Polarization Studies with W's in STAR

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Contents

Spin physics at RHIC STAR

- Nucleon, QCD
  - Gluon polarization in the proton
    - direct photon + jet
    - dijet
    - inclusive jet
    - heavy quark
  - Antiquark polarization in the Proton
  - Quark polarization in the Proton
    - $W^{\pm} \rightarrow e^{\pm}$
  - Transversity structure function $h_1(x)$
    - dijet, two mesons correlation, D-Y
- Single spin inclusive asymmetry
  - inclusive hadrons
- Standard model and beyond
  - New physics via Parity Violation?
  - New physics via CP Violation?

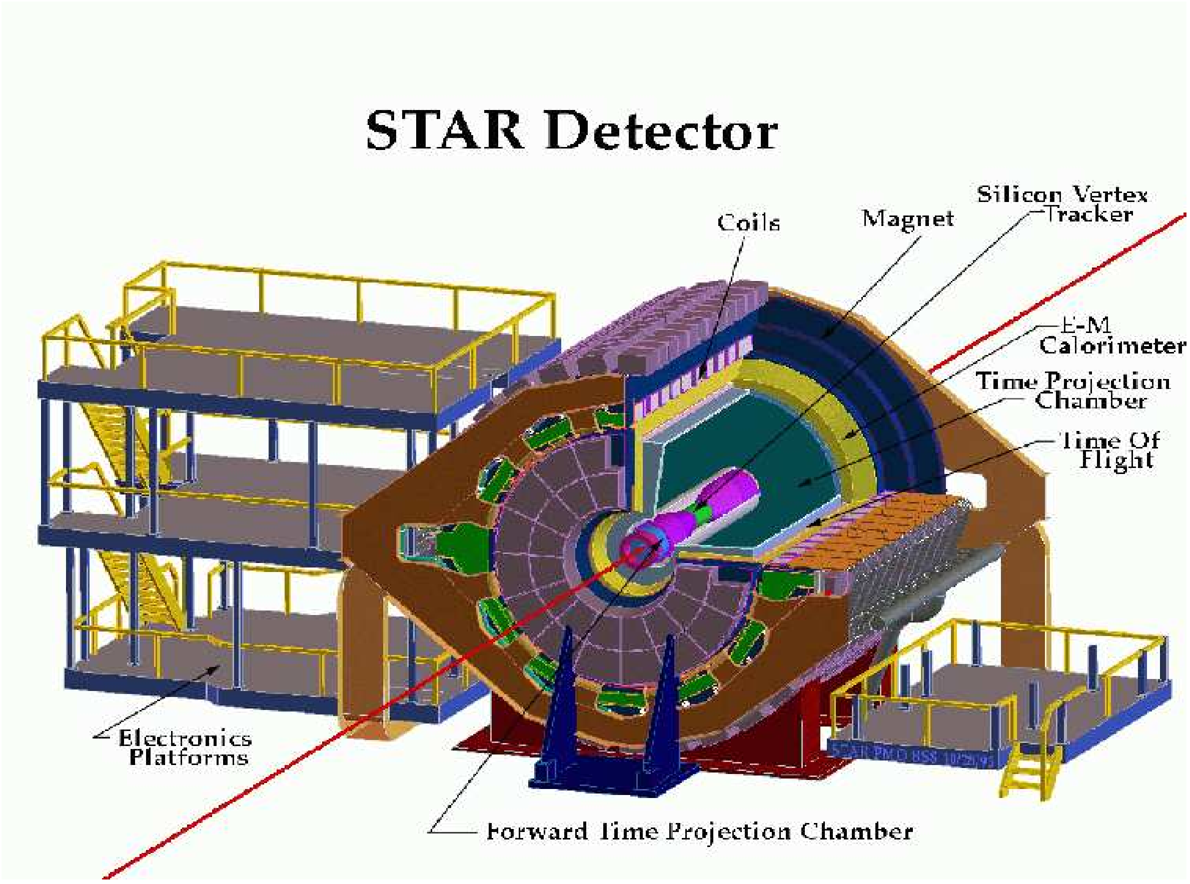
The STAR Detector

- 0.5 Tesla Solenoid Magnet
- Time Projection Chamber
- Silicon Vertex Detector
  - Tracking charged particles
  - Measurement of p_T
  - Particle identification using dE/dx
- ElectroMagnetic Calorimeter
- Shower max detector
- Pre shower detector
  - photon, π^0 detection/energy measurement/separation
  - electron hadron separation
  - triggering high p_T events
- Trigger/TOF counter
  - triggering
  - Particle identification

