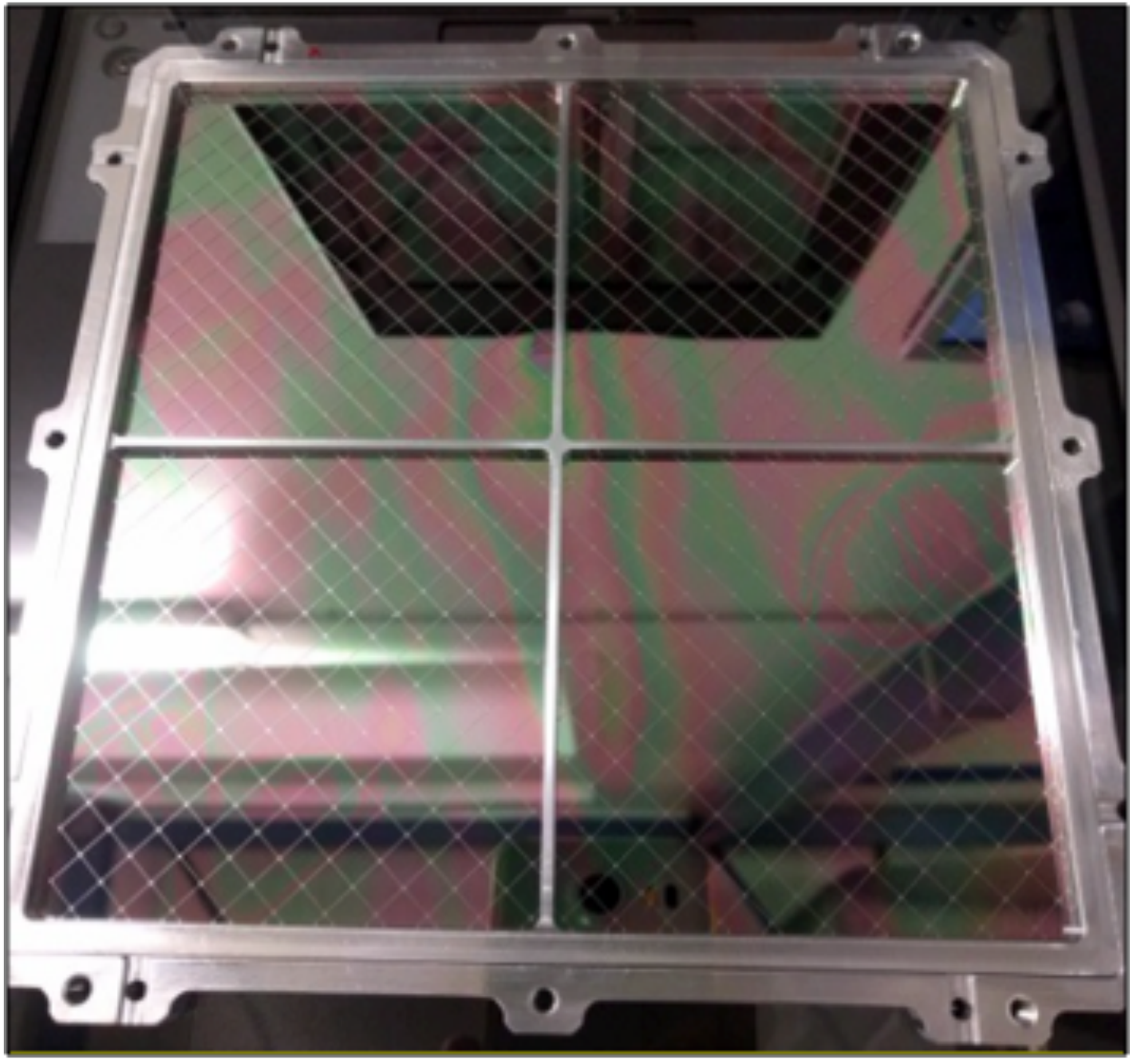
OPTICAL BLOCKING FILTER

1 - ON-CHIP: 90nm Al+30nm Si_3N_4+20nm SiO_2

2 - FW: 30nm Al on 150nm polyimide

- 170x170mm²
- FW w/o vacuum enclosure
- Challenge: acoustic noise loads during launch
- frame + mesh + cross-shaped stiffening

