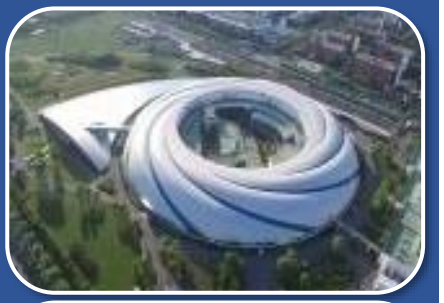




Large Science Projects in China

Yifang Wang

Institute of High Energy Physics

Science-Facility-related Government Agencies in China

State Council/Science & Technology committee

MoST NSFC

- Research
- Mid-large scale instrumentation

DYB，PandaX, CDEX，ALICPT

CAS

- Infrastructure
- Research
- Instrumentation
- Facility
- Personal

DYB, ALICPT JUNO

MoE

- Infrastructure
- Research
- Personal

PandaX, CDEX

NDRC

- Construction of Large facilities, including for science

BEPC, BSRF, CSNS, HEPS, EAST, FAST, …

MoII NSA

- Space projects: Construction, operation and research

HXMT,EP, SVOM, eXTP

MoF

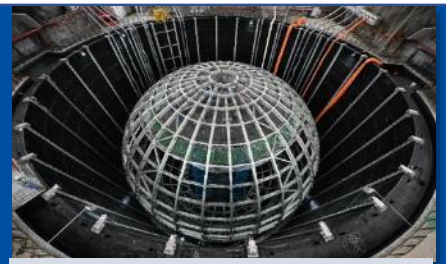
- Operation of Large science facilities

BEPC, BSRF, CSNS, HEPS, EAST, FAST, …

+ local government support for land, infrastructure, construction and operation

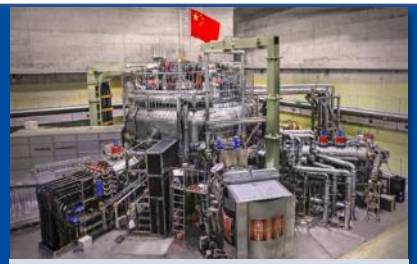
Examples of Large Science Facilities in China

Dedicated Research Facility for Basic Science



Jiangmen Underground Neutrino Observatory

Beijing Electron-Positron Collider



EAST Superconducting Tokamak

Heavy Ion Research Facility in Lanzhou

Multi-disciplinary Research Platform

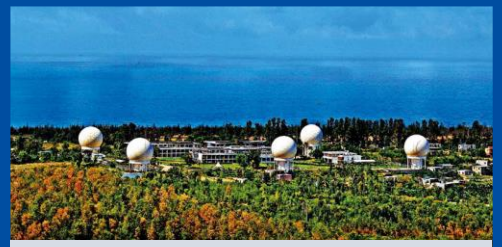
China Spallation Neutron Source

Shanghai Synchrotron Radiation Facility

Steady High Magnetic Field Facility

Hefei Synchrotron Radiation Facility

Infrastructure for Public Usage



China Remote Sensing Satellite Ground Station

BPL Time Service Systems

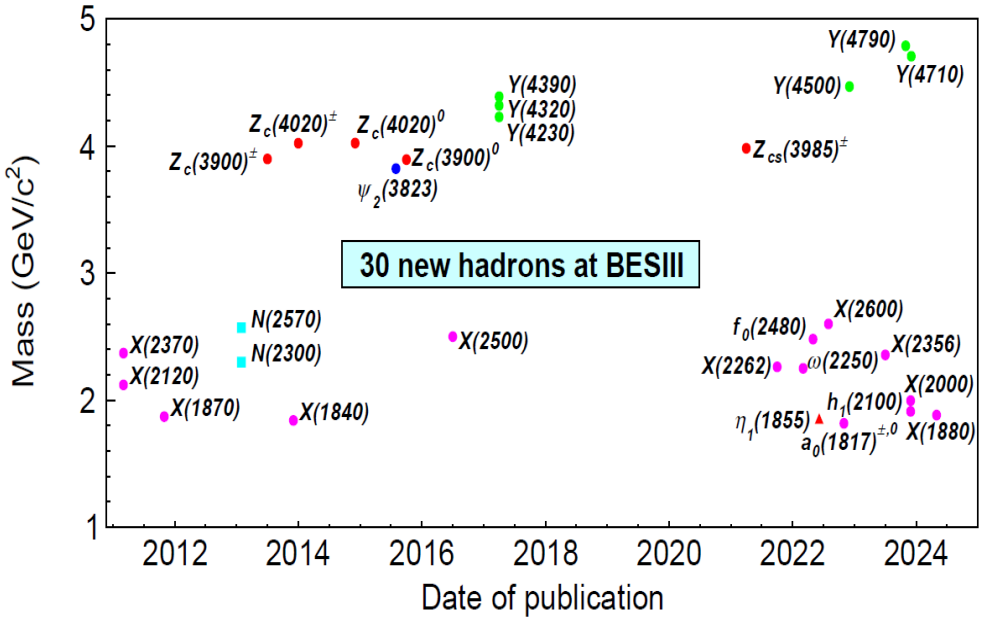
Germplasm Bank of Wild Species in Southwest China

Multi-Purpose Oceanographic Research Vessel

Dedicated Research Facility for Basic Science

Beijing Electron Positron Collide(BEPC)

- Beginning of large science facilities and Particle Physics in China
- Construction: 1984-1988, upgrade: 2004-2009
- For light hadron physics, Charm and Charmonium, QCD, etc.
- **The BESIII Collaboration** consists of more than 600 members from 89 institutions in 17 countries and regions
- **Highlights :** 30 new hadrons discovered, including 4-quark states $Z_c^{\pm}(3900)$, $Z_c^{0}(3900)$, $Z_c^{0}(4020)$, $Z_{cs}(3985)$, etc.

