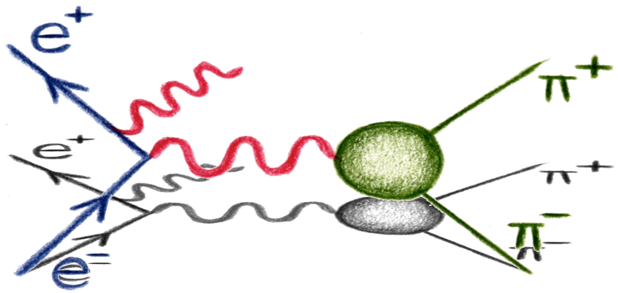
MC Tools used and needed in the KLOE small angle analysis for $|F_\pi|^2$



S. Müller
(KLOE ππγ group)

RADIO MONTECARLow

WG Meeting in Frascati, 11.4.2008

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%

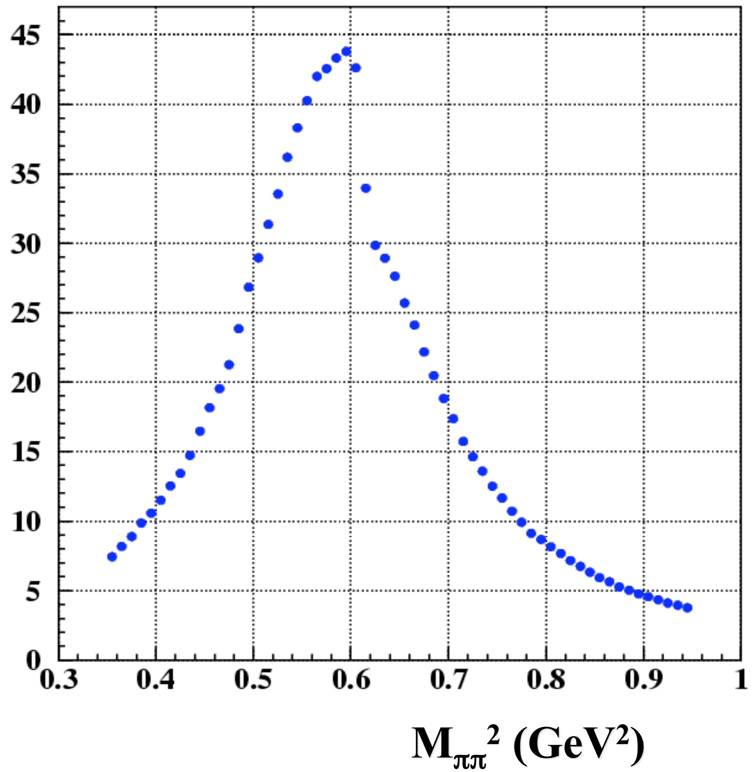
experimental fractional error on a_μ = 0.7%

Radiator H	0.5%

total fractional error on a_μ = 0.9%

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

F_π resolution effects unfolded

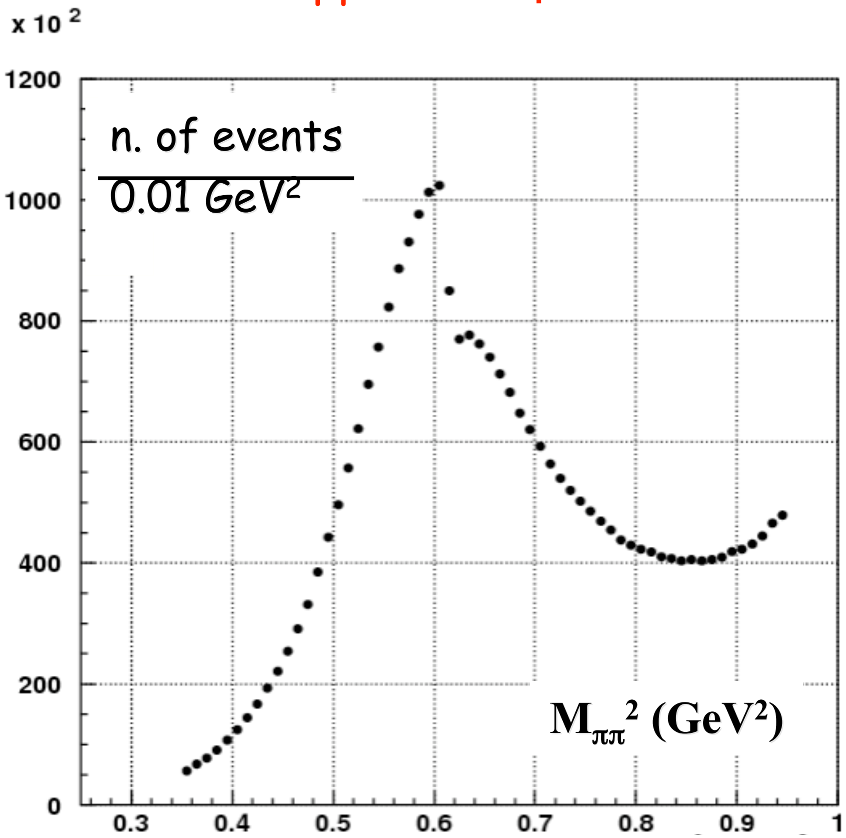


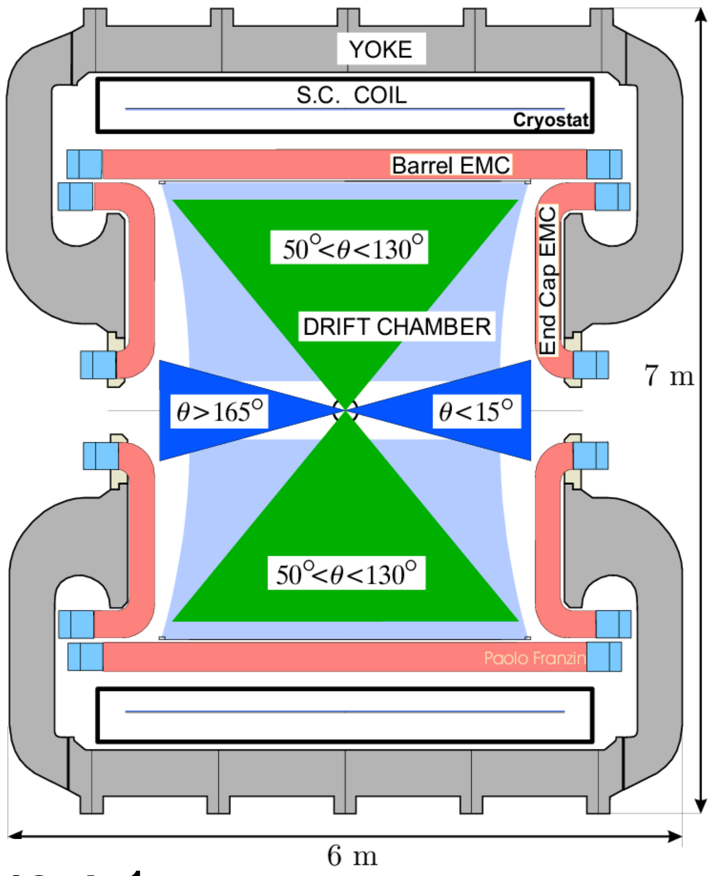
Selection of $\pi\pi\gamma$ events at small angle

