Alikhanov Institute for Theoretical and Experimental Physics
Russian Federation State scientific center

Preliminary results of FLucton INTeractions experiment

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For FLINT collaboration

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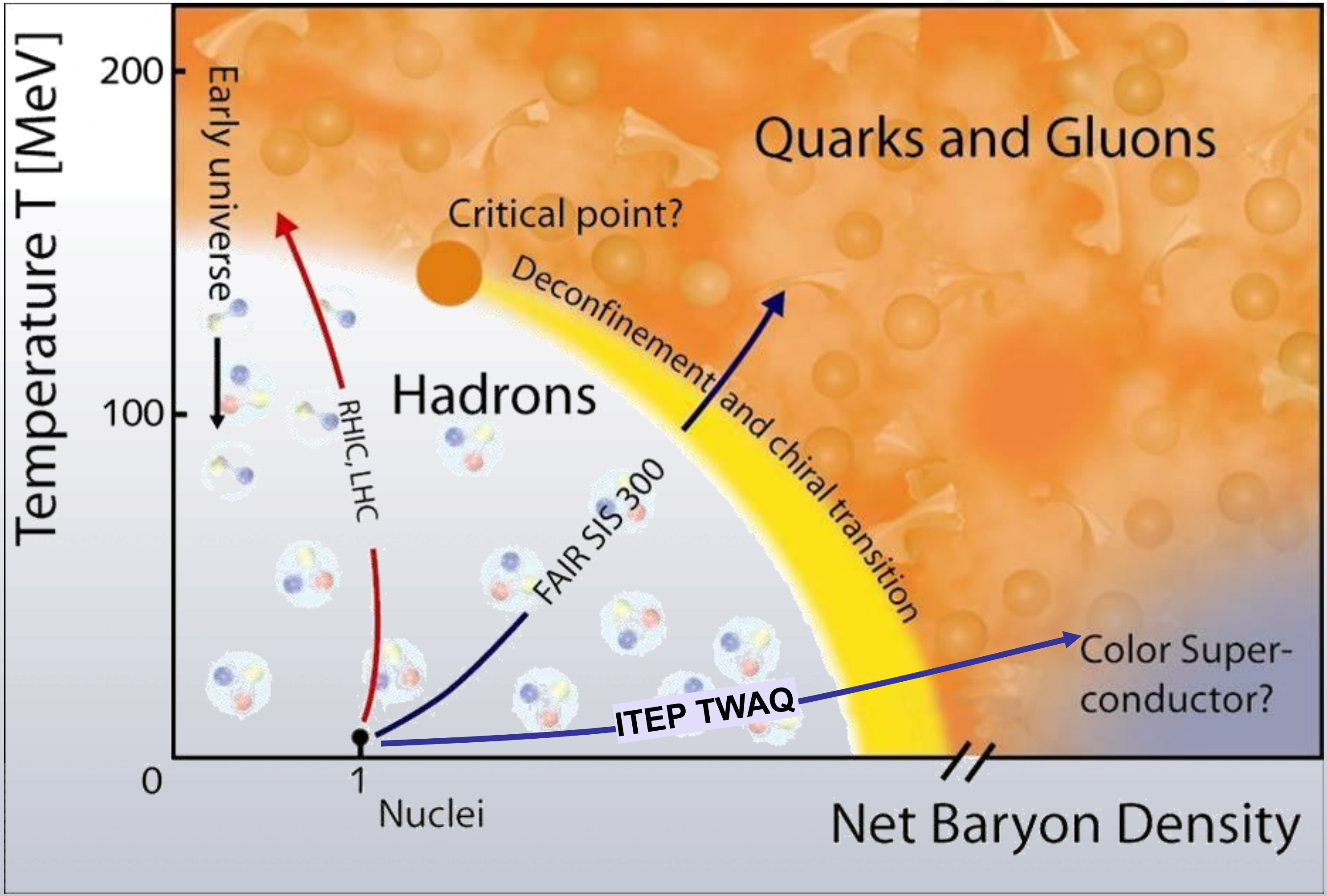
Outline

- Physics motivation
- Experimental setup
- First measurements
  - Data analysis
  - Comparison with models
- Summary

Phase diagram of nuclear matter

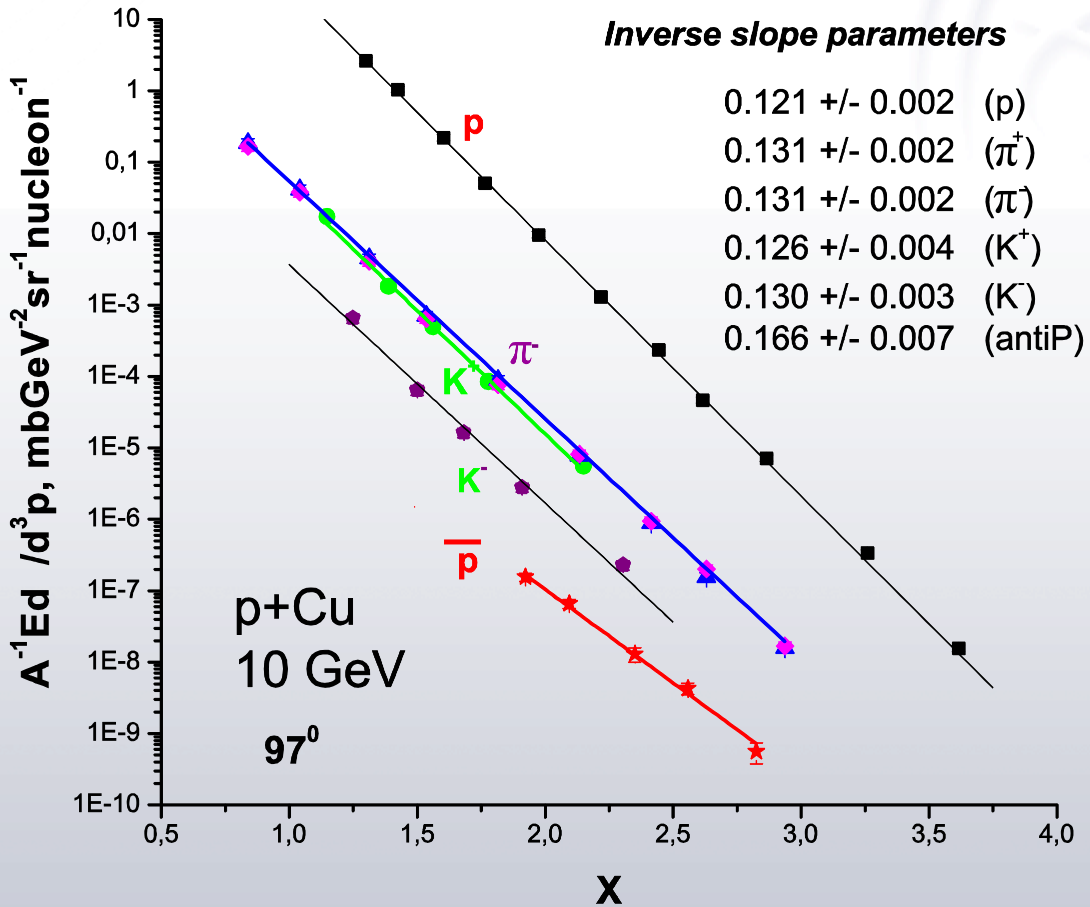


Cumulative effect

- 1966 G.A. Leksin: pC →p(137)X @ 1.0, 6.0 GeV
  - no peaks from pd-, pt-,pHe-… reactions in inclusive spectra.
  - the protons spectra beyond *NN* kinematical limits
- 1970 A.M. Baldin :
  - a) Particle production c.s. in pA → superposition of N+N, N+2N, 2N+N…
  - c) iN+jN subprocess will follow the scaling
    (the same x-dependence as for N+N int.)
- **Cumulative effect**: Particle production in the kinematical region <u>beyond the kinematical limits</u> for free nucleon-nucleon collisions.

It is considered as the signature for the interaction where at least one of the participants is <u>high density multinucleon</u> fluctuation of nuclear matter (**flucton**).

STATUS I

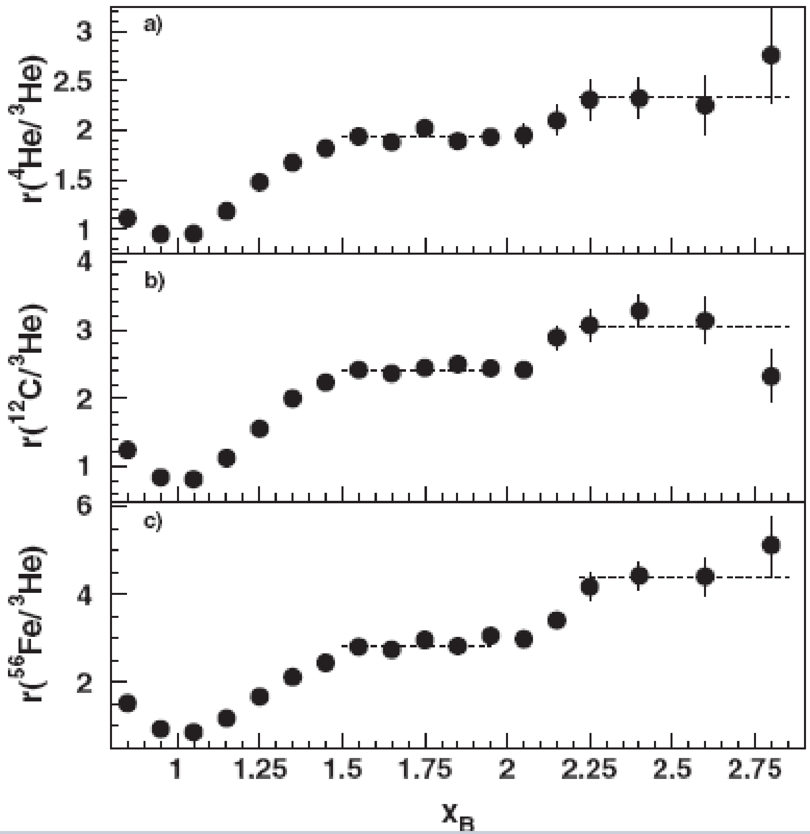


FAS @ ITEP (Boyarinov et.al Yad.Fiz 57 (1994) 1452)

X – minimal target mass [m_N] needed to produce particle

Status II

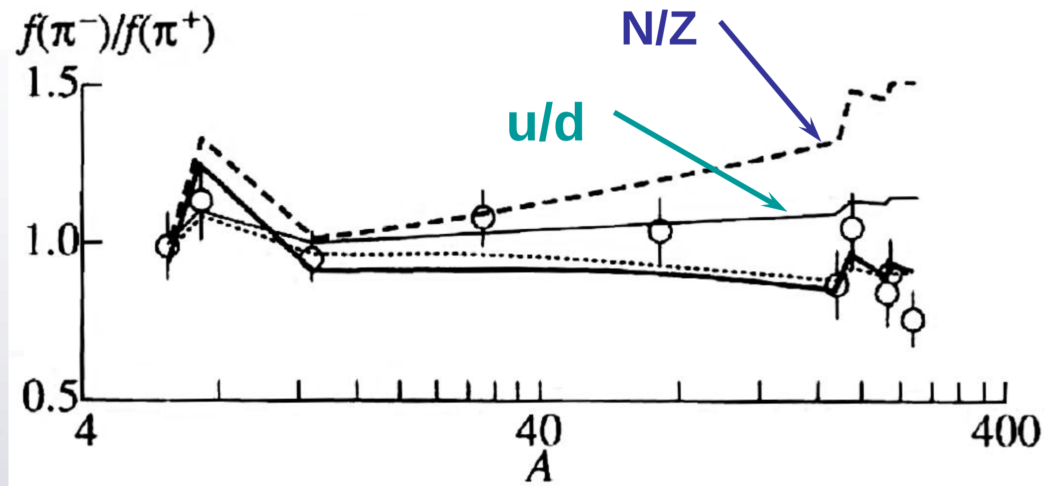
CLAS e$^-$A→aX @~4 AGeV



$$\boldsymbol{x}_B = Q^2/2m_N U$$

K.S. Egiyan et al. Phys. Rev. Lett. 96, 082501 (2006)

