

# NICER

Neutron star Interior Composition Explorer

## *Capabilities and Status*

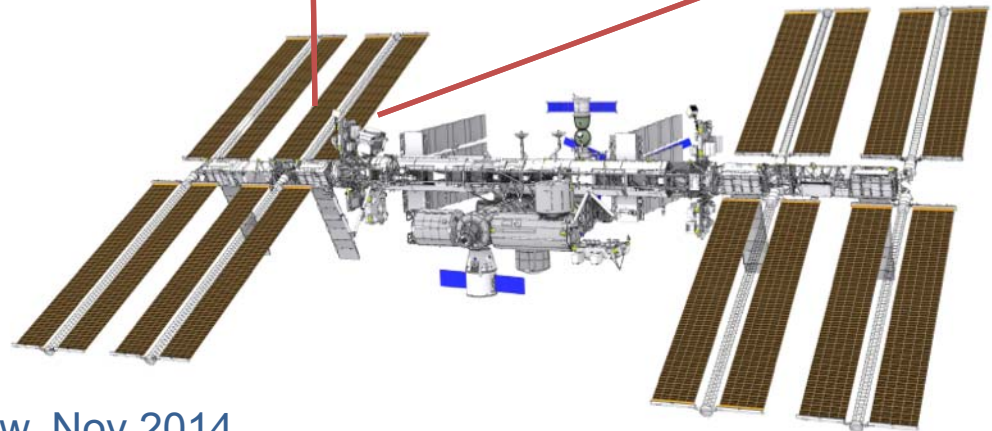
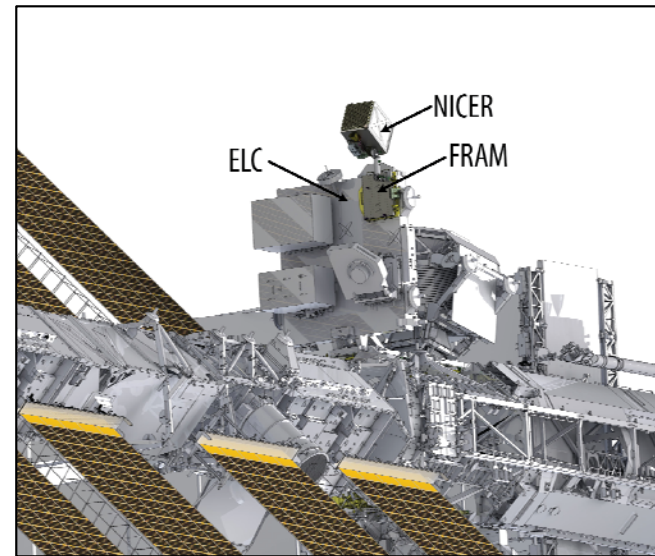
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CRESST & NASA GSFC





## Astrophysics Mission of Opportunity on the International Space Station

- **Science:** Understanding ultra-dense matter through soft X-ray timing of neutron stars
- **Launch:** August 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 in Year 2
- **Instrument:** X-ray (0.2–12 keV) “concentrator” optics and silicon-drift detectors; GPS position & absolute time tagging
- **Enhancements:**
  - Guest Observer program
  - Demonstration of pulsar-based navigation
- **Status:**
  - Passed CDR, Sep 2014
  - Passed ISS Phase 2 Safety Review, Nov 2014

