The BESIII Experiment at BEPCII

Changzheng YUAN （苑长征）
(for the BESIII Collaboration)
IHEP, Beijing

KEK, Mar. 8-10, 2012

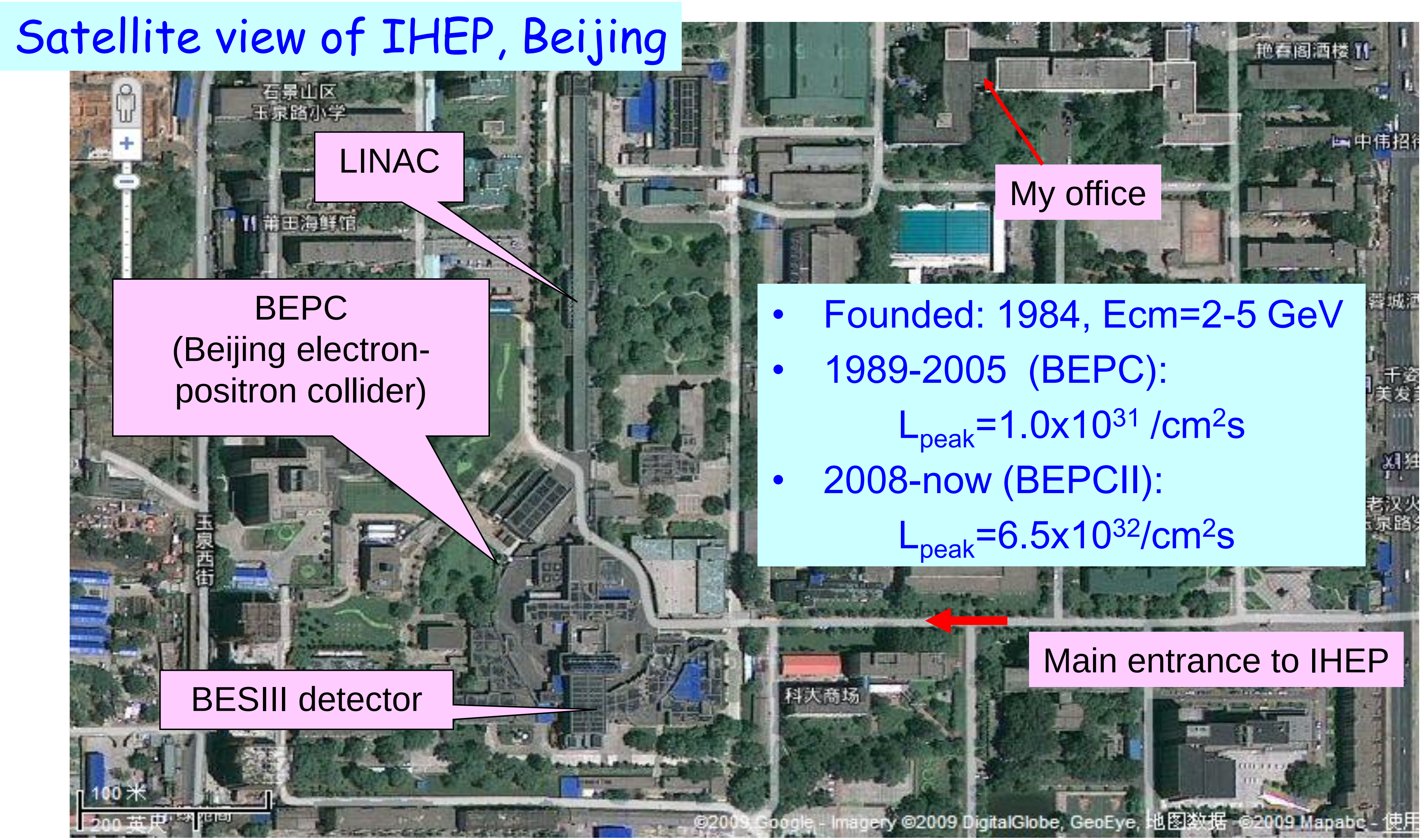
Where is the experiment

2 days + 2 hour if one follows the google recommended travel plan.

Where is the experiment

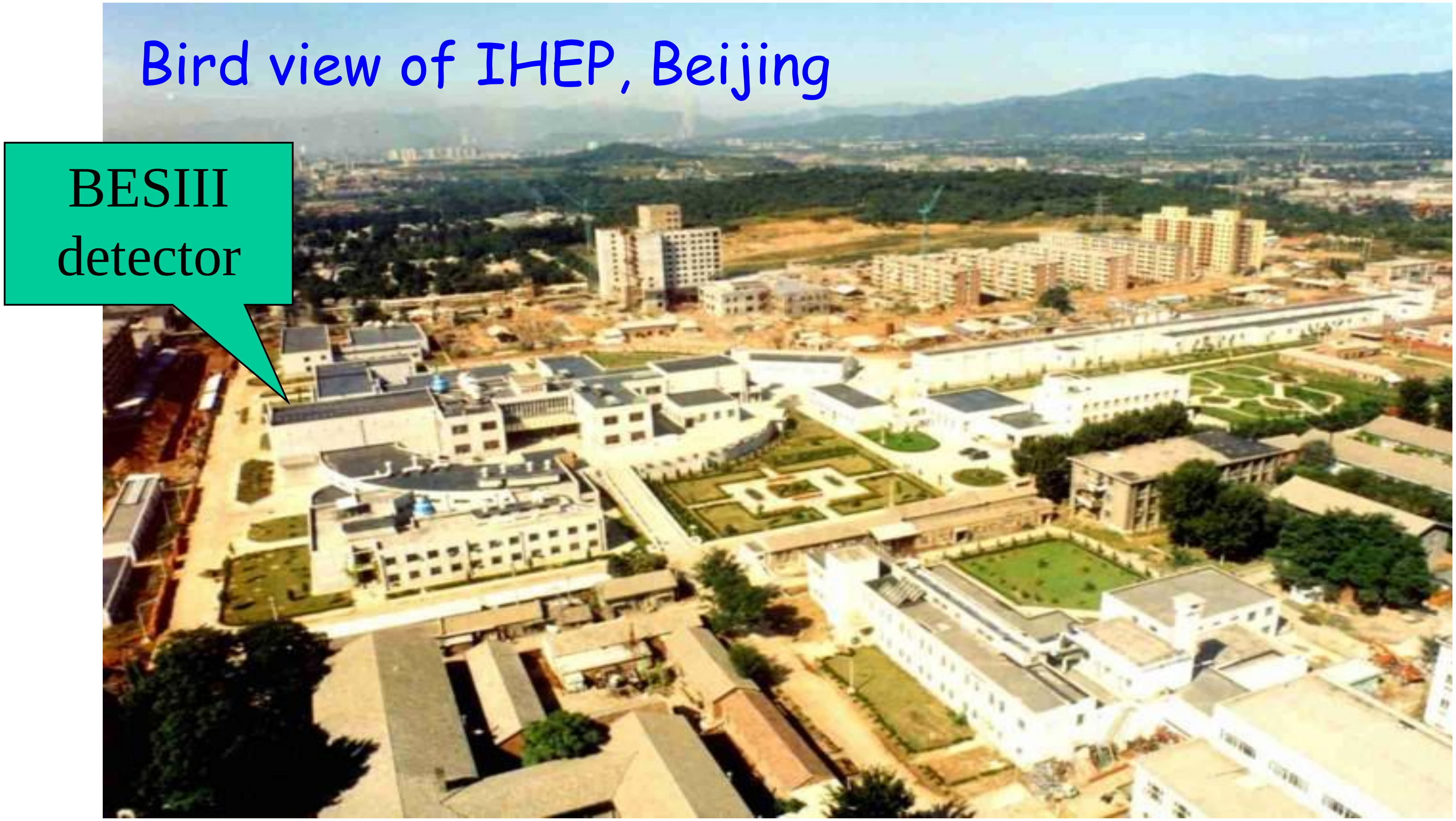
45 kilometers = 1 hour by taxi, or 1.5 hours by subway

The Beijing Electron Positron Collider



- Founded: 1984, Ecm=2-5 GeV
- 1989-2005 (BEPC):
  L_{peak}=1.0x10^{31} /cm^{2}s
- 2008-now (BEPCII):
  L_{peak}=6.5x10^{32}/cm^{2}s

The Beijing Electron Positron Collider

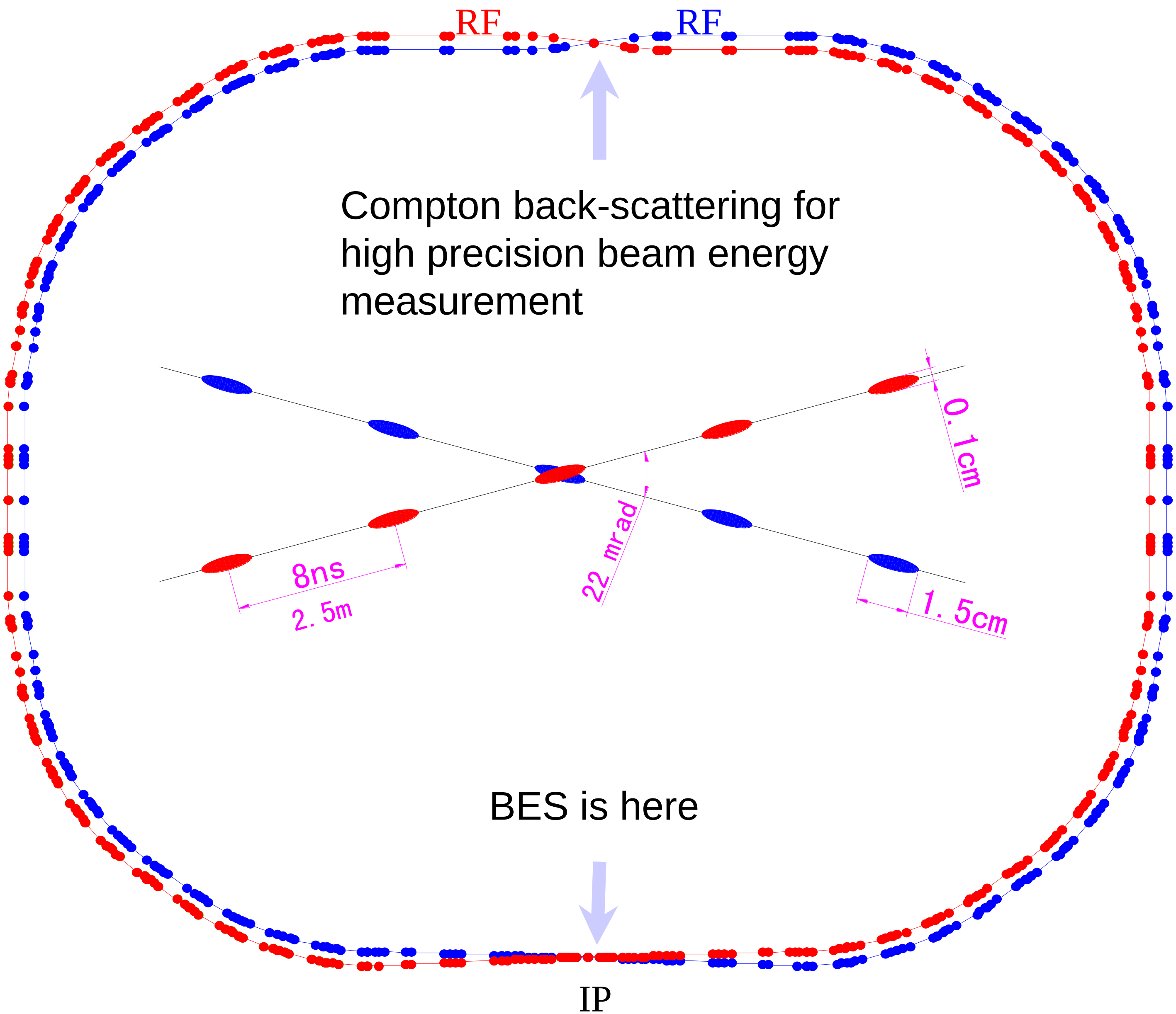


Founded: 1984, Ecm=2-5 GeV

1989-2005 (BEPC): L_{peak}=1.0x10^{31} /cm^2s at Ecm=3.77 GeV

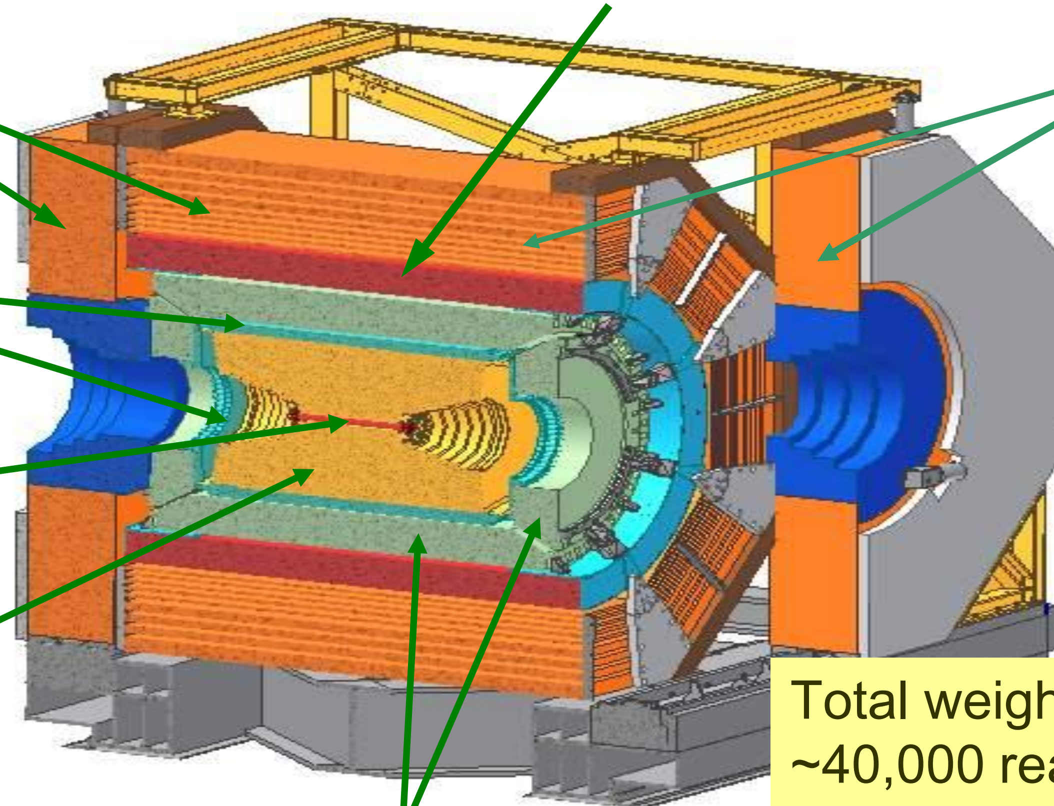
2008-now (BEPCII): L_{peak}=6.5x10^{32}/cm^2s at Ecm=3.77 GeV

BEPC II: Large crossing angle, double-ring

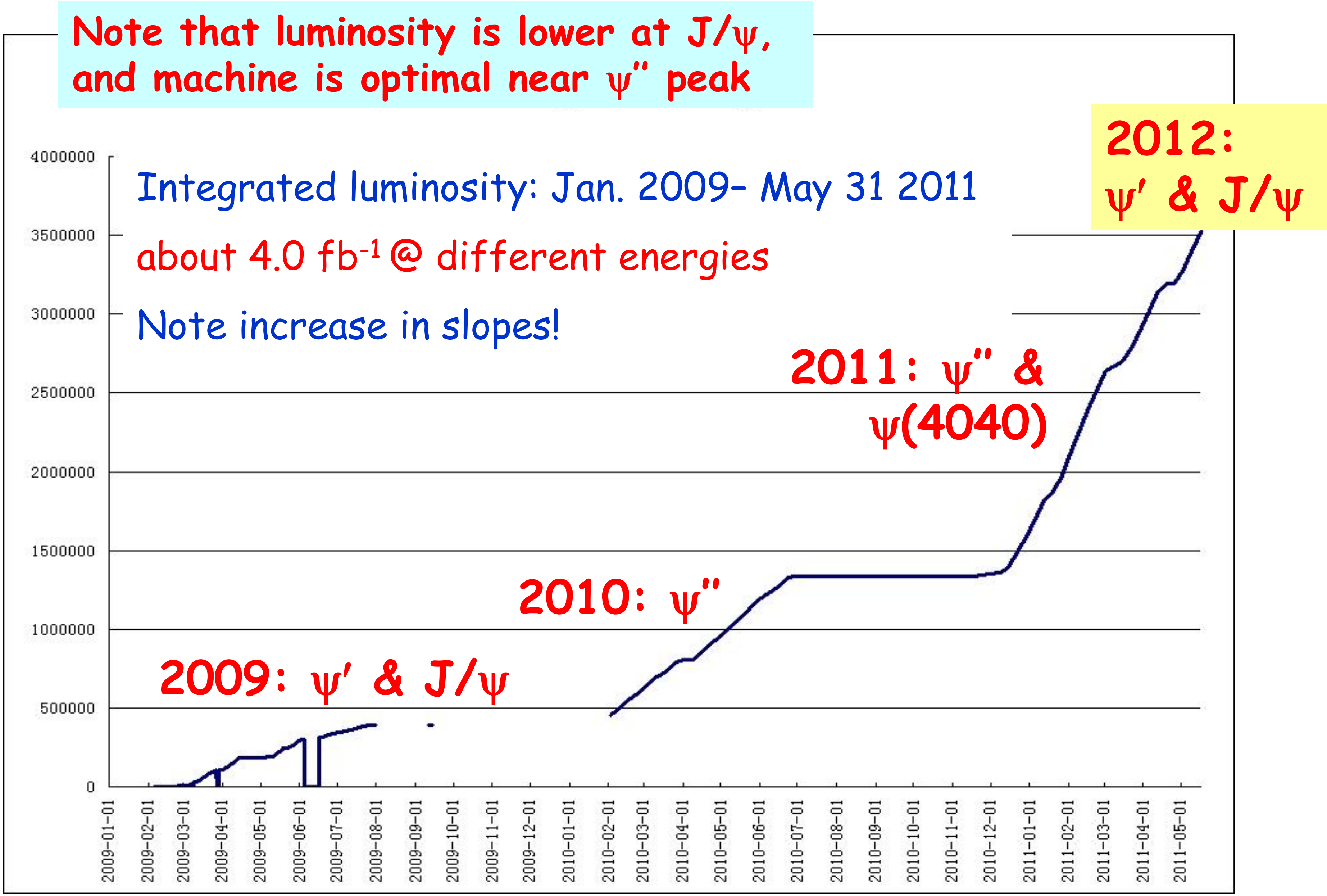


Beam energy:
 1.0-2.3 GeV
Luminosity:
 1×10^{33} $cm^{-2}s^{-1}$
Optimum energy:
 1.89 GeV
Energy spread:
 5.16×10^{-4}
No. of bunches:
 93
Bunch length:
 1.5 cm
Total current:
 0.91 A
SR mode:
 0.25A @ 2.5 GeV

BESIII Detector



Luminosity since startup



BESIII [and BESII, CLEO-c] data

Data	BESII	CLEOc	BESIII (2012)
J/ψ	58 M	--	225 M (+1.0 B)
ψ'	14 M	26 M	106 M (+0.7B~1.0 B)
ψ''	0.033 fb^{-1}	0.818 fb^{-1}	2.9 fb^{-1}
$\psi(4040)$	-	0.006 fb^{-1}	0.5 fb^{-1}
Continuum	6.4 pb^{-1} ($\sqrt{s}$=3.65 GeV)	21 pb^{-1} ($\sqrt{s}$=3.67 GeV)	44 pb^{-1} (+120 pb^{-1}) ($\sqrt{s}$=3.65 GeV)

Performance	BESII	CLEOc	BESIII
$\sigma p/p$	$1.7\%/\sqrt{1+p^2}$	0.6%@p=1GeV	0.5%@p=1GeV
$\sigma E/E$	$22\%/\sqrt{E}$	2.2%@E=1GeV	2.5%@E=1GeV
PartID	dE/dx+TOF	dE/dx+RICH	dE/dx+TOF
Coverage	80%	93%	93%

BESIII Physics Programs

This is not a BESIII logo!

BESτ

- B (looks like DD for D or charm physics)
- E (looks like cc for charmonium physics)
- S (for light hadron Spectroscopy [+exotics])
- T (for tau physics, looks like a Roman number “III”)

Charm physics

No results yet!

