
NICER
Neutron star Interior Composition ExploreR
The NICER mission: a partnership in science and technology on the ISS
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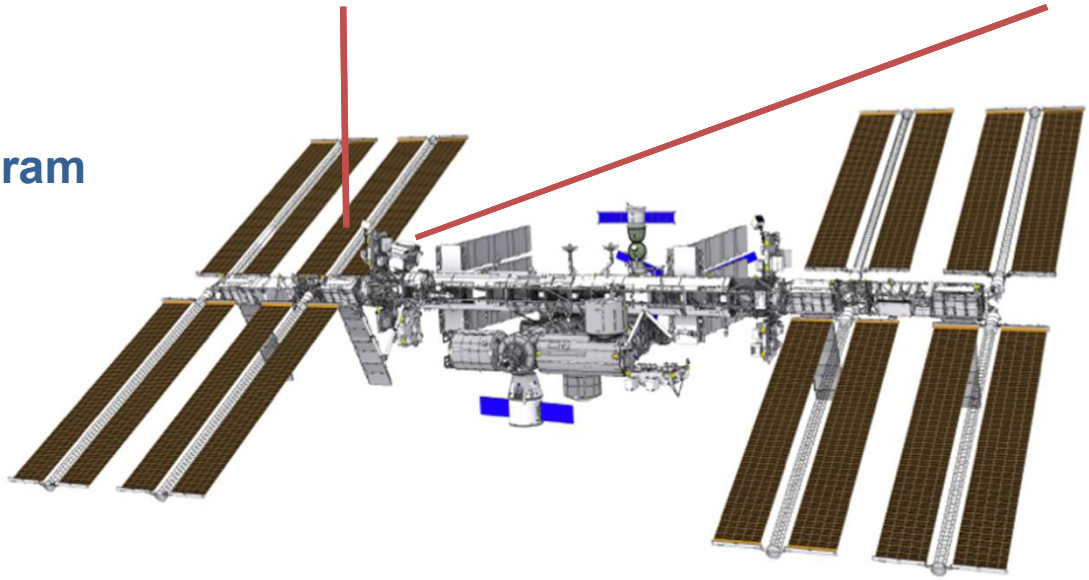
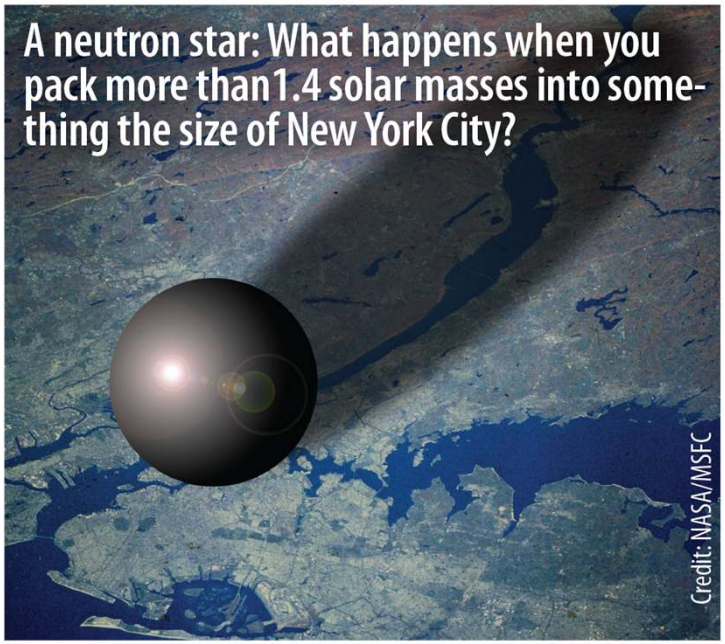
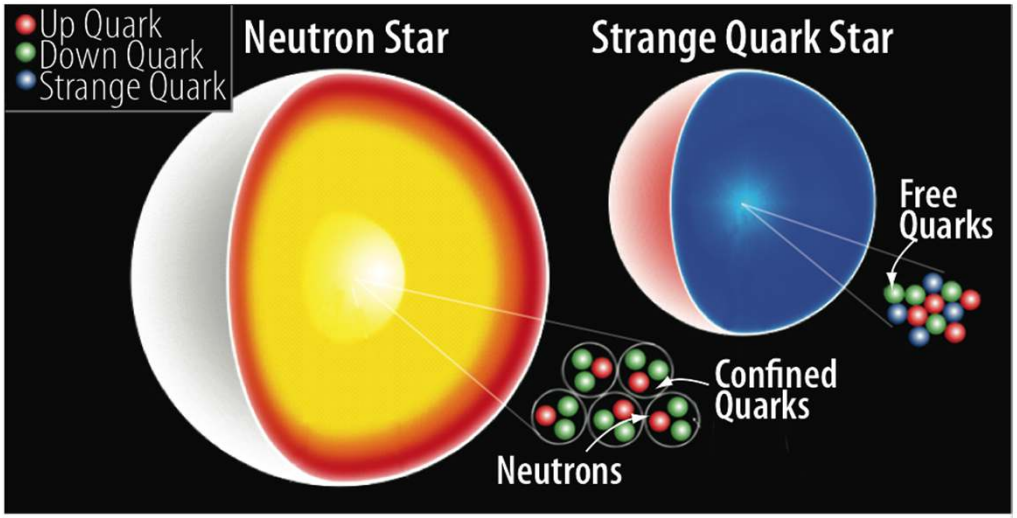
An Astrophysics Mission of Opportunity on the International Space Station

- *Science:* Understanding ultra-dense matter through observations of neutron stars in the soft X-ray band
- *Launch:* October 2016, SpaceX-12 resupply
- *Platform:* ISS ExPRESS Logistics Carrier (ELC), with active pointing over nearly a full hemisphere
- *Duration:* 24 months including Guest Observer program
- *Instrument:* X-ray (0.2–12 keV) "concentrator" optics and silicon-drift detectors. GPS position & absolute time reference
- *Enhancements:*
  - Guest Investigator/Observer program
  - Demonstration of pulsar-based spacecraft navigation
- *Status:*
  - Passed CDR, Sept 2014
  - All critical ETUs in hand
  - Significant flight hardware done



