$\eta \rightarrow \pi^0\gamma\gamma$ analysis status of the work

B. Di Micco & P. Gauzzi

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ϕ decay working group

Summary of the last presntation to this group

Main background problems

- $\eta \rightarrow 3\pi^0$ with 2 lost photons
- with 1 lost 2 merged ones
- with 2 merged couples

Solutions:

- kinematic fit with unknowns and Δ variable
- kinematic fit (cut variables: energy of the lost photon, angle of the lost photon)
- Likelihood for merged clusters

MC sample and pre-analysis cuts

MC rad04 production
data runs range 23100 – 25300

N. $\eta \rightarrow 3\pi^0$ 7206813
N. η 22451100 ($540 pb^{-1}$)

Cut	$\varepsilon(\%)$
cluster in time = 5	60.4 ±0.4
E_{min} > 20 MeV	84.0 ±0.4
E_{tot} > 800 MeV	98.70 ± 0.13
cuts to fast analysis	95.8 ± 0.2
Overall	48.4 ± 0.4

cluster in time definition

$$t - \frac{r}{c} \leqslant \min(5\sigma_t, 2\,\mathrm{ns})$$

2 lost cluster identification

	only Δ	Kin fit passed
$\varepsilon(\eta \to \pi^0\gamma\gamma)$	75.7%	87.4%
$\varepsilon(\eta \to 3\pi^0)_{2\ \text{lost}}$	35.3%	50.0%
$\frac{\epsilon(\eta\to\pi^0\gamma\gamma)}{\sqrt{\epsilon(\eta\to 3\pi^0)_{2\text{lost}}}}$	1.27	1.24

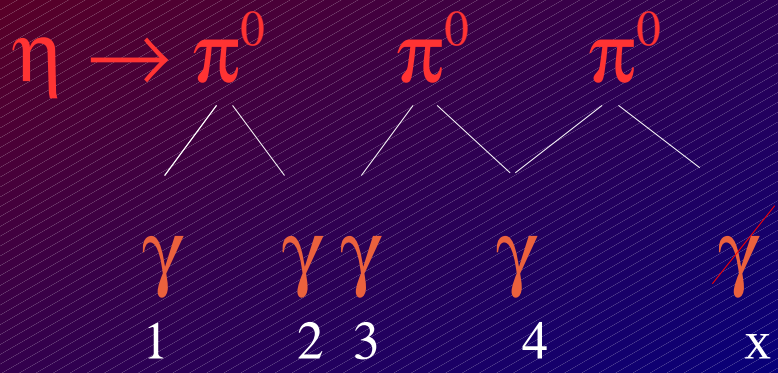
to check better after all cuts

Merged cluster identification (Gauzzi Likelihood – Discriminant Analysis)

	Likelihood	D.A.
$\varepsilon(\eta \to \pi^0\gamma\gamma)$	56.0%	54.1%
$\varepsilon(\eta \to 3\pi^0)_{\text{not 2 lost}}$	21.1%	19.8%
$\frac{\epsilon(\eta \to \pi^0 \gamma\gamma)}{\sqrt{\epsilon(\eta \to 3\pi^0)_{\text{not 2 lost}}}}$	1.27	1.22

better DATA/MC agrement

Kin fit 1 lost – 1 merged couple case (description)



The angle of the 2 merged photons is taken from the merged cluster

Initialization values

$$\begin{cases} \vec{P}_x = \vec{P}_{missing} \\ (p_3 + p_{4.1})^2 = m^2_{\pi^0} \\ (p_x + p_{4.2})^2 = m^2_{\pi^0} \end{cases}$$

$$\begin{cases} \vec{P}_x = \vec{P}_{missing} \\ E_{4.1} = \dfrac{m^2_{\pi^0}}{E_3(1-\cos\theta_{34})} \\ E_{4.2} = \dfrac{m^2_{\pi^0}}{E_x(1-\cos\theta_{3x})} \end{cases}$$

5 unknowns:

p_x, p_y, p_z of the lost photon

E_1, E_2 of the 2 merged photons

32 measured quantity:

E,x,y,z,t of the 5 clusters

E, p_x, p_y, p_z of the ϕ

x,y,z of the vertex

14 constraints:

$5x(t-r/c)$, $4momentum$, $3xm(\pi^0)$, $m(\eta)$, $E_{4.1} + E_{4.2} = E_4$

We always have a good solution

discriminant variables – 1 lost-2merged case

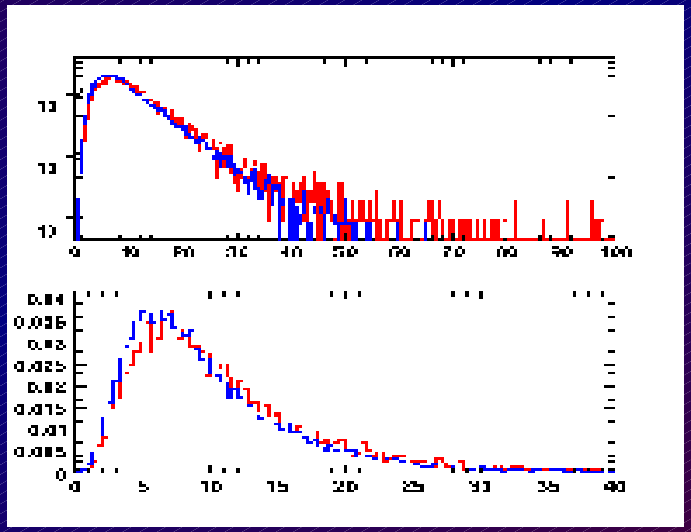
kinematic fit requirement

$\varepsilon(\eta \rightarrow \pi^0\gamma\gamma) = 98.0\%$

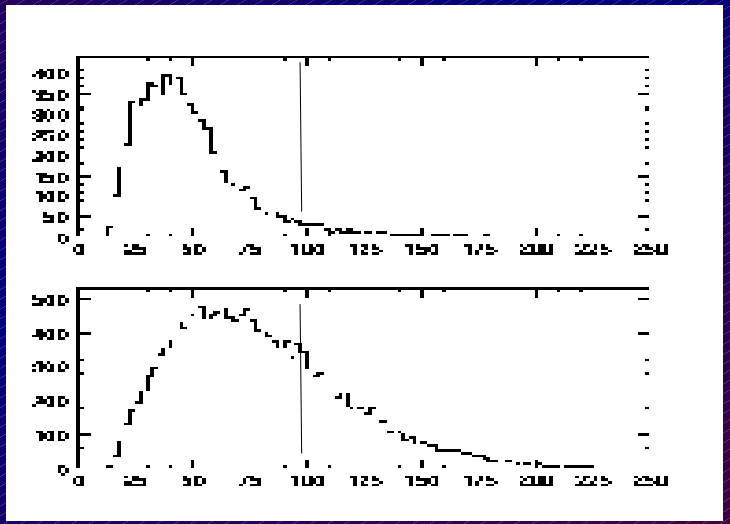
$\varepsilon(\eta \rightarrow 3\pi^0) = 98.7\%$

1 lost – 2 merged

χ^2 distribution



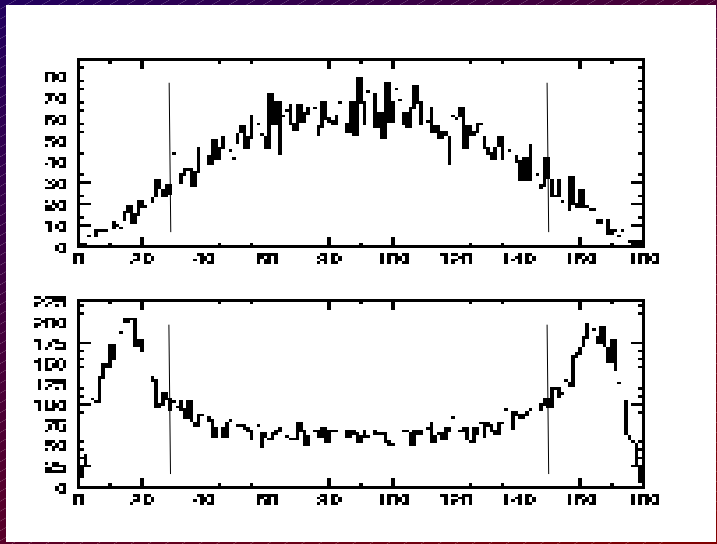
energy of the missing photon



$E_x < 100$ MeV

$30^o < \theta_x < 150^o$

angle of the missing photon



efficiencies

$\varepsilon(\eta \to \pi^0\gamma\gamma)$ 84.1%

$\varepsilon(\eta \to 3\pi^0)_{\text{1 lost-1 merged}}$ 41.5%

$$\frac{\epsilon(\eta \to \pi^0 \gamma\gamma)}{\sqrt{\epsilon(\eta \to 3\pi^0)_{1\,\text{lost}-2\,\text{merged}}}}$$ 1.3

Analysis cuts summary

Photon energy in η rest frame

Pre cuts:

$E_{min} > 30\,MeV$

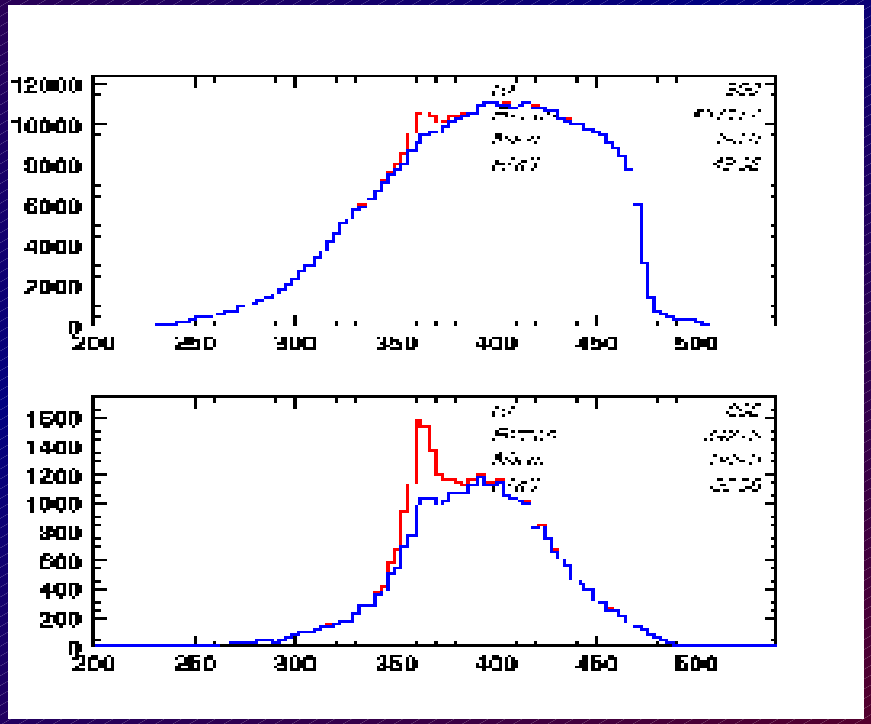
$\theta_{\gamma\,min} > 20^{o}$

$\chi^2_{\pi^0_{min}} < 30$

$X^2_{\pi^0\pi^0} > 20$

$X^2_{\omega\pi^0} > 60$

$X^2_{\eta\pi_0} > 10$



Before cuts:

S/(S+B) = 1.6%

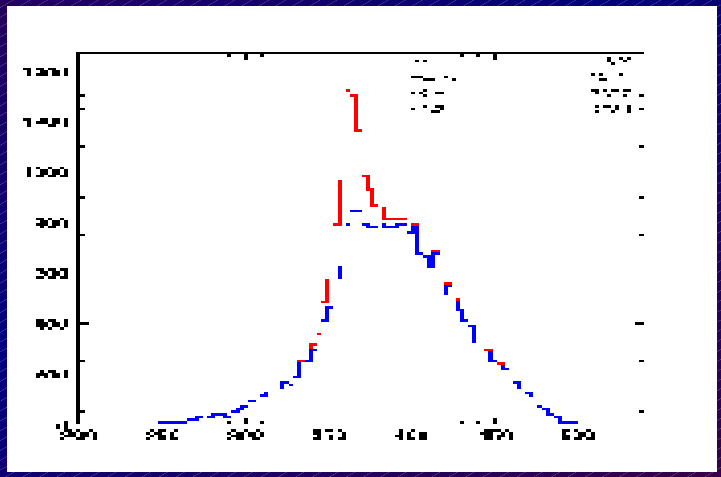
After cuts:

9.1%

Analysis cuts summary

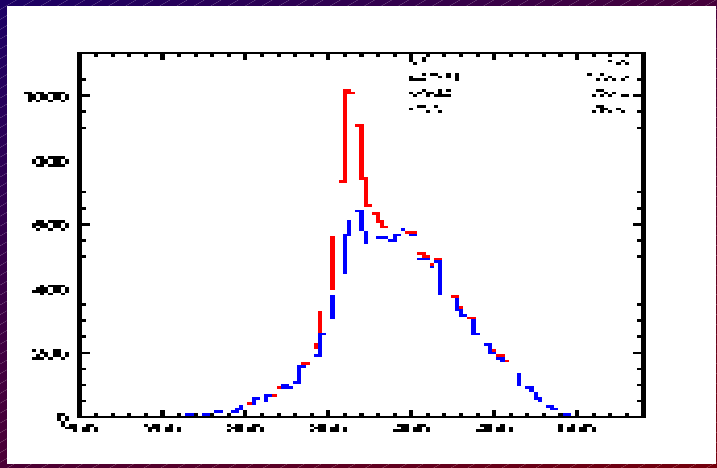
2 lost photons identification

S/(S+B) = 11.1%

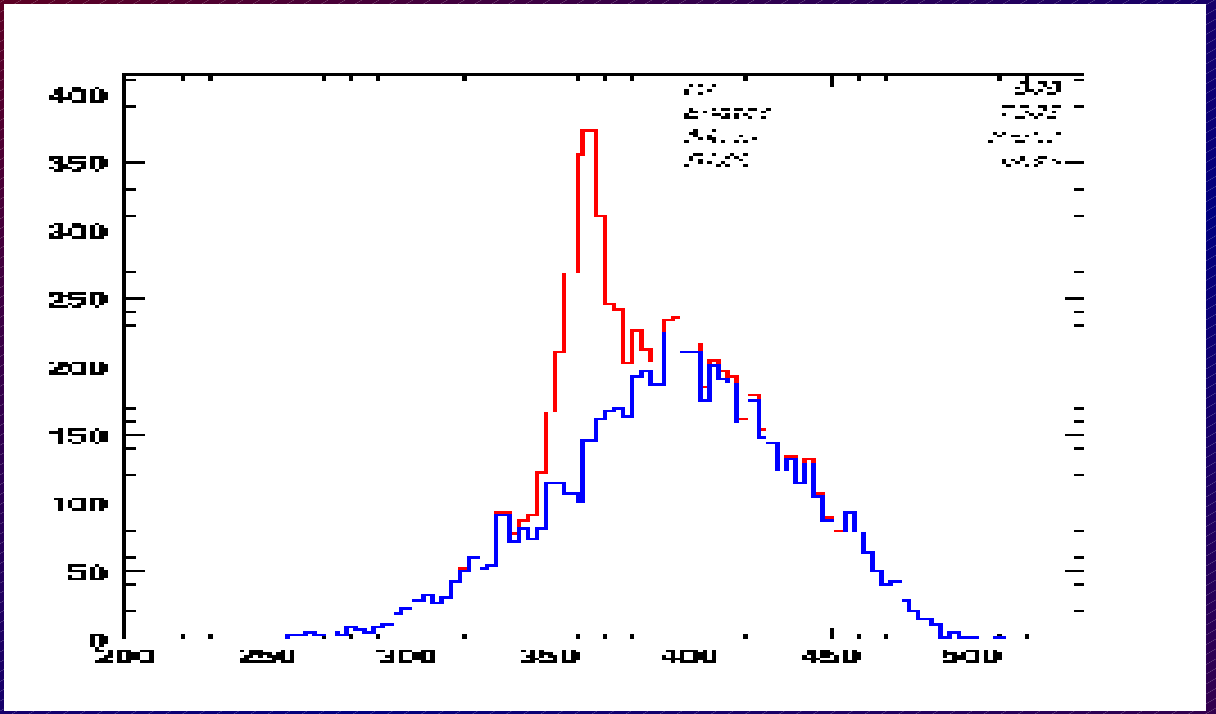


1 lost – 2 merged id

