Results and Future Plans from BESII/ BEPC

Zhengguo ZHAO
IHEP of CAS, Beijing for

I Status

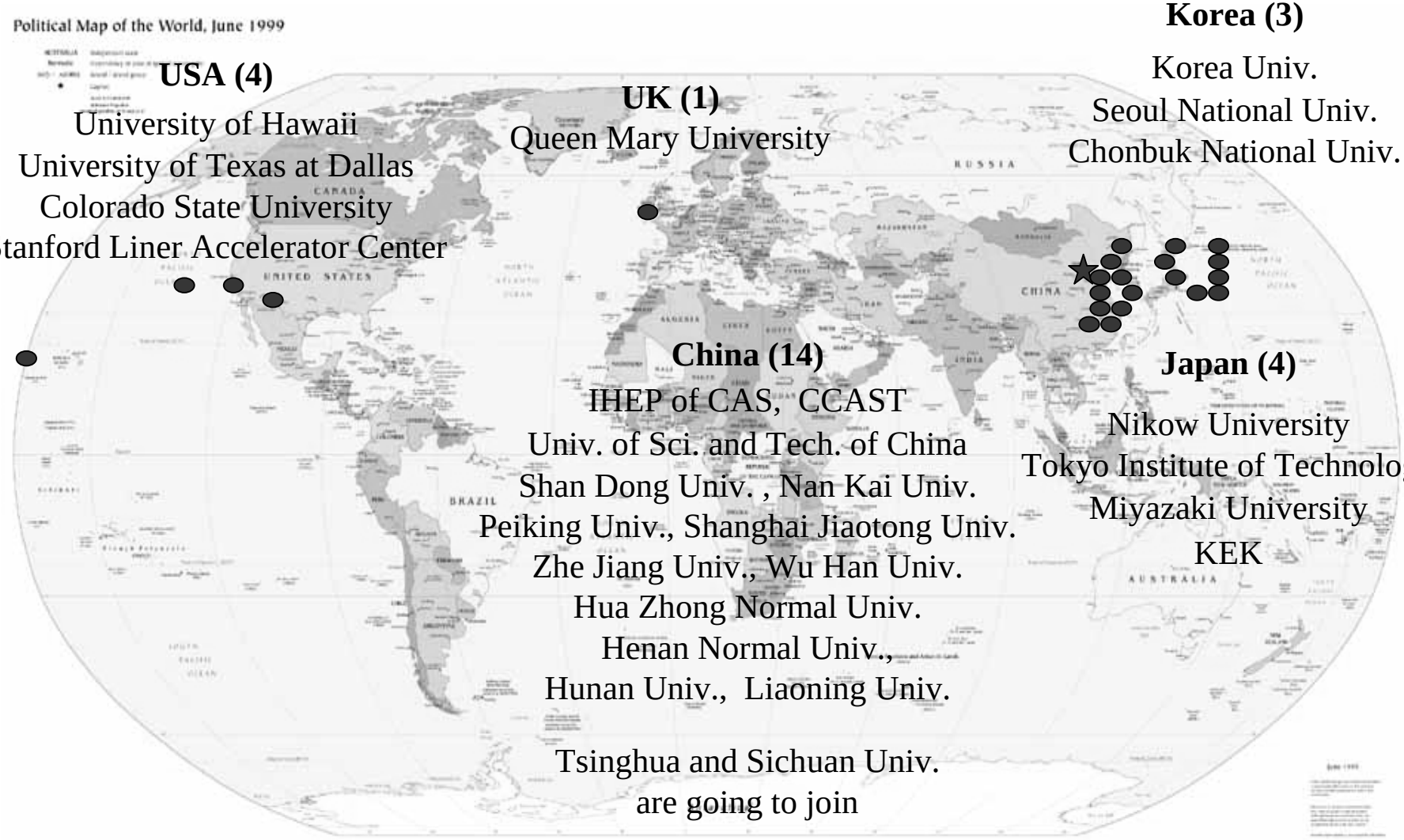
II Recent Results

III Future Plans

IV Summary

e^+e^- Physics at Intermediate Energies Workshop, SLAC, April 29-May, 2001

The BES Collaboration



USA (4)

University of Hawaii
University of Texas at Dallas
Colorado State University
Stanford Liner Accelerator Center

UK (1)

Queen Mary University

Korea (3)

Korea Univ.
Seoul National Univ.
Chonbuk National Univ.

China (14)

IHEP of CAS, CCAST
Univ. of Sci. and Tech. of China
Shan Dong Univ. , Nan Kai Univ.
Peiking Univ., Shanghai Jiaotong Univ.
Zhe Jiang Univ., Wu Han Univ.
Hua Zhong Normal Univ.
Henan Normal Univ.,
Hunan Univ., Liaoning Univ.

Tsinghua and Sichuan Univ.
are going to join

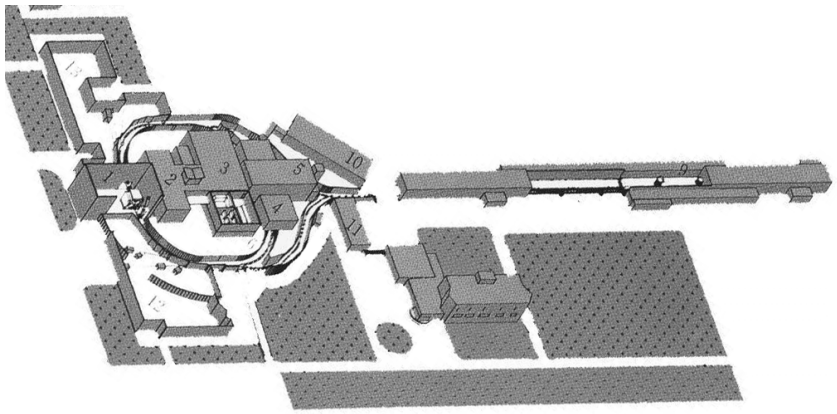
Japan (4)

Nikow University
Tokyo Institute of Technology
Miyazaki University
KEK

The Beijing Electron Positron Collider

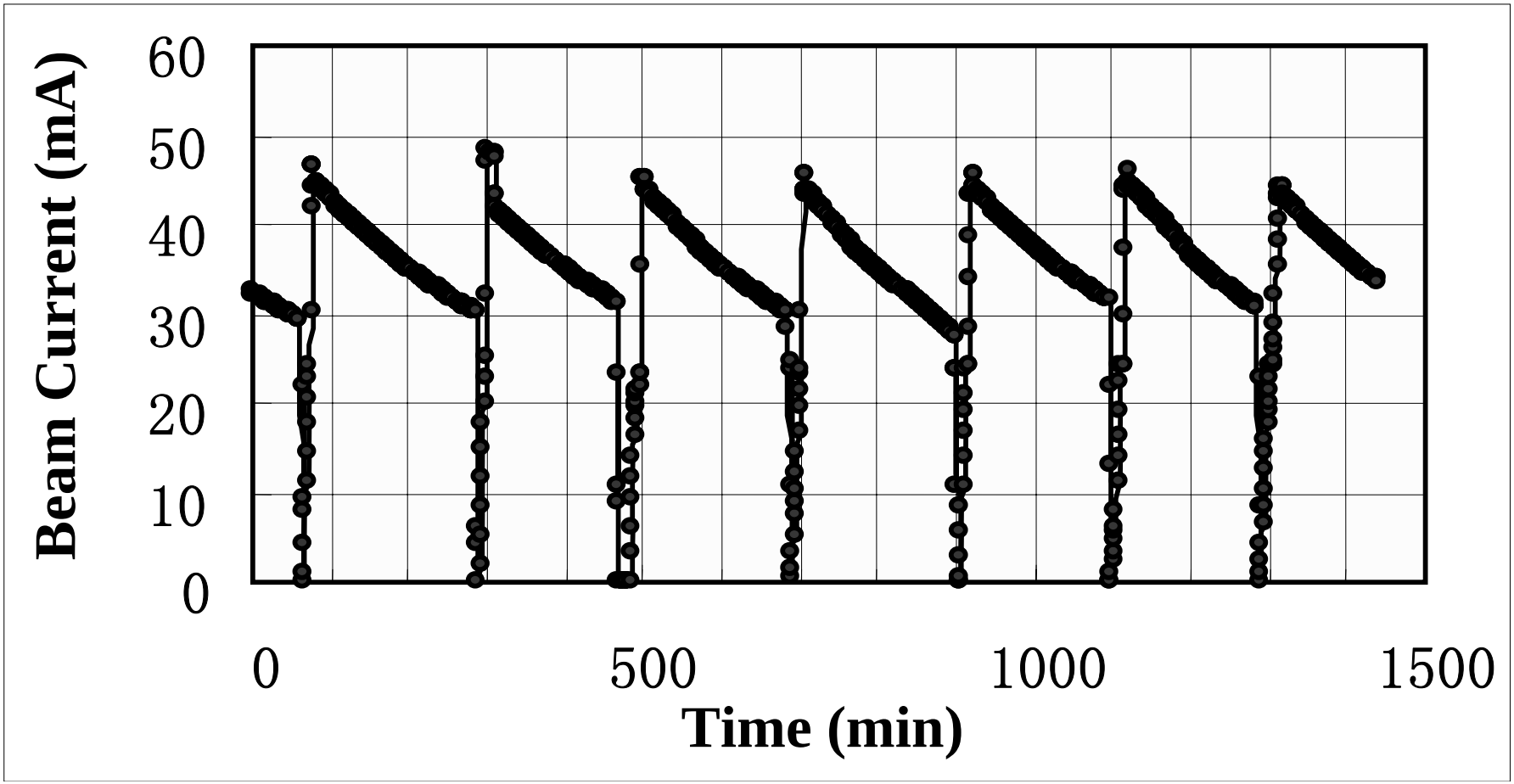
A unique e^+e^- machine operating in 2-5 GeV since 1989.