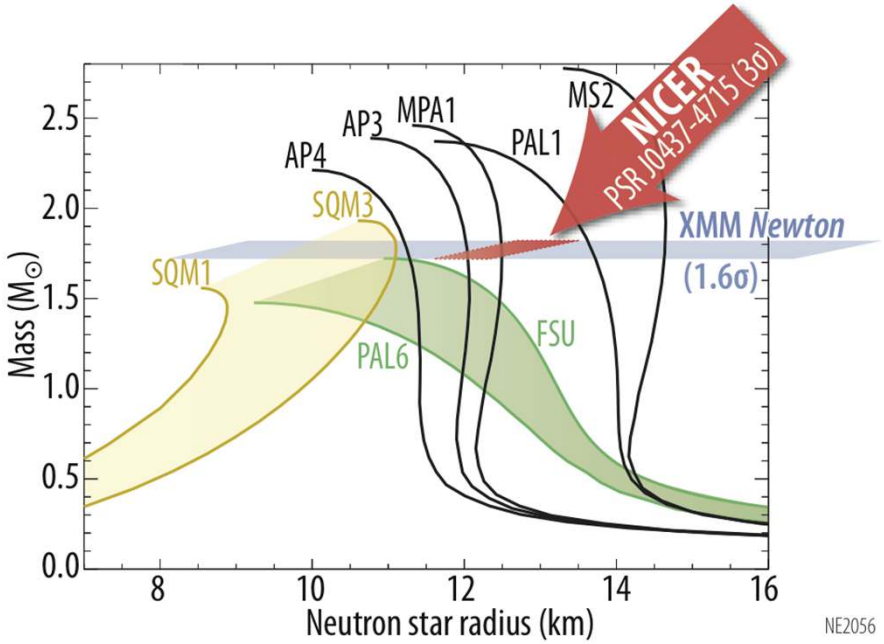
How big is a neutron star?
Its size reveals what it's made of…





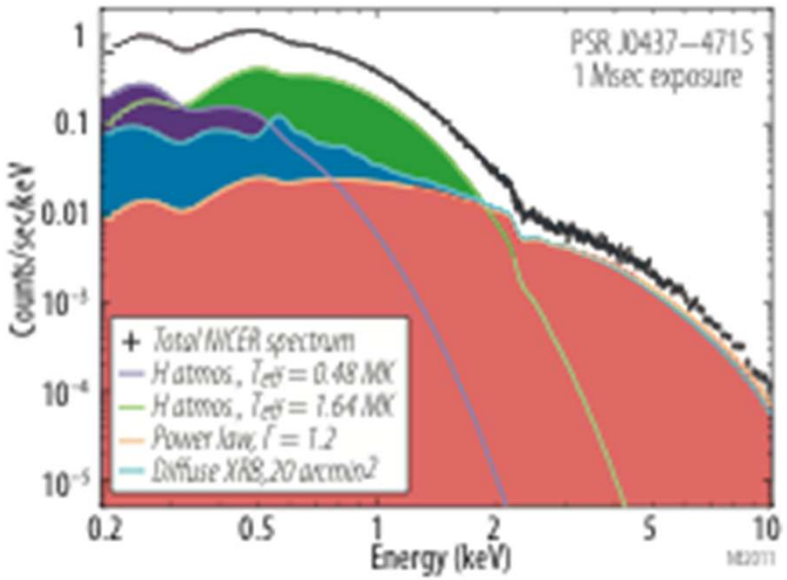
Credit: CXC

NICER will determine the radii of neutron stars to 5%, an order of magnitude better than known today

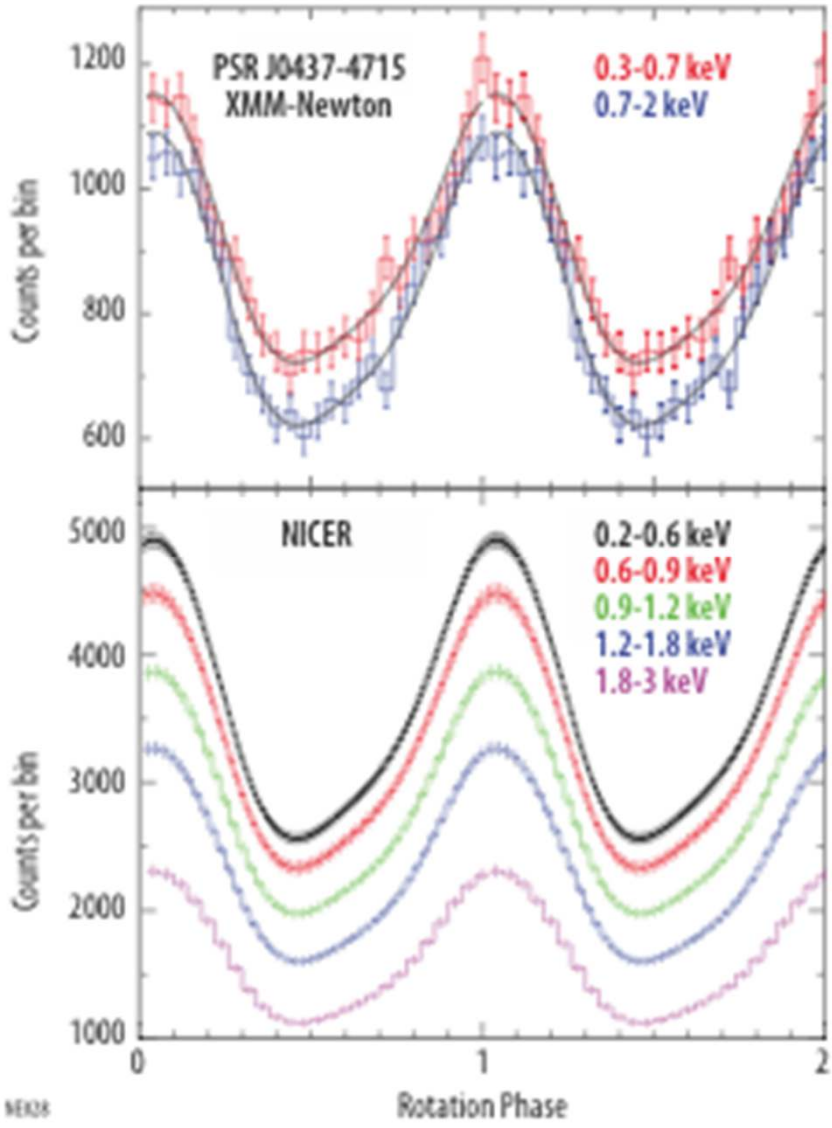


Unprecedented photon statistics enable high-precision measurement

- **NICER is sensitive where neutron stars are brightest**
- **Absolute time resolution enables coherent light curve integration over years**
- **Energy resolution enables phase resolved spectroscopy**



