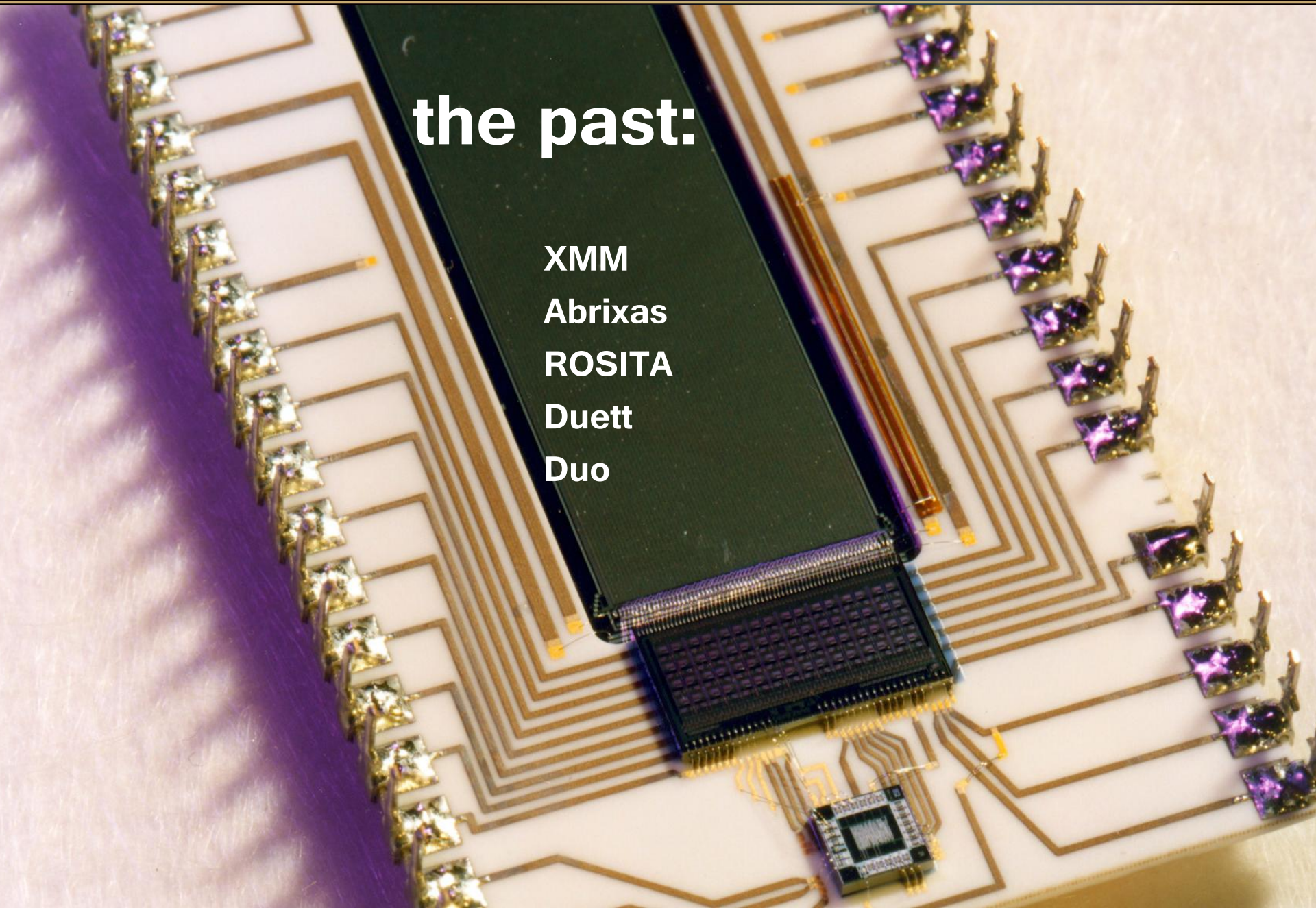
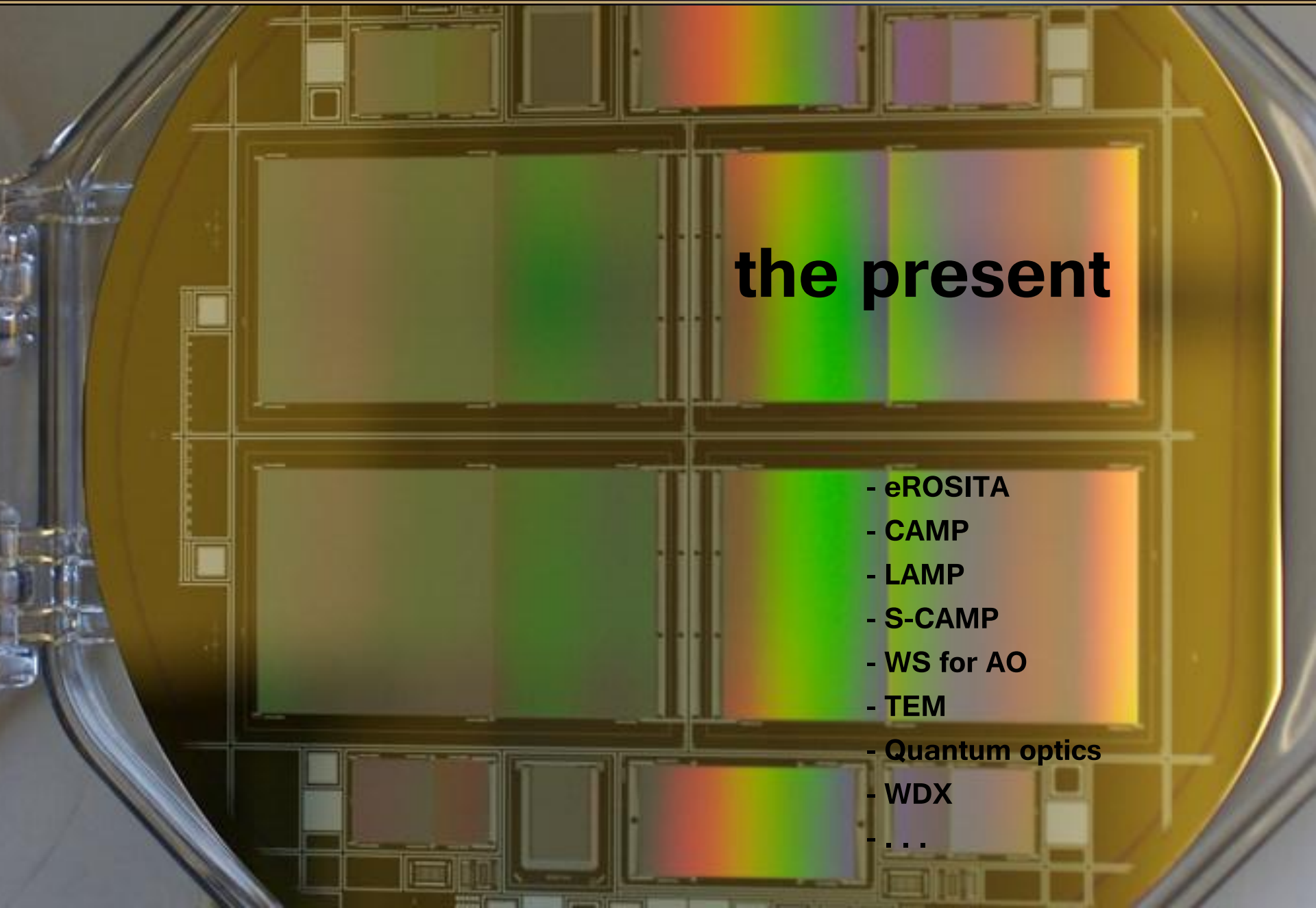
WFI ON IXO


the past:
XMM
Abrixas
ROSITA
Duett
Duo



the present

- eROSITA
- CAMP
- LAMP
- S-CAMP
- WS for AO
- TEM
- Quantum optics
- WDX
- . . .

the future

- BepiColombo
- IXO
- E-XFEL
- . . .

The IXO Wide Field Imager Team

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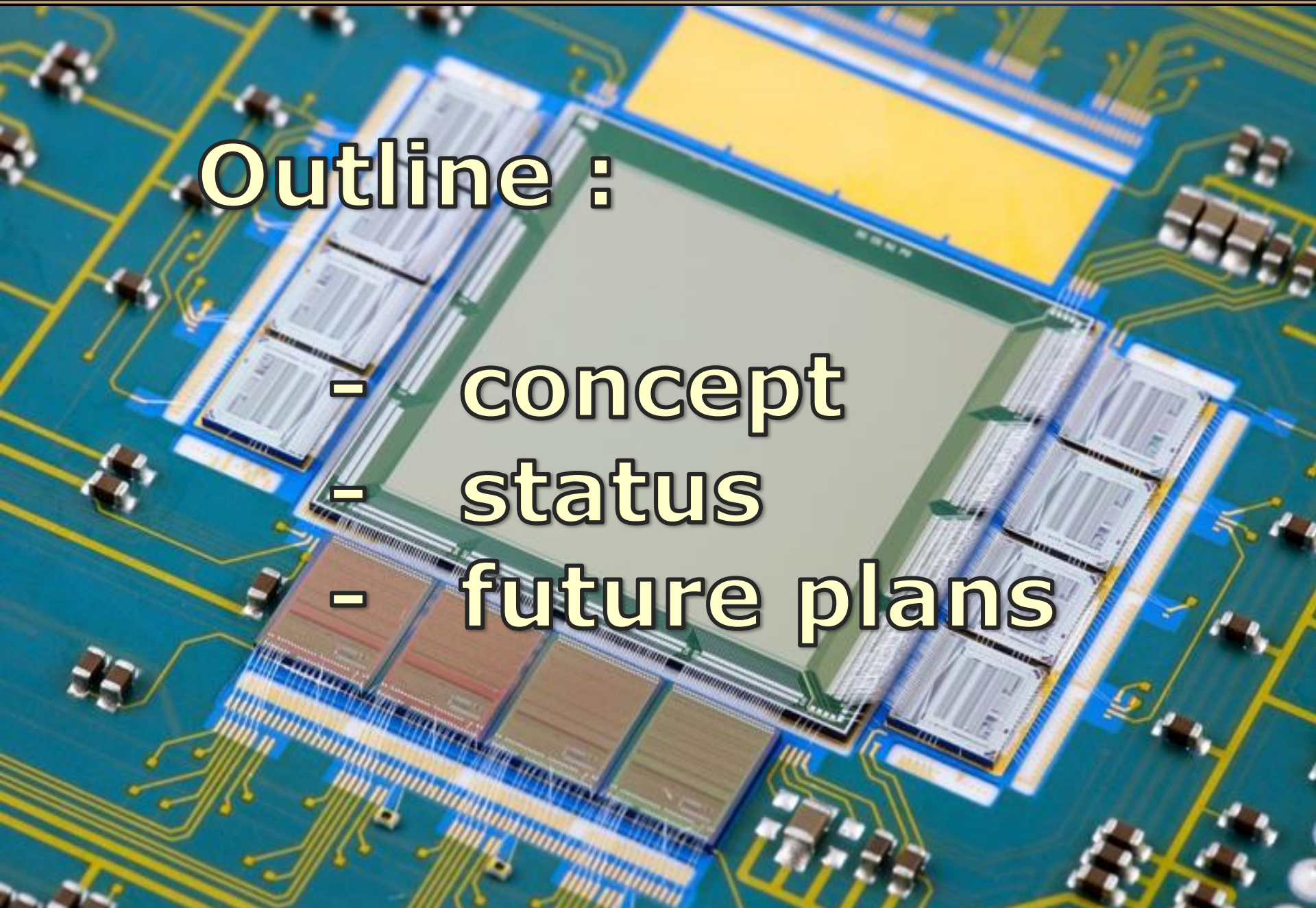
S. Murray	Harvard-Smithsonian CfA	
H. Tsunemi	Osaka University	• calibration
J. Wilms, C. Schmid, M. Martin, Ingo Kreykenbohm	ECAP Erlangen	• simulation • science software
M. Kuster	XFEL GmbH	
S. Hauf, P.-M. Lang	TU Darmstadt	

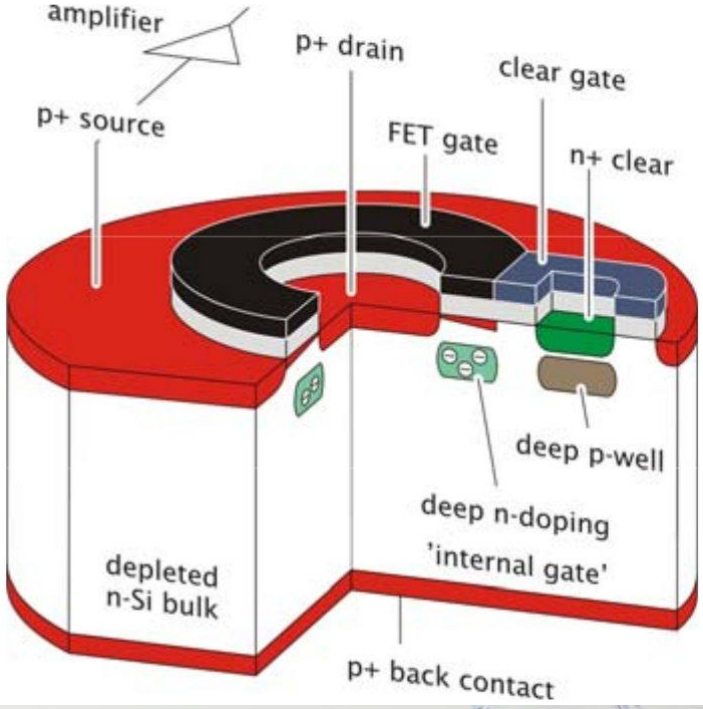


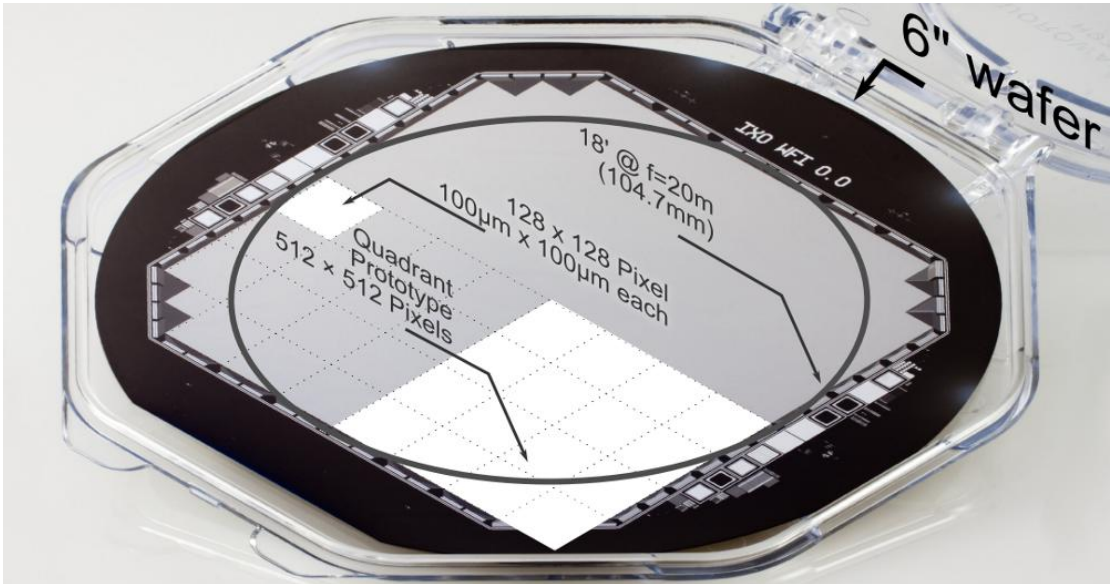
Outline :

