PHENIX Central arm physics with $\sqrt{s}$=500GeV (polarized) pp collisions

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(The presentation was performed with the Japanese version.)

RHIC spin program

—RHIC

The polarized proton proton collider
The maximum collision energy is 500GeV

—3 programs

Longitudinal spin program
Transverse spin program
W boson program ← **$\sqrt{s}$=500GeV program**
It's about started!

What's the W boson program? →

(anti-) quark components of proton spin

—Measurements before RHIC

Semi Deep Inelastic Scattering (SDIS)

We rely (anti-) quark fragmentation models

—RHIC W-boson program

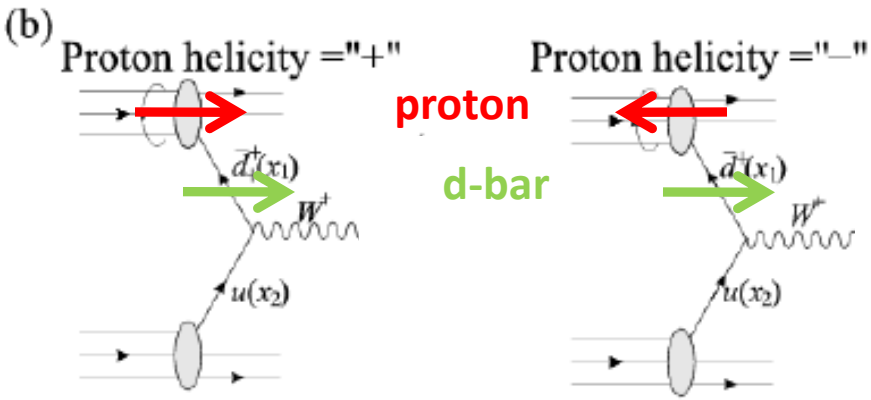
W-bozon production violates the parity

d-bar+u $\rightarrow$W+

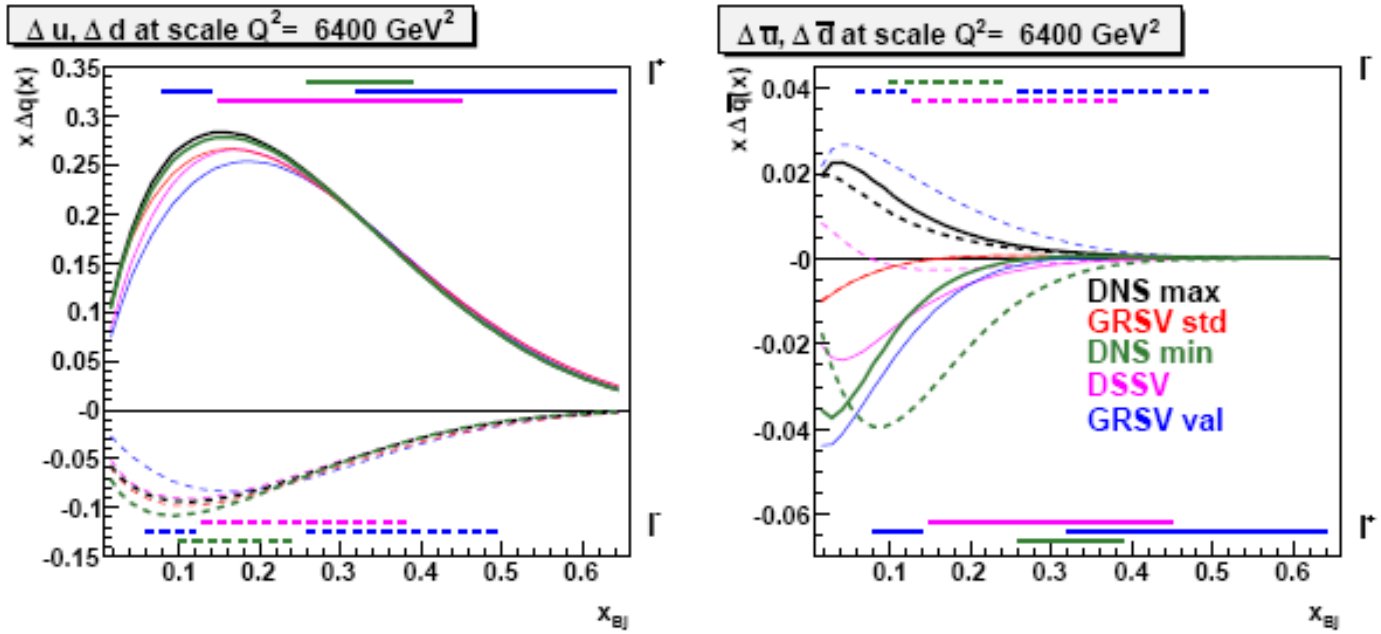
u-bar+d $\rightarrow$W-

d-bar, u-bar is always positive helicity

W+ A_L: Longitudinal single spin asymmetry
Information of d-bar in the proton



The current knowledge



$$A_L^{W+} = -\frac{\Delta u(x_1)\bar{d}(x_2) - \Delta\bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)},$$

It's important to know how W is produced for the x-dependence
But it isn't so easy.

