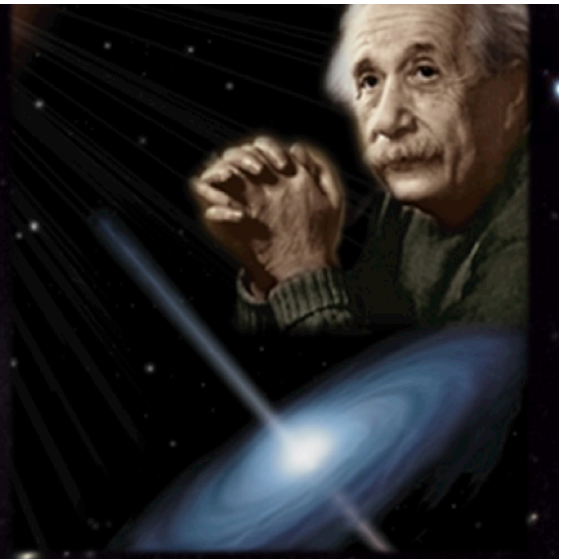
A mission proposed for the ESA-CAS joint mission
http://ep-ecjm.bao.ac.cn



Einstein Probe

exploring the dynamic X-ray Universe

Weimin Yuan

Space Science Division
National Astronomical Observatories of China

and the Einstein Probe team

Einstein Probe team

Space Science Division
National Astronomical Observatories of China (NAOC), CAS

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

Tsinghua University, China

