Study of the systematics of the $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ measurement

B. Valeriani for the $\pi^+\pi^-\gamma$ group

- Our efforts have been concentred on the study of:
  1) **Geometrical acceptance;**
  2) **Efficiencies;**
  3) **Background ($e^+ e^- \gamma$, $\mu^+\mu^-\gamma$, $\pi^+\pi^-\pi^0$);**
  4) **Machine background and reconstruction effects;**
  5) **Resolution effects and unfolding;**
  6) **Luminosity (see talk of A. Denig).**

- The following studies have been performed on **134 pb^{-1}** from the **2001** statistics.

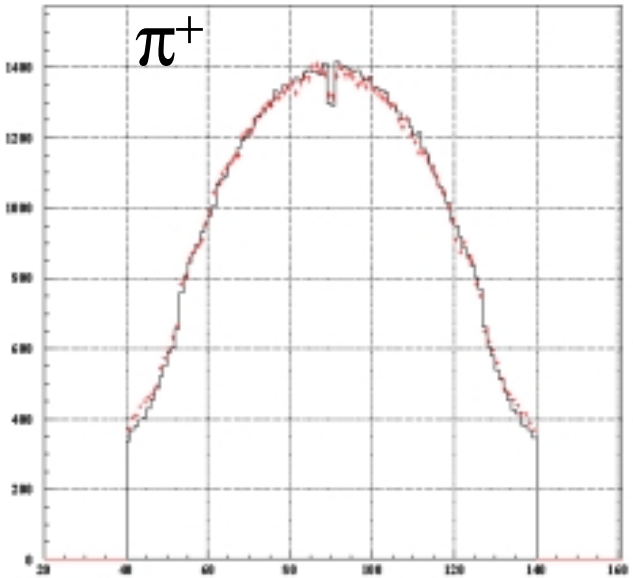
Acceptance studies

The geometrical acceptance corresponding to the cuts $40^o < \theta_\pi < 140^o$, $\theta_\Sigma < 15^o$-$\theta_\Sigma > 165^o$ must be evaluated using MC.

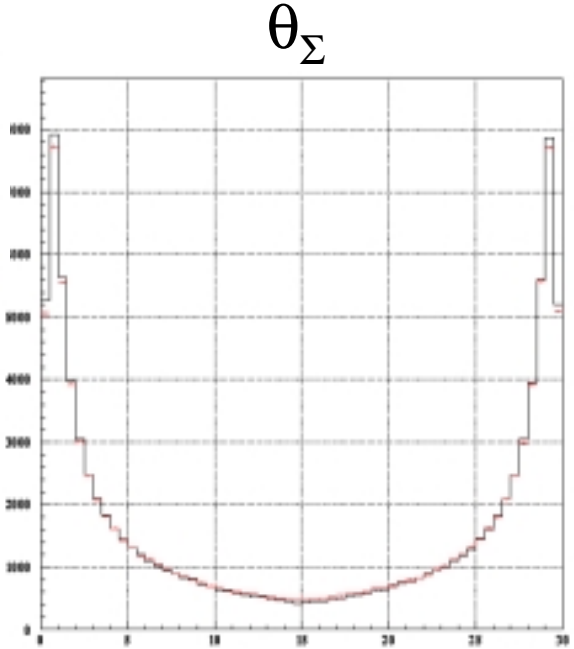
The polar angle distribution of π^+ and π^- and the θ_Σ distribution have been compared with the MC ones.

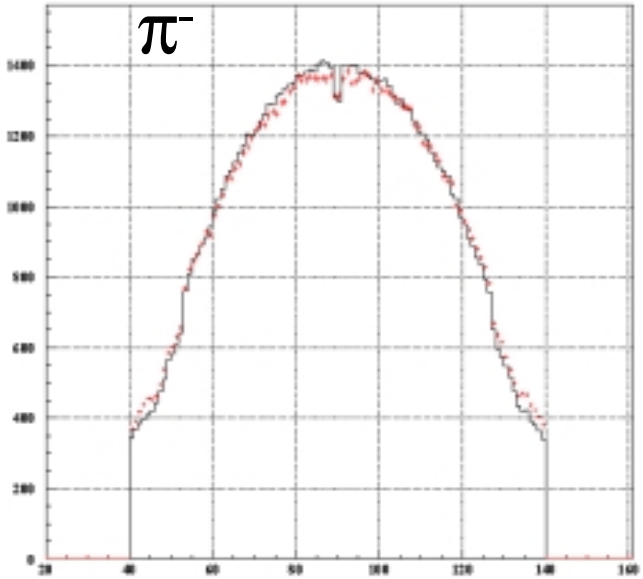
- Events have been selected by the AND of the Likelihood, in order to reject completely any contribution from Bhabha events.
- The expected contributions from $\mu\mu\gamma$ and $\pi^+\pi^-\pi^0$ have been added to the MC distributions.
- A precise evaluation of the selection efficiency for data, necessary to get a more realistic MC-DATA comparison, is still going on.

DATA-MC comparisons



Polar angle





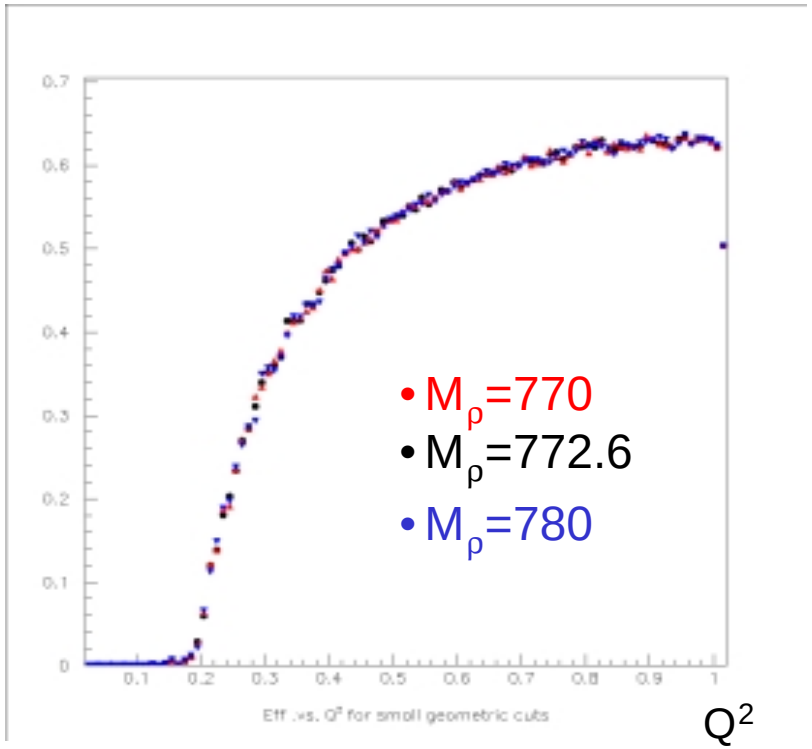
Polar angle

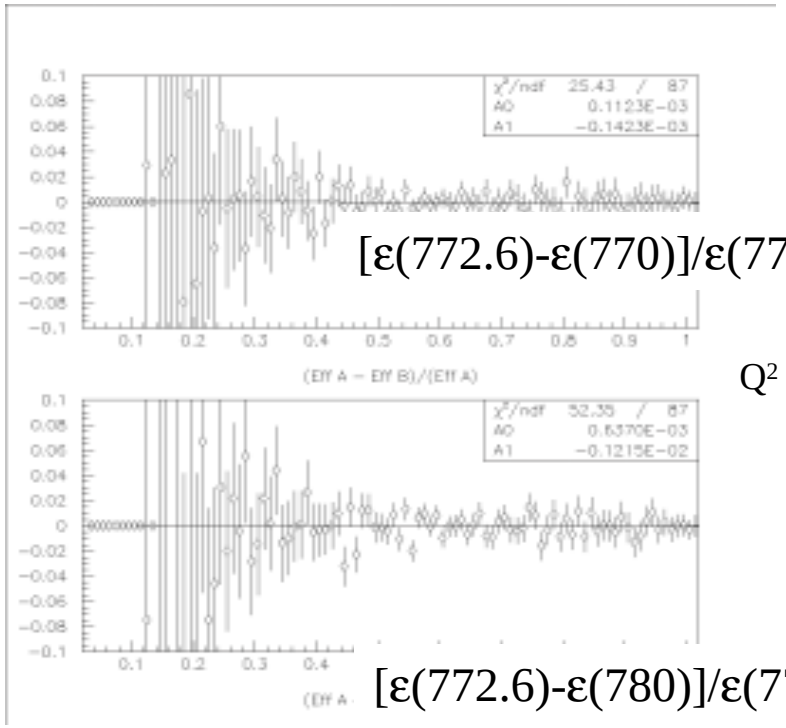
--- Mc

• Data

Acceptance studies

The dependence of the acceptance on the **ρ-ω parameters** used in the MC generation has also been studied.