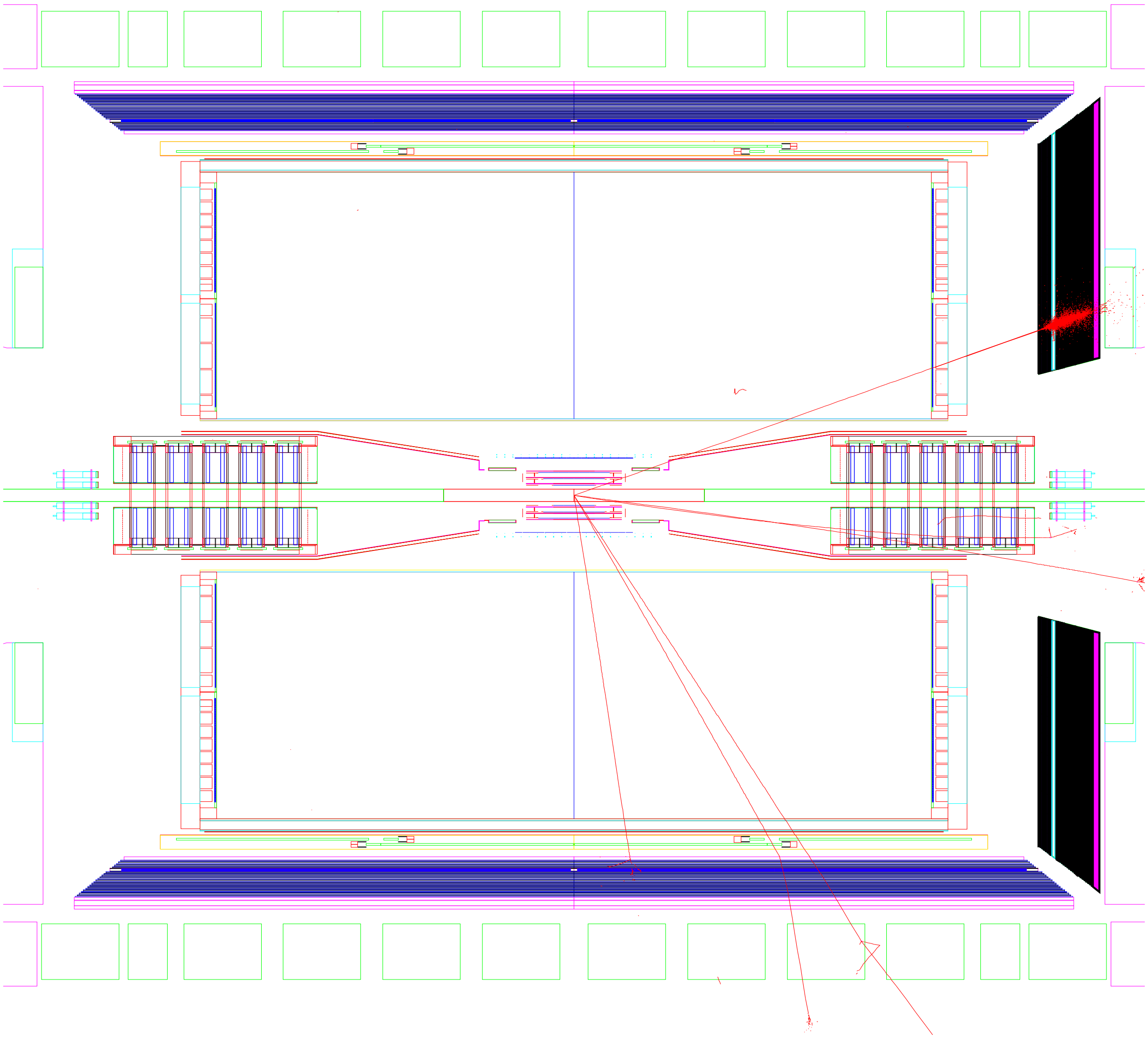
Wide acceptance for both charged hadrons and Electro Magnetic allow STAR to measure Jets

Charged hadrons	$-2.0 < \eta < 2.0$
electron/positron	$-1.0 < \eta < 2.0$ (1.0)
photon/π^0	$-1.0 < \eta < 2.0$ (1.0)
jet	$-0.3 < \eta < 1.3$ (0.3)

(with endcap EMC) and (without endcap EMC)

