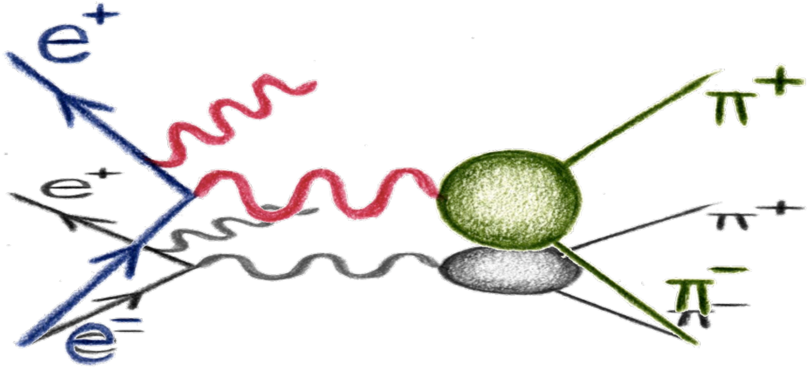
Update on the Large Photon Polar Angle Analysis using 2006 data

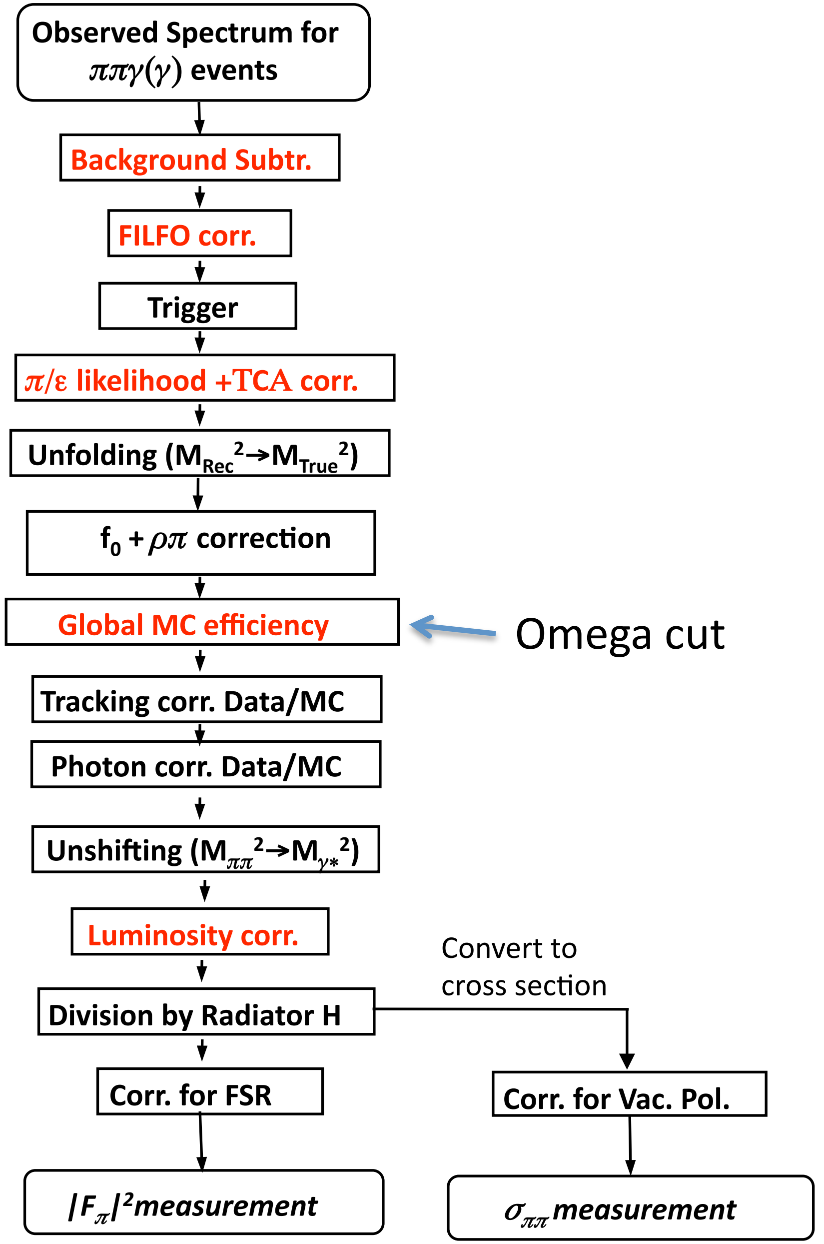


S. Müller

(ππγ group)

Phidec-Meeting in Frascati, 27.4.2009

ANALYSIS FLOW:



FILFO:

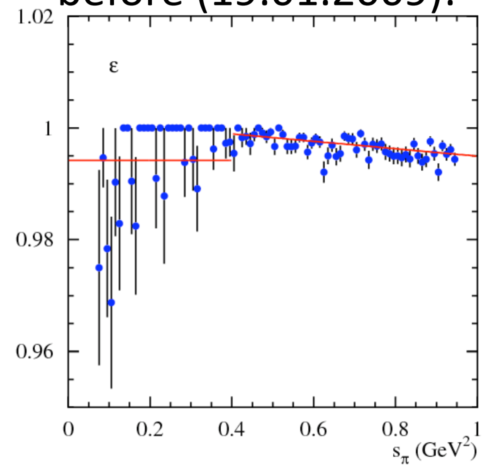
FILFO efficiency is evaluated from a downscaled unbiased sample, then approximated by

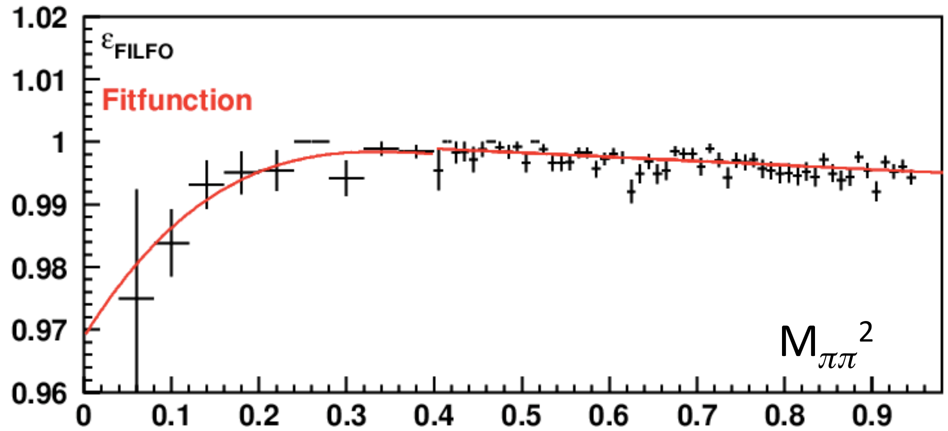
- a 3rd order polynomial below 0.4 GeV^2 (using larger binning to increase statistics):
ε_{FLF}=0.969+0.225 s_π-0.554 s_π^{2} +0.434 s_π^{3}

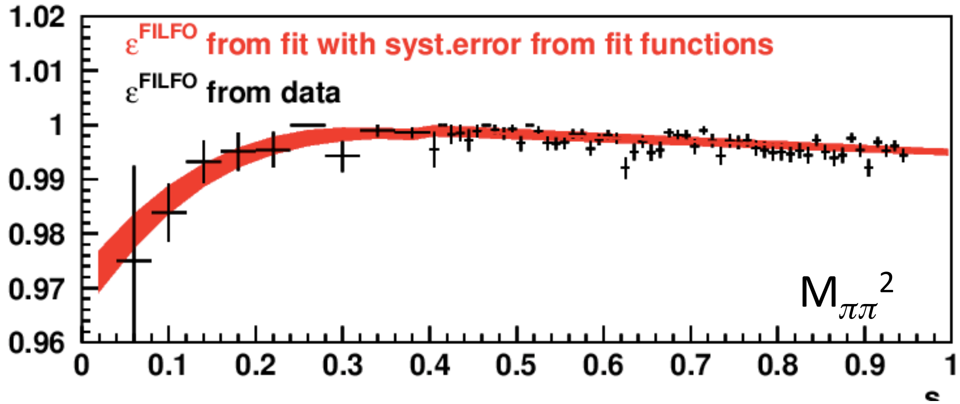
- a P1 above:
ε_{FLF}=1.002 - 0.007 s_π

The systematic uncertainty has been estimated from the errors of the fit parameters.
The effect on the syst. error of $a_\mu^{\pi\pi}$ between 0.1 and 0.85 GeV^2 is 0.19% (was 0.28%), while the value of $a_\mu^{\pi\pi}$ drops by 0.05%.

before (19.01.2009):



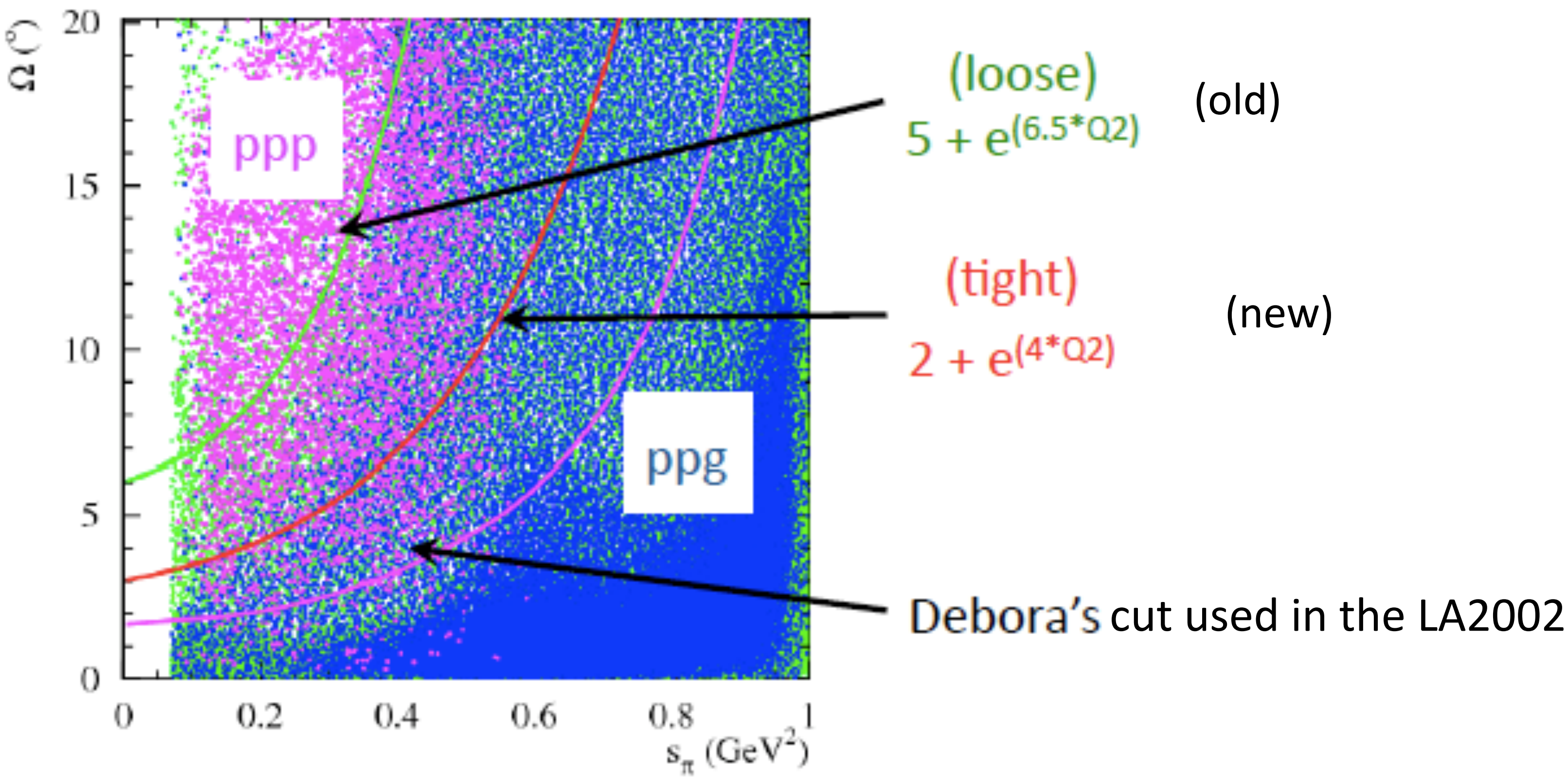




Omega-Cut: To reduce the background contamination, our referees suggested to use a tighter cut in Ω (= 3d angle between detected photon direction and missing momentum direction)

omega loose = $5 + e^{(6.5*Q2)}$ ← Used in the analysis (until now)

