KLOE General Meeting
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LNF

Measurement of the Pion Form Factor at $s=1.0$ GeV^2

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in collaboration with
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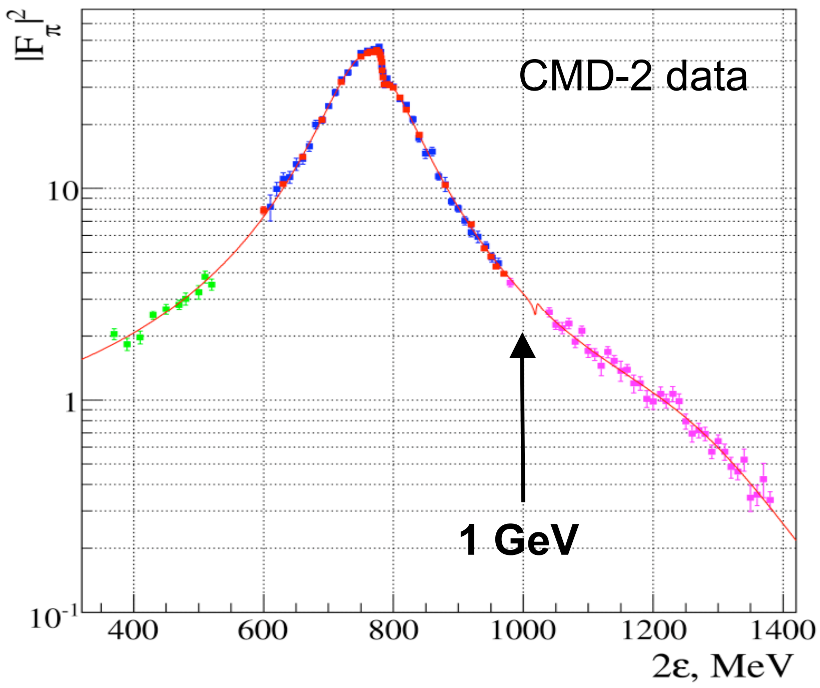
Thanks to Alexei Sibidanov for providing momenta values from the MCGPJ Monte Carlo for us!

Motivation

Method:

POP 2006 data allows to measure $F_{\pi}(1\ \mathrm{GeV}^2)$ by standard energy scan
Approach almost background free



Motivation:

- No existing data for $|F_{\pi}(1\ \mathrm{GeV}^2)|^2$
- Form factor at $s=1\ \mathrm{GeV}^2$ badly needed for the Monte-Carlo prediction of the charge asymmetry → test of model of scalar QED for FSR
- together with scan points (2005/06) we can fit $\sigma(e^+e^- \to \pi^+\pi^-)$ and extract the BR($\phi(1020) \to \pi^+\pi^-$)
- Knowledge of pion form factor at high masses by means of an independent method is a valuable cross check of our radiative return measurements and of the radiator function

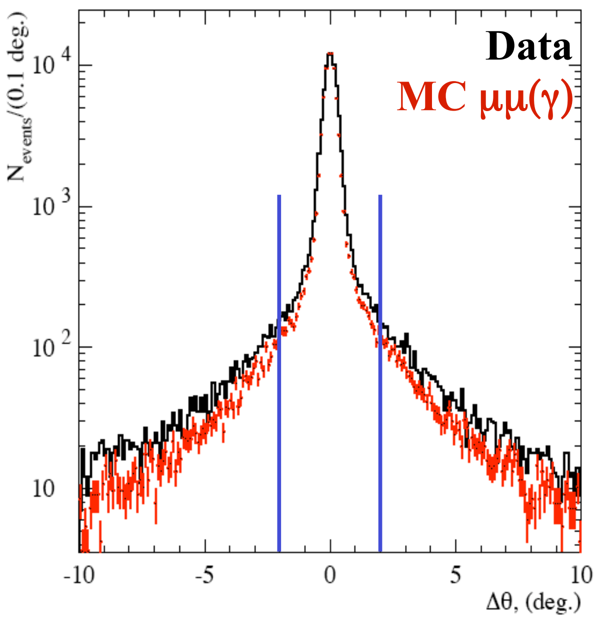
Event Selection

Selection:

