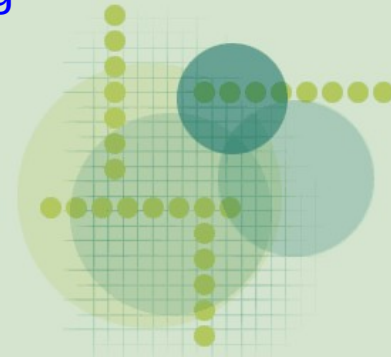




The fractal dimension estimations for the events of Au(Pb) + Em interactions

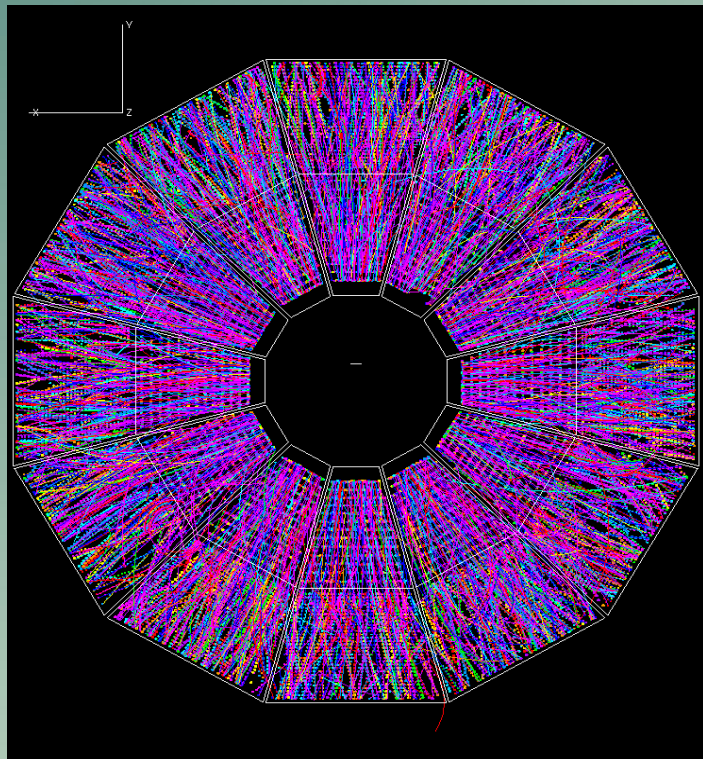
ISHEP 2010

Rogachevsky Oleg
Vokal Stanislav
JINR



Deterministic Chaos

Collections of small entities (particles or whatever) behave haphazardly, even though physical laws govern the particles individually



Deterministic chaos – chaos results from deterministic process

How to measure chaos ?

Fractals deal with geometric patterns (represented chaos) and quantitative way of characterizing these patterns. Chaos, in contrast, deals with time evolution and its underlying or distinguishing characteristics

Garnett P. Williams “Chaos Theory Tamed”

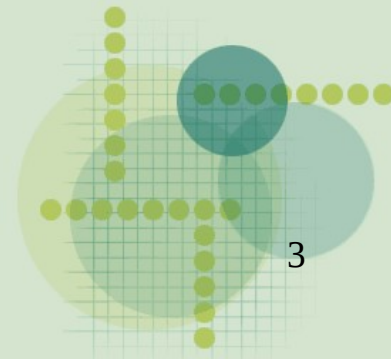
The **fractal dimension** of sets observed in the dynamics can be used as quantitative measure of the chaoticity

Fractal

According to Mandelbrot, who invented the word:

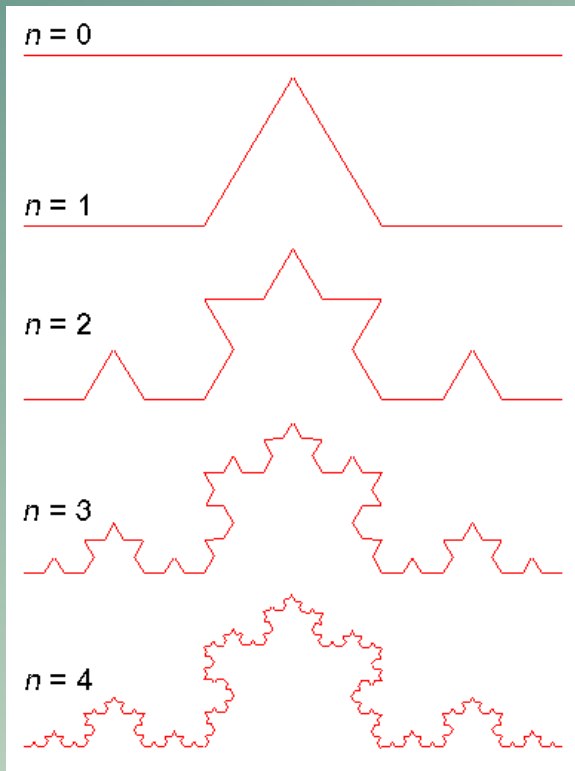
"I coined **fractal** from the Latin adjective fractus. The corresponding Latin verb "frangere" means "to break:" to create irregular fragments. It is therefore sensible - and how appropriate for our needs! - that, in addition to "fragmented" (as in fraction or refraction), fractus should also mean "irregular," both meanings being preserved in fragment."

(The Fractal Geometry of Nature, page 4.)



