New Initiative of Space Science Programs in China

----- Strategic Pioneer Program of CAS

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- Double Star Program as the first space science mission of China
- Main themes and questions need to be answered by future missions
- Strategic Pioneer Program on Space Science
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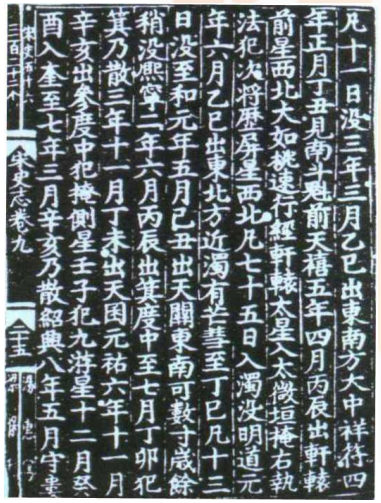
History of Space Science in China

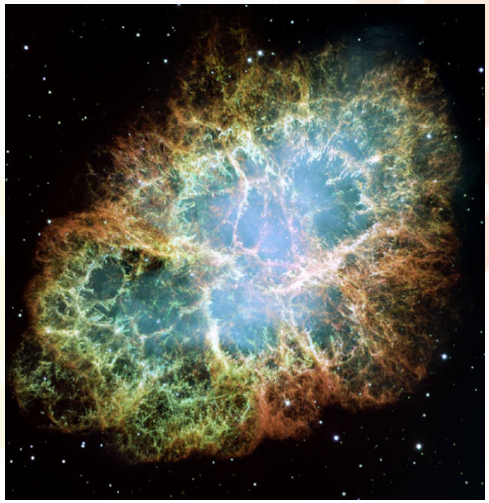
Ancient Chinese Observation and Learning of Space

- 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

Ancient Chinese Observation and Learning of Space

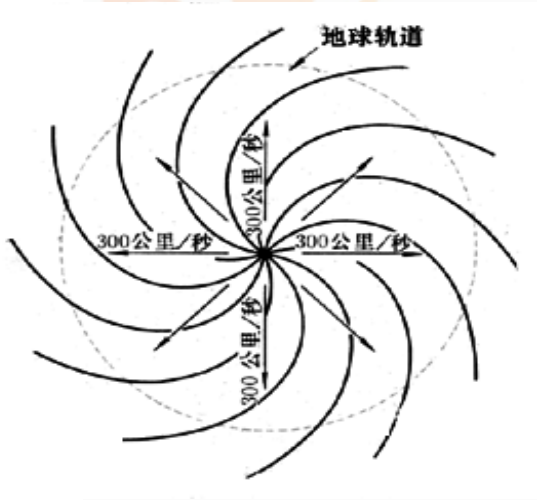
- Observation of Comet:
  - ✓ Halley's Comet: two earliest observations (613 BC & 476 BC), Recorded in "*Spring and Autumn Annals*".
  - ✓ The 28 returns of Halley's Comet (240 BC~ 1910 AD) : all found in ancient Chinese books.
    - Observation from Halley: in 1682 AD, 76 years period
  - ✓ Ancient Chinese first pointed out that the direction of Comet tail was always against the sun.
  - ✓ No less than 500 records of Comets can be found in ancient Chinese books.

29 Comet pictures were found in the silk books unearthed from Hunan Mawang Dui in 1973.

Ancient Chinese Observation and Learning of Space

- Observation of Sun-Spots: the most complete records are found in China.
  - ✓ Observation: started from 28 BC, "1000 years earlier than the Western world"——Joseph Needham
  - ✓ Size: close to a "copperplate" or an "egg"…
  - ✓ The Sun God Bird images (3000 years ago): found in Chengdu Jinsha Relic (unearthed in 2001).

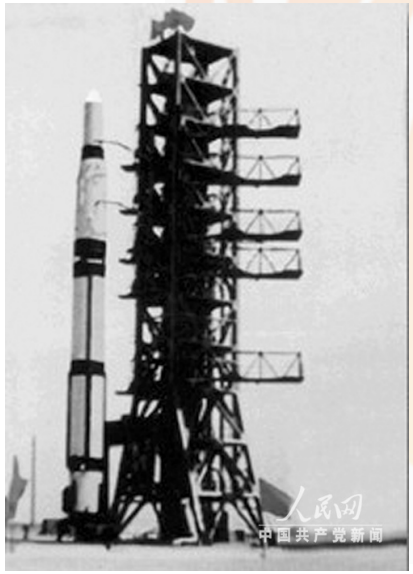
——It resembles the spiral structure of interplanetary magnetic field.



Early Days of Modern Chinese Space Program

- Rocket Industrial Initialized from 1955 and Dr. Qian can back from the US

MAO with QIAN Xuesen, father of LM rocket

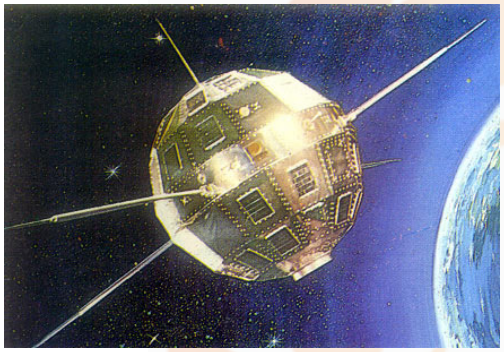


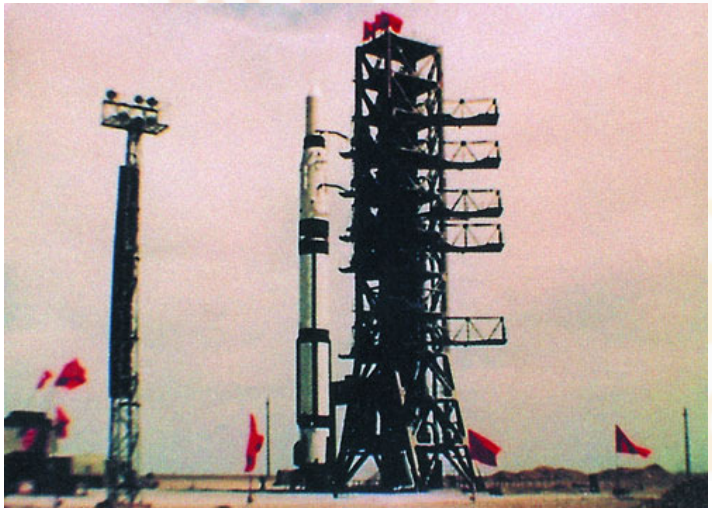
Early Days of Modern Chinese Space Program

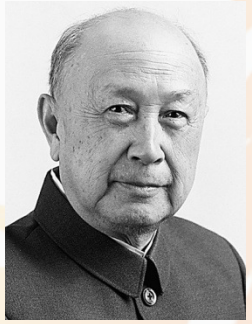
- In 1958, less than one year after Sputnik was launched, the central government of China decided to develop the first Chinese satellite
- An institute was then established dedicated for this job, which is now NSSC
- Dr. Jaw led a delegation to visit USSR in Oct. right after this

Early Days of Modern Chinese Space Program

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





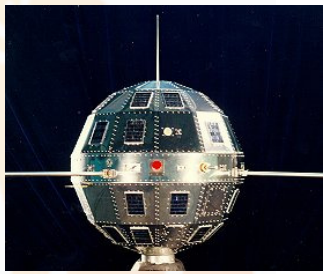


Qian, Jaw and Sun

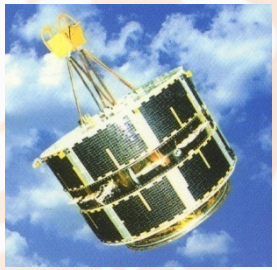
Early Days of Modern Chinese Space Program

- Space science instruments got fly opportunities

1971 SJ-1 High energy particles



1981 SJ-2 Geo-transfer orbit environment



1994 SJ-4 Single particle event

1999 SJ-5 Single particle event and microgravity

Double Star Program as the first space science mission of China

The Earth's Magnetosphere Exploration

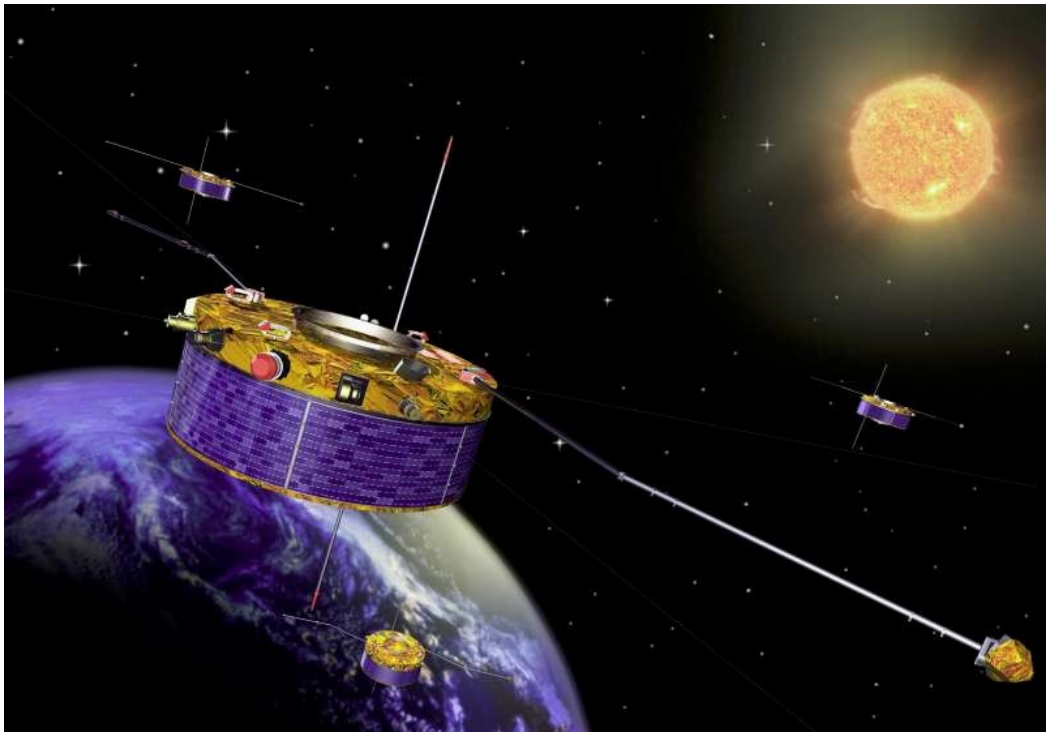
- **Cluster** – One of the cornerstone missions of **ESA** Horizon 2000 science program, which consists of **four identical satellites** launched in two pairs in mid. 2000 and flying as a constellation in a polar orbit. It is still in operation after 10 years.

