Luminosity Frontier of Two-photon Physics

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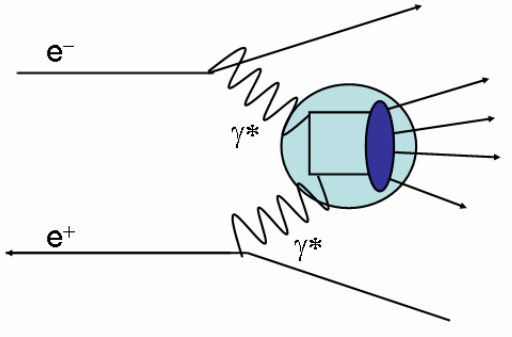
Hadron production in two-photon collisions

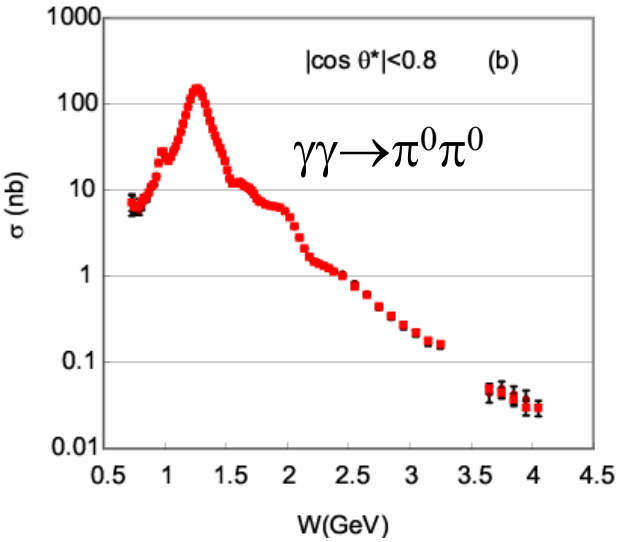
Physics Themes:

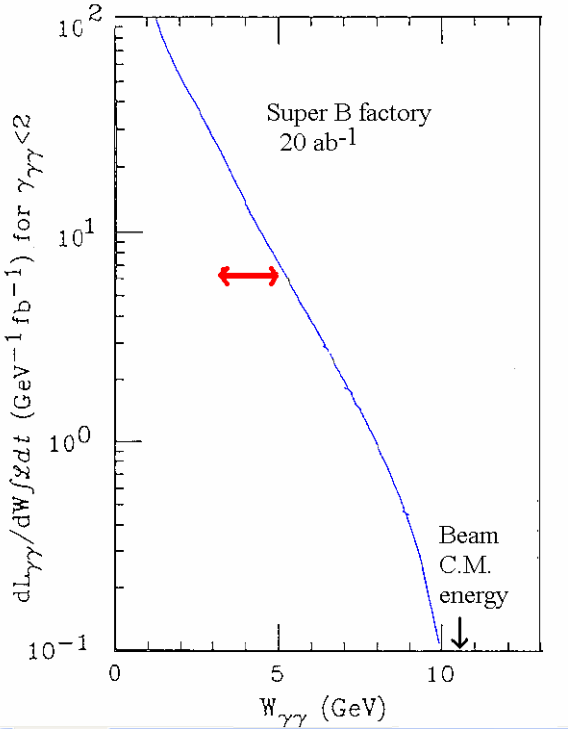
Resonance production and decays

Test of QCD models

Researching features of hadron production







Luminosity Frontier

Low-cross section/small-branching fraction

Charmonia,

Exotic resonances (small but finite $\gamma\gamma$ coupling)

Baryon production in High-Energies

⇔ Light-quark resonances

larger cross sections

and/or larger backgrounds

systematic-error dominant

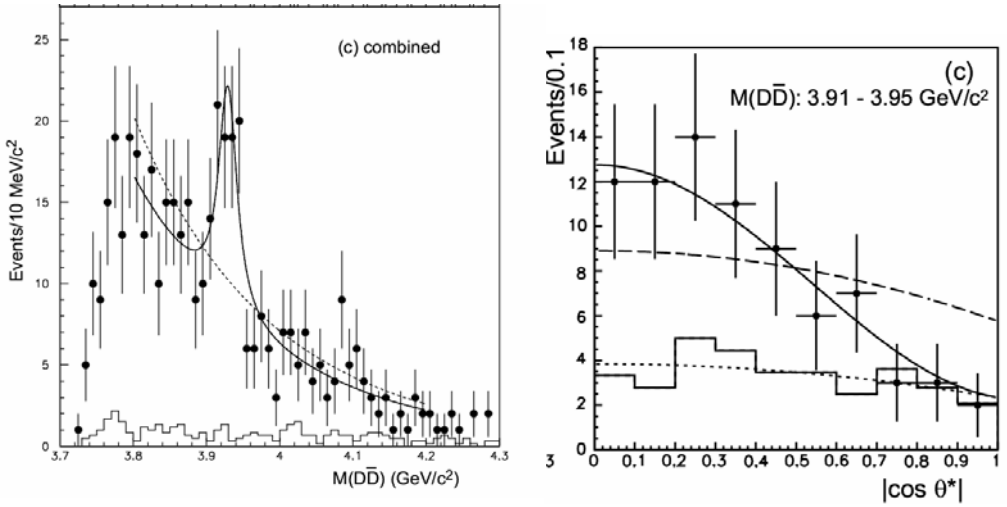
Search for new charmonium or charmonium-like particle