- concept
- status
- future plans

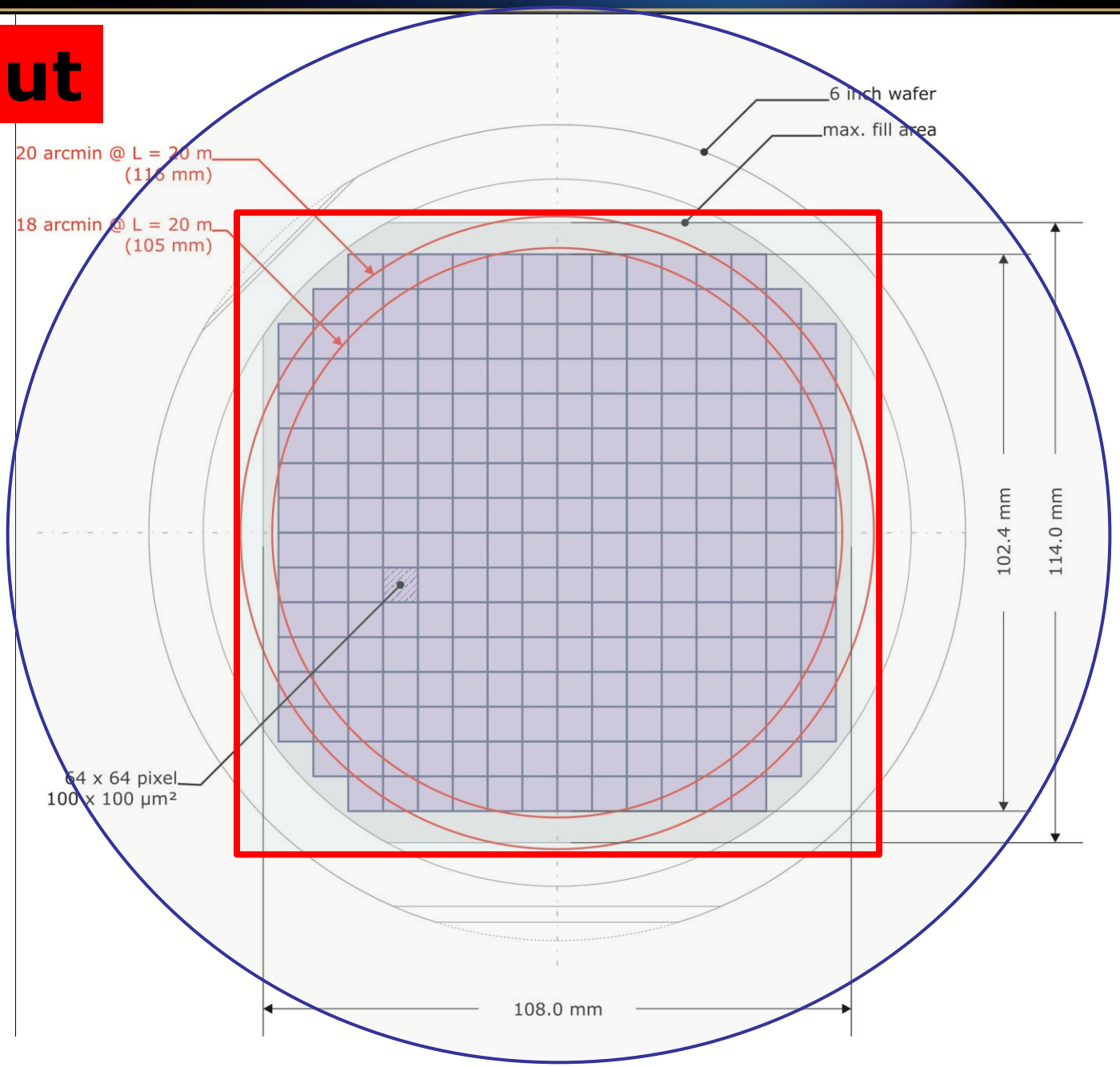
WFI concept

- DEPFET APS array
- 1024 x 1024 pixels
- 10 x 10 cm^2
- 18’ FoV
- 125 eV (FWHM) @ 5.9keV
- 2 - 4 µs per row
- 450 µm thick
- 100 x 100 μm^2 pixels
- random pixel access





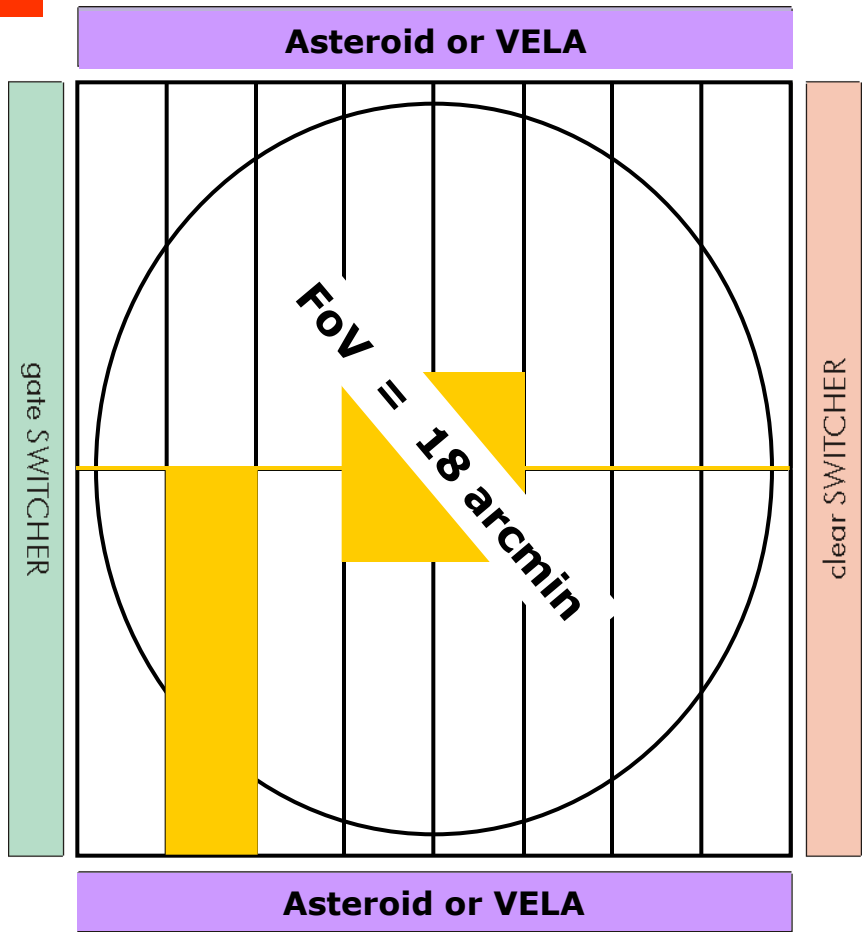
FoV Layout

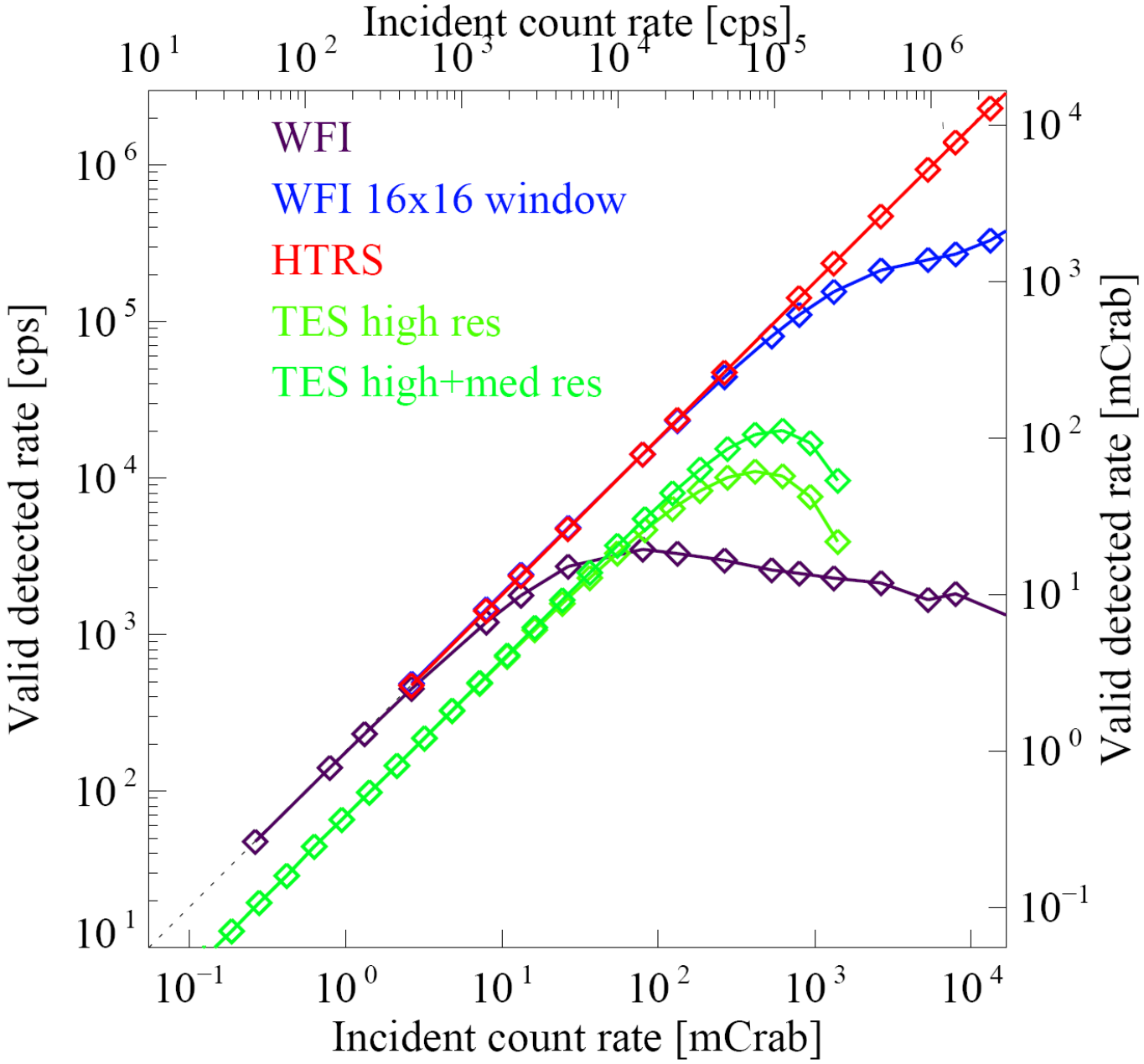


8 inch Si wafer implemenation for a 20 – 22 arcsec FoV implementation

DEPFETs for the IXO WFI

1. Flexible operating modes
2. low power dissipation (less than 2 W in 100 cm^2, DePFETs only)
3. Fano limited energy resolution from 0.5 keV to 30 keV
4. Spatial resolution better than 20 µm @ 100 µm pixel size
5. Homogeneous radiation entrance window
6. Intrinsic radiation hardness, no charge transfer needed
7. ENC was lowered to 0.2 e^- rms with RNDR
8. Thin optical ``Blocking Filter´´ can be directly integrated
9. Operation at ``warm temperatures´´, e.g. – 40 ° C





Count rate capabilities Of IXO

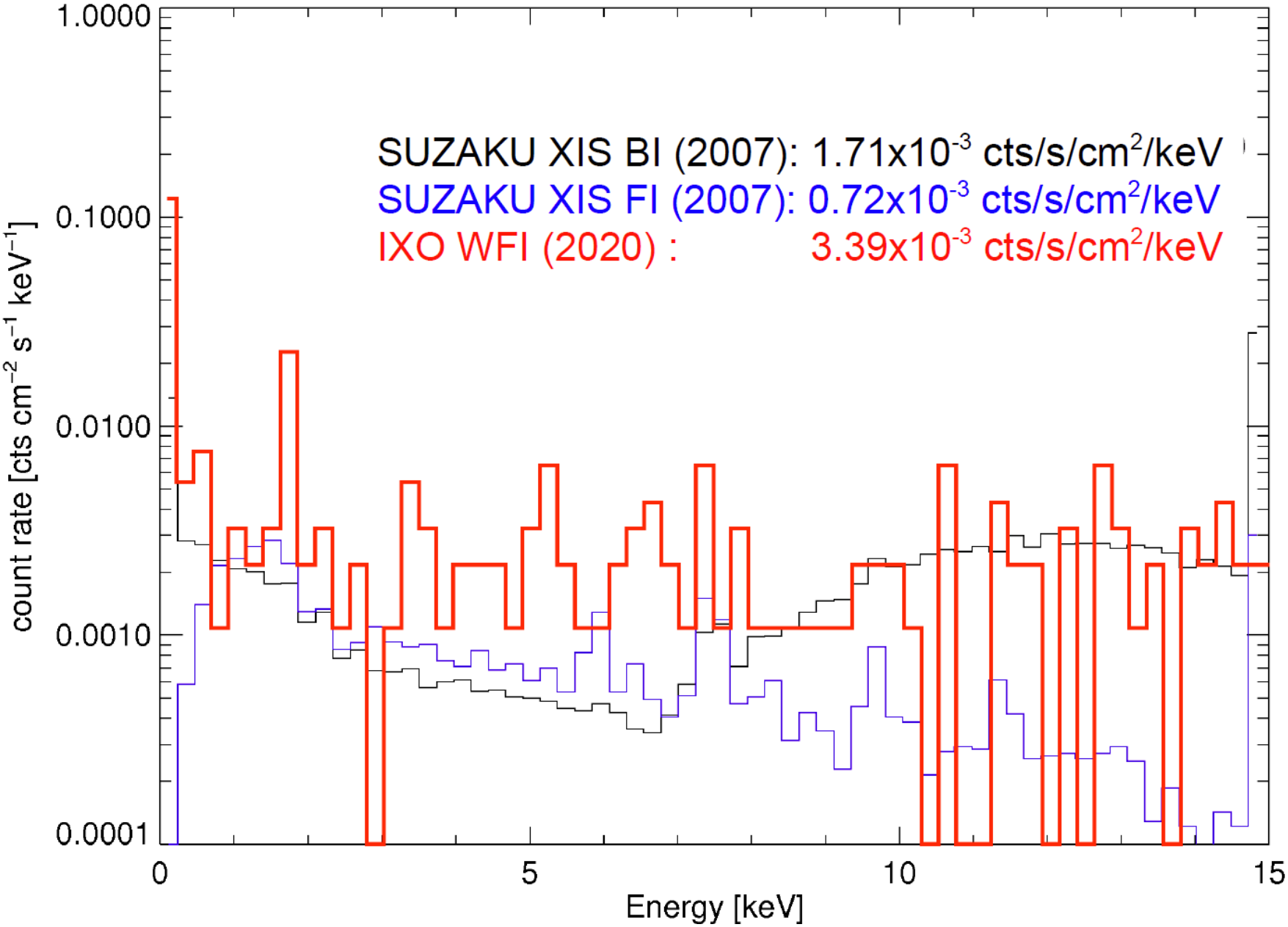
Assumptions:

