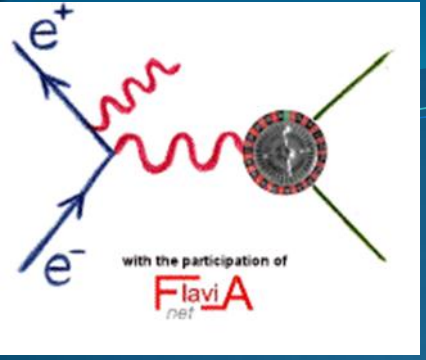


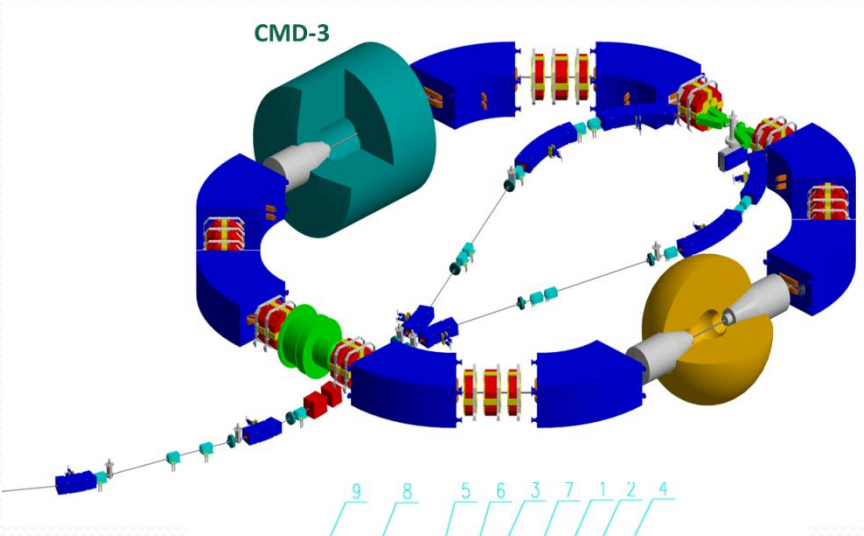
Development of Monte Carlo Generator for $e^+e^- \to 6\pi$ process study in CMD-3 experiment