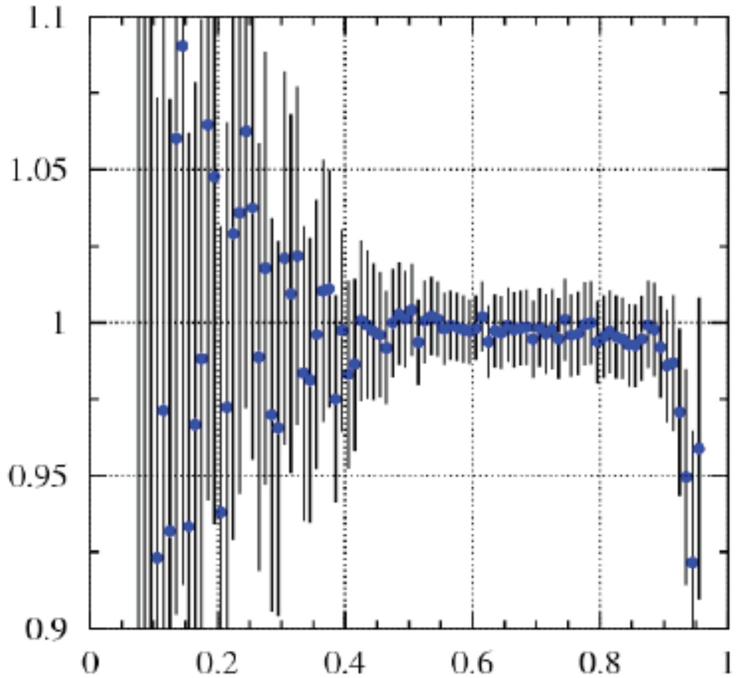
omega tight = $2 + e^{(4*Q2)}$ ← Check



Comparison Ω loose and Ω tight

(Spectrum – bkg) / ppg MC | Ω tight
―――――――――――――――――
(Spectrum – bkg) / ppg MC | Ω loose

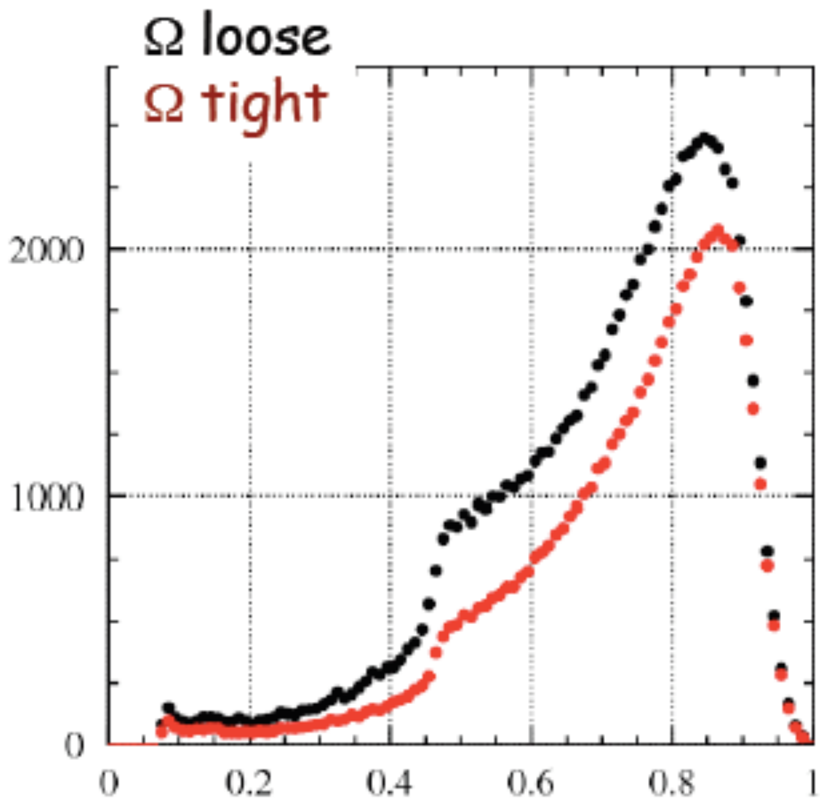
Double ratio technique:
spectrum and background performed with the different W cut, so also the weights from the bkg fit procedure have been evaluated for that specific cut

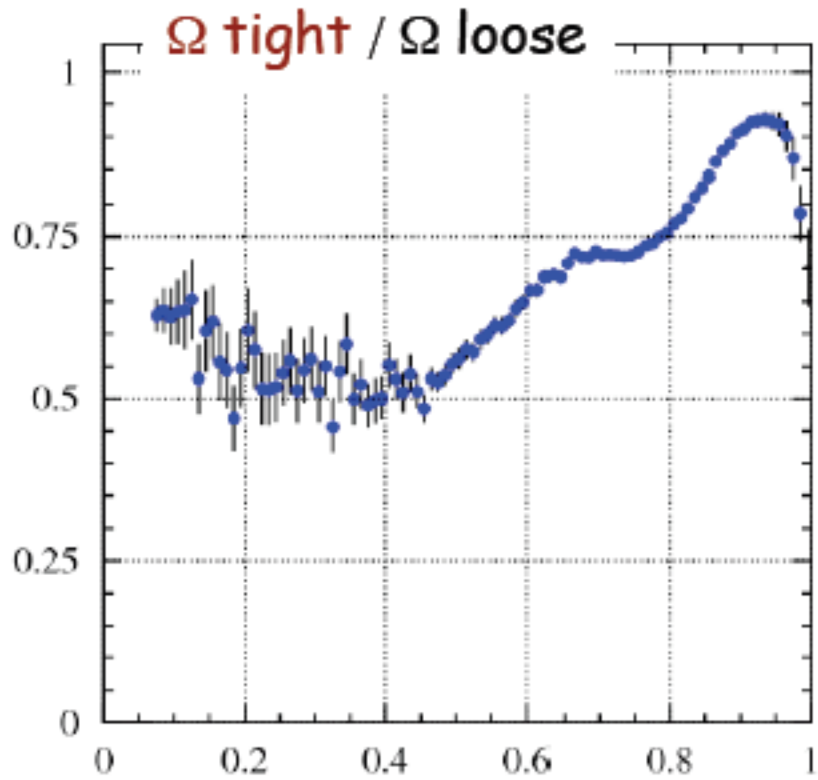


Agreement between the two different cuts (in the analysis range Q^2<0.8 GeV^2):
- **good estimation of the background**
- **robustness of the cuts**

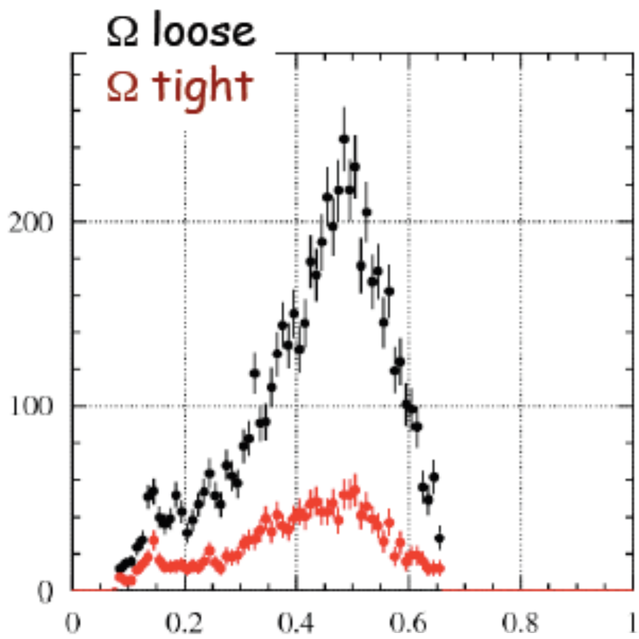
Needs to be redone with larger binning below 0.4 GeV^2, to reduce fluctuations

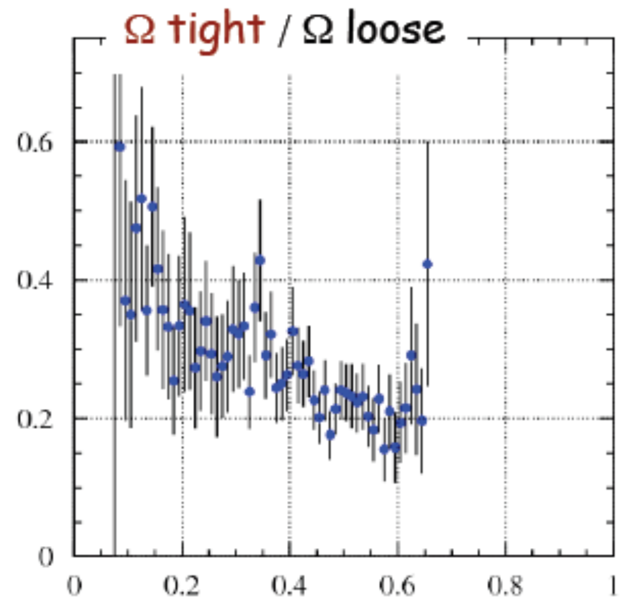
Effect of tighter cut on total background contribution



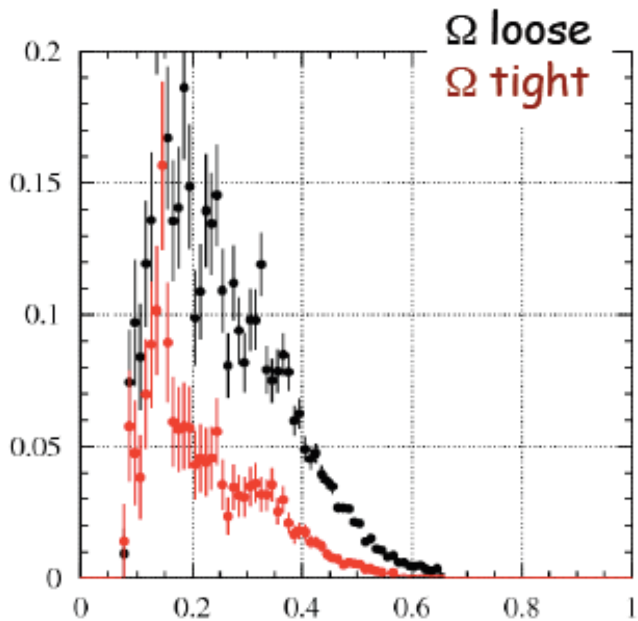


Effect of tighter cut on $\pi\pi\pi$ background contribution





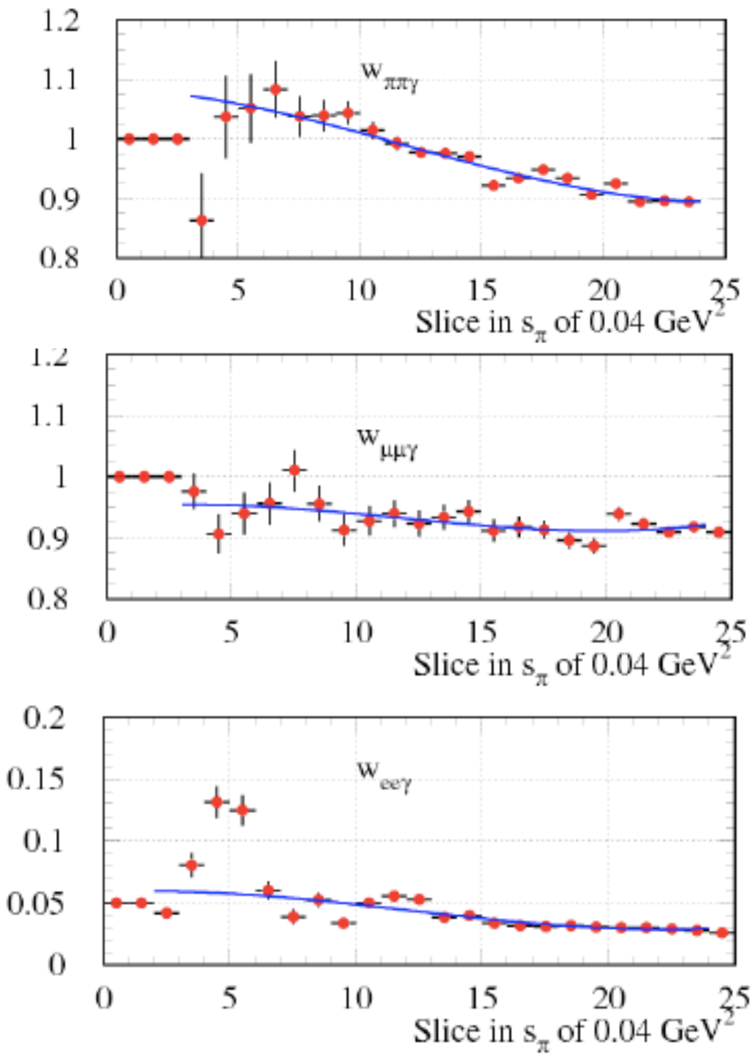
fract. background contribution to data spectrum:



How does the new cut in Ω affect the background fit procedure?

