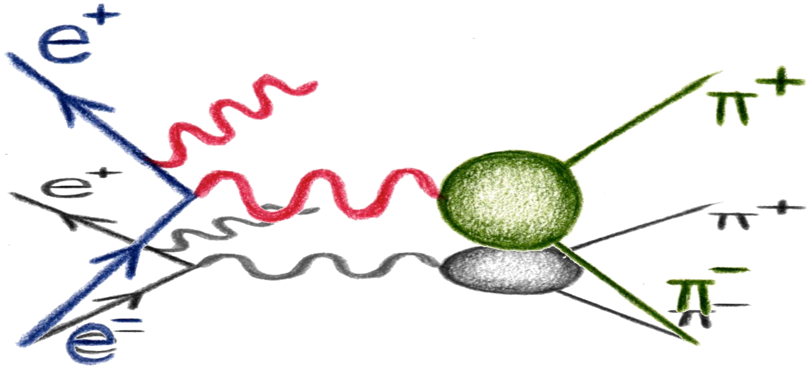
Update on the Large Photon Polar Angle Analysis using 2006 data



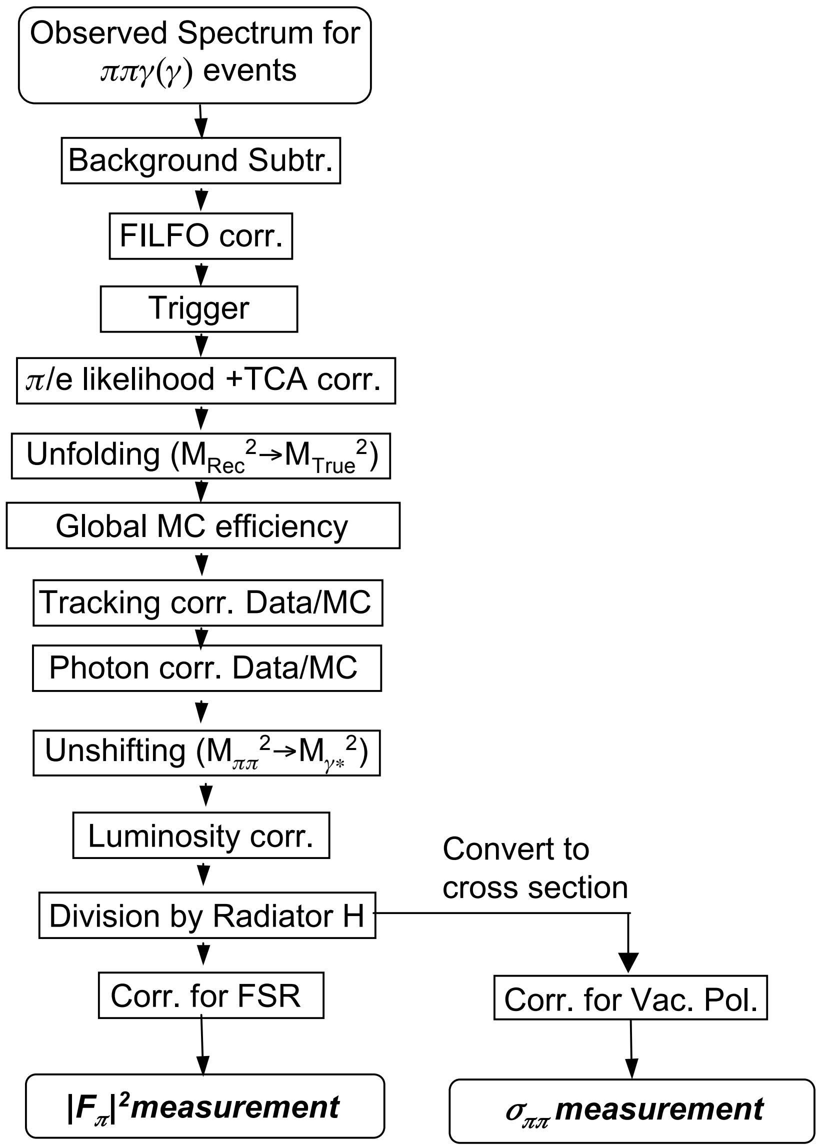
S. Müller
(ππγ group)

Phidec-Meeting in Frascati, 16.1.2009

Analysis Cuts:

- $\rho_{PCA} < 8$ cm,
  $|z|_{PCA} < 12$ cm
- $\rho_{FirstHit} < 50$ cm
- **no vertex**
- $50^o < \theta_{\pi,\gamma} < 130^o$
- $E_\gamma > 20$ MeV
- $|p| > 200$ MeV/c
- **.or.** of π-e likelihood
- $M_{trk}(s_\pi)$
- $\Omega_{p_{miss}-\gamma}(s_\pi)$

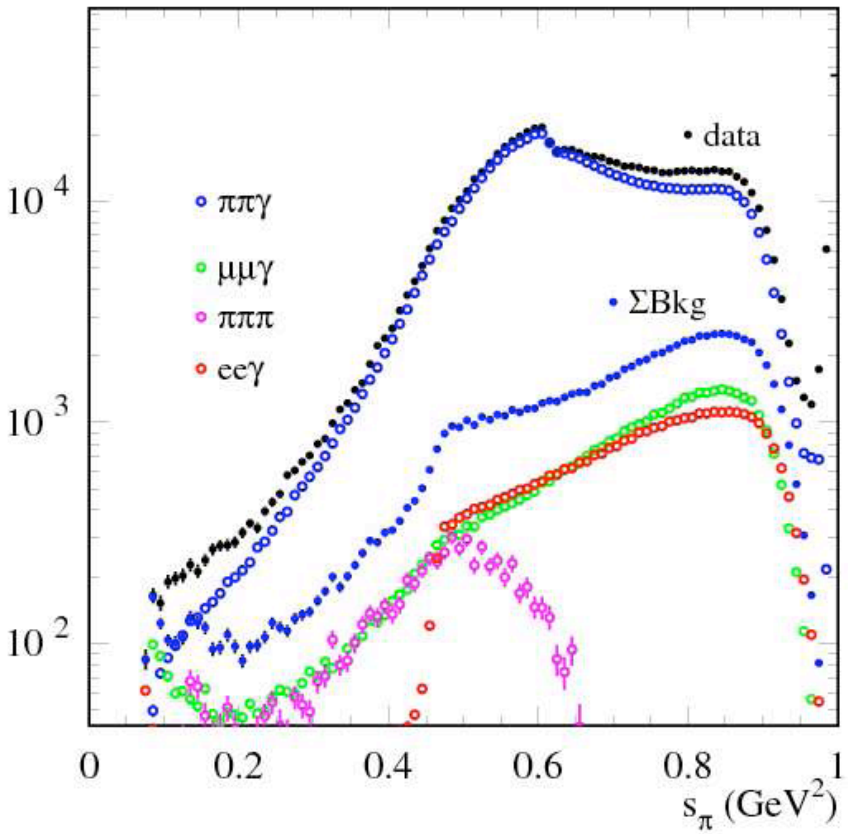
Analysis Flow:

