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One classical method - Multiplicity in N-N collisions at SPS/CERN

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   and EMU 01 Collaboration

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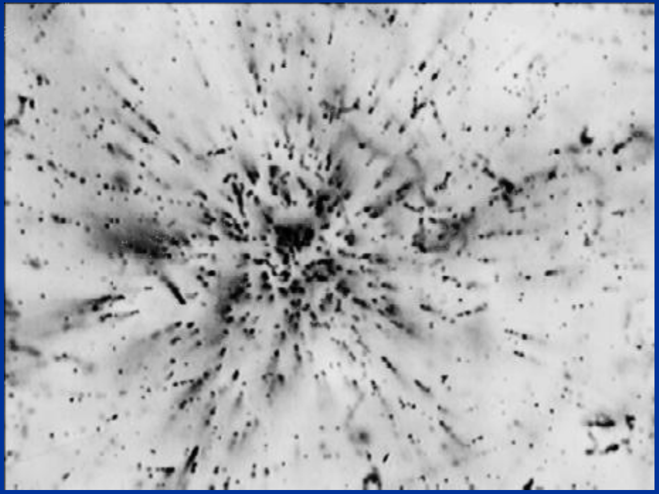
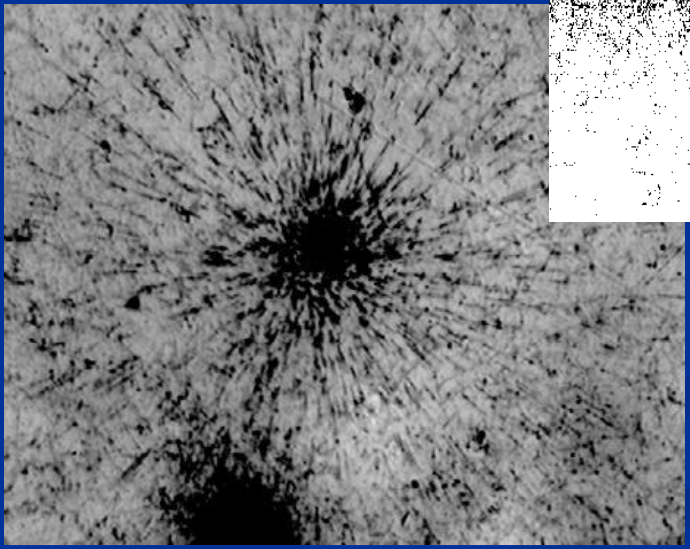
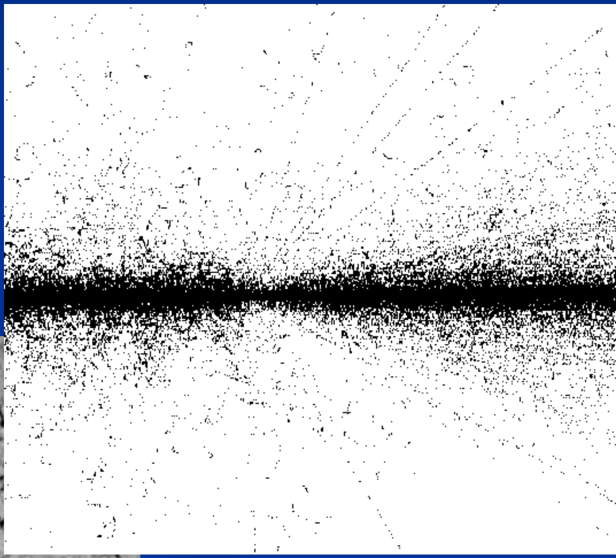
Introduction

N-N Collisions and Lund MC FRITIOF



Au + Au, 200AGeV





Pb + Pb, 160AGeV

Nuclear Emulsion

WHAT IS Emulsion ?

Usually equal parts by volume of silver halide crystals which are about 0.3 ± 0.05 microns in size (Ilford G5, C2 for ex.)

embedded in an organic matrix material, composed mostly of gelatin with water, glycerol etc. added to form a gel (density approx. 1.29 gm/ml at 58% R.H.)

