Plans for transversity measurement at Compass

- Transversity with a lepton beam
- Experimental method
- extraction of transverse P.D.F
- simulations for COMPASS
- Conclusions

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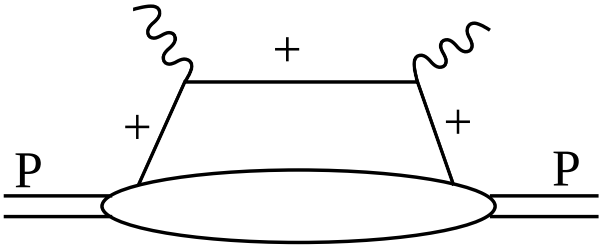
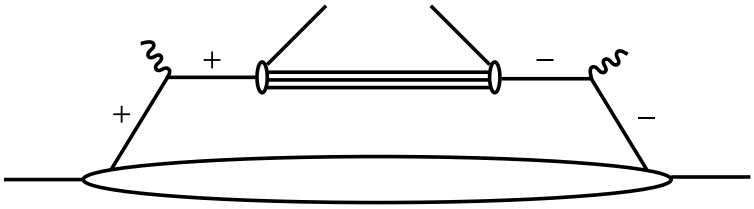
Transversity with lepton beam

- 3 P.D.F. at leading twist : $q(x)$, $\Delta q(x)$, $\Delta_T q(x)$
- $\Delta_T q(x)$ not measured
- It requires Helicity flip:



Inclusive NO



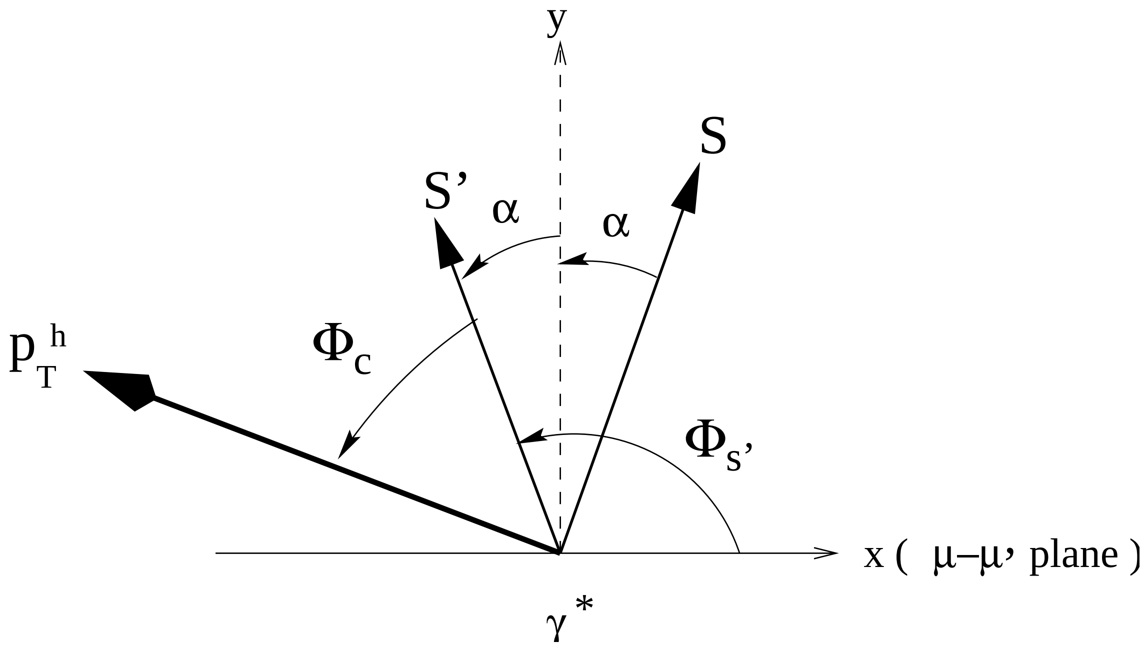
Semi inclusive: OK

- Transversely polarized target
  no need of beam polarization

- 3 possibilities:
  - Λ polarization
    $\Delta_T q(x) \Delta_T D_{\Lambda/q}(z)$
  - single π distribution $(\vec{p}_\gamma \times \vec{p}_\pi).\vec{s}_{q'}$ $\Leftarrow$
    $\Delta_T q(x) \Delta_T^0 D_{\pi/q}(z)$ (Collins)
  - 2 π distribution $(\vec{p}_{\pi_1} \times \vec{p}_{\pi_2}).\vec{s}_{q'}$
    $\Delta_T q(x) \delta \hat{q}_I(z)$

