MAX-PLANCK-INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK

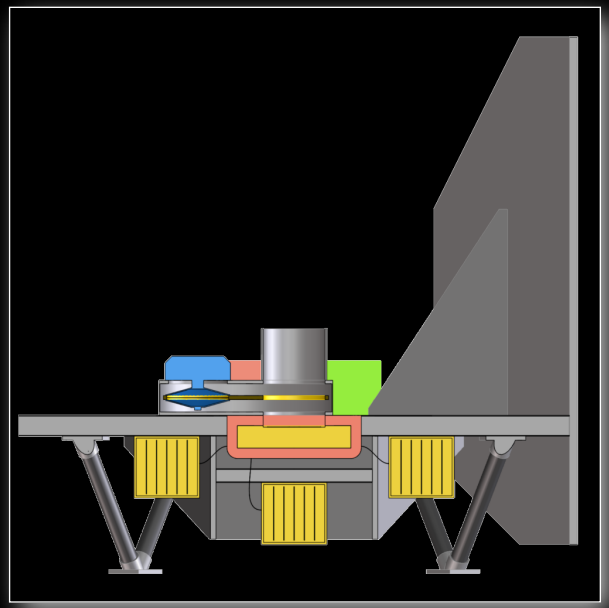
Wide Field Imager

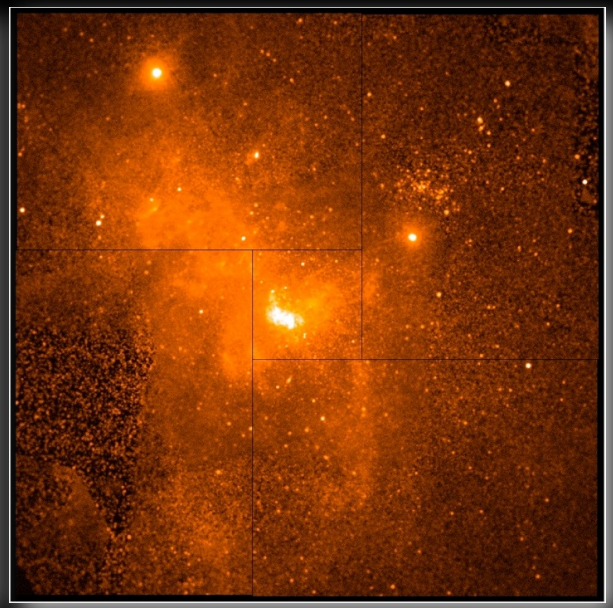
ATHENA

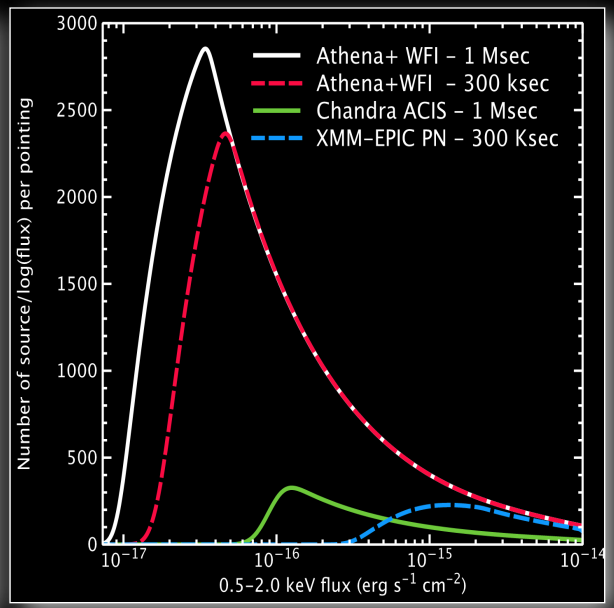
The Wide Field Imager for the Athena X-ray Observatory

Arne Rau

(Athena/WFI Project Scientist, MPE - on behalf of the WFI Team)

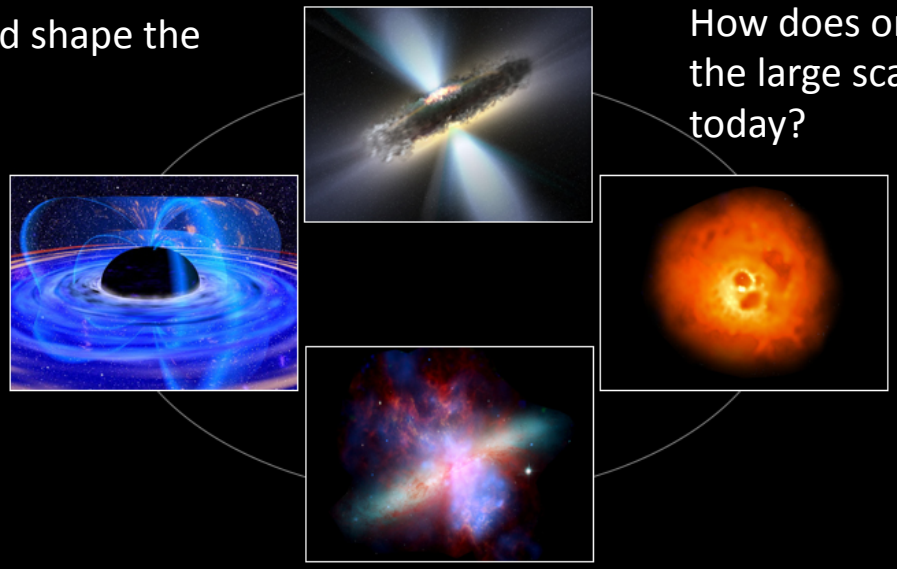






The Hot and Energetic Universe - Science Theme for ESA's L2 Mission

How do black holes grow and shape the Universe?