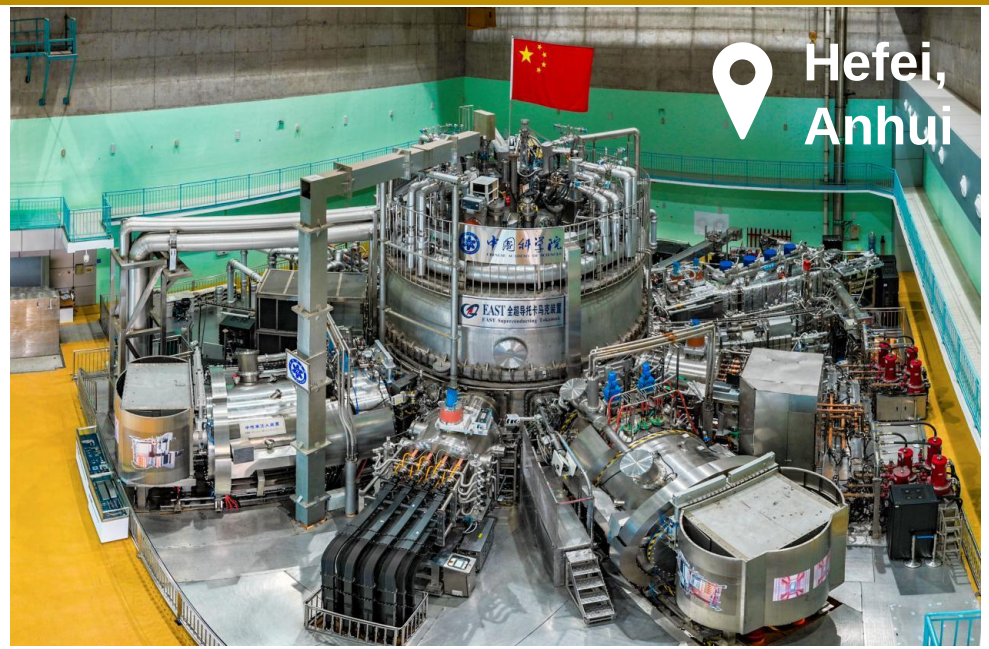


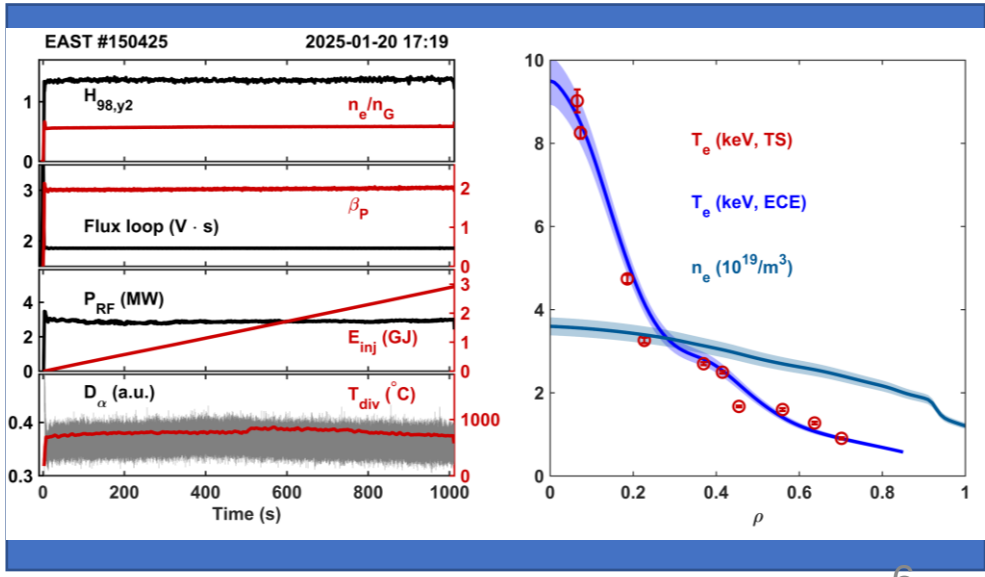
EAST Superconducting Tokamak

- **The world's first superconducting tokamak,** operational since 2007
- The only site and test platform before ITER

- **Highlights:**
  - ✓ Stably and repeatedly achieved 120 million ºC for plasma over 100 seconds
  - ✓ Achieved1066 seconds at 100 million ºC, the longest operation time for high temperature plasma

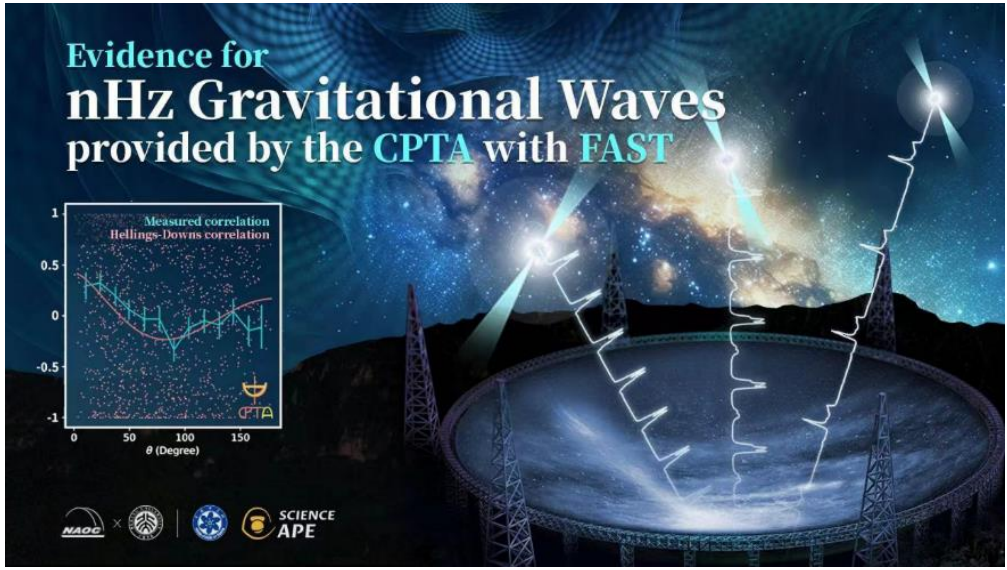
- **International Collaboration:**
  - ~30% international proposals carried out in last 3 years
  - Established cooperative relationships with 120+ fusion research institutions and 50+ countries and regions