- $\Delta_T D_{\Lambda/q}(z)$, $\delta \hat{q}_I(z)$ and $\Delta_T^0 D_{\pi/q}(z)$ still unknown
  $\Longrightarrow$ shape of $\Delta_T q(x)$

single pion distribution



- Collin's angle: $(\vec{p}_\gamma \times \vec{p}_\pi).\vec{s}_{q'} \propto sin\phi_c = sin(\phi_h - \phi_{S'})$

  QED : $(P_{q'})_x = -D_{nn}(P_q)_x \qquad D_{nn} = \frac{2(1-y)}{1+(1-y)^2}$

  $(P_{q'})_y = D_{nn}(P_q)_y$

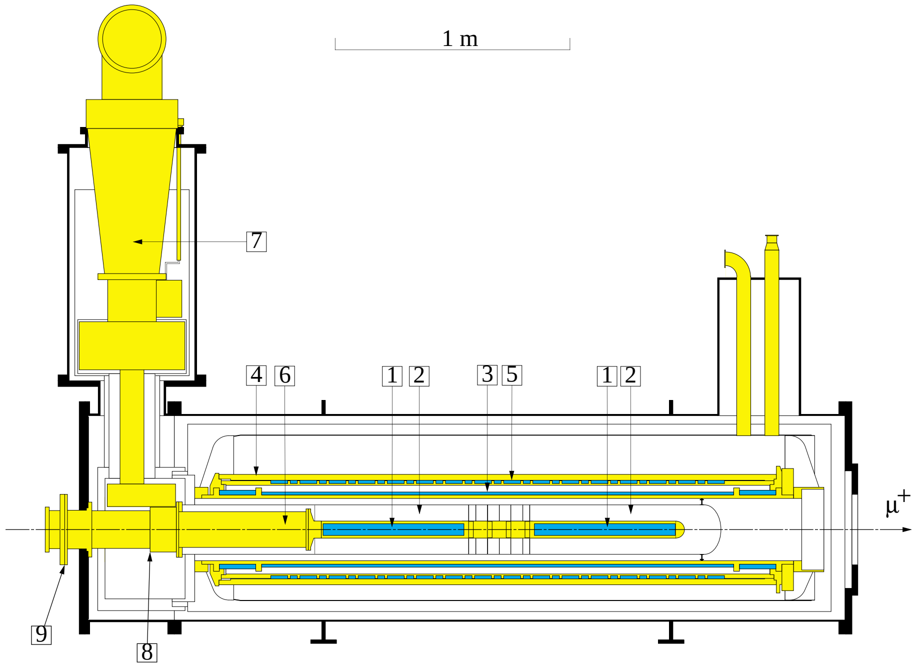
  so $\phi_{S'} = \pi - \phi_S$ and :

$$\boxed{\phi_c = \phi_h + \phi_S - \pi}$$

- $N = N_0 \left[1 \pm f P_T D_{nn} A^h \sin\phi_c\right]$

$$\boxed{A^h = \frac{\Sigma\, e_q^2 \Delta_T q(x) \Delta_T^0 D_q^h(z)}{\Sigma\, e_q^2 q(x) D_q^h(z)}}$$

Experimental method



- Dilution fridge
- Solenoid ($\vec{B} \parallel$ beam), 2.5 T, $\Delta B/B < 10^{-4}$ for DNP
- Dipole ($\vec{B} \perp$ beam), 0.5 T
- 2 cells with opposite polarization

Data taking :

- Solenoid field, polarization by DNP, $T \approx 1$ K
- stop μW, $T \approx 50$ mK
  Polar relax time very large “frozen spin”
- field rotation, solenoid $\Rightarrow$ dipole
- take transverse data.

