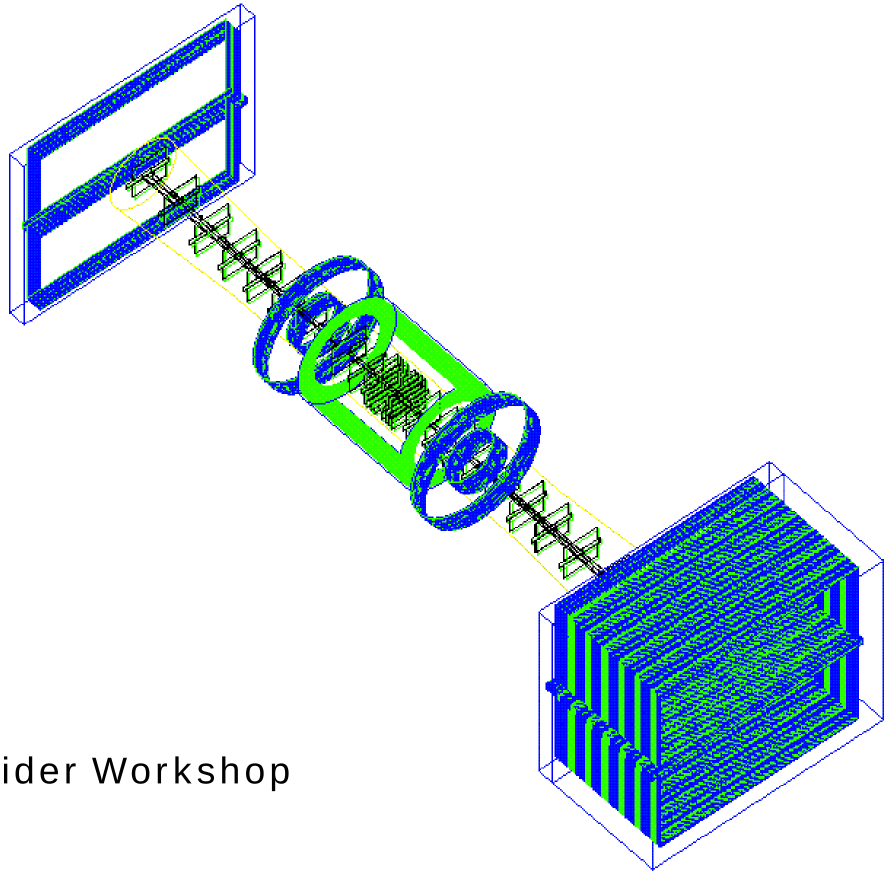
eRHIC Detector Performance



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Jefferson Lab
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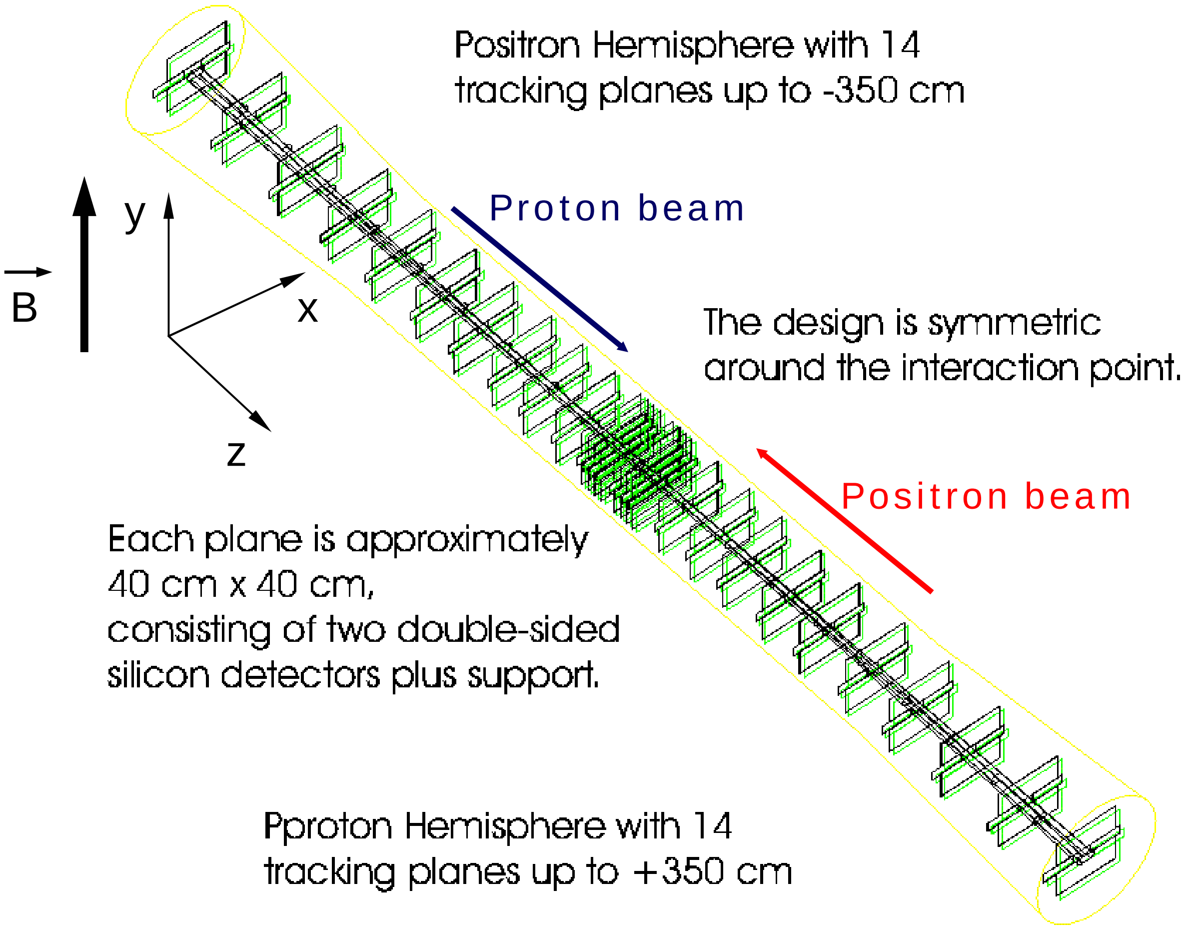
Outline

- Detector requirements
- Detector design
- Performance
  - electron (positron) acceptance
  - momentum resolution
  - energy resolution
  - e/π separation
- F_2 measurement
  - event reconstruction
  - kinematical range
  - systematic errors
- Summary