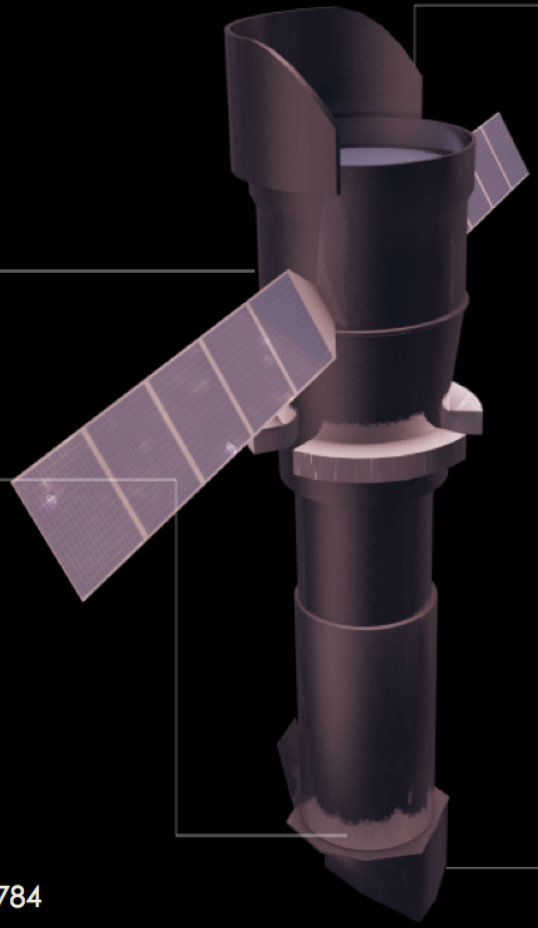
How does ordinary matter assemble into the large scale structures that we see today?

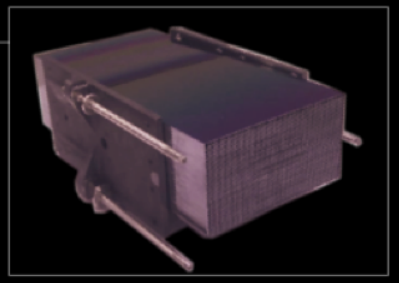
Nandra et al. 2013, arXiv 1306.2307

The Athena Observatory

Willingale et al, 2013 arXiv1307.1709

L2 orbit Ariane V
Mass < 5100 kg
Power 2500 W
5 year mission

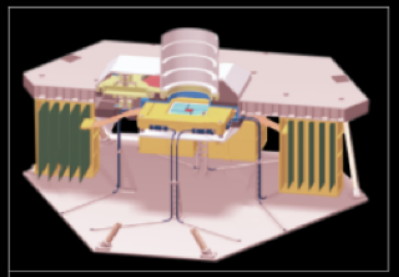




Silicon Pore Optics:
2 m^2 at 1 keV
5 arcsec HEW
Focal length: 12 m
Sensitivity: 3 10^{-17} erg cm^{-2} s^{-1}

X-ray Integral Field Unit:
ΔE: 2.5 eV
Field of View: 5 arcmin
Operating temp: 50 mk

Barret et al., 2013 arXiv:1308.6784



Wide Field Imager:
ΔE: 125 eV
Field of View: 40 arcmin
High countrate capability

Rau et al. 2013 arXiv1308.6785

For more information please listen to talks in the Plenary Session on Thursday

The Hot and Energetic Universe & The Athena Mission

Kirpal Nandra

The X-ray Integral Field Unit

Didier Barret

Measurement Principle

Active pixel sensor

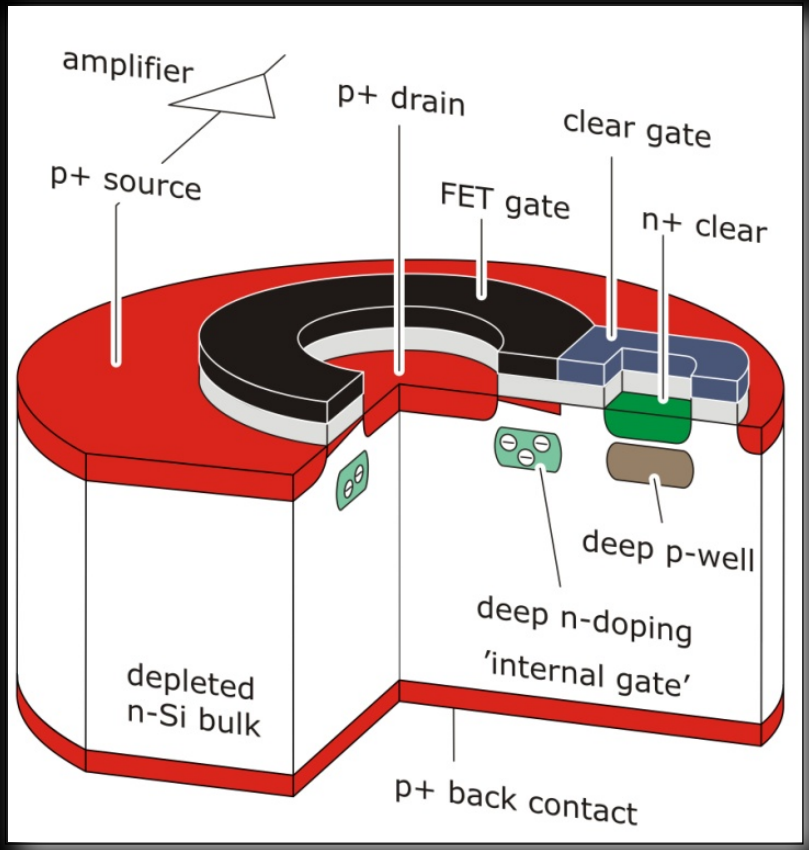
Depleted **P**-channel **F**ield **E**ffect **T**ransistor

p-FET on depleted n-bulk

- signal charge collected in potential minimum below FET channel

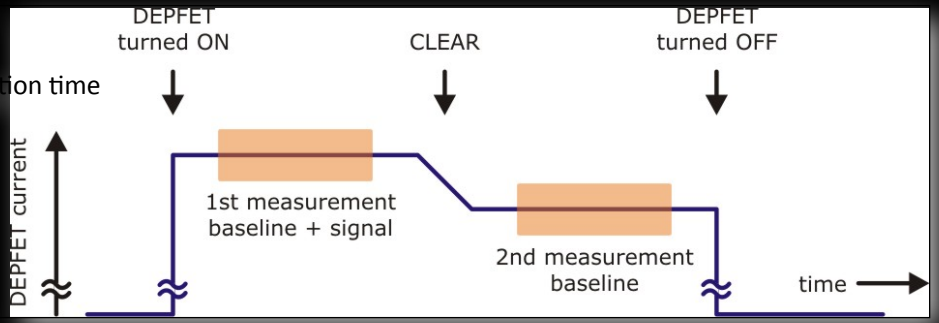
combined function of sensor & amplifier

- low capacitance (20 fF) and noise
  – excellent spectroscopic performance
- charge storage capability
  – readout on demand
- back-illuminated, fully depleted
  – excellent quantum efficiency



