NIS-GIBS spectrometer starts hypernuclei research with Li beam

A.Averyanov on behalf of NIS-GIBS collaboration

(Dubna-Prague-Řež)

October, 2008, Dubna

Hypernuclei production via target excitation:

1) Negative kaon beams of "magic"momentum (proposed by Podgorecky)

$$K^- + A \rightarrow \pi^- + {}_{\Lambda}A$$

2) Stopping kaons (DAΦNE, Fraskati)

$$K^- + A \rightarrow \pi^- + {}_{\Lambda}A$$

3) Pion beams $\pi^+ + A \rightarrow K^+ + {}_{\Lambda}A$

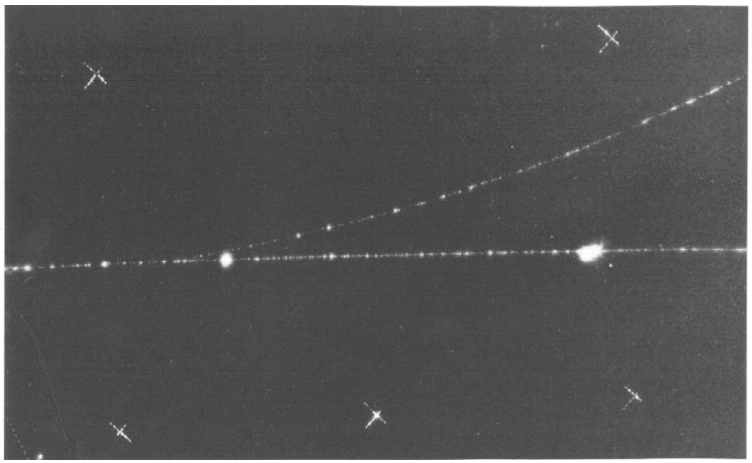
4) Electron beams $e + A \rightarrow e + K + {}_{\Lambda}A$

Production via beam nuclei (fragment) excitation.

$$A + C \rightarrow {}_{\Lambda}F + X$$

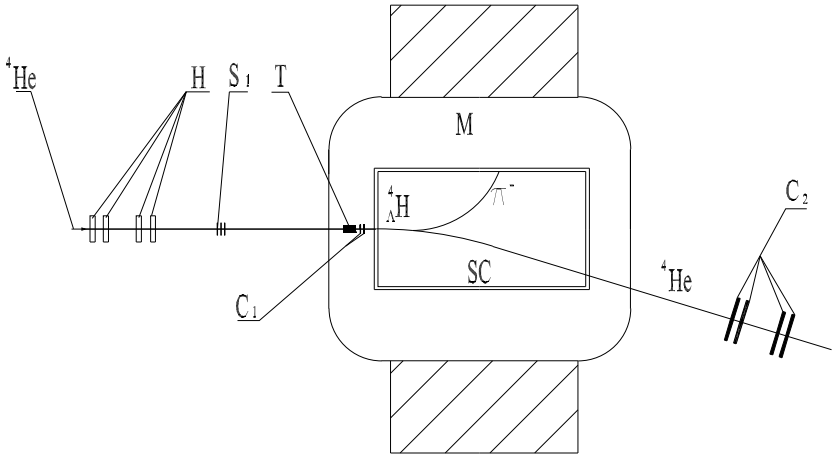
F = A - i (i=0,1,2..)

Approach was elaborated at Dubna
now at Dubna and Darmstadt - see talk of O.Borodina.



The first Dubna experiment.

Hypernucleus ${}^{4}_{\Lambda}\mathrm{H} \rightarrow {}^{4}\mathrm{He} + \pi^{-}$ decay observed in the streamer chamber.



Scheme of the experiment. H - beam hodoscopes, S - monitor counters, T - target, $C_{1,2}$ - trigger counters, SC - streamer chamber, M - magnet

The measured lifetime values are τ=220$^{+50}_{-40}$ ps for $^{4}_{\Lambda}$H (30 events) and τ=240$^{+170}_{-100}$ ps for $^{3}_{\Lambda}$H. Production cross sections, streamer chamber experiment, theory — H.Bandō, T.Motoba, J.Žofka, Int. J. Mod. Phys., A 5(1990) 4021.

