Di-hadron beam spin asymmetry with CLAS data

Marco Mirazita
INFN – Laboratori Nazionali di Frascati

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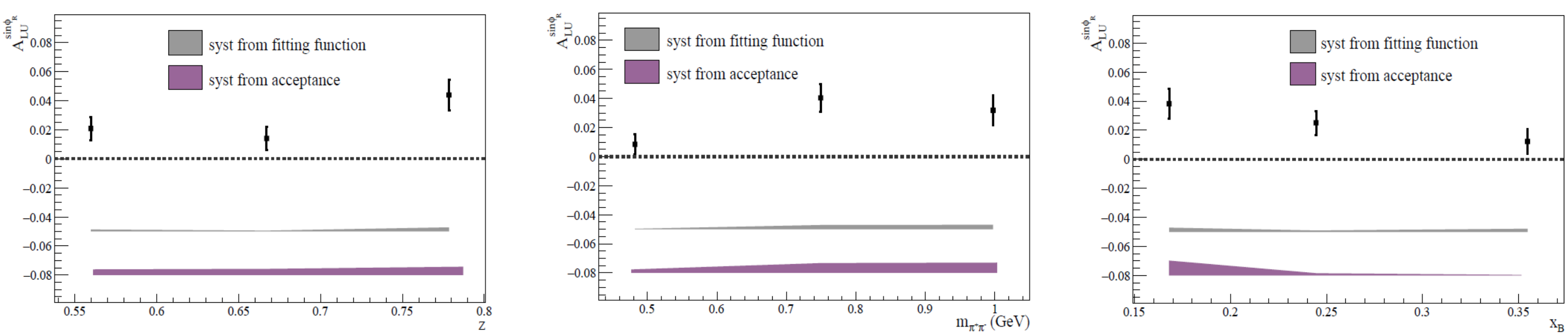
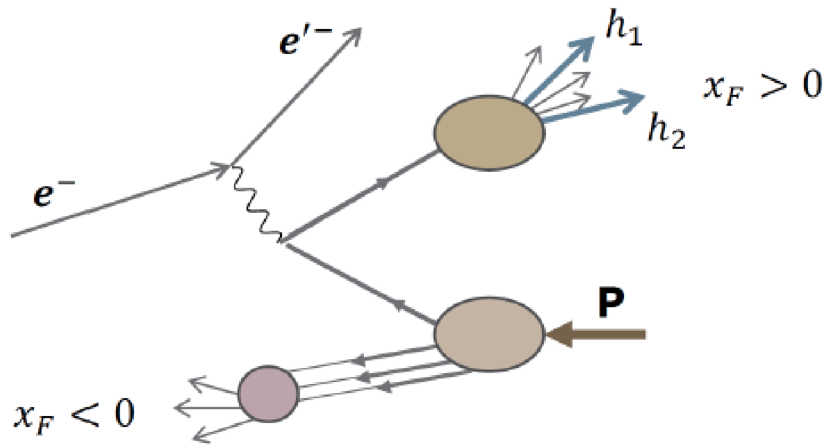
Status of the analysis

- Measurement of the Beam Spin Asymmetry in SIDIS $\pi+\pi-$ electroproduction with e1f data
  - access to higher twist PDF e(x)
  - connection with nucleon scalar charge, πN sigma-term, etc.
- Analysis under responsibility of S. Pisano (LNF)
  - analysis completed in 2014
  - preliminary results presented at Conferences in 2013-14
  - theoretical interpretation of the data by A. Courtoy
- Analysis review started on April 24, 2014
  - review committee: Angela Biselli (Chair), Brian Raue , Sebastian Kuhn
  - 4 rounds of review
  - last iteration on October 2016, never completed
    - o open issues: some PID cut, fit of the BSA phi dependence, MC studies
  - draft of the paper ready

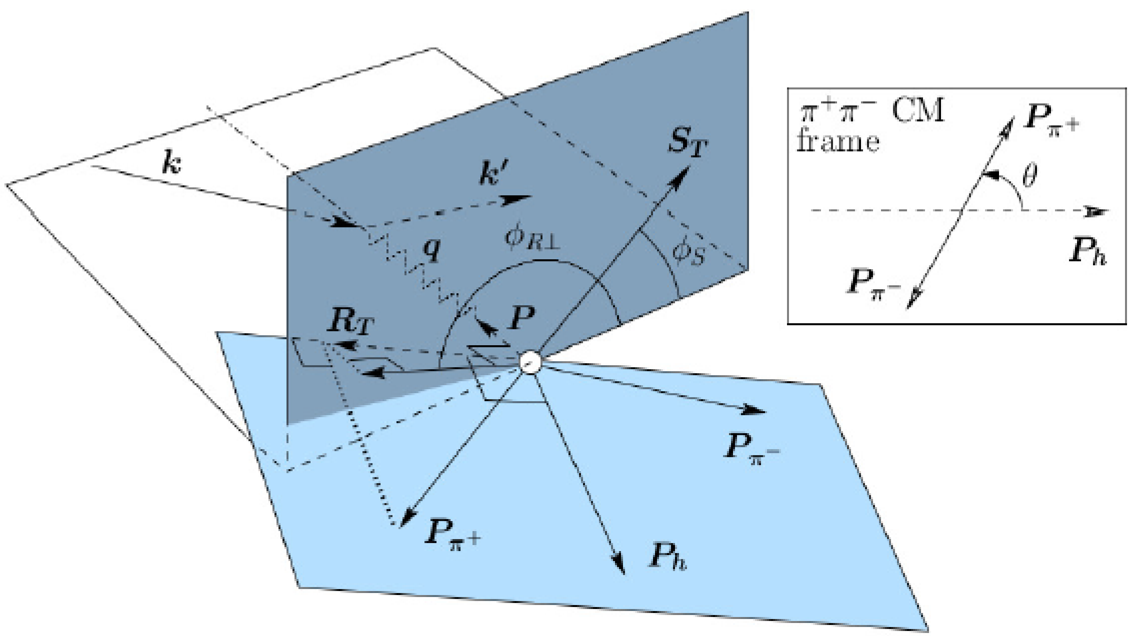


Di-Hadron Kinematics



Target fragmentation region

$x_F > 0$



ϕ_h : azimuthal angle of the pion pair momentum

ϕ_R : azimuthal angle of the transvers component of the momentum difference

Resuming the analysis

- e1f data available in the form of nt10 root tree: "e" and "eposneg" skims
- Monte Carlo data: clasDIS + gsim + gpp
  - lower final statistics than the experimental data
- Silvia's analysis code is available: first goal is to reproduce her results

"Standard" e1f corrections, fiducial and particle identification cuts

- electrons: z-vertex, calorimeter S.F. and total energy, Cherenkov npe (with/without ϕ and θ matching)
- pions: β from TOF, calorimeter energy, Cherenkov npe

