
ADVANCED OBSERVATORY DESIGN FOR THE IMAGING X-RAY POLARIMETER EXPLORER (IXPE) MISSION

34th Space Symposium, Technical Track, Colorado Springs,
CO, USA
16 April 2018

14:05 – 14:25

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 - **Luca Baldini – Italian Co-Principal Investigator, INFN**

- **Introduction**
- **Overview of science**
- **Project partners and roles**
- **Technical summary**
 - Observatory
 - Payload
 - Spacecraft
- **Milestones and Conclusions**
- **Acknowledgements**

***IXPE* SCIENTIFIC OBJECTIVES**

▪ **Science Objectives:**

- Enhance our understanding of the physical processes that produce X-rays from and near compact objects such as neutron stars and black holes
- Explore the physics of the effects of gravity, energy, and electric and magnetic fields at their extreme limits

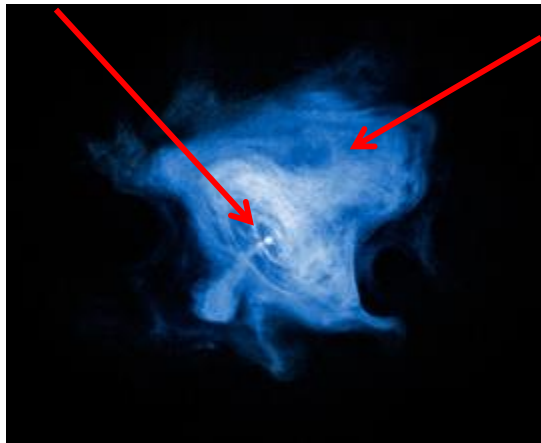
▪ ***IXPE* addresses key questions in High Energy Astrophysics**

- What is the spin of a black hole?
- What are the geometry and magnetic-field strength in magnetars?
- Was our Galactic Center an Active Galactic Nucleus in the recent past?
- What is the magnetic field structure in synchrotron X-ray sources?
- What are the geometries and origins of X-rays from pulsars?

Polarimetry of X-ray sources largely unmeasured
Opens a new window on the X-ray Universe

- X-ray emission from energetic processes: In-fall of matter into Neutron Star or Black Hole, synchrotron or shock emission, or very hot regions
- Can originate both from point and extended sources; *Imaging* separates these sources
- *Polarization* of X-rays if there is anisotropy in emission geometry or mag field, plasma reflections, or general relativistic effects

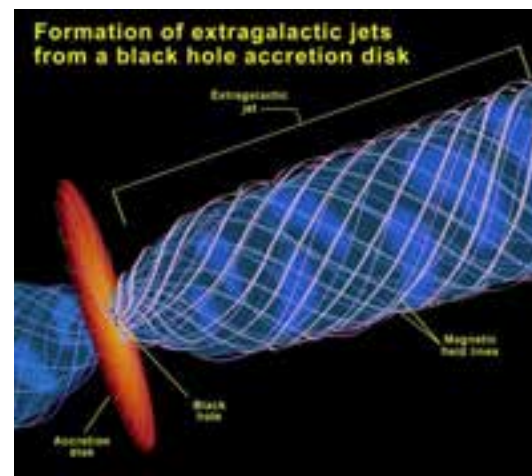
Crab Pulsar



Extended X-ray emission

Credit: [NASA/SAO](#)

Imaging separates regions with different emission mechanisms

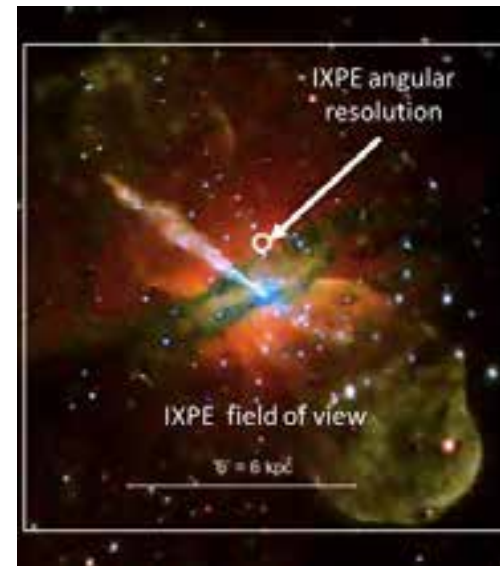
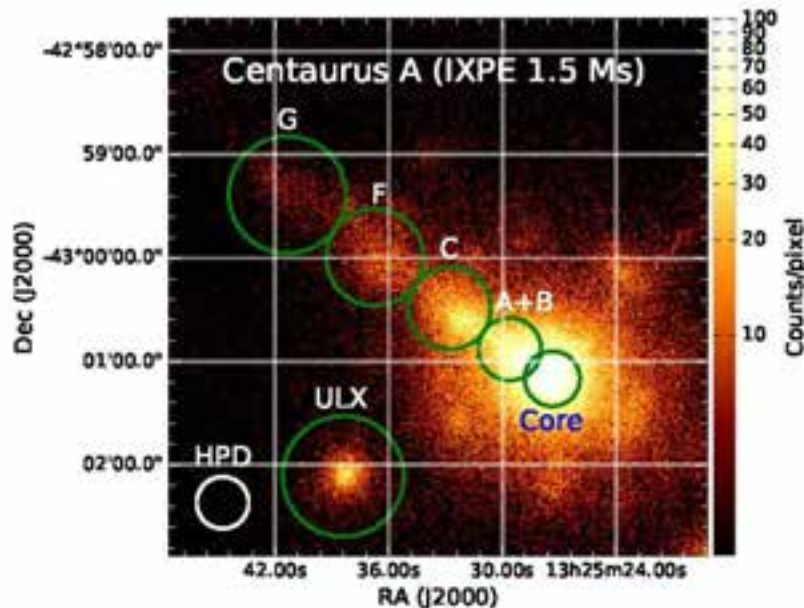


