Single-Spin Asymmetry in Inclusive π^0 Production Measured at the Protvino 70 GeV Accelerator.

L. Nogach

On behalf of the PROZA collaboration

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Outline

- A_N of inclusive π^0 production in polarized target fragmentation region in reaction $\pi^- + p_\uparrow \to \pi^0 + X$ at 40 GeV
- Theoretical models and expectations
- A_N in inclusive π^0 production at central region in reaction $p + p_\uparrow \to \pi^0 + X$ at 70 GeV
- New scaling search
- Conclusions

Single-spin asymmetry definition

$$A_N^H(x_f,p_t) = \frac{1}{P_{target}} \frac{1}{<cos\phi>} \cdot \frac{\sigma_\uparrow^H(x_f,p_t) - \sigma_\downarrow^H(x_f,p_t)}{\sigma_\uparrow^H(x_f,p_t) + \sigma_\downarrow^H(x_f,p_t)}$$

P_{target} – mean target polarization;

ϕ – azimuthal angle;

(at small angles $\phi \sim 0^\circ, < cos\phi >= 1.$)

Measured asymmetry

$$A_N = \frac{D(x_f,p_t)}{P_{target}} \cdot A_N^{raw}(x_f,p_t) = \frac{D(x_f,p_t)}{P_{target}} \cdot \frac{n_\uparrow(x_f,p_t) - n_\downarrow(x_f,p_t)}{n_\uparrow(x_f,p_t) + n_\downarrow(x_f,p_t)}$$

D - dilution factor

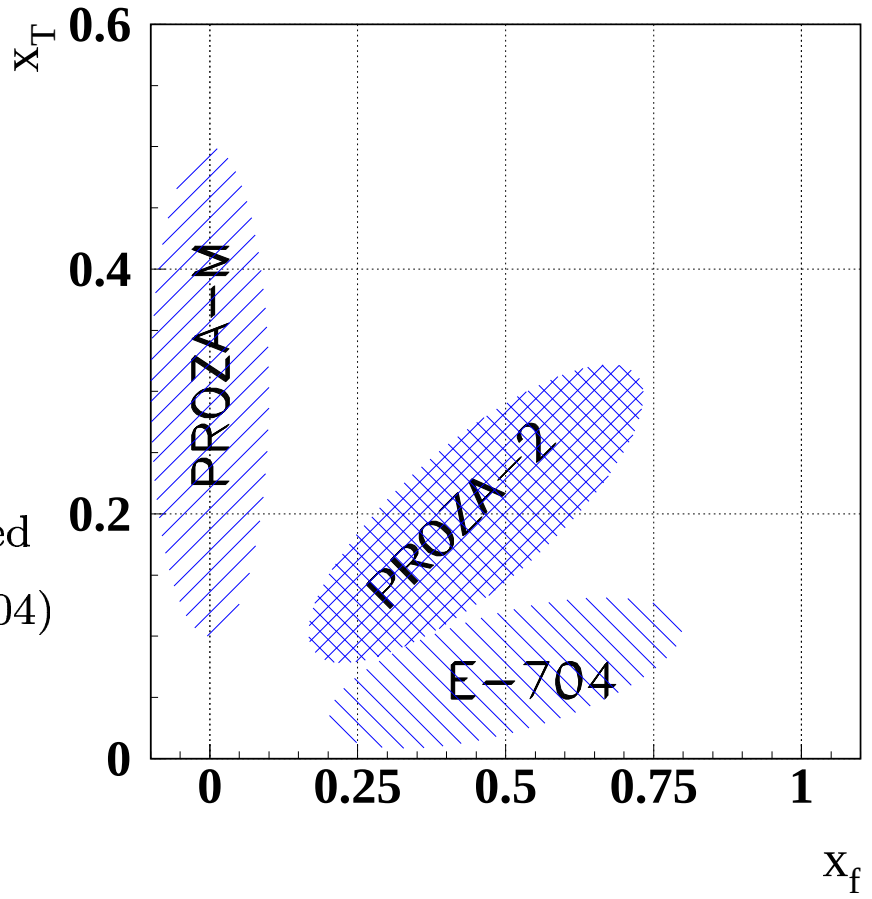
A_N in reaction $\pi^- + p_\uparrow \to \pi^0 + X$ at 40 GeV

- At the first time A_N was measured in the polarized target fragmentation region

(The asymmetry is expected to be similar to the measurements in the polarized beam fragmentation region – E704)

