Purple Mountain Observatory – Recent Activities

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Outlines

1, General Introduction of Purple Mountain Observatory (PMO)

2, Institute Vision and Short-term Initiatives

3, Introductions to Divisions and Areas

- Space Astronomy & Dark Matter
- Antarctic Astronomy & Radio Astronomy
- Planetary Sciences & Space Debris

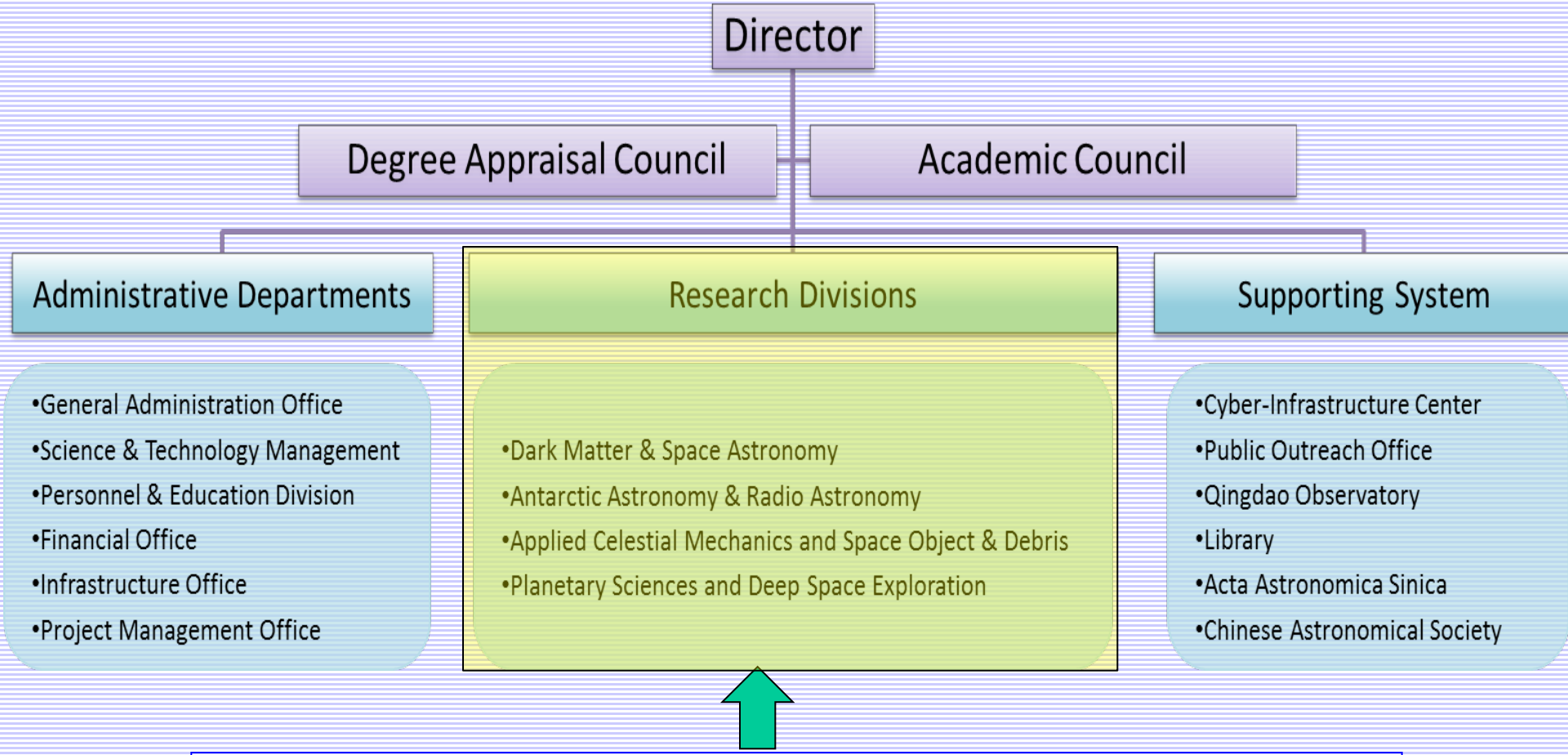
4. Working Summary

PMO Introduction

Purple Mountain Observatory, PMO, is one of the major astronomical institutes under Chinese Academy of Sciences. It was found in 1950 based on Institute of Astronomy, Academia Sinica since 1928.

PMO has 326 employee by the end of 2015, including 209 professional staff members, and 54 senior researchers.

- There are 153 graduate students，including 80 PhD students and 73 master students. The institute refreshed 23 PhD students and 25 master students in 2015.
- There are 13 postdocs.



