# JINR's and Russian groups

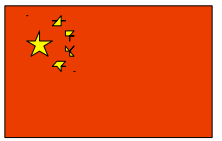
Alexey Zhemchugov
*JINR Dubna*

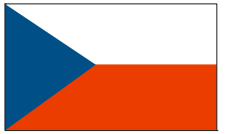
# Joint Institute for Nuclear Research is located in the city of Dubna in 120 km from Moscow

# JINR was founded in 1956 as an international scientific organization


Albania


Bulgaria

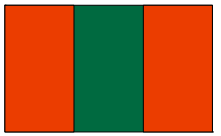

China


Czechoslovakia

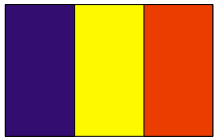

GDR


Hungary


D.P.R.Korea


Mongolia


Poland


Romania


USSR

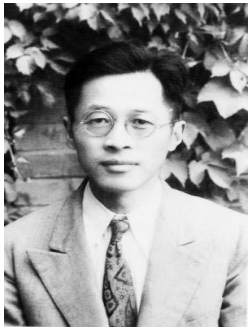

Vietnam

*The Institute has been established with the aim of uniting the efforts, scientific and material potentials of the Institute Member States for the investigations of the fundamental properties of matter.*

*The main directions of research at the Institute are elementary particle and atomic nuclei physics, physics of condensed states of matter using nuclear physical methods.*

Charter of the JINR

# More than 140 Chinese physicists worked in Dubna in 1956 - 1965



Wang Ganchang ( 王淦昌 )

Zhang Wenyu （张文裕 )

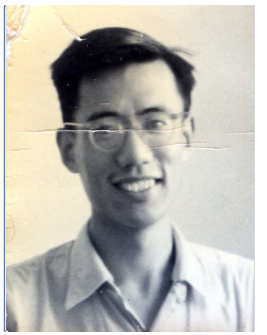
Wang Shufen ( 王树芬 )

Tang Xiaowei ( 唐孝威 )

Hu Ning ( 胡宁 )

Li Yi ( 力一 )

Ding Dazhao ( 丁大钊 )



Fang Shouxiang ( 方守贤 )

Zhou Guangzhao ( 周光召 )

Lu Min ( 吕敏 )

Yan Fuqing ( 杨芙清 )


Zhu Hongyuan(朱洪元)

# More than 140 Chinese physicists worked in Dubna in 1956 - 1965

- People's Republic of China was among the founders of JINR in 1956. Group of Chinese scientists greatly contributed to the development of JINR and to obtaining the physics results and making the discoveries in 1956 – 1965.
- Large part of prominent scientists, working in nuclear and particle physics in China in 1970s-1990s, has gained knowledge and experience in Dubna.
- However, China has withdrawn from JINR in 1965, mainly due to general political and ideological tensions between PRC and USSR
- Scientific cooperation between JINR and China broke off for almost 40 years.
- It were the BES-III (and DayaBay) experiments which made the first steps to revive the cooperation!

# Cooperation agreement between JINR and IHEP was signed in 2004

**ATTACHMENT**
**TO THE AGREEMENT ON CO-OPERATION**
**BETWEEN**
**THE JOINT INSTITUTE FOR NUCLEAR RESEARCH**
**(JINR, DUBNA, RUSSIAN FEDERATION)**
**AND**
**THE INSTITUTE OF HIGH-ENERGY PHYSICS**
**(IHEP, BEIJING, PEOPLE'S REPUBLIC OF CHINA)**
**OF 19 AUGUST 2004**

**1. Introduction**

Based on the Agreement on co-operation between JINR and IHEP of 19 August 2004, the Parties declare there willingness to join efforts in the following projects:

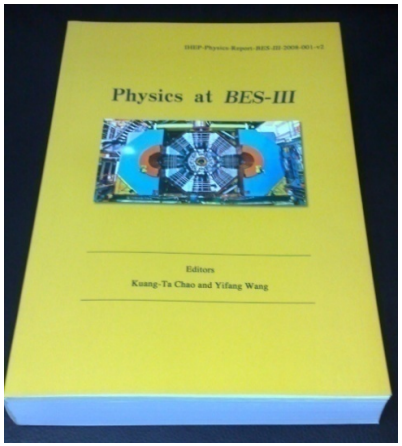
a. Neutrino oscillation experiment aimed at measuring $\sin^2 2\theta_{13}$ with an accuracy no worse than 0.01 at the Daya Bay nuclear power plant (Shenzhen, People's Republic of China).

b. BESIII experiment on the study of charmed $\tau$-particle physics at the $e^+e^-$ collider of IHEP (Beijing, People's Republic of China).