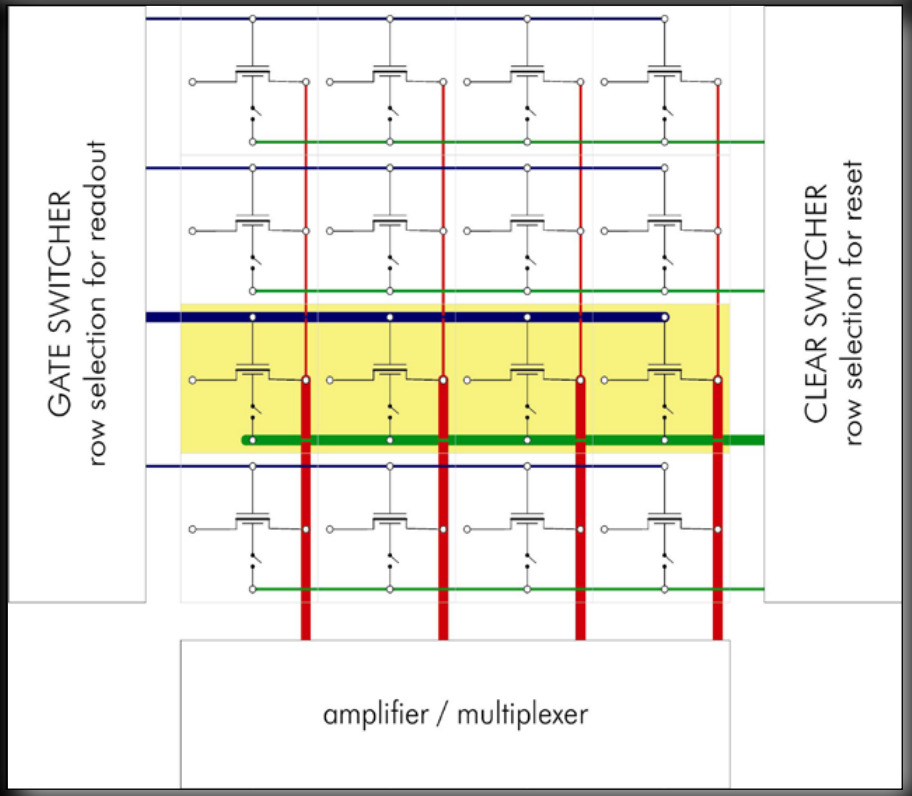
readout sequence

- 1st measurement: signal + baseline
- clear: removal of signal charges
- 2nd measurement: baseline
- difference = signal



matrix organisation

- common bulk & back contact
  - thin homogeneous entrance window
  - 100% filling factor
- row connection of ext. gate + reset
- column connection of r/o nodes (drain)
  - windowing option



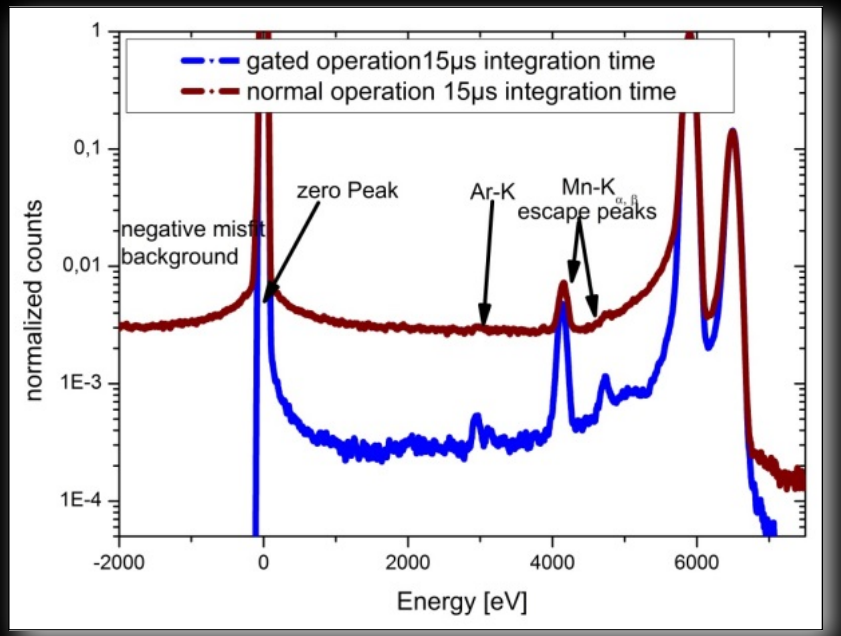
operation philosophy

- one active row
  - fast, parallel processing
- all other rows turned off
  - minimum power consumption
  - signal charge integration

Problem: photon hits during signal sampling → E_{meas} (<E_X)

Step 1: **gateable DEPFET**

- Electronic shutter built-in in each pixel
  - suppresses signals during sampling period
  - 10 x lower background



