Recent Results from Protvino Polarized Experiment PROZA-M

V.Mochalov

on behalf of PROZA-M collaboration

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Outline

Search for single-spin asymmetry in inclusive π^0 production in central region in $pp_\uparrow$-collisions at 70 GeV/c.

Measurement of the single-spin asymmetry in inclusive π^0 production in polarized target fragmentation region in collisions of the negative pions with protons at 40 GeV/c.

Asymmetry behaviour on dependence of π-meson center of mass energy.

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} – average target polarization;

ϕ – azimuthal angle;

(Due to small angles ϕ, it was considered $|\cos\phi| = 1$).

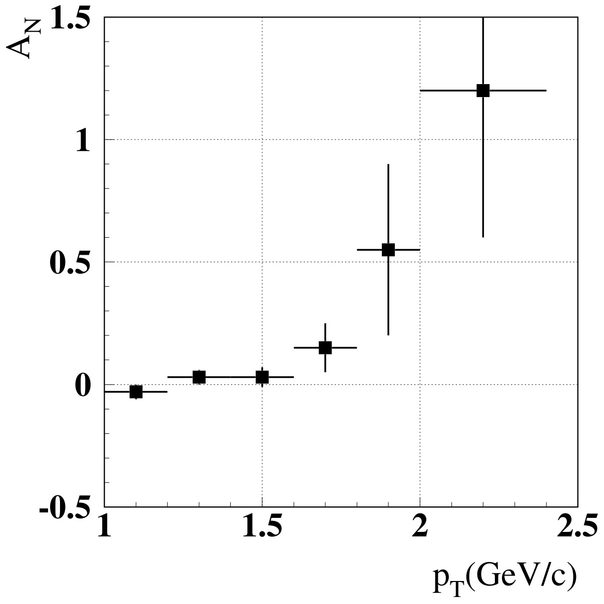
Measured asymmetry

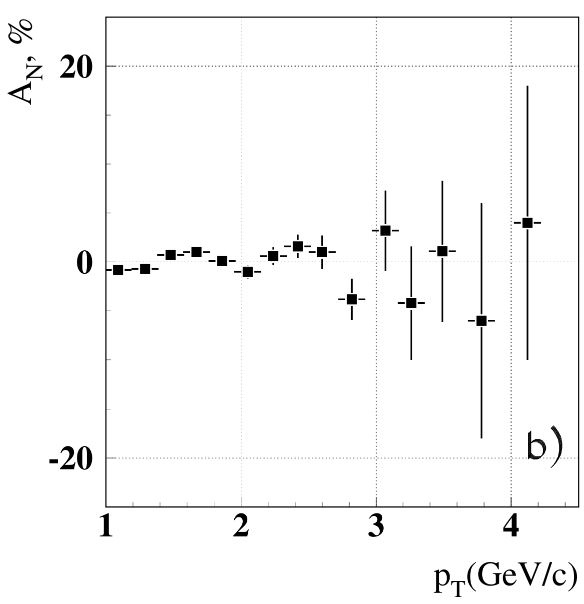
$$A_N = \frac{D(x_f,p_t)}{P_{target}} \cdot A_N^{raw}(x_f, p_t) = \frac{D(x_f,p_t)}{P_{target}} \cdot \frac{n_\uparrow(x_f,p_t) - n_\downarrow(x_f,p_t)}{n_\uparrow(x_f,p_t) + n_\downarrow(x_f,p_t)}$$

D - Dilution factor (Complex nuclei)

Search for single-spin asymmetry in inclusive π^0 production in central region in $pp_\uparrow$-collisions at 70 GeV/c.

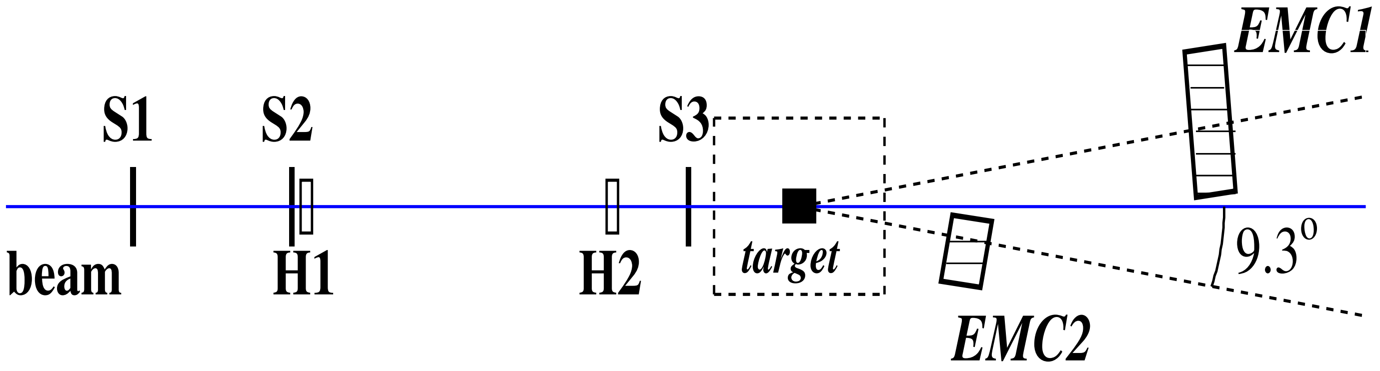
There is difference between CERN (24 GeV, left) and FNAL (200 GeV, right) results.





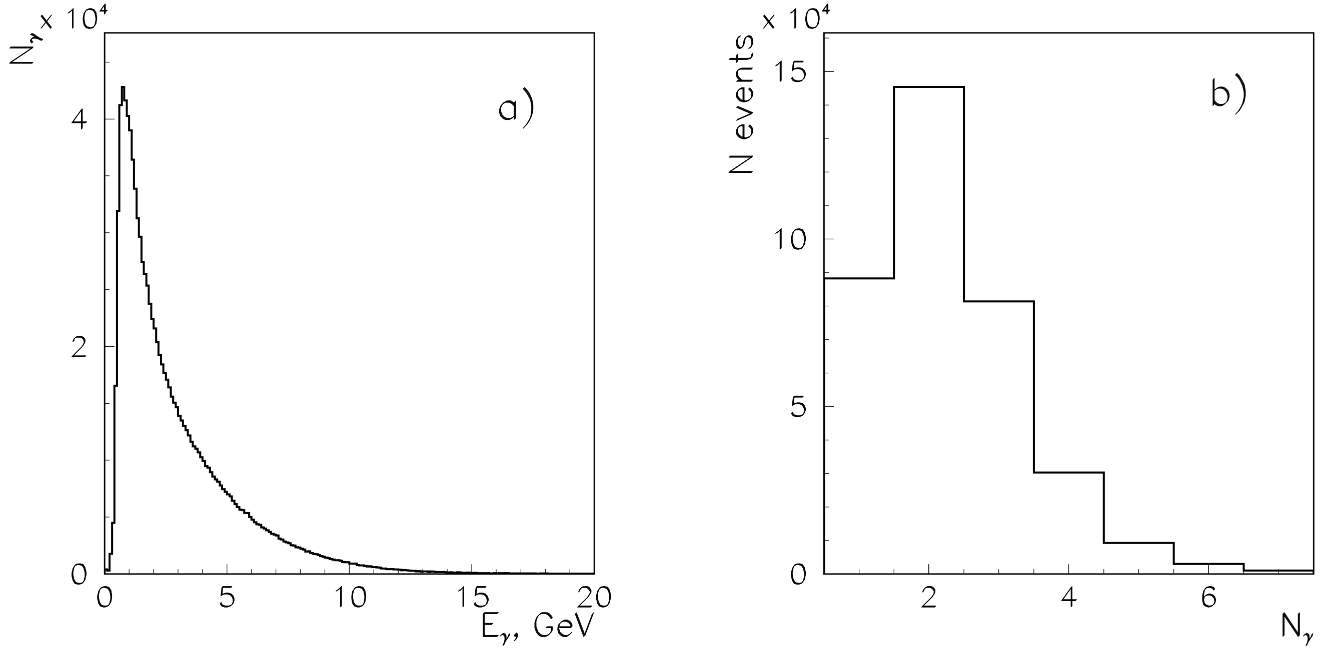
Experimental setup

- Experiment was carried out at the U-70 accelerator in 1996.
- The proton beam was extracted using bent crystal (Intensity up to 10^7 protons/cycle)
- Polarized hydrogen target ($C_3H_8O_2$) with 80% average polarization
- γ-quanta were detected by two electromagnetic calorimeters EMC1 and EMC2 of 480 cells and 144 cells (7 m and 2.8 m downstream target)
- S1-S3: scintillation counters; H1-H2: 5-mm and 2-mm hodoscopes
- 1st level trigger on transverse energy E_T