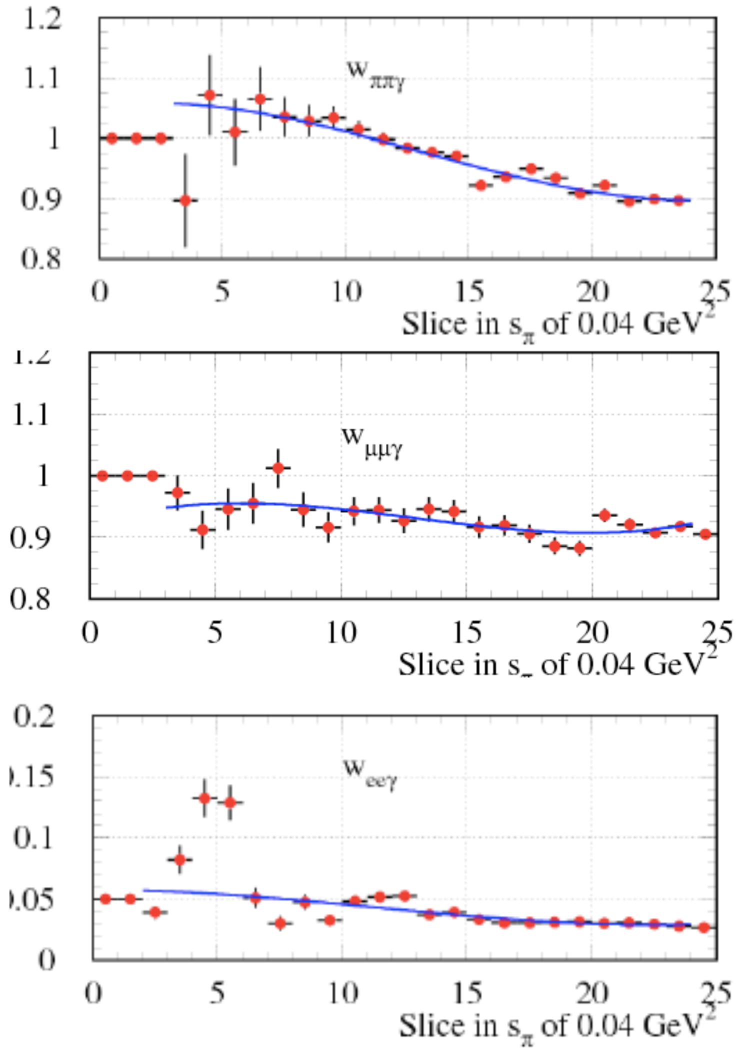
With

omega < 5 + $e^{(6.5*Q2)}$



With

omega < 2 + $e^{(4*Q2)}$



$\pi\pi\gamma$

$\mu\mu\gamma$

$ee\gamma$

How does the new cut in Ω affect the background fit procedure?

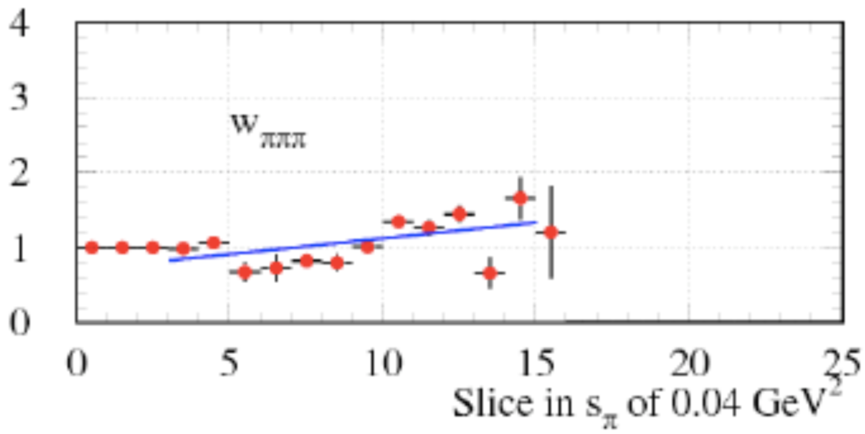
With

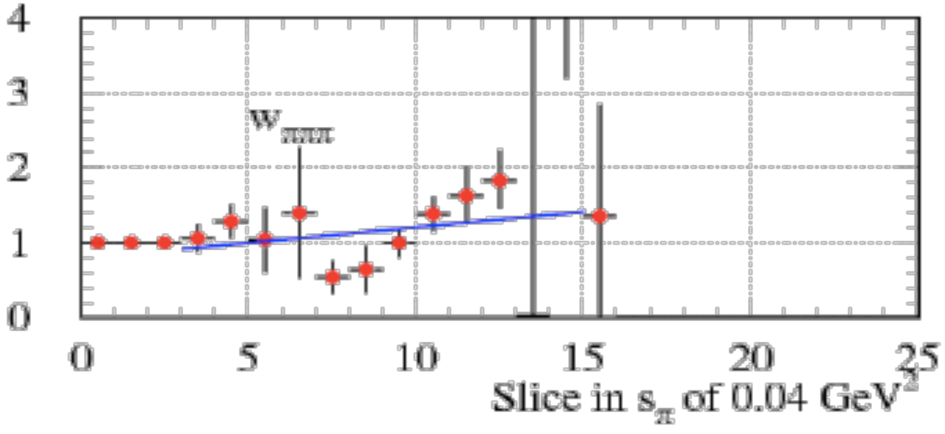
omega < 5 + $e^{(6.5*Q2)}$

$\pi\pi\pi$

With

omega < 2 + $e^{(4*Q2)}$





No big change in all the weights (apart form the obvious reduction in statistics for the $\pi\pi\pi$ channel), therefore no significant change in the systematic error coming from the background fitting procedure.

Systematic uncertainty

$$\frac{\text{(Spectrum - bkg) / ppg MC} \mid \Omega + 1\sigma}{\text{(Spectrum - bkg) / ppg MC} \mid \Omega}$$

&

$$\frac{\text{(Spectrum - bkg) / ppg MC} \mid \Omega - 1\sigma}{\text{(Spectrum - bkg) / ppg MC} \mid \Omega}$$

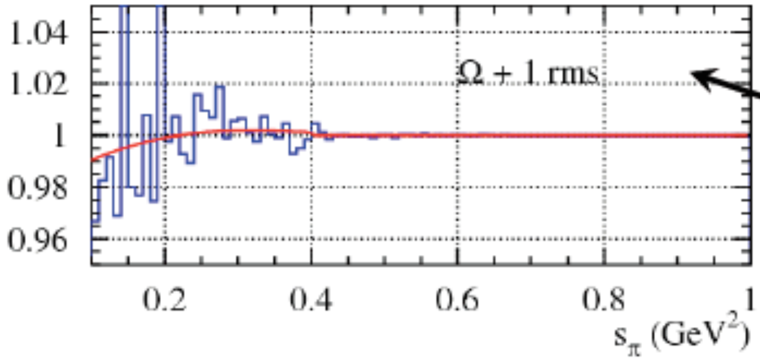
Maximum deviation from 1 between the two

Same weights used both for $\Omega - 1\sigma$ and for Ω

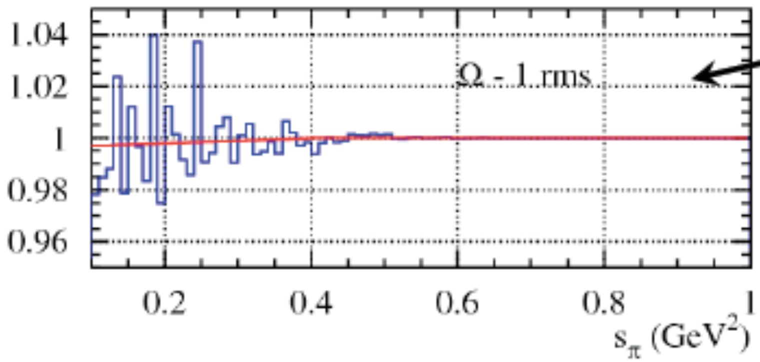
Double ratio technique:
spectrum - background / ppg signal with the Ω cut varied (+/-) by one rms
over
spectrum - background / ppg signal with the Ω standard cut
Systematic uncertainty obtained as the maximum deviation from 1 between $+1\sigma$ and -1σ

Systematic uncertainty for standard Ω cut

$\Omega < 5 + e^{(6.5*Q2)}$



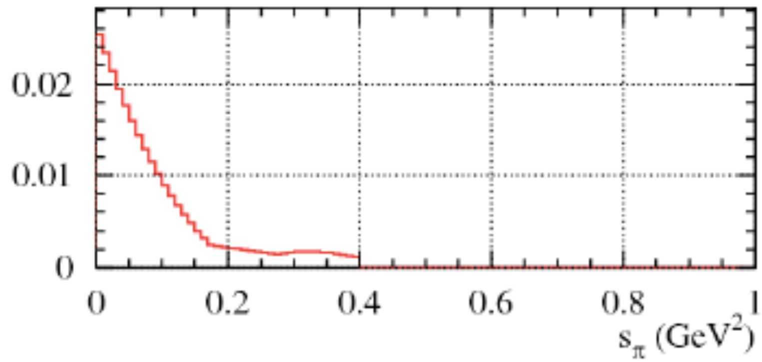
Double ratio with Ω + 1σ



Double ratio with Ω 1 1σ

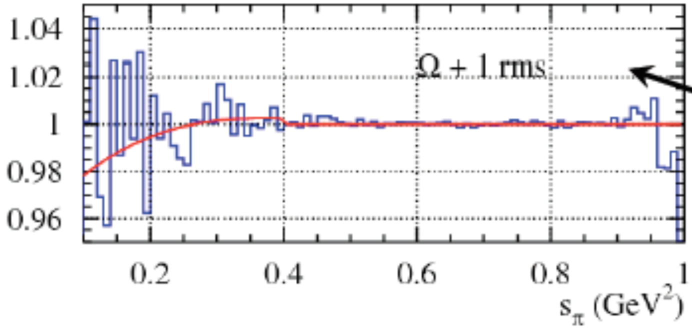
Red line:
third order function up to 0.4 GeV^2