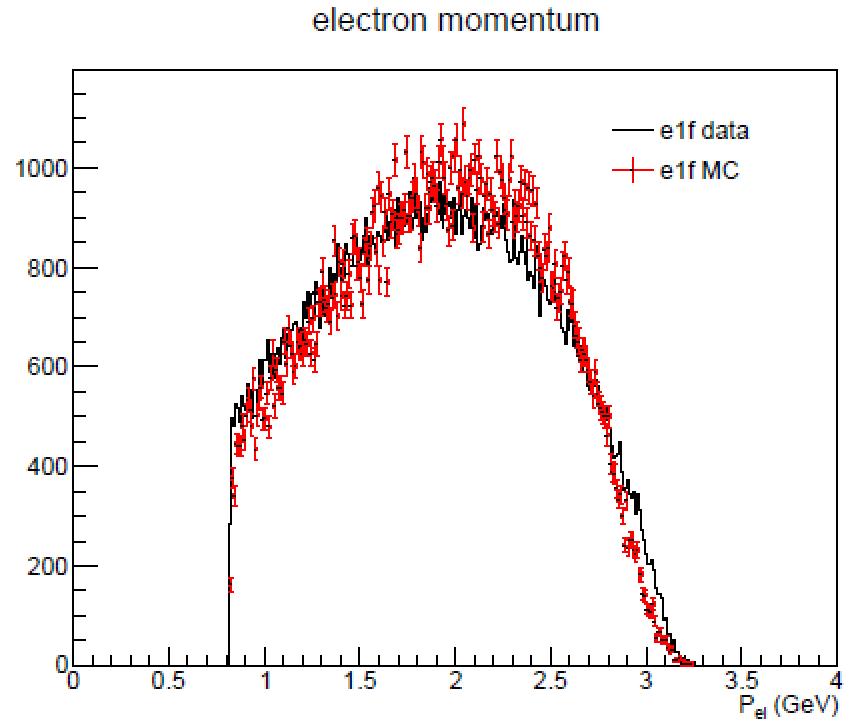
DIS cuts

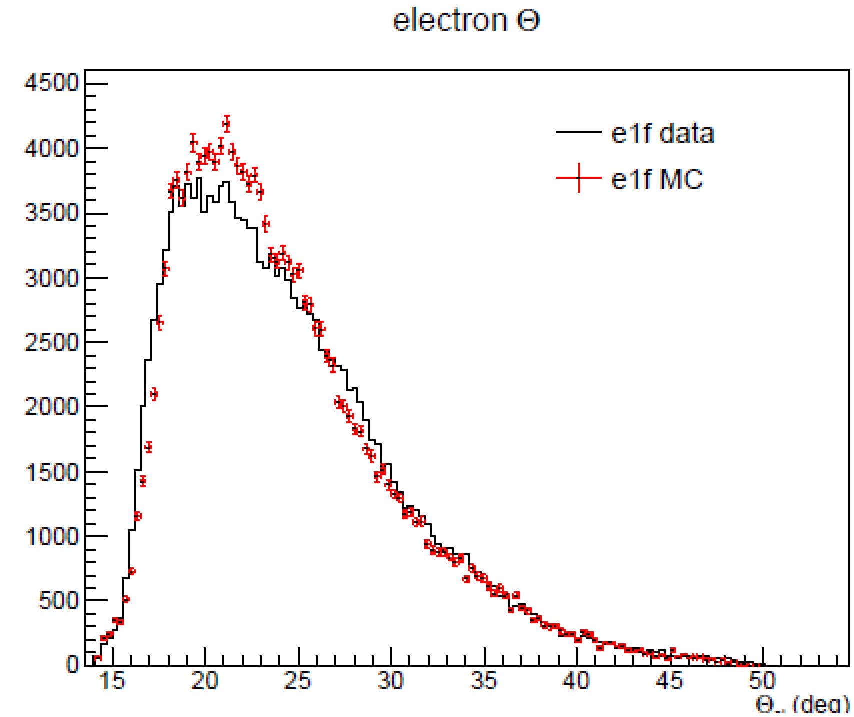
- Q^2>1 GeV2, W>2 GeV, y<0.85
- MM(e π+π- X) > 1.05 GeV
- current fragmentation region: $x_F > 0$

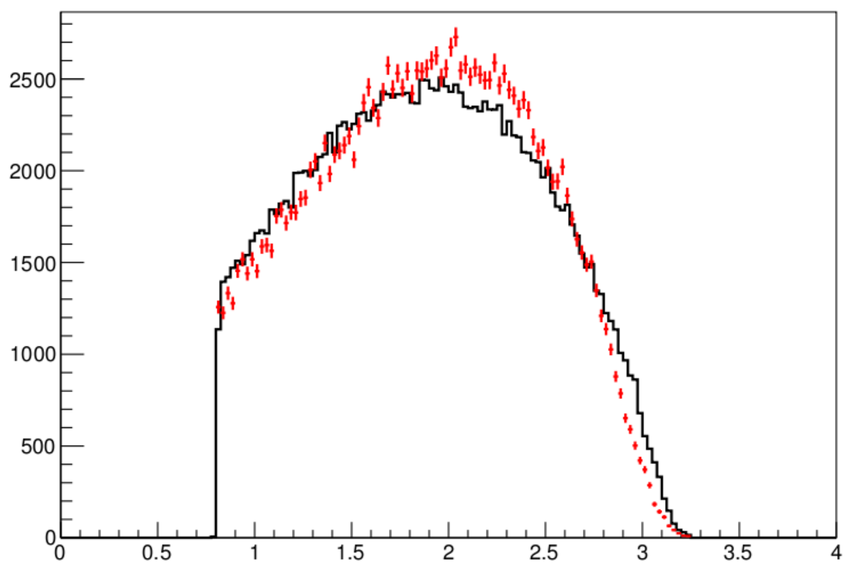
Next slides show the comparison between new (bottom) and old (top) analysis

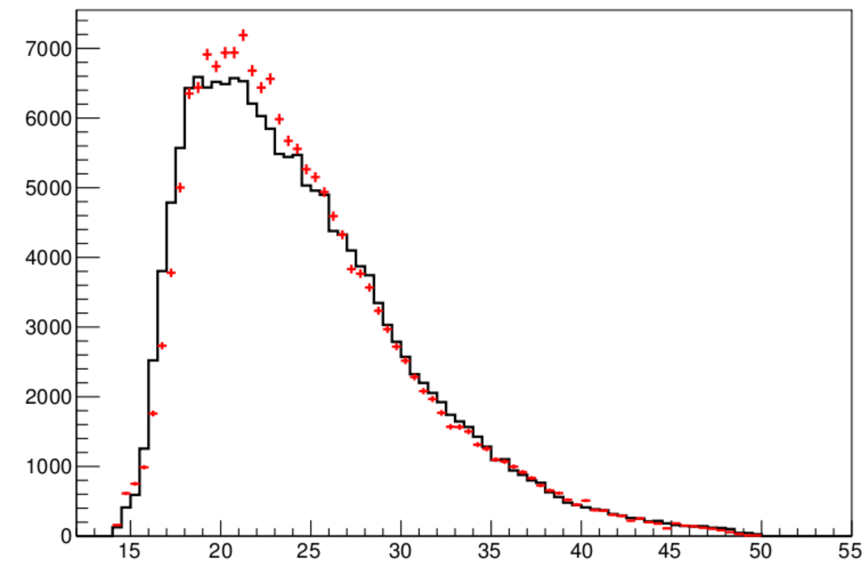
- experimental data in black (histograms)
- Monte Carlo data in red (points)
- overall relative normalization by the number of reconstructed di-hadron pairs

