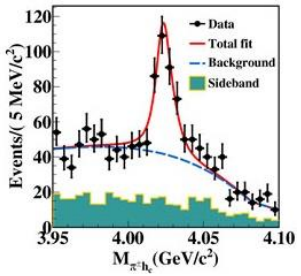
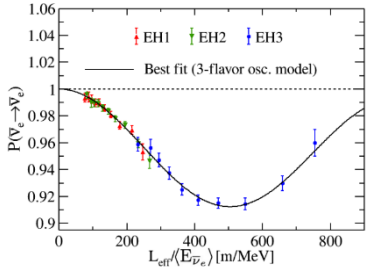
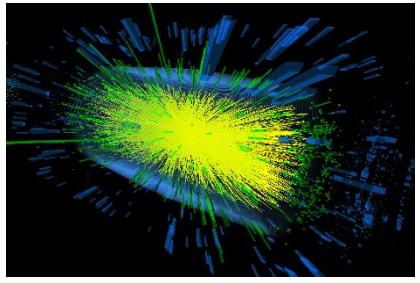
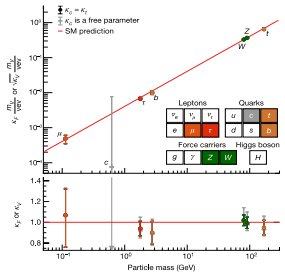
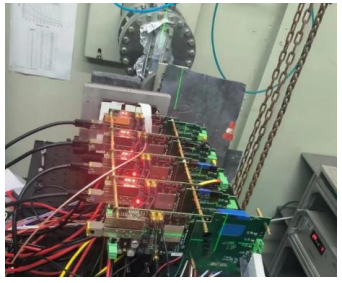
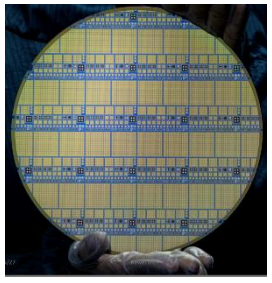




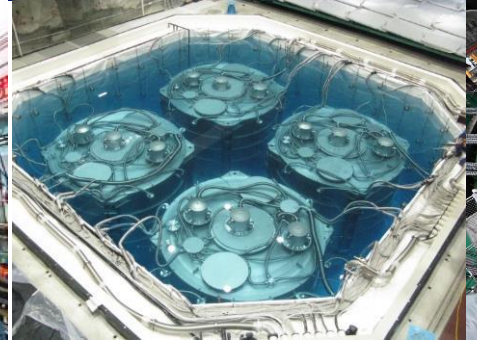



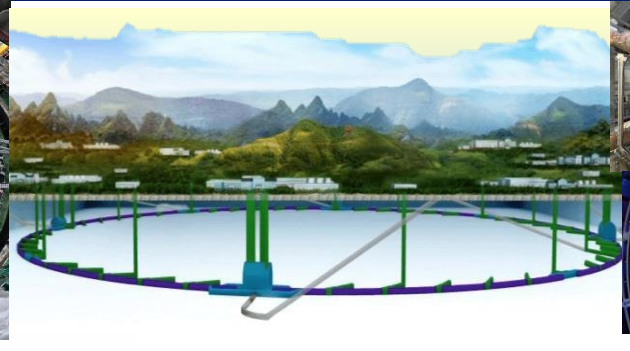
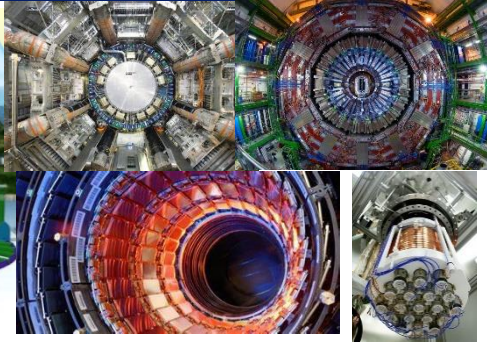
Experimental Physics Division

Jun Cao

Institute of High Energy Physics

IHEP Institutional Assessment, Sep. 20, 2023

Outline

- Mission, Focuses, and Status (manpower, funding, publications)
- Highlights over the past 5 years
- Strategic Planning
- Addressing issues from previous Institutional Assessment
- Summary and Challenges


Jun Cao


Xinchou Lou


Xiaoyan Shen


Zheng Wang


Changgen Yang


Jianchun Wang


Liangjian Wen

EPD Mission

To conduct high-quality research in particle physics, to be one of world's leading high energy physics research centers

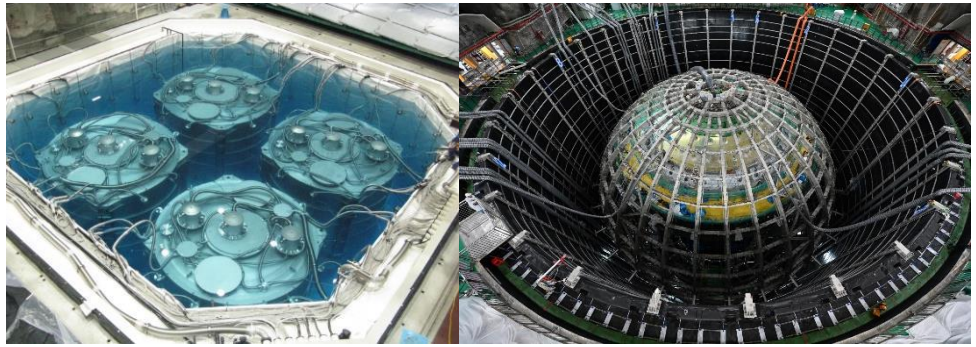
- To produce important physics results in **charm physics at BEPCII/BESIII**
- To conduct world-leading **neutrino studies with JUNO** and other facilities
- To be at the forefront in accelerator based program with the **CEPC** and contribute to the experiments at **CERN**
- To develop particle detection technology
- To contribute to the construction of large science facilities and support the applications of technology at IHEP
- To educate and train the next generation of particle physicists

IHEP "1-7-5 Development Plan"	
One Vision: One of the world's leading particle physics research centers, and a world-class, large-scale, comprehensive, multidisciplinary research base.	
Seven Priority Development Areas	**1. Charm physics**
	2. Neutrino physics
	3. Particle Astrophysics
	4. High Energy Photon Source
	5. CSNS-II and SAPS
	6. Key tech of large-scale research infrastructures
	7. Development and application of radiation tech
Five Emerging and Frontier Areas	**1. High Energy Colliders and Collider Physics**
	2. Extreme universe and high energy cosmic rays
	3. Quantum computing and AI in HEP
	4. Plasma wakefield acceleration
	5. Electronic technology for wireless detectors

