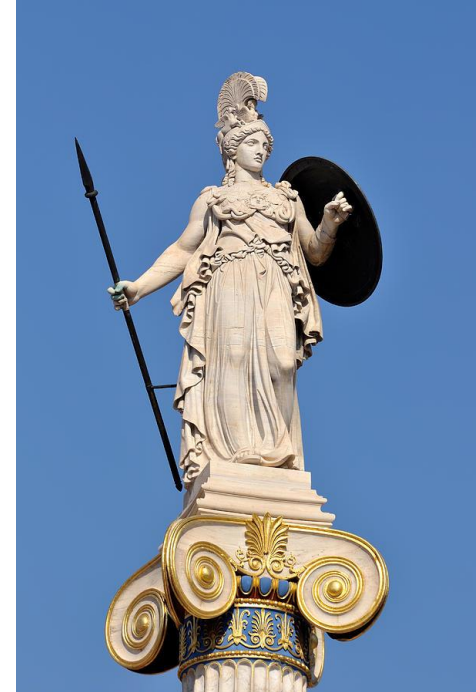


# Athena Update

Randall Smith

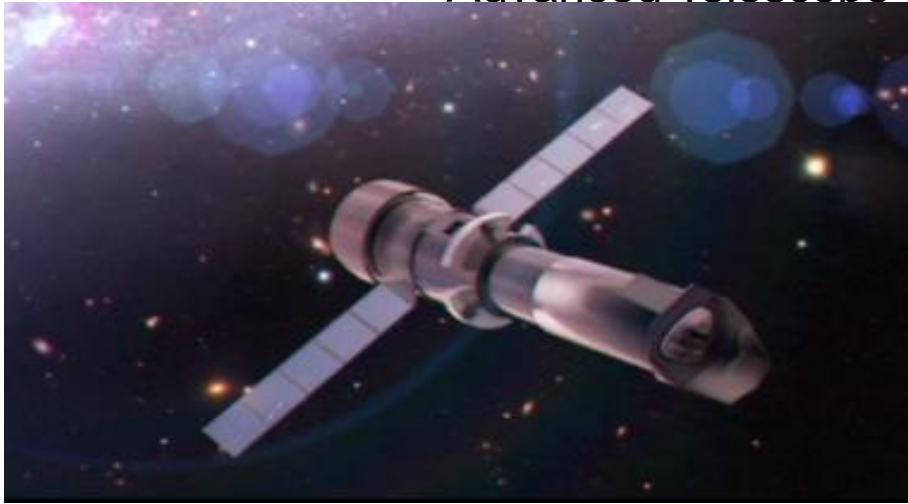
US Representative

Athena Science Study Team



# Athena

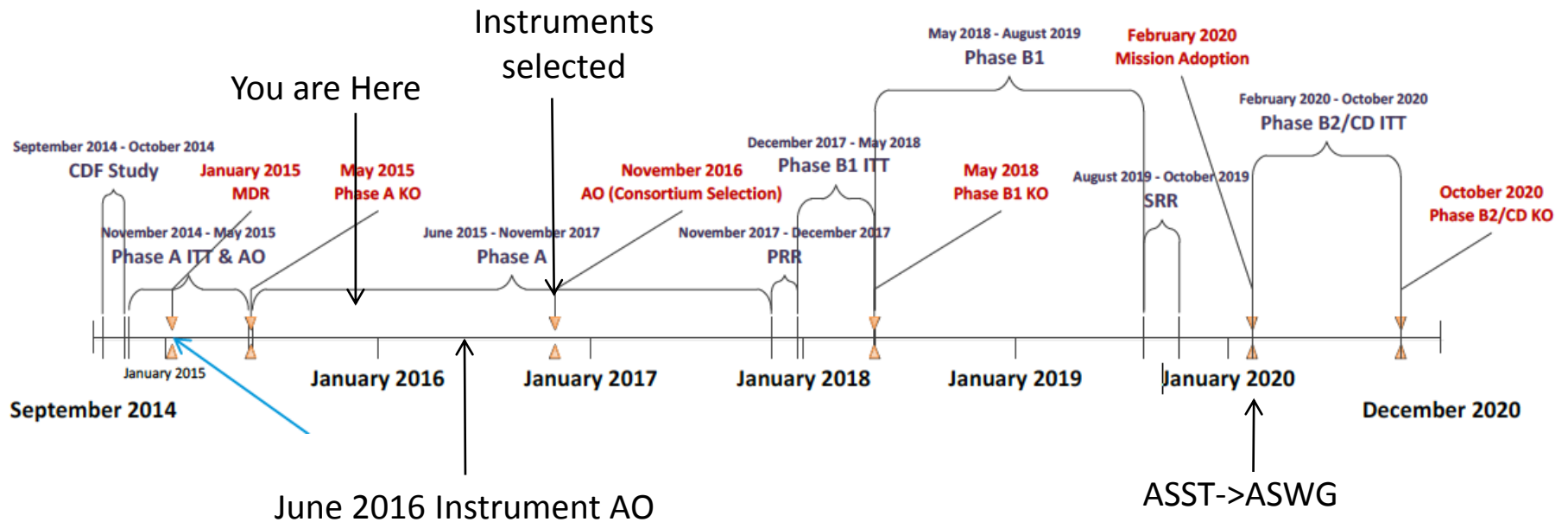
## Advanced Telescope for High Energy Astrophysics



### CURRENT STATUS:

- Selected as 2<sup>nd</sup> Large mission in ESA Cosmic Visions Program
  - Currently in 2 year Study Phase
  - NASA and US community involved in Study Phase via membership on ESA-chartered Athena Science Study Team and Science Working Groups
  - NASA budgeting for a \$100M-\$150M hardware contribution, plus a US GO program and a U.S. data center
  - NASA will provide the sensor array for the X-ray Integral Field Unit (calorimeter)
  - NASA and ESA are discussing other possible NASA contributions, such as:
    - A contribution to the Wide Field Imager
    - Use of the NASA XRCF for Calibration
    - Contribution to science data center (U.S. node)
  - NASA continues to invest in Athena technologies via SAT and directed investigations.
- **Second ESA Cosmic Vision Large mission**
    - L-class with NASA/JAXA participation
    - Decadal Survey recommendation
    - Large X-ray mirror, X-IFU and WFI instruments
  - **Launch Date:** 2028
  - **Breakthrough Technologies:**
    - High Throughput, Wide FOV, High spectral resolution X-ray Astronomy
    - 10x Chandra area, 100x improved non-dispersive spectral resolution, 5x FOV.
  - **Science Objectives:** The Hot and Energetic Universe: How does ordinary matter assemble into the large scale structures that we see today? How do black holes grow and shape the Universe?