Beam	Hyper-nuclei	Energy (GeV/nucleon)	Cross sections (μb) Theory	Experiment
^{3}He	$^{3}_{\Lambda}$H	5.14	0.03	$0.05^{+0.05}_{-0.02}$
^{4}He	$^{3}_{\Lambda}$H	3.7	0.06	< 0.1
	$^{4}_{\Lambda}$H	2.2	0.08	< 0.08
		3.7	0.29	$0.4^{+0.4}_{-0.2}$
^{6}Li	$^{3}_{\Lambda}$H	3.7	0.09	$0.2^{+0.3}_{-0.15}$
	$^{4}_{\Lambda}$H	3.7	0.2	$0.3^{+0.3}_{-0.15}$
^{7}Li	$^{7}_{\Lambda}$Li	3.0	0.11	< 1
	$^{6}_{\Lambda}$He	3.0	0.25	< 0.5

Physics subjects for new experiments:

- Study of neutron rich hypernuclei. Glue effect of hyperons in nuclei. Neutron very rich hypernuclei (search for ${}^{6}_{\Lambda}\mathrm{H}$, proposed by L.Majling).

- Matrix elements for weak ΛN interaction. Unique possibility to get the values measuring partial widths of nonmesonic weak decays $\Gamma^{n}_{\alpha\alpha i}({}^{10}_{\Lambda}\mathrm{Be})$, $\Gamma^{p}_{\alpha\alpha i}({}^{10}_{\Lambda}\mathrm{B})$

- Precise binding energy value for loosely bound hypernuclei ${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{6}_{\Lambda}\mathrm{He}$. Interaction of hypernuclei beams.

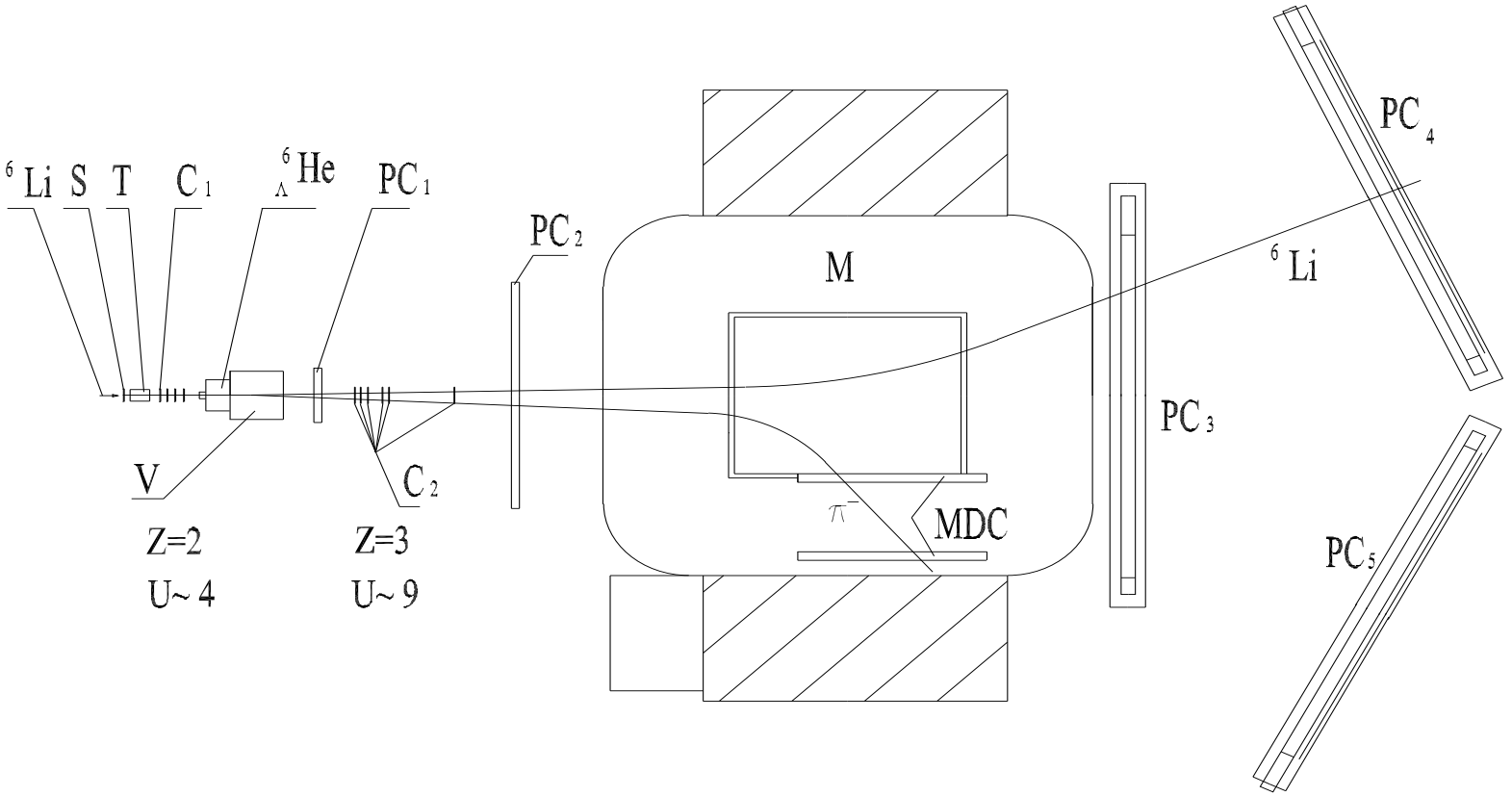
Study of neutron rich hypernuclei.

