Current and Future Space Science Programs in China

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- Current Missions 2011-2017
- New Missions in Preparation for 2018-2022
- Final Remarks

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- Highlights of Current Missions 2011-2017
- New Missions in Preparation for 2018-2022
- Final Remarks

Chinese Civil Space Activities (ref. 2001 White Paper)

1. Space Technology
2. Space Applications
3. Space Science

Strategic Priority Program on Space Science (2011-2017)

- DArk Matter Particle Explorer (DAMPE)
- ShiJian-10 (SJ-10)
- QUantum Experiments at Space Scale (QUESS)
- Hard X-ray Modulation Telescope (HXMT)

1. DArk Matter Particle Explorer (DAMPE)

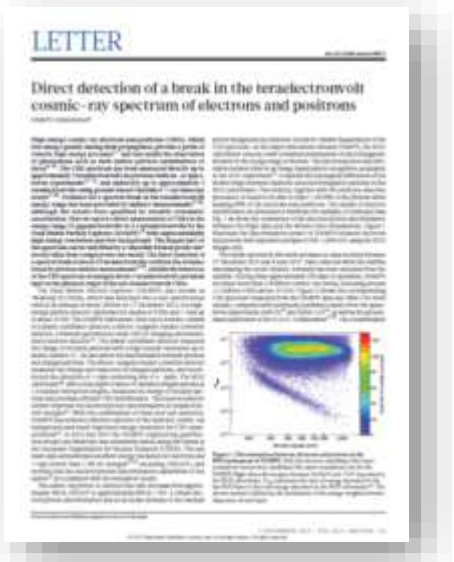
- Science Objectives
  - Find and study dark matter particle through high-resolution observation of high energy electron, gamma-ray spectrum and its space distribution
  - Study the origin of cosmic ray through observation of high energy electron spectrum and anisotropy above TeV
  - Study the propagation and acceleration mechanism of cosmic ray through the observation of its heavy ion spectra
- Launch: Dec. 17, 2015

悟空 / Monkey King
悟：understanding
空：space

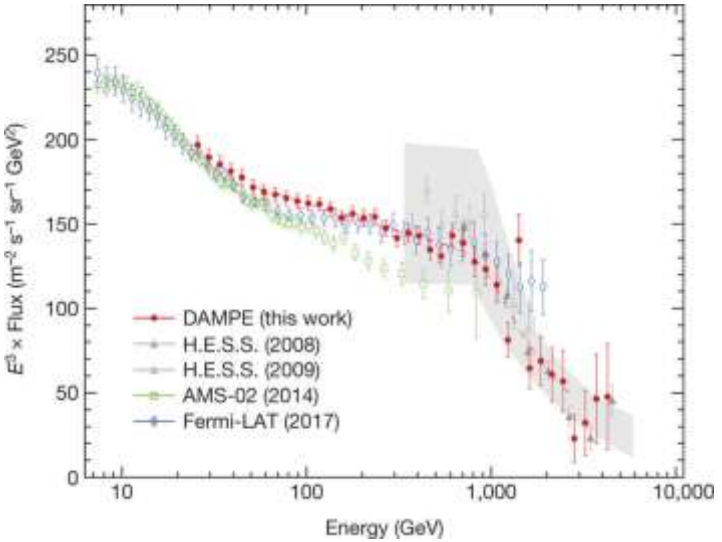
Scientific Output

- Direct detection of a break in the Tev cosmic-ray spectrum of electrons and positrons
- Up to Jun. 2017, 3.3 billion high-energy particle has been detected, covering the whole sky for three times

J.Chang et al, *Astroparticle Physics*, P6-24, VOL 95, Jun. 24, 2017



DAMPE Collaboration, *NATURE*, P63-66, VOL 552, Dec. 7, 2017



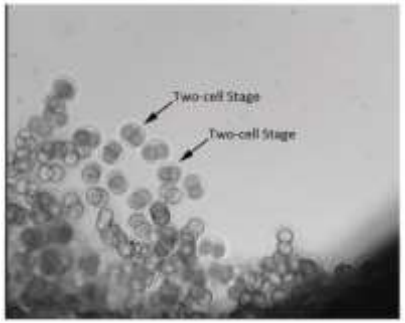
- Red dashed line: a smoothly broken power-law model that best fits the DAMPE data in the range 55 GeV to 2.63 TeV;
- AMS-0214 and Fermi-LAT16： direct measurements； H.E.S.S：indirect measurement

2. Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)

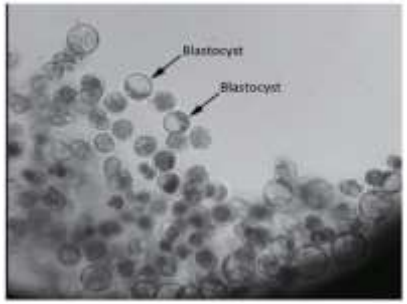
- SJ-10, the 24th recoverable satellite of China, provides a mission of 19 space microgravity experiments, selected from more than 200 applications
- Scientific Objectives
  - The basic laws of motion for matter
  - High performance material preparation
  - Mechanism of combustion
  - Biological effects of gravity or space radiation, and space biotechnology
- Launch: mission carried from April 6-18, 2016

Scientific Output

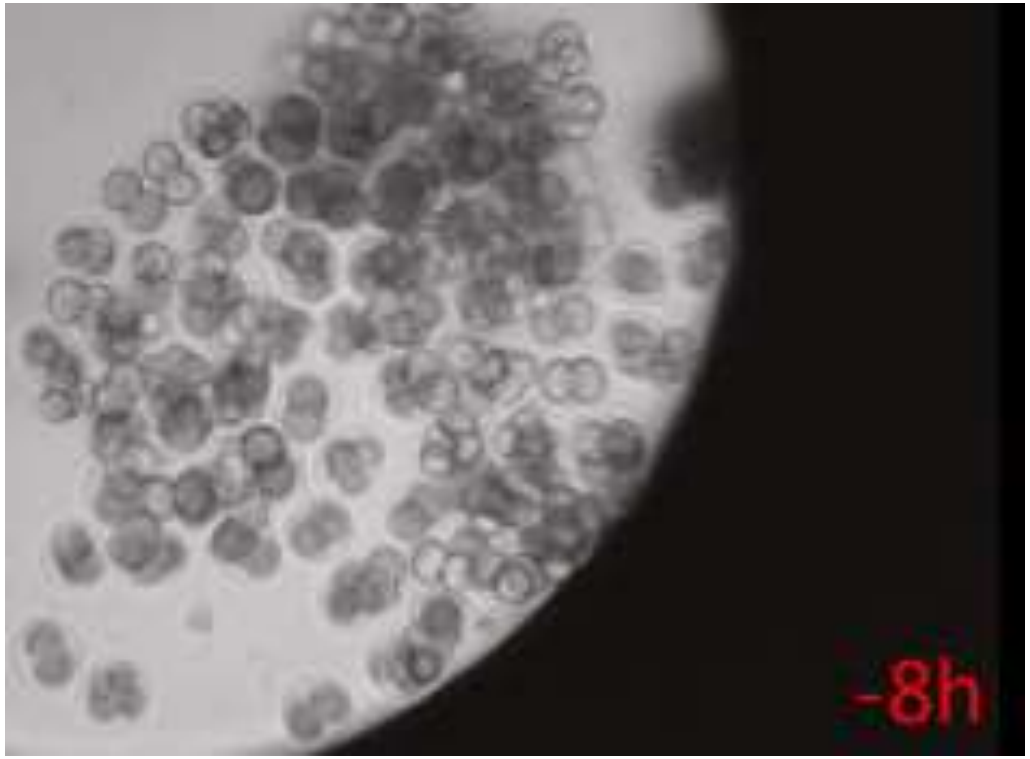
Mammal embryos developed in space for the first time