Credit: [NASA/ESA](#) and STScI

Polarization probes the source geometry and mag field strength

IXPE IMAGING LIMITS SOURCE CONFUSION

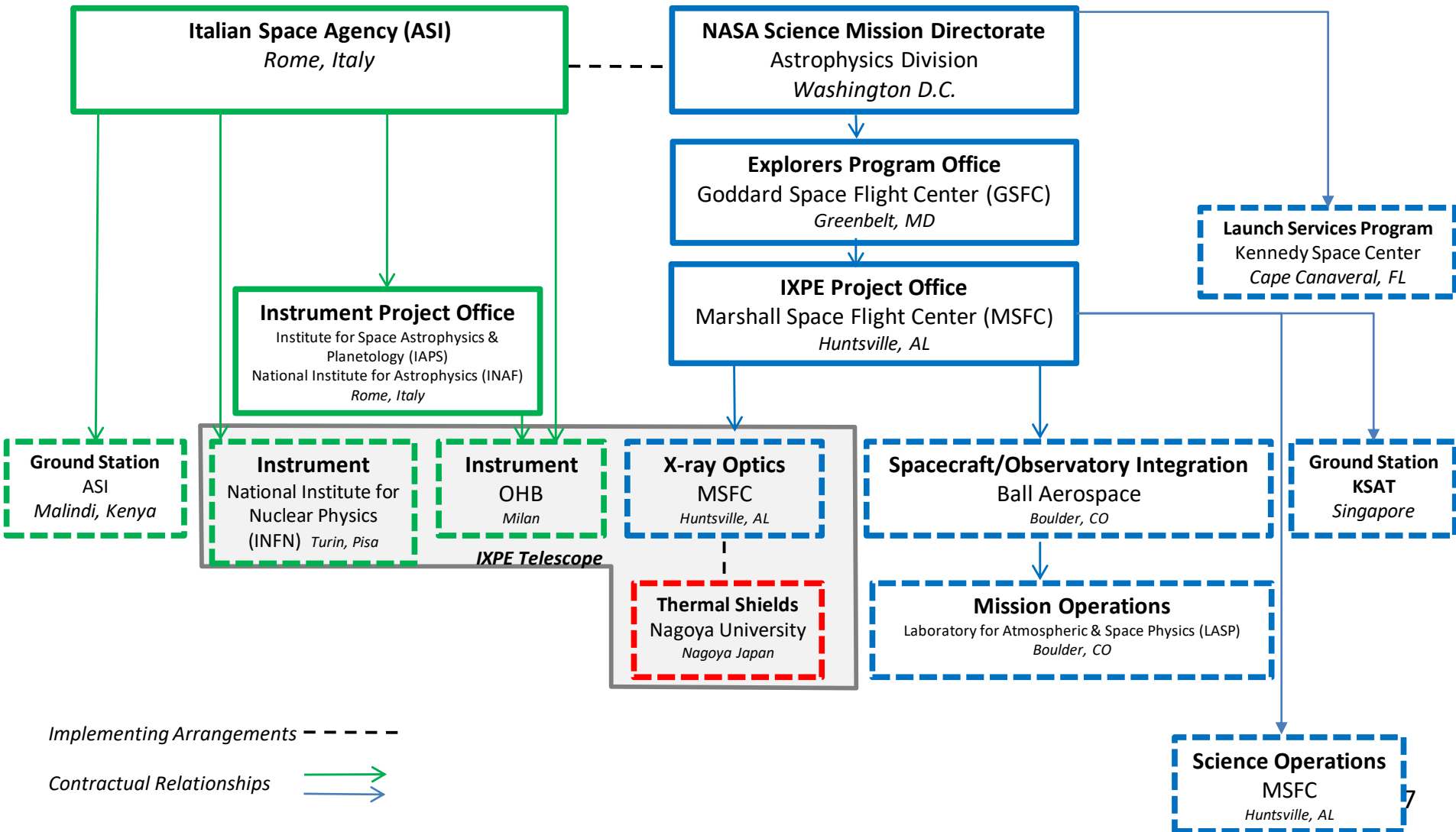
- **Active galaxies are powered by supermassive Black Holes with jets**
 - Radio polarization implies the magnetic field is aligned with jet
 - Other models also consistent with current observations
- **IXPE can image the Cen A jet and separate from other sources in the field (e.g., Ultra Luminous X-ray source)**



LEO observatory that measures spatial, spectral, timing, and polarization state of X-rays from 49 known astrophysical targets

WHO'S MAKING THE MISSION HAPPEN?