π^0 - registration

- γ - quanta energy from 1 to 20 GeV
- γ -quanta multiplicity – 2.3



Mass spectra

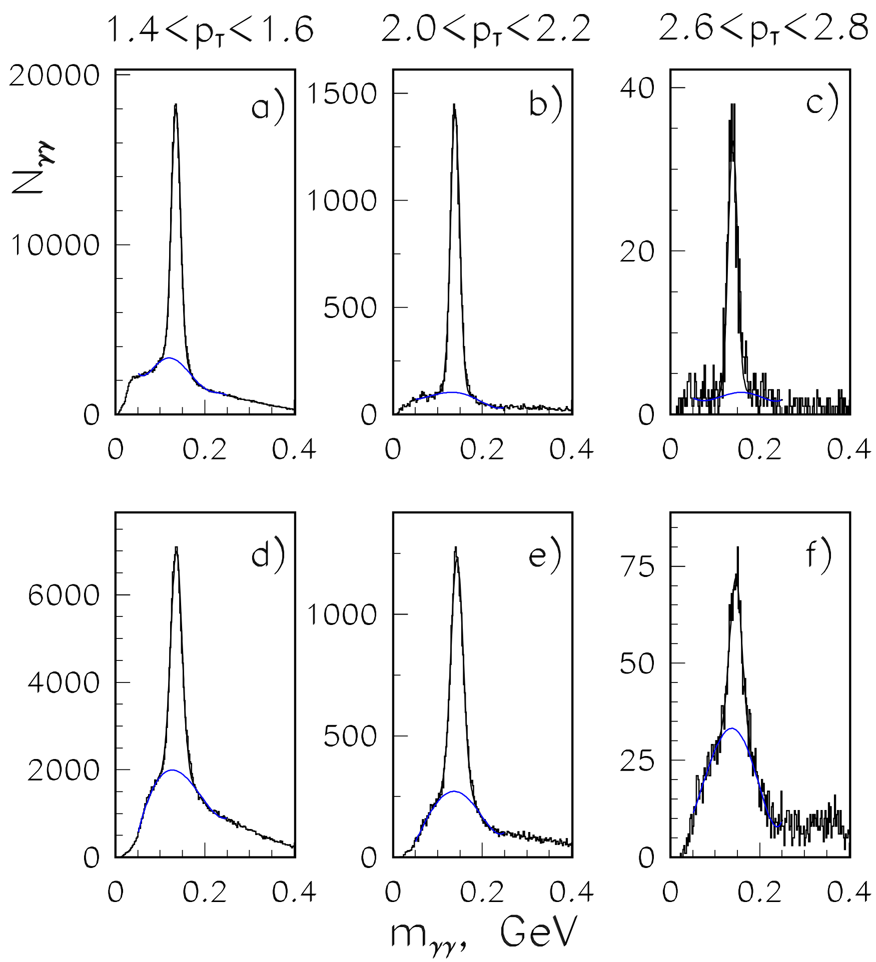
π^0 -resolution:

< 11 MeV for EMC1

from 12 to 17 MeV
for EMC2

in different p_T intervals

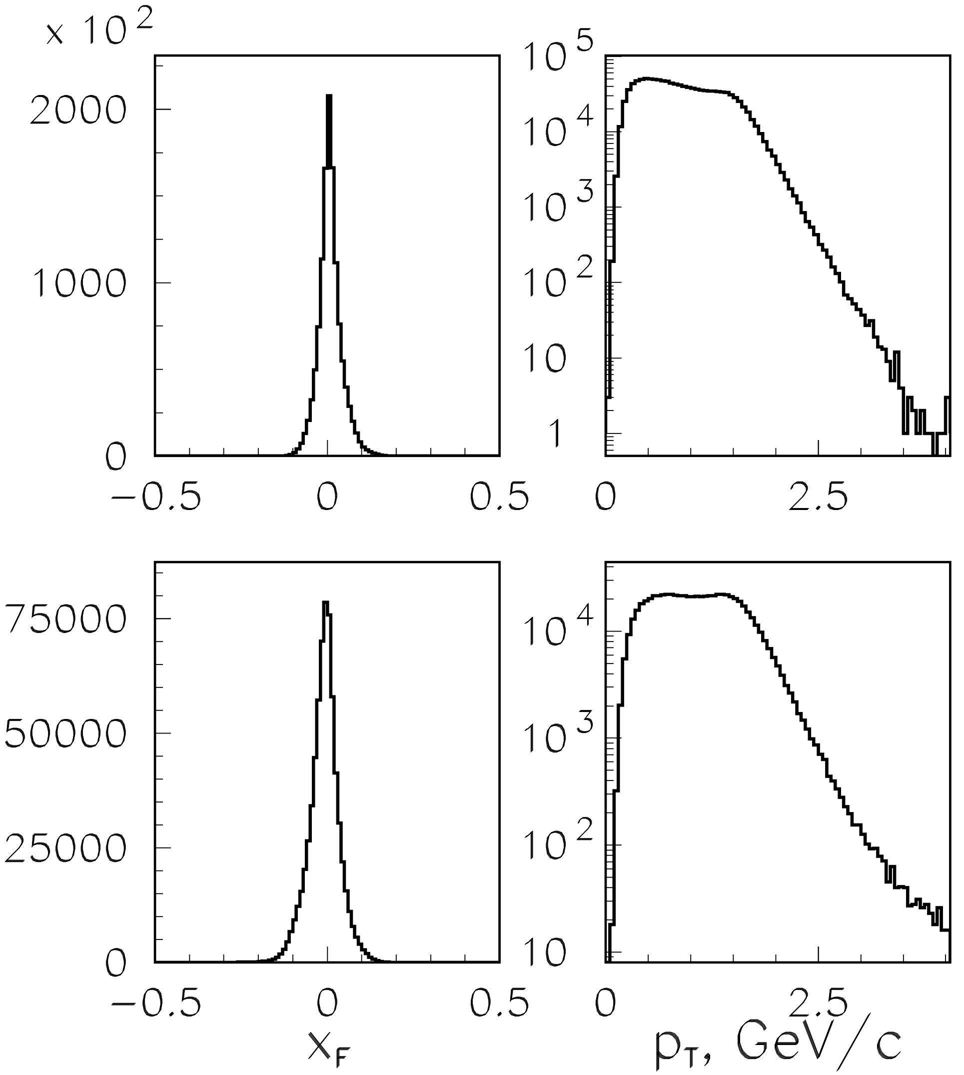
Signal/background > 7



Kinematics

x_F (left) and p_T distribution of γ-pairs for EMC1 (upper row) and EMC2 (bottom) at π^0-mass region.

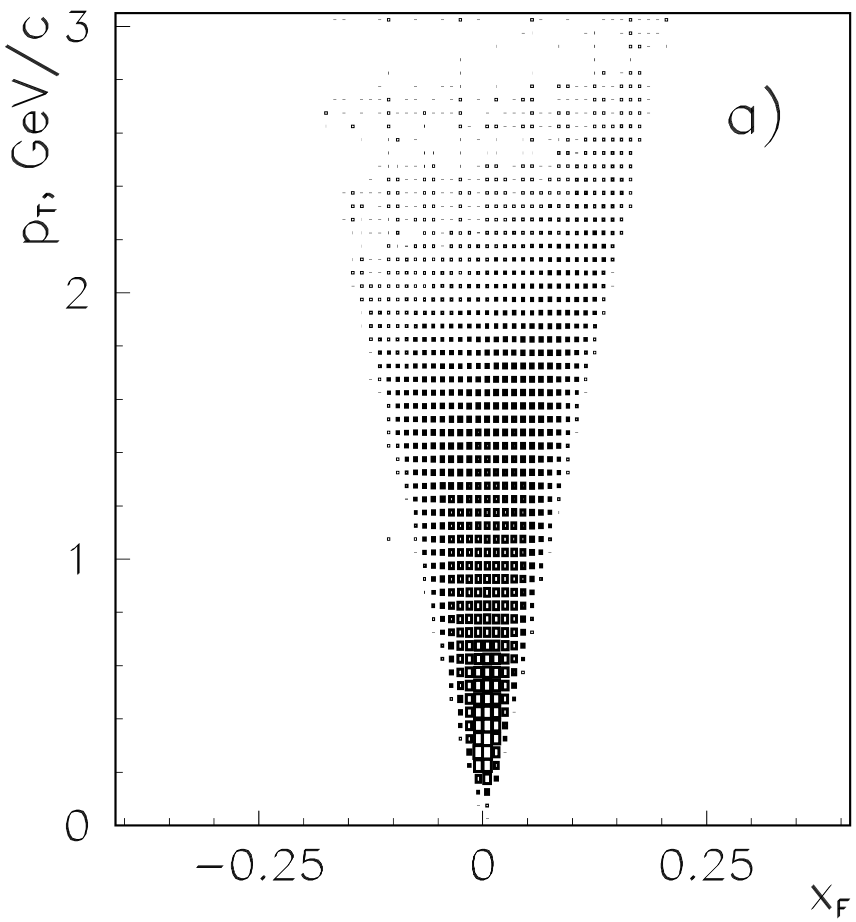
Registration efficiency is not taken into account