PSF: 5 arcsec

photon pile-up: rejected
pattern pile-up: rejected

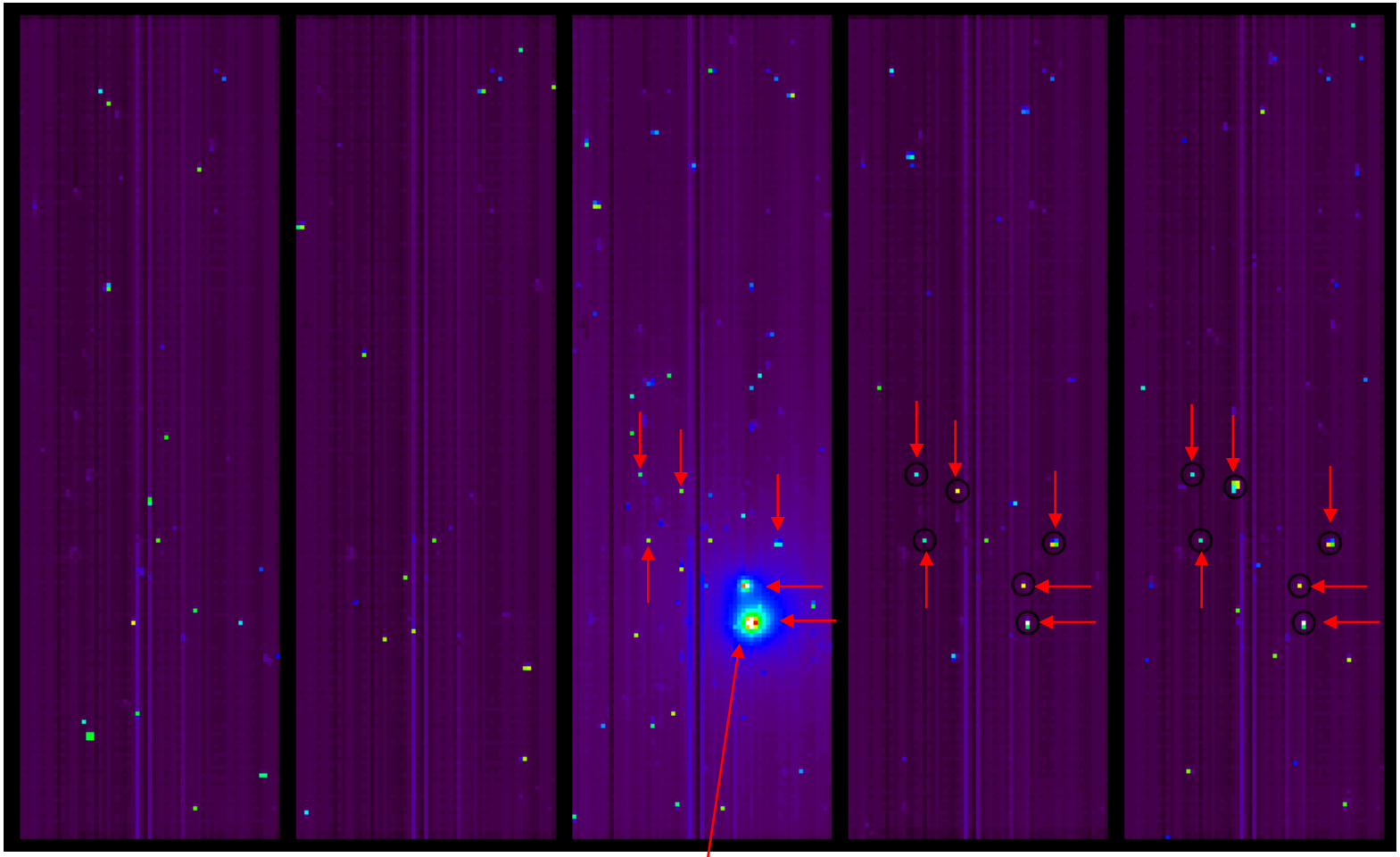
Poisson statistics for incident photons

A_{eff} = 3 m²


SUZAKU XIS BI (2007): 1.71x10-3 cts/s/cm2/keV
SUZAKU XIS FI (2007): 0.72x10-3 cts/s/cm2/keV
IXO WFI (2020) : 3.39x10-3 cts/s/cm2/keV
count rate [cts cm-2 s-1 keV-1]
1.0000
0.1000
0.0100
0.0010
0.0001
0
5
10
15
Energy [keV]

Analysis of scatter particles: pnCCD damage

impact of particles → 17 bright pixels at 6 locations

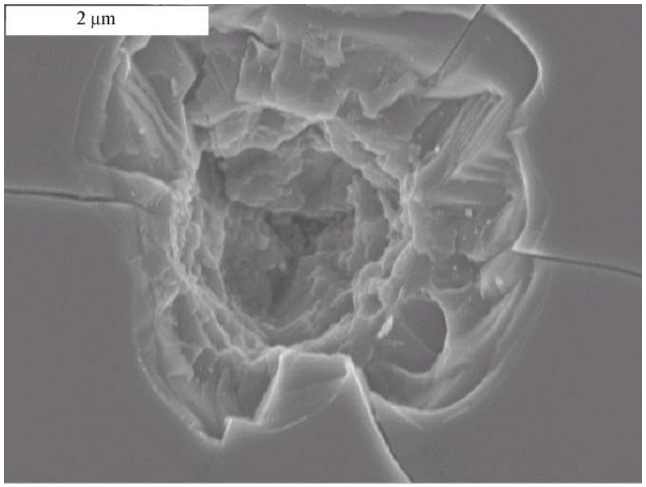


Frame # 11777 11778 11779 11780 11781 (44ms/frame)

light flash

Analysis of scatter particles: SEM

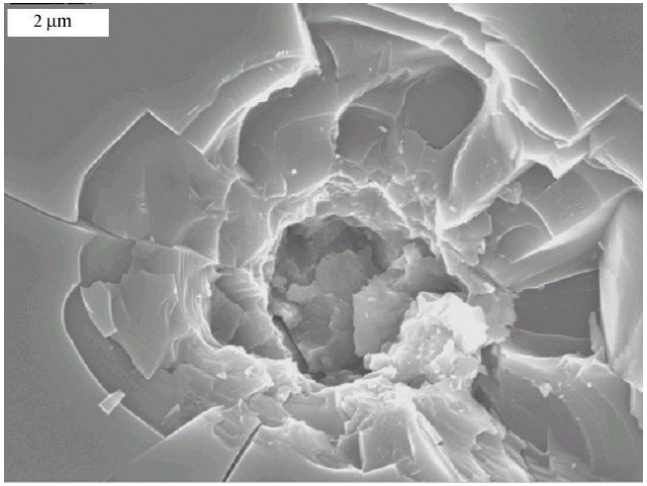
Dust particle impact:

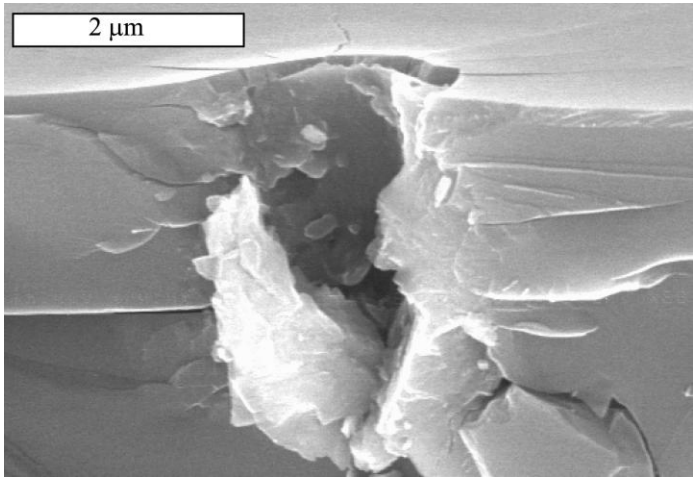


experiment with
Silicon wafers

- Fe particles of r = .3 µm, v = 10 km/s
- craters in silicon: 0.1 µm and 10 µm

Scatter particle impact:



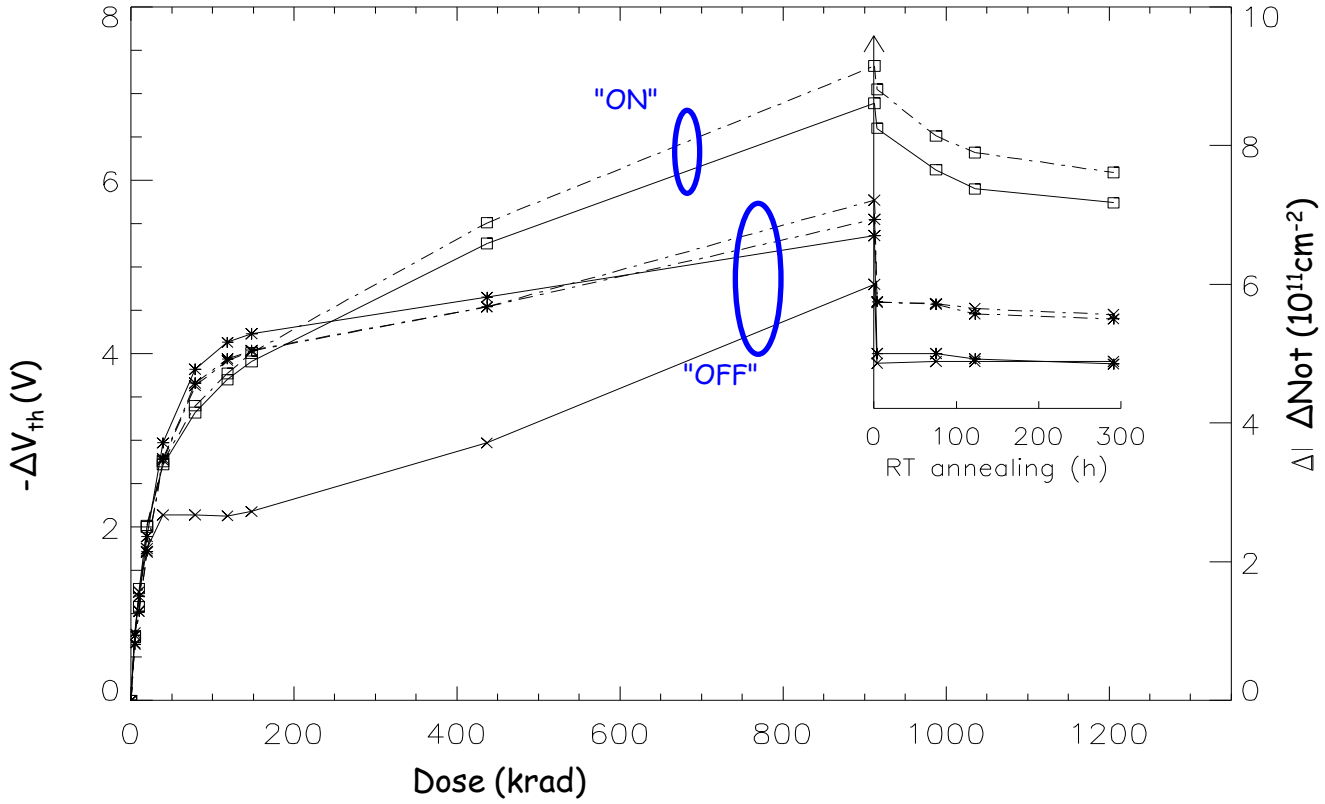


Threshold voltage shift

- GSF – National Research Center for Environment and Health, Munich

^{60}Co (1.17 MeV and 1.33 MeV)

No annealing during irradiation
→ ~ 3 days irradiation
Dose rate: ≈ 20 krad(SiO_2)/h

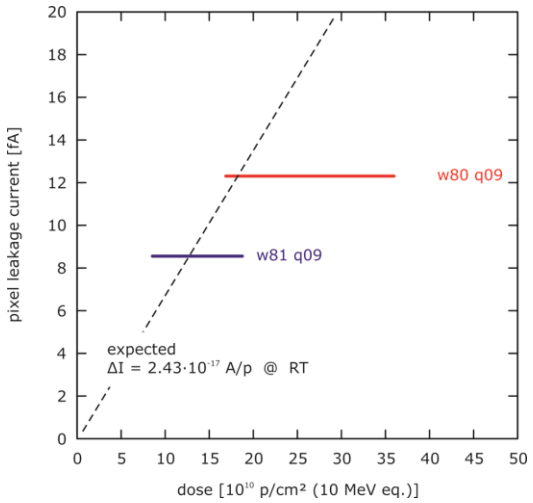


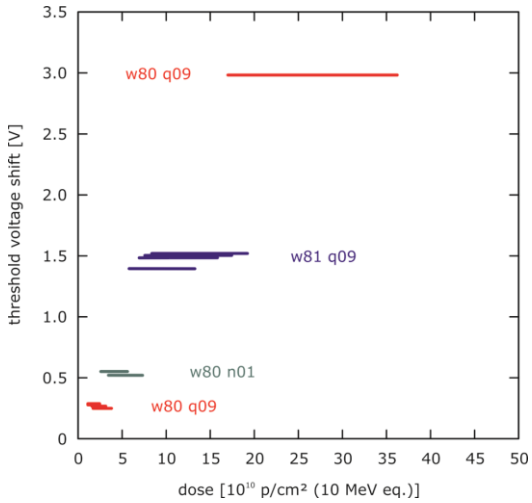
Long Term Stability

- radiation hardness - protons
  - ▷ 10 MeV protons
  - ▷ 10^{11} p (10 MeV)/cm²
  - ▷ leakage current