Gelatin, hydrolyzed from calf or pig hides, not only determines the mechanical properties of the emulsions, plays a strong part in the in the photochemical process as it is amphoteric, permits penetration of solutions, is insoluble in alcohol etc.

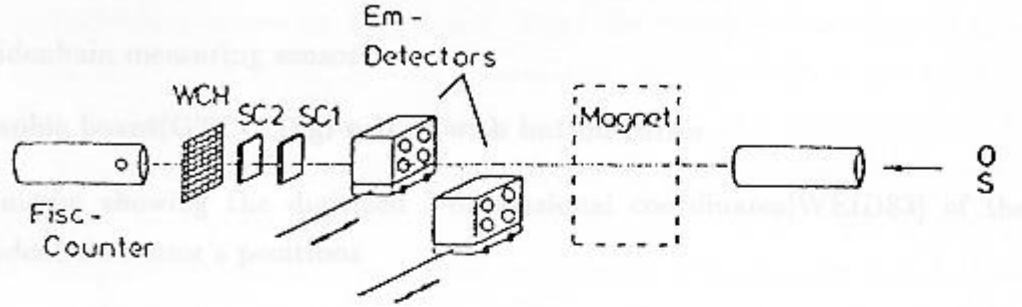


Figure 4: EMU-01 experimental set-up

Experimental set-up & Measuring device

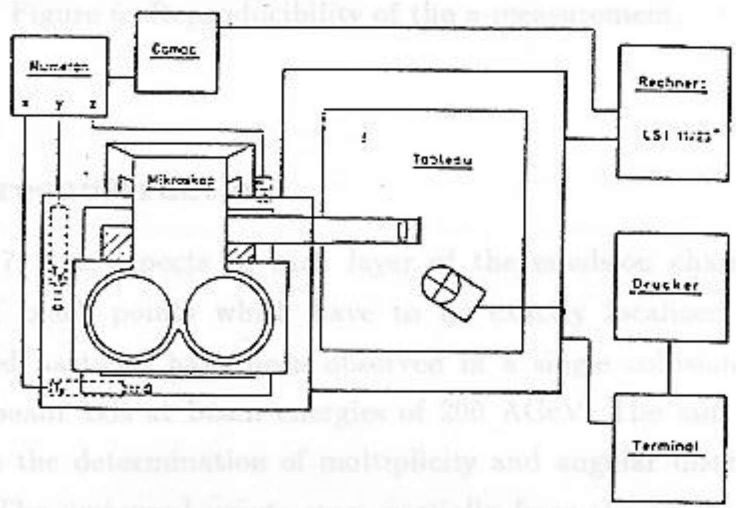


Figure 5: The measuring device at Marburg

2 Types of Emulsion detectors

Chamber vs Stack

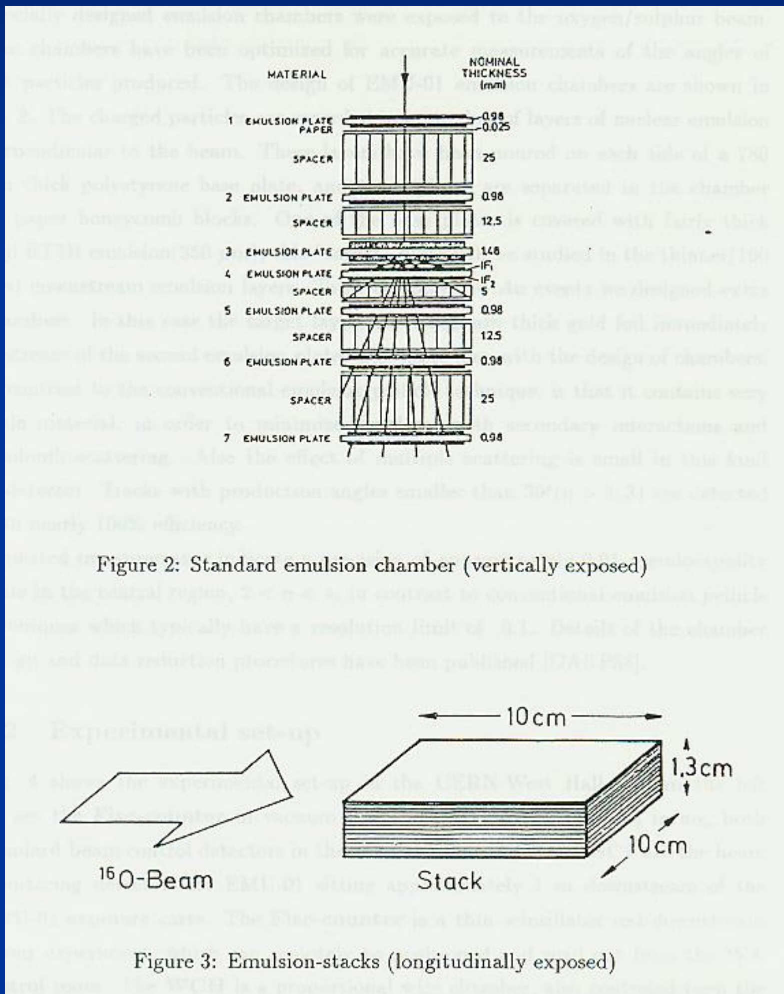
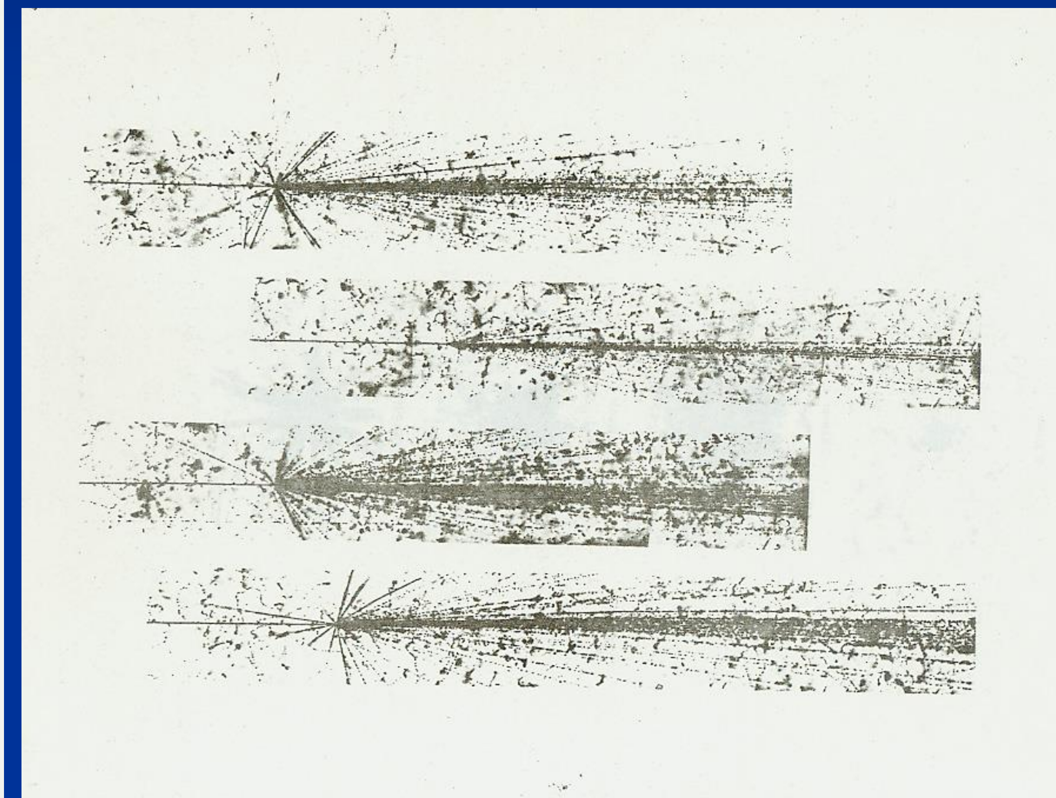