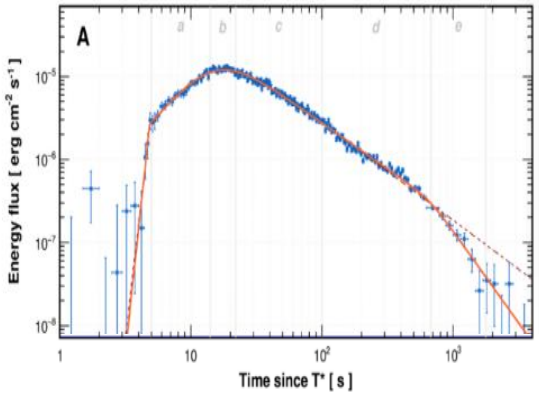
Five-hundred-meter Aperture Spherical Radio Telescope(FAST)

- **The world's largest single-dish radio telescope**, with a diameter of 500 meters
- Innovative design sets a new record and created a new way to build large radio telescopes
- **Highlights:**
  - nanohertz gravitational waves
  - more than 1000 new pulsars, fast radio burst studies
- **International Collaboration:**
  - Open to international community since 2021
  - Application from 15 countries and a total of ~900 hours observation time approved



Large High Altitude Air Shower Observatory(LHAASO)

- Construction 2018-2021
- **World largest air shower array**(with e, μ, water Č detectors and Č telescope) for the high energy γ-astronomy and cosmic-ray physics



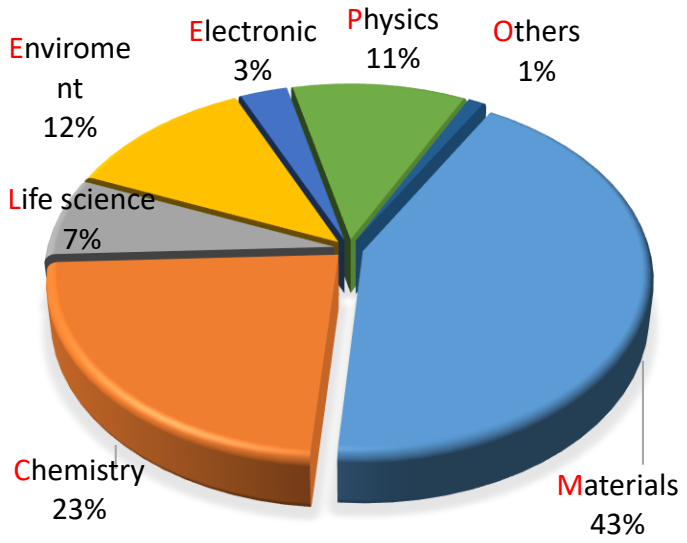
- **Highlights:**
  - The brightest-of-all-time GRB
  - 43 PeVetrons, highest energy γ-rays
  - a UHE γ-ray bubble spanning at least 100 deg^2 up to ~PeV around Cygnus X

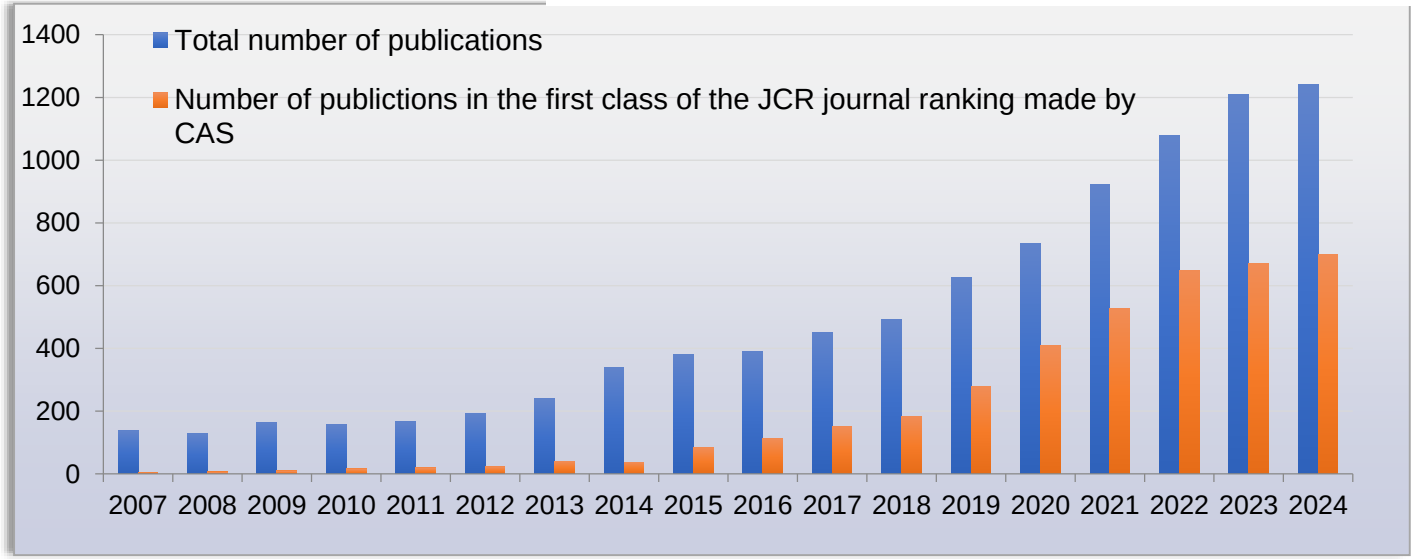
- **International collaboration**
  - 6 countries, 32 institutions, 280 members
  - Network: 6 experiments

Multi-disciplinary Research Platform

Beijing Synchrotron Radiation Facility(BSRF)

- Operational since 1990, first in China
- 14 beamlines & end-stations
- Dedicated mode: 2 months/year，2.5GeV/200 mA
- Parasitic mode: 1-2.5 GeV, 500-900 mA
- Users: ~1800/year
- Papers: ~1000/year