- Decay constants
- Form factors and CKM matrix elements
- Strong phase and impact on ϕ_3 measurements
- D mixing & CPV
- Rare decays

Charm cross section at ψ" peak

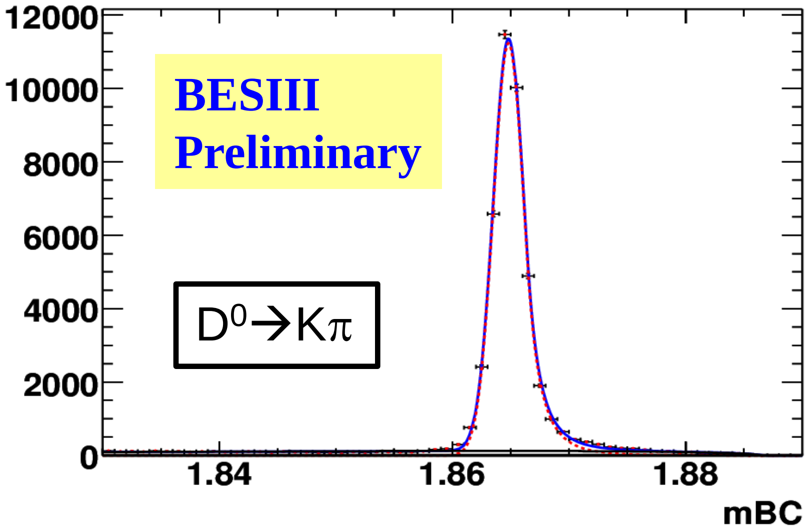
D^+D^-: ~2.8 nb; $\bar{D}^0D^0$: ~3.6 nb

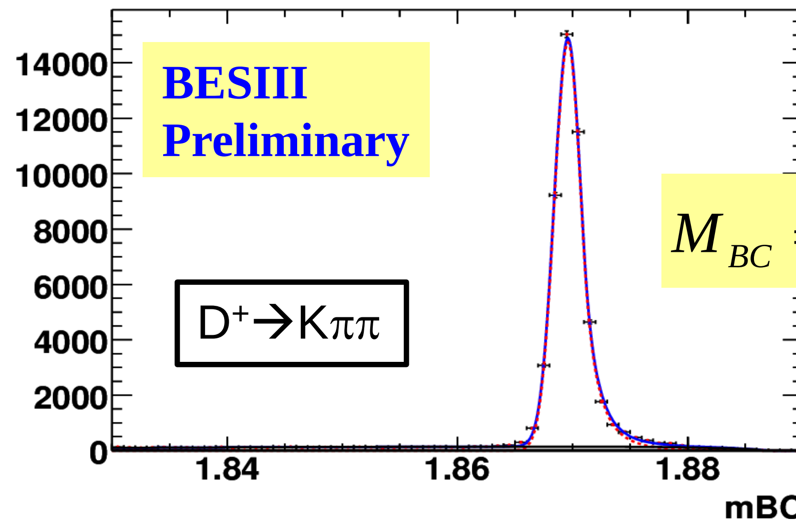
N^{prod} in 2.9 fb^{-1}

$N(D^+D^-)$:~8 M; $N(\bar{D}^0D^0)$: ~ 10 M

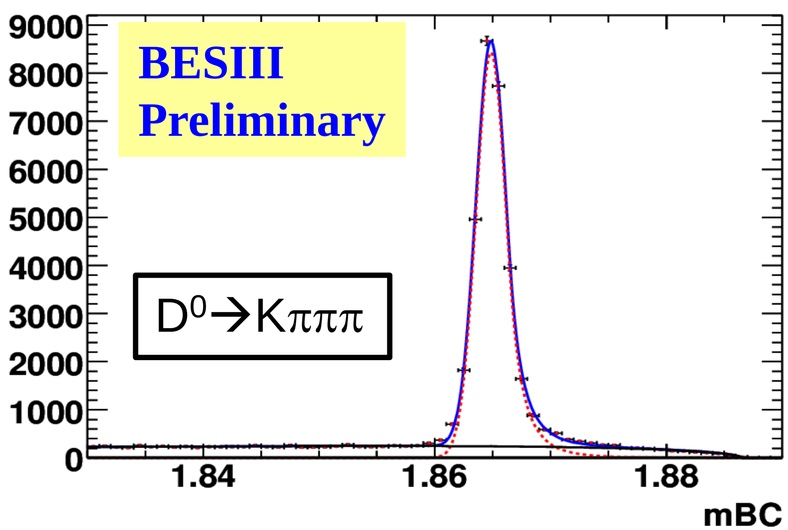
Clean tagged charms

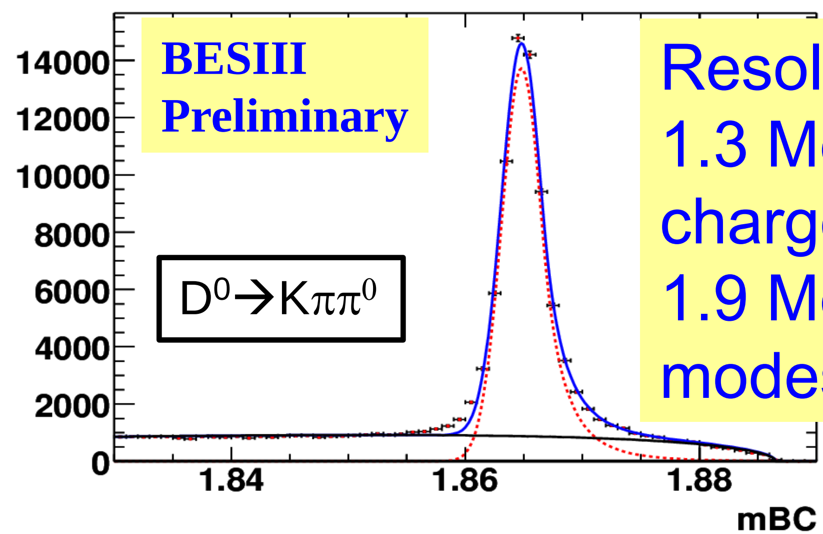
In 2.9 fb^{-1} data, we tagged 1.6M D^+ and 2.7M D^0





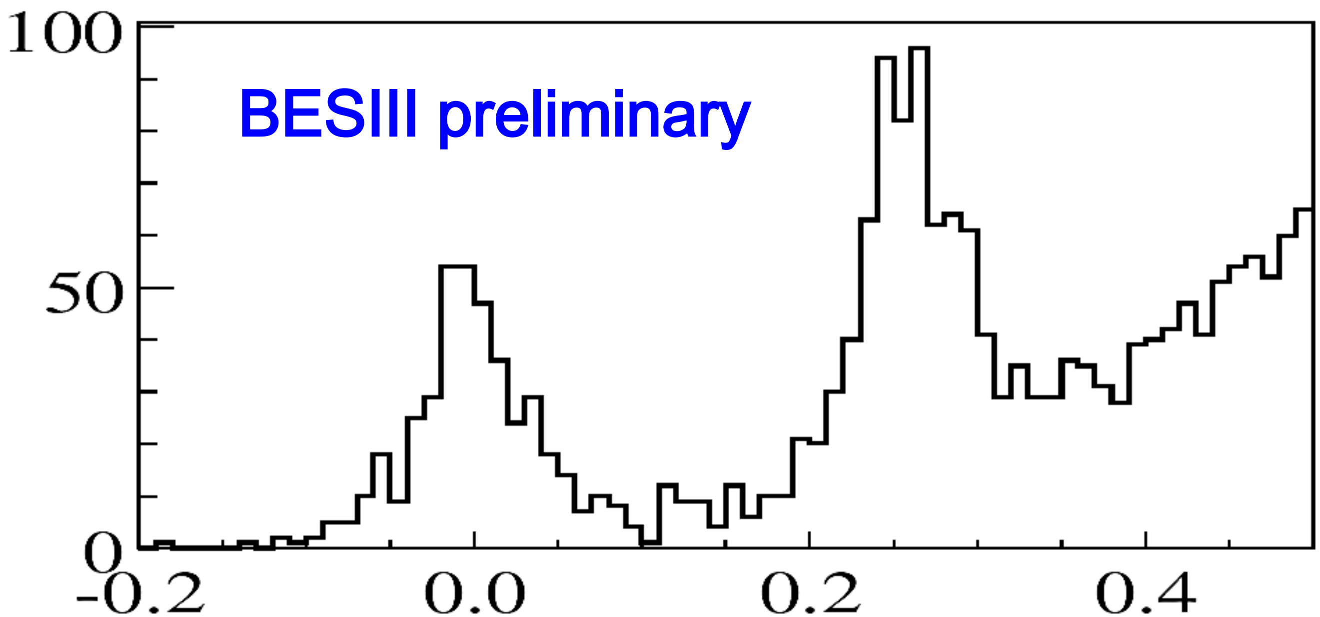
$$M_{BC} = \sqrt{E_{beam}^2 - |p_D|^2}$$





Resolution:
1.3 MeV for pure charged modes;
1.9 MeV for modes with one π^0.

Pure leptonic decays of D^+



Umiss=Emiss-pmiss

BESIII MUC helps reduce hadron background

$N^{obs}(D^+ \to \mu^+\nu) \sim 400 \to \sigma B/B \sim 5\%$; $\sigma f_D/f_D \sim 2.5\%$

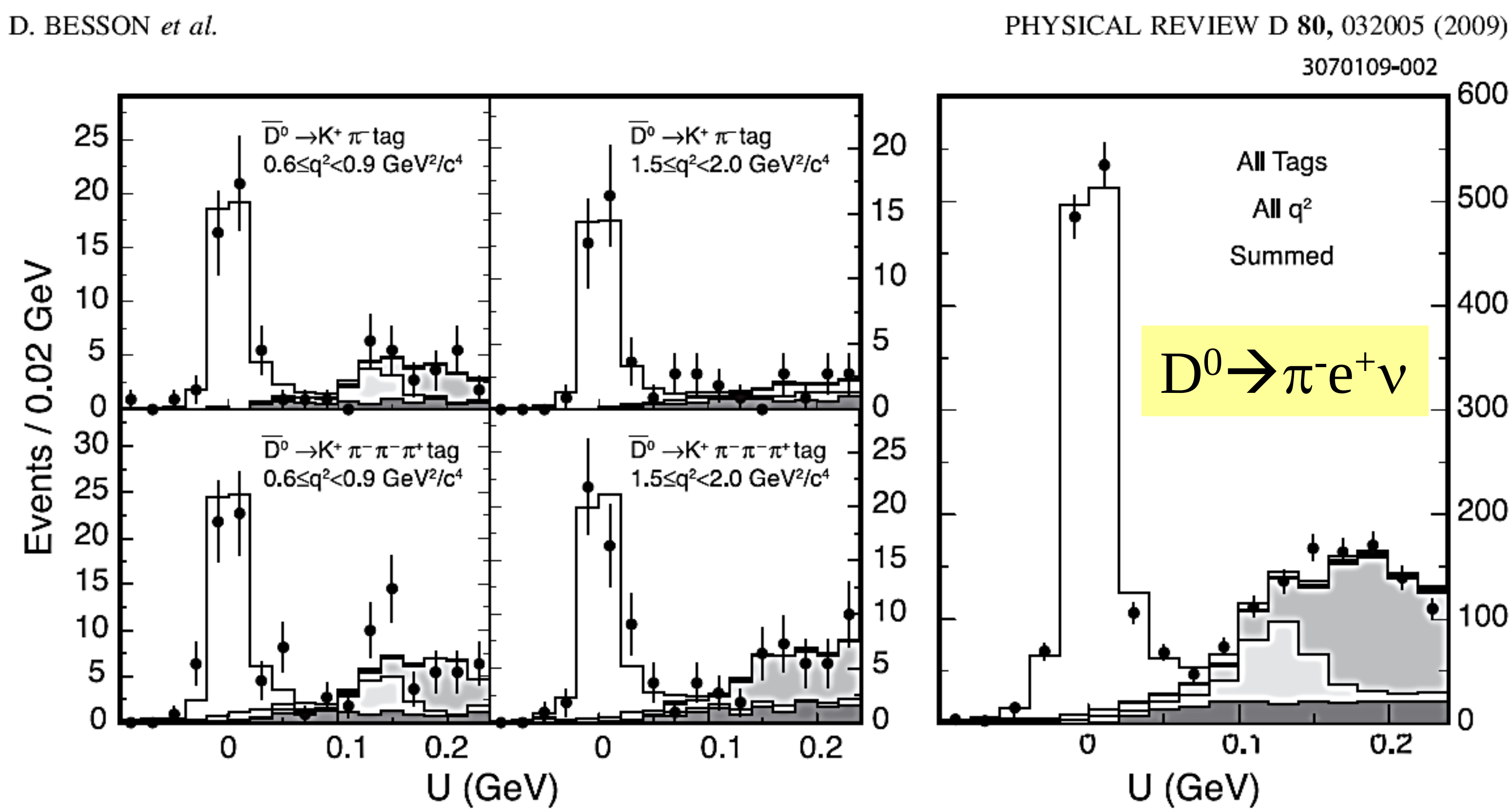
Statistical error limited, systematic error on B ~ 1.5% level

In 20 fb^{-1} data, errors can be scaled by 1/2.6

$N^{obs}(D^+ \to \mu^+\nu) \sim 2700 \to \sigma B/B \sim 2\% \oplus 1.5\%$; $\sigma f_D/f_D \sim 1\% \oplus 0.8\%$

[f_D: PDG: ±4%; LQCD: ±2%]

Semi-leptonic decays of D^0



CLEOc with 818 pb^{-1} data, ~ 1400 events $D^0 \to \pi^- e^+ \nu$

BESIII with 2.9 fb^{-1} data, ~ 6000 events

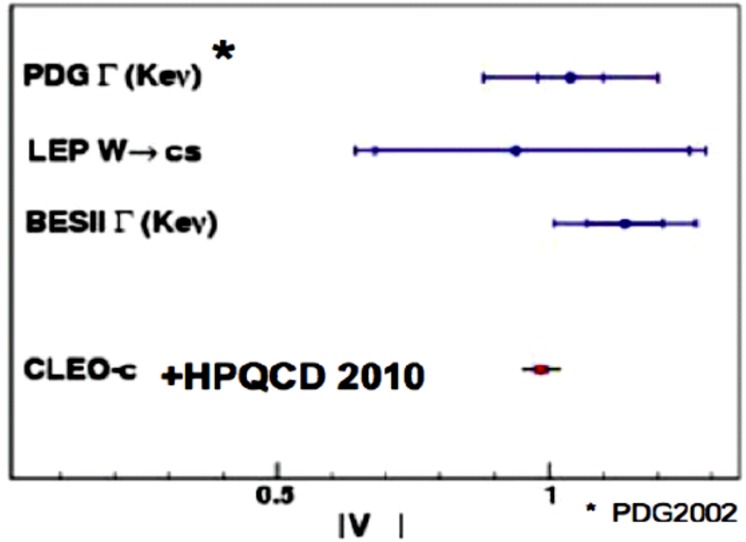
Vcs / Vcd at CLEOc

From CLEOc talk

The data determine $|V_{cs(d)}|f_+(0)$.
To extract $|V_{cs(d)}|$, we combine the measured $|V_{cs(d)}|f_+(0)$ values using the Becher-Hill parameterization with (FNAL-MILC-HPQCD) for $f_+(0)$

CLEO-c: the most precise *direct* determination of $|V_{cs}|$ $\sigma(|V_{cs}|)/|V_{cs}| \sim 1.1\%(\text{expt}) \oplus 2.5\%(\text{theory})$

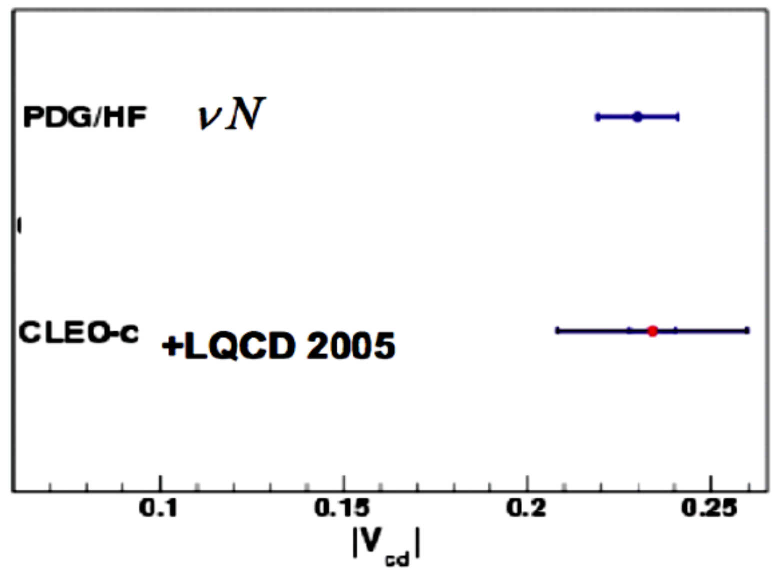
$CLEO-c$	$\|V_{cs}\|$
($818\ pb^{-1}$)	$0.963 \pm 0.009 \pm 0.006 \pm 0.024$
	stat syst theory



CLEO-c: $\sigma(|V_{cd}|)/|V_{cd}| \sim 3.1\%(\text{expt}) \oplus 10\%(\text{theory})$

νN remains most precise determination

$CLEO-c$	$\|V_{cd}\|$
($818\ pb^{-1}$)	$0.234 \pm 0.007 \pm 0.002 \pm 0.025$
	stat syst theory



Vcd will be improved at BESIII by a factor of 2 with 2.9 fb^{-1}.

Semi-leptonic decays of D^0

- In 2.9 fb^{-1} data, with 2.7M tagged D^0 events

  $N^{obs}(D^0 \to K^- e^+ \nu) \sim 60k$

  $N^{obs}(D^0 \to \pi^- e^+ \nu) \sim 6k$

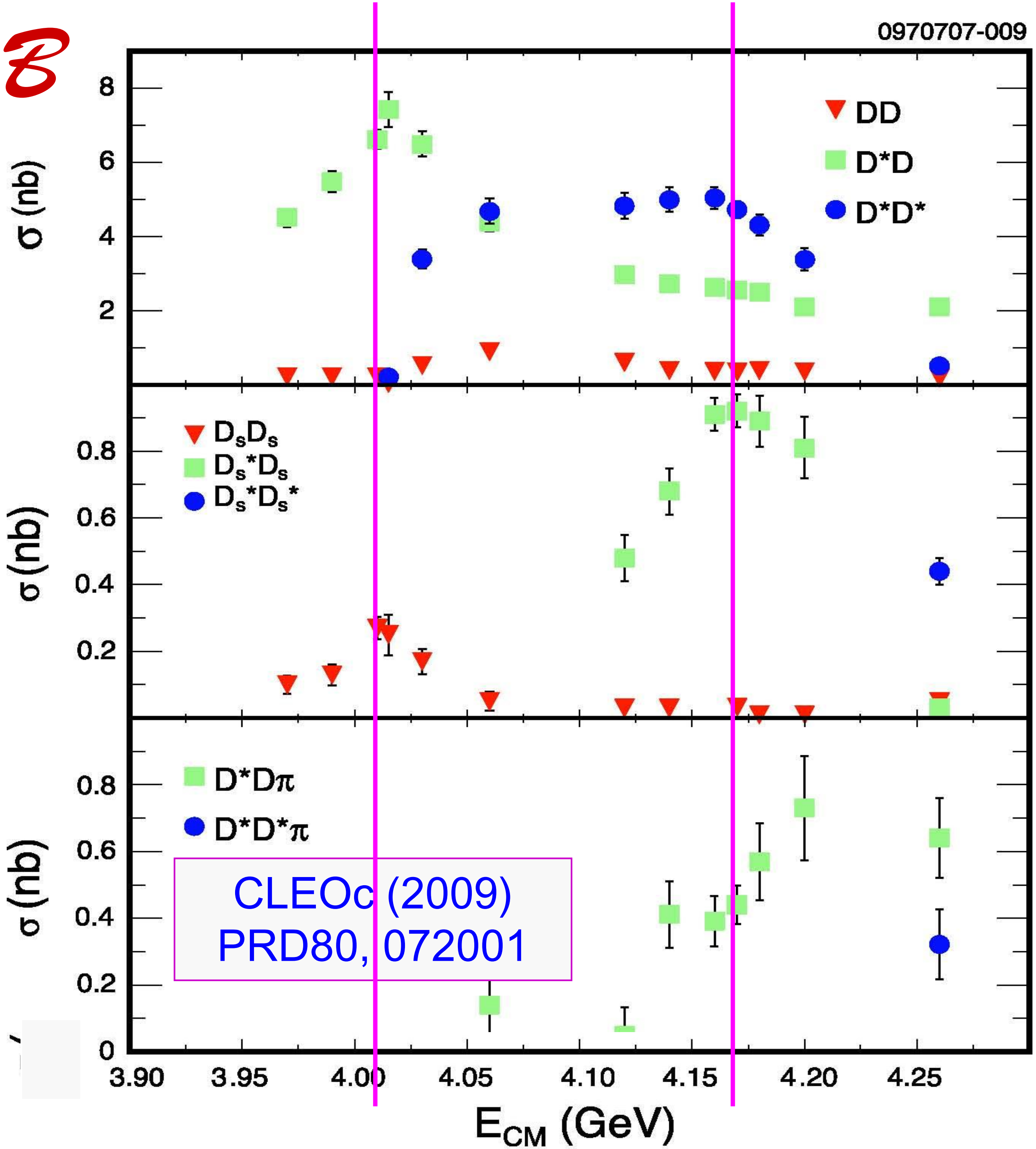
Statistical error limited, systematic error on B ~ 2% level [CLEOc~1%]

- In 20 fb^{-1} data, statistical errors negligible, systematic errors dominant, need to investigate how to reduce them

  (tracking, PID, bkg subtraction, q^2 smearing, FSR, …)

- Form factor measurement depends on parameterization.
- Vcs, Vcd extraction limited by FF uncertainty from LQCD.

[Kaneko, this workshop]



BESIII took 0.5/fb data at 4.01 GeV!

