

A_N at small negative values of x_F in the reaction
 $p + p_{\uparrow} \rightarrow \pi^0 + X$ at 70 GeV and
universal threshold in inclusive pion production.

V. Mochalov

On behalf of the PROZA-M collaboration

List of authors

A.M. Davidenko, A.A. Derevschikov, V.N. Grishin,
V.Yu. Khodyrev, Yu.A. Matulenko, Yu.M. Melnick,
A.P. Meschanin, V.V. Mochalov, L.V. Nogach, S.B. Nurushev,
P.A. Semenov, A.F. Prudkoglyad, K.E. Shestermanov,
L.F. Soloviev, A.N. Vasiliev, A.E. Yakutin
(IHEP, Protvino, Russia)

N.S. Borisov, A.N. Fedorov, V.N. Matafonov, A.B. Neganov,
Yu.A. Plis, Yu.A. Usov
(JINR, Dubna, Russia)

A.A. Lukhanin
(KhPTI, Kharkov, Ukraine)

Outline

Search for single-spin asymmetry in inclusive π^0 production in the polarized target fragmentation region in pp_{\uparrow} -collisions at 70 GeV/c.

General behavior of pion single-spin asymmetries between 13 and 200 GeV beam energy and universal threshold.

Future measurements at PROZA-M setup.

Single-Spin Asymmetry Definition

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

P_{target} – average target polarization;

ϕ – azimuthal angle;

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

Measured asymmetry

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

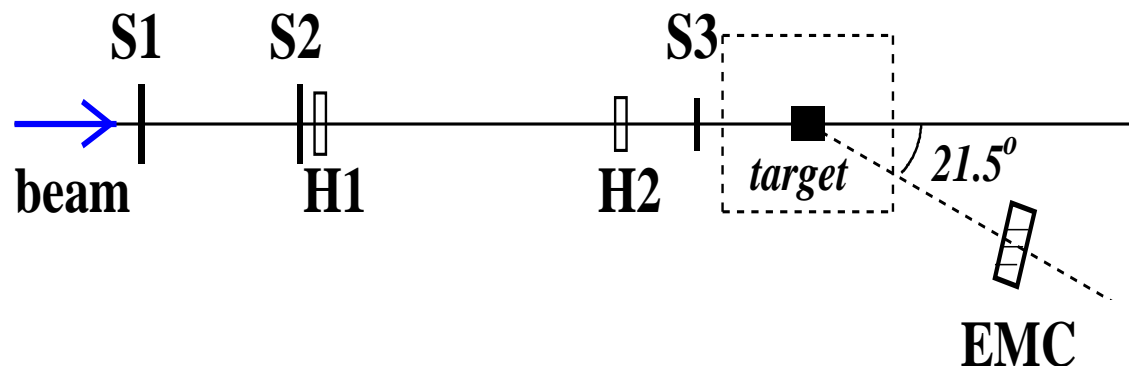
D - Dilution factor (Complex nuclei)

