The enhanced X-ray Timing and Polarimetry Mission

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on behalf of Marco Feroci and the eXTP team

Porquerolles 2017

The eXTP International Consortium

Principal Investigator:
Shuang-Nan Zhang
IHEP/CAS

CAS — 中国科学院 CHINESE ACADEMY OF SCIENCES

CNSA

IHEP Beijing — Institute of High Energy Physics, Chinese Academy of Sciences

Tsinghua University — 清華大學 Tsinghua University

Tongji University — 同濟大學 TONGJI UNIVERSITY

CAST — 中国空间技术研究院 China Academy of Space Technology / 中国航天

Italy: INAF, INFN

Germany: Eberhard Karls Universität Tübingen, MPE, FAU Friedrich-Alexander Universität Erlangen-Nürnberg

France: cea

Spain: CSIC, IEEC Institut d'Estudis Espacials de Catalunya

Switzerland: Université de Genève, ISDC

Denmark: DTU

Poland: CBK PAN, CAMK PAN

Czech Republic: asu Astronomical Institute of the Czech Academy of Sciences

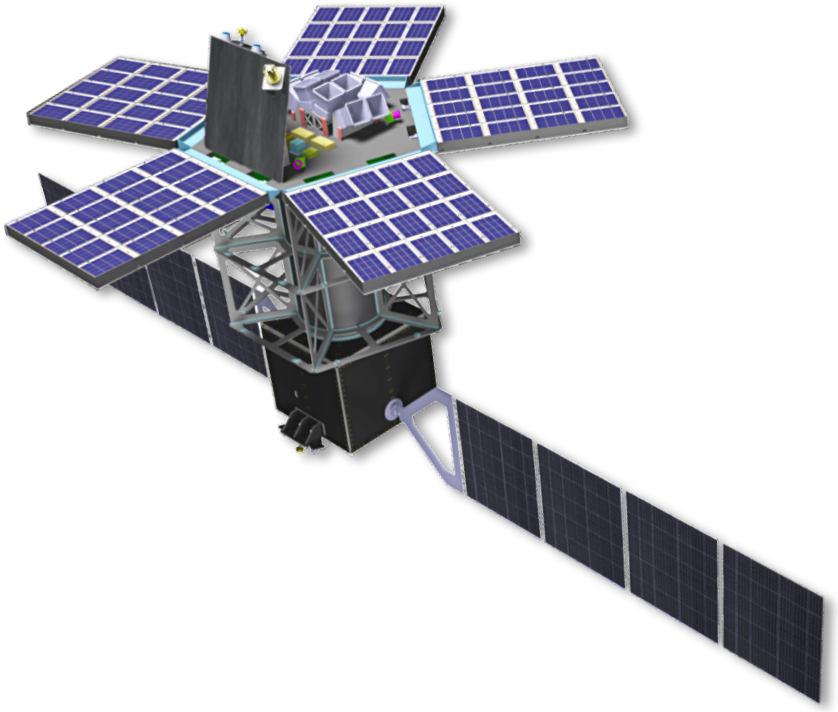
United Kingdom: UCL MSSL, University of Leicester

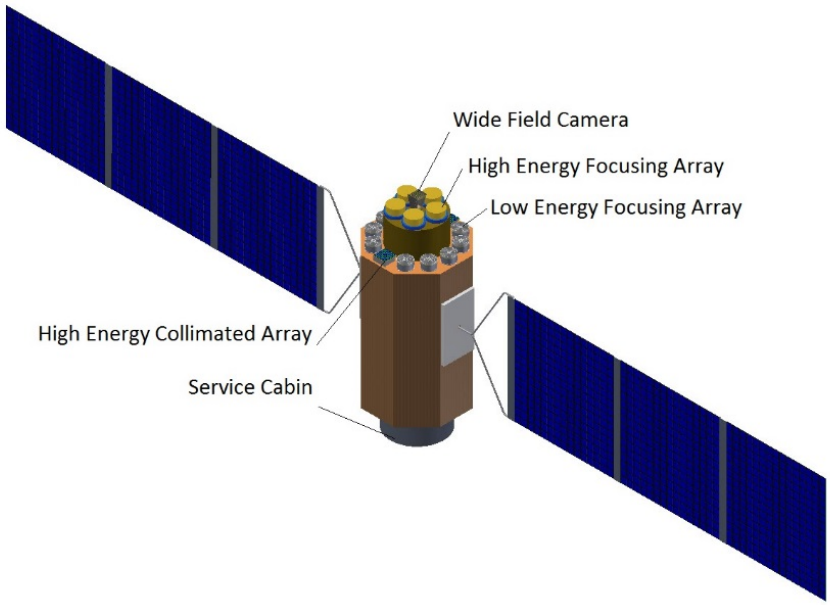
The Netherlands: University of Amsterdam, SRON

LOFT+XTP ⇨ eXTP

- Mission proposed to ESA to study matter under extreme conditions (NS EoS, SFG)
- Selected in 2011 by ESA as one of the 4 M3 candidate missions in Cosmic Vision
- Phase A study by ESA and LOFT Consortium in 2011-2014

- Mission proposed to CAS to study matter under extreme conditions (NS EoS, SFG, Strong Magnetism)
- Selected in 2011 as one of 8 «Background missions»
- Phase A study by IHEP in 2011-2014



