Priority Program on Space Science of CAS

WU Ji

National Space Science Center, CAS

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- Brief History of Space Science Development in China
- Strategic Priority Program on Space Science 2011-2016
- Looking at the Future

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Brief History of Space Science in China

- Everything started from October 18, 1955, when Dr. Xian came back to China

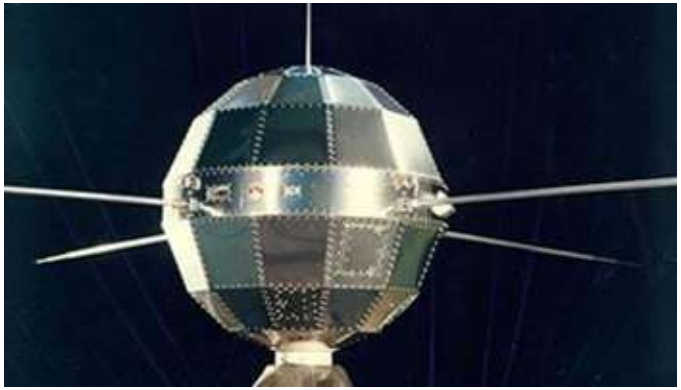
Brief History of Space Science in China

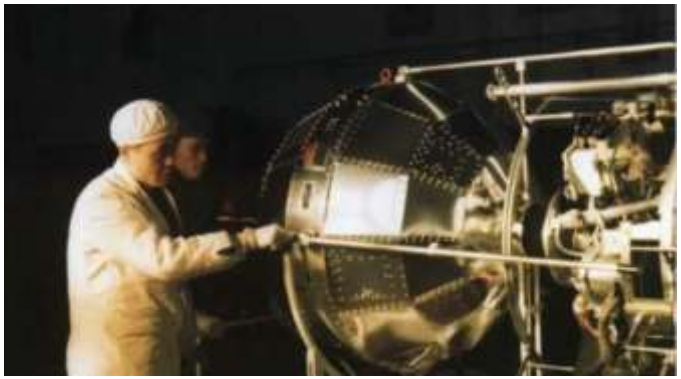
- Chinese rocket industrial was started then in 8 Oct. 1956, 60 years from now

June 1964 DF-2 rocket was successful launched which is preliminary model of LM-1

Brief History of Space Science in China

- The first Chinese satellite was launched in 24 April, 1970

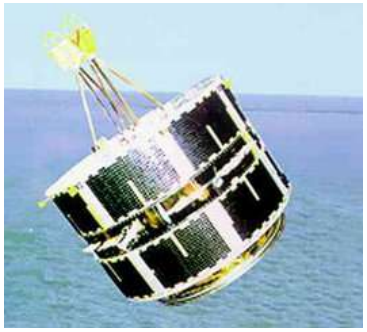




Brief History of Space Science in China

- Shi Jian series (SJ) is dedicated to space environment exploration

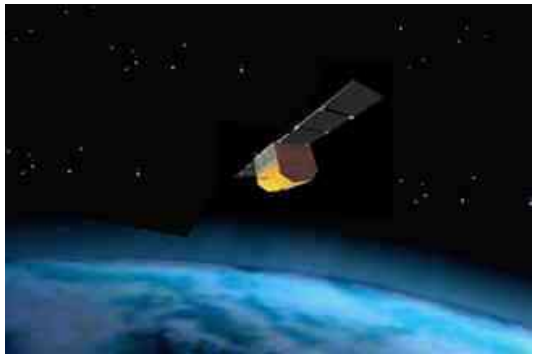
1971



1984

1994

1999



Brief History of Space Science in China

- **Double Star Program** as the first space science mission. It is also an international cooperation program with ESA's Cluster mission

2 satellites were launched 30 Dec, 2003 and 25 July, 2004

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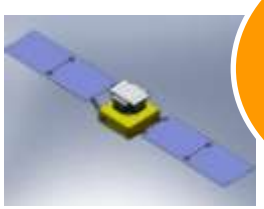
Strategic Priority Program on Space Science (2011-2016)



DArk Matter Particle Explorer (DAMPE)

QUantum Experiments at Space Scale (QUESS)

ShiJian-10 (SJ-10)

SPP on Space Science

Hard X-ray Modulation Telescope (HXMT)

Intensive Study of Future Space Science Missions

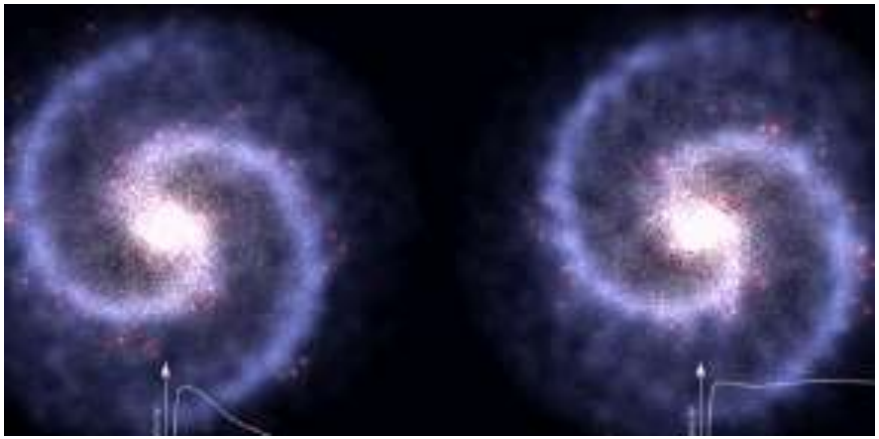
Advanced Research of Space Science Missions and Payloads

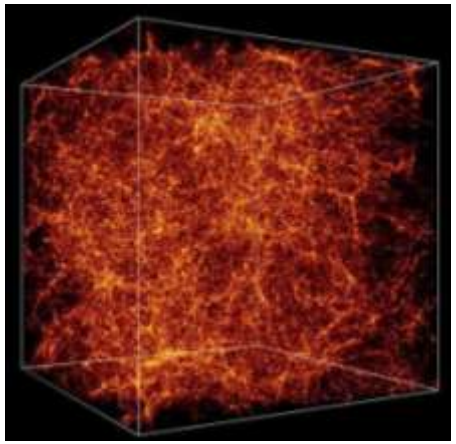
Strategic Priority Program on Space Science (2011-2016)

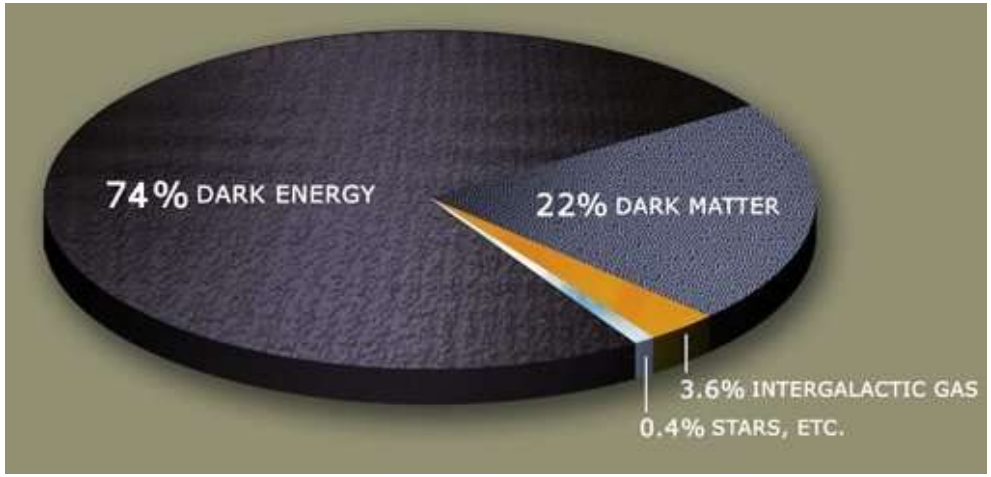
DArk Matter Particle Explorer (DAMPE) launched 17 Dec. 2015

[Wukong / Monkey King]

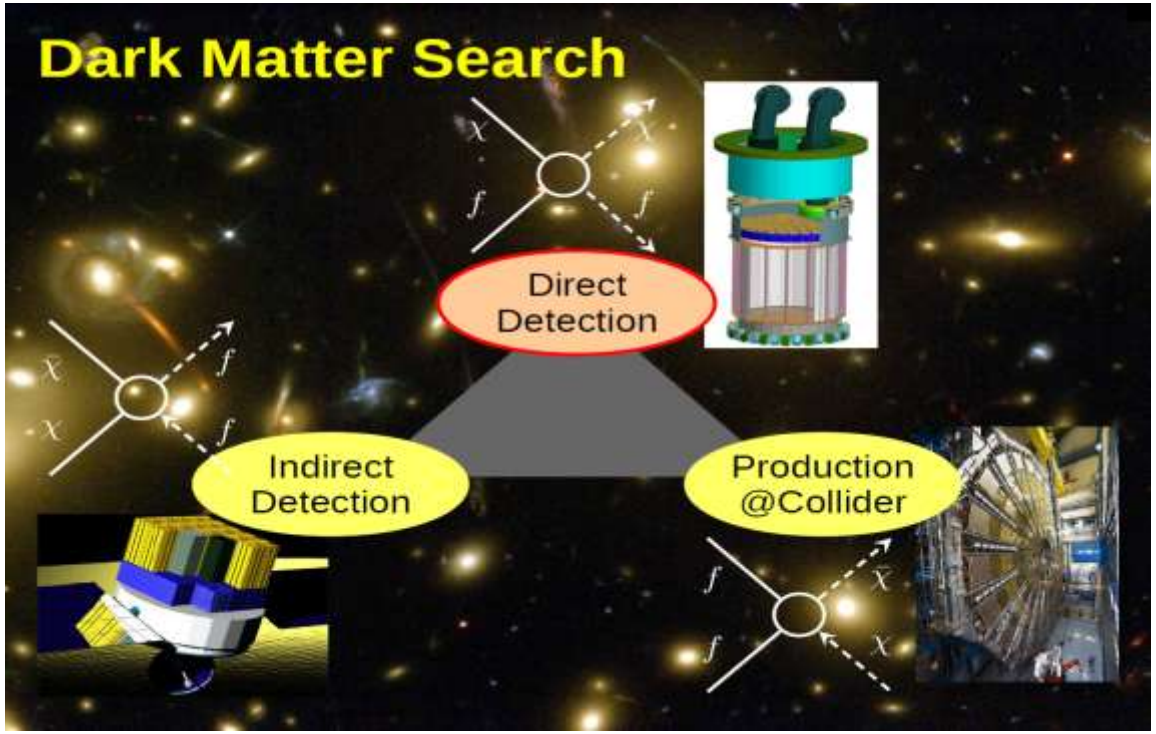
What is dark matter ?

