深度探索极端宇宙
Deep Exploration of the Extreme Universe

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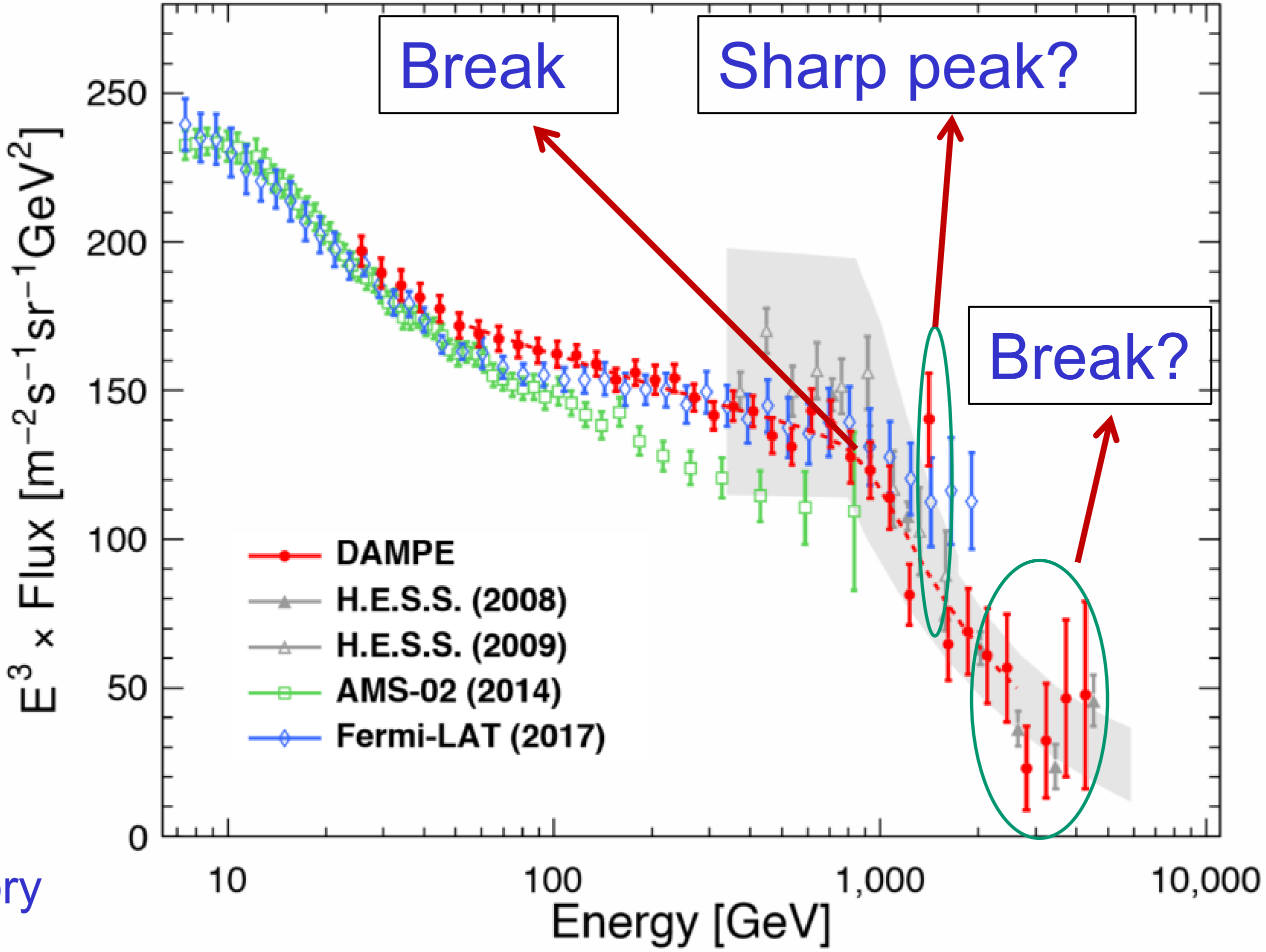
22nd Lomonosov Conference on Elementary Particle Physics, MSU, Moscow, Russia, 21-27 August, 2025

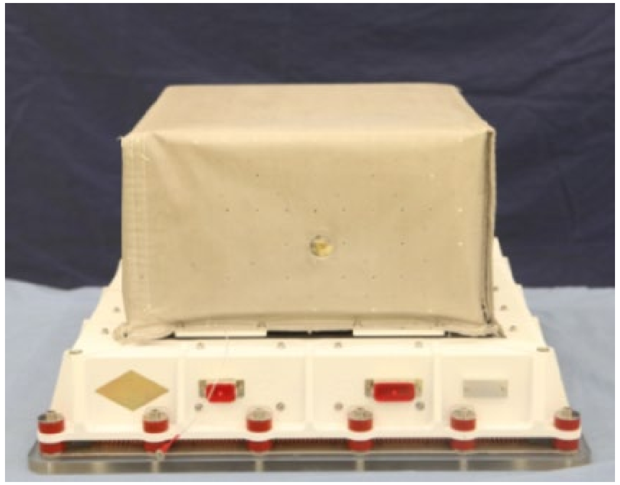
“Wukong” launch: milestone in China's exploration of the extreme universe!

PI: Chang Jin from Purple Mountain Observatory

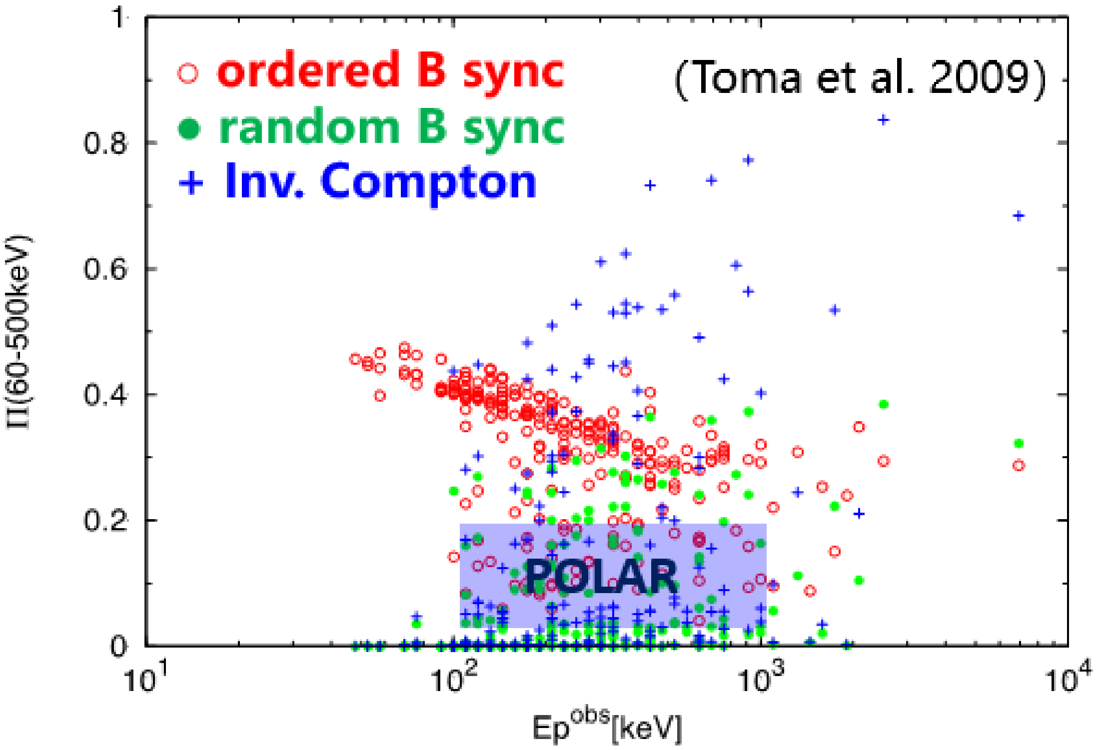


The Dark Matter Particle Explorer was launched on December 17, 2015, obtaining the most precise cosmic high-energy electron spectrum and discovering signals that may indicate dark matter annihilation!

China has begun exploring the extreme universe: POLAR



PI: Zhang Shuang-Nan from the Institute of High Energy Physics



The GRB Polarimeter POLAR was launched with Tiangong-2 on September 15, 2016, achieving the most precise and largest sample of GRB polarization measurements, challenging the mainstream relativistic jet model of GRBs.

China has begun exploring the extreme universe: Insight-HXMT

sciencemag.org

China successfully launches x-ray satellite | Science

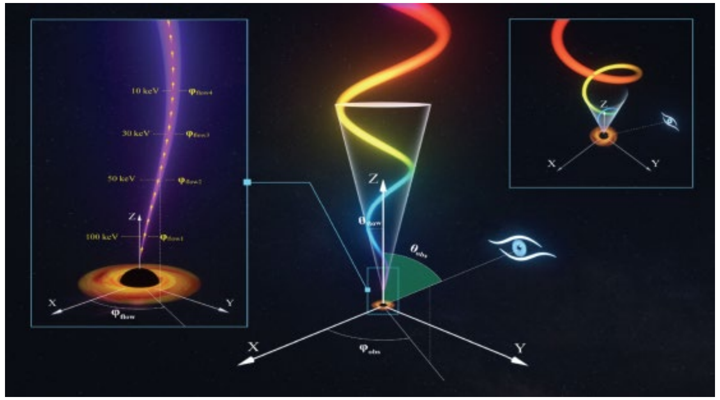
By Dennis NormileJun. 15, 2017 , 11:00 AM

4-5 分钟

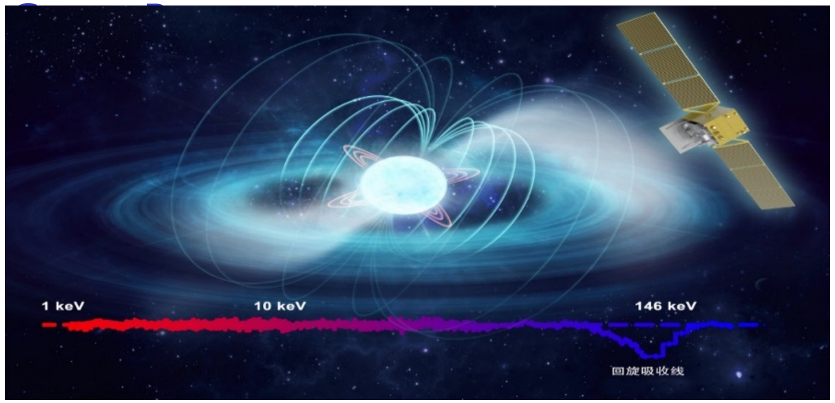
A rocket carrying China's new x-ray telescope blasts off.

Launched on 2017.6.15

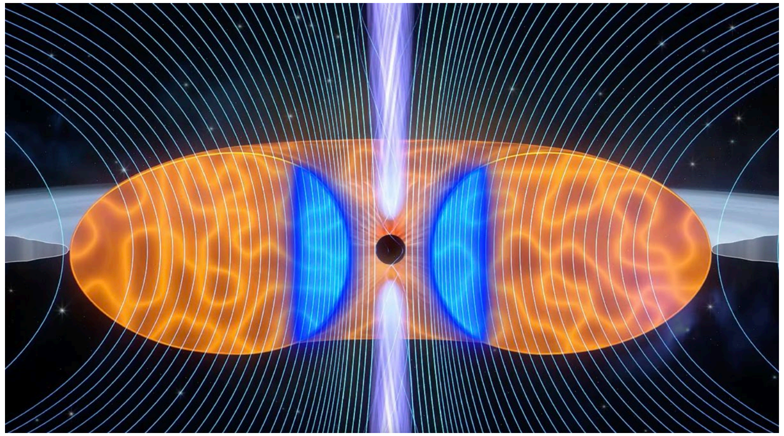
Highest energy (>200 keV) QPO around a BH, closed X-ray jet from a BH



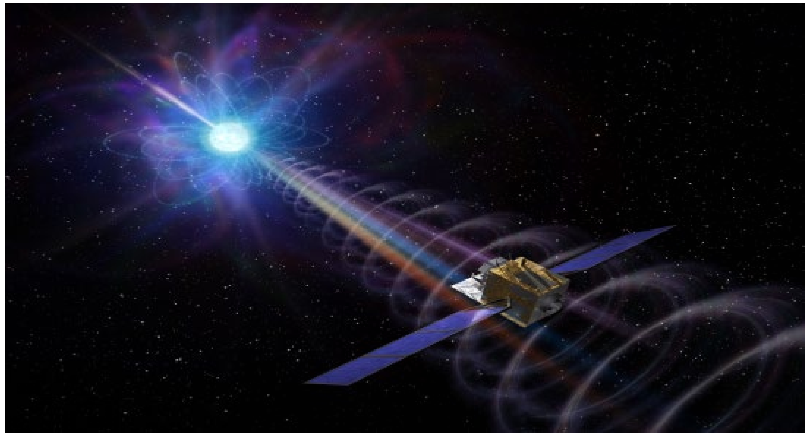
Highest energy (~150 keV) cyclotron absorption line of a neutron star: 10^{13}



First direct evidence of magnetically arrested accretion disk



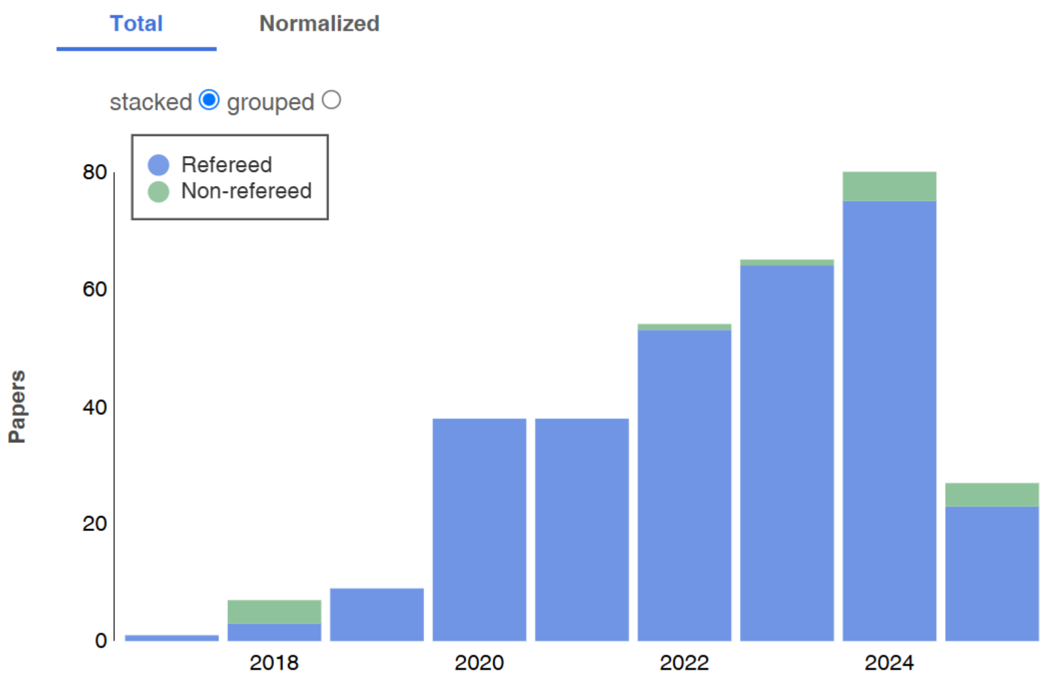
Identification of first X-ray counterpart (magnetar) of a Fast Radio Burst

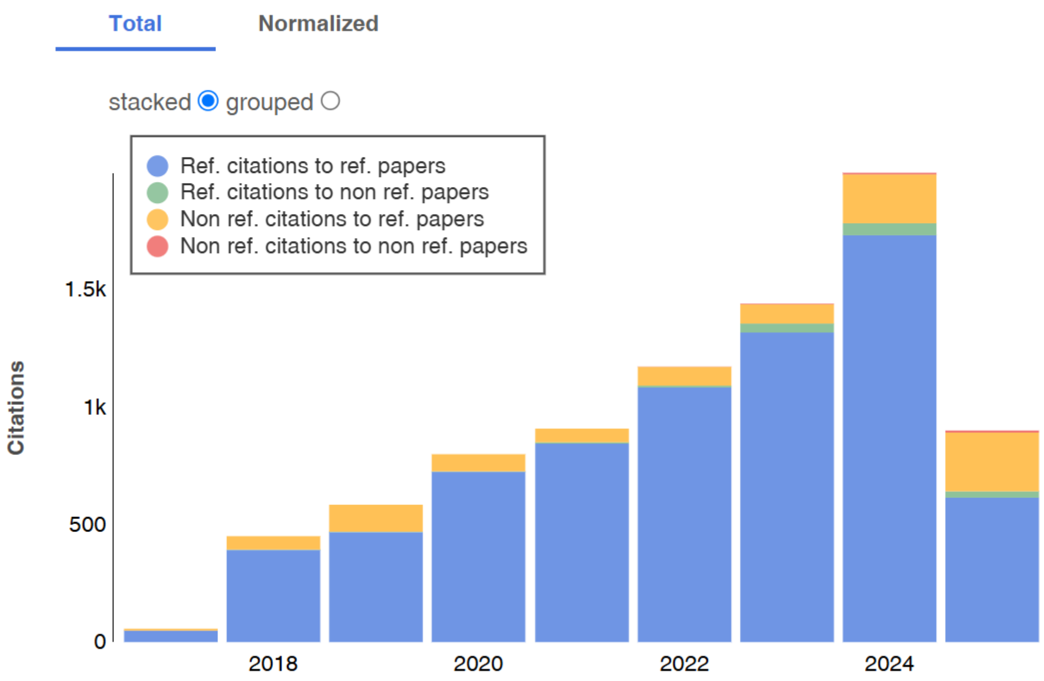


PI: Li Tipei from Institute of High Energy Physics → Zhang Shuang-Nan

Papers based on Insight-HXMT are steadily increasing.

Up to April 2025





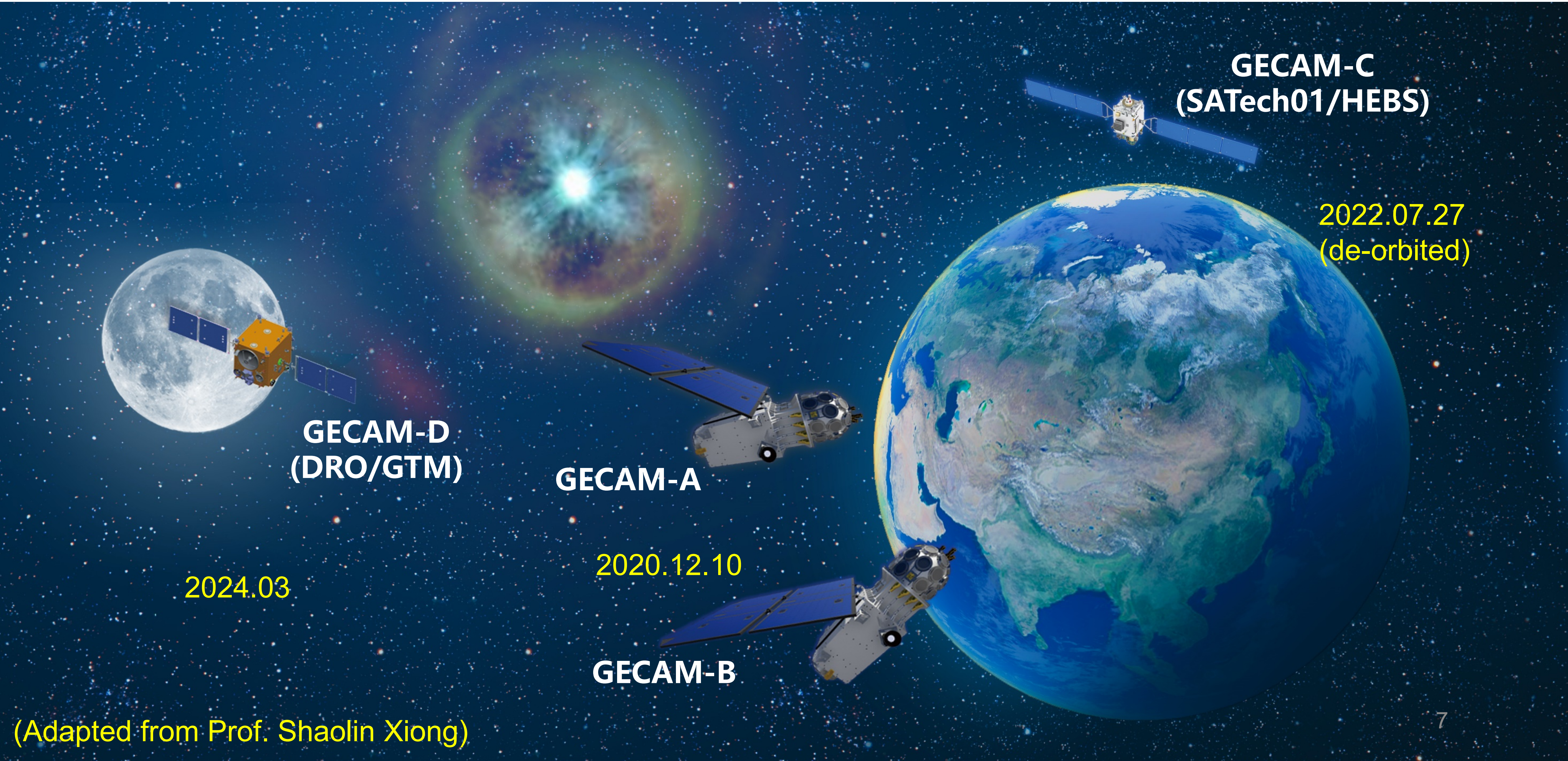
All instruments on the Insight-HXMT satellite are operating well, and it is expected to remain in orbit for at least another three years. Data and analysis software from the Insight-HXMT satellite are open to the public. Welcome to download and use them at hxmt.cn.

GECAM: A Project Serving Multi-Messenger Astronomy

- **Sciences**
  - GW GRB (GW EM from keV to MeV)
  - Fast Radio Bursts (FRB), High Energy Neutrinos (HEN), GRB, Magnetar
- **Performance**
  - 100% all-sky FOV, high sensitivity, wide energy band, good localization (~1 deg)
- **Innovations**
  - Two small satellites, ALL-TIME ALL-SKY
  - BeiDou navigation system, real-time data
- **Mission of Opportunity**
  - Proposed in 2016, approved in 2018
  - **First launched on 2020.12.10, currently there are 4 GECAM series small satellites in orbit, which have already achieved many results**

PI: Shaolin Xiong from the Institute of High Energy Physics

GECAM Constellation



(Adapted from Prof. Shaolin Xiong)

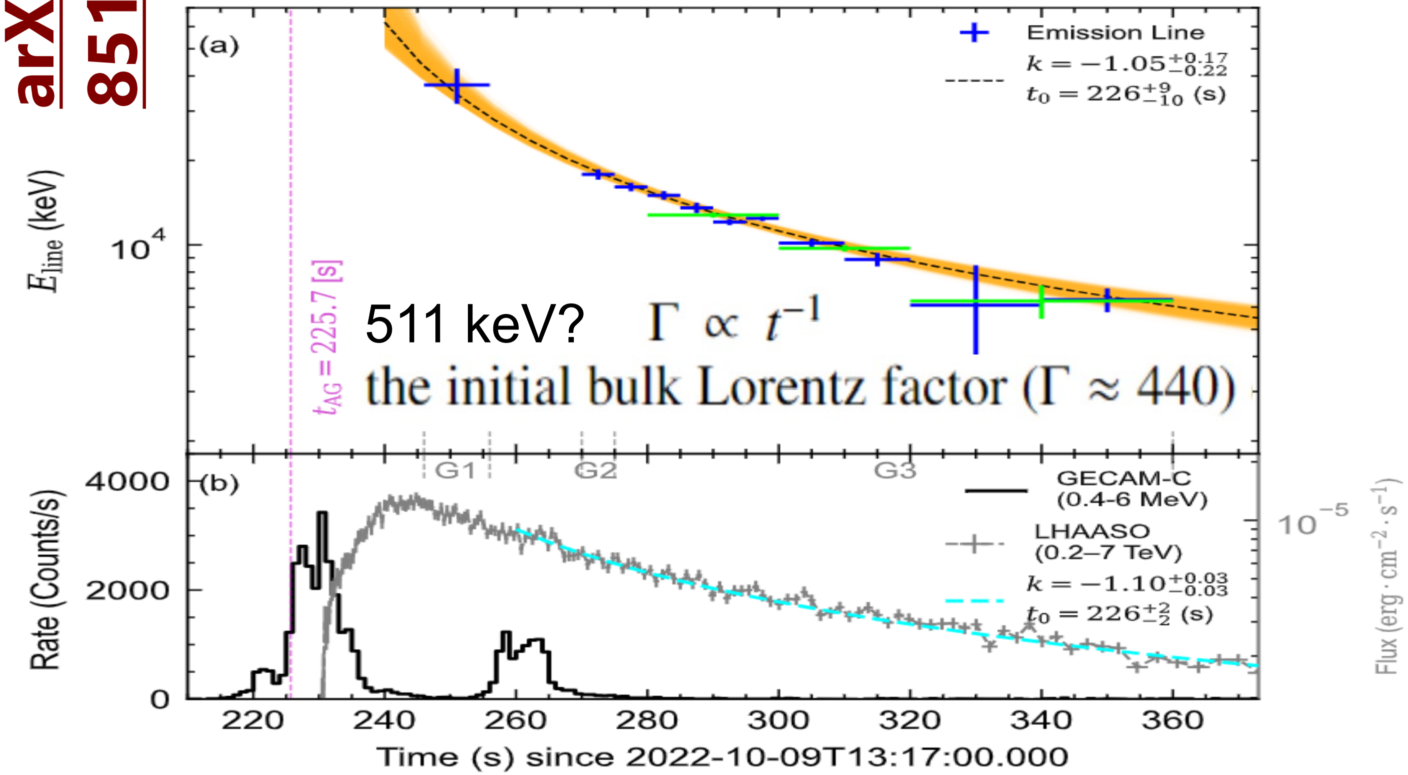
First Discovery of Gamma Emission Lines from a GRB: Brightest GRB in History

