Chinese Academy of Sciences Astro Program Updates

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NAS 2015-04-01

Outline

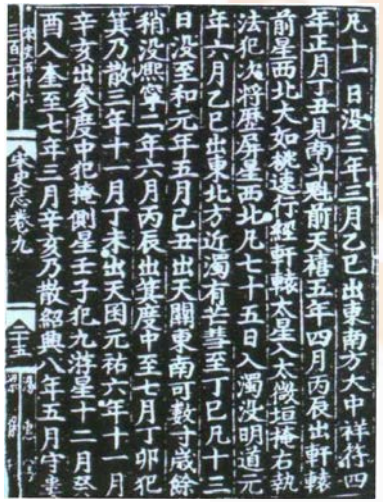
- From Ancient Observations to Modern Time
- Main scientific themes
- DAMPE
- QUESS
- HXMT
- XTP
- S-VLBI
- EP
- STEP
- International cooperation
- Remarks

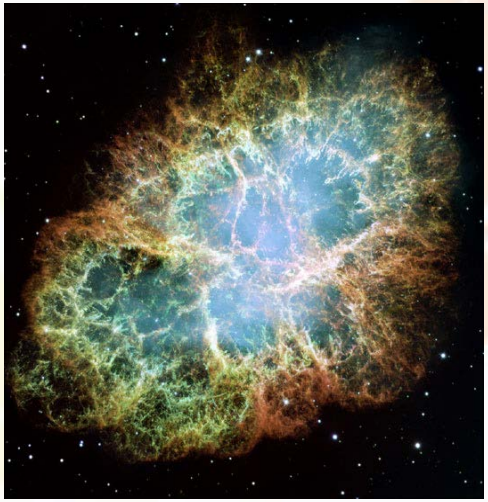
Fromm Ancient Observation to Modern Time

- Observation of Solar Eclipse:

  "*The Book of History: Yinzheng*" as the earliest observation record of solar Eclipse (2042 BC) in China

- Observation of Nova:
  - ✓ The oracle bones of Yin Dynasty Ruins (1300 BC) as the earliest records of Nova in the world "——Joseph Needham （李约瑟）
  - ✓ *"The Astronomy Part of the Records of Song Dynasty"*: Supernova Explosion (1054 AD)

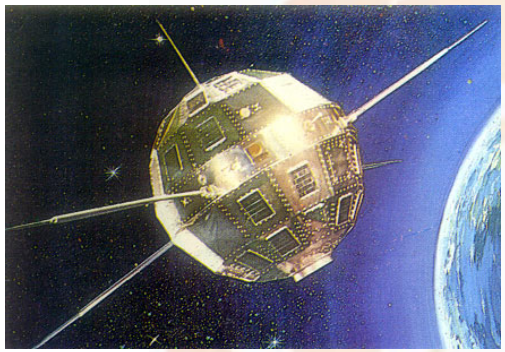


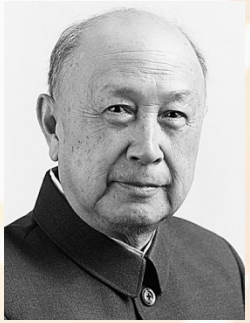


Remnant: Crab Nebula

Fromm Ancient Observation to Modern Time

- First Chinese satellite was launched in 24 April, 1970
  - ✓ DFH-1: 173kg, 439-2384 km elliptical orbit





Qian

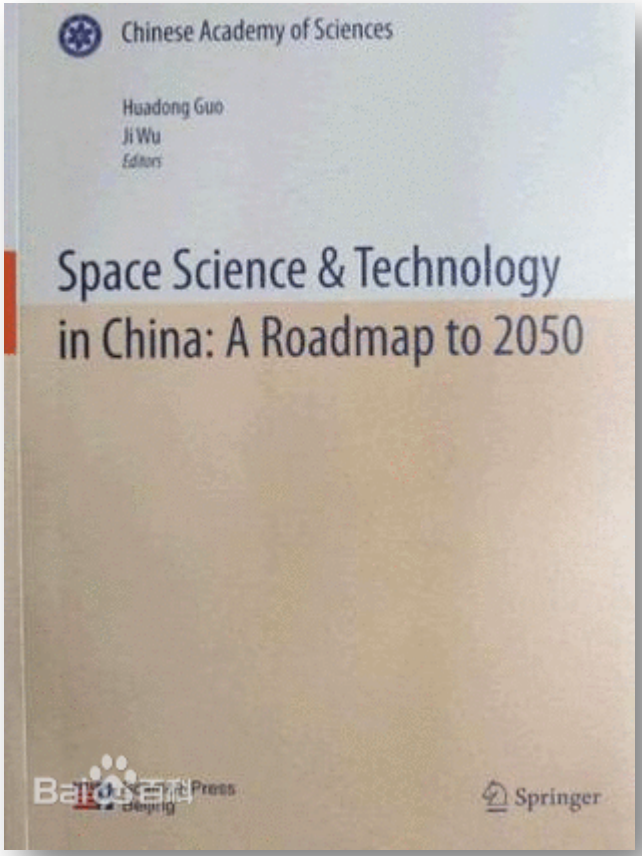
Jaw

Sun

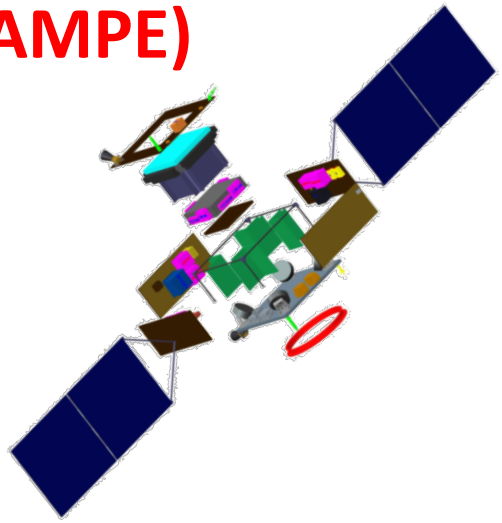
Two Themes of Space Science Towards 2050

Theme 1. How did matter originate (universe and life), how does it evolve and move?

