Status Report of BEPC and BES

Zheng Zhipeng and Qi Nading

Center of High Energy Physics and Synchrotron Radiation, CCAST(World Laboratory) and Institute of High Energy Physics(IHEP), Academia Sinica, P.O.BOX 918, Beijing 100039
The People s Republic of China

1. FOREWORD

The October of 1988 may be a normal month for most of people in the world. For China, especially for Chinese experimental scientists, it is very different and extremely important. In that month, a new era in China's scientific history started. China became a new member of the high energy e^+e^- collider club. On 16th and 23rd of that month, the first e^+e^- collission at 1.6 Gev for each beam with peak luminosity of $4 \times 10^{27} cm^{-2} s^{-1}$ was realized in BEPC (Beijing Elelctron Positron Collider) and the first graphic display of cosmic ray was obtained by BES(BEijing Spectrometer), respectively. Now, the BES sits at the intersection point of the BEPC and is collicting data.

2. COMMISIONING BEPC AND BES

The project of the BEPC and the BES was approved by the Chinese government on April 24 of 1984. The construction began with the ground breaking ceremony on October 7, 1984. It took just four years that the BEPC and the BES were completed. Table 1 and 2 show the milestone of the BEPC and BES and the financial summary of the project, recpectively.

3. THE COLLIDER SYSTEM

Fig.1 shows a layout of the BEPC, which composed of a 202m long LANAC(electron preinjectior; positron generator; main accelerator of 1.5 GeV) and SR(Storage Ring) of circumference of 240 meter with 2

Table 1 Milestone of BEPC and BES

1981	Sep.	Project to build a collider of 3 - 5.6 GeV in China was approved.
1983	Apr.	Official approval of conceptual design.
1984	Apr.	The project was approved by Chinese Government.
	Jun.	The detailed design and budget were approved.
	Oct.7	Ground breaking ceremony. Civil eng. started.
1985	Jan.	The manufacture of BEPC and BES was kicked off (most of the builders were of Chinese company).
1986	May - Oct.	Main parts of the collider and the detector were placed to the construction site of IHEP, Beijing. Installation started.
1987	Feb.	Installation of the BEPC was mostly completed; commisioning its subsystems and then the whole system.
	May	Mapping of magnetic field of the BES.
	JUN.	Installation of the BES started.
	Nov.	Electron beam was obtained for the first time with the BEPC.
1988	Jul.	Positron beam was successfully stacked with 12 mA at 1.1 - 1.6 GeV.
	Oct.	Assembly of the whole detetor was completed.
	Oct.16	Realization of e^+e^- collision at 1.6 GeV ($4 \times 10^{27} cm^{-2} s^{-1}$) for the first time with the BEPC.
	Oct.23	The first graphic display of cosmic ray was obtained by the BES. The cosmic ray test continued until early Jan. of 1989.
	Oct.24	Mr. Deng Xiao-ping and other Chinese top leaders came to IHEP, look into BEPC, BES.
	DEC.	Realization of peak luminosity of $2 \times 10^{30} cm^{-2} s^{-1}$ with the BEPC.
1989	Apr. - May	The BES was moved into IP of the BEPC and came into operation and test; Bhabha events and other kind of events have been seen.

intersection points, only one of which in use now because one detector has been built due to the shortage of our budget. Table 3 and 4 summarize the main parameters of the LINAC and the SR.

Generally speaking, the performance of the BEPC is satisfactory, [1] as the designed requirements have all been met or close to. The accelrator people is still working on both of injector and storage ring for excellent running.

4. THE DETECTOR AND THE ANALYSIS SYSTEM

The BES is a general purpose magnetic spectrometer,[2] which sitting at the southern IP of the BEPC, was designed to provide particle identification and energy measurement. The philosophy of the BES is the followings:

— large solid angle coverage(96% of 4π for CDC, MDC and TOF; 93% for SC);

— good momentum resolution($\Delta p/p$ for MDC, when p = 1 GeV);

— good charged particle identification(time resolution 200 ps for TOF; space resolution 200 μm for MDC; etc);

— good efficiency for cutting of low energy photons(photon energy criterial of 100 MeV with approximate 100% efficiency).

Fig.2 is the schematic drawing of the BES.

The main parts of the BES are followings:

A beam pipe of thin aluminium has a wall thickness of 0.3 mm reinforced by 2 mm thick carbon fibre. The radiation length of the wall is about 10.4×10^{-3}. The outer diameter of the pipe is 15.4 cm.

The CDC(Central Drift Chamber) has a inner diameter of 18.8 cm, an outer diameter of 29.6 cm, and is 110 cm long. The solid angle coverage is 96% of 4π. There are four concentric layers of sense wires, each layer having 48 wires; they are offset by half a cell in alternate layers. Each sense wire is surrounded by six field wires positioned in hexagonal form. The design space resolution σ_x is about 150 *microns*.

The MDC(Main Drift Chamber) has an inner diameter of 31 cm, an outer diameter of 230 cm and is 220 cm long. Multi-sense-wire cell design is adopted. Each cell has four sense wires, and each wore is staggered alternately 350 *microns* from the mid-plane of the cell. This provides local left-right ambiguity resolution. Four hits or three hits within a cell

Table 3 Main Parameters of the BEPC Injector

Parameter	Value or Amount
Energy per beam	1.4 - 1.55 GeV
Beam energy spread σ_E/E	0.6 MeV
Beam current	1 - 2 A for positron production 0.2 A for electron injection
Bombarding energy for positron production	150 MeV
Positron yield (e^+/e^-)	0.02
Pulse duration	2.5 ns
Pulse repetition rate	12.5 - 50 pps
Operation frequency	2856 MHz
Number of klystrons	16
RF power/klystron	16 - 22 MW
Vaccum level	10^{-8} torr

