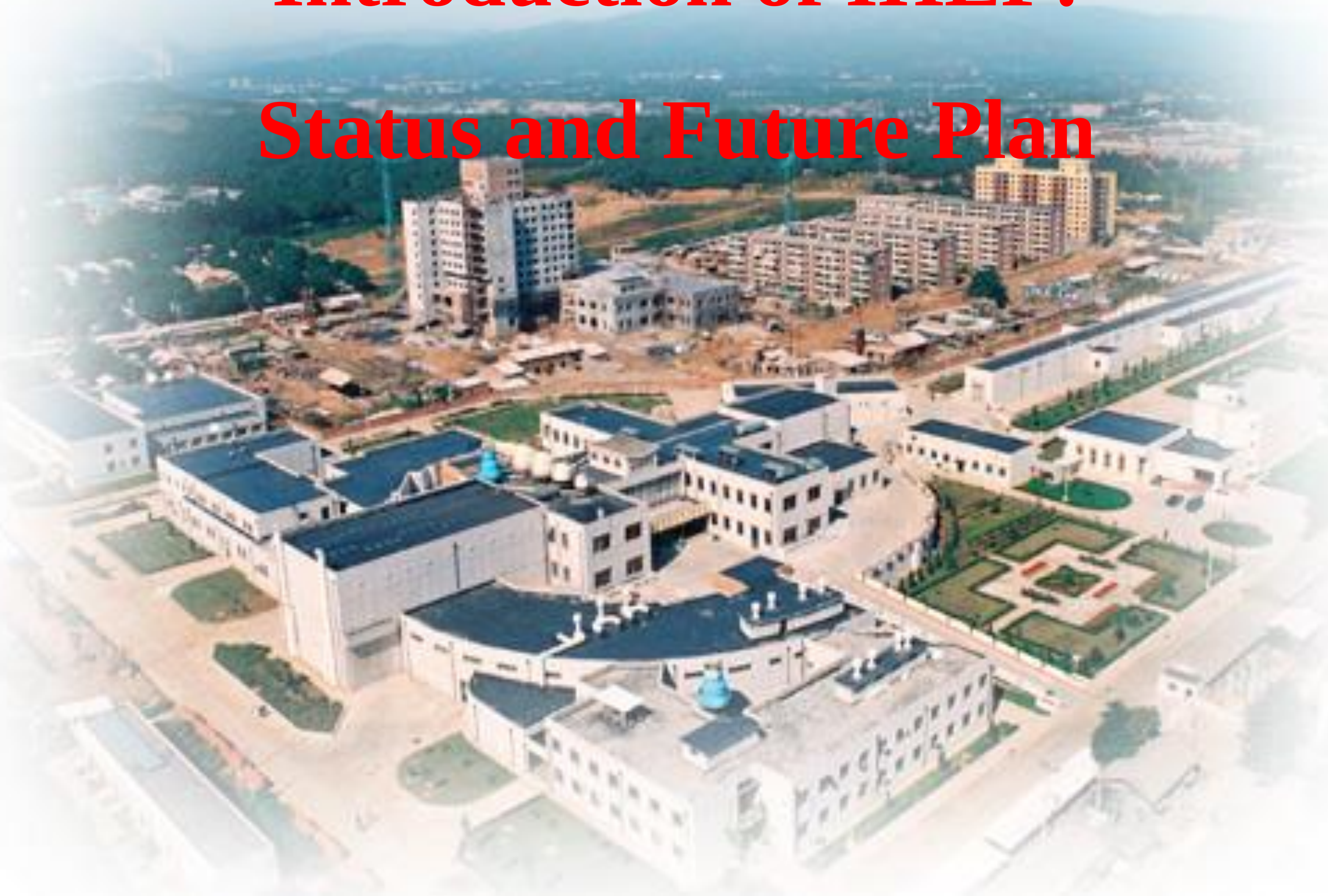
Introduction of IHEP:

Status and Future Plan



History

May 19, 1950 :
Institute of Modern Physics, CAS
Oct. 6, 1953:
Institute of Physics, CAS
July 1, 1958 :
Institute of atomic energy
Feb. 1, 1973:
Institute of High Energy Physics, CAS

Main research Disciplines

Physics

- HEP Exp. Based on Accelerators
- Particle Astrophysics & Neutrino Exp.
- Particle Detection and Electronics
- Particle Physics Theory

→ **Science**

Accelerator Physics and Technologies

- High Luminosity Electron Accelerator
- High Intensity Proton Accelerator
- Applied Research and Technology Transfer

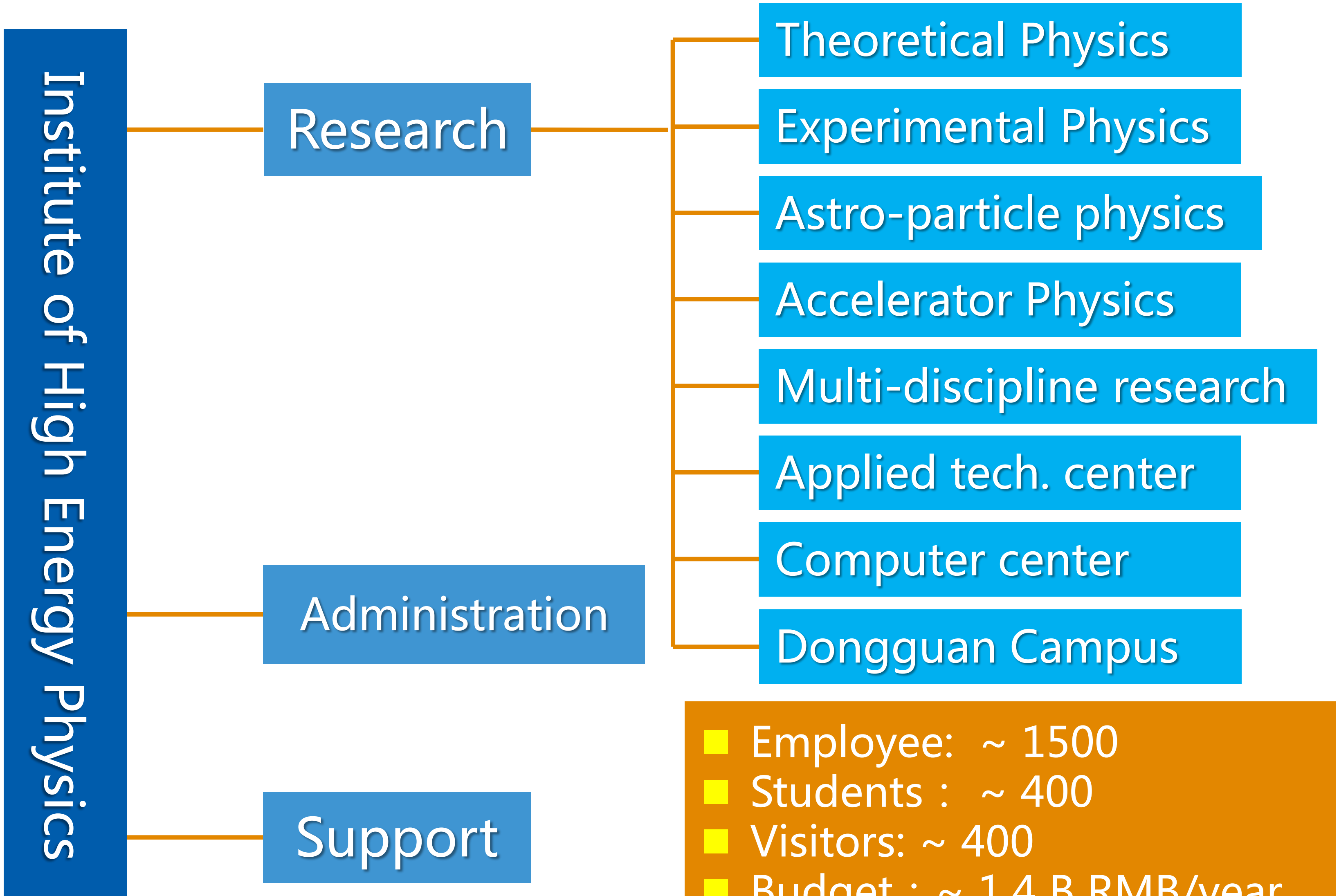
→ **Technology**

Radiation Technologies and Applications

- Synchrotron Radiation Techniques & Applications
- Neutron Scattering Techniques & Applications
- Nuclear Analytical Techniques & Applications