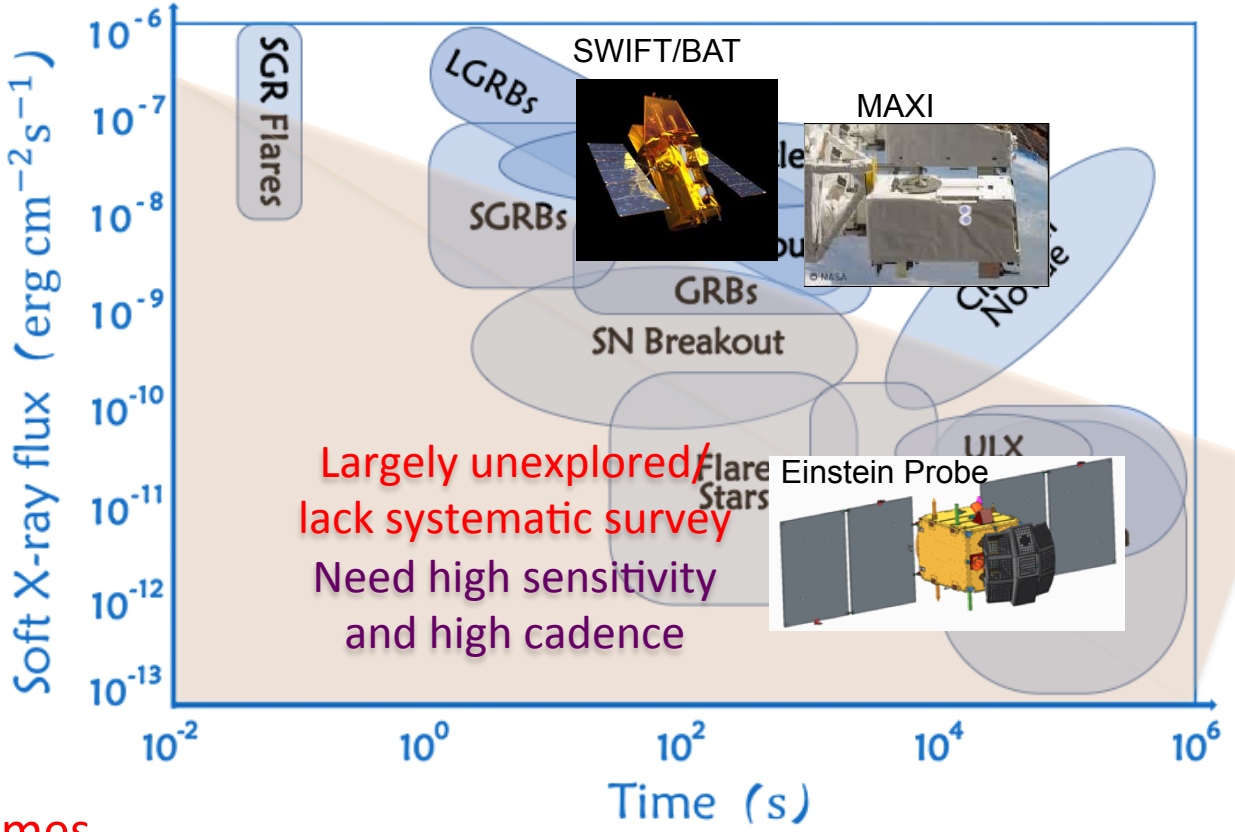
UK

Science team

YNAO

SHAO

Cosmic X-ray transients and variable sources



ESA Cosmic Vision grand themes

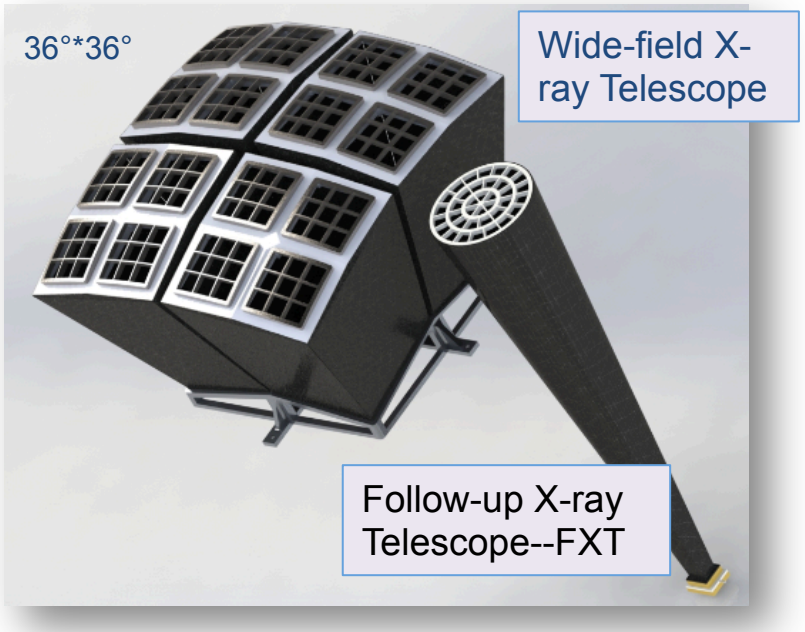
3. what are the fundamental physical laws of the Universe?

4. How did the Universe originate and what is it made of?

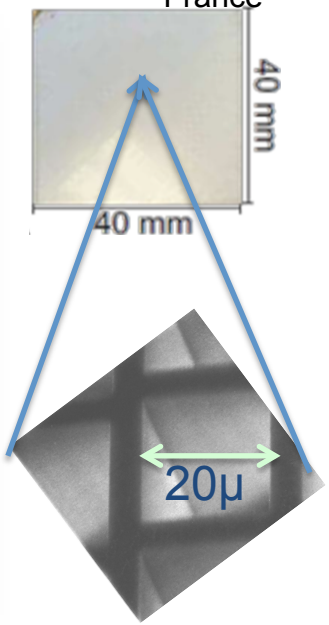
Collapse of stars/formation of BH/NS
Change in black hole accretion
Merger of compact objects
Extreme conditions