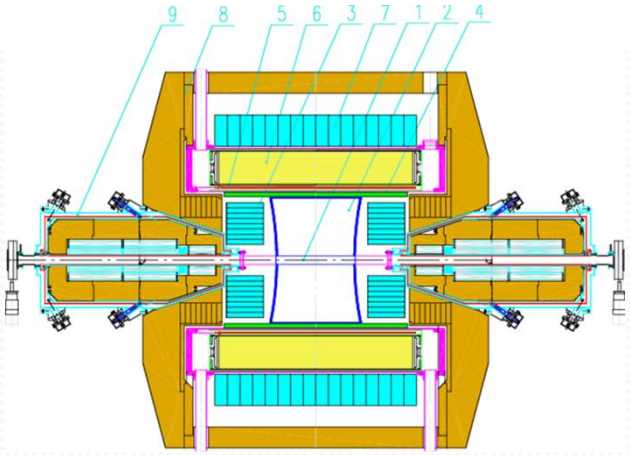
Peter A. Lukin

Budker Institute of Nuclear Physics, Novosibirsk, Russia

Motivation

VEPP-2000 (2010 - …) , E = 0.36 – 2,0 ГэВ





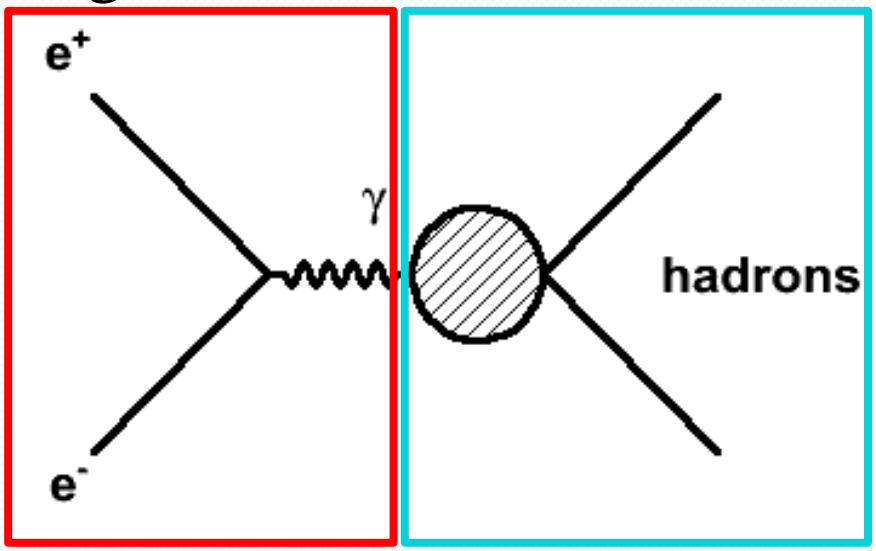
1 – vacuum chamber
2 – drift chamber
3 – electromagnetic calorimeter BGO
4 – Z – chamber
5 – CMD SC solenoid
6 – electromagnetic calorimeter LXe
7 – electromagnetic calorimeter CsI
8 – yoke
9 – VEPP-2000 solenoid

Physics program at VEPP-2000

1. Precise measurement of the quantity
   R=σ(e+e-- > hadrons)/ σ(e+e-->μ+μ-) – GOAL <1% systematic for major channels
2. Study of hadronic channels:
   e+e-- > 2h, 3h, 4h …, h= π,K,η
3. Study of 'excited' vector mesons: ρ',ρ'', ω', ϕ',..