Fractal dimension

Koch's arc



A **fractal** is a shape made of parts similar to the whole in some way

E.Feder

$$D = \lim_{r \rightarrow 0} \frac{\log N(r)}{\log (1/r)}$$

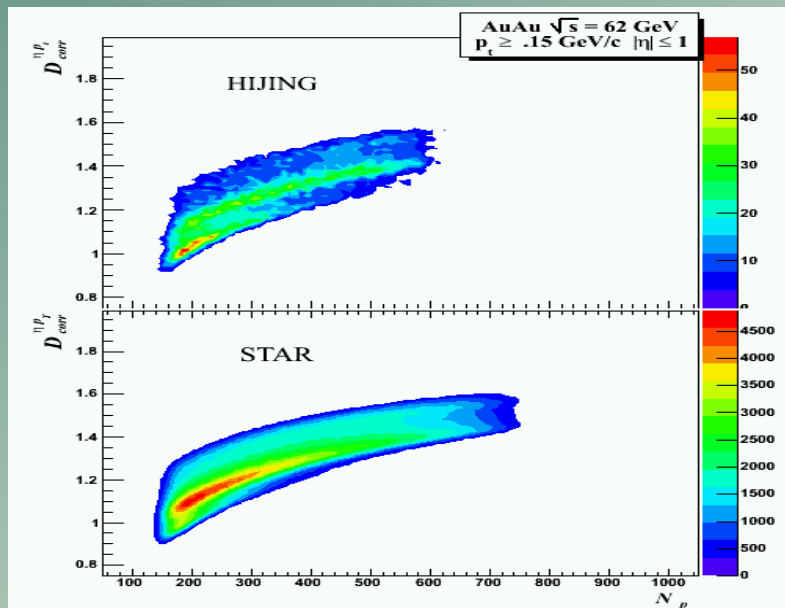
• r - scale

• $N(r)$ number of elements in fractal at given scale

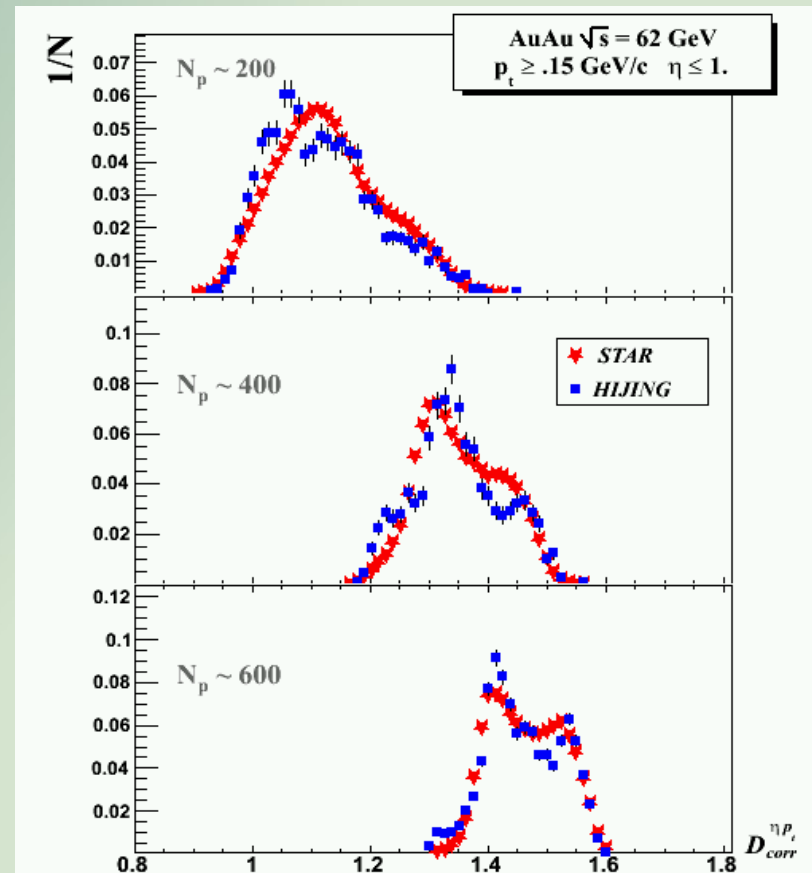
$$D^{\text{Koch's arc}} = \lim_{n \rightarrow \infty} \frac{\log 4^n}{\log 3^n} = \frac{\log 4}{\log 3} = 1.261\dots$$

STAR Au+Au $\sqrt{s} = 62$ GeV

Fractal dimensions in ηp_t space
RO ICHEP 2006



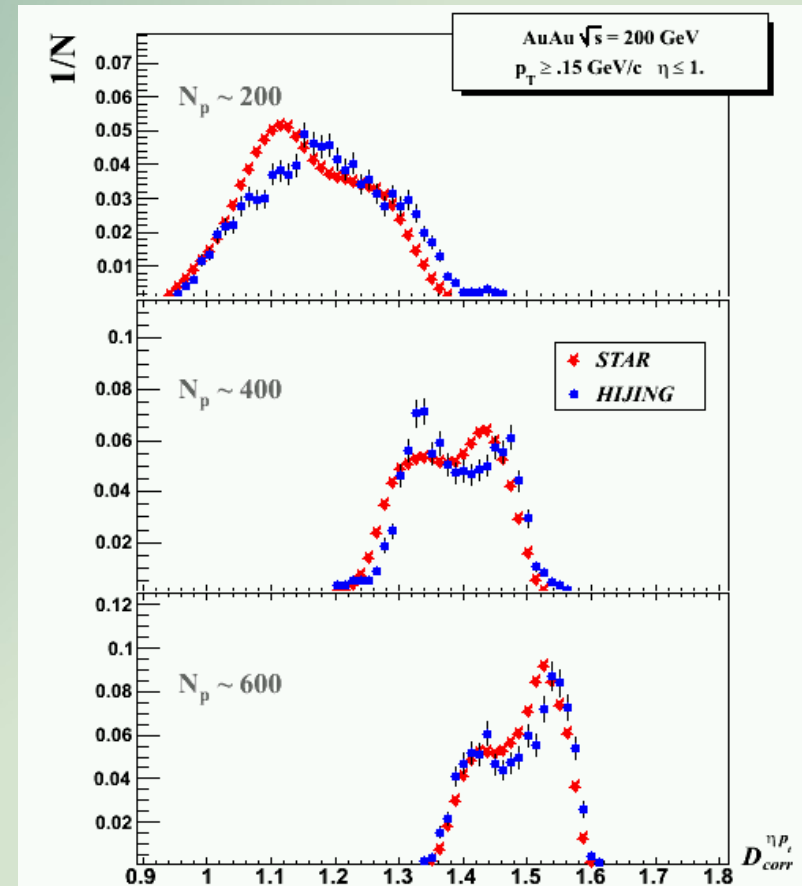
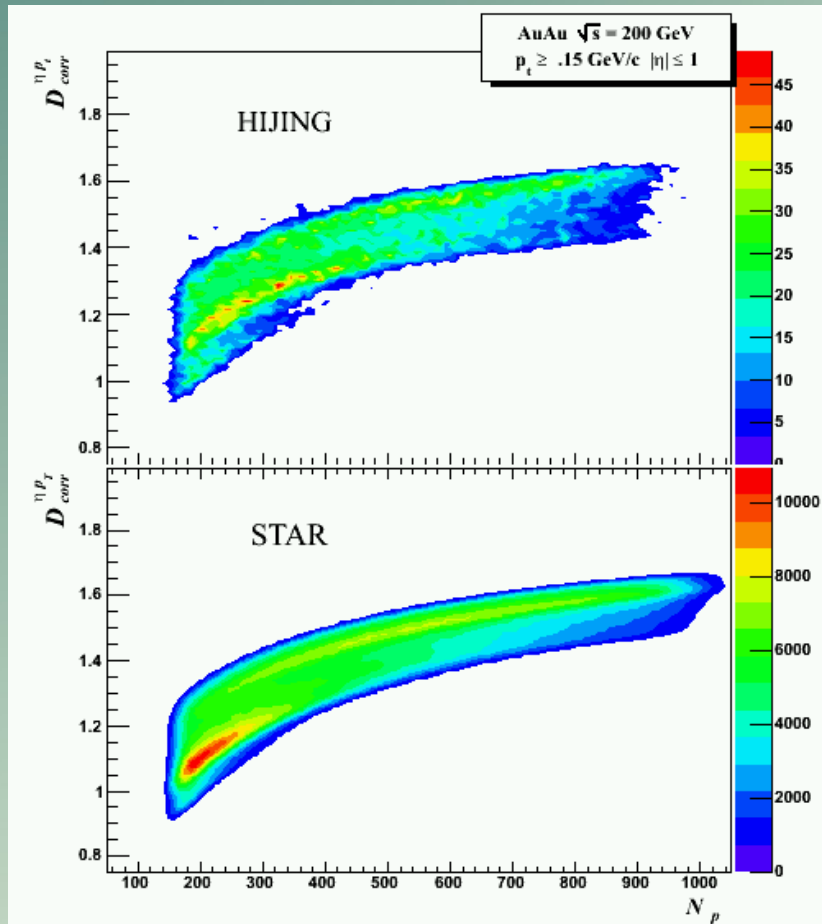
The choice of the parameters for algorithm define the position of the gap