# Athena Study-Phase Schedule



- Two configurations being studied:
  - As CDF determined meets 1B ESA cap, 1.4m<sup>2</sup>
  - As proposed, 2.0m<sup>2</sup>
- International contributions can be to Member States or ESA
- Instrument contributions may result in Guaranteed Time

# Athena Science Study Team

ESA appointed the ASST to provide guidance on all scientific aspects during the Assessment Phase for the Athena mission, under the leadership of an Athena Lead Scientist. The following tasks have been charged by ESA to the ASST:

1. Provide scientific oversight in the fields associated to the scientific theme “The hot and energetic Universe”, as described in the “Report of the Senior Survey Committee on the selection on science themes for the L2 and L3 missions in the Cosmic Vision programme” (available at <http://sci.esa.int/cosmic-vision/53261-report-on-sciencethemes-for-the-l2-and-l3-missions/#>)
2. Review and propose updates to the mission scientific requirements
3. Assess the scientific aspects of the mission performance
4. Assist in making any top-level trade-offs
5. Support the preparation of the observing plan and calibration strategy
6. Assist in setting-up scientific requirements on the Science Ground Segment
7. Advise on the preparation of the Science Management Plan
8. Produce the Definition Study report
9. Act as a focus for the interests of the broad scientific community

# ASST Working Groups

After ESA created the ASST, the ASST created Working Groups to assist it. An Athena Science Team will replace the ASST after mission adoption (~2020). The Working Group structure proposed here will likely continue supporting the new team.