a) 2 tracks with $50^o < \theta_{track} < 130^o$
b) small angle γ ($\theta_\Sigma \equiv \theta_{\pi\pi} < 15^o$)

kinematics: $\vec{p}_\gamma = \vec{p}_{miss} = -(\vec{p}_+ + \vec{p}_-)$

✓ high statistics for ISR ($\sim \theta^{-2}$)
✓ low relative FSR contribution
✓ suppressed $\phi \to \pi^+\pi^-\pi^0$ wrt the signal





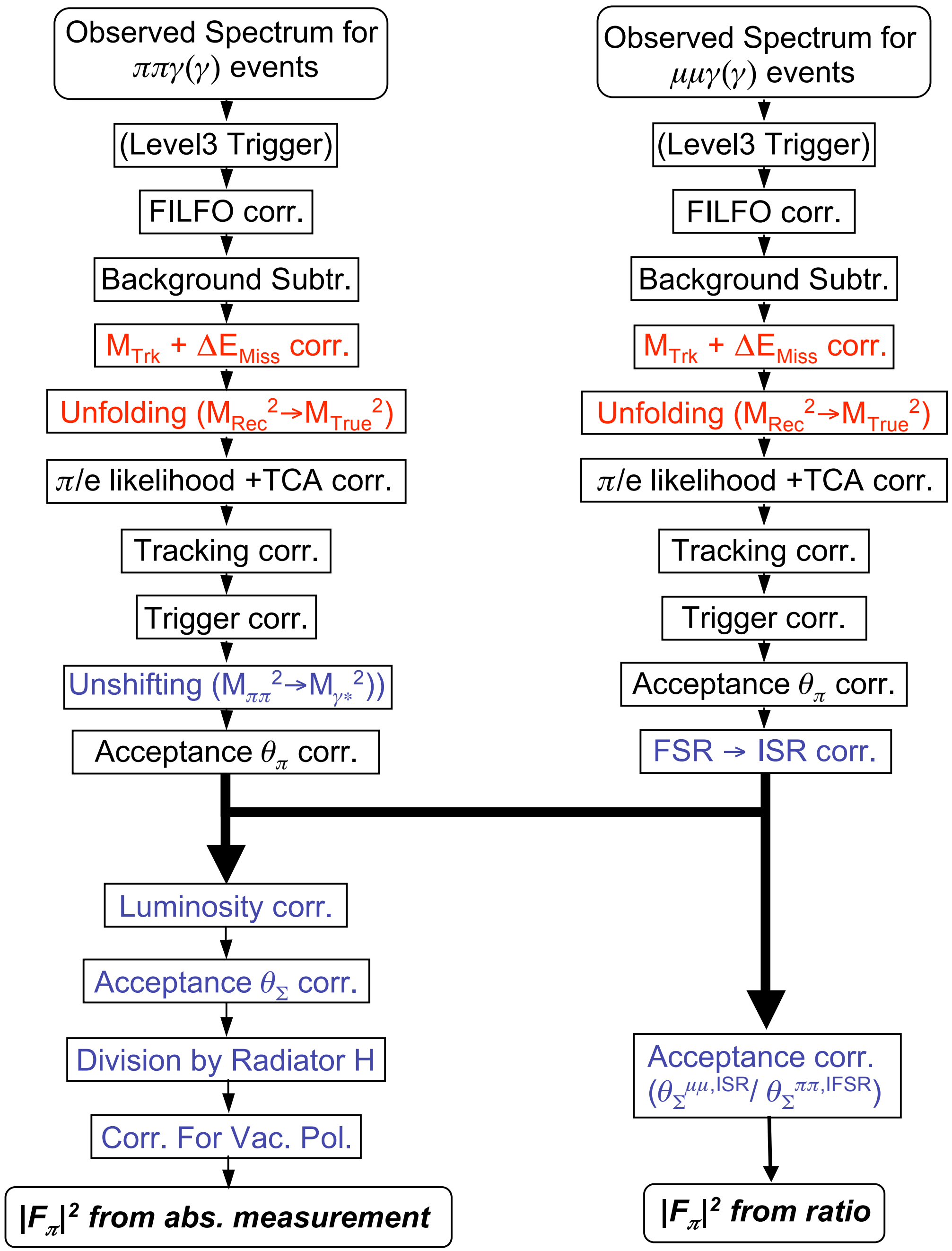
statistics: 242pb^{-1}

3.4 Million Events

“Analysis Flow”

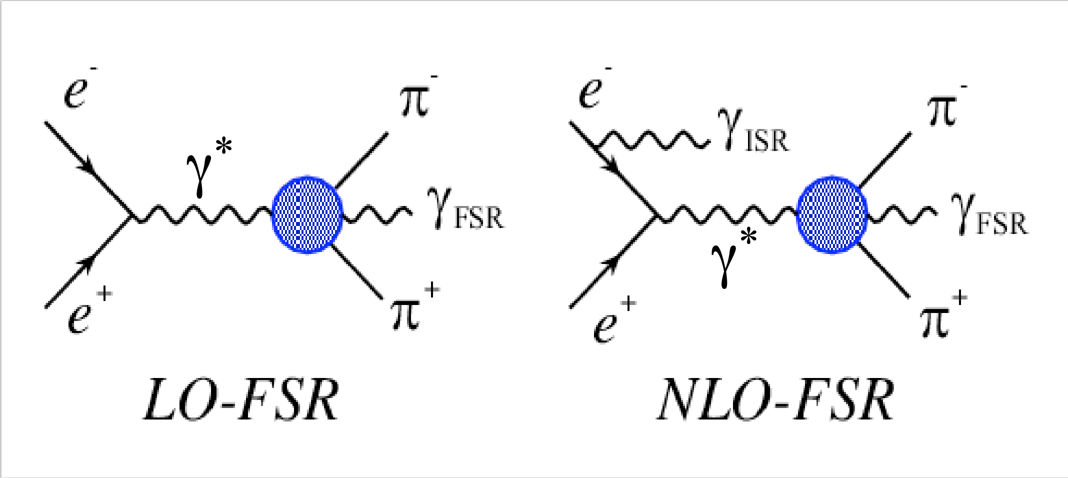
MC+Detector simulation enters

Strong dependence on MC and/or radiative corrections



Final State radiation:

The cross section for $e^+e^- \to \pi^+\pi^-$ has to be inclusive with respect to final state radiation events in order to evaluate a_μ. We consider two kinds of FSR contributions:



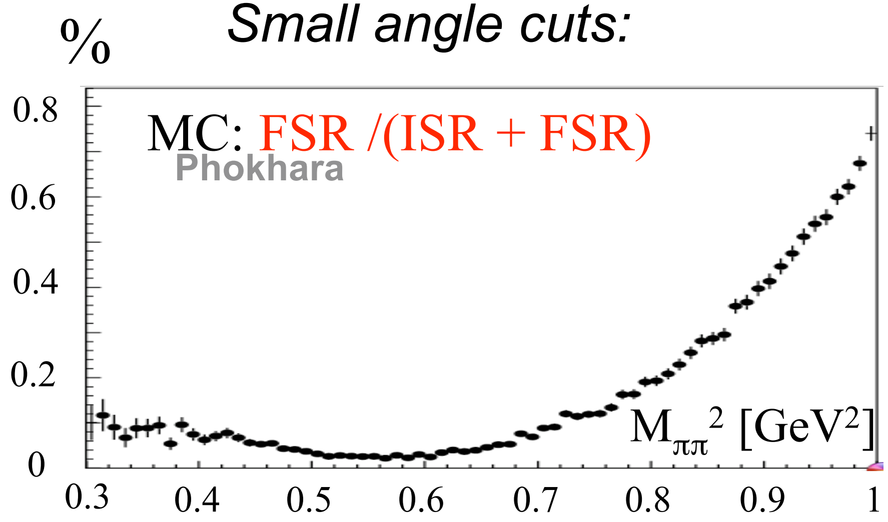
LO-FSR: No initial state radiation, e^+ and e^- collide at the energy M_ϕ=1.02 GeV
This is clearly the dominant part, and it enters our spectrum since $M^2_{\pi\pi} < M^2_{\gamma*}$

NLO-FSR: Simultaneous presence of one photon from initial state radiation and one photon from final state radiation

The cut on $\theta_\Sigma < 15^0$ reduces very much the relative contribution from FSR with respect to ISR.

The correction for θ_Σ at the end of the analysis chain "adds" back the most part of the FSR

Small angle cuts:

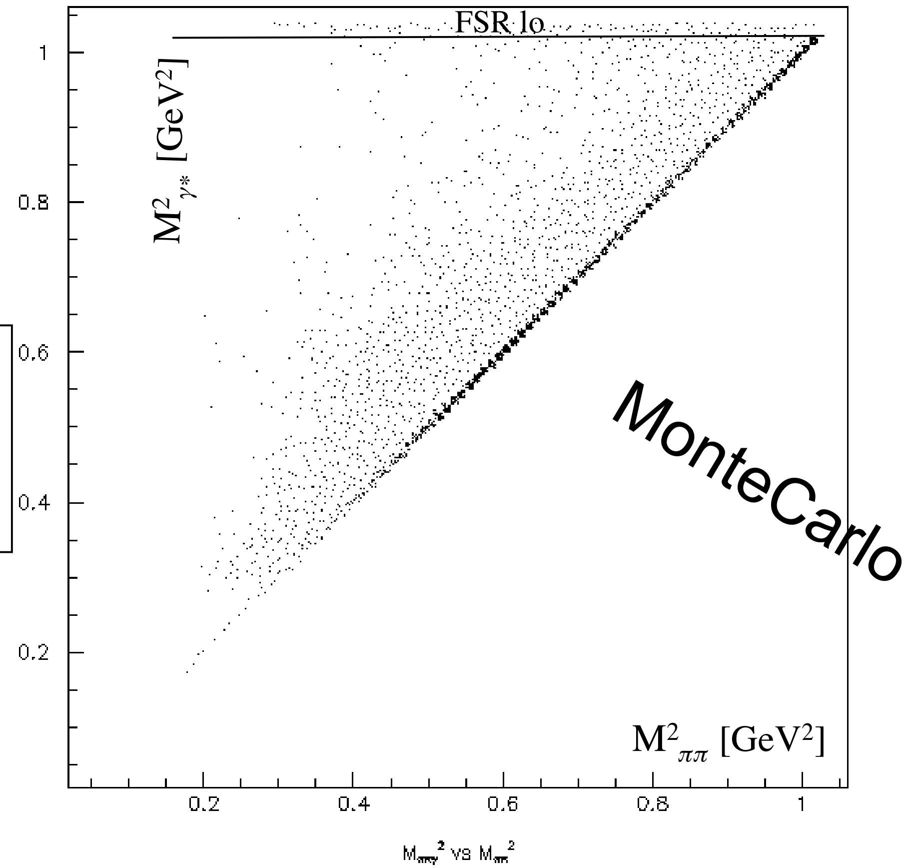


“Unshifting”

Go from $M^2_{+-} \rightarrow M^2_{\gamma*}$

The presence of γ_{FSR} results in a shift of the measured quantity $M^2_{\pi\pi}$ towards lower values:

$$M^2_{\pi\pi} < M^2_{\gamma*}$$



Use special version of PHOKHARA which allows to determine whether photon comes from initial or final state → build matrix which relates $M^2_{\pi\pi}$ to $M^2_{\gamma*}$.

