

# Exploring the transient X-ray sky with Einstein Probe

**Weimin Yuan**

National Astronomical Observatory of China (NAOC)  
Chinese Academy of Sciences (CAS)

On behalf of the Einstein Probe team

# Scientific drivers for future X-ray sky monitoring

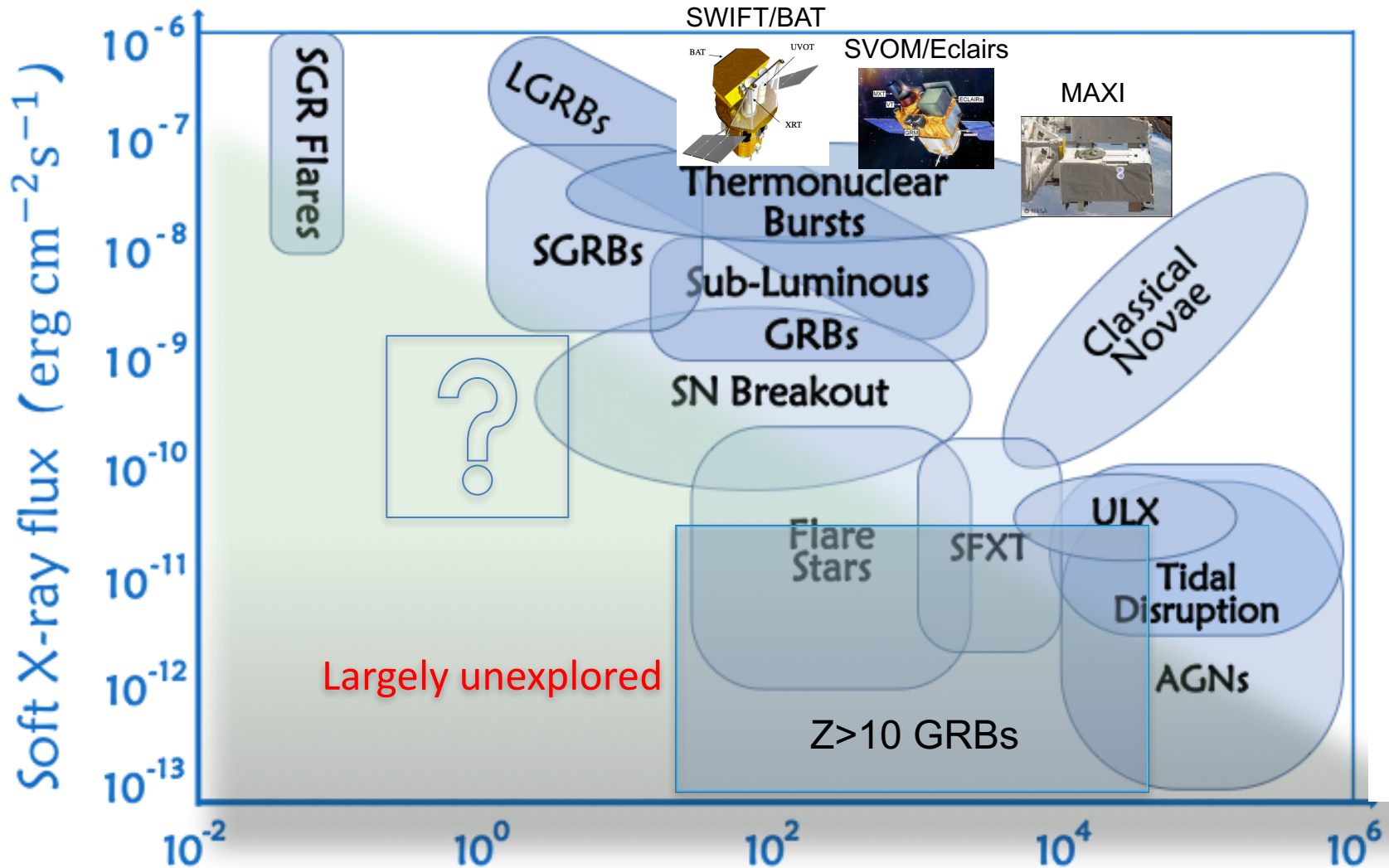
- ★ X-ray transients and variables pervade the Universe
- ★ A rich variety discovered, yet many not well understood



- ★ New phenomena continue to be discovered and appeal for observational characterisation on a large scale, e.g.
  - ★ Tidal disruption events (a few dozens)
  - ★ Supernova shock breakouts ( a few )
  - ★ GRBs up to  $z > 7$  (several)
- ★ New types ?
- ★ Associated sources with gravitational wave events?



