



HELMHOLTZ-CAS WORKSHOP.

Large Science Facilities in China and Related Research

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Existing and Under-construction Large Science Facilities

Particle Physics

- Beijing Electron Positron Collider (BEPCII)
- Daya Bay Reactor Neutrino Experiment
- Jiangmen Underground Neutrino Observatory (JUNO)

...

Nuclear Physics

- Lanzhou Heavy Ion Accelerator (HIRFL)
- High Intensity Heavy-ion Accelerator Facility (HIAF)
- Chinese initial Accelerator Driven System (CIADS)

...

Astronomy and Astrophysics

- Large Sky Area Multi-object Fiber Spectroscopic Telescope (LAMOST)
- Five-hundred-meter Aperture Spherical radio Telescope (FAST)
- Hard X-ray Modulation Telescope (HXMT)
- Large High Altitude Air Shower Observatory (LHAASO)
- Chinese Survey Space Telescope (Xuntian Space Telescope)
- Einstein Probe (EP)
- enhanced X-ray Timing and Polarimetry (eXTP) Observatory
- High Energy cosmic-Radiation Detector (HERD)

...

Light Source & Neutron Source

- Beijing Synchrotron Radiation Facility (BSRF)
- Hefei Light Source (HLS)
- Shanghai Synchrotron Radiation Facility (SSRF)
- China Spallation Neutron Source (CSNS)
- High Energy Photon Source (HEPS)
- Hefei advanced Light Source (HALS)
- China Spallation Neutron Source II (CSNS-II)

...



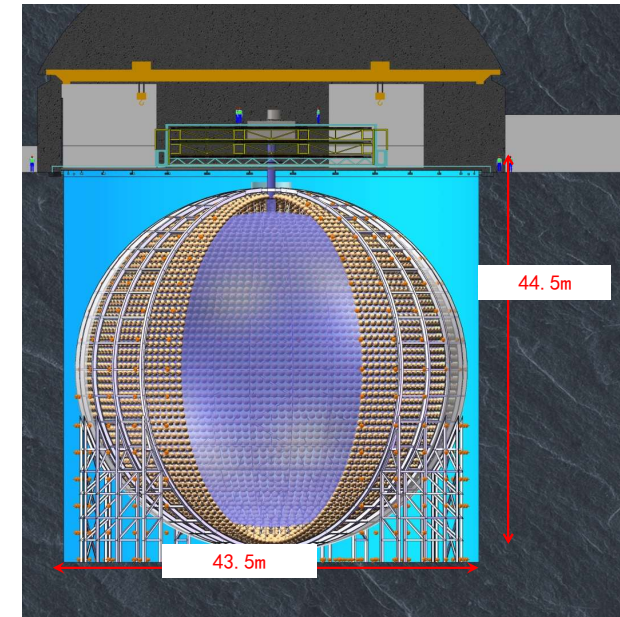
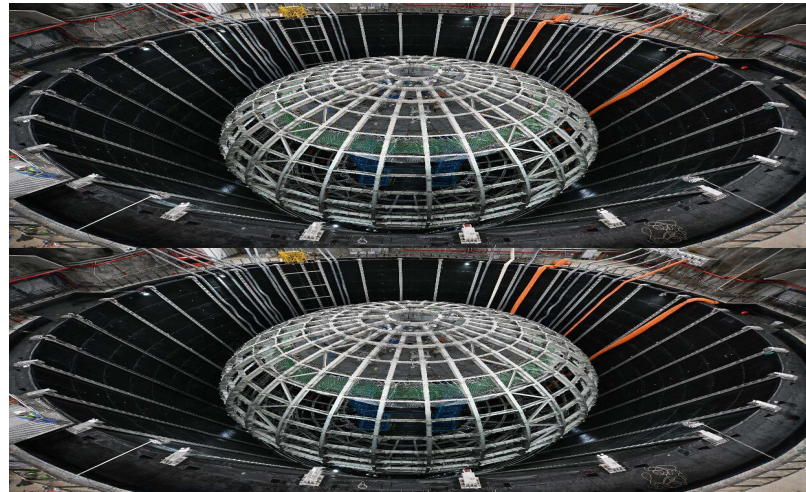
Reactor Neutrino Experiment

Jiangmen Underground Neutrino Observatory (JUNO):

- A 20 kt liquid scintillator detector with unprecedented 3% energy resolution (at 1 MeV) under the 700-meter overburden
- Science: To determine neutrino mass hierarchy and precisely measure oscillation parameters, observe supernova neutrinos, solar neutrinos, geoneutrinos, ...
- Large German participation
- Construction will be completed in 2023