→ **Scientific infrastructure for multi-disciplinary studies**

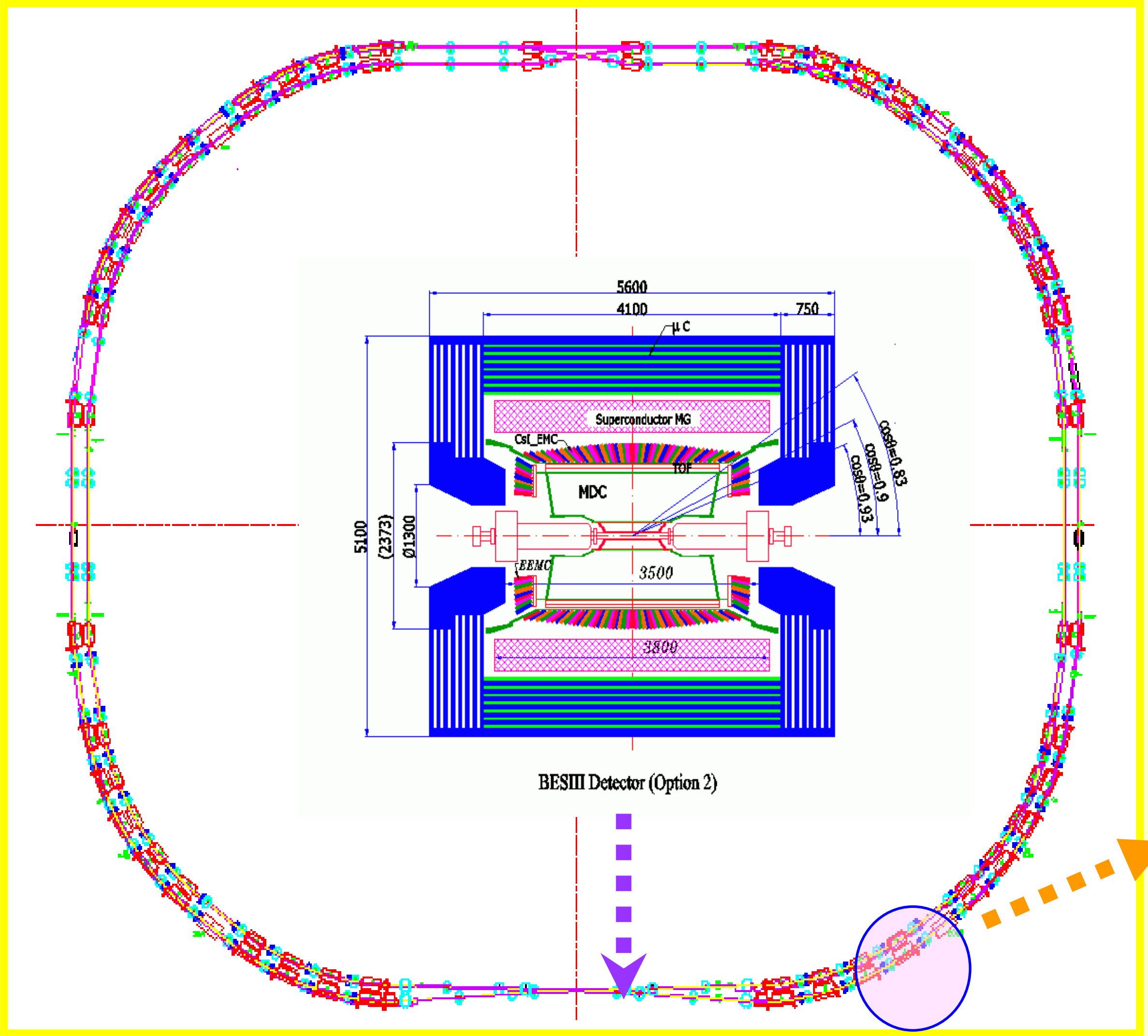
Management system

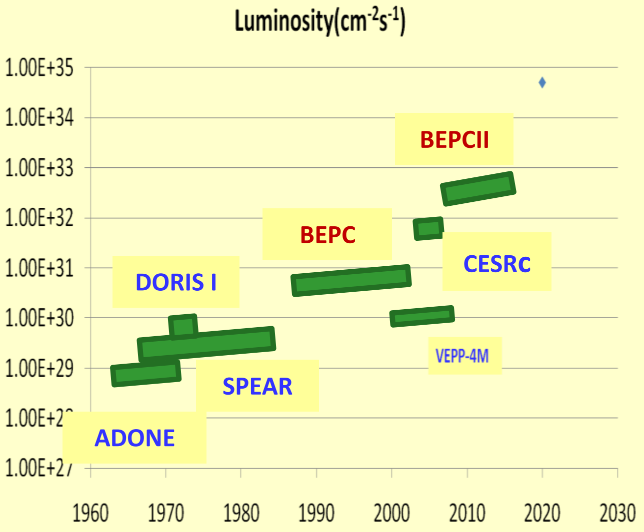


- Employee: ~ 1500
- Students : ~ 400
- Visitors: ~ 400
- Budget : ~ 1.4 B RMB/year

Particle physics in China started from BEPC

BEPCII/BESIII: Operational since 2009





e^+e^- collider at tau-charm

BESIII: an international collaboration

US (5)
Univ. of Hawaii
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

EUROPE (13)
Germany: Univ. of Bochum, Univ. of Giessen, GSI，Mainz，HIM
Russia: JINR, Dubna; BINP, Novosibirsk
Italy: Univ. of Torino，Frascati Lab, , Ferrara Univ.
Netherland: KVI/Univ. of Groningen
Sweden: Uppsala Univ.
Turkey: Turkey Accelerator Center

Korea (1)
Souel Nat. Univ.

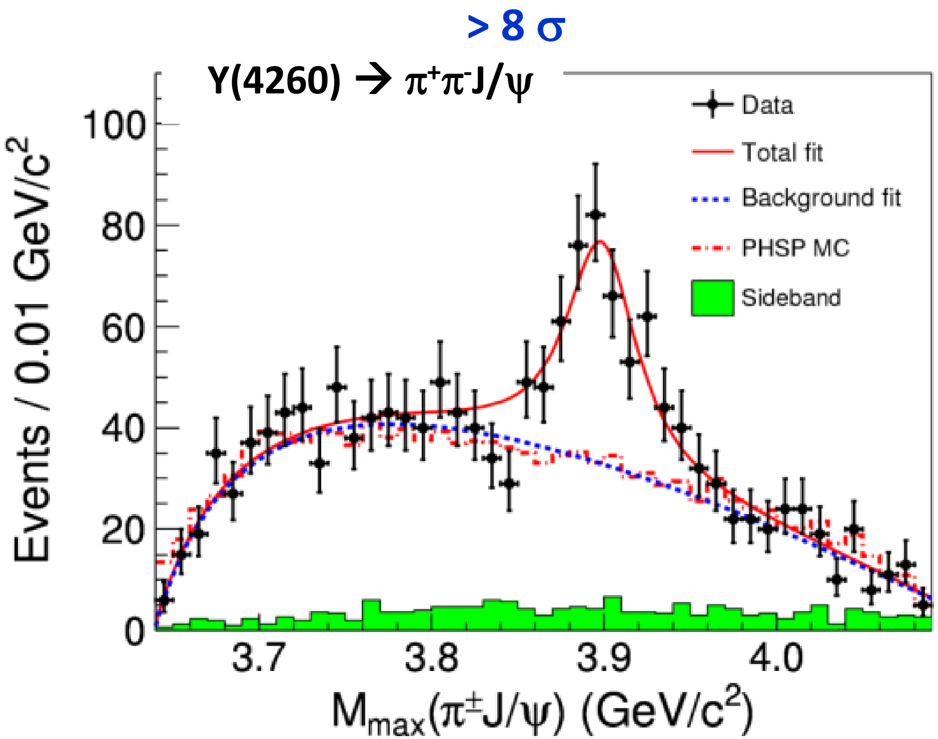
Japan (1)
Tokyo Univ.

Pakistan (2)
Univ. of Punjab
COMSAT CIIT

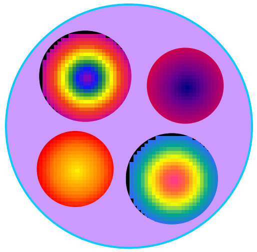
China(32)
IHEP, CCAST, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ
Suzhou Uni., Hangzhou Normal Uni.
Hunan Univ., Liaoning Univ.
Henan Uni. of Sci. & Tech.,
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Hong Univ., Hong Kong Chinese Univ.

50 institutions
~ 300 collaborators

BESIII example: discovery of Z_c (3900)



- A charged charmonium state: 4 quarks !



- M = (3899.0±3.6±4.9) MeV
- Γ = (46±10±20) MeV

PRL110, 252001 (2013)

Opens a new way to fully understand XYZ particles

Reports by Media

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SCIENCE | physics

Mysterious Subatomic Particle May Represent Exotic New Form of Matter

BY ADAM MANN 06.17.13 9:30 AM

Physics spotlighting exceptional research

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Viewpoint: New Particle Hints at Four-Quark Matter

Eric Swanson, University of Pittsburgh, Pittsburgh, PA 15260, USA

Published June 17, 2013 | Physics 6, 69 (2013) | DOI: 10.1103/Physics.6.69

nature International weekly journal of science

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Archive > Volume 498 > Issue 7454 > News > Article

NATURE | NEWS

عربي

Quark quartet opens fresh vista on matter

First particle containing four quarks is confirmed.

Devin Powell

IOP Physics World - the member magazine of the Institute of Physics

physicsworld.com

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- 2013
  - October 2013
  - September 2013

'Charged charmonium' confounds particle physicists

Jun 18, 2013 7 comments

livescience

TECH HEALTH PLANET EARTH SPACE STRAN

TRENDING: Hurricane Season 2013 // Global Warming // 3D Printing // OurAmazingPlanet // Nutriti

New 'Charmed' Particle Represents Rare State of Matter

Clara Moskowitz, LiveScience Senior Writer | June 19, 2013 09:50am ET

3

NewScientist Physics & Math

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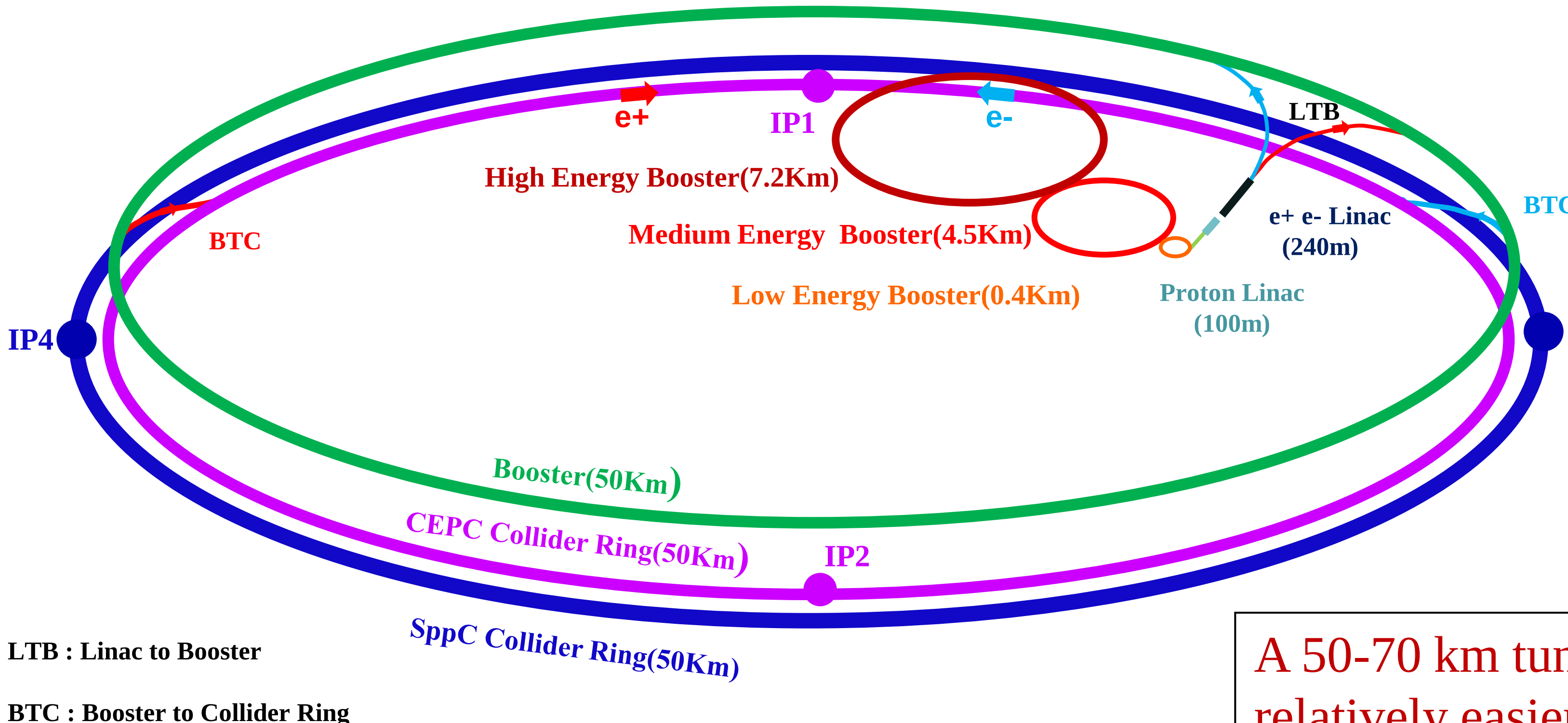
What a new jumbo particle reveals about extreme matter