Kinematics (cont'd)

Two-dimensional p_T vs x_F π^0-distribution

Distribution is symmetrical on x_F

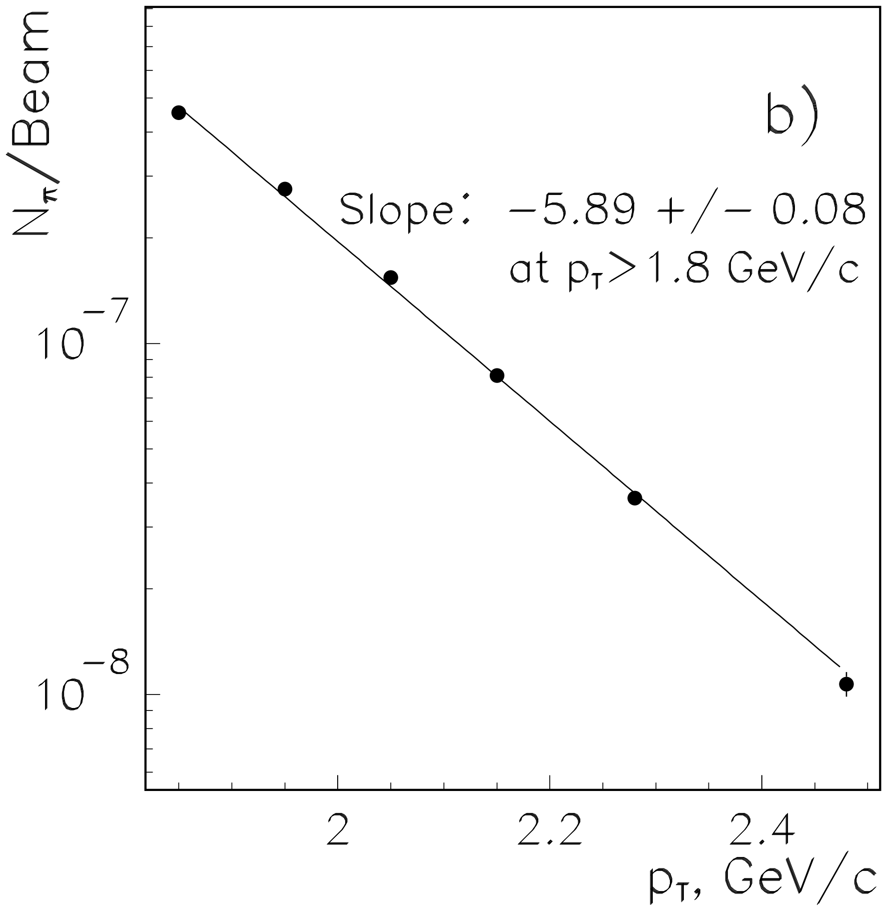


p_T slope

Invariant cross-section slopes at $p_T > 1.8$ (FODS) at 70 GeV (V.Abramov et al., IHEP Preprint 84-88)