# Dubna group in BESIII

- ~ 8 authors (~5 FTE)
- Tasks:
  - «Yellow book» preparation (2007-2008)
  - Software and computing system development (2005 - )
  - Physics analysis (2008 - )

# Preparation of physics research program




Int. J. Mod. Phys A24, Supp.1 2009

**Three sections in The BES-III Yellow Book**

- Study of the Lorentz Structure (I.Boyko, D.Dedovich)
- Tau Hadronic Spectral Functions (I.Boyko, D.Dedovich)
- Two-photon Physics (V.Bytev, A.Zhemchugov)

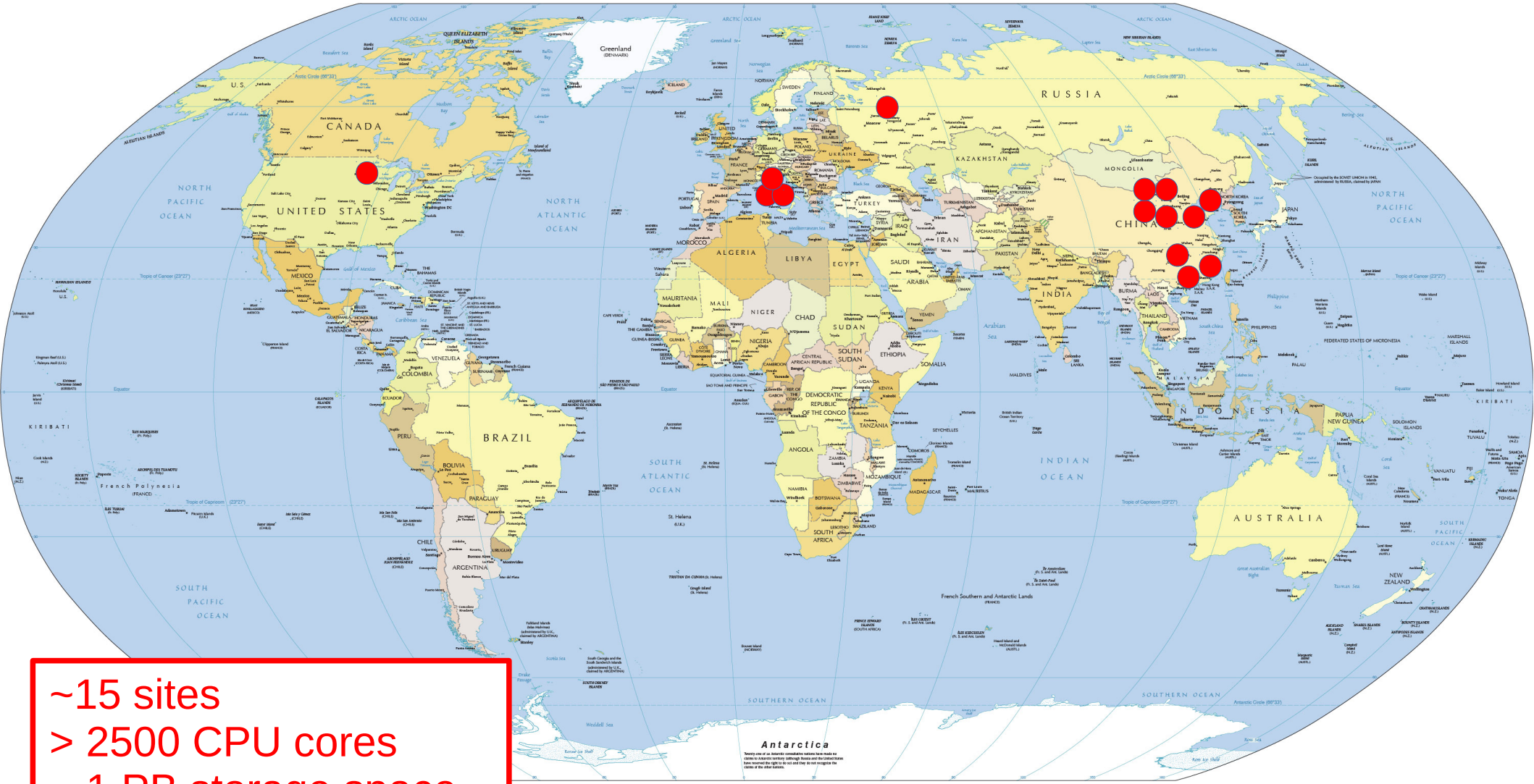
Two workshops on BES-III physics program have been organized at JINR in 2007, with participation of physicists from JINR, IHEP CAS and Irkutsk university.

