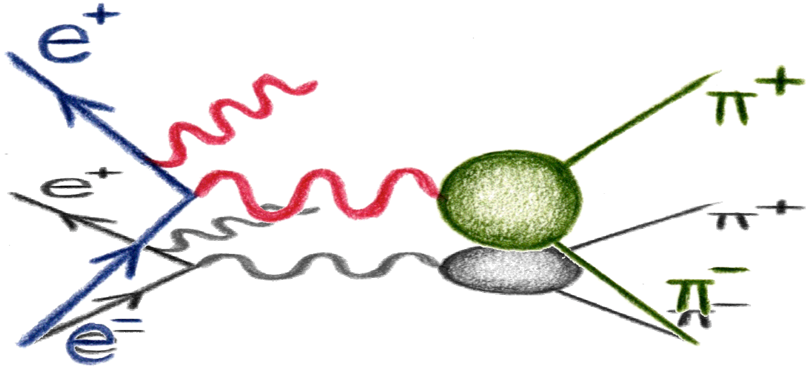
$\pi^+\pi^-\gamma$ analysis at small angle



S. Müller
(ππγ group)

Phidec-Meeting in Frascati, 14.5.2008

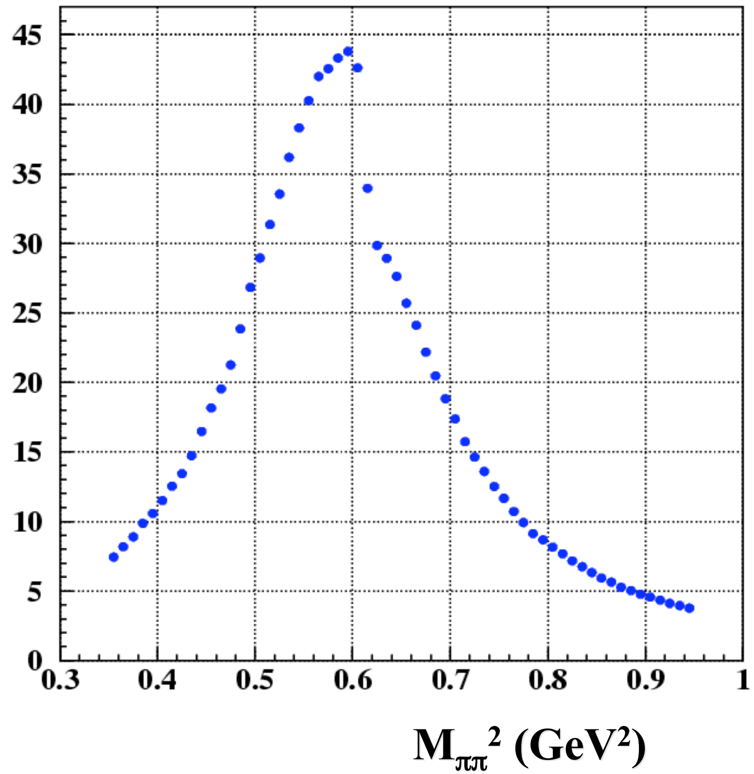
Federico Nguyen, PHIPSI08 conference:

Error table and results

Background	M^2 dep (0.1-0.4%)
M_{trk} cuts	0.2%
Particle ID	0.3%
Tracking	0.3%
Trigger	0.1%
Acceptance	M^2 dep (0.1%)
Unfolding	0.2%
L3 Trigger	0.1%
Luminosity $(0.1_{th} \oplus 0.3_{exp})\%$	0.3%

