Space correlations in pionless interactions of light nuclei with protons

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CONTENTS

- Study of interactions of light nuclei with protons in the hydrogen bubble chamber
- Spacial correlations in mesonless breakup and elastic scattering light nuclei
- Comparison dp and ^{4}Hep-reactions
- Features of charge exchange reactions
- Some words about thermonuclear synthesis

dp 3,34 GeV/c, N=237413*, σ_{tot} = 82.889±0.063 mb [D.V.Bugg et al, Phys.Rev. 146,980 (1966)]

Pionless channels

	Reaction	Number of events	Cross section (mb)
1.	**dp→dp**	**16 184***	**10.0±0.7**
2.	**dp→ppn**	**102 778**	**37.2±1.4**
	Total	**118 962**	

* Without corrections on losses at the small momenta transfer

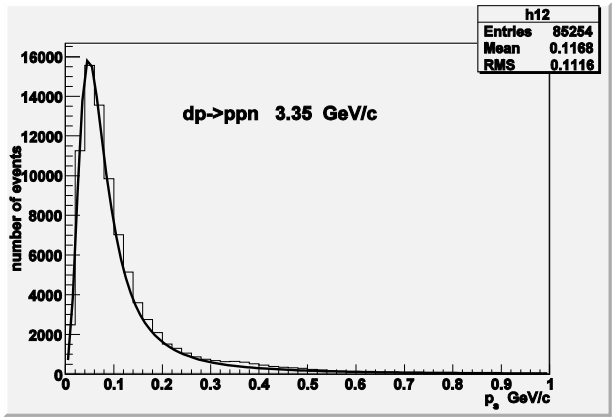
^{4}Hep 8.6 GeV/c, N=38625*, σ_{tot} = 143.0±1.6 mb

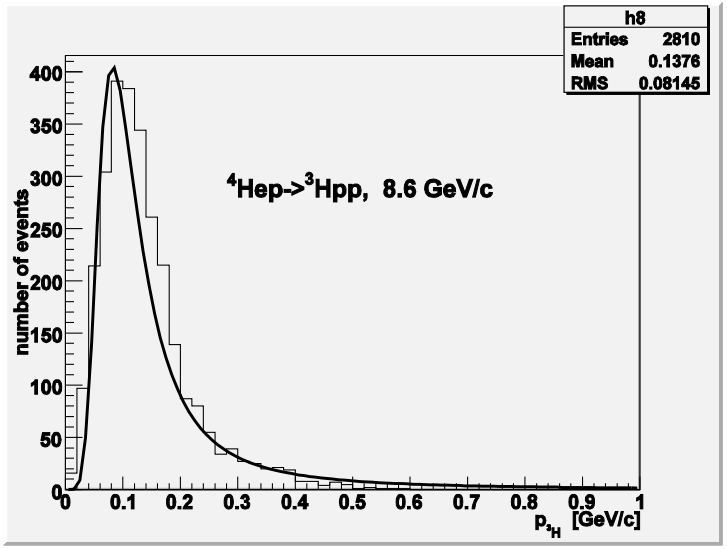
Pionless channels

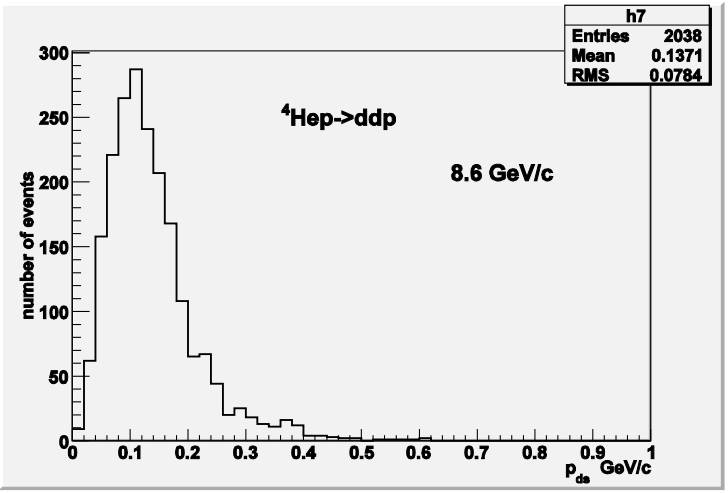
	Reaction	Number of events	Cross section (mb)
1.	^{4}Hep→^{4}Hep	2587*	36.00±3.00
2.	→^{3}Hepn	3765	12.60±0.22
3.	→^{3}Hpp	3249	12.28±0.22
4.	→dppn	2997	9.91±0.19
5.	→pppn	3074	11.39±0.21
6.	→ddp	411	1.53±0.08
7.	→^{3}Hed	54	0.20±0.14
	Total	16137	

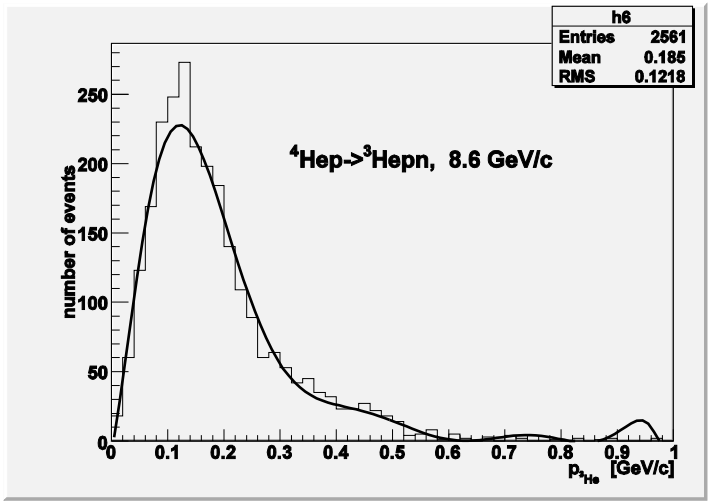
* Without corrections on losses at the small momenta transfer

Spectra of spectator nuclei

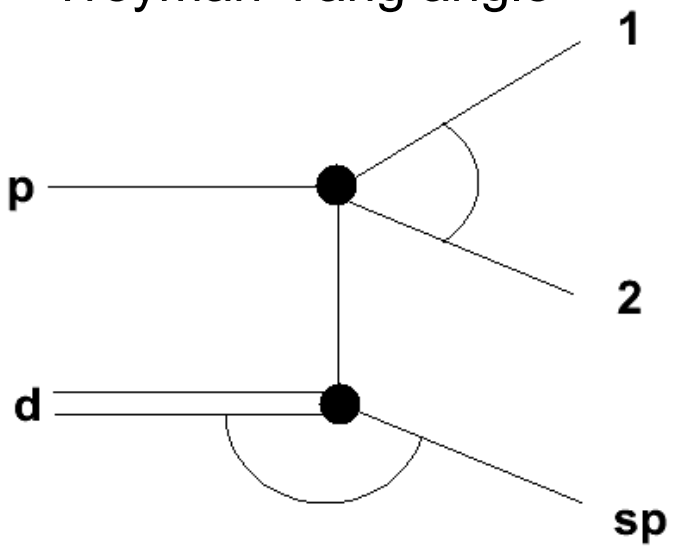








V.M. Kolybasov,G.A.Leksin, I.S.Shapiro UFN,113,239 /1974/
Treyman-Yang angle



$$\Phi_{TY}=\mathrm{acos}([p_d \times p_{sp}]\,[p_{fast} \times p_{slow}])/(|[p_d \times p_{sp}]|\,|[p_{fast} \times p_{slow}]|)$$

