

Search for η_b in $\gamma\gamma$ collisions with the DELPHI detector

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OUTLINE

- Theoretical description of η_b
- Data selection and analysis
- Conclusion

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η_b – theoretical description

$$\begin{aligned}\eta_b(1s) & J^{PC}(0^{-+}) \\ \Upsilon(1s) & J^{PC}(1^{--})\end{aligned}$$

η_b is the ground state of bottonium

$$\begin{aligned}m_{\eta_b} &< m_{\Upsilon}(9.46 \text{ GeV}) \\ \Delta m(\Upsilon, \eta_b) &\simeq 10 \div 130 \text{ MeV}\end{aligned}$$

$$m_{\eta_b} \simeq 9.33 \div 9.45 \text{ GeV}$$

η_b production

$$\sigma(\gamma\gamma \rightarrow \eta_b) = 8\pi \cdot F^2(q_1^2, q_2^2) \cdot \frac{\Gamma_{\gamma\gamma}(\eta_b) \cdot \Gamma_{tot}(\eta_b)}{(W^2 - M_{\eta_b}^2)^2 + M_{\eta_b}^2 \Gamma_{tot}^2(\eta_b)}$$

$$\begin{aligned}m_{\eta_b} &= 9.4 \text{ GeV}, \\ \Gamma_{tot}(\eta_b) &\simeq \Gamma_{tot}(\eta_c) \simeq 16.0 \text{ MeV}, \\ \Gamma_{\gamma\gamma}(\eta_b) &\simeq .4 \div .5 \text{ keV}\end{aligned}$$

$$\sigma(\gamma\gamma \rightarrow \eta_b) |_{\sqrt{s_{ee}}=200\text{GeV}} \simeq (.21 \div .27) \text{ pb}$$

$$\mathcal{L} = 700 \text{ pb}^{-1}, \quad N(\eta_b) \simeq (150 \div 187) \text{ events}$$

$$\begin{aligned}BR(\eta_b \rightarrow 4\pi^{\pm}(\text{K}^{\pm})) &\simeq 2\%, \\ BR(\eta_b \rightarrow 6\pi^{\pm}(\text{K}^{\pm})) &\simeq 2\%, \\ BR(\eta_b \rightarrow 8\pi^{\pm}(\text{K}^{\pm})) &\simeq 2.2\%.\end{aligned}$$

Search for η_b

$$e^+e^- \rightarrow e^+e^-\gamma^*\gamma^* \rightarrow e^+e^-\eta_b,$$

$\eta_b \rightarrow 4$ charged particles,

$\eta_b \rightarrow 6$ charged particles,

$\eta_b \rightarrow 8$ charged particles.

	Year	\sqrt{s} , GeV	\mathcal{L} , pb ⁻¹
LEP II	1996	161	10.2
		172	10.2
	1997	183	56.1
	1998	189	157.6
	1999	192	29.9
		196	76.4
		200	87.4
	2000	202	43.6
		207	158.6
Σ LEP II		195.7	630.

Data selection

TRACK SELECTION

Charged tracks

- $p > 150 \text{ MeV}/c$
- Impact parameters $\Delta_{xy} < .5 \text{ cm}$
 $\Delta_z < 2 \text{ cm}$
- $10^\circ < \theta < 170^\circ$
- track length $> 30 \text{ cm}$
- $\Delta p/p < 30\%$

Neutral tracks

- γ el.mag. shower with $E > 1. \text{ GeV}$ or
converted γ with $E > .2 \text{ GeV}$

Event selection

- TPC and RICH have a good quality operation ($\mathcal{L} = 630 \text{ pb}^{-1}$)
- Number of charged tracks – 4, 6 or 8 $\pi^\pm(\text{K}^\pm)$
- $\sum Q_i = 0$
- no muons (\geq standard cut)
- no electrons (\geq standard cut)
- no protons
- no gammas
- $(\sum \vec{p}_i)^2 < 0.08 \text{ GeV}^2$

