First Results with Υ(1S,2S) Datasets at

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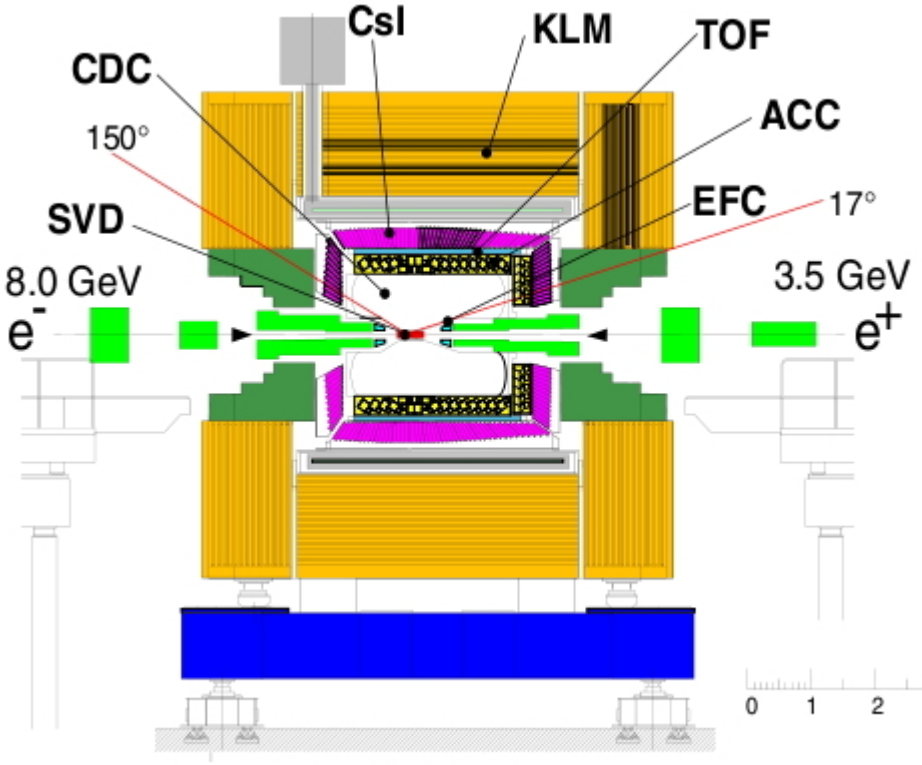
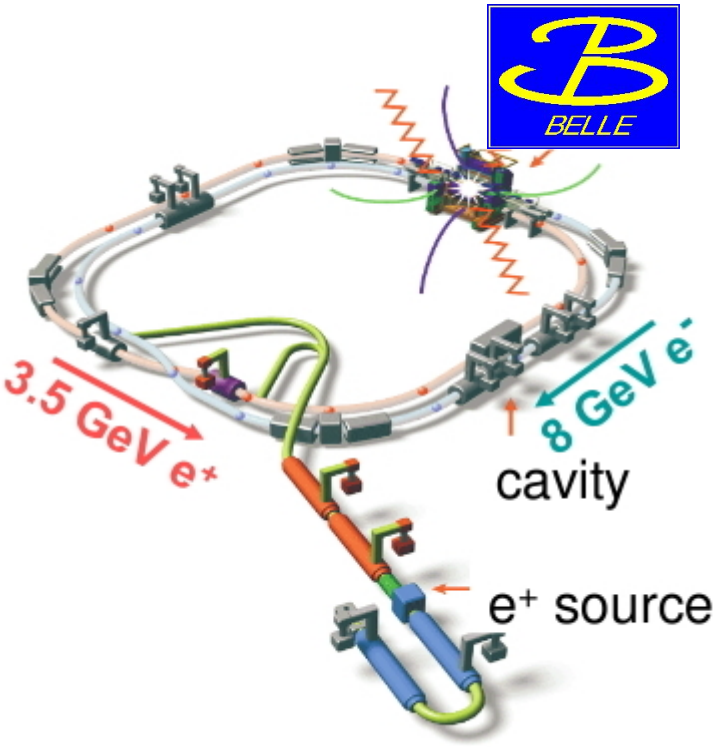
Fermilab

7th QWG workshop, May 19,2010

Belle detector and KEKB





Trigger thresholds rescaled for lower energy running at 1S and 2S

E(e+) and E(e-) are decreased by 10.6% (1S) or 5.3%(2S), keeping Lorenz $\gamma\beta$=0.425

E(e+): 3.500 GeV → 3.130(1S) , 3.316 (2S) GeV
E(e-): 7.996 GeV → 7.149(1S) , 7.575 (2S) GeV

Data samples

Y(1,2,3S) Data taken in 2008-9

BABAR:

Jan-Feb 2008: 120 M Y(3S) decays

March 2008: 100 M Y(2S) decays

BELLE:

June 2008: 100 M Y(1S) decays +1.8fb^{-1} below Y(1S)

December. 2008: 46 M Y(2S) decays

November 2009: 124 M Y(2S) decays+1.7fb^{-1} below Y(2S)

Overall summary on Y(1,2,3S) samples (units 10^6) :

	CLEO-III	BABAR_ISR(a)	BABAR	BELLE_ISR(b)	BELLE
1S	20	6.80	[19+5]	11.8	100[33]
2S	9	5.95	100	10.4	170
3S	6	10.0	120	17.4	11

(a) from 347.5/fb at Y(4S)

(b) from 604.5/fb at Y(4S)

* []= ππ tagged Y(2,3S) decays

Y(1S)

