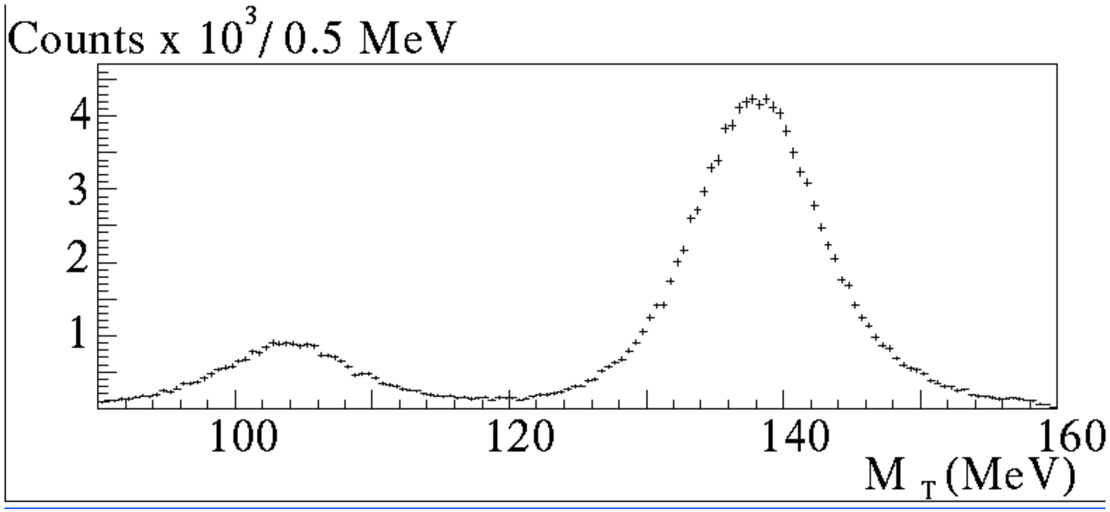
Status of $f_0(980) \rightarrow \pi^+\pi^-$ analysis

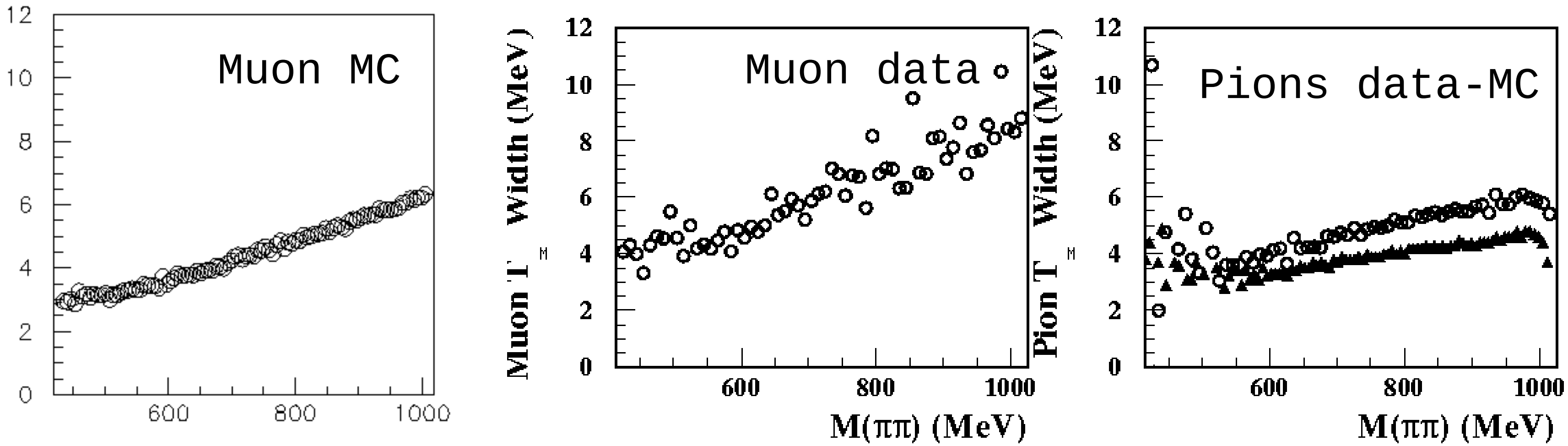
- Study of background sources ($\mu^+\mu^-\gamma$, $\pi^+\pi^-\pi^0$, $\pi^+\pi^-$)
  ρ^0 line shape and ρ^0-ω interference
- Three different fits to the same spectrum
- Charge asymmetry

1.Study of background sources

$\mu^+\mu^-\gamma$: new generation based on *phokhara3*

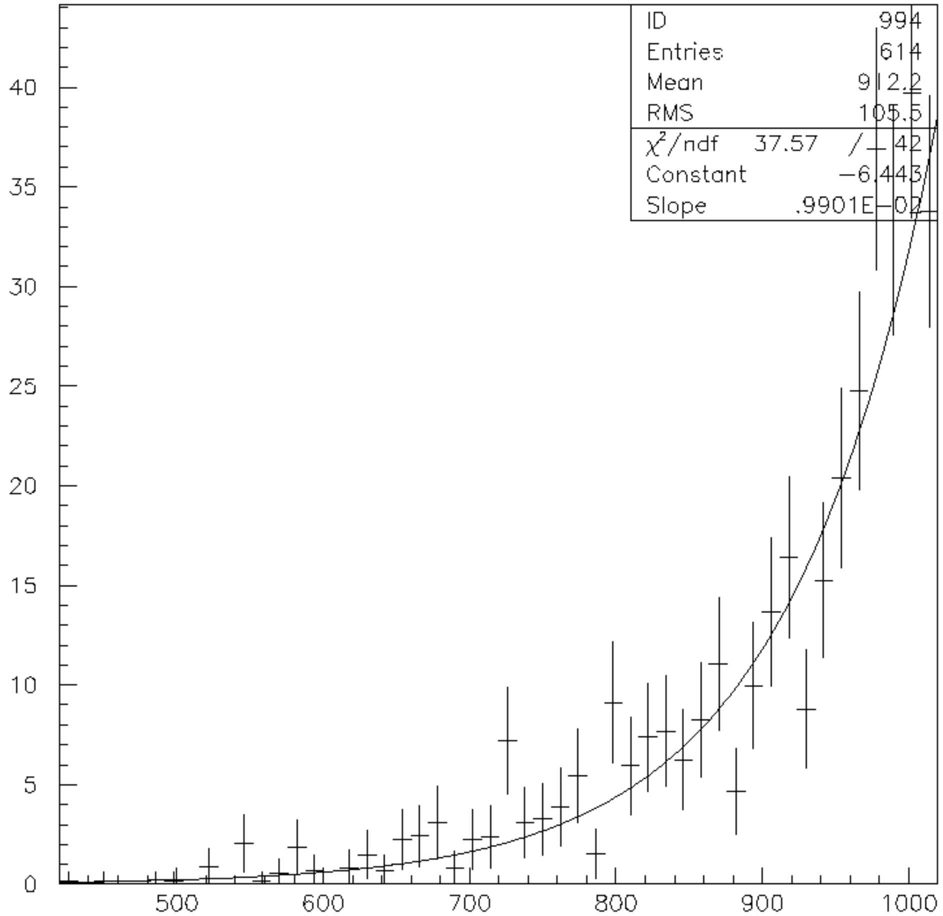
Trackmass: comparison data-MC





239 pb-1 MC sample → 360 evts surviving

→ 526 evts in the full sample (6.8 x 10^5 data sample)

