Particle and Astro-Particle Physics in China

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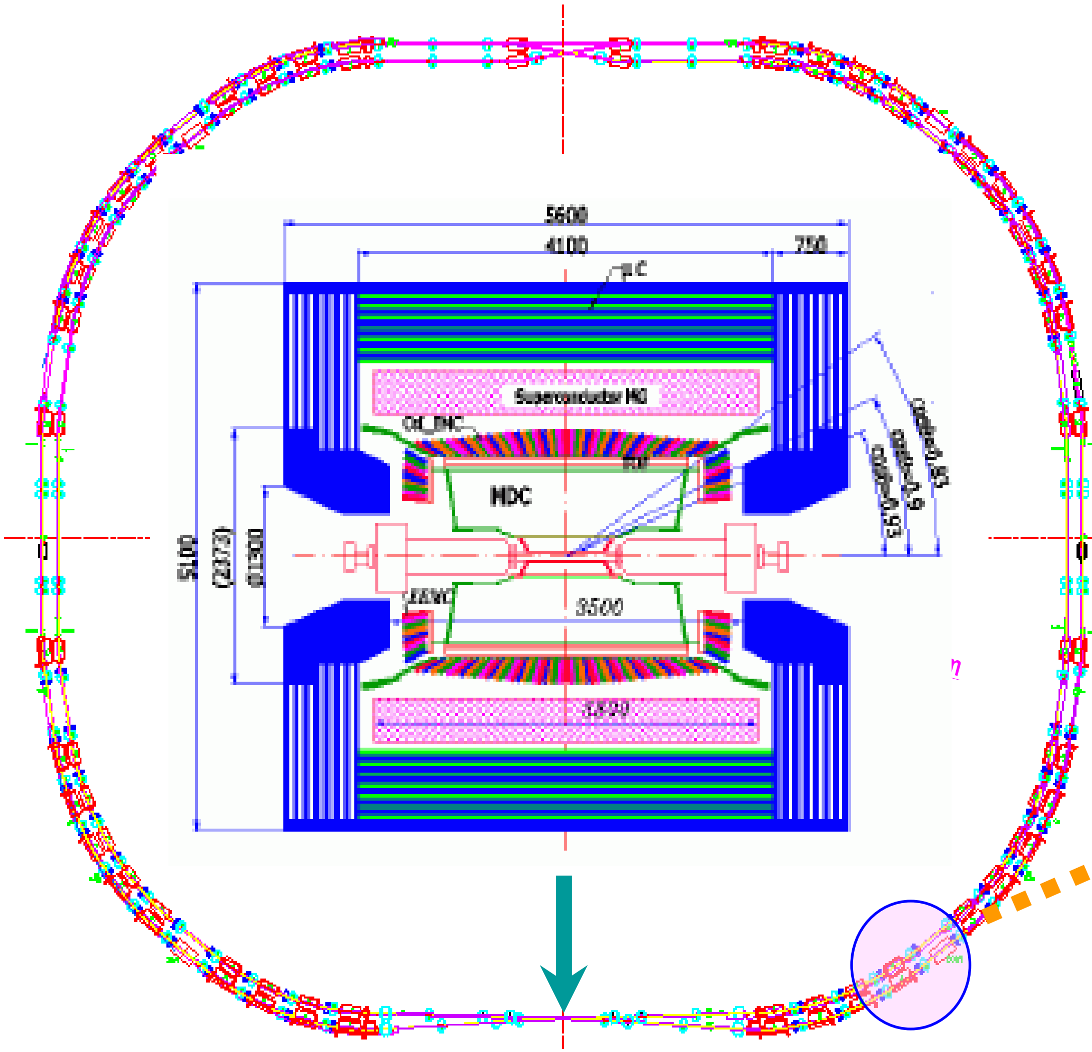
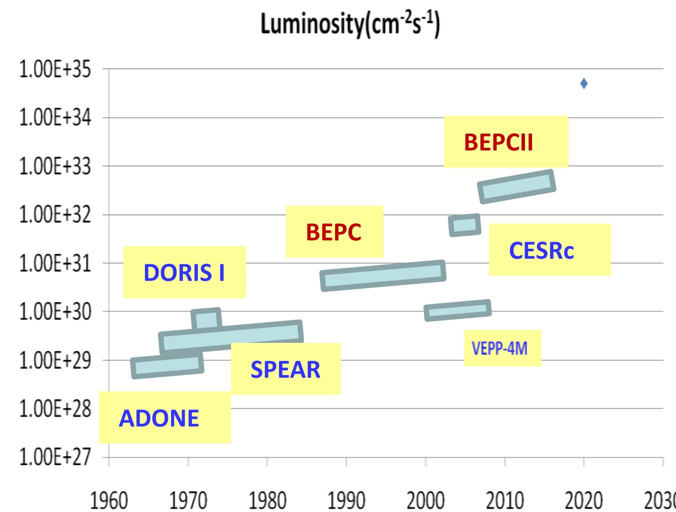
Institute of High Energy Physics

LISHEP 2018, Sep. 12, 2018

HEP in China Started from BEPC





BEPCII/BESIII Upgrade: 2004-2008

BESIII Collaboration

Europe (16)

Germany: Univ. of Bochum, Univ. of Giessen, GSI, Univ. of Johannes Gutenberg, Helmholtz Ins. In Mainz, Univ. of Munster
Russia: JINR Dubna; BINP Novosibirsk
Italy: Univ. of Torino, Frascati Lab, Ferrara Univ.
Netherland: KVI-CART/Univ. of Groningen
Sweden: Uppsala Univ.
Turkey: Turkey Accelerator Center
UK: Oxford Univ., Univ. of Manchester

US (4)

Univ. of Hawaii
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Indiana

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

Mongolia (1)

Institute of Physics and Technology

India (1)

Indian Institute of Technology

Pakistan (2)

Univ. of Punjab
COMSAT CIIT

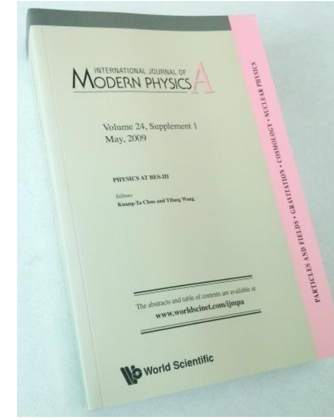
China(37)

IHEP, CCAST, UCAS, Shandong Univ., Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll., Shanghai Jiaotong Univ.
Huazhong Normal Univ., Wuhan Univ., Xingyang Normal Univ.
Zhengzhou Univ., Henan Normal Univ., Hunan Normal Univ.
Peking Univ., Tsinghua Univ. , *Beijing Inst. of Petro-chemical Tech.*
Zhongshan Univ.,Nankai Univ., Beihang Univ.
Shanxi Univ., Sichuan Univ., Univ. of South China
Hunan Univ., Liaoning Univ., Univ. of Sci. and Tech. Liaoning
Nanjing Univ., Nanjing Normal Univ., Southeast Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Jinan Univ., Fudan Univ.

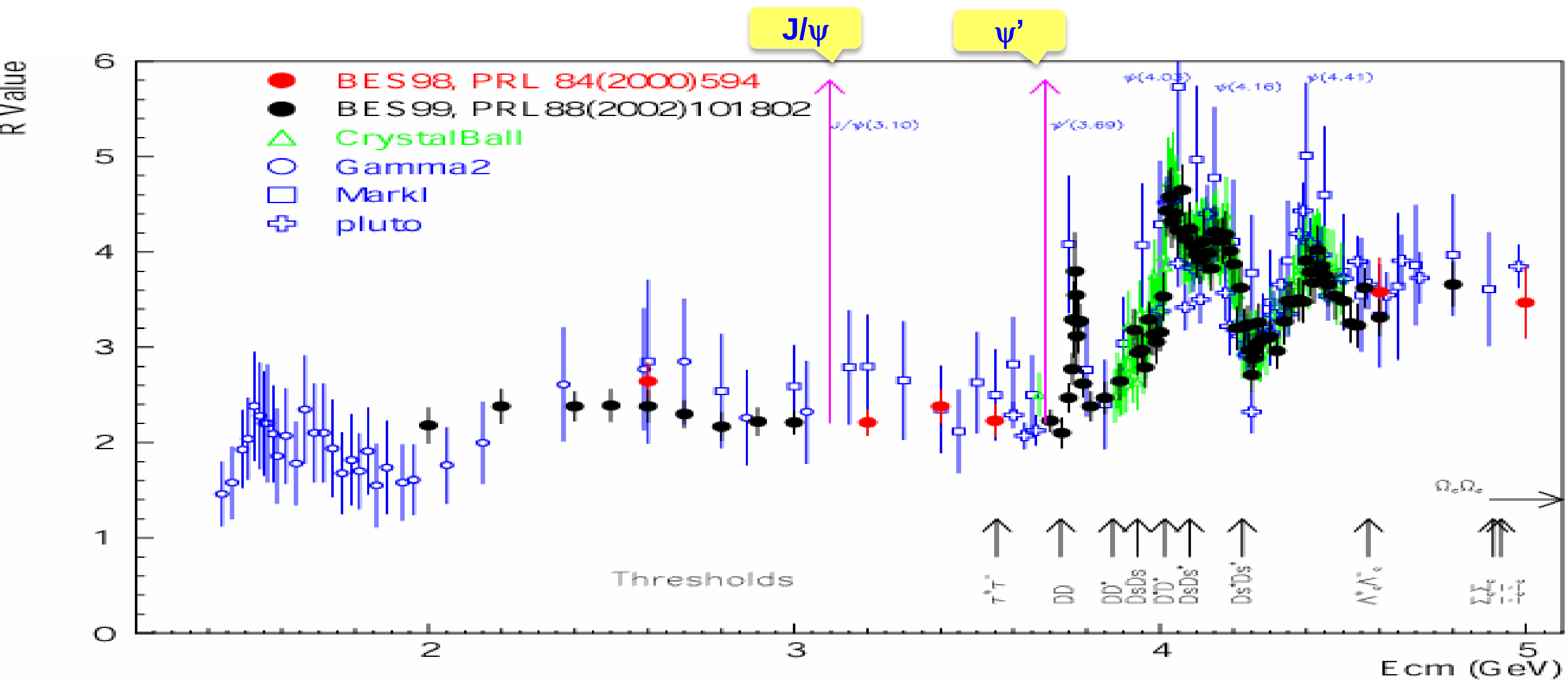
~ 450 members
from 64 institutions in 14 countries

Physics at BESIII

- Hadron spectroscopy and non-conventional hadron searches
- Charmonium production and decays: XYZ states
- Precision study of R, form factors, tau mass, CKM matrix, etc.

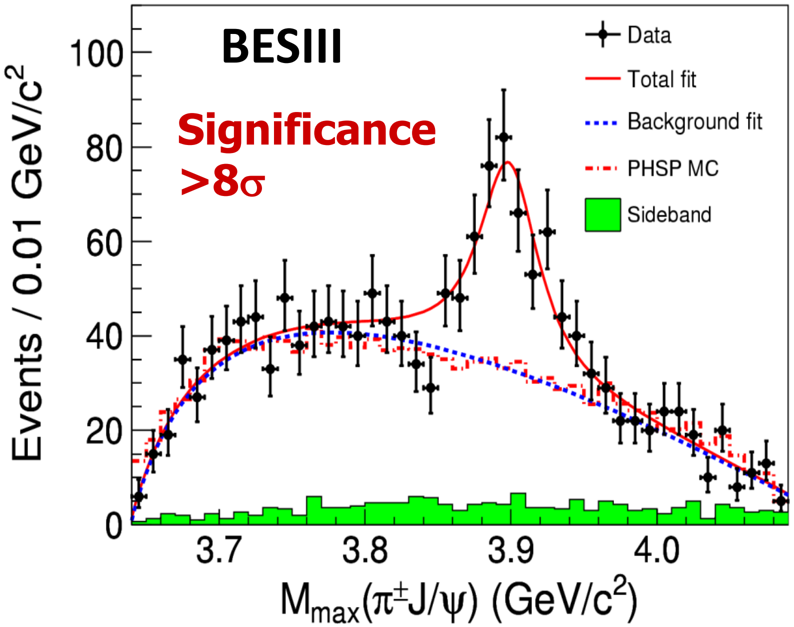


Int. J. Mod. Phys. A, Vol. 24 (2009)



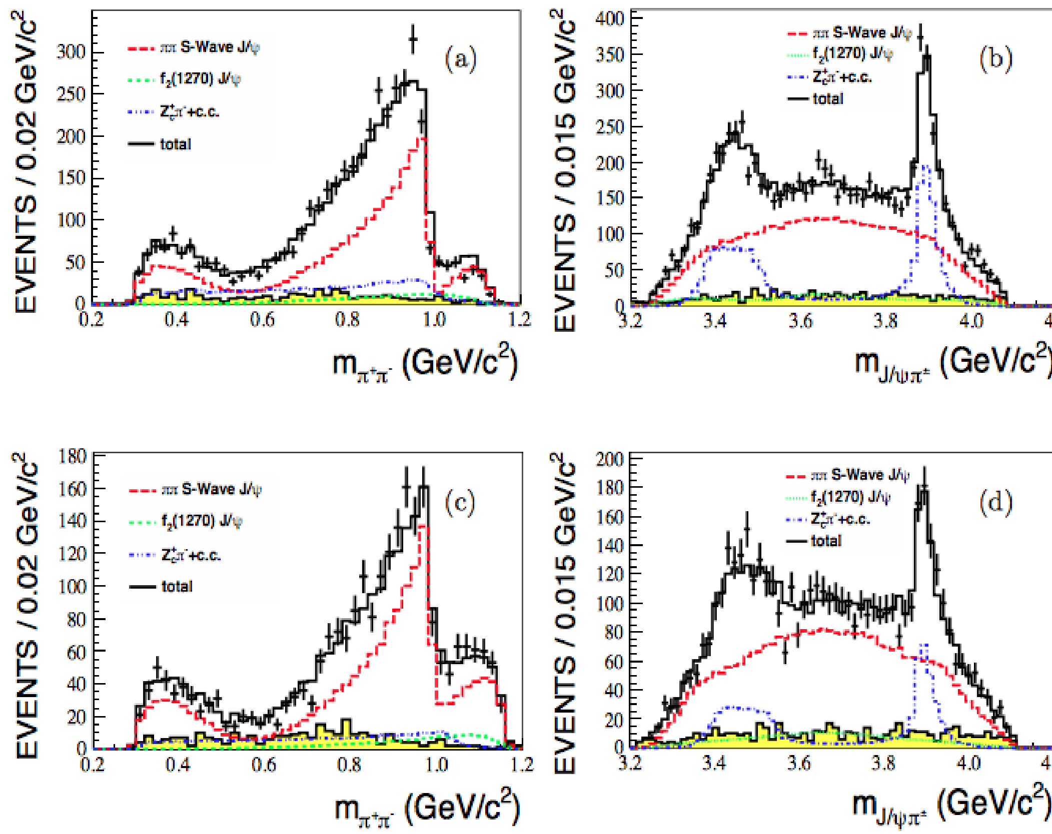
$Z_c^+(3900)$ in $e^+e^- \rightarrow Y(4260) \rightarrow \pi^+\pi^- J/\psi$

BESIII: PRL110, 252001 (2013)



- M = 3899.0±3.6±4.9 MeV
- Γ = 46±10±20 MeV
- 307 ± 48 events

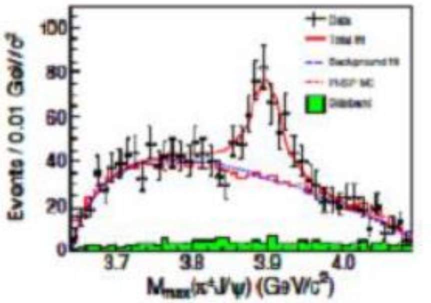
PRL 119, 072001 (2017)