Polar orbit ~ 90º

Apogee: 130,000 km

(1/3 Moon distance)

Perigee: 25,000 km



The Earth's Magnetosphere Exploration

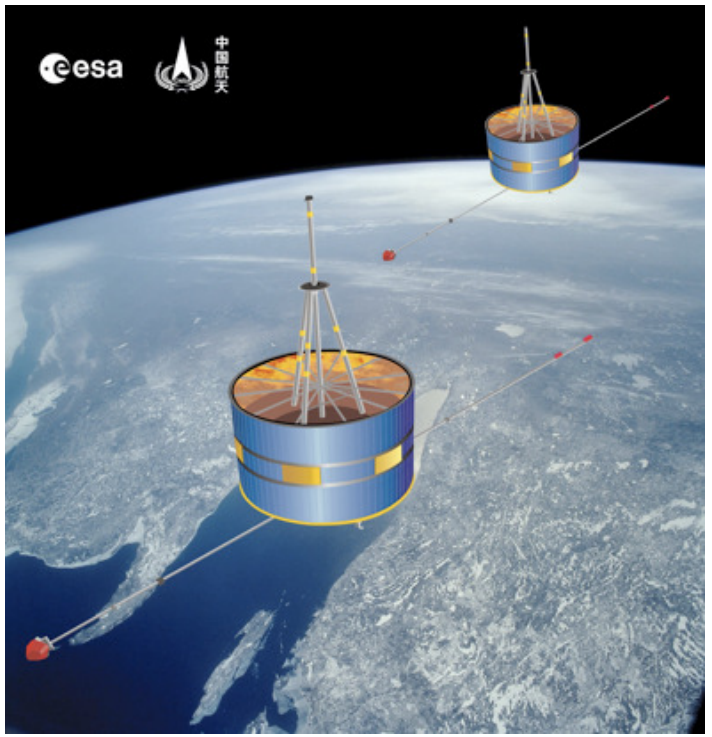
- **The Geospace Double Star Program -** The first Chinese space science satellite mission, which consists of two satellites, TC-1 and TC-2, launched on 30 December 2003 and 25 July 2004 into equatorial and polar orbits respectively. The operations of TC-1 terminated in Oct. 2007 and TC-2 terminated in Aug. 2008.

TC-1 Equatorial 28º

565-78,960km

TC-2 Polar 90º

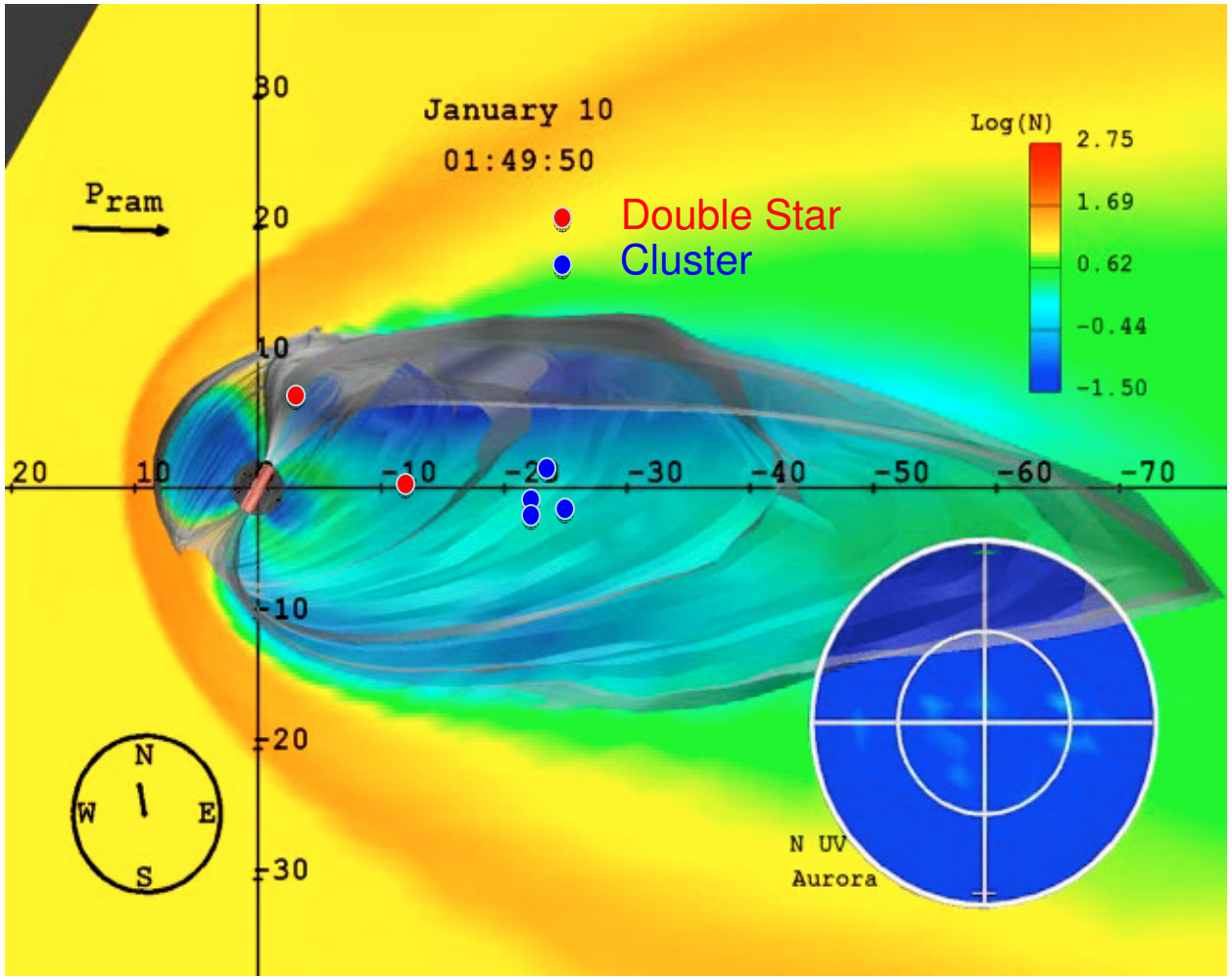
684-38,216km



The Earth's Magnetosphere Exploration

During **2004-2007,**DSP and Cluster provided **six-point** measurements of the dynamics of the Earth's magnetosphere.

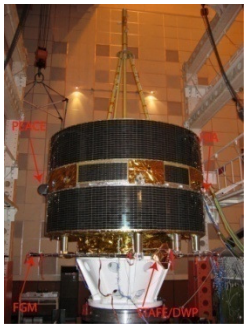
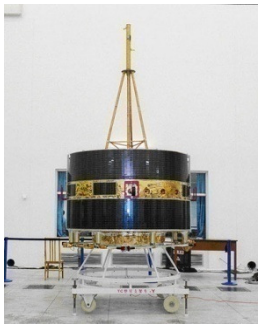
Result: a number of discoveries, verification of theoretical predictions, improvement of models.