$L \sim 5 \times 10^{30}/cm^2 \cdot s$ at J/ψ peak E_{cm}~2-5 GeV



Daily J/ψ operation of BEPC

Period	Days	Beam time (hrs.)	J/ψ events	$L_{max}(10^{30}cm^{-2}\ s^{-1})$	τ(hrs)
99-00	142	2323	24 M	~4	8-10
00-01	110	1900	25 M	~5	8-10

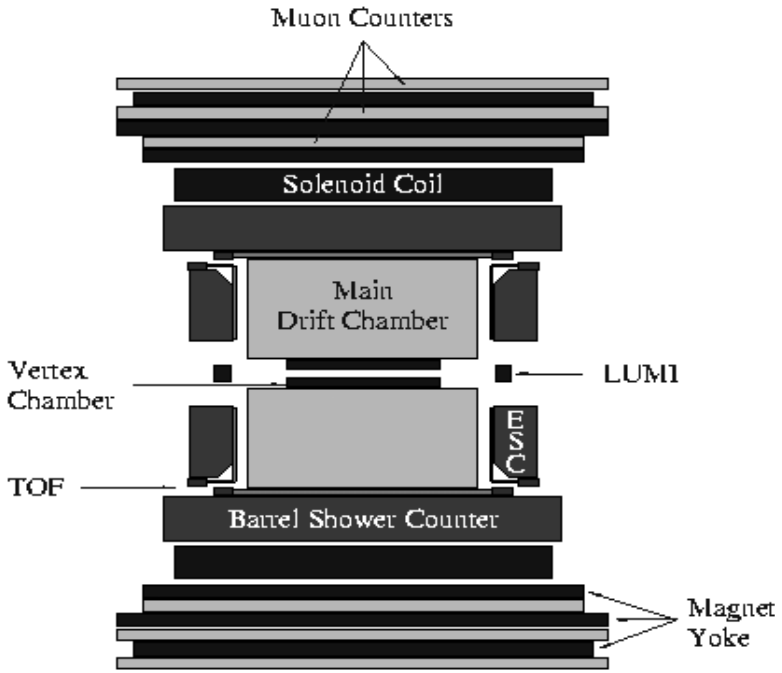


BEPC Beam Time Distribution

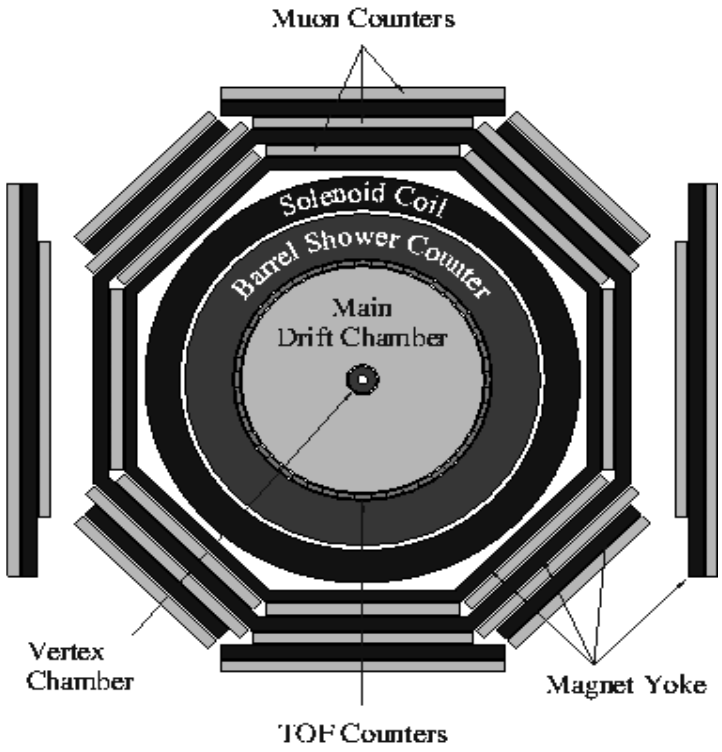
Unit: month

HEP	SR	BEPC	Summer maintenance
5	3	1.5-2	2.5-2

BESII Detector



Side view of the BES detector



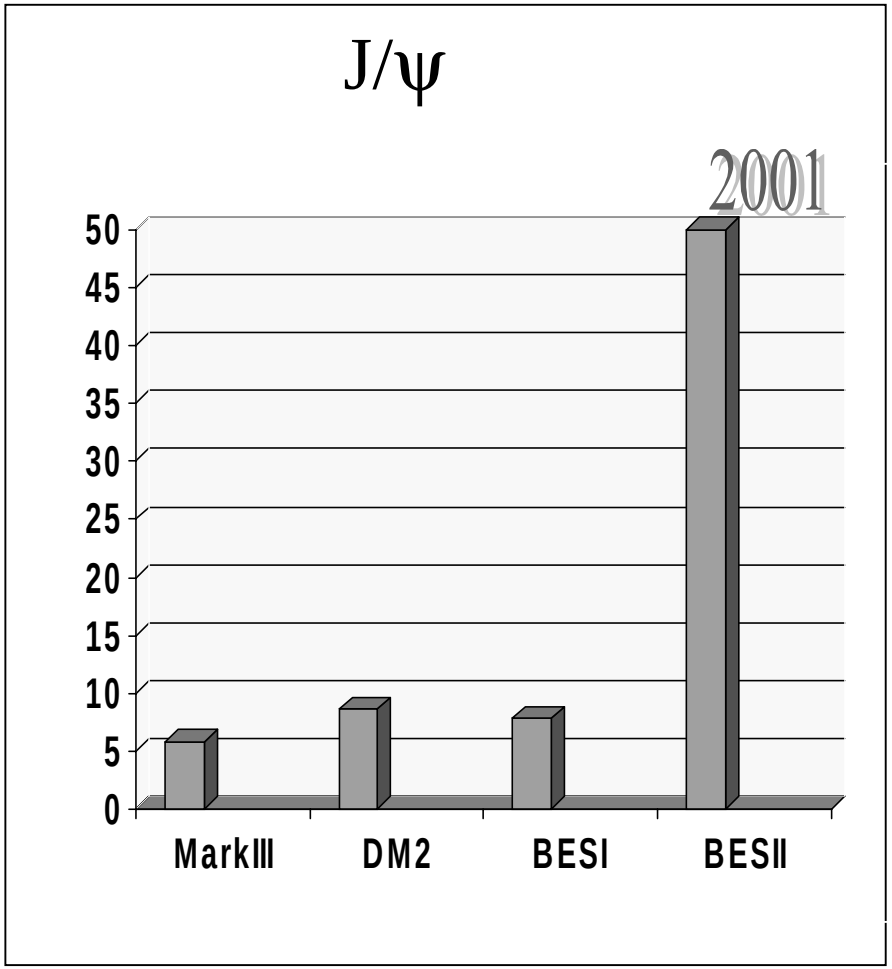
End view of the BES detector

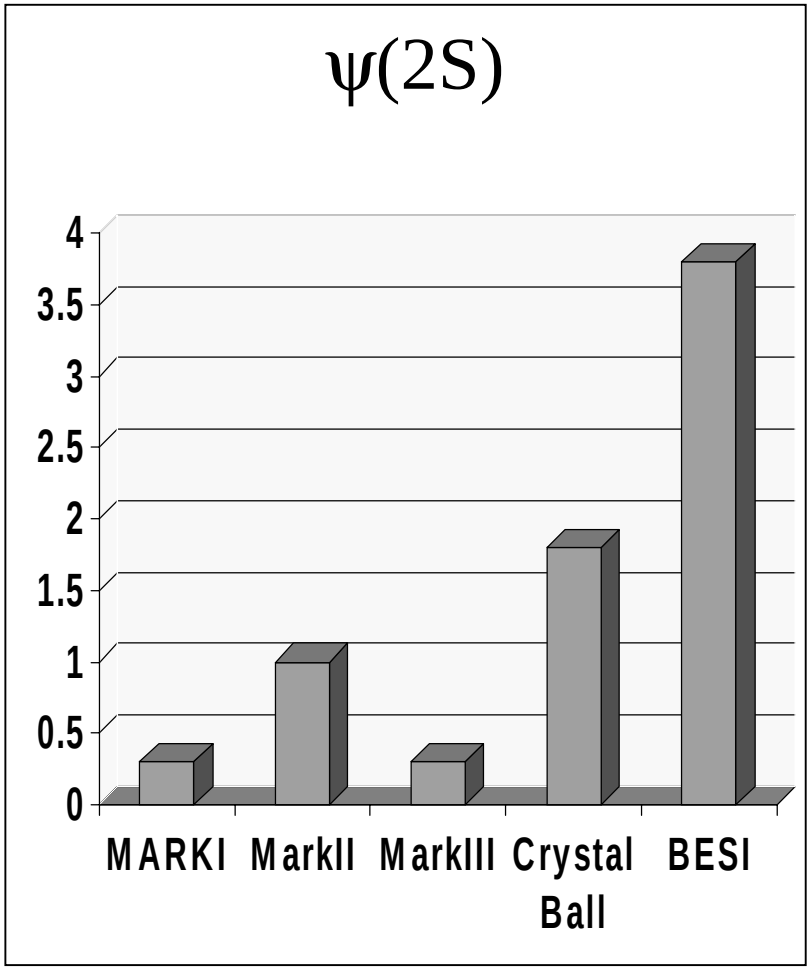
VC: σ_{xy} = 100 μm	TOF: σ_T = 180 ps	μ counter: $\sigma_{r\phi}$ = 3 cm
MDC: σ_{xy} = 200 μm	BSC: $\Delta E/\sqrt{E}$ = 22 %	σ_z = 5.5 cm
$\sigma_{dE/dx}$ = 8.4 %	σ_ϕ = 7.9 mr	B field: 0.4 T
$\Delta p/p = 1.8\sqrt{(1+p^2)}$	σ_z = 2.3 cm	Dead time/event: 10 ms

Data Collected with BESI and BESII

E_{cm} (GeV)	Physics	BES	Other Labs
3.1	J/ψ	7.8×10^6	8×10^6
3.69	ψ(2S)	3.9×10^6	1.8×10^6
4.03	τ	1×10^3	10^6 (LEP)
4.14	D, $D_{s,}$	22.3 pb^{-1}	CLEO
3.55	m_τ	5 pb^{-1}	
2-5	R scan	6+85 pts	γγ2, MarkI, Crystal Ball, Pluto…
3.1	J/ψ	5×10^7	

World J/ψ and ψ(2S) Samples (/10^6)



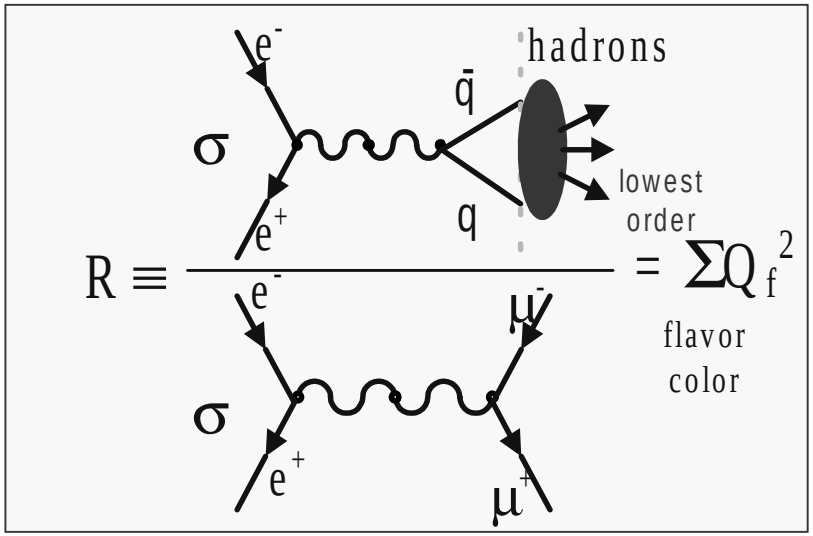


Recent Results from BES

- R Scan in 2-5 GeV
- Charmonium physics
  - Results from J/ψ data
  - Results from ψ(2S) data

Definition of R

R: one of the most fundamental quantities in particle physics



Experimentally

$$R = \frac{1}{\sigma_{\mu+\mu-}} \cdot \frac{N_{had} - N_{bg}}{L \cdot \varepsilon_{had} \cdot (1+\delta)}$$