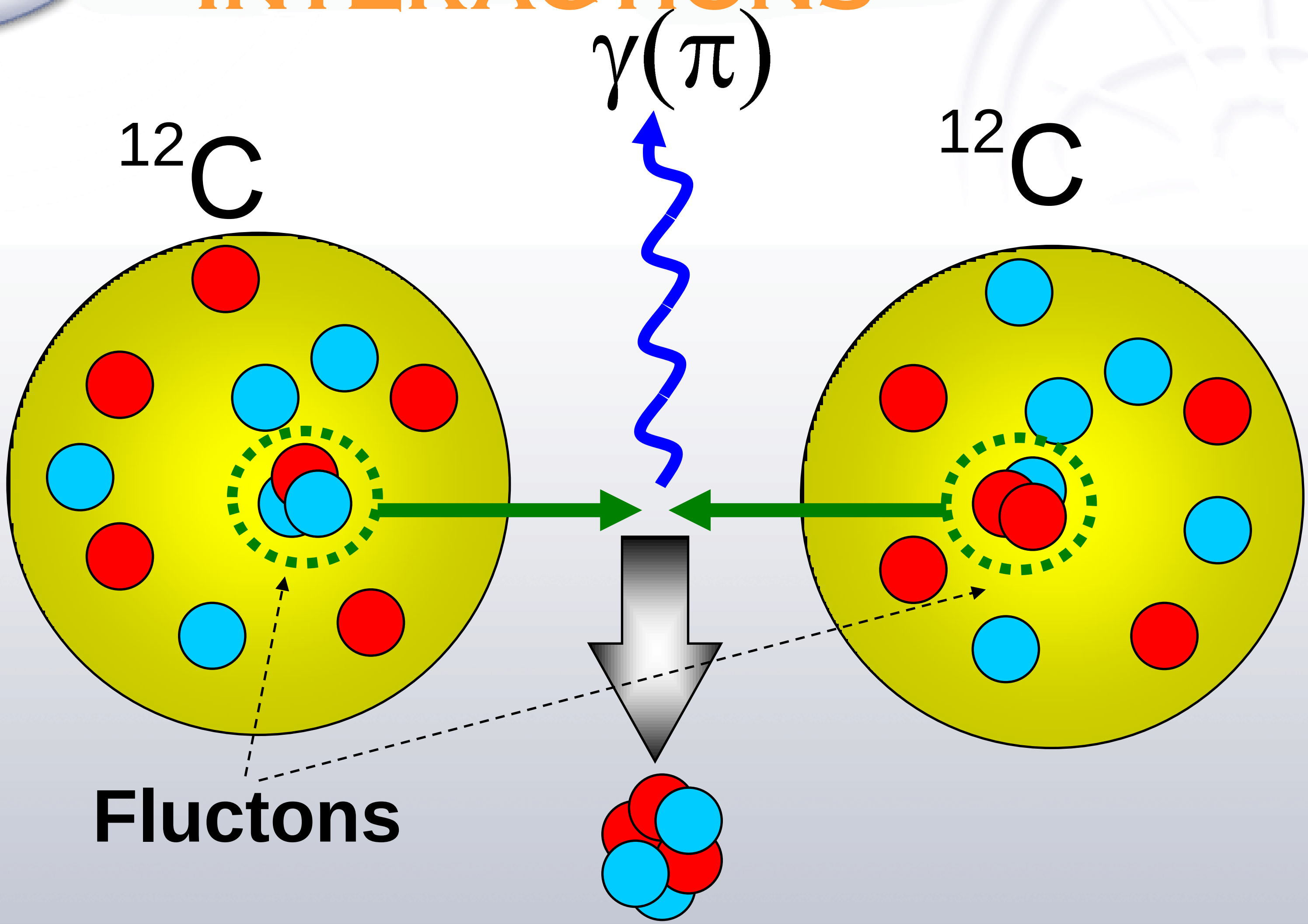
Isotopic effect (JINR)



Yad.Fiz. 59 4 694 (1996)

- Spin effect (JINR)
- Corellations (ITEP, JLAB)

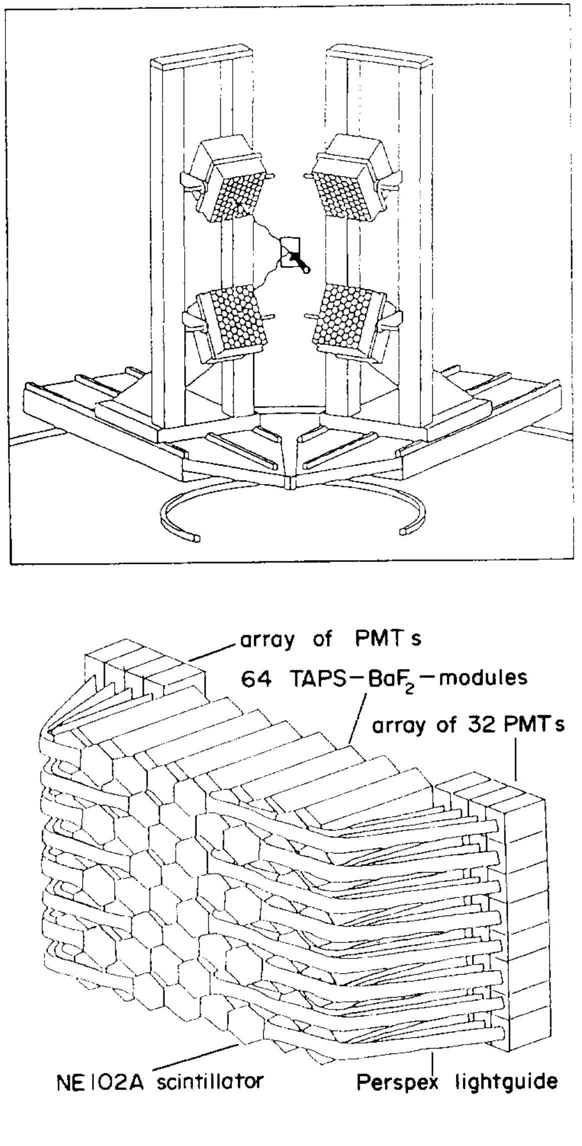
Flucton-flucton interactions

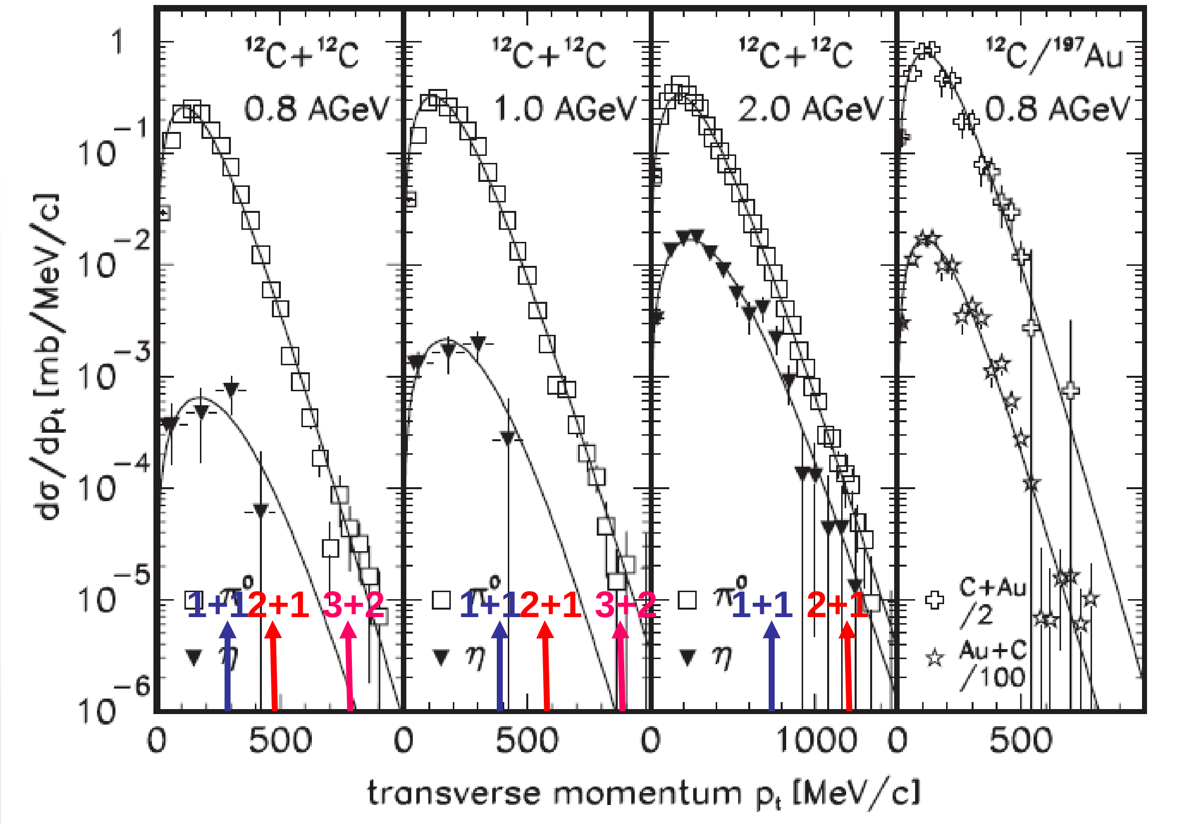


Dense baryon system

TAPS

$^{12}C+^{12}C \to \pi\ (\eta)X$ @ 0.8, 1.0 & 2.0 AGeV

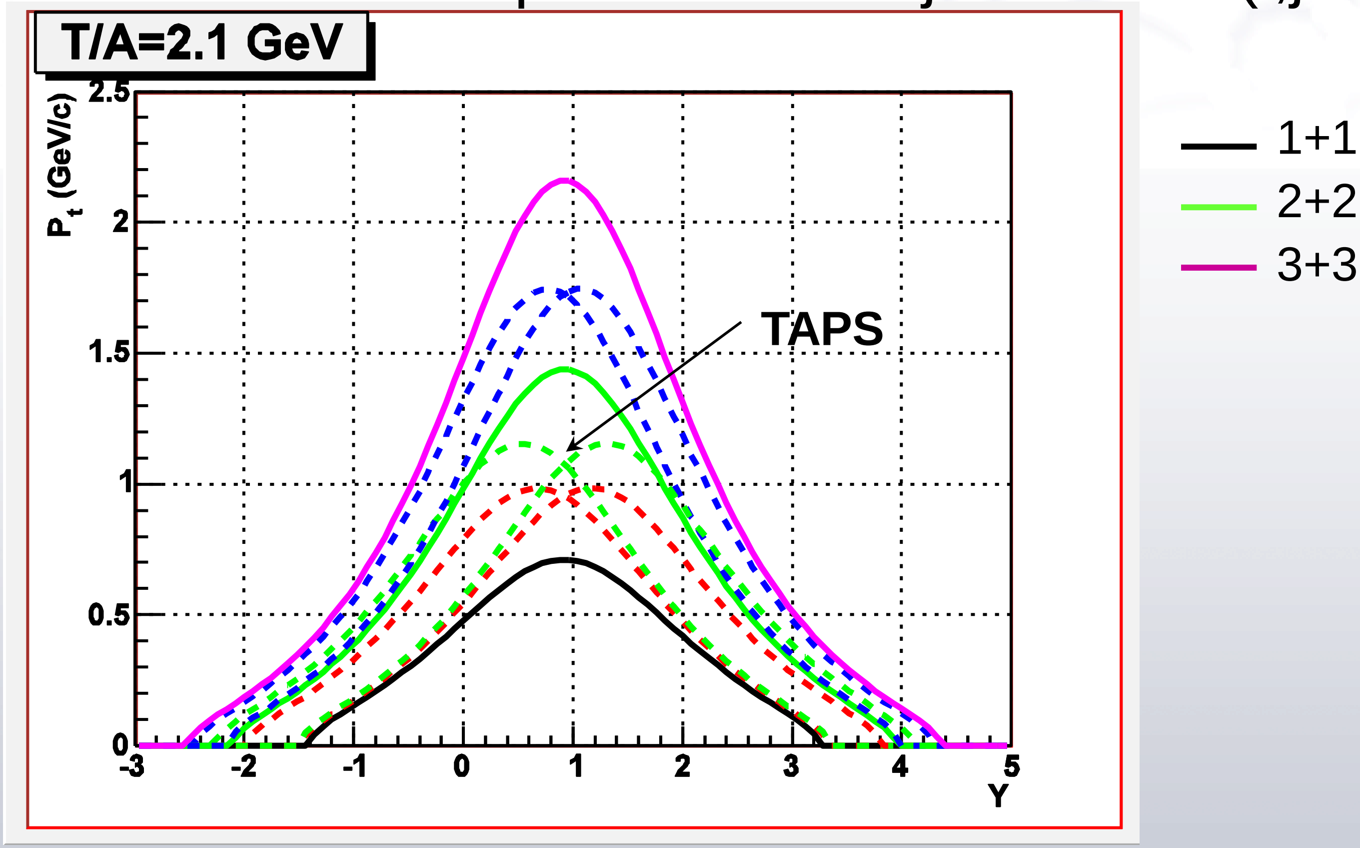




Z. Phys. A 359, 65–73 (1997)

Kinematical limits

Kinematical boundaries for processes iN+jN → π°+X (i,j=1,2,3)