Good field to search for C-even charmonium $\Leftrightarrow$ C-odd only from ISR

Belle Collaboration (S. Uehara et al.). Phys. Rev. Lett. 96 (2006) 082003.

A new resonance found in $\gamma\gamma \to D\bar{D}$

showing a peak at 3.93 GeV **Z(3930)**



The spin is likely to be 2.

Attributed to χ_{c2}(2P) candidate

$\chi_{c2}(2P)$

$I^G(J^{PC}) = 0^+(2^{++})$

OMITTED FROM SUMMARY TABLE

$\chi_{c2}(2P)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
3929±5±2	64	UEHARA	06	BELL	10.6 $e^+e^- \to e^+e^- D\bar{D}$

$\chi_{c2}(2P)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
29±10±2	64	UEHARA	06	BELL	10.6 $e^+e^- \to e^+e^- D\bar{D}$

$\chi_{c2}(2P)$ PARTIAL WIDTHS

$\chi_{c2}(2P)$ $\Gamma(\gamma\gamma)\Gamma(i)/\Gamma(\text{total})$

$\Gamma(\gamma\gamma) \times \Gamma(D\bar{D})/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_2/\Gamma$

VALUE (keV)	EVTS	DOCUMENT ID		TECN	COMMENT
0.18±0.05±0.03	64	[1] UEHARA	06	BELL	10.6 $e^+e^- \to e^+e^- D\bar{D}$

[1] Assuming $B(D^+D^-) = 0.89\ B(D^0\bar{D}^0)$.

$\chi_{c2}(2P)$ BRANCHING RATIOS

$\Gamma(D^+D^-)/\Gamma(D^0\bar{D}^0)$ Γ_3/Γ_4

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.74±0.43±0.16	64	UEHARA	06	BELL	10.6 $e^+e^- \to e^+e^- D\bar{D}$

Search of Exotic charmonium-like particle

- Searching for formation and decay to
  a charmonium + light meson(s)

  (with C-even combination in total)

  $J/\psi\omega$, $J/\psi\pi^+\pi^-$, $\eta_c\pi^0$, $\eta_c\eta$ etc.
  (I=1) (I=1)

  of course,
  $D\bar{D}$, $D\bar{D}^*$
  (but detection of the slow-pion is generally inefficient)

Mass production of η_c, $\eta_c(2S)$

- $\sim 10^8$ η_c and $\sim 10^7$ $\eta_c(2S)$ are produced from 10 ab^{-1} e+e- collisions at Super-B factory.

  BF and efficiency have to be multiplied,

  Still a big source of these particles.

Study of various decay branches

Measure ratios $\Gamma(2S \rightarrow \text{some}) / \Gamma(1S \rightarrow \text{the same})$

Similar study is possible at Charm factory on the J/ψ energy

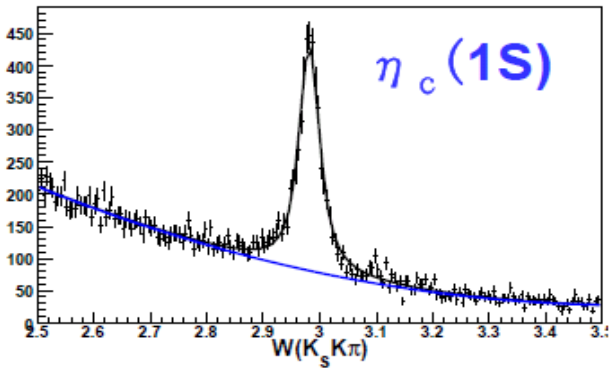
Systematics are different due to a small mass difference, J/ψ – η_c

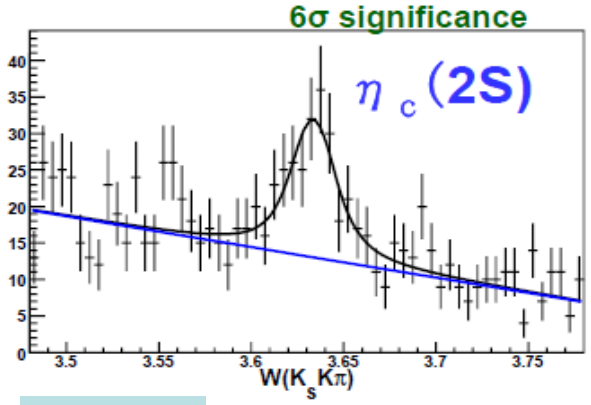
Comparison of interference effects among different processes

As for χ_{c0} and χ_{c2}, measurements of decays by two-photon production has no prominent predominance over charm-factory measurements.