4. CVC tests: comparison of e+e-- > hadr. (T=1) cross section with τ-decay spectra
5. Study of nucleon-antinucleon pair production – nucleon electromagnetic form factors, search for NNbar resonances,
6. Hadron production in 'radiative return' (ISR) processes
7. Two photon physics
8. Test of the QED high order processes
   2->4,5

Method (Kuhn,Czyz?)

Every process of e+e- annihilation into hadrons can be express using diagram:



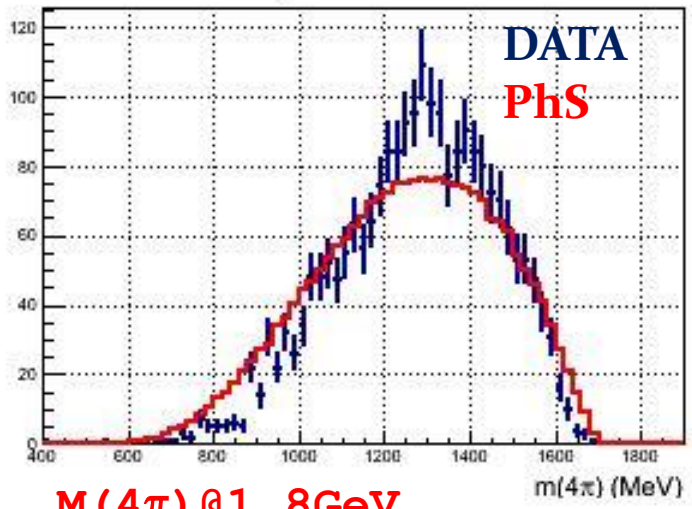
Common for all processes **Depend on the final state**

$$M_{fi} \propto J_{el} \times J_{had} \cdot \Phi$$

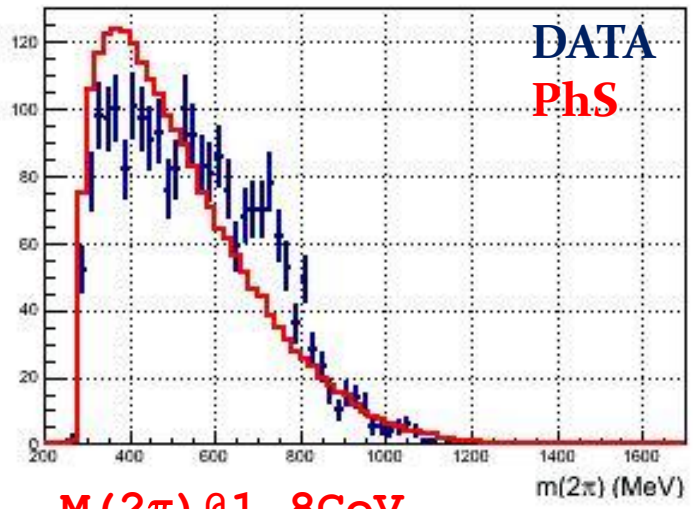
To study hadronic final state one have to provide hadronic current

