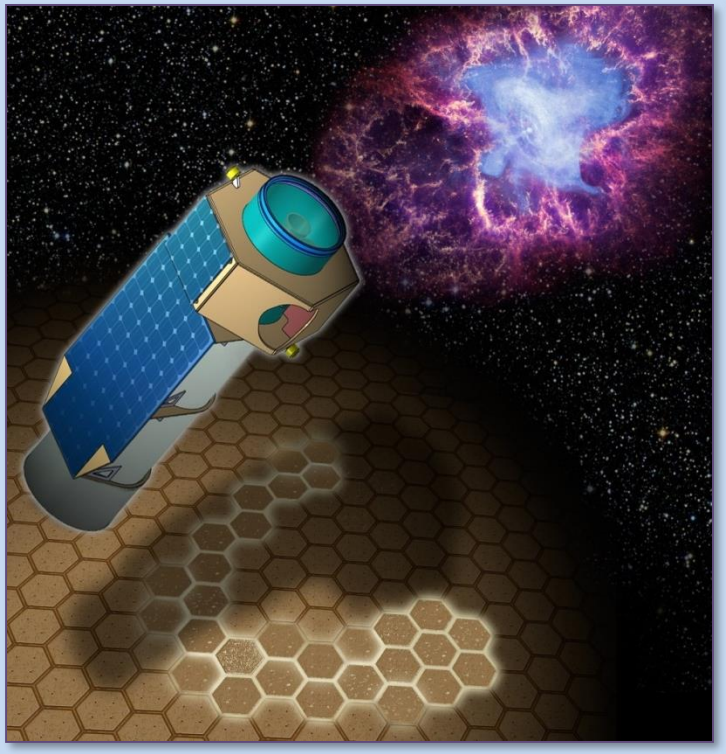
XIPE & IXPE

Paolo Soffitta

IAPS-INAF

High-throughput X-ray Astronomy in the eXTP era
Rome, 6-8 February 2017

Picking the right direction
Xipe



XIPE participating Institutions

BR: INPE; **CH**: ISDC - Univ. of Geneva; **CN**: IHEP, NAOC, NJU, PKU, PMO, Purdue Univ., SHAO, Tongji Univ, Tsinghua Univ., XAO; **CZ**: Astron. Institute of the CAS; **DE**: IAAT Uni Tübingen, MPA, MPE; **ES**: CSIC, CSIC-IAA, CSIC-IEEC, CSIC-INTA, IFCA (CSIC-UC), INTA, Univ. de Valencia; **FI**: Oxford Instruments Analytical Oy, Univ. of Helsinki, Univ. of Turku; **FR**: CNRS/ARTEMIS, IPAG-Univ. of Grenoble/CNRS, IRAP, Obs. Astron. de Strasbourg, **IN**: Raman Research Institute, Bangalore; **IT**: Gran Sasso Science Institute, L'Aquila, INAF/IAPS, INAF/IASF-Bo, INAF/IASF-Pa, INAF-OAA, INAF-OABr, INAF-OAR, INFN-Pi, INFN-Torino, INFN-Ts, Univ of Pisa, Univ. Cagliari, Univ. of Florence, Univ. of Padova, Univ. of Palermo, Univ. Roma Tre, Univ. Torino; **NL**: JIVE, Univ. of Amsterdam; **PL**:CopernicusAstr. Ctr., SRC-PAS; **PT**: LIP/Univ. of Beira-Interior, LIP/Univ. of Coimbra; **RU**: Ioffe Institute, St.Petersburg: **SE**: KTH Royal Institute of Technology. Stockholm Univ.: **UK**: Cardiff Univ., UCL-MSSL, Univ. of Bath; **US**: CFA, Cornell Univ., NASA-MSFC, Stony Brook Univ., Univ. of Iowa, Boston Univ., Institute for Astrophysical Research, Boston Univ., Stanford Univ./KIPAC.

ESA & NASA

ESA

In 2014 **ESA** issued an AOO for the 4th Scientific Mission of Medium Size (M4) with a budget of 450 M€ (+ national contributions). Dead-line January 2015.

3 missions have been selected in June 2015 for phase A study:

1) XIPE: an X-ray Imaging Polarimeter based on GPD

2) ARIEL: a mission for the spectroscopy of Exoplanets

3) Thor: a mission to study turbolence on Solar Wind

Phase A will be completed in March 2017 with the issue of documentation and of the Yellow Book

One of these 3 missions will be selected for flight.

Launch in 2024

NASA

In 2014 **NASA** issued an AOO for a Small Explorer Mission (budget of ~ 175 M$). Dead-line Dec 2014.

On July 30th **NASA selected 3 missions for phase A study.**

1) IXPE: a Mission of X-ray Polarimetry based on GPD; P.I. Martin Weisskopf

2) Praxys: a Mission of X-ray Polarimetry based on TPC

2) SPHEREx: a Mission of All Sky Survey of NearIR spectroscopy

Phase A accomplished in July 2016. Site Visit at MSFC the 17th Nov 2016

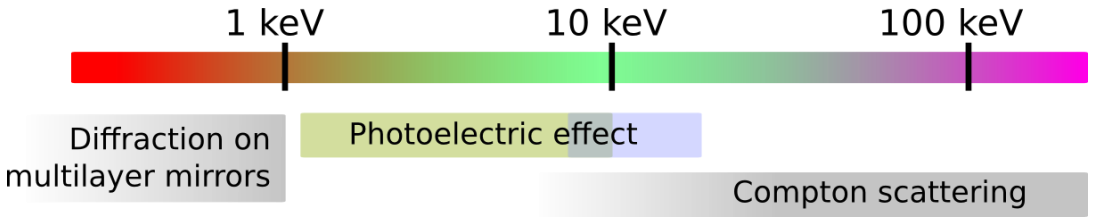
On 3rd January 2017 NASA selected IXPE for flight.

Launch in November 2020

Three out of 6 missions studied by ESA and NASA are of X-ray Polarimetry

The energy band

Scientific goal	Sources	< 1keV	1-10	> 10 keV
Acceleration phenomena	PWN	yes (but absorption)	yes	yes
	SNR	no	yes	yes
	Jet (Microquasars)	yes (but absorption)	yes	yes
	Jet (Blazars)	yes	yes	yes
Emission in strong magnetic fields	WD	yes (but absorption)	yes	difficult
	AMS	no	yes	yes
	X-ray pulsator	difficult	yes (no cyclotron ?)	yes
	Magnetar	yes (better)	yes	no
Scattering in aspherical geometries	Corona in XRB & AGNs	difficult	yes	yes (difficult)
	X-ray reflection nebulae	no	yes (long exposure)	yes
Fundamental Physics	QED (magnetar)	yes (better)	yes	no
	GR (BH)	no	yes	no
	QG (Blazars)	difficult	yes	yes
	Axions (Blazars, Clusters)	yes ?	yes	difficult



Why this is now possible

The Gas Pixel Detector

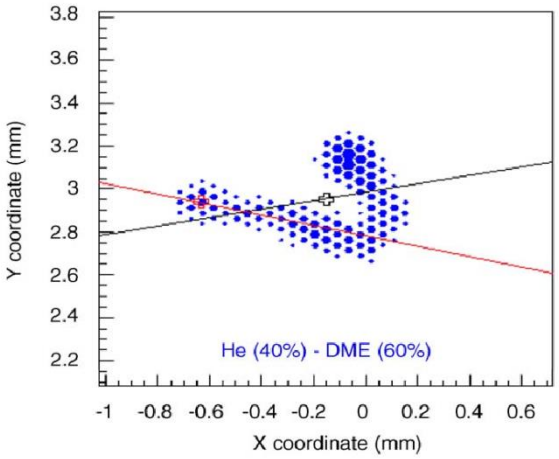
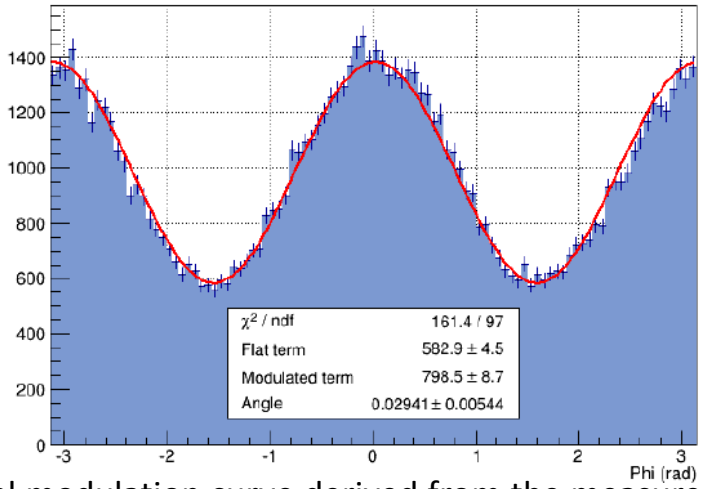
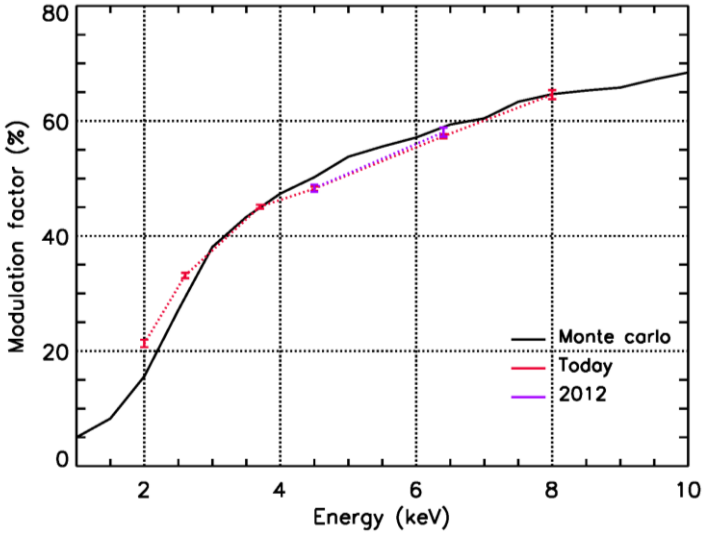


