

IXPE Status and Prospects

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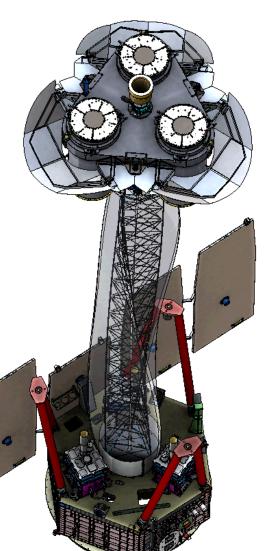
Meeting Gruppo2 – Torino, 13 Giugno 2019

IXPE Mission Overview



• IXPE is a NASA SMEX mission:

- Selected January 2017
- Italian contribution due December 2019
- Launch April 2021
- Cost-capped (200M\$) rigid aggressive schedule
- Italian Contribution supported by ASI, INAF, INFN
 - ASI manages funding through 3 direct contracts to Institues and industry
 - OHB-I (FCW, DSU)
 - INFN (DU)
 - INAF (System Engineering and Calibration)

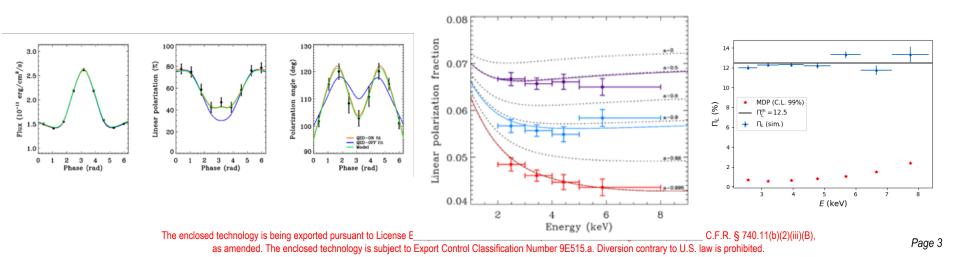


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Why X-ray Polarimetry ?

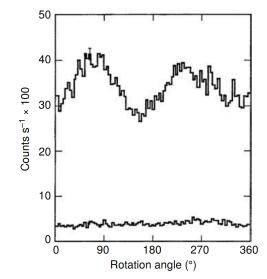
- Polarized X-rays expected from most astrophysical systems
 - Anything non spherical
- Polarized X-rays bring insight into
 - emission processes
 - synchrotron, non-thermal bremsstrahlung, Inverse Compton
 - geometry
 - scattering in aspherical geometries, propagation in magnetized plasmas
 - fundamental physics
 - strong gravitation/magnetic fields (BH spin), QED vacuum birefringence, propagation through cosmological distances (LIV), unexpected polarization from photon-ALP mixing (Clusters)

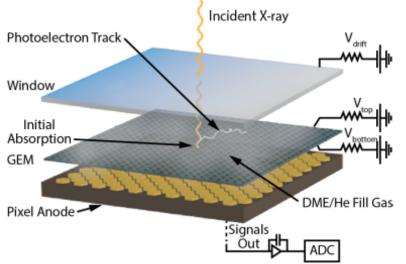


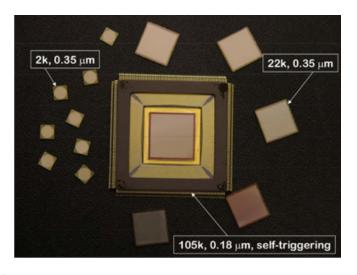




- Single historical (1978) measurement from the Crab Nebula
 - Through rotating angle-selective Bragg crystals in need of long exposure to achieve required large photon statistics
- INFN Gas Pixel Detector opens the way to X-ray polarimetry
 - 10+ years development of key detector parts (GEM, ASIC)
 - Measures direction of every single X-ray absorbed
 - Several mission proposals before IXPE