1. Investigation of "rare"hypernucleus ${}^{6}_{\Lambda}$He
(up to now 31 event observed, emulsion experiments).
^{6}Li + C$\rightarrow {}^{6}_{\Lambda}$He +. . . $\rightarrow {}^{6}$Li + π^{-}+p

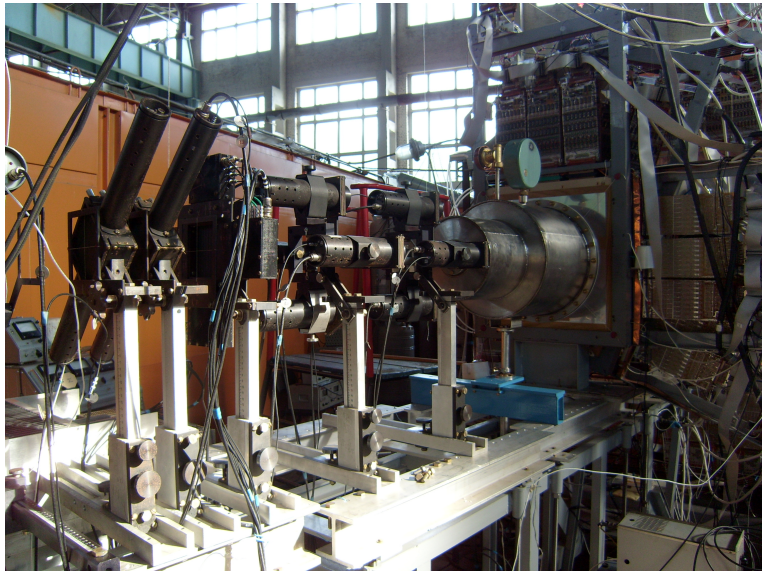
2. Search for unobserved hypernucleus ${}^{6}_{\Lambda}$H with ^{7}Li beam
^{7}Li + C$\rightarrow {}^{A}_{\Lambda}$H +p+. . . $\rightarrow {}^{A}$He + π^{-}+p A=6,4,3.