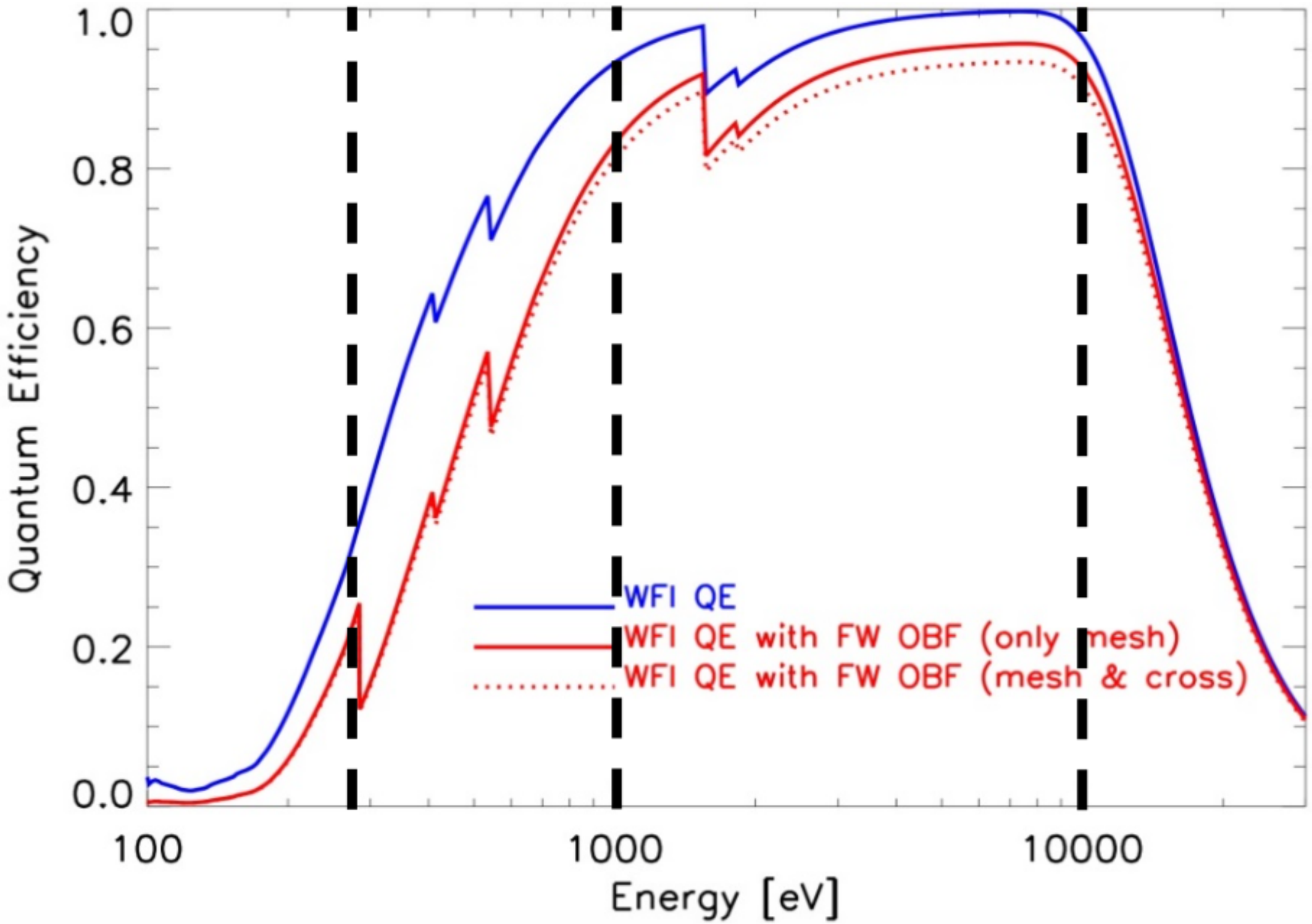




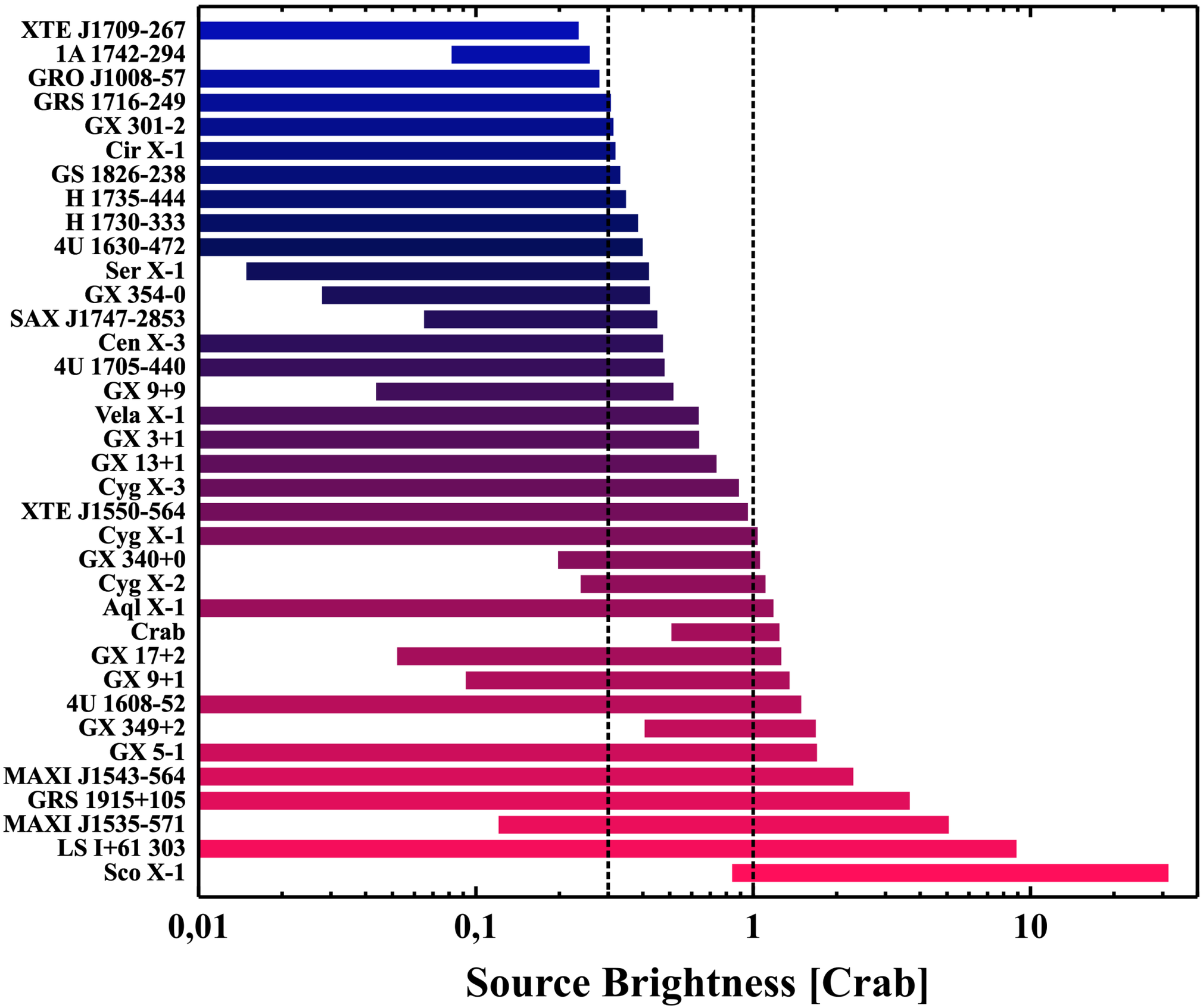
0.277 keV