TEAM IXPE: PARTNERSHIPS & RELATIONSHIPS



IXPE HAS A STRAIGHT FORWARD MISSION CONCEPT

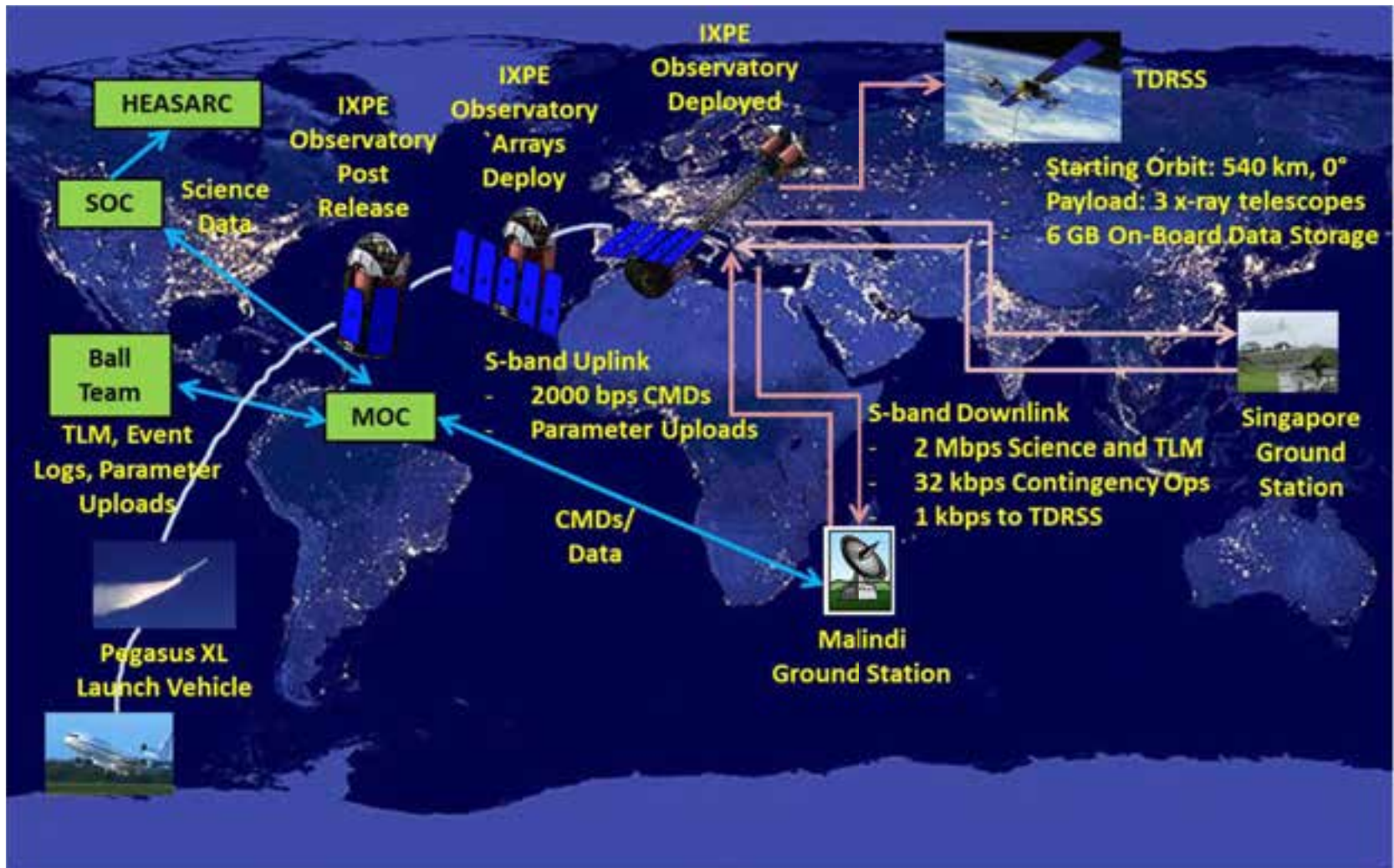
- **NASA Small Explorer (SMEX) Mission**
 - Class D Mission
- ***IXPE* Observatory is a single flight element**
- **Observatory launched to a 540 km, 0° orbit**
- **Pegasus XL launch vehicle is baselined**
- **2 year baseline mission with 1 year extended mission option**
- **3 deployments, all during contacts**
- **Point and stare at known targets**
- **Omni-directional S-band uplink/downlink**
- **Launch April 2021**