Image of a real photoelectron track. The use of the gas allows to resolve tracks in the X-ray energy band.

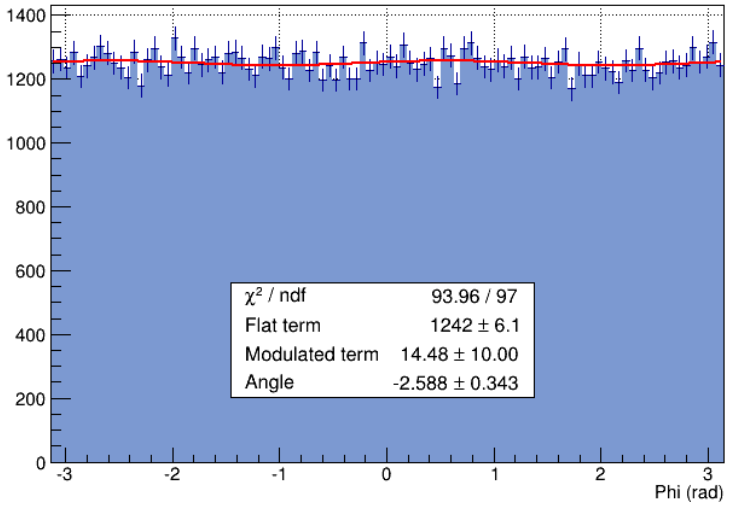


Real modulation curve derived from the measurement of the emission direction of the photoelectron.



Muleri et al. 2008,2010

Modulation factor as a function of energy.



Bellazzini et al. 2012

Residual modulation for unpolarised photons.

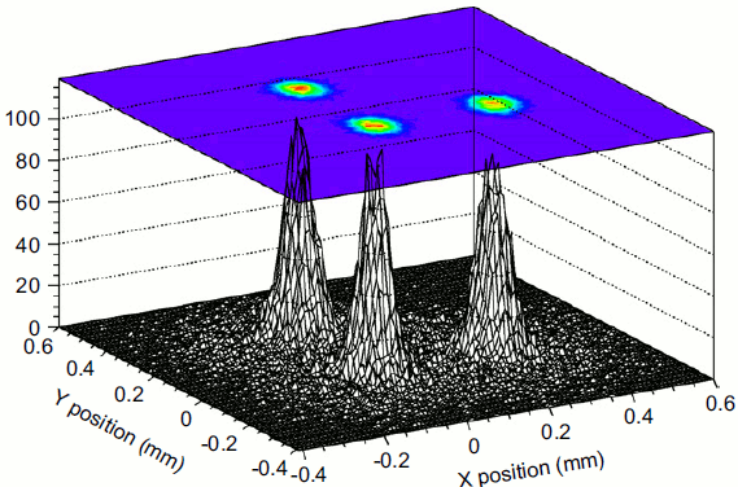
Why this is now possible

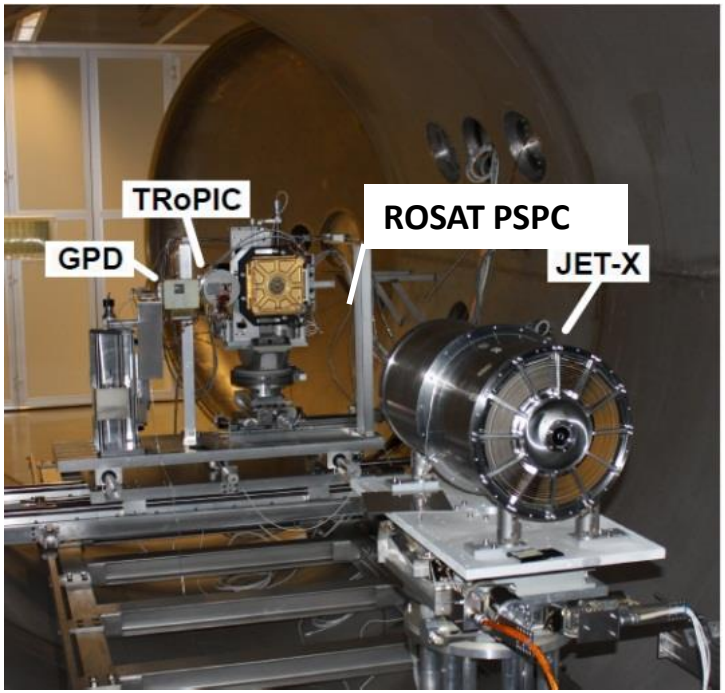
Imaging capabilities of GPD tested at PANTER

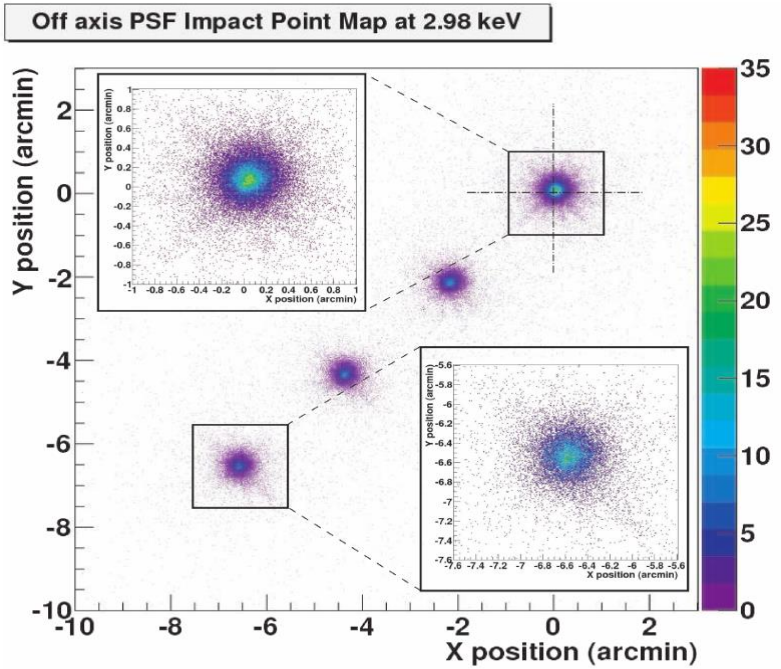
- Good spatial resolution: 90 µm Half Energy Width

- Imaging capabilities on- and off-axis measured at PANTER with a JET-X telescope (Fabiani et al. 2014)

