# ATHENA: Status & Milestones

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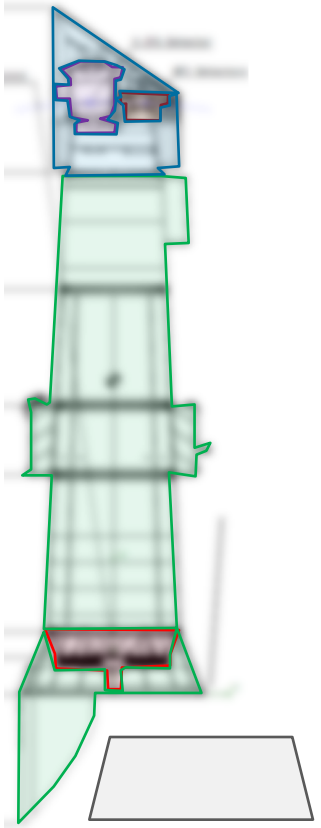
ESA *Athena* Study Team (ESTEC)

# ATHENA – SC Overview



nb: Nominal mass/power (Basic + DMM)

SIM (exc. PLs):
Mass: 874 kg
Power: 307 W

WFI:
Mass: 297 kg
Power: 730 W

X-IFU:
Mass: 880 kg
Power: 3860 W

SVM + FMS
Mass: 2984 kg
Power: 1023 W

MAM (inc. ISM)
Mass: 961 kg
Power: 1985 W

LVA
Mass: 200 kg
Power: 0 W

SC Mass Properties:
- Nominal Mass (wet): 5996 kg
- System Margin: 20.6 % against 7150 kg SC limit
- CoG height w.r.t. I/F plane: 6.7 m
- Largest inertia w.r.t. CoG: 175000 kg.m$^2$

SC Power (based on sizing operations case):
- Nominal Power: 7.9 kW
- System Power: 9.5 kW (with 20% System Margin)

Main Risk Areas & evolutions:
- X-IFU uncertainty in mass & (dissipated) power
- A-64 capability growth anticipated (>7.35 tonnes inc. LVA)
- But, SC MCI properties versus A-64 capability is open point

# ATHENA – Study Status [i]

**Key Points** (TDA=Technology Development Activity)

- MFR concluded successfully and ATHENA now in B1 – however target adoption delayed to June 2022 due to:
  - A partially successful Critical Design Review (CDR) in the X-IFU Detector Cooling System (DCS) TDA
  - The need to provide SIM Primes additional time to absorb responsibility for the cryostat
  - Delays in procurement of the MAMD activity.

**Spacecraft (SC) & Science Instrument Module (SIM) Studies**

- SIM A/B1: Parallel studies with new industrial partners awarded and kicked off, contract changes under discussion to absorb cryostat responsibility and extend schedule
- S/C B1: Parallel studies with existing industrial partners awarded and kicked off, currently no change to contracts to match delay

**X-IFU**

- Demonstrator 50mK TDA CDR declared partially successful due to technical and financial issues for the cryostat
- CNES management also expressed concern about cryostat provision for flight programme
- CNES<>ESA discussion led to decision to transfer cryostat (& cooling chain down to 2K I/F) to SIM Primes

**Launcher**

- Framework contract with *Arianespace* for launch analysis support kicked off, and performance/trajectory analysis commenced. Preliminary assessment suggests an increased mass envelope (~7.8 tons). Coupled Load Analysis preparatory work commenced

# ATHENA – Study Status [ii]

**Technology development**

- **Optics:** Recent performance improvements are encouraging as these indicate that a HEW somewhere between 4.3'' to 8'' across the whole aperture should be achievable (see later)
- Decision on the performance to be assumed for the Red Book ~early 2021
- SPO-EQM (final MM-level activity) kicked off
- Mirror Assembly Demonstrator (MAMD) proposals under evaluation, KO foreseen end June
- Update and freeze of the MA-layout completed for the TDAs, but also for the flight programme TBC, taking into account:
    - SC Prime Phase A designs (spacing/clearances)
    - MS-manufacturing limits (diameter limit)
    - MM-manufacturing limits (maximum widths)
    - Dowel-pin mechanical loads/distortions (# MMs per row, most critical for inner rows)

- **50mK DCS:** This development is the major item on the critical path – demonstration objectives and planning being reformulated against the adoption date after CDR

- **System TDAs:**
- TDAs ongoing for TRL 5/6 mid-2021: Magnetic diverters, OBM, Science Instrument Bench, Low-Temperature LHPs, High Accuracy STR EM, Instrument Switching Mechanism, High pre-load & low-shock HDRM…

# ATHENA – Study Status [iii]

**I/F Working Groups**

- Making good progress in maturing key I/F specifications:
    - SIM<>SC, SC<>MM, SC<>LS, MA<>Fac, WFI<>SIM, WFI<>SC
- X-IFU<>SIM, X-IFU<>SC under rework for new responsibility split
- Despite this, we are gradually freezing key parameters in the SC/SIM geometry