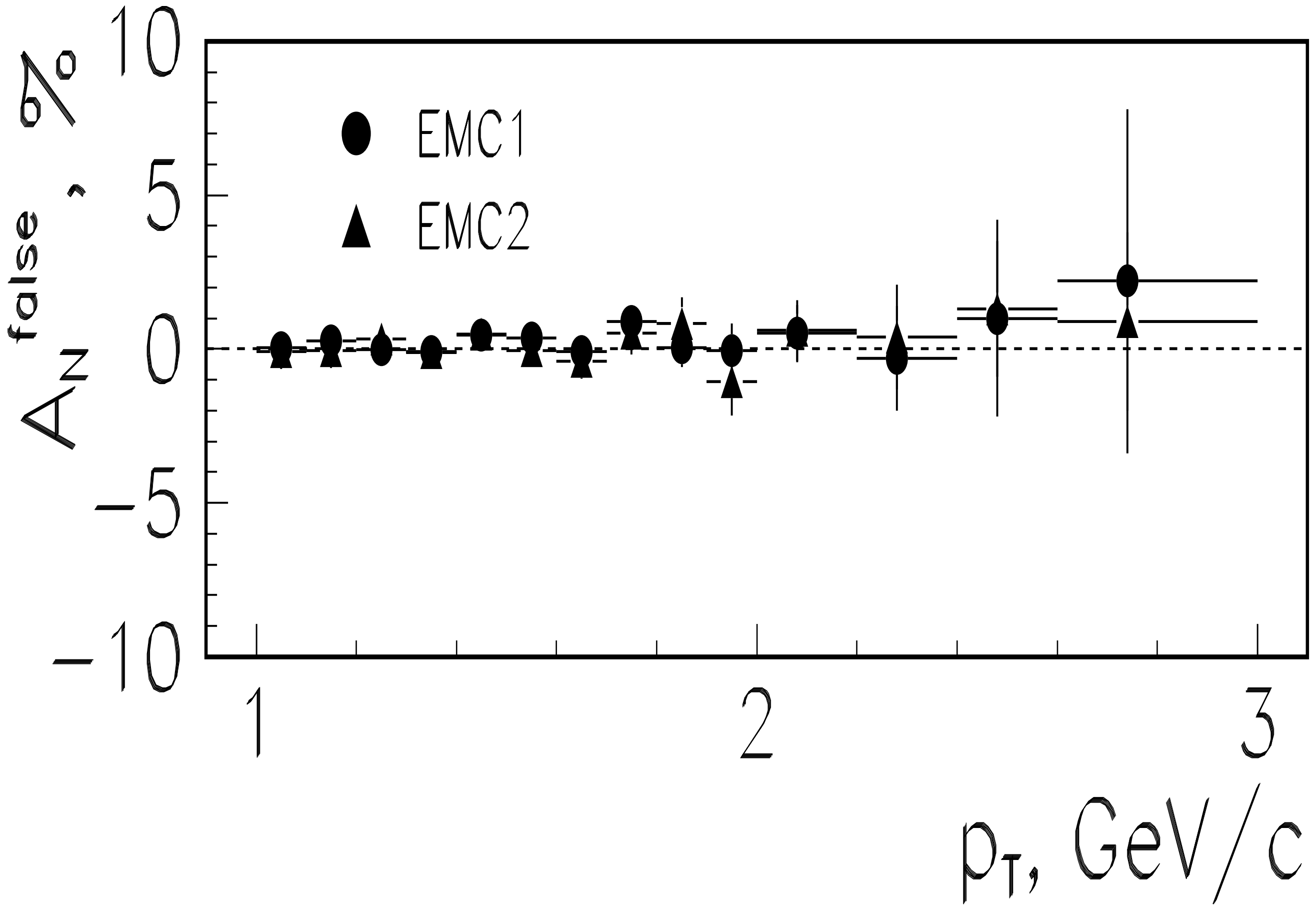
-5.68 ± 0.02 for $\pi+$

-5.88 ± 0.02 for π^-

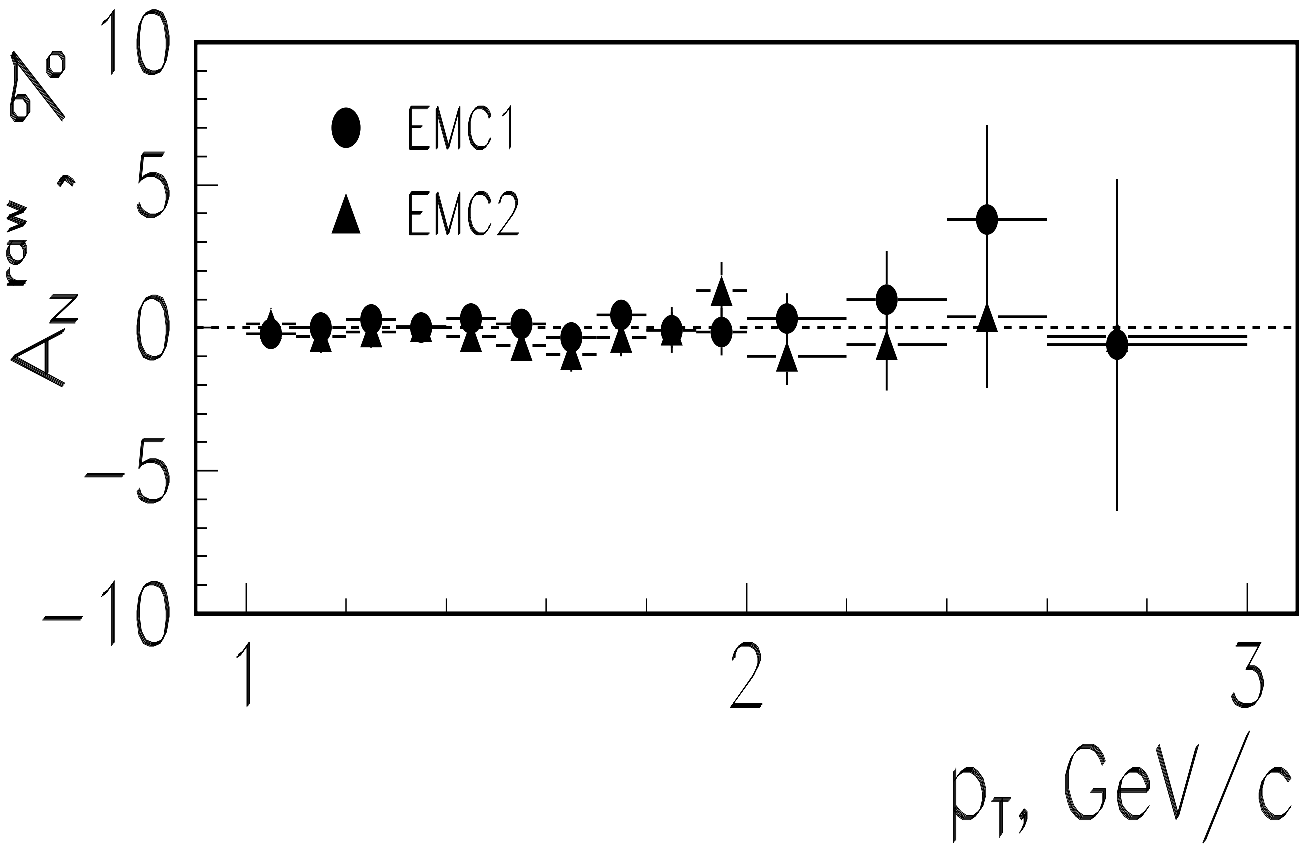


p_T resolution 0.08 GeV/c

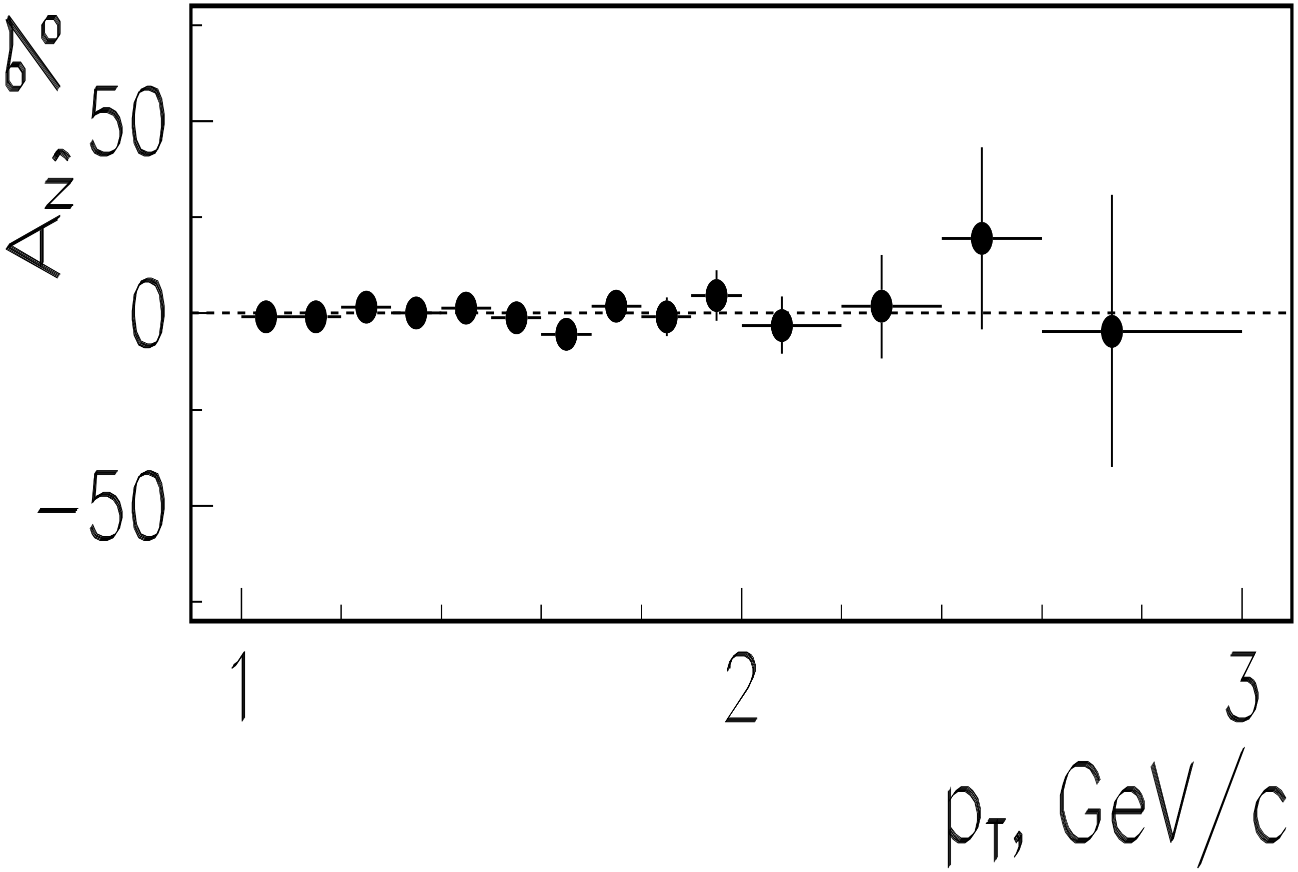
False asymmetry



Asymmetry for two different detectors



Final (summed) asymmetry



Conclusion from 70 GeV data

- Asymmetry in $p + p_{\uparrow} \rightarrow \pi^0 + X$ at 70 GeV and $1.0 < p_T < 3.0$ GeV/c equals zero within error bars in agreement with E704 measurements at 200 GeV and differs from CERN 24 GeV data.

- From comparison of presented result with 40 GeV pion data we may conclude that the asymmetry depends on quark flavor.

- Theoretical models predict small asymmetry in this region.

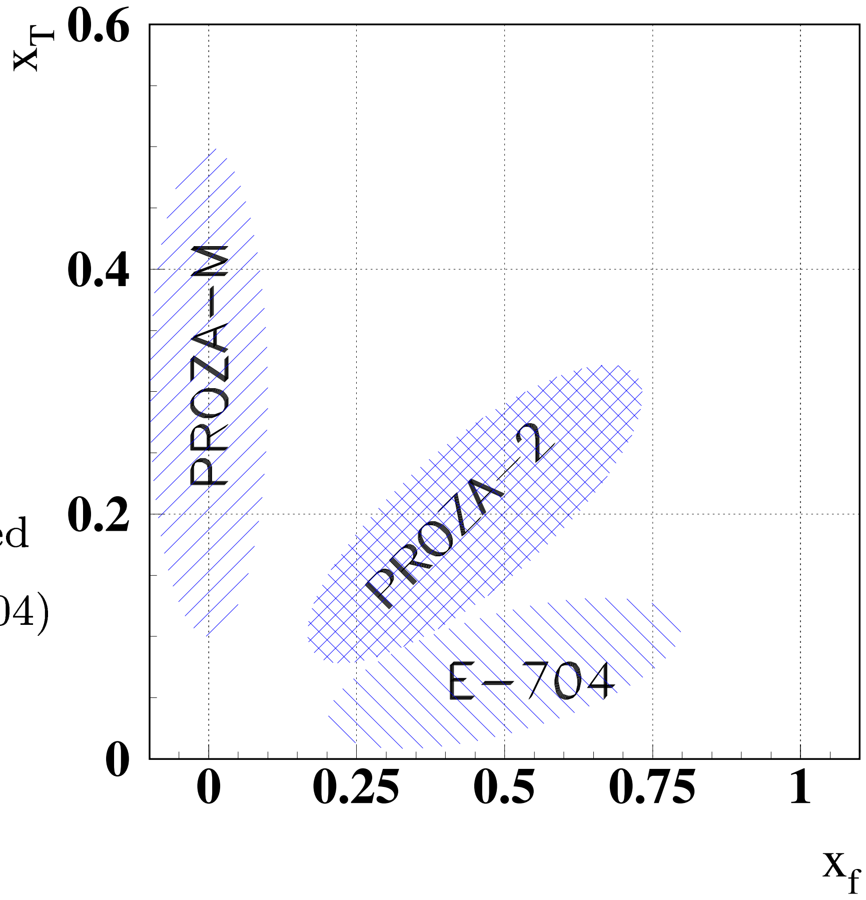
Measurement of the single-spin asymmetry in inclusive π^0 production in polarized target fragmentation region in collisions of the negative pions with protons at 40 GeV/c.

