Notetaker: Panayiotis Tzanavaris

Presentations: Titles in underlined bold; entries in bold but not underlined refer to slide headings

Notes include extra points presented by speakers that did not seem to be in the slides as such, ad hoc questions and answers during talks, and general discussion.

Action items appear in red.

Matteo Guainazzi

Athena Study Status

New ESA ASST since last Sep. replacing Andy Fabian and Dick WIllingale

New chairs of SWG1 and 2, and for 1.2 1.3, 2.1
Two new panels: Athena-MM 3.6 and 3.7 Beyond Standard Model

Number of modules, geometry; in terms of these "frozen mirror"

ASST recommends switch to L1 orbit (ESA AREMBES contract recommended because soft p^+ flux better known & less variable than in L2: see right panel p^+-flux vs energy - L2 is grey band; left panel; in L2 solar flare flux is higher)

Tech note to be written for full justification.

AHEPaM instrument essential for NXB = non X-ray background

Adoption and implementation

Red Book

Optics

Angular resolution

Plot: evolution of ang. res. ; ref curve is red dashed
Outer radius similar; inner radius quite worse.

→ Andy Ptak: will there be energy-dependent (e.g.,1 vs. 7 keV) PSF requirement given that PSF res. twice as bad at inner radius?
Matteo G: Already have different between 7 and 10 keV. Have not discussed yet update at ASST level. In any case this is all in flux.
Andy: If not get better say than 10" at 6 keV, that won't be compliant with a 5" requirement independent of energy.
→ Matteo: All requirements will need to be revised, with respect to mission adoption. We could treat separately.

Sensitivity performance results:

For res > 6” lose science of high-z AGN. X-IFU science relatively unaffected, but if worse than > 8” feedback to ICM and radio galaxies will be affected but sample in low z will not reach statistically required threshold.

Effective area

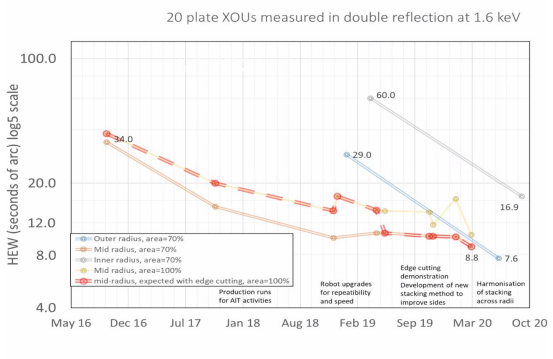
(Instr. Eff already compliant)
Multi-layer could increase Aeff up to 50%

Vignetting

Questions

• Mark Bautz:
Particle monitor energy range?
-Doesn’t go beyond 1-2 GeV.

• Seb. Heinz: Degradation at high energies for ang. Res: prospects that could improve for cluster science (Fe line important for kinematics)
-This is not a very worrying issue. Both latest measurements of outer and inner radii were first attempts to create stacks with standard recipe. Workhorse of activity is medium radius. From plot should take that trend of improvement for middle radius is replicated by outer and inner ones without doing anything to them → confidence that whatever improvement you get at middle radius will be replicated at inner and outer → Next attempt should be much better.



• A Ptak: Are there measurements at higher energies than 1.6 keV?
-I think they are at similar / comparable energies. Can do at higher if needed.

NASA Athena Project Independent Programmatic & Cost Review
Rob Petre

Projectization began ~1 year ago (Study → formal NASA Project after KDPA; there were some technical issues [ill defined requirements] and some programmatic.
Plan: combine KDPA+B reviews to have in May 2022 (So we’ll go directly to Phase B - not a first time for a mission).

We are only delivering pieces /services → a lot of NASA documents do not apply as they are written → have to reform (HQ and GSFC project experts very helpful) existing documents.
Study Manager Robin Krause reaches retirement → Betsy Park takes over

The Indep Prog Cost Review is challenging. LISA have done that and will be interesting to see the differences between the two.
Review took several months.
Main focus was cost capped at $100M-150M (but were other issues as well, also looked into).