Einstein Probe: a wide-field imager using novel X-ray focusing technology

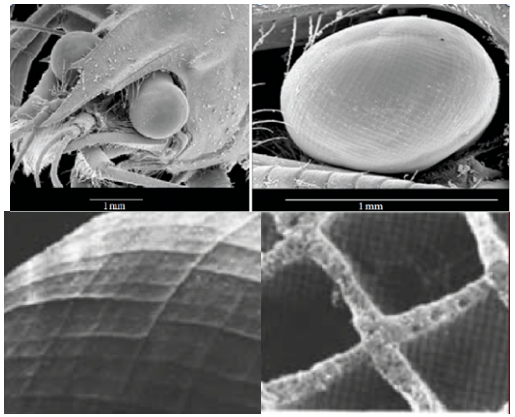
Micro-pore (MPO) lobster-eye telescopes

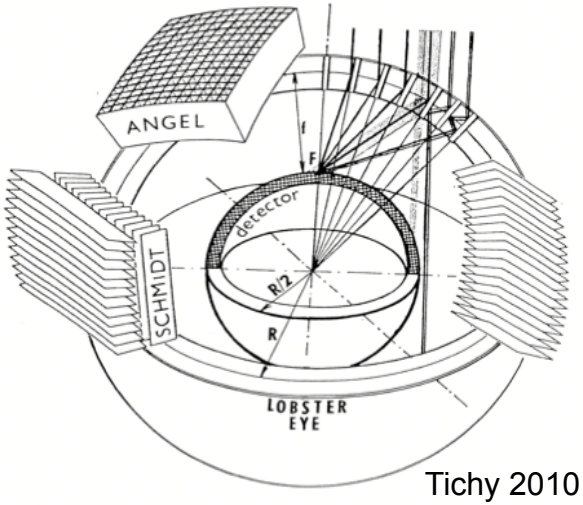


Photonis SAS France



Optics of lobster-eye





Tichy 2010

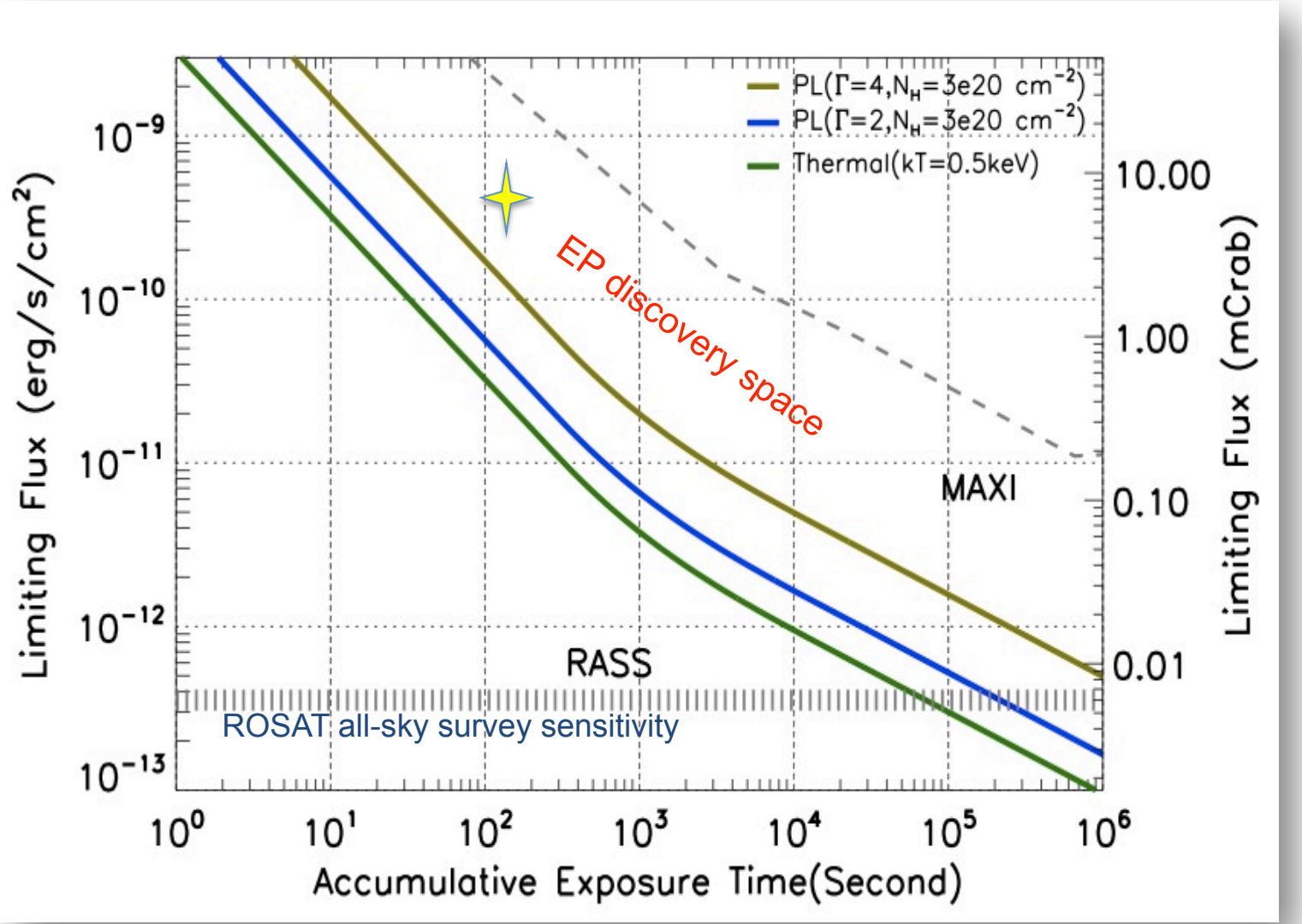
Wide-field X-ray Telescop—WXT

FoV 36°*36° (1345 sq.deg.)
Bandpass: 0.5-4keV
FWHM ~ 4'
Detectors: gas/MCP detectors

