Status of the BESIII Experiment

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Abstract: The operation of the BEPCII/BESIII started in 2008. During the last running period, BESIII successfully collected about 100 million $\psi(2S)$ events and 200 million J/ψ events, respectively. The most recent status of the BEPCII/BESIII is presented. Performances of the BESIII detector and selected preliminary physics results are shown.

The upgrade of the Beijing Electron-Positron Collider was started in 2003 and successfully completed in 2008. The accelerator, called BEPCII, is a double-ring machine with a designed luminosity of 10^{33} cm$^{-2}s^{-1}$ at a beam current of 0.93 A. The electron and positron beams are accumulated in the storage ring at the end of Oct. 2007, and the first e^+e^- collision occurred on Nov. 18, 2007. The beam current soon reached the level of 500 mA, and the collision luminosity is close to 10^{32}cm^{-2}s^{-1} in March 2008. In the mean time, the BESIII detector completed installation at the end of 2007 and the first full cosmic-ray event was recorded in March 2008. At this point, both the machine and the detector are ready, and the detector was successfully moved to the interaction point on April 30, 2008.

Status of BEPCII

With the existence of the BESIII detector at the interaction point, the machine operation is limited by the allowed backgrounds, which may permanently damage the CsI(Tl) crystal calorimeter, particularly during the beam injection. The first e^+e^- collision event was observed in the BESIII detector on July 19, 2008, and a total of 14 million ψ' events was collected until Nov. 2008. Over this period, the BEPCII performance continued to improve by the lattice optimization, system debugging, and vacuum improvements. After a 1.5-month synchrotron radiation run and a winter maintenance, the machine resumed collision and its luminosity gradually improved from 1×10^{32} cm$^{-2}s^{-1}$ to 3×10^{32} cm$^{-2}s^{-1}$, as shown in Fig. 1.

In fact, during the winter shutdown, a screen monitor in the beam pipe, which turned out to be the main source of the longitudinal instability, was removed. Another major improvement is the choice of the working point, from $v_x = 0.53$ to $v_x = 0.51$, as shown in Fig. 2. These two measures contributed mainly to the improvement of the luminosity.

Until May of 2009, the main parameters of the storage rings achieved in the collision mode compared to the designed values are listed in table 1.

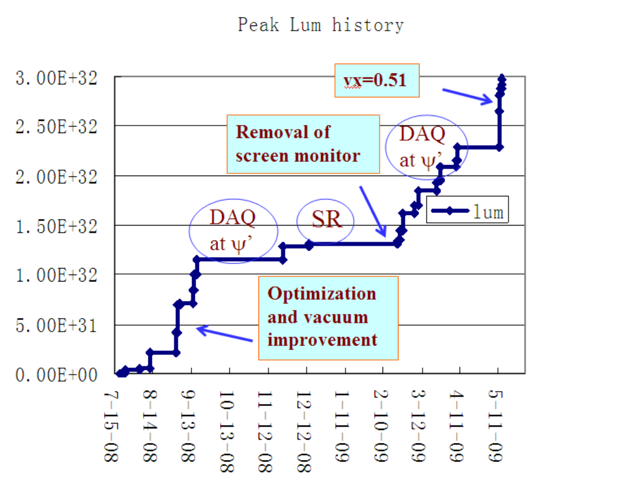

Figure 1: The improvement of the BEPCII luminosity over time.

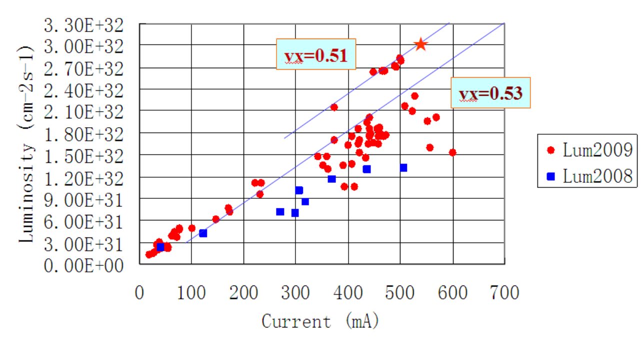

Figure 2: The BEPCII luminosity as a function of the beam current.