Previous inclusive measurements at Protvino

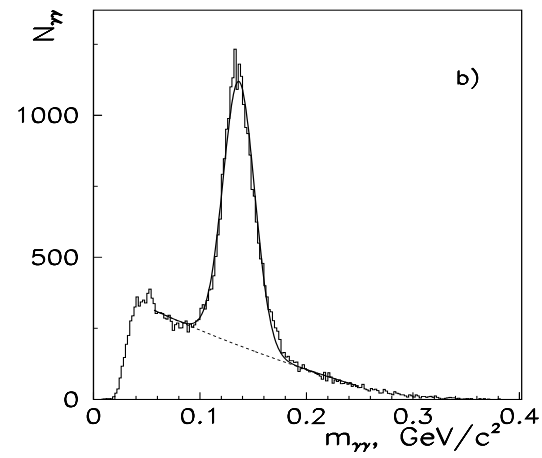
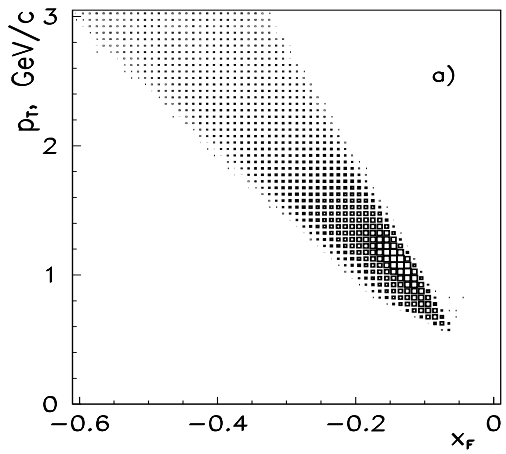
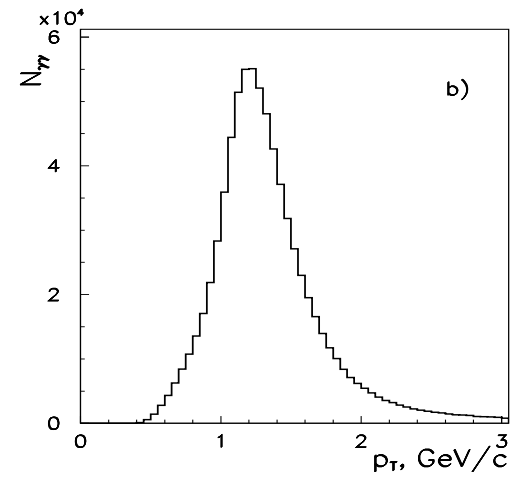
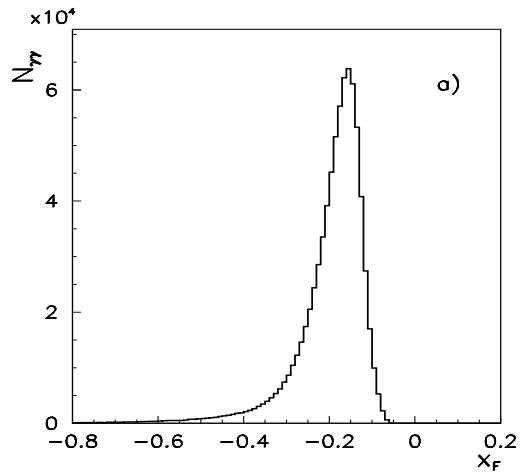
- OBSERVATION OF SIGNIFICANT SPIN EFFECTS IN HARD COLLISIONS AT 40-GEV/C
Phys.Lett.B243:461-464,1990
- Single-spin asymmetry of inclusive π^0 -meson production in 40 GeV pion interactions with a polarized target in the target fragmentation region This conference (S. Nurushev talk), IHEP Preprint 2003-21, Phys of Atomic Nuclei, Vol. 67, No. 8, p.1495, (2004)
- Searches for single-spin asymmetry in the inclusive production of neutral pion's in the central region with a proton beam energy of 70 GeV This conference (S. Nurushev talk), IHEP Preprint 2003-22, Phys of Atomic Nuclei, Vol. 67, No. 8, p.1487, (2004)