# Software development

## JINR's technical contribution to the experiment

- Adaptation of the Monte-Carlo event generators (EvtGen, Phokhara, Bhlumi, Bhwide, Twogam) for the BES-III software.
- Core framework development and maintnance (event navigation, beam background simulation, database interface etc.)
- Analysis tools (BEAN: ROOT-based analysis framework, PWA software etc.)
- Distributed computing (BES-III Grid & Cloud)
- Software distribution
- Development of machine learning algorithms for the track reconstruction
- Shift booking software

# BES-III Grid




~15 sites
> 2500 CPU cores
~ 1 PB storage space

# Results of JINR group: data analysis

Study of semileptonic decay
D → **Kπεν**

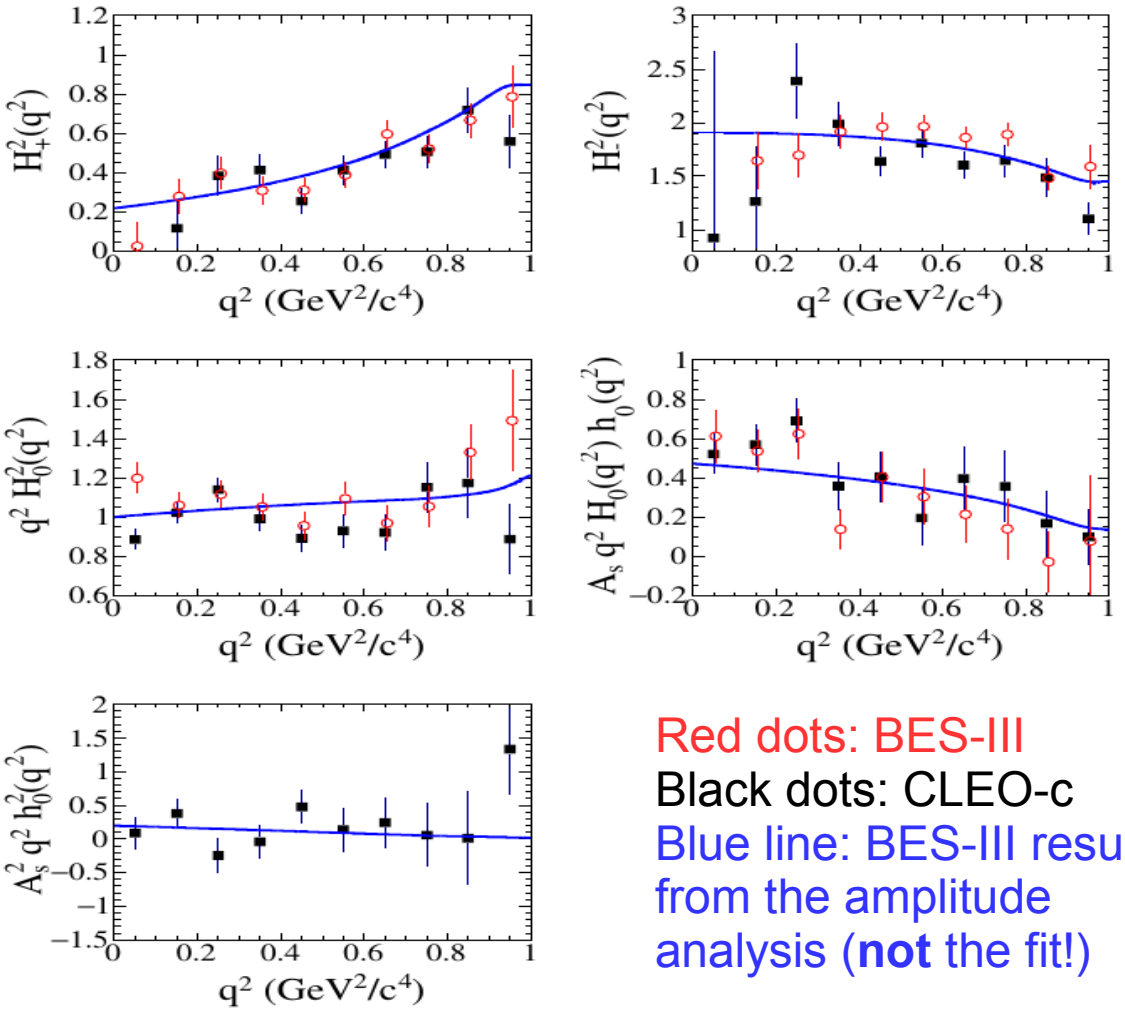
Goal: determination of branching ratio and model-independent measurement of hadronic form-factors