- Angular resolution for XIPE: <26 arcsec

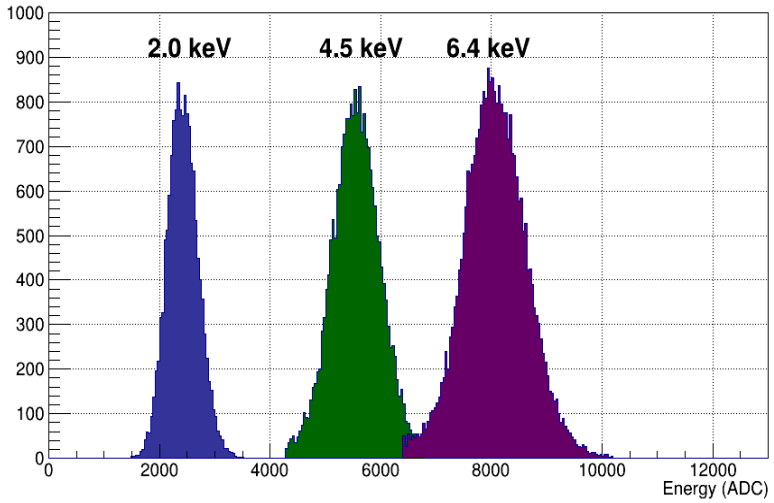


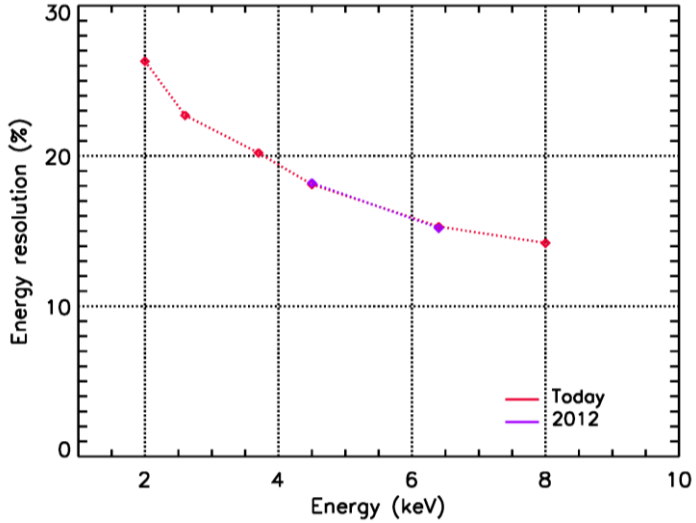




The Gas Pixel Detector

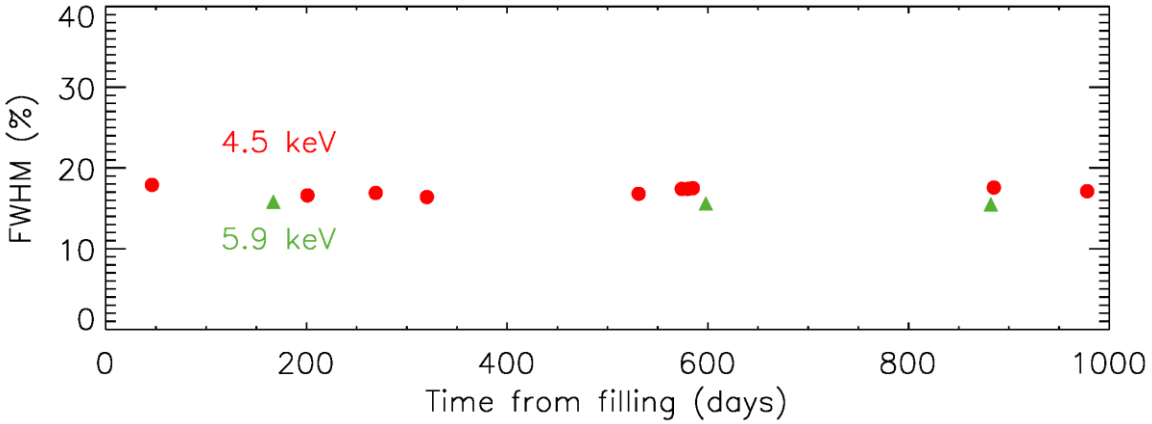
Spectroscopic capabilities





- Adequate spectrometer for continuum emission (16 % at 6 keV, Muleri et al. 2010).

- Stable operation over 3 years



The X-ray Imaging Polarimetry Explorer

Proposed by

Paolo Soffitta, Ronaldo Bellazzini, Enrico Bozzo, Vadim Burwitz, Alberto J. Castro-Tirado, Enrico Costa, Thierry J-L. Courvoisier, Hua Feng, Szymon Gburek, René Goosmann, Vladimir Karas, Giorgio Matt, Fabio Muleri, Kirpal Nandra, Mark Pearce, Juri Poutanen, Victor Reglero, Maria Dolores Sabau, Andrea Santangelo, Gianpiero Tagliaferri, Christoph Tenzer, Martin C. Weisskopf, Silvia Zane

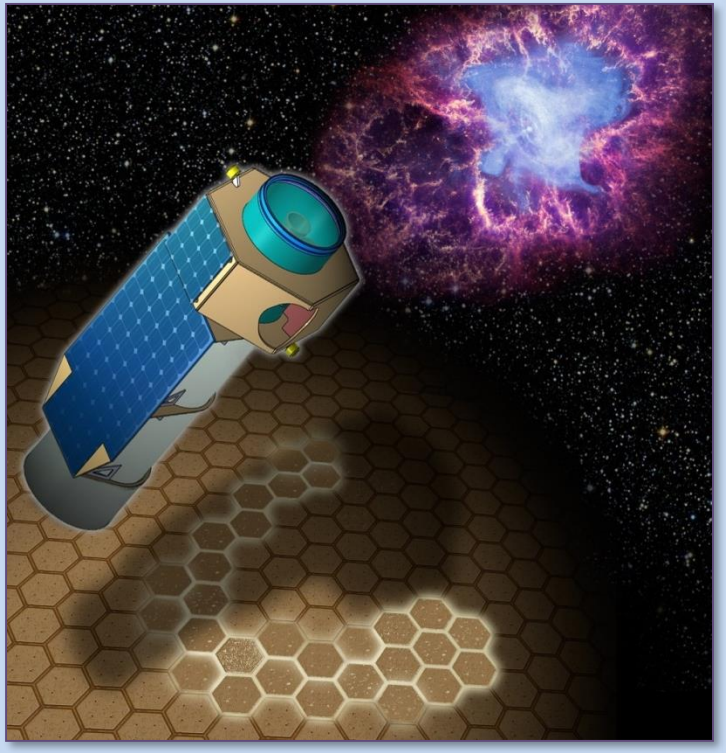
XIPE Science Team

Agudo, Ivan; Aloisio, Roberto; Amato, Elena; Antonelli, Angelo; Atteia, Jean-Luc; Axelsson, Magnus; Bandiera, Rino; Barcons, Xavier; Bianchi, Stefano; Blasi, Pasquale; Boër, Michel; Bozzo, Enrico; Braga, Joao; Bucciantini, Niccolo'; Burderi, Luciano; Bykov, Andrey; Campana, Sergio; Campana, Riccardo; Cappi, Massimo; Cardillo, Martina; Casella, Piergiorgio; Castro-Tirado, Alberto J.; Chen, Yang; Churazov, Eugene; Connell, Paul; Courvoisier, Thierry; Covino, Stefano; Cui, Wei; Cusumano, Giancarlo; Dadina, Mauro; De Rosa, Alessandra; Del Zanna, Luca; Di Salvo, Tiziana; Donnarumma, Immacolata; Dovciak, Michal; Elsner, Ronald; Eyles, Chris; Fabiani, Sergio; Fan, Yizhong; Feng, Hua; Ghisellini, Gabriele; Goosmann, René W.; Gou, Lijun; Grandi, Paola; Grosso, Nicolas; Hernanz, Margarita; Ho, Luis; Hu, Jian; Huovelin, Juhani; Iaria, Rosario; Jackson, Miranda; Ji, Li; Jorstad, Svetlana; Kaaret, Philip; Karas, Vladimir; Lai, Dong; Larsson, Josefin; Li, Li-Xin; Li, Tipei; Malzac, Julien; Marin, Frédéric; Marscher, Alan; Massaro, Francesco; Matt, Giorgio; Mineo, Teresa; Miniutti, Giovanni; Morlino, Giovanni; Mundell, Carole; Nandra, Kirpal; O'Dell, Steve; Olmi, Barbara; Pacciani, Luigi; Paul, Biswajit; Perna, Rosalba; Petrucci, Pierre-Olivier; Pili, Antonio Graziano; Porquet, Delphine; Poutanen, Juri; Ramsey, Brian; Razzano, Massimiliano; Rea, Nanda; Reglero, Victor; Rosswog, Stephan; Rozanska, Agata; Ryde, Felix; Sabau, Maria Dolores; Salvati, Marco; Silver, Eric; Sunyaev, Rashid; Tamborra, Francesco; Tavecchio, Fabrizio; Taverna, Roberto; Tong, Hao; Turolla, Roberto; Vink, Jacco; Wang, Chen; Weisskopf, Martin C.; Wu, Kinwah; Wu, Xuefeng; Xu, Renxin; Yu, Wenfei; Yuan, Feng; Zane, Silvia; Zdziarski, Andrzej A.; Zhang, Shuangnan; Zhang, Shu.

XIPE Instrument Team

Baldini, Luca; Basso, Stefano; Bellazzini, Ronaldo; Bozzo, Enrico; Brez, Alessandro; Burwitz, Vadim; Costa, Enrico; Cui, Wei; de Ruvo, Luca; Del Monte, Ettore; Di Cosimo, Sergio; Di Persio, Giuseppe; Dias, Teresa H. V. T.; Escada, Jose; Evangelista, Yuri; Eyles, Chris; Feng, Hua; Gburek, Szymon; Kiss, Mózsi; Korpela, Seppo; Kowaliski, Miroslaw; Kuss, Michael; Latronico, Luca; Li, Hong; Maia, Jorge; Minuti, Massimo; Muleri, Fabio; Nenonen, Seppo; Omodei, Nicola; Pareschi, Giovanni; Pearce, Mark; Pesce-Rollins, Melissa; Pinchera, Michele; Reglero, Victor; Rubini, Alda; Sabau, Maria Dolores; Santangelo, Andrea; Sgrò, Carmelo; Silva, Rui; Soffitta, Paolo; Spandre, Gloria; Spiga, Daniele; Tagliaferri, Gianpiero; Tenzer, Christoph; Wang, Zhanshan; Winter, Berend; Zane, Silvia.