Experimental setup

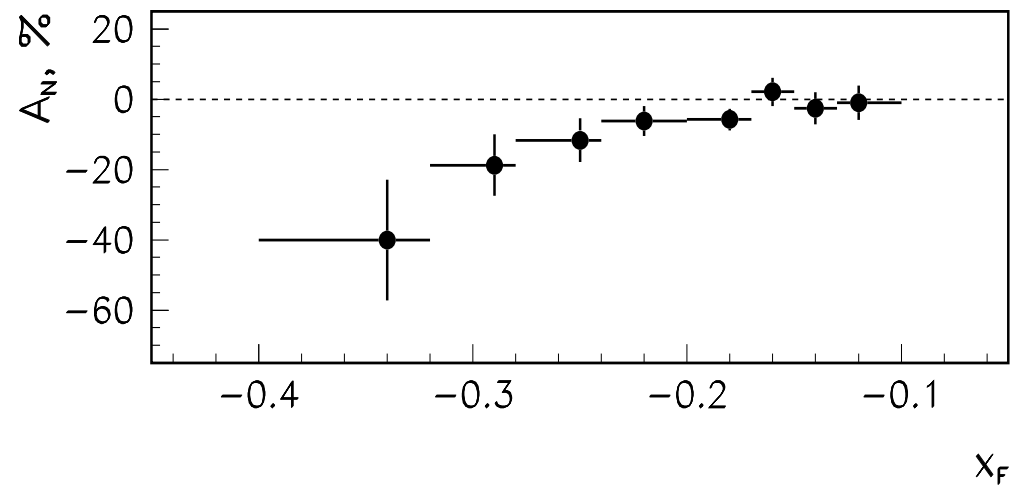
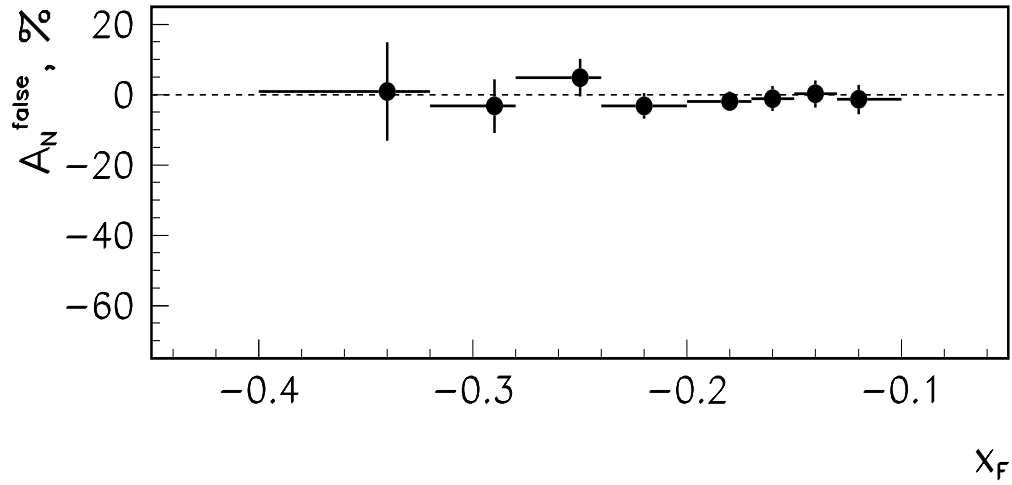
- Experiment was carried out at the U-70 accelerator in 1996.
- The proton beam was extracted using bent crystal ($I_{\text{intensity}}$ up to 10^7 protons/cycle)
- Polarized hydrogen target ($C_3H_8O_2$) with 80% average polarization
- γ -quanta were detected by electromagnetic calorimeter (144 lead glasses) 2.8 m downstream target)
- S1-S3: scintillation counters; H1-H2: 5-mm and 2-mm hodoscopes
- 1st level trigger on energy E



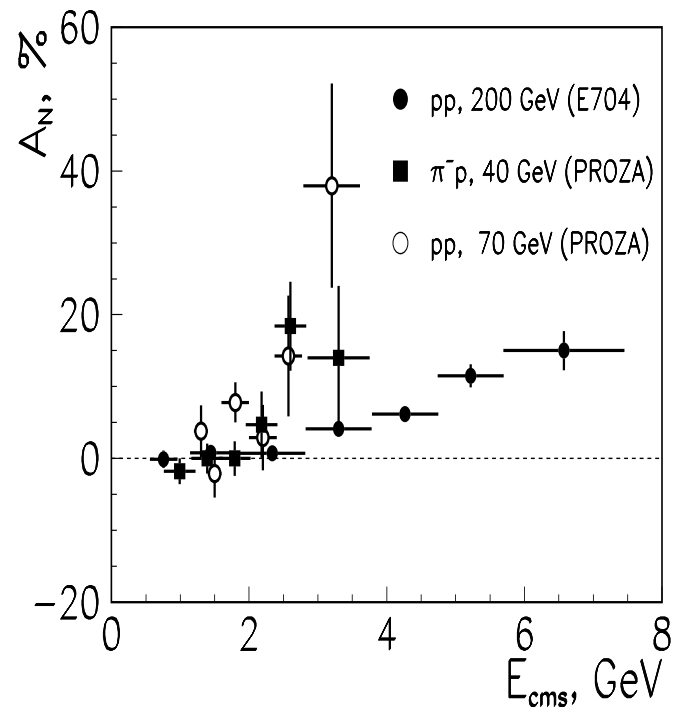
Kinematics



Measured Asymmetry



Comparison with other experiments



Experiment	$ A_N , \%$
E704, FNAL	12.4 ± 1.4
STAR, BNL	14 ± 4
PROZA-M, π^-	13.8 ± 3.8
This experiment	11 ± 3