Theme 2. What is the relationship between solar system and human beings?

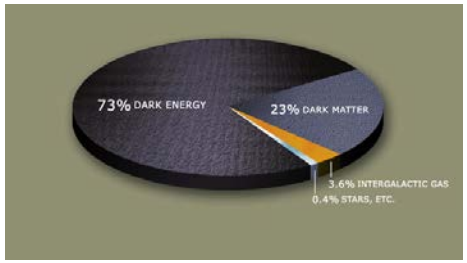


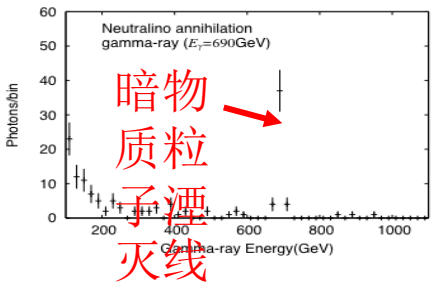
DArk Matter Particle Explorer (DAMPE)



➢ Scientific Objectives

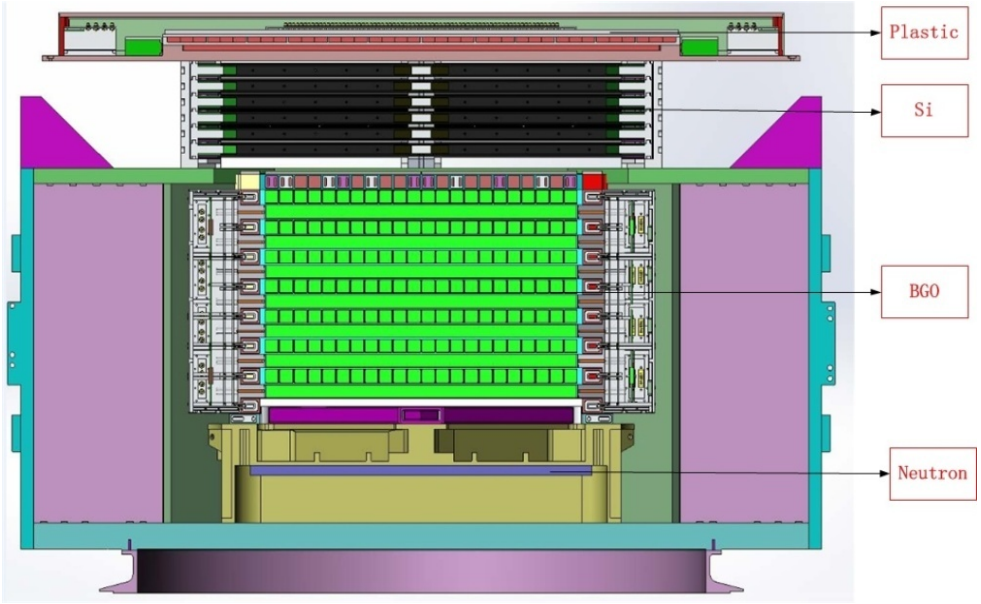
- ✓ **Find and study dark matter particle through high-resolution observation of high energy electron, gamma-ray spectrum and its space distribution**
- ✓ **Study the origin of cosmic ray through observation of high energy electron spectrum and anisotropy above TeV**
- ✓ **Study the propagation and acceleration mechanism of cosmic ray through the observation of its heavy ion spectra**





DArk Matter Particle Explorer (DAMPE)

- **The only Payloads with four layers 1400kg**



Plastic Scintillation Hodoscope Array

(to detect the particle direction and to discriminate gamma-rays from particles)

Silicon-Pin Array

(to detector the charge of the injected particle)

BGO Calorimeter

(14 layers, to measure the energy of the incident particles and to discriminate electrons from protons)

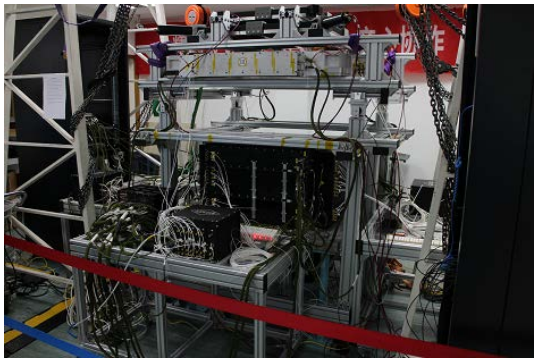
Neutron Detector

(scintillation detector, to improve the discrimination of electrons from protons)

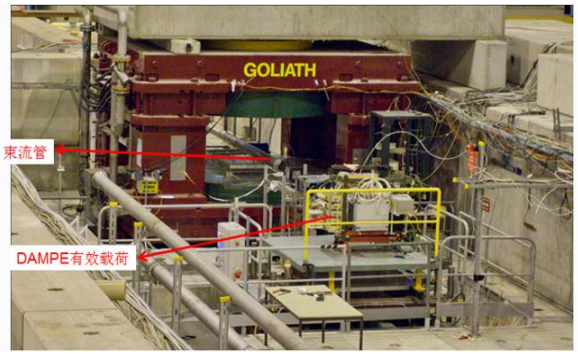
Status of DAMPE

- October-Norvermber 2014, DAMPE engineering model has done beam tests at CERN
- October 2014 flight model design finished and now it is in the flight model development phase
- Another beam test in CERN is planned this and next month
- Planned launch date is in November this year