$$\sigma_{\pi\pi} = \frac{\pi\alpha^2\beta_\pi^3}{3s}|F_\pi|^2$$

F_π resolution effects unfolded

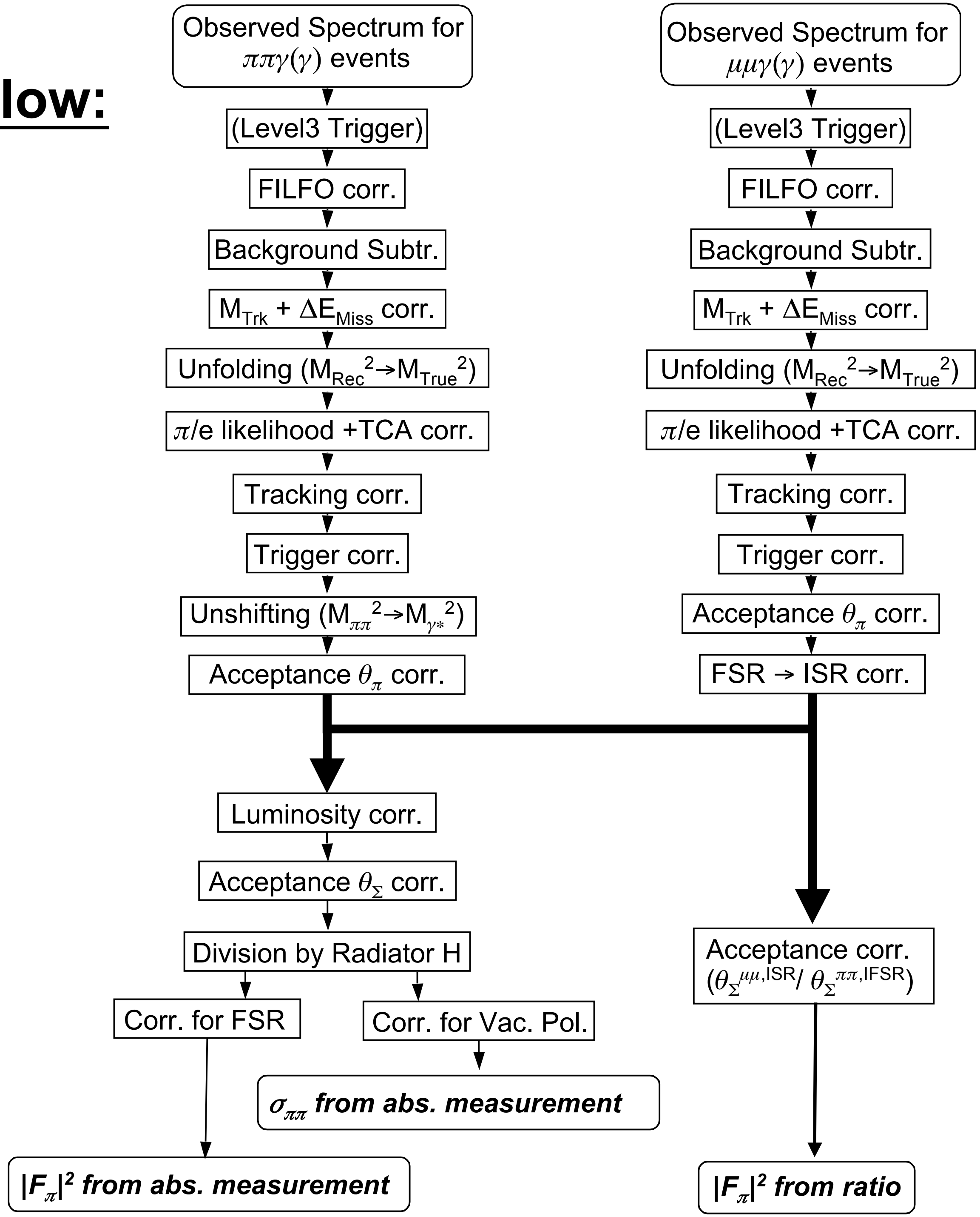


experimental fractional error on a_μ = 0.7%

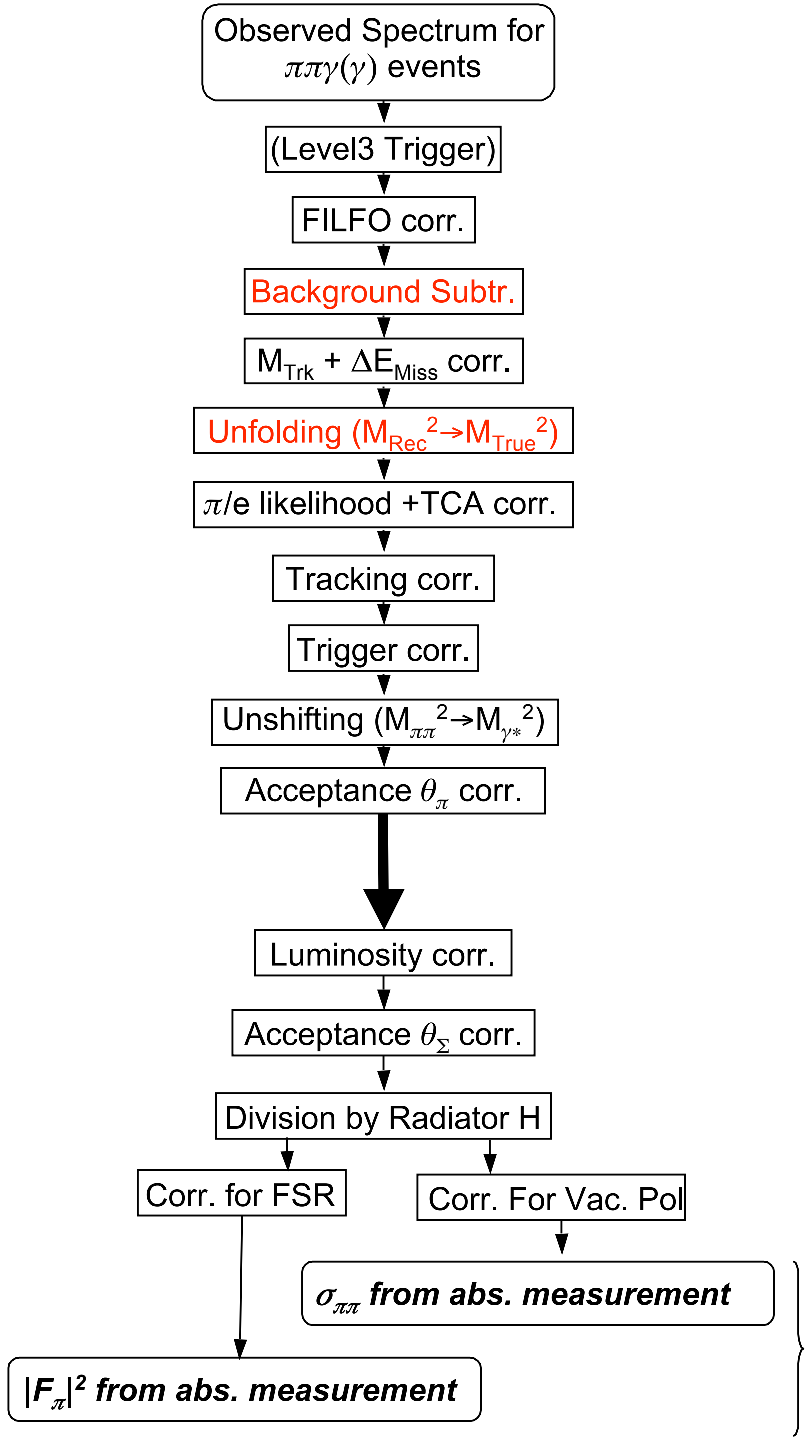
Radiator H	0.5%

total fractional error on a_μ = 0.9%

Analysis Flow:



Analysis Flow:

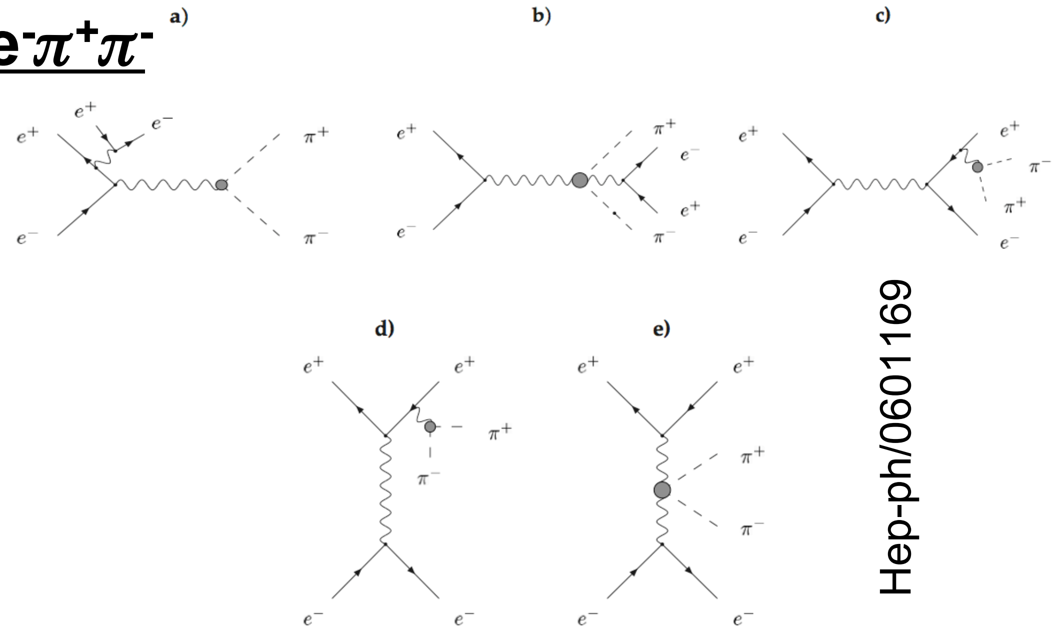


Consistent with Novosibirsk definition

Background from $e^+e^- \rightarrow e^+e^-\pi^+\pi^-$

We estimate the contribution of $e^+e^- \rightarrow e^+e^-\pi^+\pi^-$ using the EKHARA generator (Czyz et al.), using reconstructed tracks from $\phi \rightarrow \eta\gamma \rightarrow (ee\pi\pi)\gamma$ to estimate the efficiency to select these kinds of events. Up to now this has been done requiring a vertex in the analysis.

Now, events have to fulfill (at least) the following cuts to end up in our spectrum:



At least one good pair with

$0 < \rho_{PCA} < 8$ cm ; $0 < |z_{PCA}| < 7$ cm ; $\rho_{FH} < 8$ cm

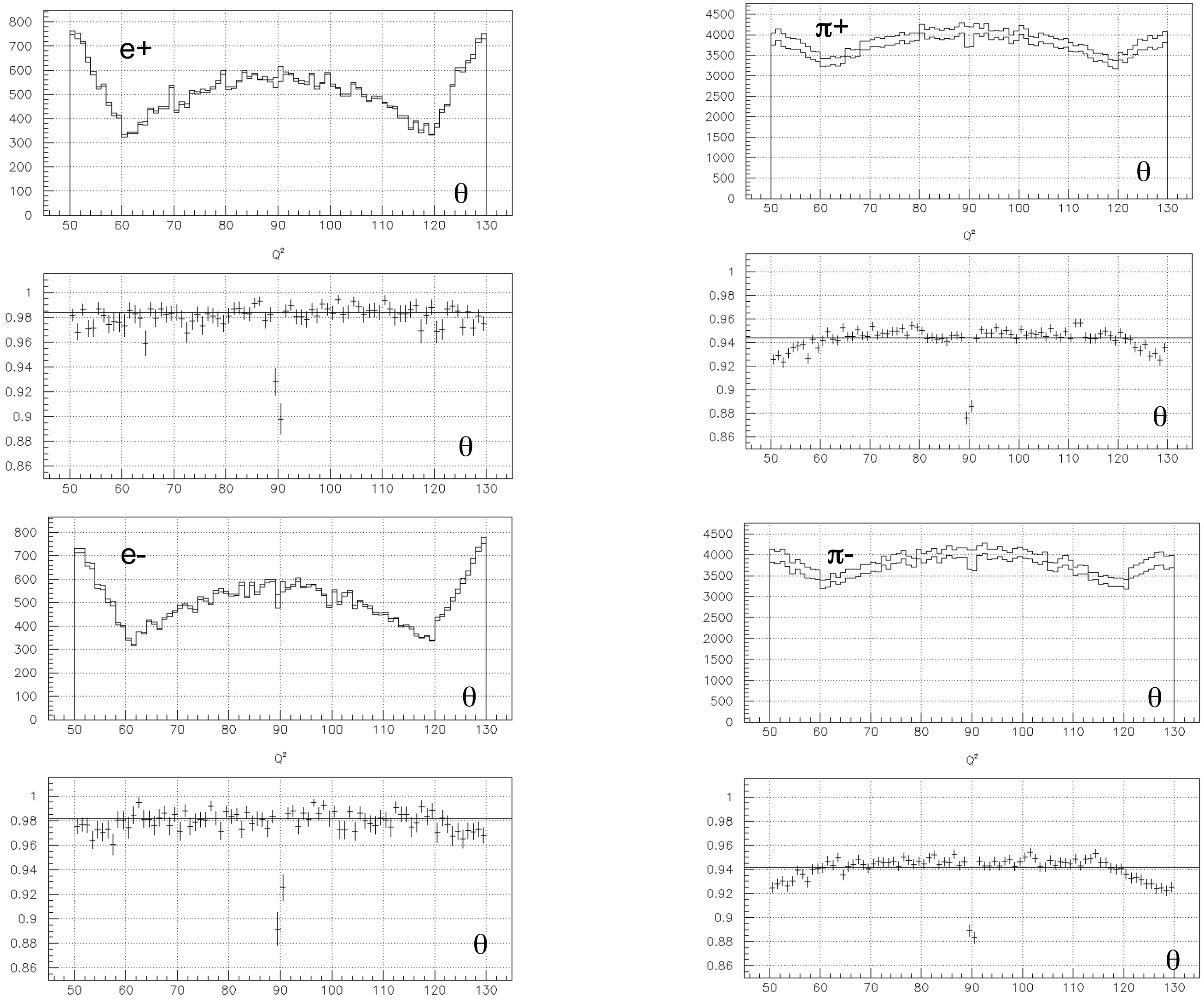
$50^0 < \theta_{Track} < 130^0$; $p_{T,Track} > 160$ MeV ; $|p_{Z,Track}| > 90$ MeV