No dependence has been observed.

Trackmass efficiency and background studies

The trackmass variable is used to separate signal events from $\mu\mu\gamma$ and $\pi^+\pi^-\pi^0$ events.

The trackmass cut efficiency has been so far evaluated using MC.

A cut on the trackmass is already applied at the level of the Event Classification to discriminate between charged radiative decays and $\pi^+\pi^-\pi^0$ events.

In order to study the same efficiency using DATA, a subsample of events, not affected by the mentioned cut, has been selected.

Study of the backgrounds

$e^+e^- \rightarrow \mu^+\mu^- \gamma$, $e^+e^- \rightarrow \pi^+\pi^-\pi^0$

A problem in the evaluation of the trackmass cut efficiency is represented by the background contamination.

On the other side the trackmass distribution can be used to evaluate the background contribution to the Q^2 spectrum of the signal.

The shape of the distribution for background events can be obtained using MC and fitted to data in order to extract the background contamination in a given Q^2 region.

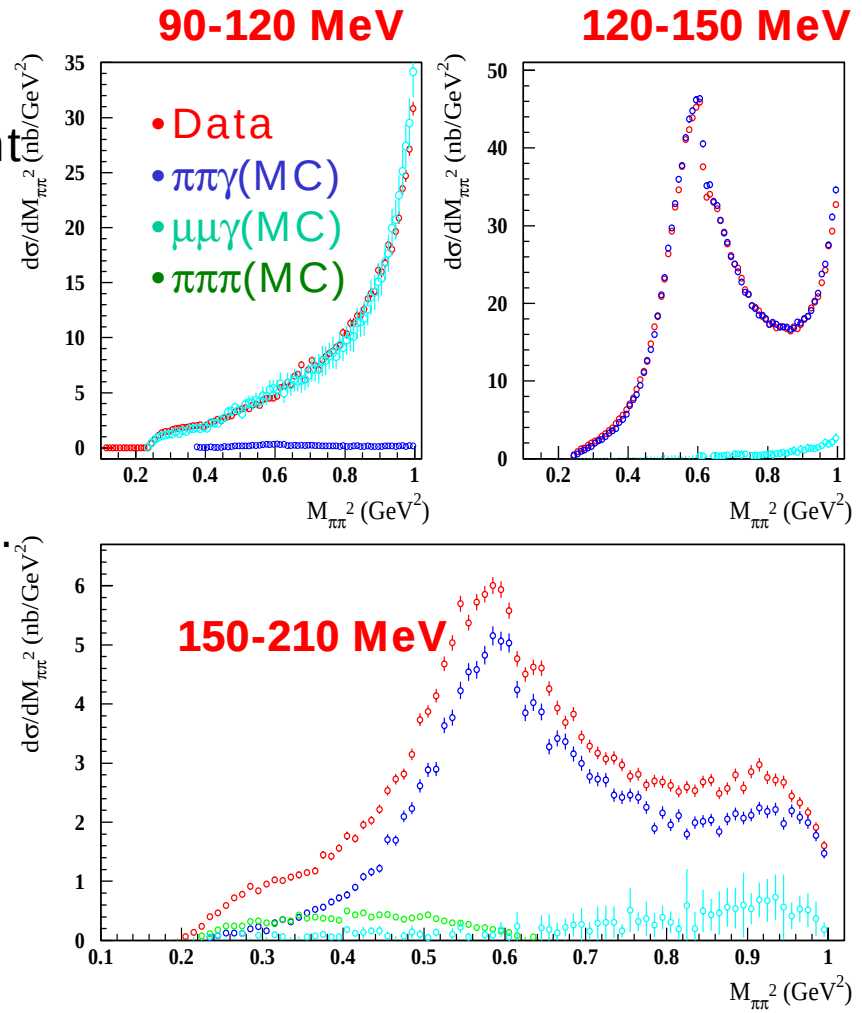
DATA-MC comparison

The contribution of signal and background to the Q^2 spectrum has been evaluated using MC for different trackmass region.

Efficiencies have been assumed to be the same for MC and DATA: only the cosmic veto efficiency on $\mu\mu\gamma$ has been evaluated using SELCOS events.

MC $\pi\pi\gamma$ and $\pi\pi\pi$ have been normalized to the expected cross sections.

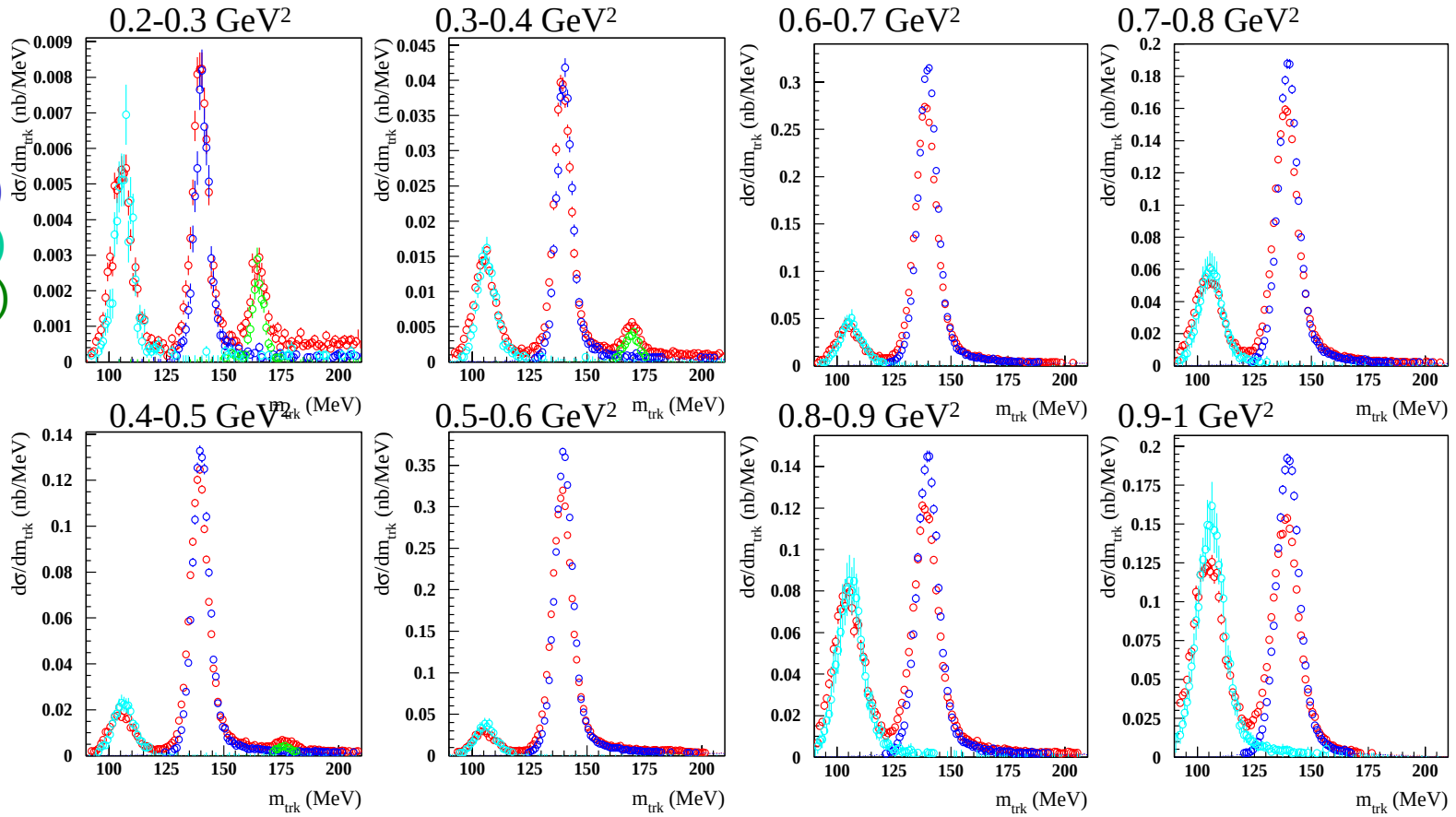
The first trackmass slice (90-120 Mev) has been used to find the normalization for $\mu\mu\gamma$ events.