“PHOKHARA Omega”

ISR only: $M^2_{\gamma*} = M^2_{\pi\pi}$

FSR photon present: $M^2_{\gamma*} = M^2_{\pi\pi\gamma_{(FSR)}}$

“Unshifting”

Go from $M^2_{+-} \rightarrow M^2_{\gamma *}$

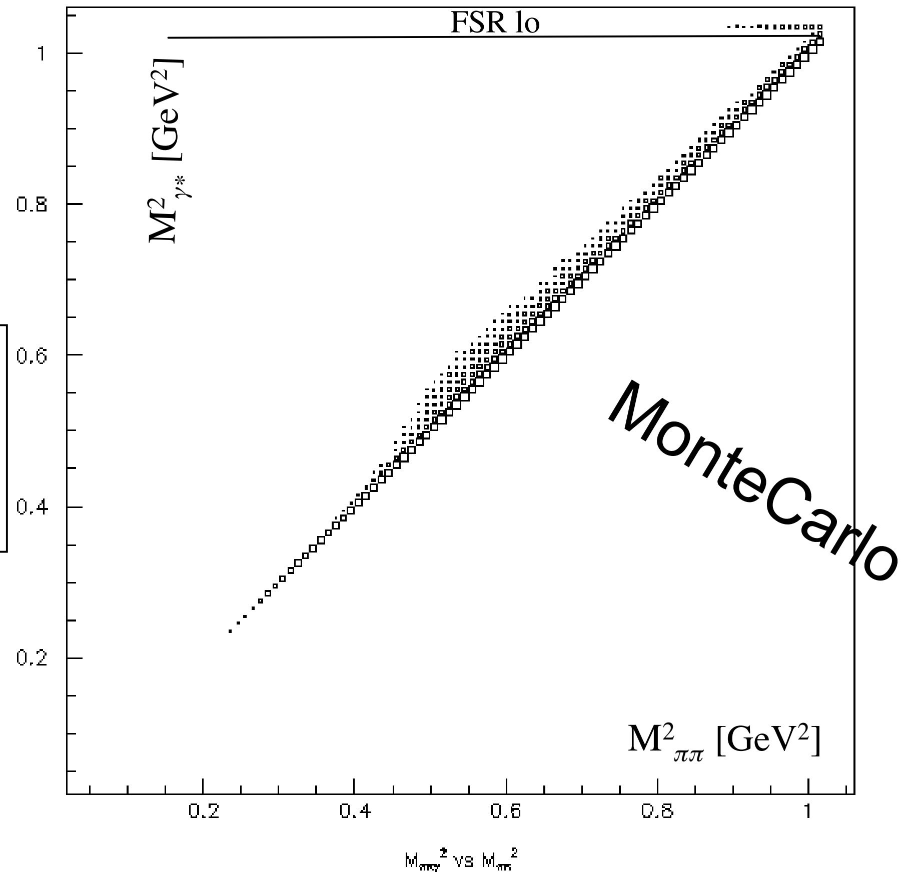
The presence of γ_{FSR} results in a shift of the measured quantity $M^2_{\pi\pi}$ towards lower values:

$$M^2_{\pi\pi} < M^2_{\gamma *}$$

Use special version of PHOKHARA which allows to determine whether photon comes from initial or final state → build matrix which relates $M^2_{\pi\pi}$ to $M^2_{\gamma *}$.

“PHOKHARA Omega”

With log. Z-scale:

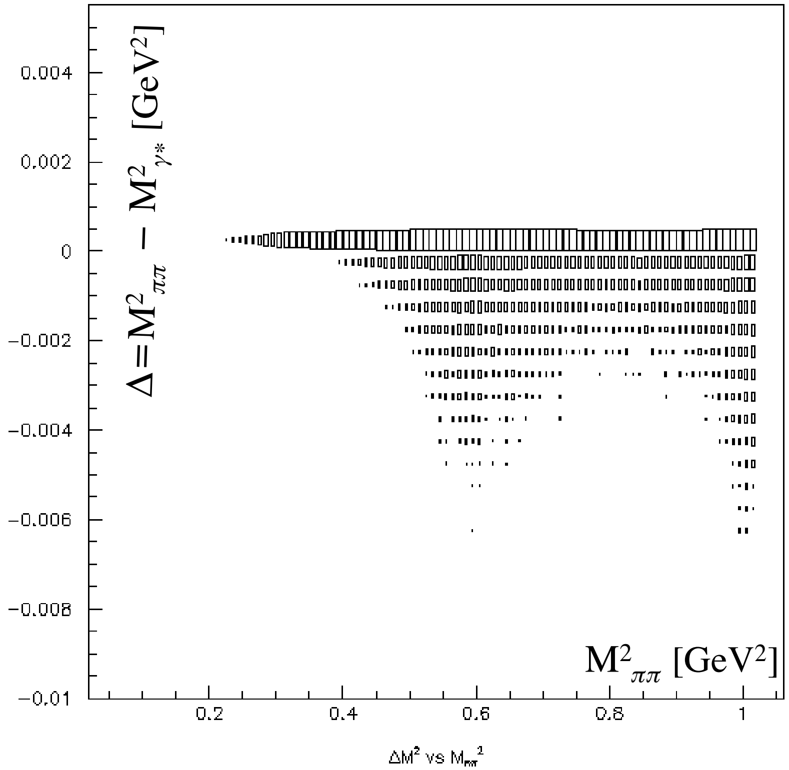


ISR only: $M^2_{\gamma *} = M^2_{\pi\pi}$

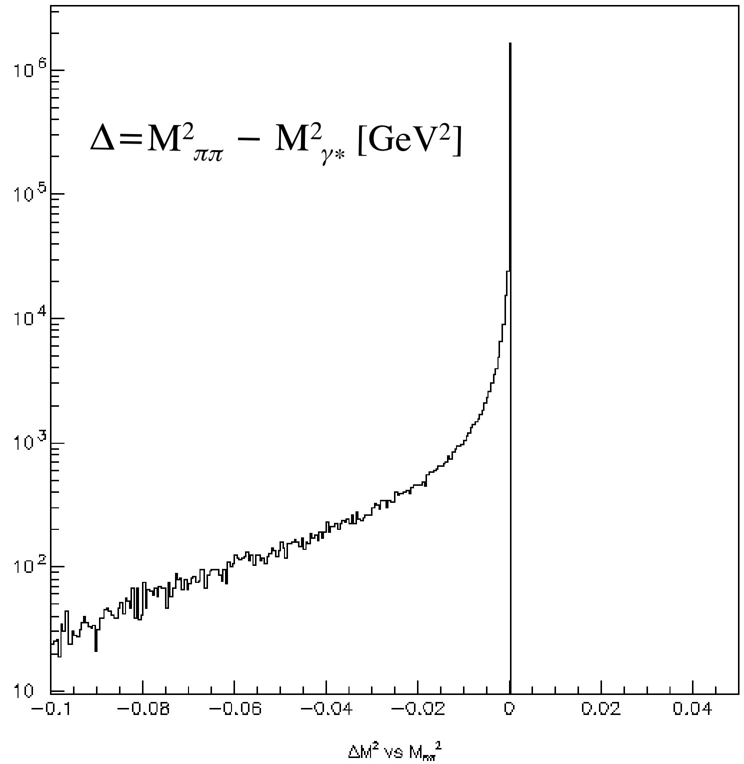
FSR photon present: $M^2_{\gamma *} = M^2_{\pi\pi\gamma(FSR)}$