Maximum deviation from 1

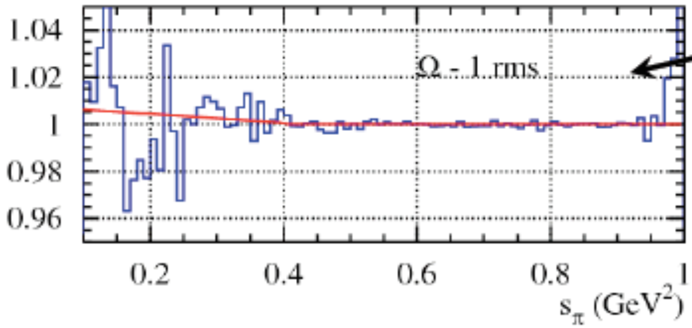


Systematic uncertainty for tighter Ω cut

$\Omega < 2 + e^{(4^*Q2)}$



Double ratio with Ω + 1σ

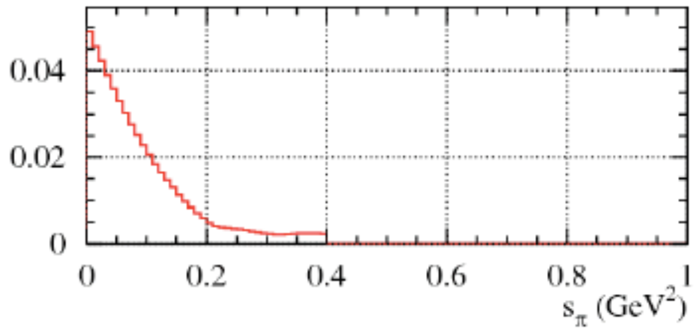


Double ratio with Ω 1 1σ

Red line:

third order function up to 0.4 GeV^2

Maximum deviation from 1



Summary Ω cut:

Tightening the Ω cut: 1. gives a stable result; 2. reduce of about 60% the $\pi\pi\pi$ contamination and of less the 5% the signal

In principle there is not strong need of reducing $\pi\pi\pi$ events, since they seem to be well described by MC and well under control in the background fitting procedure

The effect on the systematic uncertainty due to the tightening of Ω is actually negligible above 0.25 GeV^2 and increases by about 2% at threshold.

The new Ω cut does not introduce significant changes in the systematic uncertainty on the background fitting procedure

It was proposed to use the tighter cut in Ω in the analysis in order to reduce the fractional background contribution.

The full implementation into the analysis is on the way.

Luminosity:

103379038 VLAB events counted in 2006 data sample
Effective VLAB cross section extrapolated from on-peak cross section used for 2002 data:

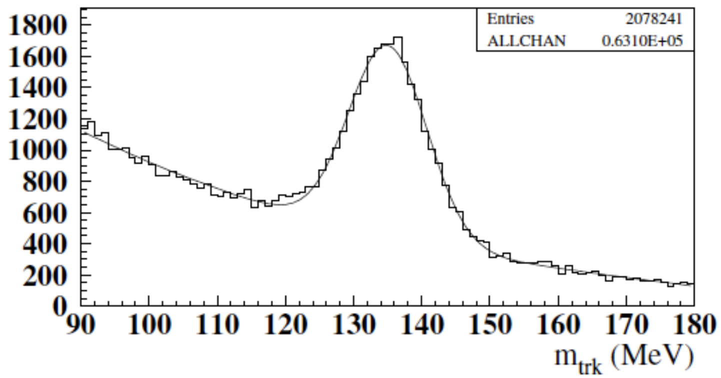
$$\sigma_{\rm eff}^{2006} = \sigma_{\rm eff}^{2002} \cdot \frac{\sigma_{\rm VLAB}^{\rm off-peak}}{\sigma_{\rm VLAB}^{\rm on-peak}} = 428.0\,{\rm nb} \cdot \frac{485.1\,{\rm nb}}{468.1\,{\rm nb}} = 443.5\,{\rm nb}$$

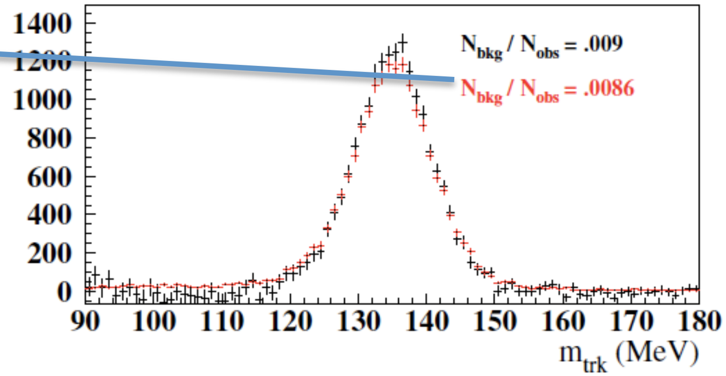
Incl. Reconst. eff. and bkg

From BABAYAGA_nlo

This yields 233.1pb^{-1} of integrated luminosity.

	2001	2002	2006
relative theoretical error on $\sigma_{\rm eff}$	0.5%	0.1%	0.1%
background correction	−0.6%	−0.7%	−0.9%
cosmic ray veto efficiency	+0.4%	negligible	negligible
relative error on $\mathcal{L}$: $\delta_{th} \oplus \delta_{exp}$	0.6%	0.3%	0.3%

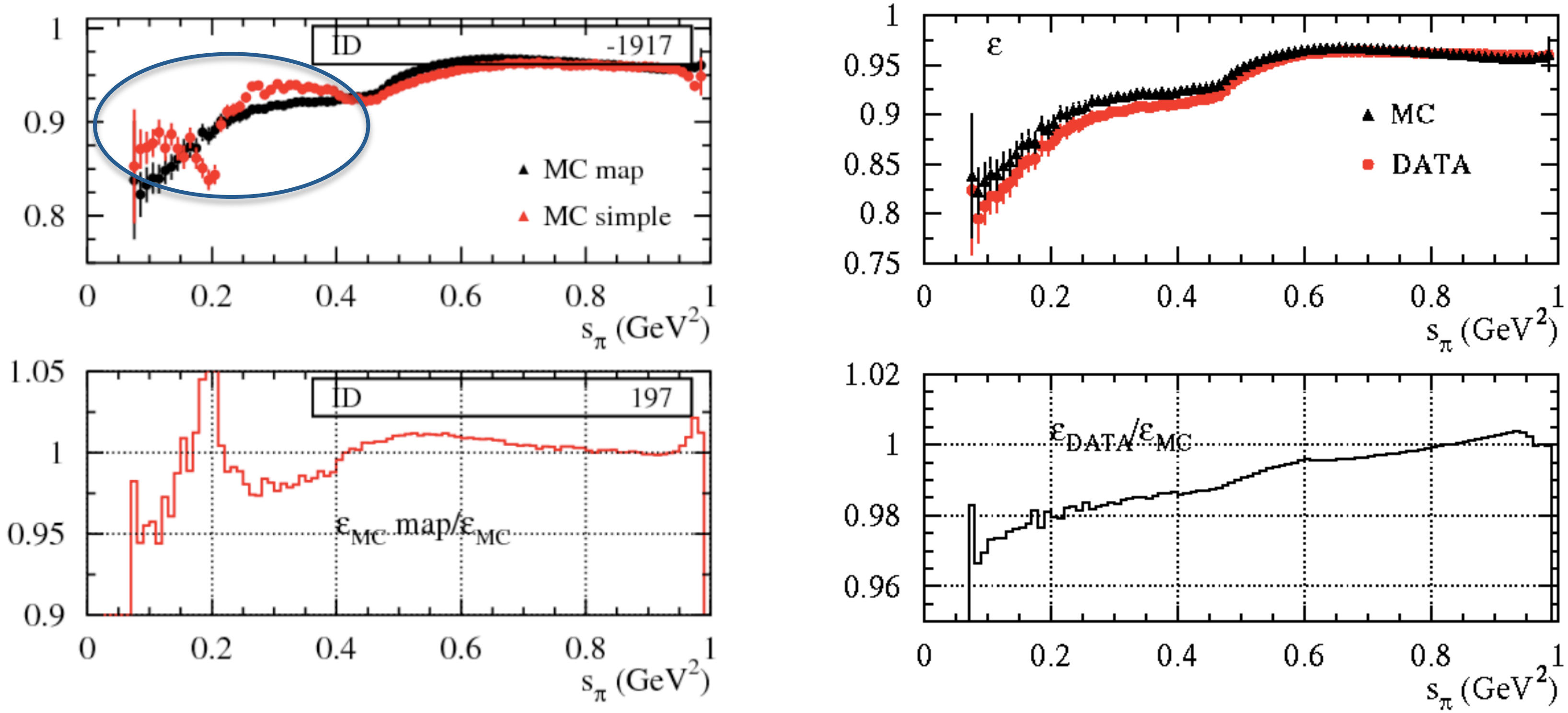




Federico is doing the checks on the acceptance using the 2006 LUMIBHA production.

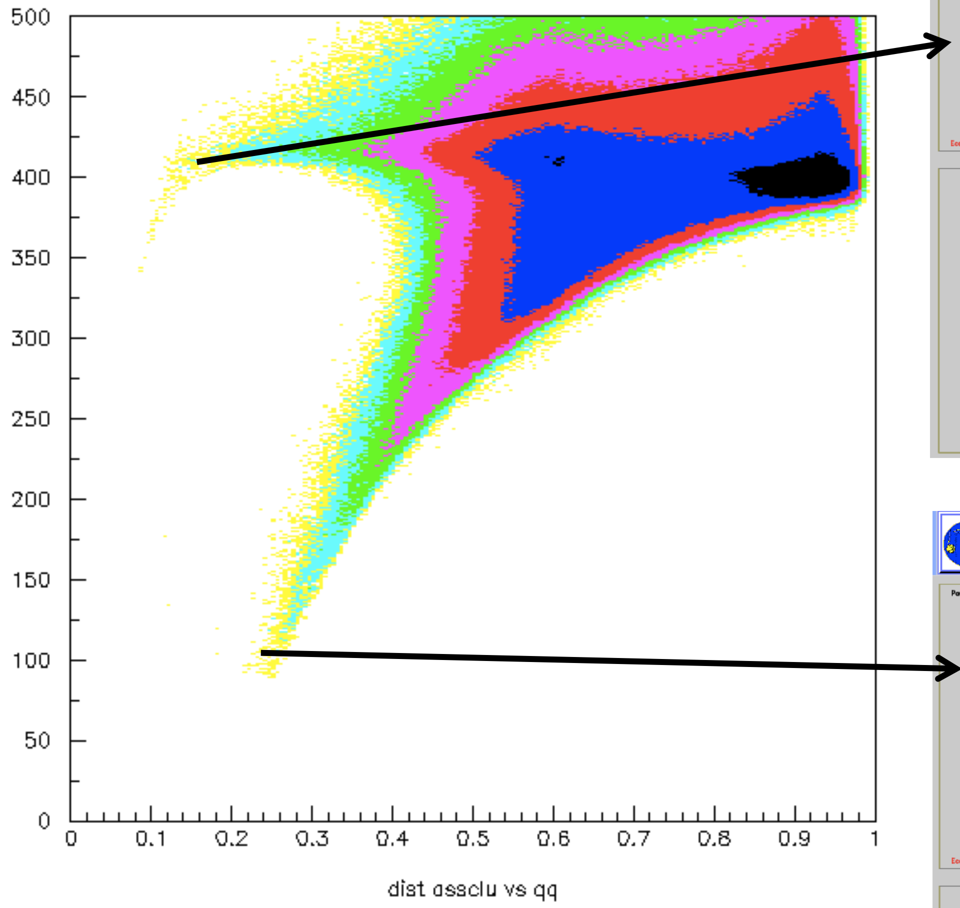
Likelihood: As a cross check for the analysis, referees asked as to perform the analysis also with the .and. of the π/e likelihood

Problem: Direct Method from MC gives different efficiency with respect to the "Mapping" based on single pion efficiency obtained from data control sample (with cut on M_{Trk} around M_{π}), then mapped to the event kinematics using $\pi\pi\gamma$ Monte Carlo



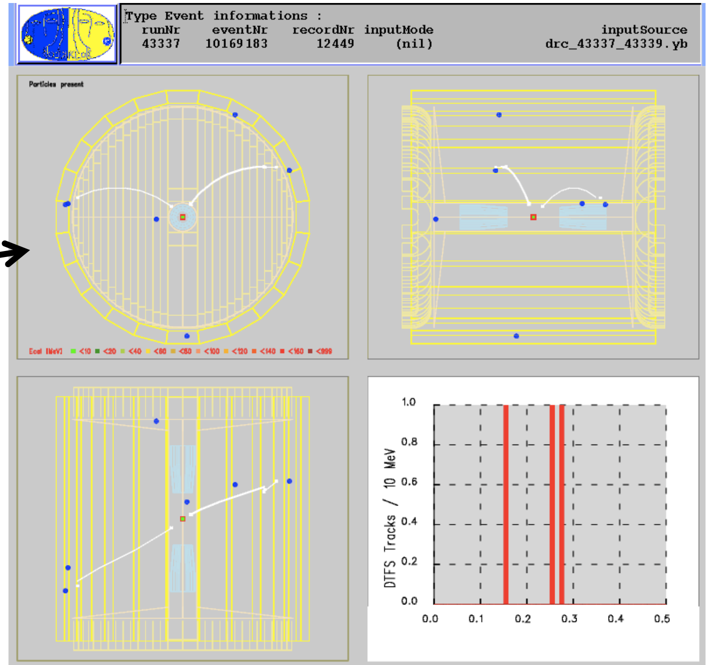
Strange "dip" between 0.15 – 0.25 GeV^2 in direct (simple) efficiency form MC. Mapping method doesn't show this behavior!

