Recent Results from BESIII

Haiping Peng

(For BESIII Collaboration)

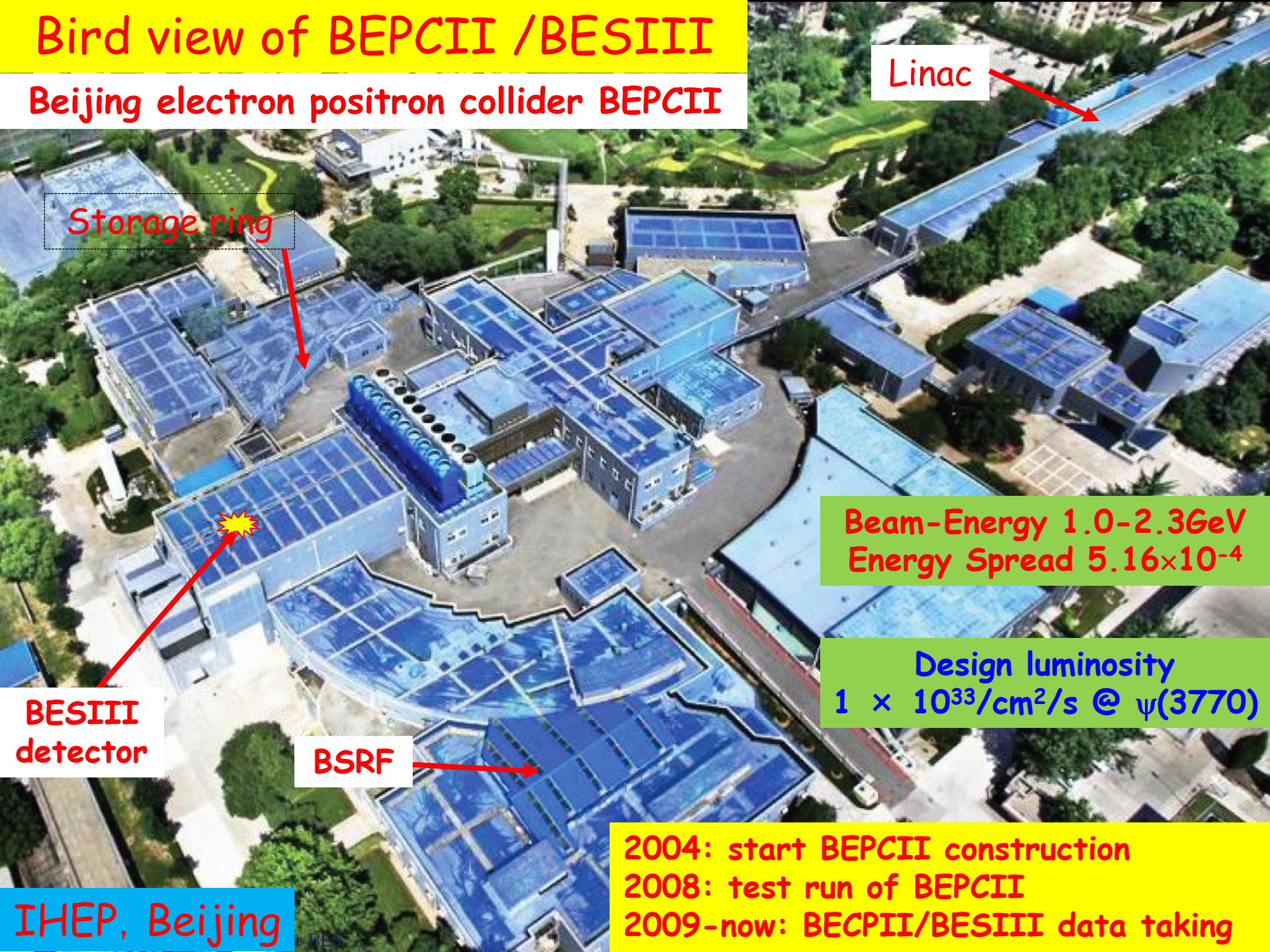
USTC, Hefei, China

Outline

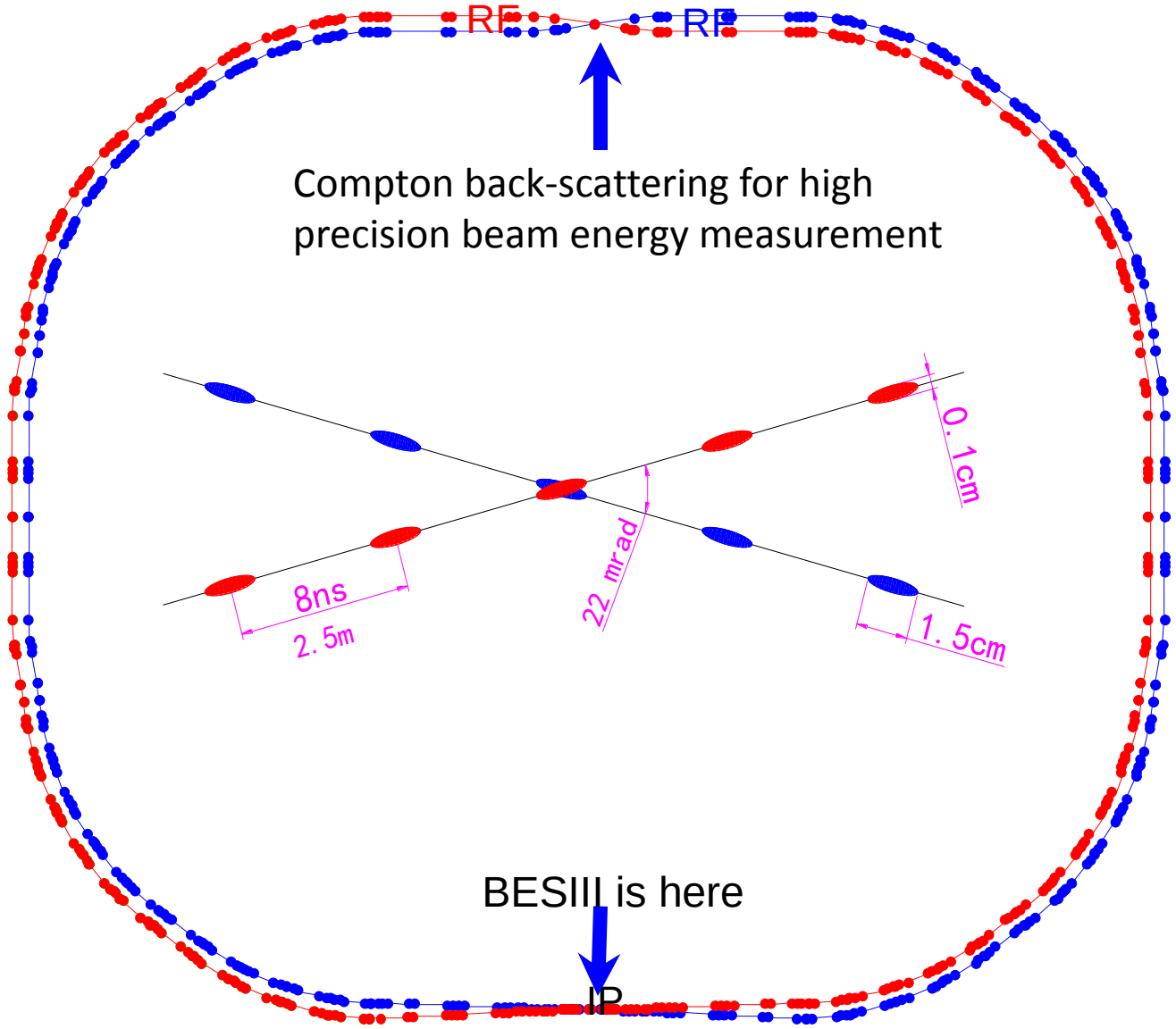
- Status of BEPCII/BESIII
- Selected Results from BESIII
  - Light hadrons spectroscopy
  - Charmonium transitions decays
  - Charm decays
- Summary

Bird view of BEPCII /BESIII

Beijing electron positron collider BEPCII



BEPCII: Large Crossing Angle, Double-ring



τ-Charm Region

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

The BESIII Detector

NIM A614, 345 (2010)

Drift Chamber (MDC)

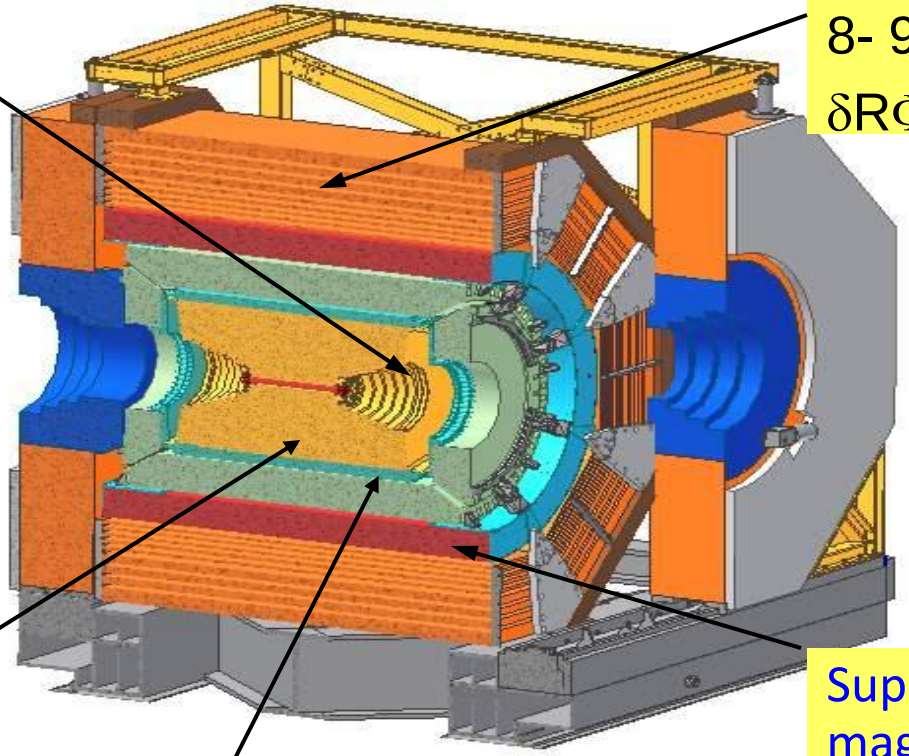
$\sigma P/P\ (^0/_0) = 0.5\%(1GeV)$

$\sigma_{dE/dx}\ (^0/_0) = 6\%$

μCounter

8- 9 layers RPC

$\delta R\Phi$=1.4 cm~1.7 cm



Time Of Flight (TOF)

σ_T: 90 ps Barrel

110 ps endcap

Super-conducting magnet (1.0 Tesla)

EMC: $\sigma E/\sqrt{E}(^0/_0) = 2.5\ \%$ (1 GeV)

(CsI) $\sigma_{z,\phi}$(cm) = 0.5 - 0.7 cm/$\sqrt{E}$

The BESIII Collaboration

http://bes3.ihep.ac.cn

Europe (11)
Germany: Univ. of Bochum,
Univ. of Giessen, GSI
Univ. ofJohannes Gutenberg
Helmholtz Ins. In Mainz
Russia: JINR Dubna; BINP Novosibirsk
Italy: Univ. of Torino, Frascati Lab
Netherland: KVI/Univ. of Groningen
Turkey: Turkey Accelerator Center

US (6)
Univ. of Hawaii
Univ. of Washington
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Korea (1)
Seoul Nat. Univ.

Japan (1)
Tokyo Univ.

Pakistan (1)
Univ. of Punjab

China(30)
IHEP, CCAST, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ
Hunan Univ., Liaoning Univ.
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Hong Kong Univ., Hong Kong Chinese Univ.
Univ. of South China, GUCAS.

>300 physicists
50 institutions from 10 countries

BESIII commissioning

- ✓July 19, 2008: first e^+e^- collision event in BESIII
- ✓Nov. 2008: ~14M $\psi(2S)$ events for detector calibration
- ✓2009: 106M $\psi(2S)$ 4×CLEO-c
  225M J/ψ 4×BESII
- ✓2010: ~0.9 fb^{-1} $\psi(3770)$
- ✓2011: ~2.0 fb^{-1} $\psi(3770)$
  } 3.5×CLEO-c
  ~0.5 fb^{-1} @ 4.01 GeV
- ✓2012: tau mass scan: ~5.0 pb^{-1} ;
  $\psi(2S)$: 0.4 billion; J/ψ: 1 billion (May 22!)

World's largest sample of J/ψ, $\psi(2S)$ and $\psi(3770)$

Physics Programs @ BESIII

✓ ***Light hardron physics***
- meson & baryon spectroscopy
- threshold effects
- multiquark states
- glueballs & hybrids
- two-photon physics
- form-factors

✓ ***Charmonium physics:***
- precision spectroscopy
- transitions and decays

✓ ***Charm physics:***
- (semi-)leptonic form factors
- f_D & f_{Ds} *decay constants.*
- CKM matrix: V_{cd} , V_{cs}
- D^0-D^0 *mixing and CPV*
- strong phases

✓ ***QCD & τ-physics:***
- precision *R-measurement*
- τ mass / τ decays

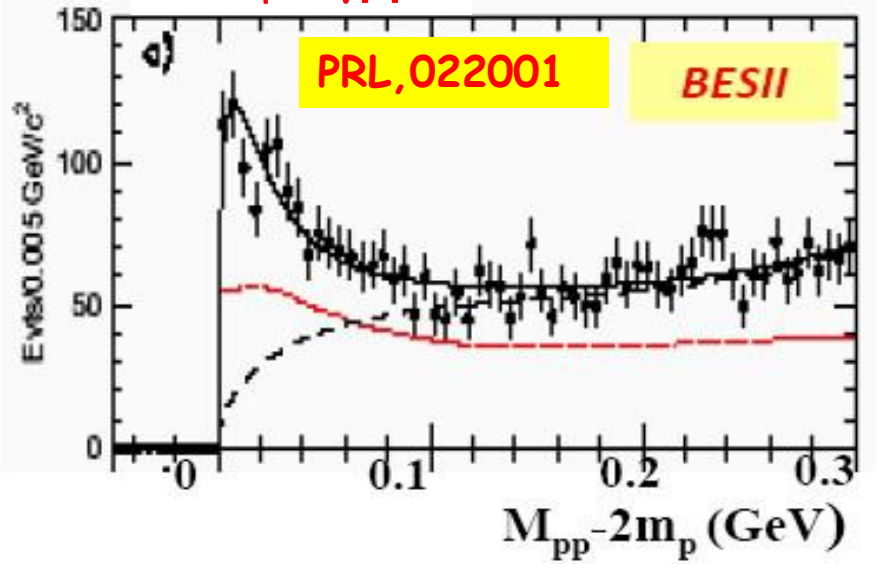
✓ ***XYZ meson physics:***
- Y(4260) $\pi\pi h_c$ decays

