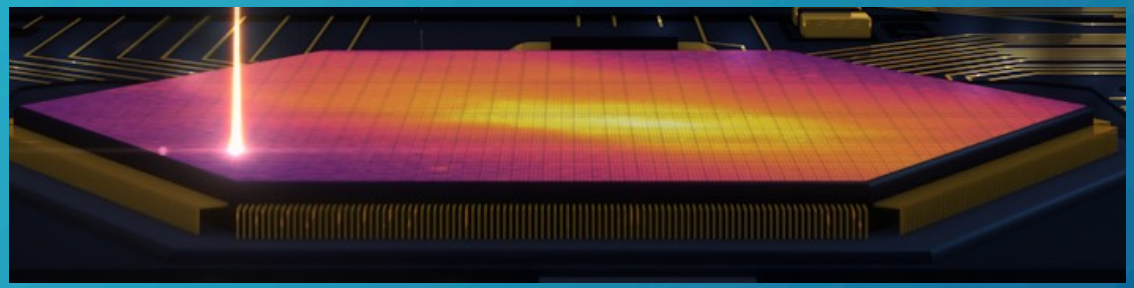
ATHENA X-ray Integral Field Unit

U.S. Contributions to the X-ray Integral Field Unit Instrument

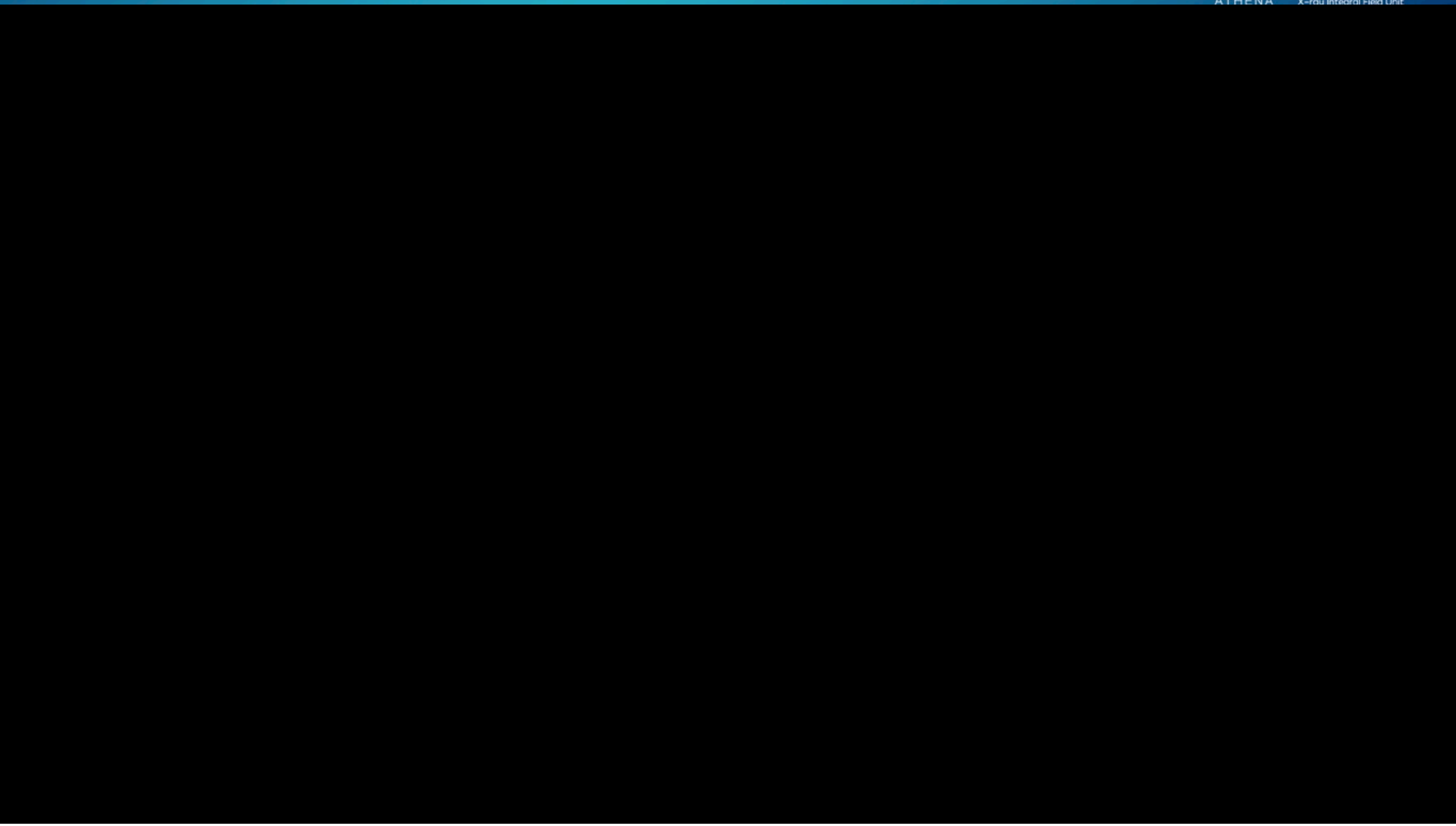
- Important X-IFU consortium activities
- LPA2.5a+: way forward to EM
- TRL development & review