π , K , p are identified by the **MACRIB** package
(It is based on neural networks and combines the benefits of both **RICH** algorithms and **dE/dx** information)

Background calculation

$\gamma\gamma \rightarrow q\bar{q}$ events PYTHIA 6.147
 $\mathcal{L} \sim 1800 \text{ pb}^{-1}$

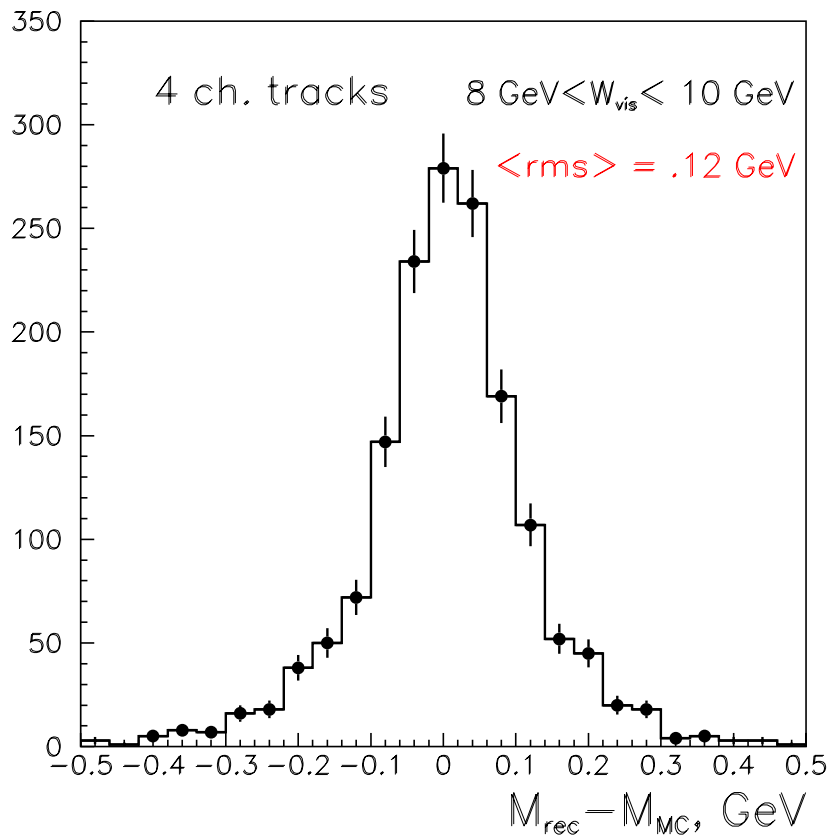
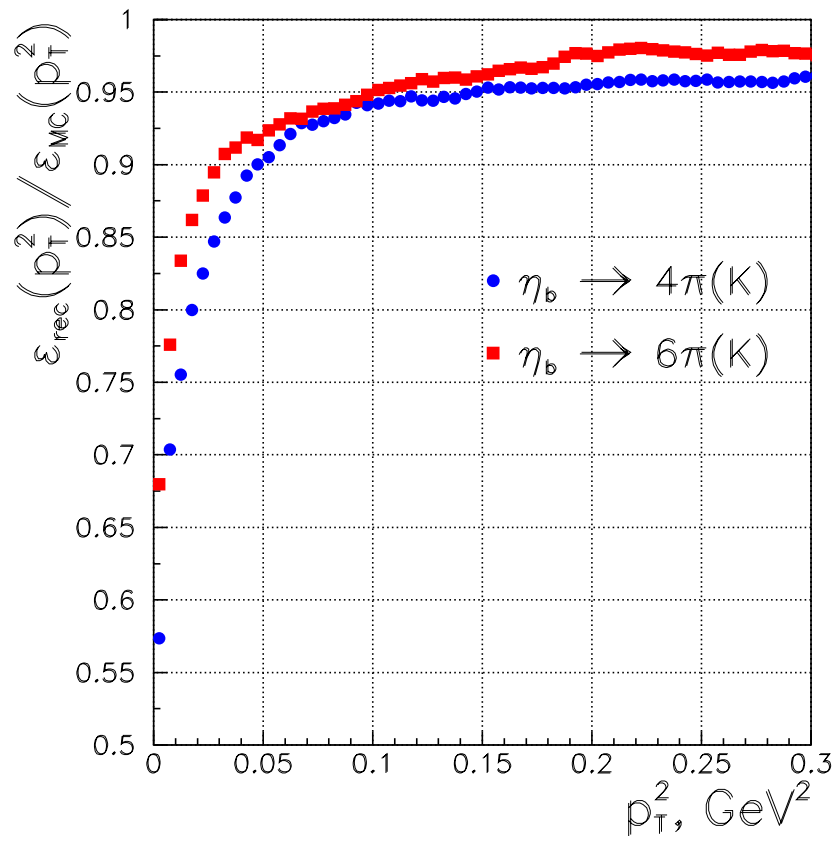
$\gamma\gamma \rightarrow \tau^+\tau^-$ events