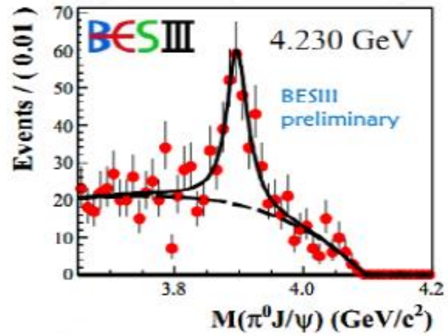
J^P of Zc favor 1^+ @7.3σ over others

- Amplitude analysis with helicity formalism
- Simultaneous fit to data at 4.23 & 4.26GeV

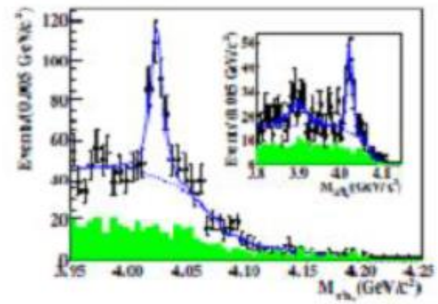
Many Z_c's at BESIII



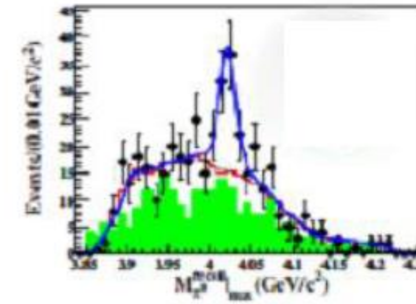
$e^+e^- \to \pi^-\pi^+ J/\psi$



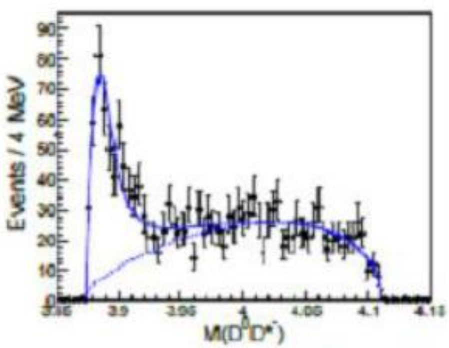
$e^+e^- \to \pi^0\pi^0 J/\psi$



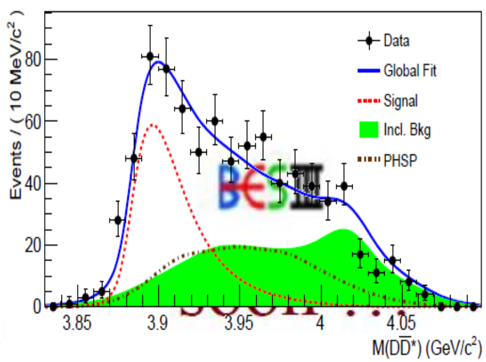
$e^+e^- \to \pi^-\pi^+ h_c$



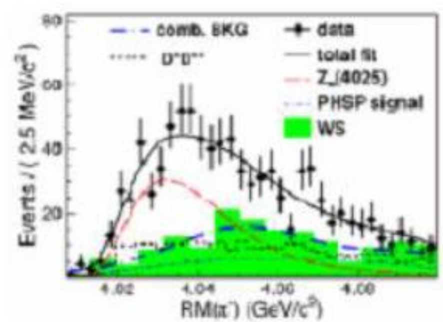
$e^+e^- \to \pi^0\pi^0 h_c$



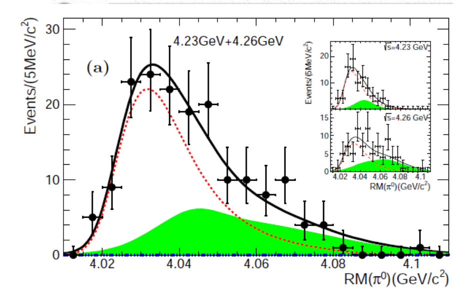
$e^+e^- \to \pi^-(D\bar{D}^*)^+$



$e^+e^- \to (D\bar{D}^*)^0\pi^0$



$e^+e^- \to \pi^-(D^*\bar{D}^*)^+$



$e^+e^- \to \pi^0 (D^*\overline{D^*})^0$

$Z_c(3900)^+$?

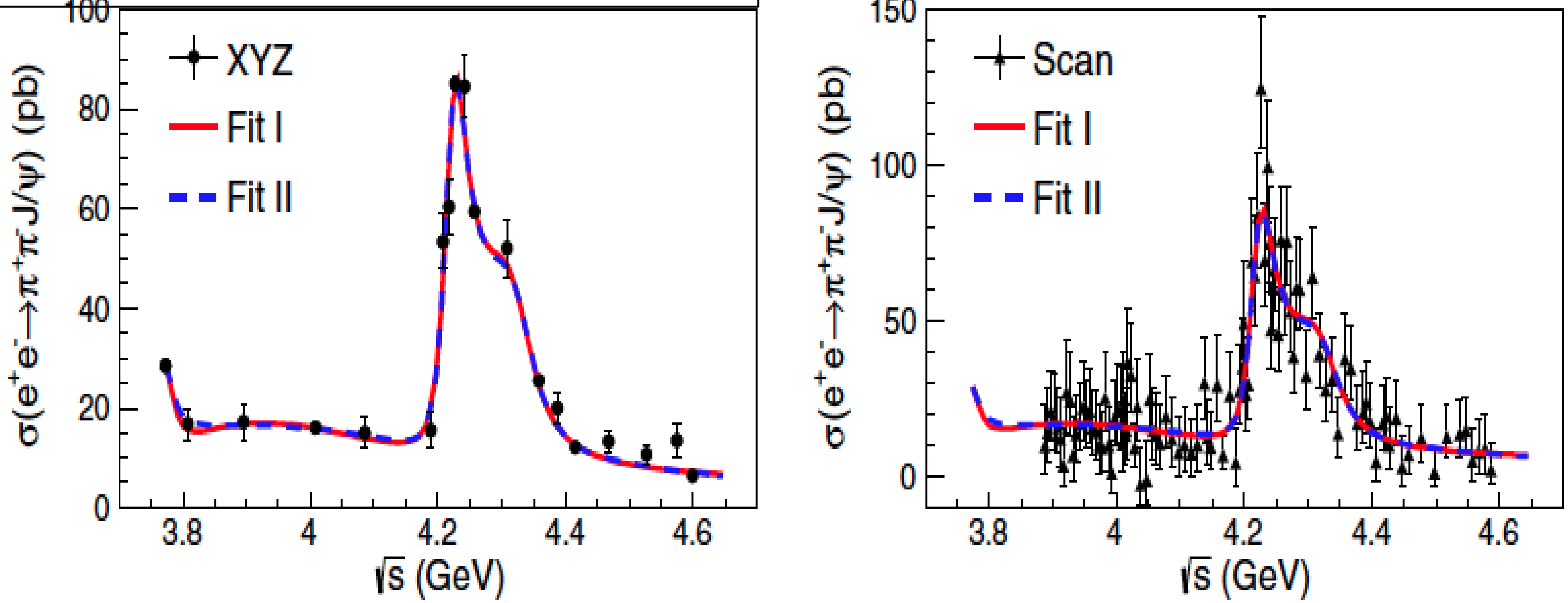
$Z_c(3900)^0$?

$Z_c(4020)^+$?

$Z_c(4020)^0$?

Y(4260): with structures

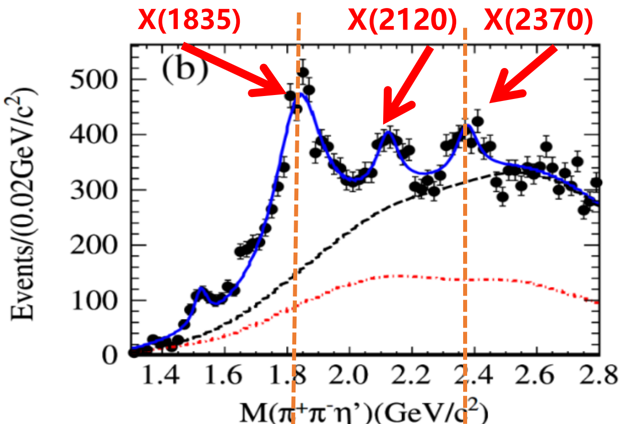
Phys. Rev. Lett. 118, 092001 (2017)



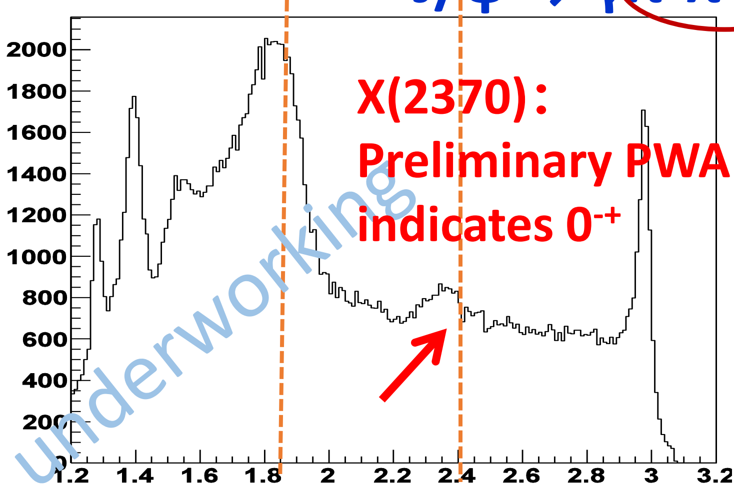
- Coherent sum of two BW-like structures + one incoherent ψ(3770)
  - M = (4222.0 ± 3.1 ± 1.4) MeV, Γ = (44.1 ± 4.3 ± 2.0) MeV
    Lower and narrower than previous Y(4260) PDG values
  - M = (4320.0 ± 10.4 ± 7) MeV, Γ = (101.4 ± 25 ± 10) MeV
    a little bit lower than Y(4360) PDG value
- Compared with one BW fit, the sig. of the second BW is 7.6σ
- Y(4260) + Y(4360) ? The first observation of Y(4360)→$\pi^+\pi^-J/\psi$?

Systematic study of glueballs at BESIII
-- X(2370): a 0^{-+} glueball candidate

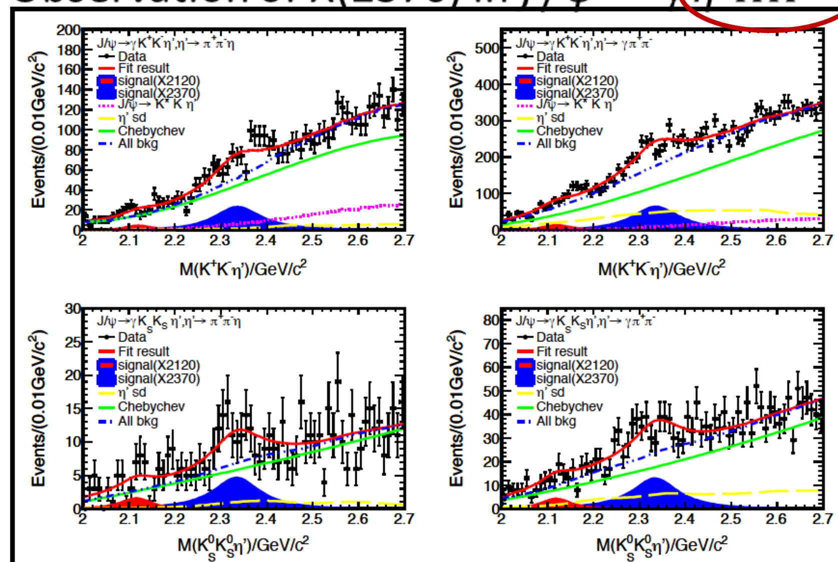
PRL 106 072002 $J/\psi \rightarrow \gamma\eta' \pi^+\pi^-$



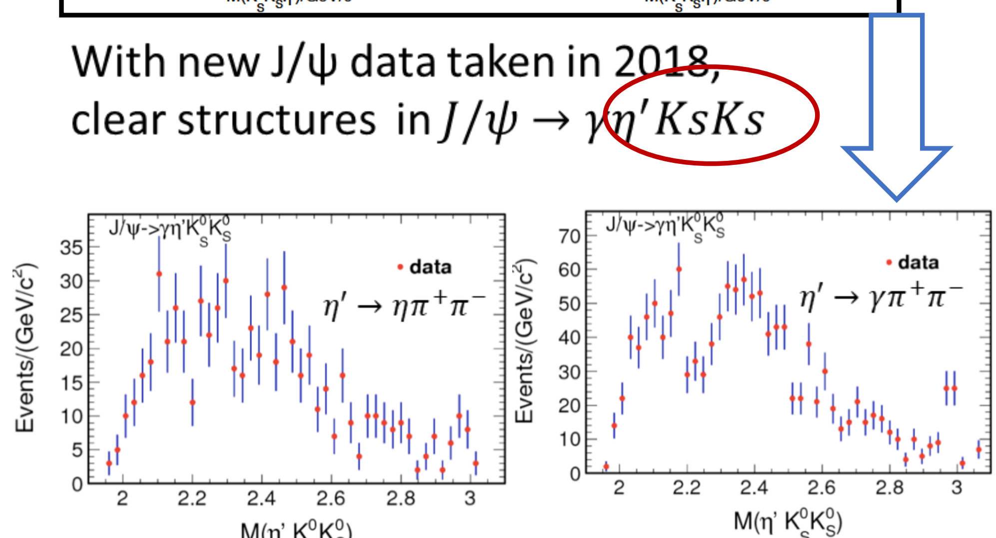
$J/\psi \rightarrow \gamma\pi^0\pi^0\eta$



Observation of X(2370) in $J/\psi \rightarrow \gamma\eta' KK$



With new J/ψ data taken in 2018, clear structures in $J/\psi \rightarrow \gamma\eta' KsKs$



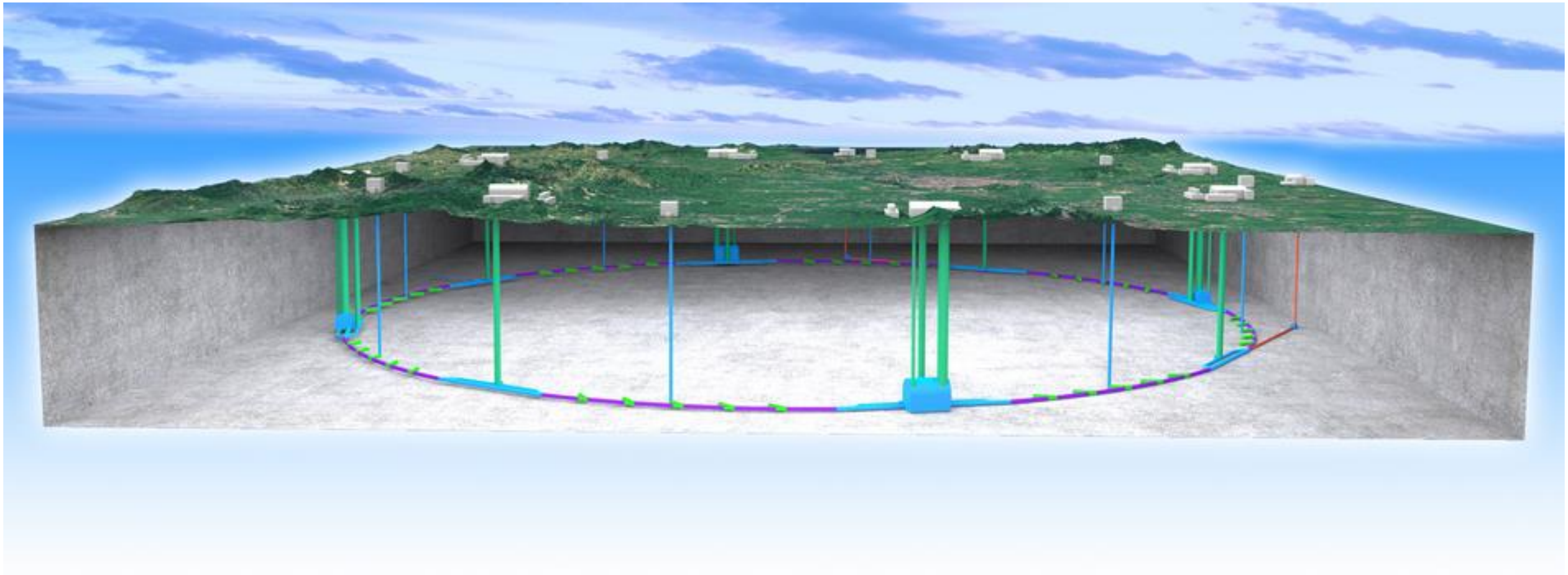
Future Plan of BEPCII/BESIII

- Up to now, ~ 20-30 papers/year, ~ 200 papers in total
- Minor upgrades completed, more under study
- BEPCII/BESIII will continue to operate for another ~8 years.