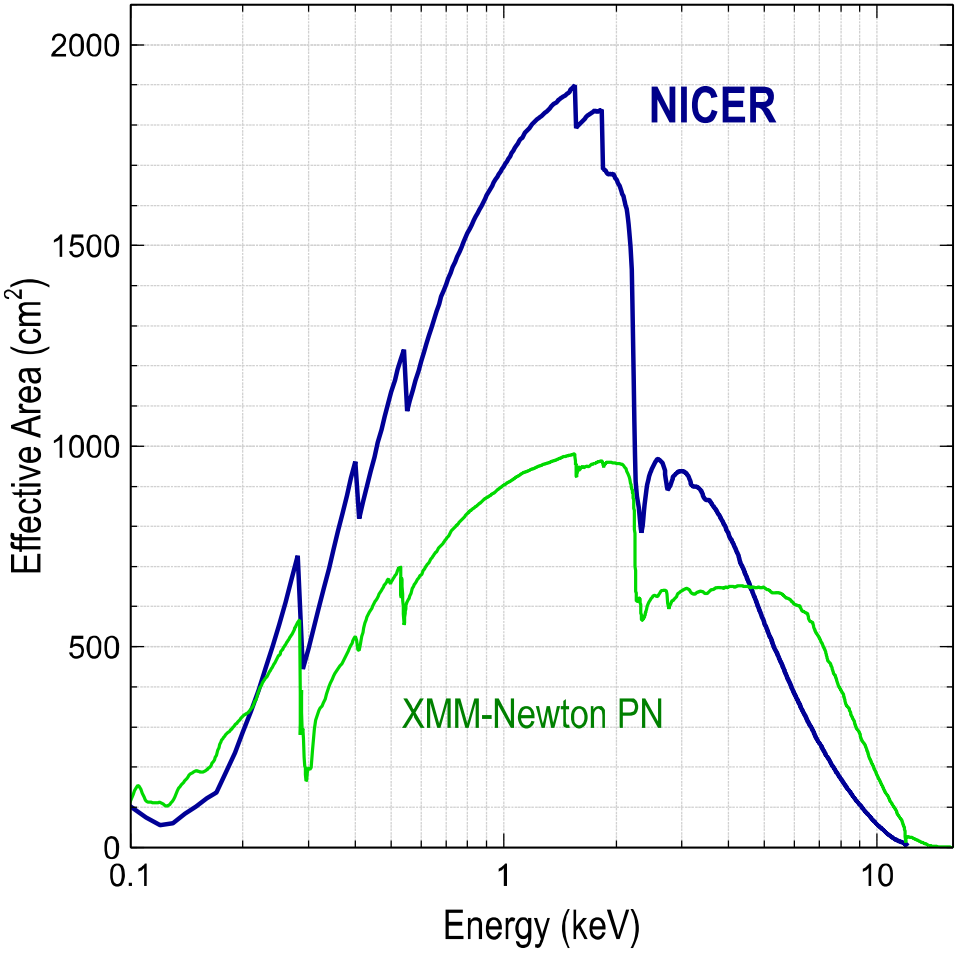
~10^6 K thermal emission peaks in soft X-rays



Science-enabling capabilities

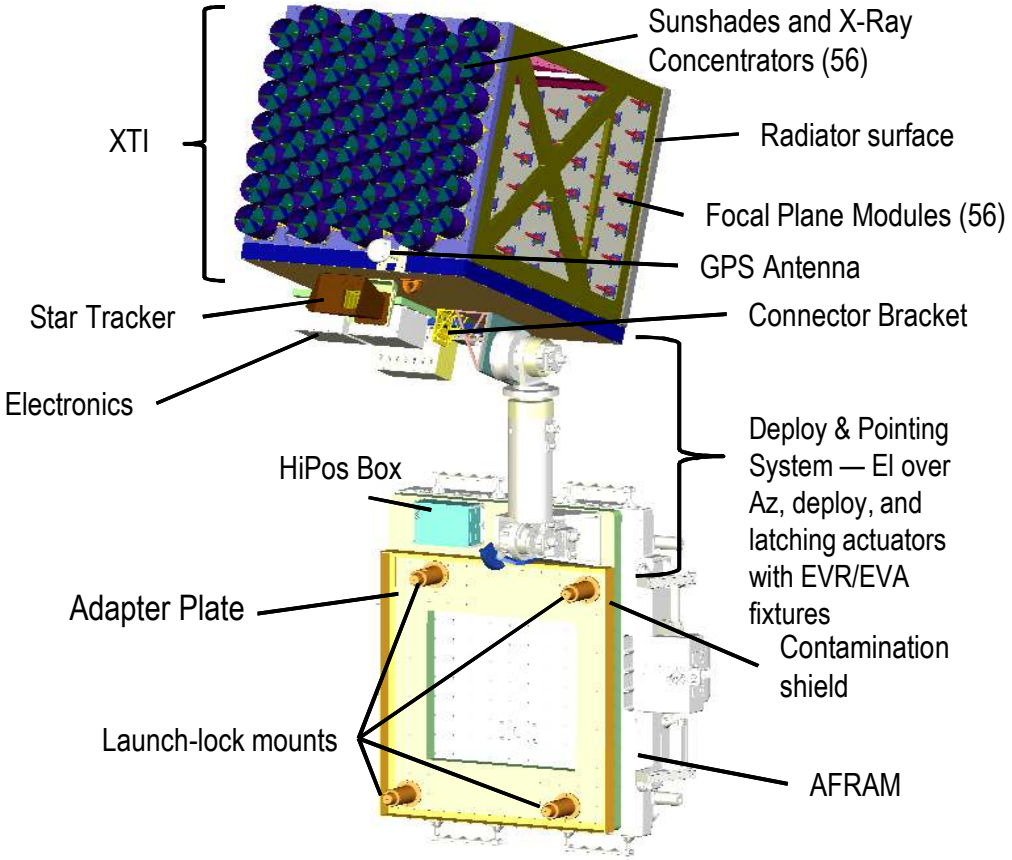
An unprecedented combination of time resolution, energy resolution, and sensitivity

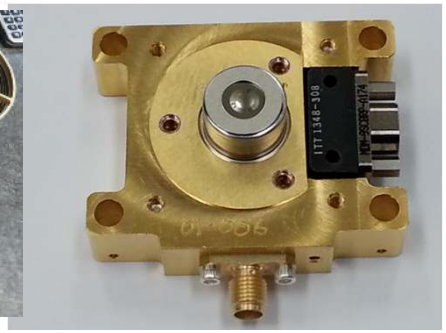
- **Spectral band: 0.2–12 keV**
  - **Well matched to neutron stars**
  - **Overlaps RXTE and XMM-*Newton***
- **Timing resolution: 100 nsec RMS absolute**
  - **50x better than RXTE**
  - **~1000x better than XMM-*Newton***
- **Energy resolution: 2.5% @ 6 keV**
  - **10x better than RXTE**
- **Angular resolution: 6 arcmin (non-imaging)**
  - **10x better than RXTE**
- **Sensitivity, 5σ: 5.3 x 10^{-14} erg/s/cm^2**
  - **0.5–10 keV in 10 ksec (Crab-like spectrum)**
  - **20x better than RXTE**
  - **3x better than XMM-*Newton*'s timing capability**