XIPE uniqueness: Time-, spectrally-, spatially-resolved **X-ray polarimetry** as a breakthrough in high energy astrophysics and fundamental physics



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The X-ray Imaging Polarimetry Explorer

A **large** number of scientific topics and observable sources:

Astrophysics

Acceleration phenomena
- Pulsar wind nebulae
- SNRs
- Jets Blazars

Emission in strong magnetic fields
- Magnetic cataclysmic variables
- Accreting millisecond pulsars
- Accreting X-ray pulsars
- Magnetar

Scattering in a-spherical situations
- X-ray binaries
- Radio-quiet AGN
- X-ray reflection nebulae

Fundamental Physics

Matter in Extreme Magnetic Fields: QED effects
- Magnetars

Matter in Extreme Gravitational Fields: GR effects
- Galactic black hole system & AGNs

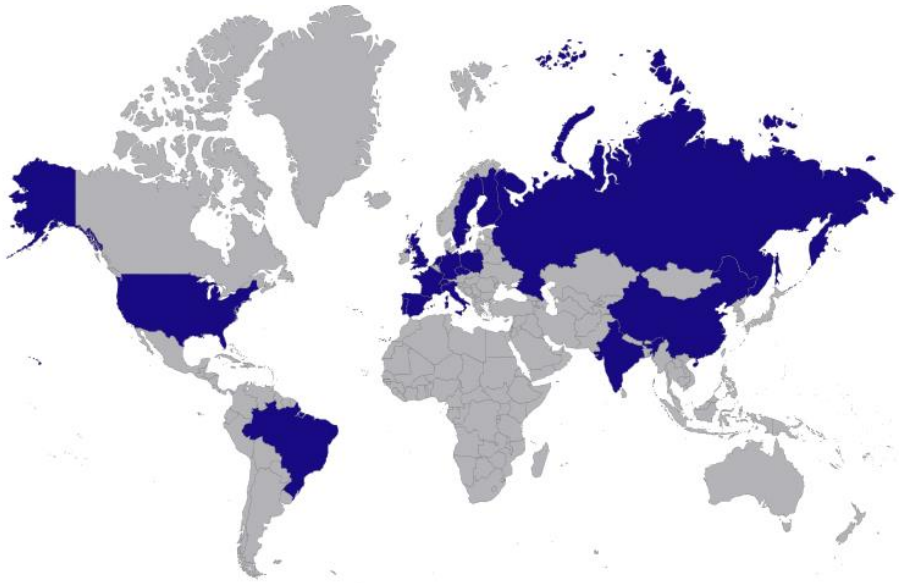
Quantum Gravity

Search for axion-like particles

Basically, XIPE will observe **almost all classes of X-ray sources**.

A **large** community involved:

- **17 countries**
- **146 scientists**
- **68 institutes around the world**



Working groups set: about 350 scientists signed for participation.

WG1. Acceleration mechanisms: Gianpiero Tagliaferri(1), Jacco Vink(2)
(1) Osservatorio Astronomico di Brera INAF, Italy, (2) Astronomical Institute Anton Pannekoek, The Netherlands

WG1.1 **Pulsar Wind Nebulae**: Emma de Ona Wilhelmi , ICE, Spain
WG1.2 **Supernova Remnants**: **Andrei Bykov,** Ioffe Physical-Technical Institute, Russia
WG1.3 **Blazars: Ivan Agudo, Instituto** de Astrofísica de Andalucía, Spain
WG1.4 **Micro-QSOs**: **Elena Gallo**, University of California, Santa Barbara, USA
WG1.5 **Gamma Ray** Bursts: **Carol Mundell**, University of Bath, UK
WG1.6 **Tidal Disruption** Events: **Immacolata Donnarumma**, IAPS/INAF, Italy
WG1.7 **Active Stars**: **Nicholas Grosso**, Astronomical Observatory in Strasbourg, France
WG1.8 **Clusters of Galaxy**: **Sergey Sazonov**, Space Research Institute, Russian Academy of Sciences, Russia

WG2. Magnetic Fields in compact objects: Andrea Santangelo (1), Silvia Zane (2)
(1) Institut für Astronomie und Astrophysik Tuebingen, (2) University College London/MSSL, UK

WG2.1 **Magnetic Cataclismic Variables**: **Domitilla De Martino**, Osservatorio di Capodimonte, taly
WG2.2 **Accreting Millisecond Pulsars**: **Juri Poutanen**, Finland Tuorla Observatory, U. of Turku,Finland
WG2.3 **Accreting X-ray Pulsars**: **Victor Doroshenko**, IAAT, Germany
WG2.4 **Magnetars**: **Roberto Turolla**, University of Padua, Italy

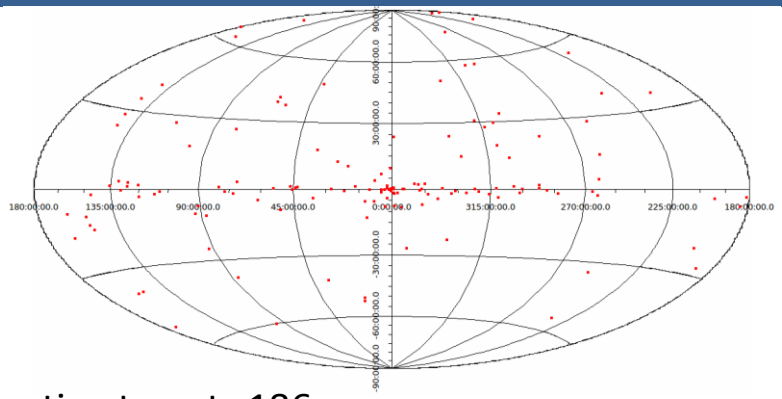
WG3. Scattering in aspherical geometries and accretion Physics: Eugene. Churazov (1), Rene‘ Goosmann(2)
(1)Max-Planck-Institut für Astrophysik, Germany (2) Astronomical Observatory in Strasbourg, France

WG3.1 **X-ray binaries and QPOs**: **Julien Malzac**, CESR/CNRS, France
WG3.2 **AGNs**: **Pierre Olivier Petrucci**, Institut de Planétologie et d’Astrophysique de Grenoble, France
WG3.3 **Molecular Clouds & SgrA***: **Frédéric Marin**, Astronomical Institute of the Academy of Sciences, Czech Republic
WG3.4 **Ultra Luminous X-ray sources**: **Hua Feng**, Tsinghua University, Beijing, China

WG4. Fundamental Physics: Enrico Costa (1), Giorgio Matt (2)
(1) INAF/IAPS, Italy (2) Universita' Roma Tre, Italy

WG4.1 **QED and X-ray polarimetry**: **Rosalba Perna**, Stony Brook University, USA
WG4.2 **Strong Gravity: Jiří Svoboda**, Astronomical Institute of the Academy of Sciences, Czech Republic
WG4.3 **Quantum Gravity**: **Philip E. Kaaret**, Iowa University, USA, **Luigi Foschini (co-chair)** IASF-Mi/INAF
WG4.4 **Axion-like particles**: **Marco Roncadelli**, University of Pavia , Italy

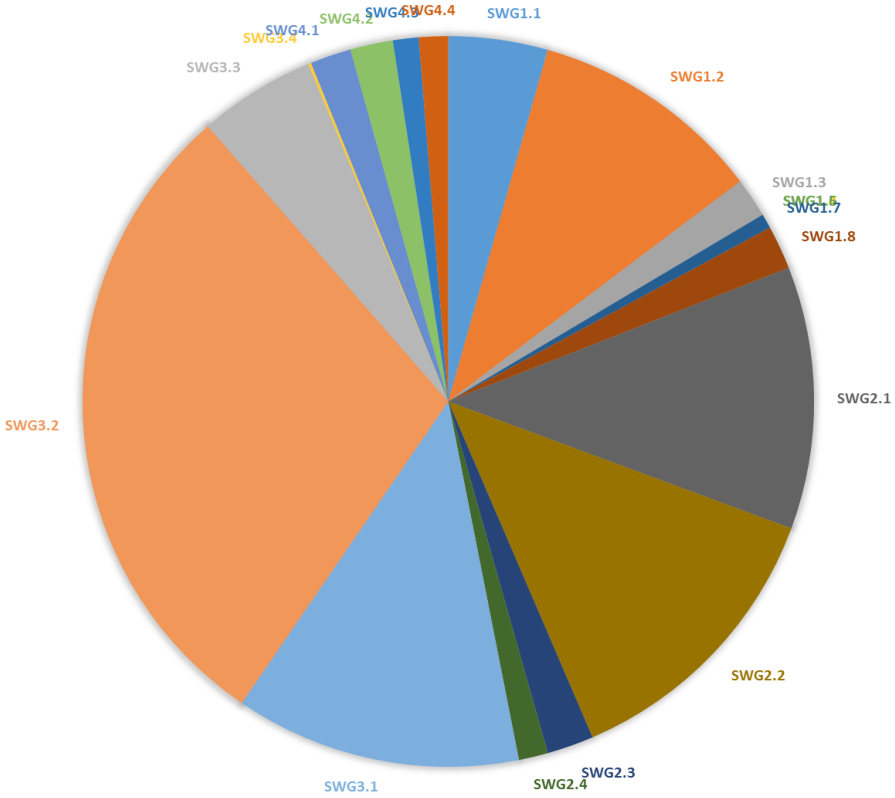
XIPE Mock Observing Plan



XIPE Interesting target

Exposure time in Ms spent on priority targets:	38,7
Exposure time in Ms spent on all targets:	129,92

