Λ production in the DIS target fragmentation region: the CLAS12 program

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SIDIS Λ

$e\,p \rightarrow e'\,\Lambda\,X$

$\Lambda \rightarrow p\,\pi^-$

- clear TFR production evidence
- narrow peak in (p π-) inv. mass
- the weak decay allow direct polarization measurement

unpolarized

double long. polarization

double transv. polarization

triple polarization

$$\frac{d\sigma^{TFR}}{dx_B dy d\zeta d\phi_S d\phi} =$$

$$= \frac{\alpha_{em}^2}{\pi Q^2 y} \sum_a e_a^2 \times$$

$$\left\{ \left(1 - y + \frac{y^2}{2}\right) \left[M(x_B,\zeta) + S_{N\parallel} S_\parallel M_L^L(x_B,\zeta) + |\mathbf{S}_{N\perp}|\,|\mathbf{S}_\perp| M_T^T(x_B,\zeta) \cos(\phi - \phi_S) \right] \right.$$

$$+ h y \left(1 - \frac{y}{2}\right) \left[S_{N\parallel} \Delta M_L(x_B,\zeta) + S_\parallel \Delta M^L(x_B,\zeta) + \right.$$

$$\left. \left. + |\mathbf{S}_{N\perp}|\,|\mathbf{S}_\perp| \Delta M_T^T(x_B,\zeta) \sin(\phi - \phi_S) \right] \right\}$$

The Fracture Functions <u>are the observables</u>
- easy extraction from the cross section

Anselmino, Barone, Kotzinian – PL B699 (2011), 108

The Λ polarization

Polarization decomposition in SIDIS

$$P_{\Lambda,i} = P^I_{\Lambda,i} + hP^T_{\Lambda,i}$$

i = x,y,z
h = beam helicity

Induced component:

$$P^I_{\Lambda,x} = C^s_x \sin\phi + C^{s2}_x \sin 2\phi$$

$$P^I_{\Lambda,y} = C^0_y + C^c_y \cos\phi + C^{c2}_x \cos 2\phi$$

$$P^I_{\Lambda,z} = C^s_z \sin\phi + C^{s2}_z \sin 2\phi$$

Transferred component:

$$P^T_{\Lambda,x} = D^0_x + D^c_x \cos\phi$$

$$P^T_{\Lambda,y} = D^s_y \sin\phi$$

$$P^T_{\Lambda,z} = D^0_z + D^c_z \cos\phi$$

In the TFR/Fracture function formalism

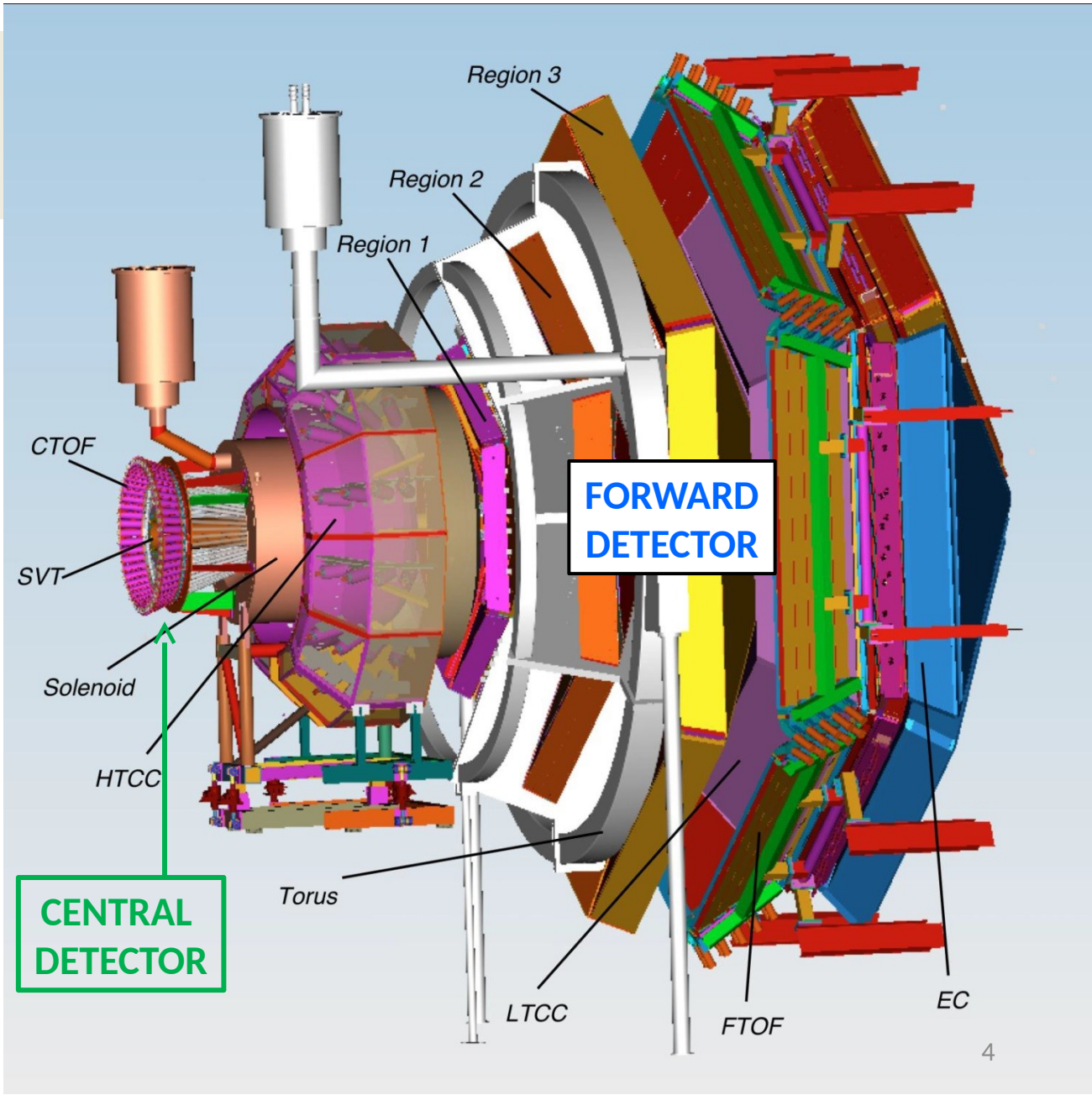
- At leading twist and integrating the transverse momenta, only D^0_z survives