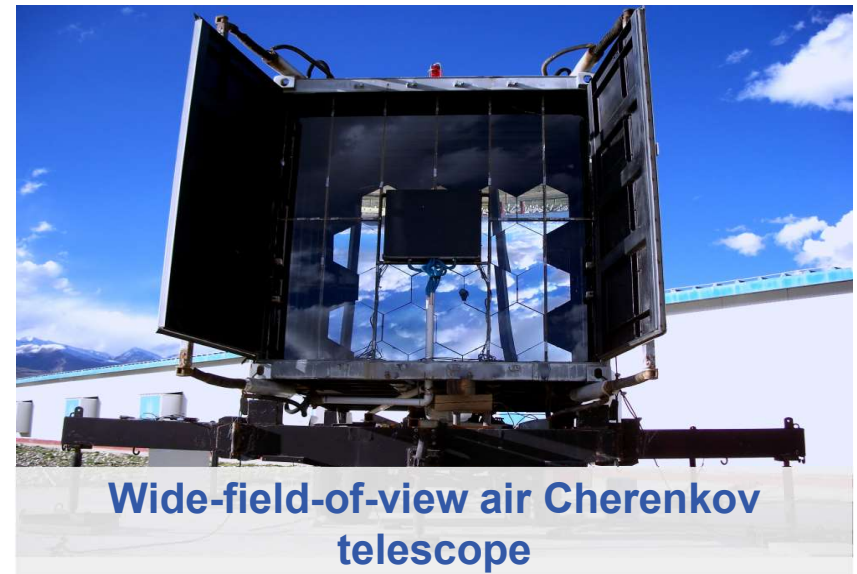
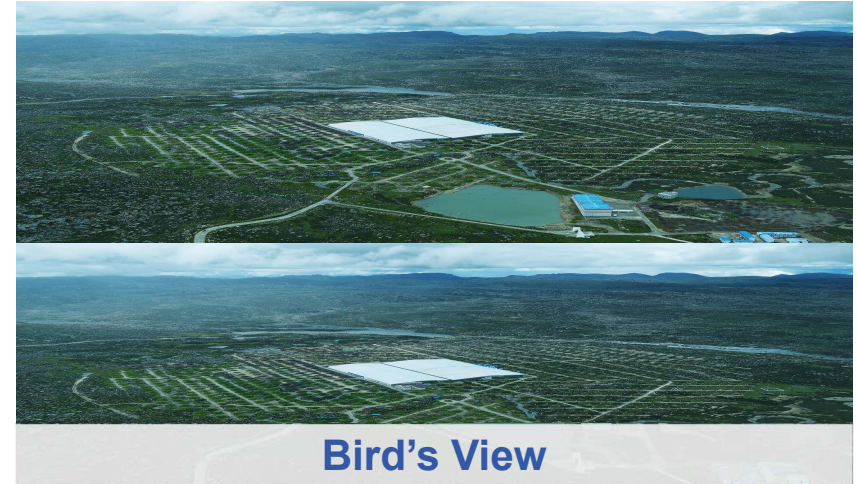
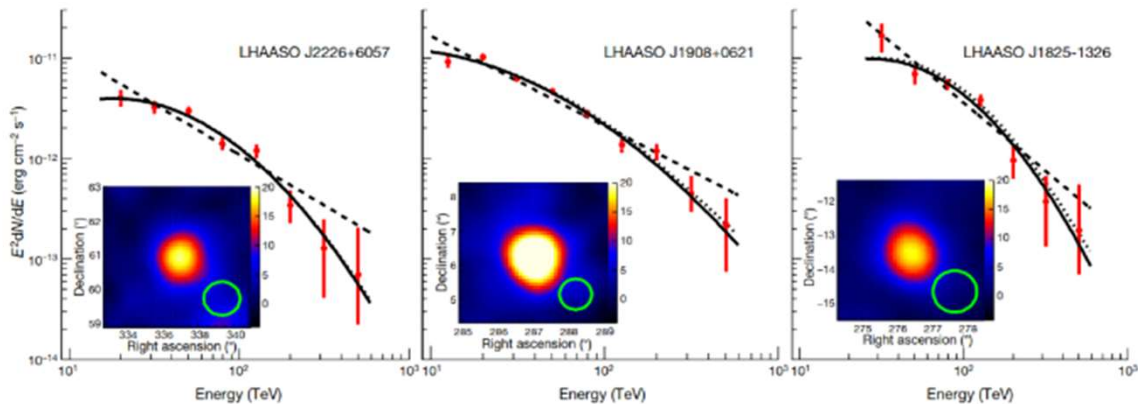
Daya Bay experiment
Decommissioned





Large High Altitude Air Shower Observatory (LHAASO)

- World largest air shower array (with e, m, water Č detectors and Č telescope) for the high energy γ -astronomy and cosmic-ray physics
- Construction completed and interesting results came out:
 - Highest g-rays from the Milky Way: 1.4 PeV
 - 12 identified γ -ray sources up to ~ 1 PeV \rightarrow PeVatrons in the Milky Way
 - Energy spectrum of high energy γ -rays from the Crab Nebula as the standard candle
- Complementary to CTA, collaboration possible





High Intensity Heavy-ion Accelerator Facility (HIAF) Chinese initial Accelerator Driven System (CiADS)



Huizhou,
Guangdong

HIAF: aiming for the strongest beam intensity for pulsed heavy ion beam in the world

Science: heavy ion physics and applications

Construction started in Dec. 2018, to be finished in ~2026

CiADS: A 10 megawatt ADS research facility to explore the safe and proper technology of nuclear waste disposal