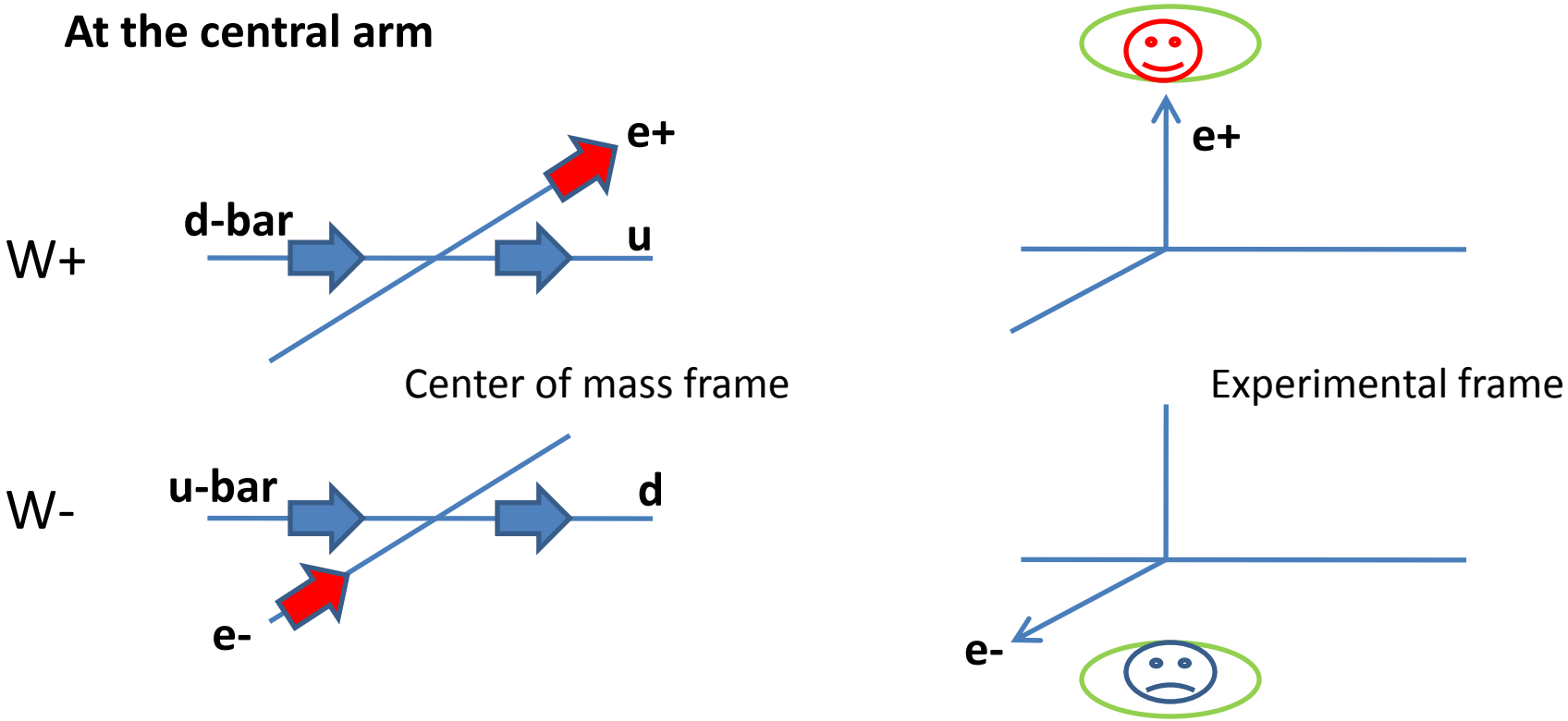
How to detect W

—PHENIX detector

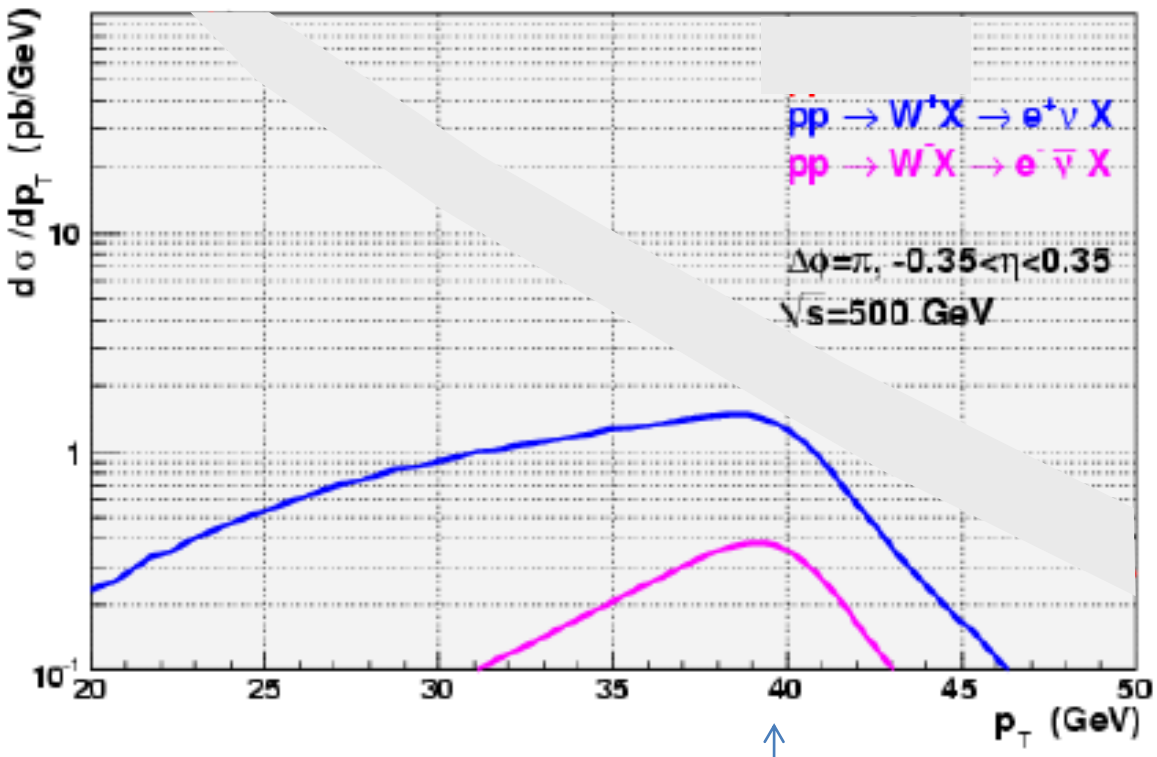
Good for detecting electrons (central arm) and muons (muon arm).
(However) It doesn't have the 4pi coverage.

