Progress of Strategic Priority Program on Space science

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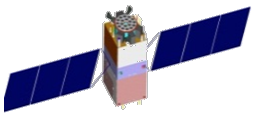
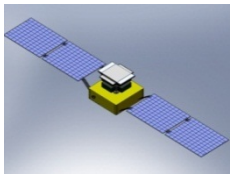
Strategic Priority Program on Space Science

- Hard X-ray Modulation Telescope (HXMT)

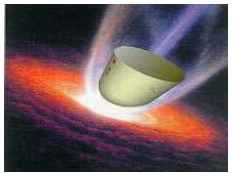


- QUantum Experiments at Space Scale (QUESS)

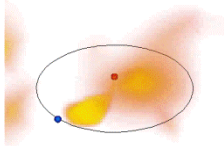
- DArk Matter Particle Explorer (DAMPE)



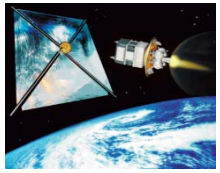
- ShiJian-10 (SJ-10)



- Intensive Study of Future Space Science Missions

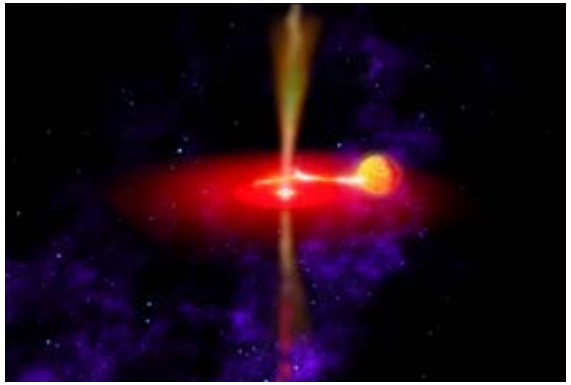


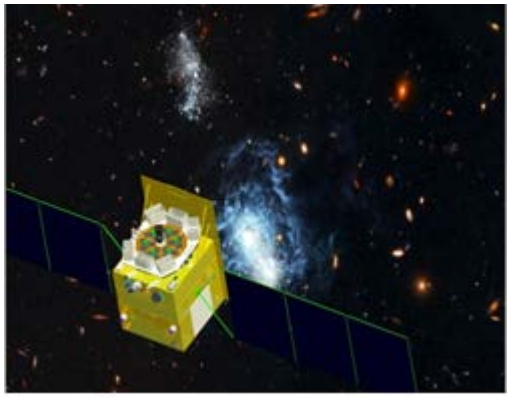
- Advanced Research of Space Science Missions and Payloads



Hard X-ray Modulation Telescope (HXMT)

- the origin of cosmic X-ray background
- the statistical properties of supermassive black holes
- the physical laws under extreme conditions.





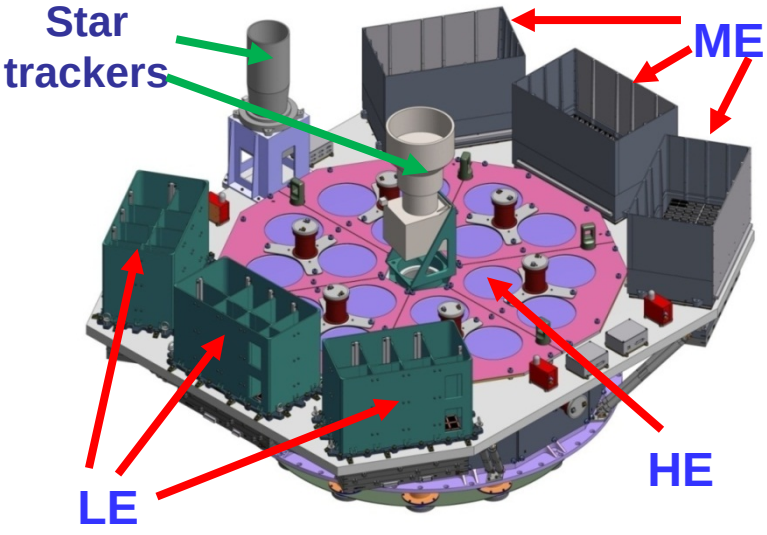
Hard X-ray Modulation Telescope (HXMT)

➢ 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 Specifications

- ✓ Mass: 2700kg, 1021kg (P/L)
- ✓ Orbit: 550km, 43°
- ✓ Life time： 4 years



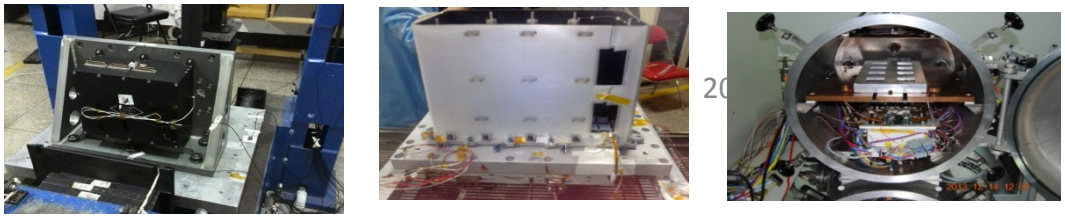
Hard X-ray Modulation Telescope (HXMT)

➢ 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

Components of the HE and the environment tests

The electronic box (left) and one detector box of ME



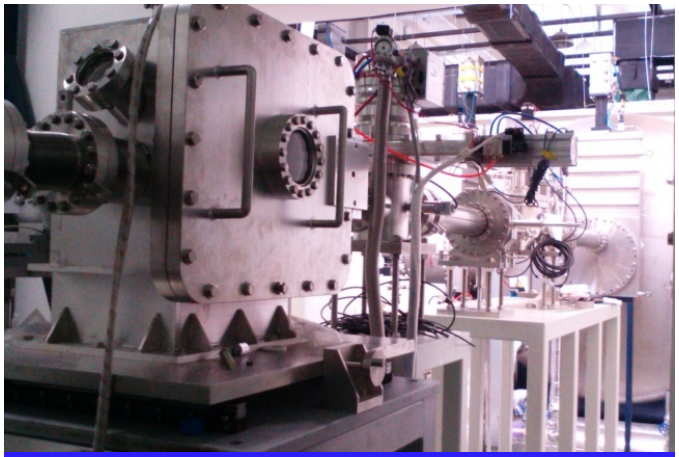
The electronic box (left) and one detector box of LE in environment tests.