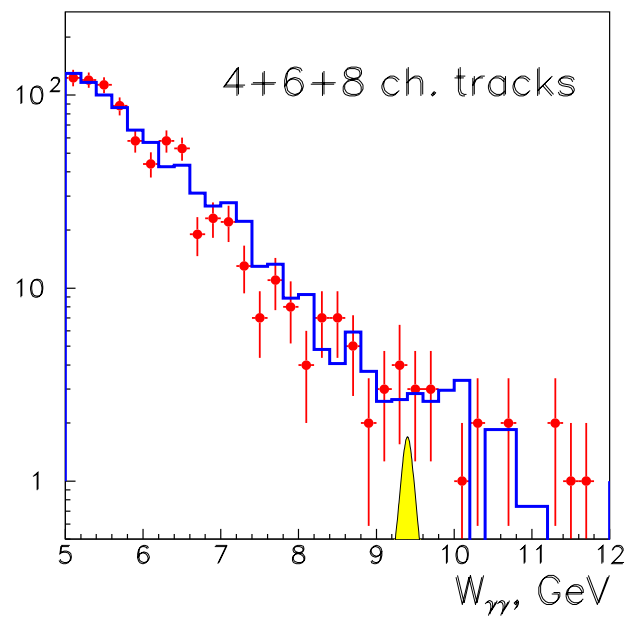
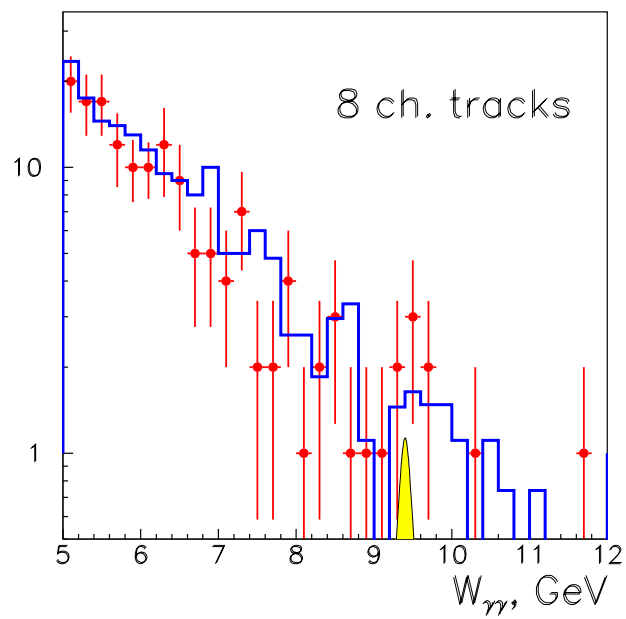
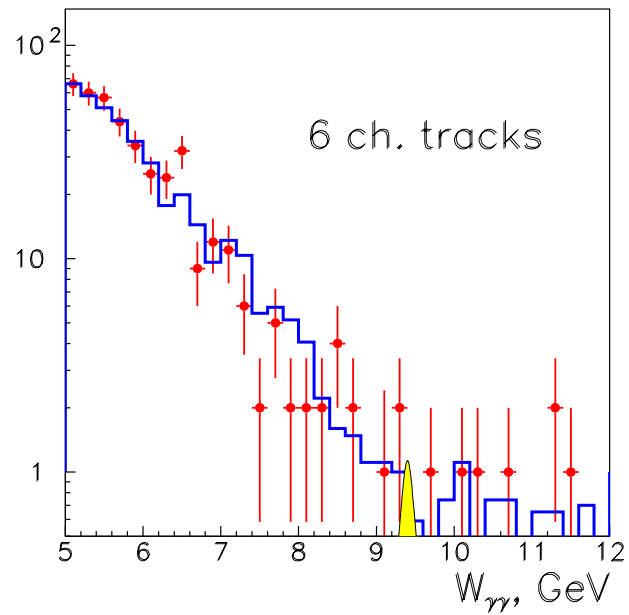
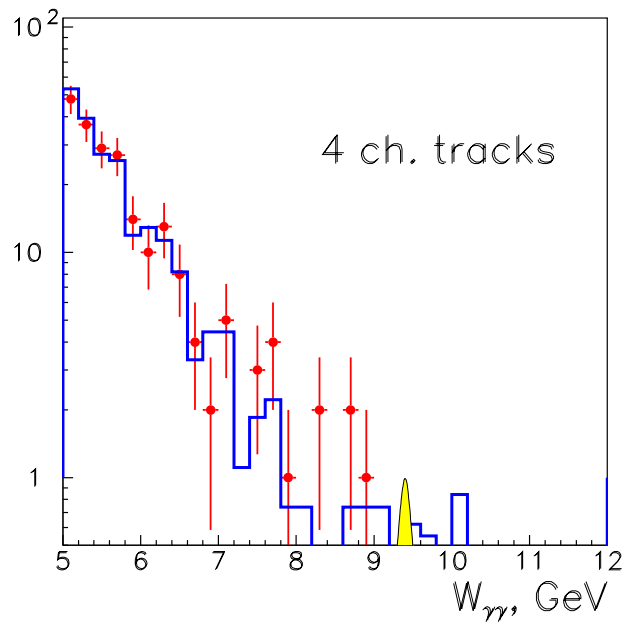
η_b efficiency calculation