	Previous data	BESIII present	Goal
J/ψ	BESII 58M	6 B 120* BESII	10 B
ψ'	CLEO： 28 M	0.5 B 20* CLEOc	3B
ψ"	CLEO： 0.8/fb	2.9/fb 3.5*CLEOc	20 /fb
Above open charm threshold	CLEO： 0.6/fb @ ψ(4160)	0.5/fb @ ψ(4040) 2.3/fb@~4260, 0.5/fb@4360 0.5/fb@4600， 1/fb@4420 Scan from 4.19 – 4.28, 10 MeV step, 500 pb^{-1}/point, 7 points	5-10 /fb
R scan & Tau	BESII	3.8-4.6 GeV at 105 energy points 2.0-3.1 GeV at 20 energy points	
Y(2175)		100 pb^{-1}	
ψ(4160)		3 fb^{-1}	

Next step: CEPC — Higgs factory

- Since 2005, we were discussing the next machine after BEPC/BEPCII
- Thanks to the low mass Higgs, there is the possibility to build a Higgs Factory: Circular e+e- Collider(CEPC)
  - Looking for Hints (from Higgs) ➔ direct searches
  - The tunnel can allow us to build pp, AA, ep colliders in the far future: Super proton-proton Collider(SppC)



Science of CEPC-SPPC

- Electron-positron collider(90, 250 GeV)
  - Higgs Factory（10^6 Higgs）：
    - Precision study of Higgs(m_H, J^{PC}, couplings)，Similar & complementary to ILC
    - Looking for hints of new physics
  - Z & W factory（10^{10} Z^0）：
    - precision test of SM
    - Rare decays ?
  - Flavor factory: b, c, τ and QCD studies
- Proton-proton collider(~100 TeV)
  - Directly search for new physics beyond SM
  - Precision test of SM
    - e.g., h^3 & h^4 couplings

Precision measurement + searches:

Complementary with each other !

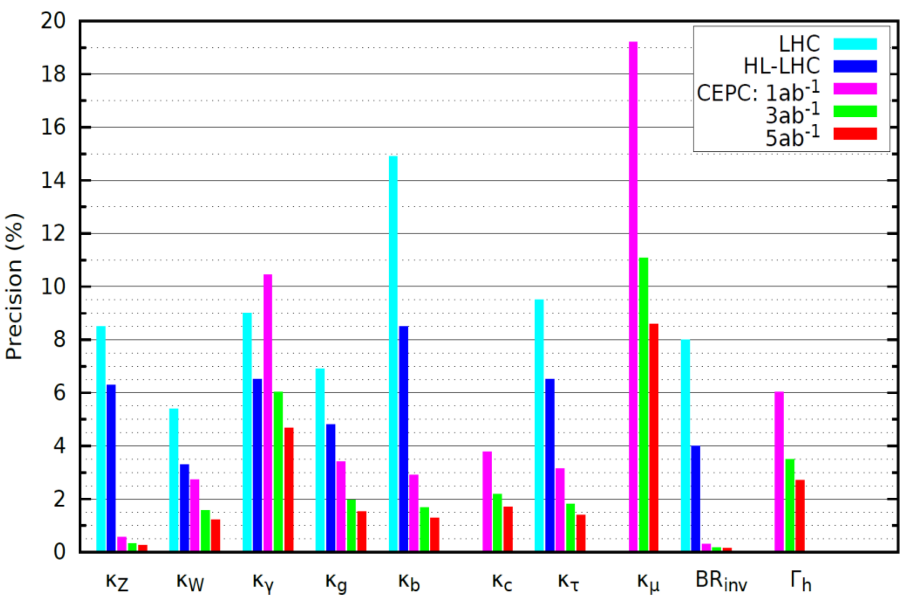
Precision Higgs Physics by CEPC

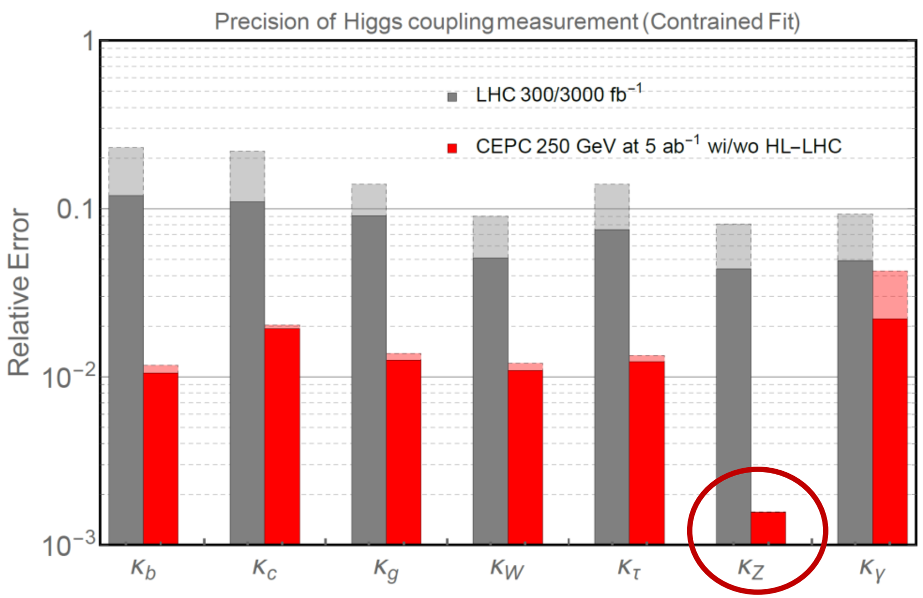
$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{c_i}{M^2} \mathcal{O}_{6,i} \qquad \delta \sim c_i \frac{v^2}{M^2}$$

A total of 10^6 Higgs
% precision ➔ M ~1 TeV
to new physics ➔ ~ ×10 over LHC

Only elementary particle
- with spin 0
- with non-gauge interactions

Related to "problems" of SM
A Step can not be skipped

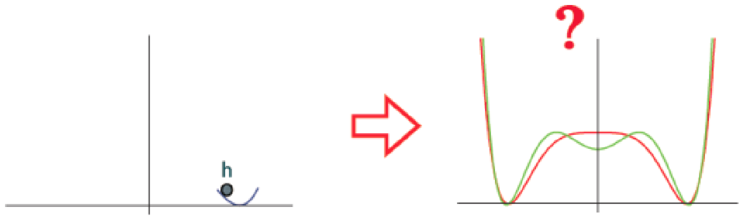


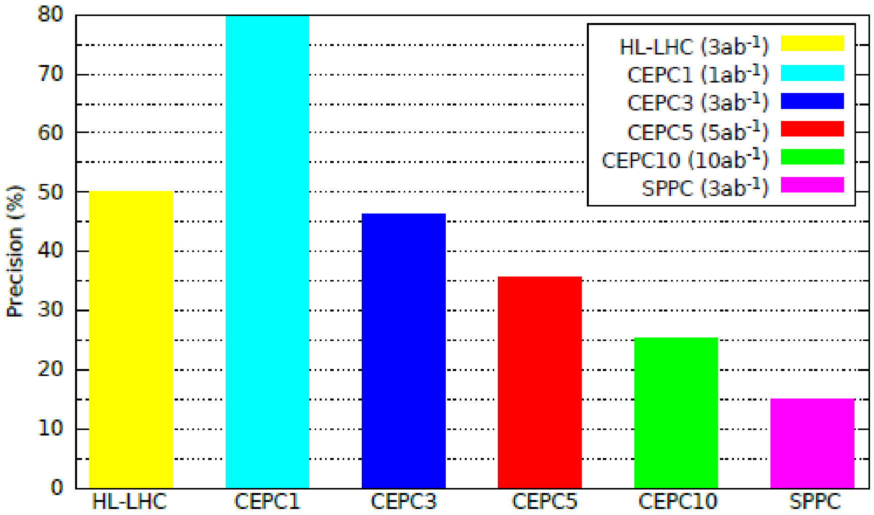


CEPC preCDR Volume 1 (p.9)

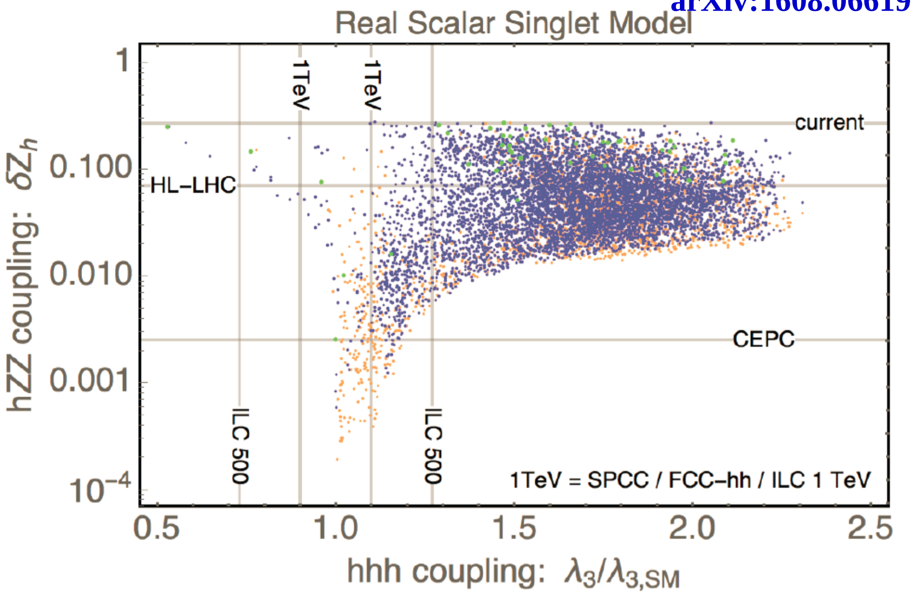
Nature of EW Phase Transition ?

- 1^{st} or 2^{nd} order ➔ Huge implications
  - O(1) deviations in h^3 coupling
  - O(1%) shift in h-Z coupling
- CEPC can determine it:
  - h^3 coupling at CEPC： 20-30%
  - h-Z coupling at CEPC： < 0.2%





arXiv:1608.06619

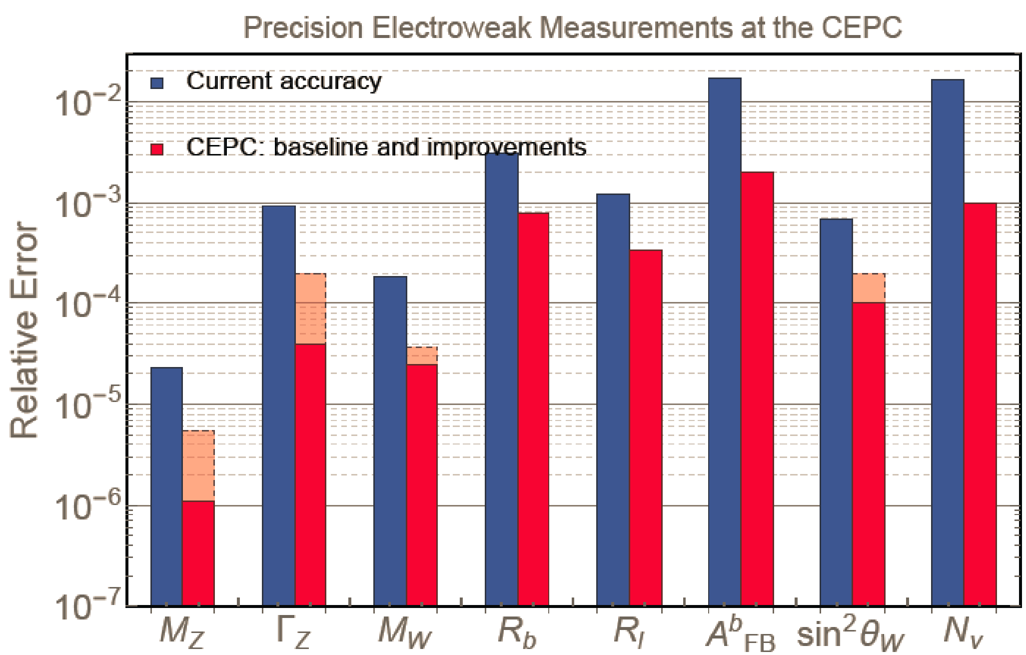


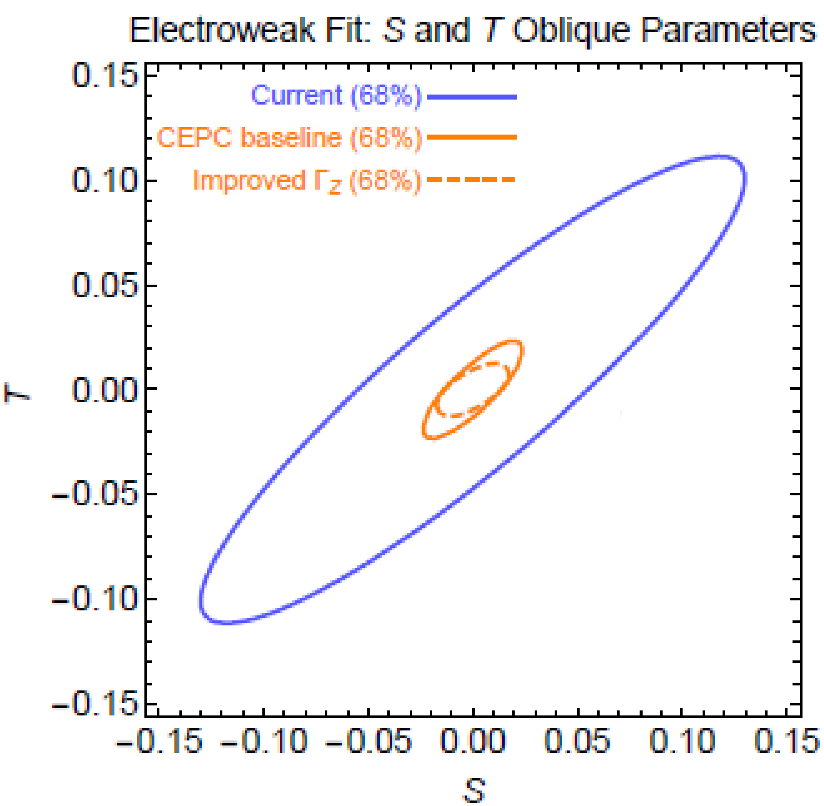
2018-9-12

M. McCullough, PRD 90(2014)015001

Improvement in Electroweak Precision

- A total of 10^{10} Z
- **A detailed study of Z & W to look for deviations from the Standard Model**
- **Can probe new physics up to ~ TeV， better than HL-LHC by a factor of 3**