    $\Delta I = 2.43 \cdot 10^{-17}$ A/p @ RT
  - ▷ threshold voltage shift

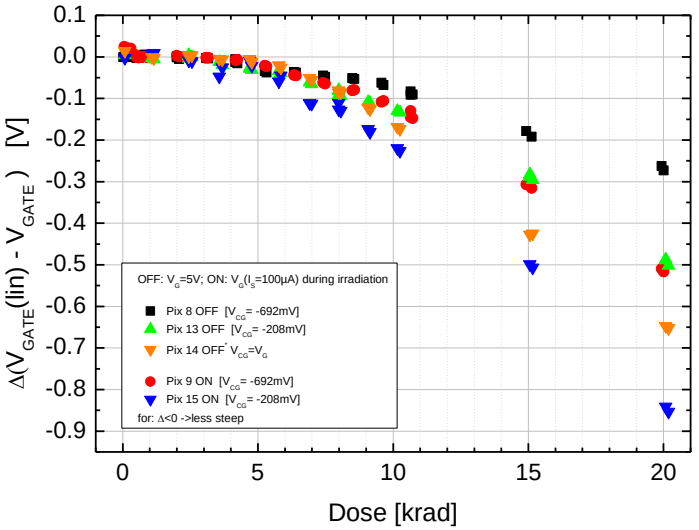
    $\Delta V\_th \ll 0.1$ V @ 10^{10} p/cm²



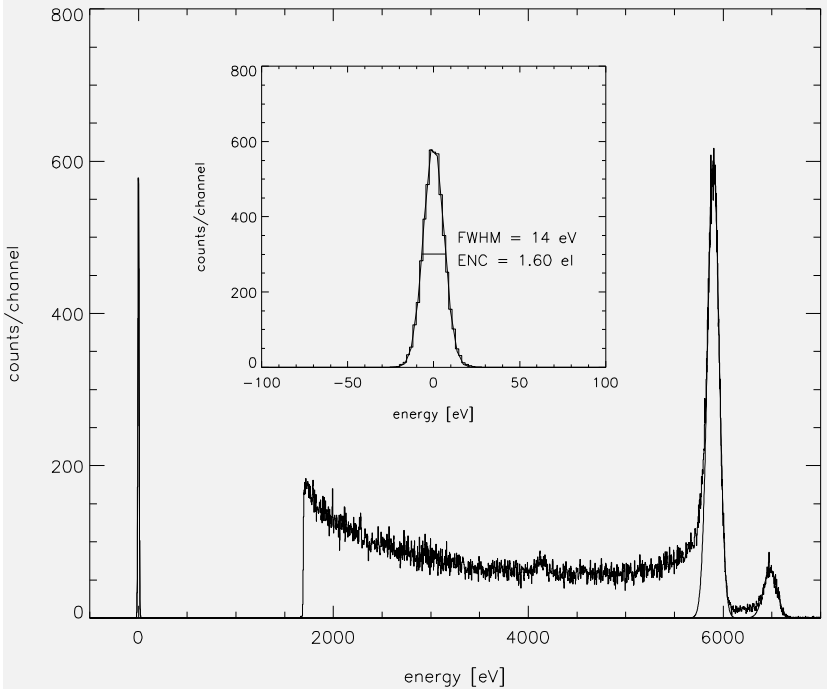


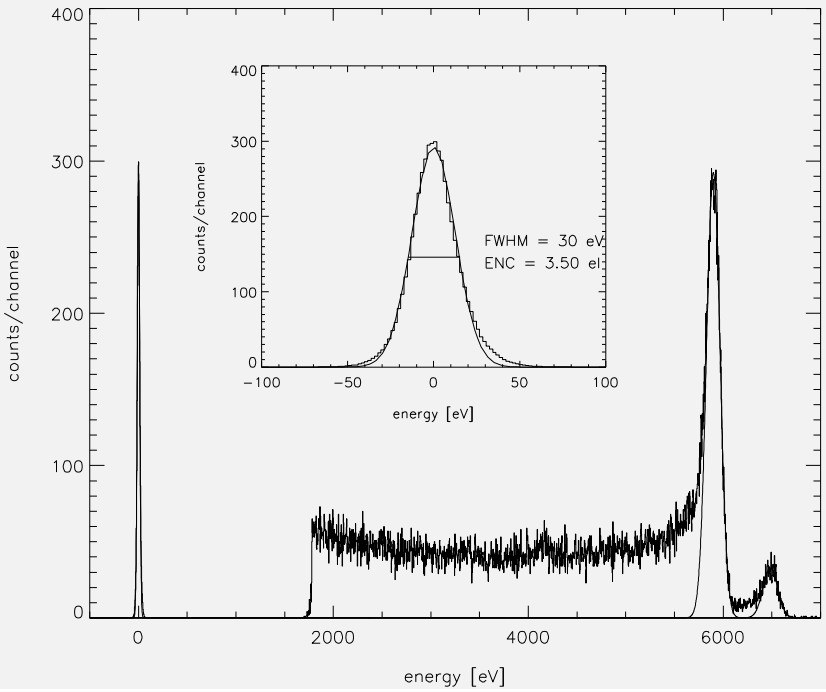
- radiation hardness - X-rays
  - ▷ X-rays (Fe-K, 6.4 keV)
  - ▷ > 20 krad
  - ▷ threshold voltage shift

    $\Delta V\_th \leq 0.2$ V @ 10 krad



^{55}Fe Spectrum (single DePFET pixel)





non-irradiated
V_{thresh}≈-0.2V, V_{gate}=-2V
I_{drain}=41 μA
time cont. shaping τ=10 μs

Noise ENC=1.6 e^- (rms)

at T>23 degC

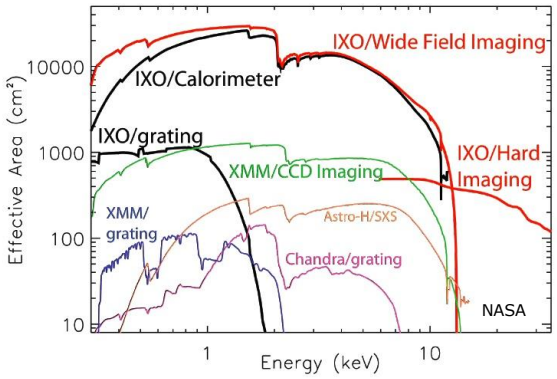
912 krad ^{60}Co
V_{thresh}≈-4.0V, V_{gate}=-6.0V
I_{drain}=40 μA
time cont. shaping τ=10 μs

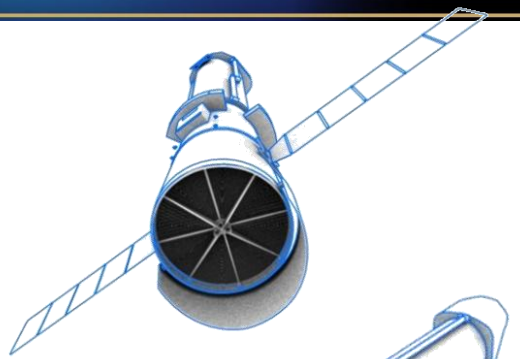
Noise ENC=3.5 e^- (rms)

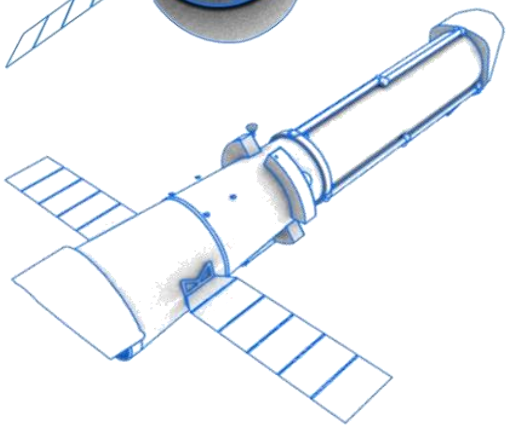
at T>23 degC

The IXO spacecraft

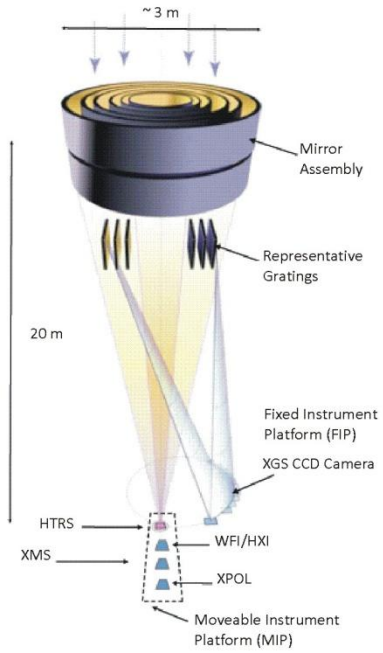
- **optics module**
  - ▷ **Wolter-I telescope**
  - ▷ **optional slumped glass / Si pore**
  - ▷ **3 m² @ 1.25 keV, 5 arcsec HPD**







- **deployment module**
  - ▷ **focal length 20 m**
  - ▷ **extension on orbit**



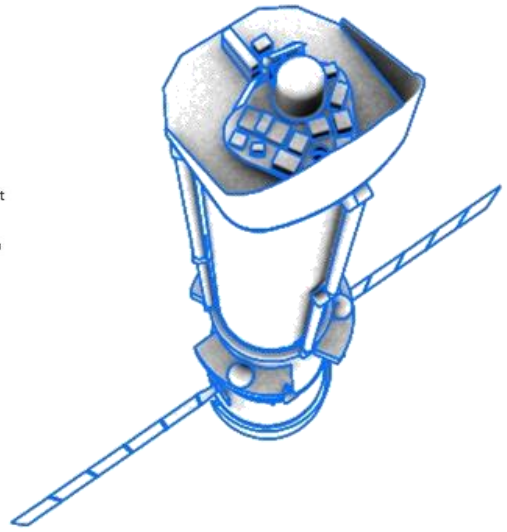
- **instrument module**

on moveable instrument platform:

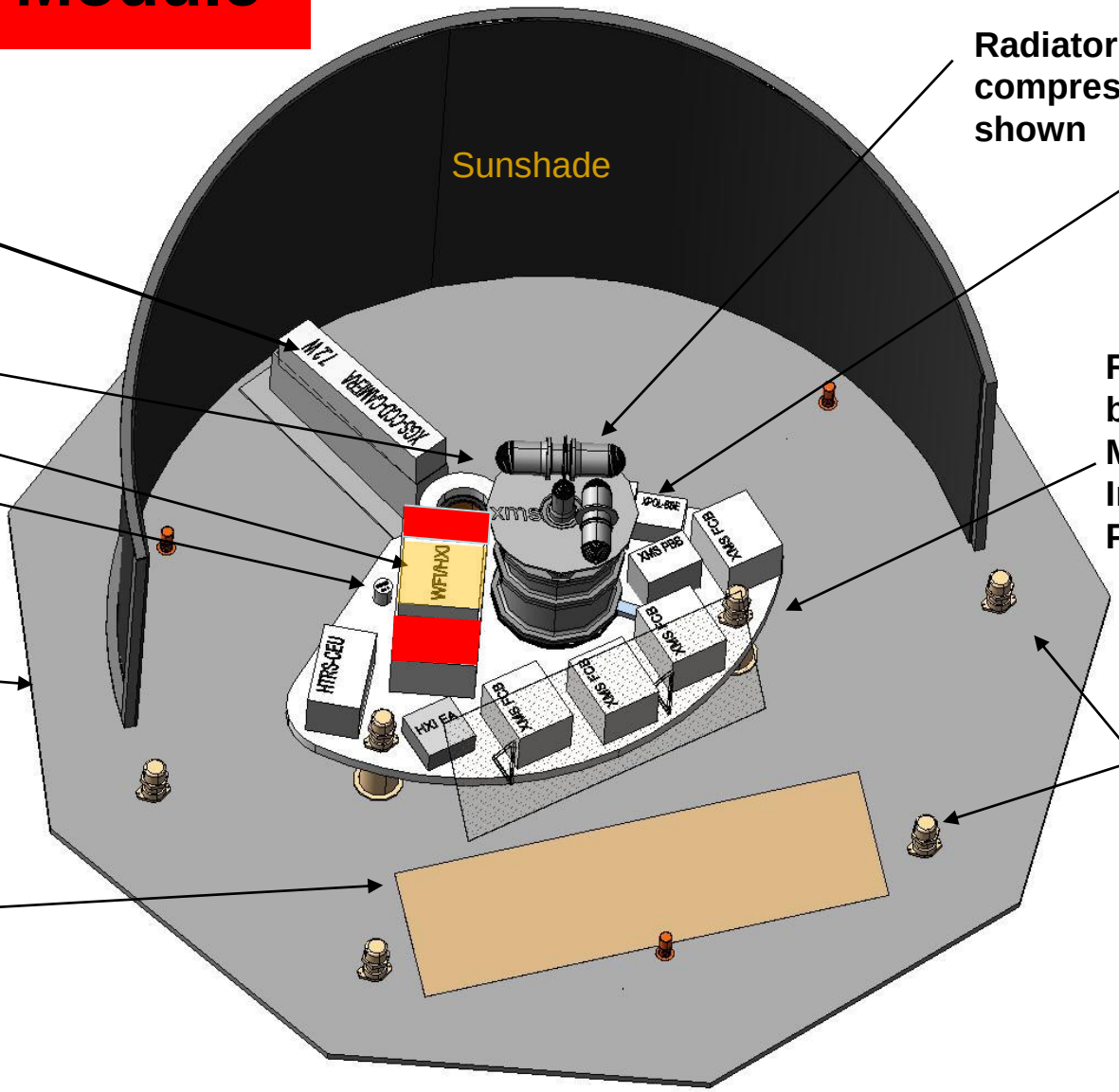
- ▷ **X-ray Microcalorimeter Spectrometer**
- ▷ **Wide Field Imager / Hard X-ray Imager**
- ▷ **X-ray Grating Spectrometer**
- ▷ **High Time Resolution Spectrometer**
- ▷ **X-ray Polarimeter**

on fixed instrument platform:

- ▷ **X-ray Grating Spectrometer**

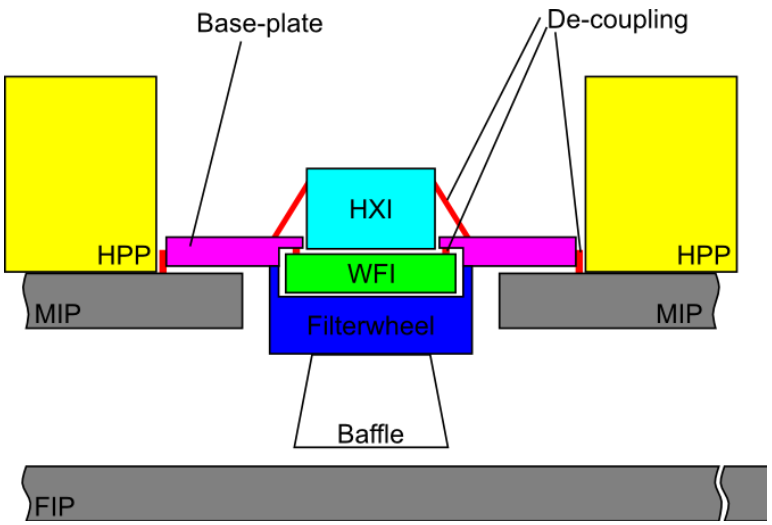


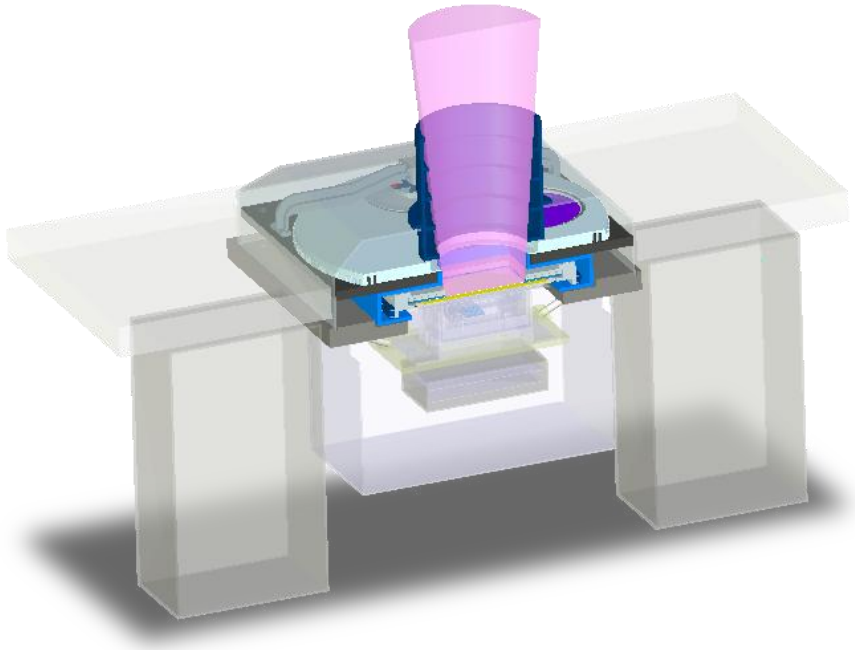
Instrument Module



WFI / HXI layout

- combined instrument WFI & HXI
  - ▷ WFI & HXI & filter wheel on common base plate
  - ▷ thermally decoupled
- Hard X-ray Imager
  - ▷ Japanese/French system
  - ▷ double-sided CdTe strip detector
  - ▷ energy coverage 15 keV to 40 keV
  - ▷ 2 Si strip anti-coincidence detectors
  - ▷ active BGO shield
- WFI data acquisition flow
  - ▷ signal digitization
  - ▷ pre-processing (offset, gain, common mode)
  - ▷ frame building, formatting & compression
  - ▷ controlled by central 'brain'





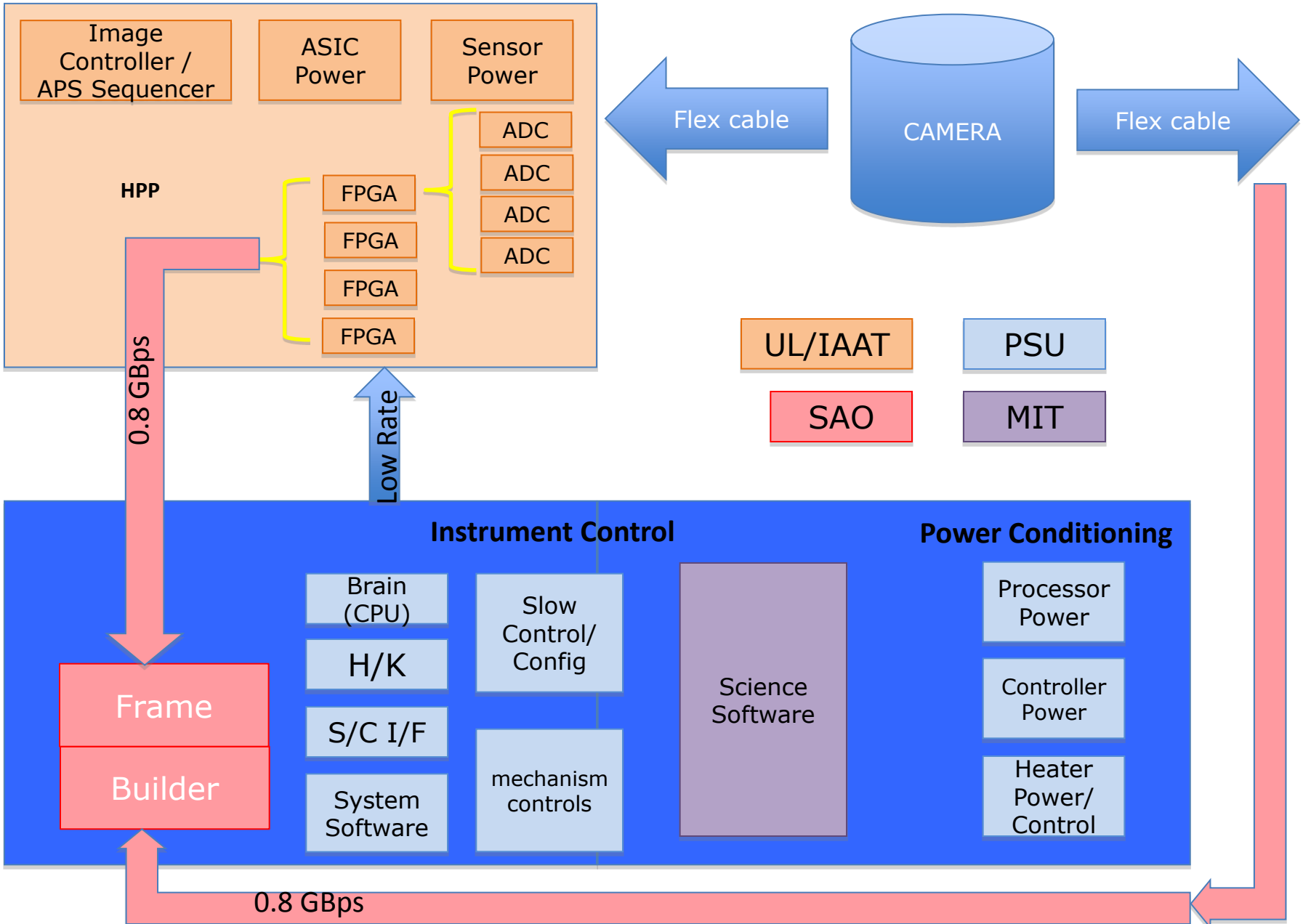
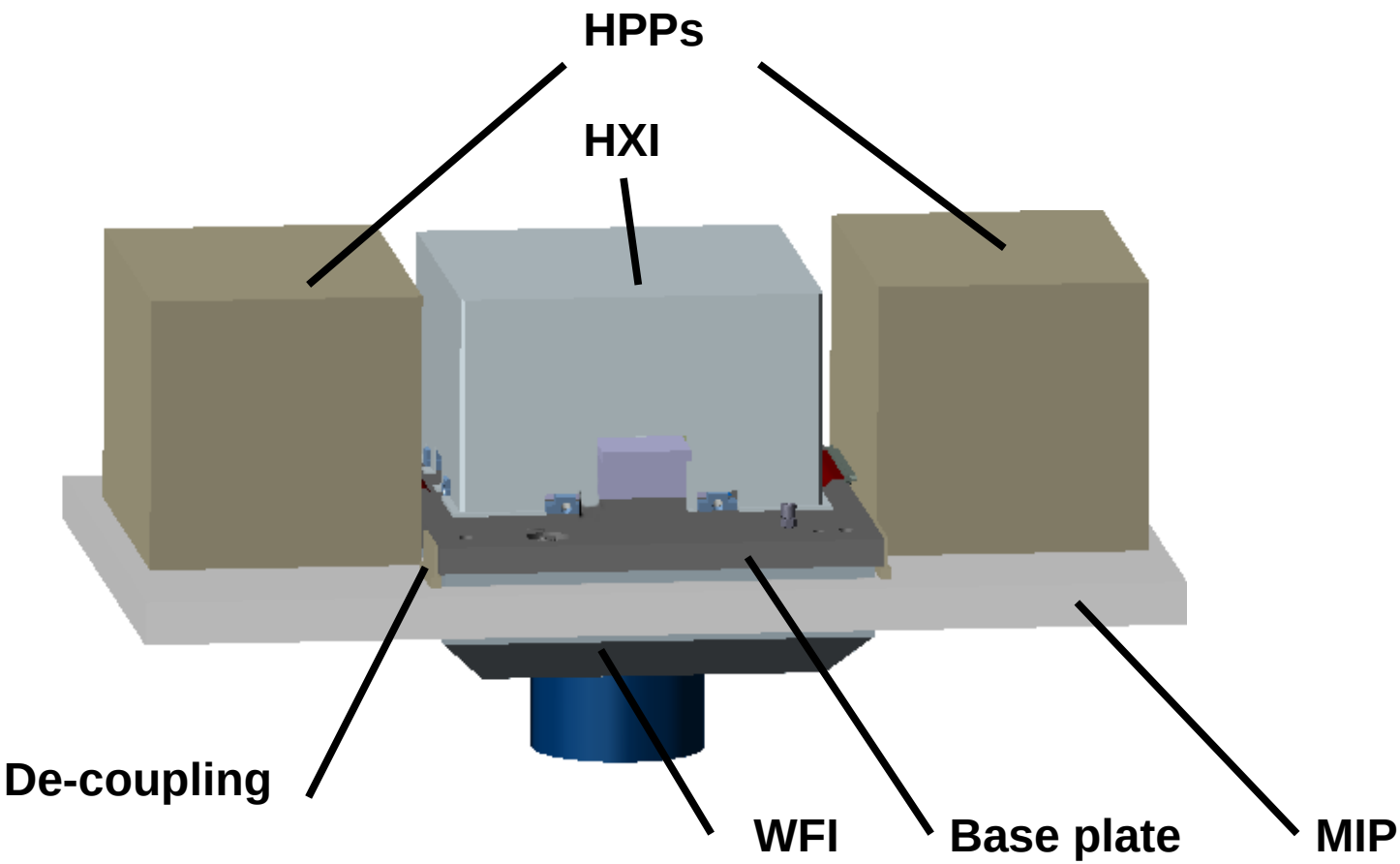
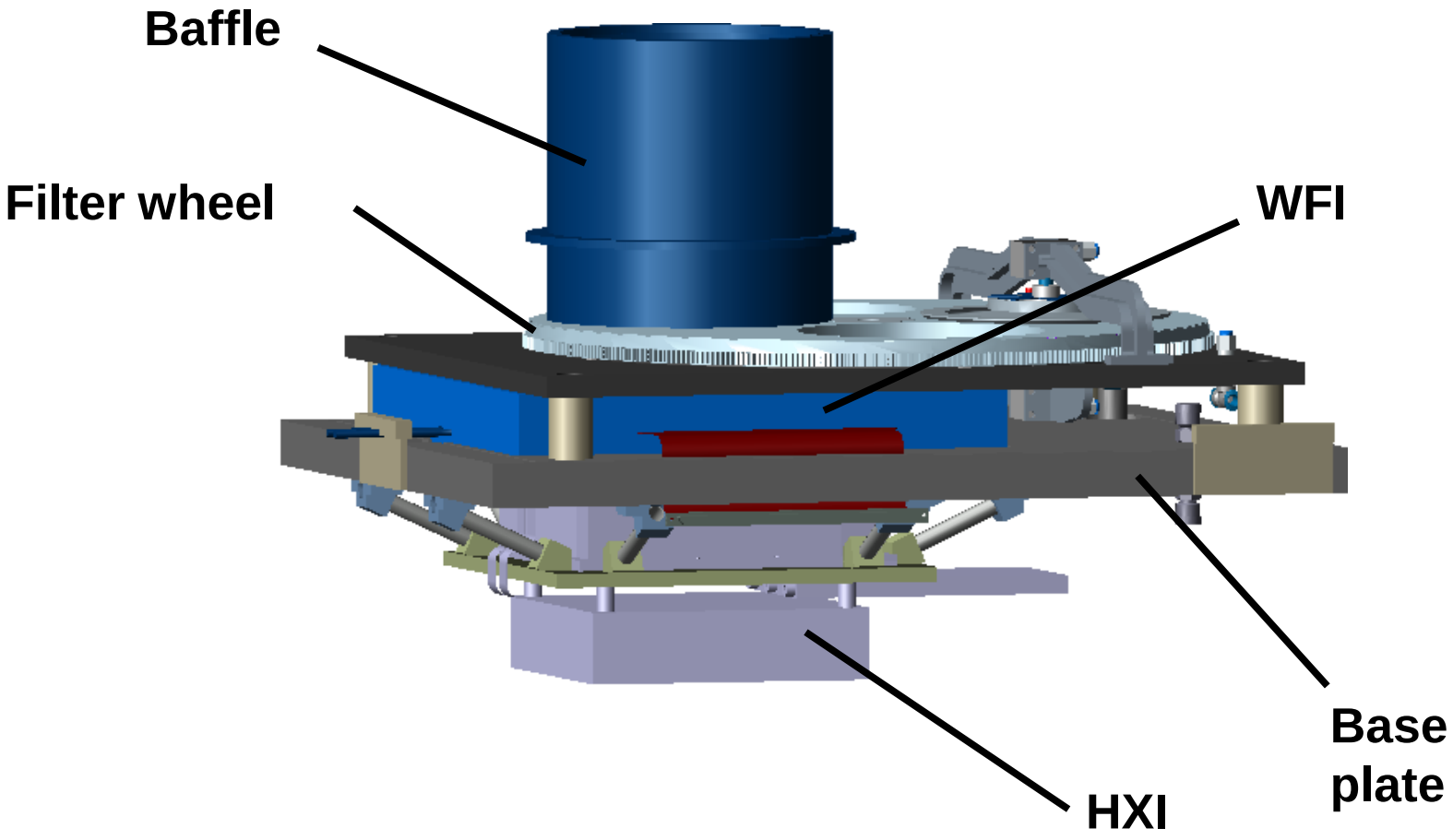


Image Controller / APS Sequencer
ASIC Power
Sensor Power
HPP
FPGA
FPGA
FPGA
FPGA
ADC
ADC
ADC
ADC
Flex cable
CAMERA
Flex cable
0.8 GBps
Low Rate
UL/IAAT
PSU
SAO
MIT
Instrument Control
Power Conditioning
Brain (CPU)
H/K
S/C I/F
System Software
Slow Control/ Config
mechanism controls
Science Software
Processor Power
Controller Power
Heater Power/ Control
Frame
Builder
0.8 GBps