## **Remit of the Working Groups**

- At the request of the ASST, WGs will conduct studies on scientific or technical aspects that are required in support of Athena
- Advise the ASST in any necessary updates of the science requirements and all other relevant studies under the responsibility of the ASST
- Advise the ASST with respect to technical issues and trade-offs
- Promote Athena as a major astronomical observatory

*ASST and WG members are volunteers. The ASST has no 'data rights' (i.e., no GTO), and so neither do WG members.*

# Athena Science Impact Exercise

*“Athena is currently in an Assessment phase. During this phase two design points for the mission are being examined. The first corresponds to the mission as proposed to ESA. The second is a modified version of the mission with a smaller outer radius for the mirror, and hence less effective area particularly at soft X-ray energies (<2 keV), which was studied in the ESA Concurrent Design Facility (CDF). The ASST, with assistance from its community-based Working Groups, has performed an assessment of the scientific performance of the two design points, which is summarized in”*

[http://athena2.irap.omp.eu/IMG/pdf/ASIE\\_final\\_public.pdf](http://athena2.irap.omp.eu/IMG/pdf/ASIE_final_public.pdf)

# Recent & Current Events

- Just held 1<sup>st</sup> Athena Science Workshop in Madrid
  - Sept 8-10, 2015;  
<http://www.sciops.esa.int/index.php?project=CONF2015&page=ATHENA2015>
- Current Athena SST work involves:
  - Finalizing Mission Requirements (L1, L2a, L2b)
    - E.g., Science Goals (L1), Measurements Needed (L2a), Obs./Inst. Capabilities Needed (L2b)
  - Finalizing Mock Observing Plan
  - Developing Calibration Plan
  - Organizing Science Ground Segment
    - Herschel-like? XMM-like? Other?
  - Commenting on Science Management Plan
    - i.e., GTO fractions, achieving mission science goals, etc
- Next Athena Science Workshop likely in 2017

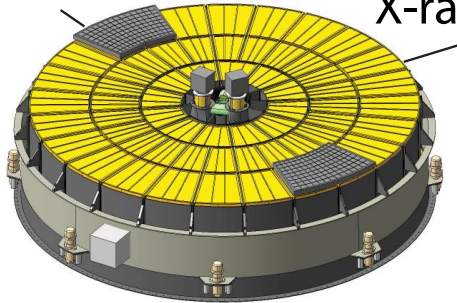
# Recent Presentation Topics to Mid-Decadal Review

1. How does Athena implement the NWNH science goals? What areas are missing? Does Athena go beyond NWNH goals in any way?
2. What is the impact of the proposed ESA descope of Athena in the light of NWNH recommendations?
3. How might US contributions to Athena increase the yield of science to the US community? What is the estimated cost?