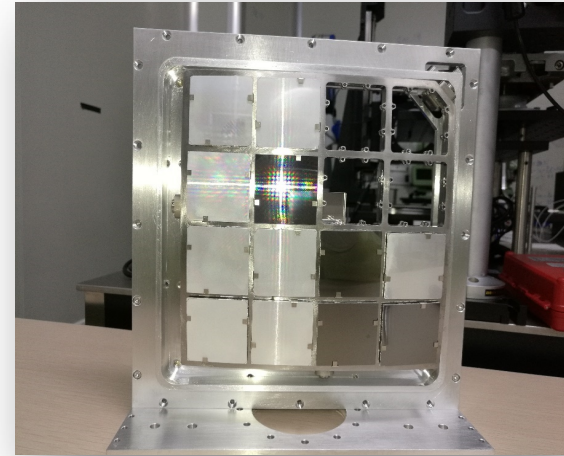
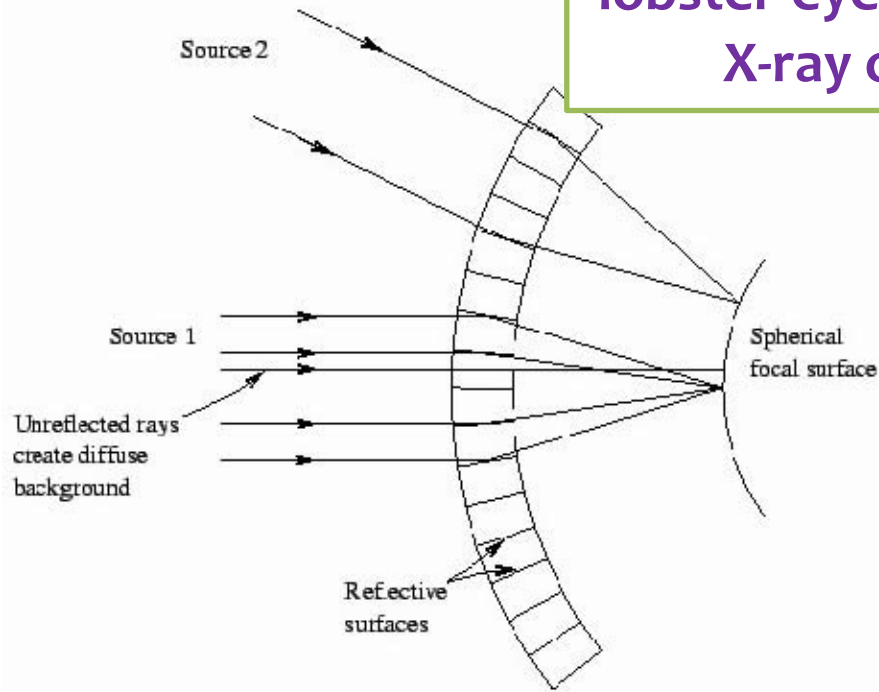
# Needs for more sensitive surveys of X-ray transients



Requirements: higher sensitivity, large FoV, and high cadence

# Established technology for wide-field focusing imaging --- lobster-eye micro-pore optics (MPO)

## lobster-eye MPO X-ray optics



Prototype of a lobster-eye X-ray mirror assembly (NAOC)