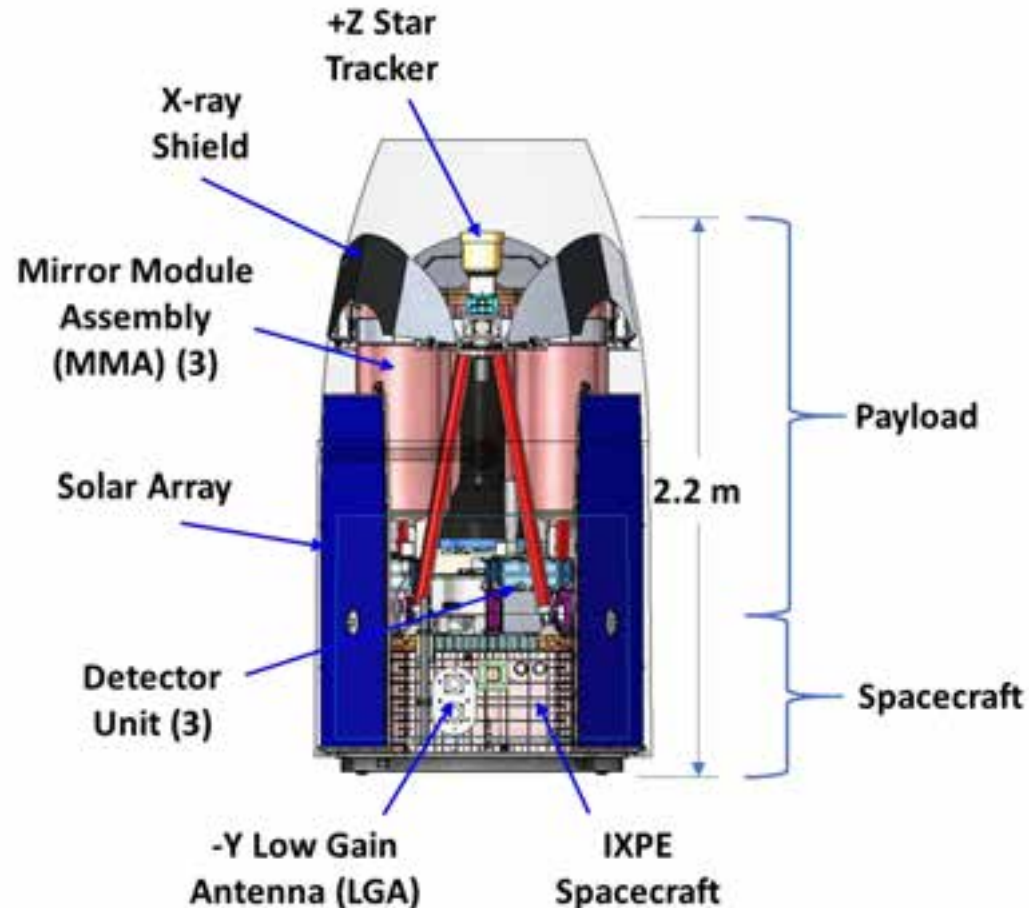
IXPE
Imaging
X-Ray
Polarimetry
Explorer

IXPE CONCEPT OF OPERATIONS OVERVIEW



IXPE OBSERVATORY – STOWED

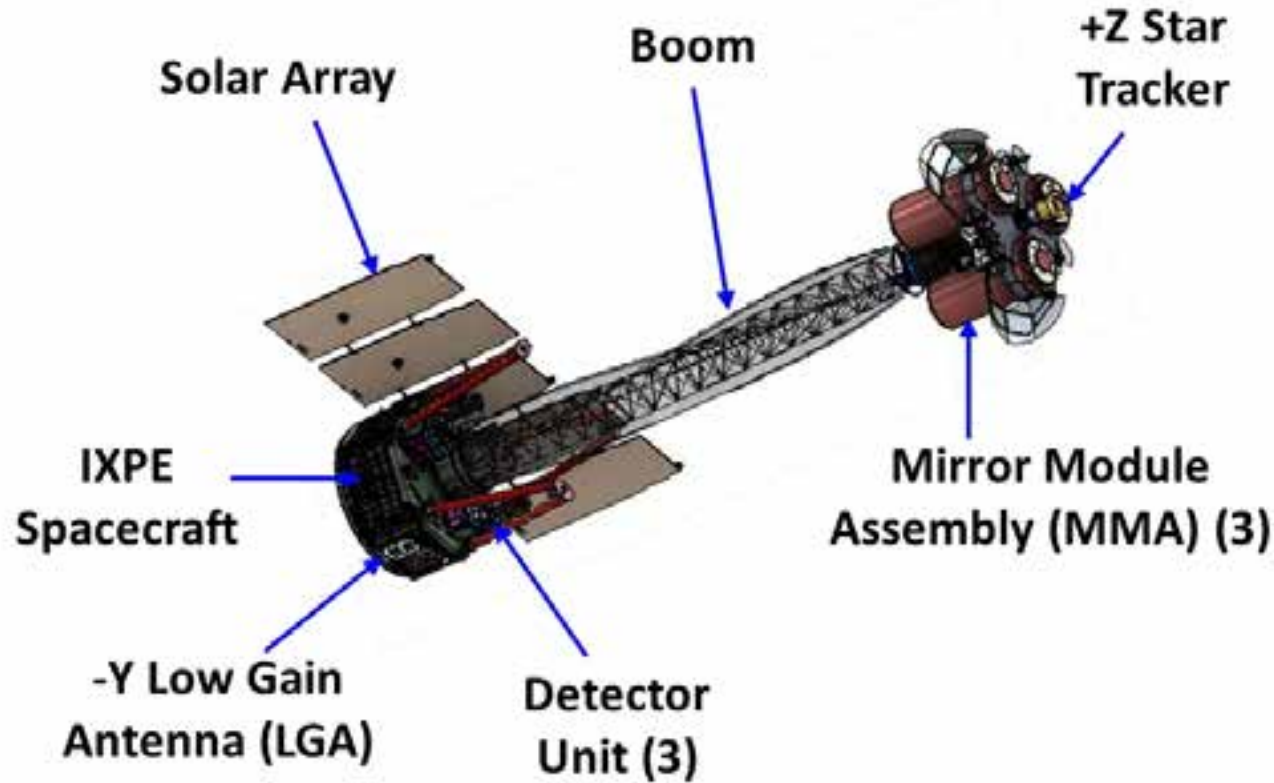