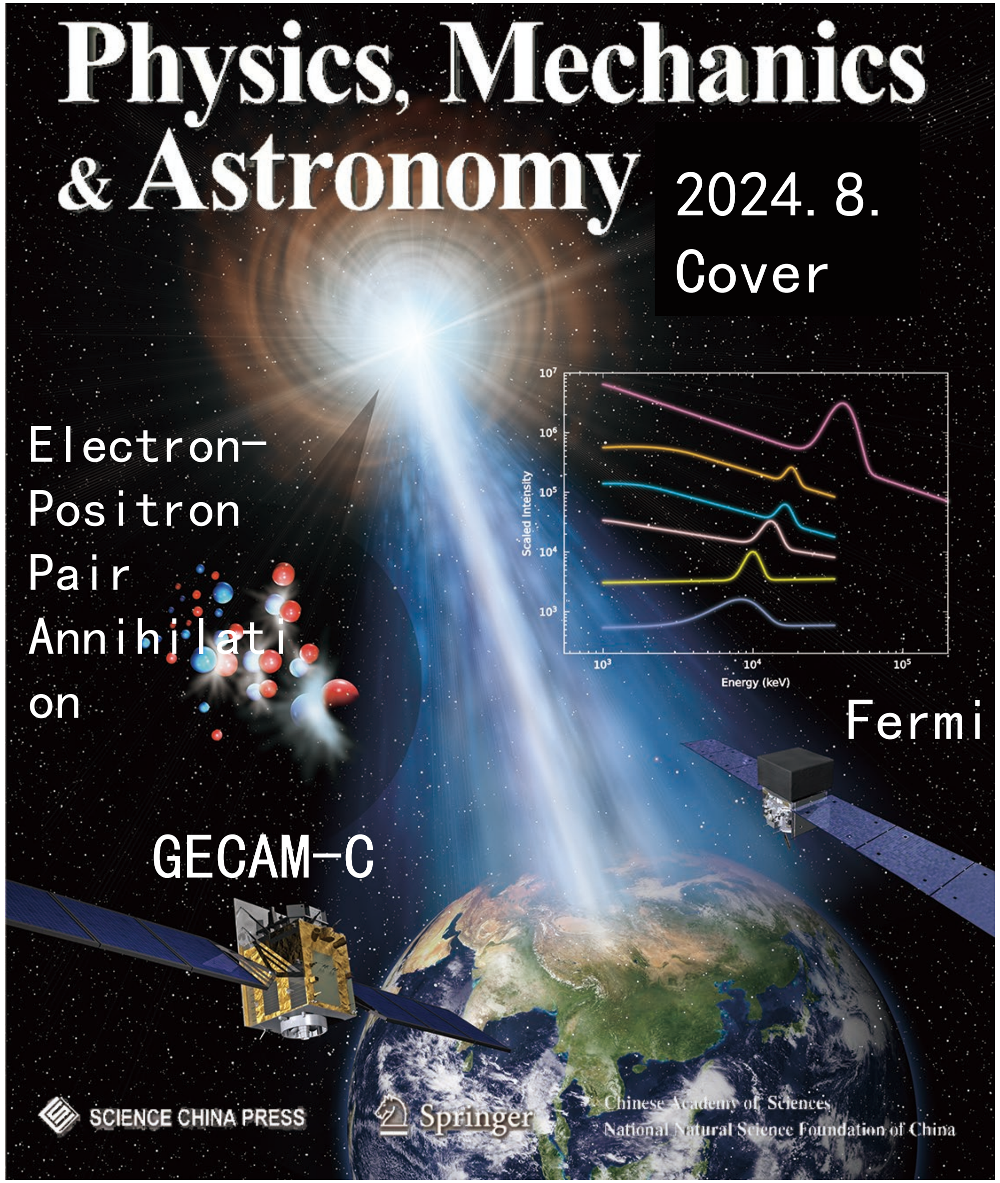
arXiv:2403.12851

Observation of spectral lines in the exceptional GRB 221009A

Yan-Qiu Zhang[1,2], Shao-Lin Xiong[1*], Ji-Rong Mao[3,4,5*], Shuang-Nan Zhang[1*], Wang-Chen Xue[1,2], Chao Zheng[1,2], Jia-Cong Liu[1,2], Zhen Zhang[1], Xi-Lu Wang[1], Ming-Yu Ge[1], Shu-Xu Yi[1], Li-Ming Song[1], Zheng-Hua An[1], Ce Cai[6], Xin-Qiao Li[1], Wen-Xi Peng[1], Wen-Jun Tan[1,2], Chen-Wei Wang[1,2], Xiang-Yang Wen[1], Yue Wang[1,2], Shuo Xiao[7], Fan Zhang[1], Peng Zhang[1,8], and Shi-Jie Zheng[1]

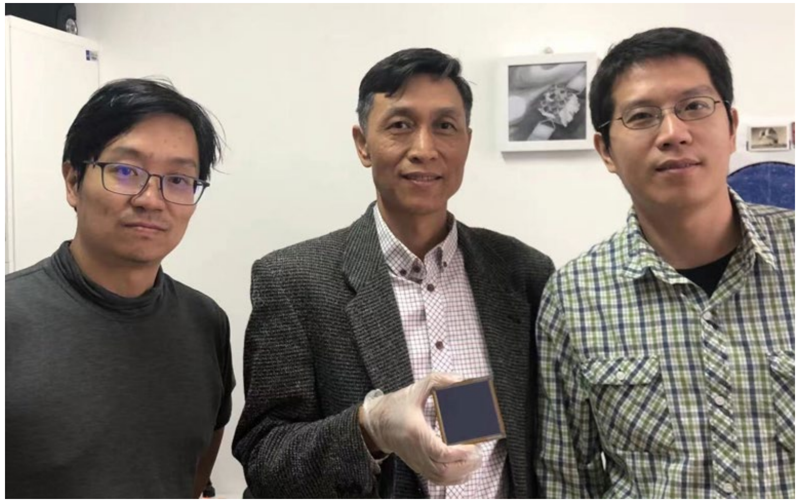
[1] *Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China;*
[2] *University of Chinese Academy of Sciences, Beijing 100049, China;*
[3] *Yunnan Observatories, Chinese Academy of Sciences, 650011 Kunming, Yunnan Province, China;*
[4] *Center for Astronomical Mega-Science, Chinese Academy of Sciences, Beijing 100012, China;*
[5] *Key Laboratory for the Structure and Evolution of Celestial Objects, Chinese Academy of Sciences, Kunming 650216, China;*
[6] *College of Physics and Hebei Key Laboratory of Photophysics Research and Application, Hebei Normal University, Shijiazhuang, Hebei 050024, China;*
[7] *Guizhou Provincial Key Laboratory of Radio Astronomy and Data Processing, Guizhou Normal University, Guiyang 550001, China;*
[8] *College of Electronic and Information Engineering, Tongji University, Shanghai 201804, China*





Einstein Probe (EP)

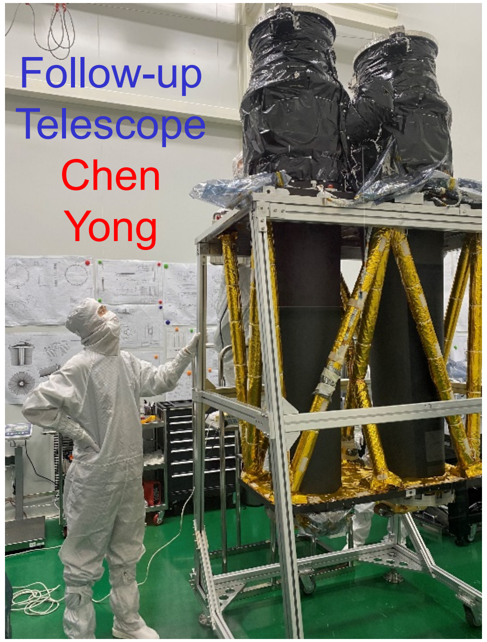
- Main scientific objectives: Various explosive sources, including black hole tidal disruption events, active galactic nuclei, gamma-ray bursts, gravitational wave bursts, and other extreme astrophysical phenomena
- Utilizes novel lobster-eye X-ray focusing technology
- **Launch date: 2024.1.9**



Lobster-eye optics Zhang Chen

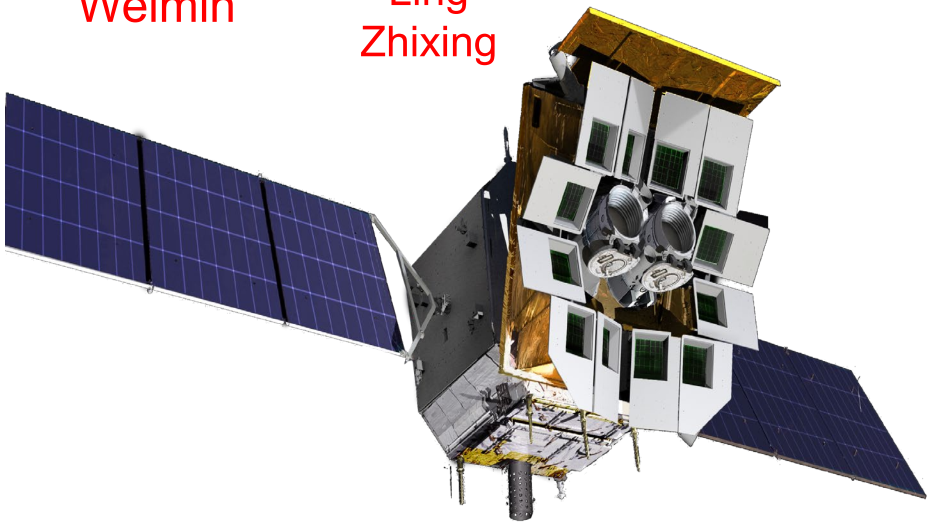
PI Yuan Weimin

CMOS Camera Ling Zhixing



Mission Characteristics

- Extremely large field of view 1.1 sr (3600 sq. deg)
- High angular resolution (~5 arcmin) and positioning accuracy (<1 arcmin)
- Soft X-ray band: 0.5-5 keV
- Sensitivity: An order of magnitude improvement over existing wide-field telescopes
- Automatic X-ray follow-up tracking (<10 arcsec positioning)
- Rapid downlink of alert data and quick uplink of opportunity observations (Beidou short message)

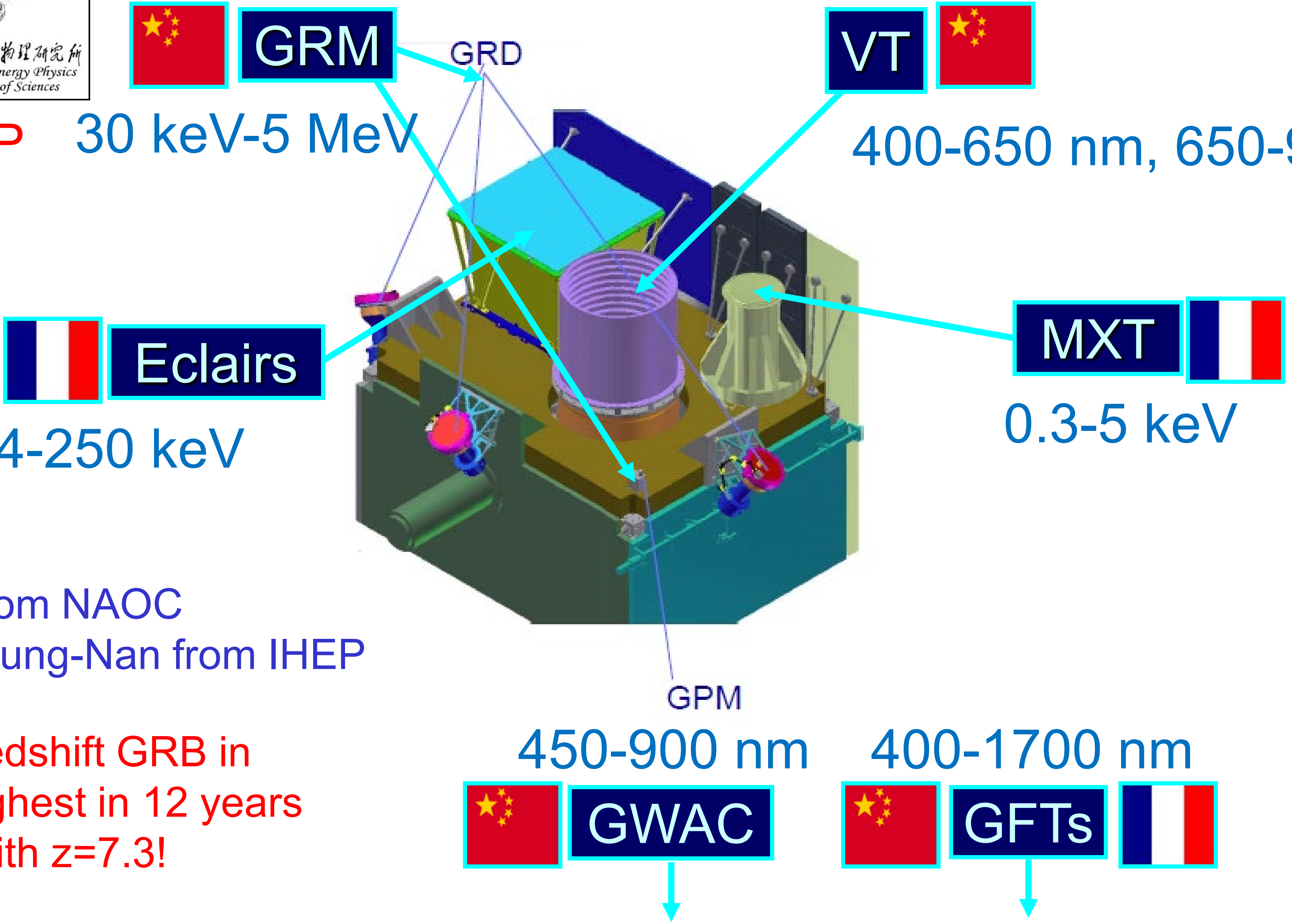


PI: Yuan Weimin, NAOC; see Prof. Hua Feng's talk

SVOM (Sino-French Cooperation Multiband Space Variable Object Monitor)

IHEP

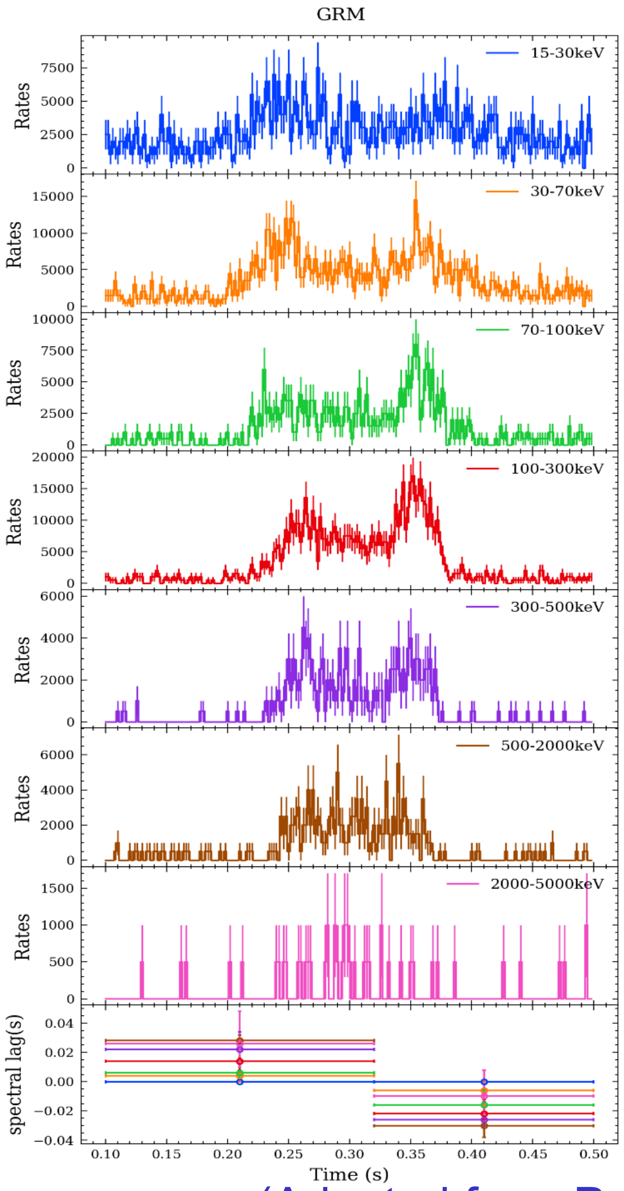
Launch date: 2024.6.22



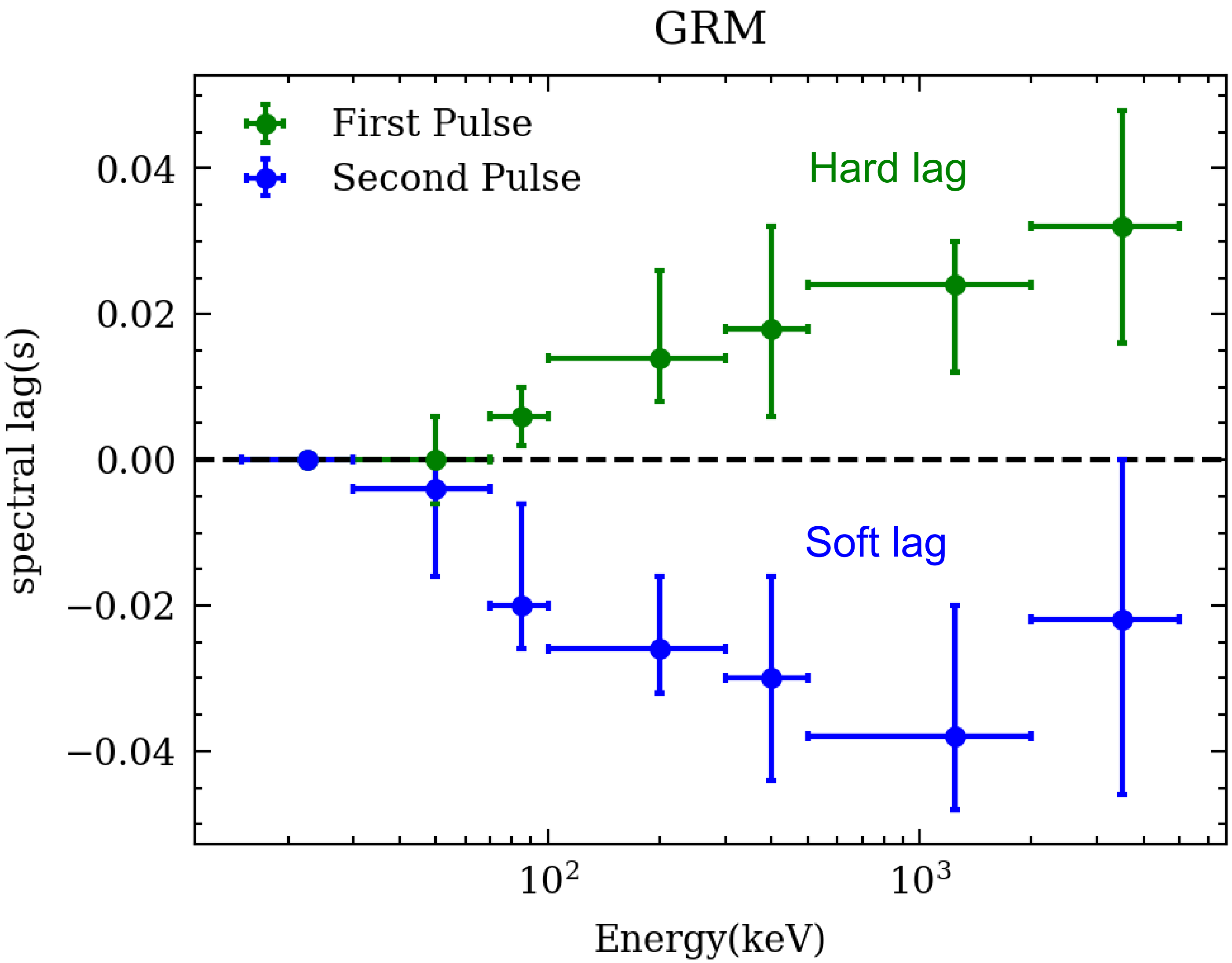
PI: Wei Jianyan from NAOC
Co-PI: Zhang Shaung-Nan from IHEP

The 3rd highest redshift GRB in history and the highest in 12 years was discovered with z=7.3!

GRB 240715A: peculiar spectral lag?



(Adapted from Prof. Shaolin Xiong)

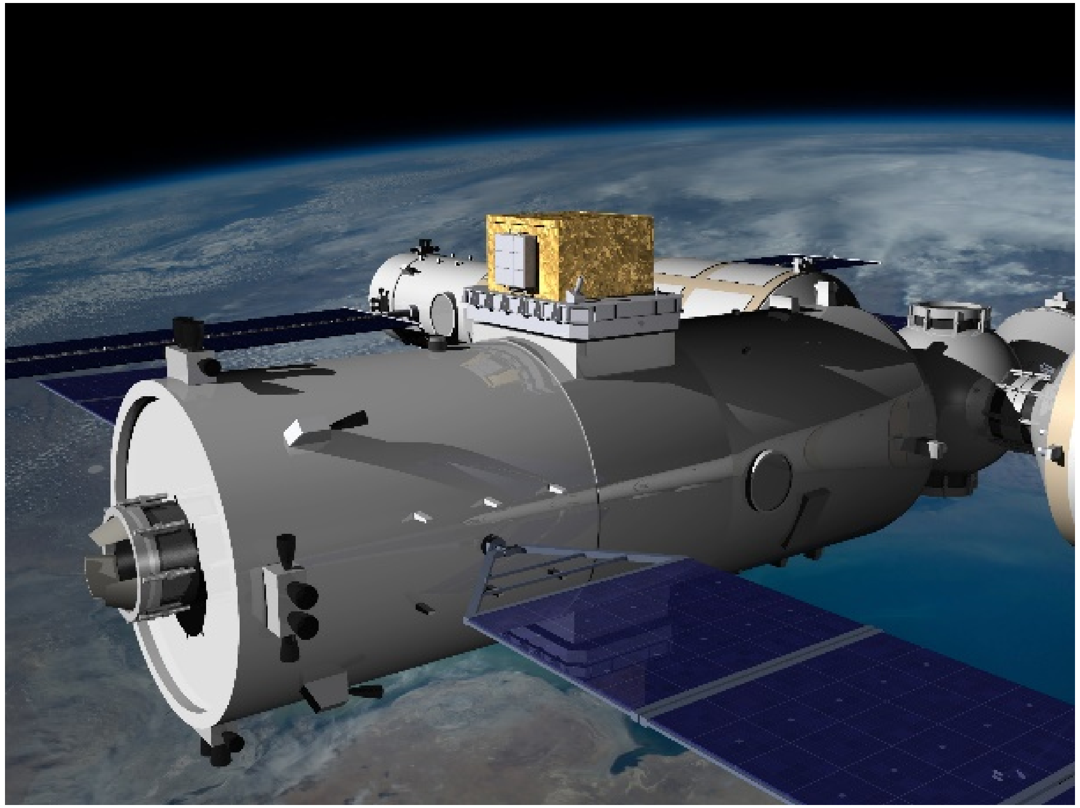


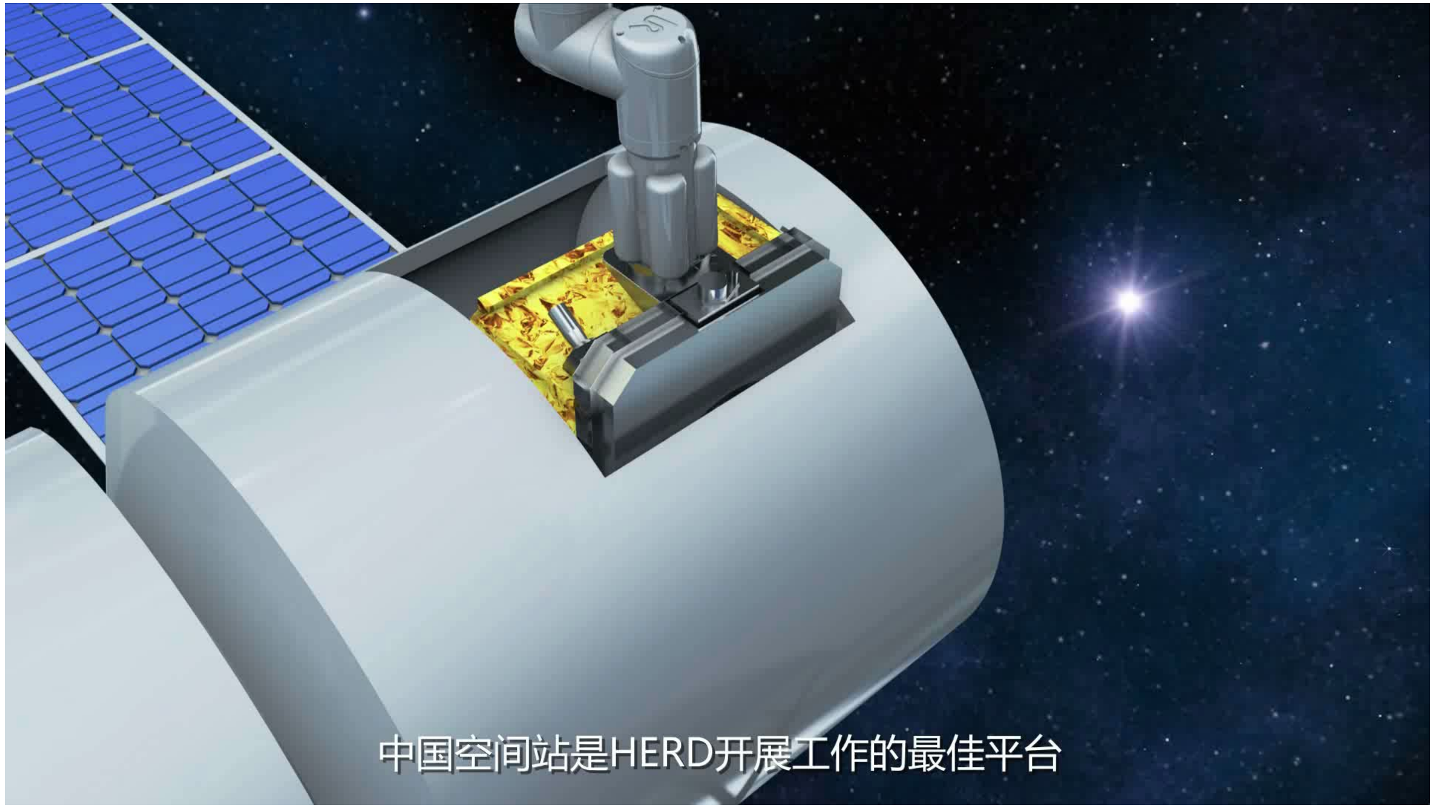
Results by Wenjun Tan@IHEP

Still un-answered questions in "extreme universe"

