Search for η_b in two-photon collisions with L3 Detector at LEP

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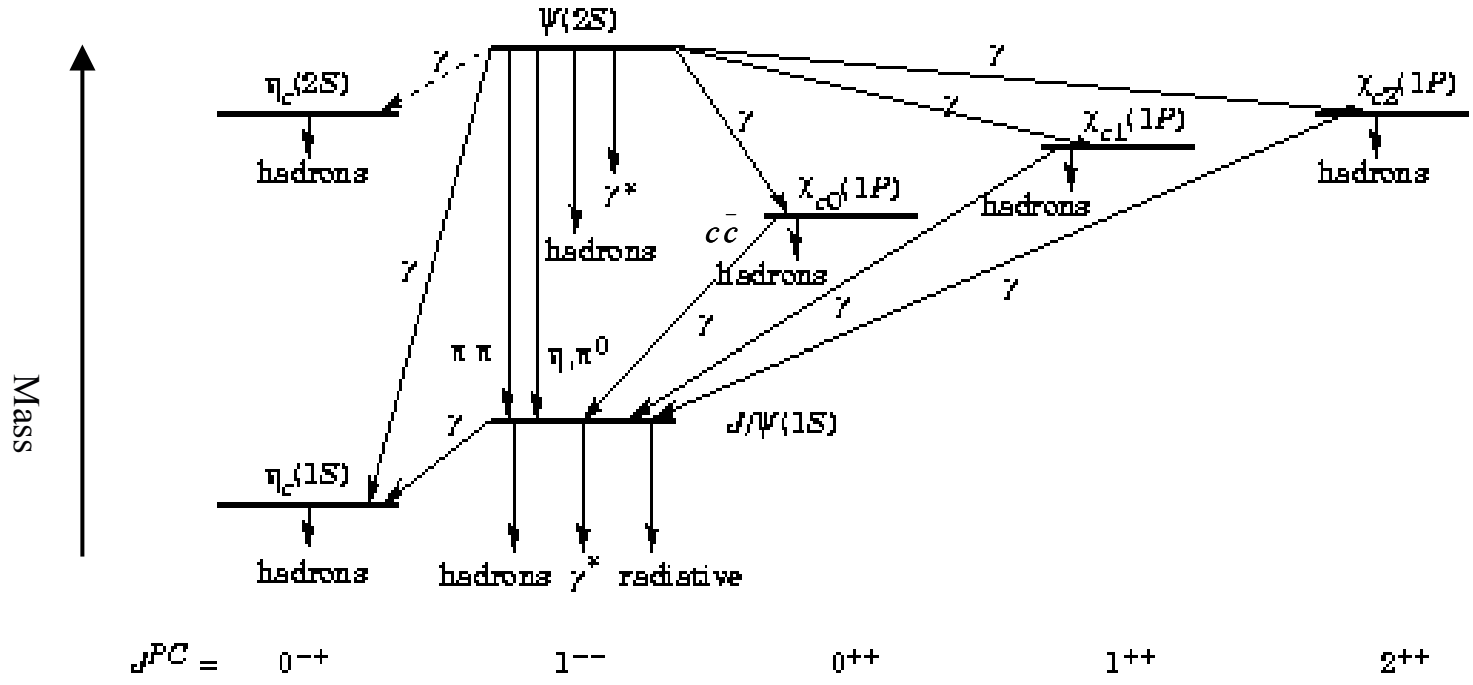
On behalf of L3 Collaboration