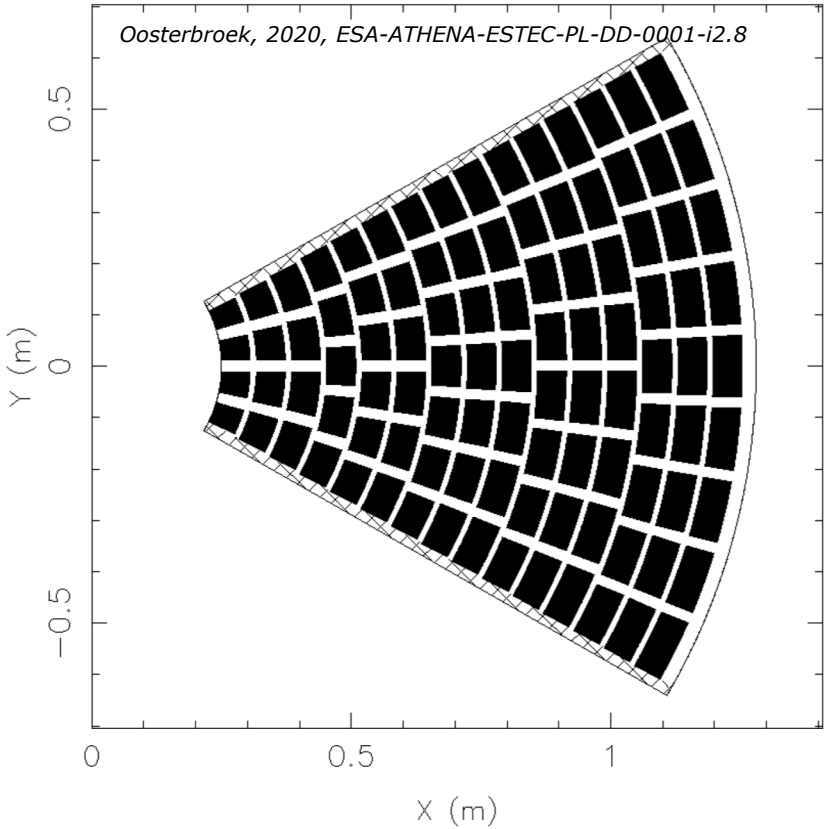
**NASA:**

- XRCF is the baseline and the only facility available in the short-term for the Mirror Demonstrator TDA
- If the 'competing' VERT-X development (alternative facility to XRCF for Mirror-level activities) is successful, both XRCF and VERT-X facilities will be used in the flight programme to perform cross-checks and share the calibration effort
- SoftRide damping system – NASA<>MOOG contract for support to Science Instrument Bench TDA is now underway
- Instrument contributions consolidating

**JAXA:**

- 2K/4K JT coolers as per before
- I/F information being provided to the SIM Primes as part of rework for new responsibility split