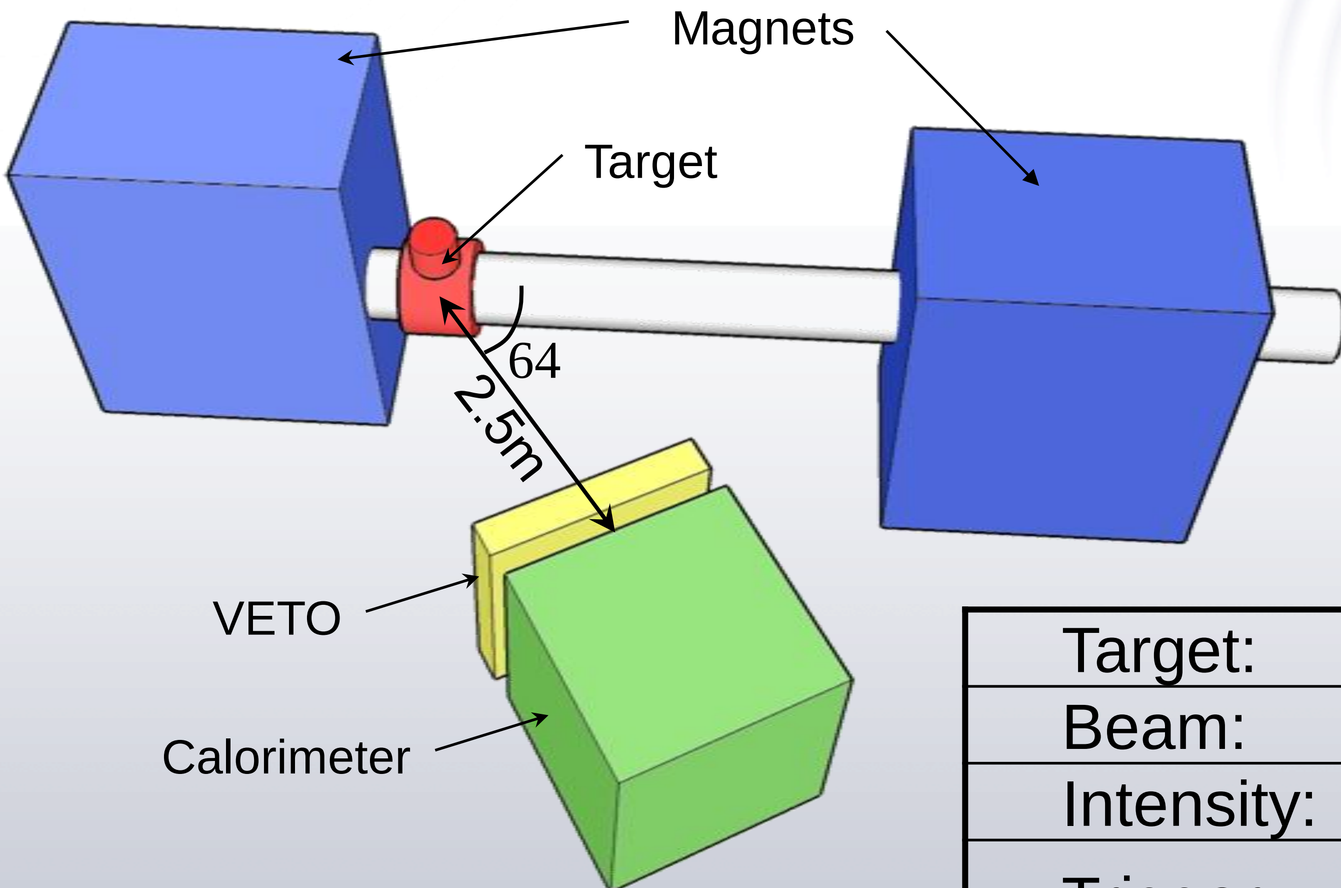


- Fragmentation regions – no arguments for FF domination
- Central Y – maximal flucton-flucton interaction probability

- Goal: **maximal iN+jN @ maximal TWAQ E_{beam}**
- Way: $A_1+A_2 \rightarrow \gamma$(maximal p_t) + X
  - A_1, A_2 lightest nuclei to avoid rescatterings
  - Why γ? – Larger $E_\gamma \rightarrow$ larger ECAL signal
    - Asymmetric π decay increases S/B ratio
    - γ: direct or from π - doesn’t matter for minimum iN+jN estimation.
  - maximal $p_t \rightarrow$ dense X

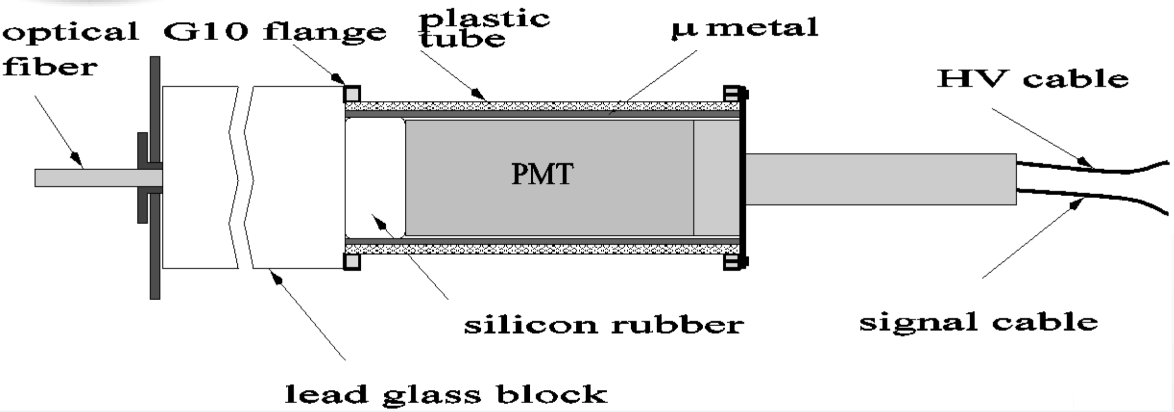
Experiment @ ITEP magnet hall

$^{12}C + Be \rightarrow \gamma + X$



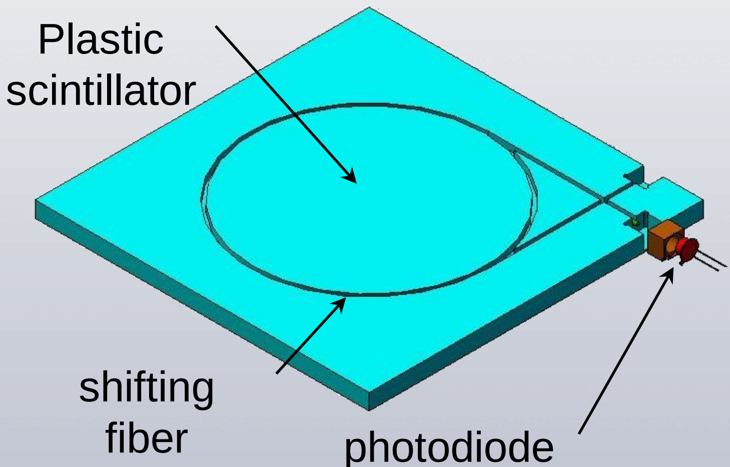
Target:	Be
Beam:	^{12}C E_K=3.2GeV
Intensity:	~10^7N/sec
Trigger	dE>1. GeV in any glass block

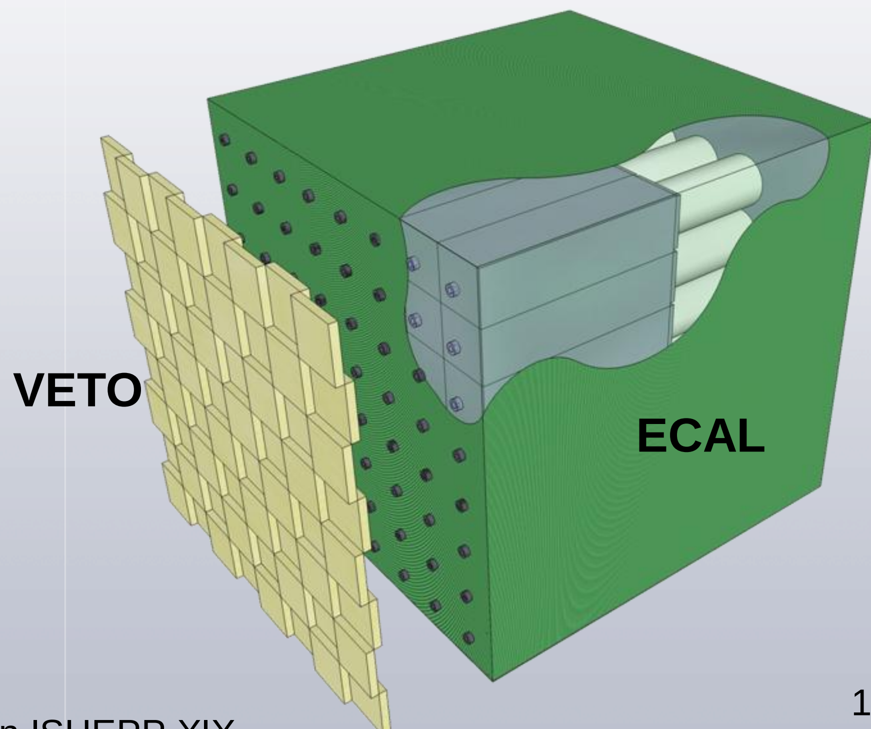
FLINT subsystems



matrix 8x8
100x100x380 mm^3
Lead glass F8
$\rho=3.6 g/cm^3$
$X_{rad}=3.1 cm$
$R_M=3.6 cm$
Mass~1.5 Tonn