Two-cell mouse embryos, four hours before launch



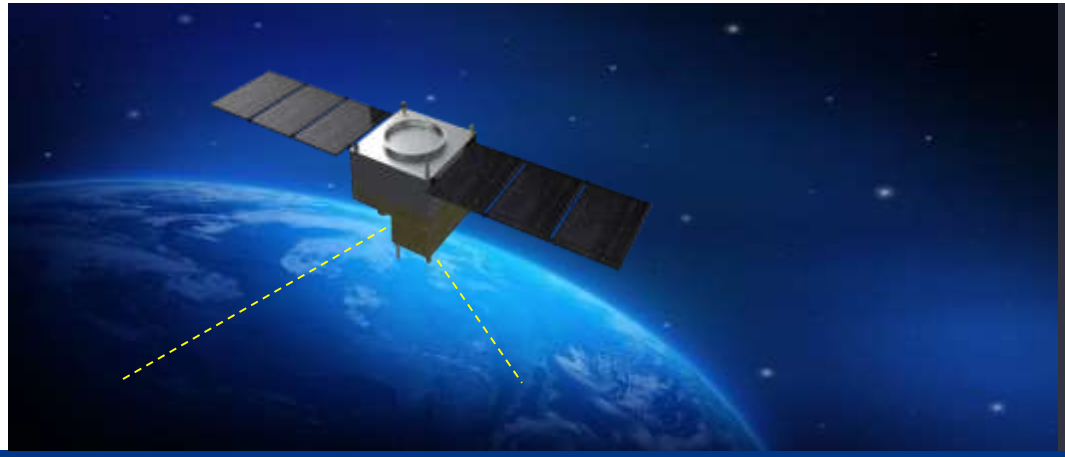
Mouse embryos that developed into blastocyst 80 hours after the launch



15 experiments were carried out for the first time

3. QUantum Experiments at Space Scale (QUESS)

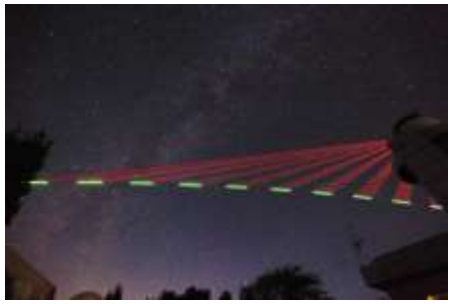
- Science Objectives
  - Implementation of long-distance quantum communication network based on high-speed quantum key distribution(QKD) between satellite and the ground station, to achieve major breakthroughs in the realization of space-based practical quantum communication
  - Quantum entanglement distribution and quantum teleportation on space scale, fundamental tests of the laws of quantum mechanics on global scale
- Launch: Aug. 16, 2016

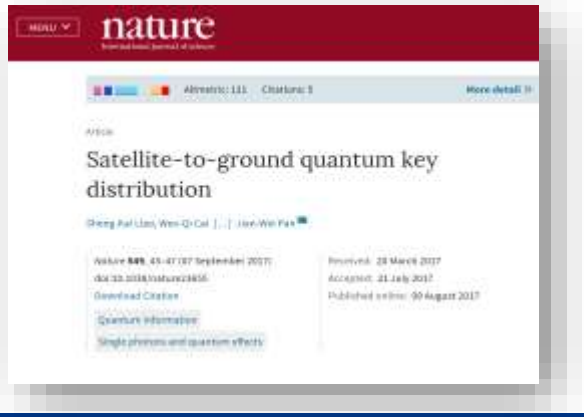


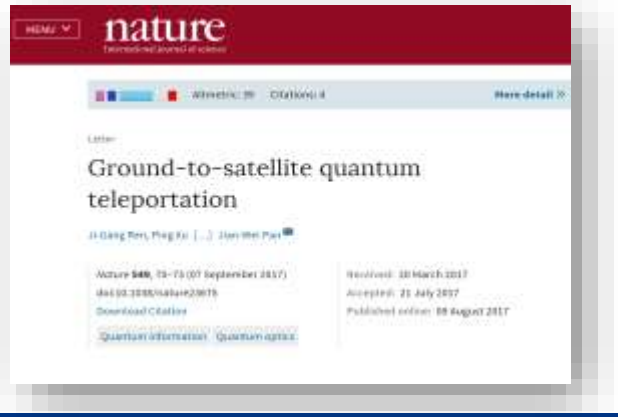
Micius/Mozi
from ~BC 468 to ~BC 376

Scientific Output

- Satellite-to-ground quantum key distribution was accomplished for the first time
- Ground-to-satellite quantum teleportation was accomplished for the first time

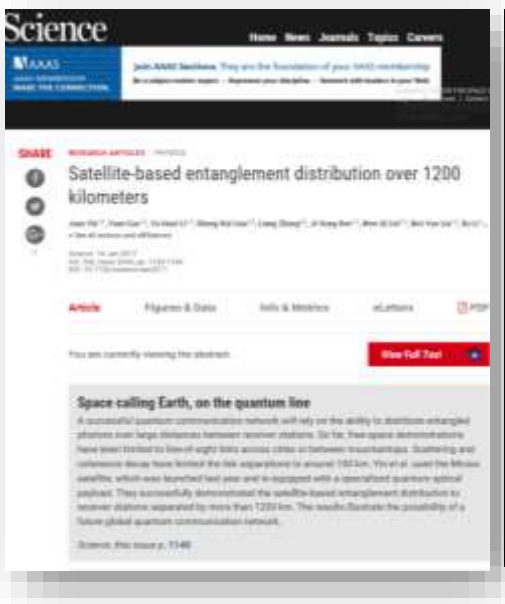


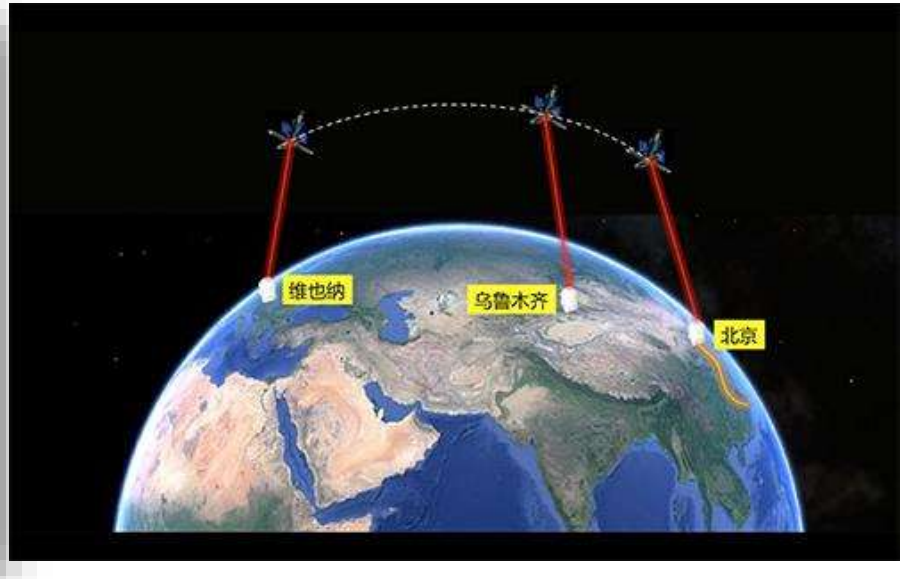




Scientific Output

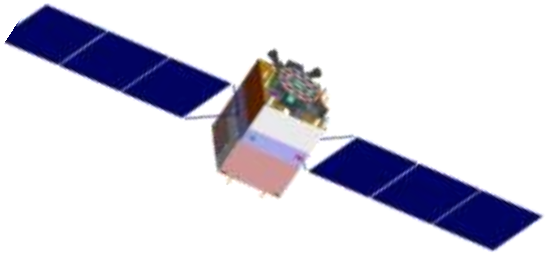
- Satellite-ground and ground-satellite entanglement distribution over 1200 kilometers was accomplished for the first time
- Intercontinental quantum communication was for the first time accomplished between China and Austria



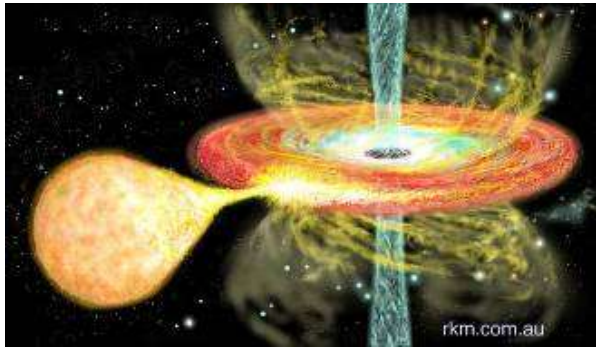


4. Hard X-ray Modulation Telescope (HXMT)

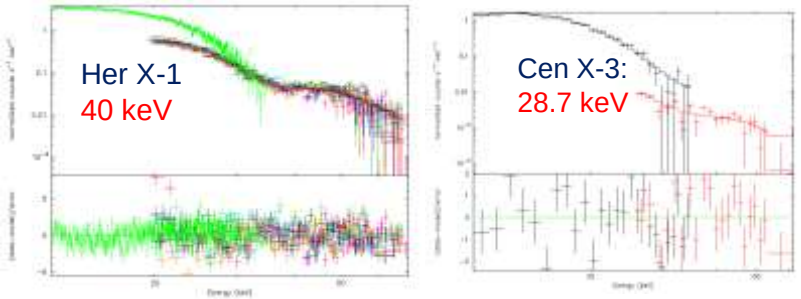
- Science Objectives
  - Galactic plane scan and monitor survey for more weak & short transient sources in very wide energy band (1-250 keV)
  - Pointed observations: High statistics study of bright sources and Long-term high cadence monitoring of XRB outbursts
  - Multi-wavelength Observations with other telescopes
  - GRBs and GW EM, FRB, etc.
- Launch：Jun. 15, 2017