The CLAS12 spectrometer

- Luminosity up to 10^{35} cm^{-2} s^{-1}
- High polarization electron beam
- H and D polarized targets
- Wide acceptance

CENTRAL DETECTOR
- solenoidal field
- vertex tracker
- time-of-flight

FORWARD DETECTOR
- toroidal field
- 6 sector geometry
- vertex tracker
- three regions of drift chambers
- time-of-flight
- two threshold Cherenkov counters
- preshower
- EM calorimeter
- RICH for K ID



The CLAS12 measurement

Proposal E12-06-112A/E12-09-008A approved in 2014

- 11 GeV electron beam, high polarization
- unpolarized liquid hydrogen target
- two main torus polarities
50% with inbending negative particles (normal)
50% with outbending negative particles (reversed)
- Running in parallel with other unpolarized CLAS12 experiments
- Scattered electron, proton and pion detected in CLAS12, the Λ is reconstructed in the IM(p π-)

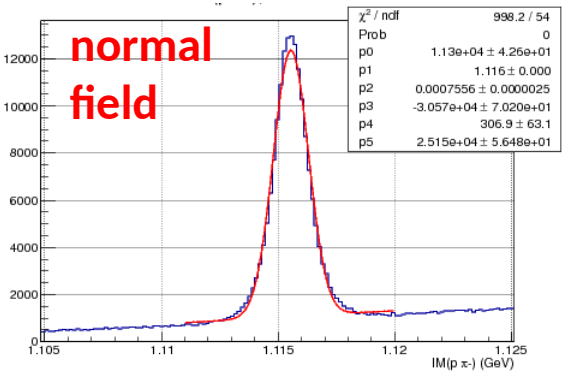
DIS cuts:
Q^2>1 GeV^2
W^2 > 5 GeV^2

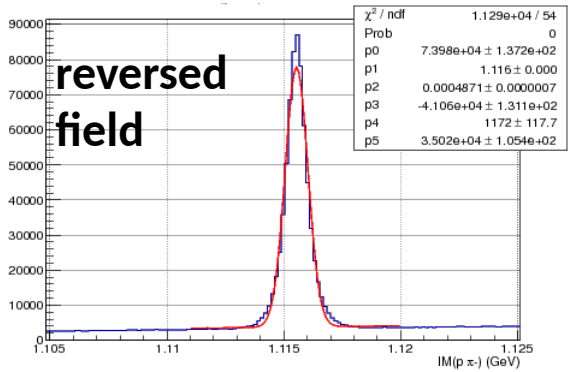
SIDIS Λ with CLAS12

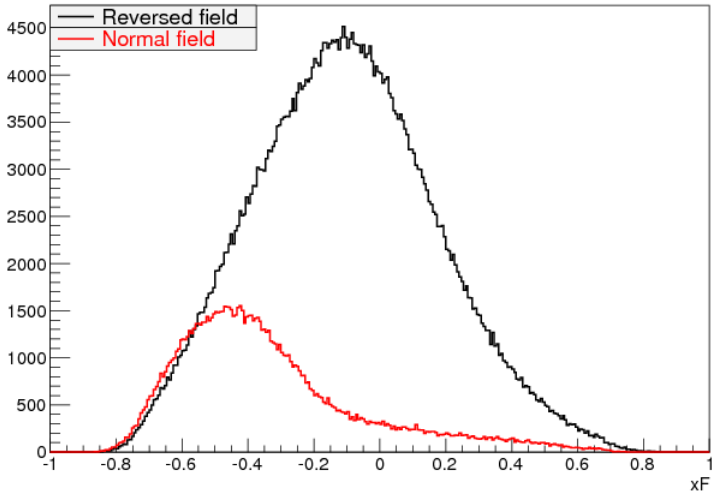
CLASDIS + FastMC simulations
- normal vs reversed torus field