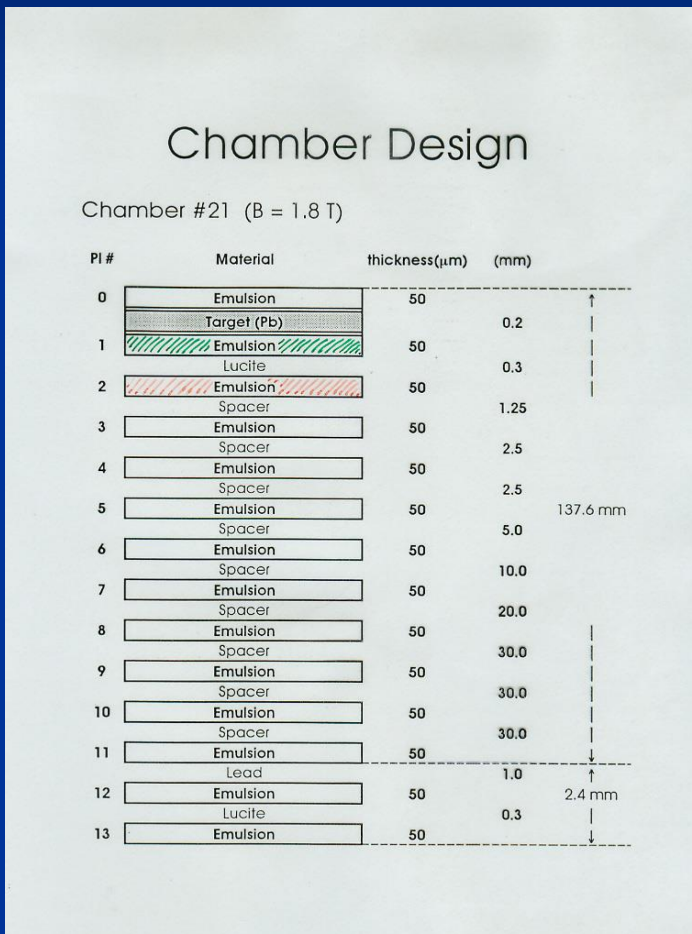
Figure 2: Standard emulsion chamber (vertically exposed)

Figure 3: Emulsion-stacks (longitudinally exposed)



Stack events by H.H.Heckman

Nuclear Emulsion Chamber (in EMU 01 Collaboration)



Chamber Design

Chamber #21 (B = 1.8 T)

Pl #	Material	thickness(μm)	(mm)	
0	Emulsion	50		
	Target (Pb)		0.2	
1	Emulsion	50		
	Lucite		0.3	
2	Emulsion	50		
	Spacer		1.25	
3	Emulsion	50		
	Spacer		2.5	
4	Emulsion	50		
	Spacer		2.5	
5	Emulsion	50		137.6 mm
	Spacer		5.0	
6	Emulsion	50		
	Spacer		10.0	
7	Emulsion	50		
	Spacer		20.0	
8	Emulsion	50		
	Spacer		30.0	
9	Emulsion	50		
	Spacer		30.0	
10	Emulsion	50		
	Spacer		30.0	
11	Emulsion	50		
	Lead		1.0	
12	Emulsion	50		2.4 mm
	Lucite		0.3	
13	Emulsion	50		