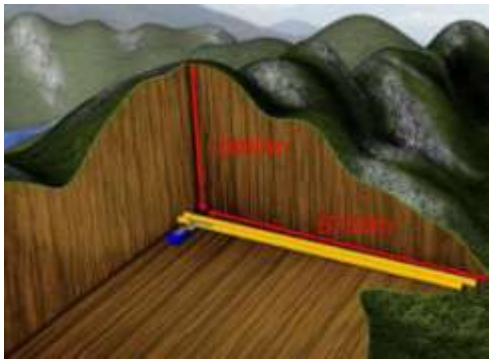




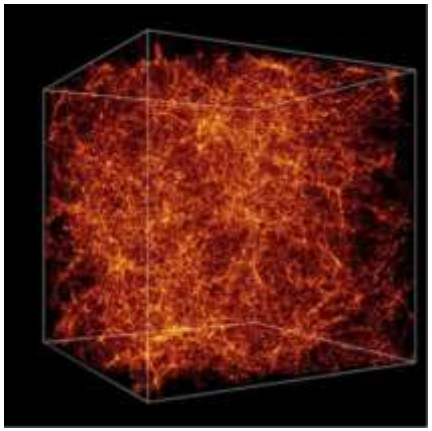


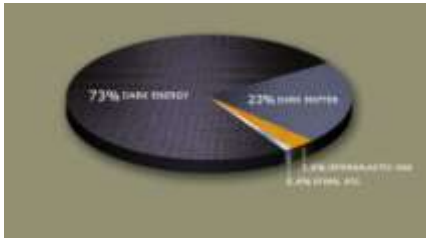
Three ways to search dark matter





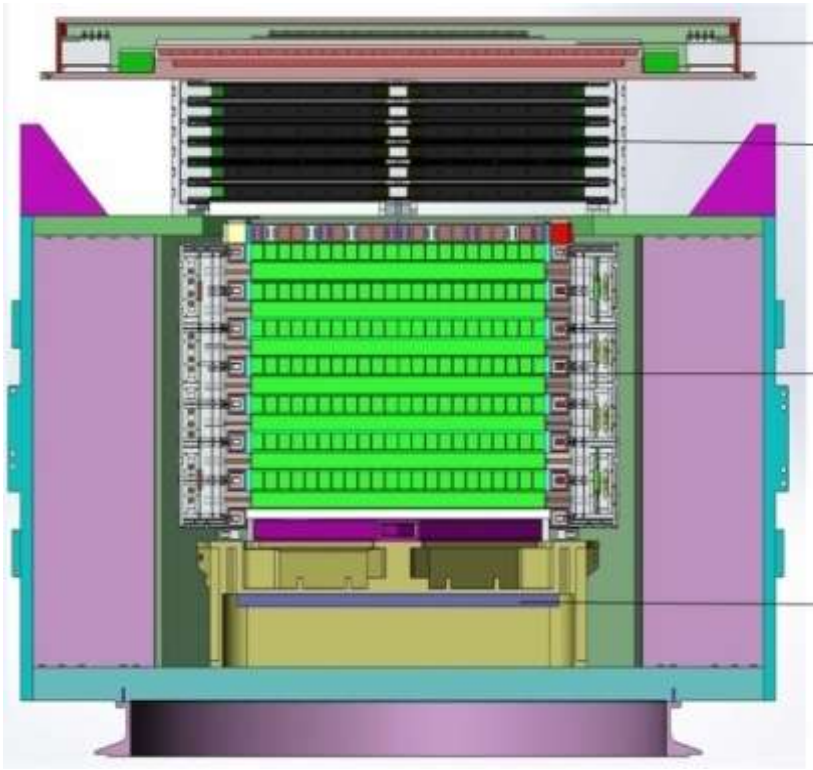
Scientific Objectives





- 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

Payloads



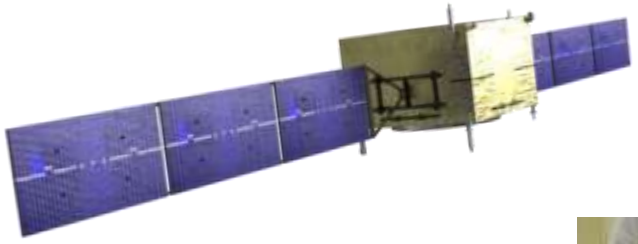
Plastic scintillation hodoscope array

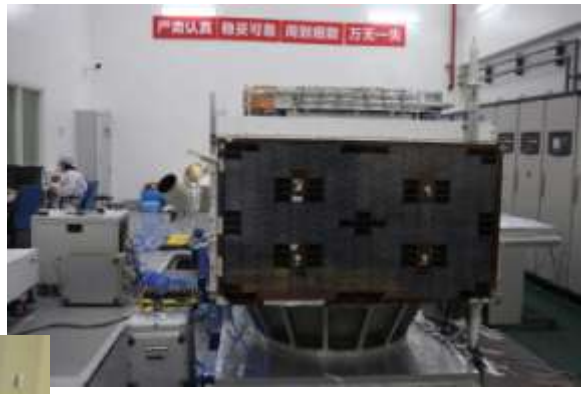
Silicon-Tungsten tracker

BGO Calorimeter

Neutron detector

Project Development





Satellite(flight model)

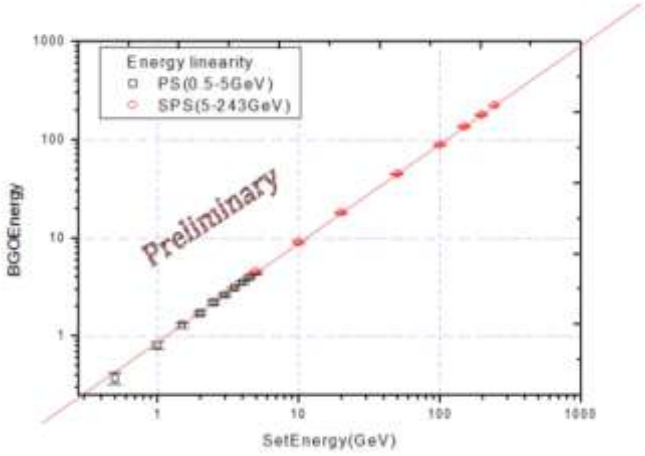
Silicon-Tungsten tracker

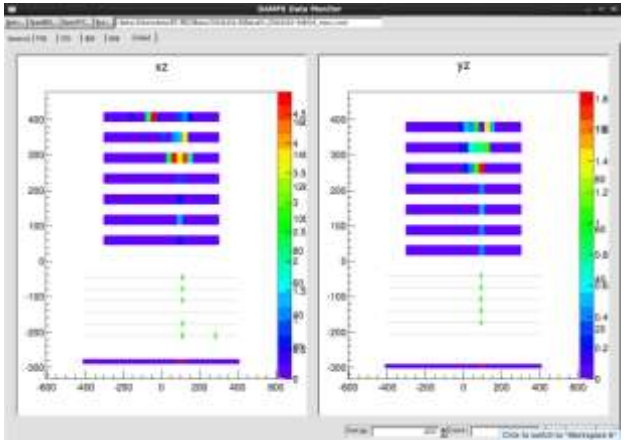
BGO calorimeter

Calibration Experiment

CERN building

The calibration experiment at CERN





Beam calibration experiment results

The lift-off of DAMPE satellite

08:12, December 17, 2015
@Jiuquan Satellite Launch Center

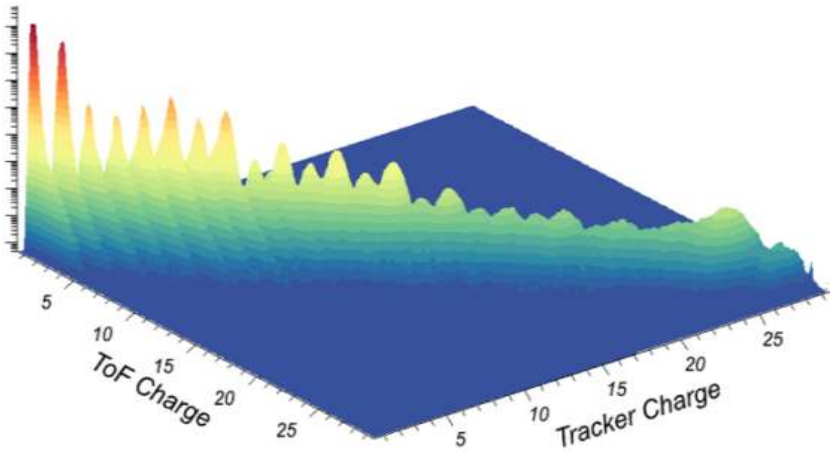
Official Delivery

March 17, 2016, Officially delivered to the scientific user —— Purple Mountain Observatory(PMO), CAS, after three-month in-orbit test

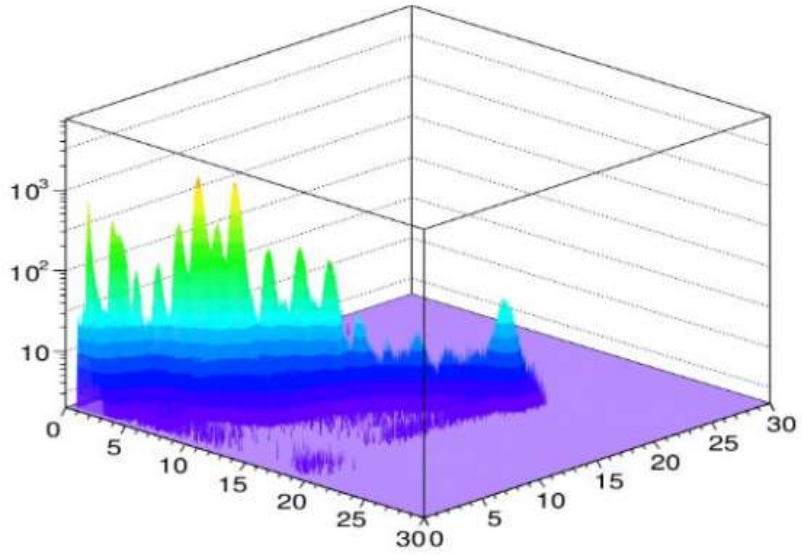
Preliminary Output

- **Electric charge : equivalent to AMS**

  The resolution of O: 0.185; Fe: 0.389



AMS

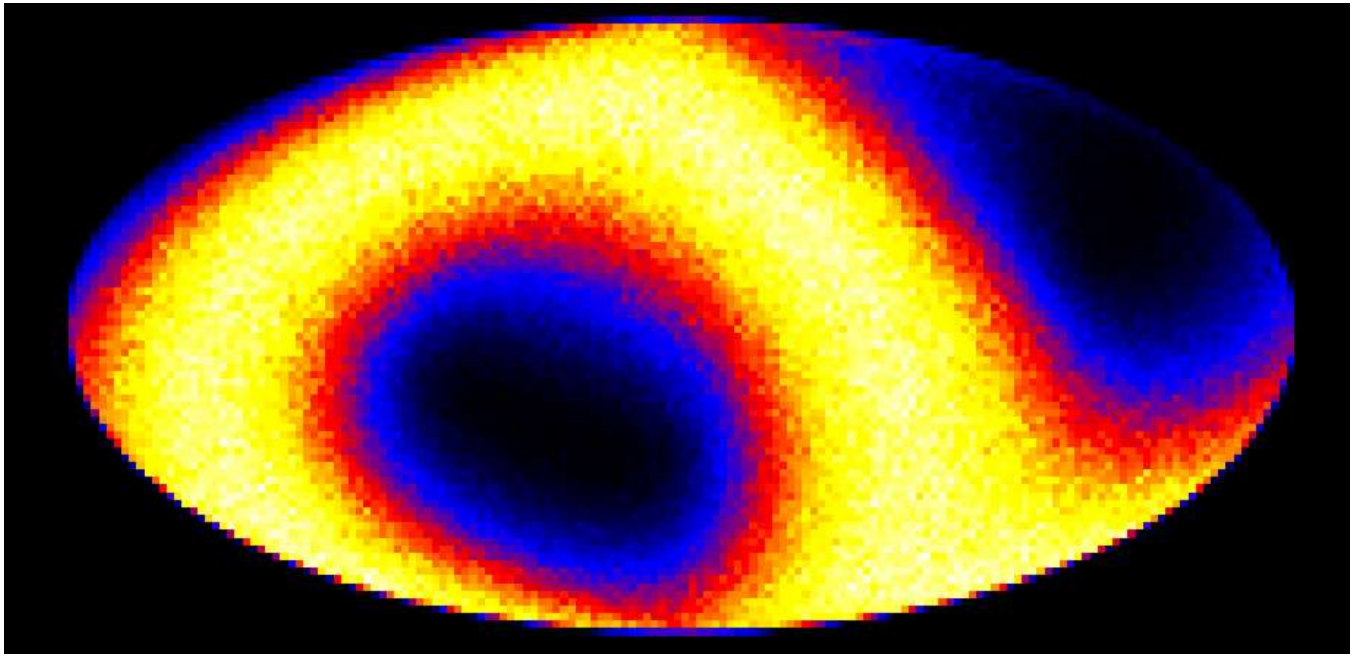


Results after 1-month observation

Preliminary Output

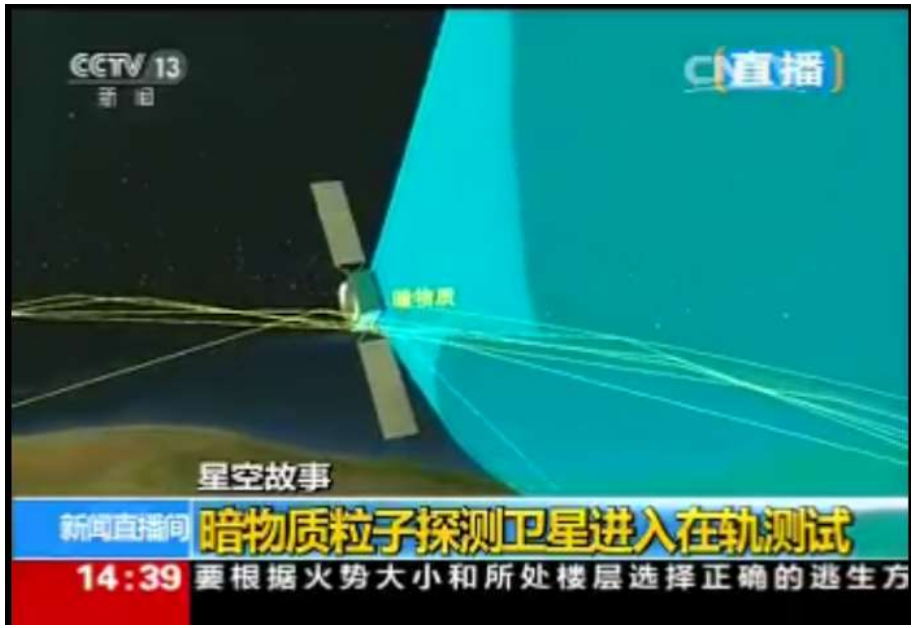
- **Direction measurement**

  The gamma-ray sky map fits well with FERMI's, proving its ability to identify direction measurement particle



Preliminary Output

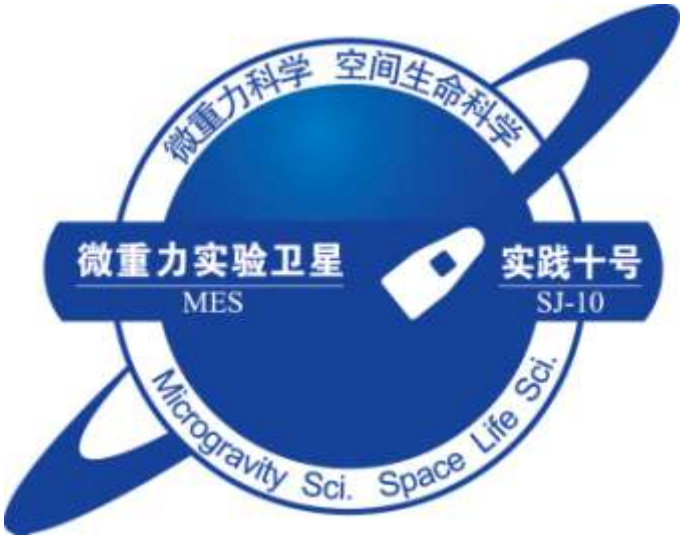
- **Data through in-orbit test：3579 tracks of data received** (up to August 16, 2016)
  - ~1.19 billion high energy particle analyzed, with all sky survey completed
  - 1B data 3.2TB, 1F data 1.8TB, and 2A data 14.3TB generated



First scientific publication on dark matter will be in a few months.