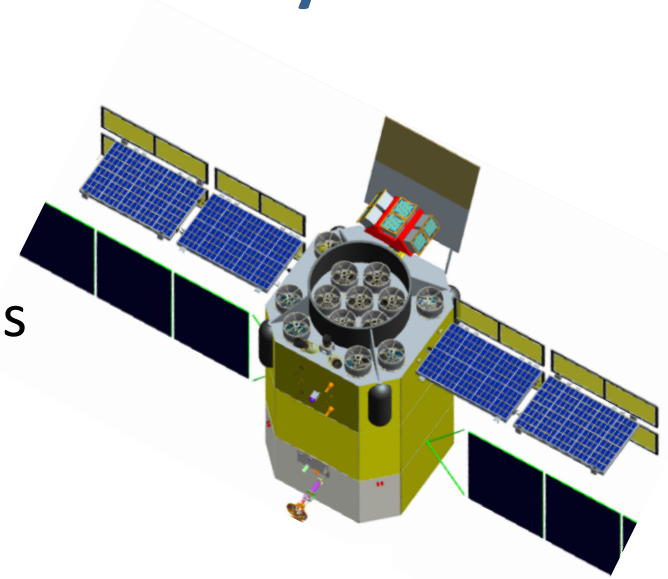


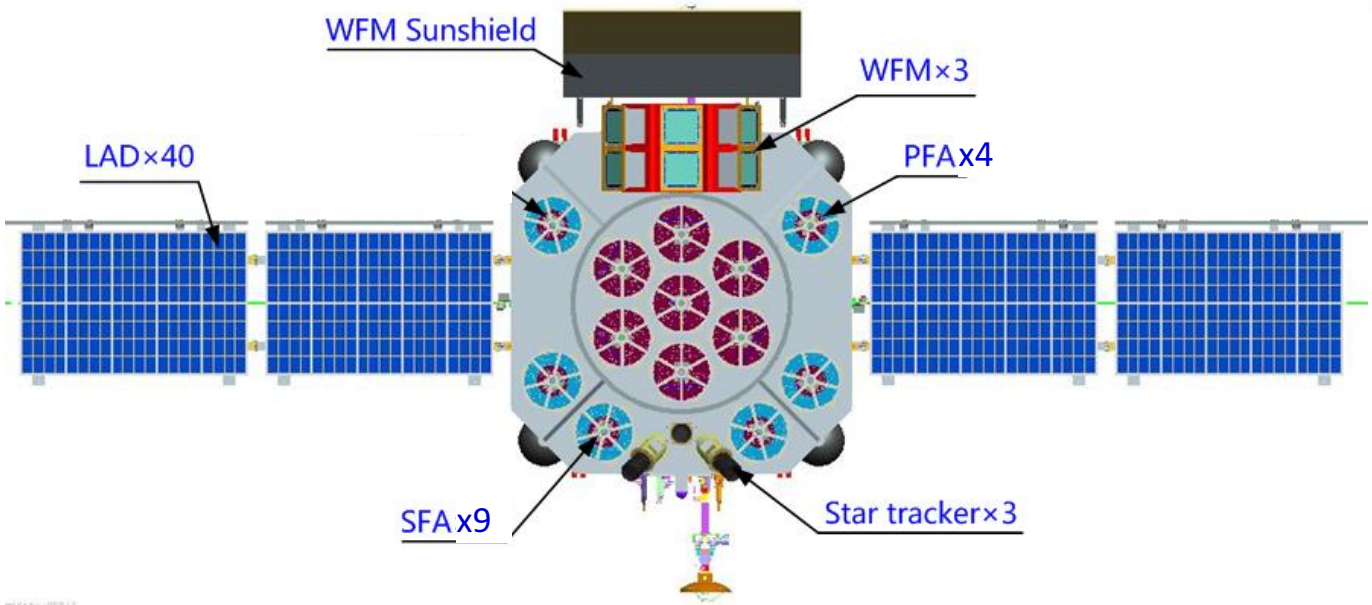
eXTP

enhanced X-ray Timing and Polarimetry

Payload concept

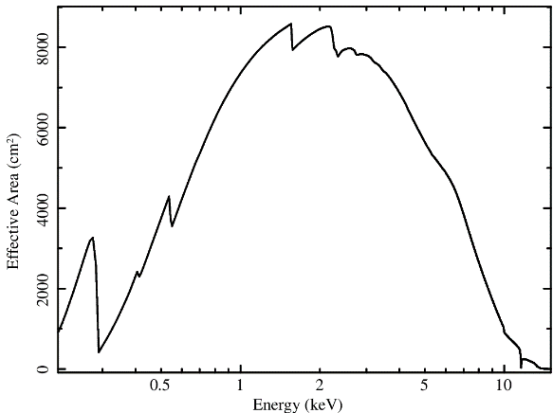
- Short focal-length for multiple modules
- Deployable panel for collimated modules
- Polarimeter with imaging capability
- Wide field monitor

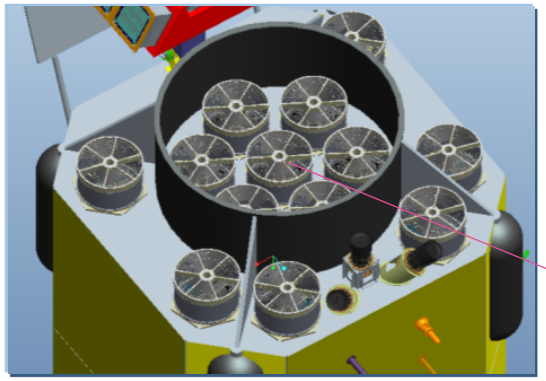


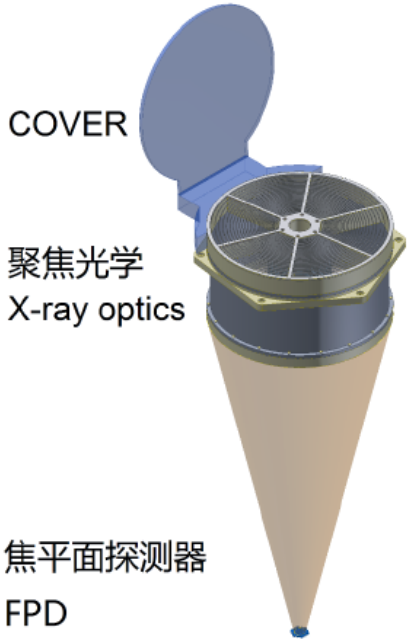


eXTP Scientific Payload

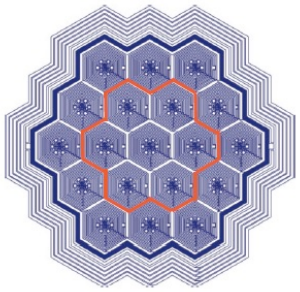
SFA – Spectroscopy Focusing Array





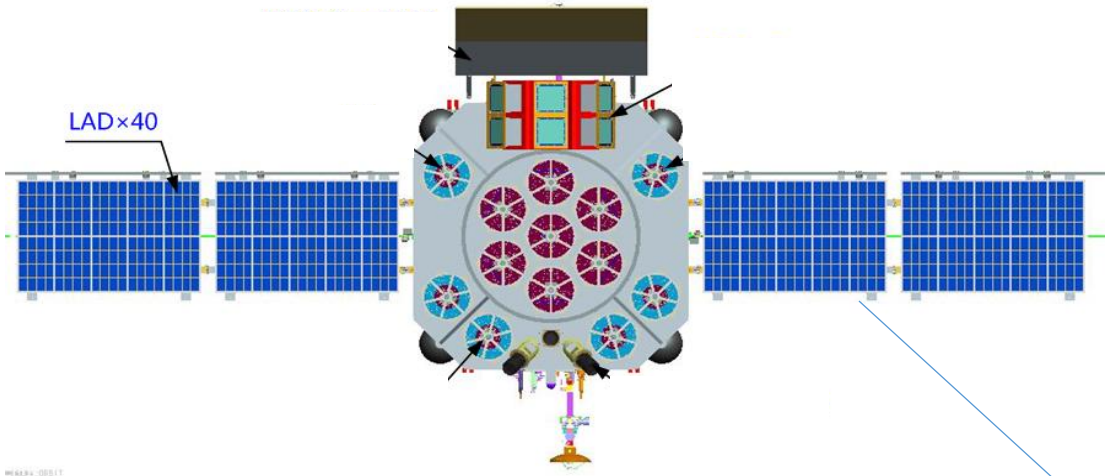


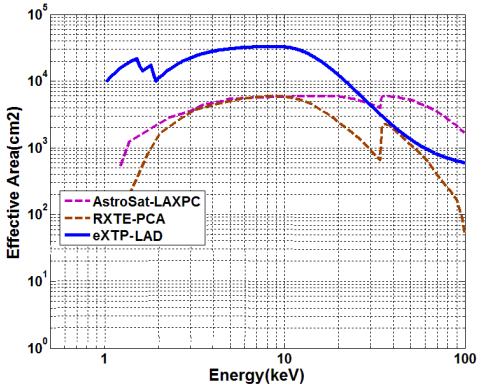
- Large collecting area achieved by multiple optics with short focal length. Baseline: 9 optics with 5.25m FL
- Non-imaging, PSF requirement 1 arcmin HPD, 12’ FoV
- Multi-pixel SDD detector (to enable background subtraction). Single photon, <100μs
- Energy band: 0.5-10 keV
- Energy resolution: <180 eV FWHM @6 keV
- Total effective area: >0.7 m^2 @1 keV, 0.5 m^2 @6 keV