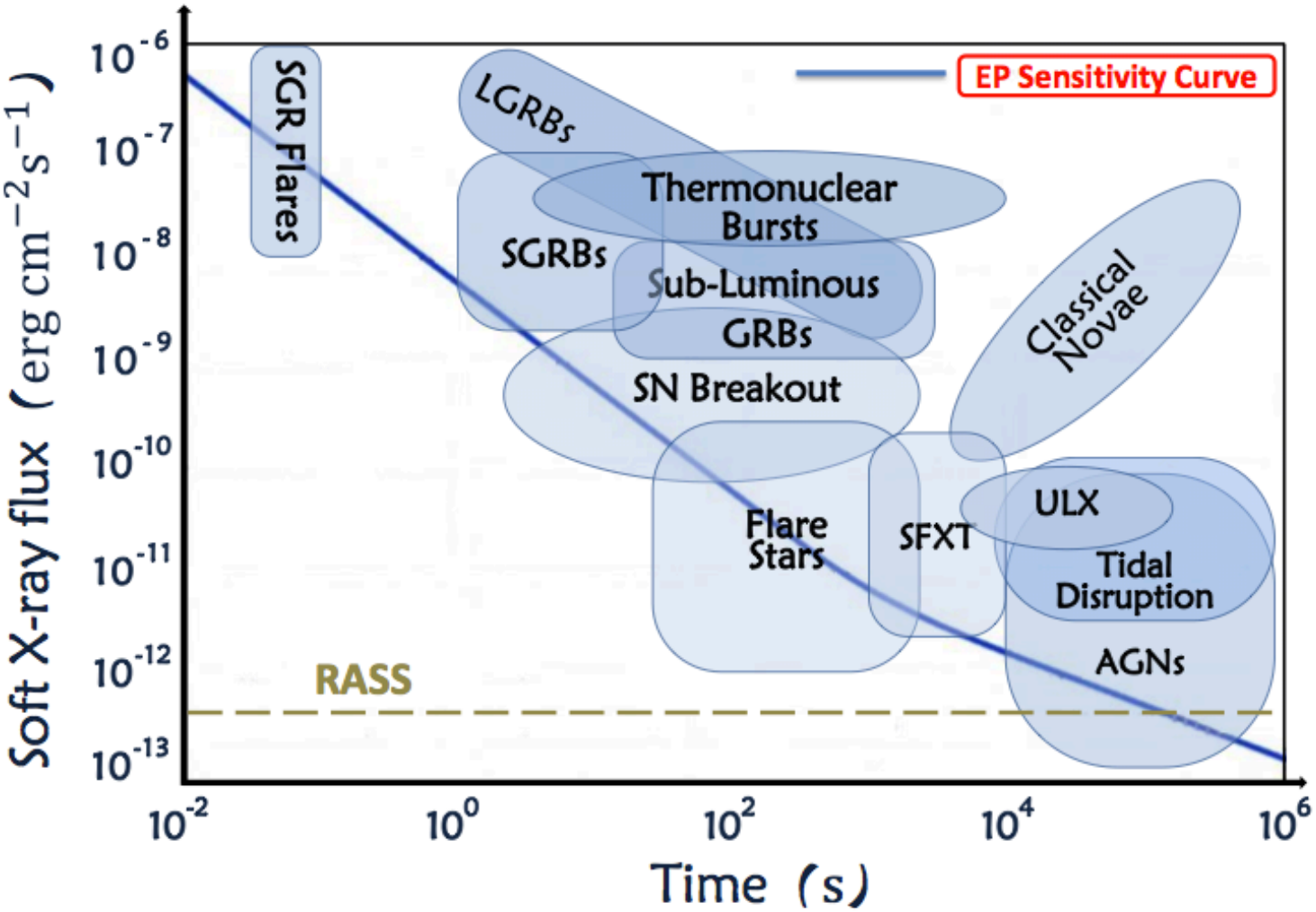
Advantage

- true imaging
- wide FoV
- vignetting-free
- low weight

Detecting sensitivity as function of exposure time



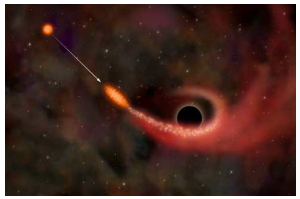
Detectability of some of the known types of X-ray transients

