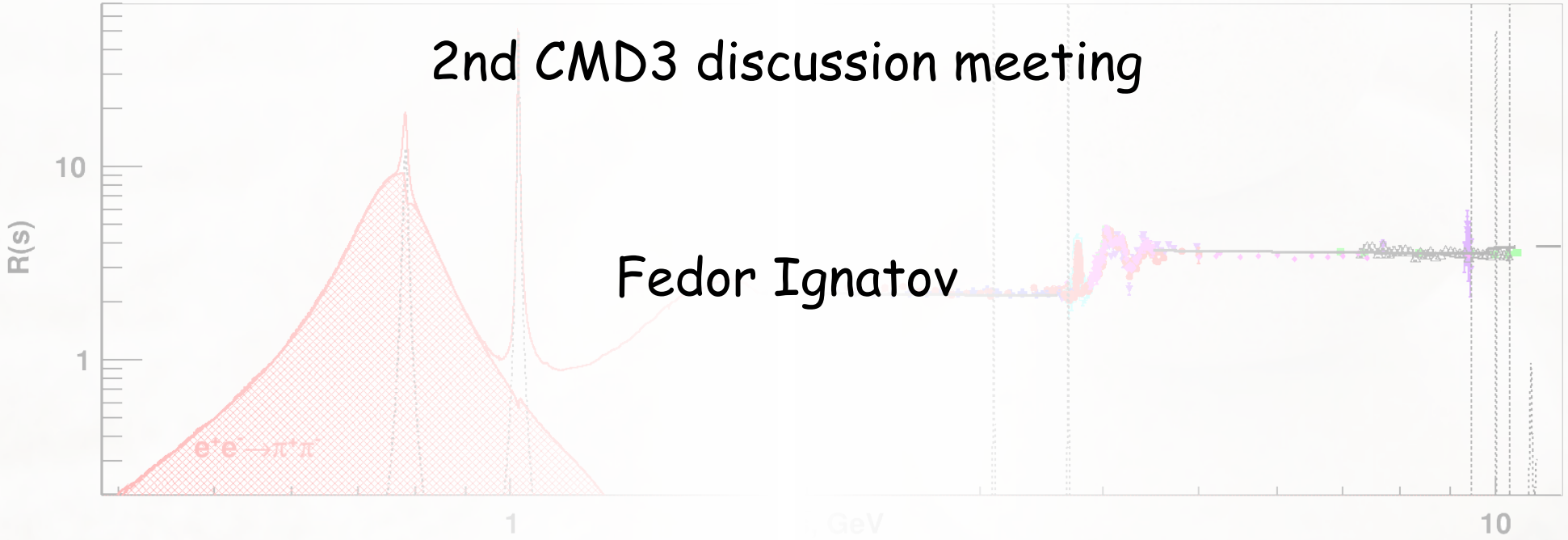
2nd CMD3 discussion meeting



Fedor Ignatov

20 July 2023

CMD-3 ππ result

E-Print: 2302.08834 [hep-ex]

Two long seminars:

KEK seminar, 17 March 2023: https://kds.kek.jp/event/45889/

TI seminar, 27 March 2023: https://indico.fnal.gov/event/59052/

49 questions list was prepared from the panelist nominated by the g-2 Theory Initiative Steering Committee: https://indico.fnal.gov/event/59052/sessions/22020/attachments/165293/219577/Complete_list_of_questions.pdf