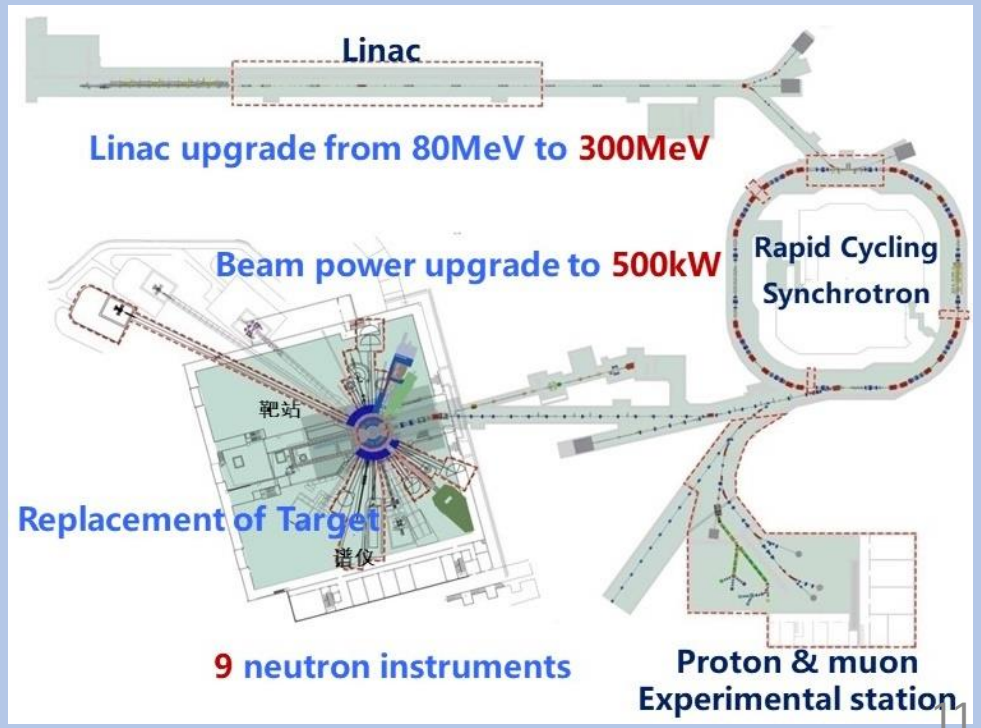


China Spallation Neutron Source(CSNS)

- User operation since October 2018
- Currently at 140 kW stably, with ~ 5000hrs/yr for users and availability of ~96%
- **International collaborative agreements with 11 institutions**

Upgrade approved and started

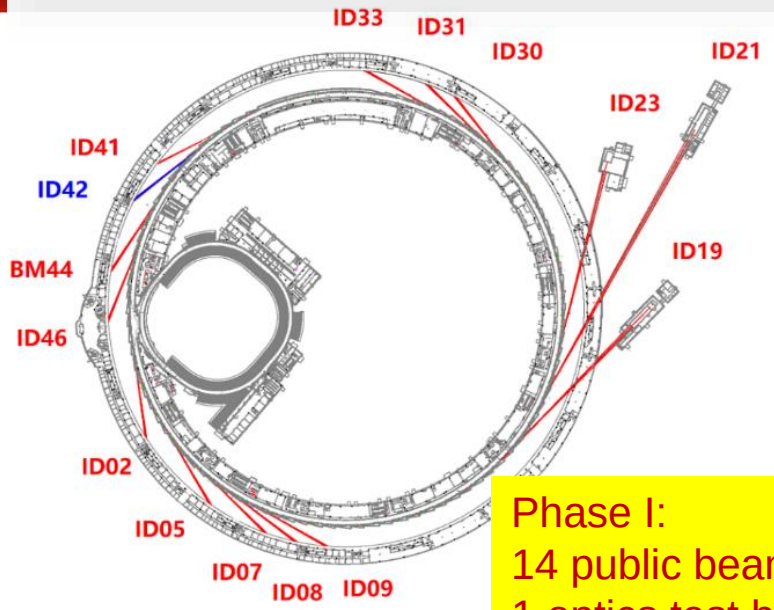
- Beam power: 100 kW ➔ 500 kW
- Add 9 beamlines
- 1 muon and 1 proton beam station
- Scheduled construction: 2024-2029



High Energy Photon Source(HEPS)

- Construction is about to finish: Jun. 2019-Dec. 2025
- A brightest fourth-generation synchrotron radiation facility in the world
- With capabilities of nm spatial resolution, ps time resolution, and meV energy resolution
- **Diverse forms of international cooperation:** MoUs, committees, workshops, and joint beamlines in the future

Parameters	HEPS
Beam energy (GeV)	6.0
Circumference (m)	1360.4
Beam current (mA)	200
Emittance (nm·rad)	0.035
No. of periods	48
Cell structure	H7BA



Phase I:
14 public beamlines
1 optics test beamline

Infrastructure for Public Usage

Meridian Project and its Phase II

- **The world first full-layer, multi-element, comprehensive three-dimensional detection and measurement for the solar and terrestrial space environment**

- **Meridian Project**
  - Operational since 2012
  - 15 observational stations and 87 sets of monitoring equipment, located along 120° E and 30° N

- **Meridian Project Phase II**
  - Construction 2019-2025
  - 16 new stations are added to have a total of 31 stations and 282 sets of monitoring equipment in a “double-cross” layout along 100° E, 120° E, 30° N and 40° N

The 313-unit full system of the circular array solar radio imaging telescope

- **International Meridian Circle Program initiated with participants from Brazil, Russia, Thailand, France, Canada, Japan, etc.**

China Remote Sensing Satellite Ground Station & Chinese Aeronautic Remote Sensing System

China Remote Sensing Satellite Ground Station

- Established on the basis of the **China-US science and technology cooperation agreement signed in 1979**
- Operational since Dec. 1986
- Five data receiving station after several upgrades: Miyun, Kashi, Sanya, Kunming, The north pole

Miyun Station

Chinese Aeronautic Remote Sensing System

- Operational since 2021
- A national airborne remote sensing platform catered for scientific experiment
- Two MA60 aircraft equipped with 10 sets of optical/microwave apparatus, a comprehensive data processing and management system