Published in Phys.Rev. D94 (2016) no.3, 032001

Branching ratio

$$\mathcal{B}(D^+ \to K^-\pi^+e^+\nu_e) = (3.71 \pm 0.03 \pm 0.08)\%,$$
$$\mathcal{B}(D^+ \to K^-\pi^+e^+\nu_e)_{[0.8,1]} = (3.33 \pm 0.03 \pm 0.07)\%$$

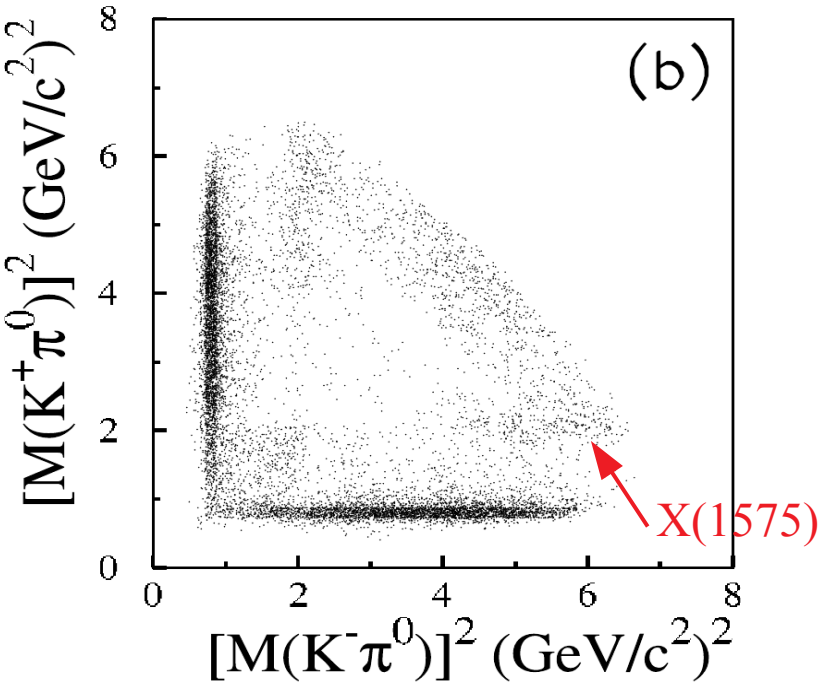
Helicity form-factors



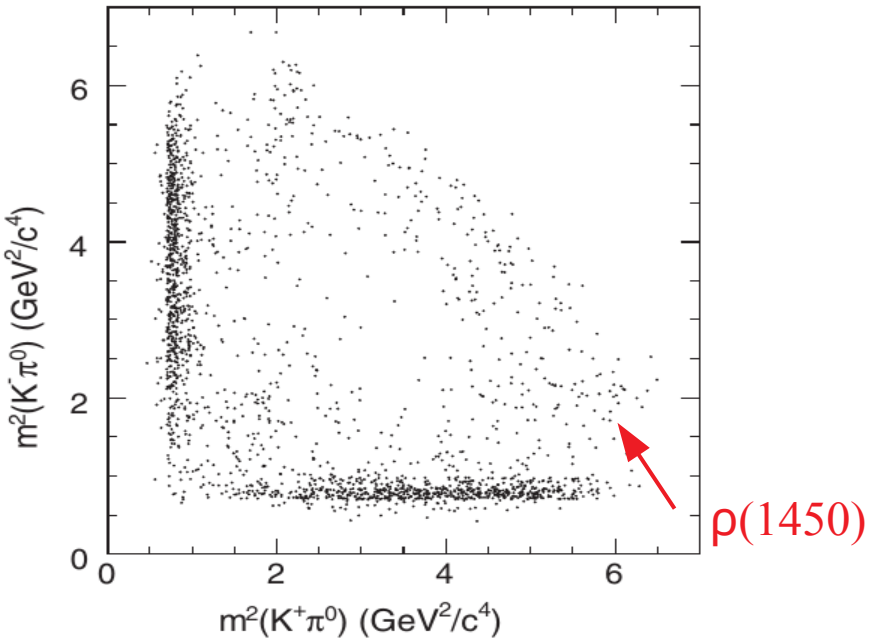

Red dots: BES-III
Black dots: CLEO-c
Blue line: BES-III results from the amplitude analysis (**not** the fit!)