$e^+e^- \rightarrow e^+e^-\gamma^*\gamma^* \rightarrow e^+e^-\eta_b$

VERMASEREN generator

η_b decay phase space





Results

LEP II $\sqrt{s_{ee}} = 161 \div 207$ GeV, $\mathcal{L} = 630$ pb⁻¹

Mass, GeV	4 ch.tr (bkg)	6 ch.tr (bkg)	8 ch.tr (bkg)
9.2 ÷ 9.4	0 (.2)	2 (1.)	2 (1.4)
9.4 ÷ 9.6	0 (.6)	0 (.6)	3 (1.7)
N_{ev} (95% upp. lim)	3.0	5.0	7.5
efficiency, ε	9.54%	5.53%	2.72%
$\Gamma_{\gamma\gamma}(\eta_b) \cdot Br$, keV (95% upp. lim)	.093	.27	.78
ALEPH	.057	.128	
L3	.3	.4	

Conclusion

- The pseudoscalar meson η_b has been searched for its decays to 4, 6, 8 charged particles in $\gamma\gamma$ interactions at LEP2.
- A few candidate events are seen in the signal region $9.2 \text{ GeV} < W_{vis} < 9.6 \text{ GeV}$. The number of the candidate are compatible with the expected one from the background processes.
- Upper limits $\Gamma_{\gamma\gamma}(\eta_b) \times \text{BR}(\eta_b)$ of
 - .093 keV (4 ch.part.),
 - .270 keV (6 ch.part.),
 - .780 keV (8 ch.part.)

are obtained with the confidence level of 95%.