The 98/99 Operation of BEPC

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Abstract

In this article, the operational status of Beijing Electron Positron Collider (BEPC) in 98-99 is mainly reviewed. The BEPC upgrades have been performed in recent years. With the low-Beta function scheme at the interaction points, optimizing tunes, orbits and other parameters, the peak luminosity at J/ψ energy is nearly doubled during this year's performance, which also benefits the R measurement and ψ' scan experiment. In addition, the stable and efficient running of the BEPC and BES ensure the successful experiment. Meanwhile, some machine studies were carried out for further improvement of the BEPC.

1 General Description

The 98/99 operation of the BEPC started on Nov. 5, 1998 and will be finished in the middle of July 1999, lasting about 9 months.

Table 1: The schedule of 98/99 operation

Nov.5 $\sim$ Nov.12	BEPC Start-up
Nov.13 $\sim$ Nov.15	Beamline test and orbit optimization
Nov.16 $\sim$ Dec.20	BSRF experiment
Dec.21 $\sim$ Jan.8	BES start-up and BEPC commissioning
Jan.8 $\sim$ Jan.16	J/ψ experiment
Jan.17 $\sim$ Feb.7	BEPC commissioning & test
Feb.8 $\sim$ Feb.9	J/ψ experiment
Feb.10 $\sim$ Feb.14	R value measurement
Feb.14 $\sim$ Feb.21	Spring festival
Feb.21 $\sim$ Feb.24	Start-up
Feb.25 $\sim$ June 8	R value measurement & ψ' scan
June 8 $\sim$ June 10	Machine studies
June 10 $\sim$ July 10	BSRF experiment

Before the running, some experiments, collaborated by BEPC and BES people, were carried out to solve the background problem of the BES. At last, after shielding some accelerator elements, such as the DCCT, the background of the BES was obviously decreased and the BES can work well under high beam current. The BEPC has been operated for 11

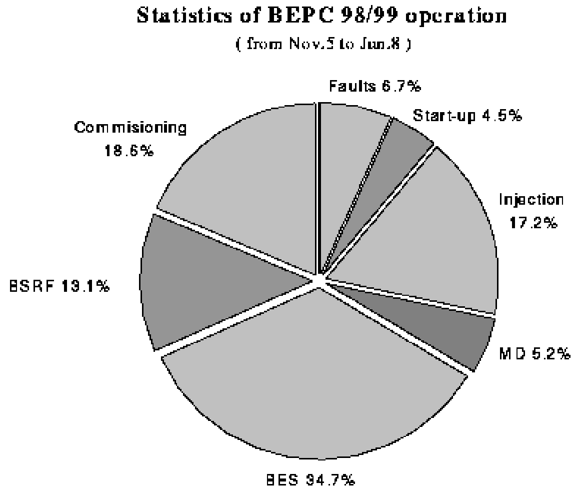

Figure 1: The statistics of 98/99 BEPC operation.

years, which performs for high energy physics, and the synchrotron radiation experiments as well. Table 1 shows the BEPC performance schedule of the 98/99.

At the beginning of this 9-month run, we spent only 8 days for the BEPC start-up. Then, one month was spent for the Beijing Synchrotron Radiation Facility (BSRF) experiments as schedule. In the following one and a half months, the BEPC passed the luminosity upgrades test successfully. Under the upgraded machine, the BEPC devoted to the BES experiment of R value measurement during the next 4 months. Figure 1 displays the statistics of the 98/99 BEPC operation.

Till June 8, the total running time is nearly 5000 hours, in which 34.7% is for the BES, 13.1% for the BSRF, 18.6% for the dedicated commissioning and 33.6% for others.

2 BEPC Upgrade Test

The goal of the BEPC upgrades is to increase the luminosity at 1.55GeV beam energy for J/ψ particle physics, which includes:

· The stable operation of machine.
· Linac energy upgrade (the injection energy was promoted from 1.3 GeV to 1.55 GeV).
· Improvements for the control and beam diagnostic system.
· Double the peak luminosity of 1992.
· Increase the integrated luminosity.
· BES and BSRF upgrades.