The Charmonium System

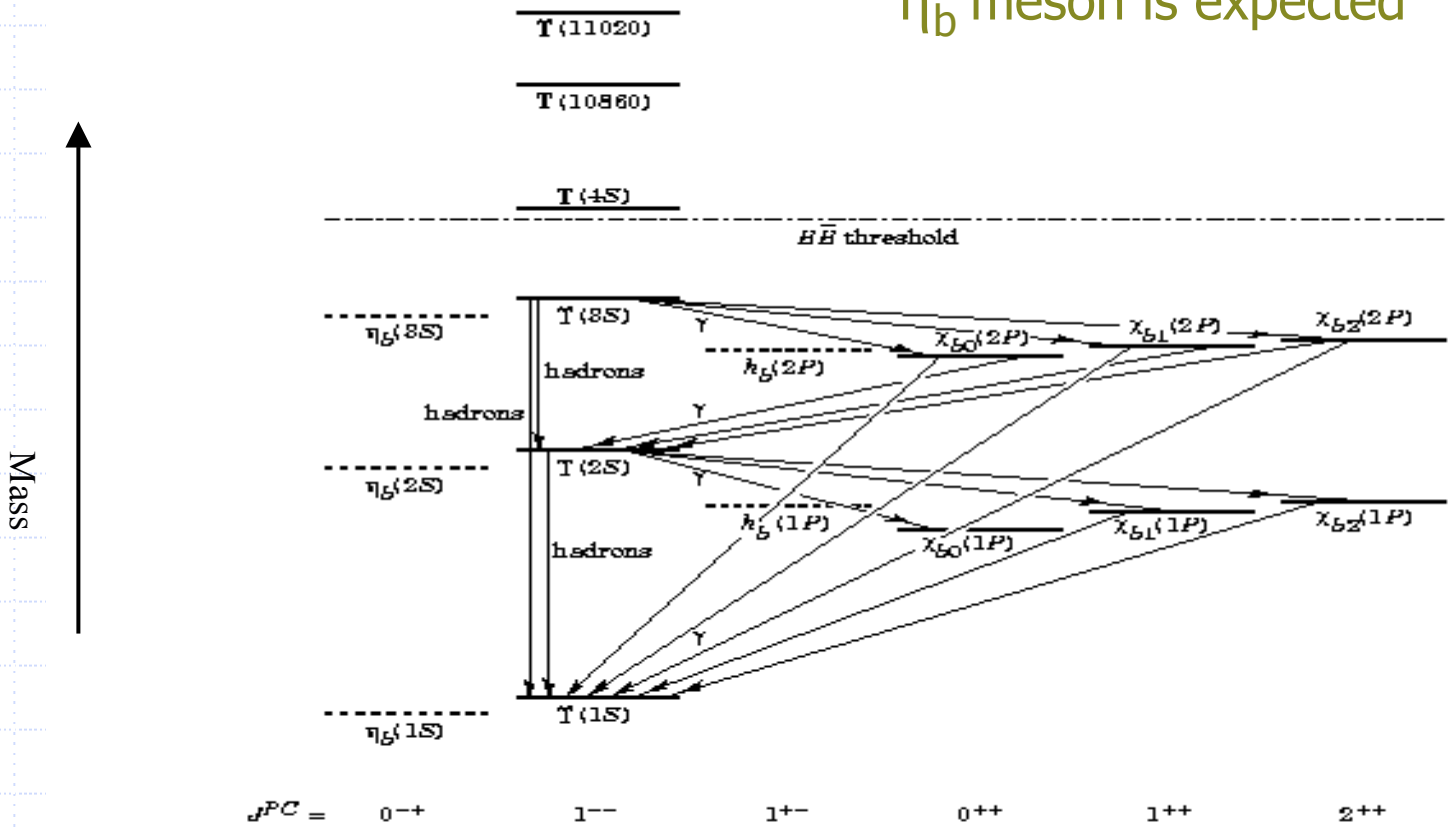
$c\bar{c}$



The Bottomonium System

---- Uncertain states
Based on charmonium system
η_b meson is expected

$b\bar{b}$



η_b $(b\bar{b})$ 1S state, J^{PC} 0^{-+} not yet seen

- Mass should be close to Υ (1S) mass (9.46 GeV)

hypothesis	$m(\eta_b)$ (GeV)	
QCD calculations		
Lattice NRQCD	9.38	A.El-Khadra hep-ph/9508266
Lattice potential	9.37	G.S. Bali et al. Phys Rev D56 (97)
1/m expansion	9.40	S.Narison, Phys Lett B387 (96)
Potential model	9.36	T. Barnes hep-hp/0103142
pQCD	9.41	N.Brambilla et al. Phys Lett B513

Experimental expectations

- High statistics of $\gamma\gamma$ collisions at LEP II

  In L3 : $\mathcal{L}_{e+e-}$ = 610 pb^{-1} , 189 GeV < $\sqrt{s}$ < 209 GeV

- $$\sigma_{e^+e^- \to e^+e^- R} = f(m_R, \Gamma_{\gamma\gamma}(R)) = \kappa \cdot \Gamma_{\gamma\gamma}$$

QCD Potential model → $\Gamma_{\gamma\gamma}(\eta_b) \sim 0.5$ keV
(predictions for η_c compatible with the measurements)

$\sigma(e^+e^- \to e^+e^-\eta_b)$ = 0.26 pb at $\langle\sqrt{s}\rangle$ = 197 GeV

η_b decays:
BR(4 charged particles) ~ 3% → 5 expected events (eff = 100%)

A.Böhrer, Search for the η_b meson, PHOTON 2001

Previous searches

- In radiative decay of the $\Upsilon(3S) \rightarrow \gamma\, \eta_b$ (CUSB & CLEO)
  - CLEO(1994)

    BR($\Upsilon(3S) \rightarrow \pi\pi\, h_b$) x BR($h_b \rightarrow \gamma\, \eta_b$) < 0.1% at 90% C.L.
    for η_b mass range from 9.32 GeV to 9.46 GeV
    Phys. Rev. D49(1994) 40

- In two-photon collisions
  - ALEPH(2002)
    - $\Gamma_{\gamma\gamma}(\eta_b)$ x BR(4 charged part) < 48 eV at 95% C.L.
      0 events found (background: 0.30±0.25)
    - $\Gamma_{\gamma\gamma}(\eta_b)$ x BR(6 charged part) < 132 eV at 95% C.L.
      1 candidate m=9.30±0.04 GeV (background: 0.70±0.34)

    Phys. Lett. B530 (2002)