（Although still useful for confirmation, systematics, interference effects)

η_c and $\eta_c(2S)$ from two-photon collisions at present KEKB/Belle

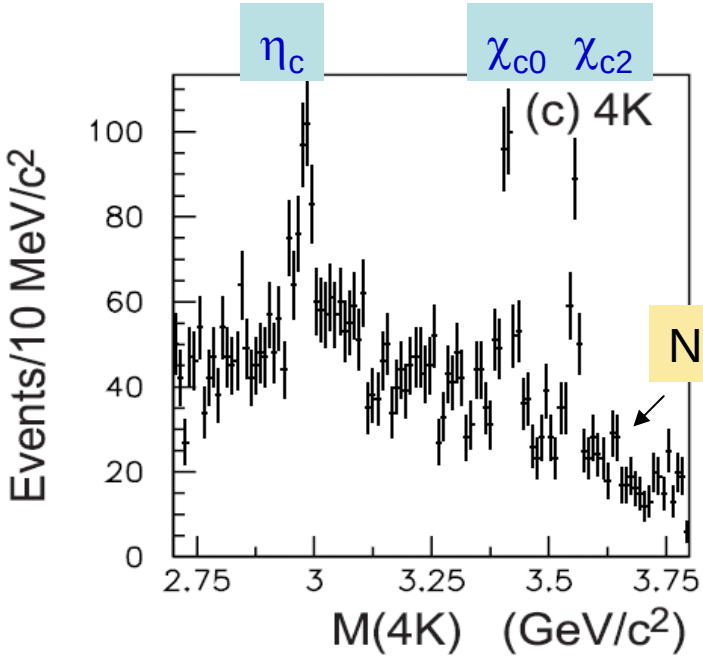




$K^0_S K\pi$ mode

0.483 ab^{-1}

20070709 Photon2007



$K^+K^-K^+K^-$ mode

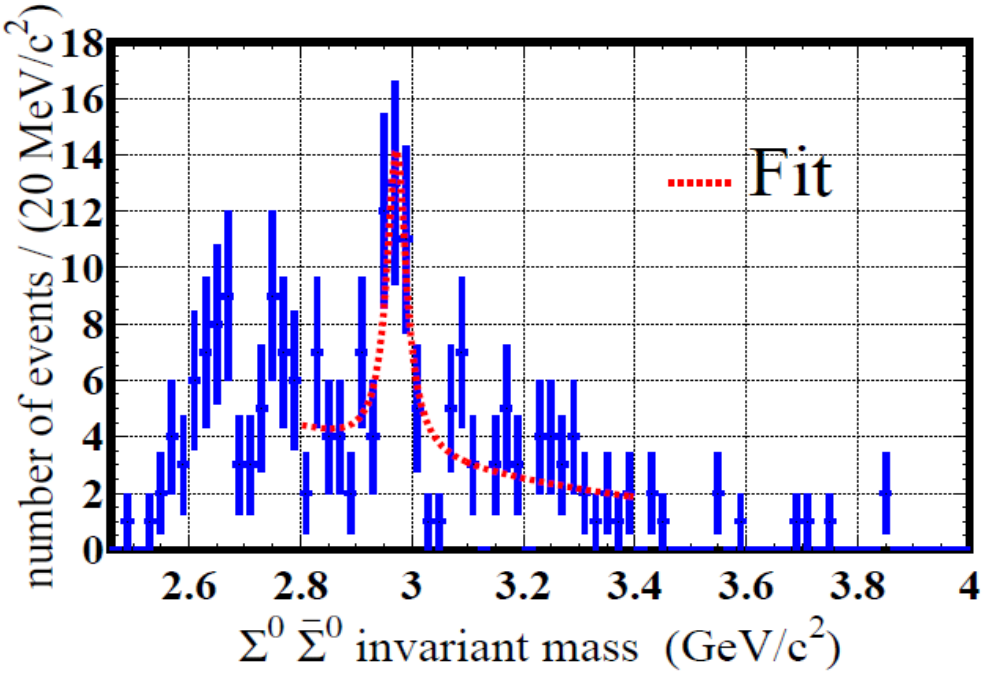
0.395 ab^{-1}

No significant $\eta_c(2S)$

Baryon-pair production in high energies

Small cross sections

$\gamma\gamma \rightarrow \Sigma^0\bar{\Sigma}^0$ from 0.464 ab^{-1}



Comparison with QCD models is possible.