Performance of the BESIII detector

The BES-III detector [1], as shown in Fig. 3, consists of the following main components: 1) a main draft chamber (MDC) equipped with about 6500 signal wires and 23000 field wires arranged as small cells with 43 layers. The designed single wire resolution is 130 μm and the momentum resolution 0.5% at 1 GeV; 2) an electromagnetic calorimeter(EMC) made of 6240 CsI(Tl) crystals. The designed energy resolution is 2.5%@1.0 GeV and position resolution 6mm@1.0 GeV; 3) a particle identification system using Time-Of-Flight counters made of 2.4 m long plastic scintillators. The designed resolution is 80 ps for two layers, corresponding to a K/π separation (2 level) up to 0.8 GeV; 4) a superconducting magnet with a field of 1 tesla; 5) a muon chamber system made of RPC.

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Parameters	Design	Achieved	
		BER	BPR
Energy (GeV)	1.89	1.89	1.89
Beam curr. (mA)	910	650	700
Bunch curr. (mA)	9.8	>10	>10
Bunch number	93	93	93
RF voltage	1.5	1.5	1.5
*ns @1.5 MV	0.033	0.032	0.032
β_x^*/β_y^* (m)	1.0/0.015	1.0/0.016	1.0/0.016
Inj. Rate (mA/min)	200 e^-/ 50 e^+	>200	>50
Lum. (10^{33}cm^{-2}s^{-1})	1.0	0.3	

Table 1: Main parameters achieved in collision mode compared to the designed values

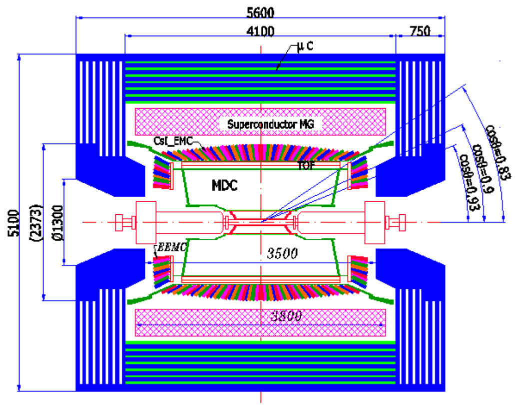

Figure 3: The schematic view of the BES-III detector.

Starting from March of 2009, BES-III successfully collected 100 million $\psi(2S)$ events and 200 million J/ψ events, about a factor of 4 larger than the previous data samples from CLEO-c and BES-II, respectively. The peak luminosity was stable, typically at the level of 2×10^{32} cm^{-2}s^{-1} during the data taking at $\psi(2S)$, and 0.6×10^{32} cm^{-2}s^{-1} at J/ψ. An energy scan of the $\psi(2S)$ lineshape shows that the beam energy spread is about 1.4 MeV, and the effective peak cross section of $\psi(2s)$ is about 700 nb. The beam-related background was substantially reduced in comparison with that of 2008, thanks to the fine tuning of the beam parameters and the movable masks installed at 8m upstream of the beam from the interaction point. The data taking efficiency of the detector is more than 85%.

The detector was calibrated using the $\psi(2S)$ events and the main performance parameters of the BES-III detector is shown in Fig. 4. Clearly, the detector is in a very good condition and all the design specifications have been satisfied.

A comprehensive Monte Carlo simulation code, largely based on the first principle of the detector response to particles interacting with materials, was developed to model the performance of the BES-III detector. Fig. 5 shows the

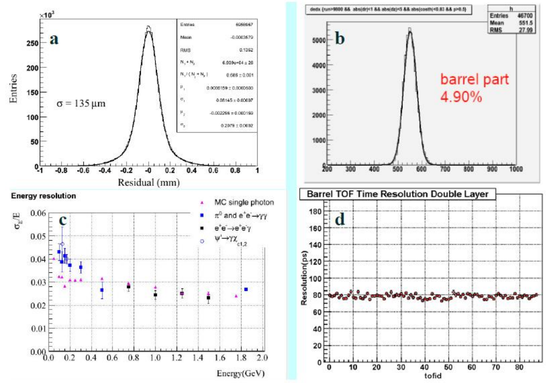

Figure 4: Main performance parameters of the calibrated BES-III detector: a) Single wire resolution of the drift chamber; b) dE/dx resolution of the drift chamber in the barrel part(w/ all wires); c) energy resolution of the CsI(Tl) crystal calorimeter as a function of photon energy from different physics processes; d) time resolution of TOF counters averaged over two layers for each counter ID in phi direction.