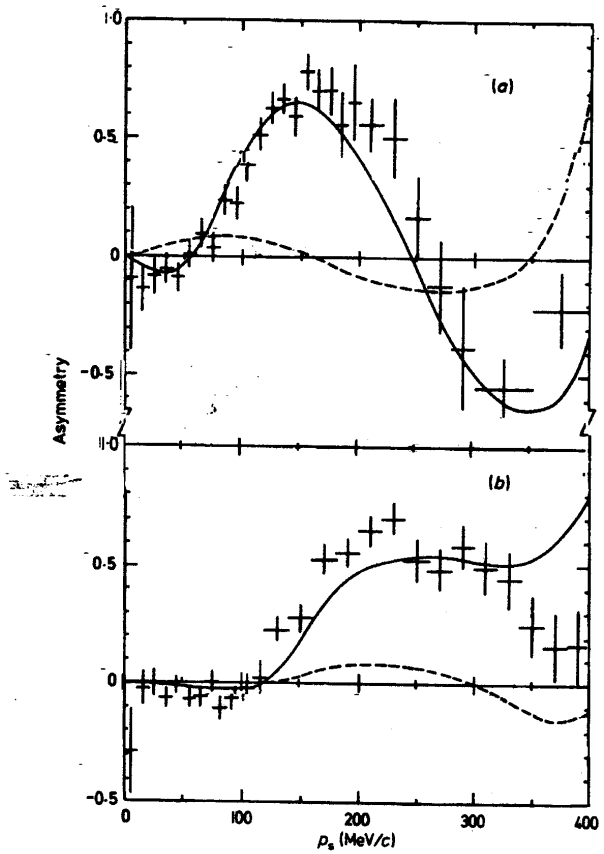
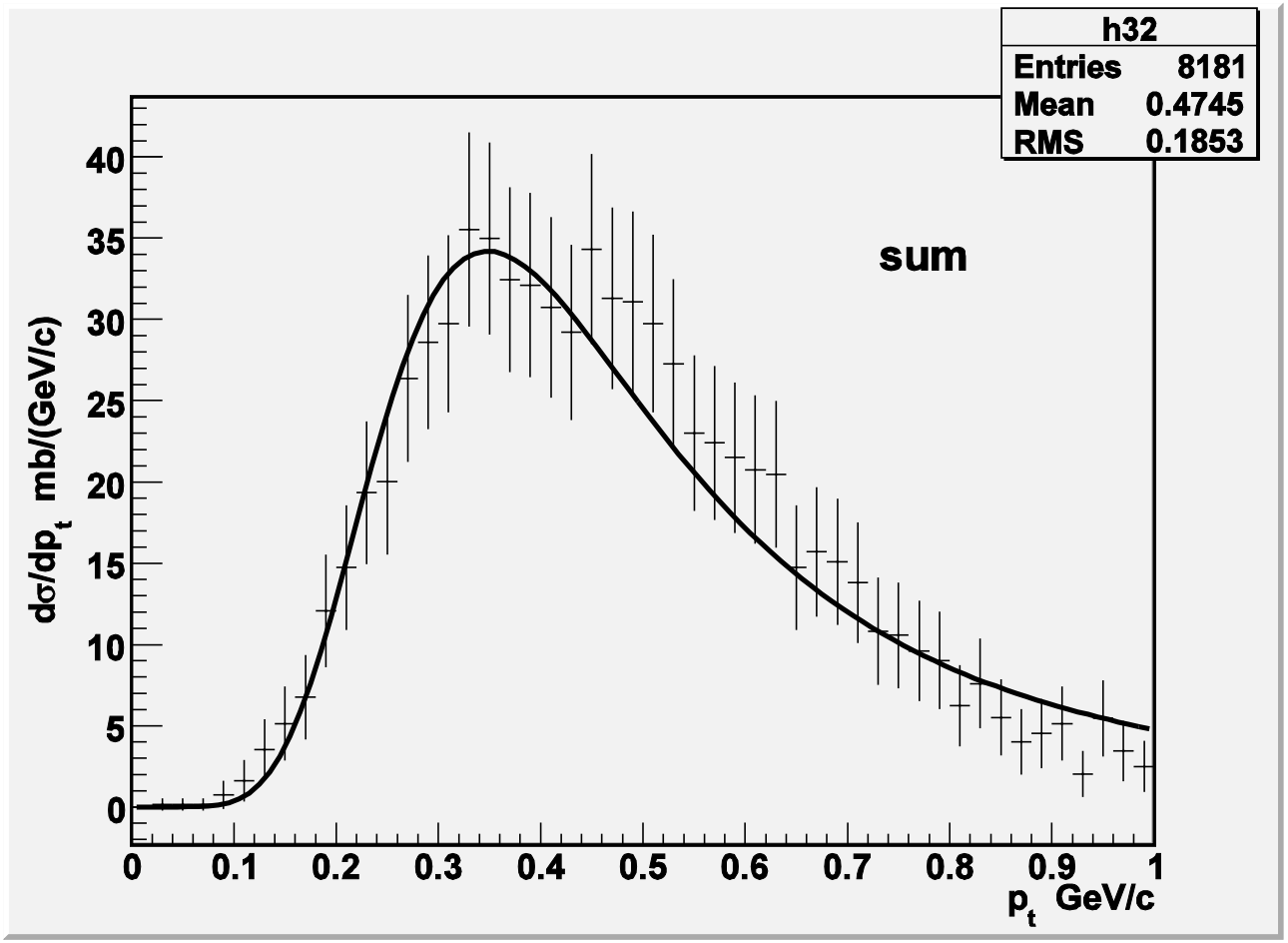


Figure 3. The asymmetry in the angle α for all spectators with (*a*) $|t| < 0{\cdot}1$ (GeV/*c*)² and (*b*) $0{\cdot}1 < |t| < 0{\cdot}4$ (GeV/*c*)². The full curve follows from the model with FSI, the broken one without.

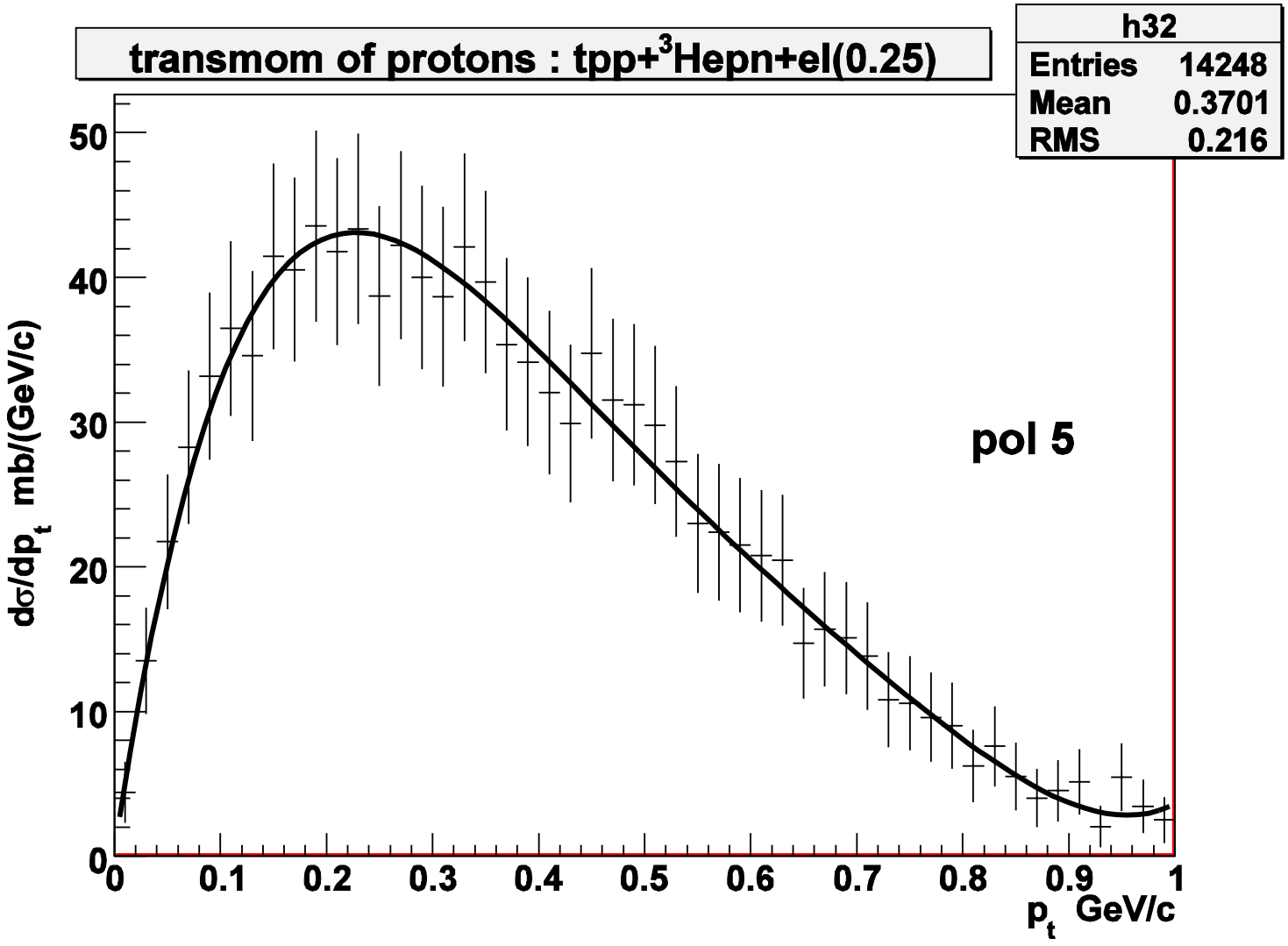
Final state interaction
in the high energy proton-deuteron b
Journal of Physics G
Nuclear Physics 3,7
(1977)
B.S.Aladashvili et al.