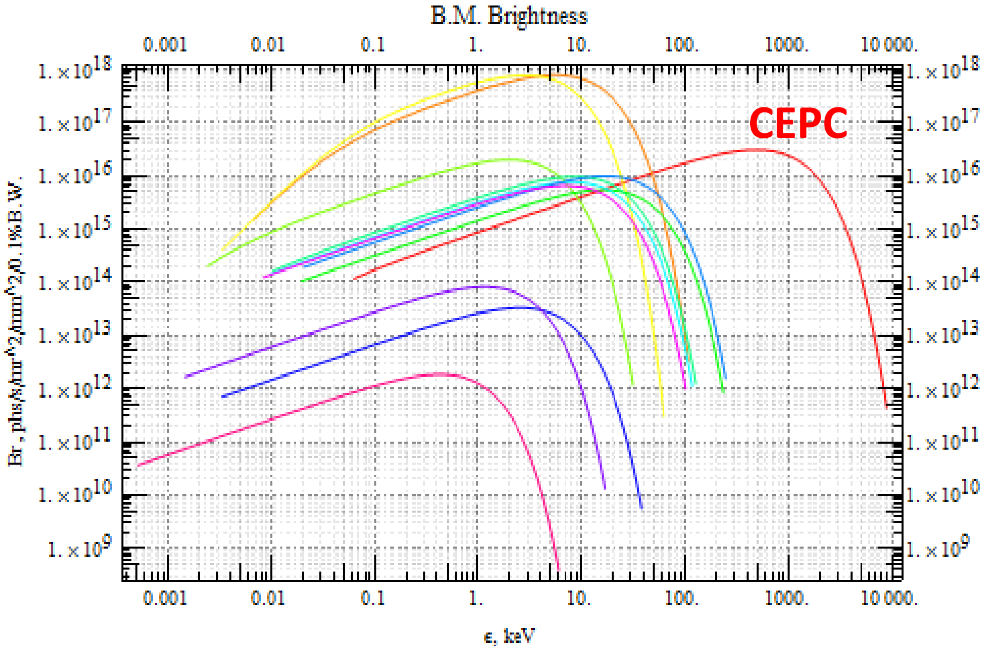


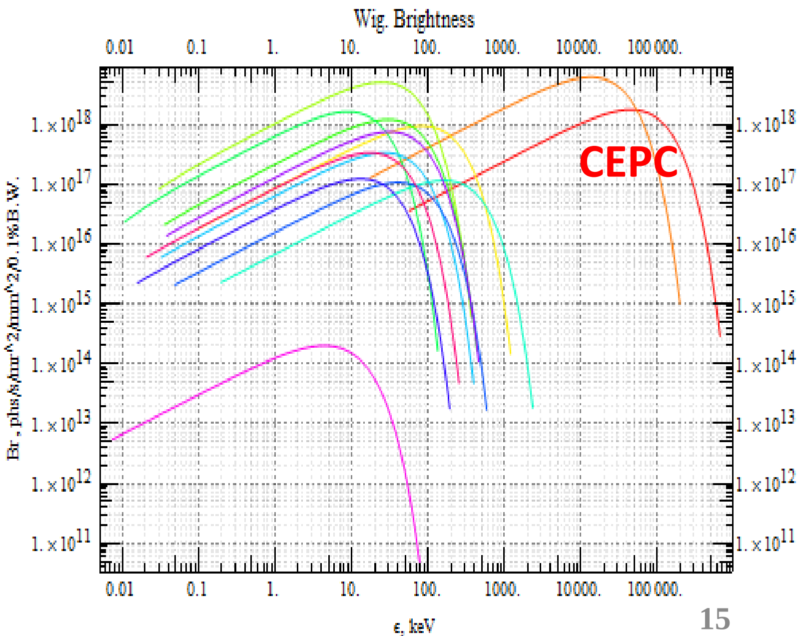


CEPC preCDR Volume 1 (p.10)

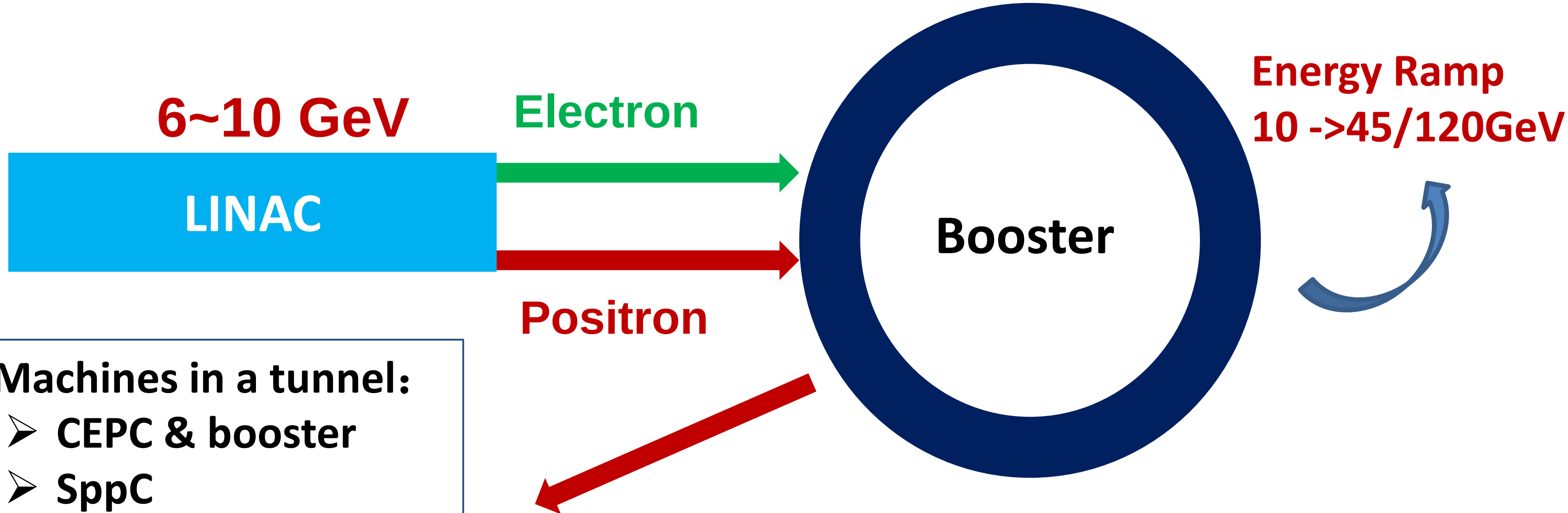
CEPC is also a great light source

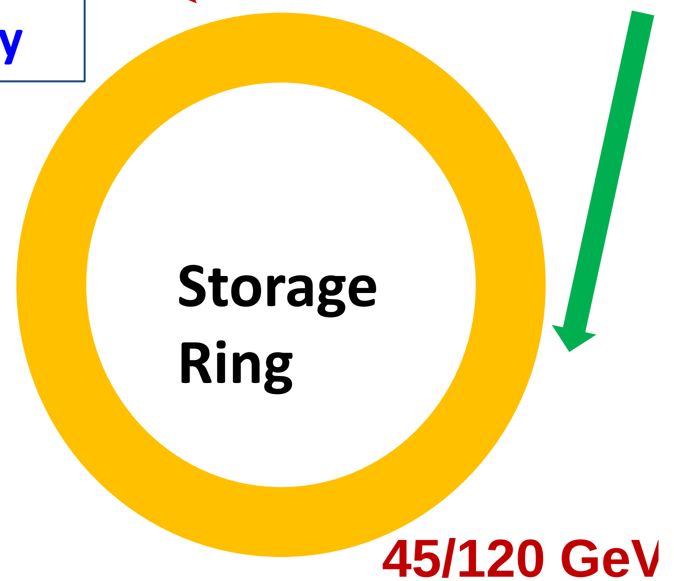
- From dipole magnet, the photon energy can reach 628keV.
- From Wiggler or undulator， the photon energy can reach 100MeV
- Incredible application on nuclear physics, material science, micro-processing, etc.





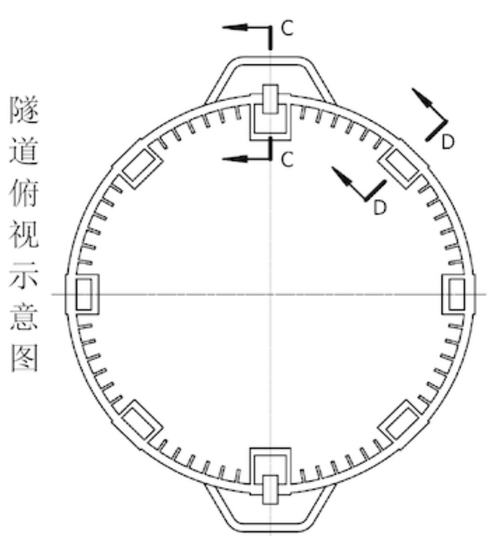
CEPC Accelerator Design

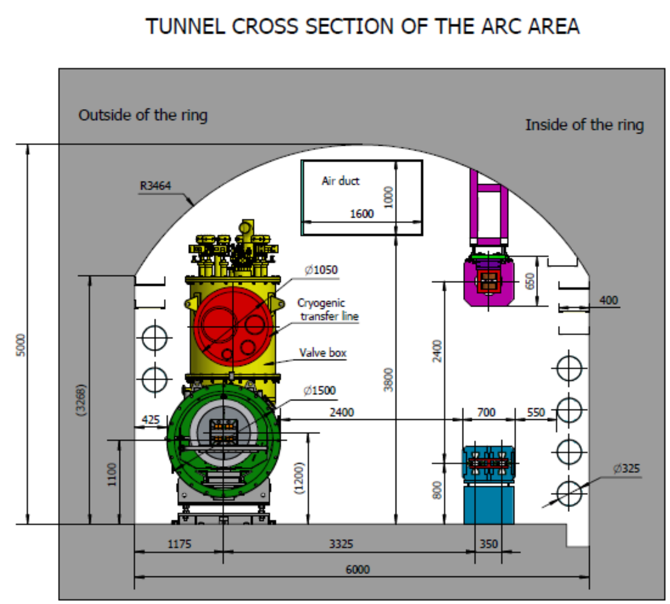




3 Machines in a tunnel:
- CEPC & booster
- SppC

Compatibility is the key

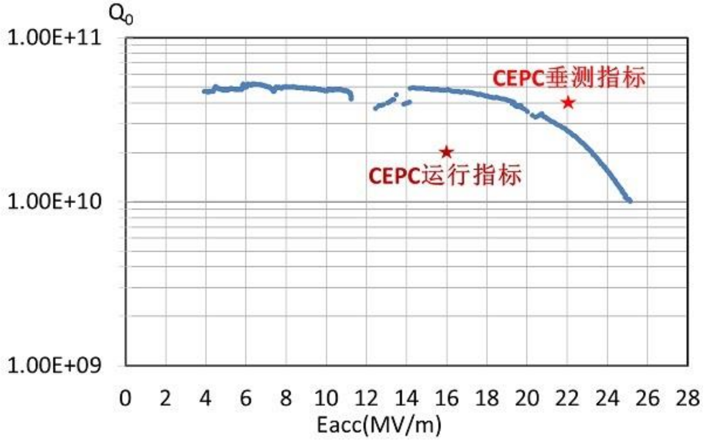




Main Parameters

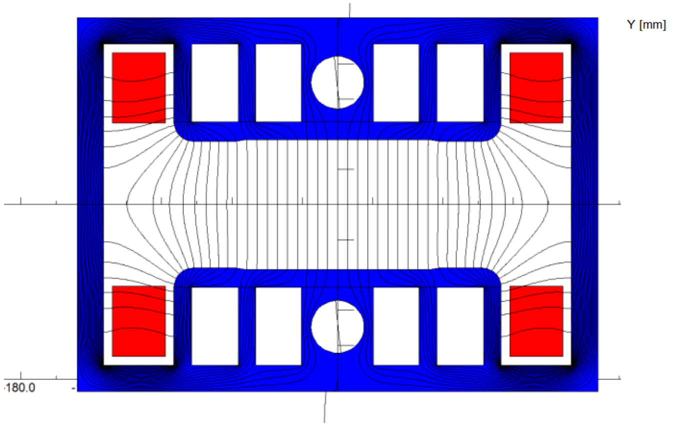
	Higgs	*W*	*Z（3T）*	*Z（2T）*
Number of IPs	2			
Beam energy (GeV)	120	80	45.5	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5×2			
Piwinski angle	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (bunch spacing)	242 (0.68μs)	1524 (0.21μs)	12000 (25ns+10%gap)	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power /beam (MW)	30	30	16.5	
Bending radius (km)	10.7			
Momentum compact (10^{-5})	1.11			
β function at IP β_x^* / β_y^* (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.031/0.109	0.013/0.106	0.0041/0.056	0.0041/0.072
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)			
Natural bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	5.9	8.5	
Betatron tune ν_x/ν_y	363.10 / 365.22			
Synchrotron tune ν_s	0.065	0.0395	0.028	
HOM power/cavity (2 cell) (kw)	0.54	0.75	1.94	
Natural energy spread (%)	0.1	0.066	0.038	
Energy acceptance requirement (%)	1.35	0.4	0.23	
Energy acceptance by RF (%)	2.06	1.47	1.7	
Photon number due to beamstrahlung	0.29	0.35	0.55	
Lifetime _simulation (min)	100			
Lifetime (hour)	0.67	1.4	4.0	2.1
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP L ($10^{34}cm^{-2}s^{-1}$)	2.93	10.1	16.6	32.1

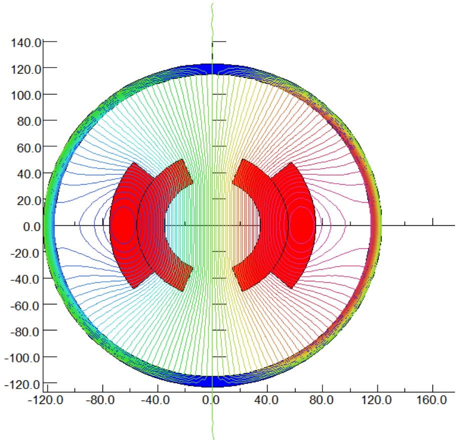
R&D and Prototypes

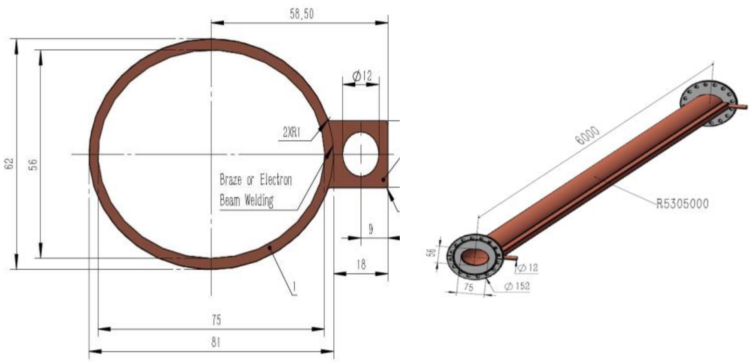


Collaborating on Klystrons

Superconducting RF Cavities







6m long vacuum pipes(Al & Cu)