Phase Space ($|M|^2 = 1$) – no model

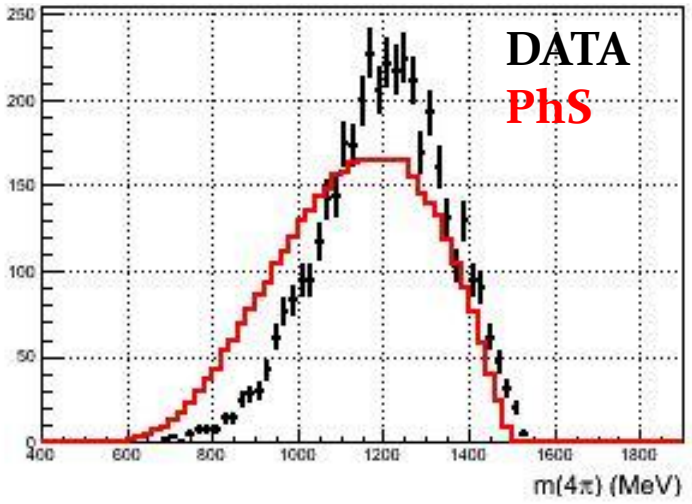
M(4π)@2GeV



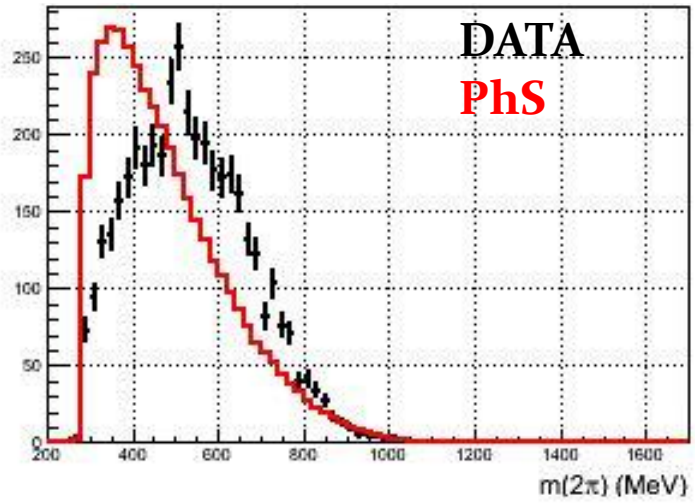
M(2π)@2GeV



M(4π)@1.8GeV



M(2π)@1.8GeV

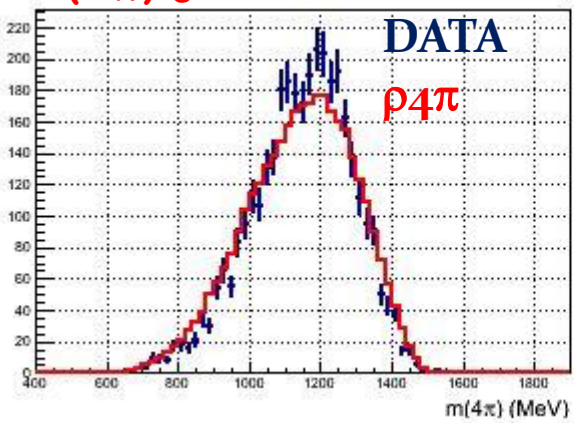


Phase space "model" could not explain anything (as expected)

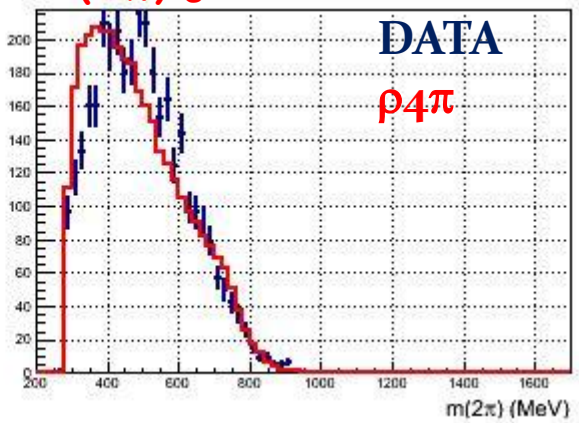
Model $e^+e^- \rightarrow \rho(770)4\pi \rightarrow 6\pi$