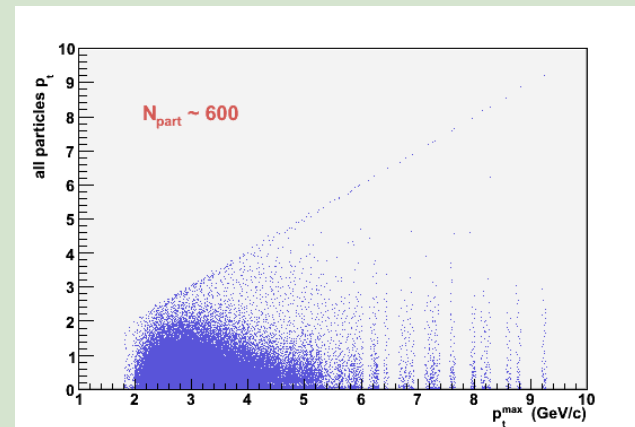
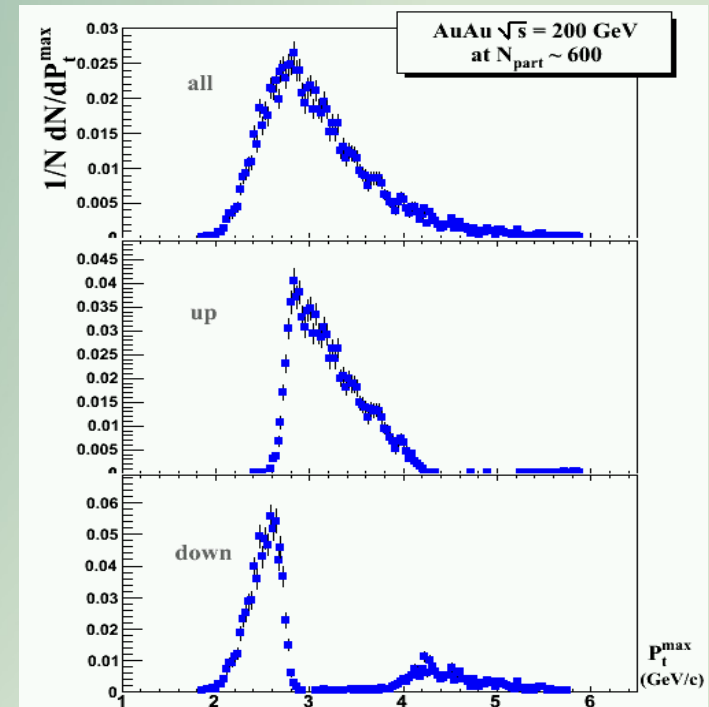
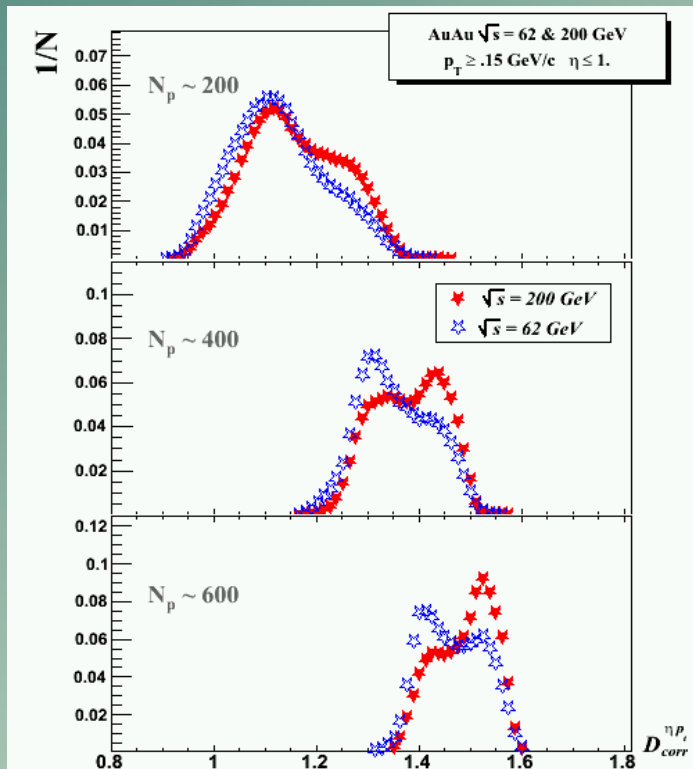
STAR Au+Au $\sqrt{s} = 200$ GeV

Fractal dimensions in ηp_t space

RO ICHEP 2006

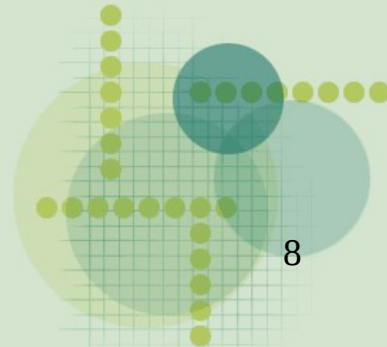
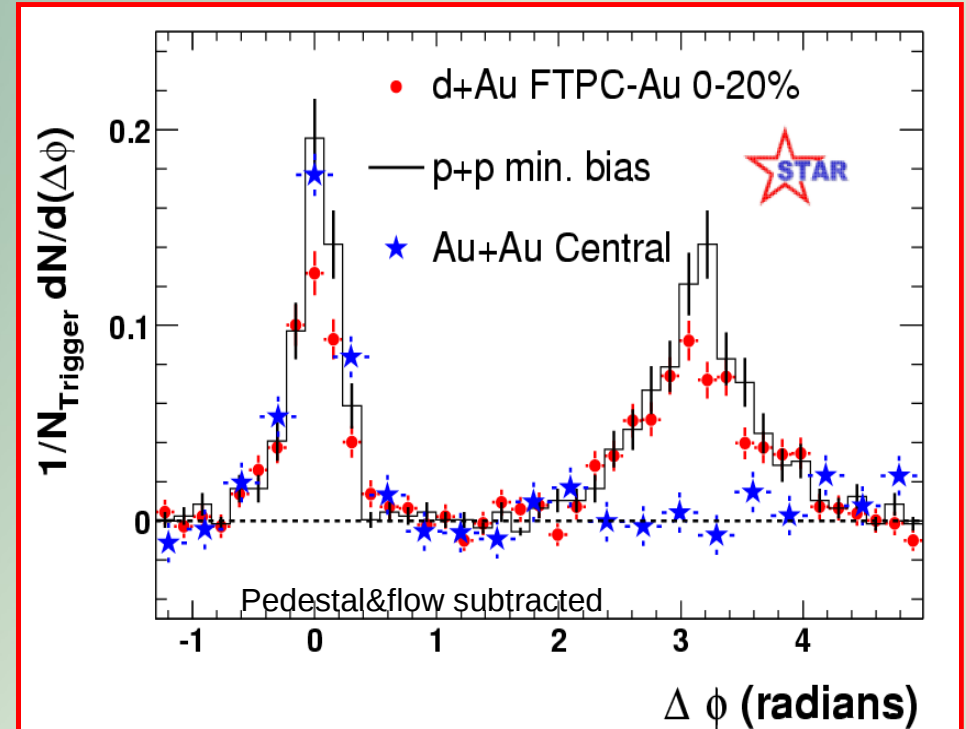
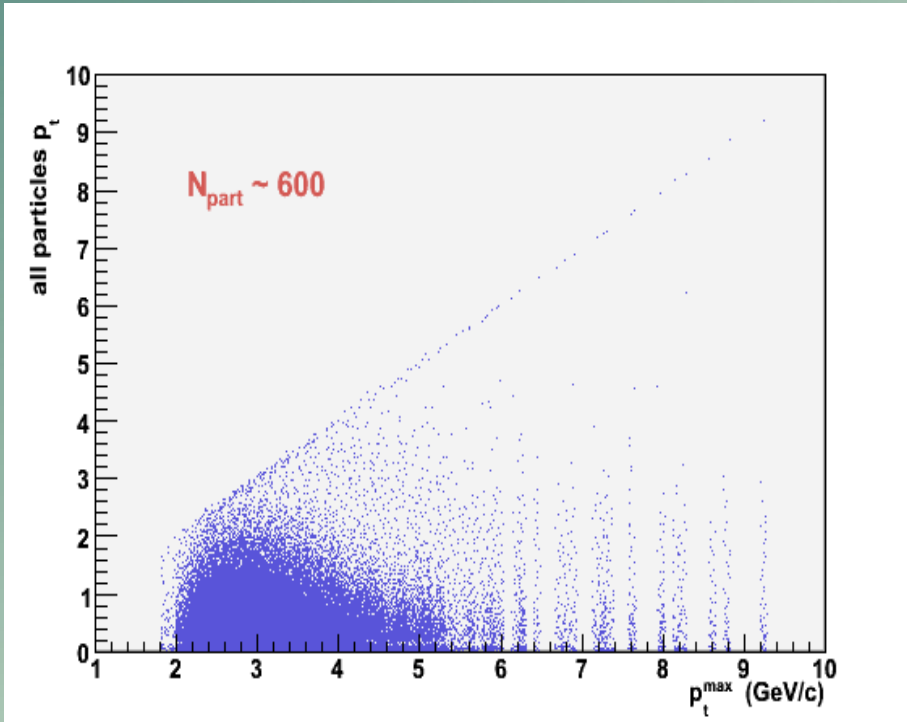