Review team
An excellent A-team

Timeline
June/July 2020 to Jan 2021

A series of 5 meetings.

Very nice interaction with many questions to be clarified.

We have come up with our response to some of the cost issues raised in Final Report.

Summary Graphic
Green=OK
Yellow=potential issues
Red=issues

The overall cost they came up with was in excess of cap.

General Observations
In general, very complimentary. They didn't really give us any surprises.
The single big worry is staying within $150M cap for the hardware contribution, while long time to launch and other risks.
However, with a sensible approach in evaluating risks it is within 150M.

List of risks
We agree with most - what got us was ESA-01: *Athena schedule Delays impacts NASA contribution*. Historically, missions launch 49 months later than expected as of phase B1. So panel added cost for that.
This however is not within our control, so if you disregard that risk, for the rest the sum total stays within 150M (for the hardware contribution).

<u>Questions</u>
• Jon Miller: In terms of science support costs, have any idea how that figure compares to CXC or XMM guest observer facility or Herschel?

-Rob: Sci Center will not be CXC nor XMM level activity - will be in the middle. We made assumptions for SGS software and amount of support to maintain activity. I expect members of data center team will play role with XRCF mirror calibration.
-Andy Ptak: We took contributions to Herschel, Integral, XMM to make estimate.
-Rob: There was a risk (they said: maybe we underestimated) of course. But is not reflected in bottom line hardware cost.
-Andy: Georges Helou who we consulted for Herschel input ended up on review panel!

Randall Smith (*no slides*)
AA special issue - Red Book - Status of transient science
Special issue really good response from community: >100 papers submitted
Sorted / negotiated with editors: They are happy with special issues and usually have small numbers of papers (=every paper will get in, so want to give good attention to them). But we want ~80 papers → they blanched.
We clarified that most are for ideas for things to do with Athena, and the editors would not insist that all of these will have to be in the special issue. Only a smaller number was Athena-technical specific and would have to be included.
Schedule: At first, to be published before or around ESA adoption but things have slipped. Put together 2 sets of specs / simulations? But point is to say the science we can do with this great mission → decided to wait until sure what mission will look like → end of year.

No official decision on new AA special issue but thinking Q4 2022
→ Matteo: Have sort of a baseline that submission should be Sep. 2022 (but this was when adoption would be June 2022- so likely to revise decision to likely Q4 2022)
→ Please hold tight! Can't do much before we have results on ang res, PSF studies, coatings for eff Area.

Red Book
Really equivalent to a concept study in US
Contributions from community
Science section 20-25 pages (v. dense for core science requirements)
Requests for simulations will come (later in the year once we know specs).

Yes, these delays are annoying but are for the best → get a better mission.
ESA makes a lot of funding available for these mirror studies; cosine has a lot of money available. That said, we can pretty much expect that once requirements are set, this is what we will get: Large sums of money going to this will be cut; also Project Manager will be assigned and told to get mission out by given date → requirements at end of this year will be what we will get.

Transient Science
We had discussed that due to Athena's large area and large FOV there would regularly be transients. Had ASST discussion → who owns transient sources? Proprietary? E.g., WFI

survey? That team was thinking of using those data. XIFU will probably also see some sources (though smaller FOV due to sensitivity).

ASST felt not necessarily something they wanted to jump on.
→ Matteo G: Not considered at present. Cannot rule out it might be later.
→ McNamara P: There *should* be a science management plan!

Process to follow?: Maybe subgroup of NAST can put together a formal memo to submit on this. Always better to write things up and have short discussion at ASST.