Certainly not a big effect, especially if done within $\theta_\Sigma < 15^0$

"Unshifting"



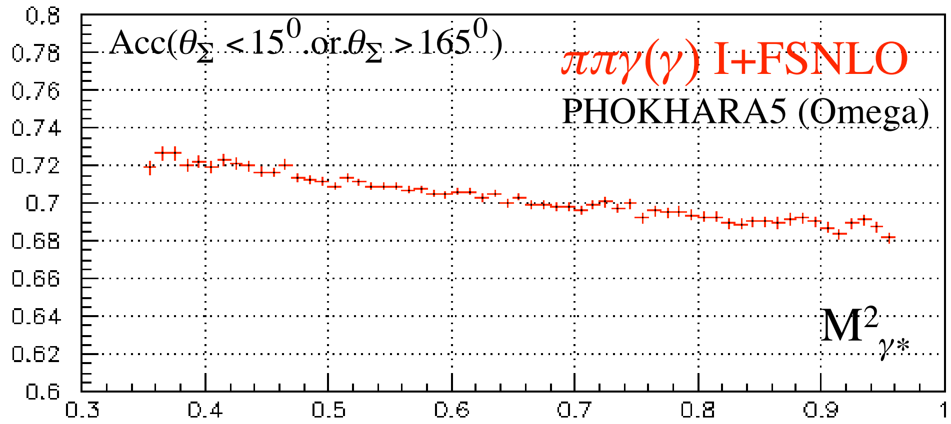
Projection in Y-axis:



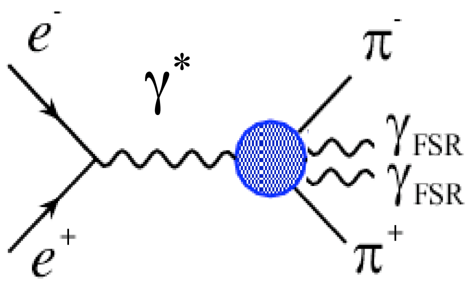
Certainly not a big effect, especially if done within $\theta_\Sigma < 15^0$

θ_Σ correction (Acceptance)

This correction now contains the biggest part of the FSR contribution to the spectrum.



What is the effect of a second hard photon from FSR to this correction??



This process is not (yet?) included in PHOKHARA, and it might affect the contribution of FSR in our spectrum.

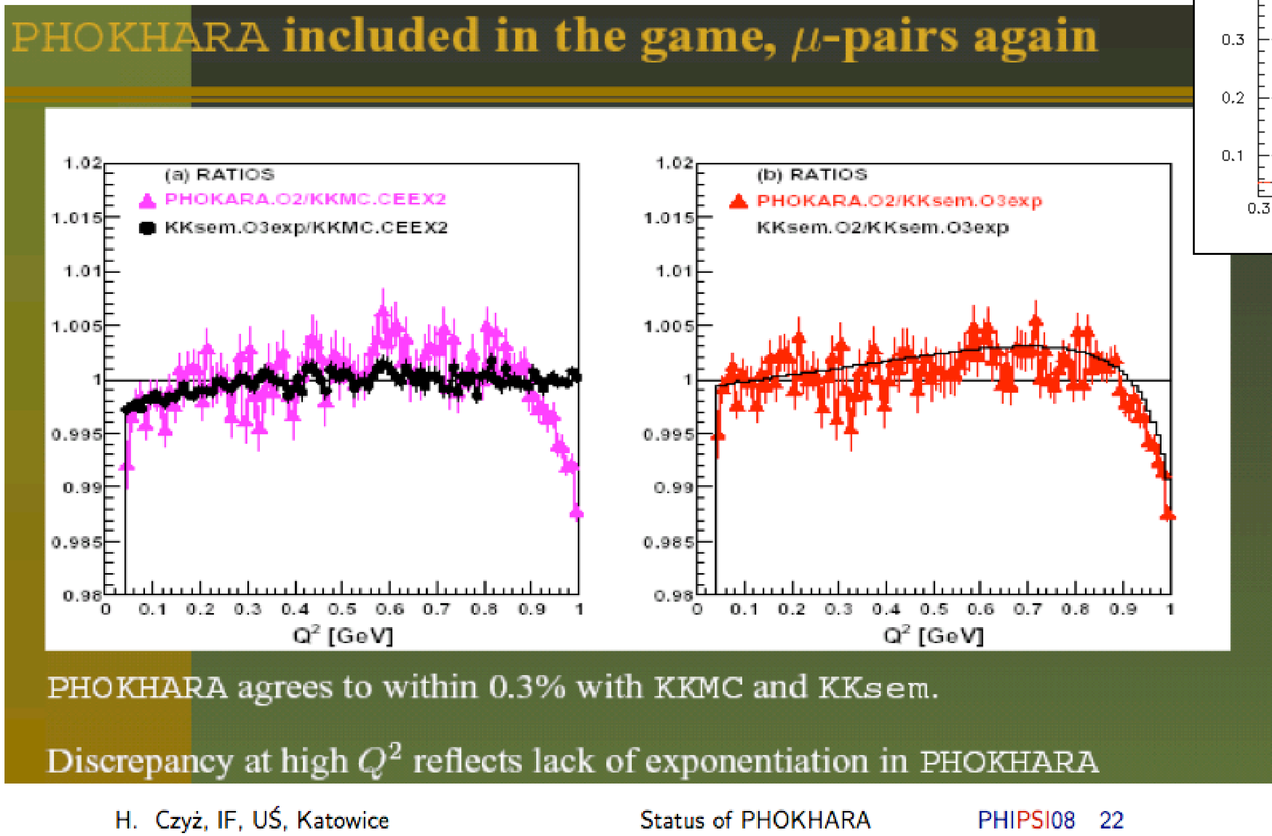
The radiator function:

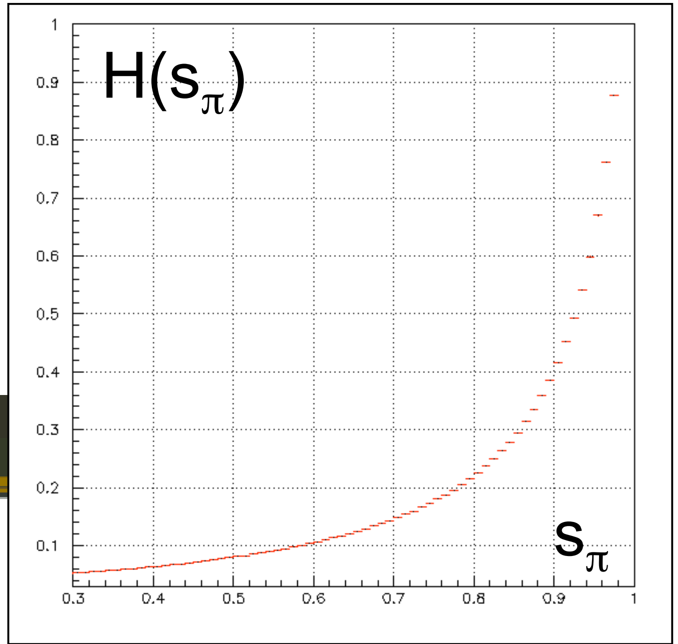
is obtained from the PHOKHARA MC using

$$H(s_\pi) = \frac{3 s_\pi}{\pi \alpha^2 \beta_\pi^3} \cdot s_\phi \cdot \frac{d\sigma_{\pi\pi\gamma}}{ds_\pi}\left(|F_\pi|^2 = 1, s_\phi\right)$$

with $\frac{d\sigma_{\pi\pi\gamma}}{ds_\pi}\left(|F_\pi|^2 = 1, s_\phi\right)$ obtained from PHOKHARA

S.Jadach: KKMC

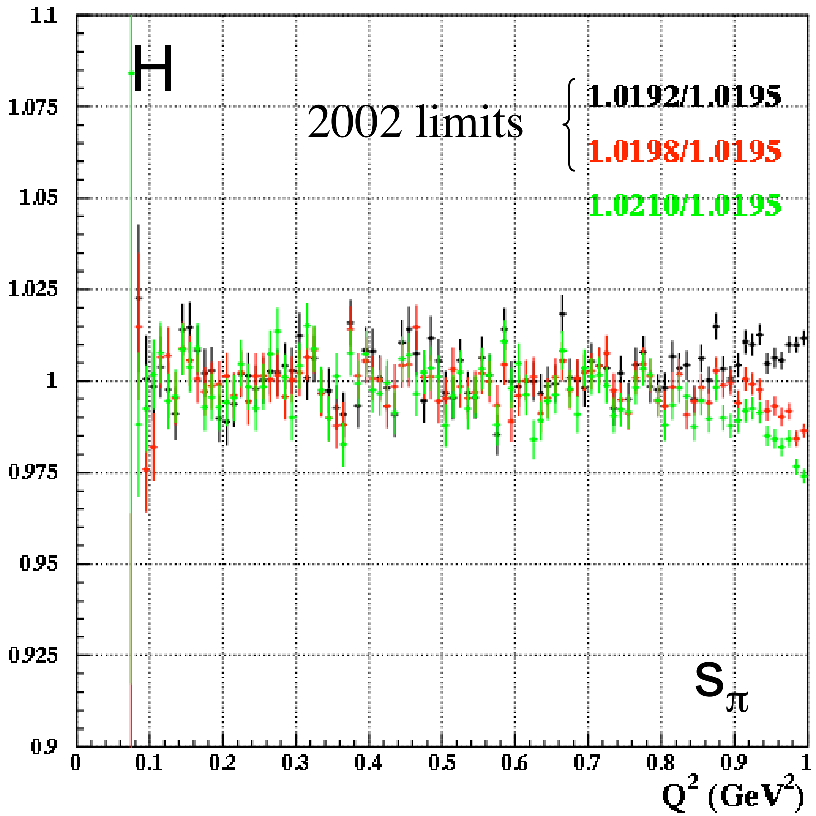




- 0.5% error translates directly to $a_\mu^{\pi\pi}$
- now biggest syst. Error from theory
- validity above 0.9 GeV²??

The radiator function:

Checks on dependence on √ s:



Difference between H evaluated at 1.0192 GeV^2 and 1.0198 GeV^2 used to estimate contribution to syst. error.

Update in the Bhabha cross section: luminosity

KLOE measures L with Bhabha scattering

F. Ambrosino et al. (KLOE Coll.)
Eur.Phys.J.C47:589-596,2006

$55° < \theta < 125°$

acollinearity < 9°

$p \geq 400$ MeV

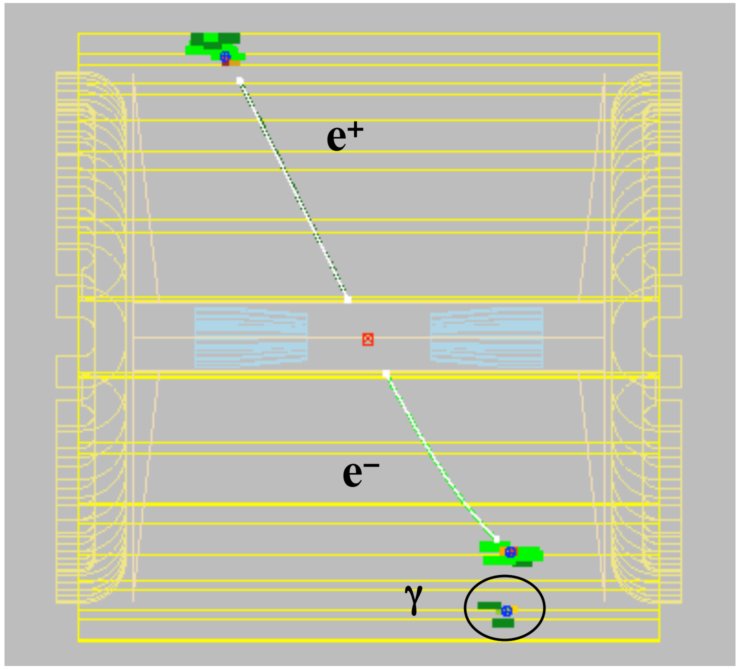
$$\int \mathcal{L}\,dt = \frac{N_{obs} - N_{bkg}}{\sigma_{eff}}$$

generator used for σ_{eff}

BABAYAGA (Pavia group):