Construction started in 2021, to be finished in ~2027

Good Collaboration with GSI/Fair



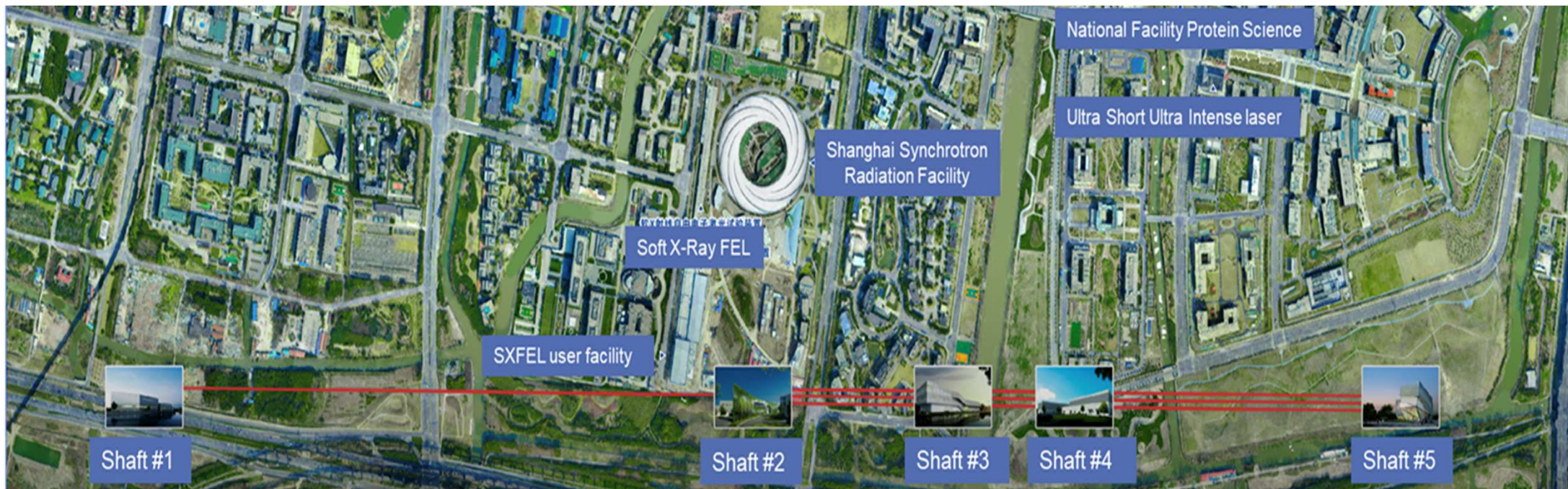


Shanghai Soft X-ray Free-electron Laser Facility (SXFEL) Shanghai High Repetition Rate XFEL and Extreme Light Facility (SHINE)

SXFEL: located at the Shanghai Synchrotron Radiation Facility campus, the first coherent X-ray light source in China with the shortest wavelength

SHINE: 8GeV e- beam for hard X-ray free electron laser with overall length of 3.1 km a 100 pW intense laser facilities

Good Collaboration with DESY/EXFEL





High Energy Photon Source (HEPS)

📍 Huairou,
Beijing

- World brightest light source: 6 GeV, 0.036nm·rad emittance, 1260m Circumference, Brilliance: $>10^{22}$ phs/s/mm²/mrad²/0.1BW
- Civil Construction started on June 30, 2019, mostly completed
- Scheduled for completion in 2025

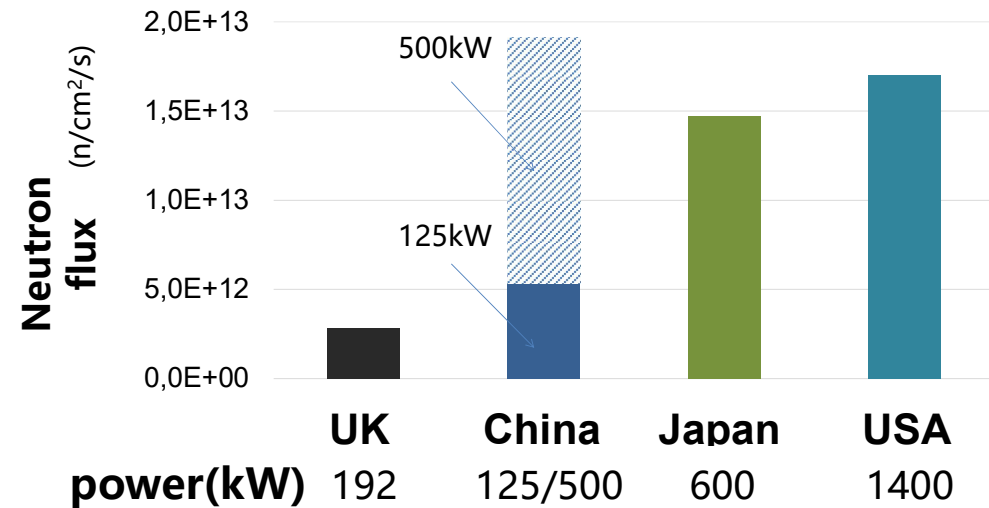




China Spallation Neutron Source (CSNS)

 Dongguan, Guangdong

- Located in Dongguan, south of China
- Smooth operation since 2019 with an efficiency > 90%
- Power reached 120 kW, 20% higher than design
- 8 beamlines, 2 to be completed



Bird's View



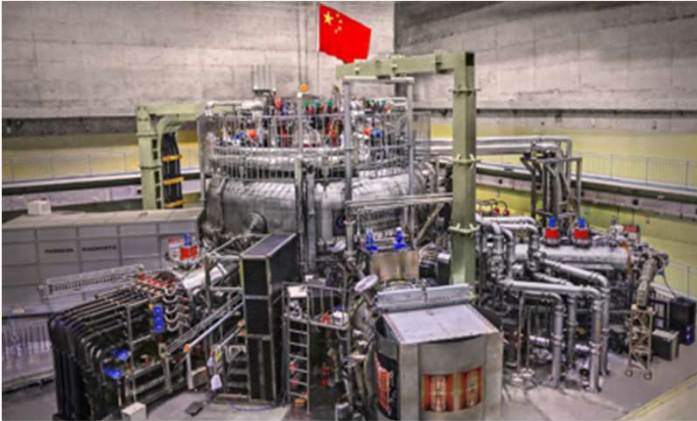
Drift Tube Linac



Target Station



Other Facilities



Experimental Advanced Superconducting Tokamak (EAST)