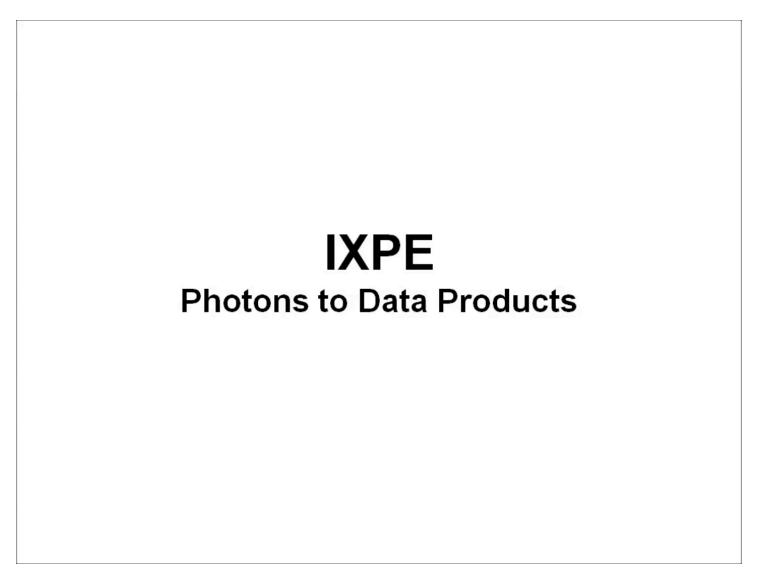




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IXPE – From photons to data products

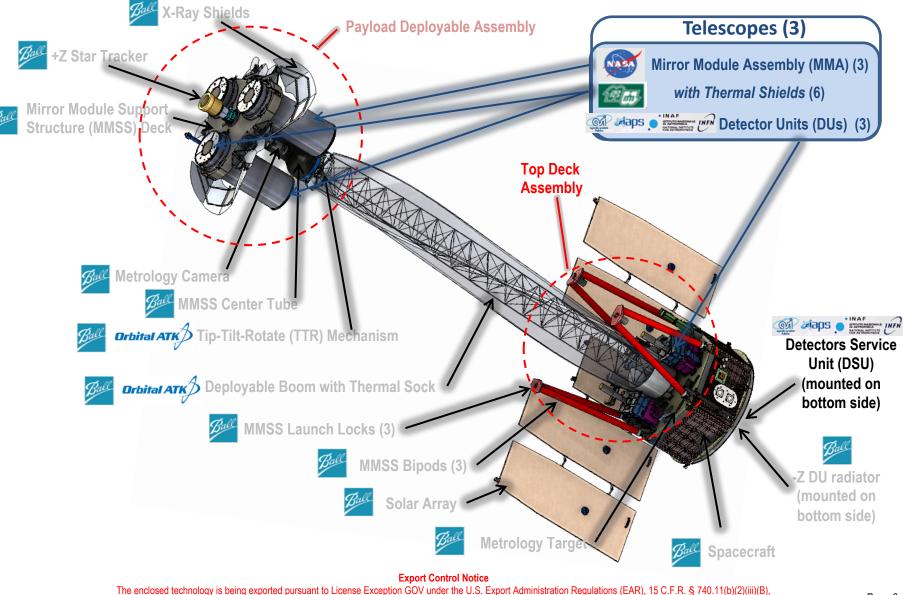




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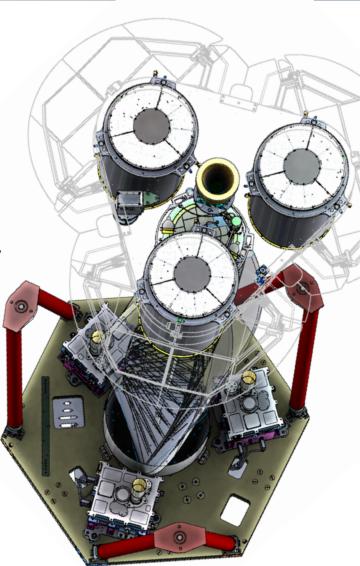
IXPE Observatory