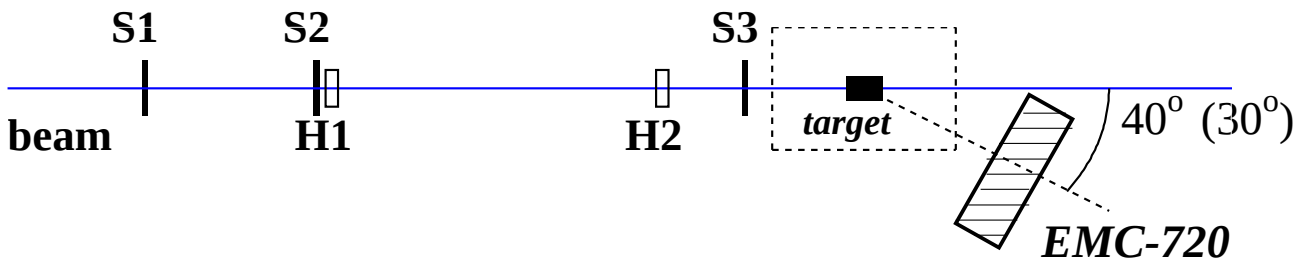
- Measurements for close values of $|x_f|$ and x_T

(In all previous experiments $|x_f| > x_T$ or $x_f \sim 0$)



Experimental setup

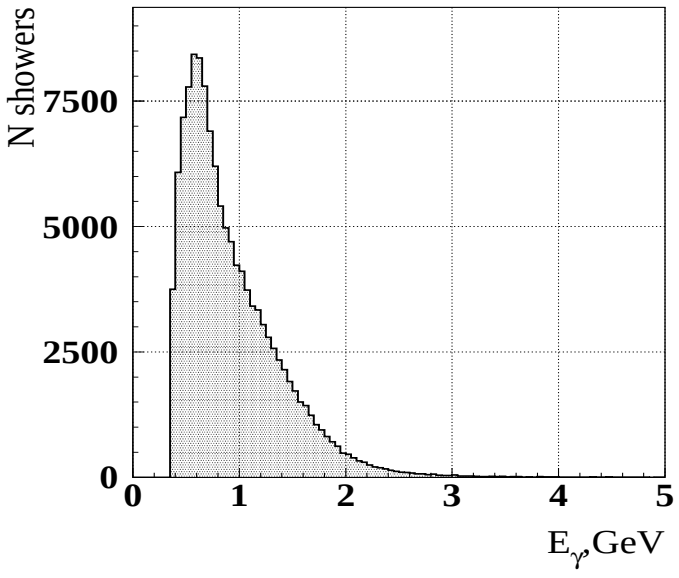
- Experiment was carried out at the U-70 accelerator in 2000.
- 40 GeV negative particles beam ($\pi^- : K^- : \overline{p} \sim 97 : 2.5 : 0.5$ (%)); intensity 10^6 particles/cycle
- Polarized hydrogen target ($C_3H_8O_2$)
- γ-quanta were detected by electromagnetic lead-glass calorimeter (32×24 cells), placed at 40^0 at the distance of 2.5 m downstream the target
- S1-S3: scintillation counters
- H1-H2: 5-mm and 2-mm hodoscopes
- 1st level trigger on large transverse energy E_T