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



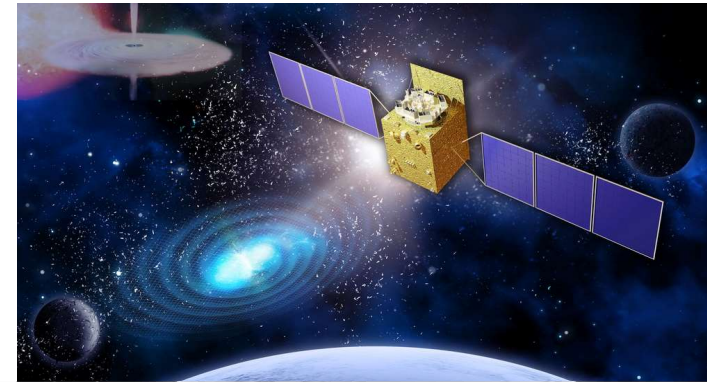
Lanzhou Heavy Ion Accelerator (HIRFL)



Steady High Magnetic Field Facility (SHMFF)



Shanghai Synchrotron Radiation Facility (SSRF)



Hard X-ray Modulation Telescope (HXMT)



Projects to be Started in 14th Five-year Plan



Hefei Light Source(HLS, HLS-II) → **Hefei Advance Light Source (HALS)**

- 2.5 GeV e- beam optimized for soft x-ray around 2keV
- high brightness, broad energy spectrum
- 10 beamlines (first phase), >35 beamlines in total
- Scheduled construction: 2023-2028

China Spallation Neutron Source (CSNS) → **CSNS-Upgrade**

- Beam power: 100 kW → 500 kW
- Add 10 more beamlines
- Team beam facility + muon beams
- Scheduled construction: 2023-2030

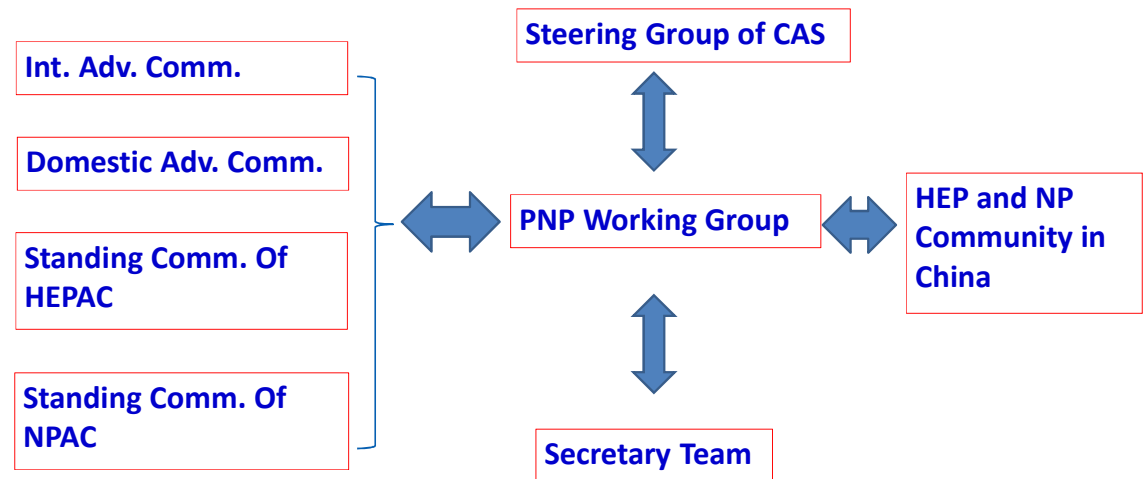




Preparation for the 15th Five-year Plan

- To better seize opportunities in Science and follow the funding cycle, Chinese Academy of Sciences organized a study of the future large science facilities
- This study is organized with 8 groups, such as particle and nuclear physics, astronomy and space, multidiscipline, etc.
- The charge is to foresee the direction of the field, and propose possible short (~ 2025-2030), mid (2030-2035) and long term(>2035) projects.

NO.	Project title
1	"Beijing Isotope-Separation-On-Line Neutron-Rich Beam Facility"
2	"The Circular Electron Positron Collider"
3	"China advanced NUclear physics research Facility, CNUF-An upgrade project for the HIAF and CiADS"
4	"High energy neutrino telescope"
5	"Search for neutrinoless double-beta decays at JUNO"
6	"PandaX-xT: Deep Underground Multi-ten-tonne Liquid Xenon Observatory"
7	"A Super Tau-Charm Facility (STCF)"
8	"Laser Compton Scattering Gamma Source Based on Hard X-ray Free Electron Laser Device (LCGS@SHINE)"
9	"CDEX-0 $\nu\beta\beta$ program"



Many colleagues from the Helmholtz Asso. are the IAC members



Preparation for the 15th Five-year Plan: Circular Electron-Positron Collider (CEPC)

- The idea of a Circular e^+e^- Collider (CEPC) followed by a possible Super proton-proton collider (SPPC) was proposed in Sep. 2012, and quickly gained the momentum in IHEP and in the world
 - Higgs study is the portal for new physics beyond LHC
 - Circular e^+e^- collider for Higgs has the best performance-cost ratio
 - The tunnel can be re-used for pp, AA, ep colliders up to ~ 100 TeV
- Conceptual design report published, R&D in good shape, no show stoppers
- Similar concept at CERN: FCC