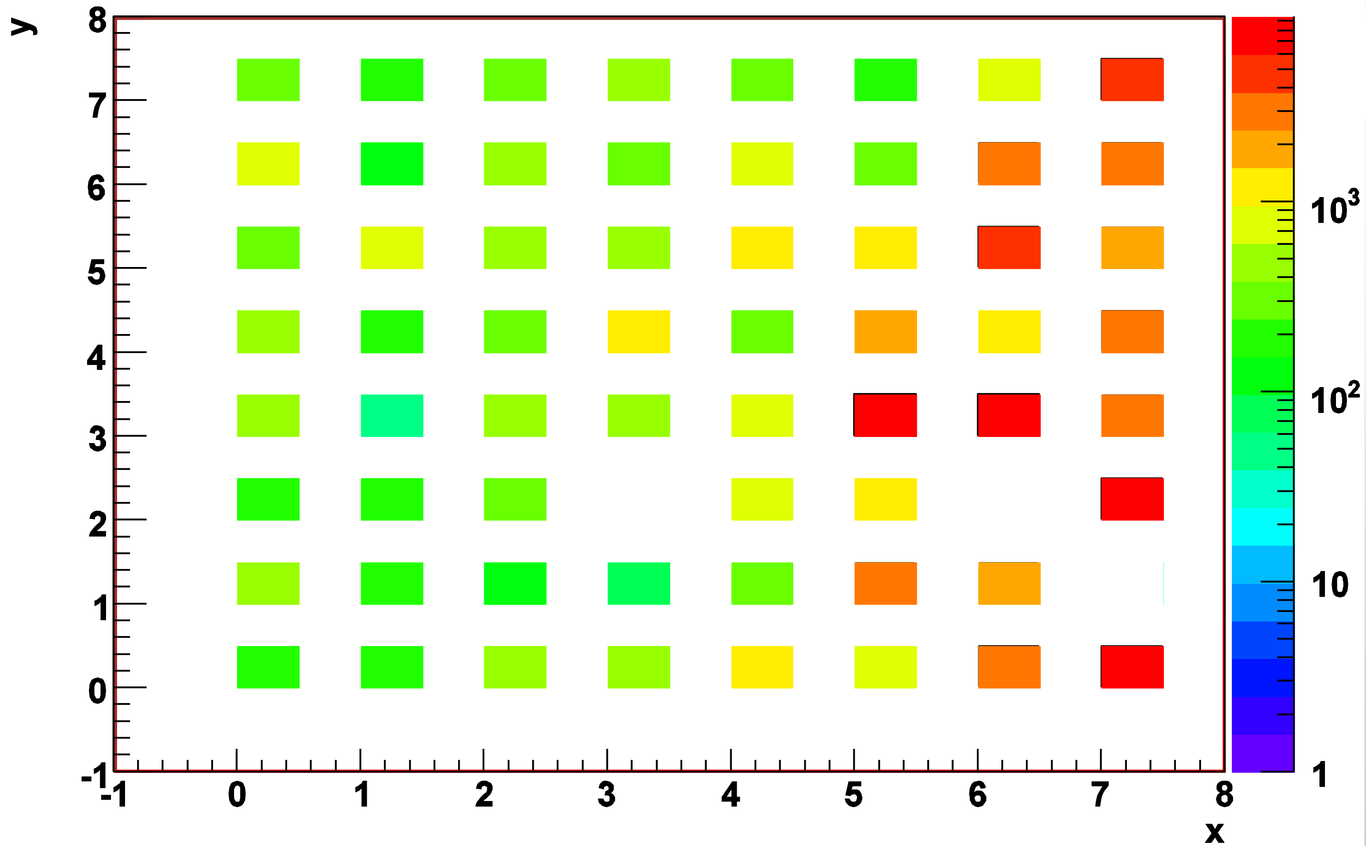
VETO counter

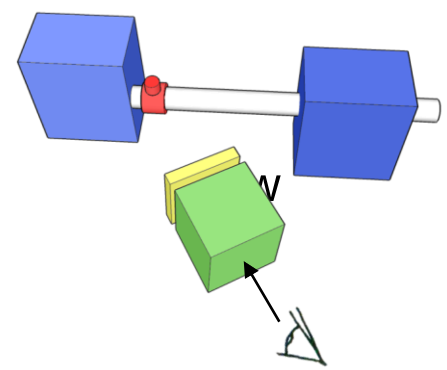




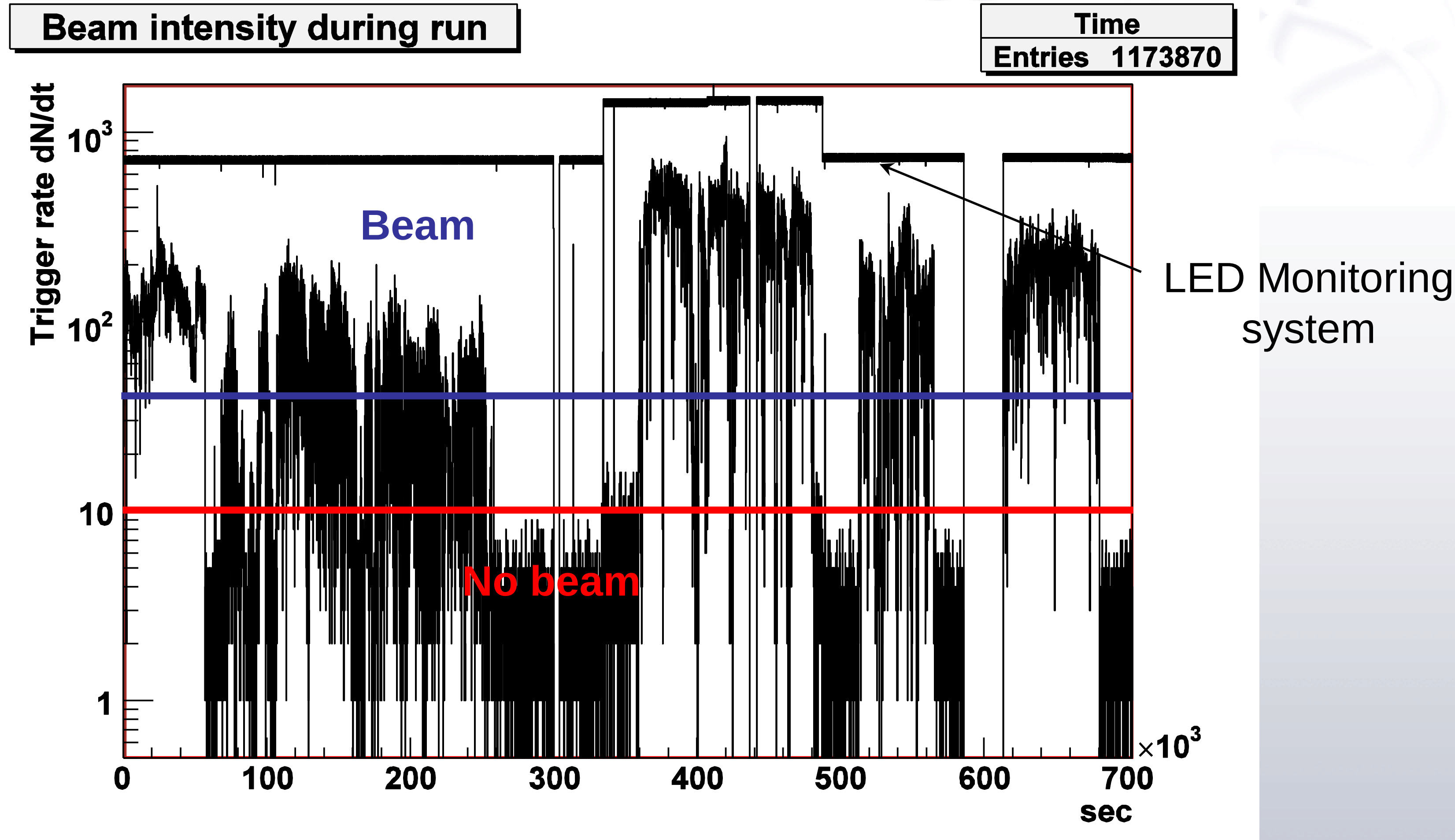
Trigger distribution

The trigger number distribution over calorimeter channels.



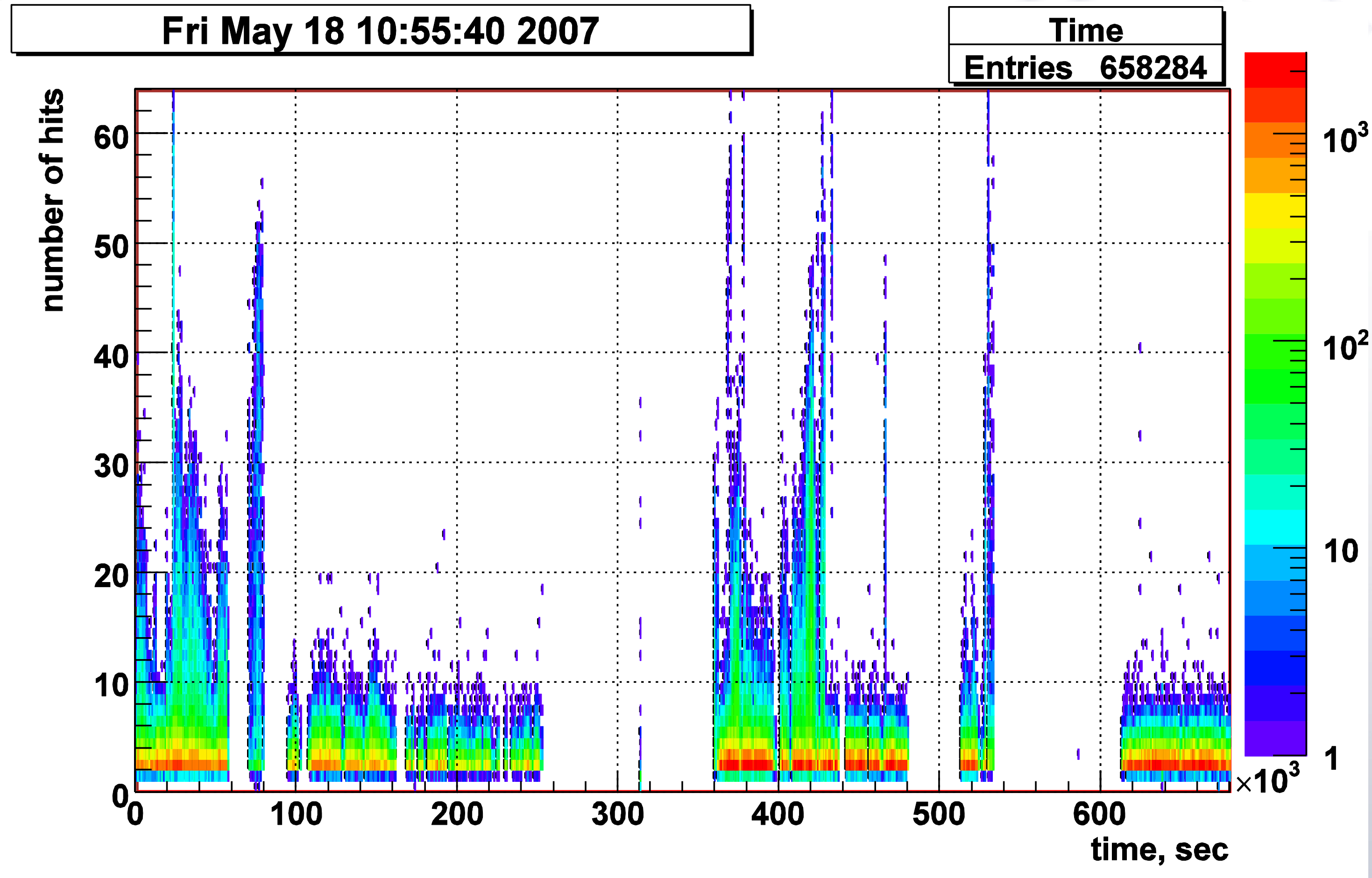


Beam intensity



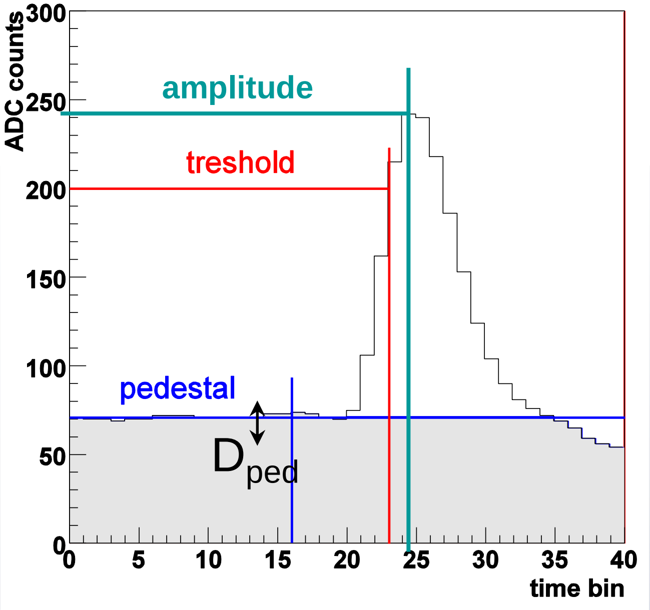
Cut: trigger rate $\upsilon_{trig} > 1Hz$

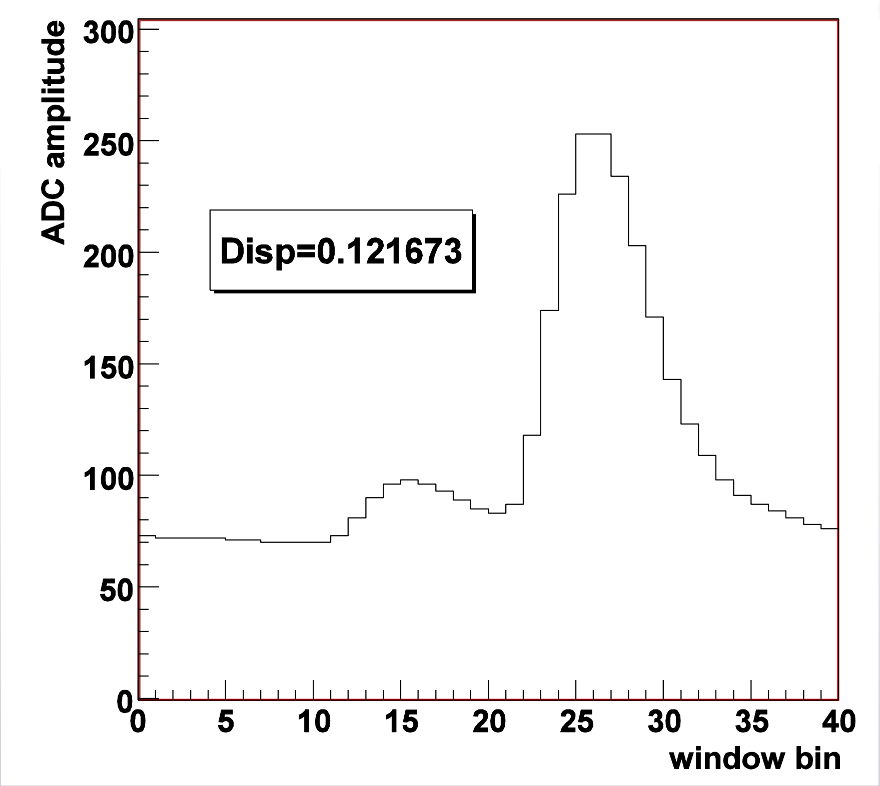
Spill structure



Cut: number of hits in event $N_{hits}<4$

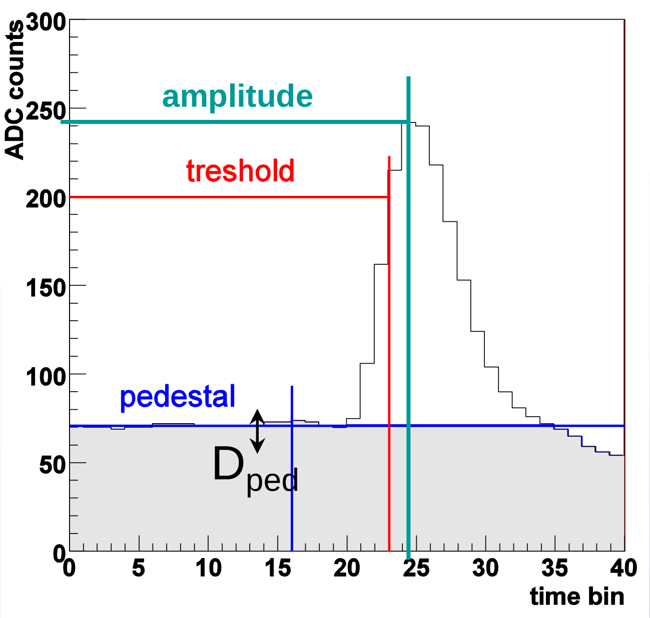
Signal shape analysis
Pedestal dispersion