Scientific questions	Extreme origin	Extreme energy	Extreme sources	Extreme explosions	Extreme gravity	Extreme B-fields	Extreme density
Specific contexts	The ratio of dark matter to ordinary matter produced by the extreme processes of the Big Bang is approximately 6:1, but dark matter particles have not yet been discovered.	The energy of cosmic rays is at least a hundred million times higher than that of man-made accelerators, but the process of extreme particle acceleration is still unclear.	High-energy gamma-ray sources in the universe are likely cosmic extreme high-energy particle accelerators, but current sky surveys have not fully confirmed this.	Gamma-ray bursts are the most intense explosive phenomena since the Big Bang, yet the nature of the extreme relativistic jets that emit gamma rays remains unclear.	Black holes provide the strongest gravitational fields in the universe, but what phenomena occur under such extreme gravitational conditions have not been precisely observed.	Neutron stars provide the strongest magnetic fields in the universe, but what vacuum fluctuations occur under these conditions have not been directly observed.	The material density inside neutron stars is the highest in the universe, but whether their interiors are composed of neutrons or quark matter remains an unsolved mystery.
Means	Space radiation detection: high-energy electrons, cosmic rays, gamma rays			Gamma-ray polarization	X-ray Variability, Polarization, and Spectroscopy		

HERD: High Energy cosmic-Radiation Detector

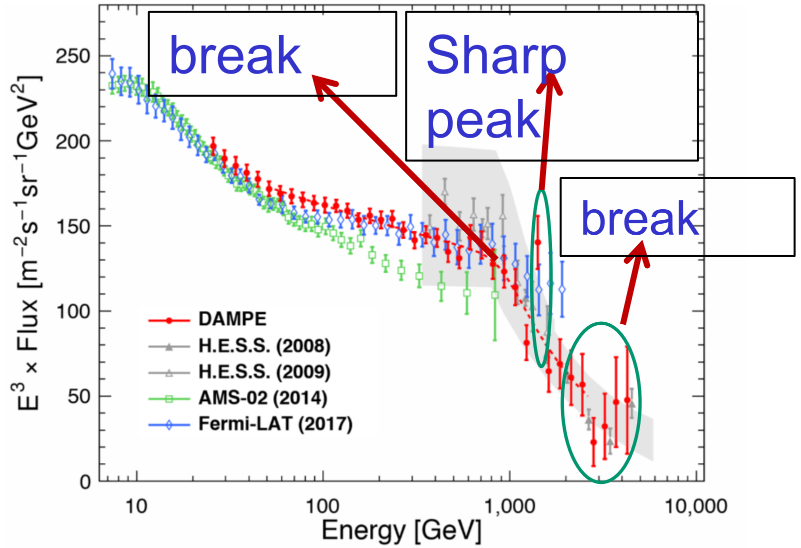


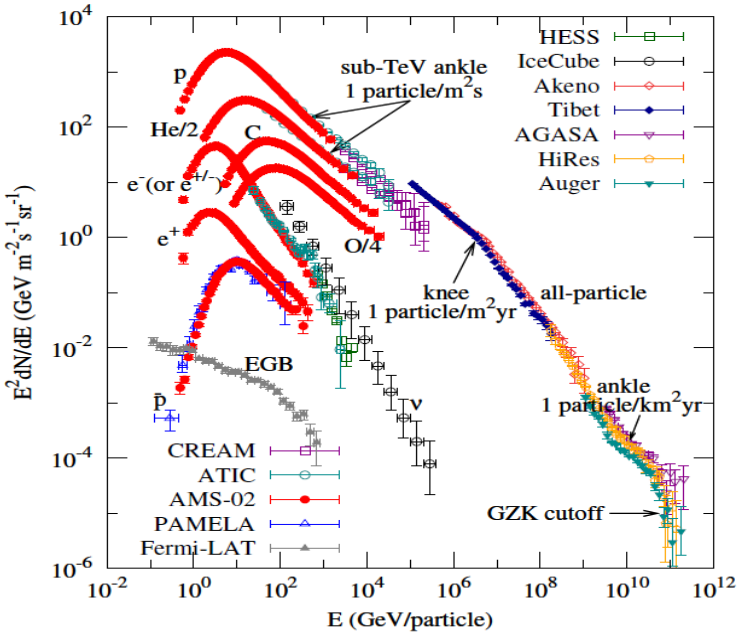


- To be onboard the China Space Station in 2028 for 10 year operation, with 3D-calorimeter and 5-side sensitive.
- To detect electrons up to 15 TeV, cosmic rays up to several PeV, and gamma-rays from 0.5 GeV to above TeV with > 2π field of views.

HERD's "Top Three Extremes" Scientific Goals

- Extreme Origins: Searching for Dark Matter with the Highest Sensitivity
  - Broader energy range and the highest sensitivity anisotropy measurement to test various non-dark matter origin hypotheses for high-energy electron spectrum anomalies.
  - The dark matter annihilation line detection sensitivity after 1 year of operation far exceeds the sensitivity of similar experiments running for over 5 years.
- Extreme Energy: Exploring the Mystery of Cosmic Ray Origins
  - First direct measurement of the cosmic ray energy spectrum and composition in the "knee" region.
- Extreme Sources: Conducting high-sensitivity surveys and monitoring of high-energy gamma rays
  - Leading significant scientific discoveries in the international high-energy astrophysics community, discovering extreme celestial bodies
  - Monitoring of most pulsars across the entire sky





HERD Scientific Requirements(1/2)

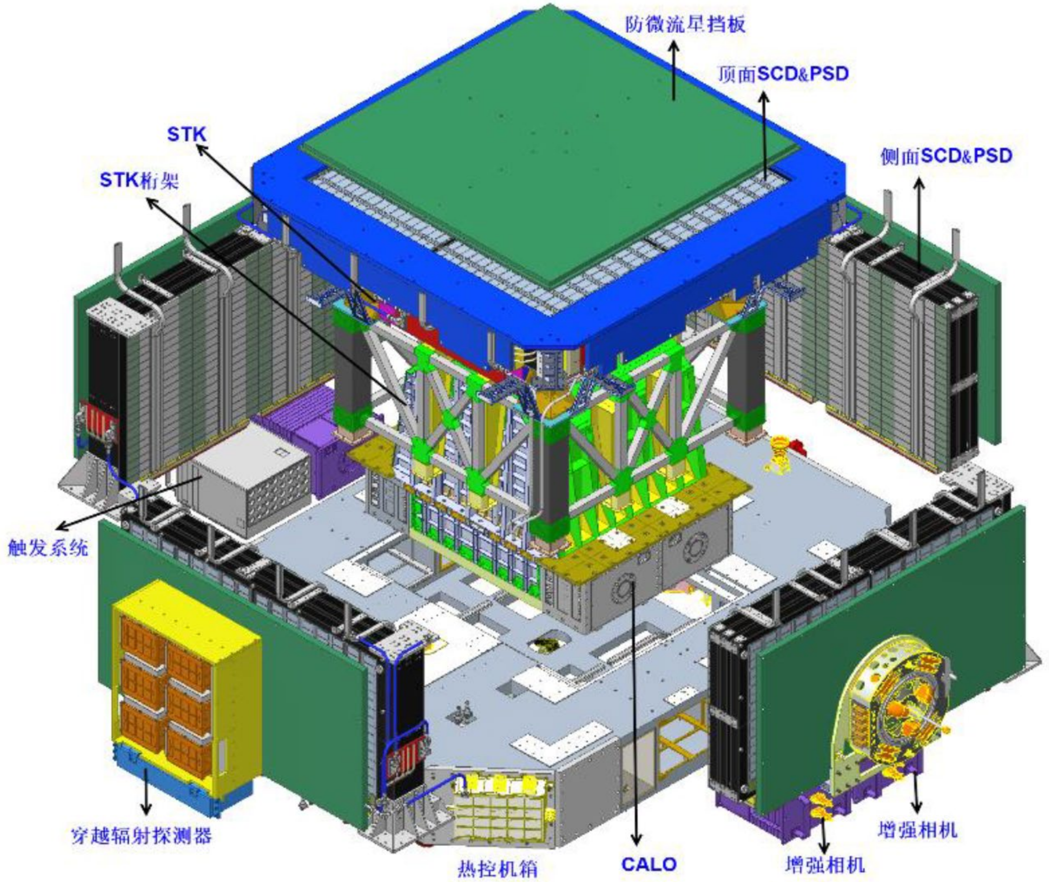
	Scientific Requirement	Detector Requirement	Design Specifications
Electron Acceptance	More than 10 events above 10 TeV (extrapolated from DAMPE measurement results)	> 1m²sr@10TeV 2m²sr@1TeV 2.3m²sr@200GeV	>3m²sr@200GeV
Proton Acceptance	More than 10 events observed above 3 PeV (based on the Horandel model)	>1.3 m²sr@3PeV 1.6m²sr@100TeV	>2m²sr@100TeV
Electron Detection Energy Range	Measure the spectrum after the TeV cutoff, detect the high-energy electron spectrum structure of nearby sources	10GeV - 10 TeV	10GeV – 100TeV
Photon Detection Energy Range	Gamma Astronomy, Dark Matter Signals	0.5 GeV - 10 TeV	0.5 GeV–100 TeV
Proton Detection Energy Range	Measure the Energy Spectrum of the Proton Knee Region	100 GeV – 5 PeV	30 GeV – 5 PeV
Charge Detection Range	Measure the Energy Spectrum from Protons to Nickel	Z=1-28	Z=1-28
Charge Resolution	Distinguish Different Atomic Nuclei	P: ≤0.15 CU; C: ≤0.2 CU	P: ≤0.15 CU; C: ≤0.2 CU

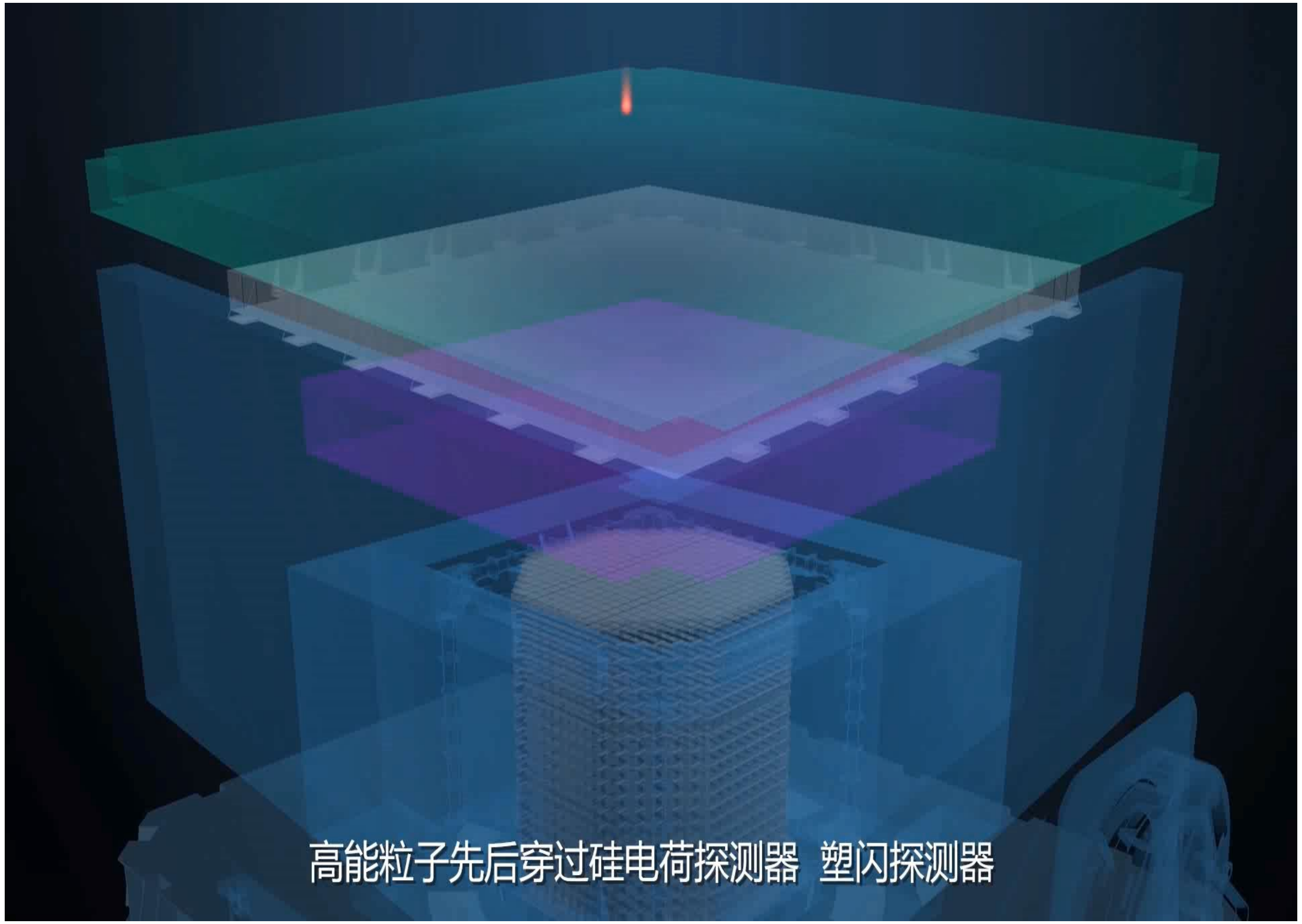
HERD Scientific Requirement Indicators (2/2)

	Scientific Requirement	Detector Requirement	Design Specifications
Electron Energy Resolution	Line Spectrum Search	≯2%@200GeV	≯1.5%@200GeV
Proton Energy Resolution	Measurement of Structures in the Proton Spectrum	≯40%@200GeV	≯25%@100GeV~PeV
Particle Identification Capability	Elimination of Proton Background	Proton rejection rate ≮$3*10^5$ at 100GeV electron efficiency of 90%	Proton rejection rate ≮$3*10^5$ at 100GeV electron efficiency of 90%
Cumulative Observation Time	More than 10 events above 3PeV (based on the Horandel model) More than 10 events above 10TeV (extrapolated from DAMPE measurement results)	≥10 years	≥10 years

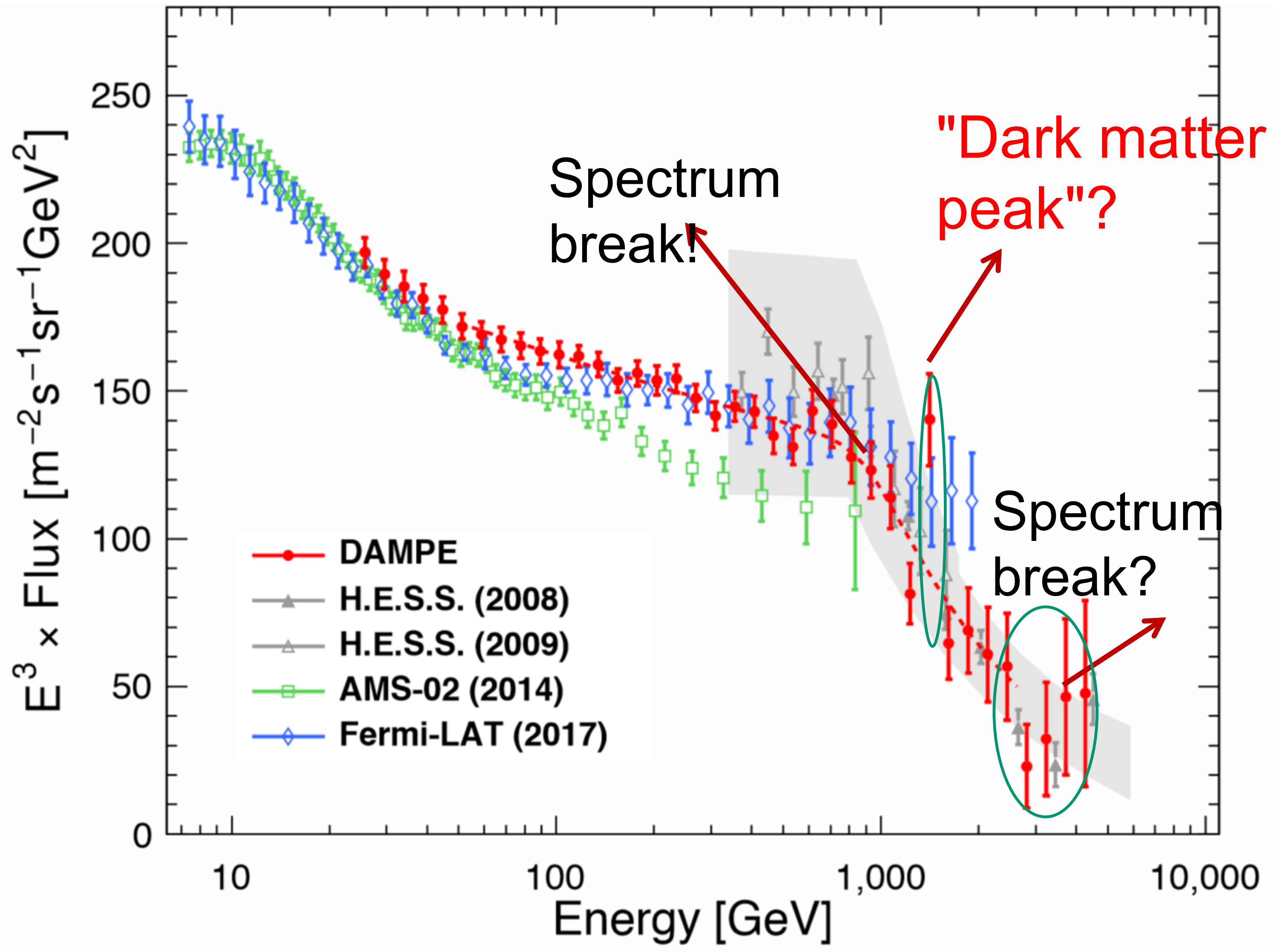
A highly complex flagship space science experiment

- The HERD payload includes: 3-D imaging calorimeter (CALO), silicon tracker (STK), plastic scintillator anti-coincidence detector, silicon charge detector, transition radiation detector.

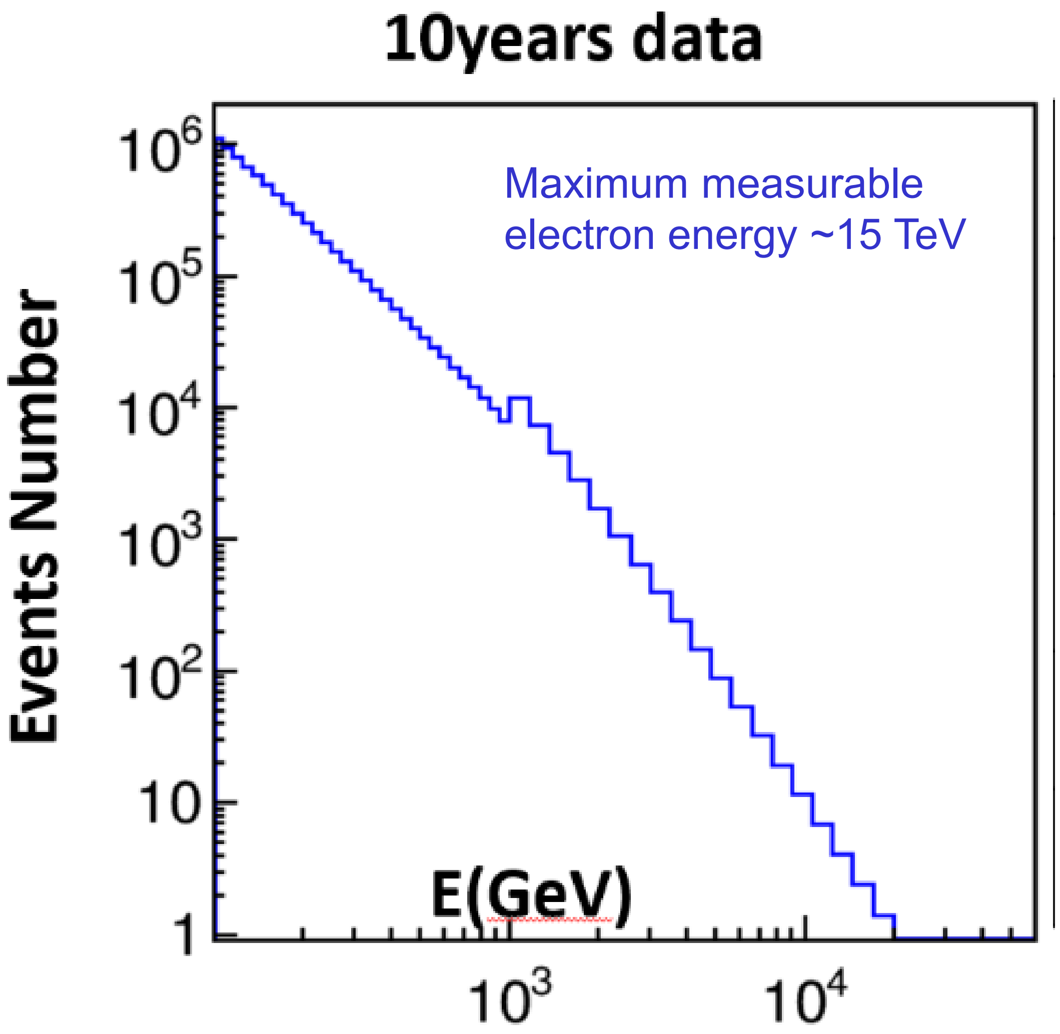


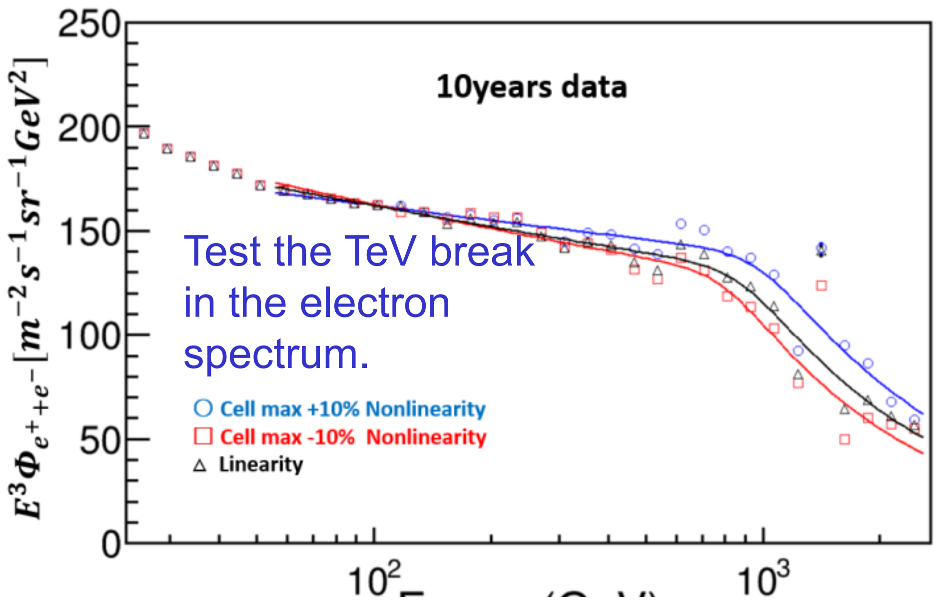


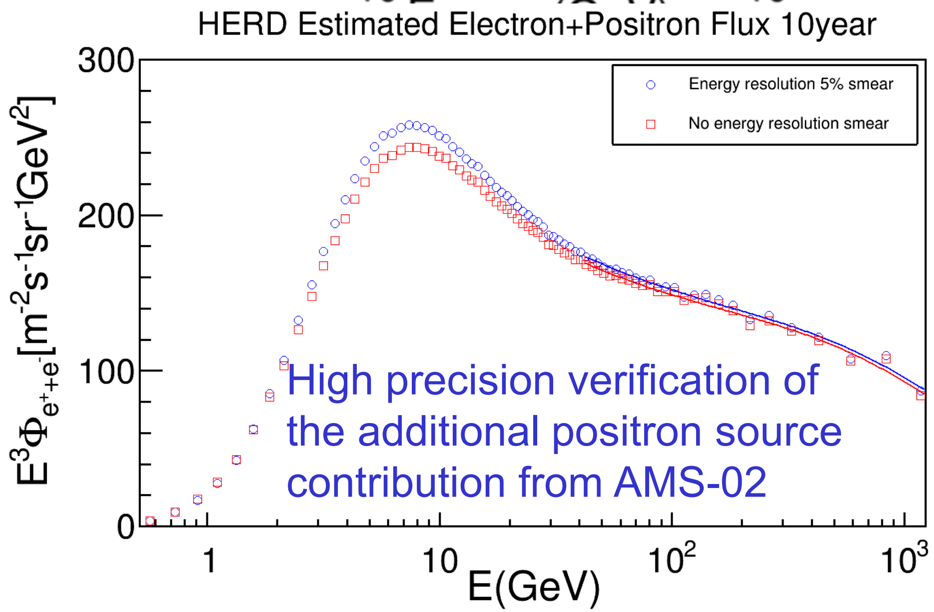
Results of "Wukong": The most precise high-energy electron spectrum



HERD directly measures cosmic electron spectra up to 15 TeV

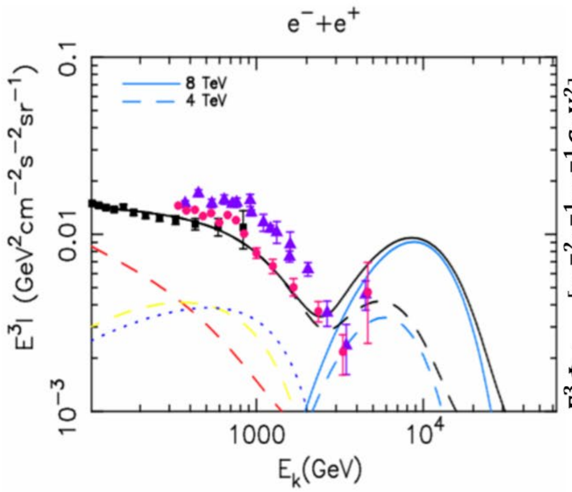


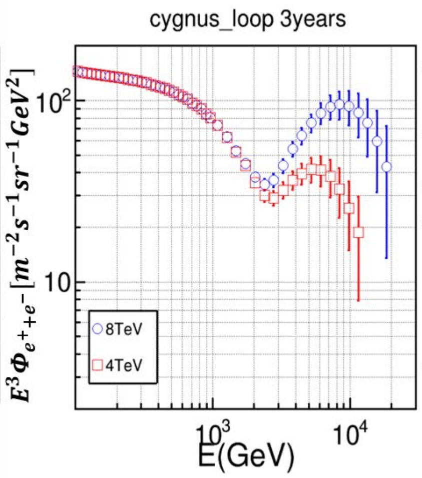


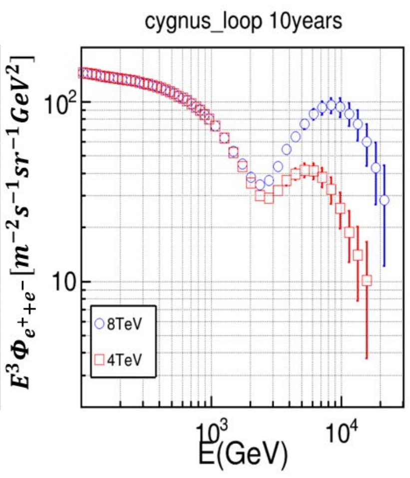


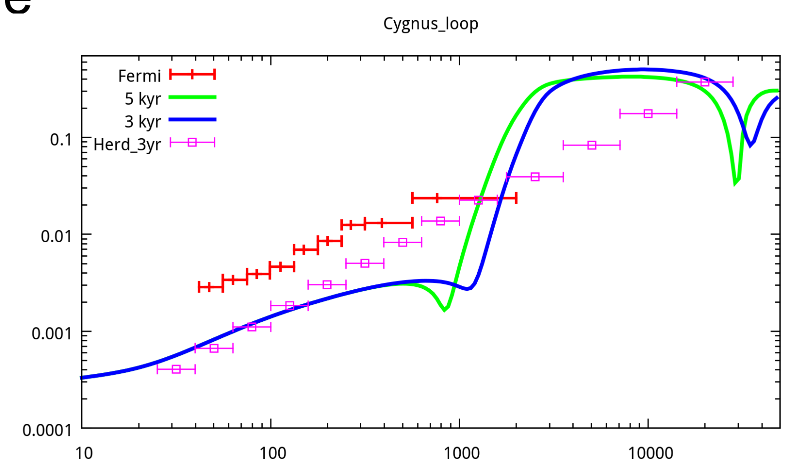
HERD can detect the expected spectral features of electrons