Updated 15:50 24 June 2013 by Lisa Grossman

The Future: CEPC+SppC

- A project after BEPCII
- Thanks to the discovery of the low mass Higgs boson, and stimulated by ideas of Circular Higgs Factories in the world, CEPC+SppC configuration was proposed in Sep. 2012



A 50-70 km tunnel is relatively easier NOW in China

Timeline (dream)

- **CPEC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-15
      - **Pre-CDR for R&D funding request**
    - R&D: 2016-2020
    - Engineering Design: 2015-2020
  - Construction: 2021-2027
  - Data taking: 2028-2035
- **SppC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-2020
    - R&D: 2020-2030
    - Engineering Design: 2030-2035
  - Construction: 2035-2042
  - Data taking: 2042 -

IHEP-CEPC-DR-2015-01

IHEP-EP-2015-01

IHEP-TH-2015-01

CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

The CEPC-SPPC Study Group

March 2015

IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

The CEPC-SPPC Study Group

March 2015

Revisions after international reviews

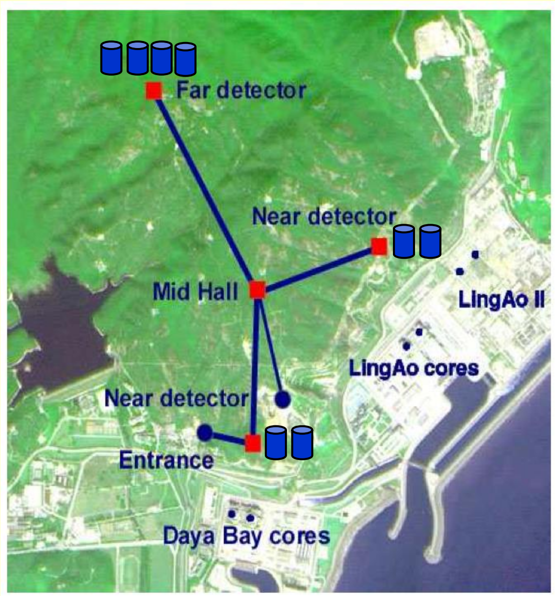
Can be downloaded from

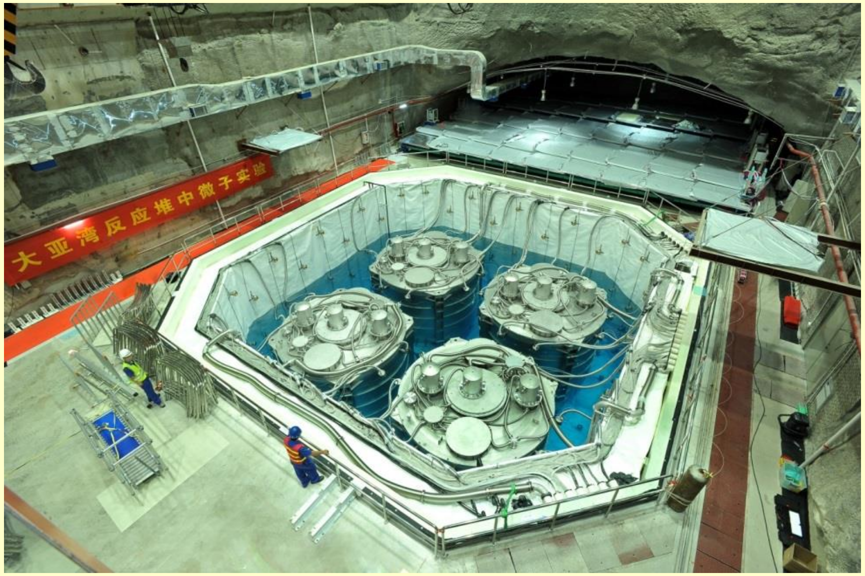
http://cepc.ihep.ac.cn/preCDR/volume.html

Particle & Astro-Particle Physics at IHEP

		Current	Future
Accelerator -based	Precision frontier	BESIII	International: ILC CEPC → SppC
		International projects: Belle II、PANDA、COMET	
	Energy frontier	CMS、ATLAS	
Non-accelerator-based	Underground	Daya Bay	JUNO nEXO
		EXO	
	Surface	ARGO/ASγ	LHASSO
	Space	AMS	HERD XTP
		HXMT	

Daya Bay reactor neutrino experiment

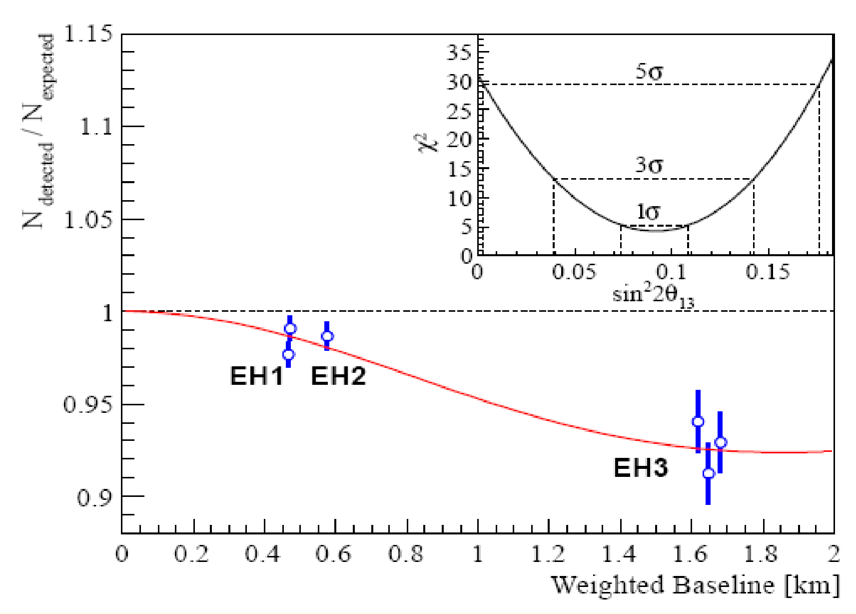




In March 2012, Daya Bay reported the measurement:

$\mathrm{Sin}^2 2\theta_{13} = 0.092 \pm 0.016(\mathrm{stat}) \pm 0.005(\mathrm{syst})$