→ Matteo: Option could be to use our weekly telecon and leave ASST for formal rubberstamping. Contrary to what mentioned for new adoption date, Paul M. will likely present plan not in March but shortly before summer, so there is time for a specific discussion at a telecon.
→ Niel Brandt: I understand concerns for people being unhappy fearing that their private data could be released. So when submitting proposal they could define a region that they would want to be protected as exclusion region. If a transient went off there, would not have those data released → would mitigate data ownership concerns.
→ Matteo: One of objections - need of rigorous definition of what transient is (less trivial than you think). E.g., Is an AGN flaring by 10x a legit new transient? You want a well-defined mechanism to implement straightforwardly.
→ Niel: I certainly had a particular type of transient in mind. I agree though that this needs some thinking.

→ Randall: E.g., *Swift*'s success was because things were thought out at the beginning. Might be worth doing a comparison of observatories / instruments in other fields to see how things are shaping for the future. Note: I have to be the one to present, but cannot do / lead the work.
→ Burrows: We have discussed this so might be a way to do that.
→ Randall: So could do telecon to discuss between interested people.
→ Andy: There has been a bullet point for the US to do *quick* analysis of transients. I brought this up at meetings, and should keep open to have detection ability at the MOC(?).
→ Jon Miller: We can come back on this!

XRCF Updates
Kristin Madsen
Hexapod inherited from JWST.

XRCF Contribution
Since last time, 1 MAMD prime selected.

MAMD campaign
Thermal test still quite simple, as ESA doesn't know exactly what they want to do with this. Once we calibrate at finite distance, we can use model for infinite distances.

What we really want to do is the gravitational comparison test for mirror deforming. We hope to do that when we get mirror back.

Current activity
LASER system to align to optical axis from *Chandra* → probably can use this (still checking)
MGSE has to be very stiff to hold mirror (~1000 kg).
Shutter: aims to isolate some of the mirror modules.

Questions - none

Dave Burrows
US Contributions to the Athena WFI

Flight like Detector fabrication
Now testing started by MPE

WFI Background Analysis
(US specific)

GEANT4 (code)
Original models by Open U. and MPE showed background requirements would not be met. This affects observations of low surface brightness in galaxy clusters. MIT imported detector model from MPE and GEANT code from OU. To understand variations in background and how they track variations in incident p^+ and solar activity, need ~10x more statistics for OU simulations (that was designed to get only overall spectrum and brightness of background). Numbers reached but open issue with normalization.
OU and MIT shapes of spectra similar, but not normalization and at this point unresolved.
Get OU and MIT to run new set of models, agreeing with exact same models, to see if they get same results. Person that did previous results is gone, so can't get full information on what / how was done.

AI approaches
Showing frames - top: actual images from simulations; bottom: AI identification of CR events. Further 2 bottom rows images show AI nicely identifies CR but not X-rays → feasibility of image segmentation algorithms to get probabilistic result whether given event is CR or X-ray.

VERITAS ASIC
Connects directly to detectors, takes data coming out, and does initial processing and amplification. Current issue is that detector fab techniques changing and not clear that process used to produce the ASIC for previous generations will still be available when flight units for WFI to be made. So doing porting of design from previous AMS to XFAB process together with MPE. A lot of this must be done in person, so more affected by COVID-19 (in particular Svenn Hermann not been able to travel to Germany).

Questions
→ Richard Griffiths: How do you treat variations over solar cycle in terms of intensity and spectrum?

→ Dave Burrows:
There is work done on background seen with XMM and other missions and how it varies with solar cycle. No work yet in simulating that with GEANT4.
→ Mark Bautz:
When interested in knowing background at 2% level, it is very challenging but there is a lot of data. E.g., we are looking at AMS data covering ~solar cycle and shows both global over entire cycle but also over scales of, e.g., ~month variation. Part of our GEANT4 simulation is to characterize that.

5 min. BREAK

Simon Bandler
Update on ATHENA X-IFU developments

Cobalt Kα lines used for energy resolution measurements. For ~250 pixels used, ΔE~ requirements met and aim to increase margin.