4.17 GeV vs. 4.01 GeV:

$\sigma(D_sD_s) = 0.27$ nb @ 4.01

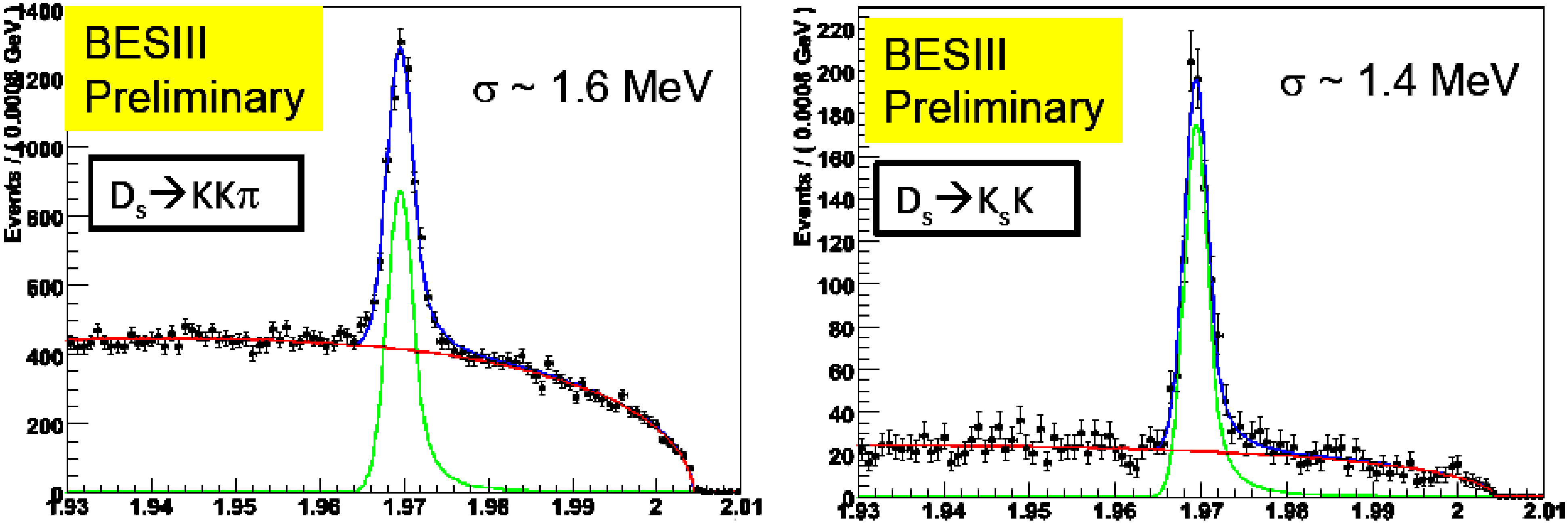
$\sigma(D_sD_s{}^*) = 0.92$ nb @ 4.17

[Need to detect one additional low energy photon at 4.17 GeV]

Data taking in May 2011 for XYZ particle search & for D_s study!

D_s tag at BESIII

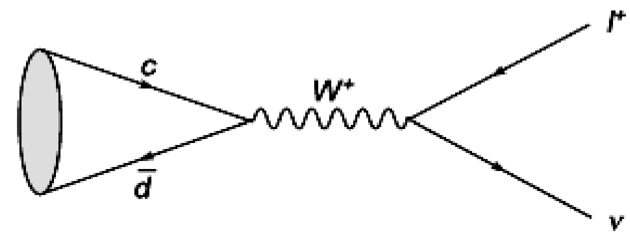
@ 4.01 GeV with ~0.5 fb^{-1} data, single-tag sample:

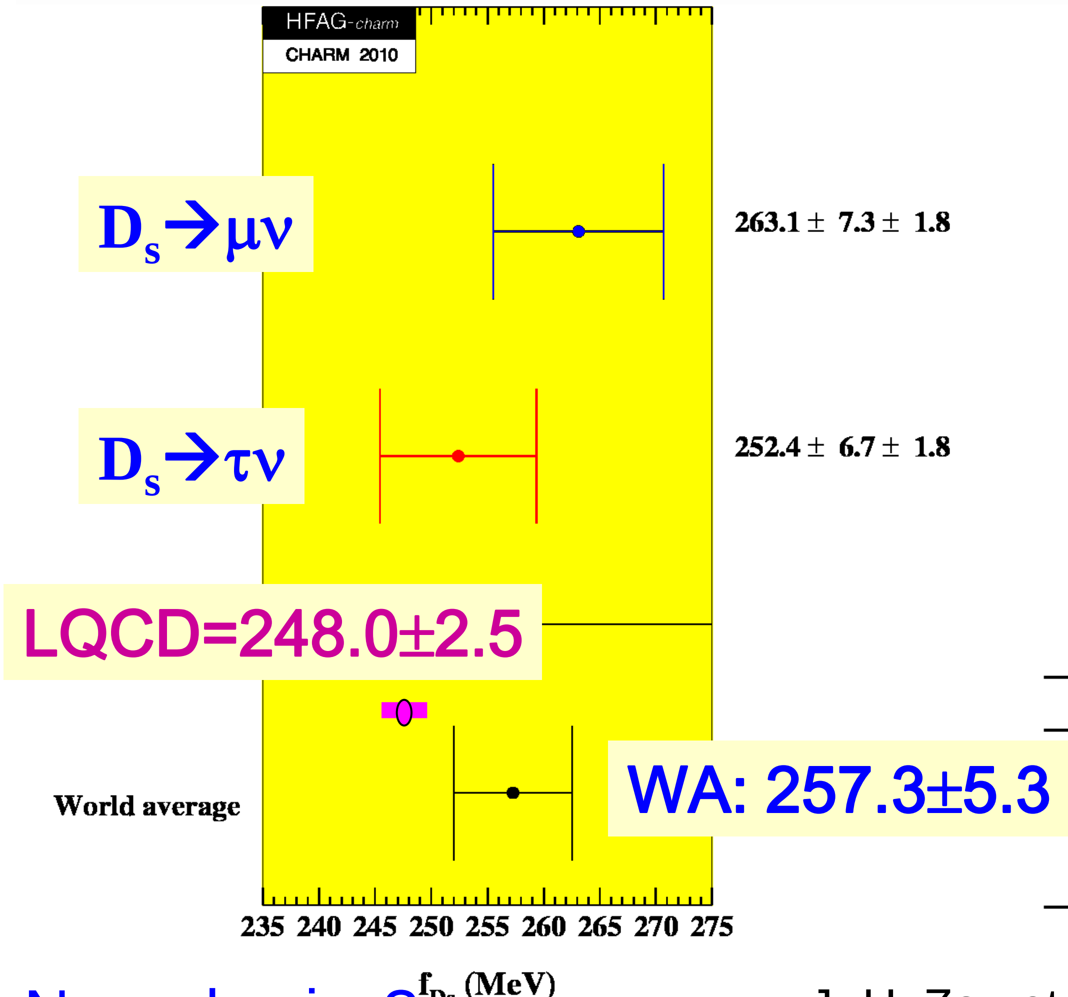


- About 11k tagged Ds (44k at CLEOc at 4.17 GeV)
- f_{Ds} (both μ and τ modes) measurement underway
- Uncertainty dominated by statistics of the signal events

Decay constant of Ds

$$\Gamma(D_{(s)} \to \ell\nu) = f^2_{D_{(s)}} |V_{cq}|^2 \frac{G_F^2}{8\pi} m_{D_{(s)}} m_\ell^2 \left(1 - \frac{m_\ell^2}{m^2_{D_{(s)}}}\right)^2$$





There is less fun in f_D since data agree with LQCD ☺

Will the ~1.6σ difference between data and LQCD persists?

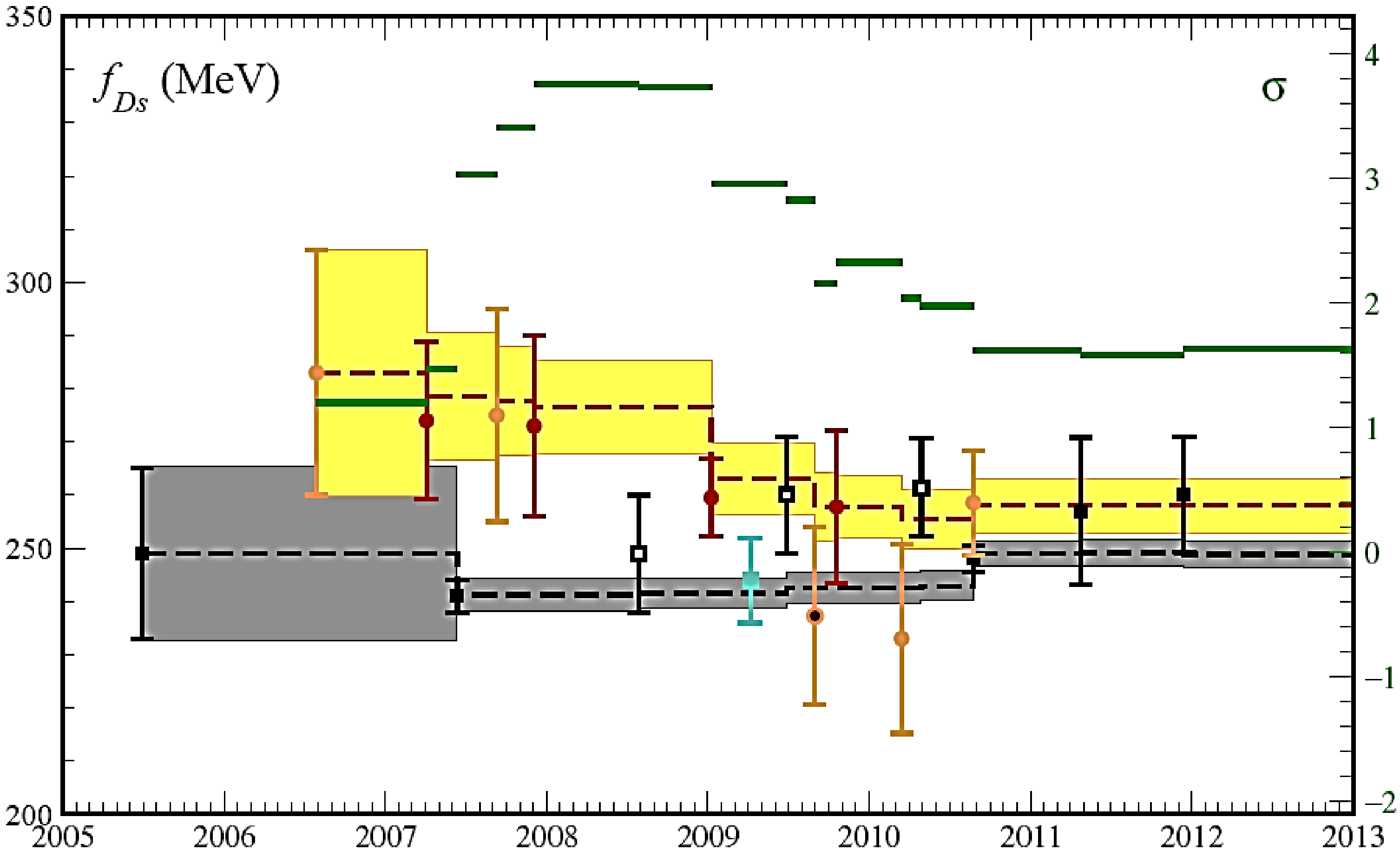
Table 3. Expected errors on the branching fractions for leptonic decays and decay constants at the BES-III with 20 fb^{-1} at $\psi(3770)$ peak and $E_{CM} = 4170$ MeV, respectively.

Observable	Error	Measurement	Error
$\mathcal{BR}(D^+ \to \mu^+\nu)$	2.0%	$f_D\vert V_{cd}\vert$	1.1%
$\mathcal{BR}(D_s^+ \to \mu^+\nu)$	2.0%	$f_{Ds}\vert V_{cs}\vert$	1.0%
$\frac{\mathcal{BR}(D_s^+ \to \mu^+\nu)}{\mathcal{BR}(D^+ \to \mu^+\nu)}$	2.6%	$\left\vert\frac{V_{cs} f_{Ds}}{V_{cd} f_D}\right\vert$	1.3%

New physics?

J.-H. Zou et al., arXiv: 0804.1822 [hep-ex]

Decay constant of Ds



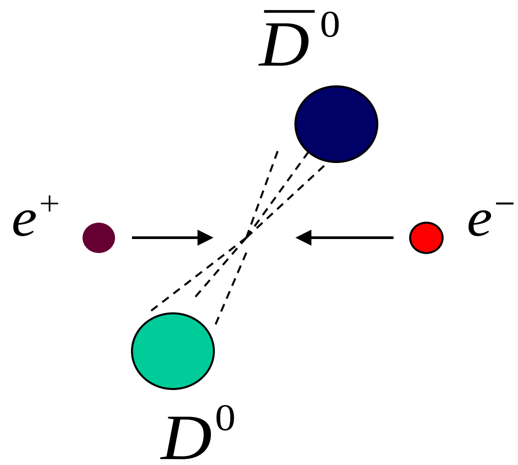
Will the ~10 MeV difference between data and LQCD persists?

1% in experiment ⊕ 1% in LQCD ~ 3.5 MeV (~3σ effect!)

A.S. Kronfeld, arXiv: 1203.1204 [hep-lat]

$\bar{D}^0 D^0$ quantum correlation @ ψ''

For a physical process producing $\bar{D}^0 D^0$ such as



$$e^+e^- \to \psi'' \to D^0\bar{D}^0$$

The quantum number of ψ'' is JPC=1- -

∴ For a correlated state C=-1:

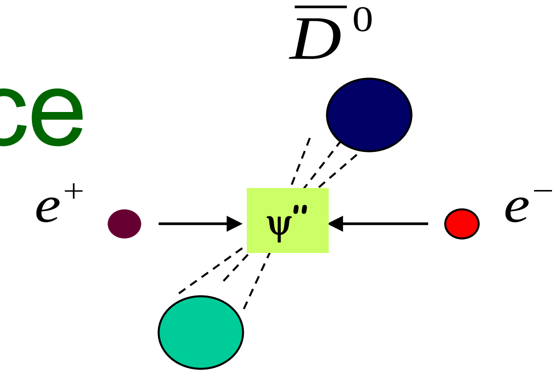
$$\psi_- = \frac{1}{\sqrt{2}}\left(|D^0\rangle|\bar{D}^0\rangle - |\bar{D}^0\rangle|D^0\rangle\right)$$

The correlated decay rate is

$$\Gamma_{ij} = \left|\langle i|D^0\rangle\langle j|\bar{D}^0\rangle - \langle j|D^0\rangle\langle i|\bar{D}^0\rangle\right|^2$$

By investigating the correlation between the $\bar{D}^0 D^0$ decays, the strong phase between Cabibbo Suppressed / Favored decays and $\bar{D}^0 D^0$ mixing/CPV information can be extracted.

Physics via Coherence



- 20 fb^{-1} data at ψ'' peak [72M produced $\overline{D}^0 D^0$]
- D^0 mixing: $R_M = (x^2+y^2)/2 \sim 10^{-4}$; $y \sim 0.003$
- CP violation in D sector: $O(10^{-3})$
- Uncertainty of ϕ_3/γ due to unknown ralative phase on Dalitz decay $\overline{D}^0/D^0 \rightarrow K_s h^+ h^-$ will be reduced to less than 1 degree.

$\bar{D}^0 D^0$ mixing at threshold

Without mixing in D^0, the following process is forbidden due to Boson-Einstein statistics, with mixing happened, it is allowed.

$$e^+e^- \rightarrow \psi(3770) \rightarrow D_H^0 D_L^0 \rightarrow (K^\pm \pi^\mp)_H (K^\pm \pi^\mp)_L$$

$R_M=(x^2+y^2)/2$ can be measured using the ratios

$$R_M = \frac{N[D^0\overline{D}^0 \rightarrow (K^-\pi^+)(K^-\pi^+)]}{N[D^0\overline{D}^0 \rightarrow (K^-\pi^+)(K^+\pi^-)]}, \quad \frac{N[D^0\overline{D}^0 \rightarrow (K^-e^+/\mu^+\nu)(K^-e^+/\mu^+\nu)]}{N[D^0\overline{D}^0 \rightarrow (K^-e^+/\mu^+\nu)(K^+e^-/\mu^-\nu)]}$$

Reaction	Events RS ($\times 10^4$)	Sensitivity R_M ($\times 10^{-4}$)
$\psi(3770) \rightarrow (K^-\pi^+)(K^-\pi^+)$	10.4	1.0
$\psi(3770) \rightarrow (K^-e^+\nu)(K^-e^+\nu)$	8.9	
$\psi(3770) \rightarrow (K^-e^+\nu)(K^-\mu^+\nu)$	8.1	3.7
$\psi(3770) \rightarrow (K^-\mu^+\nu)(K^-\mu^+\nu)$	7.3	

X.D. Cheng et al., PRD75, 094019 (2007)

$\bar{D}^0D^0$ mixing at threshold

For C=-1 initial $\bar{D}^0D^0$ state, y can be expressed as function of double tag rates to lepton and CP eigenstate and single tag rate to CP eigenstate:

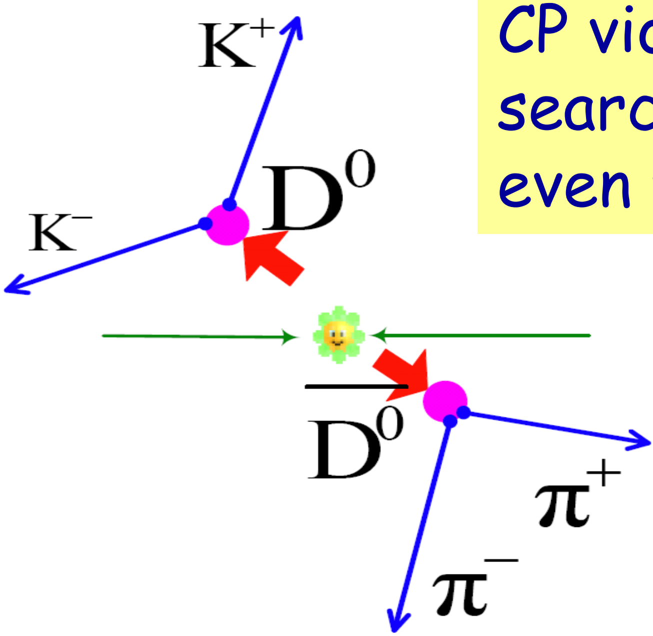
$$y = \frac{1}{4}\left(\frac{\Gamma_{l;f_+}\Gamma_{f_-}}{\Gamma_{l;f_-}\Gamma_{f_+}} - \frac{\Gamma_{l;f_-}\Gamma_{f_+}}{\Gamma_{l;f_+}\Gamma_{f_-}}\right)$$

$$\Delta(y) = \frac{\pm 26}{\sqrt{N(D^0\bar{D}^0)}} = \pm 0.003$$

Depends on assumed CP-tagging efficiency and BRs, but the uncertainty should not change much.

X.D. Cheng et al., PRD75, 094019 (2007)

CP violation at BESIII



CP violating asymmetries can be measured by searching for events with two CP odd or two CP even final states: $\pi^+\pi^-$, K^+K^-, $\pi^0\pi^0$, $K_S\pi^0$

for the decay of $\psi'' \to D^0\overline{D}^0 \to f_1 f_2$

$$CP(f_1 f_2) = CP(f_1)\cdot CP(f_2)\cdot(-1)^L = -$$
$$CP(\psi'') = +$$

A_{CP} sensitivity : ΔA ~$O(10^{-3})$

CP violation in mixing can be measured with:

$$A_{SL} = \frac{\Gamma_{l^+l^+} - \Gamma_{l^-l^-}}{\Gamma_{l^+l^+} + \Gamma_{l^-l^-}} = \frac{1 - |q/p|^4}{1 + |q/p|^4}$$

With 10^8 $\bar{D}D$ pairs in $(K^+e^-\nu)(K^+e^-\nu)$ mode, $|q/p|$ can be measured with (20-30)% accuracy. Current world averaged value is 0.89±0.16 .

CPV in D decay at BESIII

Direct CP violation in D decays is expected to be small in SM.

For CF and DCS decays direct CP violation requires New Physics.
Exception: $D^{\pm}\to K_{S,L}\pi^{\pm}$ with $A_{CP}=-3.3\times10^{-3}$.

For Singly Cabibbo Suppressed (SCS) decays SM CPV could reach 10^{-3}.

$$A_{CP}=\frac{\Gamma(D\to f)-\Gamma(\bar{D}\to\bar{f})}{\Gamma(D\to f)+\Gamma(\bar{D}\to\bar{f})}$$

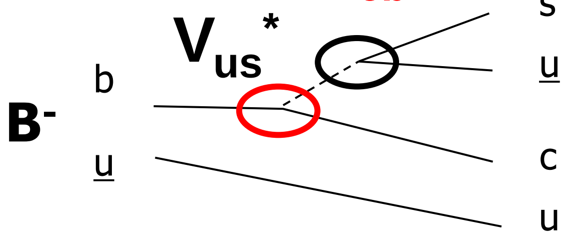
D.S.Du , EPJC5,579(2007)
Y. Grossman et al
PRD75, 036008(2007)

At BESIII, CP asymmetry can be tested with $O(10^{-3})$ sensitivity for many final states.