Recent Results on Light Hadron Spectroscopy

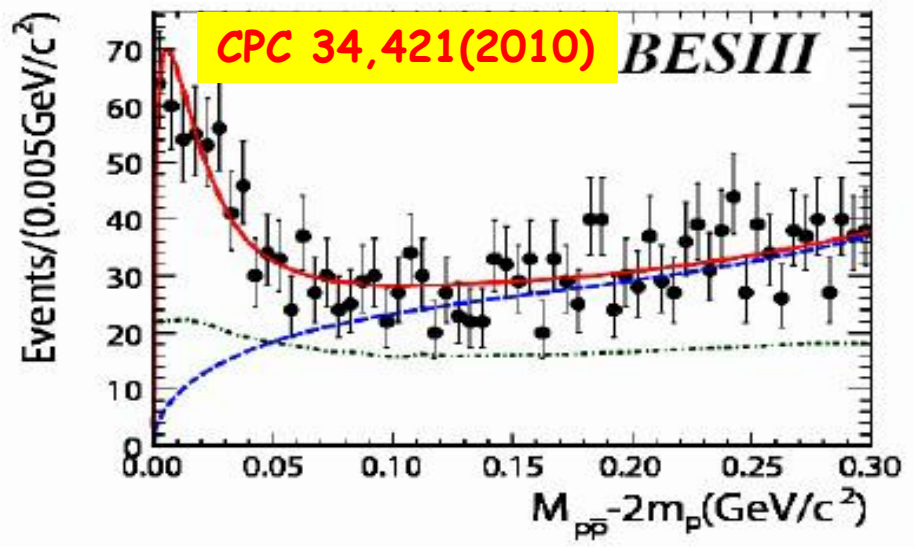
- ✓ $p\bar{p}$ mass threshold structure in $J/\psi \to \gamma p\bar{p}$
- ✓ X(1835) and two new structures in $J/\psi \to \gamma\pi^+\pi^-\eta'$
- ✓ $\eta(1405)$ in $J/\psi \to \gamma f_0(980)\pi^0$, $f_0(980) \to \pi\pi$

Enhancement at $p\bar{p}$ threshold in $J/\psi \to \gamma p\bar{p}$

$J/\psi \to \gamma p\bar{p}$

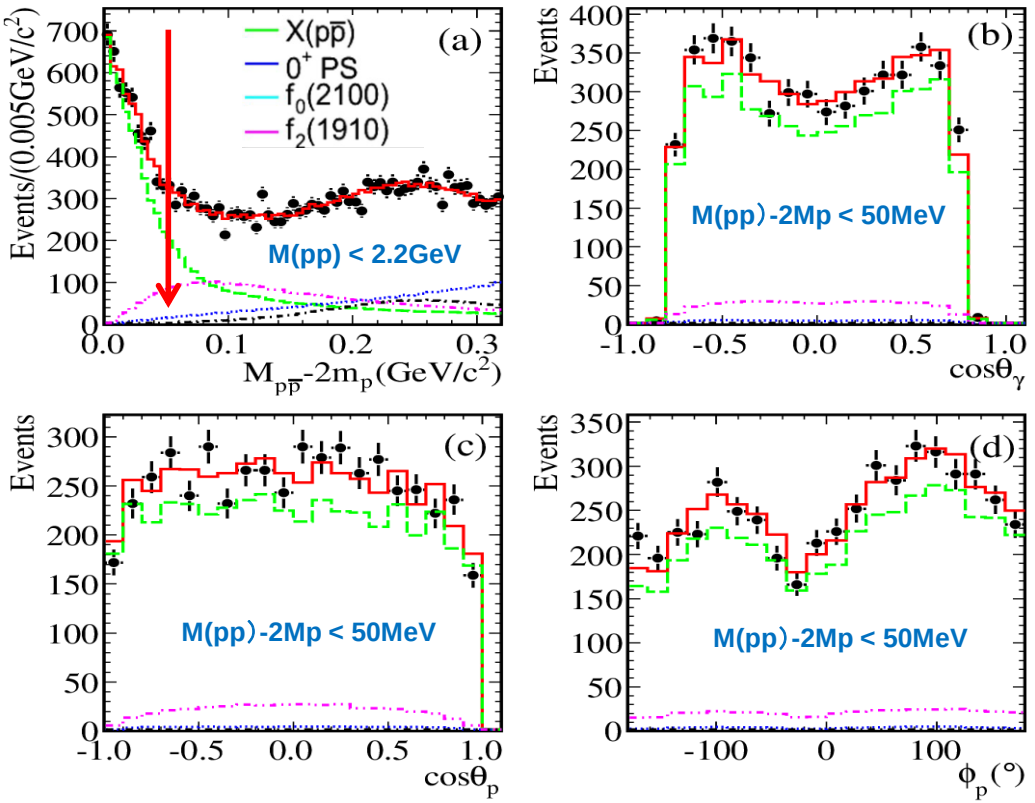


$\psi' \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma p\bar{p}$



- ✓ **Observed at BESII in 2003:**
  - Agree with spin zero expectation
  - $M = 1860^{+3+5}_{-10-25}$ MeV/c^2
  - $\Gamma < 38$ MeV/c^2 (90% C.L.)
- ✓ **Confirmed at BESIII in 2010:**
  - $M = 1859^{+6+6}_{-13-26}$ MeV/c^2
  - $\Gamma < 30$ MeV/c^2 (90% C.L.)
- ✓ **Many theoretical Interpretation:**
  - Normal meson/ $p\bar{p}$ bound state/ multiquark/ glueball/ Final state interaction (FSI).....
- ✓ **Spin-parity analysis:**
  - Is essential for determining place in the spectrum and possible nature.

PWA of $J/\psi \to \gamma p\bar{p}$ ($M_{p\bar{p}} < 2.2$GeV)



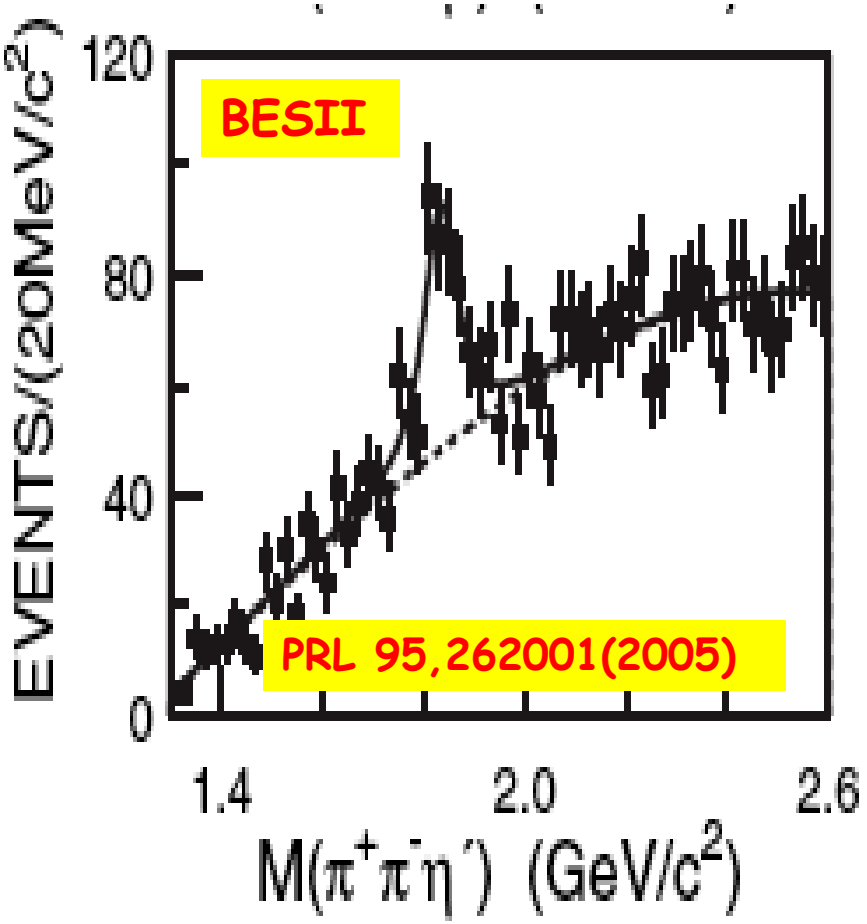
- ✓ **Four components:**
  - **$X(p\bar{p})$, $f_2(1910)$, $f_0(2100)$ and 0^{++} PS**
- ✓ **Include the FSI effect**
- ✓ **Fit features:**
  - **The fit with BW and S-wave FSI (I=0) factor can well describe $p\bar{p}$ mass threshold structure.**
  - **It is much better than that w/o FSI effect (7.1σ)**
  - **Different FSI model → Model dependent uncertainty**

✓ BESIII Results:

PRL 108,112003(2012)

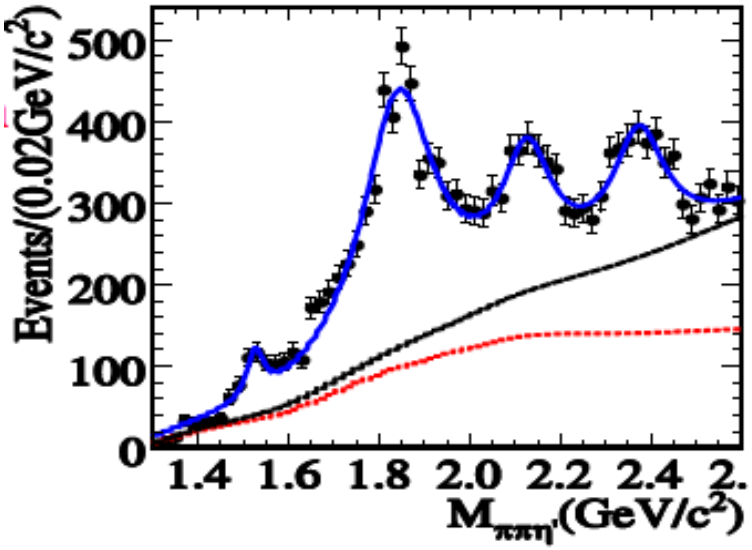
- **$J^{PC} = 0^{-+}$, $>6.8\sigma$ better than other J^{PC} assignments.**
- **$M = 1832^{+19}_{-5}(\text{stat})^{+18}_{-17}(\text{syst}) \pm 19(\text{model})$ MeV/c^2**
- **$\Gamma = 13 \pm 39(\text{stat})^{+10}_{-13}(\text{syst}) \pm 4(\text{model})$ MeV/c^2 or $\Gamma < 76$MeV/c^2 @ 90 C.L.**
- **$Br(J/\psi \to \gamma X(p\bar{p})) \times Br(X(p\bar{p}) \to p\bar{p}) = (9.0^{+0.4}_{-1.1}(\text{stat})^{+1.5}_{-5.0}(\text{syst}) \pm 2.3(\text{model})) \times 10^{-5}$**

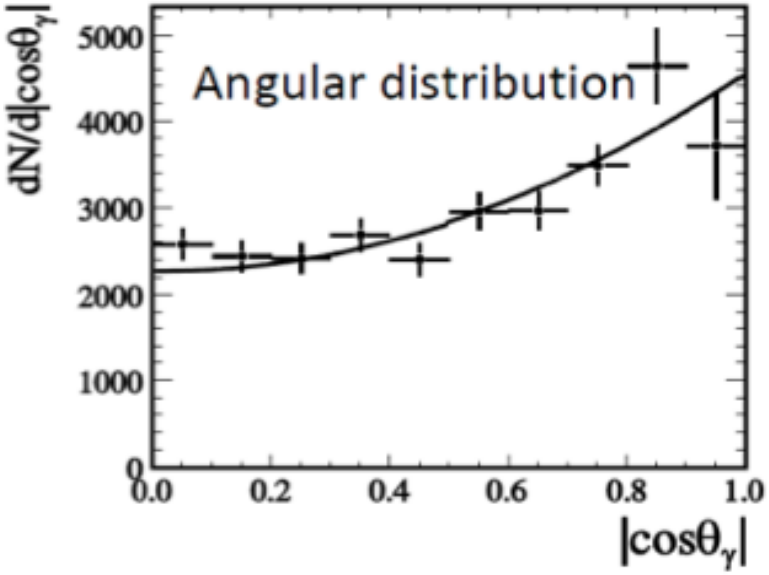
X(1835) in $J/\psi\to\gamma\pi^+\pi^-\eta'$@BESII



- ✓ **BESII Results:**
  - **M=1833.7±6.1(stat)±2.7(syst) MeV/c^2**
  - **Γ=67.7 ±20.3(stat) ±7.7(syst) MeV/c^2**
  - **$B(J/\psi\to\gamma X(1835))B(X(1835)\to\pi^+\pi^-\eta')$ $=(2.2\pm0.4(stat)\pm0.4(syst))\times10^{-4}$**
  - **Statistical Significance 7.7σ**
- ✓ **Many Theoretical interpretation:**
  - **$p\bar{p}$ bound state**
  - **η excitation**
  - **….**
  - **Are X($p\bar{p}$) and X(1835) from the same source?**

X(1835) in $J/\psi\to\gamma\pi^+\pi^-\eta'$@BESIII





PRL 106, 072002 (2011)

resonance	$M(\ \mathrm{MeV}/c^2)$	$\Gamma(\ \mathrm{MeV}/c^2)$	significance
X(1835)	1836.5 ± 3.0	190.1 ± 9.0	$>> 20\sigma$
X(2120)	2122.4 ± 6.7	84 ± 16	$> 7.2\sigma$
X(2370)	2376.3 ± 8.7	83 ± 17	$> 6.4\sigma$

✓ **BESIII Results:**

— **$B(J/\psi\to\gamma X(1835))B(X(1835)\to\pi^+\pi^-\eta')$=**

$$(2.87 \pm 0.09(stat)^{+0.49}_{-0.52}(syst)) \times 10^{-4}$$

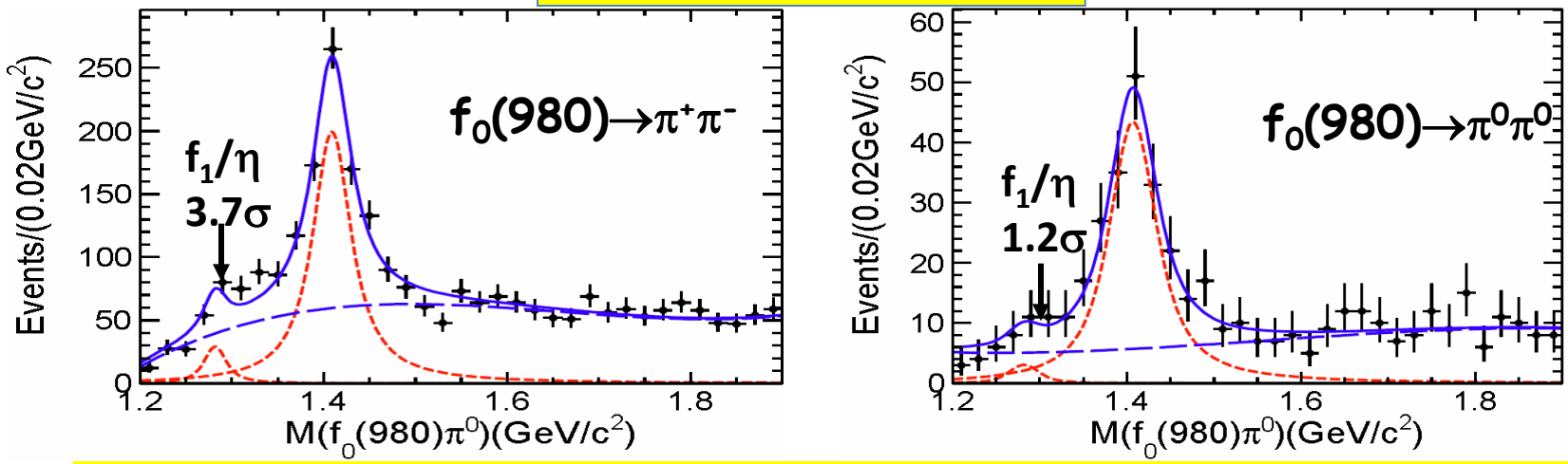
— **The polar angle of the photon is consistent with expectation for a pseudoscalar**

— **Two more structures are observed.**

PWA is needed, interference among the resonances needs to be considered.