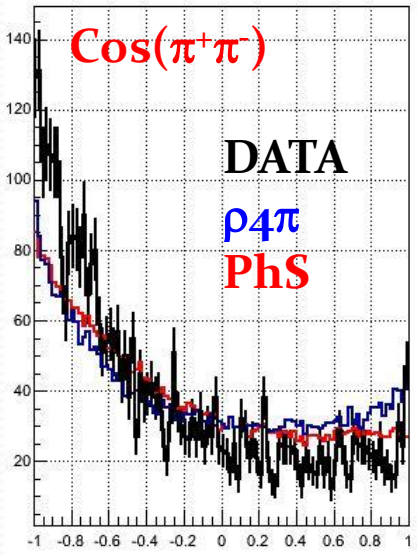
$$J_{had} = \sum_{\pi^+}\sum_{\pi^-} \frac{p_{\pi^+} - p_{\pi^-}}{D_\rho(Q^2_{\pi^+\pi^-})}$$

M(4π)@1.8GeV

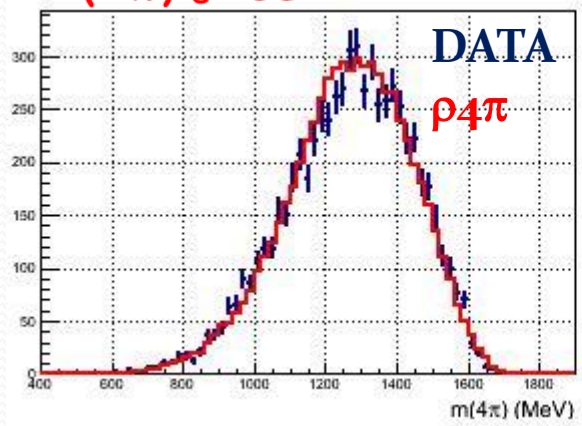


M(2π)@1.8GeV

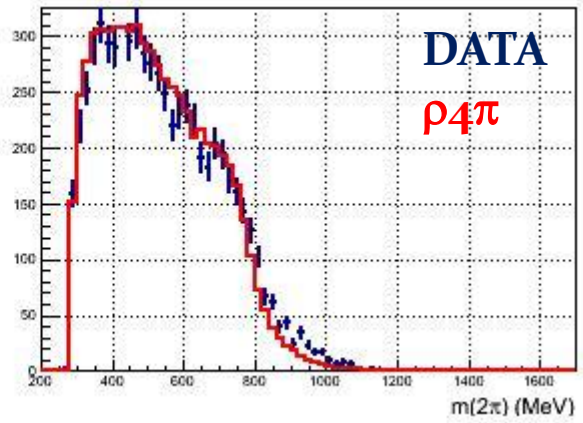


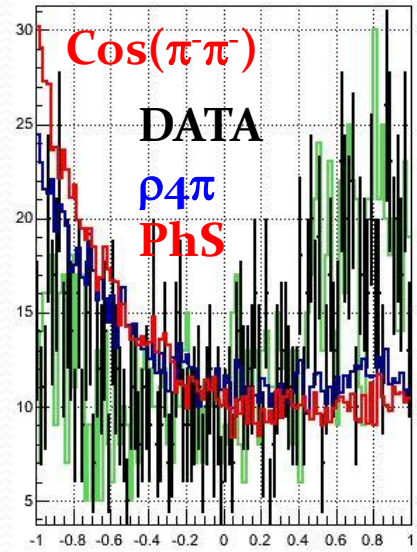


M(4π)@2GeV



M(2π)@2GeV

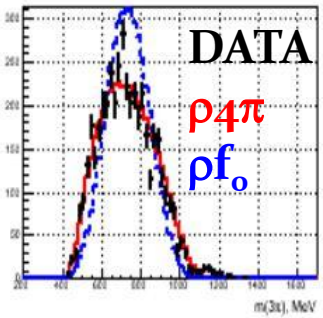




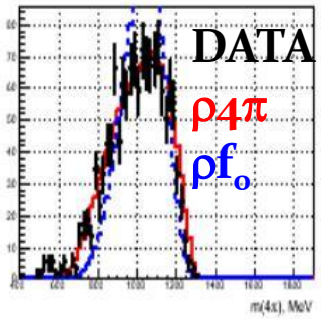
Model $e^+e^- \to \rho(770)f_0(1370) \to 6\pi$

$$J_{had} = \bigcup\bigcup_{\pi^+ \ \pi^-} \frac{p_{\pi^+} - p_{\pi^-}}{D_\rho(Q^2_{2\pi})} \cdot \frac{1.0}{D_{f_0}(Q^2_{4\pi})}$$