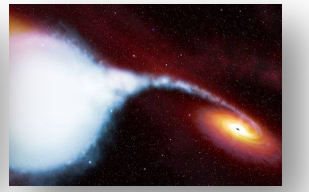


Mission key science goals

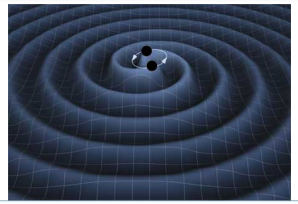
Uncover (otherwise) quiescent Black holes at all astrophysical mass scales by capturing their rare transient flares → black hole finder & explorer

Supermassive BH, Intermediate-mass BH, stellar-mass BH





Systematic survey of soft X-ray transients and monitoring variability of known X-ray sources at high sensitivity over wide time-scales



Detect and localize electromagnetic-wave sources of gravitational-wave events by working with new generation of gravitational-wave detectors

ESA Cosmic Vision

themes & questions

Matter under extreme conditions

Do BHs exist in almost every galaxy?

Ho lve ?

Ho

Ho ?

Ma ons

Phy elds?

The

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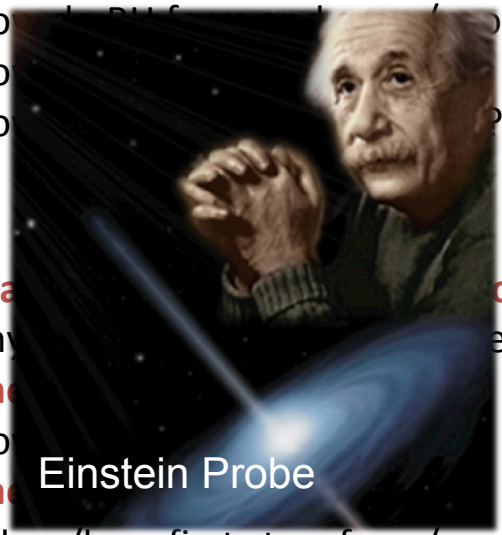
The

When/how first stars form/explode?



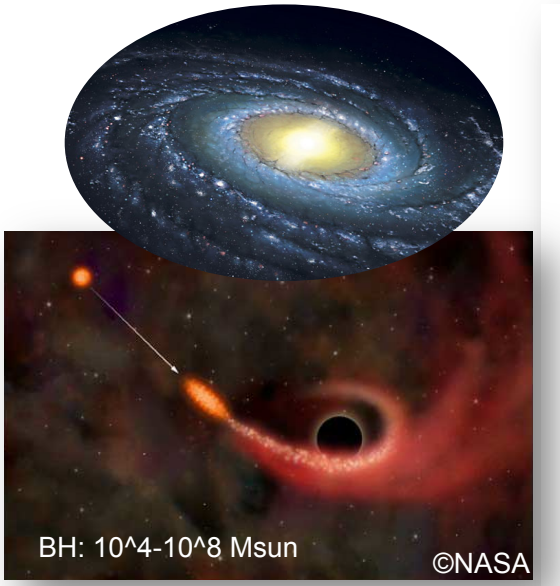
The gravitational Universe

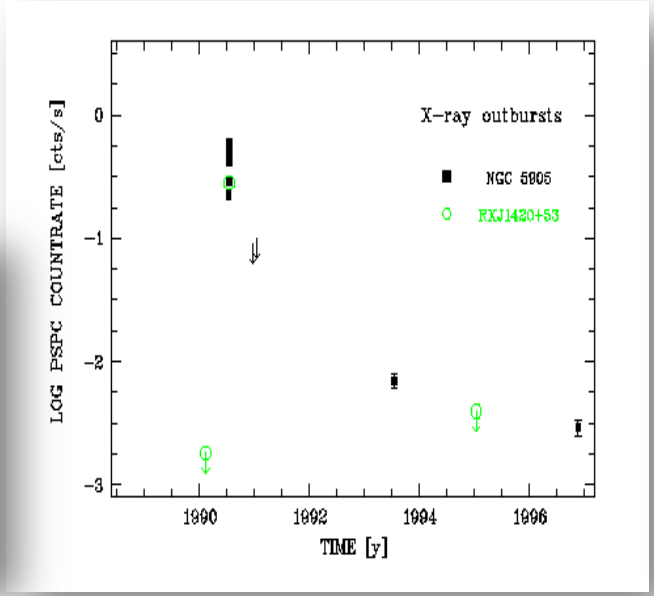
What are the EM source of GW events?