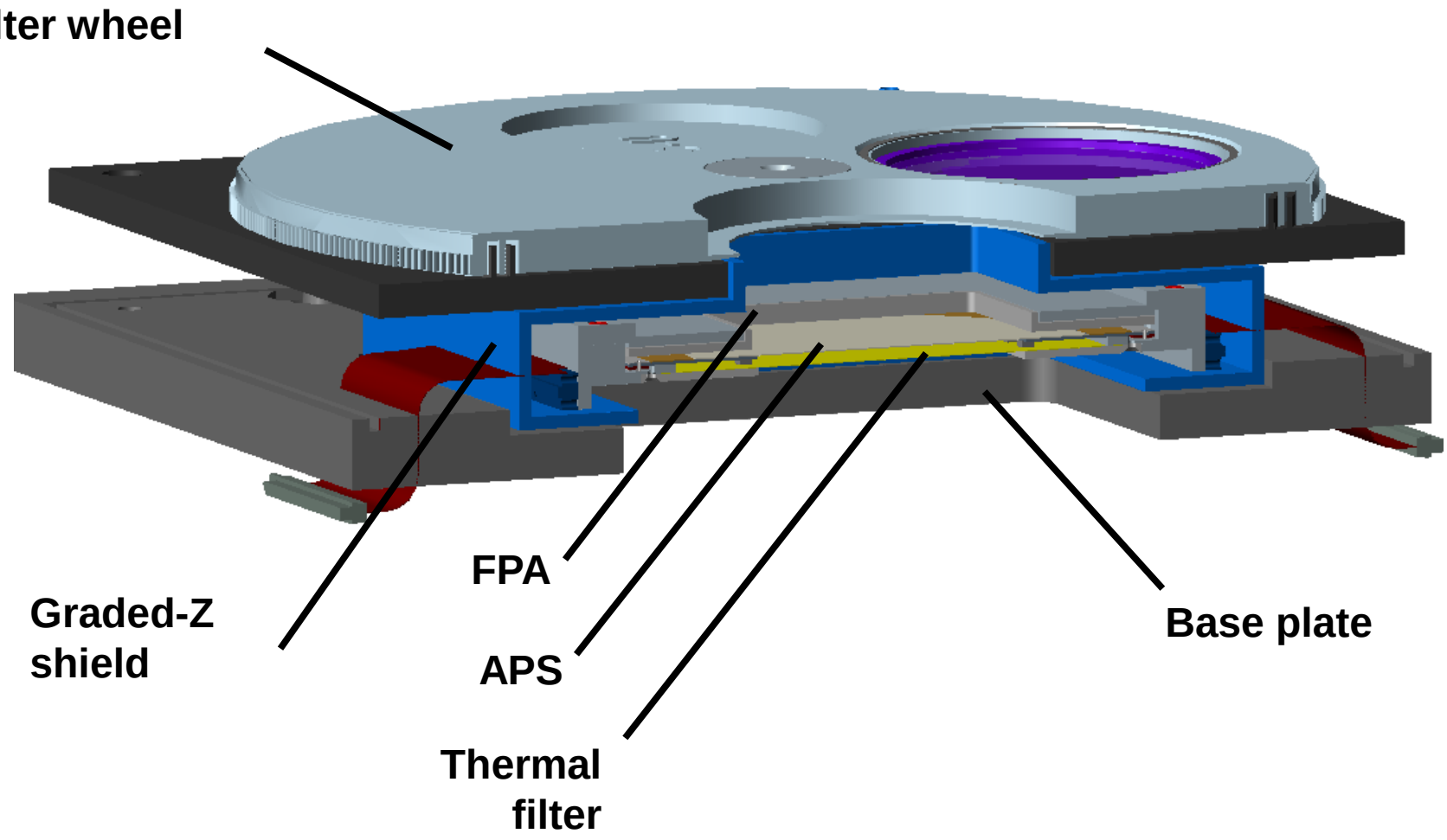
Mechanical model: Overview



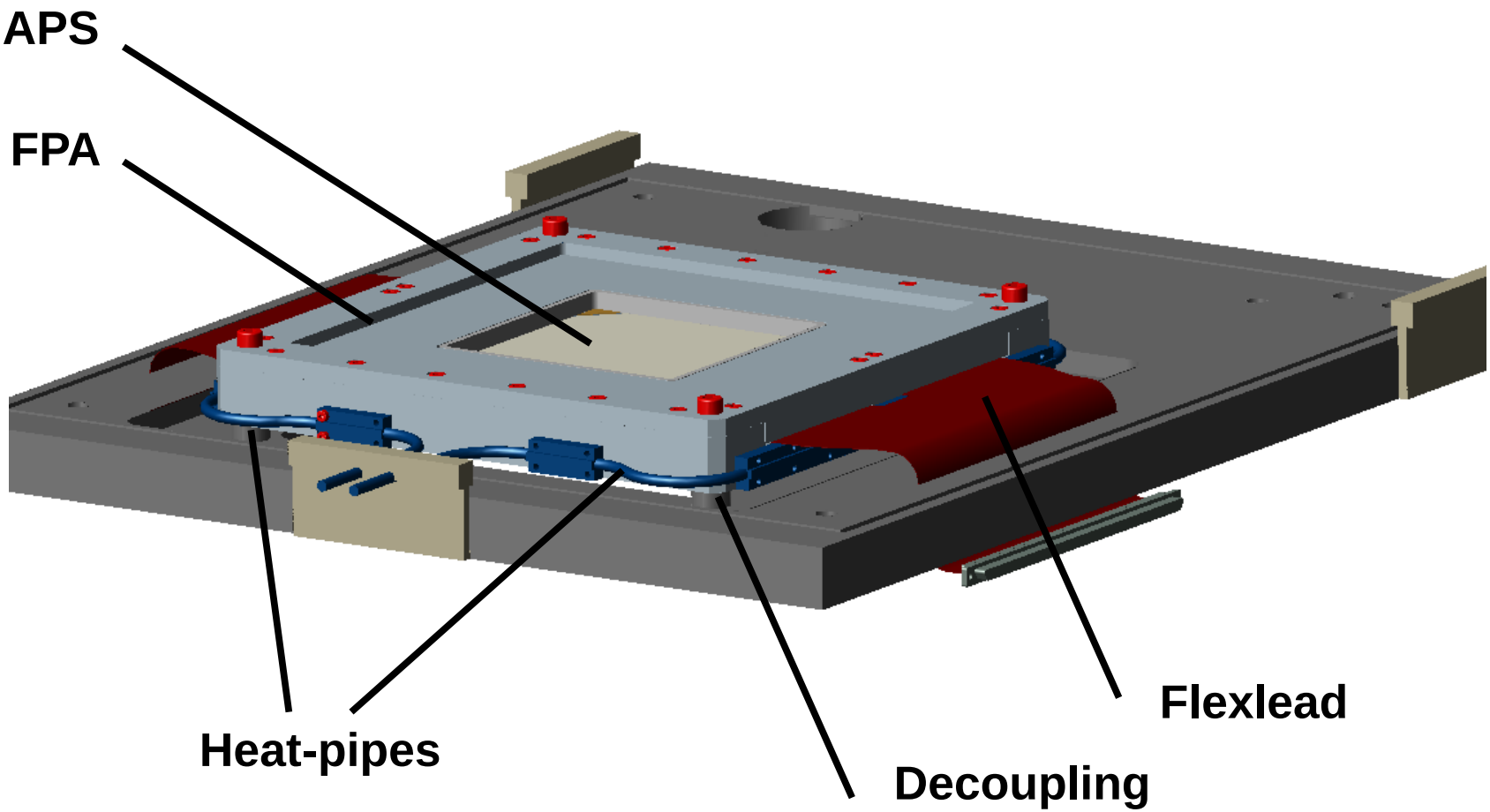
Mechanical model: HXI & WFI on baseplate