S/(S+B) = 13.0%



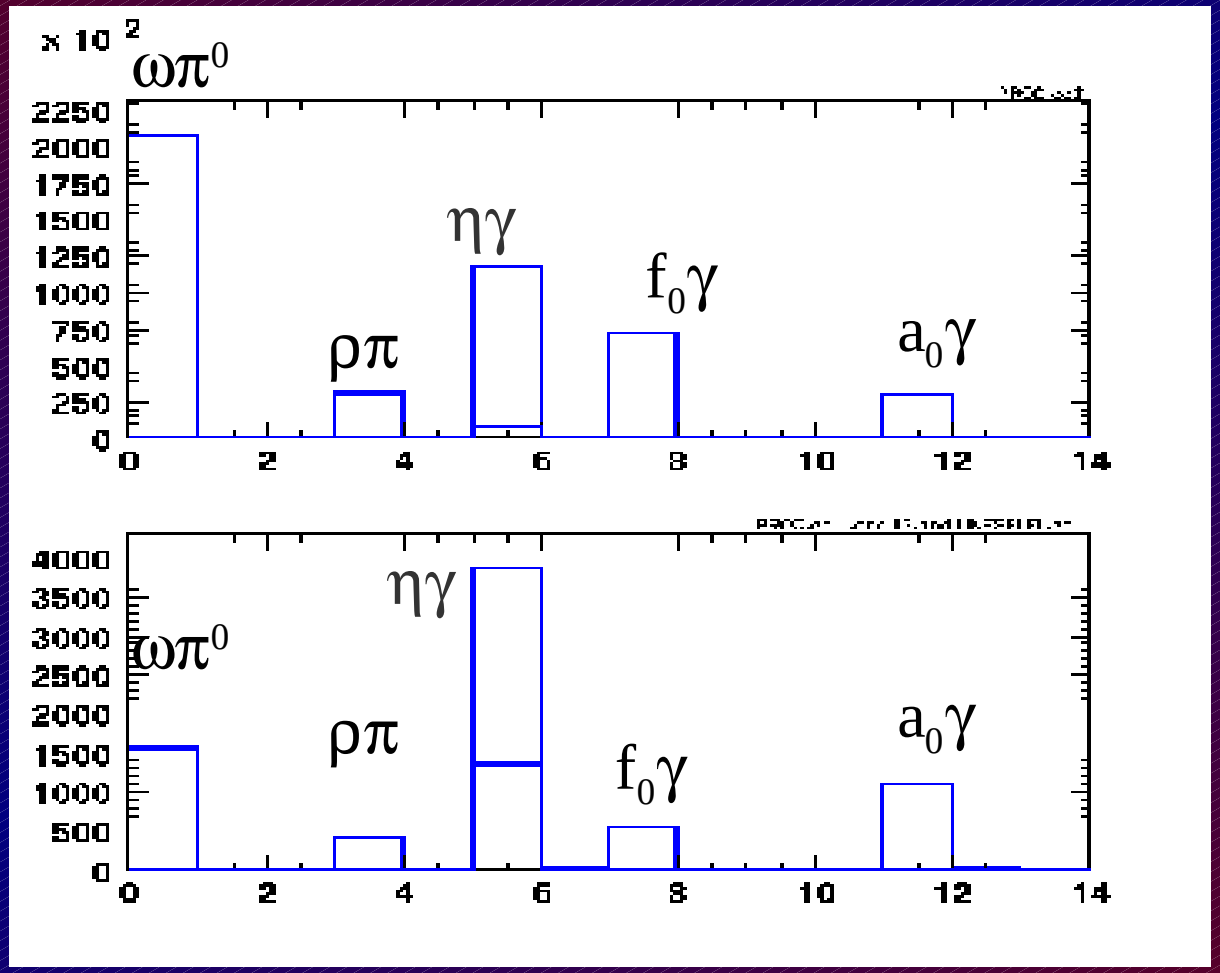
Likelihood



S/(S+B) = 18.1%

ε = 8.8%

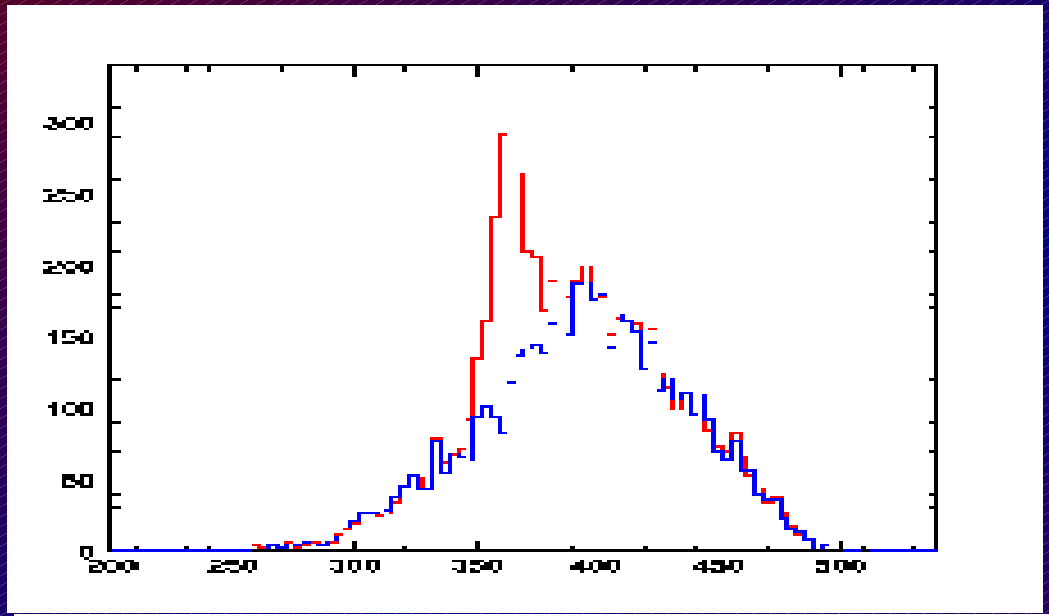
Signal and Background distribution before and after cuts