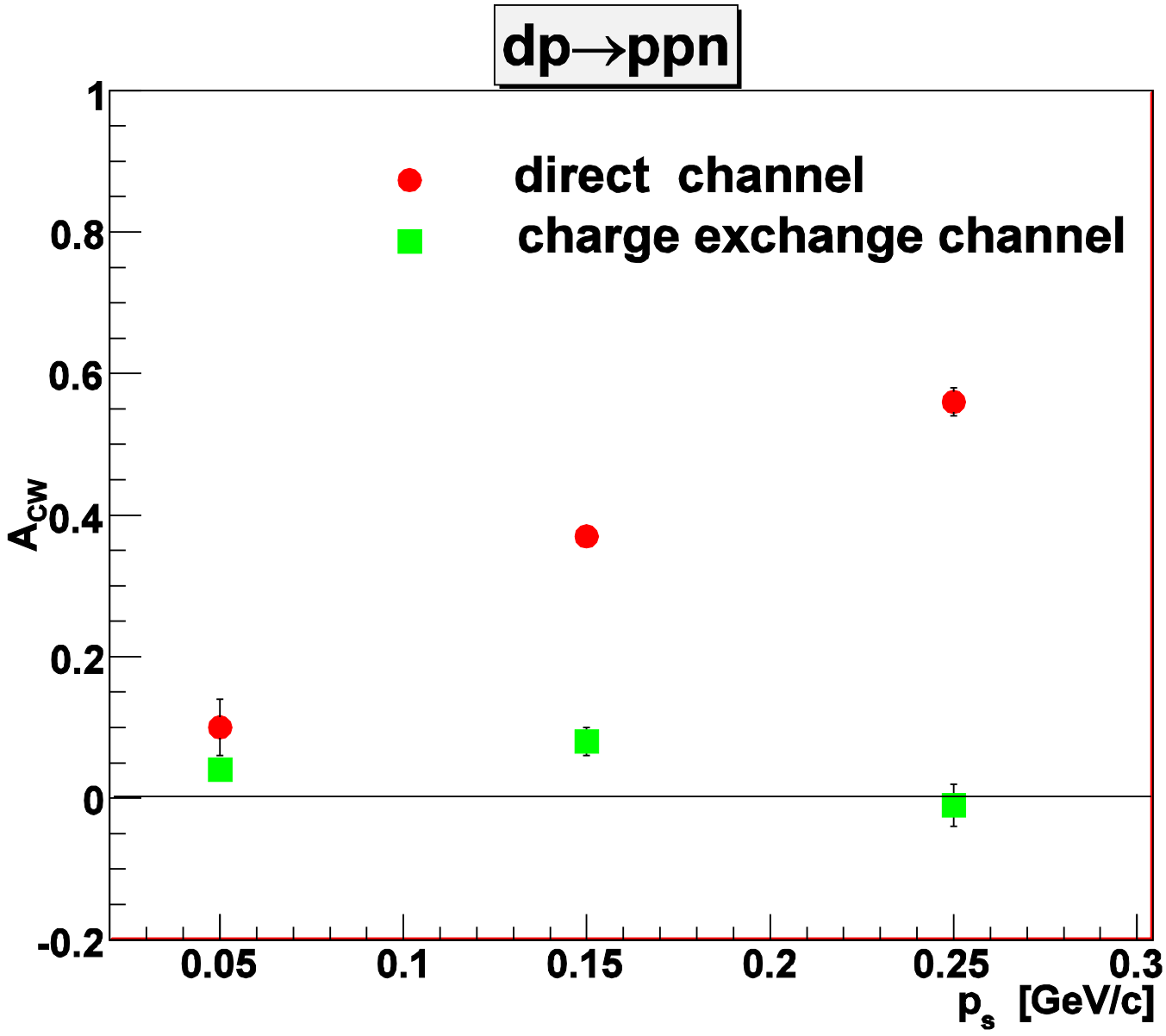
$$A \equiv \frac{N(\alpha < 90°) - N(\alpha > 90°)}{N(\alpha < 90°) + N(\alpha > 90°)}.$$

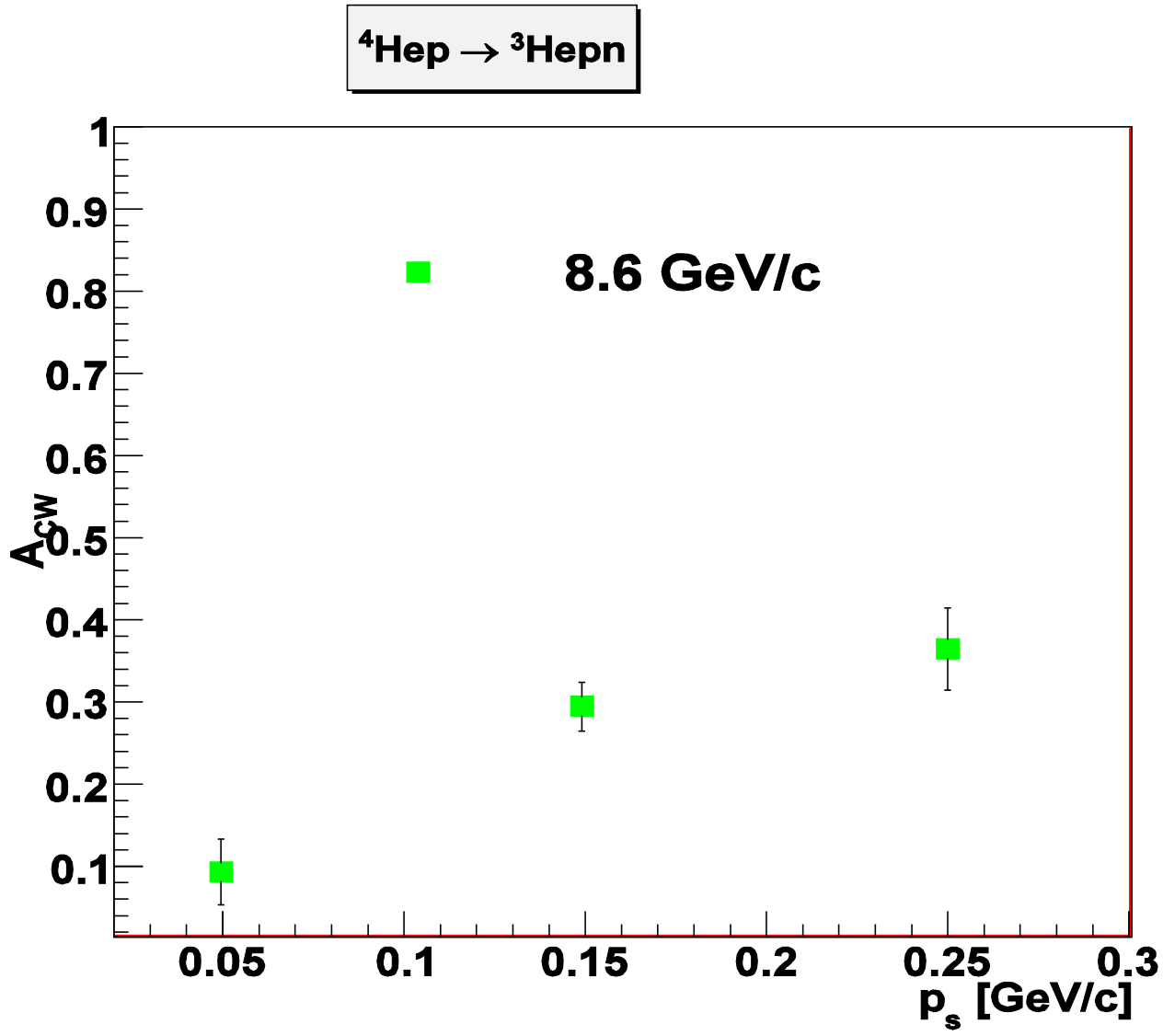
$\cos\alpha_{cw}=(p_s q)/(|p_s||q|)$, where p_s – spectator momentum and
q – 3 - dimensional momentum transfer from target to scattering nucleons