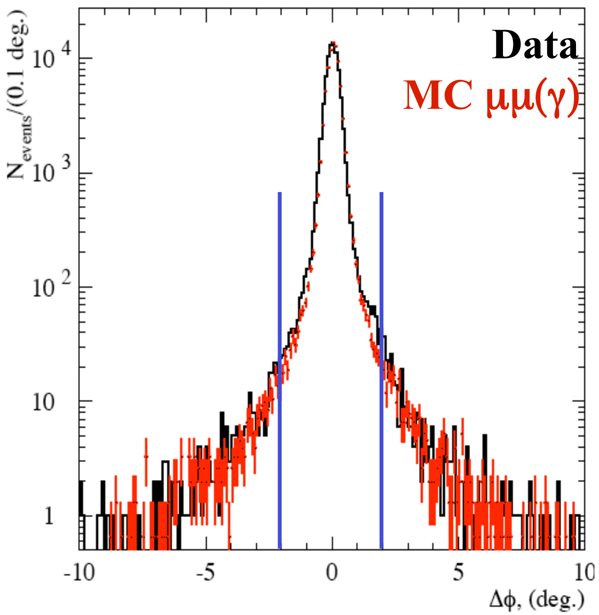
- DTFS information, 2 tracks with closest DPCA
- Select collinear $\pi^+\pi^-$ events via $\Delta\theta$, $\Delta\phi$, Δp
- Large angle pion tracks $50° < \theta < 130°$
- Background: collinear $\mu^+\mu^-$ events; no other
- Can use standard $\pi\pi\gamma$ ntuples (`ppgtag`)
- Huge statsitics: we use sample of 8.45 pb^{-1}

MCs (within GEANFI):

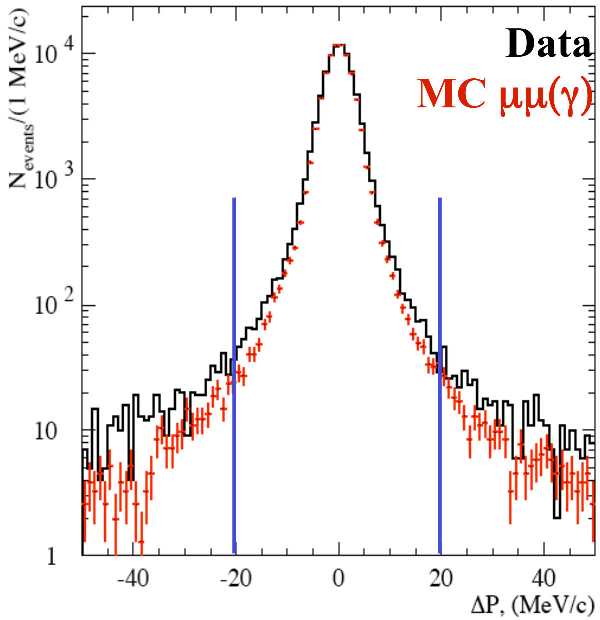
- **MCGPJ: Arbuzov et al. ($\pi\pi$ + $\mu\mu$)**
- **Babayaga vs. 3 ($\mu\mu$)**
- Babayaga@NLO ($\mu\mu$)