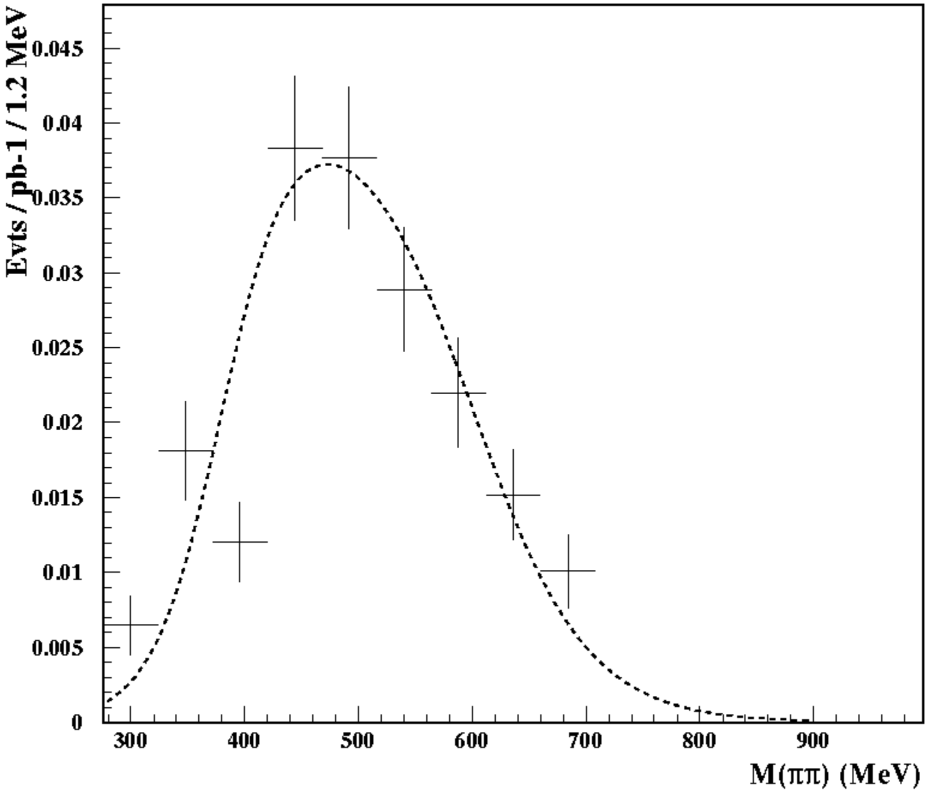


M(μμ) in ππ hypothesys

This curve is added to the fit function

$\pi^+\pi^-\pi^0$ **higher statistics new generation**

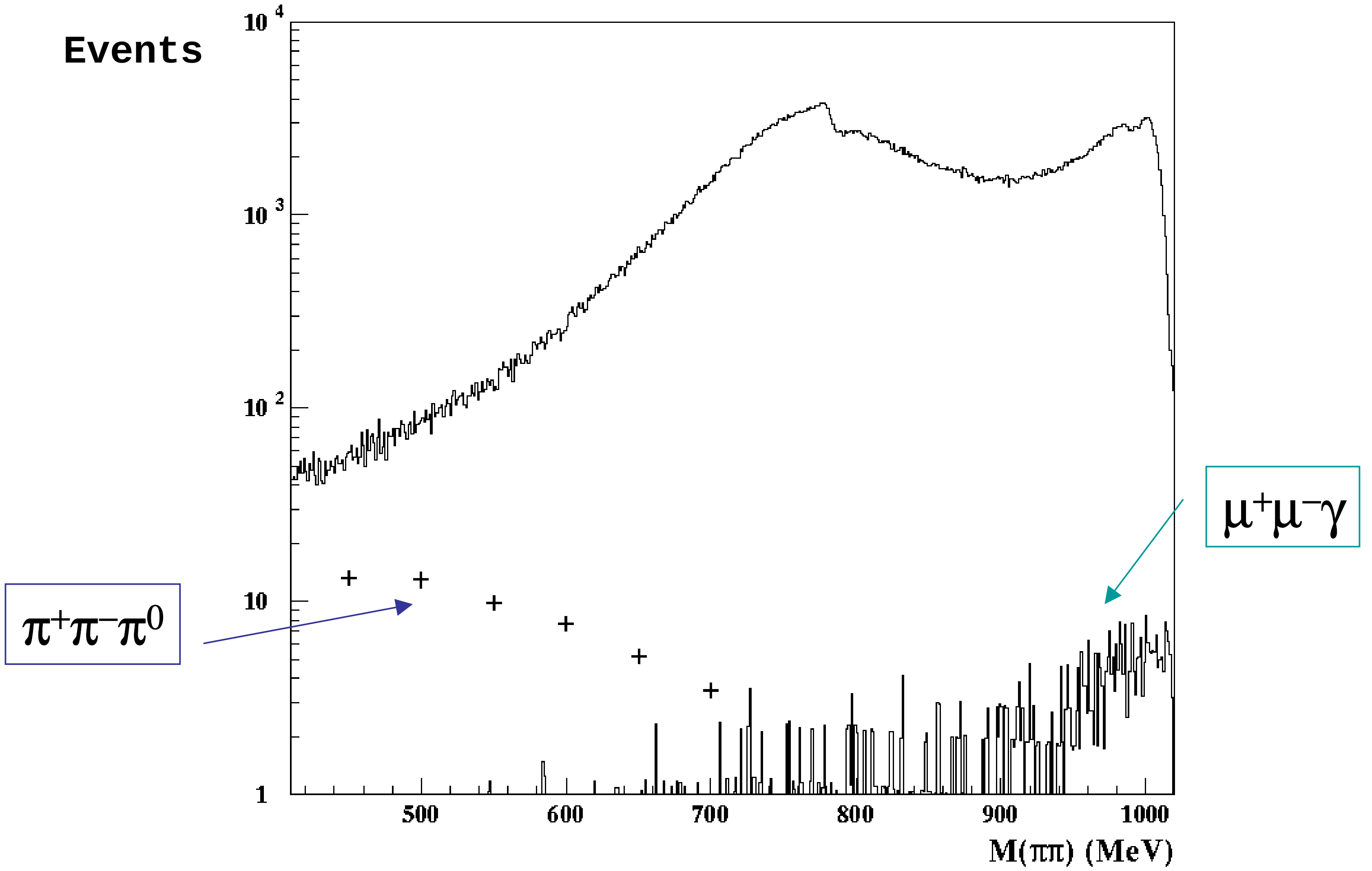
➔ **new function to add in the fit**



$\pi^+\pi^-$ **new two-body generator done**

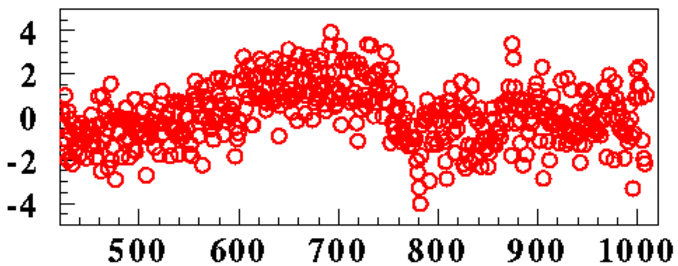
➔ **see possible tail on the high mass region**

