# Physics of BES III and Particle Physics Programme 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

# 1. Particle Physics Experiments in China

- **High energy frontier:**
  - **LHC exp.: CMS, Atlas, LHCb, Alice**
  - **ILC R&D:  1.3GHz SC cavities, Positron source**
- **Intensity frontier:**
  - **Charm and tau physics at BEPCII**
  - **Daya Bay neutrino experiment**
- **Cosmic frontier**
  - **Yangbajing cosmic ray observatory**
  - **Space Experiments**

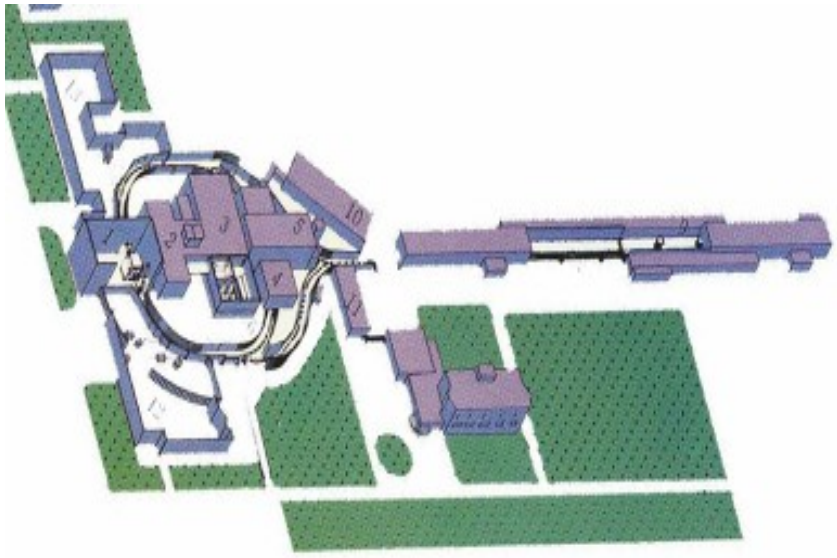
# 2. Beijing Electron Positron Collider (BEPC)

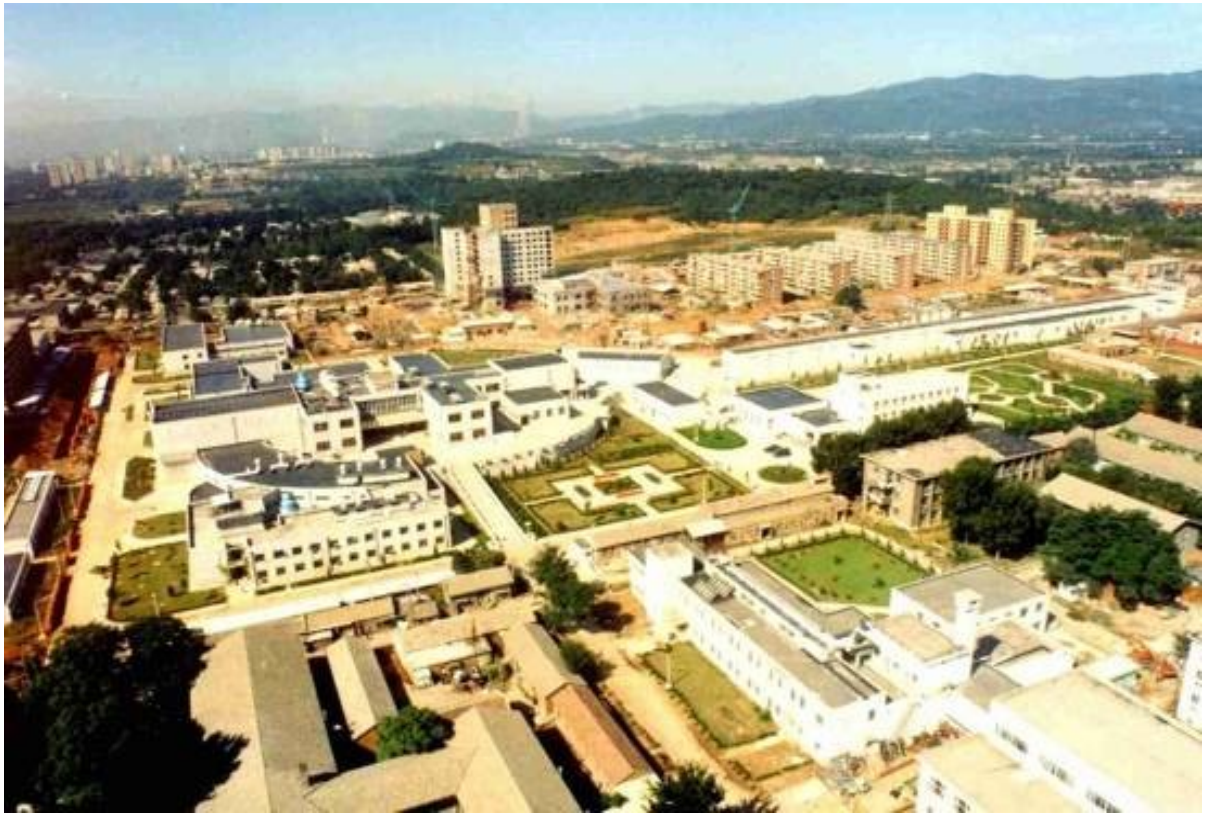
**BEPC: constructed 1984-1988** $E_{beam}$~ **1–2.5 GeV**

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

**BECPII upgraded 2004-2008** **Ebeam~ 1–2.3 GeV**

- **BESIII: run from 2008**





# With BESI and BESII data

- precision measurement of $\tau$ 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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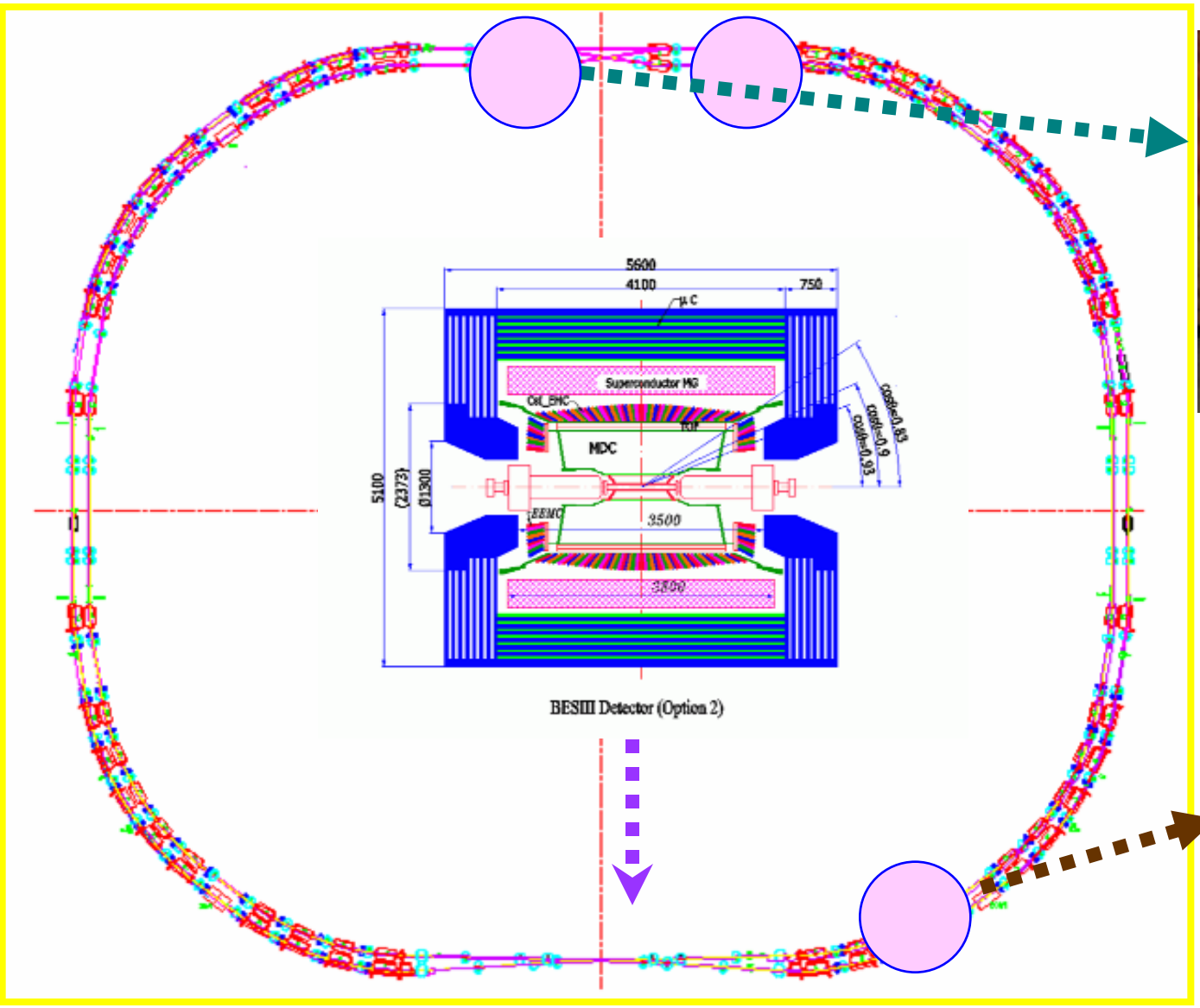
# BEPCII: a high luminosity double-ring collider




SC RF

Two rings

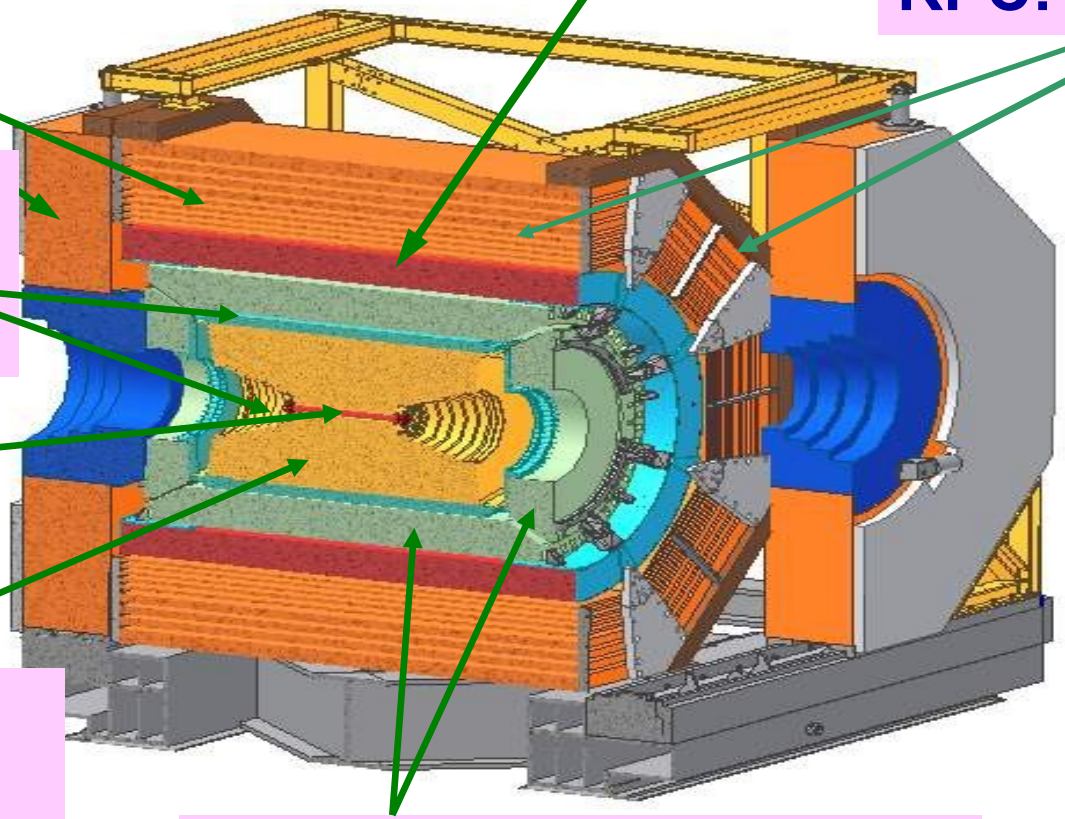
# Storage Ring installation finished

# The BESIII Detector

**Magnet yoke**

**SC magnet, 1T**

**RPC: 9 layers**



**TOF,**
$\sigma_T$ (ps) = 100 ps Barrel
110 ps Endcap

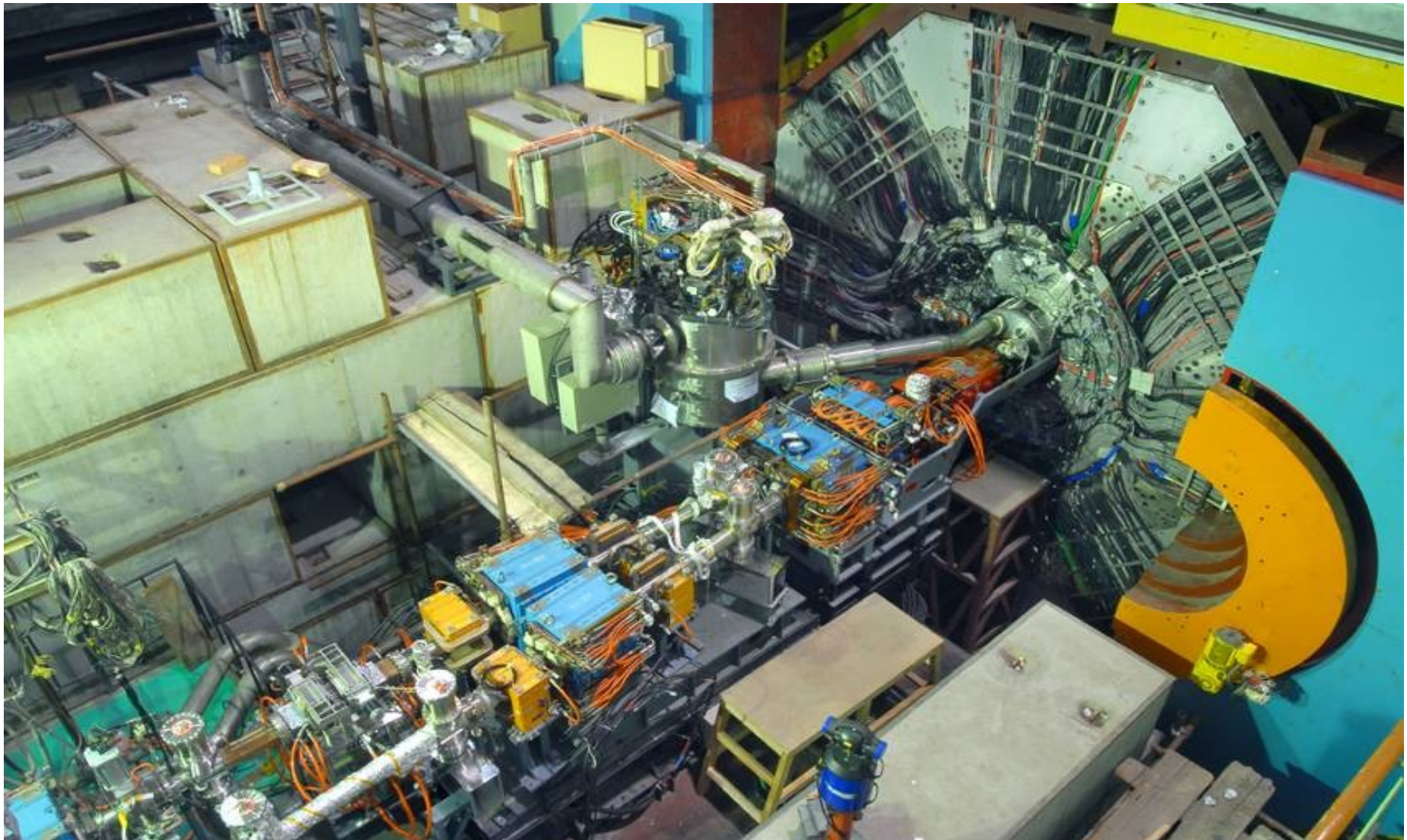
**Be beam pipe**

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

**CsI(Tl) calorimeter,**
△E/√E = 2.5 % (1 GeV)
$\sigma_z$,ϕ(cm) = 0.5cm/√E

# Joint Commissioning

- BESIII detector  moved into the IR in May 2008
- Joint commissioning started 22 June 2008.



# 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 |

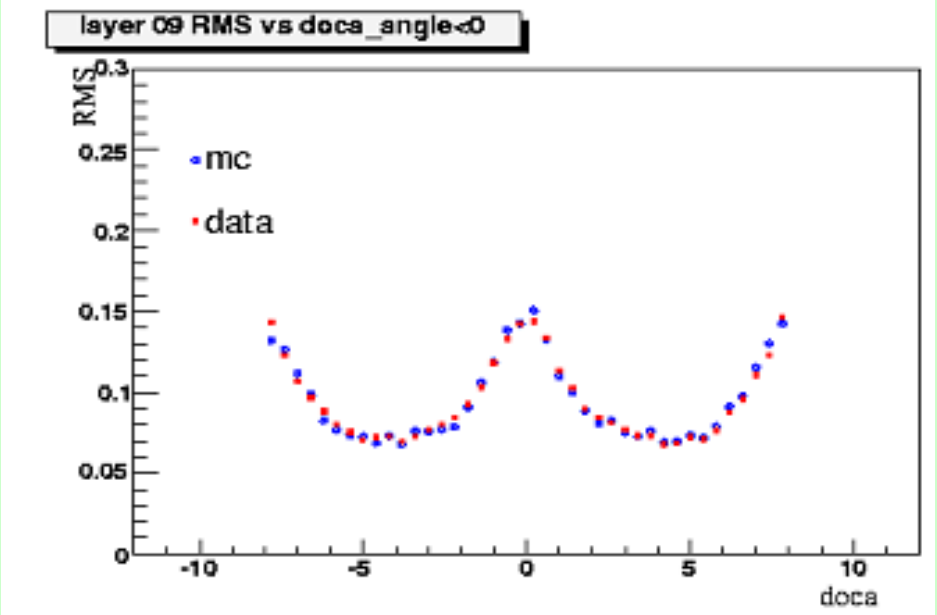
**positron injection rate improved by > factor of 15**

# Performance of BEPCII Storage Ring

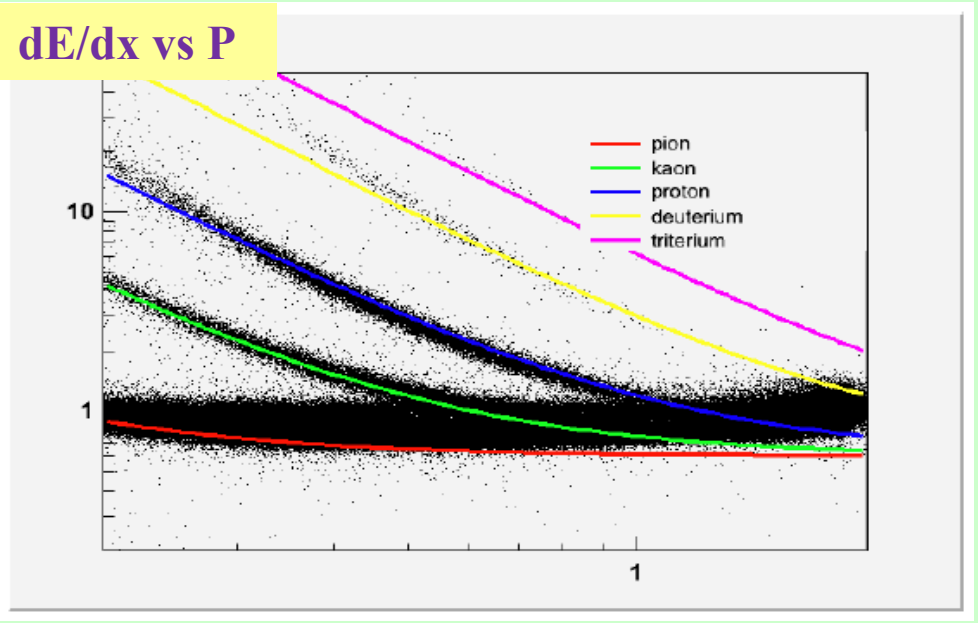
| Parameters | Design | Accept test result | |
|---|---|---|---|
| | | BER | BPR |
| Energy (GeV) | 1.89 | 1.89 | 1.89 |
| Beam current. (mA) | 910 | 650 | 700 |
| Bunch current. (mA) | 9.8 | >10 | >10 |
| Bunch number | 93 | 93 | 93 |
| RF voltage | 1.5 | 1.6 | 1.6 |
| $\nu_s$ @ $V_{RF}$= 1.5MV | 0.033 | 0.032 | 0.032 |
| $\beta_x^*/\beta_y^*$ (m) | 1.0/0.015 | ~1.0/0.0135 | ~1.0/0.0135 |
| Injection rate (mA/min) | 200 $e^-$/50 $e^+$ | >200 | >50 |
| $L$ ($10^{33}cm^{-2}s^{-1}$) | 1.0 | 0.33 | |