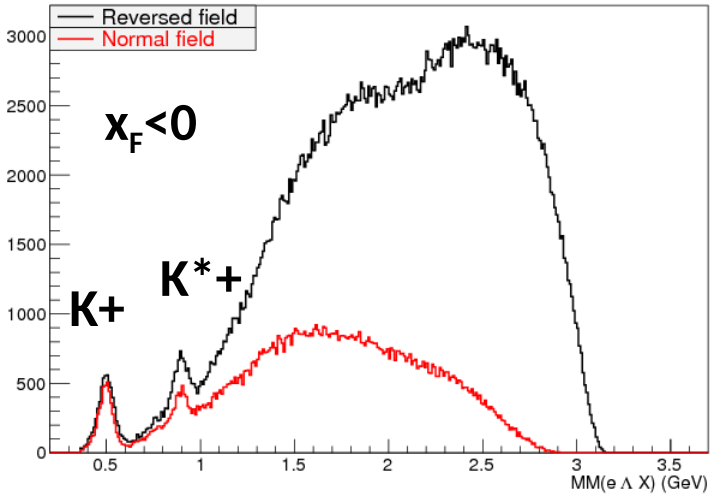
Λ reconstruction

- better acceptance and resolution with rev. field



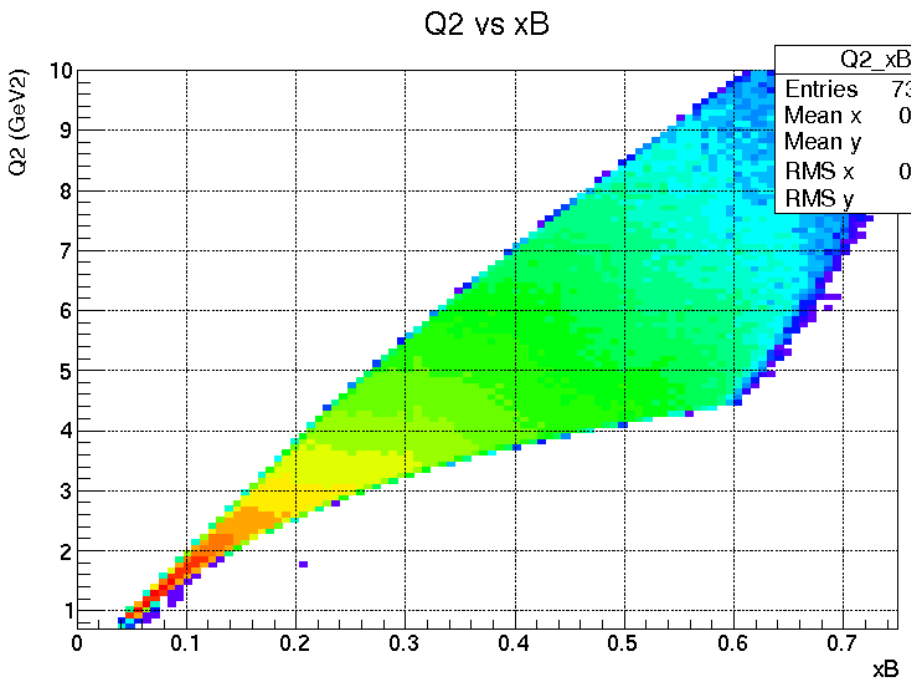


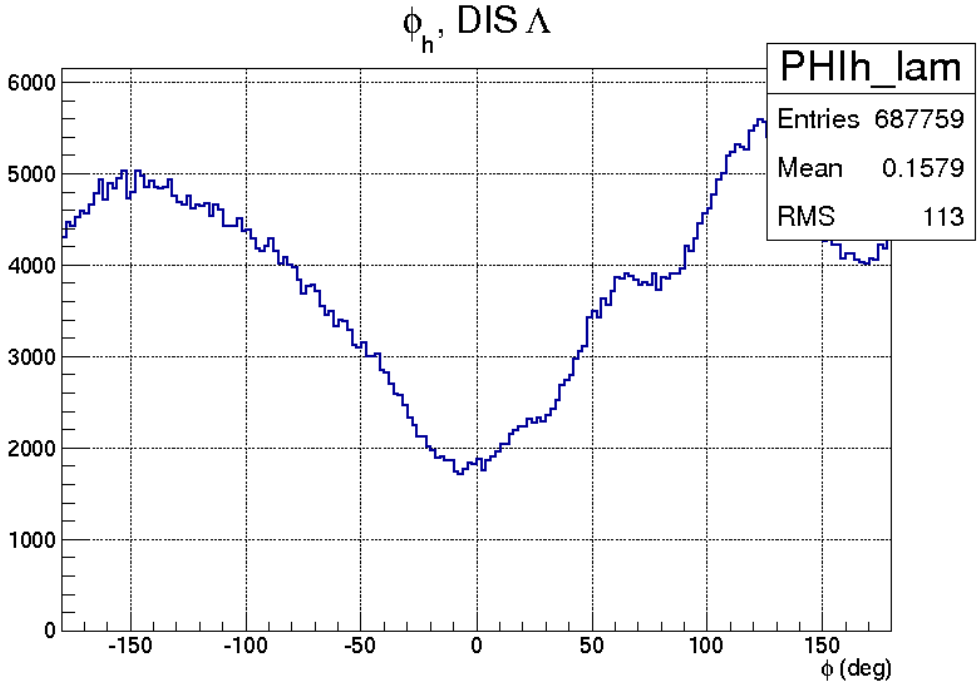




- better acceptance for the low energy decay pion with reversed field
- normal field data useful to check systematics

Kinematics (rev. field)





- Q^2 coverage up to ~10 GeV^2
- much better ϕ coverage than CLAS, acceptance never goes to 0