At 7 keV we are below resolution requirement. Hope to meet requirement: At 1 keV below 2 eV

Yield
The new requirement of 95% is much more reasonable than previous 99%. There might be some loss in area in this process (and will be also affected by overall area issues).

X-IFU time division multiplexers -SQUID-based read out chips
We can now provide readout within the area available.

Schedule
Engineering module detector delivery is our toughest deadline.

Questions
→ Andy Ptak:
1. Is energy res calibration requirement in terms of eV or % → Simon: ~0.04 eV
2. How big an array needs to be tested to demonstrate TRL5 and 6, min. number of pixels? → Even at the higher level they are planning to populate some of side panels and electronic planes, not a full module; we are planning for 85-90% of pixels, statistically that should give us fairly high confidence

→ Steve Allen: What should we as users be thinking of taking calibration information taken once, how would environment be changing?

→ Scott Porter: Will be continuous monitoring gated and cut out of your target (like with XRISM).

→ Steve: thus this means every observation will be calibrated at that time.

→ Richard Griffiths: Schedule slide - are goals prioritized, what is the critical path there?
→ Simon: We are concerned about vibration requirements in particular (need to make holes for testing). Also radiation testing planned and important.

Andy Ptak
NASA Athena Science Ground Segment
Also Project Scientist for Science Ground Segment

These slides presented to Instrument Science Consortium.
We are doing Herschel model for science pipeline.

Main new thing: **NASA ATHENA Programmatic Review (slide)**
(→ Steve Allen: Chat- Is that FTE years, rather than FTEs?
Randall Smith To Everyone
4:15:22 PM
Yes, I believe that's the implication
Robin Krause To Everyone
4:15:43 PM
That's the sum total over the length of the effort.
)

Questions
→ Mark Bautz:

NASA ATHENA SGS Staffing Plan

Notional distribution of ~ 130 FTEs but also being used for near-term funding requests

Year	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37	FY38
Deputy Project Scientist	0.7	0.8	0.8	0.9	0.9	1	1	1	1	1	1	1	1	1	1	1	1	1
SGS senior scientists										1	2	2	1	1	1	1	1	0.5
SGS support scientists	1	1.6	1.6	1.7	2	2	2	3	3	4	5	5	4	4	3	1	1	0.5
SGS programmers					0.5	1	1	2	3	3	4	3	3	2	2	1	1	0.5
Data Center Management						0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1
Data Center Budget Personnel						0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
GO Support Team								1.0	2.0	2.0	2.0	2.0	3.0	4.0	4.0	4.0	4.0	3.0
Total FTEs	1.7	2.4	2.4	2.6	3.4	4.6	4.6	7.6	10.1	12.1	15.1	14.2	13.2	13.2	12.2	9.2	9.2	6.7

Your FTE estimate- please elaborate:
That technically has started already; a trickle now, then peaks.

Open Discussion

Community Concerns

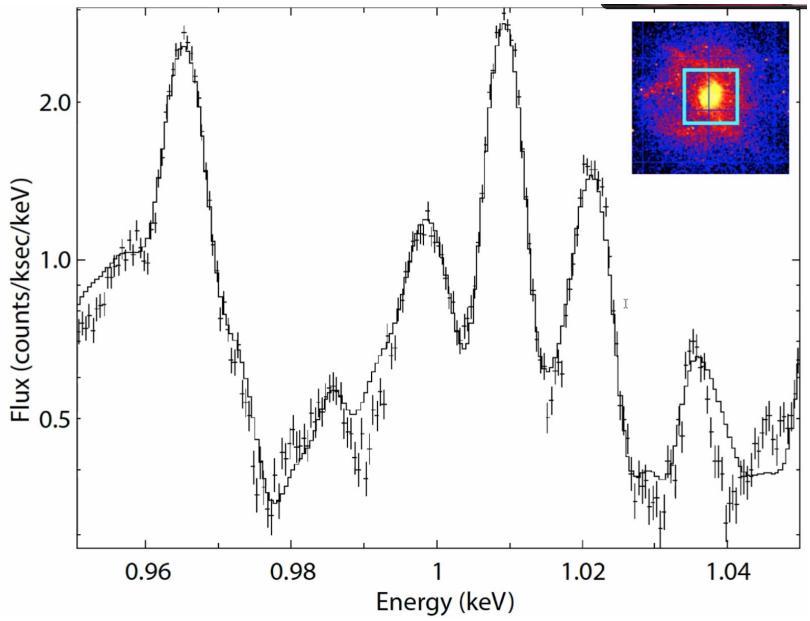
Jon Miller: Most pressing might be funding for groups to do atomic physics:

Randall Smith: This spreadsheet is where we are now:
Color coded is from me for initial thoughts / implications.
There is already some funding for this in Europe (e.g., Luigi Piro). Ideally, we would coordinate across US-Europe. Happy to have people look at this and take your thoughts.

	Reference and short description	Requirement (science objective)	Quantification	RKS Initital Thoughts on Spectral Implications	
The Hot Universe	R-SCIOBJ-111 First groups	Athena shall find distant evolved groups of galaxies with hot gaseous atmospheres at z>2 with M_{500}>5x10^{13} M_{Sun}, of which at least 10 shall have global gas temperature estimates.	10 galaxy groups with gas temperature at z>2 to investigate L-T relation.	Groups will have kT ~< 2 keV, dominated by lines not brems. Temperature results will depend on CSD, line fluxes, abundances. Not a giant effect but should be studied	
	R-SCIOBJ-112 Cluster bulk motions and turbulence	Athena shall measure how gravitational energy is dissipated into bulk motions and gas turbulence in the galaxy cluster population, by achieving a 5σ detection of these quantities in a sample of 10 massive clusters.	Kinetic energy dissipated from gravitational assembly in 10 galaxy clusters in the nearby Universe.	Requires measuring line shape/broadening. Weak line strength & position (esp DR satellites) will impact this	
	R-SCIOBJ-121 Cluster entropy profile evolution	Athena shall determine the evolution of the gas thermodynamics during hierarchical gravitational collapse as a function of cosmic epoch by measuring the structural properties (e.g. the entropy profiles) of a limited sample of high mass clusters. The measurements shall be achieved out to R_{500} up to z~2, with an uncertainty <25% (at R_{500} at z=2). Athena shall also resolve the accretion regions (R_{500} to R_{200}) in a limited number of high mass local (z <0.5) objects. Furthermore, Athena shall measure the evolution of the scaling relations between bulk properties of the hot gas (e.g., the L_x-T relation) out to at a redshift of 2, to a precision of <25%.	Cosmic history of the injection of entropy in cluster hot gas at 0<z<2. Investigate 10 clusters in each of 4 redshift bins (total 40 clusters)	Requires measuring Lx and T as a function of position, in some cases with relatively low counts but high spectral resolution. No obvious atomic physics issues but may be subtle ones	
	R-SCIOBJ-122 Cluster chemical evolution	Athena shall explore the production and circulation of metals in the deep potential wells of massive galaxy clusters across time. Metal production will be estimated from the abundances of the most common elements (e.g. O, Si, S, Fe — at 5σ) and their relative number will be related to the number of time-integrated SNIa and SNcc products. The measurements (5σ) of trace elements (e.g., Al, Cl, Mn, Co) shall allow constraints to be put on initial metallicity of the SNIa progenitors. These measurements will be spatially resolved at up to R_{500} and the evolution derived over 10 Gyr of cosmic time (0<z<2) for the most massive clusters.	Metal production and dispersal in cluster hot gas out to z=2. Observe 10 clusters in each of 3 redshift bins out to z~2 (total 30 clusters).	Systematic CSD uncertainties make accurate abundance measurements beyond 15% challenging/impossible; not clear from description what requirement is beyond 5σ detection.	
	R-SCIOBJ-131 Physics of cluster feedback	Athena shall measure the energy stored dynamically and thermally in the hot gas around the bubbles in a statistical sample of clusters, selected to cover a range in jet power, by achieving a 5σ detection of bulk motion and turbulence induced through AGN feedback and allow measurements of the spatially-resolved velocity structure in the best-studied systems.	Statistical sample of 25 objects is designed to cover a range in central AGN jet power, with a tiered strategy allowing spatially resolved studies of the velocity structure in the feedback region with the deepest observations, and at least a single detection of velocity structure otherwise.	Bulk motion requires only wavelength of selected strong lines, most of which are well known. Turbulence again requires knowledge of nearby weak lines, esp DR lines, which are far less well measured.	