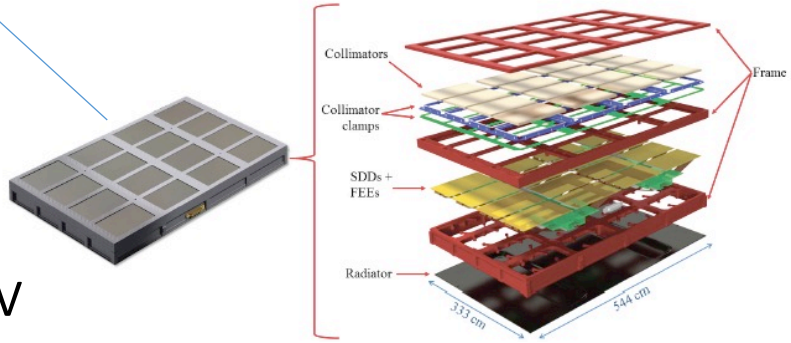


eXTP Scientific Payload

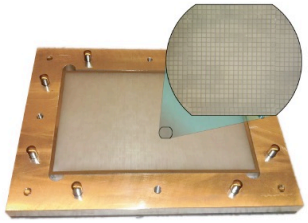
LAD – Large Area Detector

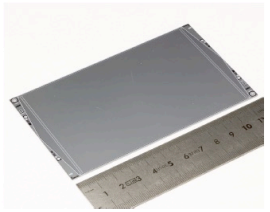






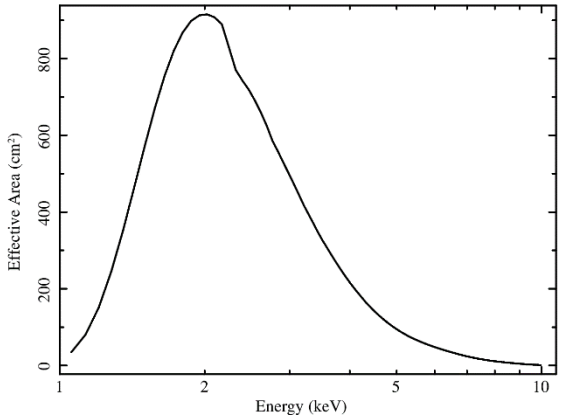
- Total effective area: 3.4 m^2 @8 keV
- Energy band: 2-30 keV
- Energy resolution: <240 eV FWHM @6 keV
- Based on the LOFT/LAD design
- 40 Modules on 2 deployable panels
- Collimated, large-area SDD detector. Single photon, <10μs

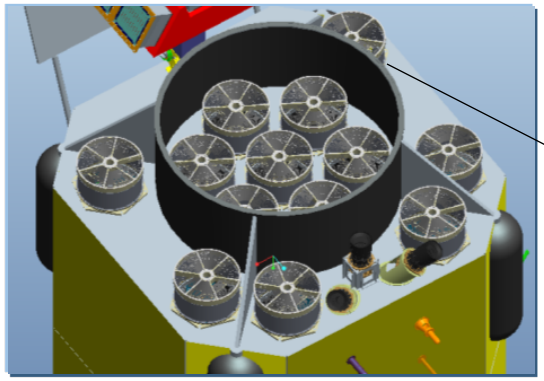


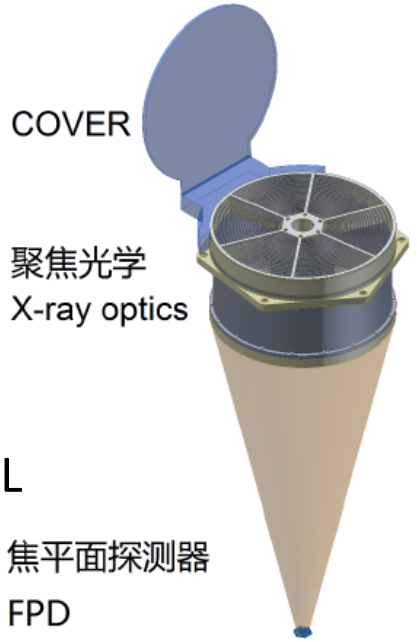


eXTP Scientific Payload

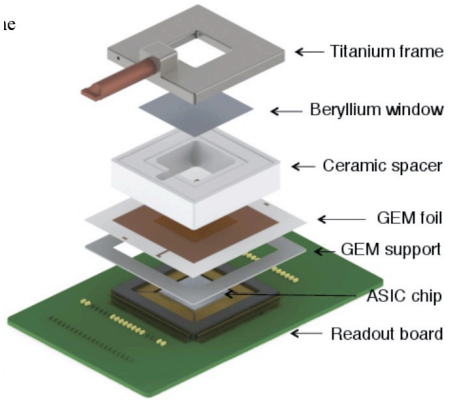
PFA – Polarimetry Focusing Array





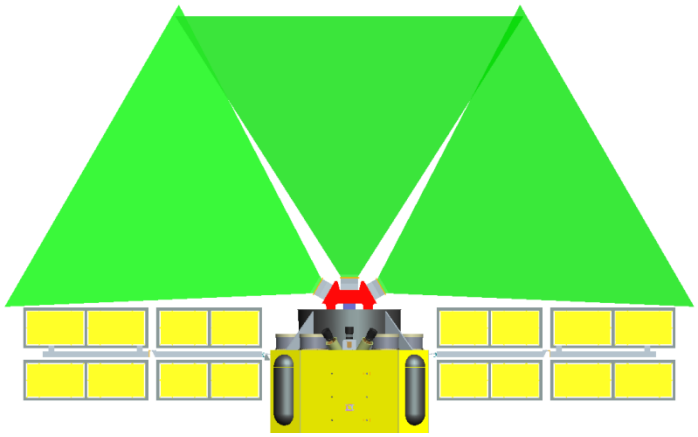


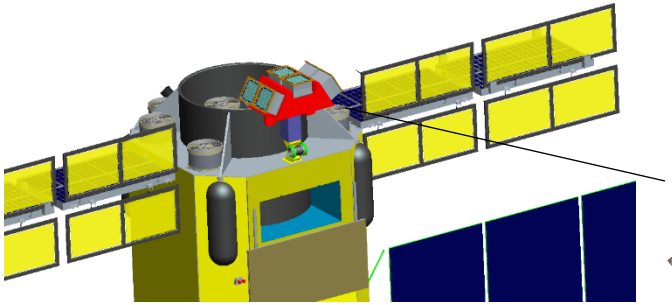
- Focal plane imaging polarimeter: 4 optics with 5.25m FL
- Imaging, PSF 20 arcsec HPD
- Gas Pixel Detector: single photon, <100μs
- Energy band: 2-10 keV
- Energy resolution: 20% FWHM @6 keV
- Total effective area: 900 cm^2 @2 keV (includes QE)