Conclusion from 70 GeV data

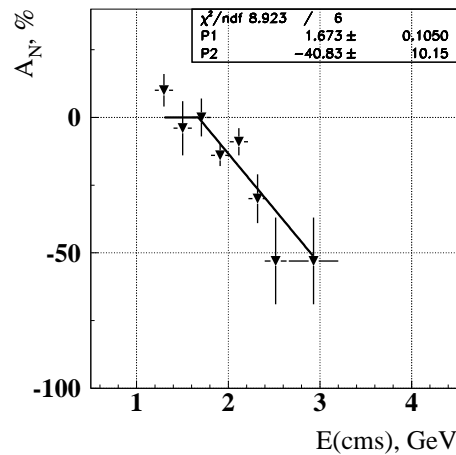
Single-spin asymmetry in the reaction $p + p_{\uparrow} \rightarrow \pi^0 + X$ at 70 GeV in the kinematic region $-0.4 < x_F < -0.1$ and $0.9 < p_T < 2.5$ GeV/ c was measured.

The asymmetry is close to zero in the range $-0.2 < x_F < -0.1$ which is in agreement with previous measurements in the central region.

The asymmetry grows up in absolute magnitude with x_F decreasing and is equal to $(-11 \pm 3)\%$ at $-0.4 < x_F < -0.2$.

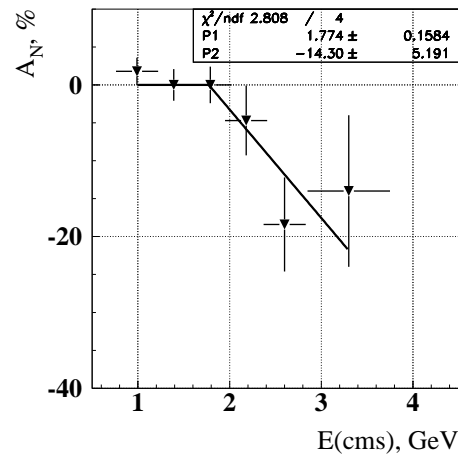
The result is published in IHEP Preprint 2004-32 and is submitted to Phys of Atomic Nuclei.

Investigation of universal threshold



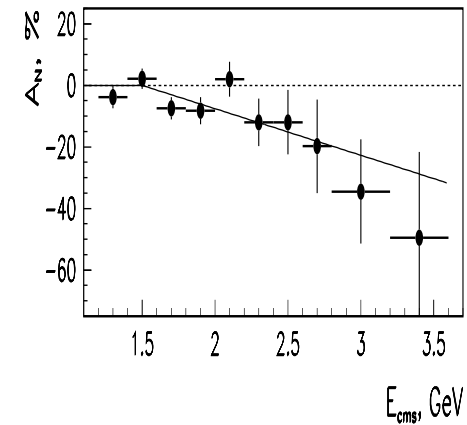
Centr (π^- beam)

The same threshold if
fitting by function



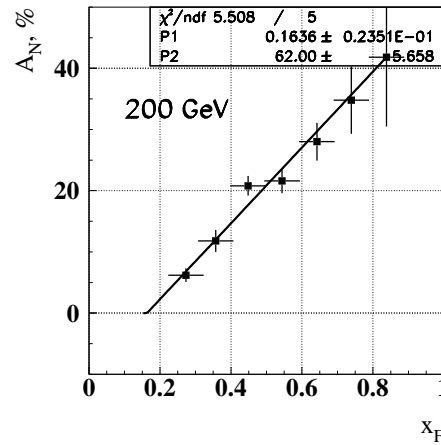
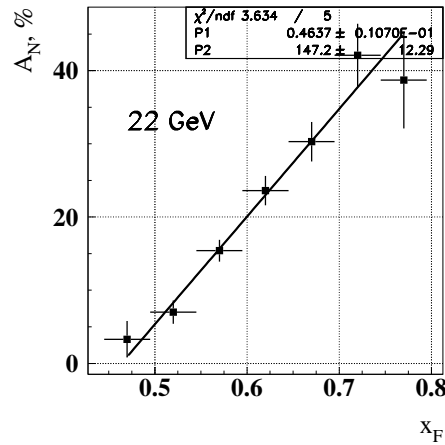
Fragm (π^- beam)