$D_{\eta pt}$ STAR Au+Au $\sqrt{s} = 200$ & 62 GeV

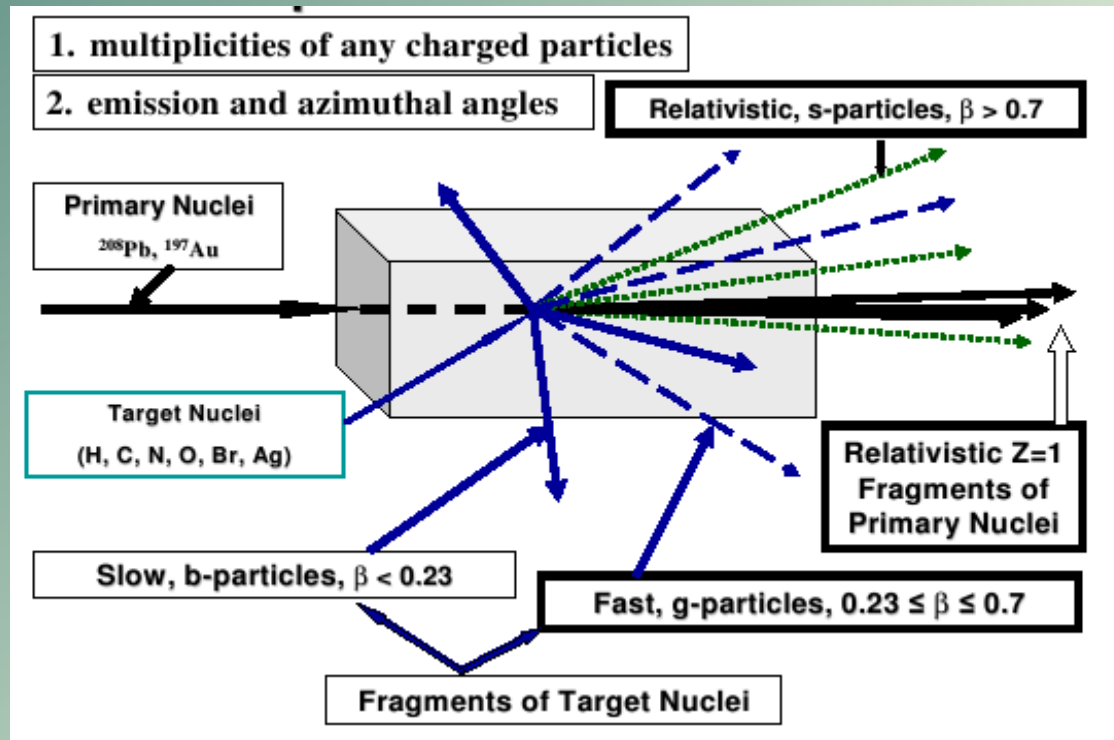


The yield of entropy events increases with growth of multiplicity and collisions energy

Jet quenching



Emulsion experiment

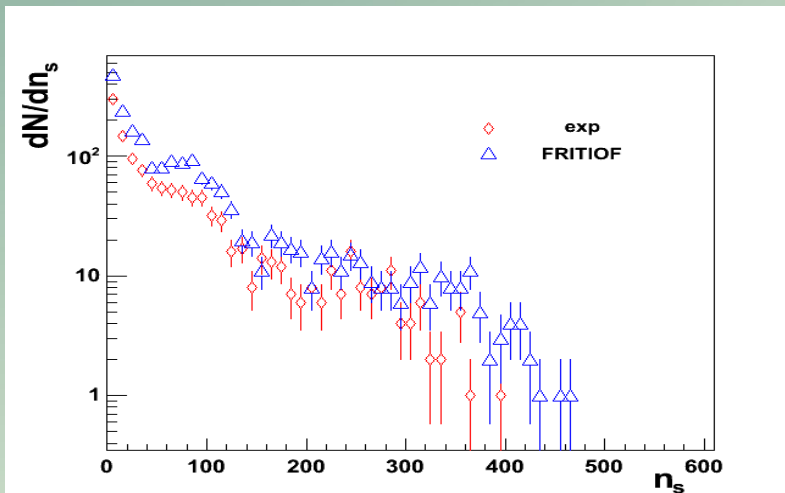
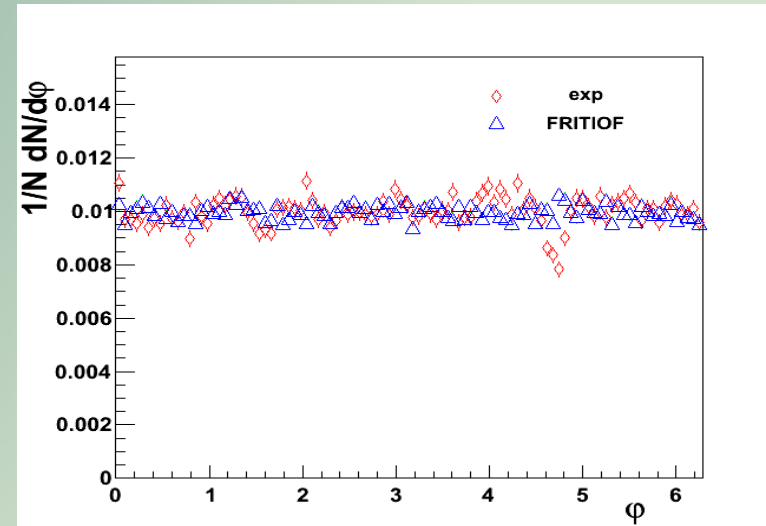
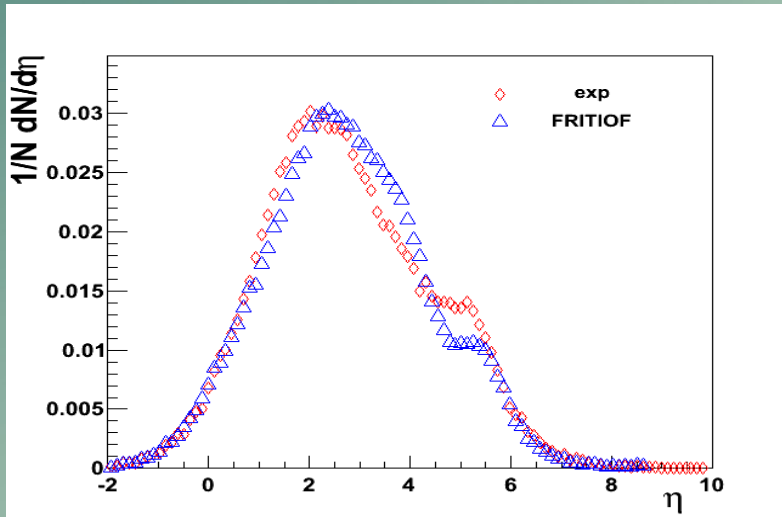