$\Delta\theta < 2°$



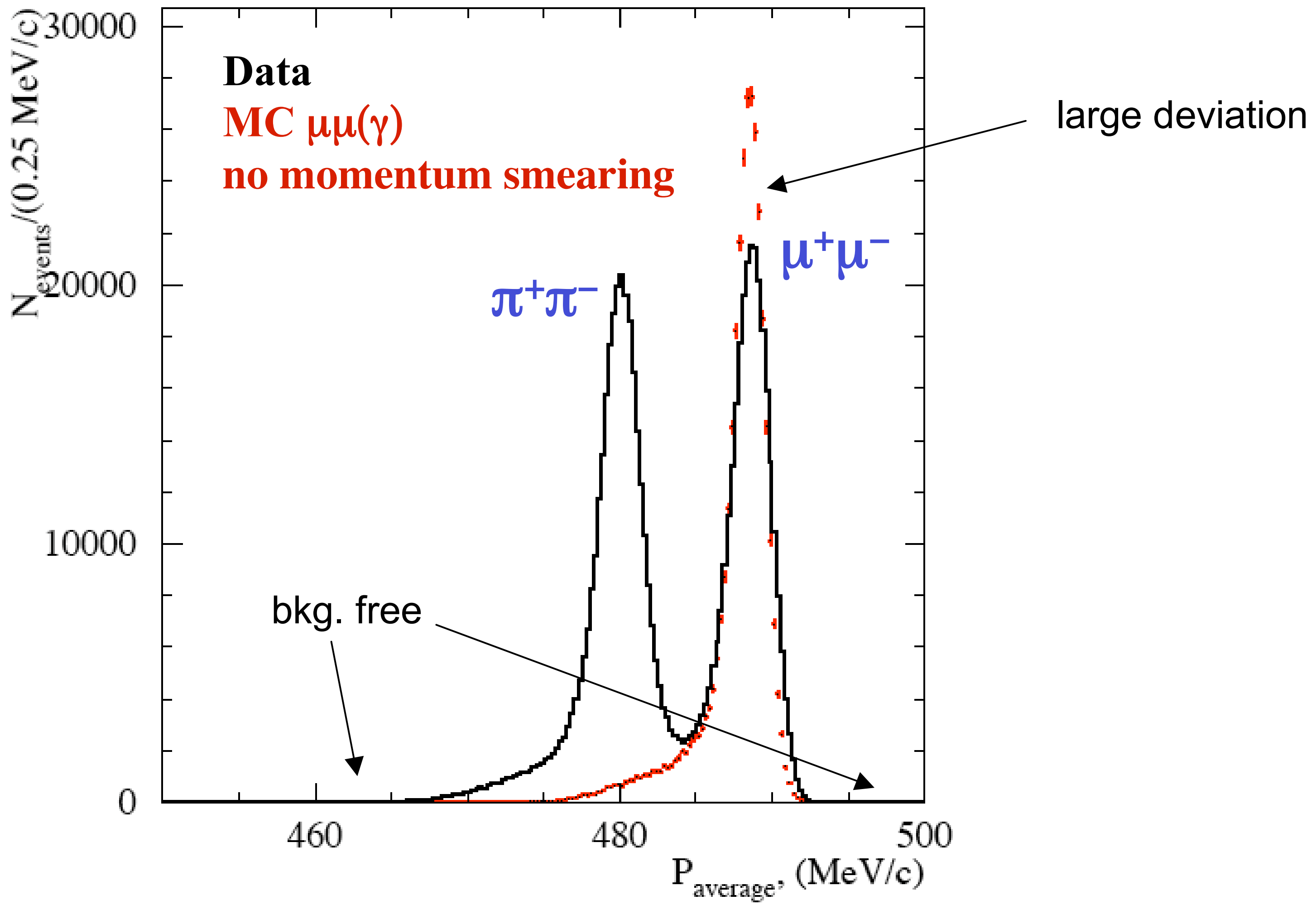
$\Delta\phi < 2°$



$\Delta p < 20$ MeV

Average Momentum

Average momentum spectrum after collinear cuts