# $J/\psi \rightarrow K^+K^-\pi^0$

BESII, PRL97, 142002 (2006)




BABAR, PRD95,072007 (2017)




Exotic X(1575):

- JPC = 1--
- Pole position:

  M ~ 1580 MeV

  G ~ 800 MeV

The enhancement attributed to ρ(1450):

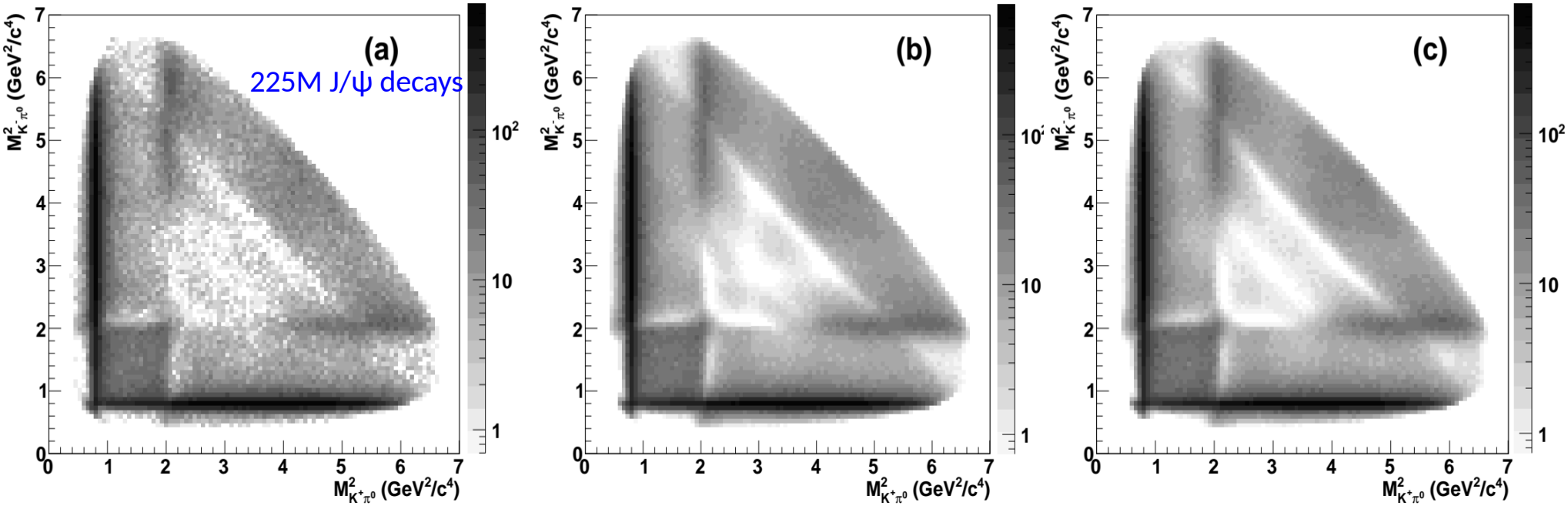
$$\frac{\mathcal{B}(\rho(1450)^0 \rightarrow K^+K^-)}{\mathcal{B}(\rho(1450)^0 \rightarrow \pi^+\pi^-)} = 0.307 \pm 0.084(\text{stat}) \pm 0.082(\text{sys})$$

ρ(1450) is a puzzling state exhibiting properties of a hybrid (e.g. see PDG review).