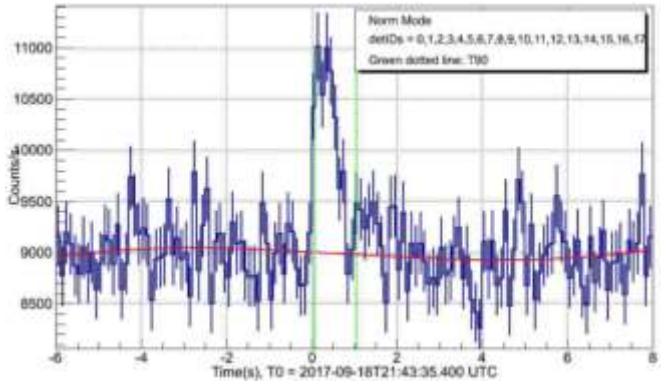
慧眼－HXMT



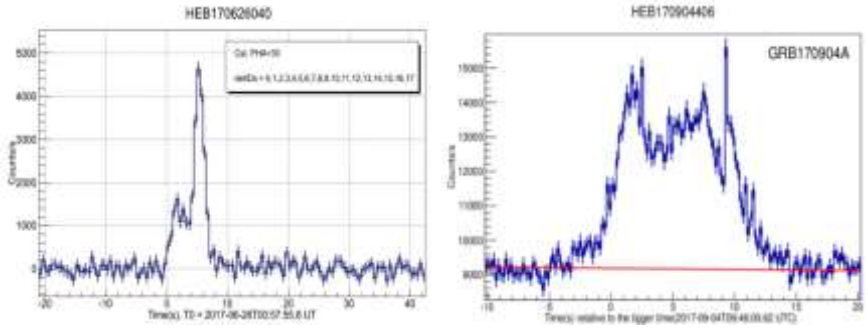
Scientific Output



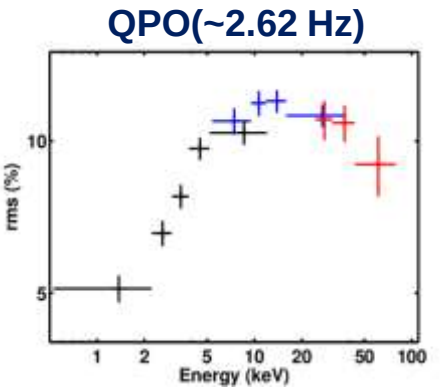
Neutron star cyclotron absorption lines



Monitored the entire GW170817 localization area and especially the optical counterpart (SSS17a/AT2017gfo) with very large collection area (~1000 cm^2) and microsecond time resolution in 0.2-5 MeV



More than 40 Gamma-Ray Bursts are detected



Quasi-Periodical Oscillations of black hole binary MAXI J1535-571

ApJ Letter Science China

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New Missions 2018-2022

- 1. Einstein Probe (EP)
- 2. Advanced Space-borne Solar Observatory (ASO-S)
- 3. Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)
- 4. Gravitational wave high-energy Electromagnetic Counterpart All-sky Monitor (GECAM)

→ Implementation

Background Study (Phase A)

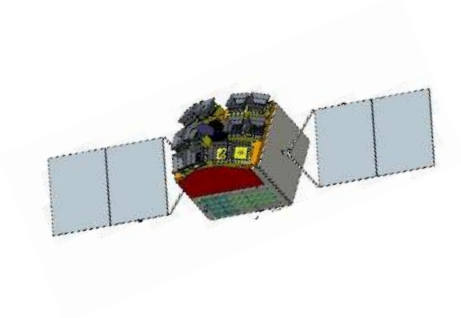
- 1. enhanced X-ray Timing and Polarimetry mission (eXTP)
- 2. Taiji Program
- 3. Mid-to-high Orbit Quantum Satellite
- 4. Small Bodies Sample Return Mission
- 5. Ultra-long Wavelength Astronomical Observation Array

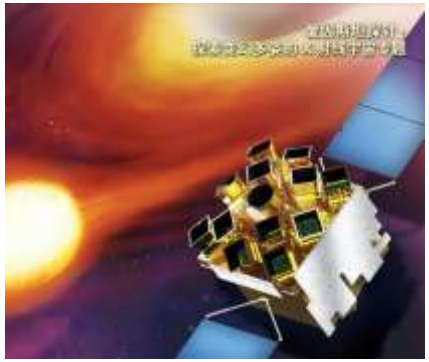
- 1. Water Cycle Observation Mission(WCOM)
- 2. Magnetosphere-Ionosphere/Thermosphere Coupling Exploration (MIT)

→ Extended Phase-A Study

1. Einstein Probe (EP)

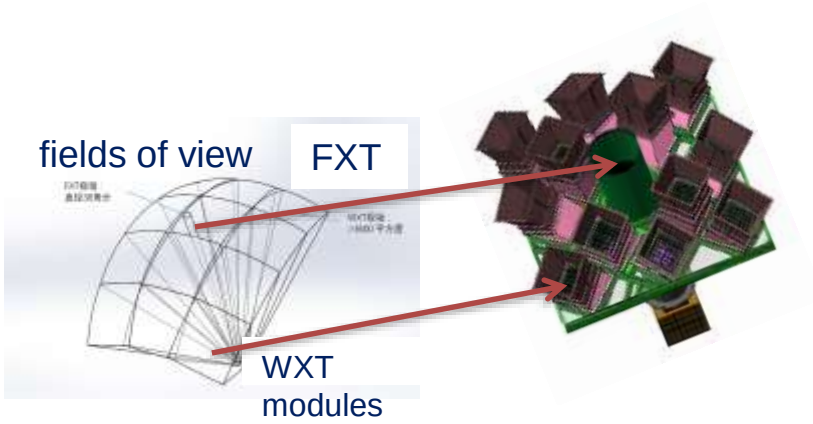
- EP is an explorer-class mission
  - Dedicated to time-domain astronomy
  - For all-sky monitoring & exploring cosmic high-energy transients
- Science Objectives
  - Demography, origin and evolution of black hole population
  - How gravitational waves are produced, and their effects?
  - Life cycle of the first generation of stars, re-ionisation
  - How supernovae explode?
  - …





Mission Profile

- Payloads
  - Wide-field X-ray Telescope (WXT)
  - Follow-up X-ray Telescope (FXT)



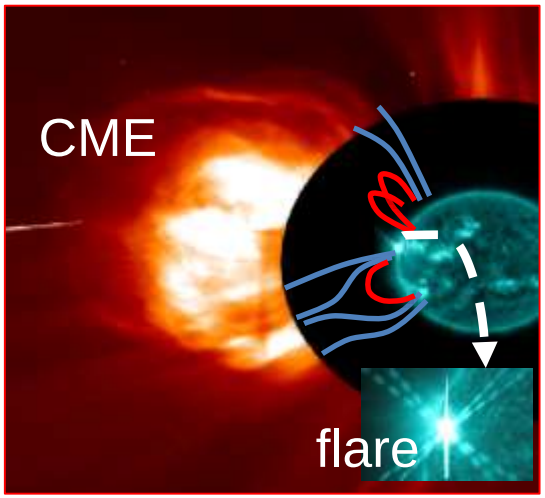
- Features
  - Large Field of View 3600 sq. deg.; grasp: ~10,000 $deg^2.cm^2$
  - Monitoring: soft X-ray band: 0.5-5keV
  - Sensitivity: > 1 order of magnitude higher than those in orbit
  - Good angular resolution (~5 arcmin) and positioning accuracy (<1 arcmin)
  - Autonomous follow-up (<10 arcsec localisation; 0.3-10keV)
  - Fast alert data downlink and (possible) fast uplink (ToO)

Schedule & Cooperation

- Schedule
  - Approved and fully funded in Dec. 2017
  - Engineering implementation started in Sept. 2017
  - Currently in Phase B
  - Planned launch: the end of 2022