Detector Requirements

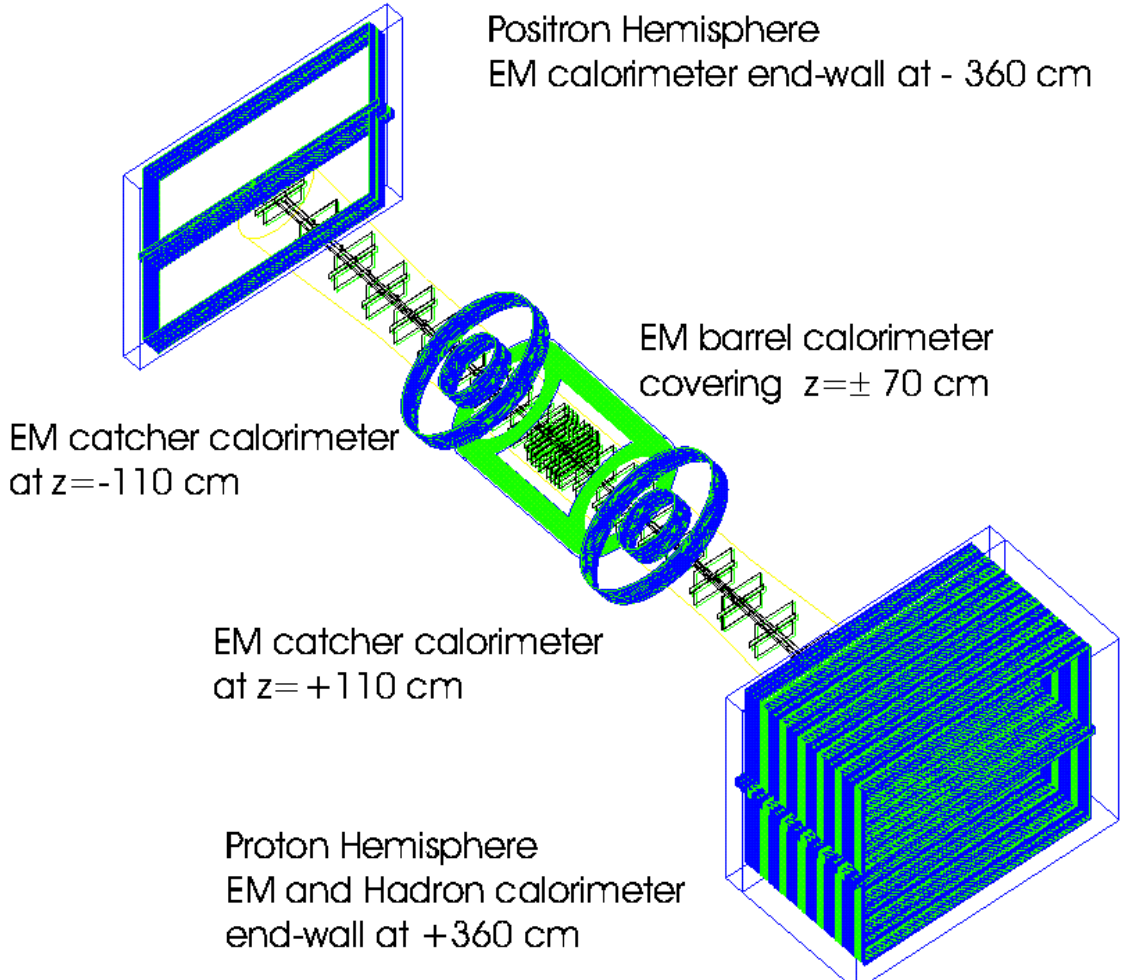
- eRHIC — a detector for e–p collider experiment
- F_2 and F_L measurement at $\boldsymbol{Q^2}$ of $0.1\mathrm{GeV}^2$ - $10\mathrm{GeV}^2$
  - low scattering angles
  - need acceptance at pseudorapidity down to η **=** -5
- The reconstruction relies on measurement of the scattered electron / positron
  - need good momentum resolution
  - need good *e / π* separation
- Vector meson
  - good momentum resolution also in the proton direction
- High ***x*** physics
  - hadronic calorimeter

Silicon Tracker

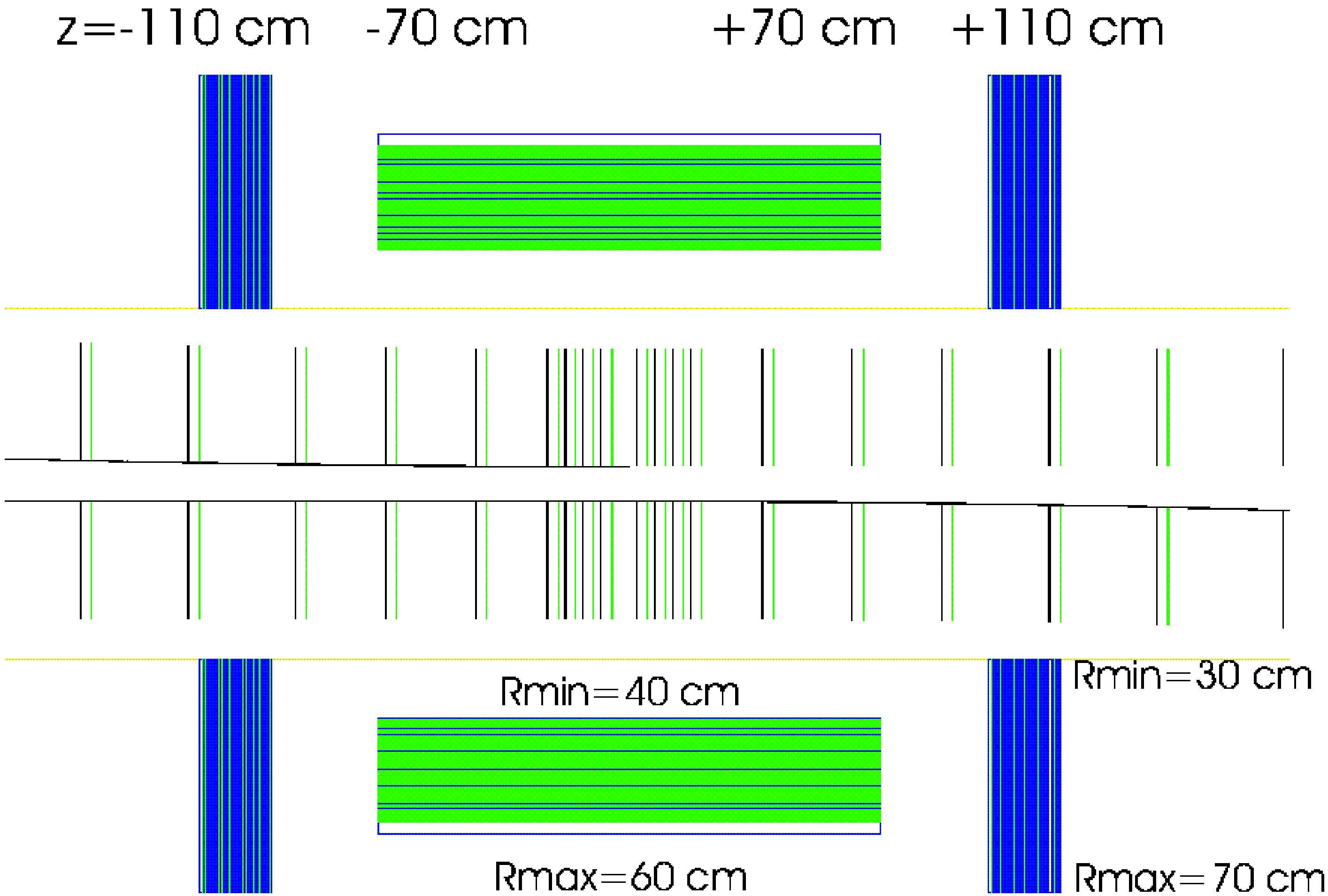


Calorimetry

- Silicon-tungsten EM calorimeters, each ~ 25 X_0 thick
- Scintillator-uranium hadronic calorimeter (ZEUS FCAL)