Cooperation Between the China and ESA on Double Star

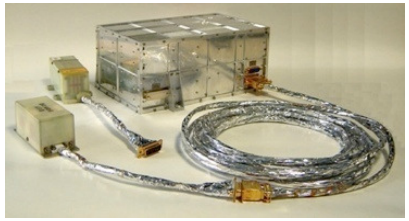
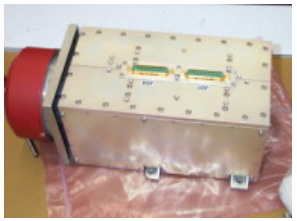
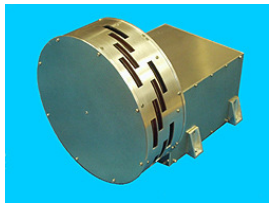
China:



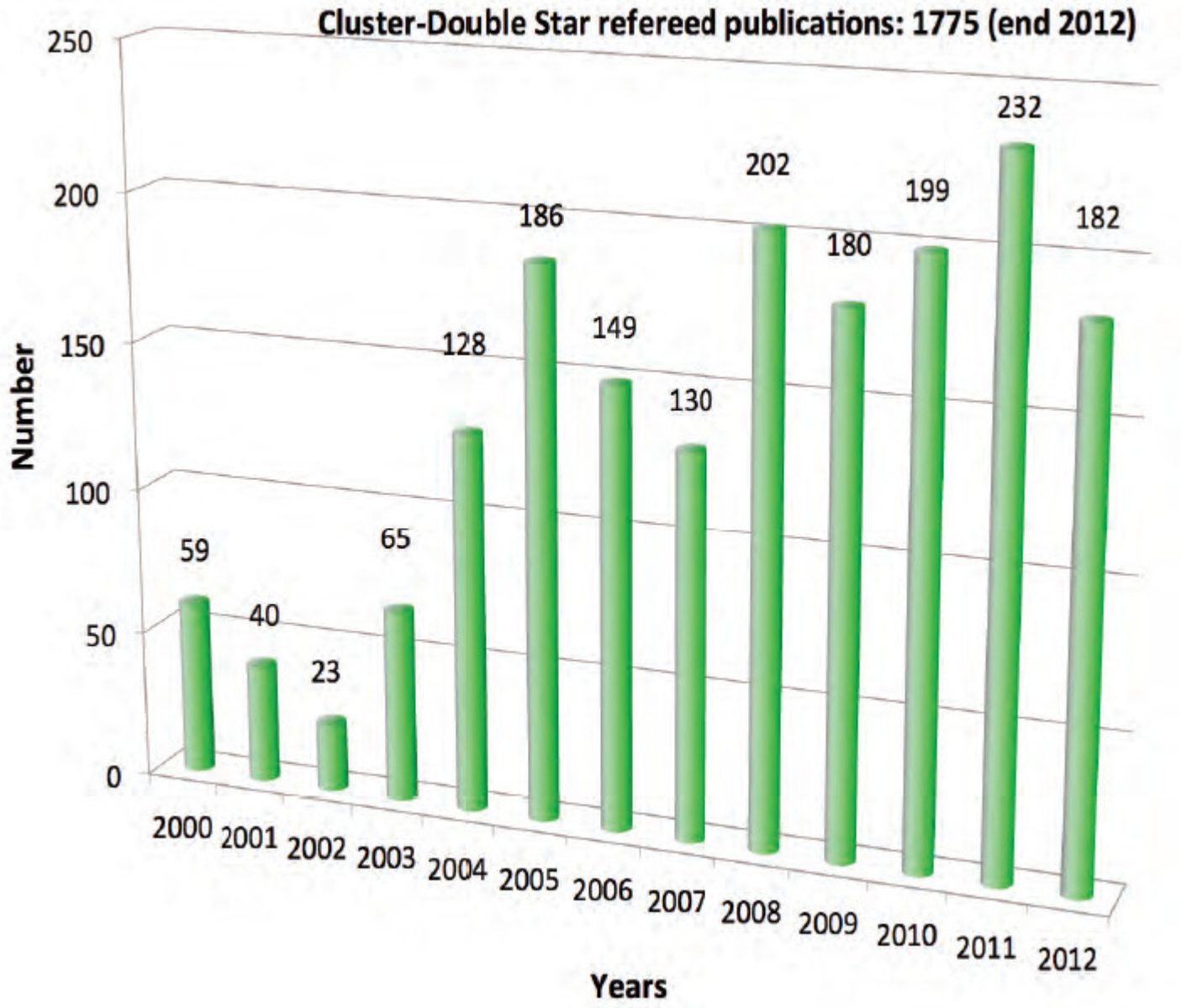

Two launchers: LM 2C, two spacecraft, 8 instruments, Operations

ESA:

8 instruments, ground station (Spain), science operations

Refereed science papers Double Star & Cluster



Cooperation Between the Two Missions

Laurels Team Achievement Award, 2010

International Academy of Astronautics (IAA)

2010 - Double Star and Cluster Team
2009 - Sea Launch Space Rocket System
2008 - International Team
2007 - Spirit and Opportunity Missions Team
2006 - Cassini - Huygens Program Team
2005 - VLBI Space Observatory Program Team
2004 - Hubble Space Telescope Team
2003 - SOHO Team
2002 - US Space Shuttle Team
2001 - Russian Mir Space Station Team

Main themes and questions need to be answered

Main Themes and Questions Need To Be Answered

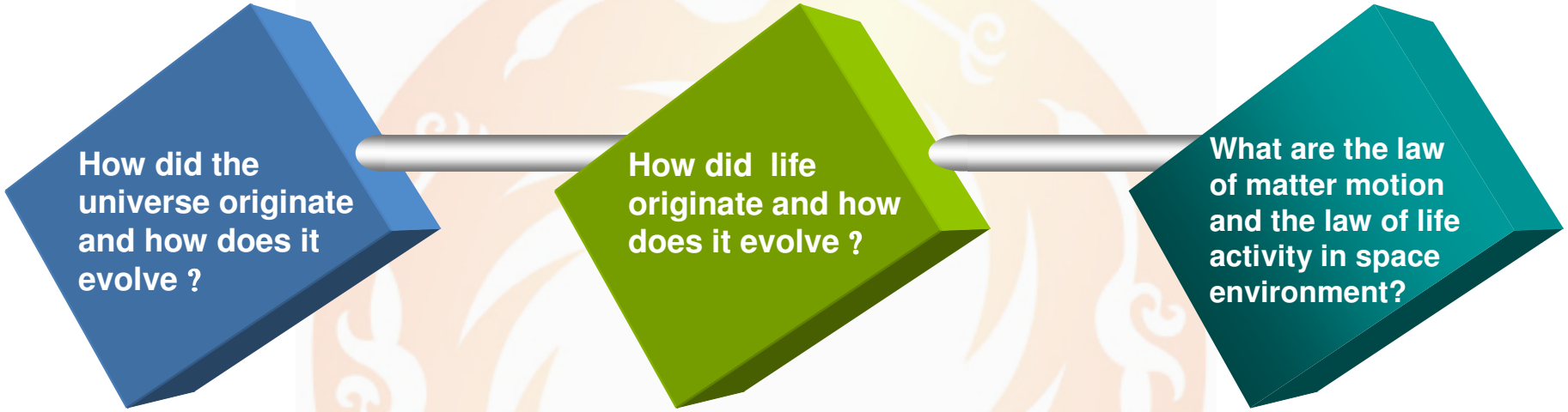
Two Themes of Space Science in 10~20 years

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?

Questions to be answered under the themes

Theme 1: How did matter originate, how does it evolve and move?



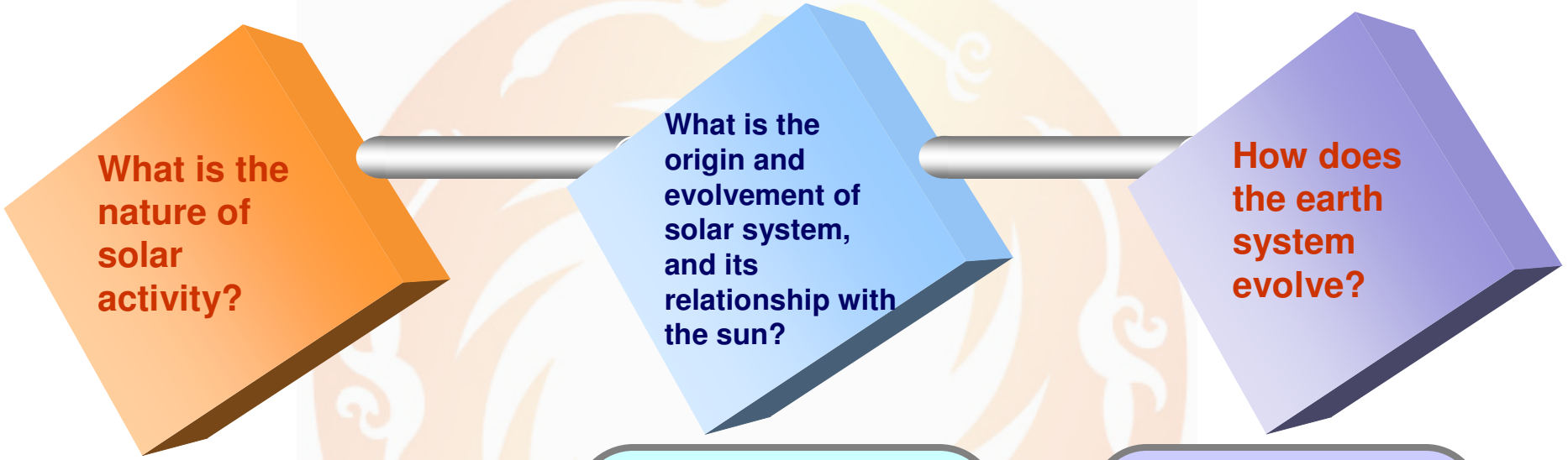
- What is the Universe made of and how does it evolve?
- What are the origins of the structures and objects of different scales in the Universe and how do they evolve?
- Is there new physics beyond the current basic physical theories?

- How did life originate and how does it evolve?
- Acquiring evidence of life elsewhere

- What is the law of matter motion in space environ-ment?
- What is the law of life activity in the space environ-ment?

Questions to be answered under the themes

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



- What is the nature of solar micro-phenomena?
- What is the nature of solar macro-phenomena?

- How did the planets in solar system originate and how do they evolve?
- How does solar activity transmit and evolve in interplanetary space ?
- How does solar activity affect earth space environment ?

- How do the various spheres of Earth interact and evolve?
- What will the earth system develop into the future?
- Can human beings live beyond the earth system?