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

PRL 108, 182001 (2012)



First observed: $\eta(1405)\to f_0(980)\pi^0$ (Large isospin breaking)

- ✓ **Helicity analysis indicates the peak at 1400MeV is from $\eta(1405)$, not from $f_1(1420)$**
- ✓ **Large Isospin-violating decay rate:**

$$\frac{BR(\eta(1405)\to f_0(980)\pi^0\to\pi^+\pi^-\pi^0)}{BR(\eta(1405)\to a_0(980)\pi^0\to\pi^0\pi^0\eta)}\approx(17.9\pm4.2)\%$$

- ✓ **In general, magnitude of isospin violation in strong decay should be <1%.**

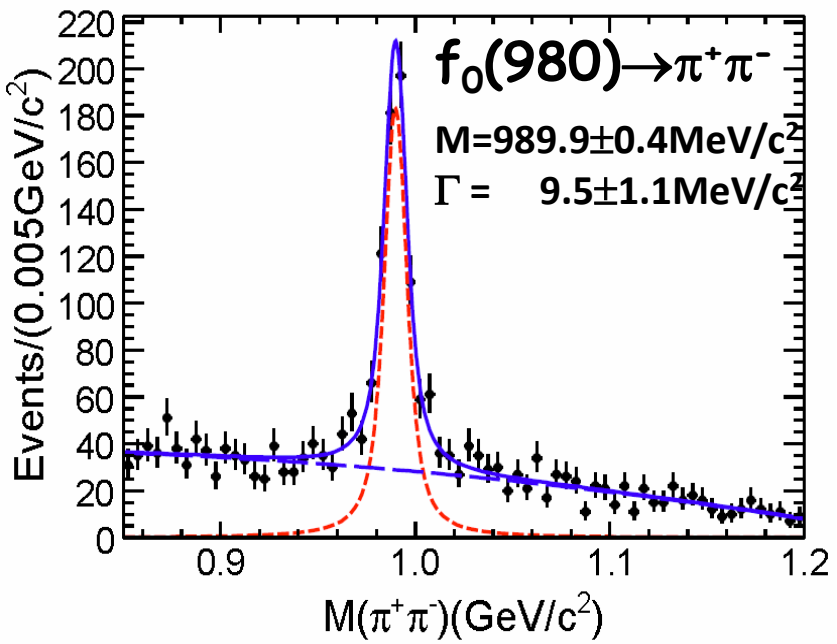
$$\xi_{af}=\frac{Br(\chi_{c1}\to f_0(980)\pi^0\to\pi^+\pi^-\pi^0)}{Br(\chi_{c1}\to a_0(980)\pi^0\to\eta\pi^0\pi^0)}<1\%(90\%\,C.L.)$$

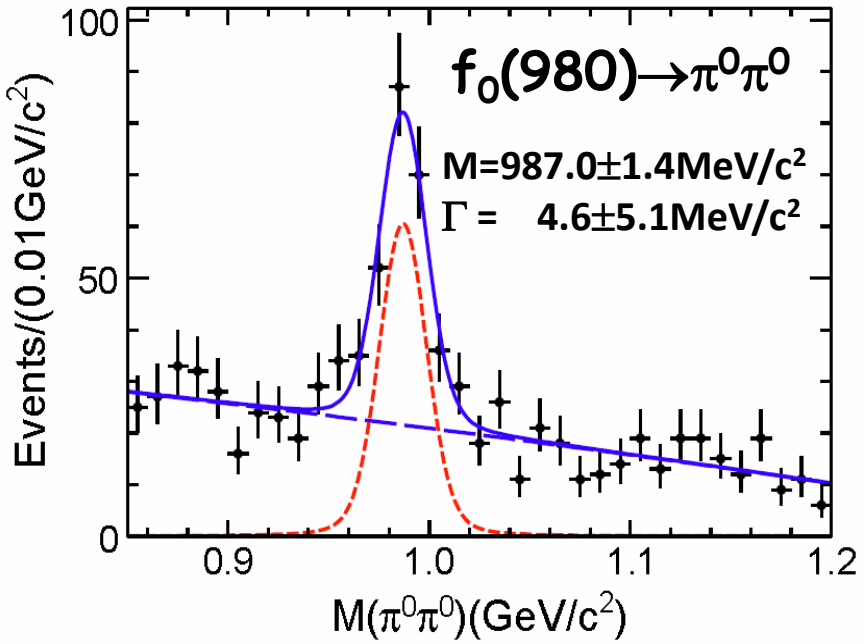
PRD, 83(2100)032003

a_0-f_0 mixing alone can not explain the branching ratio of $\eta(1405)\to f_0(980)\pi^0$

Anomalous line shape of $f_0(980)$ in $J/\psi \to \gamma 3\pi$

PRL 108, 182001 (2012)





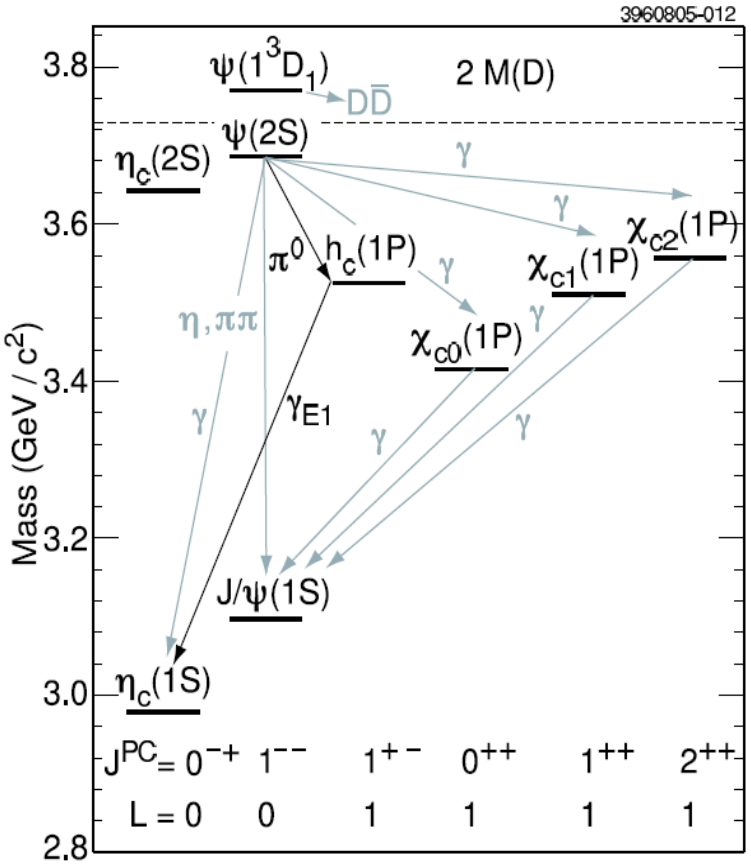
- ✓ **Surprising result:**
- — very narrow $f_0(980)$ width: <11.8MeV/c²@90 % C.L.
- — much narrower than the world average (PDG 2010: 40-100 MeV/c²)

A possible explanation is KK* loop, Triangle Singularity (TS)
(J.J. Wu et al, PRL 108, 081803(2012))

Recent results on Charmonium spectroscopy

- ✓ Properties of h_c
- ✓ Mass and width of η_c
- ✓ Observation evidence of $\psi' \to \gamma \eta_c(2S)$
- ✓ First observation of $\psi' \to \gamma\gamma J/\psi$

Property of $h_c(^1P_1)$



- ✓ **First evidence (E835): $pp \to h_c \to \gamma\eta_c$**

  PRD72, 092004(2005)

- ✓ **CLEO-c observed : $\psi' \to \pi^0 h_c$, $h_c \to \gamma\eta_c$**

  $\Delta M_{hf}(1P) = 0.08 \pm 0.18 \pm 0.12$ MeV/c^2

  PRL104, 132002(2010)

- ✓ **Study isospin forbidden transition:**

  $\psi' \to \pi^0 h_c$

- ✓ **Measure as well the E1 transition:**

  $h_c \to \gamma\eta_c$

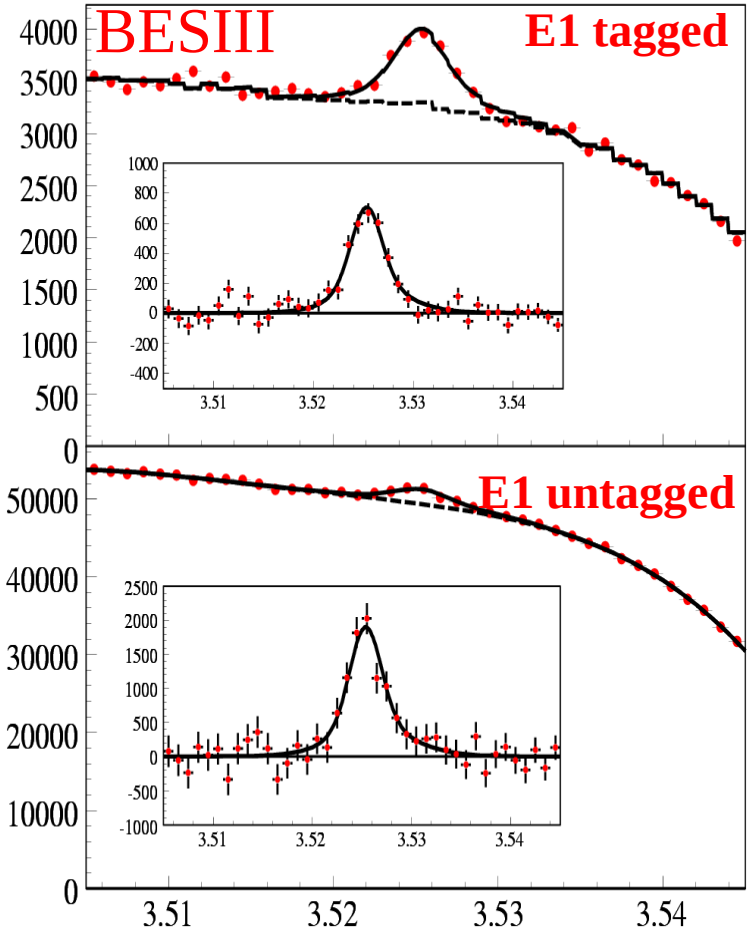
- ✓ **M(h_c) gives access to hyperfine splitting of 1P states:**

  $\Delta M_{hf}(1P) = M(h_c) - 1/9(M(\chi_{c0}) + 3M(\chi_{c1}) + 5M(\chi_{c2}))$

A none zero hyperfine splitting may give indication of nonvanishing spin-spin interactions in Charmonium potential models

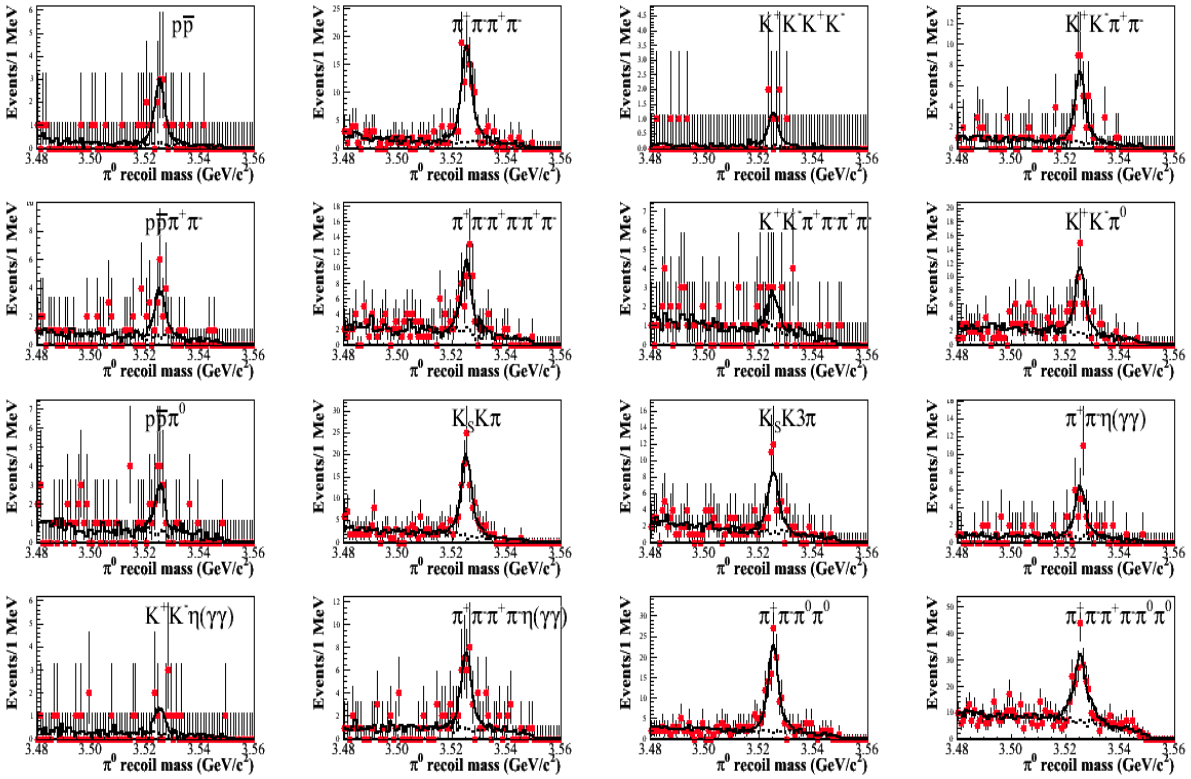
$\psi' \to \pi^0 h_c$

PRL104, 132002, (2010)