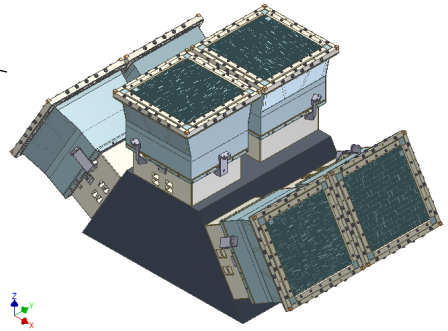


eXTP Scientific Payload

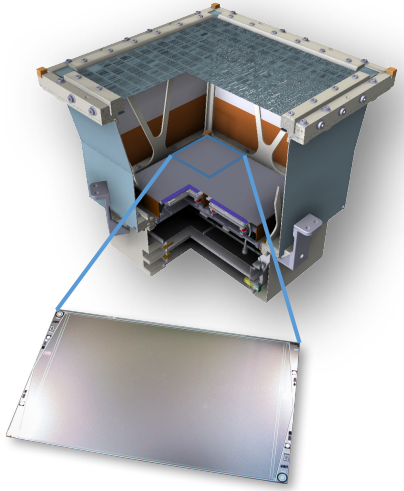
WFM – Wide Field Monitor







- Field of View: 4 steradian (at 20% response)
- Imaging, <5 arcmin angular resolution, 1 arcmin PSLA
- Energy band: 2-50 keV
- Energy resolution: 300 eV FWHM @6 keV
- Effective area: 80 cm^2 @6 keV (1 unit, on axis)
- Same design as LOFT/WFM, 3 units (6 cameras)
- Same detectors as LAD (SDD). Single photon, <10μs



eXTP Mission Profile

Parameter	Value
Orbit	550 km, <2.5° inclination
Launcher	Long-March CZ-7
Mass	3700 kg
Power	3.6 kW
Telemetry	3 Tb/day
Ground Stations	China, Malindi
Pointing	3-axis stabilized, < 0.01°
Sky visibility	50% (goal 75%)
Mission Duration	5 years (goal 10 years)
Launch date	2025

Soft Response

Large area

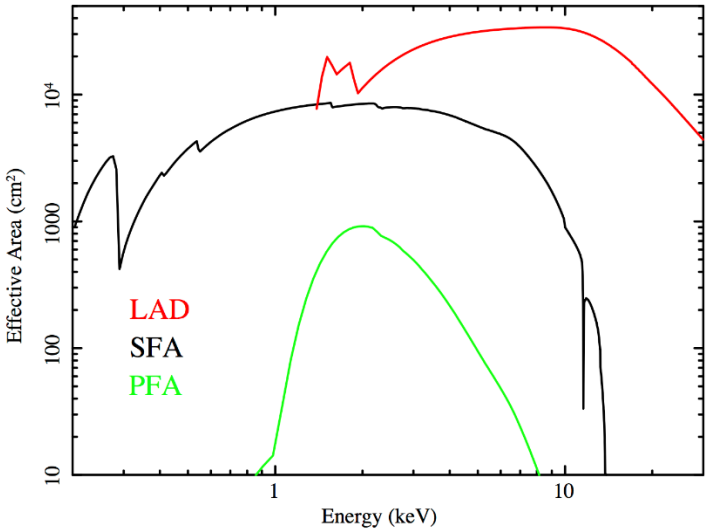
Polarization

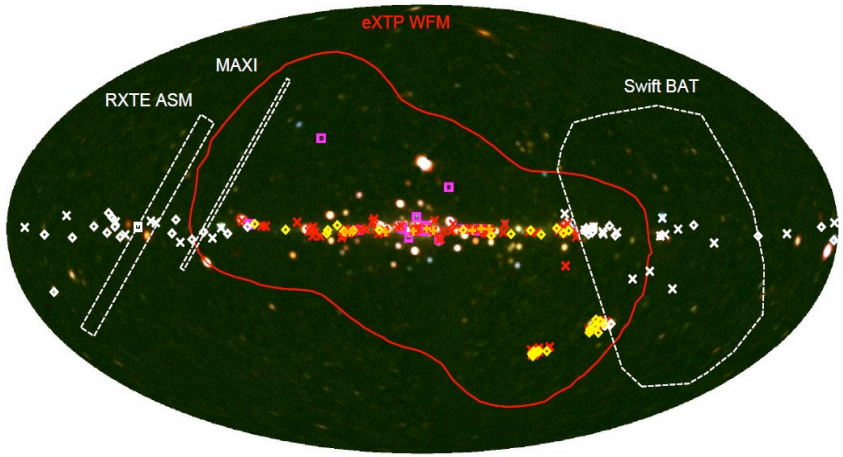
Monitoring

Payload	Parameter	Specification
SFA	Energy range	0.5-10 keV
	Effective area	>7000 cm^2 @1 keV, >5000 cm^2 @6 keV
	Energy resolution	<180 eV FWHM @6 keV
	FoV/HPSD	12 arcmin / 1 arcmin
	Focal plane detector	Pixelated SDD (19 pixels)
LAD	Energy range	2-30 keV (extended: 30-80 keV for out-FoV)
	Effective area	34000 cm^2
	Energy resolution	<240 eV FWHM @6 keV
	FoV	1° (FWHM)
	Detector	Large area SDD (640 units, 40 Modules)
PFA	Energy range	2-10 keV
	Effective area	>900 cm^2 @2 keV (including QE)
	Energy resolution	1.2 keV FWHM @6 keV
	FoV/HPD	12 arcmin / 20 arcsec
	Focal plane detector	GPD (4 units)
WFM	Energy range	2-50 keV
	Energy resolution	300 eV FWHM @6keV
	FoV	>4 sr (at 20% of peak response)
	Angular resolution	<5 arcmin
	Localization accuracy	<1 arcmin
	Detector	Large area SDD