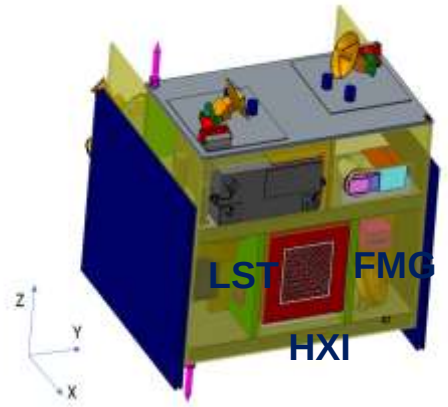
- International Cooperation
  - ESA: invest >10M euro in-kind contribution
  - MPE (Germany): hardware contribution
  - French Space Agency: VHF system

2. Advanced Space-borne Solar Observatory (ASO-S)



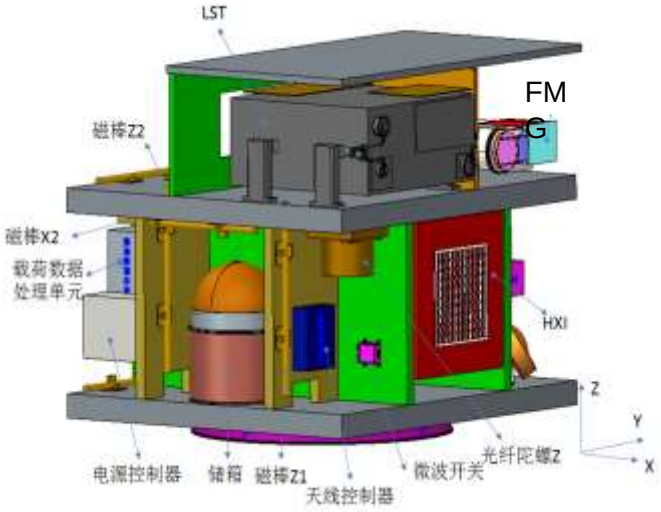
- Science Objectives
  - Relationship between solar magnetic field and solar flares
  - Relationship between solar magnetic field and CMEs
  - Relationship between solar flares and CMEs

- Payloads
  - Full-Disc Vector Magnetograph (FMG)：solar magnetic field
  - Hard X-ray Imager (HXI)：solar flare
  - Lyman-alpha Solar Telescope(LST): CME



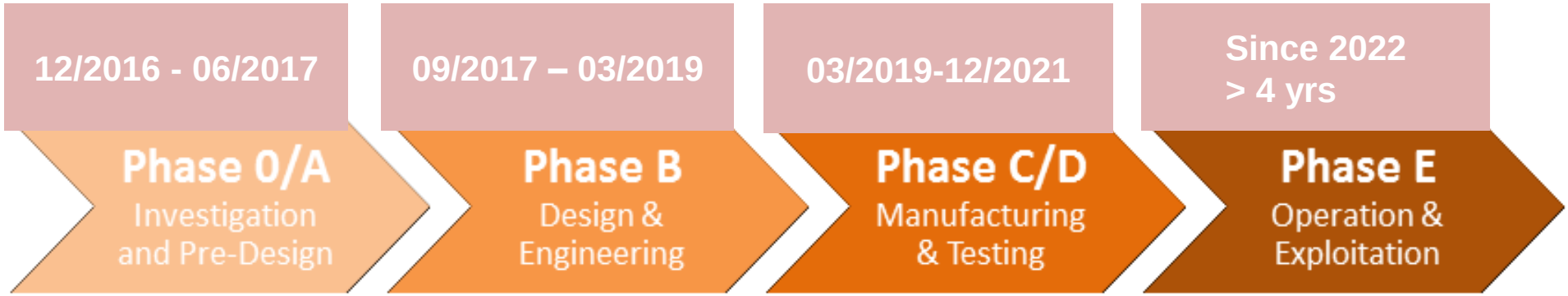
Mission profile

- Orbit: solar synchronous
- Attitude: 720 km
- Attitude Control: 3-axis stabilization
- Pointing accuracy: 0.01º
- Stability: 0.0005º/s (1-2”/20s)
- Payload Mass: <335 kg
- Payload power: 300 W
- Data downlink: 492 GB/day
- Eclipse time:
  <18min/day during eclipse season



Schedule

- The idea proposed in 2010 or earlier, a partial heritage from SMESE
- A conceptual study granted by CAS and NNSFC (Oct. , 2011-Mar., 2013, ~ 90K$)
- Intensive Study (so-called background phase) undertaken from Jan., 2014 to Apr., 2016, jointly supported by CAS and NNSFC (~ 1600K$)
- Intensive Study (extended): May 2016-Nov. 2016

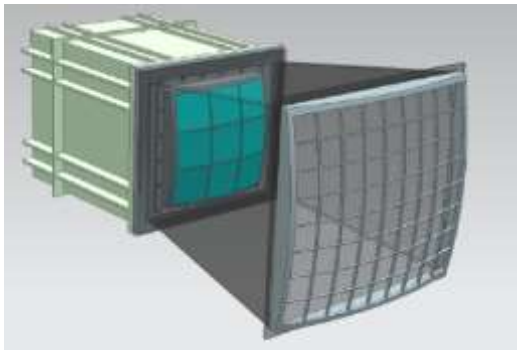


3. Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)

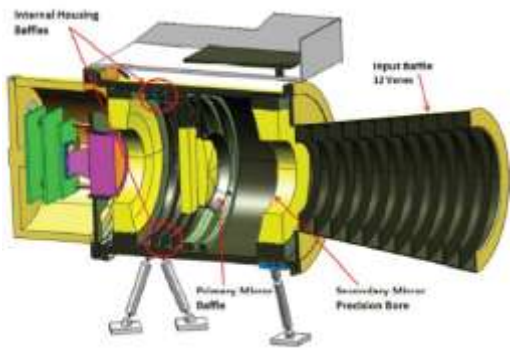
- Science Objectives
  - Determine when and where transient and steady magnetopause reconnection dominates
  - Define the substorm cycle, including timing and flux transfer amplitudes
  - Define the development of CME-driven storms, including whether they are sequences of substorms
- Scientific Significance
  - Expected to carry out global imaging of the interaction between solar wind and magnetosphere for the first time, with the new soft X-ray Imager and ultra-violet imager
  - A new milestone of geospace exploration, enabling the great leaps from the local to the global detection

Payloads

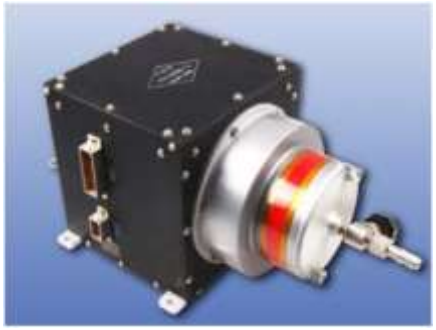
- Soft X-ray Imager (SXI)
- Ultra-Violet Imager (UVI)
- Light Ion Analyzer (LIA)
- MAGnetometer (MAG)



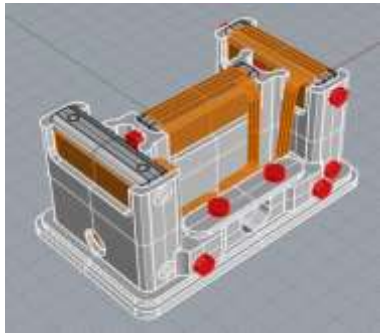
SXI



UVI



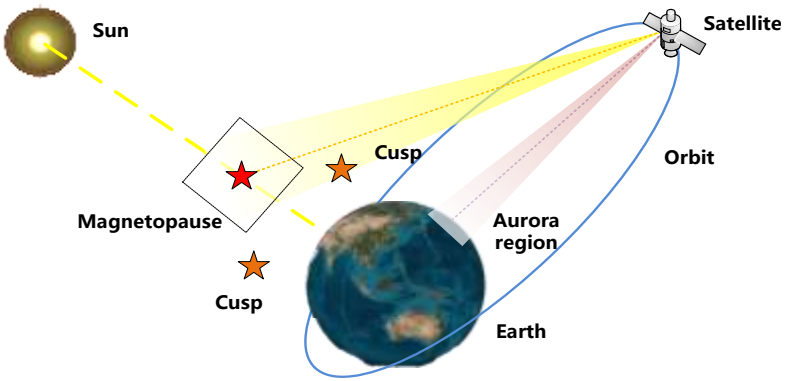
LIA



MAG

The payload and satellite will be provided by scientists and industry from both Europe and China