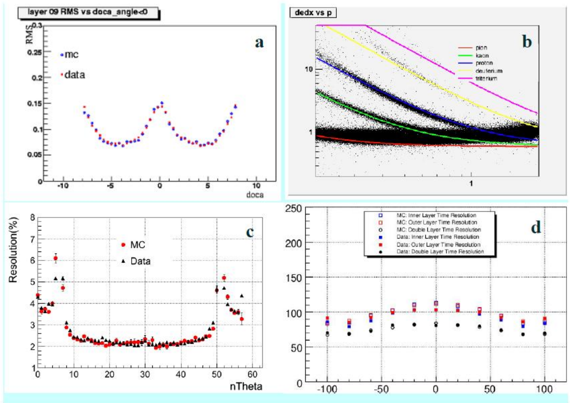

Figure 5: Comparison between data and Monte Carlo simulation on the performance of the BES-III detectora) Single wire resolution as a function of the drift distance; b) dE/dx of the drift chamber for various particles at different momentum; c) Energy resolution of the CsI(Tl) Crystal calorimeter for Bhabha events at each crystal ID along the polar angle θ; d) average time resolution of all barrel TOF counters as a function of position along the beam direction(open points for Monte Carlo and filled dots for data).

comparison. For example, the resolution and efficiency of each wire of the drift chamber was modelled as a function of the drift distance, entrance angle, distance of closest approach, charge amplification etc. The time response of the TOF counter has the light collection, scintillator properties, PMT pulse shape and the readout electronics built in. A good agreement can be observed, not only on average numbers, but also on the details functional shape. This agreement ensures the well control of systematic errors and precision physics measurement.

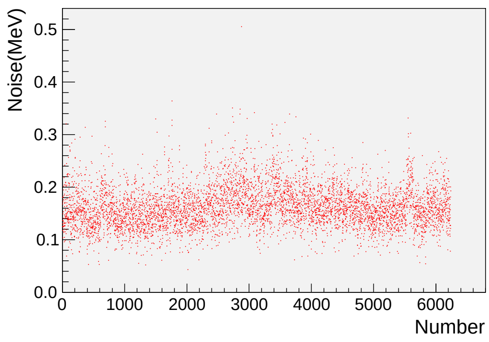

Figure 6: Electronics noise in each channel of the CsI(Tl) crystal calorimeter during data taking.

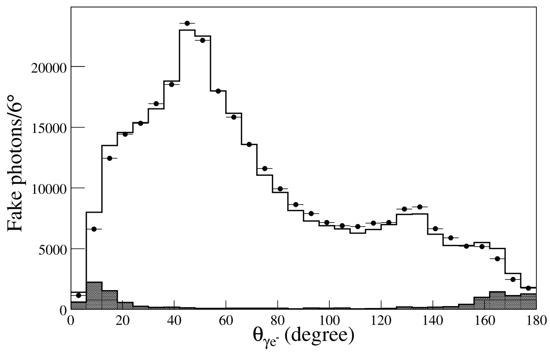

Figure 7: Opening angle between charged tracks seen by MDC and neutral particles in EMC. (Dots: data, shadowed histogram: Monte Carlo events, histogram: Monte Carlo events mixed with random trigger events as backgrounds).

The well behaved BES-III detector is also demonstrated by the noise level during the data taking. Figure 6 shows the electronics noise in each channel of the CsI(Tl) crystal calorimeter. The average is less than 200 KeV, well below the specification and almost all the crystal calorimeters built in the last twenty years. The beam related noise was simulated by mixing randomly taken events with that of Monte Carlo. Figure 7 shows the opening angle between charged tracks seen by MDC and neutral particles in EMC. Excellent agreement between data and Monte Carlo can be seen after random events are taken into account.

Preliminary physics results

Physics at BESIII are very rich [2]. An initial physics program has been planned for the $\psi(2S)$ data set, including, but not limited to, the following topics:

- Spin-singlet studies(h_c, η_c, η_c');
- $\psi(2S)$ hadronic decays ($\rho\pi$ puzzle, new states);
- χ_c decays (search for new states and new decays).

A first glance of the $\psi(2S)$ data shows that a lot of resonances can be clearly seen. Fig. 8 shows the inclusive photon spectrum from the electromagnetic calorimeter. Signals from the electromagnetic transition between charmonium states can be well identified and they demonstrate the impressive performance of the CsI(Tl) crystal calorimeter.