**Factor of 33 improvement in luminosity at May 2009**

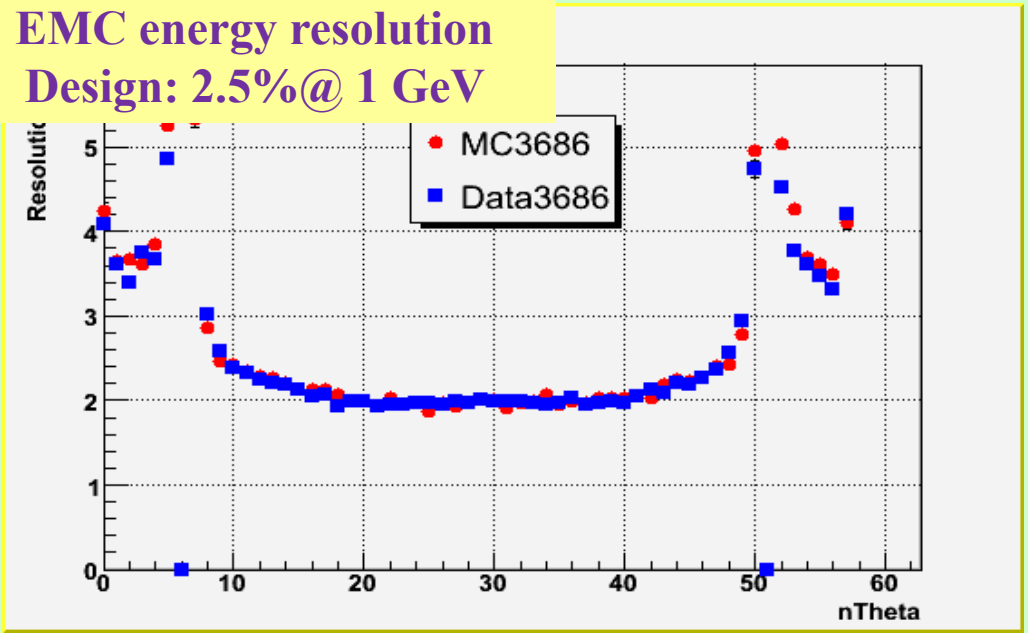
# Excellent detector performance




dE/dx vs P

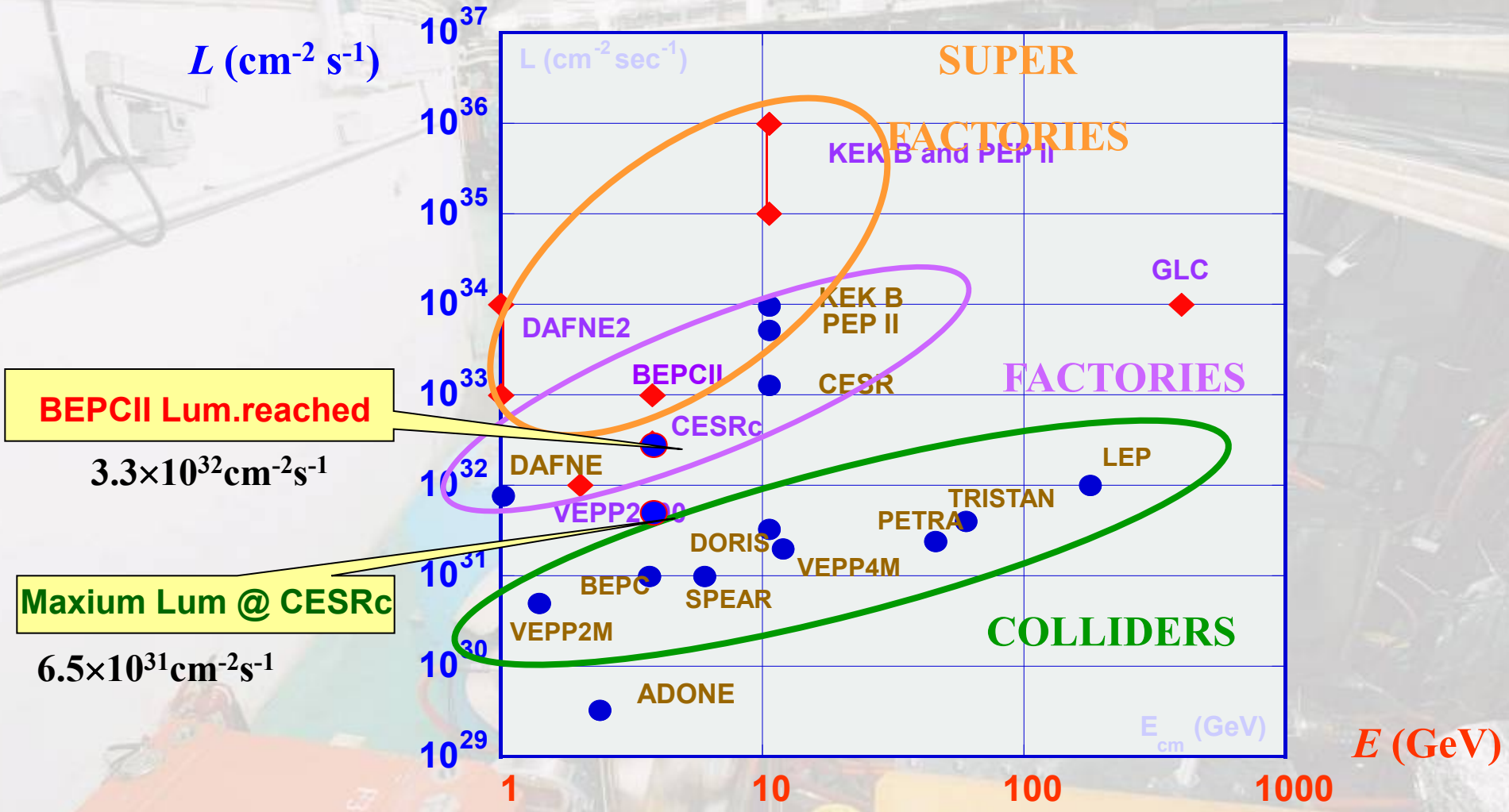



EMC energy resolution
Design: 2.5%@ 1 GeV




Time resolution
Design: 80ps

# Electron Positron Colliders



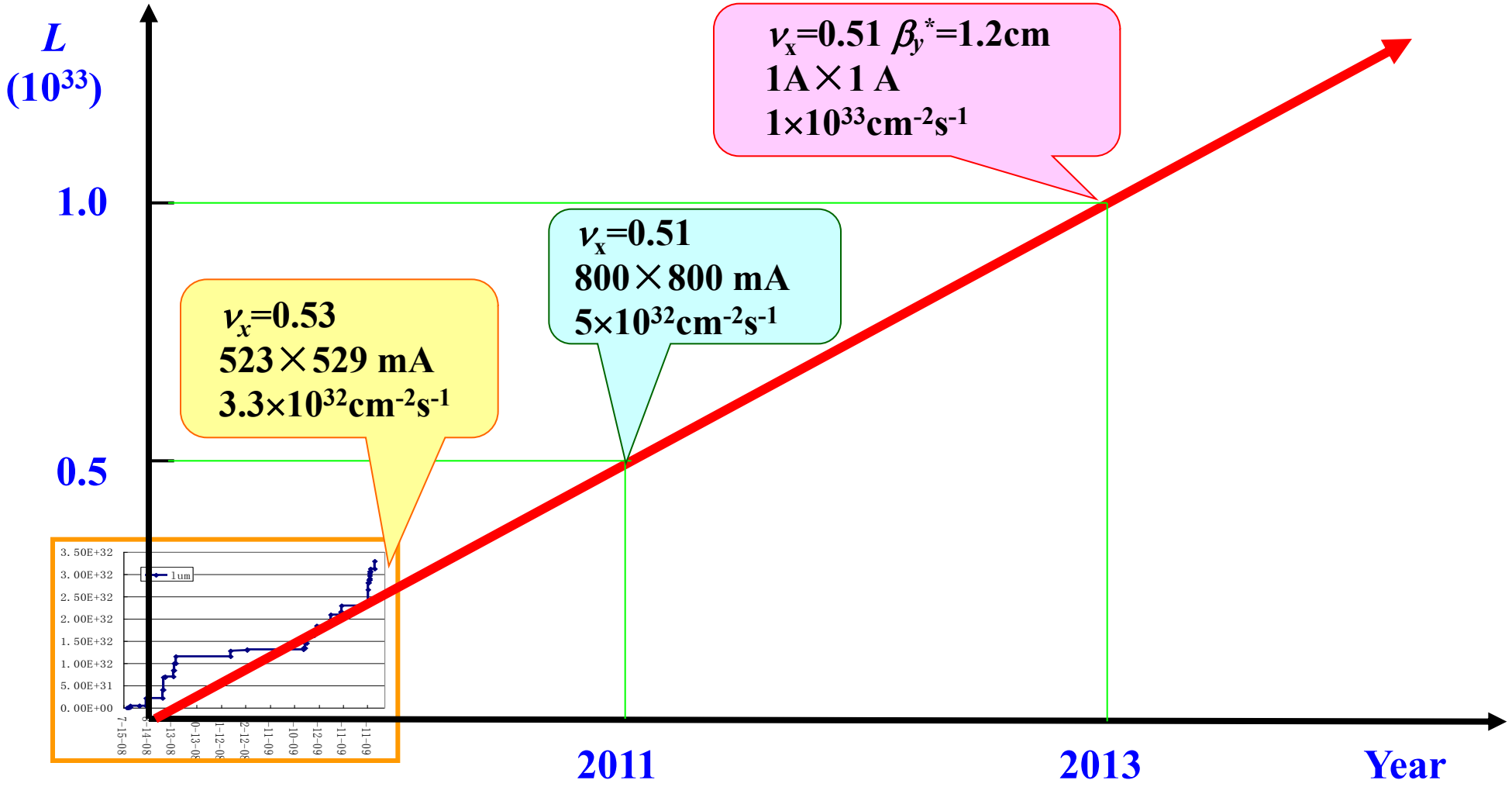
# On going upgrades

- To increase single bunch current in collision
- To enhance beam-beam parameter towards 0.04
- To move horizontal tune to 0.51
- To increase colliding bunch number and pattern
- Squeeze $\beta y^*$
- …

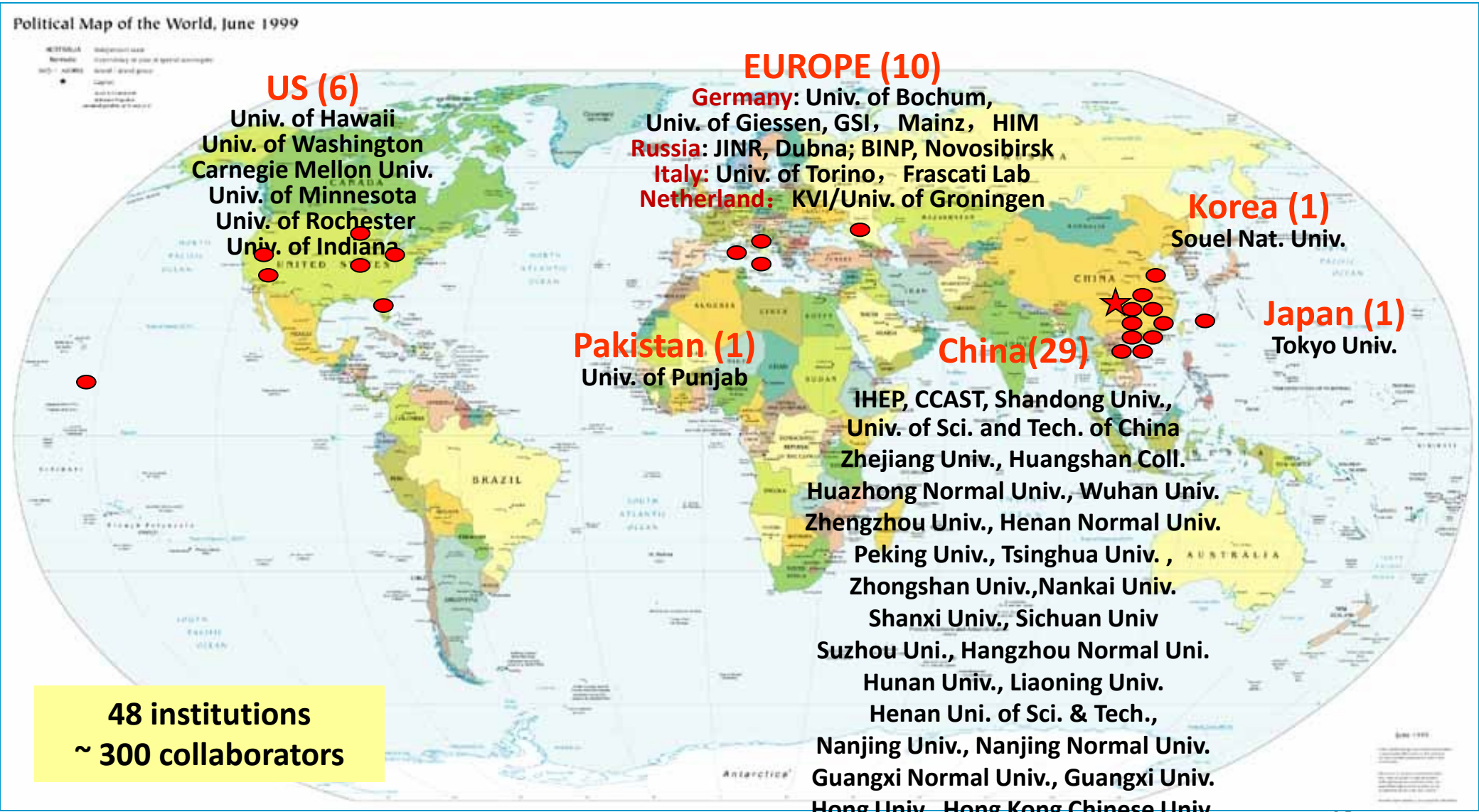
# Longterm upgrades (under discussion)

- Increasing beam energy? (2.3GeV now)
- Crab-waist for higher luminosity
- Collision with polarized beam
  - Physics requirements
  - e- beam? location for rotators ?

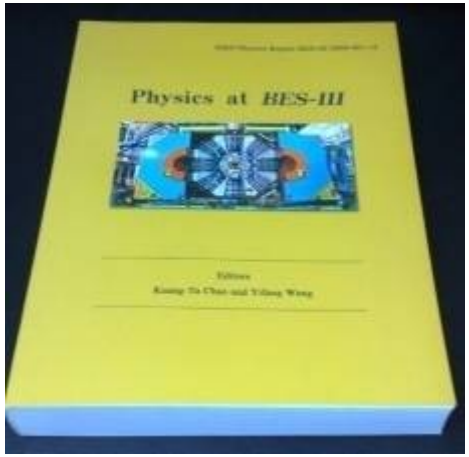
# BEPCII luminosity plan



# BESIII collaboration



# BESIII Physics: Precision tests of SM and search for new physics



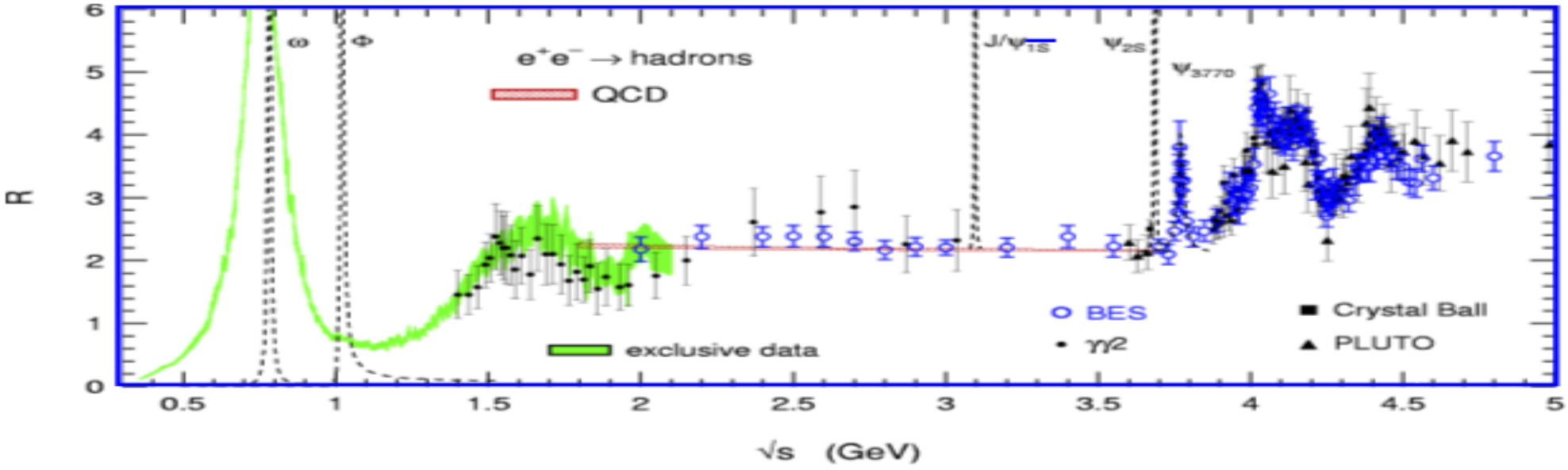

hep-ex/0809.1869

IJMP A V24,No 1(2009) supp

- Light hadron spectroscopy
  - Full spectra: normal & exotic hadrons QCD
  - How quarks form hadron ? non-pQCD
- Charm physics
  - CKM matrix elements ➔ SM and beyond
  - $D\overline{D}$ mixing and CPV ➔ SM and beyond
- Charmonium physics
  - Spectroscopy and transition ➔ pQCD & non-pQCD
  - New states above open charm thresholds ➔ exotic hadrons ?
  - pQCD: $\rho\pi$ puzzle ➔ a probe to non-pQCD or ?
- Tau physics and QCD
  - Precision measurement of the tau mass and R value
- Search for rare and forbidden decays

# BESIII data taking status & plan

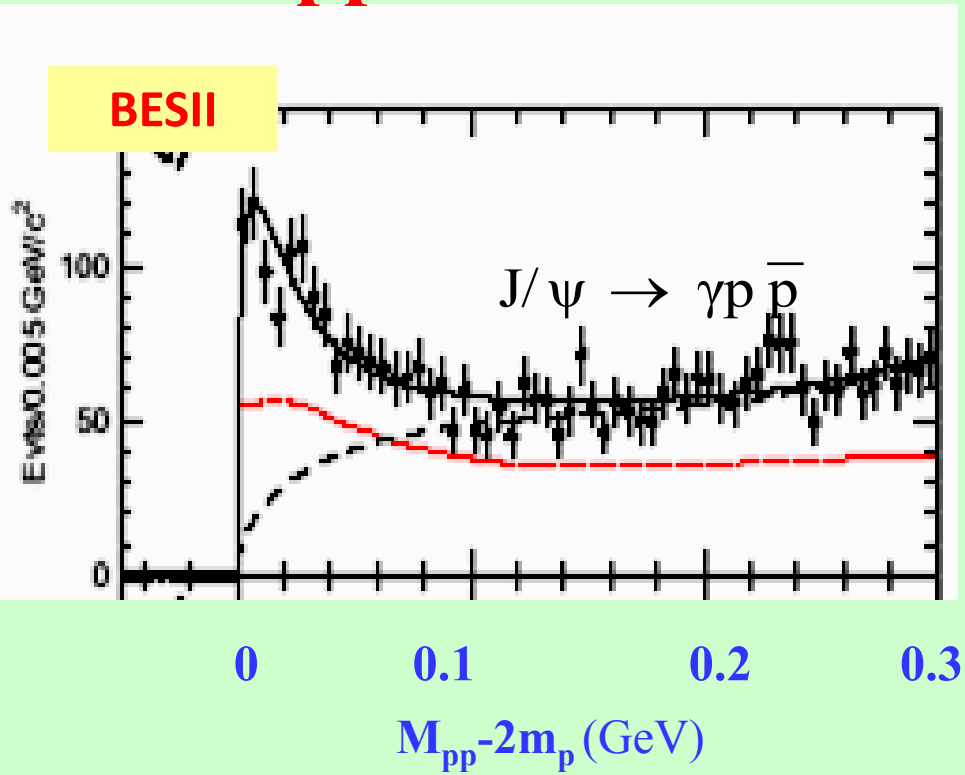
| | Previous Data set | BESIII Near future |
|---|---|---|
| J/psi | BESII 58M | 2009：200M，2012：1 B |
| Psi’ | CLEO：28 M | 2009：100M |
| Psi” | CLEO：0.8 /fb | 2010：0.9/fb，2011-12：3.5/fb |
| ψ(4040)/ψ(4160) & scan | CLEO：0.6/fb @ ψ(4160) | 2011：0.4/fb @ ψ(4040)<br>2013：4/fb |
| R scan & Tau | BESII | 2014 |



# BESIII： First physics results

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

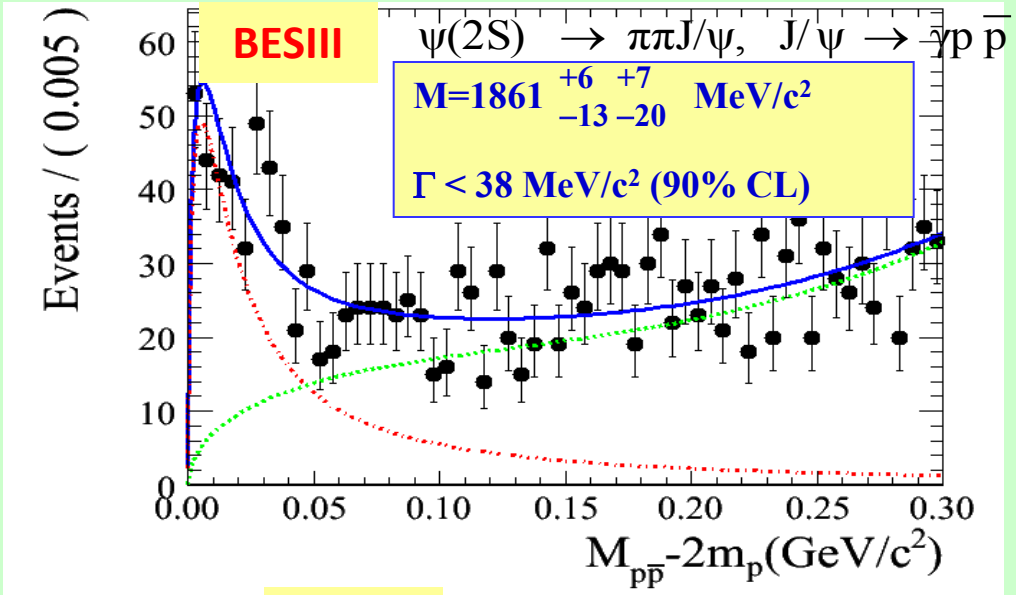
# Confirmation of the BESII observation: $\bar{p}p$ threshold enhancement in J/ψ decays