Electron kinematics

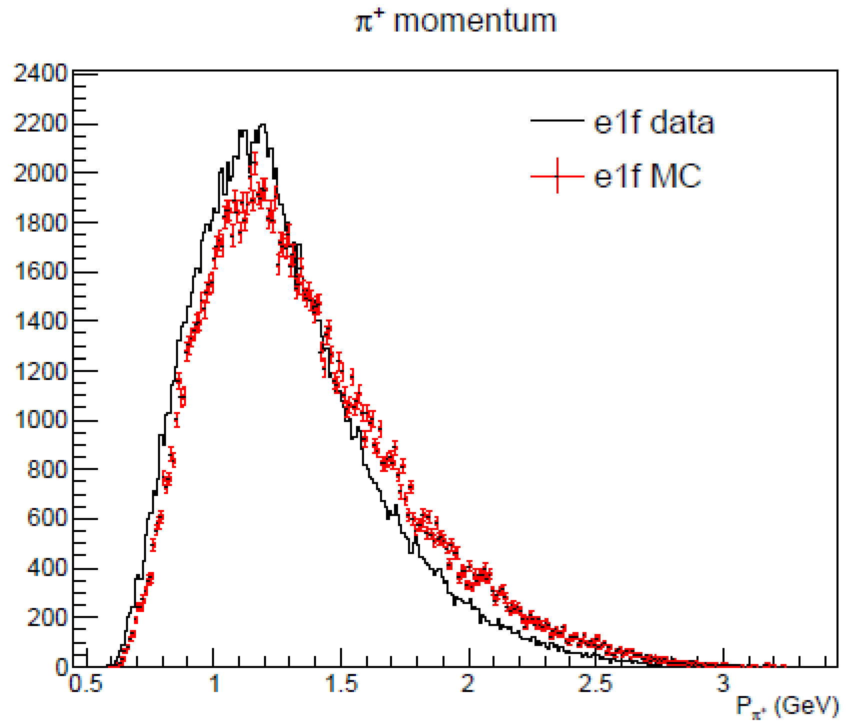


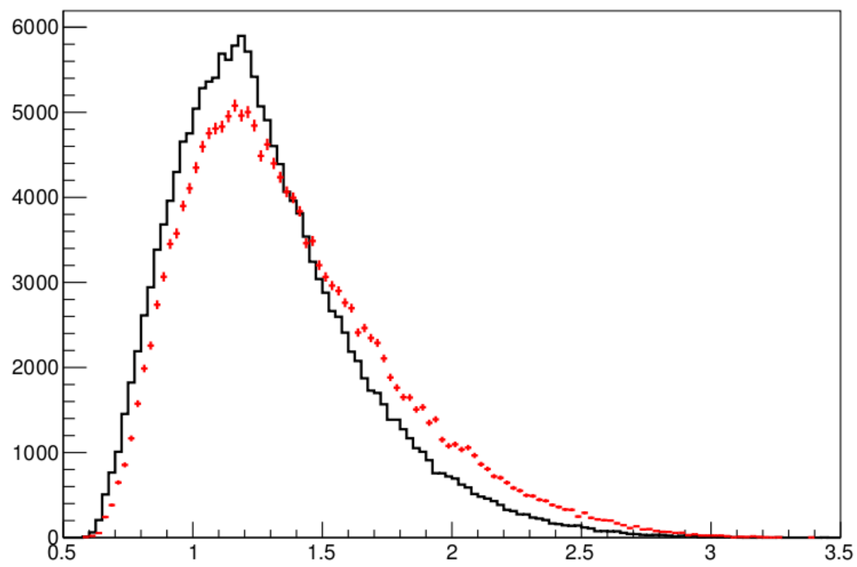


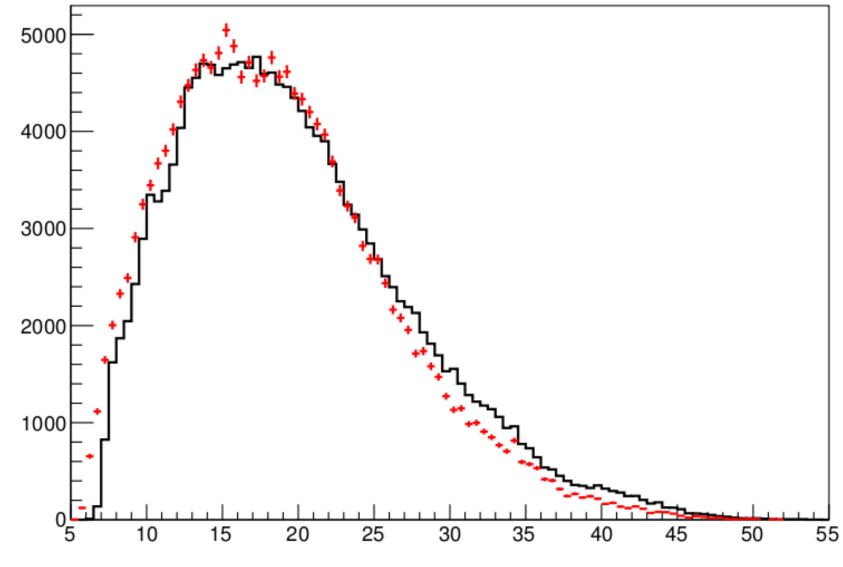




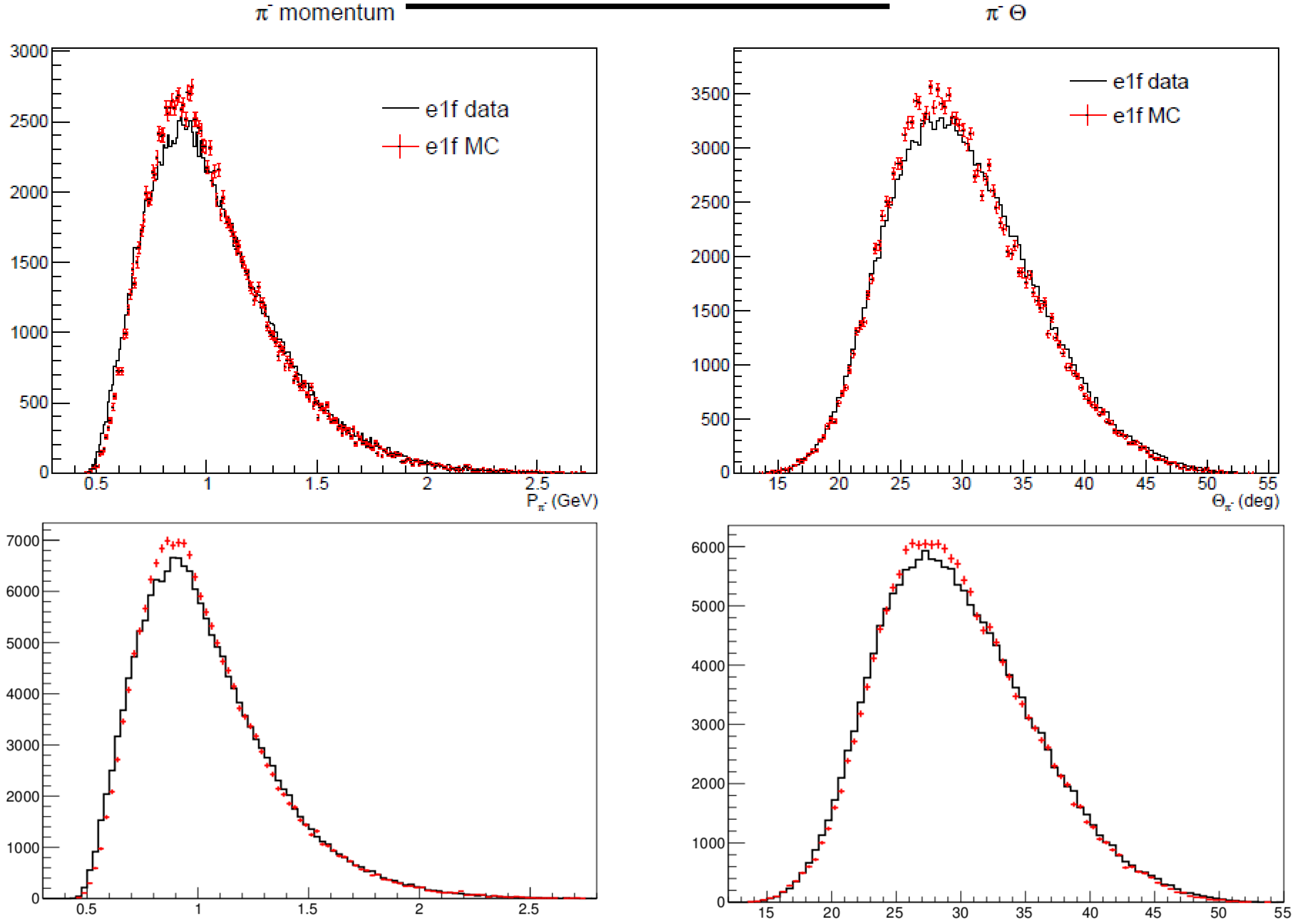
Pi+ kinematics



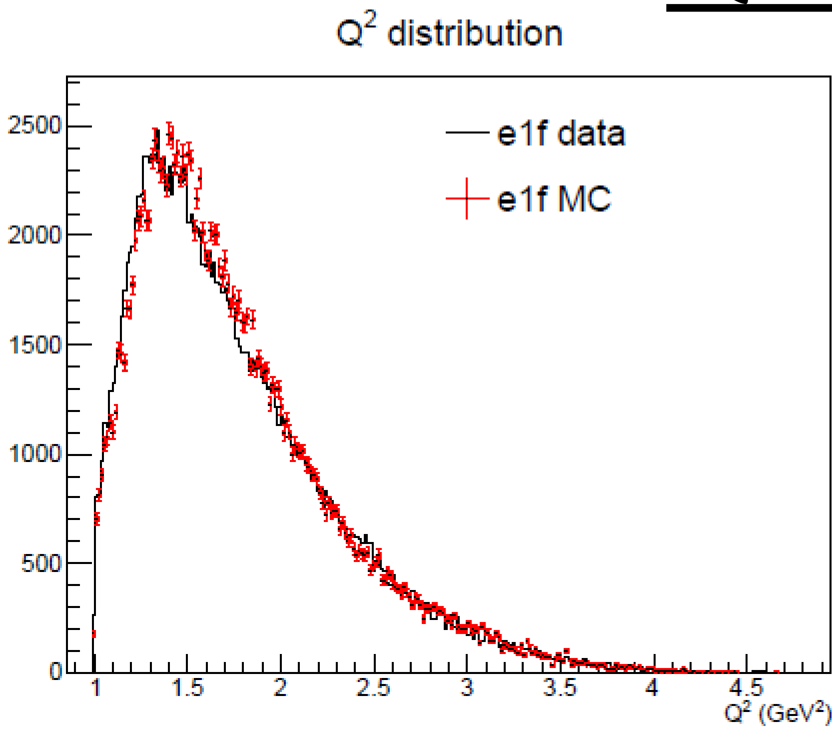