Simon Bandler NASA/GSFC

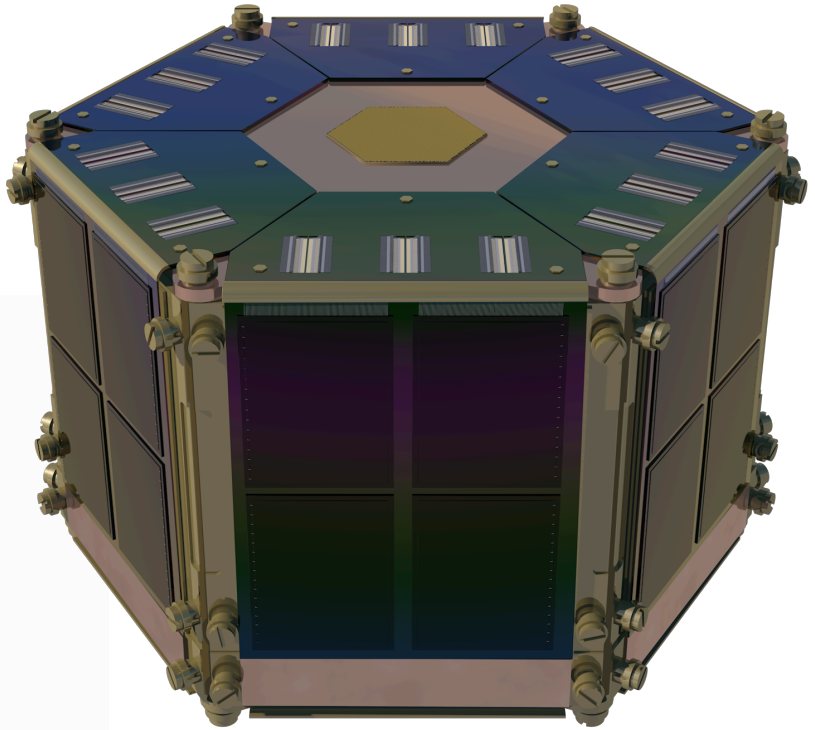
- On behalf of the U.S. contribution to the X-IFU
- *NAST Meeting, July 14th, 2020*

X-IFU Movie



The Athena X-IFU

- **For an introduction to the Athena X-Ray Integral Field Unit Instrument, please see the following 2-minute video: https://youtu.be/_WvV6tLDNF8**

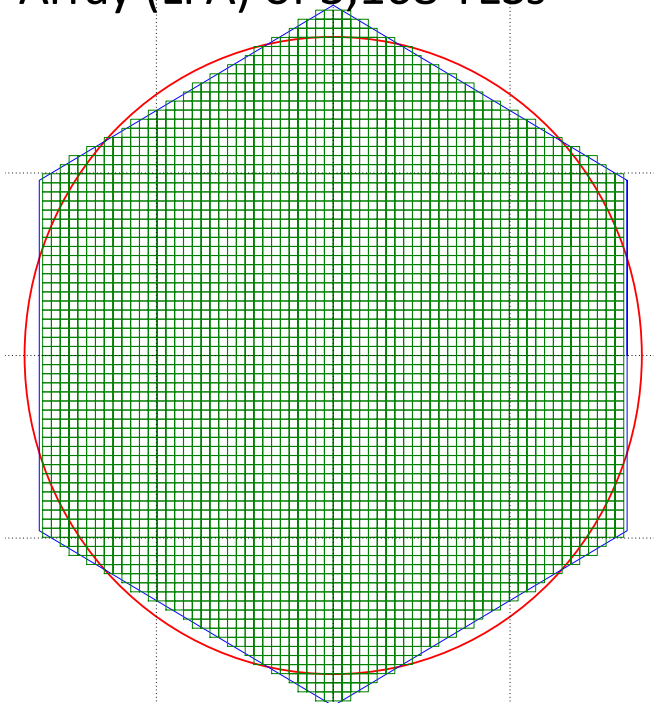


The X-IFU 50 mK focal plane assembly (FPA)

Description of the X-ray Microcalorimeter Array

Parameter	
Pixel pitch	275 µm
TES size	50 µm
Normal state resistance, R_n	8.8 mΩ
Transition temperature, T_0	89 mK
Heat capacity, C	0.73 pJ/K
Thermal conductance, G_b	72 pW/K
Transition parameters, α, β at 1 mΩ	619, 22
ETF fall time, τ_{ETF}	1445 µs
Damped fall time, τ_-	785 µs
Small signal resolution, ΔE	1.72 eV