Strategic Pioneer Program on Space Science

Strategic Pioneer Program on Space Science

2010.3.31

No.105 Executive Meeting of the State Council

- **Approved Innovation 2020 of CAS**
- **Agreed CAS to take the lead to implement Strategic Pioneer Program**
- **Space Science Strategic Pioneer Program: first take off**

Strategic Pioneer Program on Space Science

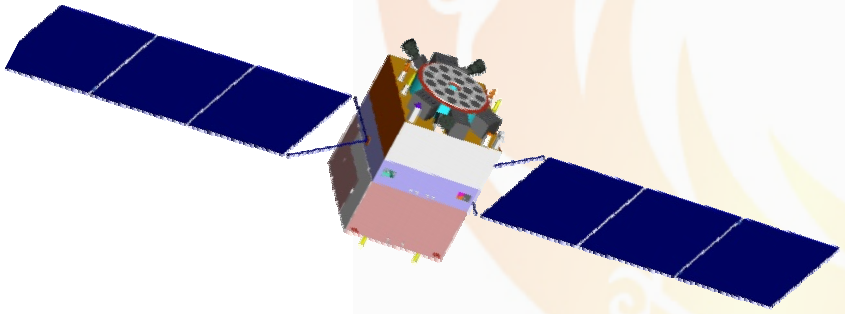
Main Goal

Through independent and co-operational science missions, dedicating to deepen our understanding of universe and planet earth, seeking new discoveries and new breakthroughs in space science.

Project 1: The Hard X-ray Modulation Telescope (HXMT)

➢Scientific Objectives:

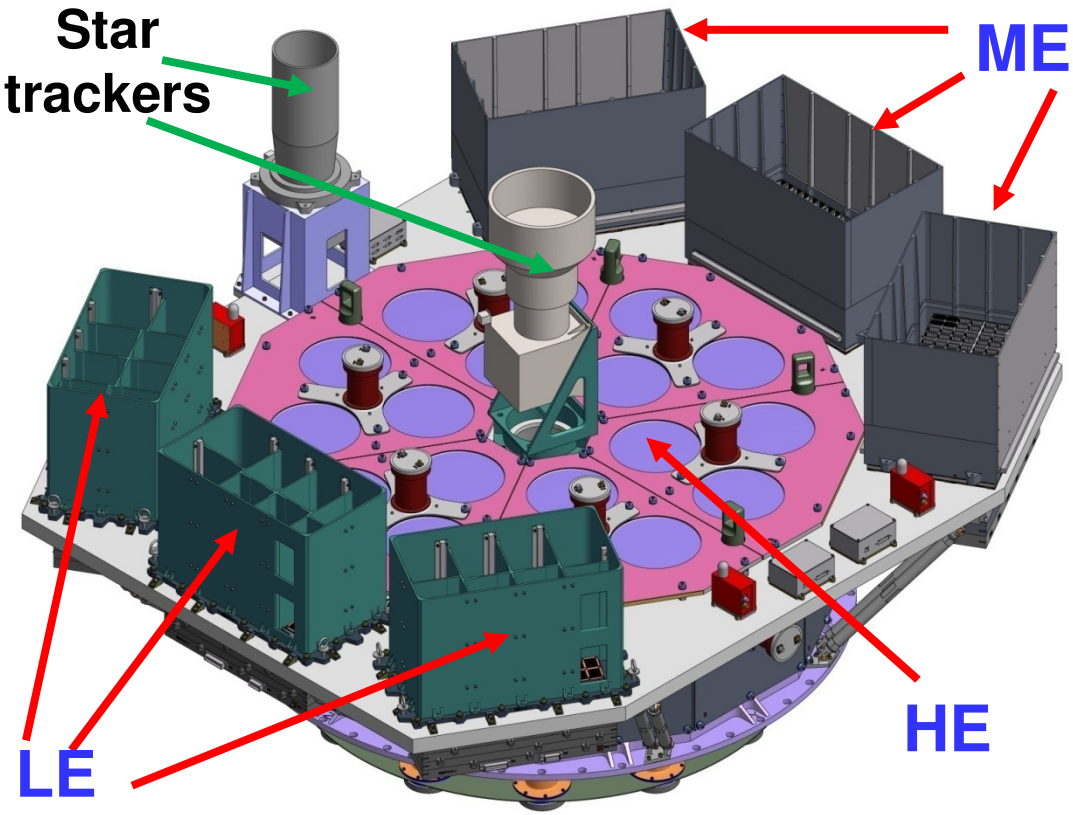
- ✓Hard X-ray full sky survey
  - •Diffuse background and cosmic variance
  - •Discover highly obscured supermassive BHs
- ✓Broad band (1-250 keV) and large collection area (5000 cm2@100 keV) pointed observations of high energy objects
  - •dynamics and radiation near BH horizons of stellar mass and supermassive BHs



Satellite Facts:

- ✓Mass: ~2800 kg
- ✓Orbit: 550 km, 43°
- ✓Attitude: 3-Axis Stabilized
- ✓ precision 0.1 °
- ✓Lifetime: 4 yrs

Project 1: The Hard X-ray Modulation Telescope (HXMT)



High Energy Telescope (HE): NaI/CsI, 20-250 keV, 5000 cm^2

Medium Energy Telescope (ME): Si-PIN,5-30 keV, 952 cm^2

Low Energy Telescope (LE): SCD,1-15 keV, 384 cm^2

Officially approved in March 2011

Entered Phase-B (Engineering model phase) in 12/2011

Now the mechanical and thermal model and the electric model are in the assembling and environment testing phases

Planned launch time: Late 2014 or 2015

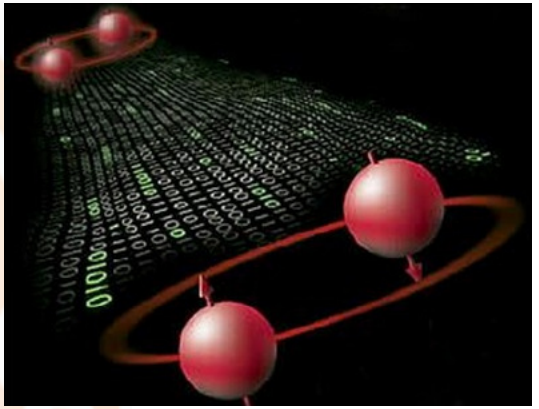
Project 1: The Hard X-ray Modulation Telescope (HXMT)

Detectors	LE: SCD, 384 cm^2;ME : Si-PIN, 952 cm^2 HE : NaI/CsI, 5000 cm^2
Energy Range	LE: 1-15 keV;ME: 5-30 keV;HE: 20-250 keV
Time Resolution	HE: 25 μ s; ME: 20 μ s;LE: 1ms
Energy Resolution	LE: 2.5% @ 6 keV ME: 8% @ 17.8 keV HE: 19% @ 60 keV
Typical Field of View of one module	LE: 6° ×1.6° ; 6° ×4° ; 60° ×3° ; blind; ME: 4° ×1° ; 4° ×4° ; blind; HE: 5.7° ×1.1° ; 5.7° ×5.7° ; blind
Source Location	<1' (20 σ source)
Data Rate	LE: 3 Mbps; ME: 3 Mbps; HE: 300 kbps
Payload Mass	~1000 kg
Working Mode	Scan survey, small region scan, pointed observation

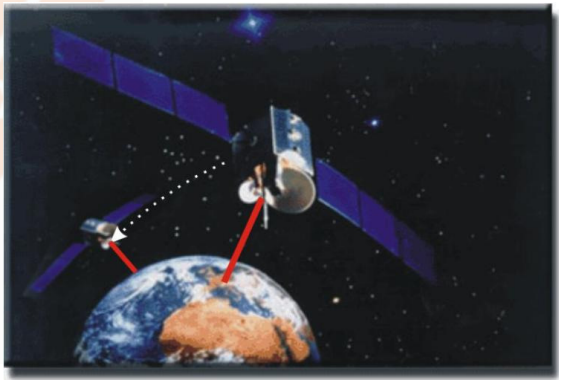
Project 2: QUantum Experiments at Space Scale (QUESS)

➢Scientific Objectives:

- ✓ Conduct experimental quantum key distribution for future secure communication based on high precision acquiring, tracking and pointing system, establish experimental large-scale quantum communication network
- ✓ Carry out satellite-to-ground quantum entanglement distribution and quantum teleportation experiment, testing the nonlocality of quantum mechanics theory



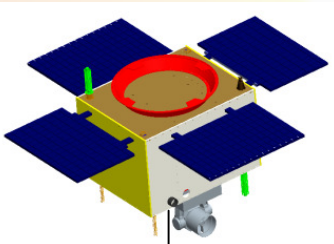
	Parameter
Orbit	600km
Inclination	97.79°
Stability	±0.02° /s
Mass	~600kg

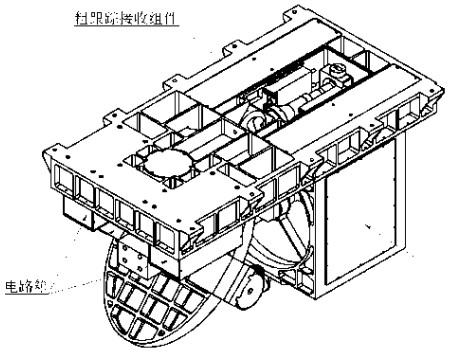


Project 2: QUantum Experiments at Space Scale (QUESS)