- ○ **Leptonic decay mode**
- × **Mass reconstruction**

At the central arm



W->e in the central arm



pT distribution
of electrons from W

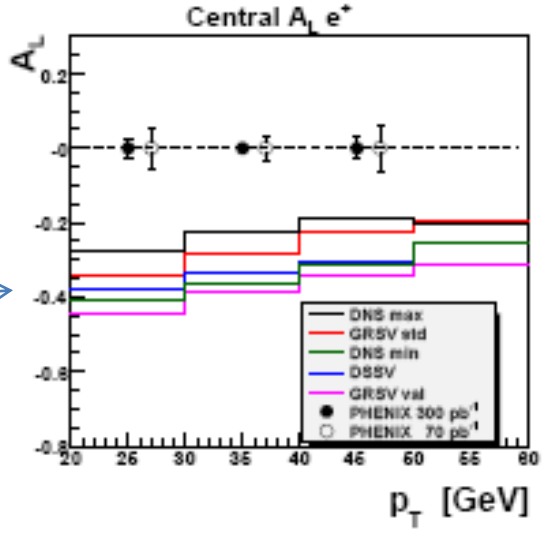
More e+ than e-
Explained in the previous slide

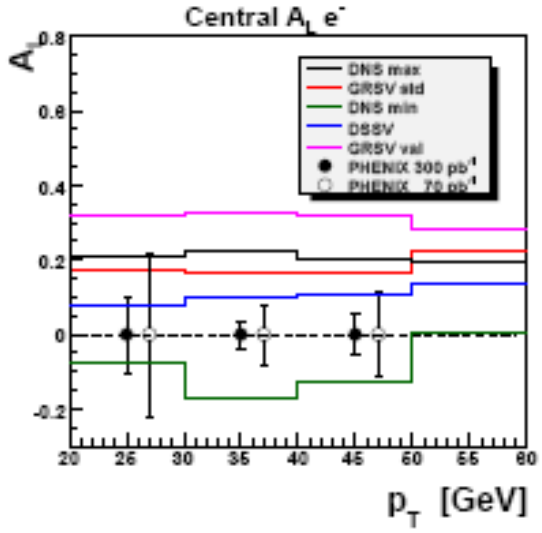
A special feature
from the 2-body decay

Jacobean peak
M_W/2

Asymmetry expected

-0.4





300/pb
70/pb

Figure 17: *Simulated asymmetries in the PHENIX central arms for $W^+ \rightarrow e^+\nu$ (left plot) and $W^- \rightarrow e^-\bar{\nu}$ as functions of p_T. The data has been obtained for GRSV standard, GRSV valence [45], DSSV [14], and DNS [47] using a maximal and minimal sea polarization scenario in RHICBOS [58] for 300 pb^{-1} (full symbols) and 70 pb^{-1} (open symbols) assuming 70% beam polarization.*

Estimation for the near future

3 weeks physics (preparation is about 5 weeks)
7.5/pb * 3 = 22.5/pb

420e+,
70e-

→ dA_L=0.07 (with 50% pol)