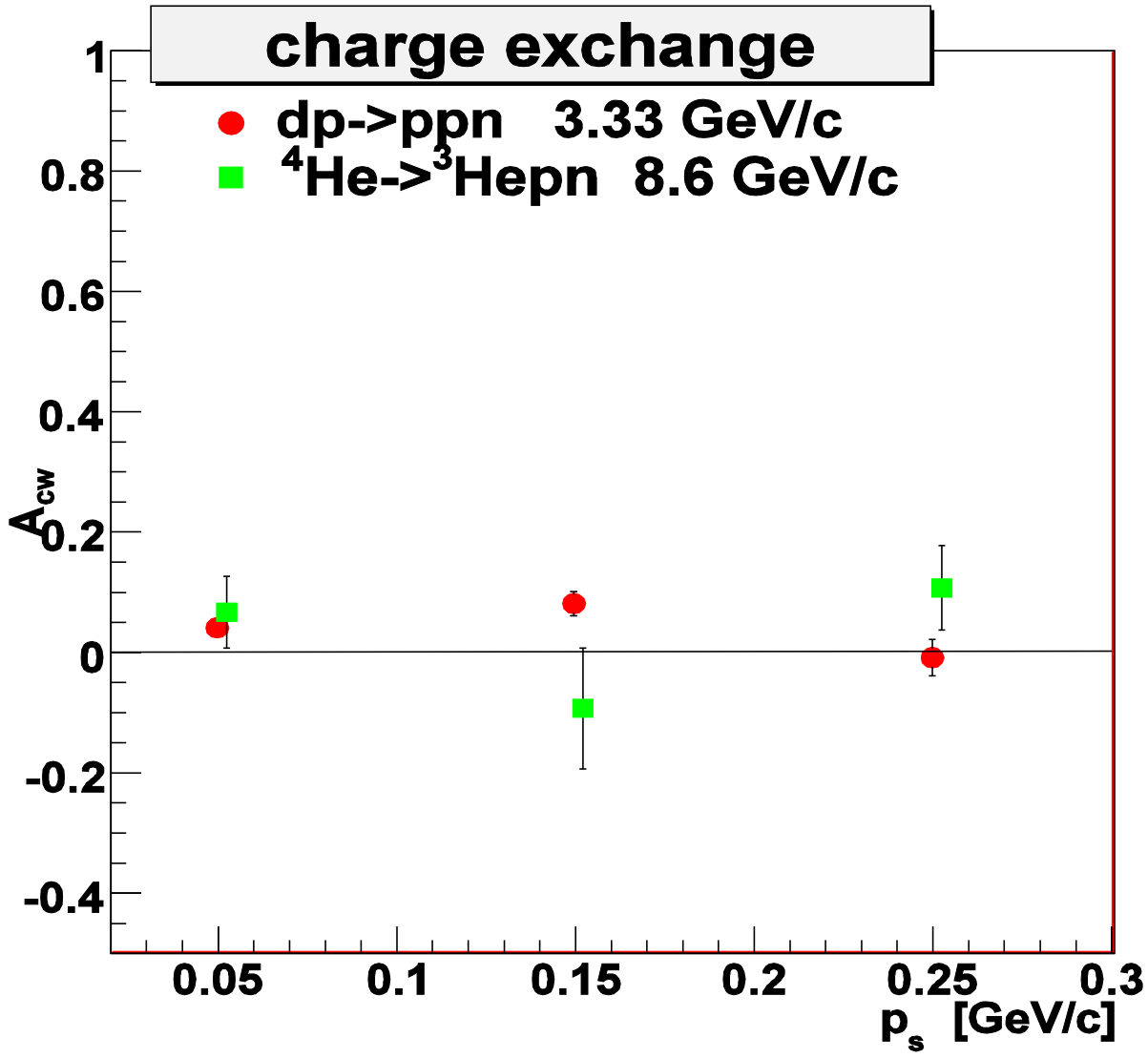


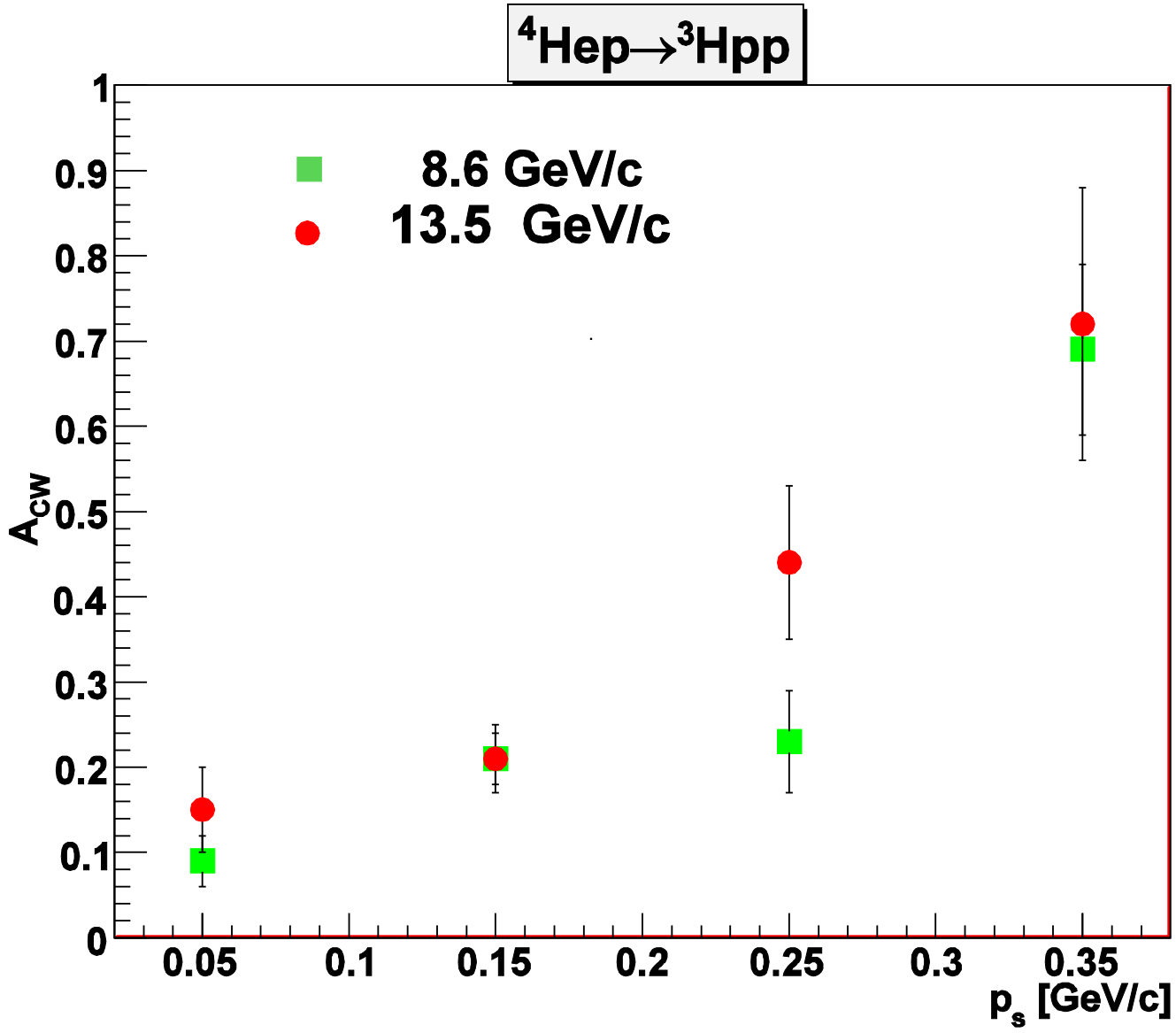
- **Transverse momenta distribution for ^{4}Hep→^{3}Hpp and ^{4}Hep→^{3}Hepn reactions**

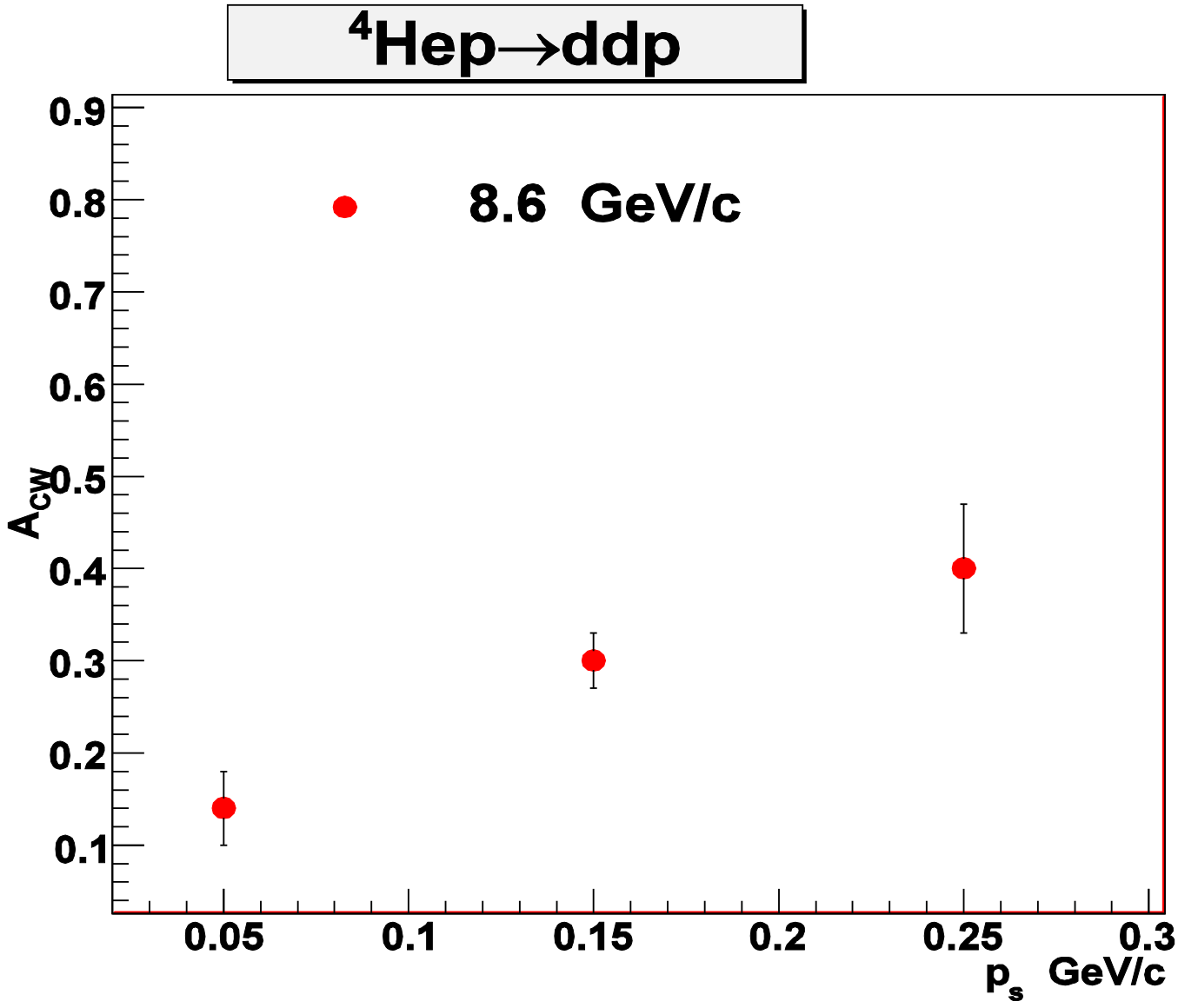

transmom of protons : tpp+3Hepn+el(0.25)
h32
Entries 14248
Mean 0.3701
RMS 0.216
pol 5
dσ/dp_t mb/(GeV/c)
p_t GeV/c
0
10
20
30
40
50
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