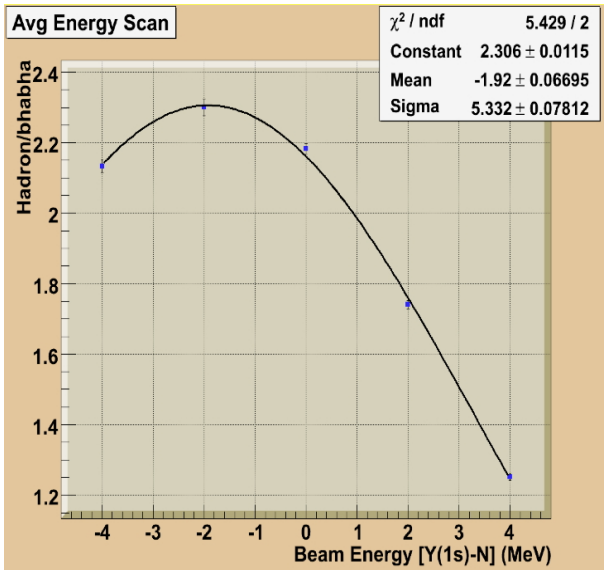
Y(1S) data taking, scans, lumi

June 2008: ~20 days

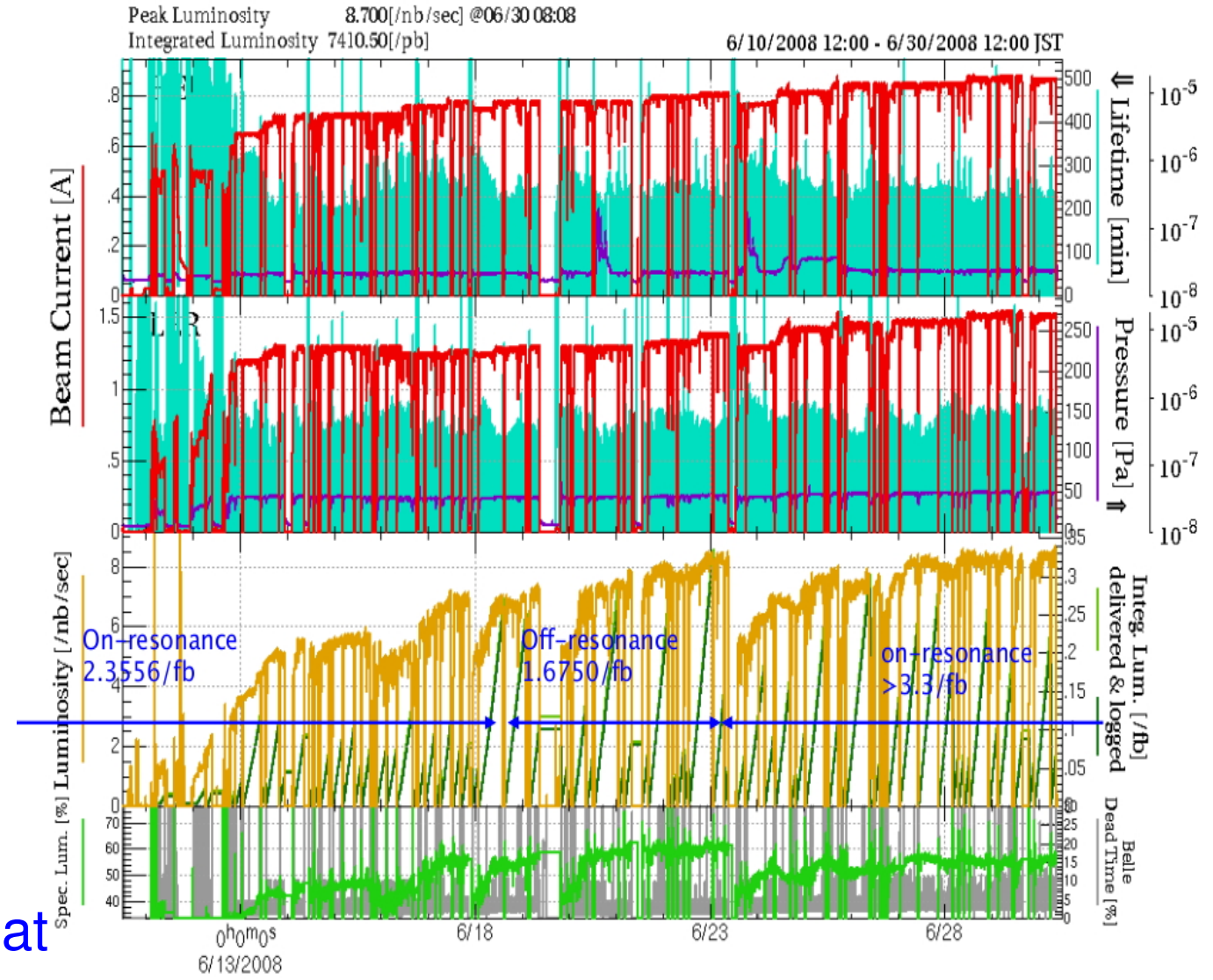
On Y(1S) peak: 5.7 fb^{-1}

$L_{max} = 0.85 \times 10^{34} cm^{-2} s^{-1}$

I_{LER}=1.5A I_{HER}=0.85 A



Continuum data taking at 9.430 GeV: 1.8 fb^{-1}



Y(1S) counts: hadronic events on continuum

Data taken at Ecm=9.43GeV were compared with continuum MC

KKMC v4.19 (0.1% at QED fractions)

Good agreement on most observables:

- Ncal – number of ECL clusters
- Ntrk – number of charged prongs
- Ecal – Sum of energy of all good clusters in ECL in c.m.s.
- Evis – visible energy in c.m.s.
- R2 – ratio of Fox-Wolfram moments H2/H0
- E γmax – maximum energy in ECL

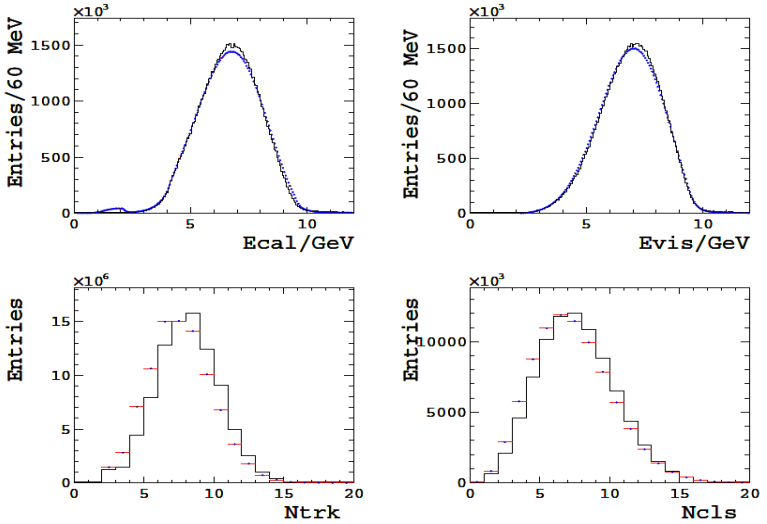
Selection of Hadronic sample: optimized cuts to reject backgrounds from 2-photon processes, and lepton-pair events.

Y(1S) counts using hadronic events

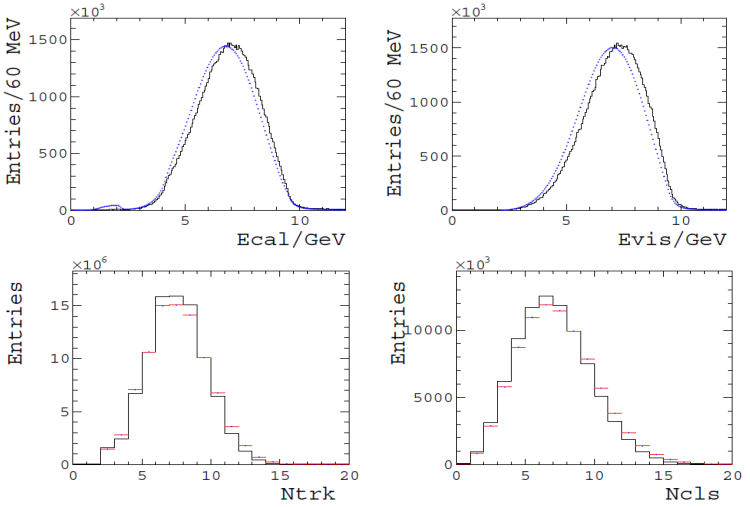
On Y(1S) peak, MonteCarlo generator (EvtGen+Pythia) is not as easy to tune,e.g. PARJ(33)(*):

- Ntrk, Ncal distributions are strongly dependent on PARJ(33)
- Efficiencies evaluated on MC subsets, reweighted with Ntrk,Ncal distributions obtained varying Pythia parameters are anyway stable, within 1.5%: this dominates the systematic error.

Preliminary estimate: N(Y(1S))= (101.5±1.6)M.