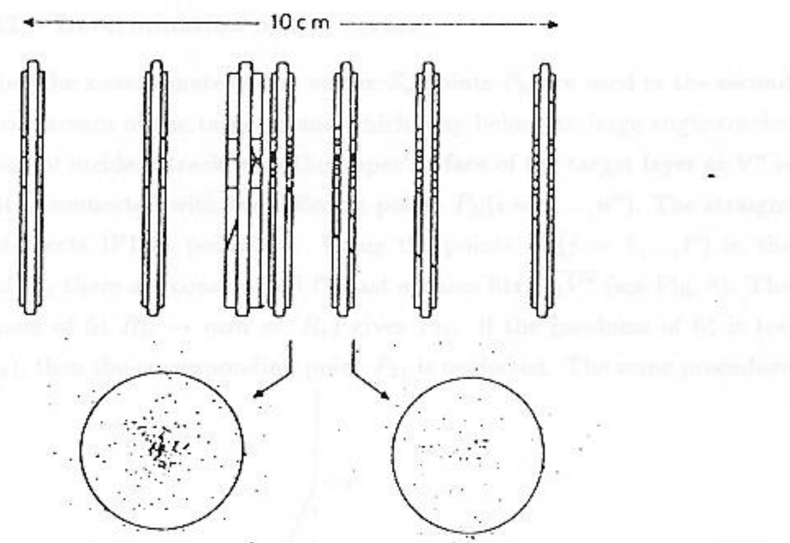
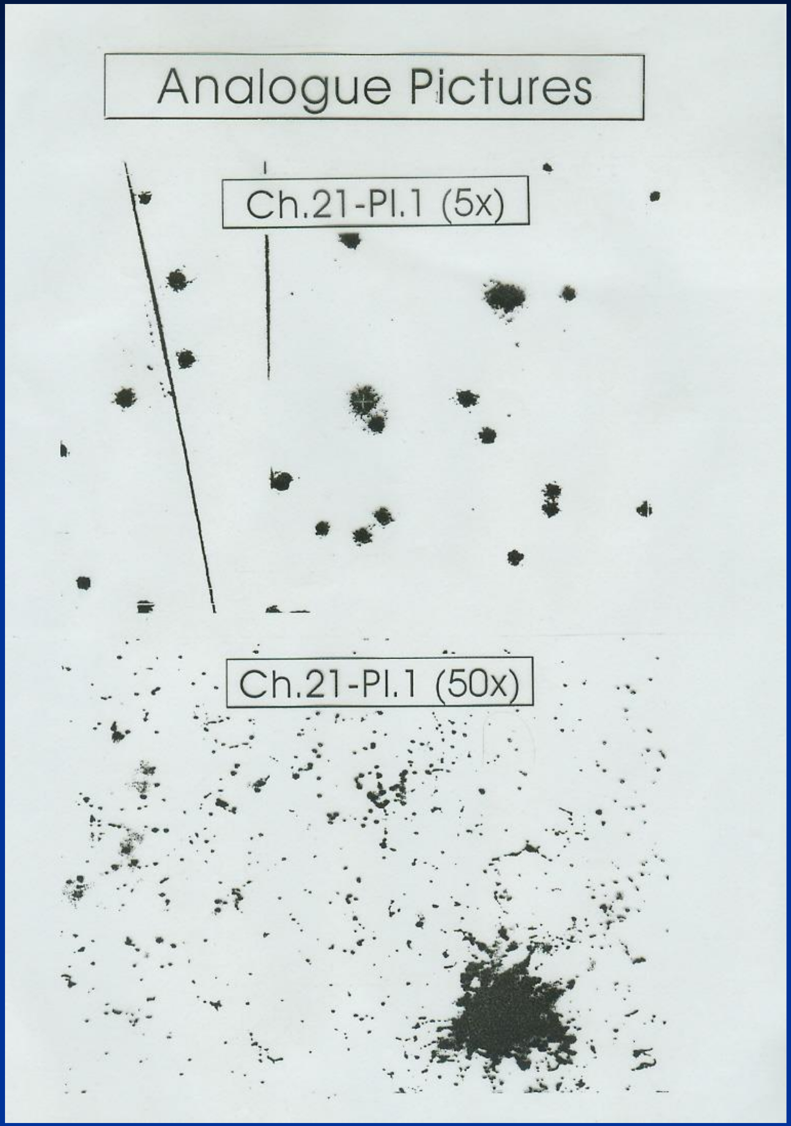