Priority targets 70. Interesting targets 186



WG1.1 **Pulsar Wind Nebulae**.
WG1.2 **Supernova Remnants**.
WG1.3 **Blazars**.
WG1.4 **Micro-QSO**
WG1.5 **Gamma Ray** Bursts
WG1.6 **Tidal Disruption**
WG1.7 **Active Stars**
WG1.8 **Clusters of Galaxy**

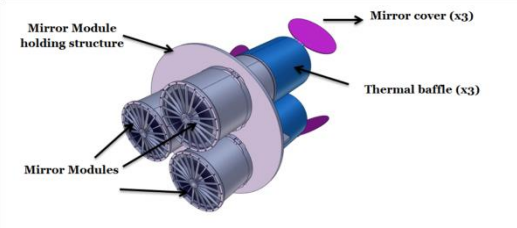
WG2.1 **Magnetic Cataclismic Variables**
WG2.2 **Accreting Millisecond Pulsars**
WG2.3 **Accreting X-ray Pulsars**
WG2.4 **Magnetars**

WG3.1 **X-ray binaries and QPOs**
WG3.2 **AGNs**
WG3.3 **Molecular Clouds & SgrA***
WG3.4 **Ultra Luminous X-ray sources**

WG4.1 **QED and X-ray polarimetry**
WG4.2 **Strong Gravity**
WG4.3 **Quantum Gravity**
WG4.4 **Axion-like particles**

The XIPE ingredients

X-RAY OPTICS



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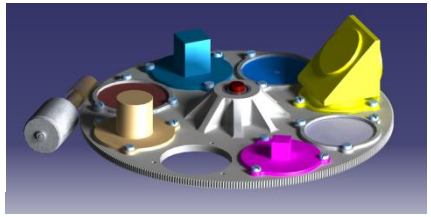
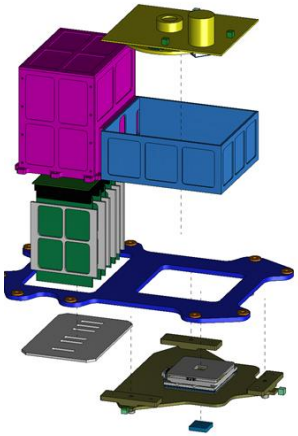
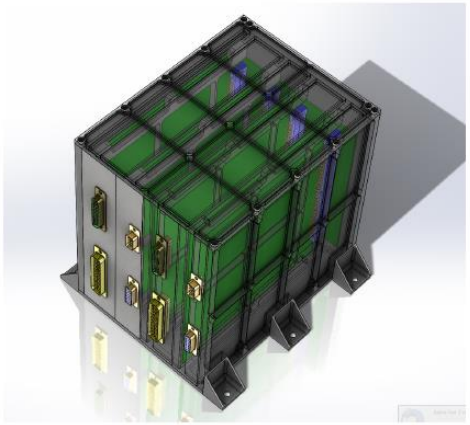


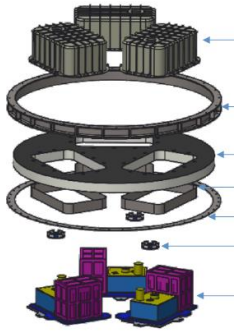
GPD



CE &EGSE



End to End Calibration

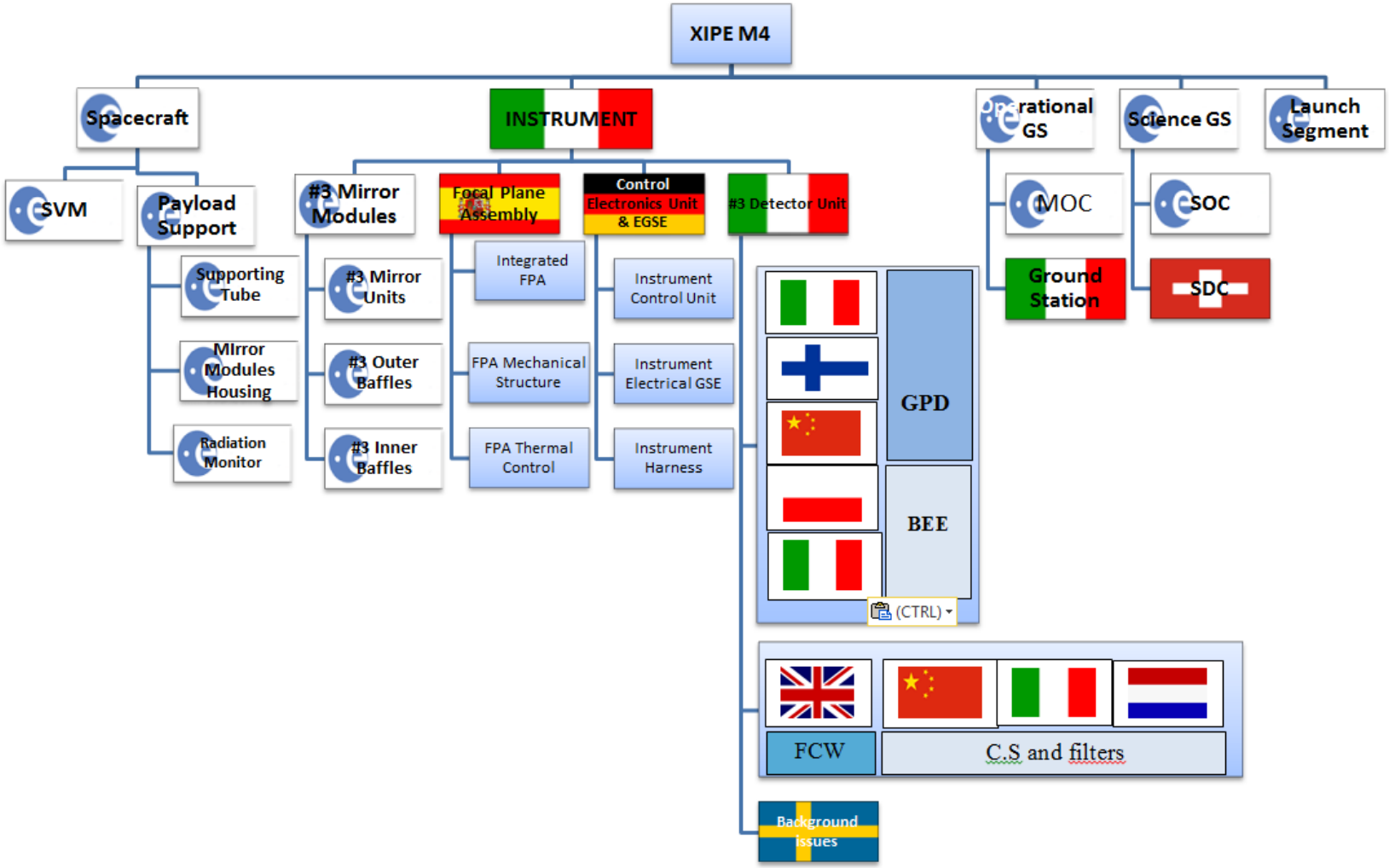


FPA & ENV. TEST

Launcher (Vega)