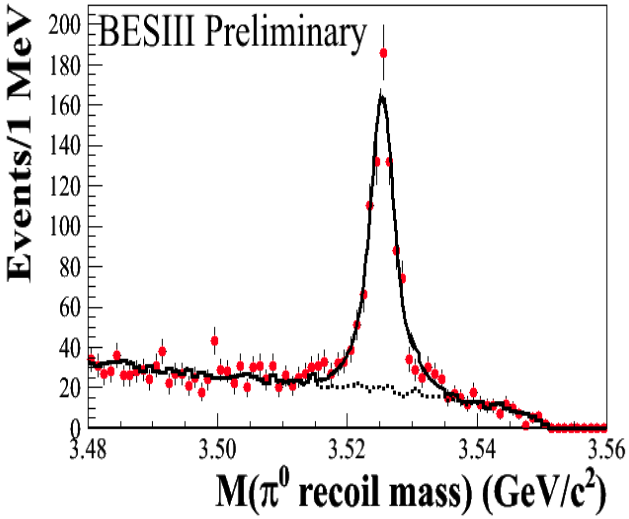
- ✓ Select inclusive $\pi^0(\psi' \to \pi^0 h_c)$
- ✓ Select E1-photon in $h_c \to \gamma\eta_c$ (E1 tagged) or not (E1 untagged)
- ✓ E1-tagged selection gives
  - $M(h_c)=3525.40\pm0.13\pm0.18 MeV/c^2$ $(\Delta M_{hf}(1P)=0.10\pm0.13\pm0.18 MeV/c^2)$
  - $\Gamma(h_c)=0.73\pm0.45\pm0.28 MeV/c^2$ $(<1.44 MeV$ at 90% C.L.)
  - $Br(\psi' \to \pi^0 h_c) \times Br(h_c \to \gamma\eta_c) = (4.58\pm0.40\pm0.50)\times10^{-4}$ (first measurement)
- ✓ E1-untagged selection gives
  - $Br(\psi' \to \pi^0 h_c) = (8.4\pm1.3\pm1.0)\times10^{-4}$
- ✓ Combining Branching fractions leads to
  - $Br(h_c \to \gamma\eta_c)=(54.3\pm6.7\pm5.2)\%$

$\psi' \to \pi^0 h_c$, $h_c \to \gamma \eta_c$, η_c exclusive decays



BESIII Preliminary

Summed π^0 recoil mass



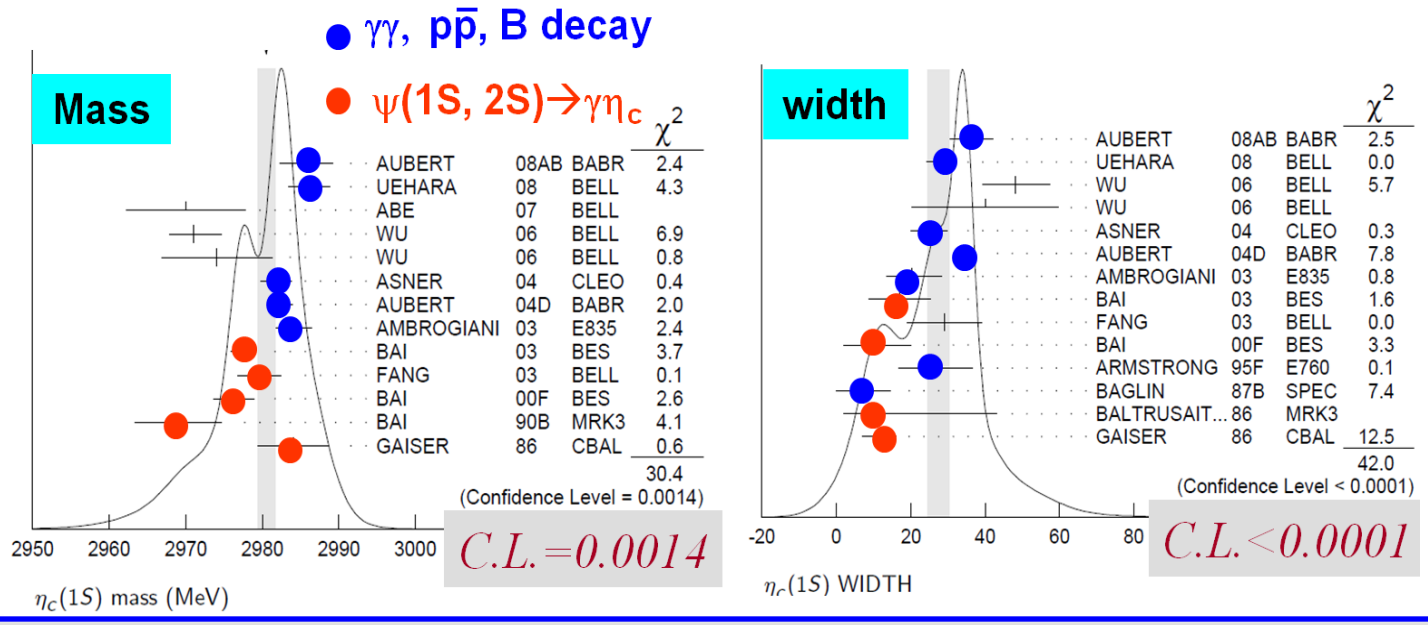
- ✓ **$\psi \to \pi^0 h_c$, $h_c \to \gamma \eta_c$, η_c is reconstructed exclusively with 16 decay modes**

- ✓ **Simultaneous fit to π^0 recoiling mass**
  - **χ^2/d.o.f. = 32/46**
  - **M = 3525.31±0.11±0.15 MeV/c^2**
  - **Γ = 0.70±0.28 ±0.25 MeV**

- ✓ **Consistent with:**
  - **BESIII inclusive results**
    PRL104,132002(2010)
  - **CLEO-c exclusive results**
    M = 3525.21±0.27±0.14 MeV/c^2
    N = 136±14
    PRL101, 182003(2008)

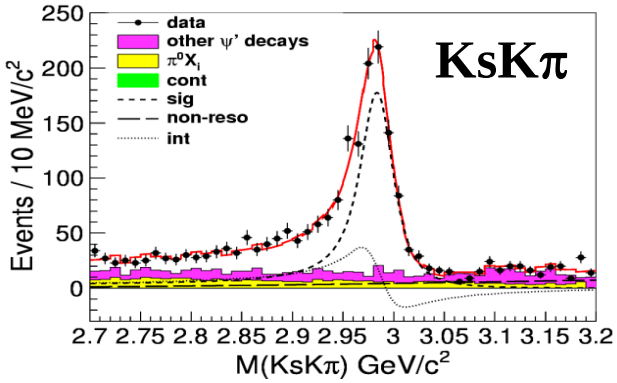
$\eta_c(1S)$

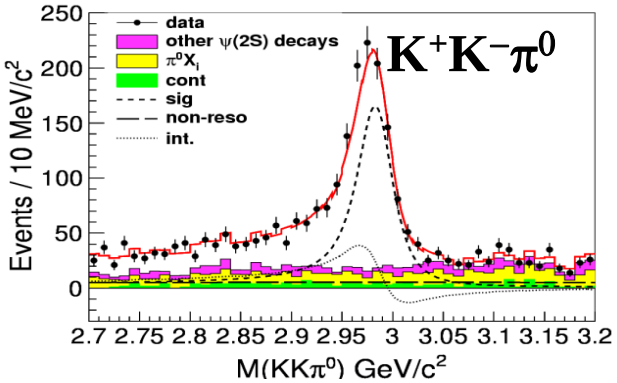
- ✓ **Ground state of charmonium discovered in 1980 by MarkII, but its properties are not well known**
- ✓ **Parameters:**
  - **J/ψ, ψ′ radiative transition: M ~ 2978.0MeV/c², Γ~ 10MeV/c²**
  - **γγ process: M = 2983.1±1.0 MeV/c², Γ = 31.3±1.9 MeV/c²**
- ✓ **CLEO-c found the distortion of the η_c lineshape in ψ′ decays**
- ✓ **Charmonium hyperfine splitting: M(J/ψ)- M(η_c) is important experimental input to test the lattice QCD, but is dominated by error on M(η_c)**

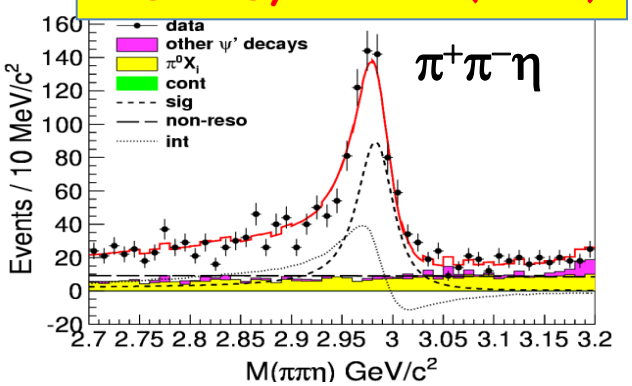


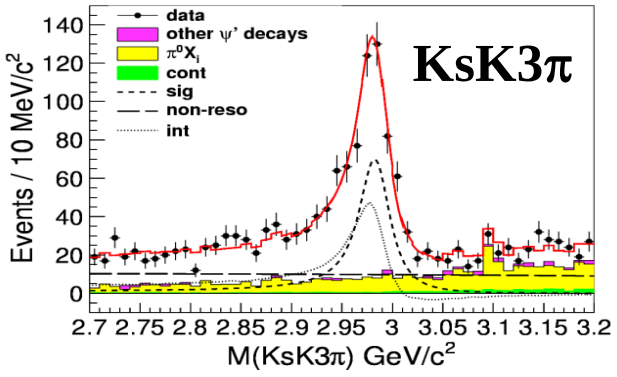
$\psi' \to \gamma\eta_c$, $\eta_c \to$ exclusive decays

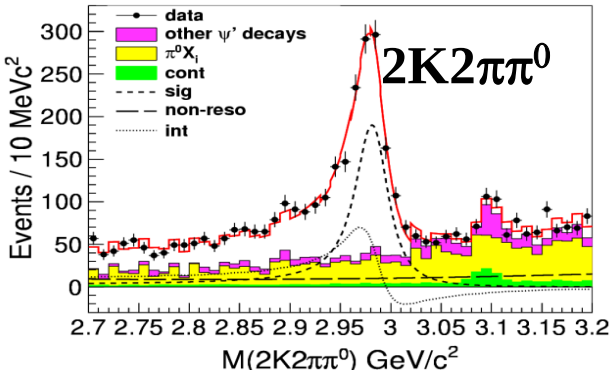
PRL 108, 222002(2012)

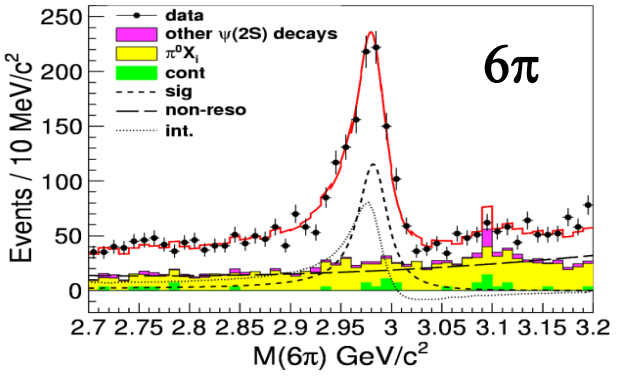












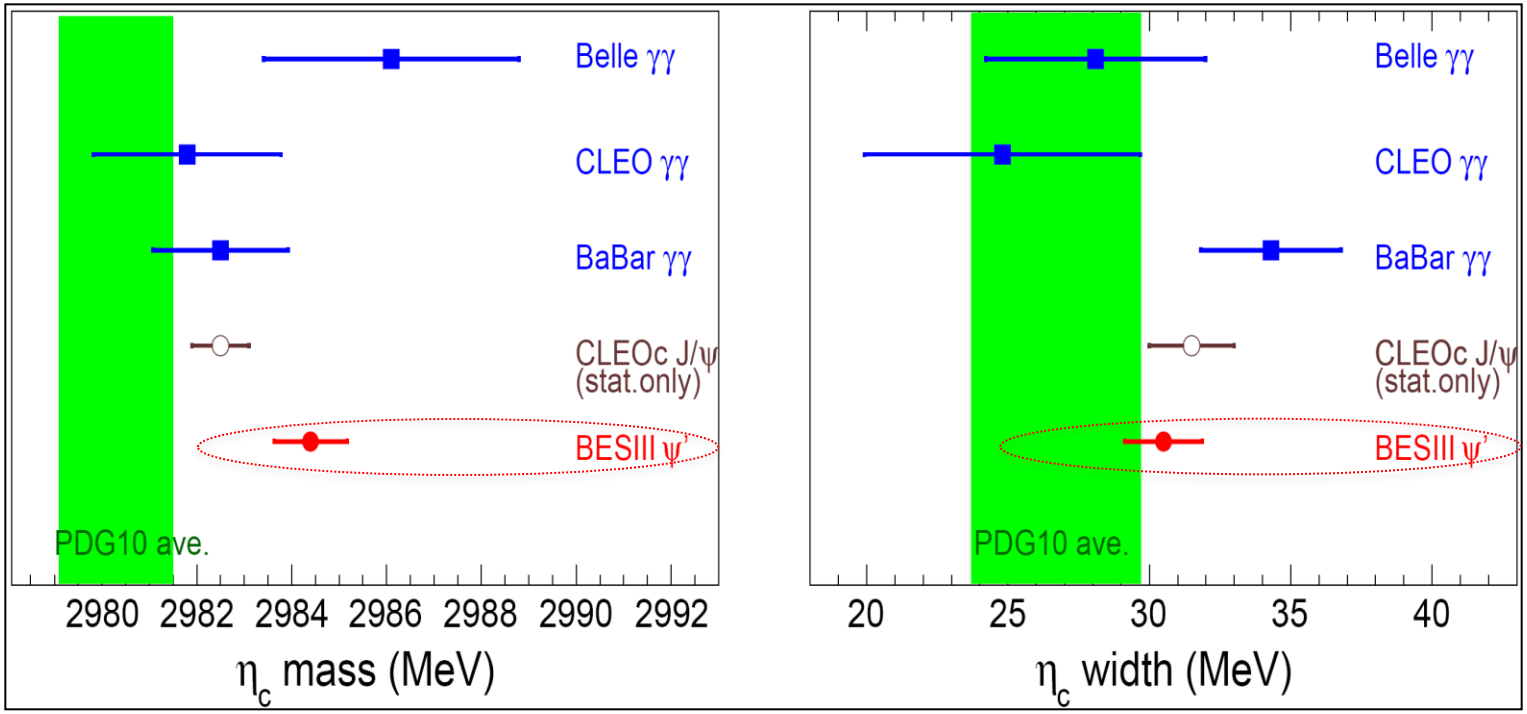
Interference with non-resonant is significant !