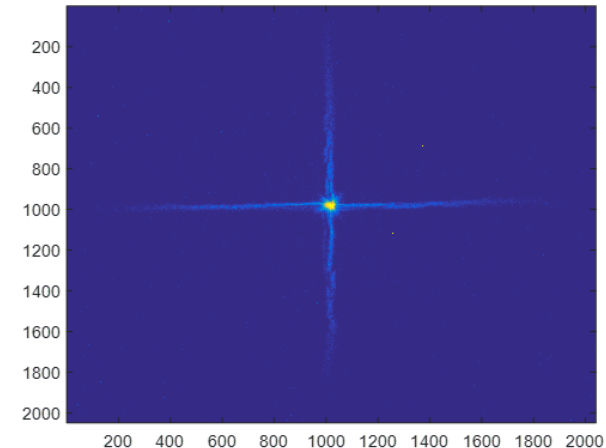
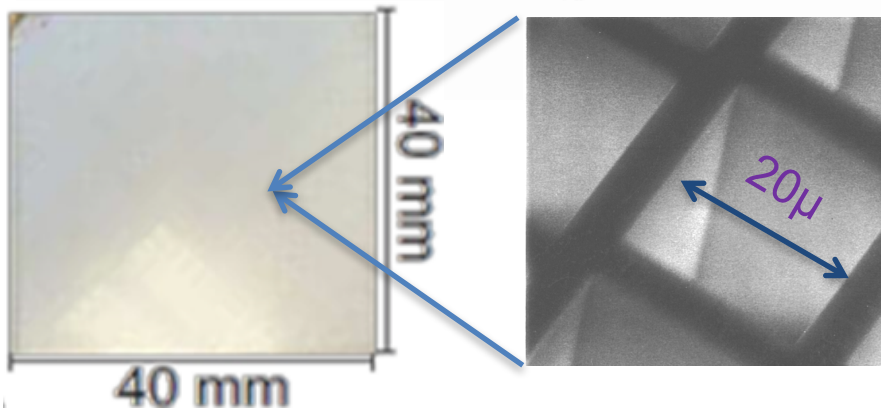
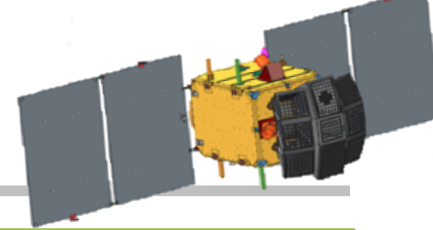


Image of focused X-ray beam

# The Einstein Probe (EP) mission



- ★ A small mission for all-sky monitoring to discover and study high-energy transients and variability in the soft X-ray band.
- ★ Proposed in 2012, and managed in the Space Science Programme of the CAS.

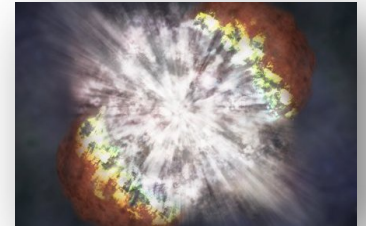
## Features

- ★ Large FoV  $1.1 \text{ sr}$  (3600 sq. deg.) grasp:  $\sim 10,000 \text{ deg}^2 \cdot \text{cm}^2$
- ★ Good angular resolution ( $\sim 5 \text{ arcmin}$ ) and positioning accuracy ( $< 1 \text{ arcmin}$ )
- ★ Soft X-ray band:  $0.5\text{-}5 \text{ keV}$
- ★ Sensitivity:  $> 1$  order of magnitude higher than those in orbit
- ★ Autonomous X-ray follow-up ( $< 10 \text{ arcsec}$  localisation)
- ★ Fast alert data downlink and (possible) fast uplink (ToO)

# Main science goals

---

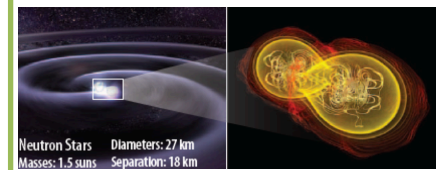
Systematic survey of soft X-ray transients and variability of X-ray sources at high sensitivity and high cadence



Discover otherwise quiescent Black holes at all astrophysical mass scales and other compact objects by capturing their transient flares



Detect and localize electromagnetic-wave sources of gravitational-wave events by synergy with GW detectors