Mission Profile

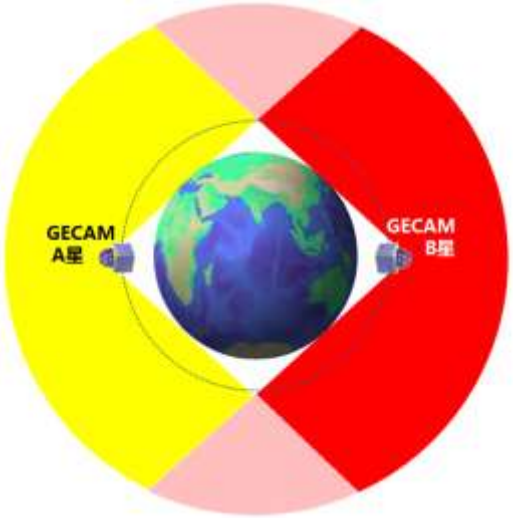


- **Orbit**: 5000km@perigee
  19 RE@apogee
- **Mass (PLM+SVM+PM)**: <2000kg
- **Planned Launch**: ~2023
- **Lifetime**: 3 years

4. Gravitational wave high-energy Electromagnetic Counterpart All-sky Monitor(GECAM)

- Sciences: GW GRB + others

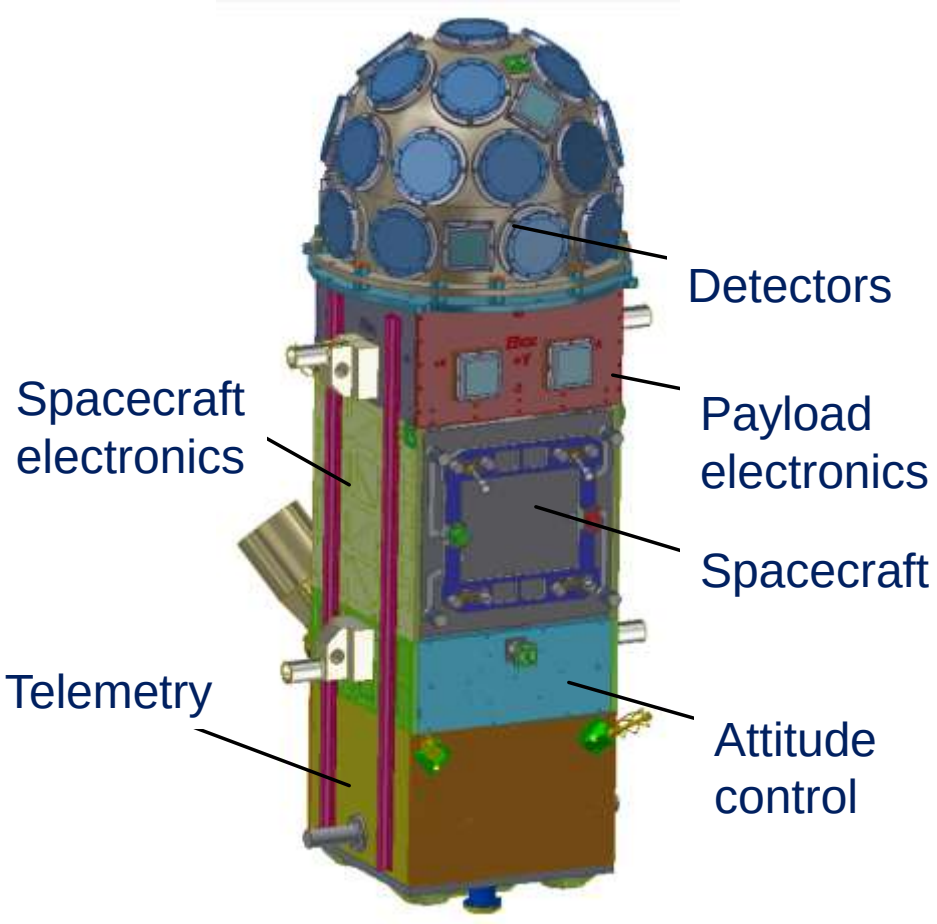
  All-time all-sky detect GW GRB, FRB, …



  - Independent confirmation of GW event
  - Accurate localization, host galaxy, redshift
  - Astrophysical content of the GW source
  - GW+EM, Cosmology, fundamental physics

Mission Profile

- Features
  - FOV： 100% all-sky
  - Sensitivity：~2E-8 erg/cm^2/s
  - Localization：~1 deg (1-sigma, stat.)
  - Energy band：6 keV – 5 MeV
- Planned to launch in the mid of 2020
- Joint observation with LIGO & Virgo when they reach best sensitivity



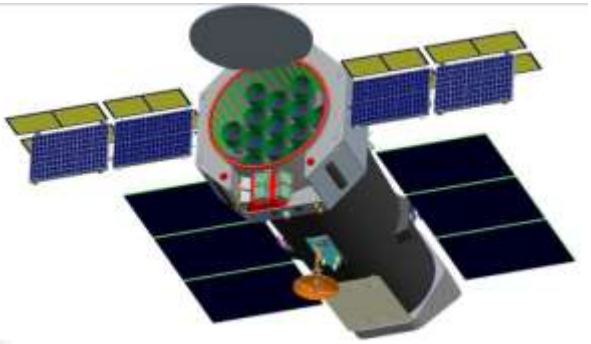
1. enhanced X-ray Timing and Polarimetry mission(eXTP)

- Overview
  - The X-ray Timing and Polarization (XTP) was proposed in 2007, and merged with the European LOFT mission and became the enhanced X-ray Timing and Polarimetry mission (eXTP) aiming for a launch in 2025
  - ~ 4.5 ton， Low equatorial orbit (550 km)

- Science objectives
  - Observe black holes, neutron stars, and magnetars to understand the physics in extreme gravity, magnetism and density
    - 1 Singularity
    - 2 Stars
    - 3 Extremes

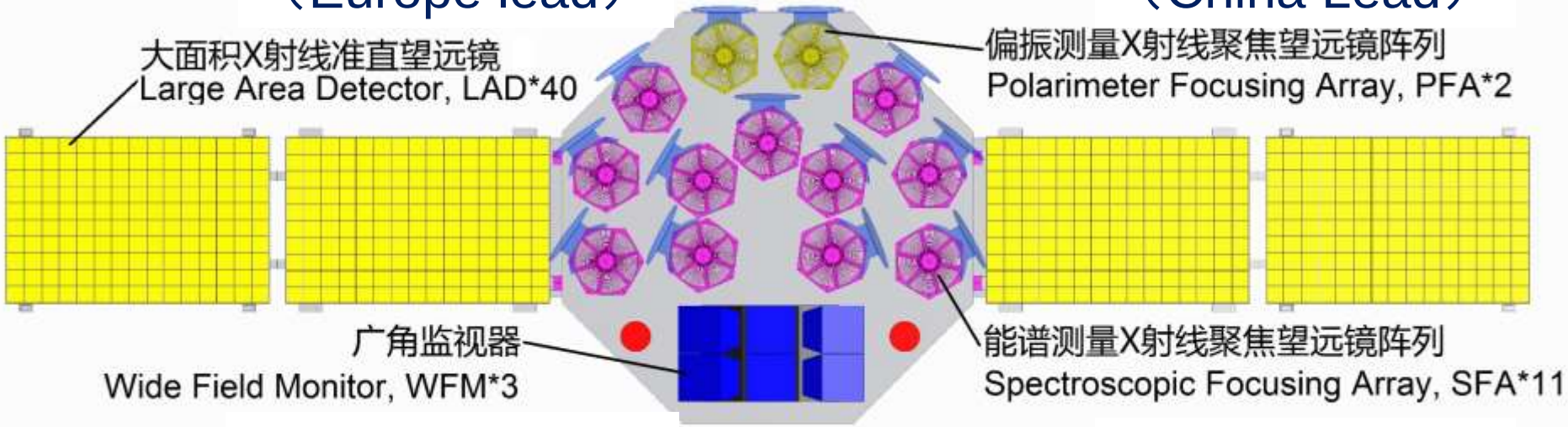
Payloads

- Short focal length telescope array
- Low energy X-ray polarimetry and imaging
- Deployable large area collimated detector array



（Europe lead）

（China Lead）



（Europe Lead）

（China Lead）

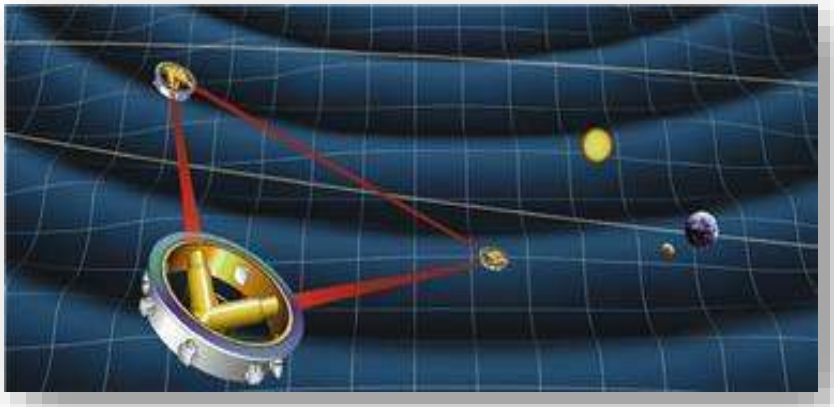
Potential European Participants

- About 20 countries and 100 international institutions involved in the mission
  - All major European countries are now members of the eXTP international consortium, including Italy, Germany, Spain, France, UK, Switzerland, Netherlands, Denmark, Poland, Czech Republic, etc
  - Many US, Japanese and Indian scientists are now contributing to the studies and prepared to join eXTP