Asymmetry extraction

longitudinal case :

- compute asymmetry from $N_u - N_d$
- reverse nucleon spins (rotate $\vec{B}$ using dipole) to cancel effect of acceptance

transverse case :

- Consider cell # 1
  - compute asymmetry from $N(\phi) - N(\phi + \pi)$
  - reverse nucleon spins (by repolarizing) to cancel effect of acceptance
- Do the same for cell # 2
- ϕ_c defined relative to lepton scatt. plane
  $\Rightarrow a(\phi_c) \approx a(\phi_c + \pi)$
  and $a(\phi_c)/a(\phi_c + \pi)$ should be pretty constant

Extraction of P.D.F

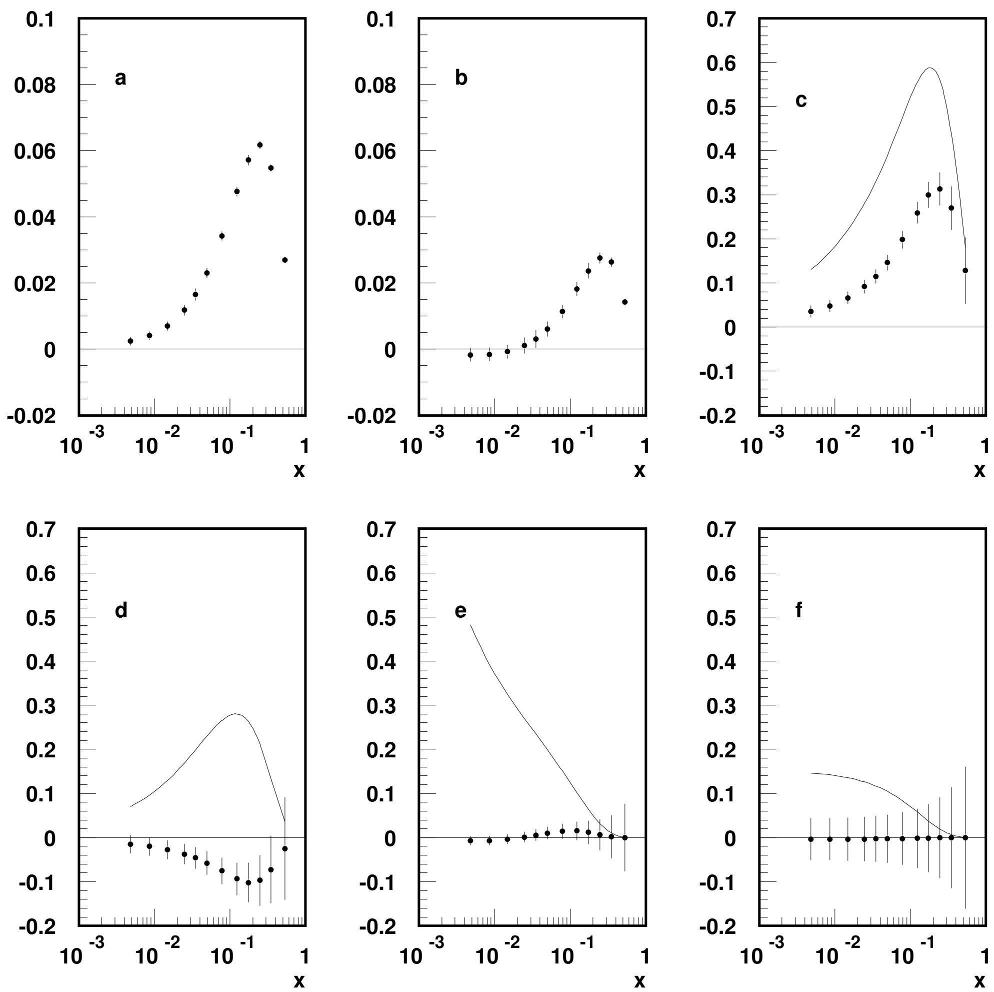
In the longitudinal case :

- $A^h = \frac{\sum e_q^2 \Delta q(x) D_q^h(z)}{\sum e_q^2 q(x) D_q^h(z)}$ and $A_1 = \frac{\sum e_q^2 \Delta q(x)}{\sum e_q^2 q(x)}$

  A_1^p, A_1^d, $A_p^{\pi^+}$, $A_p^{\pi^-}$, $A_d^{\pi^+}$, $A_d^{\pi^-}$ gives 6 equations (+ possibly K asymmetries).