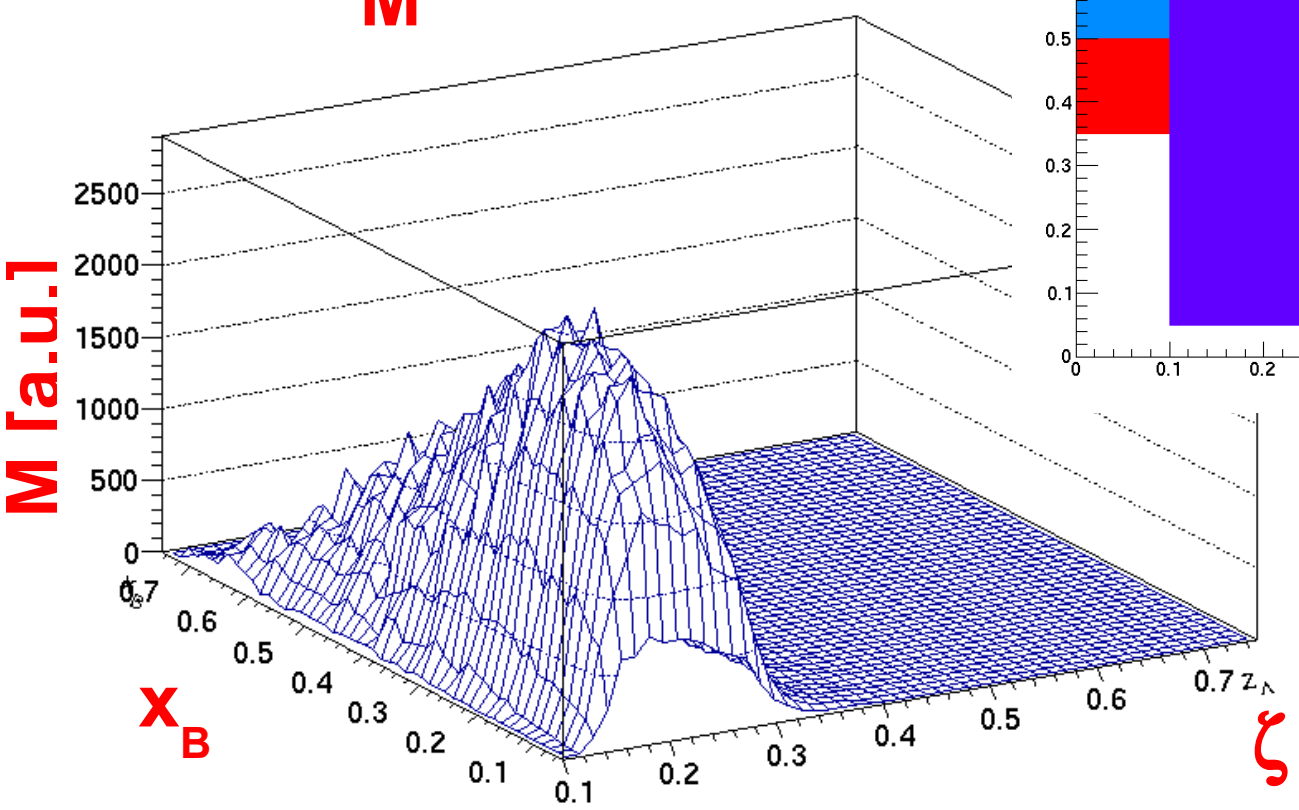
The data will allow the study of the ϕ-dependence

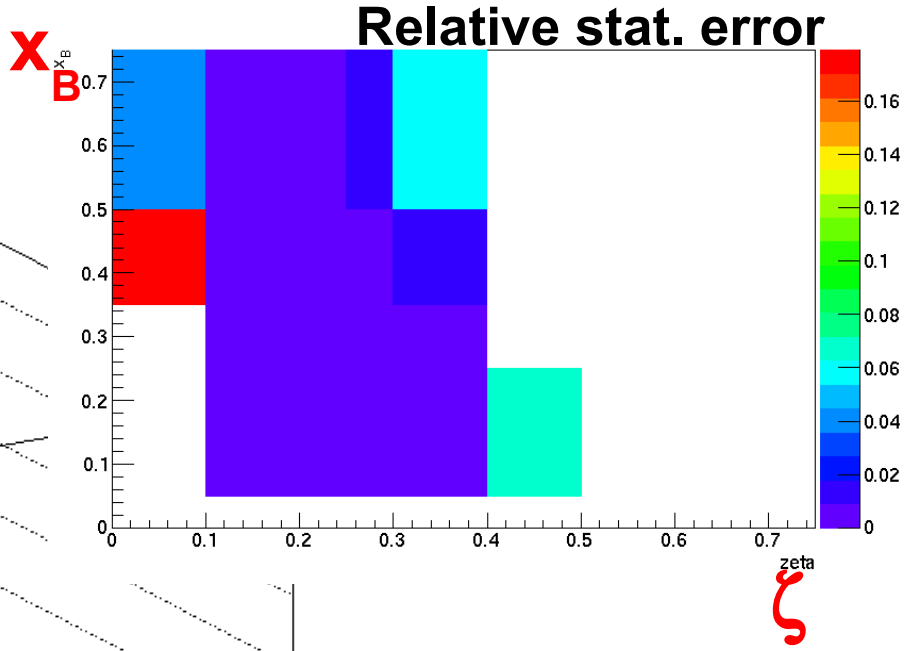
Unpolarized Fracture Function(s)