QE = 23 %

1 keV
QE= 83 %

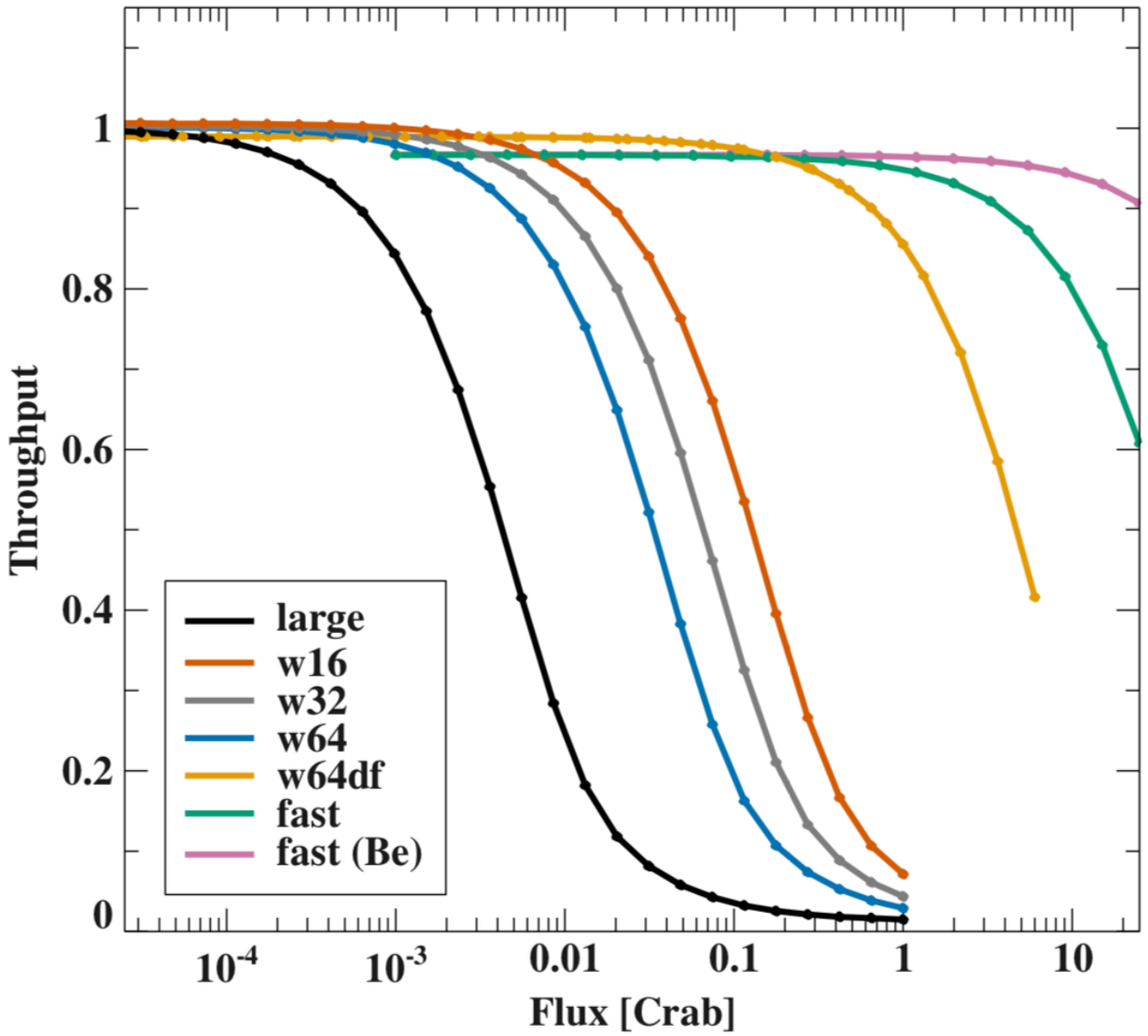
10 keV
QE = 92 %