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

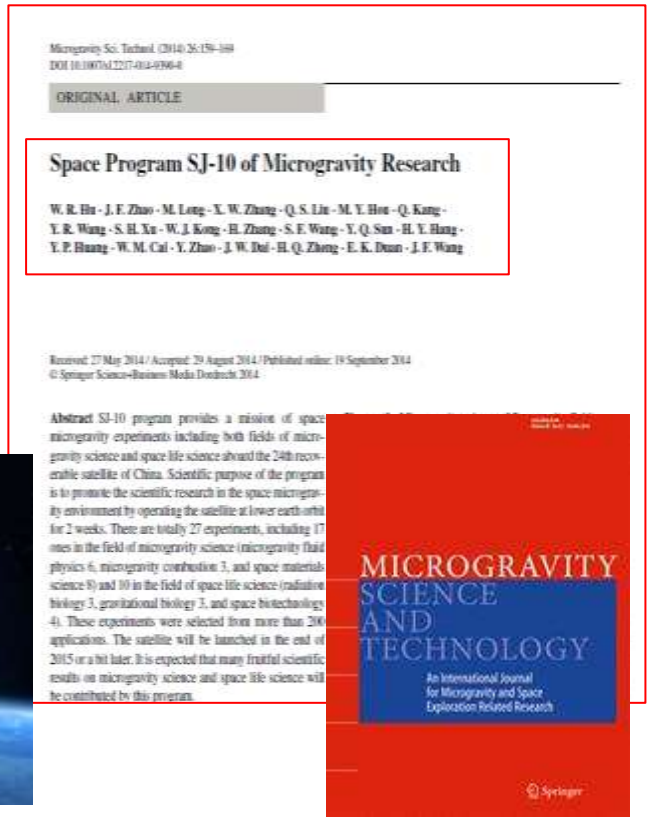
Mission carried from 6-18 April, 2016



Scientific Objectives

SJ-10, the 24th recoverable satellite of China, provides a mission of 19 space microgravity experiments, selected from more than 200 applications.

- the basic laws of motion for matter
- high performance material preparation,
- mechanism of combustion
- biological effects of gravity or space radiation, and space biotechnology



Microgravity Sci. Technol. (2014) 26:159–160
DOI 10.1007/s12217-014-9366-8

ORIGINAL ARTICLE

Space Program SJ-10 of Microgravity Research

W. R. Hu · J. F. Zhao · M. Long · X. W. Zhang · Q. S. Liu · M. Y. Hou · Q. Kang · Y. R. Wang · S. H. Xu · W. J. Kong · H. Zhang · S. F. Wang · Y. Q. Sun · H. Y. Hang · Y. P. Huang · W. M. Cai · Y. Zhao · J. W. Dai · H. Q. Zhang · E. K. Duan · J. F. Wang

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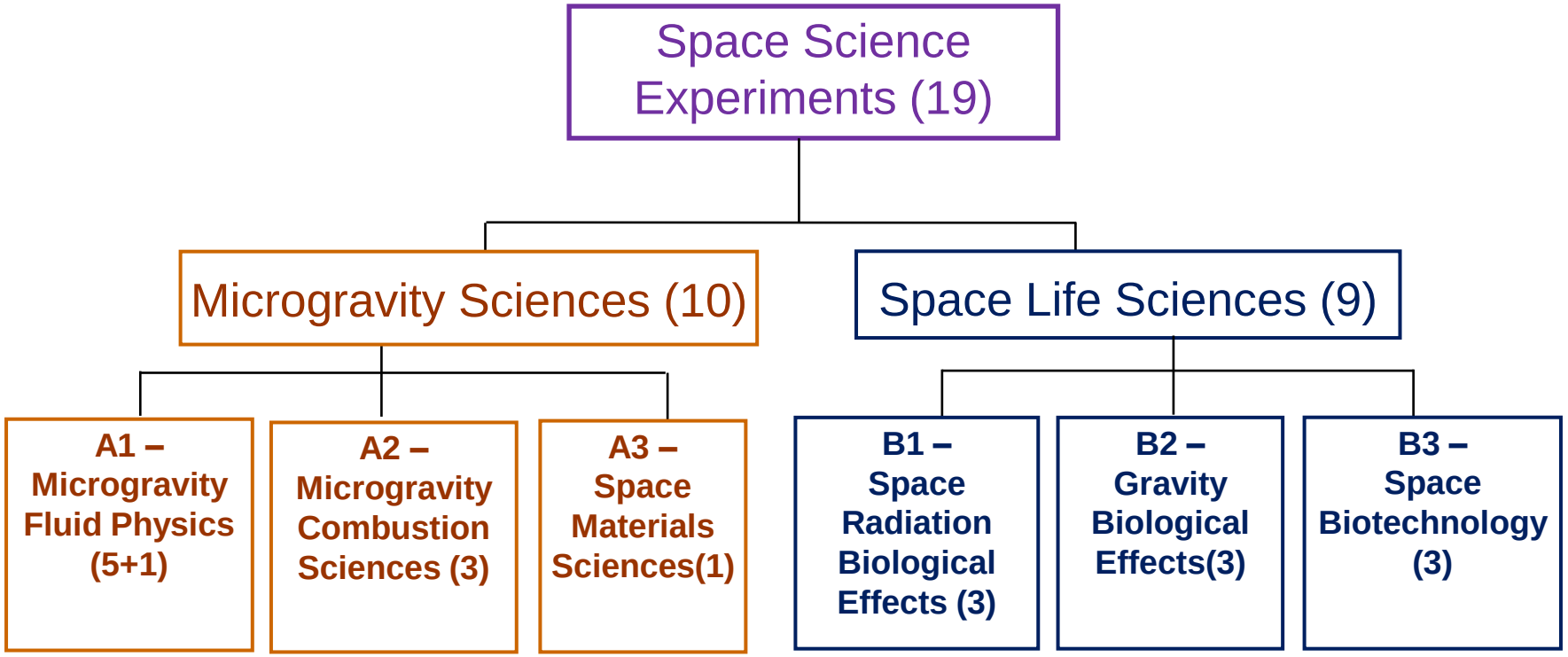
Abstract SJ-10 program provides a mission of space microgravity experiments including both fields of microgravity science and space life science aboard the 24th recoverable satellite of China. Scientific purpose of the program is to promote the scientific research in the space microgravity environment by operating the satellite at lower earth orbit for 2 weeks. There are totally 27 experiments, including 17 ones in the field of microgravity science (microgravity fluid physics 6, microgravity combustion 3, and space materials science 8) and 10 in the field of space life science (radiation biology 3, gravitational biology 3, and space biotechnology 4). These experiments were selected from more than 200 applications. The satellite will be launched in the end of 2015 or a bit later. It is expected that many fruitful scientific results on microgravity science and space life science will be contributed by this program.

Science Experiments



8 experiments aboard the orbit capsule + **11** aboard the reentry capsule

SJ-10 Payloads

System Test

Flight model system level tests

SJ-10 satellite under experiment

The launch of SJ-10 satellite

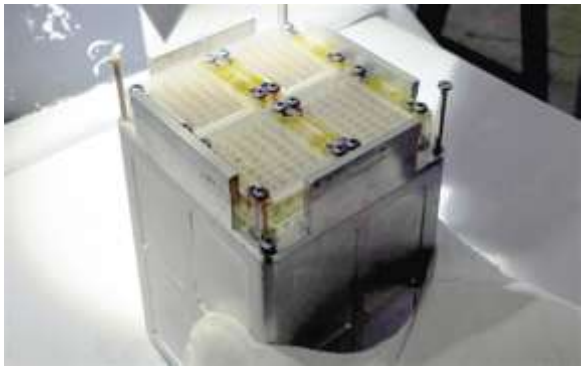
01:38，on April 6, 2016
@Jiuquan Satellite Launch Center

SJ-10 Mission Operation Center

The landing of SJ-10 re-entry capsule
in Inner Mongolia on April 18, 2016

The experiments carried out in SJ-10 re-entry capsule when back to the Earth:

The disassembly of SJ-10 re-entry capsule

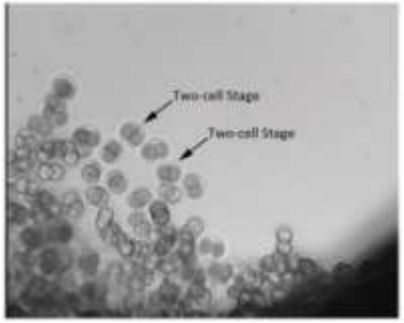


The biological radiation box

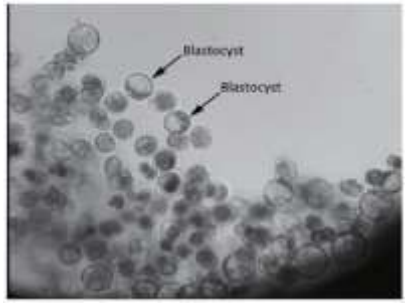
The embryo culture box

The advanced vegetation box, with arabidopsis thaliana flowering in space

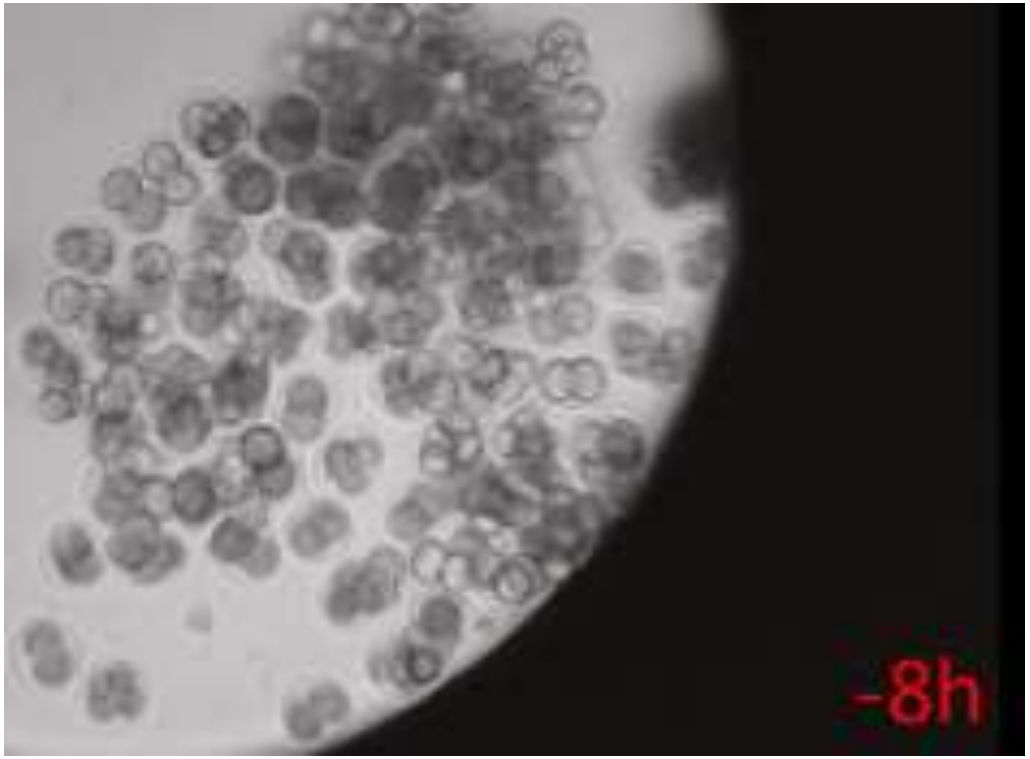
Mammal embryos developed in space for the first time