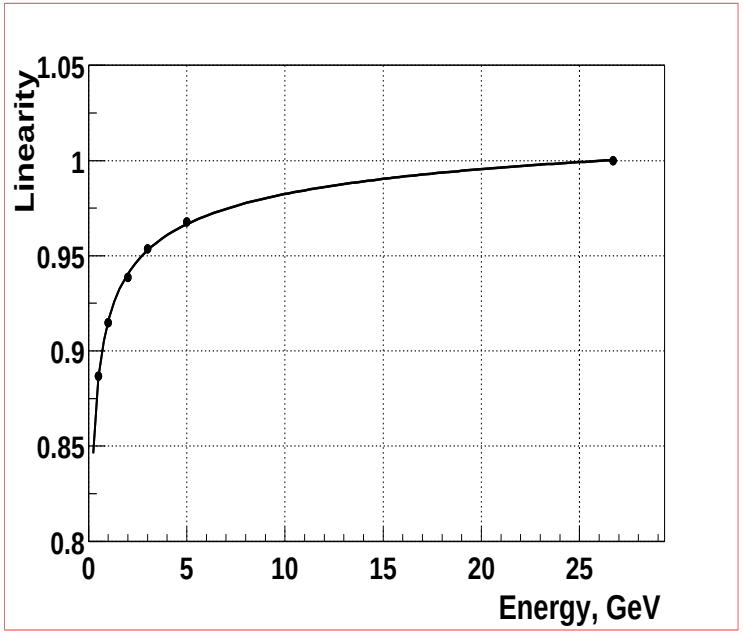


γ - quanta reconstruction

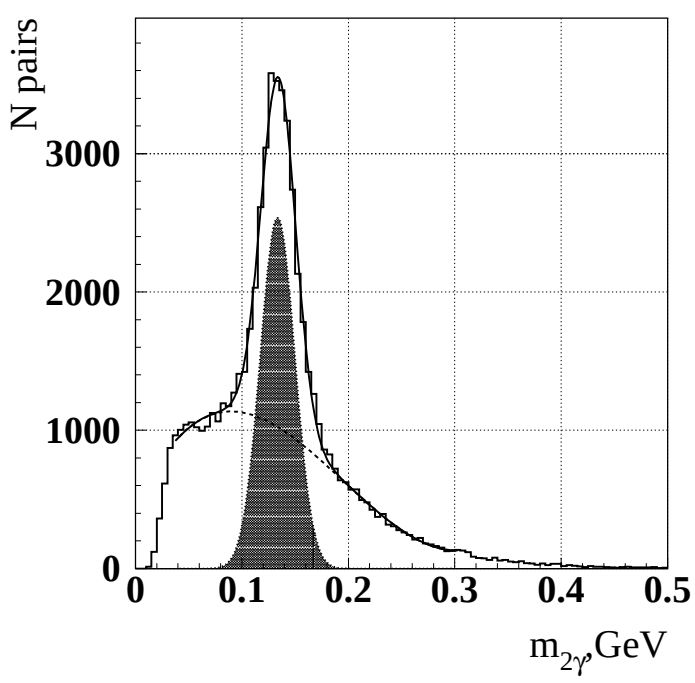
- Low E_γ (0.5 – 4.5 GeV) and electronics threshold $\sim$ 20 MeV $\Rightarrow$ energy losses
- Cherenkov light simulation

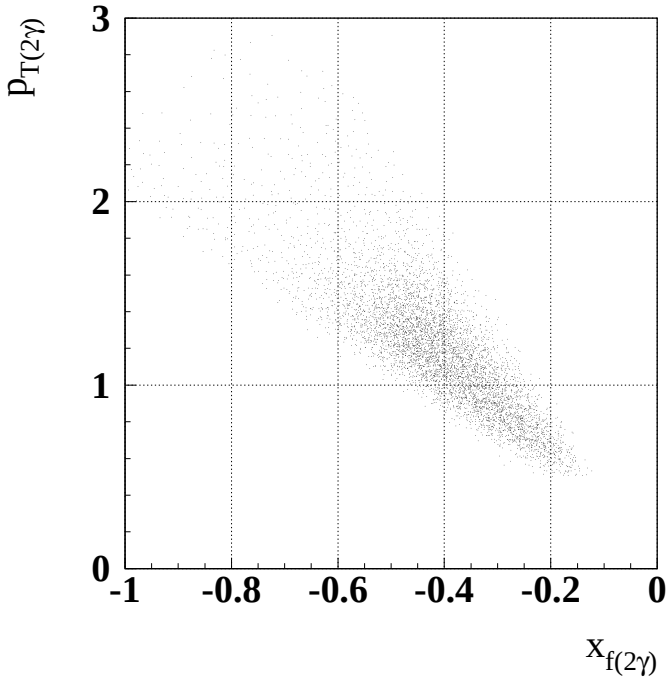
Reconstructed energy and γ-quanta reconstruction efficiency