EPD Focuses

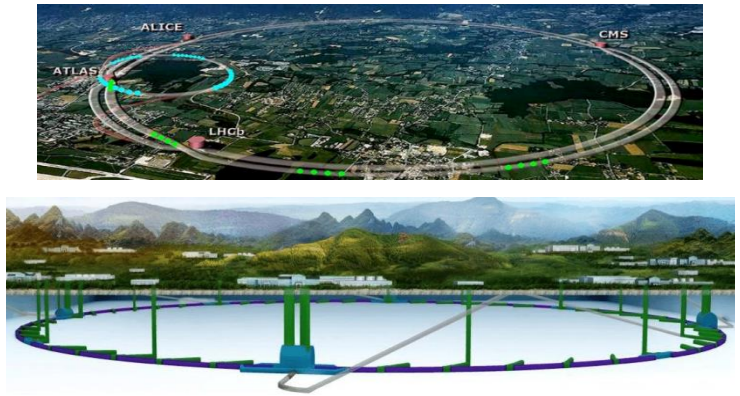
Charm Physics

BESIII, BelleII, PANDA, GlueX



Neutrino Physics

Daya Bay, JUNO, EXO, DarkSide, COMET

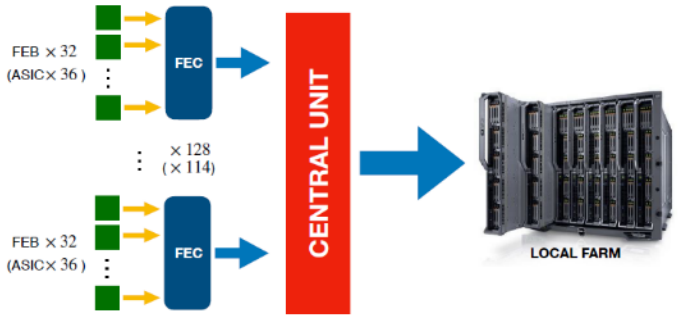


High Energy Frontier

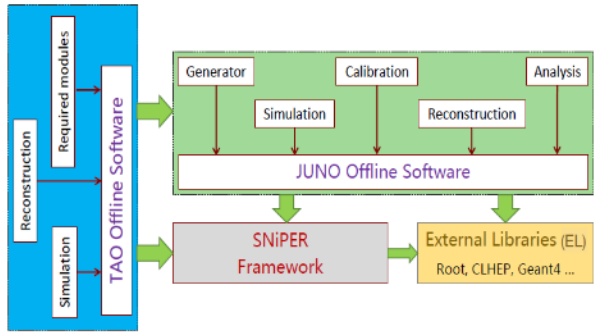
CEPC, LHC (ATLAS/CMS/LHCb)

Detector

Electronics



Trigger, DAQ, DCS

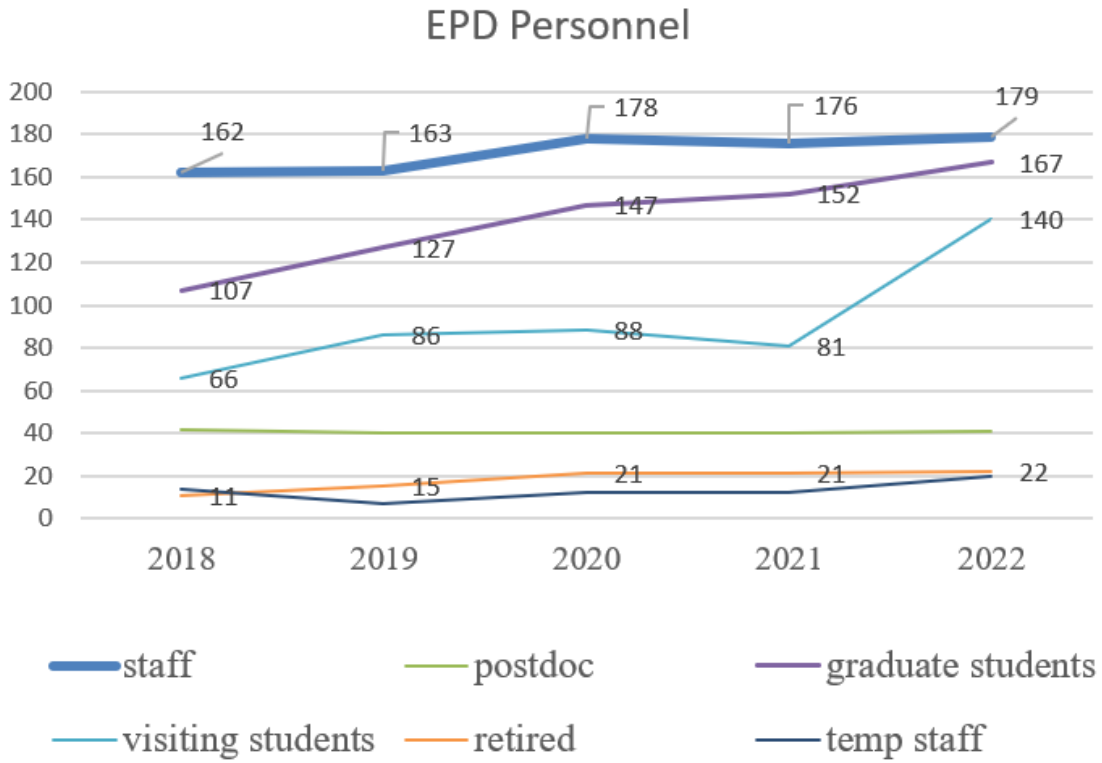


Software

Complete chain of design, construction, and operation of large-scale experiments, R&D of advanced technology

179 staff, 390 temporary (including postdoc, students), totaled 569 people (Dec. 2022)

EPD- People



Year	Staff	Mean Age	Postdoc	Graduate Students	Visiting Students	Retired	Temp Staff	Sum
2018	162	42	42	107	66	11	14	402
2019	163	43	40	127	86	15	7	438
2020	178	43	40	147	88	21	12	486
2021	176	43	40	152	81	21	12	482
2022	179	43	41	167	140	22	20	569

- **Following the comment of the 2018 IA Committee, the Neutrino (Nu-2) group and the CMS group in the Particle Astrophysics Division merged into the EPD, and Superconducting Magnet group move to Accelerator Division in 2020.**

Organization: Matrix Management

- Grouped "Permanently" by **research area**, "temporarily" by **projects**
- Two neutrino groups due to historical reason. Trigger and DAQ combined in 2021. ATLAS, CMS, and CEPC combined into one group in 2022
- **Other Int'l** includes AMS, BelleII, COMET, Darkside, EXO, GlueX, PANDA
- **Free exploring research** ~11%. Contracted assistants 13

	Total	Hadron	Nu-1	Nu-2	High Energy	Software	Det-1	Det-2	Det-3	Elec.	TDAQ	Mech.	Secretariat
Total	179	18	10	12	30	22	18	13	8	25	12	9	2
JUNO	**55.1**		•	•		•	•	•	•	•	•	•	
Daya Bay	2.0		•	•									
BESIII	**42.2**	•			•	•	•	•	•	•	•	•	
CEPC	**24.9**	•			•	•	•	•	•	•	•	•	
CMS	**10.7**				•	•	•	•			•		
ATLAS	**11.6**				•	•	•			•		•	
LHCb	2.0				•		•						
Other Int'l	5.1	•	•		•	•	•	•		•	•		
LHAASO	4.5									•	•		
Free explo	19.0	•	•	•	•	•	•	•	•	•	•	•	
Support	2												•