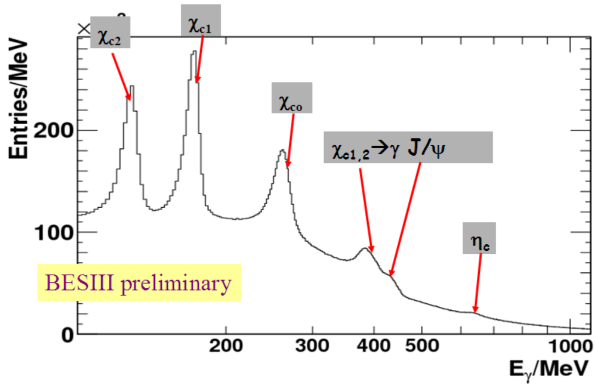

Figure 8: Measured inclusive photon spectrum from $\psi(2S)$ decays.

Preliminary physics results have been obtained, ranging from the confirmation of BES-II and CLEO-c results, to completely new observations. Fig. 9 shows the prompt photon spectrum from $\psi(2S) \to \gamma\pi^0\pi^0$ (left) and $\psi(2S) \to \gamma\eta\eta$ (right). Signals from χ_{c0} and χ_{c2} are observed and their branching ratios are measured. Results are consistent with that of previous measurements from CLEO-c [3]. The last member of the charmonium

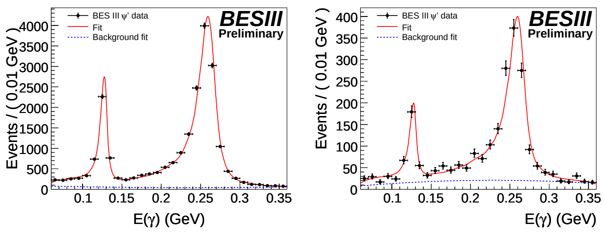

Figure 9: Observed χ_{c0} and χ_{c2} signal from $\psi(2S) \to \gamma\pi^0\pi^0$ (left) and $\psi(2S) \to \gamma\eta\eta$ (right) channels.

family below the open charm threshold called h_c was observed by CLEO-c in 2005 from $\psi(2S)$ decays to $\pi^0 h_c$, $h_c \to \gamma\eta_c$ [4]. Fig. 10 shows the BES-III observation of h_c by tagging the prompt photon in the h_c decays. By tagging π^0 from $\psi(2S)$ decays, clear signals can be also seen and branching fractions of $\psi(2S) \to \pi^0 h_c$, $h_c \to \gamma\eta_c$ can be individually measured.

BES-III also confirmed many observations by BES-II [5]. Fig. 11 shows the $p\bar{p}$ invariant mass from a) $\psi(2S) \to \pi\pi J/\psi$, $J/\psi \to \gamma p\bar{p}$, and b) $\psi(2S) \to \gamma p\bar{p}$. Clearly, a threshold enhancement can be seen in J/ψ decays, but not in $\psi(2S)$ decays, consistent with BES-II observations.

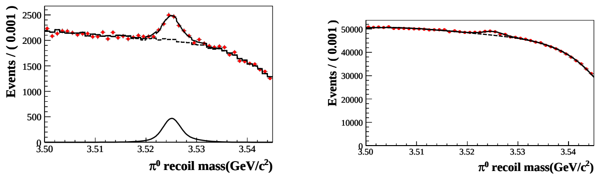

Figure 10: h_c observed in BES-III. Left: tagging the prompt photon in the $h_c \to \eta_c$ decays, right: tagging π^0 from $\psi(2s) \to \pi^0 h_c$ decays.

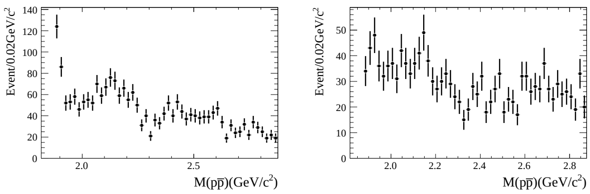

Figure 11: Invariant mass of $p\bar{p}$ from (left) $\psi(2s) \to \pi\pi J/\psi$, $J\psi \to \gamma p\bar{p}$, and (right) $\psi(2s) \to \gamma p\bar{p}$.

Summary

In summary, BEPCII and BES-III are successfully constructed and operated. The BEPCII luminosity has reached highest record in the history and a large data sample of J/ψ and $\psi(2S)$ has been collected. The performance of the BES-III detector is excellent and physics analysis has been started. From preliminary results we obtained up to now, we are confident that a great leap of tau-charm physics can be expected.

References

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