$$\eta = -\ln \left[\tan \frac{\Theta}{2} \right]$$

- In the measured interactions all charged particles were classified according to the commonly accepted emulsion experiment terminology into groups.
- The group of relativistic (shower) particles includes particles with $\beta > 0.7$ produced in the interactions as well as fast single-charged projectile spectators.
- The polar (Θ) and azimuthal (Ψ) emission angles of all tracks have been measured.
- The value of pseudorapidity has been calculated for each relativistic particle

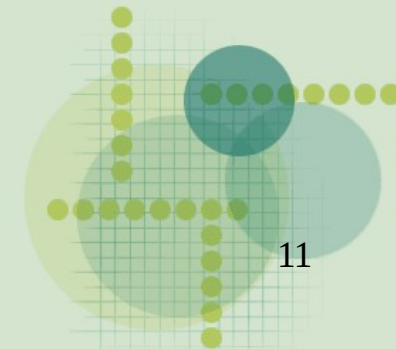
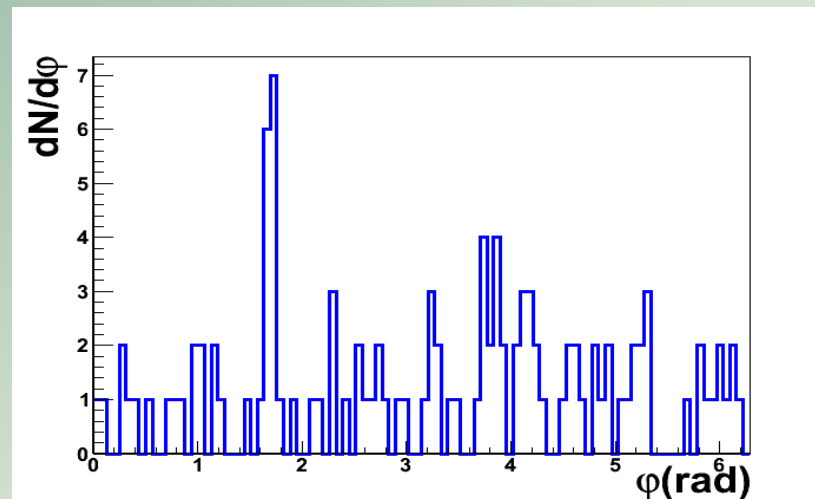
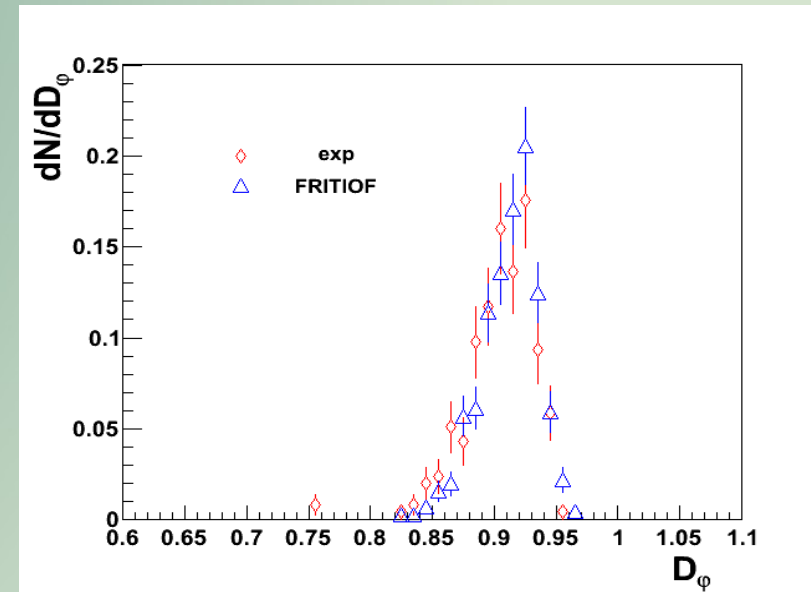
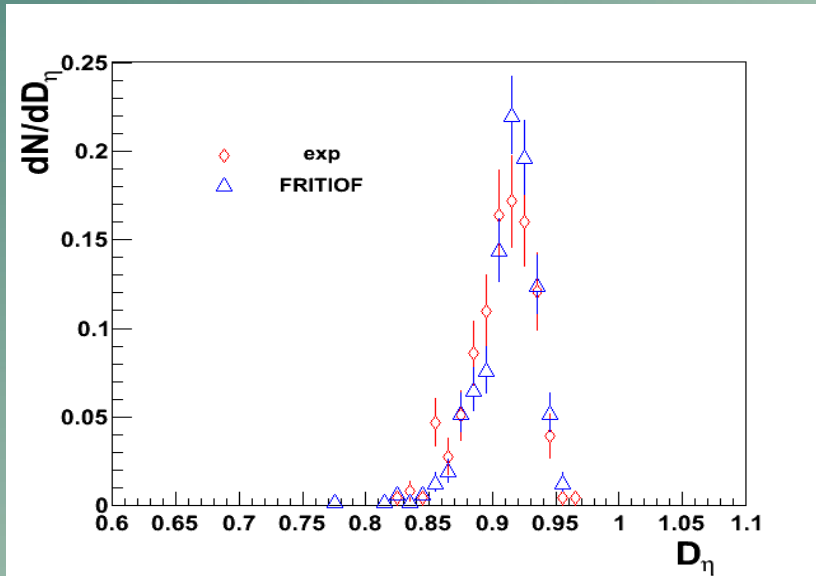
Au + Em collisions