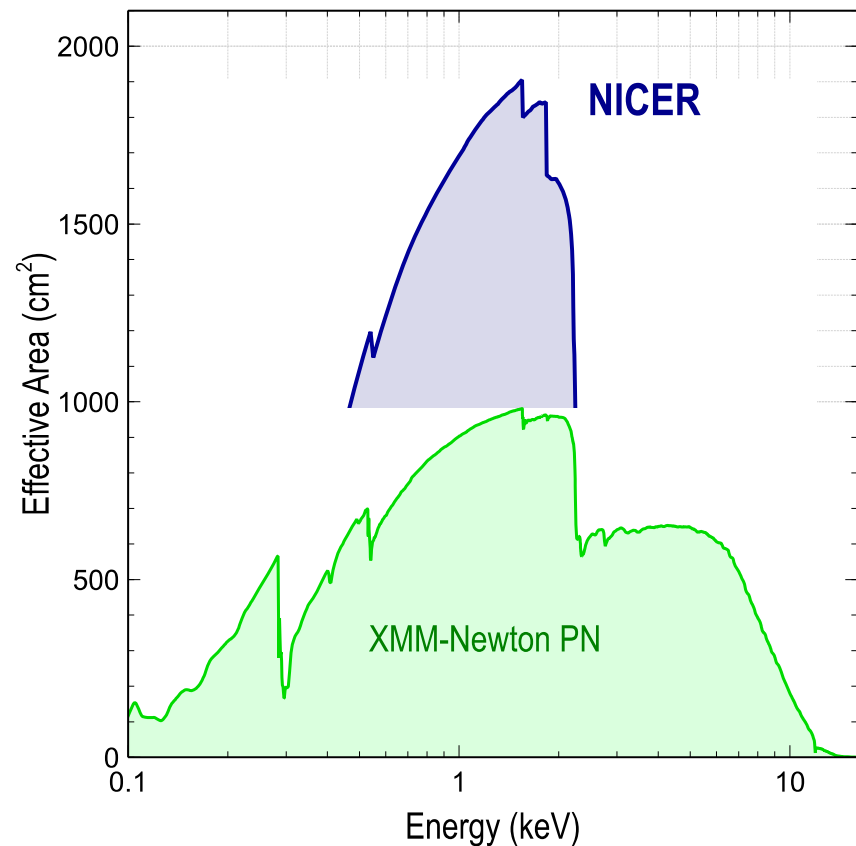




## Unique Capabilities, New Discovery Space

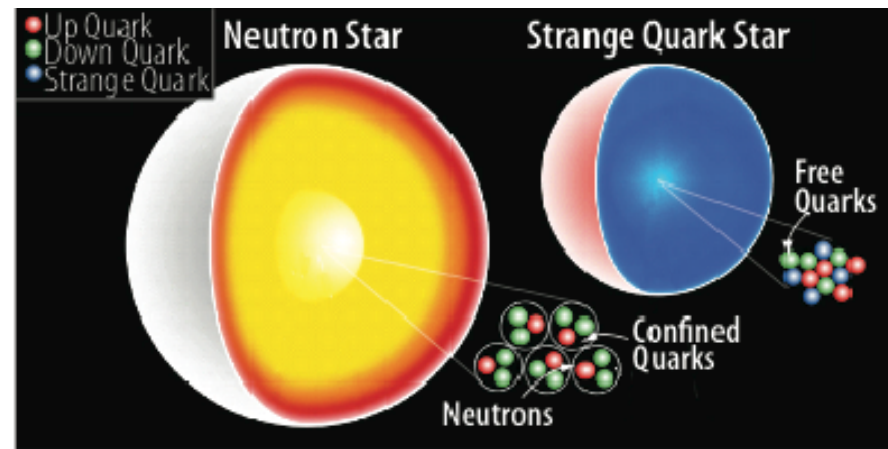
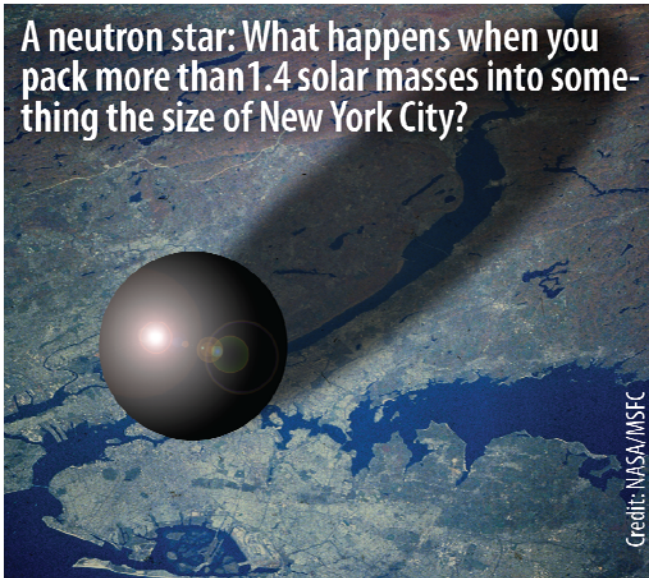
*An unprecedented combination of sensitivity, timing, and energy resolution*