The weak phase φ_3/γ

Interference between tree-level decays; theoretically clean

Favored: V_{cb}

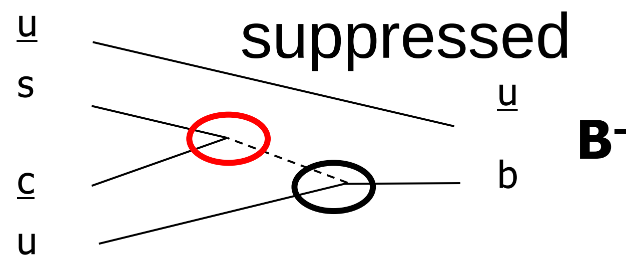


$K^{(*)-}$

Common final state

$K^{(*)-}$

V_{cs}^* V_{ub}: suppressed



$D^{(*)0} \longrightarrow f \longleftarrow \bar{D}^{(*)0}$

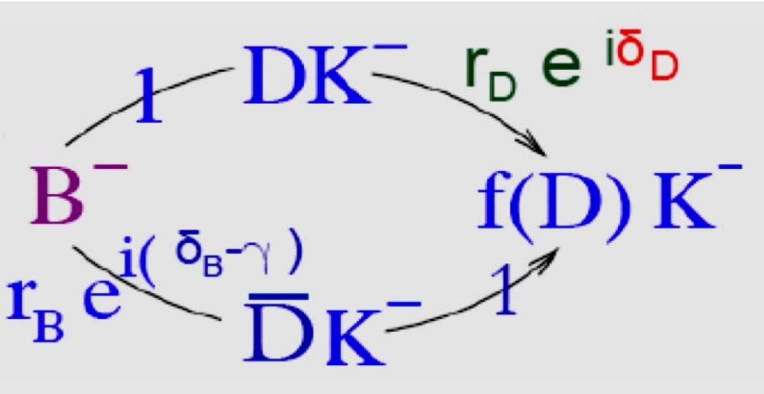
$$\frac{A\left(B^- \to \bar{D}^0 K^-\right)}{A\left(B^- \to D^0 K^-\right)} = r_B e^{i\delta} e^{-i\phi_3}$$

Parameters: ϕ_3, (r_B, δ) per mode

Three methods for exploiting interference (choice of D^0 decay modes):

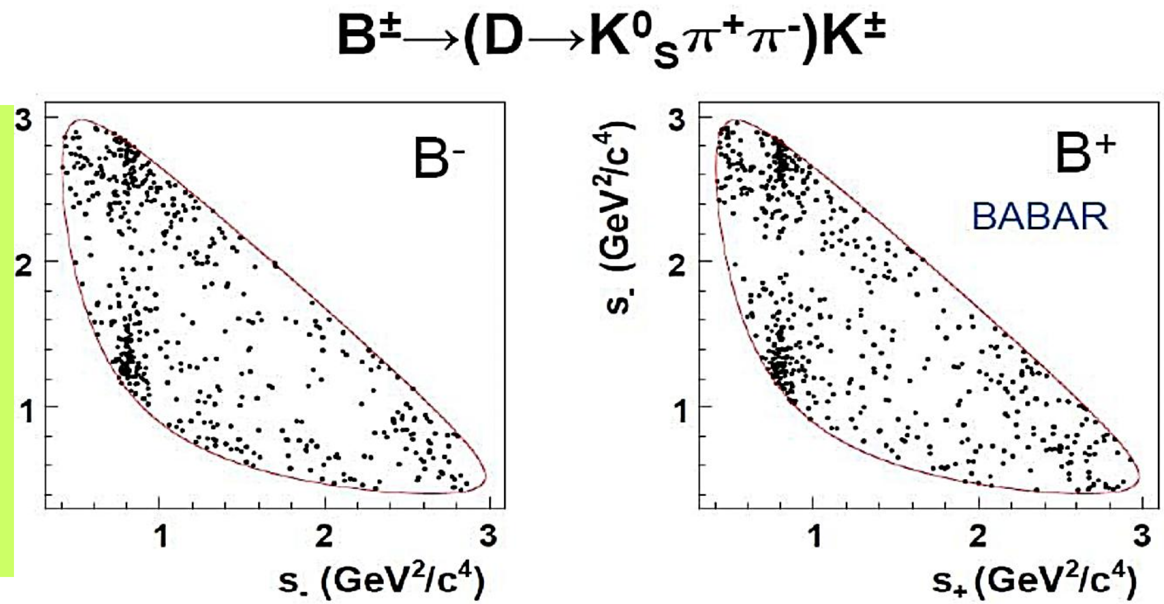
- Gronau, London, Wyler (GLW): Use CP eigenstates of $D^{(*)0}$ decay, e.g. $D^0 \to K_s\pi^0$, $D^0 \to \pi^+\pi^-$
- Atwood, Dunietz, Soni (ADS): Use doubly Cabibbo-suppressed decays, e.g. $D^0 \to K^+\pi^-$
- Giri, Grossman, Soffer, Zupan (GGSZ) / Belle: Use Dalitz plot analysis of 3-body D^0 decays, e.g. $K_s\,\pi^+\pi^-$

$B^- \to D(K_s h^+ h^-) K^-$ Dalitz plot for ϕ_3/γ at B factory



A powerful choice of common state f(D) in $K_s h^+ h^-$
BABAR: PRL 105, 121801 (2010)
Belle : PRD 81, 112002 (2010)

Differents between B^- and B^+ Dalitz plots allow ϕ_3/γ extracted in unbinned fit. However, need to understand different amplitudes from D^0 and $\bar{D}^0$ decay modes across Dalitz space, esp. variation in strong phase.

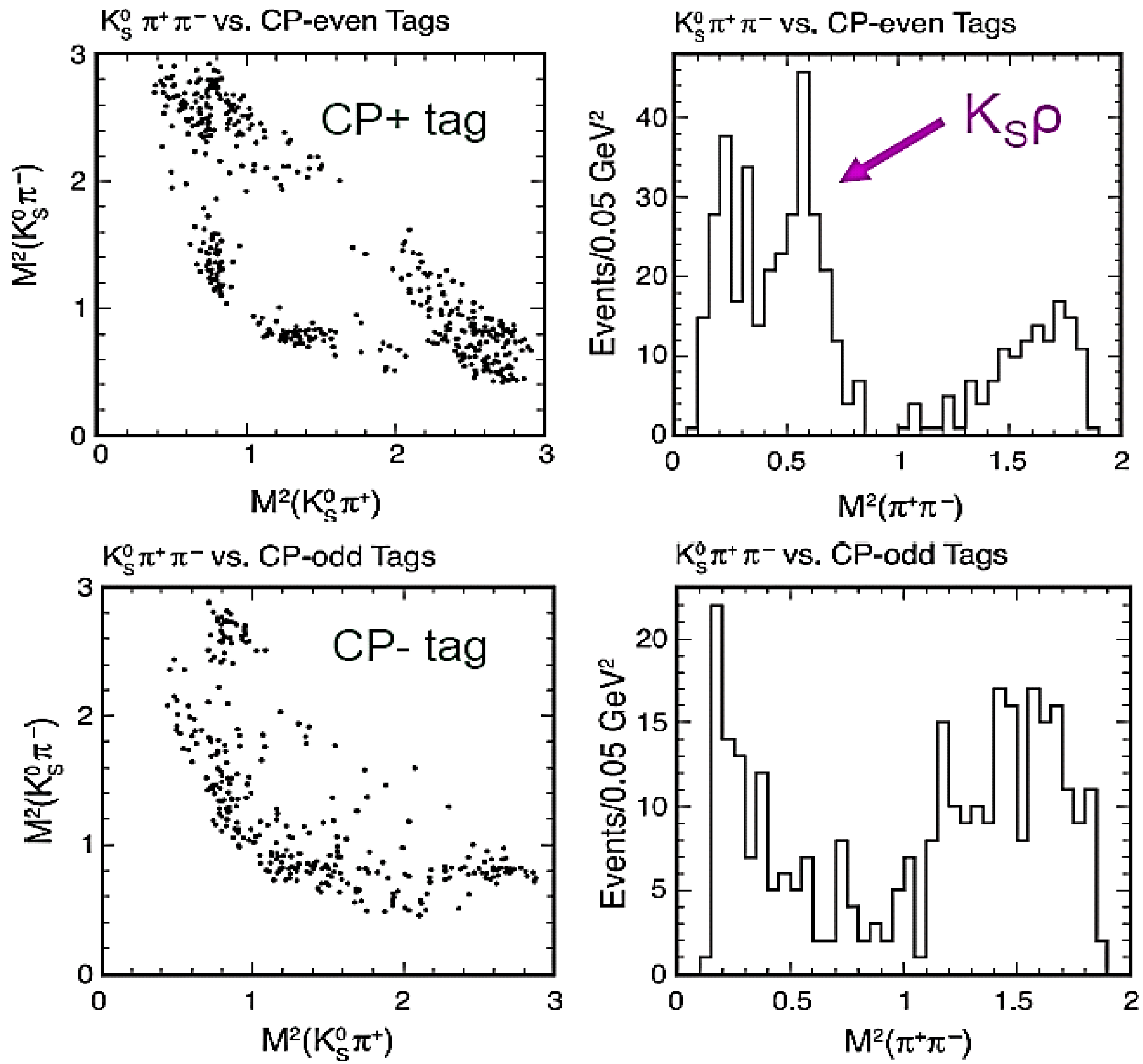


B factories: construct Dalitz plot model of D with flavor-tagged decays, estimated model uncertainty of 3-9 degrees, which is « statistical error.
But super-B and LHCb will start to be limited by this model uncertainty –
Highly desirable to have precision model independent approach!

CP-tagged Dalitz plots of $D^0 \to K_s\pi^+\pi^-$

Clear difference between CP-even and CP-odd tagged Dalitz plots.

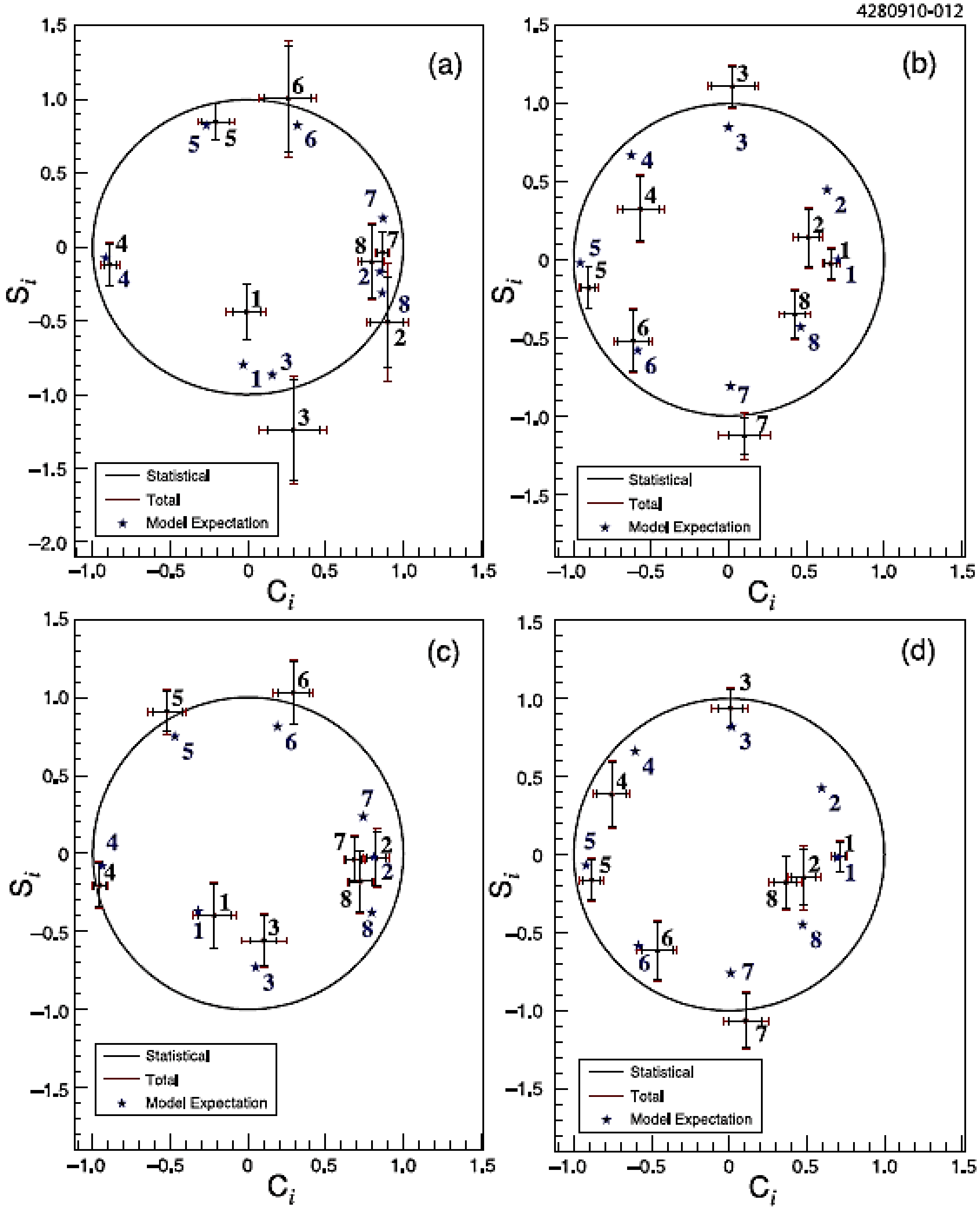
CLEO-c, PRD 80 (2009) 032002



818 pb^{-1}

ψ'' data

at CLEOc



CLEOc:
PRD82, 112006 (2010)

- Different binning causes different results!
- Projected uncertainty on ϕ_3/γ varies from 1.7 to 3.9^0!
- Bias at O(1^0) level is observed!

➔ Low statistics in each bin!

BESIII will reduce this error to less than 1^0 !

Sensitivities for rare charm decay

- $D \to V\gamma$ will be reached at 10^{-6}

  $D^0 \to \phi\gamma$, $K^*\gamma$ will be confirmed and improved

  $D^0 \to \rho\gamma$, $\omega\gamma$ will be improved or found

- $D^0 \to \gamma\gamma$ can be measured with tag or without tag

  the sensitivity will be 10^{-6}

- $D \to Xl^+l^-$ can be reached at 10^{-6}

  BESIII will reach contribution from long distance

- $D^0 \to l^+l^-$ will be reached at 10^{-6} [$<10^{-8}$ @LHCb: this workshop]

- $D^+ \to e^+\nu$: 10^{-6} (SM: 10^{-8})

We really donot have that much compared with LHCb (LHCc?).

Charmonium physics

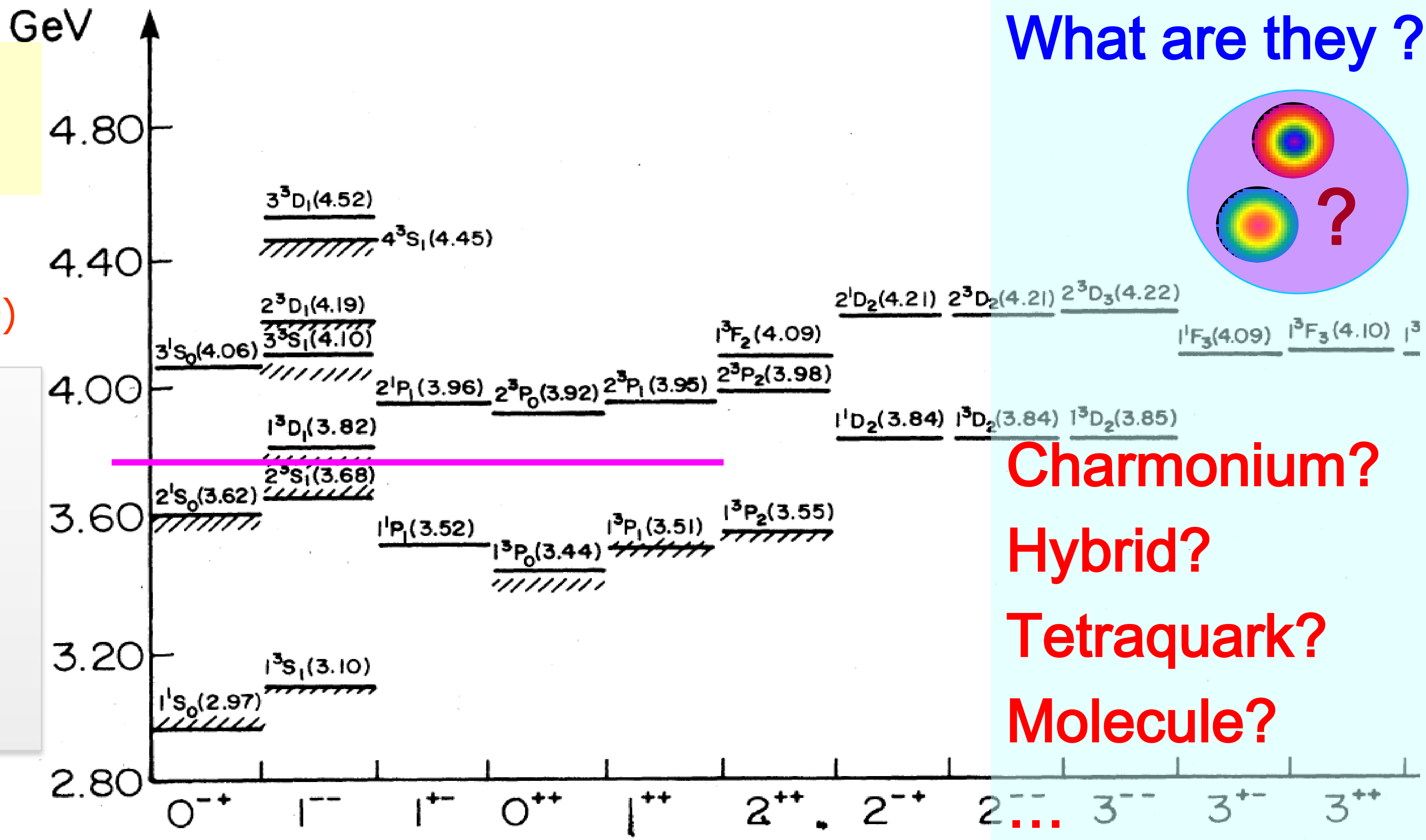
Charmonium + XYZ states

Z(4430)
Z(4250)
Z(4050)

X(3872)

XYZ(3940)

X(3915)
X(4160)
Y(4008)
Y(4140)
Y(4260)
Y(4360)
X(4350)
Y(4660)



What are they ?

Charmonium?

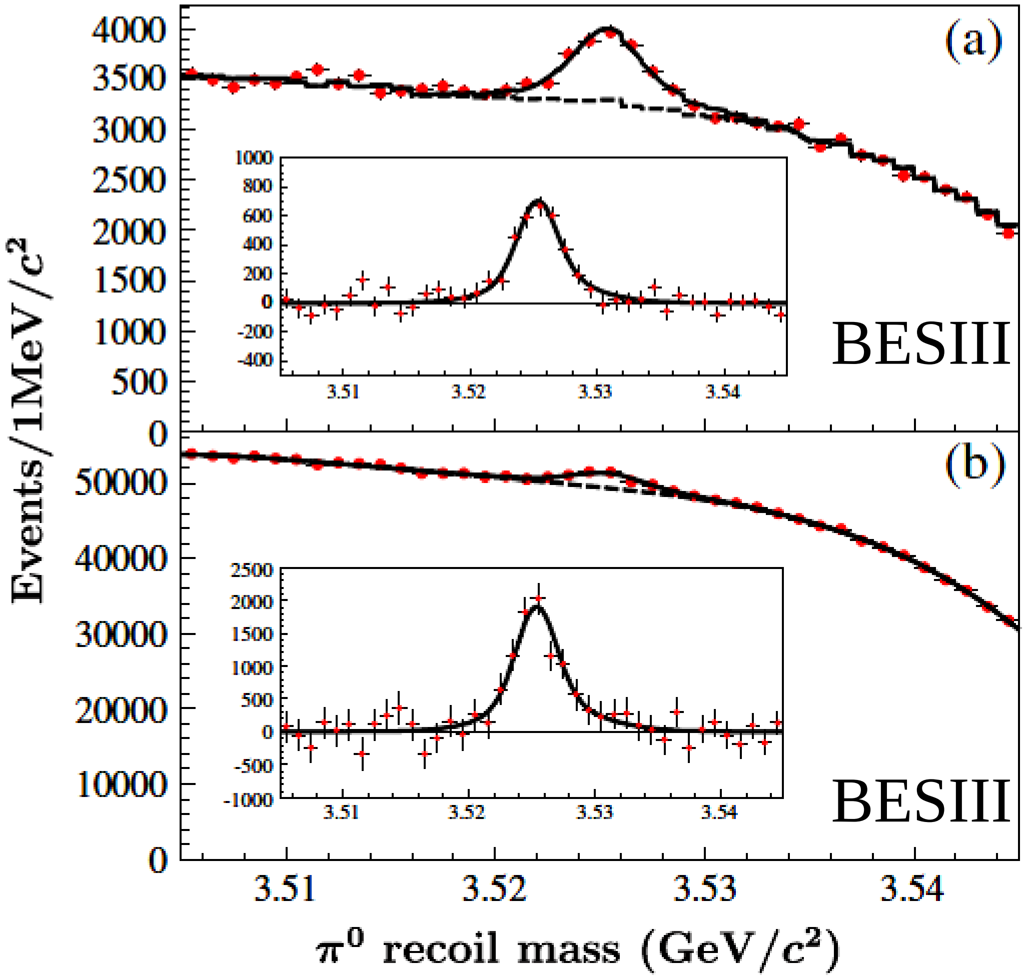
Hybrid?