# Instruments

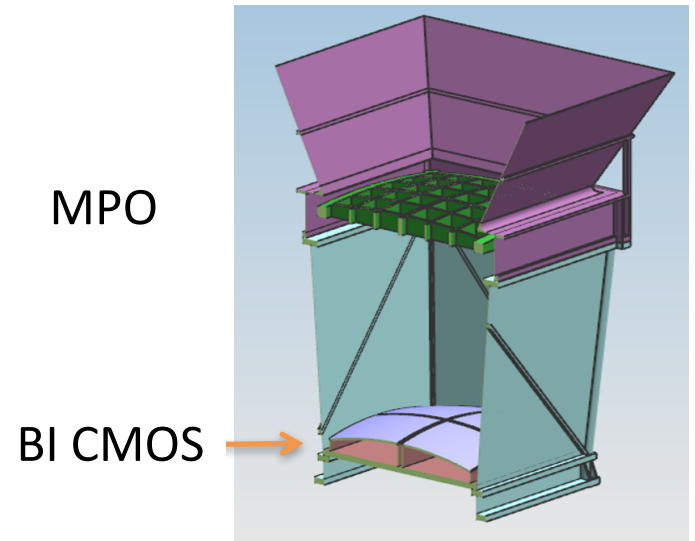
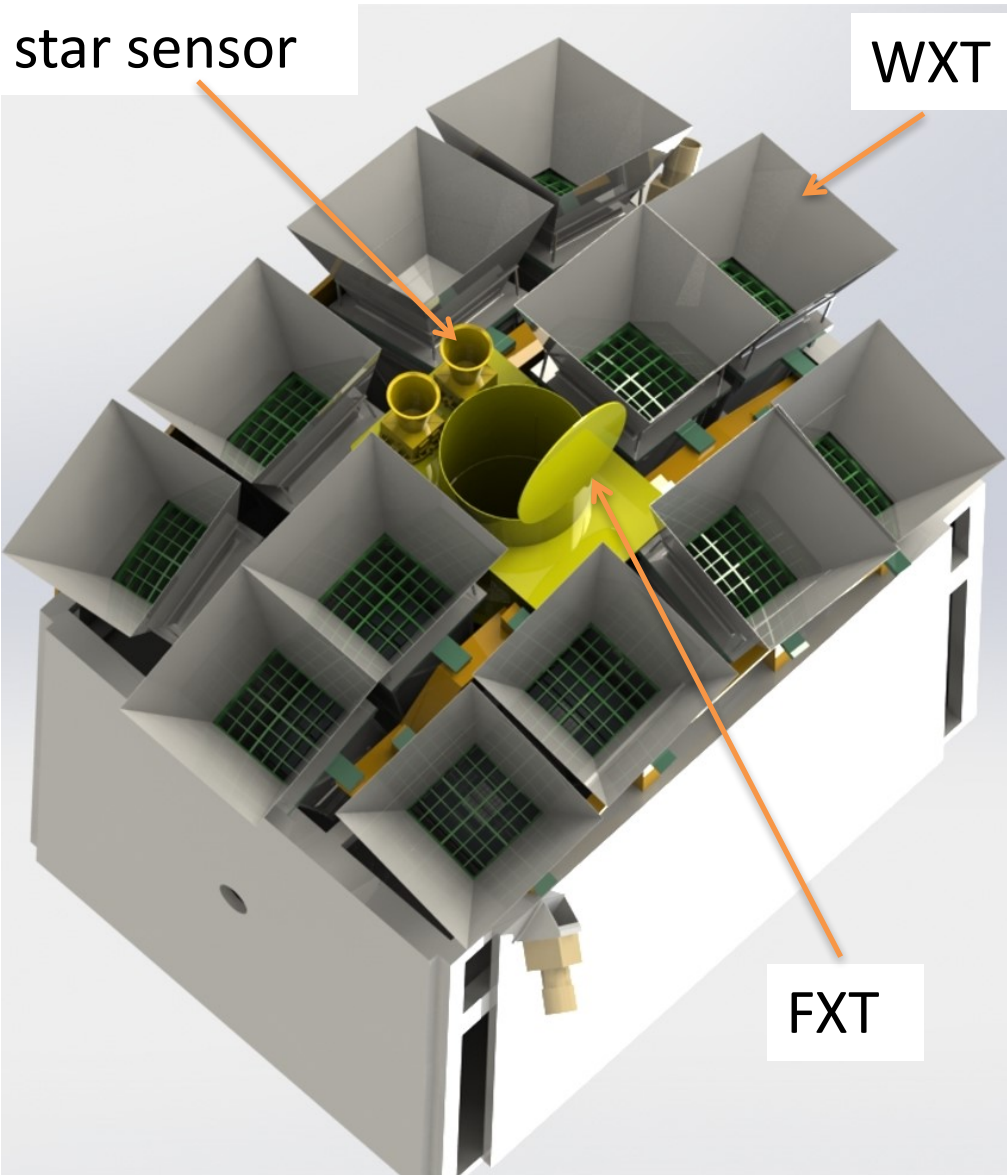
## Wide-field X-ray Telescope (WXT)