The NICER payload

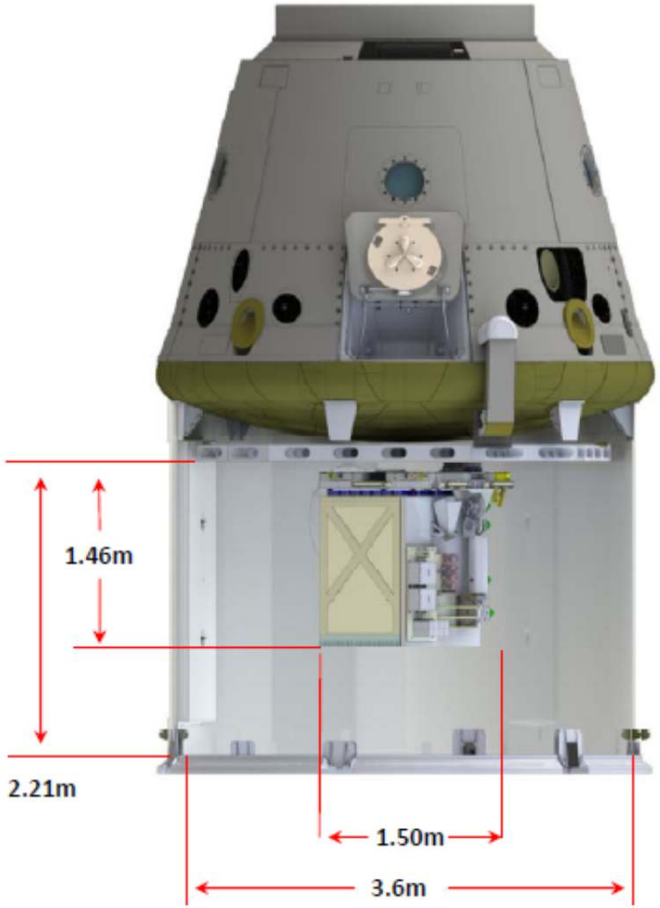
An innovative combination of high-heritage components



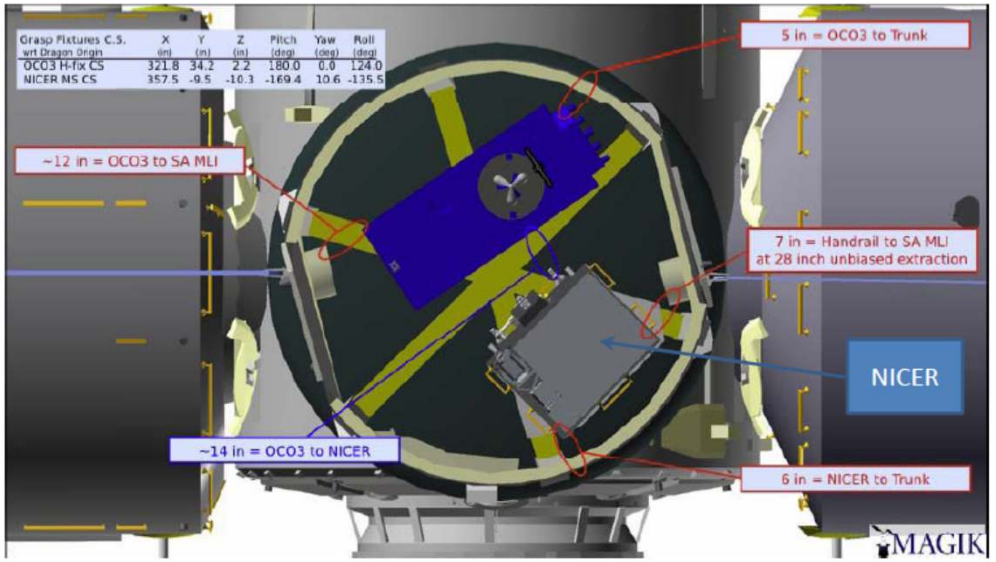


- **X-ray Timing Instrument (XTI)**
  - **Assembly of 56 X-ray concentrators and detectors**
  - **Detects individual X-ray photons, returns energy and time of arrival**
  - **Held together in the Instrument Optical Bench**
- **Thermal system**
  - **Maintains thermal-mechanical alignment**
- **Pointing System**
  - **Composed of high-heritage components**
  - **Allows the XTI to track pulsars**
  - **Slews XTI between targets**
- **C&DH**
  - **Digital interface to ISS for commands, data**
  - **Supports pointing system**
- **Flight Releasable Attachment Mechanism**
  - **Electrical & mechanical interface to ISS and transfer vehicle**
  - **Provided by ISS program**