150 MeV $< |p_1| + |p_2| <$ 1020 MeV
(-220) MeV $< \Delta E_{Miss} <$ 120 MeV
$\theta_\Sigma < 15^0$ or $\theta_\Sigma > 165^0$
130 MeV < Trackmass M_{Trk} < elliptical cut in M_{Trk} vs $M_{\pi\pi}$-plane
at least one of the tracks in the pair is a pion

$0 < \rho_{PCA} < 8$ cm ; $0 < |z_{PCA}| < 7$ cm ; $\rho_{FH} < 8$ cm

PCA+FH efficiency for electron and pion tracks obtained from reconstructed $\phi \to \eta\gamma \to (ee\pi\pi)\gamma$ events satisfying **$50^0 < \theta_{Track} < 130^0$; $p_{T,Track} > 160$ MeV ; $|p_{Z,Track}| > 90$ MeV**

The efficiencies are then used as (additional) weights in the EKHARA generator.

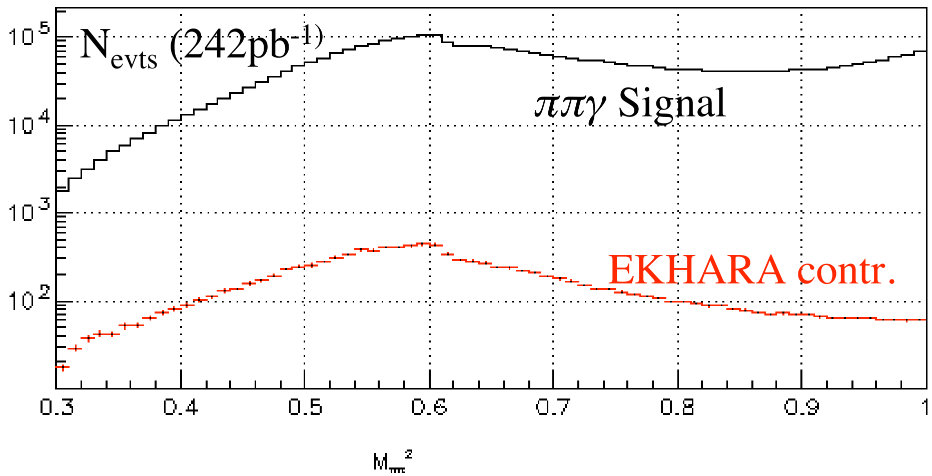


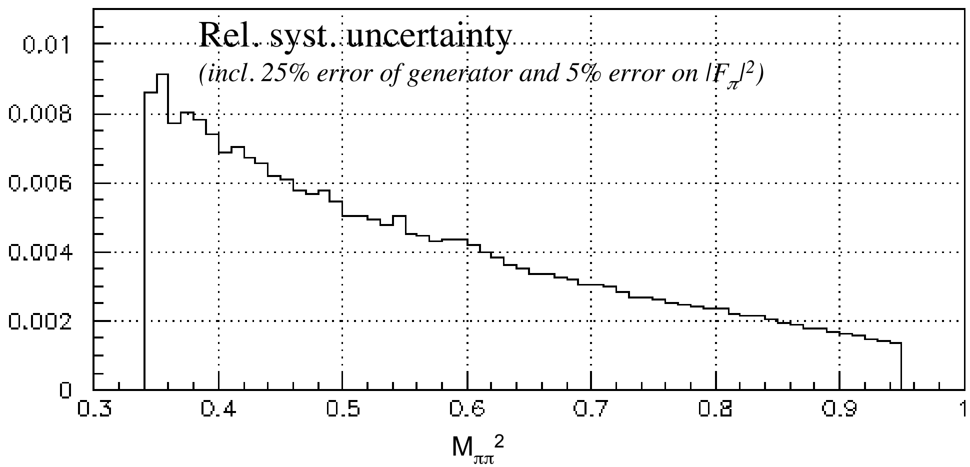
$\varepsilon_{e+,e-} \approx 0.98$ $\varepsilon_{\pi+,\pi-} \approx 0.94$