EPD- Funding

- Funding from national level impacted slightly by pandemic, flat compared w/ previous 5 years.
- CAS Dev. Fund varies with the JUNO construction progress
- Total funding increased by 50% in last 5 years, comparing w/ previous cycle

	Source\Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
National level	MOST	14.60	5.52	10.44	26.70	21.98	22.84	13.99	8.11	9.00	21.88
	Other sources	2.05	10.46	2.06	1.03	1.40	2.89	0.08	0	2.28	0.08
	NSFC	12.73	18.44	20.78	18.49	19.57	21.01	17.20	21.83	24.90	43.84
Int'l collab.	Foreign sources	10.48	4.45	3.51	4.03	3.17	1.95	0.65	2.38	0.47	0.43
CAS	CAS Target Fund	11.10	5.72	7.55	13.63	25.37	14.25	23.79	21.87	20.20	16.41
	CAS Dev. Fund	65.45	78.72	118.12	107.87	279.19	233.91	269.52	273.21	124.30	203.00
	CAS Op. Fund	41.46	10.26	9.25	12.56	24.50	21.44	26.35	25.78	25.02	16.71
	CAS Key Lab.	6.34	3.75	3.96	4.24	4.30	24.12	5.78	3.93	4.80	4.56
	Contracts/grants	2.98	0.70	2.67	0.45	2.29	0.70	0.15	3.30	1.07	1.71
IHEP	IHEP R&D Fund	11.80	7.33	1.67	7.52	4.67	5.88	13.48	5.45	11.23	1.48
	Sum	178.99	145.35	180.01	196.52	386.45	348.99	370.97	365.86	223.28	310.1

unit = million CNY

Total 1087.3

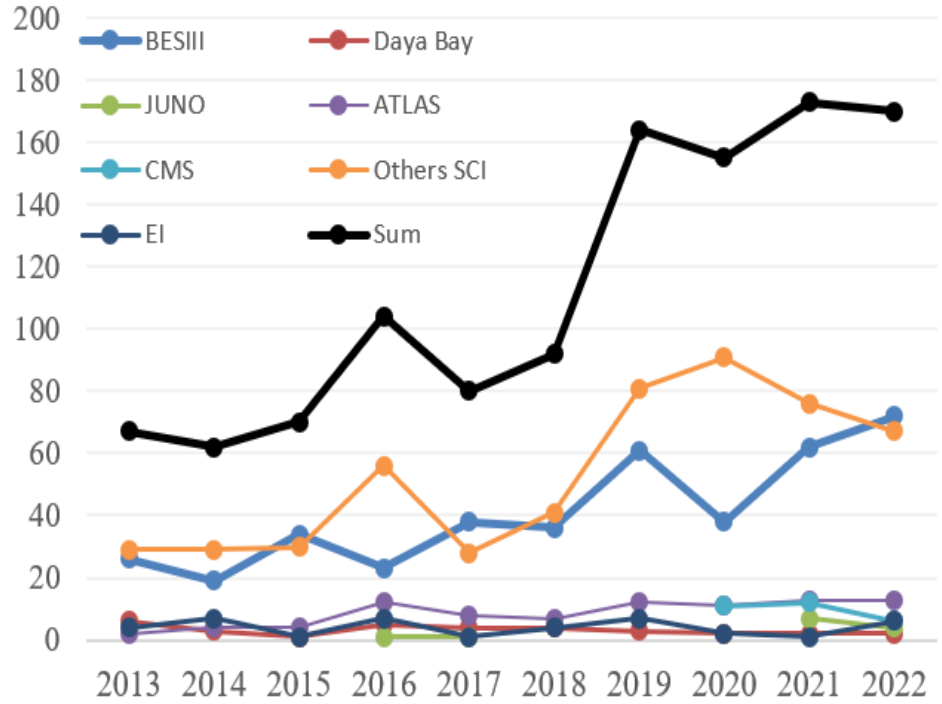
Total 1619.2

EPD- Publications

- **Publication doubled in the past 5 years.**
  - BESIII and Others (mainly hardware papers) contribute 36% and 46% papers
  - Inclusion of CMS (w/ leading contribution from IHEP, as ATLAS)
  - JUNO starts to produce papers

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
BESIII	26	19	34	23	38	36	61	38	62	72
Daya Bay	6	3	1	5	4	4	3	2	2	2
JUNO				1	1				7	4
ATLAS	2	4	4	12	8	7	12	11	13	13
CMS								11	12	6
Others SCI	29	29	30	56	28	41	81	91	76	67
EI	4	7	1	7	1	4	7	2	1	6
Sum	67	62	70	104	80	92	164	155	173	170

Total 383 **Total 754**



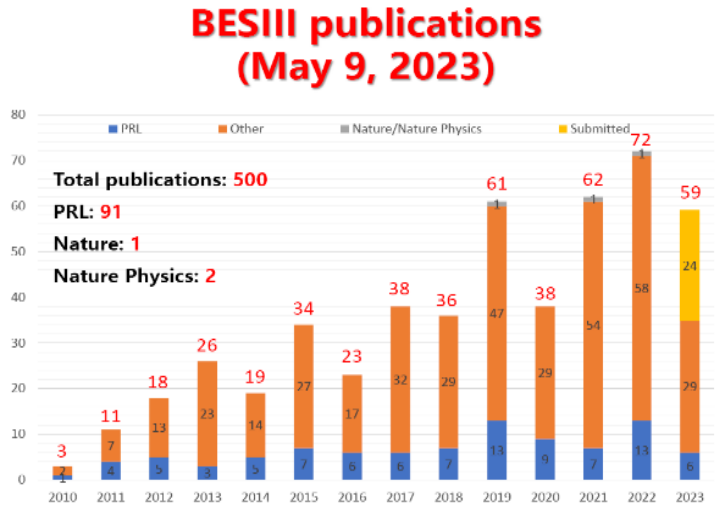
EPD- Staff Recruitment Plan& Progress

- **EPD maintains a high standard in talent recruitment**
- **28 new staff, including 15 in talent programs, 4 technicians, 5 engineers, and 4 assistant professors**