Space Projects

Insight-HXMT: Hard X-ray Modulation Telescope

sciencemag.org

China successfully launches x-ray satellite | Science

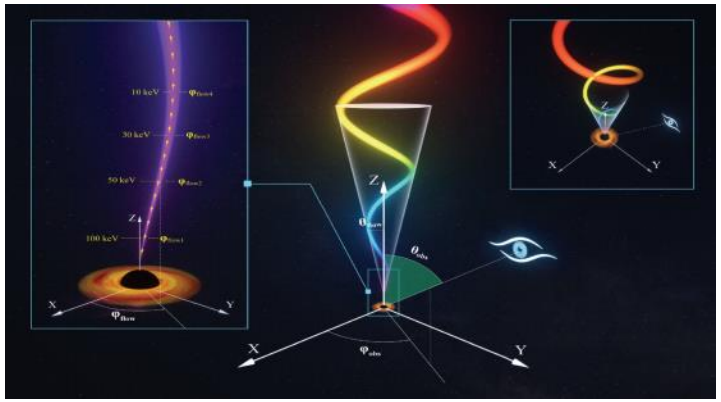
By Dennis NormileJun. 15, 2017 , 11:00 AM

4-5 分钟

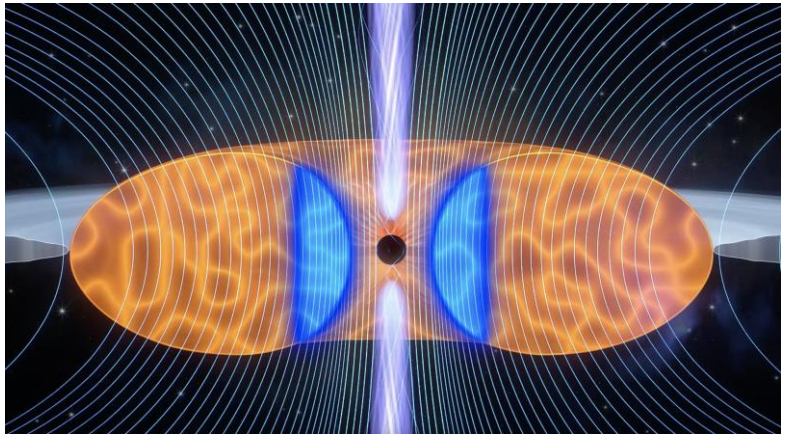
A rocket carrying China's new x-ray telescope blasts off.

Launched on 2017.6.15

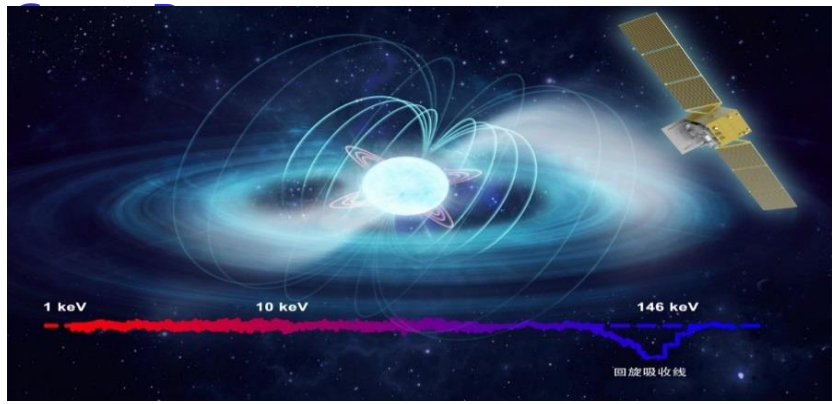
Highest energy (>200 keV) QPO around a BH, closed X-ray jet from a BH



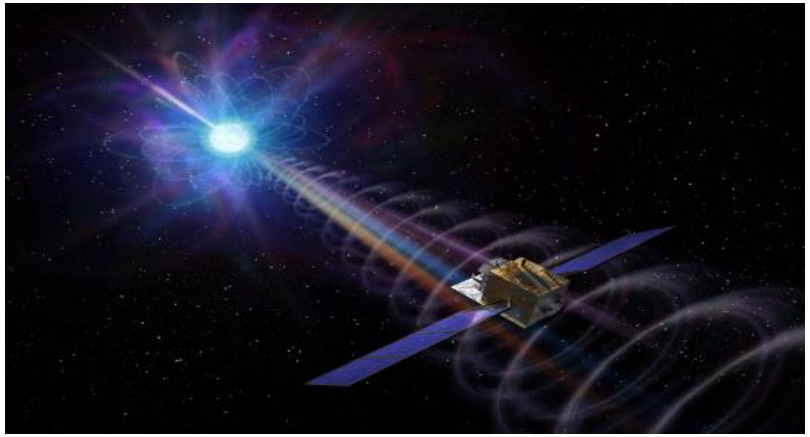
First direct evidence of magnetically arrested accretion disk



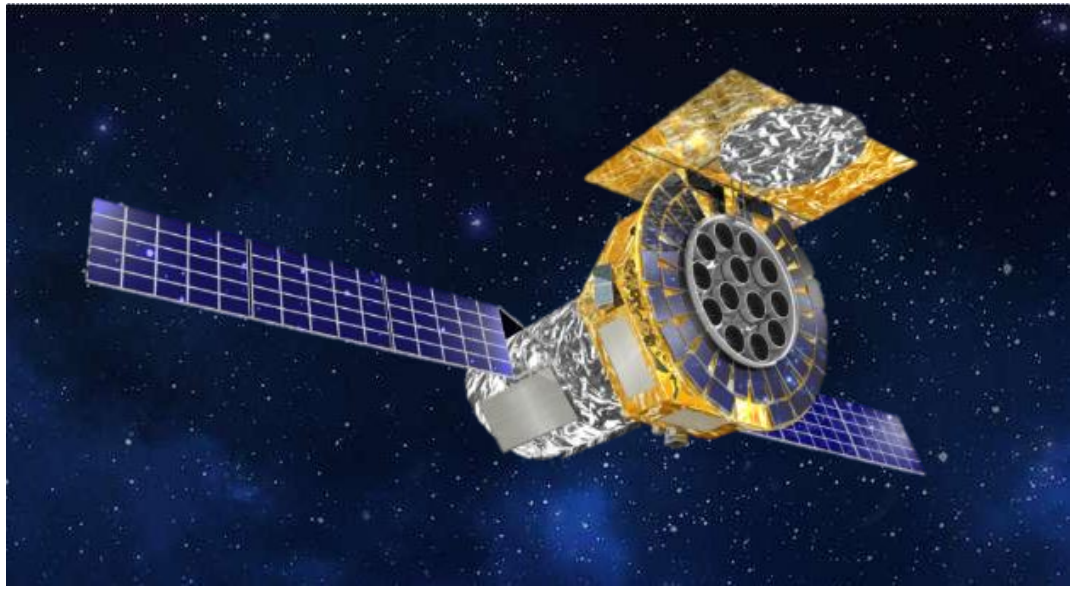
Highest energy (~150 keV) cyclotron absorption line of a neutron star: 10^{13}