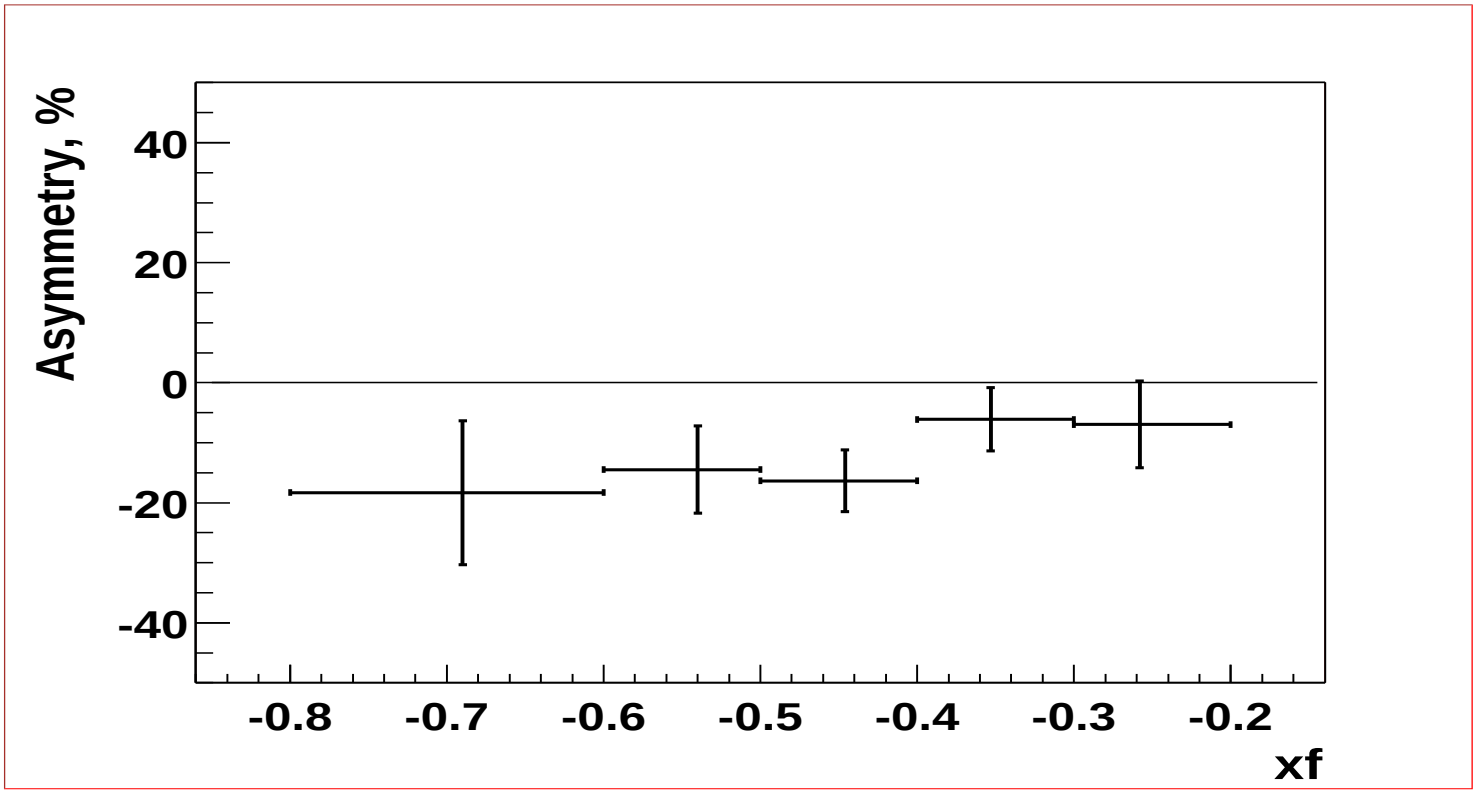
2 γ-kinematics





2γ mass ($\sigma_m = 15$ MeV) (left) and p_t vs x_f distribution (right).