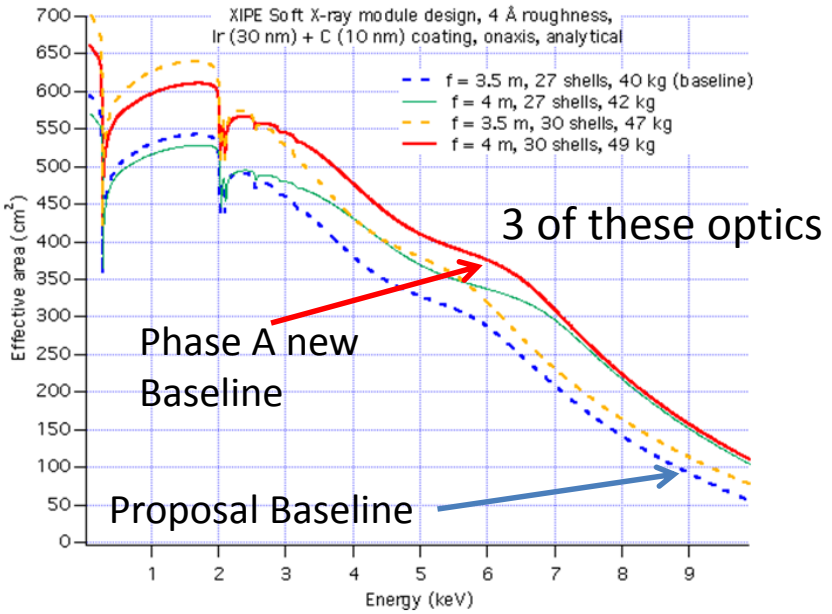
SDC

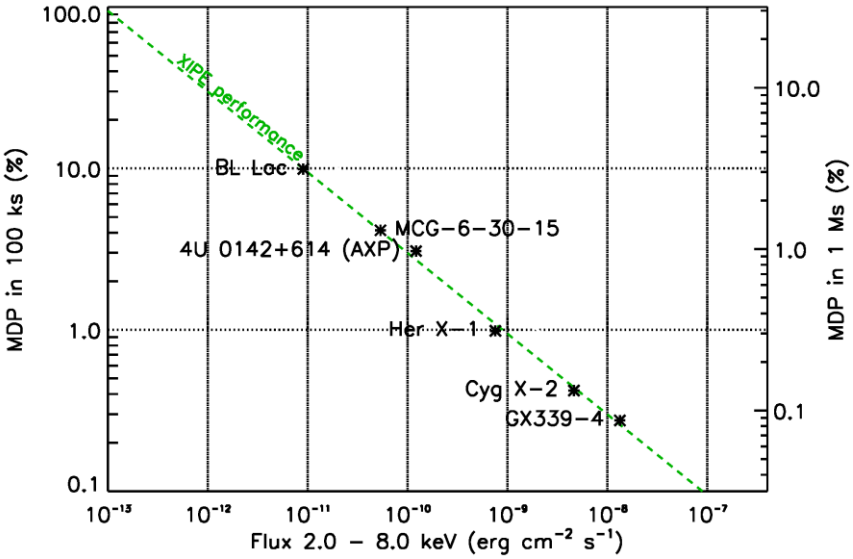
All Europe and more



XIPE facts

Polarisation sensitivity	1.2% MDP for $2x10^{-10}$ erg/s cm^2 (10 mCrab) in 300 ks
Spurious polarization	<0.5 % (goal: <0.1%)
Number of telescopes	3
Angular resolution	22'' (CBE)
Field of View	12.9x12.9 arcmin^2
Focal Length	4 meters
Total Shell length	600 mm
Range Shell Diameter	407-181 mm
Range of thickness	0.2-0.35 mm
Effective area at 3 keV	1530 cm^2 (three telescopes)
Spectral resolution	16% @ 5.9 keV
Timing	Resolution <8 μs
	Dead time 180 μs
	Accuracy 2 μs
Operational phase	3 yr + 2 (extension)
Energy range	2-8 keV
Background (req)	$8x10^{-4}$ c/s/cm2/keV/det
Sky coverage, Orbit	50 %, 550 km (< 6°)





A world-wide open European observatory

CP: Core Program (25%):

- To ensure that the key scientific goals are reached by observing a set of representative candidates for each class.

GO: Guest Observer program on competitive base (75%):

- To complete the CP with a fair sample of sources for each class;
- To explore the discovery space and allow for new ideas;
- To engage a community as wide as possible.

In organising the GO, a fair time for each class will be assigned. This will ensure “population studies” in the different science topics of X-ray polarimetry.

Principal Investigator: M. Weisskopf (MSFC)

Deputy Principal Investigator and Instrument Payload Scientist B. Ramsey

Italian Principal Investigator (IPI): P. Soffitta

Italian Co-PI and Senior Co-Investigator R. Bellazzini

Project Scientist S. O'Dell (MSFC)

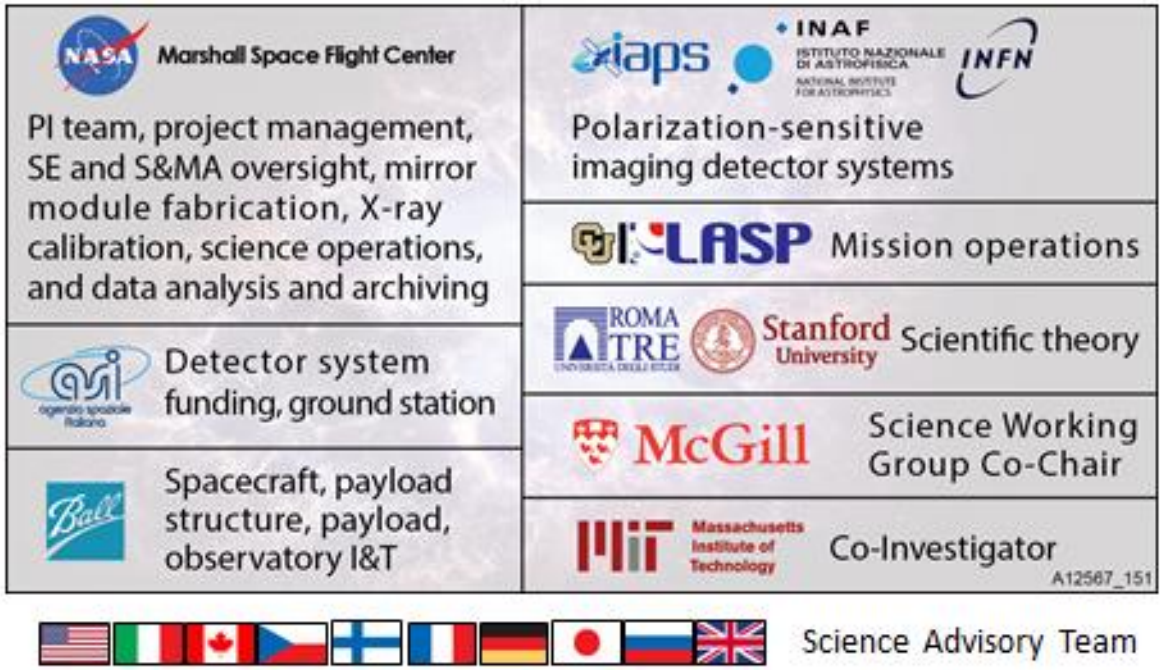
Senior Co-I emeritus E. Costa

Co-I: A. Tennant, H. Marshall, F. Muleri, J. Kolodziejczak, R. Romani, G. Matt, V. Kaspi, R. Elsner, L. Baldini, L. Latronico

Unfunded Collaborators: N. Bucciantini, E. Churazov, M. Dovciak, R. Goosmann, S. Gunji, V. Karas, F. Marin, G. Pavlov, P. Petrucci, J. Poutanen, M. Salvati, L. Stella, R. Sunyaev, R. Taverna, R. Turolla, K. Wu & S. Zane.

Contributed Collaborators: (INFN): A. Brez, N. di Lalla, M. Kuss
A. Manfreda, M. Minuti, N. Omodei, M. Pesce-Rollins, M. Pinchera, M. Razzano, C. Sgrò, F. Spada, G. Spandre. These collaborators will participate in the design, construction, and
(IAPS/INAF): E. Del Monte, I. Donnarumma, Y. Evangelista, S. Fabiani, L. Pacciani and A. Rubini

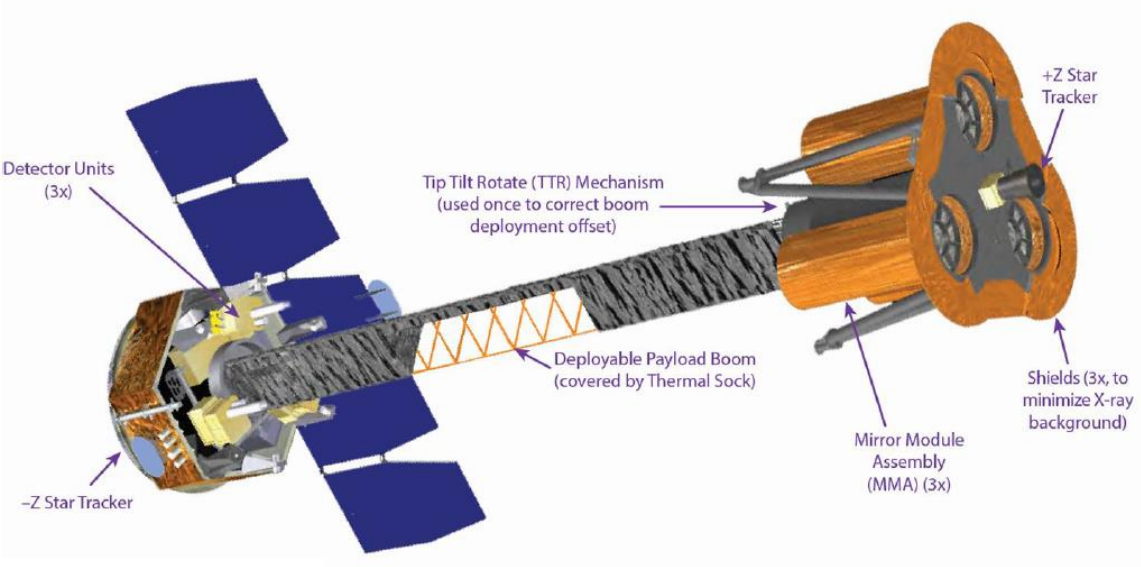
Who is involved?