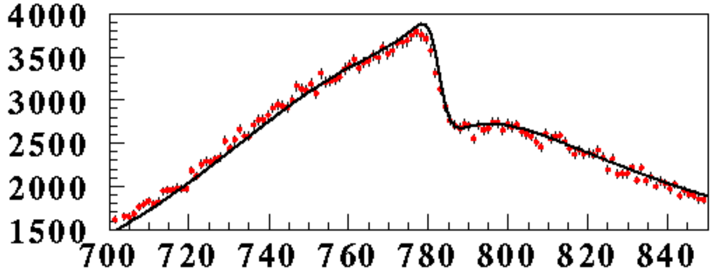
Present estimated backgrounds:



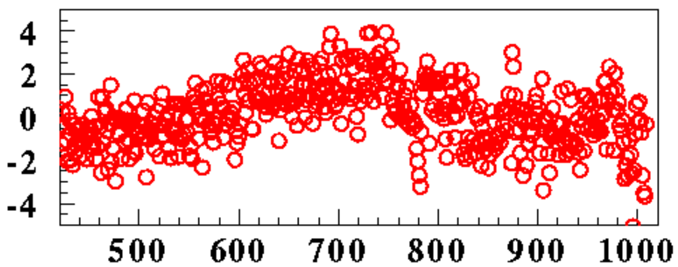
2. ρ^0 line shape and ρ^0-ω interference
ρ^0 mass and width (773.3 and 144.1 MeV) "not consistent" with $\pi^+\pi^-\pi^0$ analysis (775.9±0.7 and 147.3±1.6 MeV). Try to force

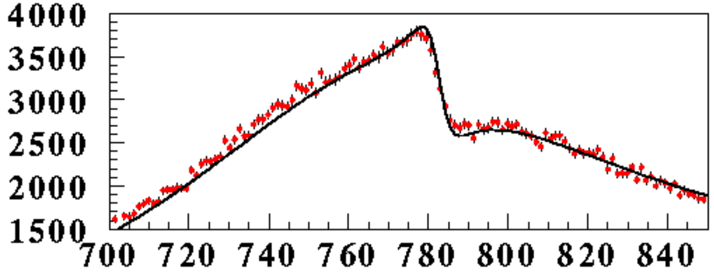
M(ρ^0) and Γ(ρ^0) forced



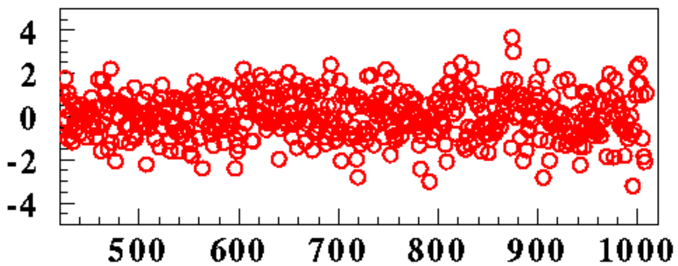


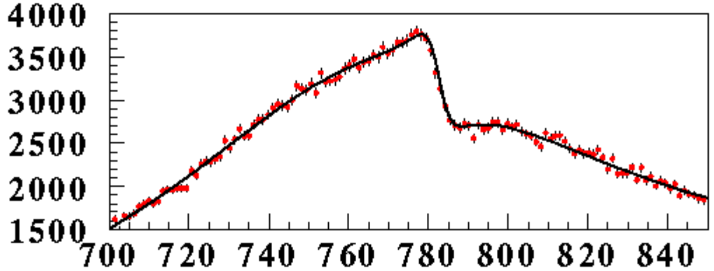
M(ρ^0) forced





M(ρ^0) and Γ(ρ^0) Free (baseline fit)



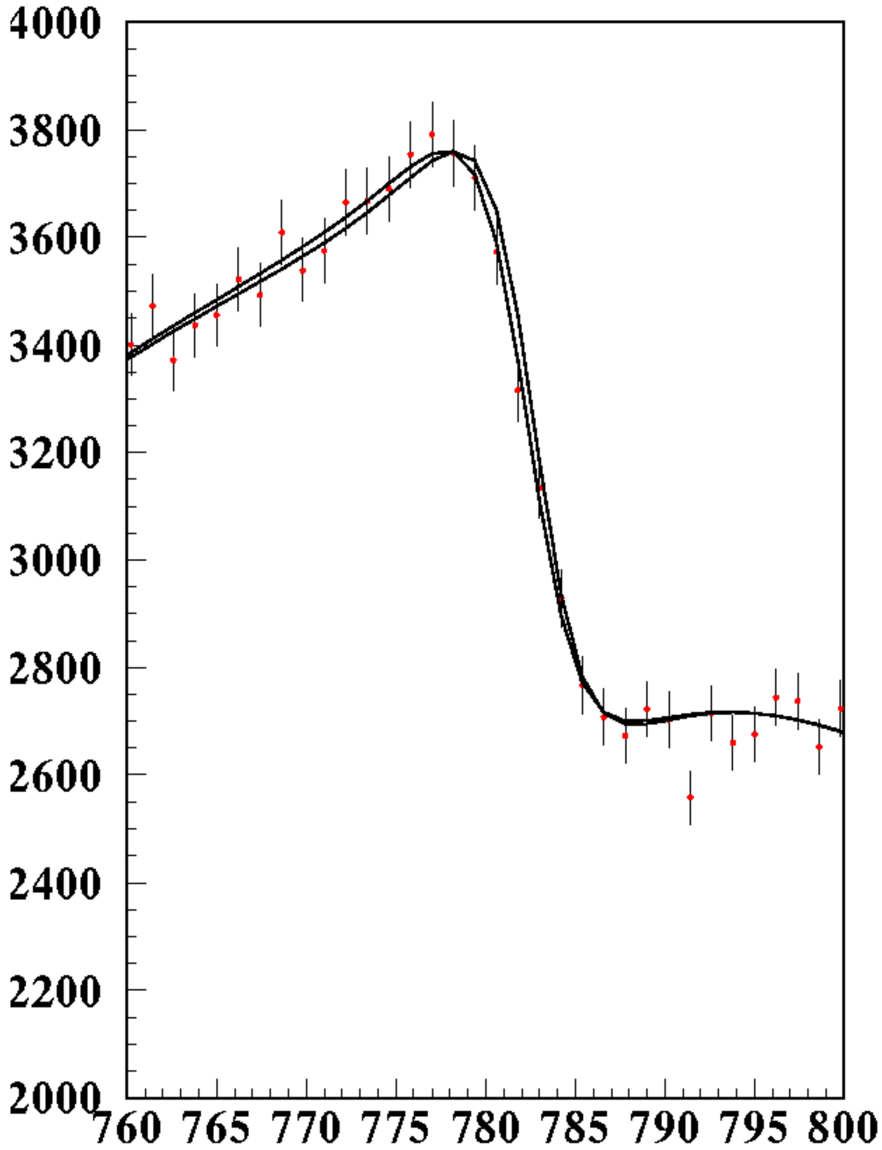


Are we sensitive to M(ω) and Γ(ω) ? Or do they Affect M(ρ^0) and Γ(ρ^0) determination ?