- 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)

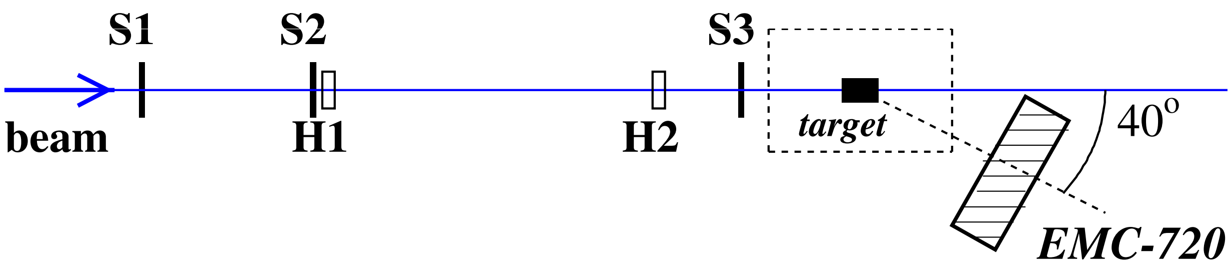
- Measurements for close values of $|x_f|$ and x_T

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



Experimental setup

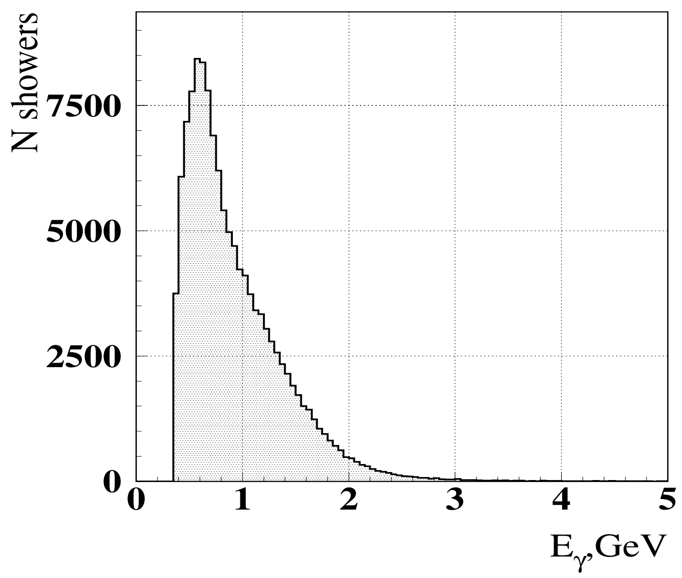
- Experiment was carried out at the U-70 accelerator in 1999-2000.
- 40 GeV negative particles beam ($\pi^- : K^- : \overline{p} \sim 97 : 2.5 : 0.5(\%)$); intensity 10^6 particles/cycle
- γ-quanta were detected by electromagnetic lead-glass calorimeter (32×24 cells), placed at 40° or 30° at the distance of 2.5 m downstream the target

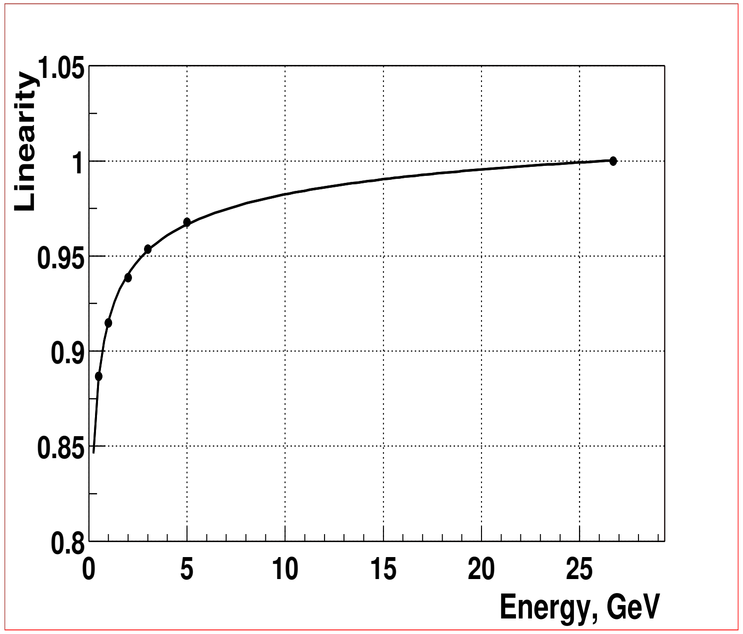


γ - quanta reconstruction

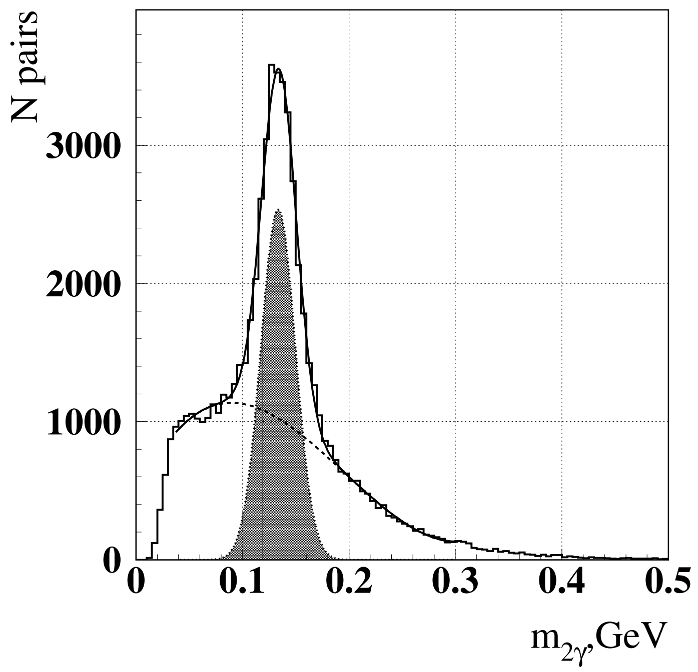
- Low E_γ (0.5 – 4.5 GeV) and electronics threshold $\sim$ 20 MeV $\Rightarrow$ energy losses
- Cherenkov light simulation

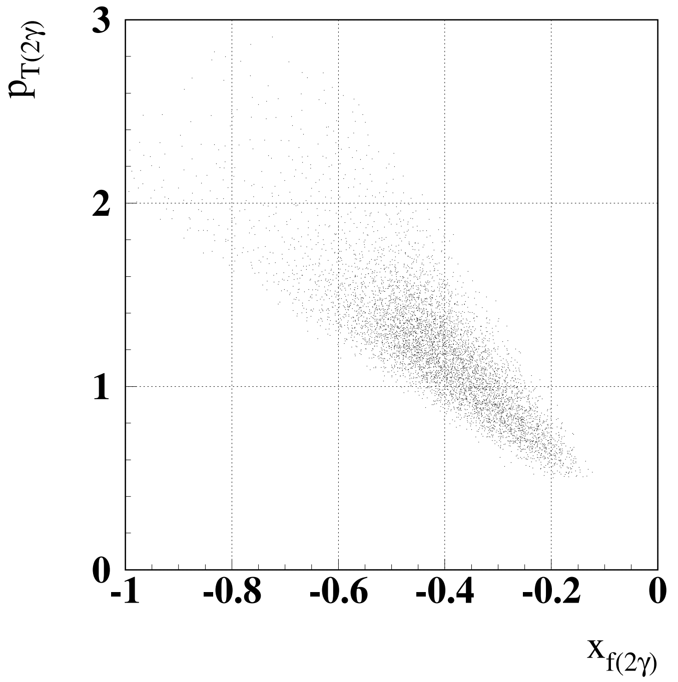
γ-quanta energy spectrum(left) and Detected energy vs true energy from MC-simulation