Key Lab for Dark Matter & Space Astronomy, CAS
Key Lab for Radio Astronomy, CAS
Key Lab for Satellite & Space Debris, CAS
Key Lab for Planetary Sciences, CAS

Institutional Strategical Plan

Mission

to build the institute into a top-ranking base for fundamental, forefront astronomical research and the achievement of research and development consistent with national strategies

Research Fields

√ high-energy astrophysics, solar physics and space astronomical exploration technology
√ star formation through the universe and corresponding terahertz technology
√ artificial satellite orbital dynamics and probing methods
√ planetary science, ephemeral astronomy and deep space exploration
√ observational cosmology and galaxy formation

Major Initiatives

- Attaining original achievements with a space-based probe of dark matter to solve major scientific problems
- Developing research and technology related to Antarctic astronomy to fulfill the construction of mega-science infrastructures
- Improving a system for the observation of objects and debris in space in order to enhance the safety and supporting capability of the nation's aerospace activity

Introduction to Division 1 : Dark Matter and Space Astronomy

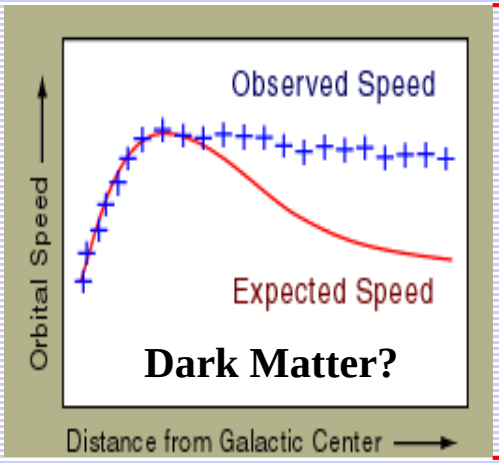
- Space Detection of Dark Matter Particles
- Gamma-ray and High-energy Astrophysics
- Solar High-energy Physics and Solar Activities
- Lunar (Chang-e) Missions and Deep Space Missions

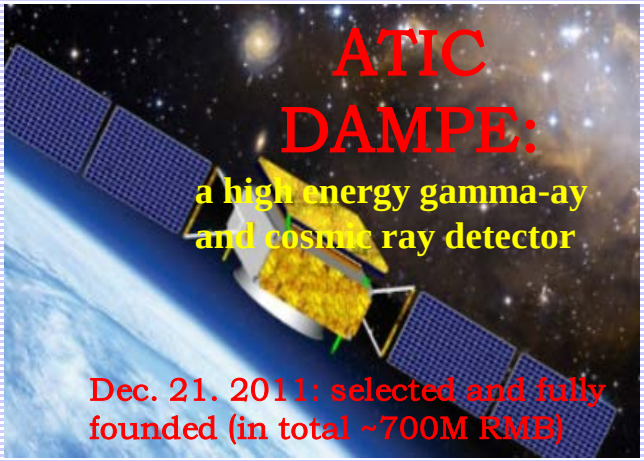
- CAS Key Lab for Dark Matter and Space Astronomy, Chair person–Chang, Jin
- Gamma-ray and Neutron Stars Group, PI–Wei, Daming
- Dark Matter Physics Group, PI–Fan, Yizhong
- Cosmic Particle Group, PI–Liu, Siming
- Solar High-energy Astrophysics Group, PI–Gan, Weiqun
- Solar Activity Group, PI–Ji, Haisheng

DArk Matter Particle Explorer (DAMPE)

Research Progress - I

DArk Matter Particle Explorer (DAMPE)





Major Goal :

To attain original achievements with a space-based probe of dark matter to solve major scientific problems.

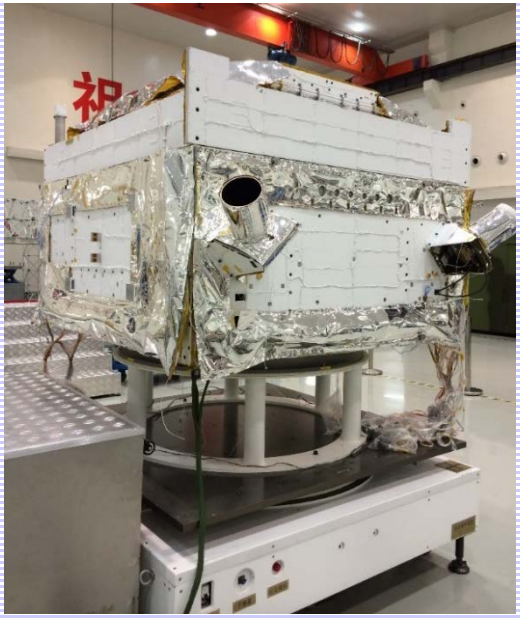
Nature of dark matter: quest for dark matter particles through high-energy resolution measurements of cosmic electrons and gamma-ray lines

Origin of cosmic rays: Study the origin of cosmic ray by high-spatial resolution observation of TeV electrons

Gamma ray astrophysics: Discover new gamma-ray sources, study radiation mechanisms of Gamma-ray burst and new physics around compact objects

Research Progress - I

DAMPE: Now is in orbit



DAMPE is in phase C

DAPME was successfully launched on Dec 17, 2015.

DAMPE provides **highest energy resolution (10 times better than Fermi-LAT)** and reasonably large acceptance. The detectors are a result of collaborations among institutes from Europe and China. Beam tests were supported by CERN as recognized experiments

The satellite is in orbit and data are collected the received routinely, over a period of 3 years