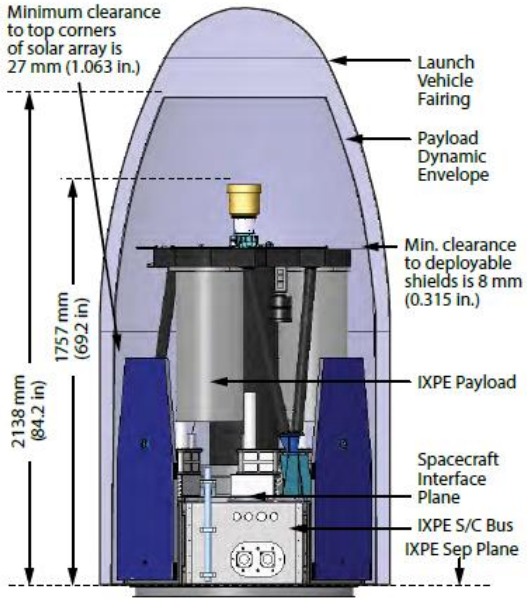


Principal Investigator M. C. Weisskopf

Co-Investigators: Brian D. Ramsey, Paolo Soffitta, Ronaldo Bellazzini, Enrico Costa, Stephen L. O'Dell, Allyn Tennant, Herman Marshall, Fabio Muleri, Jeffery Kolodziejczak, Roger W. Romani, Giorgio Matt, Victoria Kaspi, Ronald Elsner, L. Baldini, L. Latronico

Collaborators: A. Brez, N. Bucciantini, E. Churazov, S. Citrano, E. Del Monte, N. Di Lalla, I. Donnarumma, M. Dovčiak, Y. Evangelista, S. Fabiani, R. Goosmann, S. Gunji, V. Karas, M. Kuss, A. Manfreda, F. Marin, M. Minuti, N. Omodei, L. Pacciani, G. Pavlov, M. Pesce-Rollins, P.-O. Petrucci, M. Pinchera, J. Poutanen, M. Razzano, A. Rubini, M. Salvati, C. Sgrò, F. Spada, G. Spandre, L. Stella, R. Sunyaev, R. Taverna, R. Turolla, K. Wu, S. Zane, D. Zanetti

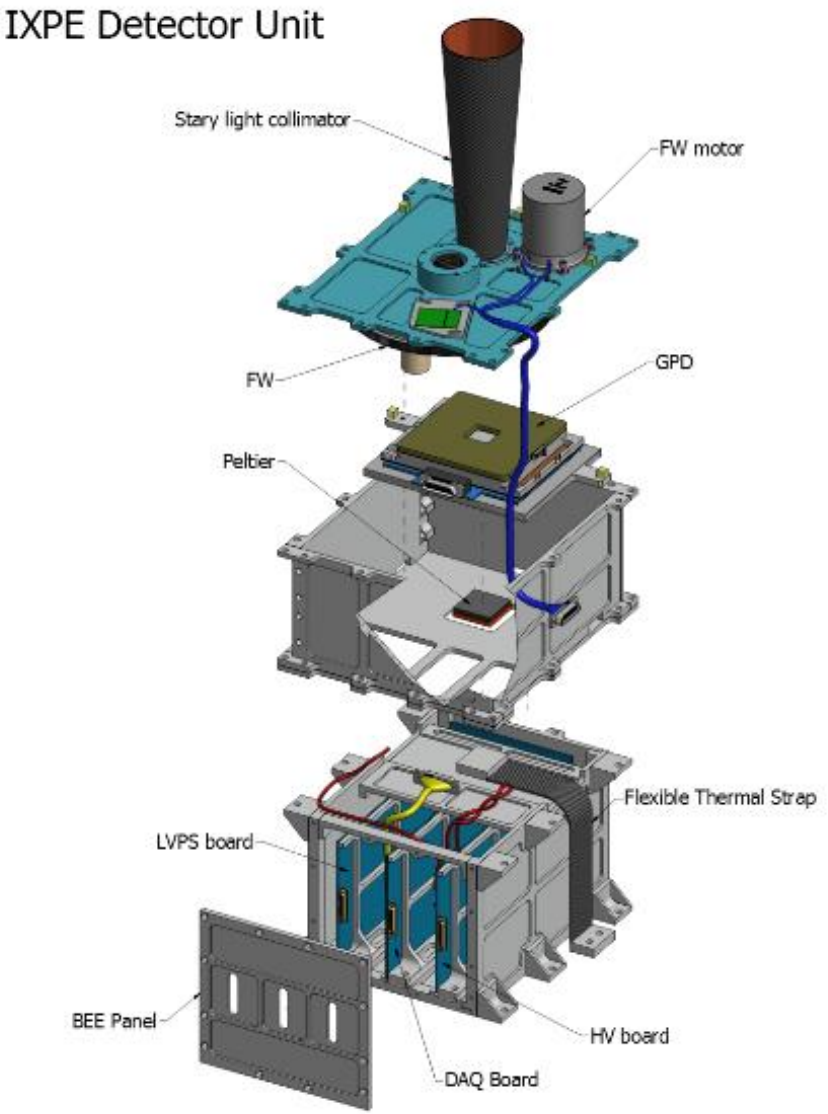




Key Spacecraft Characteristics

- 3-axis, zero net momentum control
- 25" (3σ) pointing accuracy (110% margin)
- Observatory mature mass: 292kg, >30% launch margin
- 257 W EOL power for 35% margin (worst case)
- S-band communications at 2Mbps downlink
- 6GB data storage (50% margin)

Polarisation sensitivity	1.8 % MDP for $2x10^{-10}$ erg/s cm^2 (10 mCrab) in 300 ks
Spurious polarization	<0.3 %
Number of Telescopes	3
Angular resolution	28'' (CBE)
Field of View	12.9x12.9 $arcmin^2$
Focal Length	4 meters
Total Shell length	600 mm
Range Shell Diameter	24 shells, 272-162 mm
Range of thickness	0.16-0.26 mm
Effective area at 3 keV	854 cm^2 (three telescopes)
Spectral resolution	16% @ 5.9 keV
Timing	Resolution <8 µs
	Dead time 180 µs
	Accuracy 150 µs
Operational phase	2 yr + extension (max 1 yr)
Energy range	2-8 keV
Background (req)	$5x10^{-3}$ c/s/cm2/keV/det
Sky coverage, Orbit	50 %, 540 (0^o)



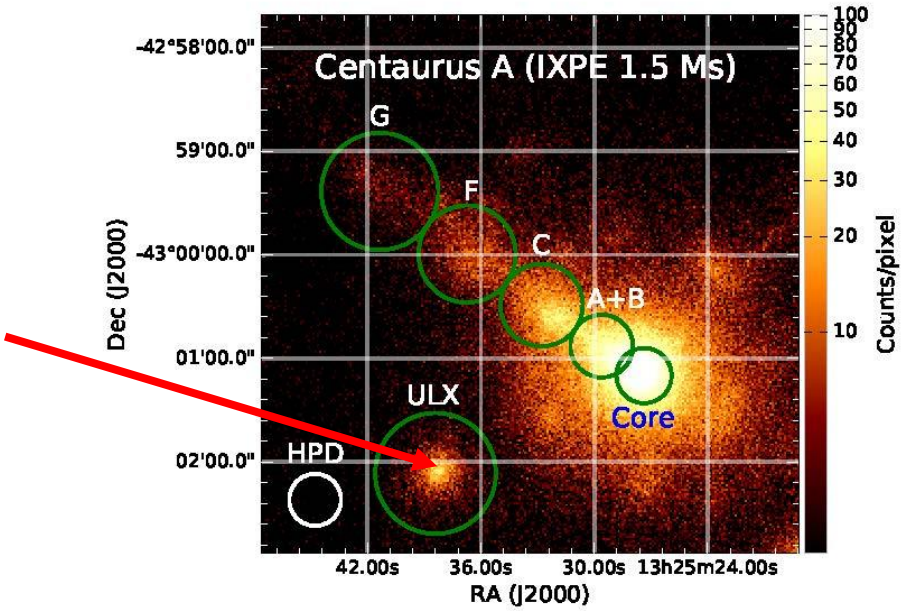
Design Reference Mission (from Proposal)

Source Class	
AGN	4 Seyfert 6 Blazars
Galactic Center	Sgr B2
Microquasars	6
Pulsar Wind Nebulae + Pulsar	3
Supernova Remnants	3
Magnetars	2
Classical Accreting X-ray pulsars	8
Accreting Millisecond X-ray pulsars and Low B binaries	7

All the dato, including those related to polarization will go public soon. No proprietary data.