Identification of first X-ray counterpart (magnetar) of a Fast Radio Burst



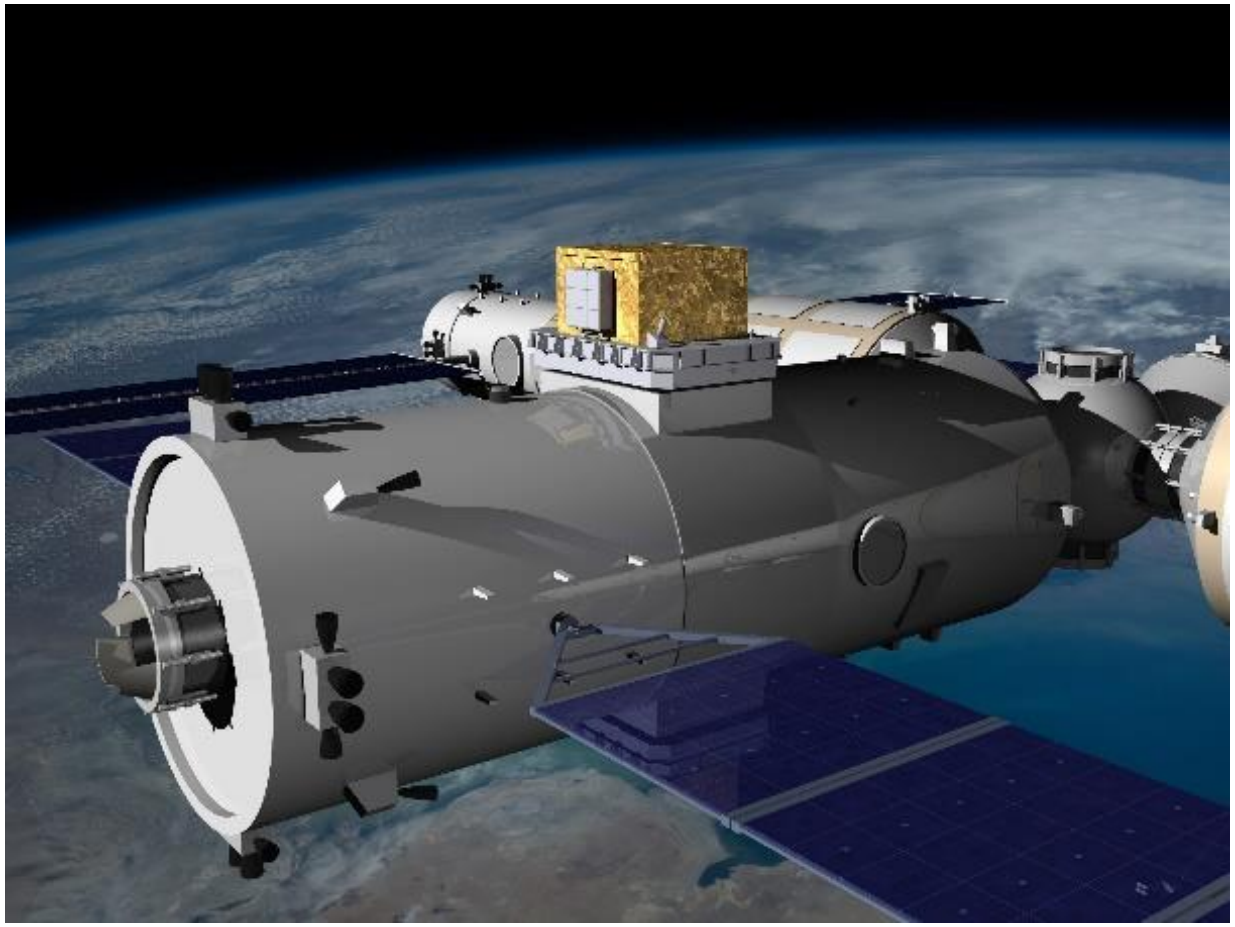
eXTP: enhanced X-ray Timing and Polarimetry Observatory