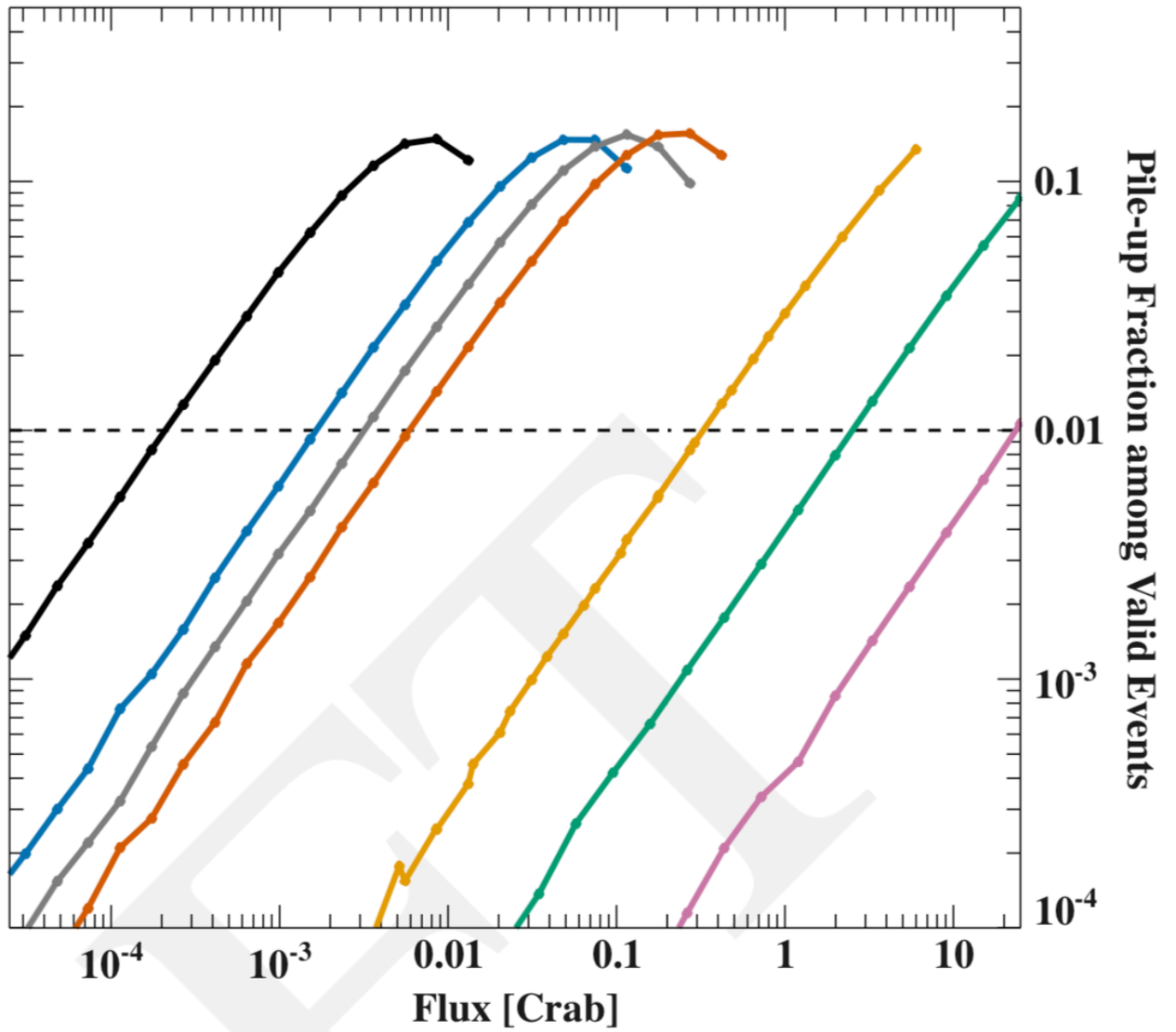


4-10keV daily flux measurements from MAXI (May 2016 - January 2018).