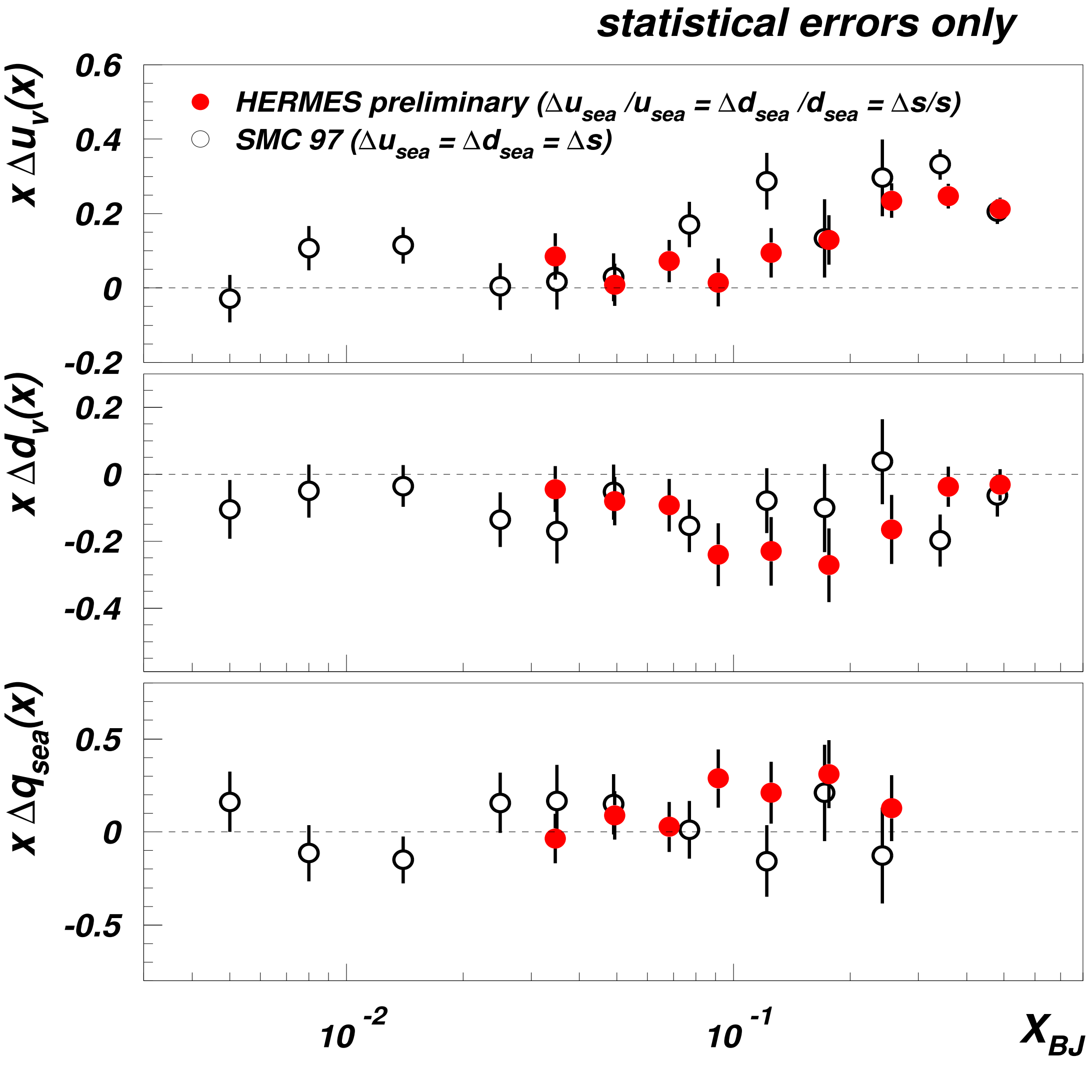


STAR Detector
Coils
Magnet
Silicon Vertex
Tracker
E-M
Calorimeter
Time Projection
Chamber
Time Of
Flight
Electronics
Platforms
Forward Time Projection Chamber



What's known about sea quark polarization

Polarized DIS (SMC, HERMES) semi-incluseve data



Cern Courier Dec 1998

$W^{\pm}$ at Proton-Proton

$$\begin{array}{rl} e^{-} \Leftarrow\Leftarrow & \Rightarrow \nu \\ W^{-} \Leftarrow & \\ \overline{u} \Rightarrow & \Leftarrow\Leftarrow d \end{array} \qquad\qquad \begin{array}{rl} \nu \Leftarrow & \Rightarrow\Rightarrow e^{-} \\ & \Rightarrow W^{-} \\ d \Rightarrow\Rightarrow & \Leftarrow \overline{u} \end{array}$$

Unpol. Proton $\quad \Rightarrow\Rightarrow\Rightarrow \;\; \Leftarrow\Leftarrow\Leftarrow \quad$ Pol. Proton

$$\begin{array}{rl} u \Rightarrow\Rightarrow & \Leftarrow \overline{d} \\ & \Rightarrow W^{+} \\ e^{+} \Leftarrow & \Rightarrow\Rightarrow \nu \end{array} \qquad\qquad \begin{array}{rl} \overline{d} \Rightarrow & \Leftarrow\Leftarrow u \\ W^{+} \Leftarrow & \\ \nu \Leftarrow\Leftarrow & \Rightarrow e^{+} \end{array}$$

$W^{\pm}$ measurement

$$\vec{p}\,p \quad \rightarrow \quad W^{\pm} + X \quad \rightarrow \quad e^{\pm} + \nu + X$$

Single spin parity violating asymmetry

$$A_L^{PV} = \frac{N_{\overrightarrow{p}\,p} - N_{\overleftarrow{p}\,p}}{N_{\overrightarrow{p}\,p} + N_{\overleftarrow{p}\,p}}$$

Beam "a" polarized $\quad \rightarrow \quad x_a >> x_b$

$$A_L(W^+) = \frac{\Delta u(x_a)\overline{d}(x_b) - \Delta\overline{d}(x_a)u(x_b)}{u(x_a)\overline{d}(x_b) + \overline{d}(x_a)u(x_b)} \quad \rightarrow \frac{\Delta u(x_a)}{u(x_a)}$$

$$A_L(W^-) = \frac{\Delta d(x_a)\overline{u}(x_b) - \Delta\overline{u}(x_a)d(x_b)}{d(x_a)\overline{u}(x_b) + \overline{u}(x_a)d(x_b)} \quad \rightarrow \frac{\Delta d(x_a)}{d(x_a)}$$