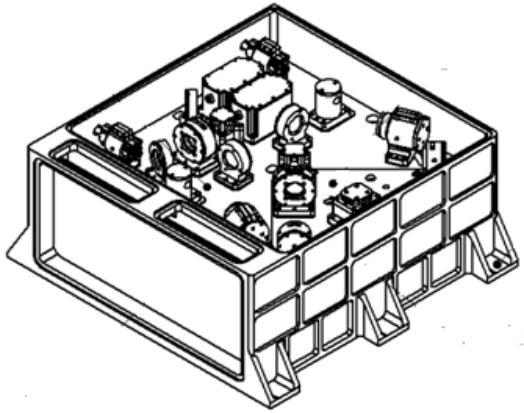
➢Payloads:

- **Prototypes completed**
- **Preparing for preliminary design Review**

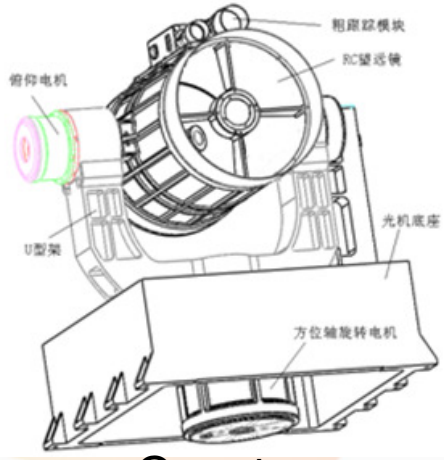




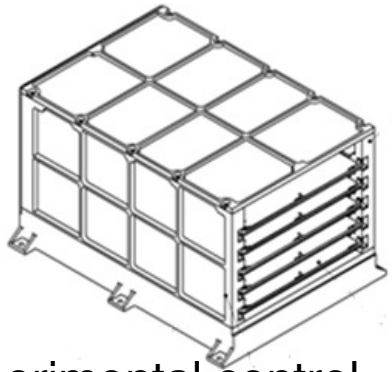
Quantum key communication equipment



Quantum entanglement source



Quantum entanglement transmitter

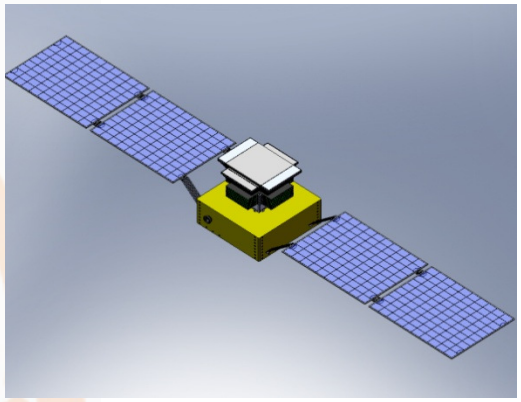


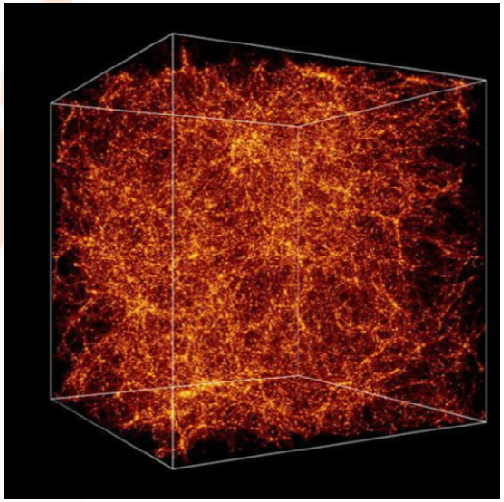
Experimental control and processing system

Project 3: DArk Matter Particle Explorer (DAMPE)

➢ Scientific Objectives:

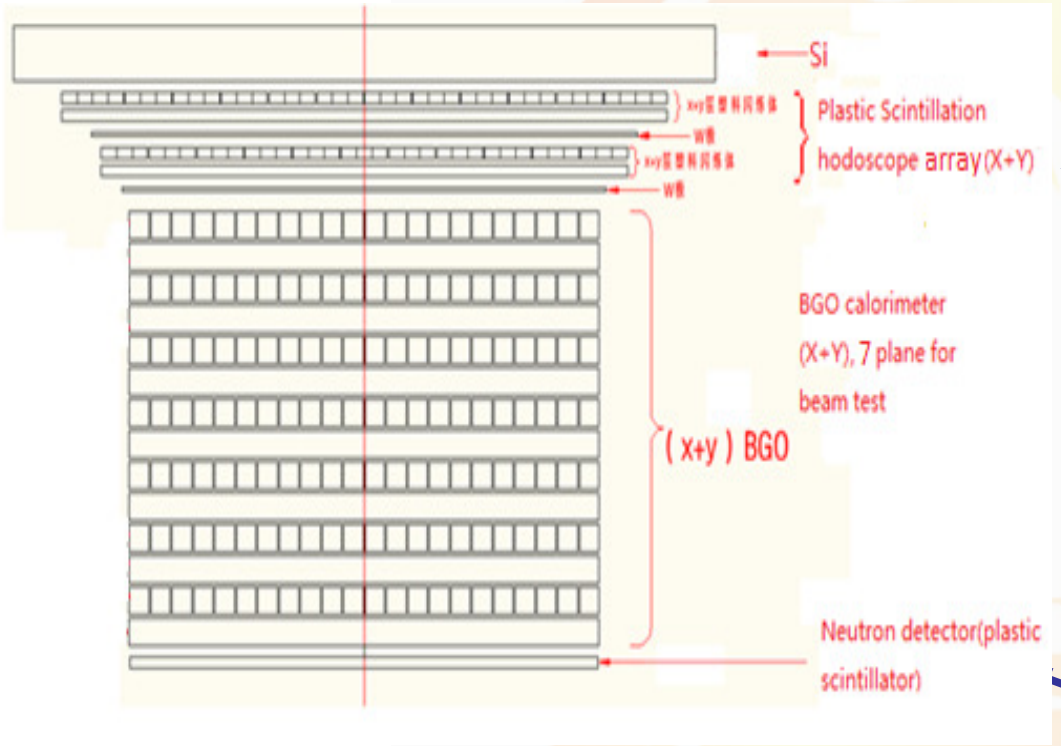
- ✓ **Find and study dark matter particle through high-resolution observation of high energy electron, gamma-ray spectrum and its space distribution**
- ✓ **Study the origin of cosmic ray through observation of high energy electron spectrum and anisotropy above TeV**
- ✓ **Study the propagation and acceleration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





Project 3: DArk Matter Particle Explorer (DAMPE)

➢**Conceptional Design:**



Si-Pin array

(to detector the charge of the injected particle)

Plastic scintillation hodoscope array

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

BGO Calorimeter

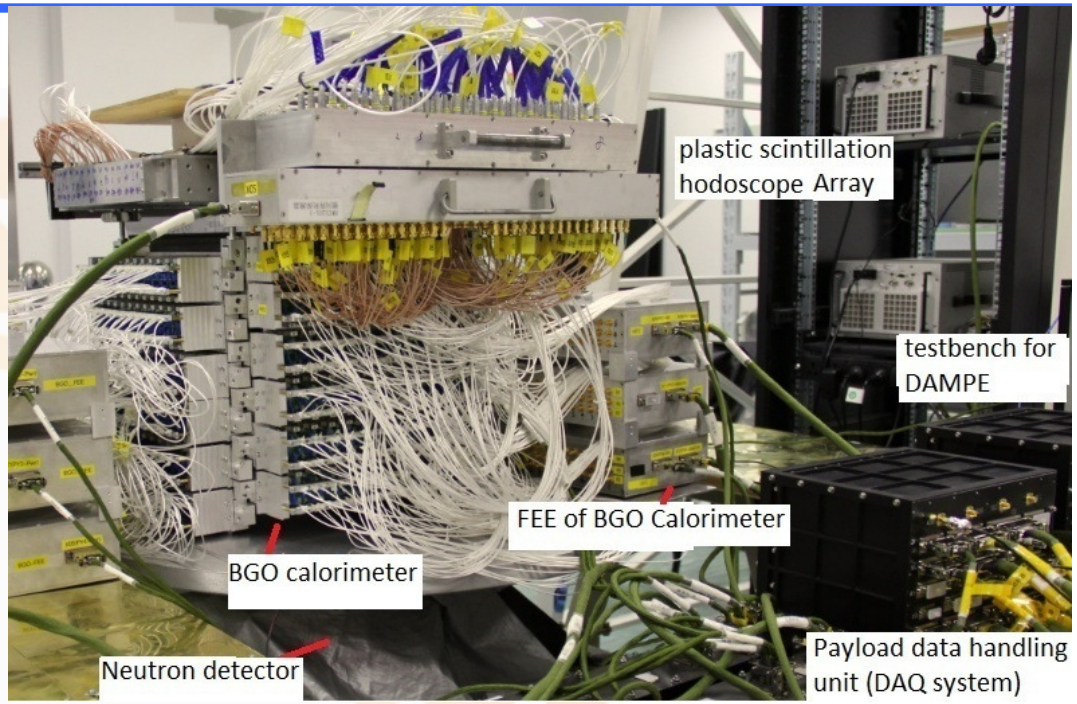
(14 layers, to measure the energy of the incident particles and to discriminate electrons from protons)