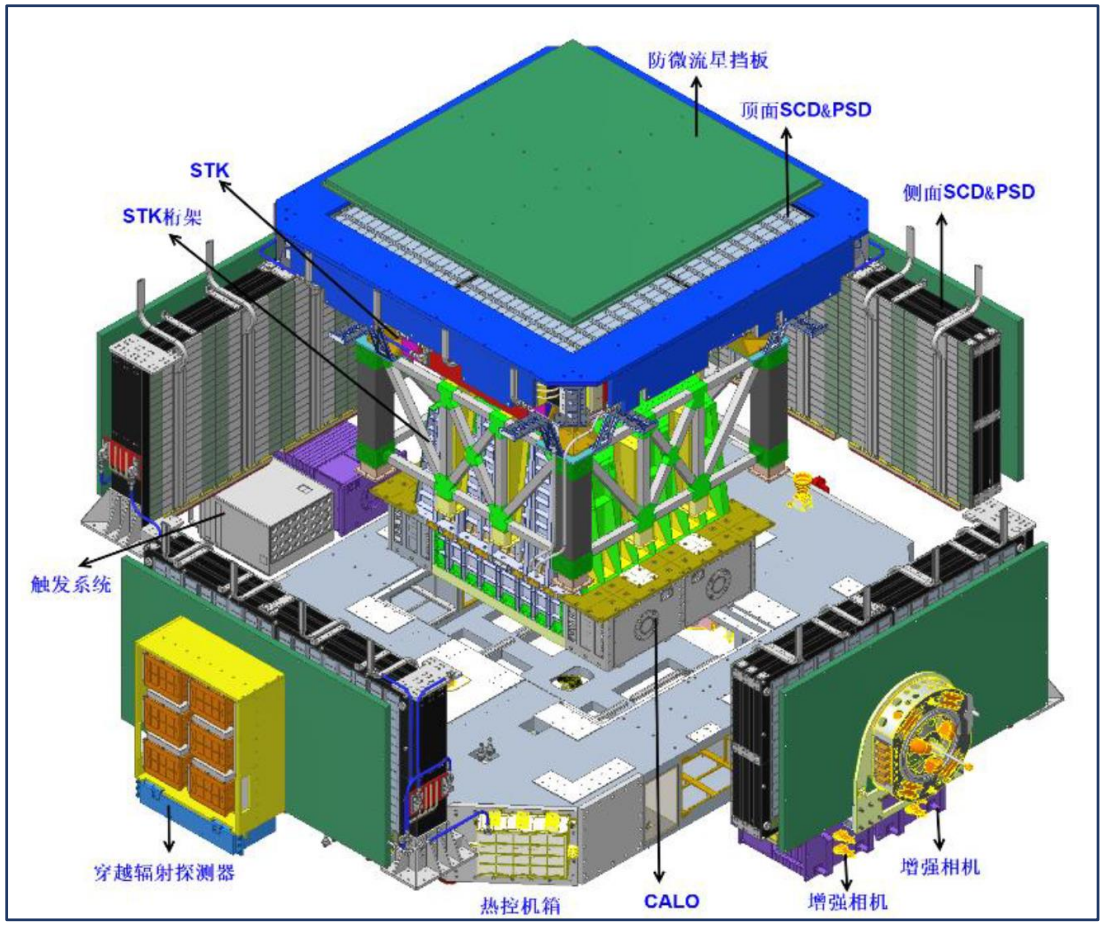


- Key Sciences
  - x-rays from Neutron stars, black holes, etc
  - For extreme gravity, magnetism, density, etc.
- Mission Profile
  - Orbit：5000km*116500km HEO
  - Weight：4.2 T; Launcher：CZ-3BE
  - **Approved for launch before 2030**

Main Payload	Configuration	Eff. area
Spectroscopy Focusing Array (SFA): 0.5-10 keV	6 telescopes (5.25 m fl)	>0.3m²@6keV
Polarimetry Focusing Array (PFA): 2-10 keV	3 telescopes (5.25 m fl)	>350cm²@2keV
Wide-field Wide-band Camera (W2C): 30-300 keV	coded mask imager	160cm²@60keV

HERD: High Energy cosmic-Radiation Detector





- To be onboard the China Space Station
- launch in 2028

- 3D-calorimeter and 5-side sensitive
- To detect electrons up to 15 TeV, cosmic rays up to several PeV, and gamma-rays from 0.5 GeV to above TeV with > 2π field of views

Approving process, NDRC as a example

• Pre-proposals organized and reviewed by ministries (e.g. CAS), and submitted to NDRC	1-10 years	Budget estimate	
• Proposals reviewed and selected by NDRC	~1 year	Budget proposal	CD0
• Review of the feasibility study by CAS	1-5 year	Budget & technical review	CD1+2
• Review of the Preliminary design by CAS & Budget review by NDRC	1-5 year	Technical design & Final budget	CD3+4

NDRC organize proposals every 5 years in "5-year plan"

Other agencies accept proposals every year(smaller projects, fewer comparison, less competitive)

Possible routes for CEPC projects

NDRC

- 5 years plan for large science projects + local support

MoST

- large international science projects (>50% international contributions)

Implementation of Projects

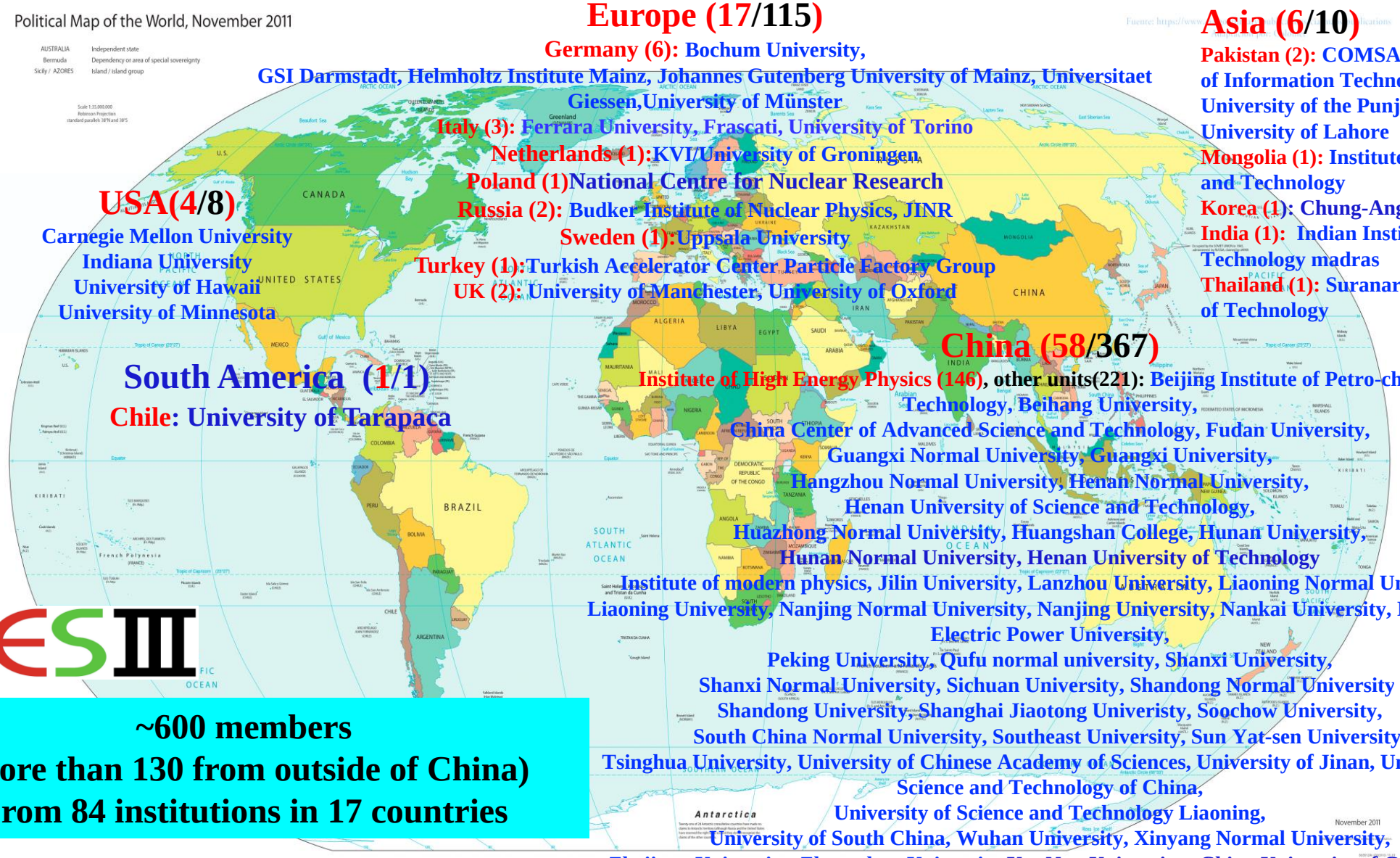
- Once the project approved, a management team by the host institution will be formally formed and approved by CAS
  - No one from CAS will bother you afterwards, unless you have a problem and ask for help
  - Partners can sign agreement with the host institution
- Funding will be given every year according to the budget
- Once completed, a check and acceptance review with be organized by NDRC
  - If successful, the project is closed
- Once the construction project is closed, the operation fund can start:
  - Funding request reviewed by CAS, and submitted to MoF by CAS
  - Yearly funding and performance review by CAS