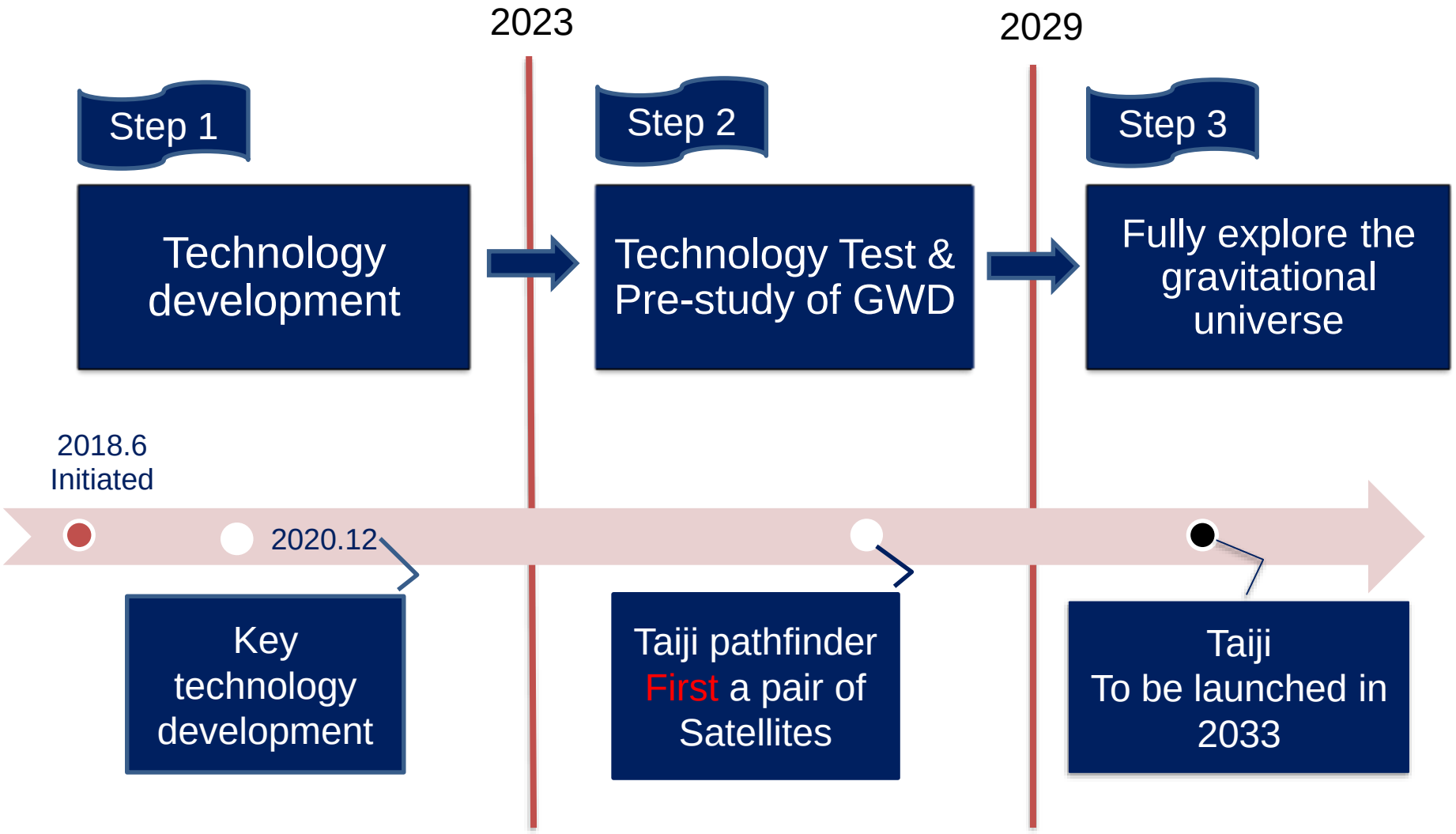
2. Taiji Program

- Science Objectives
  - Observe gravitational wave from mergence of binary black holes or great massive celestial bodies and so on

- Technologies
  - Ultra precise & key techniques
    - Pico-meter measurement within millions of kilometers
    - Sub-femto g drag-free technology
  - Ultra complex & key techniques
    - Strong confusion of G.W. signals
    - Strong couplings of subsystems

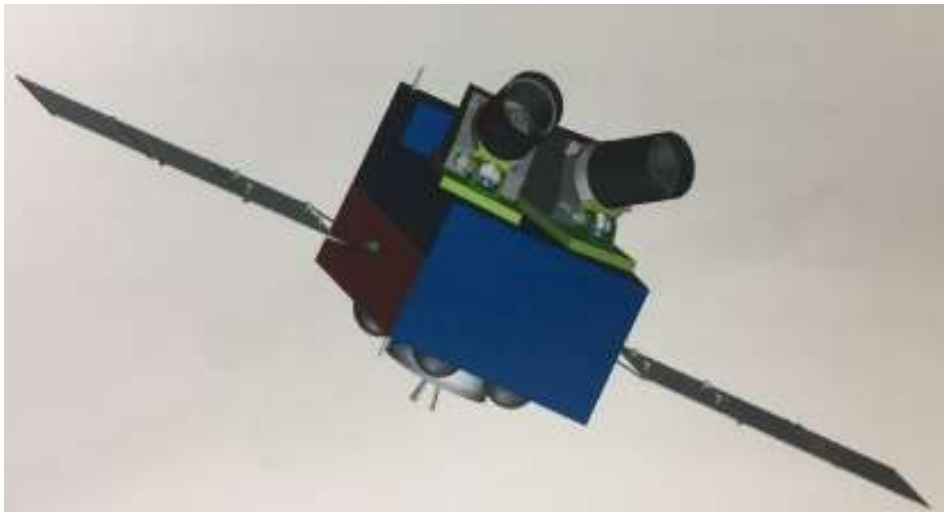


Roadmap: “Three step” strategy



3. Mid-to-high Orbit Quantum Satellite

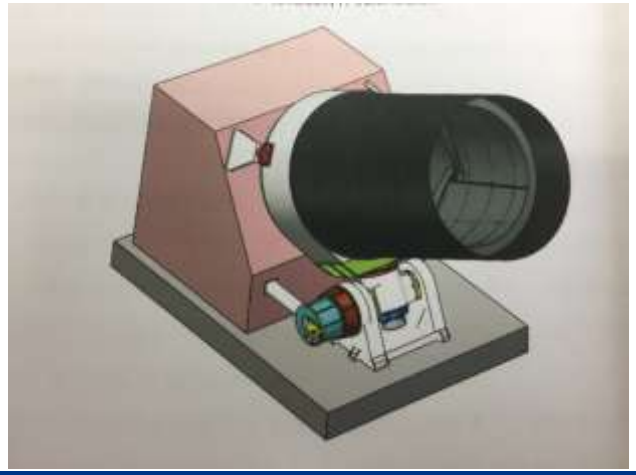
- Science Objectives
  - Realize quantum light modulation, 10,000-kilometers link establishment over, and real-time quantum key extraction
  - Achieve a sub-picosecond quantum real-time frequency transmission
  - Realize < 100pK quantum gas and an ultra-cold atomic quantum interferometer



Mission Profile

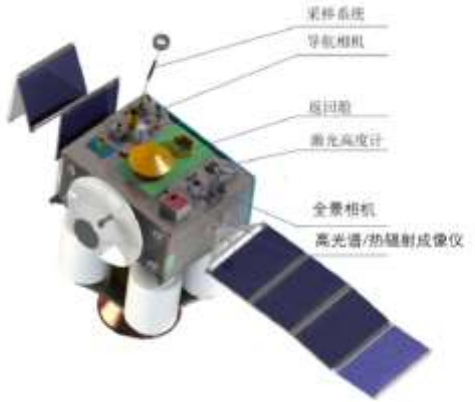
- A mid-to-high orbit satellite platform with the ability to switch orbits and multiple operating modes