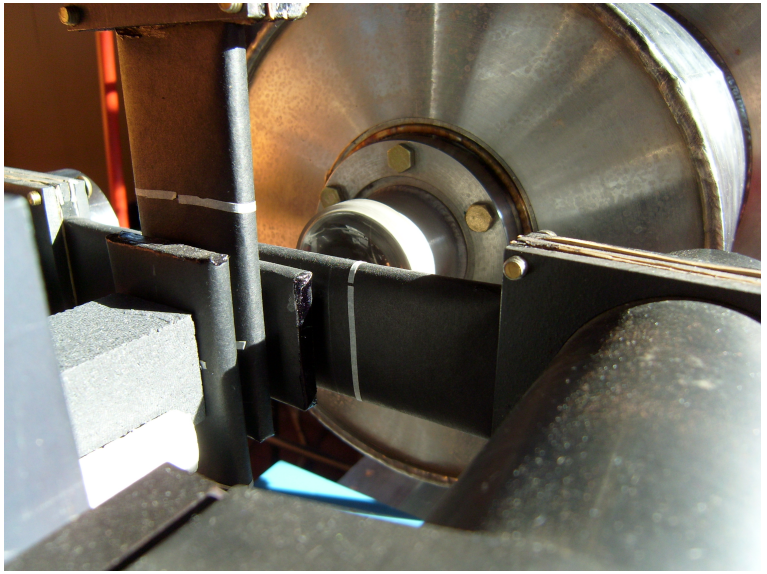
To measure:
1.Lifetime,
2.Production cross section (estimate, taking into account uncertainty of decay branching ratio),
3.Hypernuclei mass $\Rightarrow$ binding energy B_{Λ}.

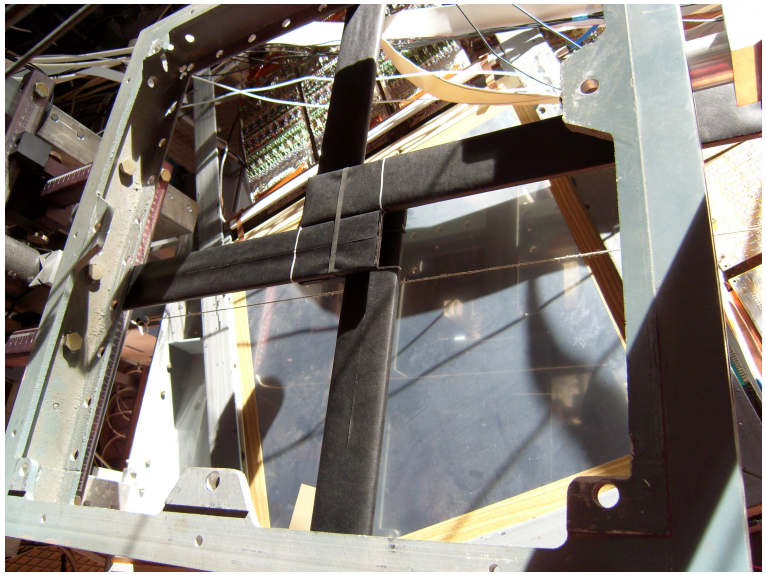
No data for ${}^{6}_{\Lambda}$H
Nothing except $B_{\Lambda} = 0.17$ for ${}^{6}_{\Lambda}$He.