C. M.C. Calame et al., NPB758 (2006) 22

see C.M.C. Calame's talk

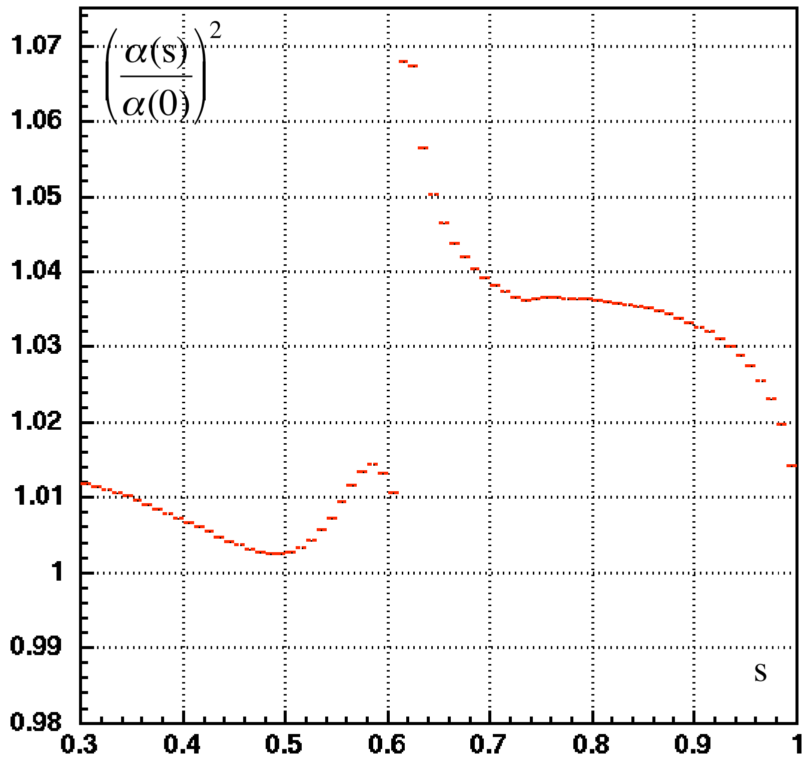


new version (**BABAYAGA@NLO**) gives 0.7% decrease in cross section, and better accuracy: 0.1%

Systematics on Luminosity	
Theory	0.1 %
Experiment	0.3 %
TOTAL 0.1 % th ⊕ 0.3% exp = 0.3%	

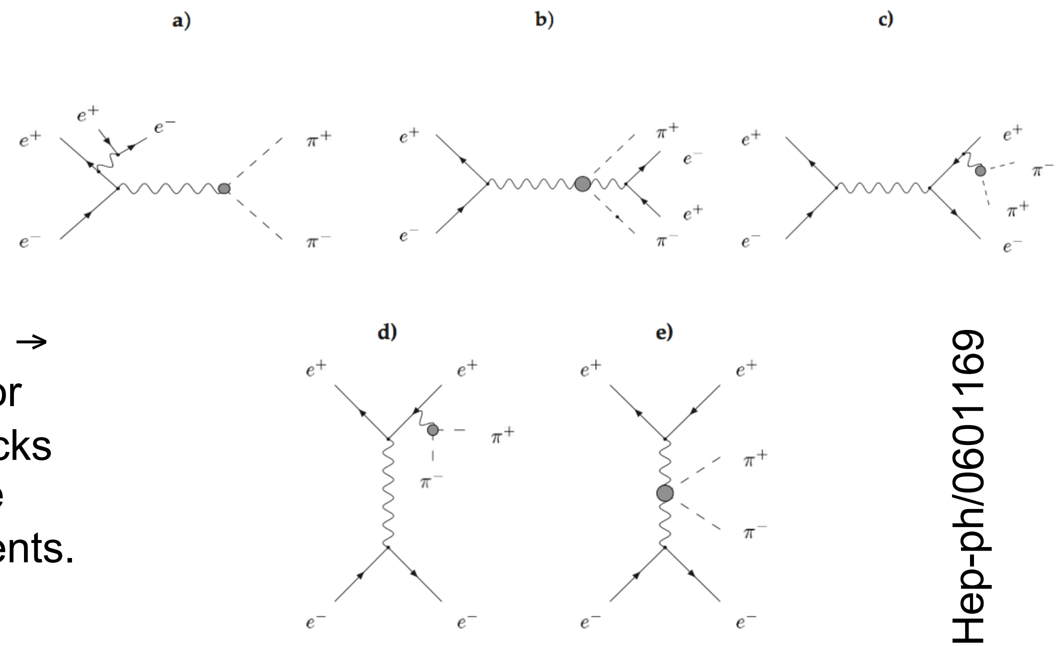
Vacuum Polarisation:

We use the routines provided by F. Jegerlehner (http://www-com.physik.hu-berlin.de/~fjeger/)



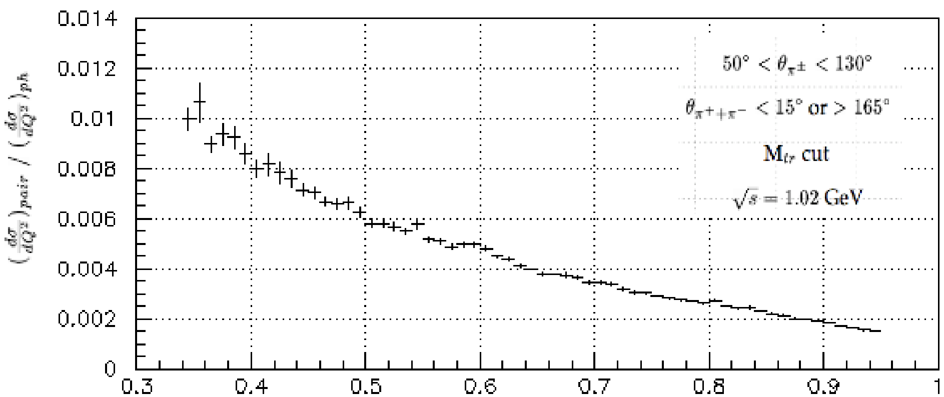
- needed to undress cross section for the dispersion integral
- comparison with Novosibirsk VP?