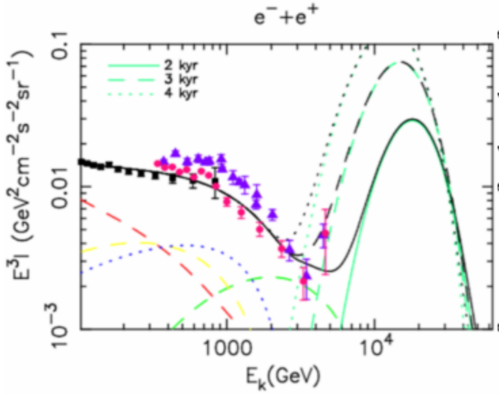
- TeV features from nearby sources: anisotropy
- TeV features from nearby sources: 10sTeV spectrum structure

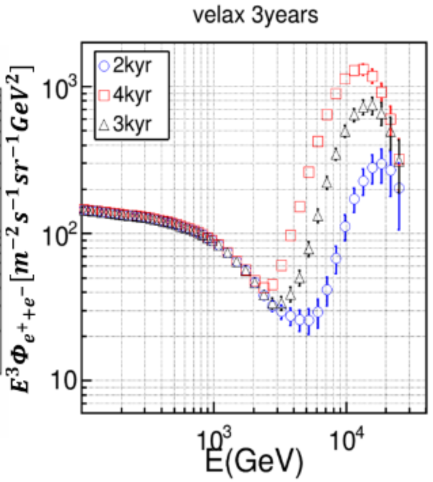


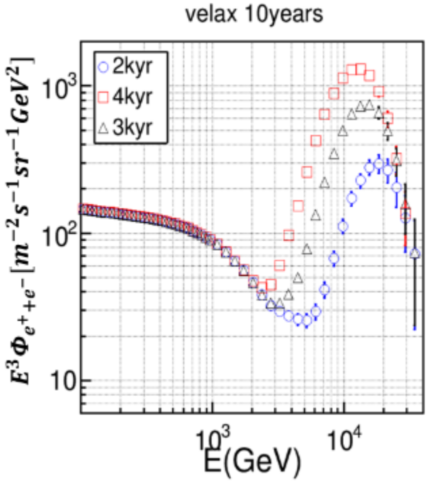


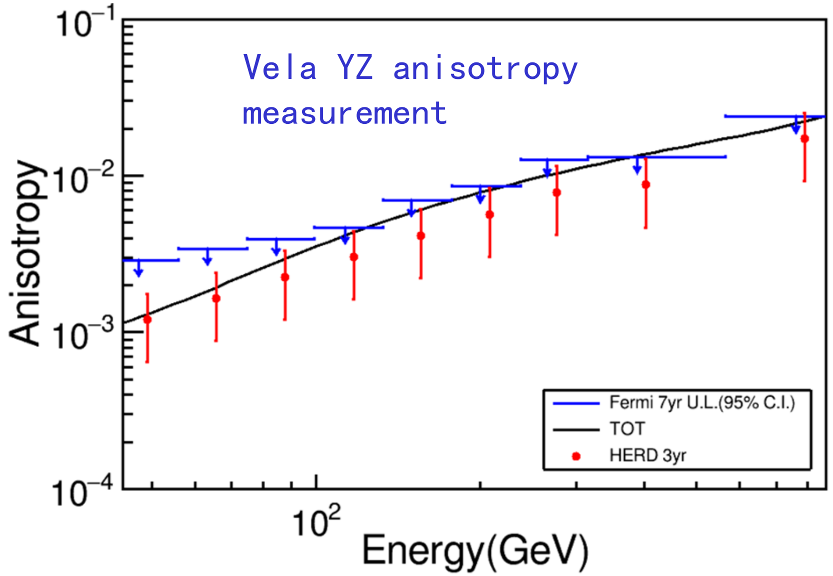




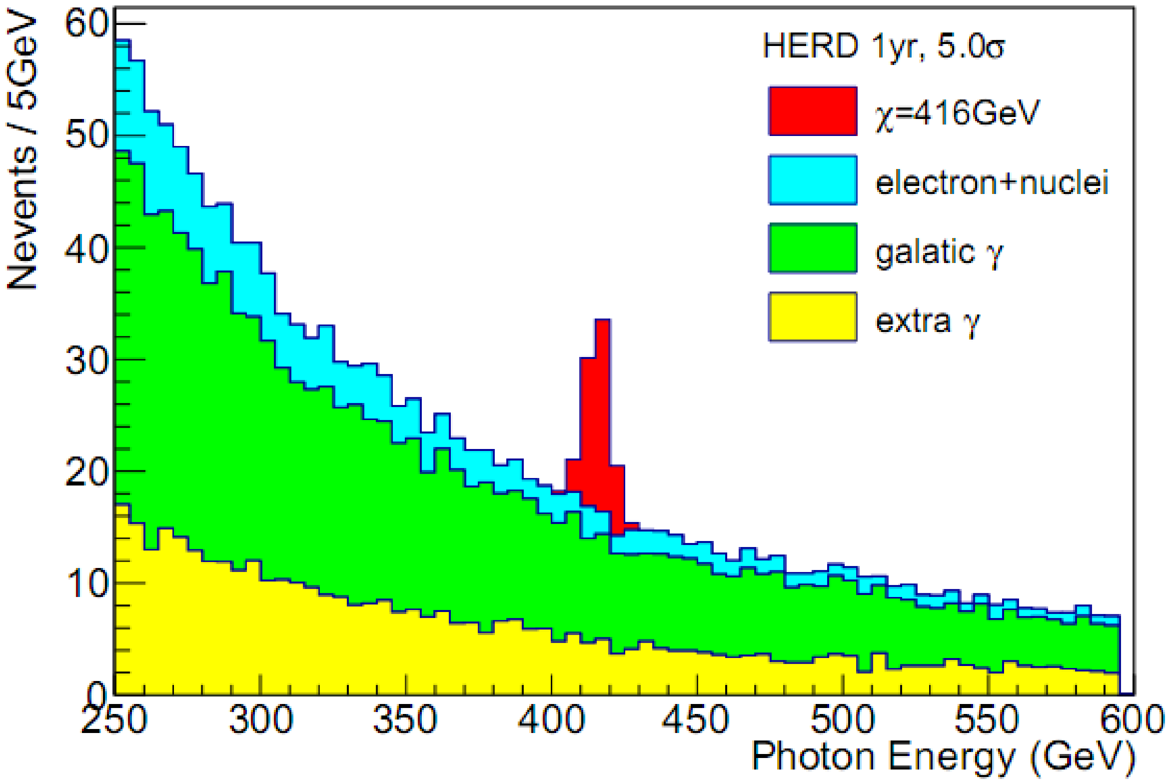








HERD's sensitivity to gamma-ray lines from dark matter annihilation



HERD has a reliable way to discover dark matter annihilation signals.

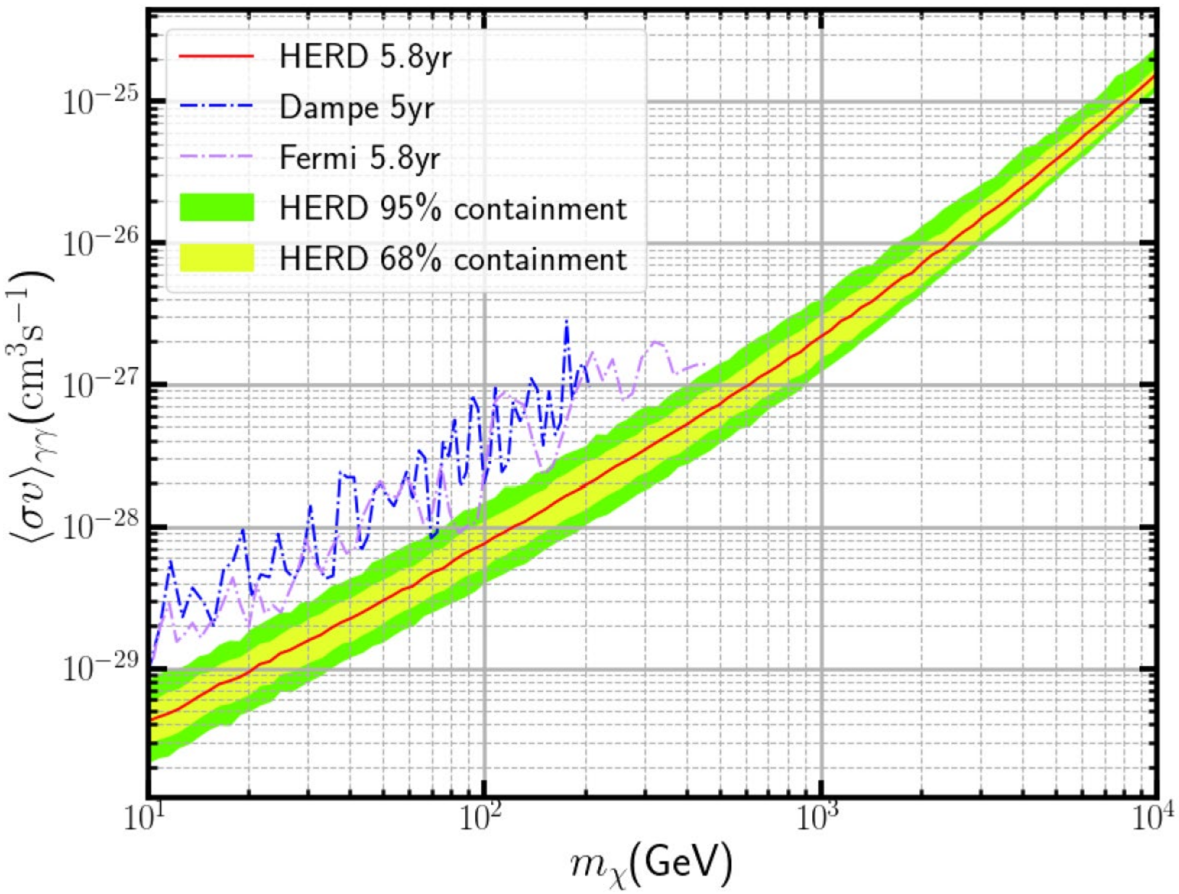
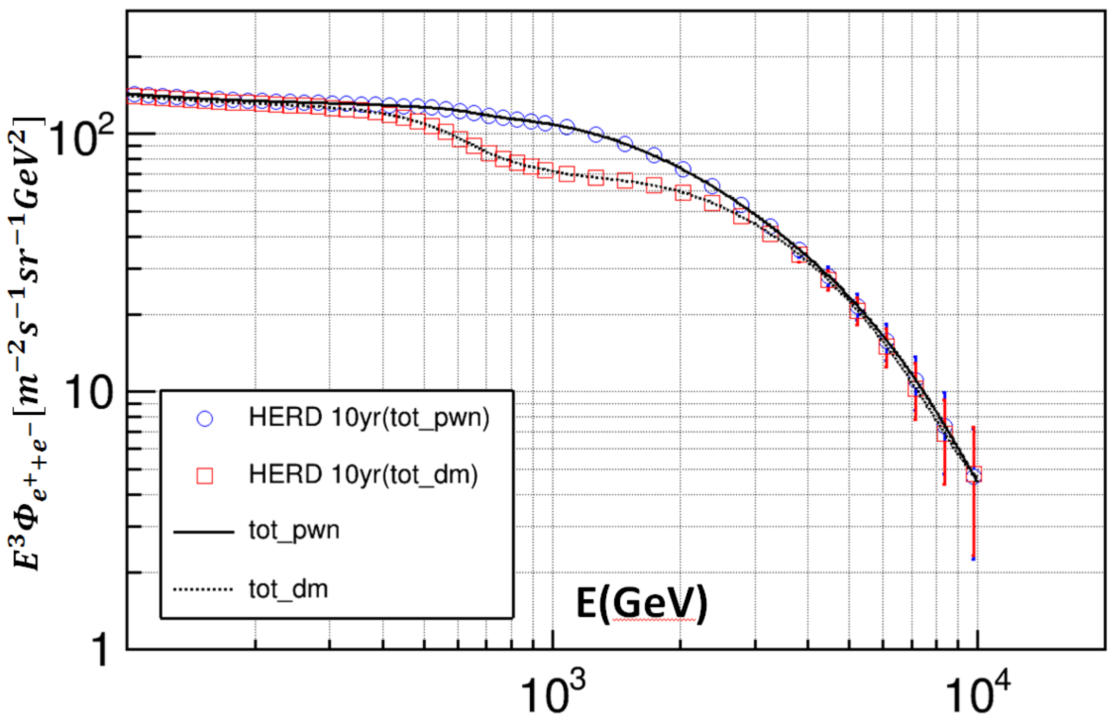


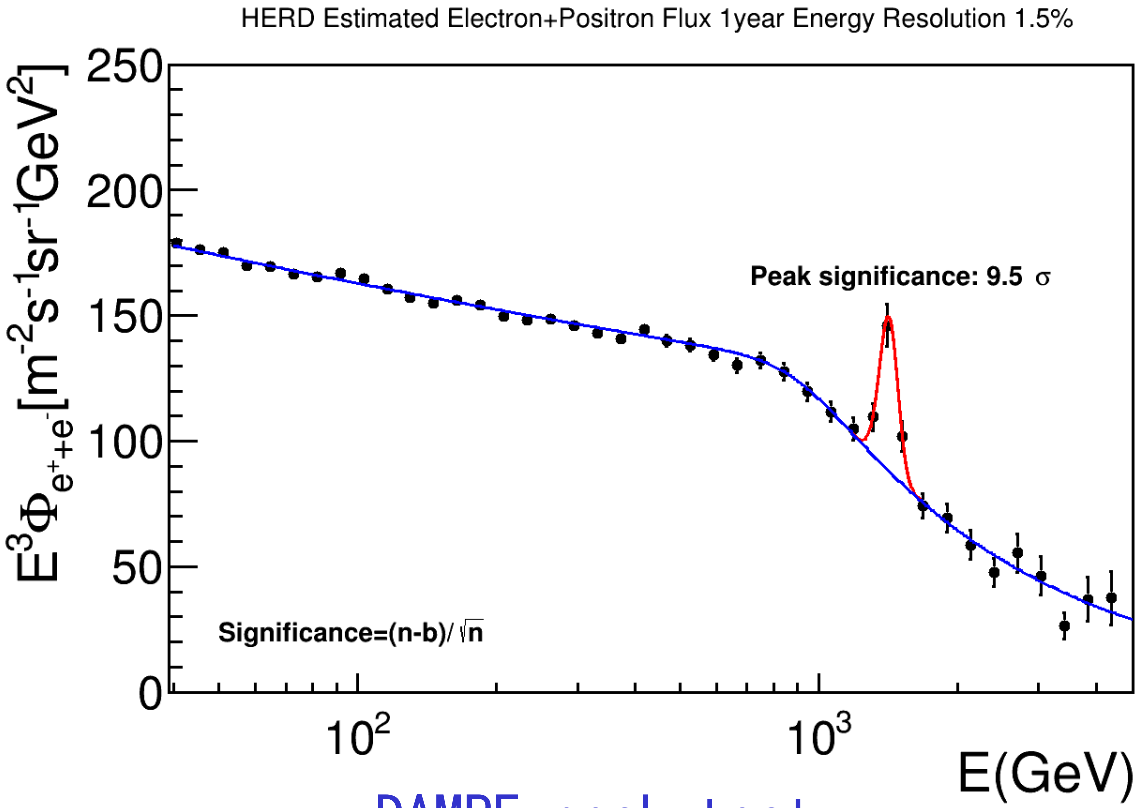
图 3-10 HERD 对暗物质湮灭线谱探测灵敏度

HERD's sensitivity for dark matter annihilation lines surpasses other experiments.

HERD will search for DM signals in H-E electron spectrum.

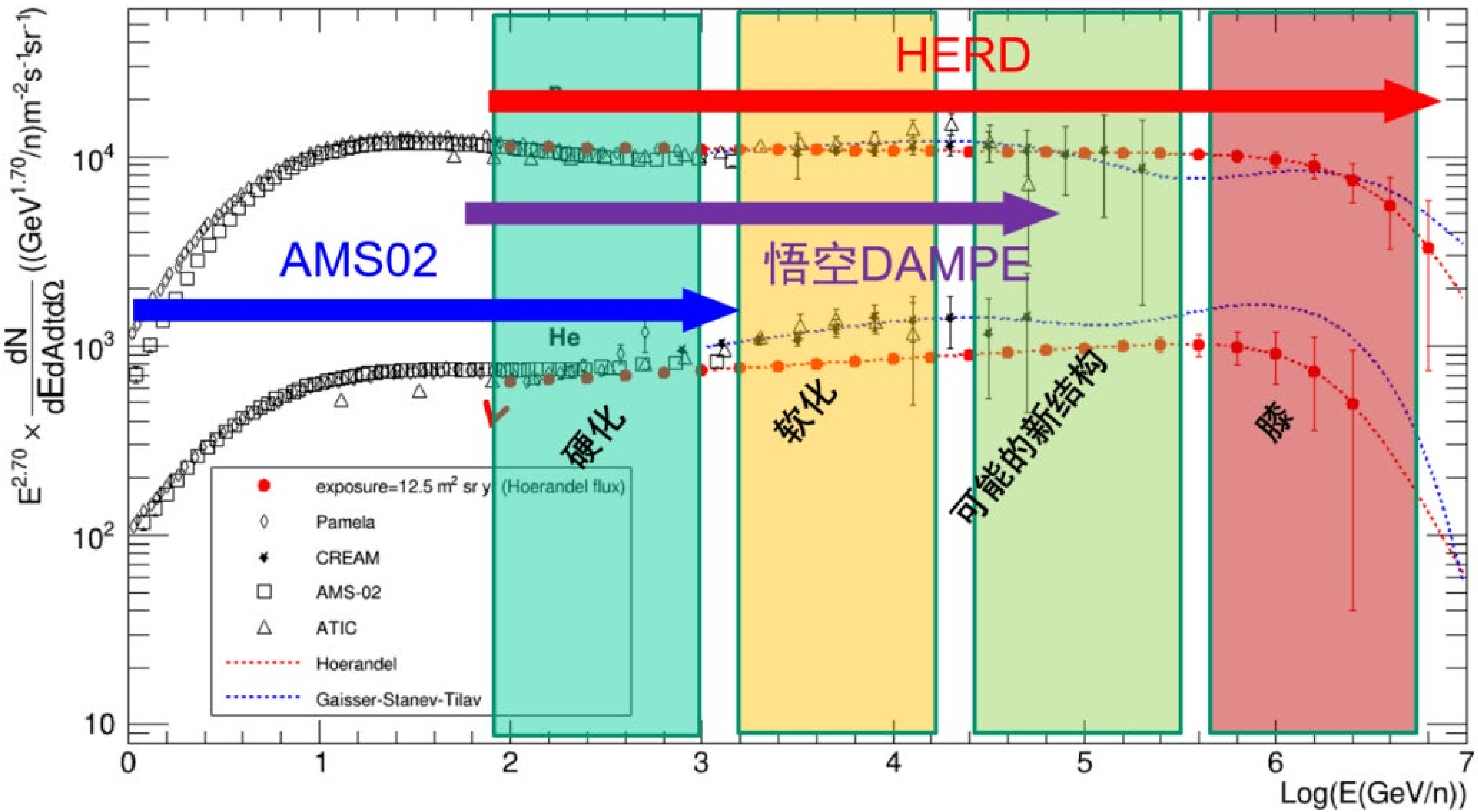


Distinguish between dark matter models and pulsar models.



DAMPE peak test

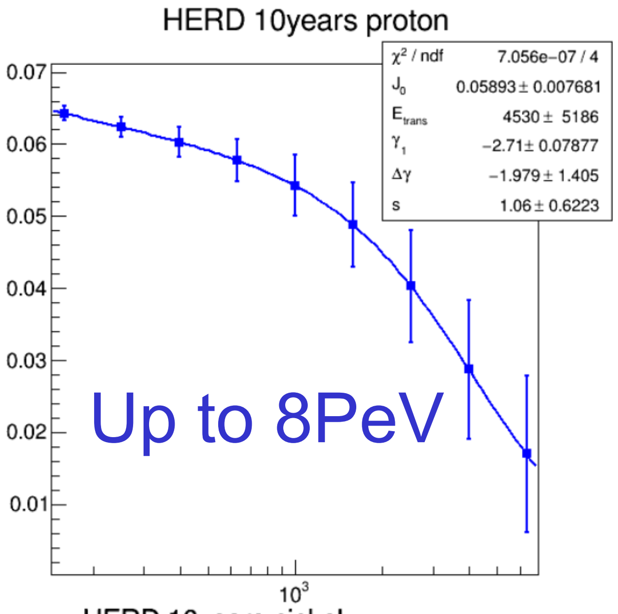
HERD P and He nucleus spectra (5 years, Hoerandel fluxes)

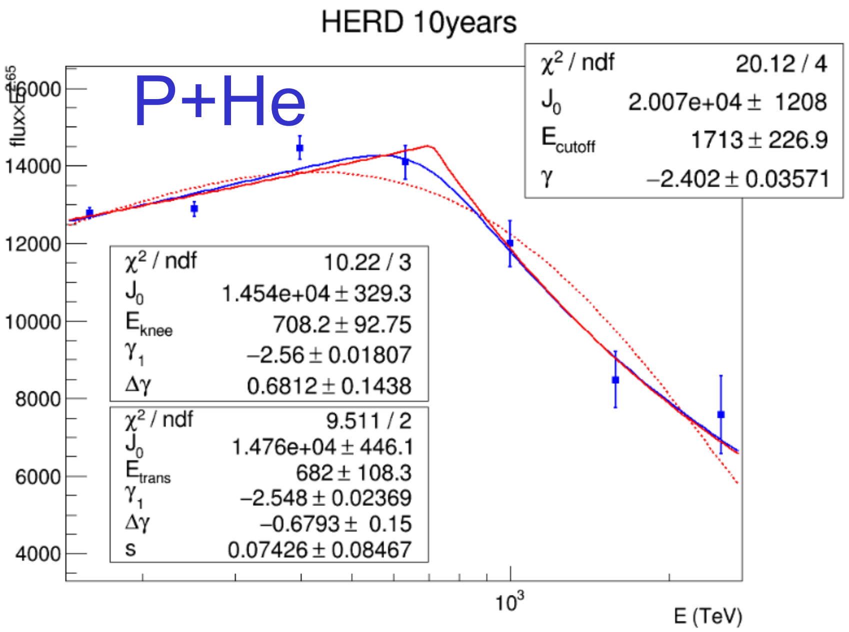


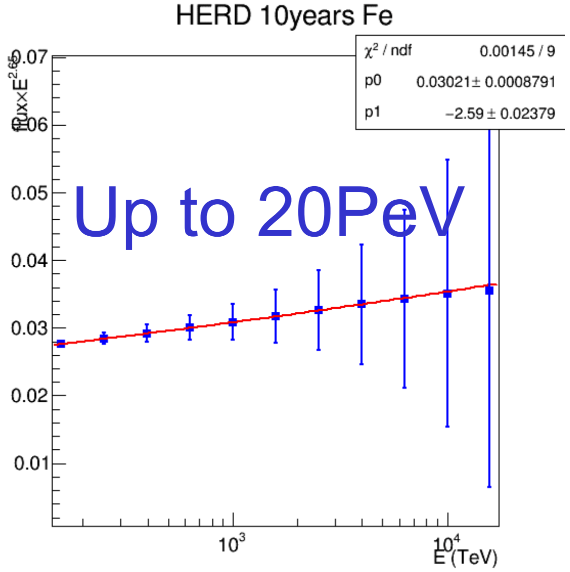
First comprehensive detection of key structures such as cosmic ray hardening, softening, possible new structures, and the knee by a single experiment.