- \* X-ray optics: **lobster-eye MPO**
- \* Detector: large format, BI **CMOS** array (China)
- \* Focal length: 375mm
- \* Eff. area:  $\sim 3\text{cm}^2$  @1keV
- \* FoV: 1.1 sr,  $\sim 3600$  **sqr. deg.**  
FWHM:  $\sim 5$  arcmin
- \* Bandpass: 0.5-5 keV
- \* PI: Chen Zhang (NAOC)

## Fellow-up X-ray Telescope (FXT)

- \* X-ray optics: Wolter-I
- \* Detector: PN-CCD (MPE)
- \* Focal length: 1.6m
- \* Eff. area:  $>120\text{cm}^2$  @1keV
- \* FWHM:  $< 1$  arcmin  
30" goal
- \* FoV:  $\sim 30$  arcmin
- \* Bandpass: 0.3-10 keV
- \* PI: Yong Chen (IHEP)

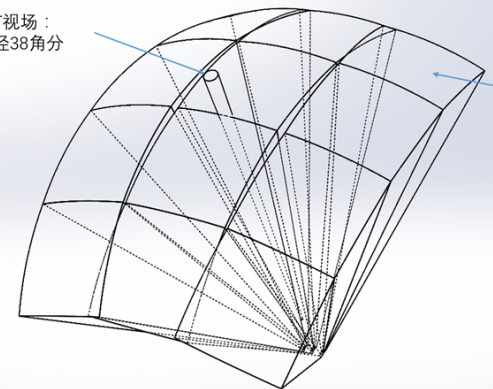
# EP Payload



FoV: 3600 sqr. deg.