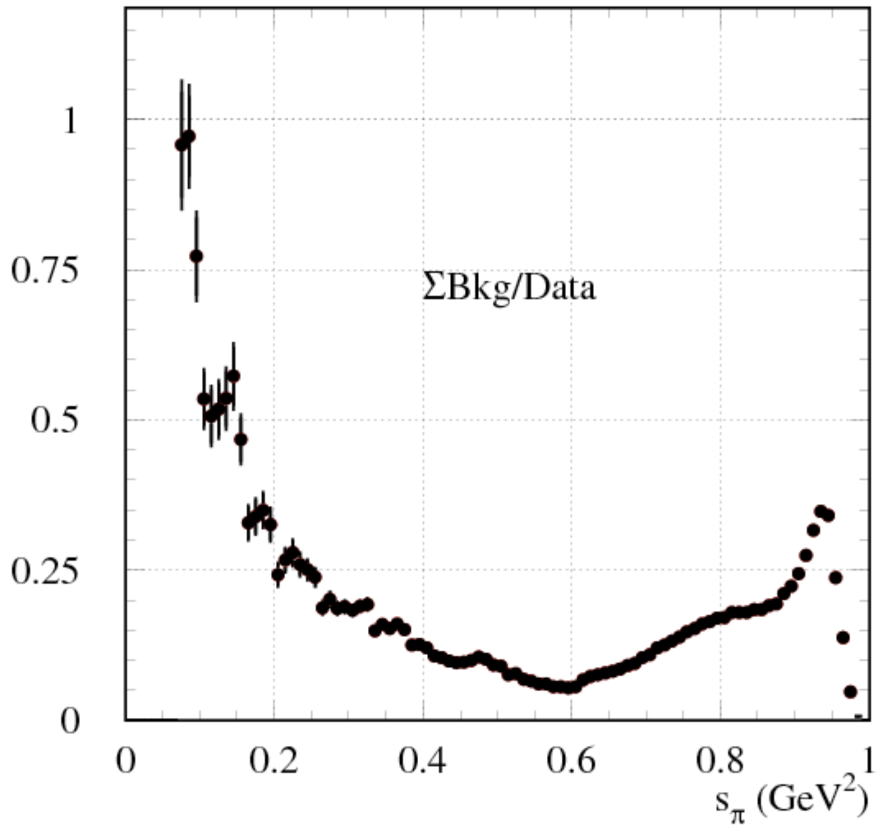


Background subtraction:

The background contribution is evaluated in two steps:

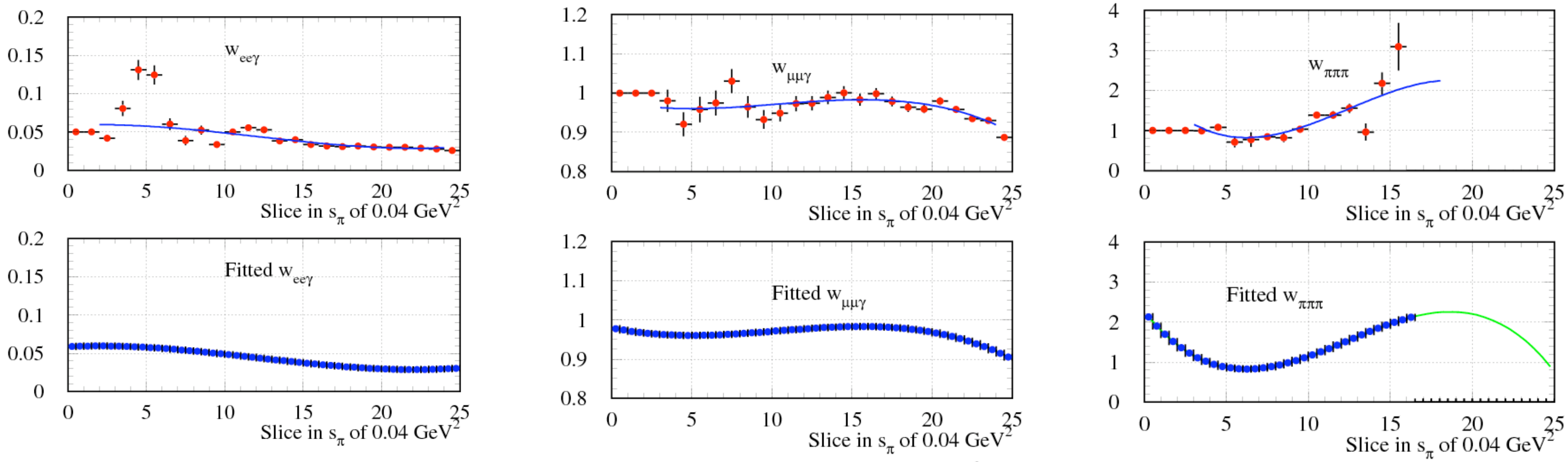
- Estimate $e^+e^-\gamma$ contribution from a $e^+e^-\gamma$ data sample (using the “nor” criteria of the π/e likelihood on data) together with MC samples for $\pi\pi\gamma$, $\mu\mu\gamma$ and $\pi\pi\pi$ fitted to data selected with the “xor” requirement (1 track e, 1 track π)
- Estimate $\mu\mu\gamma$ and $\pi\pi\pi$ contributions by fitting them (together with the fixed $ee\gamma$ contribution obtained in the previous step)





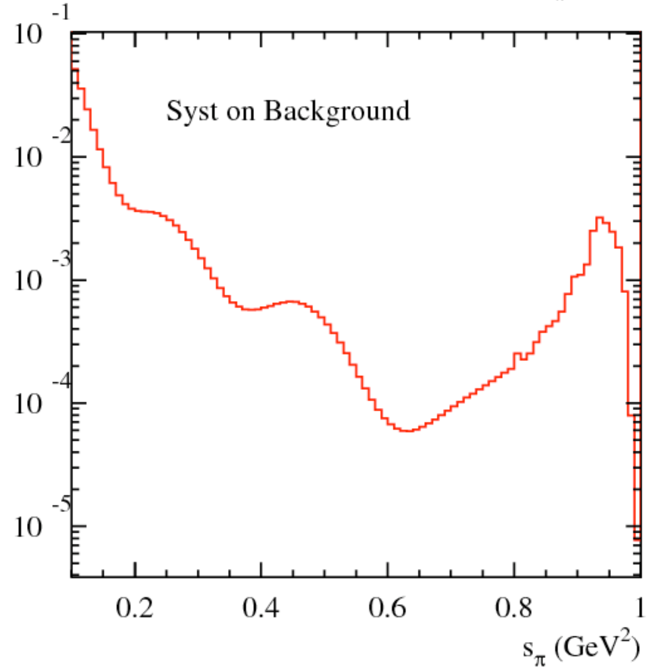
Background subtraction (2):

The obtained weight-factors are smoothed using polynomial functions, which are then extrapolated to get weight-factors for the first 2-4 slices:



The systematic uncertainty due to background subtraction is composed of 2 contributions:

- δ^{wgt} is estimated from the distance between the smoothing function and the weight points.
- δ^{func} estimates the stability of the fit of the smoothing polynomials by changing the fit range and evaluating the effect due to the change in the polynomial fit parameters on the background estimation



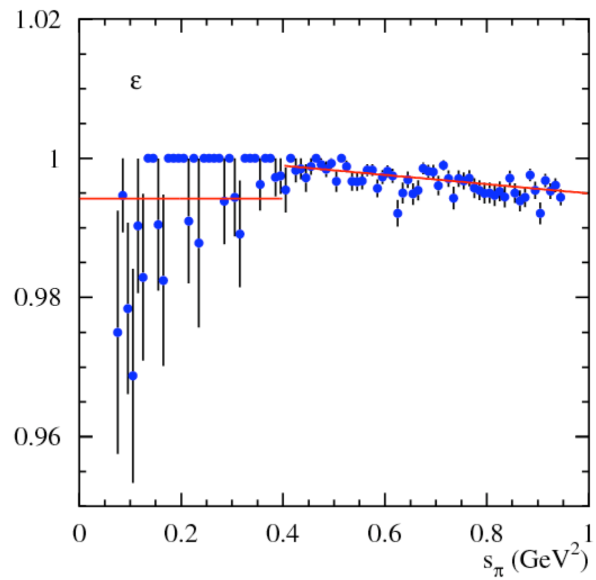
For each background channel

$$\partial_{syst} = (\partial^{wgt} + \partial^{func}) \cdot \frac{N_{bkg}}{N_{data}}$$

FILFO:

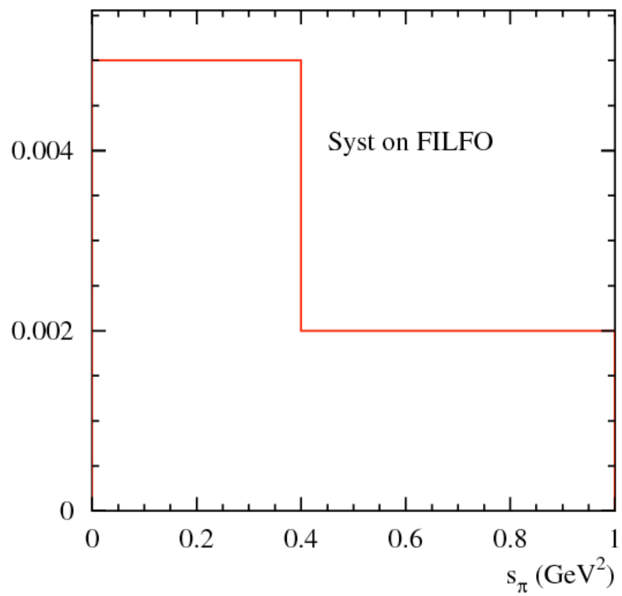
FILFO efficiency is evaluated from downscaled unbiased sample, then approximated by

- the mean value below 0.4 GeV^2
- a P1 above



The fractional systematic uncertainty is evaluated from

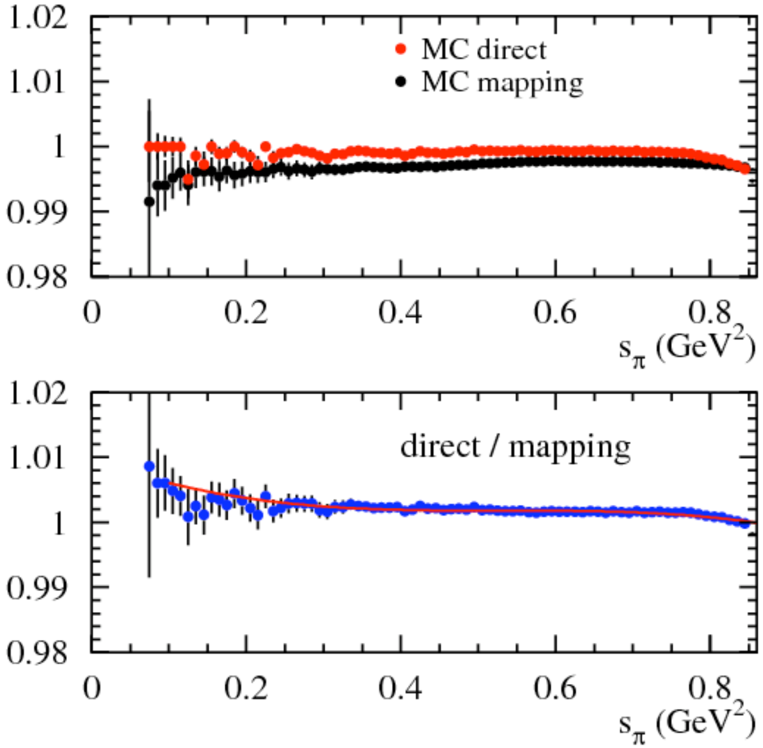
- the average difference between red line and blue circles below 0.4 GeV^2
- The propagation of the errors of the P1-parameters above

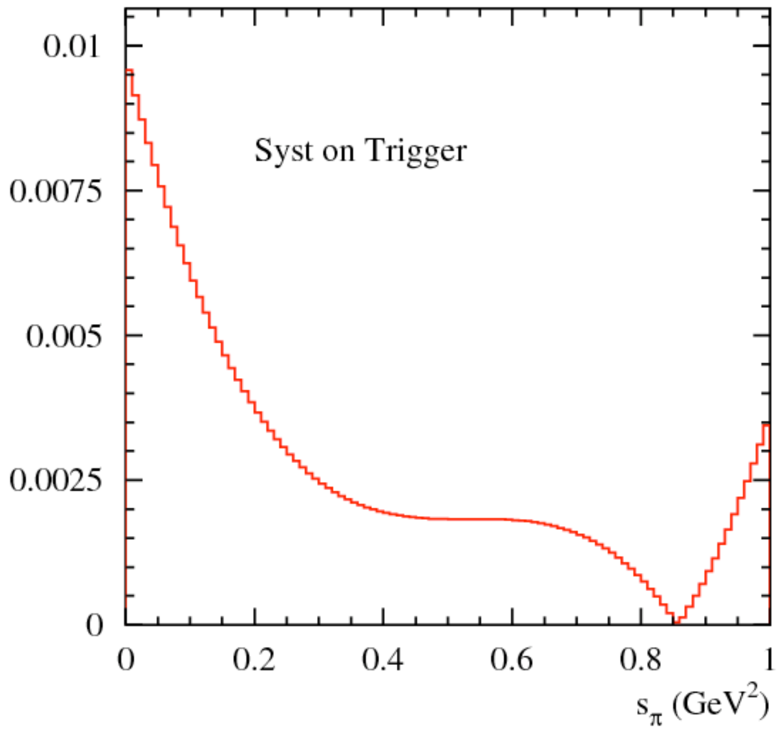


Trigger:

The trigger efficiency is evaluated from the single particle efficiencies for firing 1 or more trigger sectors.
These efficiencies are obtained from unbiased data control samples ($50pb^{-1}$) as functions of momentum and θ, and is then mapped to the event kinematics using $\pi\pi\gamma$ Monte Carlo.

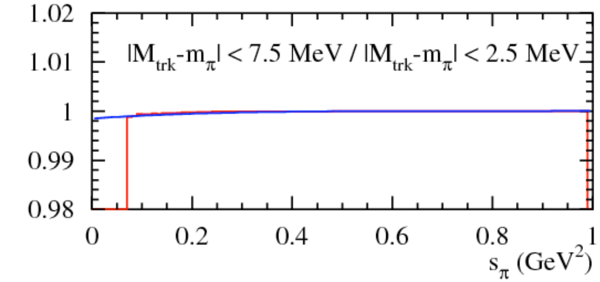
A MC comparison is performed between the single particle method and the direct efficiency evaluation. The difference between the 2 methods is smoothed by a polynomial fit.
The deviation from "1." of this function is used as the systematic uncertainty due to the trigger evaluation.



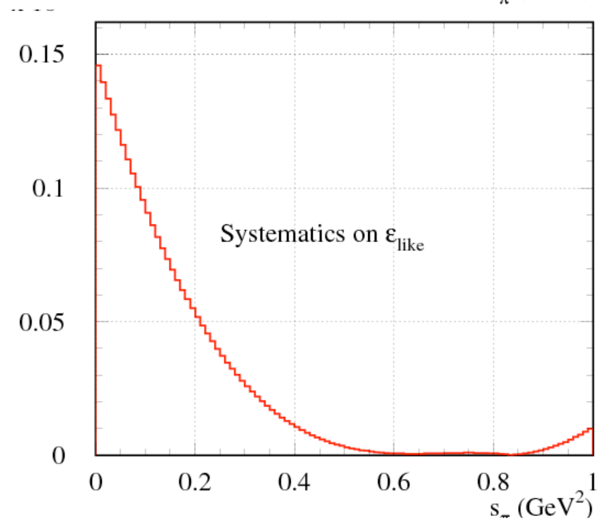


π/e likelihood and TCA ("or"):

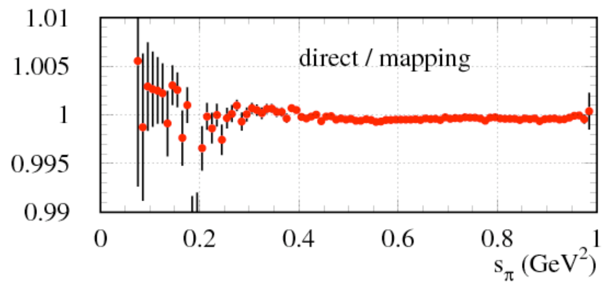
Single pion efficiency obtained from data control sample (with cut on M_{Trk} around M_π), then mapped to the event kinematics using $\pi\pi\gamma$ Monte Carlo (similar to trigger efficiency). Combined efficiency is >99% in "or" configuration.