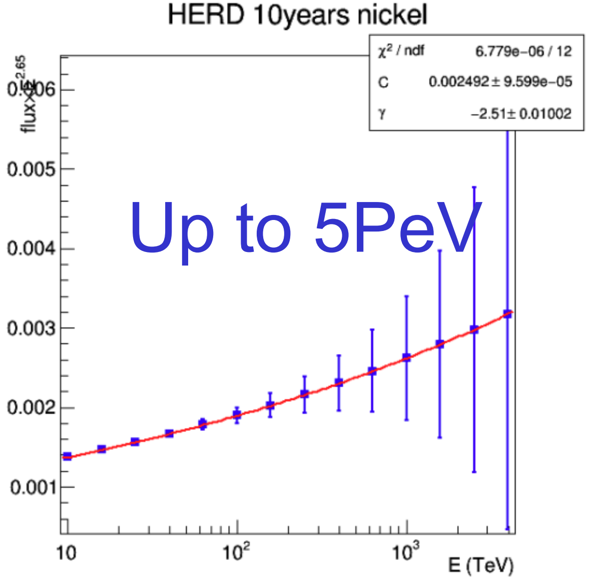
Direct measurement of cosmic rays up to PeV energy

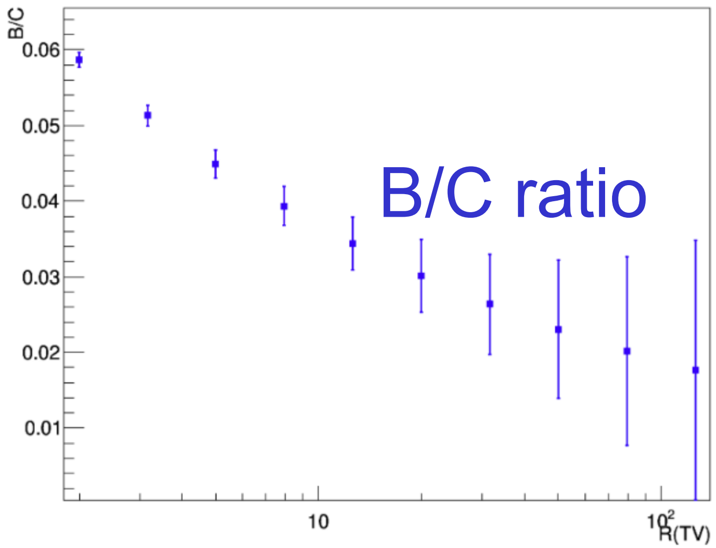
- First direct measurement of the cosmic ray "knee region"
- Capable of measuring charge up to Z=28



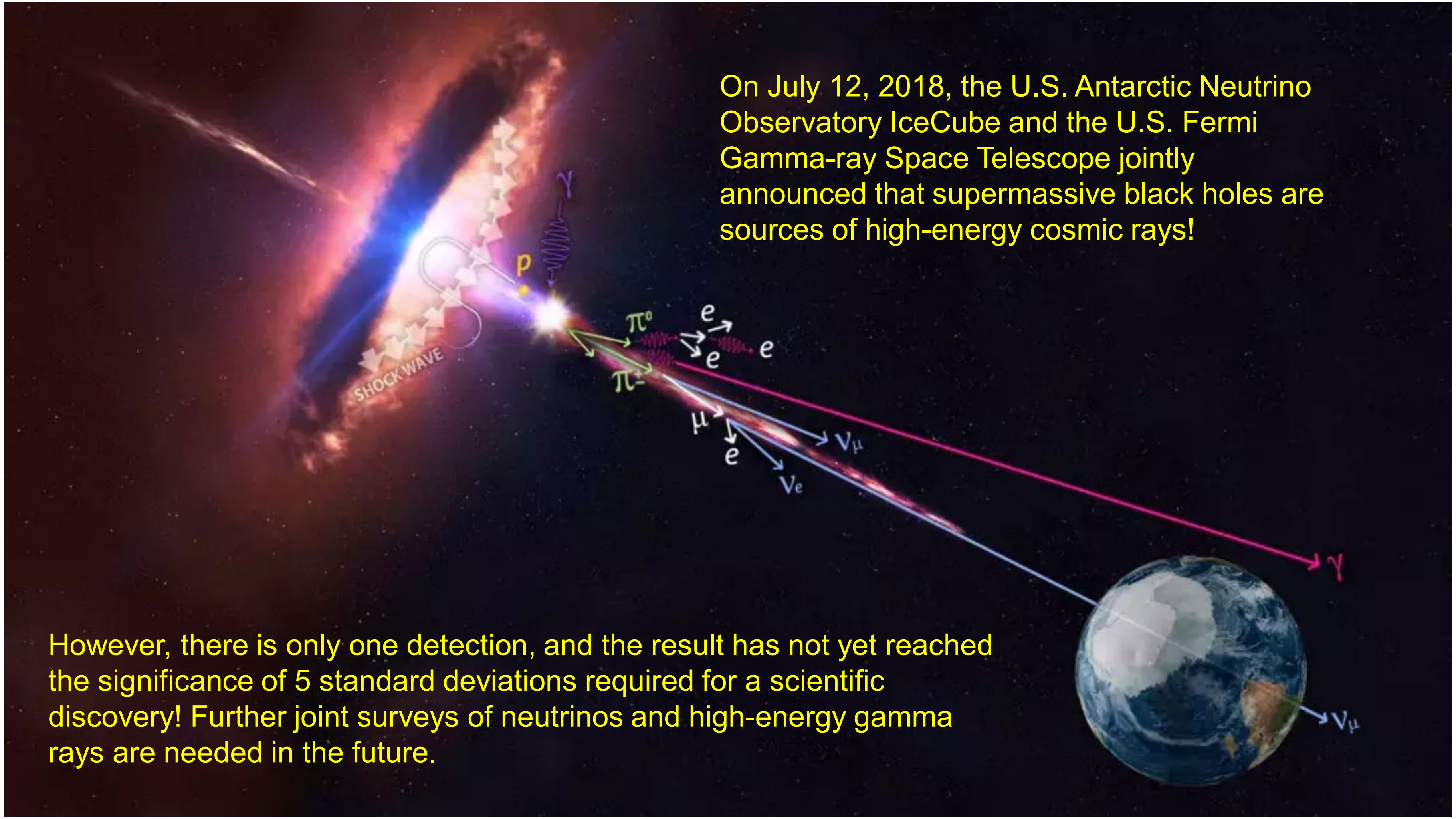








Extreme Universe 3: What extreme sources produce high-energy cosmic rays?



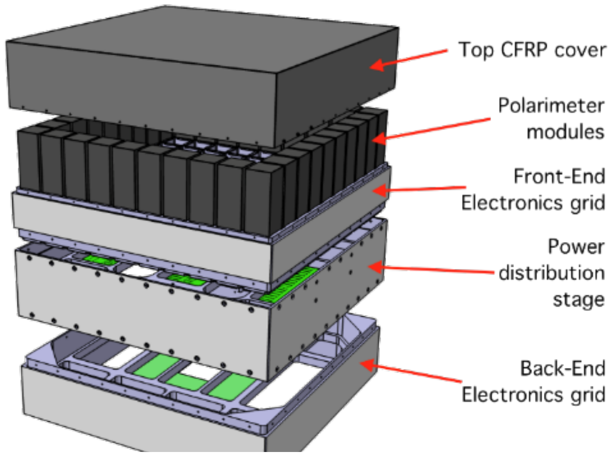
On July 12, 2018, the U.S. Antarctic Neutrino Observatory IceCube and the U.S. Fermi Gamma-ray Space Telescope jointly announced that supermassive black holes are sources of high-energy cosmic rays!

However, there is only one detection, and the result has not yet reached the significance of 5 standard deviations required for a scientific discovery! Further joint surveys of neutrinos and high-energy gamma rays are needed in the future.

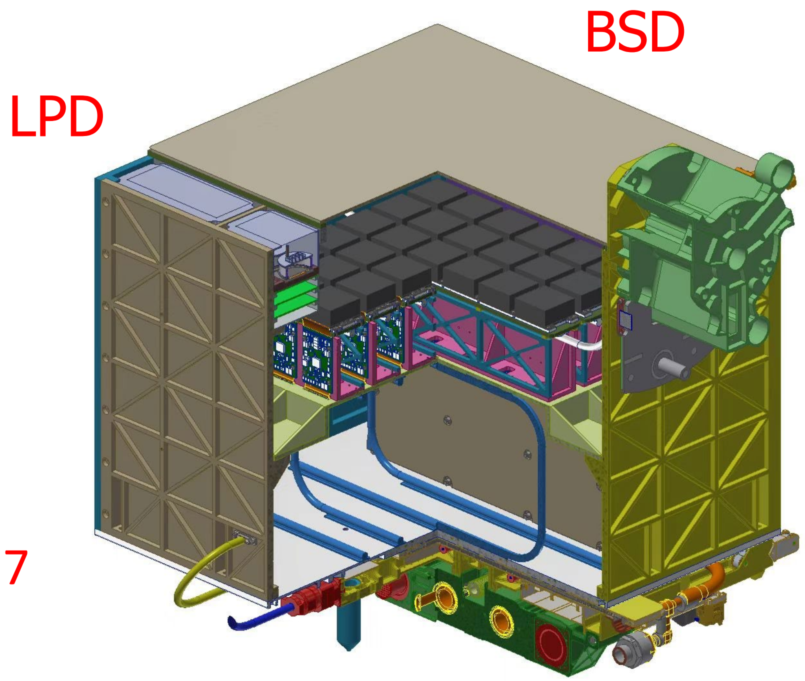
HERD will become the gamma-ray observatory with the largest field of view.

Extreme Universe 4: Extreme Explosion: GRB Polarimeter POLAR-2

- High-energy Polarization Detector: HPD
- E-range for polarimetry: ~30-800 keV
- 100 modules, 6400 plastic scintillator bars
- Effective area: > 2000cm^2, > 1000cm^2 for Pol.
- FOV: ~50% sky
- Collaborations: UNIGE/IHEP/MPE/NCBJ
- Has been approved through United Nations



- Low-energy Polarization Detector: LPD, GXU, China
  - ~2-10 keV X-ray polarimetry
- Broad energy-band Spectrum Detector: BSD, IHEP/CAS, China
  - ~10-2000 keV for spectroscopy
  - Accurate GRB localization: < 1°
- Status: under final review for approval

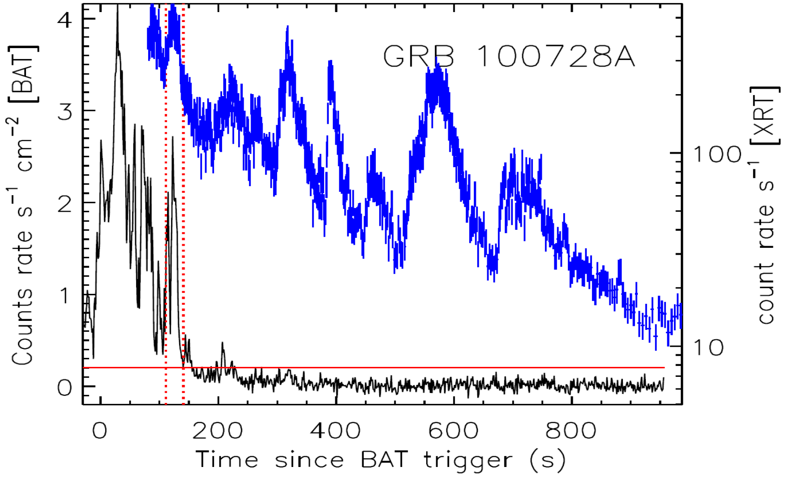


PIs: Shuang-Nan Zhang (IHEP), Xin Wu (UniGe); launch in 2027

POLAR-2 to measure polarization of GRB & X-ray flares simultaneously

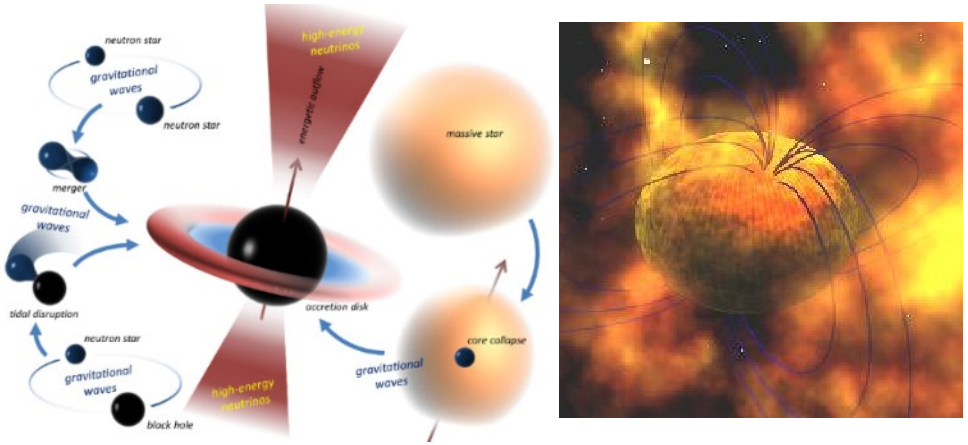
Unresolved GRB problems:

- Central engine and its evolution?
- Jet geometry and magnetic field topology?
- Particle acceleration and radiation in jet?



Simultaneous GRB and X-ray flare polarimetry may answer:

- Are the central engine, magnetic field topology and radiation mechanism the same between GRBs and X-ray flares?
- Is polarization evolution during a GRB common among GRBs?

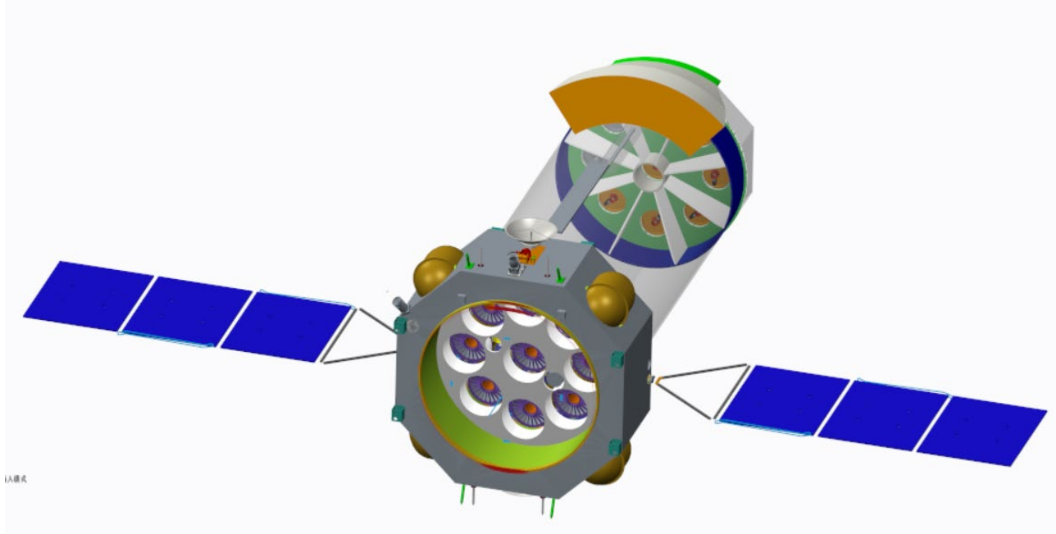


Super accretion BH/NS

Magnetar

POLAR-2 will also provide GRB triggers to HERD in real time.

eXTP: enhanced X-ray Timing and Polarimetry Observatory



Observatory for X-ray Timing-Spectro-Polarimetry

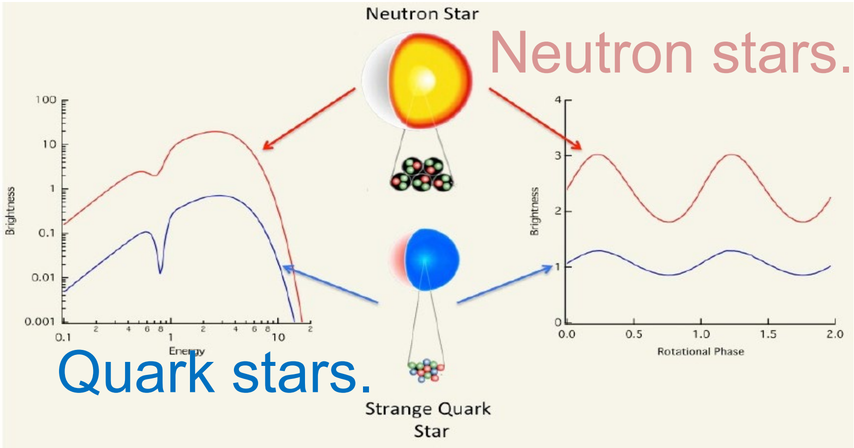
- Key Sciences
  - Extreme gravity, magnetism, density
  - Neutron stars, black holes, etc
- Mission Profile
  - Orbit：610 km, inclination 20°
  - Weight：4.2 T; Launcher：CZ-7
  - Approved for launch in 2030

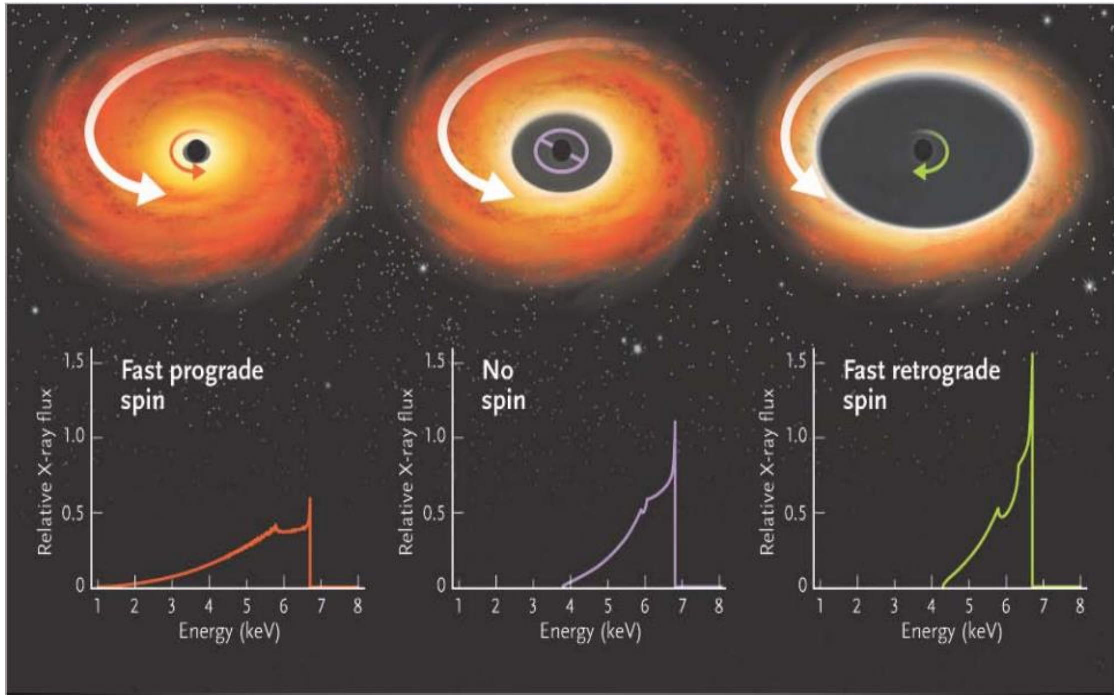
Main Payload	Configuration	**Eff. area**
Spectroscopy Focusing Array (SFA): 0.5-10 keV	**6 telescopes (5.25 m fl)**	**>0.3m²@6keV**
Polarimetry Focusing Array (PFA): 2-10 keV	**3 telescopes (5.25 m fl)**	**>350cm²@2keV**
Wide-field Wide-band Camera (W2C): 30-300 keV	**coded mask imager**	**160cm²@60keV**

The largest X-ray telescope array with unprecedented and simultaneous timing, spectroscopy and polarization capabilities to study black holes, neutron stars and extreme physics.

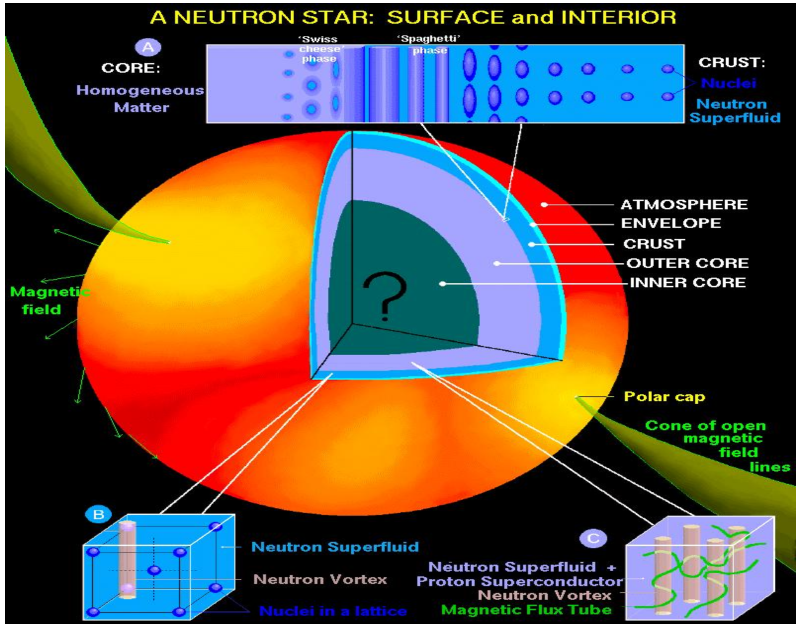
eXTP's “Last Three Extremes” Scientific Objectives.

- Unprecedented capabilities reveal the physical laws under extreme conditions: matter in the intense gravitational field of a black hole or on the surface and core of a neutron star.
- "One Singularity, Two Stars, Three Extremes": Understanding the physical laws of **three extremes (gravity, magnetic field, and density)** through observing black holes, neutron stars/quark stars.





Extreme gravitational effects near black holes.



Vacuum fluctuations, neutrons, or quarks?

Six NEW eXTP White Papers on arXiv astro-ph on 2025.06.11

arXiv:2506.08101 [pdf, ps, other] astro-ph.HE astro-ph.IM

The enhanced X-ray Timing and Polarimetry mission -- eXTP for launch in 2030

Authors: Shuang-Nan Zhang, Andrea Santangelo, Yupeng Xu, Hua Feng, Fangjun Lu, Yong Chen, Mingyu Ge, Kirpal Nandra, Xin Wu, Marco Feroci, Margarita Hernanz, Congzhan Liu, Huilin He, Yusa Wang, Weichun Jiang, Weiwei Cui, Yanji Yang, Juan Wang, Wei Li, Xiaohua Liu, Bin Meng, Xiangyang Wen, Aimei Zhang, Jia Ma, Maoshun Li , et al. (136 additional authors not shown)

arXiv:2506.08104 [pdf, ps, other] astro-ph.HE astro-ph.SR hep-ph nucl-th

Dense Matter in Neutron Stars with eXTP

Authors: Ang Li, Anna L. Watts, Guobao Zhang, Sebastien Guillot, Yanjun Xu, Andrea Santangelo, Silvia Zane, Hua Feng, Shuang-Nan Zhang, Mingyu Ge, Liqiang Qi, Tuomo Salmi, Bas Dorsman, Zhiqiang Miao, Zhonghao Tu, Yuri Cavecchi, Xia Zhou, Xiaoping Zheng, Weihua Wang, Quan Cheng, Xuezhi Liu, Yining Wei, Wei Wang, Yujing Xu, Shanshan Weng , et al. (58 additional authors not shown)

arXiv:2506.08105 [pdf, ps, other] astro-ph.HE gr-qc

Probing the Strong Gravity Region of Black Holes with eXTP

Authors: Qingcui Bu, Cosimo Bambi, Lijun Gou, Yanjun Xu, Phil Uttley, Alessandra De Rosa, Andrea Santangelo, Silvia Zane, Hua Feng, Shuang-Nan Zhang, Chichuan Jin, Haiwu Pan, Xinwen Shu, Francesco Ursini, Yanan Wang, Jianfeng Wu, Bei You, Yefei Yuan, Wenda Zhang, Stefano Bianchi, Lixin Dai, Tiziana Di Salvo, Michal Dovciak, Yuan Feng, Hengxiao Guo , et al. (18 additional authors not shown)

arXiv:2506.08369 [pdf, ps, other] astro-ph.HE

Physics of Strong Magnetism with eXTP

Authors: Mingyu Ge, Long Ji, Roberto Taverna, Sergey Tsygankov, Yanjun Xu, Andrea Santangelo, Silvia Zane, Shuang-Nan Zhang, Hua Feng, Wei Chen, Quan Cheng, Xian Hou, Matteo Imbrogno, Gian Luca Israel, Ruth Kelly, Ling-Da Kong, Kuan Liu, Alexander Mushtukov, Juri Poutanen, Valery Suleimanov, Lian Tao, Hao Tong, Roberto Turolla, Weihua Wang, Wentao Ye , et al. (24 additional authors not shown)

arXiv:2506.08368 [pdf, ps, other] astro-ph.HE astro-ph.CO astro-ph.GA

Prospects for Time-Domain and Multi-Messenger Science with eXTP

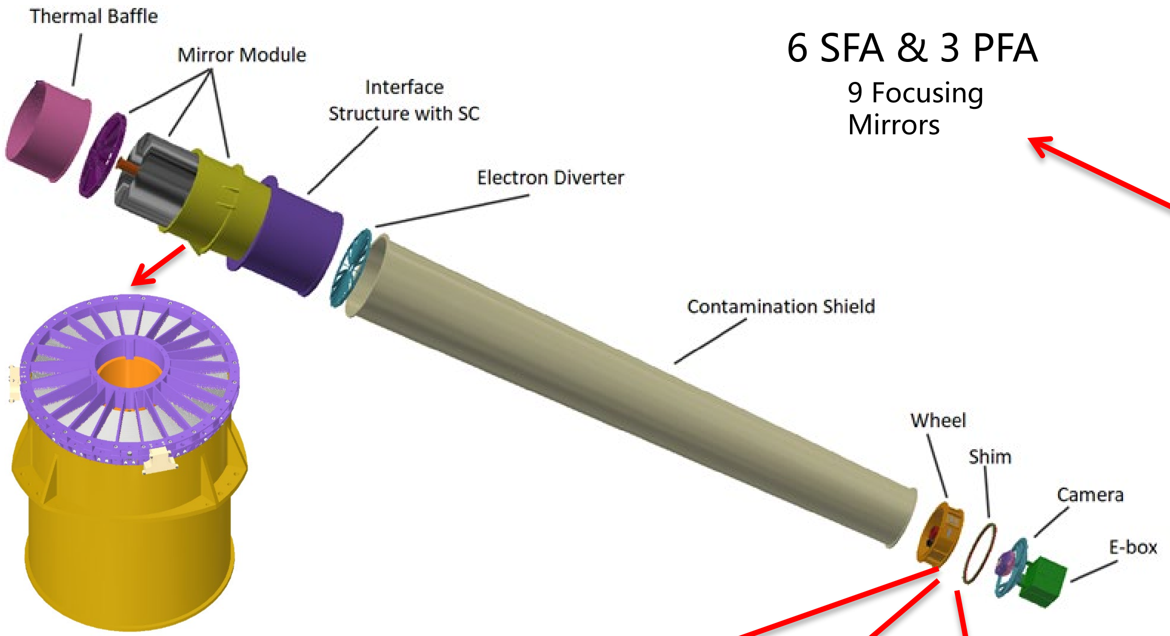
Authors: Shu-Xu Yi, Wen Zhao, Ren-Xin Xu, Xue-Feng Wu, Giulia Stratta, Simone Dall'Osso, Yan-Jun Xu, Andrea Santangelo, Silvia Zane, Shuang-Nan Zhang, Hua Feng, Huan Yang, Junjie Mao, Junqiang Ge, Lijing Shao, Mi-Xiang Lan, He Gao, Lin Lin, Ning Jiang, Qingwen Wu, Tong Liu, Yun-Wei Yu, Xiang-Yu Wang, Jin Zhang, Dafne Guetta , et al. (49 additional authors not shown)

arXiv:2506.08367 [pdf, ps, other] astro-ph.IM astro-ph.GA astro-ph.HE astro-ph.SR

Observatory Science with eXTP

Authors: Ping Zhou, Jirong Mao, Liang Zhang, Alessandro Patruno, Enrico Bozzo, Yanjun Xu, Andrea Santangelo, Silvia Zane, Shuang-Nan Zhang, Hua Feng, Yuri Cavecchi, Barbara De Marco, Junhui Fan, Xian Hou, Pengfei Jiang, Patrizia Romano, Gloria Sala, Lian Tao, Alexandra Veledina, Jacco Vink, Song Wang, Junxian Wang, Yidi Wang, Shanshan Weng, Qingwen Wu , et al. (75 additional authors not shown)

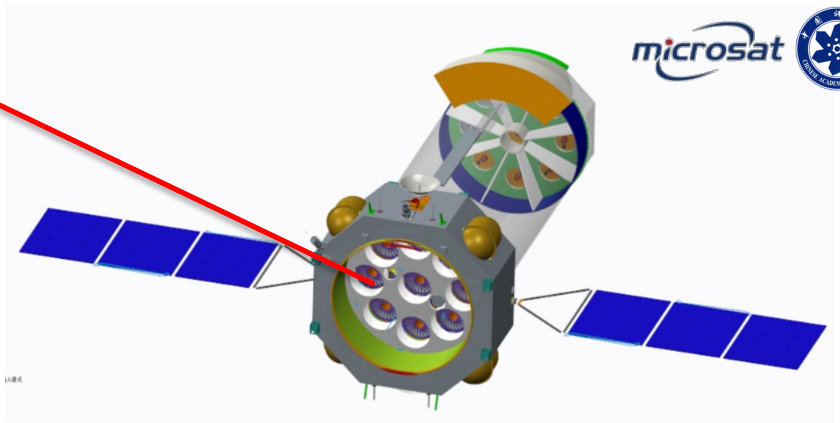
eXTP Payload Configuration

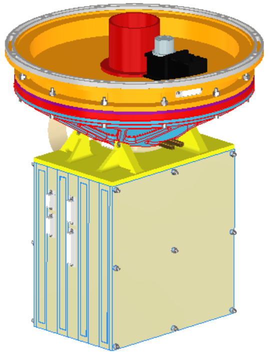


Mirror Assembly (9)

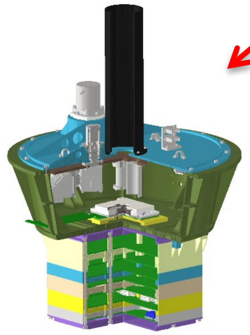
6 SFA & 3 PFA

9 Focusing Mirrors

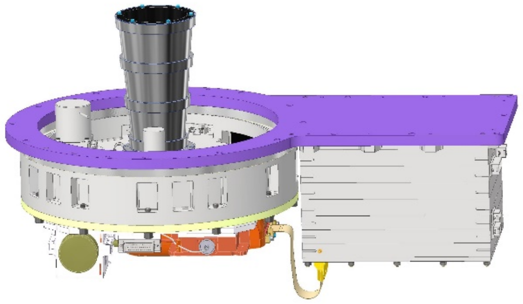




SFA-T Focal Plane Camera (5)



PFA Focal Plane Camera (3)



SFA-I Focal Plane Camera (1)

- The centers of the fields of view for SFA and PFA are aligned, recording X-ray photons from the target;
- The selection of target sources and necessary follow-up observations are achieved by adjusting the satellite's attitude.