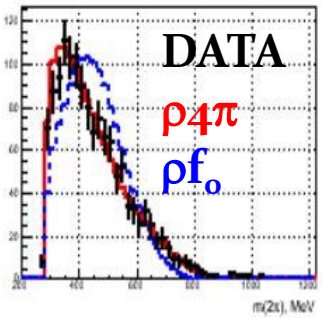
M(3π)@1.6GeV



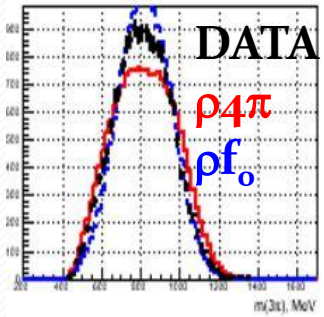
M(4π)@1.6GeV



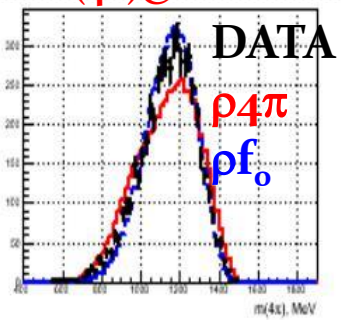
M(2π)@1.6GeV



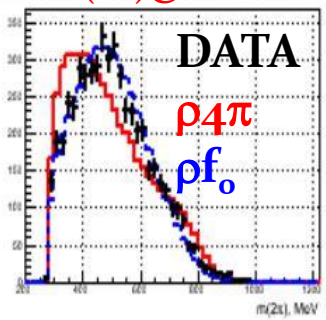
M(3π)@1.8GeV



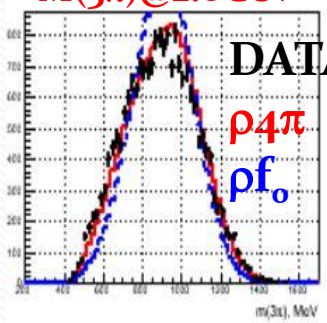
M(4π)@1.8GeV



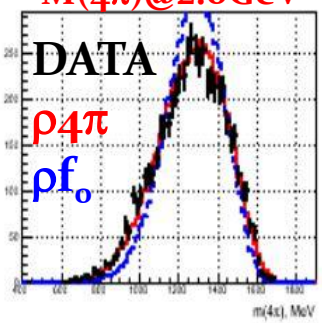
M(2π)@1.8GeV



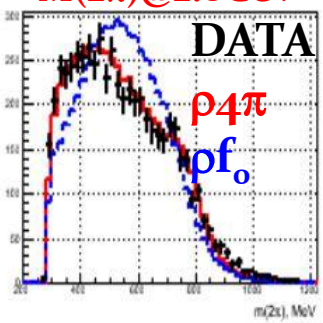
M(3π)@2.0GeV

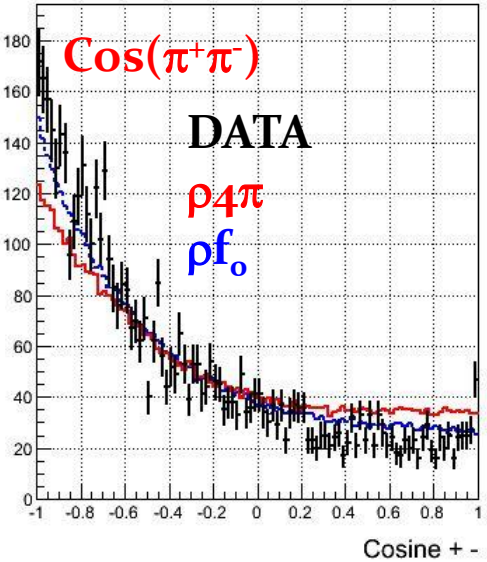


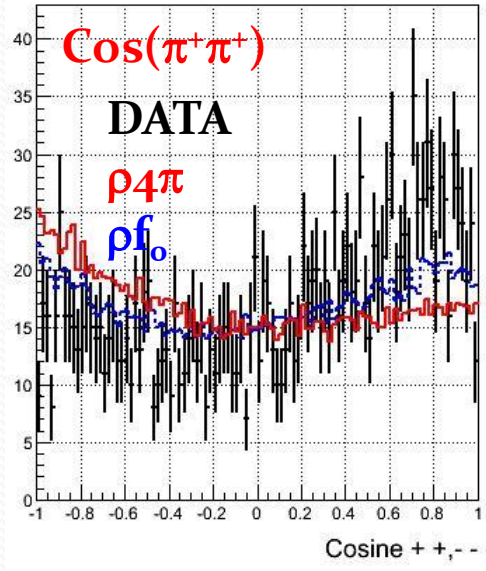
M(4π)@2.0GeV



M(2π)@2.0GeV







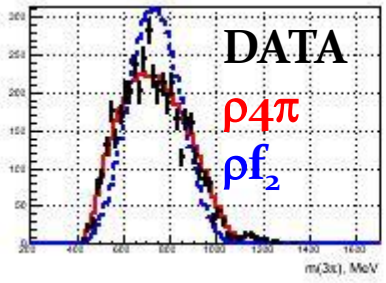
Model $e^+e^- \to \rho(770)f_2(1270) \to 6\pi$

$$J_{had} = \bigcup_{1,3,5} \bigcup_{2,4,6} j_{123456}$$

$$j_{123456} = \frac{F^2_{f_2}(Q^2_{4\pi})}{D_\rho(Q^2_{2\pi})D(Q^2_{4\pi})} \Big\langle \Big[f^{0\mu}(p_1^\mu p_2^i - p_1^i p_2^\mu) + f^{i\mu}(E_1 p_2^\mu - E_2 p_1^\mu) \Big] \times$$

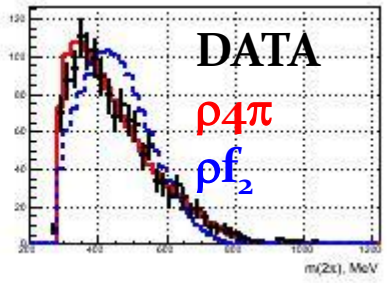
$$f^{ab}\left[p_3^a p_5^b (p_4 p_6) - p_3^a p_6^b (p_4 p_5) + p_4^a p_6^b (p_3 p_5) - p_4^a p_5^b (p_3 p_6) \right] \Big\rangle$$