High precision, low field dipole magnet

CEPC Schedule (ideal)

design issues
R&D items
preCDR

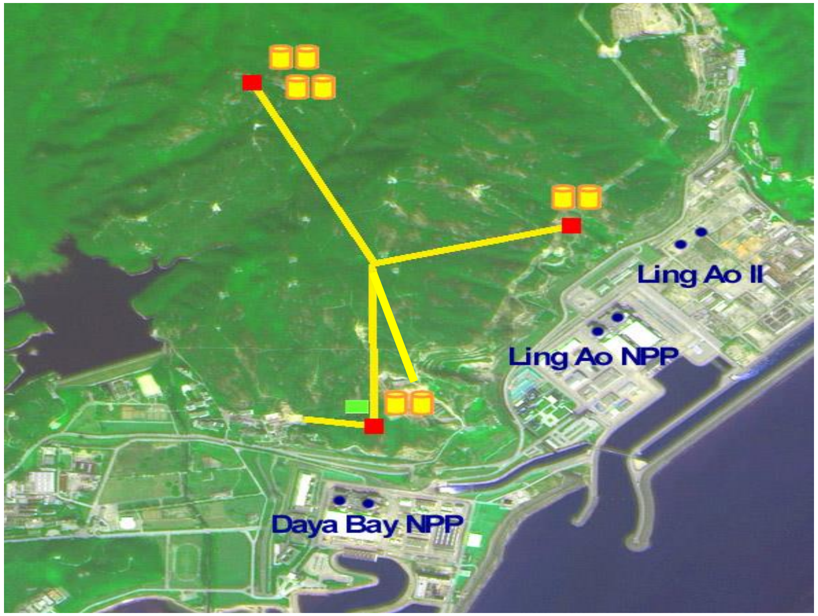
design, funding
R&D program
Intl. collaboration
site study

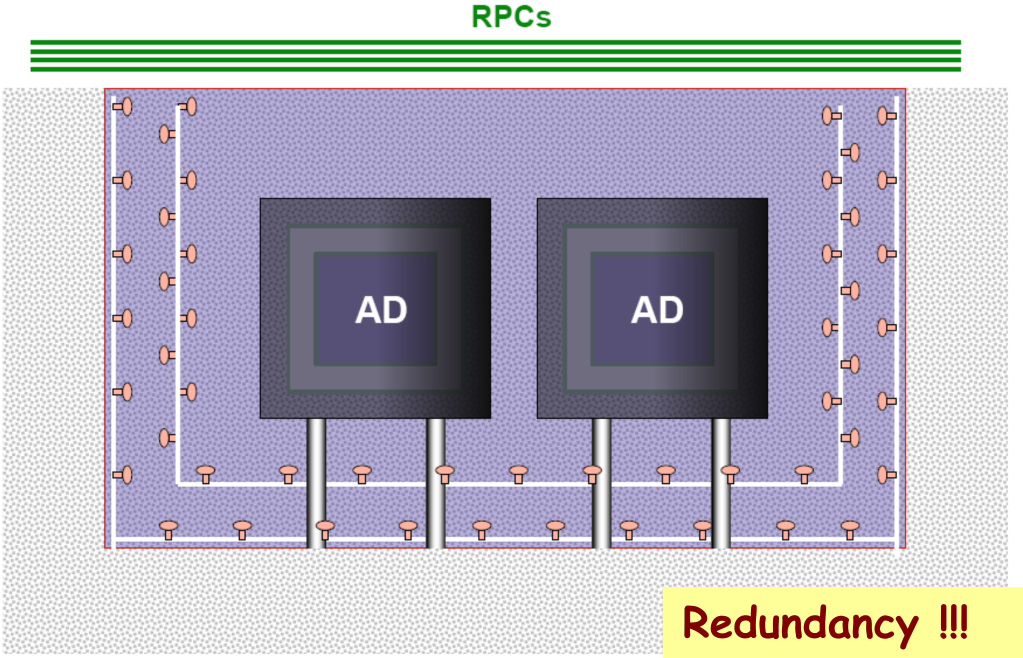
seek approval, site decision
construction during 14th 5-year plan
commissioning

Major Projects: Current and Future

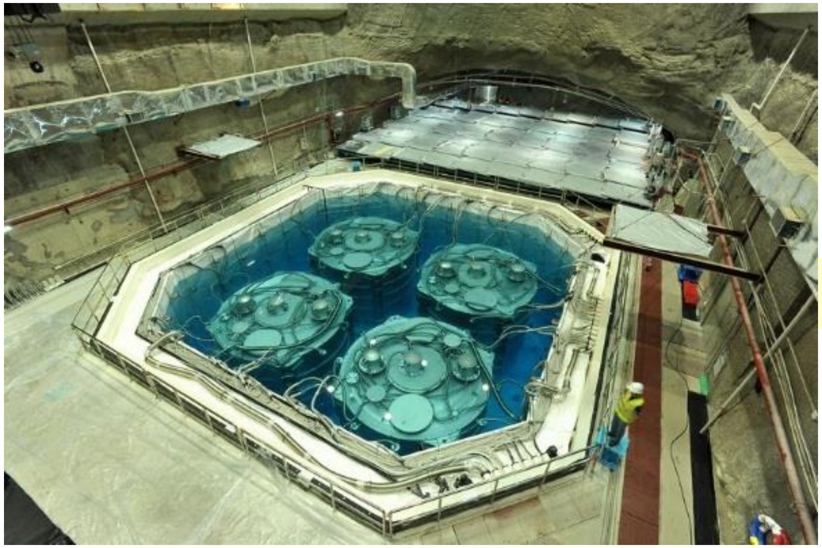
		Current	Future
Accelerator -based	Precision frontier	BESIII	ILC, FCC ? CEPC ➔ SppC ?
		LHCb, Belle II、PANDA、COMET	
	Energy frontier	CMS、ATLAS	
Non-accelerator-based	Underground	Daya Bay	JUNO
		Jinping: PANDAx, CDEX	Exp. ?
	Surface	ARGO/ASγ	LHASSO
	Space	AMS	HERD ? XTP ?
		HXMT,Polar,DAMPE	

Daya Bay Experiment



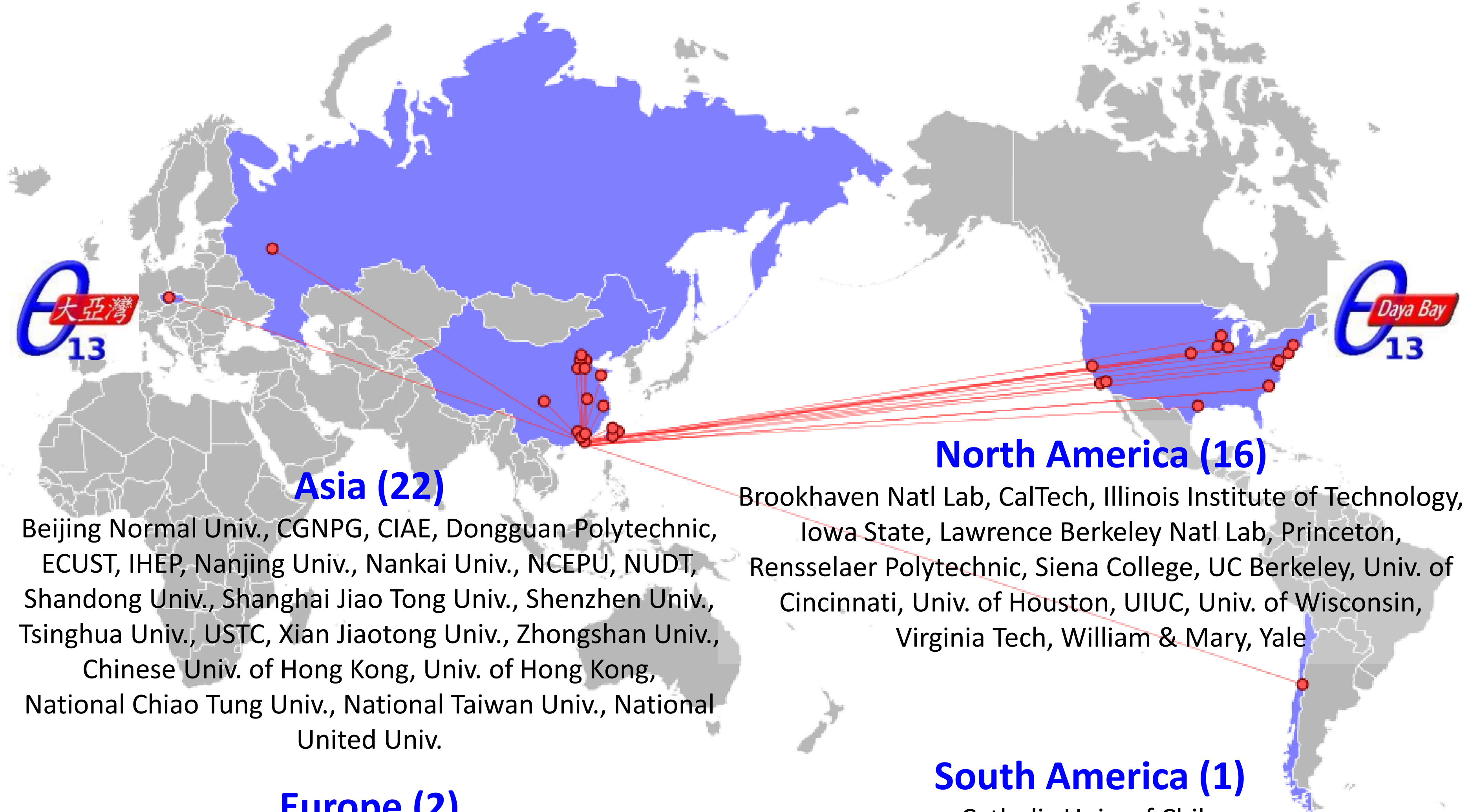


- **Successful construction(2007-2011):**
  - ⇨ 3 km tunnel, 5 halls
  - ⇨ 200t Gd-loaded LS, 8 identical detector modules
  - ⇨ 3 water Č detectors
  - ⇨ 3200 m2 RPC detectors
  - ⇨ 8000 readout channels
  - ⇨ Calibration system



Daya Bay Collaboration

41 institutions, 193 collaborators



Asia (22)

Beijing Normal Univ., CGNPG, CIAE, Dongguan Polytechnic, ECUST, IHEP, Nanjing Univ., Nankai Univ., NCEPU, NUDT, Shandong Univ., Shanghai Jiao Tong Univ., Shenzhen Univ., Tsinghua Univ., USTC, Xian Jiaotong Univ., Zhongshan Univ., Chinese Univ. of Hong Kong, Univ. of Hong Kong, National Chiao Tung Univ., National Taiwan Univ., National United Univ.

Europe (2)

Charles University, JINR Dubna

North America (16)

Brookhaven Natl Lab, CalTech, Illinois Institute of Technology, Iowa State, Lawrence Berkeley Natl Lab, Princeton, Rensselaer Polytechnic, Siena College, UC Berkeley, Univ. of Cincinnati, Univ. of Houston, UIUC, Univ. of Wisconsin, Virginia Tech, William & Mary, Yale

South America (1)

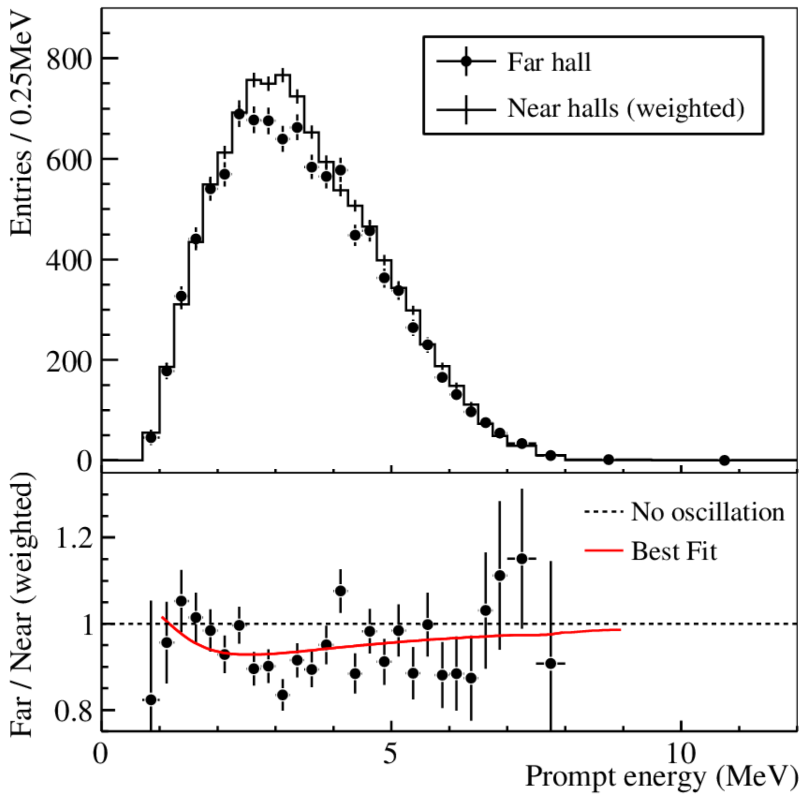
Catholic Univ. of Chile

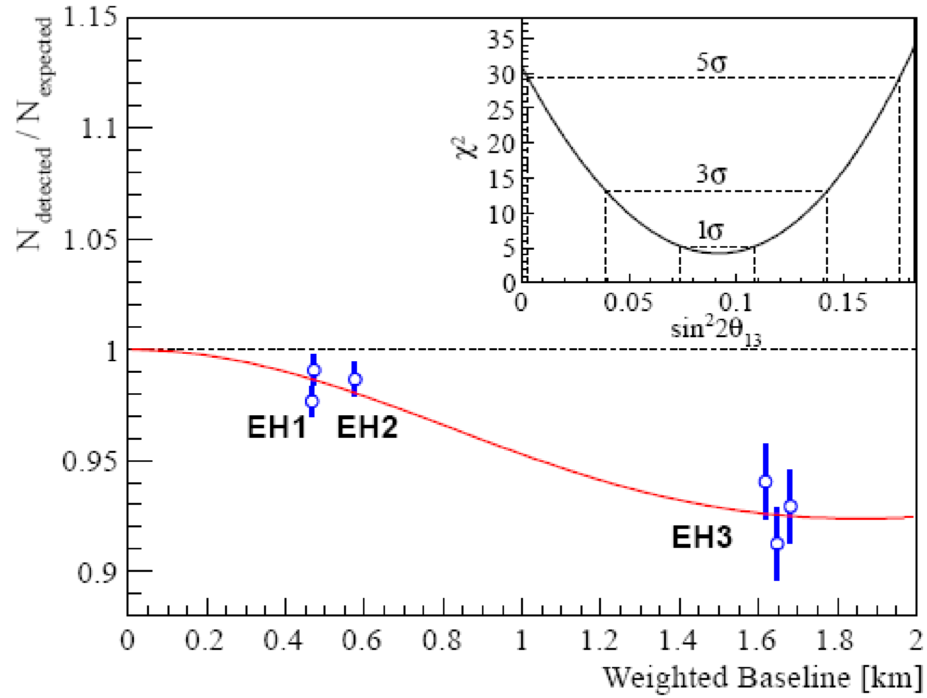
A New Type of Oscillation

- **Electron anti-neutrino disappearance:**

  R = 0.940 ±0.011 (stat) ±0.004 (syst)