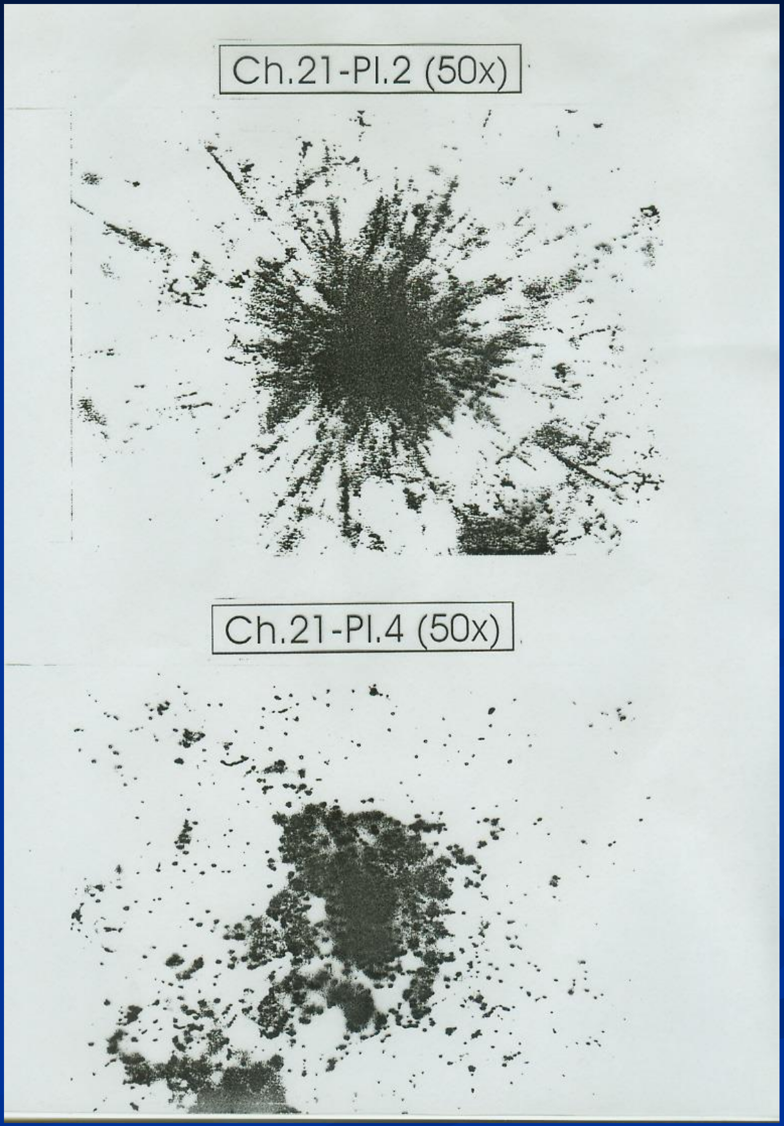