$50^0 < \theta_{Track} < 130^0$; $p_{T,Track} > 160$ MeV ; $|p_{Z,Track}| > 90$ MeV

$150 \text{ MeV} < |p_1| + |p_2| < 1020 \text{ MeV}$
$(-220) \text{ MeV} < \Delta E_{Miss} < 120 \text{ MeV}$
$\theta_\Sigma < 15^0$ or $\theta_\Sigma > 165^0$
130 MeV < Trackmass M_{Trk} < elliptical cut in M_{Trk} vs $M_{\pi\pi}$-plane
at least one of the tracks in the pair is a pion

Single - and Two-Track-Kinematics obtained from the EKHARA generator.

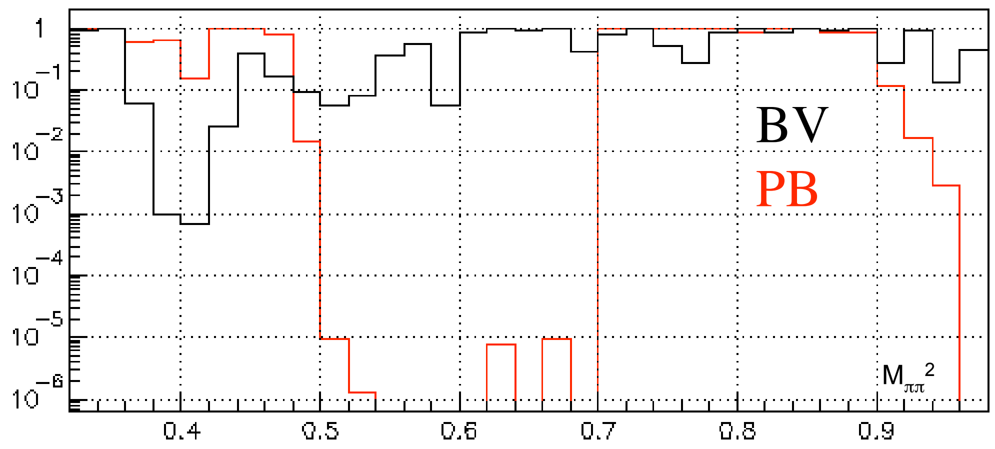




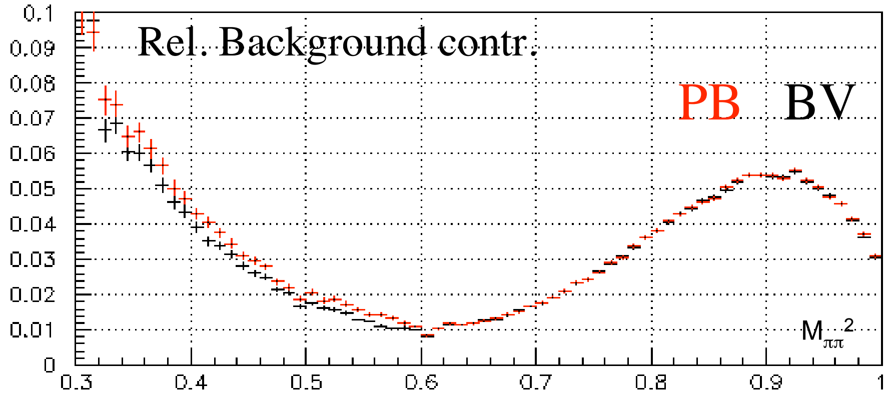
Effect of different „Tuning“ of MonteCarlo

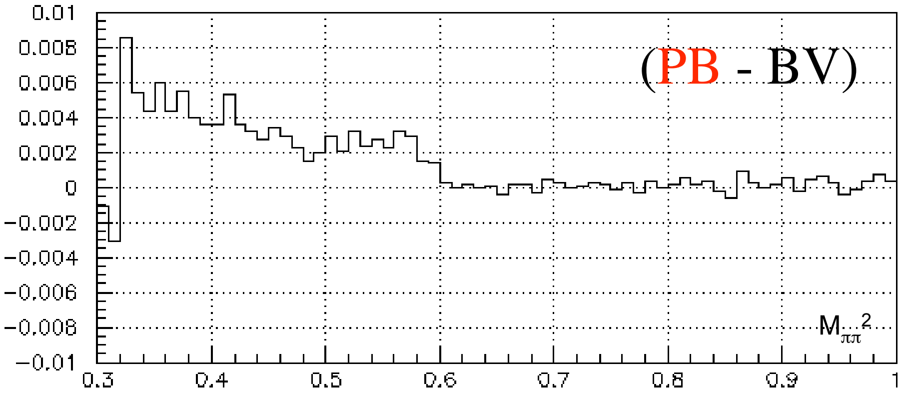
MonteCarlo momenta and θ–angles of tracks get tuned to match data distributions (M_{Trk}). We use a prescription developed by B. Valeriani (+C. Bini). Paolo Beltrame has developed a different procedure, which can be used to estimate the uncertainty the „Tuning“ gives to the background fit.