Distance between assigned clusters for the two tracks over QQ:

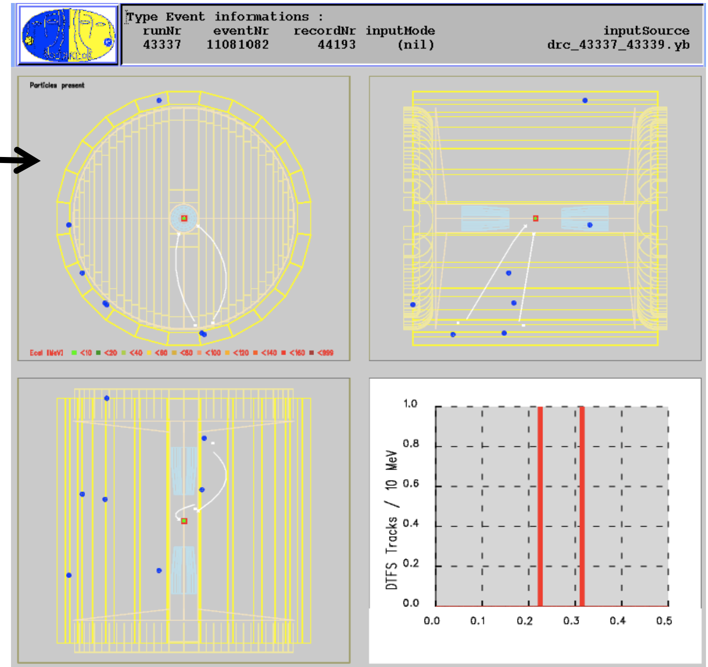


Events with both tracks sharing one associated cluster fall always in 0.15 GeV^2 – 0.25 GeV^2!!

0.20GeV^2



0.21GeV^2

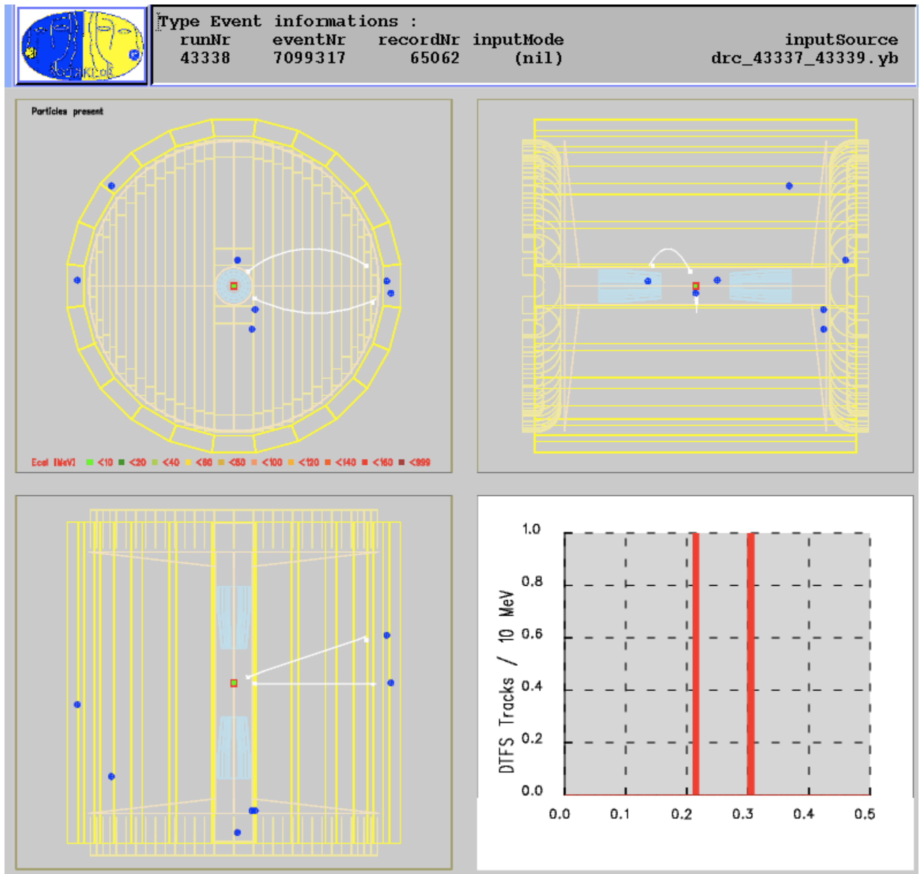


What is happening between 0.15 and 0.25 GeV^2:

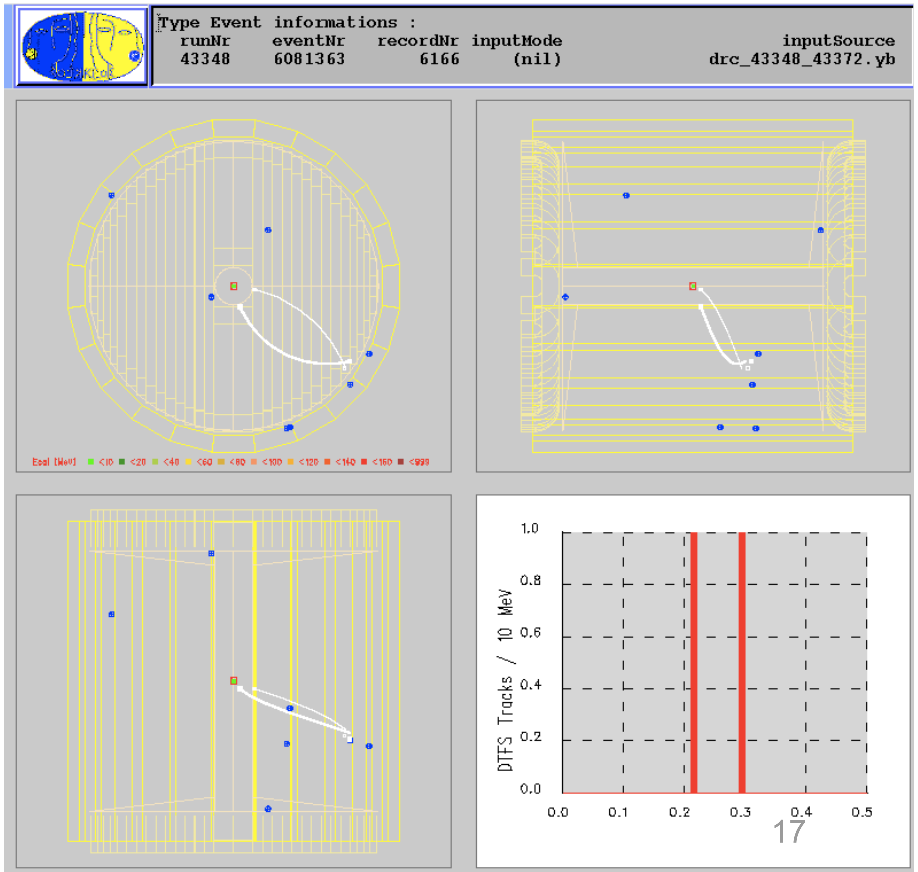
- Below 0.25GeV^2, some tracks curve in a way that their associated clusters come very close

- If the Q^2 becomes smaller, the tracks cross each other, and the distance between ass. clusters increases again

0.205 GeV^2



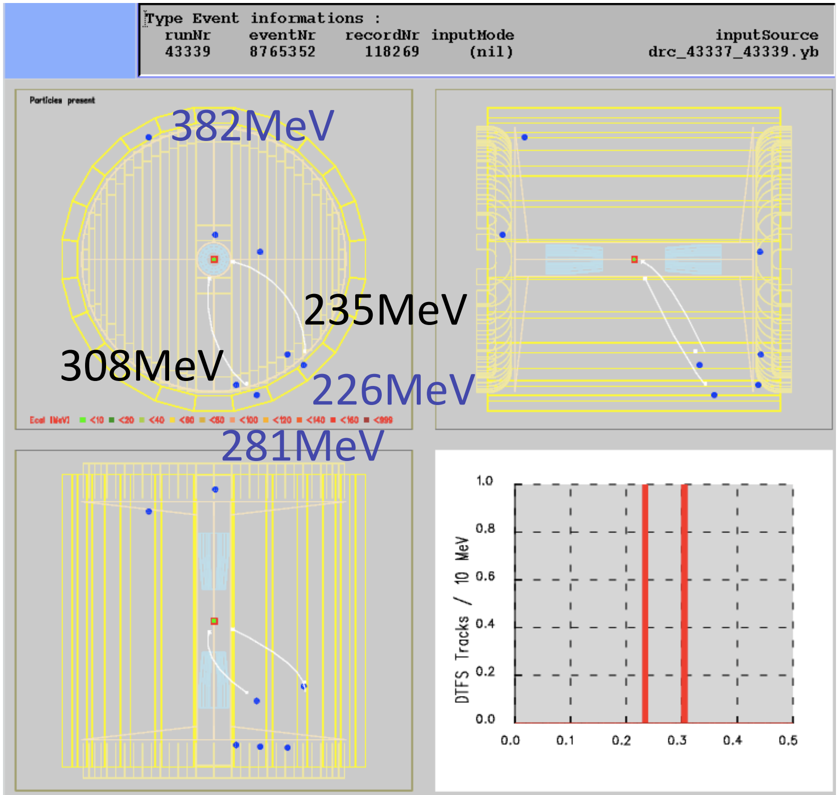
0.16 GeV^2



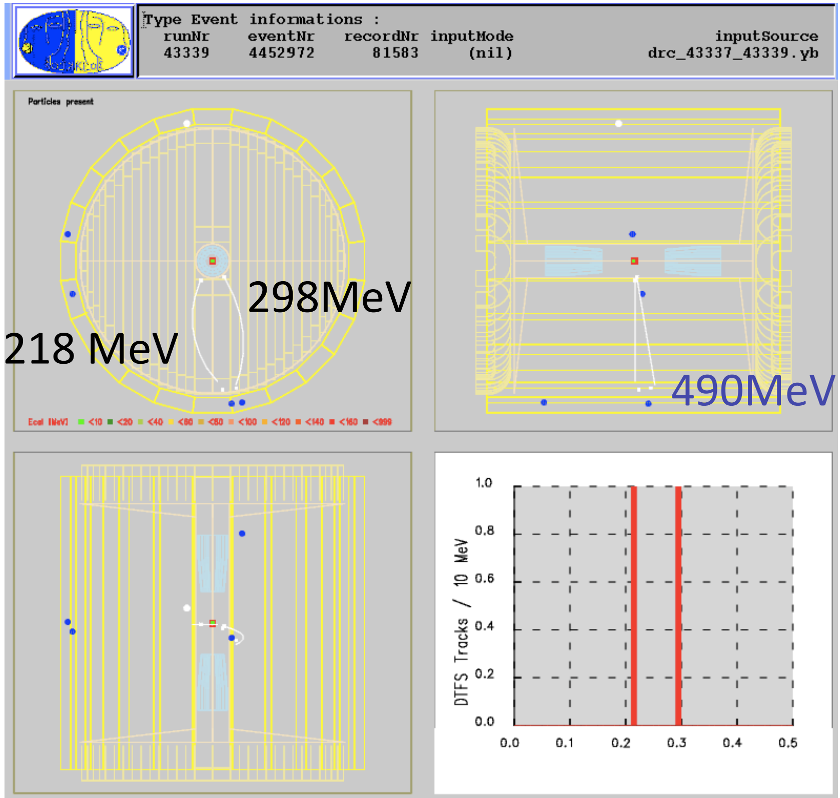
a) In most of the cases, the clusters are well separated, and could be associated to each track

b) Rarely it can happen that both tracks hit the calorimeter in the same place, creating one big cluster (about 10% of all tracks with same ass. cluster)

0.23 GeV²



0.18 GeV²



a) In most of the cases, the clusters are well separated, and could be associated to each track

The get_assclu-procedure collects all clusters with distance of 90cm around extrapolated impact point of the track, and passes this list to get_likelihood.