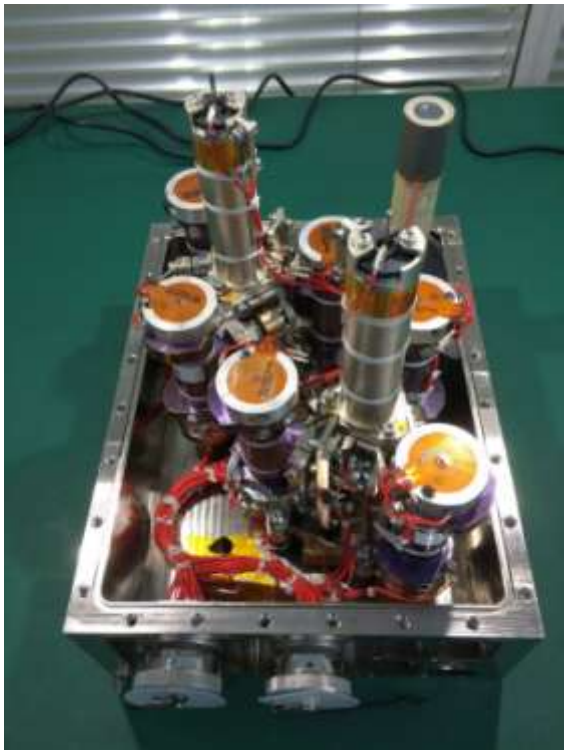
Two-cell mouse embryos,
four hours before launch



Mouse embryos that developed into blastocyst 80 hours after the launch



China-ESA oil experiment up and running in space as cooperation blossoms



Soret Coefficient in Crude Oil (SCCO), designed to sharpen understanding of deep crude oil reservoirs

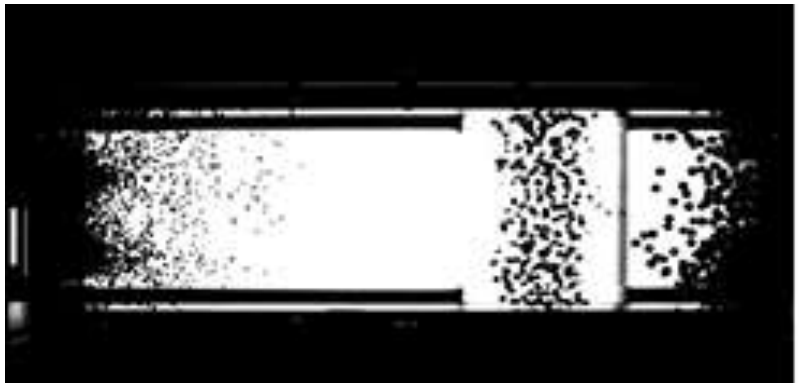
esa

European Space Agency

Chinese and European colleagues work on installation of SCCO

Results achieved in orbit for the first time in the following aspects in kinetic theory of granular flow:

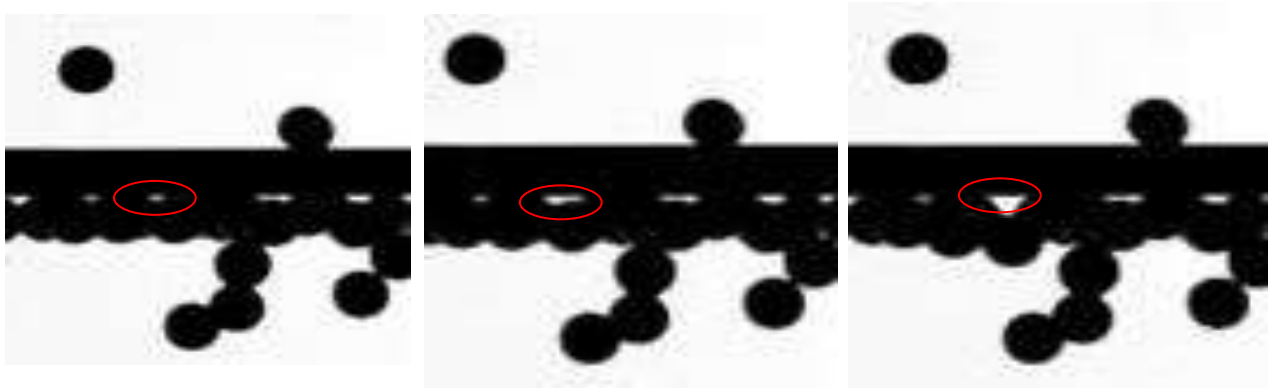
formation of cluster, granule cooling behavior, and double bin separation Maxwell's demon phenomenon



The single bin granular distribution

The obvious double bin separation imaged for the first time under microgravity conditions

Coal combustion observed for the first time in space



Vibration, exciting granular flow experiments systematically carried out on a long microgravity time scale for the first time

15 experiments were carried out for the first time

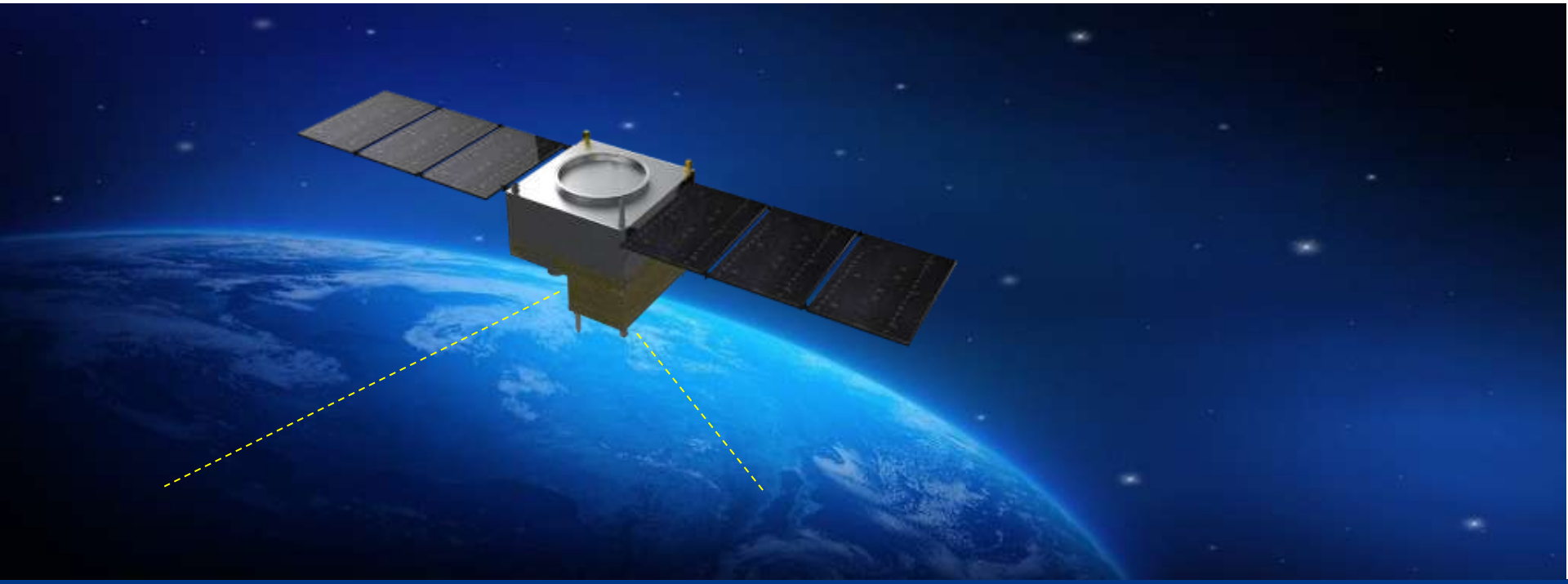
Strategic Priority Program on Space Science (2011-2016)

QUantum Experiments at Space Scale (QUESS)
Launched 16 August, 2016

Micius/Mozi
from ~BC 468 to ~BC 376

Scientific Objectives

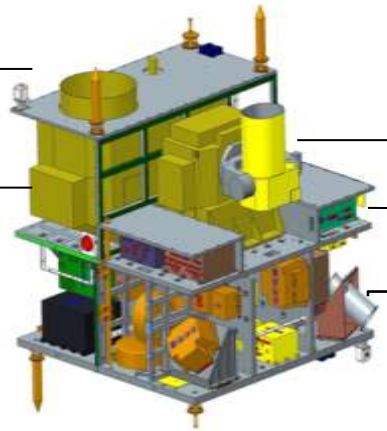
1. Implementation of long-distance quantum communication network based on high-speed quantum key distribution(QKD) between satellite and the ground station, to achieve major breakthroughs in the realization of space-based practical quantum communication

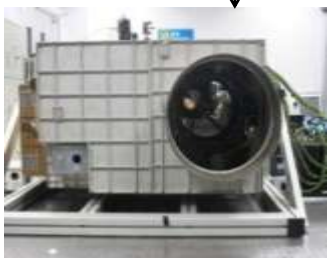


Scientific Objectives

2. Quantum entanglement distribution and quantum teleportation on space scale, fundamental tests of the laws of quantum mechanics on global scale

Payloads

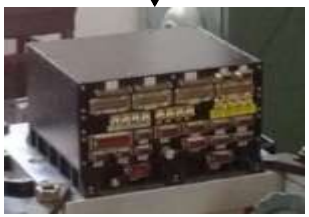




Quantum key communication equipment

High-speed coherent laser communication demonstration

Quantum entanglement transmitter

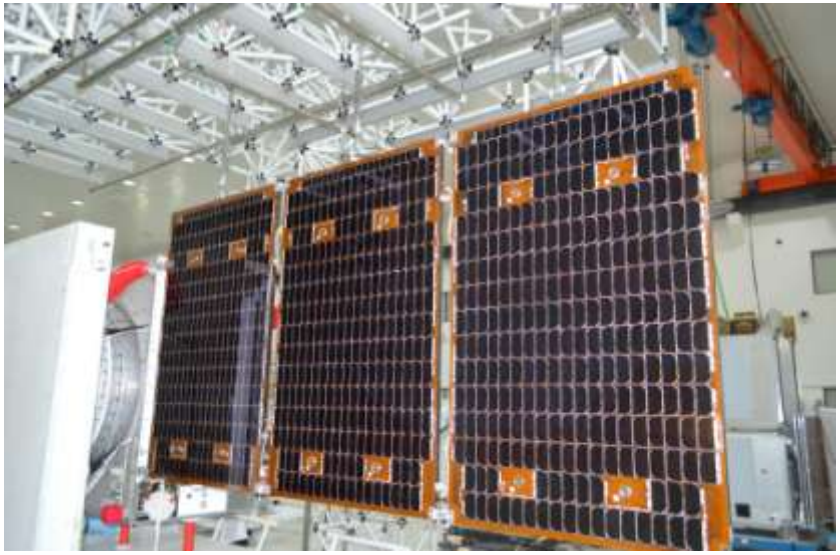


Experimental control and processing system

Quantum entanglement source

Progress

Satellite integrated test



Solar panel deployment test

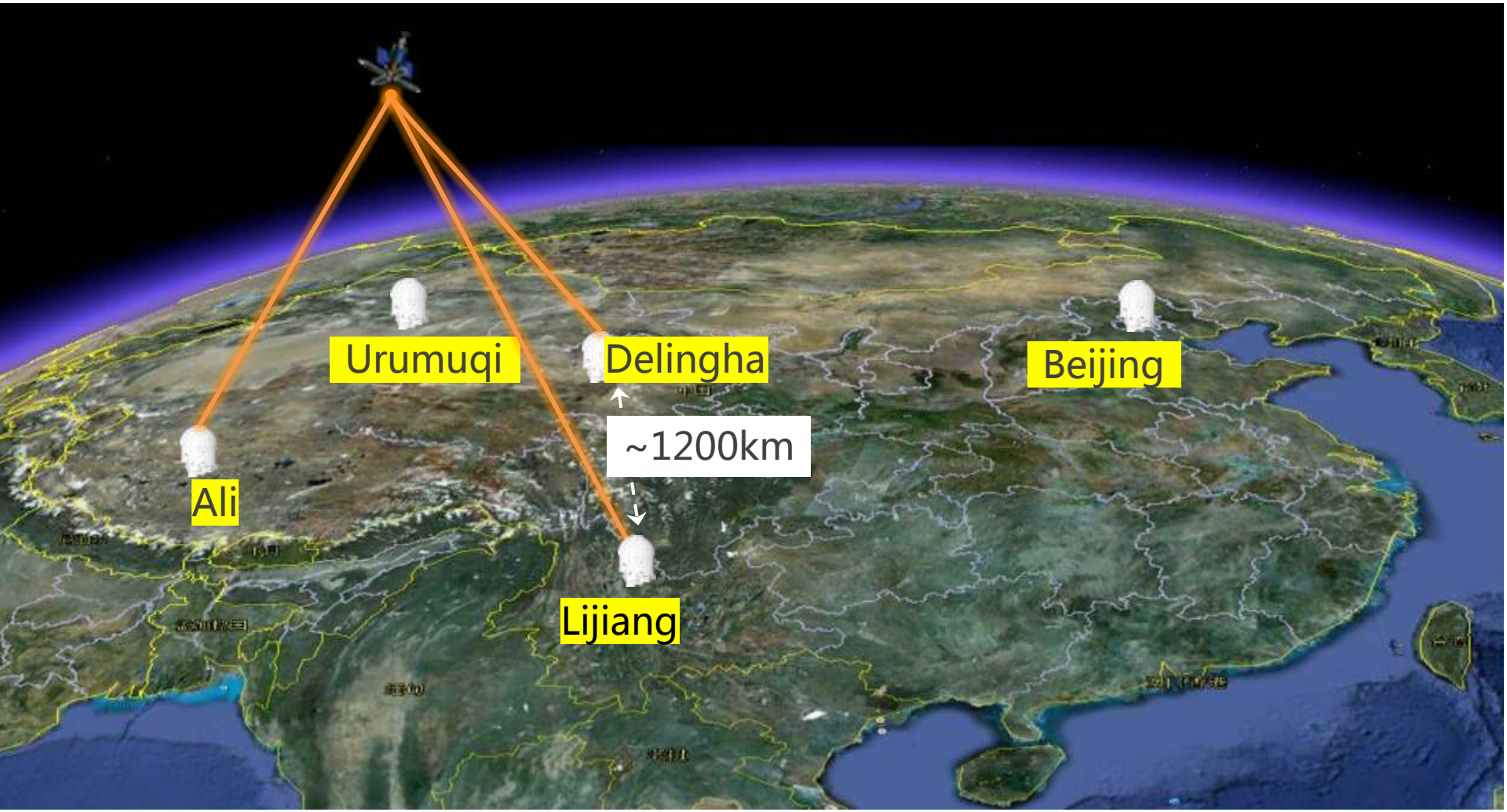
Flight model

Progress

- Two newly built optical telescopes passed the acceptance tests in 04/2015
- Construction of optical ground station in Xinjiang and Qinghai province completed in 09/2015