W2C: Wide-field Wide-energy band Camera

Table 7 W2C specifications

Field of View	Full coding: 49° × 9.6° Half coding: 60° × 16° FWZR: 68° × 22°
Angular Resolution	∼20′ @ 30-100 keV
Positioning Accuracy	∼5′ @ 30-100 keV
Effective Area	∼160cm^2 @ 60keV (normal incidence)
Sensitivity	$\sim 4 \times 10^{-7}$ erg· cm^{-2}· s^{-1} @ 10–1000 keV in 1 s
Energy Range	30–600 keV
Energy Resolution	≤30% @ 60keV
Time Resolution	≤25 μs

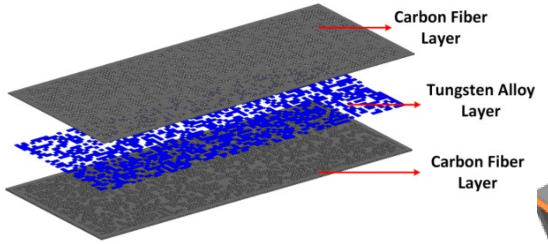


Figure 16 Design of the the coded-aperture mask plate of W2C.

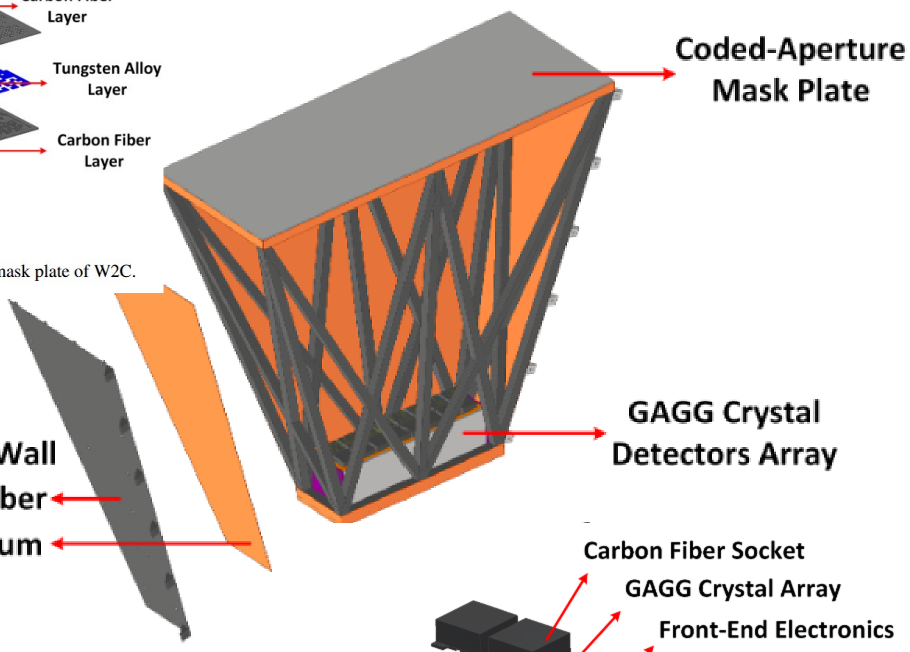


Figure 15 Schematic drawing coded-aperture mask plate, GAG end electronics.

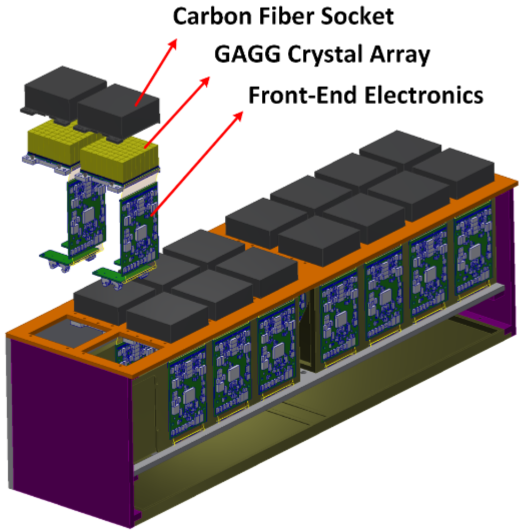
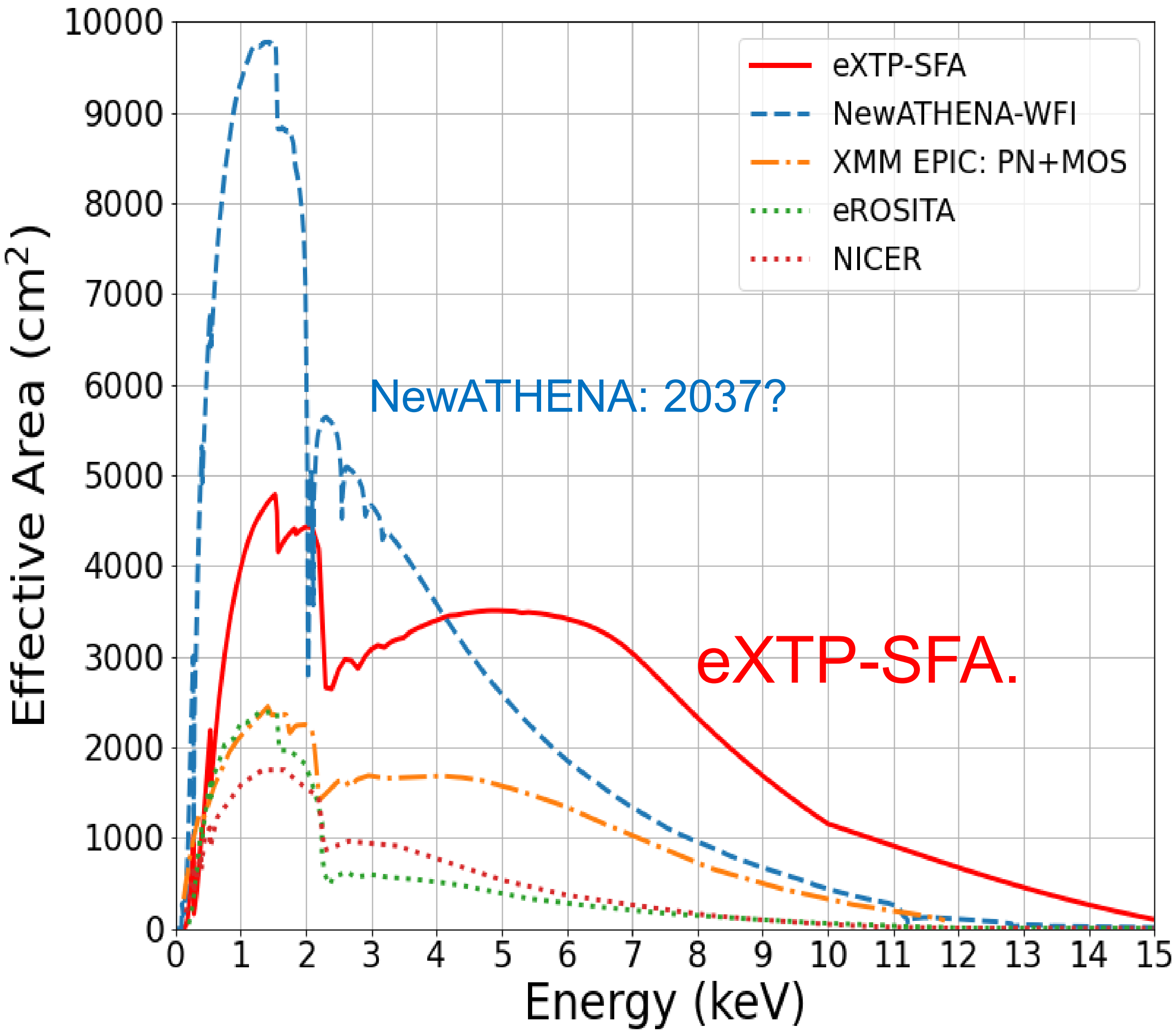
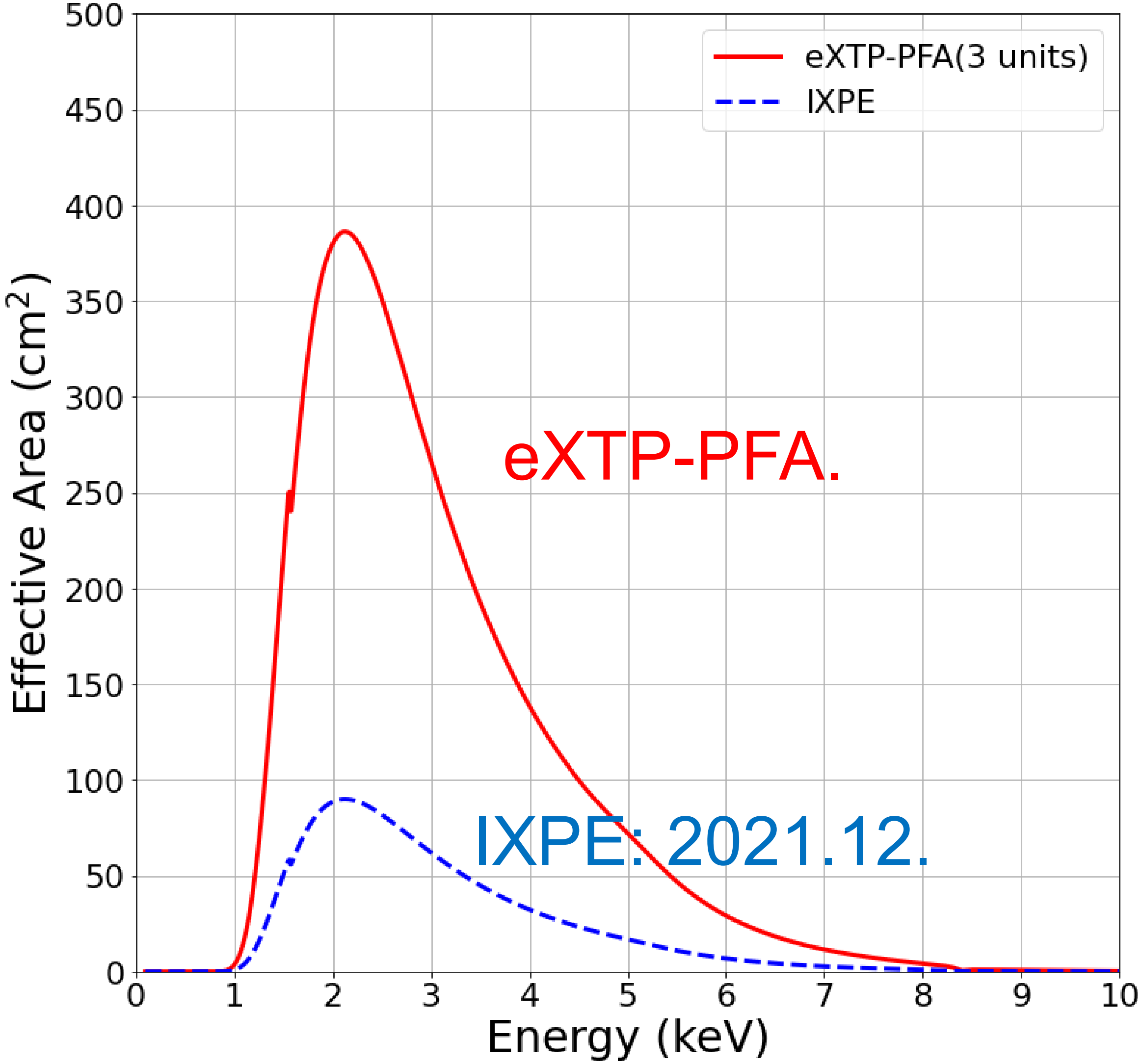


Figure 17 Schematic diagram of the GAGG crystal detector array of W2C.

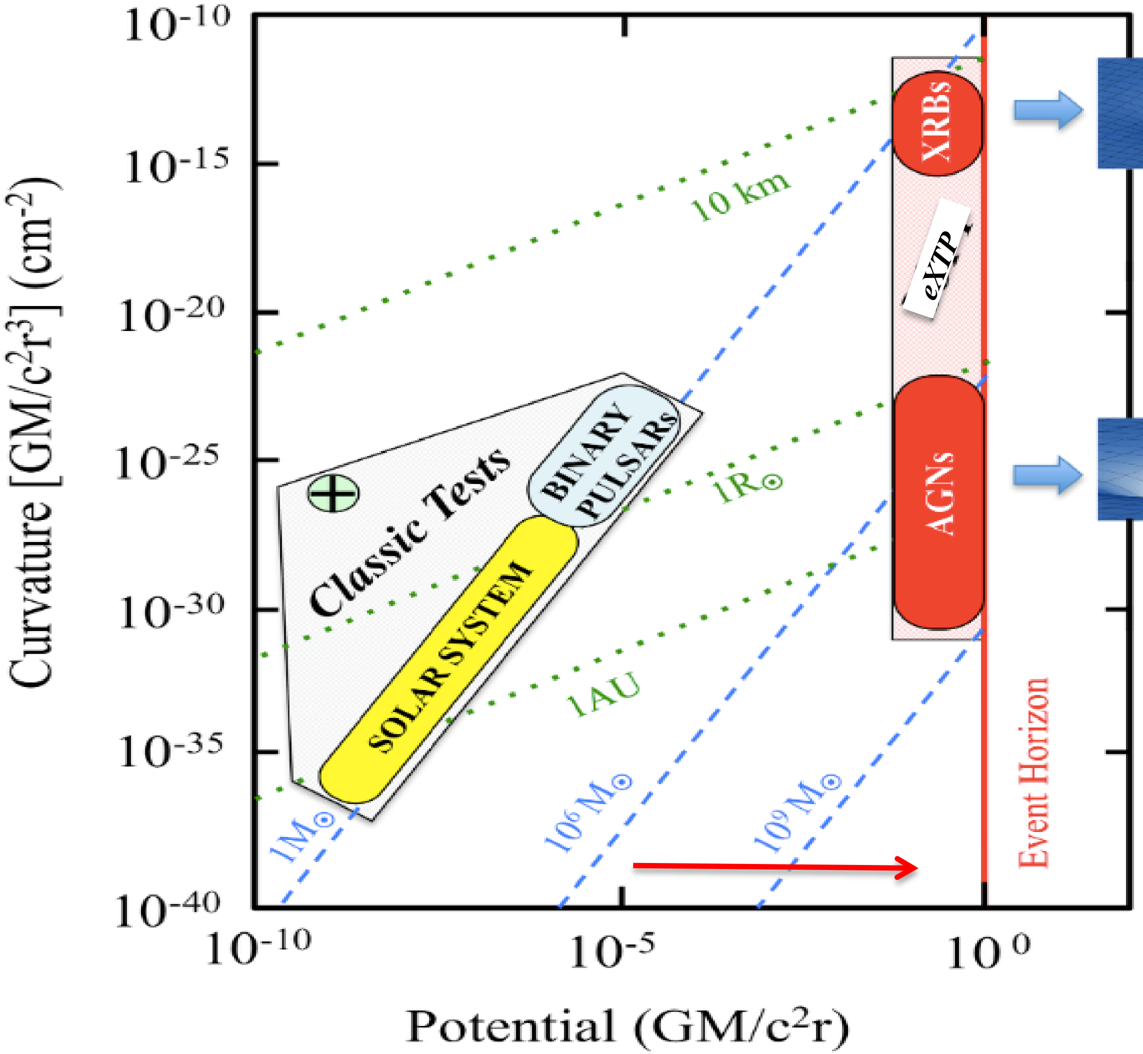
Code-mask imager (similar to SVOM/Eclairs)
Adapted from POLAR-2/BSD

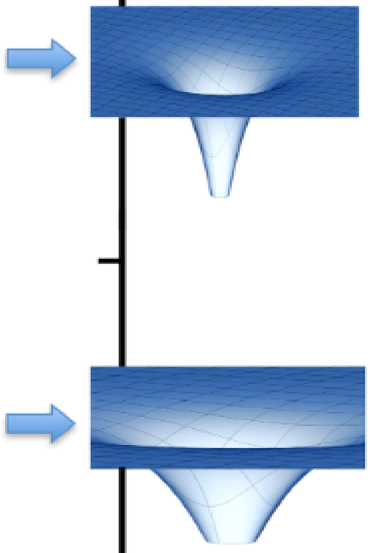
eXTP SFA and PFA effective area





Extreme Universe 5: Extreme Gravity Near Black Holes!



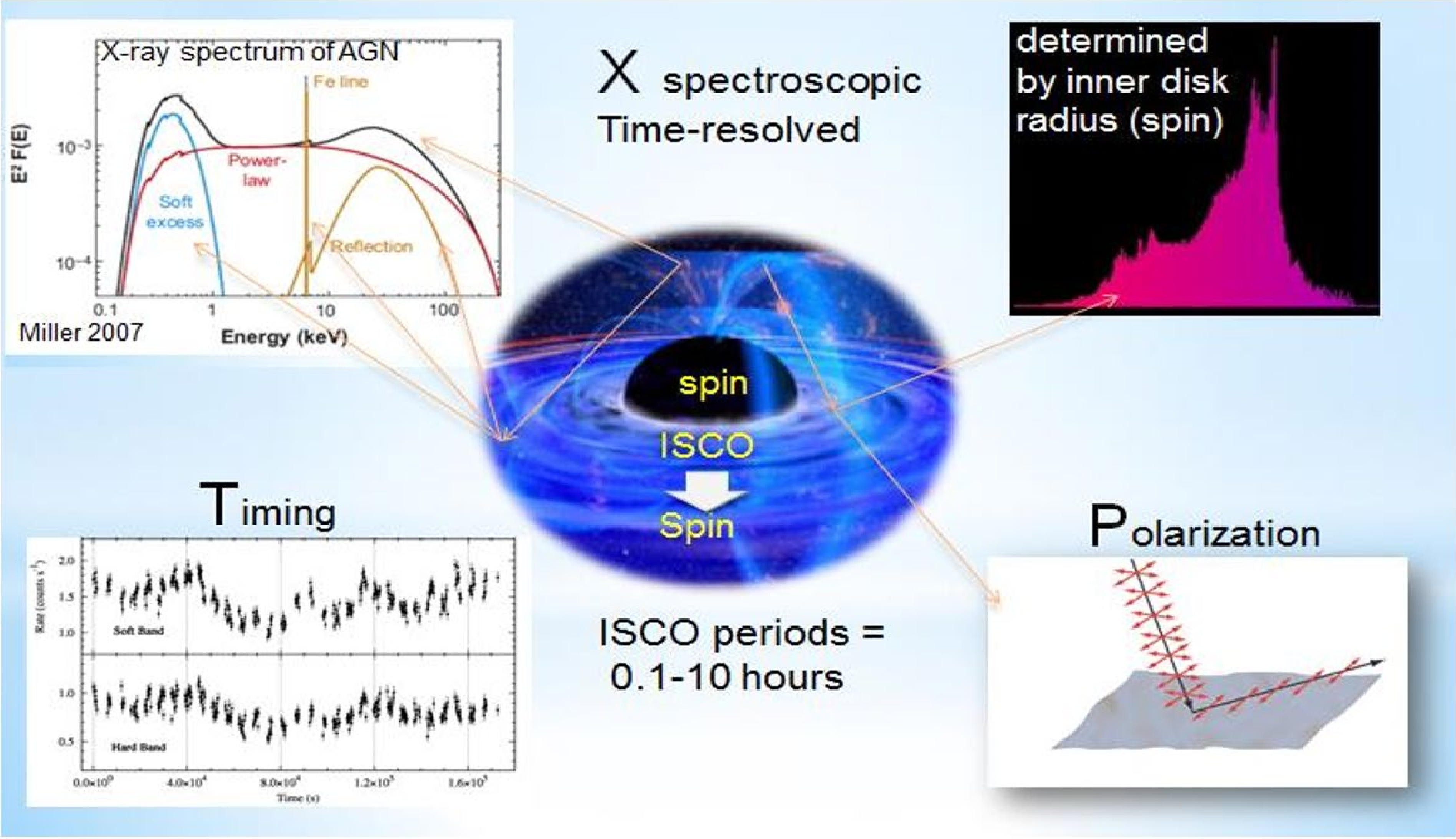


Covers a space curvature 10^{12} times greater

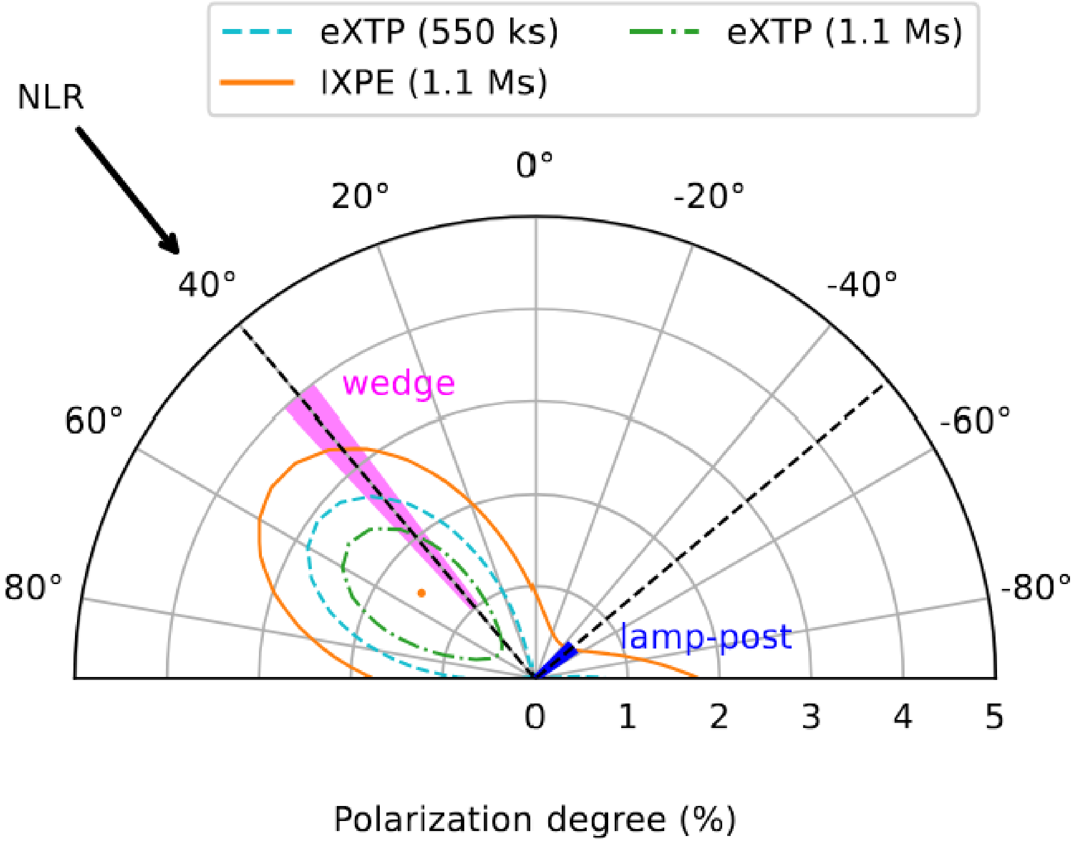
Covers gravitational field strength 10^5 times greater

The extreme gravity near black holes is a billion times stronger than Earth's gravity and has a space curvature a quadrillion times higher than Earth's.