eXTP Scientific Payload

Performance in context

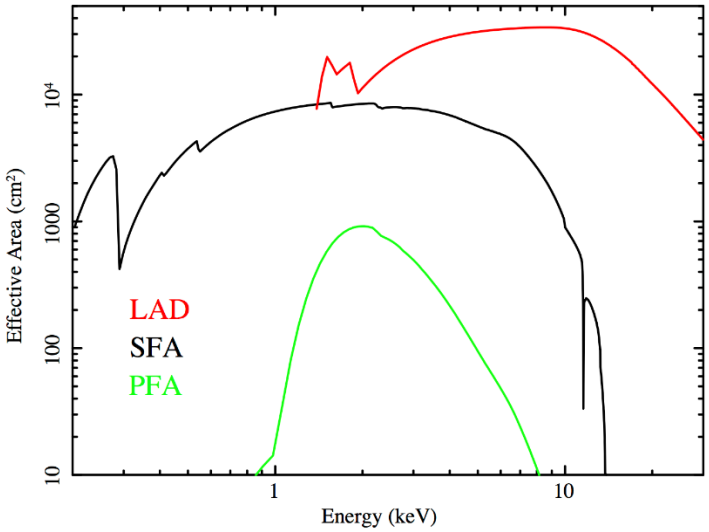


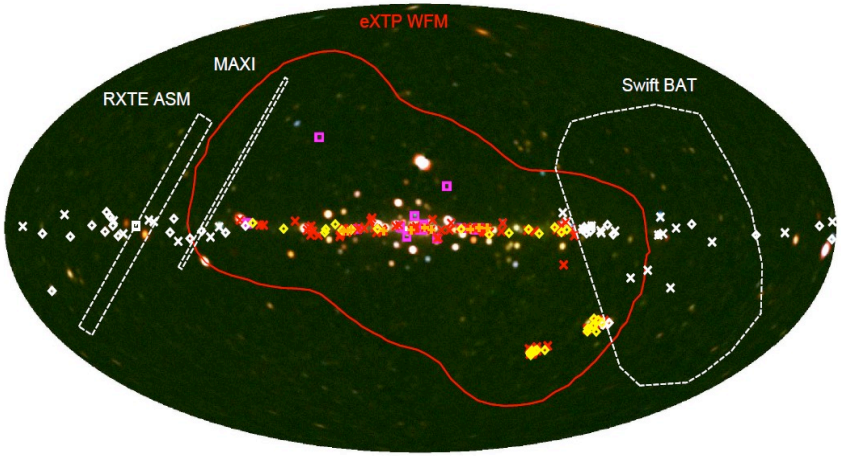


- **LAD**: 6x RXTE/PCA, 35x XMM-Newton (*but collimated*!) + hard-X response
- **SFA**: 8x XMM-Newton and 0.3-2x Athena/WFI (*but multiple optics and large PSF*!). Limiting sensitivity ~10^{-14}-10^{-15} erg cm^{-2} s^{-1}
- **PFA**: 5x IXPE, 2x XIPE. Sensitivity: 1% MDP in 50ks for a 100 mCrab source
- **WFM**: largest FoV ever, first time with 300 eV resolution. 3 mCrab in 50ks

eXTP Scientific Payload

Performance in context





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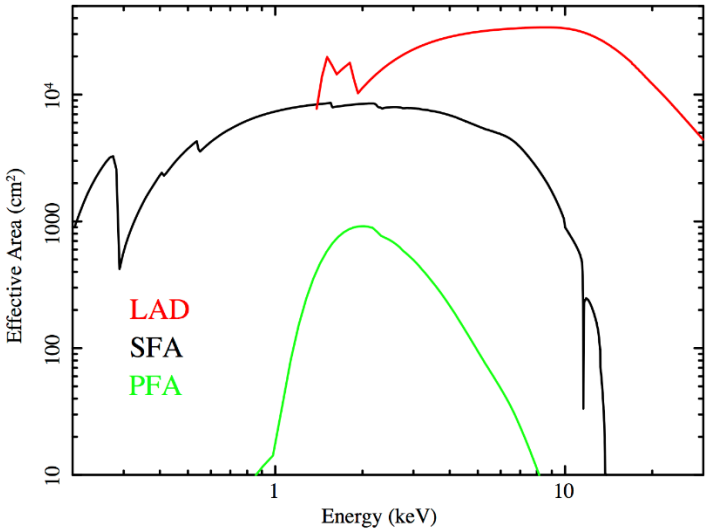

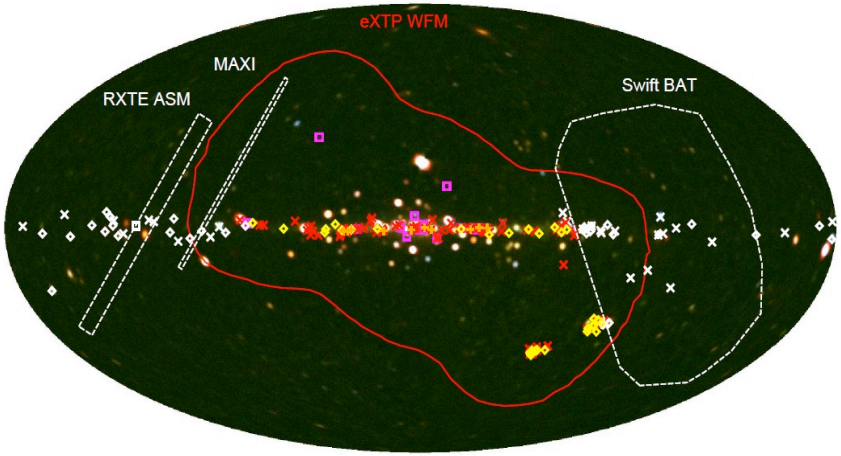

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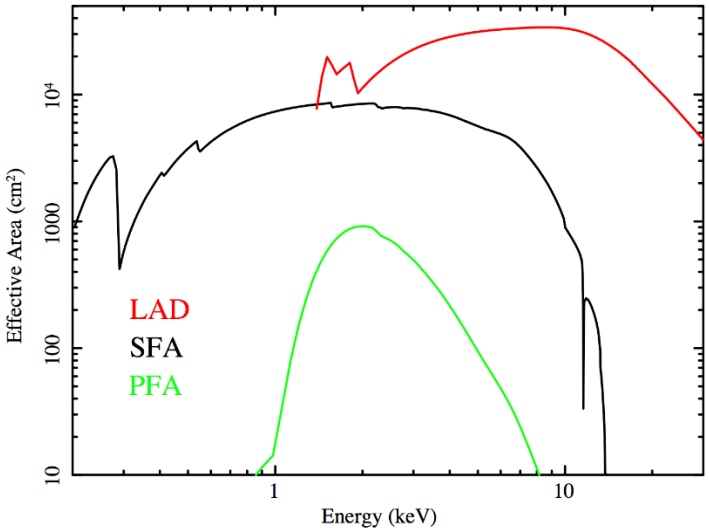
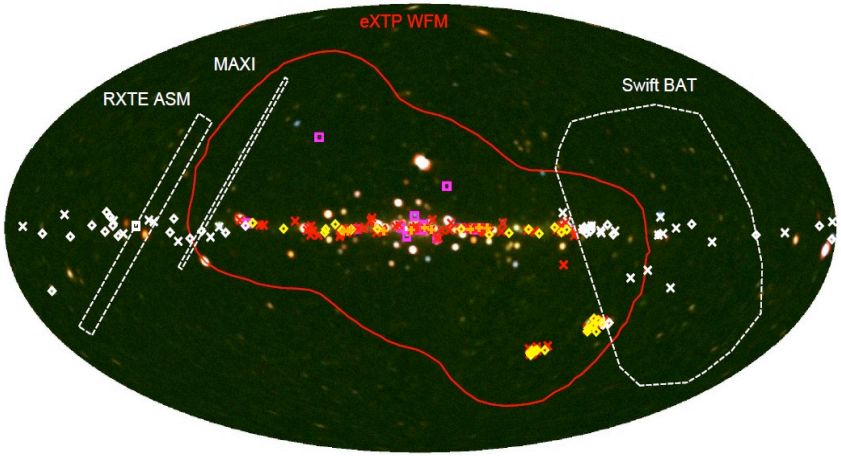
eXTP Scientific Payload

