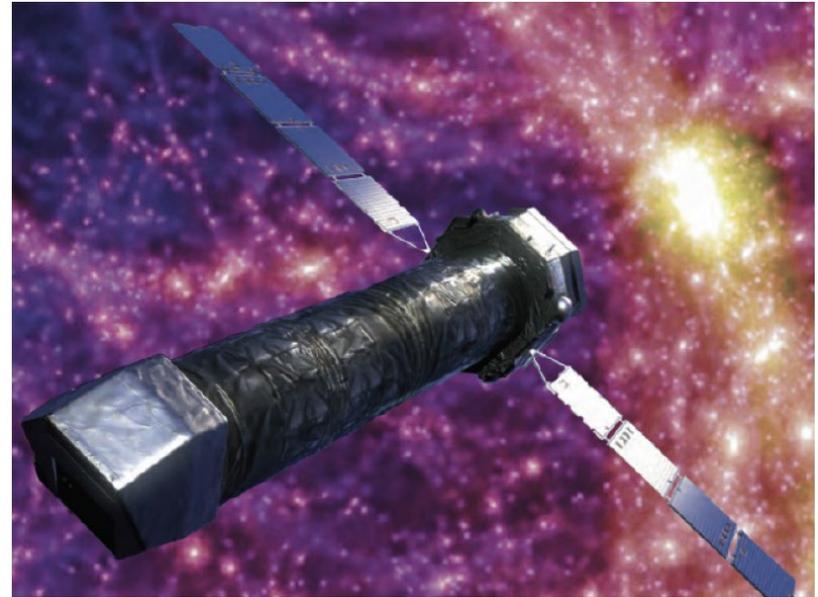




Athena Update

Andy Ptak

NASA Athena Project Scientist
and Point of Contact for
Athena MRT





Overview



- **Athena was first accepted by ESA as the L2 mission circa 2012, with a launch date of 2028**
 - Budget to ESA at the time was set or assumed to be ~ 1 B€, with (European) member states providing the instruments
 - Main requirements: a 5" PSF mirror with ~ 2 m² effective area at 1 keV (later reduced to 1.3 m²), two instruments: a wide-field imager 40' x 40' with a CCD-like fast detector (WFI) and an X-ray calorimeter with 2.5 eV resolution, 5' FoV
- **After multiple delays to adoption and launch, adoption seemed to be on track for 2022 or 2023, launch \sim 2035**
- **May 2022: ESA cost coming in as part of Athena adoption showed Athena was over-budget (1.9 B€)**



(Current) NASA Contributions



- X-IFU sensor and read-out
- NASA Marshall Space Flight Center X-ray Cryogenic Facility (XRCF) for mirror calibration & testing
- Vibration Isolation System (VIS) – “SoftRide” reduces launch loads on the Science Instrument Module
- NASA Athena Data Center contribution to Science Ground Segment (SGS)
 - Prior to establishment of NASA Athena Data Center participating in Athena SGS meetings, helping with simulation software
- Consultation for the WFI ASIC
- WFI Background Analysis Modeling (BAM)
 - Main goal is to use detector simulators and observed instrument X-ray backgrounds to develop advanced background characterization and rejection techniques
 - This effort also includes some minor work in support of a potential transient detection capability to produce rapid alerts of WFI-detected transients



Current Plan



- **ESA decided on a cap of 1.3 B€ cost to ESA**
- **Established a Mission Reformulation Team (MRT) and a Science Reformulation Team (SRDT)**
 - SRDT's job is to advise on the science, including updating the original science case, but also to ultimately decide if "NewAthena" still counts as a flagship mission
 - Flagship defined as doing game-changing science
 - Plan is for MRT and SRT to work for ~ 18 months (starting from last Sept)
 - A. Ptak appointed as NASA "point of contact" for MRT
 - Rachel Osten (STScI) and Lia Corrales (UMich) appointed as NASA reps on the SRT
- **MRT has been most active working on reducing cost of X-IFU to ESA**
- **Hope is to have a workable NewAthena solution roughly worked out to present to a June 2023 SPC meeting, with more mature costs and designs by the ~ the end of the year**
- **NASA is still committed to Athena at the same level and will work with ESA on re-prioritizing the potential contribution**
 - Right now NASA Athena project is still pre-phase-A, cost cap is phase A-D, will likely enter phase A close to adoption
 - NASA Athena science center, project science, science grants don't count towards total
 - The NASA contribution plan was strongly endorsed by Astro2020