Central Part

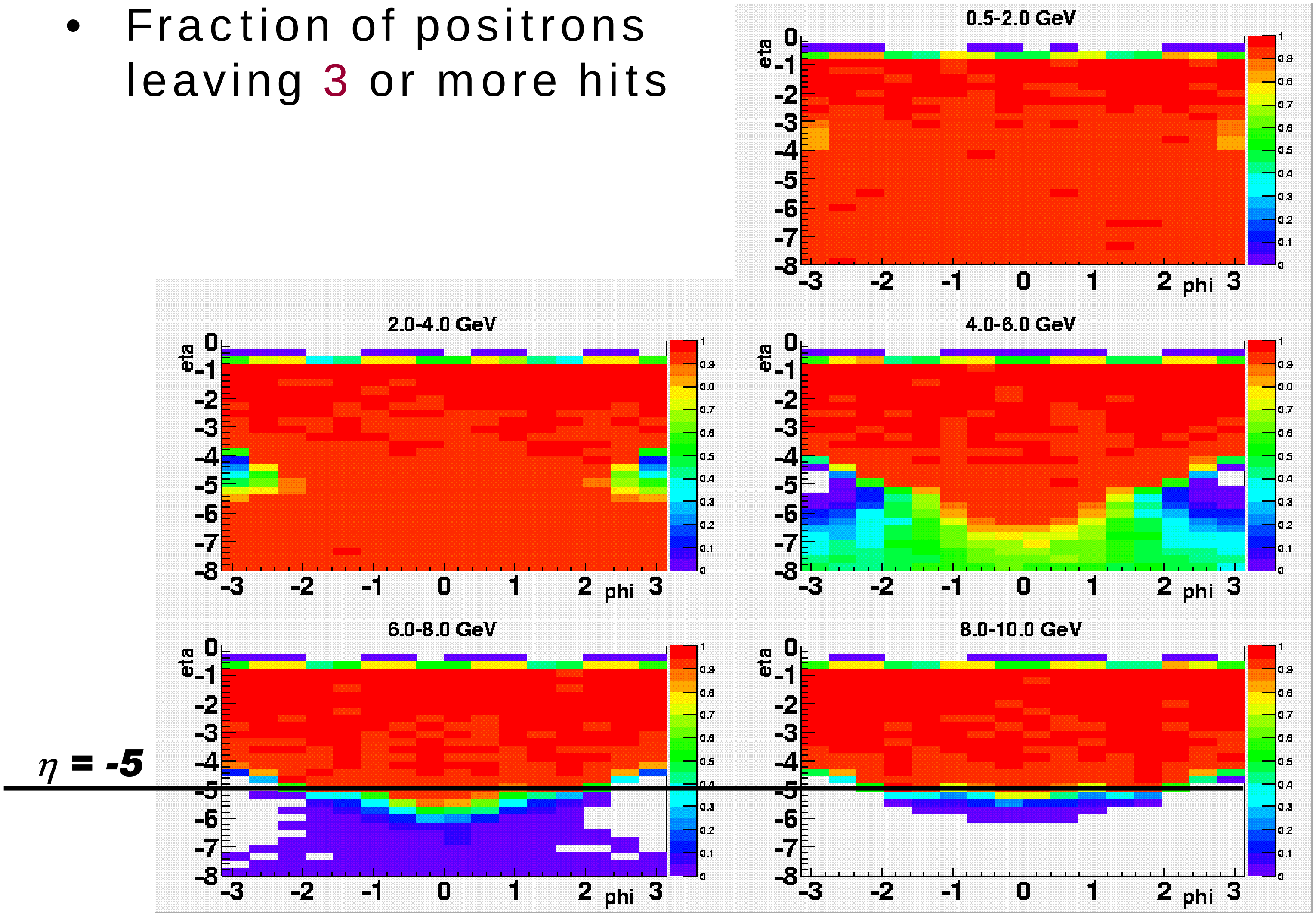


$\eta \in$

[-2,-1.3] [-1.3,1.3] [2,1.3]

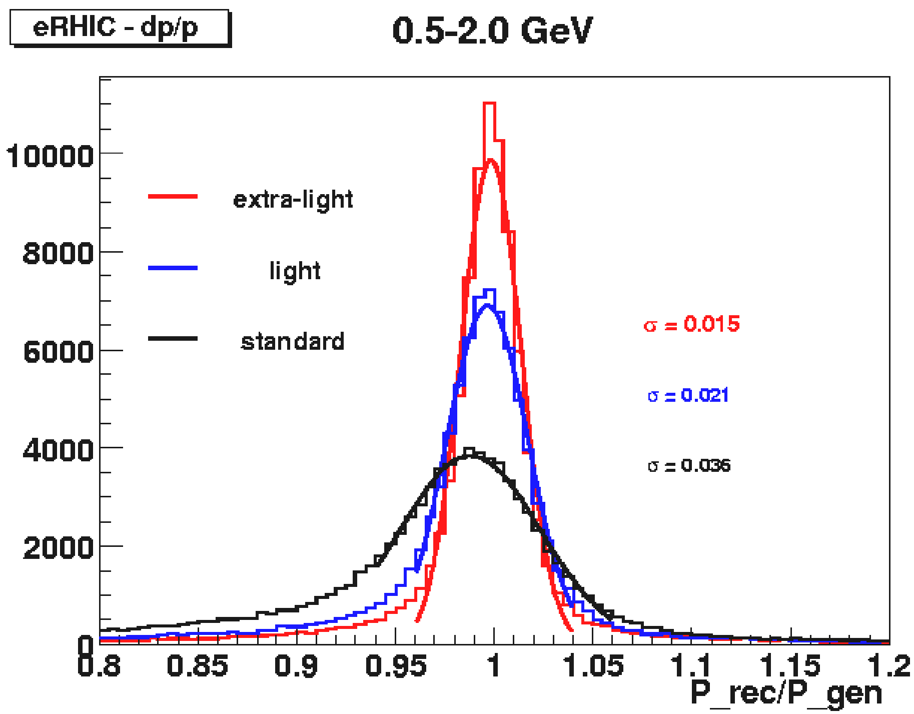
Tracker Acceptance

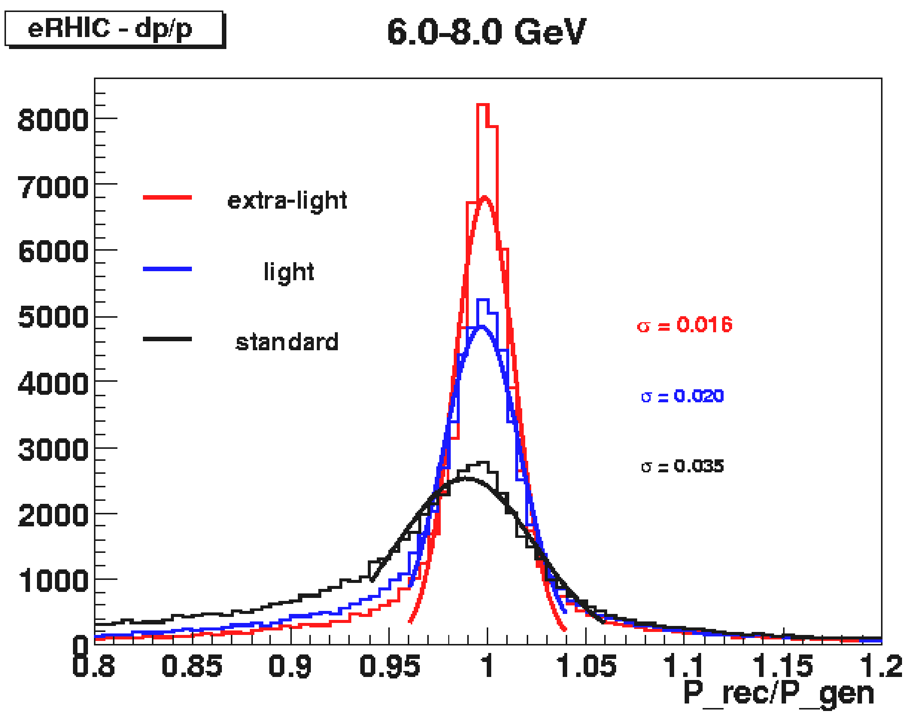
- Fraction of positrons leaving 3 or more hits