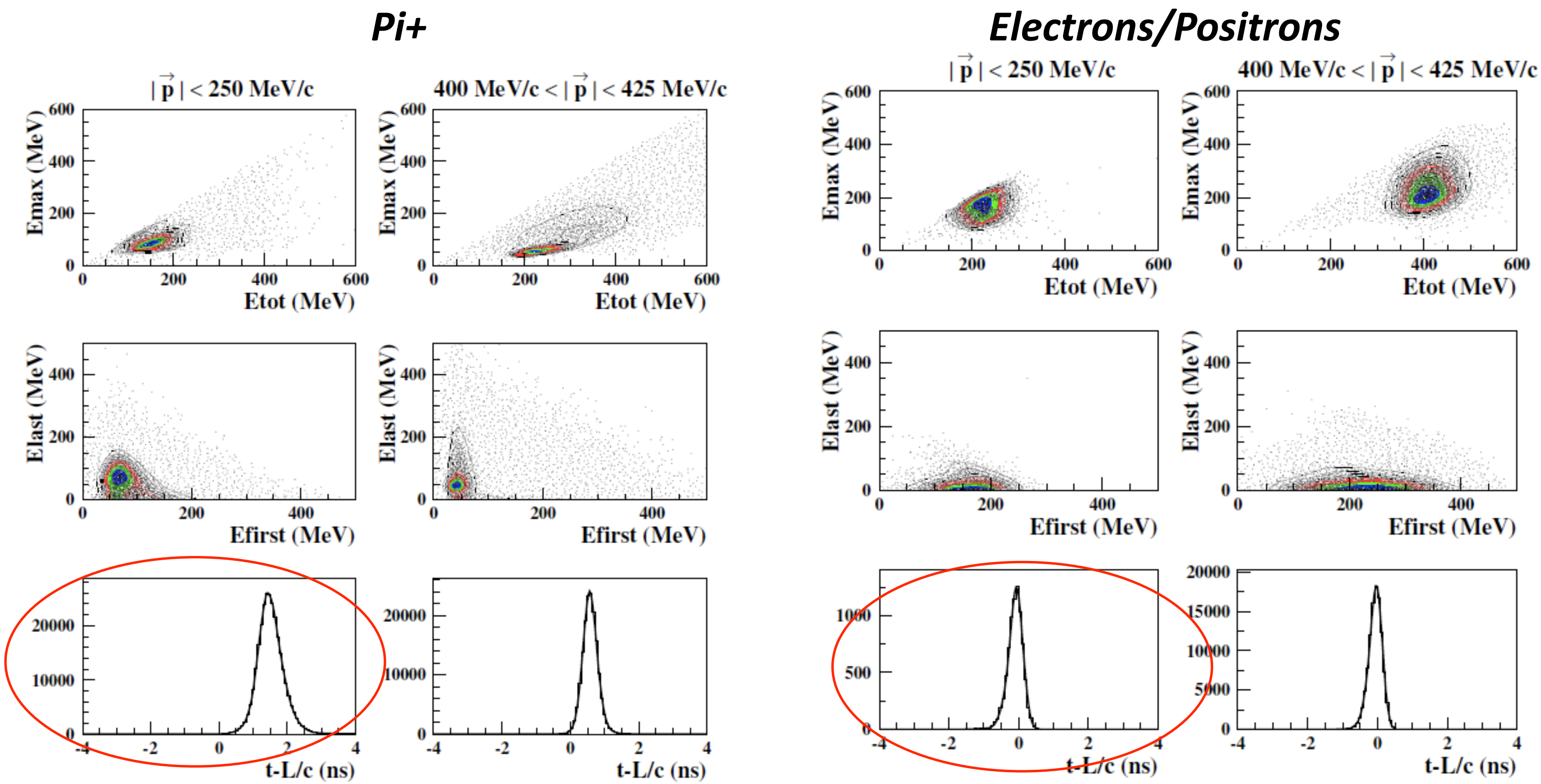
get_likelihood then takes the ***most energetic*** *of these clusters as the "linked cluster", and uses it to evaluate its input variables:*

- Etot: The total energy of the cluster;
- Emax: The maximum energy release among the five planes of the calorimeter;
- Efirst: The energy release in the first fired calorimeter plane;
- Elast: The energy release in the last fired calorimeter plane;
- DeltaT: The difference $(t - L/c)$: t is the time of the cluster, L the track length from the interaction point to the centroid of the cluster, c the speed of light.

The track with the lower energy (the lower energetic cluster) gets assigned the cluster of the other track as linked cluster, so all the Etot, Emax, Efirst, Elast are shifted to higher values for this track.

Furthermore, as the track length L used in DeltaT receives a contribution called "Clulen" (distance impact point of track to linked cluster), for this track, this contribution may be overestimated by up to 90cm, leading to a shift in DeltaT of -3ns!!!

Likelihood reference distributions for pions and electrons:
(Barbara's thesis, p. 54-56)

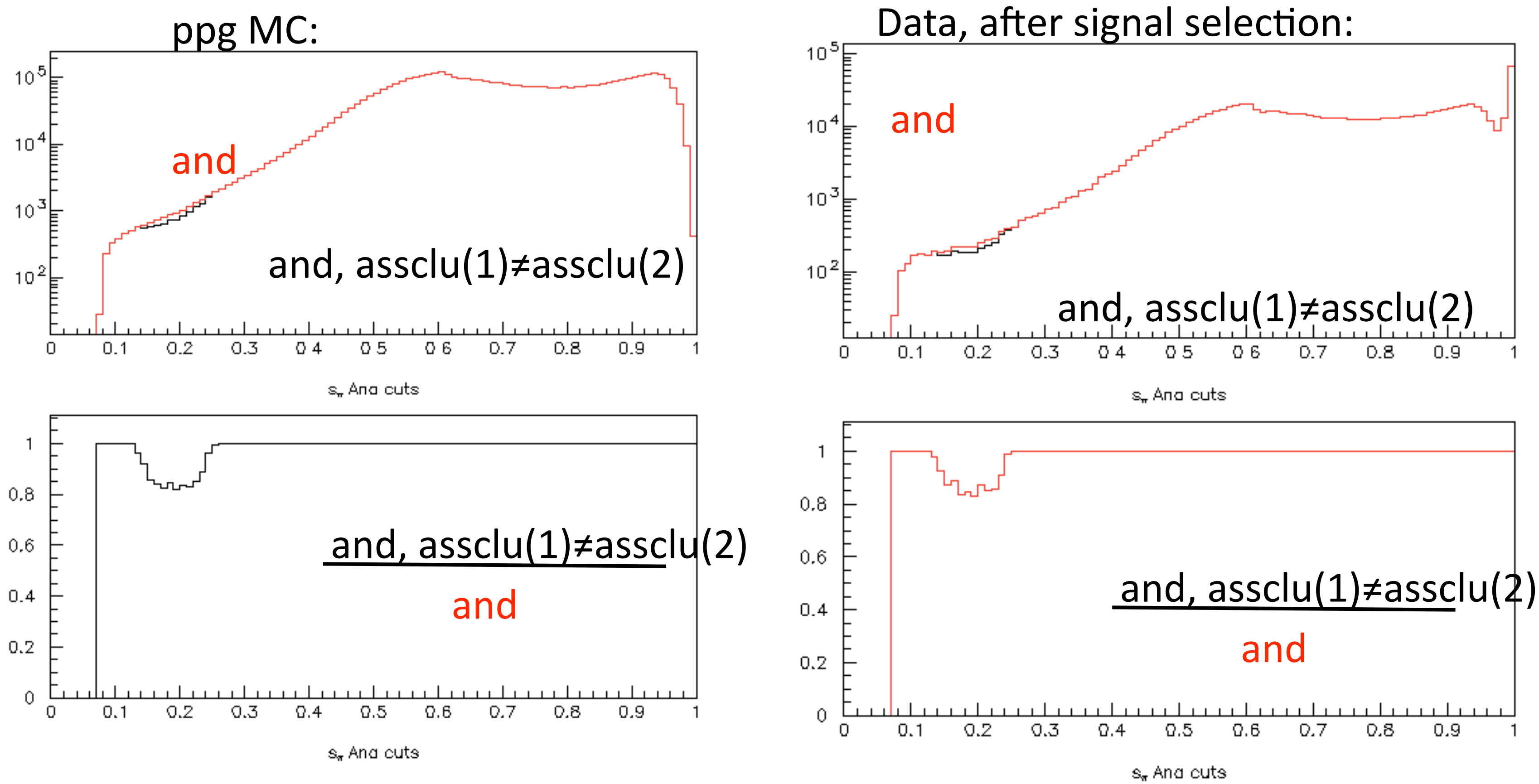


The shift of up to -3ns moves the DeltaT-value of the track with the wrong linked cluster towards a value for electron/positrons, resulting often in a negative logrl!

➔The .and. selection condition fails!!

(effect on .or. is much smaller, since there is always one track with the correct cluster ass.!)