Fit with M(ω) and Γ(ω) free: ρ^0 parameters do not change: values found:

M(ω) =	**782.2**	**± 0.6**
(PDG)	**782.59**	**± 0.11**
Γ(ω) =	**8.9**	**± 0.8**
(PDG)	**8.49**	**± 0.08**

Good momentum scale calibration.
No smearing required



3. Three different fits to the same spectrum:

KL = Kaon-loop approach (N.N.Achasov et al)

IM = "no structure" (G.Isidori, L.Maiani)

BP = based on scattering amplitudes (M.E.Boglione, M.Pennington)

$$A(\phi \to S\gamma \to \pi^+\pi^-\gamma) = -\frac{esm_\phi^2}{4f_\phi D_\phi(s)(s-m^2)}\{M\}$$

$$M_{KL} = \frac{g_{f\pi\pi}g(m^2)e^{i\delta_m(\theta)}}{D_f(m^2)}$$

$$M_{IM} = (s-m^2)\left[\frac{g_{f\pi\pi}g_{\phi f\gamma}}{D_f(m^2)} + \frac{c_0}{m_\phi^2} + c_1\frac{m^2-m_f^2}{m_\phi^4}\right]e^{i\lambda}$$

$$M_{BP} = (m^2-m_o^2)\left[(a_1+b_1m^2)T(\pi\pi\to\pi\pi)+(a_2+b_2m^2)T(KK\to\pi\pi)\right]e^{i\lambda}$$

The fitting function:

$$\frac{d\sigma}{dm} = \left(\frac{d\sigma}{dm}\right)_{ISR} + \left(\frac{d\sigma}{dm}\right)_{FSR} + \left(\frac{d\sigma}{dm}\right)_{\rho\pi} + back(\pi^+\pi^-\pi^0 + \mu^+\mu^-\gamma)$$
$$+ \left(\frac{d\sigma}{dm}(|A|^2)\right)_{Scalar} + \left(\frac{d\sigma}{dm}(A)\right)_{\mathrm{int}.Scalar+FSR}$$

Free parameters:

(1) for the "background" $M(\rho^0)$ $\Gamma(\rho^0)$ α β $a_{\rho\pi}$

(2) for the "signal"

KL (m_f g_{fKK} R)

IM (m_f Γ_f gg c_0 c_1 fase)

BP (a_1 b_1 a_2 b_2 s_0 fase)