Since 1996 we have done many extensive machine studies with the low-β function configuration. The major optics configuration consists of several scenarios such as Double Interaction Point (DIP) scheme with small emittance, DIP scheme with large emittance, and Single Interaction Point (SIP) scheme. During the performance of last year, the SIP scheme had been commissioned successfully. From Figure 2 we can see the peak luminosity was about $4.4 \times 10^{30} cm^{-2} s^{-1}$ with the β_y^*=7cm, while the maximum current could reach 49mA. The exciting data on DIP scheme came from the 98/99 performance after the machine was commissioned for about one month. Some major machine parameters such as tunes, orbits, chromaticities, emittance, RF conditions, etc., were optimized. Finally, the peak luminosity reached $4.88 \times 10^{30} cm^{-2} s^{-1}$, while the maximum vertical beam-beam parameter was about 0.045 and the hadronic event rate at this energy increased by a factor of 2, shown in figure 3 and figure 4. That's the best status of the BEPC since 1996. And the table 2 gives some machine parameters during the J/ψ commisioning.

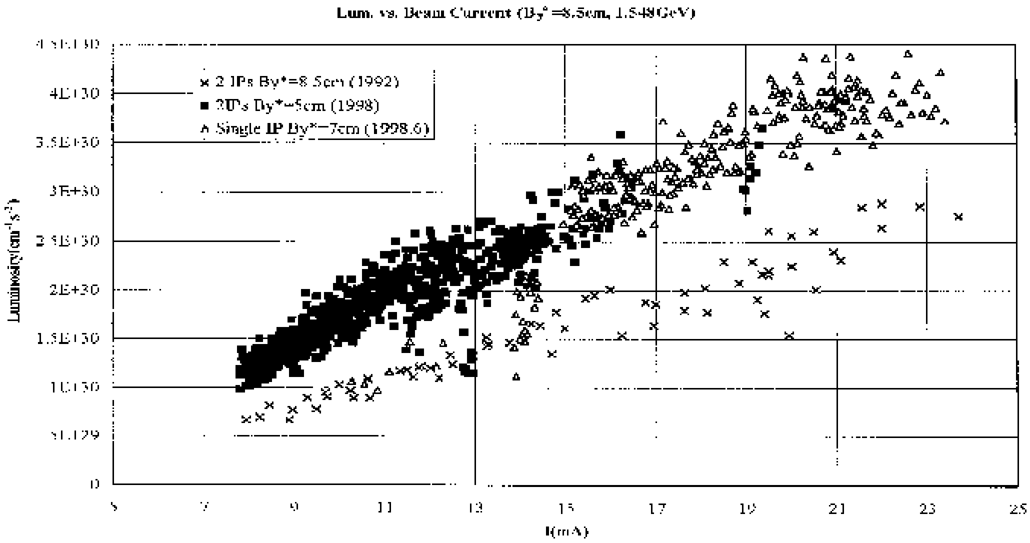

Figure 2: Luminosity increase with SIP scheme.

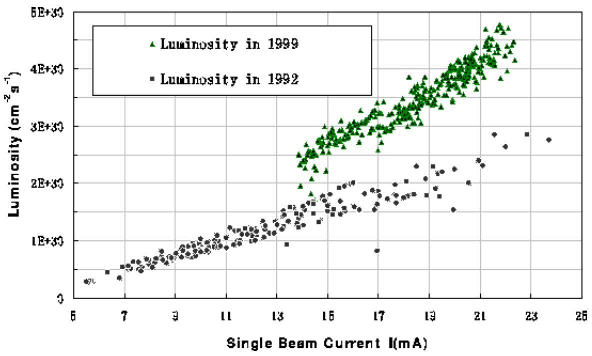

Figure 3: Luminosity increase with SIP scheme.

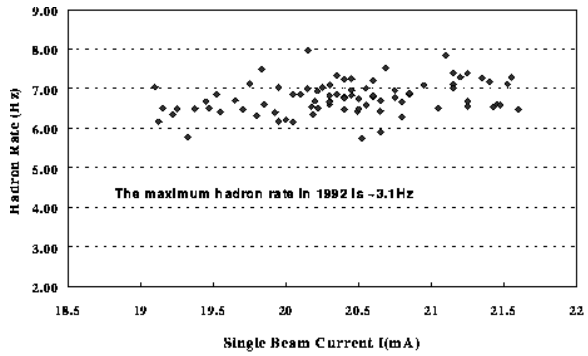

Figure 4: The hadronic event rate vs. beam current.