	Name	Previous institute, Year	Areas/projects
Professor Level (3)	Jianchun Wang	Syracuse, USA, 2018	CEPC, AMS, LHCb
	Hideki Okawa	Fudan, China, 2022	ATLAS
	Jingbo Ye	Southern Methodist U., USA, 2022	Elec., ATLAS
Associate Professor Level (12)	Wuming Luo	Ohio State U., USA, 2018	JUNO
	Gaosong Li	Stanford, USA, 2020	JUNO, EXO
	Yichen Li	DESY, Germany, 2020	JUNO
	Xuefeng Ding	Princeton, USA, 2021	JUNO
	Yi Wang	UCLA, USA, 2020	Darkside
	Peilian Liu	LBNL, USA, 2019	BESIII, ATLAS
	Yong Liu	JGU Mainz, Germany, 2018	CEPC, CMS
	Jin Wang	U. Sydney, Australia, 2018	CMS, CEPC
	Shanzhen Chen	INFN, Italy, 2020	CEPC, LHCb
	Xuhao Yuan	Syracuse, USA, 2022	LHCb, AMS, CEPC
	Zijun Xu	SLAC, USA, 2022	CEPC, ATLAS
	Yunyun Fan	IHEP, China, 2022	CEPC, ATLAS

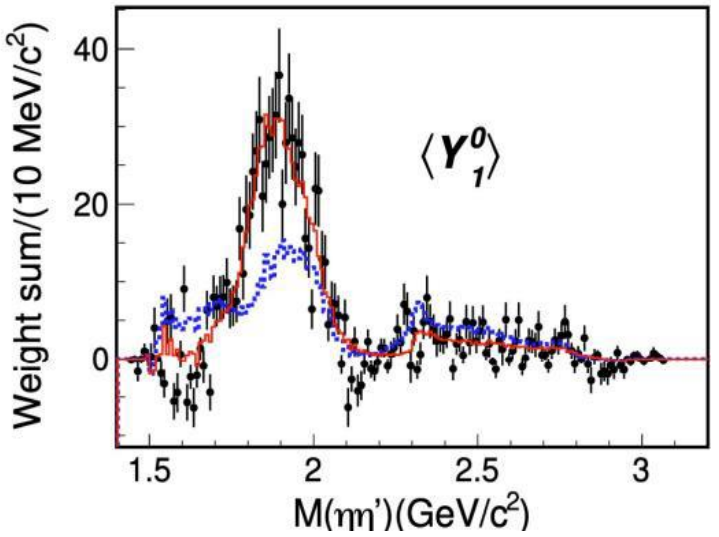
Highlights – BESIII (See H.B. Li's report)

- BEPC/BES (1980s) → BEPCII/BESIII (2009-now), focuses on tau-charm physics.
- BEPC-II luminosity reached $1.1 \times 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ in 2023, 10% > design
- Increase the fraction for collider physics: 8.2 fb^{-1} in 2023, 40% more than 2022
- Great achievements on exotic hadrons, form factors, hyperon physics, charmed meson and baryon decays with data near thresholds

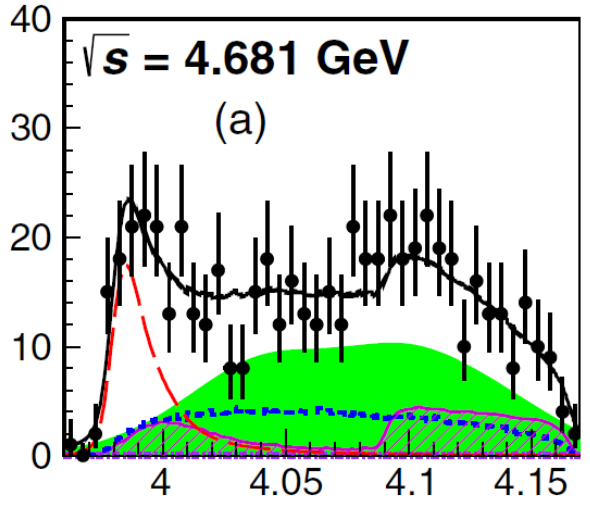


Celebration for the 500th publications

328 publications since 2018!



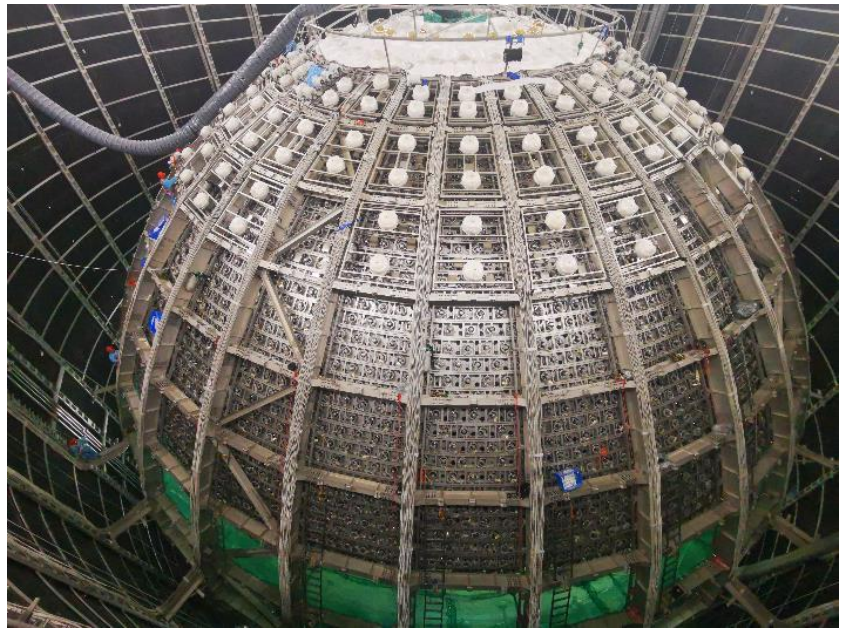
Discovery of Exotic 1^{-+} Isoscalar $\eta_1(1855)$



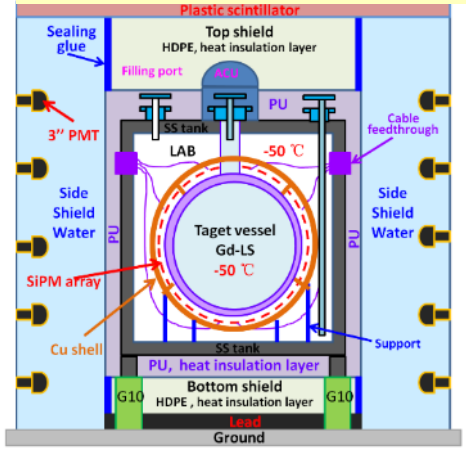
Discovery of $Z_{cs}(3985)$

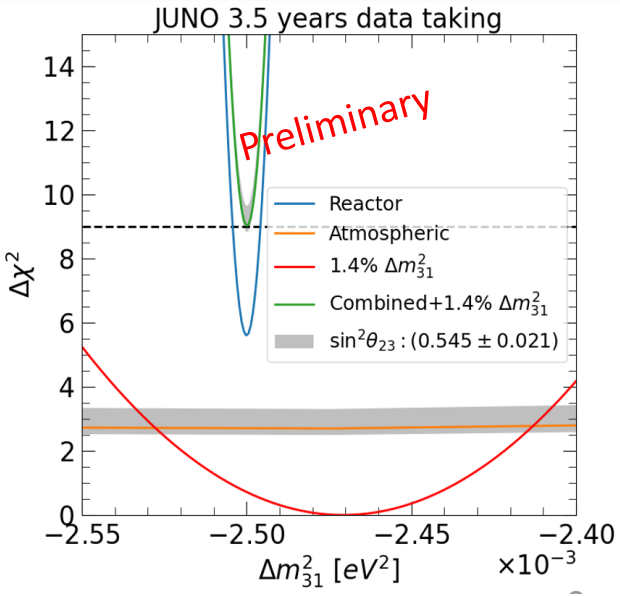
Highlights – Neutrino (See L.J. Wen's report)