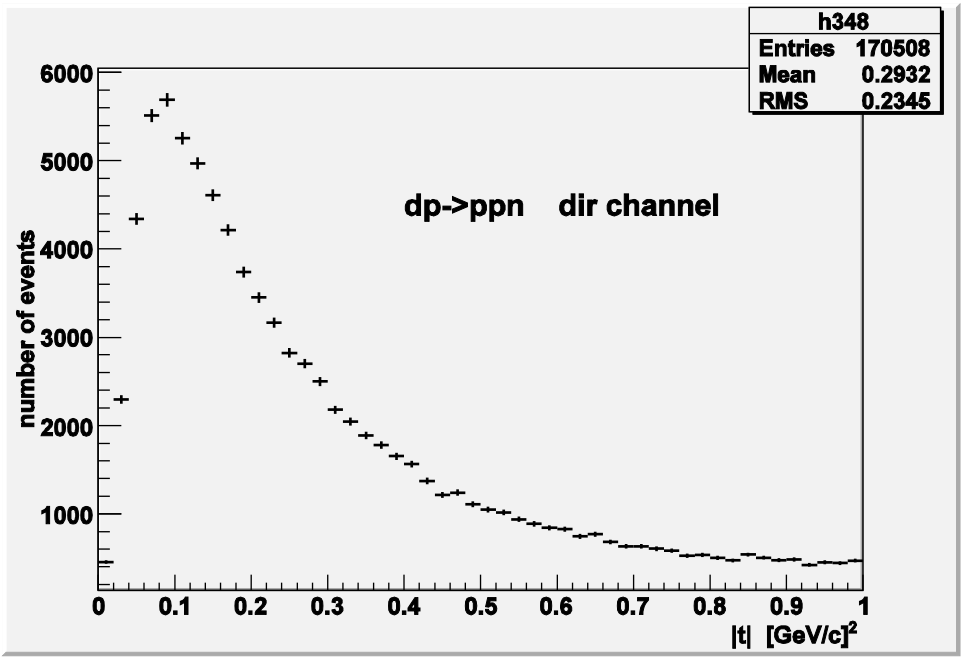

dp→ppn
direct channel
charge exchange channel
A_{CW}
1
0.8
0.6
0.4
0.2
0
-0.2
0.05
0.1
0.15
0.2
0.25
0.3
p_s [GeV/c]

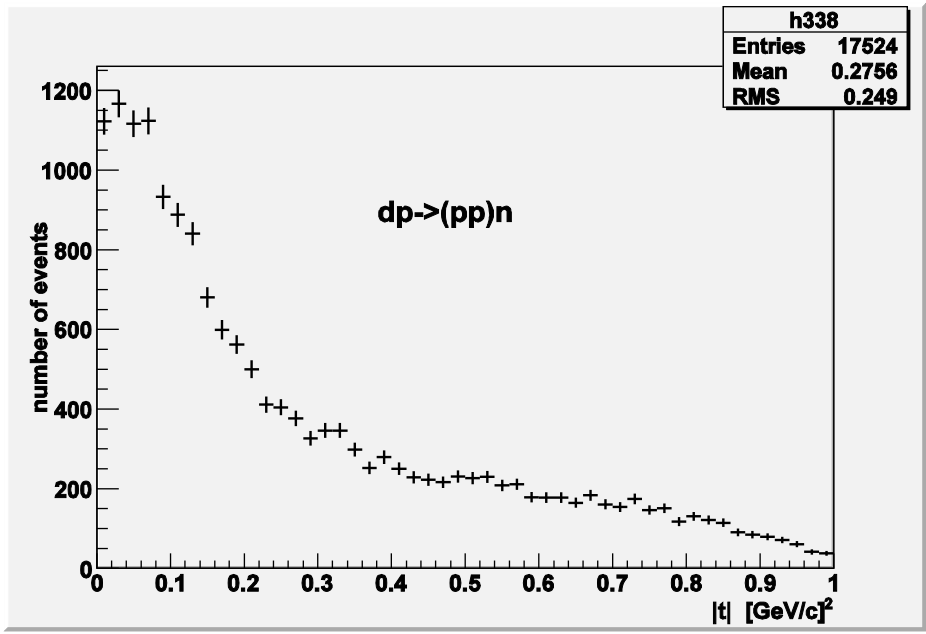

^{4}Hep → ^{3}Hepn
8.6 GeV/c
A_{CW}
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.05
0.1
0.15
0.2
0.25
0.3
p_s [GeV/c]


charge exchange
dp->ppn 3.33 GeV/c
4He->3Hepn 8.6 GeV/c
A_cw
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0.05
0.1
0.15
0.2
0.25
0.3
p_s [GeV/c]

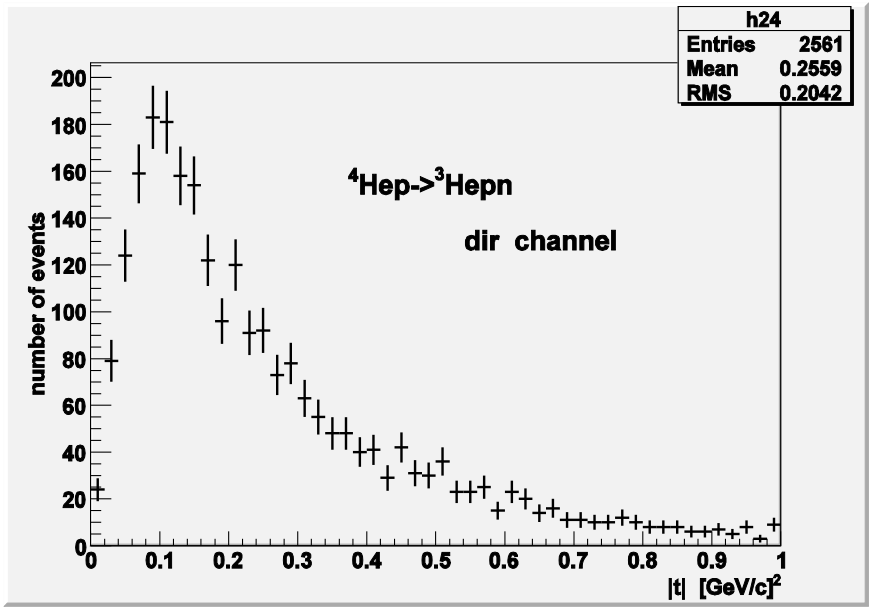

^{4}Hep→^{3}Hpp
8.6 GeV/c
13.5 GeV/c
A_{CW}
p_s [GeV/c]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.05
0.1
0.15
0.2
0.25
0.3
0.35

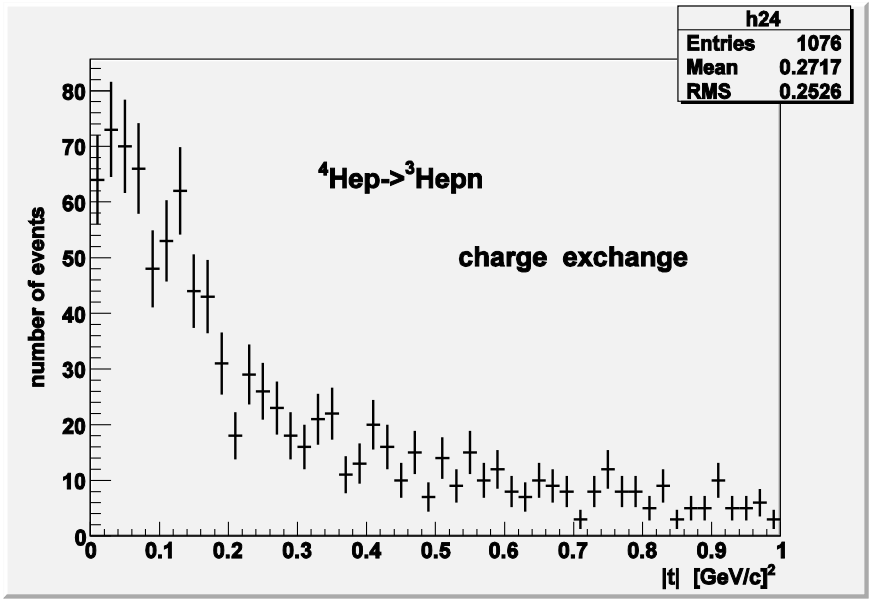

^{4}Hep→ddp
8.6 GeV/c
A_{CW}
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.05
0.1
0.15
0.2
0.25
0.3
p_s GeV/c



