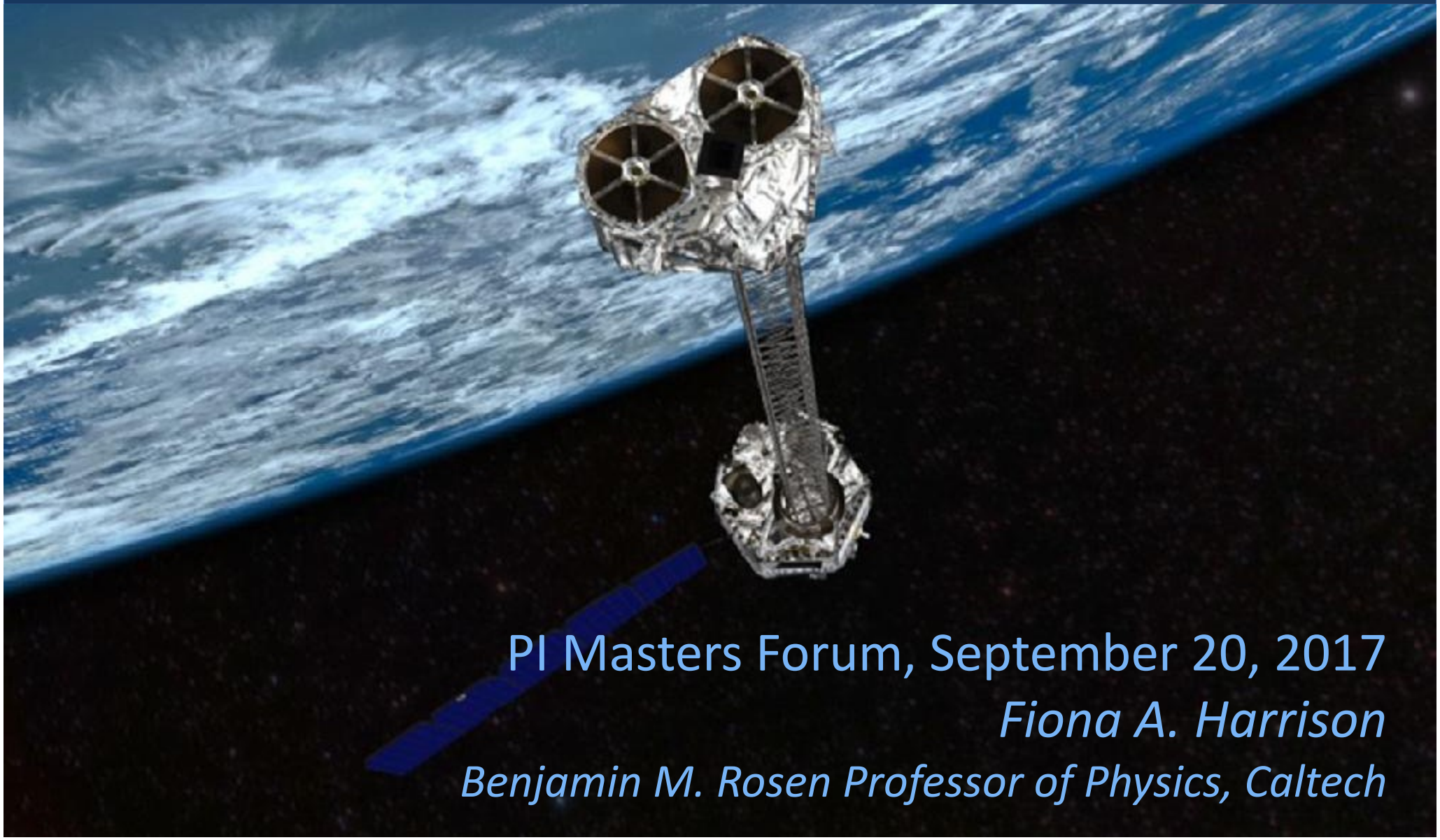
NuSTAR Lessons Learned



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Fiona A. Harrison

Benjamin M. Rosen Professor of Physics, Caltech

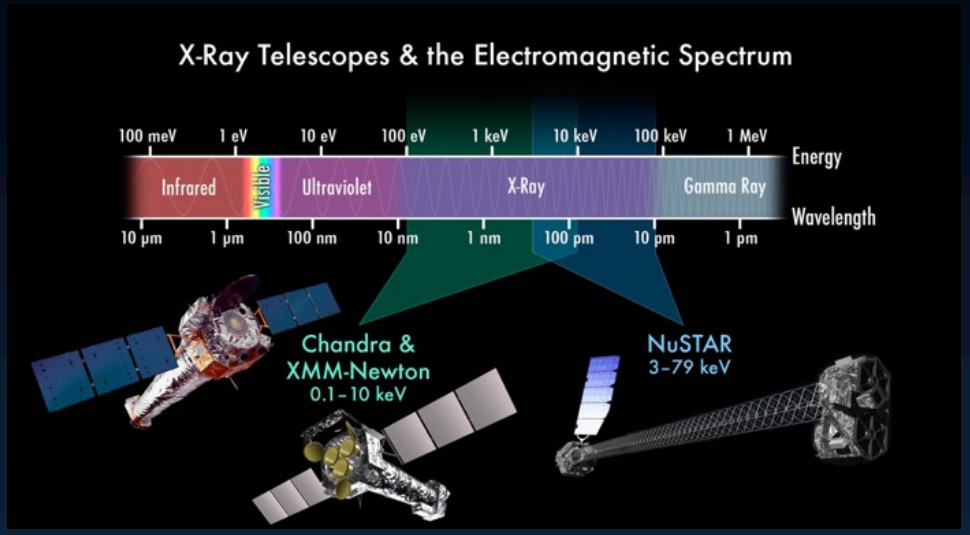
NuSTAR Project Overview

Summary

- Small Explorer (105 M$ A/B/CD cap)
- High Energy X-ray focusing telescope
- Phase B start: 2/25/08, Launch: 6/13/12
- 2-year prime mission
- GO phase began 2015, now in AO3
- Category 3, Class D (enhanced) mission