Thermo-vacum test



Vibration Test

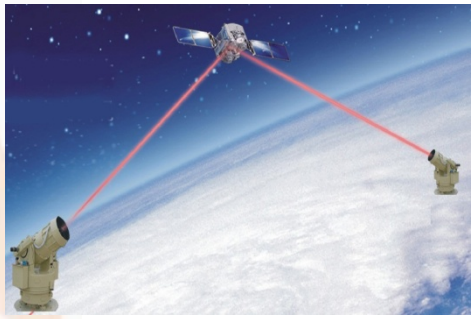


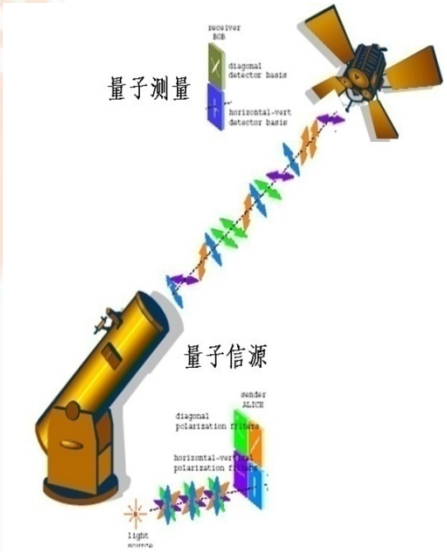
Beam test at CERN

Quantum Experiments in Space Scale (QUESS)

Scientific Objectives

- Implementation of long-distance quantum communication network based on high-speed quantum key distribution(QKD) between satellite and the ground station, to achieve major breakthroughs in the realization of space-based practical quantum communication.
- Quantum entanglement distribution and quantum teleportation on space scale, fundamental tests of the laws of quantum mechanics on global scale.

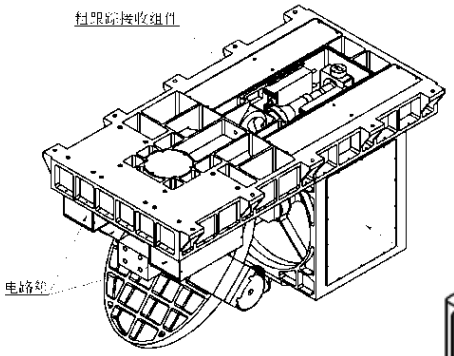




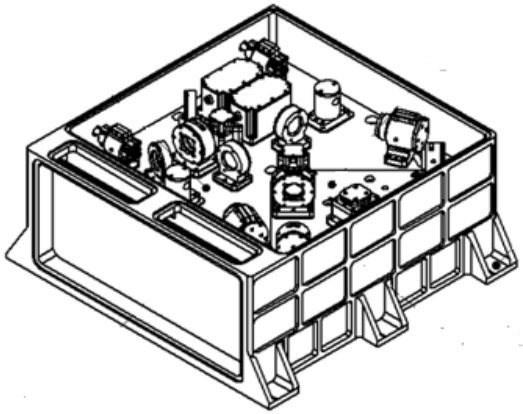
Quantum Experiments in Space Scale (QUESS)

	Parameter
Orbit	600km
Inclination	97.79°
Mass	~620kg

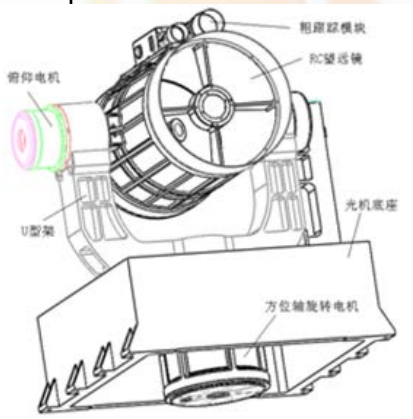
Four scientific Payloads:



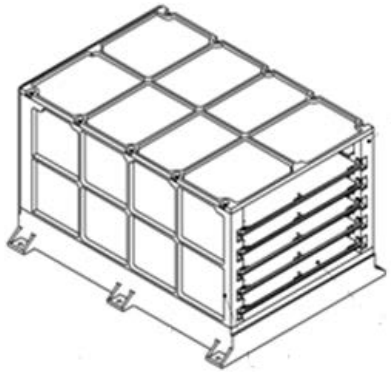
Quantum key communication equipment



Quantum entanglement source



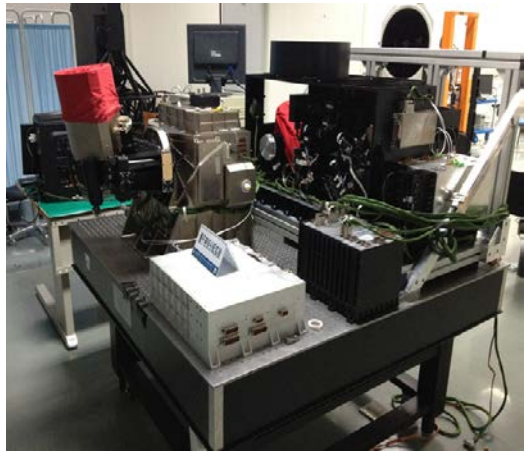
Quantum entanglement transmitter



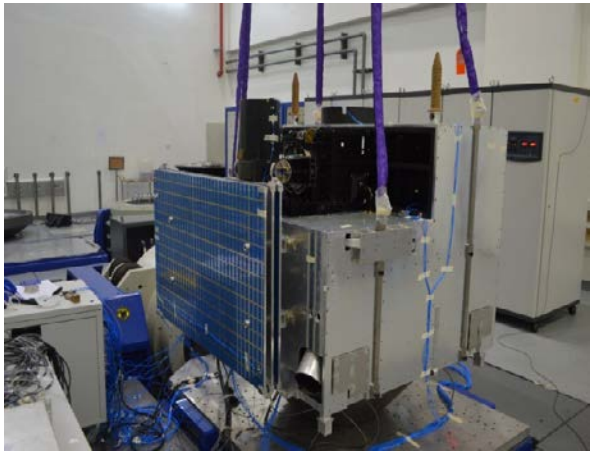
Experimental control and processing system

Status of QUESS

- 10.2013-12.2014 Engineering Demonstration phase
- Jan. 2015 flight model design finished and now is in the development of flight model
- Four ground stations with telescope from 1-2 meters are prepared as the ground segment of experiments.
- Possible launch date: first half of 2016