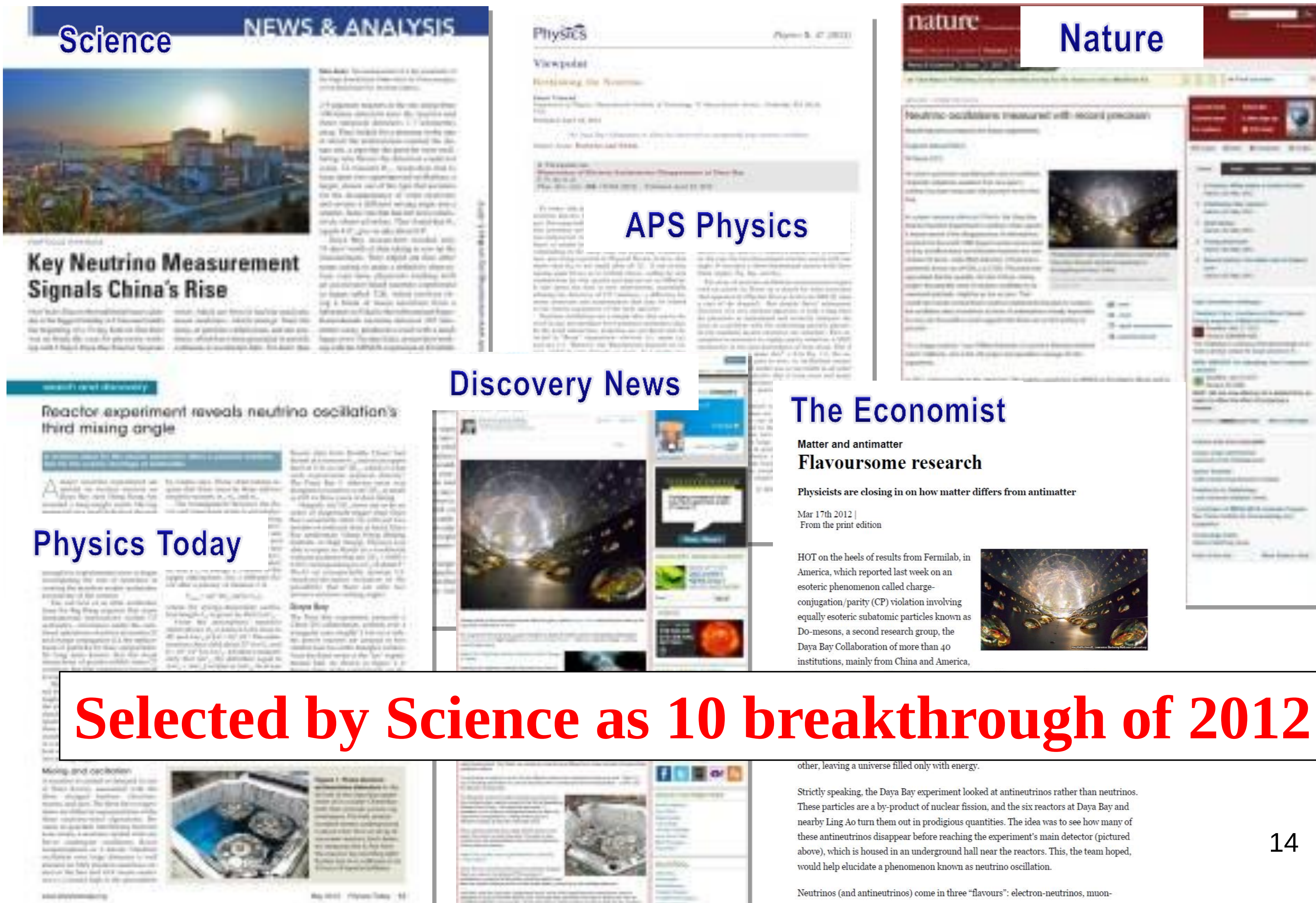
Probability of non-zero θ_{13} 5.3 σ



F.P. An et al., Phys. Rev. Lett. 108, (2012) 171803

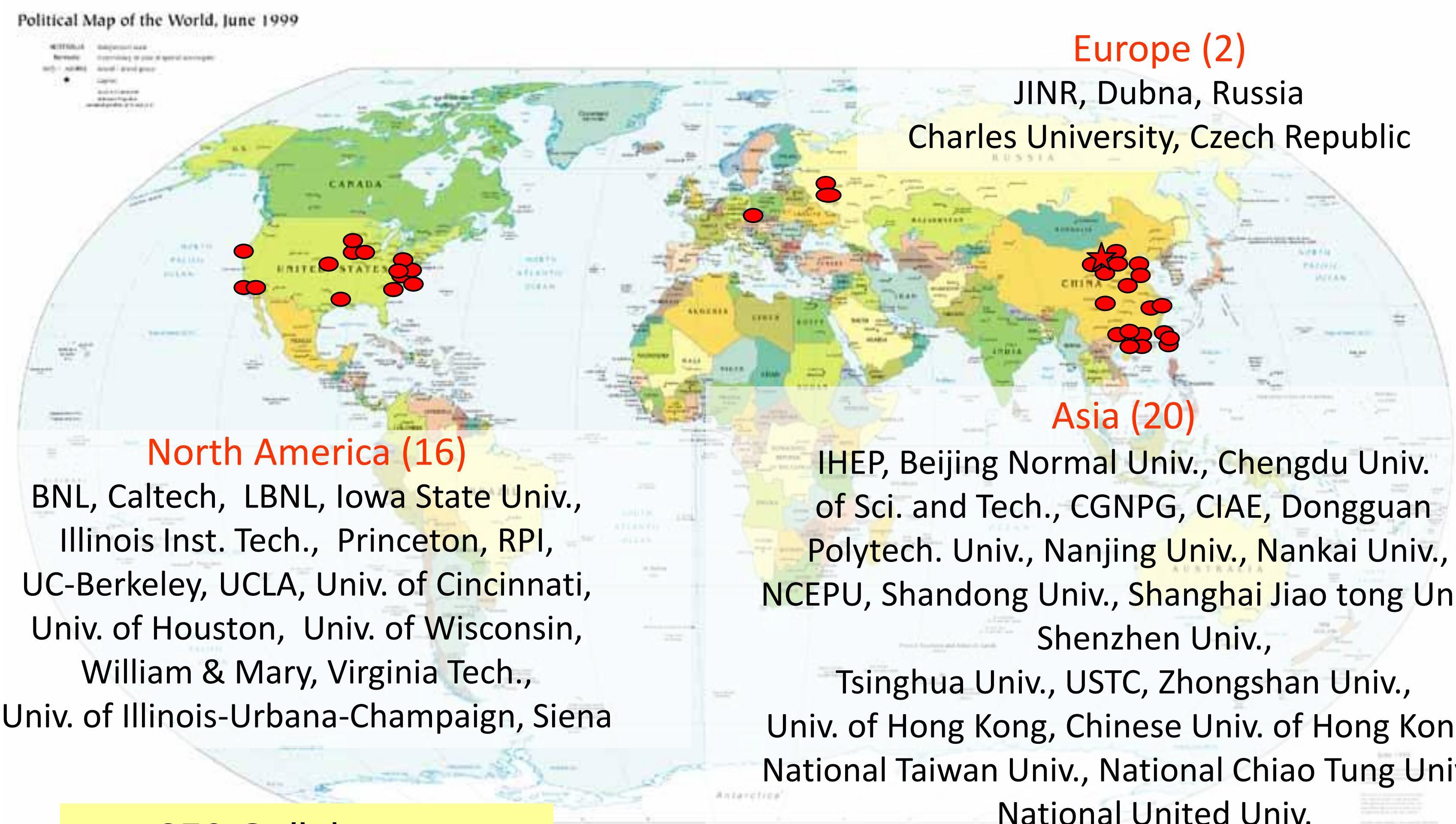
citations > 1100

Reported by major international science journals



Selected by Science as 10 breakthrough of 2012

Daya Bay Collaboration



Europe (2)

JINR, Dubna, Russia
Charles University, Czech Republic

North America (16)

BNL, Caltech, LBNL, Iowa State Univ., Illinois Inst. Tech., Princeton, RPI, UC-Berkeley, UCLA, Univ. of Cincinnati, Univ. of Houston, Univ. of Wisconsin, William & Mary, Virginia Tech., Univ. of Illinois-Urbana-Champaign, Siena

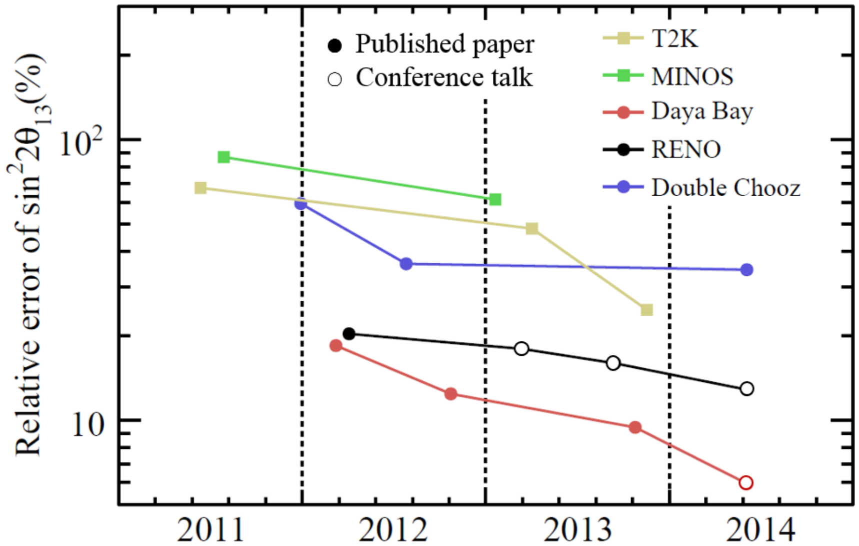
Asia (20)

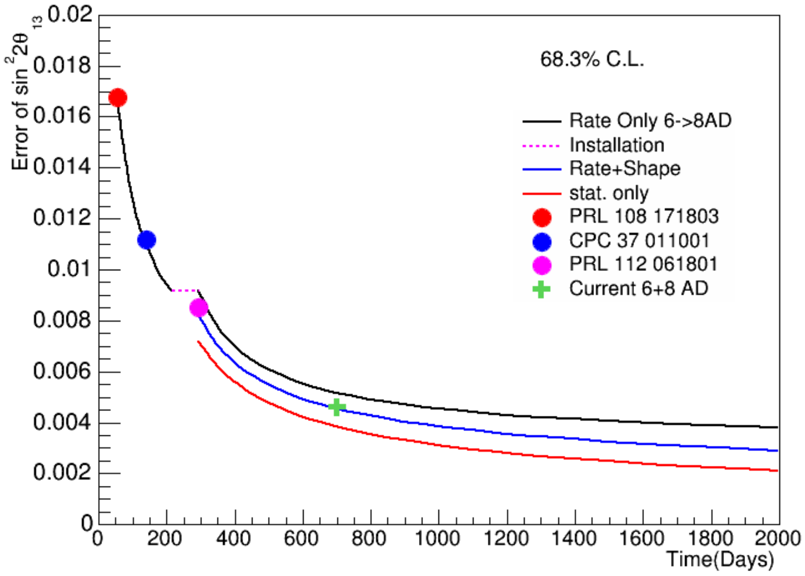
IHEP, Beijing Normal Univ., Chengdu Univ. of Sci. and Tech., CGNPG, CIAE, Dongguan Polytech. Univ., Nanjing Univ., Nankai Univ., NCEPU, Shandong Univ., Shanghai Jiao tong Univ., Shenzhen Univ., Tsinghua Univ., USTC, Zhongshan Univ., Univ. of Hong Kong, Chinese Univ. of Hong Kong, National Taiwan Univ., National Chiao Tung Univ., National United Univ.