Optical telescope

Xinjiang and Qinghai optical ground


Urumuqi
Delingha
Beijing
~1200km
Ali
Lijiang

Satellite beacon (532nm)

Ground station beacon (671nm)

Established link with Xinglong station

Teleportation Ground Station in Ali, Tibet, China

Established link with Ali station

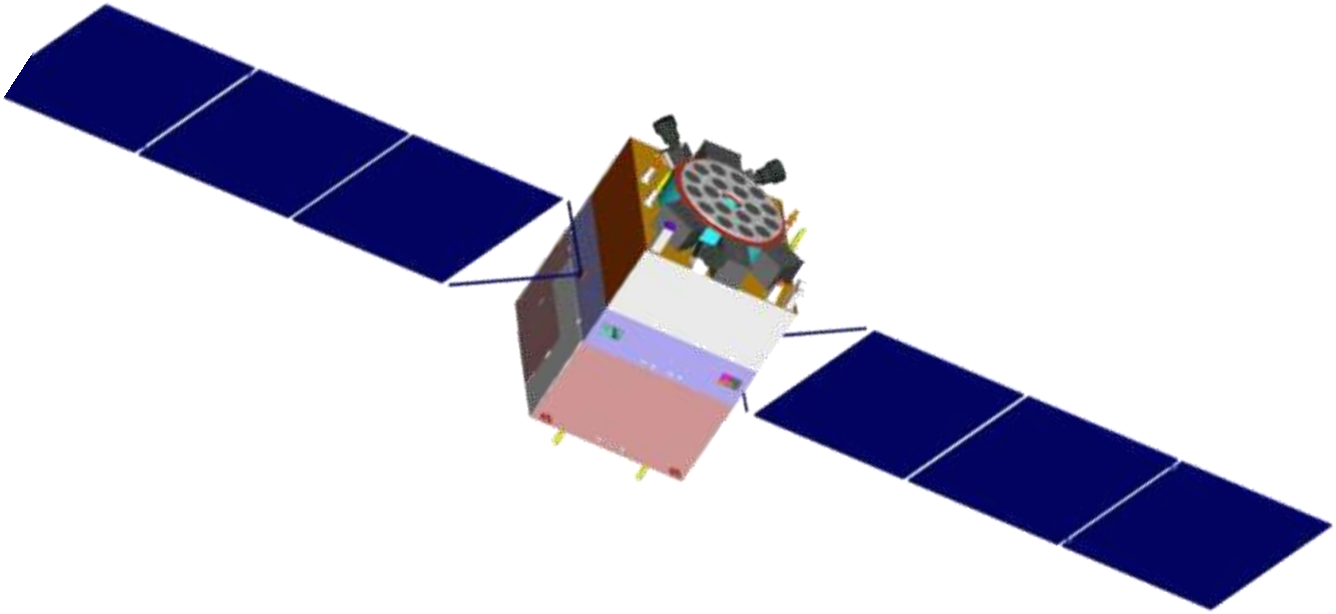
Nssc

Operation teams at the Ali station, 5300m altitude.

Established link with Nanshan station

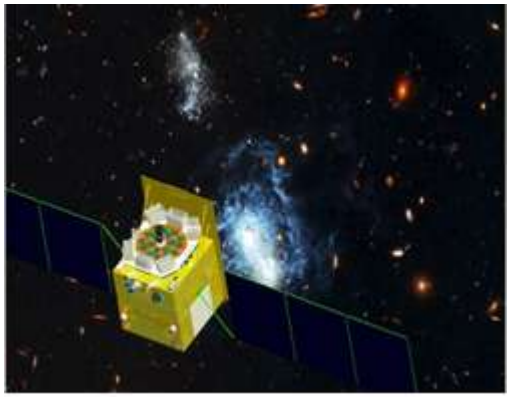
All technical systems so far are working very well and producing successful scientific data. Commissioning phase will be finished in the mid Nov.

Hard X-ray Modulation Telescope (HXMT)

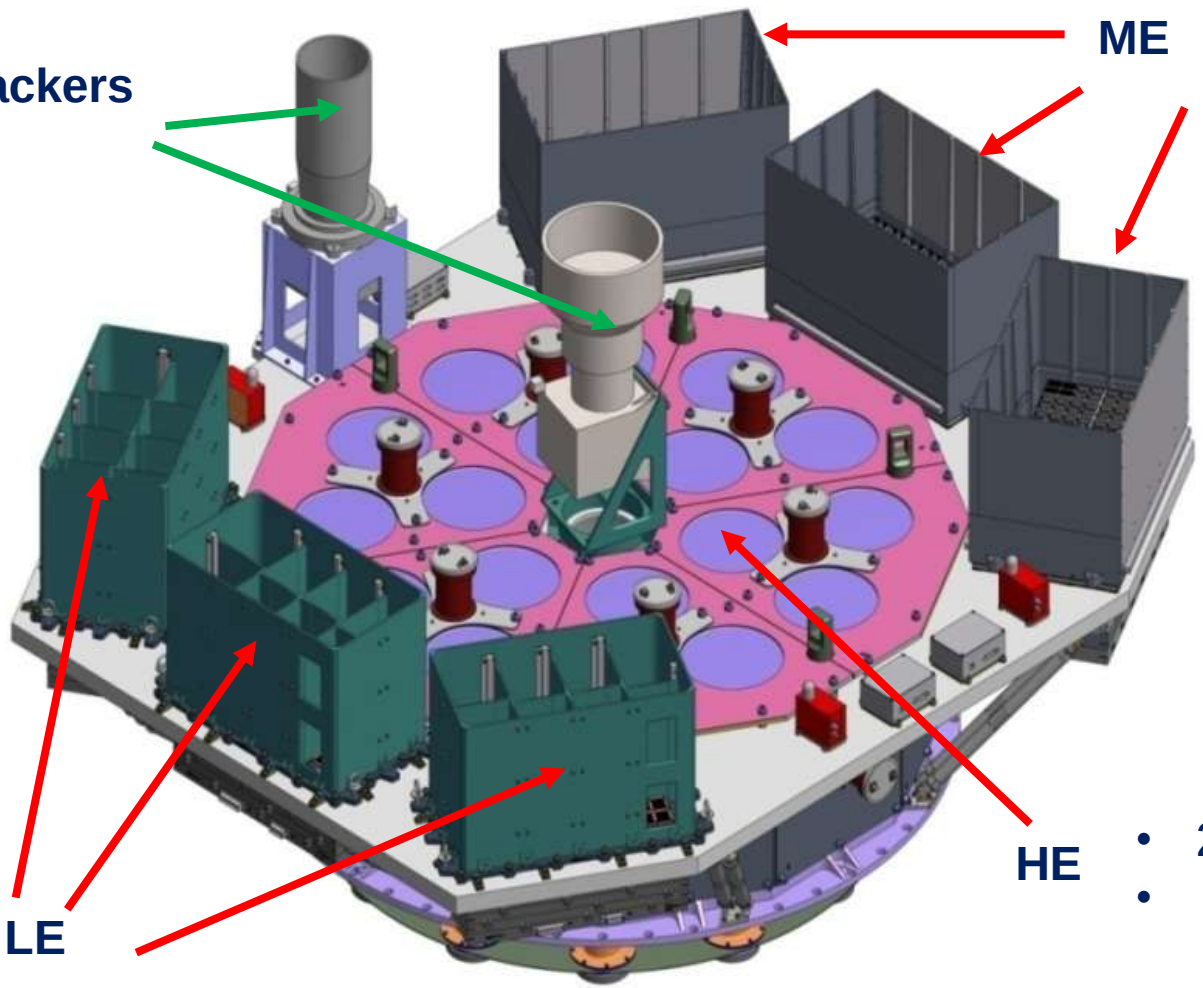


Scientific Objectives

- to scan the Galactic Plane to find new transient sources and to monitor the known variable sources
- to observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields



Payloads


Star trackers
ME
• 5-30 keV
• 952 cm²
HE
• 20-250 keV
• 5100 cm²
LE
• 1-15 keV
• 384 cm²

Progress

- Formally approved in 03/2011
- Preliminary Design Review (PDR) completed in 06/2012
- Critical Design Review (CDR) completed in 12/2013
- All the space qualification models and their environment tests were completed in late 2014, now in Flight Model Phase

Progress

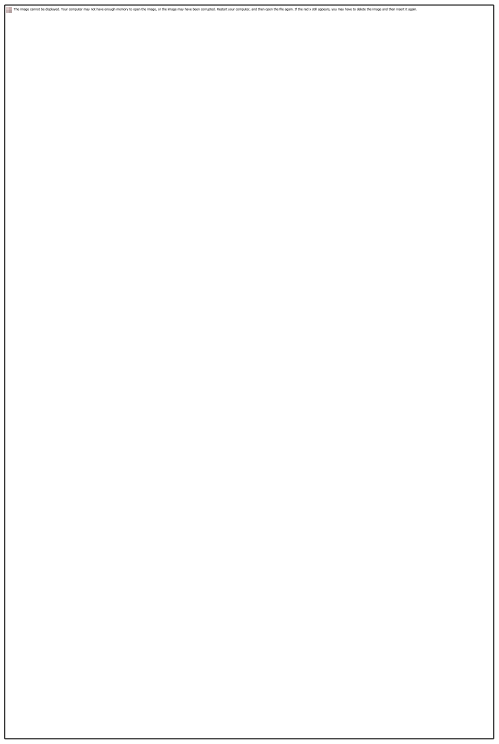
- Construction of two X-ray calibration facilities completed in 2014

HE calibration facility

ME&LE calibration facility

- Flight models: delivered to China Academy of Space Technology (CAST) for integration in early 2016