Neutron detector

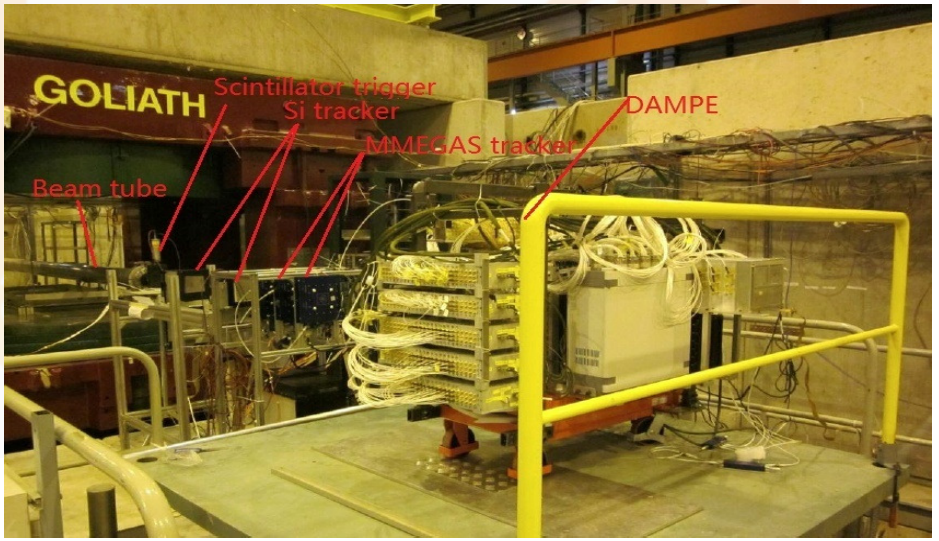
(Scintillation detector , to improve the discrimination of electrons from protons)

DArk Matter Particle Explorer (DAMPE)

- **Progress:**
  - **Prototype design of DAMPE (20/12/2011-20/07/2012)**
  - **Cosmic test of prototype (20/07/2012 -20/09/2012)**
  - **Beam test of DAMPE in CERN (01/10/2012-08/10/2012)**



Cosmic test in Nanjing

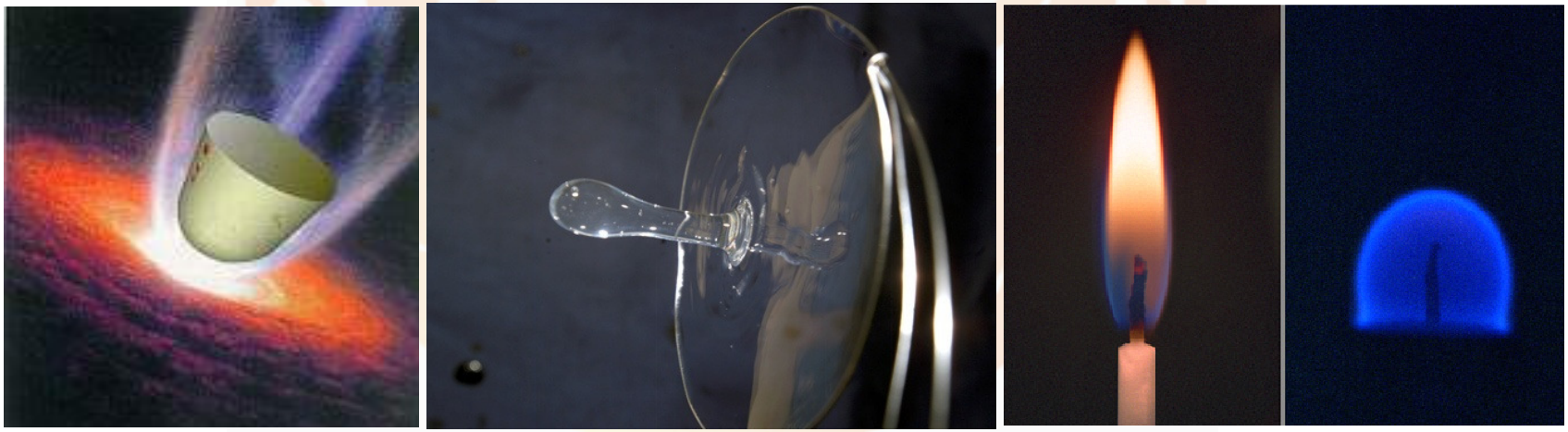


Beam test in CERN

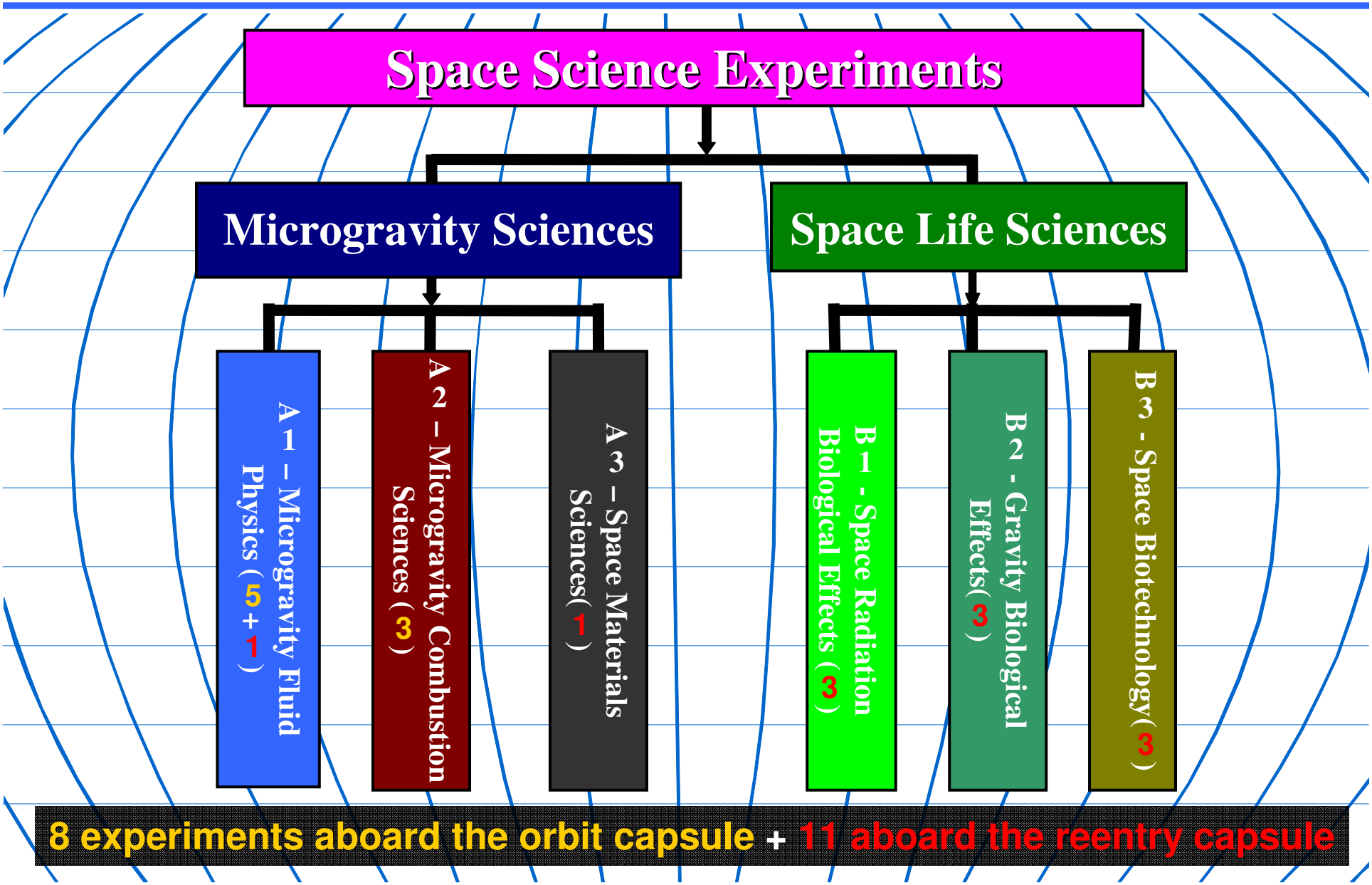
Project 4: Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)

SJ-10 is expected to make breakthroughs in

- ✓ **the basic laws of motion for matter**
- ✓ **biology gene expression**
- ✓ **efficient drug development**
- ✓ **efficient combustion of coal ...**

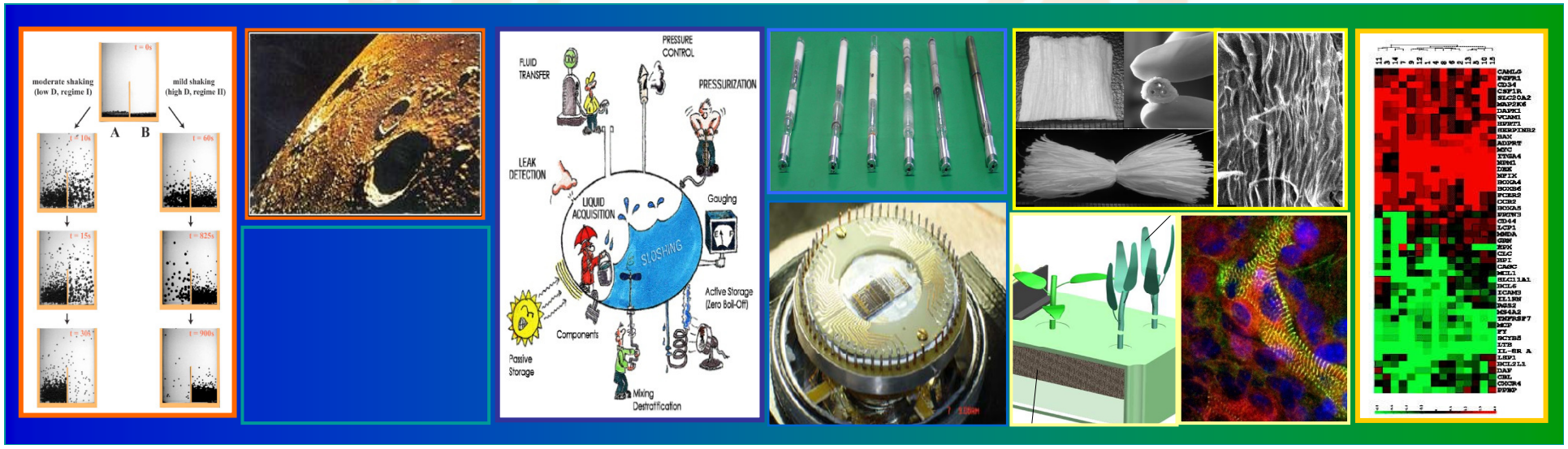


Project 4: Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)



