Prospect of Particle Physics in China

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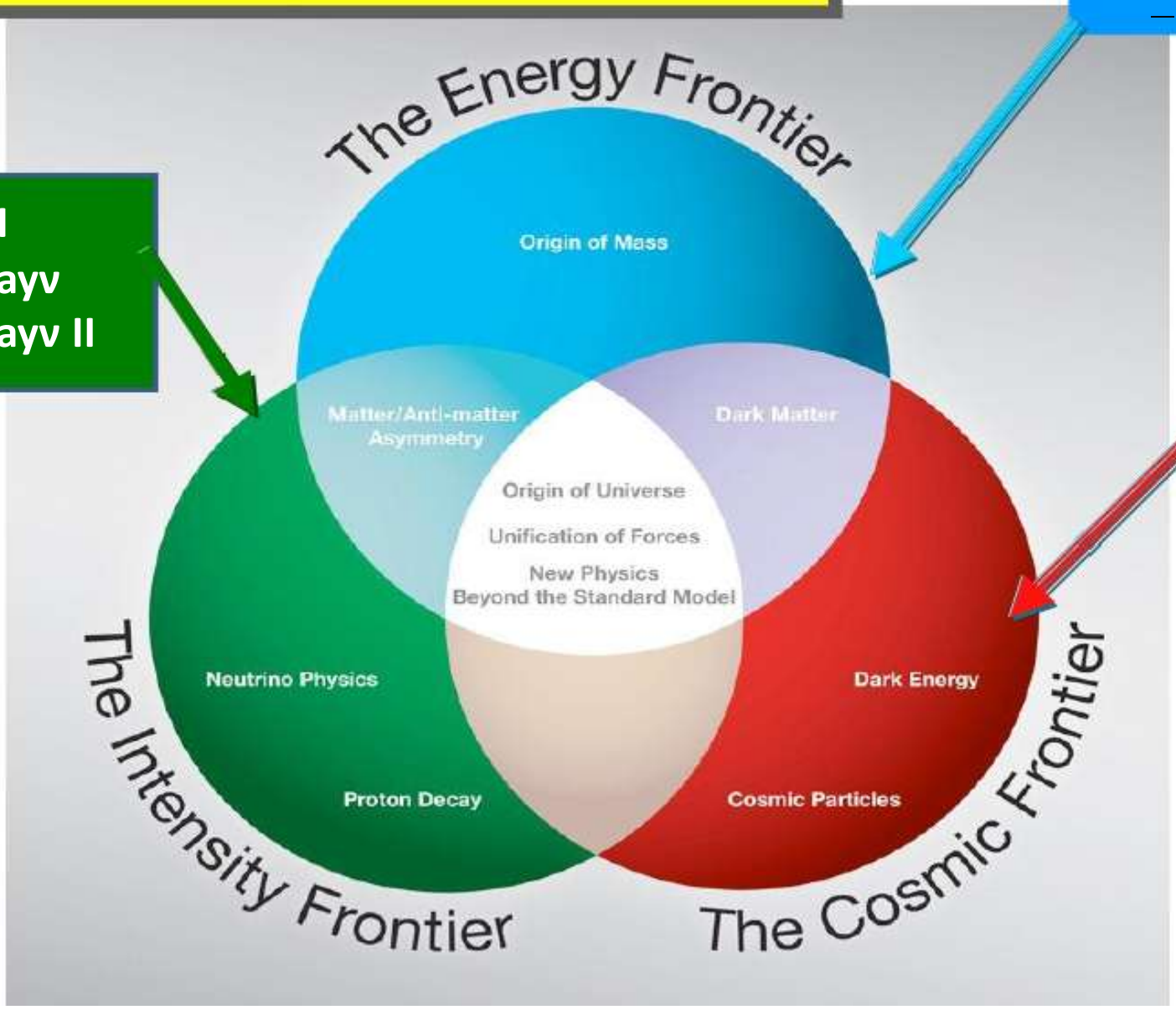
Outline

1. Introduction
2. BEPC/BEPCII
3. Daya Bay reactor neutrino experiment
4. Particle astrophysics experiments
   a) Yanbajing cosmic ray observatory
   b) Space experiments
5. Future plan
6. Closing remarks

Frontiers of Particle Physics in China

Intl. Cooperation:
- LHCexp. :
- ILC/CLIC?
- …

- BEPCII
- DayaBayv
- DayaBayv II



- Cosmicrays
- Space experiments
- Deep underground

Institute of High Energy Physics

- **Institute of Modern Physics: established at 1950**
- **Institute of High Energy Physics: independent Institute for Particle physics at 1973**

  → Comprehensive and largest fundamental research center in China
  - **1300 employees, 3/4 of them are physicists and engineers,**
  - **500 PhD Students and 60 postdoctors**
- **Goal of IHEP: multiple discipline research center based on large scientific facilities.**

Major research fields at IHEP

- Particle physics:
  - Charm physics @ BEPC
  - LHC exp.
  - Yangbajing cosmic ray observatory
  - particle astrophysics: HXMT, SVOM
  - ν physics: Daya Bay reactor ν exp.
  - Deep Underground Exp.
- Accelerator technology and applications
  - High Lumi. e+e- collider: BEPCII
  - High power proton accelerator:CSNS,ADS
- Radiation technologies
  - Synchrotron radiation source and applications
  - Spallation neutron source and application
- Multiple discipline research: lifescience, nano-sciences, nuclear imaging, environment……

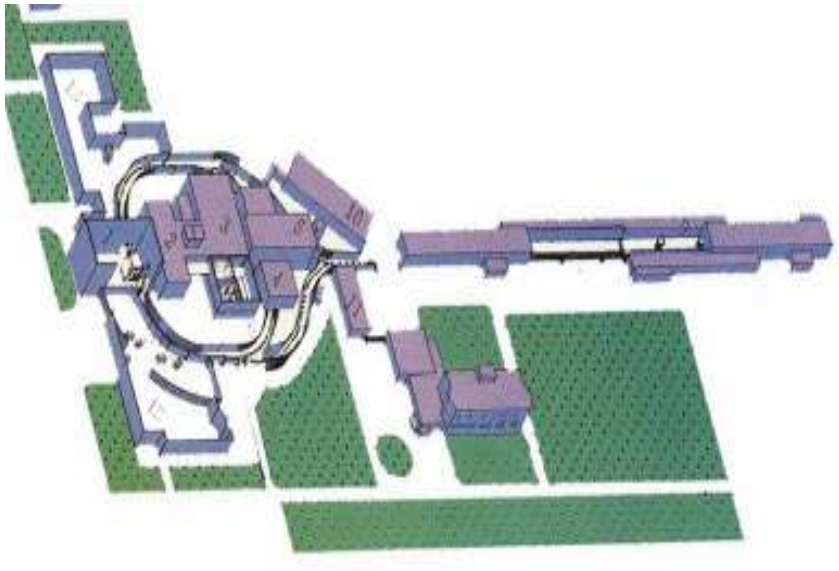
2. Beijing Electron Positron Collider (BEPC)

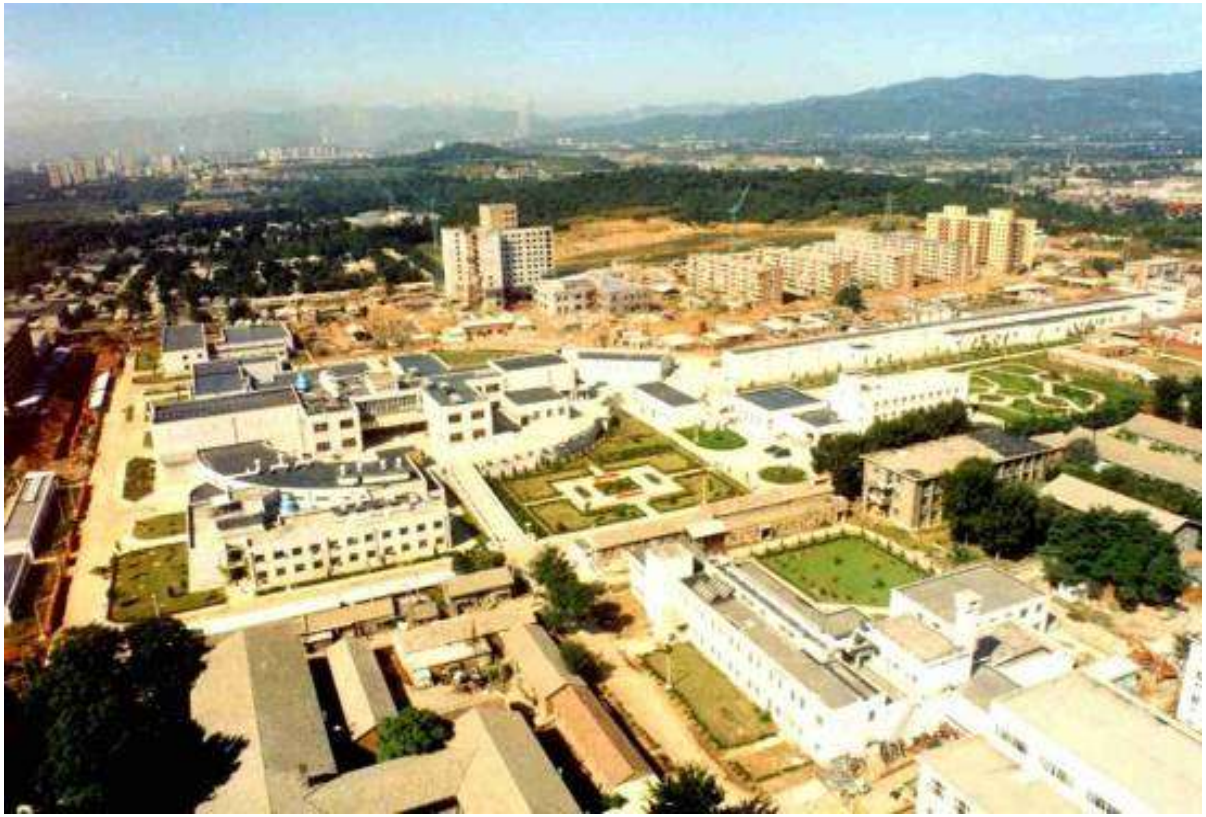
BEPC: constructed 1984-1988 E_{beam} **~ 1–2.5 GeV**

- **BESI: run from 1989-1998**
- **BESII: run from 1999-2004**

BECPII upgraded 2004-2008 E_{beam} **~ 1–2.3 GeV**

- **BESIII: run from 2008**





With BESI and BESII data

- **precision measurement of τ mass: 10 times improved. Lepton universality!**
- **R measurements improve uncertainties by a factor of 2-3 ($\Delta R/R \sim 6\%$). Great impact to M_H, $\alpha(M_z^2)$, g-2**
- **Some new particles X(1835) observed. Hard to be interpreted as conventional hadrons. ppbar bound state?**

Precision measurements on the Charm physics require high statistics and small sys. errors →

Major upgrade: BEPCII / BESIII (2004-2008)

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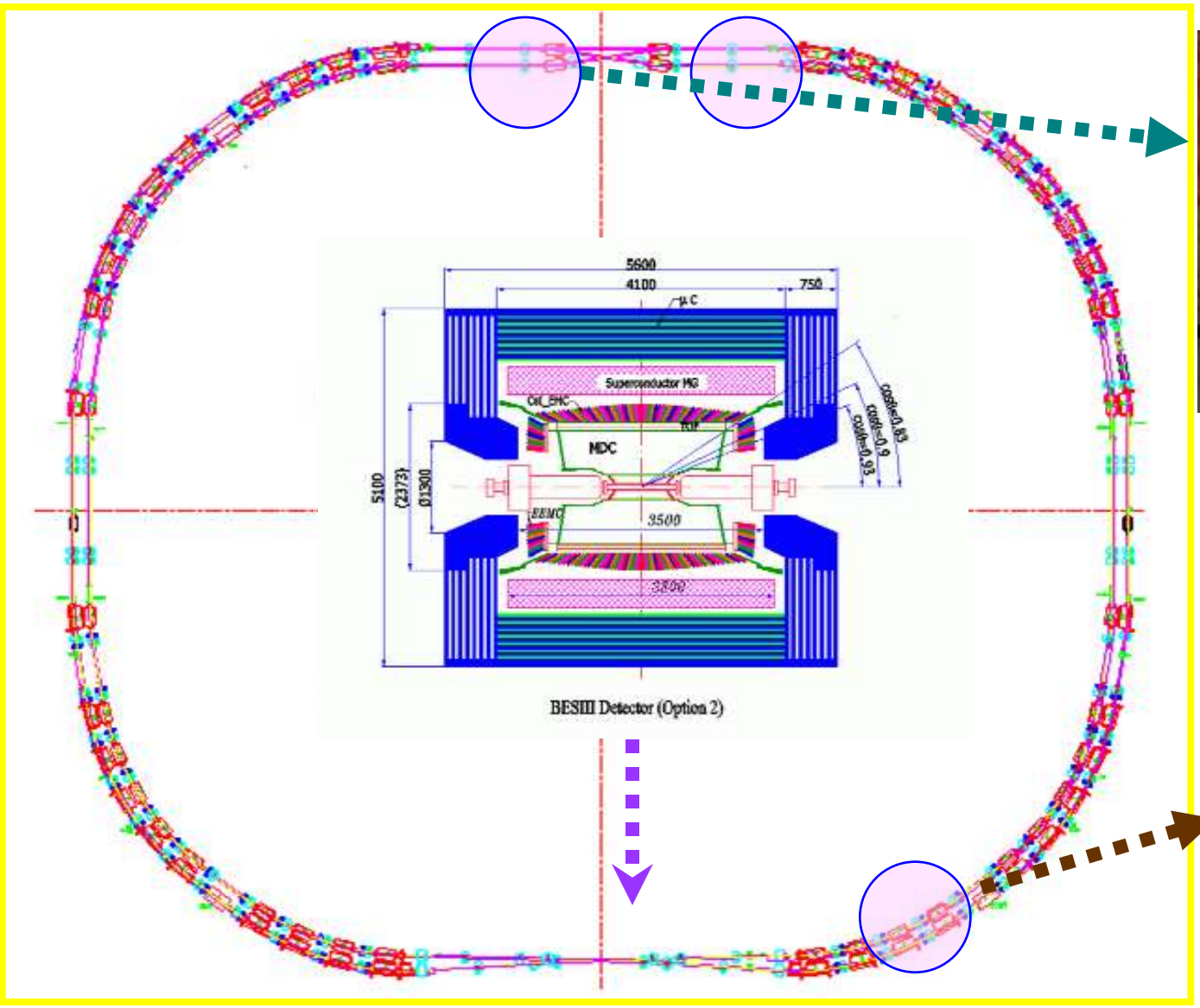
BEPCII: a high luminosity double-ring collider



SC RF

Two rings

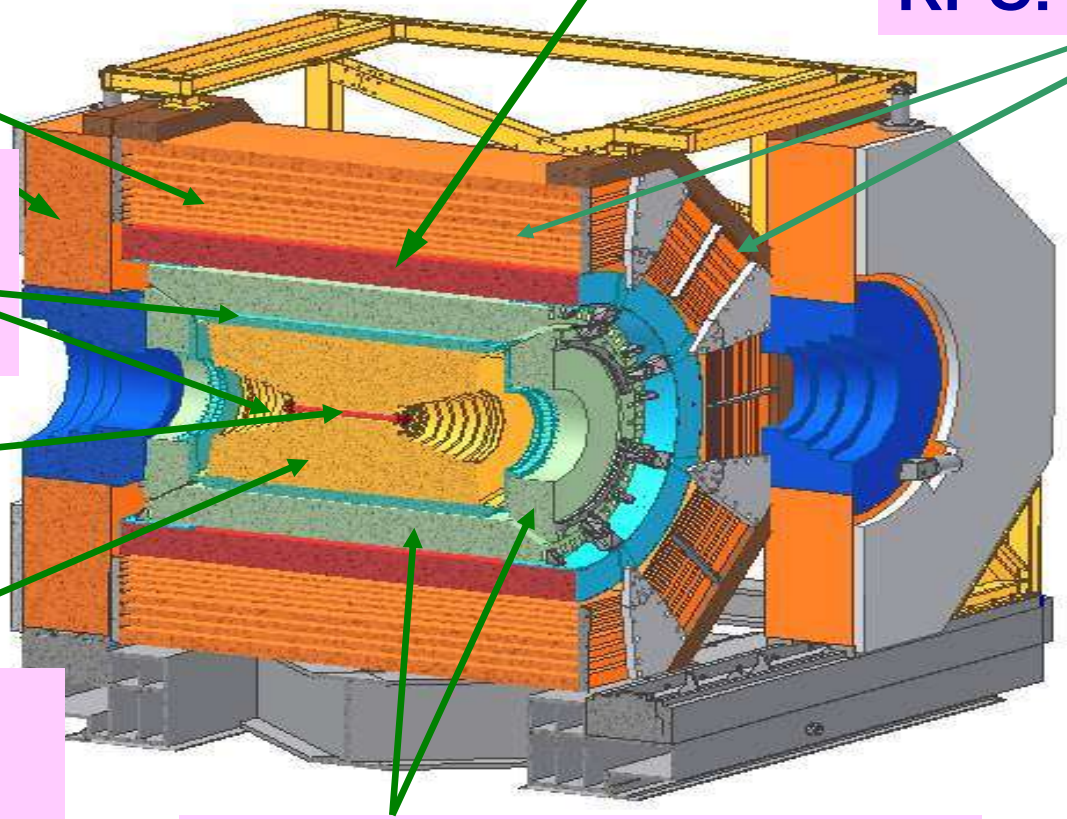
Storage Ring installation finished

The BESIII Detector

Magnet yoke

SC magnet, 1T

RPC: 9 layers



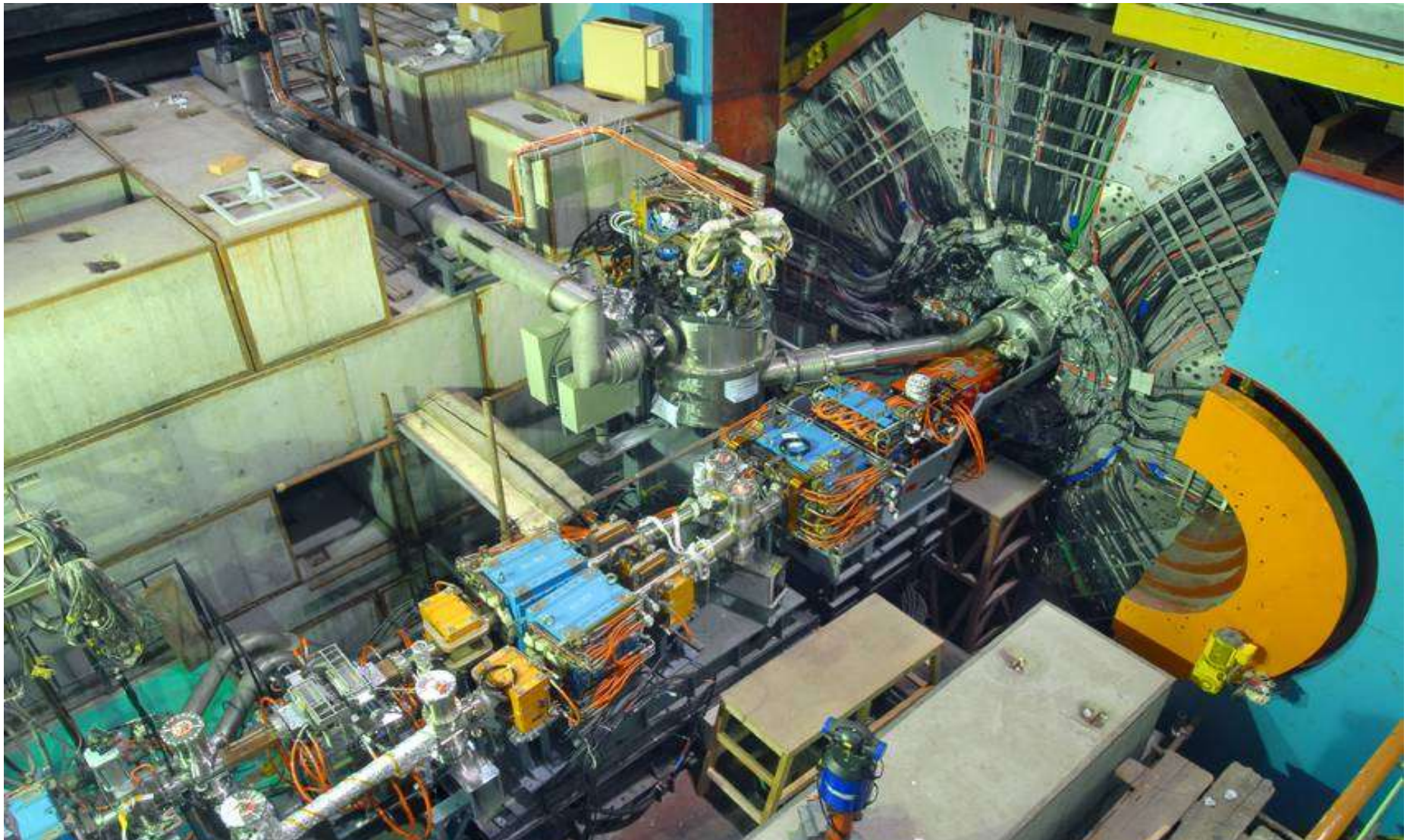
TOF,
σ_T (ps) = 100 ps Barrel
110 ps Endcap

Be beam pipe

MDC,
σ_{XY} (μm) = 130
△P/P = 0.5 % (1 GeV)
$\sigma_{dE/dx}$ = 6-7 %

CsI(Tl) calorimeter,
△E/√E = 2.5 % (1 GeV)
σ_z,ϕ(cm) = 0.5cm/√E

Interaction Region of BEPCII



Performance of BEPCII injector linac

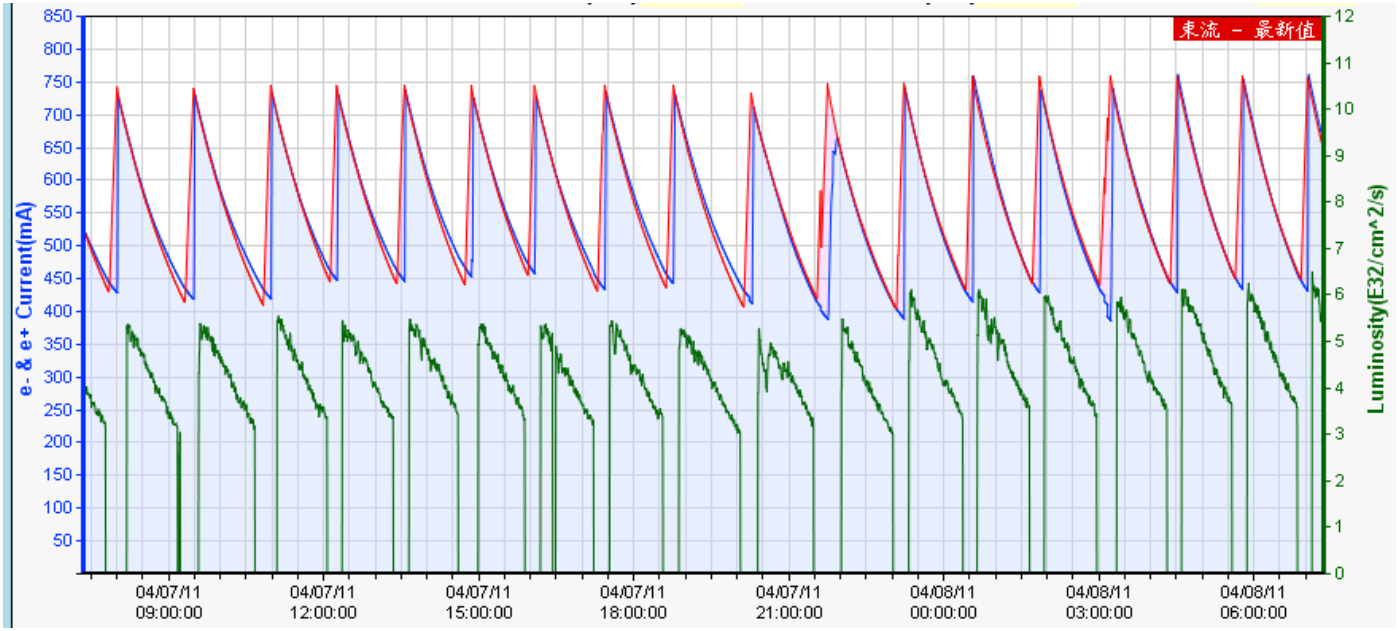
Parameters		Design	Accept test	BEPC
Energy (GeV)		1.89	1.89	1.30-1.55
Current (mA)	e+	37	66	~5
	e-	500	550	300
Emittance (1 ∫) (mm-mrad)	e+	0.40	0.35 ~ 0.27	----
	e-	0.10	0.097~0.079	----
Energy spread (1σ) (%)	e+	0.50	0.371	~0.80
	e-	0.50	0.295	~0.80
Energy stability (%)		±0.15	±(0.050 ~ 0.035)	----
Orbit stability (mm)		±0.30	±(0.119 ~0.058)	----
Repeatation rate		50	50	12.5
e^+ inj. rate (mA/min.)		50	61.5	1 ~ 3

positron injection rate improved by > factor of 15

Operation of BEPCII

- 5 – 6 months operation for HEP experiments @ different beam energy: ψ(3770), D_s, ψ′, τ, J/ψ, etc.
- 3 months for SR users, dedicated SR mode @ 2.5GeV

Data taking @ ψ(3770)



Peak luminosity: $6.5\times10^{32}cm^{-2}s^{-1}$ @ 719 × 732mA ($e^+ \times e^-$)