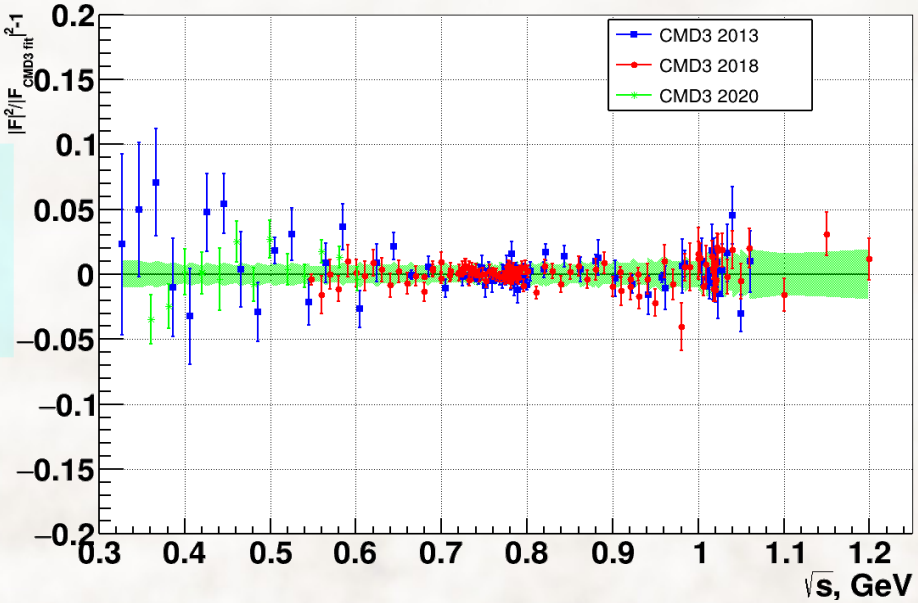
Answers had been prepared

(shorter list was already given during the TI seminar)

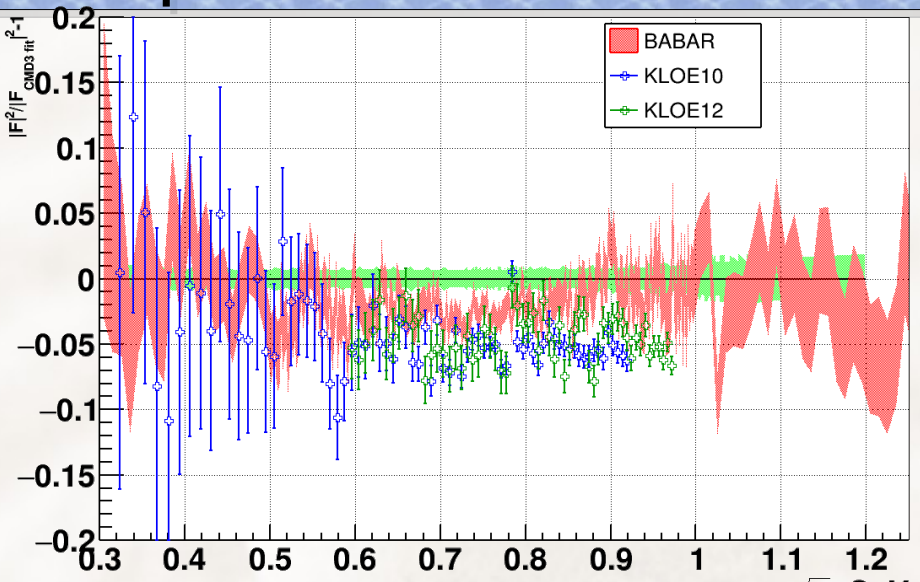
CMD-3 vs other experiments

π+π- data relative to CMD-3 fit,
green band – CMD-3 systematic value

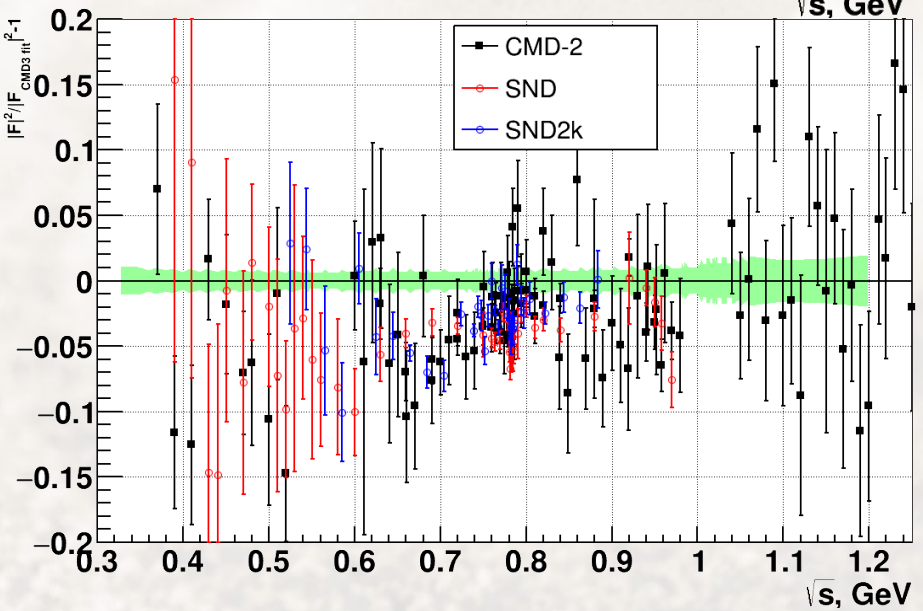
CMD-3



vs ISR



vs direct scan



CMD-3

- Statistical precision is a few times better than any other experiments
- Cross section is higher by ~ 2-5%

e+e- → π+π- by CMD3

Advantages of the CMD-3 experiment vs previous scan experiments:

- Better detector:

  vs CMD-2 (totally different detector): new drift chamber → reconstruction efficiency, momentum resolution x2 better ; 2 systems to control the detection volume; etc

- Large collected statistics (34m of $\pi^+\pi^-$ events, x30 of CMD-2):

  sharper view on the detector effects → more detail study of systematic effects,
  more of consistency checks

- e/μ/π separation:

  3 independent methods for cross checks

- fiducial volume determination:

  <0.1% consistency in forward-backward asymmetry vs prediction, variation with angle cut

  conservative estimation of systematic contribution

Event separation

events separation is done either

1) by momentum

2) or by energy deposition

Separation of $\pi^+\pi^-$, $\mu^+\mu^-$, e^+e^-, …. final states is based on likelihood minimization:

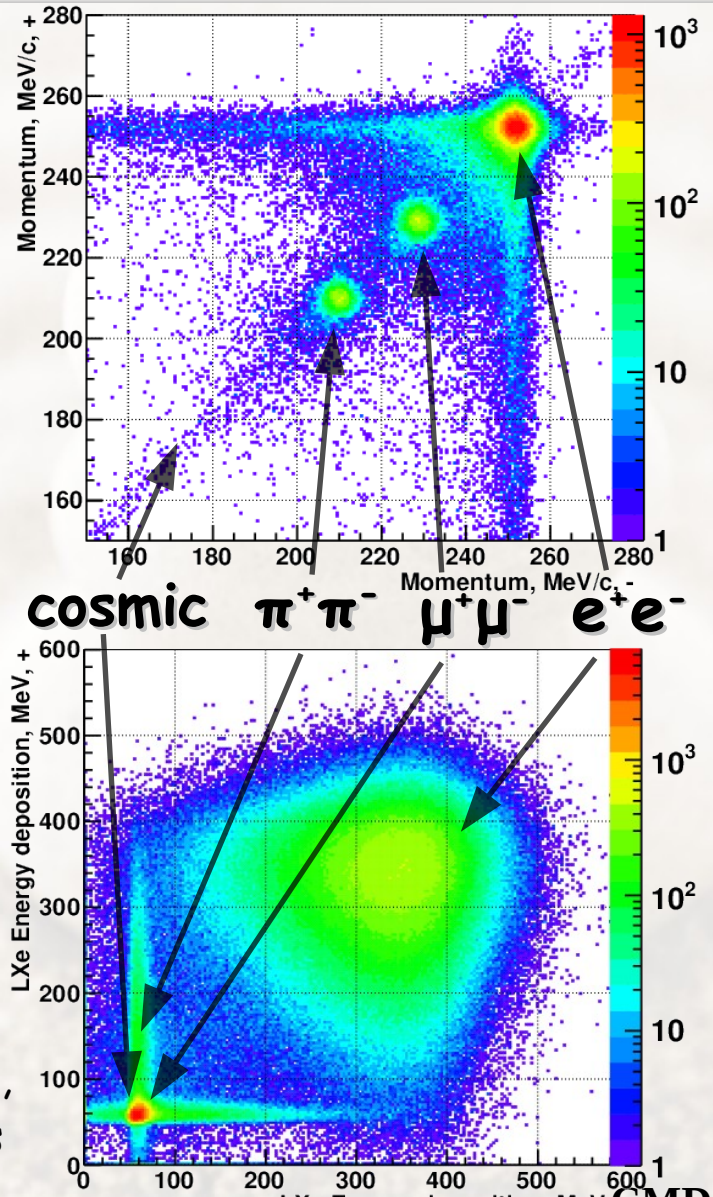
$$-\ln L = -\sum_{events} \ln\left[\sum_i N_i f_i(X^+, X^-)\right] + \sum_i N_i$$

<u>Momentum-based separation:</u>

PDFs are constructed from MC generator spectra convolved with detector response function (momentum resolution, bremsstrahlung, pion decays)

<u>Energy deposition-base separation:</u>

PDFs is described by a generic functional form (log-gaus, etc), trained on the data: by tagged electron, cosmic muons