3 Performance for High Energy Physics Experiment

The BEPC, as a collider, mainly works in the τ-charm energy region for high energy physics experiments. In this run, before the R value measurement, about one month was devoted to the J/ψ operation. Due to the well-optimized machine parameters during the BEPC upgrades test, the commissioning at J/ψ energy was quite smooth and BES can acquire data at a high efficiency. In this one-month J/ψ running, the integrated luminosity sometimes could reach 140nb^{-1}/day, whcih was the highest in the passed years.

After the spring festival, the prime physics experiments were the measurement of the R value and the ψ' scan. As an important parameter in particle physics, the accurate

Table 2: Machine parameters during the J/psi commissioning

Commissioning scheme	DIP
Injection energy	1.5479 GeV
e^+ injection rate	~2.2 mA/min
e^- injection rate	~50 mA/min
Colliding beam energy	1.5482 GeV
Maximum colliding current	45.4 mA
Peak luminosity	$4.88 \times 10^{30} cm^{-2} s^{-1}$
Maximum vertical tune-tune shift	0.045
Hadronic event rate	7.7 Hz
Close orbit distortion	X_{rms}=1.83 mm; Y_{rms}=1.69 mm
Tunes	ν_x/ν_y= 5.82/6.70
Vertical β function at IP	5.0 cm
RF voltage	~600 kV
Beam lifetime	~7 hours

measurement of the R value is a significant work on the BES. With the collaborative efforts of both the BEPC and BES people, the experiments have been accomplished successfully till June 8. The reasonable data were taken at 98 key points in which the beam energy spanned a wide range from 1.0GeV to 2.4GeV. Figure 5 and figure 6 display the maximum colliding current and luminosity of all the key points during the R value measurement and the ψ' scan. The peak colliding current reached 74.6mA, while the observed peak luminosity got to $9.25 \times 10^{30} cm^{-2} s^{-1}$ at the energy of 2.1GeV.

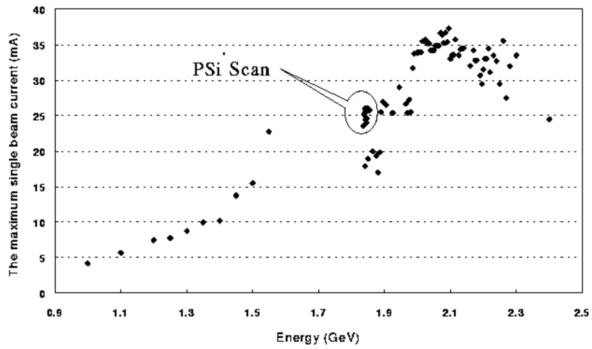

Figure 5: The maximum single beam colliding current at 98 key energy points.

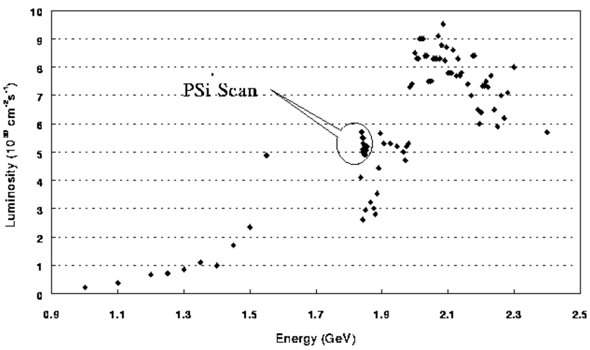

Figure 6: The maximum luminosity at 98 key energy points.

From the BEPC, it's really a difficulty to optimize the beam at so wide an energy range required by the R value measurement. The given commissioning time of optimizing the configuration is also very little. So the injection time, showed in Figure 1, containing the optimizing time, occupied about 17% in total operation time. It is obviously longer than before. Usually, it took little time to commission the beam on each energy point. The most difficult point is 1.0GeV, on which the damping time of the beam is much longer than the higher energies, causing difficulties on beam injection. The energy of linac should also be down to 1.0GeV for the data taking on energies below 1.3GeV. On the high energy, such as 2.4GeV, it's a challenge to both the power supply system and RF system, which never run for long time at such a high energy.

During the data taking of the BES, accelerator people overcame many difficulties on hardware failures. Including the linac, many equipment of the BEPC is being aged very seriously. Except the kicker power supply replacement, no any big failure caused the BEPC to stop for more than one day. The total faults of this run keep the average level as before.

4 Dedicated Synchrotron Radiation Operation

The BSRF have 8 beamlines and 12 experimental stations. Usually, the BEPC provides beams to the BSRF for about two months in a year. During this run, the first month after BEPC start-up and the last month before shutdown were devoted to the BSRF experiments in various research fields.