$^{197}\text{Au} + \text{Em}$ at 11.6 A GeV/c
BNL AGS, Experiment E863

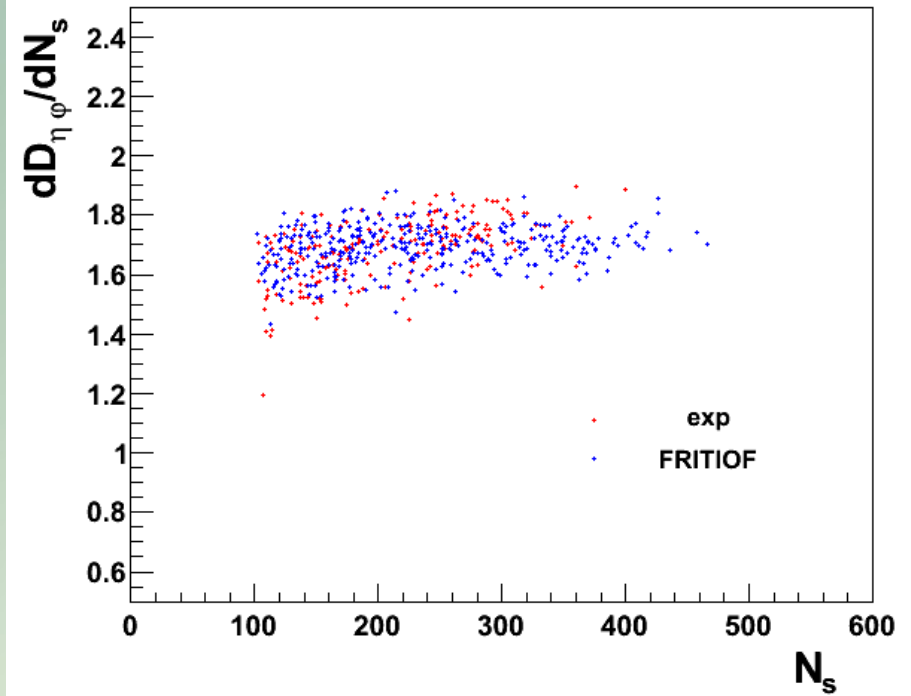
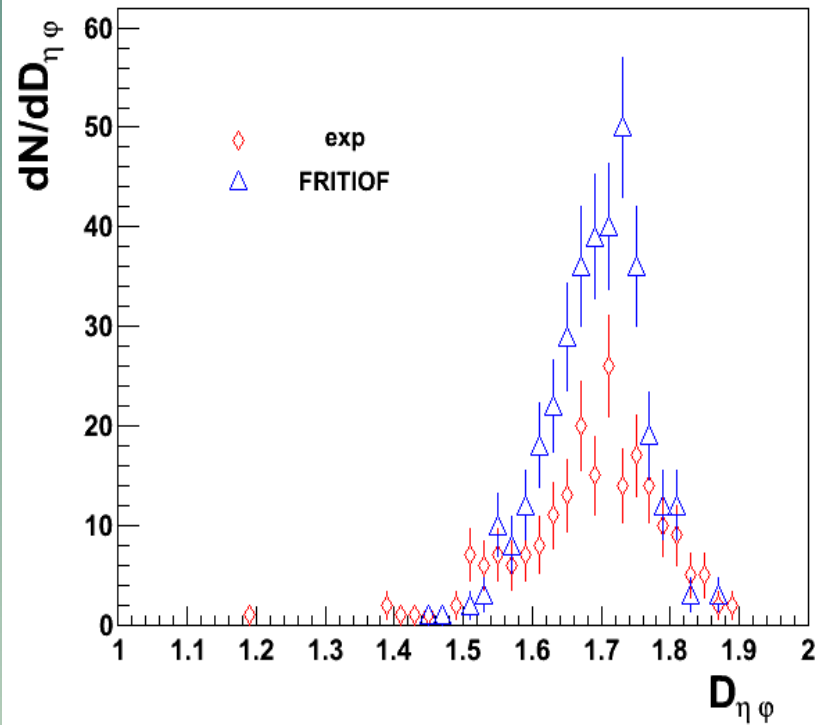


1165 minimum bias events
Adamovich M. I. et al.,
Eur. Phys. J. A., 1999, V.5, p.429.

η & φ dimensions for Au + Em



$\eta\phi$ dimensions for Au + Em



Pb + Em collisions

$^{208}\text{Pb} + \text{Em}$ at 158 A GeV/c

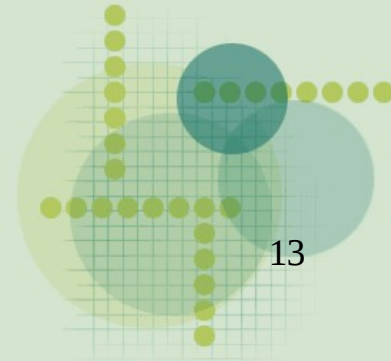
CERN SPS, EMU12 Experiment

628 minimum bias events

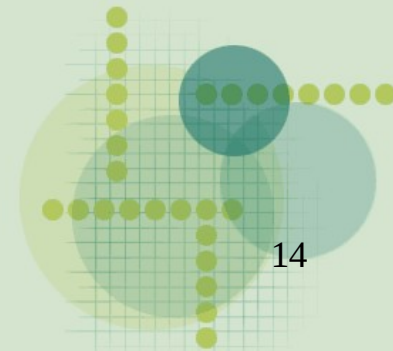
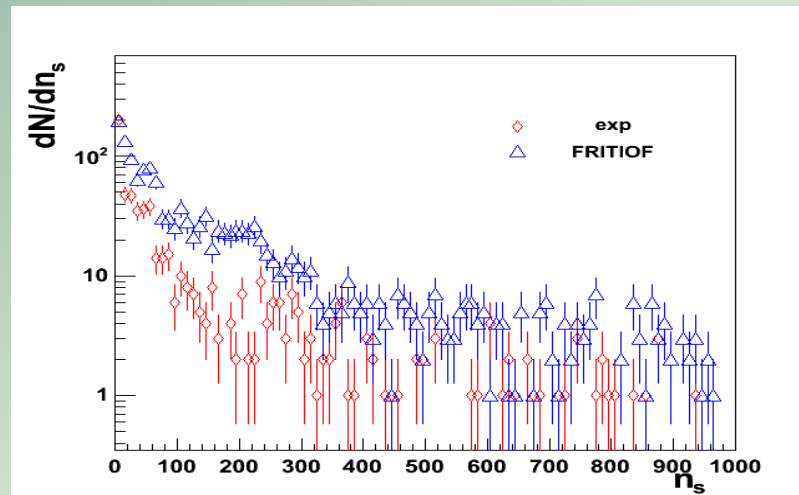
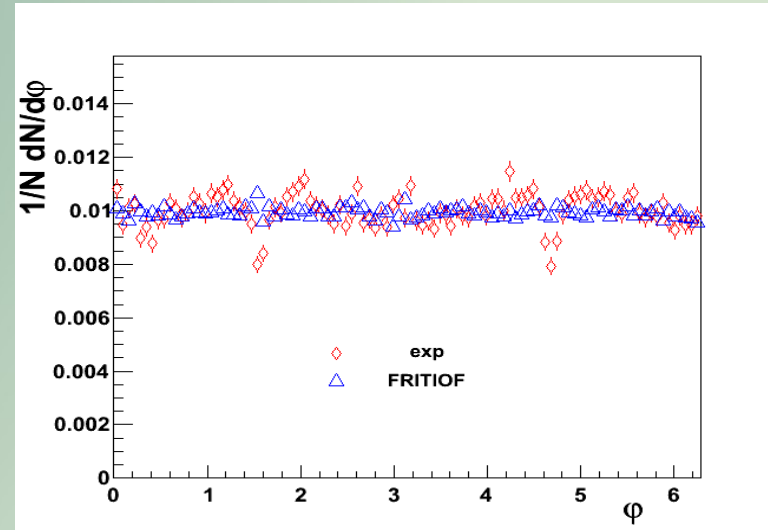
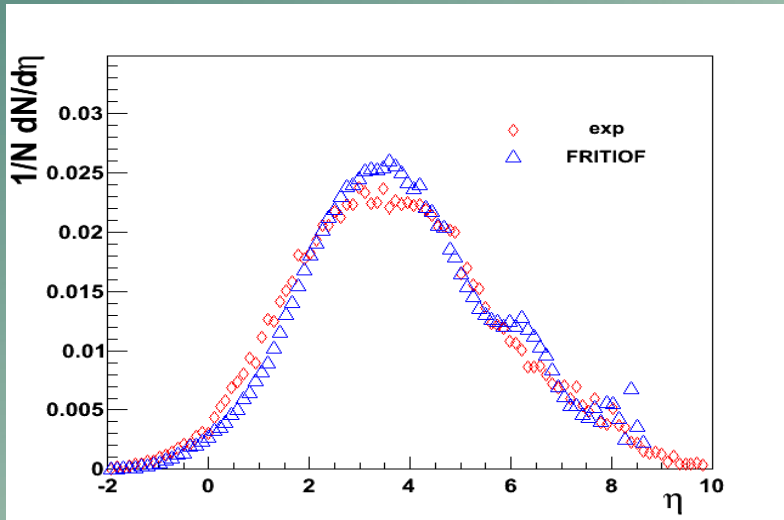
Gaitinov A. Sh. et al.,