- 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
  - 100x–1000x better than XMM-Newton
- Energy resolution: 2% @ 6 keV
  - 10x better than RXTE
- Non-imaging FOV: 6 arcmin
  - 10x better than RXTE
- Sensitivity,  $5\sigma$ :  $5.3 \times 10^{-14}$  erg/s/cm<sup>2</sup>
  - 0.5–10 keV in 10 ksec (Crab-like spectrum)
  - 20x better than RXTE
  - 3x better than XMM-Newton's timing capability



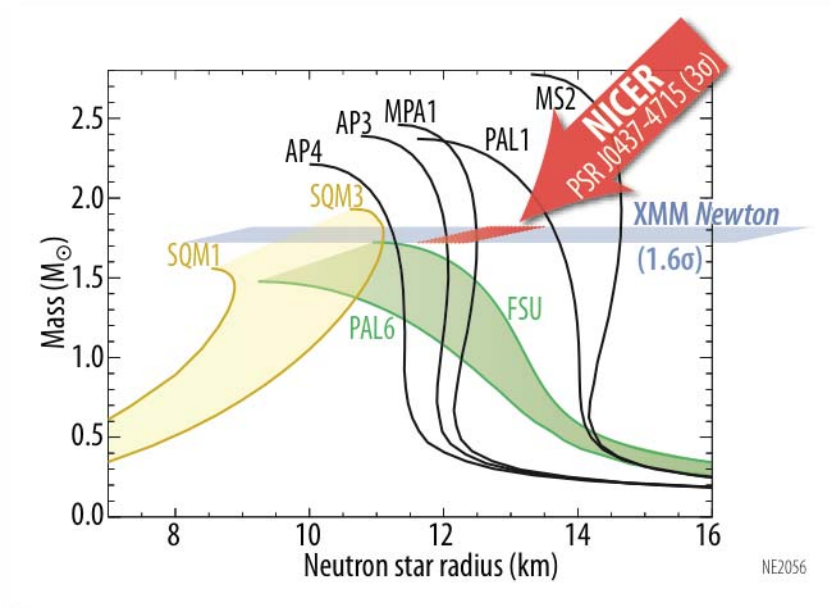


# How big is a neutron star? Size reveals composition



Credit: CXC

NICER's key science objective: determine the radii of several neutron stars to  $\pm 5\%$