Payload integration test

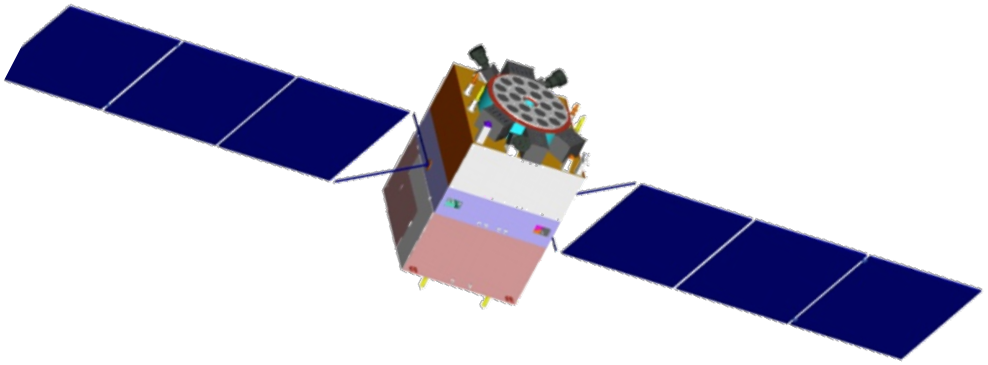


Vibration Test

Hard X-ray Modulation Telescope (HXMT)

➢Scientific Objectives

- ✓Large area X-ray survey
  - •Cosmic and Galactic diffuse X-ray background
  - •Discover new transients and monitor bright sources
- ✓Broad band (1-250keV) and large collection area (5000cm^2@100keV) pointed observations of high energy objects
  - •Dynamics and radiation near BH horizons of stellar mass



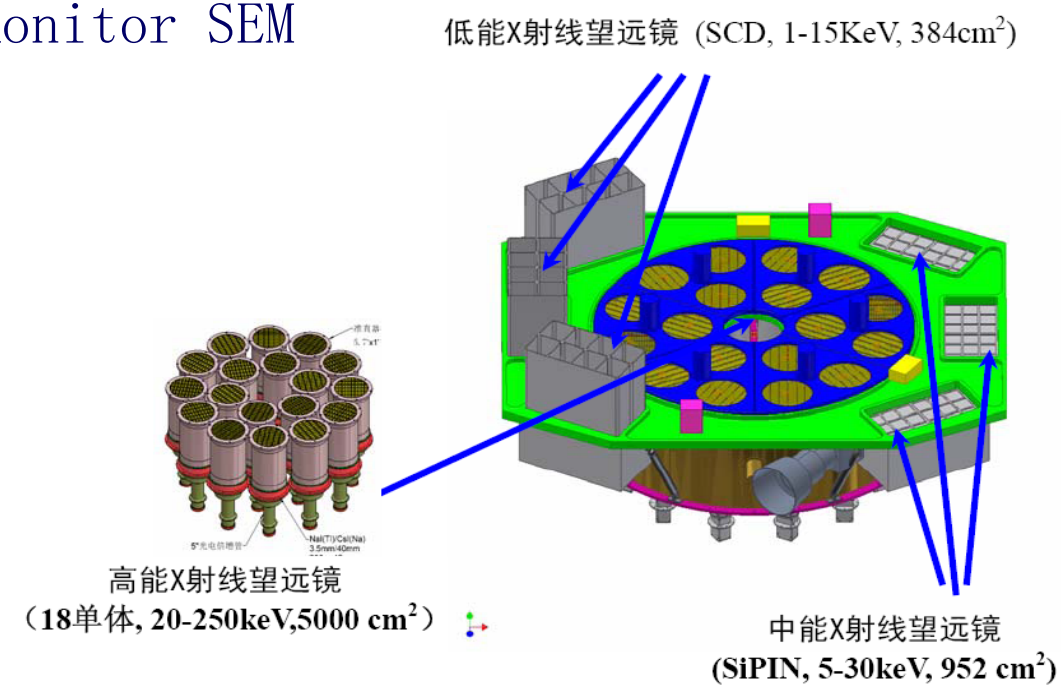
➢ Satellite Facts

- ✓ Mass: ~2800kg
- ✓ Orbit: 550km, 43°
- ✓ Attitude: 3-axis Stabilized
- ✓ Precision 0.1 °
- ✓ Lifetime: 4 years

Hard X-ray Modulation Telescope (HXMT)

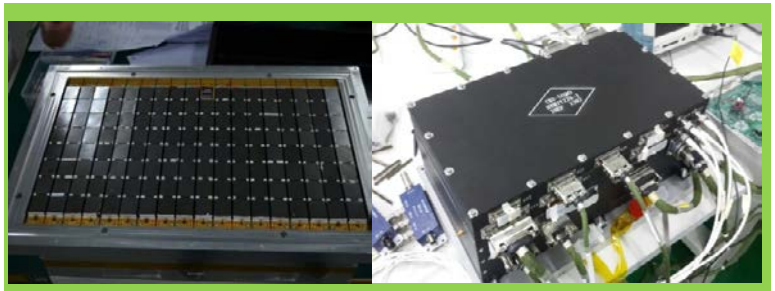
Science Payloads:

- High energy X-ray telescope HE
- Medium energy X-ray telescope ME
- Low energy X-ray telescope LE
- Space Environment monitor SEM

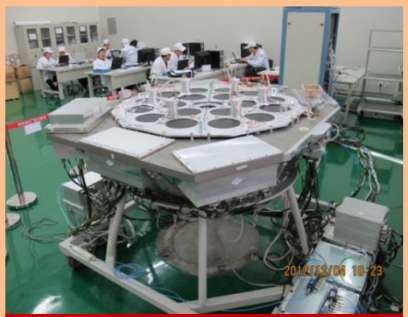


Status of HXMT

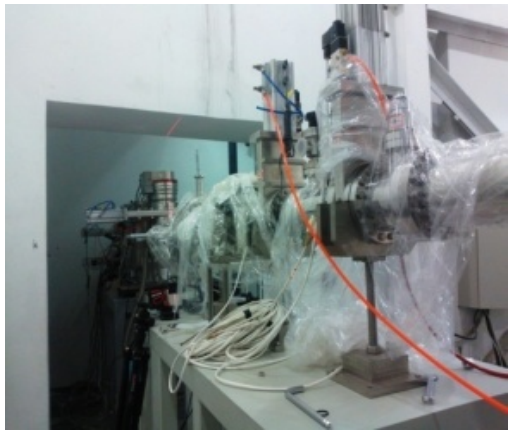
- 12.2012 spacecraft finished the flight model design
- 12.2014 all payloads finished the flight model design and the delivery of flight model payloads to s/c will be end of this year, with complete calibration test this year.
- Planned launch date is the second half of 2016