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



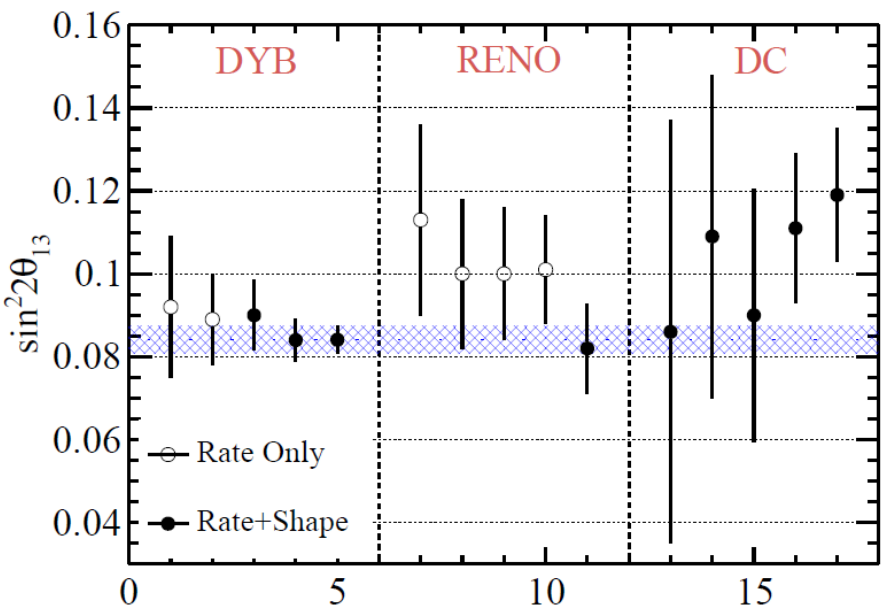


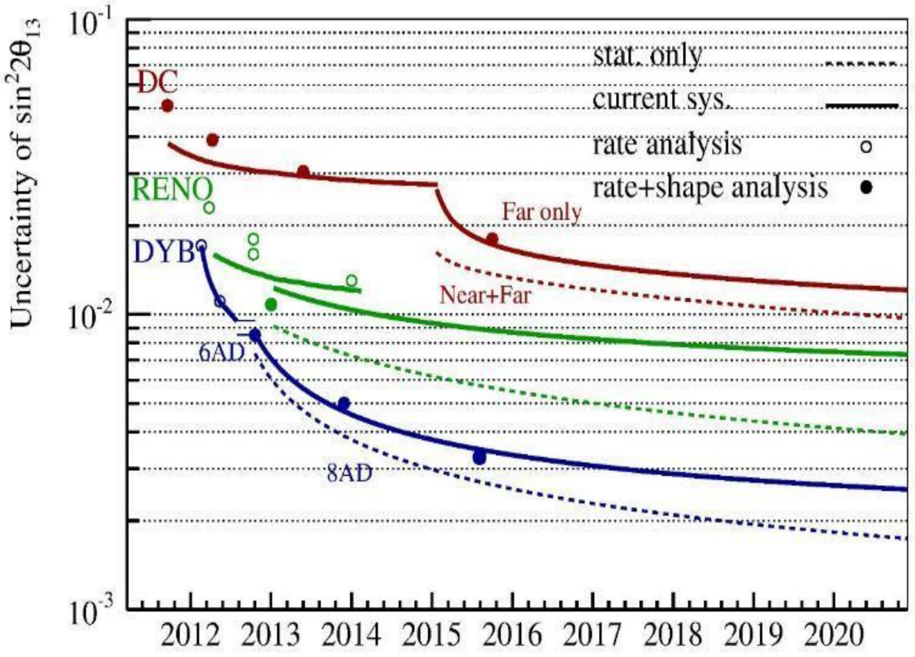
$\sin^2 2\theta_{13} = 0.092 \pm 0.016(\text{stat}) \pm 0.005(\text{syst})$

$\chi^2/\text{NDF} = 4.26/4$, 5.2 σ for non-zero θ_{13}

Oscillation Results and Prospects

- $\sin^2 2\theta_{13}$ Precision improved from ~ 20% to ~ 4%
- Continue to operate until 2020, to measure both $\sin^2 2\theta_{13}$ and Δm^2_{ee} to < 3%

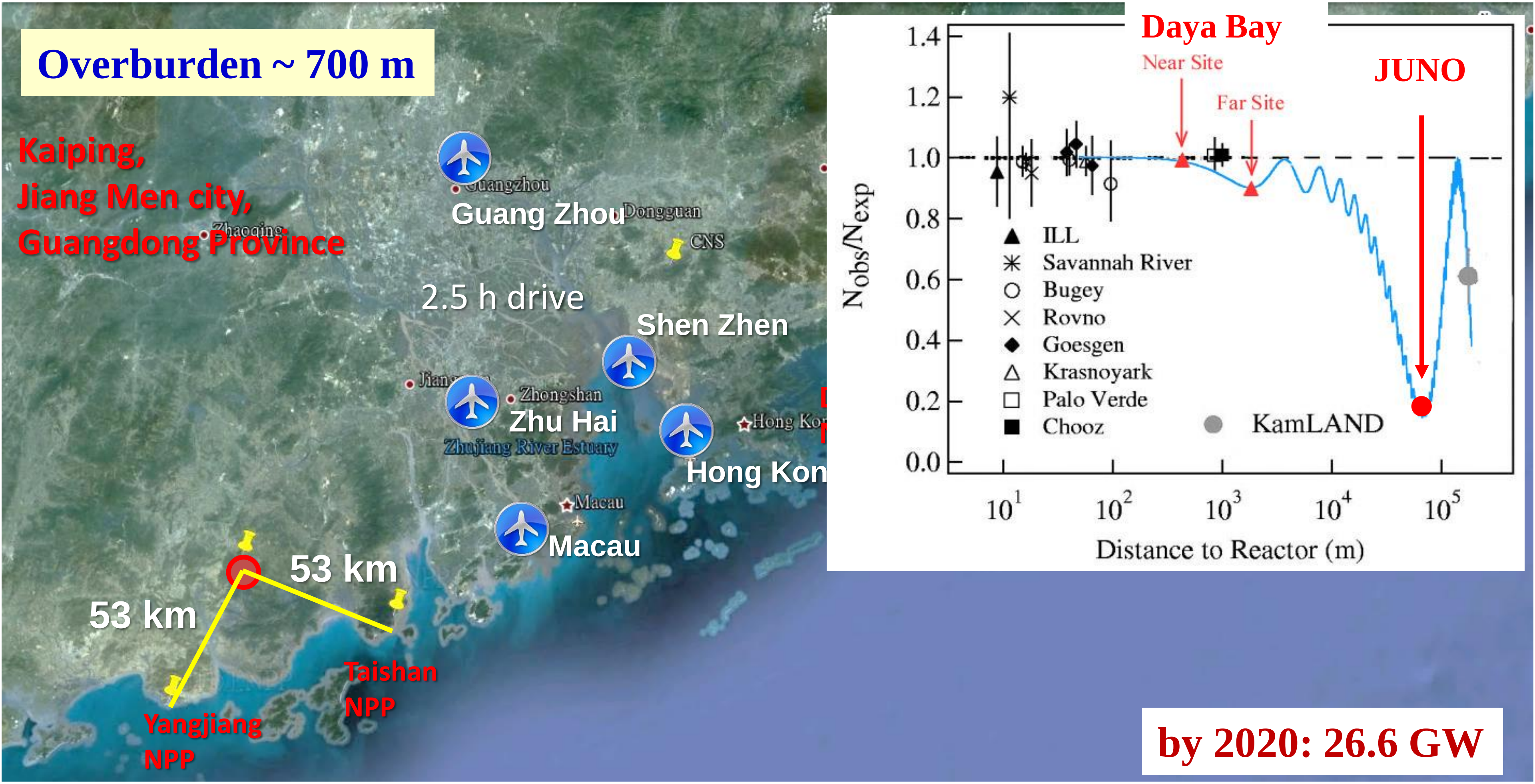




Release time	Data	Config	$\sin^2 2\theta_{13}$	Δm^2_{ee}
2012/3/8 [17]	55 days	6 ADs	$0.092 \pm 0.016 \pm 0.005$	-
2012/10/23 [18]	139 days	6 ADs	$0.089 \pm 0.010 \pm 0.005$	-
2013/10/24 [20]	217 days	6 ADs	$0.090^{+0.008}_{-0.009}$	$2.59^{+0.19}_{-0.20}$
2014/6/24 [19]	217 days	6 ADs (nH)	0.083 ± 0.018	-
2015/5/13 [21]	621 days	6+8 ADs	0.084 ± 0.005	2.42 ± 0.11
2016/3/14 [22]	621 days	6+8 ADs (nH)	0.071 ± 0.011	-
2016/7/5 [23]	1230 days	6+8 ADs	0.0841 ± 0.0033	2.50 ± 0.08

Next Step： JUNO Experiment

NPP	Daya Bay	Huizhou	Lufeng	Yangjiang	Taishan
Status	Operational	Planned	Planned	Under construction	Under construction
Power	17.4 GW	17.4 GW	17.4 GW	17.4 GW	18.4 GW



by 2020: 26.6 GW

Physics at JUNO

Mass Hierarchy: For 6 years, JUNO can determine the MH independent to CP phase with a significance:

	Relative Meas.	Use absolute Δm^2
Ideal case	4σ	5σ
Realistic case	3σ	4σ

Other Physics topics:

- Supernova neutrinos
- Geo-neutrinos
- Solar neutrinos
- Double beta decays

Precision Measurement of Mixing Parameters: Probing the unitarity of U_{PMNS} to ~1% level !

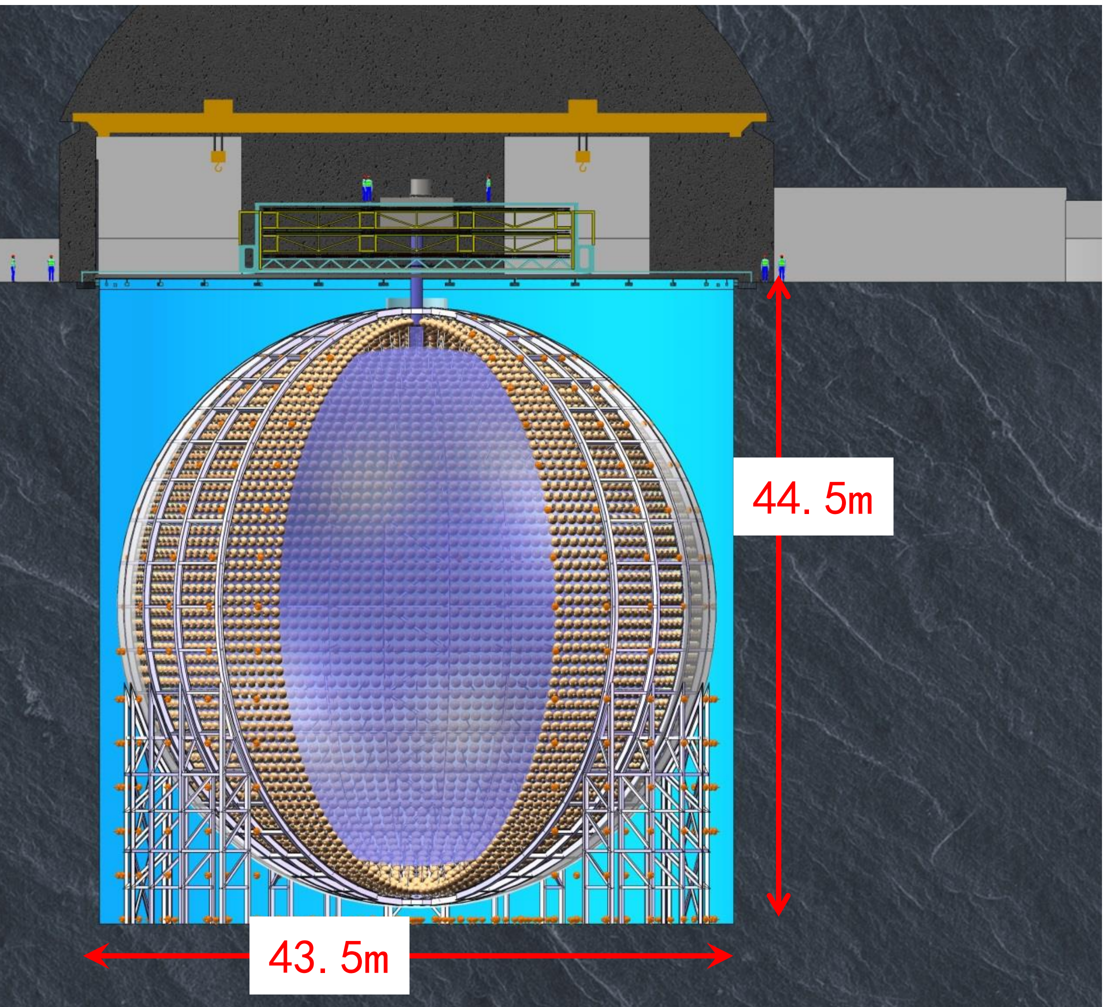
	Current	JUNO
Δm^2_{12}	3%	0.6%
Δm^2_{23}	3%	0.6%
$\sin^2\theta_{12}$	4%	0.7%
$\sin^2\theta_{23}$	11%	N/A
$\sin^2\theta_{13}$	10%	-

More precise than CKM matrix elements !

J. Phys. G 43: 030401 (2016)
(arXiv:1507.05613)

JUNO Detector and Challenges

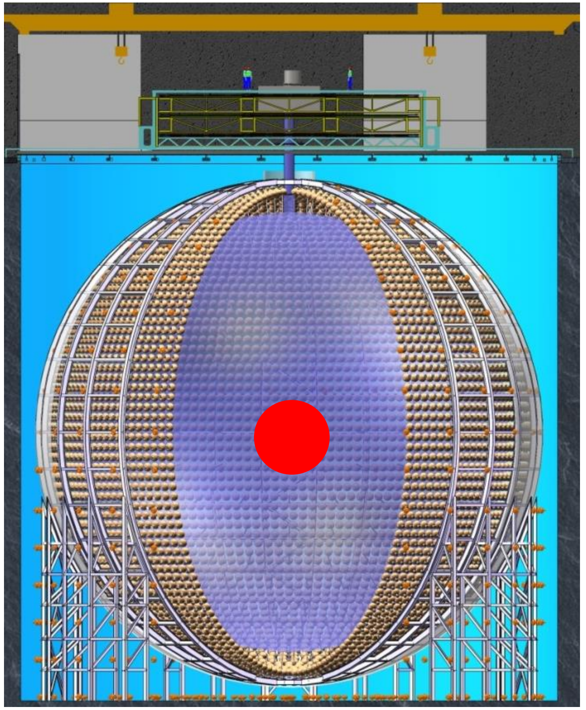
- Largest LS detector ➔ × 20 KamLAND， × 40 Borexino
- Highest light yield ➔ × 2 Borexino， × 5 KamLAND



- Hugh cavern:
  - ~ 48m× 70m
- Largest Acrylic tank:
  - Φ 35.4米(13m@SNO)
- 20 kt LS
  - Best attenuation length: 25m (15m @ Daya Bay)
- 20000 20” PMT
  - Highest photon detection efficiency : 30%*100% = 30%（25%*60%=15% @ SuperK）

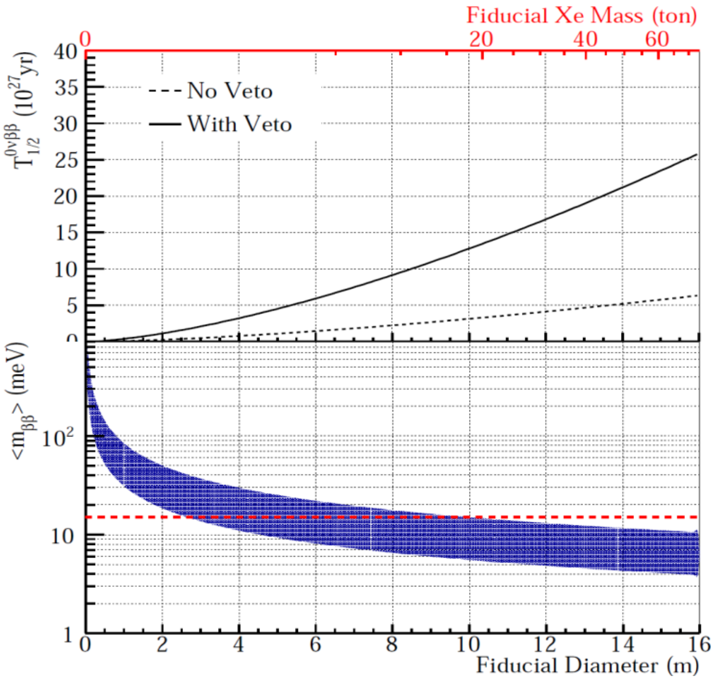
JUNO-ββ

- Insert a balloon filled with ^{136}Xe-loaded LS (or ^{130}Te) into the JUNO detector
- Cosmic-induced backgrounds are removed by cutting a volume around the muon track
- Yes, sensitivity does scale with the mass