Total unpolarized yield in the TFR from Monte Carlo data

$$Y \propto \frac{1-y+y^2/2}{yQ^2} \sum_a e_a^2 M_a(x_B, \zeta)$$

M

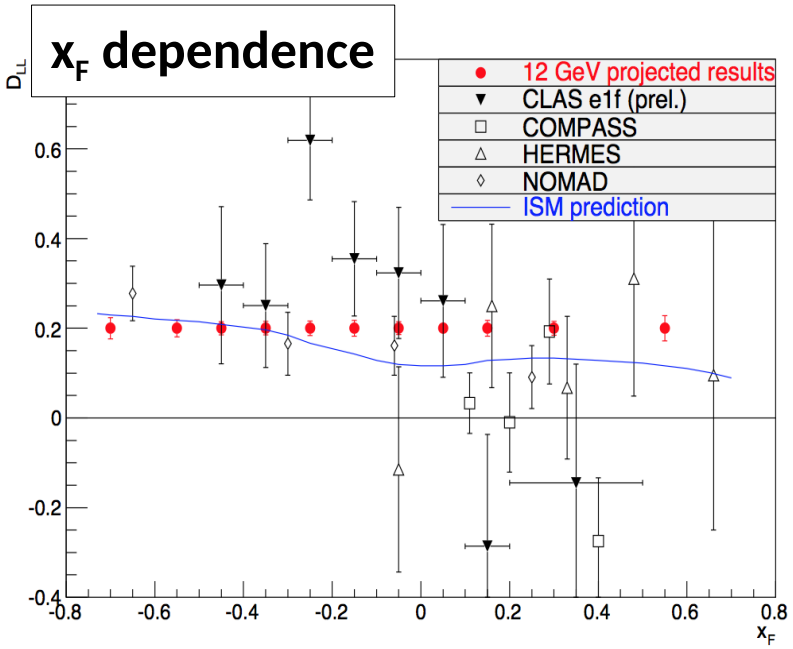


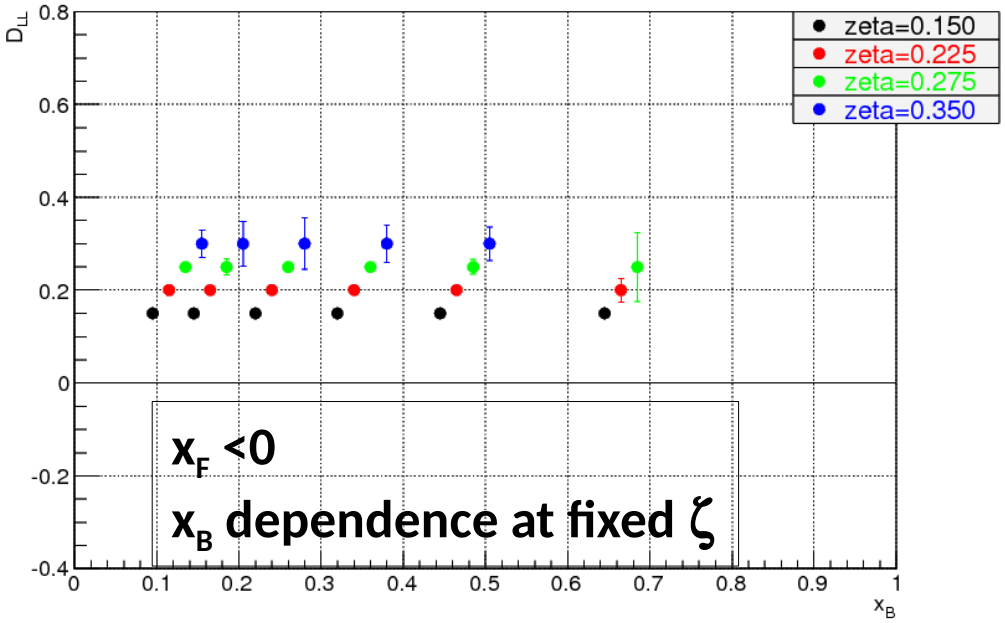


Long. Polarized Fracture Function(s)

Long. Polarization transfer from the beam to the Λ

$$D^{LL} \propto \frac{\sum_a e_a^2 \Delta M_a^L(x_B, \zeta)}{\sum_a e_a^2 M_a(x_B, \zeta)}$$





More than one order of magnitude than CLAS data
- statistical error on the yield below 10% in the double x_B-ζ binning