Problem: e-shutter → dead time

Step 2: **gateable DEPFET with intermediate storage region**

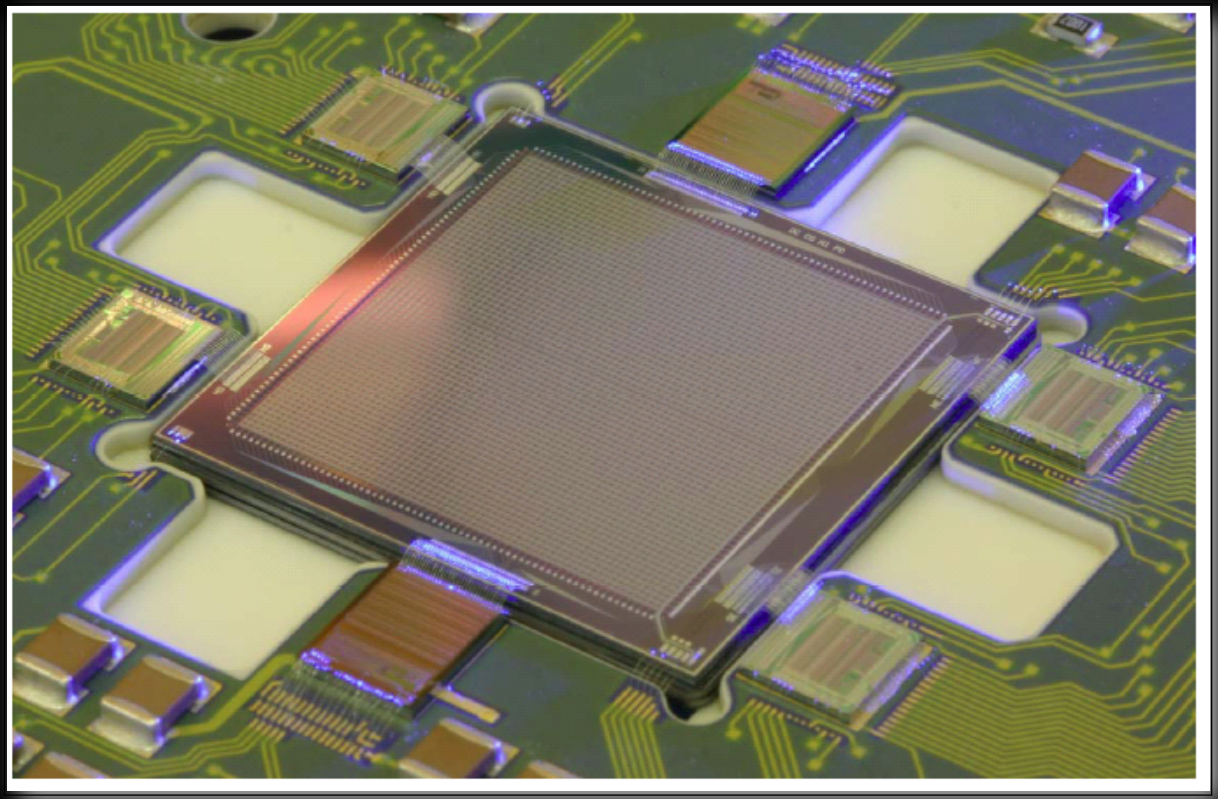
- e^- are stored for later processing
- low background & dead time

Advantages wrt CCD

- no charge transfer
  - » less sensitive to radiation damage
  - » faster readout
  - » flexible windows

DEPFETs developed for

- SIMBOL-X, XEUS, IXO, Athena prototypes
- MIXS on ESA's BepiColombo



Conceptual Design

Focal Plane Layout

WFI: **Wide field** survey power + **high count-rate/timing** capability

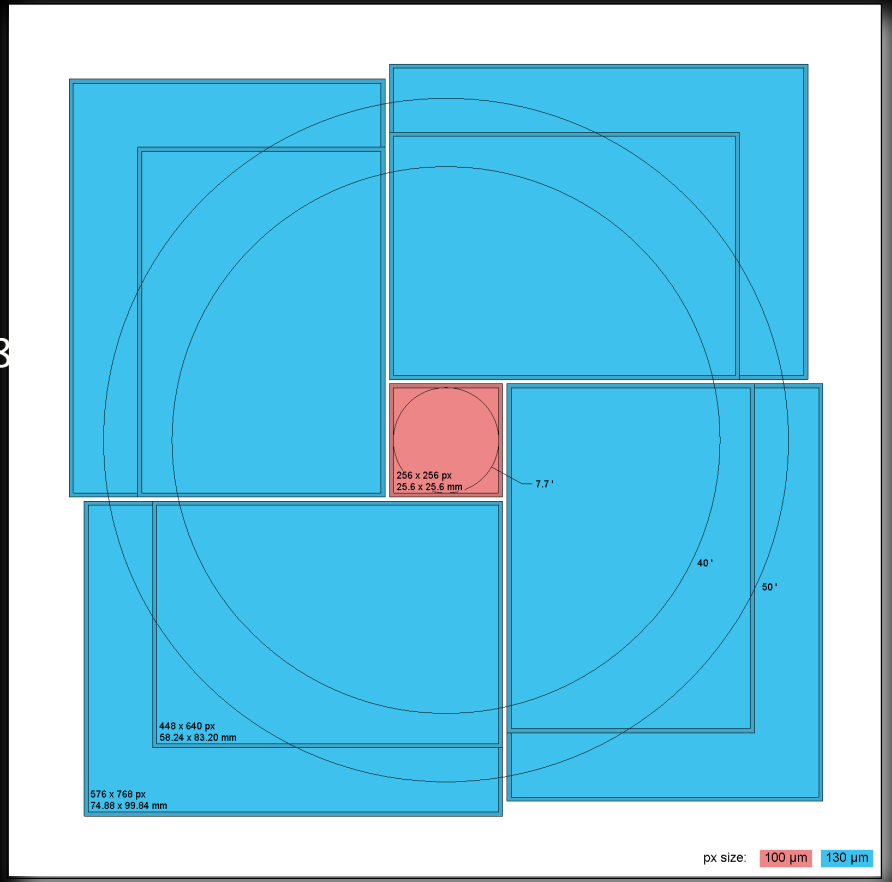
- FoV = 40 arcmin
- fast + 4 large DEPFET APS