Selection

Studied decays

4 charged particles and 4 charged particles + π^o

6 charged particles and 6 charged particles + π^o

Charged particles are π and/or K

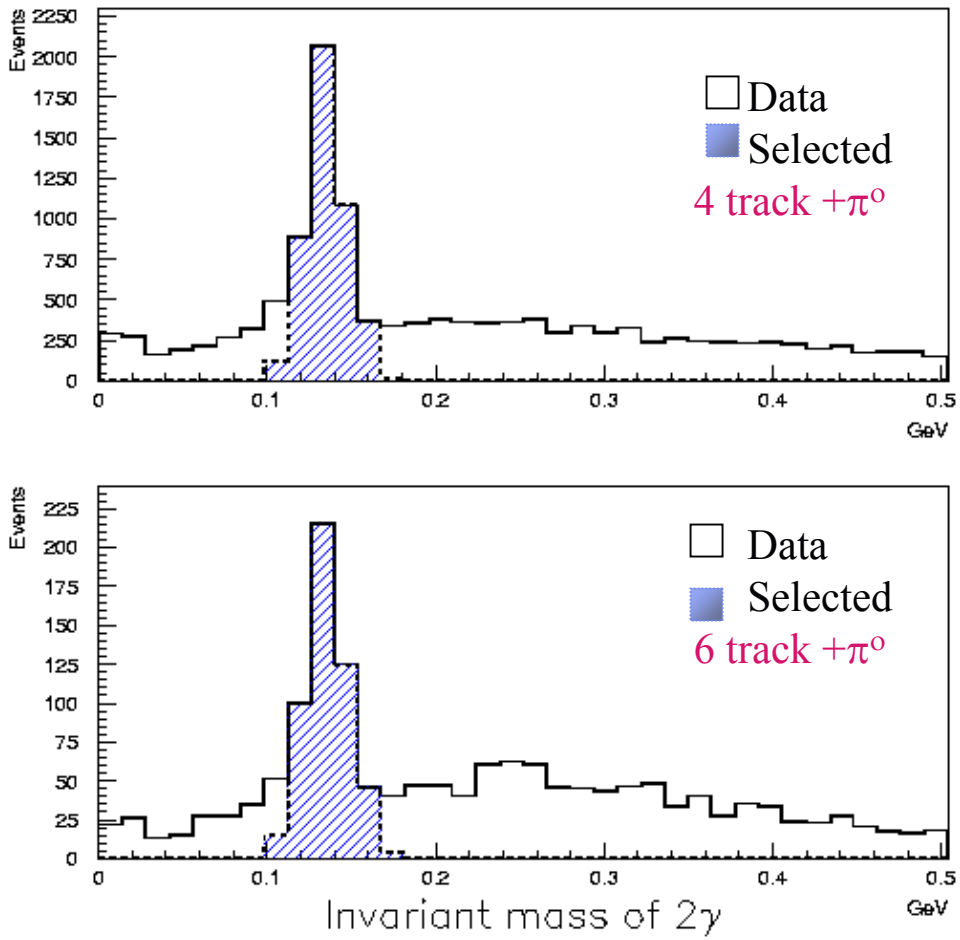
I. Preselection: to define good tracks with p_T>150 MeV and e.m. cluster compatible with photons from π^o (E_γ> 80 MeV)

II. Selection: $\gamma\gamma \rightarrow R \rightarrow$ n charged particles

- n tracks (no other accidental tracks must be present)
- $\Sigma\, p_T^2 < 0.1$ GeV^2
- Reject: photon conversions, cut: $m(e^+e^-)$>50 MeV

  $\gamma\gamma \rightarrow \tau^+\tau^-$, cut: $m(3\pi) > 1.9$ GeV

- 2 bumps from π^o (mass($\gamma\gamma$) $= \pi^o$ mass (105-165 MeV))