- **Daya Bay decommissioned in 2021. Published the final nGd results ~ 2.8%** (PRL 130,161802)
- **JUNO: a 20 kton liquid scintillator detector, data taking in 2024. Near detector JUNO-TAO.**
  - Technology: acrylic bonding, Low bkg acrylic, PMT, PPO, LS purification; underwater electronics
  - 15k 20-in MCP-PMT (invented by IHEP) efficiency reached **31.3%**, much higher than the requirement 27% ➔ Expected energy resolution **2.95% @ 1 MeV**
  - Mass ordering, precision, supernova, atmospheric ν, solar ν, nucleon decay, indirect DM, … ***Yellow Book*** in JPG 2016, **1106 citations**; ***JUNO physics and detector*** in PPNP 2022, **188 citations**.



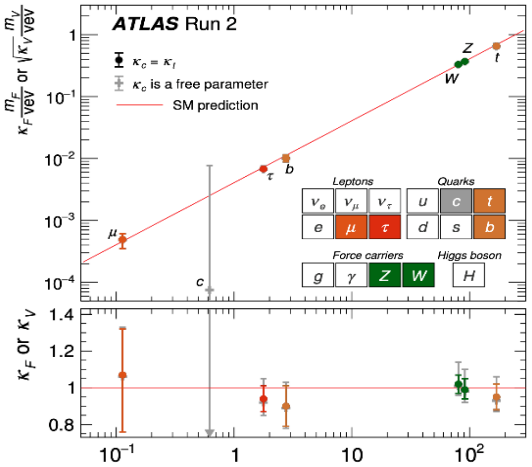
The first low-temperature Liquid Scintillator detector w/10 m² SiPM JUNO-TAO, energy resolution <2%



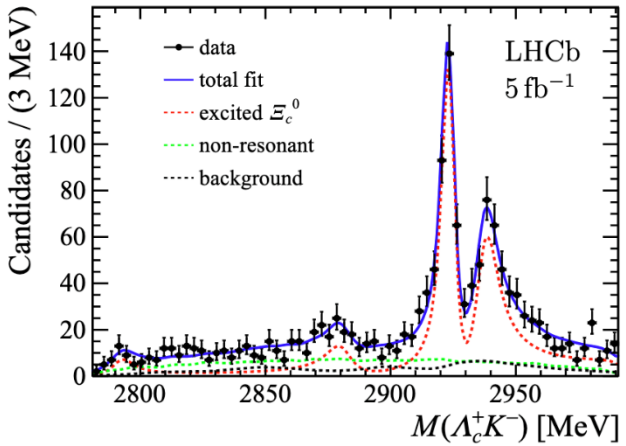


Highlights – LHC Physics

- **Commitments to ATLAS and CMS significantly increased, including upgrade, operation/performance, and physics**
- **~10 papers/year w/ leading or major contribution in each of ATLAS and CMS collaborations with Run2 data**
  - Higgs properties, BSM/SUSY particles, precision EW
- **LHCb team established since 2018, with a focus on UT upgrade, and physics interests on heavy hadron spectroscopy and CKM**

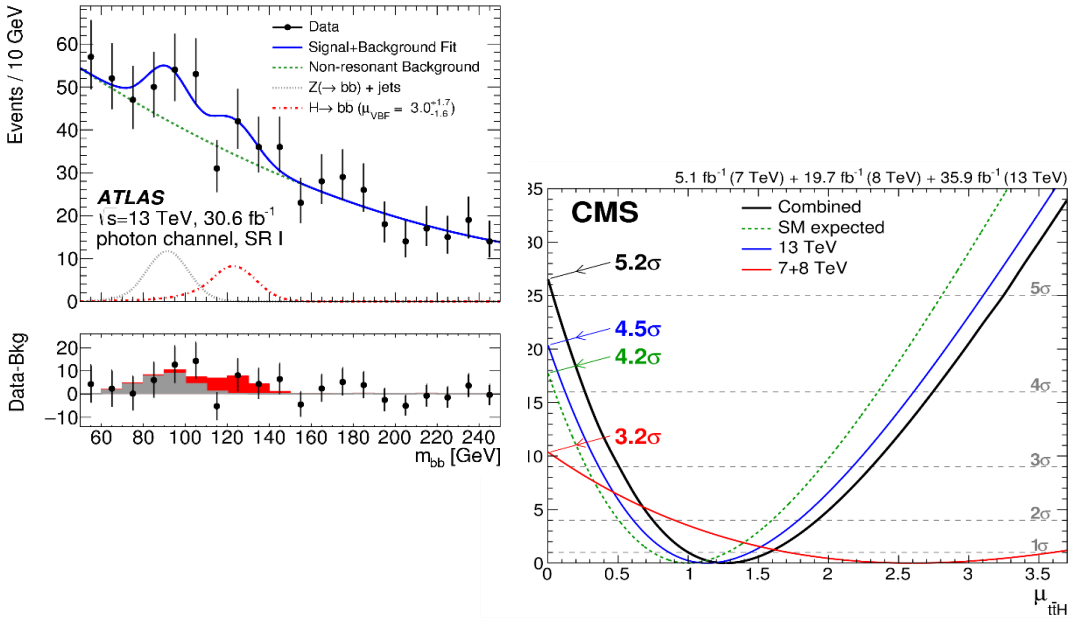


Evidence of $\Xi_c(2880)^0$



Higgs properties @ 10 years since discovery

Observation of H->bb @ ATLAS
led the VBF analysis (proposed a new photon final state), and contributed significantly to VH(bb)



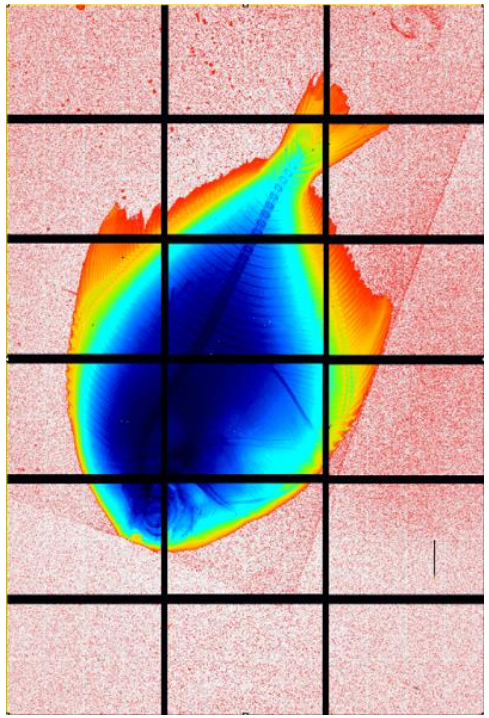
Observation of ttH @ CMS
significant contributions to the multi-lepton final state (the most sensitive sub-channel for ttH search)