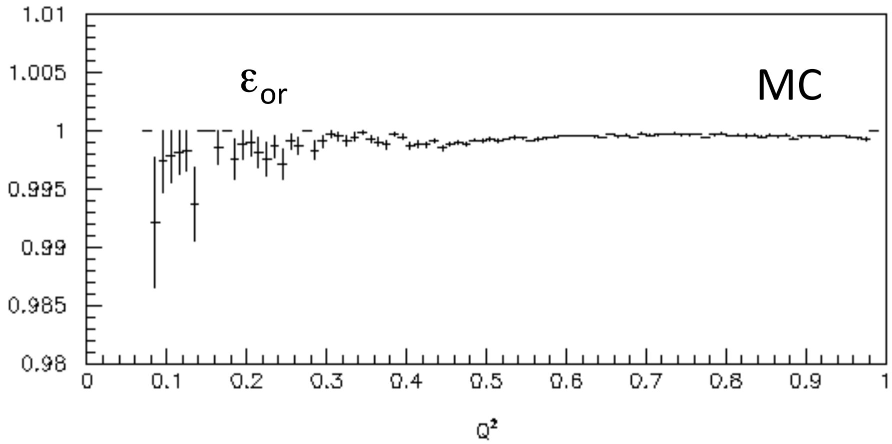
Possible solution: Take out all events which have assclu(1)=assclu(2)



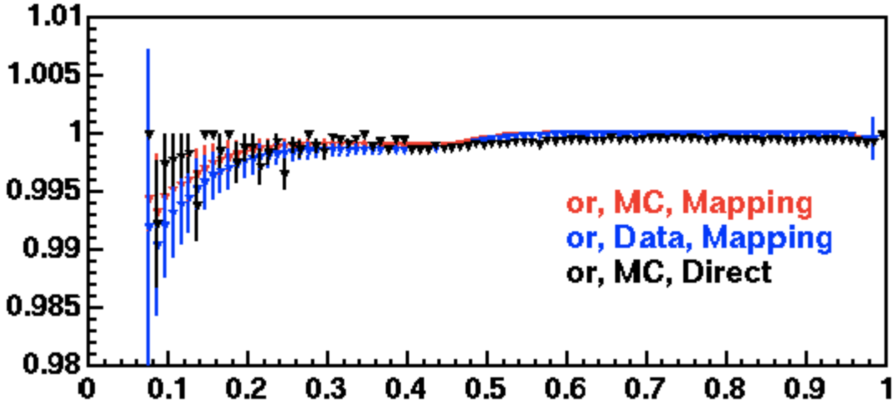
- Affects really only a small region between 0.15 and 0.25 GeV^2, and only about 20% of the statistics in this region

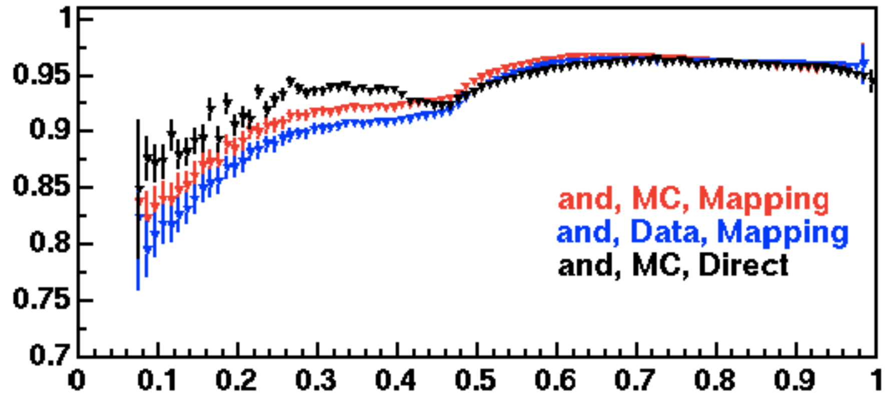
- Effect seems to be well reproduced by MC

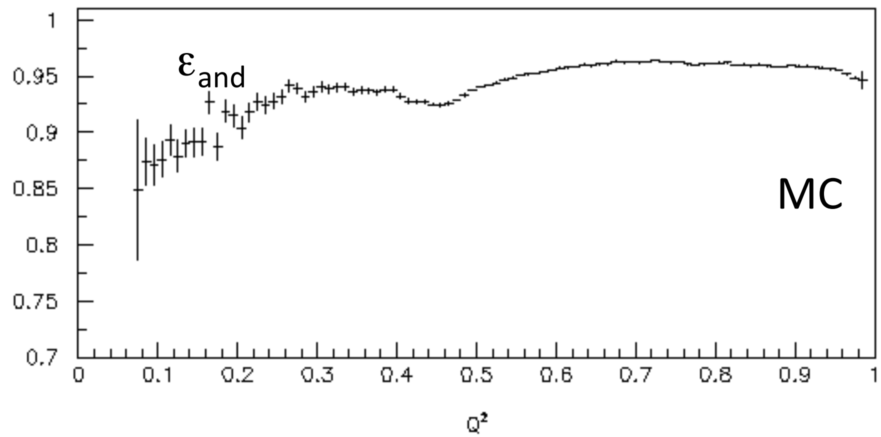
Taking out the events with assclu(1)=assclu(2), the likelihood efficiencies from **the direct MC method** do not show a particular behavior anymore in the region 0.15-0.25 GeV^2:



Also the likelihood efficiencies from **the direct MC method and the Mapping Method** now look more similar, although the direct method is larger below 0.45 GeV^2 -> to be understood!







However, it has been proven that the origin of the dip in the direct method was a physical effect due to the overlapping cluster ass. radii of the two tracks.

LIKELIHOOD Conclusions:

• If two tracks have clusters in the calorimeter close to each other, the likelihood will take the most energetic one of the clusters for both of them, resulting in a wrong cluster ass. for one of the tracks

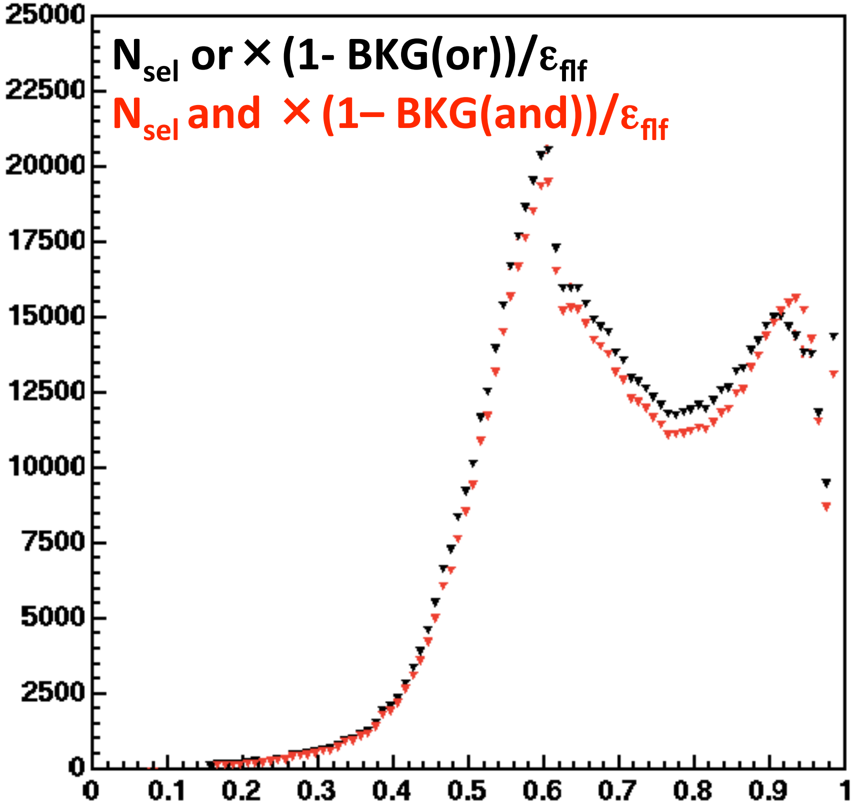
• This affects the DeltaT-variable in the likelihood evaluation, as a part of the track length gets overestimated (the distance between extrapolation point and linked cluster), moving the logrl-value for this track towards negative values.

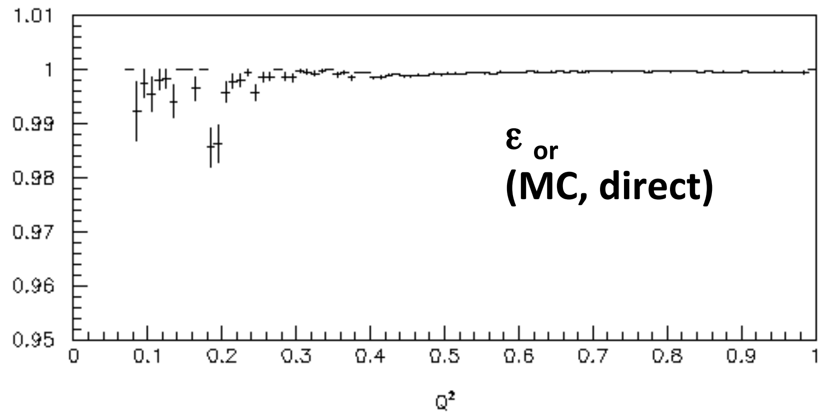
• If both tracks hit the same cluster, while the energy is too large in this cluster, the timing and the track length are correct, so for this (rare) class of events, the drop in likelihood efficiency is small

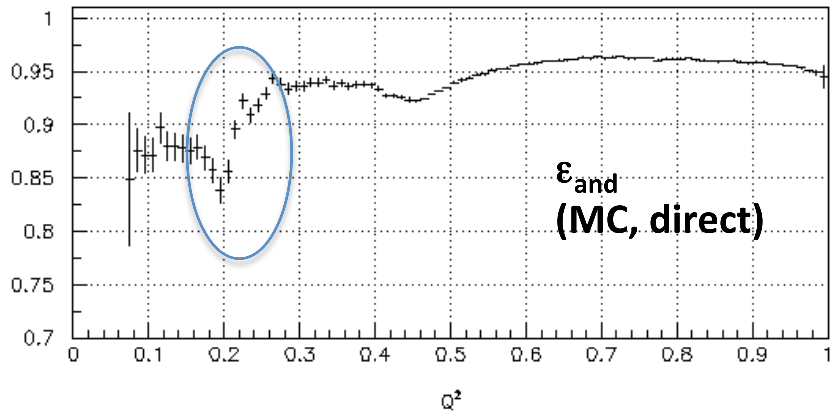
• Lowering the cluster association radius to 60cm (from 90cm) would reduce the effect to about half, but it would still be present.

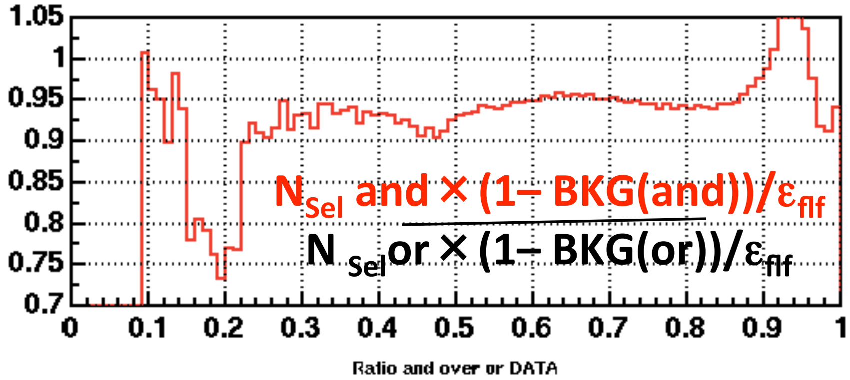
• A next step could be to perform the analysis as a cross check rejecting events with assclu(1).ne.assclu(2)

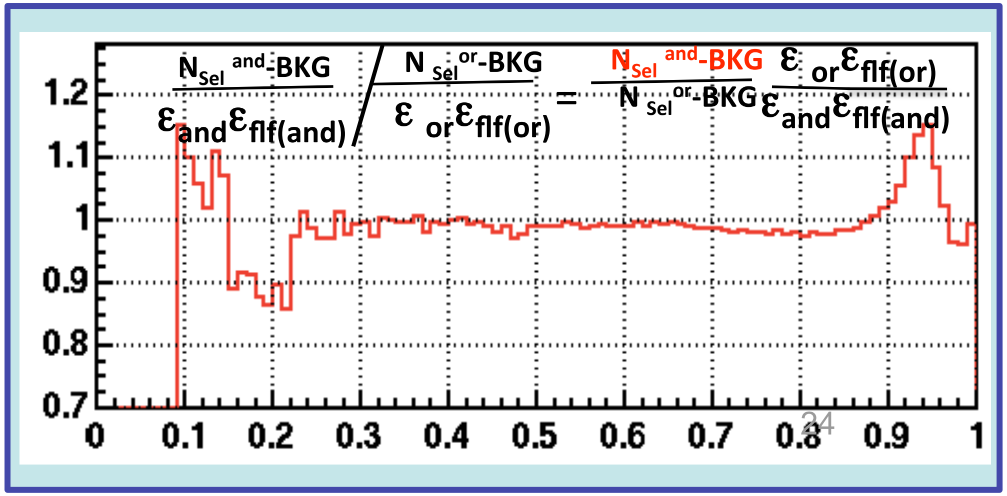
Likelihod efficiency: Direct method from Monte Carlo (division of two histograms)









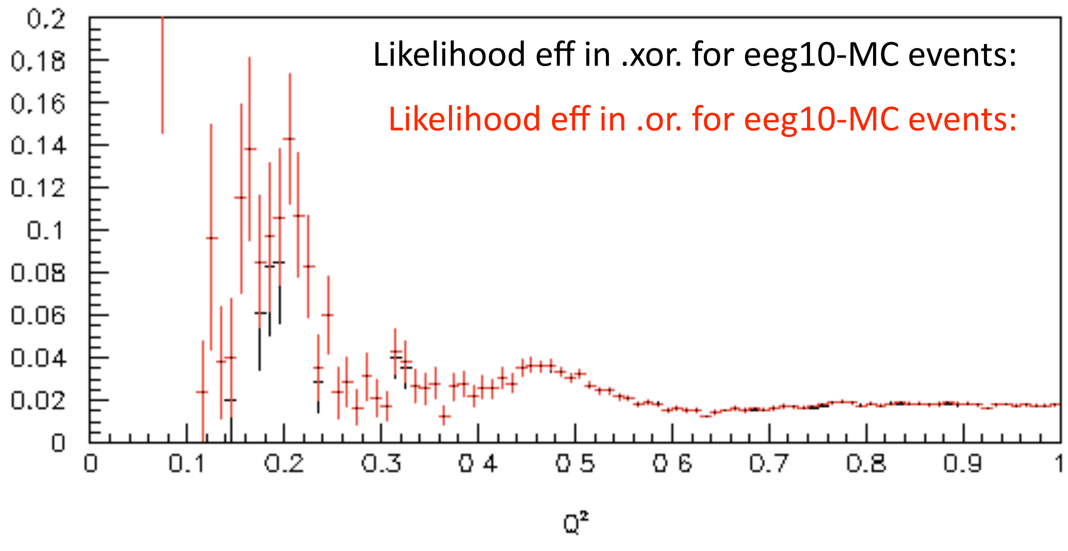


ε_{flf} identical for .or. and .and. selected samples -> background responsible for the hole?