- Pegasus XL
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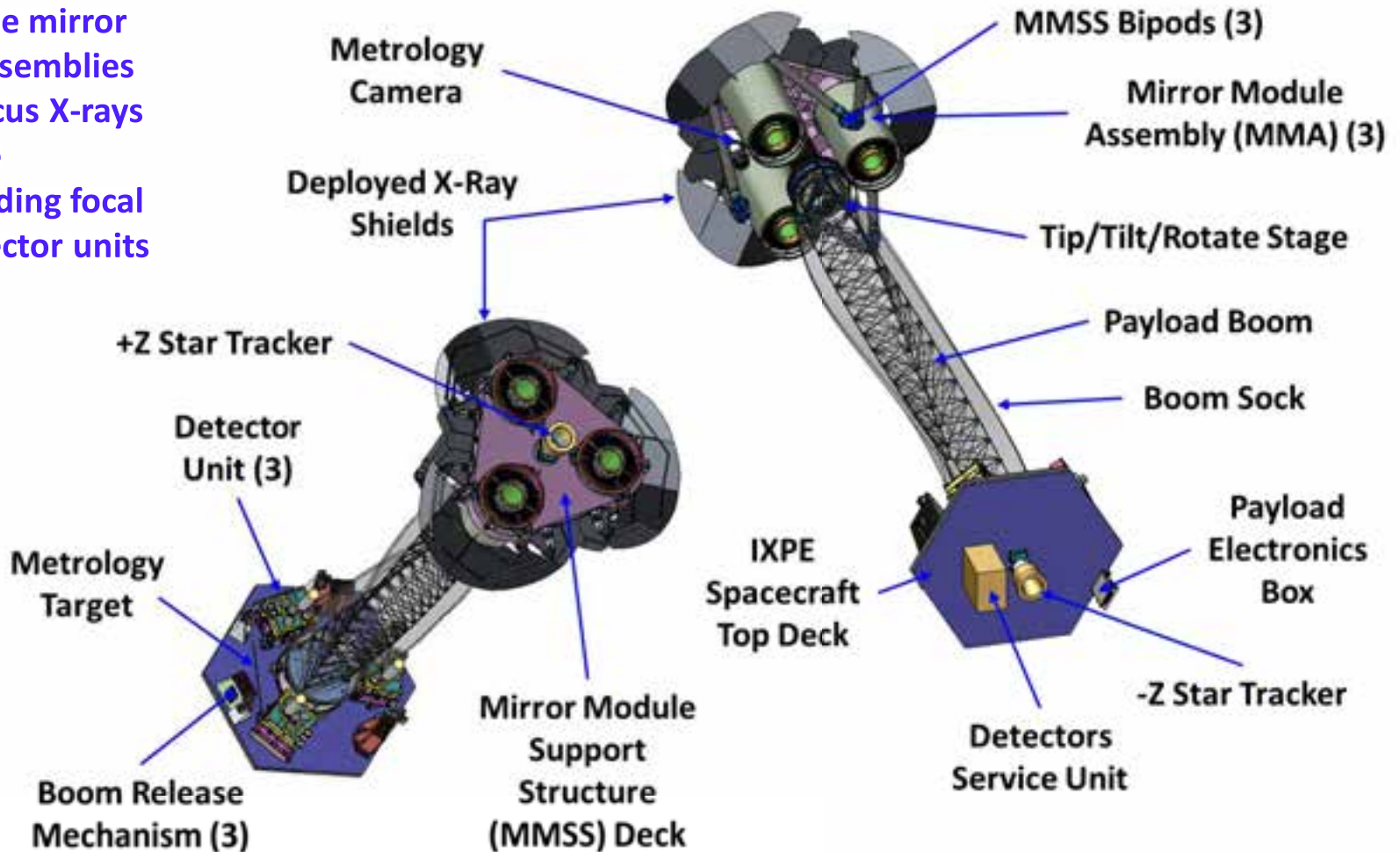
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IXPE OBSERVATORY – DEPLOYED