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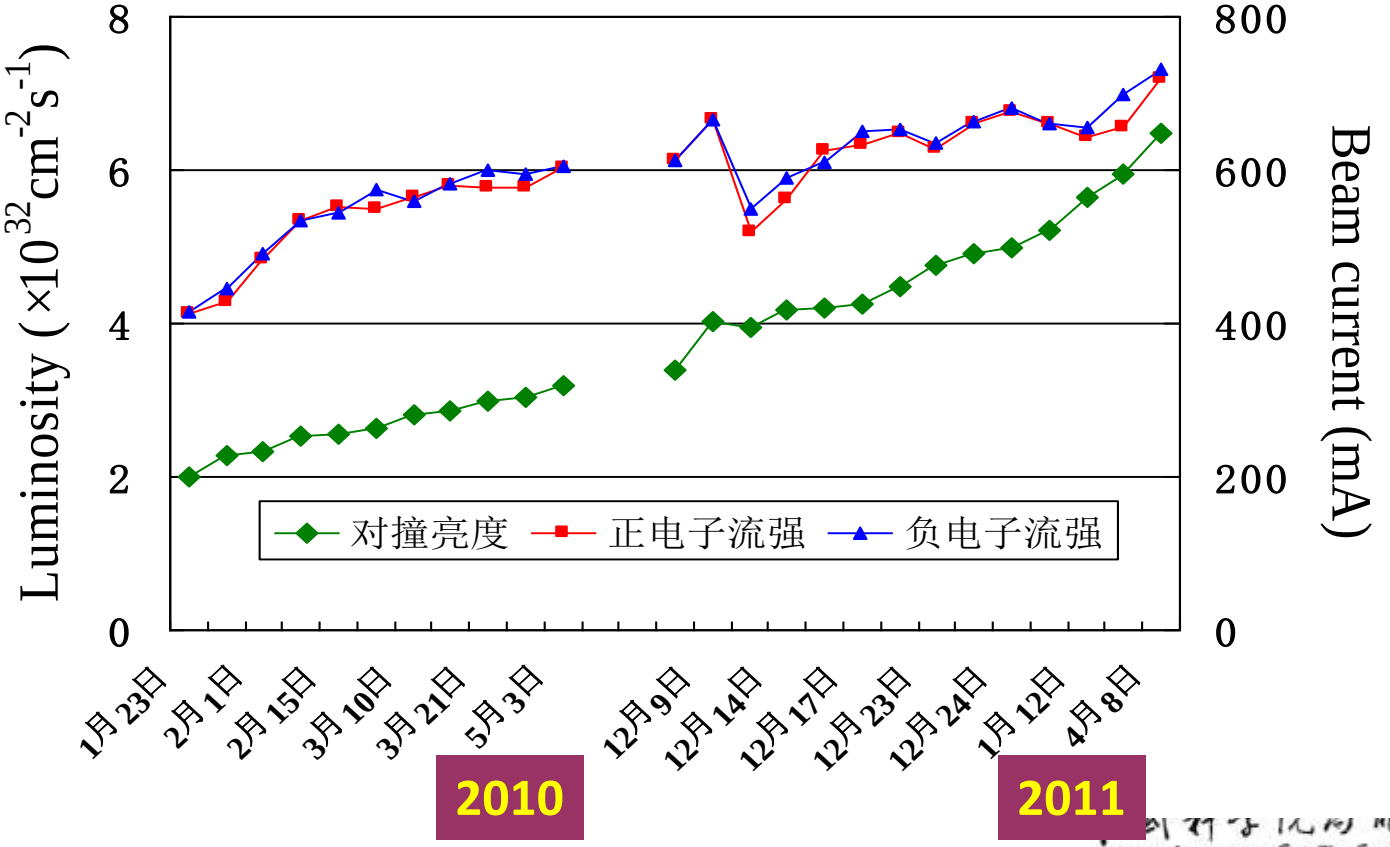
Peak Lumi@3.77GeV: 6.5×10^{32} 8XCESR$_c$

- Luminosity enhanced: ν_x --> 0.5 (0.506), reducing emittance coupling, and increasing beam current



Data accumulation for physics

- July 19, 2008: first e^+e^- collision event in BESIII
- Nov. 2008: ~ 14M $\psi(2S)$ events for detector calibration
- 2009: 106M $\psi(2S)$ 4*CLEOc
  225M J/ψ 4*BESII
- 2010: 900 pb^{-1} $\psi(3770)$
- 2011: 1800 pb^{-1} $\psi(3770)$ (daily Lumi. X90)
  470 pb^{-1} @ 4.01 GeV

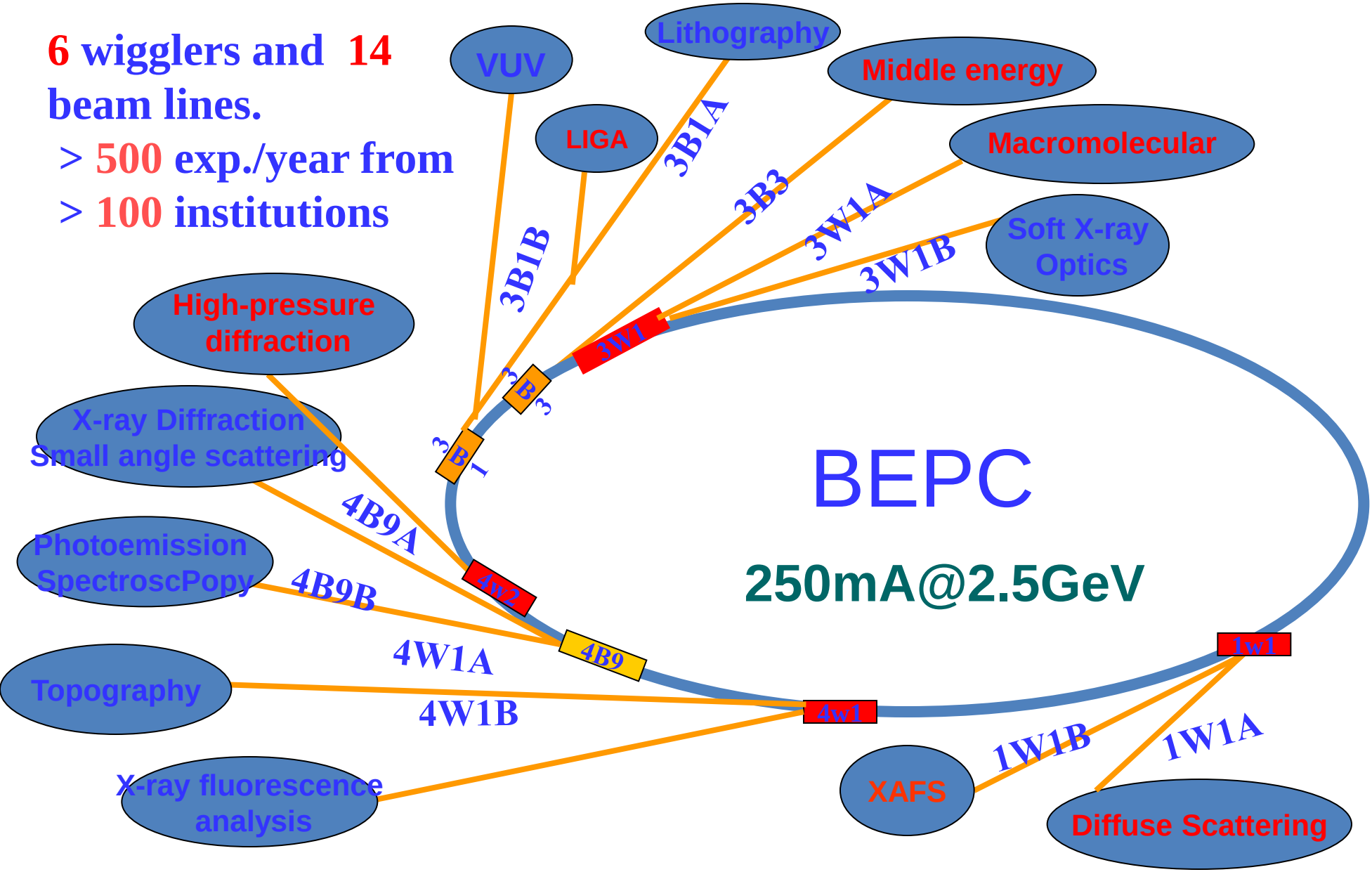
  } 3 .5*CLEOc

- 2012: ~0.4 billion $\psi(2S)$
  1 billion J/ψ (04/05- 05/22) : Daily Lumi. X120

6 wigglers and 14 beam lines.

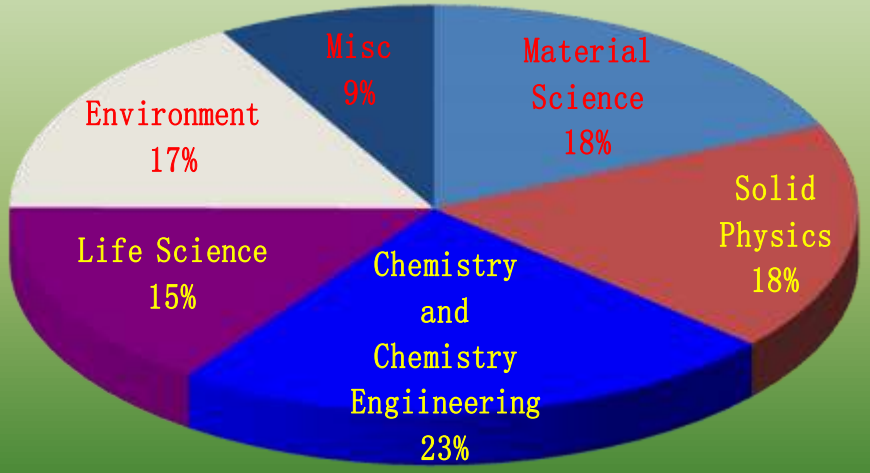
> 500 exp./year from

> 100 institutions



Beijing Synchrotron Radiation Facility

Distribution of user's subject

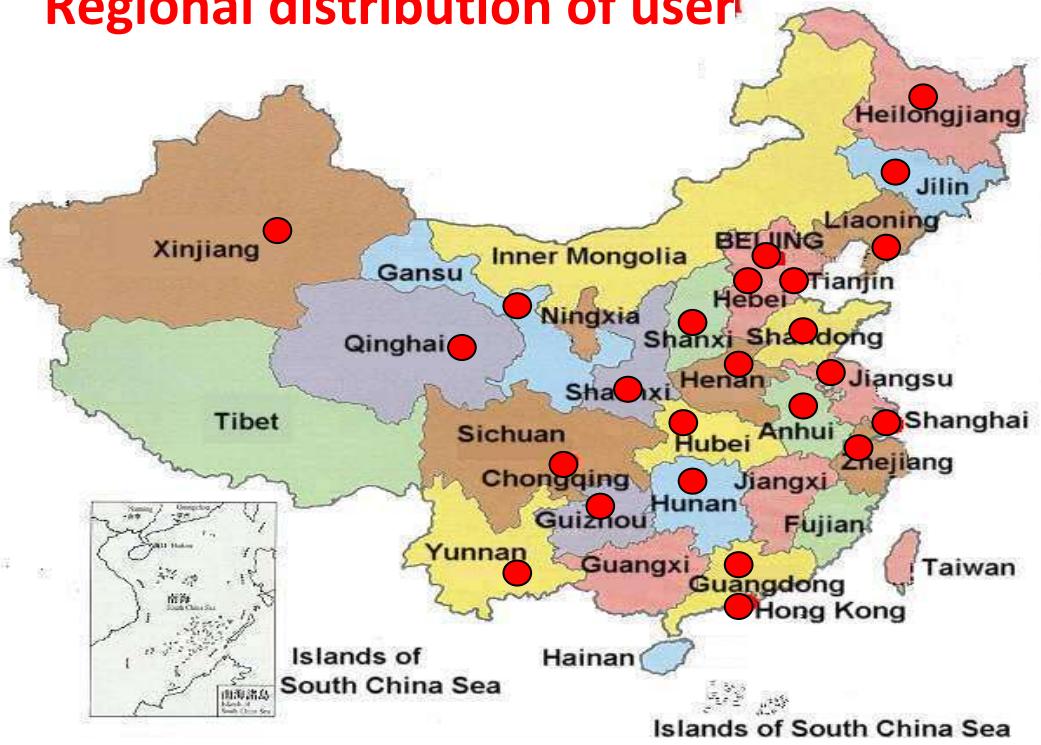


Two modes running for users:

Dedicated mode, E = 2.5 GeV, 15 beam lines on

Parasitic mode, 6 beam lines on when running for HEP

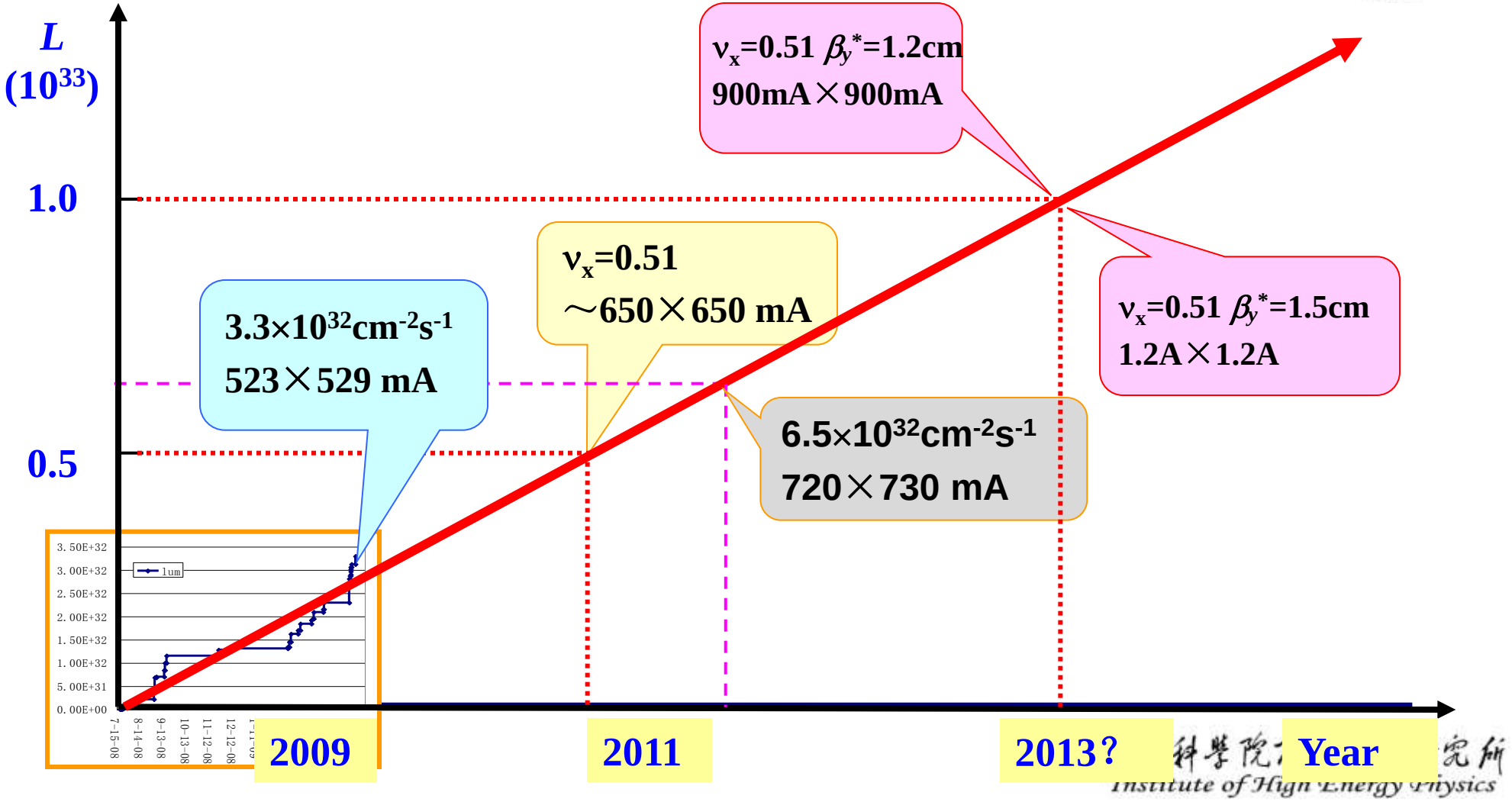
Regional distribution of user



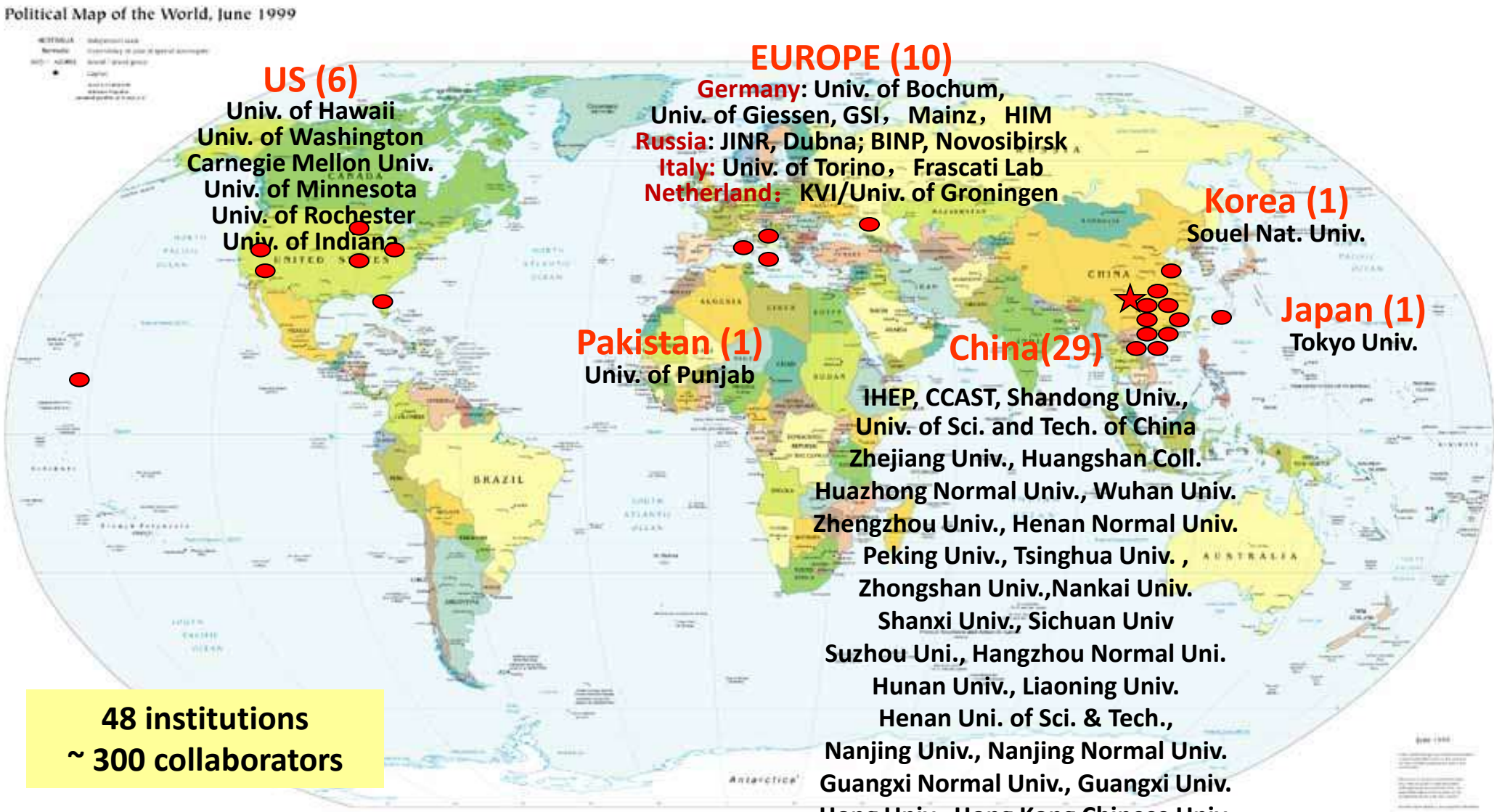
Main parameters of BEPCII achieved in operation

Parameters	Design	Achieved	
		BER	BPR
Energy (GeV)	1.89	1.89	1.89
Beam current (mA)	910	800	800
Bunch current (mA)	9.8	9.0	9.0
Bunch number	93	80 – 88	80 – 88
RF voltage (MV)	1.5	1.5 – 1.7	1.5 – 1.7
β_y^* (cm)	1.5	1.4 – 1.5	1.4 – 1.5
Lifetime (hrs)	3.5@910mA	~1.8@720mA	~1.8@720mA
Beam–beam parameter	0.04	0.0327	
Lum. ($\times 10^{32} cm^{-2} s^{-1}$)	10	6.492	

BEPCII Luminosity Roadmap



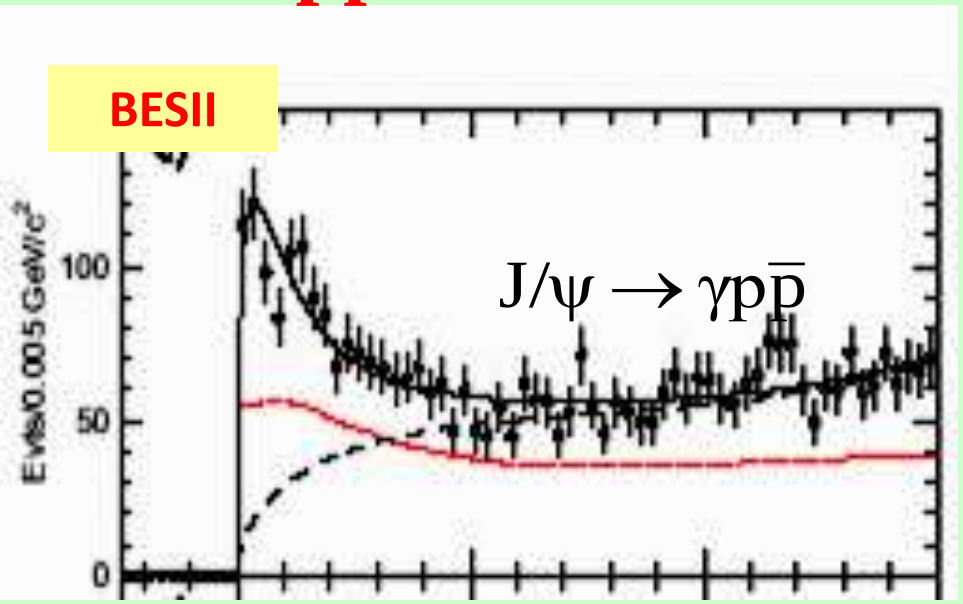
BESIII collaboration



BESIII： First physics results

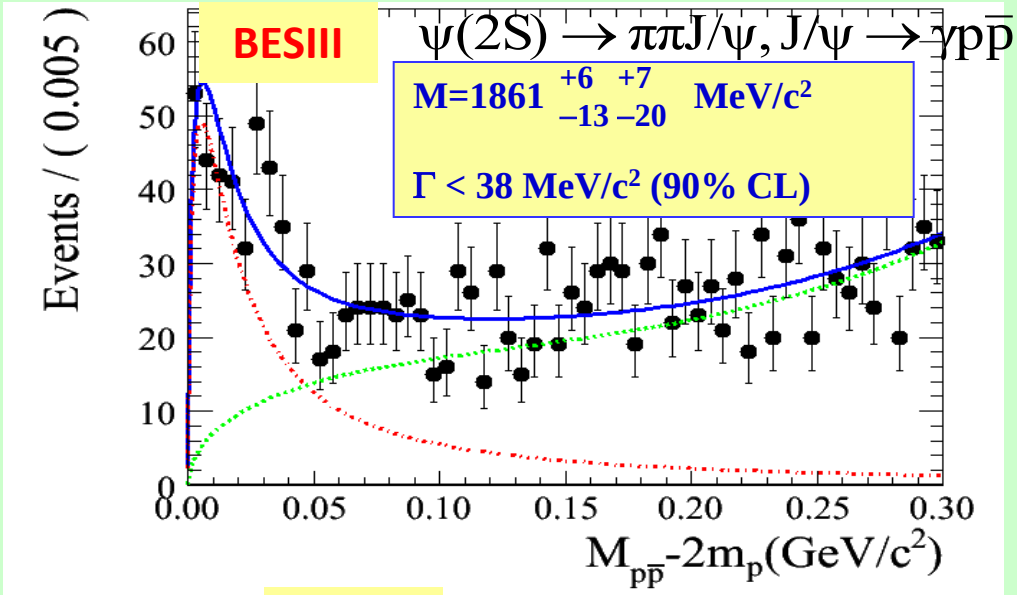
- **Light hadron physics**
  - **Confirmation of BESII results: threshold enhancement γppbar, $\gamma\omega\phi$, X(1835), …**
  - **New resonances**
  - **New observations: e.g. a_0-f_0 mixing**
- **Charmonium physics**
  - **Improved measurements: h_c, η_c, χ_{cJ}, , …**
  - **D physics**
  - **New observations**
    - **χ_{cJ} decays**
    - **h_c decays**

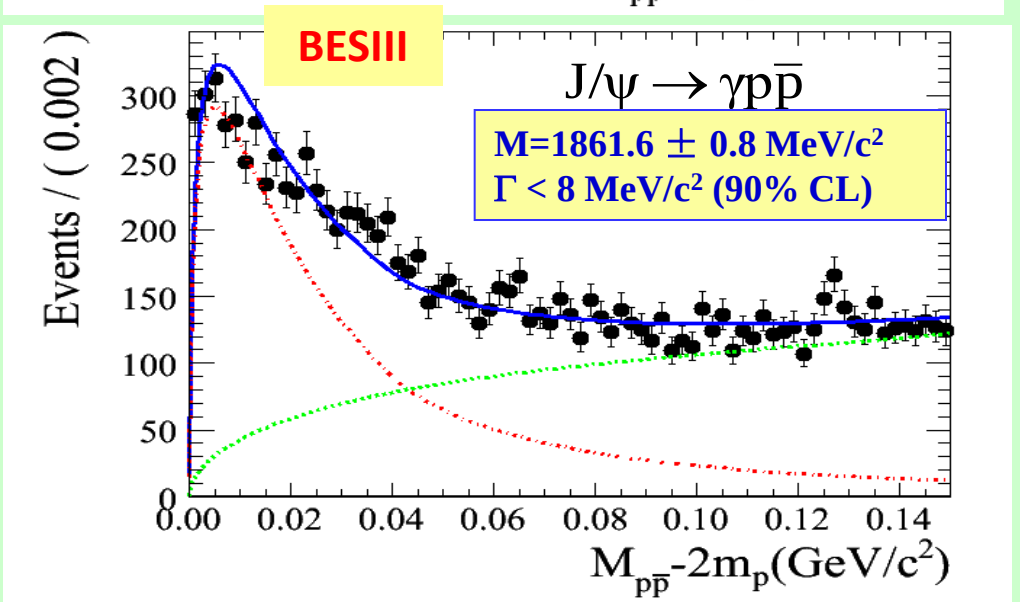
Confirmation of the BESII observation: $p\bar{p}$ threshold enhancement in J/ψ decays