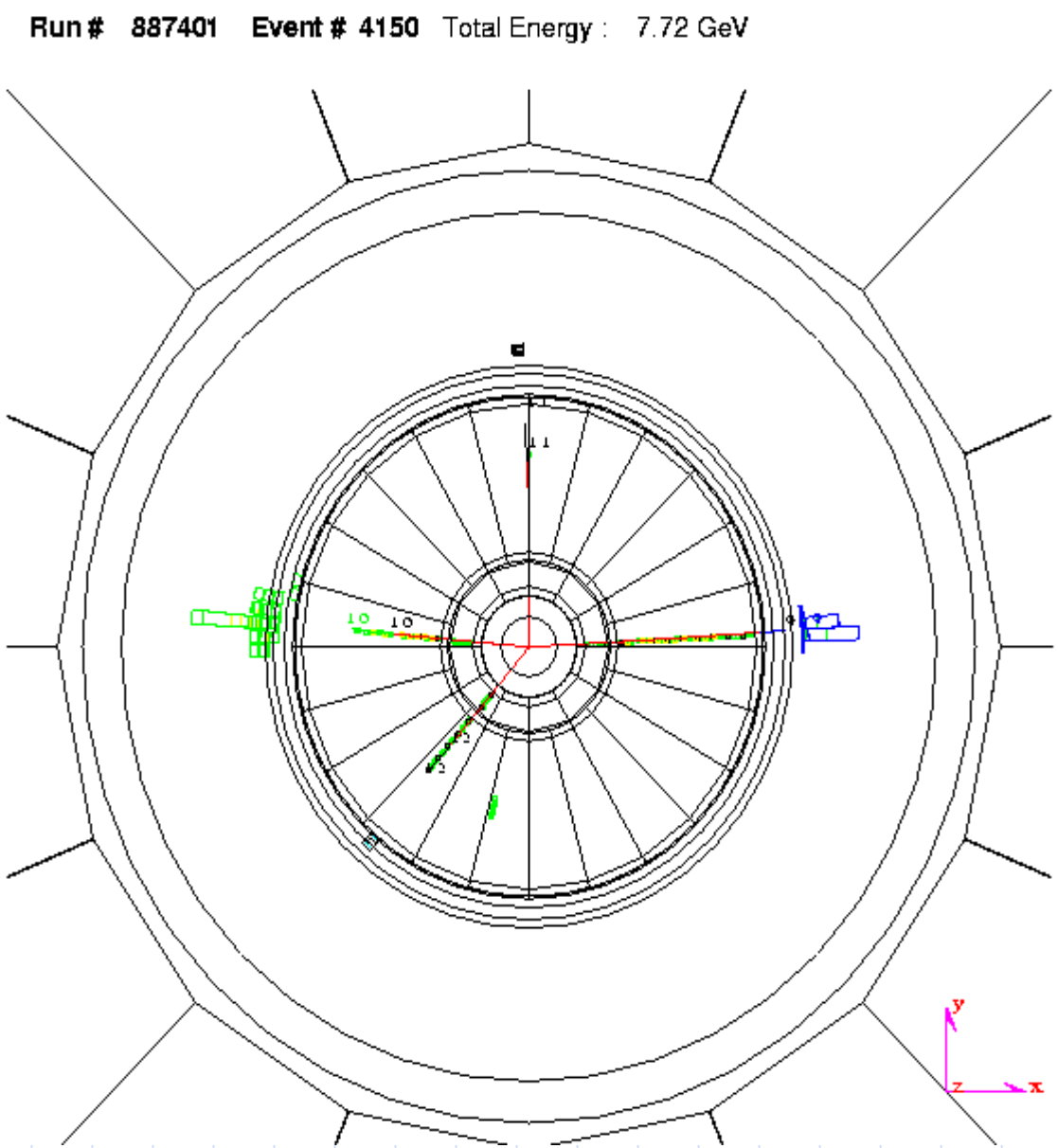


Results

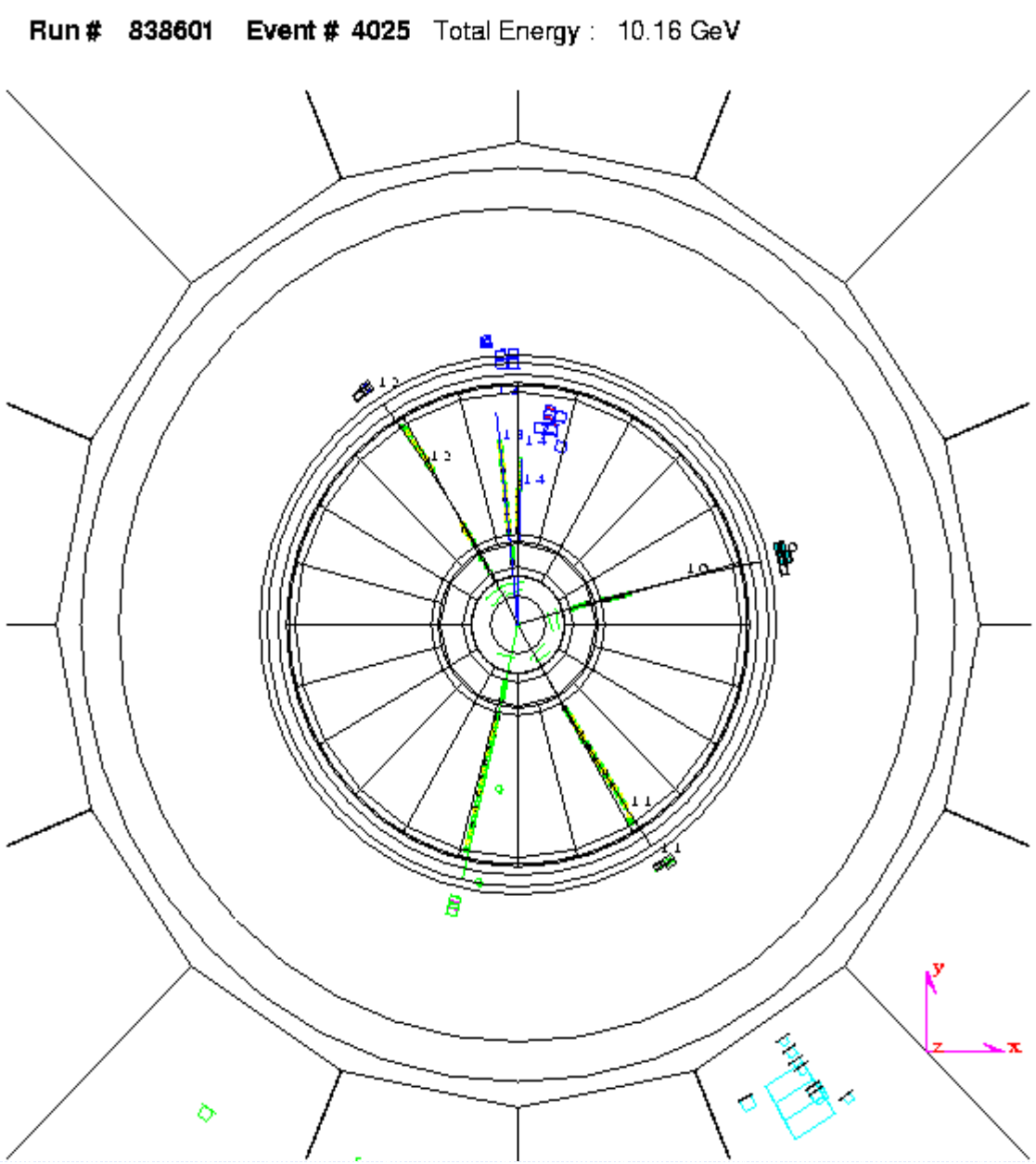
$W_{\gamma\gamma}$ between 9 —10 GeV

Channel	Selected Events	Eff(%)	Expected Background	Reconstructed Mass (GeV)
4 tracks	1	4.9	0.25±0.06	9.9±0.3
4 tracks +π^o	0	1.9	0.09±0.01	
6 tracks	1	3.6	0.65±0.06	9.4±0.3
6 tracks +π^o	1	0.9	0.29±0.07	9.9±0.3