Announcement of Opportunity

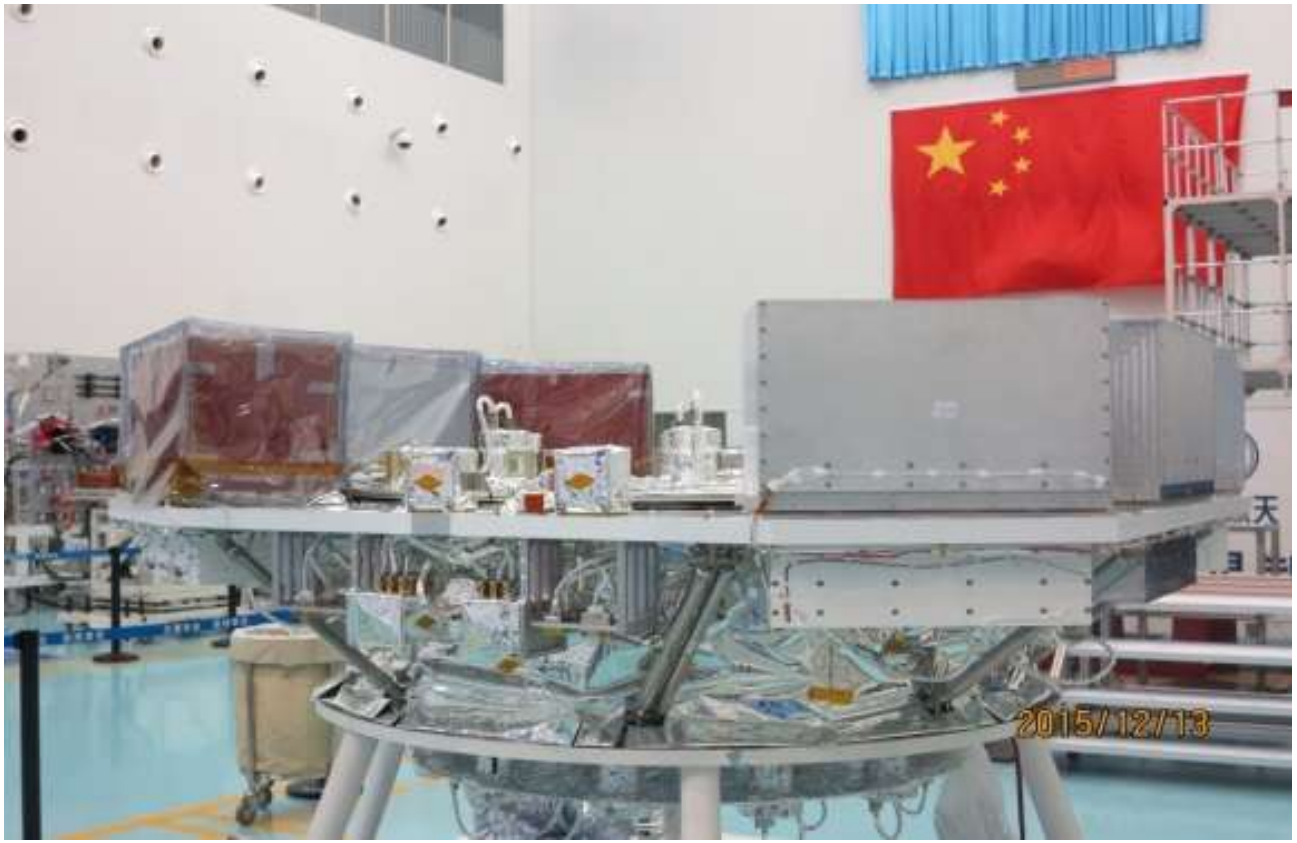


Announcement of Opportunity for Observing Proposals

Workshop on HXMT Observing Proposals

Status

HXMT is planned to be launched in late 2016



HXMT flight model under AIT

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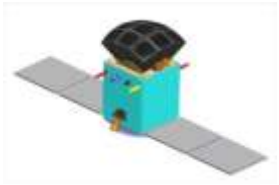
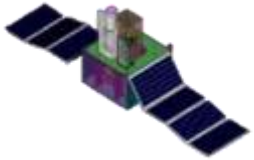
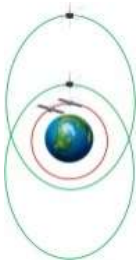
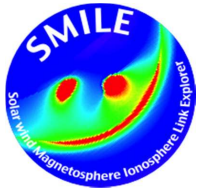
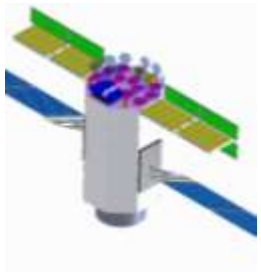
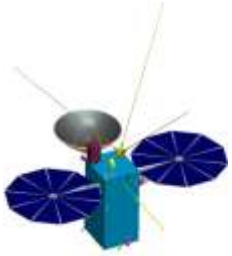
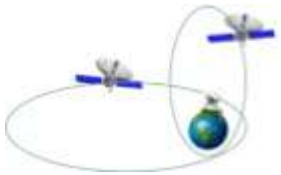
Intensive Study of Future Space Science Missions




Einstein-Probe (EP)

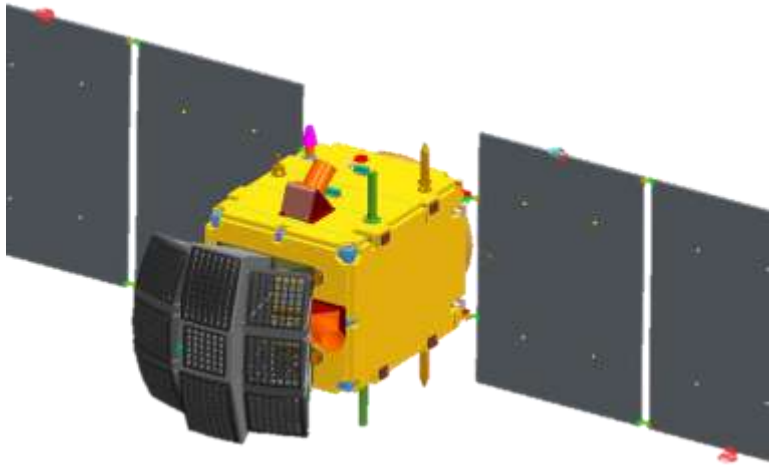
Scientific Objectives: Time-domain census of soft X-ray transient and variable sources in the universe

- 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

Einstein-Probe (EP)

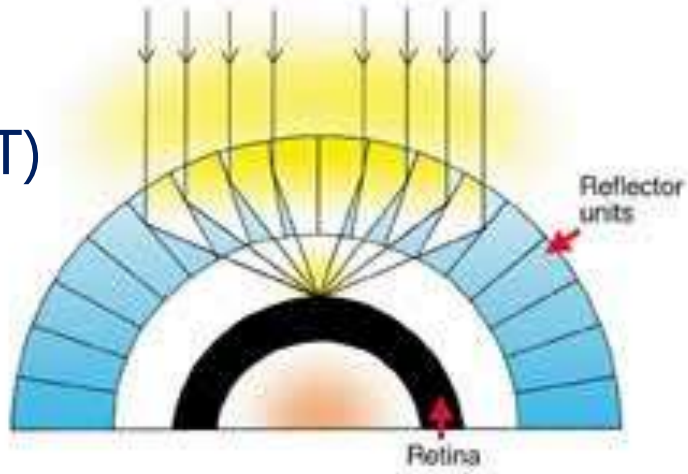
Satellite Specifications

- Orbit: 600km, circular, 30°
- Mass: 380kg
- Life time: 5 years



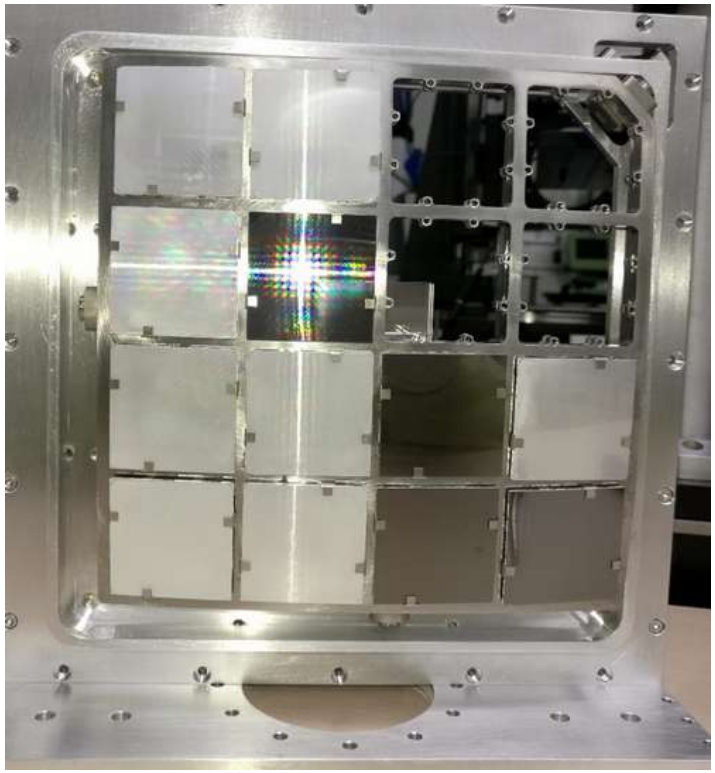
Payloads

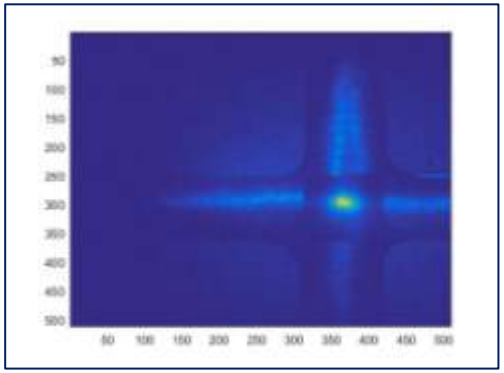
- Wide-field X-ray telescope (WXT)
- Follow-up X-ray telescope (FXT)



Einstein-Probe (EP)

The final review of EP's *intensive study phase* completed in 05/2016



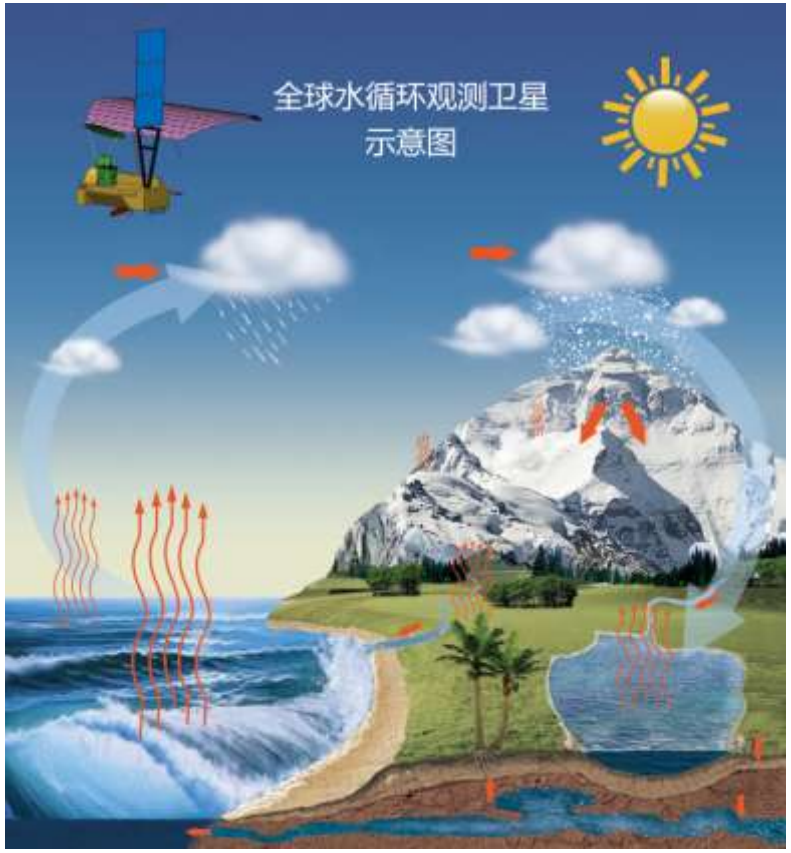


Optical components' prototype of Wide-field X-ray telescope (WXT, Lobster eye)

Water Cycle Observation Mission (WCOM)

Scientific 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…)



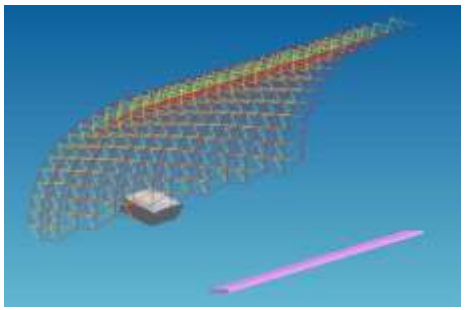
Water Cycle Observation Mission (WCOM)

Satellite Specifications

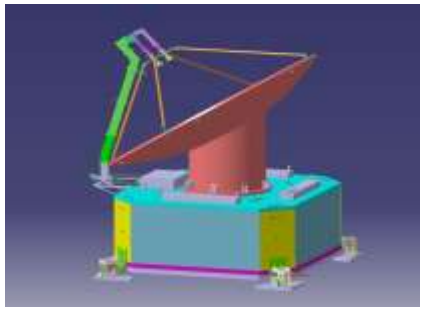
- Orbit：600km，97.79°
- Mass：1050kg，450kg (P/L)
- Lifetime：3-5 years

Payloads

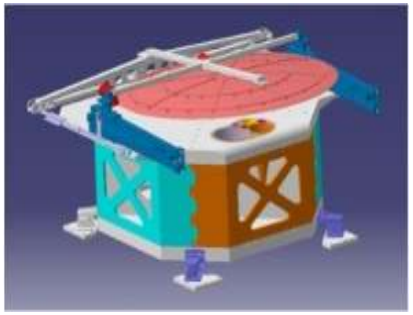
- Interferometric Microwave Imager (IMI)
- Dual-frequency Polarized microwave Scatterometer (DPS)
- Polarimetric Microwave Imager (PMI)