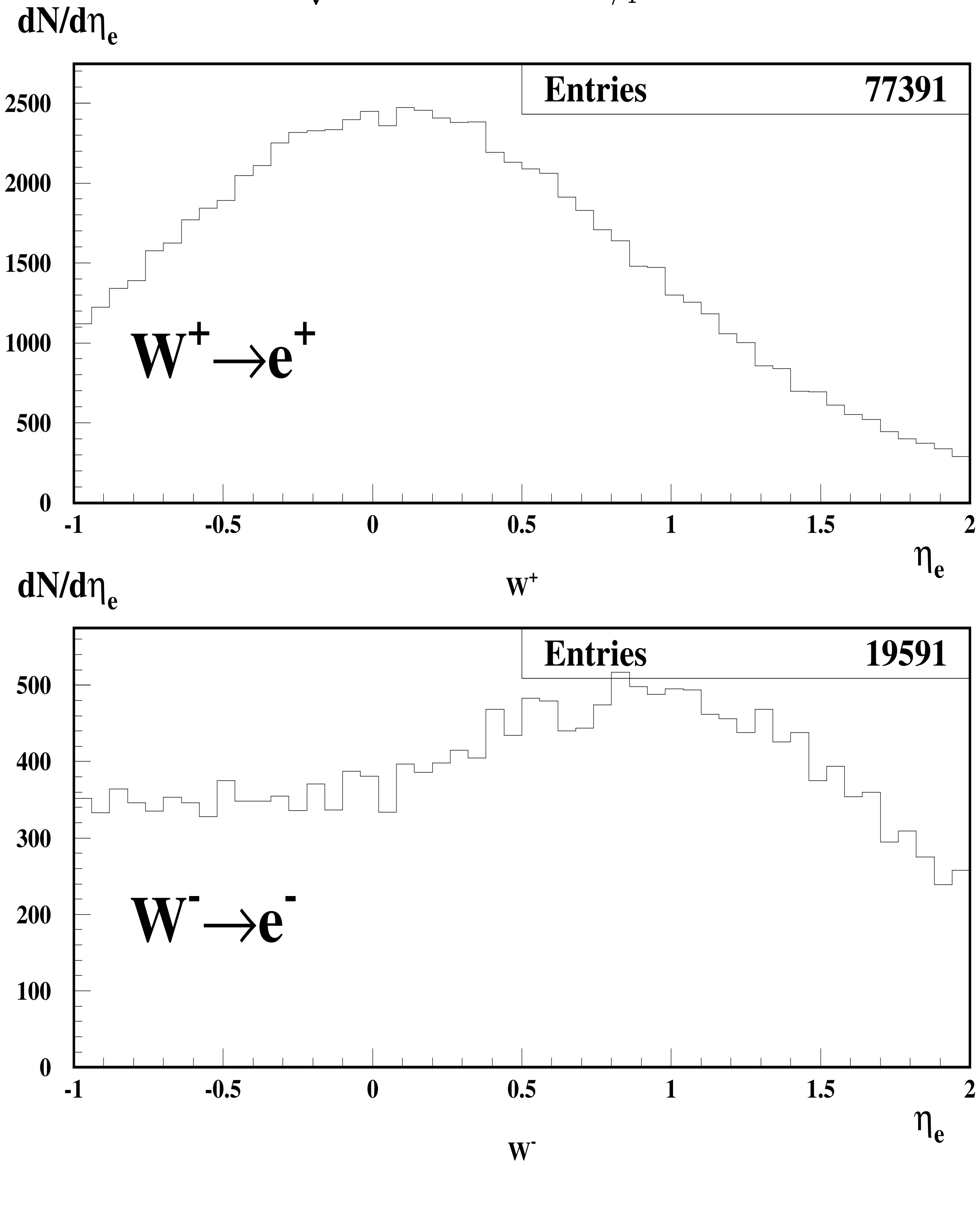
Beam "b" polarized

$$A_L(W^+) = \frac{u(x_a)\Delta\overline{d}(x_b) - \overline{d}(x_a)\Delta u(x_b)}{u(x_a)\overline{d}(x_b) + \overline{d}(x_a)u(x_b)} \quad \rightarrow \frac{\Delta\overline{d}(x_a)}{d(x_a)} + \frac{\overline{d}(x_a)\Delta u(x_b)}{u(x_a)\overline{d}(x_b)}$$

$$A_L(W^-) = \frac{d(x_a)\Delta\overline{u}(x_b) - \overline{u}(x_a)\Delta d(x_b)}{d(x_a)\overline{u}(x_b) + \overline{u}(x_a)d(x_b)} \quad \rightarrow \frac{\Delta\overline{u}(x_a)}{u(x_a)} + \frac{\overline{u}(x_a)\Delta d(x_b)}{d(x_a)\overline{u}(x_b)}$$

$$\underline{p + p \rightarrow W^{\pm} + X \rightarrow e^{\pm}\nu + X}$$

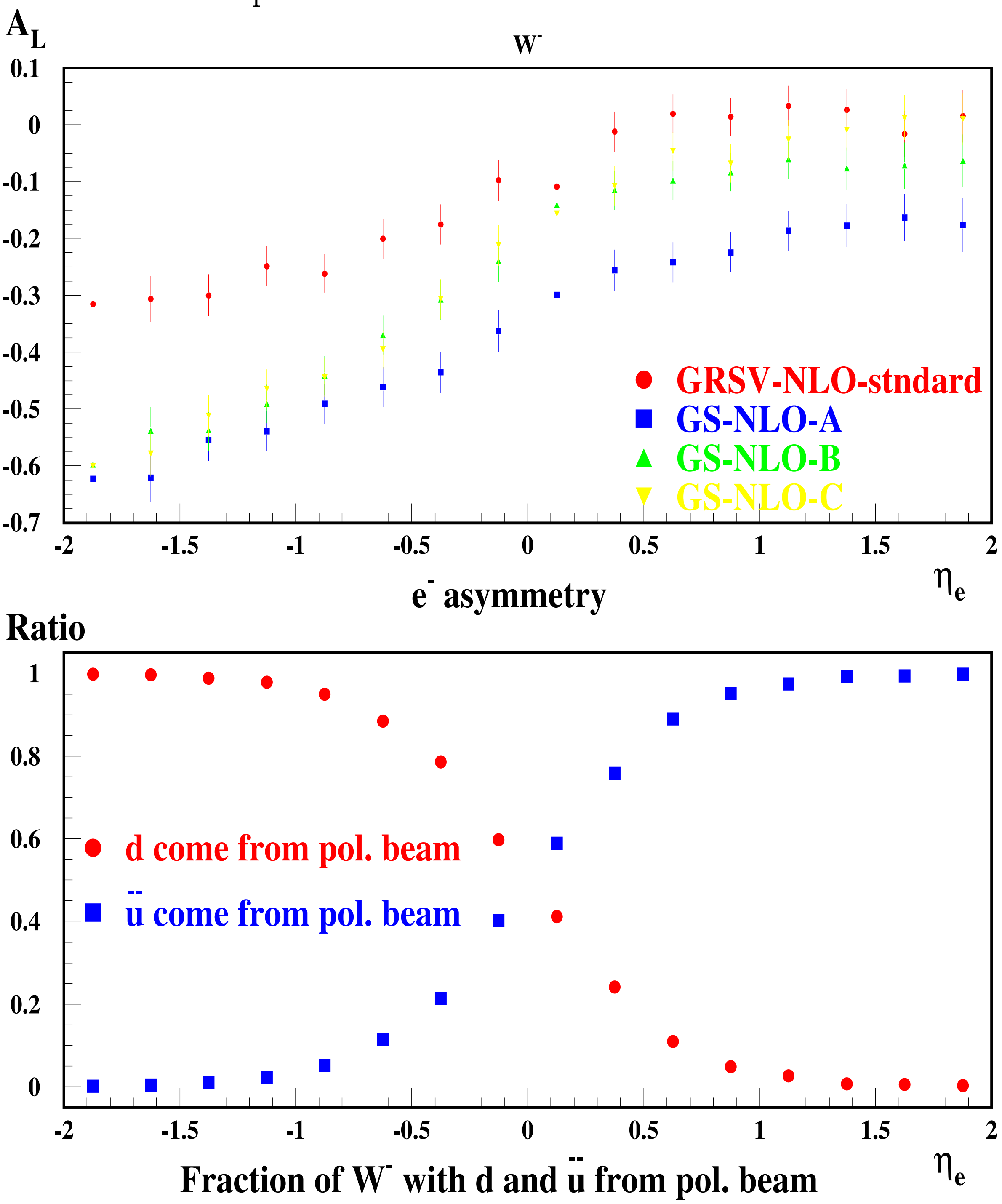
$\sqrt{s} = 500GeV \quad 800/\mathrm{pb}$