Uniform Large Pixel Array (LPA) of 3,168 TESs



- **Baseline detector array for DC bias referred to as 'LPA2.5a'.**
- **Currently assumed there will be 96 channels of TDM read-out, each reading out 34 TESs.**
- **In each channel, 33 detector pixels, and 1 TES "dummy" for read-out drift corrections.**
- **Small design iterations being investigated to slow pixels down, to make read-out easier.**

Important X-IFU Consortium activities

Read-out

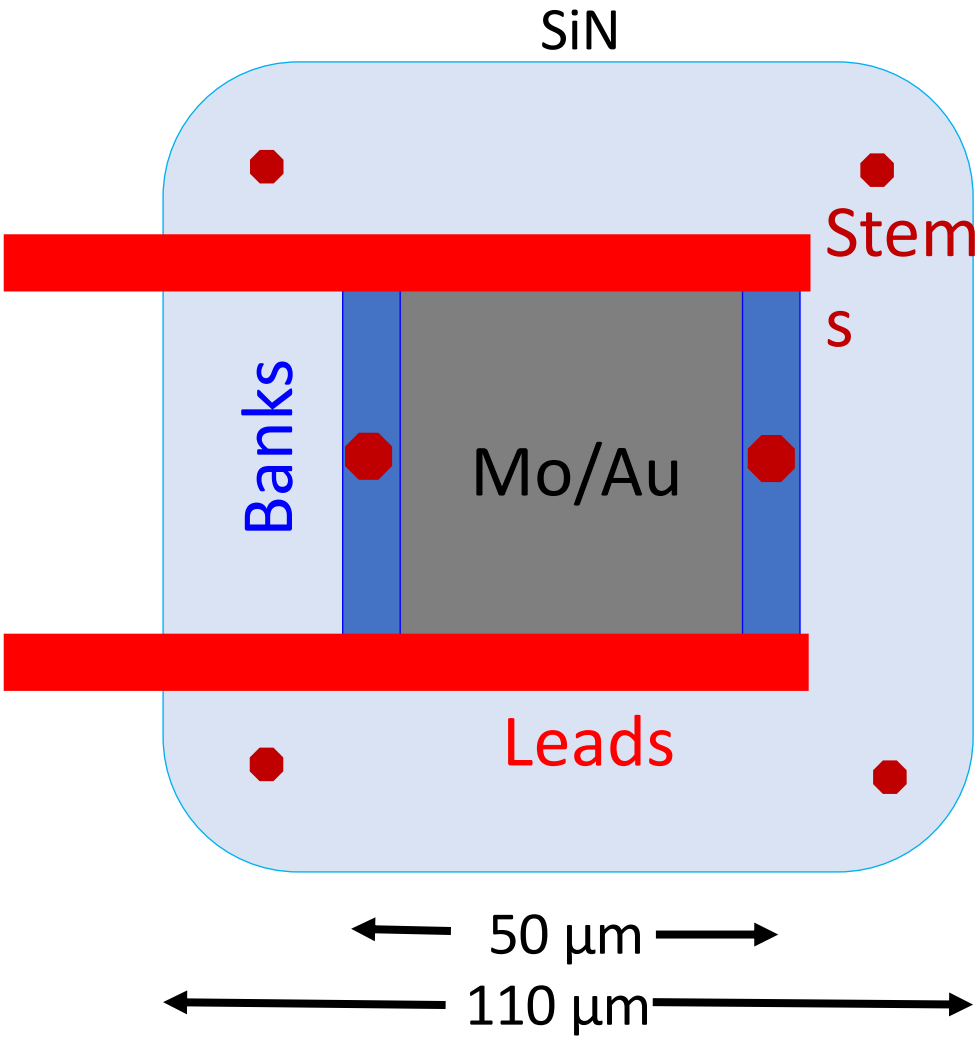
- Baseline readout switched from Frequency Domain Multiplexing (FDM) to Time Domain Multiplexing (TDM)
  - SRON keeps system responsibility of the focal plane assembly
- Larger US contribution in providing, in addition to the focal plane array:
  - 1) The first stage multiplexing SQUIDs (NIST)
  - 2) Support to the TDM implementation (NIST & GSFC)
- No performance degradation assumed for the red book/MAR