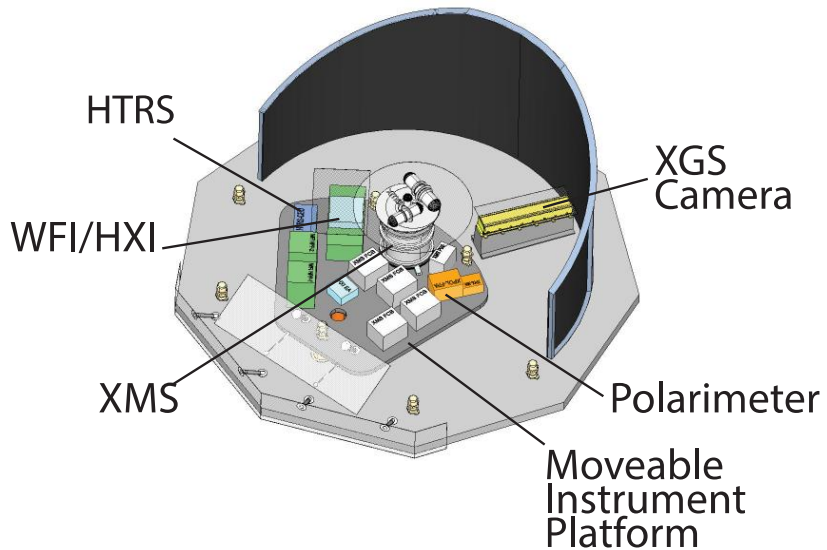


# IXO Base Design

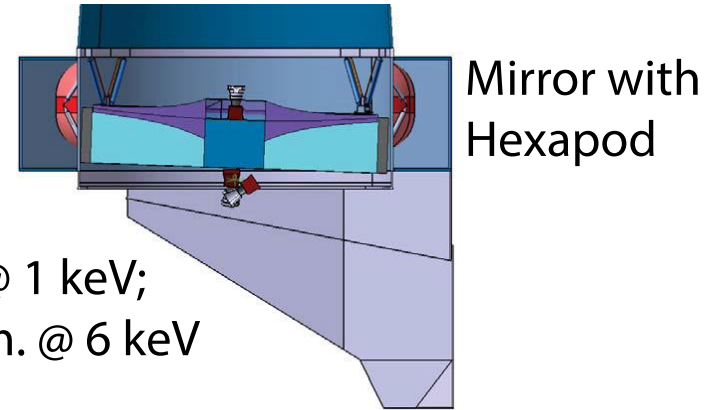
X-ray Grating Array  
Soft & Hard X-ray Mirrors



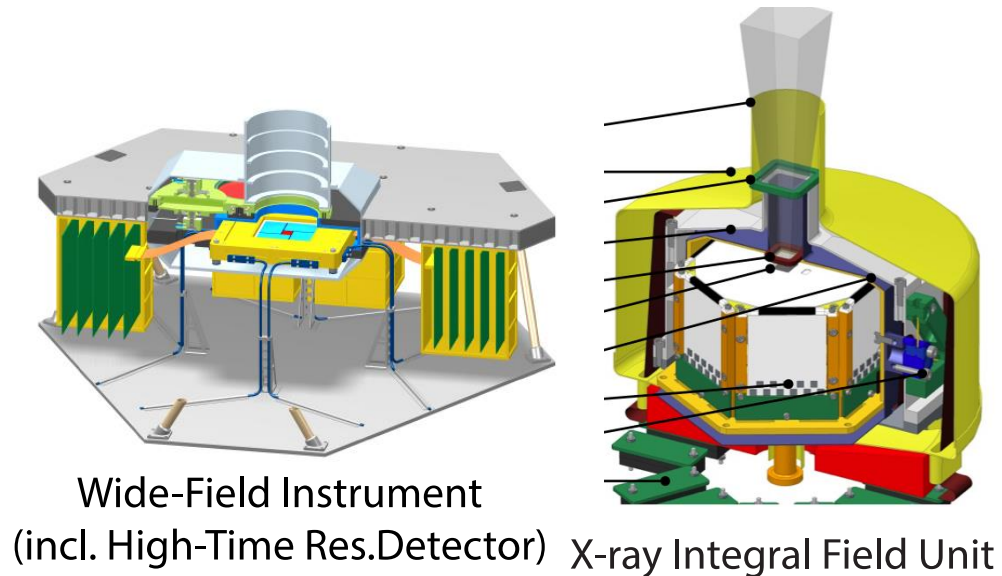
5" PSF  
~2.5 sq. m @ 1.25 keV;  
~0.65 sq. m. @ 6 keV



# Athena Base Design



5" PSF  
~2 sq. m @ 1 keV;  
~0.25 sq. m. @ 6 keV



# What is the impact of the proposed ESA descope of Athena in the light of NWNH recommendations?

- *From the cosmic dawn science plan:*

20% more time req.

- ✓ Use GSMT and **IXO** to monitor the exchange of gas between the galaxies

20% more time req.