Electron Asymmetry for W^-

$\sqrt{s} = 500 GeV$ 800/pb P_b=0.7

Unpol. beam $\rightarrow$ $\leftarrow$ Polarized beam



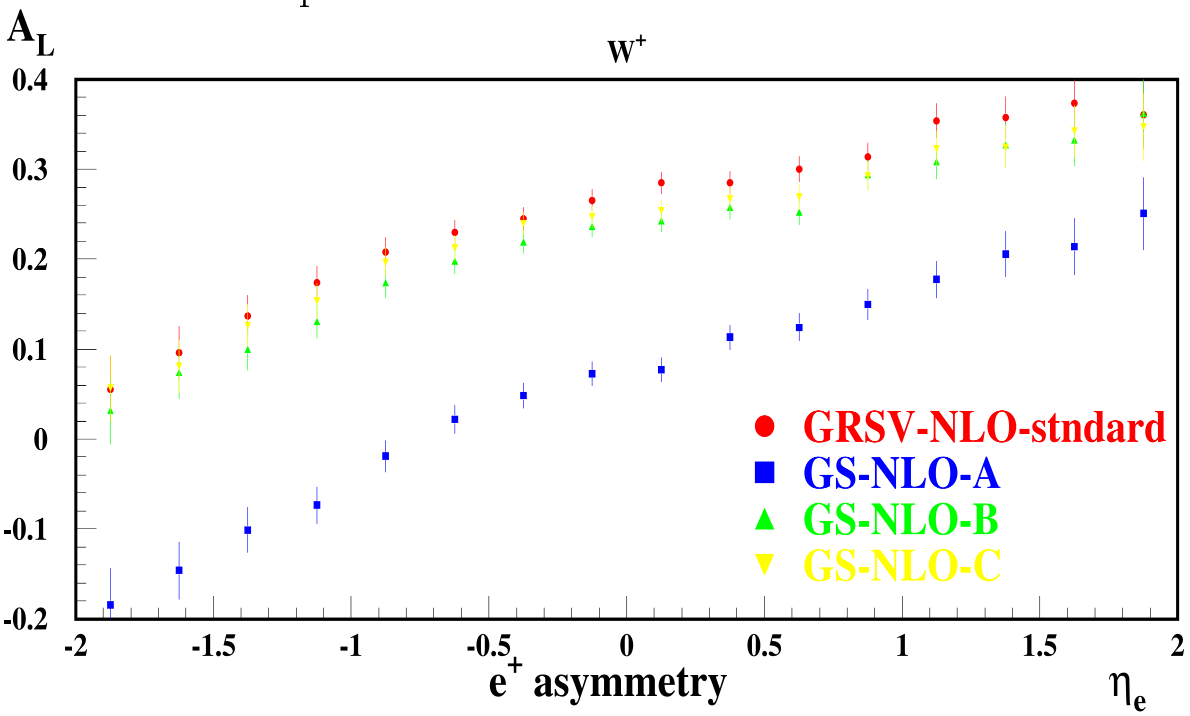
e^- emitted preferentially along W^- momentum

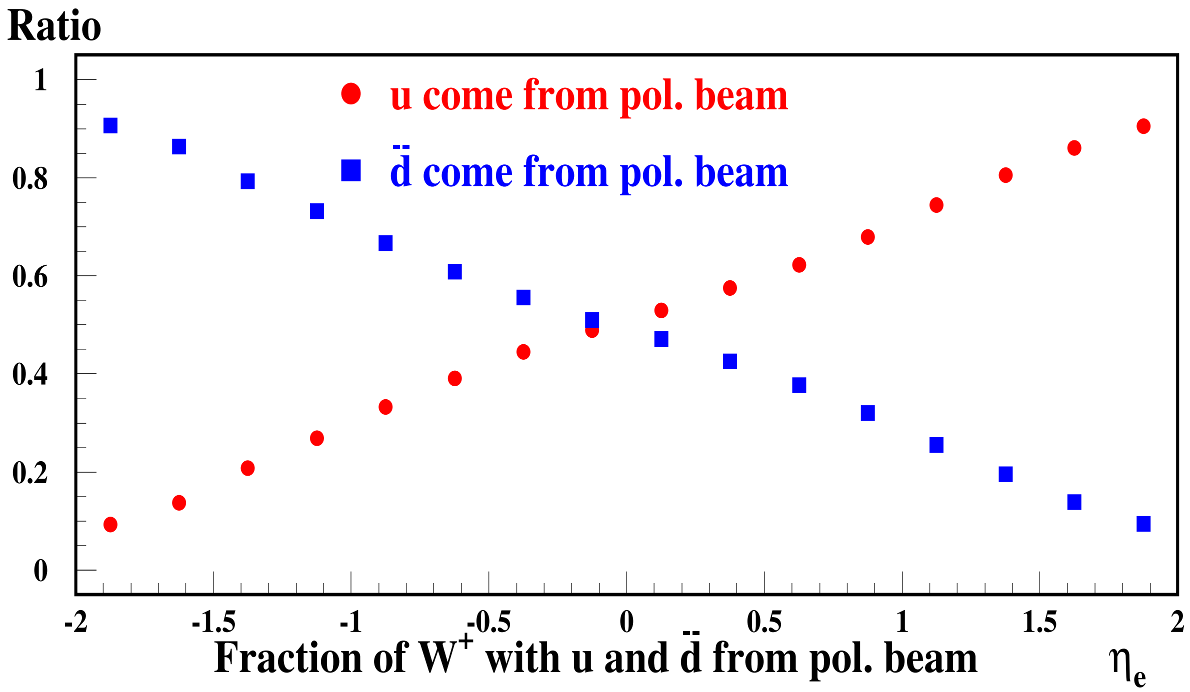
Looking at high η at Endcap gives clean measurement