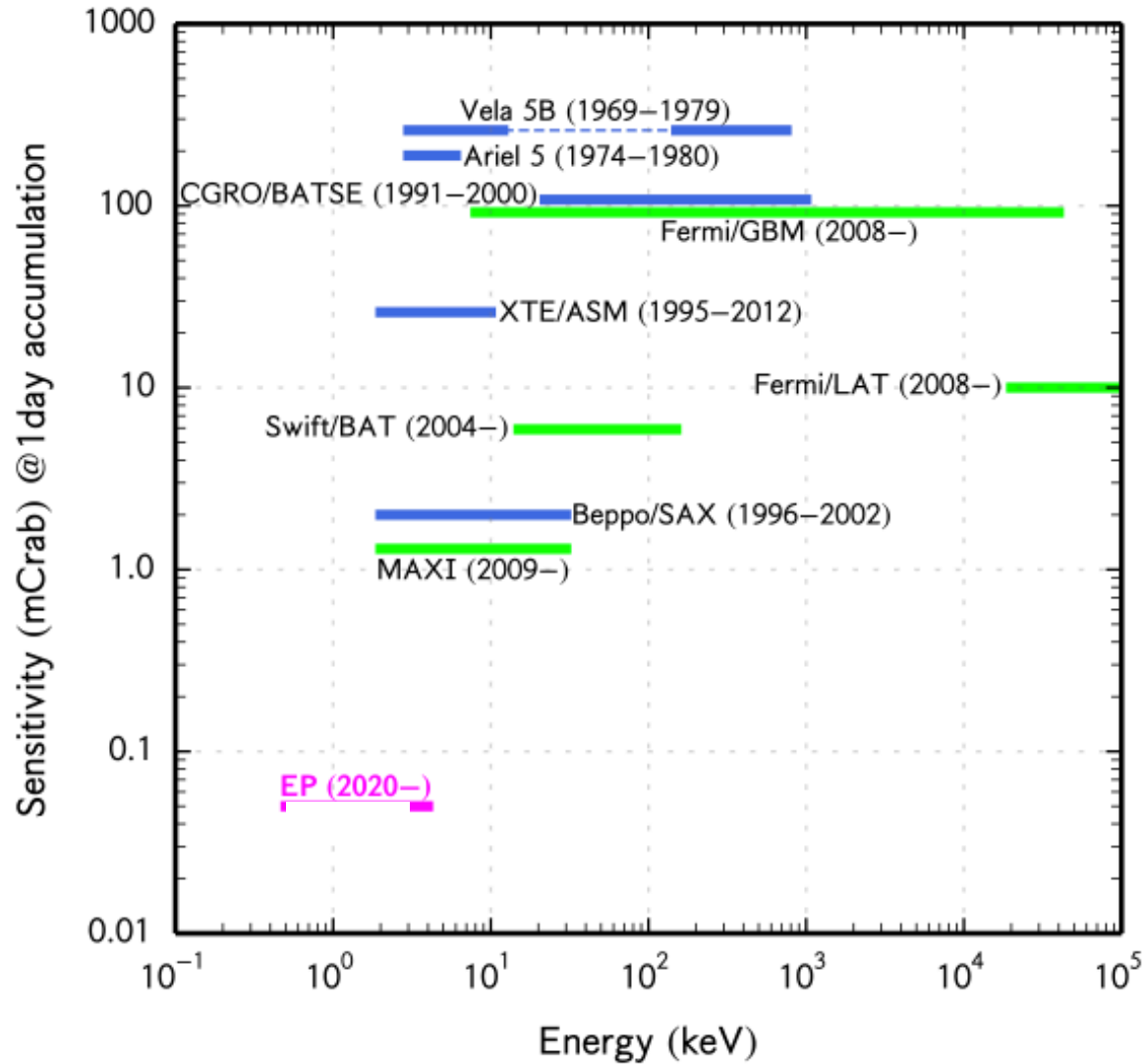
FXT视场：  
直径38角分

WXT视场：  
>3600 平方度





# Monitoring sensitivity



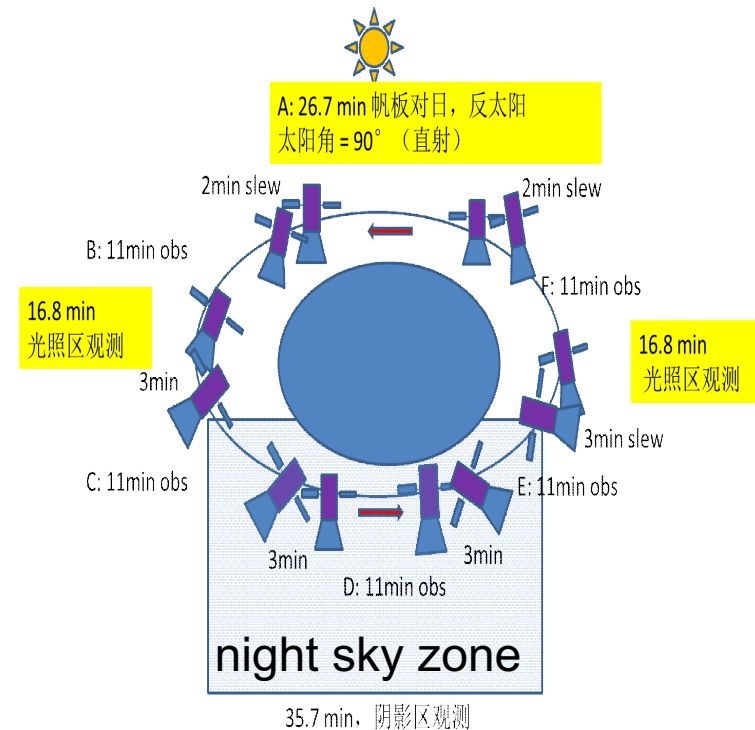
# Estimated detection rates of some transients

---

Type of events	Estimated detections per year
Tidal disruption events (TDE)	20-120 (onset/peak)
TDE with jets	20 - 40
SN shock breakout	7
GRB $z > 6$ (8)	7 (3)
magnetar	1
X-ray flash	~10
Low-luminosity GRB	< 8
SFXT	~ 13
Stellar flares	many

# Mission profile

- ★ Orbit: 600km (97min),  $i < 30\text{deg}$
- ★ Observation mode
  - ★ **Survey mode:** 5 pointings per orbit to the night-sky, each 11min exposure
  - ★ cover the whole night sky in 3 orbits
  - ★ **Follow-up mode:** pointing with FXT
  - ★ **ToO** (including fast ToO)
- ★ On-board data reduction & transient search
- ★ Alert data downlink/uplink
  - ★ Baseline: ‘Beidou’ system
  - ★ backup: VHF network (French)
- ★ Nominal lifetime: 3 +2 years