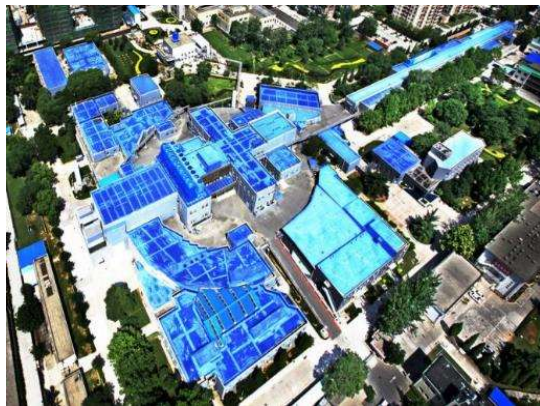


*2022 Update of the European
Strategy for Particle Physics
—by the European Strategy Group*



Example of a research Institution: IHEP

- The largest research institute on basic science in China, with 4 campuses, ~1,500 employees, ~1,000 graduate students and an annual budget of ~ \$500M.
- A world-class research center for high energy physics, astroparticle physics and multi-disciplinary research based on synchrotron radiation and spallation neutron facilities



Shijingshan, Beijing
Beijing Electron Positron
Collider



Dongguan, Guangdong
China Spallation Neutron
Source



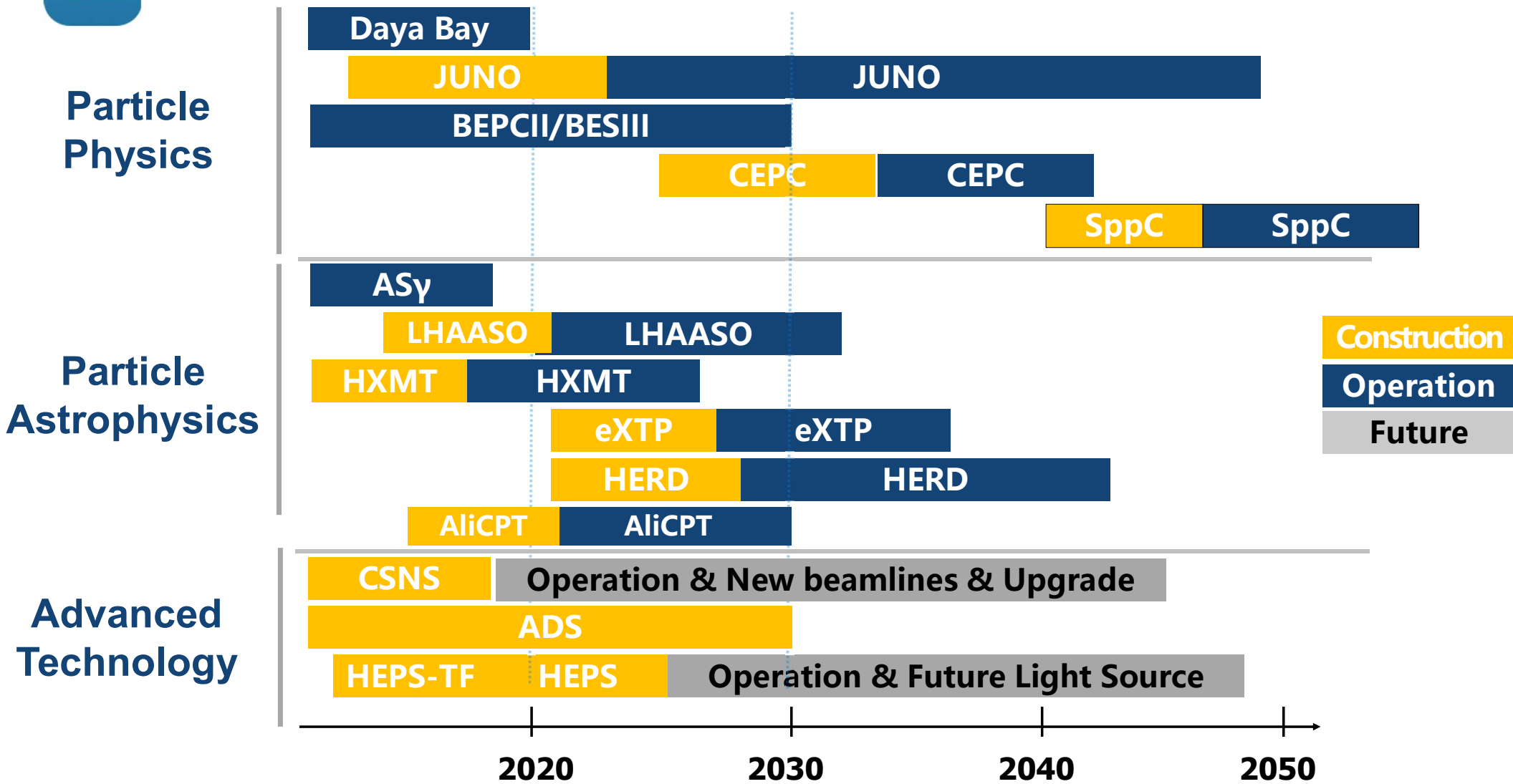
Huairou, Beijing
High Energy Photon
Source