Transport on SpaceX Dragon

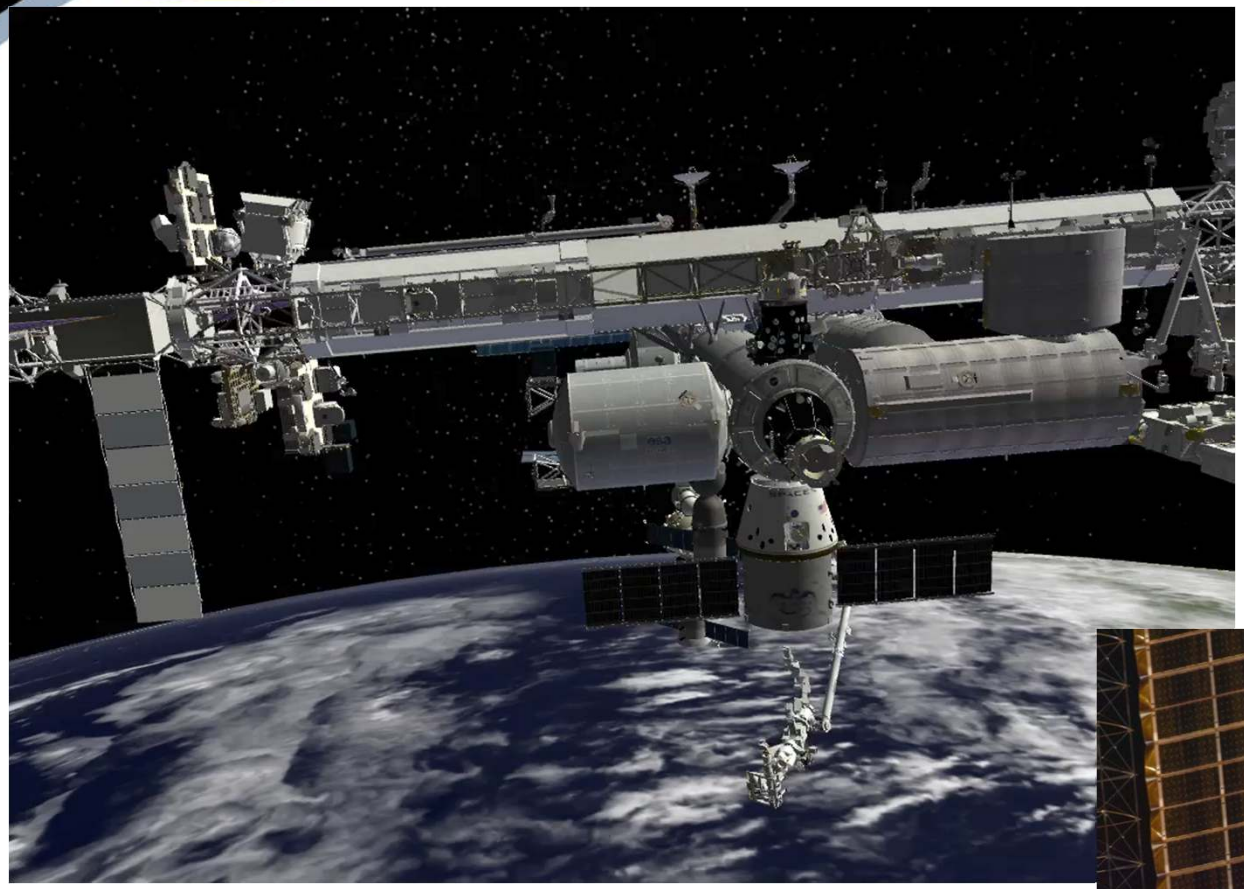


- Manifested with one other payload on SpaceX-12 ISS re-supply mission
- Located in the unpressurized “trunk”
- *Dragon* provides survival power during transport.