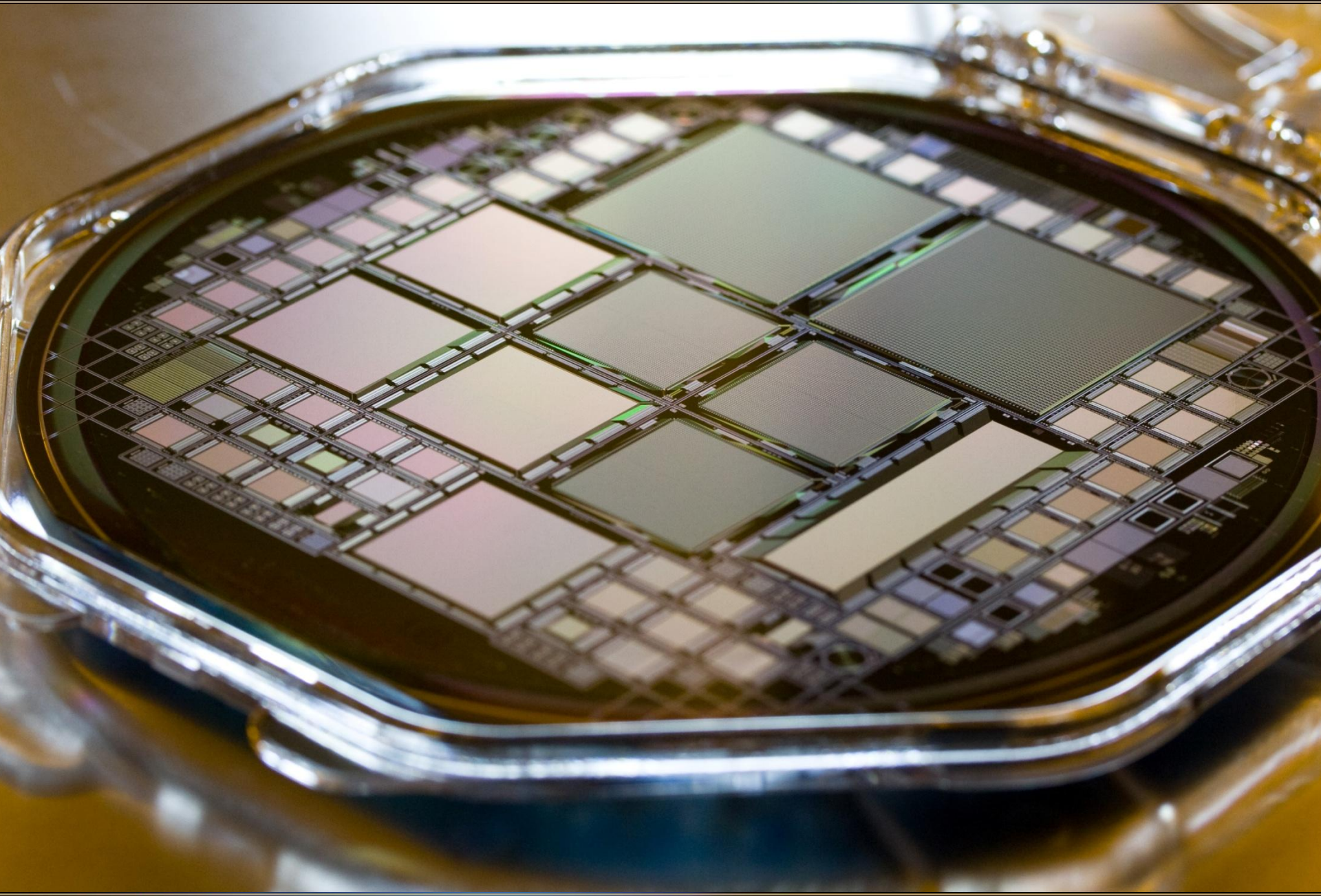


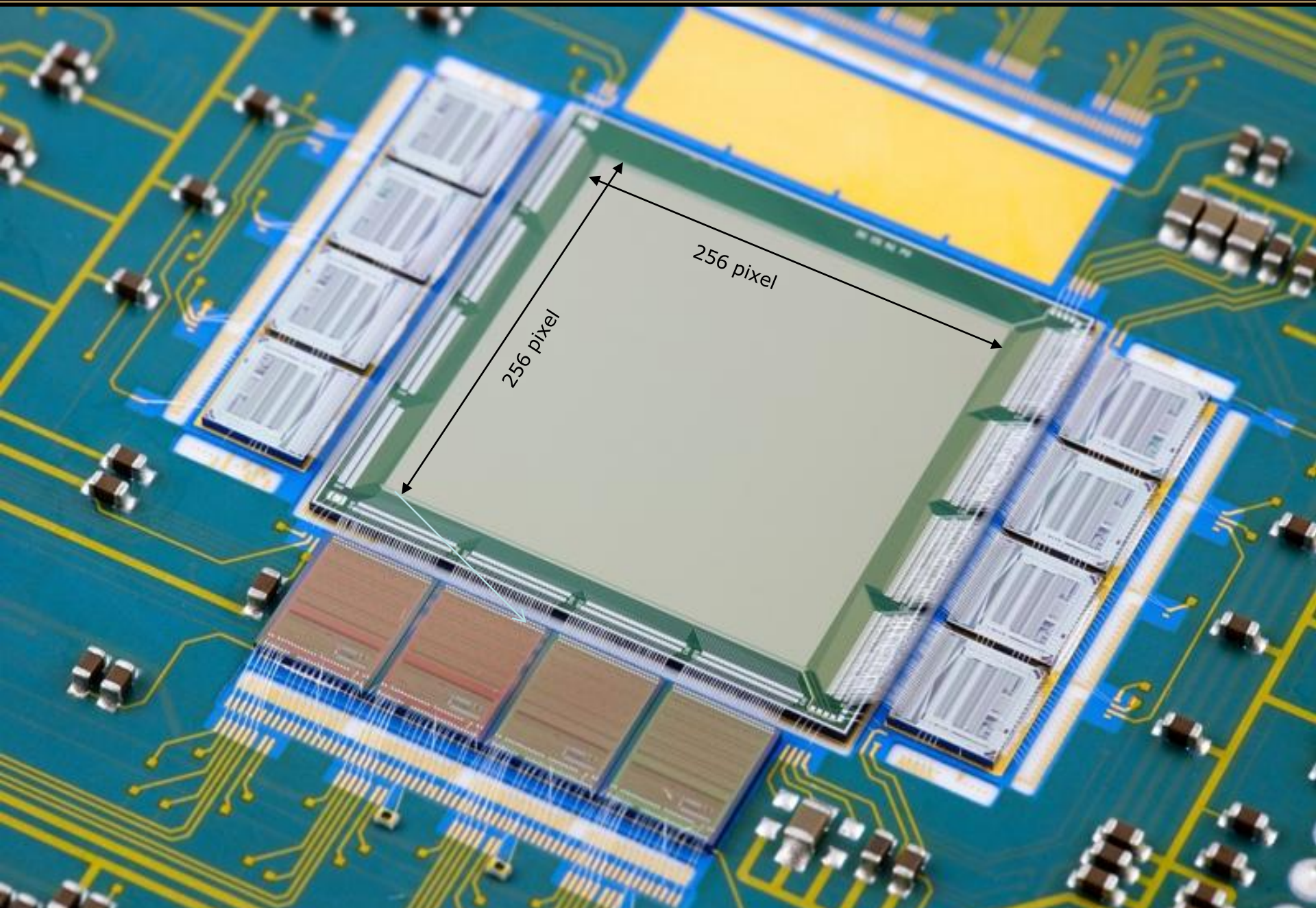
Mechanical model: WFI and filter wheel

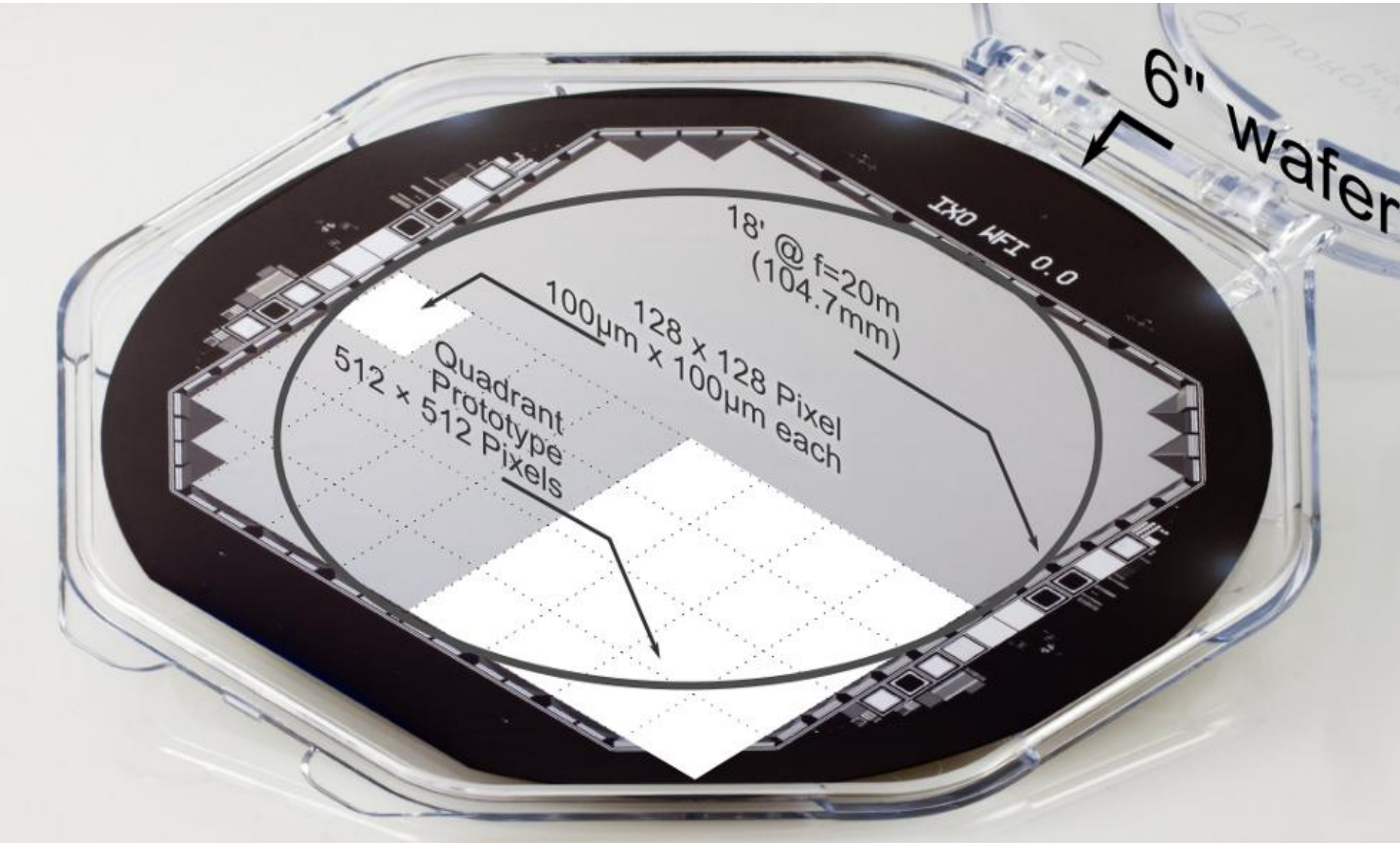


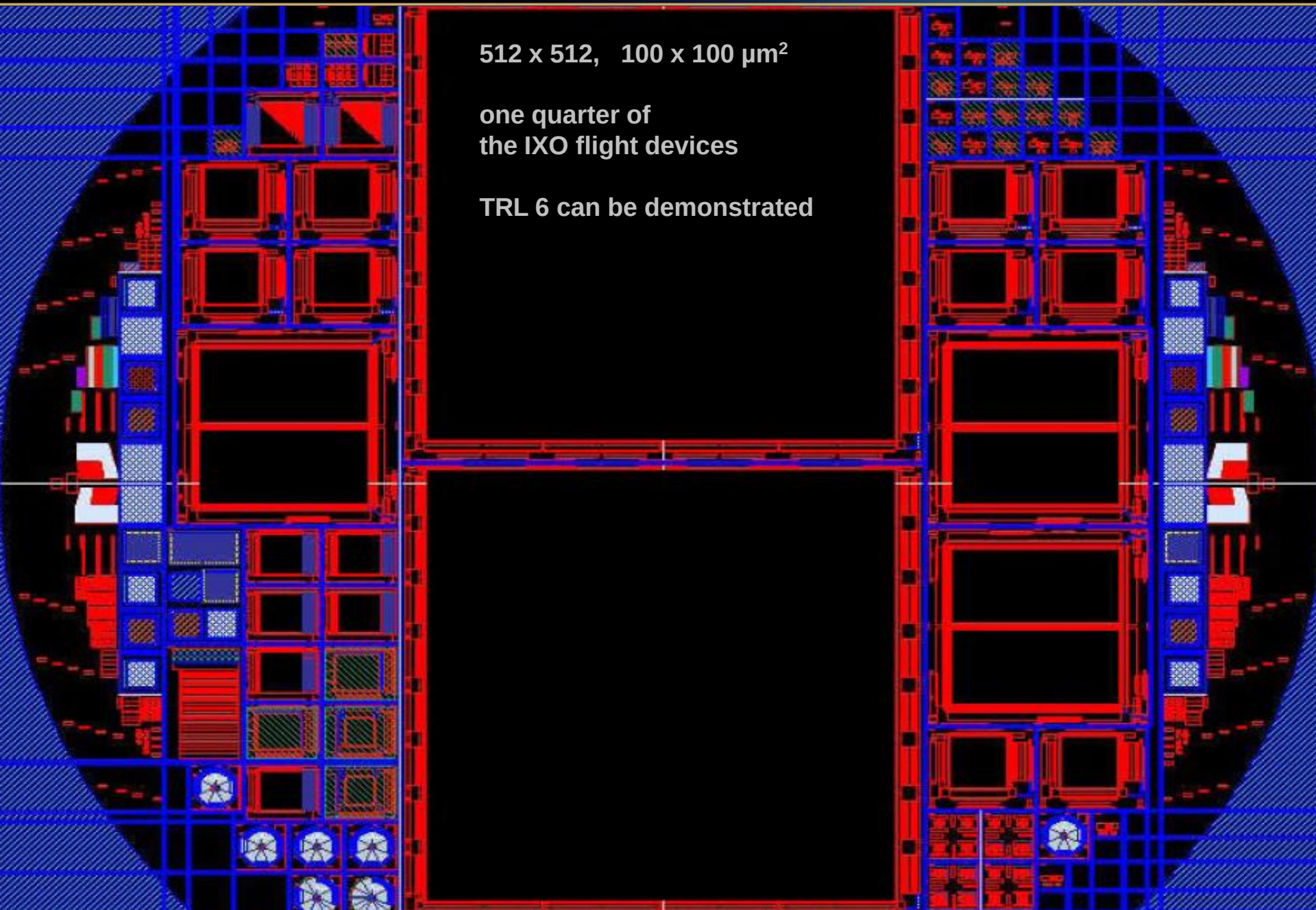
Mechanical model: Focal Plane Assembly






256 pixel
256 pixel


6" wafer
IXO WFI 0.0
18' @ f=20m
(104.7mm)
128 x 128 Pixel
100µm x 100µm each
Quadrant
Prototype
512 x 512 Pixels

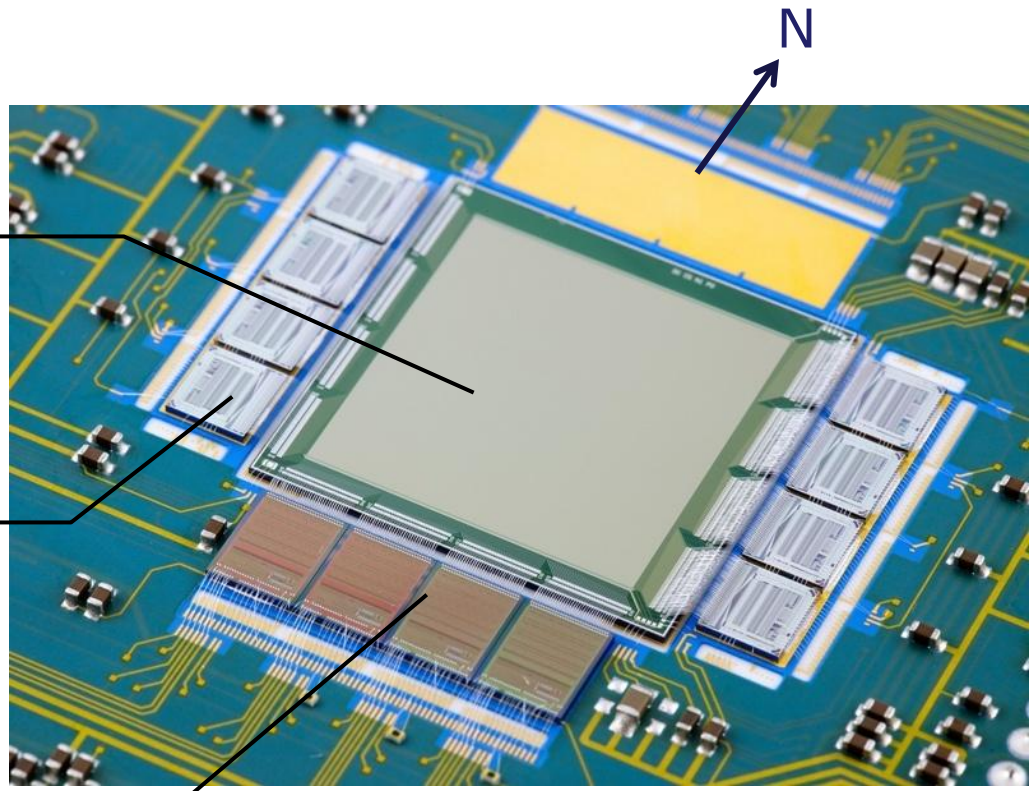

512 x 512, 100 x 100 µm²
one quarter of
the IXO flight devices
TRL 6 can be demonstrated

XL DEPFET device

256 x 256 DEPFET pixels of 75 x 75 μm²

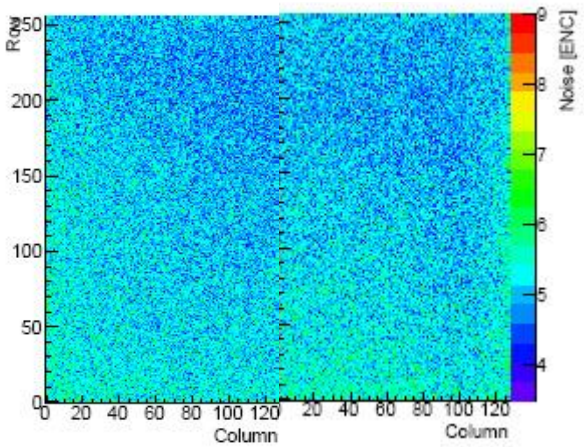
Eight 64-channel Switcher 2b ASICs for row-wise readout

Four 64-channel Asteroid 1.0 ASICs for column parallel readout



Noise uniformity

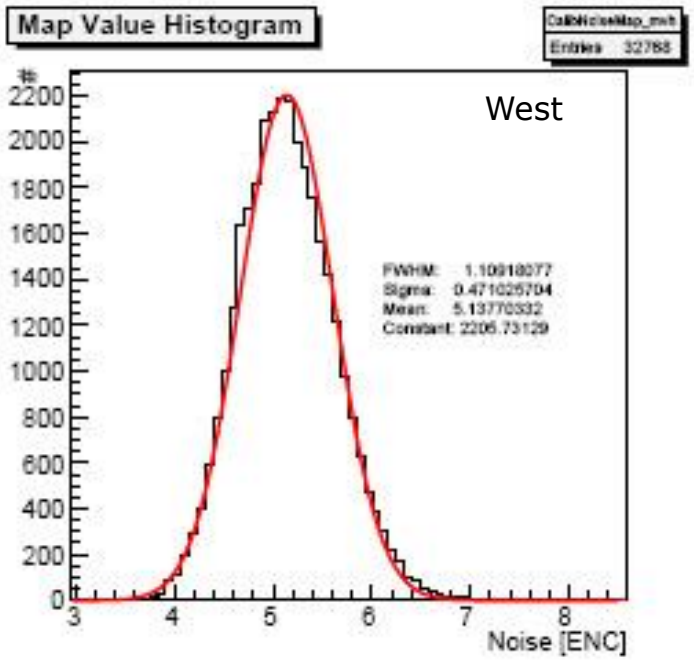
- **ENC = 5.15 el. Rms @ - 5 ° C**
- **Standard deviation 0.46 el. rms (9 %)**