中能望远镜的探测器机箱（左图）和电控箱（右图）



HXMT有效载荷电性件联

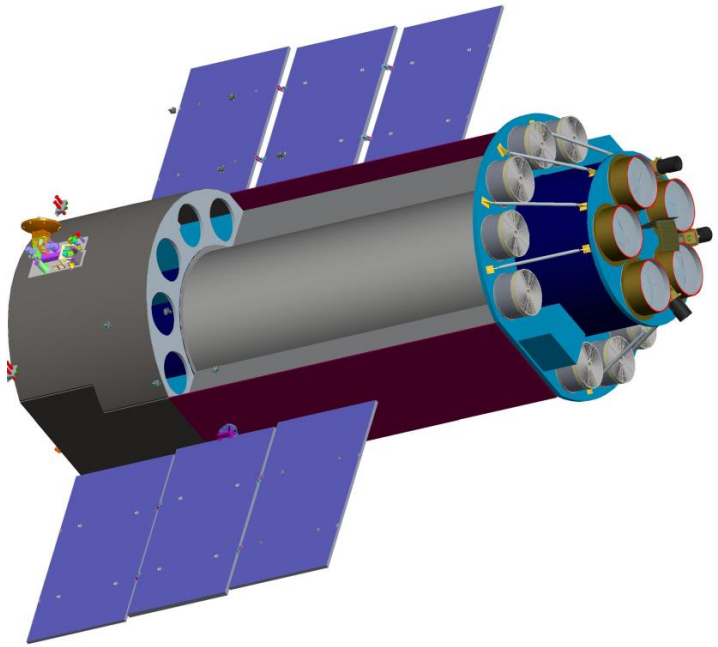


X-ray Timing and Polarization Mission (XTP)

➢ Scientific Objectives

1-singularity (BH); 2-stars (NS and magnetar); 3-extremes (gravity, density, magnetism)

- ✓ Precise light curve + energy spectrum: matter under extreme conditions, NS state equation, BH parameters
- ✓ Polarization of X-ray: BH spin, nature of magnetars, pulsar radiation mechanism…

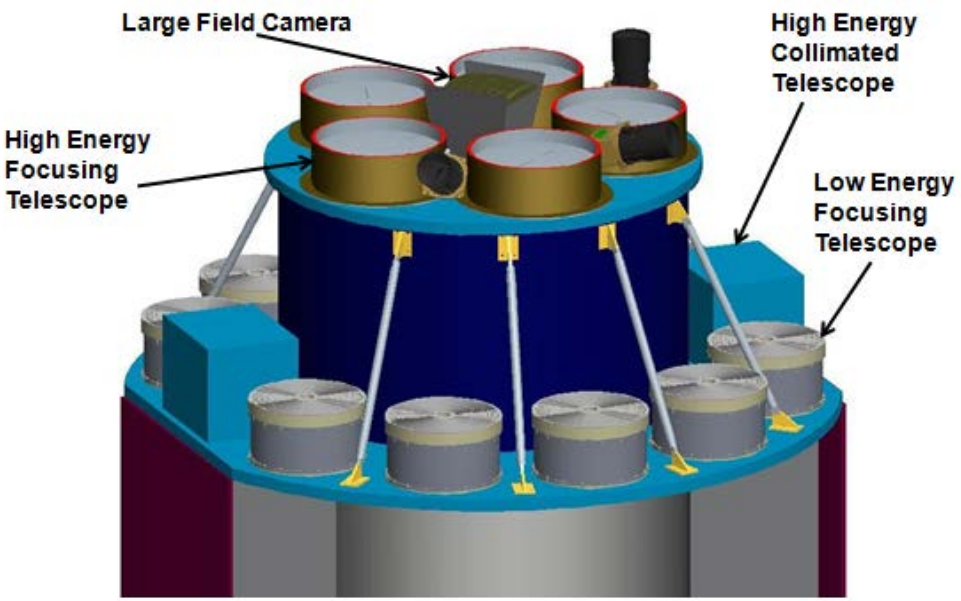


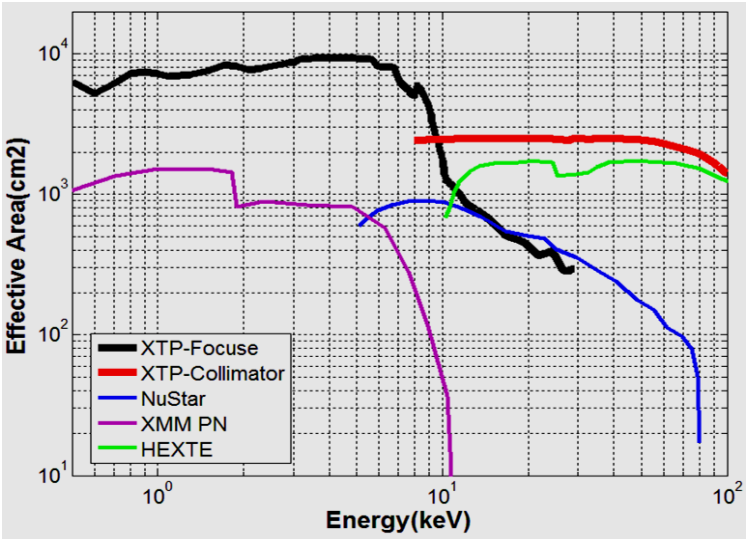
➢ Preliminary Design of the Satellite

- ✓ Mass: 3500kg (1200kg for payloads)
- ✓ Height: 7m
- ✓ Orbit: 550km circular orbit inclination: 28°
- ✓ Launch Vehicle: CZ-3C