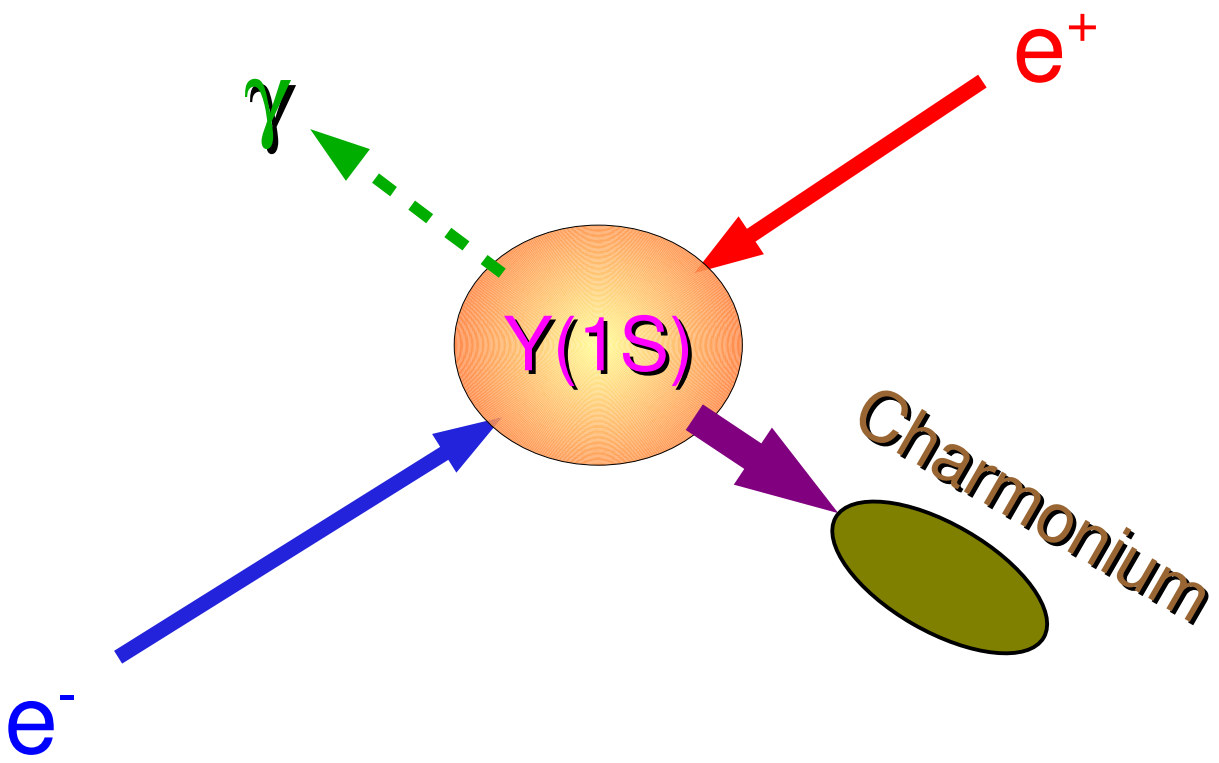
P33=0.3 GeV



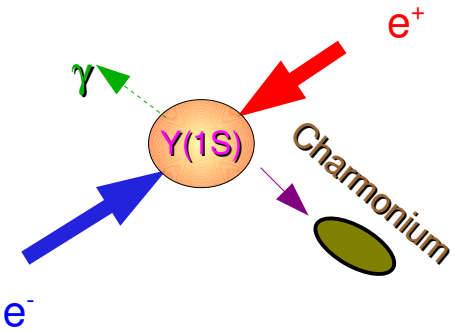
P33=1.1 GeV

(*)PARJ(33): energy where parton fragmentation stops and final hadrons are formed

Y(1s) radiative decays to charmonium



Y(1s) radiative decays to charmonium



Ideal process to bridge bottomonium with charmonium within the same framework

KT Chao et al, (hep-ph/0701009) provides a very large set of NRQCD predictions on many interesting processes:

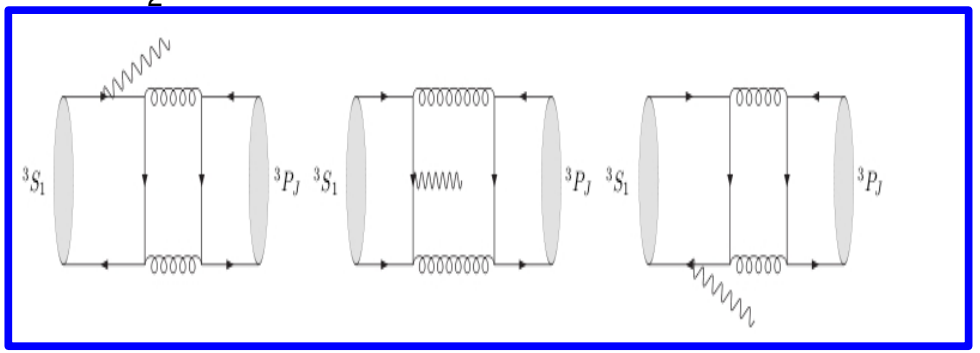
$\Upsilon(1S) \rightarrow \gamma\eta_c$, $\gamma\chi_c$,

$\Upsilon(1S) \rightarrow \gamma f_J$ [0.63×10^{-4} , exp:$(1.0\pm0.1)\times10^{-4}$ for $f_2(1270)$]

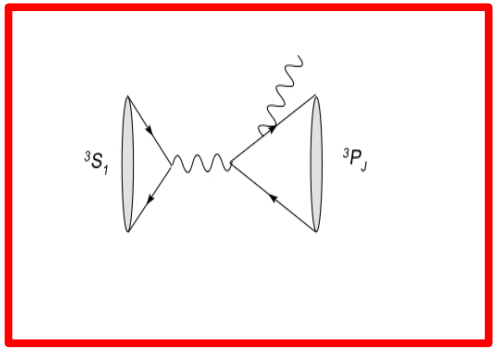
$\chi_{c,b}(1P) \rightarrow \gamma\rho$, $\gamma\omega$, $\gamma\phi$

$\chi_b(1P) \rightarrow \gamma J/\psi$

$\eta_b(1P) \rightarrow \gamma J/\psi$



A NLO prediction for $\Gamma_{tot}(\eta_b) = 11$ MeV is also included.



Significant corrections are expected from interference between QCD and QED amplitudes.

Besides these predictions, also recently discovered exotic charmonia (X3872,X3915,Y4140) deserve a search...

Υ(1s) → γ J/ψ π+π–

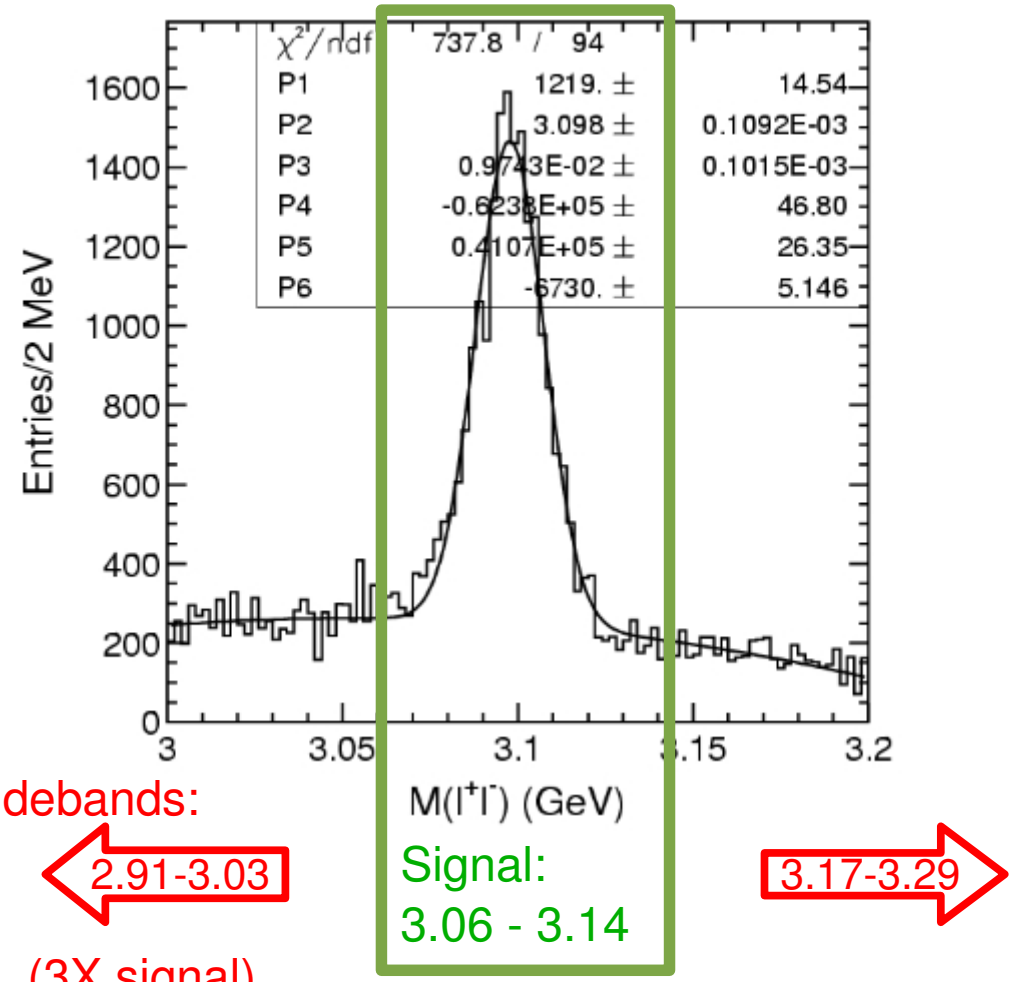
Selection criteria(*):