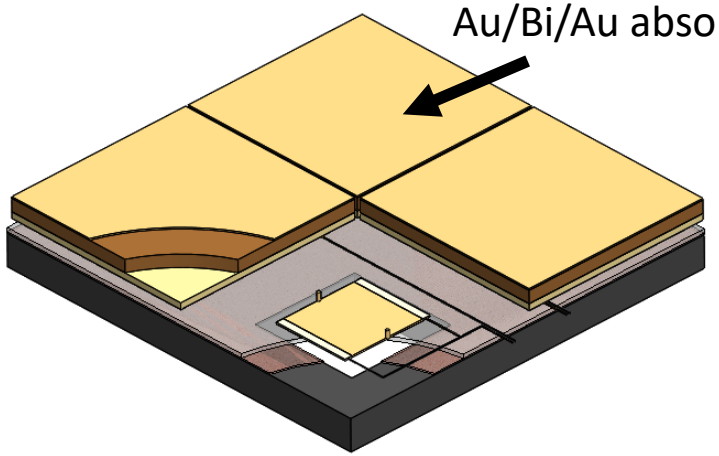
Cryostat

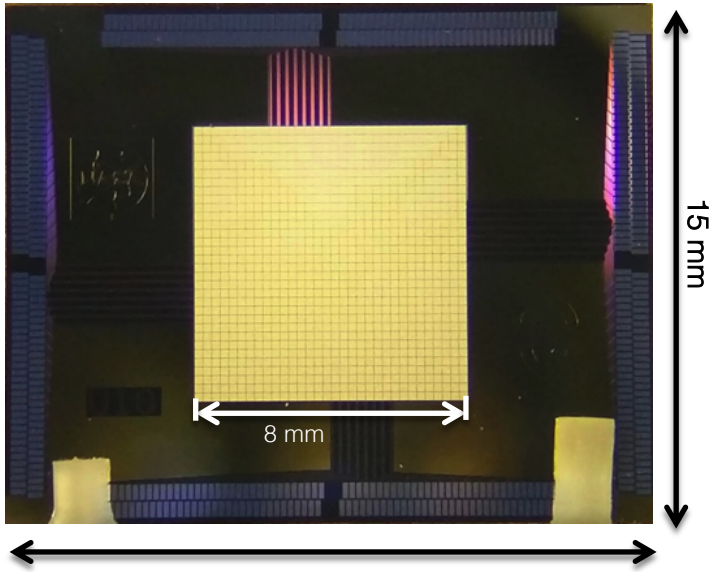
- Cryostat demonstration model "DCS" CDR unsuccessful; DCS will not be in time for the MAR.
  - Unanticipated technical and funding issues related to the system complexity.
- Risk that similar /larger difficulties are faced for EM and FM cryostats - deemed unacceptable by X-IFU PM/PI and ESA
  - Major risk raised during MFR (team heritage, team size, need for industrial support).
- ***Hence it has been decided that ESA will procure the cryostat through an industrial contract.***
- Both potential spacecraft industrial partners now also bidding to provide the X-IFU cryostat as well (Thales & Airbus).
- Draft of interface requirements document (IRD) has already been provided by X-IFU consortium to these partners, update to these requirements expect by ~ September in order to fix them allow design phase to begin.

Overall impact on schedule of these two major changes, as well as COVID-19 not yet known, FPA sub-system currently assuming a 9-month delay