Enlarging the window in M_{Trk} from ±2.5 MeV to ±7.5 MeV (about 1σ) allows to check the dependence of the efficiency on the purity of the control sample.



The difference is smoothed by a polynomial fit.
The deviation from "1." of this function is used as the systematic uncertainty due to the pion identification. It is at maximum 0.1%.

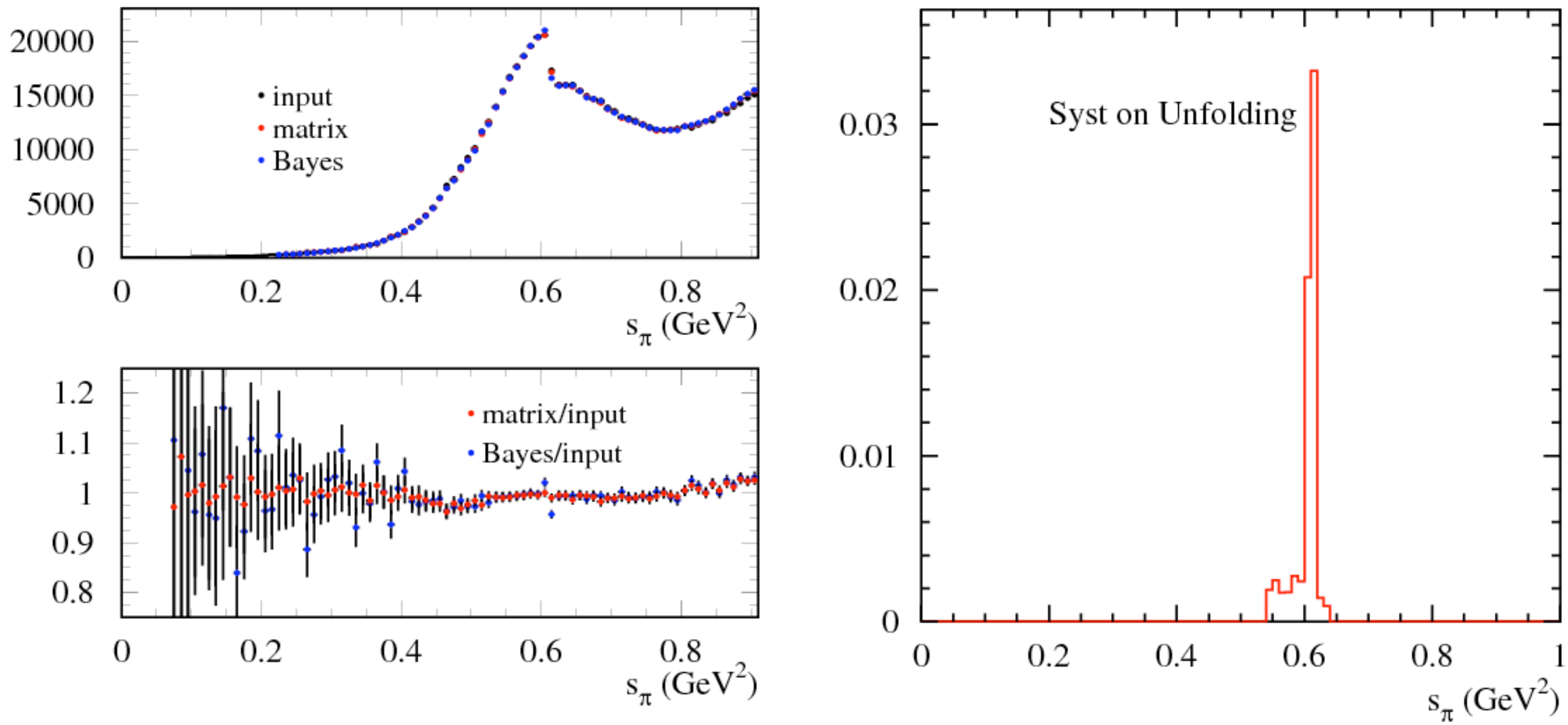


A MC crosscheck is performed between the single pion method and the direct efficiency evaluation has been done.

Unfolding:

The unfolding for the detector resolution
has been performed using the Bayesian appoach by D'Agostini. As in the pubished small angle analysis, the systematic error has been estimated by comparing it to a simple matrix multiplication method. Significant differences have been found only in the region around the $\rho-\omega$ interference.

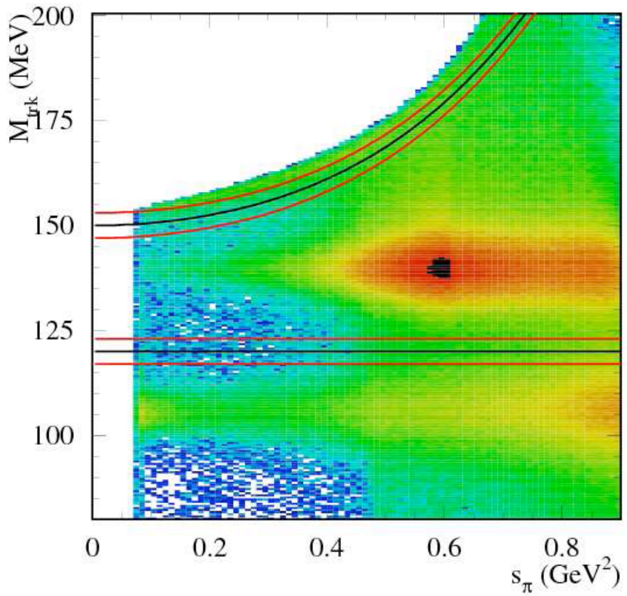
This uncertainty should not be considered in the integral for $a_\mu^{\pi\pi}$.



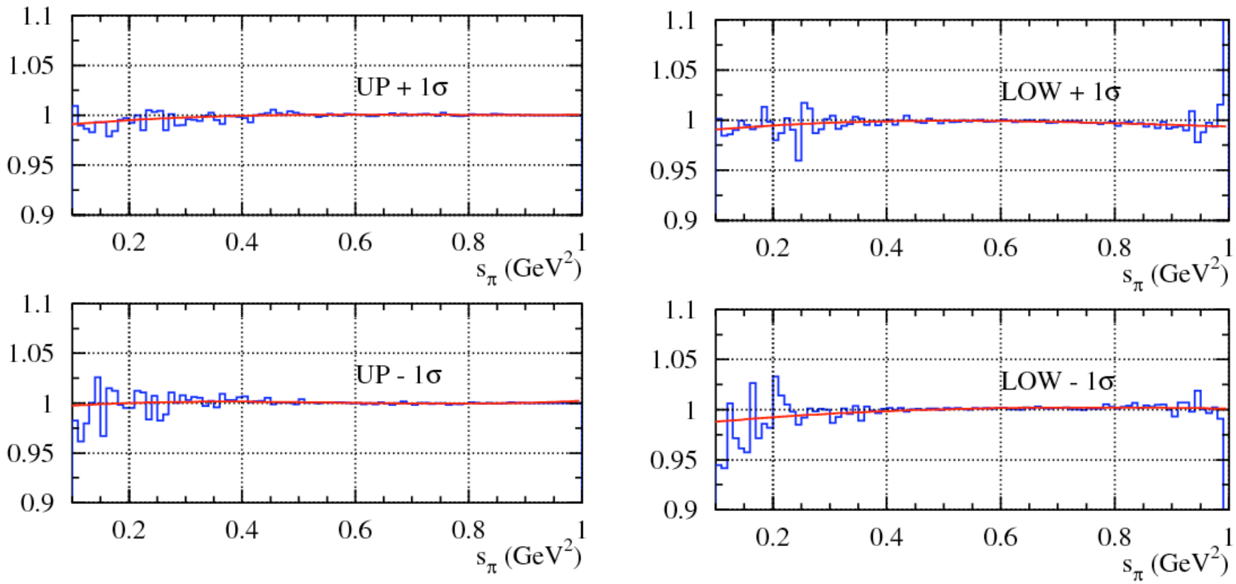
Trackmass:

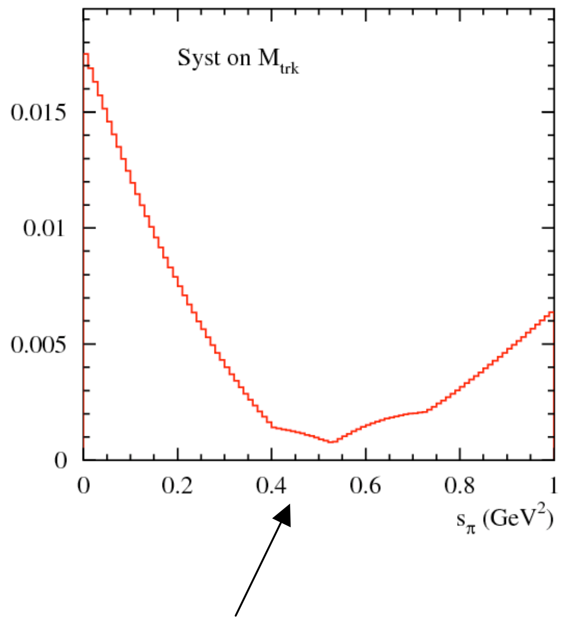
The trackmass efficiency is contained in the “Global MC efficiency”. To evaluate the systematic uncertainty, each cut is shifted by ±1σ (3.5 MeV) and a double ratio between data and MC is constructed:

$$\frac{(dN/ds_\pi\,|\mathrm{cut}')^{\text{Data-Bkg}} \Big/ (dN/ds_\pi\,|\mathrm{cut}')^{\text{MC}\pi\pi\gamma}}{(dN/ds_\pi\,|\mathrm{cut})^{\text{Data-Bkg}} \Big/ (dN/ds_\pi\,|\mathrm{cut})^{\text{MC}\pi\pi\gamma}}$$



For the 2 cuts in M_{Trk}, one obtains 4 doube ratios:

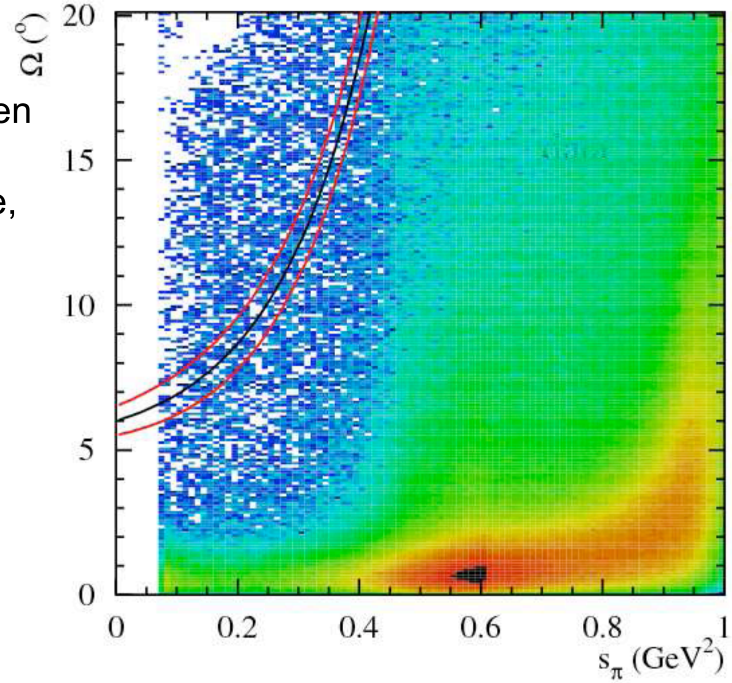




As a systematic errror then the maximum deviation from “1.” of the 4 smoothing functions is taken.

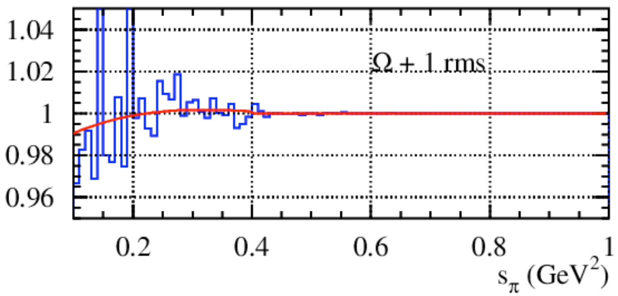
Cut on Ω angle:

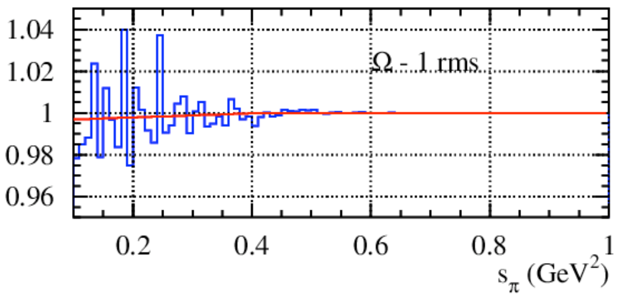
The Ω angle s defined as the smallest of all the angles between the missing momentum and the momenta of the detected photons. Below 0.85 GeV², its effect on the signal is negligible, but takes out a large part of πππ events.

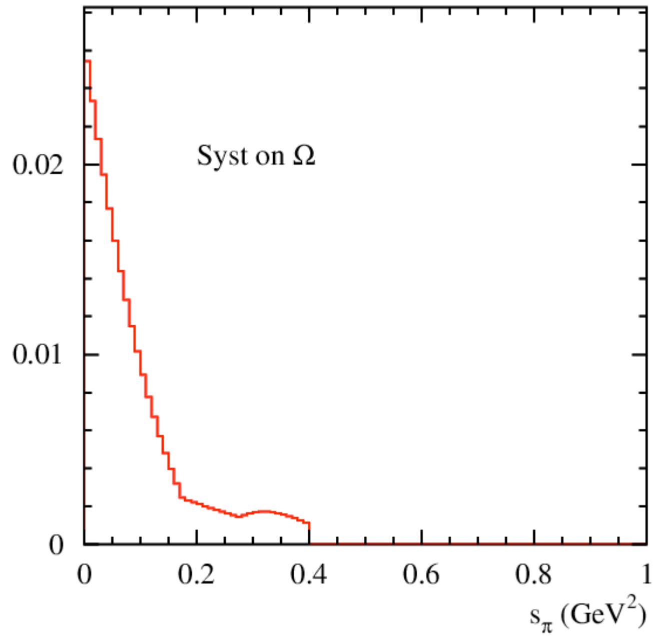


Again the double ratio is used to estimate a systematic uncertainty, shifting the Ω cut by 1 rms (1-2°)

$$\frac{(dN/ds_\pi\,|\,\text{cut}')^{\text{Data-Bkg}} \Big/ (dN/ds_\pi\,|\,\text{cut}')^{\text{MC}\pi\pi\gamma}}{(dN/ds_\pi\,|\,\text{cut})^{\text{Data-Bkg}} \Big/ (dN/ds_\pi\,|\,\text{cut})^{\text{MC}\pi\pi\gamma}}$$