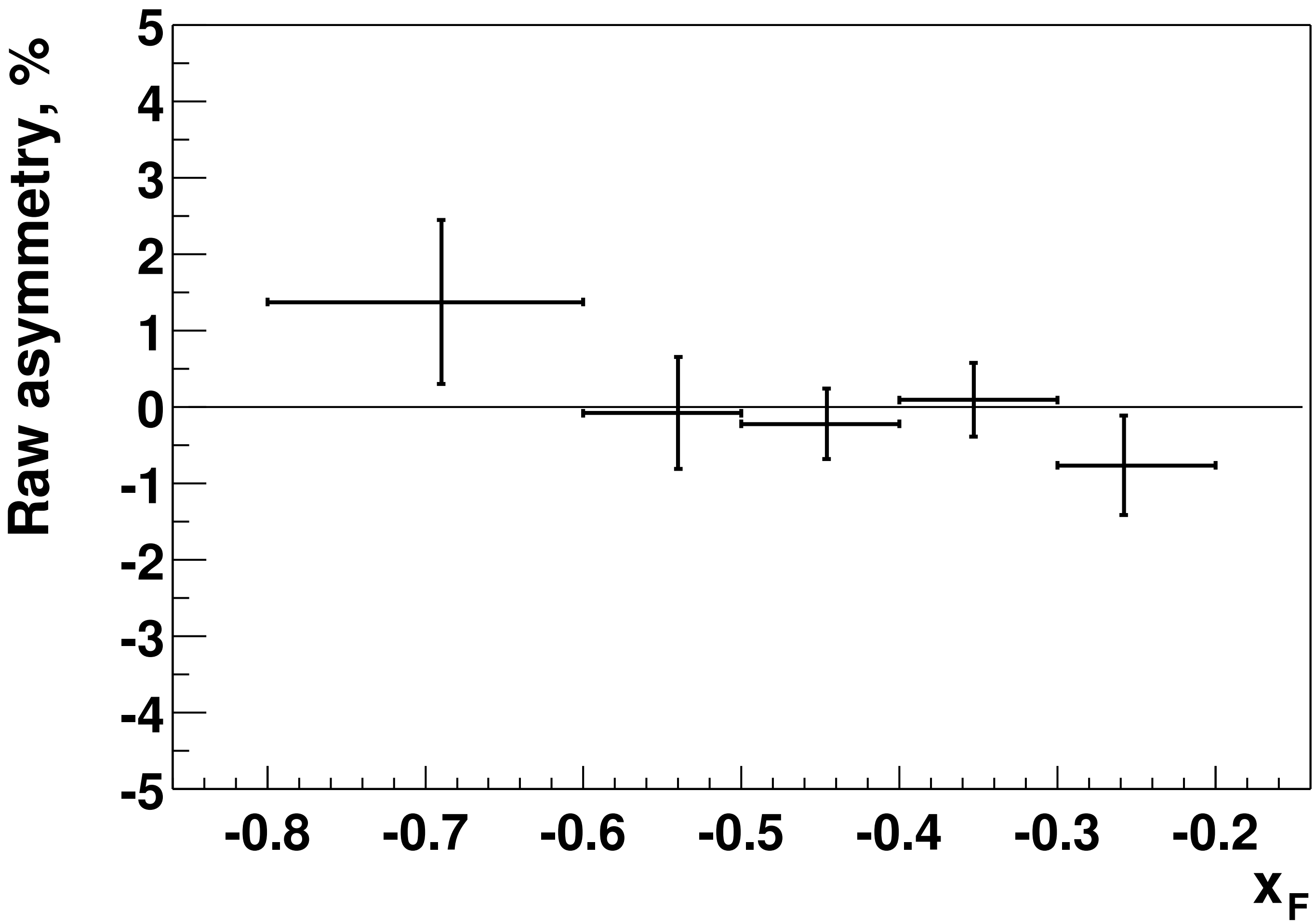
2 γ-kinematics



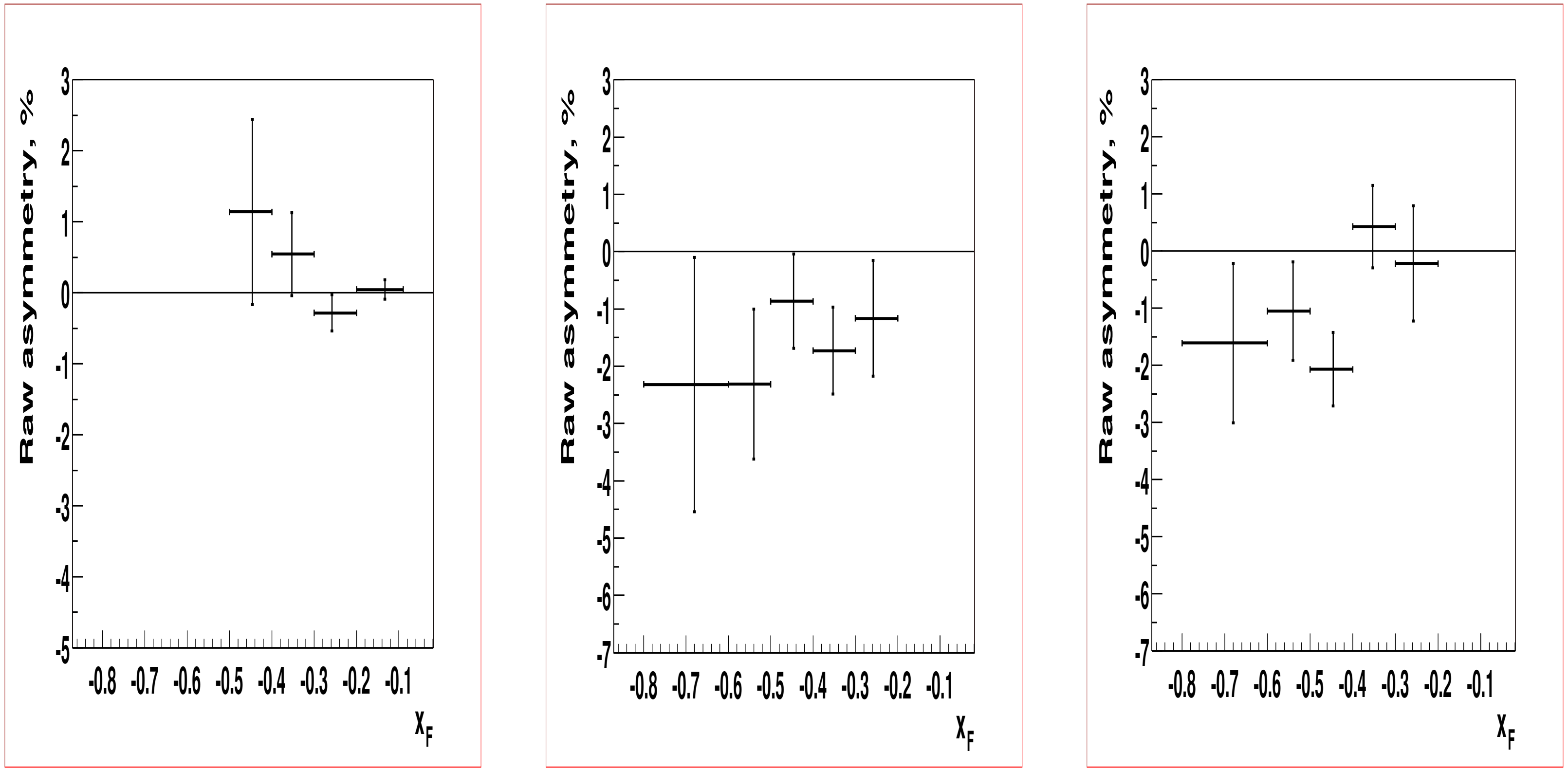


2γ mass ($\sigma_m = 15$ MeV) (left) and p_t vs x_f distribution (right).