Tetraquark?

Molecule?

- Below $\bar{D}D$ threshold: spin-singlets, decay properties
- Above $\bar{D}D$ threshold: excited ψs, XYZ states, decay properties

$\psi(2S) \rightarrow \pi^0 h_c$ transition



BESIII: PRL 104, 132002 (2010)

Mass: 3525.40±0.13±0.18 MeV

Width: 0.73±0.45±0.28 MeV

(<1.44 MeV @ 90% C.L.)

CLEOc: PRL101, 182003 (2008)

Mass: 3525.28±0.19±0.12 MeV

Width: fixed to 0.9 MeV

ΔM_{hf}= <M(^3P_J)>-M($^1P_1$)

Agrees with zero within ~0.5 MeV

Information on spin-spin interaction.

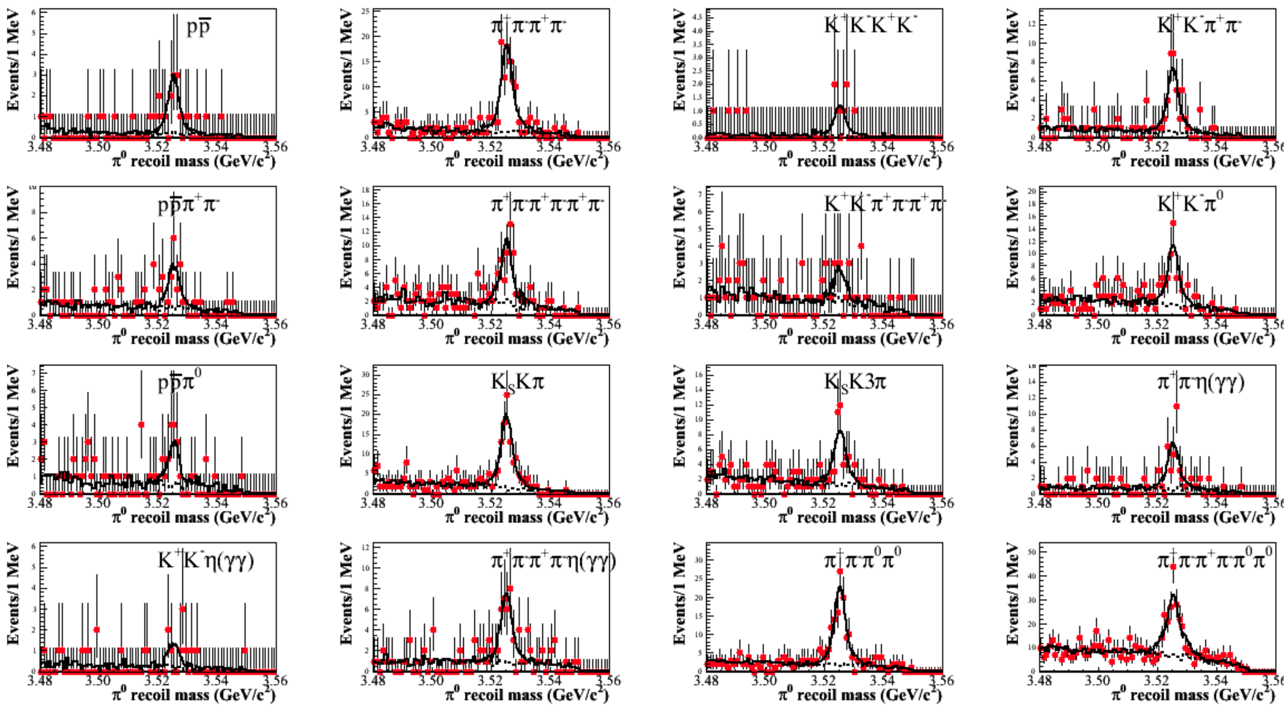
Combined inclusive and E1-photon-tagged spectrum (First measurements)

$B(\psi' \rightarrow \pi^0 h_c)$ = [8.4±1.3(stat.) ±1.0(syst.)]×10^{-4}

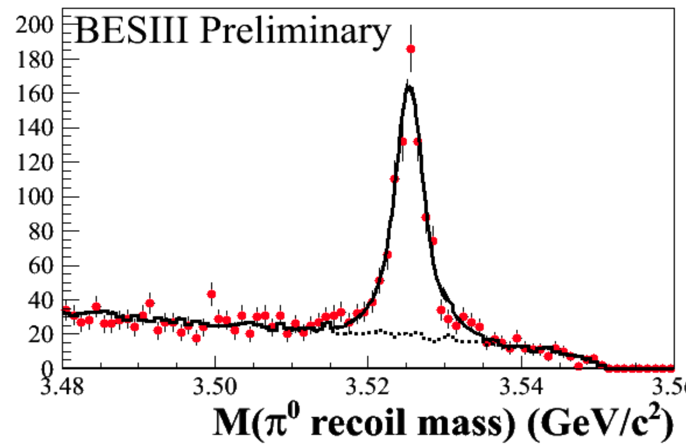
$B(h_c \rightarrow \gamma \eta_c)$ = [54.3±6.7(stat.) ±5.2(syst.)] %

Agree with predictions of Kuang, Godfrey, Dudek, et al.

$\psi(2S) \to \pi^0 h_c$, 16 η_c exclusive decays



Summed π^0 recoil mass



Simultaneous fit to π^0 recoiling mass

$M(h_c) = 3525.31 \pm 0.11 \pm 0.15$ MeV/c^2

$\Gamma(h_c) = 0.70 \pm 0.28 \pm 0.25$ MeV

$N = 832 \pm 35$

χ^2/d.o.f. = 32/46

Consistent with CLEO-c exclusive

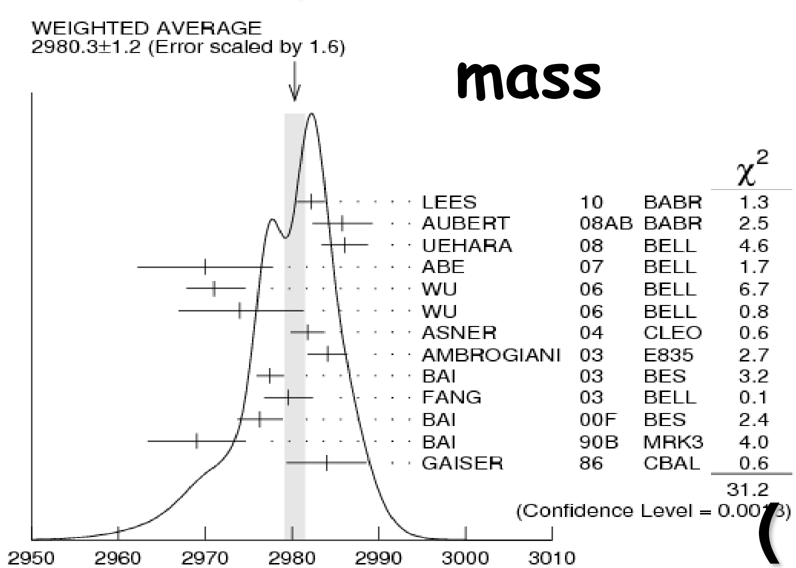
$M(h_c) = 3525.21 \pm 0.27 \pm 0.14$ MeV

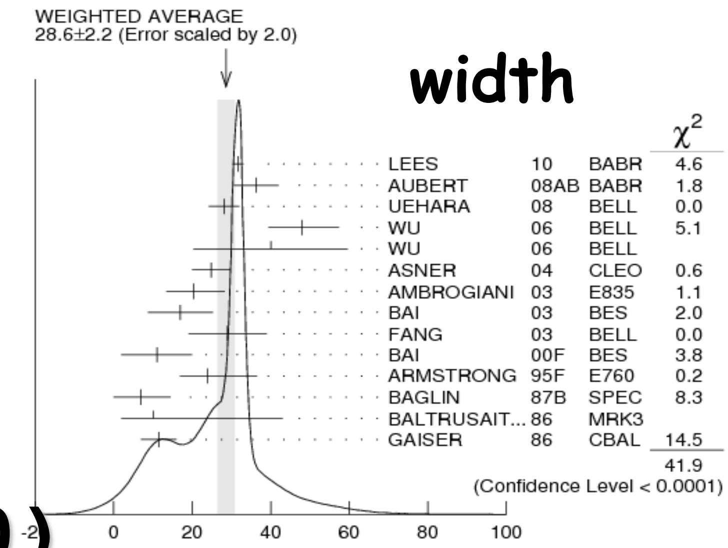
$N = 136 \pm 14$

PRL101, 182003(2008)

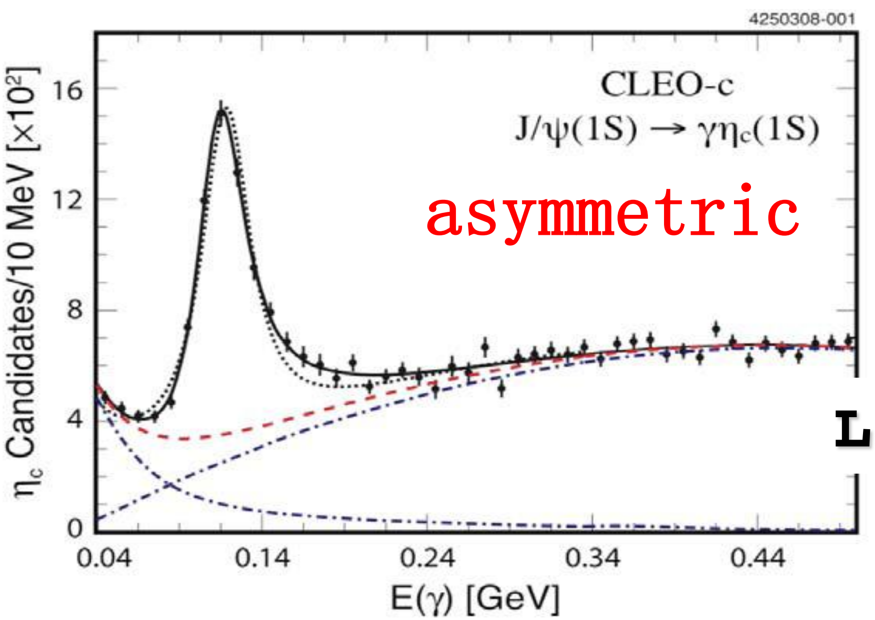
BESIII preliminary

η_c, the lightest charmonium state

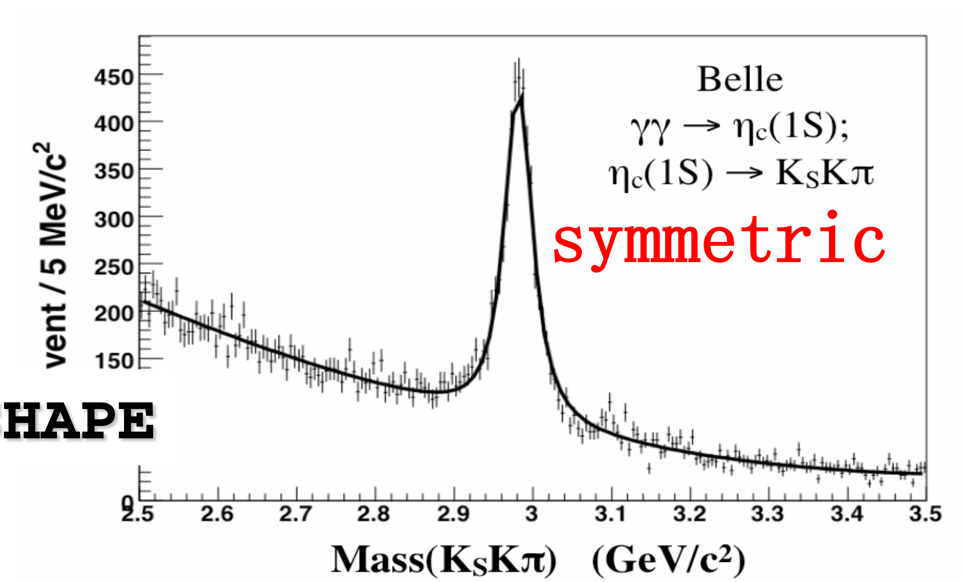




PDG (2010)

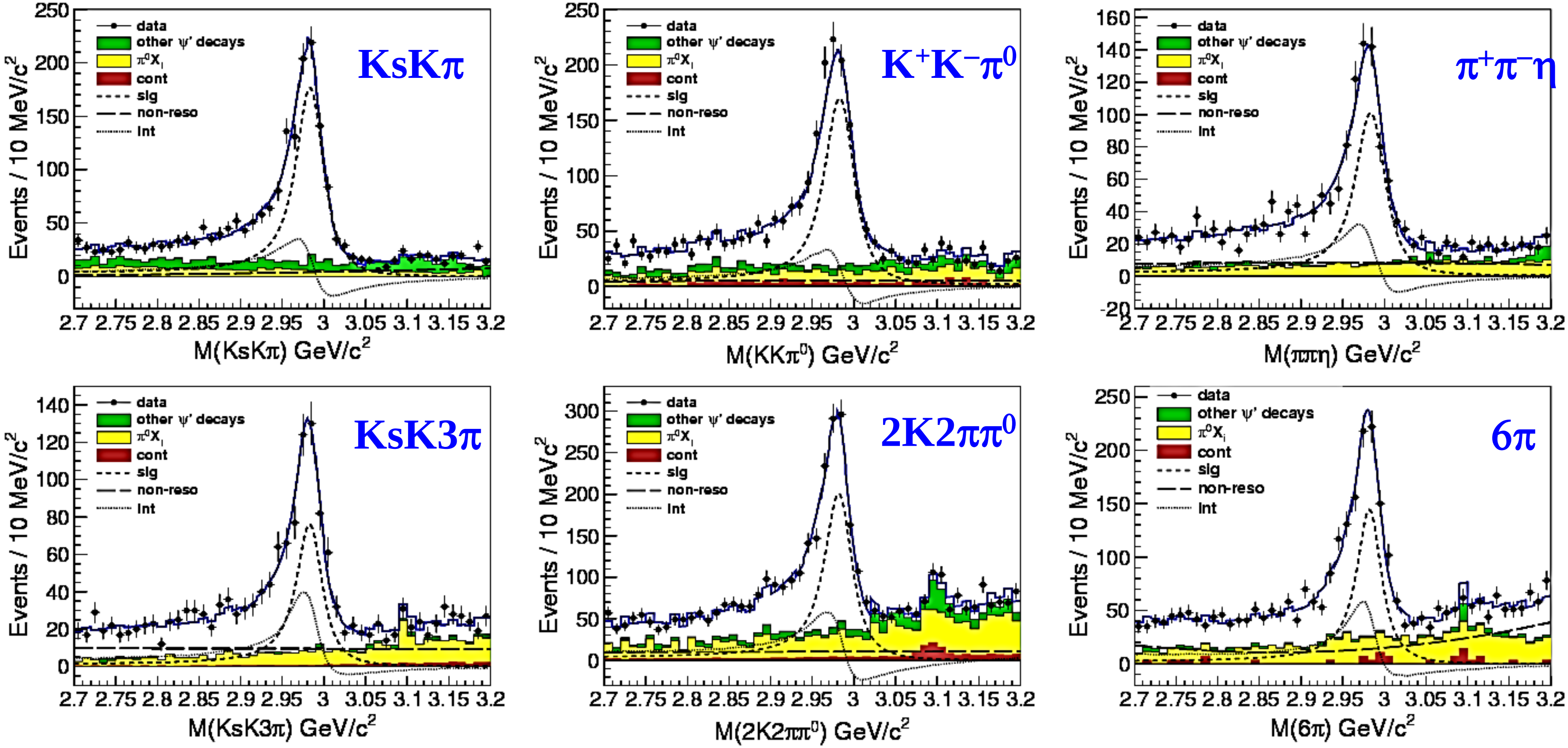


LINESHAPE



η_c resonance parameters from $\psi'\to\gamma\eta_c$

arXiv:1111.0398, submitted to PRL



Simultaneous fit with modified Breit-Wigner (hindered M1) with considering **interference** between η_c and non-η_c decays

Mass and Width of η_c

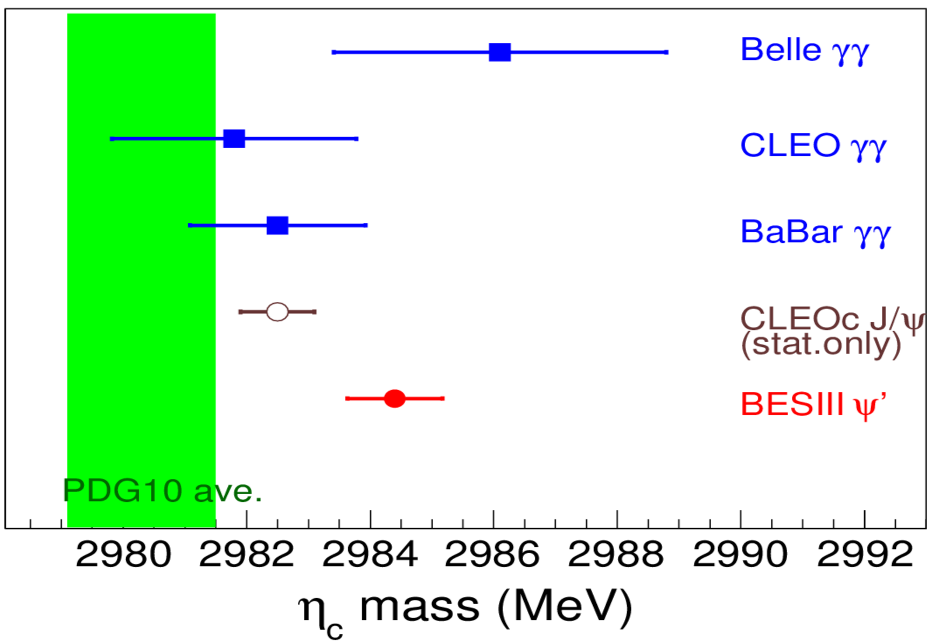
Mass = $2984.3 \pm 0.6_{stat} \pm 0.6_{syst}$ MeV/c^2

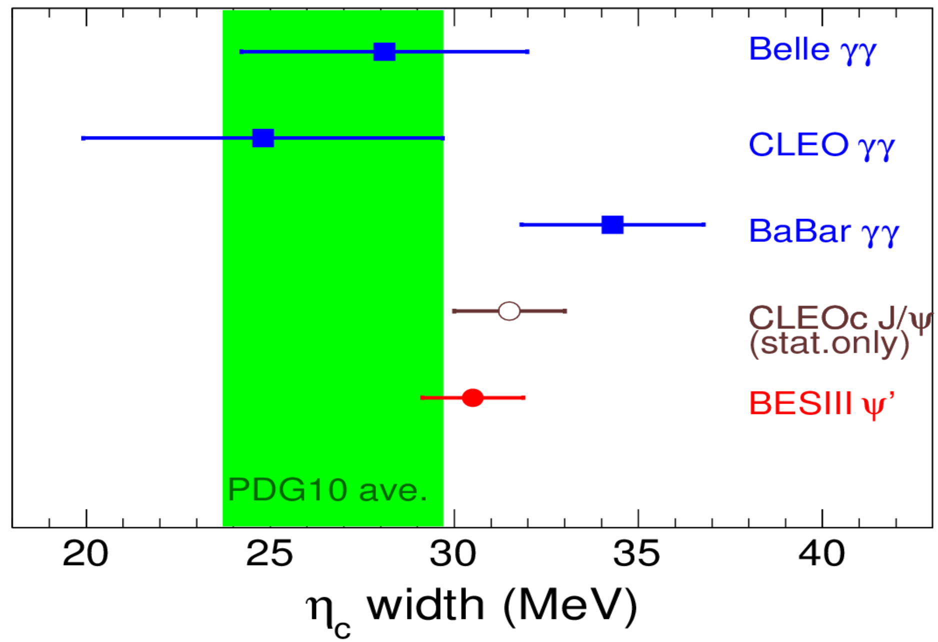
Width = $32.0 \pm 1.2_{stat} \pm 1.0_{syst}$ MeV

$\phi = 2.40 \pm 0.07_{stat} \pm 0.08_{syst}$ rad or $4.19 \pm 0.03_{stat} \pm 0.09_{syst}$ rad

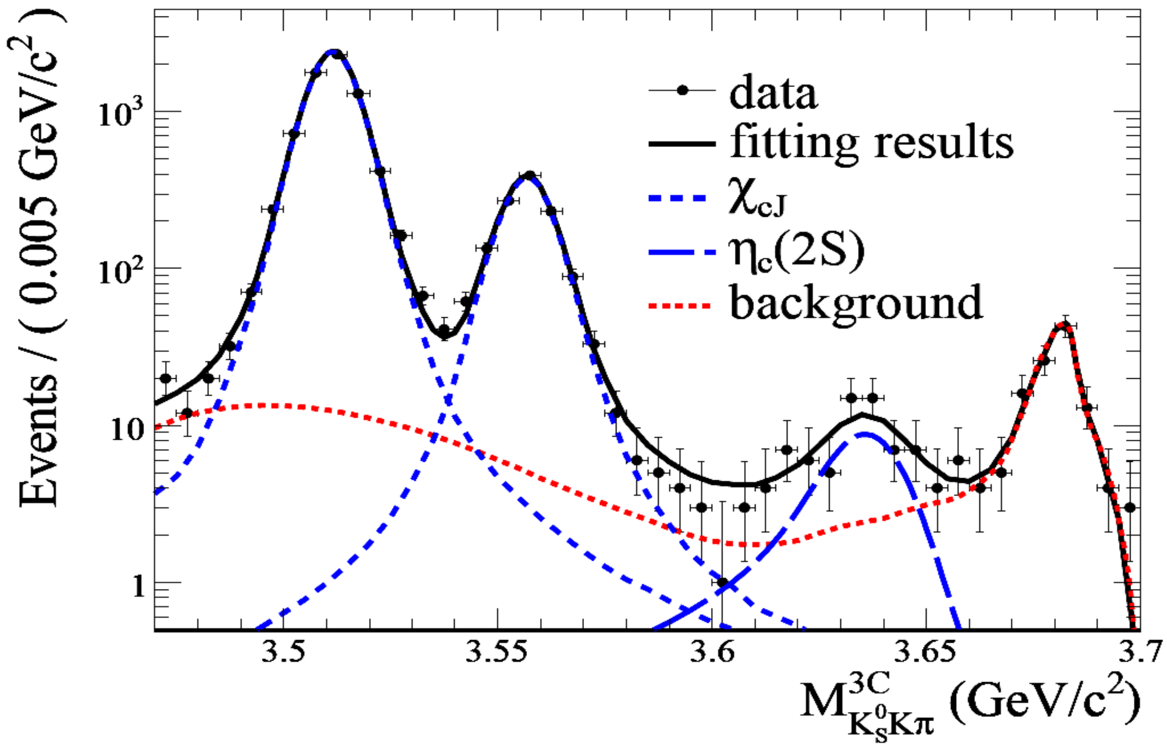
arXiv:1111.0398, submitted to PRL

World average in PDG2010 uses earlier measurements.