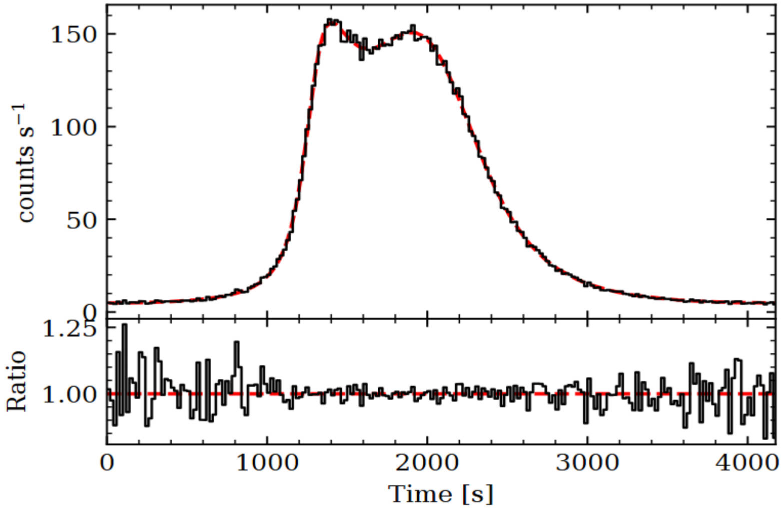
Spectro-timing-polarimetry: Extreme gravity in black hole accretion systems

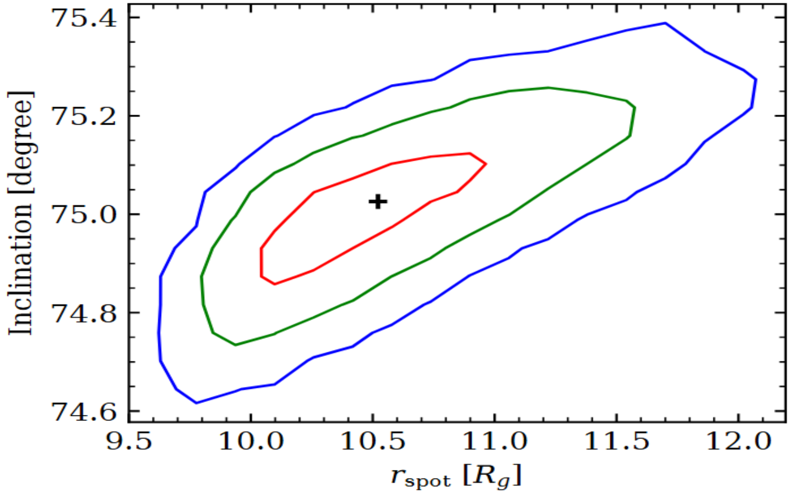


Spectro-Polarimetric Measurements to Study the Hot Corona Around BHs



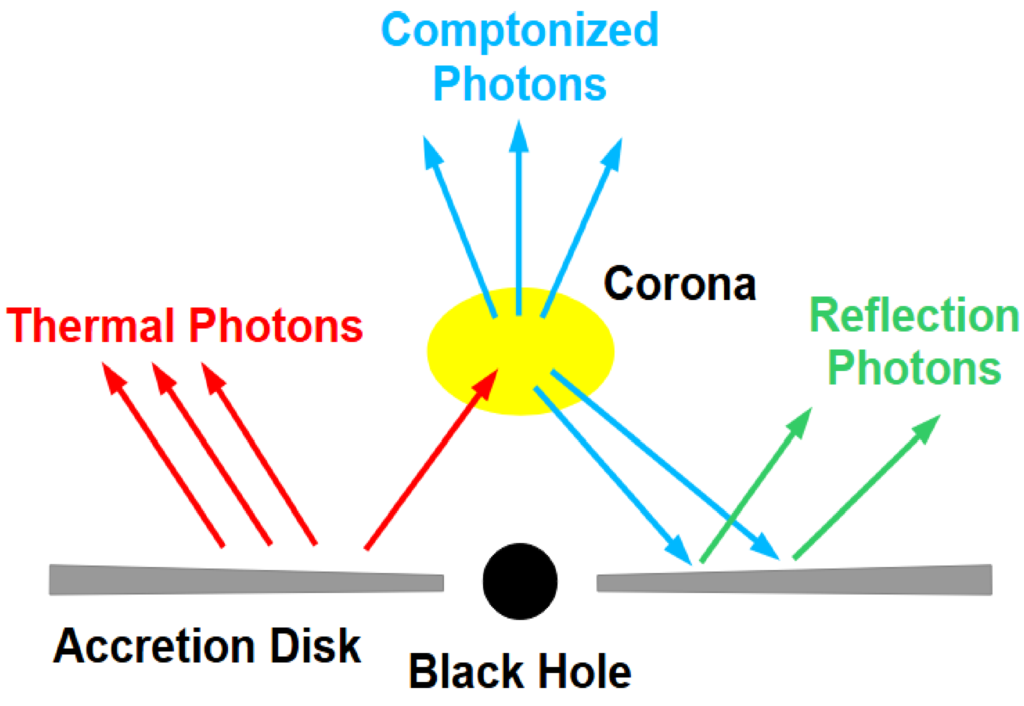
eXTP's Results on the Structure of the Hot Corona Near the Black Hole in the Active Galactic Nucleus MCG-5-23-16

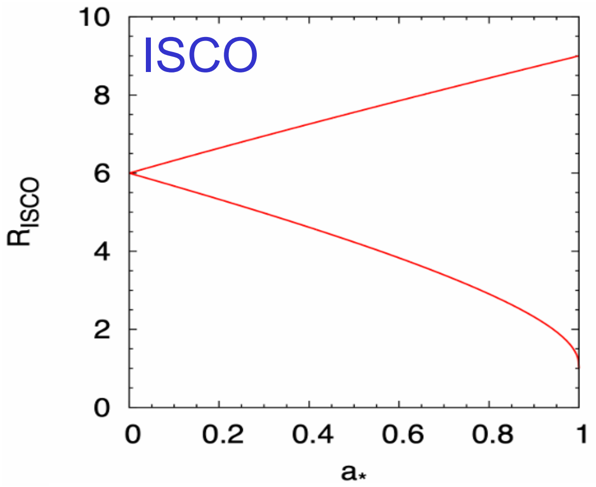


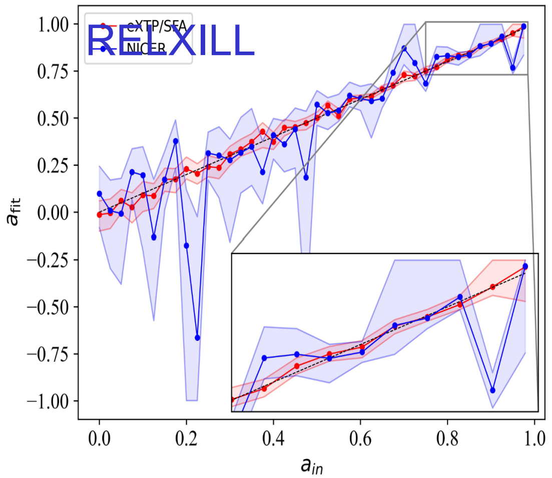


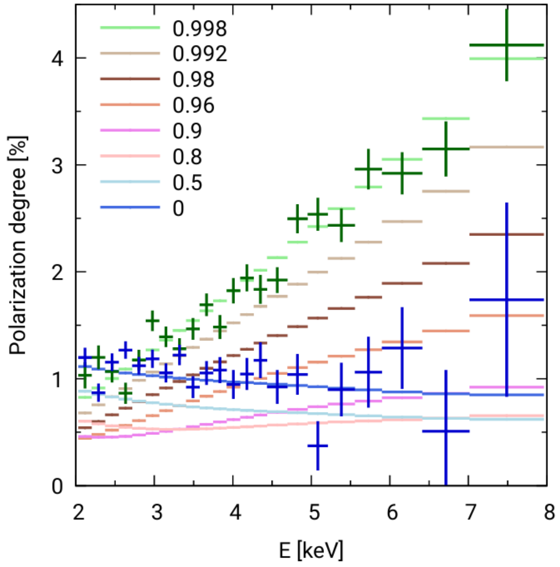
eXTP's High-Precision Reverberation Mapping Observations of X-ray Variability in a Typical Active Galactic Nucleus

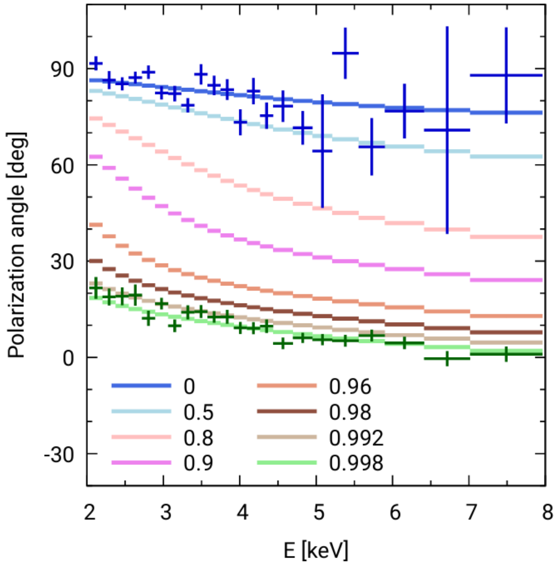
Measuring BH Spin with Spectral-Polarization and Iron Line Methods





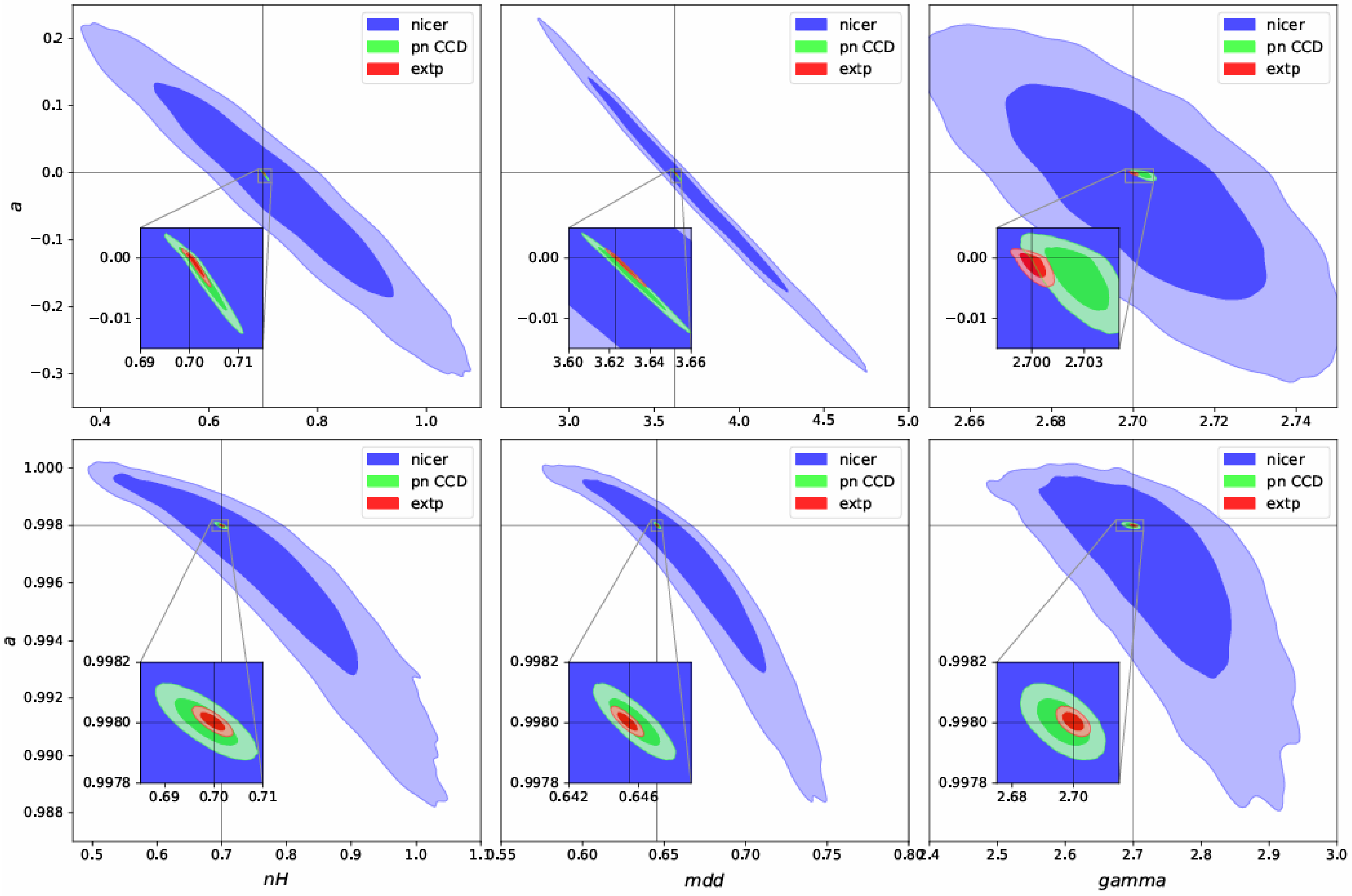






The spectral-polarization method complements and cross-verifies the continuum fitting and iron line methods proposed S.N. Zhang and Fabian for measuring black hole spin.

Measuring BH Spin Using the Continuum Fitting Method



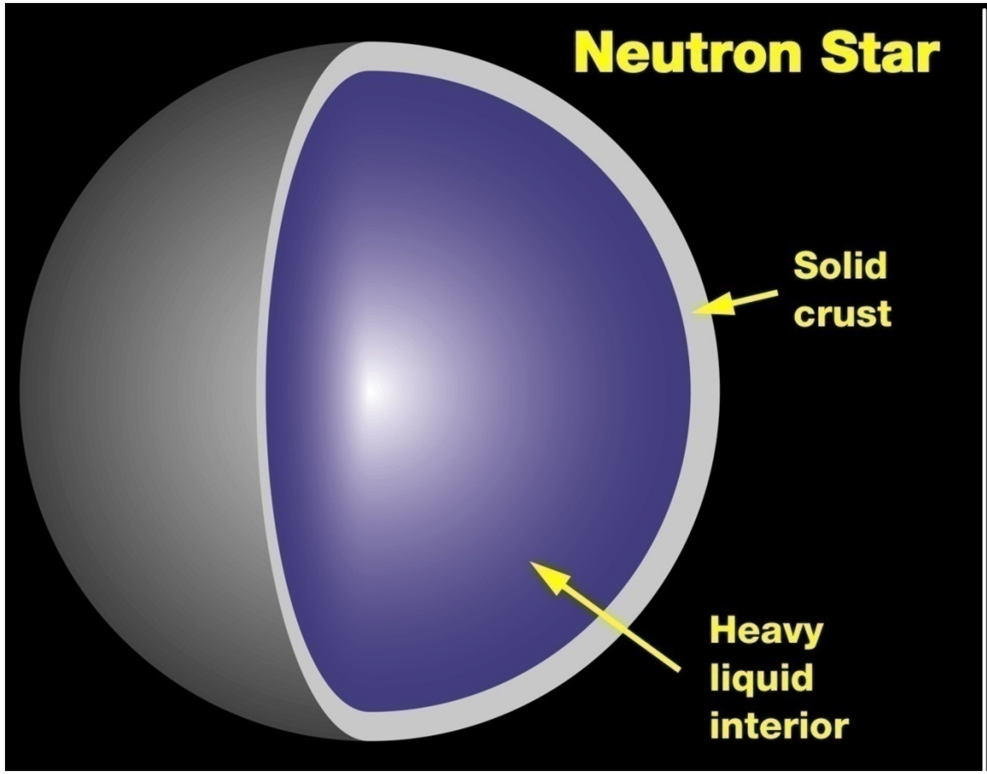
Kerrbb: Continuum Fitting

SFA-T(5×SDD)+

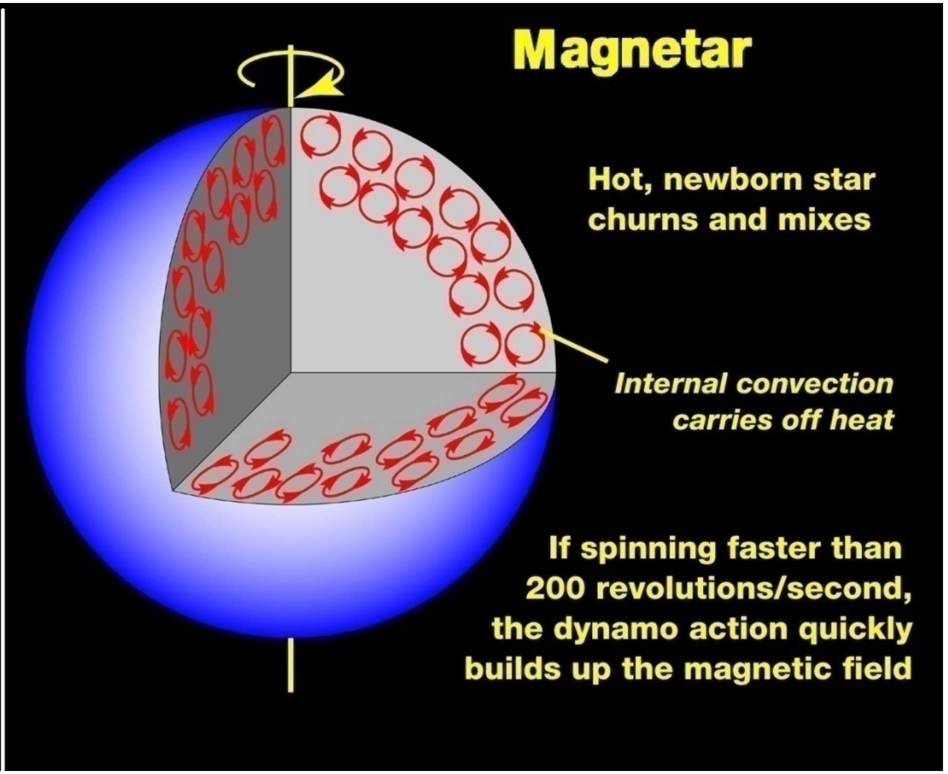
SFA-I(1×pnCCD)

Compared to the NICER on the International Space Station, significantly improves the precision of black hole spin measurements.

Test the predictions of quantum electrodynamics under extreme B-field



Ordinary neutron star
Surface stable magnetic field ~10^{4-9} T

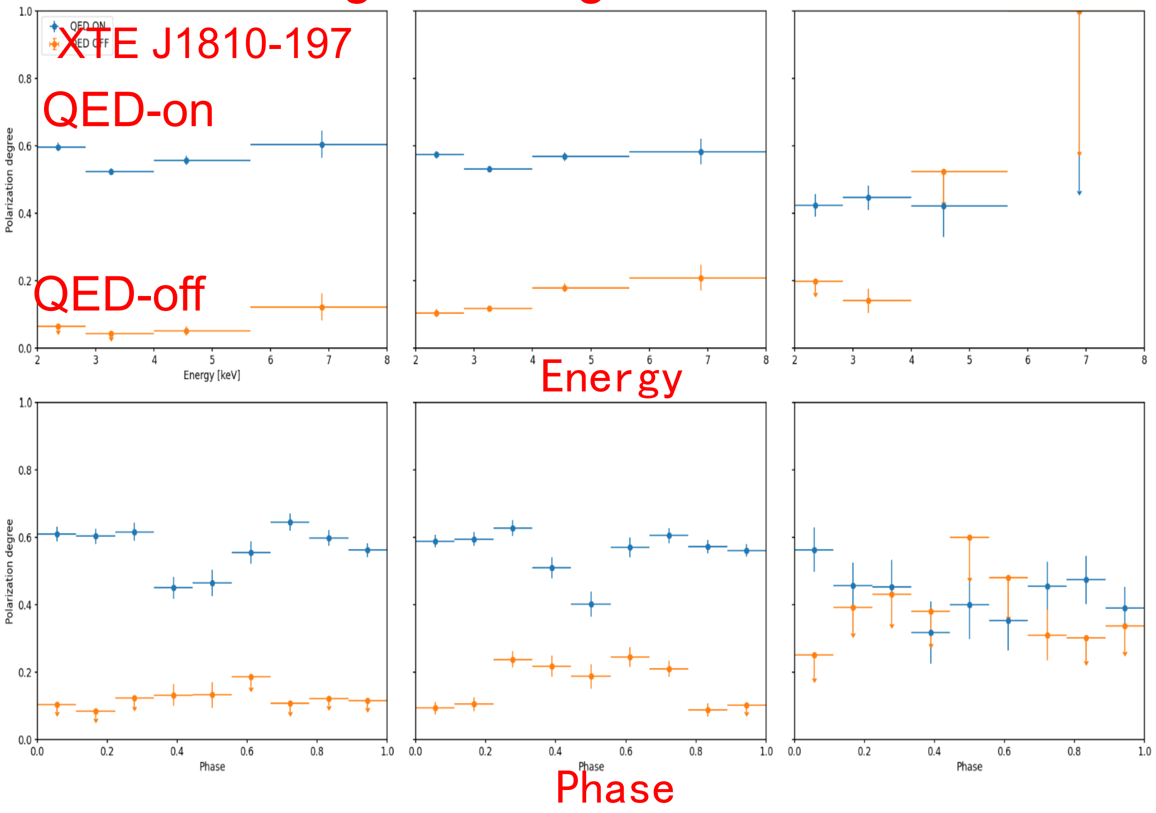


Magnetar
Surface stable magnetic field ~10^{10} T

Earth's surface stable magnetic field ~10^{-4} T, strongest stable magnetic field in the laboratory ~10 T

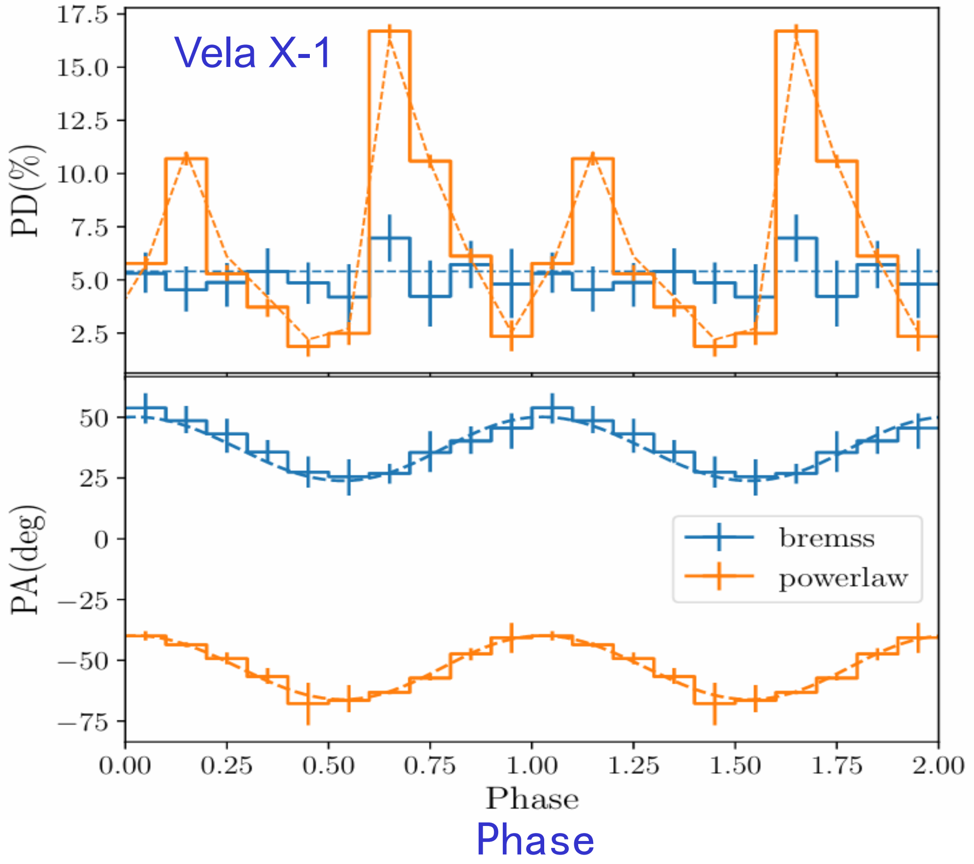
Quantum Electrodynamics Effects Under Extreme B-Field Conditions

Evolution of Polarization Degree in Three Stages of Magnetar Outbursts



Differences in polarization between magnetars and ordinary NSs: birefringence effects caused by vacuum fluctuations leading to changes in X-ray polarization with NS rotation

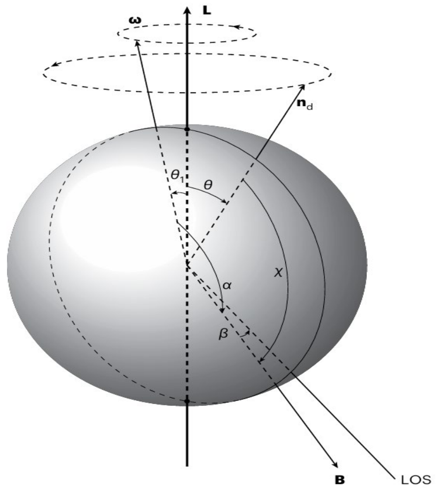
Precisely Measure Changes in Polarization with Phase

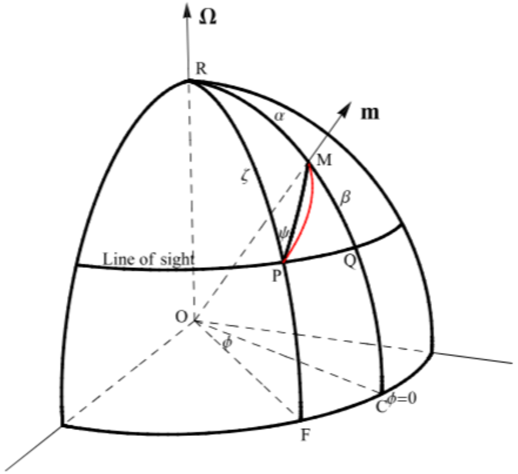


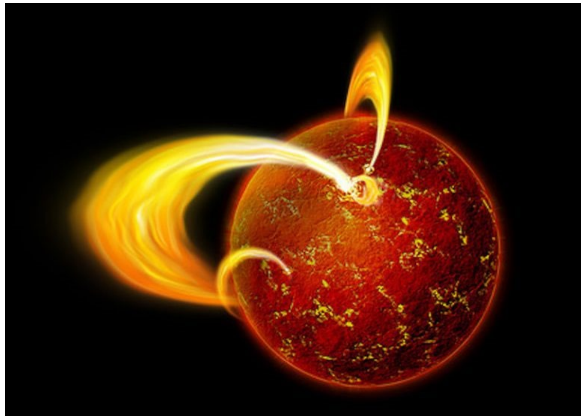
Distinguish different spectral models to understand the radiation mechanisms of strongly magnetized accreting pulsars