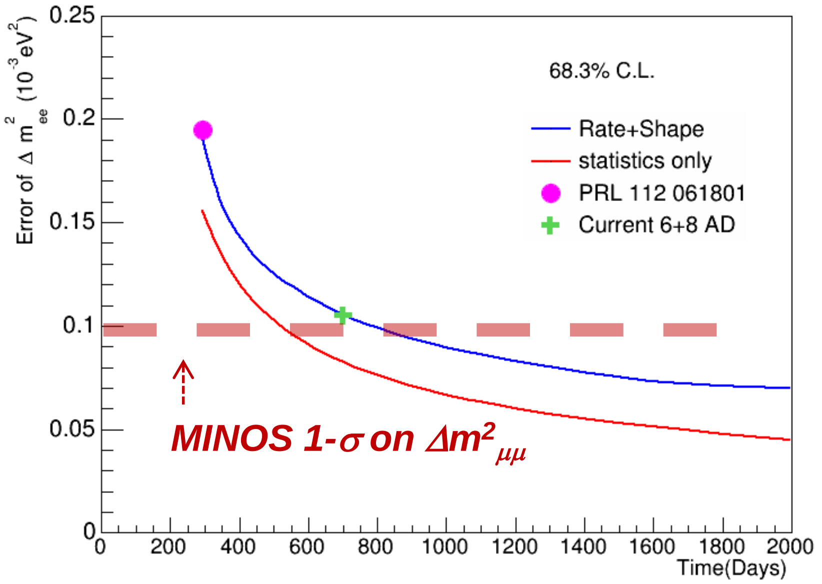
~250 Collaborators

Future Prospects

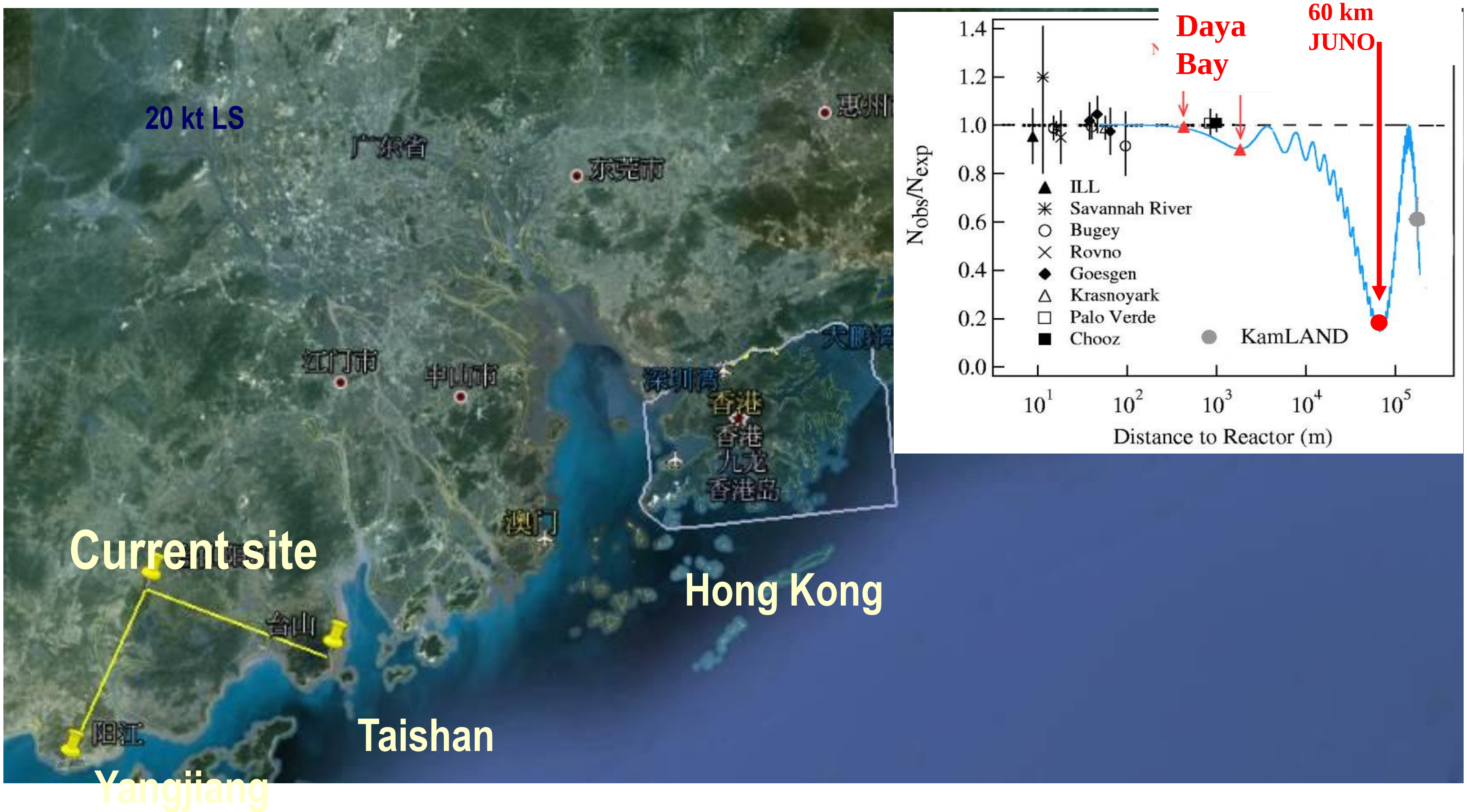
- **Data taking for θ_{13} until 2017**
- **Precision can reach $\Delta(\sin^2 2\theta_{13}) \sim 3\%$; the best for the foreseeable future**
- **Other physics topics:**
  - ⇨ **Cosmogenic isotope production**
  - ⇨ **Supernova neutrinos**
  - ⇨ **Correlated cosmic-ray events**







Next Step: JUNO for Mass Hierarchy

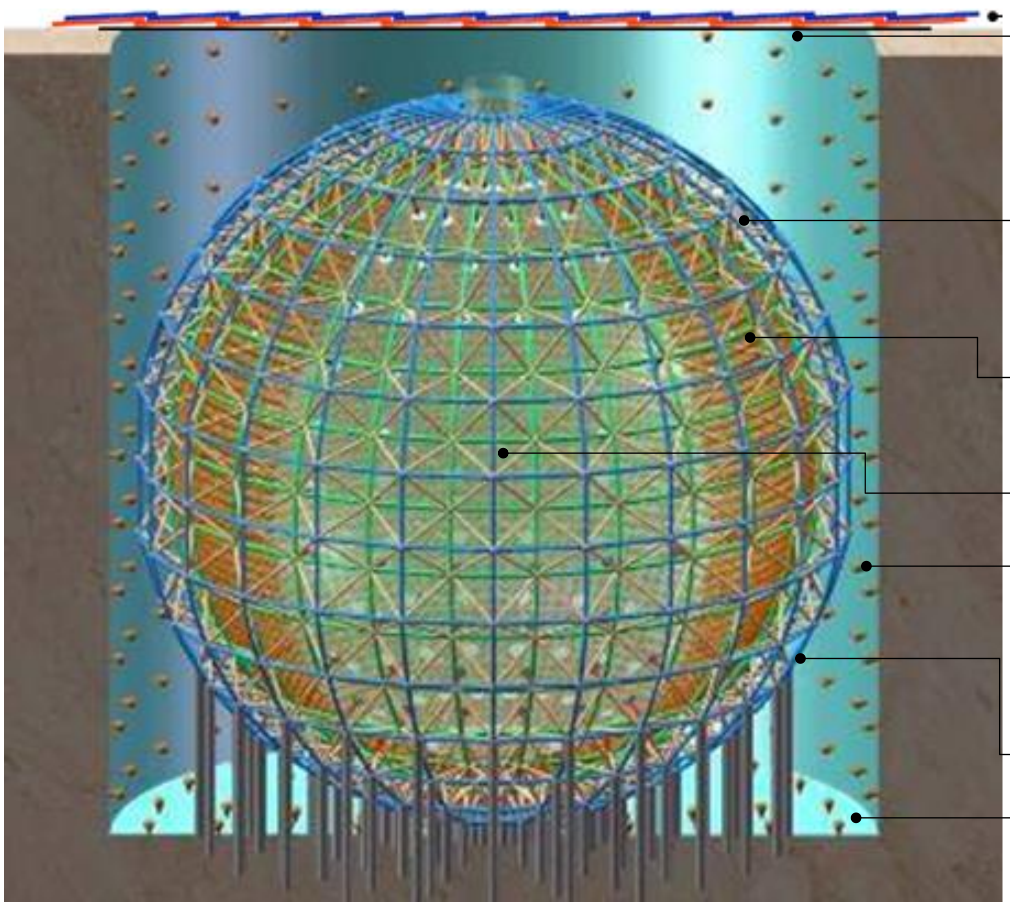


- The only one based on reactor: independent of CP phase

JUNO

– LS volume:× 20 ➔ for statistics (40 events/day)
– light(PE) × 5 ➔ for resolution ($\Delta M^2_{12}/ \Delta M^2_{23}$ ~ 3%)

- **Mass hierarchy**
- Precision measurement of mixing parameters
- Supernova neutrinos
- Geoneutrinos
- Sterile neutrinos
- ……



Physics Reach

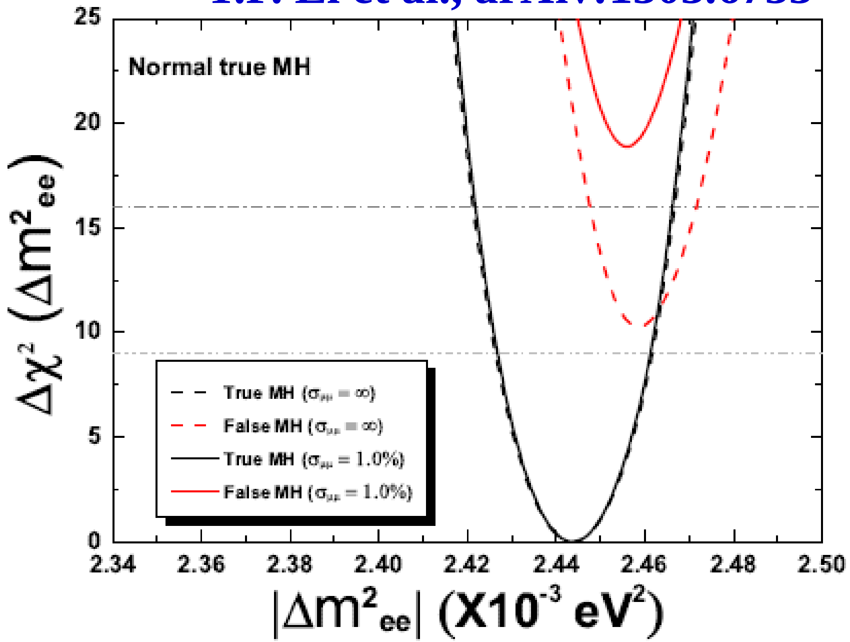
Thanks to a large θ_{13}

- **Mass hierarchy**
- Precision measurement of mixing parameters
- Supernova neutrinos
- Geoneutrinos
- Sterile neutrinos
- ……