Table 4 Main Parameters of the Storage Ring

Parameter	Value or Amount
Energy maximum per beam	1.5 - 2.8 GeV
Peak luminosity	$(5-17)\times 10^{30} cm^{-2}s^{-1}$
No. of particles	$(1.8-3.3)\times 10^{11}$
Revolution frequency	1.247 MHz
Circulating current/beam	65 mA
RF frequency	199.53 MHz
Overall beam lifetime	6.5 $hours$
Harmonic number	160
Peak RF voltage	1.35 MV
Total RF power	200 KW
Energy spread(RMS)	7.4×10^{-4}
The length of bunch(RMS)	5.2 cm
Horizontal natural emittance	0.66 $mm \times mrad$
Vaccum levle	10^{-10} torr
Control system	VAX11/750 computer

can give a small vector of track, which makes track reconstruction easier. The sense wires are 1 *cm* apart, and potential wires are placed between them in order to reduce crosstalk. Altogether there are ten layers. The solid angle coverage of the second layer is 96% of 4π. The number of cells per layer counted from the innermost layer is 48,48,60,48,58,68,78,88,98 and 108, for a total amount of 702 cells with 2808 sense wires. The total number of wires is 19380. the z measurement is obtained by stereowire layers. There are five axial layers and five stereo layers. Time information and dE/dx are measured simultaneously from each sense wire. The design space resolution σ_x is about 200 microns; σ_z is about 3 4 *mm*. Fig.3 shows the schematic drawing of the cell structure.

Time-Of-Flight counter(TOF)

The TOF system consists of a barrel TOF counter and two end-cap TOF counters, with solid-angle coverage of 76% and 20%, respectively. For the barrel TOF counter, we have 48 pieces of 5 cm thick NE110 scintilator, each of 15 $cm\times$ 284 *cm*. In order to get good time resolution, we have investigated the relationship between the light transmission efficiency of the scintilator and the thickness of it. For the barrel part(284 *cm* long), 5*cm* is the optimum thickness. The two end-cap TOF counters, made of 2.5 *cm* thick NE102A scintilator, comprise of 2×24 sections forming two disks, each with an inner diameter of 75 *cm* and an outer diameter of 211 *cm*. The photomultipliers used are of XP2020. The time resolution of the barrel TOF is 200 *ps*. For this time resolution and a flight distance of 1.17*m*, P ¡ 1.07 GeV/c for 2σ separtation of π/k and P ¡ 1.78 GeV/c for k/p separation. The time resolution of the end-cap TOF is 250 *ps*.

Shower Counter(SC)

This counter consists of 24 sandwich layer of aluminium-clad lead plate and gas-distance sampling counters. The total radiation length is 12 X_0. The self-squenching streamer discharge(SQS) mode is used for the gas-discharge counter, and the gas used is a mixture of argon(25%) + CO_2(50%) + n-pentane(25%). The output on 50 *Om* impedance is about 50mV; the signal is much bigger than from the proportional discharge mode, so the readout electronics are much simplified. One disadvantage is that the gas mixture is inflammable and harzardous.

The shower counter system consists of a barrel SC and two end-cap SCs. The solid angle coverage if 80% and 13%, respectively, and the expected energy resolution ΔE/E is about 15%$\sqrt{E}$(E in GeV). The z measurement is obtained by charge division, $\sigma_E < 5mm$ is expected. Each layer of the barrel SC consists of 560 cells, to a total of 13440. The end-cap

SCs have 24 layers and 190 cells/layer, totalling 9120 cells. In order to decrease the number of readout channels, some cells are grouped together. Thus the actual number of readout channels is 6720 for the barrel and 6840 for the end-cap.

Solenoid Magnet

The solenoid magnet is a conventional one with maximum field strength of 4.5 kG. It has an inner diameter of 348 *cm*, an outer diameter of 414 *cm*, and the length is 360 *cm*. Aluminium conductor of 52× 52 mm^2 cross-section with a hole of 27 *mm* diameter is used. The iron yoke is in three layers, the thickness of each layer is 12 *cm*, 14 *cm* and 14 *cm* counted from the inner one. The magnetic inhomogeneity in tracking area is less than 3%.

Muon Counter(MC)

Three layers of muon counter are placed on the three layers of iron yoke. Proportional mode is used. Each layer consists of two layers of staggered gas-discharge cells, each cell having a cross-section 60.9 *mm* wide and 50.8 *mm* high. The gas used is a mixture of 90% of argon and 10% of CH_4. The space resolution are as followings: $\sigma_r = \sigma_\phi = 3\ cm$ and $\sigma_z = 4.5\ cm$, the latter is obtained by charge division method.

Luminosity Monitor

The luminosity monitor consists of four pieces , two at each end of the beam pipe. Each piece consists of 24 *mm*× 76 *mm*× 3 *mm* of scintilator(called the P counter), 55 *mm*× 90 *mm*× 5 *mm* of scintilator(called the C counter), and 87 *mm*× 120 *mm*× 130 *mm* sadwich lead sheets and plastic scintilator shower counter(total 12 X_0)(called S counter). The P counter are placed nearest to the interaction point and used to detect the Bhabha scattering particle. the C counter are placed behind P counters and are used to detecte the other Bhabha scattering particle(recoil from the particle which enters the P counter at the opposite end of beam pipe). The S counter are used to measure the energy of the Bhabha event particle. The upper and lower limits of acceptance of the luminosity monitor are 73 mrad and 29 mrad, respectively.