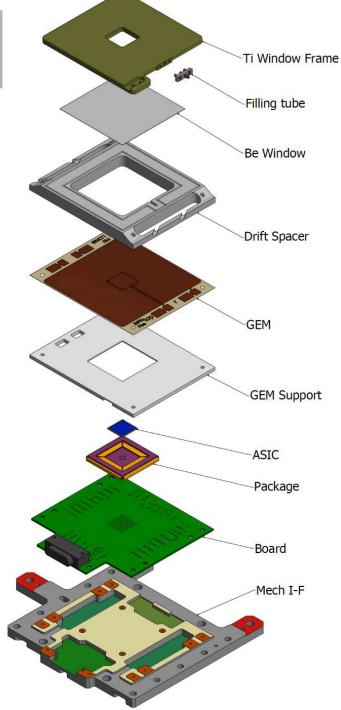
IXPE Focal Plane Systems

- Design, Integration and Test at INFN
 - ~6.5M from ASI to INFN
 - INFN provides in-kind personnel (~1.5M) and facilities (CR, workshop), ~1M from CSN2
- Gas Pixel Detectors enabling technology for X-ray polarimetry invented at INFN
 - Luca Baldini Italian Co-PI
 - Luca Latronico Detector Unit Project Manager
- System level calibration, including Detector Service Unit, managed by INAF/IAPS
 - Paolo Soffitta Italian PI



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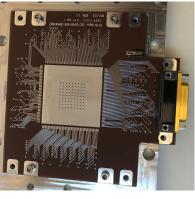


GPD - Gas Pixel Detector









Designed and integrated at INFN

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GPD production and performance testing

Fit model: ixpeFe55 Chisguare: 485.0 / 82

Amplitude0: 2755 ± 27

Amplitude1: 608 ± 55 Peak: 5801.8 ± 8.5

Resolution: 0.1763 ± 0.0021

Sigma: 434.5 ± 5.2

3500

3000

2500

1000

500

0

105

55Fe peak [adc]

104

460

470

480

0

1000

2000

3000

4000

5000

Pulse Invariant Inorm. ADC counts1

GPD 31 Gain Scan

490

ΔV GEM [V]

500

510

6000

7000

•

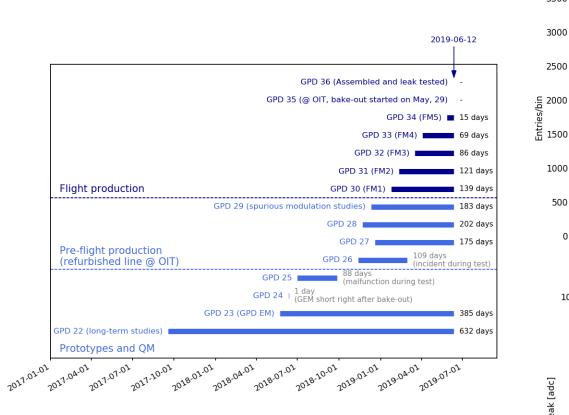
8000

BOT= 450 V

BOT= 400 V

9000





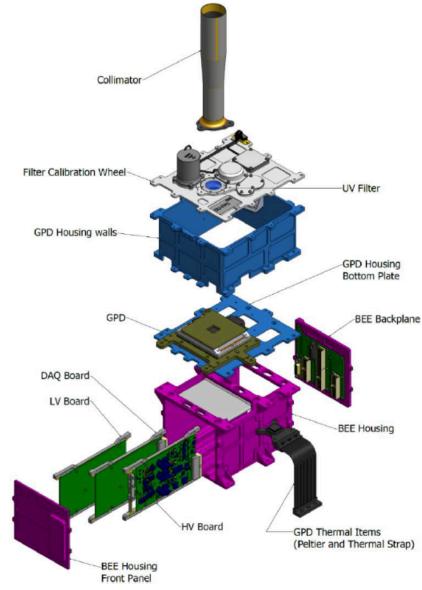
Acceptance and performance tests at INFN and IAPS, full calibration at DU level



520

DU - Detector Unit





• INFN

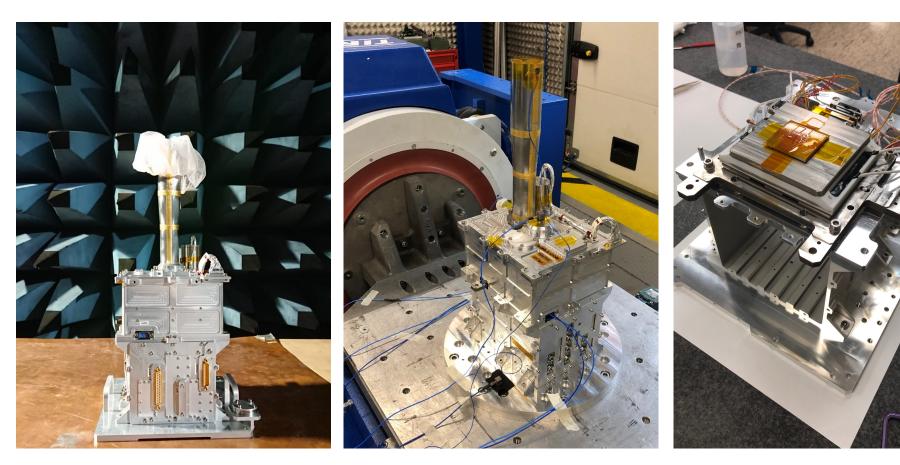
- GPD and associated thermal control
- DAQ, Low-Voltage boards and associated backplane (OHB-I through INFN contract)
- Stray-light collimator
- DU Integration & Test
- IAPS
 - Calibration sources
 - UV filter
- OHB-I (through ASI contract)
 - High-voltage board
 - Filter and calibration wheel