Research Progress - II

Macronova: optical counterparts of neutron star mergers/strong GW sources

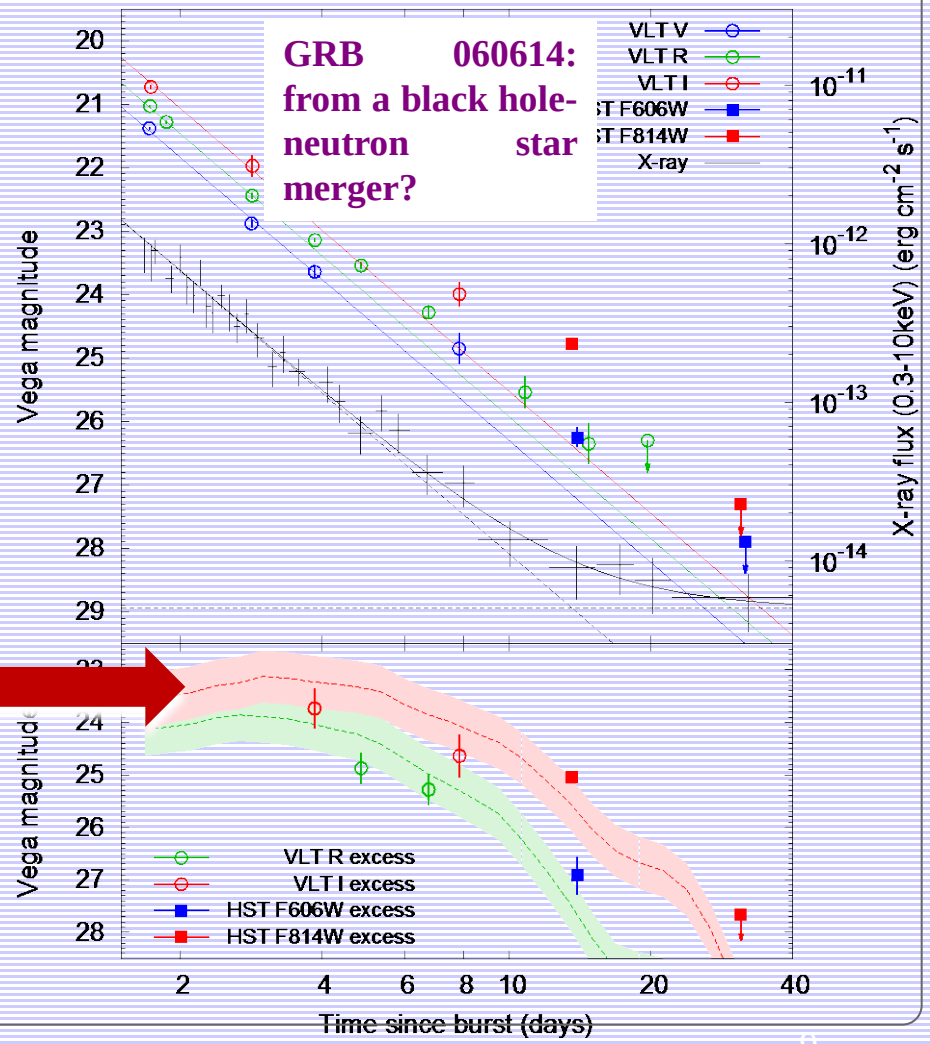
Tanvir et al. (2013 Nat.) found the first possible signal in short GRB 130603B (consisted of a signal Hubble F160W data point)

With the publically-available HST and VLT data:

◆Yang, Jin* et al. (2015 Nat. Commun.): found the first macronova signal in long-short burst (GRB 060614)

◆Jin et al. (2015 ApJL): got the first macronova lightcurve

◆Jin et al. (2016 Nat. Commun.): found the 3rd macronova signal in short GRB 050709, reported a broadened-line like spectral structure and studied GRB-macronova connection both for the first time!



Introduction to Division 2: Antarctic Astronomy & Radio Astronomy

- Dark Energy & Cosmology
- Large-scale Structure, Galaxy Formation & Evolution
- Galactic Structure
- Molecular Clouds & Star Formation
- Stellar Structure & Evolution

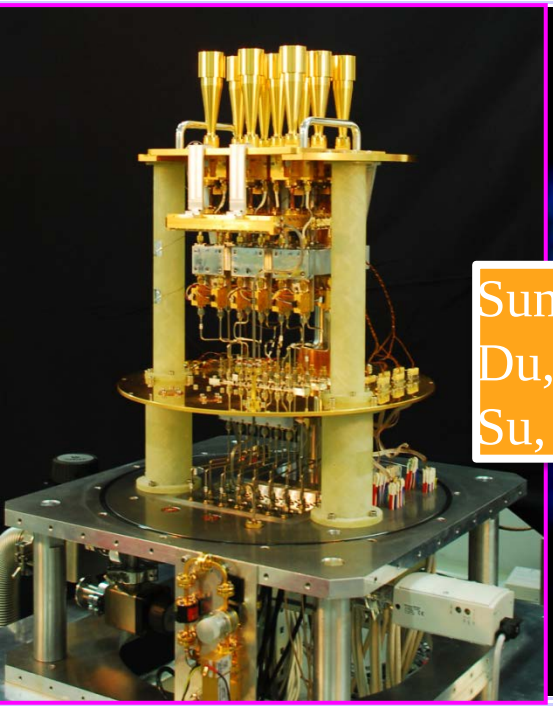
- CAS Key Lab for Radio Astronmy, Chairperson –Shi, Shengcai
- Chinese Center for Antarctic Astronomy, Chairperson–Wang, Lifan
- Galaxies, Cosmology and Dark Energy group, PI–Kang, Xi
- Star Formation in Galaxies Group, PI–Gao, Yu
- Galactic Struture/Delingha, PI-Xu,Ye
- Molecular Clouds & Star Formation Group, PI–Wang, Hongchi
- Stellar Structure, Evolution and Pulsation Group, PI-Xiong, Daren