Hard X-ray Modulation Telescope (HXMT)

➢ Progress:

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

HE calibration facility



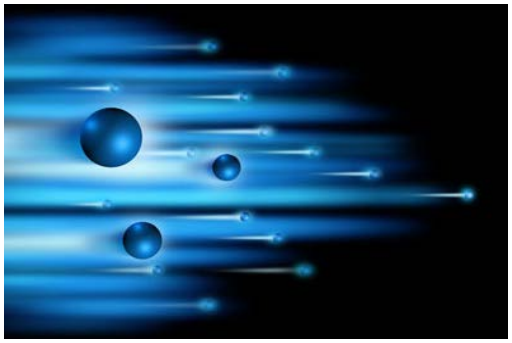
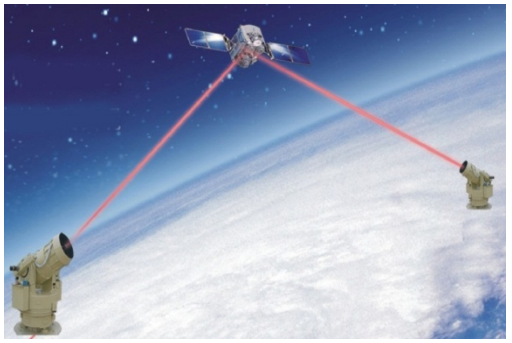
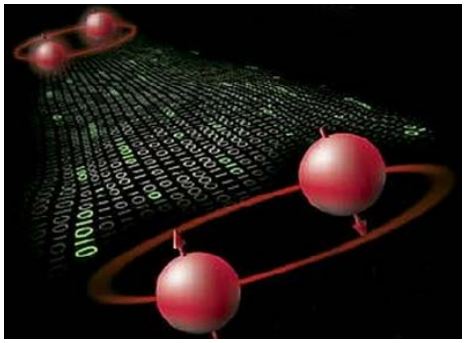
ME、LE calibration facility

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

✓ Planned launch: late 2016

QUantum Experiments at Space Scale (QUESS)

- carry out satellite-to-ground quantum entanglement distribution and quantum teleportation experiment;
- test the non-locality of quantum mechanics theory.

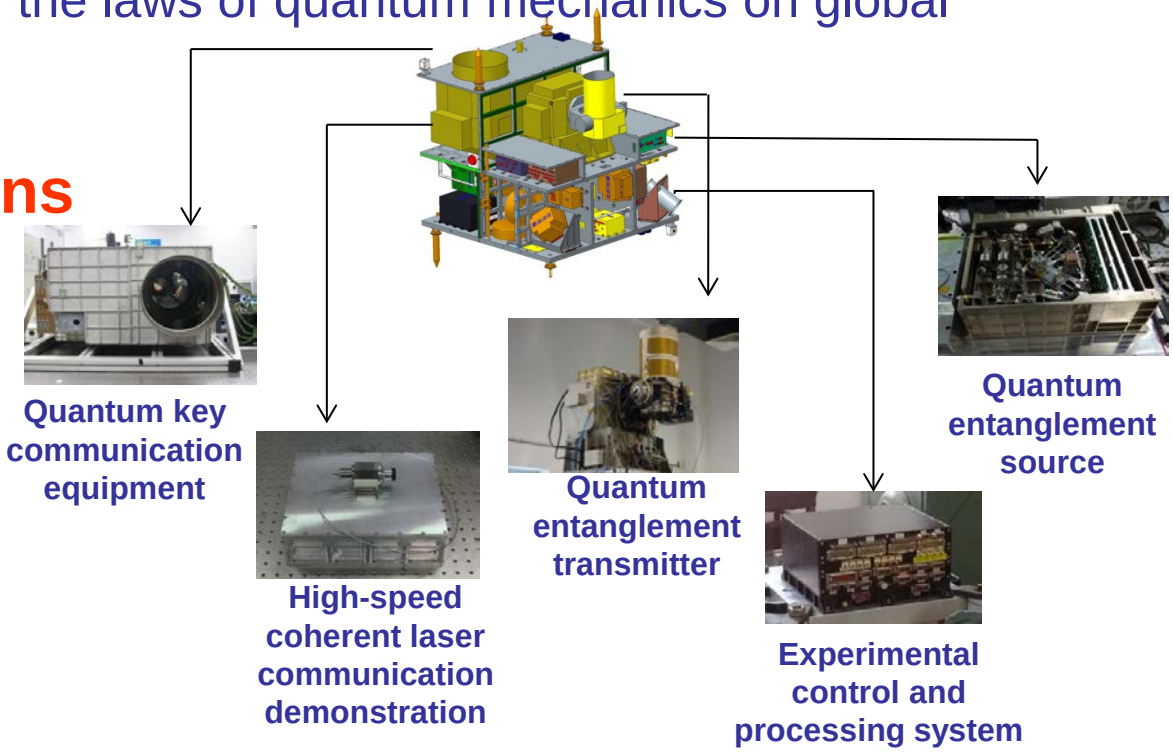
QUantum Experiments at Space Scale (QUESS)

➢ 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.