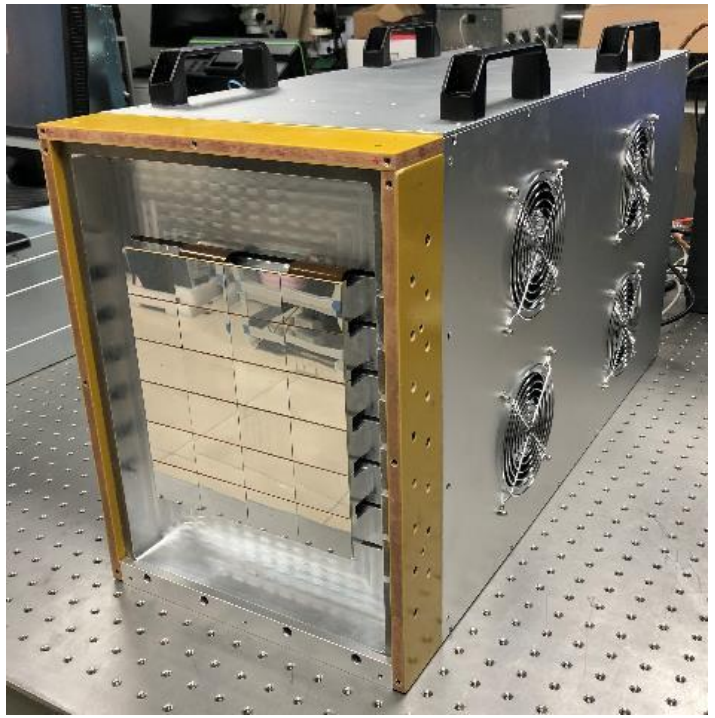
Highlights – Detector and Electronics

- **Semi-conductor detector R&D developed fast in recent years** (led by Jianchun Wang)
  - **Manpower from 10 → 18 FTE**
  - Much increased contributions in the international collaborations.
  - Detector R&D for major facilities:

Facility	Technology / Detector
HEPS	Pixel Detector
CEPC	Pixel / Vertex Detector
	Pixel / Si Tracker
ATLAS	Strip / ITk (inner tracker)
	LGAD pixel / HGTD (timing detector)
CMS	Pad / HGCAL (sampling calorimeter)
LHCb	Strip / UT (upstream tracker)
AMS	Strip / L0 Tracker

- **Silicone pixel detector for light source** (led by Wei Wei)



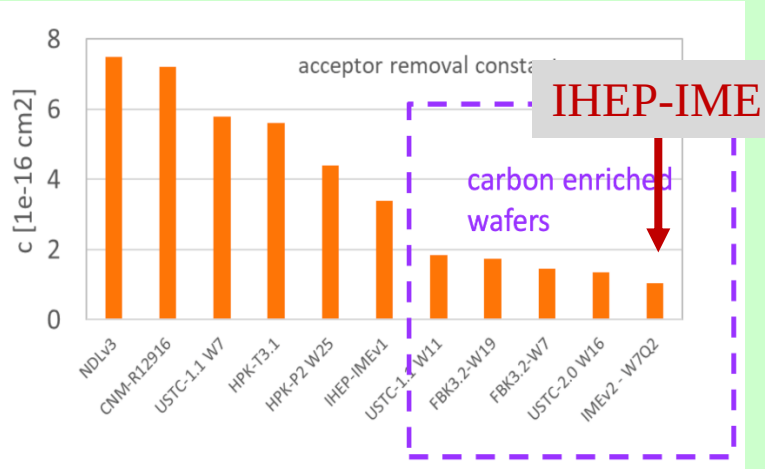


1.44 M pixels, pixel size 150×150 μm²

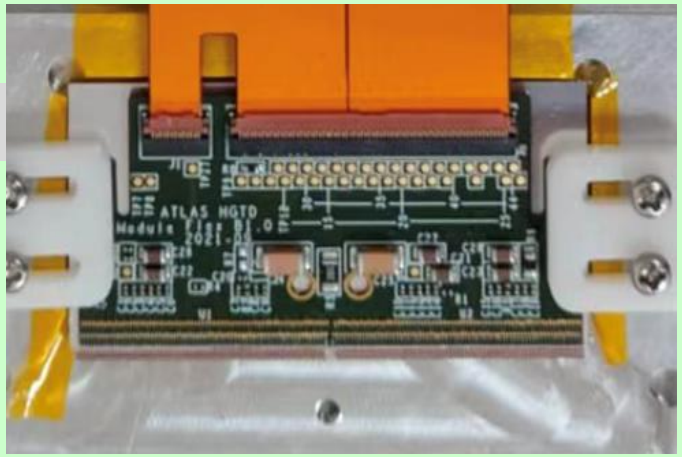
2 Mcps / pixel, energy range 8-20 keV

Highlights – Int'l Cooperation

Radiation-hard LGAD



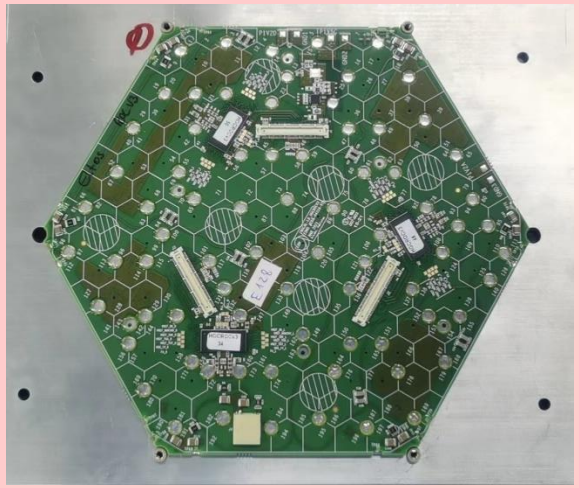
HGTD Full size Module



ATLAS HGTD

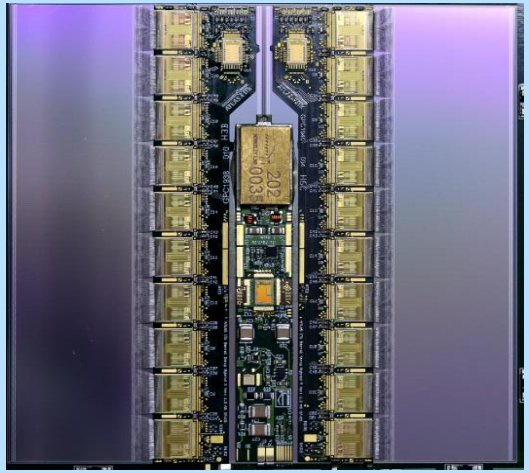
- IHEP-IME LGAD chip has the best radiation-hardness performance.
- IHEP will produce 33% LGAD chips, and 45% det. modules
- Project led by IHEP (Joao Guimaraes da Costa)