	Current	Daya Bay II
Δm^2_{12}	4%	0.6%
Δm^2_{23}	4%	0.6%
$\sin^2\theta_{12}$	6%	0.7%
$\sin^2\theta_{23}$	10%	N/A
$\sin^2\theta_{13}$	6% → 4%	~ 15%

Detector size: 20kt
Energy resolution: 3%/√E
Thermal power: 36 GW

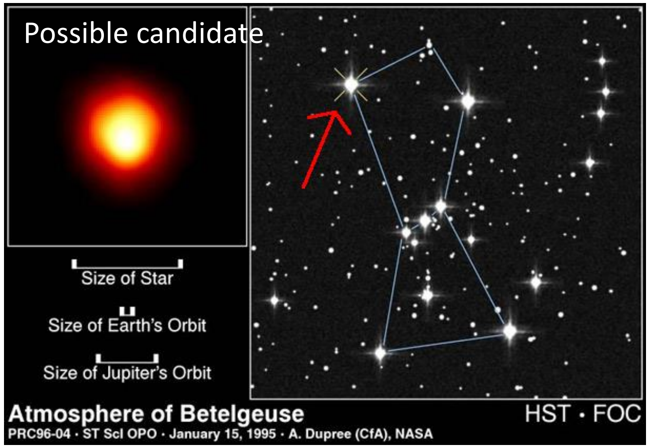
Y.F. Li et al., arXiv:1303.6733

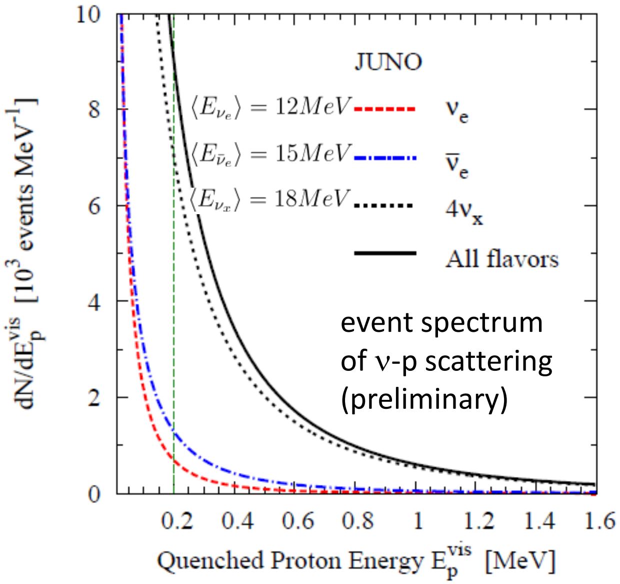


For 6 years, mass hierarchy cab be determined at 4σ level, if $\Delta m^2_{\mu\mu}$ can be determined at 1% level

Supernova neutrinos in Giant LS detector

- **Less than 20 events observed so far**
- **Assumptions:**
  - **Distance: 10 kpc (our Galaxy center)**
  - **Energy: 3×10^{53} erg**
  - **L_ν the same for all types**





Estimated numbers of neutrino events in JUNO (preliminary)

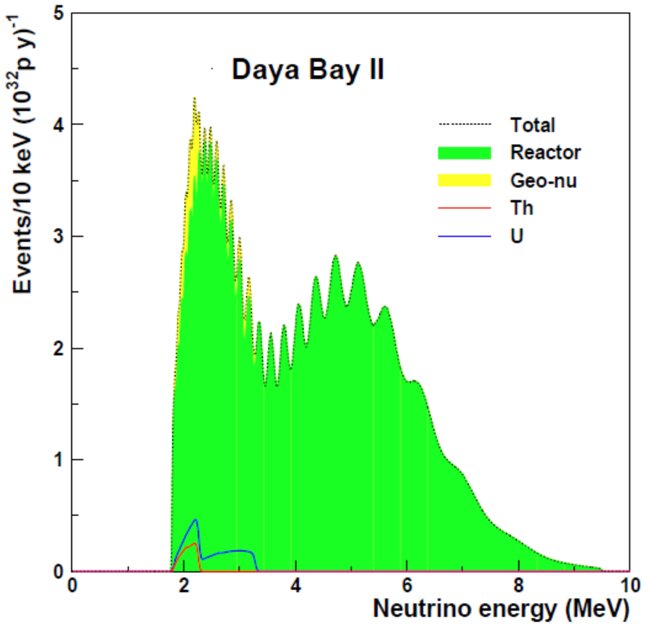
Channel	Type	Events for different $\langle E_\nu\rangle$ values		
		12 MeV	14 MeV	16 MeV
$\overline{\nu}_e + p \to e^+ + n$	CC	4.3×10^3	5.0×10^3	5.7×10^3
$\nu + p \to \nu + p$	NC	6.0×10^2	1.2×10^3	2.0×10^3
$\nu + e \to \nu + e$	NC	3.6×10^2	3.6×10^2	3.6×10^2
$\nu + {}^{12}C \to \nu + {}^{12}C^*$	NC	1.7×10^2	3.2×10^2	5.2×10^2
$\nu_e + {}^{12}C \to e^- + {}^{12}N$	CC	4.7×10^1	9.4×10^1	1.6×10^2
$\overline{\nu}_e + {}^{12}C \to e^+ + {}^{12}B$	CC	6.0×10^1	1.1×10^2	1.6×10^2

LS detector vs. Water Cerenkov detectors:
much better detection to these correlated events

→ Measure energy spectra & fluxes of almost all types of neutrinos

Other Physics with Giant LS detector

- **Geo-neutrinos**
  - **Current results:**
    - KamLAND: 30±7 TNU *(PRD 88 (2013) 033001)*
    - Borexino: 38.8±12.0 TNU *(PLB 722 (2013) 295)*
  - **Desire to reach an error of 3 TNU: statistically dominant**
  - **JUNO:**
    - ×10 statistics
    - Huge reactor neutrino backgrounds
    - Expectation: ? ±5%±5%



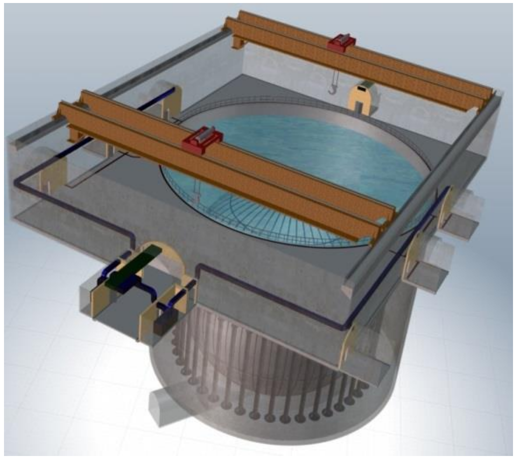
Stephen Dye @Neutrino 2012

- **Solar neutrinos**
  - need LS purification, low threshold
  - background handling (radioactivity, cosmogenic)
- **Atmosphere neutrinos**
- **Nucleon Decay**
- **Sterile neutrinos**

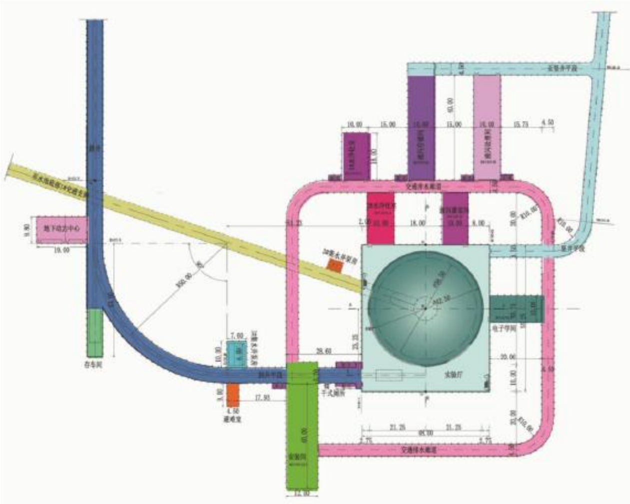
Schedule & Current Status

Schedule:

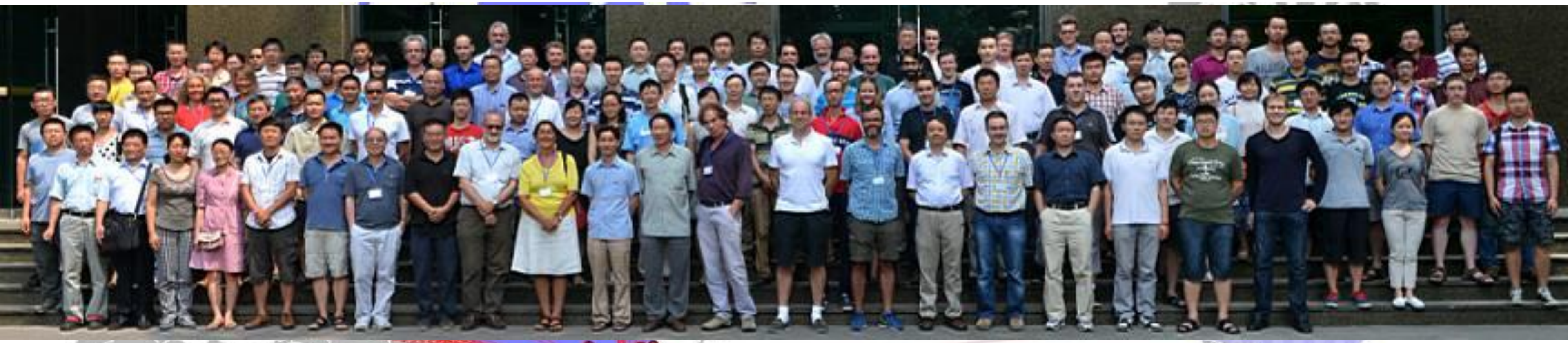
- **Civil preparation：2013-2014**
- **Civil construction：2014-2017**
- **Detector component production：2016-2017**
- **PMT production：2016-2019**
- **Detector assembly & installation：2018-2019**
- **Filling & data taking：2020**



Grounding breaking on Jan. 10, 2015



JUNO collaboration established



Europe (24)

France(5)
- APC Paris
- CPPM Marseille
- IPHC Strasbourg
- LLR Paris
- Subatech Nantes

Czech(1)
- Charles U

Finland(1)
- U.Oulu

Russia(2)
- INR Moscow
- JINR

Italy(7)
- INFN-Frascati
- INFN-Ferrara
- INFN-Milano
- INFN-Mi-Bicocca
- INFN-Padova
- INFN-Perugia
- INFN-Roma 3

Armenia(1)
- Yerevan Phys. Inst.