- ✓ **Relative phase ϕ values from each mode are consistent within 3σ**
- — **use a common phase value in the simultaneous fit.**

M: $2984.4 \pm 0.5 \pm 0.6$ MeV/c^2
Γ: $30.5 \pm 1.0 \pm 0.9$ MeV/c^2
ϕ : $2.35 \pm 0.05 \pm 0.04$ rad

Comparison of the mass and width for η_c

The world average in PDG2010 was using earlier measurements



Hyperfine splitting: $\Delta M_{hf}(1S)$ = 112.6 ± 0.8 MeV/c^2

- ✓ Consistent with B factory results in other production mechanisms.
- ✓ Agree with lattice QCD calculations of the charmonium hyperfine splitting

$\eta_c(2S)$

- ✓ **First "observation" by Crystal Ball's in 1982:** PRL 48, 70(1982)
  - "Seen" in inclusive photon spectrum of ψ' decay $\psi' \to \gamma X$
  - Branch fraction and parameters are far from modern measurements
  - M=3.592GeV/c^2, Br = 0.2%-1.3%
  - Never confirmed by other experiments

- ✓ **The M1 transition $\psi' \to \gamma\eta_c(2S)$ have not be observed**
  - CLEO-c not found signal in 25M ψ' samples, Br($\psi' \to \gamma\eta_c$ (2S))<7.6×10^{-4}
  - Experimental challenge : search for photons ~ 50MeV/c^2

PRD 81 052002 (2010)

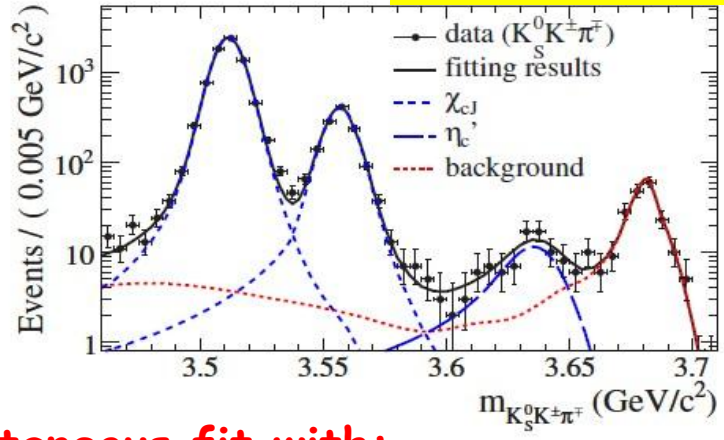
- ✓ **Observed in different process other than radiative transition**

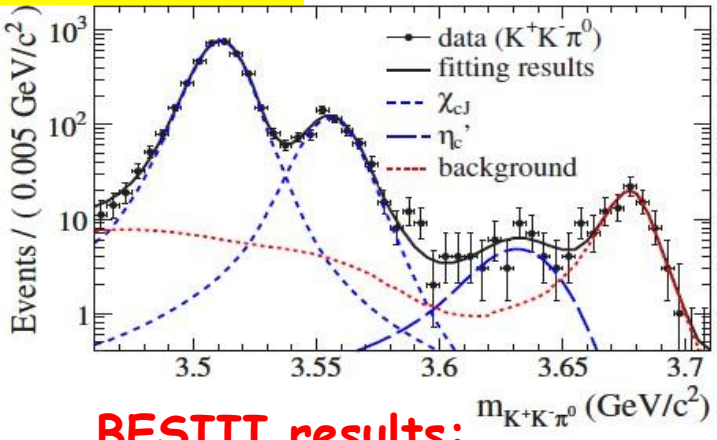
Experiment	M [MeV]	Γ [MeV]	Process
Belle [1]	$3654 \pm 6 \pm 8$	—	$B^{\pm} \to K^{\pm}\ \eta_c(2S), \eta_c(2S) \to K_S K^{\pm}\pi^{\mp}$
CLEO [2]	$3642.9 \pm 3.1 \pm 1.5$	$6.3 \pm 12.4 \pm 4.0$	$\gamma\gamma \to \eta_c(2S) \to K_S K^{\pm}\pi^{\mp}$
BaBar [3]	$3630.8 \pm 3.4 \pm 1.0$	$17.0 \pm 8.3 \pm 2.5$	$\gamma\gamma \to \eta_c(2S) \to K_S K^{\pm}\pi^{\mp}$
BaBar [4]	$3645.0 + 5.5^{+4.9}_{-7.8}$	—	$e^+e^- \to J/\psi c\bar{c}$
PDG [5]	3638 ± 4	14 ± 7	—

- ✓ **Better chance to observe $\eta_c(2S)$ in ψ' radiative transition with ~106M ψ' data at BESIII**
  - Decay mode studied : $\psi' \to \gamma\eta_c(2S) \to \gamma K_S K\pi / K^+K^-\pi^0$

Observation of $\psi' \to \gamma\eta_c$ (2S)

arXiv:1205.5103, submit to PRL





Simultaneous fit with:

✓η_c(2S) signal:

— PDF: $(E_\gamma^3 \times BW(m) \times damping(E_\gamma)) \otimes Gauss(0,\sigma)$

M1 transition

$$\frac{E_0^2}{E_\gamma E_0 + (E_\gamma - E_0)^2}$$

✓χ_{cJ} signal:

— MC shape smeared with Gaussian

✓Background:

—$e^+e^- \to KK\pi$ (ISR), $\psi' \to KK\pi$ (FSR),
$\psi' \to \pi^0 KK\pi$

—Measured from data

BESIII results:

✓Statistical significance>10σ

✓M=3637.6±2.9±1.6MeV/c^2

✓Γ =16.9±6.4±4.8MeV/c^2

✓Branching fraction:

—$Br(\psi' \to \gamma\eta_c(2S) \to \gamma KK\pi) = (1.30 \pm 0.20 \pm 0.30) \times 10^{-5}$

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

(PRD78 012006 (2008))

—$Br(\psi' \to \gamma\eta_c(2S)) = (6.8 \pm 1.1 \pm 4.5) \times 10^{-4}$

- Potential model predicts (0.1~ 6.2)*10^{-4} PRL89 162002 (2002)
- CLEO-c: <7.6*10^{-4} PRD81 052002 (2010)

$\psi' \to \gamma\gamma J/\psi$

- ✓ Two photon transitions are well known in excitations of molecules, atomic hydrogen, and positronium.

  F. Bassani et al, PRL 39, 1070 (1977);A. Quattropani et al., PRL 50, 1258 (1983)

- ✓ Never been observed in the quarkonium system. PRD 78,011102(2008)

— CLEO-c: upper limit of Br($\psi' \to \gamma\gamma$ J/ψ) is 1×10^{-3}

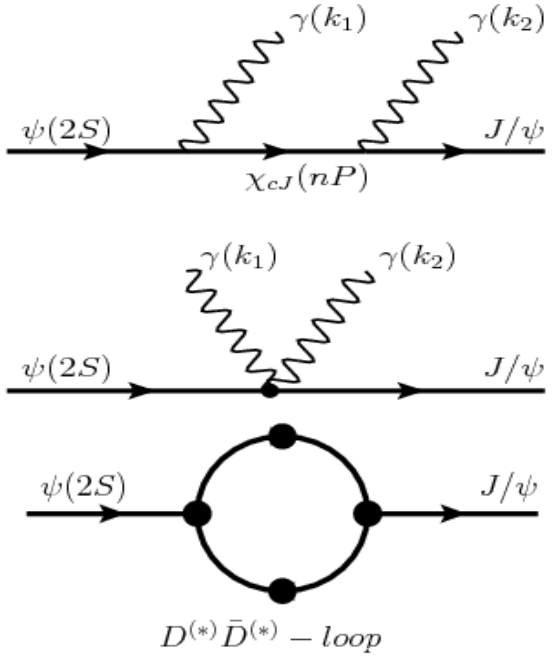
- ✓ Observation helpful to understand heavy quarkonium spectrum & strong interaction

Theoretically:

✓Potential models give discrete spectra
($\psi' \to \gamma\chi_{cJ}$, $\chi_{cJ} \to \gamma J/\psi$)

✓Possibility of testing the hadron-loop effect

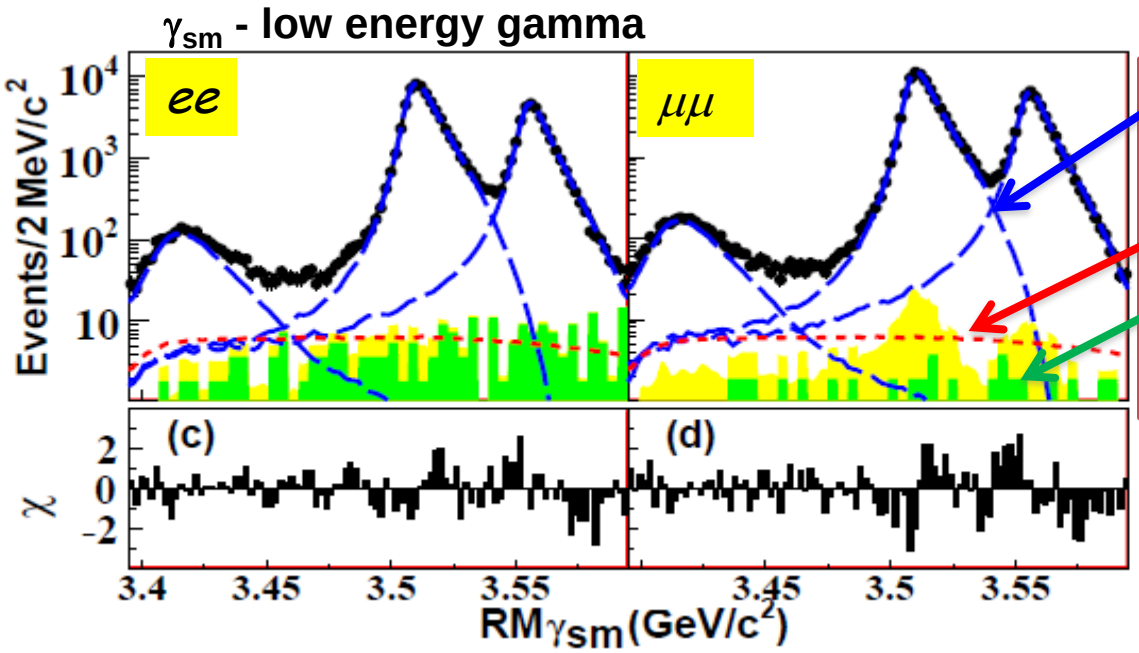
✓Coupled channel: the hadron-loop effect also may play a important role in the continuous spectra



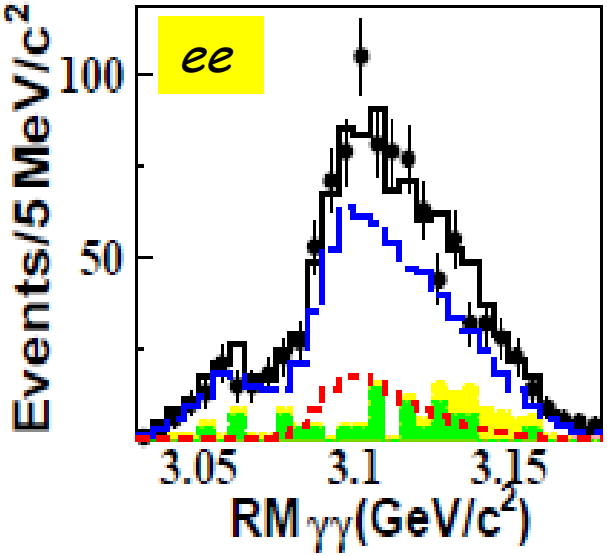
First evidence of $\psi' \to \gamma\gamma J/\psi$

Select $\psi' \to \gamma\gamma J/\psi$, $J/\psi \to e^+e^-/\mu^+\mu^-$ events

arXiv: 1204.0246 Submitted to PRL



- the χ_{cJ} components: double E1 scaling
- yields of the two-photon events
- continuum(green) + ψ(2S) decay BG(yellow)



- ✓ Global fit of the $\gamma\gamma$ process and cascade χ_{cJ} processes
- ✓ See clear excess over BG+continuum
- ✓ $Br(\psi' \to \gamma\gamma J/\psi) = (3.3 \pm 0.6^{+0.8}_{-1.1}) \times 10^{-4}$ (both e^+e^- and $\mu^+\mu^-$)
- ✓ Significance : 3.8σ including systematics
- ✓ $Br(\psi' \to \gamma\chi_{cJ}, \chi_{cJ} \to \gamma J/\psi)$ are also measured

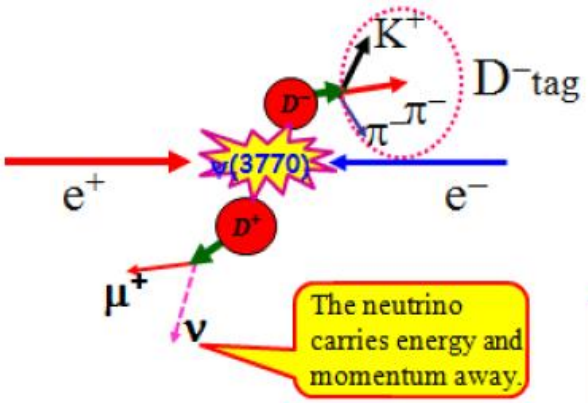
3.44<RM(γ_{sm})<3.48GeV

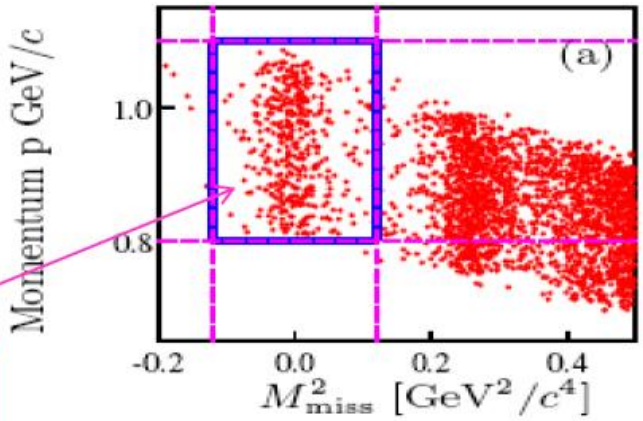
Preliminary results on D analysis

- ✓ Leptonic Decays
- ✓ Semi-leptonic Decays

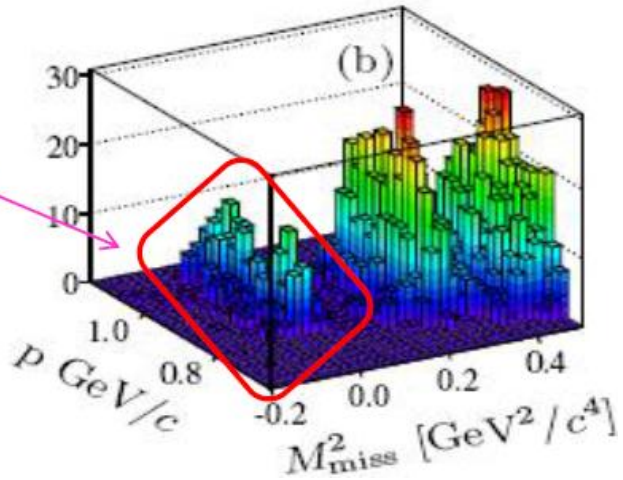
Preliminary results of $D^+ \to \mu^+ \nu$