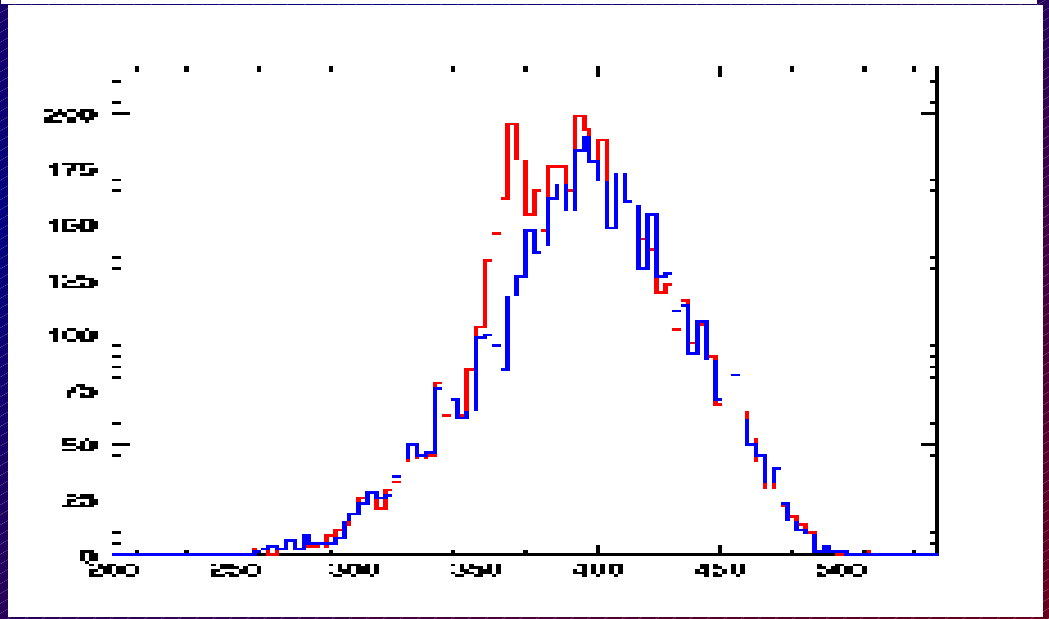
before

after

Distribution at real 2001+2002 luminosity 450pb^{-1}



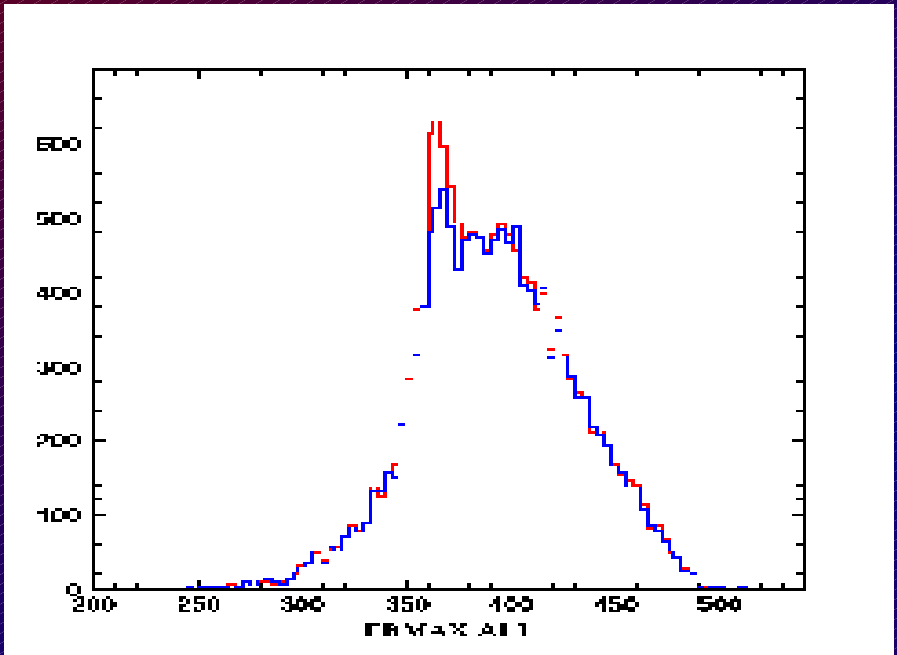
Gams Br



CB preliminary Br

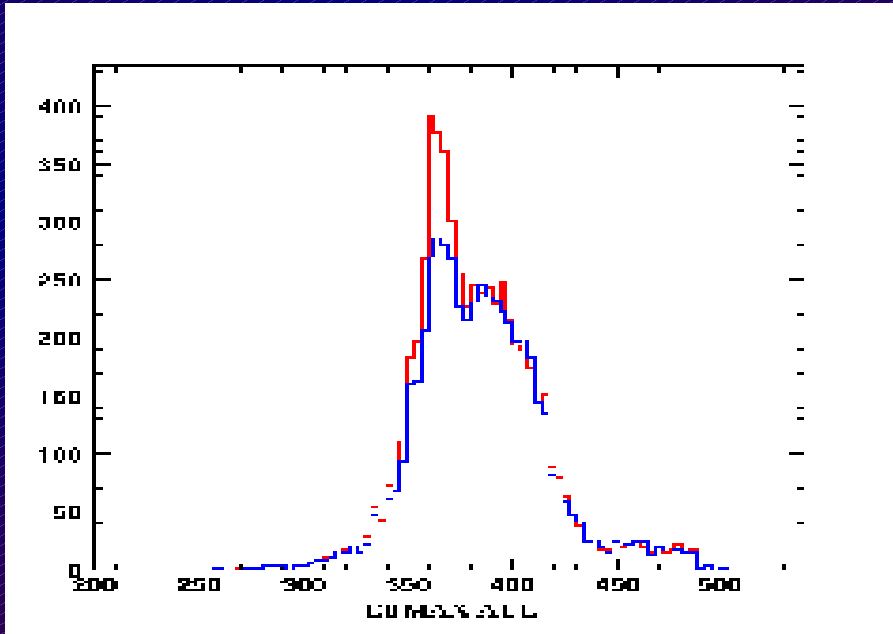
Distribution at real 2001+2002 luminosity 450pb^{-1} no likelihood