Positron Asymmetry for W^+

$\sqrt{s} = 500 GeV$ 800/pb P_b=0.7

Unpol. beam → ← Polarized beam

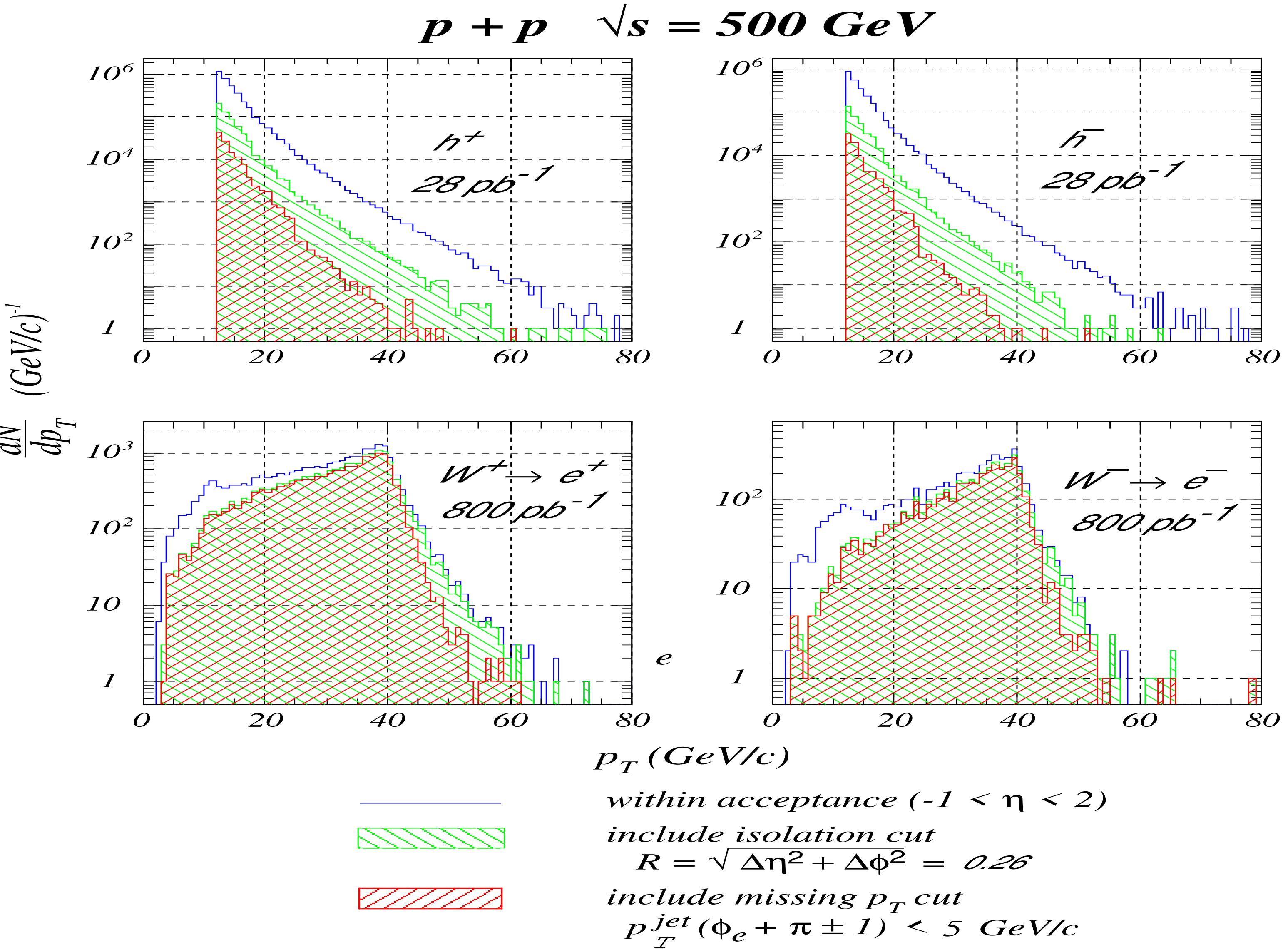




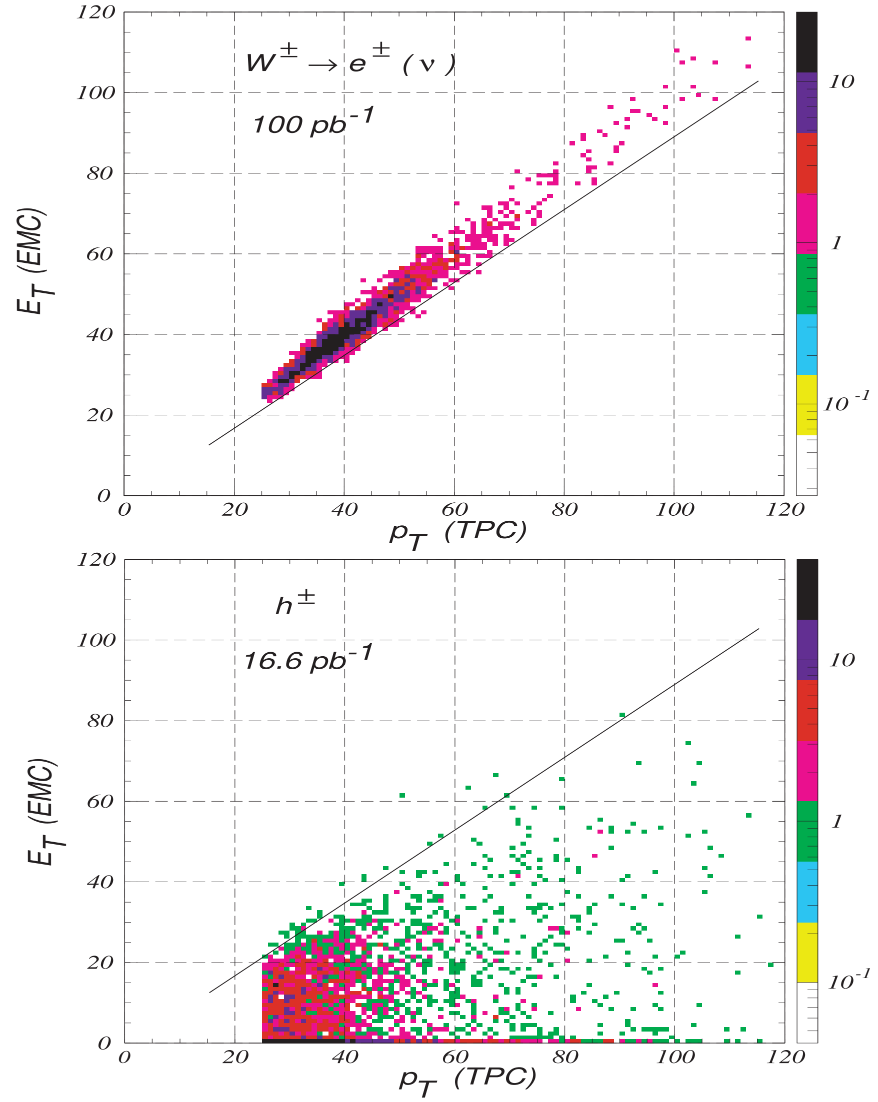
e^+ emitted preferentially opposite W^+ momentum