➢ Satellite Specifications

- ✓ Orbit: 500km, sun-synchronous,97.37°
- ✓ Life time: 2 years
- ✓ Mass：＜650kg



QUantum Experiments at Space Scale (QUESS)

- Progress:
  - ✓ Formally approved in 12/2011
  - ✓ Qualification models developed and tested in 10/2014
  - ✓ PDR completed in 11/2012
  - ✓ CDR completed in 12/2014
  - ✓ S/C & P/L entered flight model phase in 12/2014

Qualification models of payloads

Vibration test in Shanghai

QUantum Experiments at Space Scale (QUESS)

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

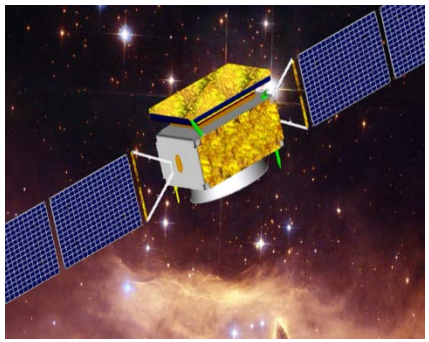
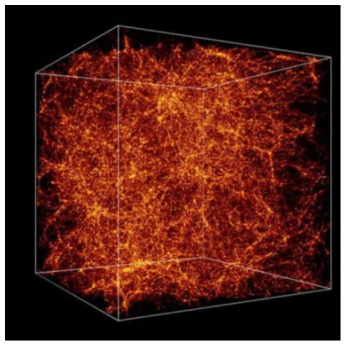
Optical telescope

Xinjiang and Qinghai optical ground

- ✓ Planned launch: 07/2016

DArk Matter Particle Explorer (DAMPE)

- will investigate dark matter particles from space by high resolution observations of gamma-rays and electrons spectra and their space distribution.
- study the transportation and acceleration of the cosmic ray in the Galaxy by measuring the energy spectra of heavy

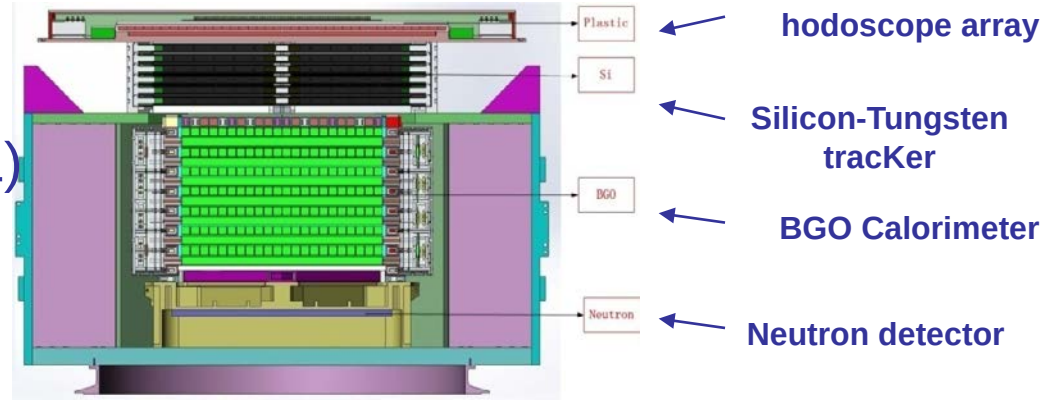
DArk Matter Particle Explorer (DAMPE)

➢ 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

➢ Satellite Specifications

- ✓ Mass: 1850kg, ~1400kg (P/L)
- ✓ Orbit: 500km, 97.4°
- ✓ Life time: 3 years



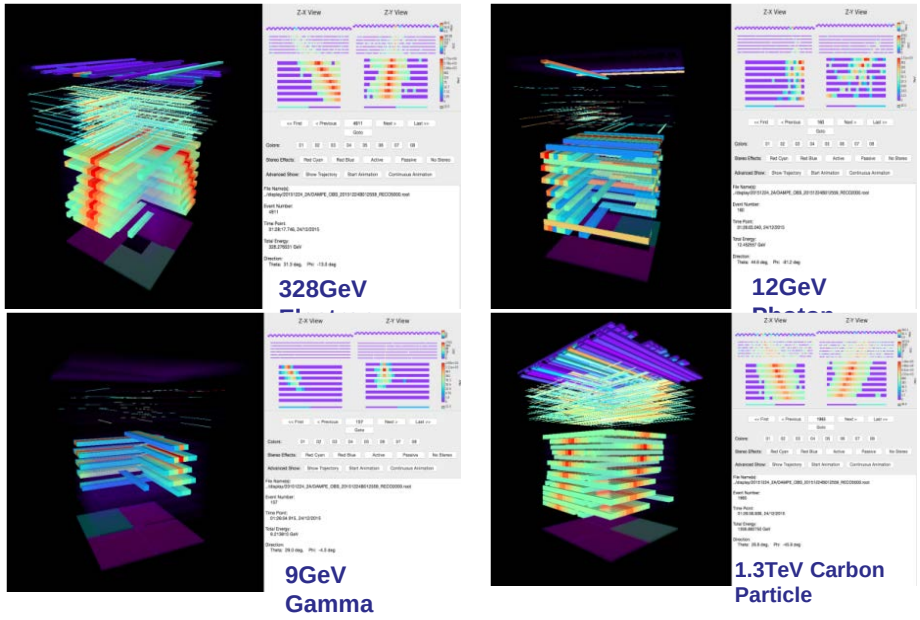
DArk Matter Particle Explorer (DAMPE)

➢Progress:

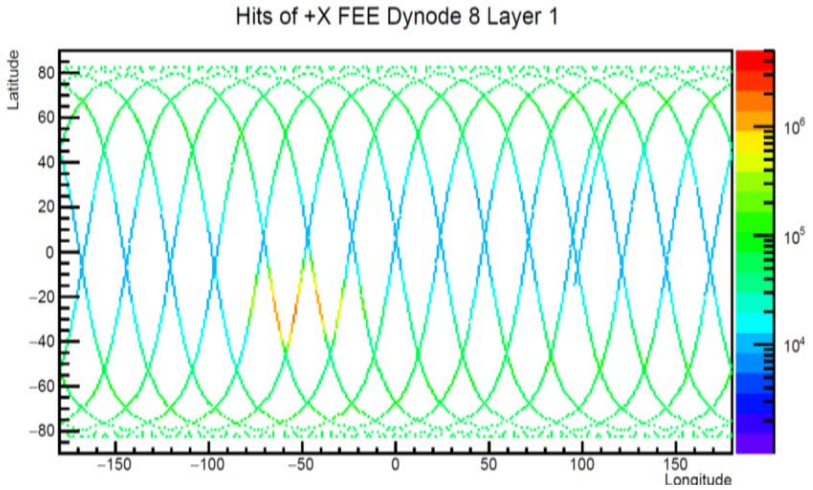
- ✓ Formally approved in 12/2011
- ✓ PDR completed in 04/2013
- ✓ CDR completed in 09/2014
- ✓ S/C entered flight model phase in 09/2014
- ✓ Silicon-Tungsten tracKer entered flight model phase in 12/2014
- ✓ Three beam calibration experiments in CERN conducted in 10/2012,10/2014 and 03/2015
- ✓ All flight models of the satellite system completed in 05/2015
- ✓ **Launch: 12/17/2015**