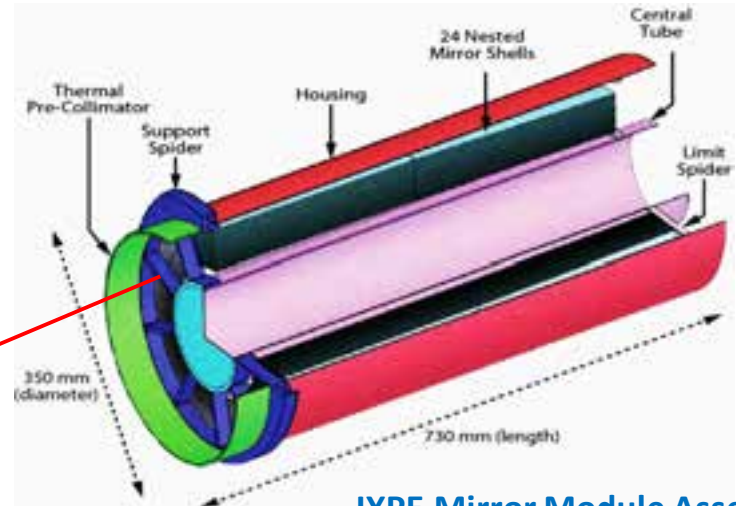
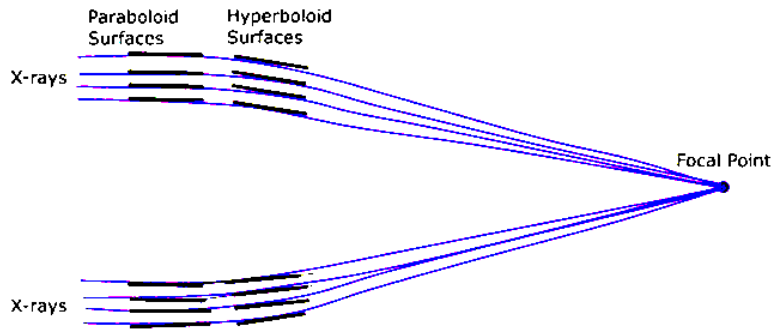


PAYLOAD OVERVIEW

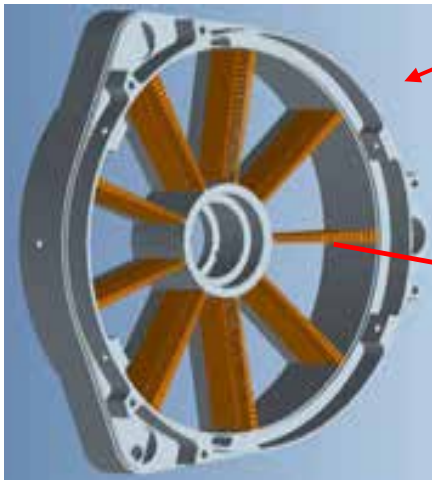
Set of three mirror module assemblies (MMA) focus X-rays onto three corresponding focal plane detector units (DU)