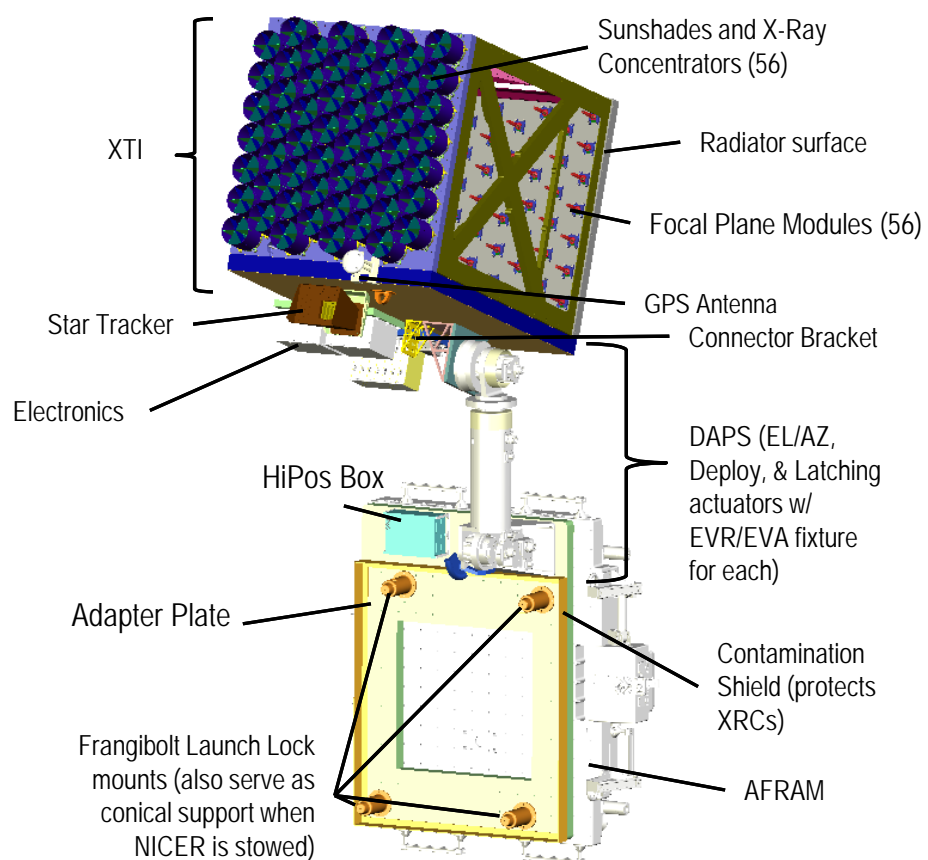


NE2056



# The NICER Payload...

*An innovative combination of high-heritage components*



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



# ... Coming Together for Flight ...

Detectors  
& Housing

First 56 Optics!