Belgium(1)
- ULB

Germany(6)
- FZ Julich
- RWTH Aachen
- TUM
- U.Hamburg
- U.Mainz
- U.Tuebingen

America(3)

US(2)
- UMD
- UMD-Geo

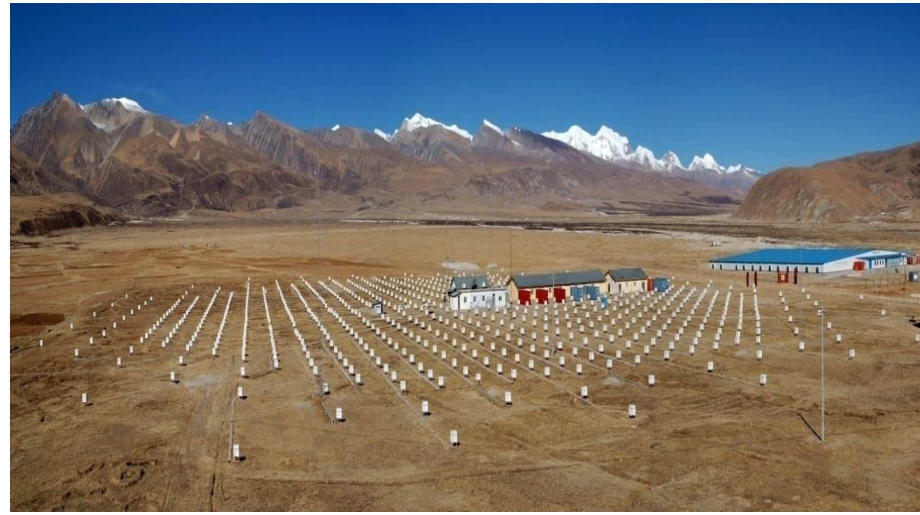
Chile(1)
- Catholic Univ. of Chile

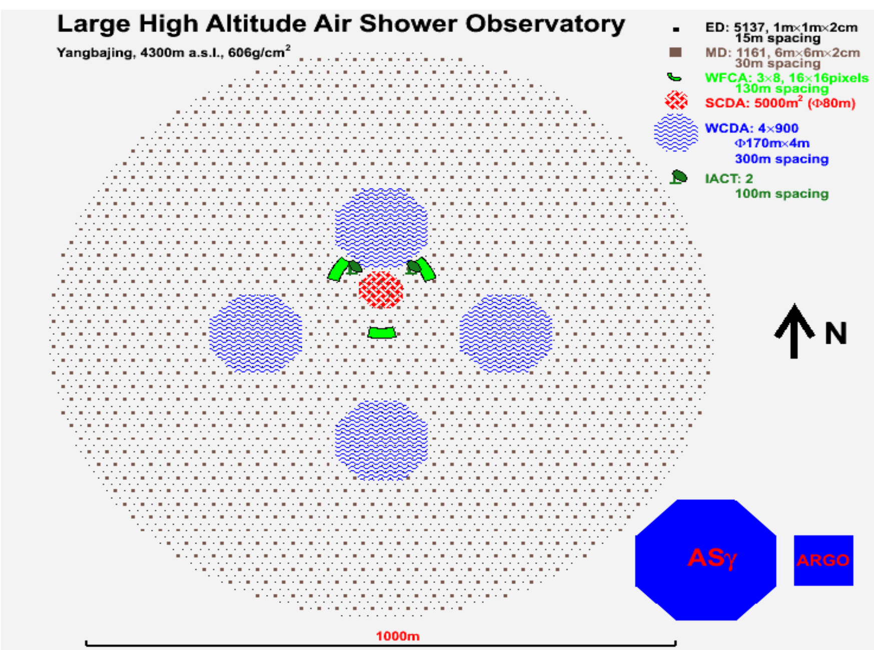
Asia (28)

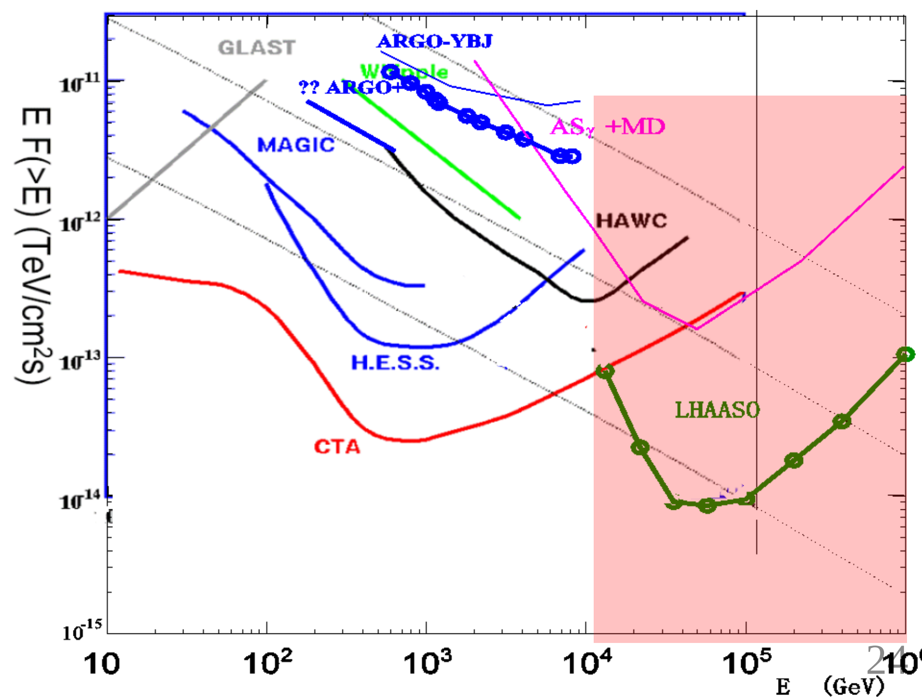
- BJ Nor. U.
- CAGS
- Chongqing U.
- CIAE
- DGUT
- ECUST
- Guangxi U.
- HIT
- IHEP
- Jilin U.
- Nanjing U.
- Nankai U.
- Natl. Chiao-Tung U.
- Natl. Taiwan U.
- Natl. United U.
- NCEPU
- Pekin U.
- Shandong U.
- Shanghai JT U.
- Sichuan U.
- SYSU
- Tsinghua U.
- UCAS
- USTC
- Wuhan U.
- Wuyi U.
- Xi'an JT U.
- Xiamen U.

From ASγ/ARGO to LHAASO

- Cosmic-rays physics and γ-ray astronomy
- Altitude ~ 4400 m @ Sichuan
- International collaboration: China, France, Italy, …
- Start construction: 2016

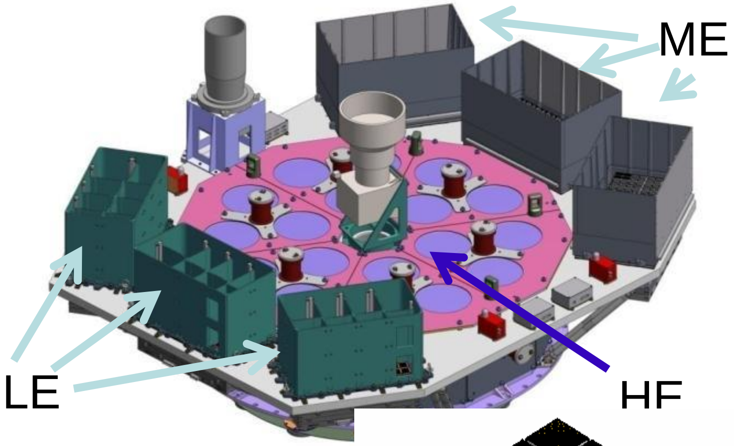


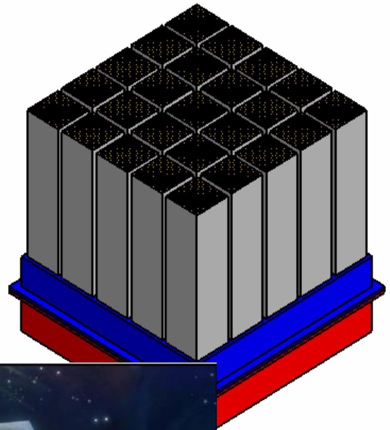


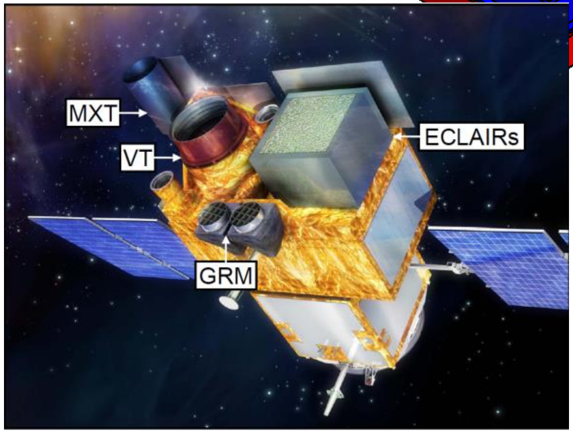


Current Space Program

- **Hard X-ray modulated telescope (HXMT):**
  - Total mass： 1021kg; Power: 350 W
  - to be launched in 2015
- **Gamma-ray burst polarization (POLAR):**
  - onboard China's Spacelab: TG-2
  - An international collaboration: China, Switzerland, France, Poland
  - Launch time ~ 2015
- **SVOM**
  - Redefined program: On board Chinese spacecraft
  - A collaboration of China and France
  - to be launched in 2017-2018
- **AMS**