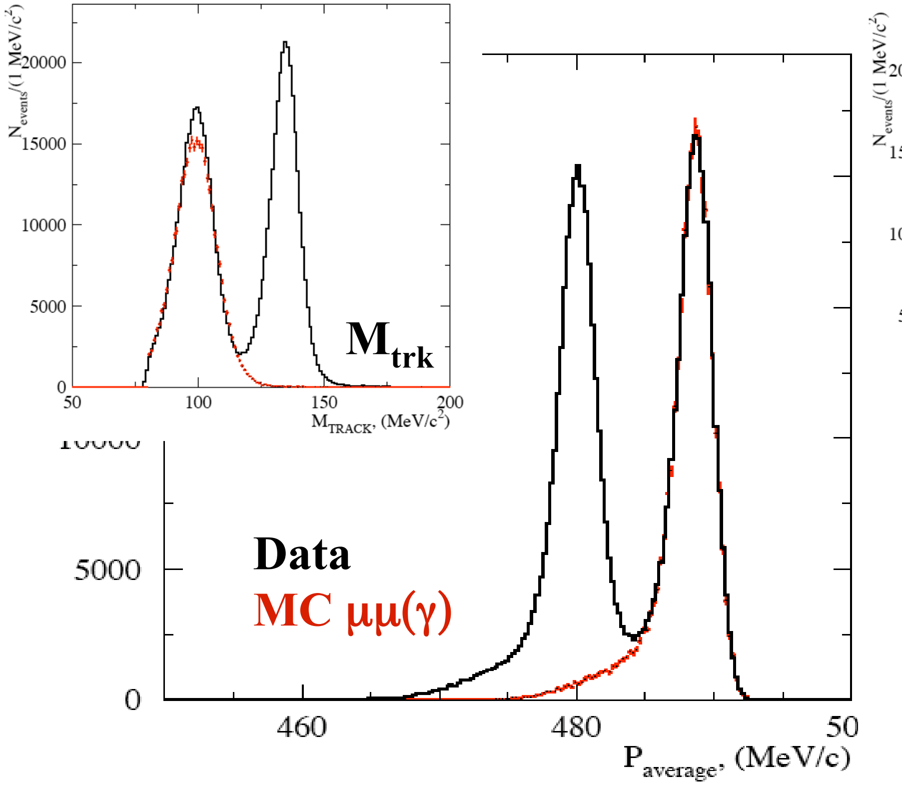


➔ **Need for some Monte-Carlo adjustment (smearing)**

Tracking Resolution Studies

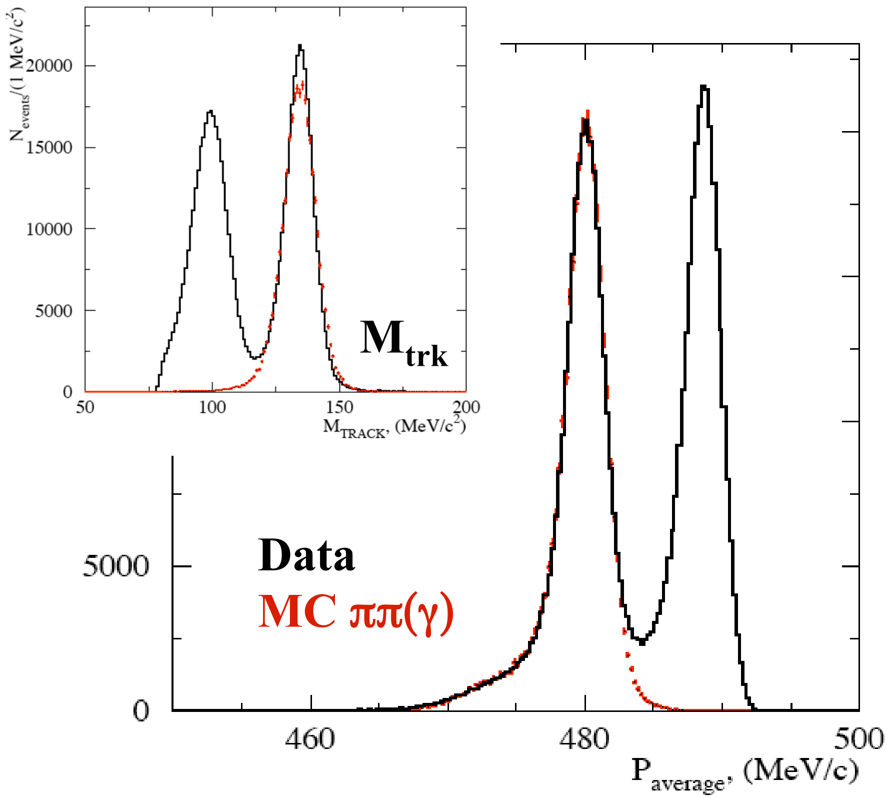
Momentum smearing (à la Bini-Valeriani):