IXPE imaging also avoids confusion and provides serendipitous benefits

- **Active galaxies are powered by supermassive BHs with jets**
  - Radio polarization implies the magnetic field is aligned with jet
  - Different models for electron acceleration predict different dependence in X-rays
- **Imaging Cen A allows isolating other sources in the field (2 Ultra Luminous X-ray sources)**



Region	MDP_{99}
Core	**<7.0%**
Jet	**10.9%**
Knot A+B	17.6%
Knot C	16.5%
Knot F	23.5%
Knot G	30.9%
ULX	**14.8%**

Includes effects of dilution by unpolarized diffuse emission

END

Mass and Power Budget

Module	Unit Level	#	Current Best Estimated (kg)	Design Maturity Margin (%)	Design Maturity Margin (kg)	Current Best Estimated+Margin (kg)
PLM			**60,133**	**20%**	**12,027**	**72,160**
Focal Plane Assembly	Detector Unit	3	30,633	20%	6,127	36,760
	Focal Plane Support Item	1	29,500	20%	5,900	35,400
SVM			**8,820**	**20%**	**1,764**	**10,584**
	Instrument Control Unit	1	8,820	20%	1,764	10,584
Total XIPE Instrument Mass			68,953	20%	13,791	82,744

CBE=Current Best Estimated

A	B	C	D	E	F	G	H	I
Module	Unit Level	#	CBE+DMM Nominal	Init (Watt)	Safe (Watt)	Stand-by (Watt)	Science (Watt)	Calibration (Watt)
PLM			**79,200**	**0,000**	**10,800**	**79,200**	**79,200**	**85,680**
Focal Plane Assembly	Detector Unit	3	79,200	0,000	10,800	79,200	79,200	85,680
	Focal Plane Support Item	1	0,000	0,000	0,000	0,000	0,000	0,000
SVM			**22,044**	**0,000**	**0,010**	**22,133**	**22,133**	**22,224**
	Instrument Control Unit	1	22,044	0,000	0,010	22,133	22,133	22,224
Total XIPE Instrument Power			101,244	0,000	10,810	101,333	101,333	107,904

CBE=Current Best Estimated

DMM=Design Maturity Margin

XIPE is devoted to the **observation of celestial sources in X-rays**

- X-ray polarimetry is photon hungry, but scientifically needed
- A dedicated mission is required

XIPE uniqueness:

- Time-, spectrally-, spatially-resolved **X-ray polarimetry**
  as a breakthrough in high energy astrophysics and fundamental physics

- It will explore this observational window after 40 years from the last positive measurement, with a dramatic improvement in sensitivity: **from one to hundred sources**

In the violent X-ray sky, polarimetry is expected to have a **much greater** impact than in most other wavelengths.

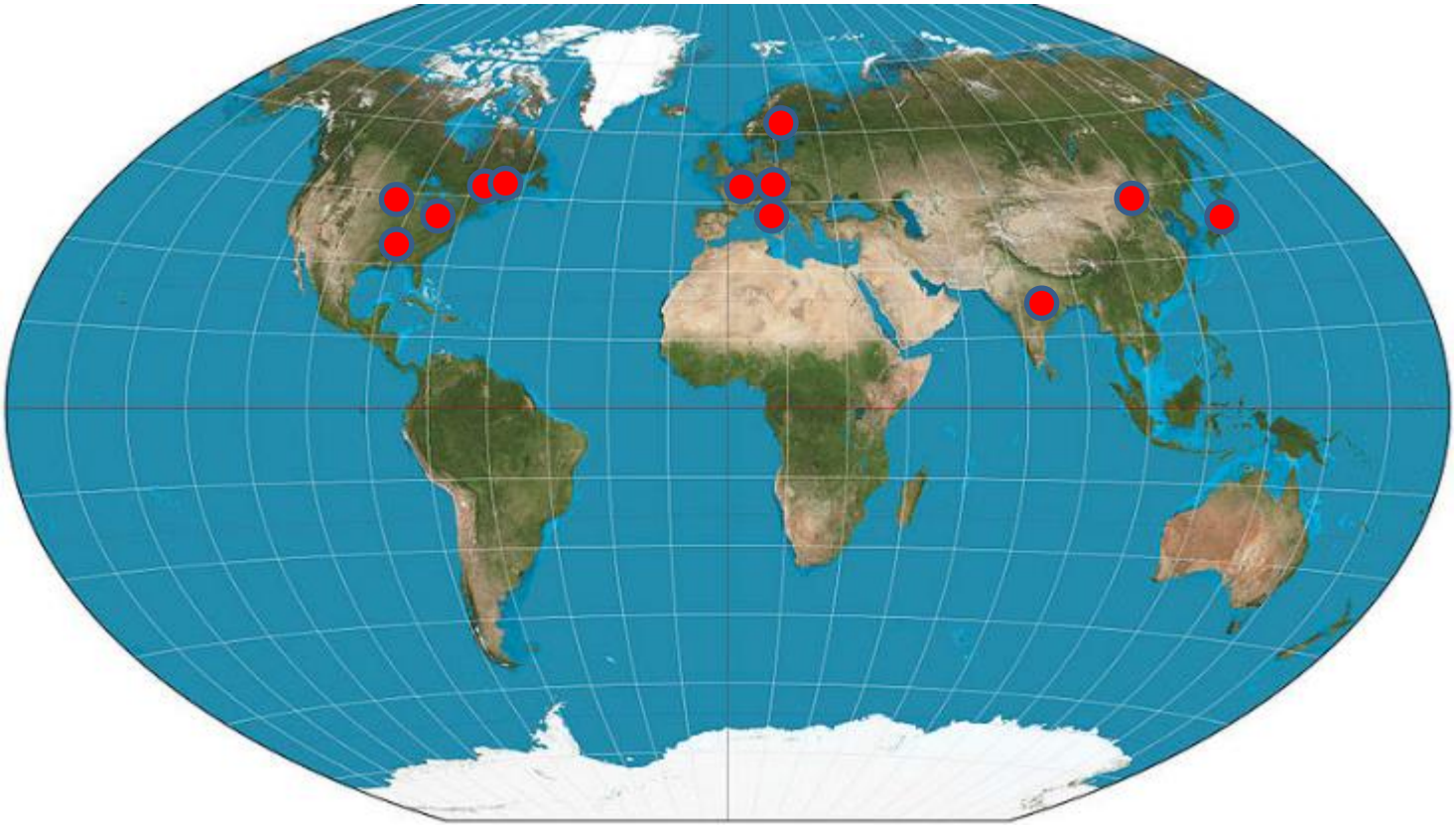
XIPE is going to exploit the complete information available in X-rays, by adding the two missing, and accessible, observables, that is, the degree and the angle of linear polarization (forgetting about circular polarisation…).

Whatn XIPE can do and IXPE cannot do

Parameter	Value
Number of mirror modules	3
Number of shells per mirror module	24
Focal length	4000 mm
Total shell length	600 mm
Range of shell diameters	162–272 mm
Range of shell thicknesses	0.16–0.26 mm
Shell material	Electroformed nickel–cobalt alloy
Effective area per mirror module	230 cm^2 (@ 2.3 keV); >240 cm^2 (3–6 keV)
Angular resolution (HPD)	≤ 25 arcsec
Field of view (detector limited)	12.9 arcmin square

Parameter	Value
Sensitive area	15 mm × 15 mm
Fill gas and composition	He/DME (20/80) @ 1 atm
Detector window	50-µm thick beryllium
Absorption and drift region depth	10 mm
GEM (gas electron multiplier)	copper-plated 50-µm liquid-crystal polymer
GEM hole pitch	50 µm triangular lattice
Number ASIC readout pixels	300 × 352
ASIC pixelated anode	Hexagonal @ 50-µm pitch
Spatial resolution (FWHM)	≤ 123 µm (6.4 arcsec) @ 2 keV
Energy resolution (FWHM)	0.54 keV @ 2 keV ($\propto \sqrt{E}$)

Today's X-ray polarimetry in the world.



Photoelectric : GPD (Italy, China) ; TPC (USA, China).
Scattering : (France, Italy, Sweden, Switzerland, India, USA, Japan)
Bragg diffraction : (China, USA)

Principal Investigator: M. Weisskopf (MSFC)

Deputy Principal Investigator and Instrument Payload Scientist B. Ramsey

Italian Principal Investigator (IPI): P. Soffitta

Italian Co-PI and Senior Co-Investigator R. Bellazzini

Project Scientist S. O'Dell (MSFC)

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