Momentum Resolution

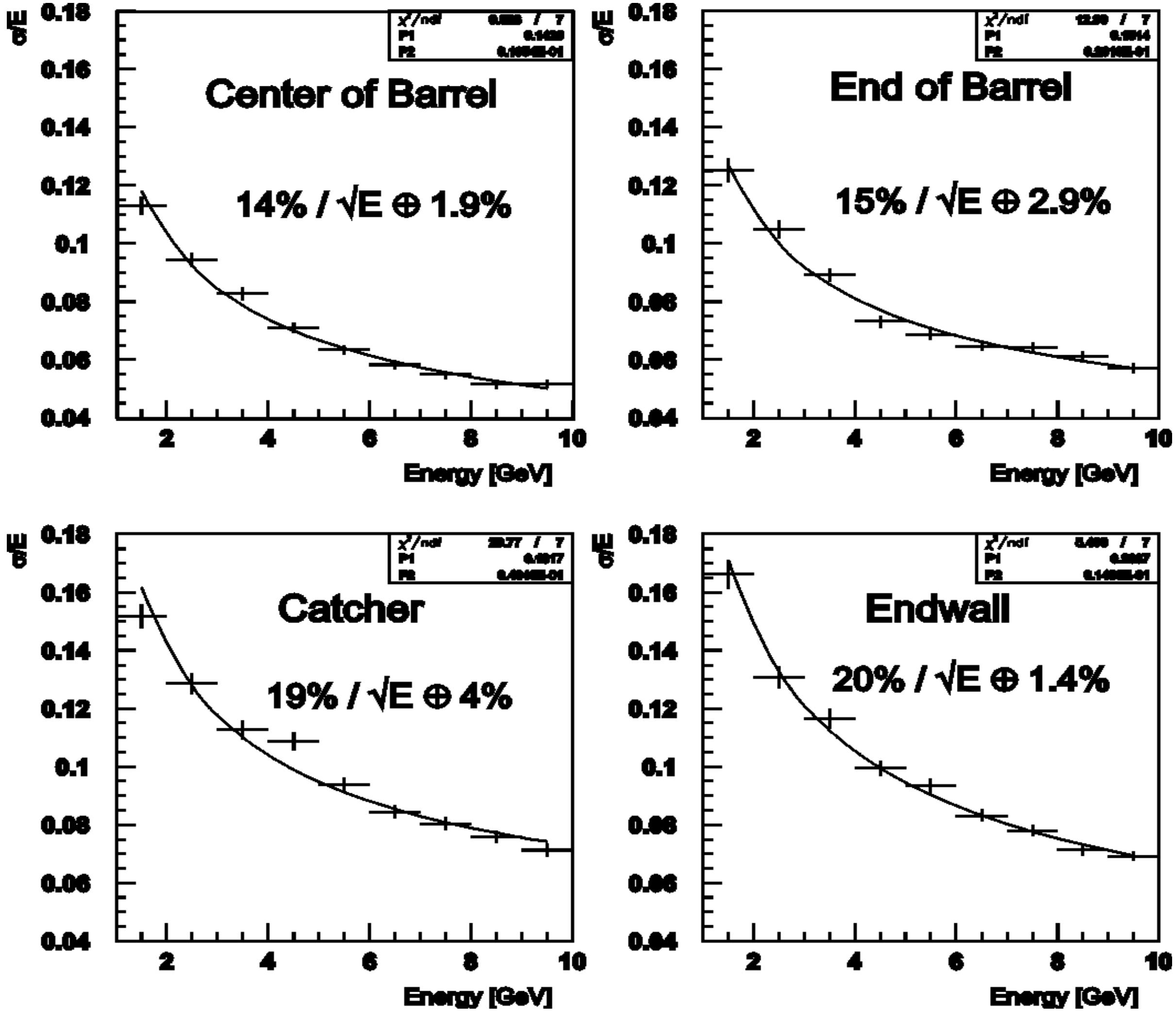
- 3 material budgets
  - extra light: 2 x 300μm silicon planes only
  - light: + 1200μm carbon support
  - standard: + 500 μm Al beam pipe





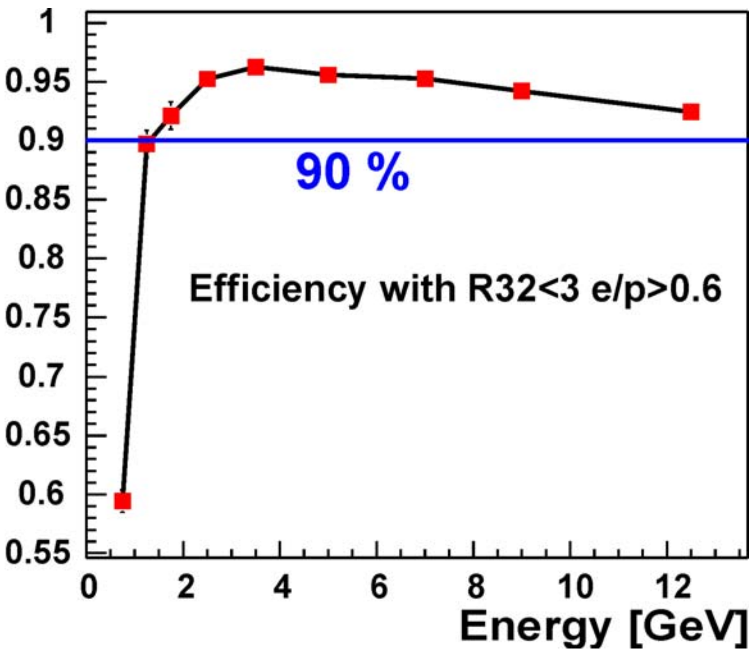
Energy Resolution

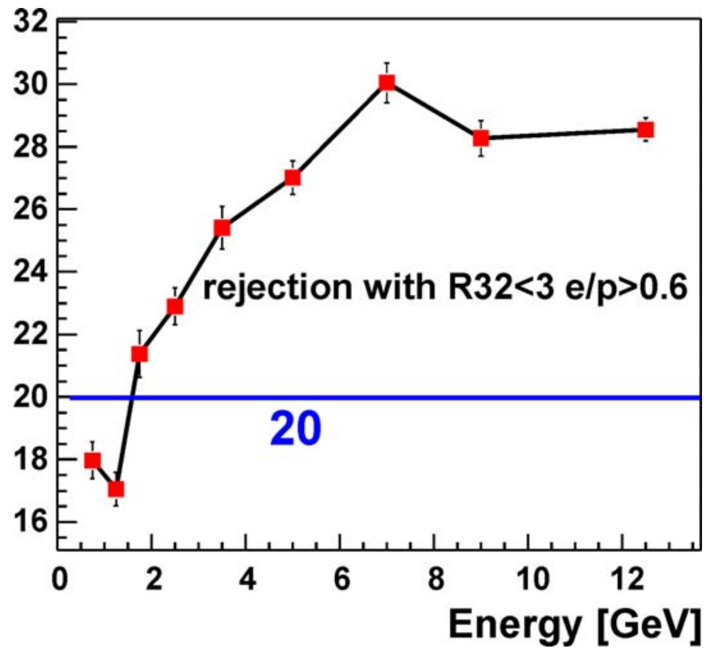
- EM calorimeters: 15% - 20% / √ E for electrons