DArk Matter Particle Explorer (DAMPE)

➢After launch:



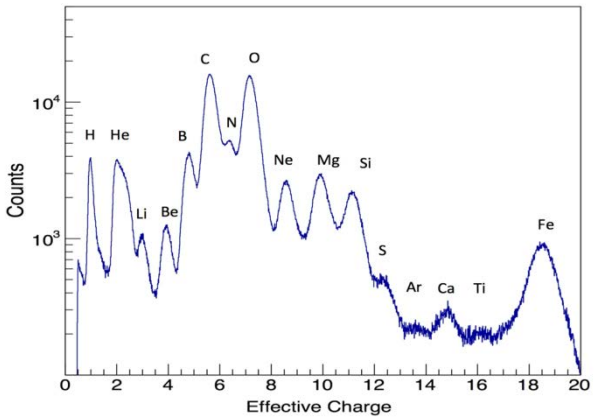
The first image DAMPE got after launch



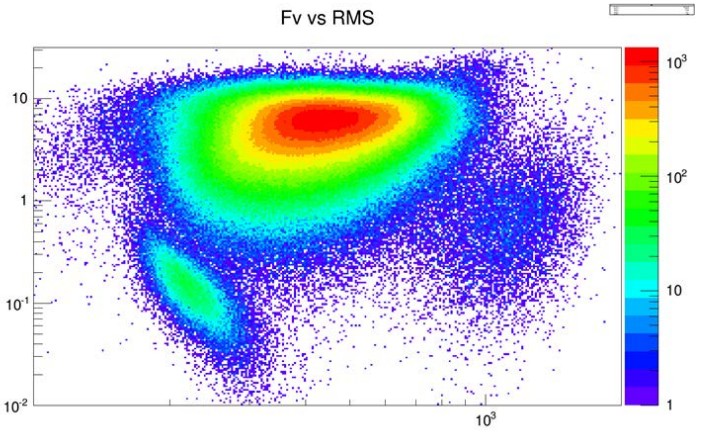
16GB data received through downlink every day, with 100GB science data acquired after ground processing

DArk Matter Particle Explorer (DAMPE)