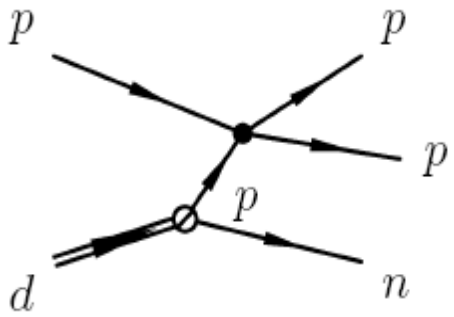


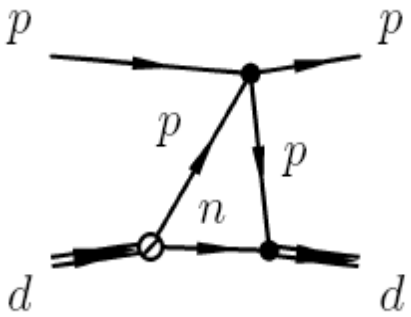
|t| - distributions

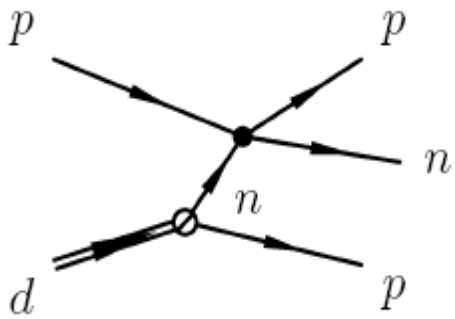


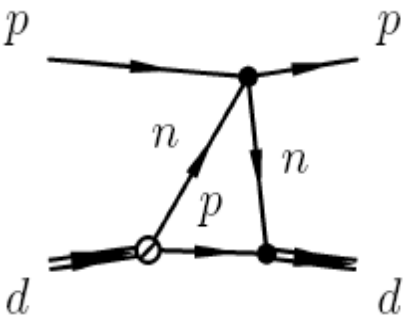


|t| - distributions

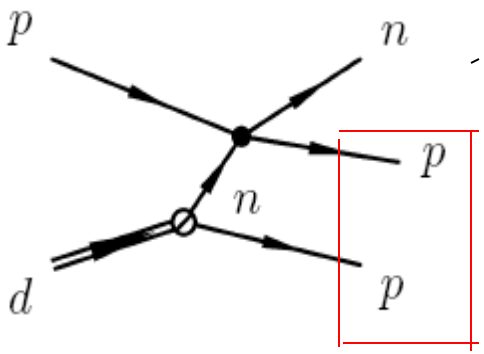




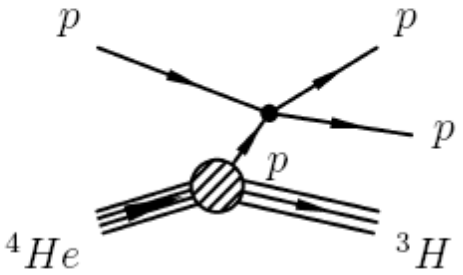


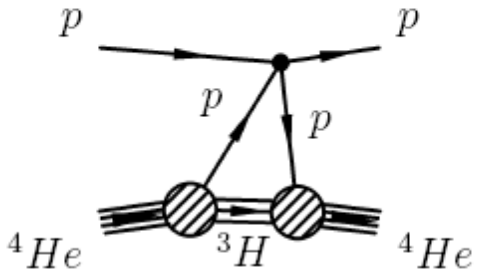


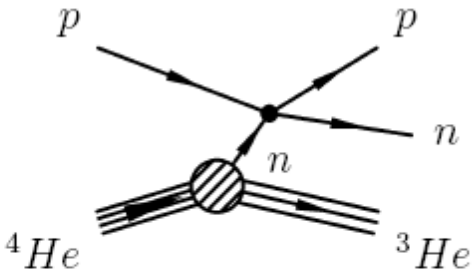
FSI

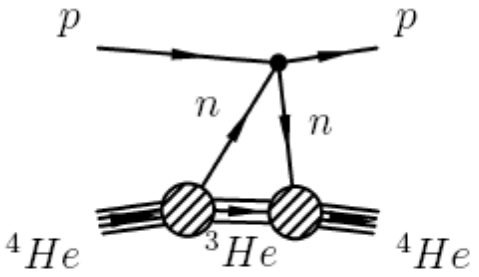


charge exchange

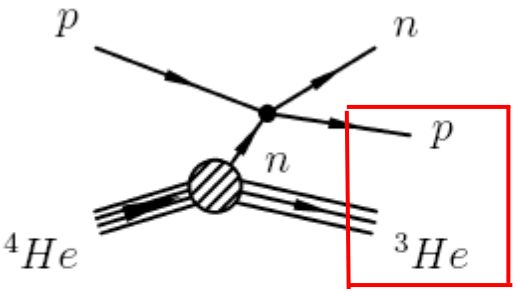








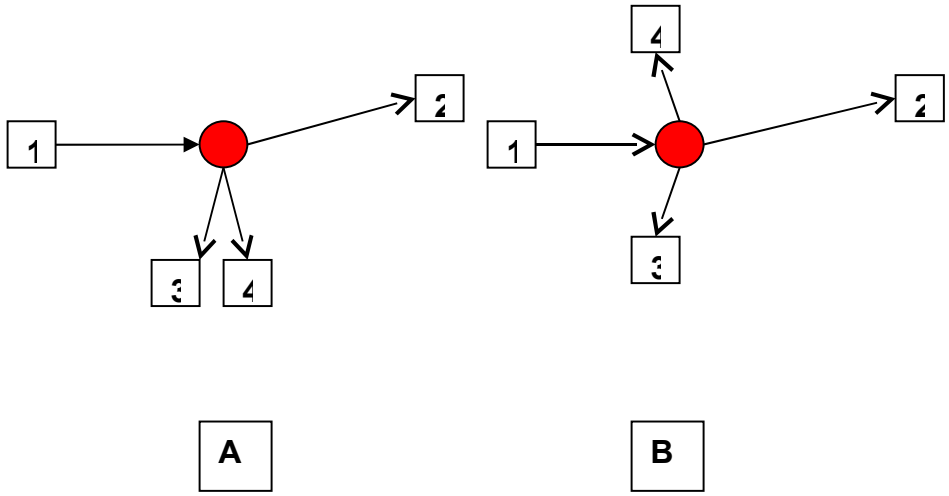
FSI



charge exchange

- **The schematic explanation the formula of asymmetry:**

$$A \equiv \frac{N(\alpha < 90^\circ) - N(\alpha > 90^\circ)}{N(\alpha < 90^\circ) + N(\alpha > 90^\circ)}.$$

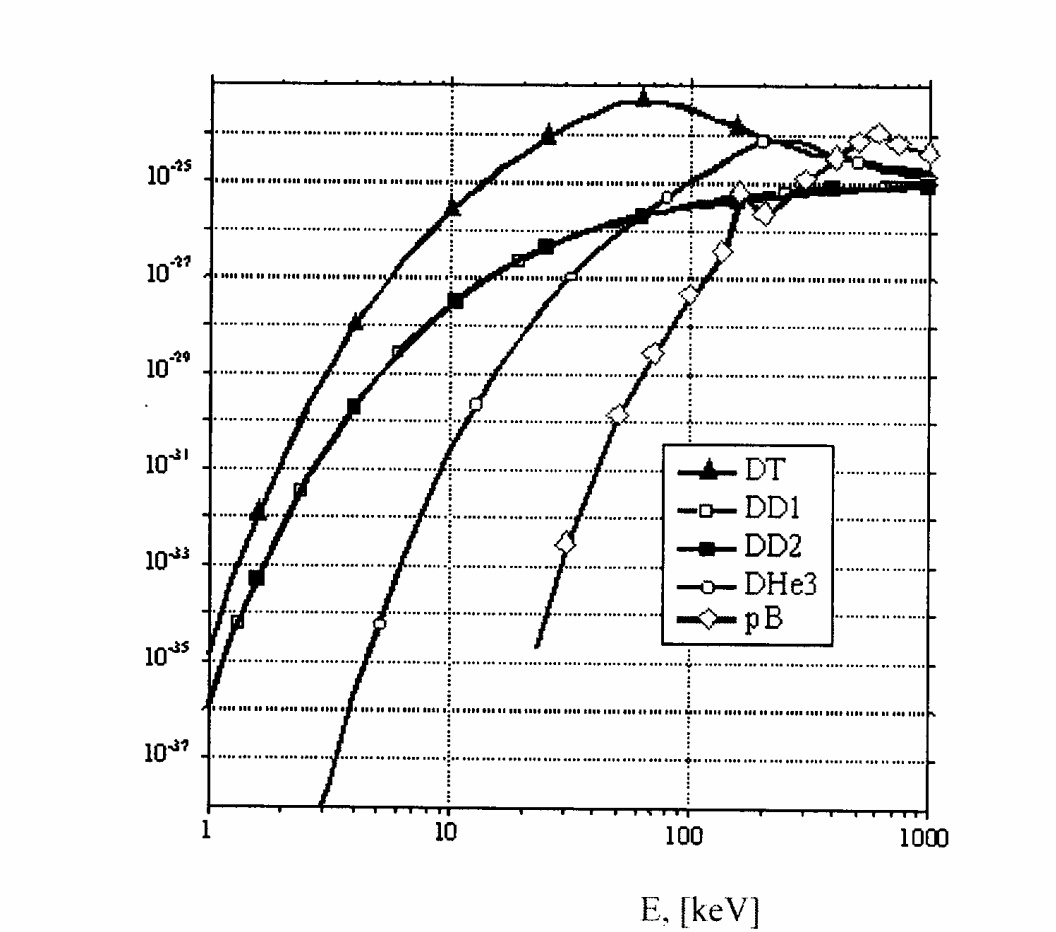


Here 1 and 2 - incident and scattering particles, 3 and 4 – spectator and recoil. The case A corresponds to a angle <90^0 and case B > 90^0. Thus, for stimulation of transition in the elastic channel (synthesis) it is desirable to organize a configuration of type B. It corresponds to a picture of collision of colliding beams.