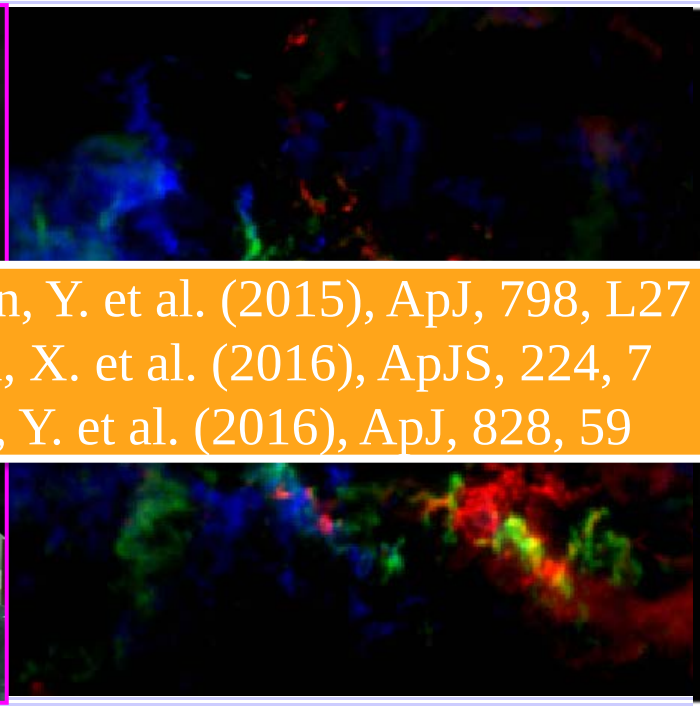
Antarctic Observatory at Dome A

Research Progress Highlight - I

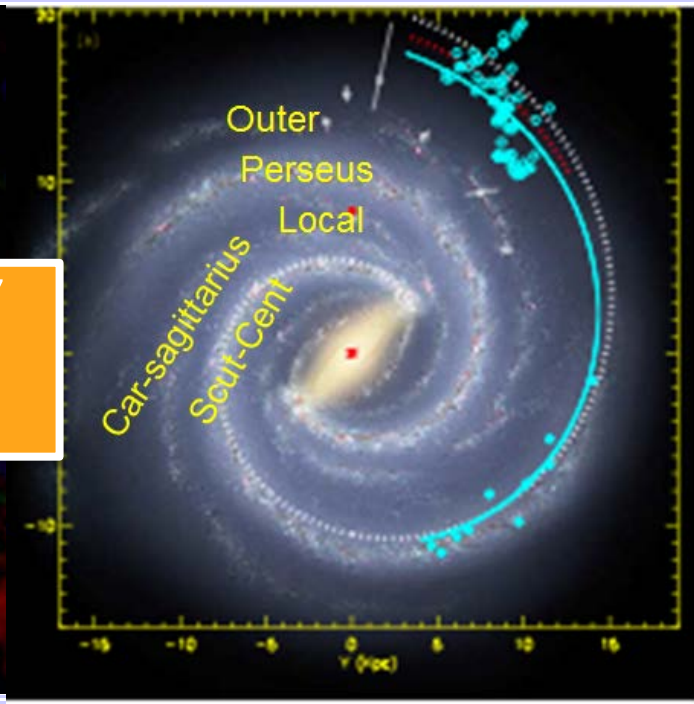
Multi-Molecular Line Survey Along the Northern Galactic Plane

- Survey along the northern Galactic Plane in 3 isotopic CO lines since 2011
- Major scientific objectives cover from deep understanding of molecular clouds and star formation, cloud dynamics, to Milky-way structure
- 1230 deg2 sky area has been mapped, and date are archived
- A major discovery is **a far side sector of the Scutum-Centaurus Arm**





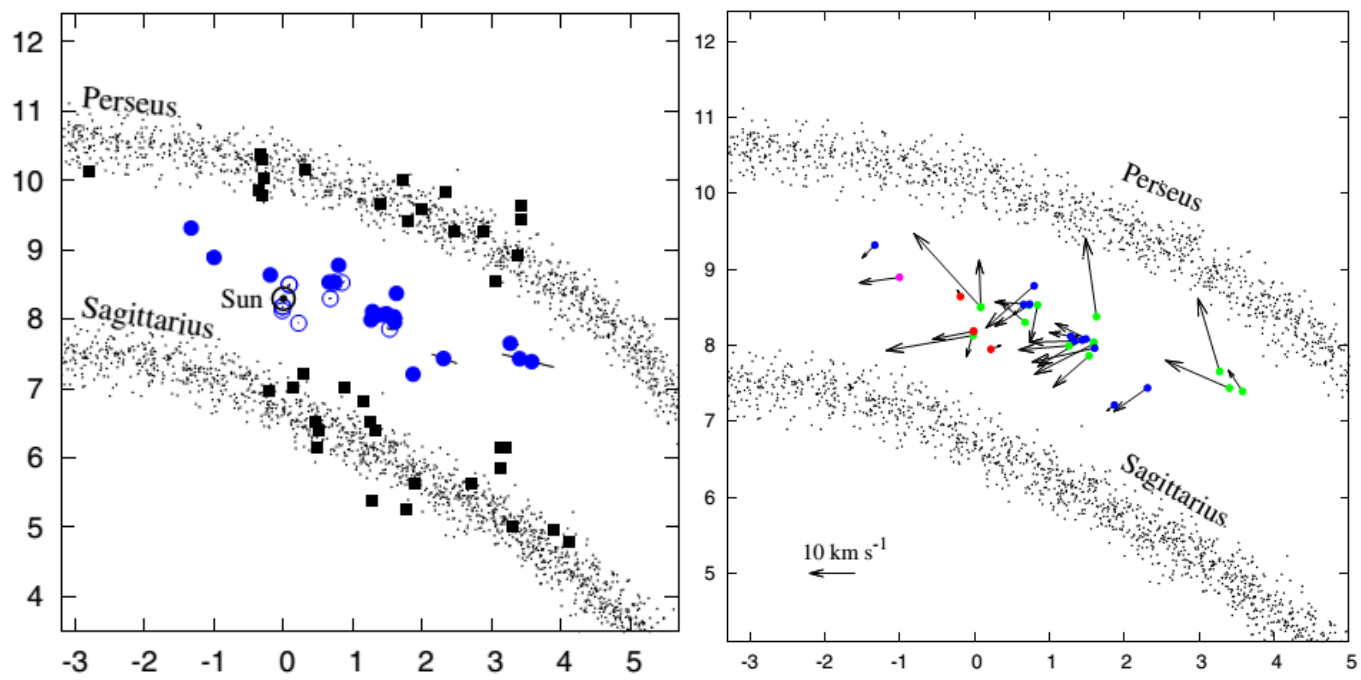
Sun, Y. et al. (2015), ApJ, 798, L27
Du, X. et al. (2016), ApJS, 224, 7
Su, Y. et al. (2016), ApJ, 828, 59