Performance in context





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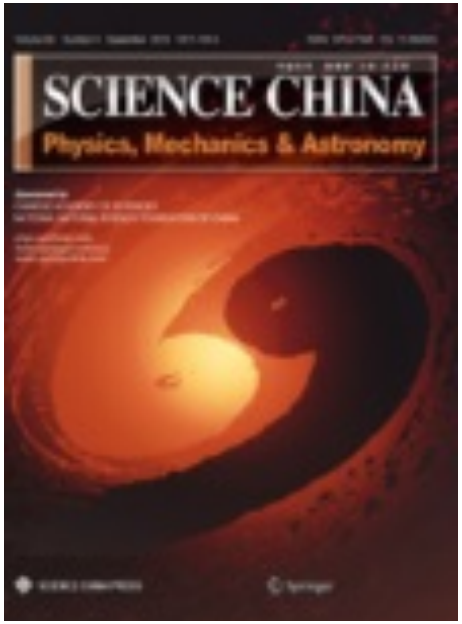
eXTP Science Working Groups

- In support to the mission study, four international working groups were preliminarily formed on the main science topics, preparing 4 White Papers (currently advanced drafts):
  - Accretion in Strong Field Gravity
  - Dense Matter
  - Strong Magnetism
  - Observatory Science
- In the framework of the ongoing joint China-Europe study, the preliminary working groups were further opened and expanded to interested scientists. Currently, a total of >260 scientists are contributing. More info at: http://www.isdc.unige.ch/extp/
- The 4 eXTP WPs are expected to be published on a special issue of the Science China journal by the end of 2017.



eXTP Science

Dense matter

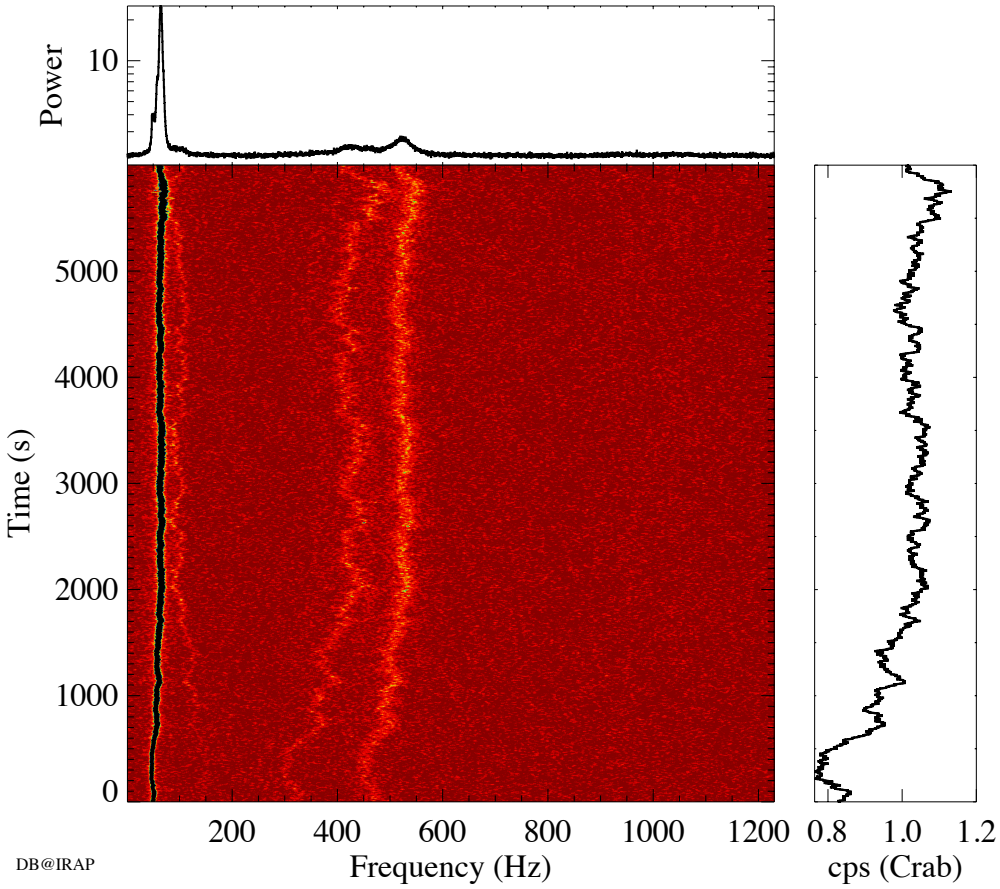
Accretion in strong field gravity

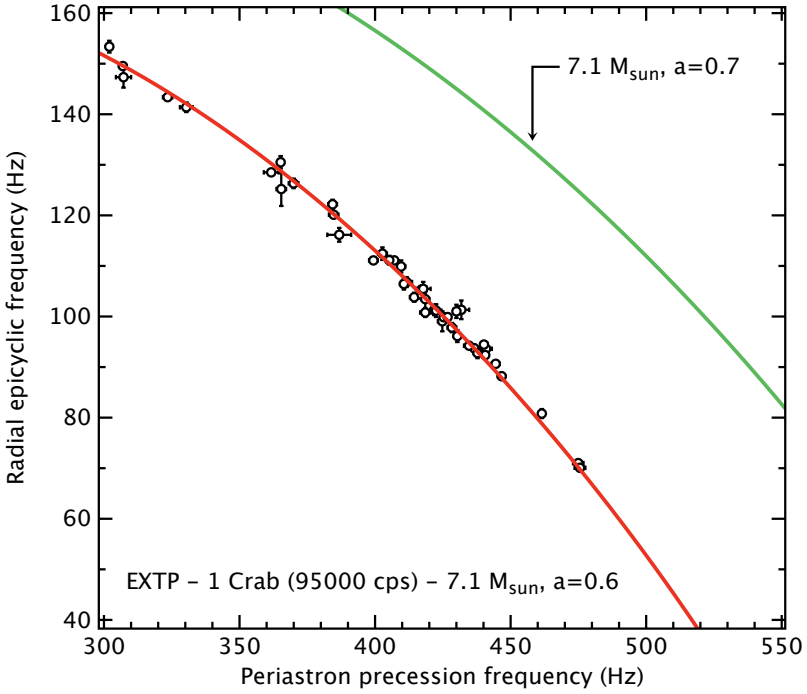
Strong magnetism

Observatory science

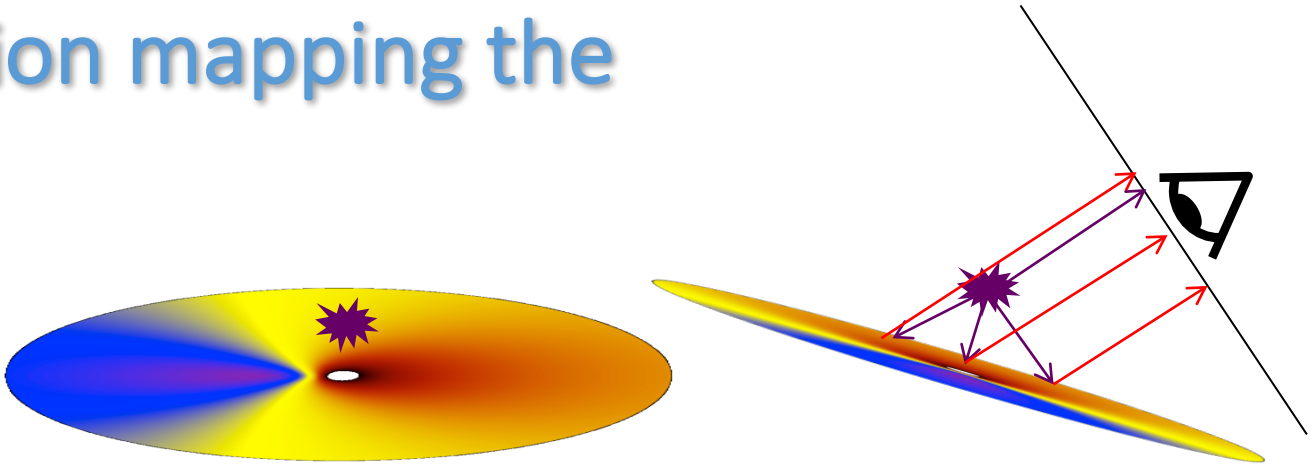
HFQPOs: probing general relativistic dynamical frequencies