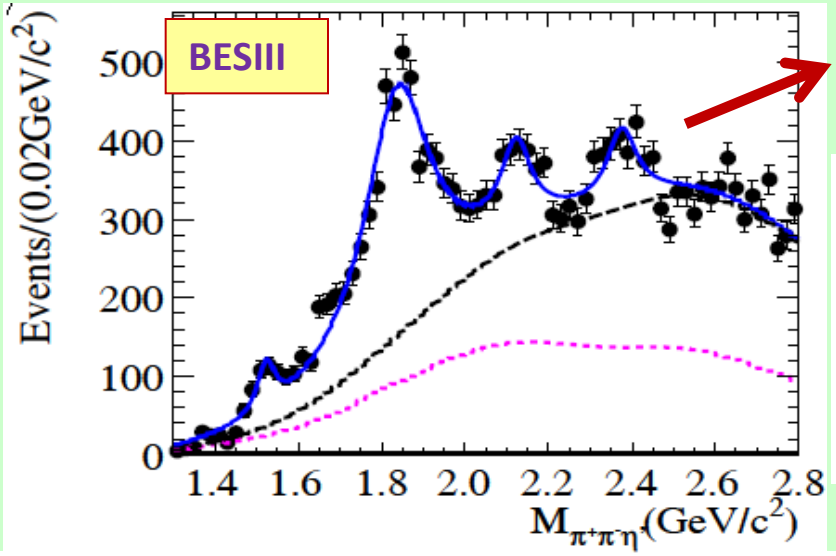
M=1859 $^{+3}_{-10}$ $^{+5}_{-25}$ MeV/c²
Γ < 30 MeV/c² (90% CL)

arXiv:1001.5328,
Chinese Phys. C 34（2010）421



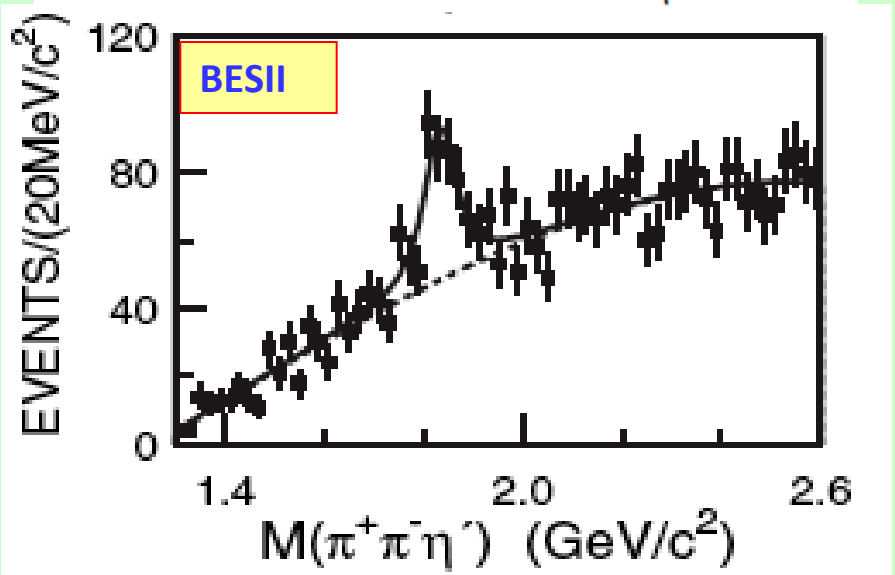


Confirmation of BESII observation: X(1835) in $J/\psi \rightarrow \gamma\eta'\pi\pi$



Two new resonance

resonance	$M(\ \mathrm{MeV}/c^2)$	$\Gamma(\ \mathrm{MeV}/c^2)$	Stat. sig.
X(1835)	1838.1 ± 2.8	179.5 ± 9.1	$> 25\sigma$
X(2120)	2124.8 ± 5.6	101 ± 14	$> 7.2\sigma$
X(2370)	2371.0 ± 6.4	108 ± 15	$> 6.7\sigma$



significance: $7.7\,\sigma$

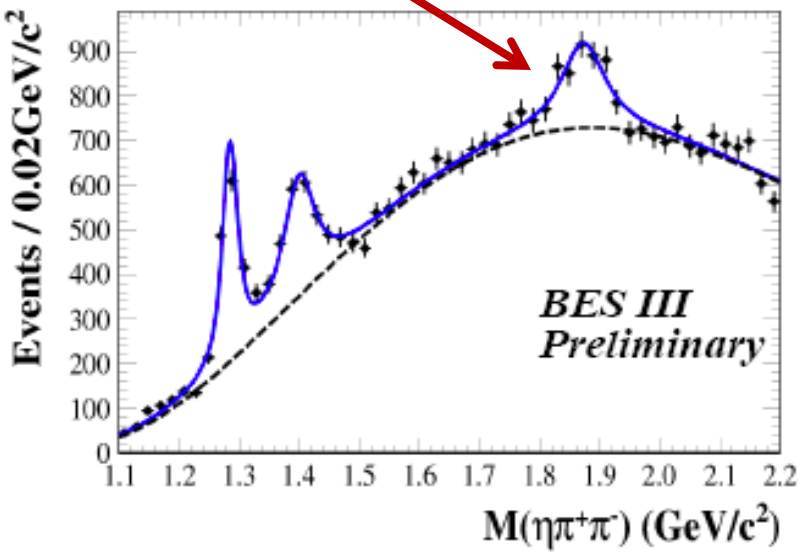
$M = 1833.7 \pm 6.1(\mathrm{stat}) \pm 2.7(\mathrm{syst})\,\mathrm{MeV}$

$\Gamma = 67.7 \pm 20.3(\mathrm{stat}) \pm 7.7(\mathrm{syst})\,\mathrm{MeV}$

To be submitted to PRL

Observation of X(1870)→ $a_0(980)\pi$ in $J/\psi \to \omega\pi^+\pi^-\eta$

X(1870)

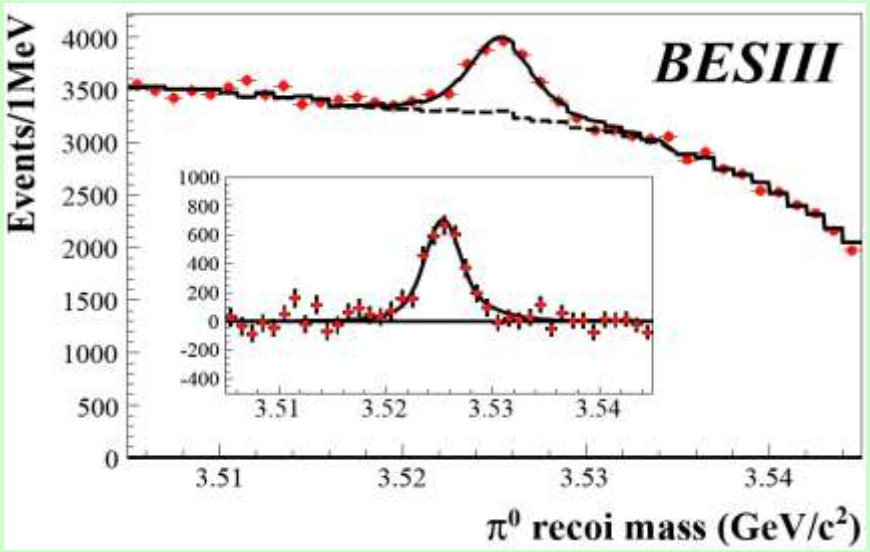


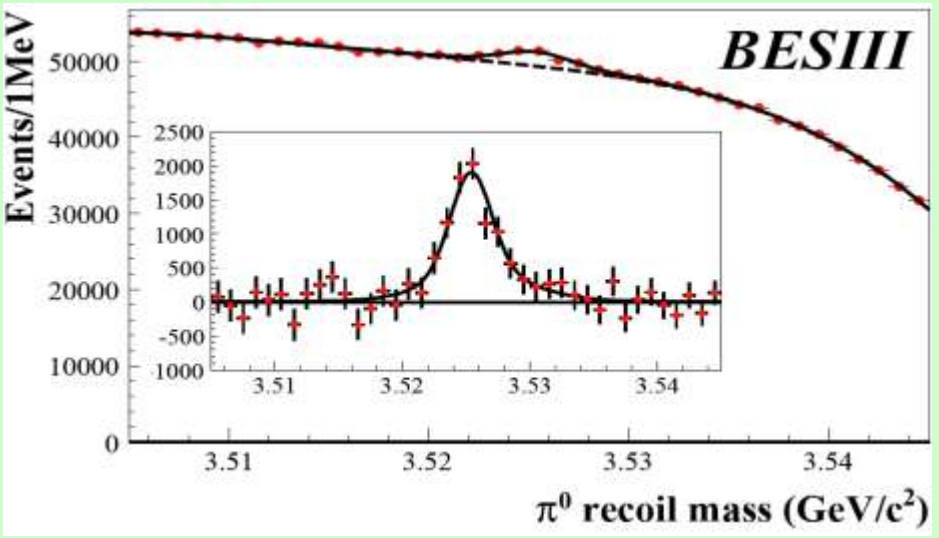
$$Fit\ result\ (stat.\ sig.\sim 7.7\sigma)$$
$$M = 1873 \pm 11 MeV$$
$$\Gamma = 82 \pm 19 MeV$$

Whether the X(1870) is the X(1835) or $\eta_2(1870)$, or a new resonance, further study is needed.

To be submitted to PRL

Observation of h_c in $\psi(2S)\to\pi^0 h_c, h_c\to\gamma\eta_c$





$M(h_c)^{Inc} = 3525.40 \pm 0.13 \pm 0.18$ MeV

$\Gamma(h_c)^{Inc} = 0.73 \pm 0.45 \pm 0.28$ MeV

$Br(\psi' \to \pi^0 h_c) \times Br(h_c \to \gamma\eta_c)^{Inc}$

$= (4.58 \pm 0.40 \pm 0.50) \times 10^{-4}$

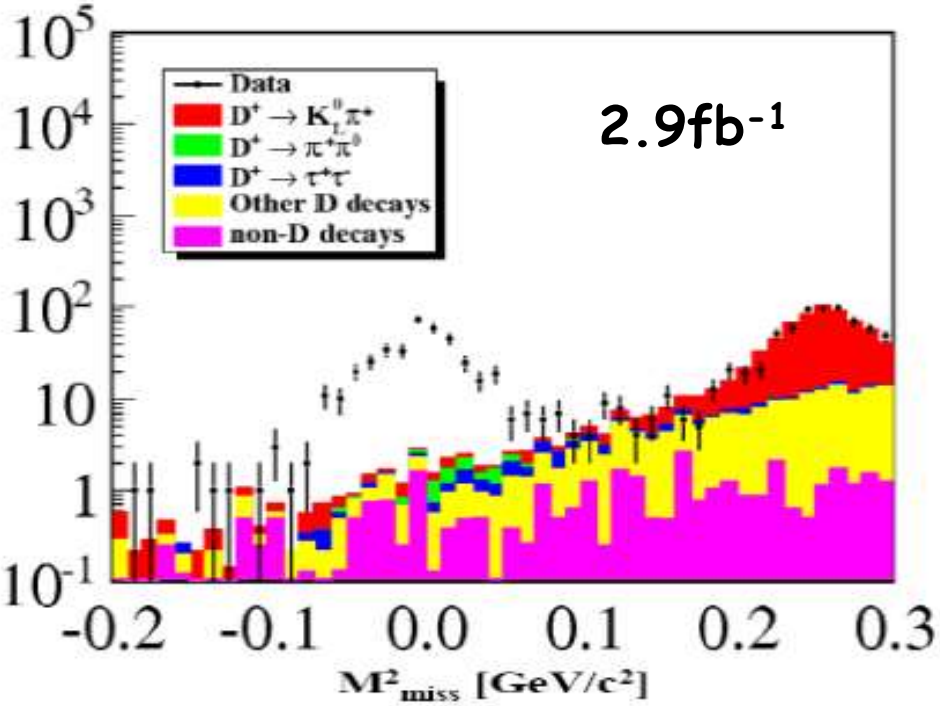
$Br(\psi' \to \pi^0 h_c) = (8.4 \pm 1.3 \pm 1.0) \times 10^{-4}$

$Br(h_c \to \gamma\eta_c) = (54.3 \pm 6.7 \pm 5.2)\ \%$

arXiv:1002.0501
Phys.Rev.Lett.
104(2010) 132002

BESIII measured for the first time
$\Gamma(h_c)^{Inc}$, $Br(\psi' \to \pi^0 h_c)$ & $Br(h_c \to \gamma\eta_c)$

D^+ Leptonic Decays



BESIII Preliminary

$$N\left(D^+ \to \mu^+ \nu\right) = 377.3 \pm 20.6$$

$$\mathcal{B}\left(D^+ \to \mu^+ \nu\right) = \left(3.74 \pm 0.21 \pm 0.06\right) \times 10^{-4}$$

$$f_{D^+} = \left(203.9 \pm 5.7 \pm 2.0\right) \text{ MeV}$$

Consistent with CLEO-c

Still statistics limited – need more data!

CLEO-c results [PRD 78, 052003 (2008)]

$$\mathcal{B}(D^+ \to \mu^+ \nu) = (3.82 \pm 0.32 \pm 0.09) \times 10^{-4}$$

$$f_{D^+} = (205.8 \pm 8.5 \pm 2.5) \text{ MeV}$$

D^0 Semileptonic Decays – Branching Fraction

BESIII Preliminary

$0.92 fb^{-1}$

Mode	measured branching fraction(%)	PDG	CLEOc
$\bar{D}^0 \to K^+ e^- \bar{\nu}$	$3.542 \pm 0.030 \pm 0.067$	3.55 ± 0.04	$3.50 \pm 0.03 \pm 0.04$
$\bar{D}^0 \to \pi^+ e^- \bar{\nu}$	$0.288 \pm 0.008 \pm 0.005$	0.289 ± 0.008	$0.288 \pm 0.008 \pm 0.003$

- Systematic uncertainties are preliminary
- Good consistency with CLEO-c, statistical precision comparable with only 1/3 data analyzed

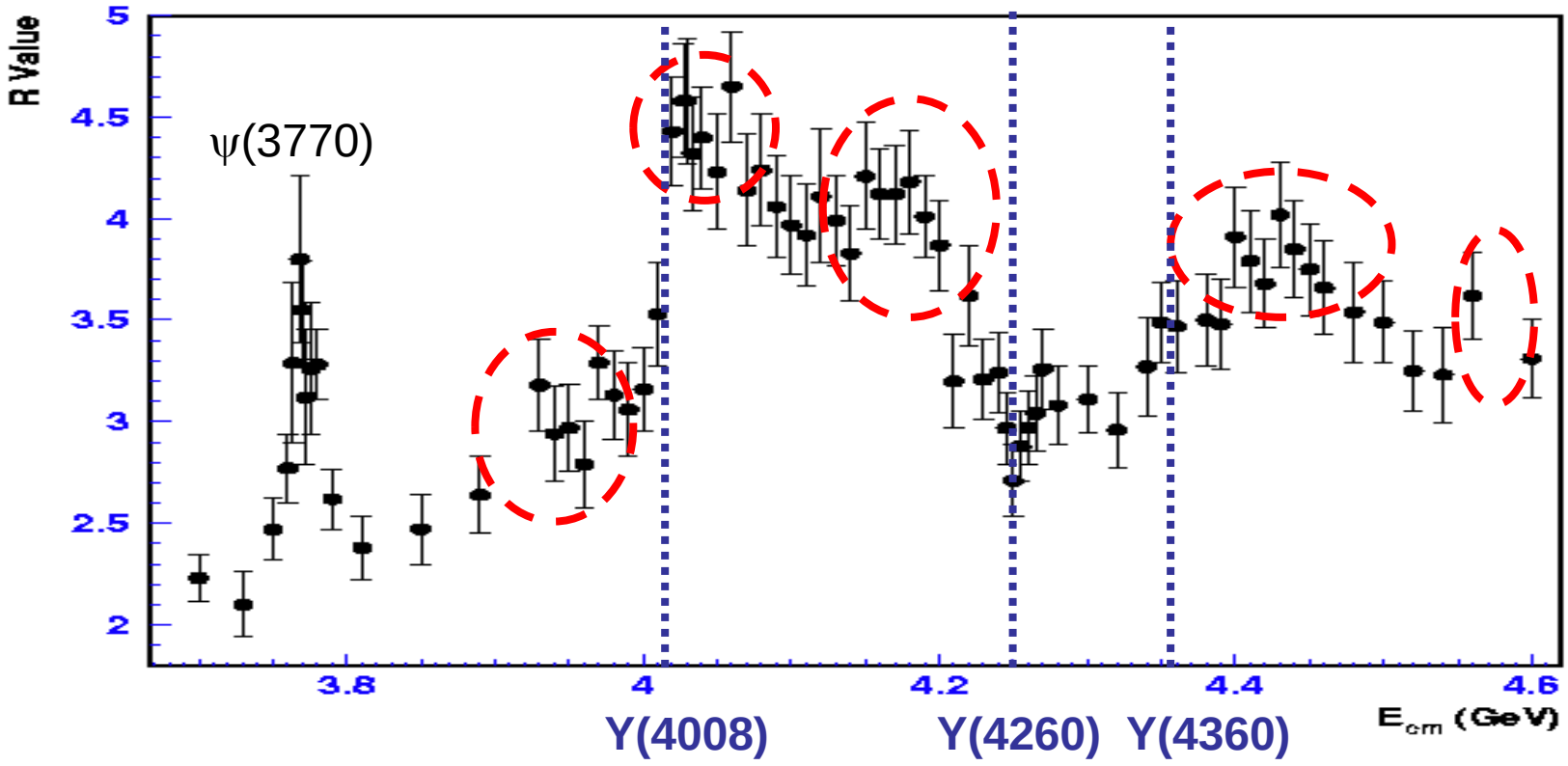
D^0 Semileptonic Decays – Form Factor Results

Simple Pole	$f_+(0)\|V_{cd(s)}\|$	m_{pole}	
$D^0 \to Ke\nu$	0.729±0.005±0.007	1.943±0.025±0.003	
$D^0 \to \pi e\nu$	0.142±0.003±0.001	1.876±0.023±0.004	
Modified Pole	$f_+(0)\|V_{cd(s)}\|$	α	
$D^0 \to Ke\nu$	0.725±0.006±0.007	0.265±0.045±0.006	
$D^0 \to \pi e\nu$	0.140±0.003±0.002	0.315±0.071±0.012	
2 par. series	$f_+(0)\|V_{cd(s)}\|$	r_1	
$D^0 \to Ke\nu$	0.726±0.006±0.007	−2.034±0.196±0.022	
$D^0 \to \pi e\nu$	0.140±0.004±0.002	−2.117±0.163±0.027	
3 par. series	$f_+(0)\|V_{cd(s)}\|$	r_1	r_2
$D^0 \to Ke\nu$	0.729±0.008±0.007	−2.179±0.355±0.053	4.539±8.927±1.103
$D^0 \to \pi e\nu$	0.144±0.005±0.002	−2.728±0.482±0.076	4.194±3.122±0.448

0.92fb^{-1}

Reasonable consistency with CLEO-c,
comparable precision with 2/3 of data still to analyze

Running Plan:
Broad resonances beyond open charm



What are these broad resonances?

Peak positions of X, Y particles were found at B factories

Y(4260) mass position corresponding to a dip on the inclusive cross section

Possible NEW resonance that not yet discoveried ?

Study decays of Y(4260) and Y(4360) at BESIII

500pb^{-1} data at each energy point (~ 4 months)

1. To learn about the Y(4260) and Y(4360).

(Their masses and widths have been established -- branching ratios are now needed to further explore their composition.)

Example analyses:

A. $Y(4260) \rightarrow \pi^+\pi^- h_c(1P)$

B. $Y(4260) \rightarrow \gamma\eta_c(1S)$ and $\gamma\chi_{c0}(1P)$

C. Other transitions to the J/ψ and $\psi(2S)$

D. Open charm cross sections

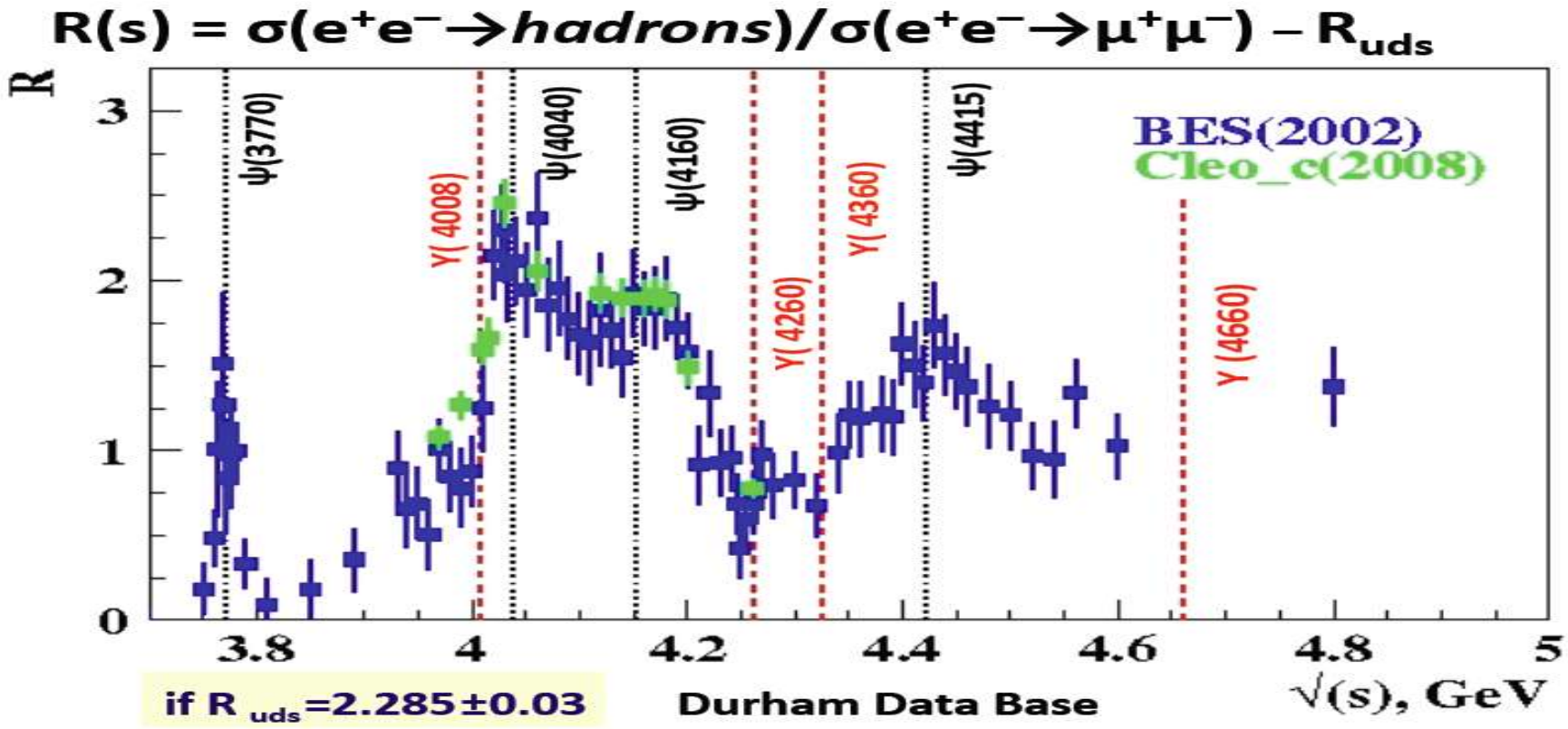
2. To search for new states in Y(4260) and Y(4360) decays.