Proc. of the XVII Meeting of the EMU01 Collaboration,

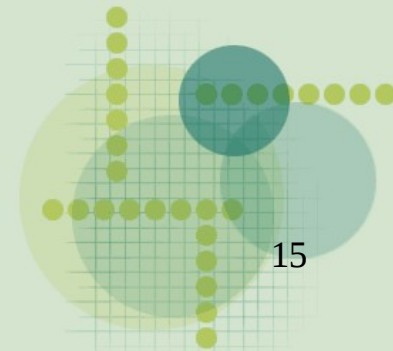
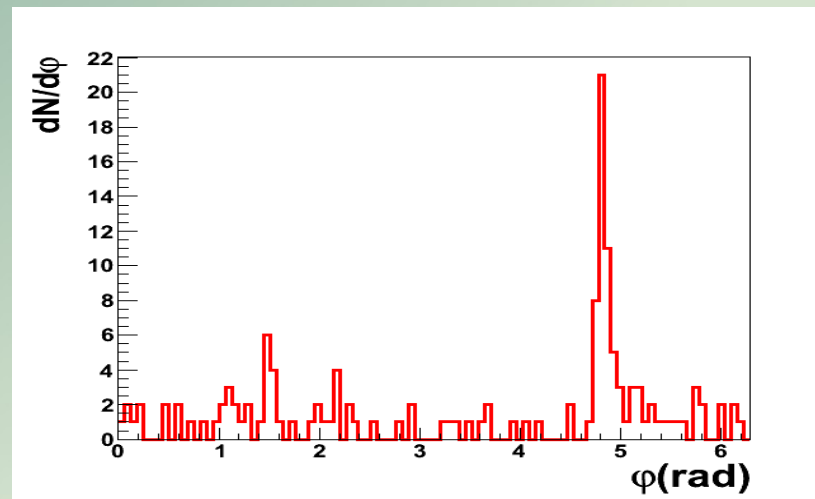
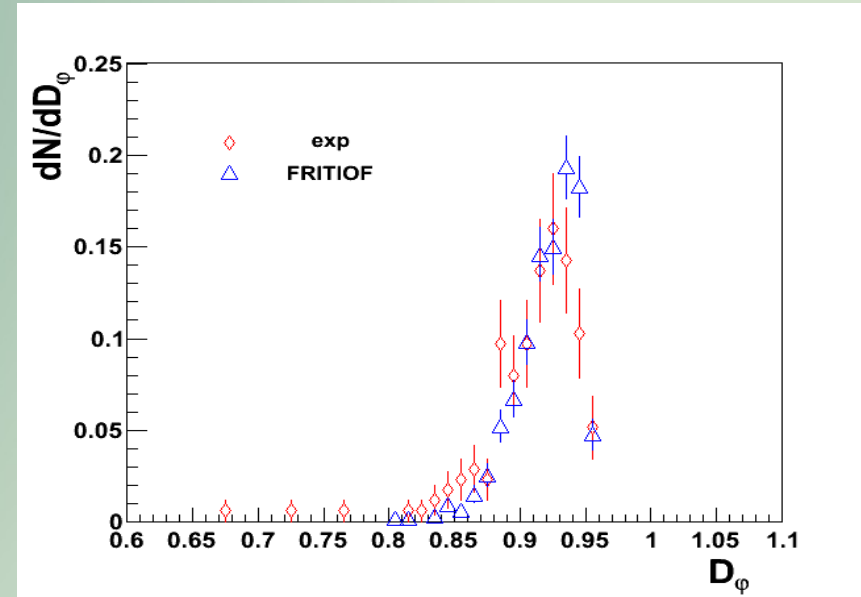
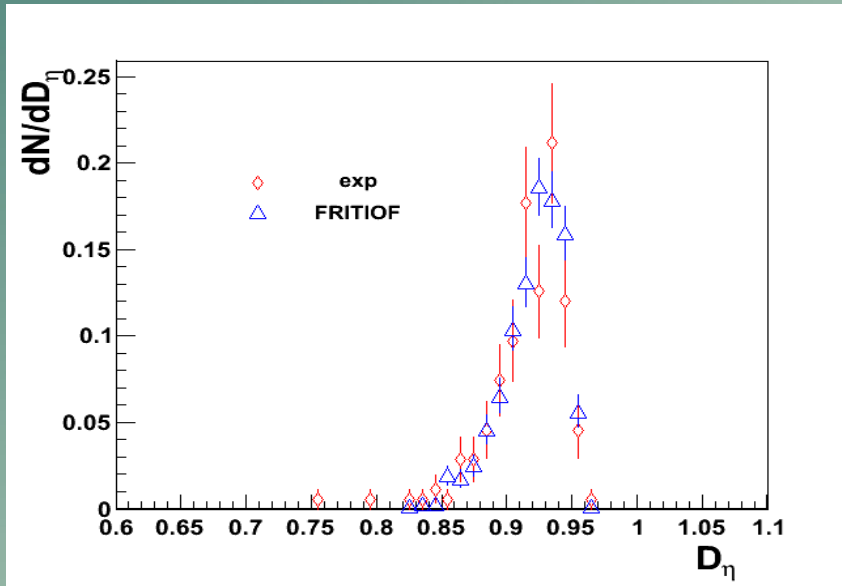
Dubna, Russia, May 18-20, 1999. Dubna, 2000. p.143.