DATA-MC comparison

For 8 different slices of Q^2, between 0.2 and 1 GeV^2, the experimental trackmass distribution has been compared with the one obtained using MC.

- Data
- $\pi\pi\gamma$(MC)
- $\mu\mu\gamma$(MC)
- $\pi\pi\pi$(MC)

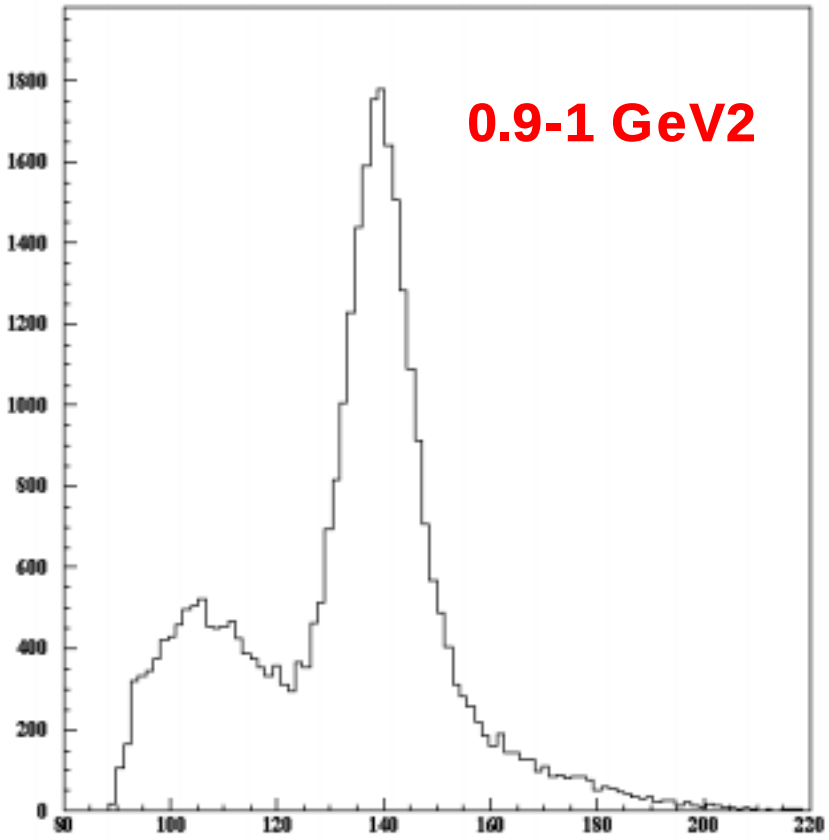


Study of the $e^+e^- \rightarrow e^+ e^- \gamma$ background

Signal events are separated from radiative Bhabhas by a Likelihood function.

After the selection, a residual contamination of Bhabha events is expected.

This contamination will contribute to the Q^2 spectrum in particular at large Q^2 values, where the initial electron population is larger.

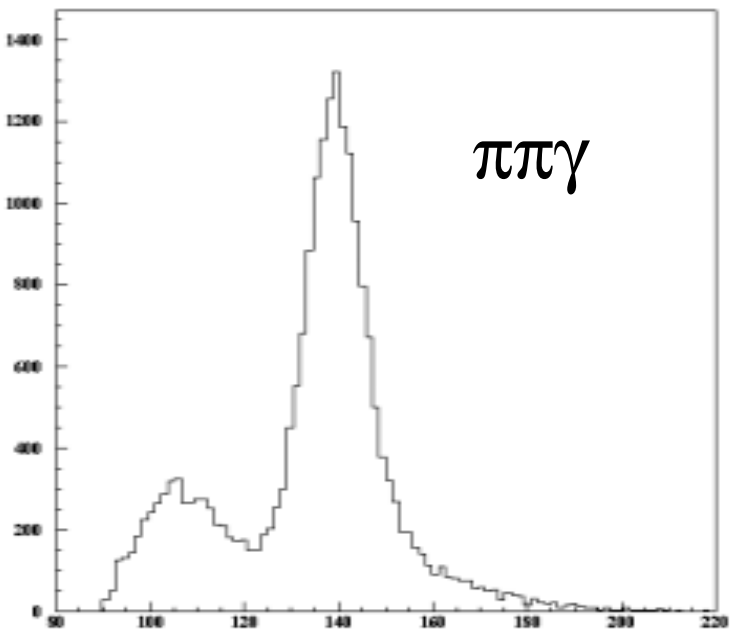


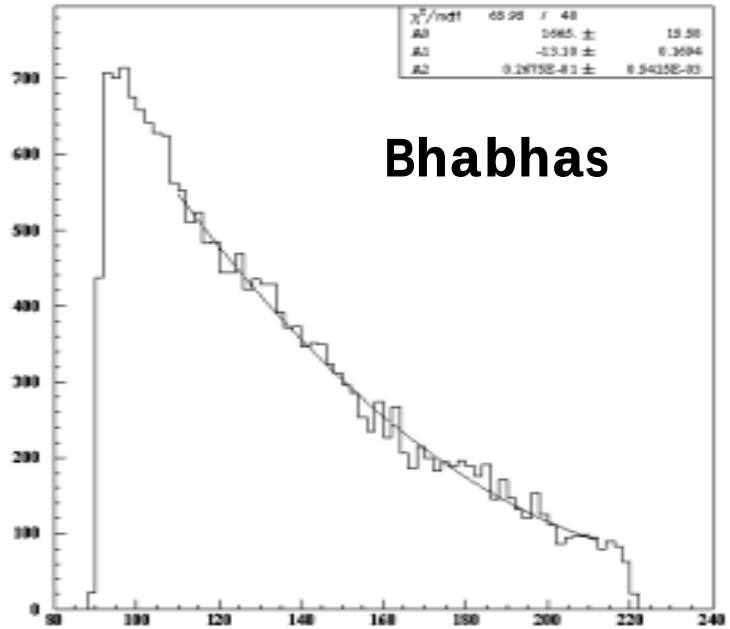
Trackmass distribution

Expected trackmass distributions for signal and background

For each bin of Q^2, we find the shape of trackmass distribution for signal and background:

- **SIGNAL**: both tracks must be selected as pions by the Likelihood function
- **BACKGROUND**: both tracks must be selected as electron tracks