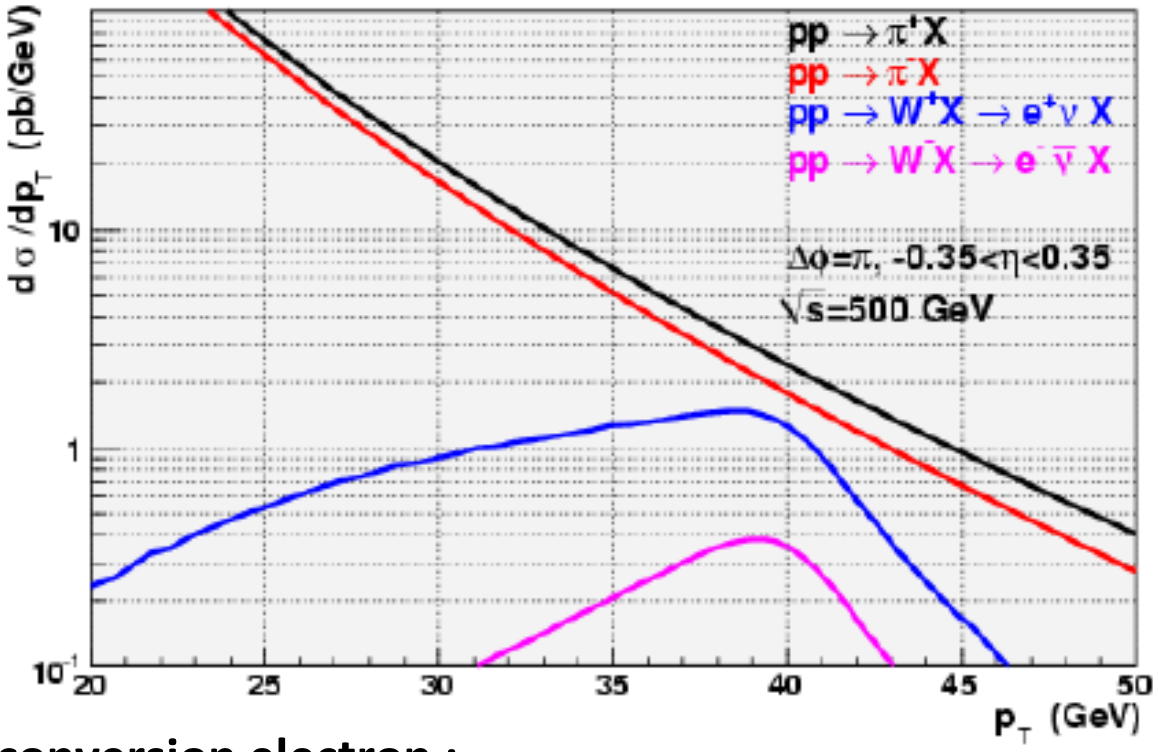
The first non-zero asymmetry from the PHENXI central arm is expected!

W→e at the central arm

Data acquisition : EMCal trigger

Charge separation of high energy particle : magnetic field, track reconstruction

Backgrounds



π0 →2γ → conversion electron :

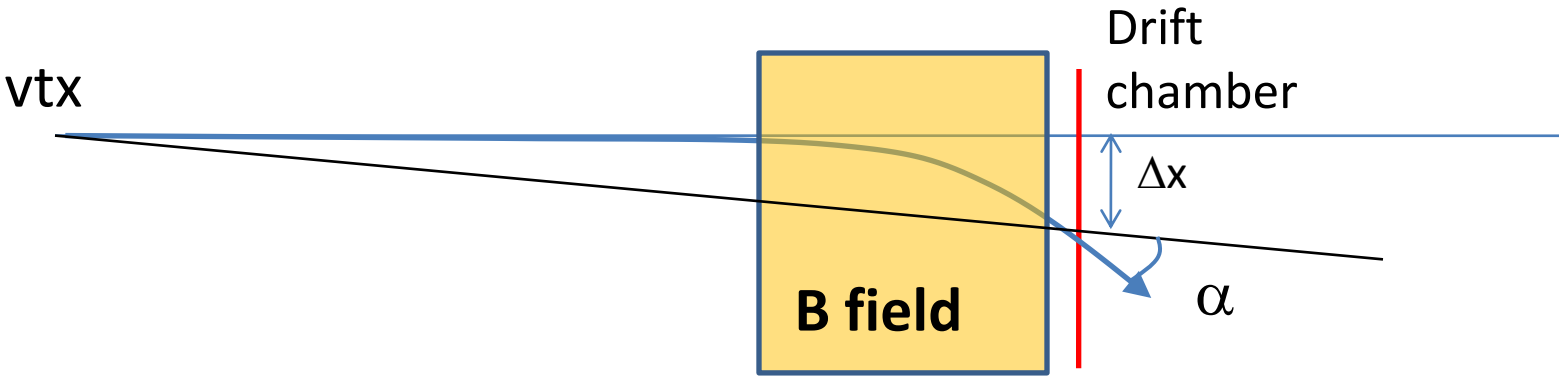
photon has the half energy on average (*0.26) & material before DC (*~3%)

π+- → hadronic interaction

Charge identification

W+ or W-

The basic algorithm in PHENIX (with no inner tracking)



For 40GeV charged particles

Magnetic field option-1 (++ field) : α=2.4 [mrad]

option-2 (+- field): α=1.7 [mrad]

vs

DC resolution
$\Delta\alpha$=0.5[mrad]