X-ray Timing and Polarization Mission (XTP)

➢ Payloads





Effective area comparison between XTP and other missions

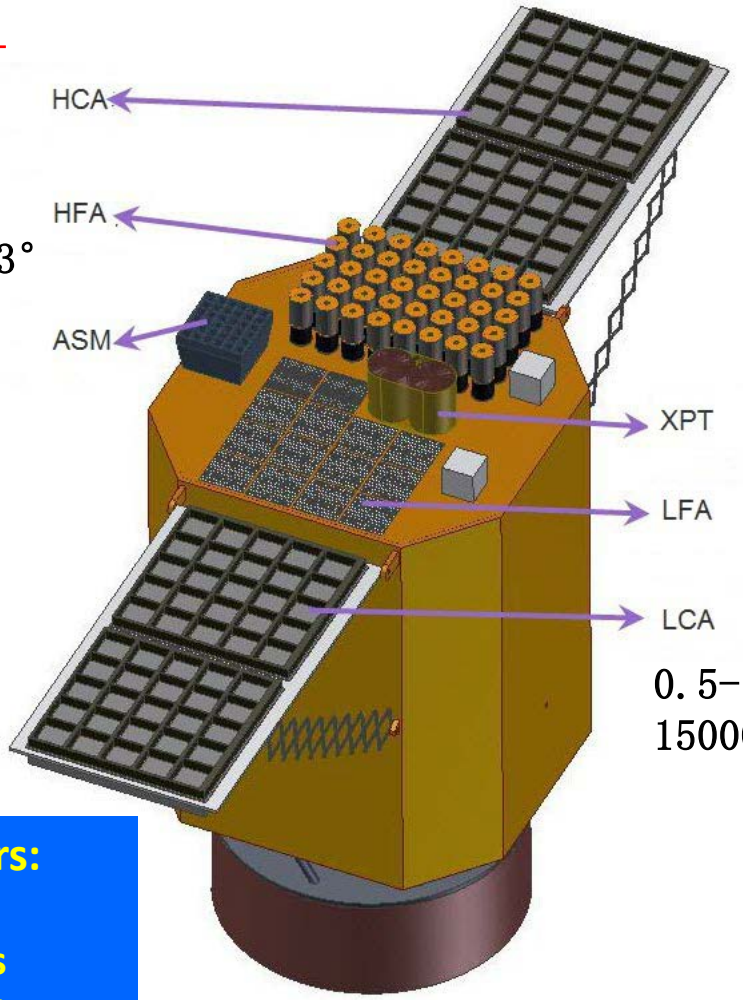
➢ Instrument Design Goal

✓ The most sensitive light curve with good energy resolution and polarization at 1-30keV → from faint X-ray binaries to bright AGNs

X-ray Timing and Polarization mission (XTP)

10-100keV，2° ×2°
15000 cm^2 (CZT, 6-100keV)

1-30keV，0.3° ×0.3°
2400 cm^2(1-6keV)
1000cm^2@ 30keV



Preliminary Concept of XTP:

Total Mass: 4500 kg

Orbit: 550-600km,
<10°

Life Time: 5 years

0.5-15keV，1° ×1°
2000 cm^2@1keV

0.5-15keV，2° ×2°
15000 cm^2(1-6keV)

Payload parameters:

- Focal length : 4 m
- Total mass: ~2 tons
- Total power: ~2kW

Status of XTP

- Feasibility-study has been supported by CAS (2011-2015)
- The Forum on TXP has organized by ISSI-BJ June 2013 with more than 40 participates from around the world of the high energy astrophysics community
- The mid-term external evaluation organized by CAS about the feasibility study on XTP was carried out in April, 2014.
- XTP has participated the selection Feb. 2015. The results will come out soon. If not selected, next chance will be in 2016.

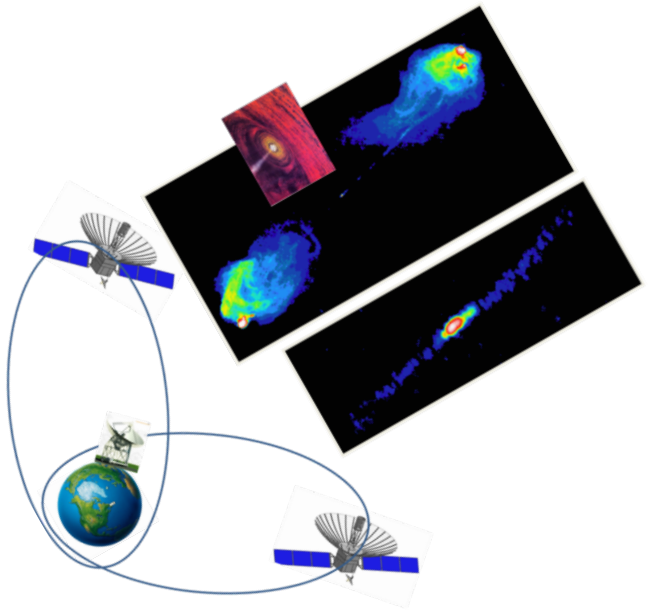
Space Millimeter-wavelength VLBI Array (S-VLBI)

➢ Major Scientific Objectives

- ✓ High-resolution imaging compact cosmic objects to study the formation and dynamics of astrophysical jets in Active Galactic Nuclei (AGN)
- ✓ Determine the supermassive black hole (SMBH) masses in nearby water mega-maser galaxies
- ✓ Expect to image the emission structure around the central SMBH in M87