$$A_N = \begin{cases} 0 & , \text{if } E < E_0 \\ k \cdot (E - E_0) & , \text{if } E \geq E_0 \end{cases}$$

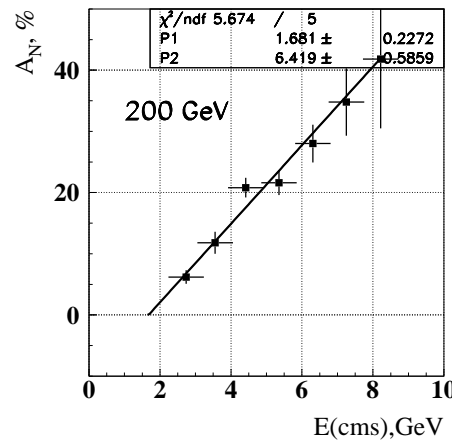
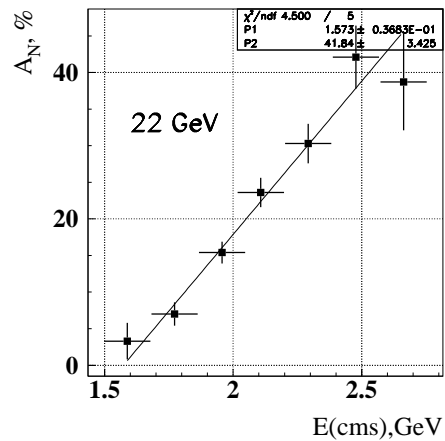