Throughput (right) and Pile-up (left) for different WFI LDA & FD modes





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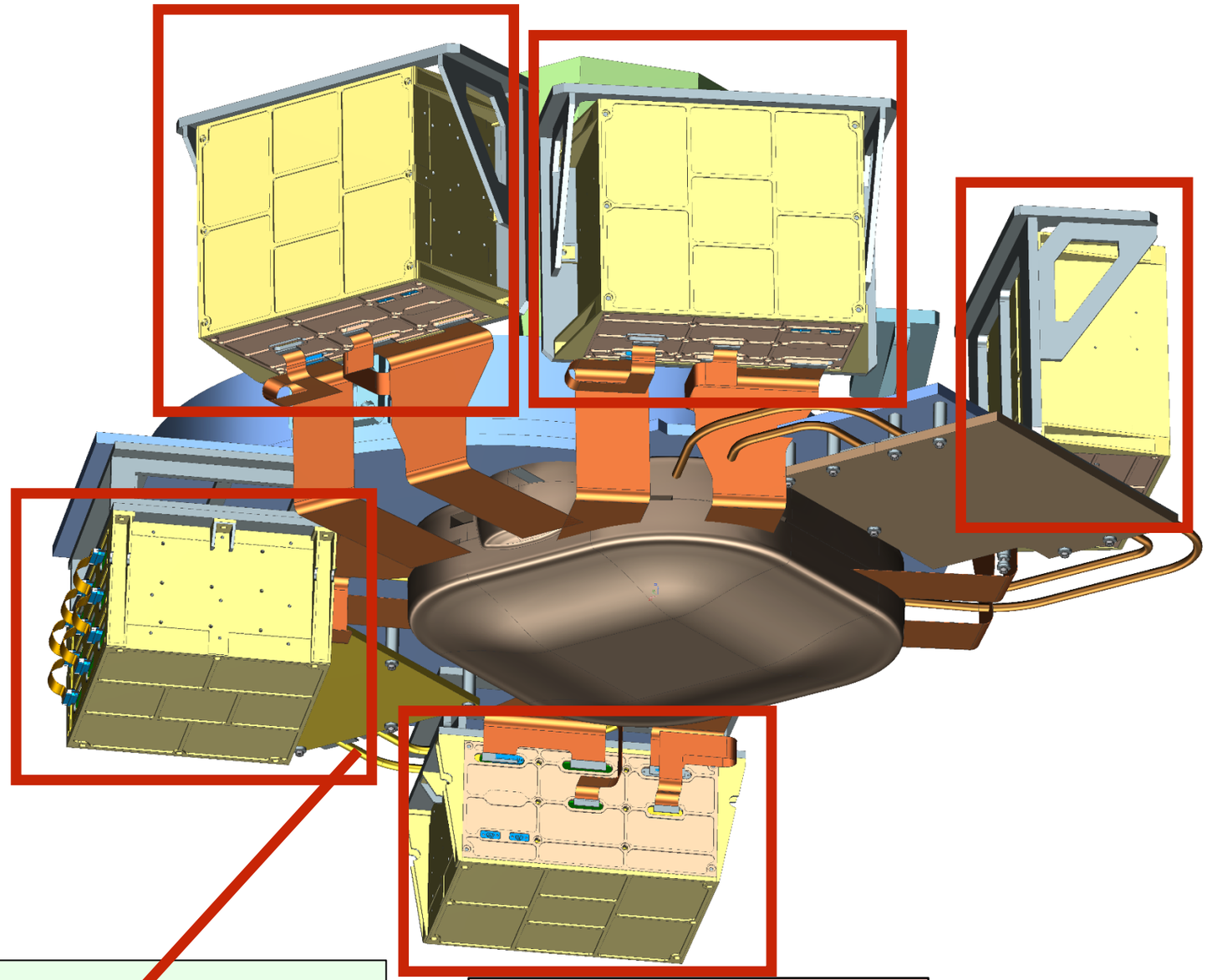