➢ Specifications

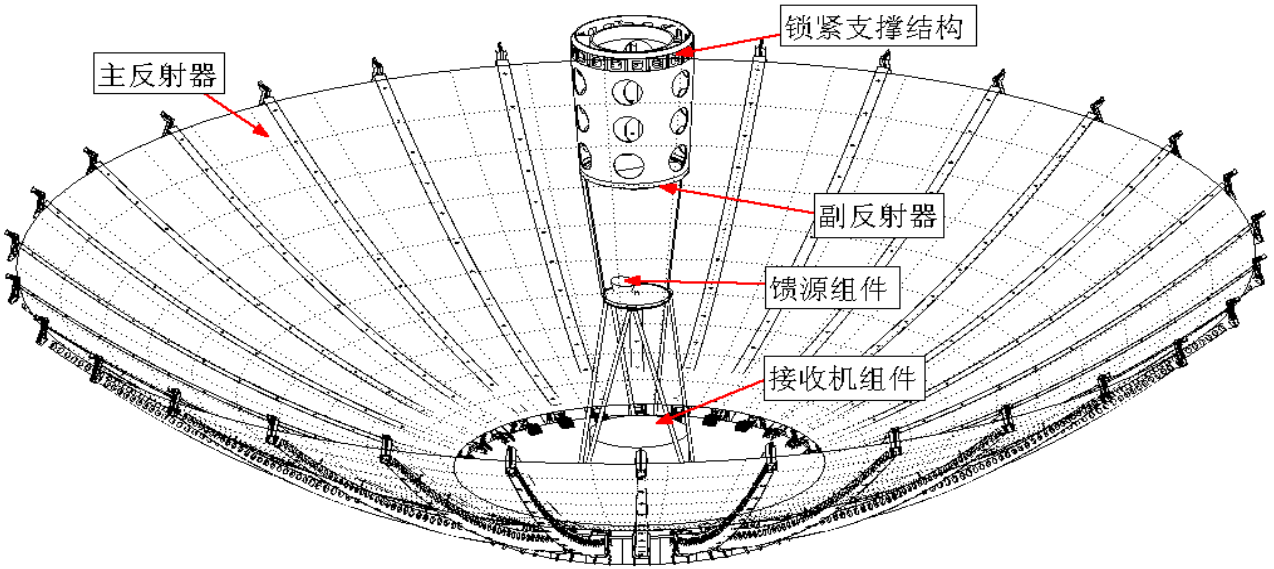
- ✓ Two 10m-diameter space antennas
- ✓ Optimized orbits for a better (u,v) coverage
  - Apogee: 60,000km
  - Perigee:1,200km
  - Inclination: 28.5deg
- ✓ Three frequency bands (43, 22 & 8GHz)
- ✓ Dual polarization (LCP/RCP)
- ✓ Data rate (1.2Gbps, up to 2.4Gbps)
- ✓ Angular resolution: 20 micro-arcsecond
- ✓ Expected lifetime: 3 years



Space Millimeter-wavelength VLBI Array (S-VLBI)

➢ Scientific Payloads

- Foldable large reflector antenna at 43 GHz
- Baseline noise/signal timing and transmission
- Laser reflector

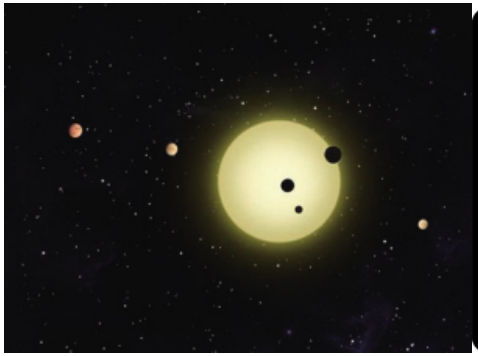


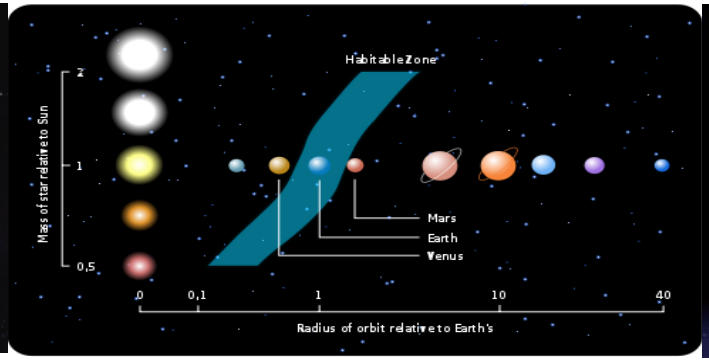
Status of S-VLBI

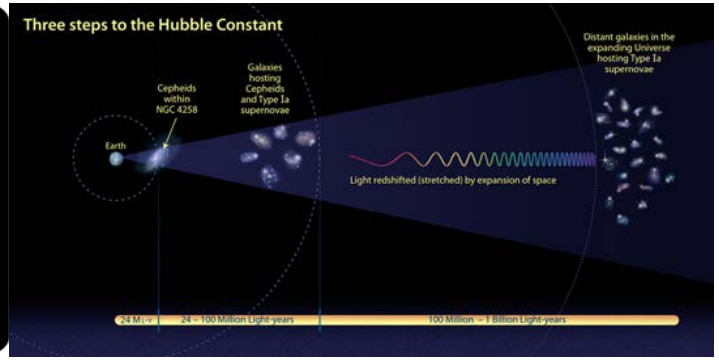
- Feasibility-study has been supported by CAS (2012-2015)
- The Forum on S-VLBI has been organized by ISSI-BJ Sept. 2014 with more than 30 participates from around the world of the radio astronomy community
- The mid-term external evaluation organized by CAS about the feasibility study on S-VLBI was carried out in April, 2014.
- Conclusion of the feasibility study will be crucial for S-VLBI to participate the new selection next year in 2016.