A_N in reaction $\pi^- + p_\uparrow \to \pi^0 + X$

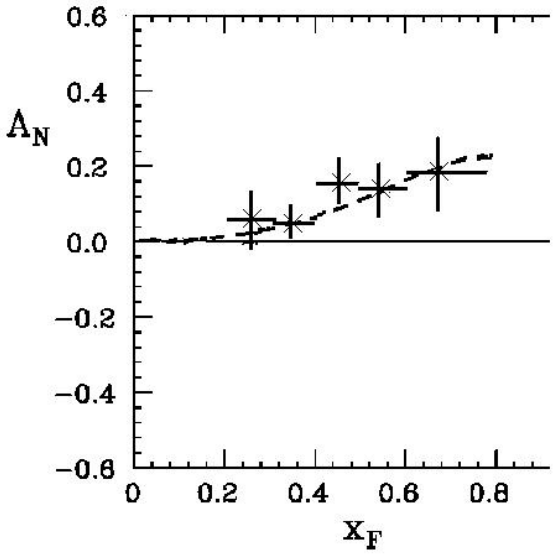


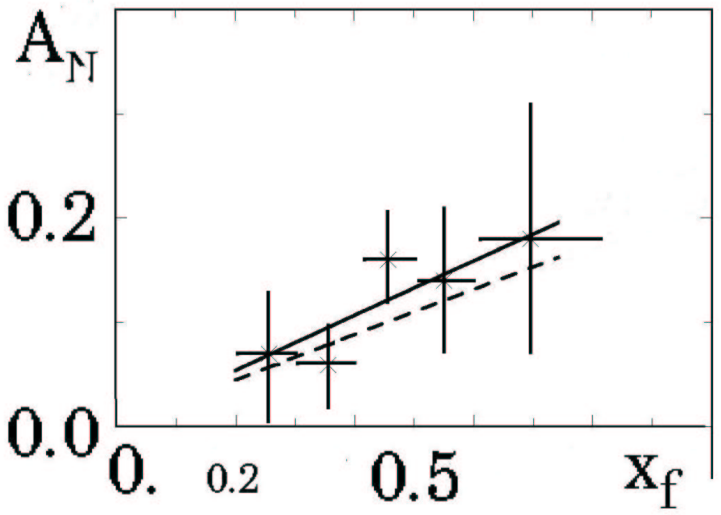
$A_N = (-16 \pm 4)\%$ at $|x_f| > 0.4$, $A_N \sim 0$ at $|x_f| < 0.4$

Models explaining single spin asymmetry

- high twist models
- additional parton transverse momenta $\boldsymbol{k}_T$
  - in density functions – *initial state* (Sivers)
  - in fragmentation – *final state* (Collins)
- quark orbital momenta
  - valence quark orbital momenta (Berlin model)
  - orbital angular momentum of quark-antiquark cloud in internal structure of constituent quarks (SU-6 model)

Theoretical models predictions

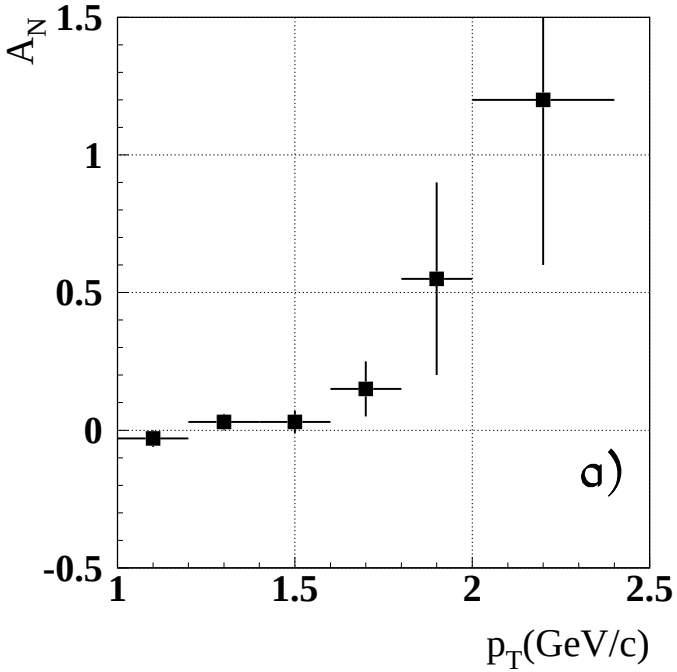


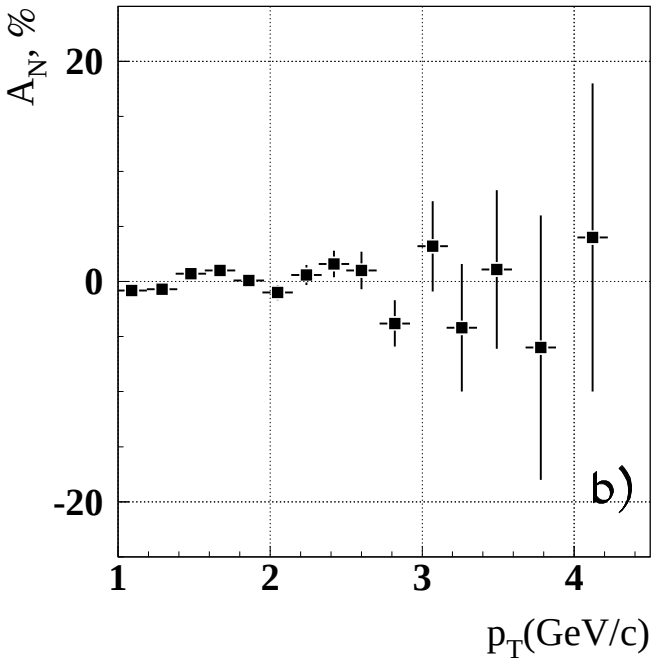


Predictions for Sivers mechanism (Anselmino) and SU-6 model (Troshin-Tyurin); points – our results (x_f and A_N are inverted to the polarized beam fragmentation coordinate system)