Jinan, Shandong
Technology Transfer



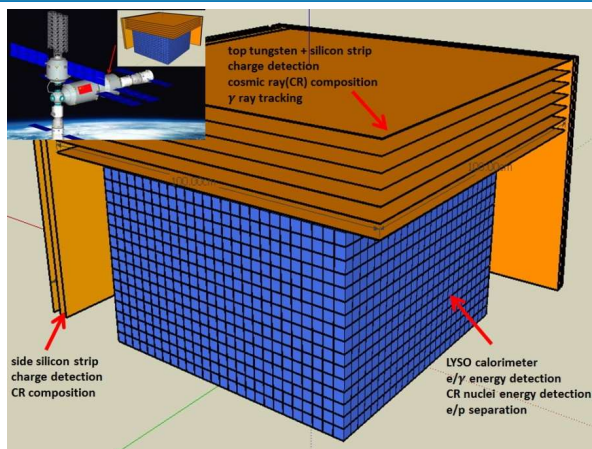
Roadmap of IHEP





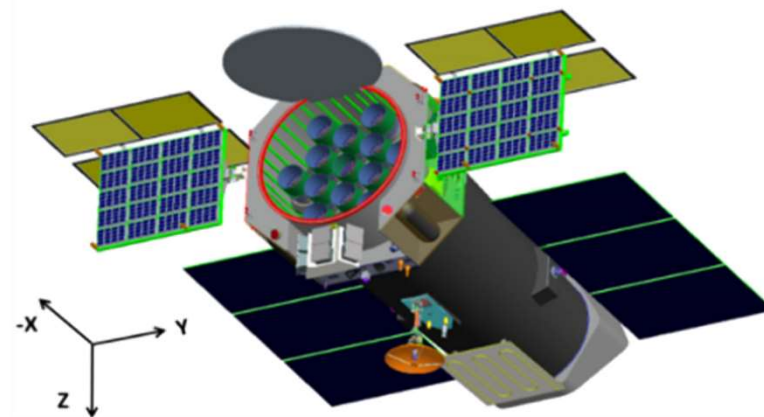
Space Programs

China Space Station: High Energy cosmic-Radiation Detector (HERD)



- 3D crystal calorimeter for dark matter searches and cosmic-rays
- Acceptance & energy range $\times 10$
- Selected for the Chinese Space Station, to be launched in ~ 2027
- In collaboration with Italy, Sweden, Switzerland, ...

enhanced X-ray Timing and Polarimetry (eXTP) Observatory



- the next generation telescope for “**Enhanced X-ray Timing and Polarization Mission**”
- A leading flagship observatory for black holes, neutron stars and extreme physics, to be launched in ~ 2027
- A large international collaboration with major German participation



Cooperation with Germany: JUNO

1. OSIRIS – Online Scintillator Internal Radioactivity Investigation System

Germany

China

Task Force

Jülich
Mainz
Aachen
TU-Munich

Institute of High Energy Physics, CAS
Sun Yat-sen University
Xi'an Jiaotong University



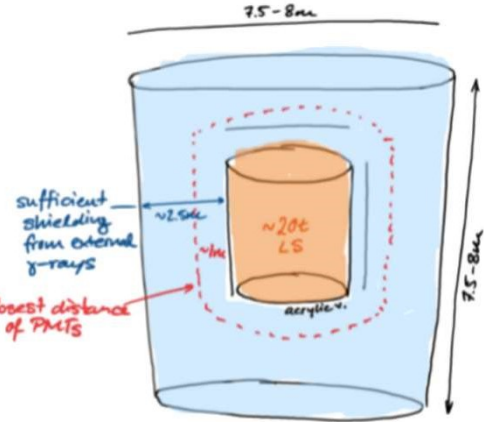
2. 20" photomultiplier tube (PMT)

Germany

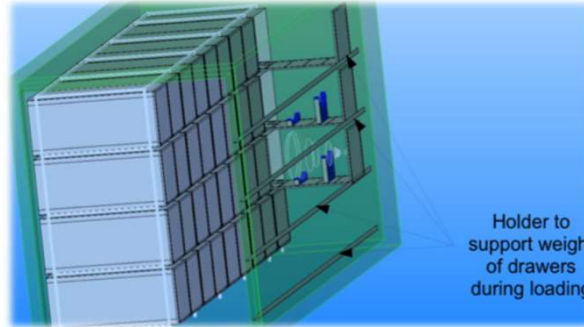
China

Hamburg
Göttingen

Institute of High Energy Physics, CAS
Sun Yat-sen University



- Formed ~1 year ago
- ~20 people from China & Germany
- calls every 3-4 weeks



The German side contributed 3 container testing systems.

20,000 PMTs test completed by joint efforts



Cooperation with Germany: Beijing Spectrometer (BESIII) Experiment

Responsibility roles (current)

- **Wolfgang Gradl, Co-spokesperson**, Member of BESIII Executive Board
- **Wolfgang Kuehn (Giessen U.)**, Convener of Charmonium working group
- **Wolfgang Kuehn (Giessen U.)** Member of Technical Board
- **Nils Huesken (JGU Mainz)**, Convener of light hadron working group
- **Riccardo Aliberti (Mainz)**, Convener of QCD and tau working group