  6 unknowns: Δu, $\Delta \bar{u}$, Δd, $\Delta \bar{d}$, Δs, $\Delta \bar{s}$,

- for 2 years at 100 GeV COMPASS would get



Extraction of P.D.F

In the Transverse case :

- $A = \frac{\Sigma\, e_q^2 \Delta_T q(x) \Delta_T^0 D_q^h(z)}{\Sigma\, e_q^2 q(x) D_q^h(z)}$

  - $A_p^{\pi^+}$, $A_p^{\pi^-}$, $A_d^{\pi^+}$, $A_d^{\pi^-}$ gives only 4 equations for 6 unknowns: $\Delta_T u$, $\Delta_T \bar{u}$, $\Delta_T d$, $\Delta_T \bar{d}$, $\Delta_T s$, $\Delta_T \bar{s}$,
  - $\Delta_T^0 D_q^h(z)$ not known
  - $|\Delta_T^0 D_q^h(z)| < D_q^h(z) \Rightarrow$ smaller asymmetries
  - neglect $\Delta_T s$ and $\Delta_T \bar{s}$ and assume $\Delta_T \bar{u} = \Delta_T \bar{d}$
  - How well this can work depends on e.g. how much $\Delta_T^0 D_q{}^h \neq \Delta_T^0 D_{\bar{q}}{}^h$

- Due to SU(2) and C

  - $D_u^{\pi+} = D_d^{\pi-} = D_{\bar{d}}^{\pi+} = D_{\bar{u}}^{\pi-}$: (Favored) $\longrightarrow D_f$ and $\Delta_T^0 D_f$
  - $D_u^{\pi-} = D_d^{\pi+} = D_{\bar{d}}^{\pi-} = D_{\bar{u}}^{\pi+}$: (Unfavored) $\longrightarrow D_u$ and $\Delta_T^0 D_u$
  - $D_s^{\pi+} = D_s^{\pi-} = D_{\bar{s}}^{\pi+} = D_{\bar{s}}^{\pi-}$: (strange) $\longrightarrow D_s$ and $\Delta_T^0 D_s$

Extraction of P.D.F

- $A^{\pi} = \dfrac{(N^{\pi^+} + N^{\pi^-})(\phi) - (N^{\pi^+} + N^{\pi^-})(\phi + \pi)}{(N^{\pi^+} + N^{\pi^-})(\phi) + (N^{\pi^+} + N^{\pi^-})(\phi + \pi)}$

$$A_p^{\pi} \approx f P_T D_{nn} \frac{4\Delta_T u + 4\Delta_T \bar{u} + \Delta_T d + \Delta_T \bar{d}}{4u + 4\bar{u} + d + \bar{d}} \times \frac{\Delta_T^0 D_f + \Delta_T^0 D_u}{D_f + D_u}$$

$$A_d^{\pi} \approx f P_T D_{nn} \frac{\Delta_T u + \Delta_T \bar{u} + \Delta_T d + \Delta_T \bar{d}}{u + \bar{u} + d + \bar{d}} \times \frac{\Delta_T^0 D_f + \Delta_T^0 D_u}{D_f + D_u}$$

- $\tilde{A} = \dfrac{N^{\pi^+}(\phi) + N^{\pi^-}(\phi + \pi) - [N^{\pi^+}(\phi + \pi) + N^{\pi^-}(\phi)]}{(N^{\pi^+} + N^{\pi^-})(\phi) + (N^{\pi^+} + N^{\pi^-})(\phi + \pi)}$

$$\tilde{A}_p \approx f P_T D_{nn} \frac{4\Delta_T u_v - \Delta_T d_v}{4u + 4\bar{u} + d + \bar{d}} \times \frac{\Delta_T^0 D_f - \Delta_T^0 D_u}{D_f + D_u}$$

$$\tilde{A}_d \approx f P_T D_{nn} \frac{3(\Delta_T u_v - \Delta_T d_v)}{5(u + \bar{u} + d + \bar{d})} \times \frac{\Delta_T^0 D_f - \Delta_T^0 D_u}{D_f + D_u}$$

$\Rightarrow$ shape of $\Delta_T(u + \bar{u})$, $\Delta_T(d + \bar{d})$, $\Delta_T u_v$ and $\Delta_T d_v$

Simulation

- Lepto 6.5 with GRV98 LO
  100,000 evts for 100 and 160 GeV

- $A_d^\pi \approx \frac{\Delta_T u + \Delta_T \bar{u} + \Delta_T d + \Delta_T \bar{d}}{u + \bar{u} + d + \bar{d}} \times a_c$

  . with $a_c = \frac{\Delta_T^0 D_f + \Delta_T^0 D_u}{D_f + D_u}$

- assume $\Delta_T q = \Delta q$

- $a_c = z \, \frac{P_T^h \sqrt{\left(P_T^h\right)^2 + M^2}}{\kappa/2 + \sqrt{\left(P_T^h\right)^2 + M^2}}$