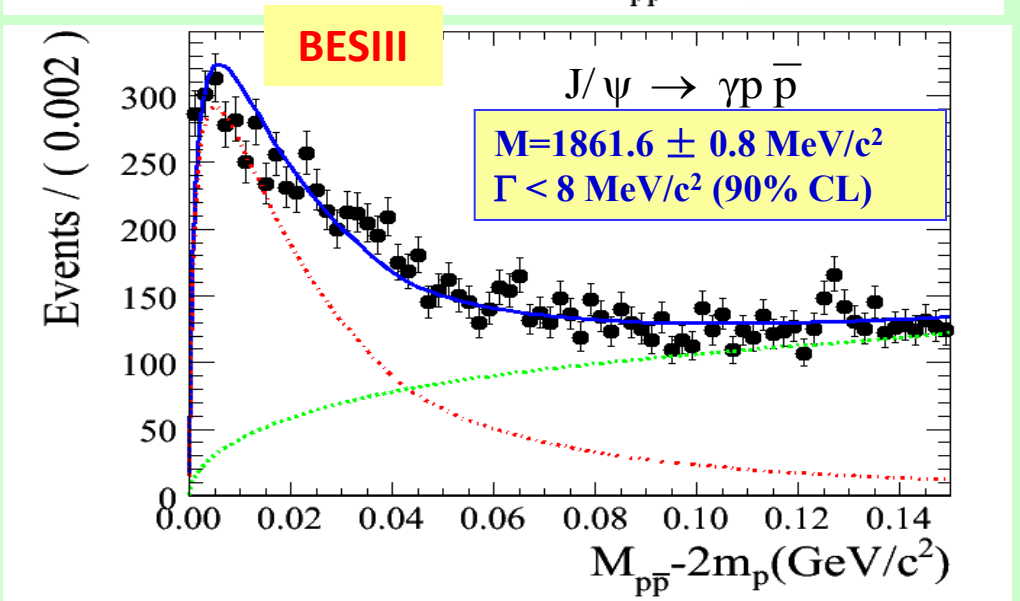



$M=1859\ ^{+3}_{-10}\ ^{+5}_{-25}$ MeV/c²

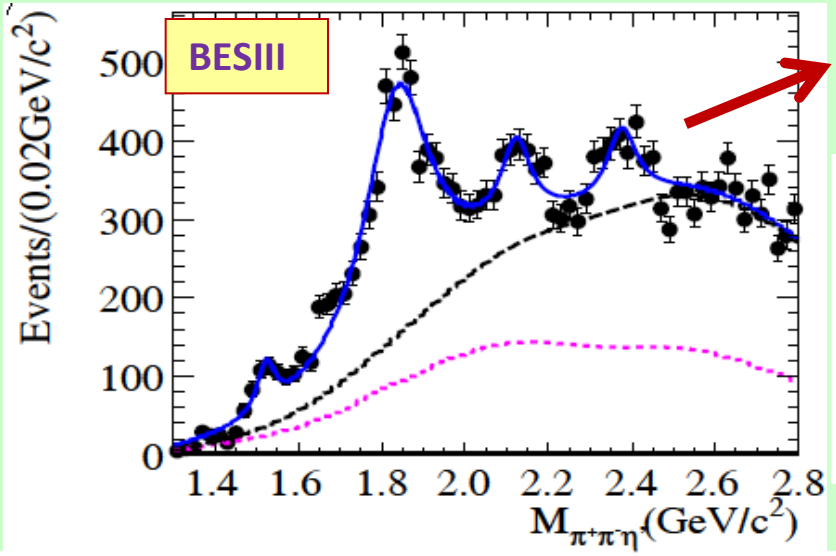
Γ < 30 MeV/c² (90% CL)

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



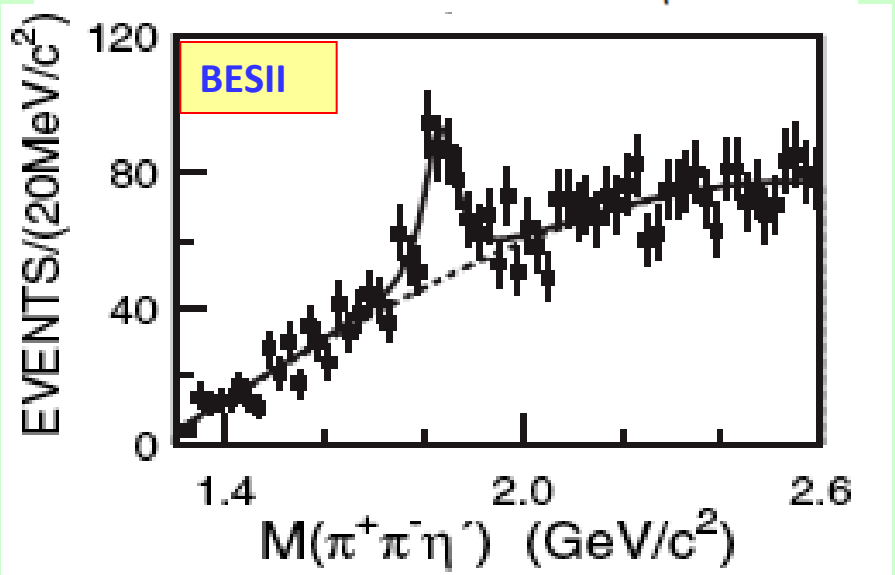



# Confirmation of BESII observation: X(1835) in J/ψ →γη'ππ




Two new resonance

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




*significan ce* : 7.7 $\sigma$

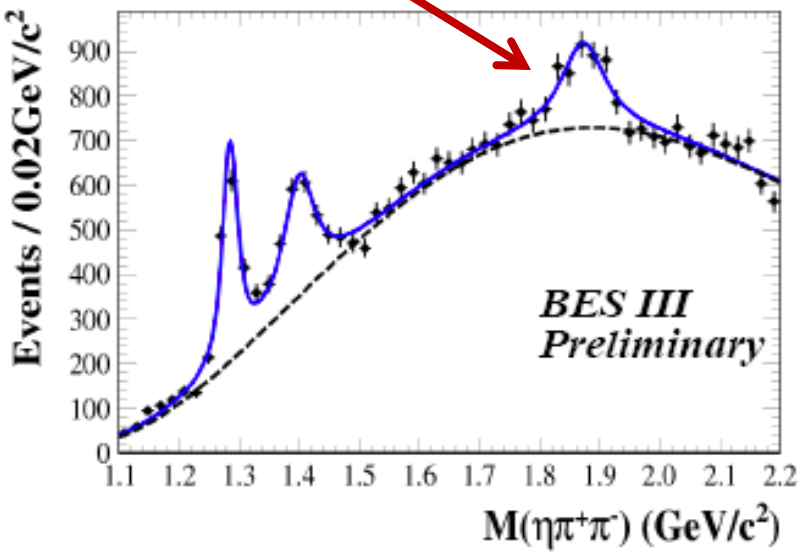
M = 1833.7 ± 6.1(stat) ± 2.7(syst) MeV

Γ = 67 .7 ± 20 .3 (stat) ± 7.7(syst ) MeV

**To be submitted to PRL**

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

X(1870)

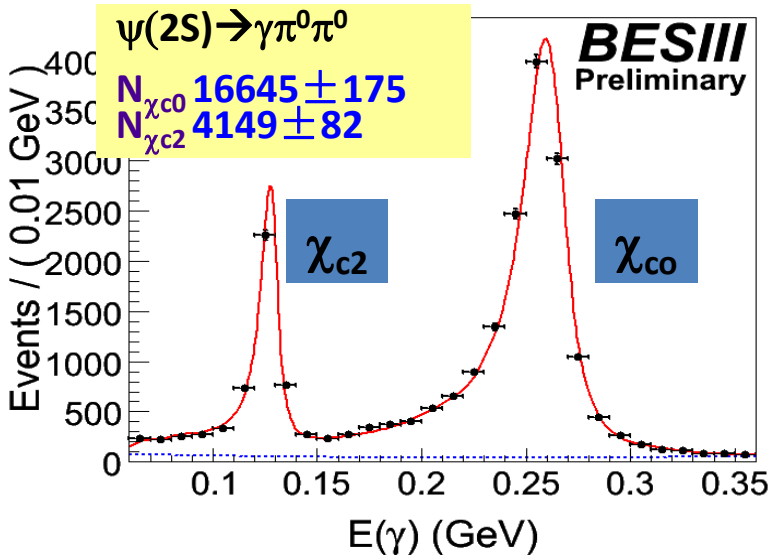


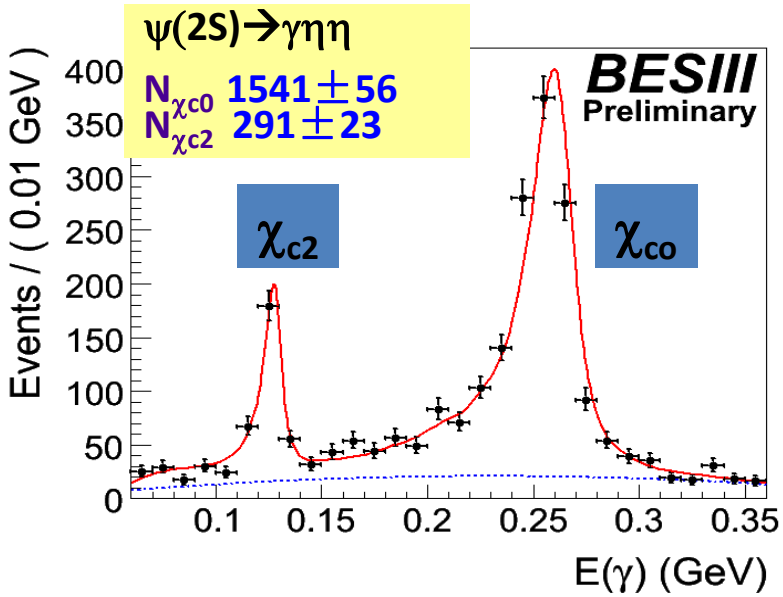

$$Fit\ result\ (stat.\ sig.\sim 7.7\sigma)$$
$$M = 1873 \pm 11 MeV$$
$$\Gamma = 82 \pm 19 MeV$$

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

# $\psi(2S) \to \gamma\pi^0\pi^0$ , $\gamma\eta\eta$ ($\eta \to \gamma\gamma$ , $\pi^0 \to \gamma\gamma$ )

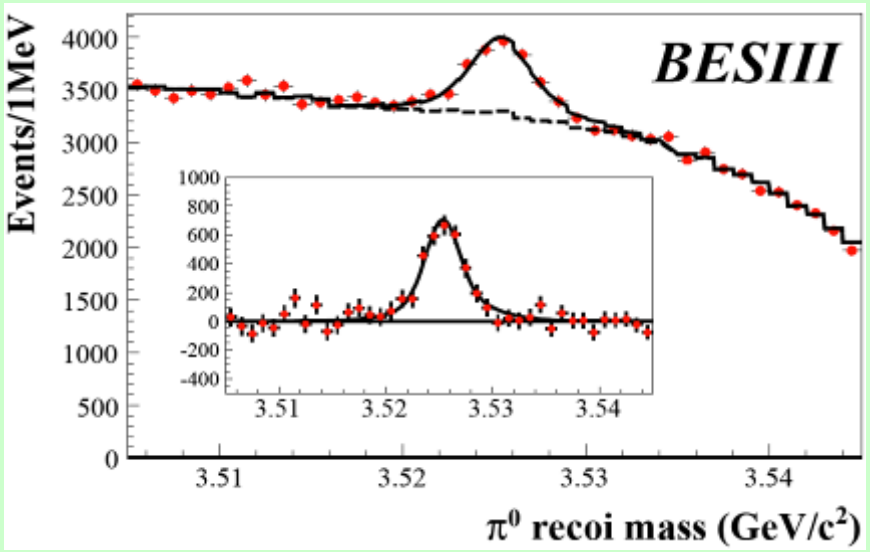


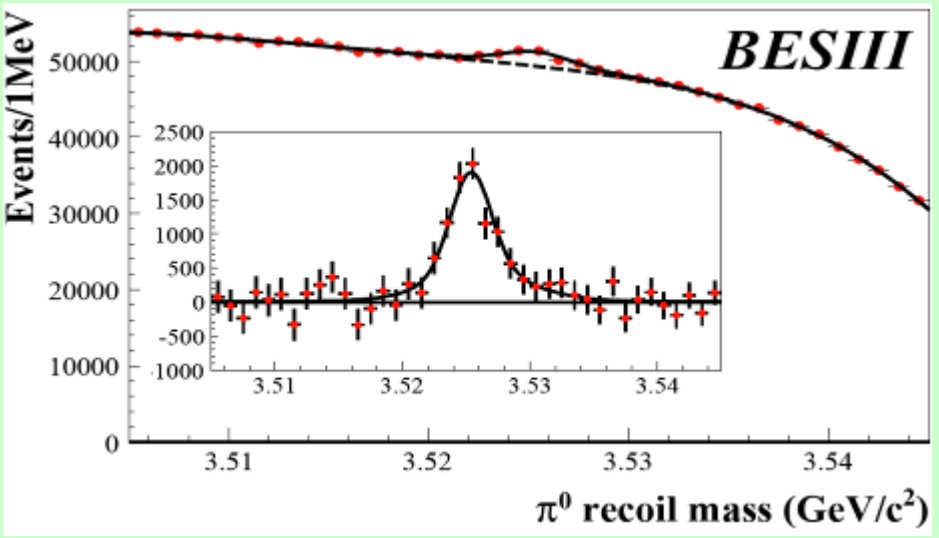




| BR ($10^{-3}$) | | $\chi_{c0}$ | $\chi_{c2}$ |
|---|---|---|---|
| $\pi^0\pi^0$ | BESIII | 3.23±0.03±0.23±0.14 | 0.88±0.02±0.06±0.04 |
| | PDG08 | 2. 43±0.20 | 0.71±0.08 |
| | CLEO-c | 2.94±0.07±0.35 | 0.68±0.03±0.08 |
| $\eta\eta$ | BESIII | 3.44±0.10±0.24±0.20 | 0.65±0.04±0.05±0.03 |
| | PDG08 | 2.4±0.4 | <0.5 |
| | CLEO-c | 3.18±0.13±0.35 | 0.51±0.05±0.06 |

Phys. Rev. D 81, 052005 (2010)

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




$M(h_c)^{Inc} = 3525.40\pm0.13\pm0.18$ MeV

$\Gamma(h_c)^{Inc} = 0.73\pm0.45\pm0.28$ MeV

$Br(\psi'\to\pi^0 h_c)\times Br(h_c\to\gamma\eta_c)^{Inc}$
$=(4.58\pm0.40\pm0.50)\times10^{-4}$

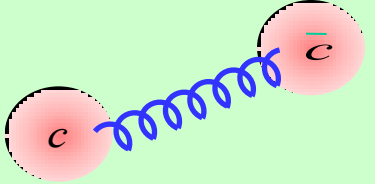
$Br(\psi'\to\pi^0 h_c) = (8.4\pm1.3\pm1.0)\times10^{-4}$

$Br(h_c\to\gamma\eta_c) = (54.3\pm6.7\pm5.2)\ \%$

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

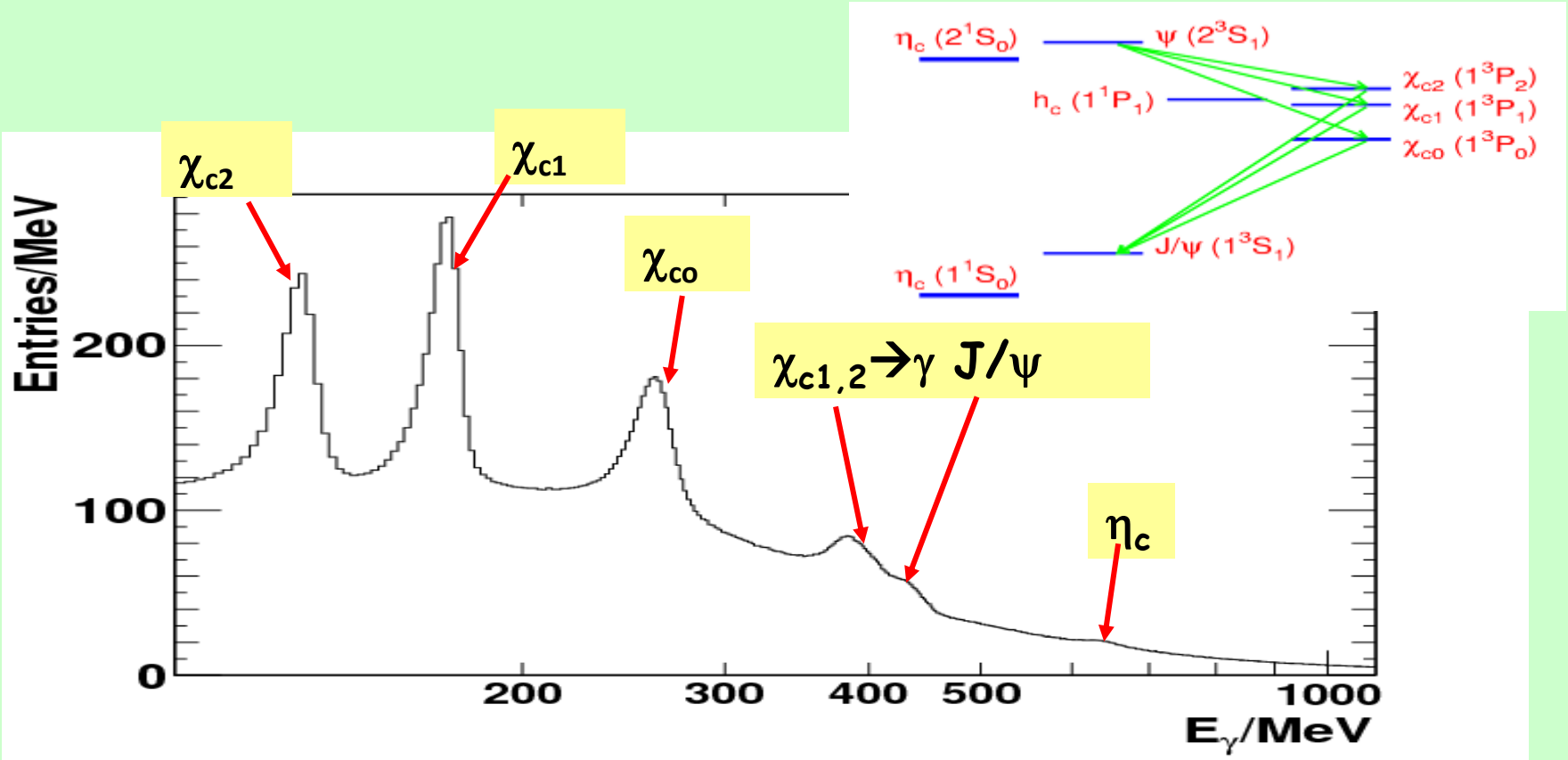
BESIII measured for the first time
$\Gamma(h_c)^{Inc}$, $Br(\psi'\to\pi^0 h_c)$ & $Br(h_c\to\gamma\eta_c)$

# Charmonium physics



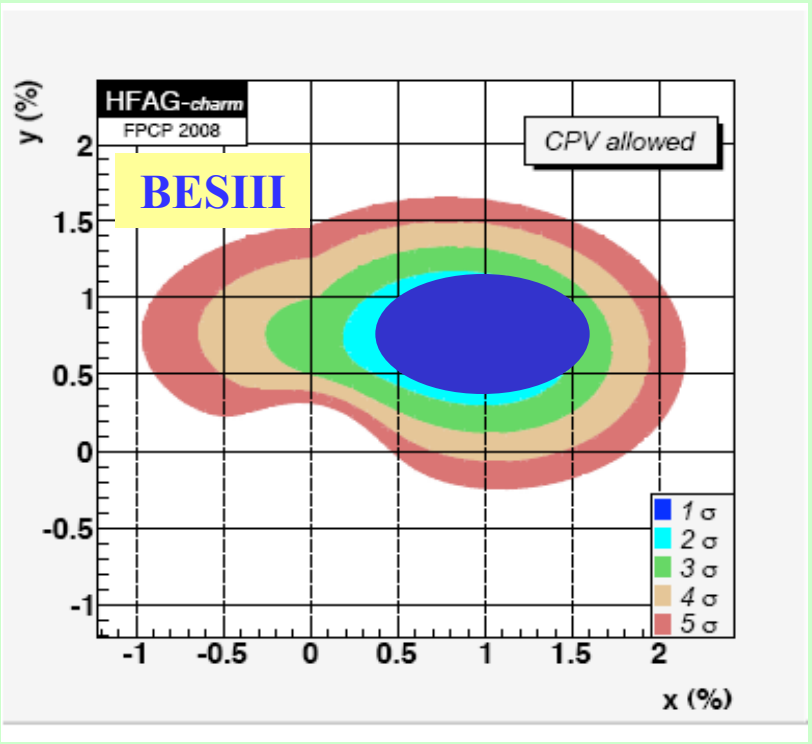

- **Understand how quarks form hadron?**
  - **Production, decays, transition, spectrum**

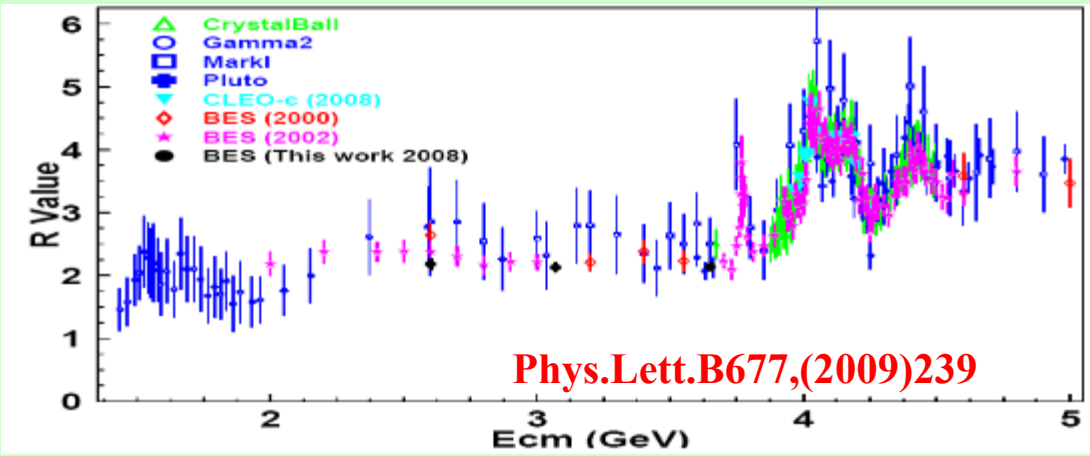
**Examples of interesting/long standing issues:**
- **ρπ puzzle, glueball**
- **Missing states ?**
- **Mixing states ?**
- **New states above open charm thre.(X,Y,Z,…)**



# Other physics programs at BESIII

- Charm physics
  - DD mixing and CPV
  - CKM matrix elements
    - $V_{cs}$: 11% ➔ 1.2%
    - $V_{cd}$: 4% ➔ 1.4%
- QCD
  - pQCD ⟺ non-pQCD
  - Form factor of hadrons
  - measurement of R & $\alpha_s$
- Tau physics
  - Tau mass
  - Tau decays:

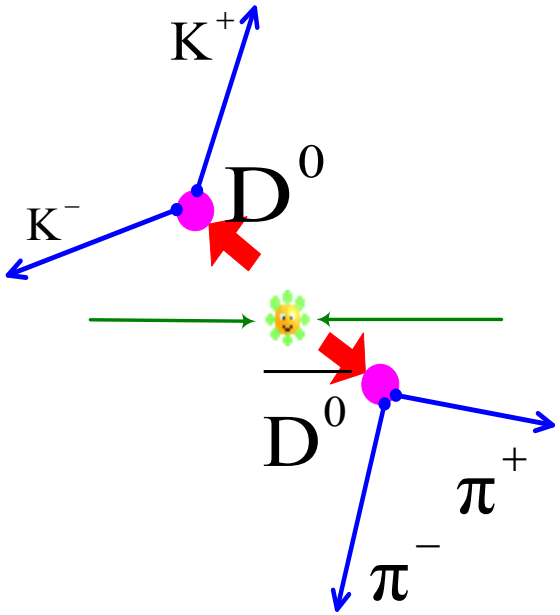


# Expected Exp. Accuracies in D decay measurements at BESIII

| Observable | CKM | QCD | Lattice | Exp meas | Exp err |
|---|---|---|---|---|---|
| $Br(D \to \ell\nu)$ | $\lvert V_{cd}\rvert$ | $f_D$ | 2% | $f_D\lvert V_{cd}\rvert$ | 1.1% |
| $Br(D_s \to \ell\nu)$ | $\lvert V_{cs}\rvert$ | $f_{Ds}$ | 1.5% | $f_{Ds}\lvert V_{cs}\rvert$ | 0.7% |
| $\frac{Br(D_s\to\ell\nu)}{Br(D\to\ell\nu)}$ | $\left\lvert\frac{V_{cs}}{V_{cd}}\right\rvert$ | $\frac{f_{Ds}}{f_D}$ | 1% | $\left\lvert\frac{V_{cs}f_{Ds}}{V_{cd}f_D}\right\rvert$ | 0.8% |
| $d\Gamma(D^0 \to \pi^-)$ | $\lvert V_{cd}\rvert$ | $F_{D\to\pi}(0)$ | 4% | $\lvert V_{cd}\rvert F_{D\to\pi}(0)$ | 0.6% |
| $d\Gamma(D^0 \to K^-)$ | $\lvert V_{cs}\rvert$ | $F_{D\to K}(0)$ | 3% | $\lvert V_{cs}\rvert F_{D\to K}(0)$ | 0.5% |
| $d\Gamma(D_s \to K)$ | $\lvert V_{cd}\rvert$ | $F_{D_s\to K}(0)$ | 2% | $\lvert V_{cd}\rvert F_{D_s\to K}(0)$ | 1.2% |
| $d\Gamma(D_s \to \phi)$ | $\lvert V_{cs}\rvert$ | $F_{D_s\to\phi}(0)$ | 1% | $\lvert V_{cs}\rvert F_{D_s\to\phi}(0)$ | 0.8% |

# CP Violation at ψ(3770) at BESIII




CP violating asymmetries can be measured by searching for events with two CP odd or two CP even final states:

$\pi^+\pi^-$, $K^+K^-$, $\pi^0\pi^0$, $K_S\pi^0$ ,

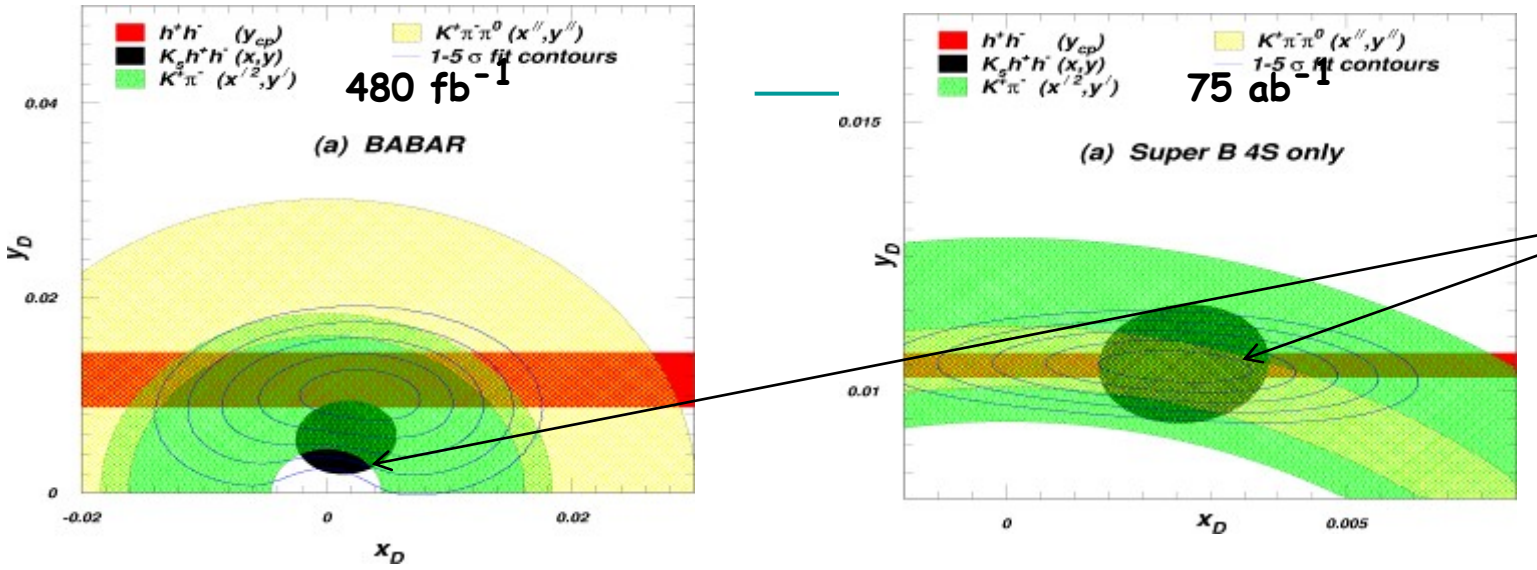
$$\text{For the decay of } \psi'' \longrightarrow f_1 f_2$$

$$CP(f_1 f_2) = CP(f_1)\cdot CP(f_2)\cdot(-1)^L = -$$

$$CP(\psi'') = +$$

**$A_{CP}$ sensitivity : $\Delta A \sim 10^{-3}$**

# Project to 75ab$^{-1}$@Y(4S):




Golden channels

**Min. $\chi^2$ fits (blue contours)**

$$x_D = (5.5 \pm^{1.3}_{1.2}) \times 10^{-3}$$
$$y_D = (8.3 \pm 1.3) \times 10^{-3}$$

→

$$x_D = (xxx^{+0.72}_{-0.75}) \times 10^{-3}$$
$$y_D = (xxx \pm 0.19) \times 10^{-3}$$

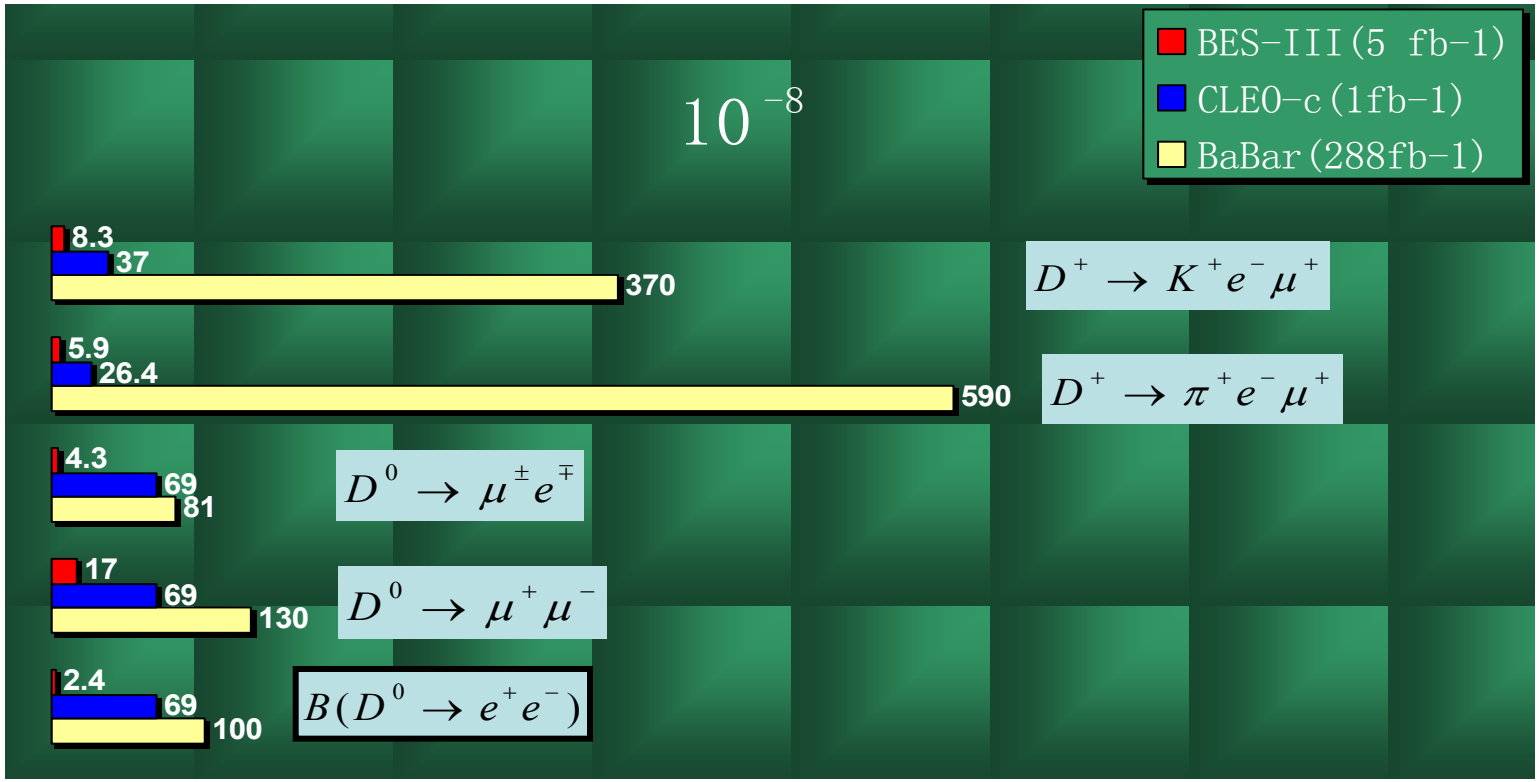
Uncertainties shrink: but are limited by the irreducible model uncertainty (biggest effect on $x_D$ )

Strong phase measurement from ψ(3770) can greatly reduce this.

$$x_D \rightarrow xxx \pm 2.0 \times 10^{-4} \qquad y_D \rightarrow xxx \pm 1.2 \times 10^{-4}$$

# Sensitivity of LFV

Improve the limits by more than order magnitude!

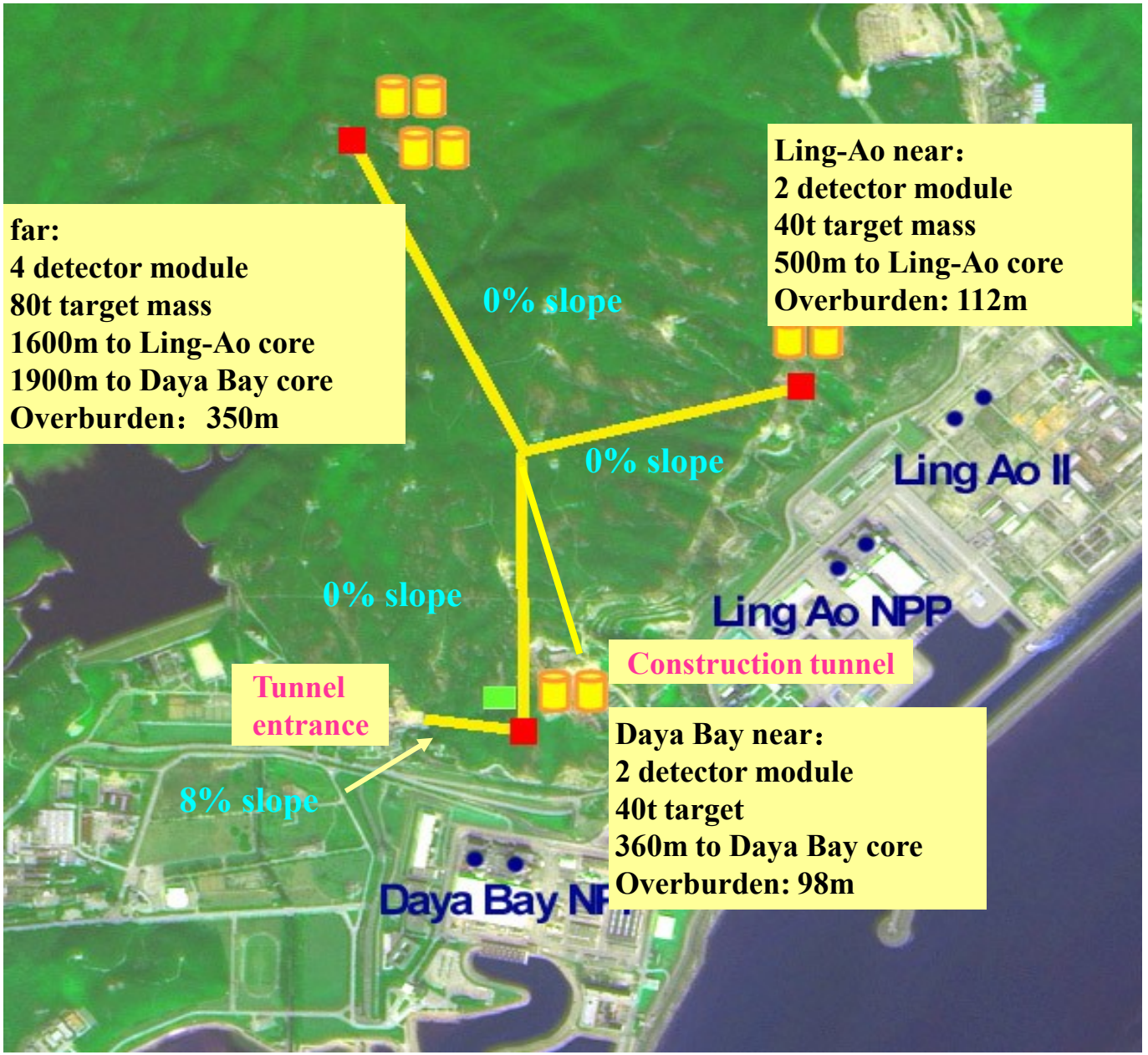



LFV and LNV are "smoking gun", any indication of deviation from zero will indicate New Physics (NP).

# 3. Precision measurement of $\nu$ mixing $\theta_{13}$
# Daya Bay reactor $\nu$ experiment

- Daya Bay nuclear power plant: 4 reactor cores, 11.6 GW
  2 more in 2011 for a total of 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 beginning 2012
- Expect to reach sensitivity of 0.01 with 3 years of running.

# Experimental layout

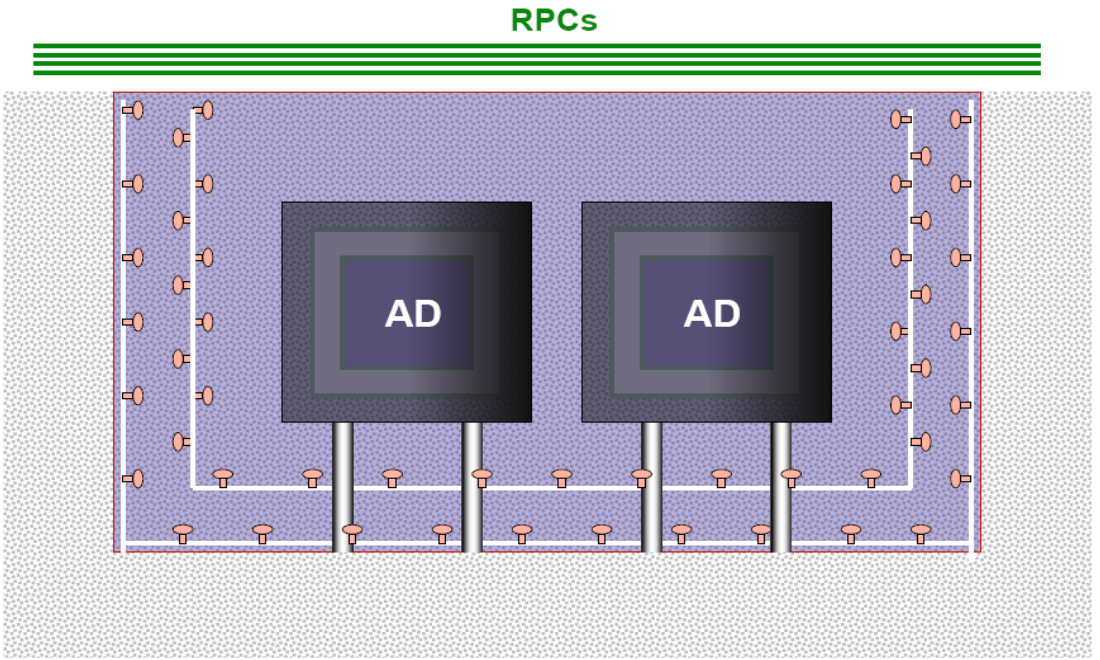


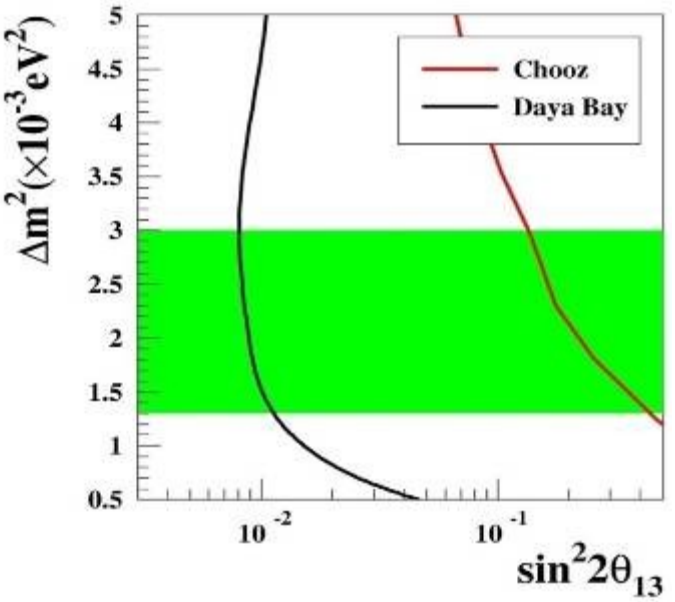

- Identical detector at near and far site to perform relative measurement in order to cancel reactor related systematic error
- Experimental halls are connected by 3000m tunnel

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

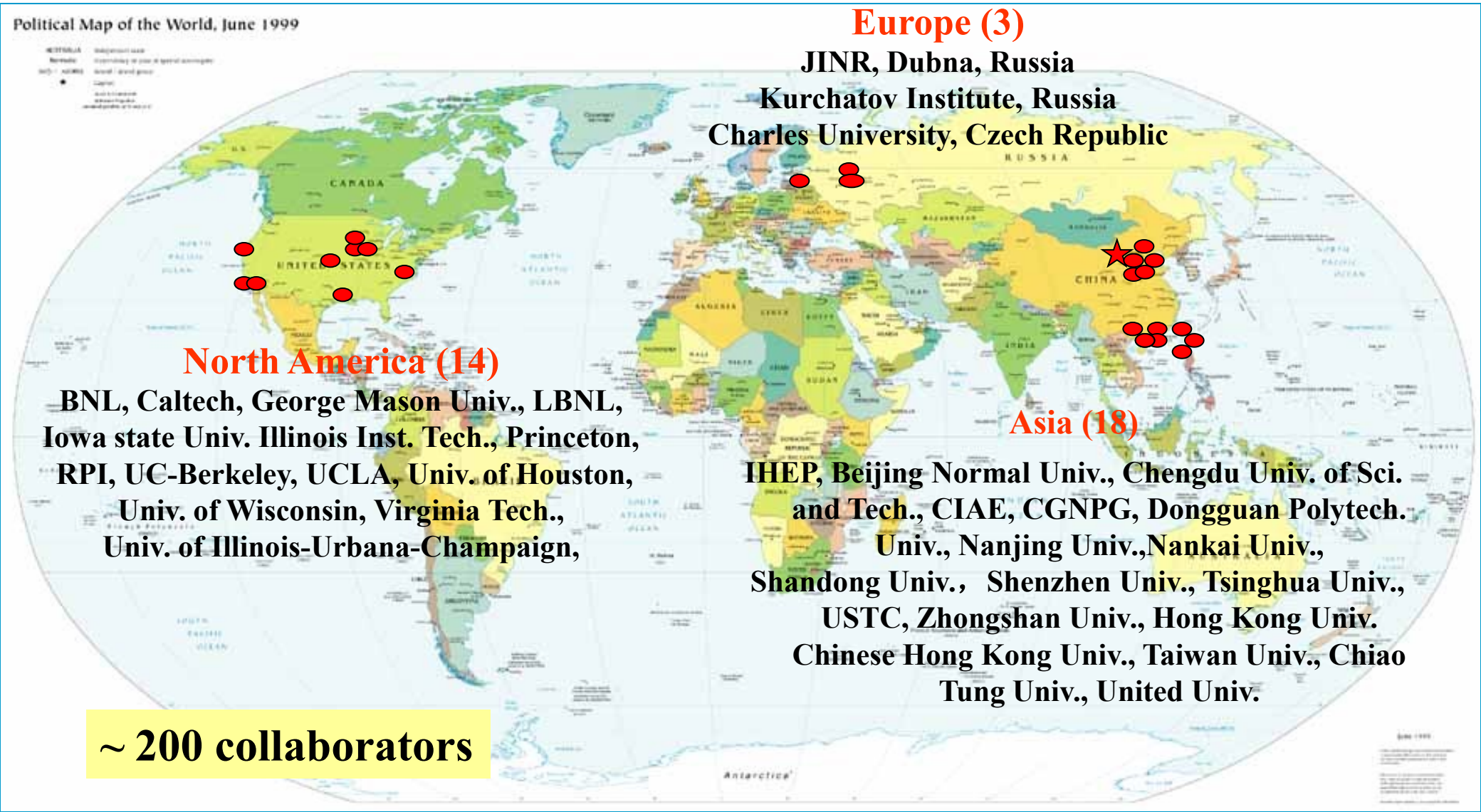
# Daya Bay experiment

- Identical near and far detectors to cancel reactor-related errors
- Multiple modules for reducing detector-related errors and cross checks
- Overburden and shielding to reduce backgrounds
- Multi-layer neutrino detector:
  - Gd-loaded liquid scintillator
  - SSV + 2 AV + reflectors
- Multi- muon veto detector for reducing backgrounds and cross checks: RPC+water Cherenkov



# 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**

# Most of Civil Construction finished

Surface assembly bldg.