NewAthena



- **Prior to "NewAthena" ESA's Athena Independent Science Review (AISR) concluded that Athena would still do flagship science if it reaches a PSF $\leq 10''$ and retains the calorimeter capability**
- **A 1.3 B€ Athena design appears to exist**
 - Retaining both instruments is a requirement
- **ESA and the X-IFU team agreed to a "passive cooling" solution where the focal plane is passively cooled to 50 K (at ESA's expense), X-IFU consortium responsible for (active) cooling to 50 mK**
- **Originally there were two prime contractors for the spacecraft/mirror and two for the science instrument module (SIM), now there will be just two contractors bidding for both the spacecraft and SIM**
 - Simplifies interfaces
- **Development time from adoption to launch < 9 years (2027 \rightarrow 2036)**
 - Large marching army costs during I&T
- **This plan requires NASA to provide a 50 K \rightarrow 4 K cryocooler**
 - RFI issued in late Dec, discussions with vendors ongoing
 - Can only be afforded under current US cost cap if XRCF contribution is dropped
 - ESA had always planned to build a vertical pencil-beam scan mirror calibration facility called VERT-X
 - Holding out remote hope to still do Athena prototype mirror (MAM-D) testing at XRCF



Recent Events



- **MRT-SRDT plenary on Jan 31 assessed key science requirement ranges for PSF, effective area, FoV, X-IFU resolution etc. (next slide)**
- **NASA Athena project will continue current efforts at levels that make sense**
 - Both instrument teams plan to continue development to beat down risk and maintain teams
 - Study of cryocooler options
 - Assessing if a cryocooler contribution is truly feasible
 - Helping with science simulation software and science simulations
 - Participation in MRT meetings when asked, will be involved of course in any change to US contributions
- **Current (unofficial) schedule**
 - Adoption in 2027, launch in 2036
 - Final decision on Athena potentially at the end of this year
- **Athena science working group structure will be retained to help with NewAthena science simulations and advocacy**
- **NASA HQ is supporting the cryocooler contribution (pending costs)**
- **NASA Athena project will be reducing costs (and effort) until ESA's reformulation effort concludes**



NewAthena Science Requirements



Parameter (<i>worse than Athena</i>)	<i>Athena</i> requirement	Best performance	Worst performance
X-IFU total effective area at 7keV	0.16 m ²	0.10 m ²	0.09 m ²
X-IFU total effective area at 1 keV	1.05 m ²	0.85 m ²	0.52 m ²
X-IFU Energy resolution at 7keV	2.5 eV	3 eV	4 eV
X-IFU Field of View (effective diameter)	5 arc mins	5 arc mins	4 arc mins
X-IFU Pixel Size	5 arc secs	5 arc secs	5 arc secs
X-IFU Background (2-7 keV)	5x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹	5x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹	5x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹
WFI Effective area at 1 keV	1.25 m ²	1.14 m ²	0.86 m ²
WFI Field of view (side)	40x40 arc mins	40x40 arc mins	30x30 arc mins
WFI Background (2-10 keV)	5x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹	5x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹	7x10 ⁻³ ph cm ⁻² s ⁻¹ keV ⁻¹
Background knowledge	2%	2%	5%
Optics angular resolution on-axis @ 1 keV	5 arc secs	5 arc secs	9 arc secs
Field-of-view averaged optics angular resolution @1 keV	N/A	on-axis + 1 arc secs	on-axis + 1 arc secs
Point source (45 off-axis) X-ray stray light area ratio against on-axis area	1x10 ⁻³	1x10 ⁻³	1x10 ⁻³
Field of regard	50%	40%	34%
ToO Response time	4 hours	4 hours	12 hours

“Athena requirement” = Athena requirements going into adoption review in 2022
 Best/worst performance = range adopted by SRDT



Conclusions



- **There is a path forward for NewAthena**
 - ESA and instrument teams (mostly X-IFU) are reducing mission complexity and cost
 - Depends on NASA providing a 50K -> 4 K cryocooler (and JAXA providing 50K cryostat)
 - Key SPC meeting this summer potentially will make initial decision on NewAthena fate
 - SRDT must agree NewAthena still does relevant flagship science (also required for continued NASA support)
- **Contribution of a cryocooler “decision” pending cost assessment, will result in XRCF contribution being dropped**
- **Final NASA contributions to Athena to be negotiated, ultimately formalized at adoption**



Backup

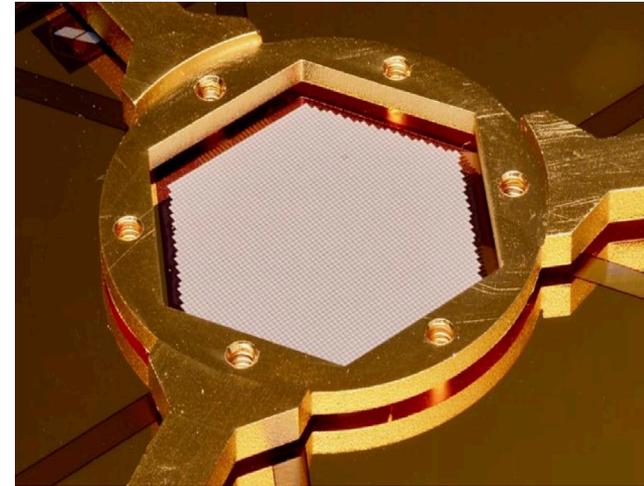




NASA Contribution Status (up to NewAthena)