# Partial wave analysis of $J/\psi \to K^+K^-\pi^0$ at BESIII

Published in PRD 100, 032004 (2019)

Data | Solution I | Solution II




Two solutions presented:

- PDG states only
- PDG states + slow changing background in the JP=3- Kπ partial wave

Set of unambiguously observed states:

- $K^*(892)^\pm$ and $K_2(1430)^\pm$ measured with high precision. For the precise measurement of the $K^*(892)$ width a new method was developed and used (JINST 10,P10028 (2015)).
- $K_2(1980)^\pm$ and $K_4(2045)^\pm$ are observed for the first time in J/ψ decays.
- Two JPC=1-- states decaying K+K- observed:
  - 1-- @1650 MeV (likely $^3D_1$ isovector state or ω(1650))
  - 1-- @2050 MeV (ρ(2150) or the state observed in PLB 491, 47 (2000))

The branching ratio of $J/\psi \to K^+K^-\pi^0$ is measured with high precision: $Br=(2.88\pm0.01\pm0.12)\times10^{-3}$ (PDG:$(2.14\pm0.24)\times10^{-3}$)

# Budker Institute and BES-III

Courtesy to M.N.Achasov

# BINP group in BES-III collaboration

In 2007 the collaboration of three groups from

Institute of High Energy Physics CAS,

*Budker Institute of Nuclear Physics SB RAS and*

*University of Hawaii*

started to design the beam energy measurement system

based on the Compton backscattering method (BEMS) for the

BES-III–BEPC-II experiment.

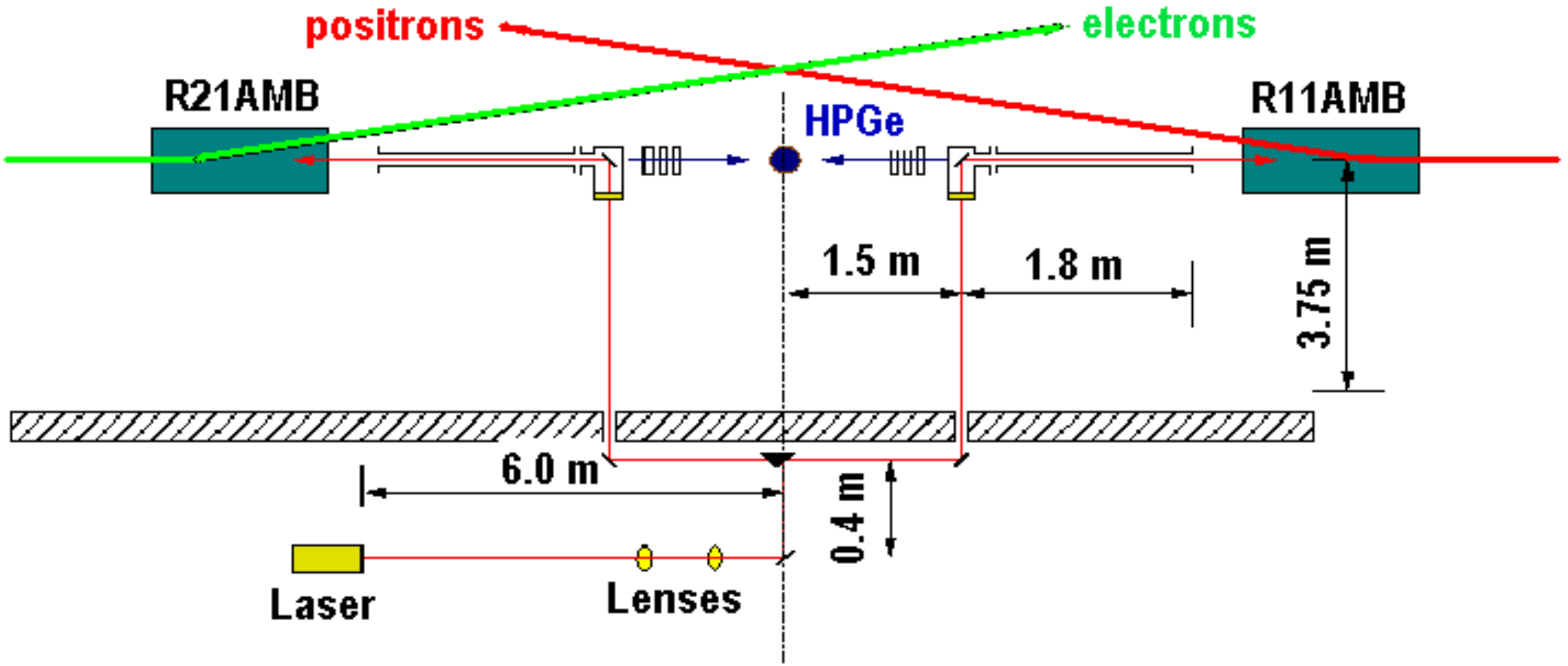
**In January, 2008 BINP had joined BES-III collaboration.**