N_{had}: observed hadronic events

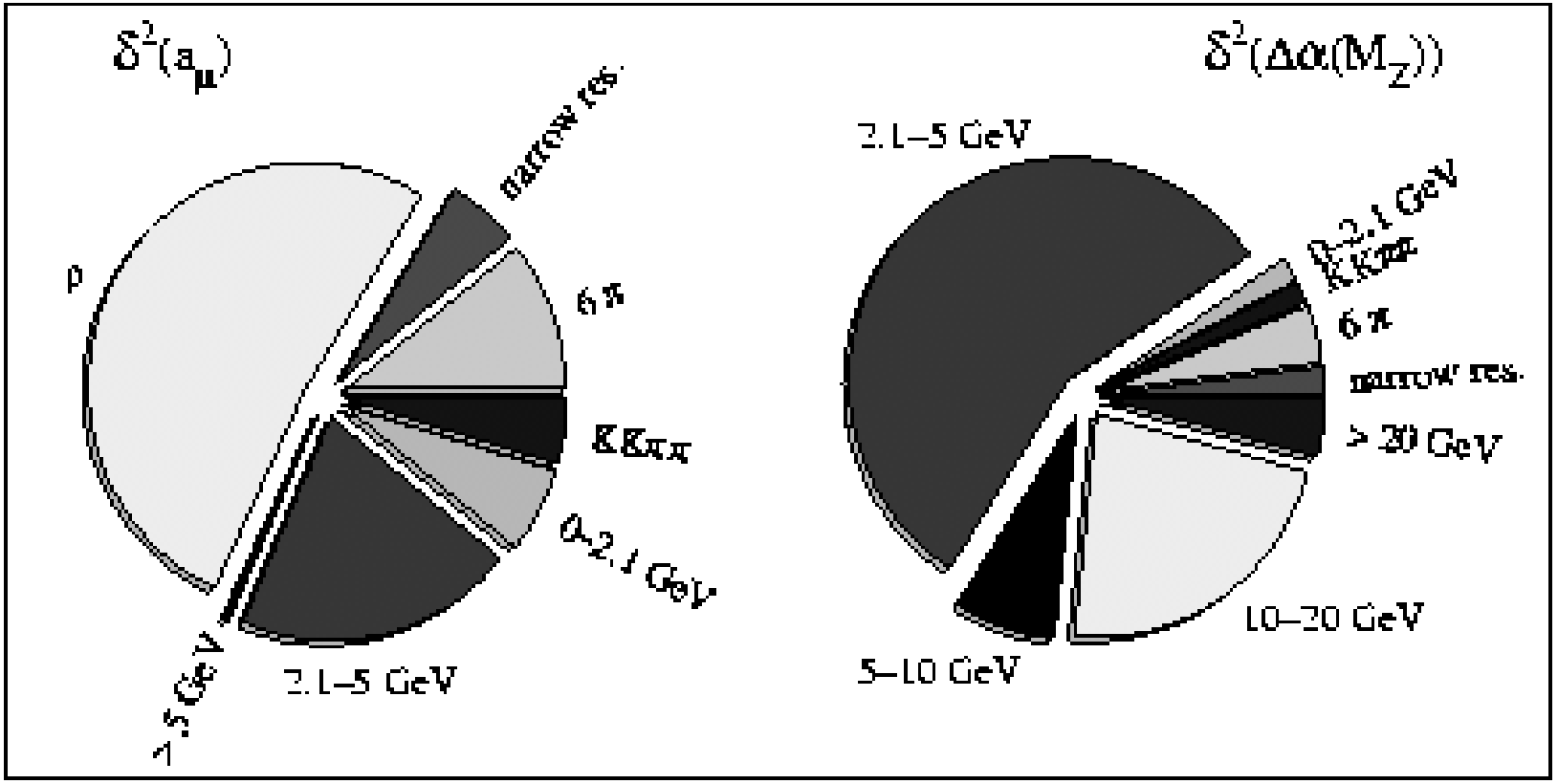
N_{bg}: background events

L: integrated luminosity

ε_{had}: detection efficiency for N_{had}

δ: radiative correction

Relative Contributions to the Uncertainties of a_μ and $\alpha(M_Z^2)$



BES R Scan in 2-5 GeV

March-May, 1998:

- 6 energy points

  at 2.6, 3.2, 3.4, 3.55, 4.6, 5.0 GeV

Feb.- June, 1999:

- 85 energy points at 2.0-4.8 GeV

  + 24 points separated beam operation

  + 7 points single beam operation for both e^+ and e^-

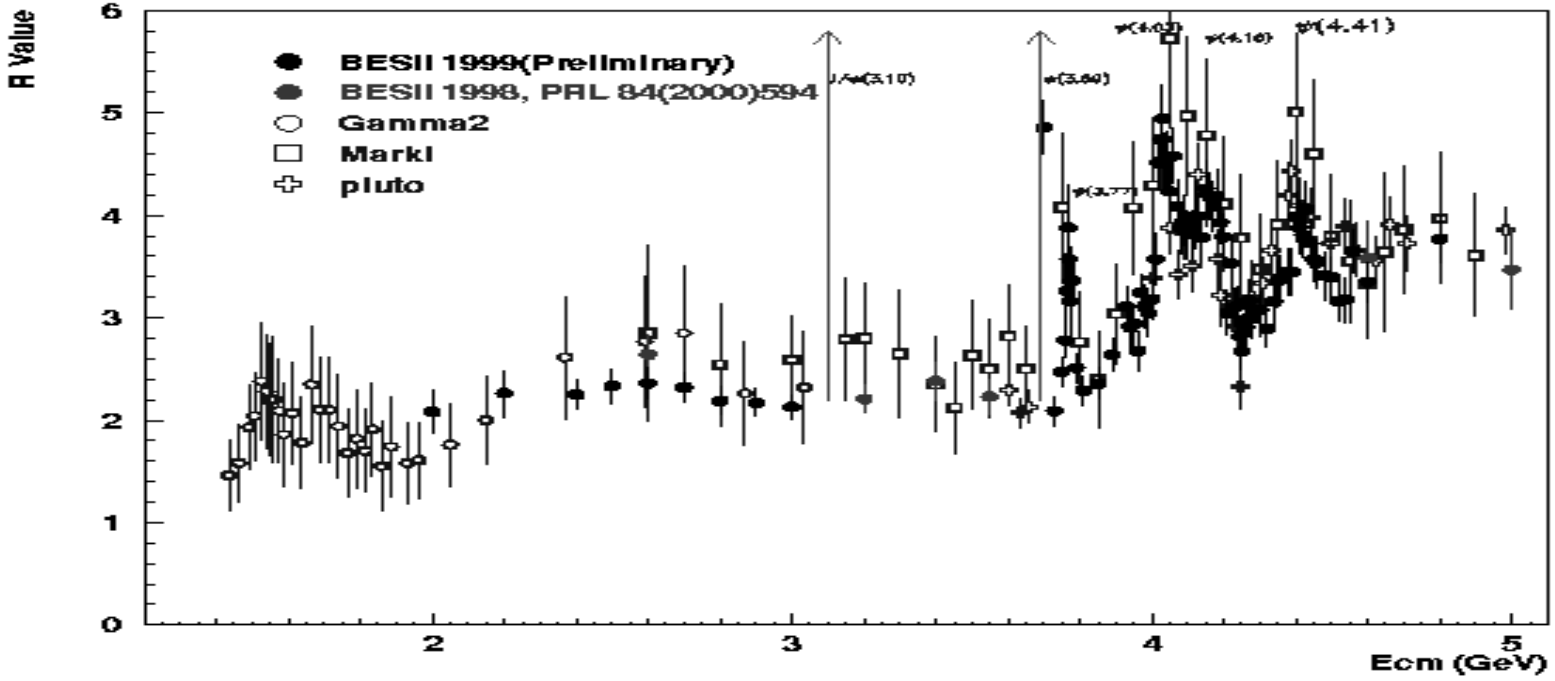
Some Values at a Few Typical Energy Points to Determine R

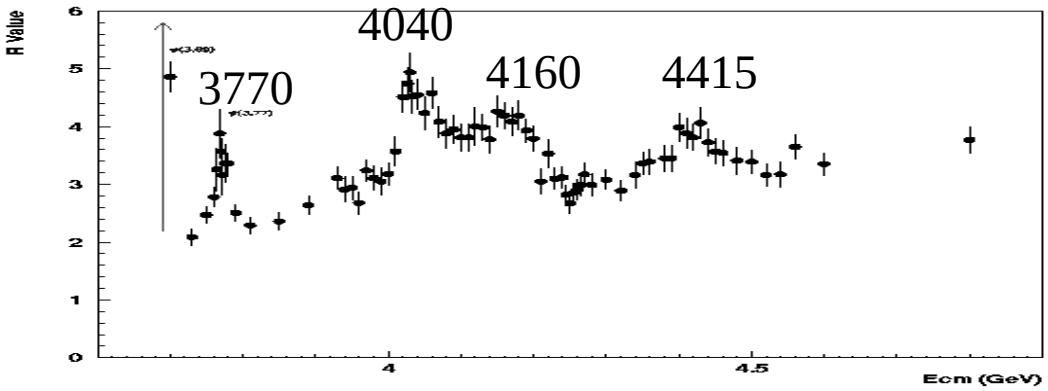
E_{cm}(GeV)	N_{had}	$N_{\ell\ell}+N_{\gamma\gamma}$	L(nb^{-1})	ε_{had}(%)	1+δ
2.0	1155.4	19.5	47.3	49.50	1.024
3.0	2055.4	24.3	135.9	67.55	1.038
4.0	768.7	58.0	48.9	80.34	1.055
4.8	1215.3	93.6	84.4	86.79	1.113