The BSRF was performed with a dedicated configuration, which had a low nature horizontal emittance. Table 3 shows the typical parameters of BEPC operation.

Table 3: The typical parameters of BEPC operation for BSRF

Circumference	240.4 m
Dipole bending radius	10.345 m
Beam energy	2.2 GeV
Energy spread	5.86×10^{-4}
Emittance	79.5 nm·rad
Harmonic number	160
RF voltage	620 kV
Momentum compaction	0.0161
Tunes	ν_x/ν_y= 8.72/4.75
Synchrotron Radiation loss/turn	200.4 keV
Bunch number	50∼60
Beam current	80∼100 mA
Beam lifetime	≥20 hours

During this performance, we stepped a high stage on providing stable beam for BSRF experiment. With some measures on curbing the instabilities and filling 60 unequal bunches into the storage ring, we finally got a large current beam with a long lifetime of more than 20 hours, which was dominated mainly by Touschek effect. Figure 6 shows the efficiency of the BSRF, which is obviously higher than before that performed with no more than four bunches.

It was found that the beam lifetime sometimes dropped suddenly to less than 2 hours. Now this phenomenon was explained as dust effect. We have done some machine studies on it and the improvement plan is being carried out step by step.

In the near future, the beam energy of the BSRF operation will be promoted to 2.5GeV as required. The dedicated configuration was commissioned smoothly during this run. Also the parasitic operation configuration for BES and BSRF at the same time is being studied.

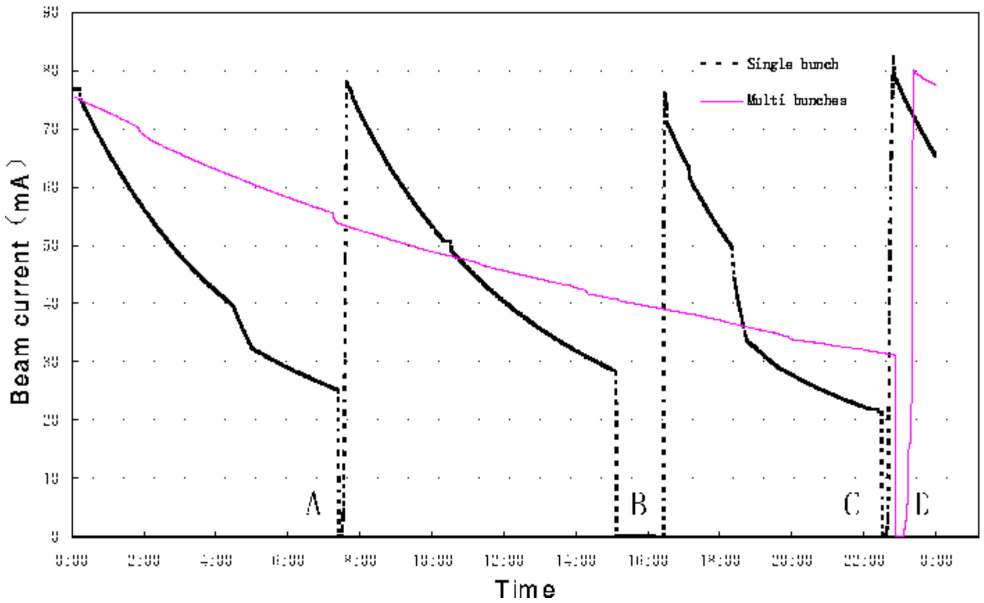

Figure 7: Beam current vs. time.

5 Machine Study

The machine study, which aims for long term improvement and some commissioning, is a significant part for a better operation status. During the 98/99 operation, many interesting machine studies were done. It took us about 5.2% of total running time.

In the machine study, the study on the control of emittance occupied most of time. There is a five-period permanent wiggler magnet on the BEPC for the BSRF research. The gap of the wiggler can be adjusted from 21.5cm to 4.3cm. We try to get a larger emittance by adjusting the gap, which was aimed at obtaining higher luminosity by increasing colliding beam current theoretically.

6 Summary

It's really a fruitful year for BES, BSRF and BEPC at the end of this century. Although there are many difficulties ahead, I'm sure it will be better in the future with our collaborative efforts. If we can get much money, we should try our best to keep machine more stable and to increase the integrated luminosity.

7 Acknowledgement

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References

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[2] Y. Luo, Proceeding of BES'98