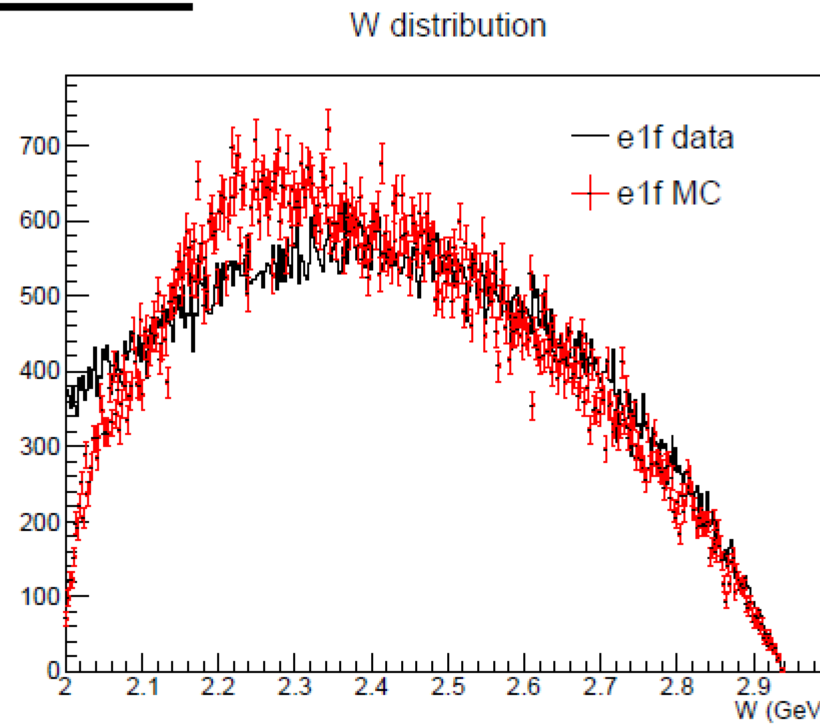


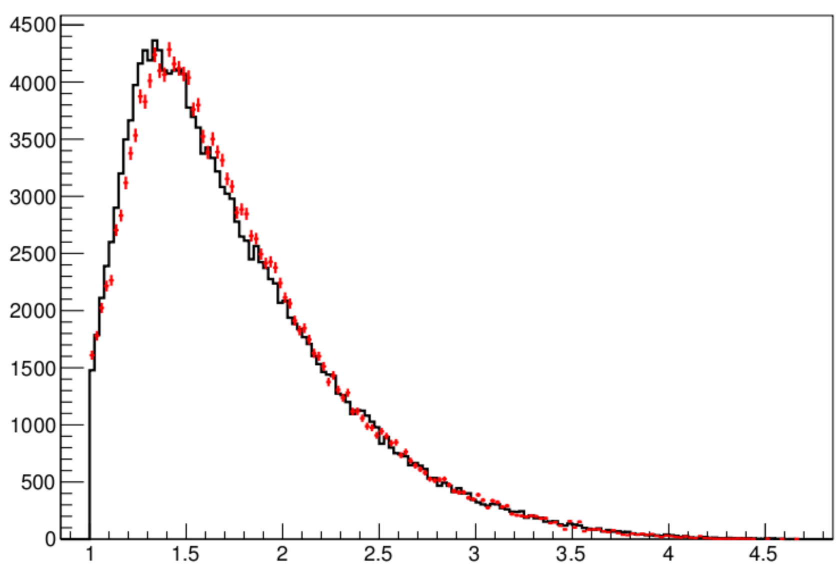
Pi- kinematics

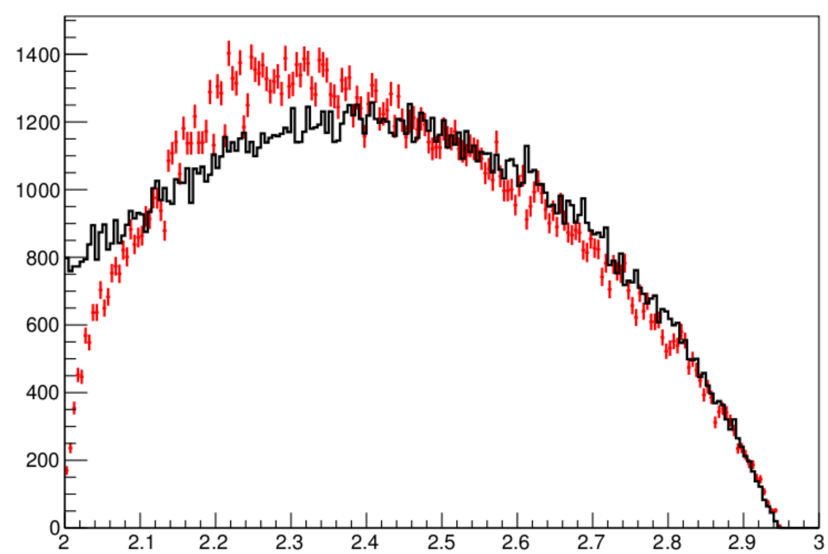


Q2 and W

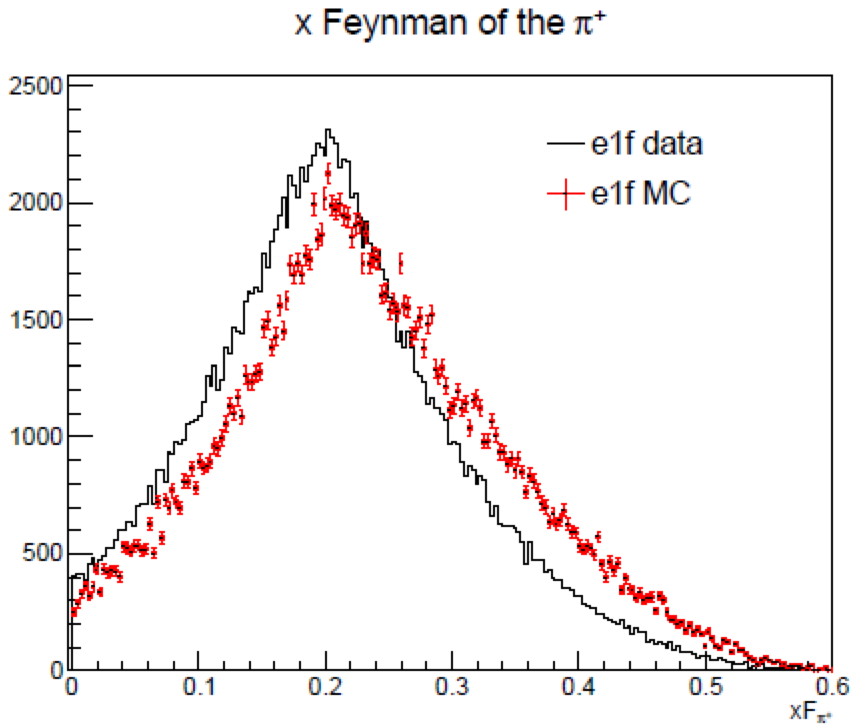

Q2 distribution
e1f data
e1f MC
Q2 (GeV2)