DC-biased TES baselined, LPA2.5a is reference design

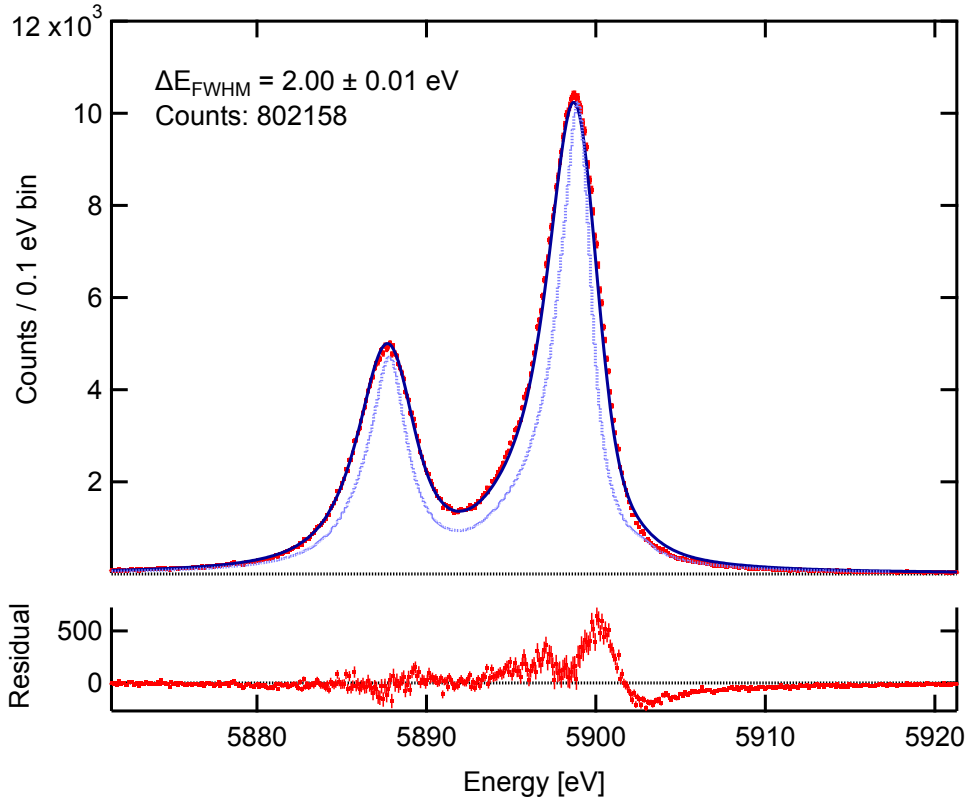




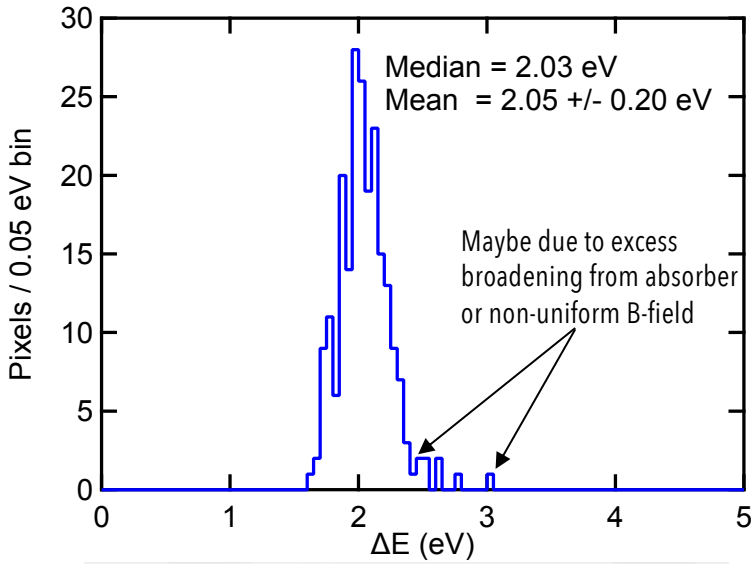


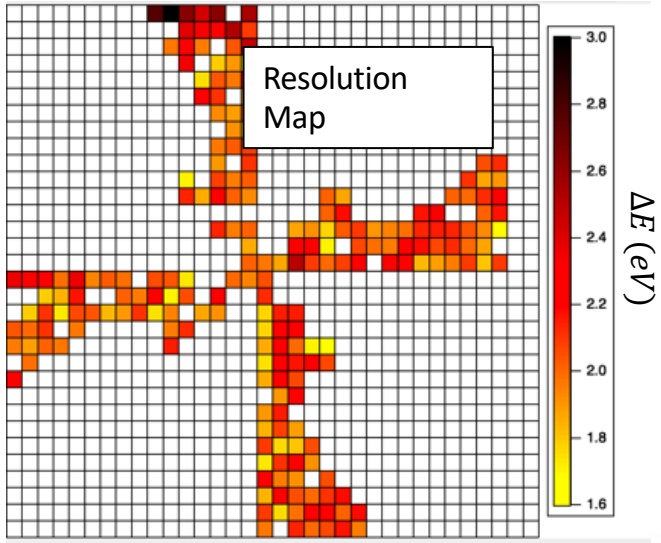
Excellent energy resolution and uniformity demonstrated