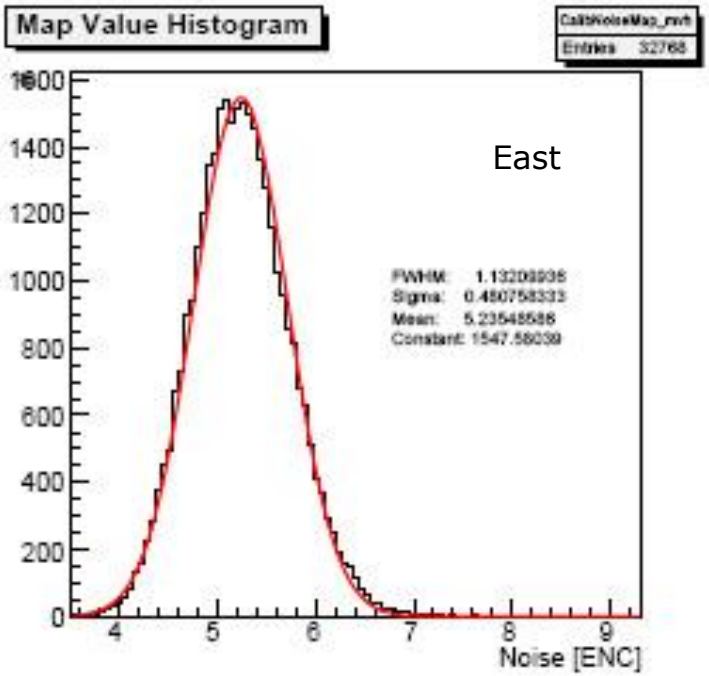


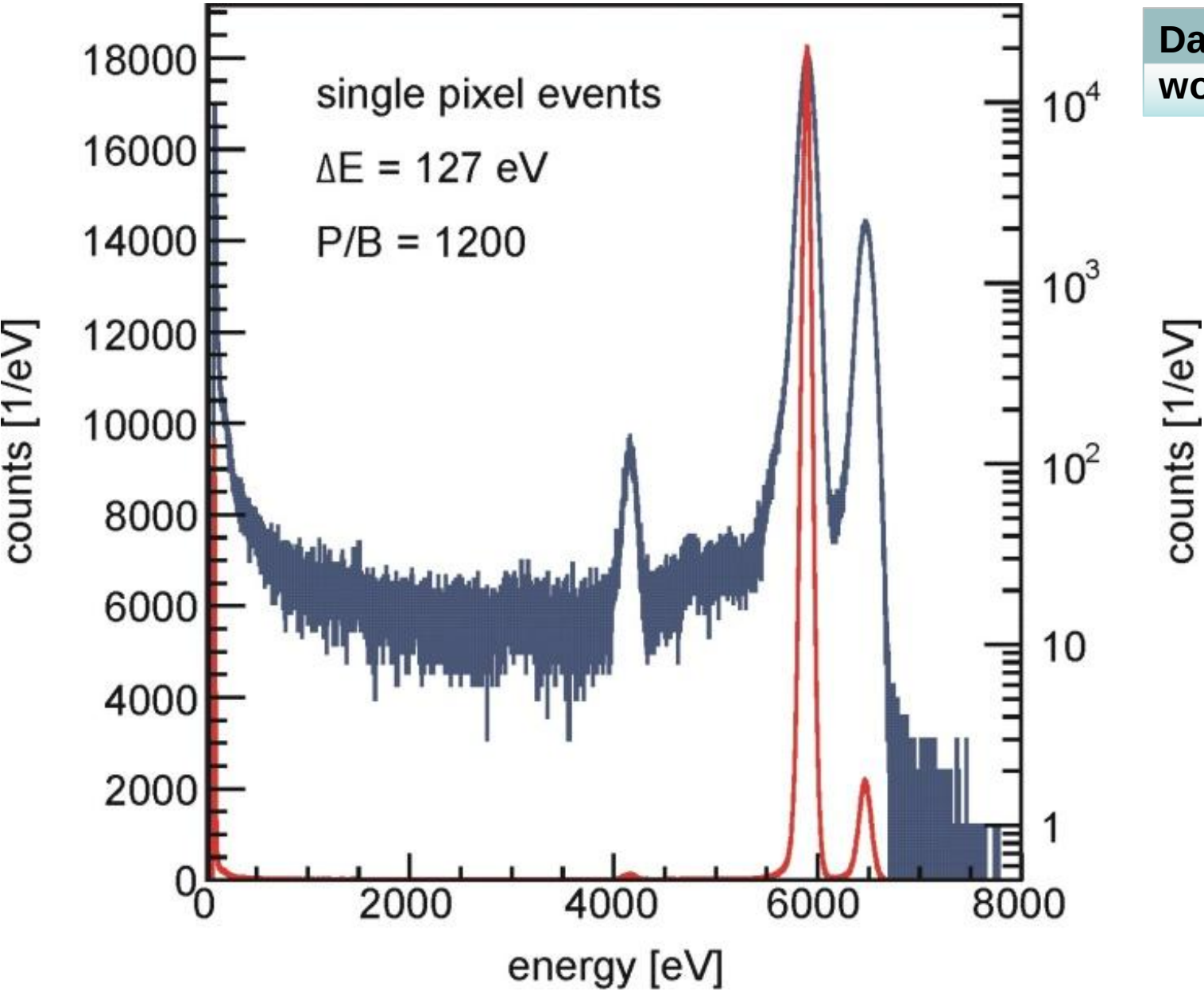
−5.4°C

Temperature

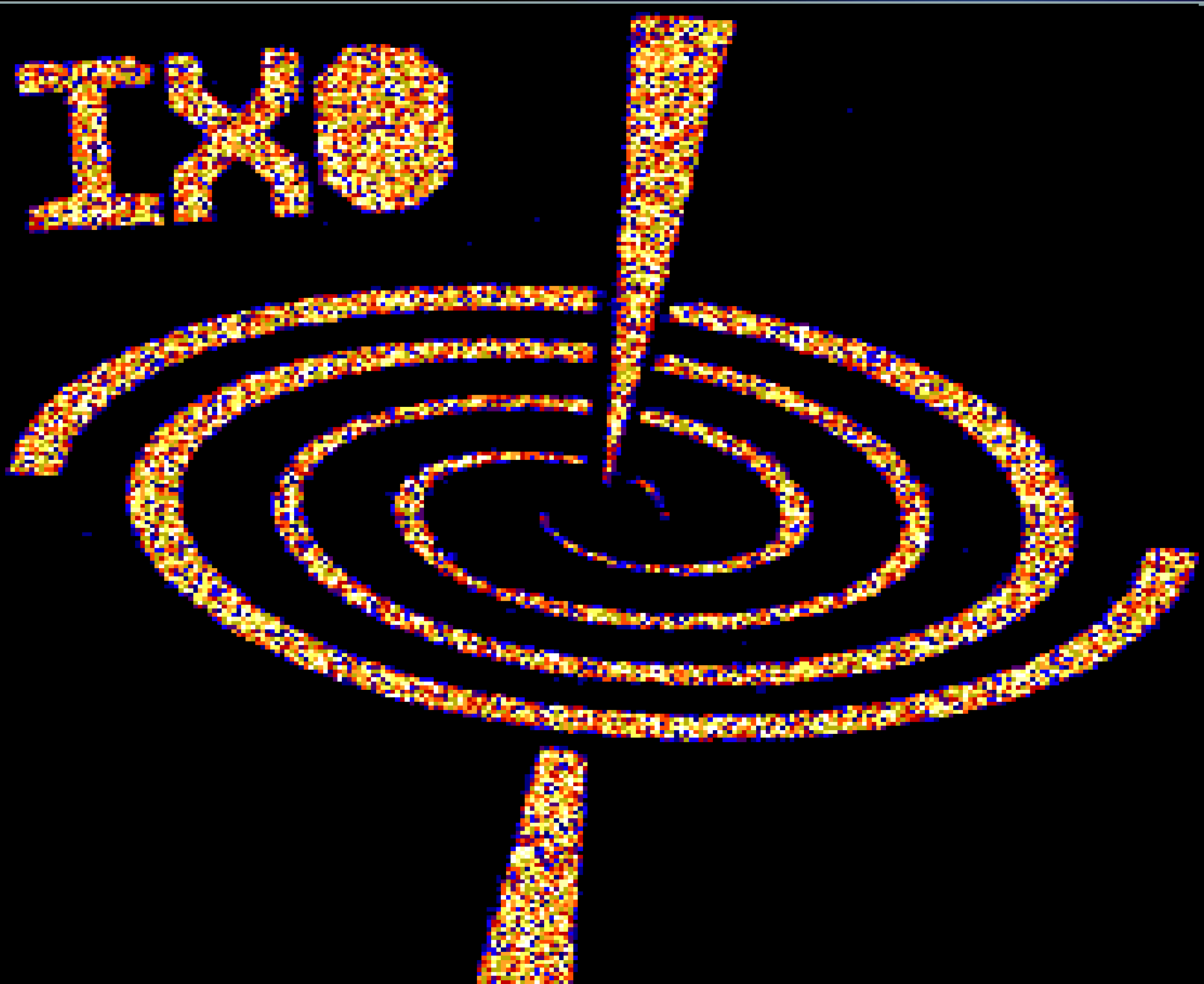
−3.8°C

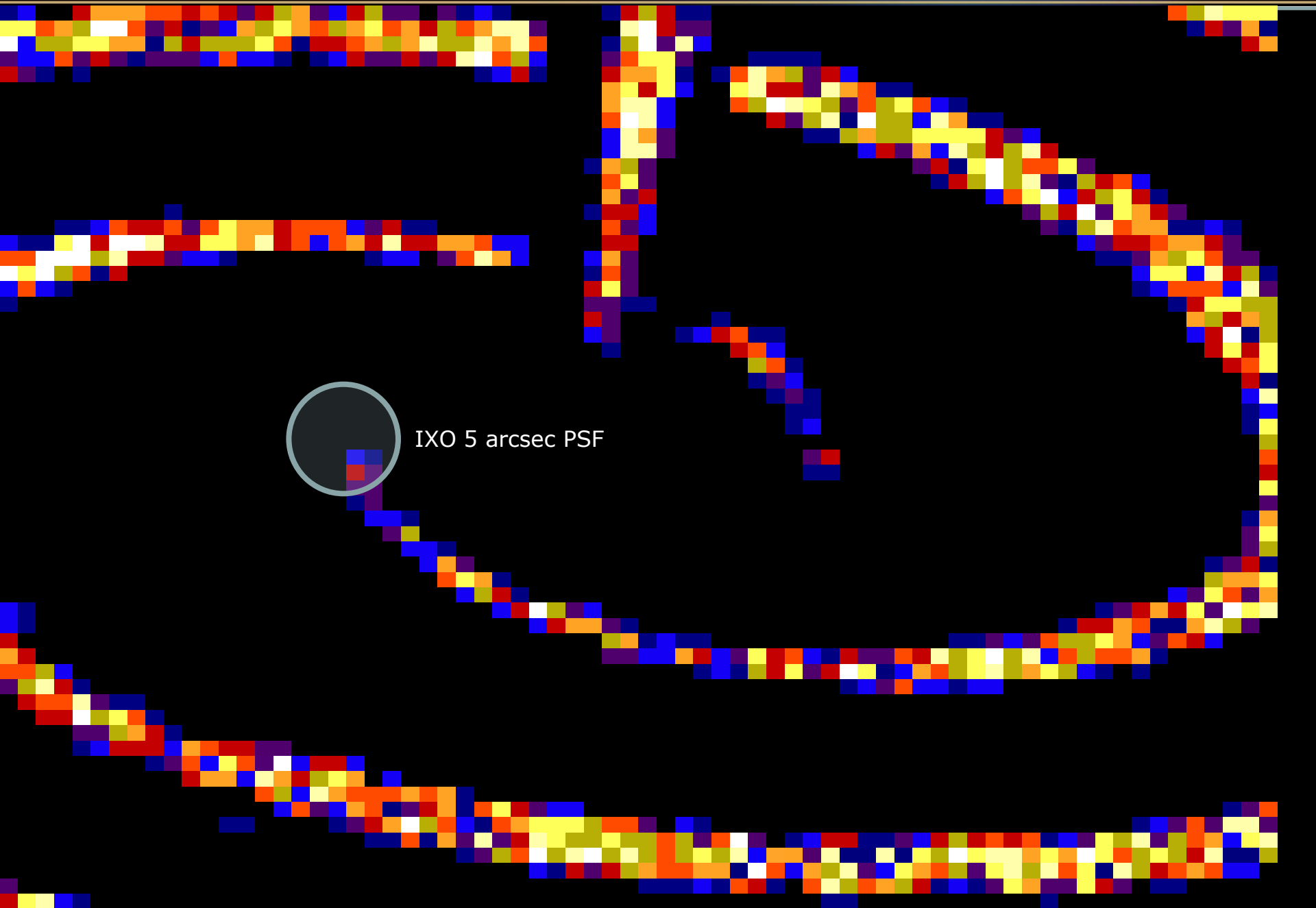






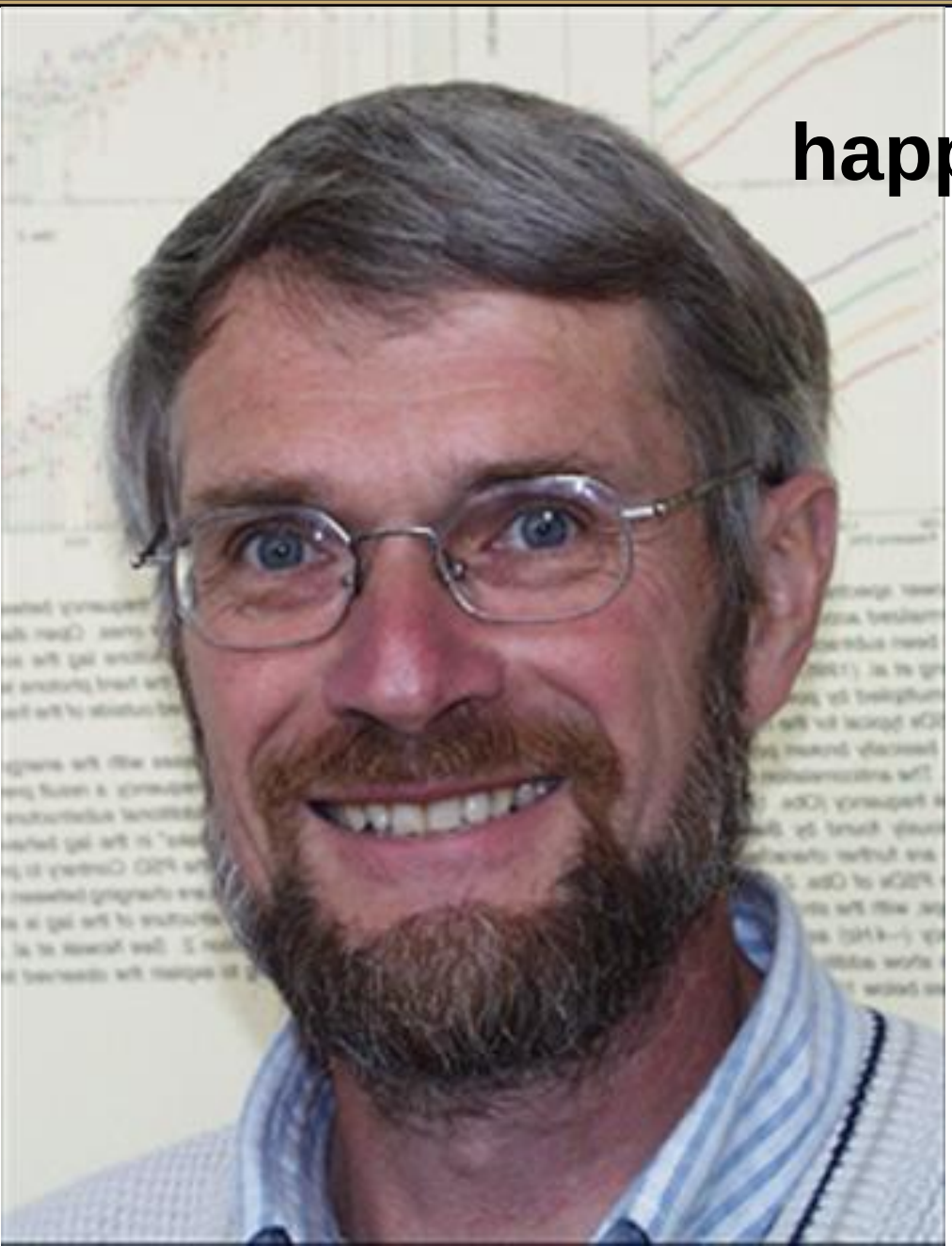
Data analysis:
work in progress


IXO


IXO 5 arcsec PSF

Conclusions

- The WFI meets all IXO requirements
- The WFI can be built within IXO´s boundary conditions of mass, power and space
- The development risks are low
- Radiation hardness verified:
  No degradation after 10 y of operation
- TRL´s can be achieved; up to TRL 5/6 after the definition phase
- IXO has been selected !



happy birthday, Eckhard

stay with us for some more time

all the best from your friends
from the HLL

What are you doing there ??

Why are you not dressed up ??