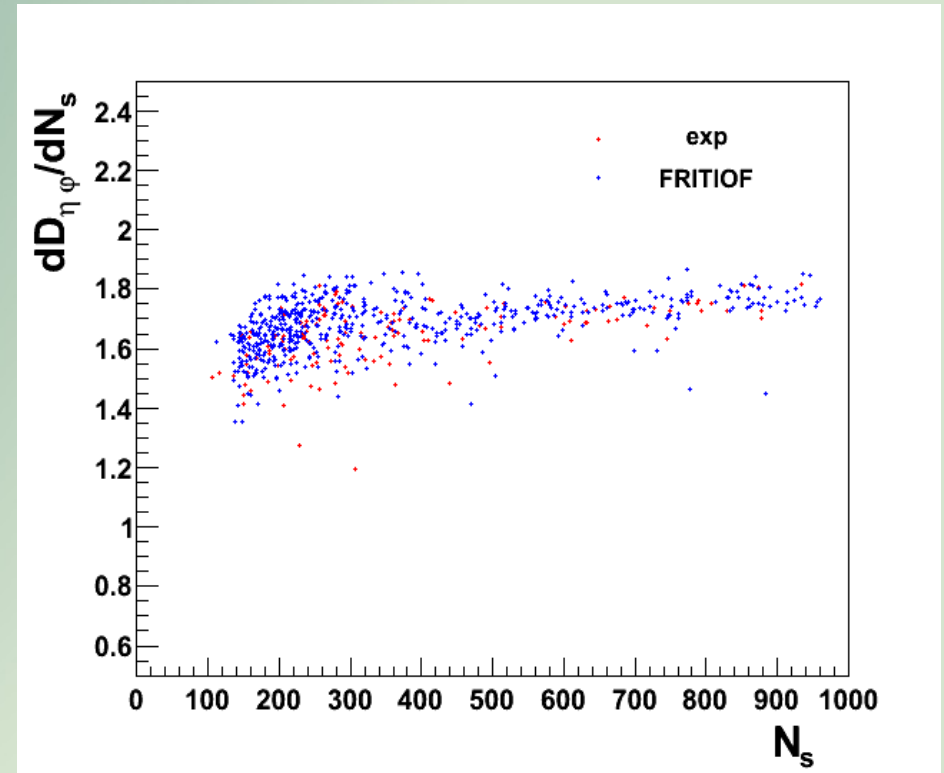
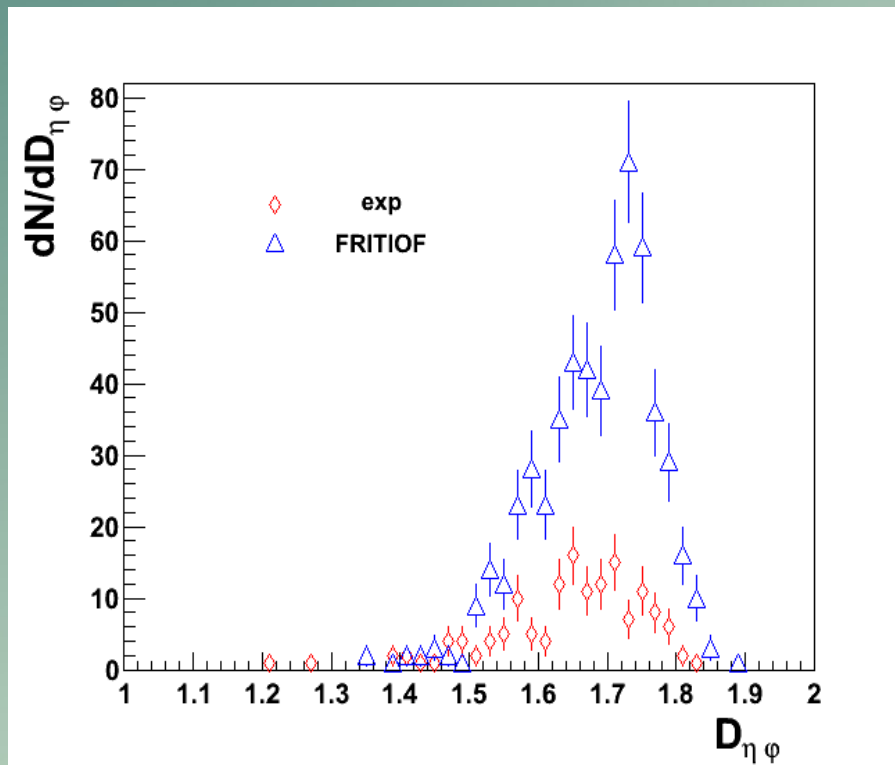
Pb + Em collisions



η & φ dimensions for Pb + Em

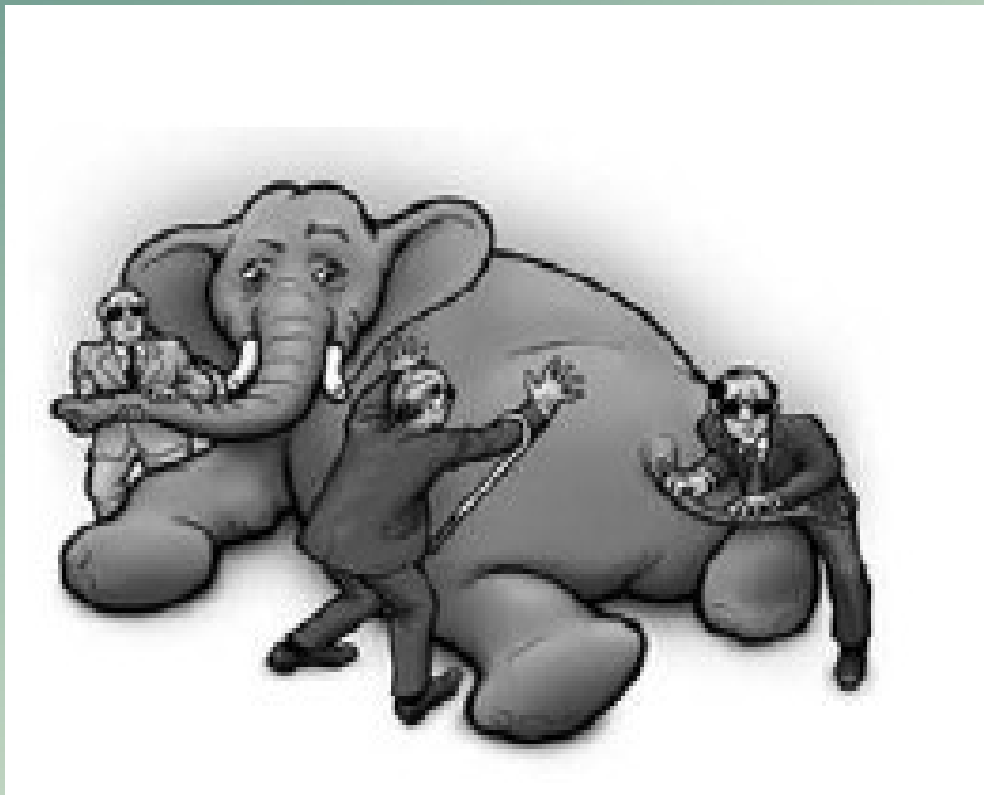


$\eta\phi$ dimensions for Au + Em



SUMMARY

Fractal dimension is sensitive to the global event structure



The legend of "The Blind Men and the the Elephant", written by John Godfrey Saxe in the late 1800s, told the story of six vision-impaired men, each valuing continuous learning, who wanted to "see" an elephant.