The system was put to operation in December 2010.

# BEMS at BEPC-II


The beam energy measurement system is located at the north interaction point.

# Beam Energy Measurement System.

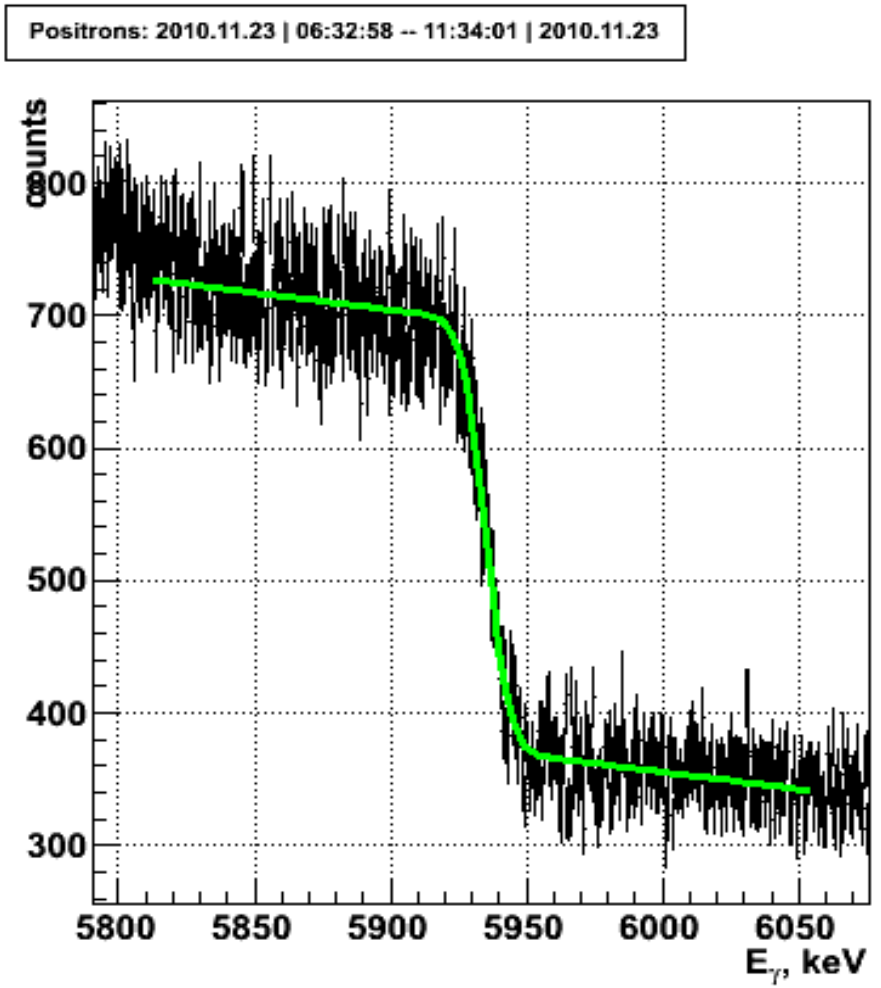



Layout of BEPC-II beam energy measurement system.