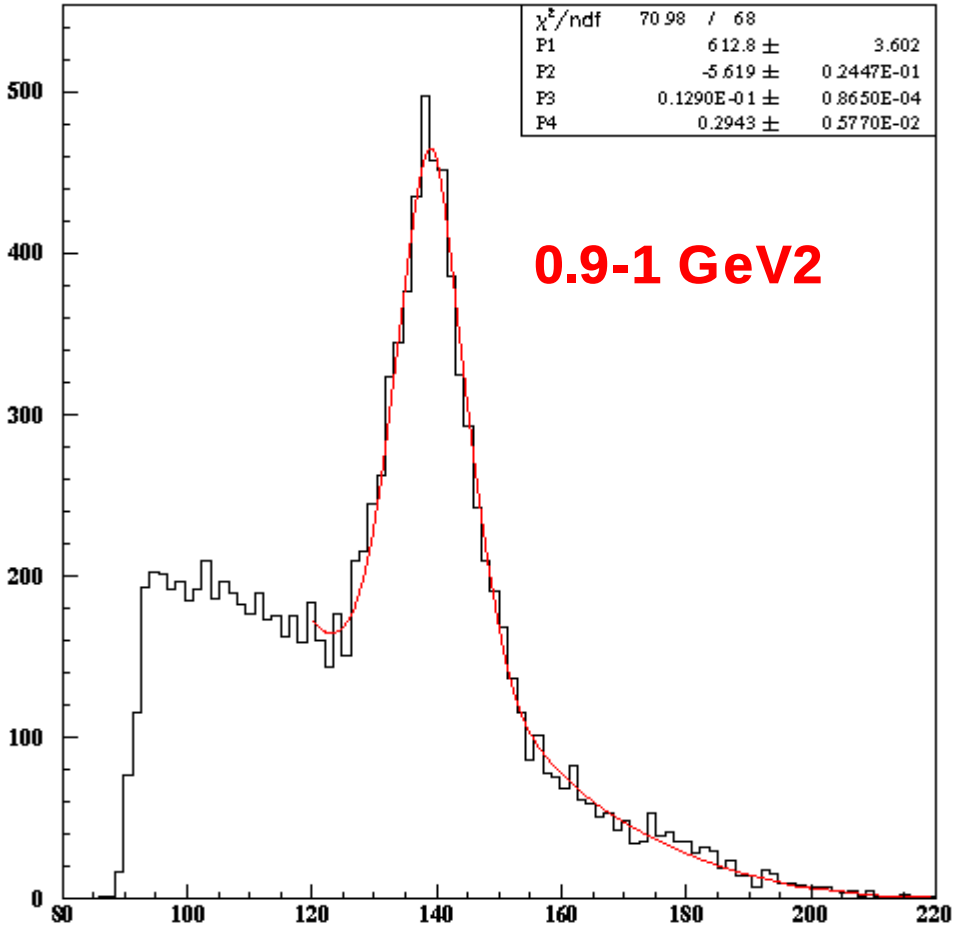
Study of the $e^+e^- \to e^+ e^- \gamma$ background

For each bin the sum of the two distributions has been fitted to DATA.

Background contamination found:

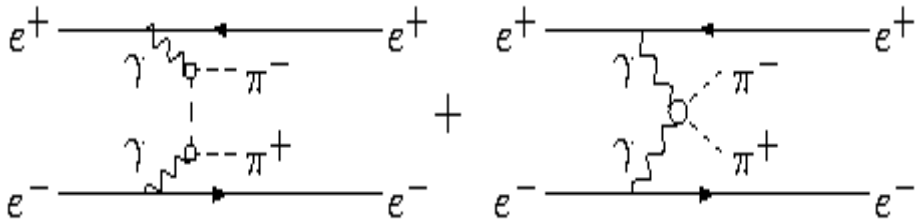
0.9-1 GeV^2	4.1%
0.8-0.9 GeV^2	3.5%
0.7-0.8 GeV^2	1.5%
0.6-0.7 GeV^2	0.3%

The precision of this evaluation is better than 10%.

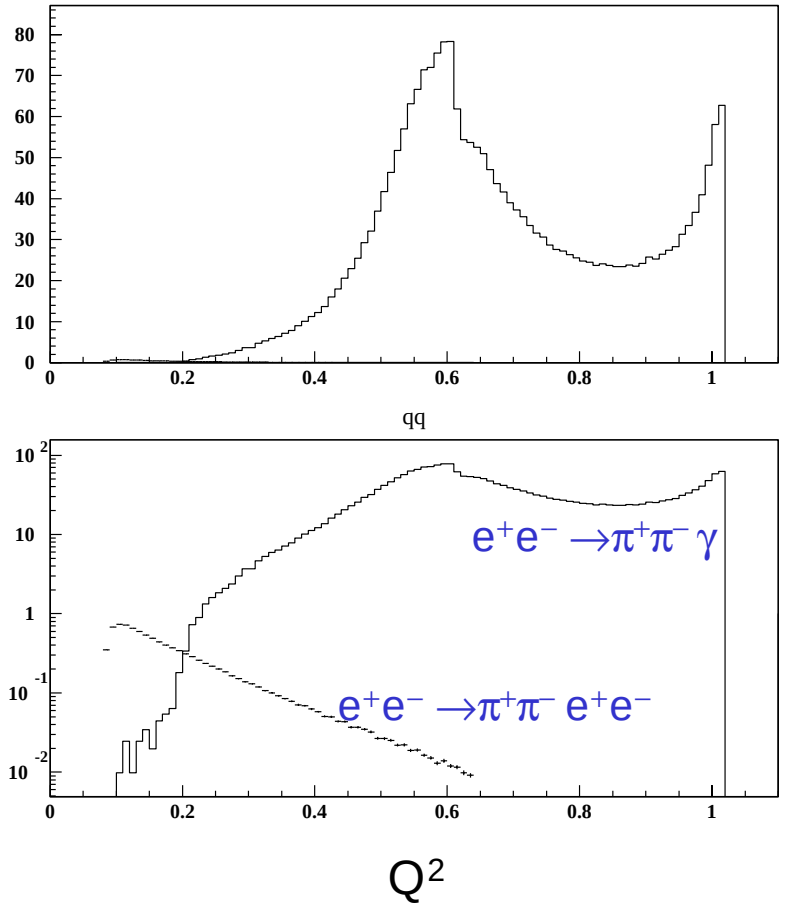


Study of the background $e^+e^- \rightarrow \pi^+\pi^- e^+e^-$

This process could represent a background for our analysis if electron and positron go along the beam pipe.



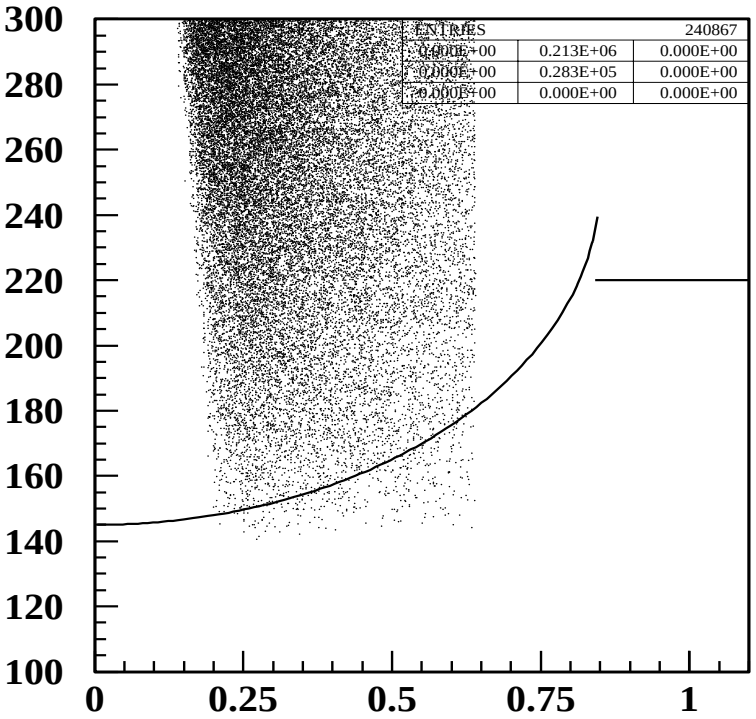
From MC (old MC generator from F. Anulli), we expect a background contribution at low Q^2 values.