- Tune data - MC agreement for average momentum distribution
- Cross check results in trackmass distribution, perform shift in M_{trk}



μ_{MC}=488.62 MeV μ_{data}=488.63 MeV

σ_{MC}=1.237 MeV σ_{data}=1.243 MeV



μ_{MC}=480.03 MeV μ_{data}=480.07 MeV

σ_{MC}=1.393 MeV σ_{data}=1.394 MeV

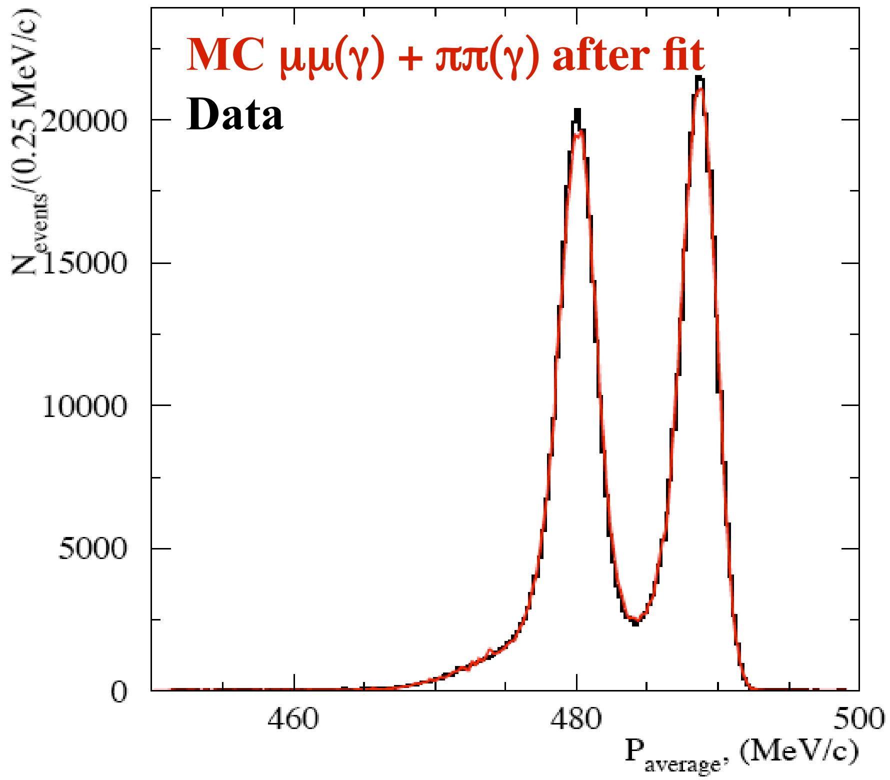
Cross Check with $\mu^+\mu^-$ Yield

Cross check of method using $\mu^+\mu^-(\gamma)$ events

- Compare extracted muon yield with Monte-Carlo prediction
- Use 3 methods for measurement of yield