  Artru et al., $M = 0.3$ and $\kappa = 0.17$

  compatible with E704

  $z = 0.4,\ P_T^h = 0.6 \longrightarrow a_c = 0.3 =$ Delphi upper limit

- SMC $A_p^{\pi^+} = -(0.11 \pm 0.06) \sin \phi_c$

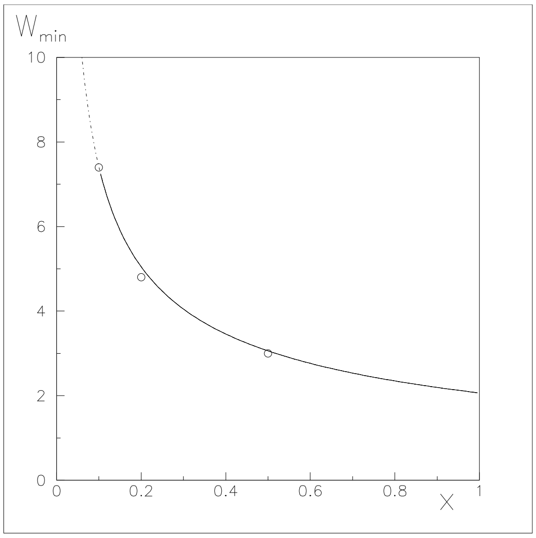
  \+ Soffer's bound $|\Delta_T q| \leq (q + \Delta q)/2.$

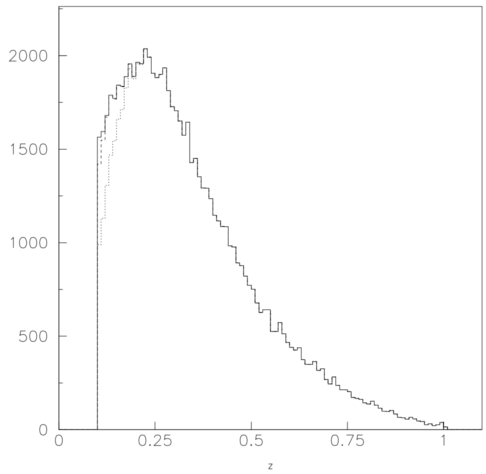
  $\Rightarrow < a_c > \geq 0.24 \pm 0.15$ (M. Anselmino and F. Murgia)

  Artru model gives $< a_c >= 0.31$.

Simulation (cuts)

- Kinematical cuts:
  $Q^2 > 1$,
  $\nu/E \geq 0.15$,
  $E'/E \geq 0.05$,
  $z = E_h/\nu \geq 0.1$ or 0.3
- leading hadron: require that the most energetic hadron be a charged pion.
- Berger criterion: To have separated target and current fragmentation regions requires large enough W.





Effect of Berger criterion on z distribution

$\Rightarrow$ at high energy very few events rejected

Results

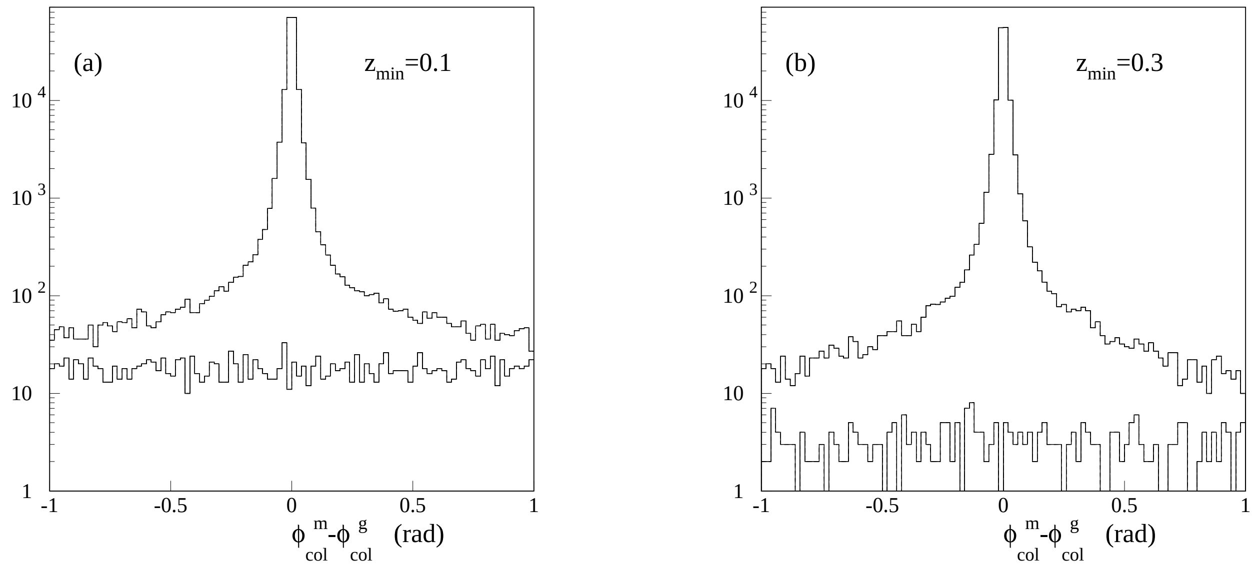
- 30 days, overall efficiency 0.25, $\mathcal{L} = 4.3 \cdot 10^{37}$ cm^{-2} per day,
- acceptance reduced due to PT magnet, 180 $\rightarrow$ 70 mrad. But going to 160 GeV instead of 100 limits the loss.
  - small $x \Rightarrow W$ large $\Rightarrow$ small angle $\Rightarrow$ no loss
  - large $x \Rightarrow$ important loss
- Asymmetry method
  - standard $A = \frac{1}{f P_T D_{nn} a_c} \frac{1}{\sin\phi} \frac{N(\phi_c) - N(\phi_c+\pi)}{N(\phi_c)+N(\phi_c+\pi)}$
  - Weighted $A = \frac{\sum w}{\sum w^2}$ with $w = f P_T D_{nn} a_c \sin\phi$