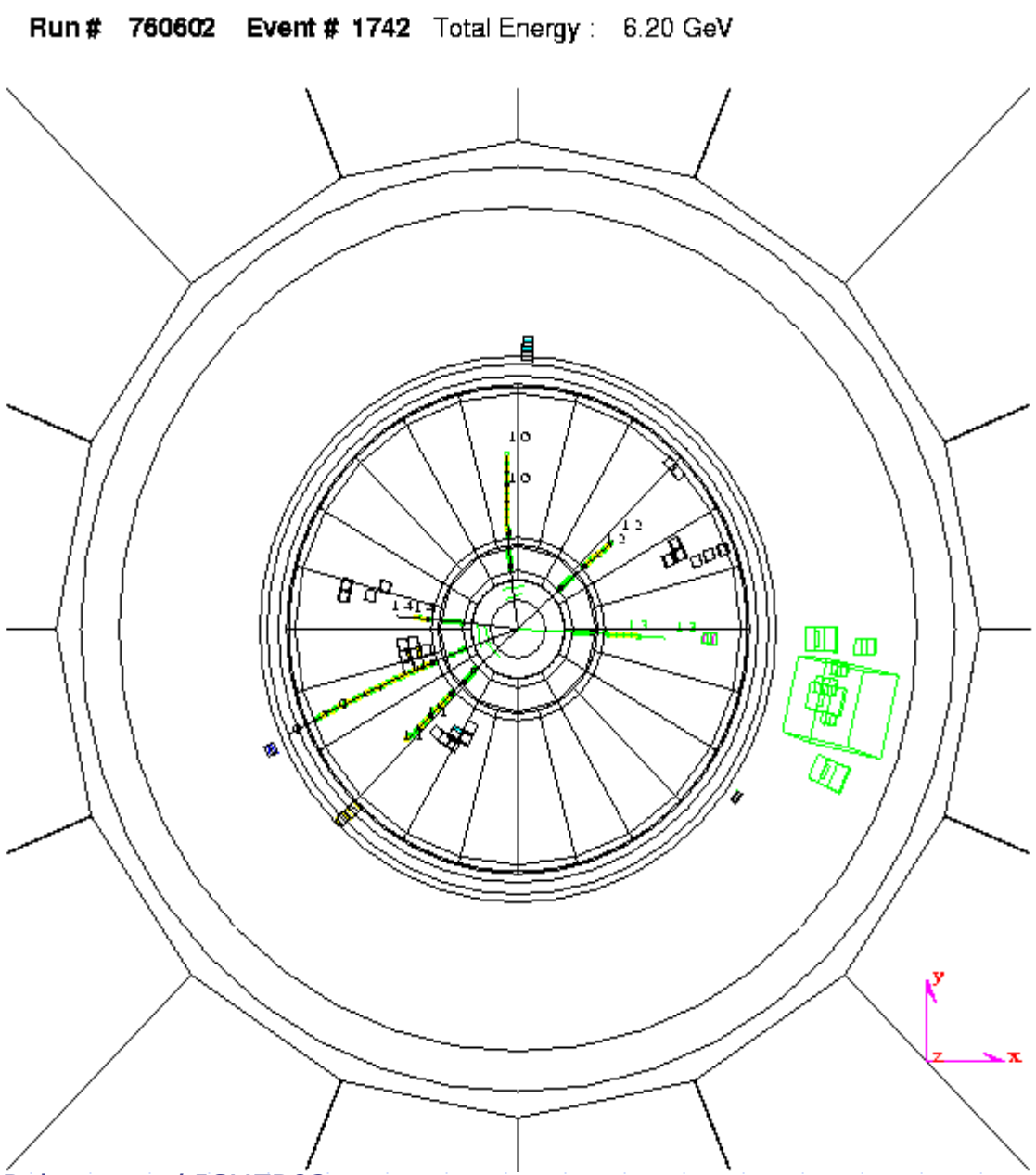
4 charged particles



6 charged particles

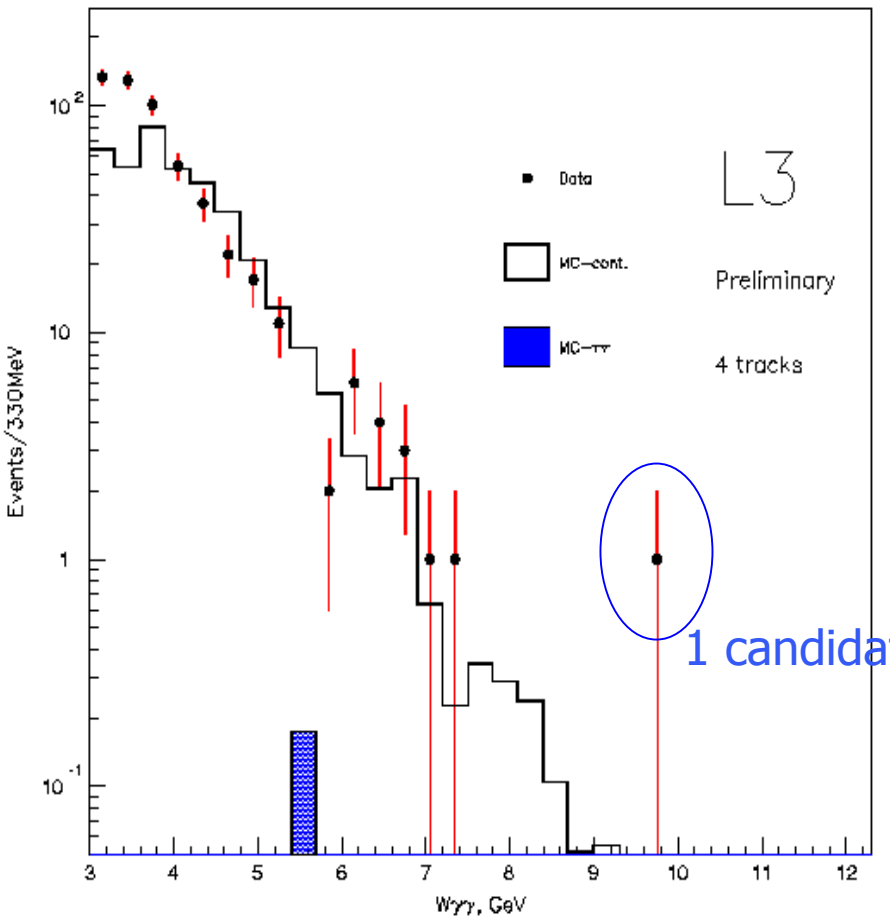


6 charged particles + π^o



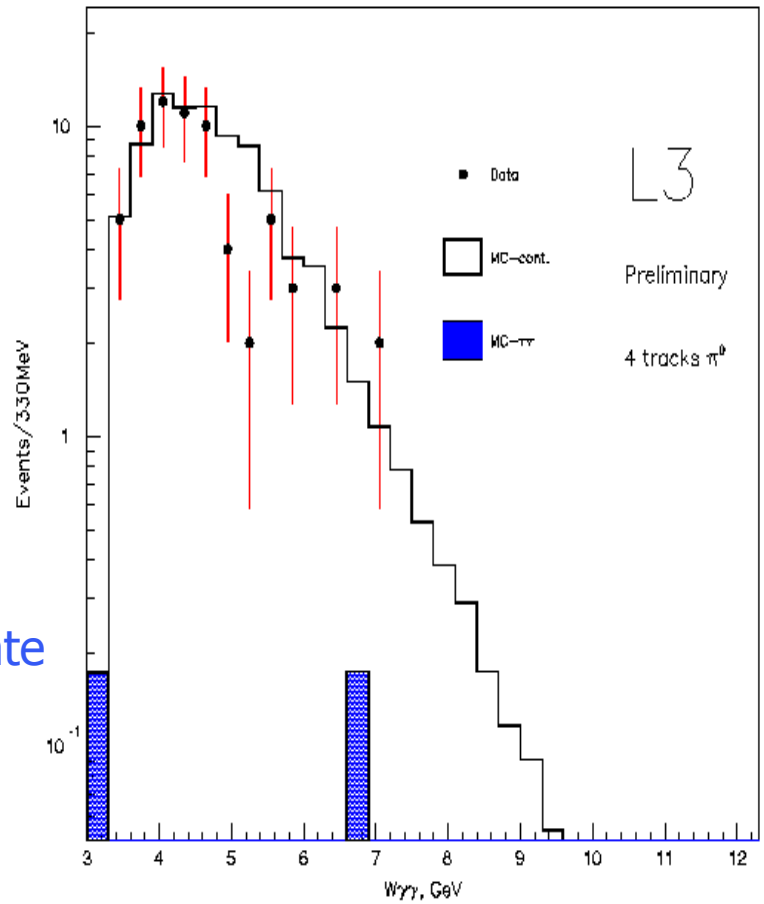
Invariant mass distribution

4 charged particles



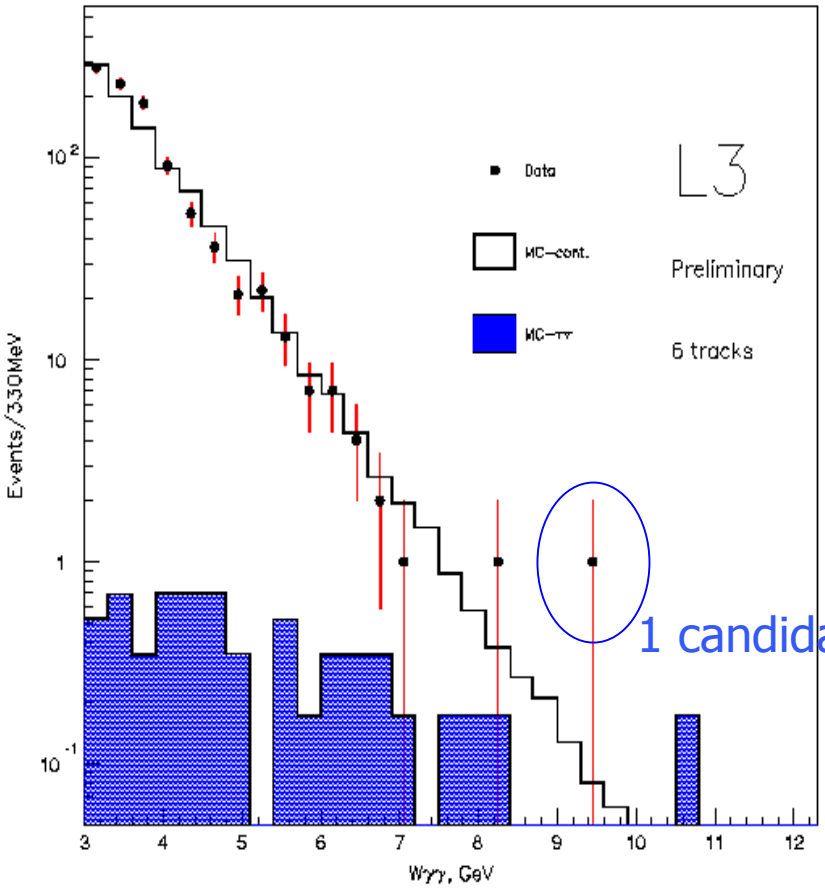
1 candidate

4 charged particles + π^0



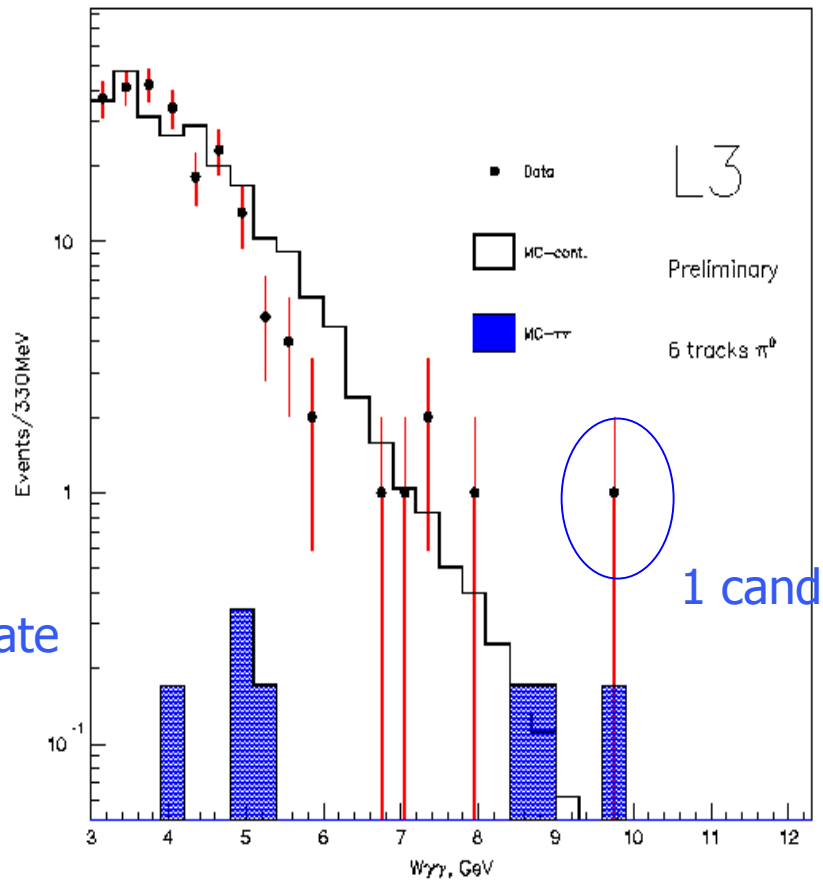
Invariant mass distribution

6 charged particles