- **X-IFU**
 - Detector and SQUID multiplexer have passed recent TRL 5 review
- **WFI**
 - ASIC and BAM consultation progressing well





NASA Contribution Status (up to NewAthena)



- **XRCF**

- Conducted successful engineering peer review last spring that identified challenges in mirror alignment but with workable solutions
- Facility was being readied for mirror demonstrator testing (MAMD) testing, which is a partially-populated but full-size Athena mirror. MAMD testing dates slipping with the rest of the Athena schedule. Previously scheduled MAMD testing dates would have been in 2024-2025.
 - Hope is to still test the MAMD at XRCF
- Plan would be to also test a qualification mirror (QM) and the final flight mirror (FM)



NASA Athena Study Team Update

Laura Brenneman (CfA)

NAST Co-chair

March 26, 2023

Charter of the NAST Task Group

- ✓ Assist NASA in developing and articulating a compelling science case supporting the NASA participation in the ESA-led Athena mission for the 2020 Decadal Survey.
- ✓ Provide the U.S. community with information on U.S. participation in Athena including activities involving the U.S. role in Athena science and technology, and provide NASA with U.S. community input regarding the U.S. role on Athena.
- ✓ Provide communication between the U.S. science community and the ESA Athena Study Science Team (ASST) and the X-IFU and WFI Consortia.
- ✓ Provide communication to NASA about Athena science and mission study activities through their role as NASA's representatives on the Athena Science Working Groups.
- ✓ Support NASA's Athena Study Office by providing analysis on scientific and technical issues, as requested.

NAST Membership

X-IFU Members

Simon Bandler (GSFC)
Tim Kallman (GSFC)
Rich Kelley (GSFC)
Caroline Kilbourne (GSFC)
Scott Porter (GSFC)

WFI Members

Mark Bautz (MIT)
Dave Burrows → *Abe Falcone (PSU)*
Ann Hornschemeier-Cardiff (GSFC)
Ralph Kraft (SAO)

Ex-officio

Kristin Madsen (GSFC/UMBC)
Robert Petre (GSFC)
Katja Pottschmidt (GSFC/UMBC)
Panayiotis Tzanavaris (GSFC/UMBC)

Science Members

Steve Allen (Stanford)
Carlos Badenes (U. Pittsburgh)
David Ballantyne (Georgia Tech)
Tamara Bogdanovich (Georgia Tech)
Niel Brandt (PSU)
Joel Bregman (U. Michigan)
Laura Brenneman (SAO)
Megan Donahue (Michigan State)
Karl Forster (Caltech)
Massimiliano Galeazzi (U. Miami)
Richard Griffiths (U. Hawaii)
Sebastian Heinz (U. Wisconsin)
Jon Miller (U. Michigan)
Paul Plucinsky (SAO)
Andy Ptak (GSFC)
Randall Smith (SAO)
Eleonora Troja (GSFC)
Scott Wolk (SAO)
Will Zhang (GSFC)

The NAST and NewAthena

- Although ESA has given Athena a major reboot, the mission is now heading in the right direction and the support systems provided by the astronomers are still in place. In the U.S., this is the NAST.
- The ASST has been dissolved and replaced by the Science Re-Definition Team (SRDT). The NAST is in close contact with the U.S. representatives on the SRDT, Rachel Osten and Lia Corrales.
- On the European side, in order to support continued community engagement with the mission, the Athena Community Office (ACO) is still operating, as are the Science Working Groups (SWGs) and Topical Panels (TPs).
 - Athena webinars
 - Regular website updates
 - Regular newsletters

Recent NAST Activities and Recommendations

- The NAST has held meetings every ~6 months for the past 3 years, most recently in February 2023.
- The NAST remains the means of collecting community input on Athena within the U.S., and delivering messages to that community. This is only possible because it has a mixture of NASA officials, people at GSFC working on technology, and scientists from around the country.
- Fitting within the mission within the €1.3B cost cap while retaining its core science depends on the U.S. contributing the cryochain. The NAST supports this contribution.
- The NAST also supports continued development of the SPO mirror technology; a number like 6.5" at the time of launch appears to be within reach.
- The NAST urges the international community and NASA to remain cognizant of the international nature of this mission, and hold to those partnerships as the process develops.

Take-Away

- The U.S. community can still influence what NewAthena's capabilities need to be!
- The NAST retains its confidence in the mission, which will bring flagship-class X-ray observing capabilities to U.S. guest observers at the cost of a SMEX and serve as a critical component of the panchromatic mission landscape of the 2030s-2040s.
- ***We call on the U.S. community to continue its support for NewAthena, urging NASA to protect the U.S. contribution to the mission and to do everything in its power to help bring the NewAthena to fruition.***