False asymmetry

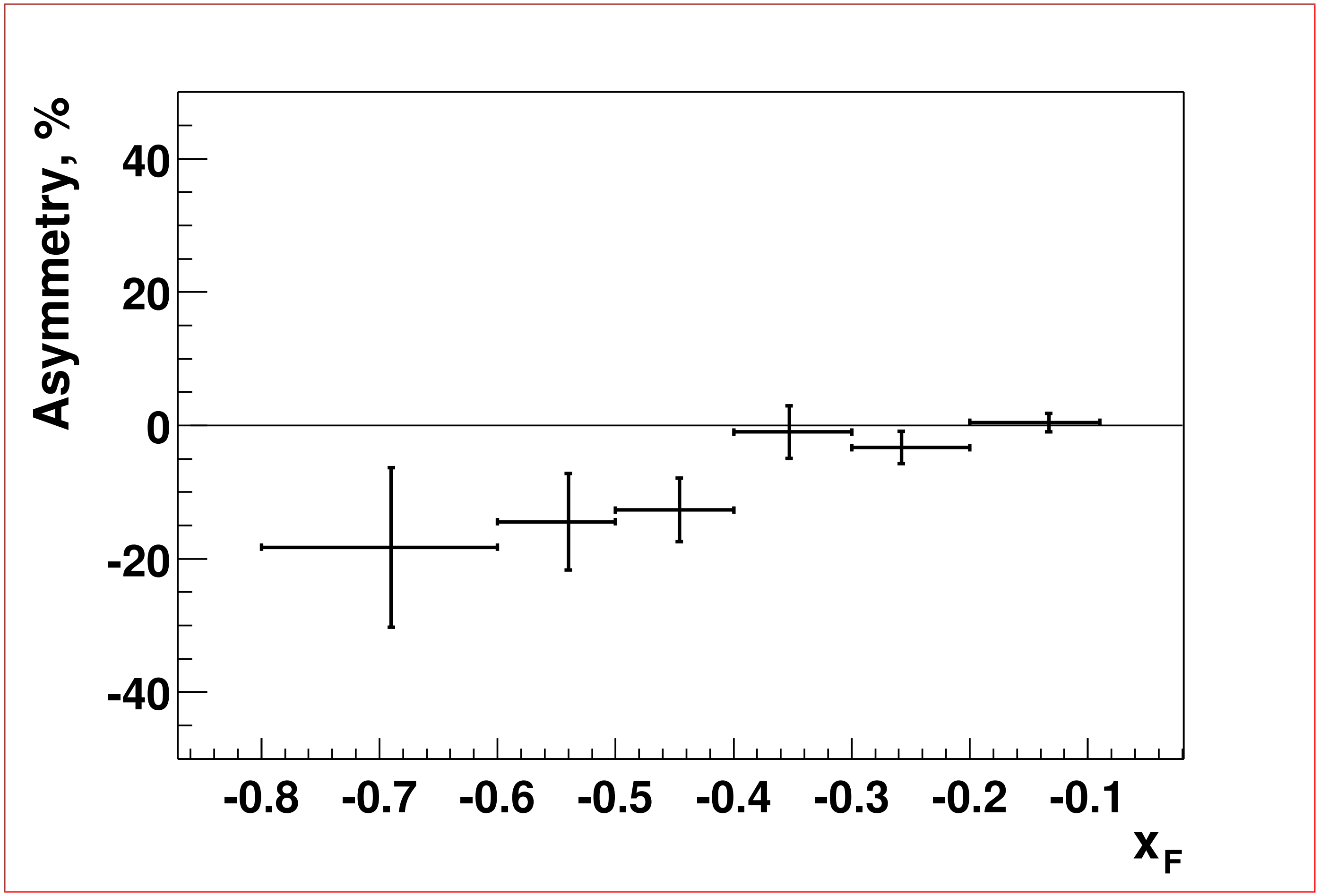


Asymmetry in three different sets of data



spring-1999   spring-2000   autumn-2000

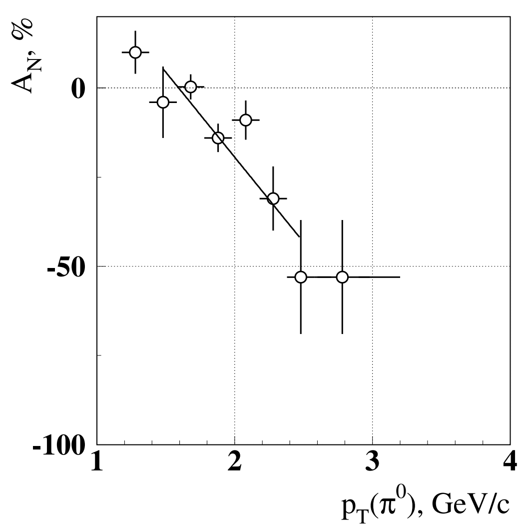
Summed Asymmetry A_N



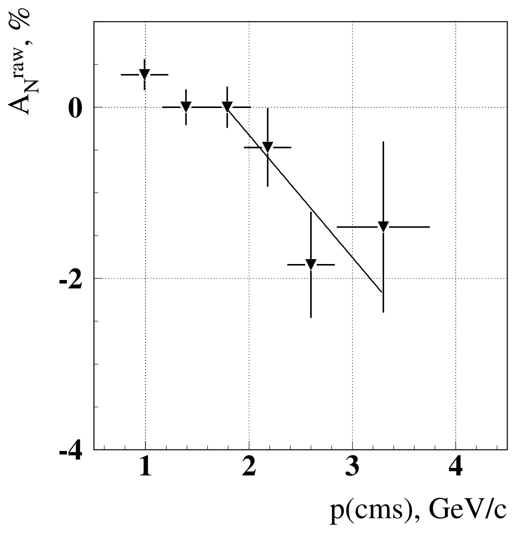
$$A_N = -13.8 \pm 3.8\% \quad -0.8 < x_F < -0.4$$

Comparison with other experiments

Experiment	$\|A_N\|, \%$
E704, FNAL	12.4 ± 1.4
STAR, BNL	14 ± 4
This experiment	13.8 ± 3.8

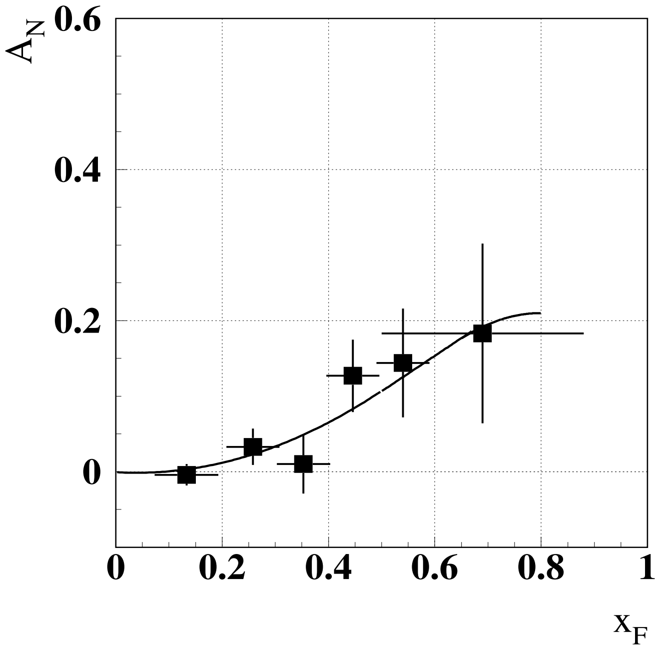


Central region

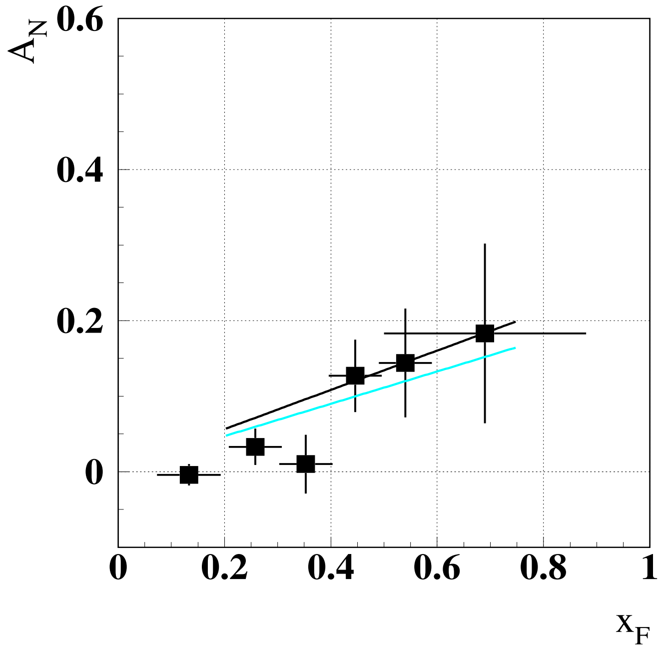


Target fragmentation region

Theoretical models prediction



Collins model



quark model for U-matrix

40 GeV Conclusions

- The π^0 inclusive production asymmetry in polarized target region was measured for the first time in reaction $\pi^- + p_\uparrow \to \pi^0 + X$.
$A_N = -13.8 \pm 3.8\%$ at $-0.8 < x_F < -0.4$ and p_T in range between 1 to 2 GeV/c.