χ^2 from background fit



Both procedures work well in complementary regions $M_{\pi\pi}^2$.

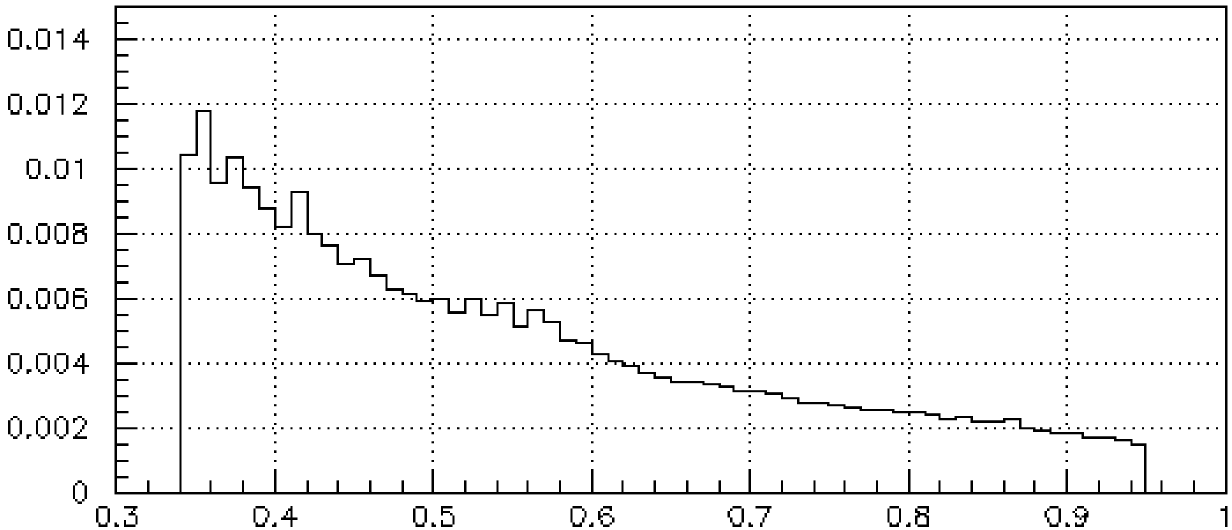




Few per mill difference below 0.6 GeV².

Syst. Error from Background evaluation:

- error on weights obtained from fit
- EKHARA
- Diff. for BV- and PB Tuning
- ee -> ee mumu leakage (<0.1%)

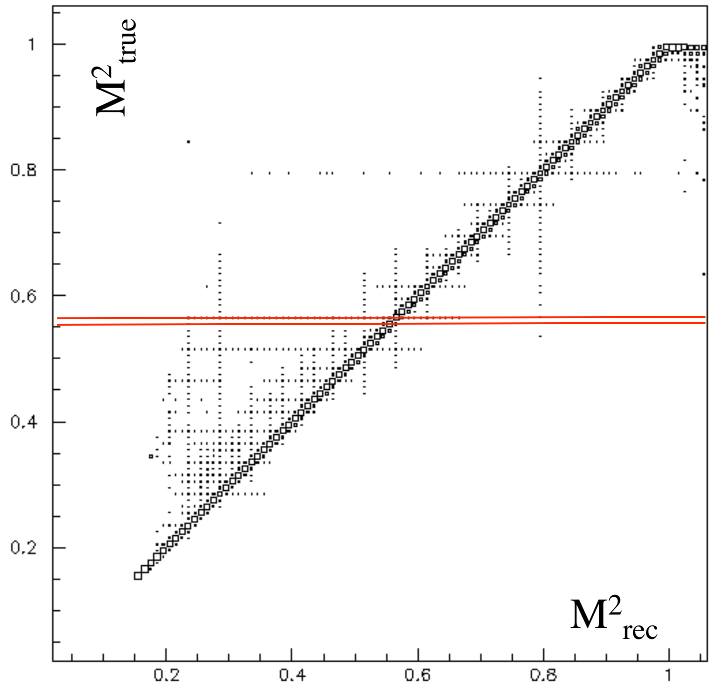


Unfolding:

a) By Matrix-Multiplication

Create Probability-Matrix P_{ij} from MonteCarlo population matrix in (M^2_{rec}, M^2_{true})
- depends less on input spectrum
- affected by difference of acceptance range between data and MC

$$N_{i,}\ true = \sum_j P_{ij} \cdot N_{j,\ rec}$$



Smearing matrix

b) Using Bayes Theorem

D'Agostini I

- method based on Bayes' theorem
  - no matrix inversion needed
  - can be applied to multidimensional problems
  - iterative algorithm; can start with a uniform distribution
- Bayes formula:

$$P(C_i|E_j) = \frac{P(E_j|C_i) P(C_i)}{\sum_{l=1}^{n_c} P(E_j|C_l) P(C_l)}$$

"true", normalized distribution

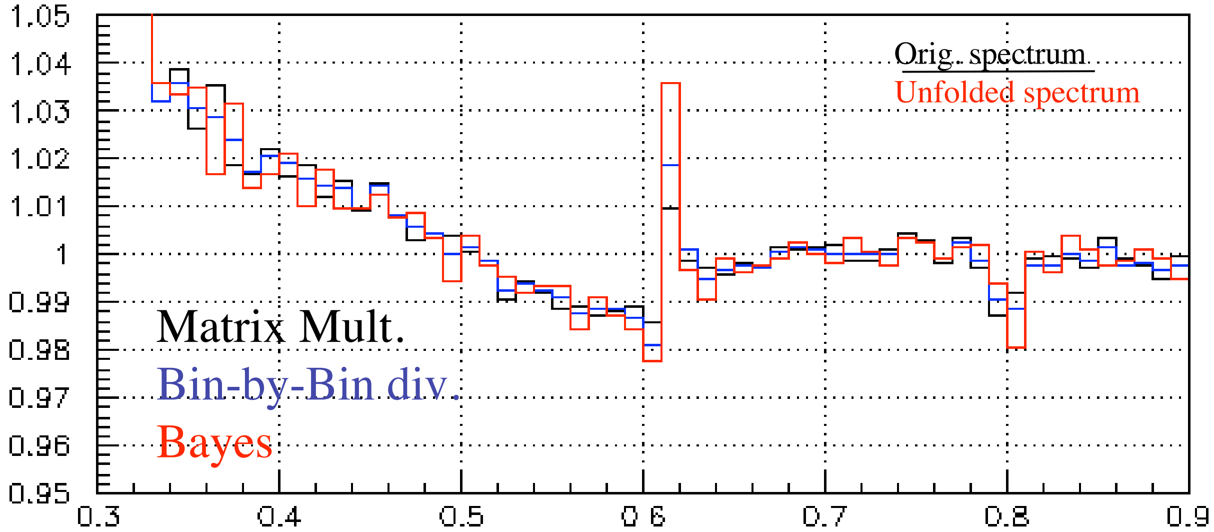
- "if we observe a single event "(effect E_j)", the probability that it has been due to the i-th cause "(C_i)," is proportional to the probability of the cause times probability of the cause to produce the effect"

D'Agostini

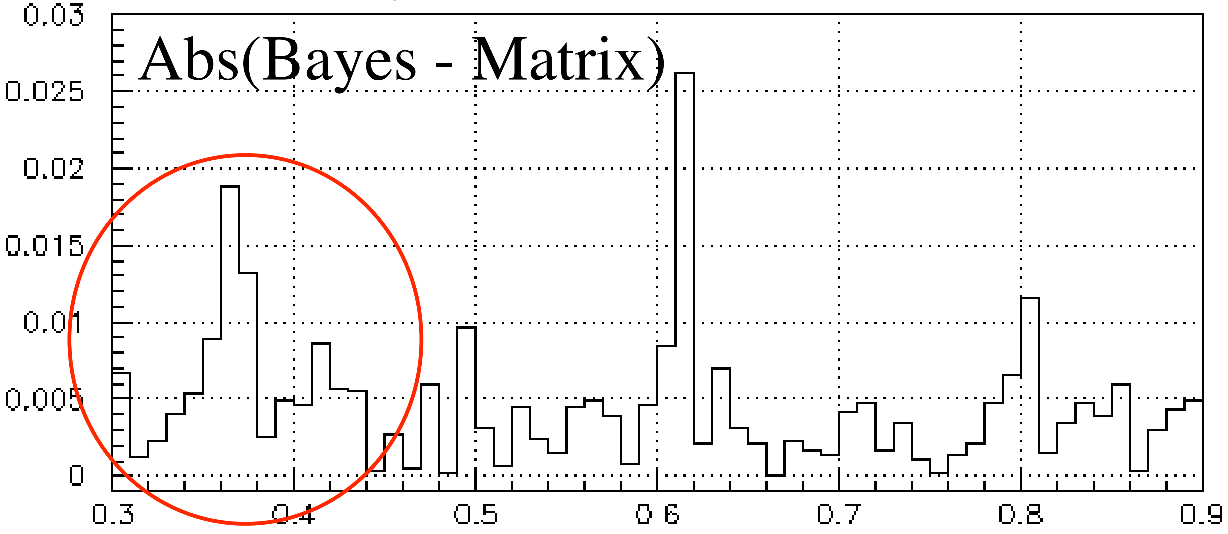
09.02.2006 Yvonne Peters 16

Needs $P(C_i)$, $P(E_j|C_i)$ from MonteCarlo. $P(C_i)$ needs not be too precise, gets iterated (I use $P(C_i)=N_i/N_{tot}$). $P(E_j|C_i)$ is obtained from the Matrix above.