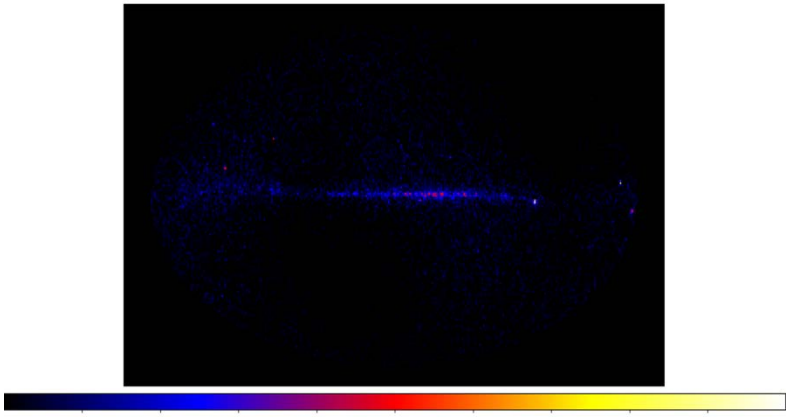
Charge Resolution:
0.389@Z=26



e p separation:
>100,000

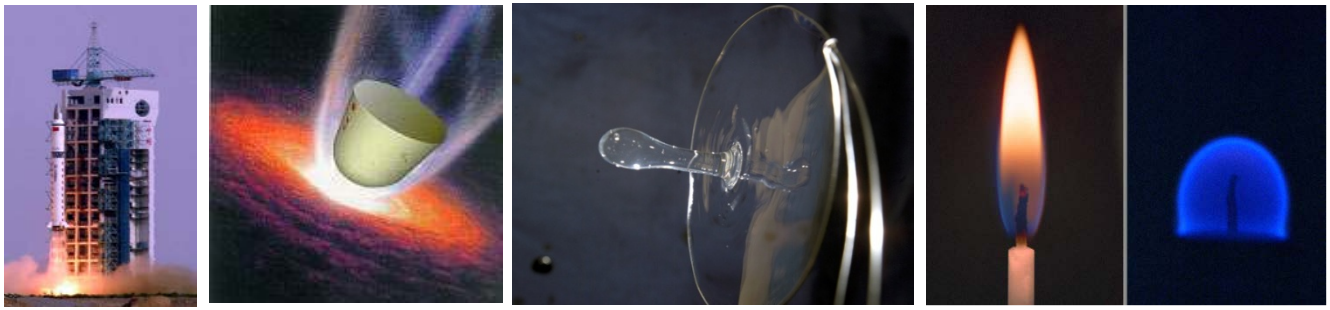


Angular Resolution:
0.2 degree@ 2 GeV



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

Progress



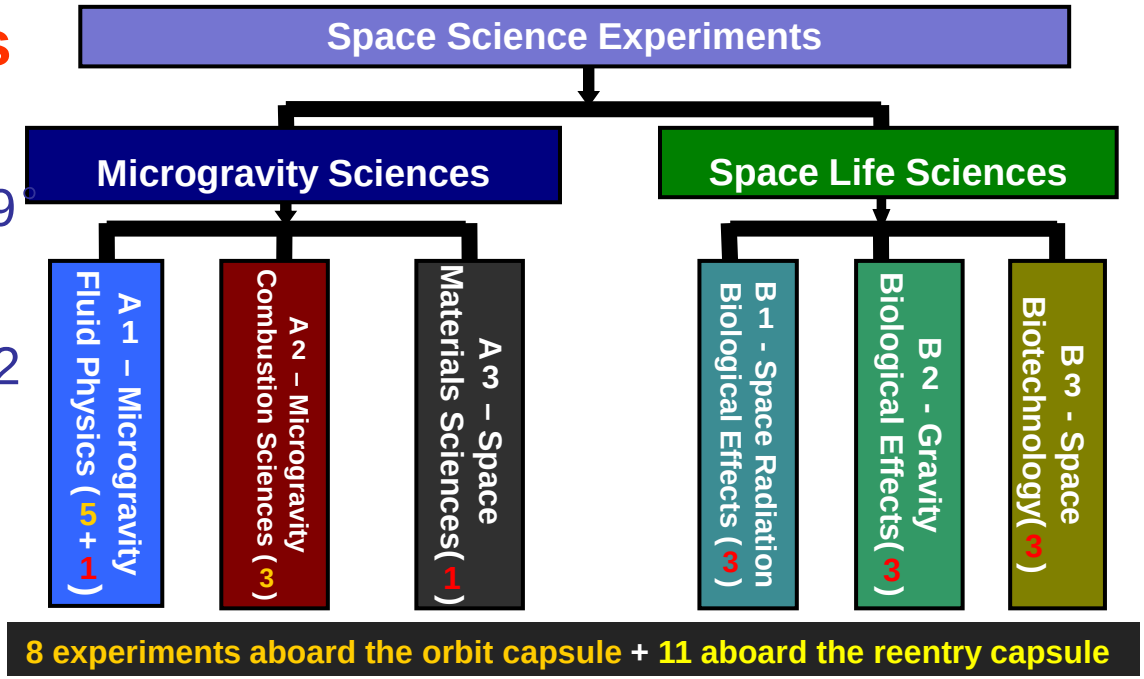
Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)

➢ Scientific Objectives

With the recoverable satellite technology, SJ-10 focuses on the behavior of matter and life activities in space. It will carry out experiments in microgravity on heat and mass transport in fluid, discrete system, bio-space adaptation, mutation and gene expression,

➢ Satellite Specifications

- ✓ Orbit: circular, 252km, 42.89°
- ✓ Microgravity: 10^{-3} g
- ✓ Life time: re-entry capsule 12 days, orbit capsule 15 days
- ✓ Mass: ≤3400kg



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

➢ Progress:

- ✓ Formally approved in 12/2012
- ✓ System Design Review (SDR) completed in 03/2013
- ✓ Satellite PDR completed in 09/2013
- ✓ Satellite CDR completed and entered flight model phase in 12/2014

SJ-10 payloads

Flight model system level tests

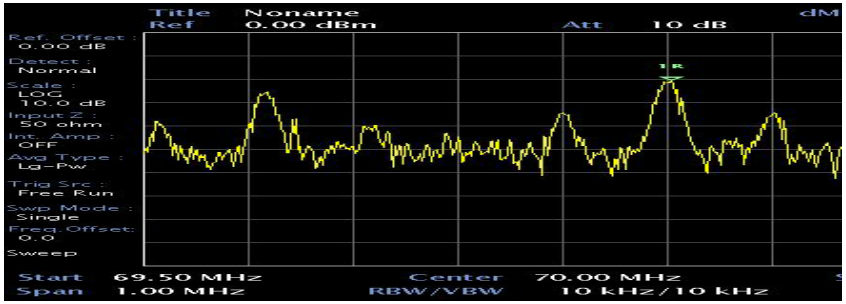
Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)

➢ Progress:

✓ Compatibility test between systems

- Compatibility test between satellite system and tracking telemetry and control (TT&C) system completed in 08/2014.
- Compatibility test between satellite system and ground support system completed in 09/2014 & 06/2015.

Ground station



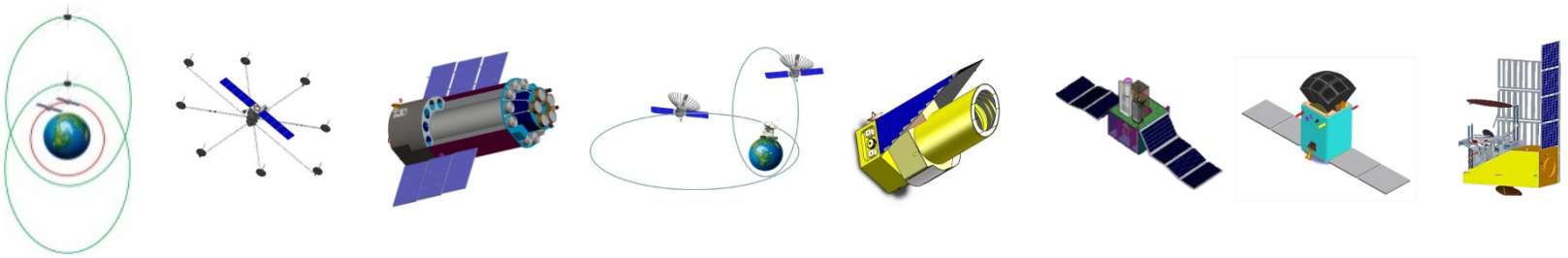
Compatibility test data

✓ P/L delivered to S/C in 06/2015

✓ Planned launch: 04/2016

Intensive Study of Future Space Science Missions

Progress



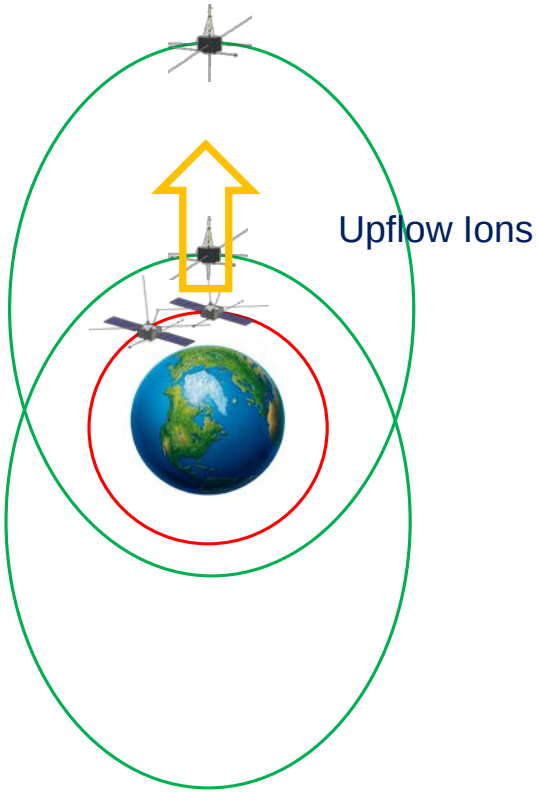
Magnetosphere—Ionosphere—Thermosphere Coupling Exploration (MIT)