Systematic Errors (in %) at a Few Typical Energy Points

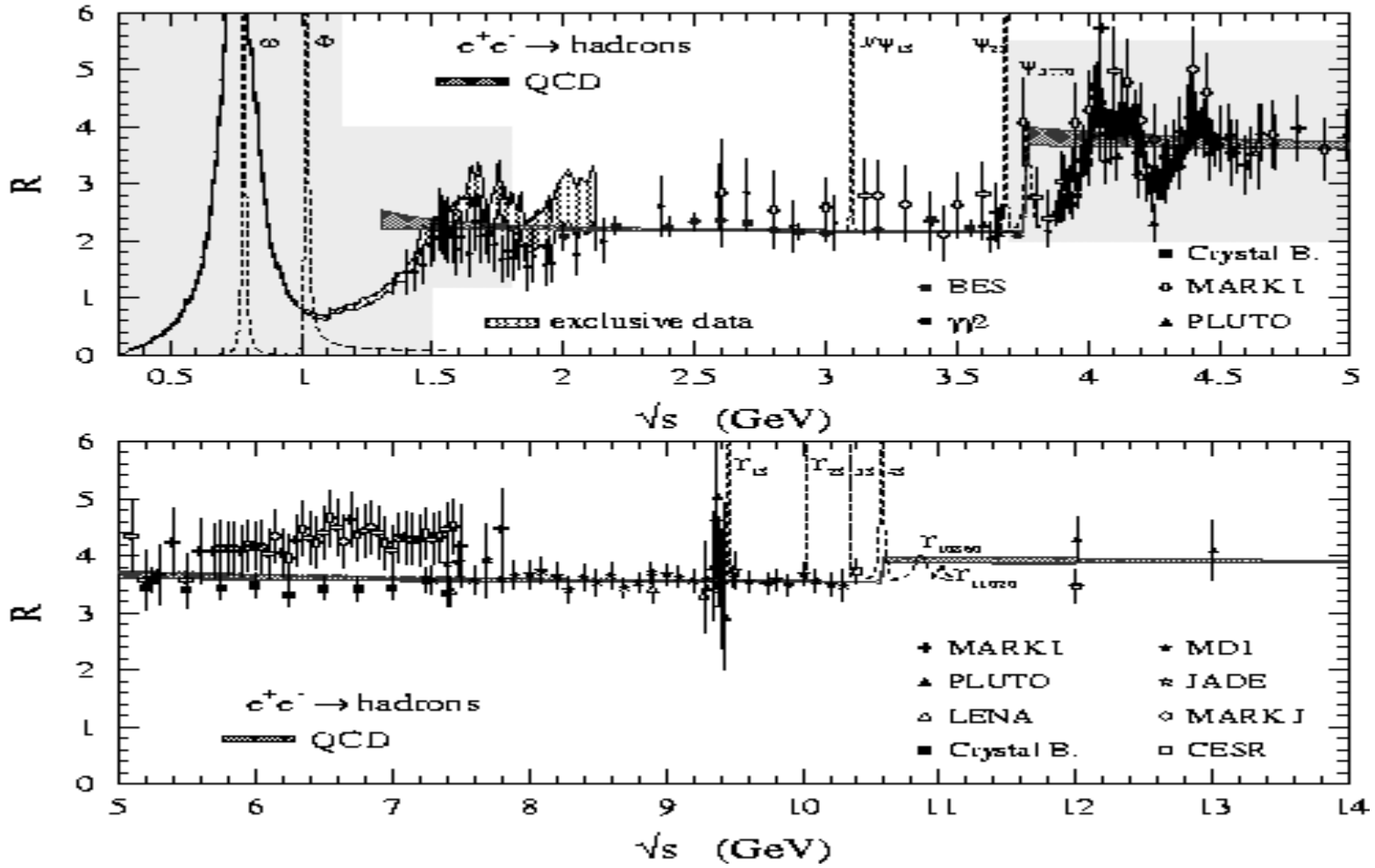
E_{cm}(GeV)	δN_{had}	$\delta\,\varepsilon_{triiger}$	$\delta L(nb^{-1})$	$\delta\,\varepsilon_{had}$	δ(1+δ)	Total
2.0	7.07	0.5	2.81	2.62	1.06	8.13
3.0	3.30	0.5	2.30	2.66	1.32	5.02
4.0	2.64	0.5	2.43	2.25	1.82	4.64
4.8	3.58	0.5	1.74	3.05	1.02	5.14

R Values in 2-5 GeV





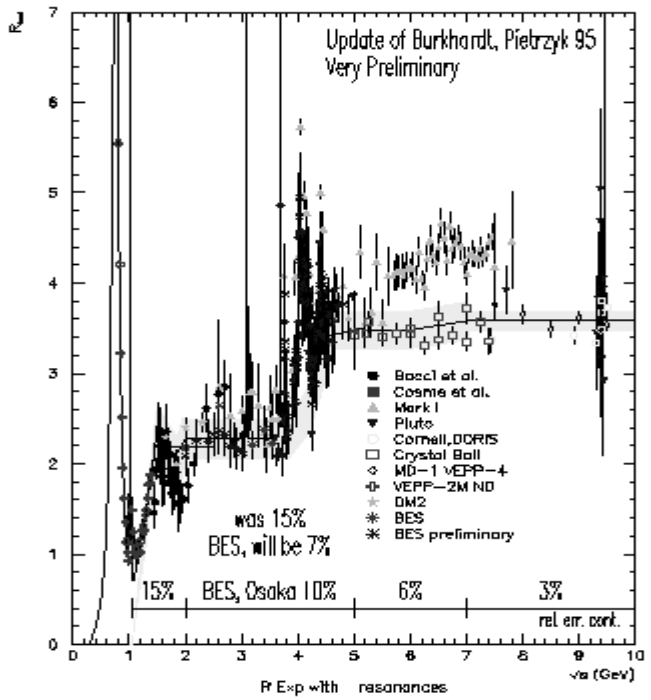
Experimental R-value Below 5 GeV and QCD Calculation



QCD calculation (M. Davier et al.) in 2-3.6 GeV agree well with our data

The Impact of BES's New R Values on the SM Fit

α_{QED} with new BES measurements

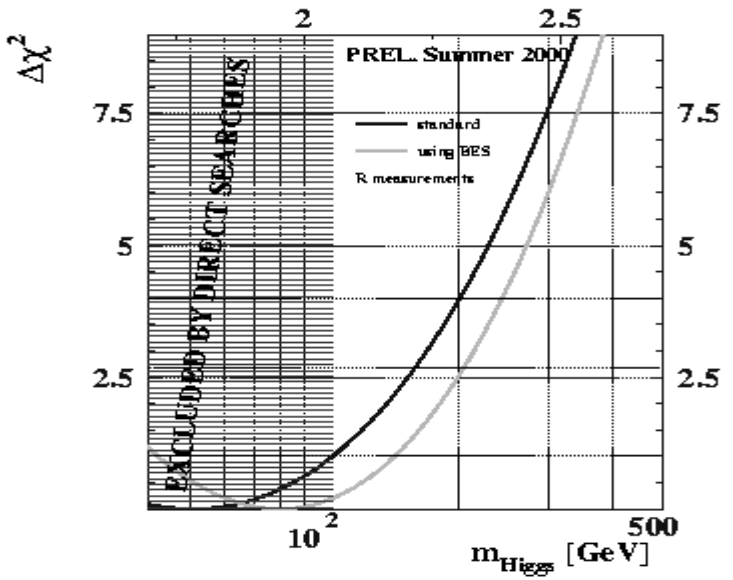


$\Delta\alpha^{(5)}_{had}(s) = 0.02755 \pm 0.00046 \leftarrow$ very preliminary

was 0.0280 ± 0.0007, central value changed by 0.7σ

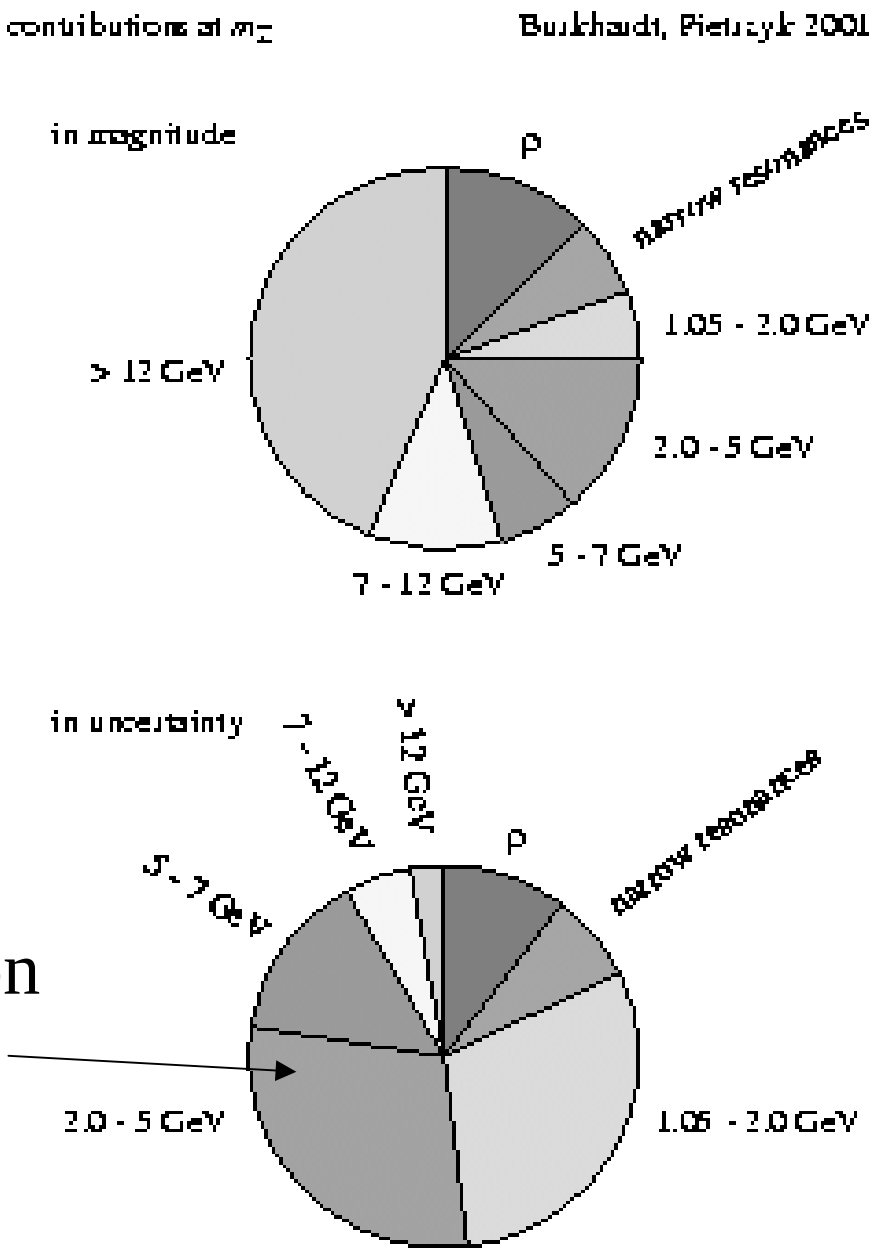
$\rightarrow \alpha^{-1} = 128.945 \pm 0.060$