Research Progress Highlight - I

Mapping the Spiral Arms in High Precision

- PMO is one of the major partners in the international BeSSeL team
- Share the task of precise measurement of the local arm determining its morphology and kinematics
- Recent result: identified the local arm as a new part of Galactic spiral arms



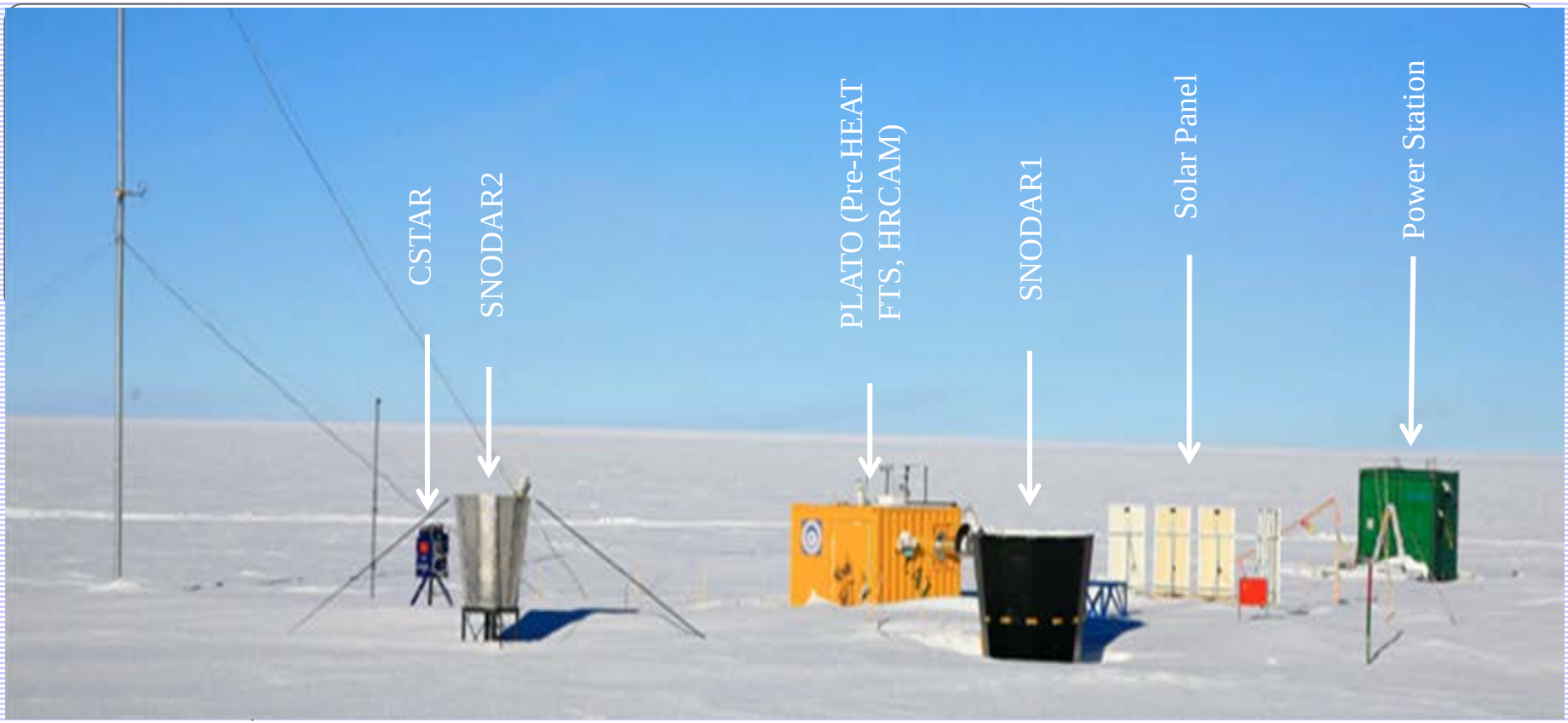
Xu et al. 2013, ApJ 769

Xu et al. 2016, In press

Research Progress Highlight - II

Site Testing and The Establishment of Early Dome A Observatory

- Organized systematic site survey by international collaborations with strong support from polar research sector
- Small and medium size telescopes for observations
- Develop concepts for future Dome A observatory with most advanced facilities