➢ Scientific Objectives

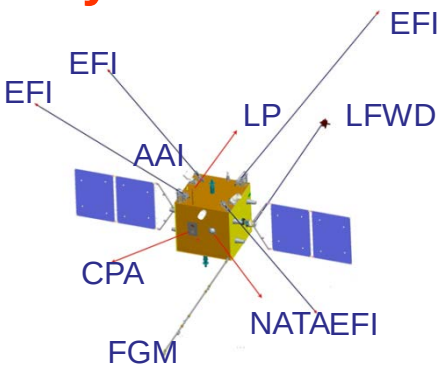
- ✓ Investigate the origin of the upflow ions and their acceleration mechanism
- ✓ Understand the impact of the outflows ions on magnetic storm development
- ✓ Characterize the ionosphere and thermosphere storm driven by magnetic storm
- ✓ Discover the key mechanism for the magnetosphere, ionosphere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

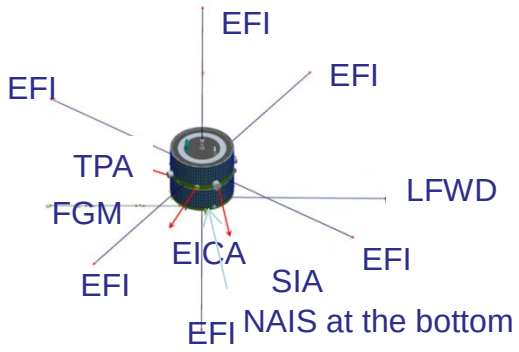
➢ Satellite Specifications

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



➢ Payloads

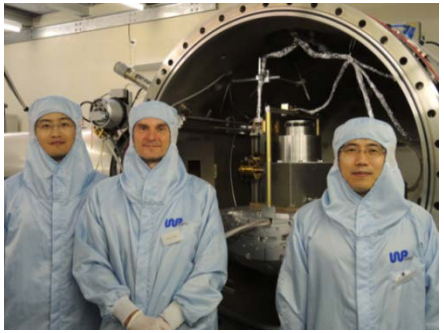




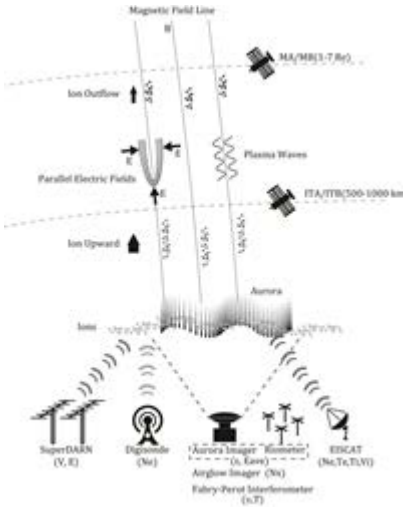
Magnetosphere－Ionosphere－Thermosphere Coupling Exploration (MIT)

➢ Progress:

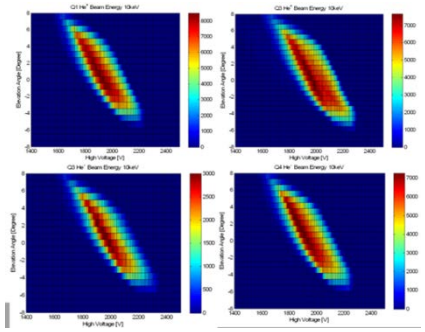
- ✓ Main Scientific objectives defined
- ✓ Orbits and payloads Scheme designed
- ✓ Prototype of newly developed payloads are finished



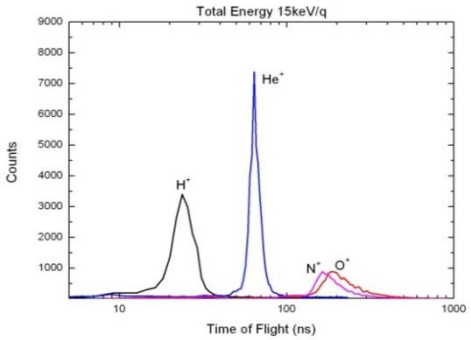
Suprathermal Ion Mass pectrometer calibrated in born university in 2014



Campaign of conjugate Ground and Spacecraft



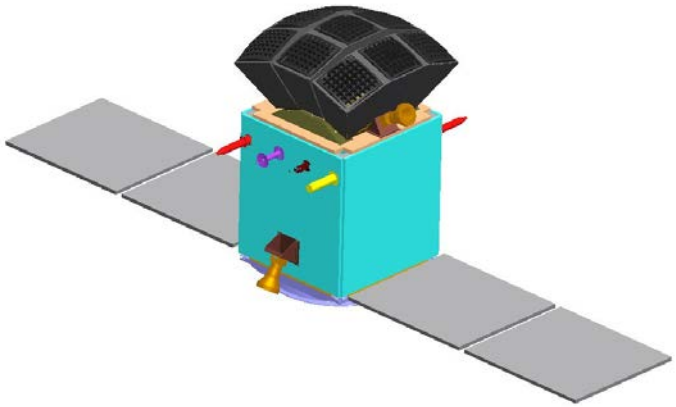
Calibration results of Elevation Angle versus Electrostatic Analyzer Voltage scanning



Calibration results of mass spectrogram

Einstein-Probe (EP)