Project 4: Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)

- **Progress:**
  - ✓ Scientific goals for each experiment have been confirmed
  - ✓ Now in system design, System Design Review (SDR) scheduled to be done by the end of 2012
  - ✓ Planned launch time: 2015 ~ 2016

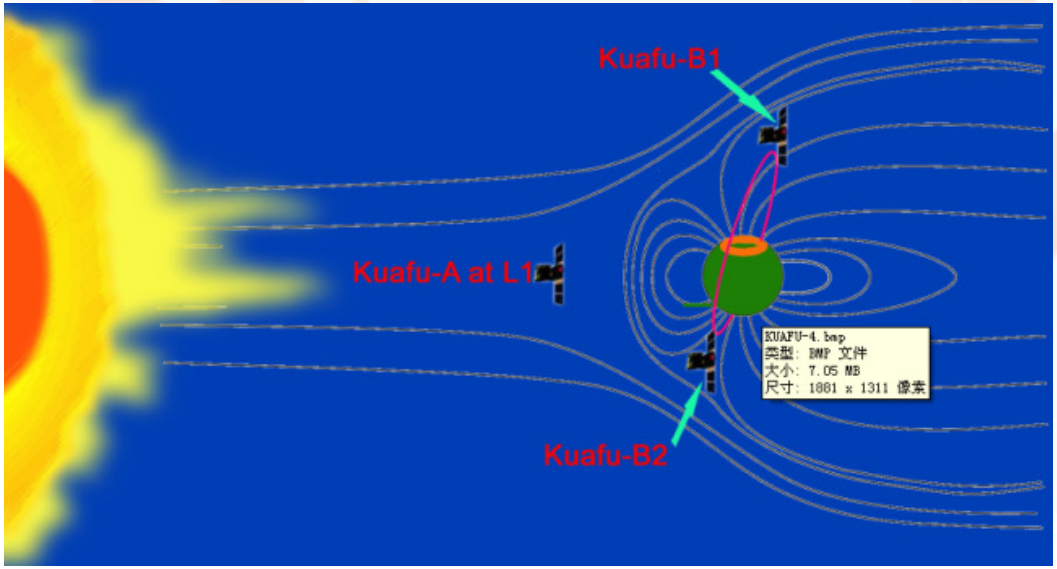


Project 5: KUAFU

- **Scientific Objectives：**

  To observe the complete chain of disturbance from the solar atmosphere to the geo-space:

  - ✓ **Solar flares, CMEs,**
  - ✓ **Interplanetary clouds, shock waves,**
  - ✓ **Their geo-effectiveness, such as sub-storms and magnetic storms, aurora activities**



Project 5: KUAFU

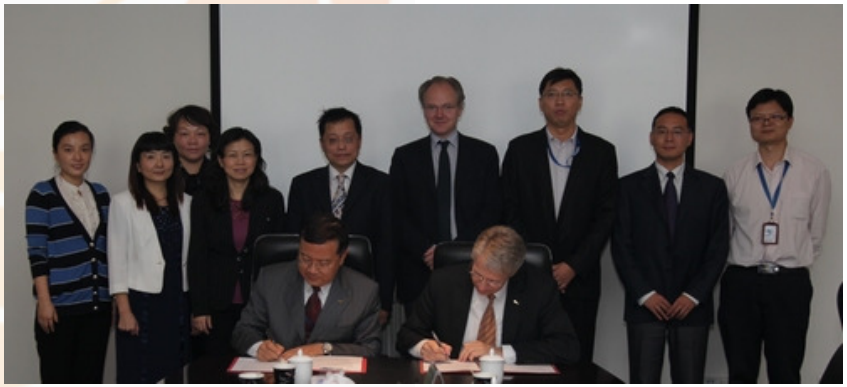
➢ KUAFU-A Payloads

Instrument	Observing Objective
Lyman-α Disk Imager	Distribution of the Lyman-α emission in the whole disk up to 1.5 Rs
Lyman-α/White Light Inner Coronagraph	Distribution of Lyman-α and white light in 1.5 – 3 Rs
Visible-light Outer Coronagraph	Distribution of white light between 2.5 and 15 Rs
Solar Heliospheric ENA Imager	Distribution of solar ENAs within 1 AU
Fluxgate Magnetometer	3D magnetic field at L1
Solar Wind Plasma Analyzer	Ion distribution function at L1
Solar Energetic Particle Telescope	Distribution function of solar energetic particles
Solar Energetic Particle Detector	High-energy electron, High-energy proton, Heavy ion
Total Solar Irradiance Radiometer	Variation of total solar irradiance

Project 5: KUAFU

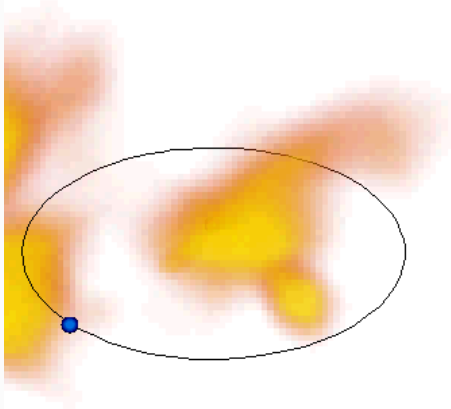
➢Progress:

- ✓ Re-evaluation of scientific objectives and payloads: 31/08/2012
  - Scientific objectives: no change
  - Payloads: Adjusted according to recent advances in space physics instruments, especially imaging ones
- ✓ Consultation Meeting (CAS and ESA) on Kuafu: 10-11/09/2012
  - A common understanding on a number of basic principles to be adopted was found
- ✓ NSSC and ESA signed Letter of Intent on Kuafu cooperation: 19/10/2012
- ✓ ESA's council meeting did not approved KUAFU B
- ✓NSSC is looking for other plans now



Project 6: Study of New Space Science Missions

- **Objectives:**
  - ✓Selecting appropriate new science missions, consolidating their scientific objectives, optimizing the exploration plans and developing key technologies
  - ✓To make good preparation for implementing the missions in next five years
- ✓ First batch of missions selected in 2011



CASS/UCSD 2002/07/26 00

Magnetosphere – Ionosphere – Thermosphere Coupling Exploration (MIT)

➢ **Scientific Objectives：**

✓Investigate the origin of the upflow ions and their acceleration mechanism

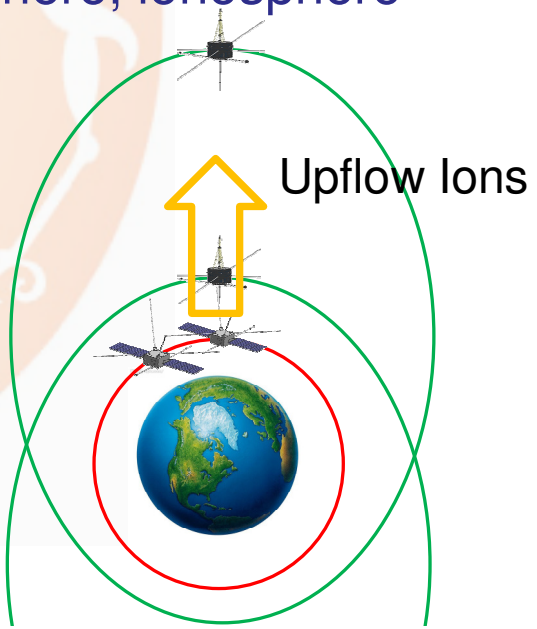
✓Understand the impact of the outflows ions on magnetic storm development

✓Characterize the ionosphere and thermosphere storm drivend by magnetic storm

✓Discover the key mechanism for the magnetosphere, ionosphere and thermosphere coupling

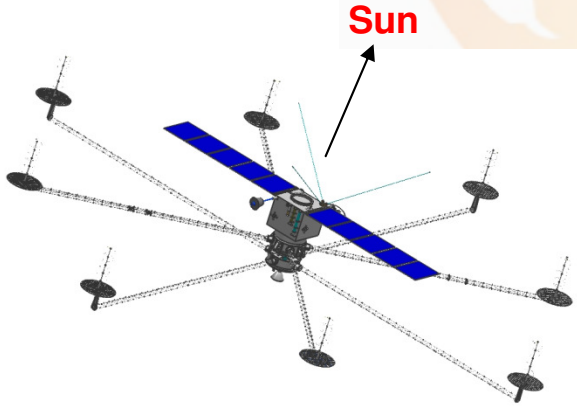
Period_MA/ Period_ITA=9:1

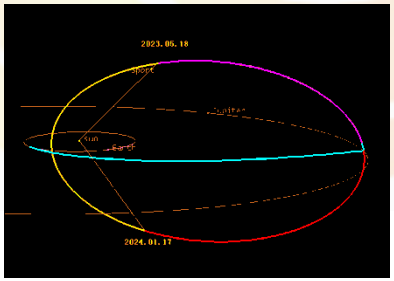
Spacecraft	ITA	ITB	MA	MB
inclination	90°	90°	75°	75°
perigee	500 km	500 km	1 Re	1 Re
apogee	1000 km	1000 km	6.7 Re	6.7 Re