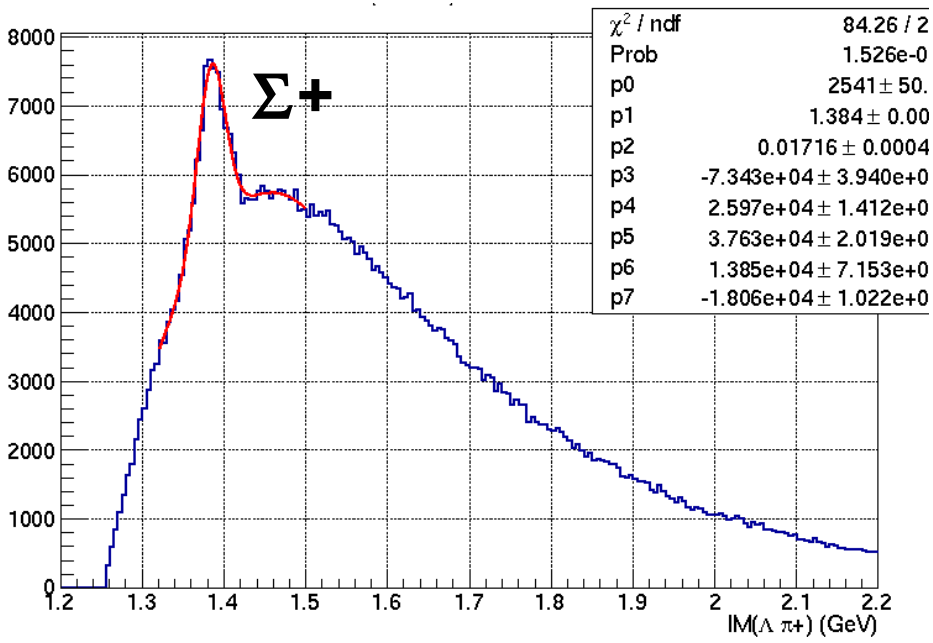
ISM model: Allis, Kotzinian et al. – EPJ C52 (2007) 183