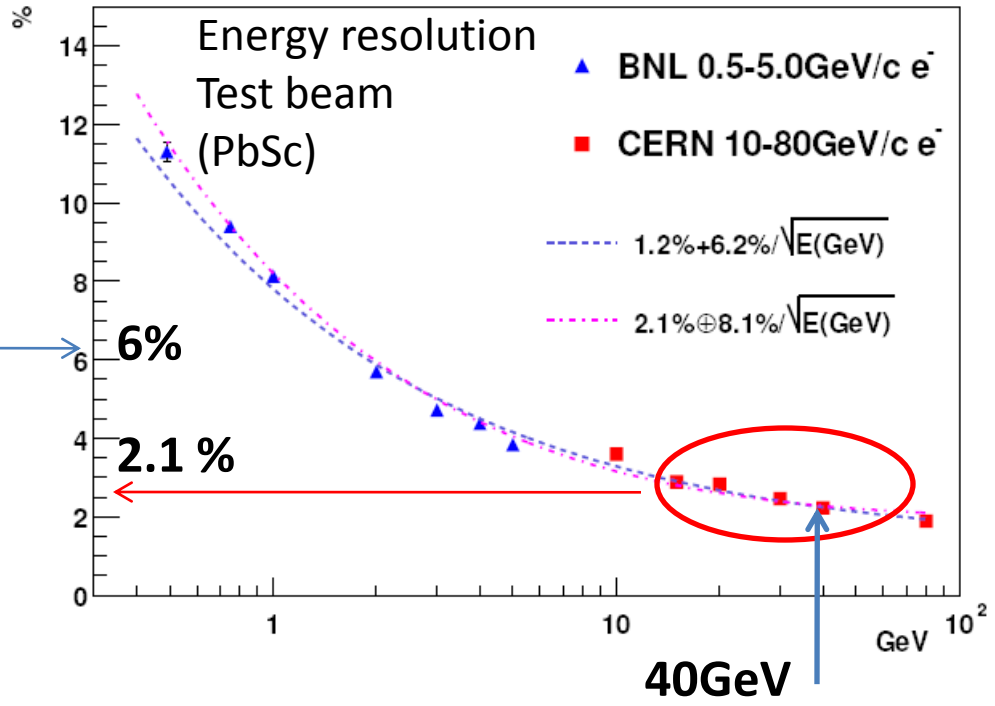
It looks feasible

But Δx is very small (3mm in the option-2),
it's important to determine the vertex position

The momentum resolution is very bad at this momentum.

EMCal energy resolution

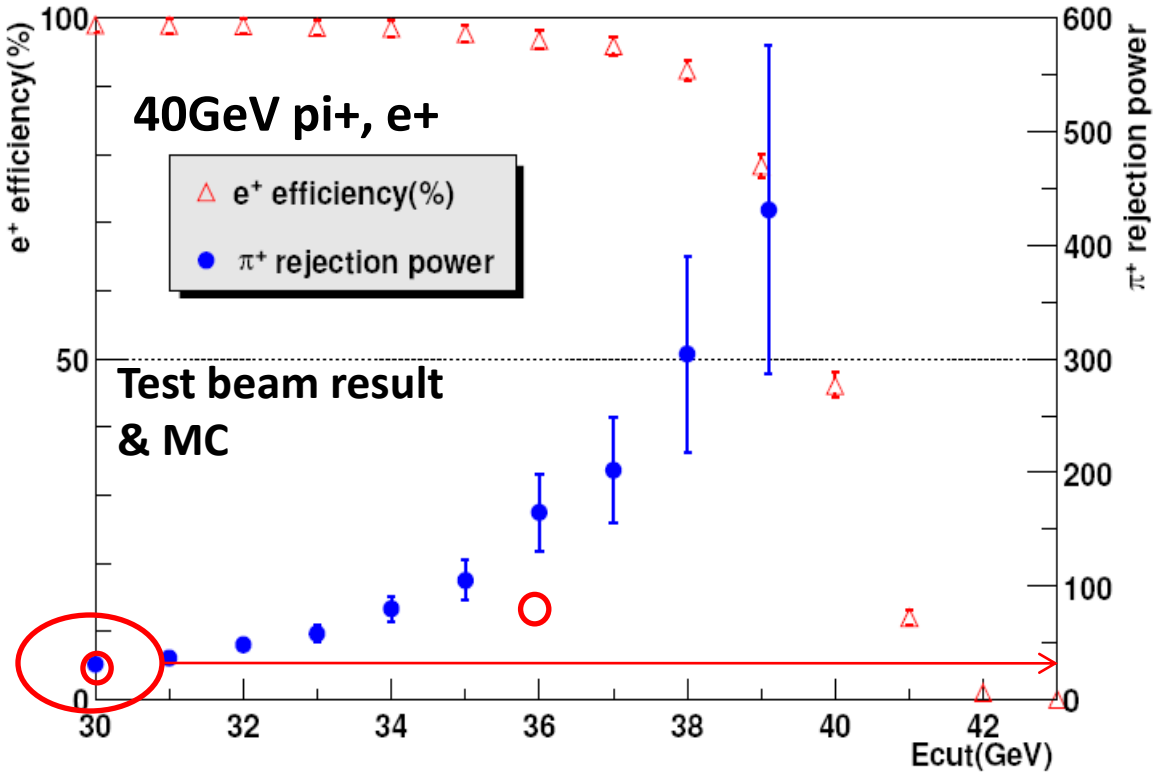
PEHNIX data ~6%⊕8%/sqrt(E)