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DU Assembly Integration & Test





DU Engineering Model EMC Test

DU Structural Model Vibrational qualification DU Flight Model 1 Integration

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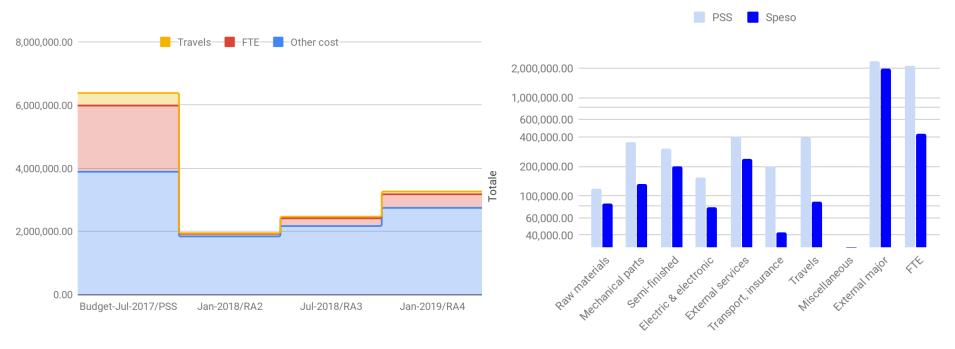


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IXPE Cash flow – ASI funds



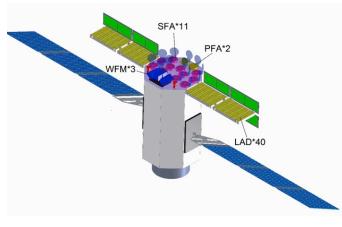
Descrizione

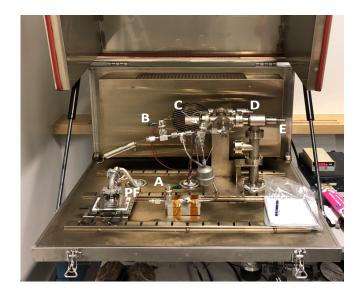
Procurement (tenders, orders) and personnel contacts managed through INFN administration



Prospects – beyond IXPE – call for volunteers

- Improve GPD performance for future missions
 - First window in 2026 with eXTP (China)
 - Large mission with several instruments for spectroscopy, imaging, timing and polarimetry
- 1. Solve systematics from spurious modulation
 - Complete test and qualification of alternative GEMs
 - Test new ASIC with dedicated readout systems
 - Evaluate new ASIC design and production
- 2. Consolidate GPD production line at INFN
 - Mechanics: build on existing design and derive more flexible parts for prototypes
 - Integration: build baking and sealing facility