- ✓ In the system recoiling against the tagged D^- with 9 different decay modes, select leptonic decay for $D^+ \to \mu^+ \nu$





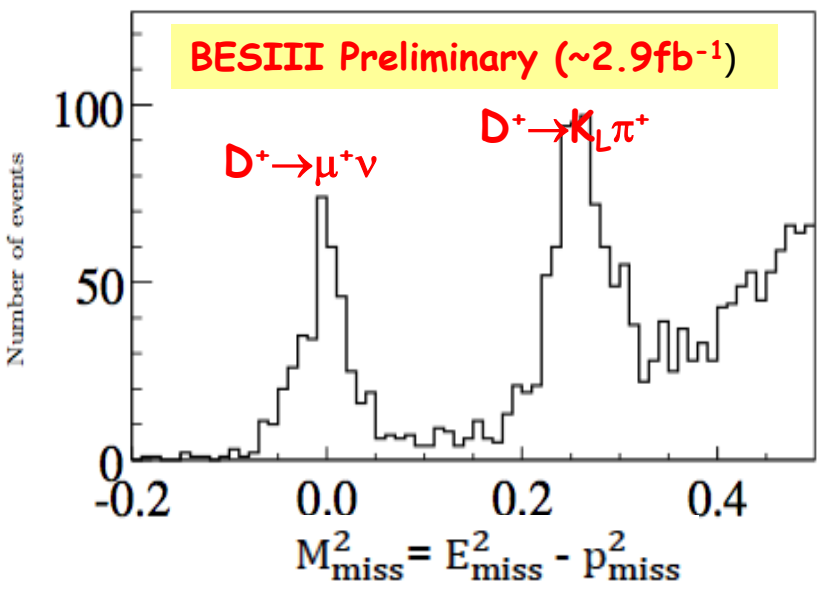
425 candidates for $D^+ \to \mu^+ \nu$

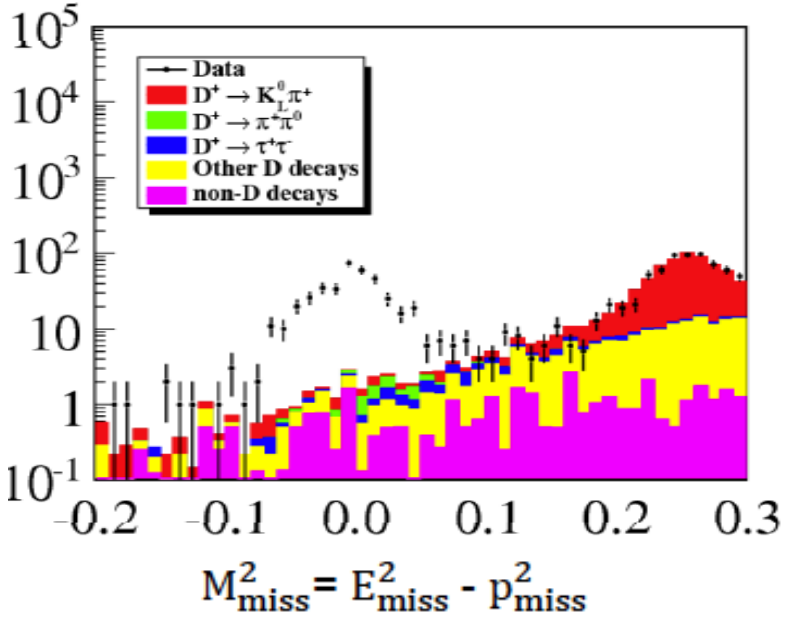


they require:

- **One charged track only**
- **Positively identified μ**
- **No isolate photon**

Preliminary results of $D^+ \to \mu^+ \nu$





Results: $N(D^+ \to \mu\nu) = 377.3 \pm 20.6 \pm 2.6$

$BF(D^+ \to \mu\nu) = (3.74 \pm 0.21 \pm 0.06) \times 10^{-4}$

$$\Gamma(D^+ \to l^+ \upsilon_l) = \frac{G_F^2 f_{D^+}^2}{8\pi} |V_{cd}|^2 m_l^2 m_{D^+} (1 - \frac{m_l^2}{m_{D^+}^2})^2$$

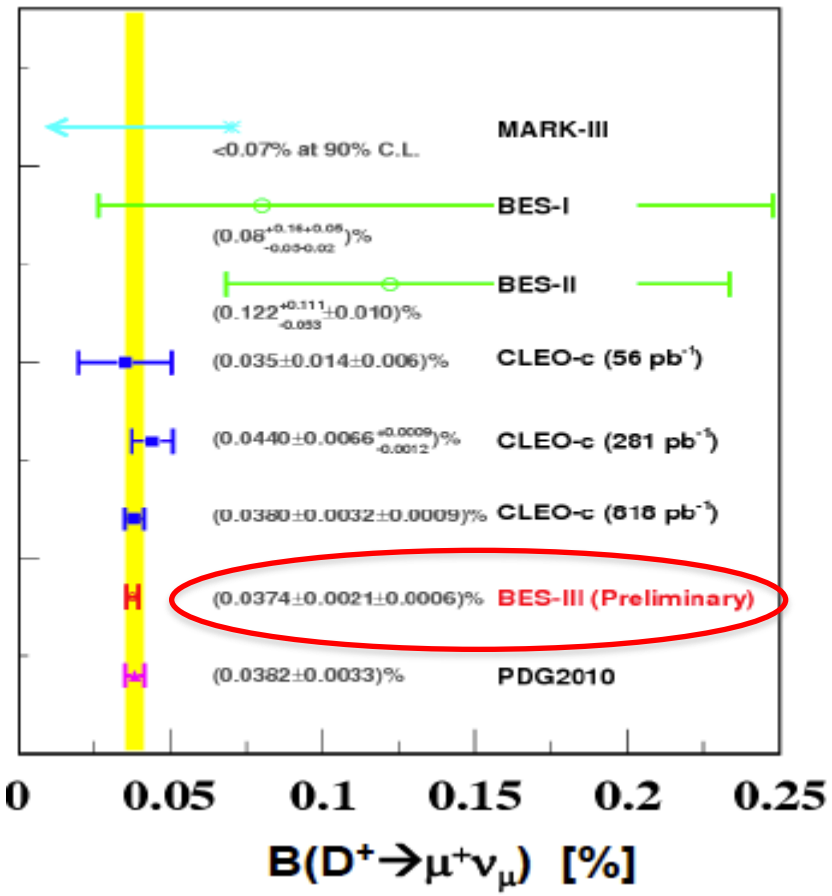
$f_{D+} = (203.91 \pm 5.72 \pm 1.97)$ MeV/c^2

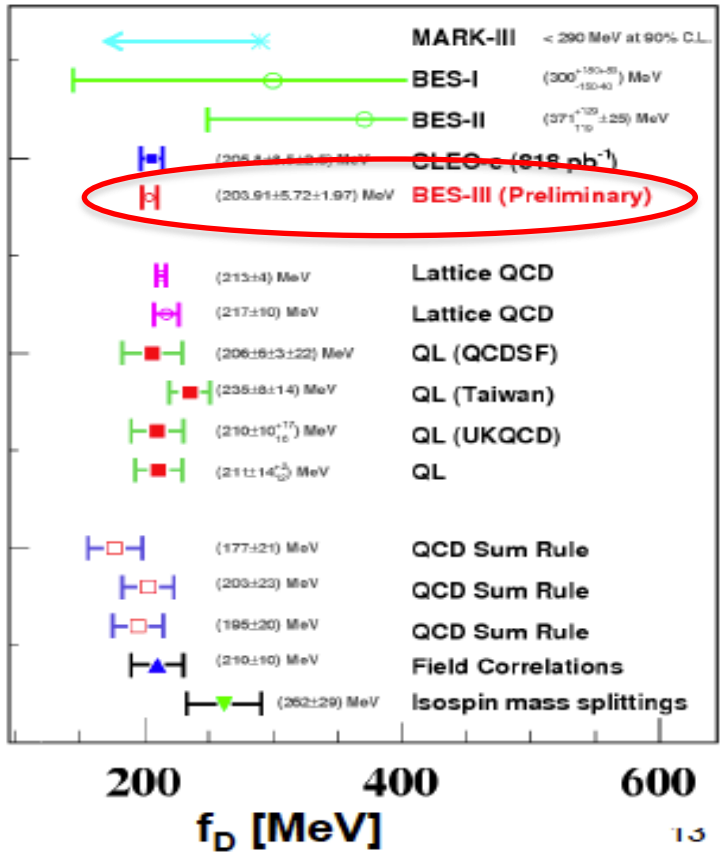
$|V_{cd}| = (0.222 \pm 0.006 \pm 0.005)$

$f_{D+} = (207 \pm 4)$ MeV/c^2 LQCD

$|V_{cd}| = (0.2252 \pm 0.007)$ CKMFitter

Preliminary results of $D^+ \to \mu^+ \nu$





- ✓ The most precise measurement is provided by BESIII
- ✓ the error is still dominated by statistics, needing more data taken at 3773 GeV to reduce it.

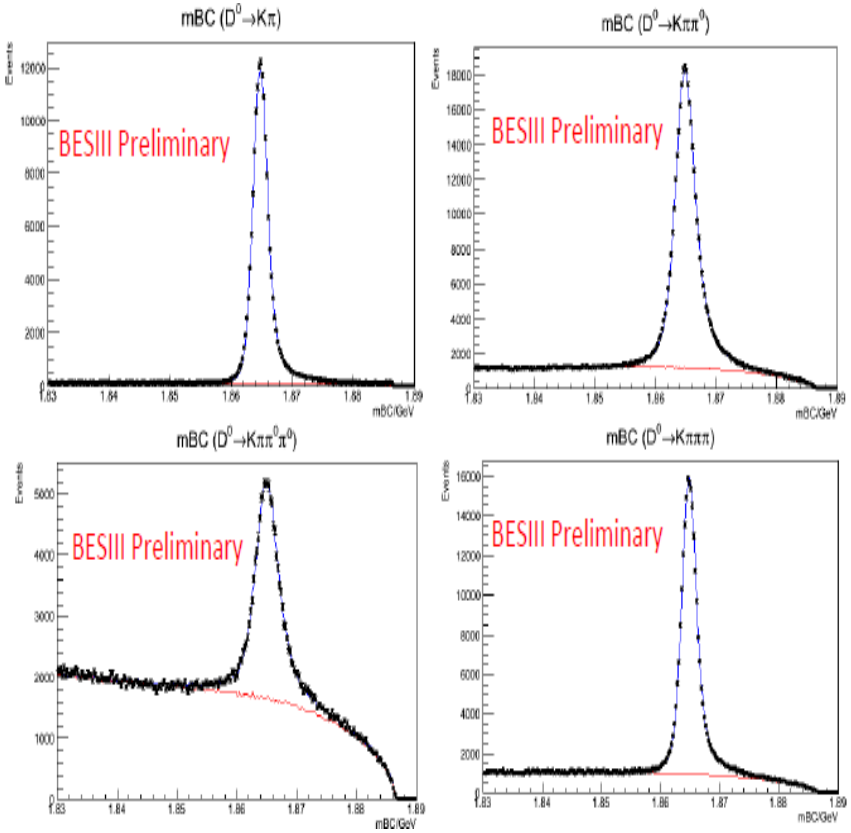
Semi-leptonic Decays $D^0 \to K/\pi\, e\nu$

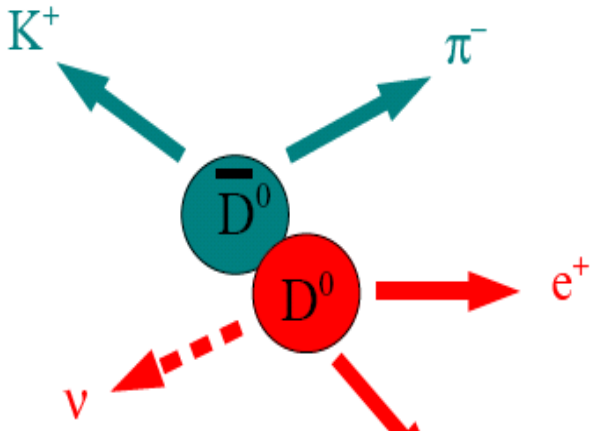
Differential decay rate function:

$$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cx}|^2 \, p_X^3 \, |f_+(q^2)|^2$$

4 tag modes, 0.92 fb^{-1} data @3.773 (BESIII reliminary)

q2 – the invariant mass square of the lepton-neutrino system

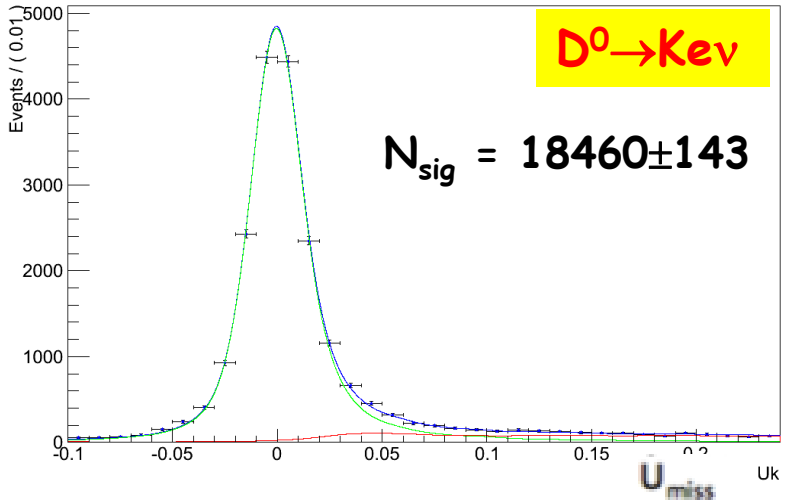


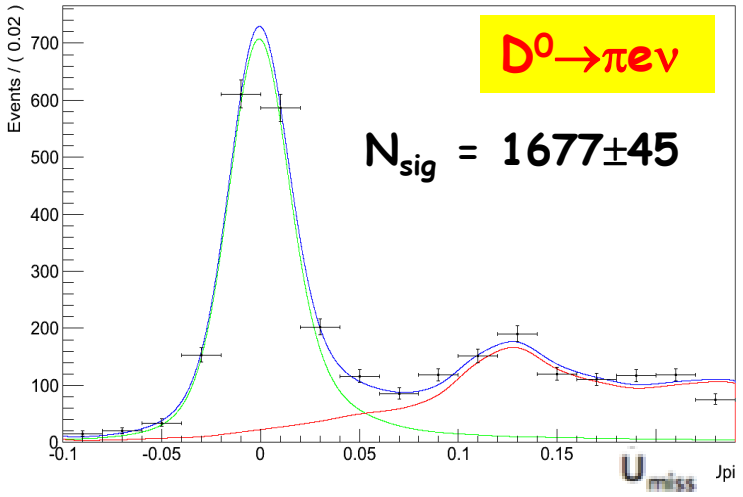


Mode	Data Yield	Fraction of All Tags (%)	Tag Efficiency(%)
$D^0 \to K^-\pi^+$	159,929 ± 413	20.7	62.08±0.07
$D^0 \to K^-\pi^+\pi^0$	323,348 ± 667	41.8	33.56±0.03
$D^0 \to K^-\pi^+\pi^0\pi^0$	78,467 ± 480	10.1	14.93±0.04
$D^0 \to K^-\pi^+\pi^-\pi^+$	211,910 ± 550	27.4	36.80±0.04