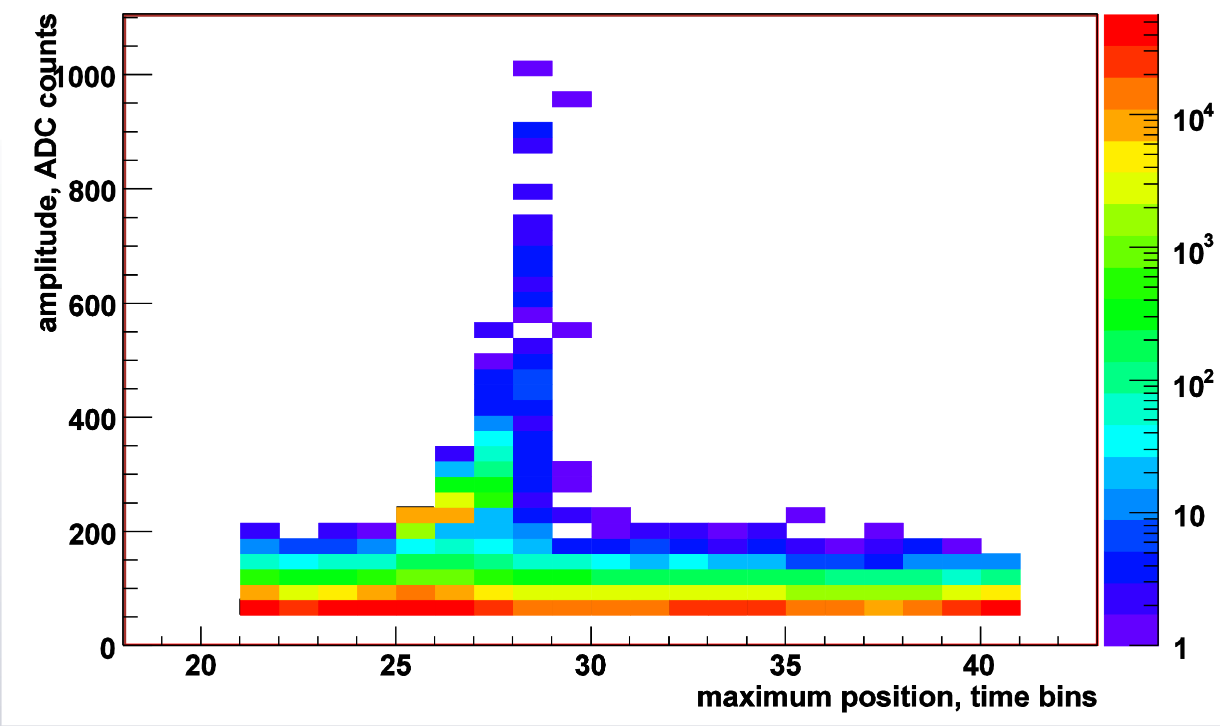




Cut: pedestal dispersion D/pedestal<10%

Signal shape analysis
Amplitude vs. Maximum position

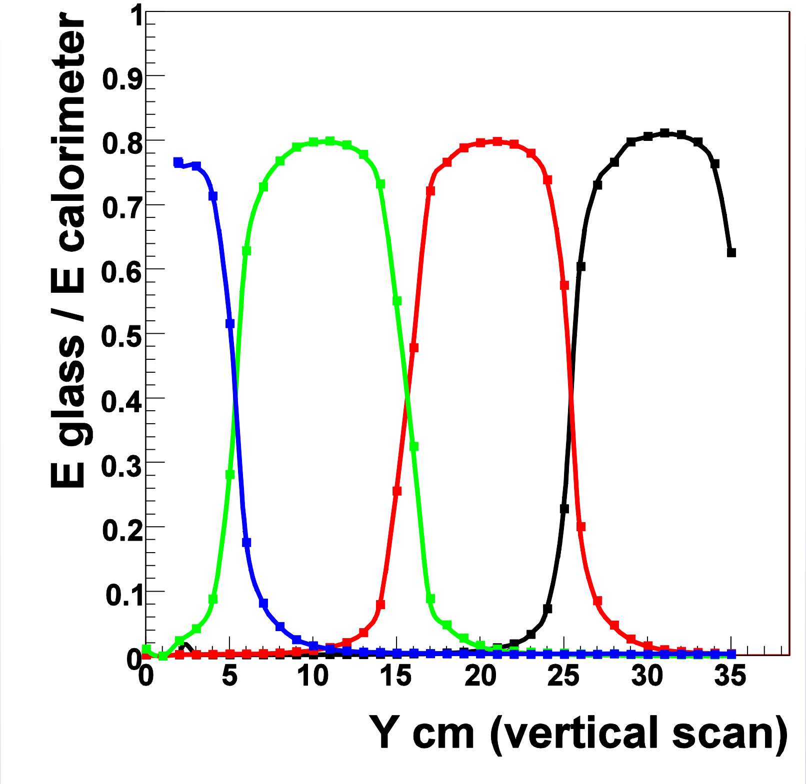


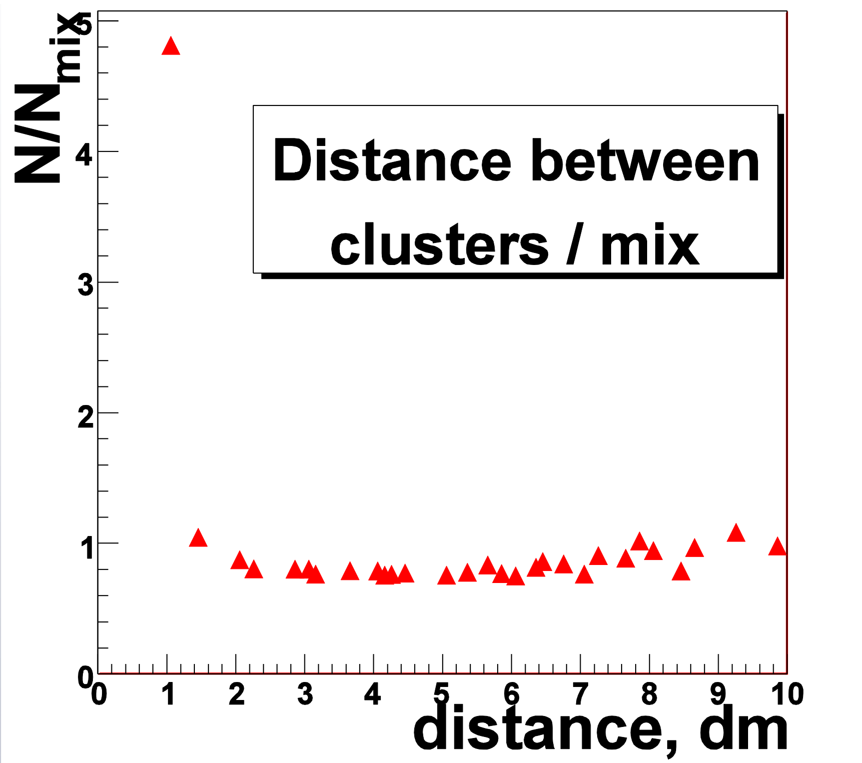


Cut: maximum position 24<MP<29

Cluster I

If a particle hits the corner of a glass block, some part of EM shower leaks into the next block. This part is small and hard to reconstruct. => central hits only