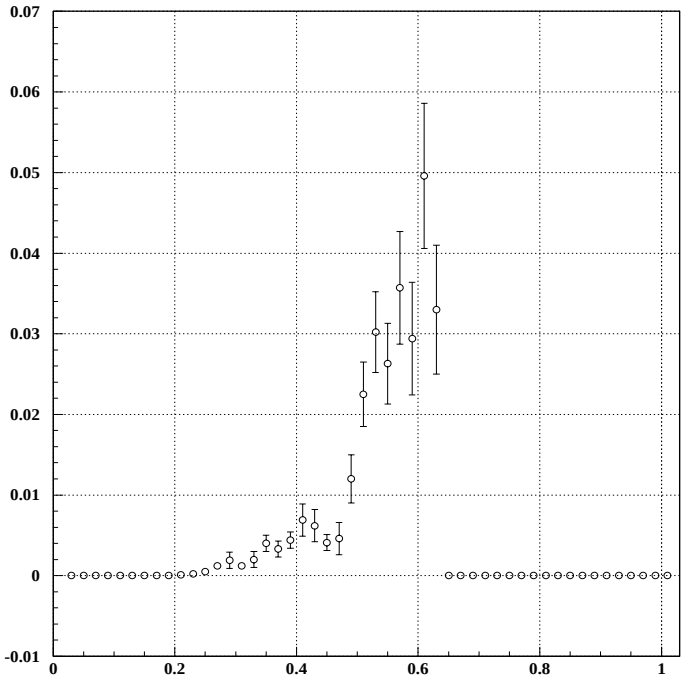
Q^2

Trackmass efficiency on $e^+e^- \rightarrow \pi^+\pi^- e^+e^-$

The background is completely rejected by the trackmass cut.



Trackmass vs Q^2



Trackmass efficiency

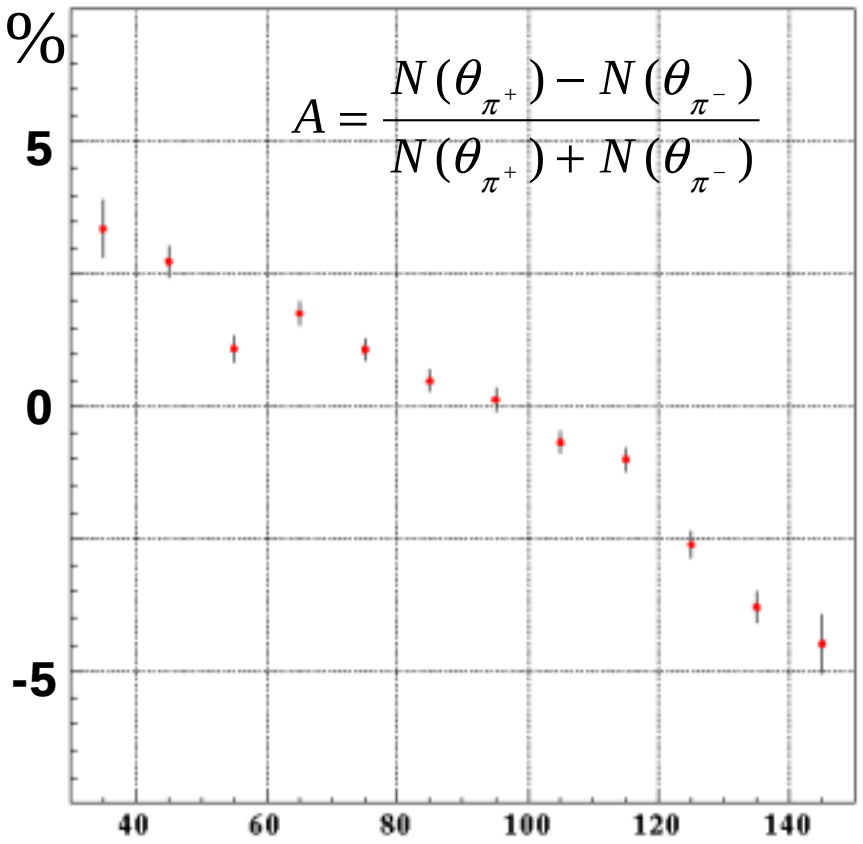
Additional background (?)

After all corrections, we observe an asymmetry in the π^+ , π^- angular distribution.

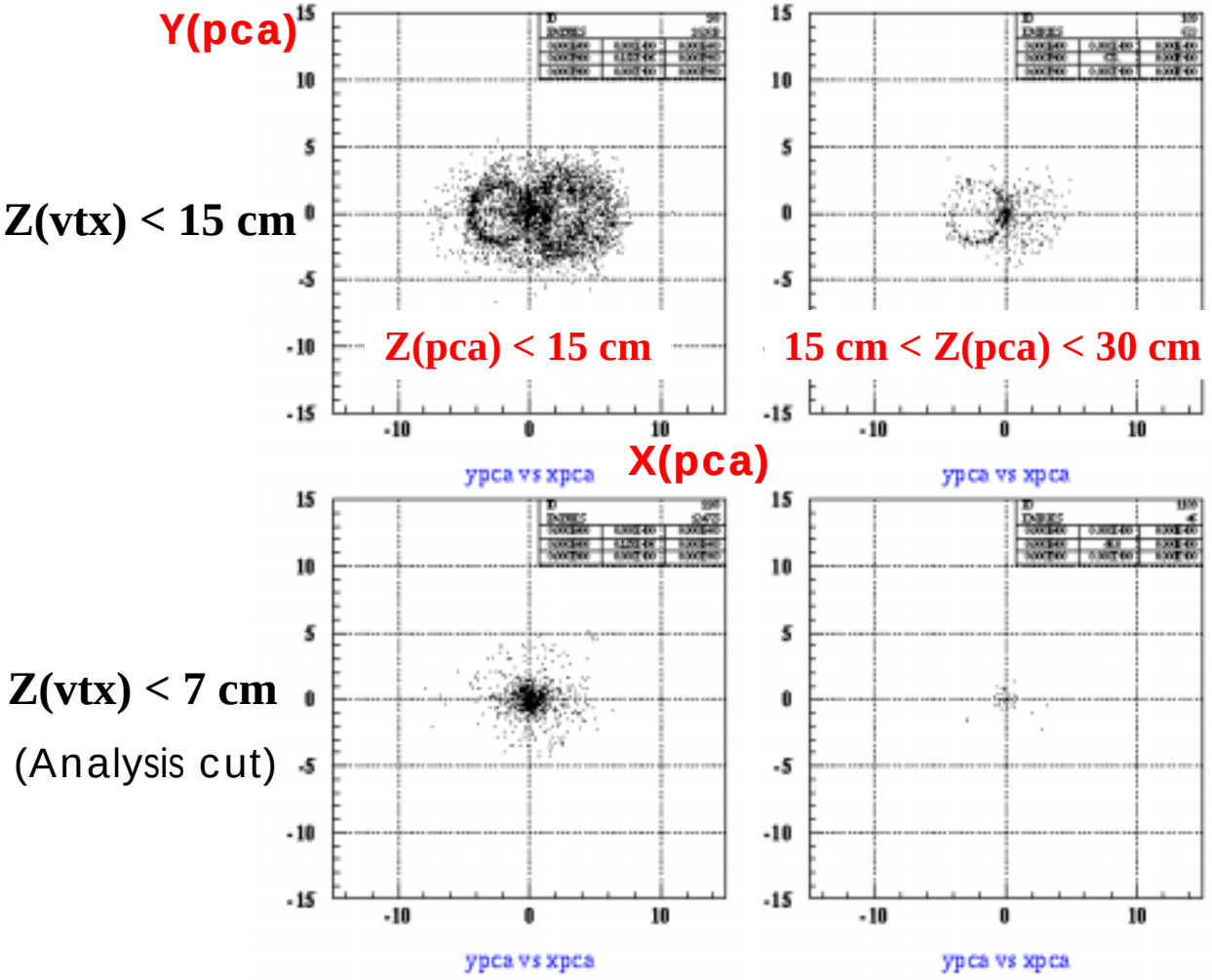
No such asymmetry is expected from MC. Possible additional background?

We have investigated the following possibilities:

- Machine background
- Reconstruction problem
- FSR contribution
- Physics background contributions



Machine background



Relaxing the cut on Z(vtx) we observe the bckg due to interactions on the beam pipe.