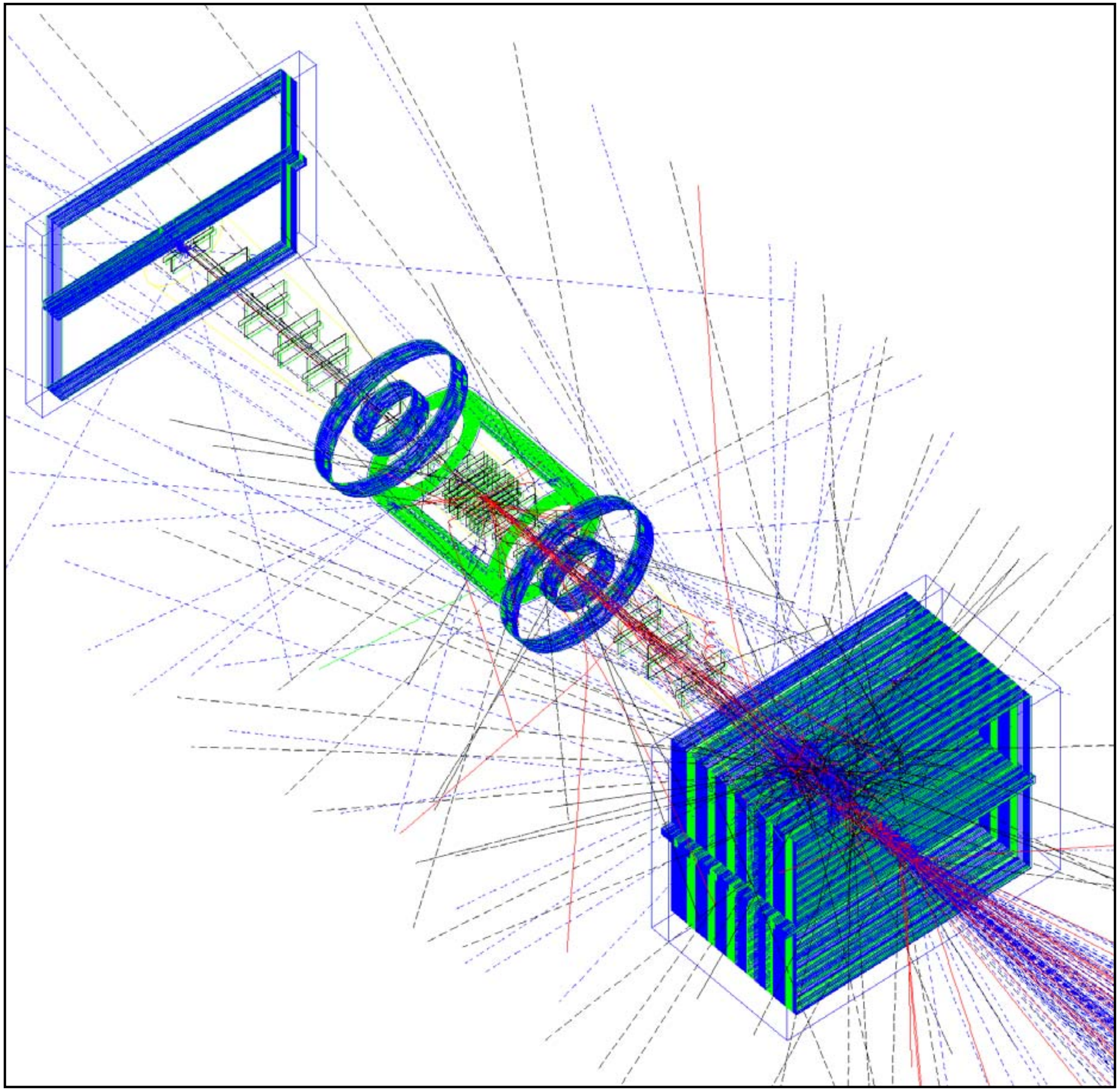
e/π Separation

- Energy deposition
  - hadronic showers are not fully contained, total thickness ~ 1 λ_I
  - E/p > 0.6
  - The resolution is 20% for 1GeV electron => 95% efficiency.
- Shower profile
  - At 2 GeV, the maximum dE/dx of the EM shower is at 4.7 X_0.
  - calorimeter divided to 3 sections – 2 X_0, 5 X_0,18 X_0
  - $E_3/E_2 < 3$





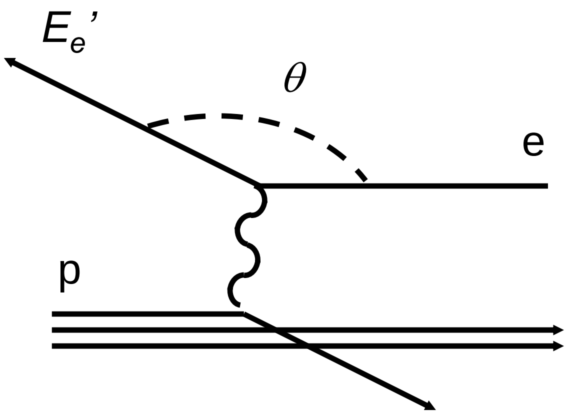
NC DIS simulation



Event Reconstruction

➢ Electron method

- for low Q^2 and low x:



$$Q^2 = 2E_e E_e^{/}(1+\cos\theta_e)$$

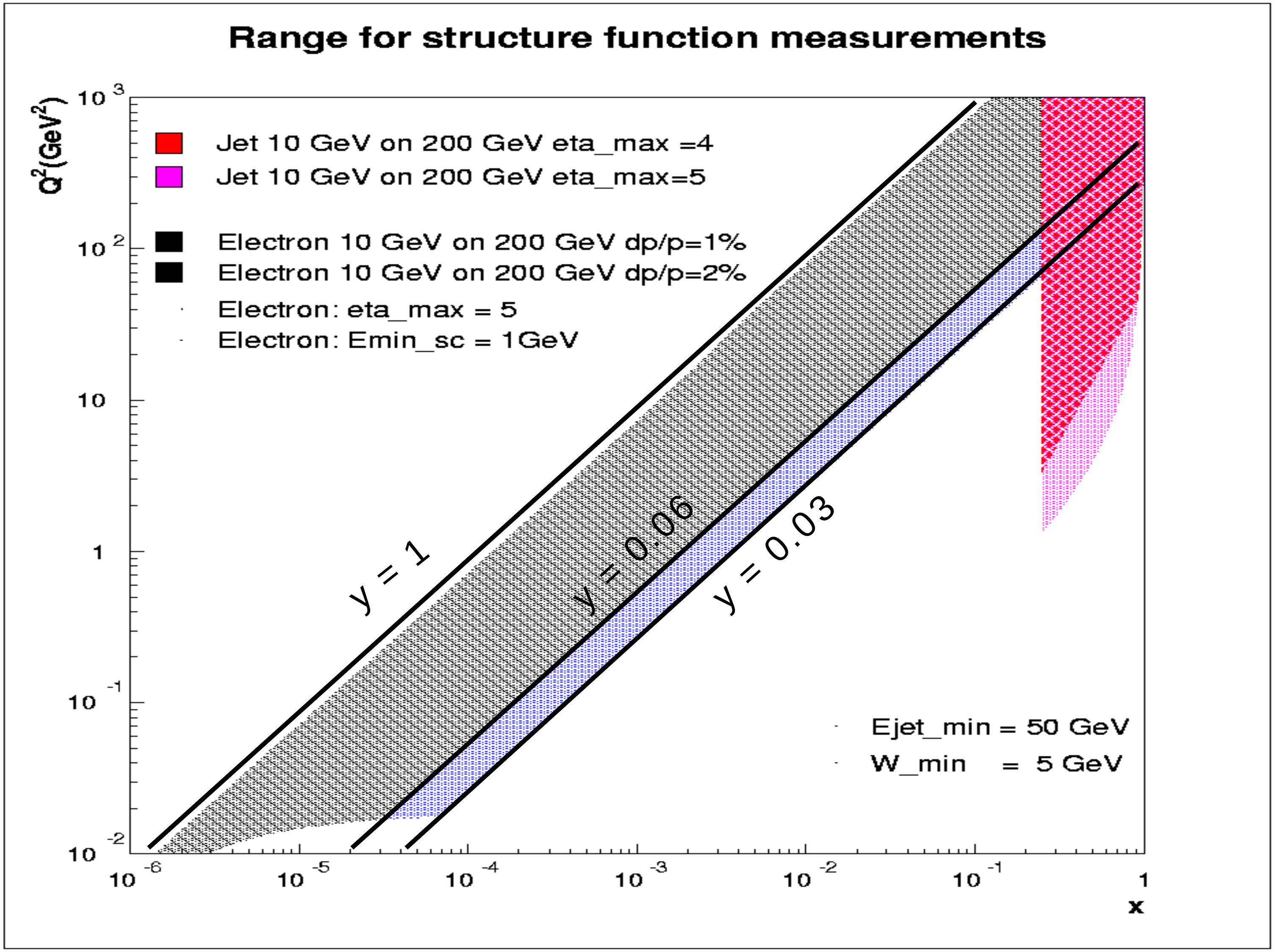
$$y = 1 - \frac{E_e^{/}}{2E_e}(1-\cos\theta_e)$$