Sigmas

e p →e' Σ(1385)+ X

→ Λπ+

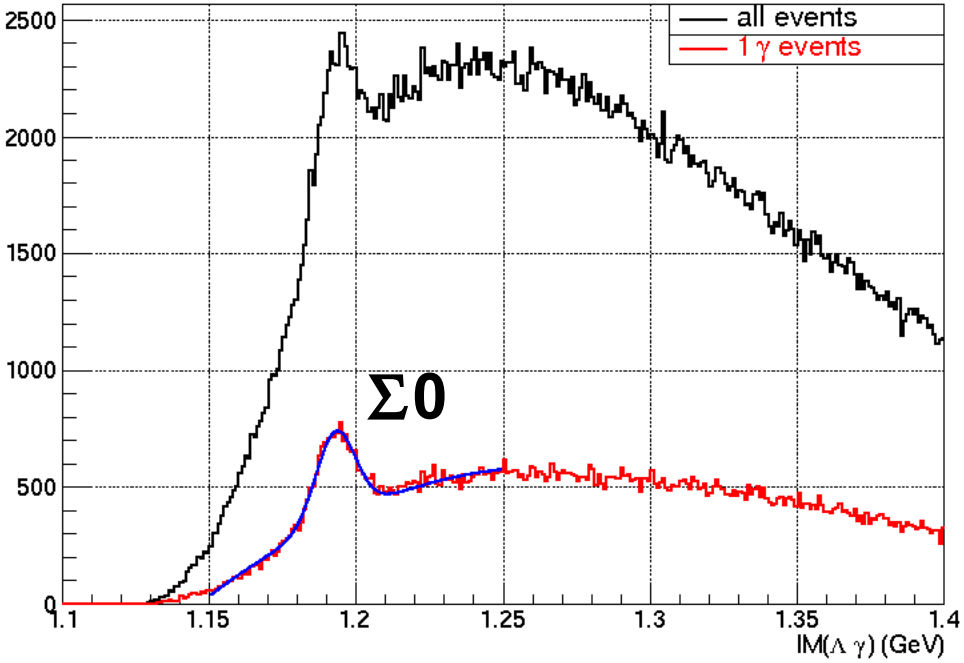
→ pπ−



e p →e' Σ0 X

→ Λγ

→ pπ−

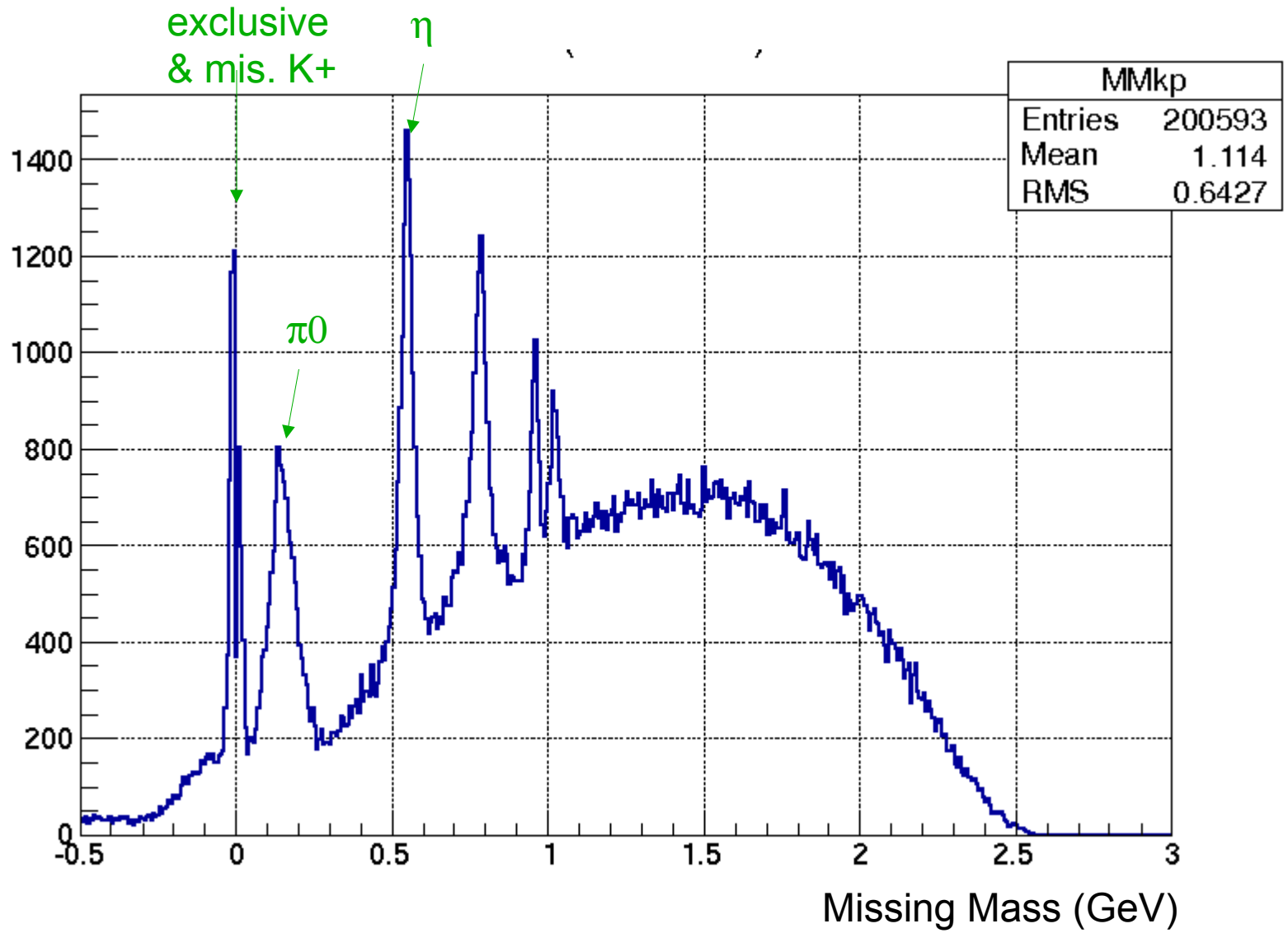


More than one order of magnitude less Σ than Λ but still several thousands

Back-to-back hadrons with Λ

e p →e' Λ K+ X

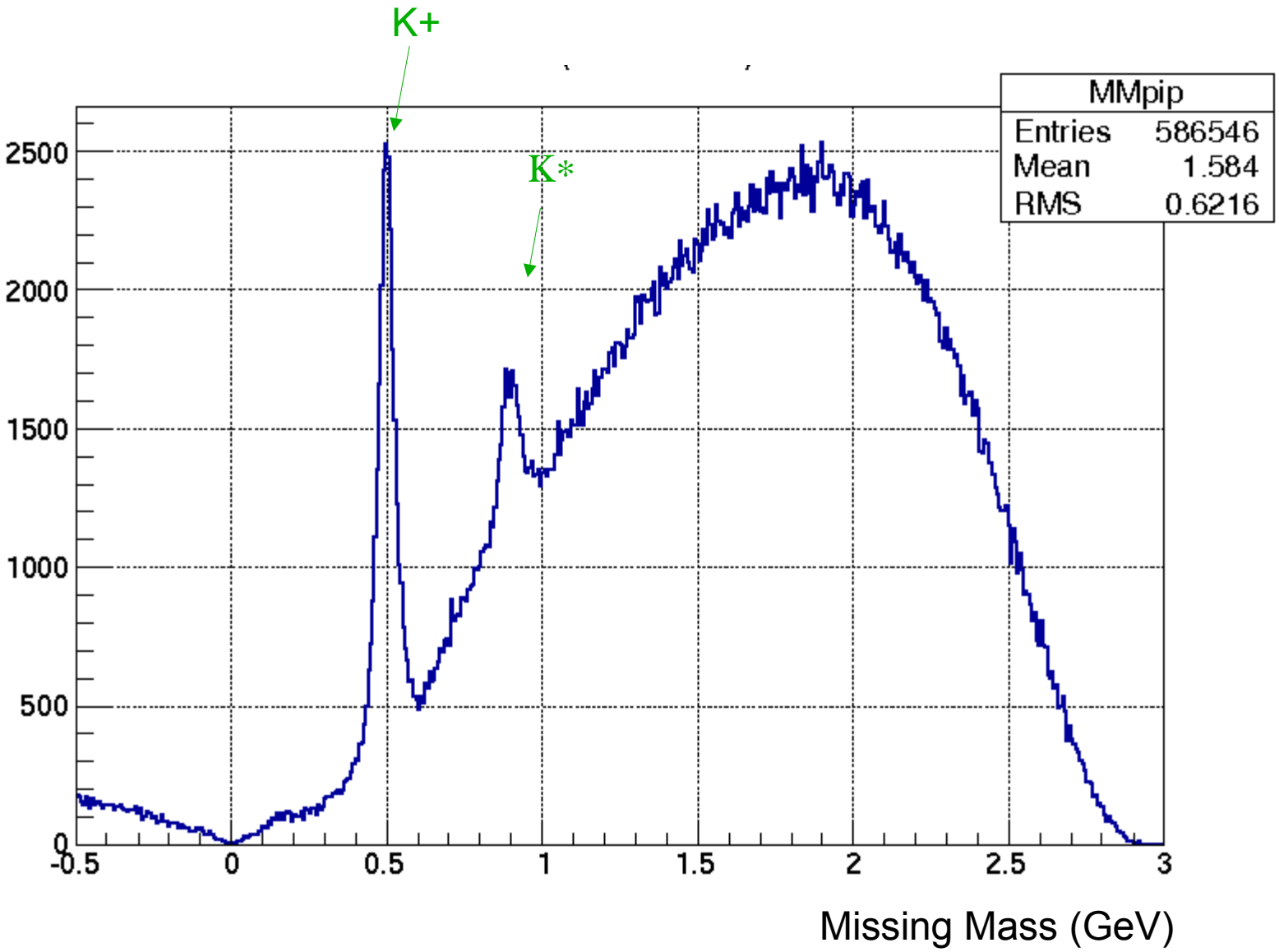