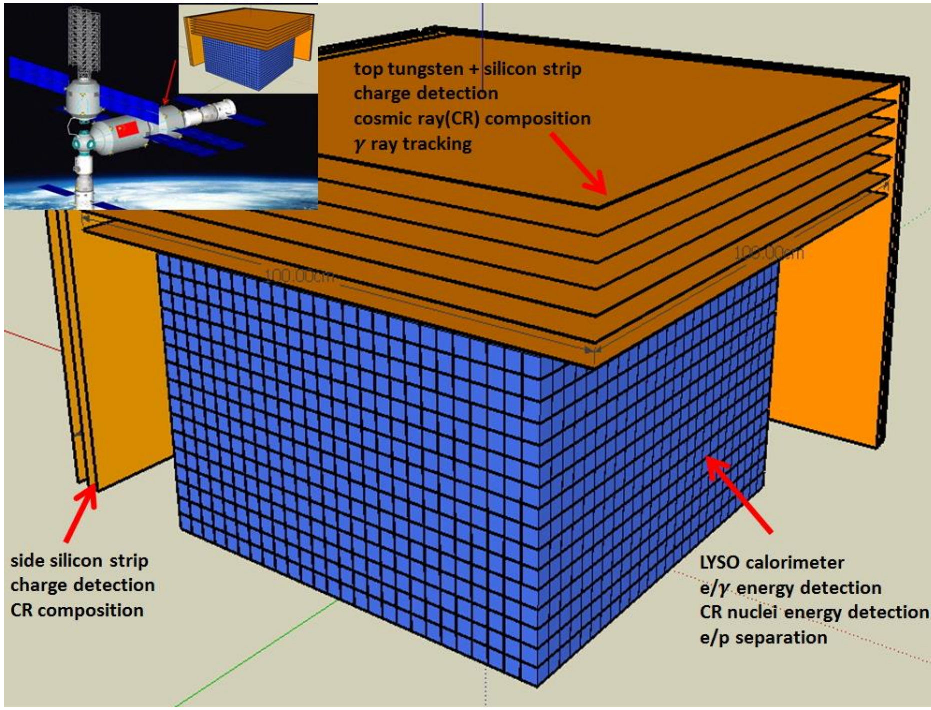






HERD @ the China's Space Station

- **Science**
  - Dark matter search: γ from 0.1 – 10,000 GeV
  - Spectral and composition measurements of CRs between 300 GeV to PeV
  - Complementary to LHAASO: directly measured composition & spectrum in space
  - Next generation cosmic-ray exp. after AMS & Fermi
- **Status**
  - Groups from China, Italy, Switzerland, Sweden,…
  - Launch in ~2023



	X0(λ)	ΔE/E for e	e/p sep	e GF m^2sr@200GeV	p GF m^2sr@100TeV
HERD (2020)	55(3)	1%	10^{-6}	3.1	2.3
Fermi (2008)	10	12%	10^{-3}	0.9	--
AMS02 (2011)	17	2%	10^{-6}	0.12	--
DAMPE (2015)	31	1%	10^{-4}	0.3	--
CREAM (2015)	20(1.5)	--	--	--	0.2

Facilities for other Sciences

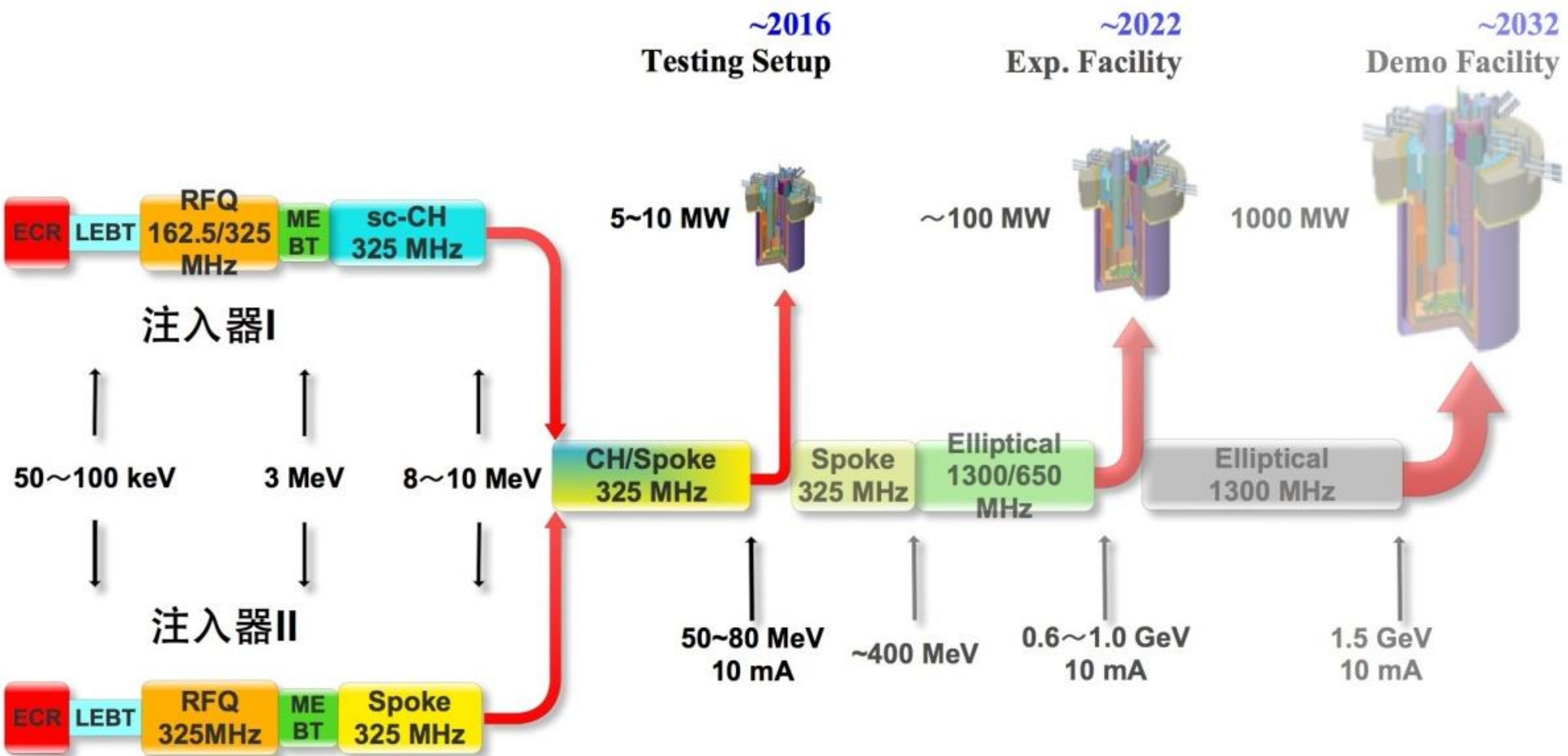
Chinese Spallation Neutron Source

Phase I： 100 kW Phase II： 500 kW
Start time: 2011 Completion time: 2017

- Started: mass production of equipment, LINAC installation
- Completed: target station & spectrometer engineering design, Civil construction of office

- Located in Dongguan, Guangdong

ADS R&D

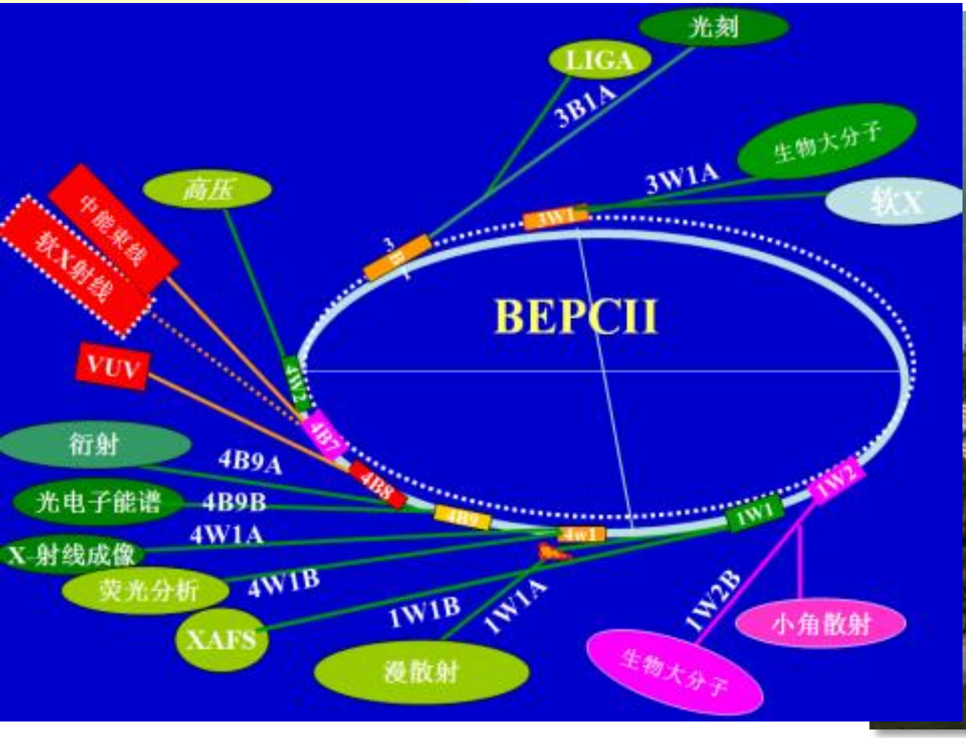


- High beam power （CW）
- Very high stability
- Very low beam loss：<1W/m .

Currently for injectors

- CW RFQ with a high intensity
- Very Low beta SC cavities

BSRF: planning for future



BSRF： 3 months operation in specific mode；6 months parasitic mode. Every year ~500 experiments.

HEPS R&D: a new machine with 1260 m circumference. R&D projects under government review

Summary

- **For the past 30 years, particle physics in China experienced an enormous growth, thanks to the economical growth of China.**
- **A lot more projects in the future.**
- **We had a lot of collaborations with international projects, such as LHC@CERN, Panda@Fair, BELLEII@SuperKEKB, EXO, COMET, …**
- **Looking forward further collaborations with Pakistan**