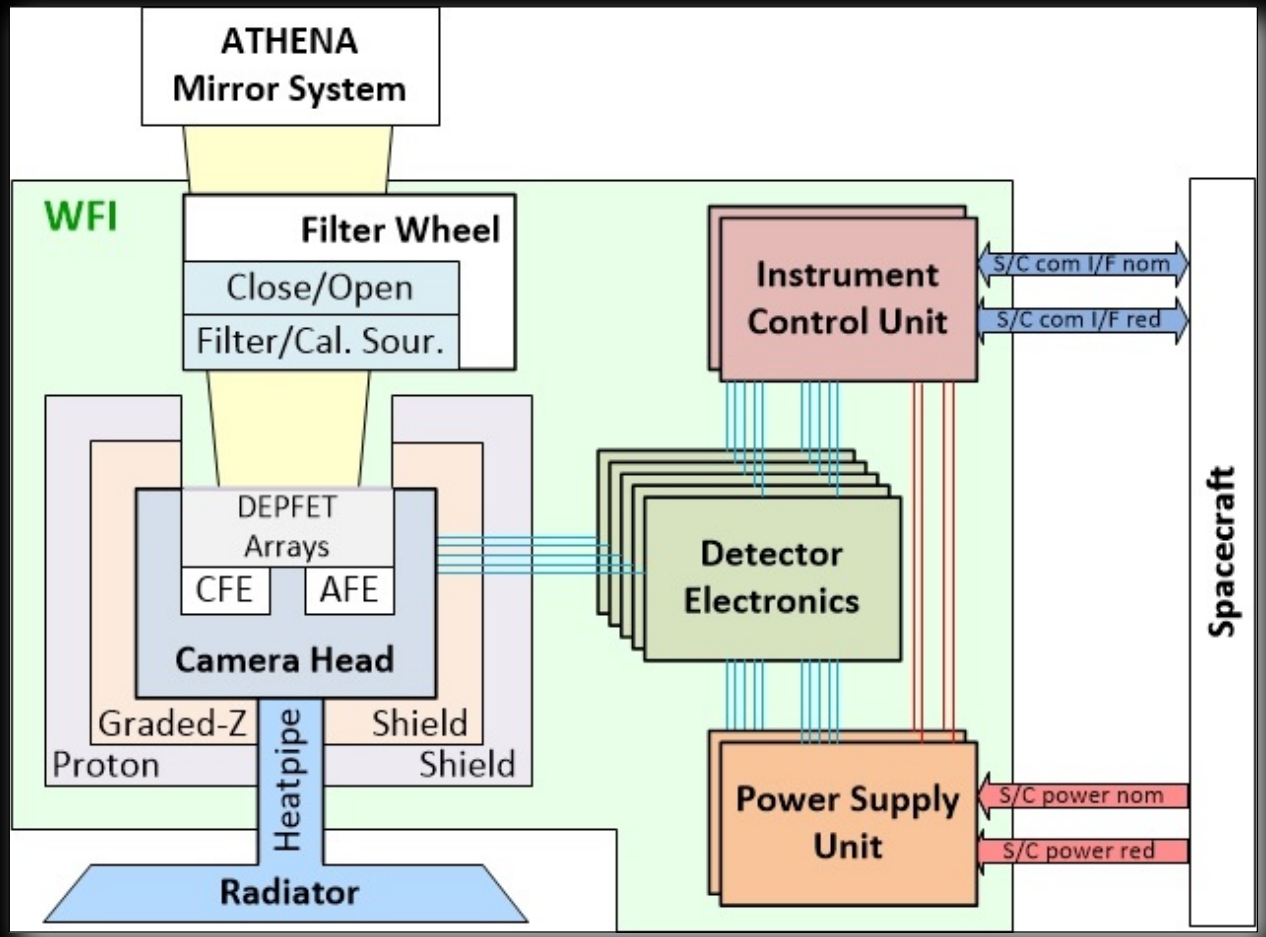
Fast chip:

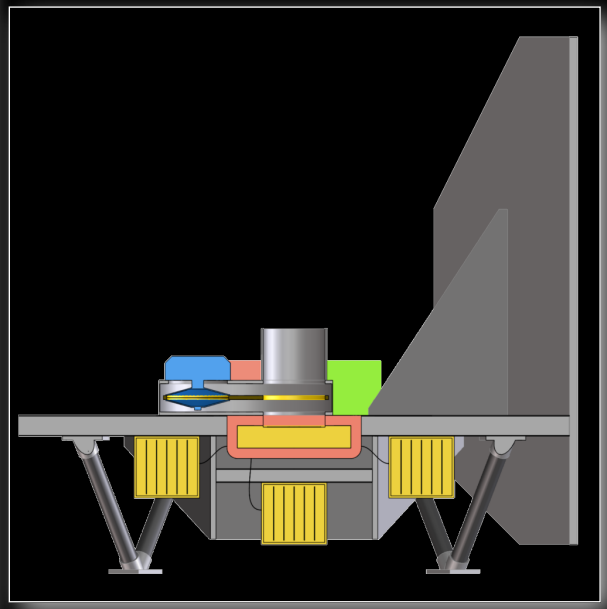
- 256 x 256 pixels; = 7.7 arcmin
- Pixel: 100 x 100 µm^2 (= 1.8 arcsec)
- on-axis PSF = 5 arcsec → oversampling: x 2.8
- two hemisphere readout
- gateable, intermediate storage DEPFET

Large chips:

- 448 x 640 pixels
- Pixel: 130 x 130 µm^2 → 58 x 83 mm^2
- non-gateable DEPFET

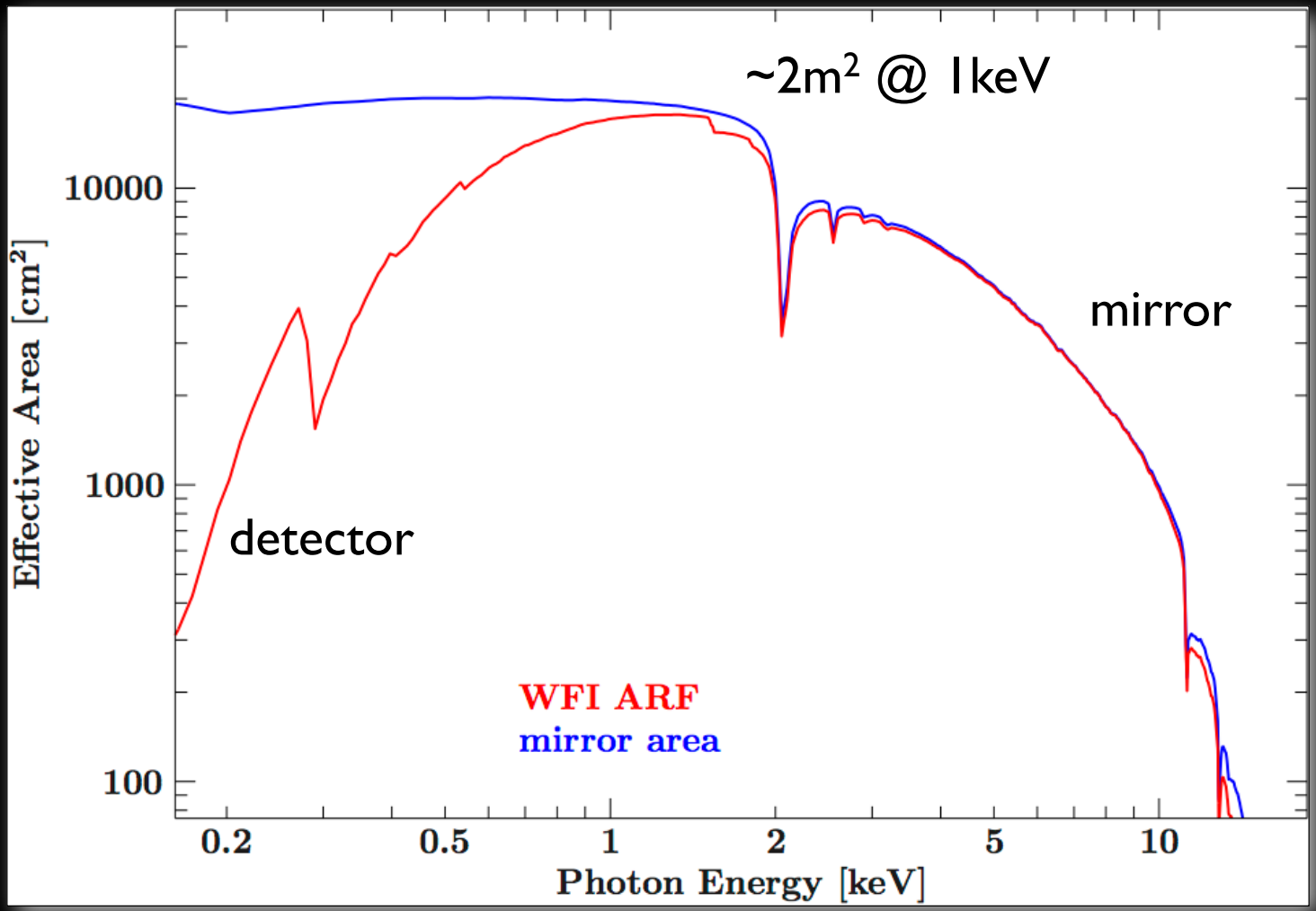



ATHENA
Mirror System
WFI
Filter Wheel
Close/Open
Filter/Cal. Sour.
DEPFET
Arrays
CFE
AFE
Camera Head
Graded-Z
Shield
Proton
Shield
Heatpipe
Radiator
Instrument
Control Unit
S/C com I/F nom
S/C com I/F red
Detector
Electronics
Power Supply
Unit
S/C power nom
S/C power red
Spacecraft

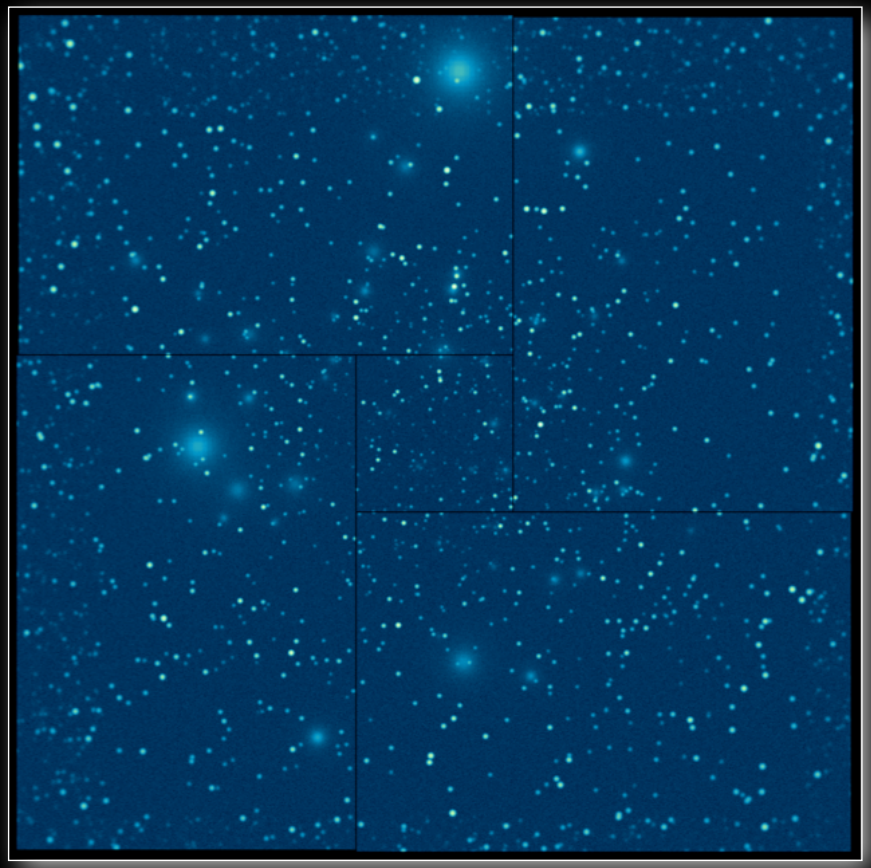


Instrument Performance

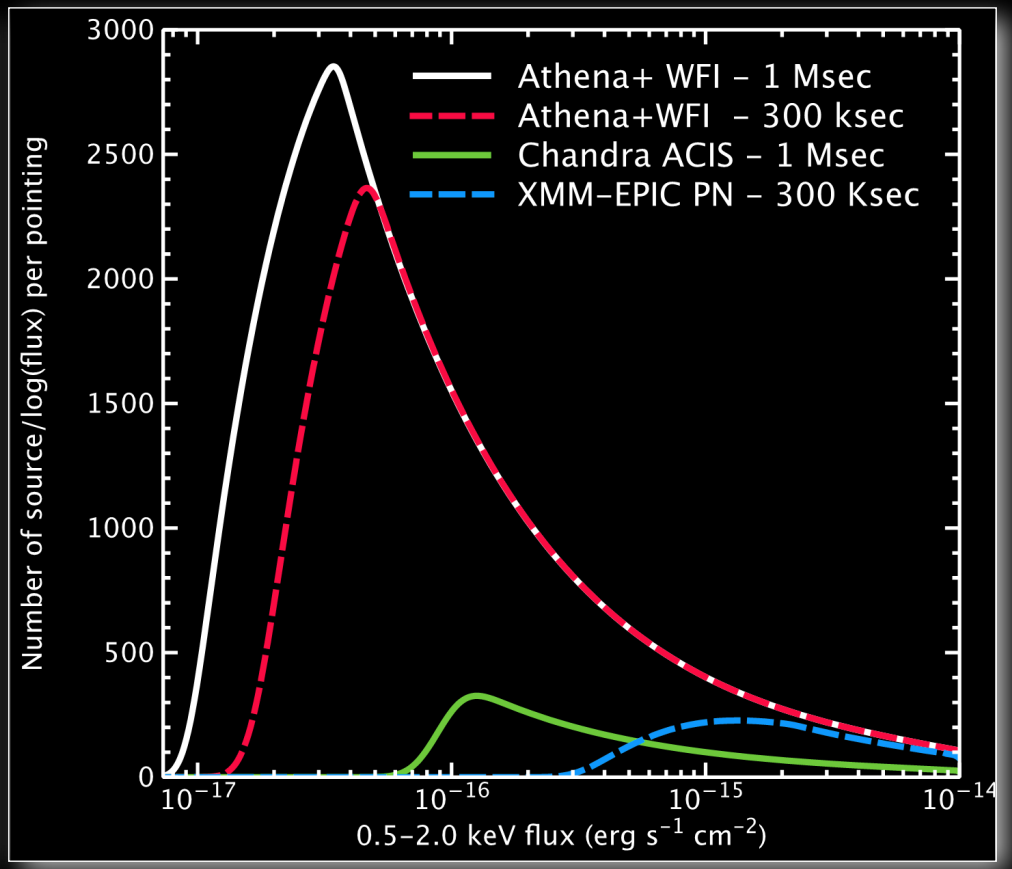
Effective Area (on-axis)