KL fit

$\chi^2 = 541/481$

$P(\chi^2) = 3.0\%$

IM fit

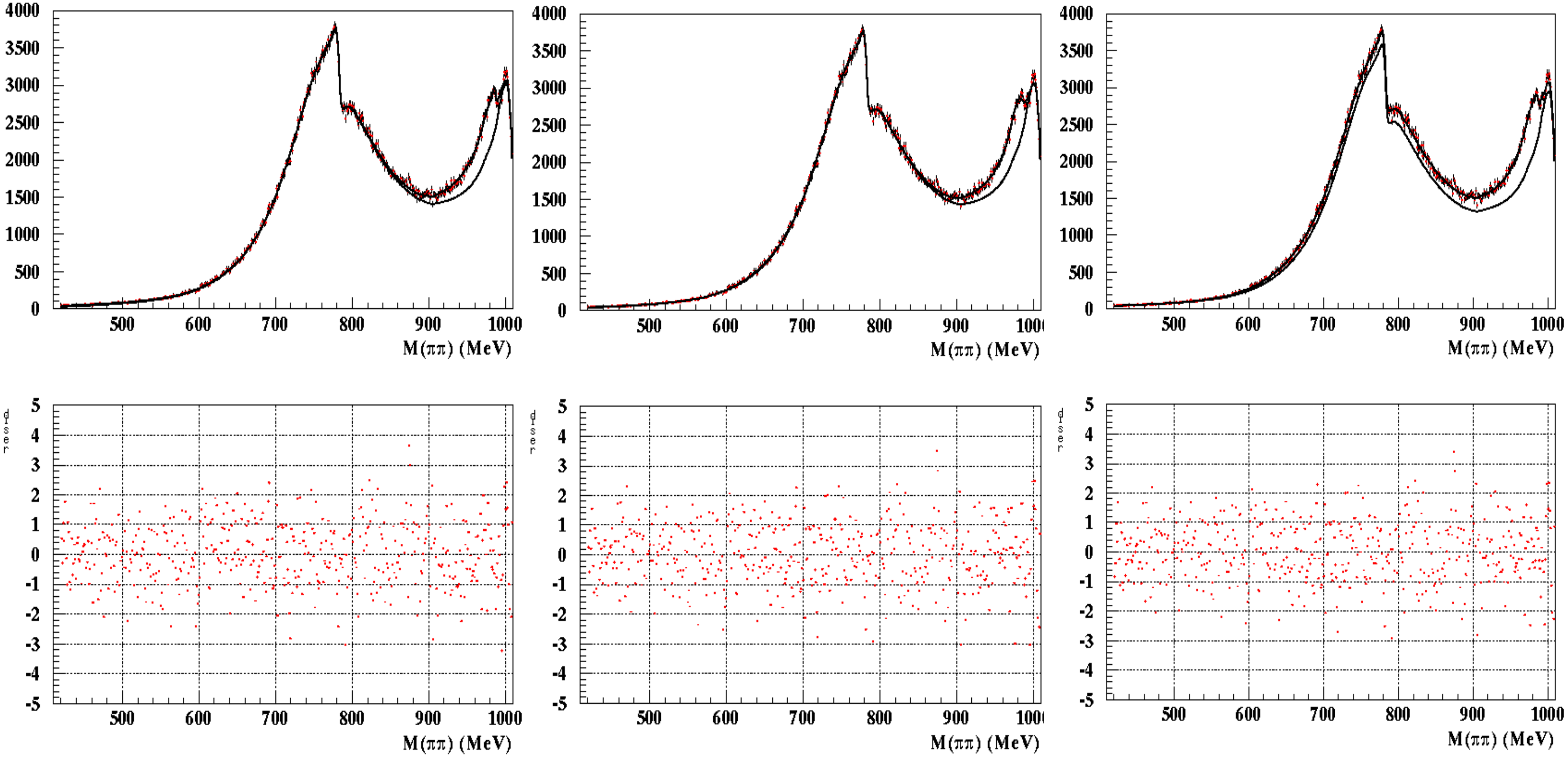
$\chi^2 = 540/478$

$P(\chi^2) = 2.6\%$

BP fit

$\chi^2 = 521/478$

$P(\chi^2) = 8.4\%$



KL fit

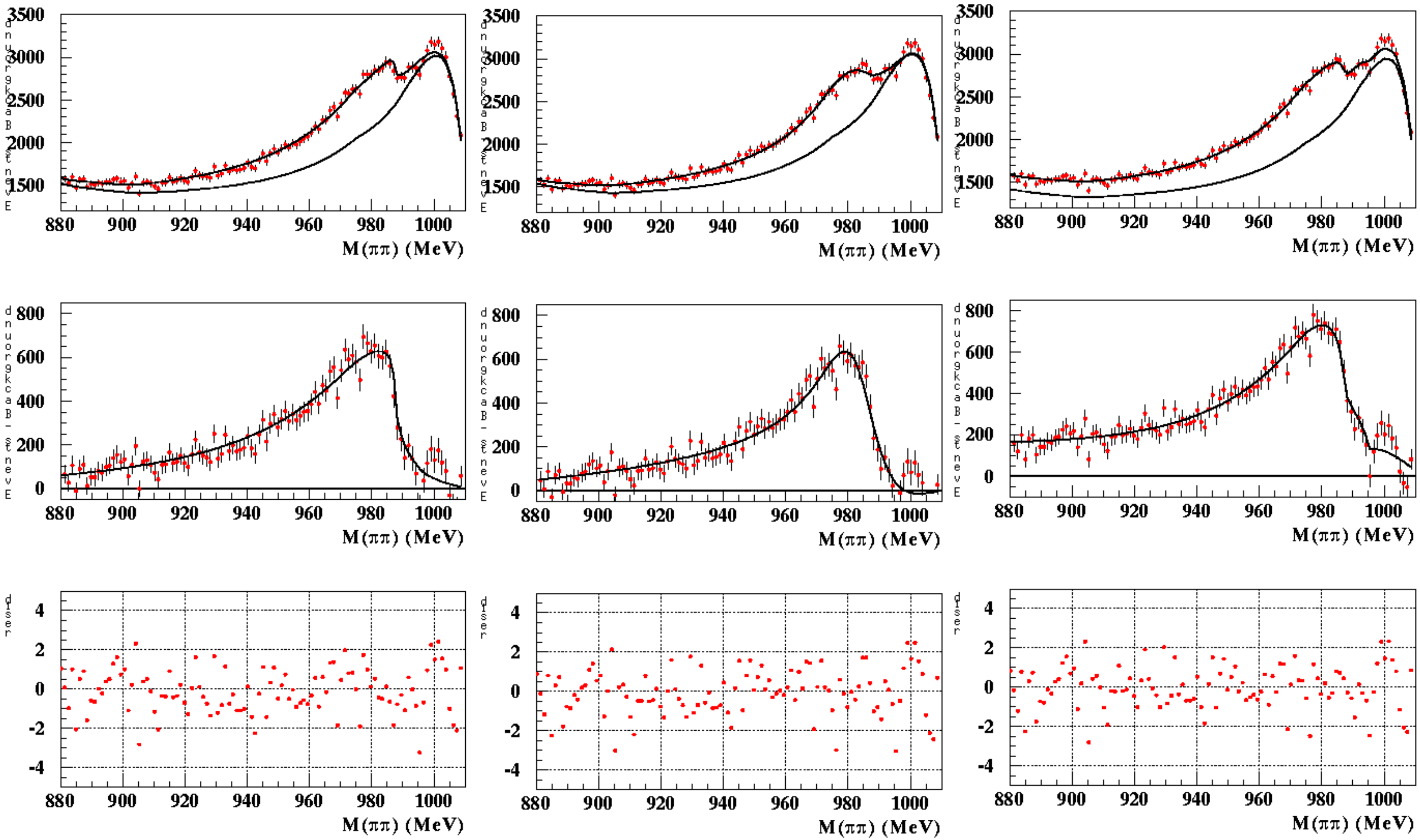
χ^2 = 131/100

IM fit

χ^2 = 139/100

BP fit

χ^2 = 119/100

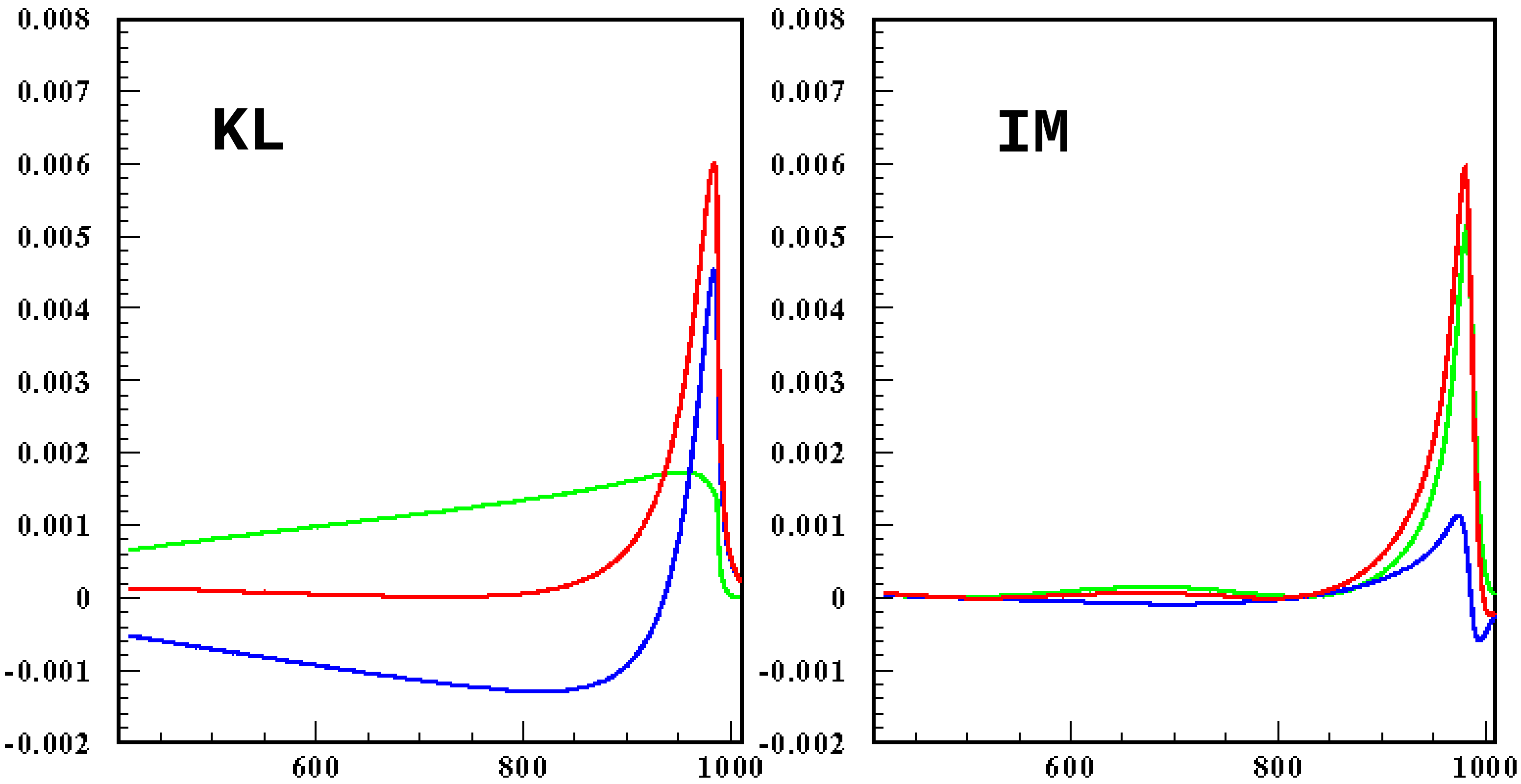


Summary of fit results

	KL		IM		BP	
χ^2/dof (all)	541 / 481		540 / 478		521 / 478	
χ^2/dof (f0)	131 / 100		139 / 100		119 / 100	
	m_f (MeV)	983.7±0.6	m_f (MeV)	984.6±0.5	a_1	-2.57
	$g^2_{fKK}/4\pi$ (GeV^2)	3.4±0.6	Γ_f (MeV)	21.3±1.1	b_1	2.56
	R	2.82±0.08	gg	1.58±0.05	a_2	3.73
			C_0	7.8±0.3	b_2	-4.13
			c_1	8.0±0.2	s_0(GeV^2)	0.21
			fase	0.80±0.32	fase	1.16
$M(\rho^0)$ (MeV)	773.3 ± 0.2		773.7 ± 0.3		772.3 ± 0.1	
$\Gamma(\rho^0)$ (MeV)	144.1 ± 0.3		145.0 ± 0.5		139.9 ± 0.1	
α ($\times 10^{-3}$)	1.68 ± 0.05		1.70 ± 0.05		1.78 ± 0.03	
β ($\times 10^{-3}$)	-122 ± 2		-126 ± 2		-154 ± 1	