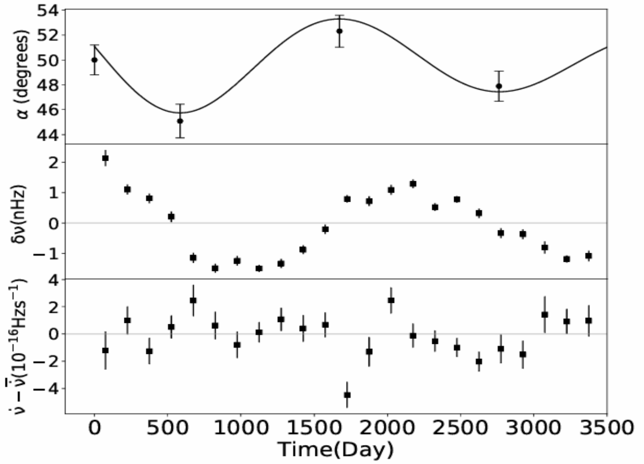
Quantum Electrodynamics Effects under Extreme B-Field Conditions

- Free Precession
- Magnetic Field Structure
- Burst Activity

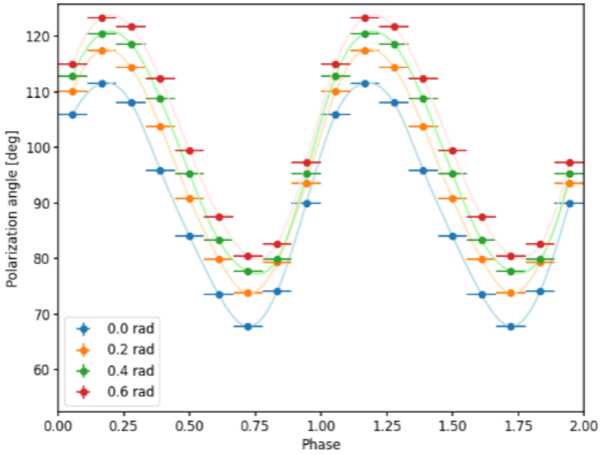




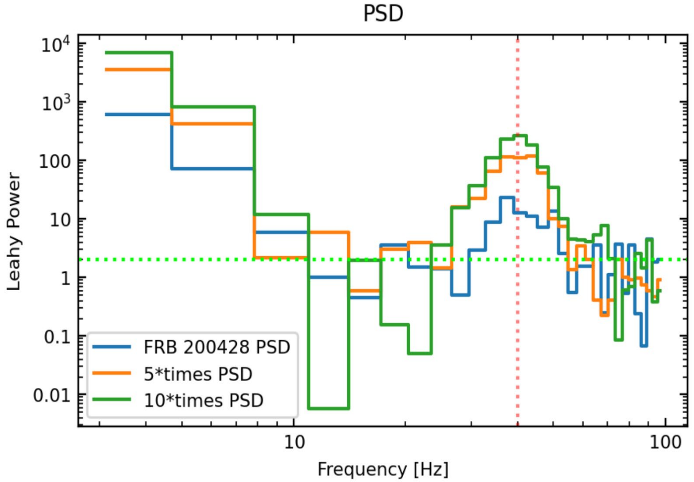




Timing Measurements of Free Precession Signals

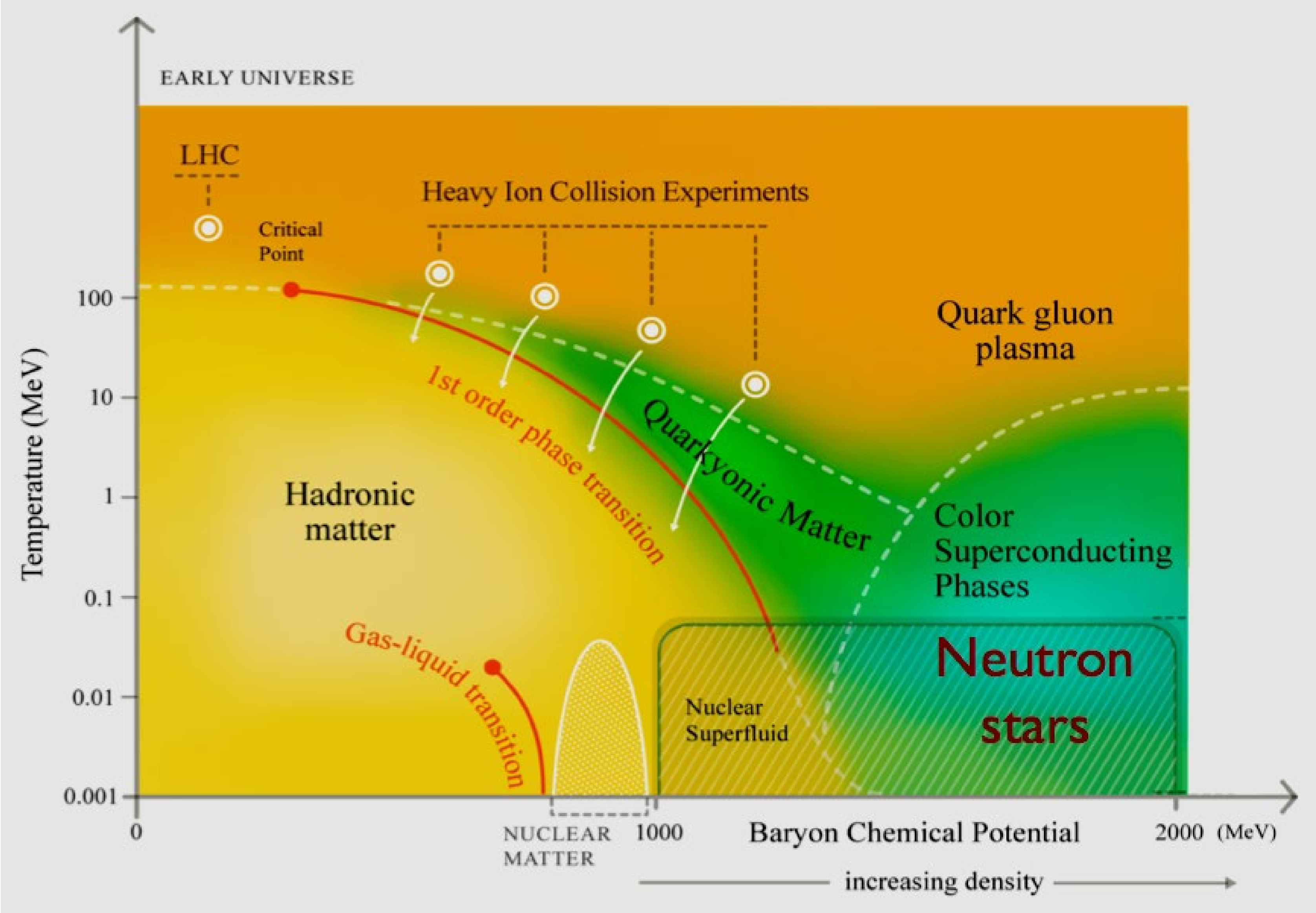


Polarization Measurements of Magnetic Field Distortion Structure

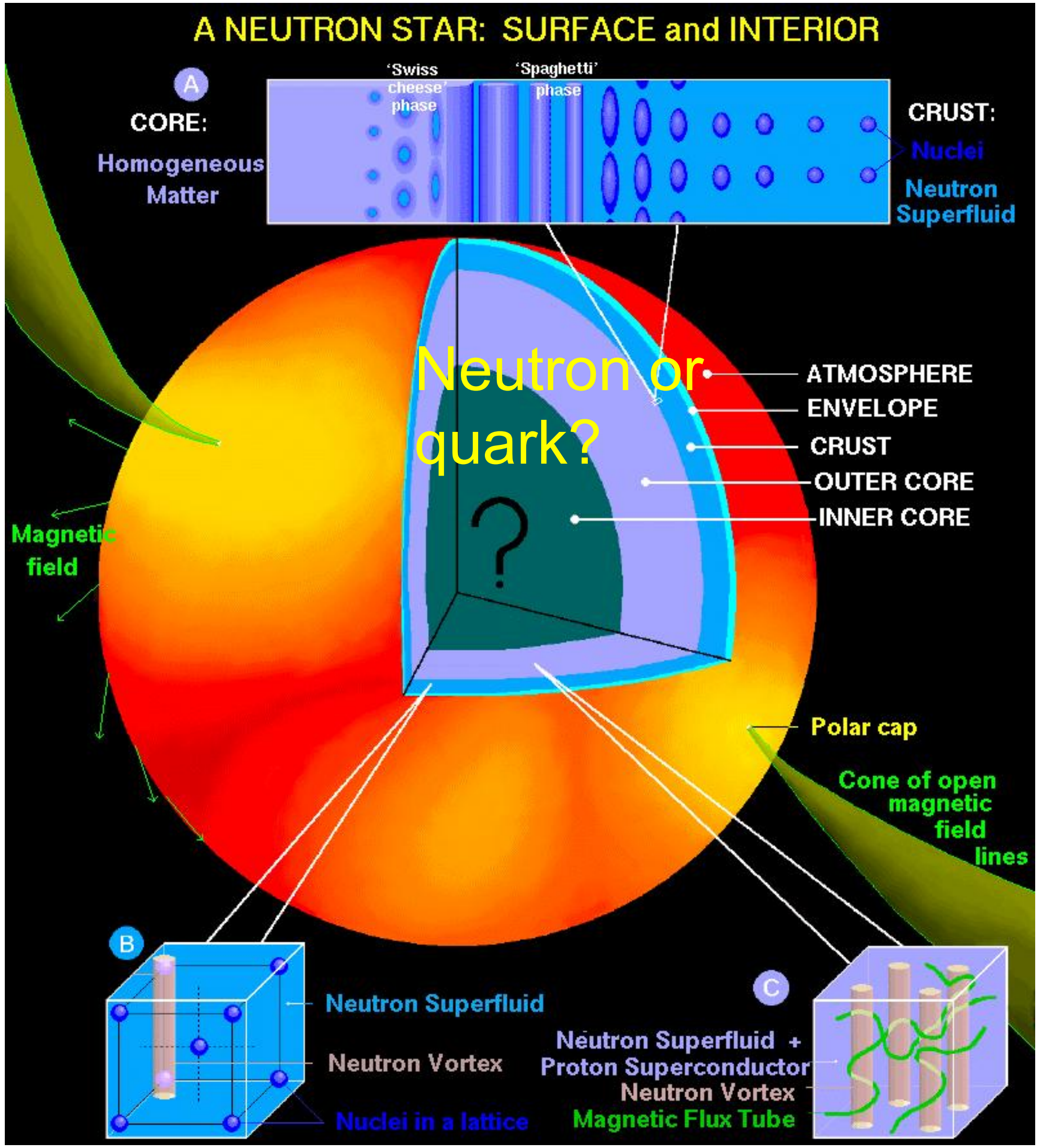


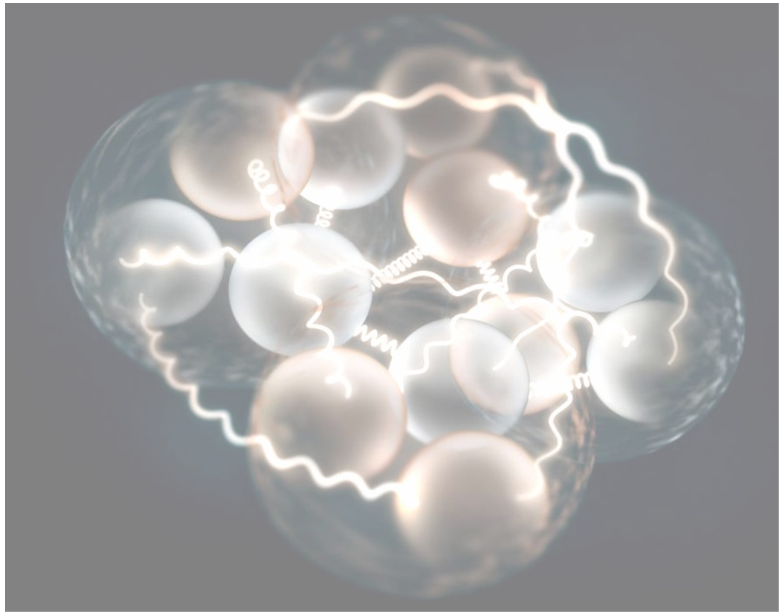
Study of Burst Mechanisms through Time-varying Burst Signals

Extreme Universe 7: Physical laws of extreme density

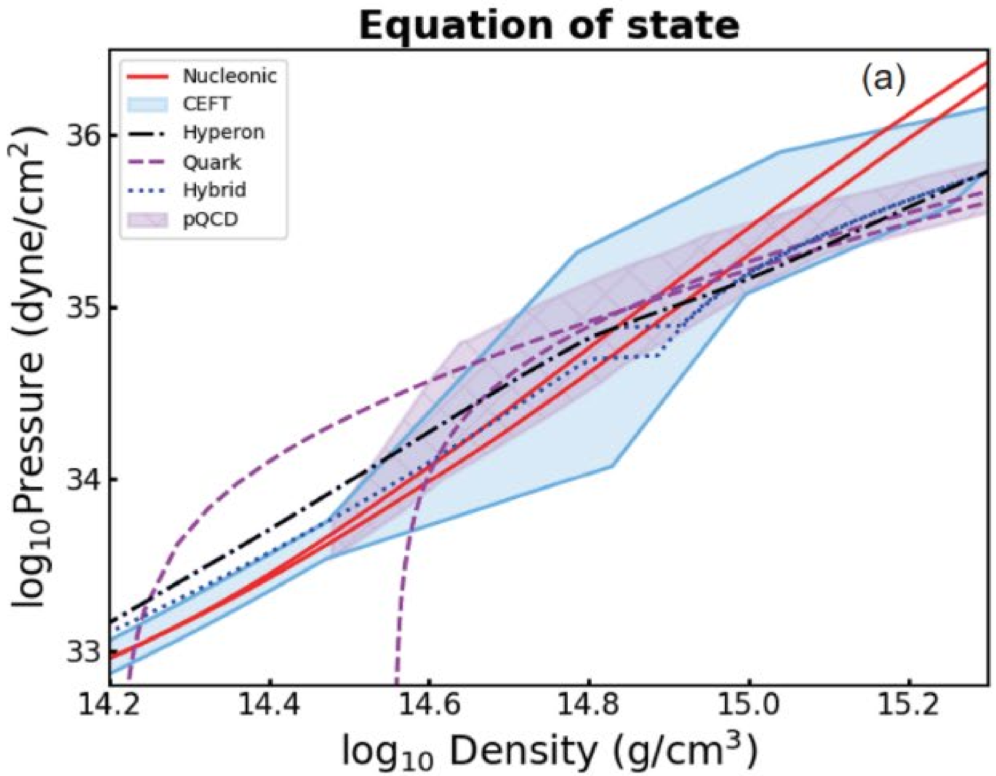


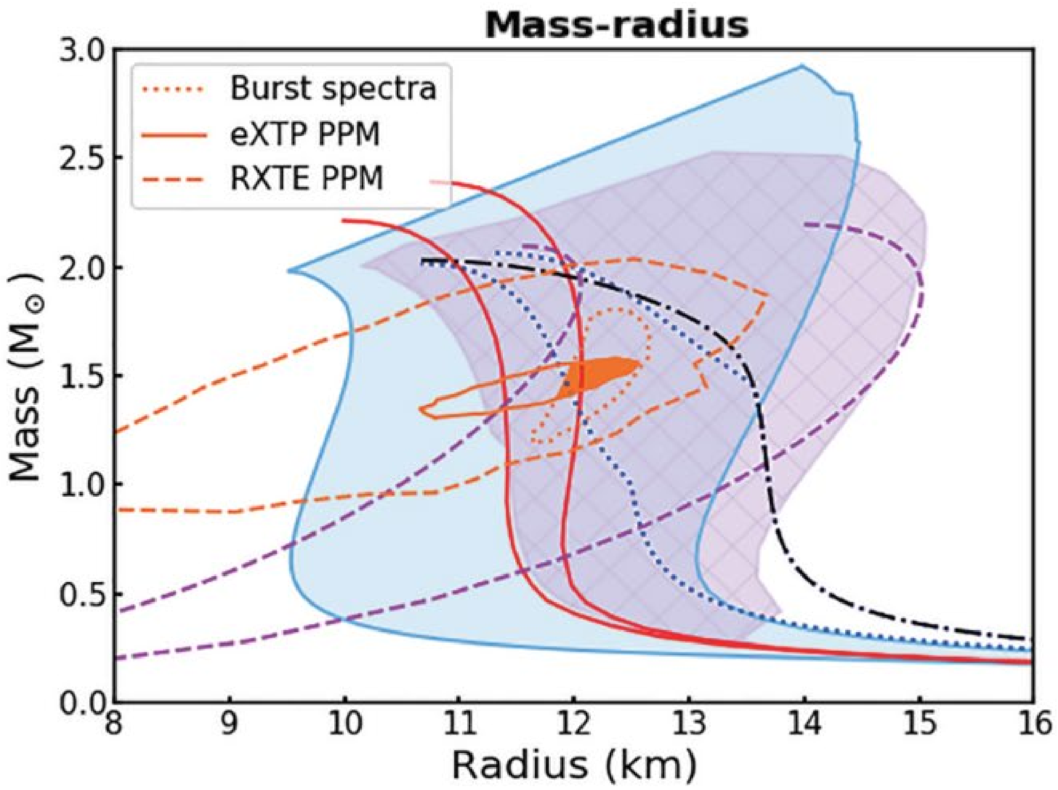
The ultimate question of extreme density: Neutron star or quark star?





Spectro-Timing-Polarimetry Study on the Equation of State of Dense Matter

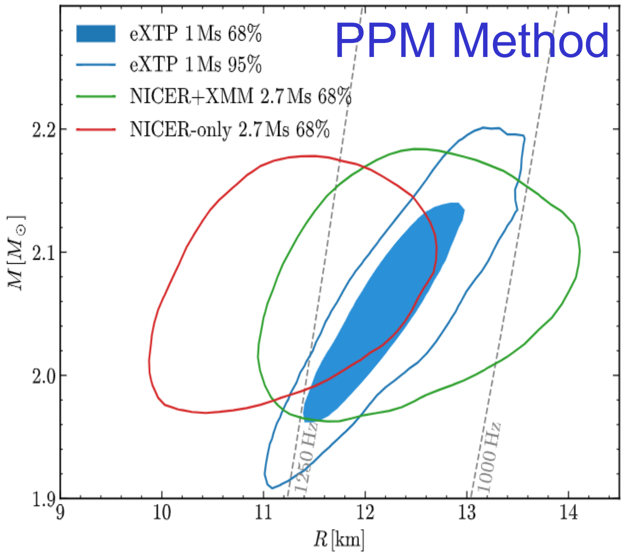


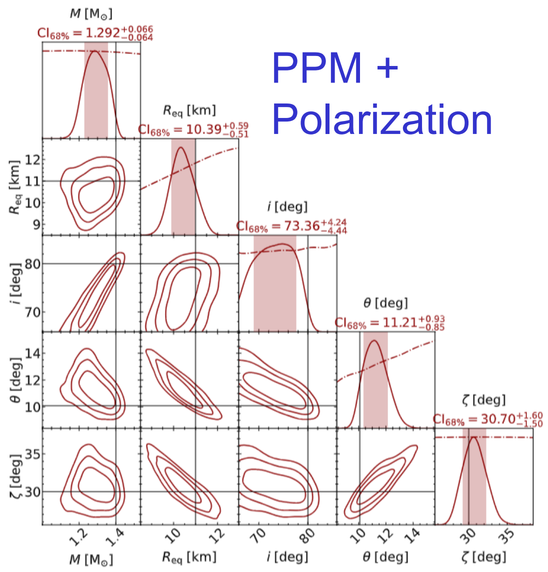


eXTP: high-precision (10%) measurements of the mass and radius of ~10 NSs

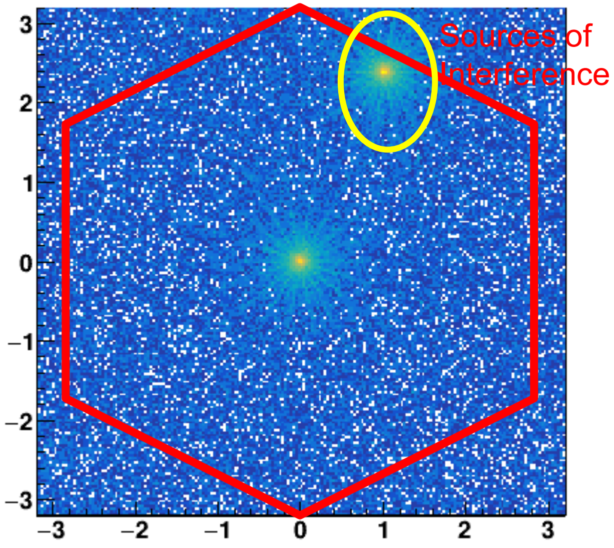
Through high-performance X-ray spectral, timing, and polarization observations, it is possible to accurately measure the mass-radius relationship of many pulsars with eXTP, potentially answering whether these extreme density celestial bodies are neutron stars or quark stars.

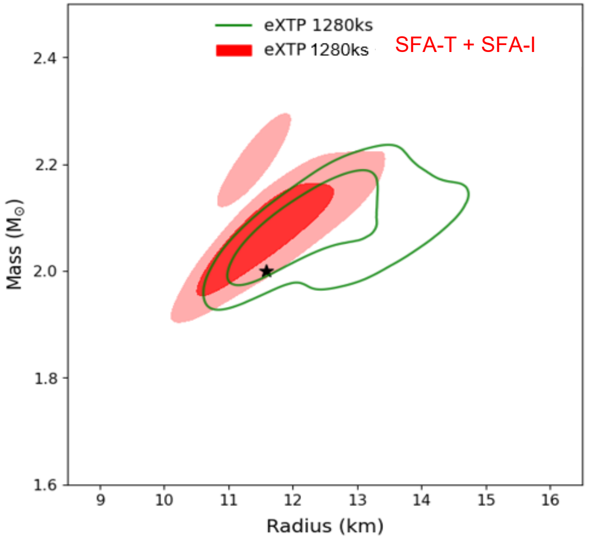
Spectro-Timing-Polarimetry Study of the Equation of State of Dense Matter

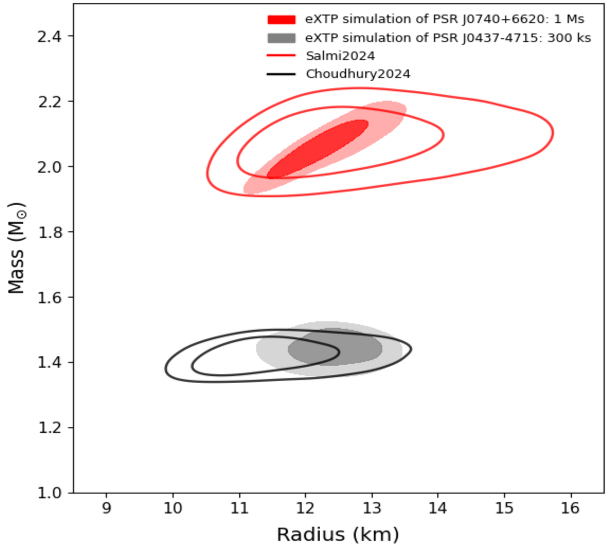




Through high-performance X-ray spectral, timing, and polarization observations, it is possible to accurately measure the mass-radius relationship of many pulsars, potentially answering whether these extreme density objects are neutron stars or quark stars.





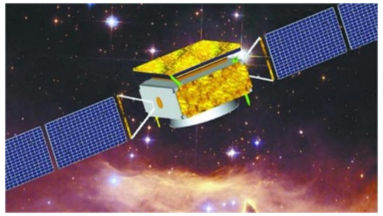


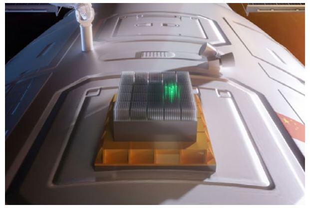
- PPM method, MR measurement accuracy better than 10%. Significantly improved over NICER results.
- pnCCD imaging and accurate background estimation are beneficial for improving MR measurements.

High-Energy Missions Exploring the Extreme Universe

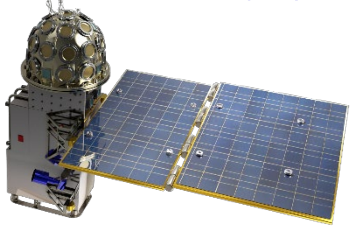
- **Wukong DAMPE# (2015)**
- **POLAR* (2016)**
- **Insight-HXMT* (2017)**
- **GECAM* (2020-)**
- **EP#(2024)**
- **SVOM# (2024)**
- **POLAR-2* (2027)**
- **HERD* (2028)**
- **eXTP* (2030)**

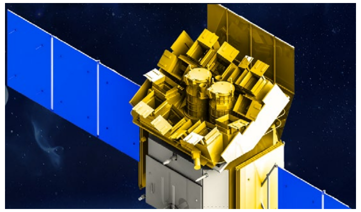
#With IHEP Instruments
*Led by IHEP

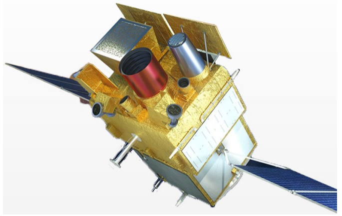

DAMPE 2015

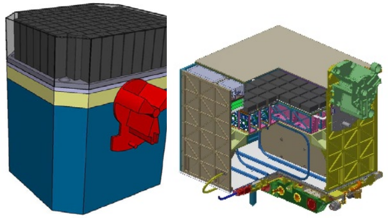

POLAR 2016

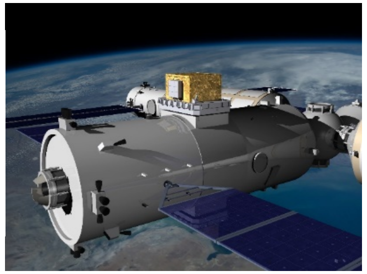

HXMT 2017

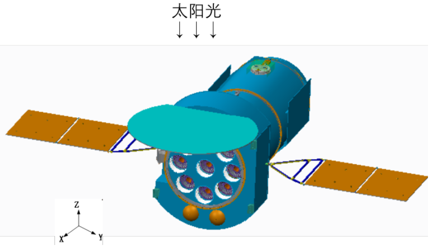

GECAM 2020-


EP 2024


SVOM 2024


POLAR-2 2027


HERD 2028



eXTP 2030

Thanks for you attention!