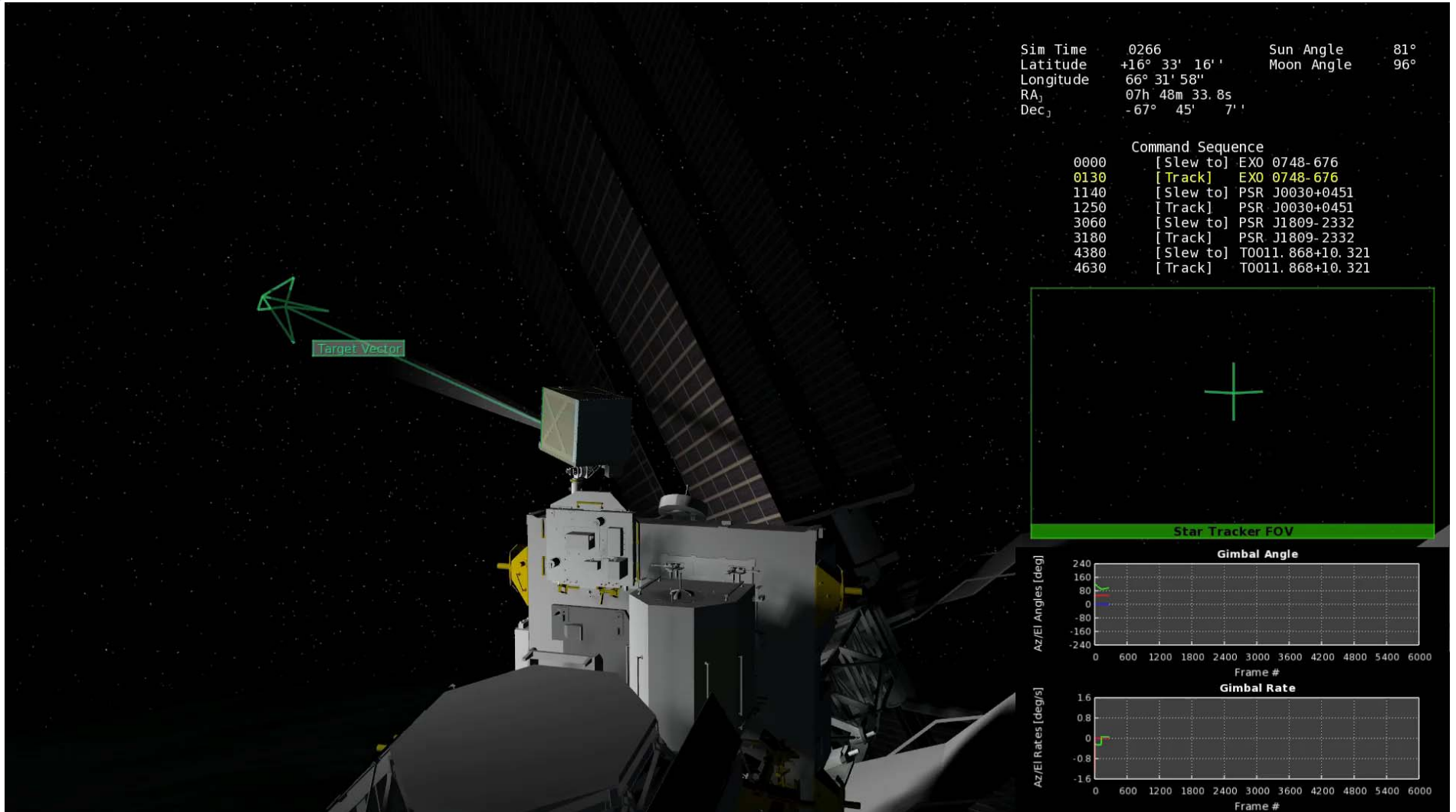
Integration Facility





# ... On an Established Platform

*ISS is a great place to do NICER science!*





# Guest Observer Program

NICER tools at HEASARC available to anticipate observations of your favorite targets

- Up to 7 Msec for general X-ray astrophysics
  - Timing-spectral studies of black holes
  - Coronal emission from stars
  - Highly redshifted iron lines
  - ... and much more!

HEASARC: NICER Guest Observer Facility

NASA National Aeronautics and Space Administration Goddard Space Flight Center

## NICER Neutron star Interior Composition Explorer

**The Neutron star Interior Composition Explorer Mission**

The Neutron star Interior Composition Explorer (NICER) is a proposed NASA Explorer Mission of Opportunity dedicated to the study of the extraordinary gravitational, electromagnetic, and nuclear-physics environments embodied by neutron stars. NICER will explore the exotic states of matter inside these stars, where density and pressure are higher than in atomic nuclei, confronting theory with unique observational constraints. NICER will enable rotation-resolved spectroscopy of the thermal and non-thermal emissions of neutron stars in the soft (0.2-12 keV) X-ray band with unprecedented sensitivity, probing interior structure, the origins of dynamic phenomena, and the mechanisms that underlie the most powerful cosmic particle accelerators known. NICER achieves these goals by deploying, following launch in late 2016, an X-ray timing and spectroscopy instrument as an attached payload aboard the International Space Station (ISS). Grazing-incidence optics coupled with silicon drift detectors, actively pointed for a full hemisphere of sky coverage, will provide photon-counting spectroscopy and timing registered to GPS time and position, with high throughput and relatively low background.

In addition to advancing a vital multi-wavelength approach to neutron star studies through coordination with radio and  $\gamma$ -ray observations, NICER will provide a rapid-response capability for targeting of transients, continuity in X-ray timing astrophysics investigations post-RXTE through a proposed Guest Observer program, and new discovery space in soft X-ray timing science.

Simulated NICER countrates and spectra can be derived using the [WebPIMMS](#) and [WebSPEC](#) tools.

**Latest News**

- Potential New NASA Mission Would Reveal the Hearts of Undeath Stars
- NASA Blueshift - (Bio) Awesomeness

**WebPIMMS**  
A Mission Count Rate Simulator  
Powered by PIMMS v4.6a

Access the multiple component model [interface](#).