Readout electronics and on-line data acquisition

The readout system adopted the folowing scheme: the signal from the detector, after it has been amplified or discriminated, is to be kept in a sample-and-hold circut converted(i.e.time signal converted into analog signal), and is to be read out later by a multiplexed intelligent ADC (i.e. the BADC of SLAC). The total number of readout channels of the BES is 19964. A VAX11/785 computer is used for on-line data acquisition. We follow the SLAC MarkIII on-line system with a VAX-CAMAC Channel(VCC).

Trigger

In order to reduce the dead-time, the BES trigger logic utilized two levels. the first-level decision for charge-particle events will used the TOF counters with a 30 *ns* time window for rejecting more than 96% of cosmic ray BG. The second-level, which has a decision time of less than two cycles is a fast programmabletrack-finding processor using RAM chips. Cell hits from the innermost four layers of the MDC are used for the track finding logic.

For the neutral events, we sum the signals from 24 radially aligned cells of the SC and use the corresponding radial energy deposit cut as a first-level decision. The second-level for the neutral events will use the total energy cut of SC and MC veto. for each level, a Boolean Logic Unit is used in the master trigger to allow up to 8 trigger modes and 16 input trigger conditions. Every input can be used as "must", "veto", and "don't care" in any mode. the trigger condition table can be loaded via CAMAC. The "OR" output will send out a master trigger signal.

Off-line Data Analysis System

The off-line software of the BES was begun to prepare after the BEPC+BES project has been approved. Now, a full off-line data analysis system has been established and used for analyzing cosmic ray and e^+e^- collision data. The off-line software has the functions which would treat raw data and carry on (1) fast filtering; (2) offline calibration; (3) event reconstruction; (4) DST(Data Summary Tape) making. The system consists of support software, which was rewritten from the similar packages of CERN, SLAC and other laboratories, and two source codes of SOBER(Simulation Of Beijing spectrometER) and DRUNK(Display and ReconstrUctioN Kit), all of which should be transformed into the format of PATCHY. The former does the work of drawing graphics, calculating math results, fitting functions and so on. The two latters are used for Monte Carlo simulation and for getting physics results. A VAX11/780, a VAX11/785 and a VAX8550 computers, placed in the computing center, are being used by off-line analysis. A VAX6330 computer will come in position late of the year.

5. SYNCHROTRON RADIATION FACILITIES

The synchrotron radiation facilities are now of building and close to be completed.

Synchrotron radiation research programmers are planned for both the parasitic mode and the dedicated operation mode of the BEPC. To meet the needs of the various disciplines, three beam ports, five beam lines, and seven experimental stations are planned in the first phase of construction. Those stations are for X-ray topography, medical research, EXAFS, small angle scattering and diffration, photoemission spectroscopy, and point like defects in crystals. In April of 1989, bright synchrotron light was observed at three photon beam ports of synchrotron radiation experimental hall. The UHV focusing synchrotron radiation beam line H4B9A-VUV first time provide its light to experiment station.[3] Fig.4 shows the layout of the synchrotron radiation experimental hall.

6. THE COSMIC RAY TEST WITH BEIJING SPECTROMETER

When the detector BES was ready to operate, the collider BEPC was in commisioning beam. Both BEPC and BES need to be checked out in the same time. For the sake of checking out our detector and analysis software, we did a cosmic ray test.[4] The first graphyic display was obtained on Oct.23,1988(see Fig.5). Afterwards, 45K(full COSMIC trigger) and 39K (the same trigger without central scintilator) events were collected. The cosmic ray test has been done well. The event rate was $0.7/second$. A lot of information about our detector were learned. The whole system(probes, amplifiers, discreminators, readout electronics, CAMAC, etc) works satisfactorily. Some problems of the detector have been found and fixed. More efficient detecting enviroment can be expected.

7. THE PHYSICS GOAL IN OUR LABORATORY

There are a lot of interesting physics problems in the region of cms energy of 3 5.6 GeV. That region has been scanned and studied by SPEAR, DORIS and other machines and many problems have been solved by MarkIII, DM2 and other experimental groups. But there are still so many unanswered and inconsistent questions in there that the BEPC and the BES can make helps.[5] A present proposal[6] on building a τ - charm factory confirm that the choice of the BEPC on the energy range of 3 - 5.6 GeV was correct. Some of the most prominent problems in physics at that energy range are described below.

(a) The determination of the glueball and hybrid is the unique prediction of QCD and there were already a number of states observed in J/ψ decays which are thought to be glueball candidates, such as $\iota(1460)$, $\theta(1730)$. Furthermore, there is still a discussion about $\xi(2230)$. The very existance of $\xi(2230)$ is controversial. If it does exist, what kind of particles is it? Is it another glueball? Radiative J/ψ decay provides the best window on glueball and hybrid. With high statistics, the quantum number and the decay properties can be investigated in great details and unprecedented precision by the BES. We hope that the study at the BES would make some progresses of determining their nature.

(b) The decay of charmed mesons(D^0, D^+ and D^-) is one of the major subjects to be studied by the BES group, such as leptonic decay constant of D^0 and $D^{\pm}$, non-leptonic decay channels, cabbibo favored and suppressed channels and so on.
BES, which is working at the comparatively "low" energy collider, is possibly able to make the physics discoveries pointing beyond the standard model. One of the examples at the moment is $D^0\overline{D}^0$ mixing – that is a quantity which is small in the standard model. It is difficult to accumulate enough data to make a significant measurement, although present experiments are approaching the appropriate level. By the same token, this is a good place to look for new physics. Where the standard effects are small(or even better, zero) is precisely where some new effects might stand out.[7] Another example is the measurement of $c \to d\nu e$ as compared to $c \to s\nu e$ decays. Such measurements, if done accurately and combined with theoretical analysis, will permit the extraction of the ratio of KobayashiMaskawa matrix elements V_{cd}/V_{cs}, if not their separate absolute values. This allow a check of unitary of the three generation matrixusing its second row.