Semi-leptonic Decays $D^0 \to K/\pi\, e\nu$

BESIII Preliminary (~0.92fb^{-1})





Mode	measured branching fraction(%)	PDG	CLEOc
$\bar{D}^0 \to K^+ e^- \bar{\nu}$	3.542 ±0.030±0.067	3.55 ±0.04	3.50 ±0.03 ±0.04
$\bar{D}^0 \to \pi^+ e^- \bar{\nu}$	0.288 ±0.008±0.005	0.289 ±0.008	0.288 ±0.008±0.003

- ✓ Systematics are preliminary
- ✓ Will improve with full data set 2.9/fb in the near future
- ✓ Form factor measurement is ongoing

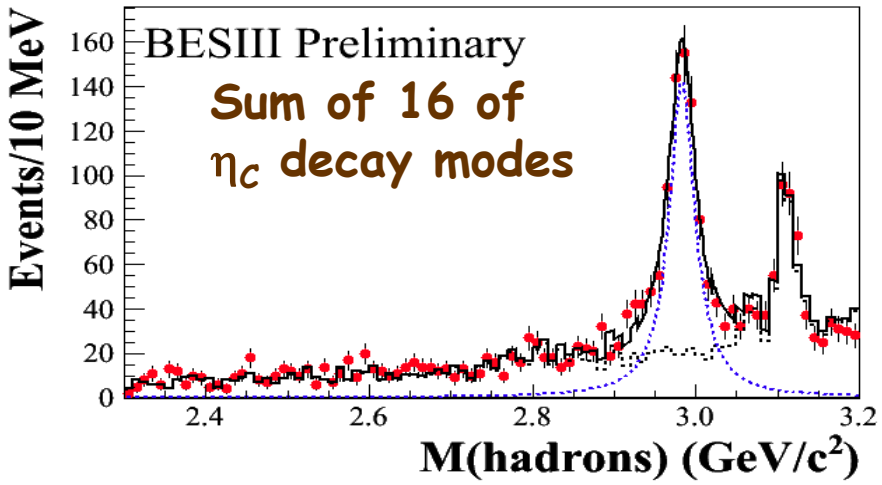
Summary

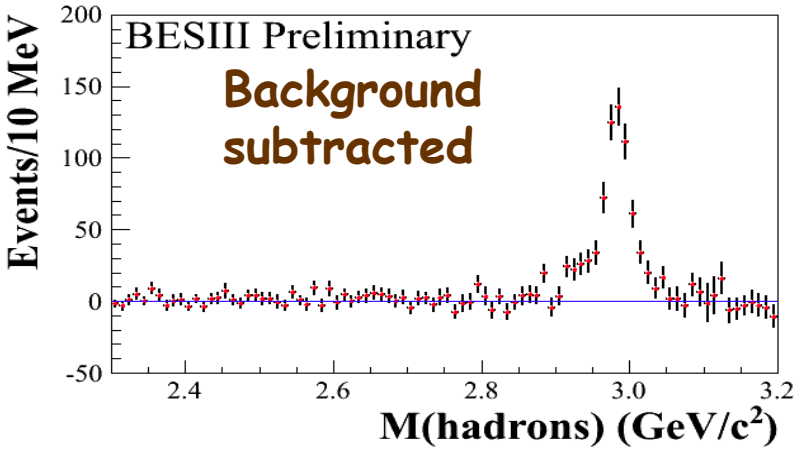
- ✓ **BESIII is successfully operating since 2008:**
  - ➢ **World largest data sample of J/ψ, ψ', ψ(3770), ψ(4040), still growing….**
- ✓ **A lot of results have been obtained:**
  - ➢ **Light quark states :**
    - — **Confirmation the enhancement at $p\bar{p}$ threshold in $J/\psi\to\gamma p\bar{p}$, $J^{pc}=0^{-+}$.**
    - — **Confirmation X(1835) with two new structures in $J/\psi\to\gamma\pi\pi\eta'$.**
    - — **First observation: $\eta(1405)\to f_0(980)\pi^0$ (isospin breaking).**
    - — **.....**
  - ➢ **Charmonium transitions :**
    - — **Precision measurements of h_c and $\eta_c(1S)$ properties.**
    - — **first observation of $\eta_c(2S)$ in $\psi'\to\gamma\eta_c(2S)$ decay.**
    - — **First evidence of $\psi'\to\gamma\gamma$ J/ψ**
    - — **.....**
  - ➢ **Charm decays:**
    - — **Leptonic decay $D^+\to\mu^+\nu$**
    - — **Semi-Leptonic decay $D^0\to K/\pi$ ev**
    - — **……**
- ✓ **Expect many more results from BESIII in the future**

Thank you

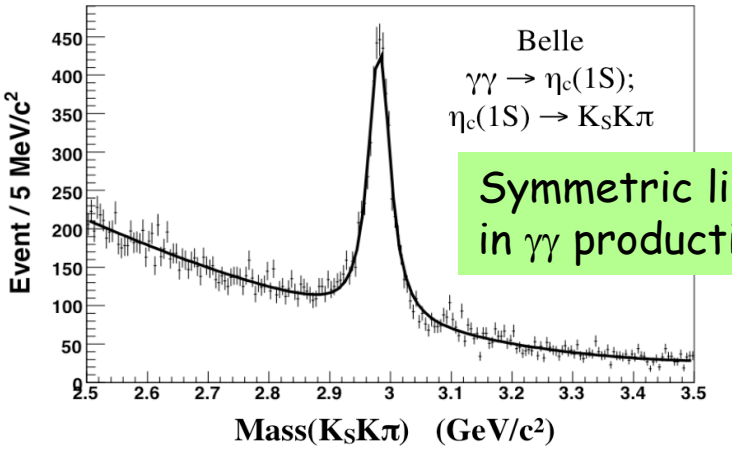
Backup

η_c lineshape from $\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma \eta_c$

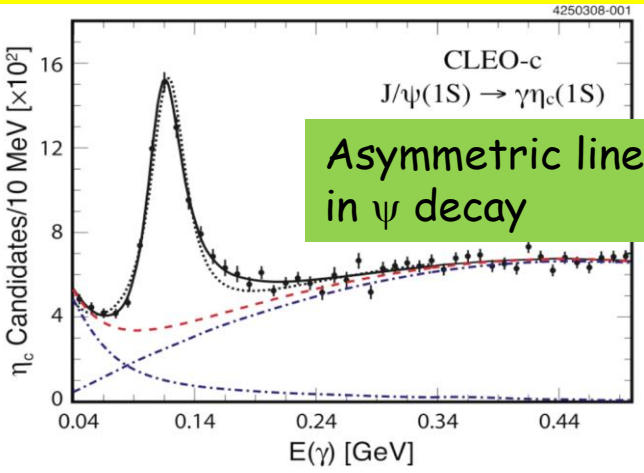




The η_C lineshape is not distorted in the $h_c \rightarrow \gamma \eta_C$, non-resonant bkg is small. This channel will be best suited to determine the η_C resonance parameters.



Symmetric lineshape in $\gamma\gamma$ production



Asymmetric lineshape in ψ decay

Is the X(1835) from the same source of X($p\bar{p}$)?

- The mass of X($p\bar{p}$) is consistent with X(1835)

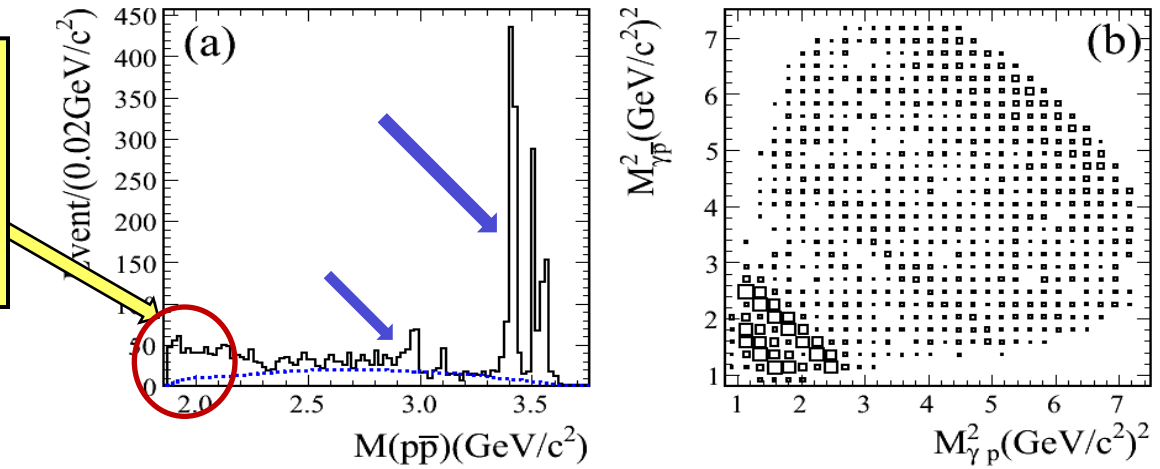
- The width of X($p\bar{p}$) is much narrower.

  Possible reasons:

  - X($p\bar{p}$) and X(1835) come from different sources
  - Interference effect in $J/\psi \to \gamma\pi\pi\eta'$ process should not be ignored in the determination of the X(1835) mass and width
  - There may be more than one resonance in the mass peak around 1.83GeV in $J/\psi \to \gamma\pi\pi\eta'$ decays.

Mpp̄ threshold structure of $\psi' \to \gamma p\bar{p}$@BESIII

Obviously different line shape of pp̄ mass spectrum near threshold from that in J/ψ decays



PWA results:

- Significance of X(pp̄) is > 6.9σ.
- The production ratio R:

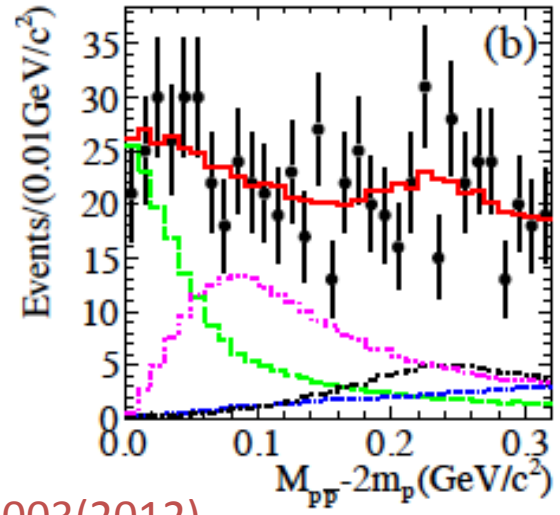
first measurement

$$R = \frac{B(\psi' \to \gamma X(p\bar{p}))}{B(J/\psi \to \gamma X(p\bar{p}))}$$

$$= (5.08^{+0.71}_{-0.45}(\text{stat})^{+0.67}_{-3.58}(\text{syst}) \pm 0.12(\text{mod}))\%$$

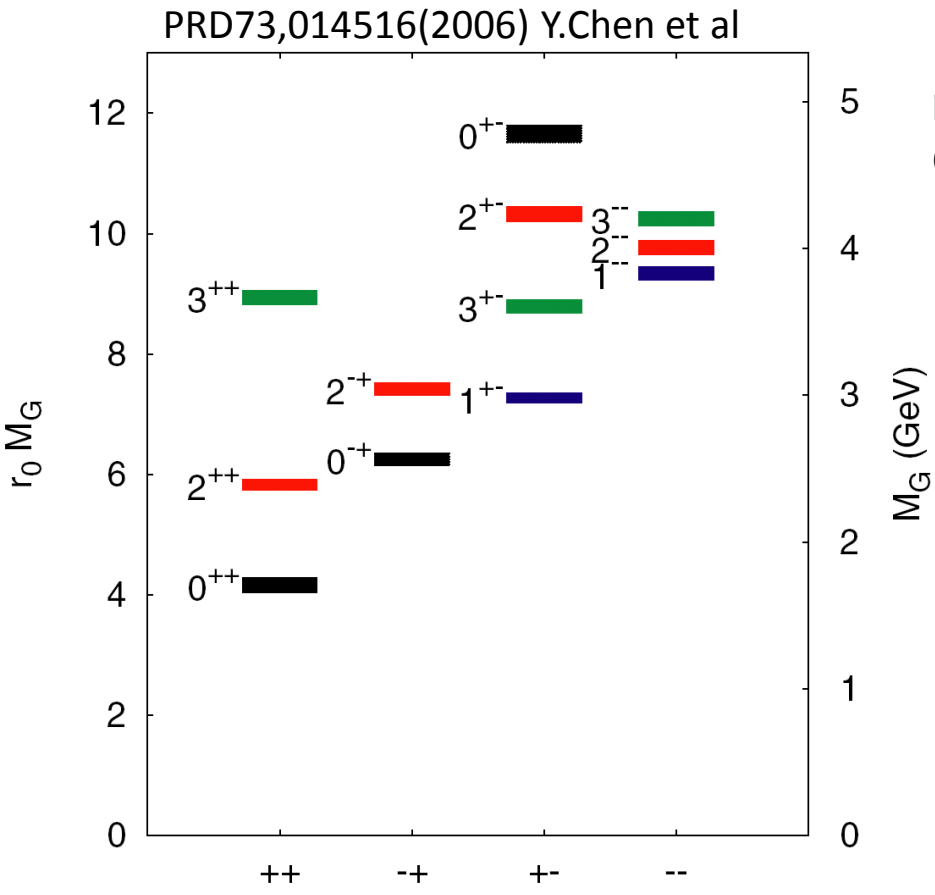
- It is suppressed compared with "12% rule".

PWA Projection:



PRL 108,112003(2012)

Why are X(2120)/X(2370) interesting?



✓It is the first time in J/ψ radiative decays resonant structures are observed in the 2.4 GeV/c^2 region,
it is interesting since:

LQCD predicts that the lowest lying pseudoscalar glueball: around 2.4 GeV/c^2.