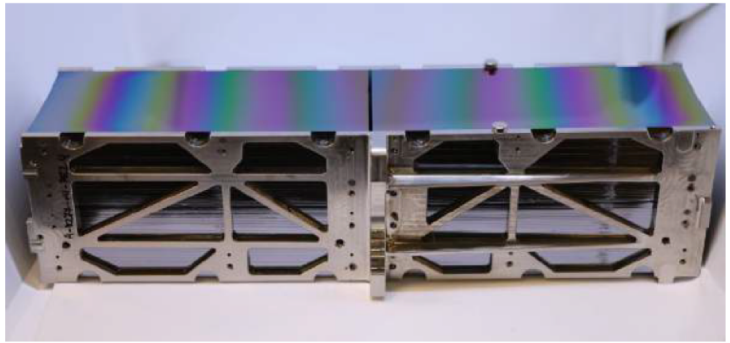
# ATHENA – mirror layout optimization

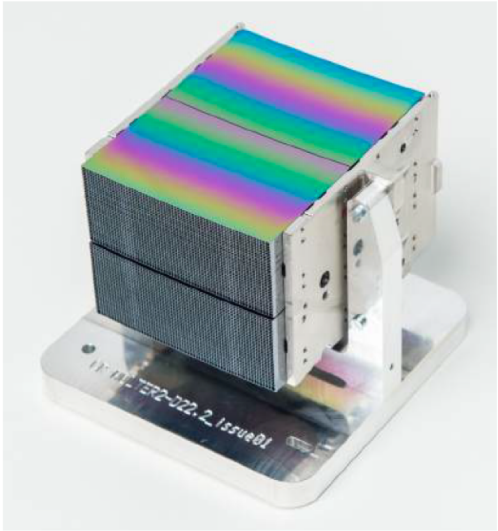


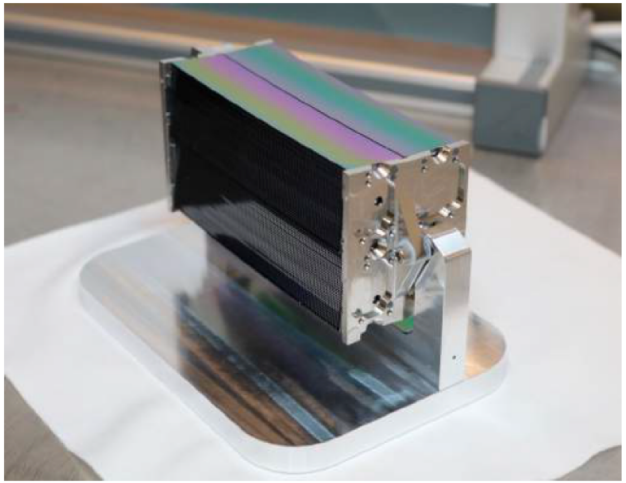

- Mirror layout optimized (and frozen) for Phase B1
- Based on 15 rows, 37-plates modules, 2.3 mm rib pitch, Ir/Ir+SiC coating
- Effective area independently estimated by ESA (cosine), Primes, TWG
- Some ~1 keV area gains are expected
- ~10% area shortfall at 7 keV expected
  - Recoverable, if Ir+$B_4C$ resurrected
- Responses available by September 2020

# The ATHENA mirror is a real thing

Athena's inner ring (R=277 mm), middle (737 mm), outer (R=1500 mm)







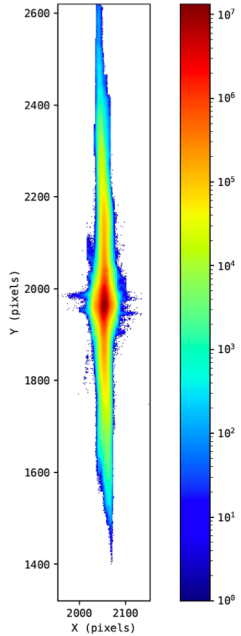
*Credit: L. Keek (cosine)*

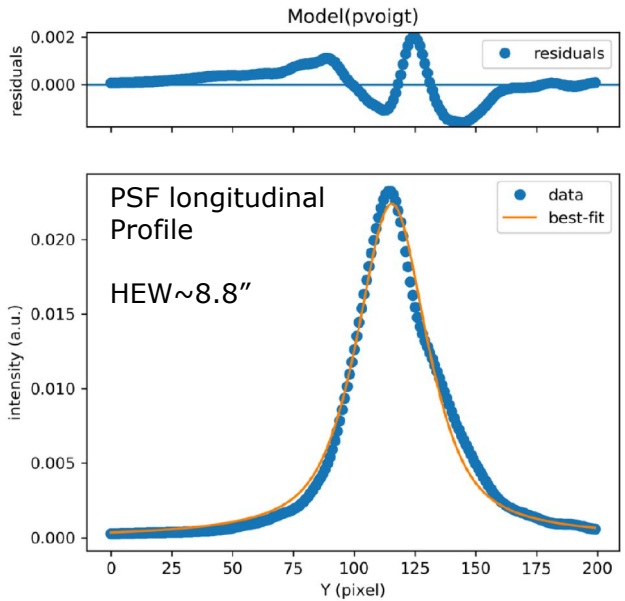
# Angular resolution performance evolution

Credit: L. Keek (cosine)

| Outer radius | XOU-066 2019 | XOU-067 2019 | XOU-92 2020 |
|---|---|---|---|
| Half-energy width (arcsec) | 17.5 | 13.2 | 9.9 |

Middle radius




Credit: G. Vacanti (cosine)

- Continuous improvements at all radii
- Contribution to HEW budget identified, and being worked on
- First experimental evidence of non-Gaussian 2-D effects
- Work to achieve 4.3” (MM-level)/5” (MA-level) continues

- Decision on the performance for the Red Book in **~early 2021**

# New ASST composition as of September 3, 2020

- Matteo Guainazzi (ESA, Chair)
- Didier Barret (IRAP, X-IFU)
- Kirpal Nandra (MPE, WFI)
- Massimo Cappi (INAF-OAS)
- Judith Croston (Open University)
- Anne Decourchelle (CEA)
- Jan-Willem den Herder (SRON; Elisa Costantini as of April 2021)
- Luigi Piro (INAF-IASP)
- Nandra Rea (ICE)
- Thomas Reiprich (University of Bonn)
- Norbert Werner (University of Brno)
- Hironori Matsumoto (University of Osaka, JAXA)
- Randall Smith (CfA, NASA)

# ATHENA - Schedule & Milestones to Adoption