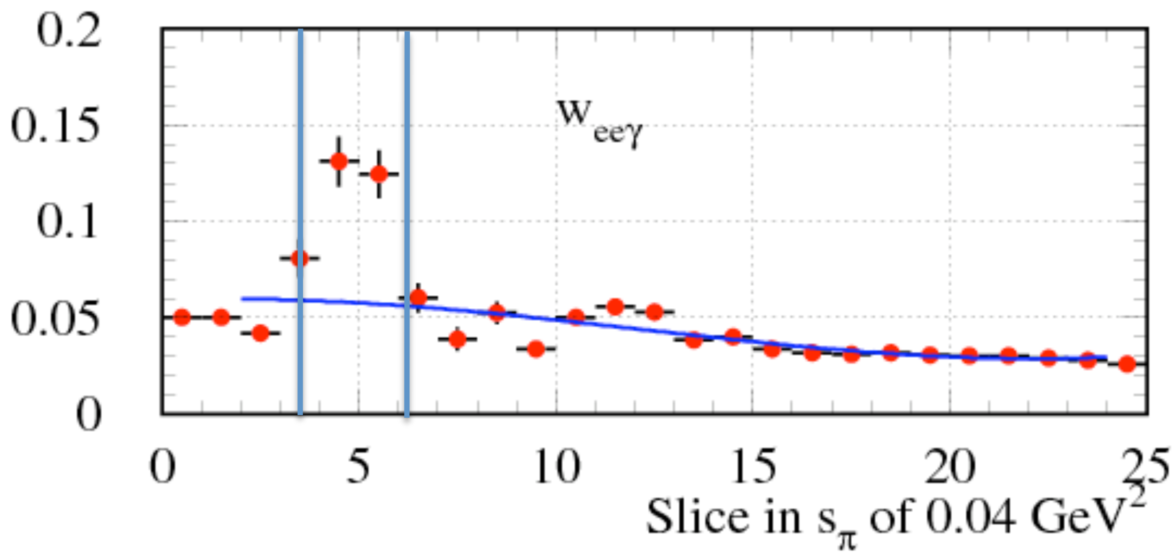
Background subtraction:

In the first step of the background subtraction procedure, a data sample selected with the
.xor. of the likelihood (1 track e, 1 track π)
is fitted with a data sample selected with the
.nor. of the likelihood (both tracks e)
plus additional MC samples from $\pi\pi\gamma$, $\mu\mu\gamma$ and $\pi\pi\pi$

From this one obtains the weights to be applied to the eeg-sample, which can be used also for the data selected in the **.or.** criteria of the likelihood (at least 1 track π), since the likelihood efficiency for eeg events is identical for .or. and .xor. selected events:

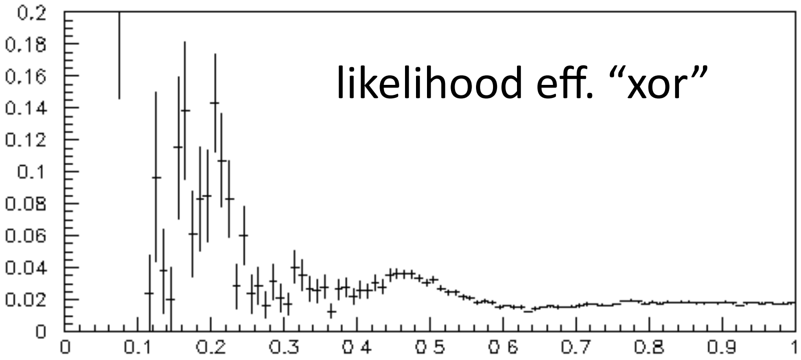


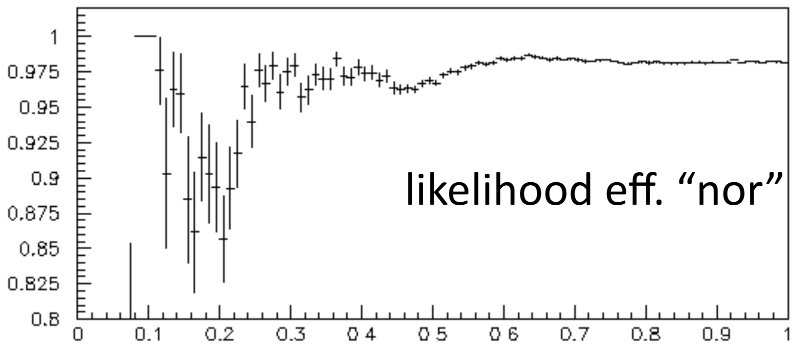
However, the resulting weights show a strange behavior around 0.15-0.25 GeV^2:



In the fit, the value obtained by the blue-line-smoothing-fit is used, and the difference between the blue line and the red points is taken as a contribution to the systematic error.

But the weights represent not only a normalisation factor, but also a change in efficiency between the fitted sample and the sample used to fit it. Evaluating the likelihood for eeg events for the .xor. and the .nor. case yield:

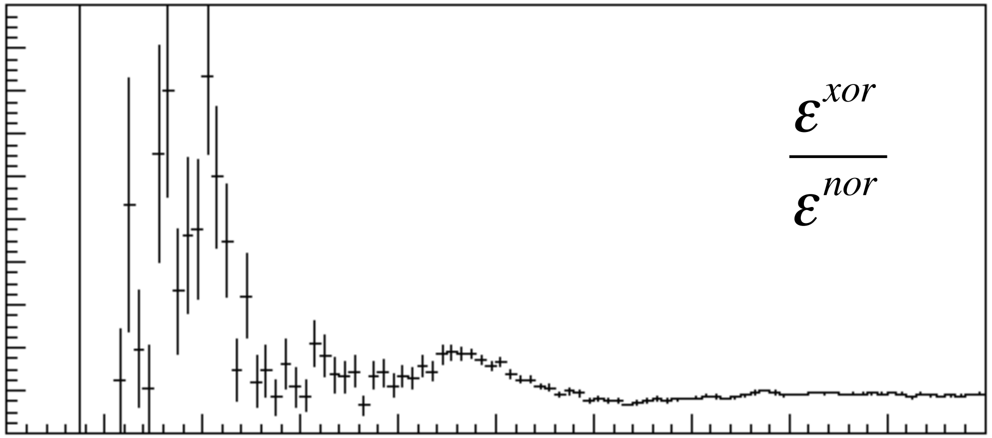




As the sum of the .nor. and .xor. selected samples contains all eeg events, the sum of the two efficiencies has to be “1.” in each bin of s_π

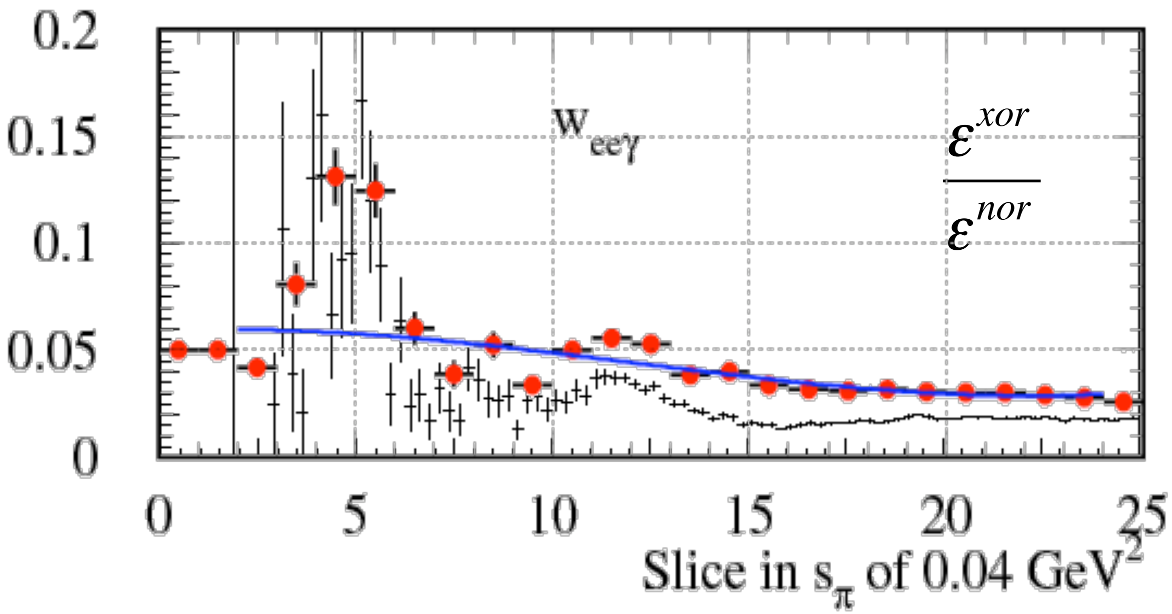
In the fitting procedure, the weights should thus be proportional to the ratio of the two efficiencies (k takes into account additional effects):

$$N_{ee\gamma}^{xor} = k \cdot \frac{\varepsilon^{xor}}{\varepsilon^{nor}} \cdot N_{ee\gamma}^{nor}$$



In the fitting procedure, the weights should thus be proportional to the ratio of the two efficiencies (k takes into account additional effects):

$$N_{ee\gamma}^{xor} = k \cdot \frac{\varepsilon^{xor}}{\varepsilon^{nor}} \cdot N_{ee\gamma}^{nor}$$



Even if the agreement between the weights and the ratio of efficiencies is not fully perfect, taking the blue line instead of the red points in the region between 0.15-0.25 GeV^2 will not give the correct result in the background subtraction.

The effect of this on the total spectrum has still to be evaluated...w.i.p.

Also how exactly the correlation between tracks affects the likelihood efficiency in the eeg case has yet to be understood.

Conclusions:

- FILFO efficiency and its systematic uncertainty has been reevaluated using a polynomial fit with larger binning below 0.4 GeV^2
- A tighter cut in Ω has been chosen to reduce the amount of residual background (mostly $\pi\pi\pi$ events), needs to be implemented in the analysis
- Background to VLAB selection in 2006 has been evaluated by Federico, checks on the acceptance in progress
- The π/e likelihood in the .and. configuration has been studied, some correlations between tracks have been found when both tracks have overlapping cluster ass. radii
- A similar effect was found in the first step of the background subtraction procedure, leading to a “peak” in the eeg-weights between 0.15-0.25 GeV^2