4 charged prongs, net charge = 0

PID to identify leptons and π's

Rejection of e^+e^- from conversions

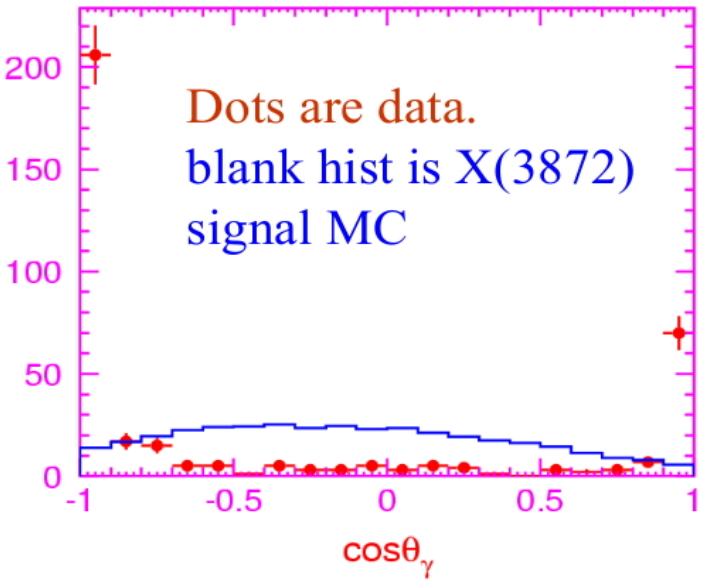
Missing Mass recoiling on 4 charged tracks consistent with a photon:
$-2<[P(1S) - P(l^+l^-\pi^+\pi^-)]^2 < 2\ GeV^2$

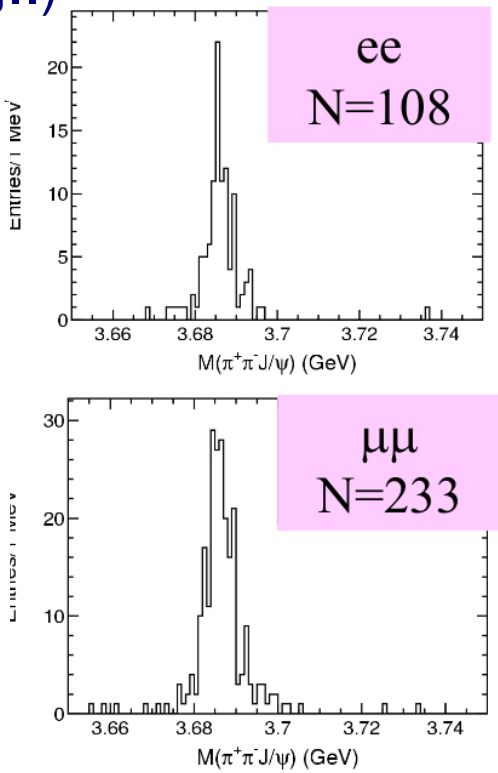


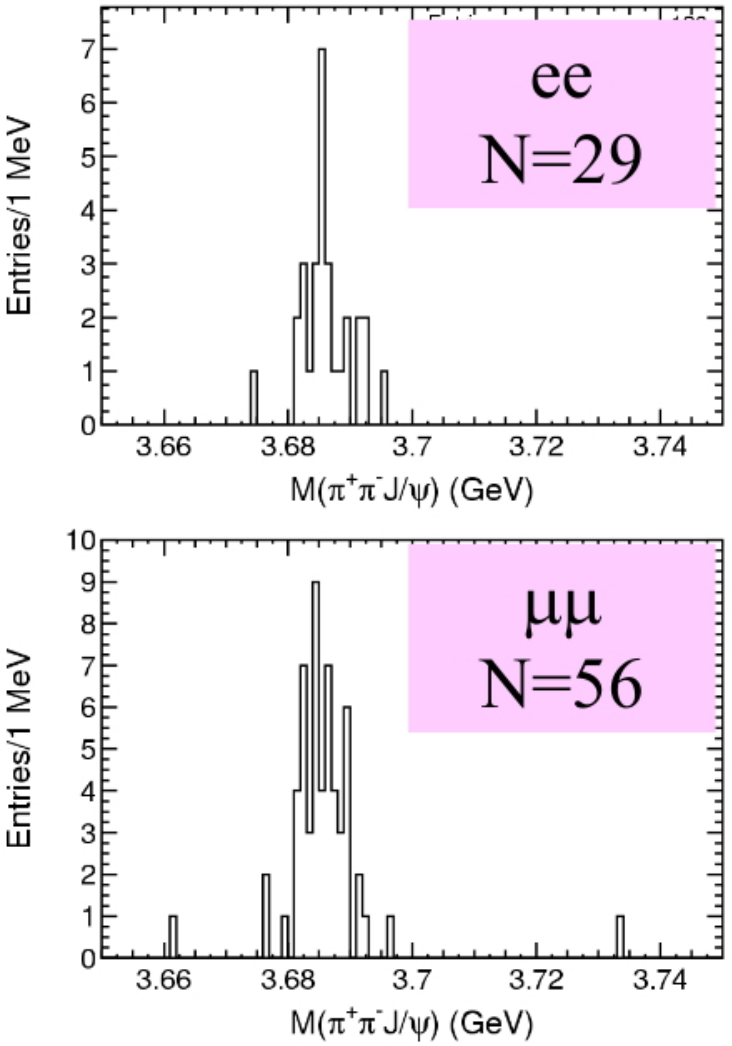
(*)similar to Y(4260) paper, PRL99 (2007) 182004

Y(1S) → γ J/ψ $\pi^+\pi^-$: ISR rejection

Dominant background is radiative return to Vector charmonia (ψ′,Y4260,..)