I. Cut $p > 484$ MeV/c
II. $M_{trk} < 120$ MeV
III. Fit $\pi\pi(\gamma)$ and $\mu\mu(\gamma)$ MC

Method	$N_{\mu\mu}$ Data	$N_{\mu\mu}$ MC / Data
I.	293.557	0.998
II.	312.874	0.993
III.	-	0.994



➔ Method seems stable within 1% precision :-)

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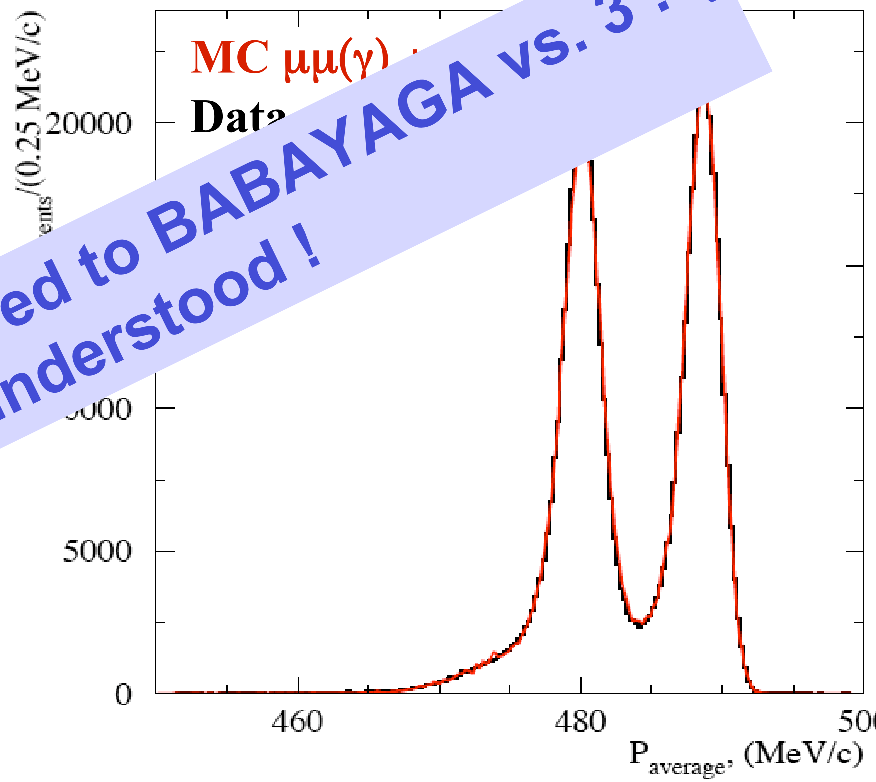


3% lower yield when compared to BABAYAGA vs. 3 :-(
Reason not understood !

➔ Method seems stable within 1% precision :-)

Pion Form Factor Extraction

Signal extraction $\pi^+\pi^-(\gamma)$ events

- Again count collinear di-muon events according to 3 methods as for $\mu\mu$
- All efficiencies taken from Monte-Carlo simulation
- Radiative corrections taken from simulation $(1+\delta) = \frac{N_{coll}}{N_0} \cdot \frac{\sigma_{tot}}{\sigma_{born} \cdot |F_\pi|^2}$

$$\sigma = \frac{N_{\pi\pi}}{\mathcal{L} \cdot \varepsilon \cdot (1+\delta)},$$

$\mathcal{L}$: 8.45 pb^{-1}; ε: Effective Efficiency; $(1+\delta)$: 0.854

$N_{\pi\pi}$:

I. Cut p < 484 MeV/c
II. M_{trk} > 120 MeV
III. Fit $\pi\pi(\gamma)$ and $\mu\mu(\gamma)$ MC

Selection	N_{events}	ε	δ_{reject}
COLLINEARS	104218	—	—
ACCEPTANCE	87569	0.840	—
TRIGGER	85543	0.821	2.3%
FILFO	84429	0.810	1.3%
TRACKING	79842	0.766	5.4%
PPGTAG	78287	0.751	2.0%
LIKELIHOOD	78257	0.751	—
$\Delta\theta$	75729	0.727	3.2%
$\Delta\phi$	74391	0.714	1.8%
Δp	73846	0.709	0.7%
Total	73846	0.709	16.7%