Background

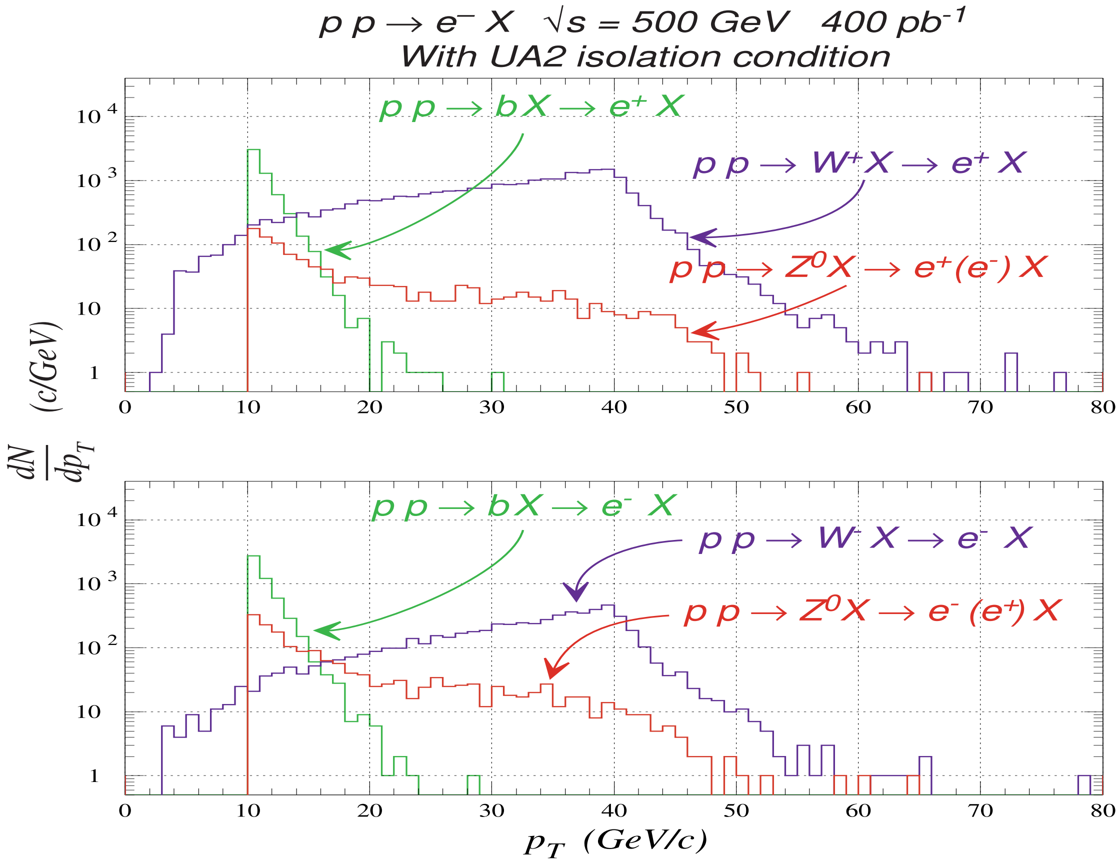
- High P_T jets



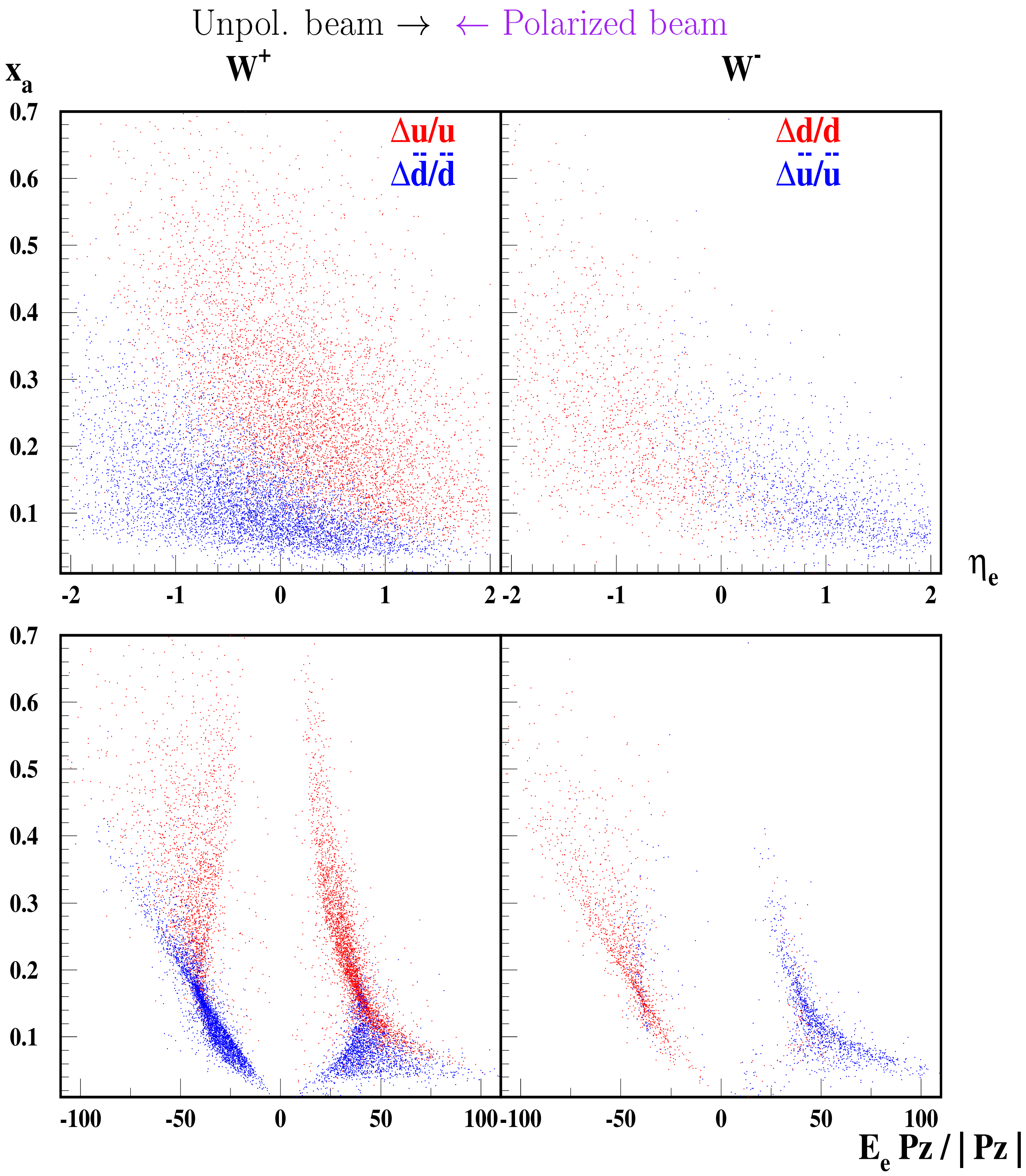
- Z^0 decay and one missing electron
- $b - quark$ decay and one missing electron



$W^{\pm} \rightarrow e^{\pm}$ (ν)
100 pb^{-1}
E_T (EMC)
p_T (TPC)
$h^{\pm}$
16.6 pb^{-1}
E_T (EMC)
p_T (TPC)
0
20
40
60
80
100
120
10
1
10^{-1}


p p → e⁻ X √s = 500 GeV 400 pb⁻¹
With UA2 isolation condition
p p → b X → e⁺ X
p p → W⁺ X → e⁺ X
p p → Z⁰ X → e⁺(e⁻) X
p p → b X → e⁻ X
p p → W⁻ X → e⁻ X
p p → Z⁰ X → e⁻ (e⁺) X
dN/dp_T (c/GeV)
p_T (GeV/c)
10⁴
10³
10²
10
1
0
10
20
30
40
50
60
70
80

x_{bj} range of quarks



Conclusion

- STAR will measure A_L^{PV} at $\sqrt{s} = 500\text{GeV}$
- Which will give provide information
  - from $W^-(e^-)$:
    - $\frac{\Delta\overline{u}}{\overline{u}}$ at $x = 0.05 - 0.3$
    - $\frac{\Delta d}{d}$ at $x = 0.1 - 0.5$
  - from $W^+(e^+)$:
    - $\frac{\Delta\overline{d}}{\overline{d}}$ at $x = 0.05 - 0.4$
    - $\frac{\Delta u}{u}$ at $x = 0.1 - 0.6$
- Endcap EMC will cover most clean, important kinamatcs range.

Time table

- Now
  - 50% polarized $23 GeV$ proton at AGS
  - STAR magnet/TPC is here!
  - A part of EMC under production
  - Siberian Snake for 1 ring, Polarimeter
  - RHIC first beam
  - (commissioning polarized proton at RHIC?)
- 2000
  - Spin rotators
  - Spin physics at RHIC start at $\sqrt{s} = 200 GeV$
  - more barrel EM calorimeter
  - ΔG by inclusive jet
  - $\Delta G(x)$ by dijet and direct photon+jet
- 2001 and later
  - Higher energy : $\sqrt{s} = 500 GeV$
  - Higher luminosity : 2×10^{32}
  - Full barrel EM calorimeter
  - Endcap EM calorimeter
  - $\Delta u(x)$, $\Delta \overline{d}(x)$ by W^+
  - $\Delta d(x)$, $\Delta \overline{u}(x)$ by W^-
  - $h_1(x)$ with transversely polarized beam
  - A_{PV} by inclusive jet
  - and more