Example analyses:

A. Search for the $h_c(2P)$

B. Search for charged Z_c states

Inclusive scan beyond open charm



Detail scan and high statistics at peak positions
Understand lineshapes of these resonances
Understand each component and its decay modes
Search for possible new resonances

Scan at high energy region 3.85-4.6 GeV

100-point fine scan, 10k events each point, assuming that L $(E_{beam}) \propto E_{beam}^{-10}$, $L_{max} = 0.65\times10^{33}$ $cm^{-2}s^{-1}$

E_{cm} (GeV)	N_{had}	$\mathcal{L}$ ($10^{33}cm^{-2}s^{-1}$)	L (nb^{-1})	T_{data} (hour)	T_{tune} (hour)
3.850	10000	0.527	746.4	0.55	1
3.890	10000	0.475	724.5	0.59	1
3.895	10000	0.469	709.8	0.58	1
3.900	10000	0.463	695.8	0.58	1
.....					
.....					
4.570	10000	0.095	717.0	2.92	1
4.580	10000	0.093	735.8	3.06	1
4.590	10000	0.091	755.5	3.21	1
4.600	10000	0.089	776.1	3.37	1
sum				132.6	105

10 days

100-point fine scan, 100k events at each energy point: 100 days

High statistics data @ 4170MeV for Ds physics

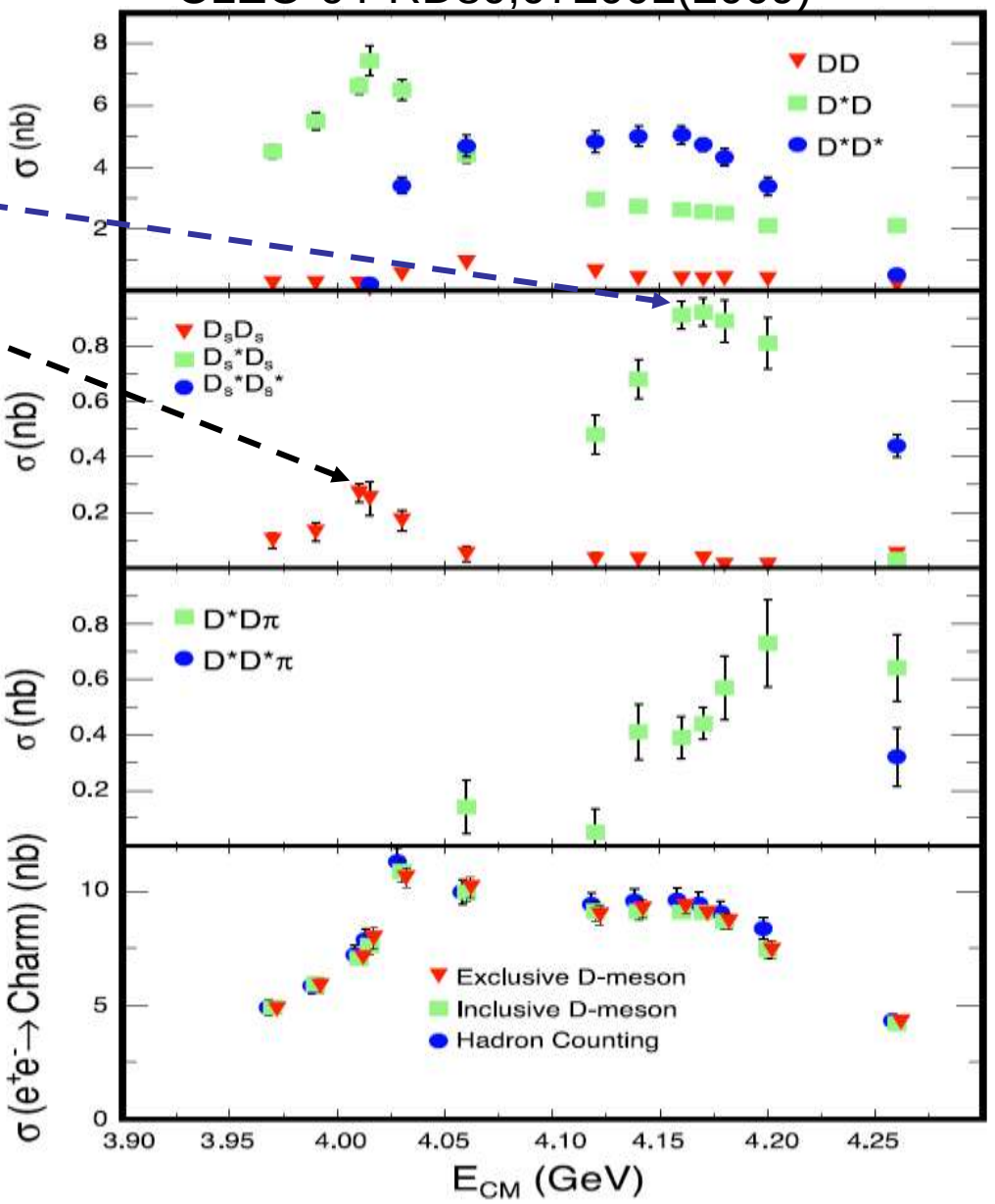
In order to find a favorable point, CLEO-c performed a energy scan:

$\sigma(D_s D_s^*) \sim 0.92$ nb @ 4170

$\sigma(D_s D_s) \sim 0.27$ nb @ 4010

CLEO-c ran at the 4170 MeV and accumulated 600 pb^{-1} data.

CLEO-c PRD80,072001(2009)



Key physics at 4170MeV for Ds meson:

- Leptonic Decays and decay constant fDs
- Semileptonic decays and form factors
- Hadronic decays
- Baryonic decays
- Dalitz Plot and Amplitude analyses
- Rare and forbidden decays
- Search for XYZ states

2.0 fb^{-1} data needed for Ds physics about 5 months data taking time.

High statistics data @ψ(3770)

We need 10 fb^{-1} integrated luminosity at DDbar threshold
3 year data taking time ? (0.65×10^{33}cm^{-2}s^{-1})

LHCb result (2011)

$$\Delta A_{CP} \equiv A_{CP}(K^-K^+) - A_{CP}(\pi^-\pi^+) \quad (3)$$
$$= [a_{CP}^{\rm dir}(K^-K^+) - a_{CP}^{\rm dir}(\pi^-\pi^+)] + \frac{\Delta\langle t\rangle}{\tau} a_{CP}^{\rm ind},$$

$$\Delta A_{CP} = [-0.82 \pm 0.21(\text{stat.}) \pm 0.11(\text{syst.})]\,\%$$

SM predicted CPV in charm Should be less than 0.1%. Large CPV indicates New Physics

Physics opportunity at ψ(3770)

- **Unique test of QCD with leptonic and semileptonic decay**
- **D0 mixing with quantum correlation**
- **CP violation– possible large CP violation at 1% level!**
- **Strong phases in D0 decays**
- **Dalitz decay**
- **Rare or forbidden decays (FCNC processes)**

The rest of life time of BEPCII can stay at 3770 MeV , to obtain higher luminosity and high data sample.

3. Precision measurement of ν mixing θ_{13} Daya Bay reactor ν experiment

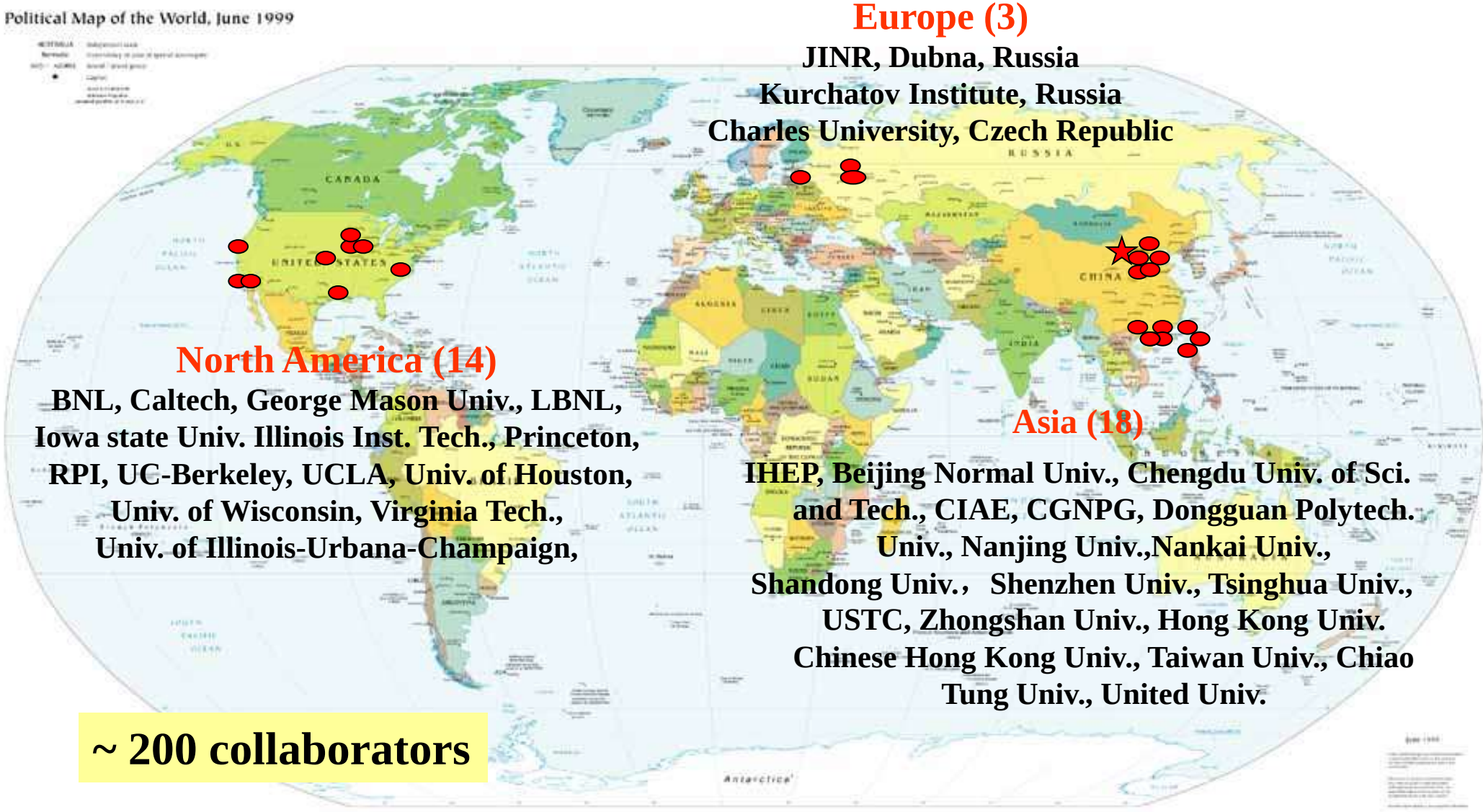
- **Daya Bay nuclear power plant: 6 reactor cores, 17.4 GW**
- **Mountains near by, easy to construct a lab with enough overburden to shield cosmic-ray backgrounds**
- **Tunnel construction finished. Begin data taking with Near sites middle 2011, Near-Far configuration Dec. 2012**
- **Expect to reach sensitivity of 0.01 with 3 years of running.**

Experimental layout

- Identical detector at near and far site to perform relative measurement in order to cancel reactor related systematic error
- Experimental halls are connected by 3000m tunnel

- Signal rate:
  ~1200/day Near
  ~350/day Far
- Backgrounds:
  B/S ~0.4% Near
  B/S ~0.2% Far

Daya Bay collaboration



Europe (3)

JINR, Dubna, Russia
Kurchatov Institute, Russia
Charles University, Czech Republic

North America (14)

BNL, Caltech, George Mason Univ., LBNL, Iowa state Univ. Illinois Inst. Tech., Princeton, RPI, UC-Berkeley, UCLA, Univ. of Houston, Univ. of Wisconsin, Virginia Tech., Univ. of Illinois-Urbana-Champaign,

Asia (18)

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

~ 200 collaborators

Daya Bay Results (Neutrino 2012)

Daya Bay has made an unambiguous observation of electron-antineutrino disappearance at ~2km and measured a far/near ratio of

$$R = 0.944 \pm 0.007\ (\text{stat}) \pm 0.003\ (\text{syst})$$

previous : $R = 0.940 \pm 0.011\ (\text{stat}) \pm 0.004\ (\text{syst})$

Interpretation of disappearance as neutrino oscillation

rules out $\sin^2 2\theta_{13} = 0$ at 7.7σ

Daya Bay precision surpasses all existing measurements.

$$\sin^2 2\theta_{13} = 0.089 \pm 0.010\ (\text{stat}) \pm 0.005\ (\text{syst})$$

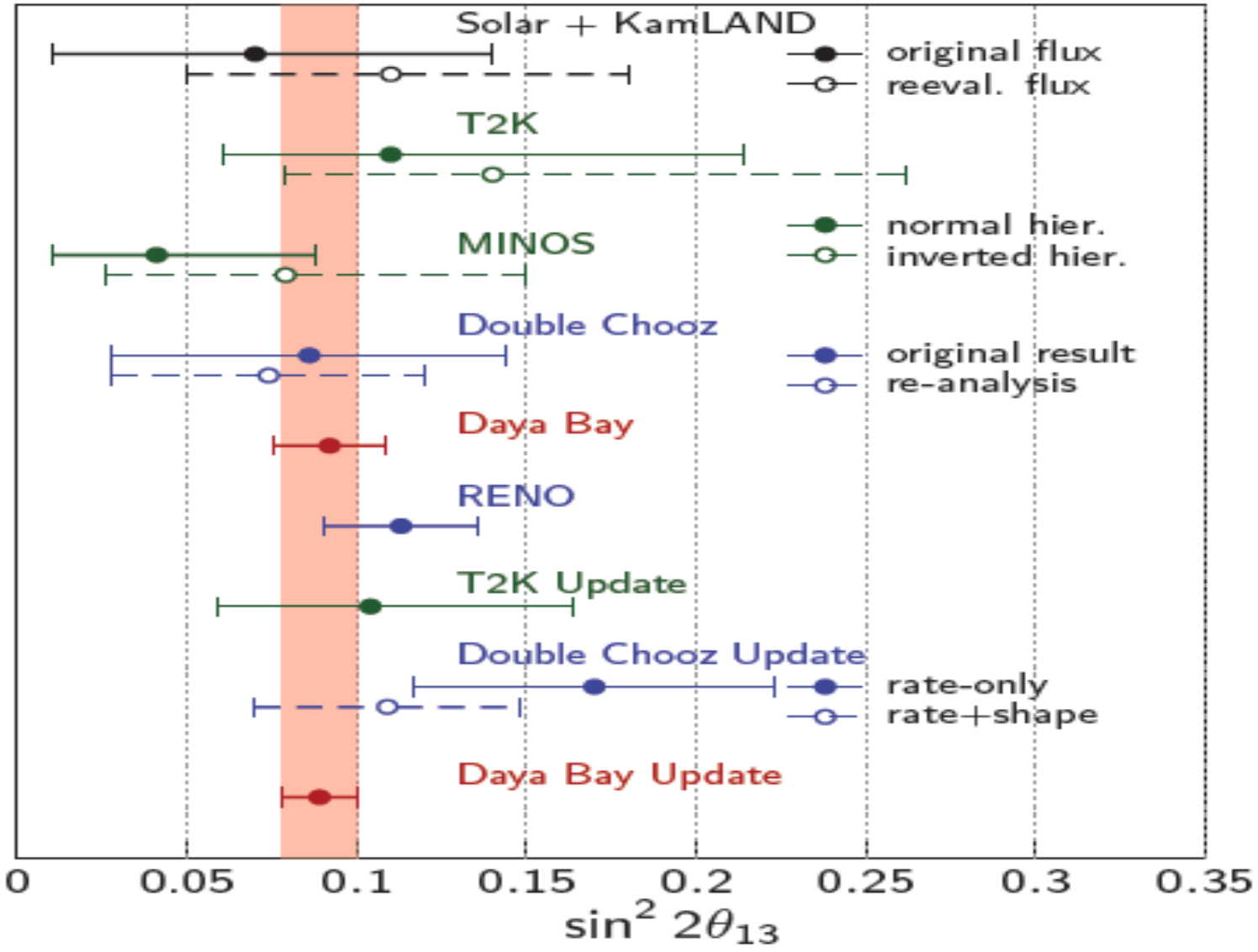
previous: $\sin^2 2\theta_{13} = 0.092 \pm 0.016\ (\text{stat}) \pm 0.005\ (\text{syst})$

Last two detectors have been installed this month.

Expect more statistics and improvements in analysis.

Daya Bay will continue to have the best sensitivity to θ_{13} among all the other experiments in operation or in construction.

World Measurement of θ_{13}



Measurement of θ13 opens an exciting future.

LHC Experiments

1. **CMS: IHEP, Peking Univ.**
   - 1/3 of CSC at muon end caps (IHEP)
   - RPC of barrel muon (Beijing Univ.)
   - Remote operation center
   - Physics and MC
2. **Atlas: IHEP, USTC, Shandong U, Nanjing U.**
   - Drift Monitor chambers (IHEP)
   - TGC (Shandong Univ.)
   - Physics and MC
3. **LCG: Tier 2 with 2000 cores**
4. **LHCb: Tsinghua Univ.**
5. **Alice: Huazhong Normal Univ. CIAE…**

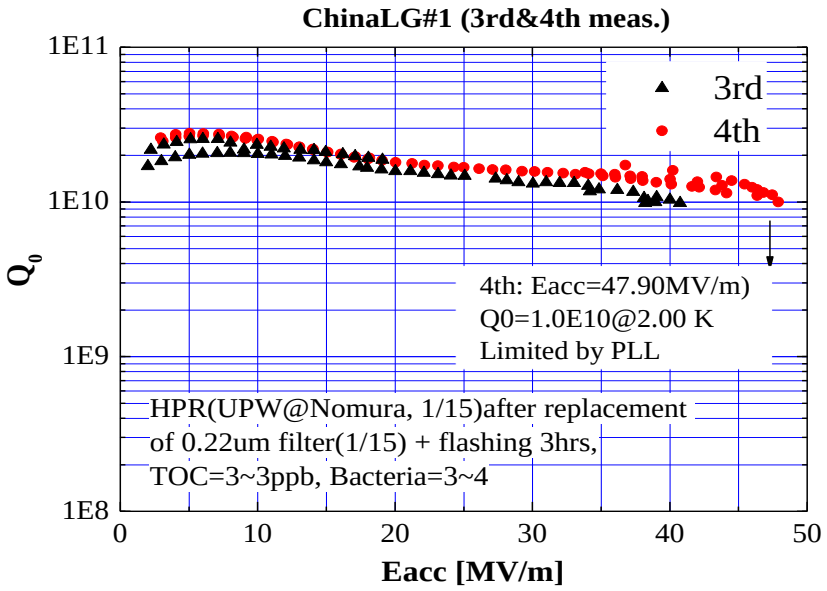
ILC R&D Activities

- **SC cavities (also for next generation light source)**
- **Dumping ring design**
- **Positron source**
- **detector R&D (IHEP and Tsinghua Univ.…)**

other R&D:

- **works for EXFEL also very useful for ILC R&D**

ILC cavity made by Chinese large grain crystal (collaborating with KEK)



47.9 MV/m（after EP)

4. Particle Astrophysics Experiments

- **Experiments finished :**
  - **γ Bust detector @ Shenzhou-2 flown 2001, First Astronomy detector of China in space**
  - **Chinese Moon project: Change-1, flown 2007**
  - **L3 Cosmic**
  - **AMS01: permanent magnet**
- **On-going Experiments:**
  - **Yangbajing experiment Asγ & Argo**
  - **Chinese Moon project: Chang'e-2: launch Oct. 2010**
  - **AMS02: permanent magnet, ECAL.**
- **Approved Experiments:**
  - **Hard X Ray Modulate Telescope: Launch by 2014**
  - **Chinese Moon project: Chang'e-3**
  - **SVOM: China -France (Satellite)**

4a Yangbajing Cosmic Ray Observatory（Tibet a.s.l. 4300m）

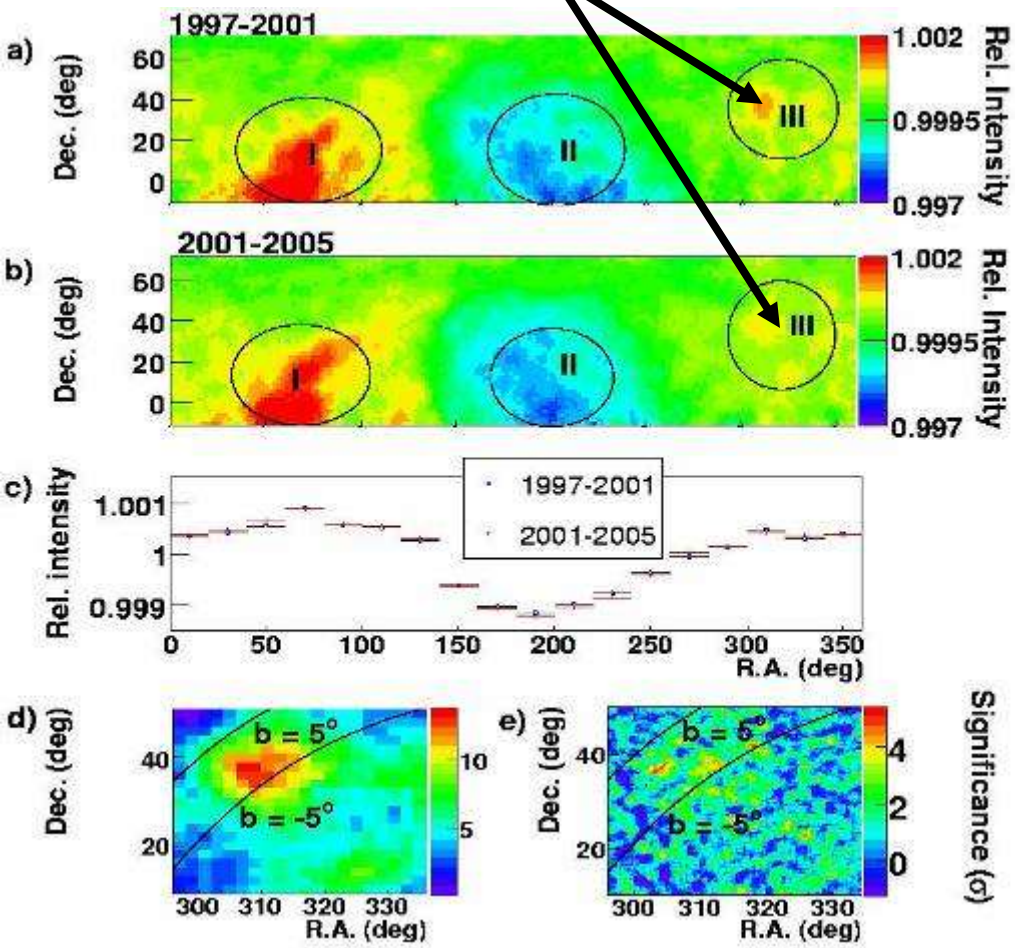
IHEP-INFN Argo RPC　　China-Japan Air Shower Array

Yangbajing: new anisotropy and corotation of GCR

(Science 314(2006) 439-443)

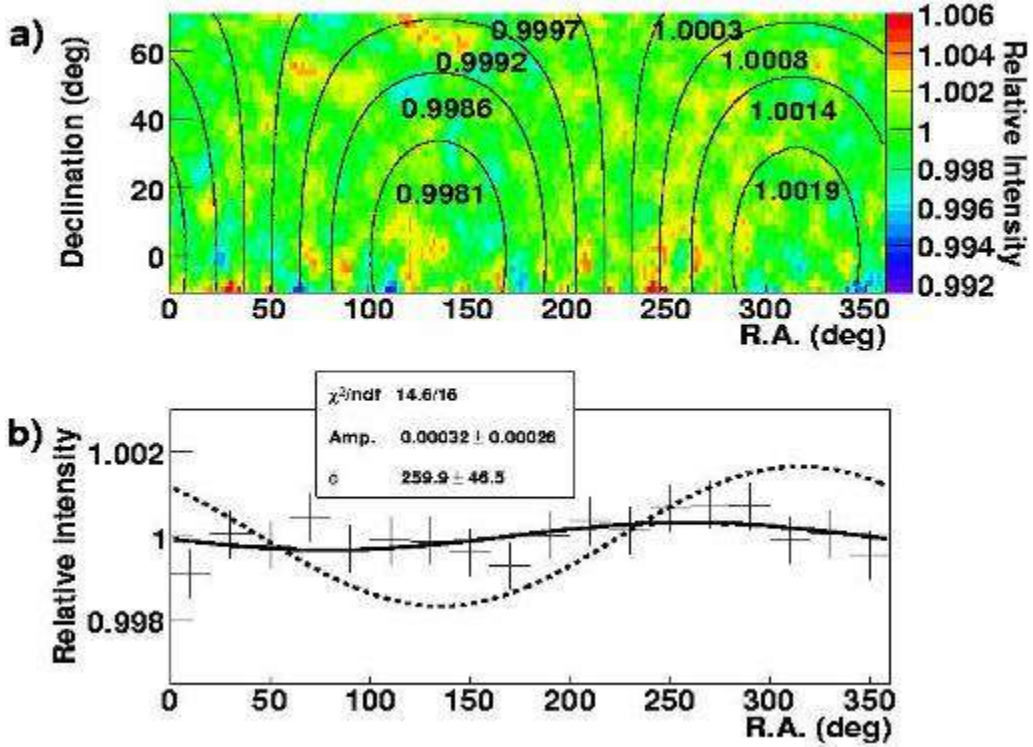
Celestial Intensity map (E~3TeV)

New anisotropy component



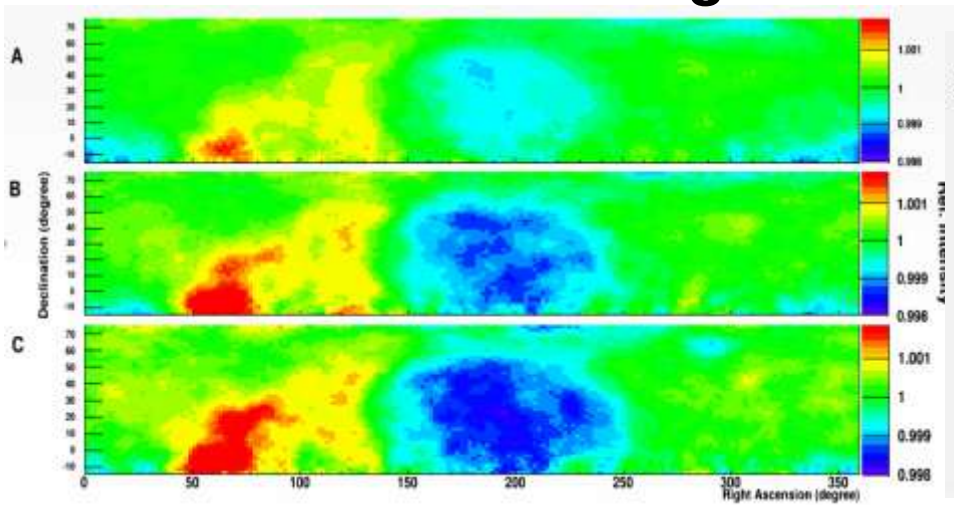
Intensity @ E~300TeV

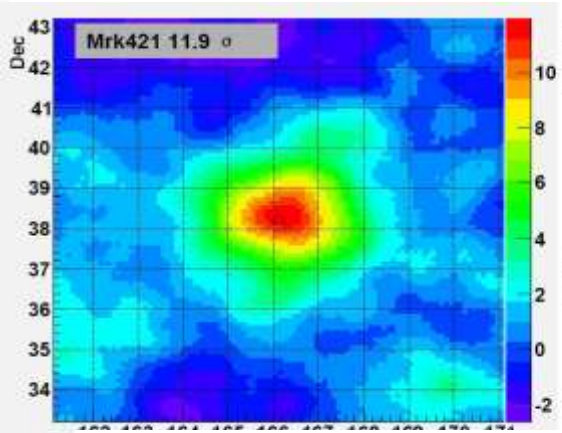
Amp=0.16% w/o corotation;
Observation: 0.03%±0.03%.