log m_H - consequence of BES R measurements



minimum moves to 90 GeV, upper limit moves to 210 GeV

↑ very preliminary ↑



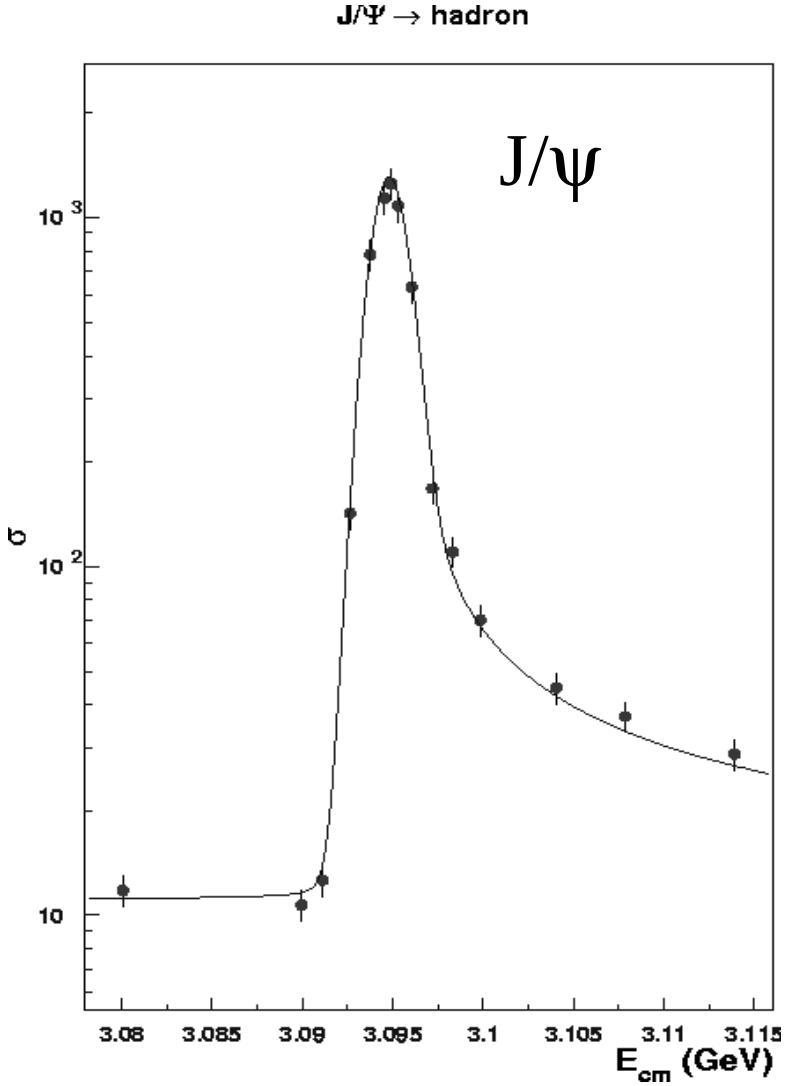
Still larger contribution

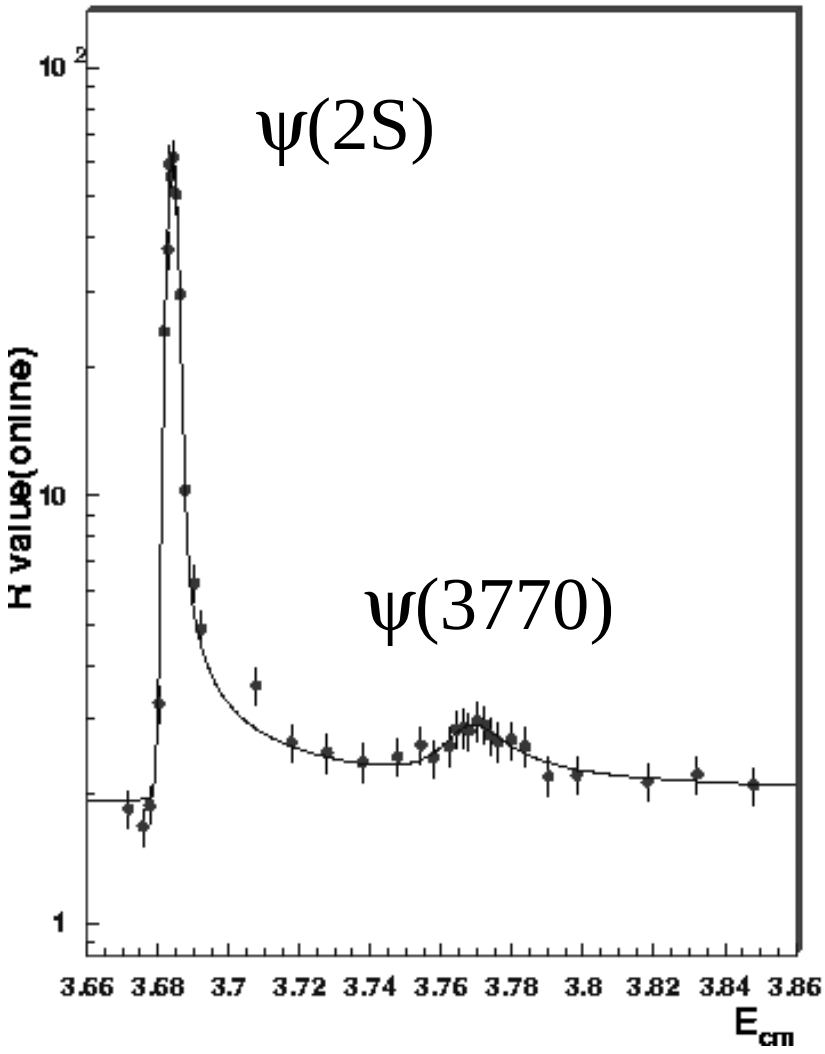
Other Topics With R Scan Data

- Pion form factor measurement
- Measurement of $\sigma(e^+e^- \rightarrow p\ \text{p-bar})$
- Events shape of the hadronic events
- Measurement of the $\psi(2S)$, $\psi(3770)$ resonance parameters
- Structures in 3.7-4.5 GeV energy region

Measurement of ψ(3770) Resonance Parameters

Online fast analysis





R Measurement in 2-5 GeV-How to Further Improve?

- Large N_{had} sample $\rightarrow$ machine with $L>10^{31}\ cm^{-2}s^{-1}$ for all points
- Detector: larger coverage, good performance
- Radiative correction should be done better than 1%
- Generator LUARLW need to be further improved and huge N_{had} event sample is required to tune the parameters
- Better handling of background, particularly beam associated ones
- Measure exclusive channels $\rightarrow$ needs high L machine

  $L \sim 10^{32}\ cm^{-2}s^{-1}$ and good detector PID
- Making use of ISR effect ?

Preliminary Results from Charmonium Decays

With J/ψ data sample, BES has been

- Searching for glueball, hybrid and exotic states
- Studying of light hadron spectroscopy and excited baryonic states
- Searching for LFV and rare decays

Recent preliminary results

- Study of the structure around 1.7 GeV mass region
- PWA analysis of $J/\psi \to \phi\pi^+\pi^-$, ϕK^+K^-
- Search for Chiral partner σ from $J/\psi \to \omega\pi^+\pi^-$

$J/\psi \rightarrow \gamma K^+K^-$ (BESII 24 M J/ψ)

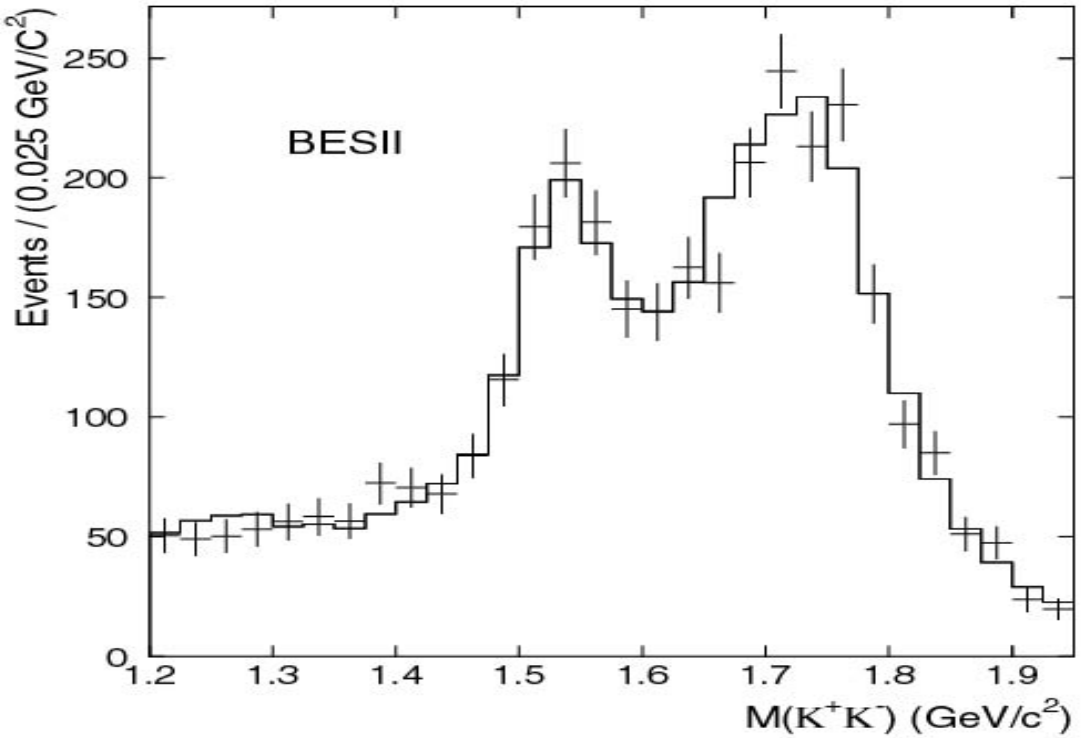
$J/\psi \rightarrow \gamma$ $f_0(400\text{-}1200)$ σ

$f_0(1500)$

$f_0(1710)$

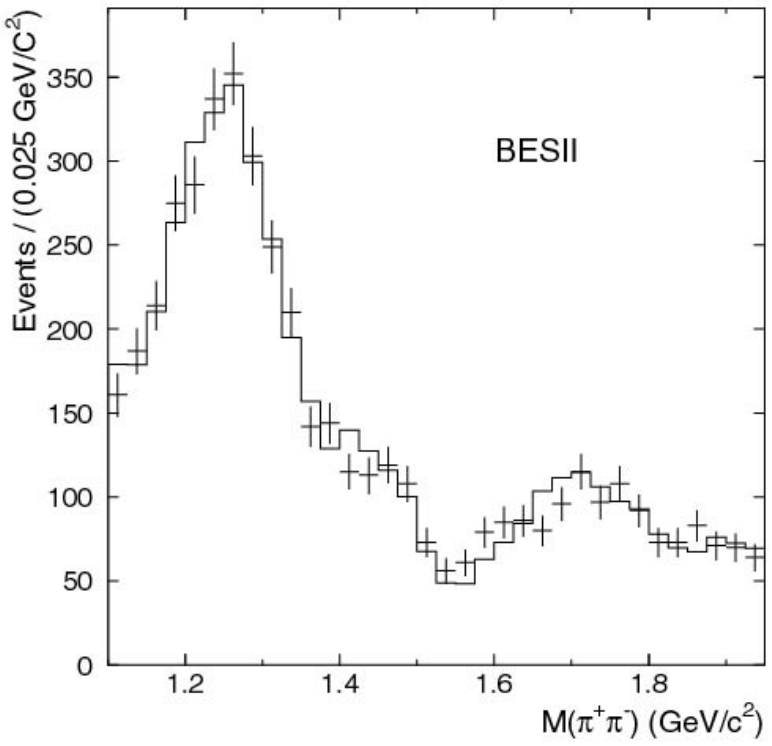
$f_2(1270)$

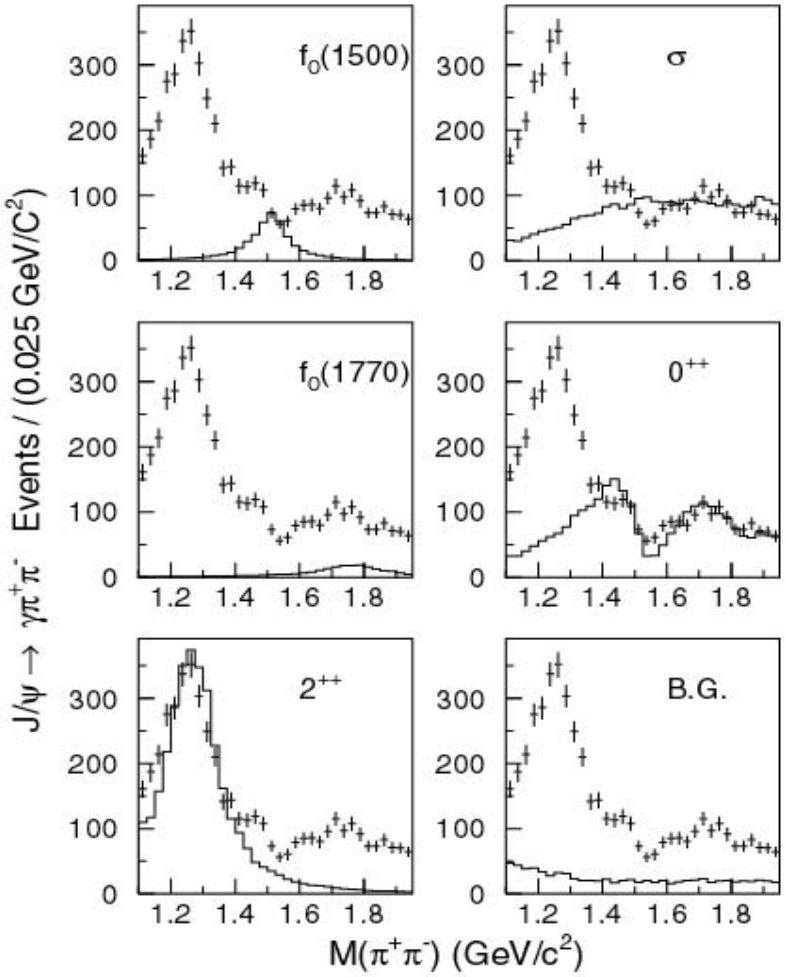
$f_2'(1525)$



- $f_2'(1525)$: M=1530 (5) MeV, Γ=80 (10) MeV
- $f_0(1710)$: M=1735 (30) MeV, Γ=180 (20) MeV
- 0^{++} is dominant in 1.7 GeV region