The nuclear reactions which are of interest operated thermonuclear synthesis.

	Reaction	Energy q , (MeV)
1.	$D + T \rightarrow {}^{4}He + n$	17.6
2.	$D + D \rightarrow {}^{3}He + n$	3.27
3.	$D + D \rightarrow T + p$	4.03
4.	$D + {}^{3}He \rightarrow {}^{4}He + p$	18.4
5.	$P + {}^{11}B \rightarrow 3{}^{4}He$	8.7
6.	${}^{6}Li + n \rightarrow {}^{4}He + T$	4.8
7.	${}^{7}Li + n \rightarrow {}^{4}He + T + n$	- 2.47

- **E.P. Velikhov, S.V. Putvinskiy. The report in Energy Center of the World Federation of Scientists. 22.10.1999**



- Cross sections of some thermonuclear reactions from the table, as function of energy of particles in system of the center of mass.

Conclusions

In work it is shown, that at interaction of light nuclei there is a competition between channels mesonless breakup and the elastic scattering, caused by final state interactions. Observed space correlations specify an opportunity of their use for stimulation of processes of operated thermonuclear synthesis.

It would be useful to carry out following research:

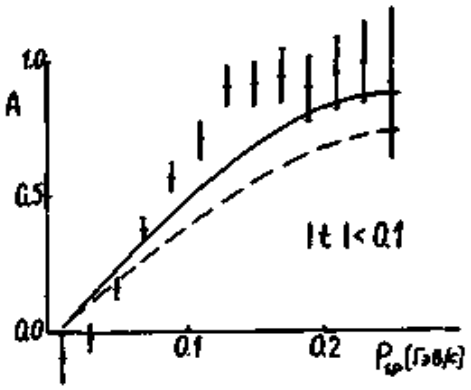
- To study the same correlations in interactions of light nuclei at the energies below a threshold of meson production,

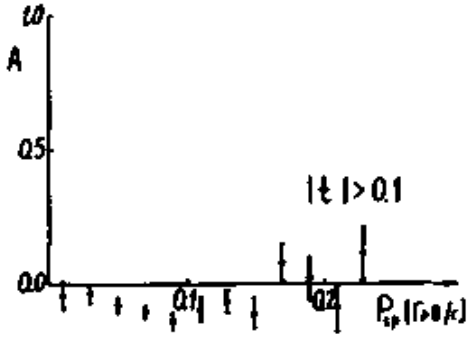
- To investigate an escape of nuclei ^{4}He in collisions of deuteron beams (or d+t) in energy range 100 KeV - 1 MeV with the purpose of search of possible strengthening an output He ("hot" catalysis),

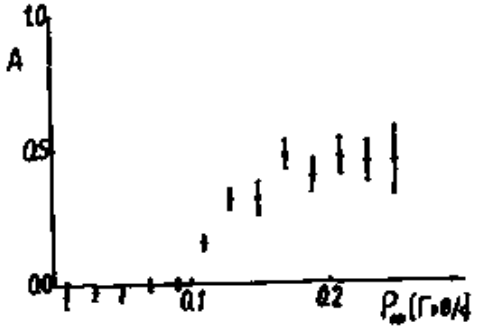
- To carry out estimations of economic efficiency.

• Nuclear physics,24,129(1976). B.S.Aladashvili et al

•reaction dp->ppn







V.Franko, R.J.Glauber. Phys.Rev., 142, 1195, 1966.

$$\left(\frac{d\sigma}{dt}\right)_{dp\to ppn} = \left(\frac{d\sigma}{dt}\right)_{sc} - \left(\frac{d\sigma}{dt}\right)_{el}, \qquad /1/$$

where

$$\left(\frac{d\sigma}{dt}\right)_{sc} = |A_p|^2 + |A_n|^2 + S(q)\,2\,\mathrm{Re}\,A_p A_n^* \qquad /2/$$

and

$$\left(\frac{d\sigma}{dt}\right)_{el} = S^2\left(\frac{q}{2}\right)\left[|A_p|^2 + |A_n|^2 + 2\,\mathrm{Re}\,A_p A_n^*\right]. \qquad /3/$$

Supposing, that scattering amplitudes np and pp are identical and imaginary, we shall receive

$$\left(\frac{d\sigma}{dt}\right)_{dp\to ppn} \sim |A_p|^2 \cdot \left[1 + S(q) - 2S^2\left(\frac{q}{2}\right)\right] \qquad /4/$$

for a case considering an interference of amplitudes and

$$\left(\frac{d\sigma}{dt}\right)_{dp\to ppn} \sim |A_p|^2 \cdot \left[1 - S^2\left(\frac{q}{2}\right)\right] \qquad /5/$$

without interference.