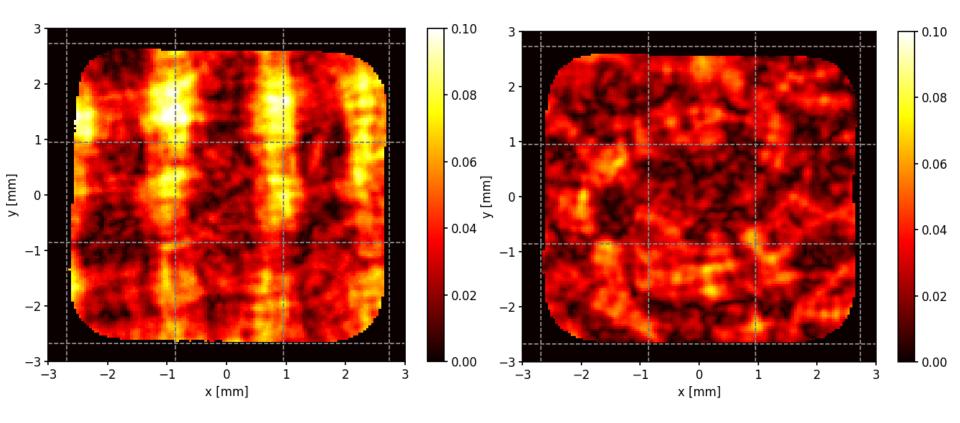
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- IXPE GPDs exhibit energy- and position- dependent residual modulation of few % from unpolarized beams
- Measurements indicate a complex mixture of many tiny effects
 - GEM geometry (holes, pitch) and processing
 - ASIC (trigger digital lines activity, pedestal and gain pixel variations)
 - Readout electronics and processing software global effects
 - Residual source polarization
- Dedicated, successful effort to recover science requirements for IXPE
 - Through dedicated calibration and observation strategies (dithering and clocking)
- Beyond IXPE understand root cause inside GPD
 - Two years R&D program in parallel to IXPE mission



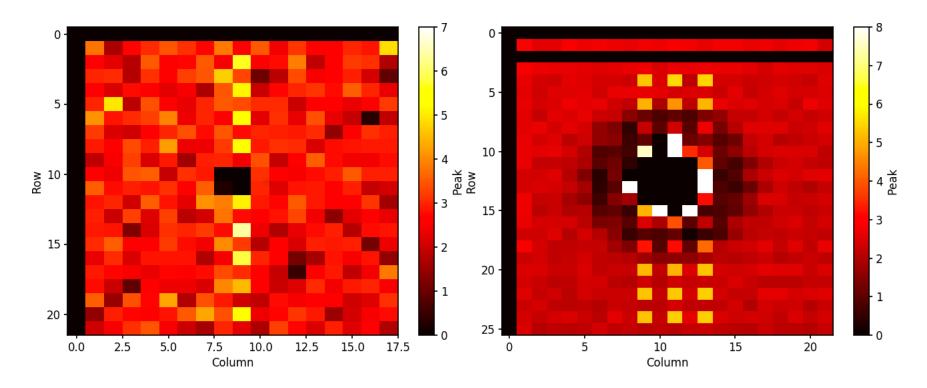
GPD Residual Modulation – GEM studies



- GPD modulation correlates with GEM gain structures
 - after gain calibration
- Different GEM manufacturing technologies induce different modulation patterns



GPD Residual modulation – measured ASIC effects

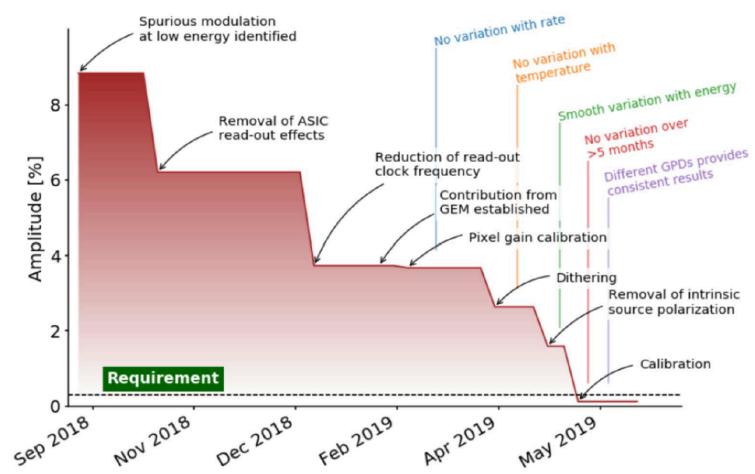


- Readout (charge injection / physics) leaves few ADC counts asimmetries
- Tiny but coherent effect can produce ~% modukation
 - 2/3 ADC counts vs ~10 noise cts, vs ~1000 signal cts



IXPE GPD Residual modulation recovery

All data referred to the flight-like GPD#29



• Final goal is to solve root cause with new generation of GPDs for future missions





- <u>https://ixpe.msfc.nasa.gov/</u> and papers therein
- Lectures on x-ray polarimetry and IXPE from
 - <u>https://www2.pd.infn.it/astro/pers/asiago2018/index.html</u>