$a_{\rho\pi}$	compatibile con 0 e con 1 (atteso)					
BR ($\times 10^{-5}$)	21.4		6.9		22.1	

KL vs IM (1):

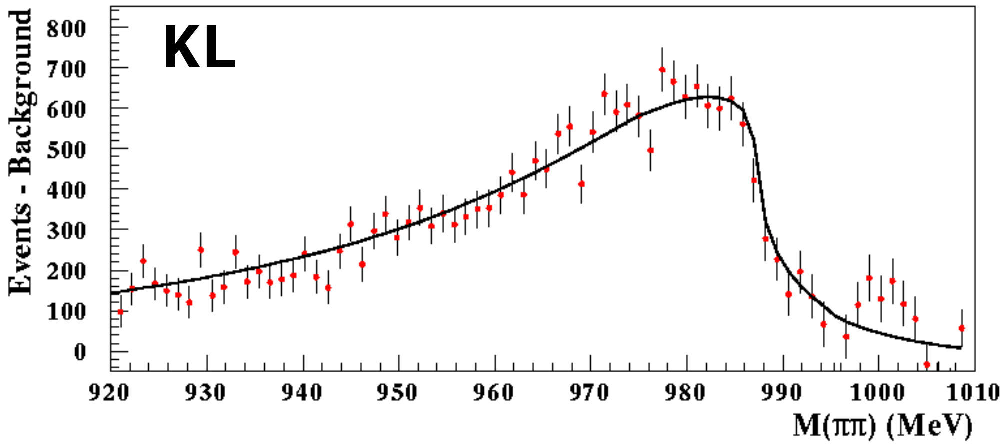
red = signal
green = direct
blue = interference



Γ_f(KL) ~ 70 MeV , Γ_f(IM) ~ 21 MeV

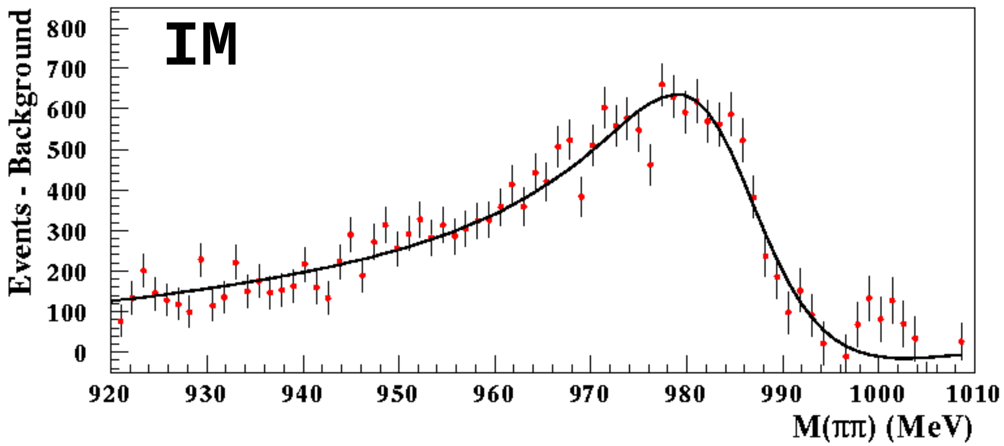
KL vs IM (2):
different "rise" of the signal:
it is due to the different propagator

$$D_f(m^2) = m^2 - m^2{}_f + \Re\Pi_f(m^2{}_f) - \Pi_f(m^2)$$



$$\Pi_f(m^2) = \sum_{ab} \Pi_{ab}(g_{fab}, m^2)$$

Flatte'- like
g_{fab} are the parameters



$$D_f(m^2) = m^2 - m^2{}_f + i m_f \Gamma_f$$

KL vs IM (3):

couplings:

KL:

$g^2_{fKK}/4\pi = 3.4\ \text{GeV}^2 \rightarrow g_{fKK} = 6.4\ \text{GeV}$

$g^2_{f\pi\pi}/4\pi = 1.2\ \text{GeV}^2 \rightarrow g_{f\pi\pi} = 3.9\ \text{GeV}$

IM:

$\Gamma_f = 21\ \text{MeV} \rightarrow g_{f\pi\pi} = 1.0\ \text{GeV}$(*)

$g_{\phi f\gamma} g_{f\pi\pi} = 1.6 \rightarrow g_{\phi f\gamma} = 1.6\ \text{GeV}^{-1}$