8″ Prototype Module



ATLAS ITk

IHEP will produce 1000 det. modules, ~10% of total



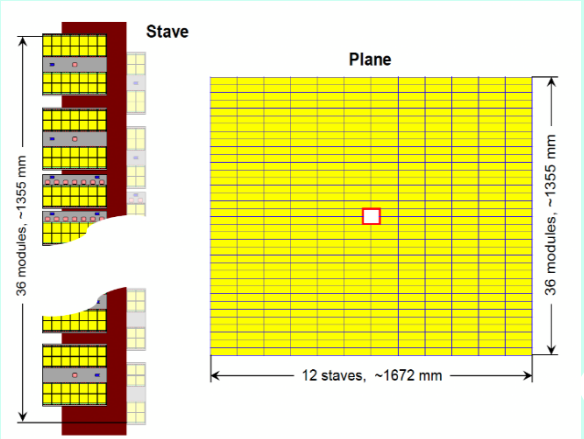
CMS HGCAL

- IHEP will produce 4500 det. modules, ~1/6 of total
- Produced the first working prototype module

Highlights – Int'l Cooperation

UT Detector Integration

Conceptual Design of Upgrade II UT

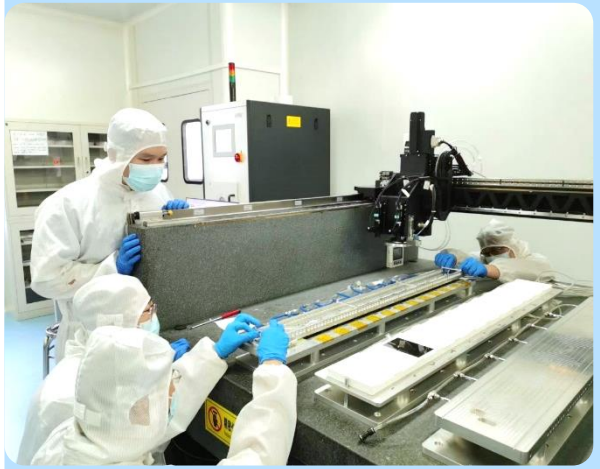


LHCb UT

- Major role in the phase I upgrade of the detector, including radiation study, installation and commissioning.
- Leading the phase II upgrade design
- Deputy Project leader (Jianchun Wang)

AMS L0 Tracker

- Design and production of the silicon strip sensor
- Will produce all detector ladders (~8 m^2)
- Joint effort of EPD and PAD



Also in

- **Europe**
  - PANDA
  - DarkSide (Detector)
- **KEK**
  - BELLE-II
  - COMET
- **US**
  - EXO/nEXO (Detector)
  - GlueX

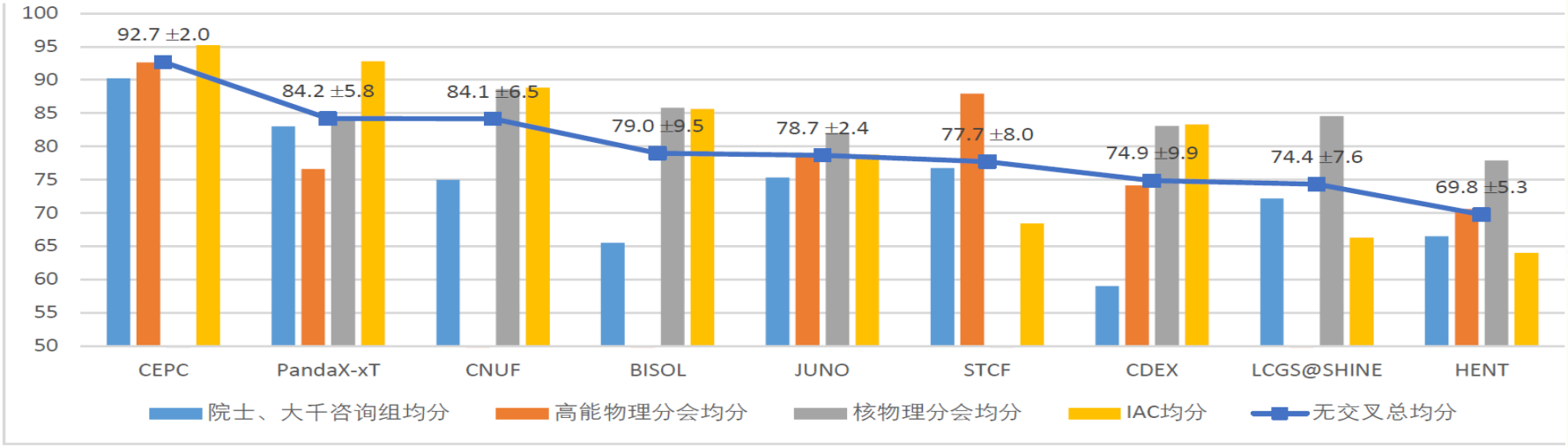
Strategic Planning

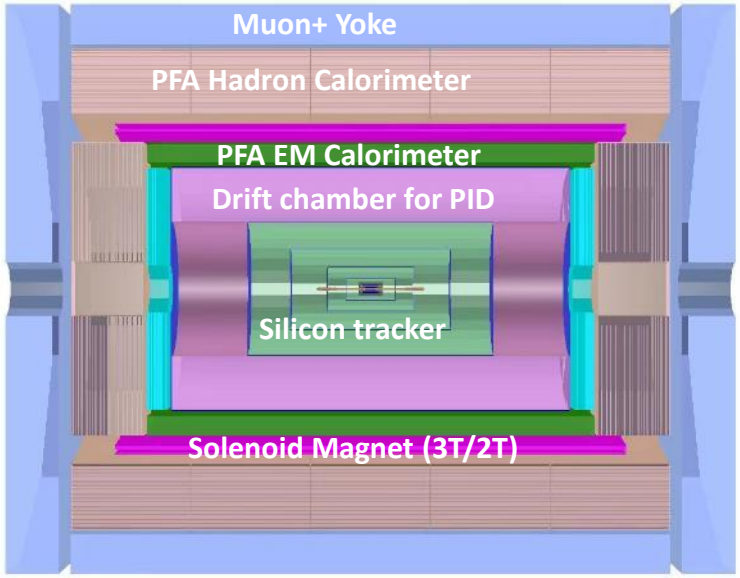
- **EPD operates BESIII and is constructing JUNO**
- BESIII detector performing well. world's largest, high-quality data samples. Many great physics results in hadron spectroscopy, charmonia, XYZ states, and charmed hadrons.
- Increase the luminosity by 3 times in >4 GeV. BESIII will operate until at least 2030 and keep producing great results.
- The Daya Bay decommissioned in 2020. Analyses completed in a couple of years.
- JUNO will start data taking in 2024 with a lifetime of 30 years. Expect to measure neutrino mass ordering to 3 sigma in 6 years and measure 3 out of 6 oscillation parameters to world-best sub-percent precision in 1 year.
- upgrade to a 0νββ experiment around 2030 (w/o hurting other physics except the mass ordering)