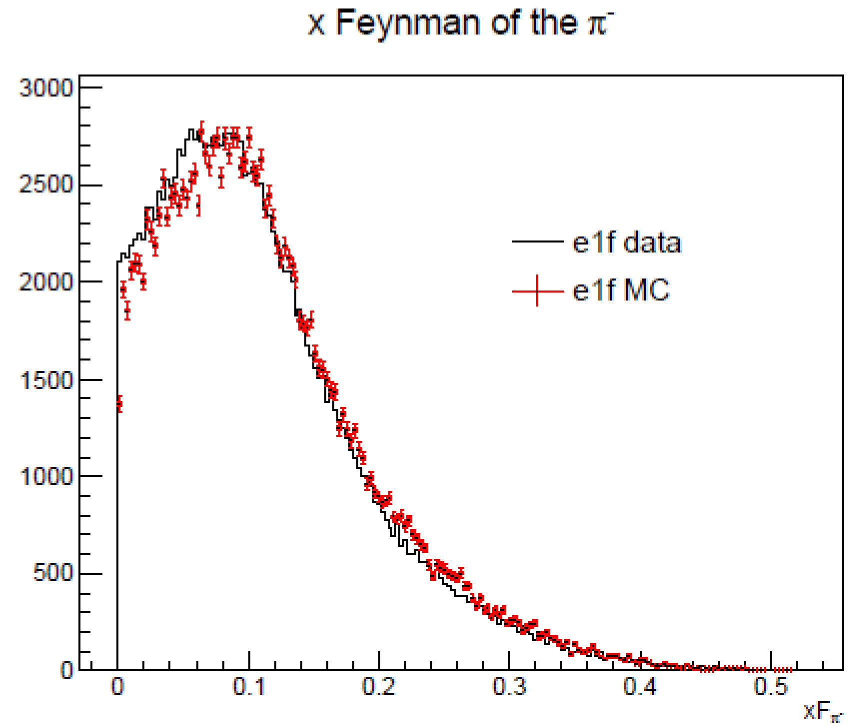

W distribution
e1f data
e1f MC
W (GeV)