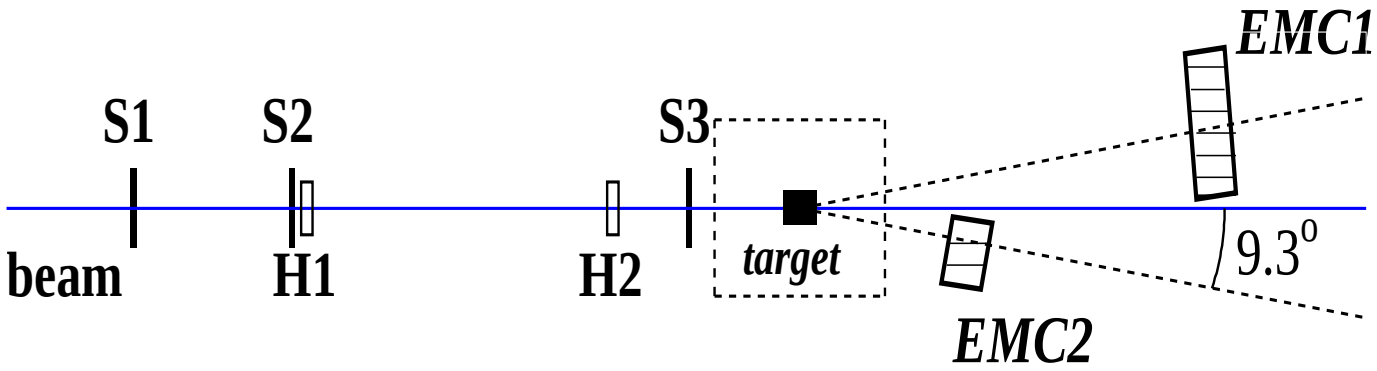
A_N in reaction $p + p_\uparrow \to \pi^0 + X$ at 70 GeV

Main goal: try to understand inconsistency between CERN (24 GeV, left figure) and FNAL (200 GeV) data at central π^0-production





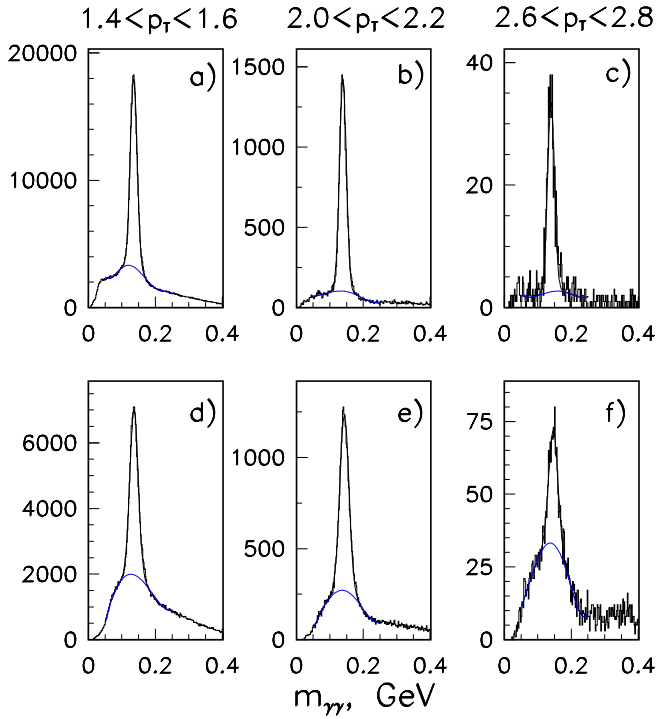
A_N measurements in central region

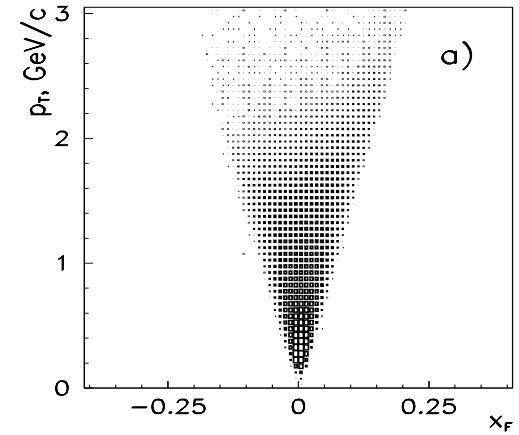


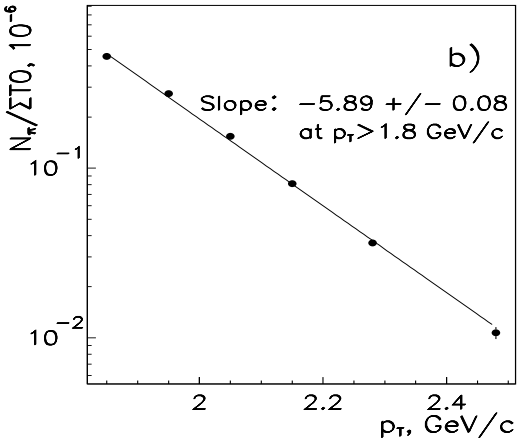
• EMC1 and EMC2: electromagnetic calorimeters of 480 and 144 lead glass cells (7 and 2.8 m downstream the target respectively)