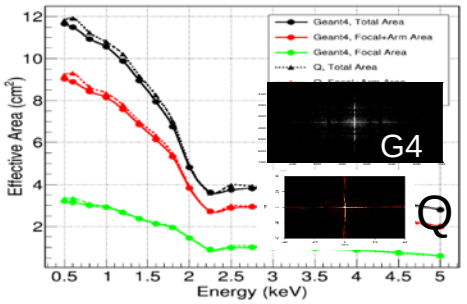
- **Science Objectives: Time-domain census of soft X-ray transient and variable sources in the universe**
  - ✓ Discover quiescent black holes over all astrophysical mass range and other compact objects via high-energy transients
  - ✓ Discover and locate electromagnetic-wave sources of gravitational-wave 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**
  - ✓ Orbit: 600km, circular, 30°
  - ✓ Mass: 380kg
  - ✓ Life time: 5 years
- ✓ **Payloads:**
  - ✓ Wide-field X-ray telescope (WXT)
  - ✓ Follow-up X-ray telescope (FXT)



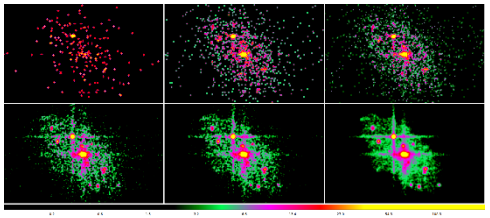
Einstein-Probe (EP)

➢ Progress:

- ✓ Developed Geant4-based ray-tracing simulation software for the design of the MPO lobster-eye optics and the simulations of the instrument performance
- ✓ Designed and built laser-guided MPO optics assembly facility at NAOC. The assembled telescope module consisting of 4x4 MPO pieces is demonstrated to meet the designed precision.
- ✓ GEM gas detector being built (without the designed thin entrance window foil yet) and demonstrated to work with the desired positional resolution

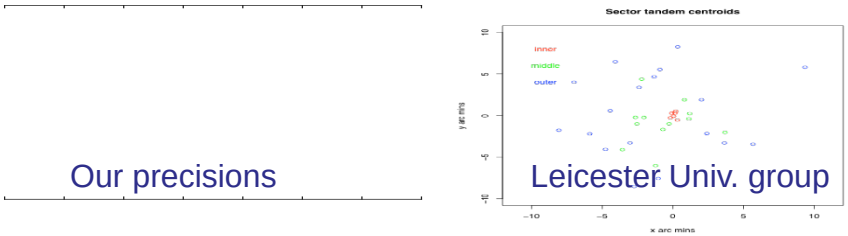


Effective area of the WXT telescope obtained using our simulation software

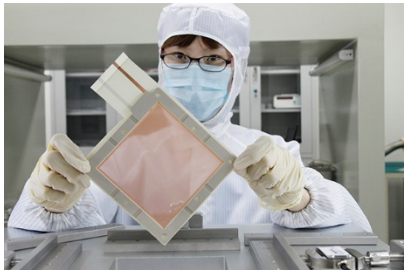


Simulated X-ray images of the Andromeda galaxy (M31) obtained with EP/WXT at various exposures using our software

Design of one MPO lobster-eye telescope optics module



Our assembly precision (left) better than those achieved by the Leicester Univ. group (right)



Prototype of GEM-based gas detector being built

Water Cycle Observation Mission (WCOM)

➢ Science Objectives

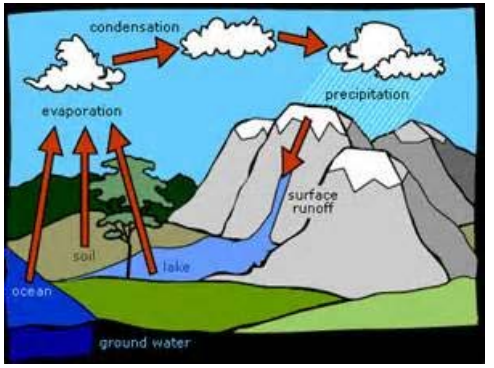
- ✓ Understand better status and process of the Earth's water cycle system under the global change environment, by simultaneous and fast measurement of a set of water cycle key parameters (soil moisture, ocean salinity, ocean surface evaporation, snow water equivalent, frozen/thaw, atmospheric vapor…)

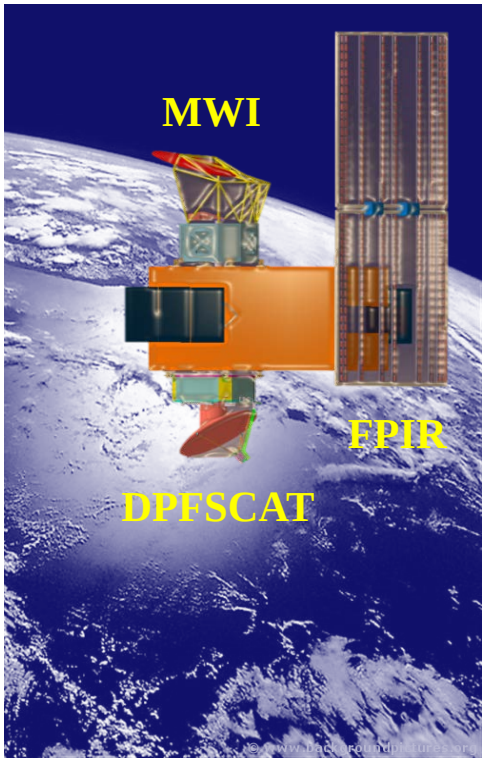
➢ Satellite Specifications

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

➢ Payloads

- ✓ Full Polarized Interferometric Radiometer(FPIR)
- ✓ Dual Frequency Polarized Scatterometer (DFPSCAT)
- ✓ Polarimetric Microwave Imager (PMI).





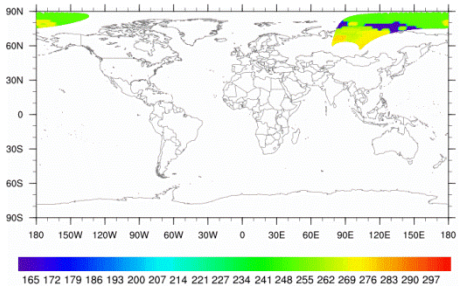
Water Cycle Observation Mission (WCOM)

➢ Progress:

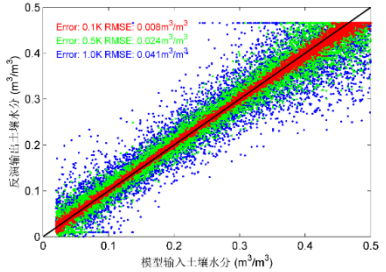
✓ Science Part

- A ground-based multi-band active/passive experiment for algorithm development and validation conducted
- A WCOM Observation Simulator for the assessment of retrieval algorithms and science requirements designed and established
- Forum on synergetic observations of the water cycle held and the international team for WCOM established

Ground-based Exp.