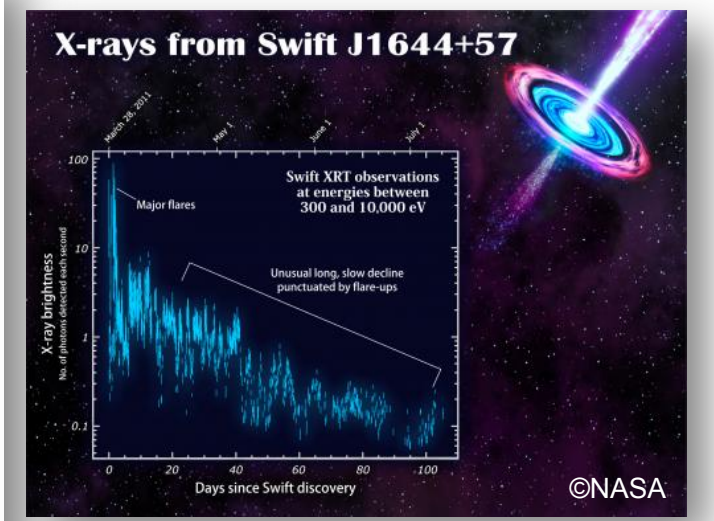
The evolving violent Universe

How two compact objects merge?

1. A new class of transients: tidal disruption of stars by massive black holes at centers of inactive galaxies





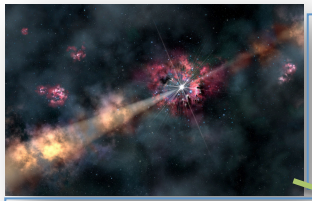


- Explore quiescent MBH and TDE rate
- Fundamental Q: are supermassive black holes prevalent in the Universe?
- A unique lab to study accretion physics
  - How matter falls into black holes?
  - Entire evolution of BH accretion process
  - How relativistic jets are set on?

- Large samples needed (~20 so far)
- Need prompt detection
  - Catch rising phase and peak
  - multi-wavelength follow-up

Einstein Probe is a perfect instrument to detect TDE; at a rate 30-300/year (jetted: several/year)

2. Systematic Survey of X-ray transients & variability

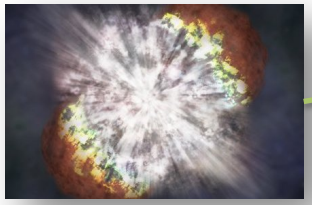


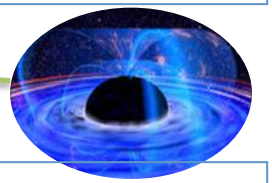
X-ray flash
& LL GRB
GRB physics

Active galactic nuclei
Extreme gravity, BH
accretion/jets/growth

High-redshift GRB
Trace first stars/BH
Early universe
4-5 detection in 3yr

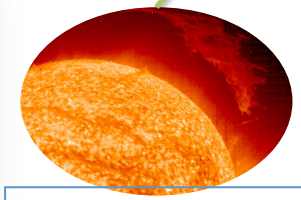
BH Tidal disruption
Quiescent MBH finder
BH accretion/jets
30-300/yr

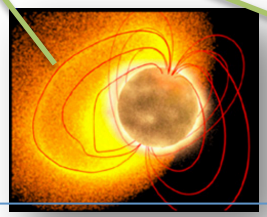


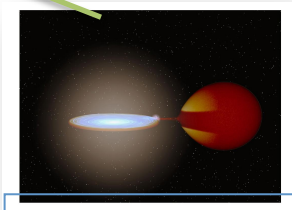


SN shock breakout
SN physics
Size of progenitors

Intermediate-mass BH
BH physics/accretion







Comets
charge exchange
emission

Star X-ray flares
Magnetic fields
Corona activity

SGR/magnetar
extreme
magnetic Field

Thermal nuclear burst
Neutron stars physics

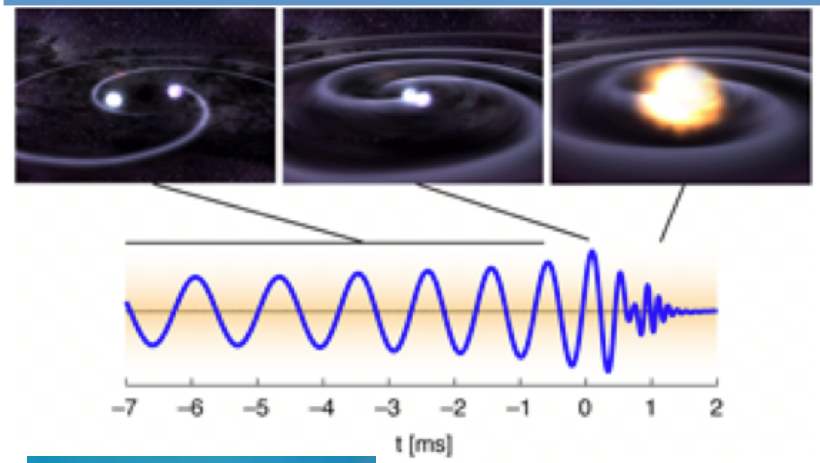
BH X-ray binary
Extreme gravity
BH physics/accretion