IHEP "1-7-5 Development Plan"	
One Vision: One of the world's leading particle physics research centers, and a world-class, large-scale, comprehensive, multidisciplinary research base.	
Seven Priority Development Areas	**1. Charm physics**
	2. Neutrino physics
	3. Particle Astrophysics
	4. High Energy Photon Source
	5. CSNS-II and SAPS
	6. Key tech of large-scale research infrastructures
	7. Development and application of radiation tech
Five Emerging and Frontier Areas	1. High Energy Colliders and Collider Physics
	2. Extreme universe and high energy cosmic rays
	3. Quantum computing and AI in HEP
	4. Plasma wakefield acceleration
	5. Electronic technology for wireless detectors

Strategic Planning

- **CEPC: EPD provides the overall project management and detector R&D (X.C. Lou's report)**
  - CEPC as an e^+e^- Higgs (+W, Z, top) factory **ranked No. 1** in particle & nuclear physics in CAS planning for the 15th 5-years plan for large science project. A final report will be submitted to CAS
  - Can be upgraded to a proton-proton machine (**SppC**) within the same tunnel
  - Detector and accelerator R&D will continue driving the technology advance at IHEP
  - Idea of the "4th Detector Concept" based on the PFA calorimeter
- **EPD enthusiastically supports new technologies, such as Quantum computing and AI in HEP, innovative detector technology and electronics, etc.**



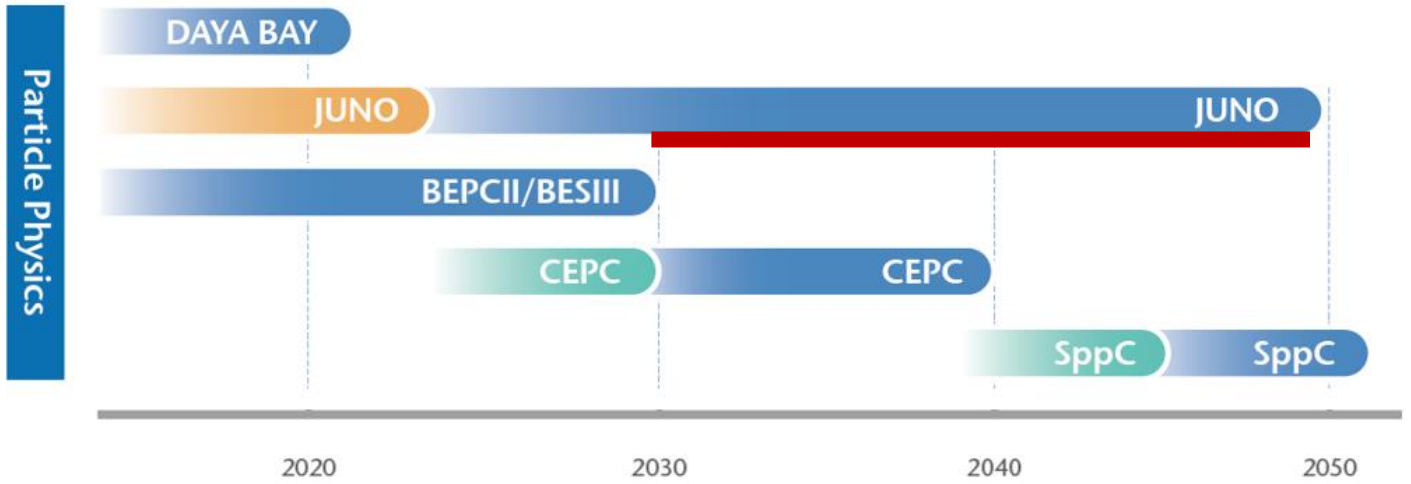


Issues from previous Assessment

- Provide input to the European Strategy on Particle Physics, especially on CEPC and JUNO.
  - JUNO and CEPC have provided documents to the European Strategy and Snowmass
- More BES III data are needed. complementarity with other approaches must be exploited (PANDA, BELLE2). …… involvement of theorists in the interpretation.
  - BESIII is taking data with high efficiency. The group maintain proper participation to international experiments. Cooperation with the Theory Division has been enhanced (see TPD report).
- Much progress has been achieved in the involvement of IHEP in ATLAS, but visibility can still be increased …… enabling the long term goal of IHEP to host world-leading accelerators.
  - Contribution to LHC experiments (ATLAS, CMS, and LHCb) has been significantly enhanced. leading the upgrade of a subdetector, and playing important roles in all participating experiments
- The preparation of the CEPC physics and detector studies should remain an important activity, maintaining necessary contacts with the ILC community and developments at CERN.
  - CEPC released the CDR for Physics and detector in 2018, white paper for Higgs physics in 2019. Other white papers are in preparation. Proposed the "4th detector". Many adv. Detector R&D conducted.
  - Cooperating w/ ILC and FCC@CERN

Summary and Challenges

- **EPD has developed very healthily in the last 5 years**
  - Made good progresses in Hadron, Neutrino, High Energy Frontier Physics, and Detector R&D.
  - Has a clear development plan
  - Manpower and funding in good shape for current researches.
- **Challenges**
  - Funding difficulties to further enlarge the team for CEPC
  - Difficulties to recruit talented young scientist for BESIII
  - Internationalization, still not attractive enough for foreign researchers



Many thanks for your evaluation!

Quantum comp., AI, wireless detectors

- **IHEP AI collaboration (~100 members)**
  - EPD is a driving force
  - Semi-annual mtg. biweekly R&D mtg.
  - Application in BESIII, JUNO, ATLAS, CMS, HEPS, Astrophysics, Accelerator, etc.
  - R&D tasks (e.g. **Dr. Sai** project: BESIII analysis with Large Language Model)
  - Good communication w/ int'l colleagues
- **Quantum Computing**
  - Three groups at IHEP: LQCD (Theory Division), PID and Quantum machine learning (EPD)
  - Computing Center provides simulation platform
  - Testing with several platforms in China
- **Wireless Detector**
  - Data transmission and control
  - WIFI, WIFI4+ scheme based on Raspberry reached 22 Mbps. Goal for the upgraded BESIII drift chamber. Considering WIFI6.
  - mmWave, based on 60 GHz ST60A2, 6 Gbps, to be tested.
  - Laser: CWDM
  - Lab established.