- Payloads
  - Light transmission sub-system
  - Quantum communication sub-system
  - Time-frequency transmission sub-system
  - Ultra-cold atom sub-system
  - Support sub-system



4. Small Bodies Sample Return Mission

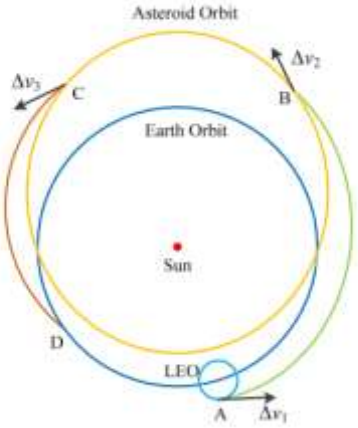
- Scientific Questions
  - Formation of the solar system
  - Formation of planets in the inner solar system
  - Accumulation of planetesimal

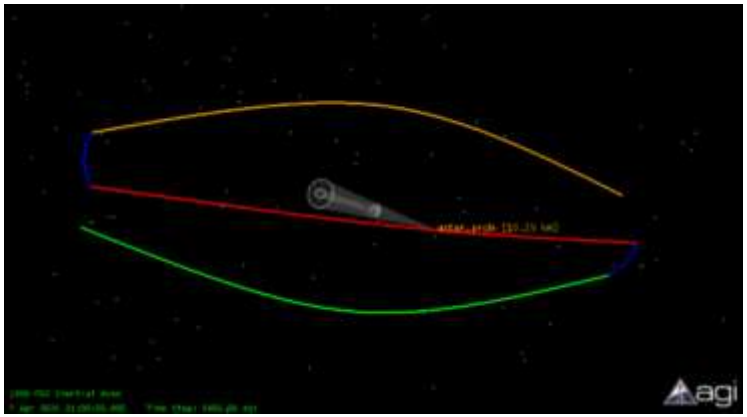


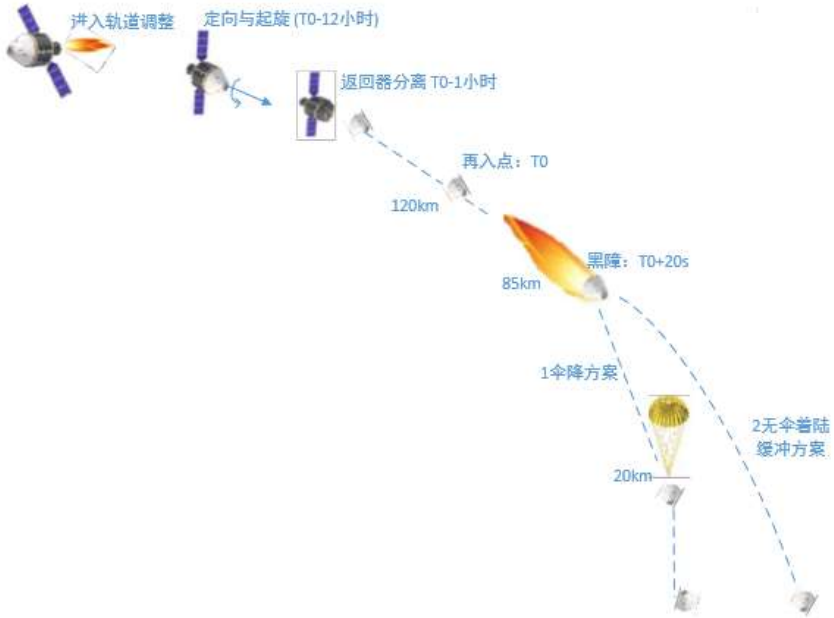
- Key Technical Improvement
  - Orbit design for low-gravitation small body accompany flying and orbiting and self-navigation
  - Precise control of satellite attitude and orbit during orbiting and landing
  - Sampling and encapsulating of samples from asteroid
  - Safe sample capsulation recovery and its atmosphere re-entry

Mission Profile

- Other Payload
  - Panoramic camera
  - Hyperspectral and thermal emission imager
  - Flux-gate magnetometer
  - Electric field and wave detector



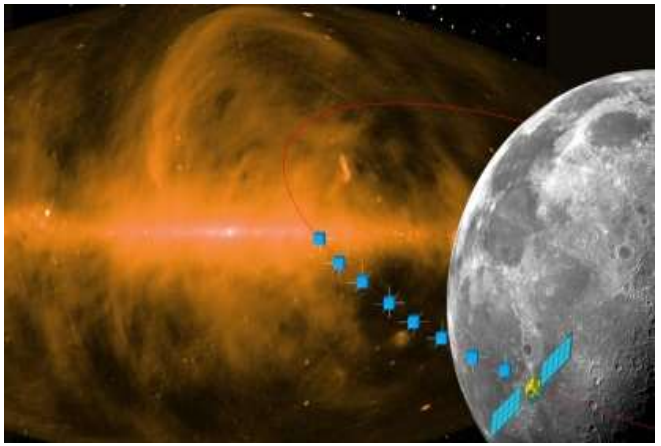




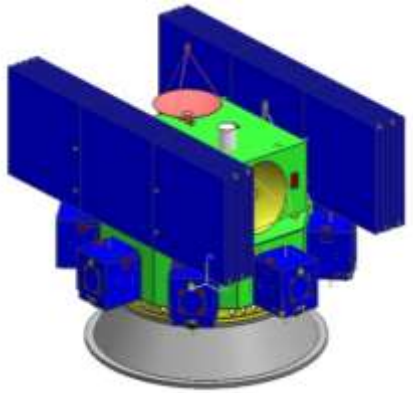
5. Ultra-long Wavelength Astronomical Observation Array

- Mission Objectives
  - Make a high angular resolution map for the whole sky
  - Take high precision measurement of the global spectrum
  - Observe radio activity of the Sun and planets

- Science Significance
  - Open up a new window for astronomical observations at the lower end of the electromagnetic spectrum
  - Obtain vital information on the astronomical sources at the ultra-long wavelength band