Background Subtraction:



We estimated 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.

Hep-ph/0601169

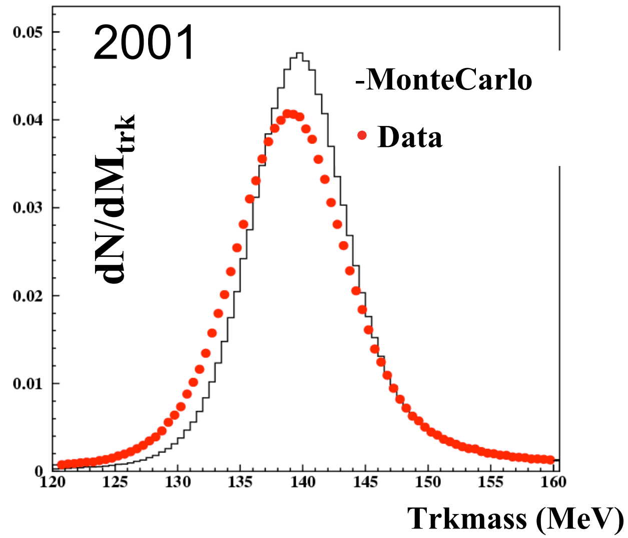


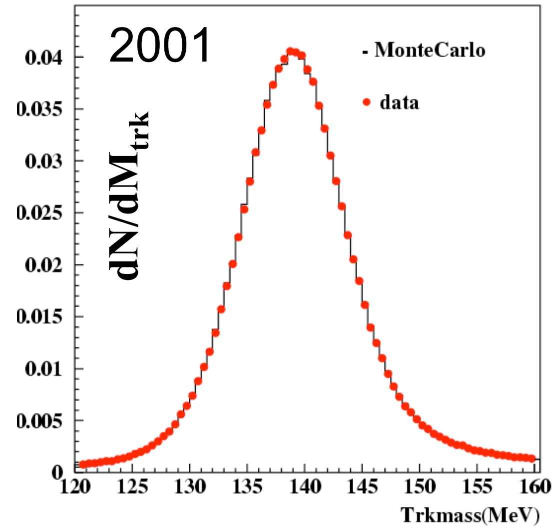
The rel. contribution estimated in this way has been added to the syst. Error of the measurement

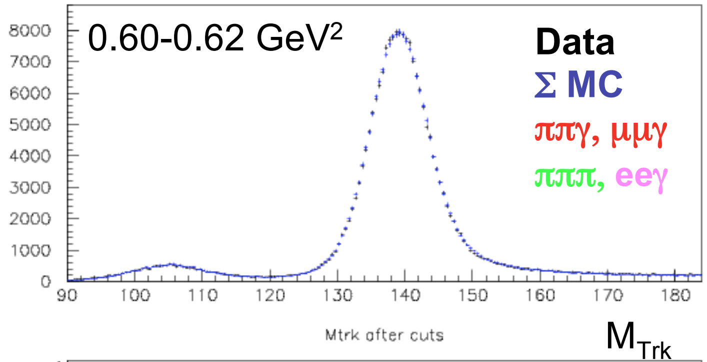
But not all of the graphs show are background - graphs a) and b) are actually some kind of signal..

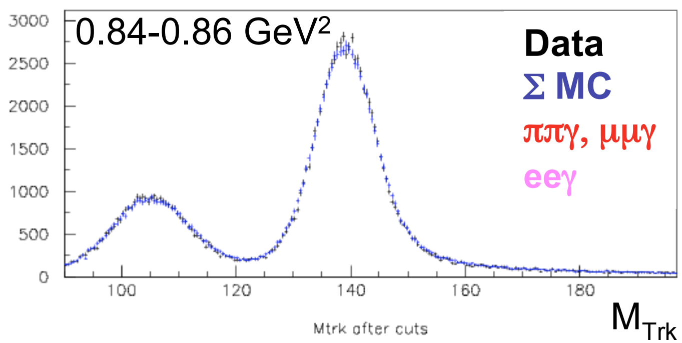
Detector simulation effect on M_{Trk}

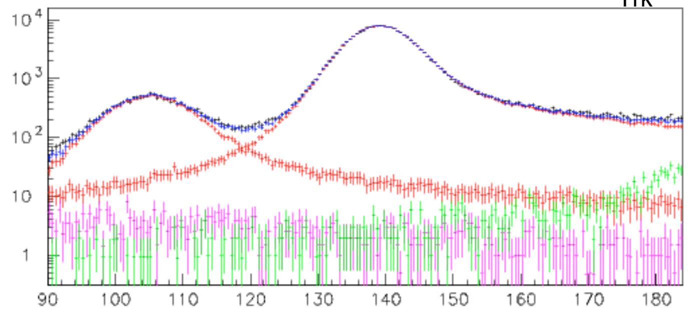
After the detector simulation, reconstructed MonteCarlo output needs to be tuned to reproduce data distributions. Effect of different “tuning”-methods on background eval., MC eff., etc. contributes to systematic error.

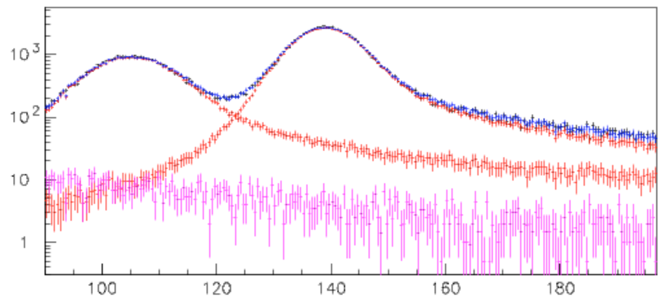












Conclusions:

- The development of both the PHOKHARA and the BABAYAGA Monte Carlo-Codes was very important to our analysis (and without these tools, we would have never reached the precision we have)

- The continuous feedback between theorists and experimentalists was crucial

- Even if the road gets harder (orders get higher…) this fruitful collaboration should be continued

- I think this Working Group is the perfect place for this enterprise