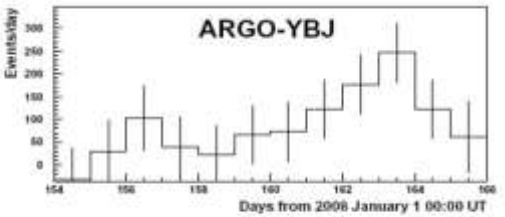


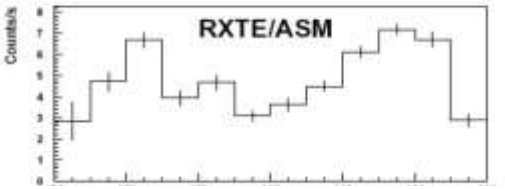
ARGO-YBJ results

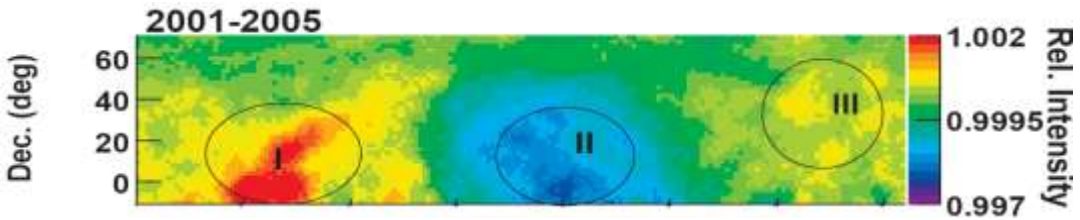
- **Cosmic ray anisotropy and its energy dependence（top down：0.5~5TeV）**
- **Long term monitoring for AGN Mrk421 bursts：accumulative significance 12S.D.**
- **Multi-wave-length analysis with X-ray observation sdemonstrates strong correlation**

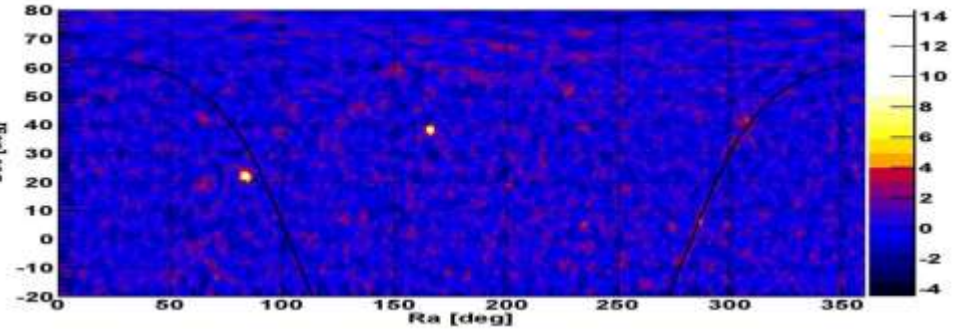




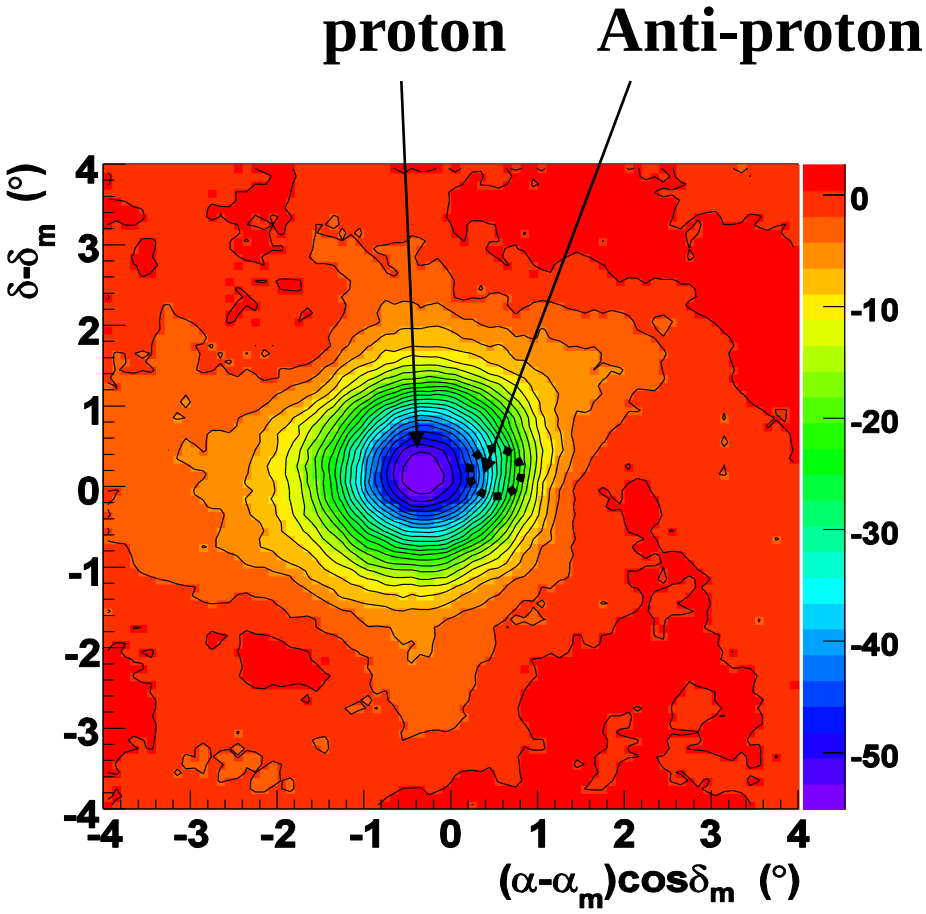


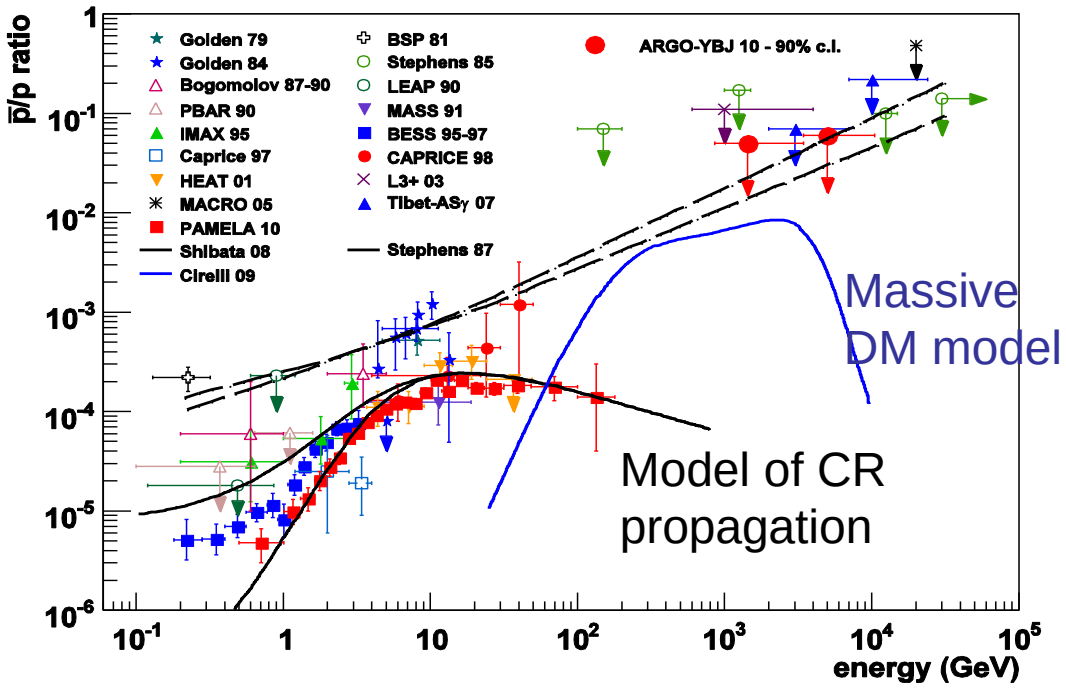






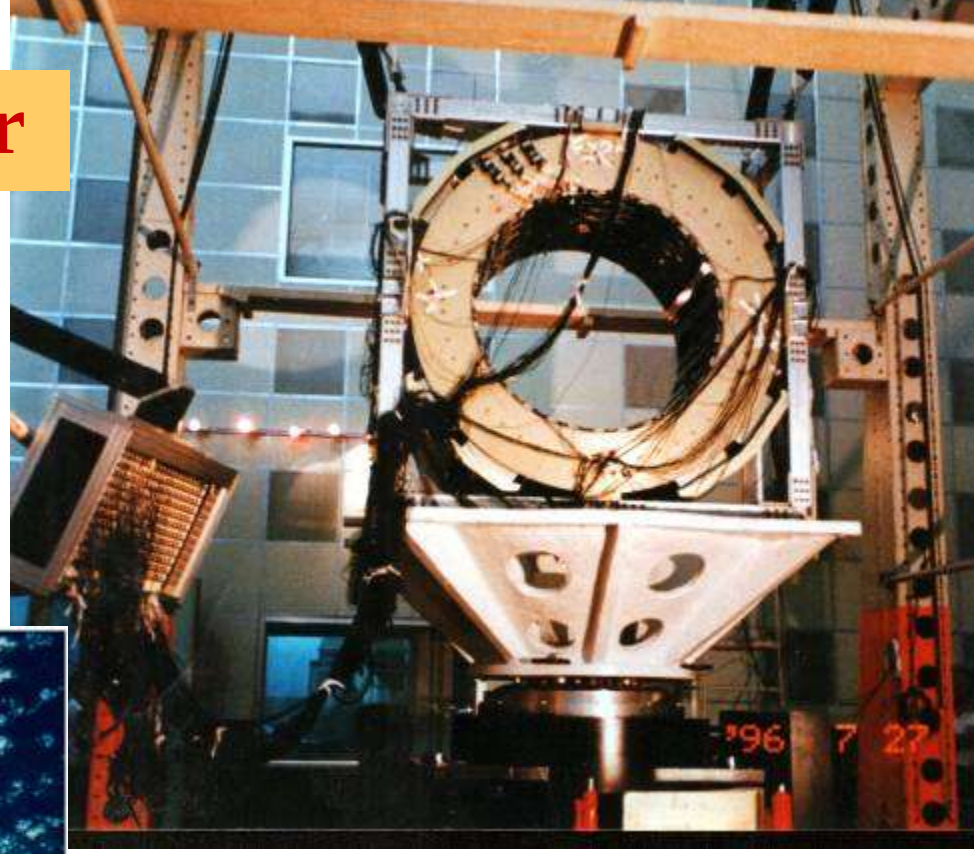
ARGO-YBJ : $\bar{p}/p$ Ratio Upper Limit by using the displacement of moon shadow in geomagnetic fields

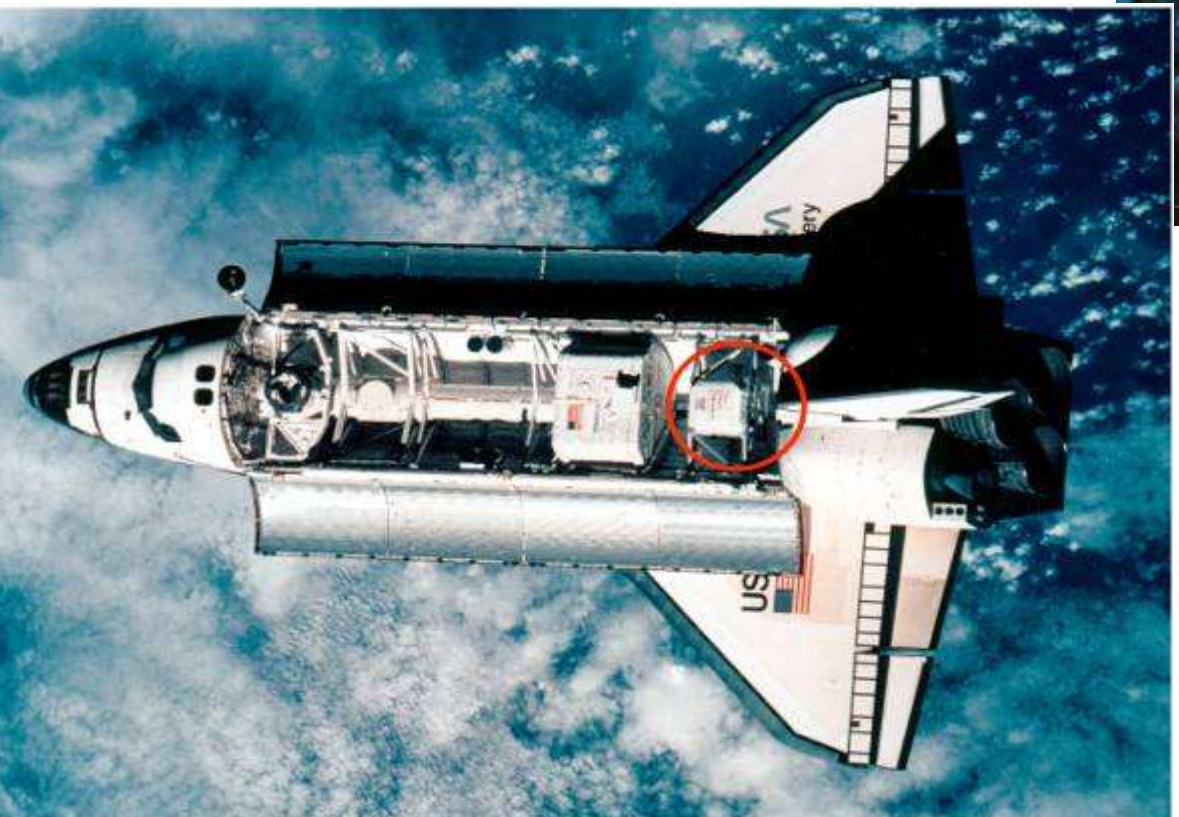




Alpha Magnetic Spectrometer

- **Search for antimatter and dark matter**
- **precision measurement of isotopes**



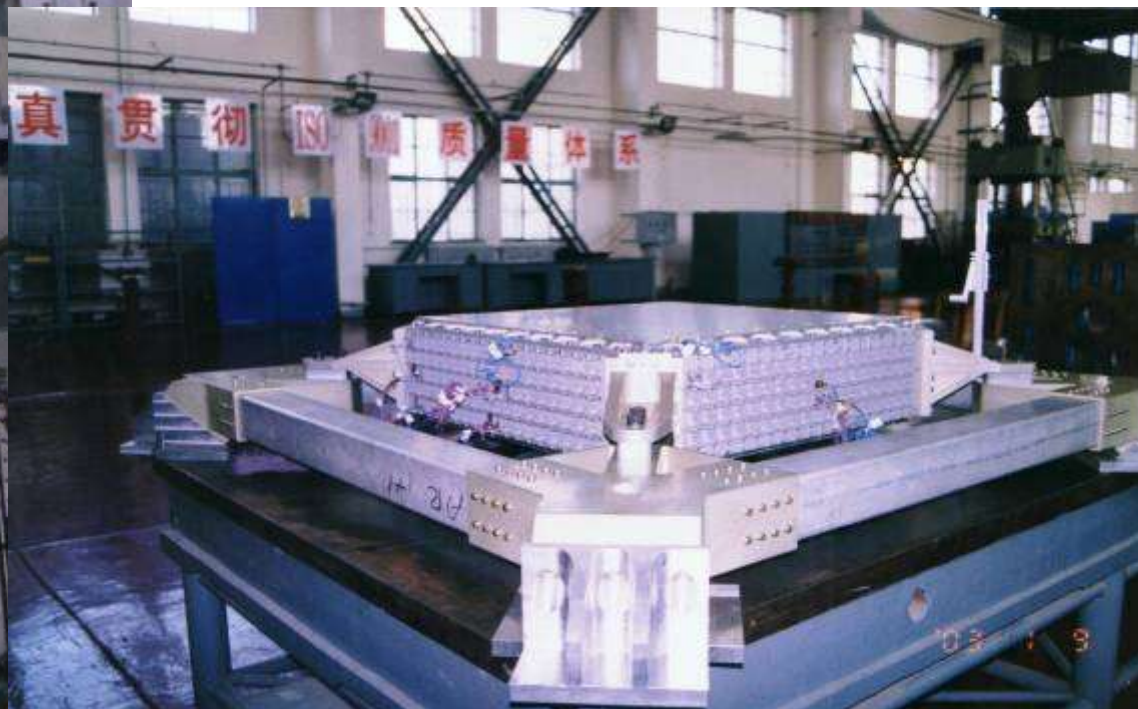


AMS01 permanent magnet and structure were built at Beijing, and became the first big magnet in space as payload of Discovery June 1998. It was sent to ISS with AMS02 May 2011.

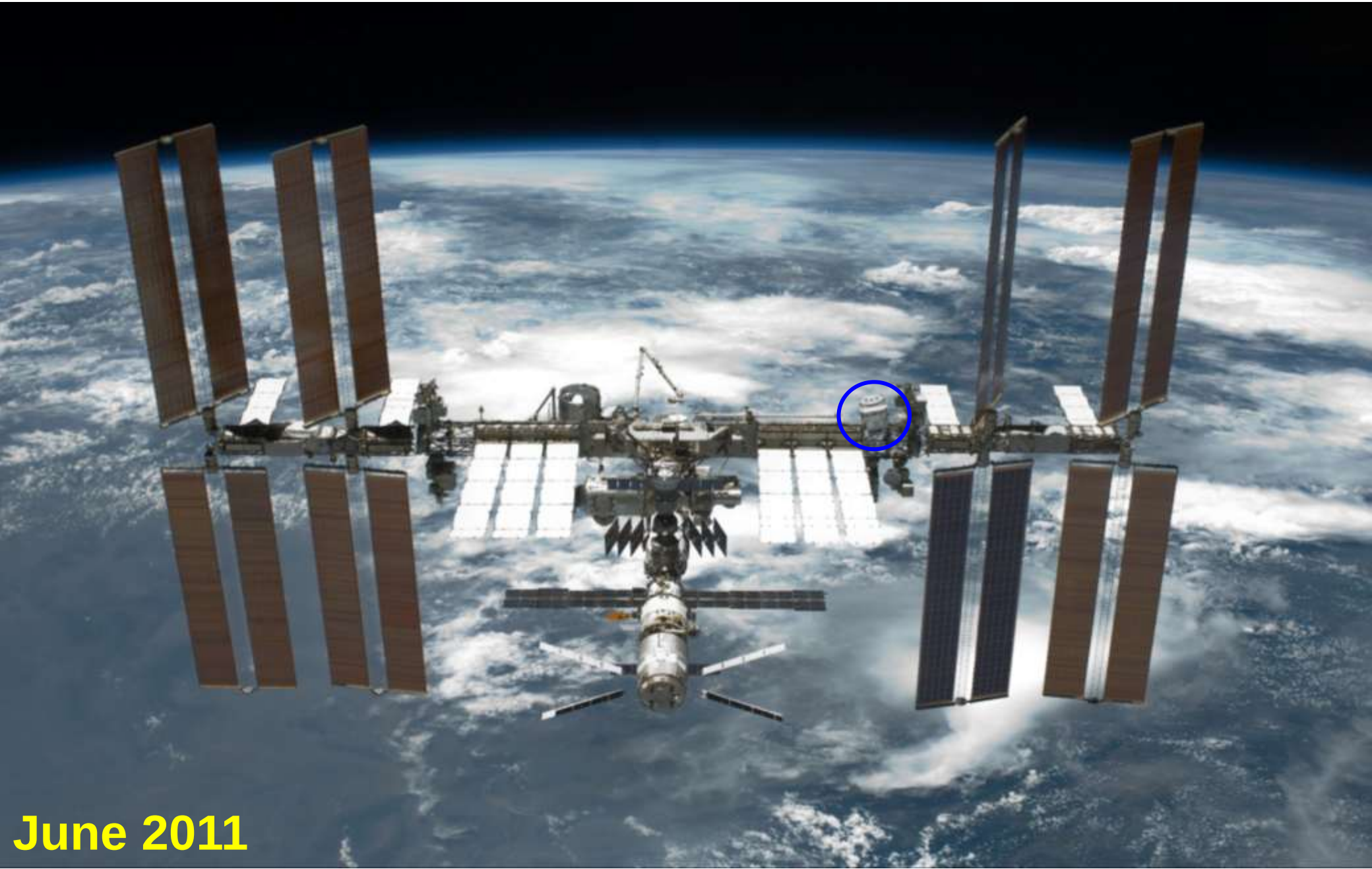
AMS02 ECAL: 700Kg
IHEP LAPP and PISA

Space qualification at Beijing

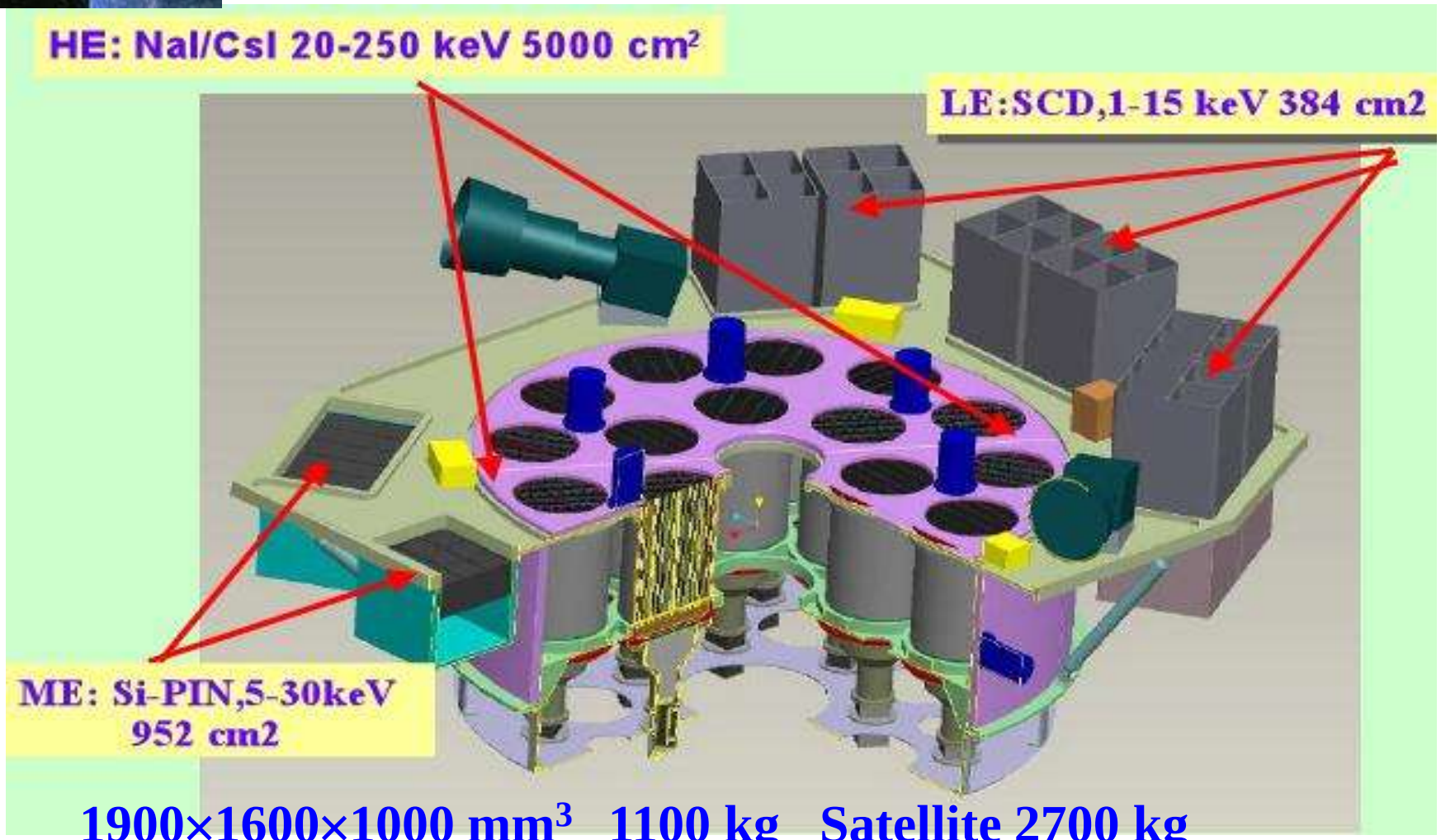
ECAL assembling at IHEP



Alpha Magnetic Spectrometer Experiment in Intl. Spacestation

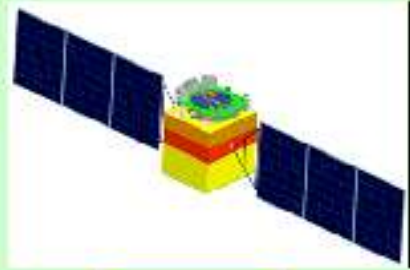


Hard X-ray Modulation Telescope (HXMT) To be launched 2014

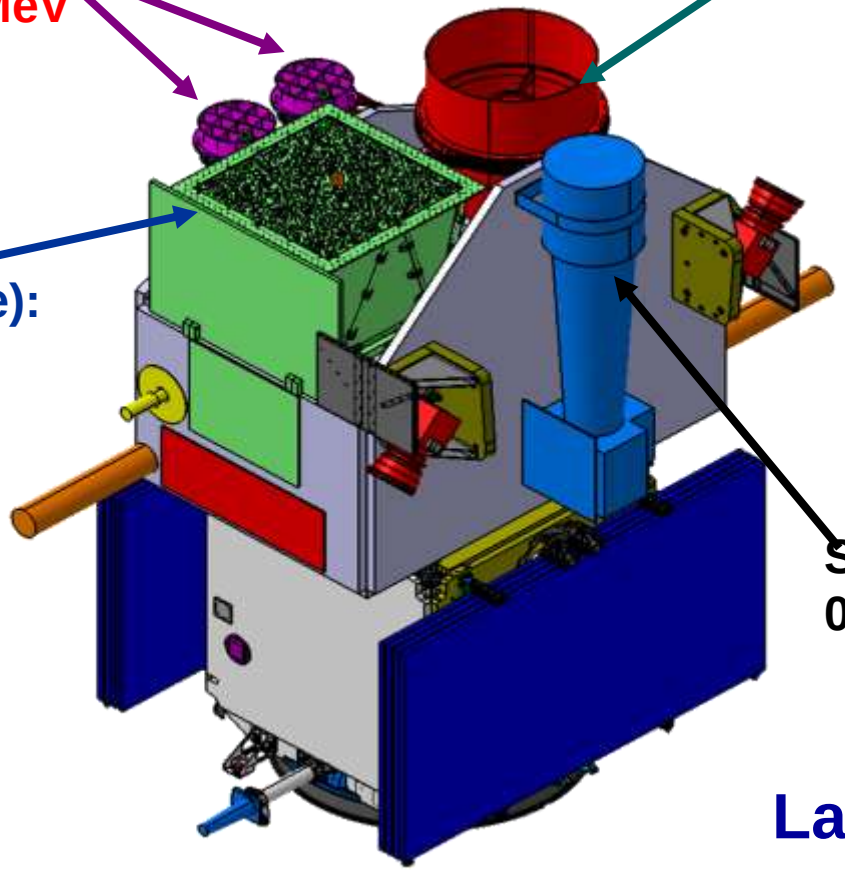


1900×1600×1000 mm³ 1100 kg Satellite 2700 kg

Comparison of HXMT and other two telescopes in the same energy band.