Past roles

Achim Denig, Ch Redmer, and M. Pelizaeus, Conveners of Physics working groups

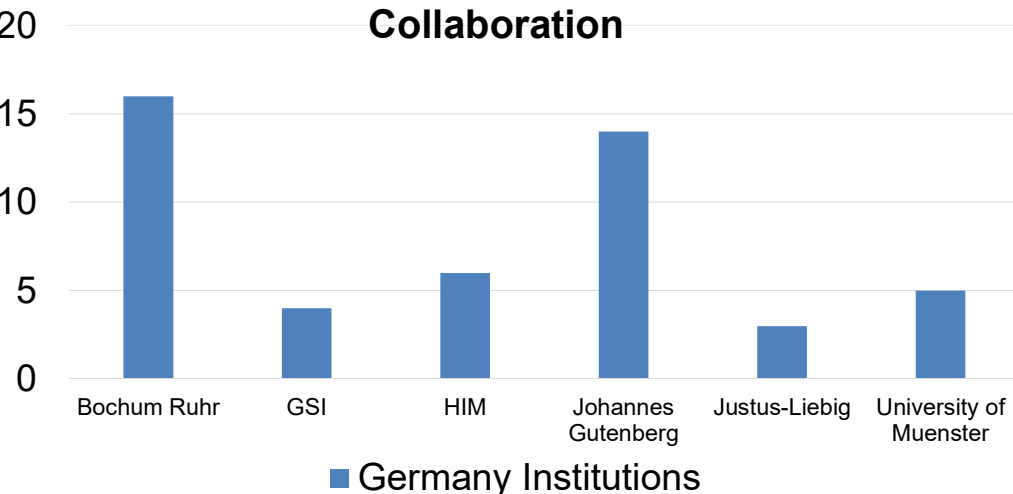
The German BESIII Collaboration:

~48 authors (~8% of the total)

Activities of the German BESIII group

- data analysis
- analyses internal review
- computing production support
- data taking shifts

6 German Institutions in BESIII Collaboration



- Construction of a Crystal Zero-Degree-Detector based on LYSO technology with SiPM readout
- Participation in the construction and simulation studies for the CGEM detector

2 Post-Doc fellow with the Helmholtz-Chinese program in Frank Mass's group (HIM)
4 Post-Doc fellows in Achim Denig's group (JGU)
3 post-doc fellows in U. Wiedner's and M. Fritsch's groups (Bochum Ruhr)



German Analyses at BESIII

- **Charmonium spectroscopy and decay**
 - Cross section measurement of $e^+e^- \rightarrow pp^- + \eta/\omega$: Phys. Rev. D 104, 092008 (2021)
 - Search for a charged charmoniumlike structure : Phys. Rev. D 103, 052010 (2021)
 - Direct production $e^+e^- \rightarrow \chi_{c1}$: arXiv:[2203.13782](https://arxiv.org/abs/2203.13782) (accepted by PRL)
 - Measurement of the $\pi^+\pi^-2\pi^0$ Cross Section;
 - Search for $X(3872) \rightarrow \pi^0 \pi^0 \chi_{cJ}$;
- **QCD and tau**
 - Measurements of R from 2.2324 to 3.6710 GeV at BESIII, Phys. Rev. Lett. 128, 062004 (2022)
 - Measurement of Proton Electromagnetic Form Factors : Phys. Rev. Lett. 124, 042001 (2020)
 - Measurement of Timelike Neutron Form Factors : Nature Physics 17, 1200 (2021)
 - Two-photon physics Analysis of the Two-Photon Production of charged Kaon Pairs
 - $e^+e^- \rightarrow p\bar{p}$ form-factor : [Phys. Lett. B 753, 629 \(2016\)](https://arxiv.org/abs/1605.08013) (One of the the most cited BESIII papers)
 - Measurement of $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ around the X(3872) mass
- **New physics** : Dark Photon Search in the Mass Range Between 1.5 and 3.4 GeV/c² :
Phys.Lett.B 774 (2017) 252-257
- **Charm**: Dalitz plot and branching fraction of $D^0 \rightarrow K^0_S K^+ K^-$

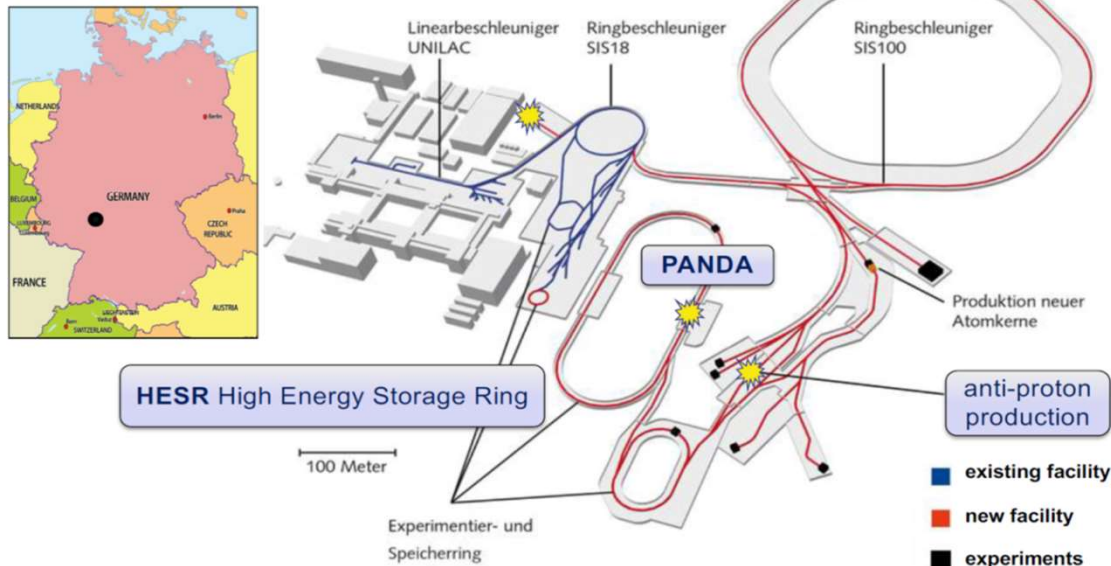


Cooperation with Germany: PANDA @FAIR

European flagship hadron physics facility for the coming decades

PANDA Collaboration—China: IHEP, IMP, Nankai Univ., USTC, USC
The new design of the Computing Node (FPGA) by IHEP and
Giessen Univ. is ready. Applying for funding from Chinese NSFC
for prototypes.