	Isotopes	Mass(t)	$<m_{\beta\beta}>$,meV
nEXO	^{136}Xe	5	7-22
GERDA	^{76}Ge	1	10-40
Majorana	^{76}Ge	1	10-40
SNO+	^{130}Te	8	19-46
KamLAND -Zen	^{136}Xe	1	~20
JUNO-ββ	^{136}Xe	50	4-12

Zhao et al., arXiv: 1610.07143, accepted by CPC



JUNO Collaboration

17 Countres & regions, 72 institution， 580 members

Europe (28)

Belgium(1)
ULB

Czech(1)
Charles U

Latvia(1)
IECS

Finland(1)
U.Oulu

France(5)
APC Paris
CPPM Marseille
IPHC Strasbourg
Subatech Nantes
CENBG-IN2P3

Italy(8)
INFN-Catania
INFN-Frascati
INFN-Ferrara
INFN-Milano
INFN-Mi-Bicocca
INFN-Padova
INFN-Perugia
INFN-Roma 3

Germany(7)
FZ Jülich
RWTH Aachen
TUM
U.Hamburg
IKP FZI Jülich
U.Mainz
U.Tuebingen

Russia(3)
INR Moscow
JINR
MSU

Slovakia (1)
FMPICU

America(6)

US(2)
UMD
UMD-Geo

Chile(2)
PCUC
UTFSM

Brazil （2）
PUC-Rio
UEL

Asia (38)

China （33）
BJ Nor. U.
CAGS
Chongqing U.
Shanghai JT U.
DGUT
ECUST
Guangxi U.
HIT
IHEP
U. Of South China
Ninan U.
Nanjing U.
Natl. Chiao-Tung U.
Natl. Taiwan U.
Natl. United U.
Nankai U.
NCEPU
Pekin U.
SDU
Sichuan U.
CIAE
SYSU
Tsinghua U.
UCAS
USTC
Jilin U.
Wuhan U.
Wuyi U.
Xi'an JT U.
Xiamen U.
NUU.

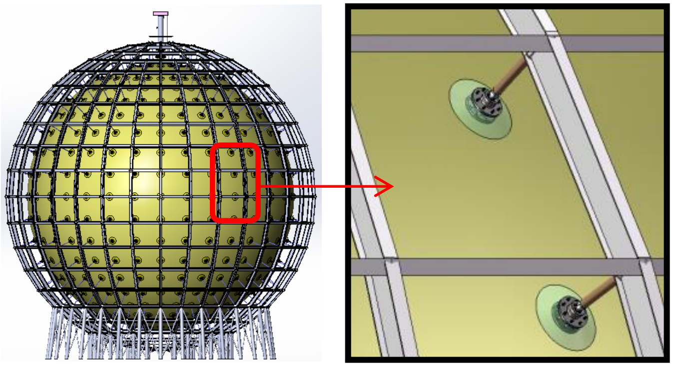
Armenia(1)
Yerevan Phys. Inst.

Thailand(3)
SUT
PPRLCU
NARIT

Parkistan(1)
PINSTECH

Detector R&D and Construction

- **A huge acrylic tank:**
  - ⇨ R&D and design completed, procedures of manufacturing understood
  - ⇨ Prototypes underway
  - ⇨ Contract signed

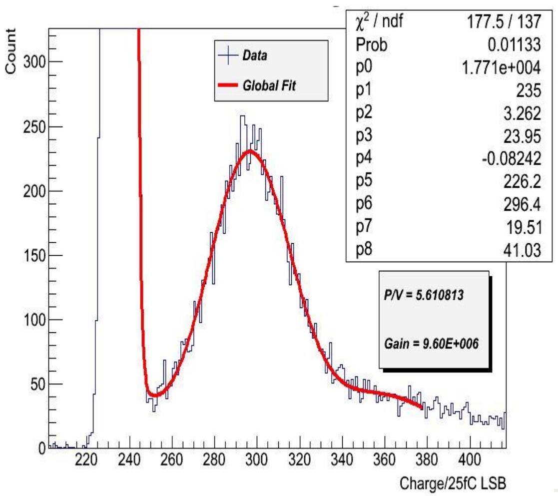


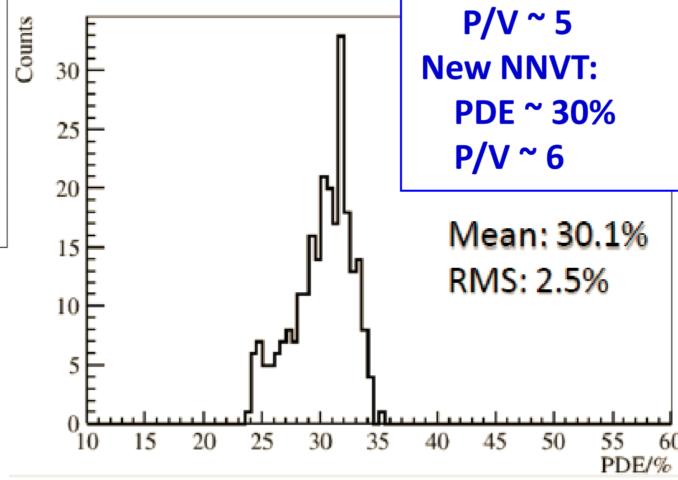
- **A SS structure to hold the acrylic tank and to mount PMTs**
  - ⇨ Design completed, contract signed
  - ⇨ Issues like tem. change, earth quake, Assembly & installation understood
- **20 kt liquid scintillator**
  - ⇨ Completed the optimization of LS for the best light yield and attenuation length
  - ⇨ Completed the 20t test of purification: attenuation length> 20 m.
  - ⇨ Radio-purity under testing

Photomultipliers

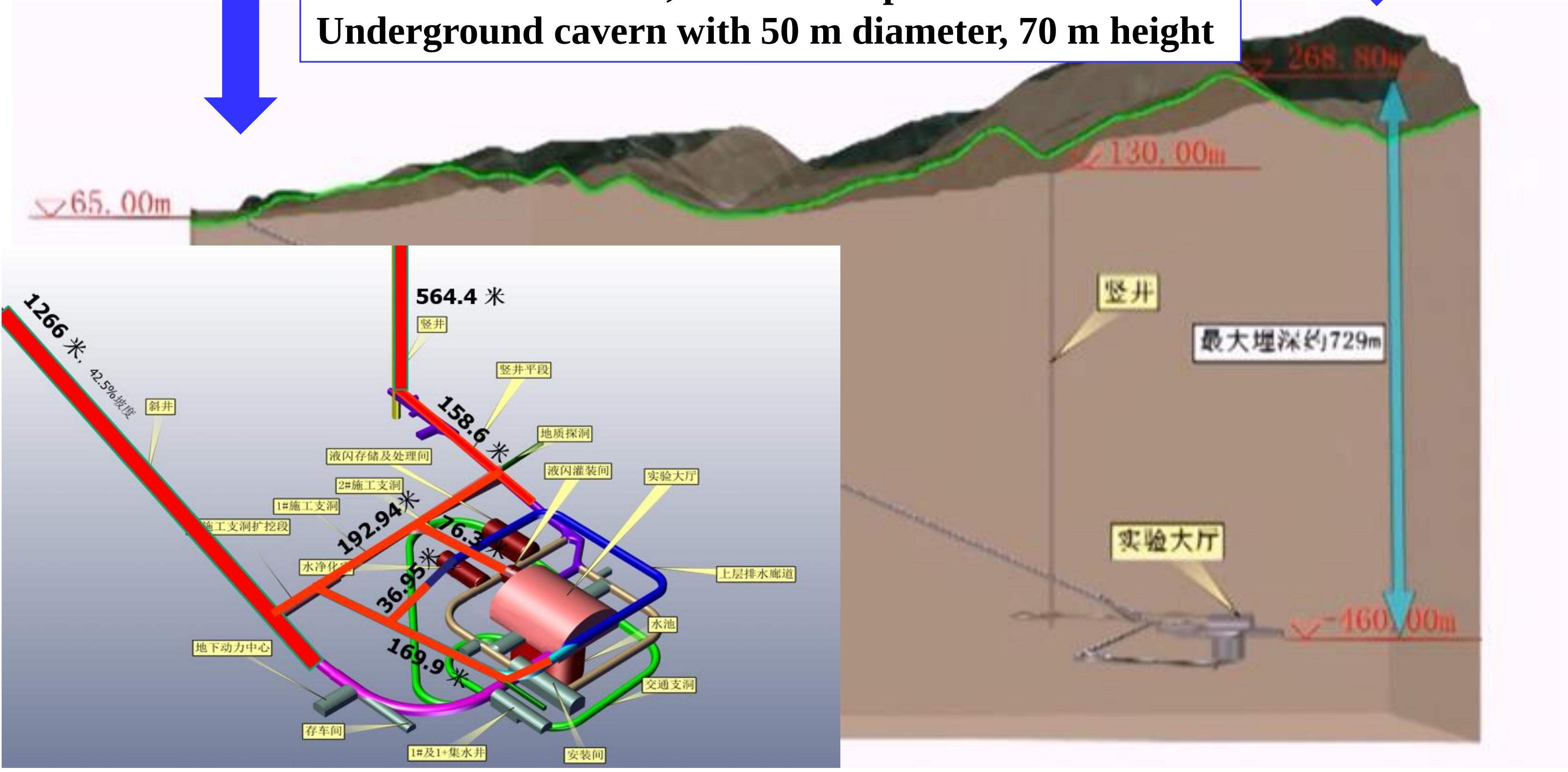
- Large, High QE PMT's is the key to obtain sufficient photons
- Efforts started in 2009 to develop MCP-PMT, with a goal of QE > 35%
- Partnered with companies and research institutes: NNVC, XIOPM, etc.
- Successful development:
  - NNVC: QE(27%)*DE(100%) > 27%
  - Hamamatsu: QE(30%)*DE(90%) > 27%
- Contract signed(based on quality, availability, cost, risk et al.)
  - 15000 from NNVC, 5000 from Hamamatsu
- More than 6000 MCP-PMT from NNVT and 4000 PMT from Hamamatsu
  - Tubes are better than spec. of the contract

Hamamatzu:
PDE ~ 28%
P/V ~ 5
New NNVT:
PDE ~ 30%
P/V ~ 6



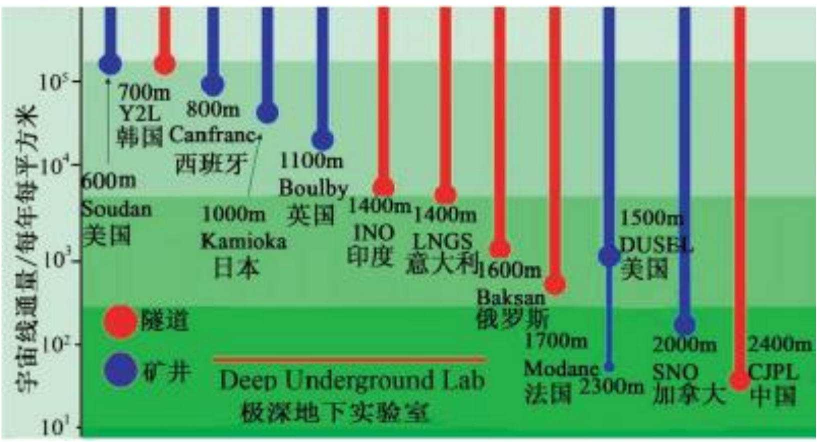


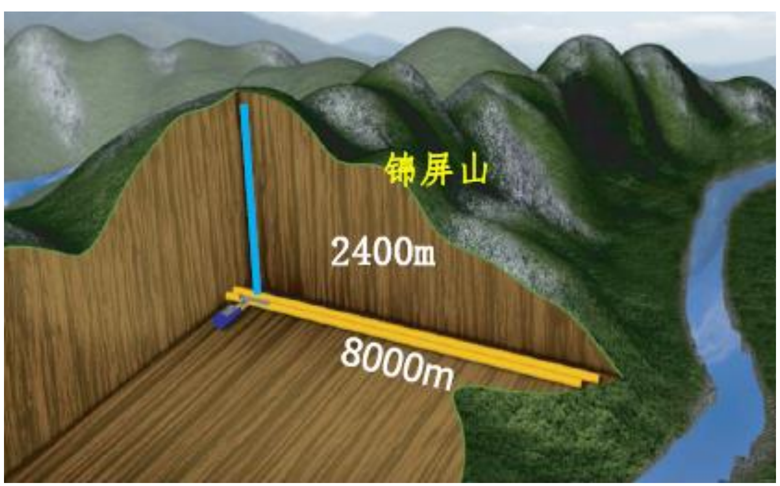
~ 600m vertical shaft, ~1300m sloped tunnel
Underground cavern with 50 m diameter, 70 m height



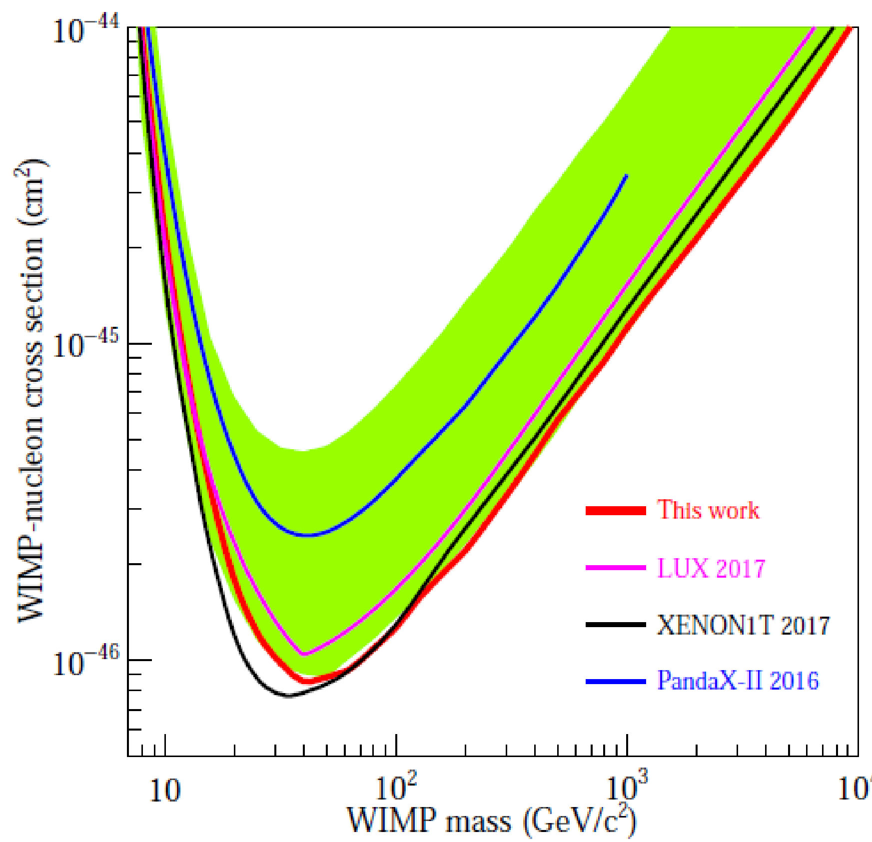
JinPin Underground Laboratory

- The deepest underground laboratory in the world: 2400 m
- Current experiments: dark matter searches
  - Xe-based PandaX
  - Ge-based CDEX