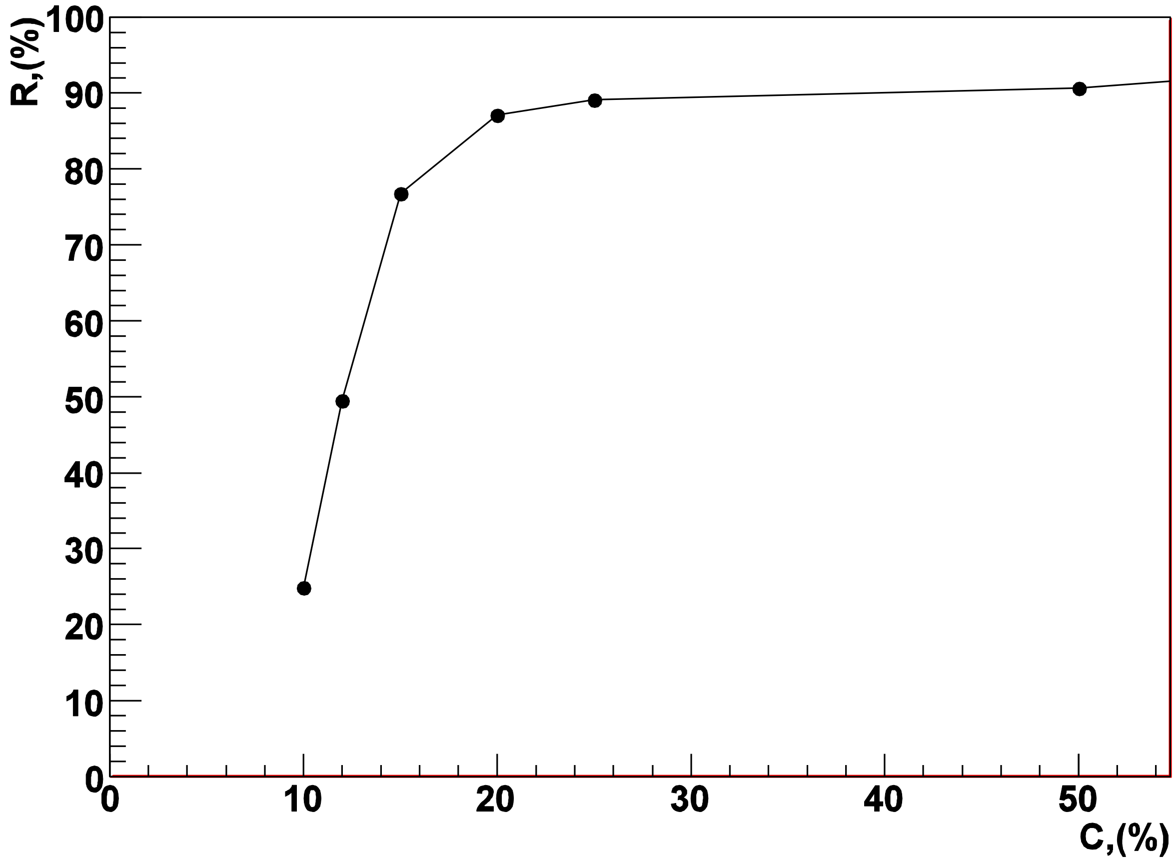




•Hits on the distance >1. dm don't belong to the cluster

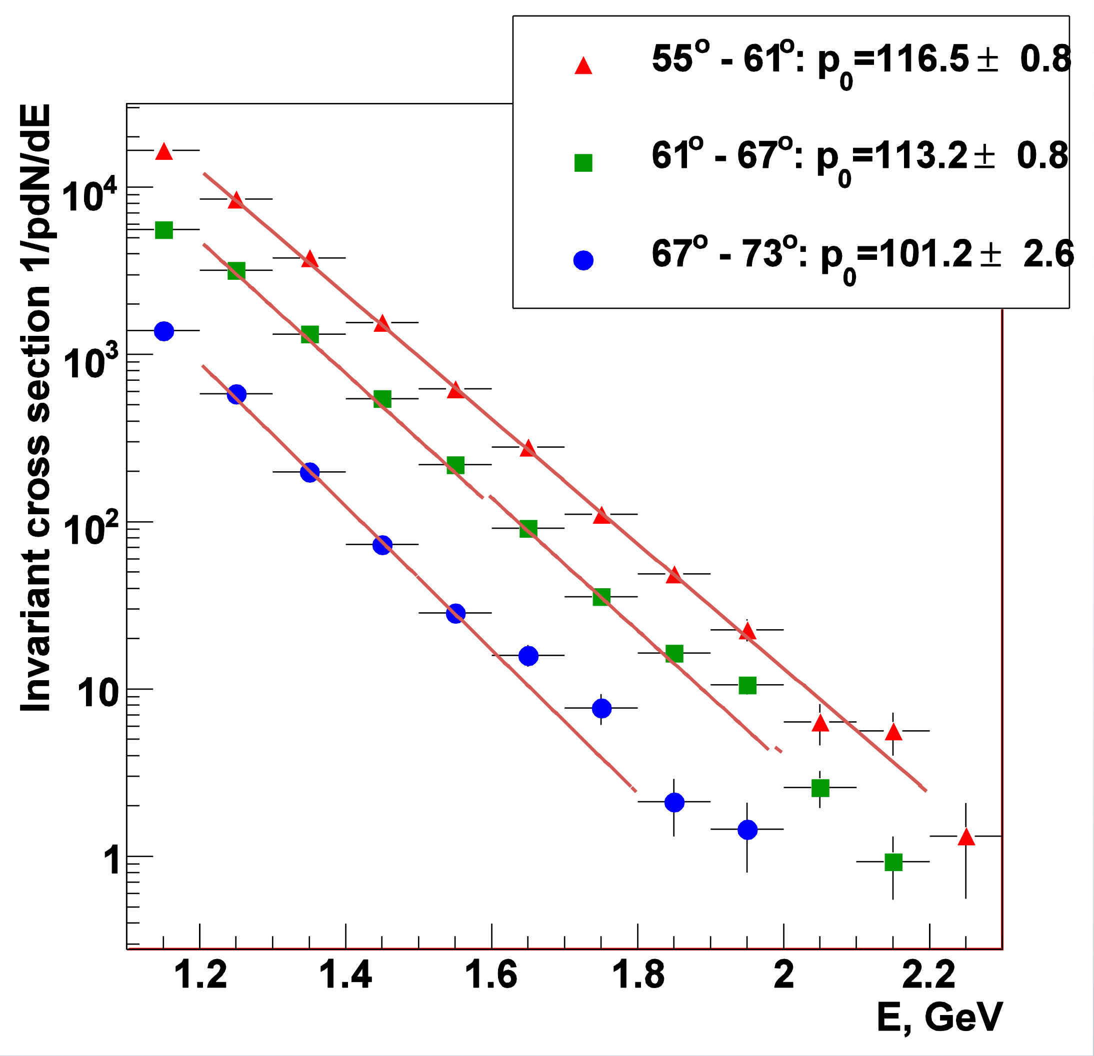
Cluster II

Part of clusters cutted R vs. Hit fraction in cluster C

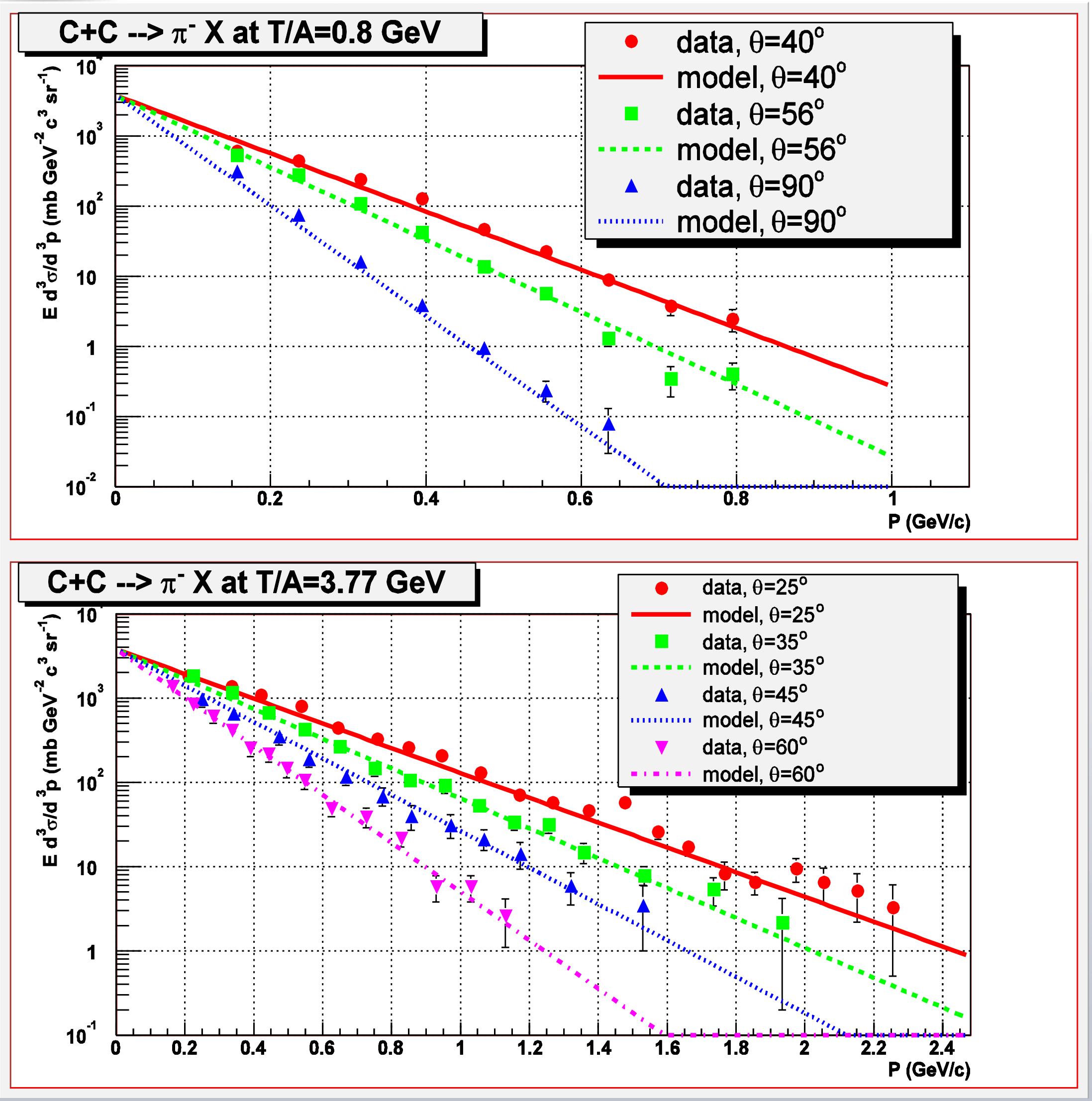


the “centrality” cut C=15% is applied to select clusters consisting of 1 hit

Results I



55° - 61°: p0=116.5 ± 0.8
61° - 67°: p0=113.2 ± 0.8
67° - 73°: p0=101.2 ± 2.6
Invariant cross section 1/pdN/dE
10^4
10^3
10^2
10
1
1.2
1.4
1.6
1.8
2
2.2
E, GeV



$$\sigma_I = C \cdot \exp\left(-\frac{p}{p_0}\right)$$

$$p_0 = \frac{k \cdot \beta\gamma}{1-\beta(\cos\theta - \cos 45^\circ) - \cos^2 45^\circ}$$

describes:

✓different initial energies (*γ* and *β*)

✓different angles *θ*

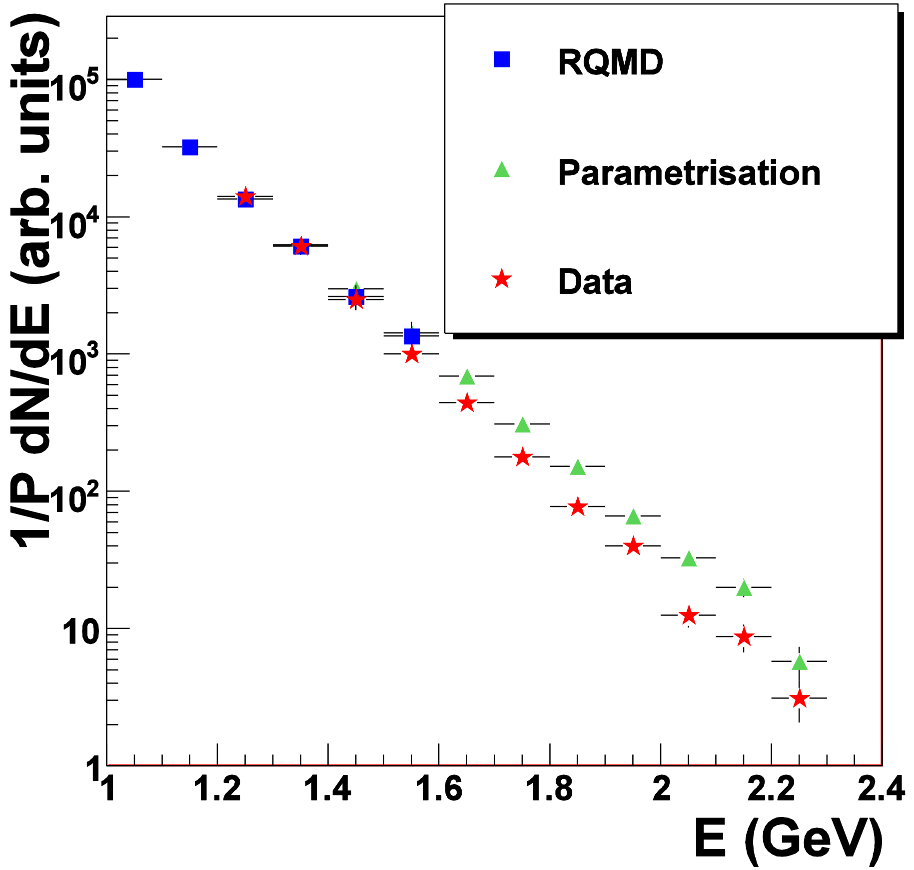
Parameters *C* = *3800*,

k* = *0.075

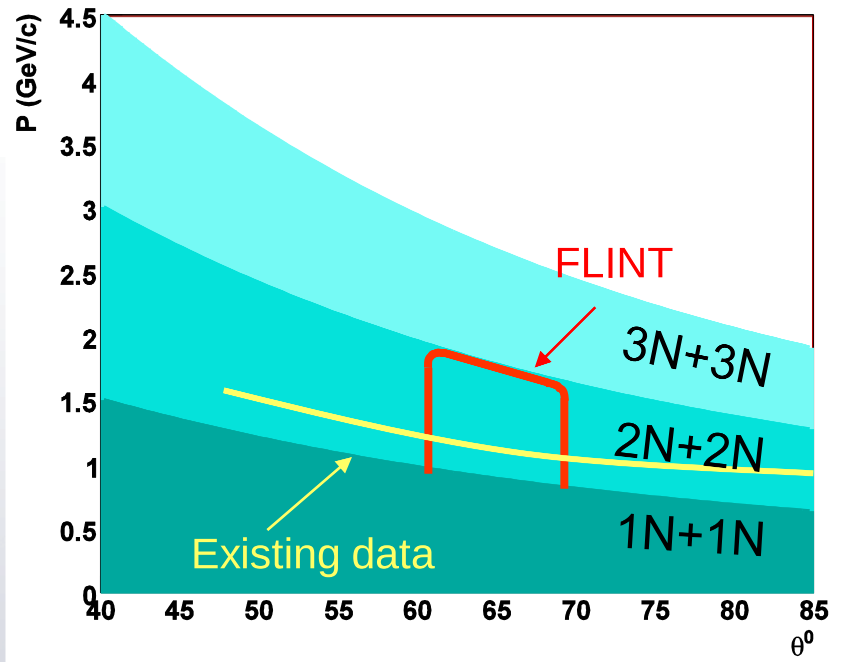
S. Nagamiya et. al. Phys. Rev. C24, 971 (1981)

G.N. Agakishiev et al., Yad. Fiz. 51, 1591 (1990)

RESULTS



RQMD
Parametrisation
Data
1/P dN/dE (arb. units)
E (GeV)



P (GeV/c)
FLINT
3N+3N
2N+2N
1N+1N
Existing data

Conclusions

- A fast effective trigger on cumulative process is made
- The kinematical area of flucton-flucton interactions is entered

- TO DO
  - Minimize noise to reach larger iN+jN region
  - Study of recoil system (back-to-back correlations)