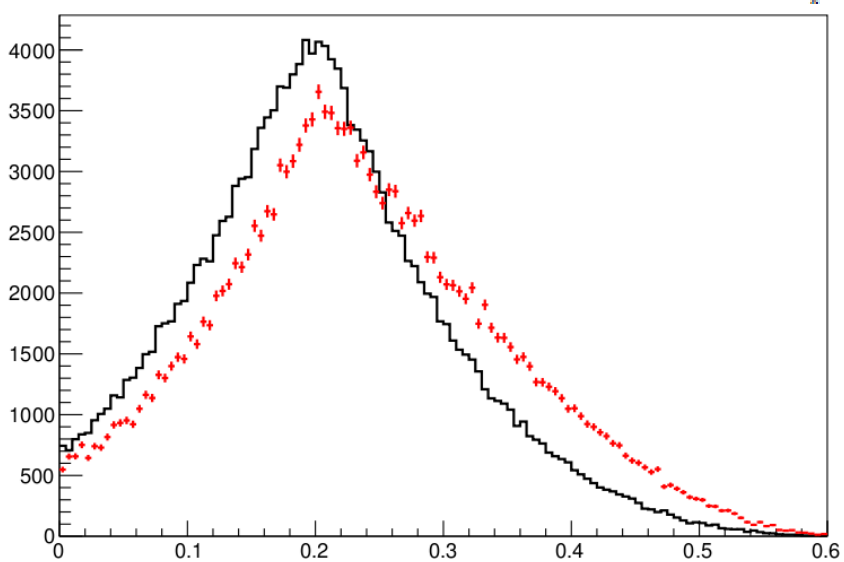


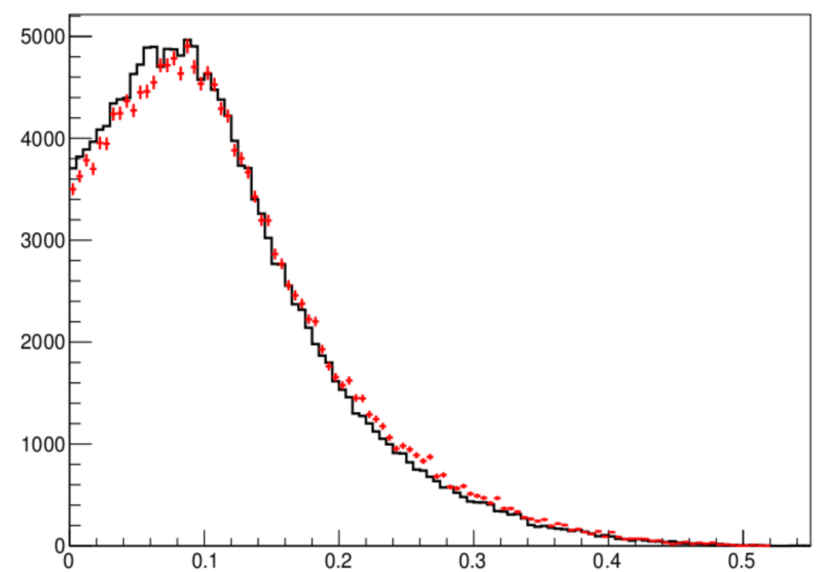


pion Feynman-x

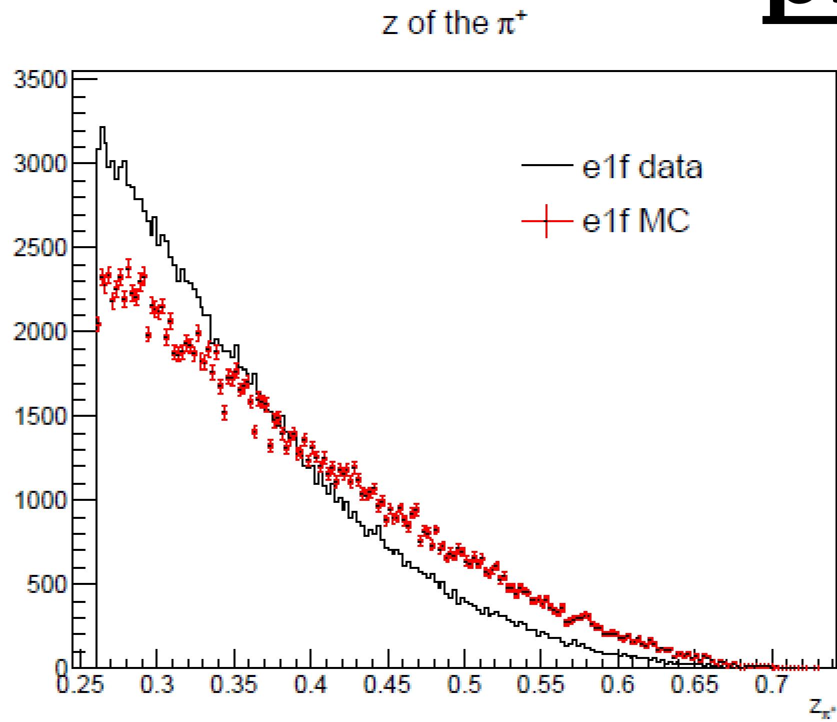


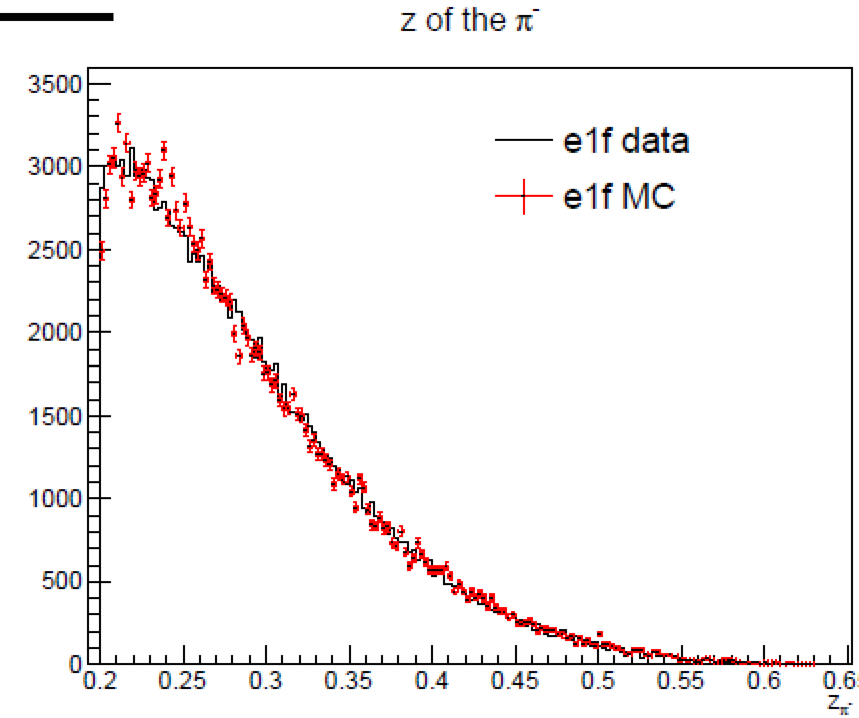


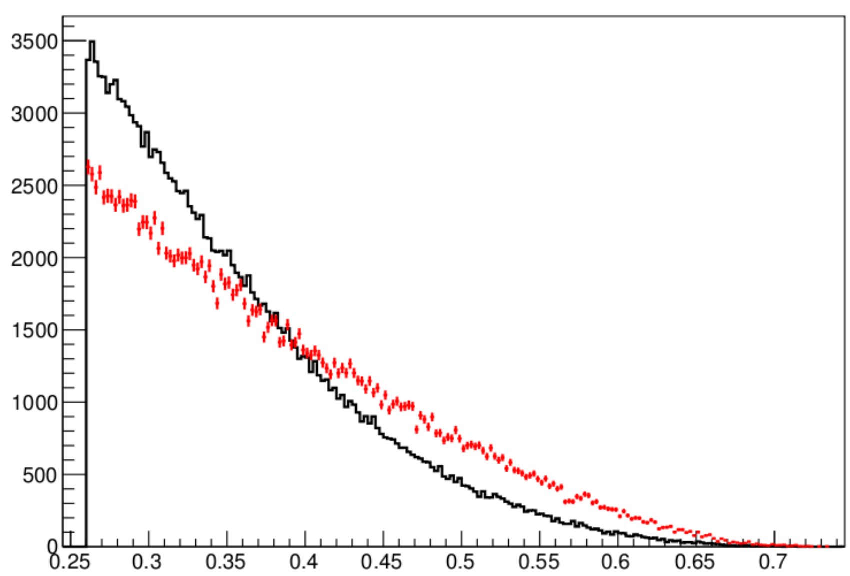


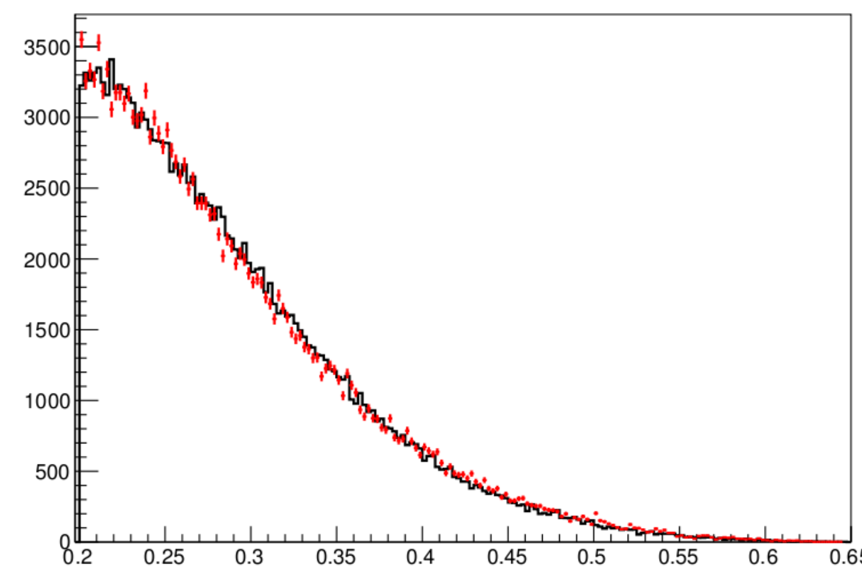


pion z