  gain in statistics 40% for $z > 0.1$ and 20% for $z > 0.3$
- z cut

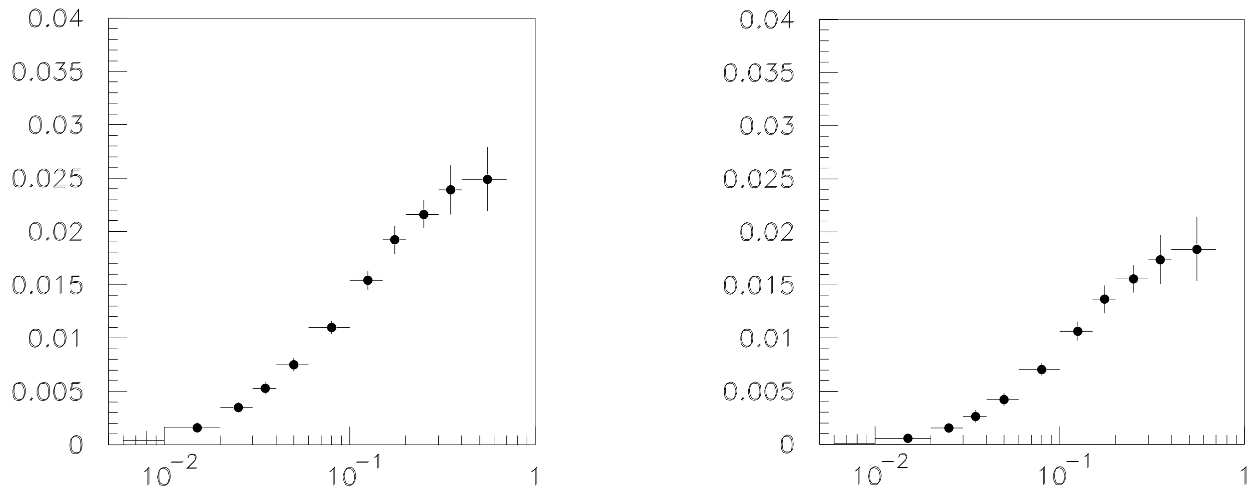
  $a_c \propto z \Rightarrow$ requiring $z > 0.3$ instead of 0.1 results in
  few % gain with standard method
  few % loss with weighted method

Re-interaction in the target

- Geant + Gheisha



- "good events" reconstructed hadron charge = generated (upper curve) ϕ_c not much affected
- "bad events" reconstructed hadron charge $\neq$ generated ϕ_c info lost $\Rightarrow$ no asymmetry $\Rightarrow$ effect of dilution.



Conclusions

- In 30 days $(\Delta_T u + \Delta_T \bar{u} + \Delta_T d + \Delta_T \bar{d}) \times a_c$
  can be measured with many σ in many bins.
  $\Rightarrow$ shape of $\Delta_T q$
  (model assumptions should be checked versus the SMC data)

- How many days we spend on $\Delta_T q$ in 2002 not decided yet.

- We need a_c and even the different $\Delta_T^0 D_q^h$