Observation of $\psi' \rightarrow \gamma\eta_c'$



- $N(\eta_c(2S)) = 50.6 \pm 9.7$
- Pure statistical significance more than 6σ
- Significance with systematic variations not less than 5σ
- $\chi^2/ndf=0.9$

- $\eta_c(2S)$ signal: modified BW (M1) with fixed width (Resolution extrapolated from χ_{cJ})
- χ_{cJ} signal: MC shape smeared with Gaussian
- BG from $e^+ e^- \rightarrow K_s K\pi$ (ISR), $\psi' \rightarrow K_s K\pi$ (FSR), $\psi' \rightarrow \pi^0 K_s K\pi$: are measured from data

BESIII preliminary

Preliminary results on $\psi' \to \gamma\eta_c' \to \gamma K_s K\pi$

- $M(\eta_c')=3638.5 \pm 2.3_{stat} \pm 1.0_{sys}$ (MeV/c^2)
- $Br(\psi' \to \gamma\eta_c' \to \gamma K_s K\pi)=(2.98 \pm 0.57_{stat} \pm 0.48_{sys}) \times 10^{-6}$

$Br(\eta_c(2S) \to KK\pi)=(1.9 \pm 0.4 \pm 1.1)\%$ from BaBar

$Br(\psi' \to \gamma\eta_c')=(4.7 \pm 0.9_{stat} \pm 3.0_{sys}) \times 10^{-4}$

CLEO-c: $<7.6\times10^{-4}$ (PRD81,052002(2010))

Potential model: $(0.1–6.2)\times10^{-4}$ (PRL89,162002(2002))

BESIII preliminary

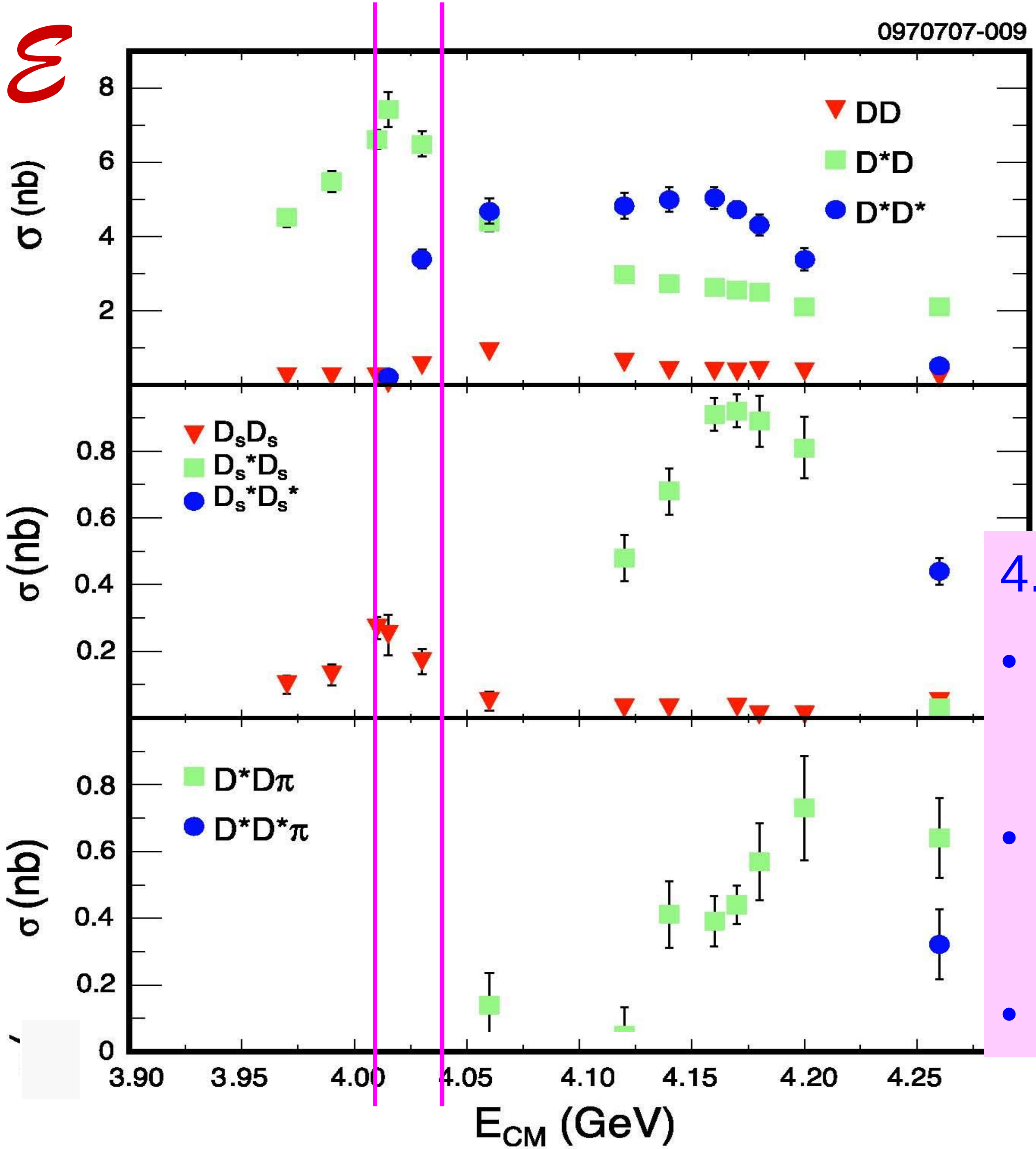
Production Rates of XYZ at BESIII

- No theoretical calculation on $\psi(3S)\to\gamma+XYZ$ if they are exotic states [neither on $\psi(2D)$, $\psi(4S)$]
- Assuming $M(\chi_{cJ}(2P)) \sim 3930$ MeV
  - $B(\psi(3S)\to\gamma\chi'_{cJ})=(7, 3, 1)\times10^{-4}$ for J=2,1,0

    [T. Barnes & S. Godfrey, PRD69, 054008 (2004)

    E. Eichten et al., Rev. Mod. Phys. 80, 1161 (2008)]

    - As masses of the $\chi_{cJ}(2P)$ states are very different from the expectation of the potential models. S-D mixing will also affect the predictions. BRs could be very different.
- Can we observe the X(3872) if it is the χ'_{c1} and the production rate is 3×10^{-4}?



BESIII took 0.5/fb data at 4010 MeV!

CLEOc
PRD80, 072001 (2009)

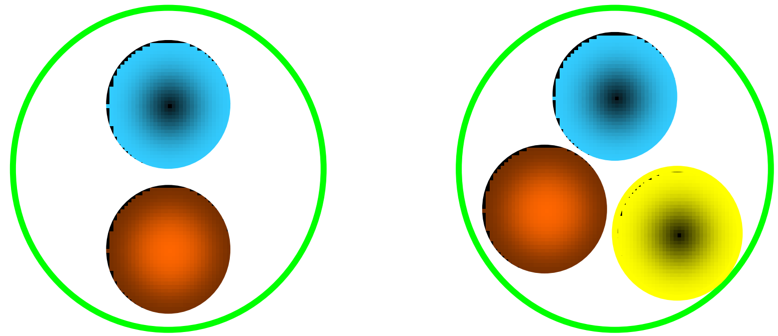
4.04 GeV vs. 4.01 GeV:

- No D*D*!
  - bkg for X3872→DD*
- More Ds!
  - Chance for f_{Ds} meas.!
- Data taking in May 2011!

Light hadrons: normal & exotic

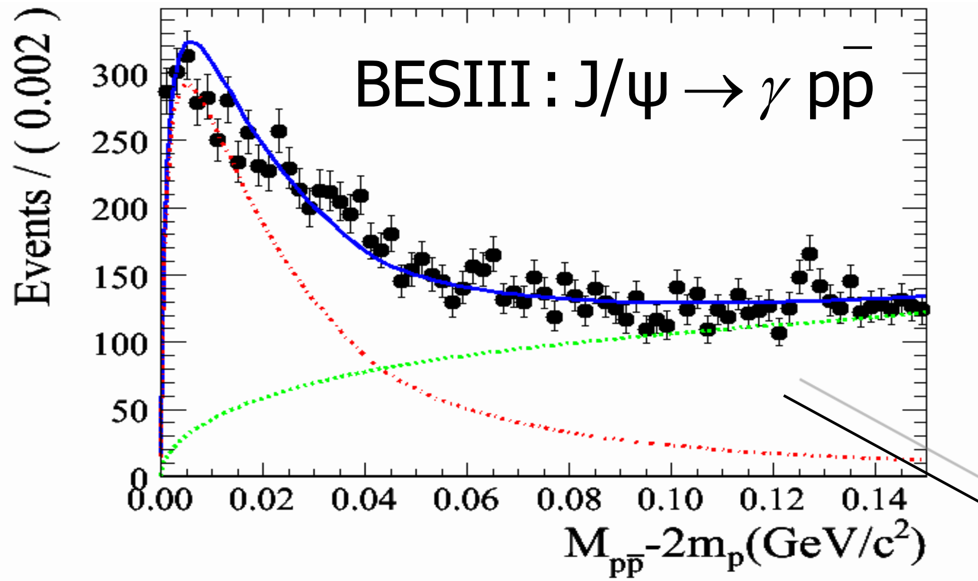
- Hadrons are composed from 2 (meson) or 3 (baryon) quarks

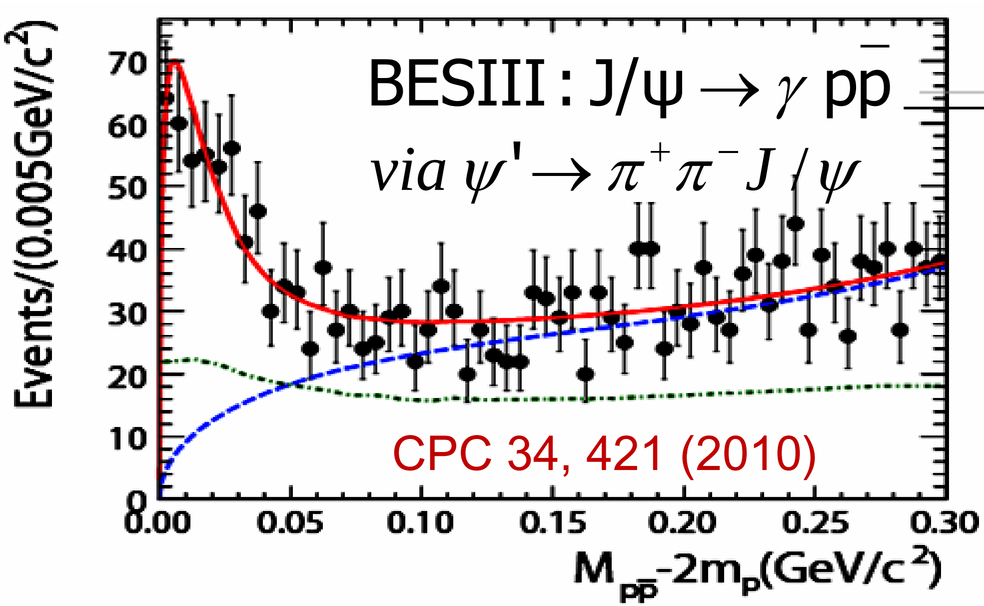
Quark model



- QCD allows hadrons with $N_{quarks} \neq 2, 3$
  - glueball : $N_{quarks} = 0$ (gg, ggg, …)
  - hybrid : $N_{quarks} = 2$ or more + excited gluon
  - Multiquark state : $N_{quarks} > 3$
  - molecule : bound state of more than 2 hadrons

Enhancement at ppbar threshold

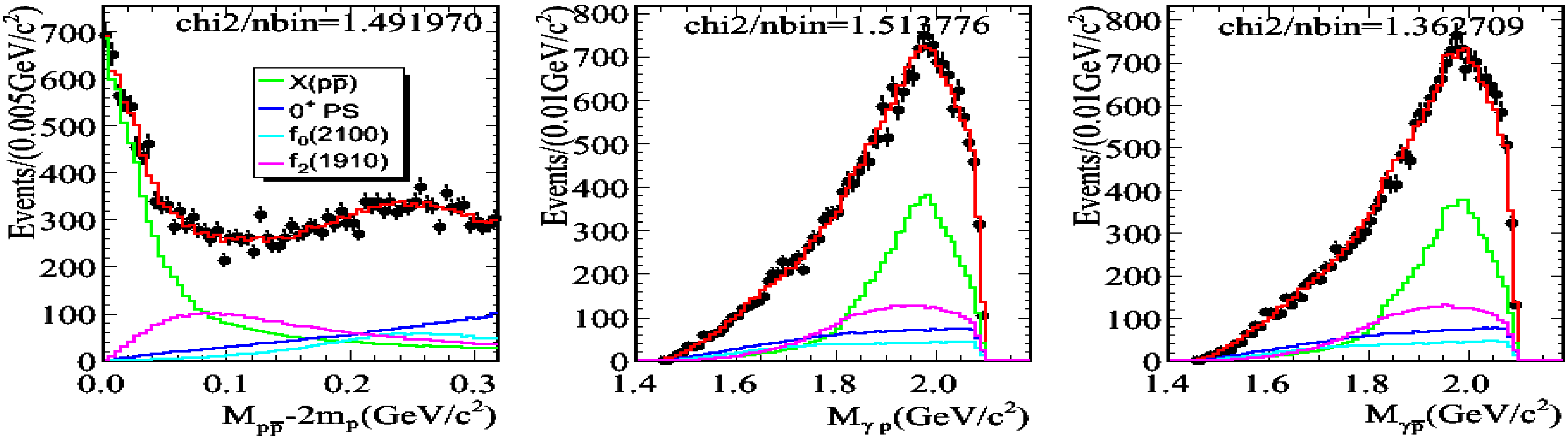




- Observed at BESII in 2003
  - PRL91, 022001
  - $M=1861^{+3}_{-10}{}^{+5}_{-25}$ MeV
  - Width < 38 MeV (90% CL)
  - Agree with spin zero expectation
- Confirmed at BESIII (& CLEOc)
  - M=1861.6±0.8 (stat.) MeV
  - Width<8 MeV @ 90% C.L.
  - $M=1859^{+6}_{-13}{}^{+7}_{-26}$ MeV
  - Width < 30 MeV (90% CL)
- Many possibilities:
  - Normal meson?
  - ppbar bound state/ multiquark/ glueball/ …

Partial wave analysis of J/ψ→γ p $\bar{p}$

arXiv:1112.0942, PRL (in press)



$J^{PC} = 0^{-+}$ FSI correction from A. Sirbirtsen et al., PRD 71, 054010 (2005)

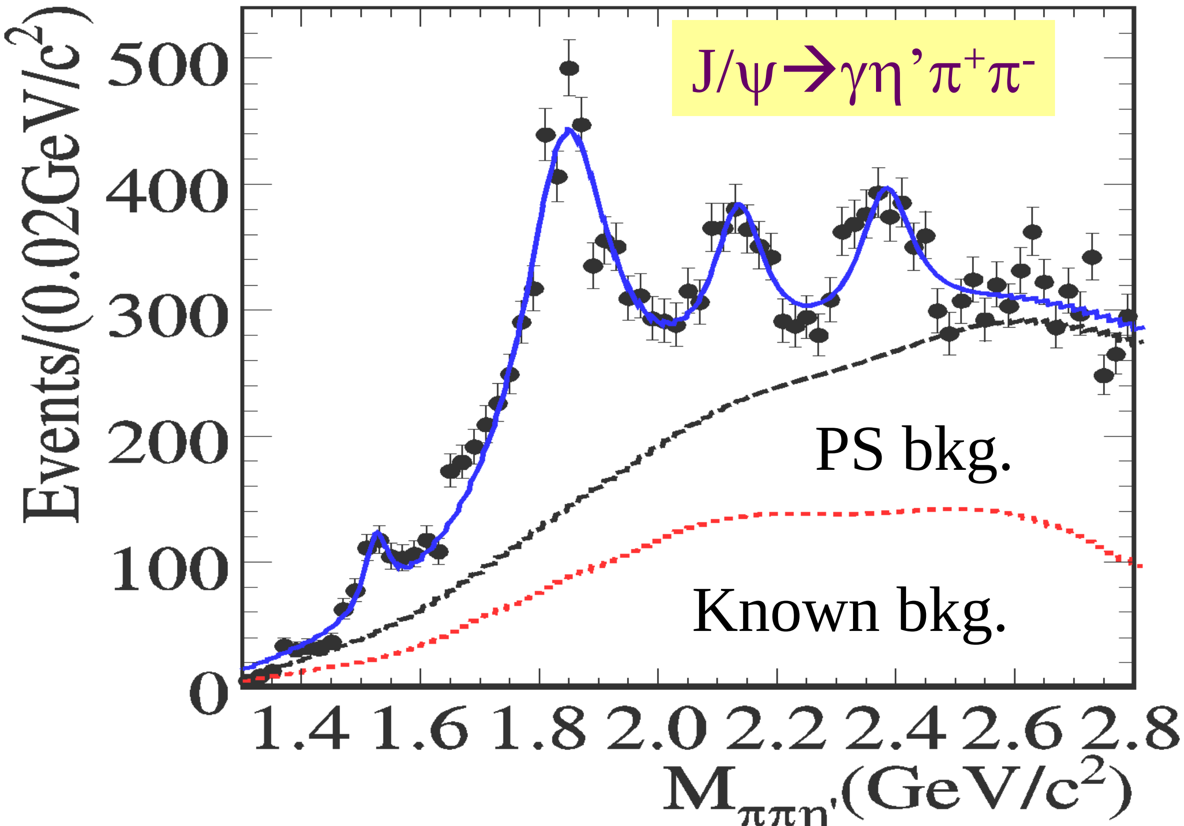
$$M = 1832^{+19}_{-5}\ (\text{stat.})^{+18}_{-17}\ (\text{syst.}) \pm 19\ (\text{model})\ \text{MeV}/c^2$$

$$\Gamma = 13 \pm 39\ (\text{stat.})^{+10}_{-13}\ (\text{syst.}) \pm 4\ (\text{model})\ \text{MeV}/c^2,\ (< 76\ \text{MeV}/c^2)$$

$$BB = (9.0^{+0.4}_{-1.1}\ (\text{stat.})^{+1.5}_{-5.0}\ (\text{syst.}) \pm 2.3\ (\text{model})) \times 10^{-5}$$

FSI changes mass from 1861 MeV to 1832 MeV!