3. Detect and precisely locate the photonic counterparts of gravitational-wave events

astrophysical gravitation wave sources

- Co-rotating compact objects (NS/BH)
- Merger of NS/BH —bursts of GW signal

PSR 1913+16
indirect evidence for GW
Nobel Price 1993



NS-NS, NS-BH mergers within several hundred Mpc (Abadie+ 10)

Position errors: 10-100 sq.deg.

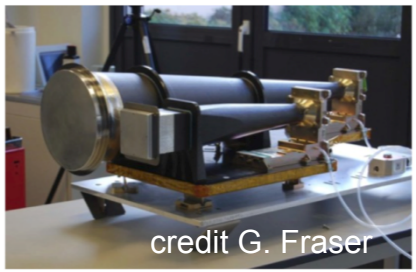
Why it is Important to detect photonic source of GW events?

- Improve S/N of GW detection
- Precise localization of GW events
  - allow multi-wavelength follow-up observations
  - identification of astrophysical counterparts
- Study astrophysical origin of GW sources, e.g. host galaxy, redshift
- Study the physics of GW sources

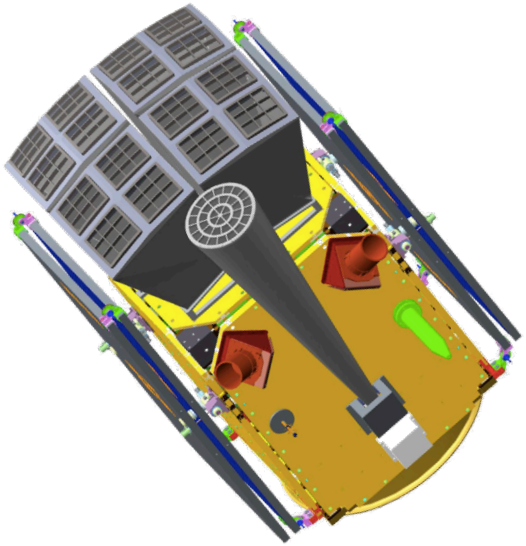
Mission concept

- Payload
  - Wide-field X-ray telescope (WXT)
  - Follow-up X-ray telescope (FXT)
- Fast alerts data downlink (French VHF)
- Budget
  - Weight: 245 Kg (payload 54.75kg)
  - Power=49 w (layload)
- Orbit: 600-650km, i<30deg
- Operation
  - A series of pointings each orbit (e.g. 11min each)
  - Cover entire night sky every 15 hrs (10 orbits)
- Mission life: 3 years
- Data
  - trigger multiwavelength follow-up worldwide
  - quick data release
  - high scientific impact

Heritage



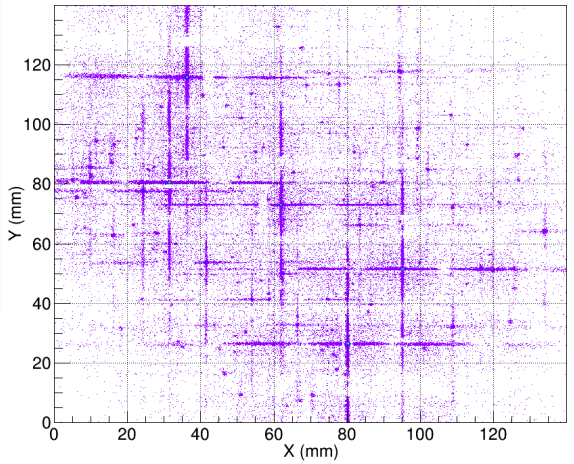
Bepi-Colombo MIXS
built @ Leicester

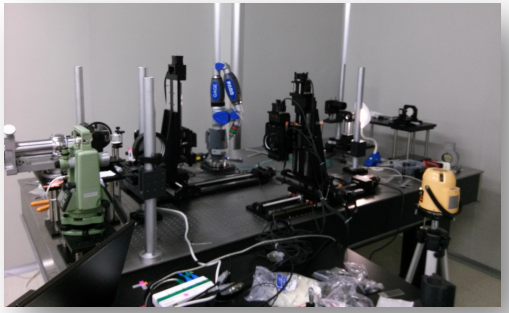


Progresses made in China

- MPO telescope design and simulations (NAOC)
- Design and test of focal plane detectors (TsHU)
- Built X-ray beam line for testing
- Designed and built telescope assembling facility