It's better for the momentum measurement than using the DC

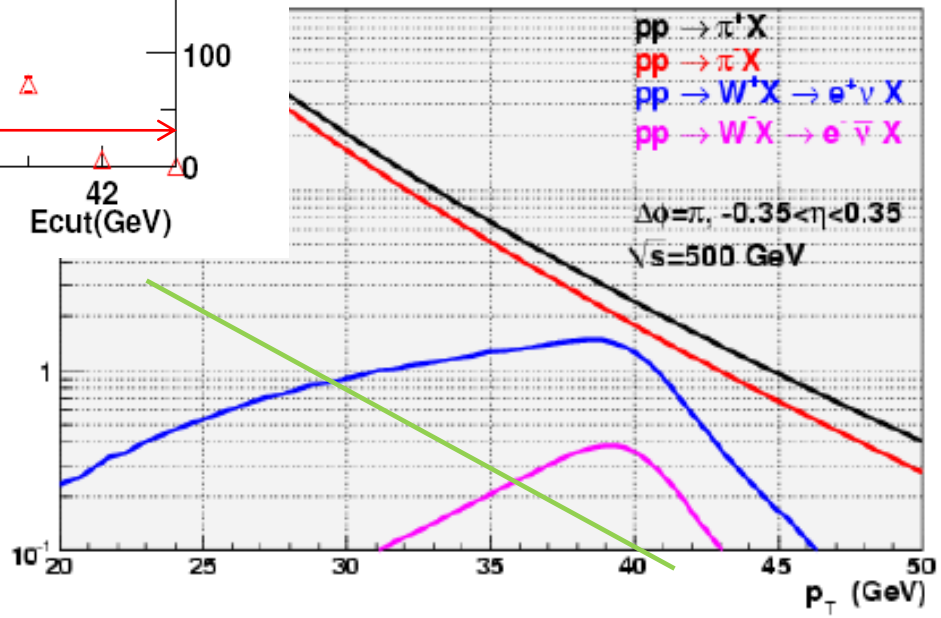
An additional merit : rejection of charged pion contribution

Rejection of charged pions



40GeV charged pions
The rejection power is about 30
With Edep>30GeV.

It looks OK for W+ > e+



Additional rejection

— **EMCal response**

E_dep measurement : ~30

E/p : we can't expect much because of bad resolution.

cluster shape cut : at most factor 2?

— **Isolation cut (study is in progress)**

From the direct photon analysis (sqrt(s)=200GeV), pi0 photons are rejected by a factor 2 with an isolation cut.

Estimation with PYTHIA : in progress

—**TEC/TRD**

Ideal with Xenon gas

The acceptance will be limited, but it can be used for the reference

Preparation

For Run9

The dynamic range of the EMCal needs to be changed (Currently ~20GeV max)
- Based on the current calibration, it's relatively easy.
- There are some bad regions. Hope to fix them at this time.

Vertex position
- Do we need to calibrate fill by fill?
- Can it be done with physics runs?

Software and analysis method

Maintenances of GEANT based MC
- reliability of hadronic shower?

Summary

One of RHIC spin programs : Measurement of (anti-) quark components of proton spin with W production.

High energy electron in the PHENIX central arm.

W+ is more than W-.

Trigger OK

Charge discrimination OK (important to know the vertex)

Background rejection

BG from neutral pions: >100

BG from charged pions: >30 $\rightarrow$enough for W+

For Run9

About 3 weeks of 500GeV run? (The priority is in 200GeV run)

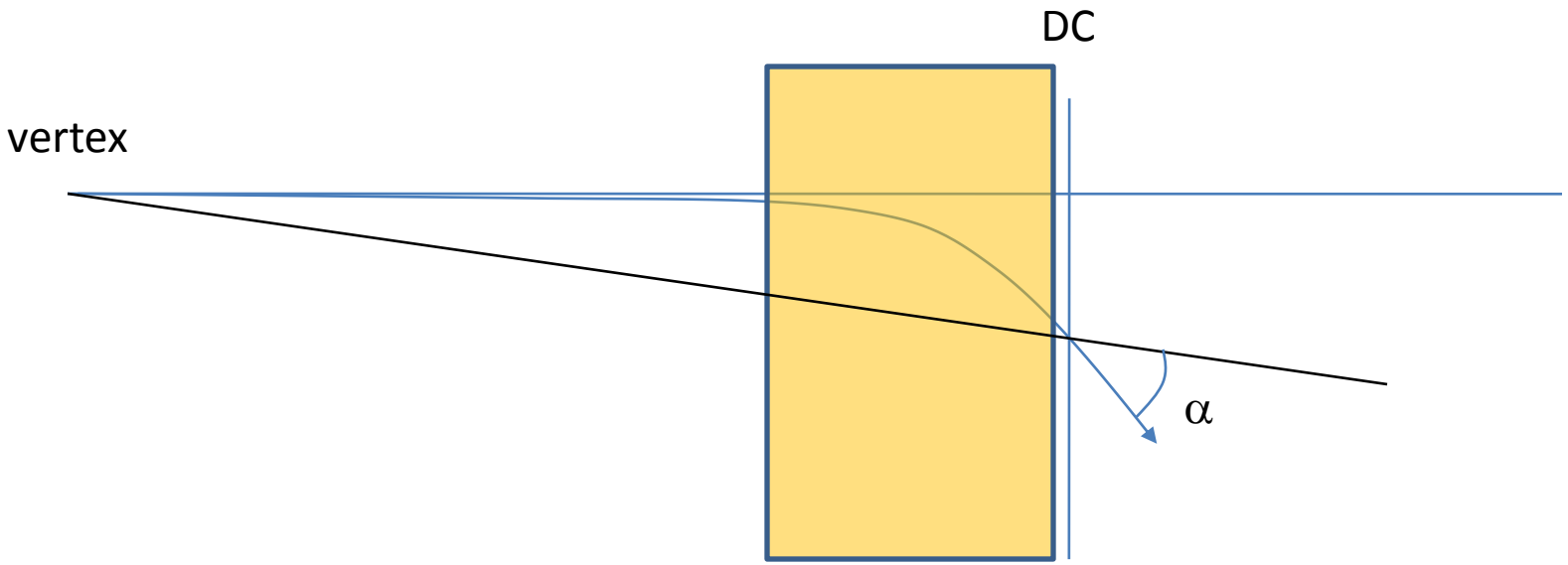
7.5/pb (recorded)* 3 = 22.5/pb

δA_L=0.07 (with 50% pol) for ~0.4 in W+$\rightarrow$e+

It is the first step to confirm the non-zero asymmetry.