More states decay into $\eta'\pi^+\pi^-$



- X(1835) at BESII
- Confirmed at BESIII, width much larger
- Two more peaks!!
- JP unknown, need PWA
- Nature?
  - X1835=X1859=ppbar bound state?
  - Pseudoscalar glueballs?
  - Excited η or η' states?
  - …

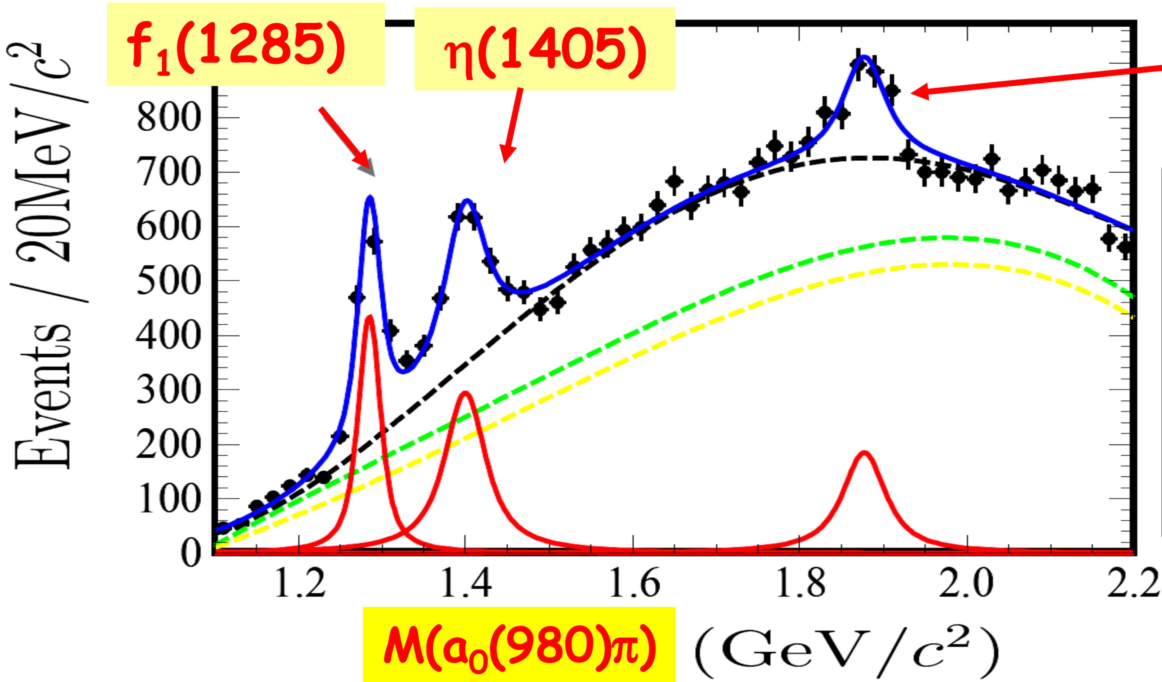
BESII X(1835): $M = 1833.7 \pm 6.1 \pm 2.7$ MeV/c²
$\Gamma = 67.7 \pm 20.3 \pm 7.7$ MeV/c²

PRL106, 072002 (2011)

State	X(1835)	X(2120)	X(2370)
Mass (MeV)	$1836.5 \pm 3.0^{+5.6}_{-2.1}$	$2122.4 \pm 6.7^{+4.7}_{-2.7}$	$2376.3 \pm 8.7^{+3.2}_{-4.3}$
Width (MeV)	$190 \pm 9^{+38}_{-36}$	$83 \pm 16^{+31}_{-11}$	$83 \pm 17^{+44}_{-6}$

States in $J/\psi \rightarrow \omega\eta\pi^+\pi^-$

- Fitting with three resonances (acceptance weighted BWxGaussian)
- Background component described by Polynomial function



① Contribution from non-ω and/or non-$a_0(980)$ BG events
② Contribution from $J/\psi \rightarrow b_1(1235)a_0(980)$
③ Contribution from "PS" process of $J/\psi \rightarrow \omega a_0(980)\pi$

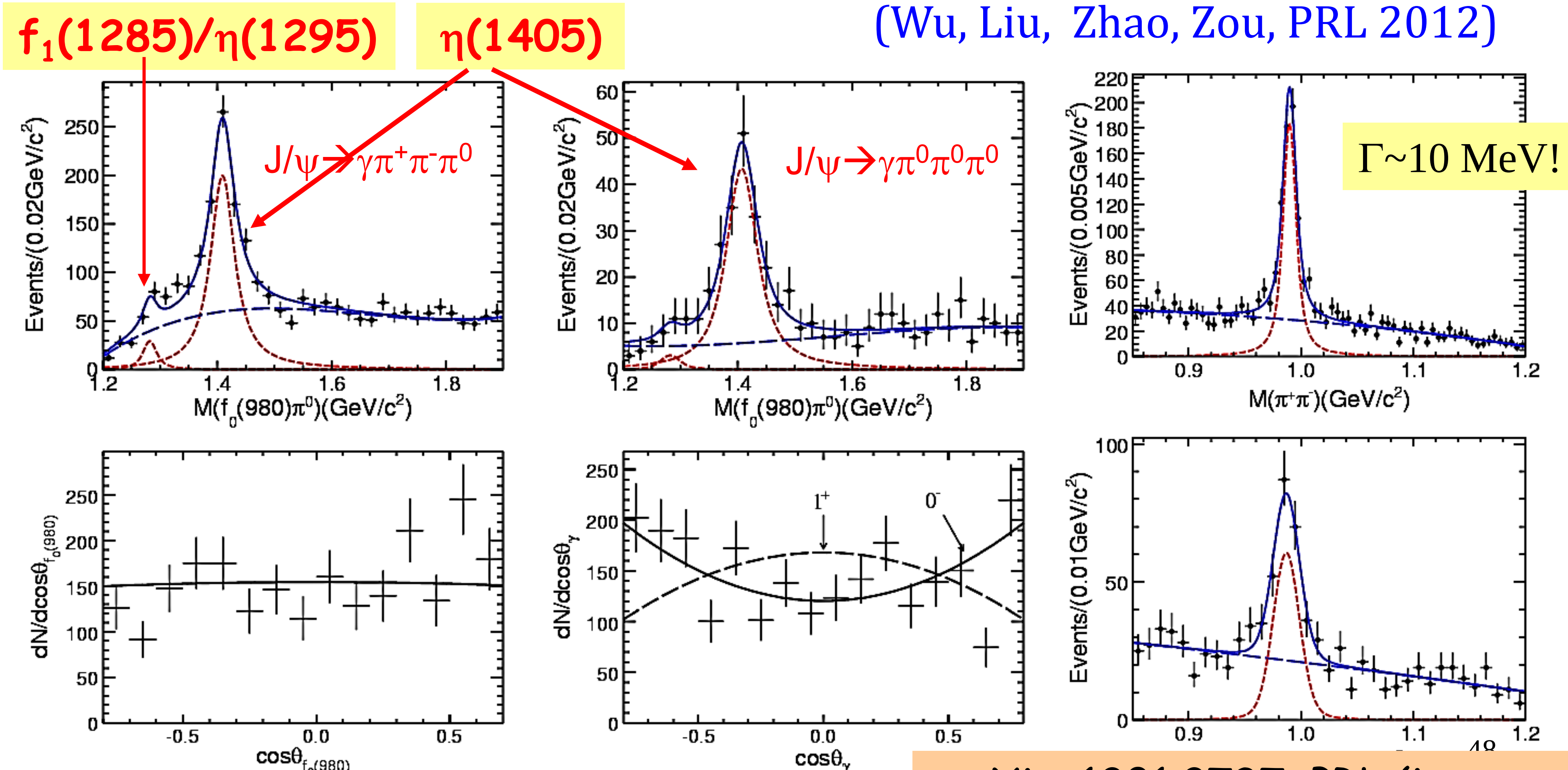
Resonance	Mass (MeV/c^2)	Width (MeV/c^2)	Branch ratio (10^{-4})
$f_1(1285)$	$1285.1 \pm 1.0^{+1.6}_{-0.3}$	$22.0 \pm 3.1^{+2.0}_{-1.5}$	$1.25 \pm 0.10^{+0.19}_{-0.20}$
$\eta(1405)$	$1399.8 \pm 2.2^{+2.8}_{-0.1}$	$52.8 \pm 7.6^{+0.1}_{-7.6}$	$1.89 \pm 0.21^{+0.21}_{-0.23}$
$X(1870)$	$1877.3 \pm 6.3^{+3.4}_{-7.4}$	$57 \pm 12^{+19}_{-4}$	$1.50 \pm 0.26^{+0.72}_{-0.36}$

arXiv: 1107.1806
PRL107, 182001 (2011)

$\eta(1405) \to f_0(980)\pi^0$ in $J/\psi \to \gamma\pi\pi\pi$

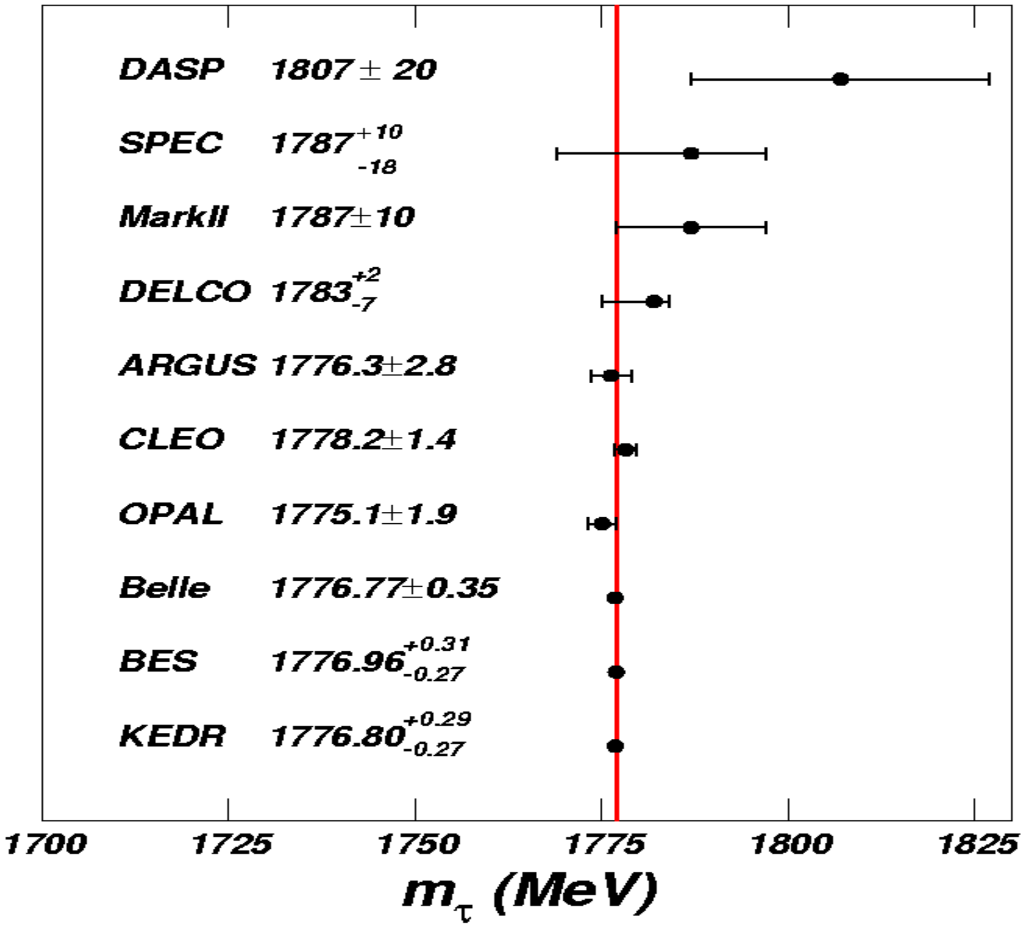
- Observed in two modes, $\eta(1405)$ mass and width agree with PDG
- Large Isospin-violating decay rate, $B(f_0\pi^0)/B(a_0\pi^0)$~18%!
- A possible explanation is KK*(K) loop, triangle singularity

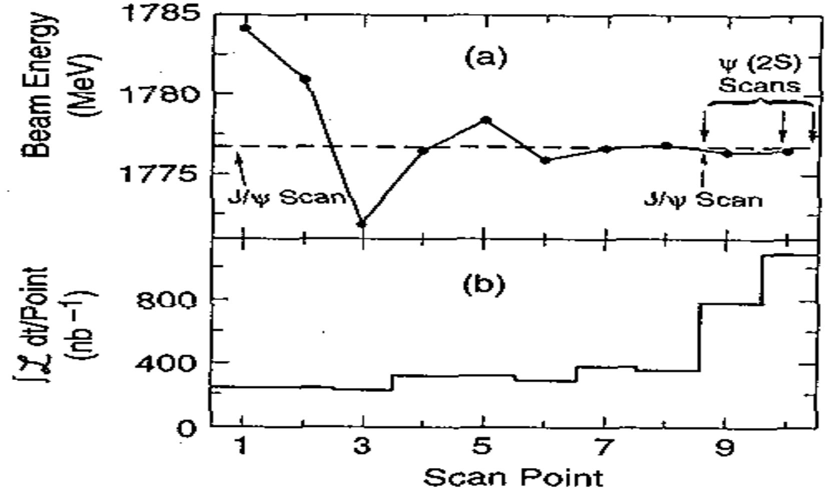
(Wu, Liu, Zhao, Zou, PRL 2012)



arXiv: 1201.2737, PRL (in press)

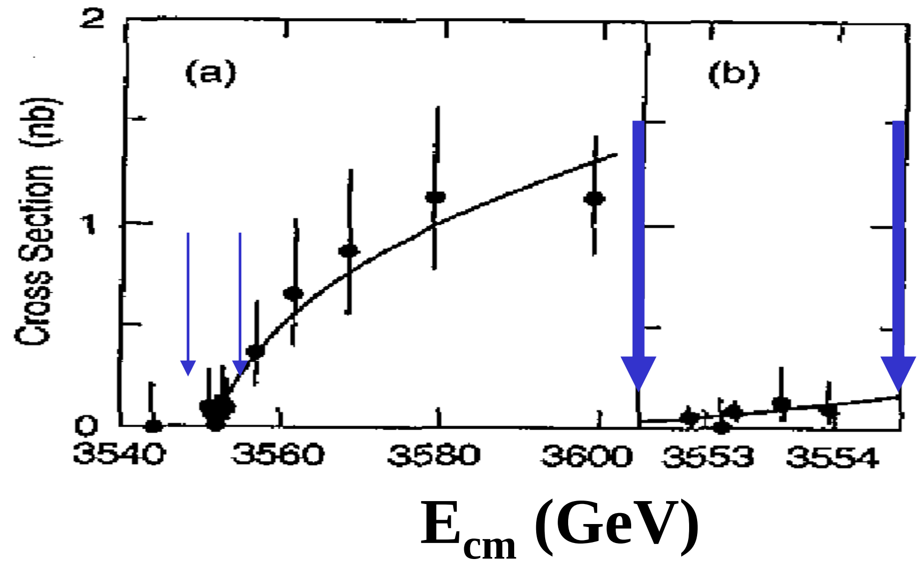
τ mass





PRD 53 (1993)20

12 points, Lum.: 5 pb^{-1}



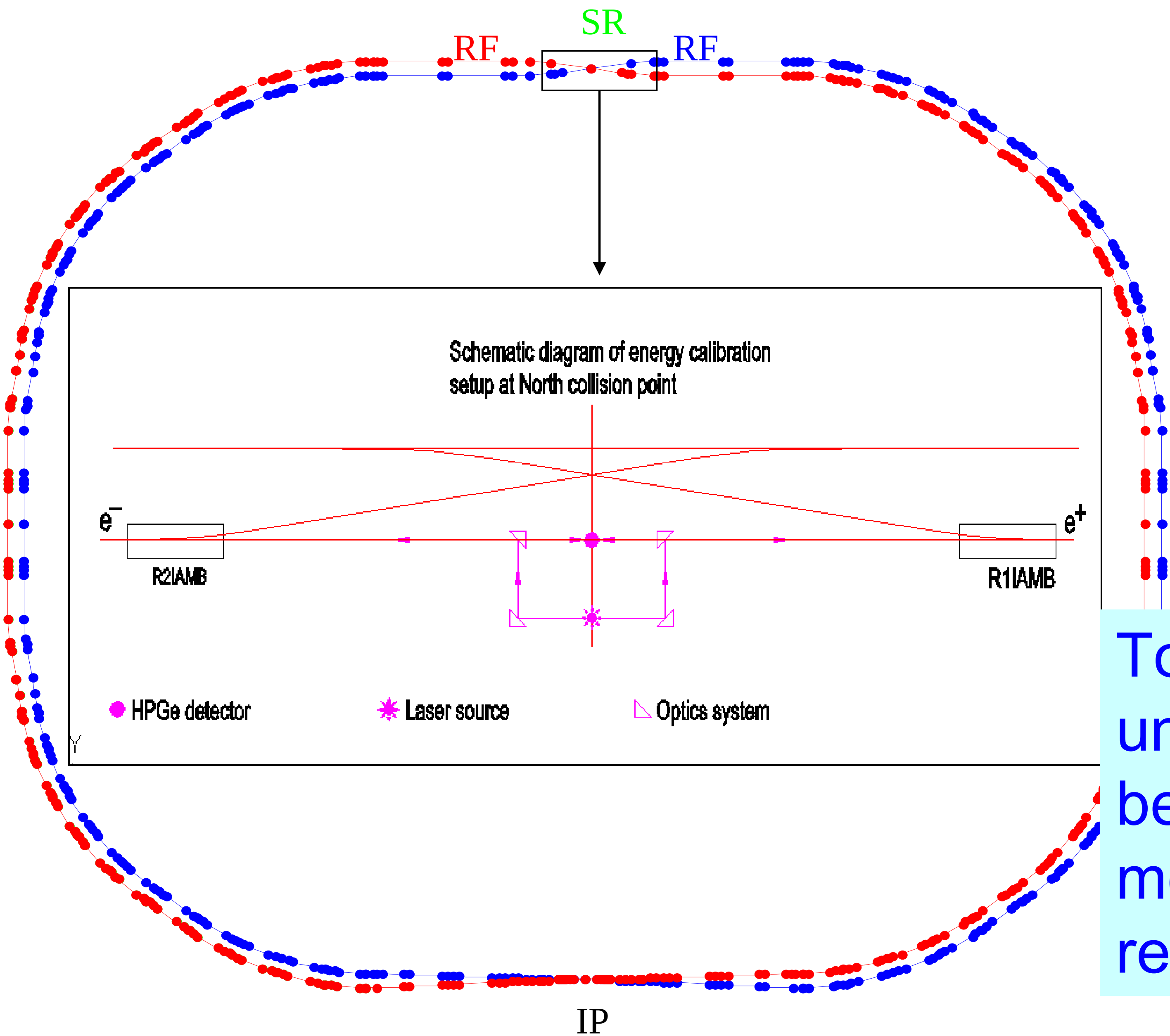
$$M_\tau = 1776.96 \ {}^{+0.18}_{-0.21} \ {}^{+0.25}_{-0.17} \ \text{MeV}$$

$$\sigma M_\tau / M_\tau = 1.7 \times 10^{-4}$$

PDG10: 1776.82±0.16 MeV

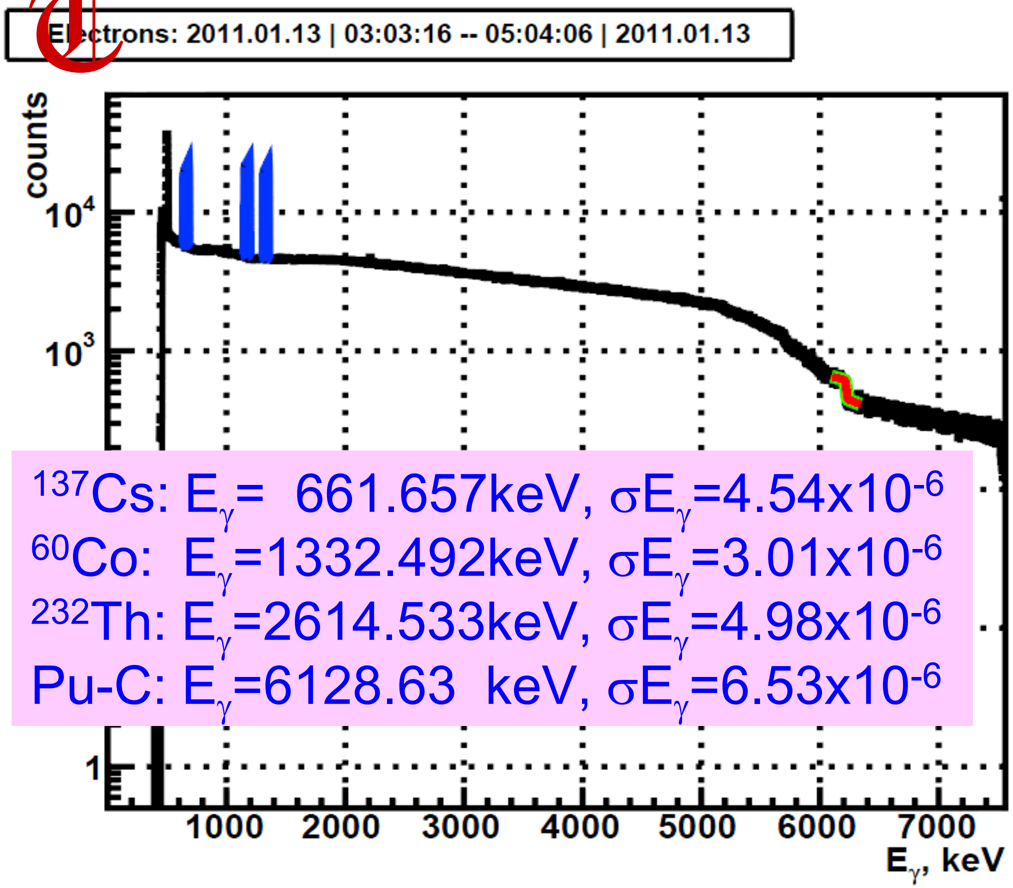
BESI results: stat. err. (0.18 / 0.21) is compatible with syst. (0.25 / 0.17)