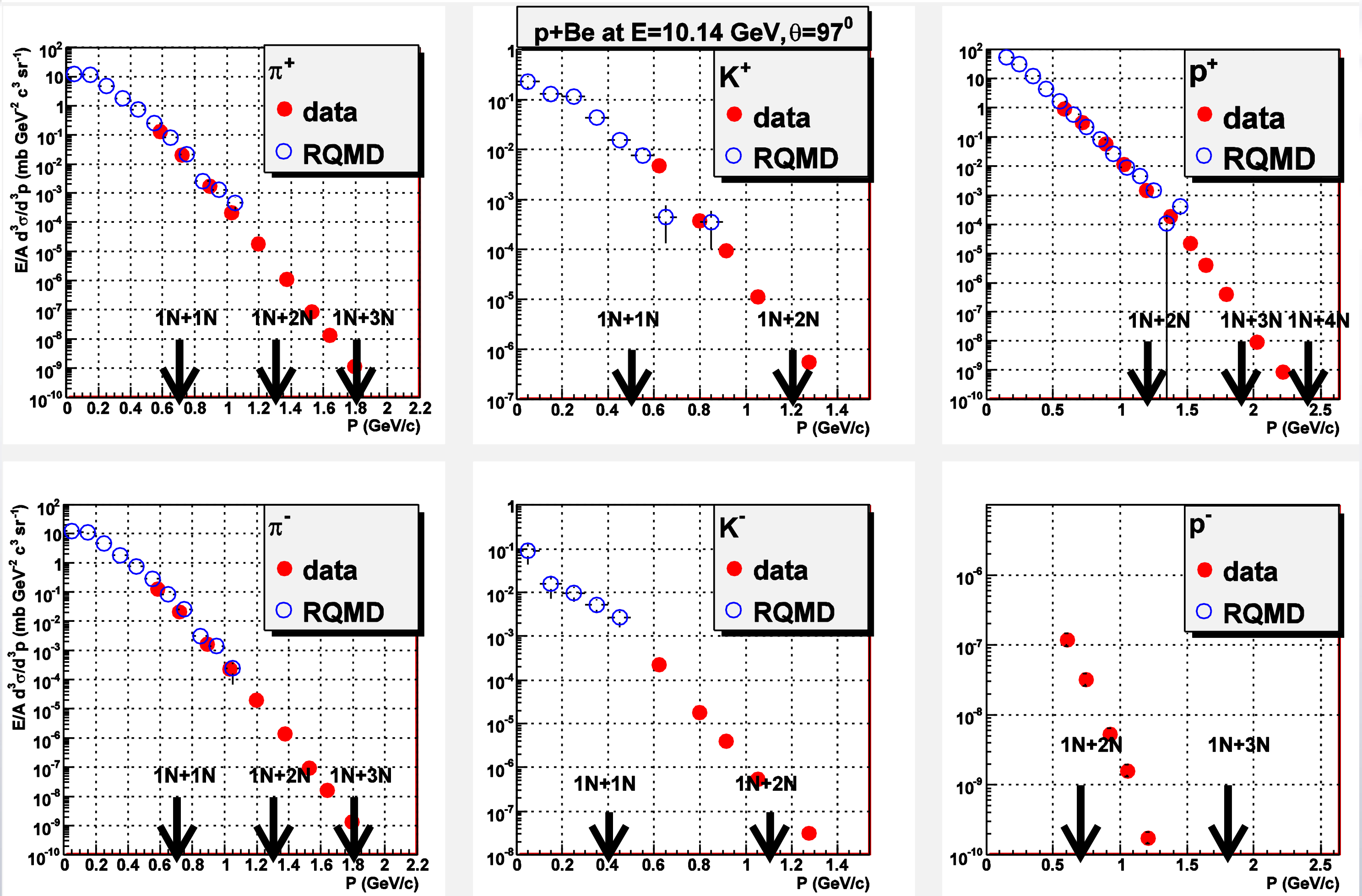
Extra slides

Comparison with models
Model I RQMD

- RQMD (<u>R</u>elativistic <u>Q</u>uantum <u>M</u>olecular <u>D</u>ynamics)

  [Phys. Rev. C52 (1995) 3291.]
- produces hadrons through the excitation of baryonic and mesonic resonances.
- Heavy resonances →string picture, Lund model
- reinteractions (baryon-baryon, baryon-meson, and meson-meson).
- complete time-dependent description

RQMD vs. pA DATA

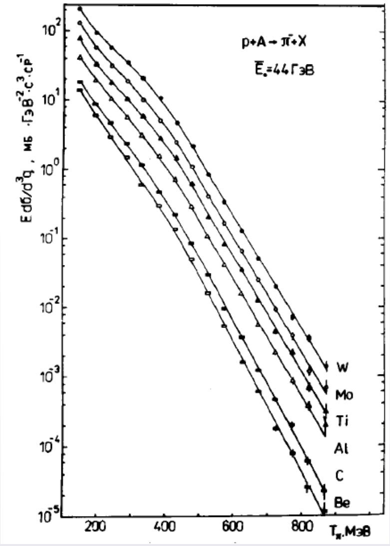


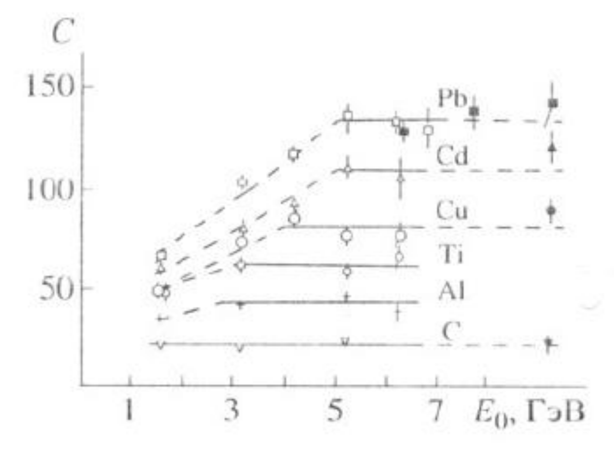
•Data from Yad.Fiz. 57 (1994) 1452

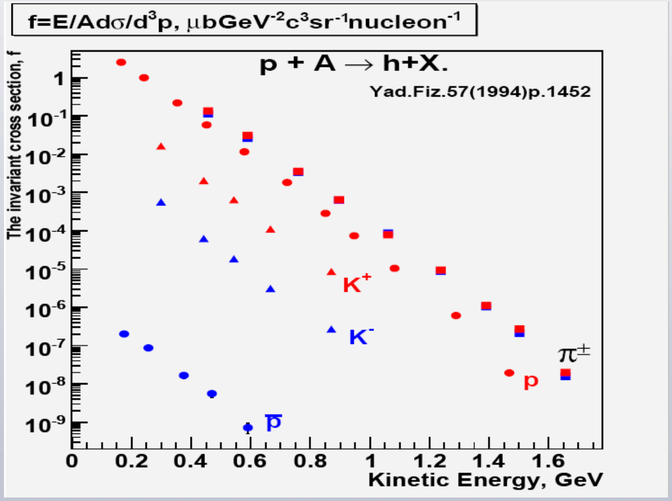
p+A @10AGeV A=Be,Al,Cu,Ta θlab=970 p±, π±, K±