We expect:

$\sigma_{ISR}(e^+e^- \to \gamma\psi') = 18.9$ pb

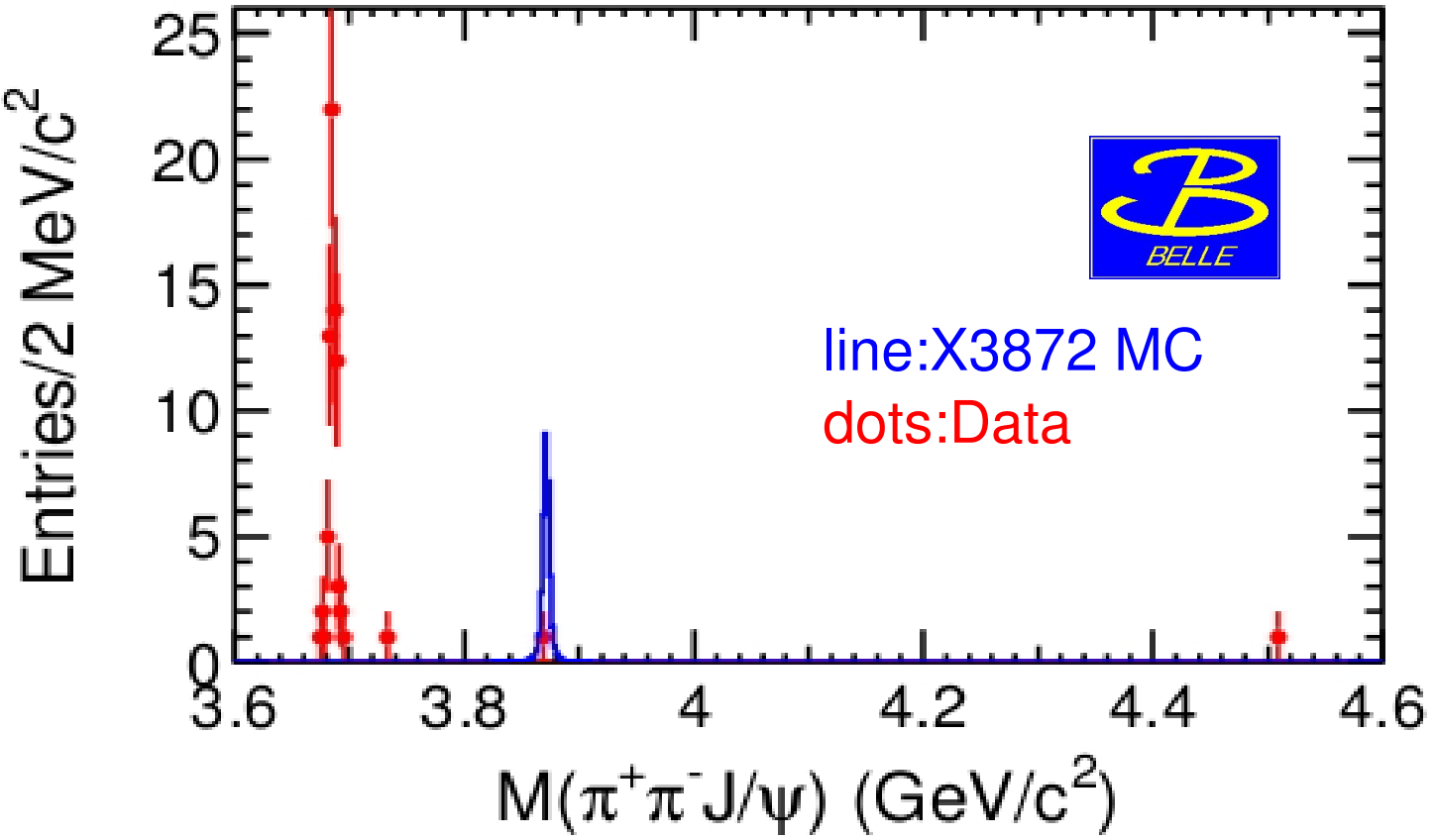
No cuts on photon:

$\sigma_{ISR}(\psi') = 20.9 \pm 1.1$ pb

Photon tagged: $|\cos\theta|<0.9$

$\sigma_{ISR}(\psi') = 21.8 \pm 2.4$ pb

Y(1s) → γ J/ψ π+π–: one X(3872)?



1 event at X(3872) with dilepton in J/ψ mass peak, none in sidebands

BR(Y(1S) → γ X3872 → γ $\pi^+\pi^-$ J/ψ) < 2.2x10^{-6} , at 90%CL

BR(Y(1S) → γ X3872)< 4.4x10^{-5} , if BR(X3872 → γ $\pi^+\pi^-$ J/ψ)=5%

No K^+K^- J/ψ events in 4-4.8 GeV. BR(Y(1S) → γ Y4140)< 4.4x10^{-5}

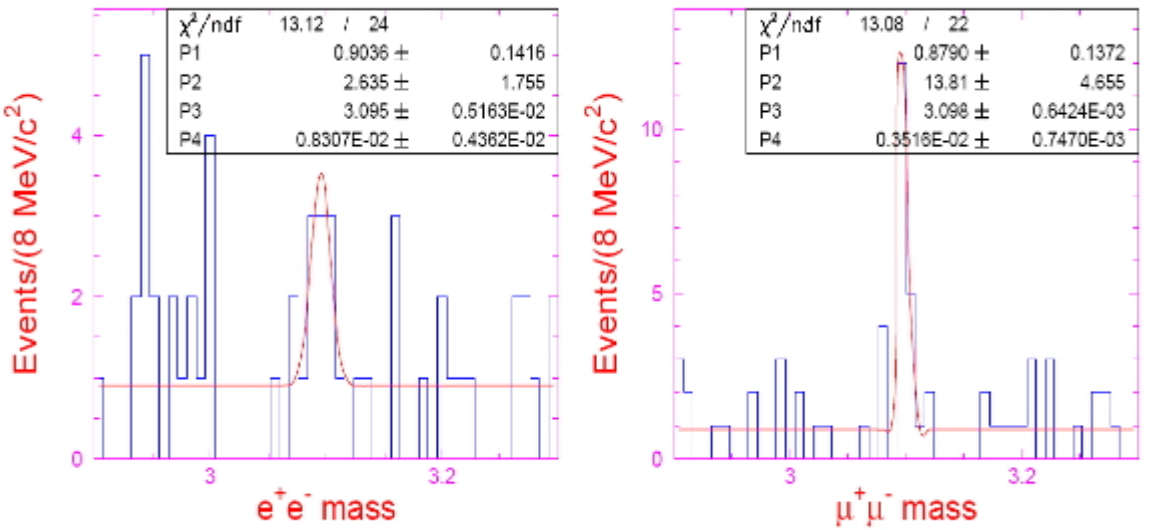
Y(1S) → γ J/ψ π+π–π0: X(3872,3915)

Selection criteria (in addition to the ones for $\pi^+\pi^-$ J/ψ)

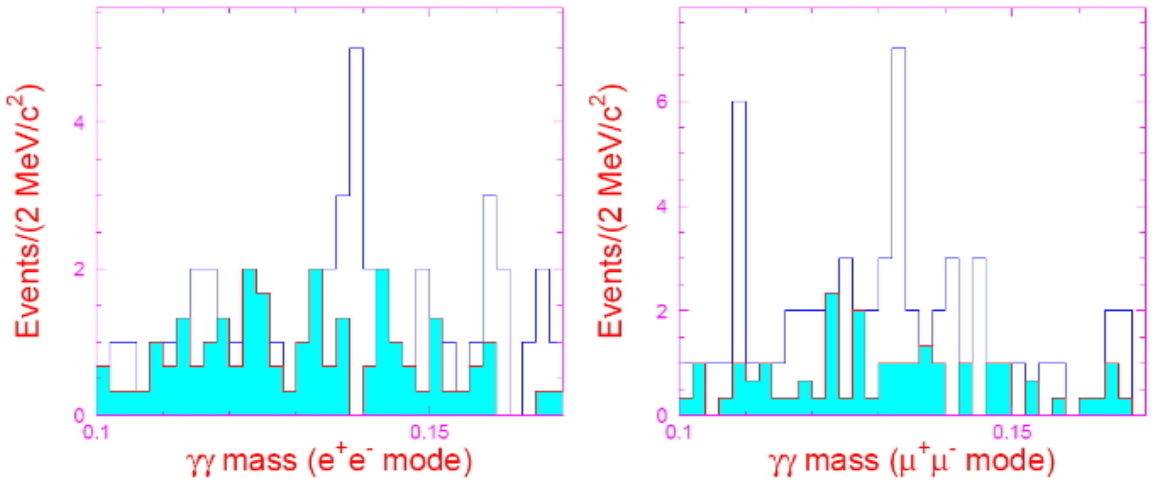
At least one γ pair (both with E>40 MeV) with:
$|M(\gamma\gamma) - M(\pi^0)| < 10$ MeV