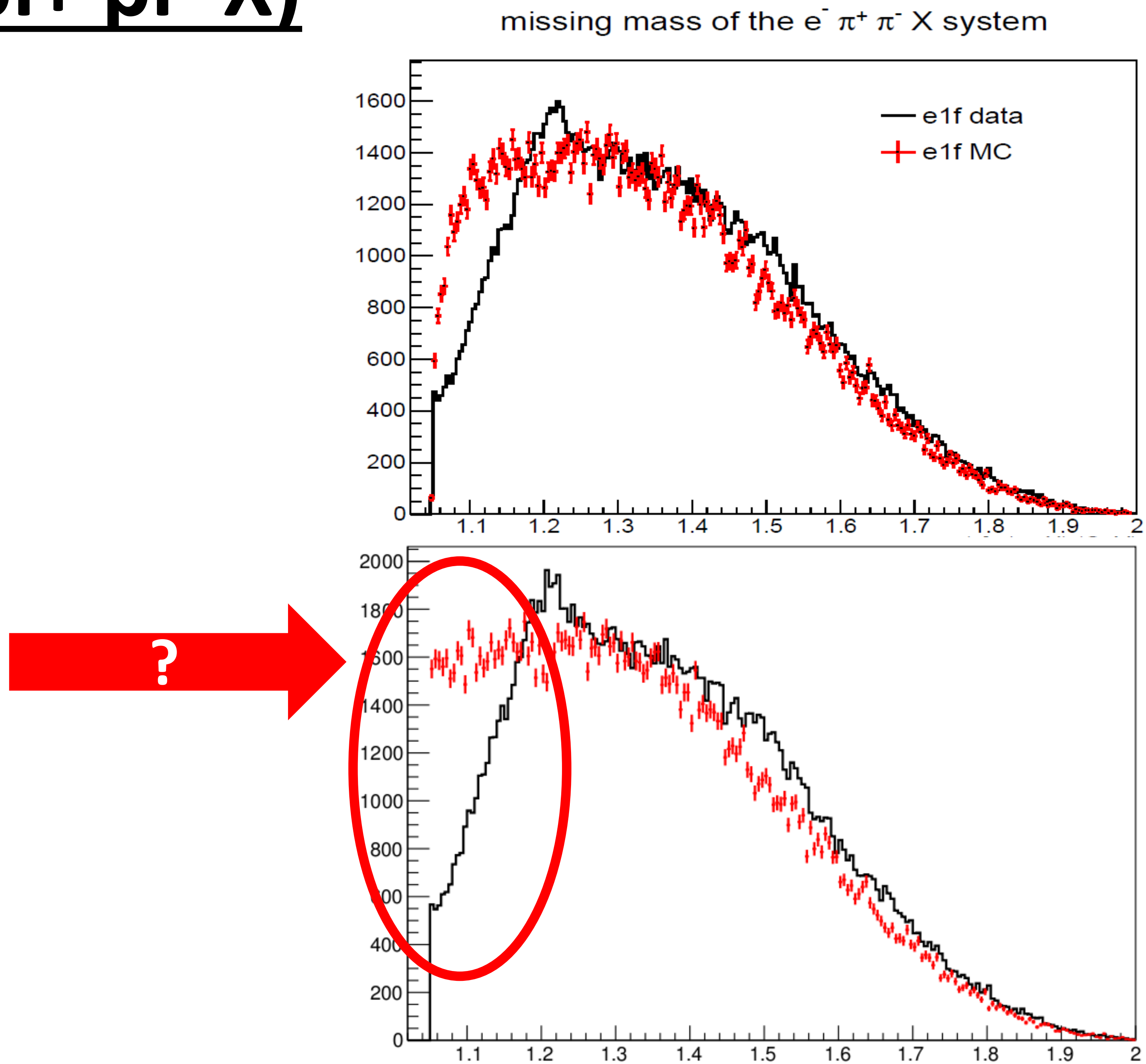




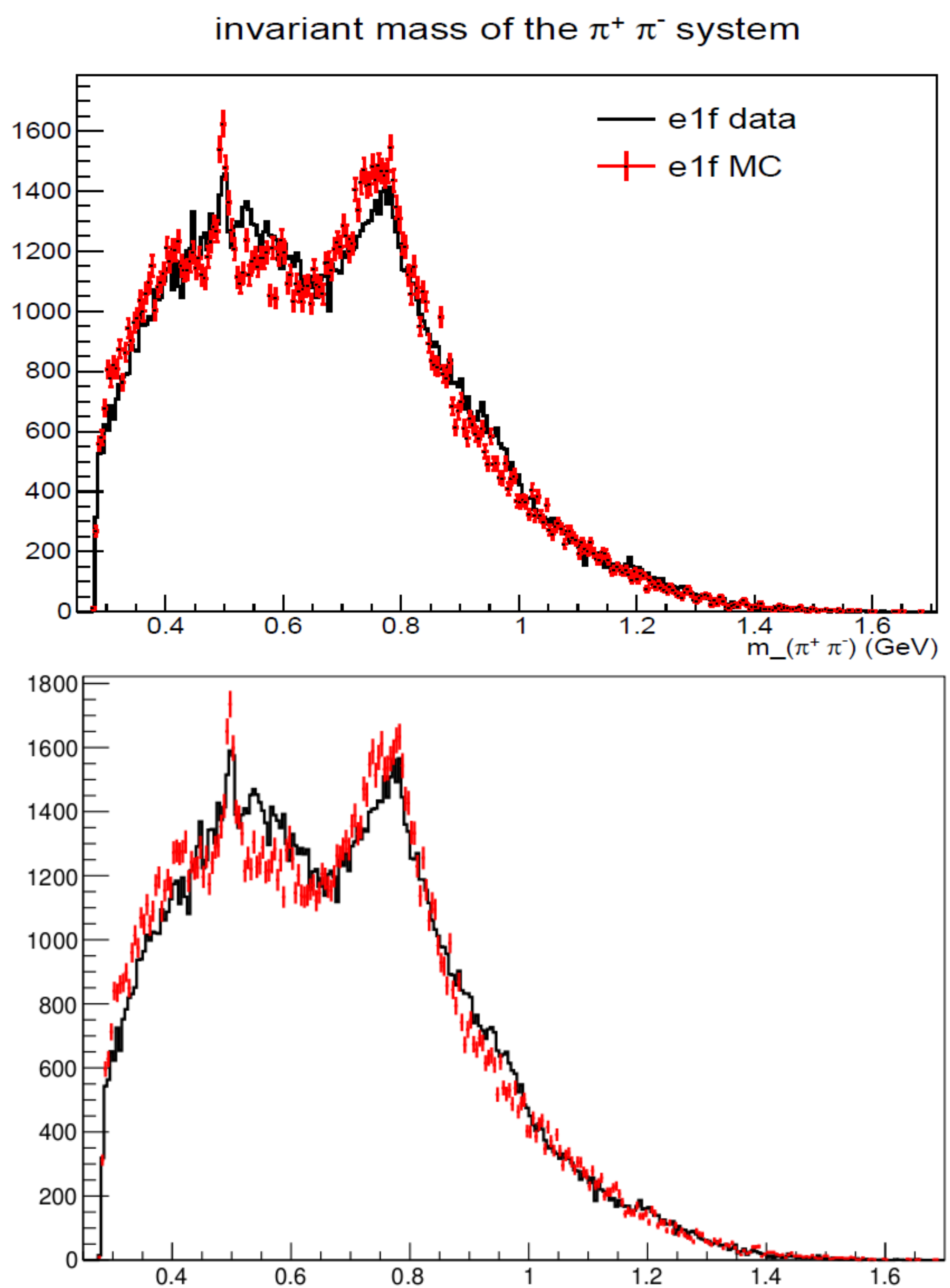




MM(e pi+ pi- X)

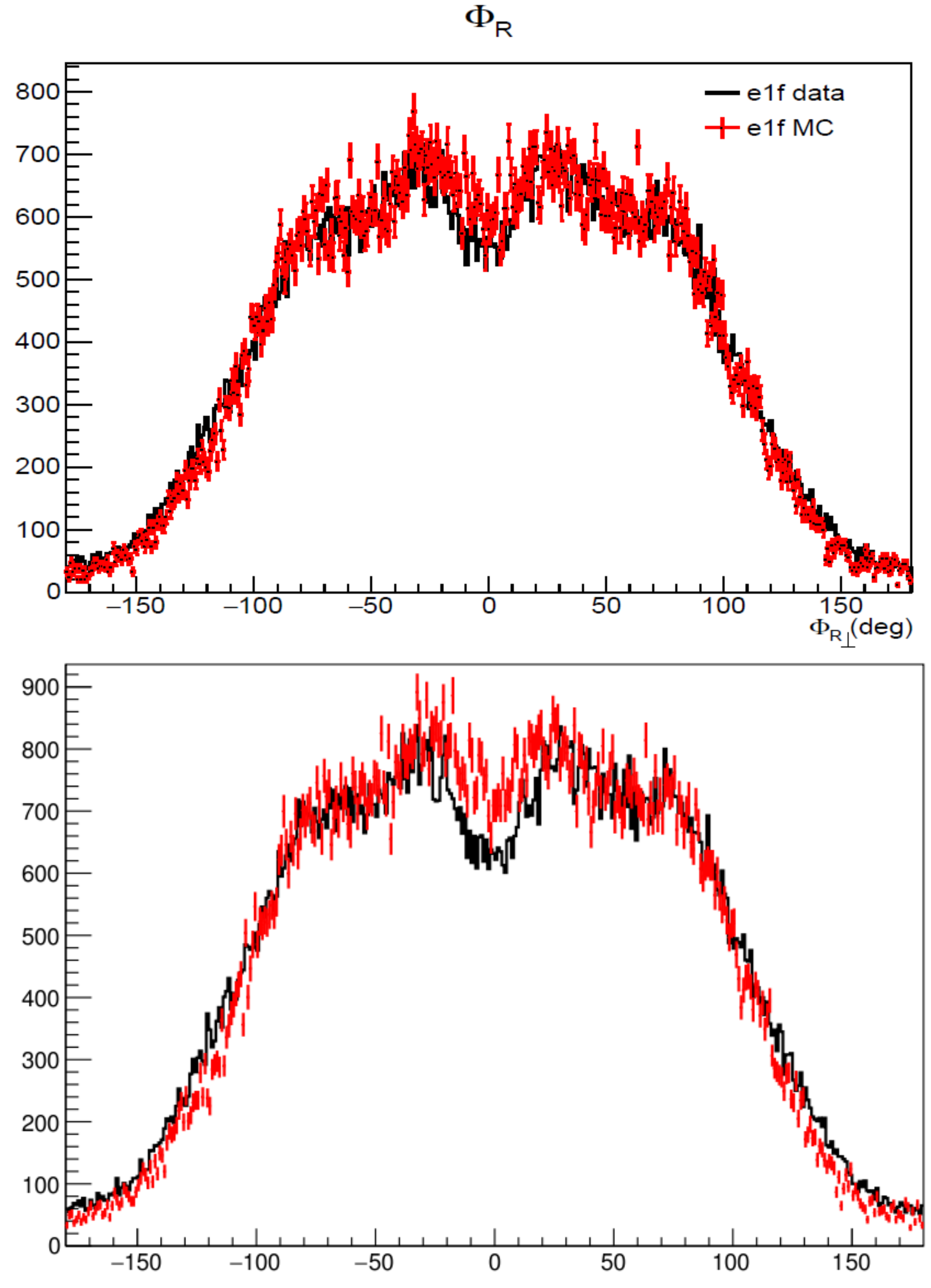

missing mass of the e⁻ π⁺ π⁻ X system
e1f data
e1f MC
0
200
400
600
800
1000
1200
1400
1600
2000
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
?