absolute normalization error ~ 25%

EXPERIMENTAL h+A→h+X DATA

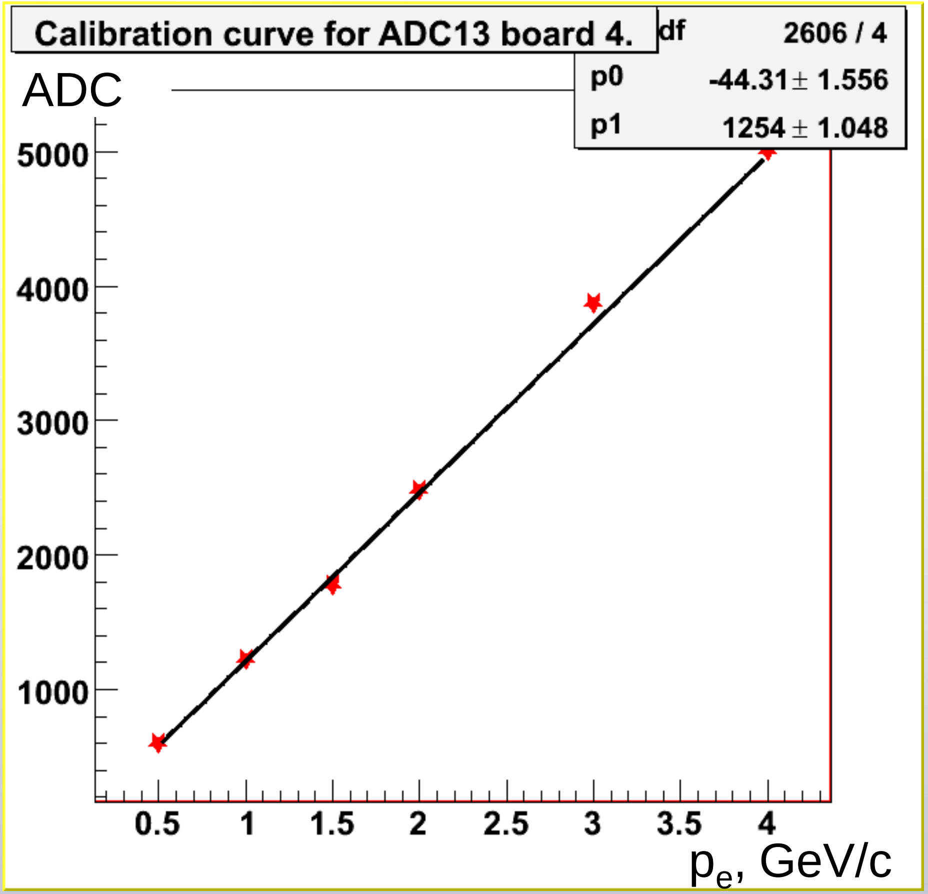


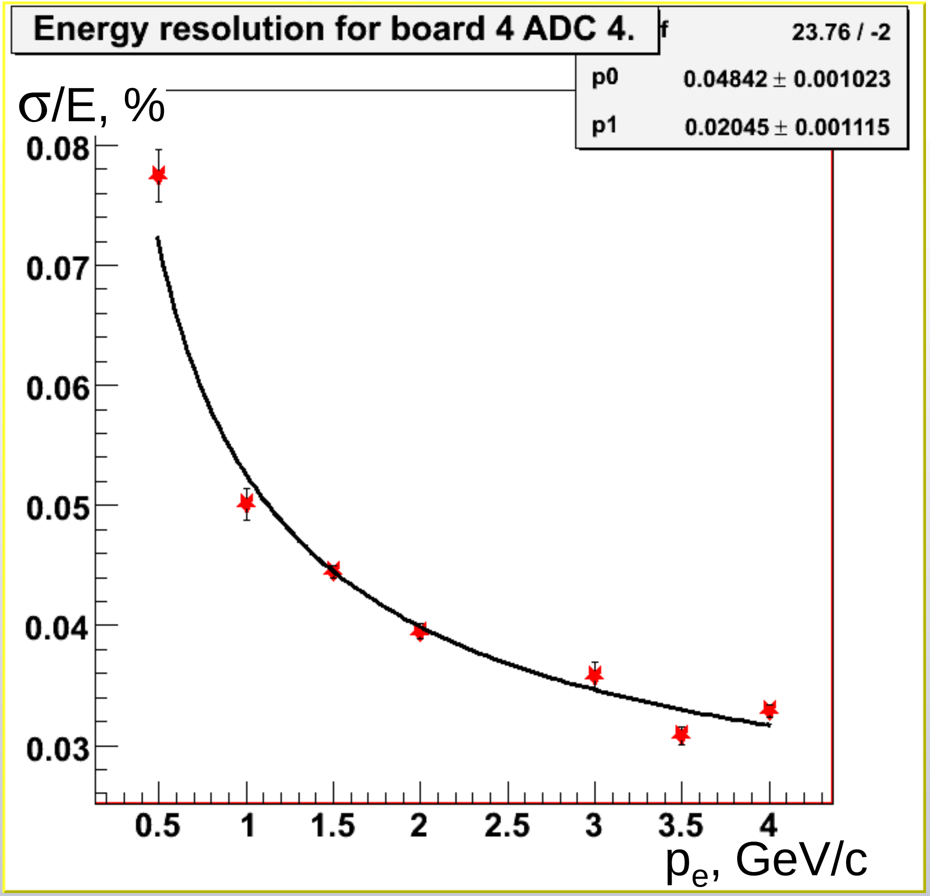


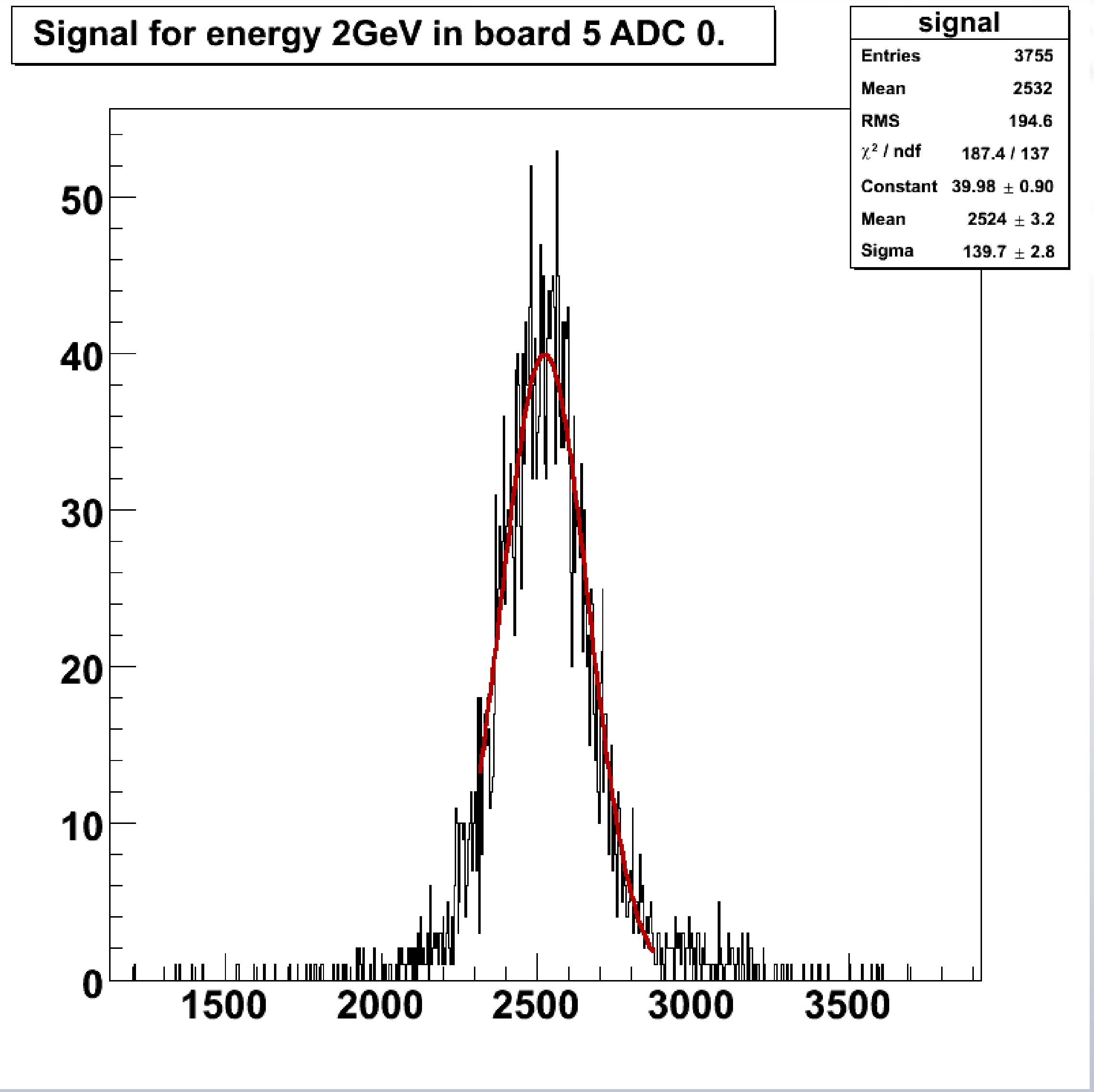


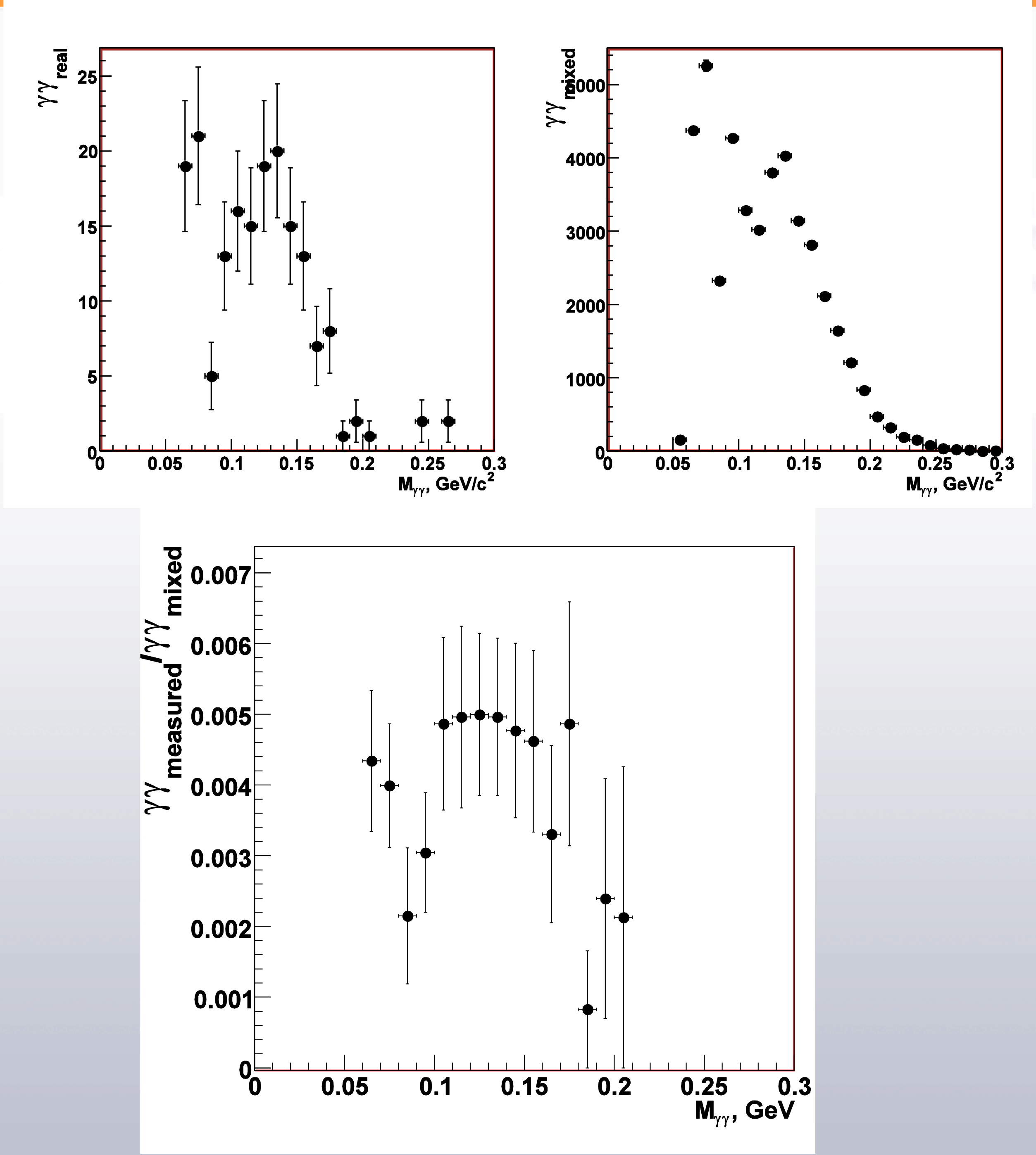
- Large amount of experimental data showed that the cross sections do not depend on initial energy of particle, its sort and mass of nuclei. => **nuclear scaling**
- The shape of the c.s. does not depend on the sort of produced particle; there is a hierarchy of particle yields, depending on quark structure of produced particle. => **superscaling**
- Not properties of nuclei, but properties of nuclear matter =>**flucton**

Calibration with e⁻ beams



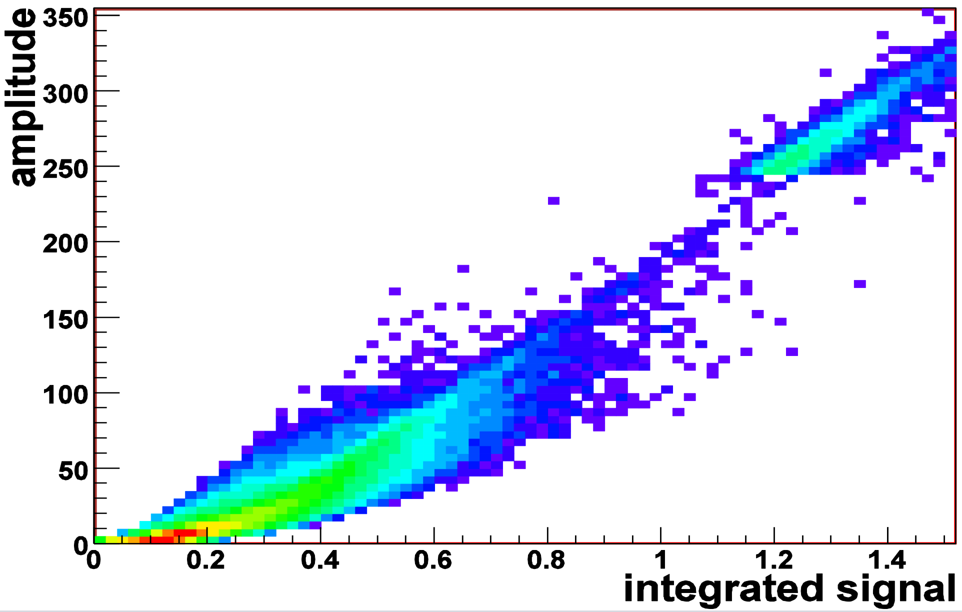


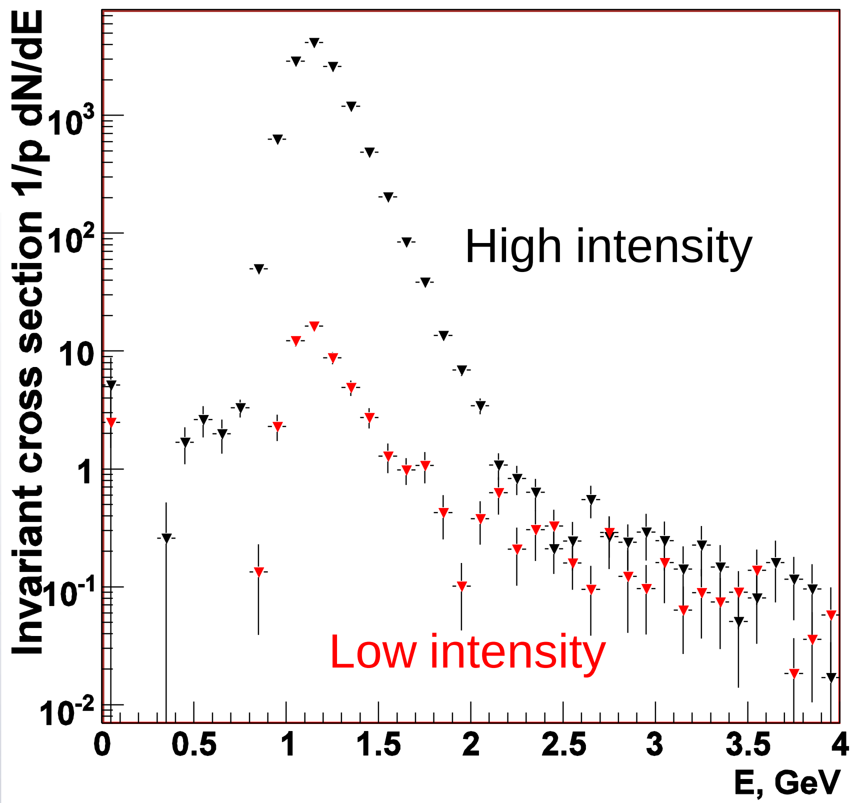

Signal for energy 2GeV in board 5 ADC 0.
signal
Entries 3755
Mean 2532
RMS 194.6
χ² / ndf 187.4 / 137
Constant 39.98 ± 0.90
Mean 2524 ± 3.2
Sigma 139.7 ± 2.8
50
40
30
20
10
0
1500
2000
2500
3000
3500



$\gamma\gamma_{real}$
$\gamma\gamma_{mixed}$
$M_{\gamma\gamma}$, GeV/c^2
$\gamma\gamma_{measured}/\gamma\gamma_{mixed}$
$M_{\gamma\gamma}$, GeV

G.N.Agakishiev et al., Yad.Fiz. **51**, 1591 (1990) [Sov.J.Nucl.Phys. **51**, 1004 (1990)]





- spectra where fitted from 1.2GeV to avoid trigger influence
- and up to the point with >10 events