Control building

HVAC/Ventillation

Tunnel entrance

Tunnel

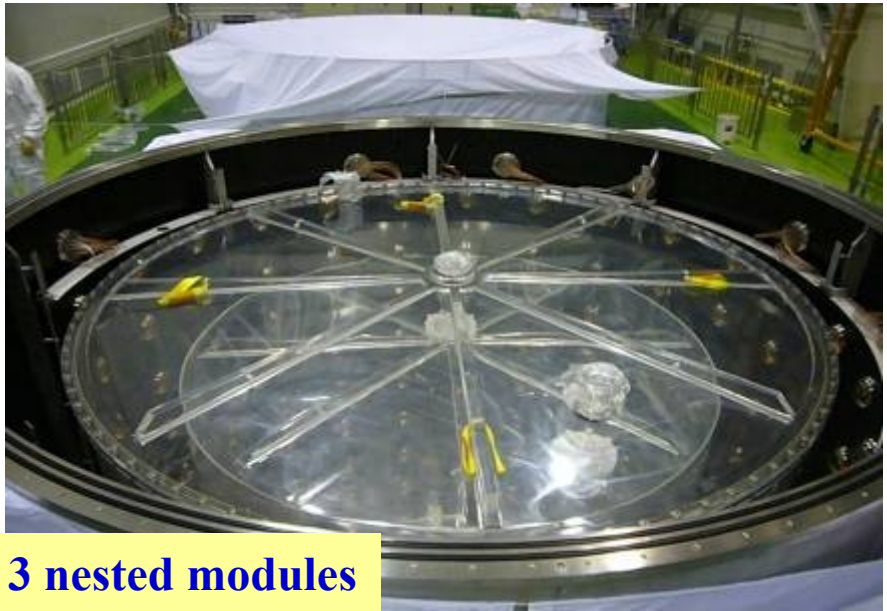
Experimental hall

# Detector components production and assemble

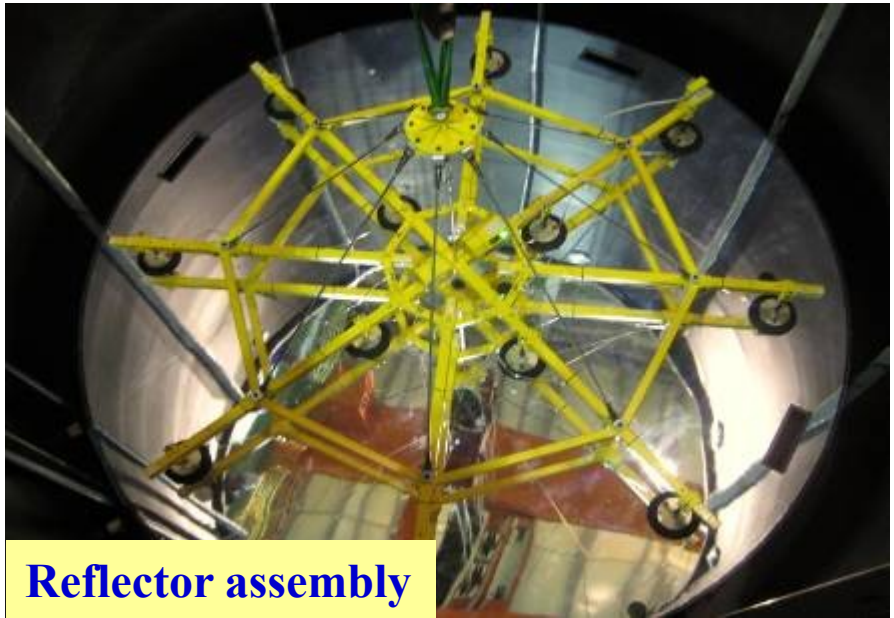
## test module successful, two modules finished

SSV under fabrication, tests include full load, negative pressure, laser survey, etc.

PMT ladder



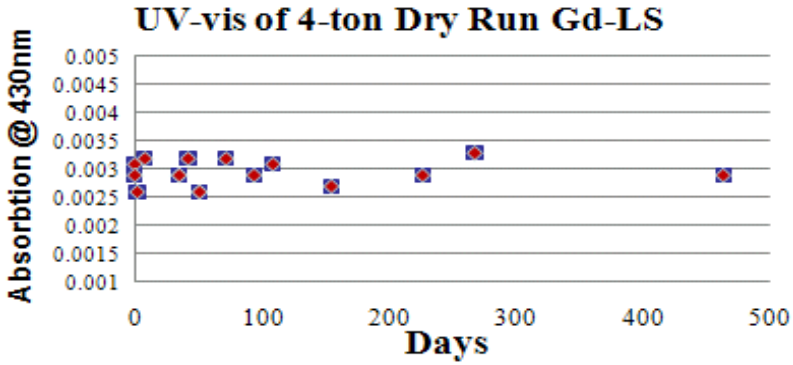
3 nested modules

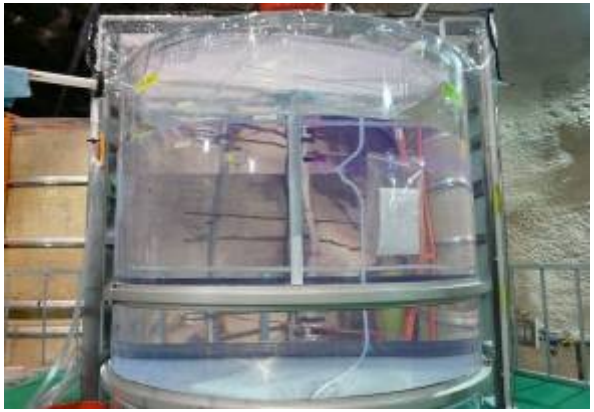


Reflector assembly

# Liquid Scintillator: production started

- Equipment successfully manufactured and tested at IHEP
- 4-ton 0.1% Gd-LS dry run successful
  - ⇨ The Gd-LS in the tank looks good up to now.
  - ⇨ High temperature aging tests show good stability
- All mixing equipments(including QA and TMHA purification system from BNL) installed and tested in Hall 5
- Mass production successfully started



# 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）

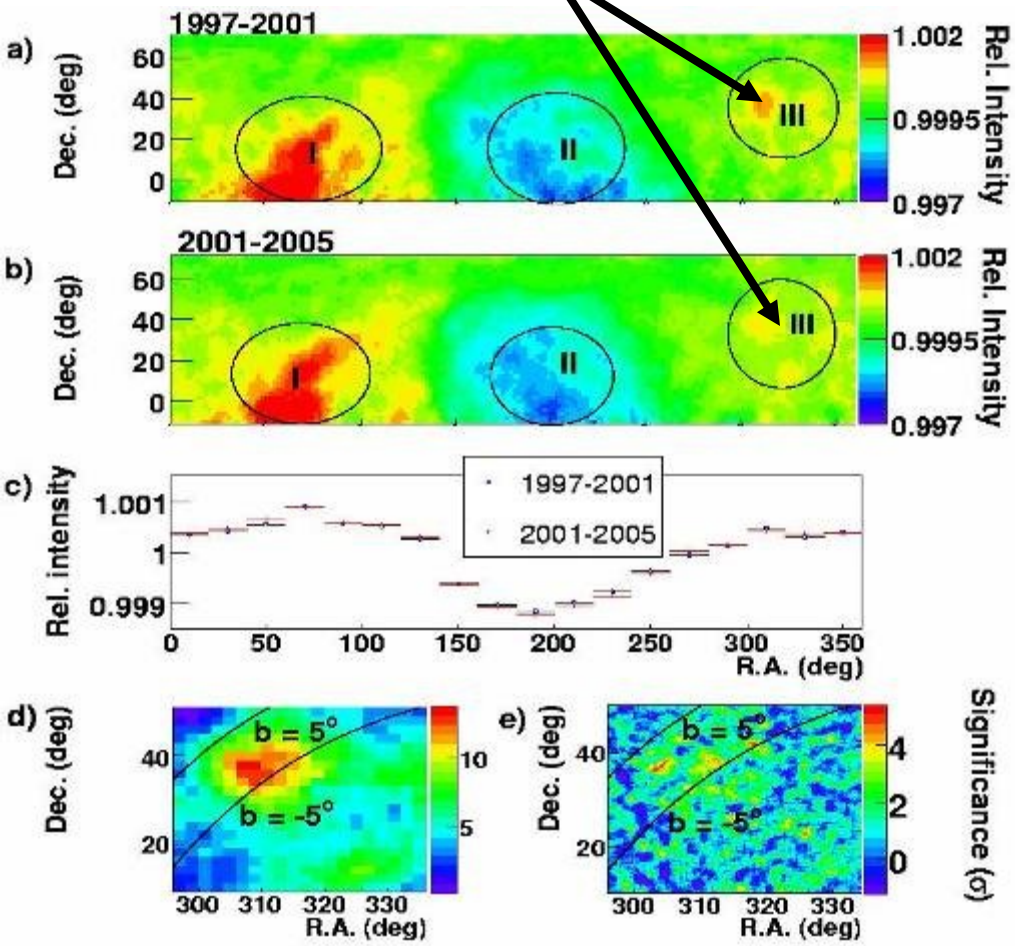
## IHEP-INFN Argo RPC　　China-Japan Air Shower Array

# Yangbajing: new anisotropy and corotation of GCR

## (Science 314(2006) 439-443)

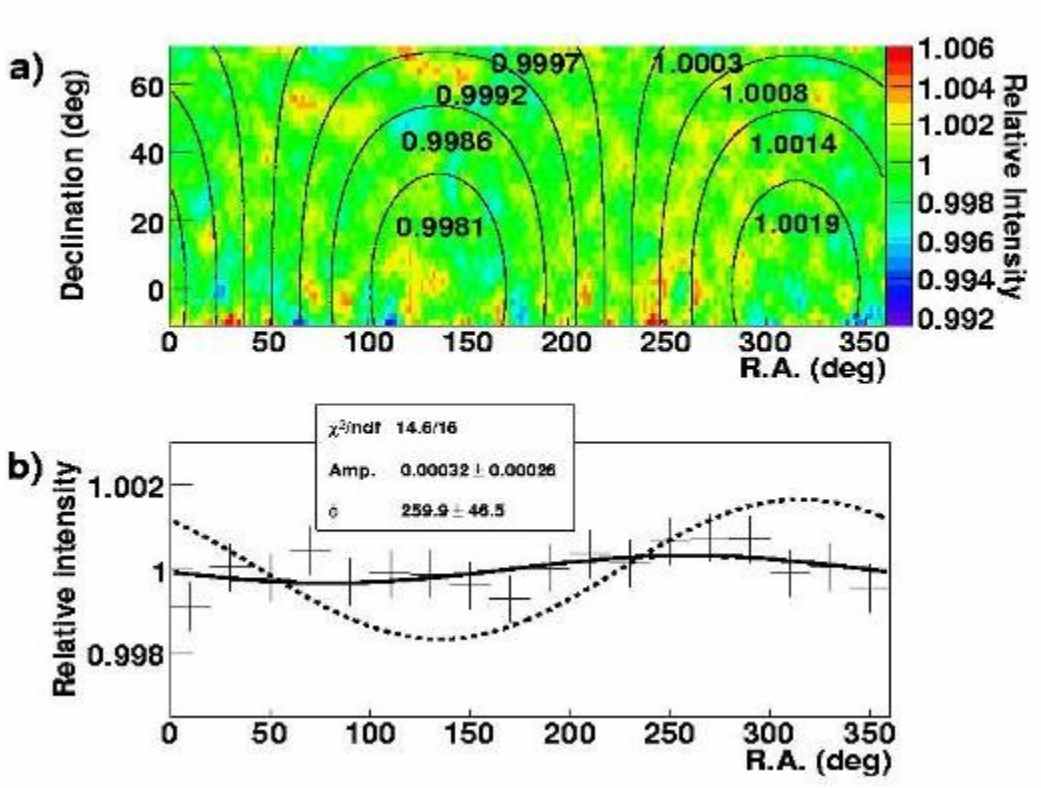
**Celestial Intensity map (E~3TeV)**

**New anisotropy component**



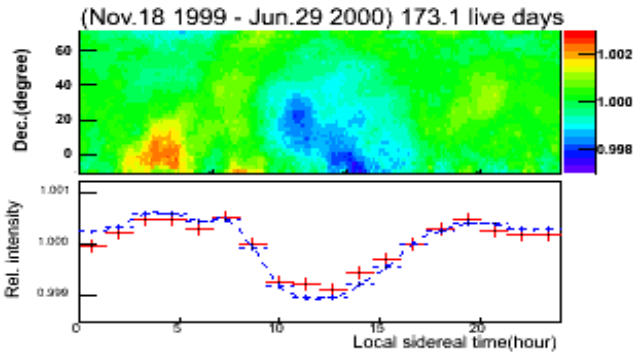

**Intensity @ E~300TeV**

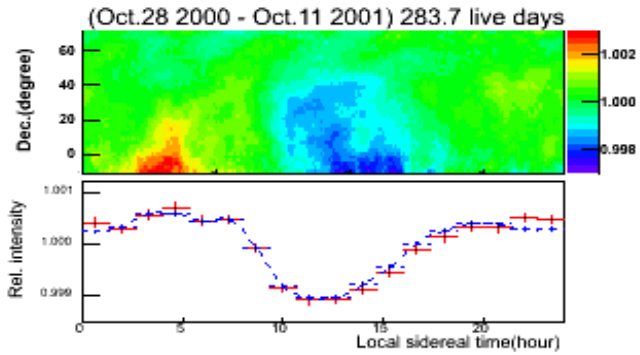
**Amp=0.16% w/o corotation;**
**Observation: 0.03%±0.03%.**

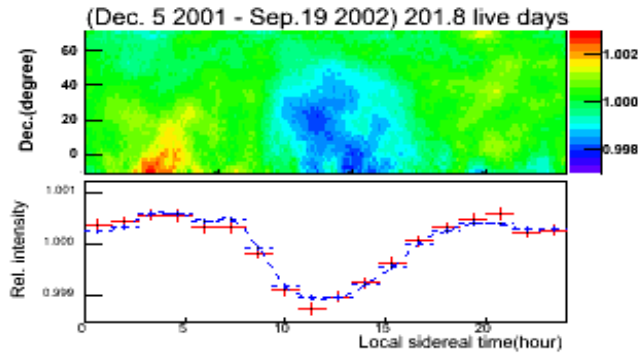


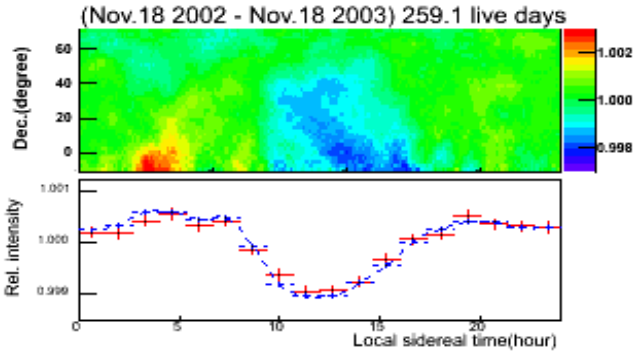
# Yangbajing Asγ: Stable Multi-TeV anisotropy - insensitive to solar activity

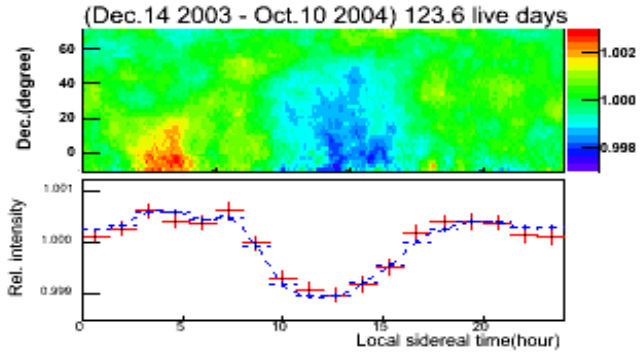
ApJ 711(2010)119-124

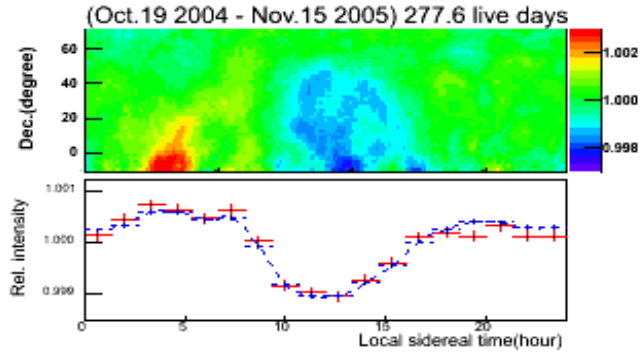


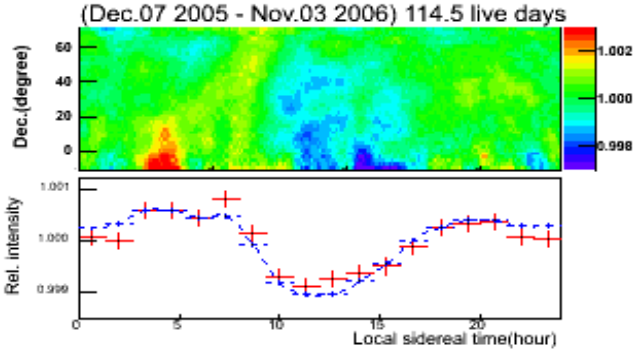



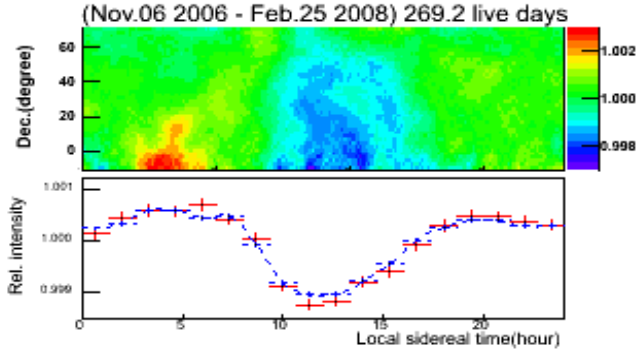



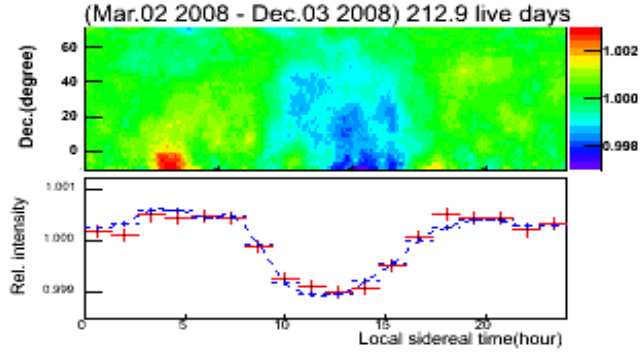



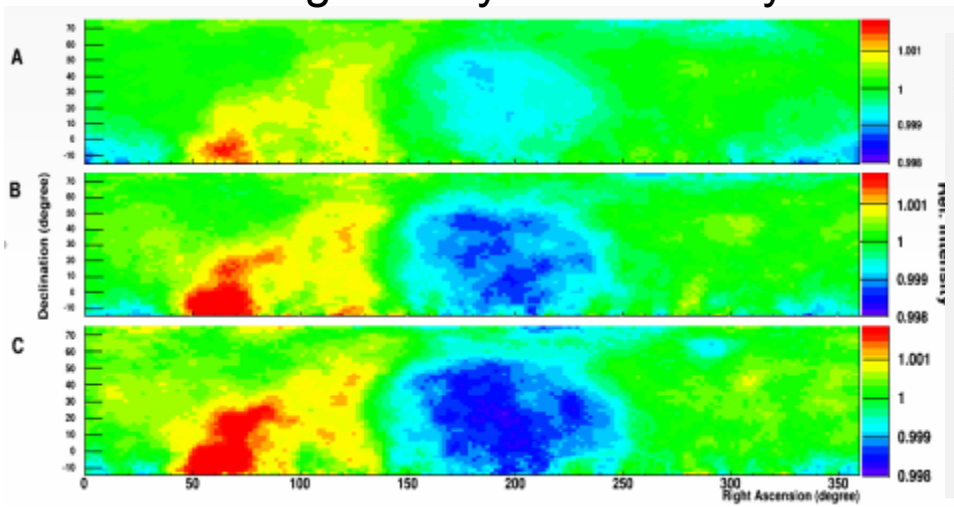



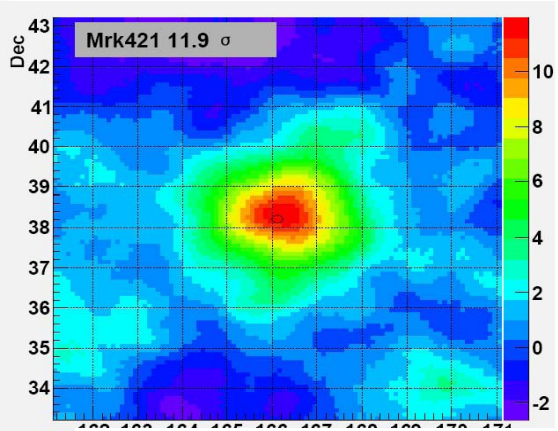



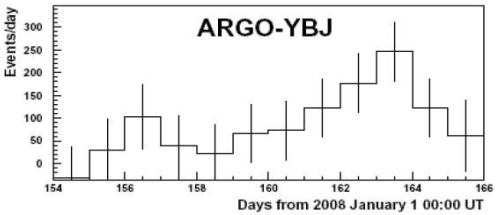



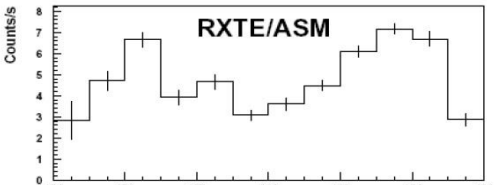



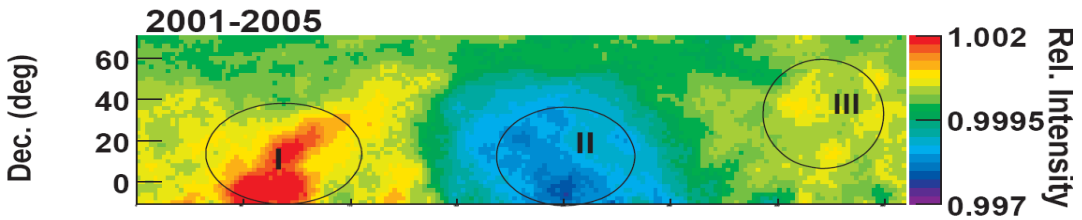

Cosmic ray anisotropy and its energy dependence（top down：0.5~5TeV）
Long term monitoring for AGN Mrk421 bursts：accumulative significance 12S.D.
Multi-wave-length analysis with X-ray observation demonstrates strong correlation