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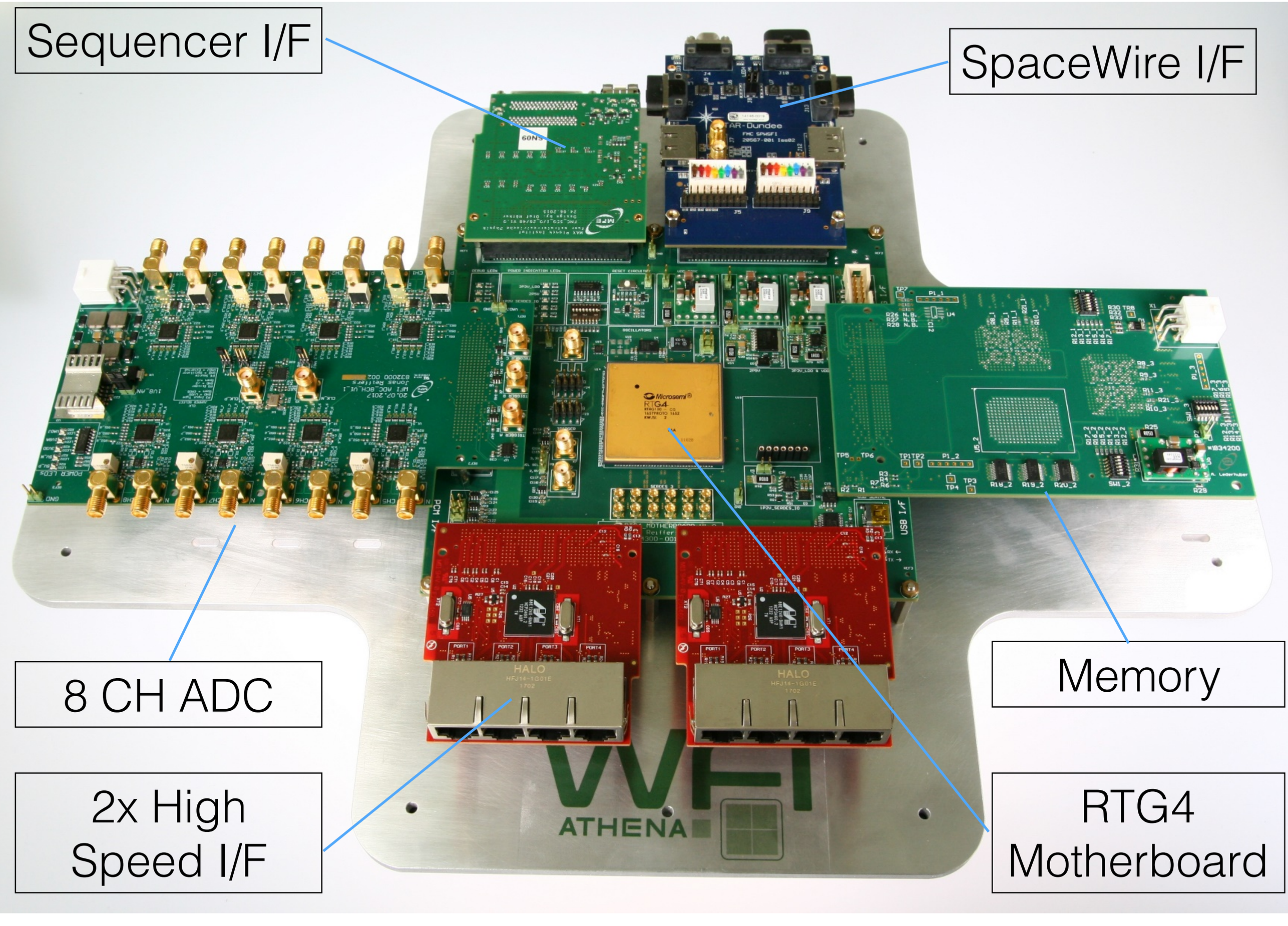
Challenge: real-time data processing (e.g., 0.72 Gbit/s per LD)

Modular Breadboard designed and manufactured

Commercially available counterparts of flight components

Analysis and component testing ongoing in preparation for design for integrated breadboard (or EM).


Sequencer I/F
SpaceWire I/F
8 CH ADC
2x High Speed I/F
Memory
RTG4 Motherboard
60NS
STAR-Dundee
FMC SPWSFI
20567-001 Iss02
Microsemi
RTG4
HALO
HFJ14-1G01E
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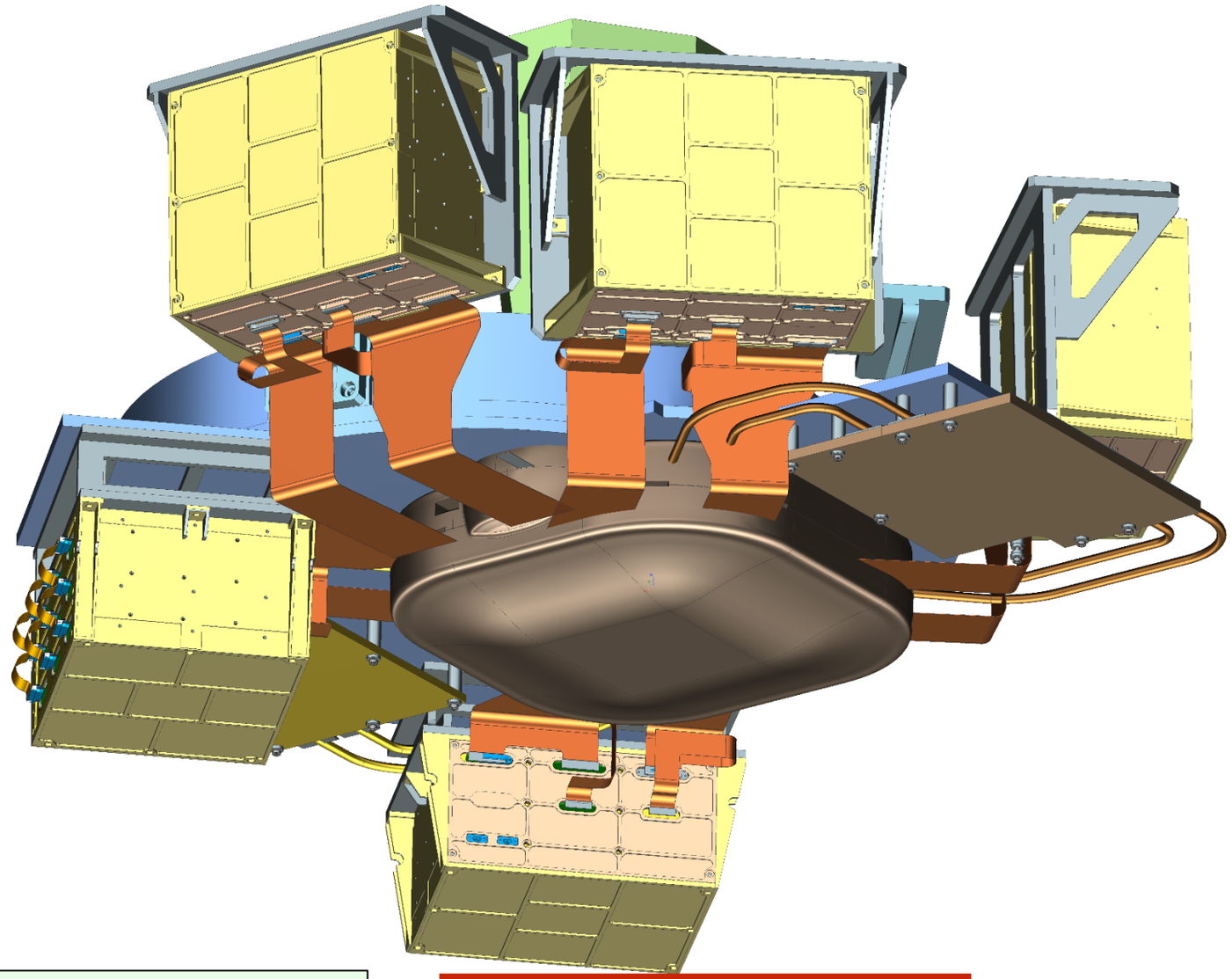