8x32 resolution at Mn-Kα

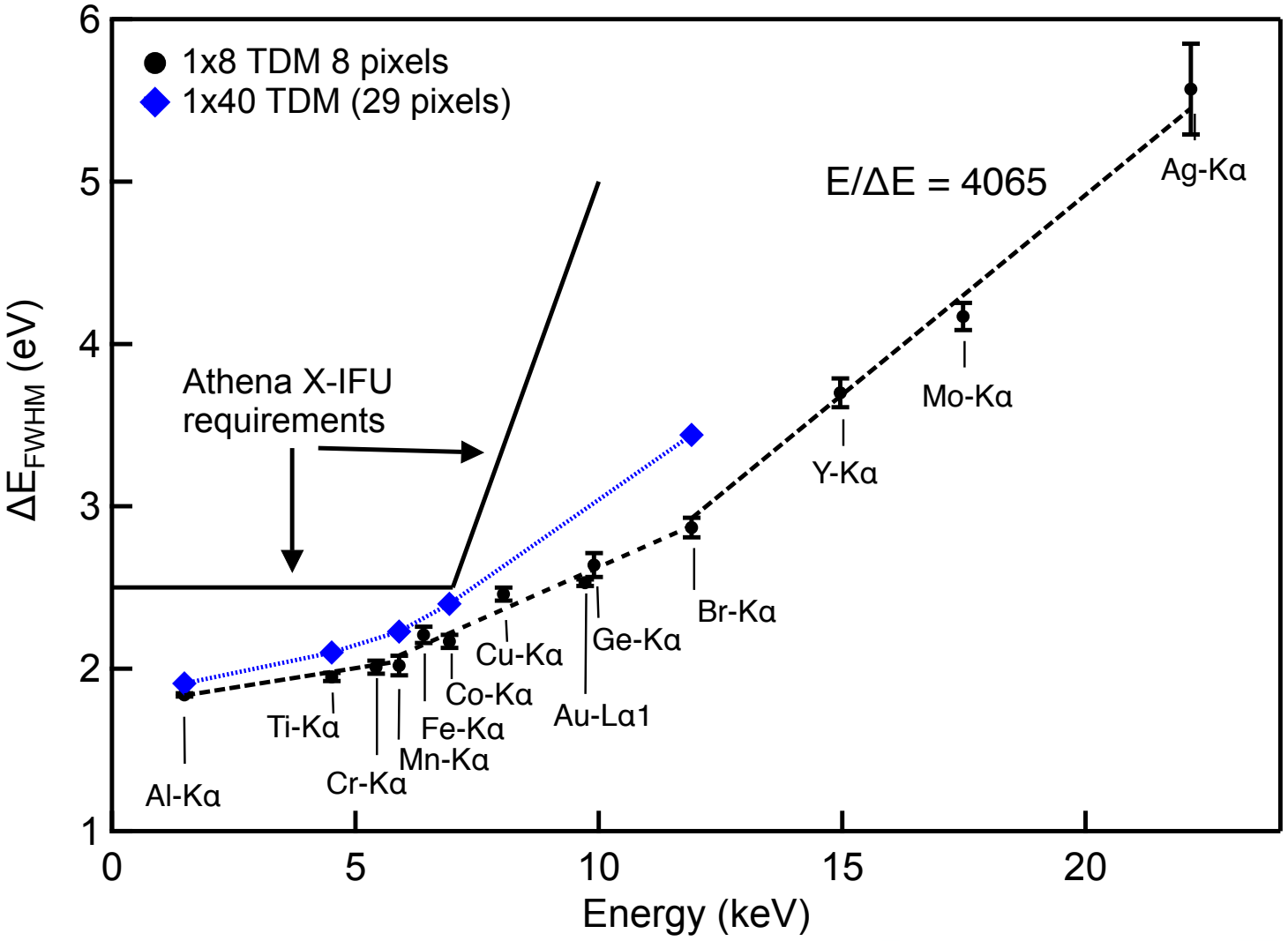


S.J. Smith et al, paper in preparation

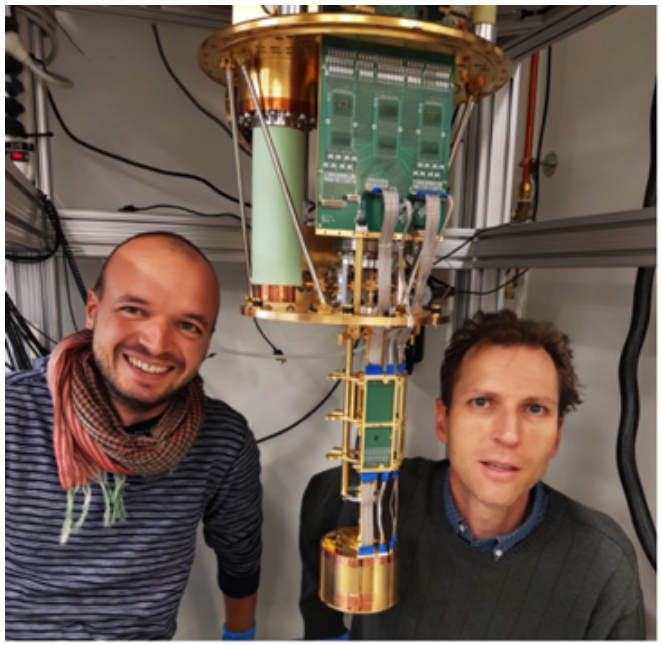


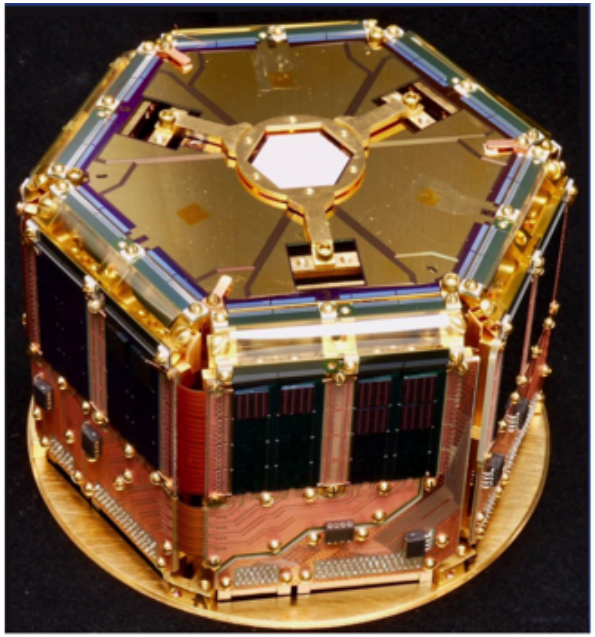


Broad-band performance

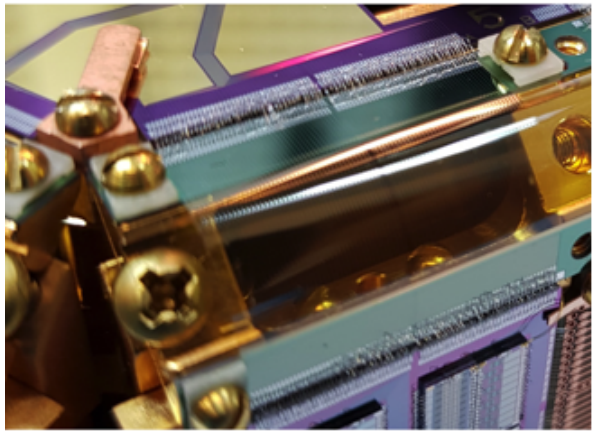


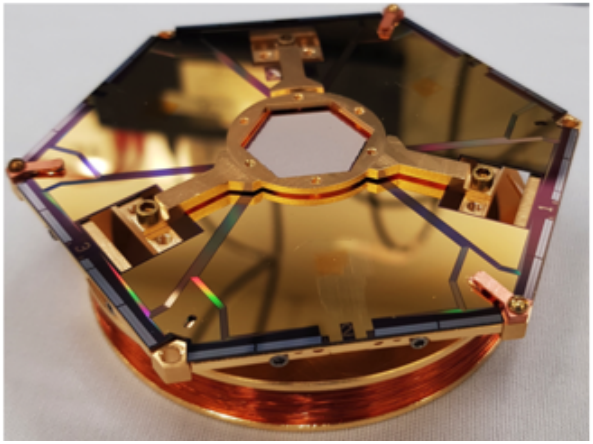
Developing "*Athena*" scale arrays & test set-ups

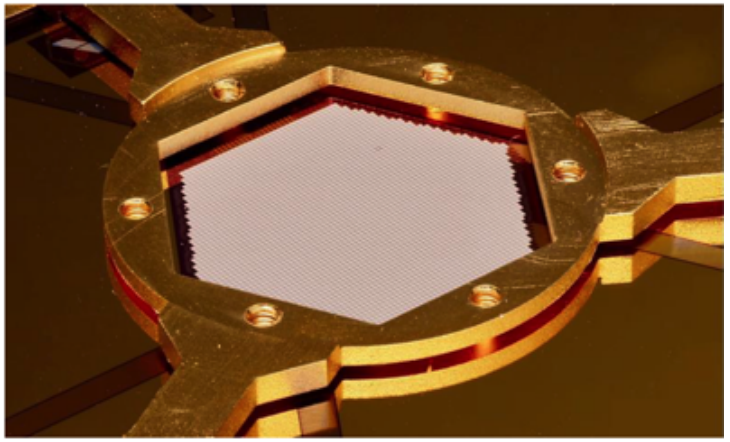




- Two platforms planned at GSFC for full-scale array testing.
- Testing has started on Athena-3b arrays.
- 3,840 sensors on 265 μm pitch.
- 960 pixels connected to bond pads currently.







Technical Readiness Level (TRL) assessments, and budget/schedule planning reviews