$$x = \frac{Q^2}{sy}$$

$$\frac{\sigma x}{x} \cong \frac{\sigma E_e^{/}}{E_e^{/}} \cdot \frac{1}{y}$$

- With momentum resolution of 1% it can be used down to y~0.03, if we require $\sigma x/x$<30%

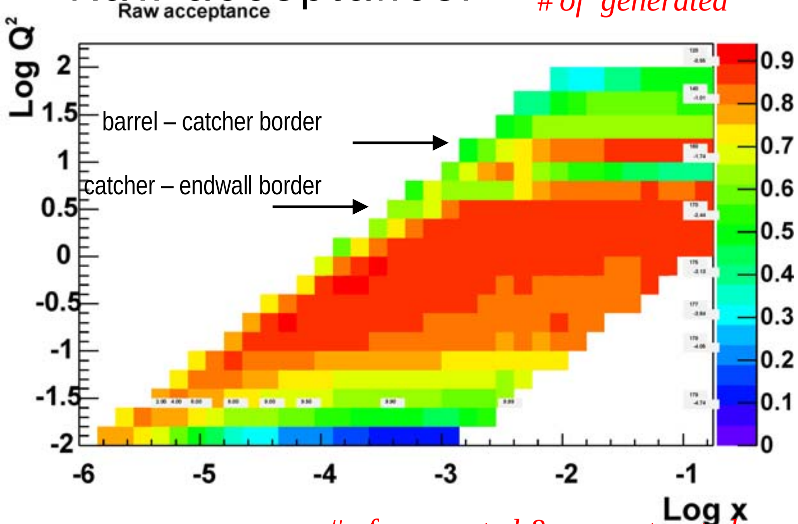
Range for F_2



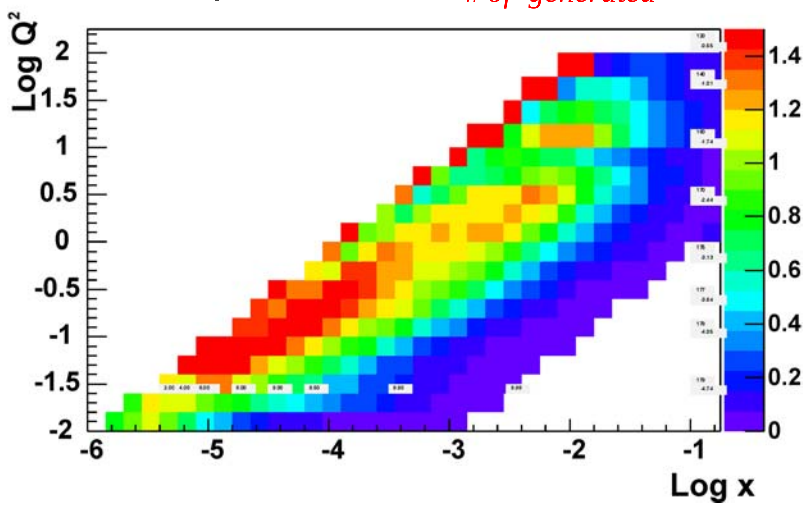
Range for structure function measurements
Q²(GeV²)
Jet 10 GeV on 200 GeV eta_max =4
Jet 10 GeV on 200 GeV eta_max=5
Electron 10 GeV on 200 GeV dp/p=1%
Electron 10 GeV on 200 GeV dp/p=2%
Electron: eta_max = 5
Electron: Emin_sc = 1GeV
y = 1
y = 0.06
y = 0.03
Ejet_min = 50 GeV
W_min = 5 GeV
x

Electron method - standard

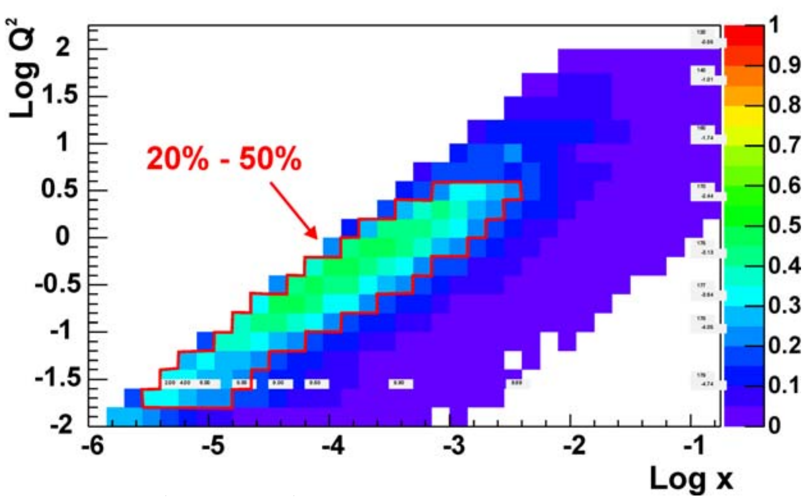
Raw acceptance: $\dfrac{\#\,of\ \ positron\ \ found}{\#\,of\ \ generated}$



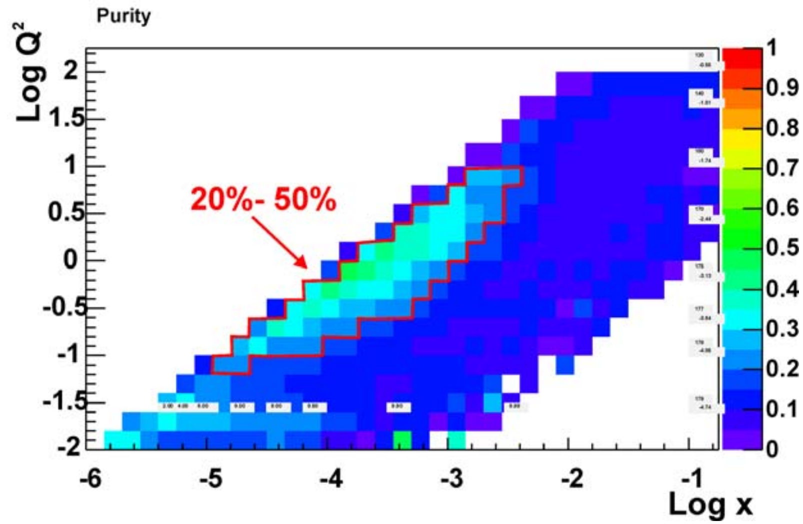
Acceptance: $\dfrac{\#\,of\ \ reconstructed}{\#\,of\ \ generated}$



Efficiency: $\dfrac{\#\,of\ \ generated\ \&\ reconstructed}{\#\,of\ \ generated}$