(c) So far, the study on the properties of D_s meson is only in the early stage. There is not much of hadronic D_s decay events obtained and no any of semileptonic and Cabbibo suppressed D_s decays have been seen yet. Further study strongly depends on how many D_s events can be accumulated. The best energy region to find D_s in e^+e^- annihilation was believed as in the energy range of 4.03 4.16 GeV. The measurement of D_s at the BES will gain insight into the dominant decay mechanism of the charmed mesons and other properties. The BES also has the better chance to make the mass measument of D_s more accurate.

(d) The discrepancy between the inclusive BR of τ lepton and the sum of its exclusive BR of final states containing one charged particle used to be puzzling people. The explaination of the discrepancy has grown up theoretically. But some of experimentalists consider that the leptonic BR of τ measured might not be right;[8] The mass of τ which is dominated by the results of DELCO paper may be imprecise[9] because in the same DELCO paper the BR of 3-prong τ decay was so big that which is far away from the recent world average. The BES has the chance to solve those doubts. The condition for measuring the τ mass in the BEPC is much better than anywhere due to its energy spread, high luminosity and the BES is the sole detector which uses the beam of BEPC. The semi-leptonic BR of τ can also be measured by BES.

(e) One needs to accumulate high integrated luminosity to provide so many τ events that its 3 - (5 -) prong decay mode can be used for getting more stringent limit on the mass of τ neutrino and that help to search for unusual couplings and decays of τ.

(f) To study precisely the charmonium spectrum, especially to find the charmonium state of 1^1P_1 $(J=1)$.

(g) To measure the decay channels of charmed baryons(Λ_c, Θ_c, etc) which is now only at the beginning stage. Some of preliminary results of Λ_c, Θ_c and others were anounced recently. Most of charmed baryons need to be investigated experimentally. BES is one of the excellent experimental arenas.

(h) BES will study the behavior of

$$R = (e^+e^- \rightarrow hadrons)/(e^+e^- \rightarrow \mu^+\mu^-),$$

especially in the region of 4 - 4.5 GeV where clarification of the $c\bar{c}$ spectrum could be useful.

With many interesting and important physics project, the BES can be expected to make some important contributions to particle physics.

There are several cms energy to be choosen. A decisive arrangement is as below.

— Firstly, we would study the production and decay of J/ψ particle with setting cms energy at 3097 MeV and collecting 2×10^7 J/ψ events which will top that of MarkIII (5.8×10^6) and of DM2(8.6×10^6). Three months should be spent with the peak luminosity of $2 \times 10^{30} cm^{-2}s^{-1}$.

Table 5
Some Parameters of "Low" Energy colliders

Name of collider	SPEAR	DORIS	DCI	BEPC
Energy spread(MeV)	1.7	1.0	1.4	0.6
Beam length(cm)	2.6	3.0	19	3.0
Peak luminosity ($10^{30}cm^{-2}s^{-1}$)	0.5	0.3	1.3	2.0

— Secondly, the machine energy will be moved to the ψ' (3770) region and study the D^0 and $\overline{D}^0$ and their mixing.

— One years later, the ψ"(4050) energy will be chosen for the machine next. D_s and $\overline{D}_s$ will be studied.

—When the cms energy raises above 3500 MeV, the study of τ begins.

— In the region approaching the machine's maximum energy, we study the Λ_c, Θ_c and other charmed baryons. This will be in the comparatively late time.

— Finally, the machine energy will be back to 3097 MeV and we would like to collect $10^8 J/\psi$ and might answer the questions about glueball, hybrid and other puzzles.

8. SUMMARY

As a result of the Chinese open and reform policy, our own collider has been built, which has high luminosity and small energy spread. Thus we can do experiments at best place of energy range 3 5.6 GeV in the world for five years. See Table 5 and Fig.6 to make a comparison of BEPC with others.

The detecor BES was modelled on the MarkIII and has been enhanced by the following:

(a) End-cap TOF scintilators with 20% solid angle coverage have been added;

(b) The dE/dx sampling of MDC bas been increased by a factor 2.7 on the basis of the MarkIII;

(c) The SQS version has been choosen for SC, which greatly raises the amplitude of output. So the preamplifier would not be needed. The structure of 560 cells(MarkIII has only 320 cells) per layer inside SC provides better space resolution of 4.5 mrad (7 mrad for MarkIII).

(d) One more MC layer has been added, which would provide a better muon identification with lower momentum cut(500 MeV/c).

Those improvements will make higher particle decting accuracy and environment in the studies of charm and τ physics. The data taking already started. We will show our first physics results soon.

9. ACKNOWLEDGEMENT

In preparing this report, we have drawn on the work of many of our colleagues(IHEP, Academia Sinica). We would like thank Ye Ming-han, Fang Shou-xian, Chen Sen-yu, Huang Tao and those who were involved in building the BEPC and the BES. Thanks to the organizers of this conference who provided for a inspiring, lively, and last but not least, nice working atmosphere in the beautiful Tsukuba-shi.

We greatly approciate all the help from the world high energy community. The PRC/US Joint Committee for HEP has contributed a lot from very beginning of the project to now. Special thanks to SLAC for the whole information about SPEAR and MarkIII with which we have built the two similarities successfully. We also thank KEK which is kindly providing the beam for testing our prototype drift chamber, SC and luminosity monitor. We and our colleagues are deeply grateful to Professor T.D.Lee without whose painstaking efforts our project could have hardly moved, as well as to Professor W.K.H.Panofsky, who has been giving us much important helps and advise.

Our project was totally supported by Chinese Governmenmt which made our dream come true.

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Fig.6 The luminosity of working colliders.