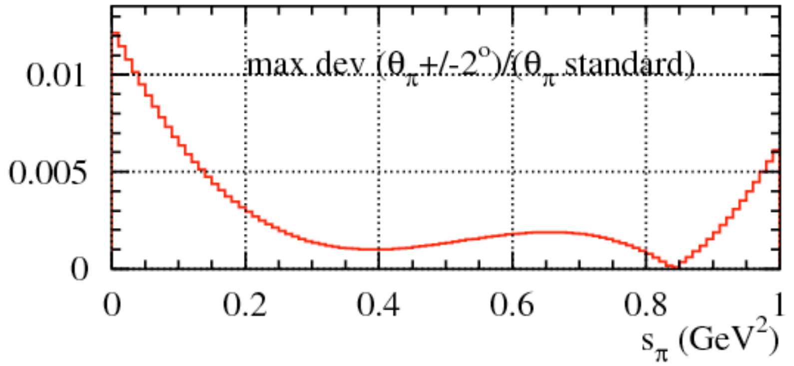


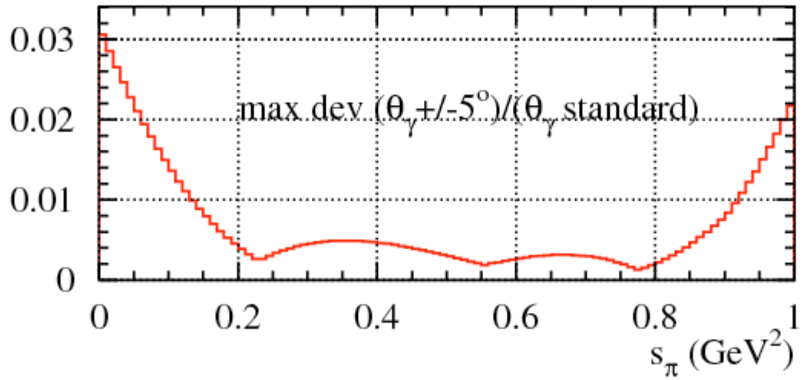


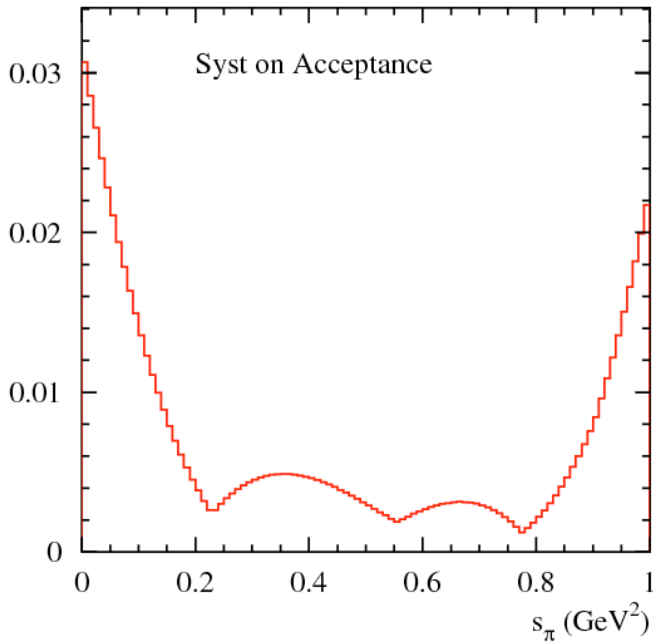


Acceptance:

For the acceptance cuts on pion and photon polar angle, again the double-ratio is evaluated, shifting the cuts by ±2° for θ_π and ±5° for θ_γ:







Tracking efficiency:

The tracking efficiency is evaluated selecting a good tagging track and 1 photon, cutting on the missing mass M_{miss} obtained from the two and searching for a track with ρ_{FH} < 50 cm, ρ_{PCA} < 8 cm and $|z_{PCA}|$ < 12 cm. The single track efficiency in θ and momentum is then mapped to the event kinematics using MC.

To estimate the systematic effect, the above cuts have been moved to:

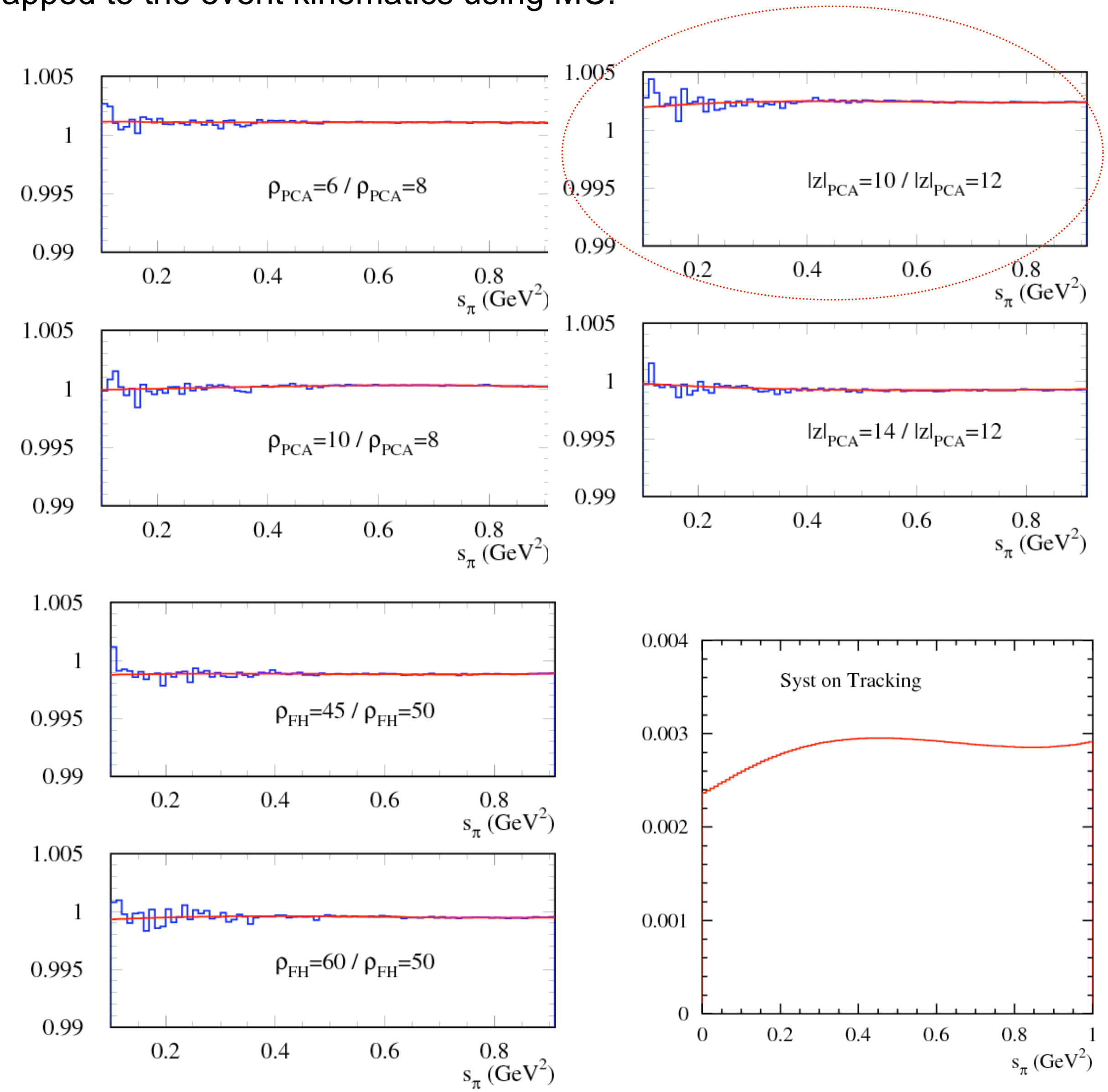
ρ_{PCA} < 6 cm, ρ_{PCA} < 10 cm

$|z_{PCA}|$ < 10 cm, $|z_{PCA}|$ < 14 cm

ρ_{FH} < 45 cm, ρ_{FH} < 60 cm

and the ratio ε(cut')/ε(cut) has been built from data

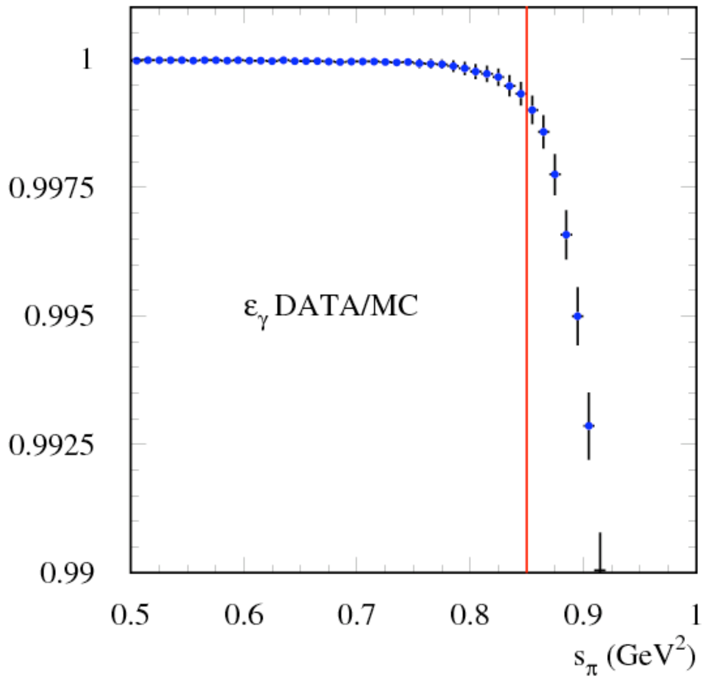
The maximum deviation from „1." of these 6 ratios is taken as the systematic uncertainty due to the tracking efficiency.



Photon detection efficiency:

Within the cut of s_π<0.85 GeV^2, the photon efficiency obtained from $\pi\pi\pi$ events is very high, and also the Data/MC ratio is very close to „1.“

Therefore, the systematic uncertainty on the photon detectyion efficiency is considered negligible.

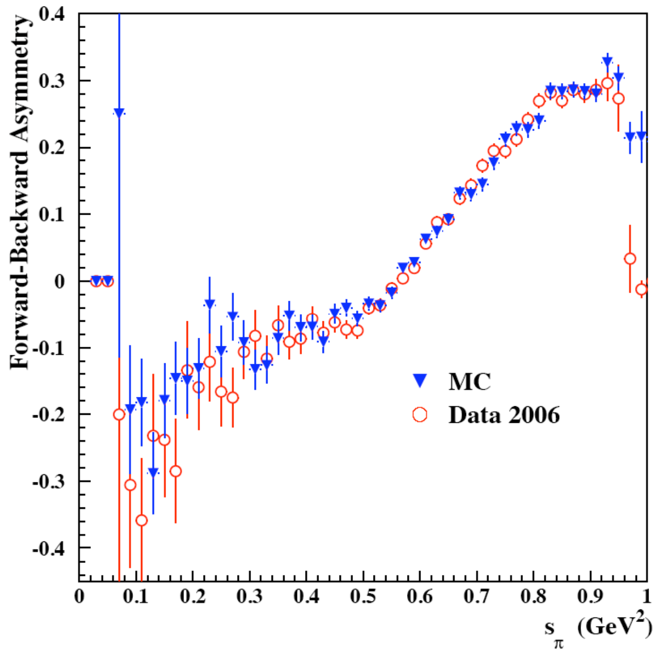


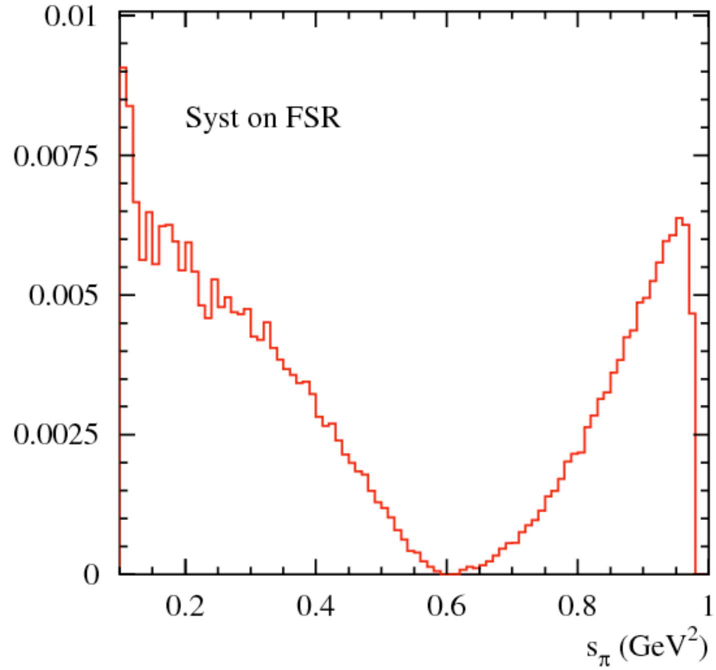
Final state radiation:

Using the Forward-Backward Asymmetry for data and MC, one can try to make a statement on the validity of the model used for FSR in the MC.

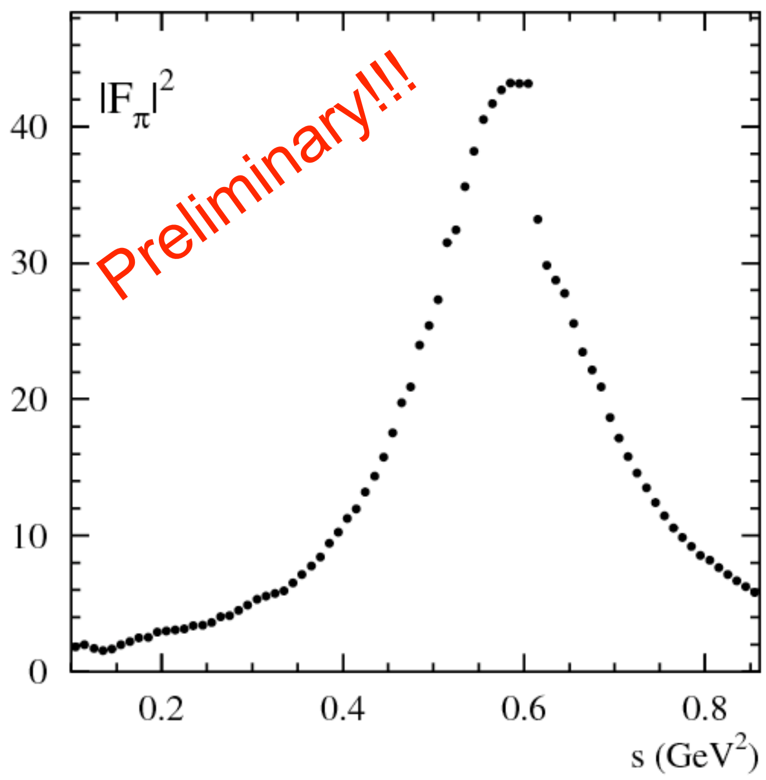
$$\mathcal{A}_{\mathrm{FB}}(s_\pi) = \frac{N_{\pi^\pm}(\theta > 90^\circ) - N_{\pi^\pm}(\theta < 90^\circ)}{N_{\pi^\pm}(\theta > 90^\circ) + N_{\pi^\pm}(\theta < 90^\circ)}$$