IMI

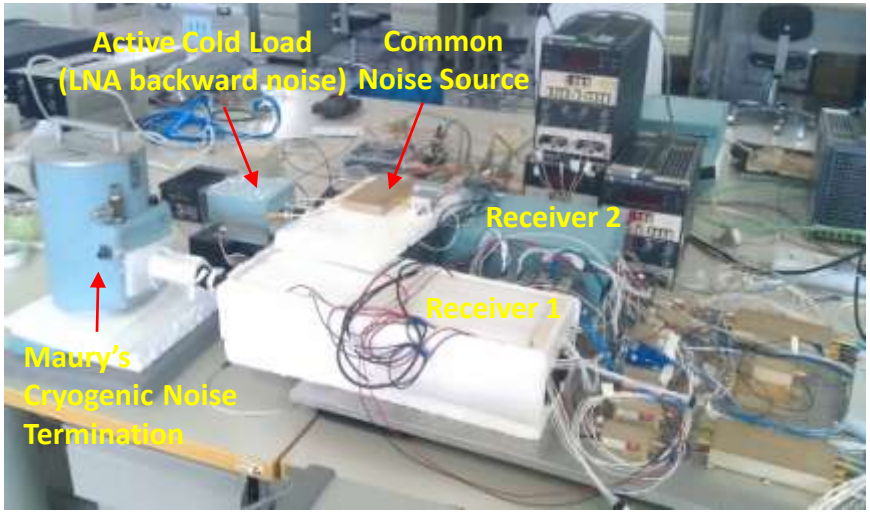


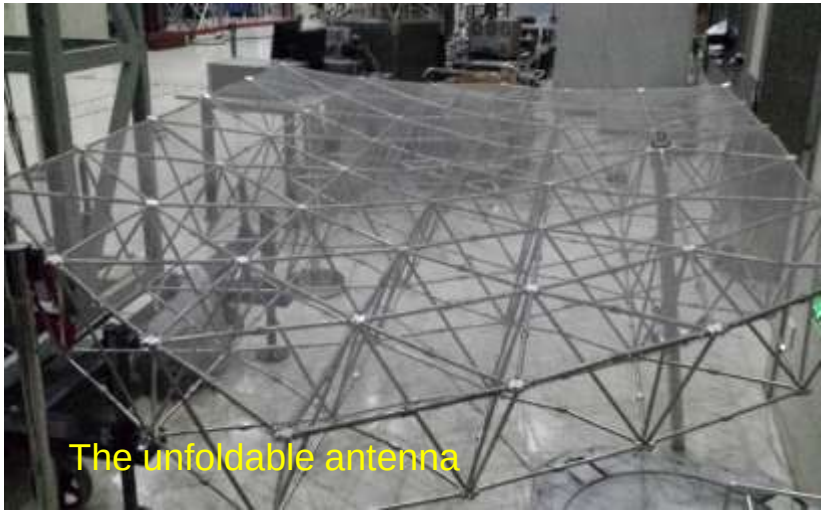
DPS



PMI

Water Cycle Observation Mission (WCOM)



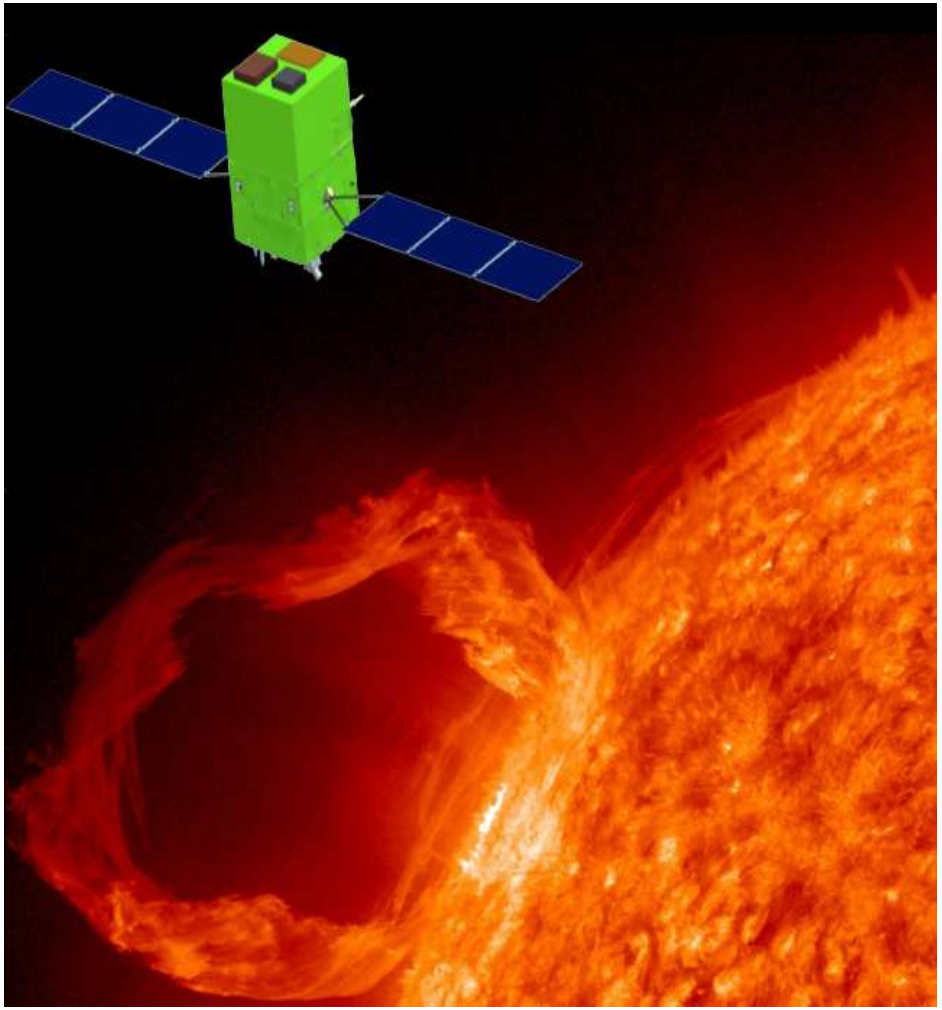


The final review of WCOM's *intensive study phase* completed in 04/2016

Advanced Space-borne Solar Observatory (ASO-S)

Scientific Objectives

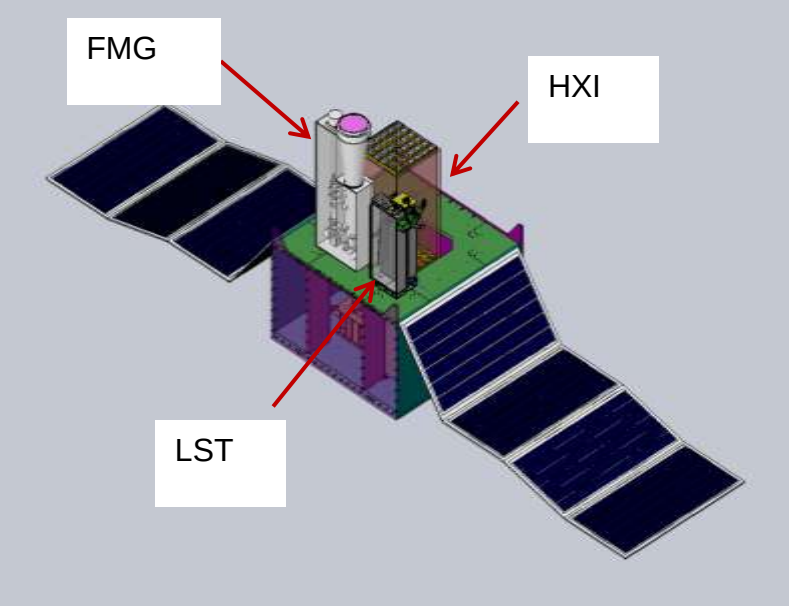
- Simultaneously observe the full disc vector magnetic field, non-thermal images of hard X-rays, and initiation of CME
- Understand the causality between magnetic field and flares, magnetic field and CMEs, flares and CMEs



Advanced Space-borne Solar Observatory (ASO-S)

Payloads

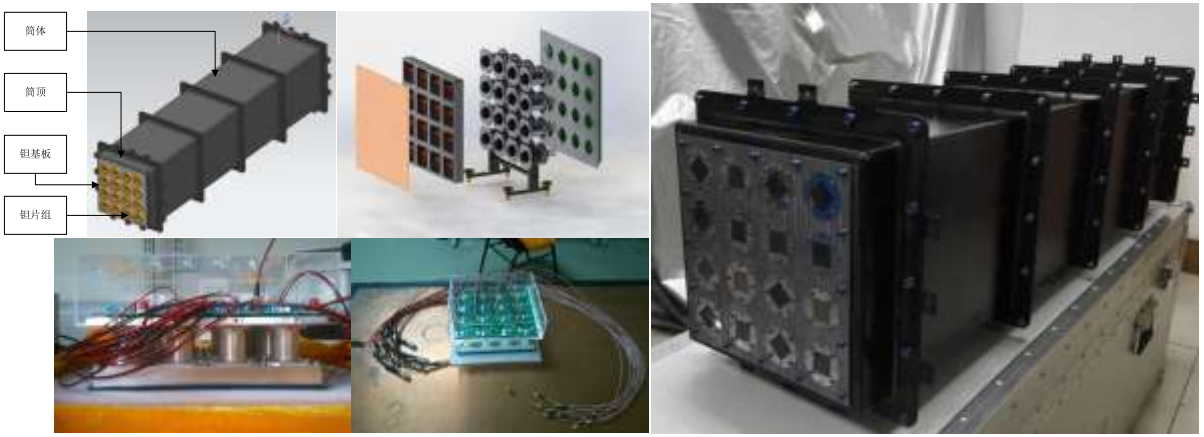
Payloads	Objectives
Full-disc vector MagnetoGraph (FMG)	Magnetic Field
Lyman-alpha Solar Telescope (LST)	CMEs
Hard X-ray Imager (HXI)	Solar Flares



Advanced Space-borne Solar Observatory (ASO-S)

The final review of ASO-S's *intensive study phase* completed in 04/2016

Prototype of filter

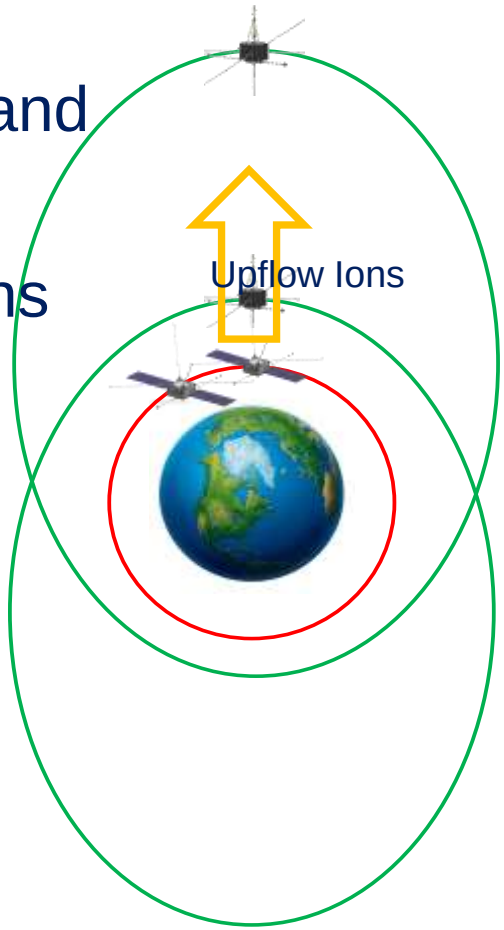


Hard X-ray Imager (HXI)

Magnetosphere – Ionosphere – Thermosphere Coupling Exploration (MIT)

Scientific Objectives

- Investigate the origin of the up flow ions and their acceleration mechanism
- Understand the impact of the outflows ions on magnetic storm development
- Characterize the ionosphere and thermosphere storm driven by magnetic storm
- Discover the key mechanism for the magnetosphere, ionosphere and thermosphere coupling

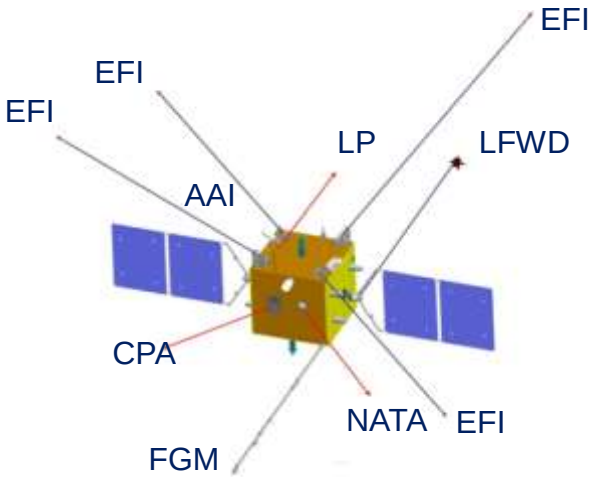


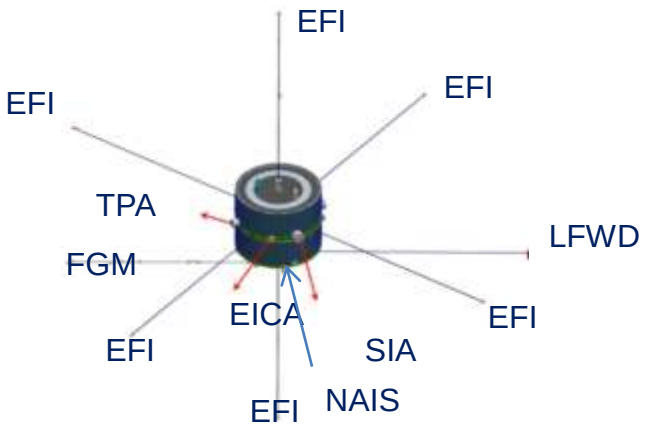
Magnetosphere – Ionosphere – Thermosphere Coupling Exploration (MIT)