Method	$N_{\pi\pi}$ ($\mu\mu$ bkg)	$\|F_\pi\|^2$
I.	306.498 (24.743)	**3.175**
II.	294.823 (4.233)	**3.185**
III.	308.793	**3.176**

➔ **Agreement within 0.3%**

Systematics

Systematics studies

• Collinear cuts rather tight due to large radiative tails
$\rightarrow$ we have systematically varied the collinear cuts

means 1.5 x sigma of core gaussian of resolution functions for $\Delta\theta$, $\Delta\phi$, Δp

	1.5σ	4.5σ	8.0σ	12.0σ	20σ
$N_{\pi\pi}$	161733	286280	309649	323895	346889
ε	0.456	0.695	0.708	0.712	0.716
$(1+\delta)$	0.722	0.797	0.845	0.876	0.923
k_μ	3.910	4.133	4.138	4.138	4.152
σ, nb	58.12	61.14	61.22	61.43	62.10
$\|F_\pi\|^2$	3.02	3.18	3.19	3.20	3.23

too narrow cut: systematic effect

Stable results over wide range of cuts

Bhabha background: 3.16 when M_{trk} method used, which rejects electrons

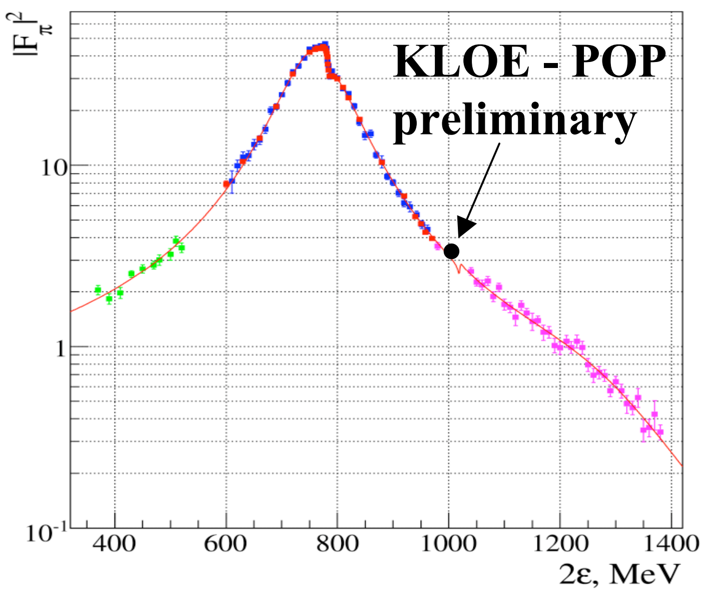
Conclusion & Outlook

Conclusion

- Selection for collinear di-pion and di-muon events worked out
- Comparison of di-muon yield gives good agreement <1% with MCGPJ generator (Arbuzov et al.), but sizeable difference wrt. BABAYAGA vs. 3
- Preliminary estimate of systematics: 1% from data vs. MC for $\mu\mu$
- Pion form factor extracted according to 3 different selections: results are stable within 0.3%

$$|F_\pi(s=1.0\ \mathrm{GeV}^2)|^2 = 3.19 \pm 0.01_{stat} \pm 0.03_{syst}$$

CMD-2 fit = 3.19 (same MC!?)



Outlook

- Try to use BABAYAGA@NLO for $\mu\mu$
- Measure trigger and tracking efficiency for collinear events (with POP analysis)
- Study stability over 2006 POP run
- Repeat analysis for 2005/06 scan points and fit $\pi\pi$ cross section
  $\rightarrow$ extract BR($\phi(1020)\rightarrow\pi^+\pi^-$)