• 70 GeV proton beam was extracted from the accelerator main ring with the use of a bended crystal (intensity 10^7 particles/cycle)

π^0 reconstruction







2γ mass (left), p_t vs x_f distribution (a)

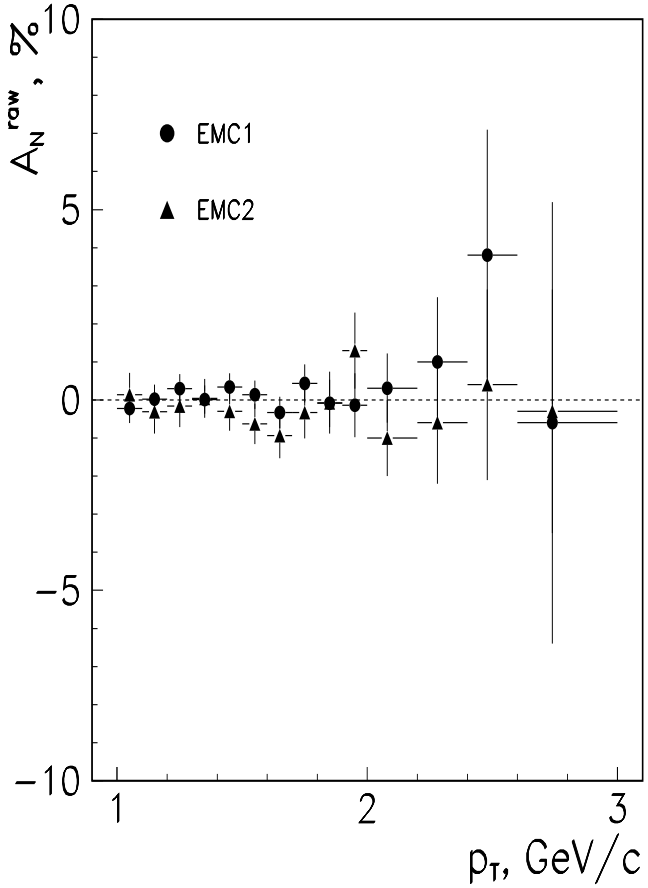
and normalized number of π^0's (b)

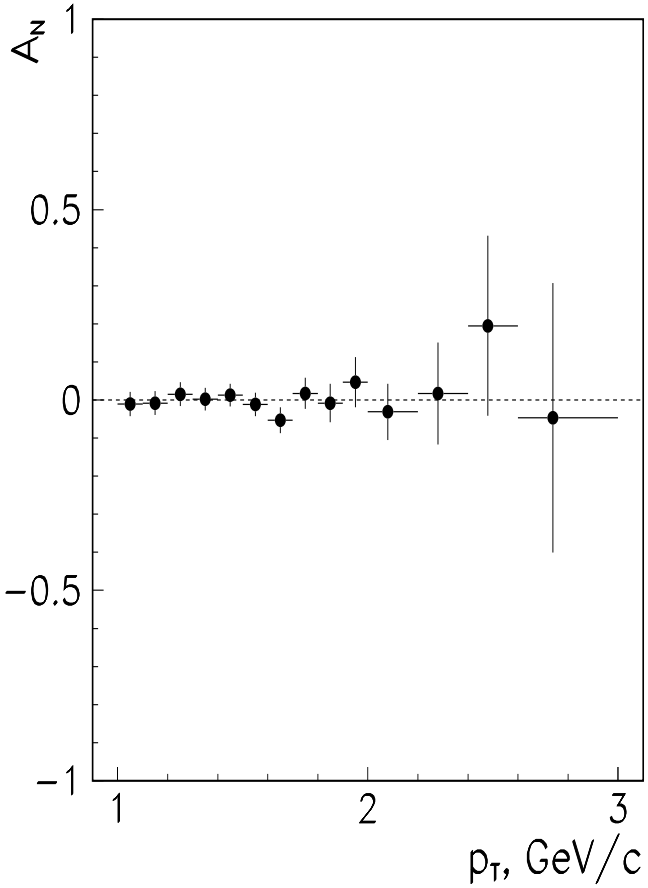
π^0-slope: -5.89 ± 0.08 (PROZA)

π^+-slope: -5.68 ± 0.02 (FODS, Protvino)