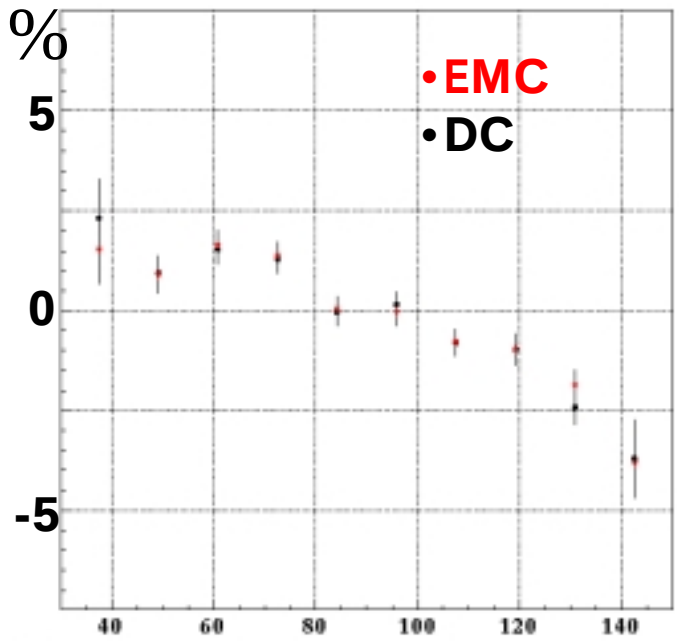
No such bckg is observed applying the standard analysis cut Z(vtx)<7cm .

We have also looked at the First Hit position, but no systematics effect has been observed

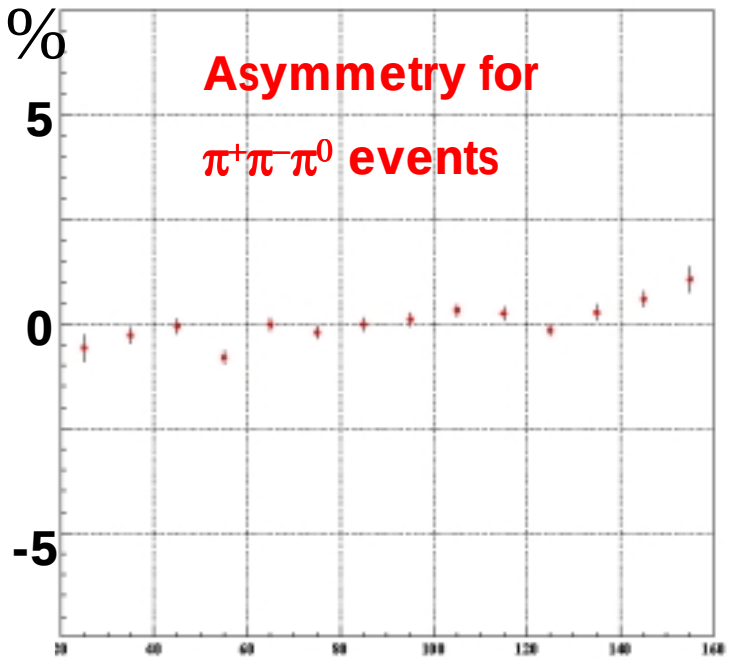
Reconstruction effect?

In order to see whether the asymmetry is due to a reconstruction problem, some further checks have been done.

- A similar asymmetry can be observed in the polar angular distribution of the associated clusters:



- $\pi^+\pi^-\pi^0$ events don´t show the same problem:



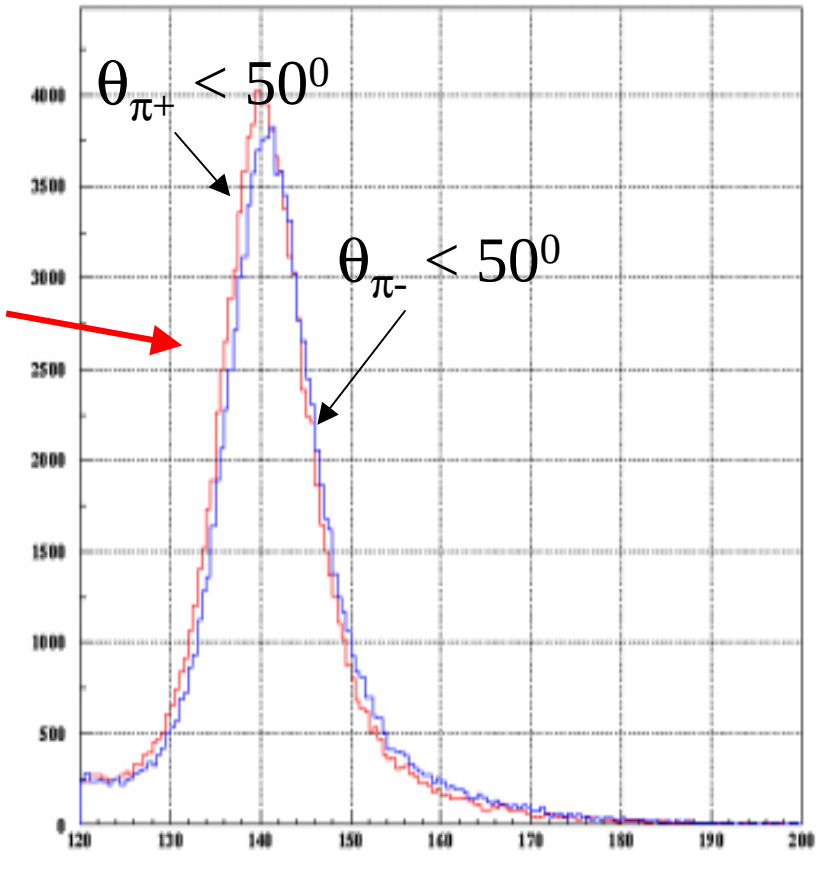
Reconstruction effects in the trackmass efficiency

The central value of the trackmass distribution seems to be affected by the kinematics of the event.

The effect can be seen by selecting a region in the π^+ or π^- polar angle distribution.

The relative shift changes with the pion polar angle: for pions in the barrel, the two distributions look the same.

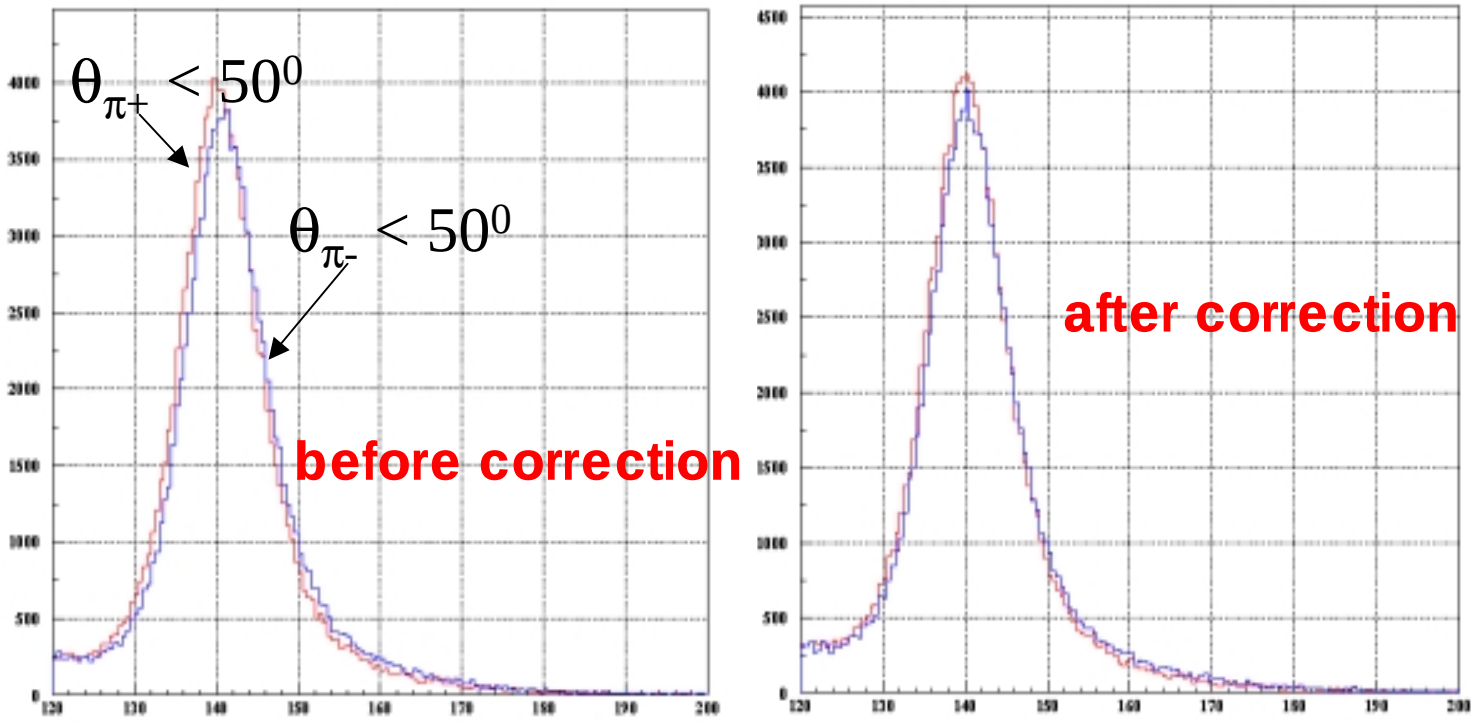
The effect could be caused by a recostruction problem.