	Integral/IBIS	HXMT/HE	wift/BAT
			
Angular Resolution	12’	< 5’	14’
Source Location (20σ)	1’	< 1’	1’
Pointed Sensitivity (mCrab@100 keV)	3.8	0.5	9
Half Year Survey Sensitivity (mCrab)	2	0.5	1
Observation Capability			
All sky survey	ok	good	yes
Selected sky deep survey	good	good	bad
Narrow field pointing observation	bad	good	no

SVOM: multi-wavelenth GRB project



Scientific instruments :

- GRMs (gamma-ray monitors)
- CXG (hard X-ray camera)
- SXT(Soft X-ray Telescope)
- VT (visible telescope)

Launch ~2015

China-France collaboration: approved

5. Future Plan

- **Intensity Frontier**
  - **Charm physics @ BEPCII: next 10 years or more. Future plan to be decided based on results of BESIII & LHC in ~ 5 - 6 years**
  - **Neutrino experiments: Daya Bay II . (> 2016)**
- **Energy Frontier: Intl. collab. @ LHC exp., ILC/CLIC…**
- **Cosmic Frontier :**
  - **Particle Astrophysics experiments in Space: Polar**
  - **Cosmic ray measurement : LHAASO @ Yangbajing**
  - **Deep underground Lab.: Dark matter search**
  - **South pole Dome A: IR and THz telescope**
- **Large Scientific Facilities**
  - **Chinese Spallation Neutron Source (CSNS): approved.**
  - **Accelerator Driven Sub-critical System: CAS started the ADS pilot project.**
  - **Beijing Advance Photon Source: construction scheduled at 2016**

Candidates of Large research infrastructurefor 12th 5-Year Plan

The projects relatedto particle physics, nuclear physics and relevant facilities

- **Yangbajing Cosmic Ray Observatory: LHASS0**
- **SSRF phaseII (SINP)**
- **Heavy Ion Facility(IMP, Lanzhou)**
- **R&D of Beijing Advance Photon Source (IHEP)**
- **Dome A Telescope(Purple Mountain Observatory, Nanjing. IHEP: IR CCD)**

Final selection will be done soon. Space Experiment program is from different agency.

Preliminary candidates of Large research infrastructure for 13th 5-Year Plan

The projects relatedto particlephysics, nuclear physics and relevant facilities

- **Beijing Advance Photon Source**
- **Daya Bay II**
- **National Deep Underground Lab.**

LHAASO Project: γ astronomy & origin of CR

Charge Particle Array

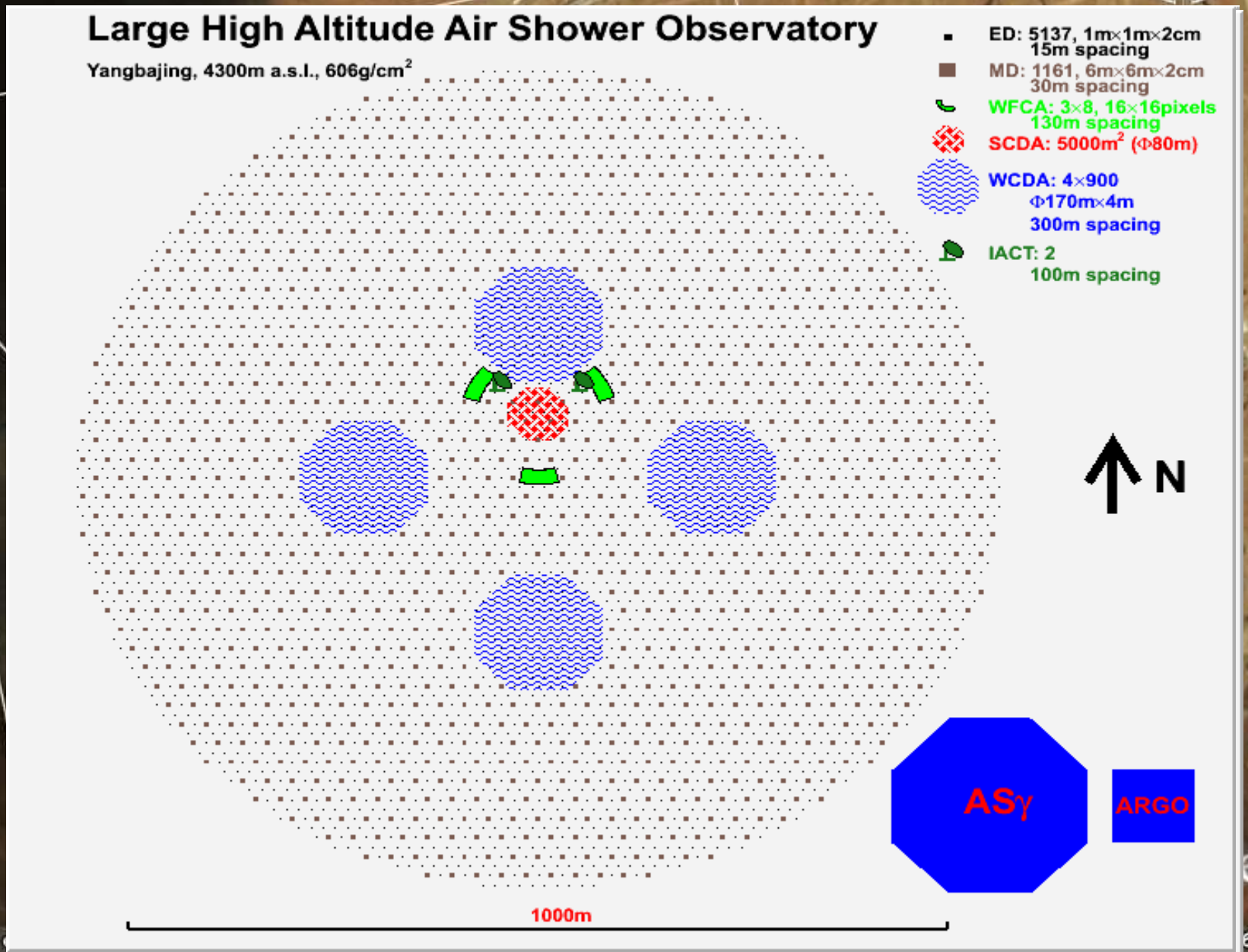
μ detector Array

Water C Array

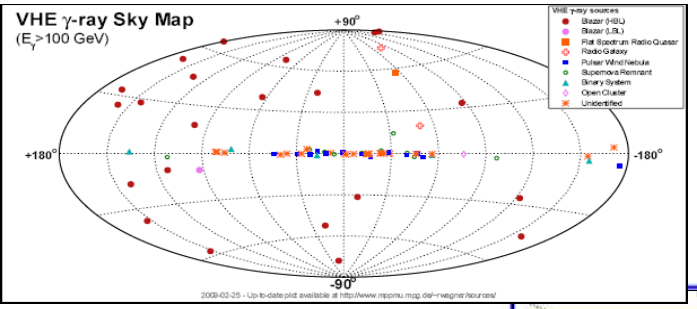
Wide FOV C-Telescope Array

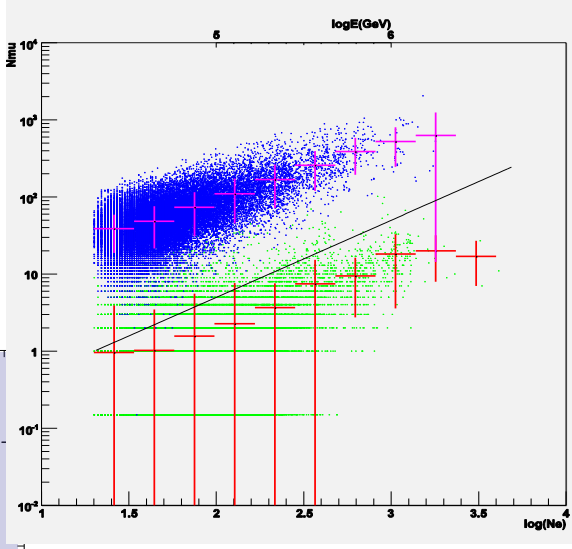
&

Core Detector Array

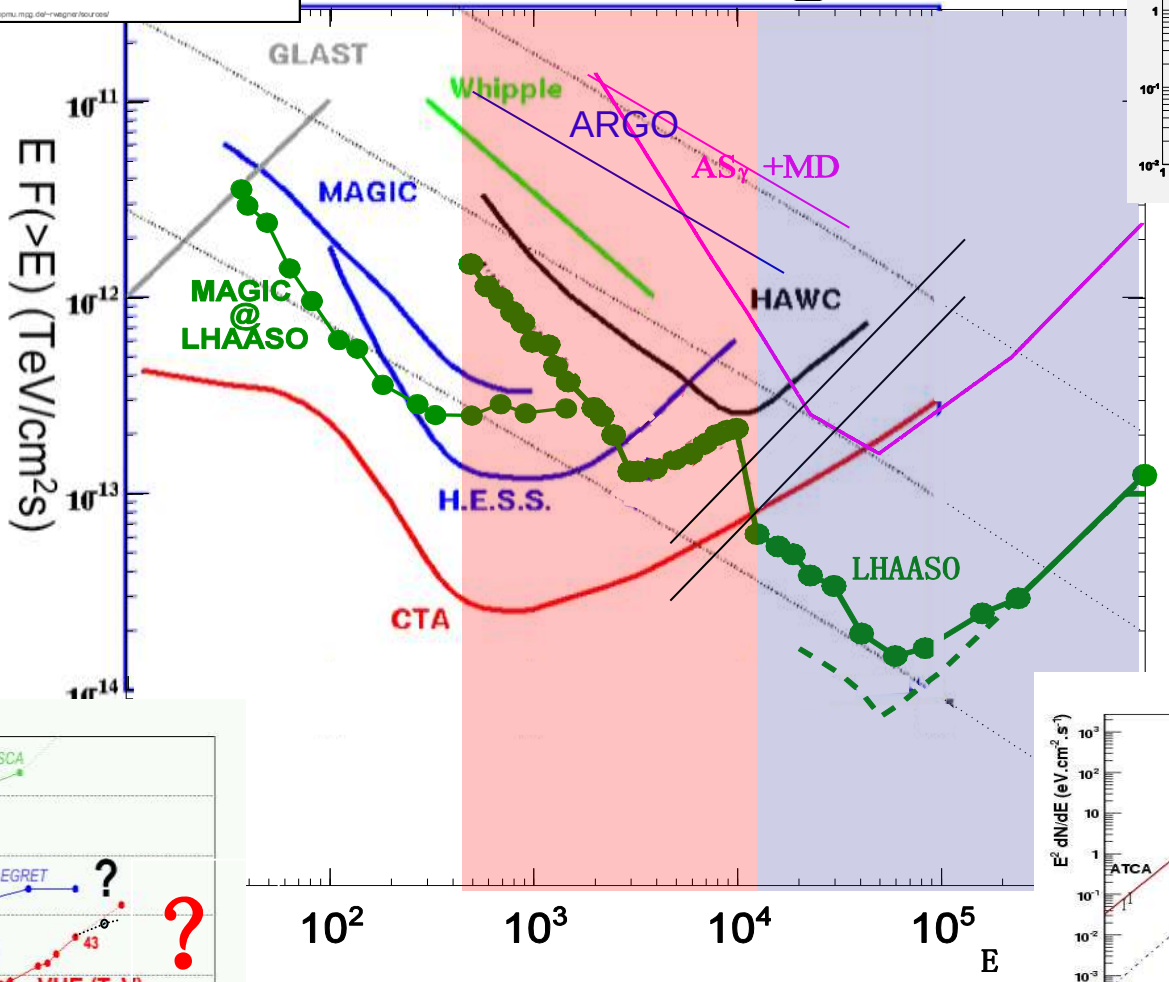


LHAASO sensitivity & scientific goals

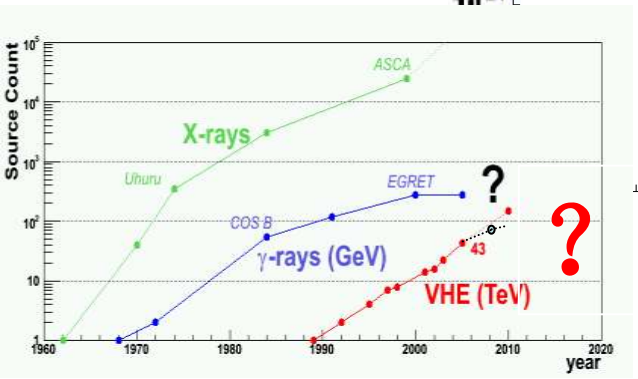


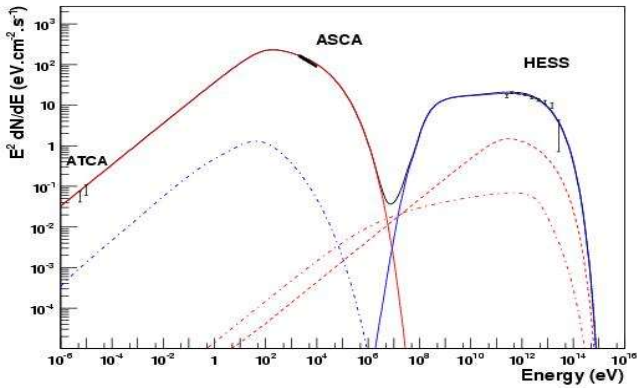


- Surveying forγray sources
- ~1000 extragalactic sources are expected in 10 years



- Above 60TeV CR BG-free(10^{-5})
- γ survival rate ~99%
- Finding Cosmic ray origins.

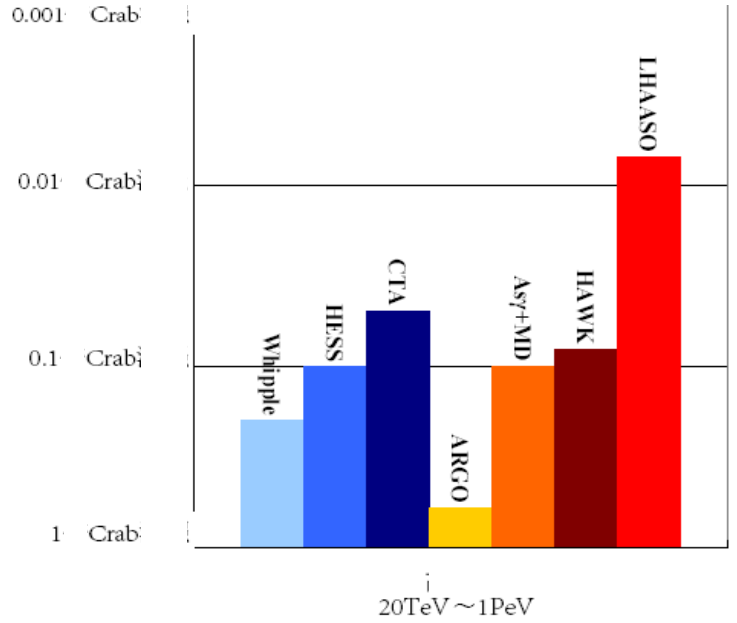


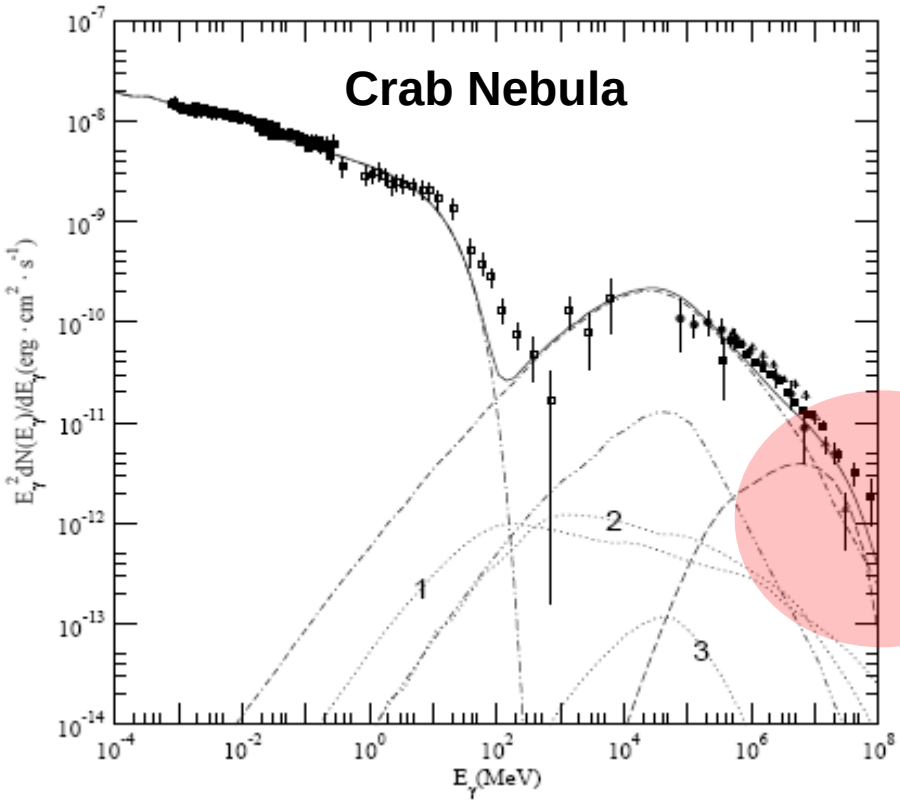


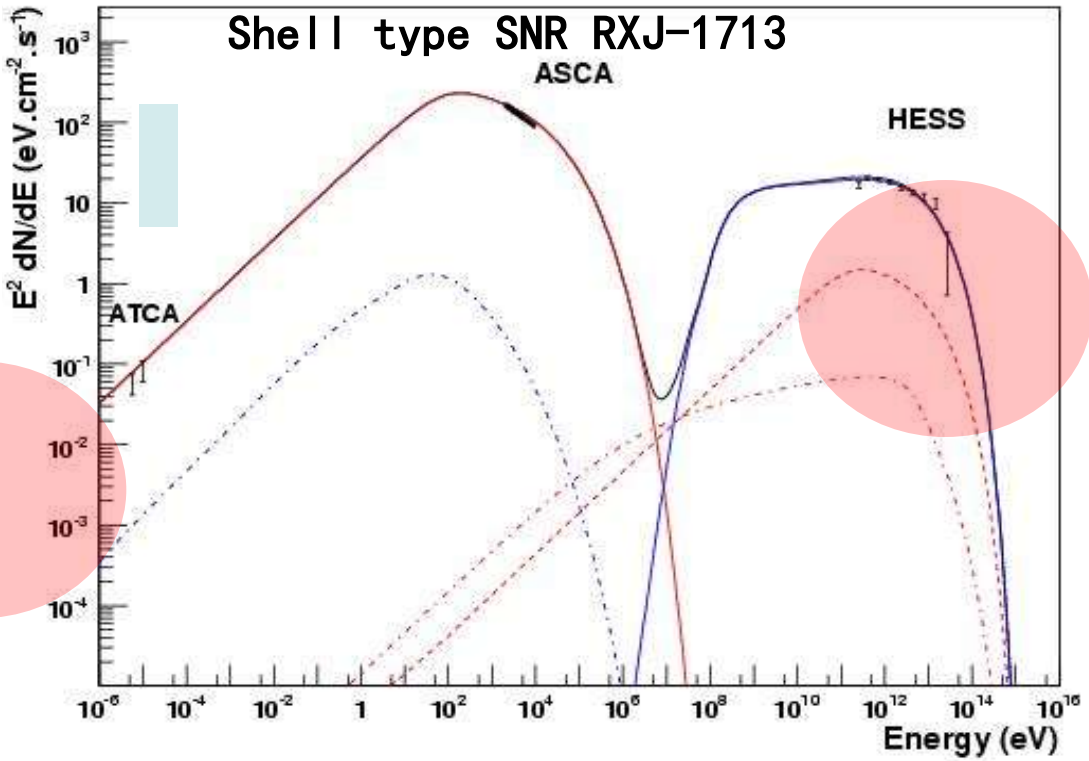
Main Goal 1: CR origin

precise measurement of energy spectrum of γ sources to 1PeV

Smoking gun: photons from $\pi^0 \rightarrow 2\gamma$

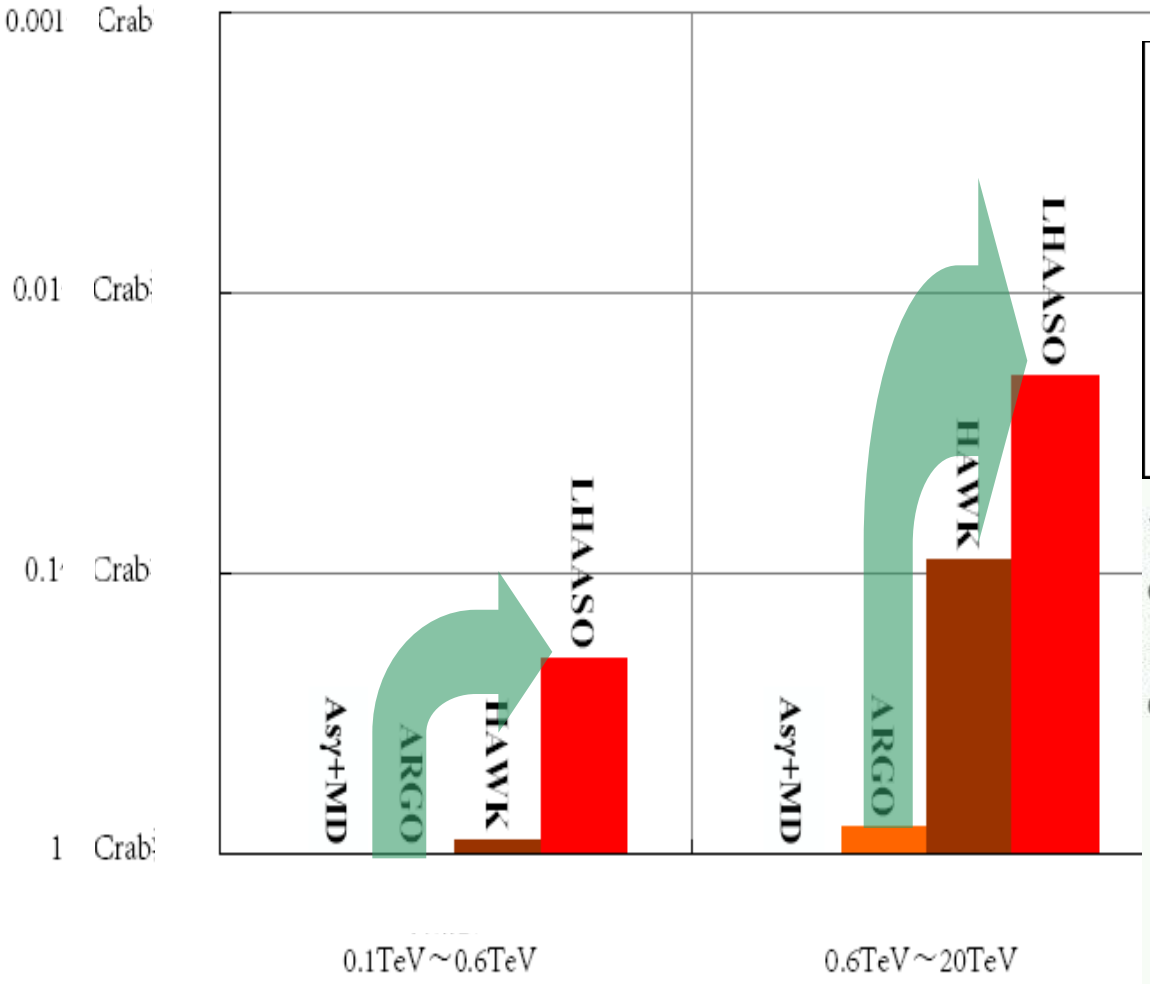


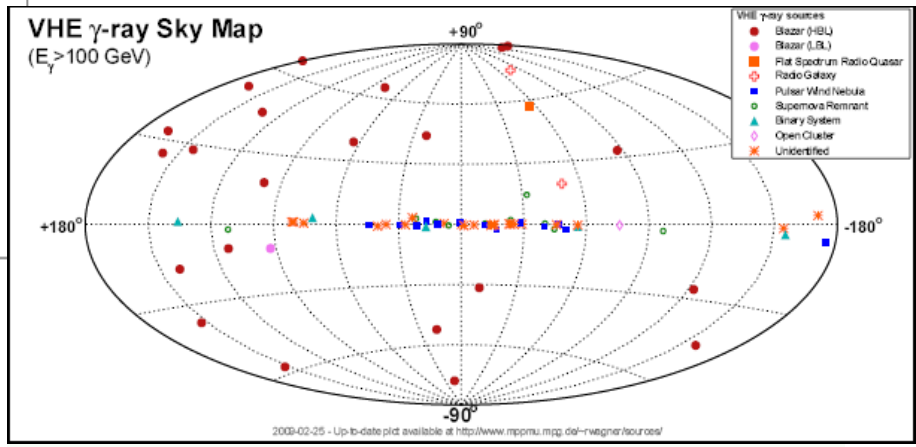


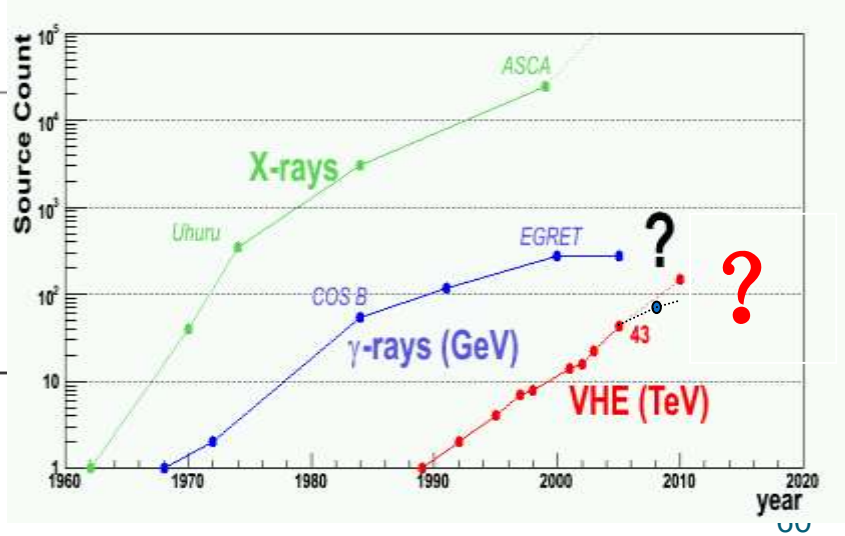


Main Goal 2: all sky survey for more extragalactic gamma ray sources

- Very high surveying sensitivity: from 100 sources to 1000



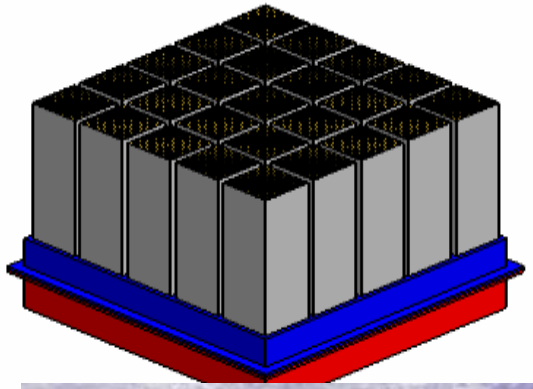




POLAR: Proposal and R&D

- **Instrument conception proposed by N. Produit, et al., NIM (2005)**
- **On board China's spacelab TG-2: launch time 2013-14 (Phase 2 of manned spacecraft)**
- **FOV of POLAR: ~½ sky**
- **MDP is 10%: >10 GRBs per year down to 10% polarization;**