π^--slope: -5.88 ± 0.02 (FODS, Protvino)

π^0 asymmetries



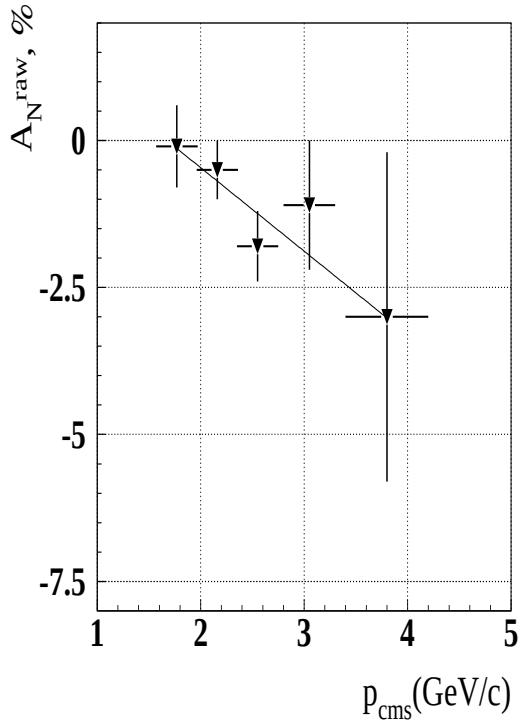


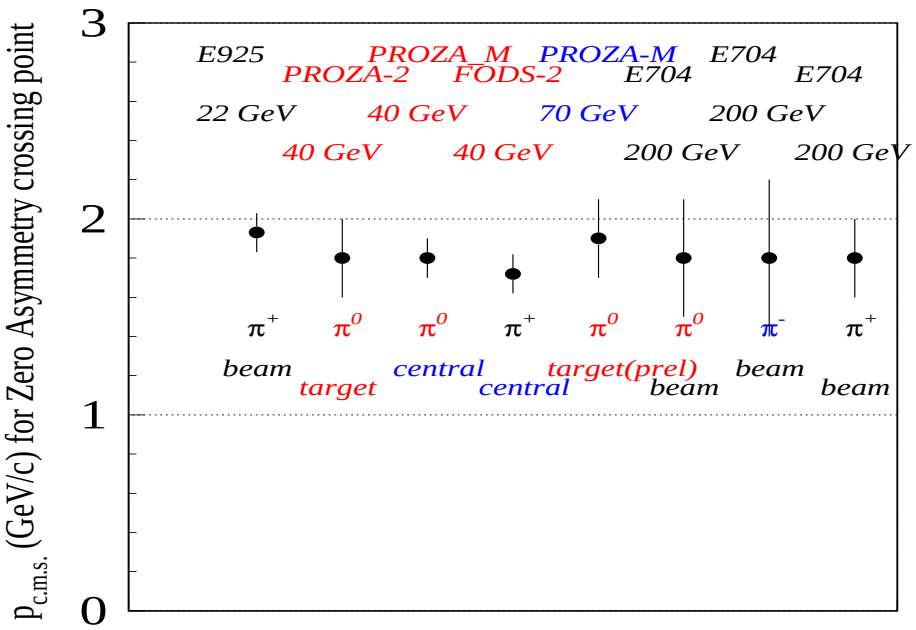
Raw asymmetries for two detectors separately (left) and summed A_N

Possible scaling search

Asymmetry starts to grow at $x_f \sim 0.2$ – E704 (FNAL, 200 GeV) and at $x_f \sim 0.55$ – E925 (BNL, 22 GeV)

Try to find p_{cms} point, where A_N starts to grow





Summary

- $A_N = (-16 \pm 4)\%$ in reaction $\pi^- + p_\uparrow \to \pi^0 + X$ in polarized target fragmentation region ($x_F < -0.4$, $p_T > 1.$ GeV/c) at 40 GeV ($\sqrt{s} \sim 9$ GeV) and close to zero at small $|x_f|$
- The result is similar to π^0 asymmetry in polarized beam fragmentation region: E704 ($(9 \pm 0.9)\%$, $\sqrt{s} = 20$ GeV) and STAR ($(1_4 \pm 4)\%$, $\sqrt{s} = 200$ GeV) – new reaction for polarimetry
- A_N in $p + p_\uparrow \to \pi^0 + X$ at 70 GeV equals to zero for $1.0 < p_T < 3.0$ GeV/c
- Results are in agreement with theoretical models predictions
- Asymmetry (if nonzero) starts to grow at $p_{cms} \sim 1.8$ GeV/c independent on E_{beam} and kinematic region

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