PANDA at FAIR
(GSI, Darmstadt, Germany)



Chinese PANDA- EMC Groups won PANDA Outstanding Achievement Award 2020

The groups from IHEP, USTC and Nankai Univ. did extraordinary work on updating the EMC offline software, paving the way to a better PANDARoot software for the simulation and reconstruction of the PANDA Electromagnetic Calorimeter.



Cooperation with Germany: LHAASO

LHAASO based Multi-Messenger Network

MoUs between LHAASO and existing Neutrino Telescopes and Cherenkov Telescope Experiments

- With MAGIC Coll. represented by MPP, Munich
- With CTA/LST Coll. represented by MPP, Munich
- With eROSITA Coll. represented by MPE, Munich (in progress)

Collaboration towards Future Experiments

SWGGO initiative represented by MPIK, Heidelberg

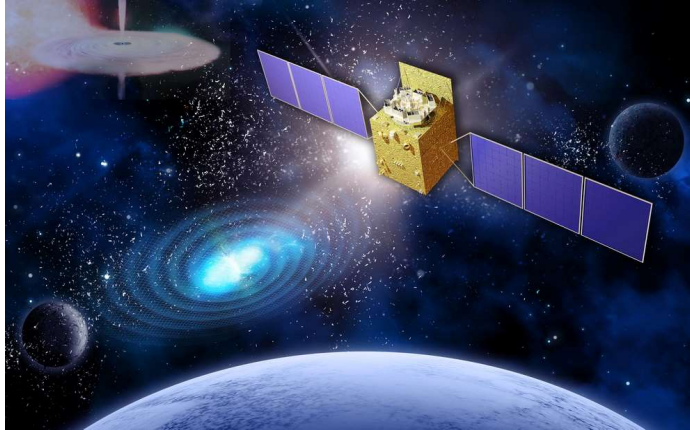


Cooperation with Germany: Space Programs



Einstein Probe satellite
focal plane detector and X-ray
telescope

**Max Planck Institute for
Extraterrestrial Physics
Prof. Kirpal Nandra**



Insight-HXMT satellite
joint data analysis on neutron
stars and black holes

**University of Tübingen
PI: Prof. Andrea Santangelo**



eXTP observatory
electronics

**University of Tübingen
PI: Prof. Andrea Santangelo**
with support from DLR

focal plane detectors
**Max Planck Institute for
Extraterrestrial Physics
Prof. Kirpal Nandra**



Cooperation with Germany: EXFEL

China was one of the 13 initial international partners in the component development

- With the financial support of the MoST, IHEP worked on the R&D of cryostat and undulator
-
- Cryostat was prototyped by IHEP and fabricated later on by Wuxi Creative Technologies
 - A total of 58 cryostats were delivered
 - Visited by the Vice Premier LIU Yandong, and the Minister of Science and Technology, WAN Gang
-





Cooperation with Germany: Institute of Modern Physics

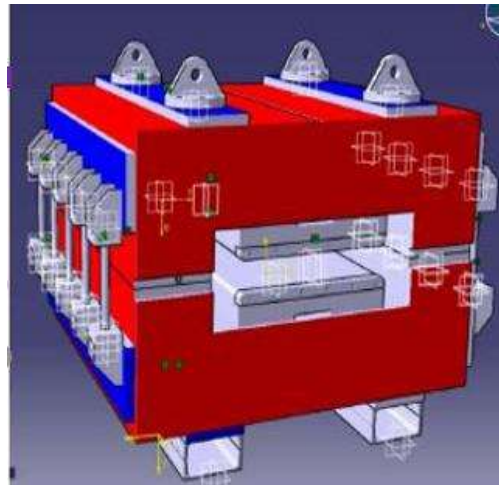
Collaborations in the fields of

- Nuclear physics research
- Application of the heavy ion physics
- Physics and technologies on accelerators research

Joint Experiments on precision mass measurements of unstable isotopes with international scientists from GSI, MPIK, etc.



Superconducting dipole magnet, low temperature, power supply and measurement systems



Large Aperture Superferric dipole for Super-FRS Prototyping examples



Dr. Norbert Angert received the Int'l Scientific and Technological Cooperation Award of the P. R. China in 2002 & the Friendship Award of the Chinese Government in 2006



Outlook for Future

- **Existing collaboration will be continued despite difficulties due to the pandemic and other issues**
- **New possibilities can be explored:**
 - LHAASO-CTA
 - CEPC-FCC
 - HIAF-FAIR
 - Light sources
 - Plasma wake field acceleration
 - Space programs, Astronomy & astrophysics
 - Administrative and management
 - Personal exchange: visit, collaboration, review, joint study, etc.
 - Bilateral and multi-lateral Conferences and forums
- **Looking forward more collaborations**



HELMHOLTZ-CAS WORKSHOP.

Thanks

谢谢

Danke