Missing Mass recoiling on 4 ch+π^0 consistent with a photon:
$-2<[P(1S) - P(l^+l^-\pi^+\pi^-\pi^0)]^2<2$ GeV^2

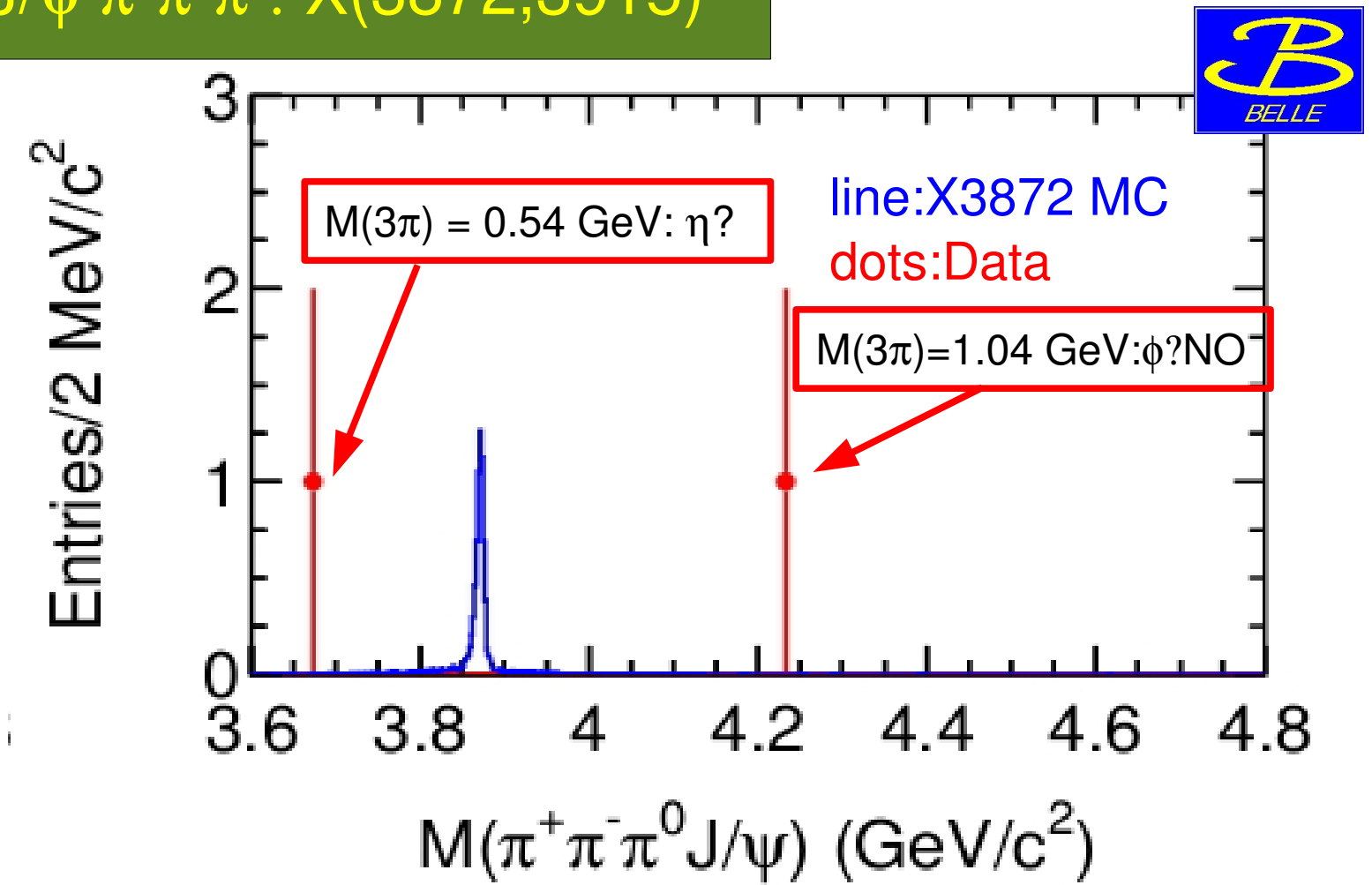
$M(l^+l^-)$



$M(\gamma\gamma)$



$\Upsilon(1s) \to \gamma J/\psi \pi^+\pi^-\pi^0$: X(3872,3915)



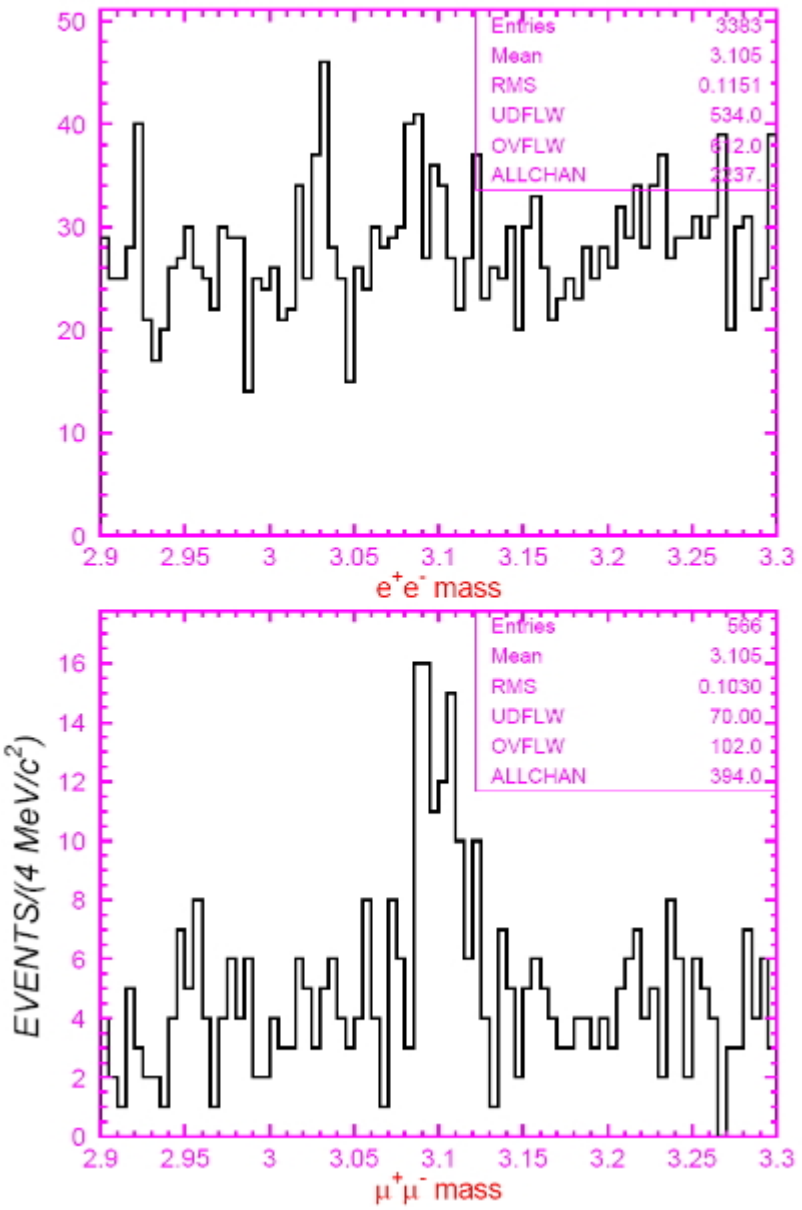
No events at X(3872) with dilepton in J/ψ mass peak