Current exp

A_N in inclusive π^+ production

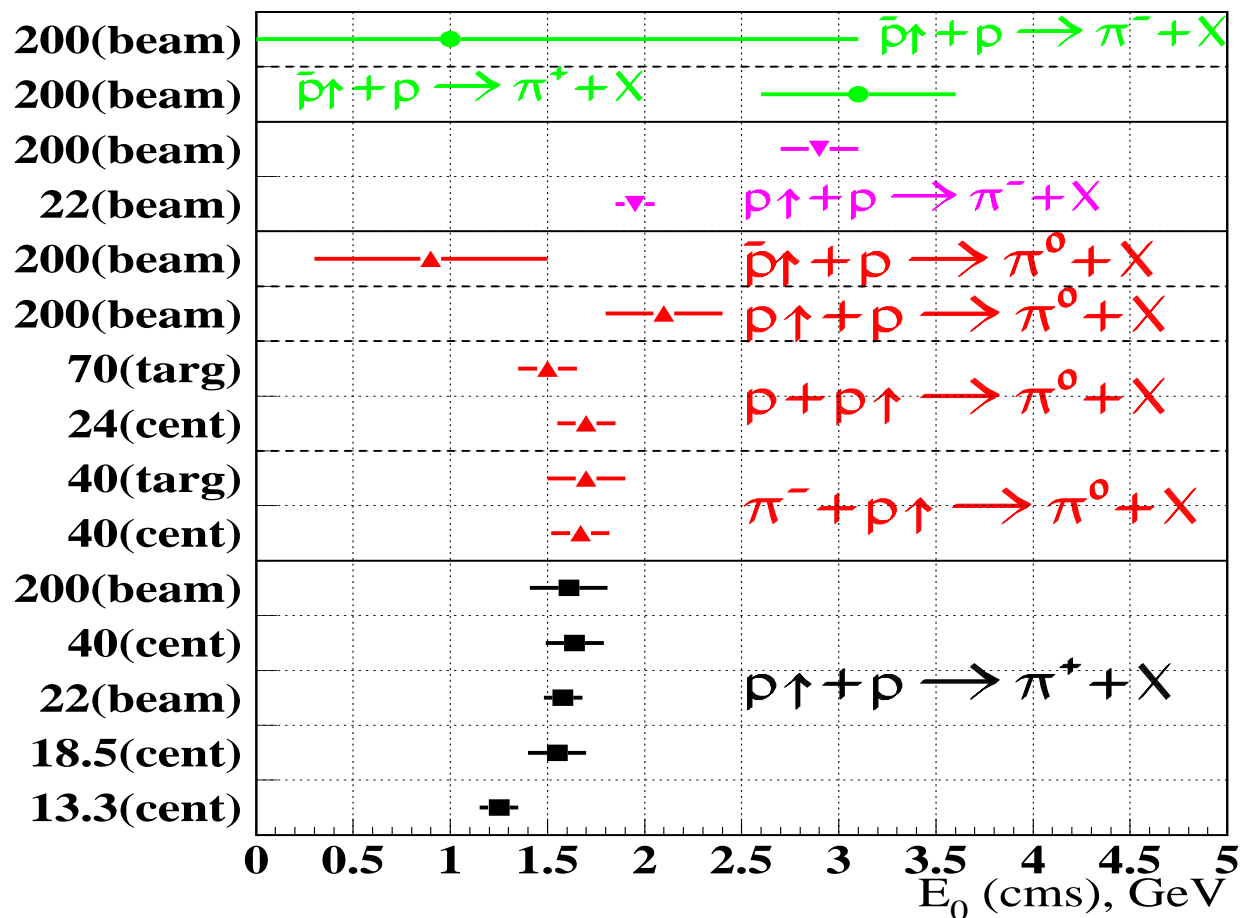


The asymmetry begins to grow at different x_F values, but at the same values in terms of E in c.m.s



The value of $E_0^{c.m.s} \approx 1.7$ GeV
The same value as for π^0 data

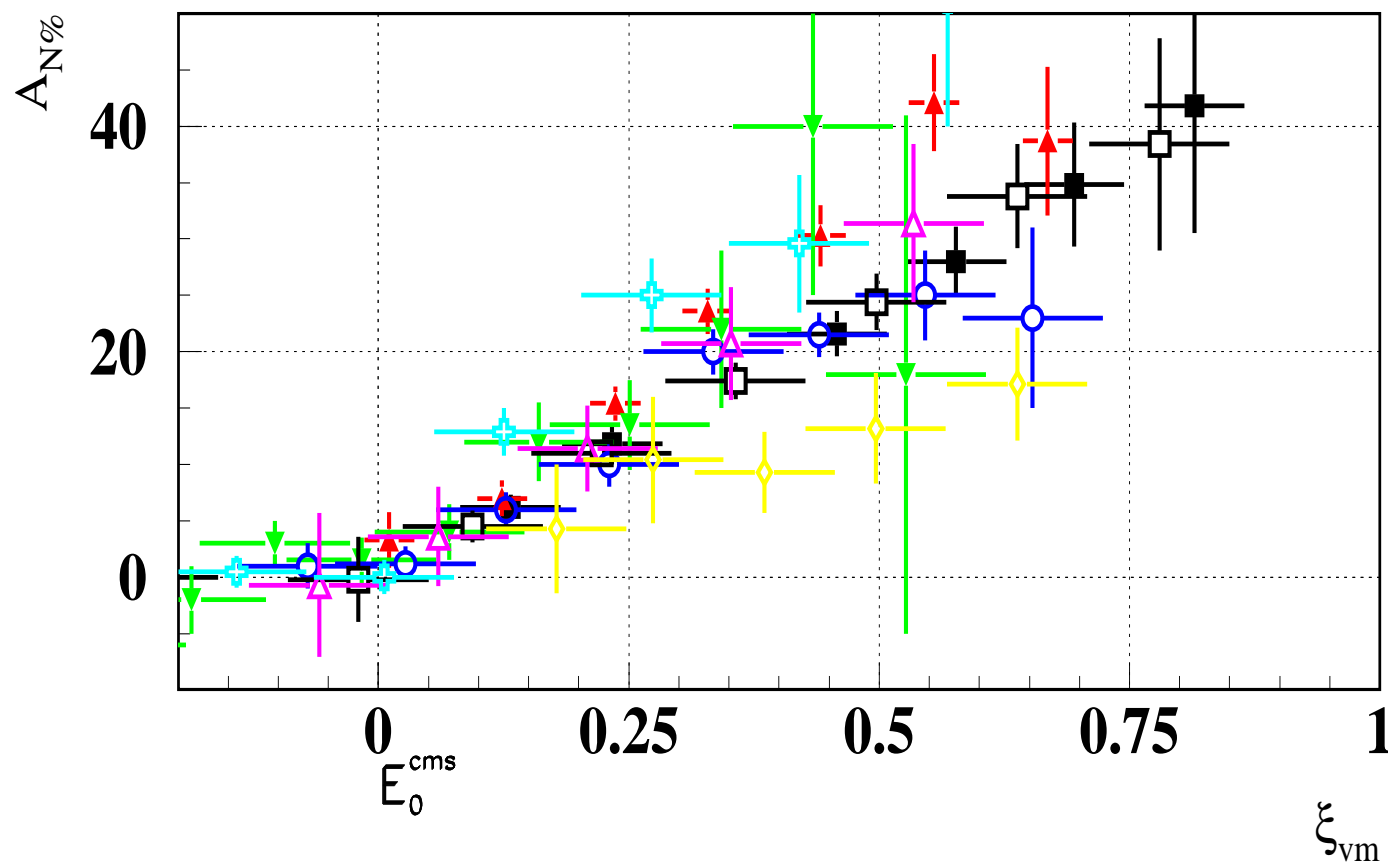
The value of threshold for all experiments