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Spacecraft

Instrument Performance

On-axis effective area

Effective Area (cm^2)

10000

1000

100

x10

Athena/WFI

XMM/EPICpn

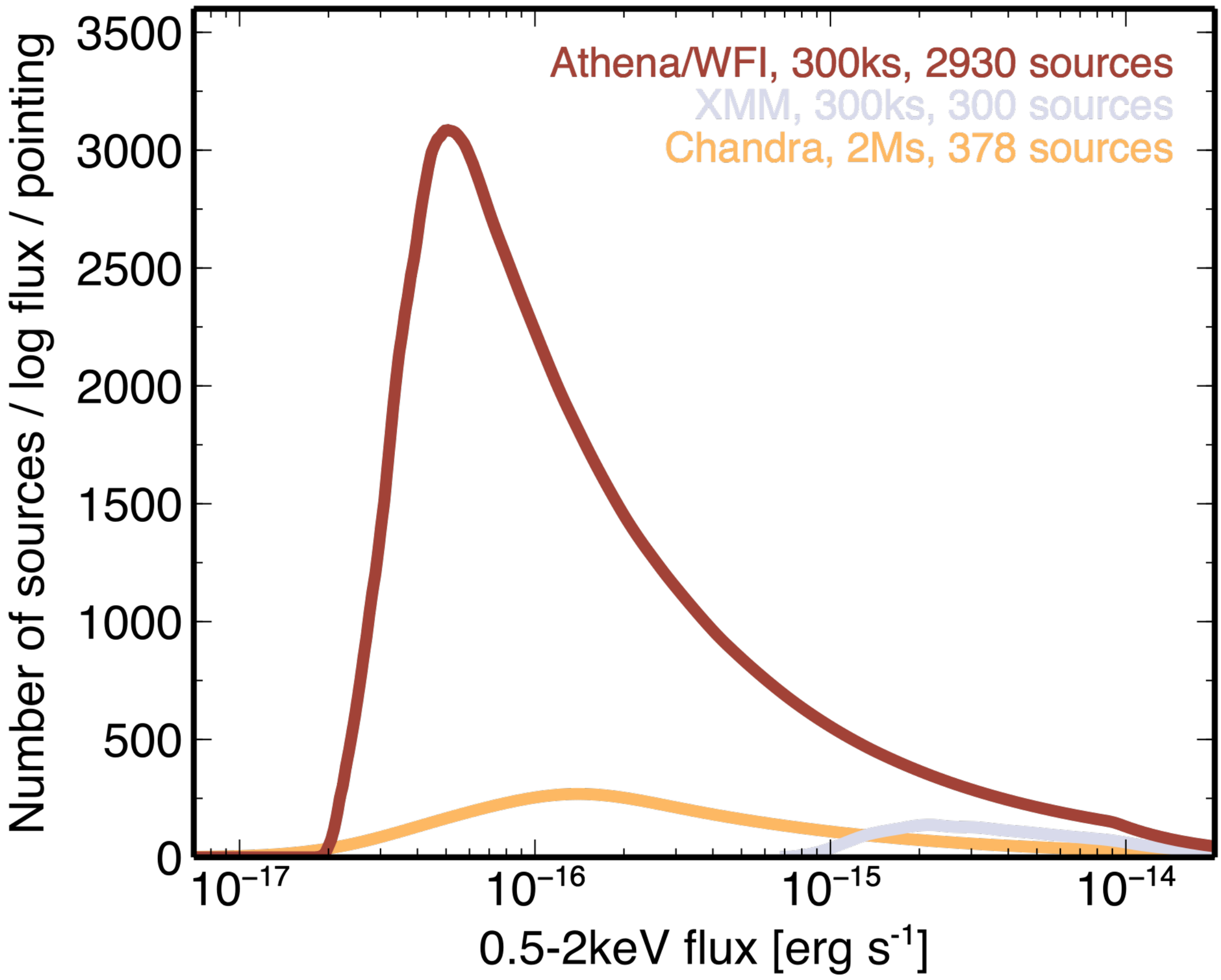
Chandra/ACIS

1.0

10.0

Energy (keV)