$P^+ \times P^-$ E_{beam}=250 MeV

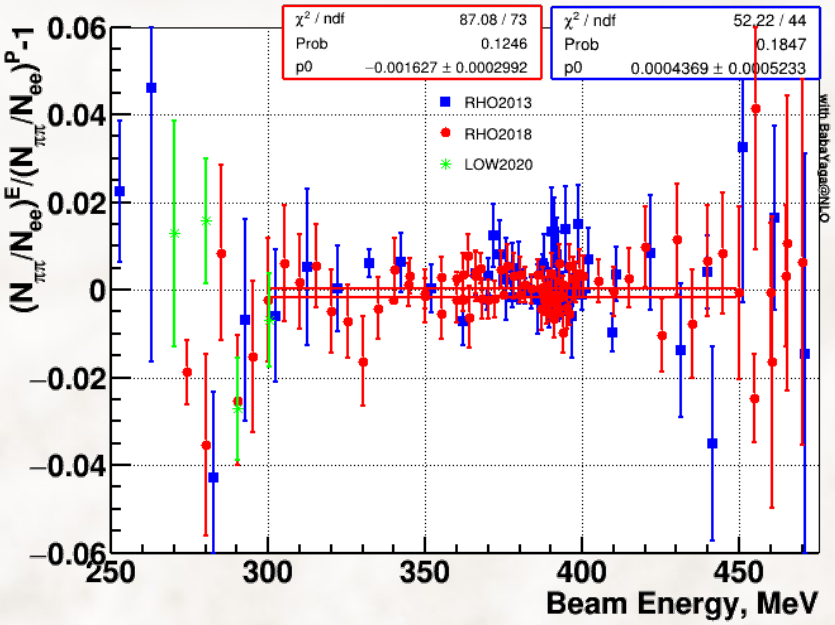
$E^+_{LXe} \times E^-_{LXe}$ E_{beam}=480 MeV

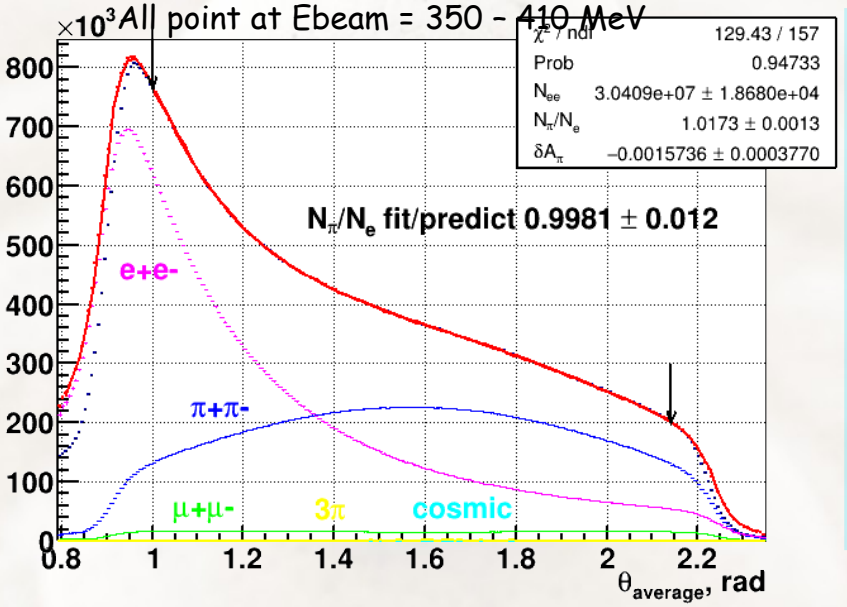
e/μ/π separation

3 methods for $N_{\pi\pi}/N_{ee}$ determination based on independent informations:

1) Momentum from DCH **2)** Energy deposition in LXe **3)** angles in DCH

E vs P separations





Fit by θ distribution

For sum of $\sqrt{s}$ = 0.7 – 0.82 GeV points

by momenta in DCH: $N_{\pi\pi}/N_{ee}$ = 1.0193 +- 0.00030

by energies in LXe $\Delta N_{\pi\pi}/N_{ee}$ = -0.09 +- 0.024%

from theta with free δA: = -0.20 +- 0.12%

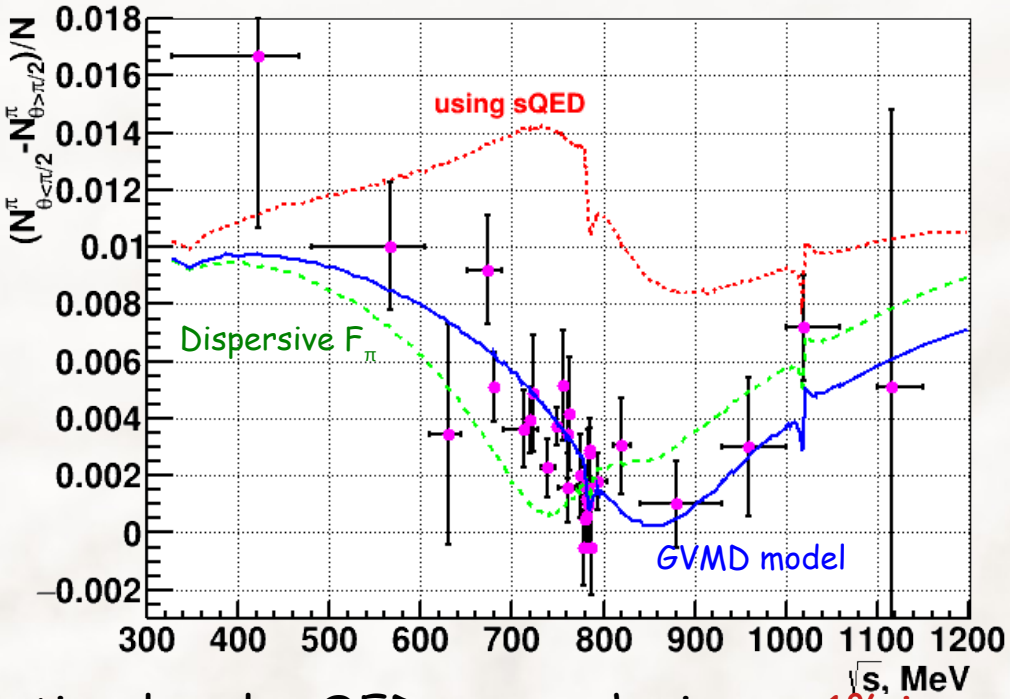
with fixed δA=0: = +0.21 +- 0.07%

consistency at ~ 0.2%

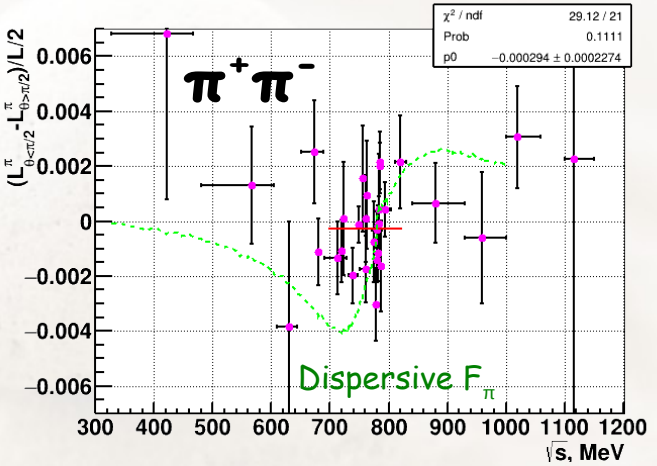
Common stat from √N: 0.026%

Charge asymmetry in e+e- -> π+π-

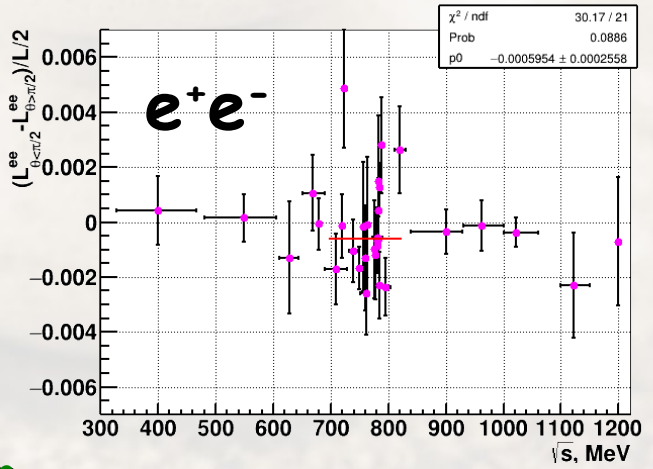
$A = (N_{\theta < \pi/2} - N_{\theta > \pi/2})/N$