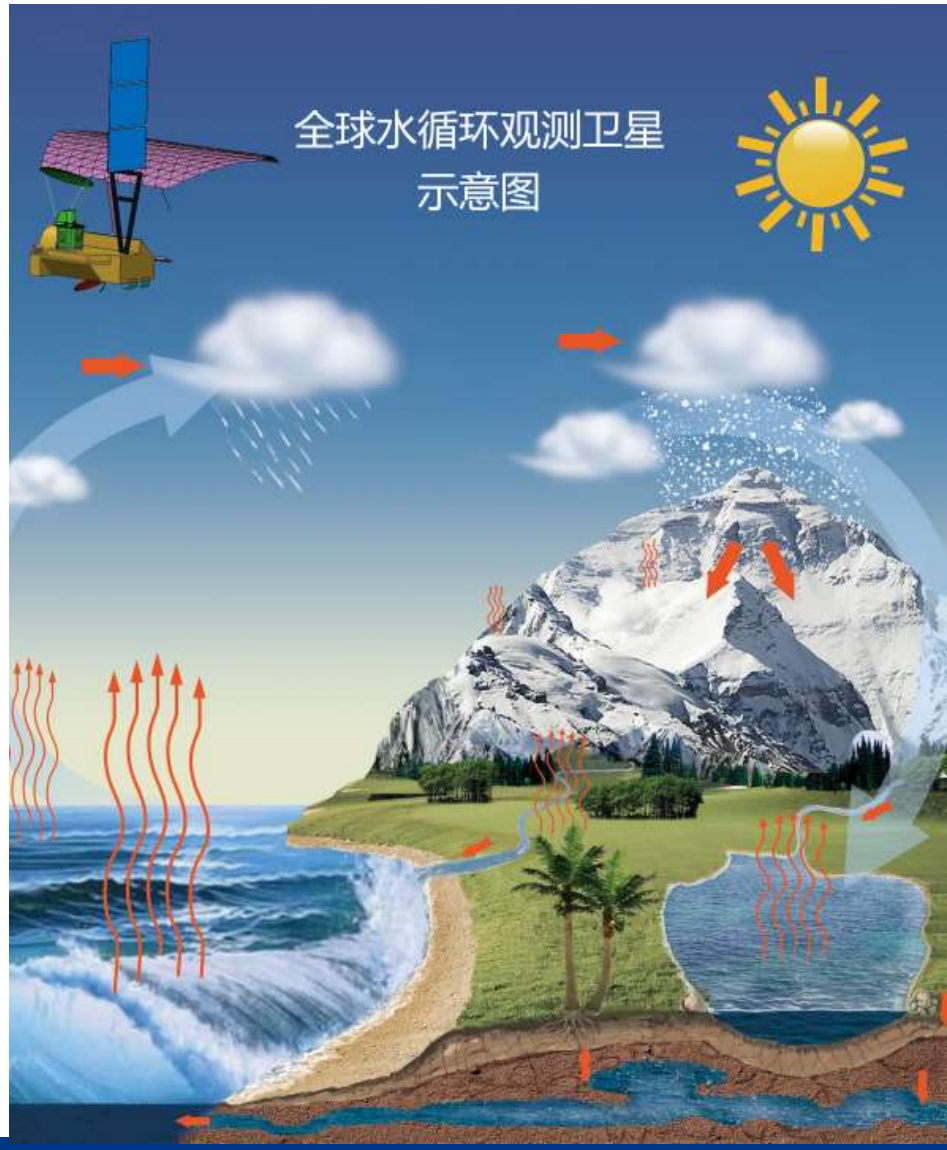
Mission Profile



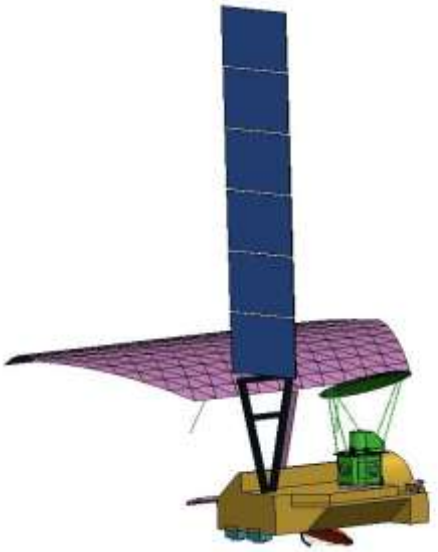
- Payload
  - High-stability ultra-long wave synchronous receiving system
  - Dynamic baseline measurement system
  - Inter-satellite communication system
- System-level index
  - 1 master satellite + 5~8 distributed small satellites
  - Orbit: 300km lunar circular orbit，30°angle
  - Baseline: 100m~100km
  - Sensitivity：better than 0.1K@30MHz（1MHz per year）
  - Angular resolution： better than 0.18°@1MHz，0.012°@30MHz

1. Water Cycle Observation Mission(WCOM)

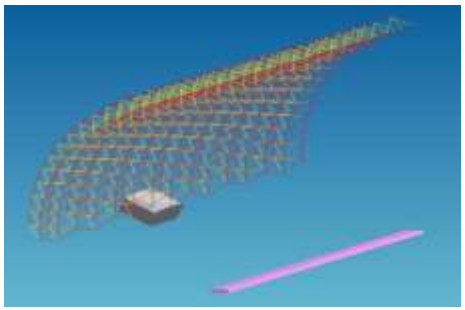
- Science Objectives
  - Understand better status and process of the Earth's water cycle system under the global change environment, by simultaneous and fast measurement of a set of water cycle key parameters (soil moisture, ocean salinity, ocean surface evaporation, snow water equivalent, frozen/thaw, atmospheric vapor…)



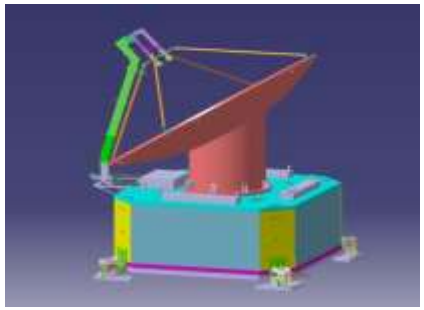
Mission Profile



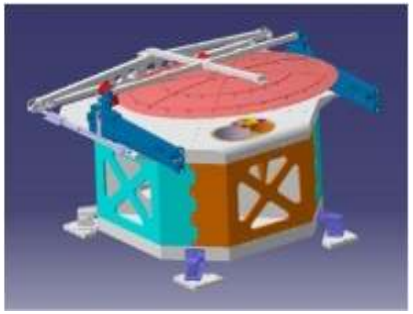
- Features
  - Orbit: 600km，97.79°
  - Mass: 1050kg，450kg (P/L)
  - Lifetime: 3-5 years
- Payloads
  - Interferometric Microwave Imager (IMI)
  - Dual-frequency Polarized microwave Scatterometer (DPS)
  - Polarimetric Microwave Imager (PMI)



IMI



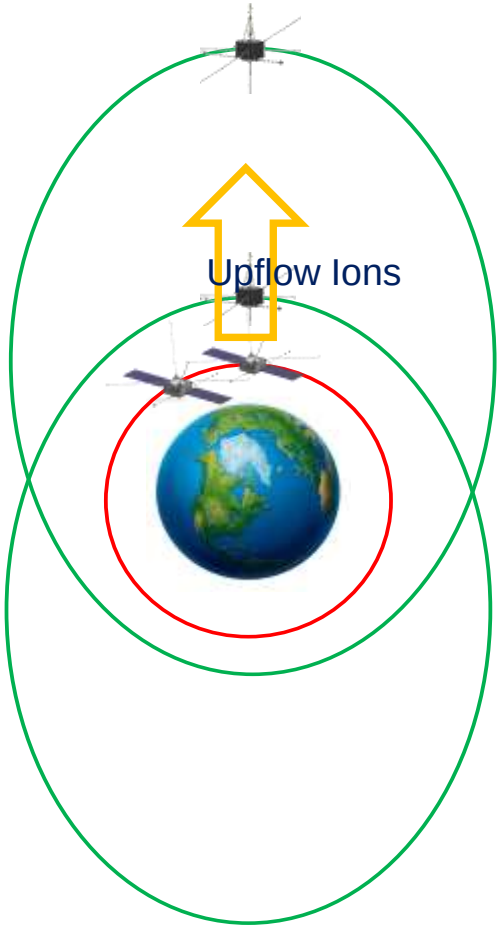
DPS



PMI

2. Magnetosphere-Ionosphere/Thermosphere Coupling Exploration (MIT)

- Scientific Objectives
  - Understanding the mechanism of ion acceleration and transport in ionosphere / thermosphere
  - Unveil the role of the coupling of the earth's spheres in triggering the space storm
  - Discover the escape process of the earth particles and deepening the understanding of the evolution of the planetary atmosphere

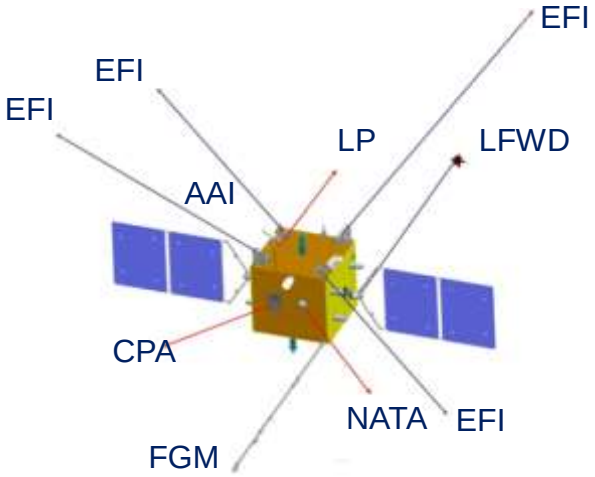


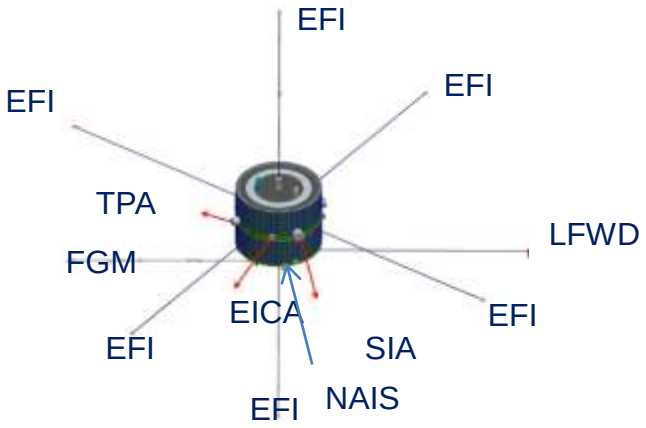
Mission Profile

- Features

Spacecraft	ITA	ITB	MA	MB
Inclination	90°	90°	90°	90°
Perigee	500km	500km	1Re	1Re
Apogee	1500km	1500km	7Re	7Re

- Payloads





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Final Remarks

- The breakthroughs in fundamental science is of great significance. Chinese will make contribution to human civilization through space science.
- A new chapter of Chinese space endeavor has been opened, with the implementation of Strategic Priority Program on Space Science. Chinese government puts a high value on space science and will continuously develop its science satellite series.
- We are open to International cooperation and welcome to join us.

Thanks for Your Attention