M(pi+ pi-)



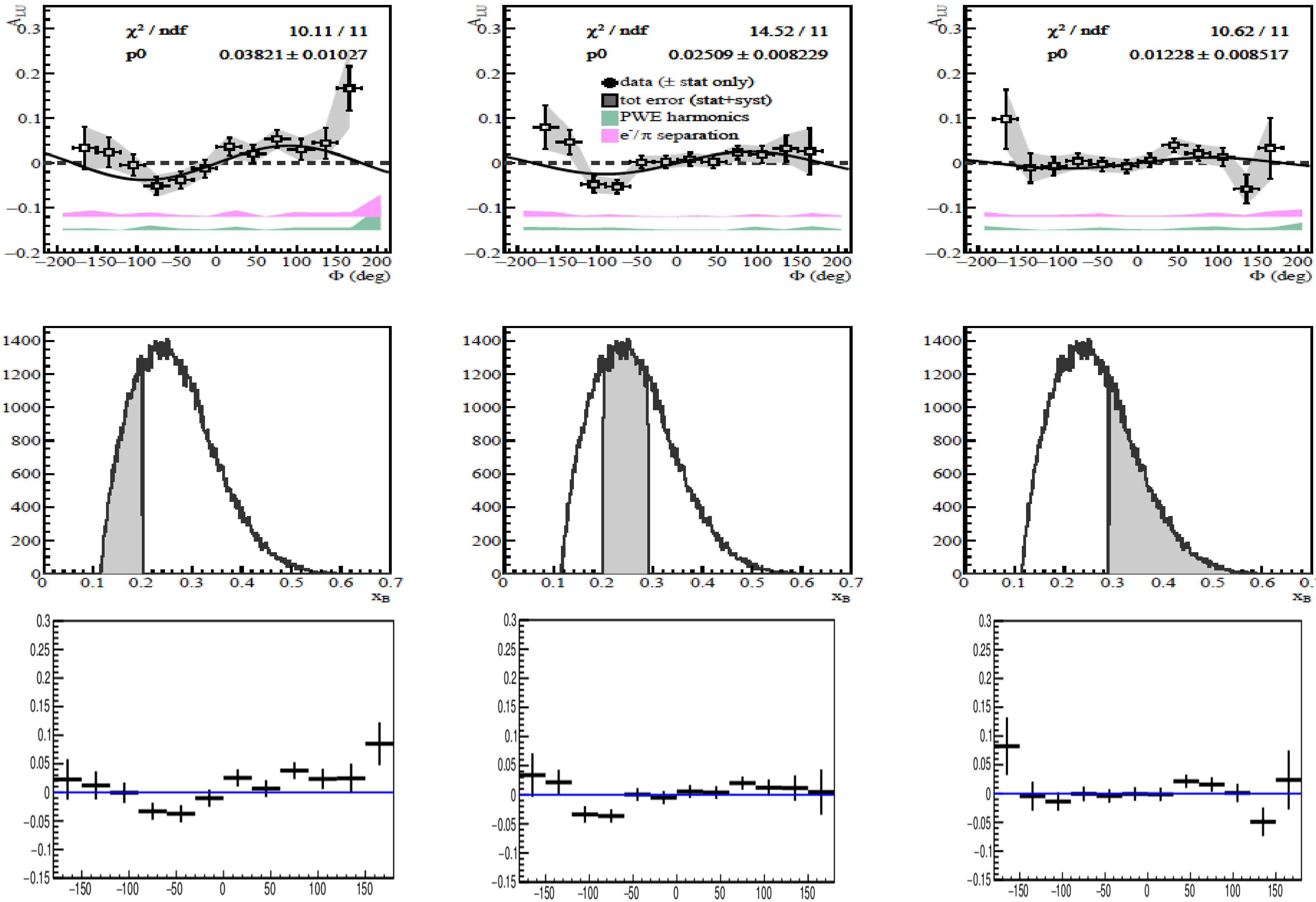
invariant mass of the π^+ π^- system
e1f data
e1f MC
m_(π^+ π^-) (GeV)
0
200
400
600
800
1000
1200
1400
1600
1800
0.4
0.6
0.8
1
1.2
1.4
1.6

phi_R



- **Agreement in all the distributions except in the MM**
- **Number of events almost the same**

BSA vs Bjorken-x



Putting asymmetry in the MC

$$N \propto 1 + hA\sin\varphi$$

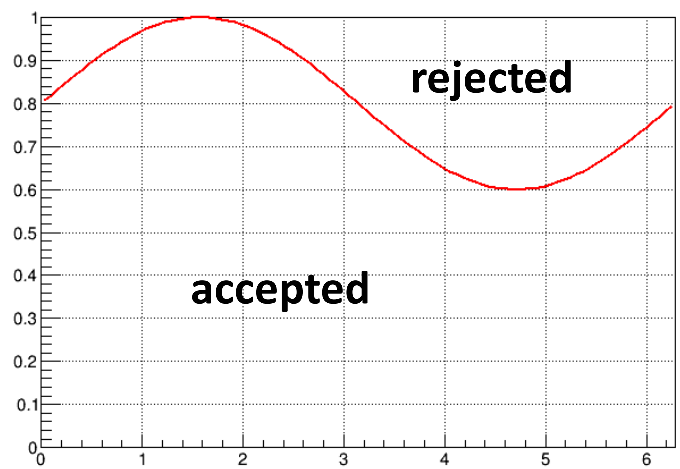
- Generate random helicity

$x < 0.5 \rightarrow h = +1$

$x > 0.5 \rightarrow h = -1$

- Probability of the event given the helicity

$P \propto (1 + hA\sin\varphi)$

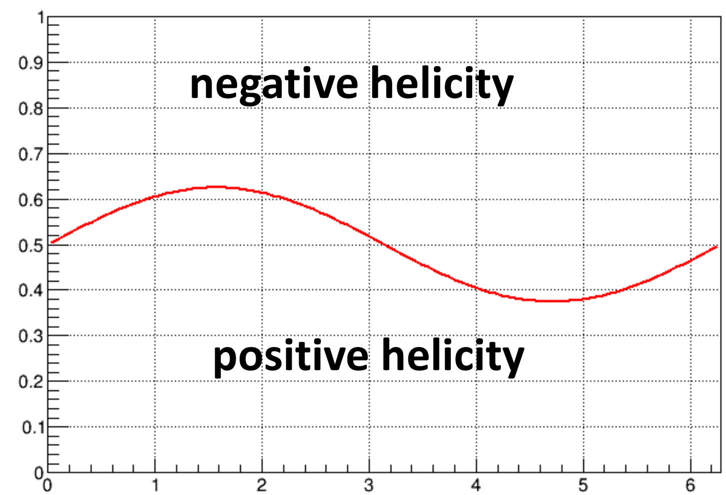


- Accept the event *i* if

$$x < \frac{(1+hA\sin\varphi_i)}{(1+|hA|)}$$

- Probability to have helicity h as a function of ϕ

$P(h = +1) = 0.5(1 + A\sin\varphi)$
$P(h = -1) = 0.5(1 - A\sin\varphi)$



- Assign the helicity to the event

$x < 0.5(1 + A\sin\varphi_i) \rightarrow h = +1$

$x > 0.5(1 + A\sin\varphi_i) \rightarrow h = -1$

- Not throwing away events

Selection of events

1) Select the final state — example: $e\,p \rightarrow e\,\pi^+ X$
   - only 1 pion?
   - at least one pion? Then use the most energetic?

2) What kinematic cuts can be applied to the events to be polarized?
   - Cutting on the independent variables entering in the cross section should be safe
   - Other cuts like P_e, MM, angles,…? Do we introduce bias in the asymmetry due to kinematic correlations (double counting)?

$$\frac{d\sigma}{dx\,dy\,d\psi\,dz\,d\phi_h\,d|P_{h\perp}|^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2\,(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T}+\varepsilon F_{UU,L}$$
$$+\quad \sqrt{2\,\varepsilon(1+\varepsilon)}\,\cos\phi_h\,F_{UU}^{\cos\phi_h}+\varepsilon\cos(2\phi_h)\,F_{UU}^{\cos 2\phi_h}$$
$$+\,\lambda_e\,\sqrt{2\,\varepsilon(1-\varepsilon)}\,\sin\phi_h\,F_{LU}^{\sin\phi_h}$$