One in ψ' mass region consistent with $\psi' \to \eta\, J/\psi$

BR($\Upsilon(1S) \to \gamma X3872 \to \gamma \pi^0\pi^+\pi^- J/\psi$) < 3.4×10^{-6} , at 90%CL

BR($\Upsilon(1S) \to \gamma X3872$)< 6.8×10^{-5} , if BR($X3872 \to \pi^0\pi^+\pi^- J/\psi$)=5%

$\Upsilon(1s) \to \gamma \chi_c$



Main backgrounds

Radiative Bhabha

χ_c from ISR production of ψ'

Selection criteria

2 leptons of opposite charge

2 photons with E>150 MeV with opening angle > 18° in CM

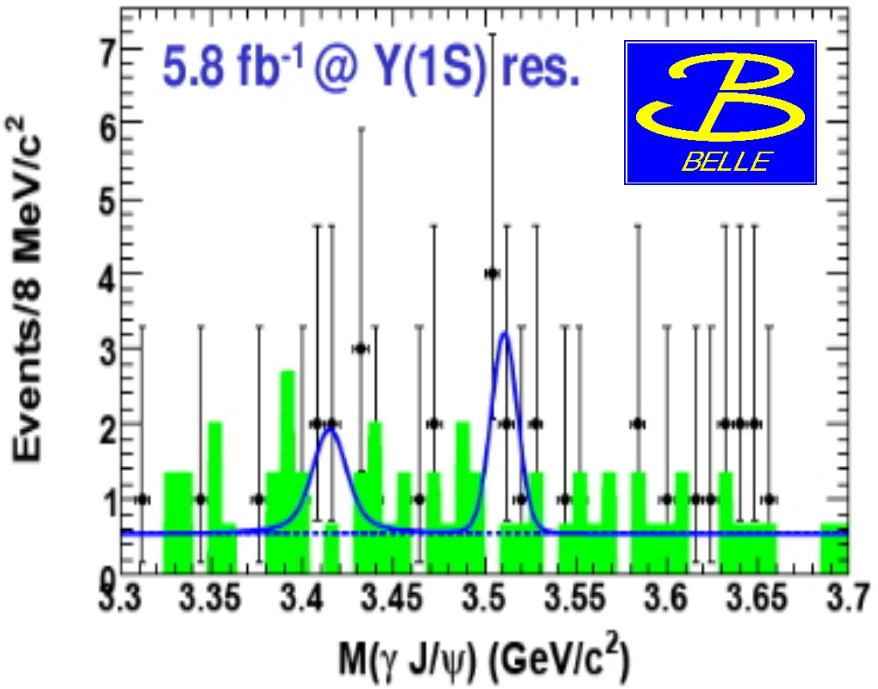
Low energy photons rejected if within a 10° cone w/respect to the leptons

Missing Mass recoiling $J/\psi+\gamma_{Low}$:

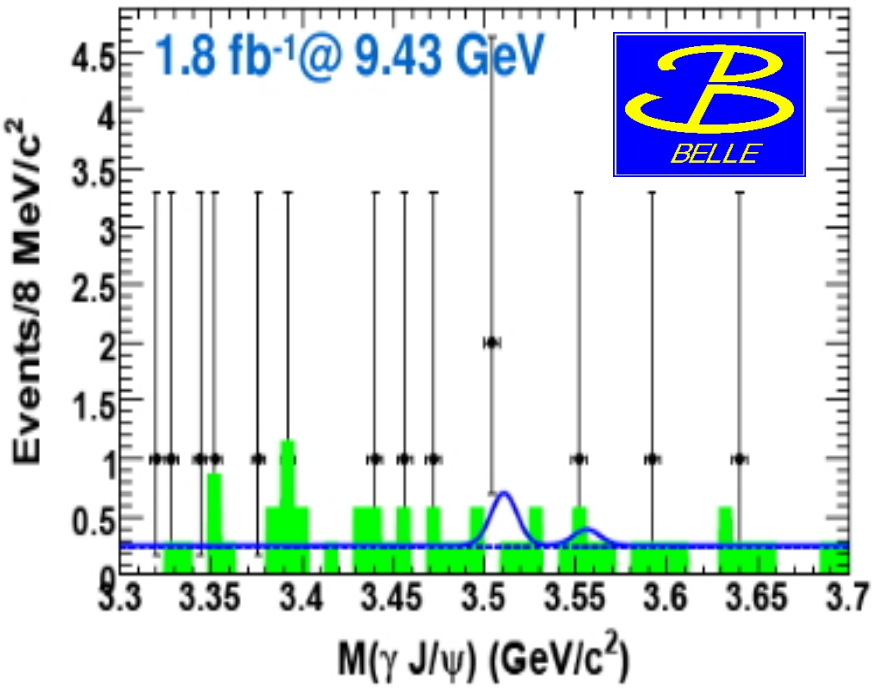
$-0.5<[P(1S) - P(l^+l^-\gamma_{Low})]^2<0.5\ GeV^2$

$\Upsilon(1s) \rightarrow \gamma \chi_c$

ON PEAK



ON CONTINUUM



$BR(\Upsilon(1S) \rightarrow \gamma \chi_{c0}) < 5 \times 10^{-4}$

$BR(\Upsilon(1S) \rightarrow \gamma \chi_{c1}) < 1.5 \times 10^{-5}$

$BR(\Upsilon(1S) \rightarrow \gamma \chi_{c2}) < 1.2 \times 10^{-5}$

$\Upsilon(1s) \to \gamma \eta_c$

$\eta_c \to K_S K^- \pi^+$ +c.c., $K^+K^-\pi^+\pi^-$, $2(K^+K^-)$, $2(\pi^+\pi^-)$, $3(\pi^+\pi^-)$ [BR=6.8%]