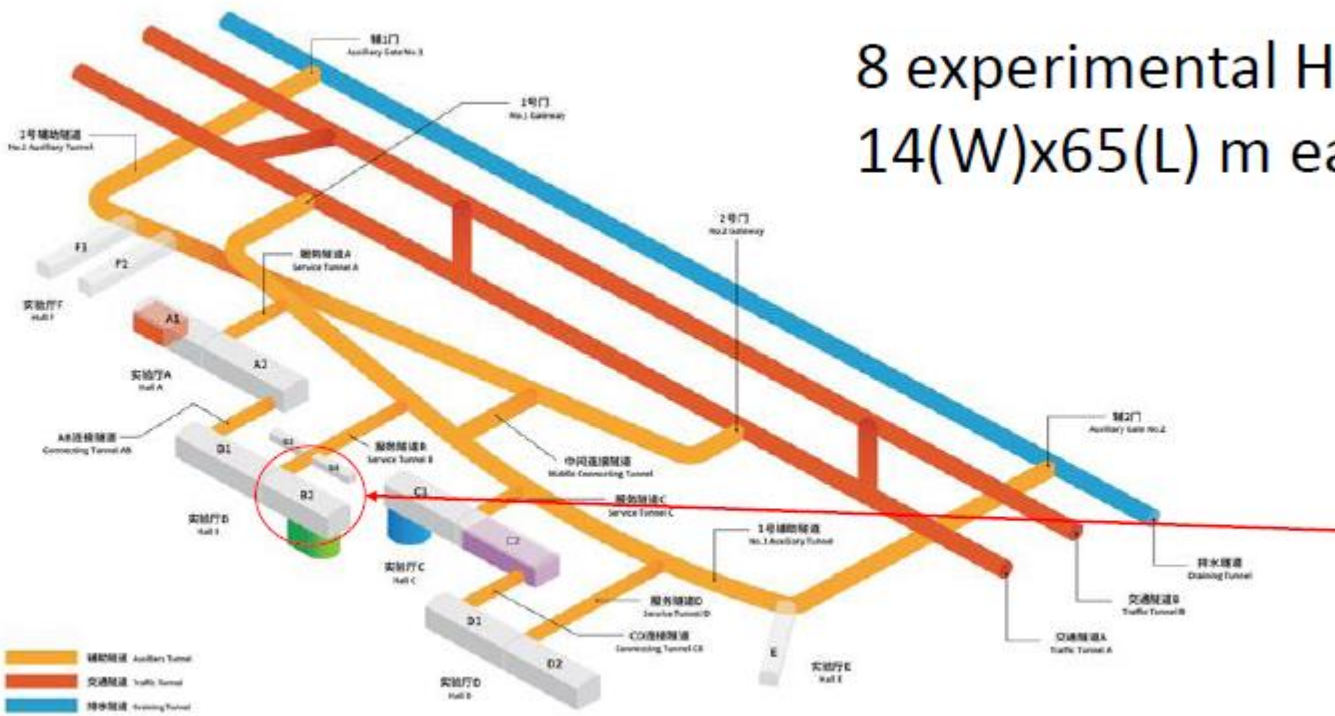


PANDAX-II： PRL 119(2017)181302



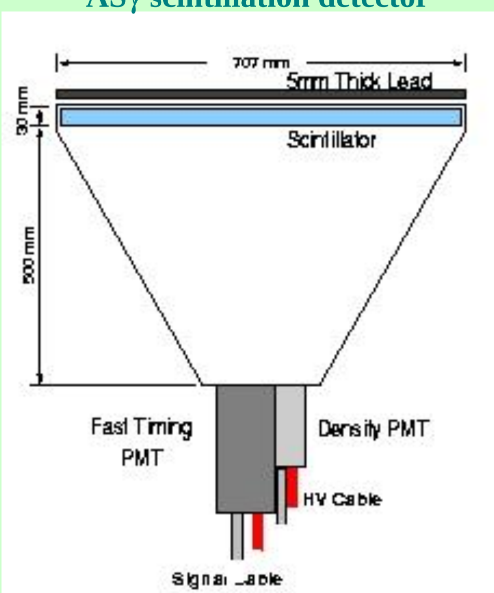
Future

- Approved for the infrastructure construction
- Next generation Xe- & Ge-based dark matter & ββ decay searches
- Other possiblities: Solar neutrinos, geoneutrinos, etc.



Yangbajing Cosmic-ray Observatory: Since 90's

ASγ scintillation detector

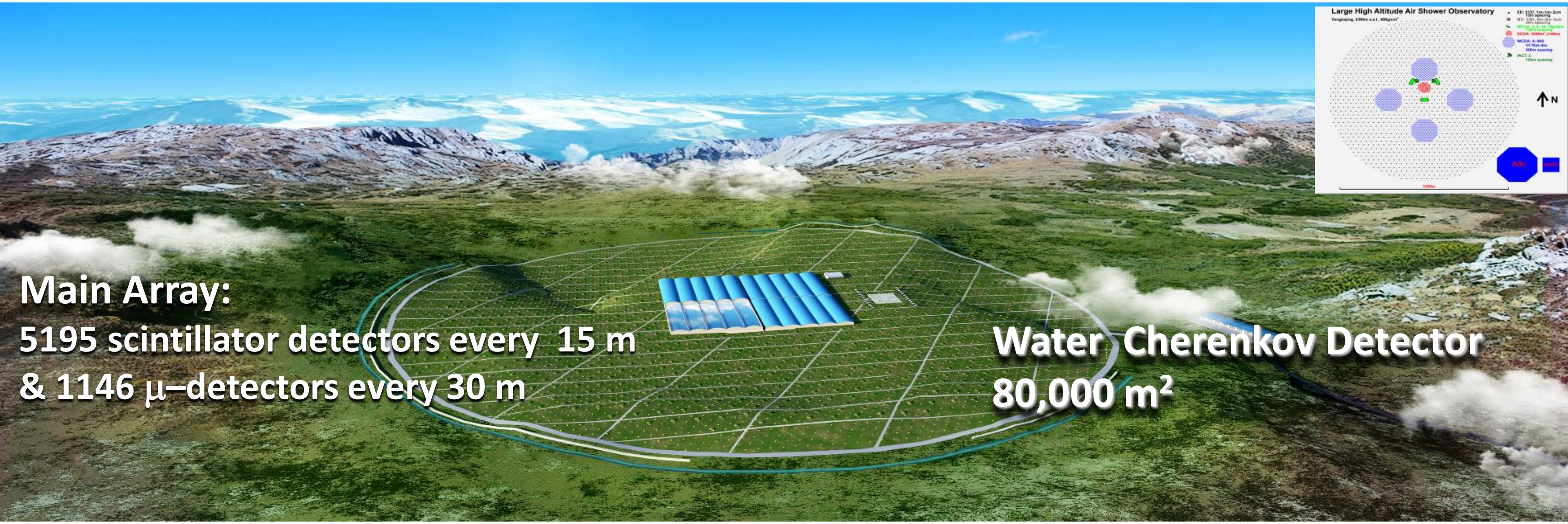


Sino-Italian ARGO experiment (part of RPC carpet)

A new Phase: LHAASO

—— Large High Altitude Air Shower Observatory

Sichuan, 4300 m a.s.l.

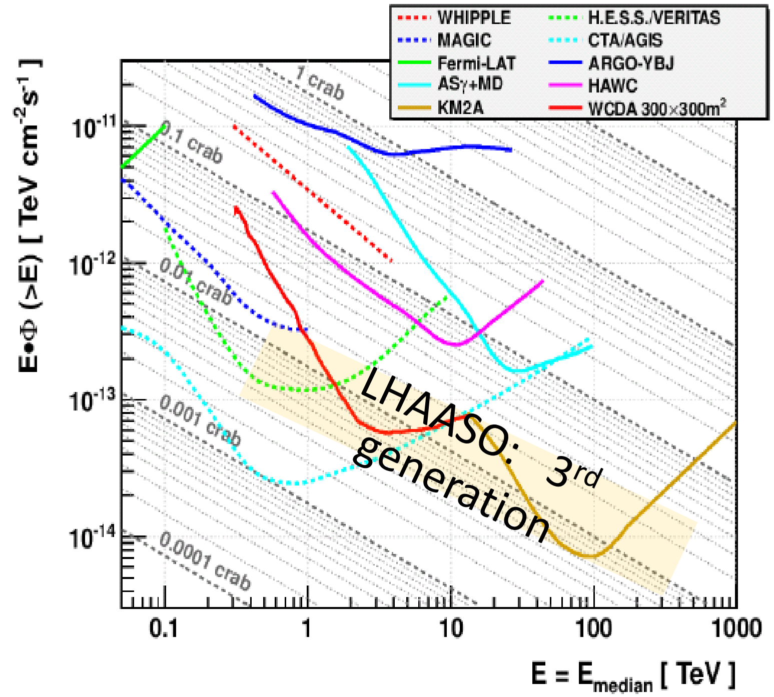


Main Array:
5195 scintillator detectors every 15 m
& 1146 μ–detectors every 30 m

Water Cherenkov Detector
80,000 m^2

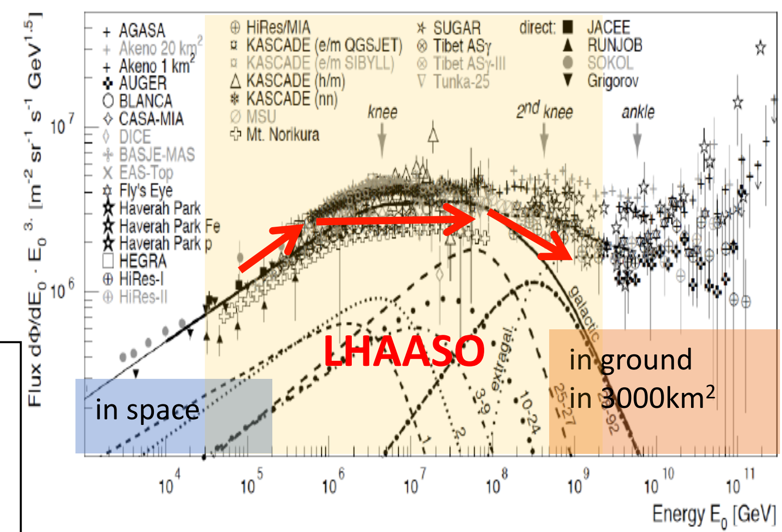
Science at LHAASO

- Unique for 10 TeV g astronomy with the highest sensitivity in the world
- Window for discovering the hadronic origins of cosmic rays
- Crucial CR data covering a very wide energy region of knees
- Exploring for new physics, such as DM or quantum gravity



Complementary to CTA:

- ➢ All the time
- ➢ All the sky
- ➢ Time-variant sources
- ➢ Extended sources
- ➢ Fast indication for CTA

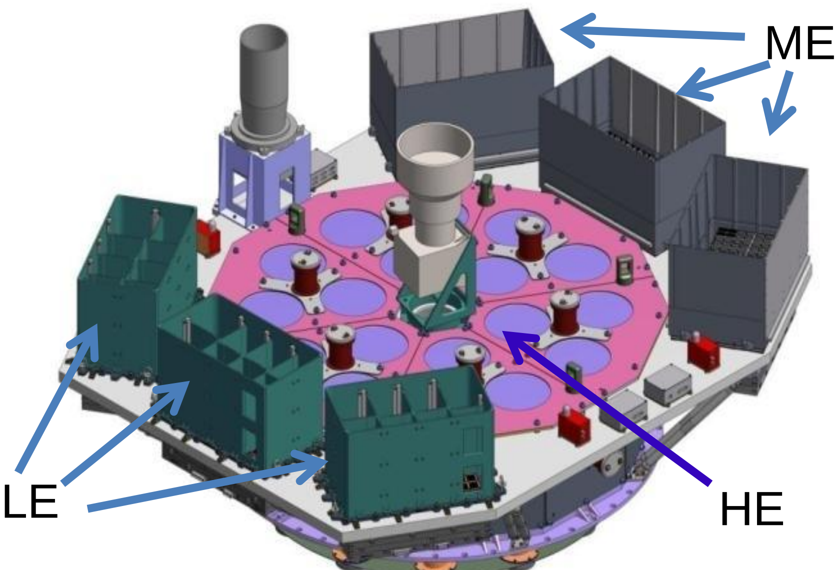


LHAASO is funded for 2016-2020, ¼ of the detector array will be operational by end of this year

Two Scientific Satellites on orbit now

Hard X-ray modulated telescope（HXMT）

- Full sky survey with good angular resolution and sensitivity
- Launched in June, 2017

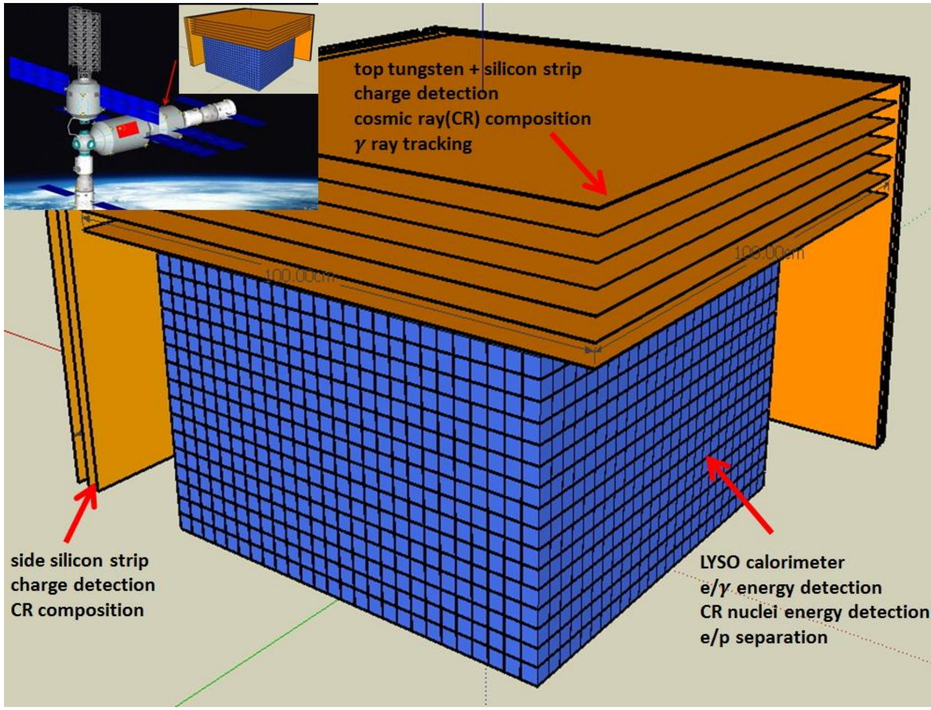


DArk Matter Particle Explorer (DAMPE)

- Cosmic-ray & gamma detector up to 10 TeV with good resolution
- Launched in Dec., 2015

HERD @ the China's Space Station

- Science
  - Dark matter search: γ from 100 – 10,000 GeV
  - γ-ray astronomy: GRBs, microquasars, Blazars and other transients down to 100 MeV
  - Spectral and composition measurements of CRs between 300 GeV to PeV with a large geometrical factor
  - Complementary to LHAASO: directly measured composition & spectrum in space
- 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

Acceptance & H-energy > 10X all others

Summary

- Particle Physics is a great field
  - Incredible success in the past
  - More to come in the future
- China is catching up, thanks to its economic growth
  - Great success on BESIII, Daya Bay and PandaX
  - Bright prospects for JUNO and CEPC
  - More active in international projects: LHC(all 4 exp.s), BELLE/BELLEII, COMET, EXO, LBNF, Panda, GlueX, …
  - More to come in Astro-particle physics: DAMPE, HXMT, LHAASO, HERD,…
- Looking forward to collaborate with the world