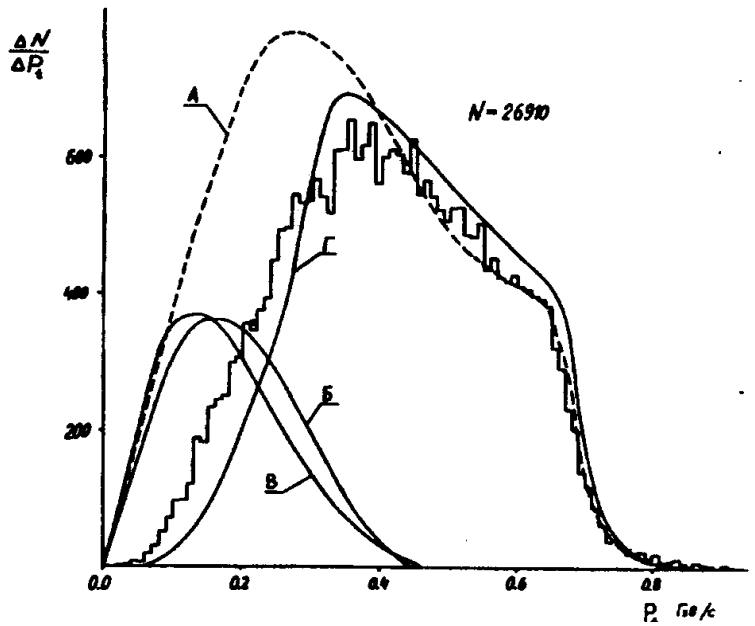
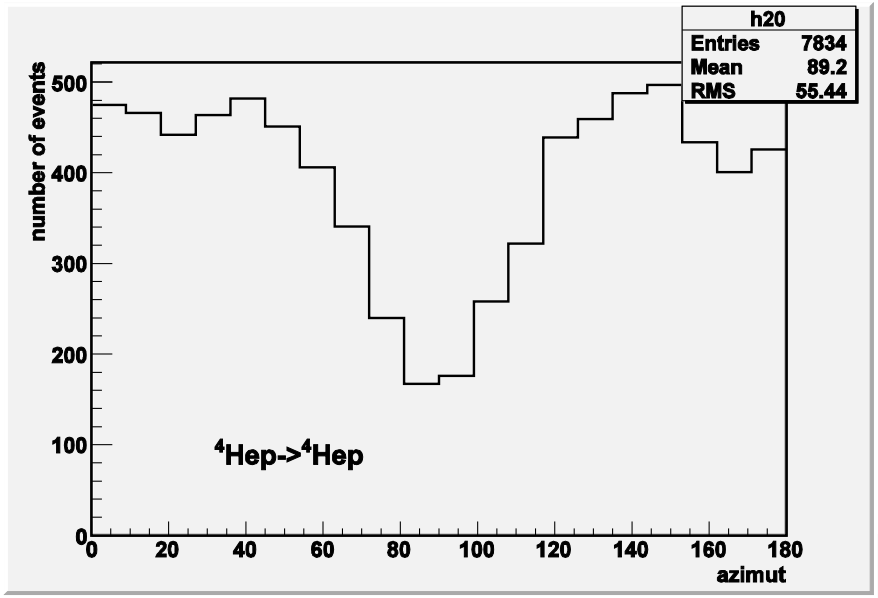
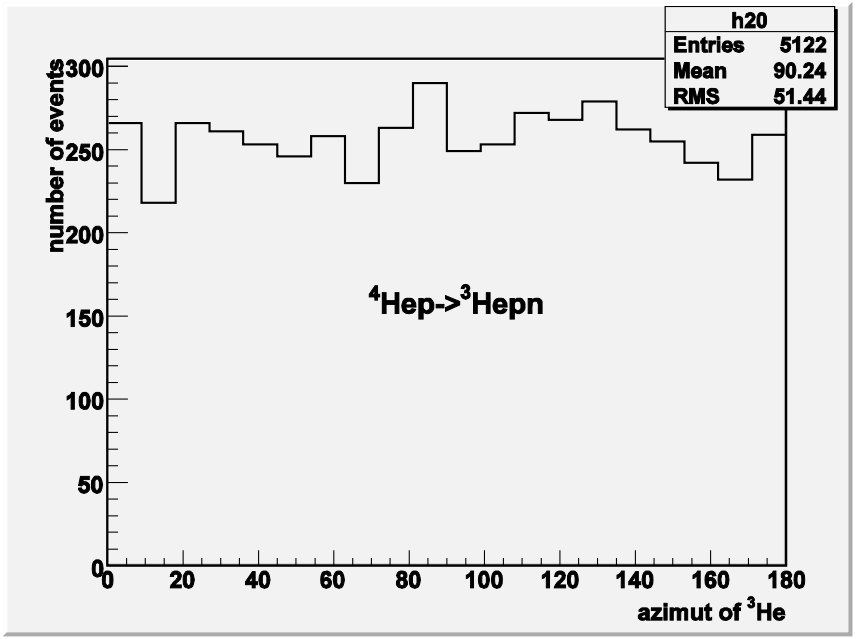
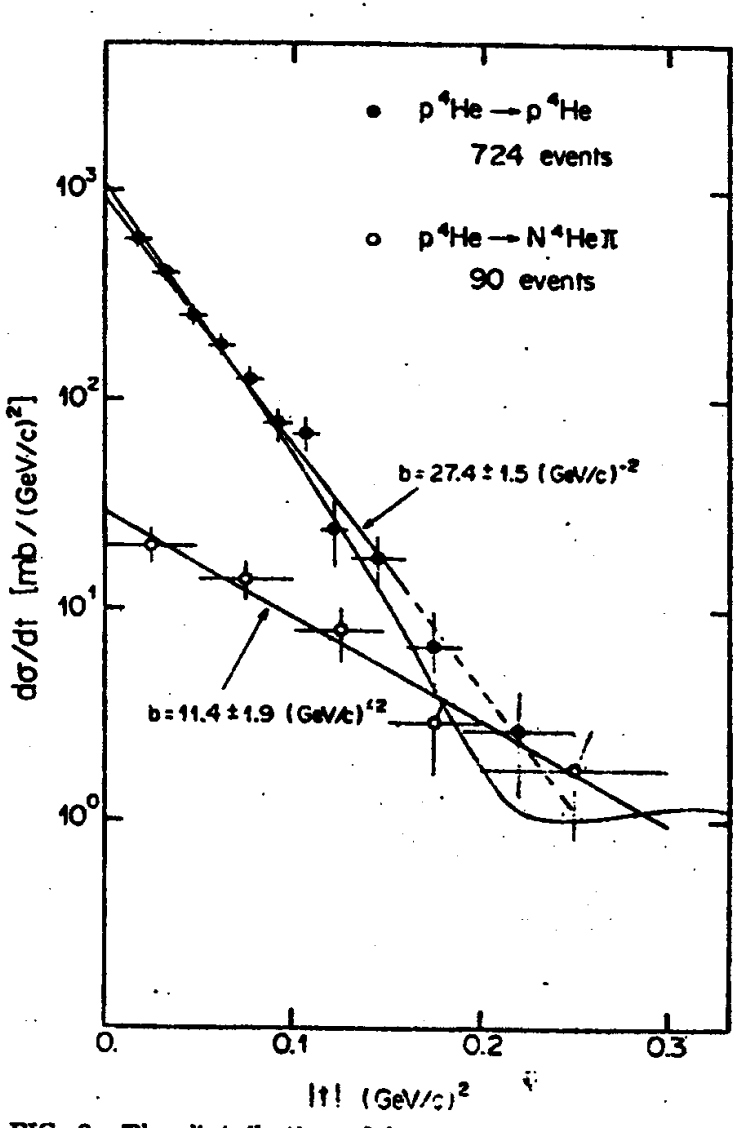


Fig 3. Distribution on transverse momentum of scattering nucleons (without spectator) from reaction dp→ ppn. А - calculation without taking into account deuteron formfactor; Б- the difference between calculation/A/and experimental distribution (is given of a smooth curve); В - distribution on transverse momentum for elastic pd-scattering; Г - calculation on Glauber model (V.Franko, R.J.Glauber. Phys.Rev., 142, 1195, 1966.) without taking into account rescattering.

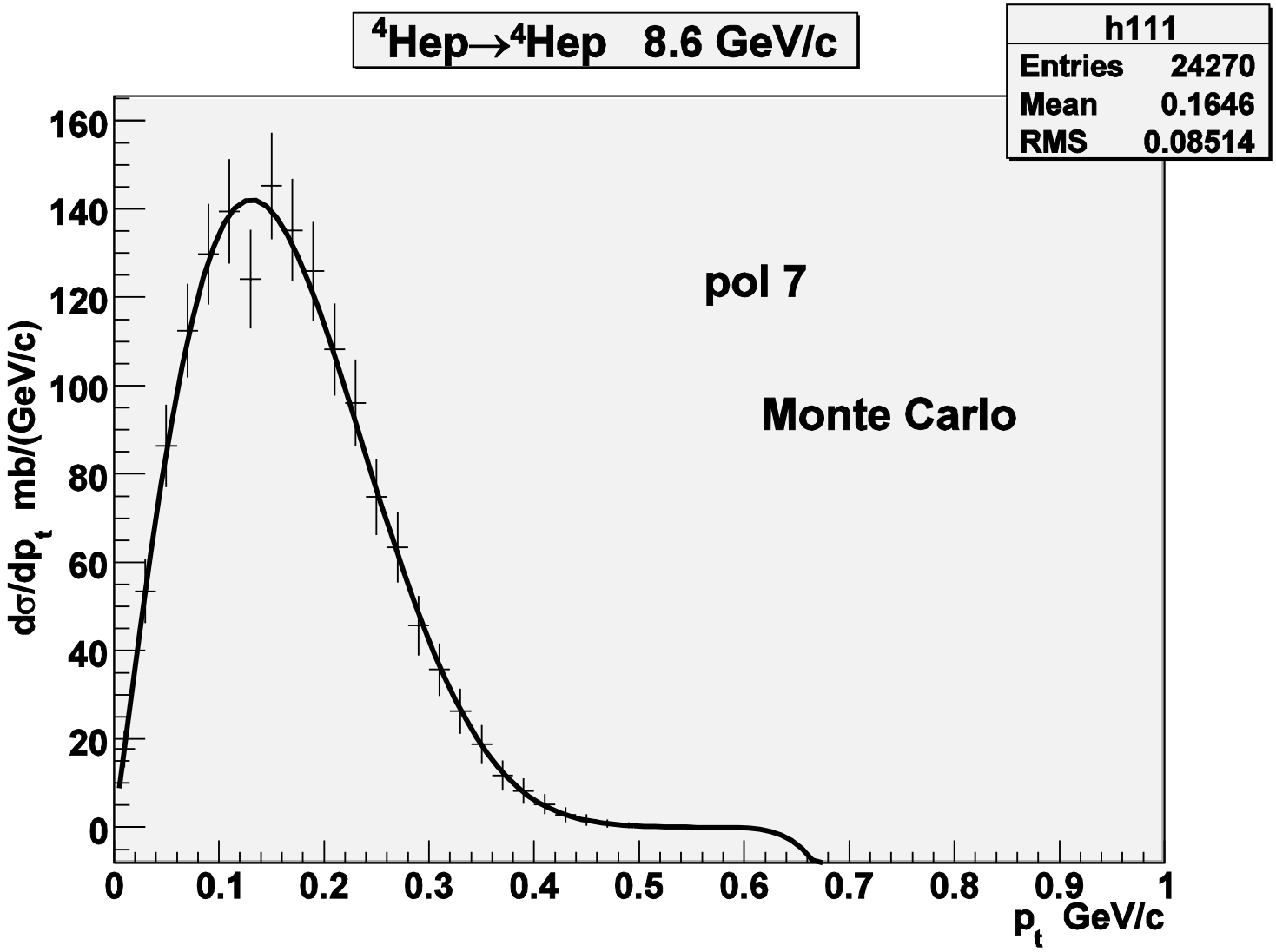




Azimuthal angle distributions.



- "Two-pronged events in ^{4}Hep collisions at 8.56 GeV/c momentum". Phys.Review C v.18 (1978)p.1382 V.V.Glagolev at al


^{4}Hep→^{4}Hep 8.6 GeV/c
h111
Entries 24270
Mean 0.1646
RMS 0.08514
pol 7
Monte Carlo
dσ/dp$_t$ mb/(GeV/c)
p$_t$ GeV/c
0
20
40
60
80
100
120
140
160
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1