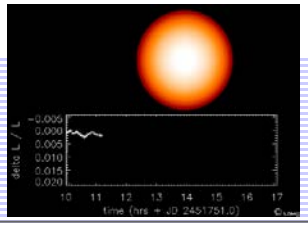
Research Progress Highlight - II

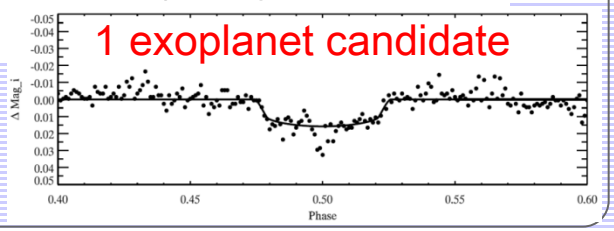
Early Dome-A Telescopes & Sciences

- AST3-#2 has been successfully operated over the winter of 2015-2016
- Key programs on SN and exoplanet surveys were allocated

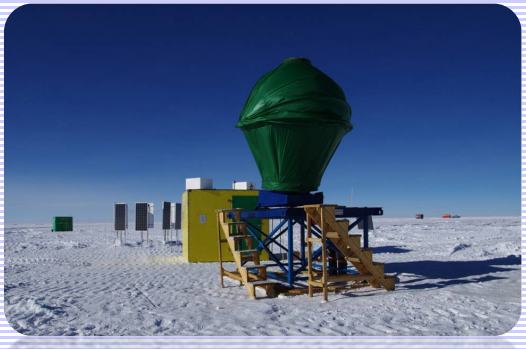
CSTAR (2008.1 – 2012.1)
Limiting mag.: ~14.5 mag @ 20s exposure

- 157+188 variable stars (binaries, pulsating stars such as δ Scuti, γ Doradus & RR Lyrae) detected, including 67 new objects discovered (Wang, L. Z., et al. 2011, 2013)
- 6 new exoplanet candidates discovered (Wang, S. H., et al. 2014, ApJS)

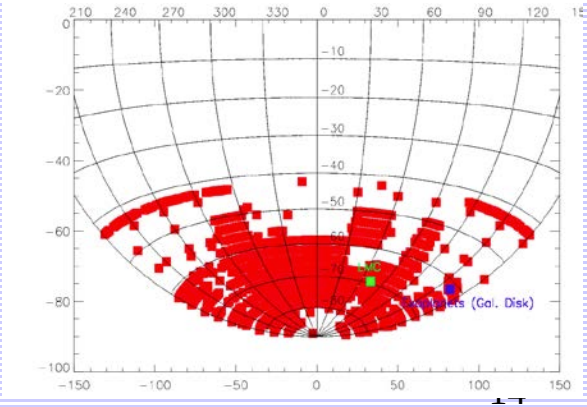




PLATO-A (NSWU/CCAA)