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References:

1. General Introduction to BEPC, Fang Shou-xian, Invited Talk at Seoul, South Korea(Feb.27,1989)
2. BEPC, The Beijing Electron-Positron Collider, Ye Ming-han and Zheng Zhi-peng(presented by Wu Wei-min), Proc. of the Inst. Europhysics Conference on HEP, Uppsala, Sweden, June 25 - July 1, 1987, 622.
3. BEPC News, Volume 2, No.2(April 1989).
4. Report on Research and Production of BES, General Detector. IHEP, Academia Sinica, March 10,1989(in Chinese).
5. Physics in BES, Huang Tao, Proc.of Charm Physics, Beijing, PRC(1987).
6. A τ Charm Factory at CERN, J.Kirkby, CERN-EP/87-210.
7. Introduction to Charm and Heavy Quark Physics, F.J.Gilman, Proc.of Charm Physics, Beijing, PRC(1987).
8. Decay of the tau lepton, P.R.Burchat, SLAC-292(1986).
9. K.K.Gan, Private communication letter with Nading Qi(Sep.1988).

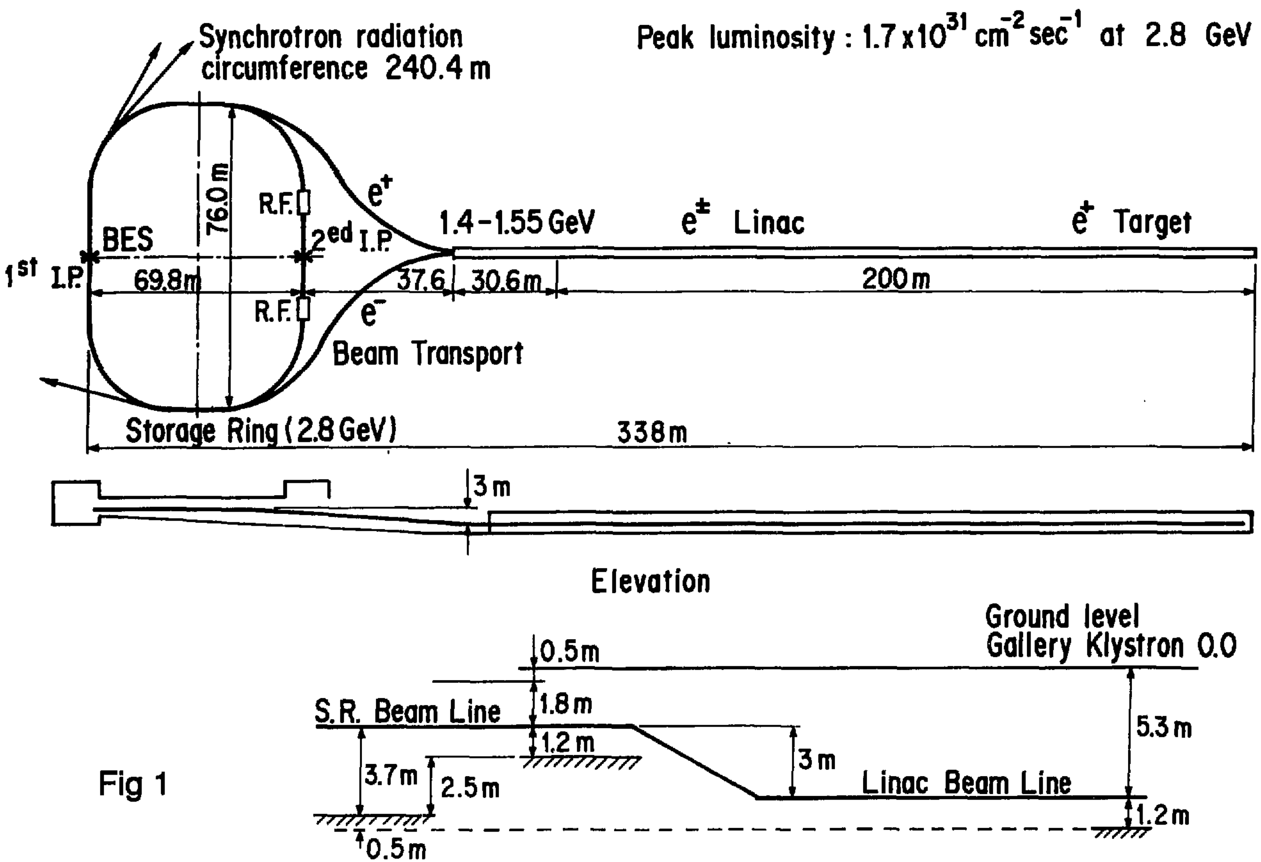
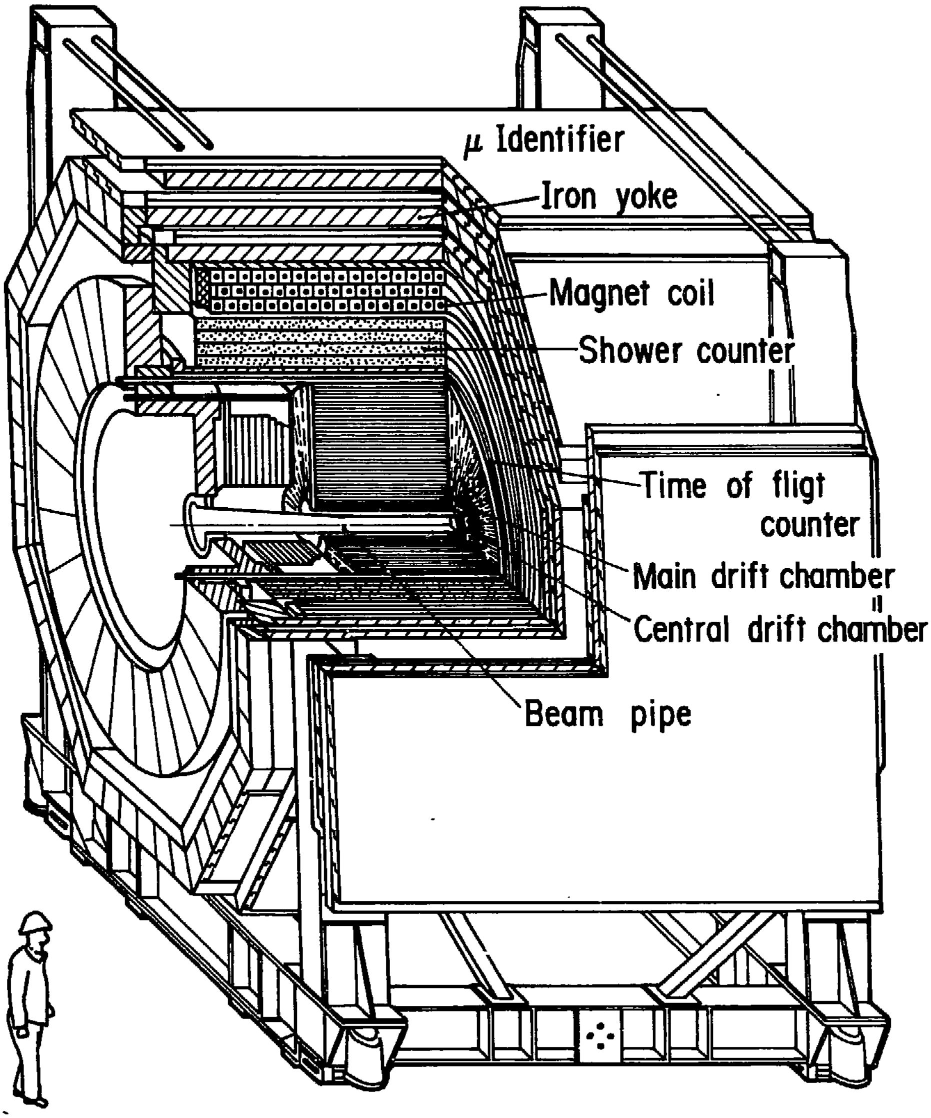