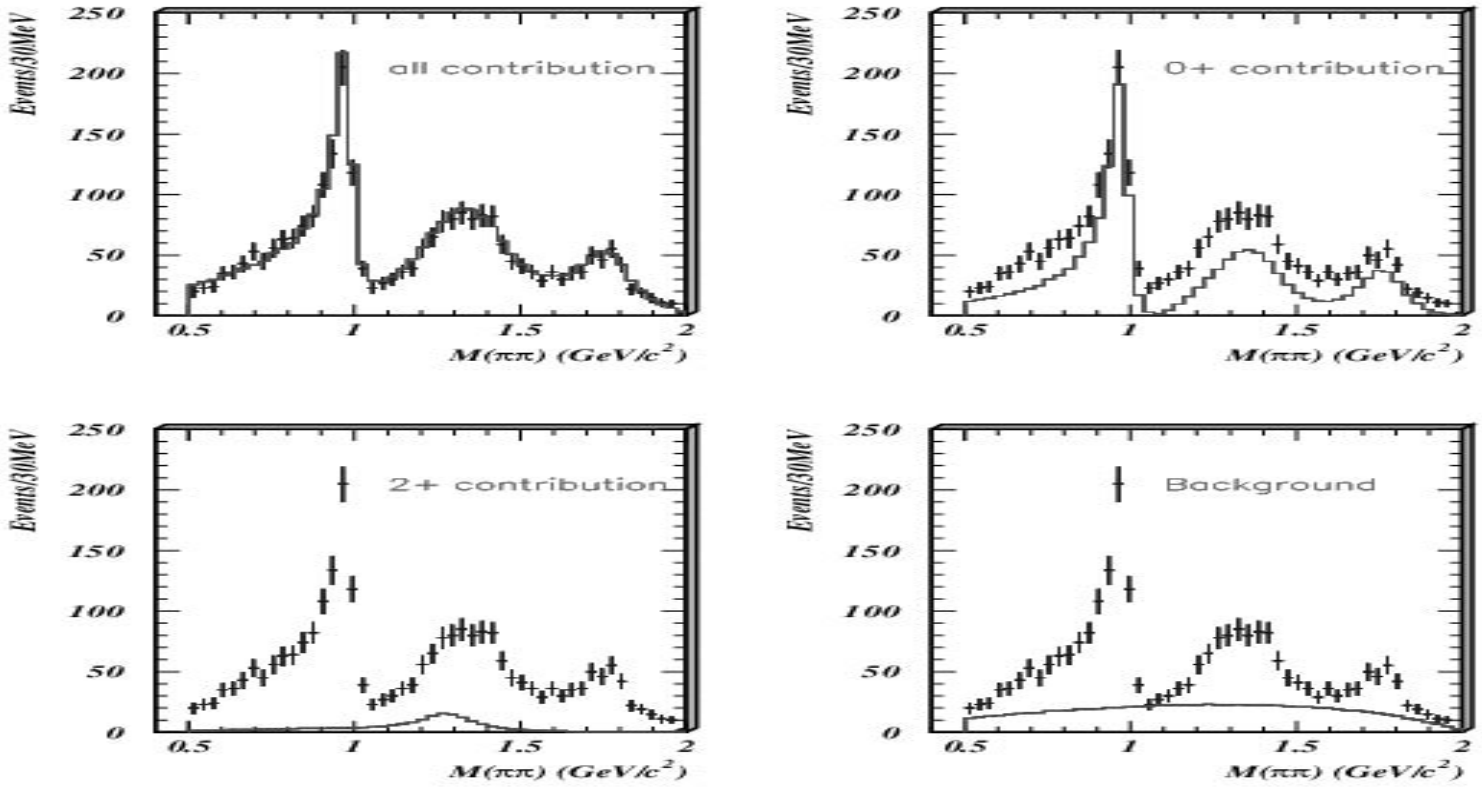
$J/\psi \rightarrow \gamma\pi^+\pi^-$ (BESII 24 M J/ψ)





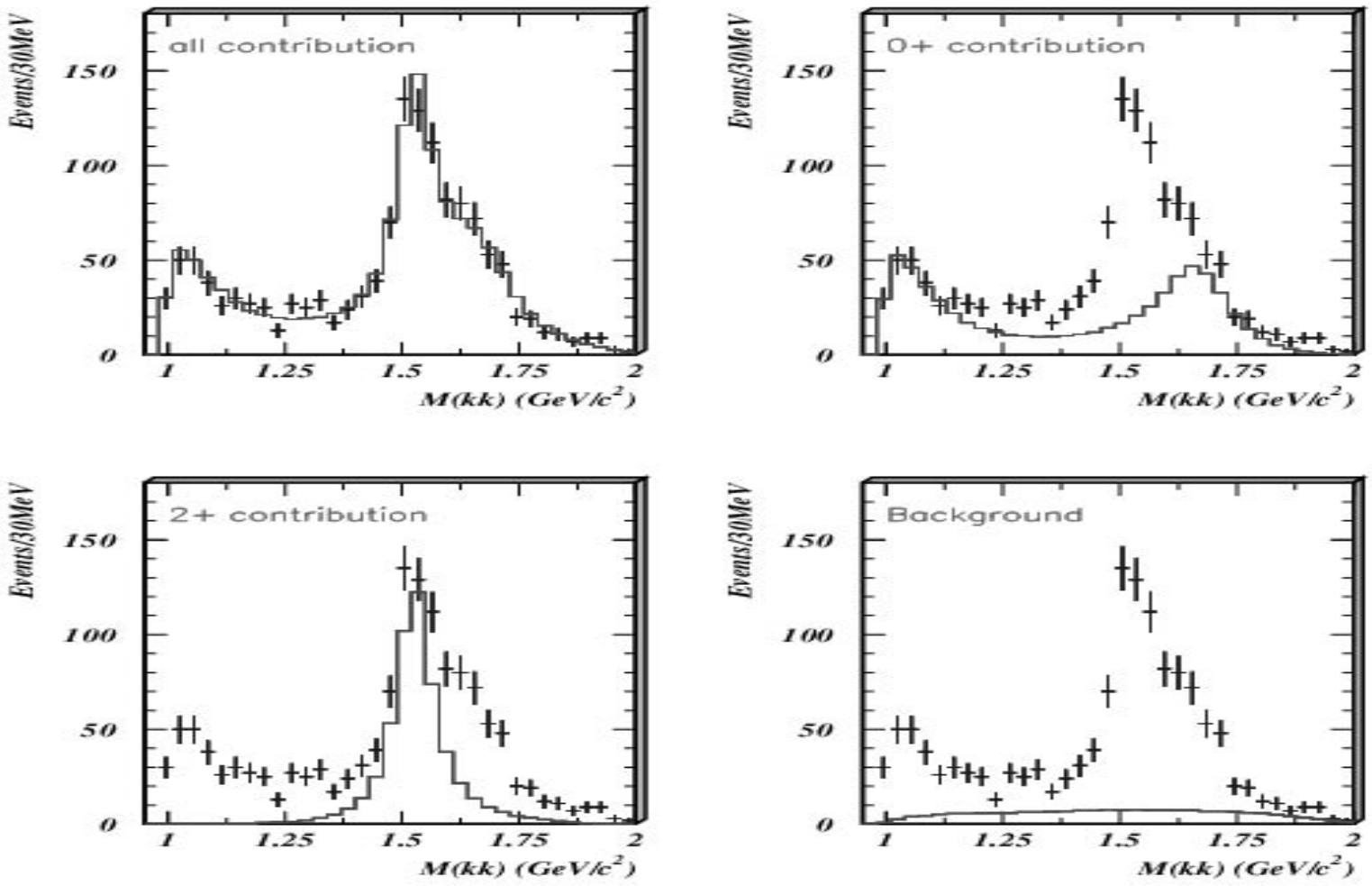
The main contribution in 1.7 GeV mass region comes from 0^{++}

PWA of $J/\psi \to \phi\pi^+\pi^-$ (BESII 24 M J/ψ)



- A strong $f_0(980) \to \pi^+\pi^-$ peaked at 980±10 MeV
- A 0^{++} signal with M=1335±30 MeV, Γ=102 ±13 MeV
- A 0^{++} at M=1770±20 MeV with Γ=130 ±40 MeV

PWA of $J/\psi \rightarrow \phi K^+K^-$ (BESII 24 M J/ψ)



- A tail of $f_0(980)$ around 1 GeV, a strong component of $f_2'(1525)$
- A 0^{++} component on the shoulder of $f_2'(1525)$ might be mainly comes from the misidentifying of K

ψ(2S) Physics (only BESI data)