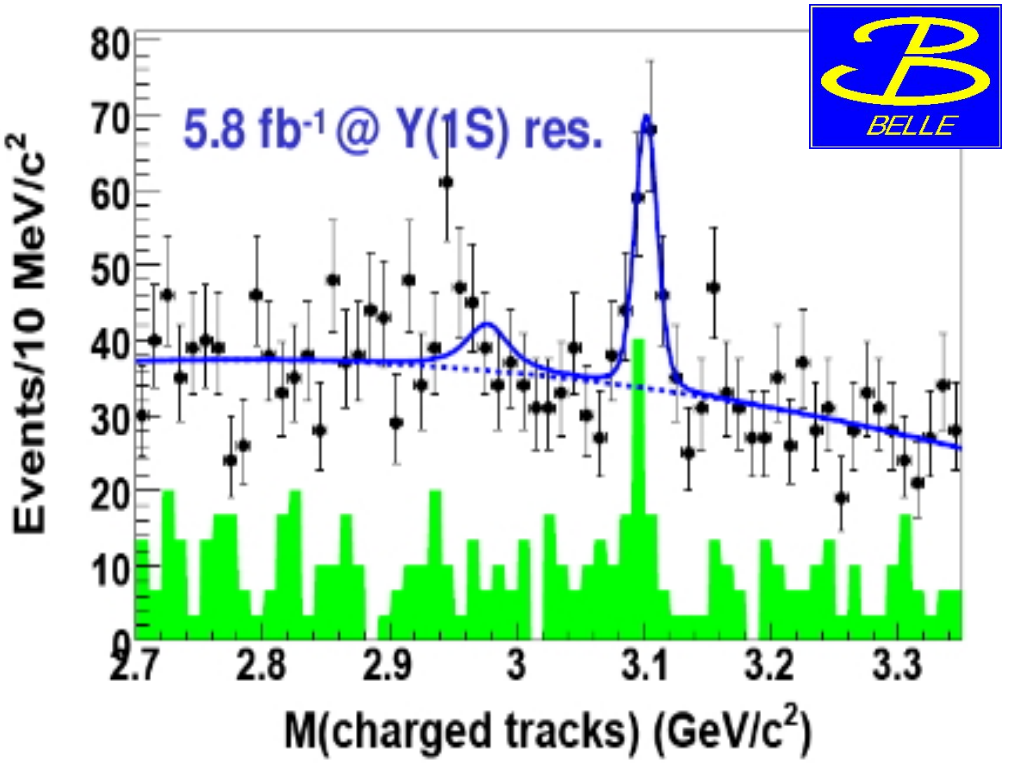
Selection criteria:

4,6 charged prongs, net charge = 0

PID to identify K and π

E_γ>3.5 GeV

Missing Mass recoiling on 4,6 charged tracks consistent with a photon:
$-1 < [P(1S) - P(\text{all chg})]^2 < 1\ \text{GeV}^2$



Peak at 3.1 GeV from ISR produced J/ψ's

BR(Υ (1S) $\to \gamma \eta_c$) < 6.4×10^{-5}

Υ(1s) → γ+charmonium: exp vs theory

BR(Υ(1S) → f)*10^6

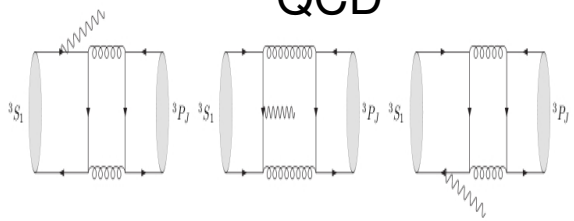
	90%CL UL
$\Upsilon(1S) \to \gamma\chi_{c0}$	500
$\Upsilon(1S) \to \gamma\chi_{c1}$	15
$\Upsilon(1S) \to \gamma\chi_{c2}$	12
$\Upsilon(1S) \to \gamma\eta_c$	64
$\Upsilon(1S) \to \gamma$ X3872 $\to \gamma\, \pi^+\pi^-$ J/ψ	2.2
$\Upsilon(1S) \to \gamma$ X3872 $\to \gamma\, \pi^0\pi^+\pi^-$ J/ψ	3.4
$\Upsilon(1S) \to \gamma$ X3915 $\to \gamma\, \pi^0\pi^+\pi^-$ J/ψ	3.4
$\Upsilon(1S) \to \gamma$ Y4140 $\to \gamma\, \phi$J/ψ	2.6

NRQCD predictions

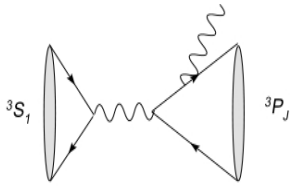
[K. T. Chao et al., hep-ph/0701009]

QCD	QCD+QED
4.0	3.2
4.5	9.8
5.1	5.6
2.9	4.9

QCD



QED



Y(2S)

Y(2S) data taking, scans, lumi

Data taking at 2S in two distinct periods:

December 2008: 46.4 M Y2S events (*) , 6.5 fb^{-1}

$L_{max} = 1.2 \times 10^{34}\ cm^{-2}s^{-1}$

(*) based on $\pi^+\pi^-$ Y(1S) , Y(1S) → $\mu^+\mu^-$

Increasing LER current, beam spread increases

→ lower resonant cross section on peak

November 2009 (preliminary): 124 M Y2S events, 18.2 fb^{-1}

$L_{max} = 1.5 \times 10^{34}\ cm^{-2}s^{-1}$ I_{LER}=1.6A I_{HER}=0.8 A

Continuum data taking at 9.993 GeV: 1.7 fb^{-1}

Y(1,2S) analyses under way

$\Upsilon(2S) \rightarrow \gamma\eta_b$

$\chi_{b0} \rightarrow \gamma\,\Upsilon(1S)$

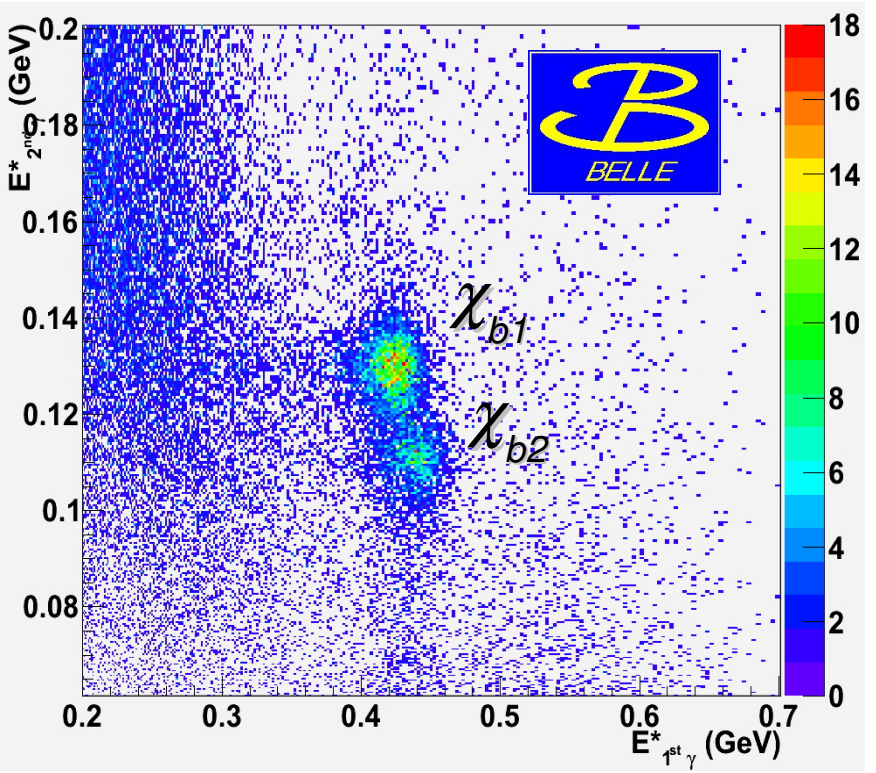
$\Upsilon(2S) \rightarrow \eta\Upsilon(1S)$

$\chi_{bJ} \rightarrow$ double charmonium

$\Upsilon(1S) \rightarrow \gamma\,A_0$

$\Upsilon(1S)$ lepton universality from
$\Upsilon(2S) \rightarrow \pi^+\pi^-\,\Upsilon(1S)$ decays

$\Upsilon(1S) \rightarrow$ inclusive dibaryons



$\Upsilon(2S) \rightarrow \gamma\gamma\,\Upsilon(1S) \rightarrow \gamma\gamma\,\mu^+\mu^-$

Stay tuned! More results will be available soon!