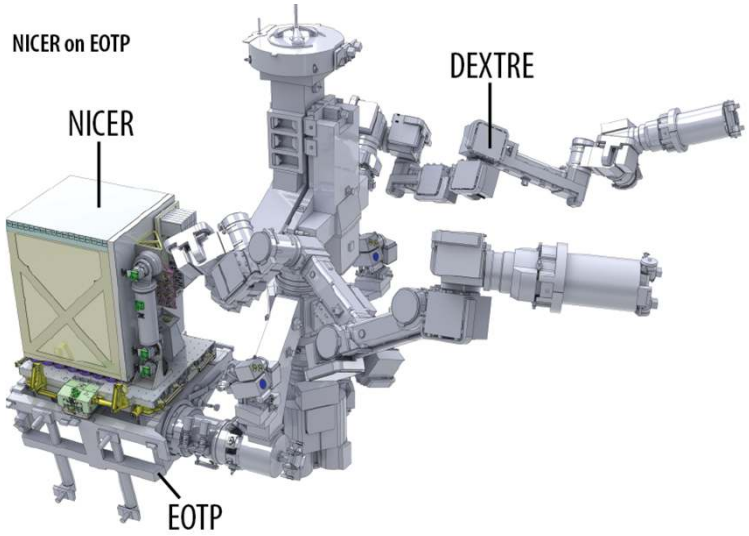


Orthographic View Looking ISS Zenith

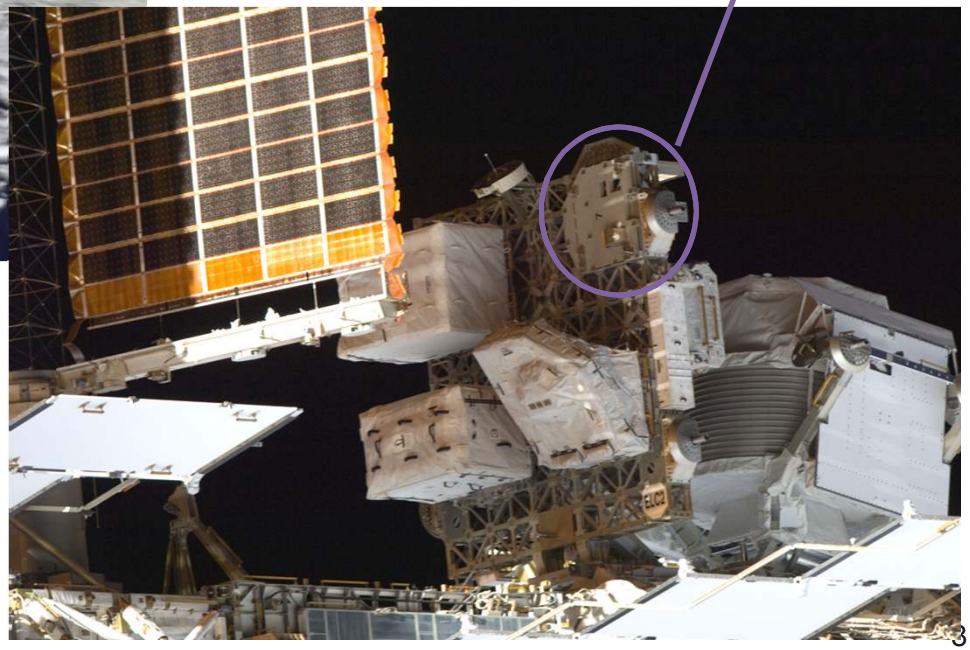
Robotic installation to ELC2 Site 7



NICER in transport

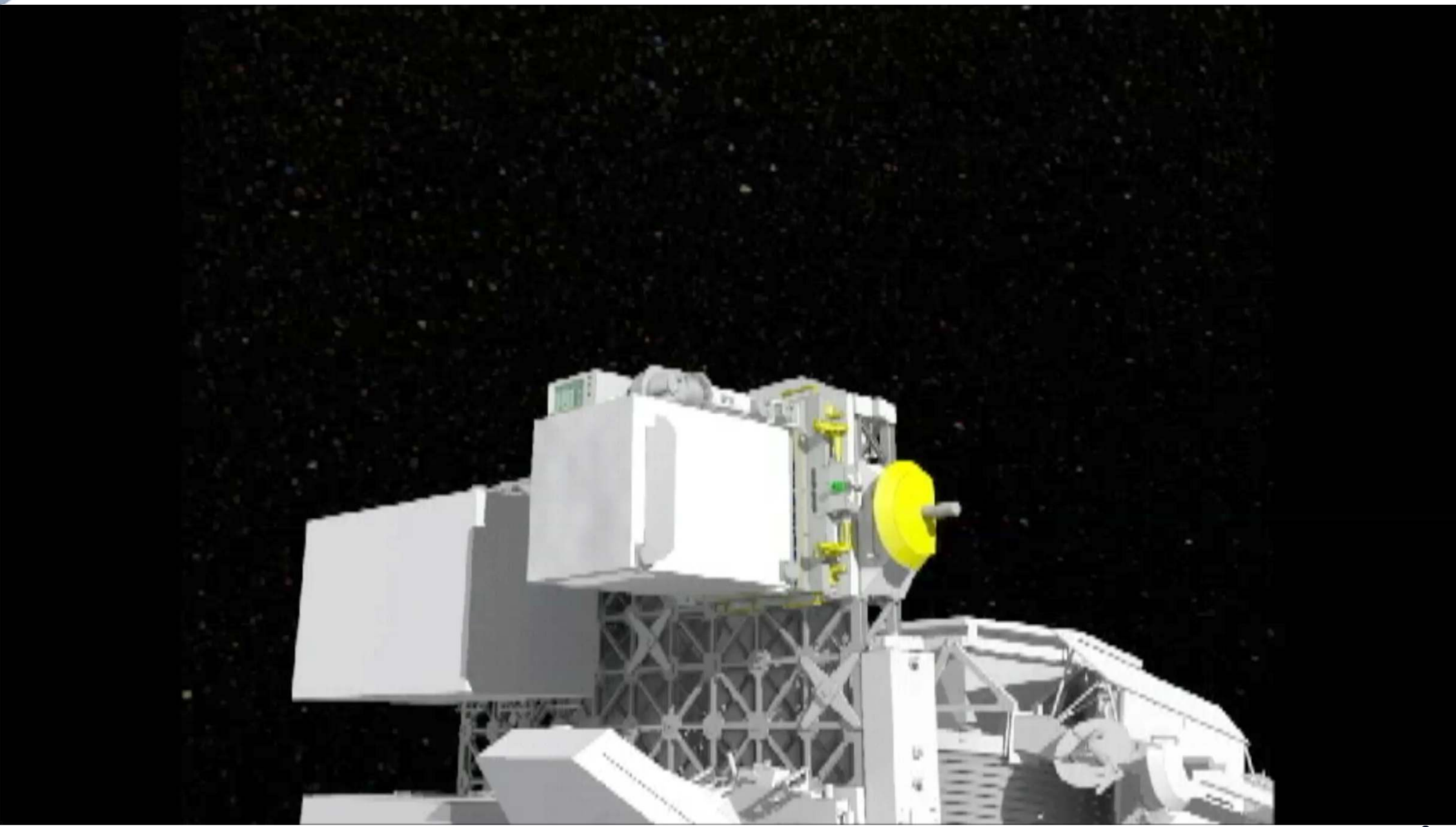


NICER's future home



- SpaceX-12 flight to the ISS in October 2016
- Robotic installation on the ISS

Deployment, Track, Slew



Established platform, benign environment — ISS is a great place to do NICER science!

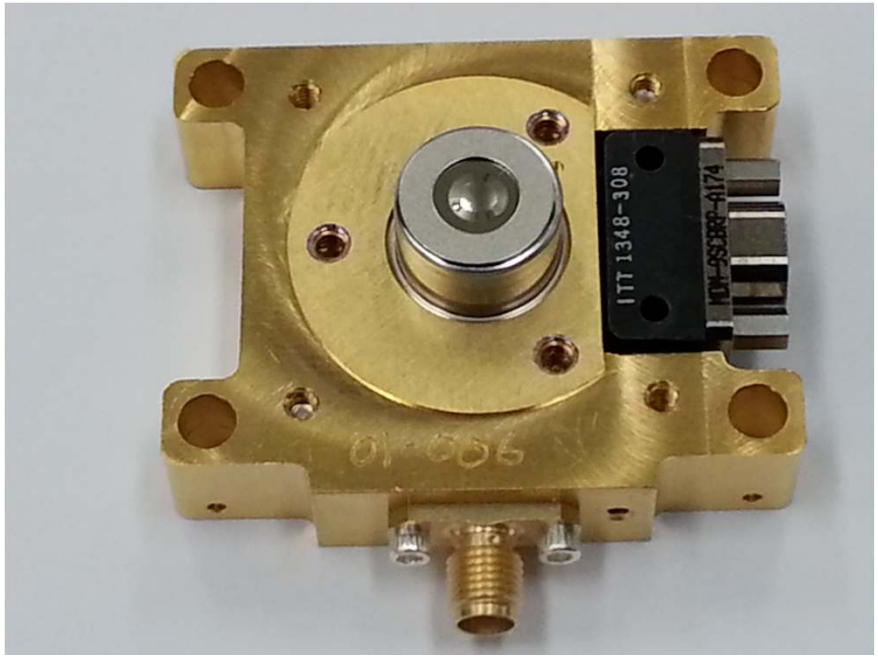
ISS offers:

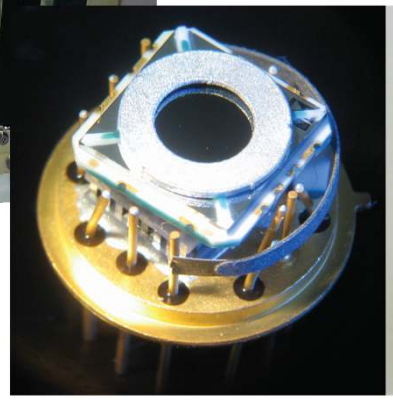
- Established infrastructure (transport, power, comm, etc.) that reduces risk
- Generous resources that simplify design, reduce cost
- A stable platform for arcmin pointing

NICER's design:

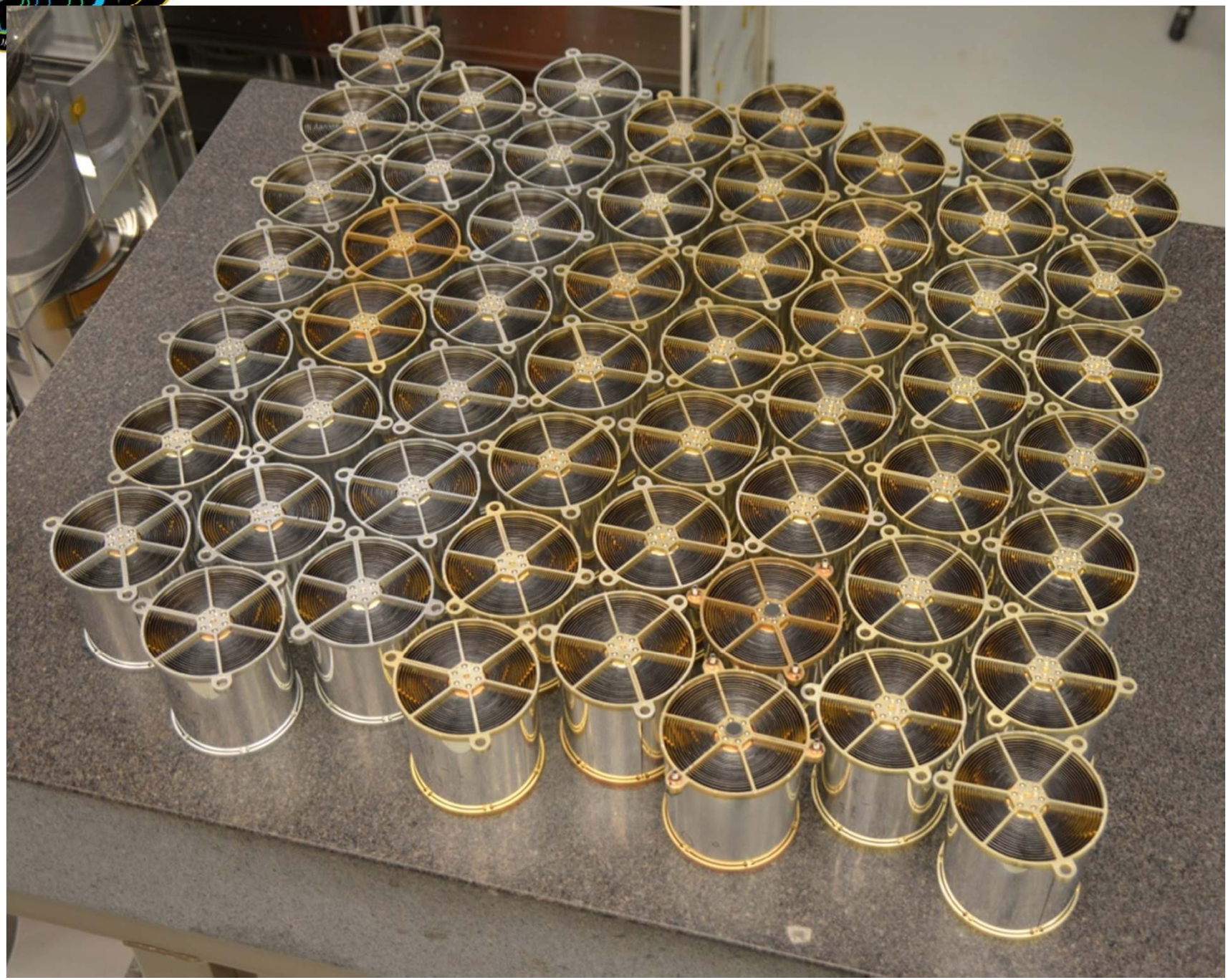
- Is tolerant of ISS vibrations
- Is insensitive to the ISS contamination & radiation environments, with safe-stow capability
- Provides high (54%) observing efficiency