Search for Terrestrial Exo-Planets (STEP)

- **Science Objectives:** **High-precision Astrometry Mission for Extra-solar Planets Detection**





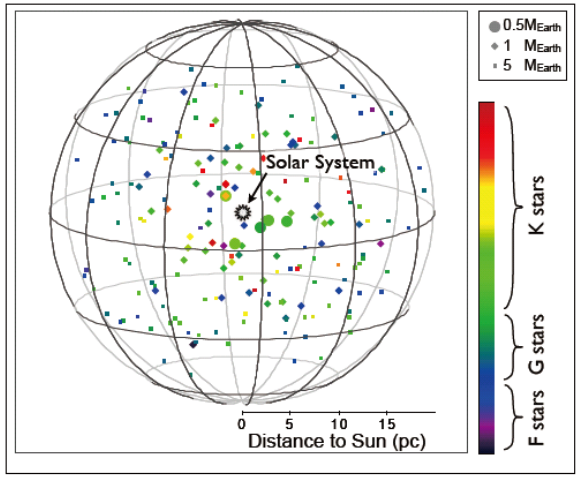


- Search for nearby (d<20pc) habitable earth twins
- Comprehensive exploration of the structure and diversity of nearby planetary system
- Calibration of the distance indicators of the universe

(Cepheids, improve the current accuracy from 10% to 1%, which will improve all the subsequent steps in the distance scale)

Search for Terrestrial Exo-Planets (STEP)

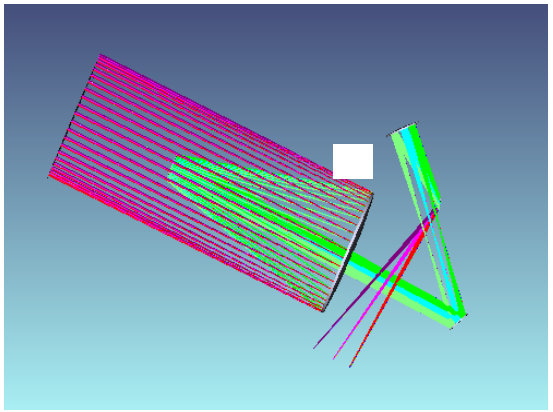
- **Satellite Specifications**
  - ✓ Orbit: Solar-earth L2 Halo
  - ✓ Mass: 500kg Life time: 5 years



➢ Highlights

- ✓ Extremely-high-precision (1μas) astrometric space mission
- ✓ Able to detect the habitable planets at earth criterion
- ✓ Get the actual planetary masses and the full orbital geometry for all components of the detected planetary system

- **Payload:** TMA Design, Astrometric Telescope

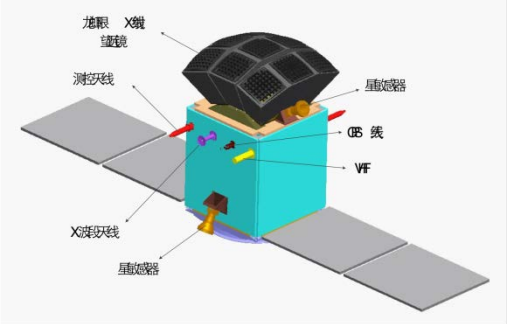


Status of STEP

- Feasibility-study has been supported by CAS (2013-2015)
- The Forum on STEP has been organized by ISSI-BJ August 2014 with more than 30 participates from around the world of the explanatory community
- STEP participated the pre-selection Feb. 2015, and the result will come out soon. If it is not selected, it has another chance to participate the next year in 2016.

Einstein-Probe (EP)

- Science Objectives: Time-domain census of soft X-ray transient and variable sources in the universe
  - ✓ Discover quiescent black holes over all astrophysical mass range and other compact objects via high-energy transients
  - ✓ Discover and locate electromagnetic-wave sources of gravitational-wave events by synergy with new GW detectors
  - ✓ Systematic census of soft X-ray transients and variability of known X-ray sources over wide time-scales at high cadence
- Satellite Specifications / Payloads
  - ✓ Orbit: 600km, circular, 30°inclination
  - ✓ Mass: 380kg
  - ✓ Life time: 5 years
  - ✓ Payloads: a wide-field (60°× 60°) monitor based on established Multi-Pole Optics (MPO) technology, with fast alerting capability



Status of EP

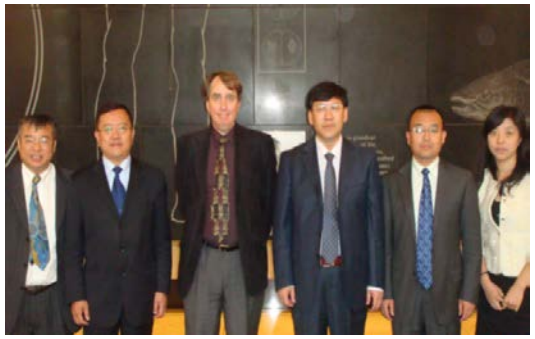
- Feasibility-study has been supported by CAS (2013-2015)
- The Forum on EP has been organized by ISSI-BJ June 2014 with more than 30 participates from around the world of the explanatory community
- EP participated the pre-selection Feb. 2015, and the result will come out soon. If it is not selected, it has another chance to participate the next year in 2016.

International cooperation

- China is open on space cooperation particularly in the area of space science.
- European countries are our main partners, leaded by ESA.
- Currently a mission (S-class) will be jointly selected with ESA more than 10 proposals have been received. The selection procedure is under taken now.

International cooperation (2)

- Cooperation with US is still remaining preliminary between scientists, supported by NAS. Selected young scientists are organized to meeting each other twice a year in 2014. Next year another young scientist workshop will be organized again in the topic of earth science and planetary science.
- Canada, Russia, Australia, Thailand, Brazil, are all have cooperation relations with China in space science.



International cooperation (3)

- China is a key contributor of COSAR and hosted 2006 Assembly in Beijing, now is proposing to host COSPAR 2020
- CAS and COSAR has a joint award called JAW science award since 2008, until now 4 awards are given, 3 awardees are US scientist
- CAS/NSSC and ISSI in Bern has opened a new international space science institute in Beijing 2013. It is running very well

Remarks

- China has long history on space observations in the ancient time
- China, as a large space country, there is no fix space science budget yet. However, it already realized that space science is a very important field in basic research therefore we have a few missions under development already
- China is open for cooperation in space science programs, therefore all kind of participation with our program are welcome.


THANK
YOU