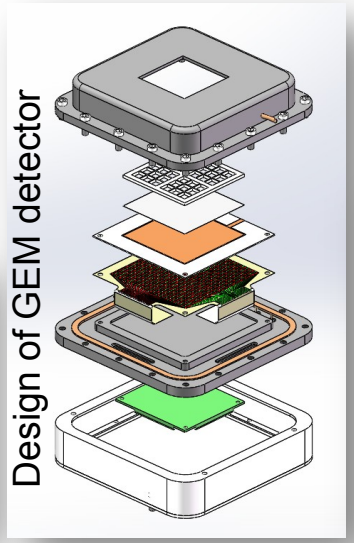
Simulated observed X-ray sky image based on ROSAT RASS data





PI: Chen Zhang
X-ray imaging Lab @NAOC

Laser-guided MPO telescope assembling bench @NAOC

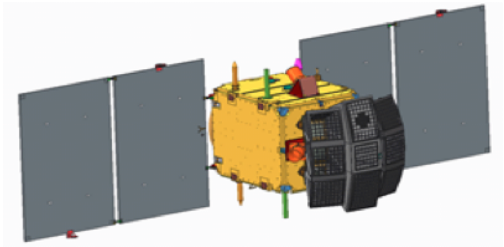


PI: Hua Feng
X-ray detector Lab @Tsinghua Univ.

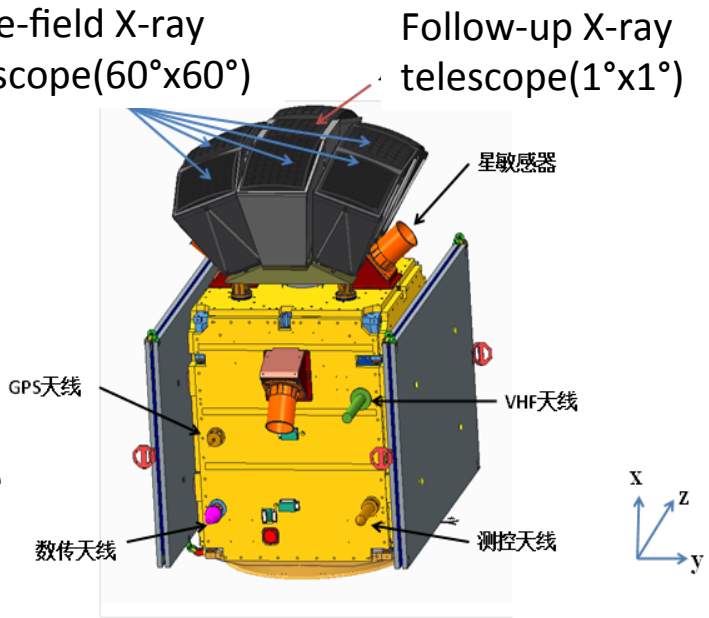
Current status

The larger-FoV version of Einstein Probe (3 x FoV) has been selected as one of the "Mission candidates for advanced study" under the CAS "Priority Strategy Space Science Programme" in July 2013

- Funded for phase A+ (half way to B) study 2014-2015
- Mission definition and proto-type building
- Built up a science working group (> 40 scientists from > 10 institutes)



Original larger-FoV version of Einstein Probe



Concluding remarks

- The first-ever X-ray all-sky monitor employing focusing imaging technology

  → unprecedented sensitivity and large combination with FoV (Grasp)
- Open a new window and make a leap forward in time-domain astrophysics
- Multifold great potential for new science frontiers
  - Tidal disruption events, high-redshift GRB, Supernovae, ……
  - EM counterparts of GW events
  - New type of transients?
- Synergy with multi-wavelength, multi-messenger facilities around 2020
- Scientific impact will span all fields of astronomy:

  from comets, stars, compact objects, BH, galaxies, cosmology, to GW, ….
- An already on-going collaboration between China and Europe

Prospects of ESA-CAS collaboration

- Collaboration with Leicester University UK already started
  - WXT and FXT design and assembling
  - Detectors
- Interests expressed from French colleagues for providing VHF network
- Opportunities of involvement are open for development of
  - WXT focal plane detectors
  - FXT detector

Thank you for your attention!