Synchrotron radiation
circumference 240.4 m
Peak luminosity : 1.7 x 10^31 cm^-2 sec^-1 at 2.8 GeV
76.0 m
R.F.
e+
BES
2ed I.P.
1.4-1.55 GeV
e± Linac
e+ Target
1st I.P.
69.8 m
37.6
30.6 m
200 m
R.F.
e−
Beam Transport
Storage Ring (2.8 GeV)
338 m
3 m
Elevation
Ground level
Gallery Klystron 0.0
0.5 m
1.8 m
S.R. Beam Line
1.2 m
5.3 m
3 m
3.7 m
2.5 m
Linac Beam Line
1.2 m
0.5 m

Fig 1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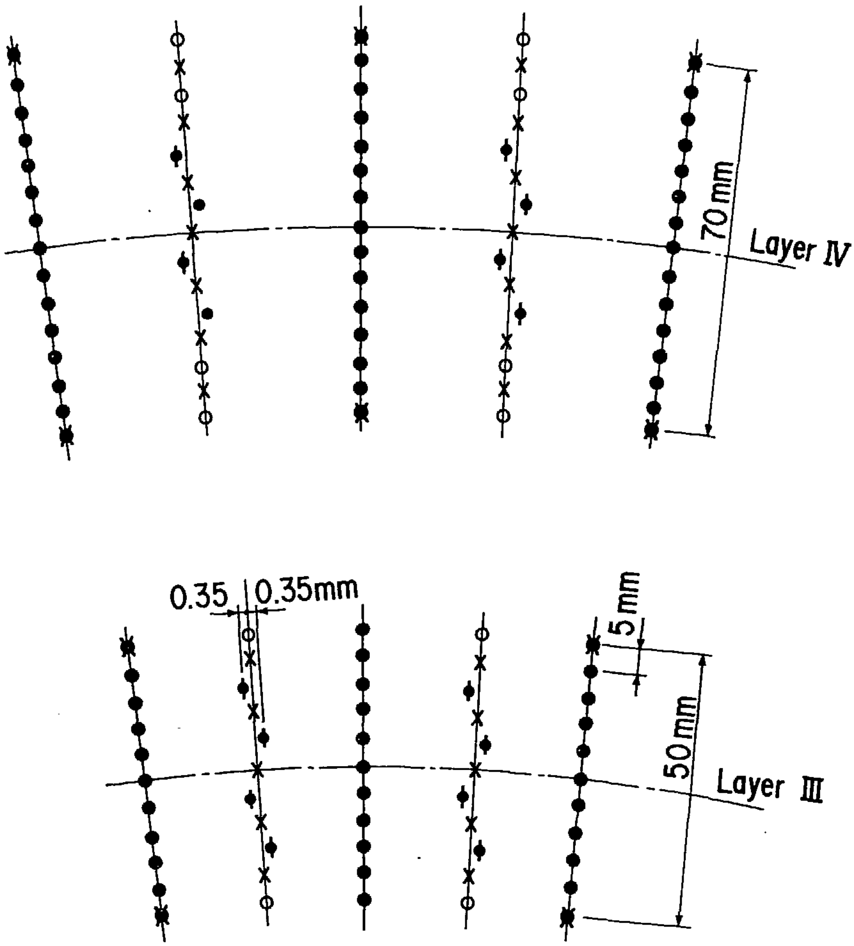
Iron yoke
Magnet coil
Shower counter
Time of fligt
counter
Main drift chamber
Central drift chamber
Beam pipe