Satellite Specifications

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

Payloads

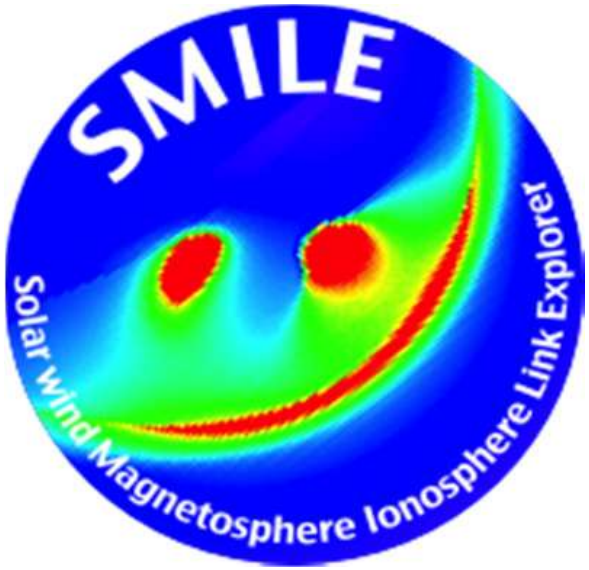




Magnetosphere – Ionosphere – Thermosphere Coupling Exploration (MIT)

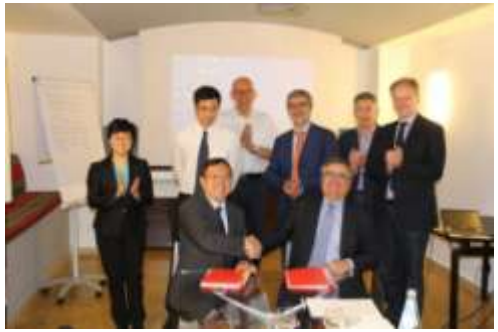
The final review of MIT's *intensive study phase* completed in 03/2016

Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)



CAS-ESA Joint Science Space Mission

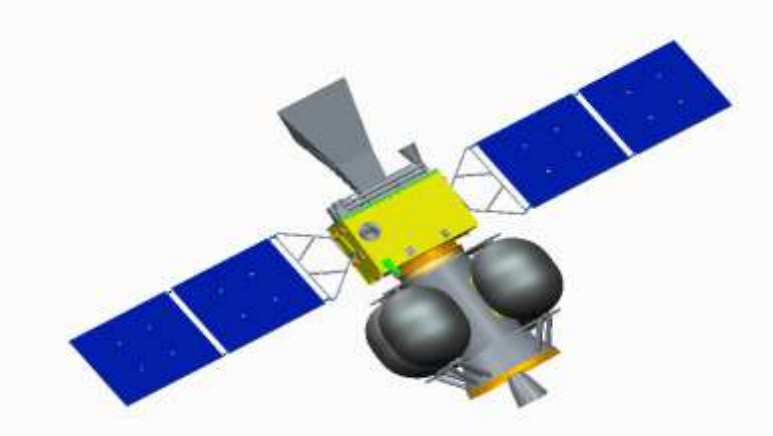
- CAS-ESA joint science Space Mission Workshop held in Chengdu ,China (02/2014) and Copenhagen Denmark (09/2014)
- Joint Call issued in 01/2015
- Technical screening conducted in 03-04/2015
- Joint scientific peer review completed in 05/2015
- ESA & CAS joint mission selection result released in 06/2015 : the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)

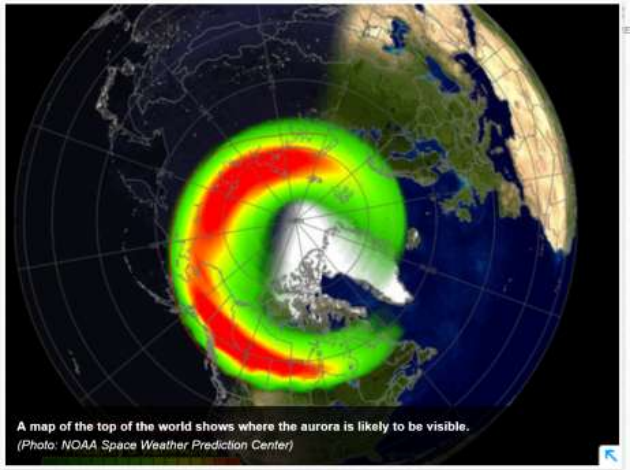


- Discussion related to technical issues of SMILE
- Draft of “Implementing Arrangement between ESA and NSSC of CAS concerning the Joint Mission”

Scientific Objectives

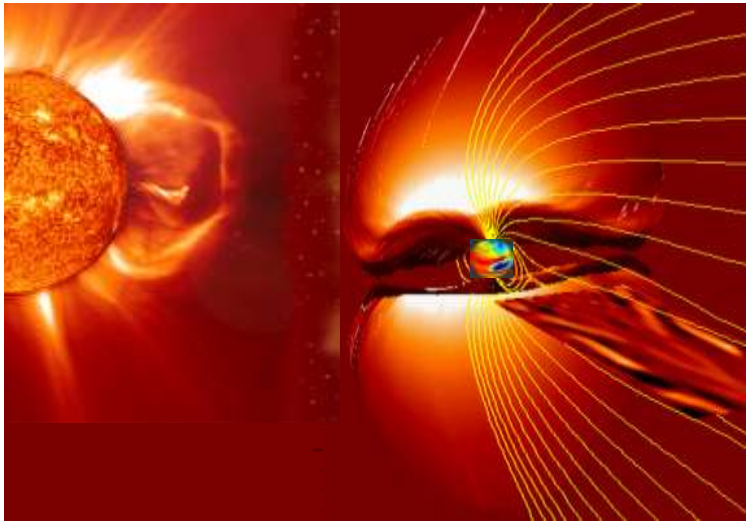
- Determine when and where transient and steady magnetopause reconnection dominates
- Define the substorm cycle, including timing and flux transfer amplitudes
- Define the development of CME-driven storms, including whether they are sequences of substorms





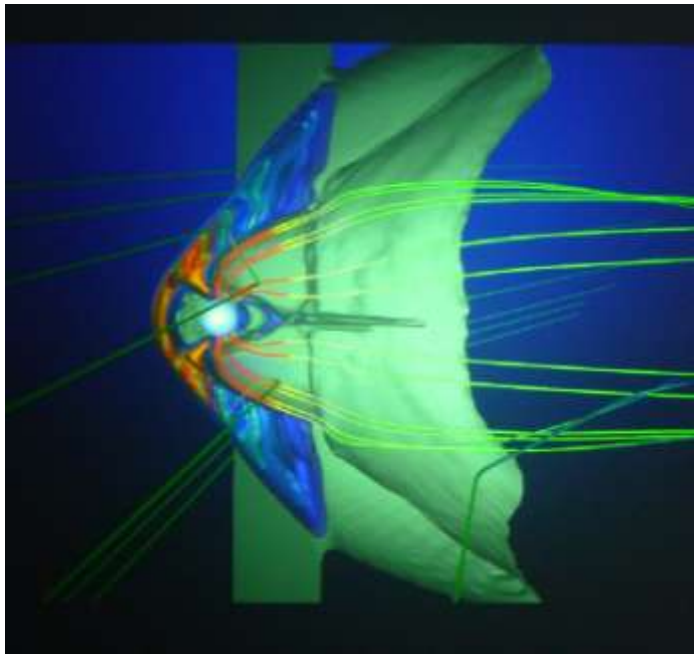
Scientific Significance

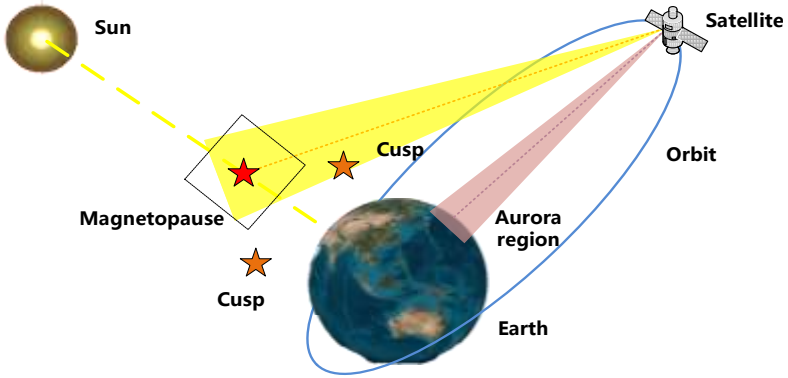
- Expected to carry out global imaging of the interaction between solar wind and magnetosphere for the first time, with the new soft X-ray Imager and ultra-violet imager
- A new milestone of Geospace exploration, enabling the great leaps from the local to the global detection



Satellite Specifications

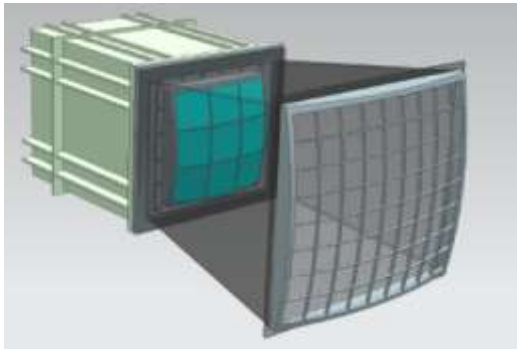
- Orbit：5000km@perigee
  19RE@apogee
- Mass (PLM+SVM+PM): <2000kg
- Lifetime：3 years



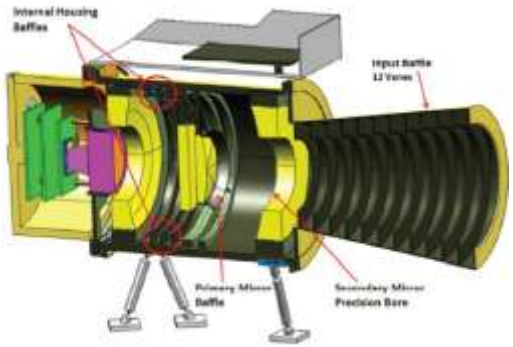


Payloads

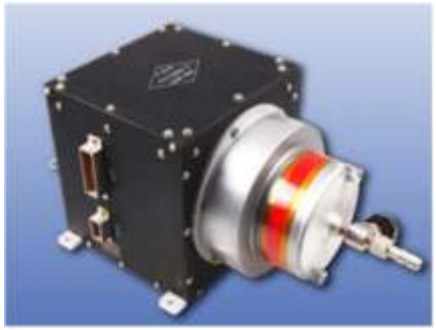
- Soft X-ray Imager (SXI)
- Ultra-Violet Imager (UVI)
- Light Ion Analyzer (LIA)
- MAGnetometer (MAG)



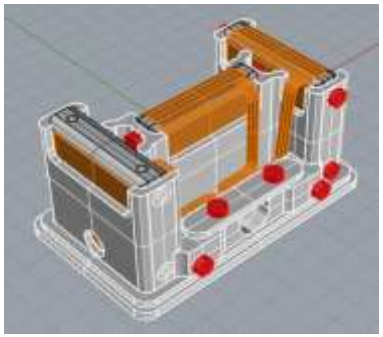
SXI



UVI



LIA



MAG

Current Status—CAS side

- Finished the technical review on May 23, 2016
- Finished the financial assessment on Sep. 30, 2016

The official go-ahead of SMILE by CAS:

HOPEFULLY SOON

Current Status—ESA side

- The PLM Invitation to Tender was published on June 10, 2016
- The feasibility study is currently on-going, to select 2 parallel contractors with a planned Kick-off in November 2016

Schedule

- ESA Industrial study kick-off: 11/2016
- Joint mission PDR (incl. ground segment): 05/2018
- Joint mission CDR (incl. ground segment): 10/2019
- Joint Qualification and Flight Acceptance Review: 08/2021
- S/C Integration Readiness Review: 01/2021
- Launch in Kourou: 11/2021

Summary

- A new chapter of Chinese space endeavor has been opened, with the implementation of Strategic Priority Program on Space Science. China will develop its own science-satellite-series in the near future.

- The breakthroughs in fundamental science is of great significance. Chinese should make its contributions to human civilization through space science instead of just making use of the knowledge created by other nation

- Welcome to getting increasingly involved in China's space science programs in the future


Thank you!