Reconstruction effect?

The following correction has been applied to each momentum component of the $\pi+$ and of the $\pi-$ momenta in order to take into account the momentum dependence on the φ angle, already observed in other final states:

$F(\varphi, charge) = (-charge \times 0.5 \times \cos\varphi + 0.3)/(2 \times 497) + 1$



Effects from physics

- FSR: FSR is negligible with respect to ISR; to test if some FSR events are left we cut on prompt energy in EMC -> the asymmetry remains.

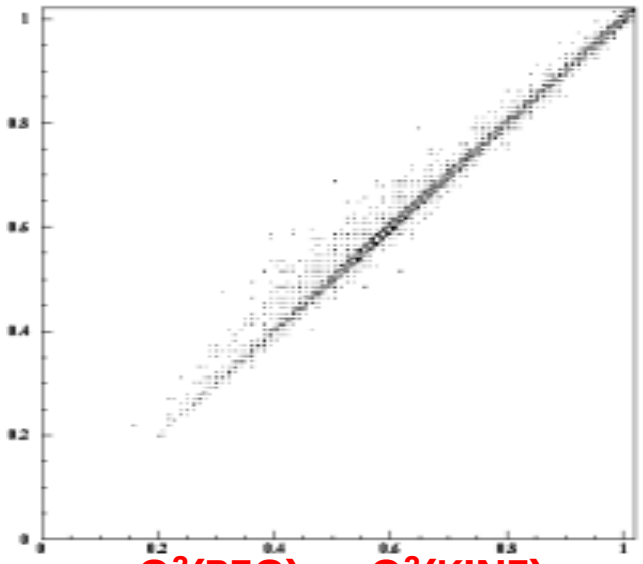
- Background from Bhabhas: to suppress Bhabhas we have applied the AND of the likelihood -> the asymmetry remains

CURRENT SITUATION: the effect is not understood, yet.

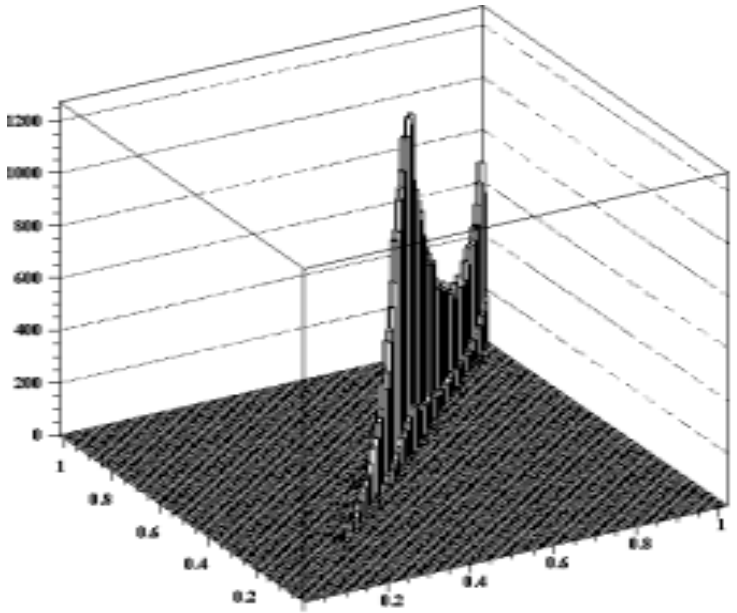
Unfolding procedure

The detector smearing has now been studied using MC:

$$f^{true}(x) = \int G(x, x-x')\, f(x')\, dx' \quad ; \quad \int G(x, x-x')\, dx' = 1 \quad \forall x$$



Q^2(REC) vs Q^2(KINE)