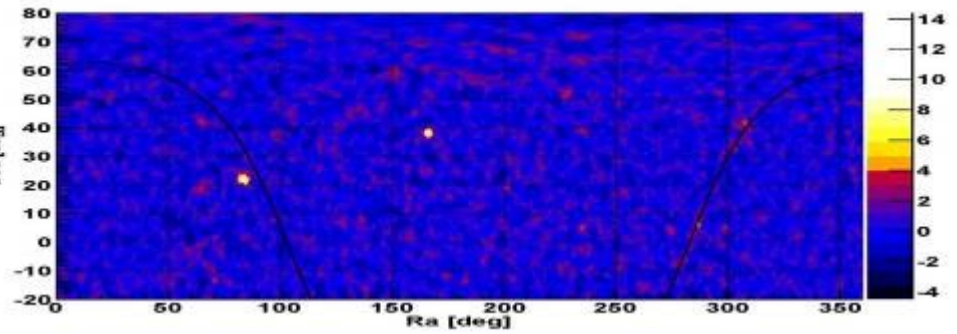


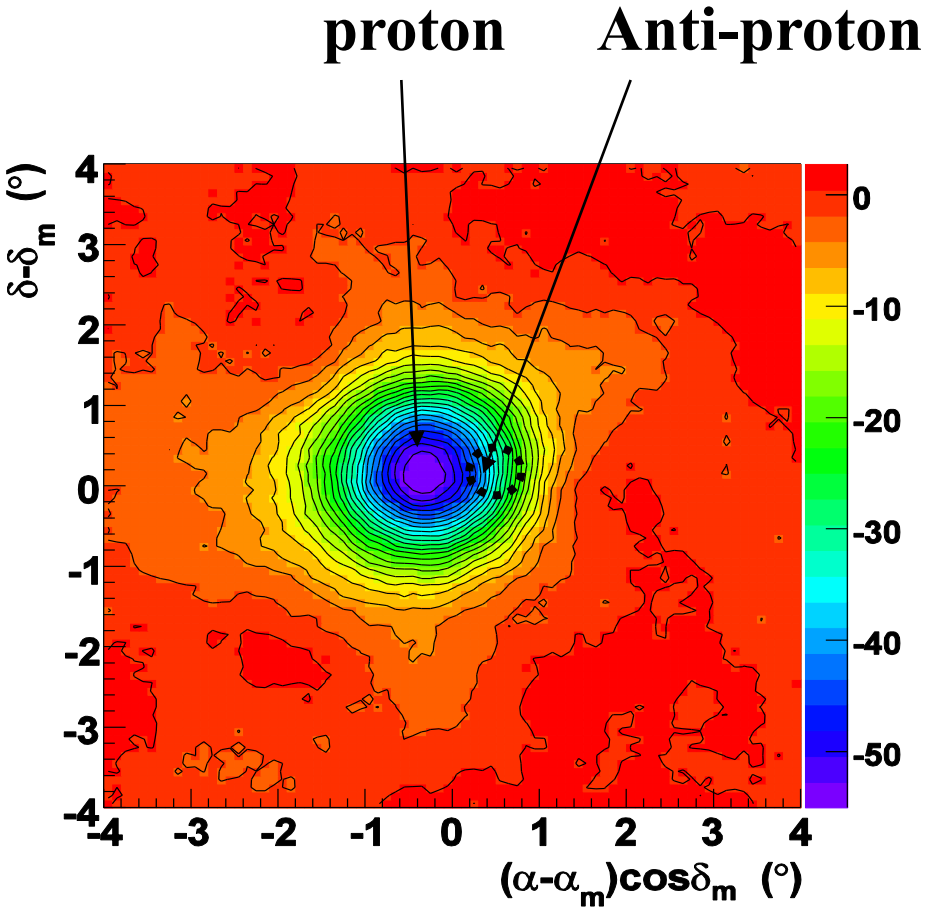



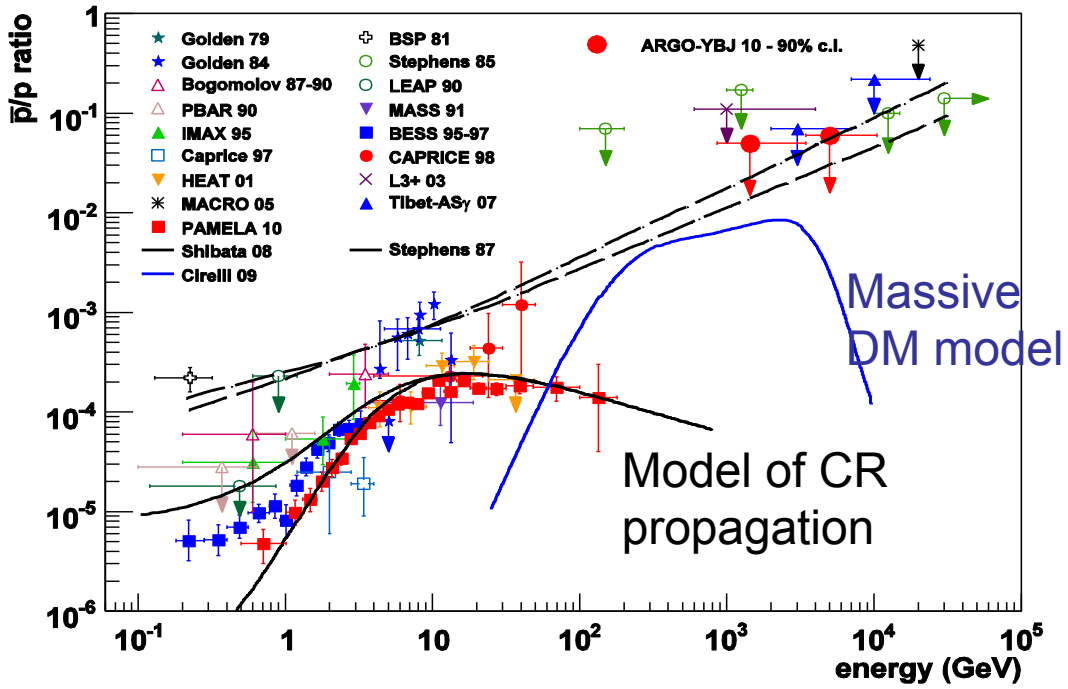



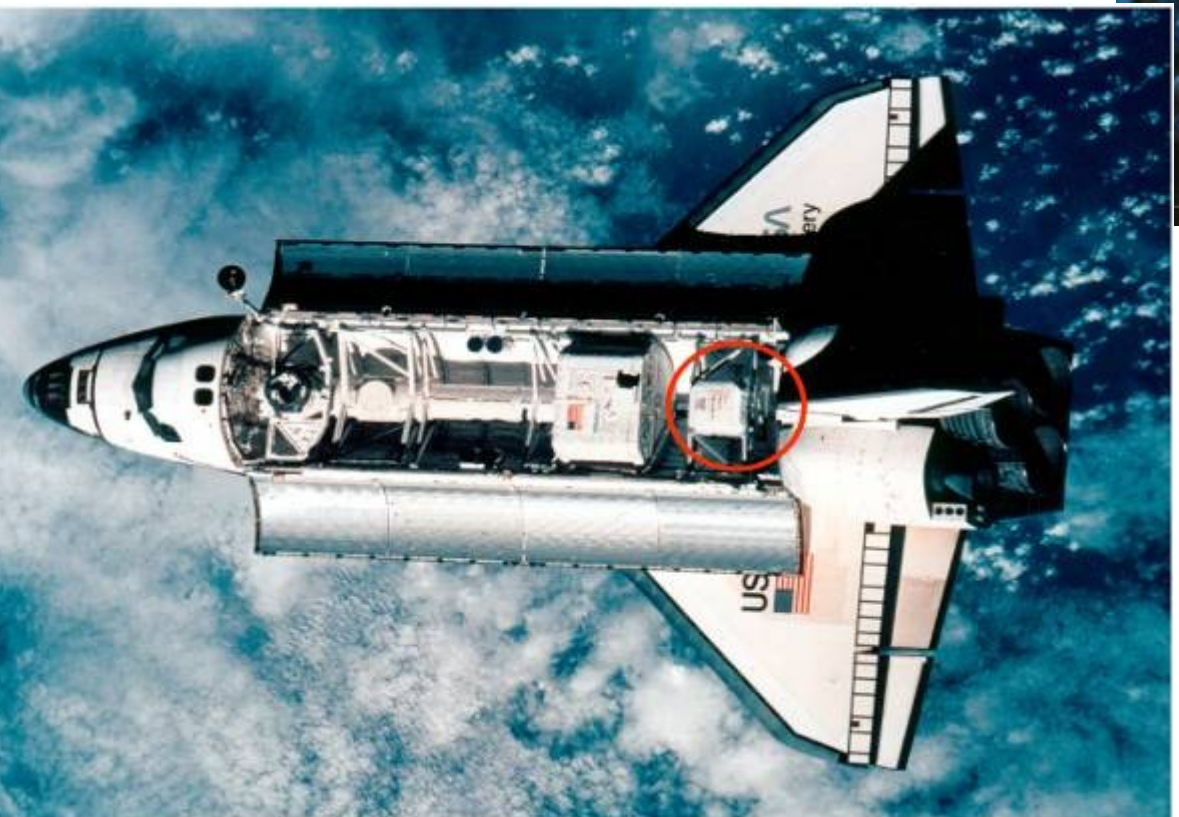
# ARGO-YBJ : $\bar{p}/p$ Ratio Upper Limit by using the displacement of moon shadow in geomagnetic fields

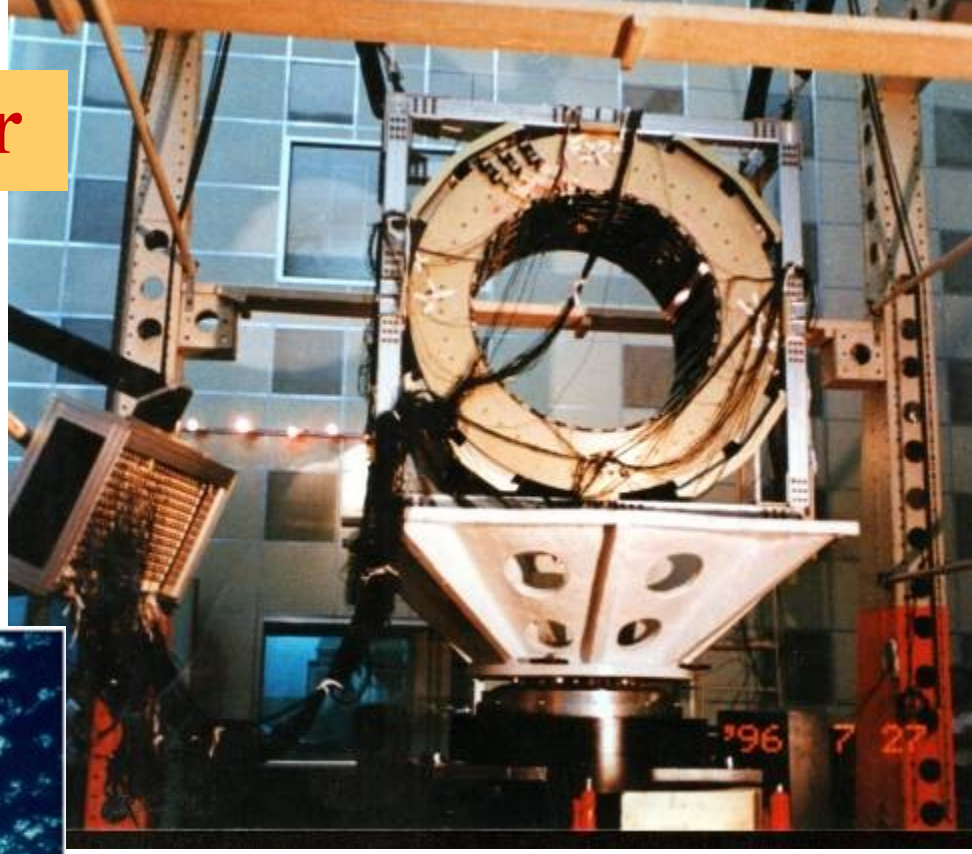


# Alpha Magnetic Spectrometer

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



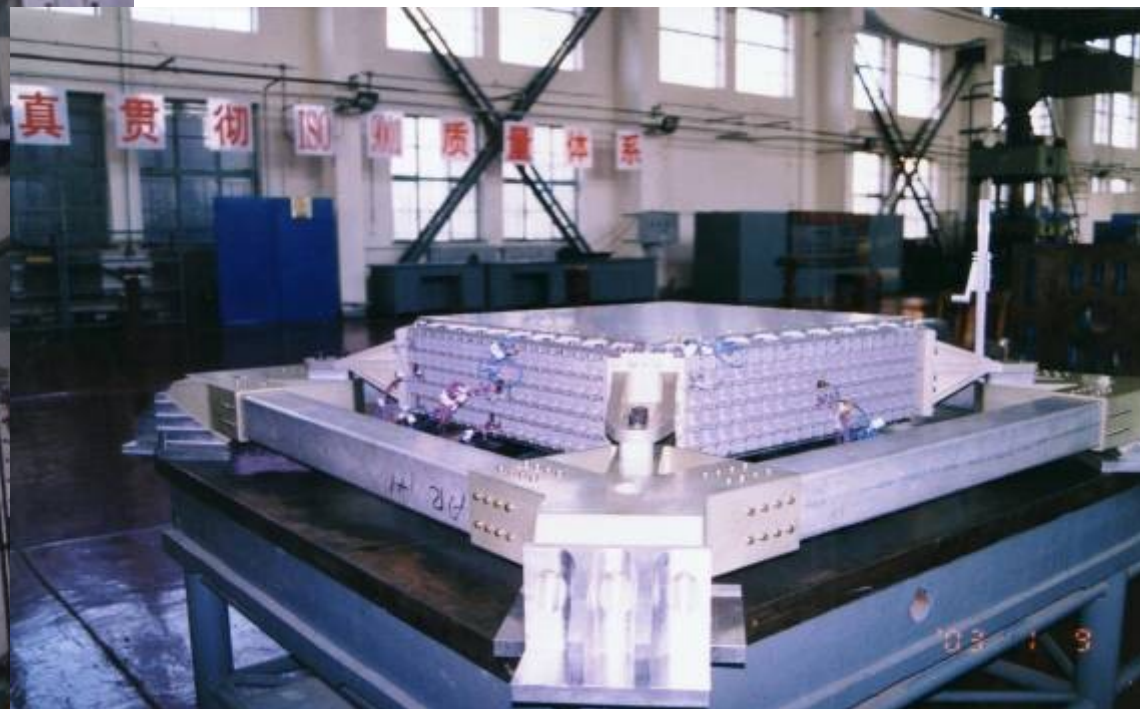



**AMS01 permanent magnet and structure were built at Beijing, and became the first big magnet in space as payload of Discovery June 1998. It will be flown again by AMS02 Feb. 2011.**

# AMS02 ECAL: 700Kg
# IHEP LAPP and PISA

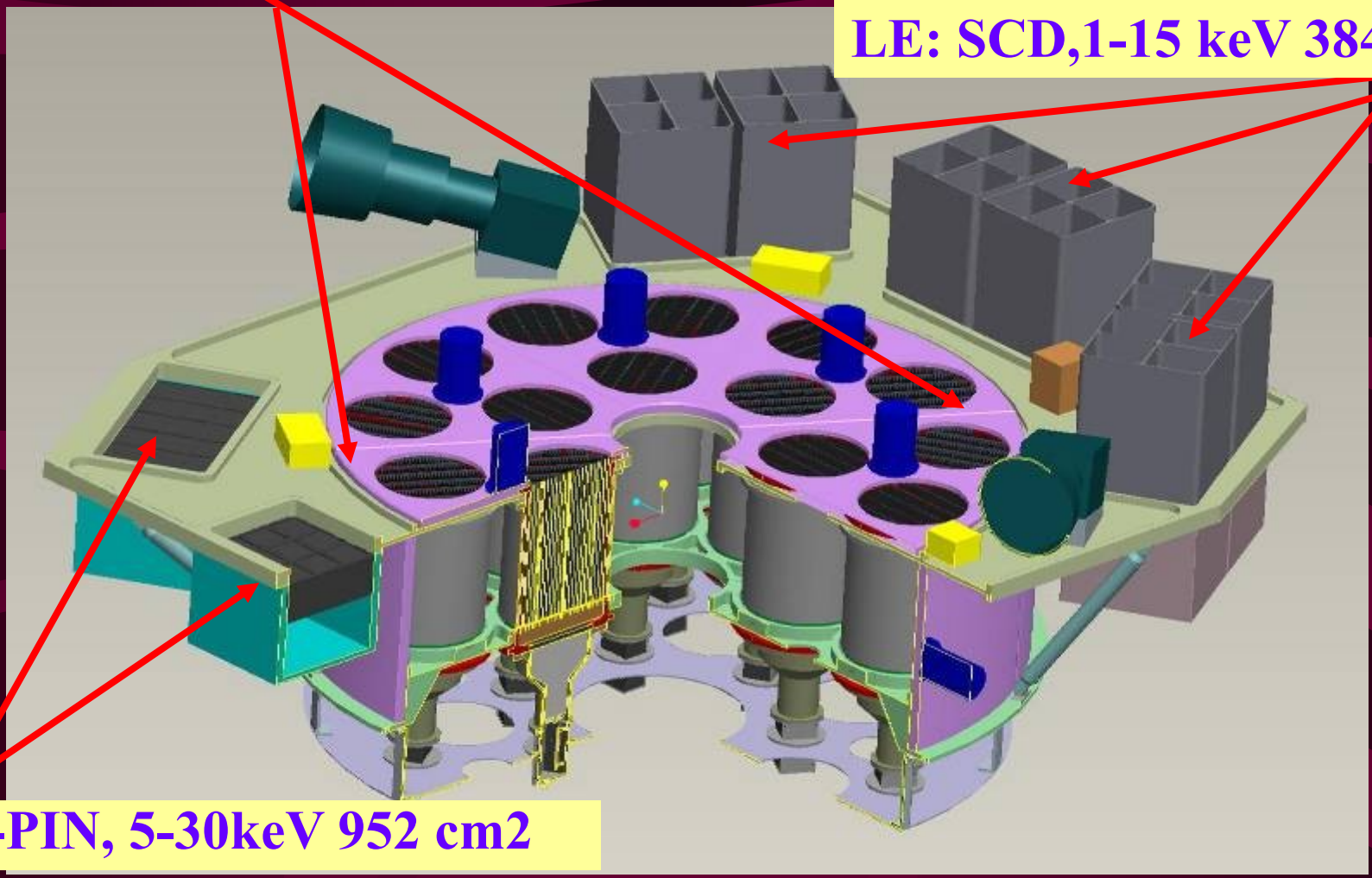
## Space qualification at Beijing

**ECAL assembling at IHEP**



HE: NaI/CsI 20-250 keV 5000 $cm^2$

LE: SCD,1-15 keV 384 $cm^2$

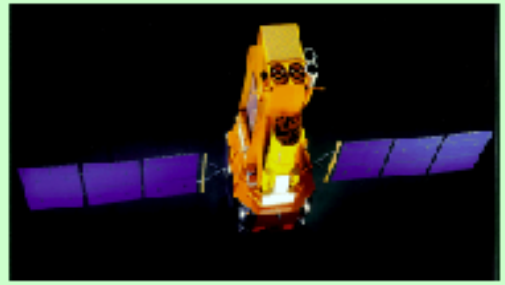
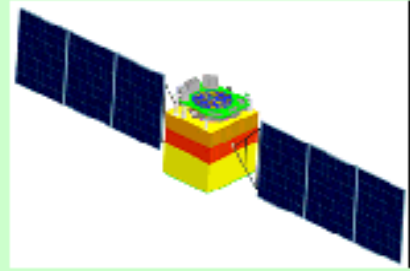


ME: Si-PIN, 5-30keV 952 cm2

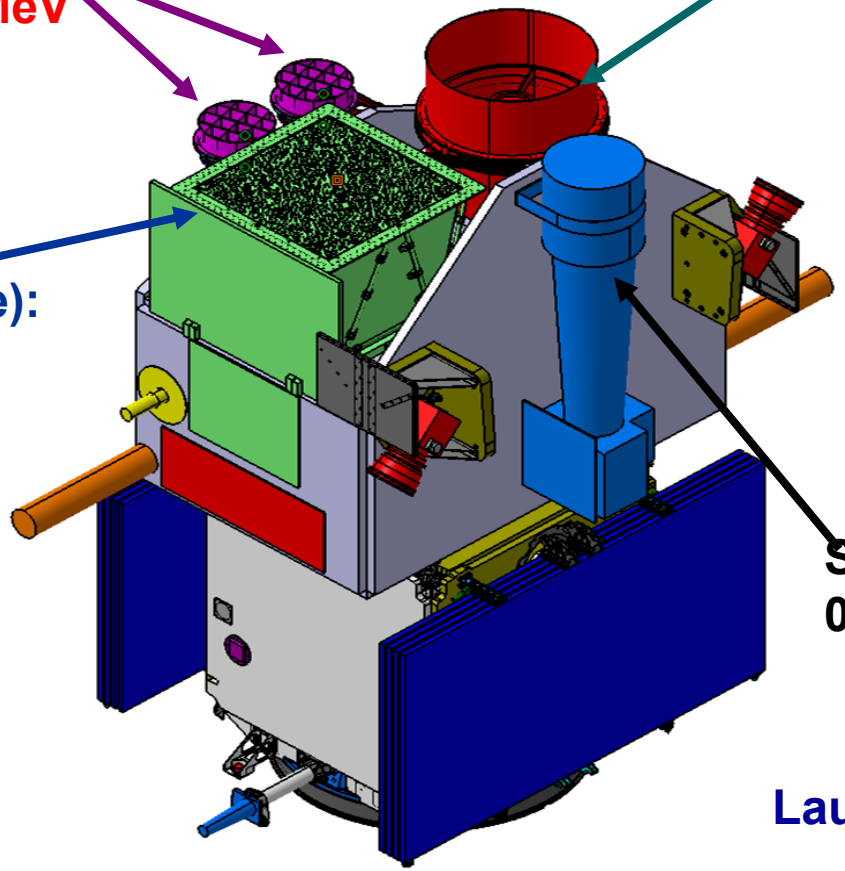
# Hard X-ray Modulation Telescope (HXMT)

To be launched 2014 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 2014-2015**

**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.: Jinping Mountain**
  - **South pole Dome A: IR and THz telescope**
- **Large Scientific Facilities**
  - **Chinese Spallation Neutron Source (CSNS): approved.**
  - **Accelerator Driven Sub-critical System: CAS is planning the ADS pilot effort.**
  - **Beijing Advance Light Source: construction scheduled at 2016**