Backup

PHENIX algorithm



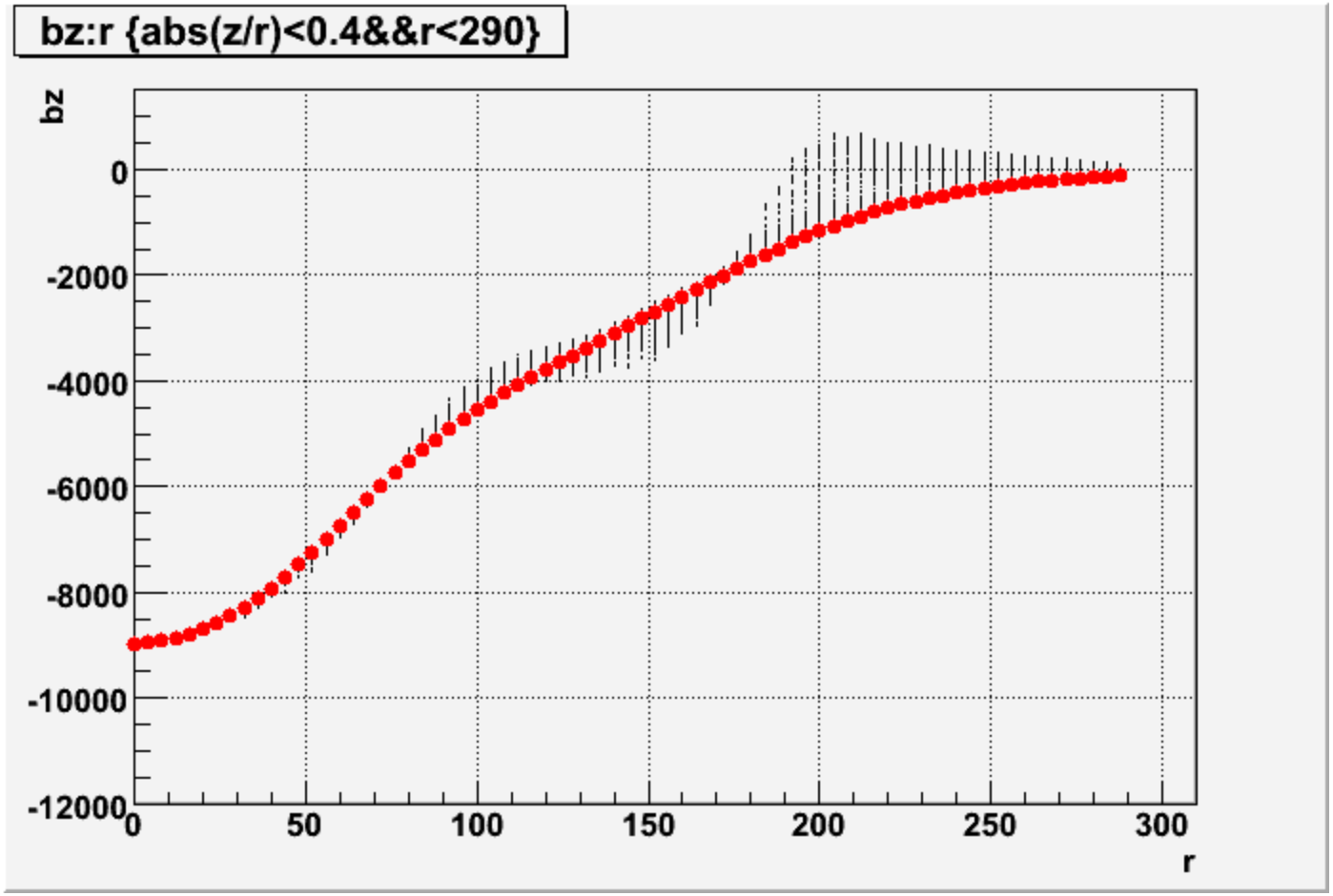
It is ideal if the magnetic field is localized at the end.

W->e charge identification

++ field

Field map (from Sim3D++.root)