Major Partners

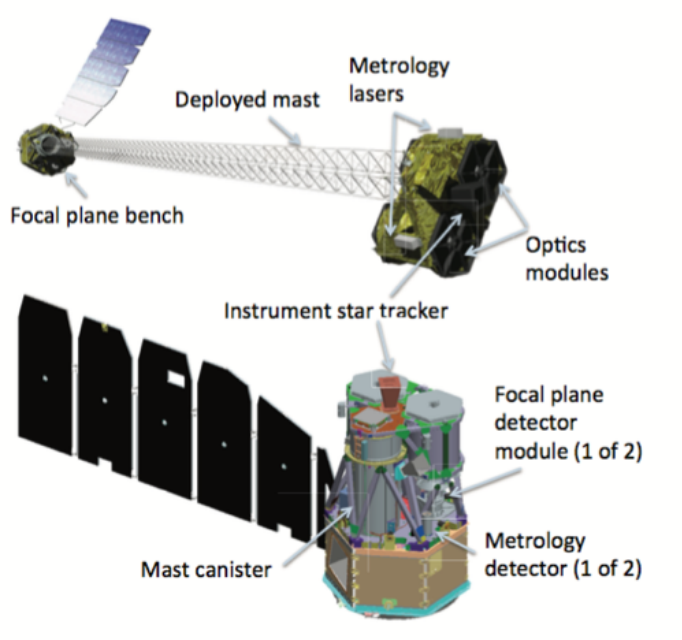
- Caltech (PI, instrument)
- JPL (management, systems engineering)
- UCB (instrument, mission operations)
- Orbital (S/C)
- ATK (extendible mast, instrument structures)
- GSFC (optics, archive)
- Columbia (optics)
- DTU (optics)
- ASI (ground station, analysis pipeline)



Mission Parameters	
Launch Mass	350 kg
Payload mass	173 kg
Power	600 W
Launch Vehicle	Pegasus XL, Kwajalein launch
Orbit	650 x 610 km, 6° LEO

Payload and Science

Instrument Parameters	
Telescope	2 grazing incidence X-ray optics
Focal length	10 m
Spatial resolution	1’ HPD
FoV	12’ x 12’
Source positioning	10” (3-sigma)



- *Survey deep extragalactic fields to study the evolution of supermassive black holes*
- *Survey Galactic fields to study populations of stellar remnant black holes and neutron stars*
- *Map the young remnants of exploded stars in radioactivity*
- *Observe core collapse supernovae in the Local Group and nearby Type 1a SNe*

343 publications to date, 5400 citations

NuSTAR Challenges

- Hardware distributed over multiple partners
- Mass margin was low from day 1
  - » Required extremely careful management
- Optics - ~500 segments, distributed fabrication (GSFC, Denmark, Columbia)
  - » Control of process was challenging
- Extendible mast
  - » Many parts, testing challenging,
- Many mechanisms, difficult testing
- Mission classification ('enhanced' class D) was new – nobody really knew what it meant

Lessons Learned

- Technical and Leadership team and organization is key
  - » Project success is determined by the technical quality of the project team – choose carefully
  - » Stable leadership is critical – no changes in high level organization
  - » Adopt a flat management approach – key people must communicate without a mid-management layer
  - » If working with a center, make sure there is an agreement on stability of top level personnel

Lessons Learned

- Beware of heritage
  - » Heritage claims tend to erode on closer review
  - » Heritage resides in people, not organizations
    - learned this the hard way with the deployable mast
  - » Seemingly small changes or scaling can be challenging
    - Detectors were custom, repackaging from balloon format and more rigorous environmental requirements led to major issues
- Takeaway : heritage arguments can lead to over-confidence, and often come back to bite

Lessons Learned

- Try to reduce process oriented work – it often adds insufficient value for the large effort
  - » We adopted an EVM-lite approach and got center buy in
  - » Tailoring JPL's mission assurance plan was essential given our cost/schedule constraints
  - » Tailored JPL's oversight requirements on contracts
- Negotiate and obtain center-level agreement early on

Lessons Learned

- Strong, independent reviews can be helpful
  - » Choose SRB members carefully for directly relevant experience .
    - Can rely on technical expertise
    - Make sure SRB members are SMEX-experienced
  - » Develop a good working relationship with board members
  - » Involve SRB members in system and subsystem reviews – leads to smoother mission-level reviews
  - » Peer reviews with carefully chosen technical experts can add real value

Lessons Learned

- Decide science team roles and responsibilities early and formalize them
  - » Your first senior review will be there before you know it
- Setting the structure, expectations and responsibilities long before launch is important
- NuSTAR's approach was to structure working groups, appoint senior leaders, but set an expectation/culture that junior scientists would be leads
  - » worked well to minimize conflict and get results out in a timely way

June 13 2012

June 13 2014