Flight and ETU hardware is coming together!

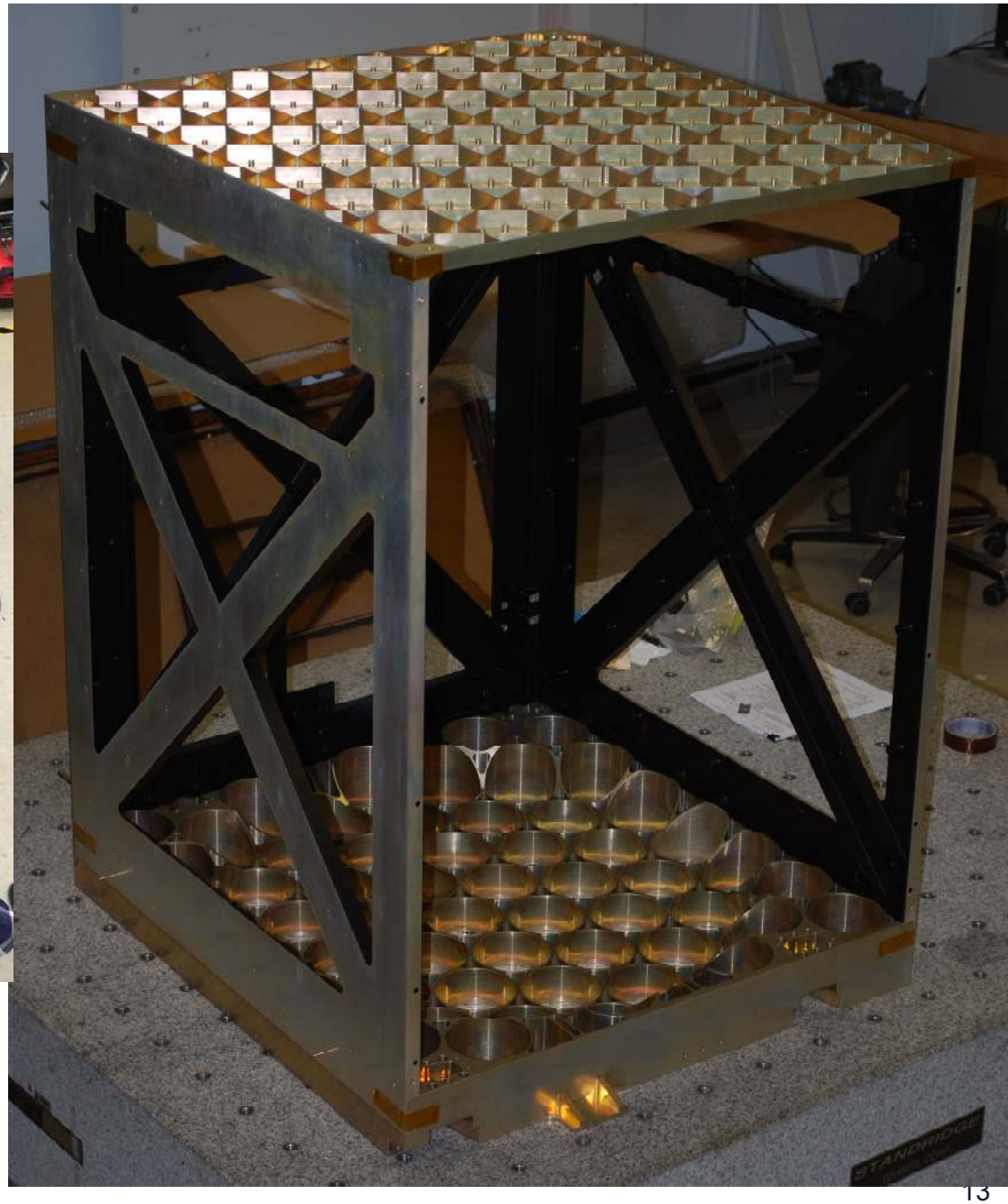




First 56 XRCs!