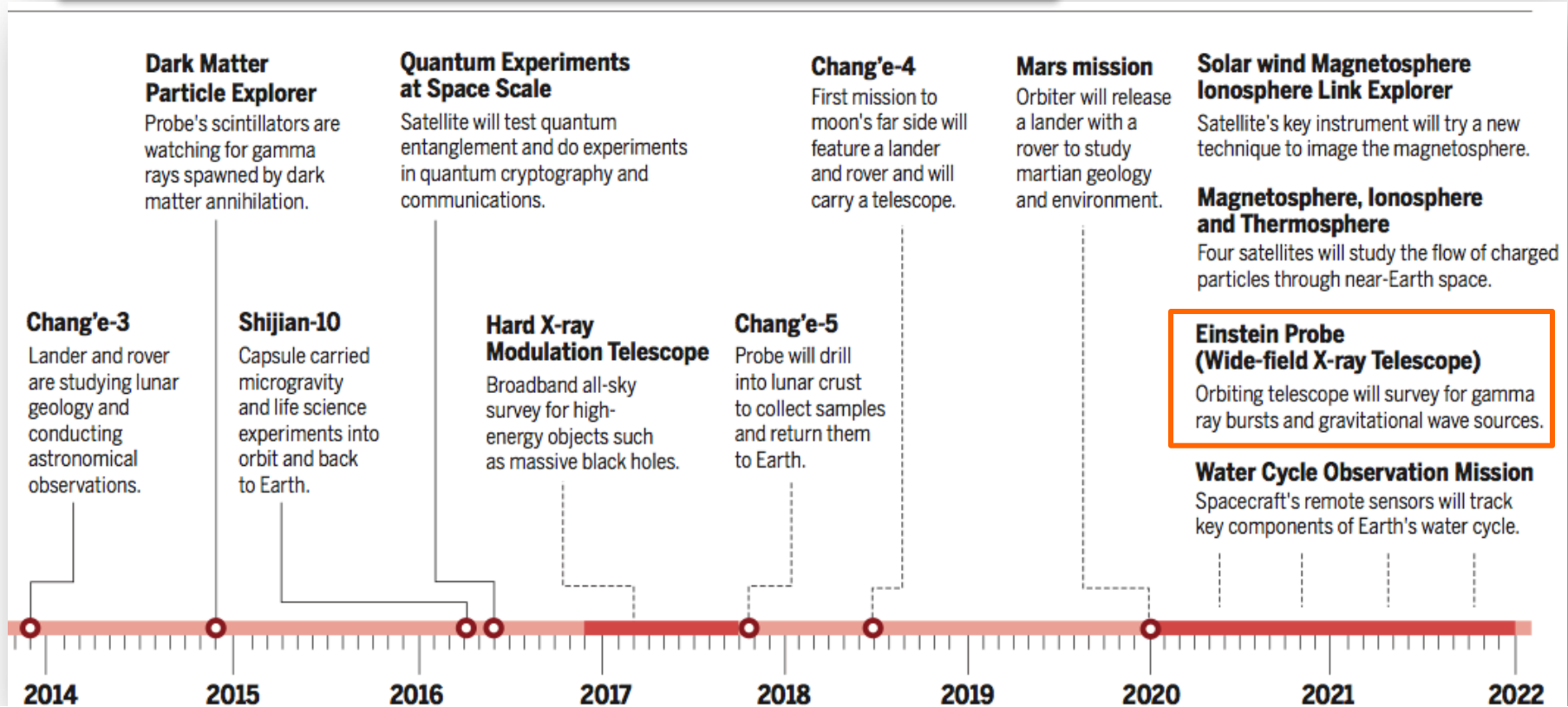


# Current status

- ★ Adopted in the government's 13<sup>th</sup>-5-year plan (2016-2020)
- ★ Currently in Phase A; planned launch date ~2021/22

## China's space science & exploration road map

*D. Normile 2016 Science*



# Team and international collaboration

---



*Key Lab of Space Astronomy & Technology*  
**National Astron. Observatories of China (NAOC) CAS**



*Key Lab of Particle Astrophysics*  
**Institute of High-energy Physics (IHEP) CAS**



*Other international partners are welcome by provision of in-kind contribution*

<http://www.ep.bao.ac>  
Contact: [wmy@nao.cas.cn](mailto:wmy@nao.cas.cn)