gauss

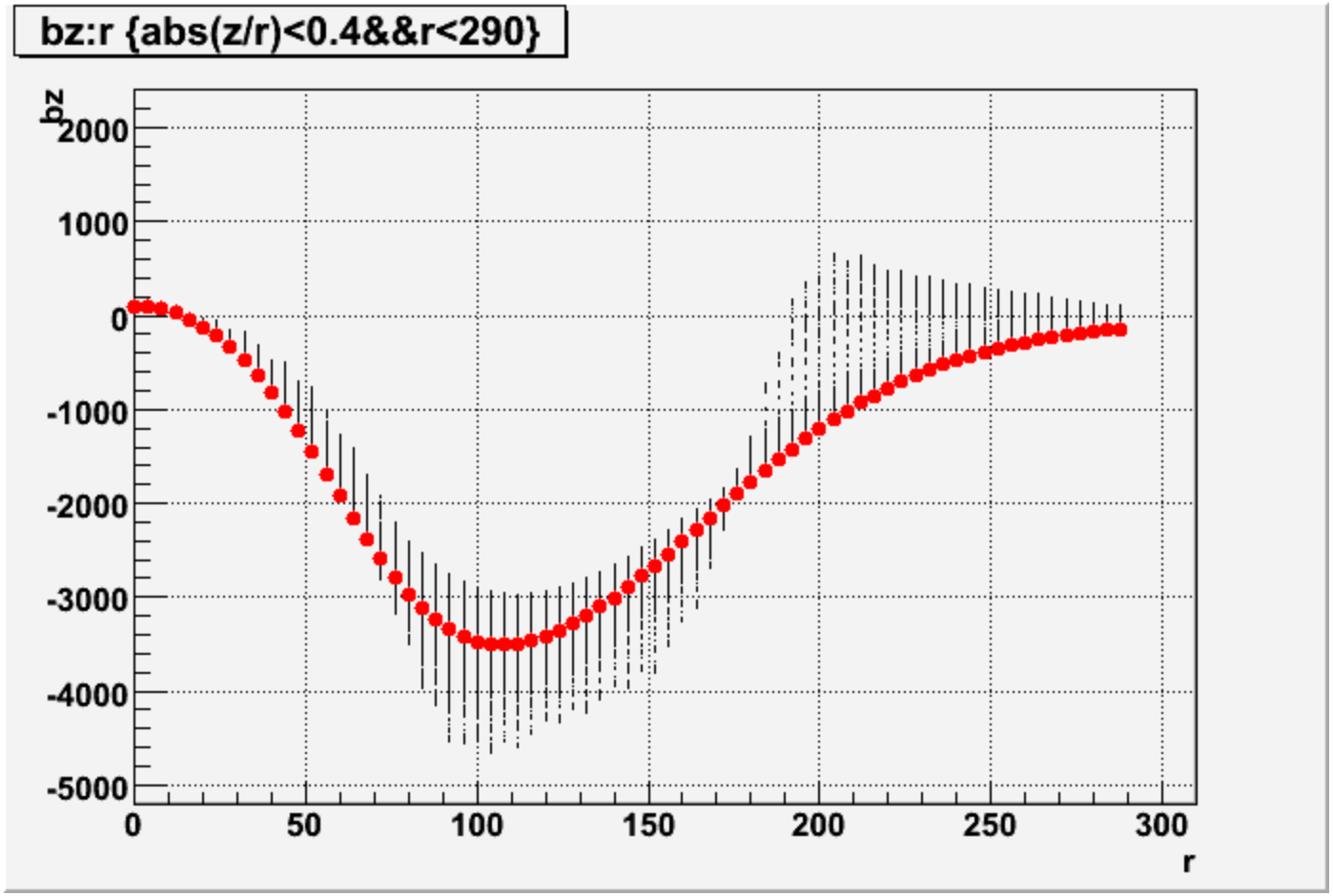


Red points
z=0,phi=0

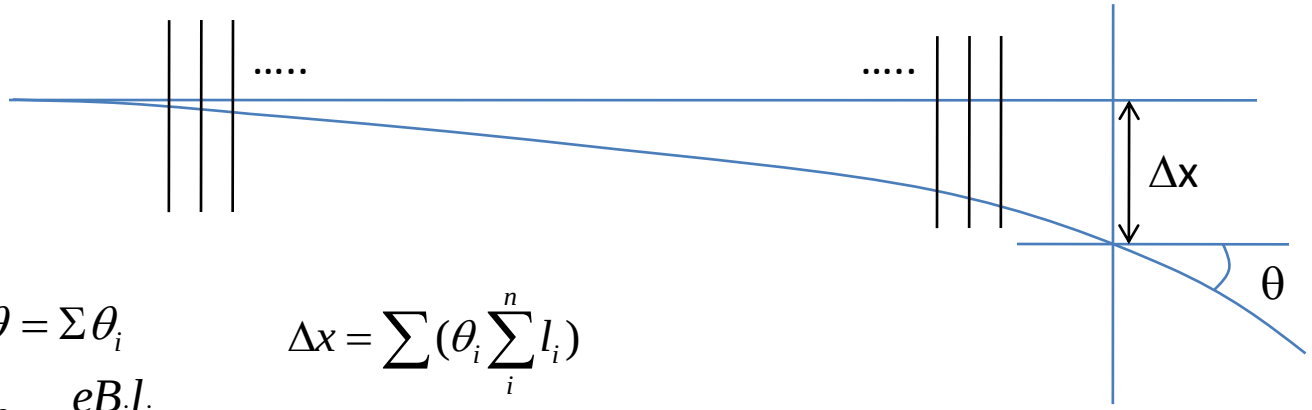
cm

+- field

Field map (from Sim3D+-.root)



Magnetic field integral



$$\theta = \Sigma \theta_i \qquad \Delta x = \sum (\theta_i \sum_i^n l_i)$$

$$\theta_i = \frac{eB_i l_i}{p}$$

$$\alpha = \theta - \Delta x / \Sigma l_i$$

40GeV charged particle

++ field : θ=7.73[mrad], Δx=0.0117[m], l=2.2m → α=2.4 [mrad]

+- field : θ=3.24[mrad], Δx=0.00331[m], l=2.2m → α=1.7 [mrad]

From DC resolution (~0.5mrad), the +- field is feasible (3σ effect).

Here it assumed ultimate vertex position resolution.

How precise can we determine the position?

The beam size itself is σ~0.3mm from the vernier scan.