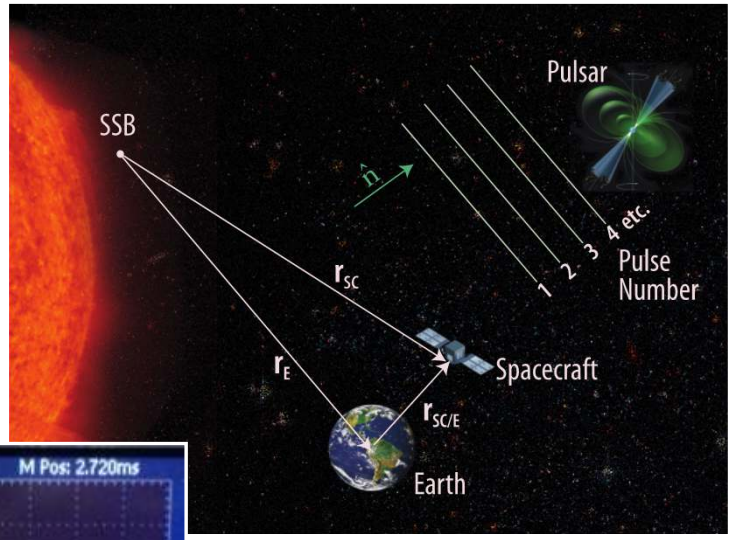


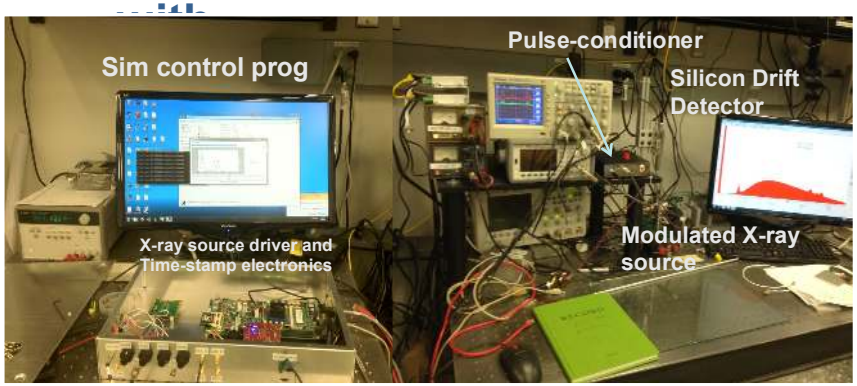
Flight IOB Fit Check

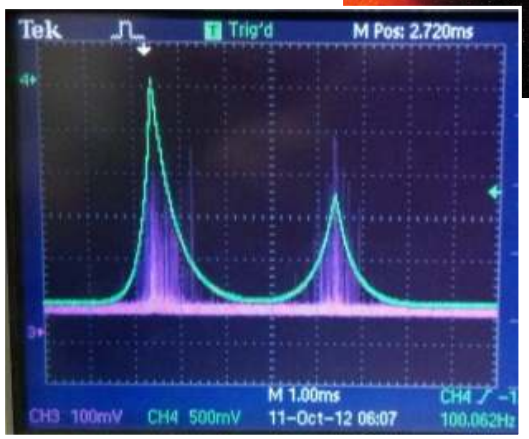


NICER is more than your average opportunity

- Space Technology Mission Directorate (STMD) supports NICER through the SEXTANT program
  - First flight demo of pulsar-based navigation
  - Fits cleanly into NICER science program, no additional hardware
- NASA gets more bang for the buck
  - NICER offers full mission science at the cost of an instrument to SMD
  - Pulsar nav will ultimately enable novel SMD missions
  - SEXTANT testbed mitigates NICER risk







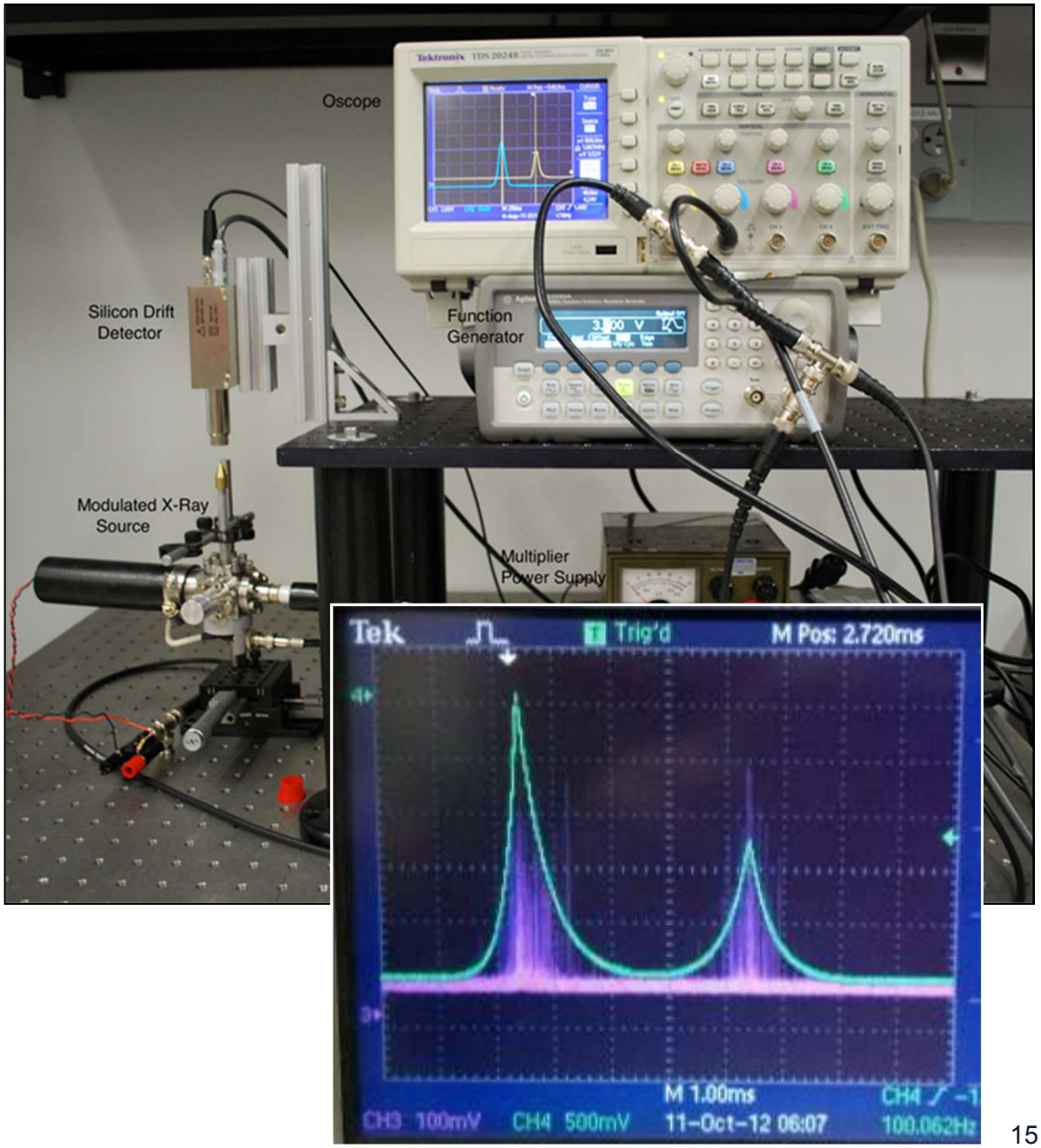
Simulated Crab Pulsar in the lab

GXLT: Table-top pulsar nav emulator

Goddard XNAV Lab Testbed (GXLT)

MXS driver
Firmware + Software simulates receiver dynamics and drives MXS hardware

Control program
Loads different scenarios (receiver orbits, pulsar observation schedule, etc.) for testing



Summary

- NICER will deliver high-visibility science using the ISS as a platform
- Scientific publication rate from the ISS will increase substantially
- NICER will connect with the American public
  - Pulsar navigation in analogy with GPS will be a significant hook for public interest
- Pulsar navigation demonstration will be a significant historical event enabled by the ISS

http://heasarc.gsfc.nasa.gov/docs/nicer