(*) assuming $f \rightarrow \pi^+\pi^-$ the only contribution to Γ

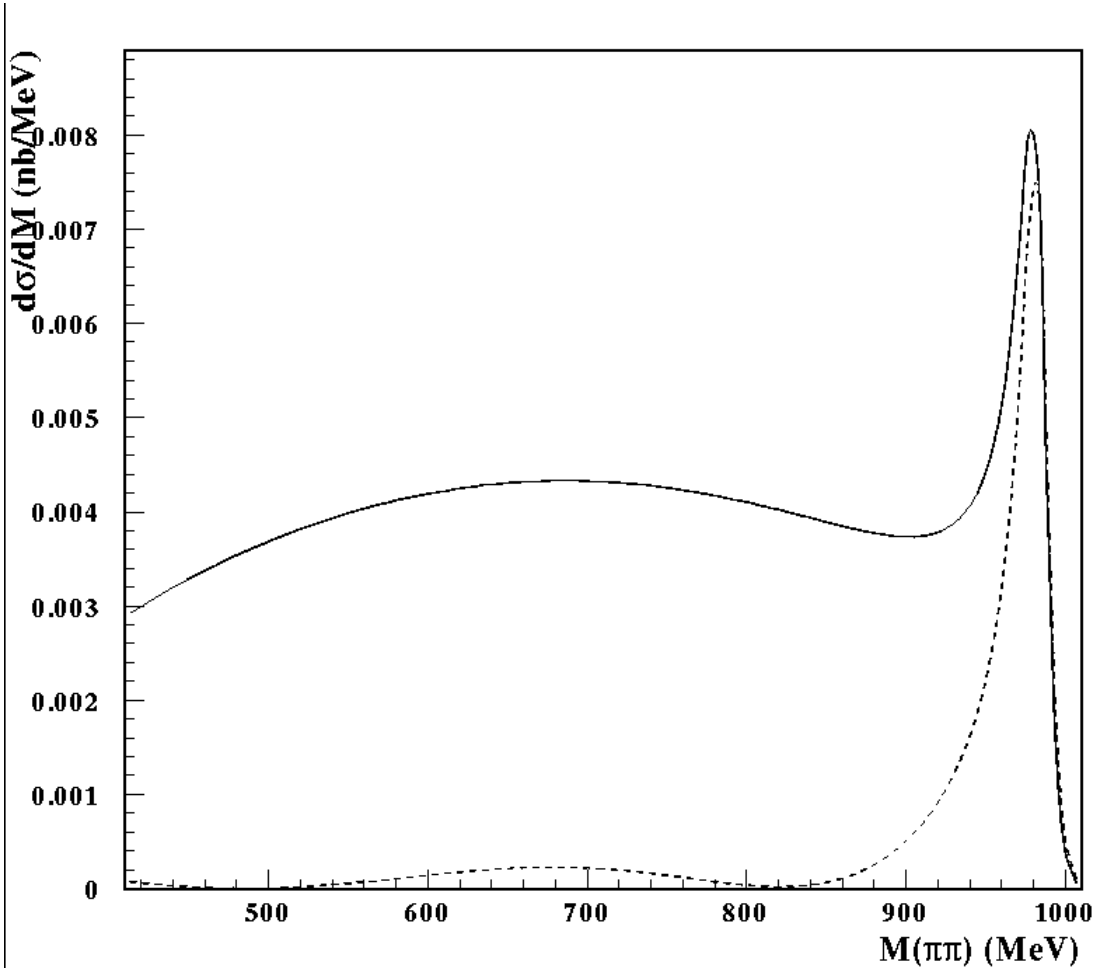
$$\Gamma(f_0 \rightarrow \pi^+\pi^-) = \frac{g^2_{f\pi\pi}\, p_{12}(m_f)}{8\pi m_f^2}$$

IM :

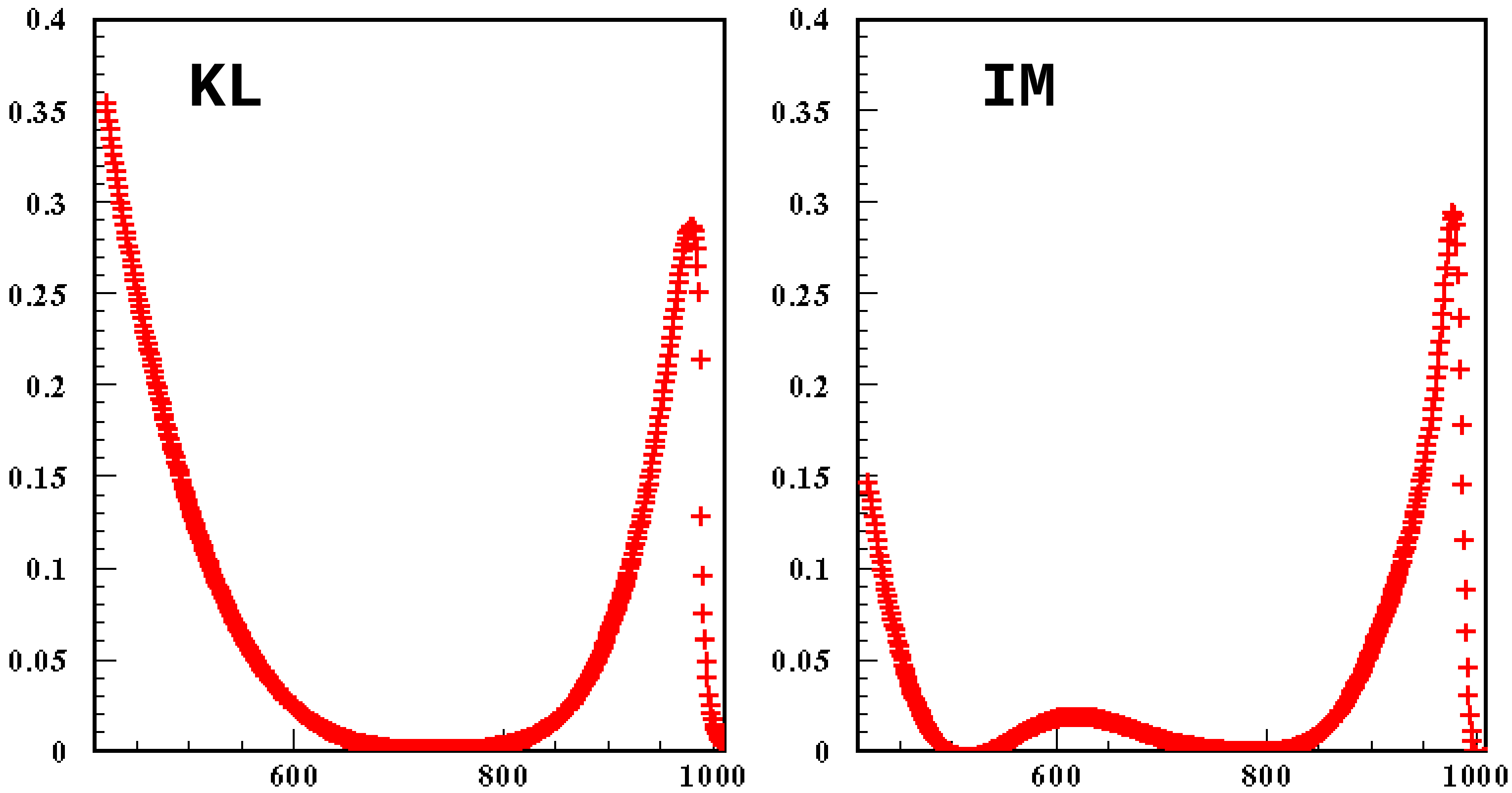
Effect of the c_0 and c_1 "background":