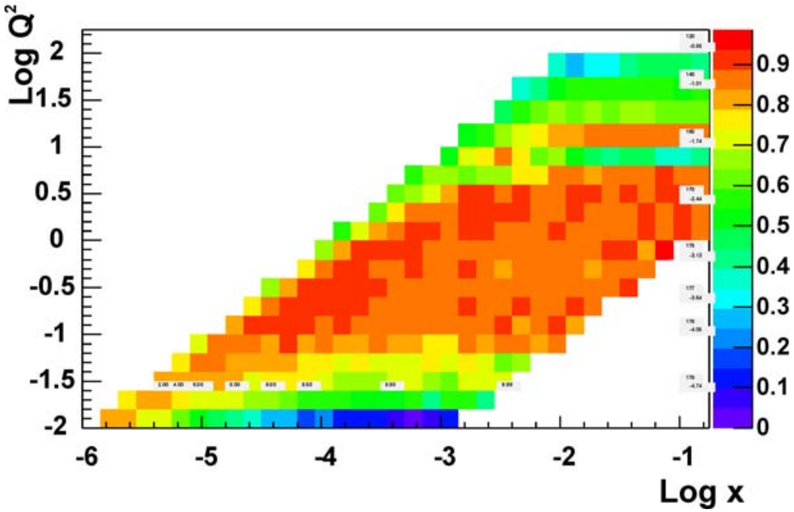


Purity: $\dfrac{\#\,of\ \ generated\ \&\ reconstructed}{\#\,of\ \ reconstructed}$

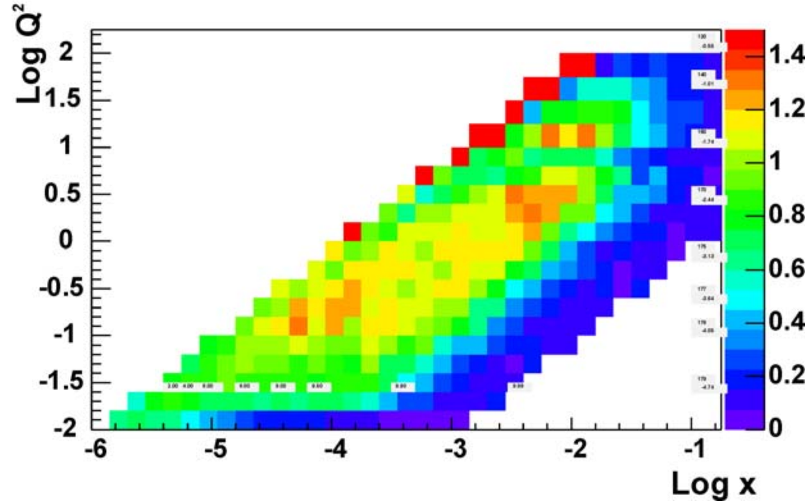


Electron method – extra light (no beam pipe)

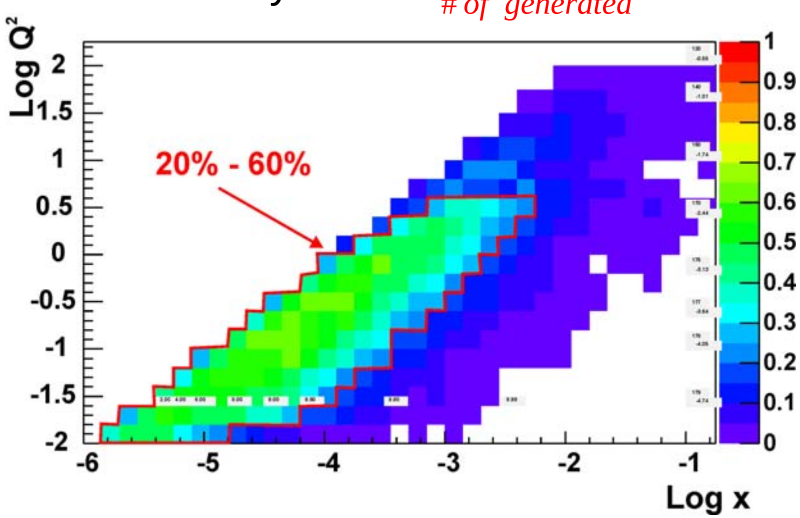
Raw acceptance: $\dfrac{\#\ of\ \ positron\ \ found}{\#\ of\ \ generated}$



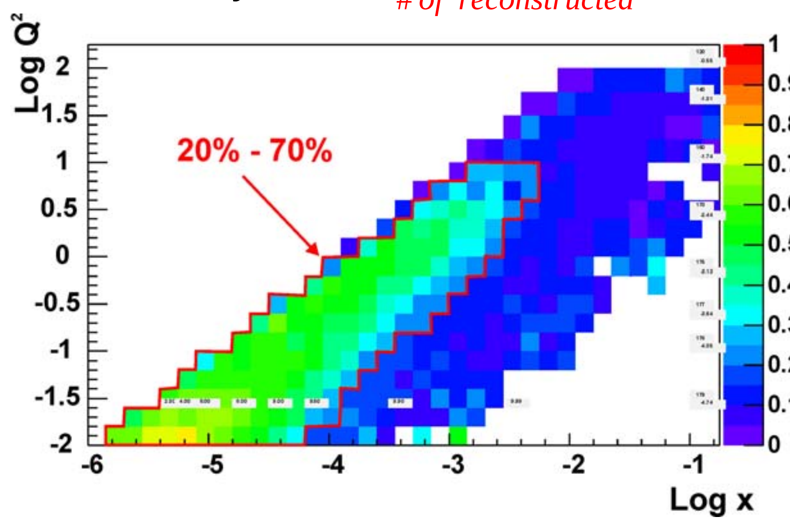
Acceptance: $\dfrac{\#\ of\ \ reconstructed}{\#\ of\ \ generated}$



Efficiency: $\dfrac{\#\ of\ \ generated\ \&\ reconstructed}{\#\ of\ \ generated}$



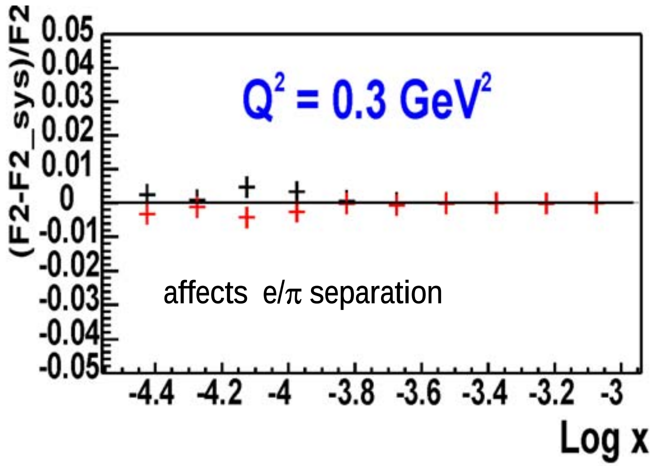
Purity: $\dfrac{\#\ of\ \ generated\ \&\ reconstructed}{\#\ of\ \ reconstructed}$