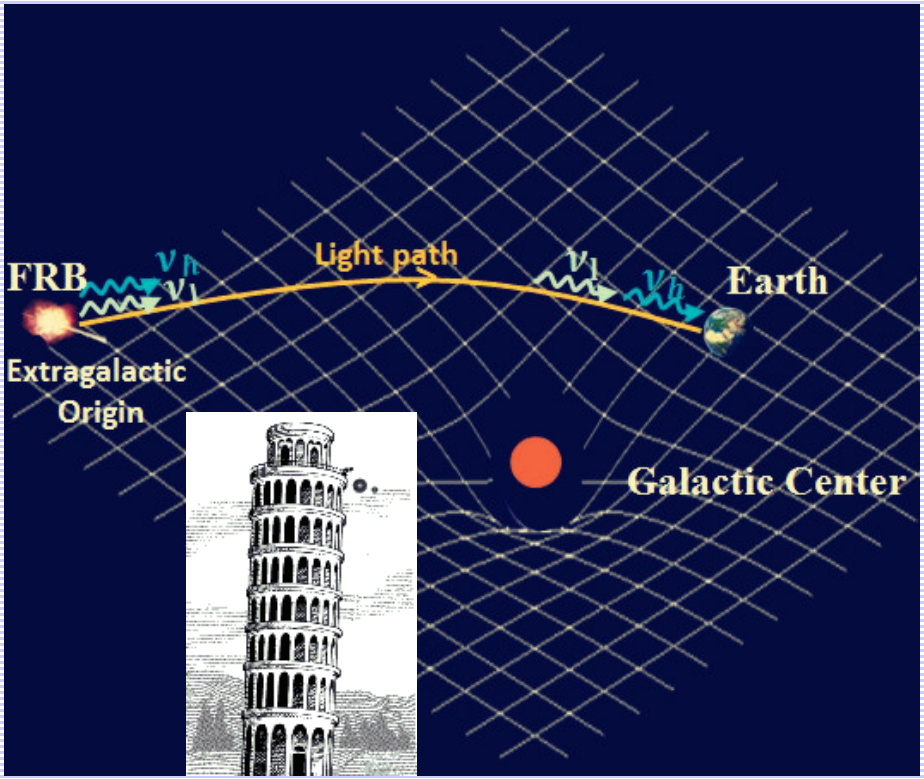


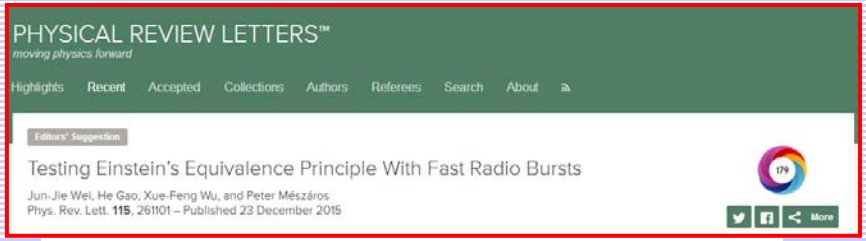
1st AST3 (2012.01, ~50days)

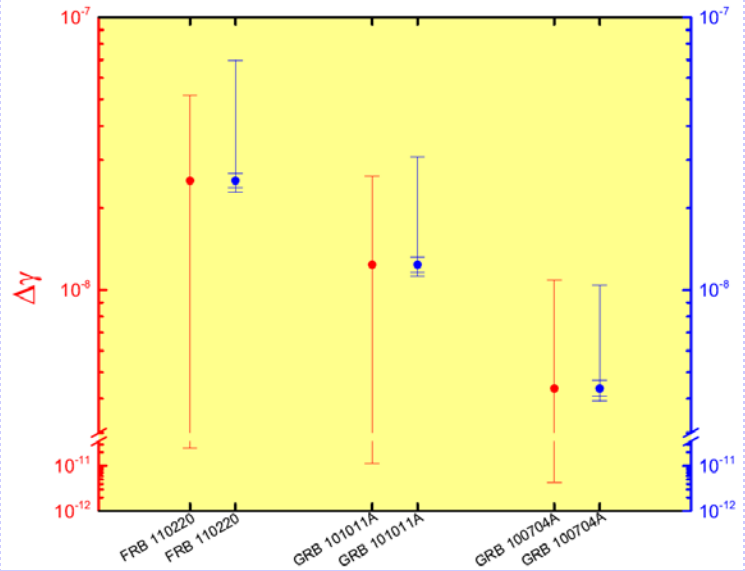


Testing Weak Equivalence Principle using FRBs

Weak Equivalence Principle： **Inertial Mass = Gravitational mass**
(The test particle is independent of its internal structure and composition)







Xuefeng Wu leaded a team to test Einstein's weak equivalence principle using FRBs (fast radio bursts) . The test is 2 orders of magnitude better than previous results.

This work was published on Phys.Rev.Lett. as Editors' Suggestion in December 2015.

Introduction to Division 3: Planets, Interplanetary Environment & Applied Celestial Mechanics

- Solar System objects and deep-space missions
- Near-Earth Monitoring and Surveillance
- Exoplanets
- Interplanetary plasma physics
- Applied dynamics for objects and space debris
- Ephemeris

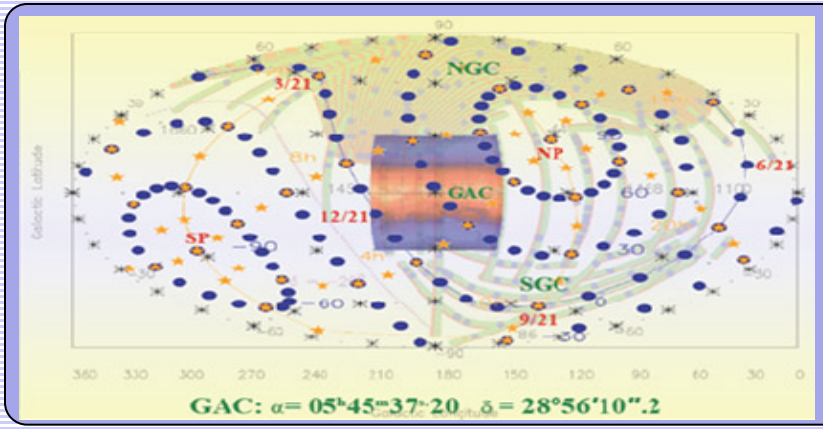
- CAS Key Lab of Space Objects and Debris, PI-Zhao, Changyin
- CAS Key Lab of Planetary Sciences, PI-Ji, Jianghui
- NEO and solar system object group, PI-Ma, Yuehua/Zhao, Haibing
- Cosmochemistry Group, PI-Xu, Weibiao
- Interplanetary Plasma Group, PI-Wu,Dejin
- Ephemeris Group, PI-Fu, Yanning