solid: $c_0 = 0$, $c_1 = 0$

dashed: c_0 and c_1 fitted

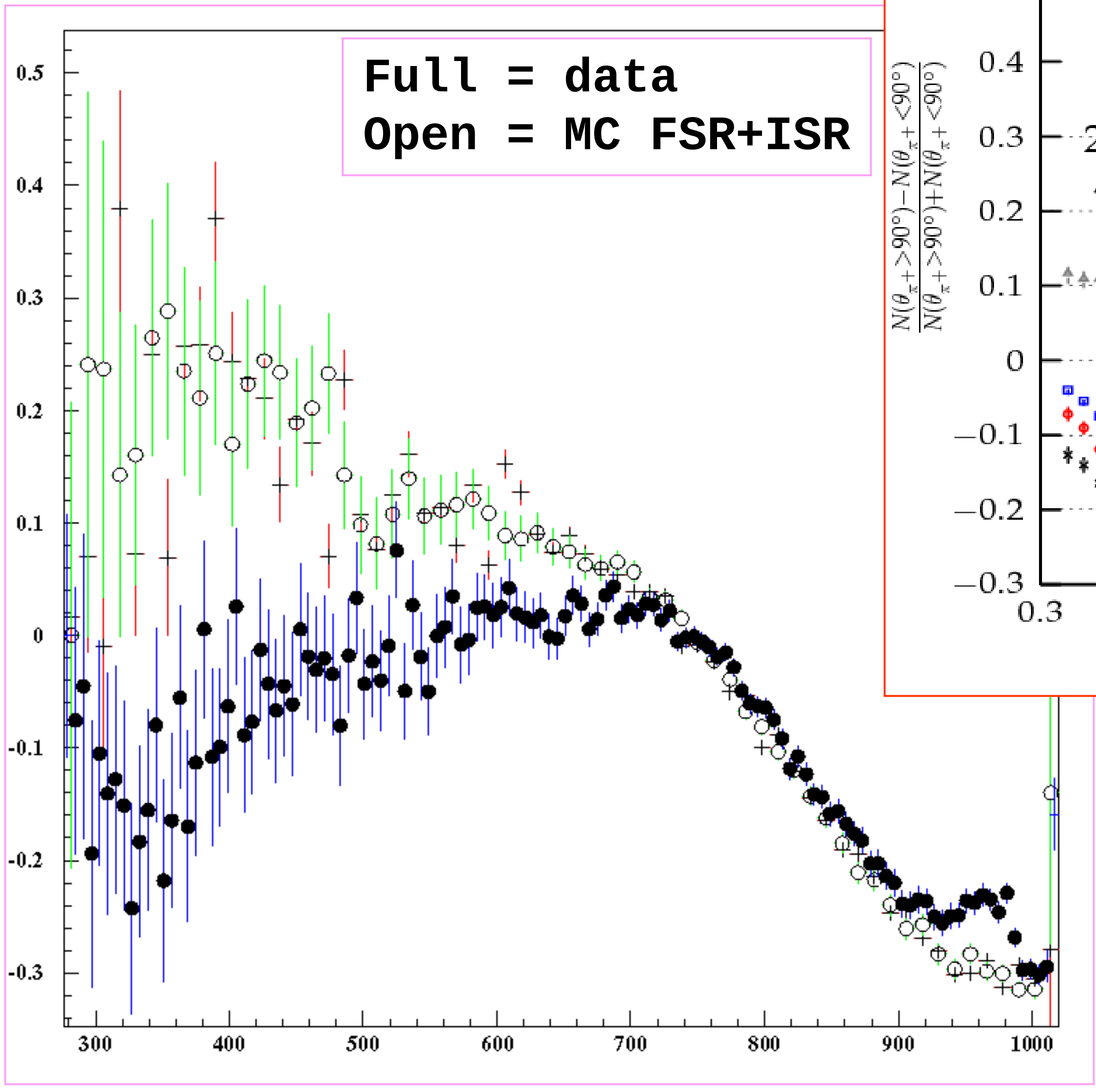


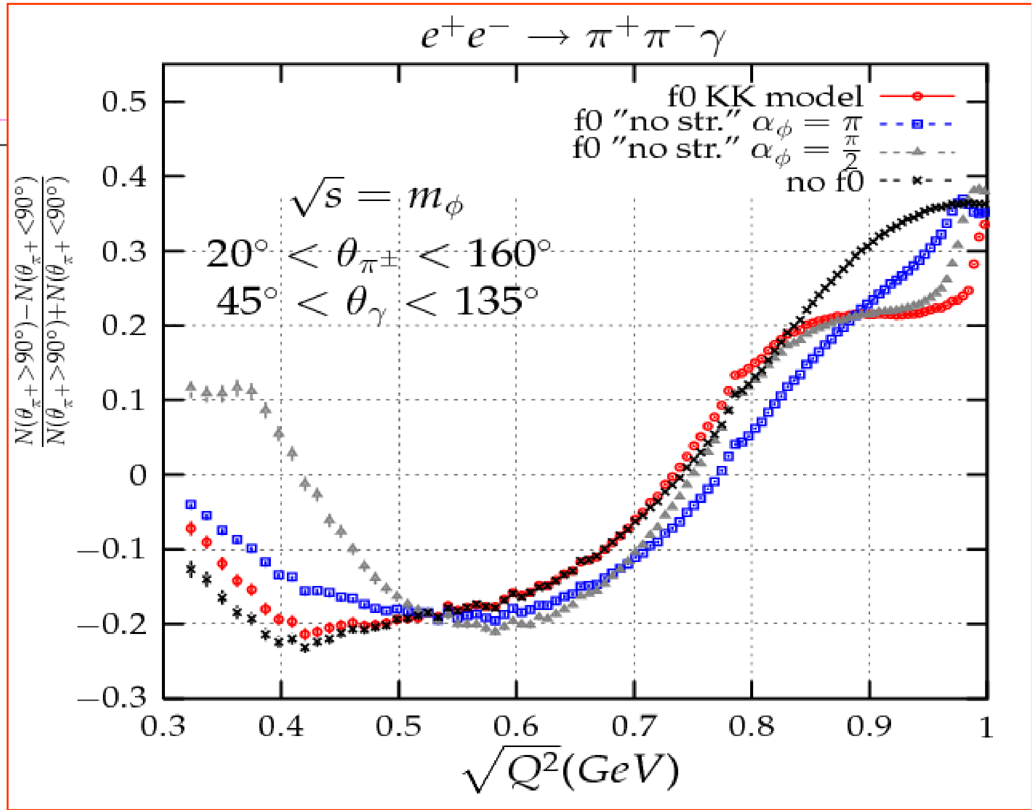
Size of the “scalar” signal respect to ISR:
peak at f0 mass (size ~ 30%)
rise at low masses



Any low mass analysis requires knowledge of the scalar contributions

4. Charge asymmetry: in hep-ph/0412239 first attempts to predict the M(ππ) behaviour.





Conclusions

- Some more checks on possible backgrounds ($\pi^+\pi^-\pi^0$ and $\pi^+\pi^-$) are needed
- The fit is OK (improve is possible for BP)
- The charge asymmetry is an interesting issue
- A message for hadronic cross-section measurement: take care of scalars even in the low mass region.
- Define a strategy for publications.