JUNO Collaboration

- Project firstly approved in China in 2013 and later in other countries. Construction started in 2015
- Collaboration established in 2014, with now ~750 collaborators from 72 institutions in 17 countries/regions

Country	Institute	Country	Institute	Country	Institute	Country	Institute
Armenia	Yerevan Physics Institute	China	Shanghai JT U.	France	IJCLab Orsay	Italy	INFN-Roma 3
Belgium	Universite Libre de Bruxelles	China	IGG-Beijing	France	LP2i Bordeaux	Pakistan	PINSTECH (PAEC)
Brazil	PUC	China	SYSU	France	CPPM Marseille	Russia	INR Moscow
Brazil	UEL	China	Tsinghua U.	France	IPHC Strasbourg	Russia	JINR
Chile	SAPHIR	China	UCAS	France	Subatech Nantes	Russia	MSU
Chile	UNAB	China	U. of South China	Germany	RWTH Aachen U.	Slovakia	FMPICU
China	BISEE	China	Wu Yi U.	Germany	TUM	Taiwan-China	National Chiao-Tung U.
China	CAGS	China	Wuhan U.	Germany	U. Hamburg	Taiwan-China	National Taiwan U.
China	ChongQing University	China	Xi'an JT U.	Germany	GSI	Taiwan-China	National United U.
China	DGUT	China	Xiamen University	Germany	U. Mainz	Taiwan-China	NKNU
China	Guangxi U.	China	Zhengzhou U.	Germany	U. Tuebingen	Taiwan-China	NTUT
China	Harbin Institute of Technology	China	NUDT	Italy	INFN Catania	Thailand	NARIT
China	IHEP	China	CUG-Beijing	Italy	INFN di Frascati	Thailand	PPRLCU
China	Jinan U.	China	ECUT-Nanchang City	Italy	INFN-Ferrara	Thailand	SUT
China	Nanjing U.	China	CDUT-Chengdu	Italy	INFN-Milano	U.K.	U. Liverpool
China	Nankai U.	China	SUSTech-Shenzhen	Italy	INFN-Milano Bicocca	U.K.	U. Warwick
China	NCEPU	Czech	Charles U.	Italy	INFN-Padova	USA	UMD-G
China	Shandong U.	Finland	University of Jyvaskyla	Italy	INFN-Perugia	USA	UC Irvine

BESIII collaboration



Europe (17/115)

Germany (6): Bochum University, GSI Darmstadt, Helmholtz Institute Mainz, Johannes Gutenberg University of Mainz, Universitaet Giessen,University of Münster

Italy (3): Ferrara University, Frascati, University of Torino

Netherlands (1):KVI/University of Groningen

Poland (1)National Centre for Nuclear Research

Russia (2): Budker Institute of Nuclear Physics, JINR

Sweden (1):Uppsala University

Turkey (1):Turkish Accelerator Center Particle Factory Group

UK (2): University of Manchester, University of Oxford

USA(4/8)

Carnegie Mellon University

Indiana University

University of Hawaii

University of Minnesota

South America (1/1)

Chile: University of Tarapaca

Asia (6/10)

Pakistan (2): COMSATS Institute of Information Technology University of the Punjab, University of Lahore

Mongolia (1): Institute of Physics and Technology

Korea (1): Chung-Ang University

India (1): Indian Institute of Technology madras

Thailand (1): Suranaree University of Technology

China (58/367)

Institute of High Energy Physics (146), other units(221): Beijing Institute of Petro-chemical Technology, Beihang University, China Center of Advanced Science and Technology, Fudan University, Guangxi Normal University, Guangxi University, Hangzhou Normal University, Henan Normal University, Henan University of Science and Technology, Huazhong Normal University, Huangshan College, Hunan University, Hunan Normal University, Henan University of Technology Institute of modern physics, Jilin University, Lanzhou University, Liaoning Normal University, Liaoning University, Nanjing Normal University, Nanjing University, Nankai University, North China Electric Power University, Peking University, Qufu normal university, Shanxi University, Shanxi Normal University, Sichuan University, Shandong Normal University Shandong University, Shanghai Jiaotong Univeristy, Soochow University, South China Normal University, Southeast University, Sun Yat-sen University, Tsinghua University, University of Chinese Academy of Sciences, University of Jinan, University of Science and Technology of China, University of Science and Technology Liaoning, University of South China, Wuhan University, Xinyang Normal University, Zhejiang University, Zhengzhou University,YunNan University , China University of Geosciences

~600 members
(more than 130 from outside of China)
From 84 institutions in 17 countries

CEPC

- The scale of CEPC and its international nature, may require a different way of management
- We will minimize such a difference, try to adapt to the existing system, while looking for modifications
- Experience at BEPCII, BESIII, Daya Bay, JUNO will help us

Welcome suggestions