- NASA Headquarters requested a TRL assessment and review of program budgets and schedules for all critical Athena contributions.
- X-IFU X-ray microcalorimeter (detector) review: Thursday July 16th.
- X-IFU TDM read-out review: Monday July 20th.

Performance Parameters/Technical Targets for *TRL-5*, demonstrating performance with full-size arrays

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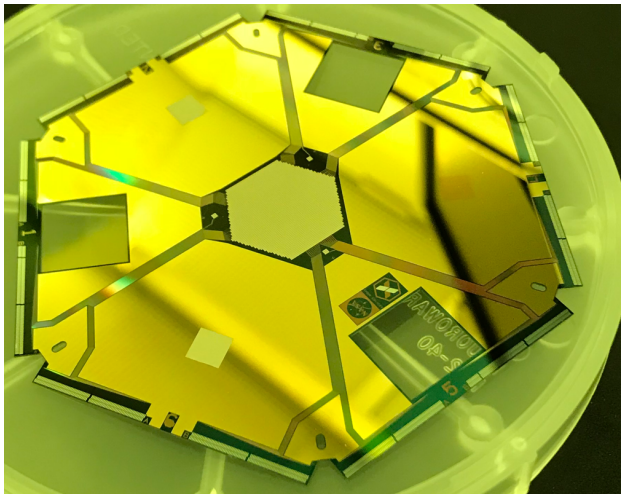
Working towards 13 milestones:

1. Sub-set of at least 100 pixels demonstrate an average energy resolution of individual pixels of < 2.1 eV at 7 keV. Pixel characteristics meet X-IFU count-rate & throughput requirements. Demonstrations should be with array size > 3000 pixels.