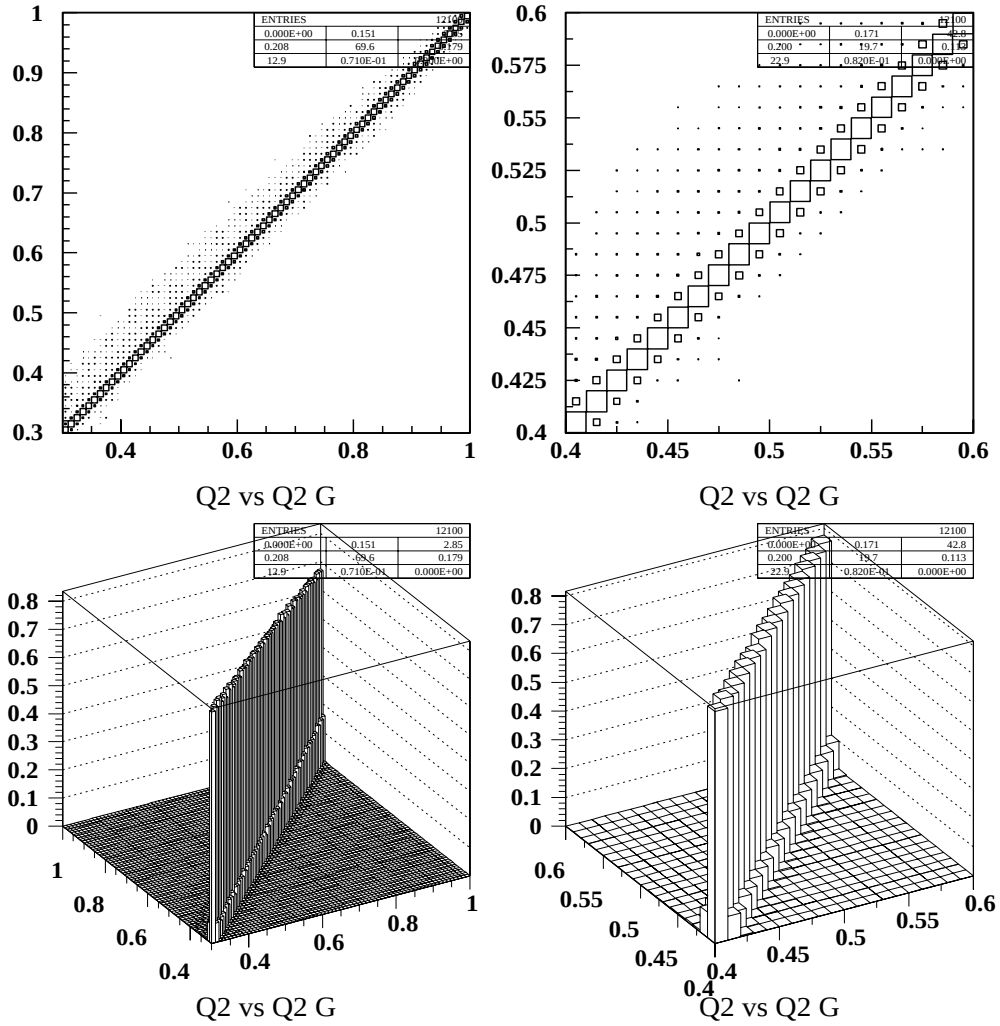


Graphical representations of the Smearing

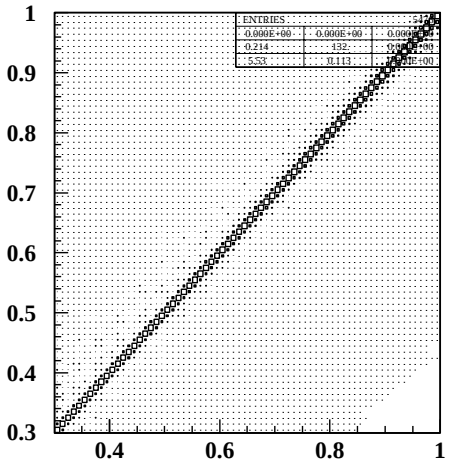
Smearing matrix

- The smearing matrix is normalized to 1 (unitarity condition)

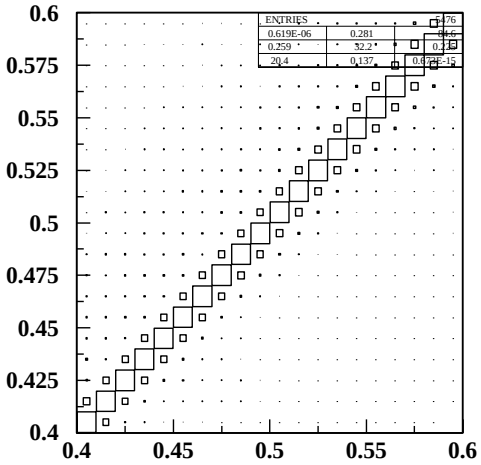
- Most of the population is on the diagonal (~70%) or in the adjacent bin: such a situation doesn't require sophisticated unfolding programs (RUN,GURU,..), but inverting the smearing matrix matrix is enough to obtain the unsmeared Q^2 spectrum.



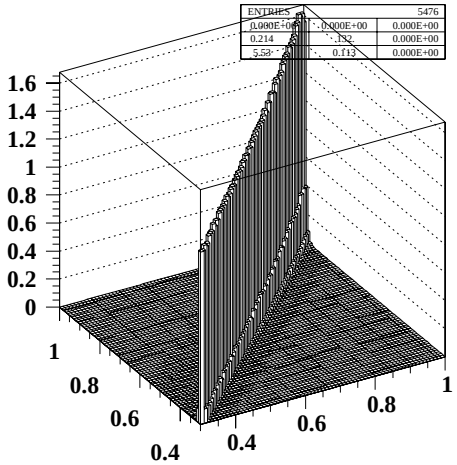
Inversion of the smearing matrix



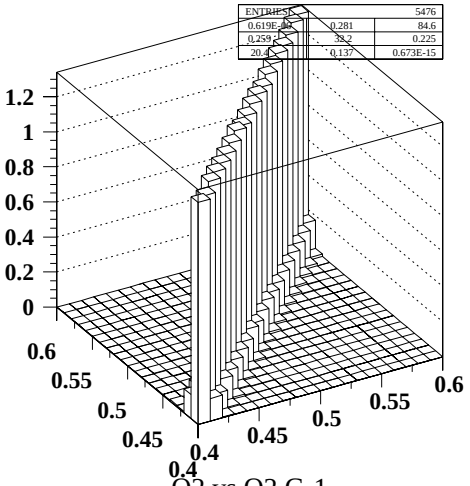
Q2 vs Q2 G-1



Q2 vs Q2 G-1



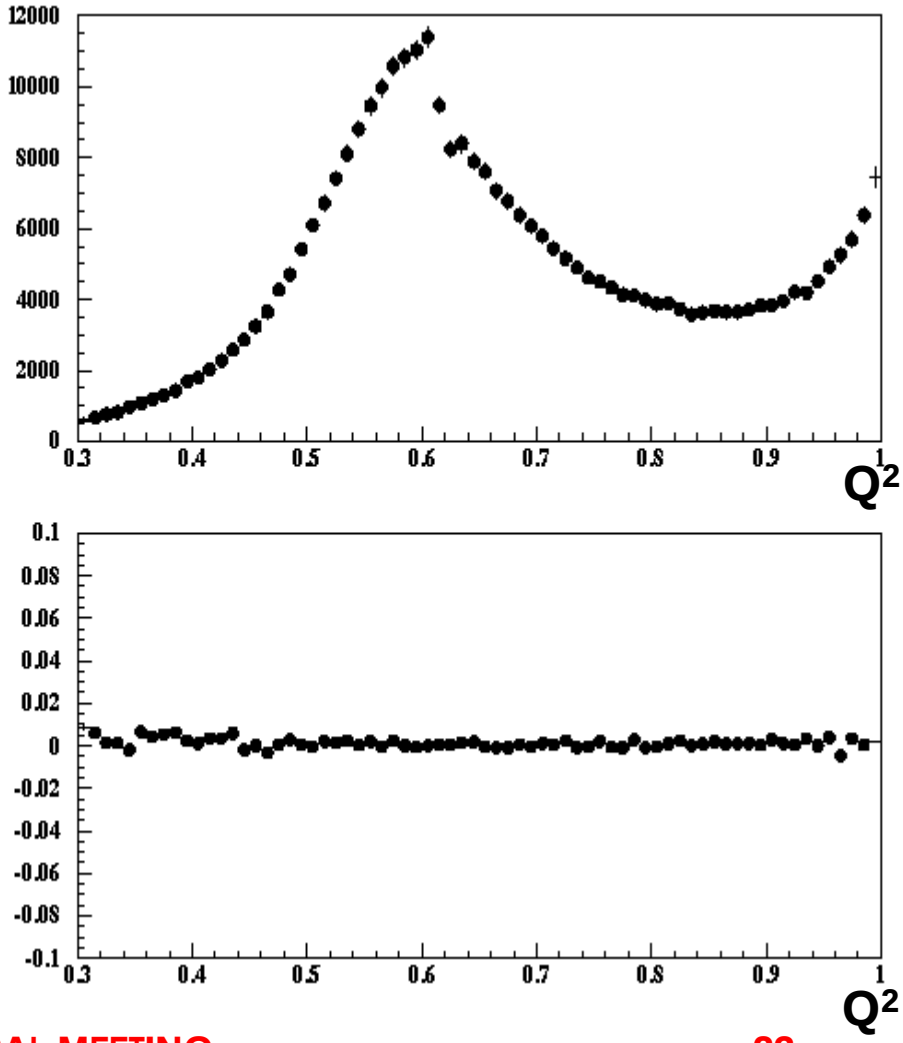
Q2 vs Q2 G-1



Q2 vs Q2 G-1

Validity test of the method

- The method has been successfully applied to a MC sample of 1000000 events.
- From the reconstructed spectrum obtained at the end of the analysis chain, the unfolded distribution has been computed by inverting the Q^2 smearing matrix, correcting for efficiencies and boundary effects.
- This distribution has been compared with the generated MC Q^2 distribution.
- The correlation between bins has been computed and found to be of 10-20%.



Conclusions

- The inversion procedure has not been applied to data, mostly because of the „asymmetry“ problem
- Efficiencies and other kinds of background are under control
- Data and MC are in qualitative agreement, but before drawing quantitative conclusions the smearing process must be applied
- The unsmearing procedure has been tested on MC and it works, since the smearing matrix is almost diagonal
- Two persons have been assigned to the writing of the draft: A.D. and G.V. ; we still plan to have the draft ready by Jan, 31.