**The energy of the electron and positron beams are measured one after another, in turn.**

# Brief description of the Compton backscattering method

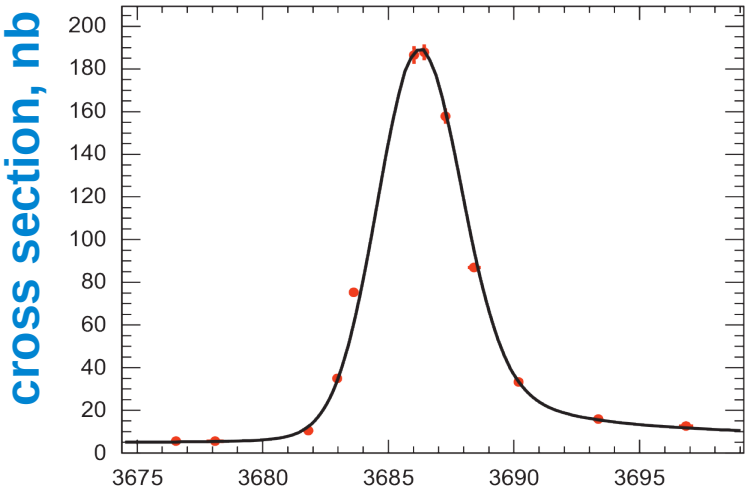
- The monochromatic radiation of the $CO_2$ laser is put in collisions with the beam.
- The energy of the backscattered photons is measured with High Purity Germanium (HPGe) detector.
- The beam energy **E** is calculated from the maximum energy $\omega_{max}$.




The fit to the edge of the photons backscattered at BEPC-II.

# Tests of BEMS using narrow resonances peaks

The masses of narrow resonances J/ψ, ψ′ obtained using CBS method are compared with their PDG values.




Mass difference $\Delta m = m_{CBS} - m_{PDG}$ is used to estimate the error of beam energy measurement $\Delta E = \Delta m/2$.

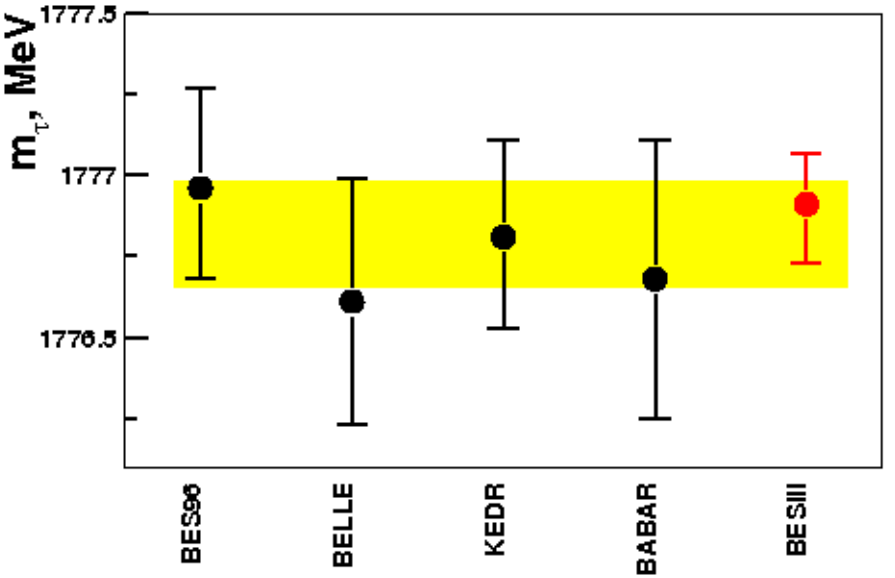
| Scan | | ΔE, keV | δE/E |
|---|---|---|---|
| J/ψ, | BES-III | $74 \pm 57$ | $6 \times 10^{-5}$ |
| ψ′, | BES-III | $118 \pm 79$ | $7 \times 10^{-5}$ |
| ψ′, | BES-III | $1 \pm 36$ | $2 \times 10^{-5}$ |

# Tau-mass measurement

One of the main tasks of the BEMS is provide the beam energy determination in the τ-mass measurement experiment.

In December 2011 BESIII has collected **25 pb$^{-1}$** at τ threshold.

**$m_\tau$=1776,91 ±0,12 $\pm^{0,10}_{0,13}$ МэВ.**
**[*Phys. Rev. D90, 012001 (2014)*]**




In order to improve the accuracy of the mass measurement in April 2018 at τ threshold BESIII has collected about **140 pb$^{-1}$**. Now the data are under analysis.

Thank you!