	R-SCIOBJ-132 Feedback-induced cluster ripples	Athena shall determine the occurrence and impact of AGN feedback phenomena by searching for ripples in surface brightness in the inner 5 arc-minutes of a statistical sample of clusters, selected by central AGN power.	Detection of ripples in cluster gas created by AGN jet activity, in a statistical sample of 25 clusters.	Largely Lx as a function of position, no obvious lab astro issues.	
	R-SCIOBJ-133 Heating/cooling balance in cluster feedback	Athena shall determine the gas that fuels the AGN jet to balance the gas cooling rate by measuring how much gas is at each temperature in cluster cores using temperature-sensitive line ratios in a representative sample of nearby clusters.	Heating-cooling balance in hot gas of 10 cluster cooling cores.	Specific line ratios will need to be calibrated; if from different ions, systematic CSD effects will be an issue, if from the same ion need to worry about blending and line flux measurements. He-like and H-like ions are in decent shape if accuracy of >10% acceptable.	You cannot do determine the using full emiss
	R-SCIOBJ-134 Shock speeds of radio lobes in clusters	Athena shall determine the shock speeds of expanding radio lobes in a representative sample of nearby powerful (FRII) radio galaxies by distinguishing the gas temperature in shocked and undisturbed regions to >3σ level, to determine the population-wide impact and evolution of jet	Shock speeds of expanding radio lobes in 10 clusters around radio galaxies for 2 source sizes and 2 radio power bins[1].	Bulk motion requires only wavelength of selected strong lines, most of which are well known.	
	R-SCIOBJ-141 Missing Baryons	Athena shall measure the local cosmological baryon density in the WHIM to better than 10% and constrain structure formation models in the low-density regime by measuring the redshift distribution and physical parameters of 200 filaments against bright background sources, selected to probe various cosmic densities; and by performing a statistical analysis of the emission lines of heavy elements in a representative sky region and high-probability targets	Detect 200 WHIM filaments in absorption, 100 towards BL Lacs and 100 towards bright GRB afterglows to sample the WHIM up to z=1.	Only requires Einstein A values for strong and well-known He-like and H-like transitions for absorption work. Not immediately clear what "Emission lines of heavy elements" means.	Heavy likely is
	R-SCIOBJ-142 WHIM in emission	Athena shall detect WHIM filaments in emission associated to absorption detected against 7 GRBs, after they faded away, as well as 2 filaments.	Detect emission of WHIM filaments associated with systems detected in absorption detected against 7 GRB afterglows. Determine metal abundances from emission lines in filaments along 2 selected regions (A2223 and COSMOS)	Systematic CSD uncertainties make accurate abundance measurements beyond 15% challenging/impossible, but statistical limitations likely to limit beyond this.	

Also from proposal that we put, arguing there is a lot of work to do even for most basic things: Simulation of elliptical galaxy NGC4636 to be observed with XRISM, points generated with single 1-temperature plasma. Can do a theoretical wavelength calculation (good to 0.5%). From spectroscopic perspective the Doppler shift is ~1,000 km/s. So this is what you get if you shift

lines randomly within these errors.