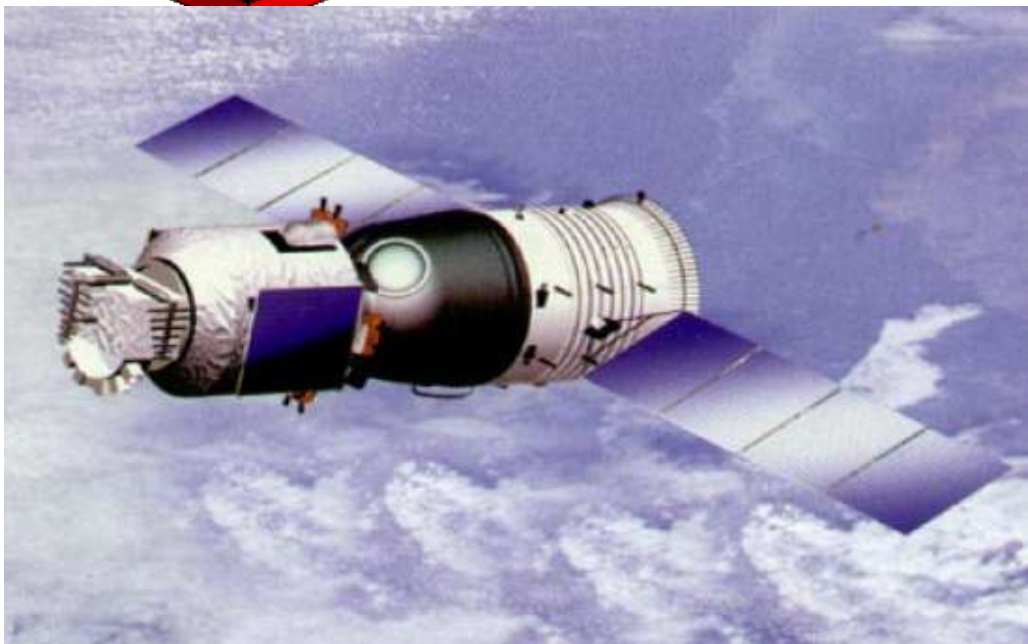
POLAR



Tian-Gong

天宫

Palace in Heaven

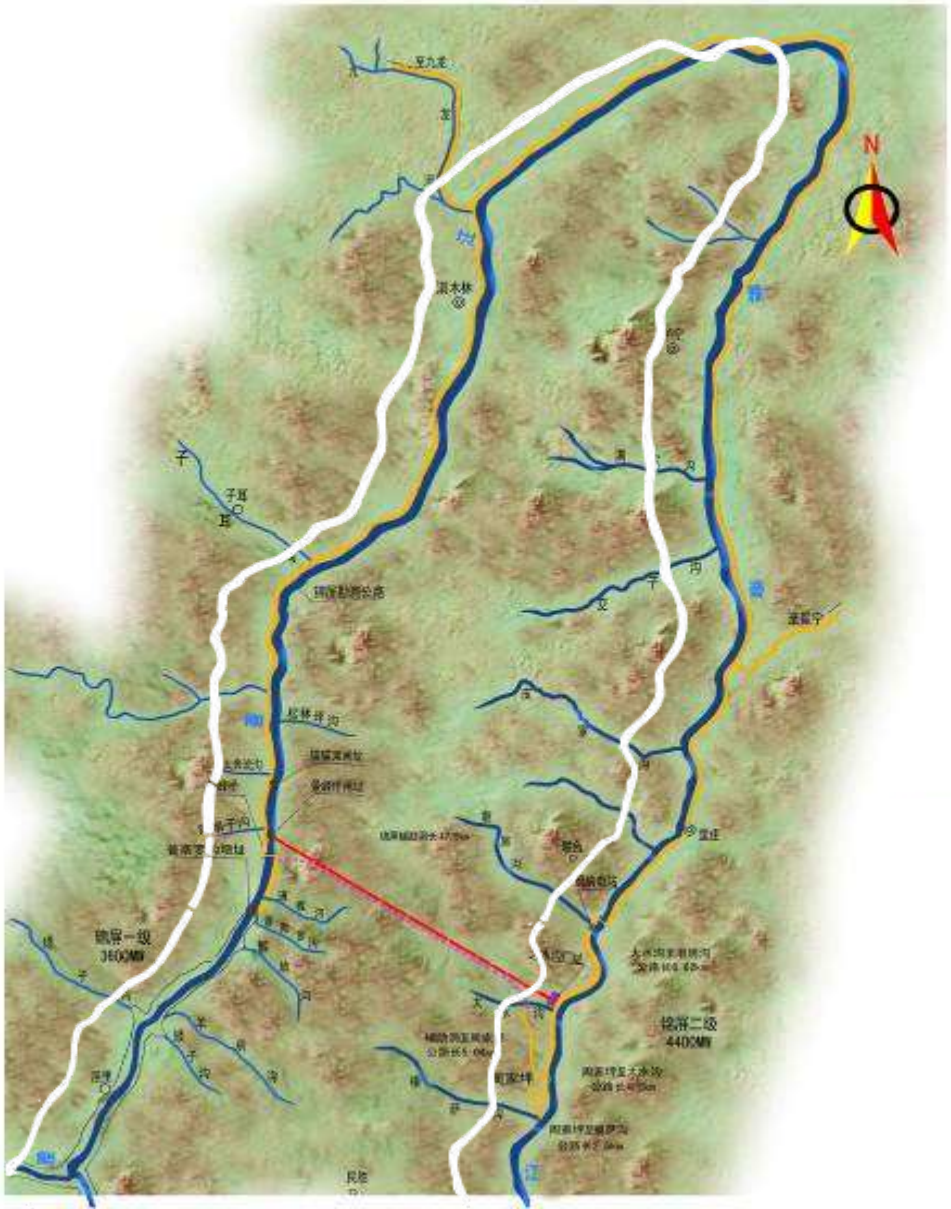


China Deep Underground Lab. (CDUL) at Jingpin mountain

Yalong River and Jingpin Hydropower station

Yalong river locates the west of Sichuan, with length of 1571km and drop height of 4420m. 21 Hydropower stations are planned, with total electricity of 30GW.

Big U-turn at Jingpin mountain



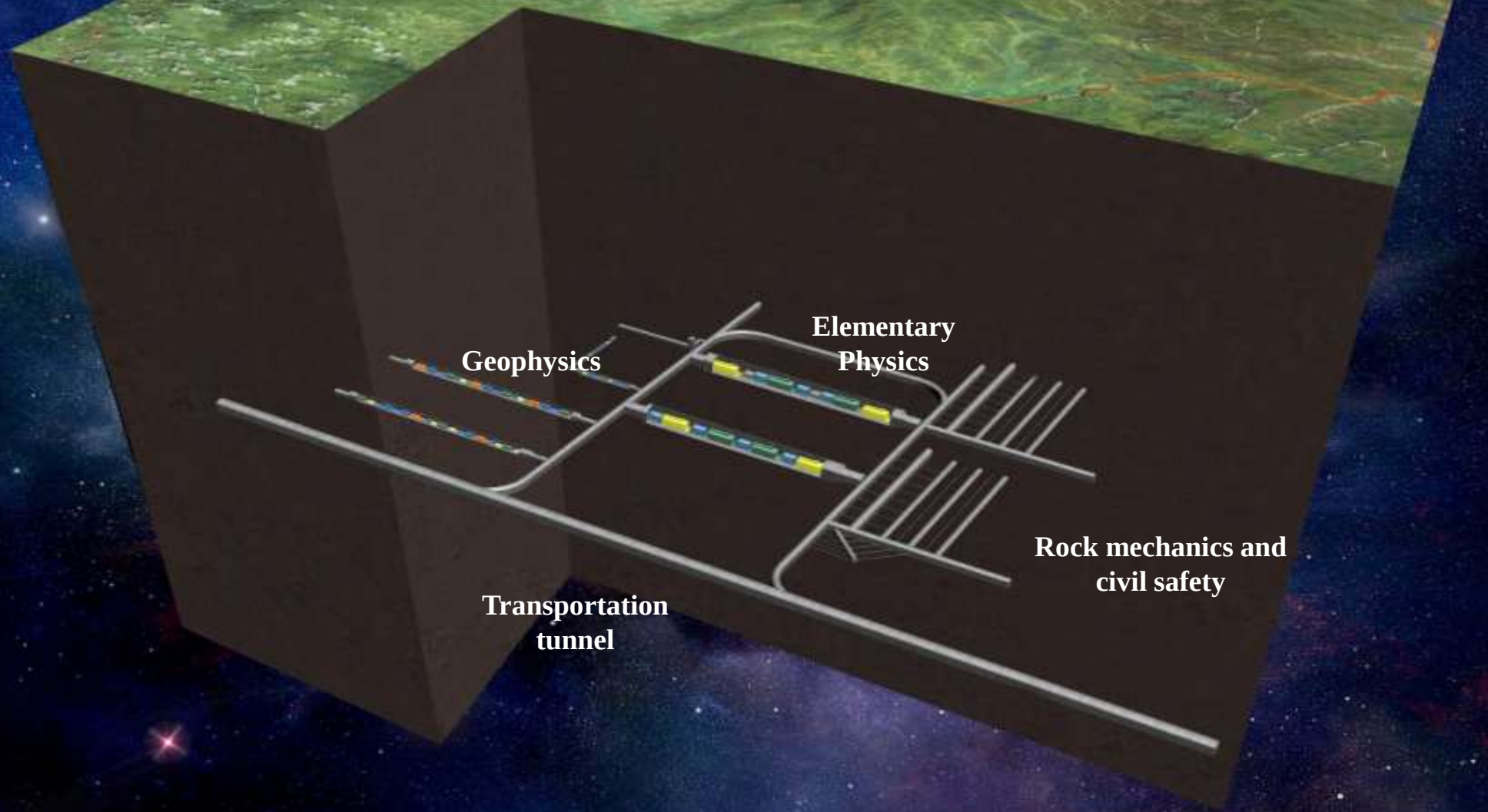
- Tunnel length of 17km
  - 4 water tunnels: ϕ 13m
  - 2 traffic tunnels: ϕ 6m
  - drain tunnel ϕ 7.2m (only used during construction)
- max. overburden 2525m
- Rock radioactivity is very low.
- Horizontal Tunnel access
- Convenient transportation, good infrastructure

Deep underground Lab. @ Jingpin mountain

- **Unique opportunity for world class deep underground science and engineering lab for multiple science research.**
  - **Physics Exp. Proposals: dark matter search, double beta decay, proton decay, nuclear astrophysics reaction, gravitation wave…**
  - **Deep underground engineering**
  - **Geophysics and geology**
- **Two 6x6x20 m exp. halls near traffic tunnel B: dark matter exp., & rock mechanics studies**
- **CAS proposal: large deep underground multiple discipline international Lab. . Under review.**

Sketch map of Jinping National Deep Underground Lab.

(13th five years plan)



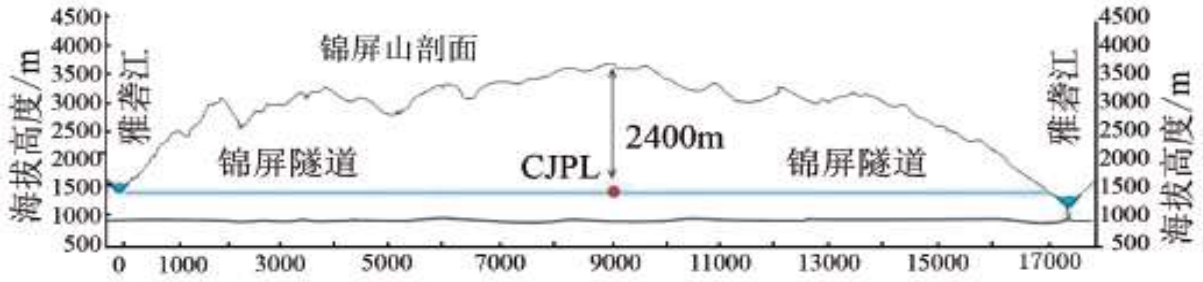


图 10　锦屏山剖面图及中国锦屏地下实验室位置示意图

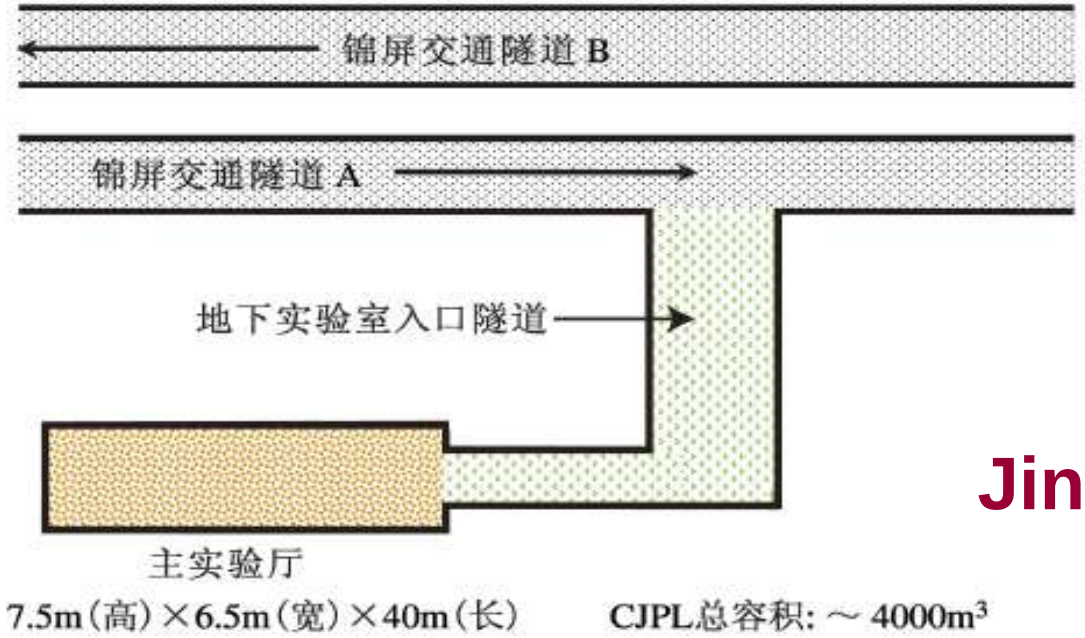


图 11　中国锦屏地下实验室平面规划图

Qinghua Univ.
Jinping Underground Lab

物理 · 40 卷 (2011 年)3 期

Jinping Lab. of Qinghua Univ.

20g HPGe running, 1kg under preparation

IHEP activities: next generation exp.

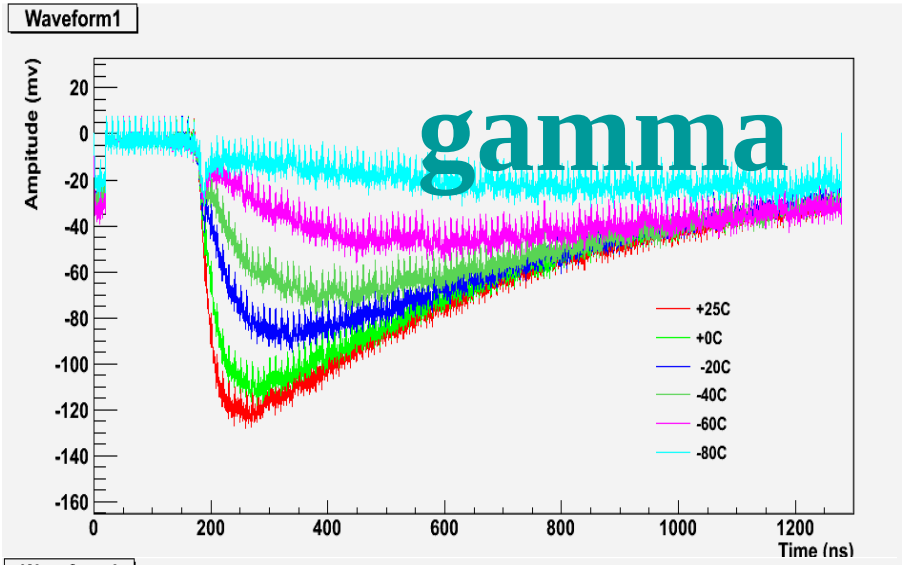
R&D for crystal detector using experience from DayaBay exp.:

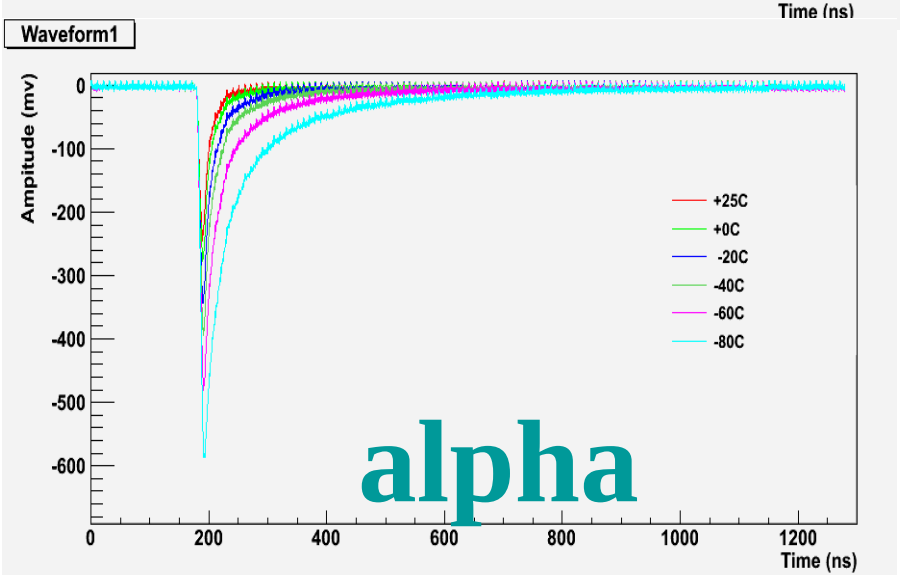
1. **Pulse shape measurement and 3D reconstruction**
2. **Veto systems**
3. **Reject BG. events from the crystal surface;**
4. **Large crystal: records multiple interaction of neutron, reduce BG.**
5. **CsI(Na) : good n/γ separation, specially for low temp; high Xsection; high density; cheaper. ⟶ detecter with large mass。**

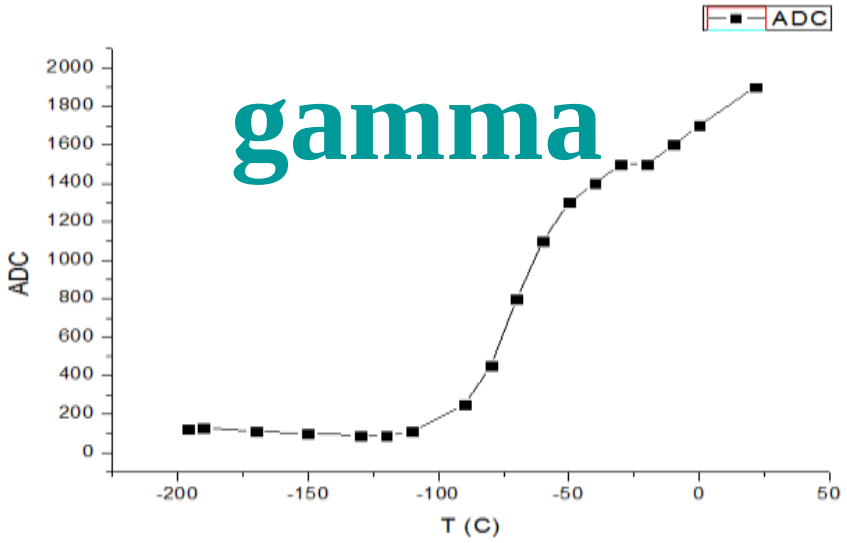
IHEP joined Dark Side exp..

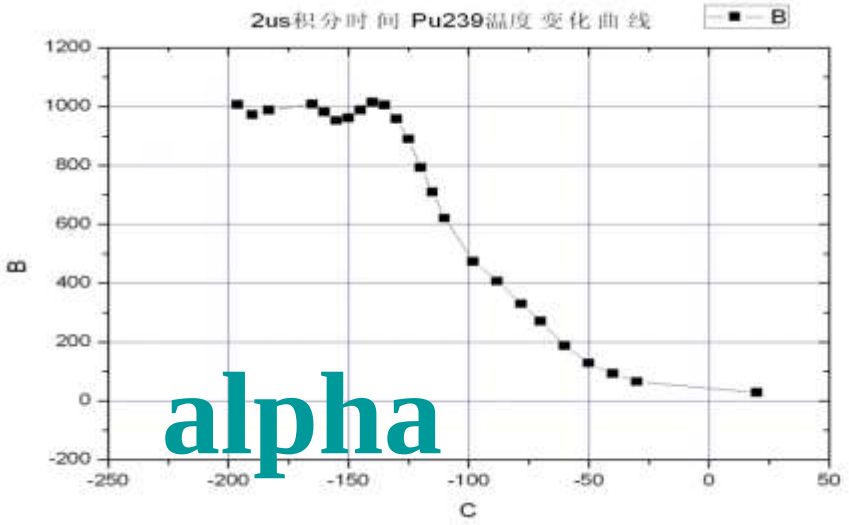
CsI(Na) performance at low temp.