(Simulations by D. Barret)

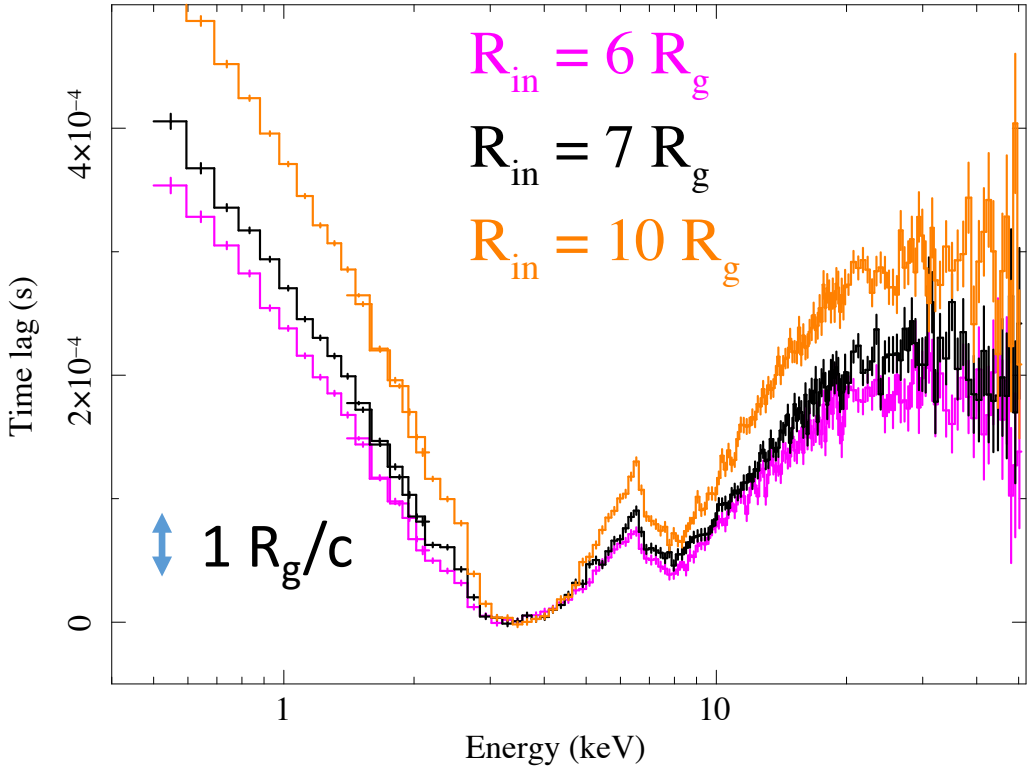




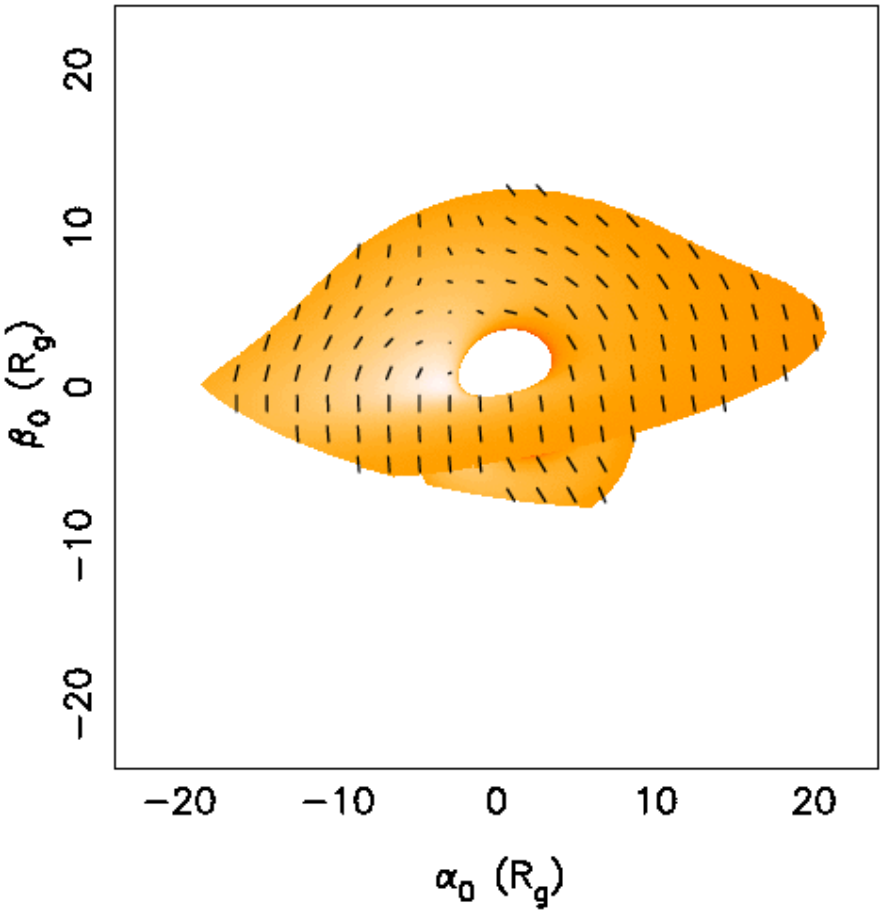
Reverberation mapping the inner disk

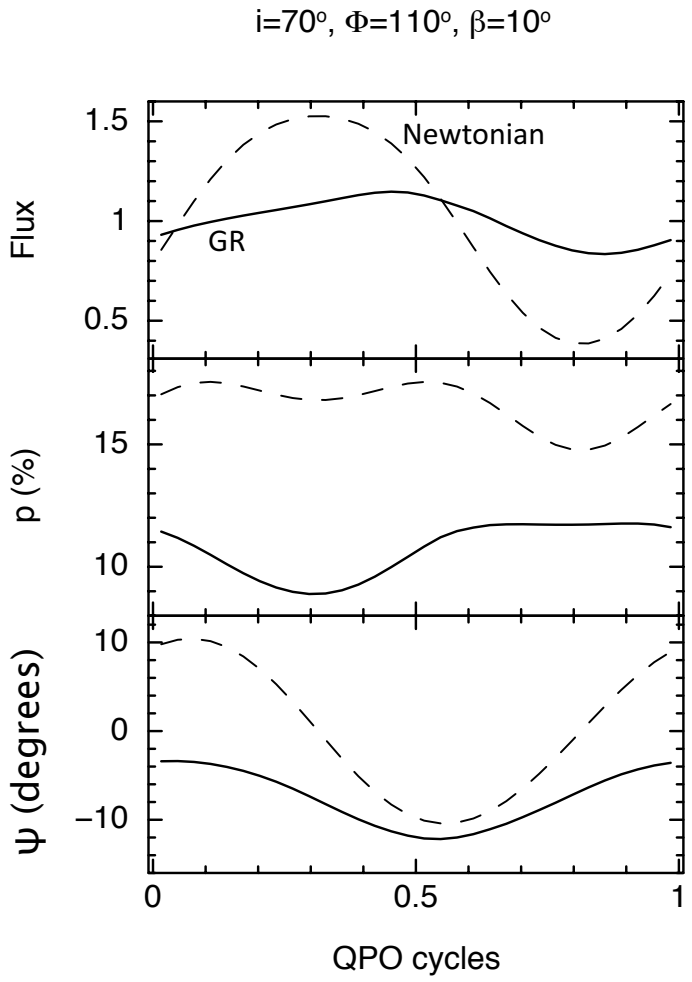


100 ks on bright hard (1 Crab) state/hard-intermediate state, lag vs energy measured in 50-150 Hz range, combination of measurements from SFA+LAD.



Simultaneous polarization variability in LFQPOs





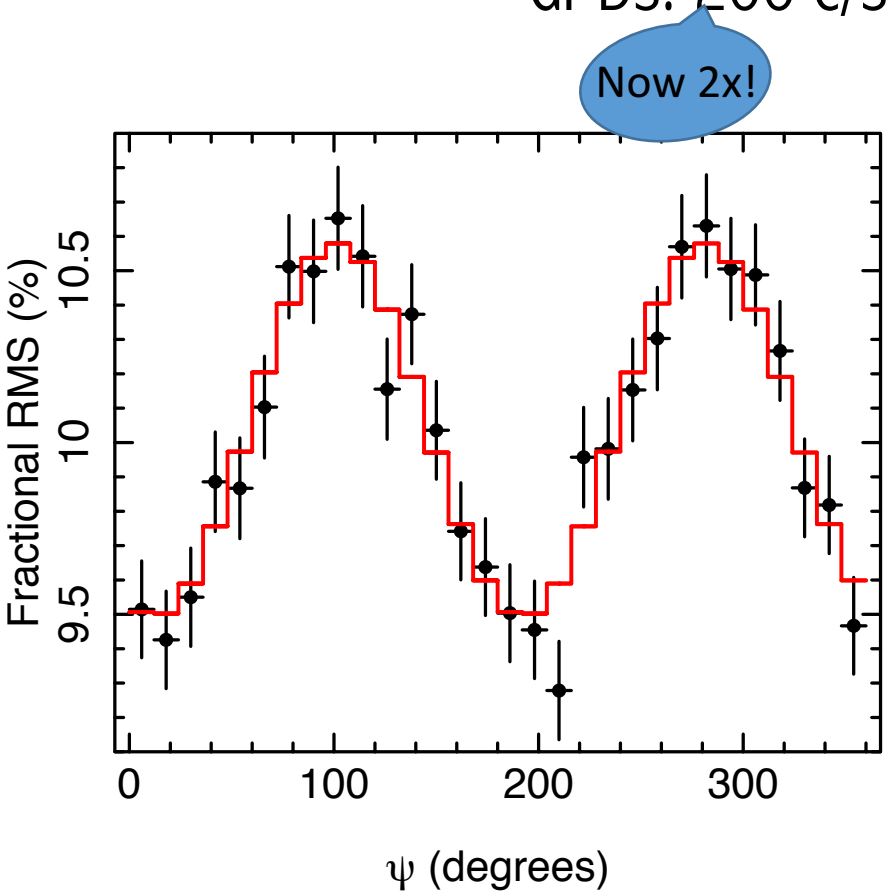
www.youtube.com/watch?v=ieZYYfCapJg&feature=youtu.be

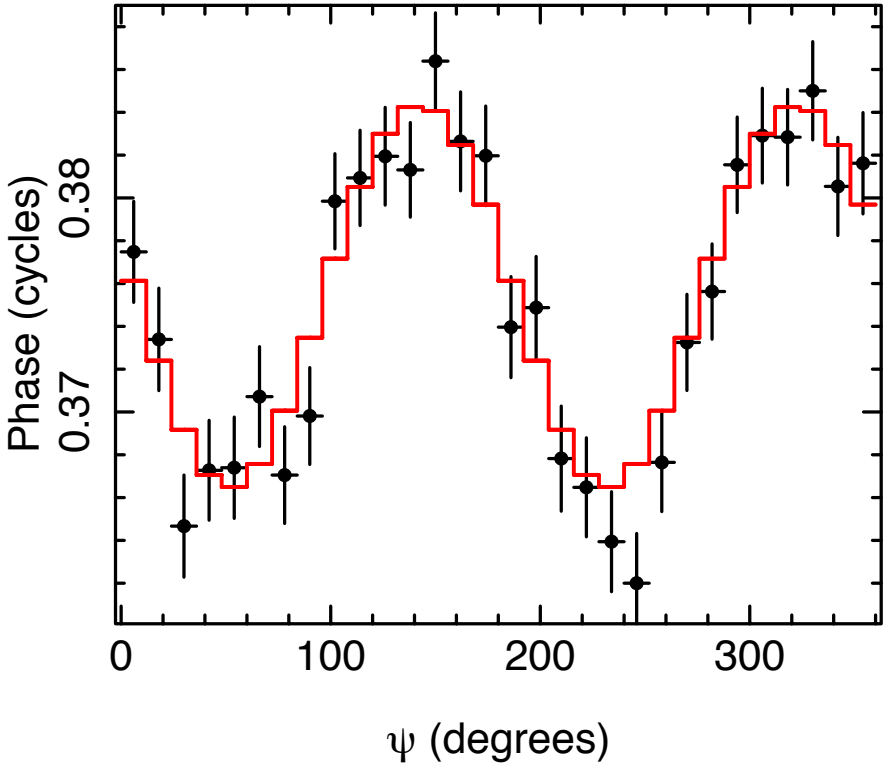
Ingram et al (2015)

Simulated eXTP detection

100 ks exposure of GX 339-4 with eXTP

GPDs: 200 c/s; LAD 38,000 c/s





Courtesy: Adam Ingram

eXTP Programmatics

Mission currently entering an **extended Phase A** study in China, in collaboration with a consortium of European institutes. Formal European participation currently under discussion. Strong interest and support available in several member states institutions and agencies.

Baseline implementation schedule:

- 2011-2016: background study (Phase 0/A1)
- 2017-2018: international coordination and preliminary design (Phase A2)
- 2019-2020: Detailed design (Phase B)
- 2021-2023: Space qualification model (Phase C)
- 2024-2025: flight model (Phase D)
- **2025: launch**

- 2025-2035: science operation

Conclusions

eXTP is conceived as the most powerful and general observatory for compact Galactic and bright extragalactic objects ever.

eXTP will change the game. It will offer for the first time the most complete diagnostics of compact sources: excellent spectral, timing and polarimetry sensitivity on a single payload.

eXTP is proposed as a cooperative effort between (at least) **China and Europe**. The support and contribution of the wide scientific community is crucial to achieve this goal.