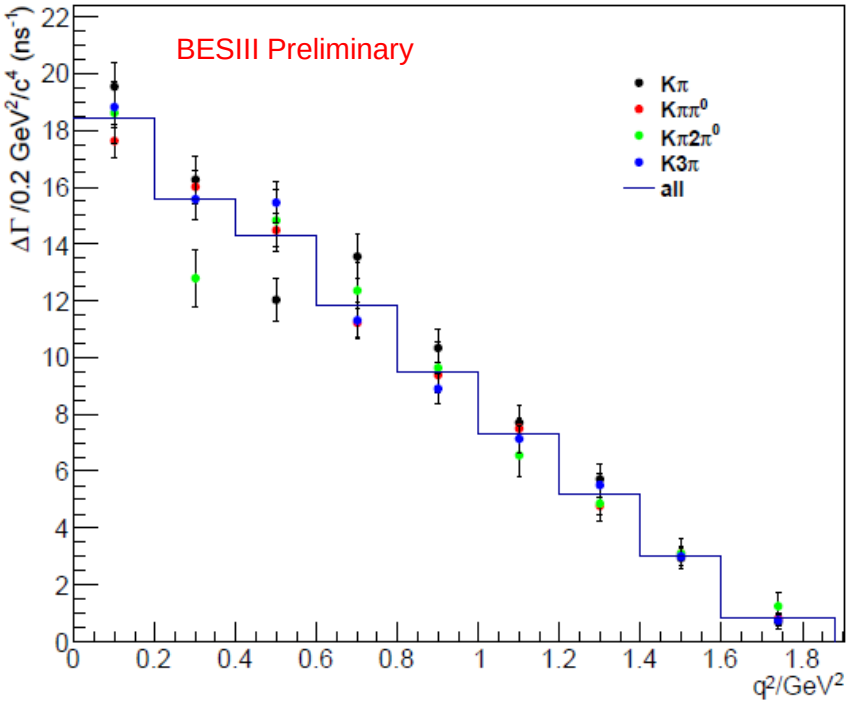
J/ψ-->γππη' decay is a good channel for finding 0^{-+} glueballs.

✓Nature of X(2120)/X(2370)
pseudoscalar glueball ?
η/η' excited states?
ΔΔ bound state?
……

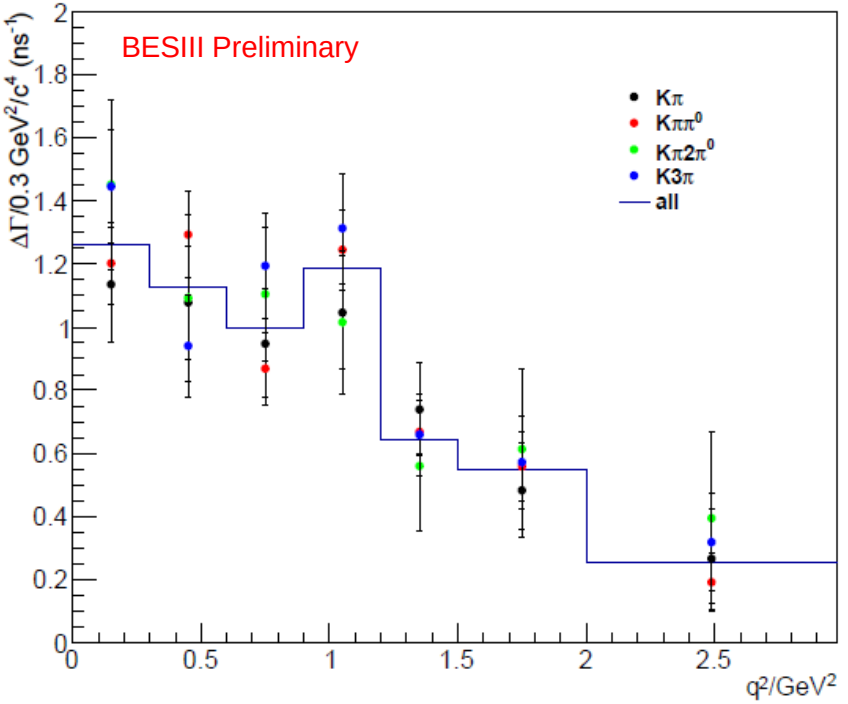
PRD82,074026,2010 (J.F. Liu, G.J. Ding and M.L.Yan)
PRD**83:114007,2011** (J.S. Yu, Z.-F. Sun, X. Liu, Q. zhao), and more…

Partial Decay Rates Results

- Measured in each q^2 bin, by fitting U distribution
- Compare results from each tag mode



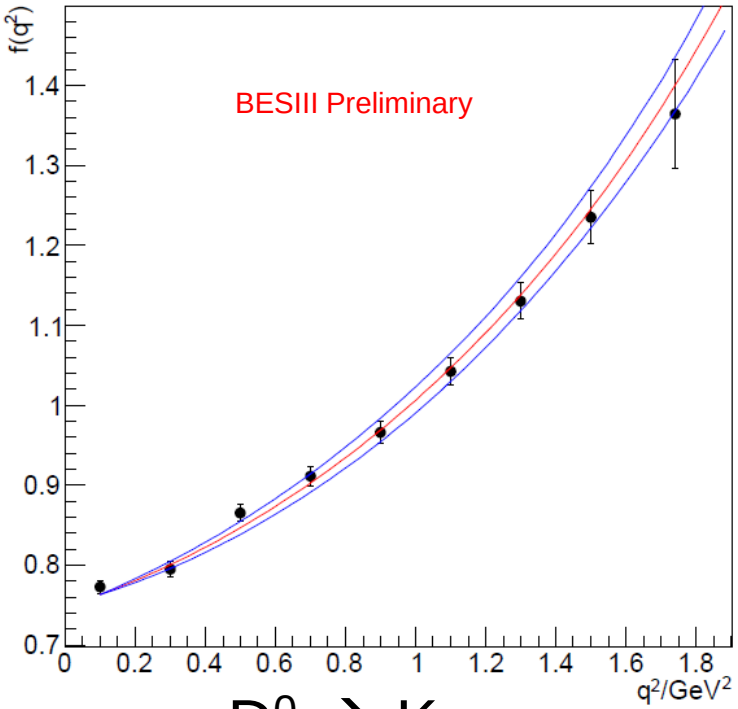
$D^0 \rightarrow K e \nu$



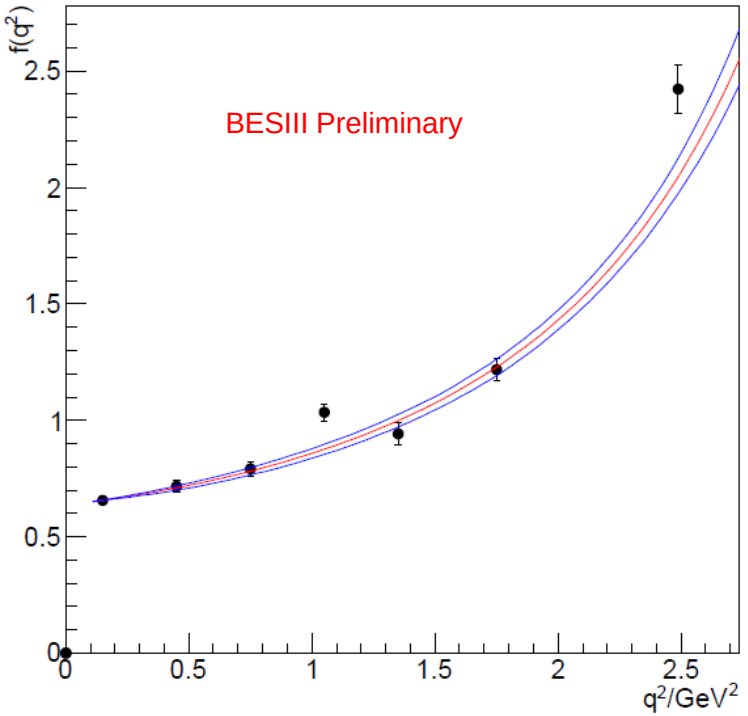
$D^0 \rightarrow \pi e \nu$

$f(q^2)$ Results

- Points: data with stat. error only
- Curves: from Fermilab-MILC within one stat. error, preliminary, **arXiv:1111.5471** (XXIX International Symposium on Lattice Field Theory);
- Other theoretical work: HPQCD, arXiv:1111.0225
- Comparing shape only here ($f_+(0)$ not known)



$D^0 \rightarrow K\, e\, \nu$



$D^0 \rightarrow \pi\, e\, \nu$

Form Factor Fits

BESIII Preliminar

Simple pole model:

$$f_+(q^2) = \frac{f_+(0)}{1 - q^2/m^2_{pole}}$$

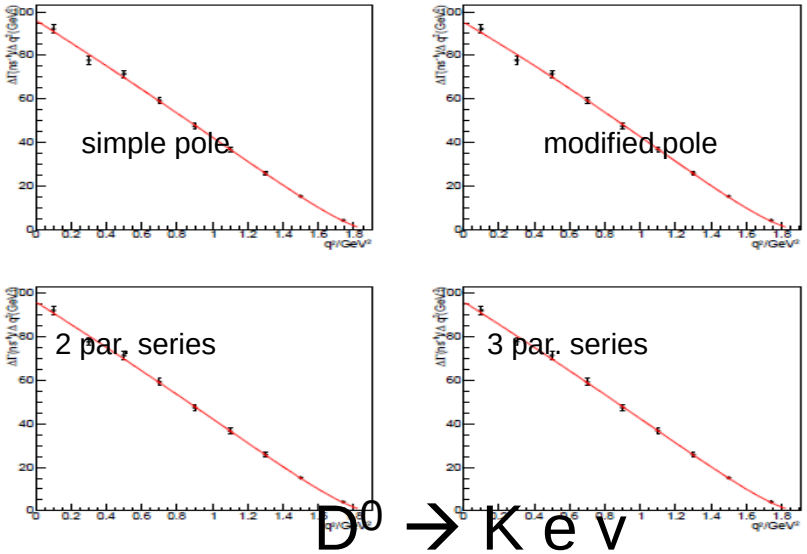
Modified pole model:
Beciirevic and Kaidalov PLB 478, 417 (2000)

$$f_+(q^2) = \frac{f_+(0)}{\left(1 - \frac{q^2}{m^2_{pole}}\right)\left(1 - \alpha\frac{q^2}{m^2_{pole}}\right)}$$

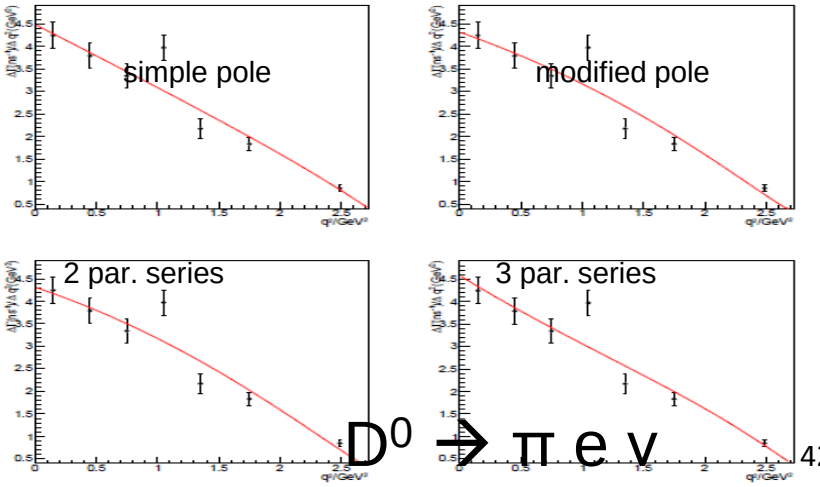
Series expansion:
Becher and Hill PLB 633, 61 (2006)

$$f_+(q^2) = \frac{1}{P(q^2)\,\phi(q^2,t_0)} \sum_{k=0}^{\infty} a_k(t_0)\,\left[z(q^2,t_0)\right]^k$$

Could fit: $f_+(0)$, $r_1 = a_2/a_1$, $r_2 = a_3/a_1$



$D^0 \to K e \nu$



$D^0 \to \pi e \nu$

Form Factor Results

BESIII Preliminary

Simple Pole	$f_+(0)\|V_{cd(s)}\|$	m_{pole}	
$D^0 \to Ke\nu$	$0.729 \pm 0.005 \pm 0.007$	$1.943 \pm 0.025 \pm 0.003$	
$D^0 \to \pi e\nu$	$0.142 \pm 0.003 \pm 0.001$	$1.876 \pm 0.023 \pm 0.004$	
Modified Pole	$f_+(0)\|V_{cd(s)}\|$	α	
$D^0 \to Ke\nu$	$0.725 \pm 0.006 \pm 0.007$	$0.265 \pm 0.045 \pm 0.006$	
$D^0 \to \pi e\nu$	$0.140 \pm 0.003 \pm 0.002$	$0.315 \pm 0.071 \pm 0.012$	
2 par. series	$f_+(0)\|V_{cd(s)}\|$	r_1	
$D^0 \to Ke\nu$	$0.726 \pm 0.006 \pm 0.007$	$-2.034 \pm 0.196 \pm 0.022$	
$D^0 \to \pi e\nu$	$0.140 \pm 0.004 \pm 0.002$	$-2.117 \pm 0.163 \pm 0.027$	
3 par. series	$f_+(0)\|V_{cd(s)}\|$	r_1	r_2
$D^0 \to Ke\nu$	$0.729 \pm 0.008 \pm 0.007$	$-2.179 \pm 0.355 \pm 0.053$	$4.539 \pm 8.927 \pm 1.103$
$D^0 \to \pi e\nu$	$0.144 \pm 0.005 \pm 0.002$	$-2.728 \pm 0.482 \pm 0.076$	$4.194 \pm 3.122 \pm 0.448$

BESIII commissioning

- ✓July 19, 2008: first e^+e^- collision event in BESIII
- ✓Nov. 2008: ~14M $\psi(2S)$ events for detector calibration
- ✓2009: 106M $\psi(2S)$ 4×CLEO-c
  225M J/ψ 4×BESII
- ✓2010: ~0.9 fb^{-1} $\psi(3770)$ } 3.5×CLEO-c
- ✓2011: ~2.0 fb^{-1} $\psi(3770)$ }
  ~0.5 fb^{-1} @ 4.01 GeV
- ✓2012: tau mass scan: ~5.0 pb^{-1} ;
  $\psi(2S)$: 0.4 billion; J/ψ: 1 billion (May 22!)

World's largest sample of J/ψ, $\psi(2S)$ and $\psi(3770)$ (and still growing)

Tentative future running plans (not Approved yet):

- ✓ 2013: D_s physics (E_{cm}=4170 MeV) + R scan (E_{cm} > 4 GeV)
- ✓ 2014: $\psi(2S)$ / τ / R scan (E_{cm} > 4 GeV);
- ✓ 2015: $\psi(3770)$: 5-10 fb^{-1} for DD physics