# LHAASO Project: γastronomy and origin of CR

Charge Particle Array

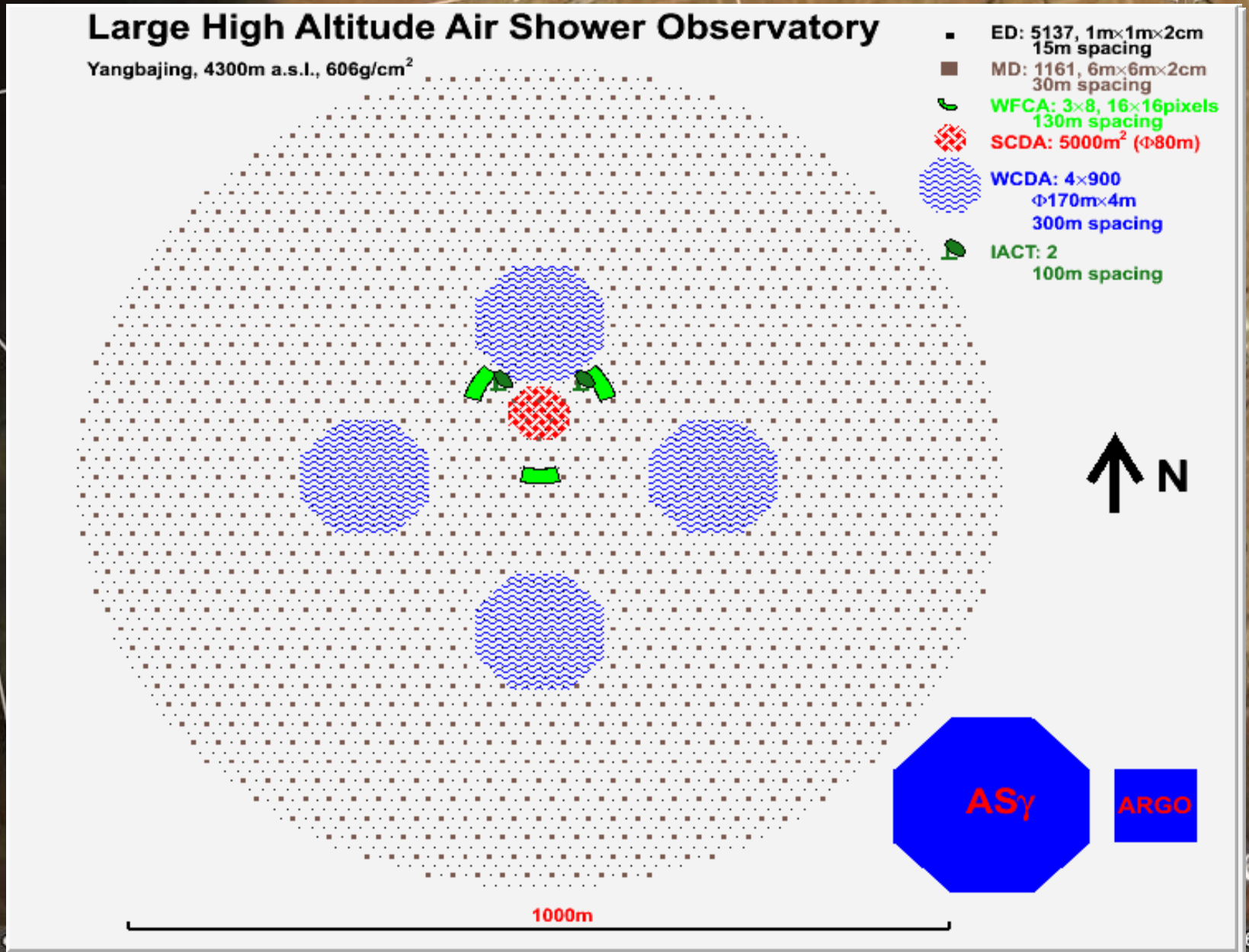
μ detector Array

Water C Array

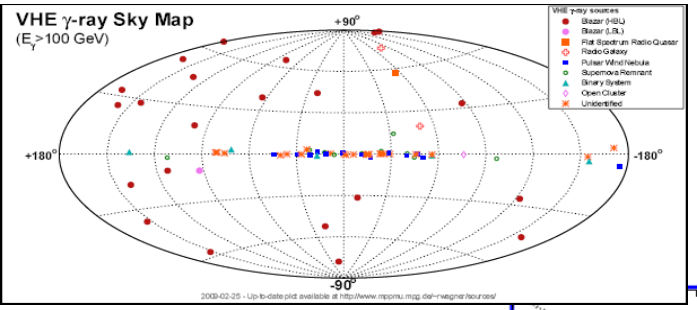
Wide FOV C-Telescope Array

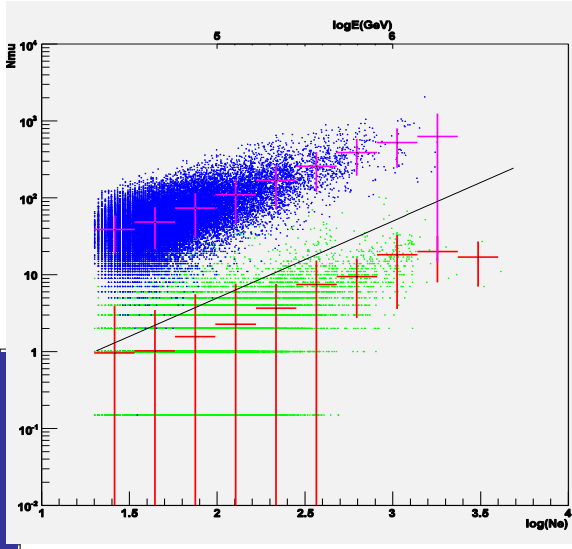
&

Core Detector Array

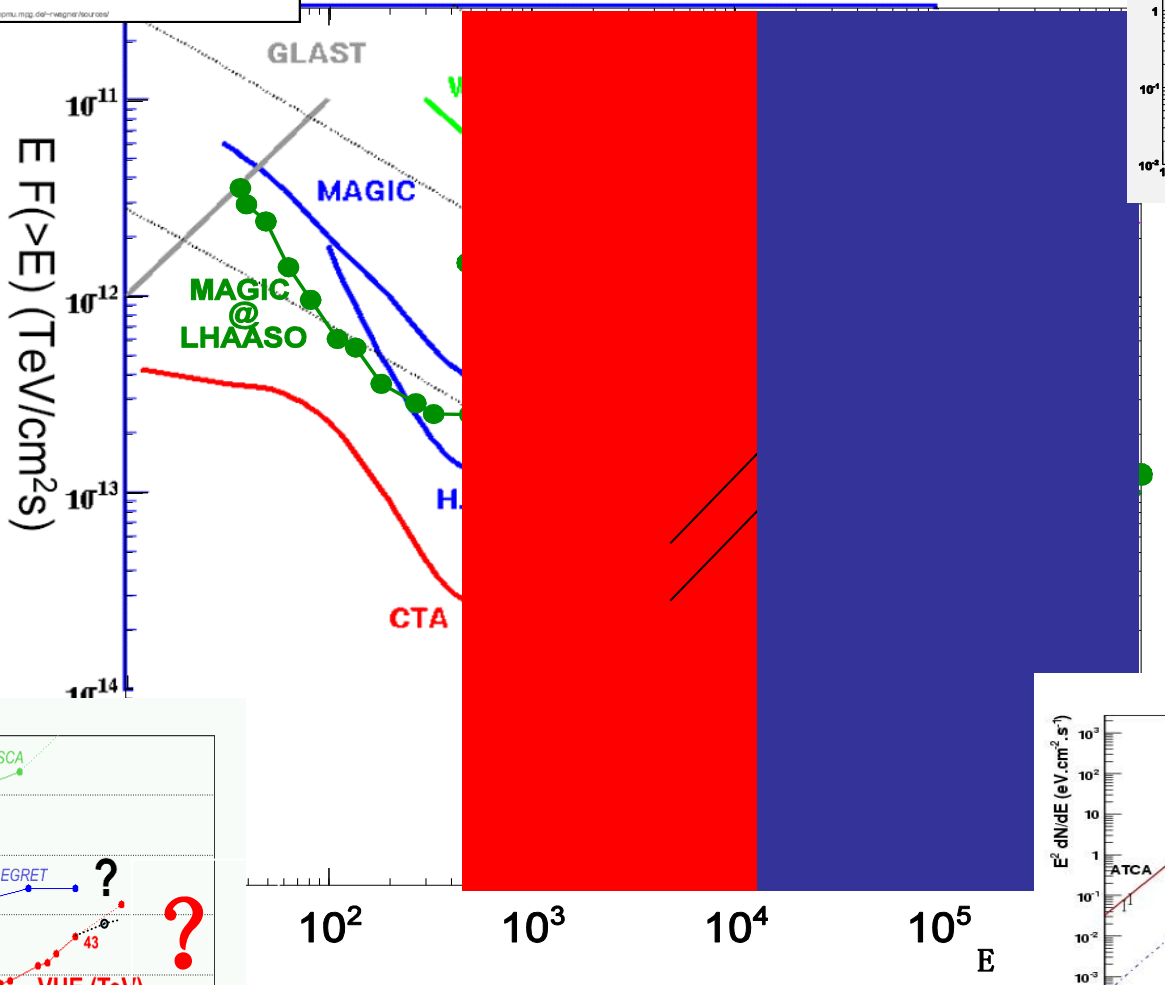


# LHAASO sensitivity & scientific goals

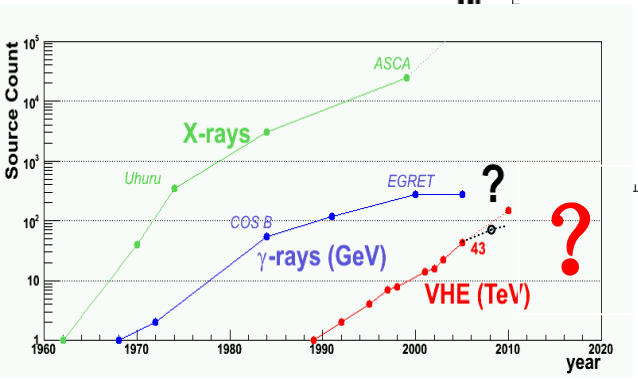


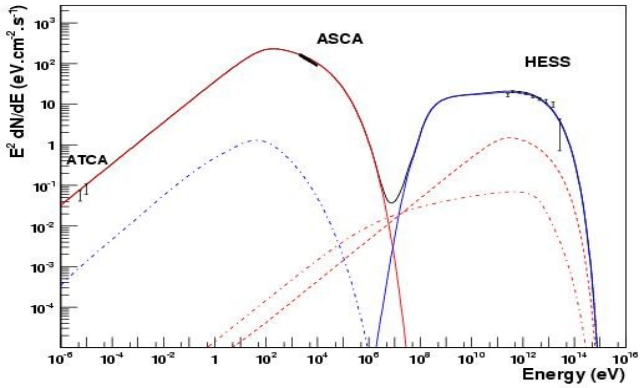




- Surveying forγray sources
- ~1000 extragalactic sources are expected in 10 years