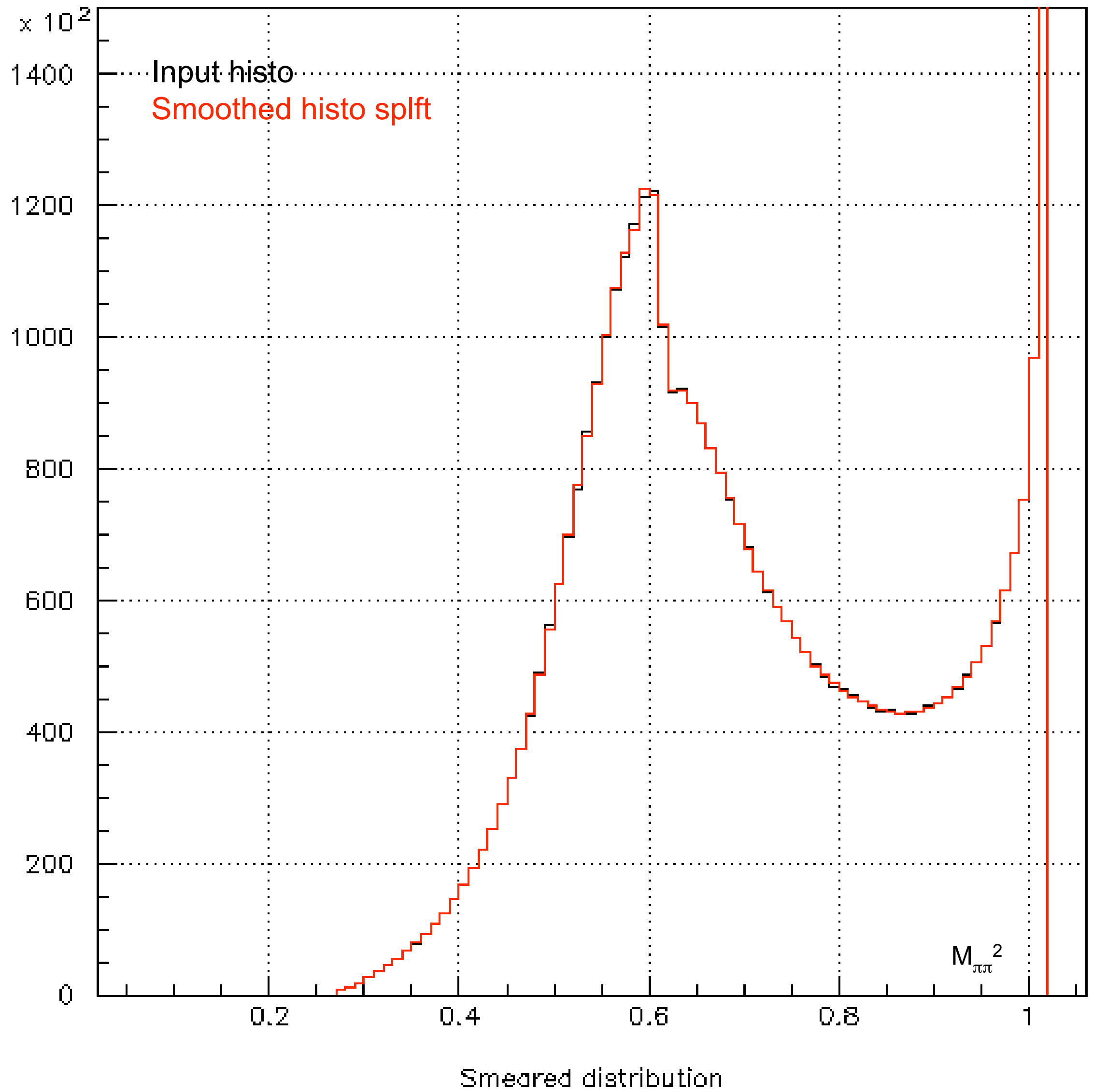
Different unfolding methods agree rather well:



In the analysis, we use the (response) matrix multiplication, since Bayes unfolding creates Some stat. fluctuations in regions, where number of events is smaller (below 0.45 GeV^2):



D'Agostini suggests a smoothing procedure to avoid stat. fluctuations splft.f -routine from V. Bobel promising (www.desy.de/~blobel/splft.f):



Work in progress to determine the best regions to be smoothed in the Bayes-Unfolding procedure

Averaging '01 and '02 spectra: errors breakdown

2001

Reconstruction filter	0.6%
Background	0.3%
M_{trk} cuts	0.2%
Particle ID	0.1%
Tracking	0.3%
Vertex	0.3%
Trigger	0.3%
Acceptance	0.3%
Unfolding	0.2%
Luminosity $(0.5_{th} \oplus 0.3_{exp})\%$	0.6%

2002

Background	M^2 dep (0.1-0.4%)
M_{trk} cuts	0.2%
Particle ID	0.3%
Tracking	0.3%
Trigger	0.1%
Acceptance	M^2 dep (0.1%)
Unfolding	0.2%
L3 Trigger	0.1%
Luminosity $(0.1_{th} \oplus 0.3_{exp})\%$	0.3%

different data sets (statistical independence), different ways to estimate the efficiencies on different data control samples and MC productions

→ systematics are independent in the two spectra

major common systematics:

Radiator H	0.5%

Averaging '01 and '02 spectra: strategy

averaging the differential cross sections for the two analyses

$$\frac{d\sigma_{\pi\pi\gamma}}{dM^2_{\pi\pi}} = \frac{N^{obs} - N^{bkg}}{\Delta M^2_{\pi\pi}} \cdot \frac{1}{\varepsilon_{sel}} \cdot \frac{1}{L}$$

extracting the $\sigma_{\pi\pi}$ from the average differential cross section
and applying the radiator function just once for all

$$M^2_{\pi\pi} \left\langle \frac{d\sigma_{e^+e^- \to \pi^+\pi^-\gamma}}{dM^2_{\pi\pi}} \right\rangle = \sigma_{e^+e^- \to \pi^+\pi^-}(M^2_{\pi\pi}) \cdot H(M^2_{\pi\pi}, \theta_{\min})$$

…and see what happens, if it results that the two spectra are not
so compatible, since statistics is not an issue → use the most recent

Conclusions/To Do:

- $\pi\pi\gamma$ analysis finished, final polishing of systematics
- Writing of paper and documentation in progress
- Combine results from 2001 and 2002 data
- Cross check for luminosity with bha20bab-events

Outlook:

- get muons under control, and extract $|F_\pi|^2$ from ratio of pions and muons
- ...
- combine efforts with LA group on PoP-data?
- $|F_\pi|^2$ down to 2-pion threshold?
- $|F_\pi|^2$ from coll. events around ϕ-meson mass?