MIRROR MODULE DESIGN



IXPE Mirror Module Assembly



Rigid Support Spider



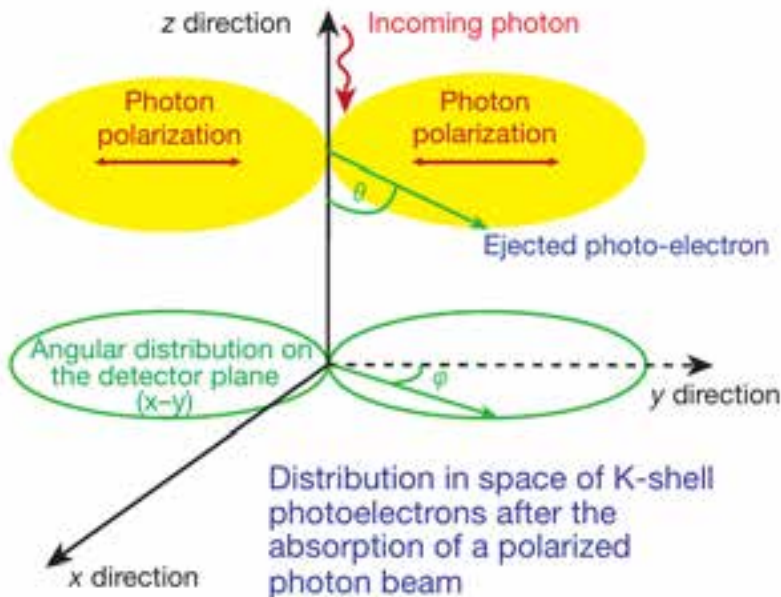
Shell Mounting Comb

Heritage Design Approach

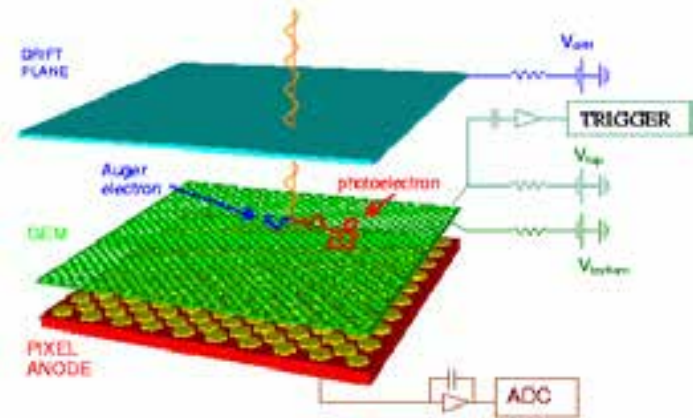
- Electroformed Ni shells use a proven fab process
- Mounting combs provide shell attachment points
- A single rigid spider supports the 24 nested shells and attach module to structure

DETECTOR A CONTRIBUTION FROM ASI VIA INFN/IAPS

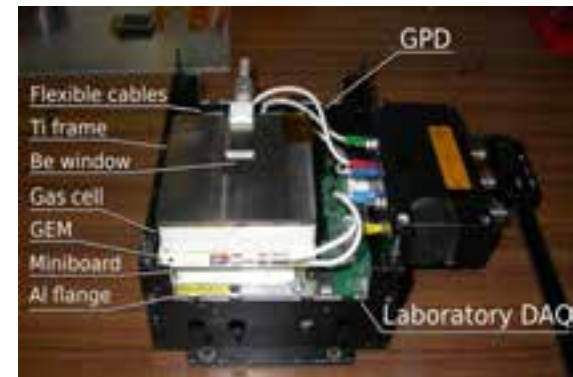
- Detection uses photoelectric effect
- X-rays absorbed in detector fill gas
- Photoelectron emission aligned with X-ray polarization vector
- Electron multiplier with pixelated detector



Gas Pixel Detector (GPD)



TRL 6 Prototype same form/function as FM



IXPE SPACECRAFT BASED ON BCP SMALL PLATFORM



- STPSat-2 – launched 11/2010
- STPSat-3 – launched 11/2013
- GPIM – launch now planned fall 2018