Best fits you get: For strong lines, match is good. But there are some discrepancies which might point to some poorly understood physics, amazing Doppler shifts. HQ is not necessarily aware that this needs to be done - funding now comes from APRA Lab Astrophysics. Teams not particularly well funded, most of this done as a side issue. Will need new or expanded groups for Athena, with really focussed groups. We need more people who are willing to put together the case.

→ Mike Garcia: The APRA lab astro path is a good one. E.g., in this year's APRA there was recognition that these would need upgrading.

→ Randall: But additional funding was $50K, really not enough.

→ Mike: We have time and we will also learn with XRISM.

→ Randall: From Matteo, group website AHEAD https://ahead.iaps.inaf.it/

SRON recently hired a person to replace Kaastra, and plan to hire more people. We are seeing how to make sure that spectral codes can access same data. Ideally to have multiple groups working on this so that can compare across models and groups.

→ Laura Brenneman: Anything NAST could put forward in particular?

Randall: I am working to convert excel spreadsheet to larger document for ASST to present to funding agencies around the world: "Here are the things we need in order to do the science we do"

I welcome assistance on this and open to suggestions.

→ Steve Allen: I agree with Laura's question - and another thought. In this new era of collaboration between DoE and NASA, there is some flexibility in nature of collaborations. Would it be effective to collaborate with national labs so that they can redirect some of personnel in collaboration with NASA?

→ Scott Porter: For Helium this already happens with Livermore ($1M). The way national labs are funded is very byzantine; you can't ask directly. Speaking for myself, we are at the limits of what can be done unless there is intervention at much higher political level.

→ Randall: Sandia Labs doing a lot of work on photoionization models. Tends to be individual.

→ Scott: Number of full time people on this is extremely small and mostly postdocs.

→ Andy: Effort chart was not $, but FTEs. Both XRISM and Athena could pay, say, same institute for this work.

How to more effectively pursue organization of working groups
→ Randall: Many of the groups doing just fine. I emphasize this is way outside our arena, we will not demand anything to be done. ASST would welcome good suggestions.

Advanced analysis tools: Don't seem to have done much?

Is there need for reorganization?

→ Jon Miller: Science Ground Segment group has been very organized. Wonder whether some of other groups face issues due to changing mission profile?

→ Matteo: ASST thinks restructure would be needed but not very urgent right now. Focus on getting the mission past adoption. Then we may start thinking about restructuring. Because whenever the need exists, ad hoc task forces are formed. In any case, inputs are very welcome.

→ Randall: Agree, we just bring it up to have time to think it over the next 6-8 months. Suggestions welcome.

Thinking about NAST membership rotation plan
→ Jon Miller: Institutional memory / knowledge for mission+improve community engagement on the US side.
→ Randall: Examples from other missions / groups?
→ Mike Garcia: Most such groups have rotation. Launch is 2033; HQ will not force a model.
→ Laura: HQ is actively trying to downsize committees / teams down to ~12?
→ Mike: There was a White House directive to limit advisory groups' size. That's gone. More than 12 people usually difficult to have face to face though.
→ Laura: NASA constituted this group. HQ would then instigate rotation?
→ Mike: Would be involved, not necessarily instigate. Official letters are useful to justify what members actually do.
→ Laura: Seems really up to us then? Andy-Rob?
→ Rob: We are early before launch. Thus we need to make sure to bring in people who are entering the field. Balance between early-mid-late career. So opportunity to bring in early-career

people. No urgency in rotating people out. Note that LISA similar committee has started rotating people (~3-year cycle?) We might be asked why we are not doing what they are doing.
→ Andy: Original idea was taking people from Science groups and funding them to go to Europe meetings to interact and report to HQ. Note that people might retire and thus rotate out.
→ Mike: Should also be on Athena page what original idea was.
→ Laura: In addition to this group providing information back to NASA, we have been tasked to be representatives for the US X-ray community and other interested parties. Depending on the Decadal results (e.g., if Lynx is not selected and Athena is the only flagship mission we can expect in the near future), this would highlight our role.