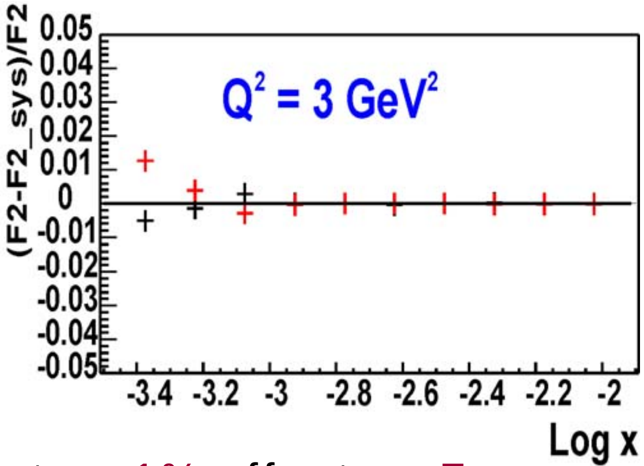


F2 - systematic errors

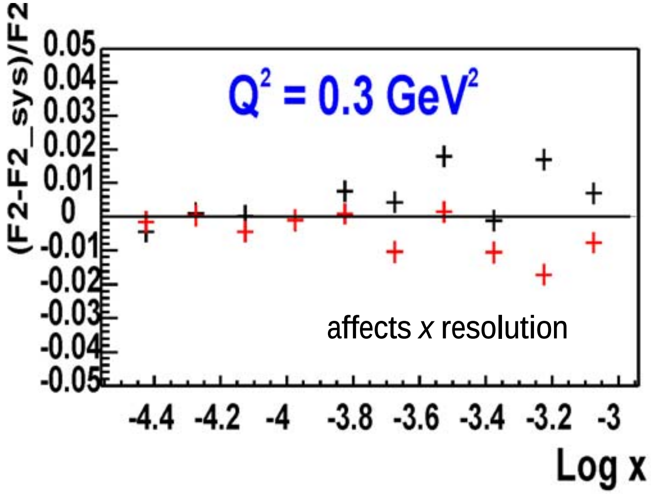
- High statistics at low ***Q²*** – only systematic errors are important
- We want to measure F_2 at 1% error – what levels of systematic uncertainties are allowed?

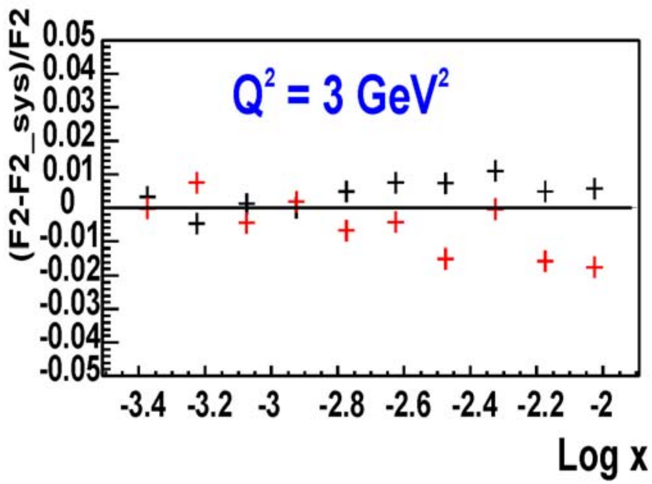
Calorimeter energy scale: 1% uncertainty < 1% effect on F_2





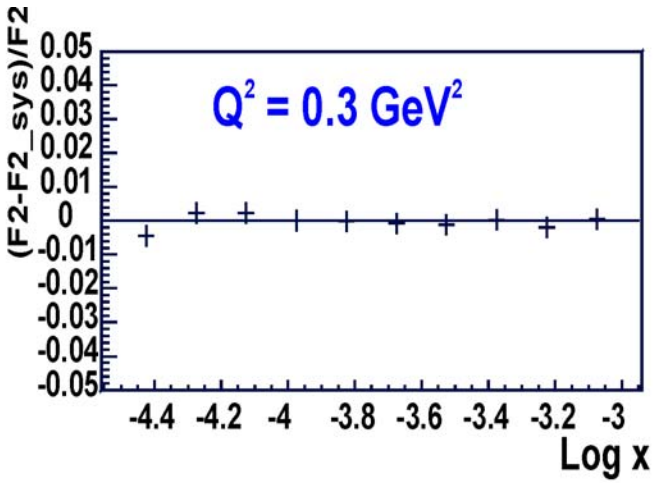
Momentum scale: 0.1% uncertainty < 1% effect on F_2

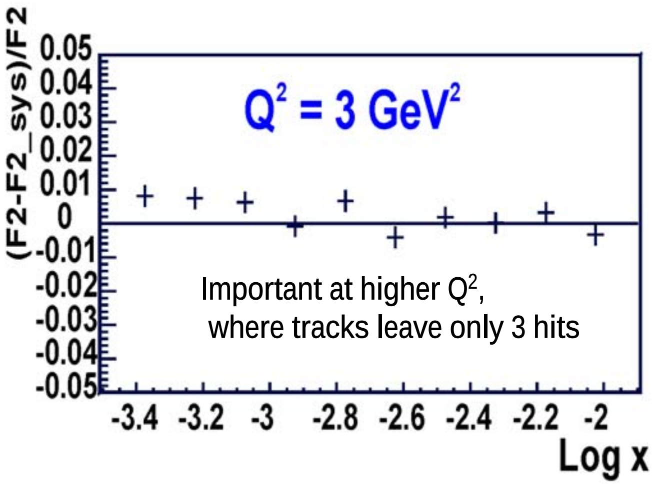




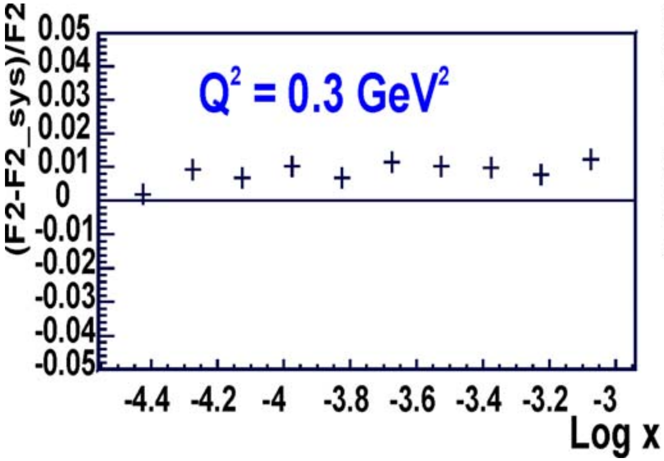
F_2 - systematic errors

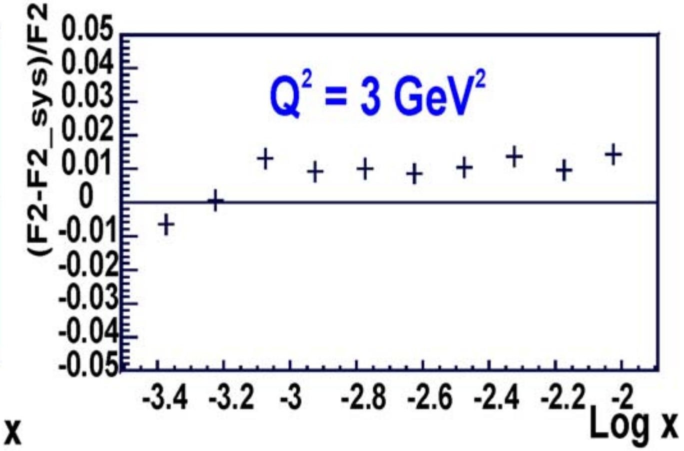
Hits efficiency: 1% uncertainty < 1% effect on F_2





Track finding efficiency: 1% uncertainty < 1% effect on F_2





Summary

- A detector for e-p collider has been designed, with focus on measurement at large rapidities.
- The detector performance has been tested using GEANT simulation.
- Good momentum resolution and high acceptance for electrons/positrons may be achieved in the desired kinematical range.
- For low Q^2 and low x, the electron method for reconstructing kinematics can be successfully used, although the beam pipe is a problem here.
- First study of systematic errors was done.
- Results are looking encouraging