Combined result

Reaction	Energy	E_0^{cms} , GeV	χ^2/N	$k \cdot (E_{max}^{cms} - E_0^{cms})$, %
$p_{\uparrow} + p \rightarrow \pi^+ + X$	13.3	1.26 ± 0.1	0.9	52 ± 6
$p_{\uparrow} + p \rightarrow \pi^+ + X$	18.5	1.46 ± 0.15	0.85	63 ± 16
$p_{\uparrow} + p \rightarrow \pi^+ + X$	21.92	1.57 ± 0.1	0.9	68 ± 6
$p_{\uparrow} + p \rightarrow \pi^+ + X$	40	1.64 ± 0.15		
$p_{\uparrow} + p \rightarrow \pi^+ + X$	200	1.68 ± 0.25	1.1	52 ± 5
$\pi^- + p_{\uparrow} \rightarrow \pi^0 + X$	40	1.67 ± 0.15	1.5	107 ± 26
$\pi^- + p_{\uparrow} \rightarrow \pi^0 + X$	40	1.76 ± 0.2	0.7	36 ± 14
$p + p_{\uparrow} \rightarrow \pi^0 + X$	24	1.7 ± 0.15	0.6	334 ± 165
$p + p_{\uparrow} \rightarrow \pi^0 + X$	70	1.5 ± 0.2	0.15	50 ± 15
$p_{\uparrow} + p \rightarrow \pi^0 + X$	200	2.1 ± 0.3	0.5	26 ± 5
$\bar{p}_{\uparrow} + p \rightarrow \pi^0 + X$	200	0.9 ± 0.6	0.5	13 ± 4
$p_{\uparrow} + p \rightarrow \pi^- + X$	21.92	1.95 ± 0.1	0.5	-87 ± 11
$p_{\uparrow} + p \rightarrow \pi^- + X$	200	2.9 ± 0.2	<0.1	-51 ± 6
$\bar{p}_{\uparrow} + p \rightarrow \pi^+ + X$	200	3.1 ± 0.5	<0.1	-59 ± 16
$\bar{p}_{\uparrow} + p \rightarrow \pi^- + X$	200	1.0 ± 2.2	0.1	25 ± 15