WCOM simulator

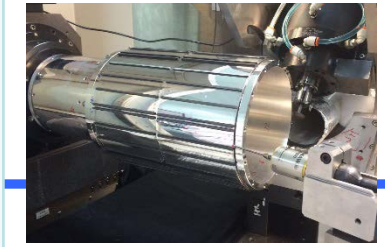


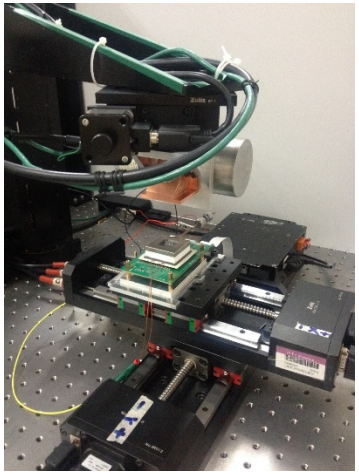
Assessment

✓ Technical Part

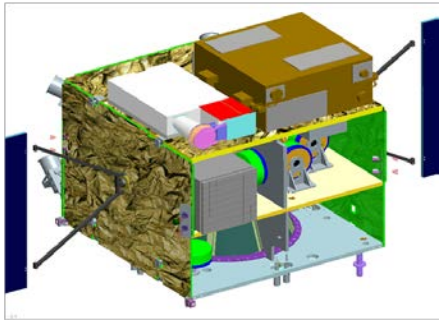
- Optimization of payload selection and specification
- Identification of the key technical focuses (large antenna, instruments calibration, and high-resolution reconstruction) and progresses on these focuses
- Design and optimization of satellite configuration (especially for payloads)

XTP	• The new baseline of eXTP payload configuration was established, which includes 11 spectral & timing telescopes, 2 polarimetry telescopes, 40 LAD modules and 3 WFM units • The SGO prototypes for beam and environmental test in December are being integrated • The prototype of GPD detector was developed. The systematic error is less than 1%, which enables the best sensitivity for polarization observation • ASIC chips for the CCD detector were developed. The energy resolution of the CCD + ASIC system is ~170 eV@ 6 keV
S-VLBI	• A prototype of deployable antenna with a diameter of 10m has been manufactured. Its high surface precision supports 43 GHz observations • Prototypes of onboard cryogenic K- and Q-band receivers have been built. The noise temperatures measured in laboratory are 30K for K-band and 60K for Q-band • Prototypes of onboard astronomical data processor with the maximum bandwidth of 512MHz were completed and tested • A close-loop reference signal transmission system based on the ground Hydrogen-Maser signal was developed





SPORT	• Define scientific objectives and their required measurements • Design an optimized solar polar orbit and two spacecraft platform models • Formulate a scientific payload configuration and fabricate key instrument prototypes • Establish international cooperation within the framework of International Living With a Star (ILWS)
STEP	• Target selection 216 F,G,K during 15pc • Metrology system and testbad demonstration in the air • New optical design TMA and more compact • 1:4 Prototype of STEP telescope
ASO-S	• Preliminary design of the satellite system is finished; • Prototype of the filter of FMG/ASO-S is almost finished; • Key technologies of LST/ASO-S are overcome (like tracking system, super-smoothed mirror, detecting system…); • Prototype of 4×4 grids for HXI/ASO-S is nearly finished.



Joint Scientific Space Mission
Chinese Academy of Sciences - European Space Agency

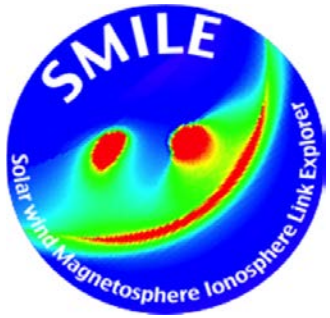
- ✓ The 9th ESA-China Space Science Bilateral Meeting held in 05/2013, both sides agreed to issue a joint call for a new space science mission to be jointly implemented.
- ✓ Follow a collaborative approach through all the phases: study, definition, implementation, operations and scientific exploitation.
- ✓ Joint Call issued in 01/2015
- ✓ Technical screening & Joint scientific peer review conducted in 03-05/2015
- ✓ ESA & CAS joint mission selection result released in 06/2015 : the Solar wind Magnetosphere Ionosphere Link Explorer(SMILE).

The technical boundary conditions

- Spacecraft launch mass < 300 kg
- Payload mass < 60 kg
- Payload power < 65 W
- Development schedule: < 4 years
- Lifetime in orbit: 2-3 years
- Potential launchers：Soyuz, Vega, CZ-C/2D
- Orbit: No a priori limitation

SMILE: A New Mission to Image the Magnetosphere

➢ Science Objectives



✓ Determine large structures and fundamental modes of the solar wind/ magnetosphere interaction

✓ Define the substorm cycle, including timing and flux transfer amplitudes

✓ Define the development of CME-driven storms, including whether they are sequences of substorms

➢ Satellite Specifications

✓ Orbit：5000km@perigee
19RE@apogee

✓ Mass：≤320kg

✓ Lifetime：3 years

➢ Payloads

✓ Soft X-ray Imager (SXI)

✓ Ultra-Violet Imager (UVI)

✓ Light Ion Analyzer (LIA)

✓ magnetometer (MAG)

➢ Status

✓ Joint CDF study in 09-12/2015

✓ CAS Board and ESA SPC have both decided to take a “go-ahead”

Summary

- As the first in a series of 4 approved missions from SPP on Space Science, the successful launch greatly inspired Chinese space scientists, expecting the successful launch of the other 3 missions in 2016.

- Several space missions are under development prepared for 2016 – 2020 period, with key technology development conducted. We are expecting the continuous support from the government.


Thank you !