- Asymmetry is close to zero at $-0.4 < x_F < -0.1$ and $p_T = 0.5 \div 1.5$ GeV/c.

- Asymmetry at $|x_F| > 0.4$ is in good agreement with E704 (200 GeV) and BNL (20 TeV in rest of target system) data. It was experimentally established, that asymmetry appears in polarized particle fragmentation region (independent beam or target).

- π^0- inclusive production in polarized proton region can be used for beam polarization measurements.

- In comparison with central production in $\pi^- + p_\uparrow \to \pi^0 + X$ at 40 GeV the asymmetry begins to grow at $p_0 = 1.7 \pm 0.15$ GeV/c for two different kinematic region .

- Theoretical models give adequate predictions.

Presence of the universal substructures in the hadrons— constituent quarks

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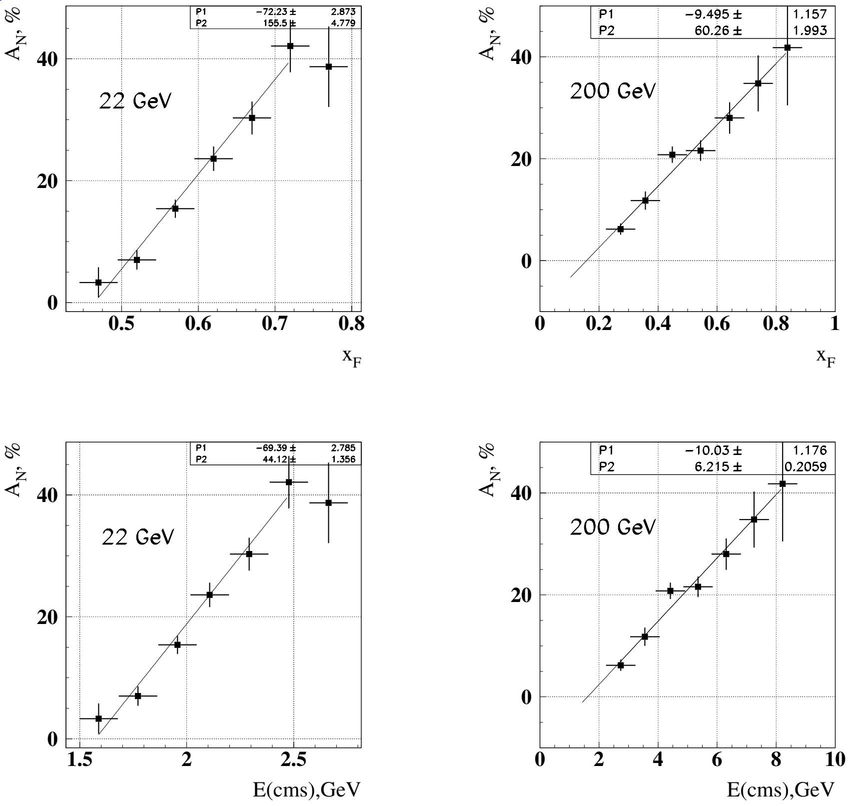
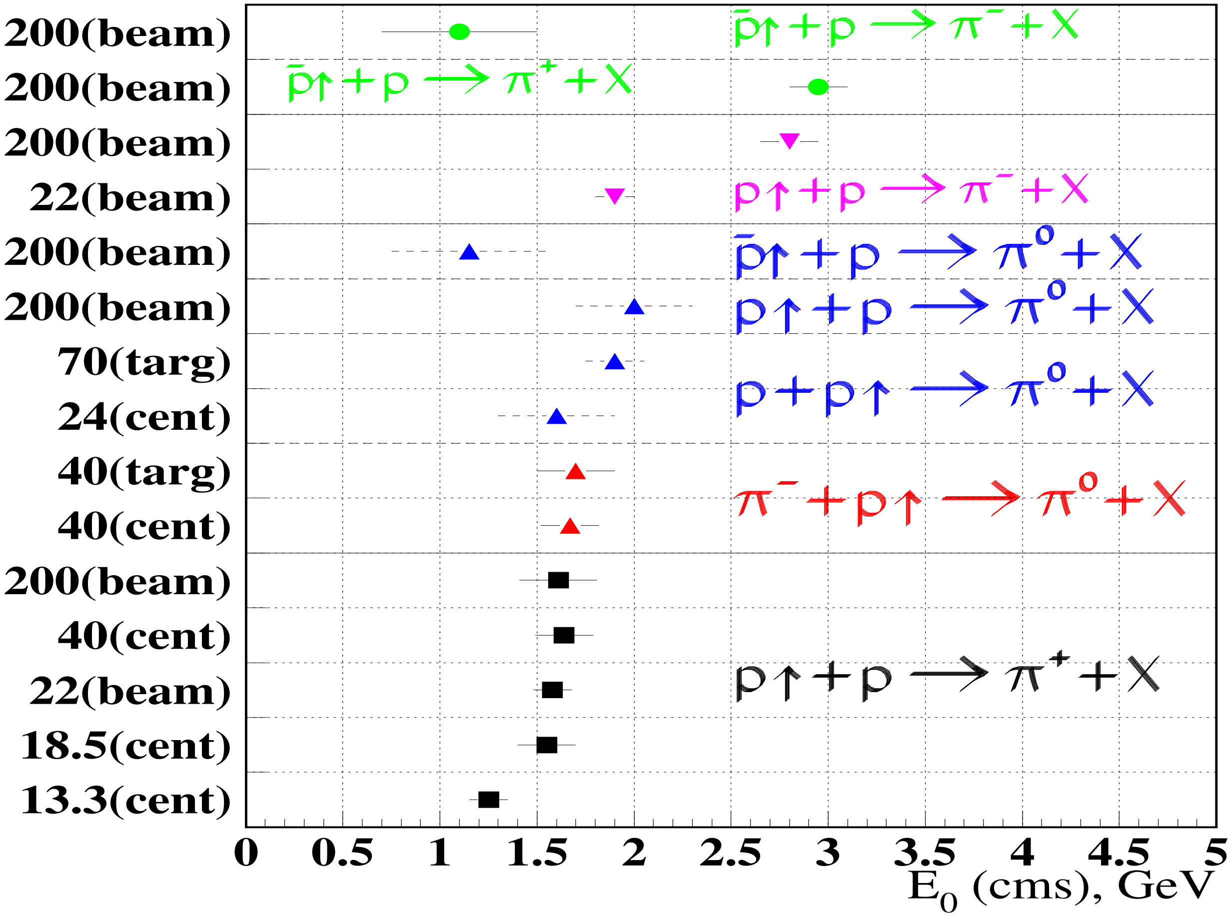
Search for general properties

In reaction $\pi^- + p_\uparrow \rightarrow \pi^0 + X$ at 40 GeV it was found that the asymmetry begins to grow at $p_0^{cms} \approx 1.7$ GeV/c



Here we investigated also data in beam fragmentation region

Zero asymmetry crossing point for different experiments



Discussion

• π meson inclusive production asymmetry begins to grow up at the energy $E^0_{cms} \sim 1.5 \div 2.$ GeV (except π^-).

• The constituent quark appears as a quasi-particle, i.e. as current valence quark surrounded by the cloud of quark-antiquark pairs of different flavors, i.e. they are structured hadron-like objects.

• The value E^0_{cms} can be related then to the minimal energy which is needed for constituent quark excitation and its dissolution. In this approach it is natural that this energy is universal since it is adherent to the properties of the constituent quarks. It should be related anyway to the scale of chiral symmetry breaking Λ^2_χ.

Summary

- Asymmetry in $p + p_{\uparrow} \to \pi^0 + X$ at 70 GeV and $1.0 < p_T < 3.0$ GeV/c equals zero in agreement with E704 at 200 GeV and differs from CERN 24 GeV data.
- The asymmetry depends on quark flavor.
- The π^0 inclusive production asymmetry $A_N = -13.8 \pm 3.8\%$ in polarized target region in reaction $\pi^- + p_{\uparrow} \to \pi^0 + X$. at $-0.8 < x_F < -0.4$ and p_T in range between 1 to 2 GeV/c in good agreement with E704 and STAR data. Established, that asymmetry appears in polarized particle fragmentation region (independent beam or target).
- π^0- inclusive production can be used for polarization measurements.
- π meson inclusive production asymmetry begins to grow up at the energy $E^0_{cms} \sim 1.5 \div 2.$ GeV.
- The value E^0_{cms} can be related then to the minimal energy which is needed for constituent quark excitation and its dissolution.

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