- ~ and the surrounding intergalactic medium

30% longer time required

- ✓ Study the rate of formation and growth of black holes in the nuclei of young galaxies using **IXO** and WFIRST

- *From the Physics of the Universe Science Plan:*

35% more time

- ✓ Find and study distant clusters of galaxies to measure the rate of growth of structure in the universe using **IXO** and microwave background observations

No impact

- ~ Observe X-rays from gas orbiting close to the event horizon of black holes using **IXO**...

- *From the New Worlds Science Plan:*

N/A

- x Assess habitability by using **IXO** to characterize the frequency and intensity of flares in host stars

## What is the impact of the proposed ESA descope of Athena in the light of NWNH recommendations?

“The main impact of the smaller CDF effective area ( $1.4\text{m}^2$ ) is that significantly longer exposure times are required to achieve most science goals. An additional  $\sim 50\text{Ms}$  beyond the baseline 5 year mission would be required to recover this science. In this scenario it would therefore be necessary either to sacrifice several major observational programs, or extend the mission lifetime by  $\sim 2$  yr, with an associated increase in operations costs and more demanding instrument requirements. ... Due to the strong inter-relation between the science objectives of the mission, the loss of any particular element has wider implications for the coherence of the overall program.”

- From the Athena Science Impact Exercise Document, based on a detailed study of the complete Athena science plan by the Athena Science Working Groups (well over 100 people involved)
- [http://athena2.irap.omp.eu/IMG/pdf/ASIE\\_final\\_public.pdf](http://athena2.irap.omp.eu/IMG/pdf/ASIE_final_public.pdf)

# How might US contributions to Athena increase the yield of science to the US community? What is the estimated cost?

- ESA CDF study has 2m<sup>2</sup> design at €1.15B Cost at Completion (CaC)
- Same study shows 1.4m<sup>2</sup> design at €1B
  - with concomitant science losses and/or risks.
- Any contribution that enables a larger mirror increases science.
  - Two independent industry studies underway, due Q2 2016
- NASA/ESA are considering other options that reduce ESA's CaC
  - For example, calibration at the XRCF at NASA/MSFC
- Contributions to the X-IFU and WFI do not reduce ESA's CaC
  - Instruments being built by member states, not ESA
  - These would provide GTO data to US astronomers

How might US contributions to Athena increase the yield of science to the US community? What is the estimated cost?

*From the NASA Astrophysics Division Director*

- 2015: NASA is pursuing a partnership with ESA to provide up to \$100-150M in components of the two instruments and/or the observatory.
  - NASA will provide the sensor array for the X-ray Integral Field Unit.
  - NASA is considering a proposal for contributions to the Wide Field Imager.
  - NASA is considering providing use of test facilities, specifically the X-ray Cryogenic Facility (XRCF) at MSFC.
  - NASA also plans for funding US members of the Athena science team, a US science data center, and US general observers during operation.
- NASA is budgeting for participation in the Athena mission, but such budgets come at an “opportunity cost” from all other Astrophysics budget lines within a constrained budget.
- Based on report of the Midterm Committee, NASA will prioritize investments toward a role in Athena against other competing priorities.

How might US contributions to Athena increase the yield of science to the US community? What is the estimated cost?

*From ESA & the ASST*

- Two separate, independent assessments were made in Europe of possible NASA contributions: Athena Science Study Team (ASST) and Project Team
- The ASST list was based on the X-ray SIG list
  - Optics core portion (support structure and thermal control)
  - Instrument switching mechanism (Chandra heritage noted)
  - Support to calibration activities (XRCF, unique facility)
- The ESA Athena team assessment of potential NASA (and JAXA) contributions is summarized in an official ESA document “ATHENA – Possibilities for International Collaboration”
  - Mirror components (hexapod mechanism, structure, modules, thermal control system, singly or in combination)
    - NASA delivery of mirror structure and interior segments called “most promising” option
  - Star tracker assembly
  - Optical metrology system
  - Focal plane module
  - Science Ground Segment support