BEPCII Storage Ring



Compton backscattering technique, accuracy up to 5×10^{-5}

Total systematic uncertainty on beam energy measurement can reach 90 keV



$E_{edge} = 6217.137 \pm 0.568$ keV

$\sigma_{E_{edge}} = 6.97 \pm 0.93$ keV

$E_{beam} = 1886.478 \pm 0.086$ MeV

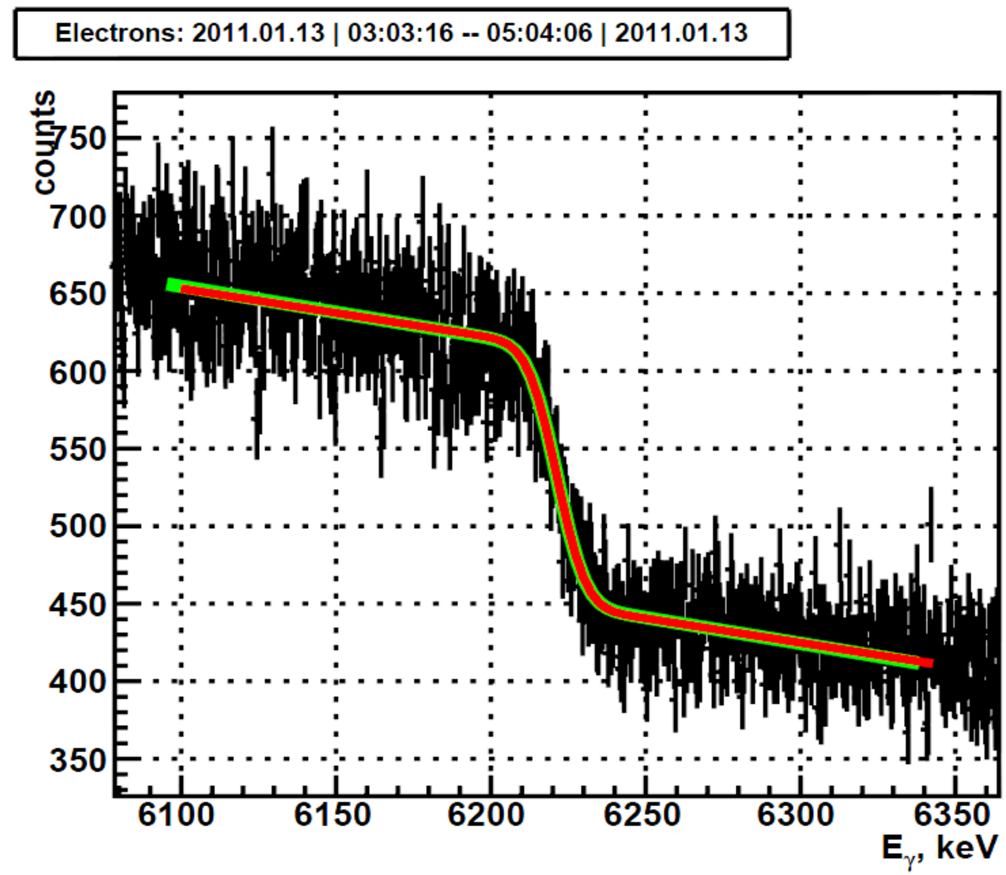
$\sigma_{E_{beam}} = 1058.0 \pm 140.6$ keV

^{137}Cs: E_γ = 661.657keV, $\sigma E_\gamma = 4.54 \times 10^{-6}$

^{60}Co: E_γ = 1332.492keV, $\sigma E_\gamma = 3.01 \times 10^{-6}$

^{232}Th: E_γ = 2614.533keV, $\sigma E_\gamma = 4.98 \times 10^{-6}$

Pu-C: E_γ = 6128.63 keV, $\sigma E_\gamma = 6.53 \times 10^{-6}$

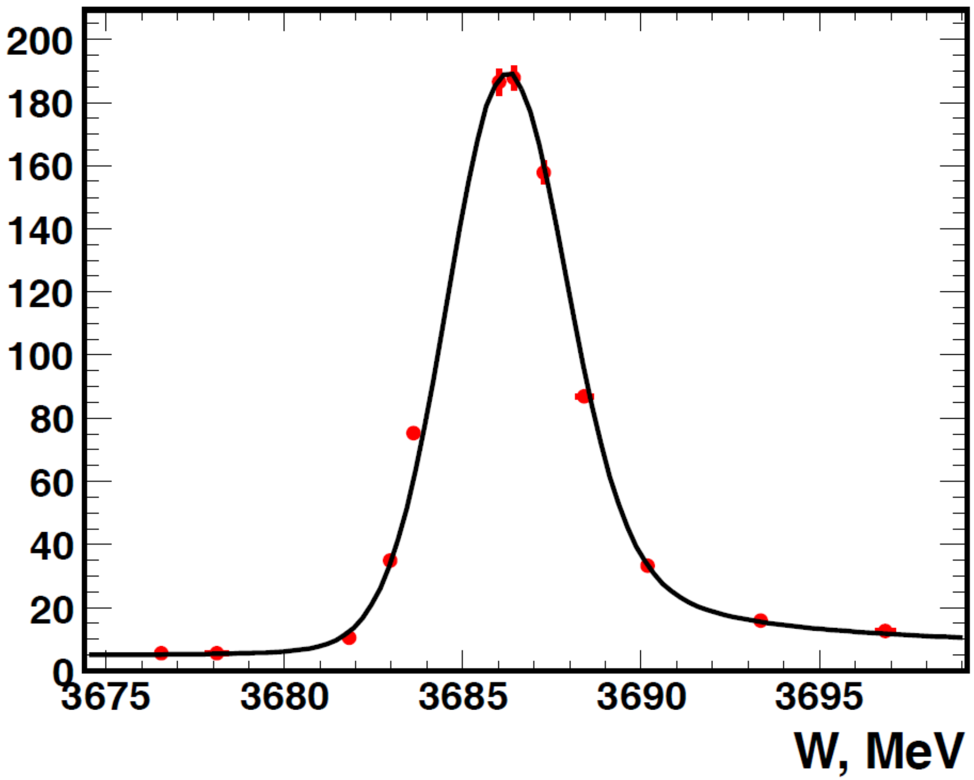


Relative error:

Meas.: 4.6×10^{-5}

Design: 5×10^{-5}

ψ' Cross Section Scan



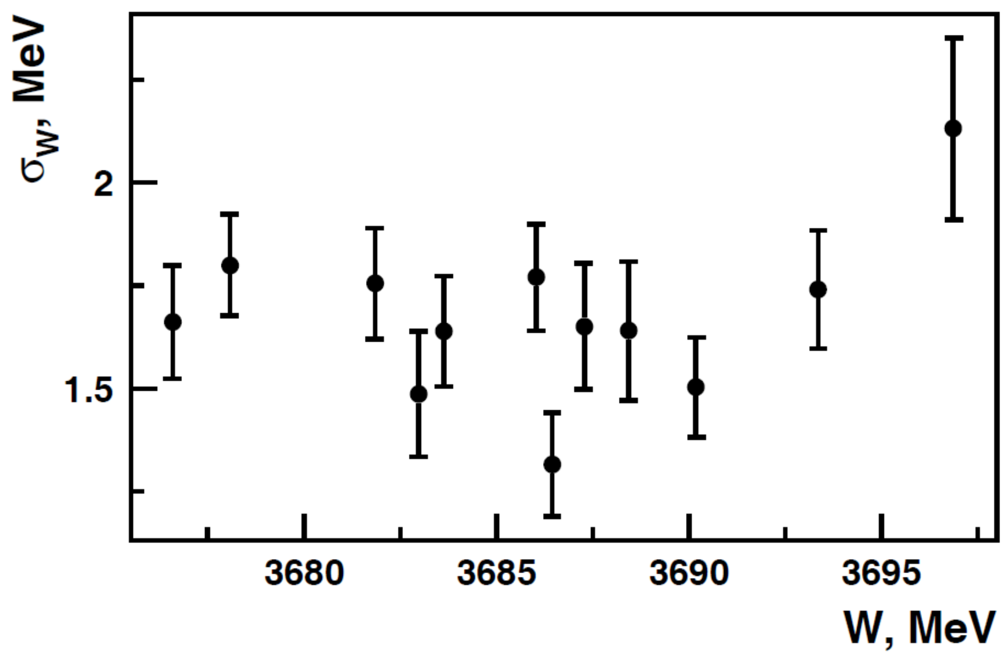
PDG2010:

3686.09 ± 0.04 MeV

Δm=17±50 keV

Accuracy: 2x10^{-5}

Beam spread: 1.65±0.04 MeV



- No efficiency correction
- Cross section in arbitrary unit

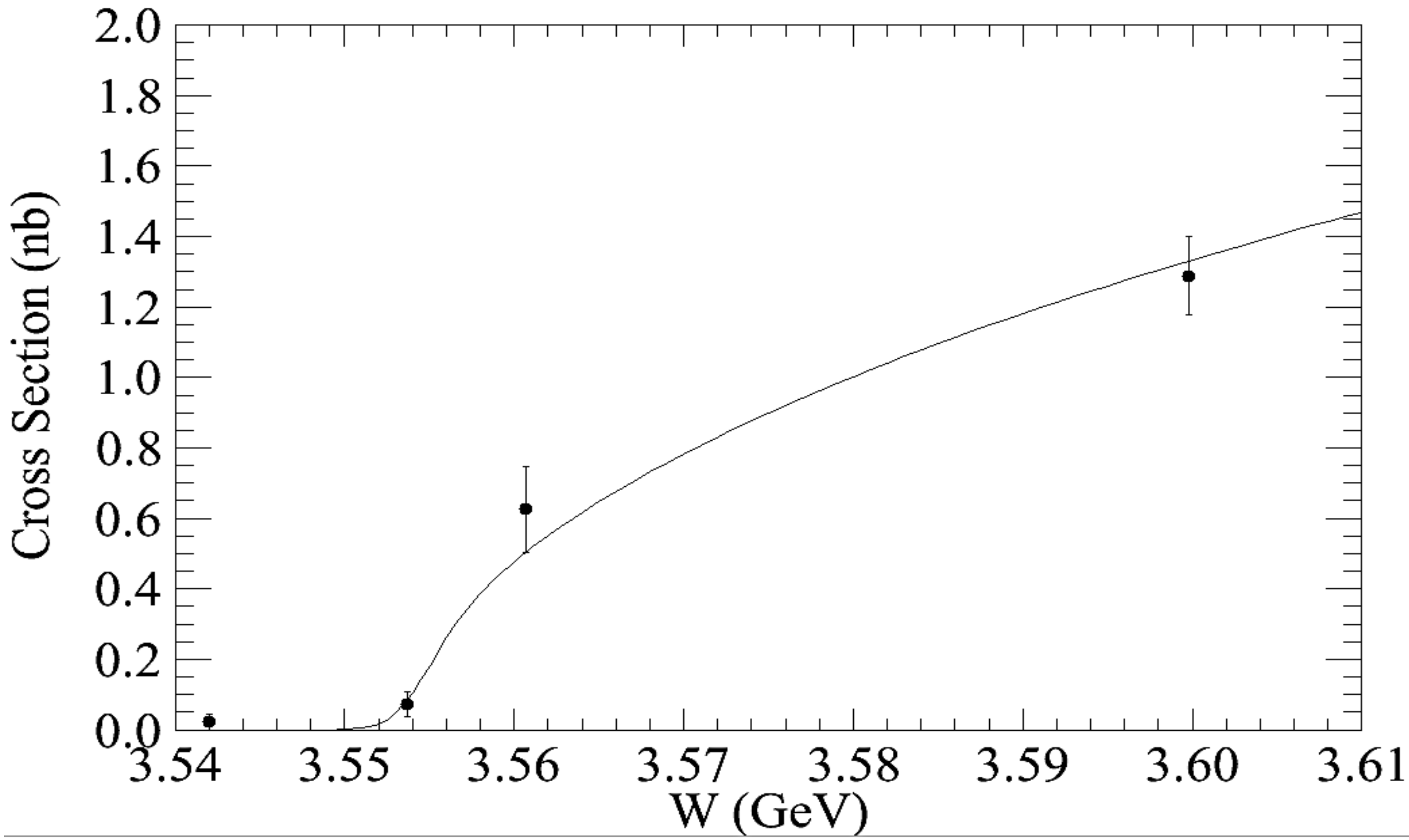
Published in NIMA 659, 21 (2011)

τ Mass measurement in 2012

Data at 4 energy points were taken, ~5 pb^{-1} at the τ threshold

Expect statistical precision is ±0.3 MeV, systematic error <0.1 MeV

More data expected in 2012 to reduce statistical precision to 0.1 MeV



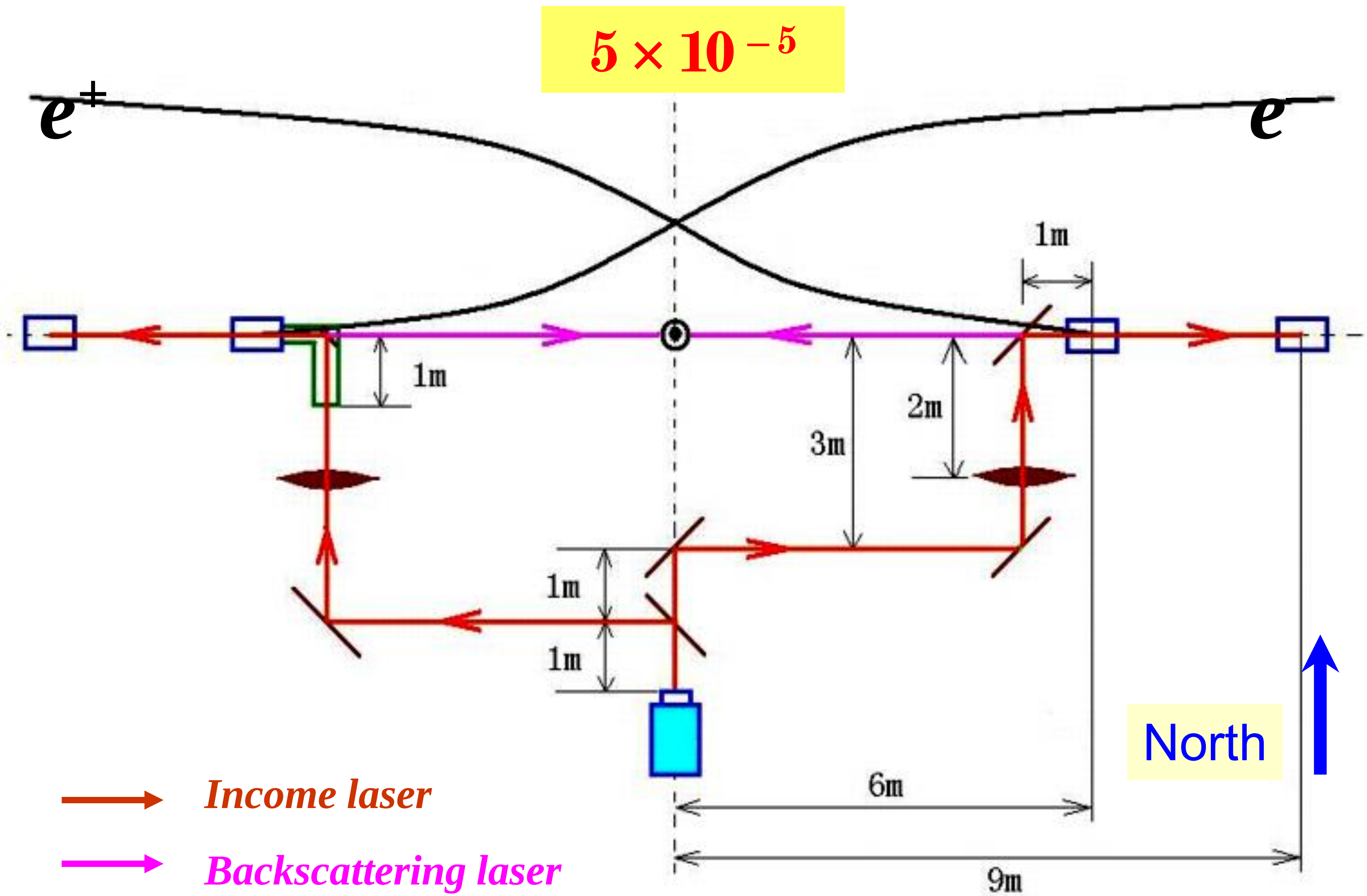
Summary

- BEPCII has reached 2/3 of its designed luminosity goal of 10^{33}/cm^2/s.
- BESIII was running very well and has accumulated world largest data samples at J/ψ, ψ', ψ'', and $\psi(4040)$ peaks.
- Lots of results have been published and more to come soon (esp. on charm)!

Thanks a lot!

backup

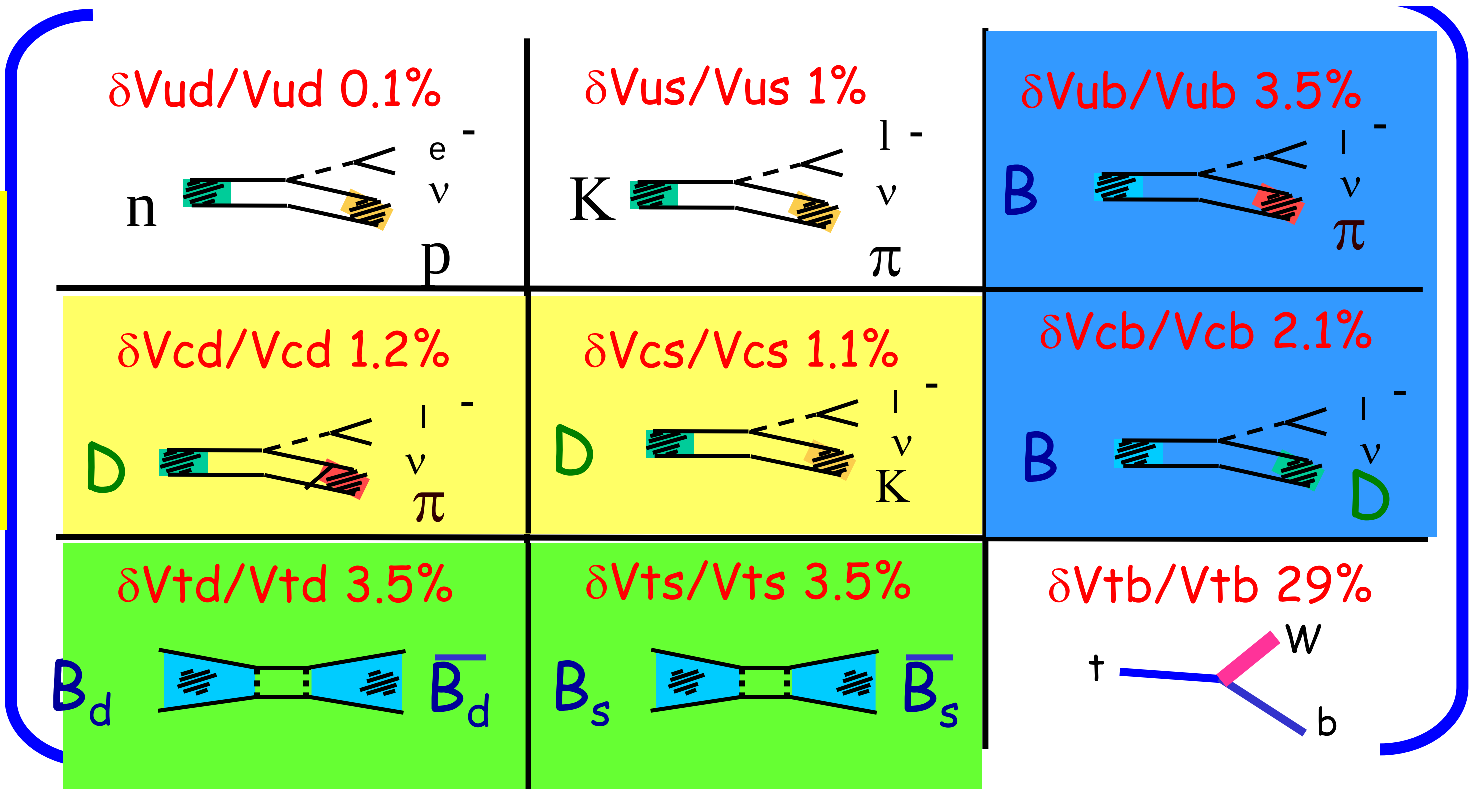
BEPC Energy Measurement System



Charm Physics: CKM matrix

20 fb^{-1} $\bar{D}D$ pairs at $\psi(3770)$ and 20 fb^{-1} $D_s^{(*)+}D_s^{(*)-}$ pairs at $\psi(4040)$ or $\psi(4160)$ for high precision charm physics.

BESIII
one year
Lumi. 5 fb^{-1}
at $\psi(3770)$
peak



BESIII

BESIII + Lattice QCD +B factories

BESIII + Lattice QCD +B-factories+pp/pp

The Goal: Measure all CKM matrix elements and associated phases in order to over-constrain the unitary triangles.