Survey Power

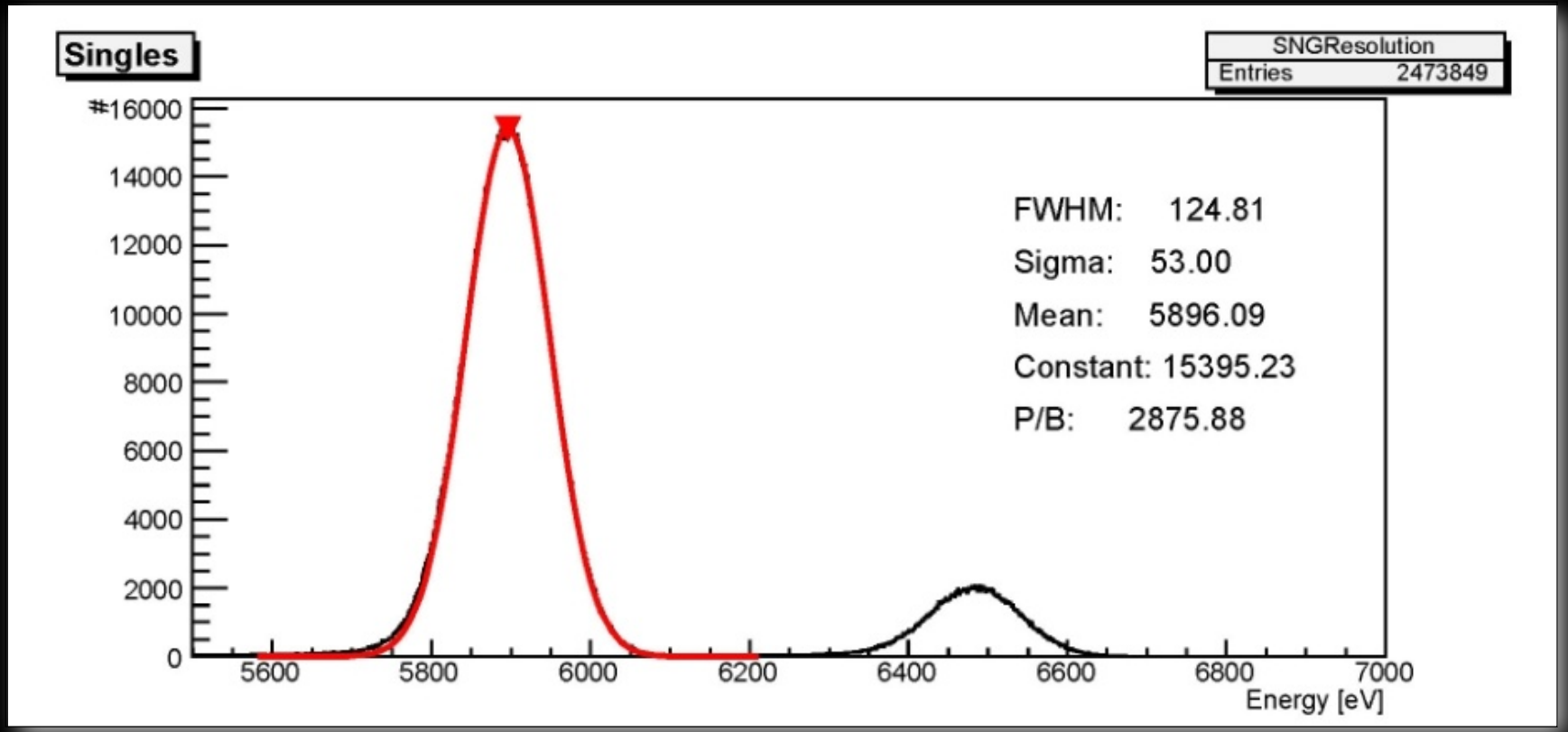


simulation of CDFS

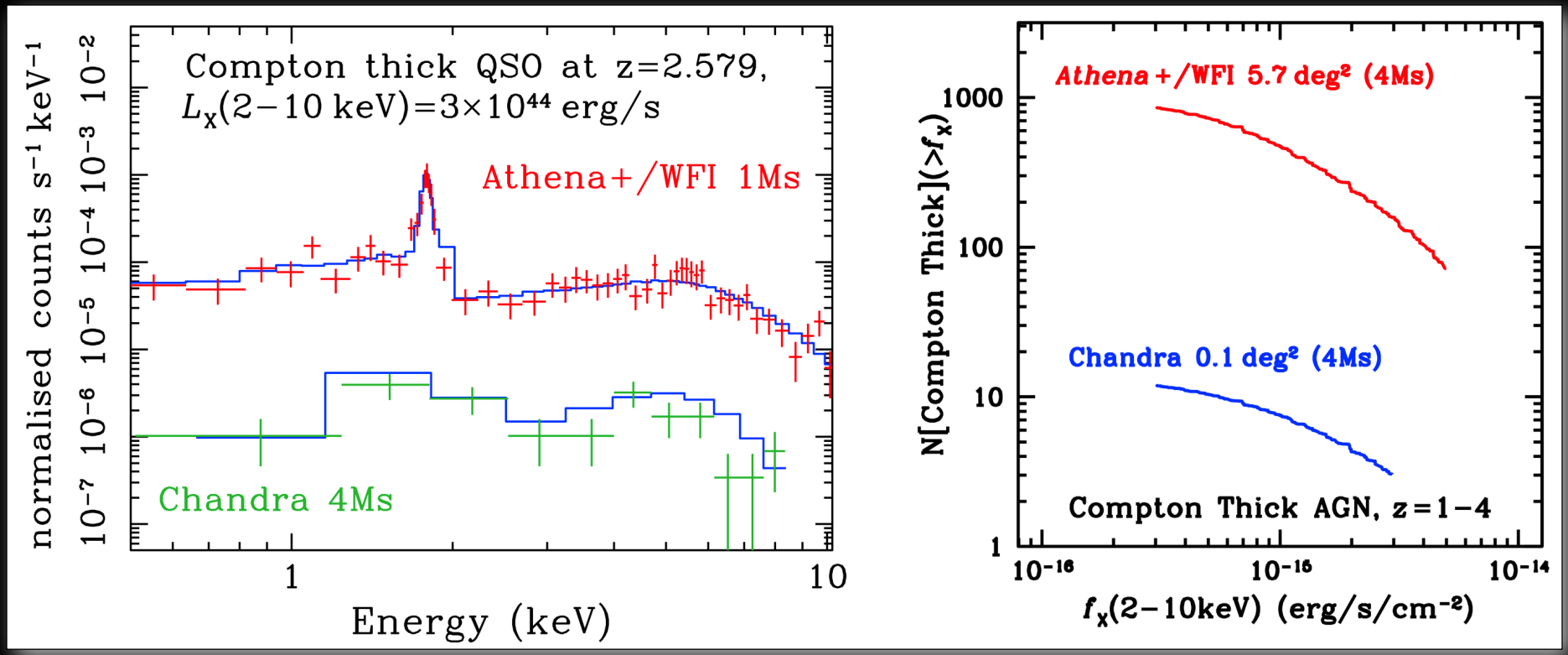


(Nandra et al 2013)

Spectral Resolution

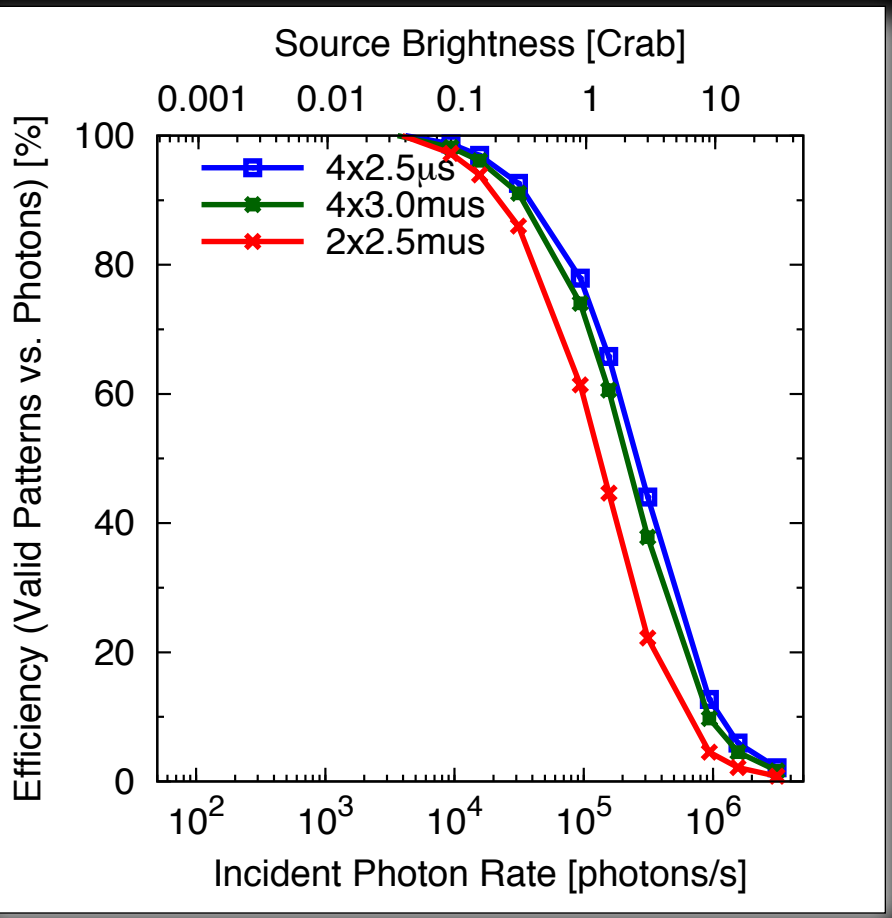


BH Growth from Compton Thick AGN



(Georgakakis, Carrera et al 2013)

High Count Rate Capabilities



(simulations by C. Schmid/ECAP)

relevant Metric:
A_{eff} x fraction of time the detector registers events

for 0.2 Crab @ 6.4keV:
~30 cm^2: XMM, Chandra
~250 cm^2: ASTRO-H
~2500 cm^2: Athena/WFI

for variable sources:
no compensation from longer observations

Summary

DEPFET Active Pixel Sensor based wide field camera

combines wide field survey power with high count rate and timing capabilities

designed to address question of the Hot and Energetic Universe science theme

Proto-Consortium lead by MPE with Partners in Germany, UK, Poland, Austria, Denmark, Italy, France, (US)

Energy Range	0.1 - 15 keV
Field of View	40` x 40` (baseline) 50` x 50` (opt.)
Central DEPFET Sensor	Format: 256 x 256 Pixel → 26 x 26 mm² Pixel size: 100 x 100 µm² (1.8")
Outer DEPFET Sensors	448 x 640 Pixel (baseline) → 58 x 83 mm² 576 x 768 Pixel (opt) → 75 x 100 mm² Pixel size: 130 x 130 µm² (2.3")
Angular resolution (on-axis)	5" (3") → oversampling by 2.8 (1.7)
Quantum efficiency (depend. optical blocking filter)	277 eV: 24% 1 keV: 87% 10 keV: 96%
Energy resolution	FWHM@6keV < 150 eV
Time resolution central sensor Window mode (16 rows)	320 µs goal (tbv): 160µs (=6.3kf/s) 20 µs goal: 10 µs (100.000 frames/s)
Time resolution outer sensor	1.5 ms (40` FoV) 1.9 ms (50` FoV)
Count rate capability	0.5 Crab: 88% throughput; 3% pile-up 1 Crab: 79% throughput; 6% pile-up