Light from α increased by a factor of 40; from γ decreased by a factor 16



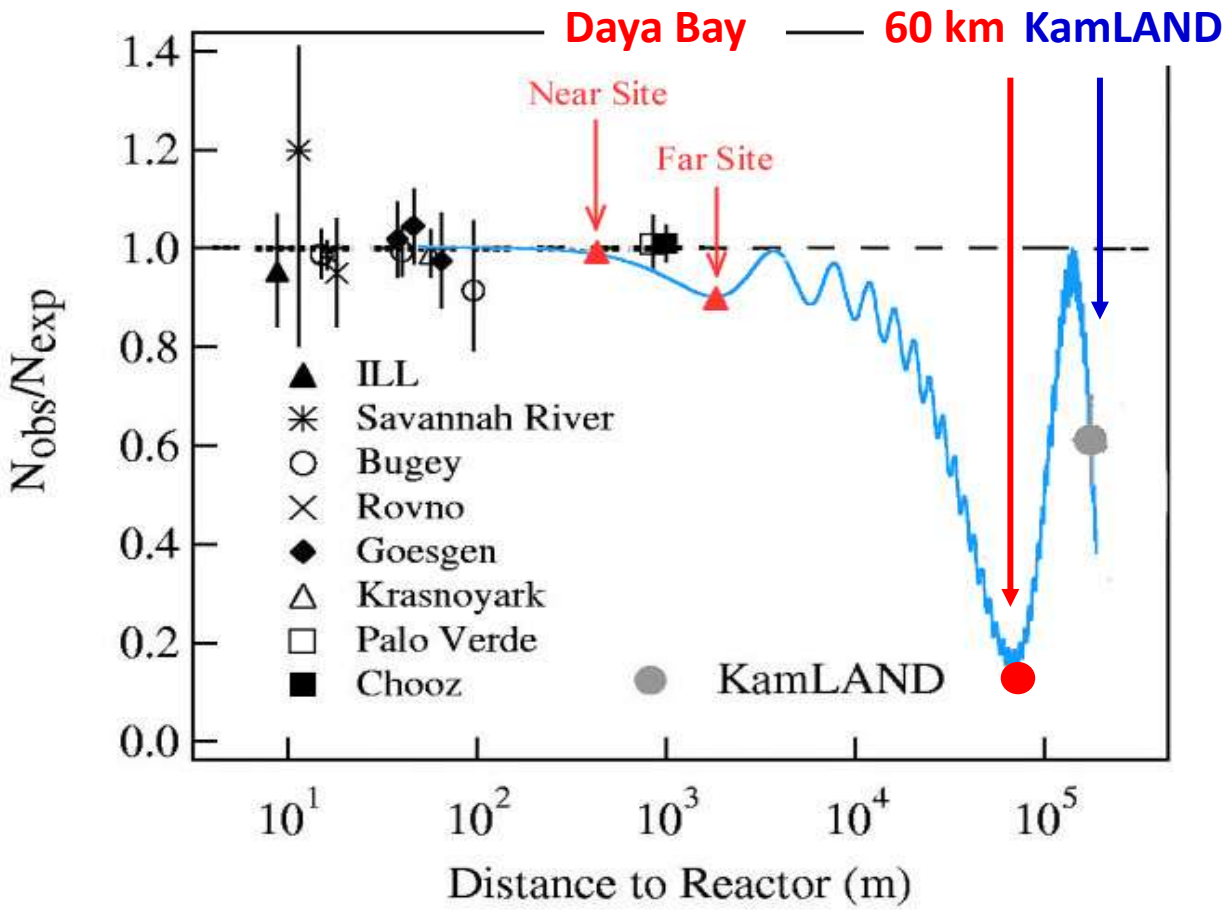






Daya Bay-II Experiment

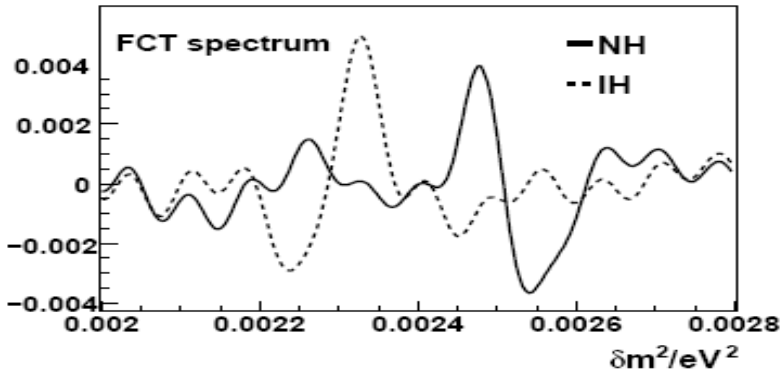
Giant Detector located at 60 km from Daya Bay reactors, the 1st maximum of θ_{12} oscillation.

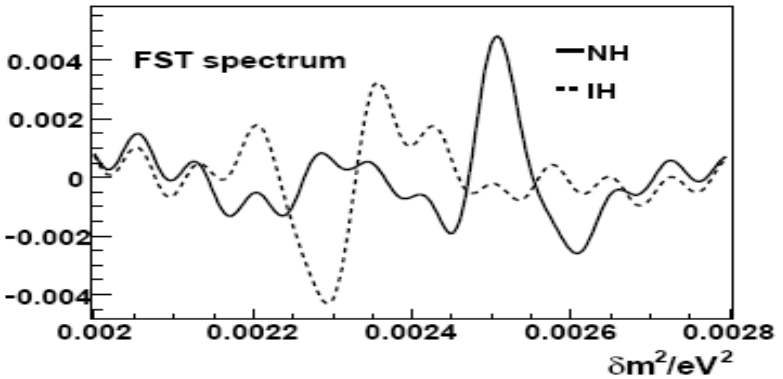


- 10-50 kton detector
- 2-3% energy resolution
- Rich physics possibilities
  - ⇨ Mass hierarchy
  - ⇨ Precision measurement of 4 mixing parameters
  - ⇨ Supernovae neutrino
  - ⇨ Geoneutrino
  - ⇨ Sterile neutrino
  - ⇨ Abnormal magnetic moment
  - ⇨ Discoveries with a high precision detector?

Mass hierarchy at reactors

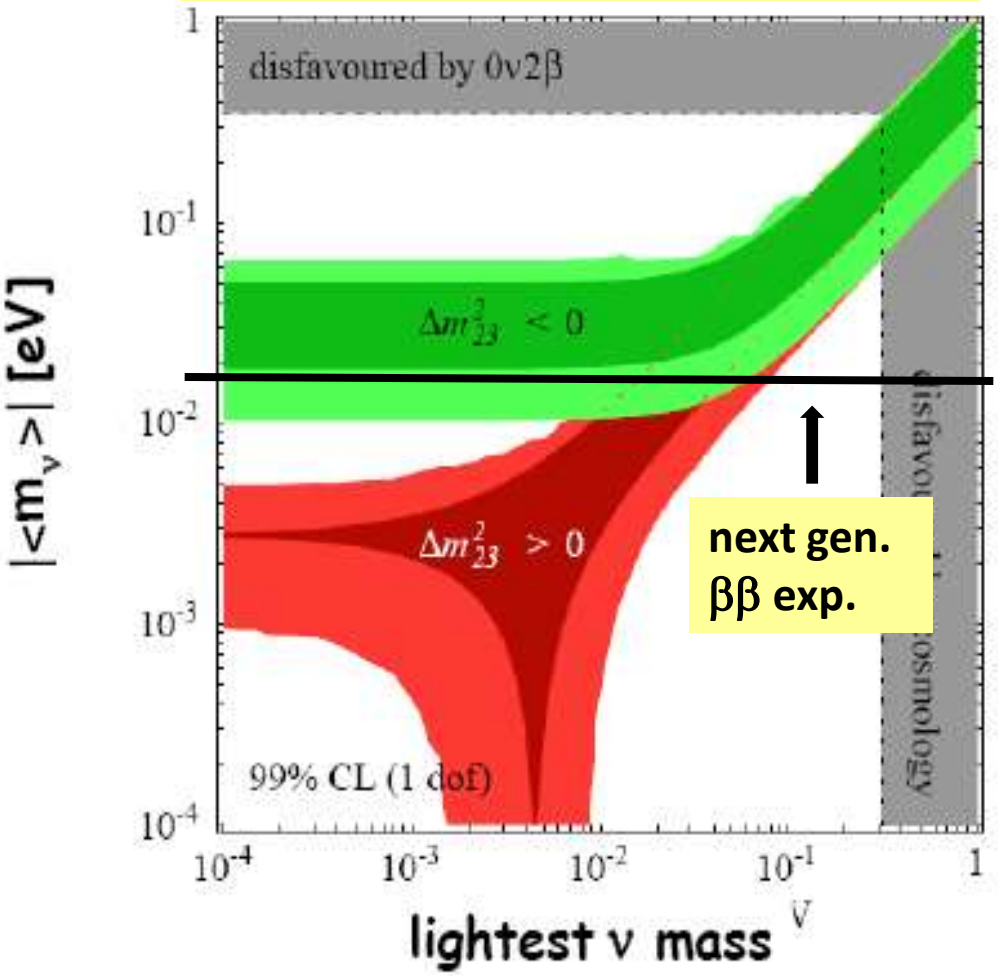
- **Effects of mass hierarchy can be seen from the distortion of neutrino energy spectrum at reactors after a Fo transformation**





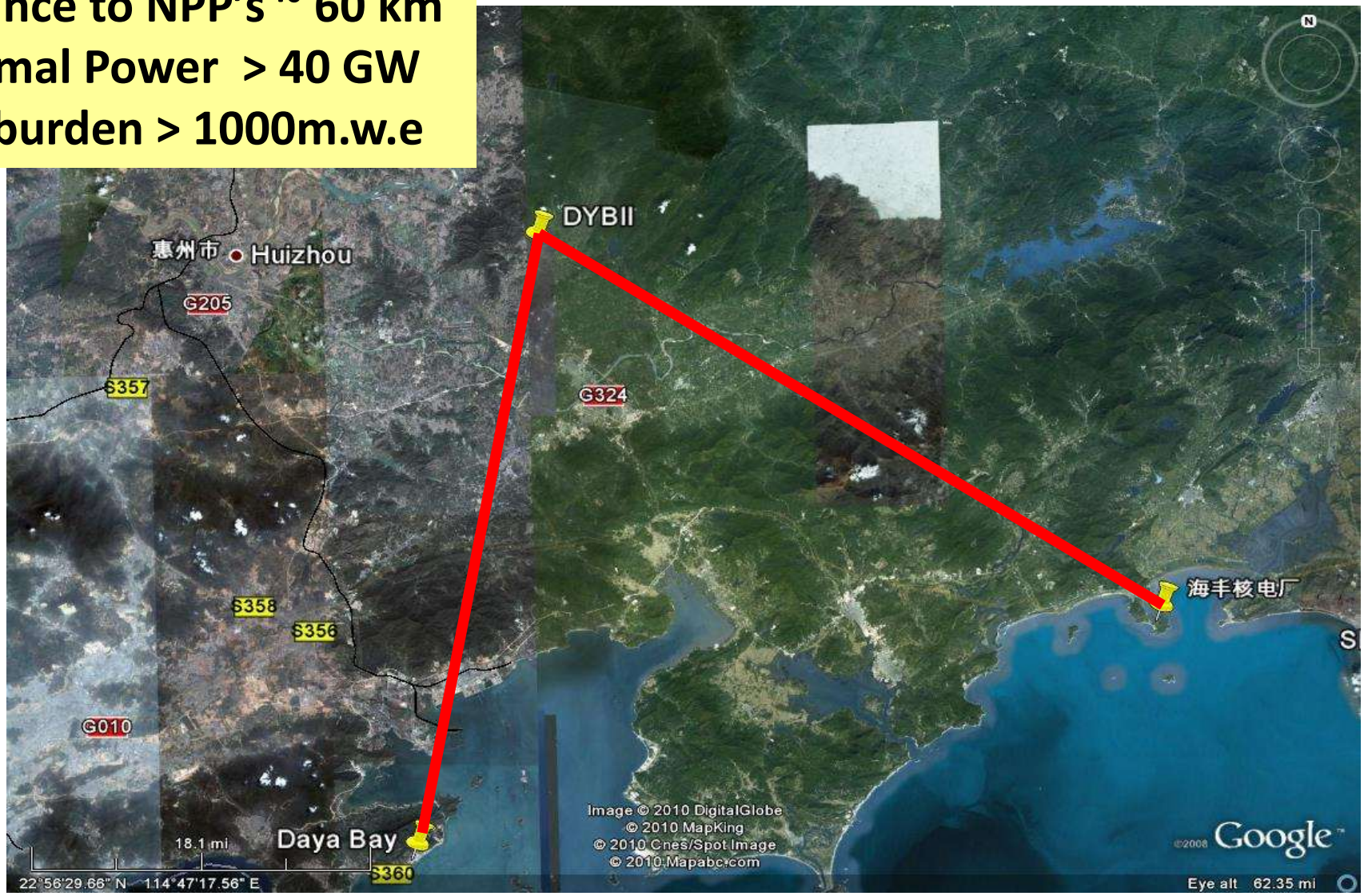
L. Zhan et al., PRD78:111103,2008

Mass hierarchy is crucial for the understanding of the Dirac/Majorana nature of neutrinos



Possible Site for Daya Bay II

Distance to NPP's ~ 60 km
Thermal Power > 40 GW
overburden > 1000m.w.e

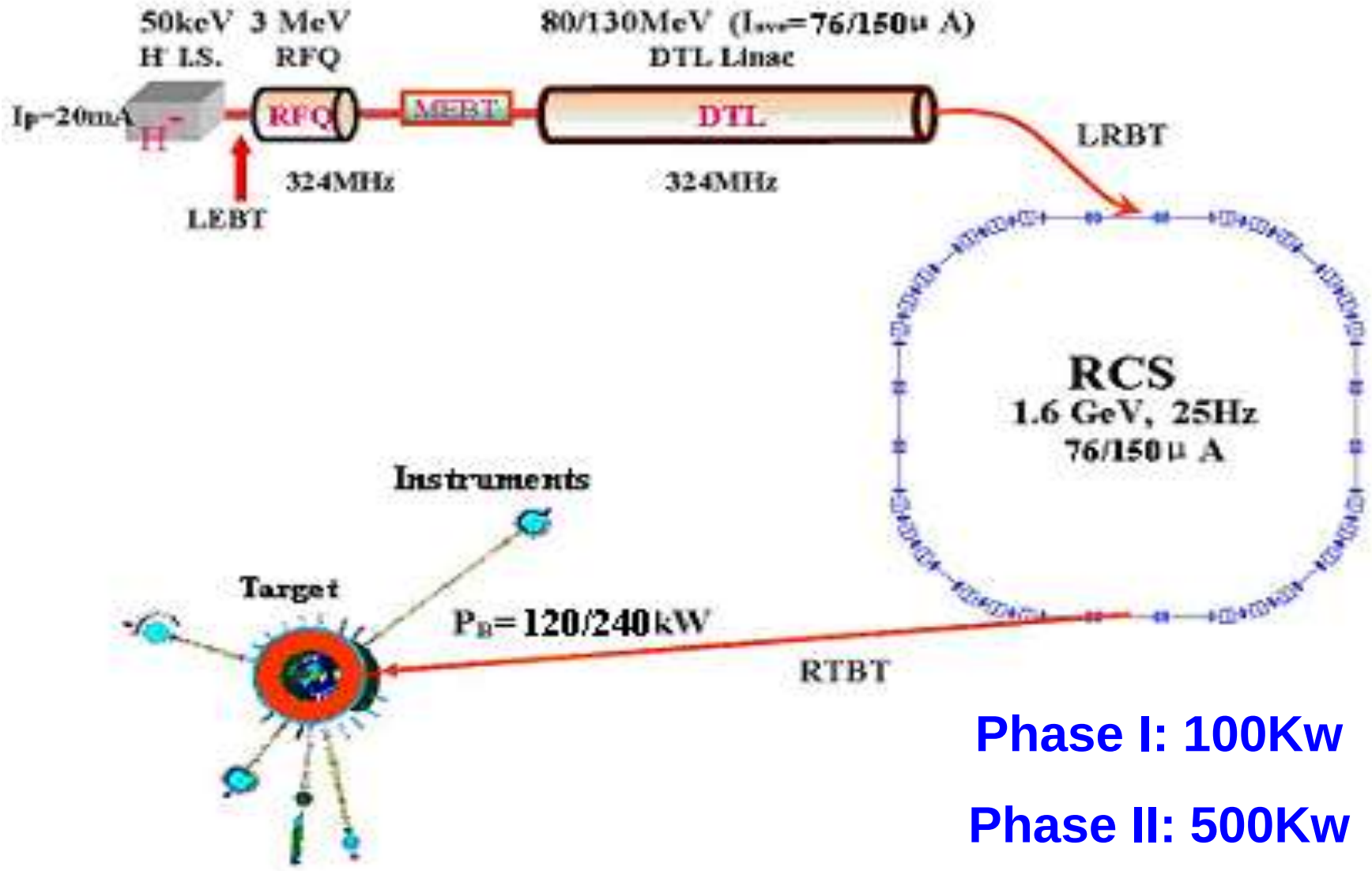


Multiple discipline research

- Large Facilities:
  - BSRF
  - CSNS
  - High current slow positron source
  - Beijing Advance Light Source (under discussion)
- Research fields:
  - Biology effects of nano-materials
  - Nuclear image and application
  - Protein structure and function
  - Environment studies with nuclear methods
  - Nano-material science
  - ……

Chine Spallation Neutron Source (CSNS)

ground breaking Oct. 2011, first beam @2016

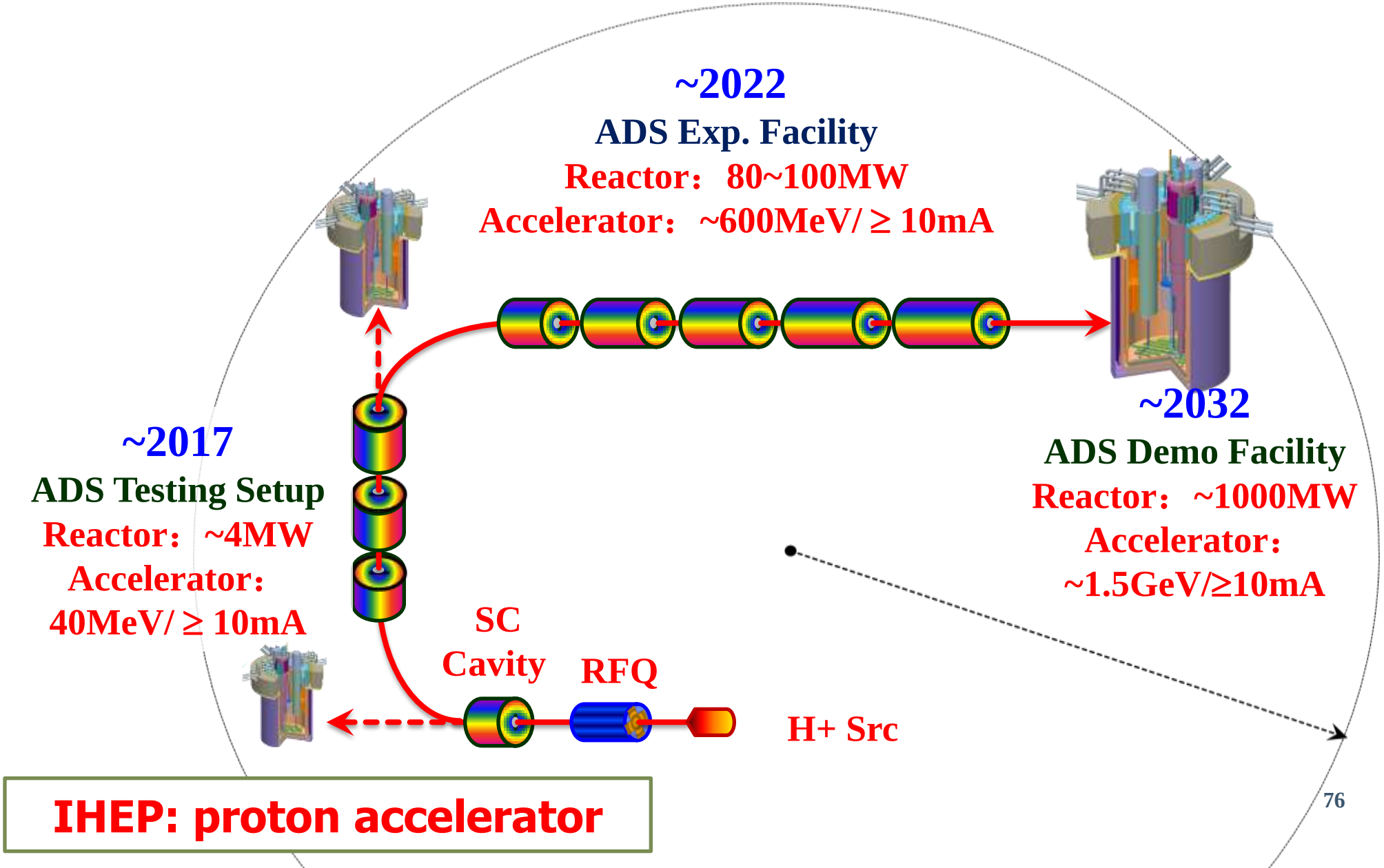


Phase I: 100Kw

Phase II: 500Kw

Chinese Spallation Neutron Source
(Dongguan, Guangdong, Branch of IHEP)

Accelerator Driven Subcritical System (ADS)



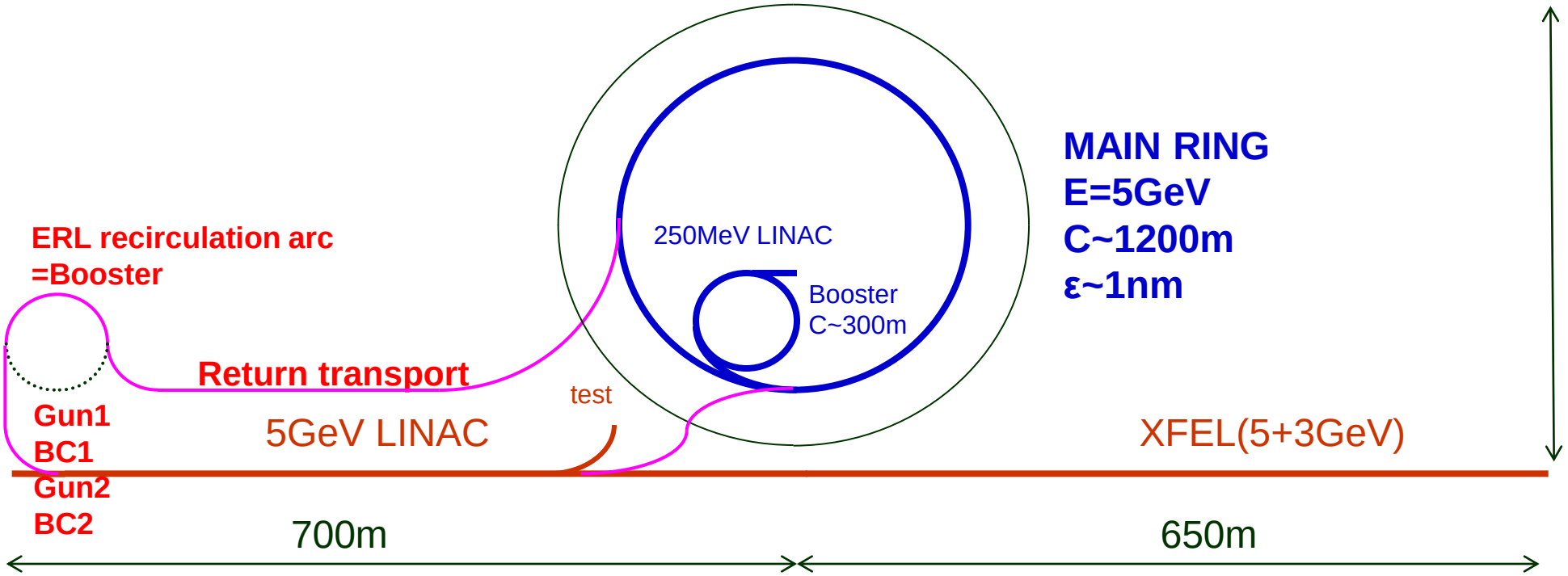
IHEP: proton accelerator

Beijing Advanced Photon Source (BAPS)

1st phase : 5 GeV Ring （BAPS，2016-2020）

2nd phase: 6~8 GeV XFEL（BXFEL，2018-2023 ）-- Coherent, short-pulse, high brilliance

3rd phase: 5 GeV ERL （BXERL，2020-）-- Partial coherent, multi-users, energy saving



Lattice Designs of BAPS

- **Three lattice designs have been carried out. Selection will be decided in 2015 depending on the technique difficulties and cost/budget.**
  - **About 1200m circumference, with 48×DBA lattice structure and 0.5 nm emittance.**
  - **About 1200m circumference, with 32×7BA lattice structure and 0.075 nm emittance.**
  - **About 1500m circumference, with 36×7BA lattice structure and 0.05 nm emittance. Further approach to Ultimate SR of 0.01nm/0.01nm (H/V) emittance is available with superconducting damping wigglers and solenoids.**

Main beam parameters of BAPS(48×DBA)

Parameter	Unit	Value
Beam energy	GeV	5
circumference	m	1200
Beam current	mA	200~300
emittance（H/V）	nm	1.44/0.014(κ =1%) 0.5/0.005 damping wiggler
Energy loss per turn(dipole)	MeV	2.67
Energy spread	10^{-3}	0.94
Momentum compact	10^{-4}	0.7
Bunch length	ps/mm	7.2/2.2
Photon critical energy(Ec)	keV	13.4(main bend) 83.1(5T SC Wig.)
Brilliances	Photons /s/mm^2/mrad^2/0.1%BW	~10^{21}

Main beam parameters of BAPS(32*7BA)

Parameter	Unit	Value
Beam energy	GeV	5
circumference	m	1263
Beam current	mA	~200
Damping partition		1.4/1.0/1.6
emittance（H/V）	pm	75/1
Energy loss per turn	MeV	1.51
Energy spread	10^{-3}	0.8
Momentum compact	10^{-4}	0.39
Bunch length	ps/mm	5.3/1.58
Photon critical energy(Ec)	keV	7.56(main bend) 83.1(5T SC Wig.)

Main beam parameters of BAPS(36*7BA)

Parameter	Unit	Value
Beam energy	GeV	5
circumference	m	1524
Beam current	mA	~100
emittance（H/V）	pm	50/1(bare lattice) 15./0.8 (60m, D.W.) 7.5/7.5(local ,with D.W. and Sol.)
Energy loss per turn	MeV	1.07(main bend) 6.05(including D.W.)
Energy spread	10^{-3}	0.705(without D.W.)
Momentum compact	10^{-4}	0.36
Bunch length	ps/mm	3.8/1.15(10MV RF)(without D.W.))
Photon critical energy(Ec)	keV	5.37(main bend) 83.1(5T SC Wig.)

D.W.: Lw=60m, λ=3.1cm,B0=2.3Tesla

Closing Remarks

- **BEPCII/BESIII will produce many interesting results in Charm physics in next 10 years. The future plan will depend on the results from BESIII+LHC+SuperB… and to be decided within 5-6 years.**
- **Dayabay neutrino exp. obtained the most precise measurement on neutrino mixing parameter θ_{13}.**
- **Experiments in the cosmic frontier are fast increasing.**
- **Large scientific research facilities: CSNS, ADS, BAPS**
- **Good opportunity and Great challenges**