The asymmetry scaling for charged pion's



$$\xi_{vm} = (E^{cms} - E_0^{cms}) / (\sqrt{s}/2 - E_0^{cms})$$

Discussion

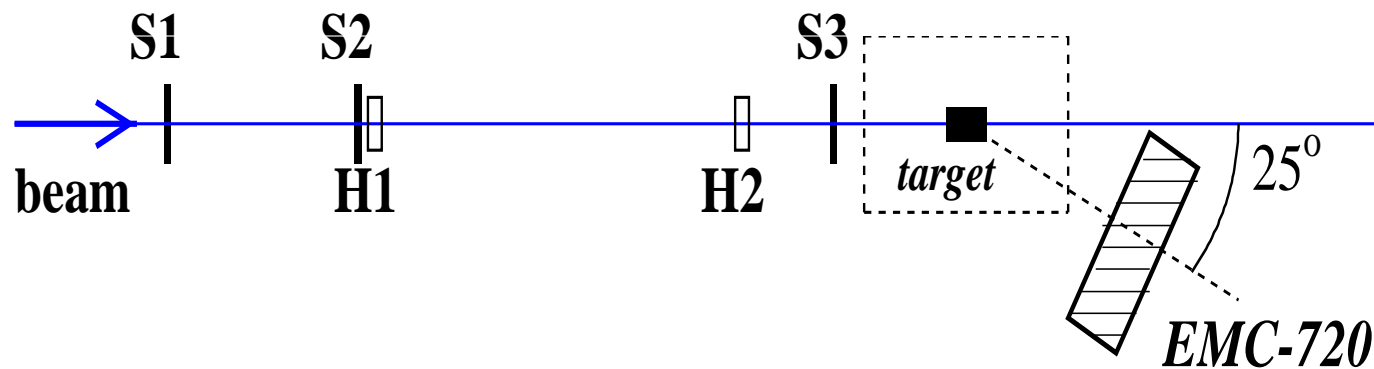
- The asymmetry starts to grow up at the same center of mass energy. (if $p_T > 0.5\text{GeV}/c$).
- π^- production seems to contradict to this because of: π^- -meson at small x_F can be produced not only from the valence d -quark but also from other channels. The interference of different channels is also responsible for asymmetry cancellation in π^0 and π^- production in the central region.
- The asymmetry behavior in $\bar{p}_\uparrow p$ interactions in π^+ and π^- production should be inversed in comparison with the $p_\uparrow + p \rightarrow \pi^0 + X$ in agreement with E704 data.
- In the reaction $\pi^- + p_\uparrow \rightarrow \pi^0 + X$ in the central region A_N is big in the contrary to the $p_\uparrow + p \rightarrow \pi^0 + X$ reaction. The valence u -quark from a polarized proton combining with the valence \bar{u} -quark from π^- gives the main contribution to π^0 production, while other channels are suppressed.

Conclusions on universal threshold

- We can conclude that the meson asymmetry produced by valence quark starts to grow up at the same universal energy $E_{cm,s}^0$.
- Also the values of the parameter $k \cdot (E_{cm,s}^{max} - E_{cm,s}^0)$ are close for all eight measurements in the inclusive production of charged pion's.
- This behavior can be explained inside constituent quark model
(see [Phys.Rev.D69:077503,2004](#) or [hep-ph/0310224](#))
- The paper is published in e-archive: [hep-ex/0312007](#)

Next measurements:

- Continue to measure asymmetry in the $p + p_{\uparrow} \rightarrow \pi^0 + X$ reaction at the target fragmentation region
- The detector of 720 cells with increased sensitivity will be placed on 30° , allowing to cover $-0.8 < x_F < -0.3$ region.
- Main goal - to increase accuracy and check universal threshold.
- The experiment is planning for 2005 and 2006.



Summary

- The asymmetry is close to zero in the range $-0.2 < x_F < -0.1$ which is in agreement with previous measurements in the central region.
- The asymmetry grows up in absolute magnitude with x_F decreasing and is equal to $(-11 \pm 3)\%$ at $-0.4 < x_F < -0.2$.
- Meson asymmetry produced by valence quark starts to grow up at the same universal energy $E_{c.m.s}^0 \approx 1.7$ GeV/c.
- New measurements will be carried out in next two years

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