Luminosity Limited

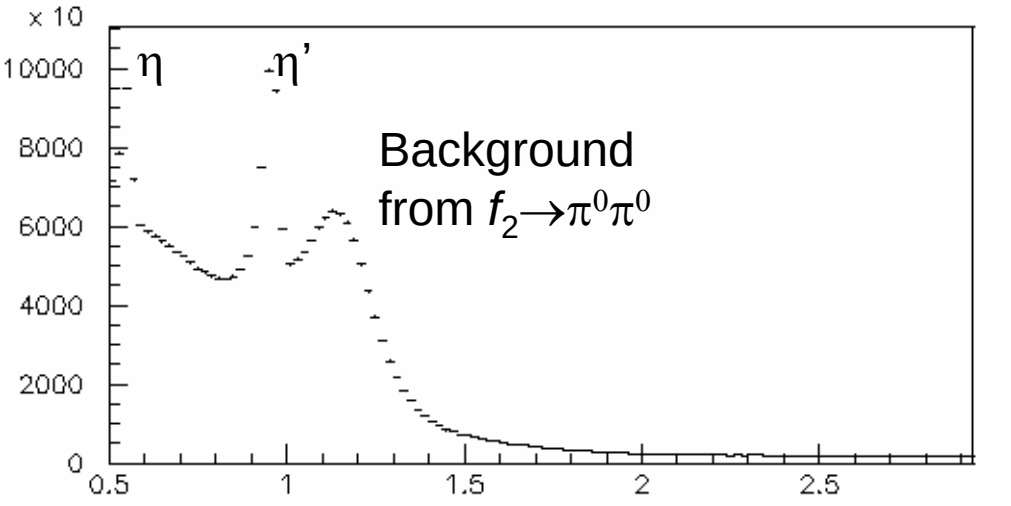
Other measurements

The elastic scattering, $\gamma\gamma \rightarrow \gamma\gamma$

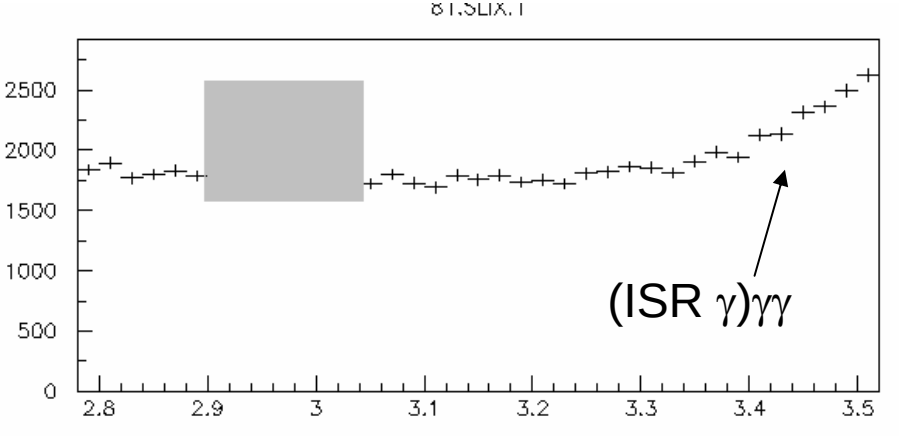
Loop effect from all the charged particles

Interference with the double-radiation process $ee \rightarrow ee\gamma\gamma$

Unseparatable background from $\gamma\gamma\gamma\gamma$



W($\gamma\gamma$) (GeV)



W($\gamma\gamma$) (GeV)

Resonances: So far only η and η' are seen.

If η_c seen, a self determination of $\Gamma\gamma\gamma$ is possible

Single-tag measurements

Determination of cross section of $\gamma^*\gamma$ scatterings

-- Formation of $J^{PC}=1^{++}$ meson resonances

-- Exotic searches of spin-1

-- Hadron form factors

-- Photon structures

$$Q^2 = 4EE'\sin^2(\theta/2)$$

Q^2 (the virtuality of a photon) determination

the tagging system

good energy resolution is necessary at

Forward or backward calorimeter (may difficult geometrically)

Use kinematics of the single-tag from the exclusive detection

φ correlation, $E' = p_t/\sin\theta$, $Mx^2=0$

Tracking only is still helpful (necessary for background rejection)

Even with ECL, we can do a good job ($Q^2>1.5GeV^2$) .

Summary

- Searches for New charmonium and exotic “hidden-charm”
- η_c factory
- Baryon production, $\gamma\gamma$ elastic scattering
- Single-tag --- forward detector and/or ECL