CB preliminary Br



S/(S+B) = 5%

ε = 16%



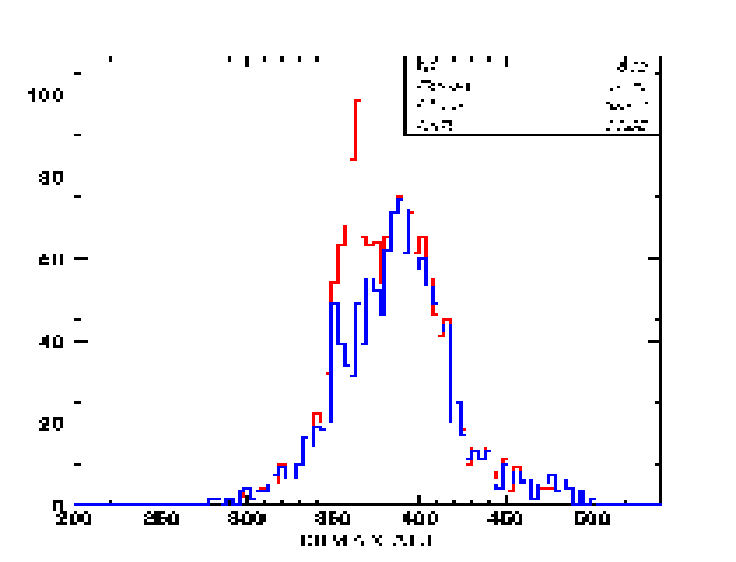
S/(S+B) = 10.0%

ε = 11%

optimized

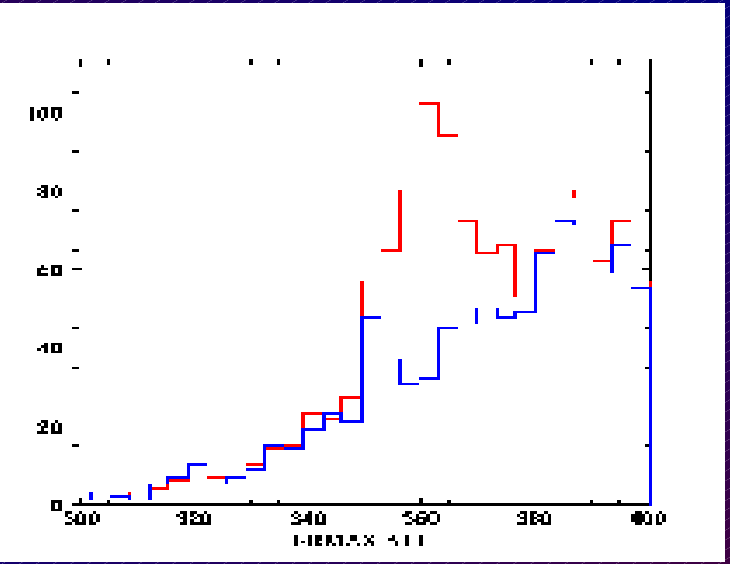
Distribution at real 2001+2002 luminosity 450pb^{-1} likelihood optiimized