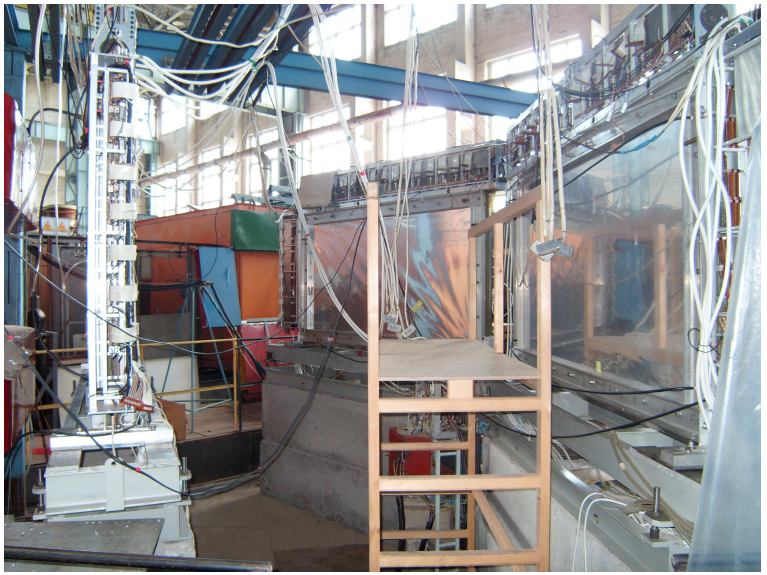


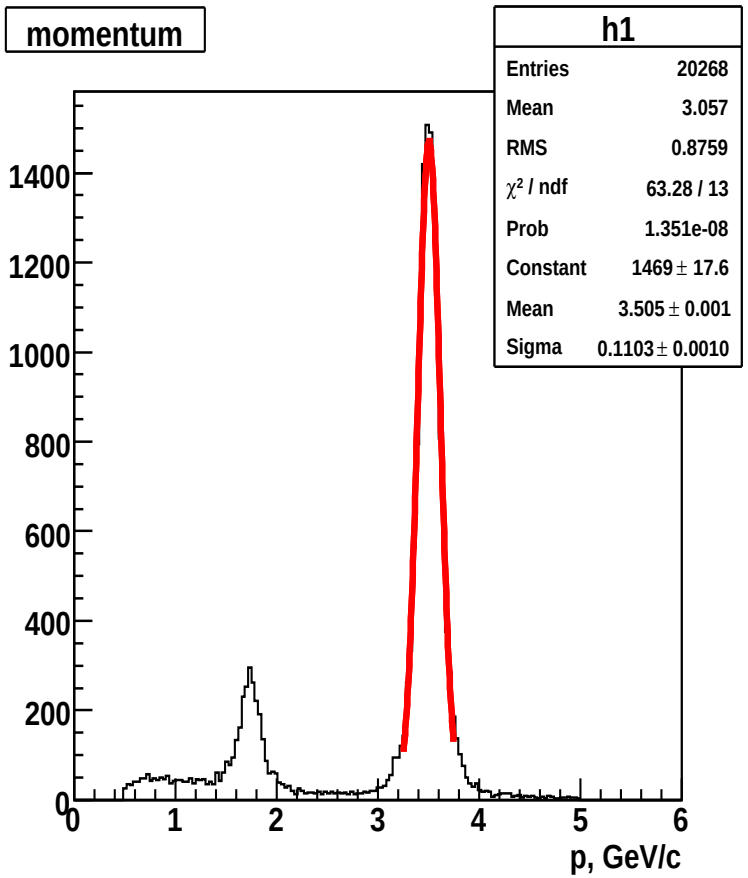
GIBS-NIS spectrometer for $^6_\Lambda$He experiment with ^{6}Li beam. T – target (carbon, 12X3X3 cm, 20.4 g/cm^2); $C_{1,2}$ – trigger counters (4X4 cm and 8X8 cm); V – vacuum decay volume; M – magnet; PC_{1-5} – proportional chambers, MDC – minidrift chambers (2010, plan).