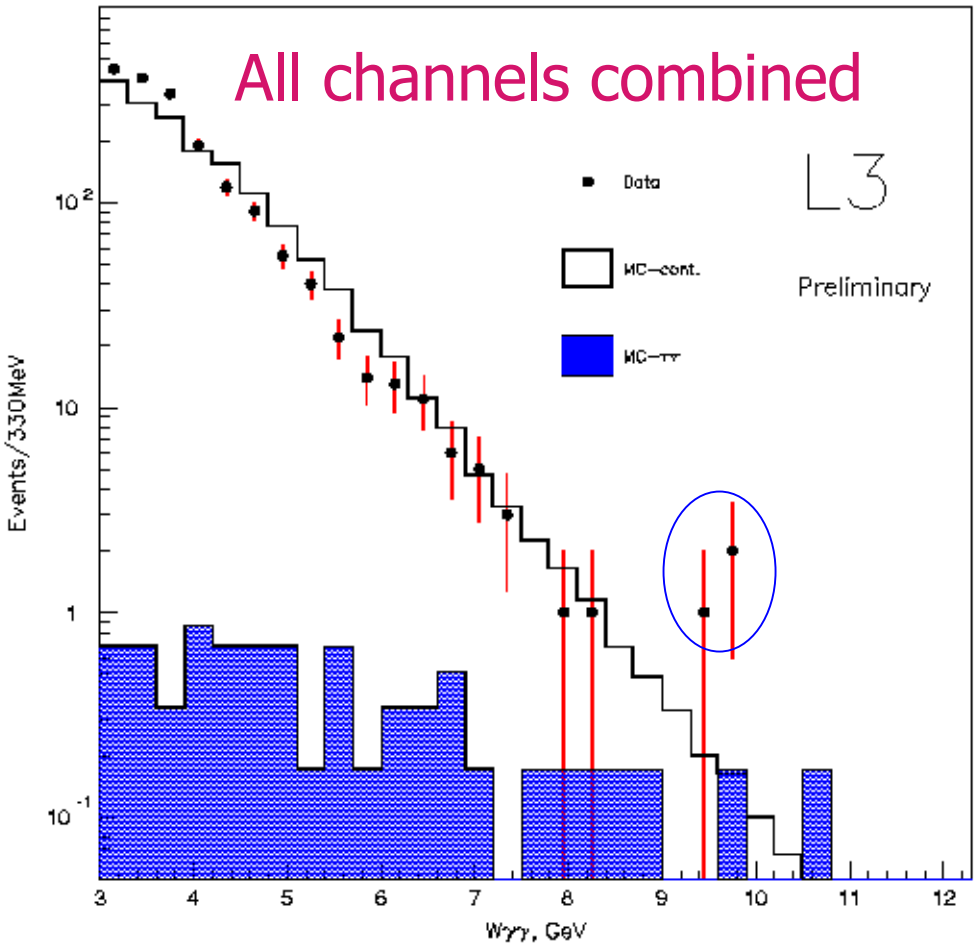
1 candidate

6 charged particles + π^0



1 candidate

Invariant mass distribution



Invariant mass of the candidates

Average reconstructed mass of the most significant candidates:

$$M = 9.7 \pm 0.3 \text{ GeV } *$$

* Mass resolution due to detector effects ~ 300 MeV
  π/K misidentification ~ 50 MeV

Possible Interpretations

- The observation is found to be compatible with the background expectation (expectation 1.3)
- If we assume the production of η_b resonance in the invariant mass range 9-10 GeV:

Upper limits on $\Gamma_{\gamma\gamma}(\eta_b)$xBR:

$\Gamma_{\gamma\gamma}(\eta_b)$ x BR(4 charged part.) < 0.3 keV

$\Gamma_{\gamma\gamma}(\eta_b)$ x BR(4 charged part. + π^o) < 0.5 keV

$\Gamma_{\gamma\gamma}(\eta_b)$ x BR(6 charged part.) < 0.4 keV

$\Gamma_{\gamma\gamma}(\eta_b)$ x BR(6 charged part. + π^o) < 1.4 keV

At 95% of C.L

Assuming the same BR for each channel:

$\Gamma_{\gamma\gamma}(\eta_b)$ x BR(all channels) < 0.2 keV at 95% of C.L.

Conclusions

- We find 3 candidates in the $W_{\gamma\gamma}$ range 9-10 GeV
- They are compatible with background (1.3 events)

  The observation is also compatible with a signal.
- The analysis will be slightly improved to increase the sensitivity