10x more sources per pointing



high-z SMBH, early groups, warm absorbers, UFOs

high-z SMBH, Compton-thick AGN at z~1-2

Compton-thick AGN at z~3

XMM-LSS

COSMOS Legacy

AEGIS

CDF-S

shallow

medium

deep

103x80ks

3x700+10x600ks

4x1Ms

Point Source Depth

10^{-14}

10^{-15}

10^{-16}

10^{-17}

0,01 0,1 1 10

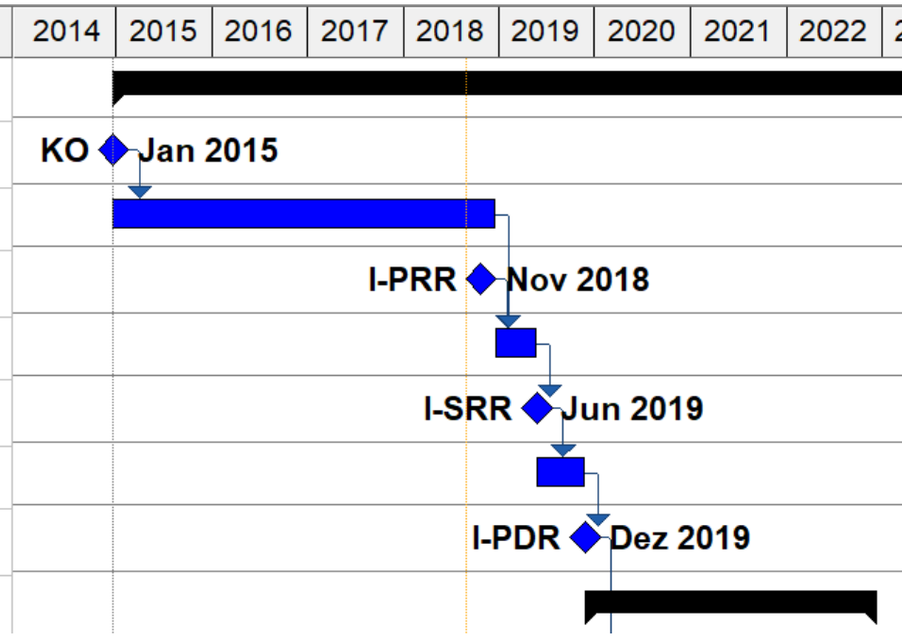
Area [deg^2]

0 2 4 6 8 10

Exposure [Ms]

Schedule and Reviews

	Name	Start	Finish
1	**Wide Field Imager - Instrument Development**	**Jan 2015**	**Jul 2027**
2	Kick-off	Jan 2015	Jan 2015
3	Technology Development Activity (Phase A)	Jan 2015	Dez 2018
4	Instrument Preliminary Requirements Review close-out	Nov 2018	Nov 2018
5	Specification and Requirement Definition (Phase B1)	Dez 2018	Jun 2019
6	Instrument System Requirements Review	Jun 2019	Jun 2019
7	Preliminary Design (Phase B2)	Jun 2019	Dez 2019
8	Instrument Preliminary Design Review	Dez 2019	Dez 2019
9	**Phase C**	**Dez 2019**	**Dez 2022**



I-PRR

- data package delivered Sep 17th
- co-location meeting Oct 18th
- board meeting Oct 31st

Parameter	**Performance**			
Energy Range	0.2-15keV			
	0.2keV	**1keV**	**7keV**	**10keV**
Quantum Efficiency; w/ external filter	5.8%	83.1%	95.6%	92.2%
Quantum Efficiency; (w/o) external filter	11.7%	93.2%	99.7%	96.3%
Eff. Area*; on-axis, w/ external filter	0.082m²	1.19m²	0.17m²	0.055m²
Eff. Area*; on-axis, w/o external filter	0.162m²	1.33m²	0.18m²	0.057m²
Energy Resolution (end-of-life)		<80eV	<170eV	
Pixel Size	130μm x 130μm (i.e. 2.24" x 2.24")			
Positional Accuracy	<1" (99.7% confidence)			
	LDA	**FD**		
Field of View	40.17' x 40.17' (outer envelope)	2.38' x 2.38'		
Frame time	5ms	80μs		
FD Count Rate Capability*	1Crab: ~0.3% pile-up, ~95% throughput (w/ standard filter) 15Crab: ~1% pile-up, ~93% throughput (w/ 100μm Be filter)			
Point Source Sensitivity (0.5-2keV)	≤2.4 x 10^{-17} erg/cm²/s (450ks)			
Surface Brightness Sensitivity (5-7keV)	≤6.2 x 10^{-16} erg/cm²/s/arcmin² (100ks; 5' circle)			
Instrumental Background	~5x10^{-3} cnt/s/cm²/keV (2-7keV)			

END