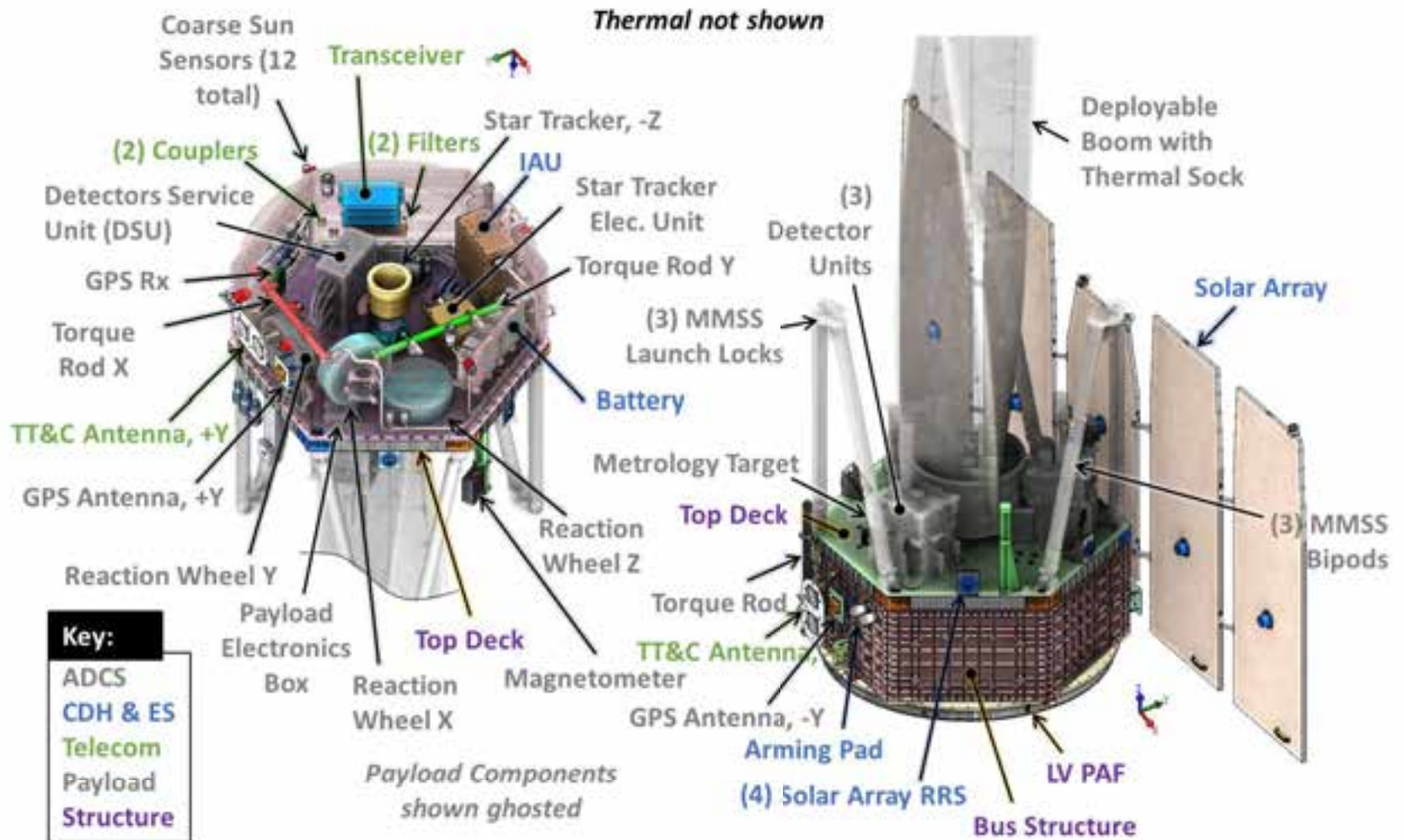




IXPE

Imaging
X-Ray
Polarimetry
Explorer

IXPE SPACECRAFT



IXPE SPACECRAFT CAPABILITIES

Spacecraft Parameter	Capability
Orbit Altitude	540 km
Orbit Inclination	0°
Launch Mass	~320 kg
Orbit Average Power (OAP)	286 W
LV Compatibility	Pegasus XL
SV Lifetime	2 years, no life-limiting consumables
Stabilization Method	3-axis
Pointing Modes	Acquire Sun State (Safe Mode), Point State (Ops Mode)
Attitude Control	40 arcsec (3σ); x- & y-axis, Point State
Bus Voltage	28 V \pm 6 V
Communication Frequency	S-Band / NEN & TDRSS Compatible
Command Rate	2 Kbps uplink
Telemetry Rate	2 Mbps downlink
On-Board Data Storage	6 GBytes
Payload mass	170 kg (total)
Payload Data Handling	Up to 2.0 Mbps from DSU
Payload Command/Data I/F	RS-422, discrete I/O, analog

PROJECT STATUS AND KEY MILESTONES

- **IXPE Project Phase B Kicked off February 2017**
- **Mission SRR held 18,19 September 2017**
- **X-ray optics build started at MSFC**
- **Gas-pixel detector fabrication started at IAPS/INFN**
- **Spacecraft PDR held 20 March 2018**
- **Payload PDR scheduled for 24-25 April 2018**
- **Mission PDR planned for June 2018**
- **IXPE Project Phase C start in August 2018**
- **Launch planned April 2021**

- **IXPE brings together an international collaboration for flying an imaging X-ray polarimeter on a NASA Small Explorer.**
- **IXPE will conduct X-ray polarimetry for several categories of cosmic X-ray sources from neutron stars and stellar-mass black holes, to supernova remnants, to active galactic nuclei that are likely to be X-ray polarized.**
- **This paper summarized**
 - IXPE mission science objectives
 - Observatory Implementation
 - Payload concept
 - Overview of Ball BCP-100 small Spacecraft and IXPE Spacecraft
- **The IXPE Project will conduct world-class science on a Small Explorers budget with a small spacecraft**

ACKNOWLEDGEMENTS

- **The Ball Aerospace IXPE Project Team would like to thank NASA Marshall Space Flight Center for their support of this work under contract number NNM15AA18C. We are grateful for the support**
- **The work described in this presentation is a culmination of efforts from teams at NASA MSFC, Ball Aerospace, ASI, INFN, IAPS, CU/LASP, Stanford, McGill University and Università degli Studi di Roma TRE**

THANK YOU