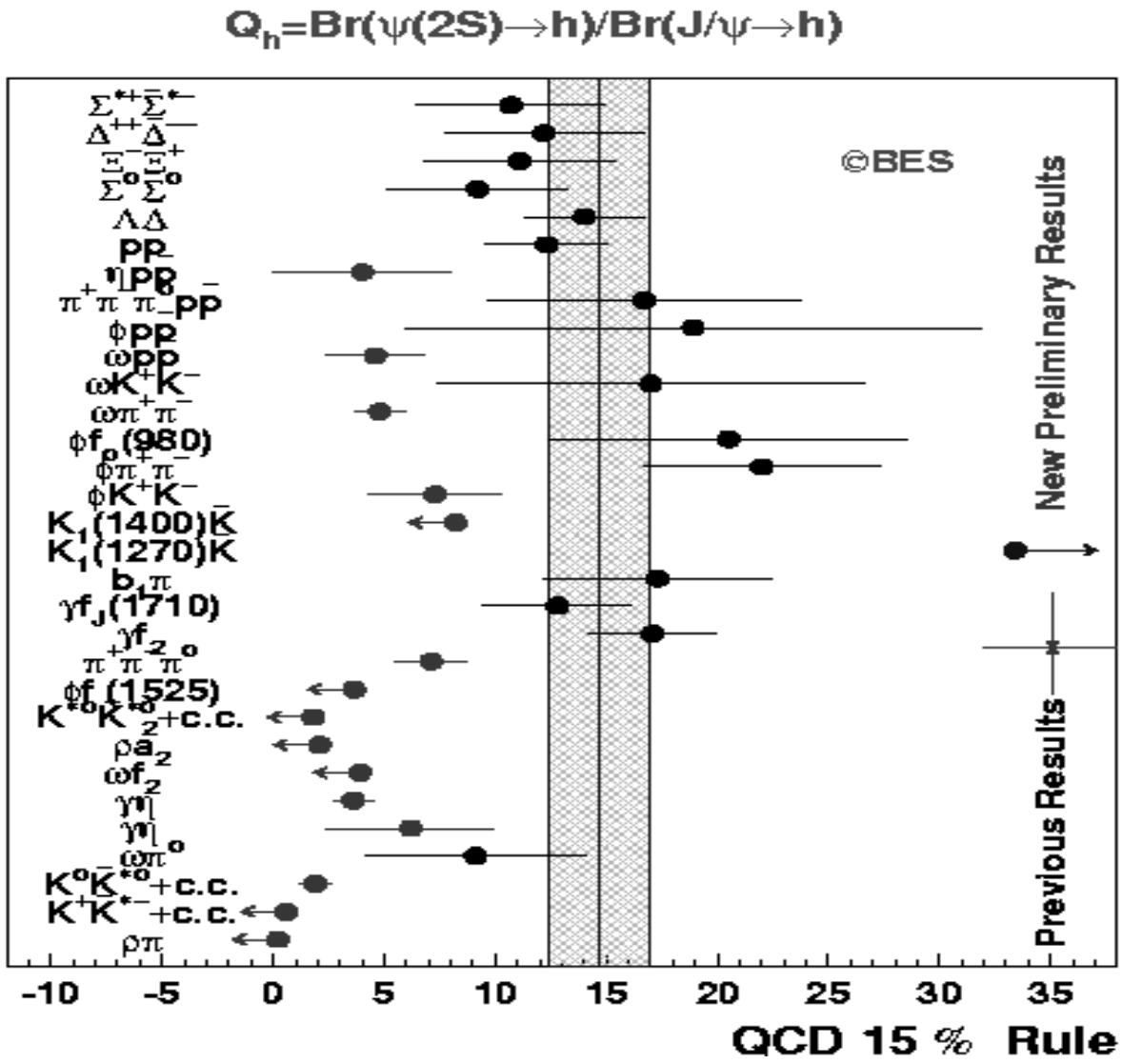
- ψ(2S) is an important laboratory to study
  - charmonium family members
  - non-relativistic perturbative QCD

  e.g. test of "15% rule" from non-relativistic perturbative QCD

$$\frac{B[\psi(2S)\to hdron]}{B[J/\psi\to hdron]}\approx\frac{B[\psi(2S)\to e^+e^-]}{B[J/\psi\to e^+e^-]}\approx 15\%$$

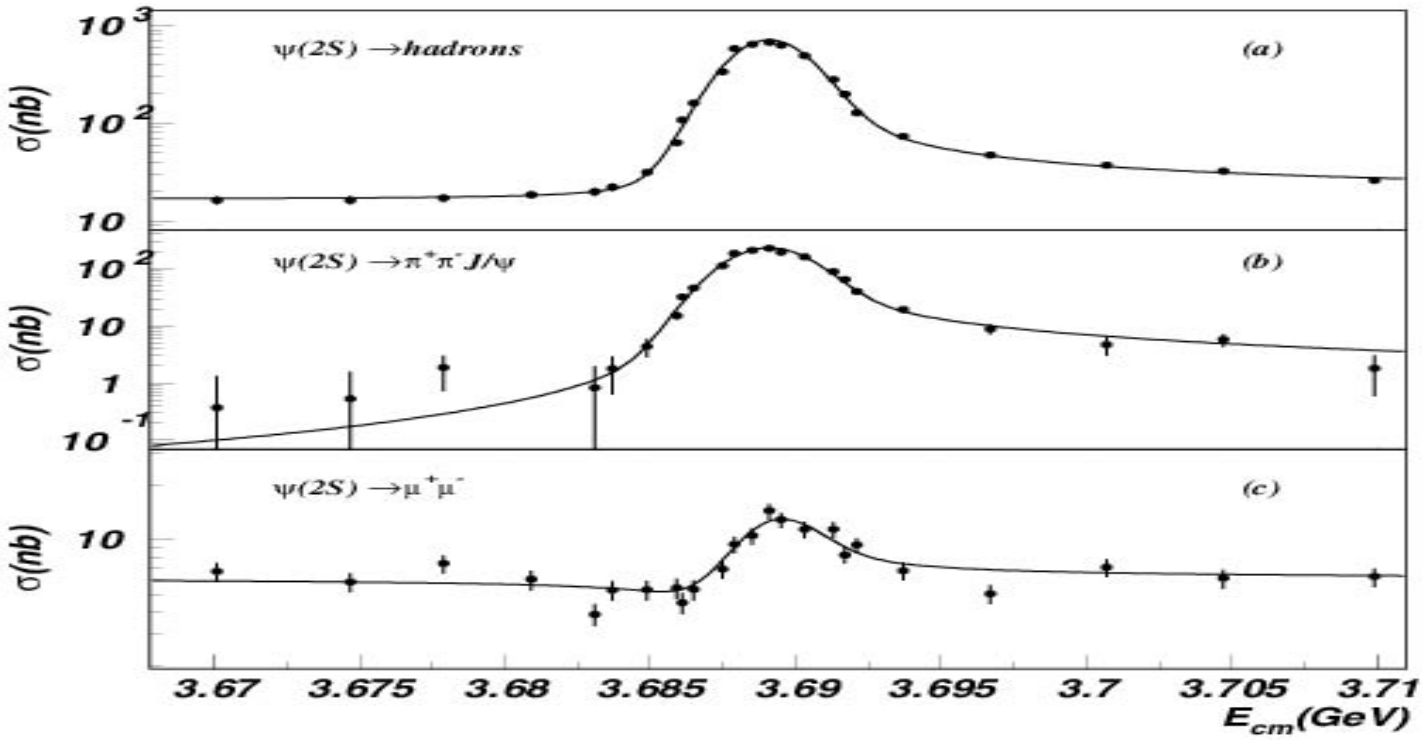
BES has measured many decay channels - many for the first time, many filled up the PDG and improve the precision

Test of “15% Rule”



ψ(2S) Resonance Parameters Measurement

Done with BESII



Future Plans

- Take data with BESII to 2003

  - $\psi(2S)$ or $\psi(3770)$ or R in 2-3 GeV?

- BESIII at BEPCII

  BESIII/BEPCII is the future of the BES

  Two options

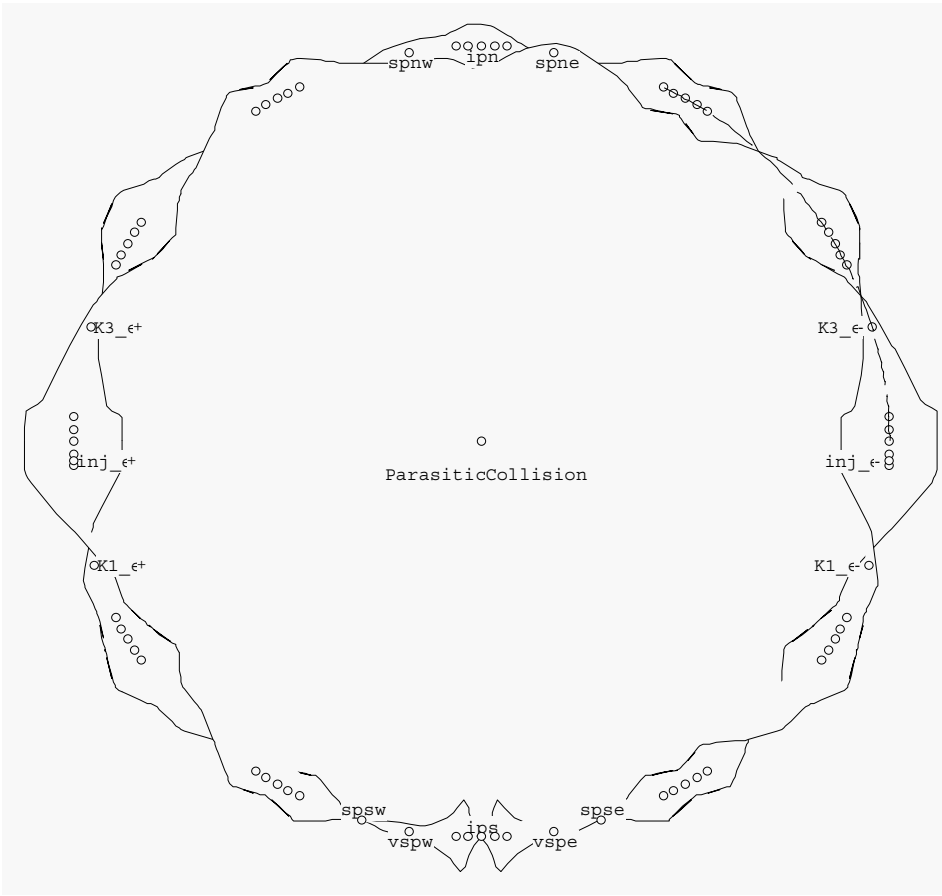
  - multi-bunch single ring: $L=3\times10^{32}$ $cm^{-2}s^{-1}$

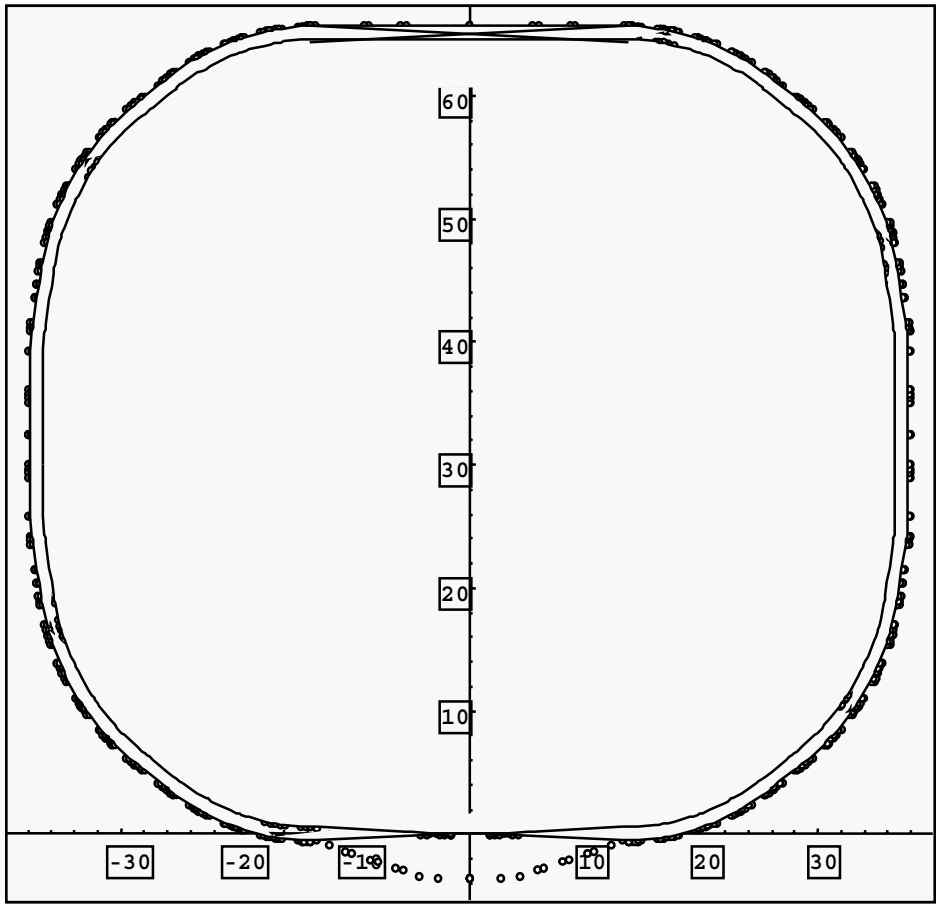
  - multi-bunch double ring: $L=10^{33}$ $cm^{-2}s^{-1}$