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

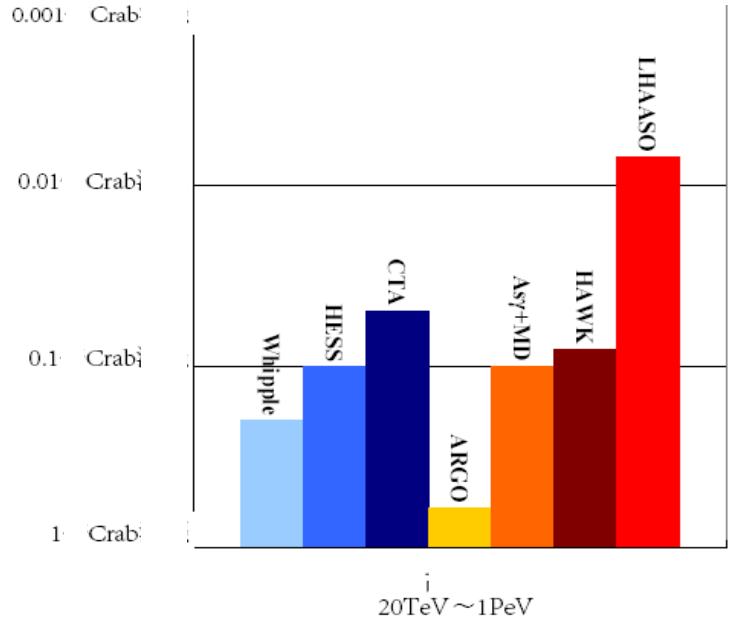


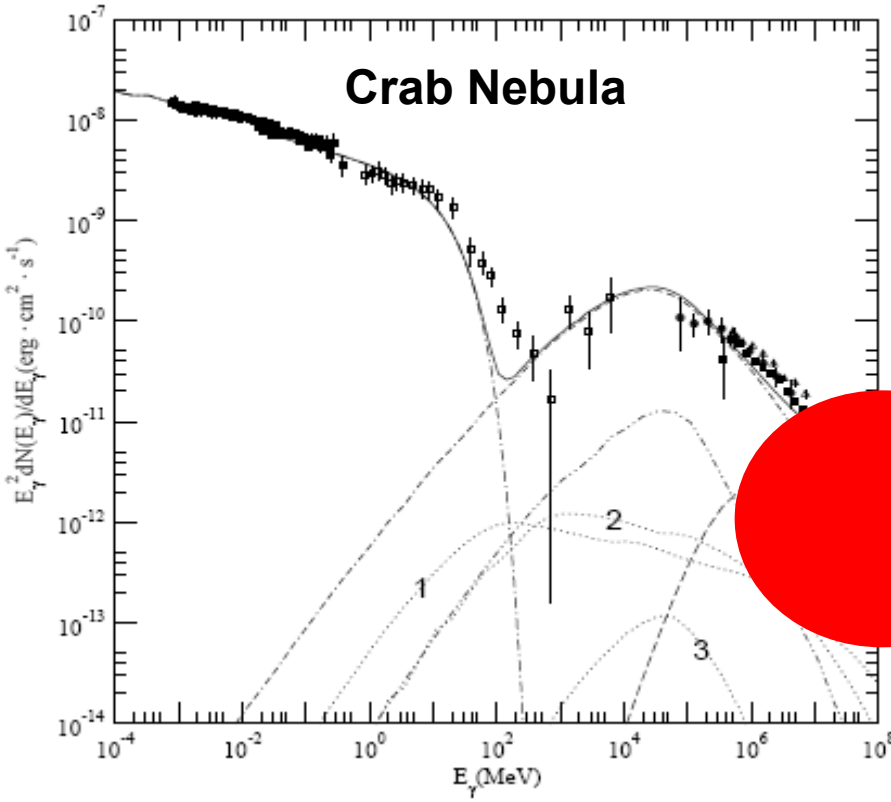



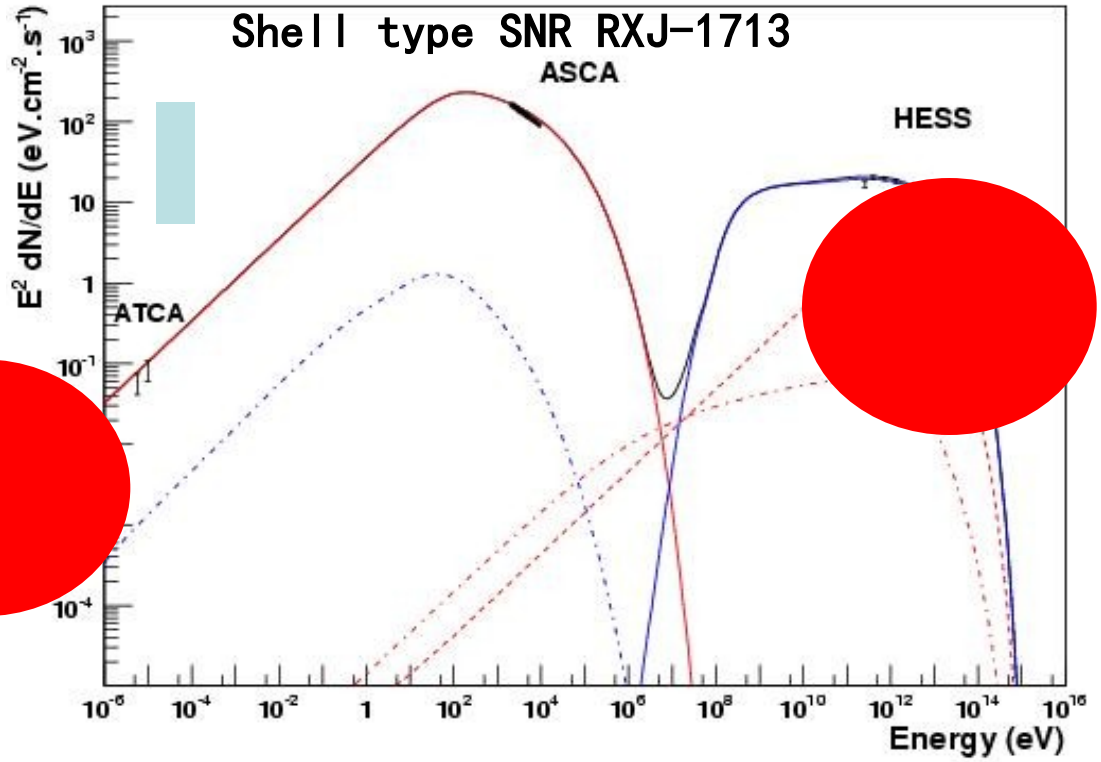
# Main Goal 1: CR origin

**precise measurement of energy spectrum of γ sources to 1PeV**

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

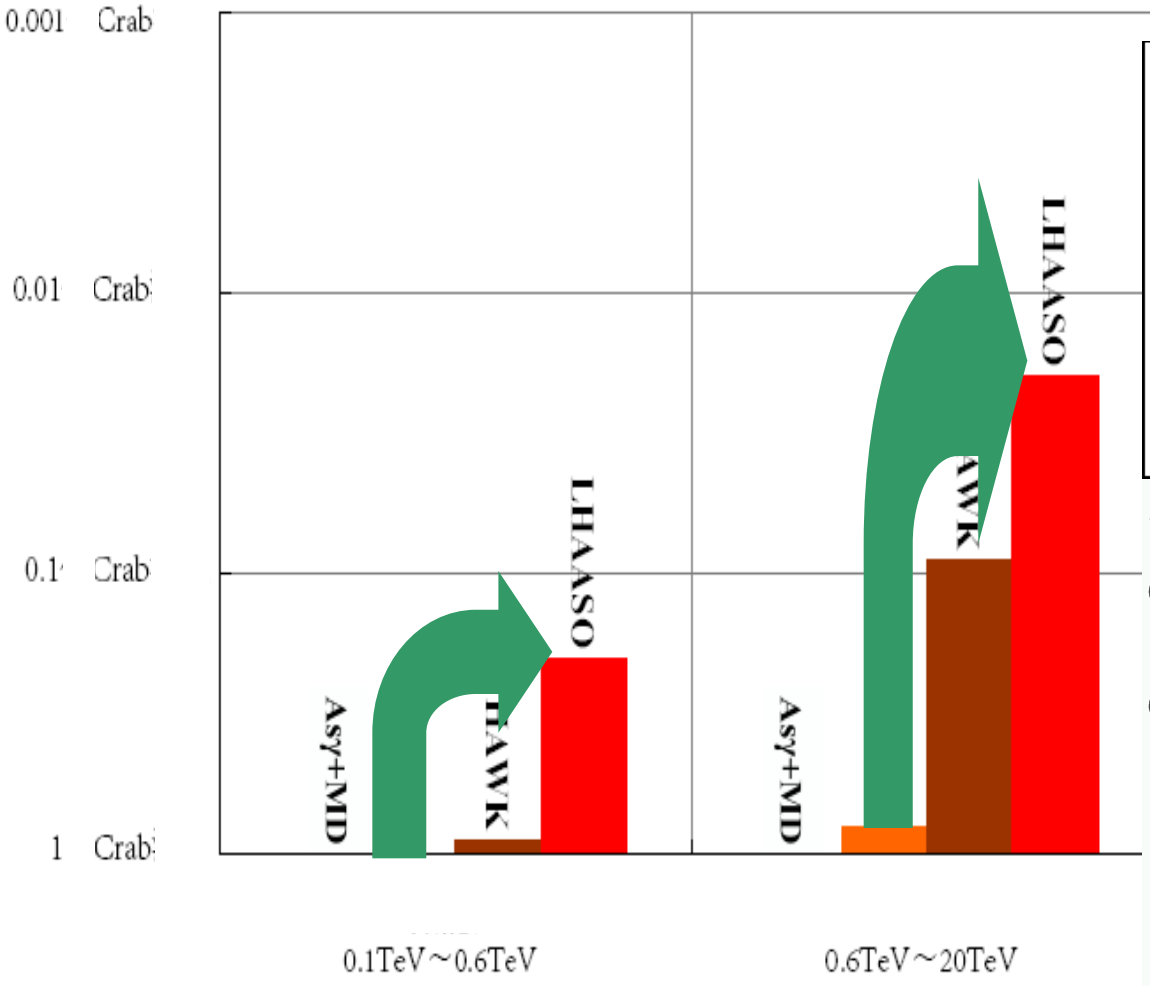


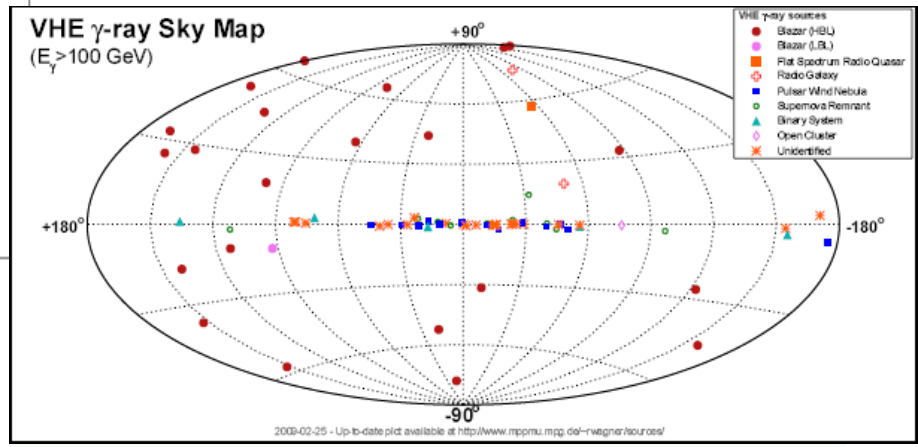



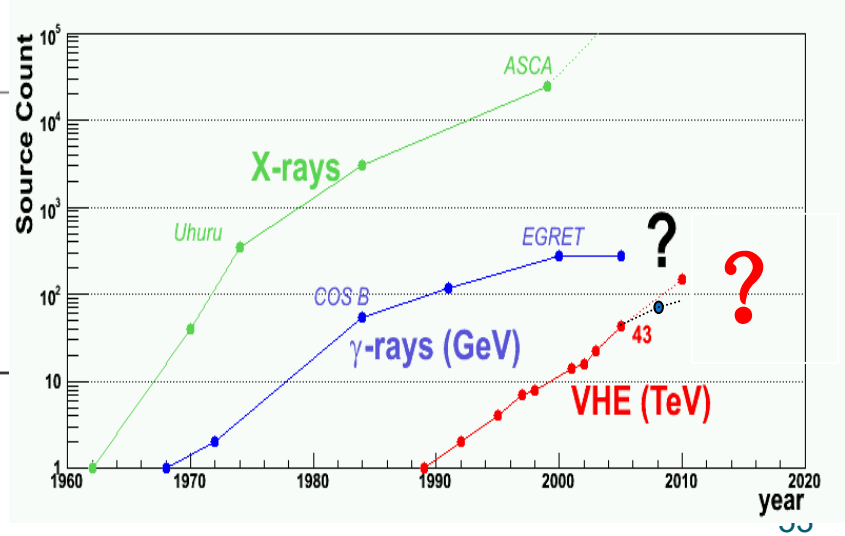



# Main Goal 2: all sky survey for more extragalactic gamma ray sources

- Very high surveying sensitivity: from 100 sources to 1000



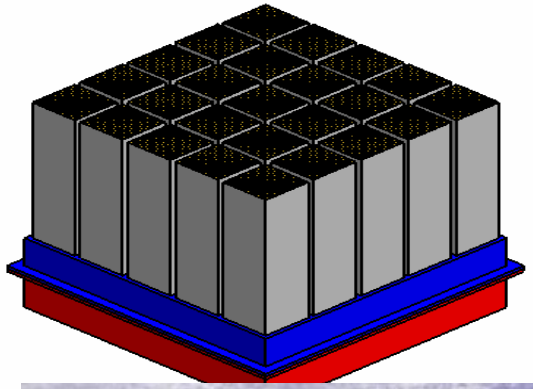



# POLAR: Proposal and R&D

- **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

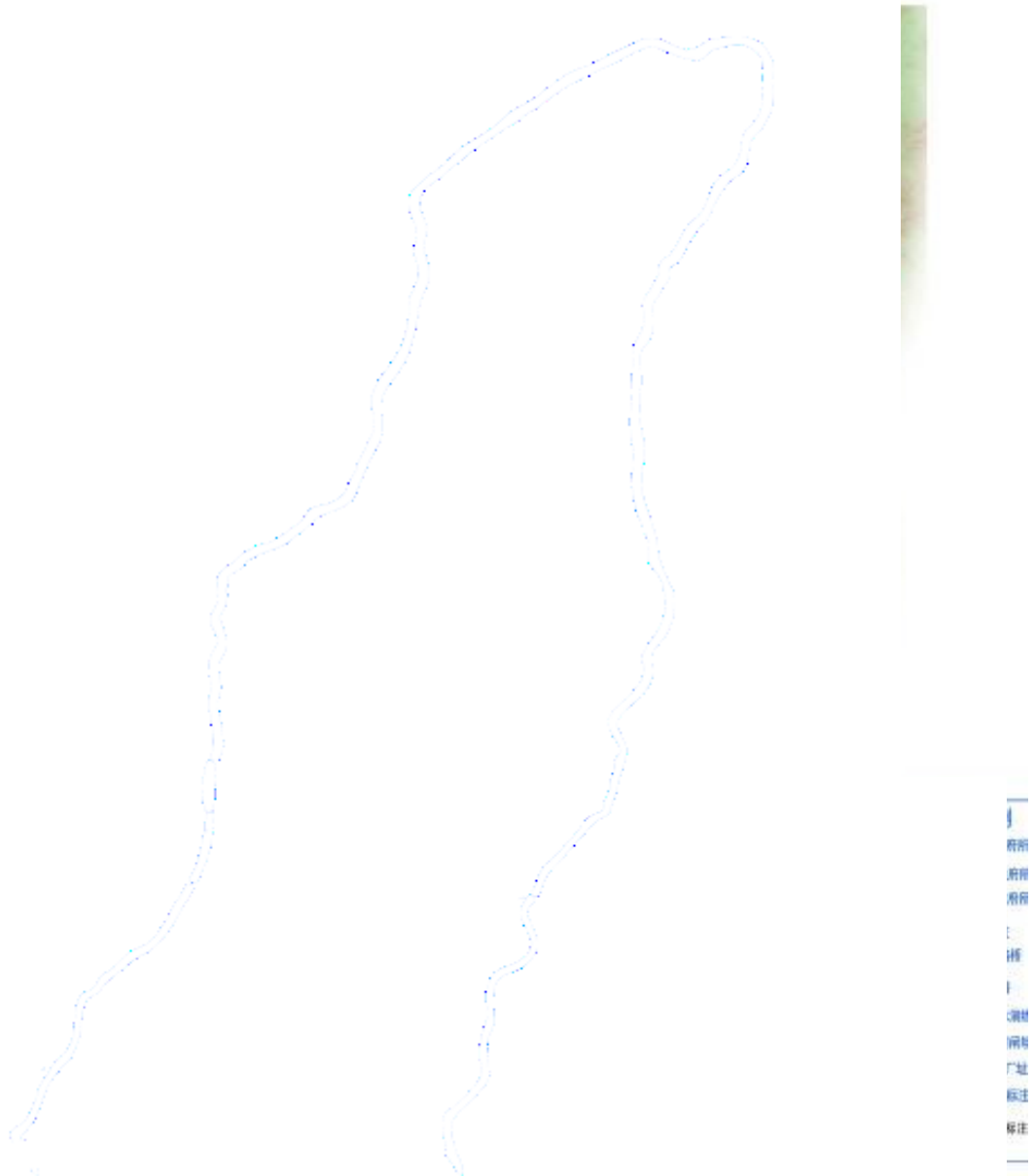
Palace in Heaven

# 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

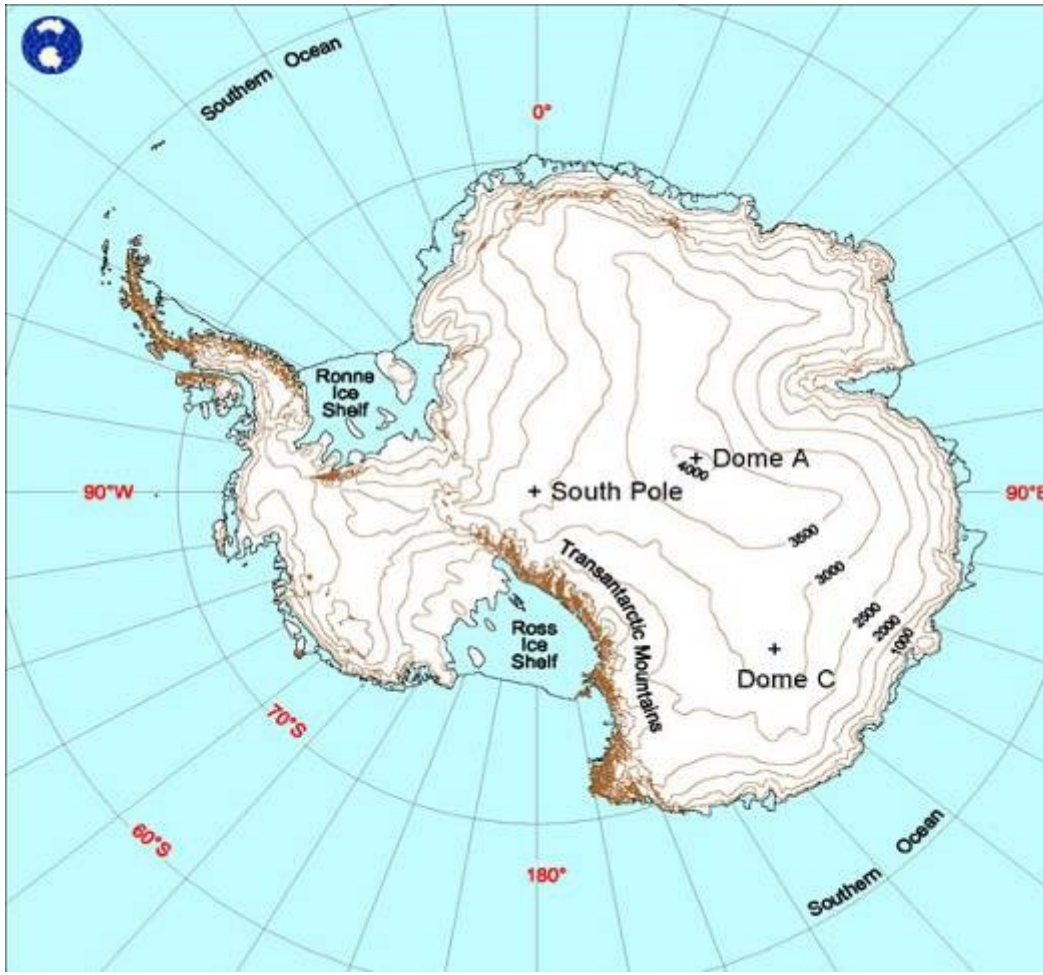
# Deep underground Lab. @ Jingpin mountain

- 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 under construction: dark matter exp., & rock mechanics studies
- CAS proposal: large deep underground multiple discipline international Lab. . Under review.

# 4m Telescope at Dome A of South Pole

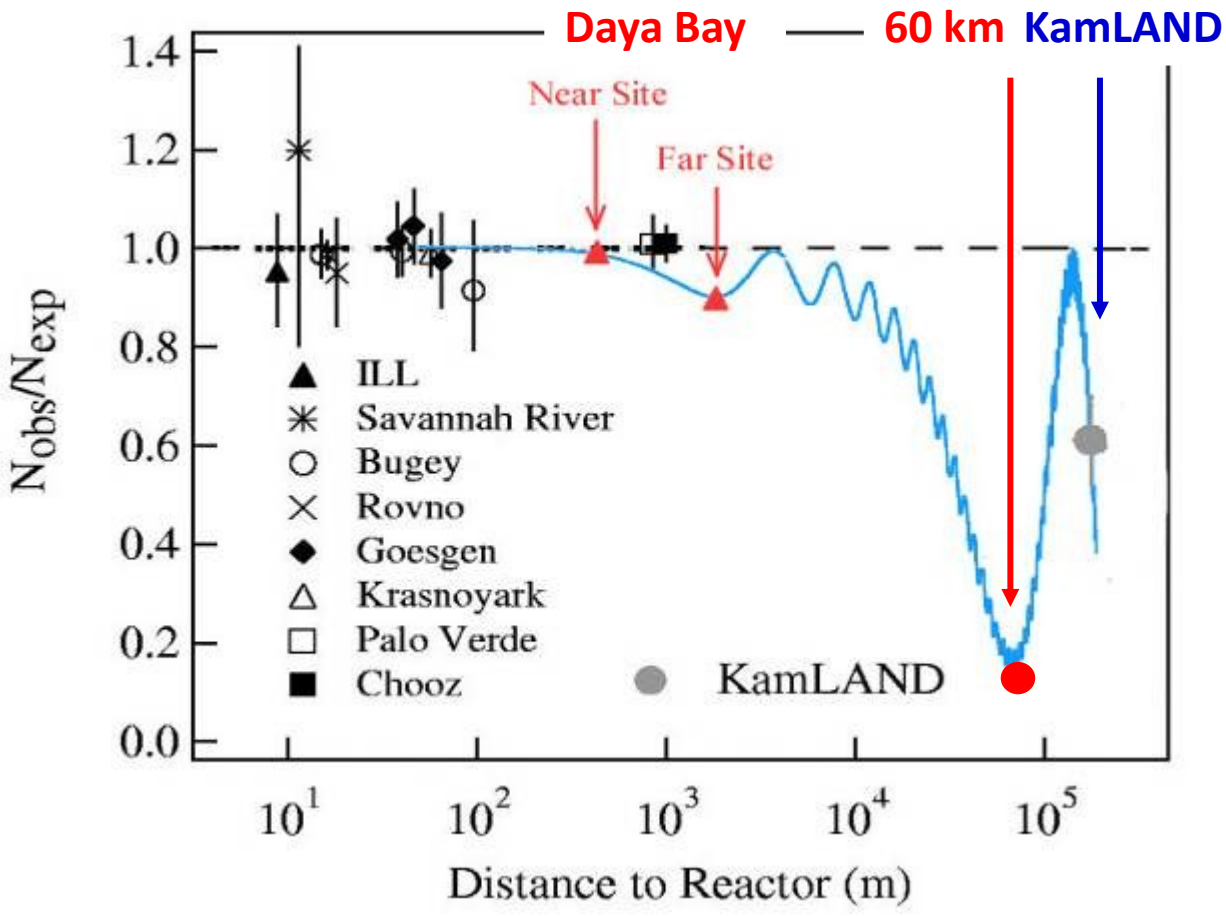
## space-quality imaging with much lower cost

- 4100m, -83°C, Highest, Driest, Coldest on earth
- Very Quiet Atmosphere, boundary layer is 9m, seeing = 0.27 arcsec
- Very good transmission from 150 to 800 μm.
- infrared bg. factor 20-100 less
- perpetual nights > 135
- possible for maintenance
- Infrared and THz: most interesting
- 15cmx4 telescope since 2006
- proposal under review



# Daya Bay-II Experiment

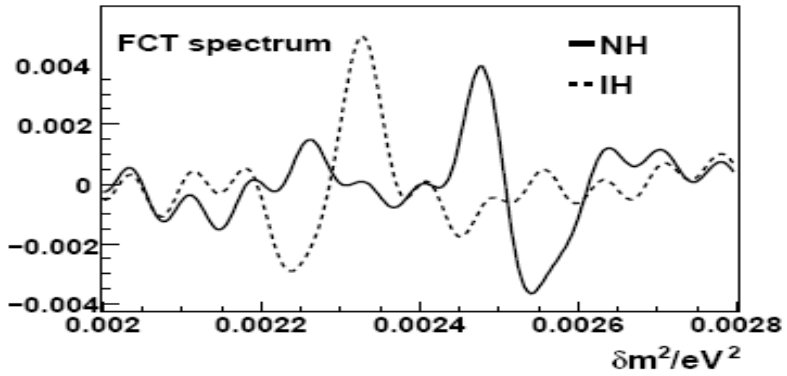
**Giant Detector located at 60 km from Daya Bay reactors, the 1st maximum of $\theta_{12}$ oscillation.**

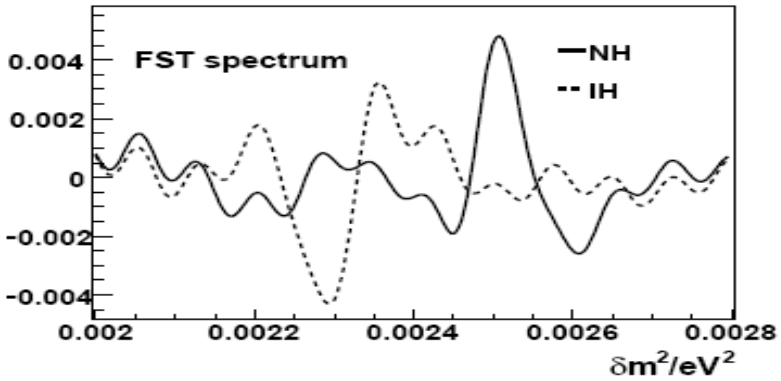



- 10-50 kton detector
- 2-3% energy resolution
- Rich physics possibilities
  - ⇨ Mass hierarchy
  - ⇨ Precision measurement of 4 mixing parameters
  - ⇨ Supernovae neutrino
  - ⇨ Geoneutrino
  - ⇨ Sterile neutrino
  - ⇨ Abnormal magnetic moment
  - ⇨ Discoveries with a high precision detector?

# Mass hierarchy at reactors

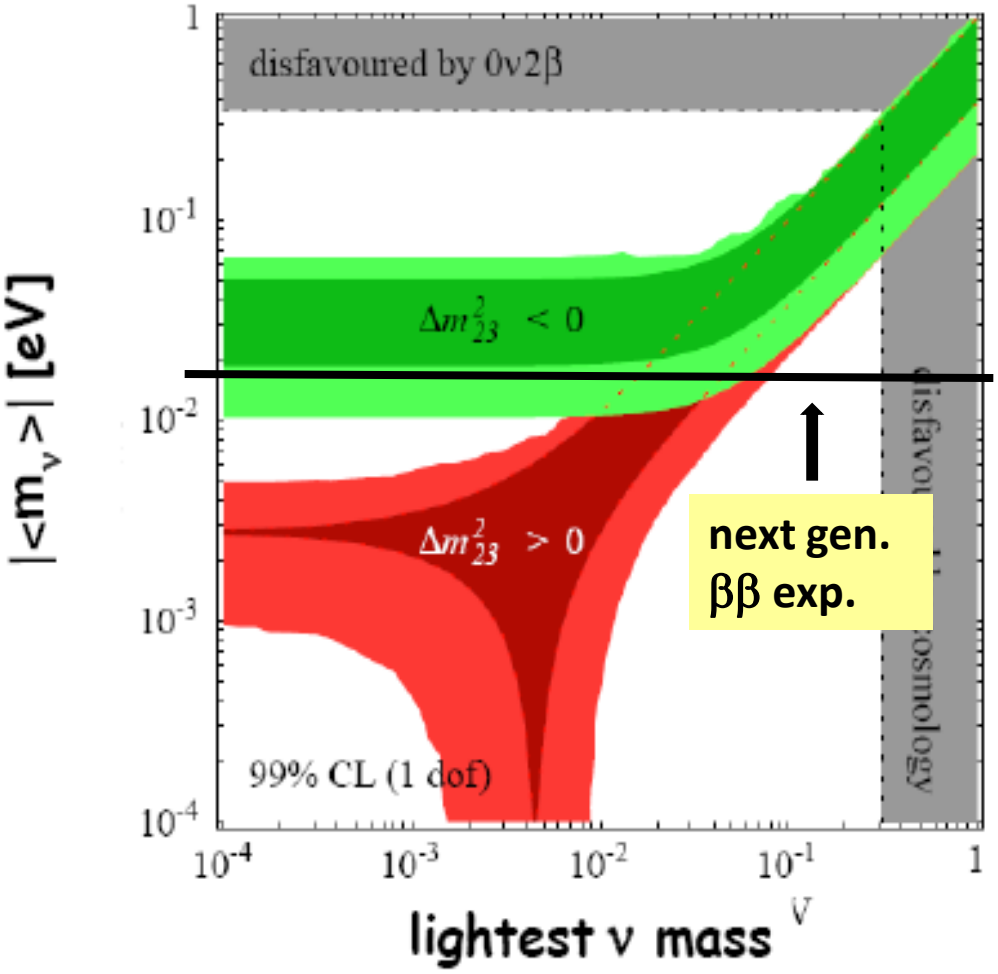
- **Effects of mass hierarchy can be seen from the distortion of neutrino energy spectrum at reactors after a Fo transformation**



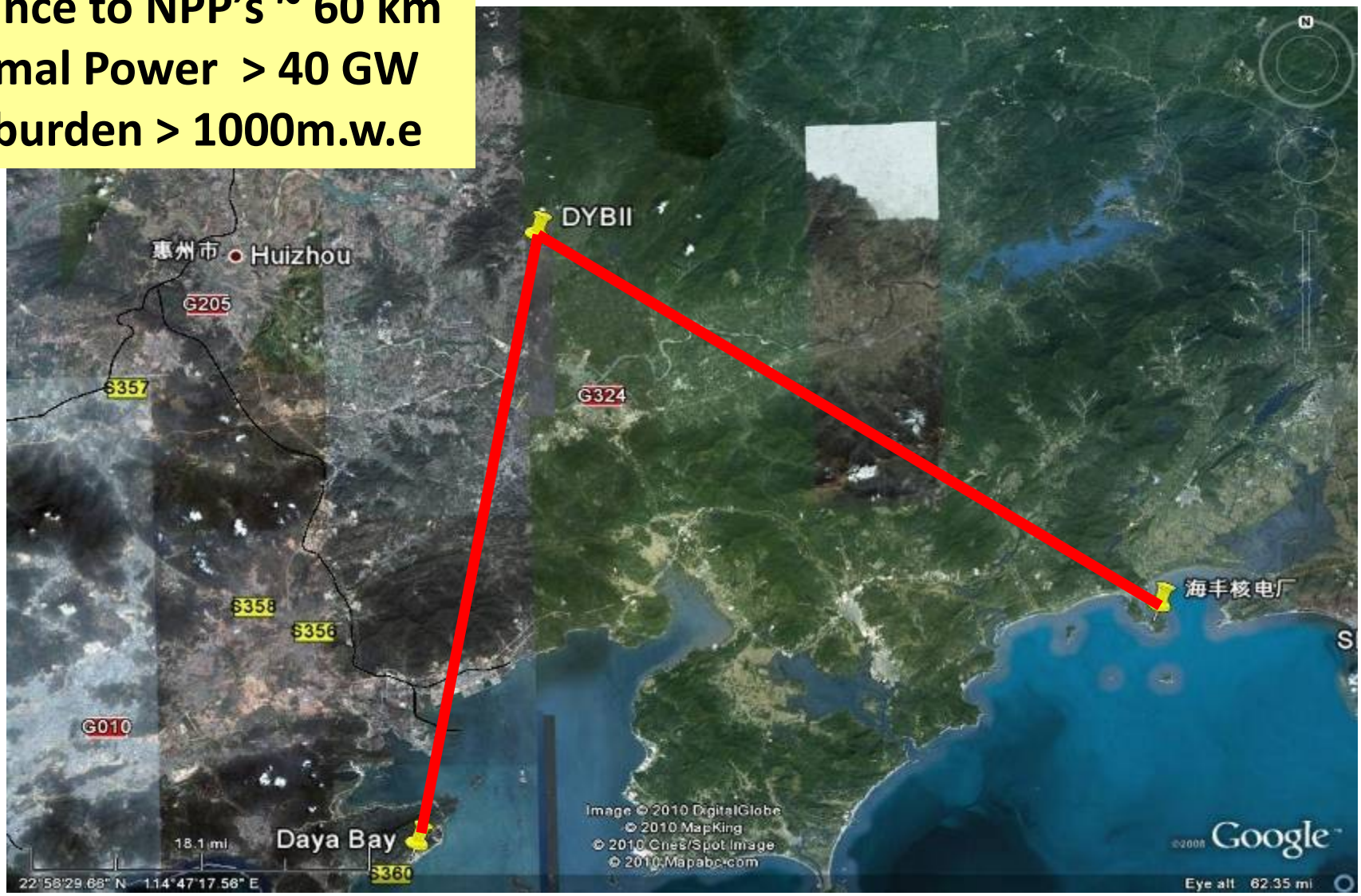

L. Zhan et al., PRD78:111103,2008

**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**



# Closing Remarks

- **BEPCII/BESIII will produce many interesting results in Charm and τ 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. Is under construction, and will start data taking next year.**
- **Experiments in the cosmic frontier are fast increasing.**
- **Future plan: next 5 years plan under review**
- **More international coopreation**
- **Good opportunity and Great challenges**