CB preliminary Br



S/(S+B) = 15.7% optimized

$\varepsilon = 5.7\%$

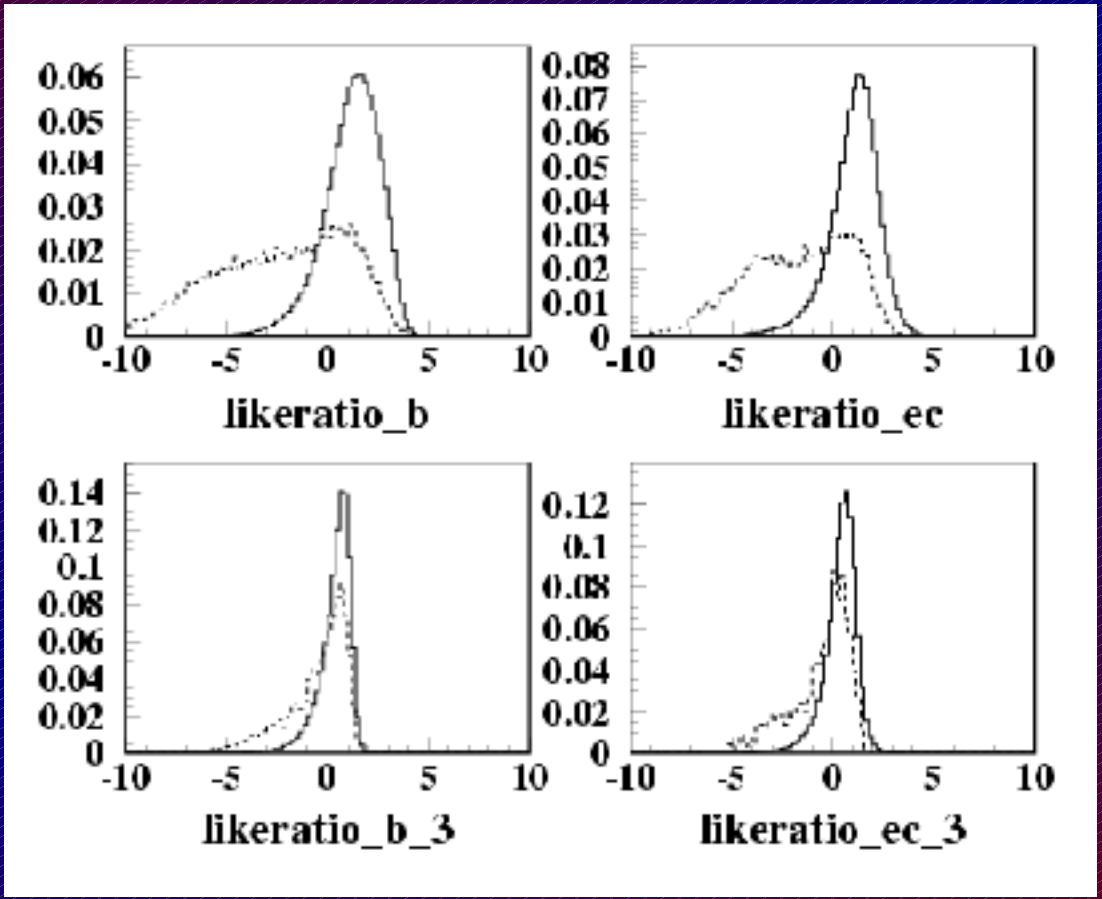


New likelihood distribbutions (the old one had a bad skewness definition)

barrel endcap

> 3 hits

3 hits

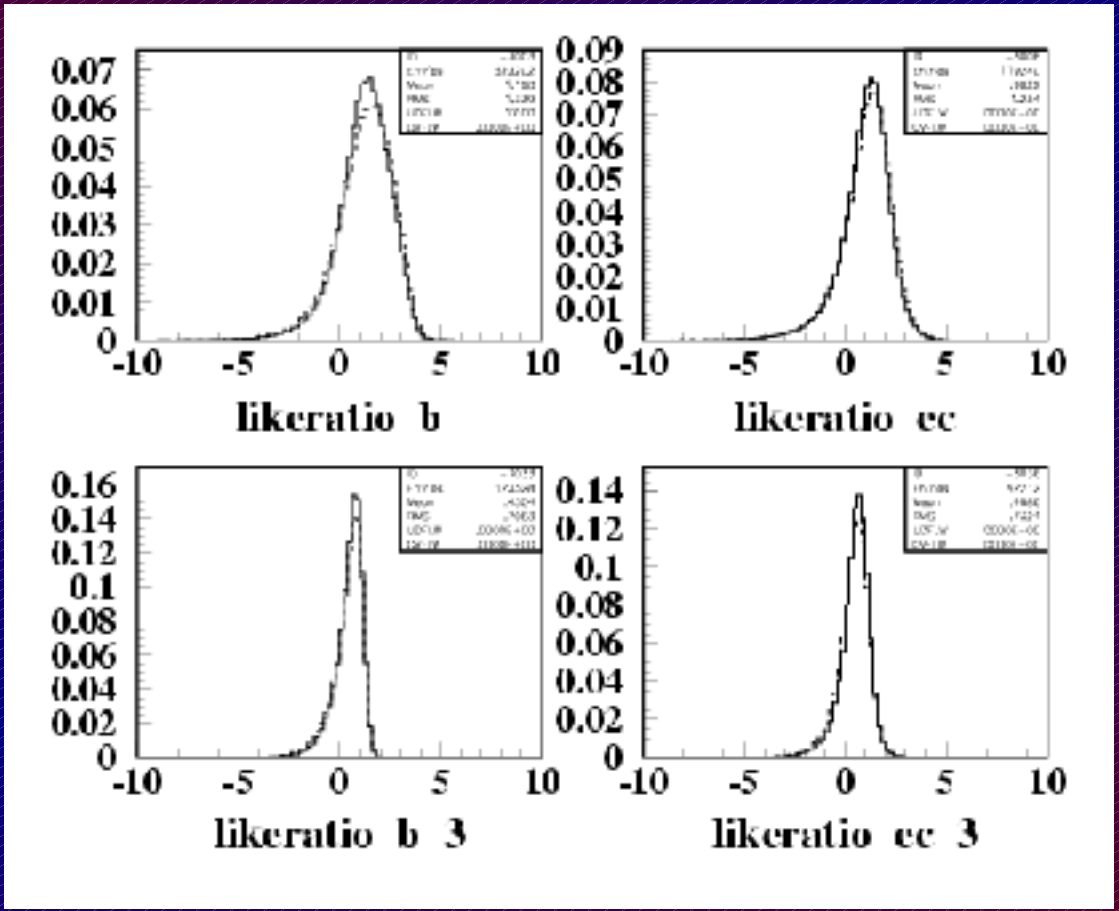


New likelihood distribbutions (DATA – MC COMPARISON)

barrel endcap

> 3 hits

3 hits



The sample is selected by requiring 5 prompt photons, so it's largely dominated by not merged clusters

Conclusions
(from the last meeting)

- Applying to 1-lost 1-merged events a similar procedure used for the 2- gammas lost ones;
- use the new likelihood in the selection;
- estimating the DATA/MC discrepancy in the merged clusters and correcting for it;

Now running

- running on the full statistic 2001/2002 and the new MC radiative production to have acceptable expected distributions;
- trying to evaluate a Br and/or an upper limit;

  evaluating all the systematic effects.