Space Debris Monitoring and Deep-space Missions

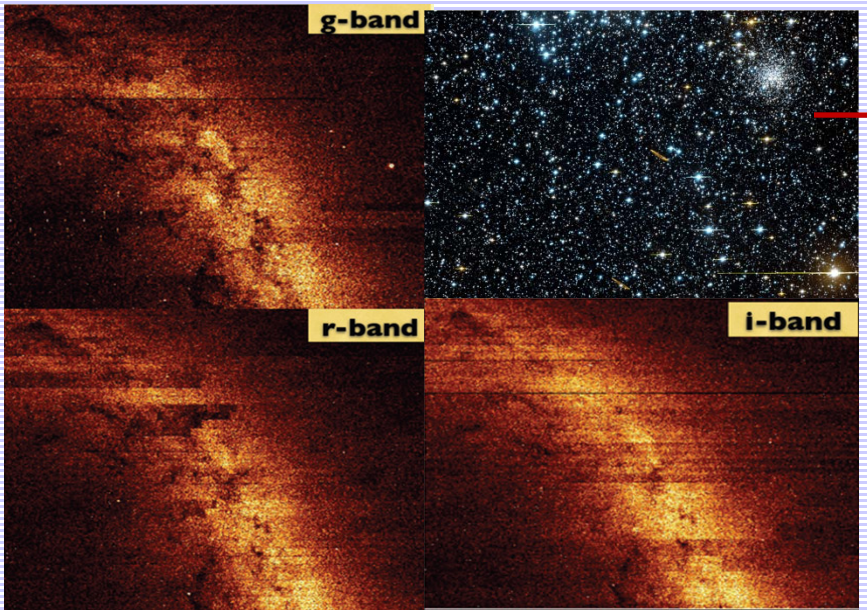
Major Achievements - I

Survey with NEOST produced the first large star catalog in China

to support the studies of galactic structure



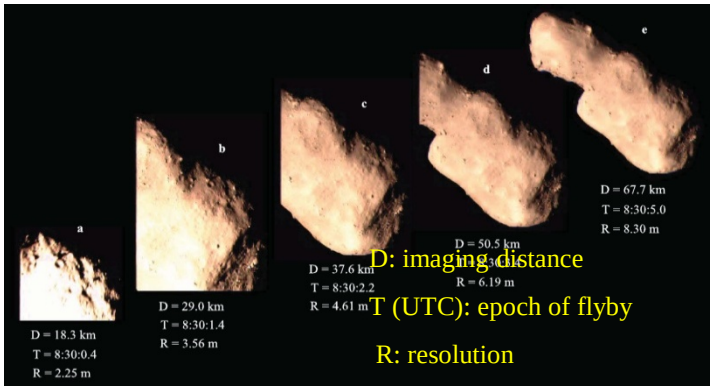
- Joint survey for more than 6,000 sdq areas, and the limiting magnitude is 19.3 (g,r,i) launched by PKU team
- The photometric accuracy is 0.02 mag (As accurate as SDSS)
- The astrometry accuracy is 80 mas (As accurate as PPMXL)



Target selection for LAMOST

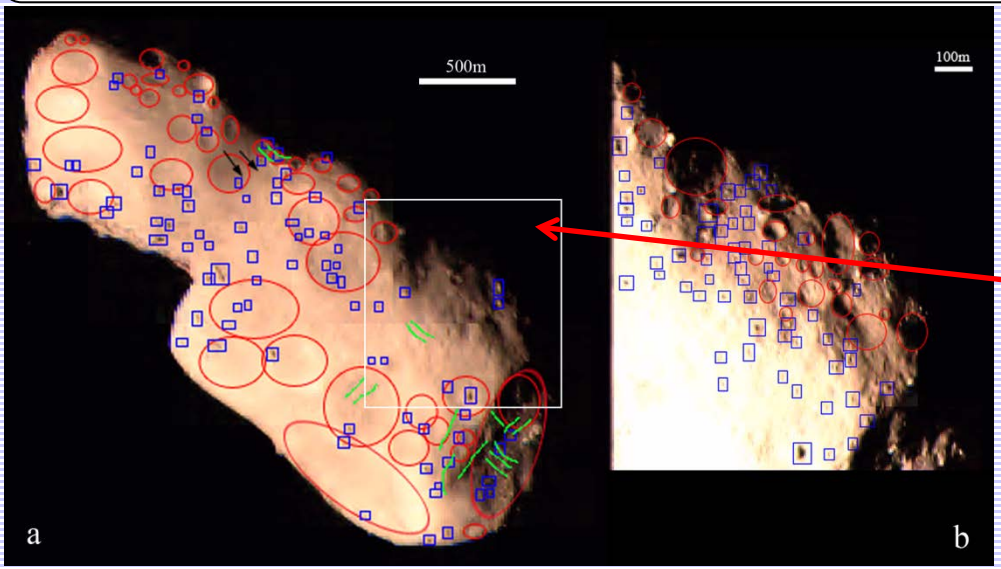
Major Achievements - II

Played an important role in the first asteroid flyby mission of China:
flyby observation of Toutatis



- **Before mission: Target Selection**
- **During mission: Orbit determination**
- **After mission: Analysis of surface feature**

Huang, Ji ,et al. 2013, Scientific Reports, 3,3411
Jiang, Ji et al. 2015 ,Scientific Reports, 5, 16029



New geological features discovered by image analysis

Several Undergoing Programs & Regional Collaboration Programs

- ASOS: Advanced Solar Observing Satellite, finished phase-A
- TeSIA: THz imaging array
- NIHAO: A joint cosmic simulation

- MALATANG: a key program on star formation observation at JCMT
- Asia-Pacific Asteroid Observation Network (APAON)

Summary of PMO Report

- PMO established a clear picture of its missions and strategic directions, including space astronomy, radio and Antarctic astronomy, applied celestial dynamics & planetary Sciences.

- PMO selected important questions in astronomy and astrophysics, including dark matter, dark energy, origin of the universe, galaxies, stars, and our planetary system.

- Significant achievements have been made in answering these questions during the last years.

- A number of regional and international collaborations have been involved in the institute research activities.