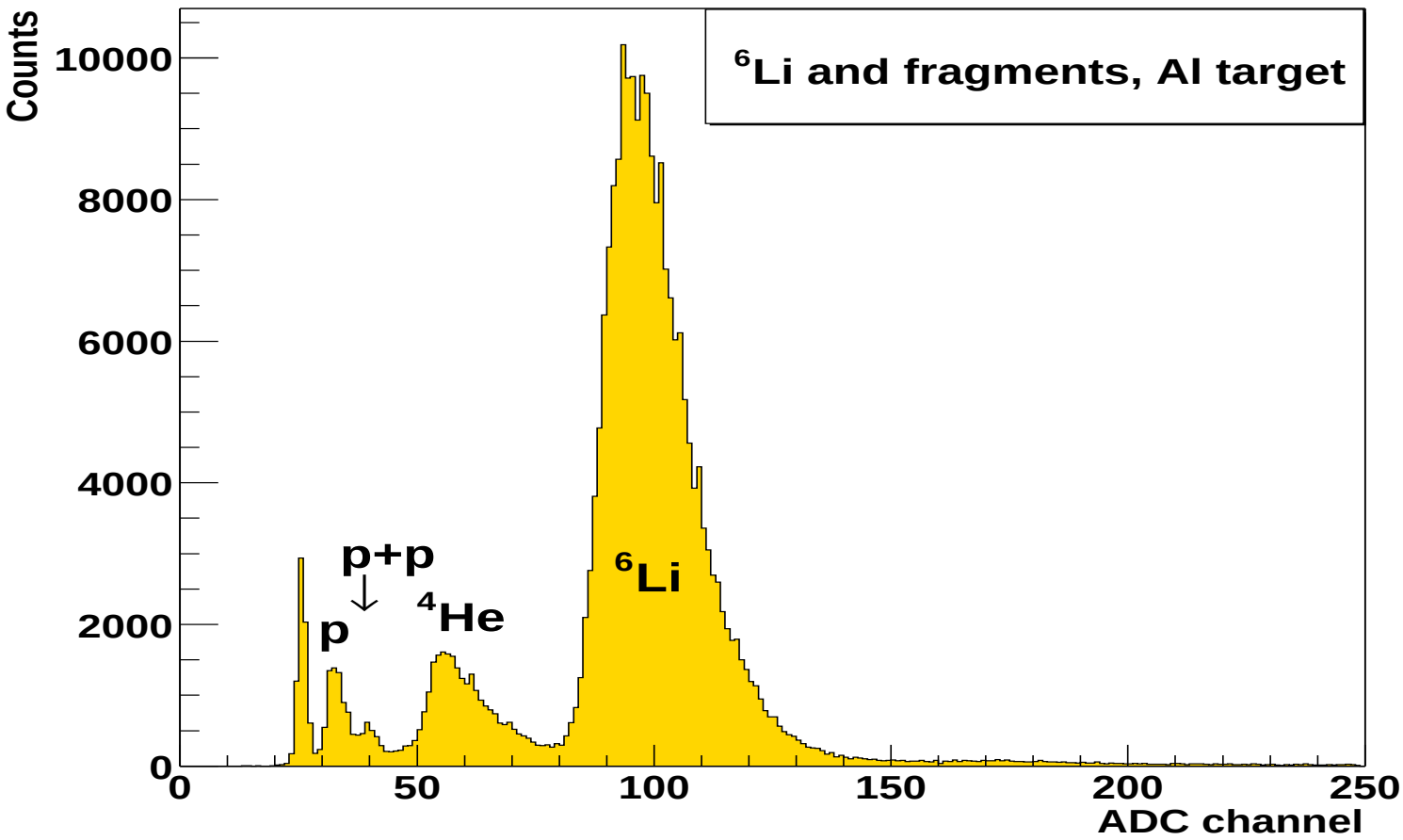




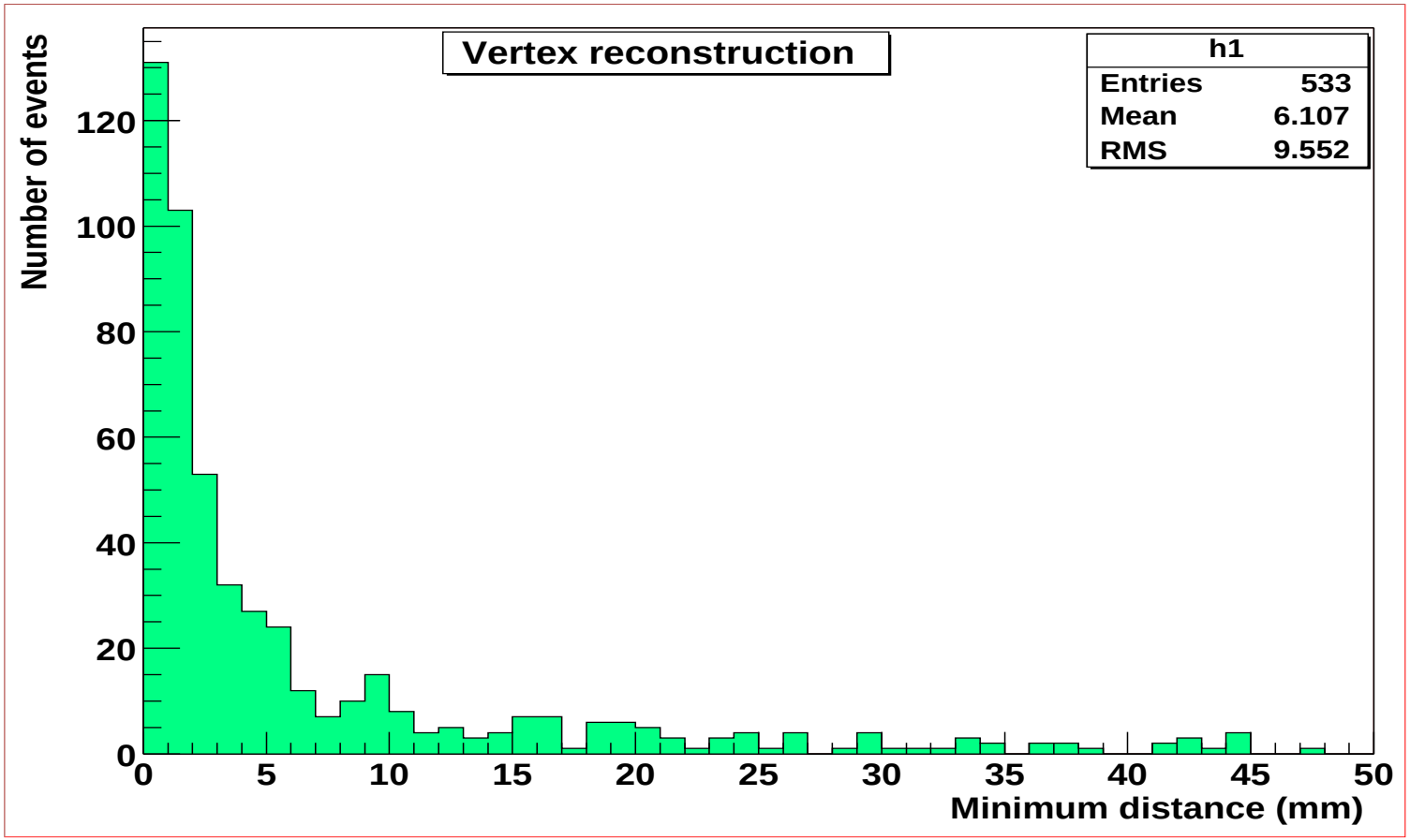




The first test of the spectrometer with deuteron beam and carbon target, wide peak momenta of fragments (drawn by O.Borodina)



Tuning of a trigger counter with lithium beam. Signal amplitude peaks: lithium beam and fragments – helium, protons, ... Left peak - zero amplitude. Coincidence of 8 or 9 counters provides background suppression $\approx 10^4$



Search for vertices – intersected tracks. The obtained (preliminary) distribution of the distance between two tracks is two times wider than ideal (Monte Carlo) and shows that tuning of proportional chamber alignment and tracking should be continued.

SUMMARY

- NIS-GIBS spectrometer was successfully tested and is ready for the first hypernuclear experiments
- Data processing is in progress, the very preliminary results obtained (few possible hypernuclei events registered, analysis in progress)
- Capability of the spectrometer will be improved with installing scintillating fiber and quartz C̄erenkov counters, minidrift chambers, sophisticated control and readout electronics.