Convert From: Flux Into: NICER

Examples of Common FLUX Input/Output Ranges

Input Energy Range (low-high): 2-10 Units: keV  
Output Energy Range (low-high): default Units: keV

Source: Flux / Count Rate 2e-8 (erg/cm<sup>2</sup>/s) (counts/s)

Galactic nh 3e21 (cm<sup>-2</sup>) Redshift none Intrinsic nh none (cm<sup>-2</sup>)

Model of Source: Power Law, Black Body, Therm. Process

Model Parameters: Photon index: 2.1, keV: [ ]

**WebSpec**

WebSpec is a web interface for the X-ray spectral fitting package, XSPEC. It simulates spectral data for a variety of X-ray missions/instruments. WebSpec can not be used to analyze real data. This page is for the simple interface. More experienced XSPEC users, may want to use an [advanced interface](#) which allows up to 9 components.

Latest News:  
12/14/12 Updated for Chandra CY-15.  
10/3/12 Updated XIS matrices for Suzaku AO-8.

Choose a Mission/Instrument: NICER

Specify the desired model expression by clicking on a model in each of the scroll boxes and indicating via the checkbox whether you want pileup and/or photoelectric absorption. If you only want one model then click on the top blank line in the second scroll box. When you are ready click the button to set model parameters. To start again click the reset button.

Pile-up: [ ] X Photoelectric Absorption: [x] + Available Models: Black Body, Power Law, Broken Pow Law, Power Law with cutoff, Gaussian, Disk Line Emission, APEC, BAPEC Available Models: Black Body, Power Law, Broken Pow Law, Power Law with cutoff, Gaussian, Disk Line Emission, APEC

I'm ready to set model parameters Reset all fields

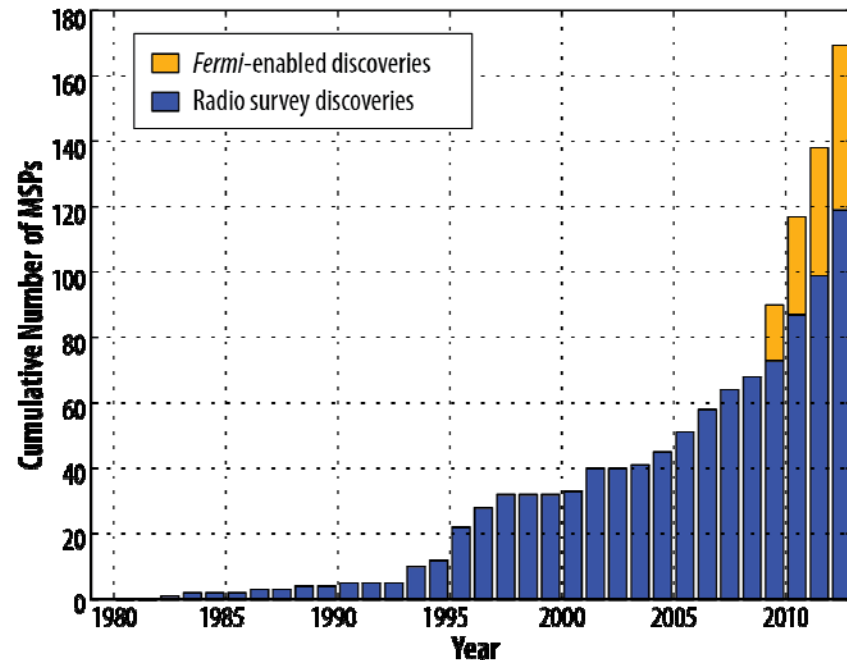




## A Good Time for NICER

- Millisecond pulsar discovery rate is booming
- Overlap with many other missions— science synergies boost returns for all
- Community awaits follow-on to RXTE
- NICER technology is mature
- ISS is ready to support science experiments

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



NICER mailing list, image gallery, tools, etc. →