2. Pixels meet requirements on sensitivity to environment, including electromagnetic compatibility (EMC)

3. Pixel yield has a credible path to 99% yield.

4. Quantum efficiency of pixels tested meets QE requirements

5. Reflectivity of absorbers is > 40% above for radiation above 1 μm.

6. Pixels meet thermal cross-talk requirements.

7. Array meets electrical cross-talk requirements.

8. Thermal design of array meets thermal background requirements due to cosmic rays

9. Supporting tests & analysis demonstrates robustness of mechanical design to launch vibrations.

10. Supporting tests & analysis demonstrates robustness of design to L2 space radiation environment.

11. For a sub-set of 100 pixels, demonstrate that energy scale can be calibrated with an uncertainty of ± 0.4 eV from 1.5–7 keV

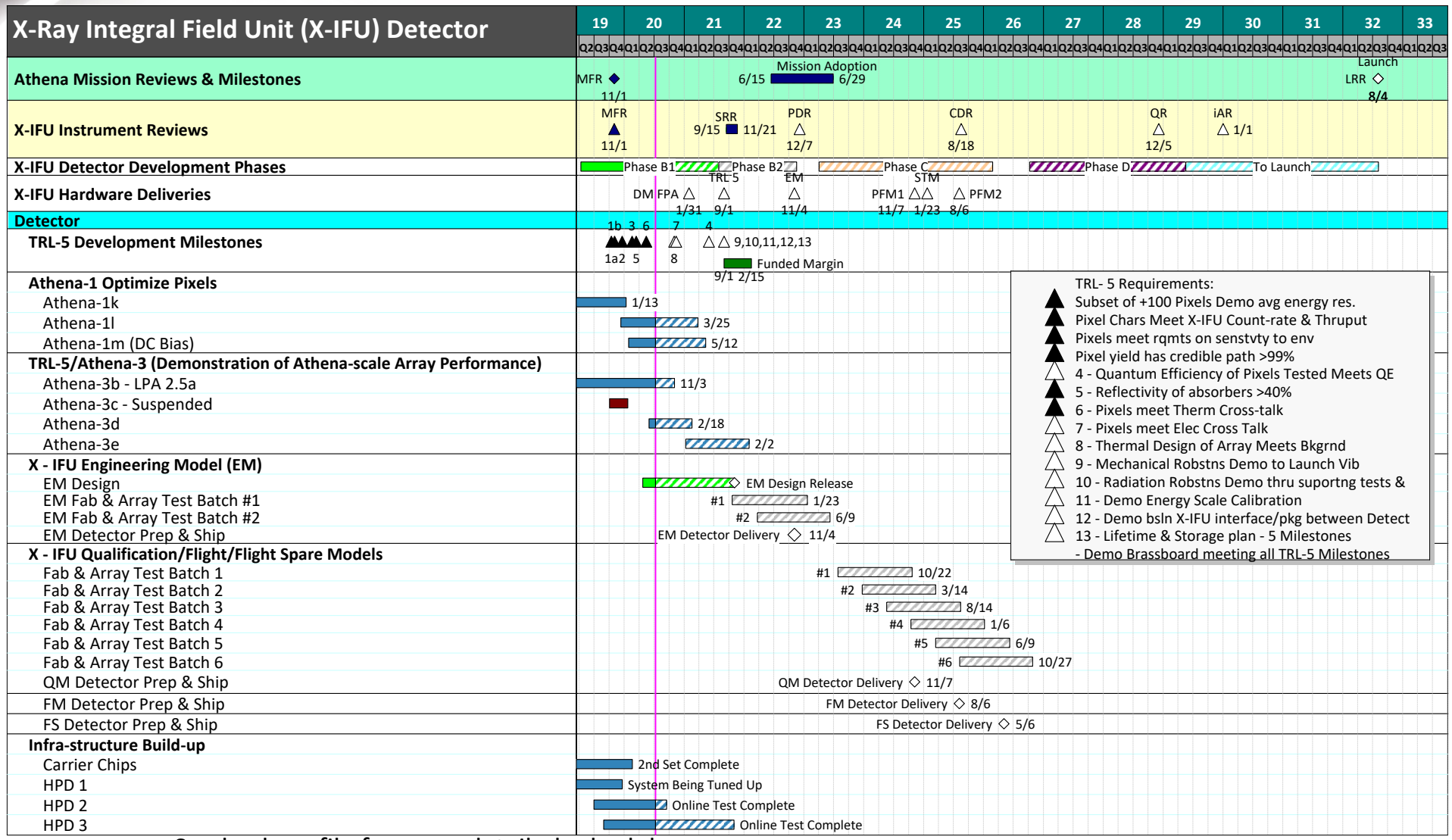
12. Must demonstrate that the baseline X-IFU interface/packaging between the detector & read-out is feasible.

13. Must determine that when stored and operated according to X-IFU requirements there is no loss of performance over the specified timescales.

Milestones consistent with TRL-5, scaling up requires reading out more pixels, greater yield etc., but no new technology development.

Schedule summary

Status Period Ending: 7/10/2020



- See back-up file for more detailed schedule