Fig 2



•	sense wire	φ 30 μm	W	0 V
x	potential	φ100 μm	BeCu	~−1.5 kV
o	guard	φ100 μm	BeCu	−(200~350) V
•	field	φ178 μm	BeCu	−(4.0 ~ 4.5) kV
✱	thick field	φ220 μm	BeCu	−(4 0 ~ 4.5) kV

Fig 3

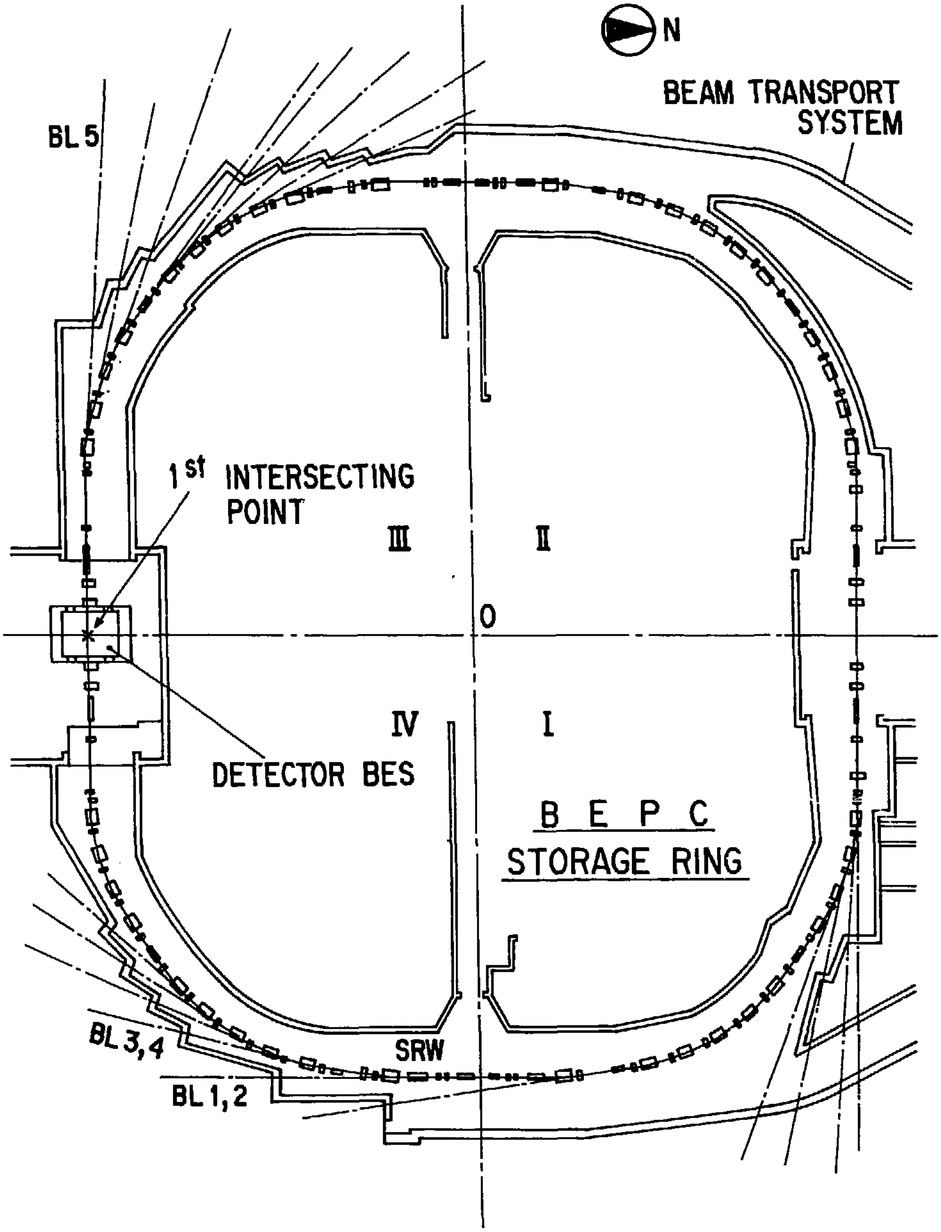
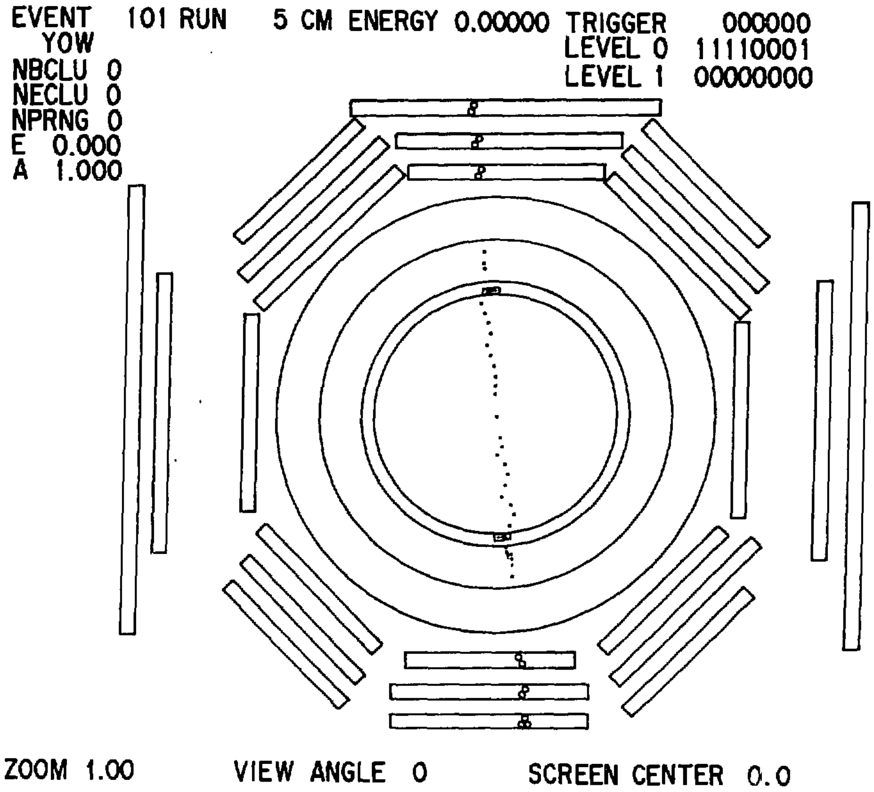