Λ and K+ detected in CLAS12



Back-to-back hadrons with Λ

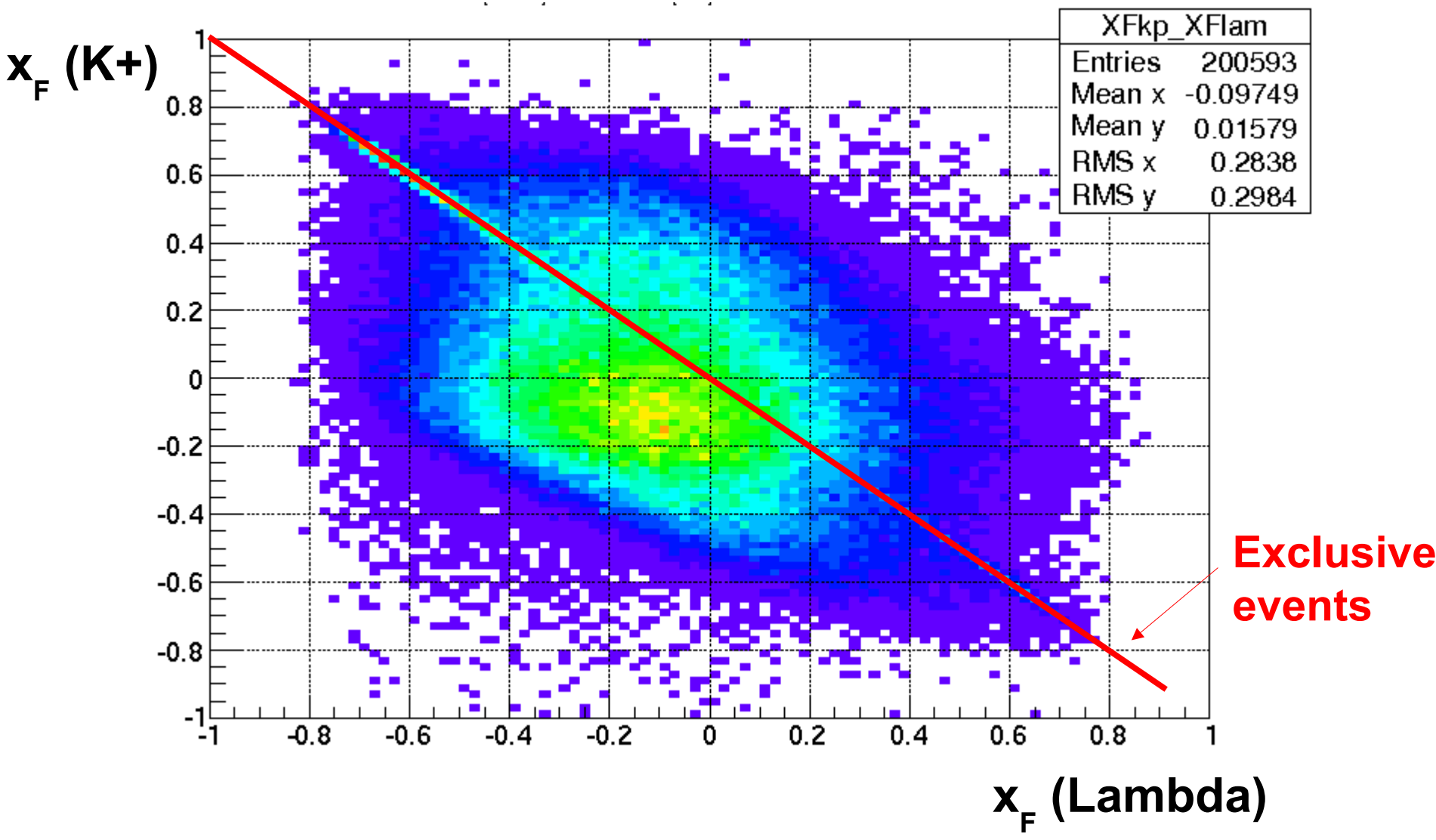
e p →e' Λ π+ X

Λ and π+ detected in CLAS12



Feynman-x distribution

$e\ p \rightarrow e'\ \Lambda\ K+\ X$



Feynman-x distribution

e p →e' Λ K+ X

MM>0.7 GeV above the η

Backward Λ, forward Kaon