Relative to GVMD prediction



to BaBaYaga@NLO



Conventional scalar QED approach gives ~ 1% inconsistency

The theoretical model within GVMD was introduced, describes well the CMD-3 data R.Lee et al., Phys.Lett.B 833 (2022) 137283 was confirmed by calculation in dispersive formalism

M.Hoferichter et al., JHEP 08 (2022) 295

Average at $\sqrt{s}$ = 0.7-0.82 GeV:

$\pi^+\pi^-$: $\langle \delta A \rangle$ = -0.029 ± 0.023 %

e^+e^-: $\langle \delta A \rangle$ = -0.060 ± 0.026 %

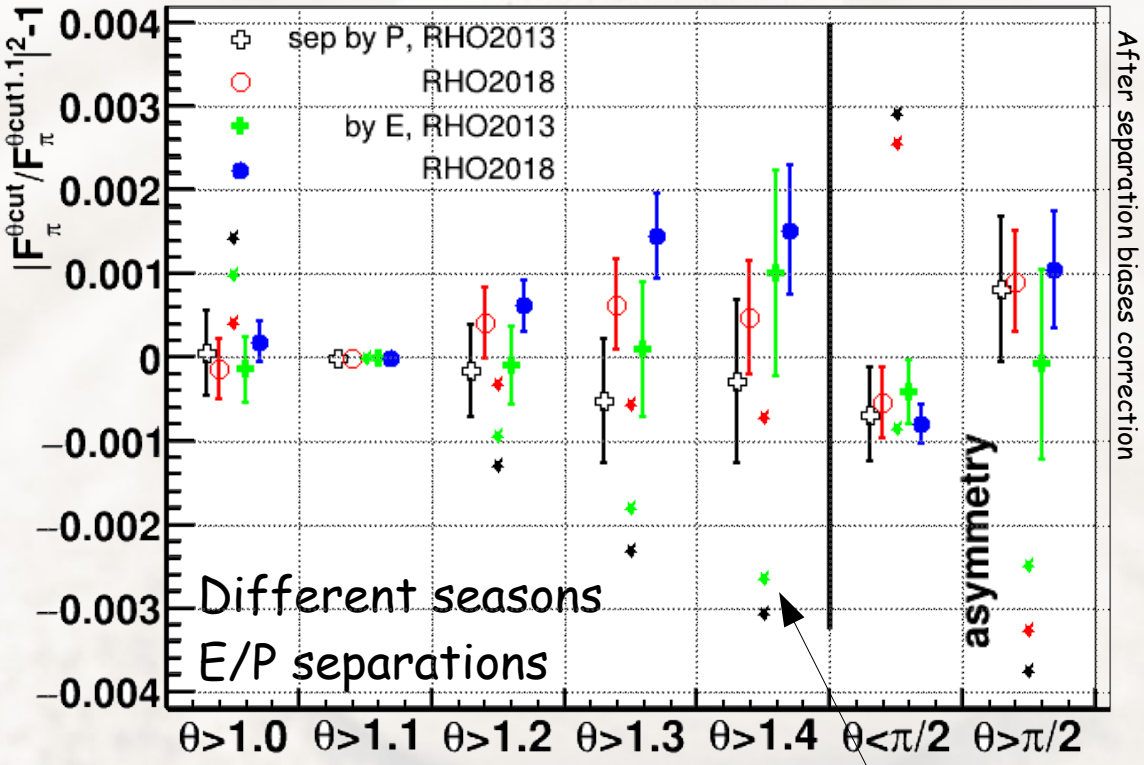
Ensure our θ angle systematics estimation for $|F_\pi|^2$

Fπ within different θ selection

Dependence on theta cut $\theta_{cut} < \theta^{event} < \pi - \theta_{cut}$

or asymmetrical selection $1 < \theta^{event} < \pi/2$ (or $\pi/2 < \theta^{event} < \pi - 1$)

Average at 2E= 0.7-0.82 GeV



$|F_\pi|^2$ stable at <0.05-0.1% level within different angle selections

Angle related systematic uncertainty estimation is quite conservative:
0.5% (RHO2018) / 0.8%(RHO2013)

Simplest possible systematics in θ angle:
- Z – length mis-calibration
- Θ^{event} common bias

if gives 0.5% total in $|F_\pi|^2$ at Θ=1 rad
should be seen with ~0.3-0.4% on this plot

With 0.5% systematic at 1 rad
★Z-length mis-calibration
★θ bias
★θ bias opposite

Backup