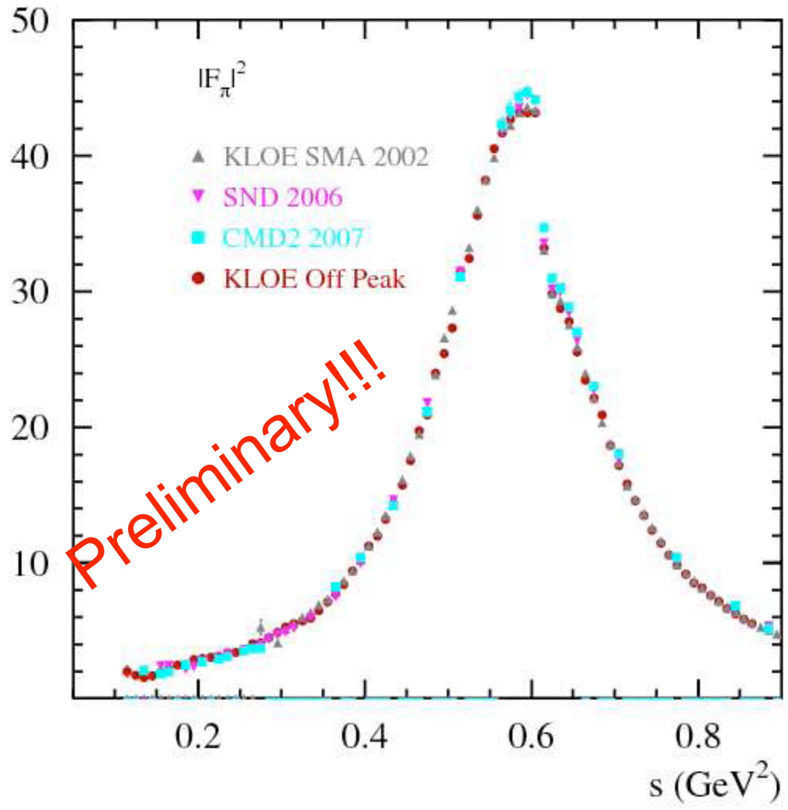
Assuming an overall agreement of 5% between data and MC, the systematic uncertainty due to the use of the pointlike-pion approach can be estimated by scaling the effective unshifting correction with 5%:





Pion form factor:





Summary of systematics on $|F_\pi|^2$:

	s (GeV^2)	[0 – 0.35]	[0.35 – 0.5]	[0.5 – 0.7]	[0.7 – 0.85]
Acceptance		1.5%	0.5%	0.3%	0.8%
Trackmass cut		1.%	0.2%		0.5%
Ω-Angle cut		0.2%-1%	-		
Background		3%	0.1%		0.3%
Unfolding		-		3%	-
Filfo		0.2%	-		
Trigger		0.7%	0.3%		0.2%
$\pi - e$ ID		0.1%	-		
Tracking		0.3%			
FSR correction		0.5%	0.2%	-	0.3%
Total		3.7%	0.8%	3% (0.6% w/o unfolding)	1.1%

Prel. evaluation of the disp. integral in the range 0.1-0.85 GeV^2:

$$a_\mu^{\pi\pi}(0.1\text{-}0.85\,\text{GeV}^2) = (479.1 \pm 1.6_{stat} \pm 3.7_{sys} \pm 2.8_{theo}) \cdot 10^{-10}$$

Prel. comparison with SMA2008 in the range 0.35-0.85 GeV^2:

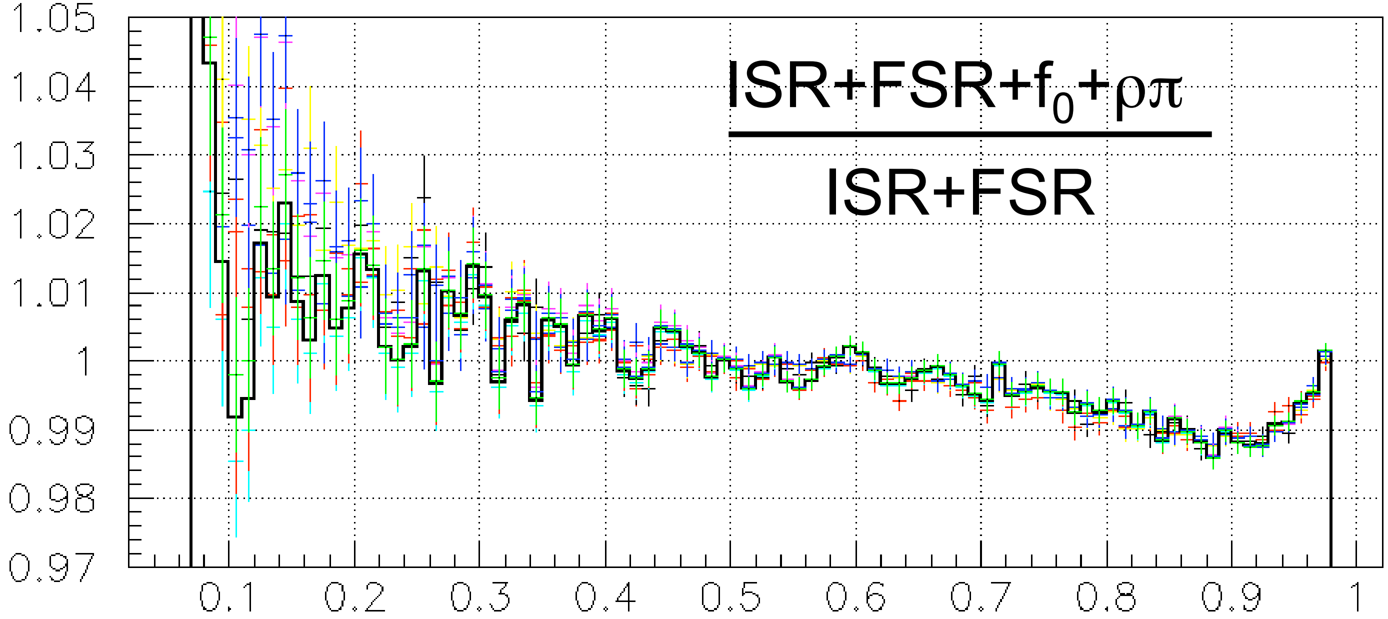
LA2009 $a_\mu^{\pi\pi}(0.35\text{-}0.85\,\text{GeV}^2) = (375.0 \pm 0.7_{stat} \pm 2.3_{sys} \pm 2.2_{theo}) \cdot 10^{-10}$

SMA2008 $a_\mu^{\pi\pi}(0.35\text{-}0.85\,\text{GeV}^2) = (379.6 \pm 0.4_{stat} \pm 2.4_{sys} \pm 2.2_{theo}) \cdot 10^{-10}$

Estimation of f_0 and $\rho\pi$ contribution with PHOKHARA 6.1:

To estimate the effect of f_0 and $\rho\pi$ contribution to the large angle spectrum at $\sqrt{s}$ = 1000 MeV, I used PHOKHARA6.1 (in which O. Shekhovtsova has inserted the f_0 and $\rho\pi$ parametrizations used in the KLOE $\pi^0\pi^0\gamma$ analysis) to produce the cross section for the large angle acceptance cuts, and compare it to the $\pi^+\pi^-\gamma$ cross section for ISR+FSR only.

Parameter sets for all 10 fit variants from the $\pi^0\pi^0\gamma$ analysis have been tried. Solid line histogram corresponds to parameter set of best fit.



Luminosity:

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

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

Incl. Reconst. eff. and bkg

From BABAYAGA_nlo

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

	2001	2002/06
relative theoretical error on σ_{eff}	0.5%	0.1%
background correction	−0.6%	−0.7%
cosmic veto efficiency	+0.4%	negligible
relative error on $\mathcal{L}$: $\delta_{th} \oplus \delta_{exp}$	0.6%	0.3%

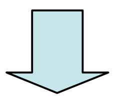
Cosmic veto argument holds also for 2006, but background correction and reconstruction efficiency for VLABS should be checked.

We have asked for a *LUMIBHA* MC production for the 2006 dataset with W≈1000 MeV at the last offline Meeting.

Conclusions:

- The Large Angle analysis using 2006 data is in good shape
- Paolo is currently studying for his examination in February
- Some work to be done concerning the $f_0+\rho\pi$ contribution
- Cross checks on luminosity need dedicated MC production

As soon as Paolo becomes „operative“ again, I‘d suggest to initiate the process towards a blessing for a preliminary result



Comment on SMA2008:

• Paper published in ***Physics Letters B 670 (2009), pp. 285-291***

• Graziano has produced a plot which compares the contribution to the dispersion integral for each bin between CMD and SND to the one of KLOE (may be useful to show at conferences):