M(3π)@1.6GeV

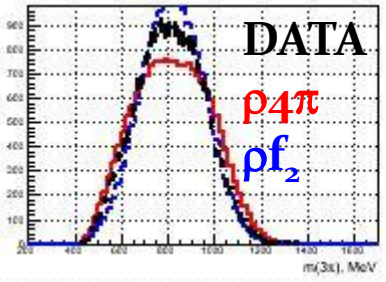


M(4π)@1.6GeV

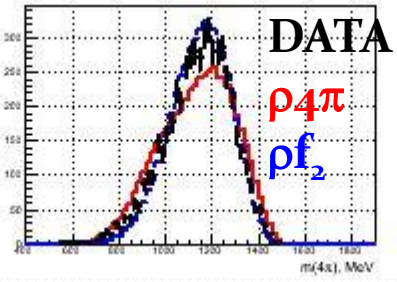
M(2π)@1.6GeV



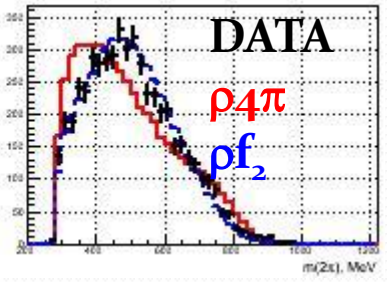
M(3π)@1.8GeV



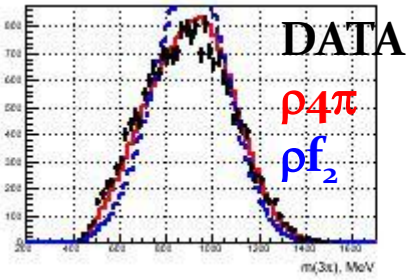
M(4π)@1.8GeV



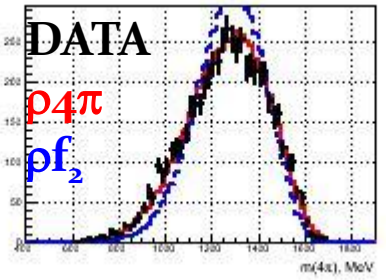
M(2π)@1.8GeV



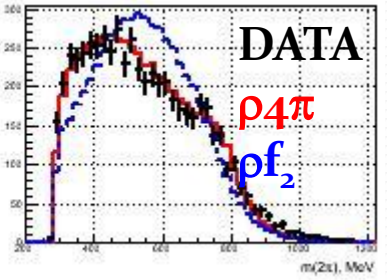
M(3π)@2.0GeV

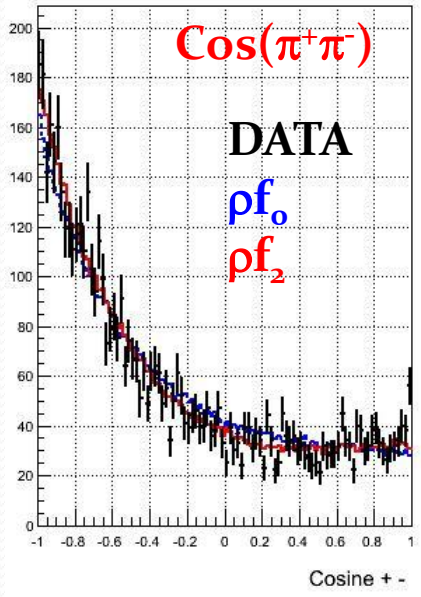


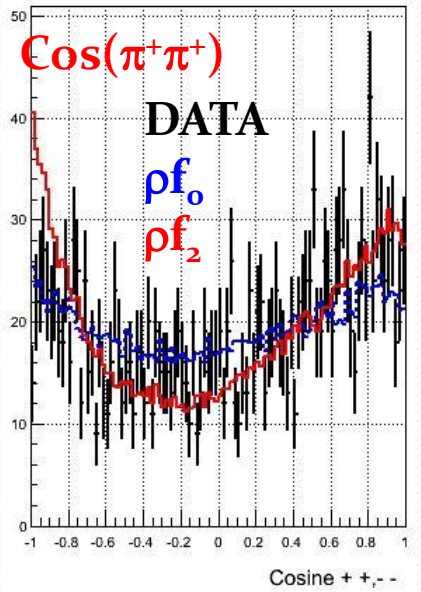
M(4π)@2.0GeV



M(2π)@2.0GeV







Conclusion

- Using Kuhn, Czyz(?) approach MC generators with more than 10 models of $e^+e^- \to 3(\pi^+\pi^-)$ production were created.
- It is shown, that model $e^+e^- \to \rho(770)4\pi \to 3(\pi^+\pi^-)$ reasonably describes pion masses distributions at energies 2E = 1.6 GeV and 2E = 2.0 GeV, but does not describe the distributions at 2E = 1.8 GeV.
- It is shown, that models $e^+e^- \to \rho(770)f_0(1370) \to 3(\pi^+\pi^-)$ and $e^+e^- \to \rho(770)f_2(1270) \to 3(\pi^+\pi^-)$ reasonably describes pion masses distributions at energies 2E = 1.8 GeV, but does not describe the distributions at 2E = 1.6 GeV and 2E = 2.0 GeV.
- It is shown, that models $e^+e^- \to \rho(770)f_0(1370) \to 3(\pi^+\pi^-)$ underestimates angular correlations between pions of the same charges and reasonably discribes angular correlations between pions of opposite charges.
- It is shown, that models $e^+e^- \to \rho(770)f_2(1270) \to 3(\pi^+\pi^-)$ overestimates angular correlations between pions of the same charges and reasonably discribes angular correlations between pions of opposite charges.

Plans

- Tune the models for $e^+e^- \rightarrow 3(\pi^+\pi^-)$ production
- Create the same models for $e^+e^- \rightarrow 2(\pi^+\pi^-\pi^0)$ production

Stay tuned! Thank You!