Solar Polar Orbit Radio Telescope (SPORT)

- **Science Objectives:** SPORT will be the first mission to image the propagation of CME continuously off the ecliptic plane.
  - ✓Imaging & tracking interplanetary CMEs propagation
  - ✓Observation on solar high latitude area
- **Payloads:**
  - ✓**Imaging Payloads:** Synthetic aperture radio imager, Heliospheric Imager, Large angle and spectrometric chronograph, Solar magnetograph, Solar ultraviolet imager (121.6nm)
  - ✓**In-situ Measurement Package:** High energetic particle detector, Heavy ion composition detector, solar wind plasma detectors, fluxgate magnetometer, low frequency wave detector, solar radio burst spectrometer



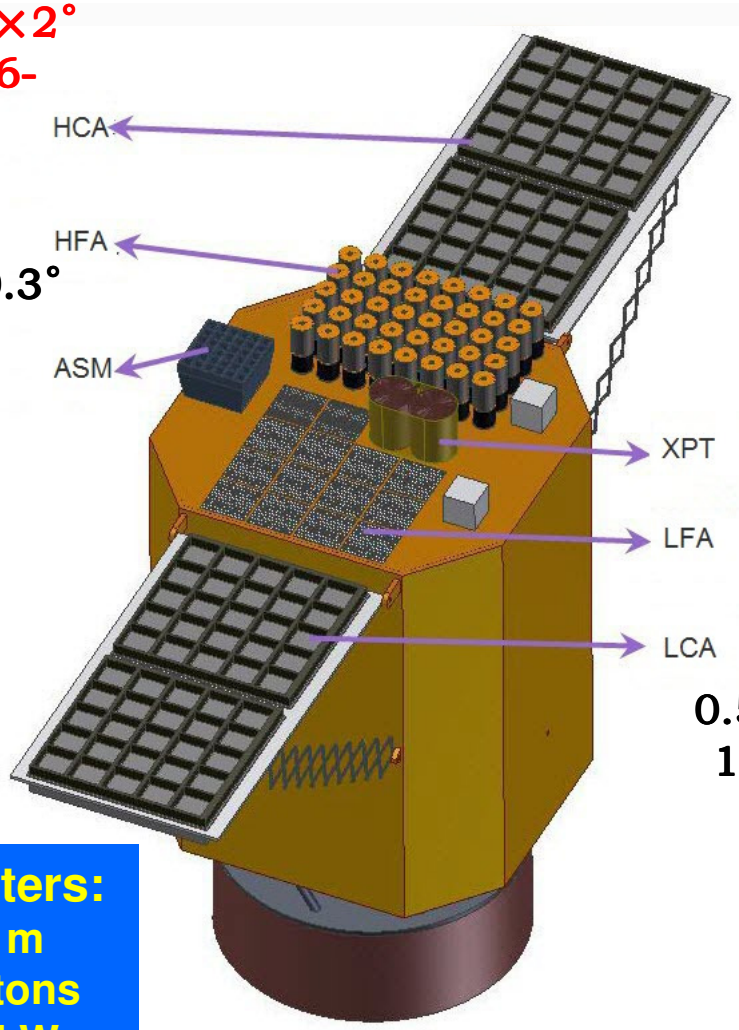


Orbit realization	solar polar orbit (with the gravity assist of Jupiter)
Inclination	>72 °
perihelion	0.7AU
aphelion	5AU

X-ray Timing and Polarization mission (XTP)

10-100keV，2° ×2°
15000 cm² (CZT, 6-100keV)

1-30keV，0.3° ×0.3°
2400 cm²(1-6keV)
1000cm²@ 30keV



Preliminary Concept of XTP:

Total Mass: 4500 kg

Orbit: 550-600km, <10°

Life Time: 5 years

0.5-15keV，1° ×1°
2000 cm²@1keV

0.5-15keV，2° ×2°
15000 cm²(1-6keV)

Payload parameters:

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

X-ray Timing and Polarization mission (XTP)

- **Scientific Objectives**
  - Measure the fundamental parameters of a sample of black holes (BHs) and neutron star (NSs)
  - probe the physics conditions in regions neighbouring the BH event horizon or NS surface
  - investigate the equation of state of matter in the interior of NSs
- **Advantages of XTP**
  - Large collecting area up to 100 keV: study the short time scale varibility of X-ray binaries (XRBs)
  - Focussing observations with fast readout timing: supermassive BHs in nearby galaxies; study the outbursts of XRBs throughout full life cycles
  - Polarization observations: measure the polarization of several hundred sources to a precision of 2%; constrain the geometry of accretion discs and the nature of neutron stars

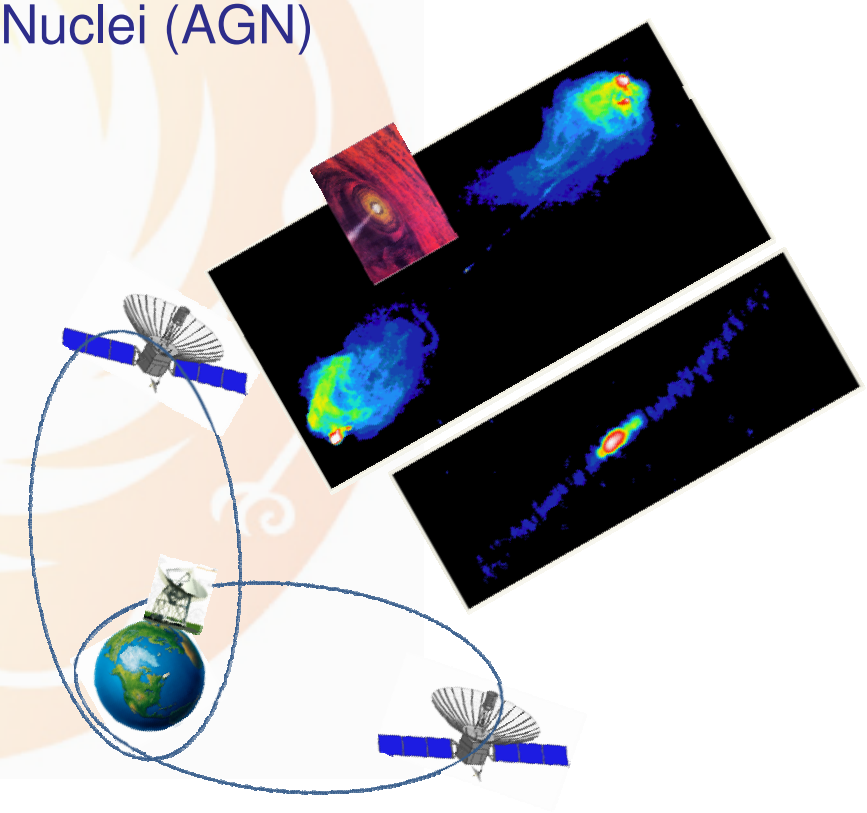
Space Millimeter VLBI Array

➢ Main Scientific Objectives:

- High-resolution imaging of emission structure surrounding super-massive black hole (SMBH) to study
  - SMBH Shadow (e.g. M87)
  - Disk structure & dynamics, SMBH mass (water mega-masers)
  - Astrophysical Jet in Active Galactic Nuclei (AGN)
- Formation and evolution of stars

➢ Specifications:

- Two 10-m (in diameter) space antennas
- Three frequency bands (8, 22 & 43 GHz)
- Dual polarization (LCP/RCP)
- Date rate (1.2 Gbps , or 2.4 Gbps)
- Angular resolution: 20 micro-arc-second
- Optimized orbits for a better (u,v) coverage
  - Apogee: 60,000 km
  - Perigee: 1,200 km
  - Inclination: 28.5 deg
- Life time: 3 year

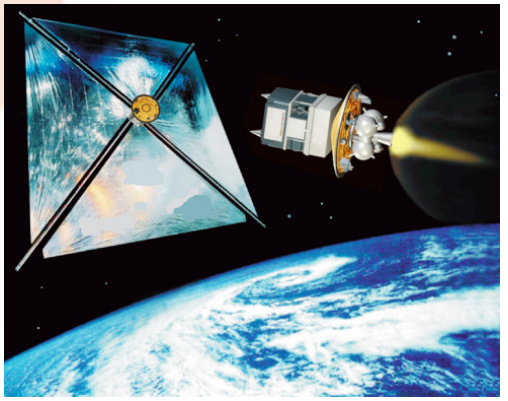


Project 6: Study of New Space Science Missions

- **The second batch of missions:**
  - ✓ **M & S class missions**
  - ✓ **International cooperation preferred**
  - ✓ **High Technical Readiness Level (TRL)**
  - ✓ **2-3 missions to be selected in the middle of 2013**

Project 7: Advanced Research of Space Science Missions and Payloads

- **Objectives:**
  - ✓aim at advanced research on key technologies for future space science satellites, through planning a cluster of research subjects:
    - new concepts of space science missions
    - key technologies of payloads
    - ground calibration for payloads
    - short-time flight demonstration for new payloads and technologies



Summary

- *China is paying more attention to space science.*
- *More efforts are needed to accomplish all the missions.*
- *China should make adequate contribution in this area while the economy is continuously developing.*
- *International cooperation is welcome and very much encouraged to participate these new mission.*


Thank You!