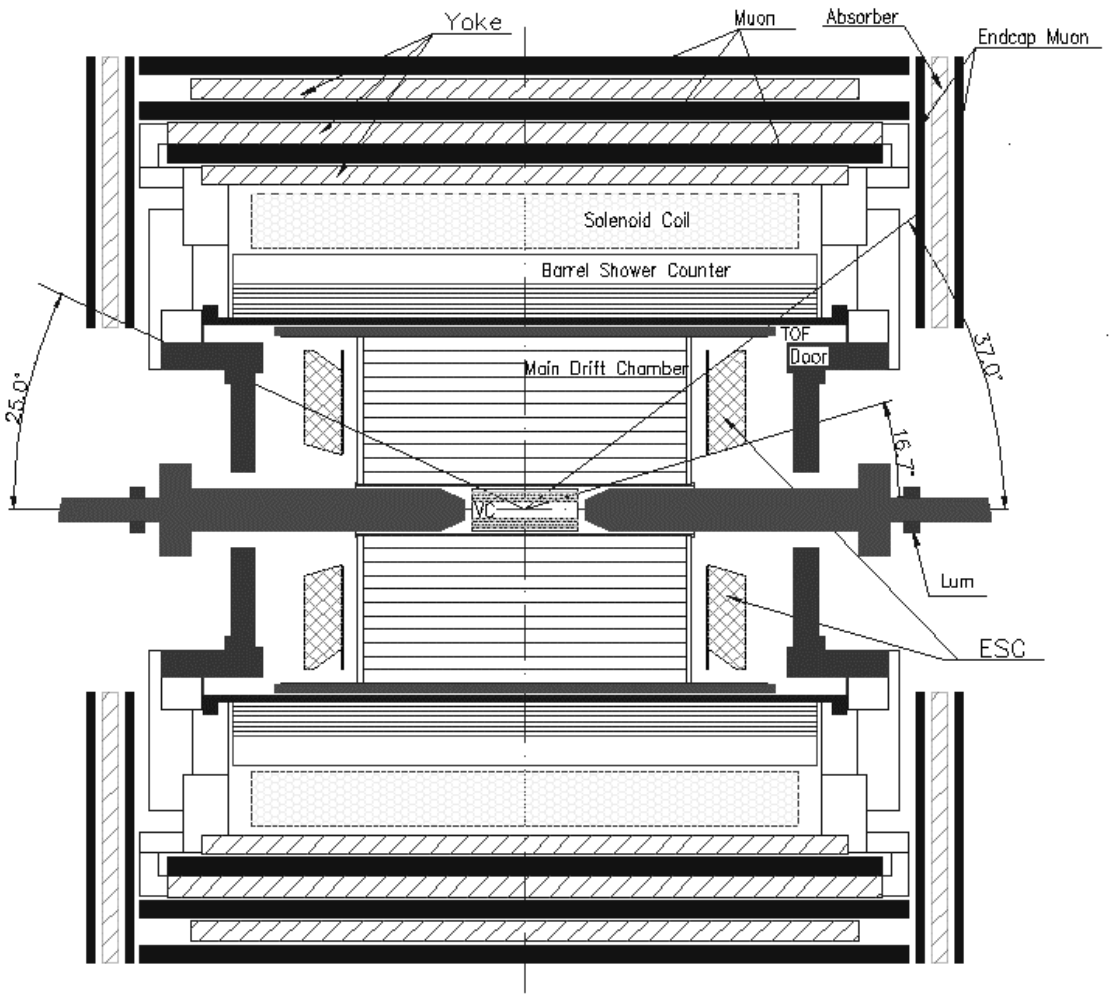
Design Goals and Main Parameters

Beam energy range		**1–2.8 GeV**
Optimized beam energy region		**1.55–1.84 GeV**
Calculated Luminosity @1.84 GeV (10^{32} $cm^{-2}s^{-1}$)	**Single-ring**	**3.8**
	Double-ring	**10**
Injection from linac		**Full energy injection: E_{inj}=1.55–1.84GeV Positron injection rate = 50 mA/min**
Dedicated SR operation		**250 mA @ 2.5 GeV, 150 mA @ 2.8 GeV**

Single-Ring and Double-Ring Schemes







From BESII to BESIII

BESIII

- New barrel e.m. calorimeter (BEMC)

  Scintillating fiber+Pb, $\Delta E/E \sim 7\%$
- Openable endcaps(door only in the first step)
- Drift chamber using Al field wires and He based gas
- New trigger and DAQ system adapting multi-bunch train
- All corresponding electronics
- New luminosity monitor (L.M.)
- New barrel time-of-flight (TOF)

  Double layer plastic scintillator or MRPC, $\Delta T \sim 100$ ps
- New vertex chamber (VC)
- New μ counter ?
- Computing and BESIII software (PC farm, C++, detector simulation based on GEANT3)

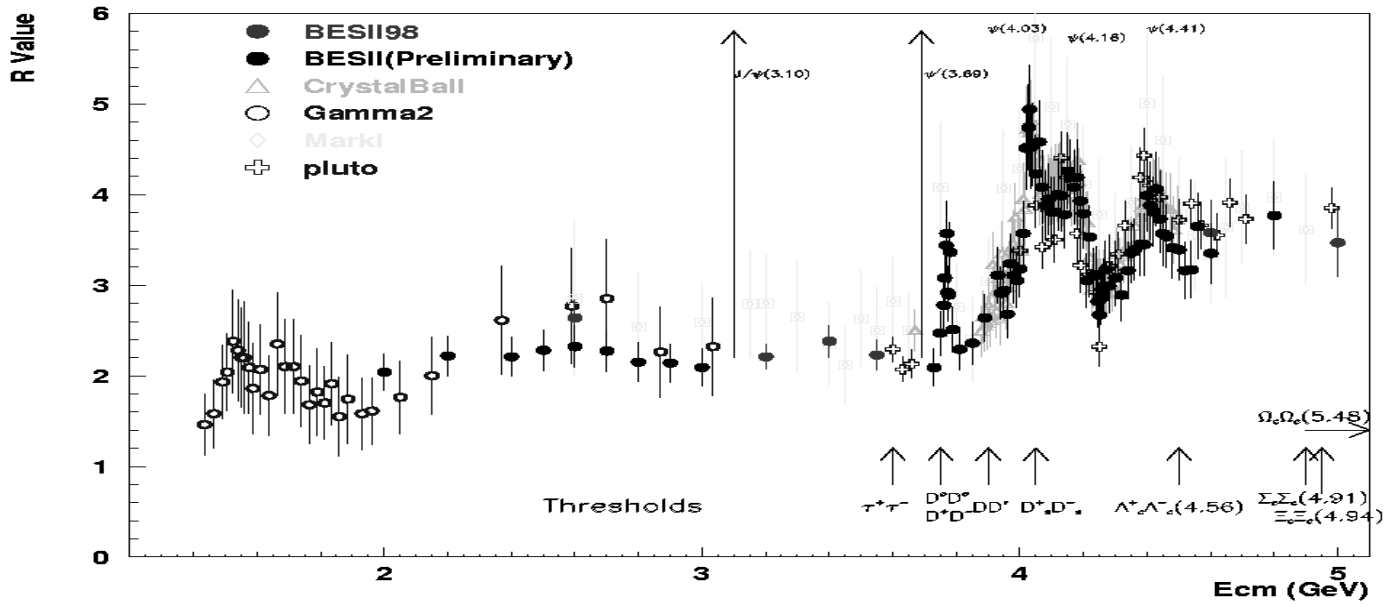
?

An other idea is to build a complete new Detector using super conducting magnets.

Seems hard to be accepted due to the limitation of the proposed and endorsed budget

Physics Features in BEPC Energy Region

- Rich of resonances, charmonium and charmed mesons
- Threshold characteristics
- Transition between smooth and resonances, perturbative and non-perturbative QCD
- Energy location of the gluonic matter and glueball, exotic states and hybrid



Physics Program

- Meson spectroscopy with J/ψ, ψ(2S) data

  qqbar, excited baryonic states (N^*, Λ^*, Σ^*, Ξ^*...), hybrid, glueball, $^1P_1$, η_c'

  Best laboratory to elucidate a tricky situation; unique opportunity for QCD studies and new level of understanding within reach

- Interactions with charmed mesons

  Absolute Br, decay constants, CKM elements (c), charmed baryons

  Unique opportunities, results needed for advances in other area, e.g. b physics. Thus complementary

Physics Program

- New study of the τ lepton
  - lower limit on ν_τ mass;
  - determination of m_τ 0.1 MeV(needed in the future to test lepton universality
  - study of τ weak current
  - extend QCD studies
- Precision R scan (at ~1% level)
  - Input for $\Delta\alpha_{had}(M_Z^2)$ and a_μ^{had}, very important for testing of SM and hunting for new physics beyond the SM
  - Unique test of QCD (hadron production mechanism, e.g. $e^+e^- \rightarrow$ V, T, Baryon pairs

  A real challenge experiment; may needs 100×BESII R data and good detector

Physics Program

- New physics
  - $D^0 D^0$bar mixing
  - CP violation in τ, J/ψ, $\psi(2S)$ decays
  - Lepton flavor violating processes

    e.g. $J/\psi \to \ell\ell'$, ℓ=e, μ, τ
  - Rare decay (e.g. $J/\psi \to$DX, Non-SM τ decay)

Taking advantage of threshold production and much high statistics.

Status of BEPCII Project

- Int. Review Meeting for feasibility study held (April 2-6). Both options are supported, double ring option is preferred.
- Two options so far. A proposal will be delivered to government in May. Budget maintain at 50M US$ from government. Additional 20 M US$ is nder discussion.
- Detector for double ring machine has not well been defined.
- Part of R&D work started.
- Expect to start running in 2005-2006.

Summary

- BES's resent results

  - Measured R in 2-5 GeV with an average uncertainties of ~6.6%.

  - 5×10^7 J/ψ events collected. Preliminary results on some of the radiative and hadronic decay using PWA.

  - Improved parameter measurement of ψ(2S) and ψ(3770)

- The short term future to 2003 of the BES with BESII has not been fully decided. Possibly accumulate data at ψ(2S), or ψ(3770) or even scan R below 3 GeV

- The future of the BES will be the BEPCII project $\rightarrow$

  Machine with L~3×10^{32}-10^{33} /cm^2·s, significantly upgrade BESII (BESIII). The commission may start from the end of 2005 or early 2006.