N
BEAM TRANSPORT
SYSTEM
BL 5
1st INTERSECTING
POINT
III
II
O
IV
I
DETECTOR BES
B E P C
STORAGE RING
SRW
BL 3,4
BL 1,2

Fig 4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YOW
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LEVEL 1 00000000
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NECLU 0
NPRNG 0
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ZOOM 1.00
VIEW ANGLE 0
SCREEN CENTER 0.0

Fig 5

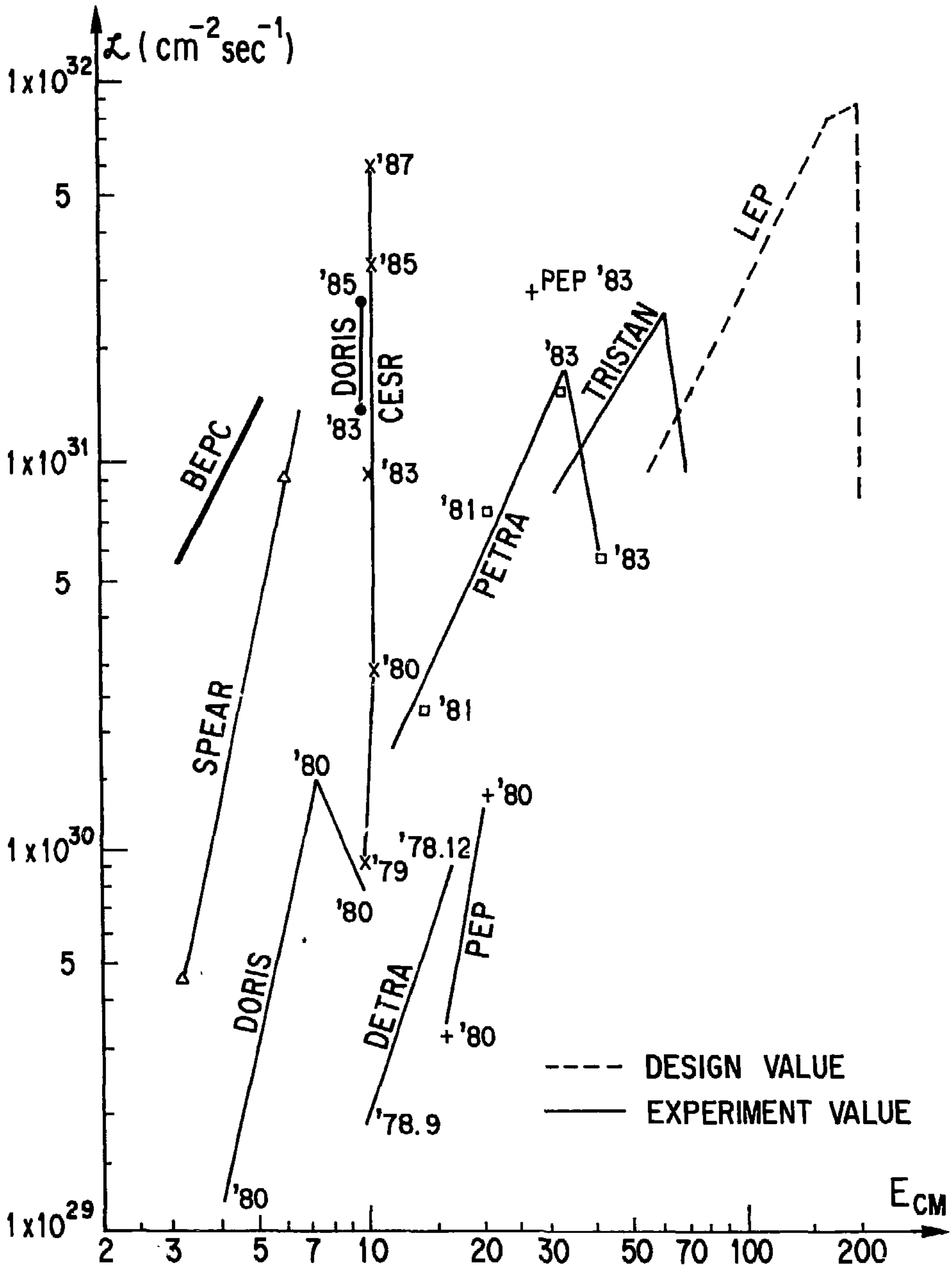
ℒ (cm⁻² sec⁻¹)
1x10^32
5
1x10^31
5
1x10^30
5
1x10^29
2
3
5
7
10
20
30
50
70
100
200
E_CM
x'87
x'85
'85
DORIS
CESR
'83
x'83
BEPC
SPEAR
+PEP '83
'83
TRISTAN
LEP
'81
PETRA
'83
x'80
'81
'80
'80
x'79
'78.12
+'80
PEP
DORIS
DETRA
+'80
'78.9
'80
DESIGN VALUE
EXPERIMENT VALUE

Fig 6