Figure 7: Layout of the emulsion chamber with two microscope fields of view.





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Track geometry
&
Reconstruction

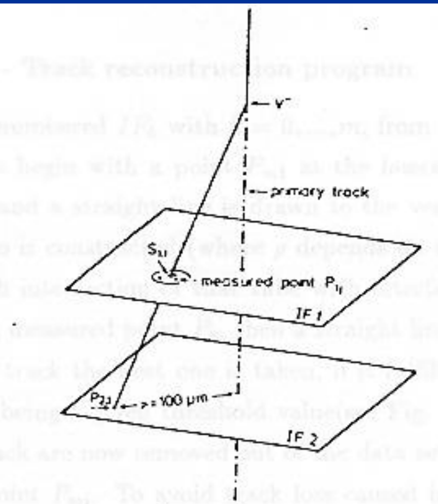

Figure 8: The straight line $\overline{P_{21}V''}$ intersects interface IF_1 at point S_{11}

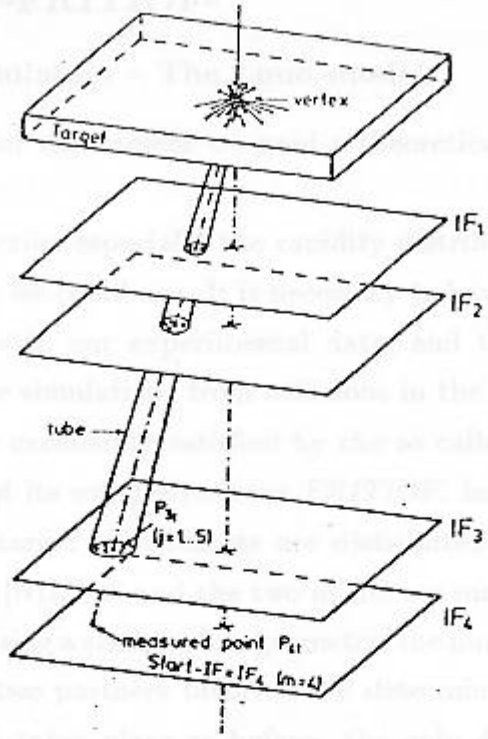

Figure 10: Single track reconstruction by the tube method

Kinematic variables Pseudorapidity vs Rapidity

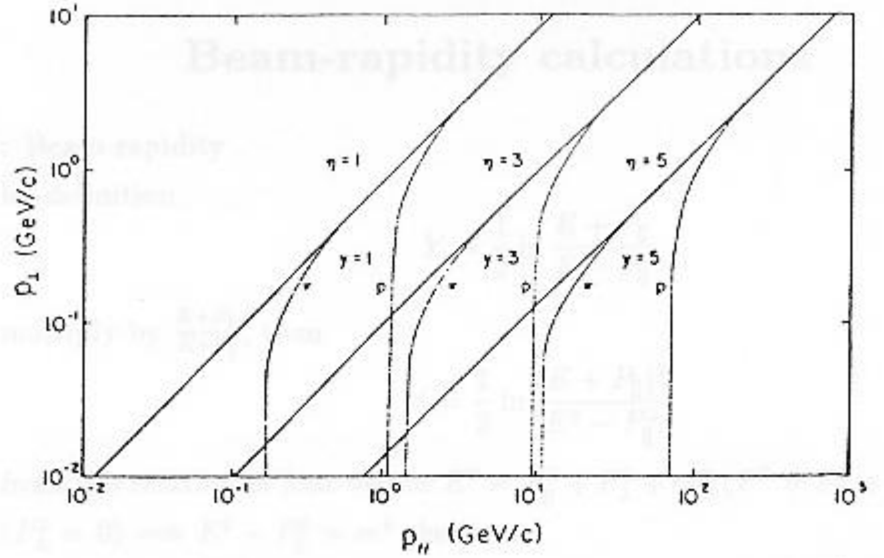

Figure 32: Values of transverse and longitudinal momenta for pions for selected values of rapidity y and pseudorapidity η [FRIE76].

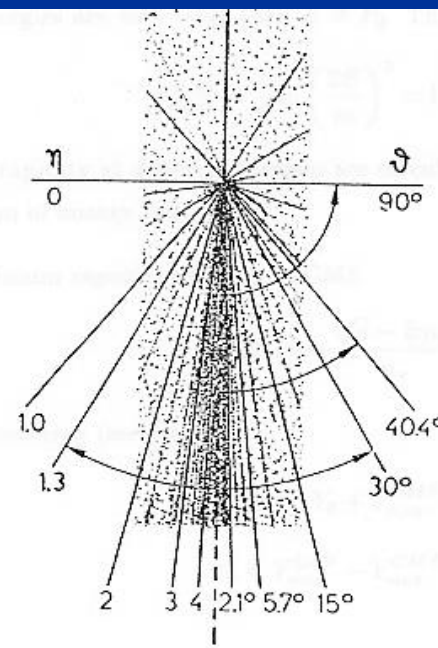

Figure 33: The measured angular region: $\eta \geq 1.3$ (*i.e.* $\theta \leq 30°$) : $\eta = -\ln \tan \frac{\theta}{2}$ [GANS78]

Rapidity $y = 1/2 \ln (E+P_Z/E-P_Z)$

Pseudorapidity $\eta = -\ln (\tan \theta/2)$

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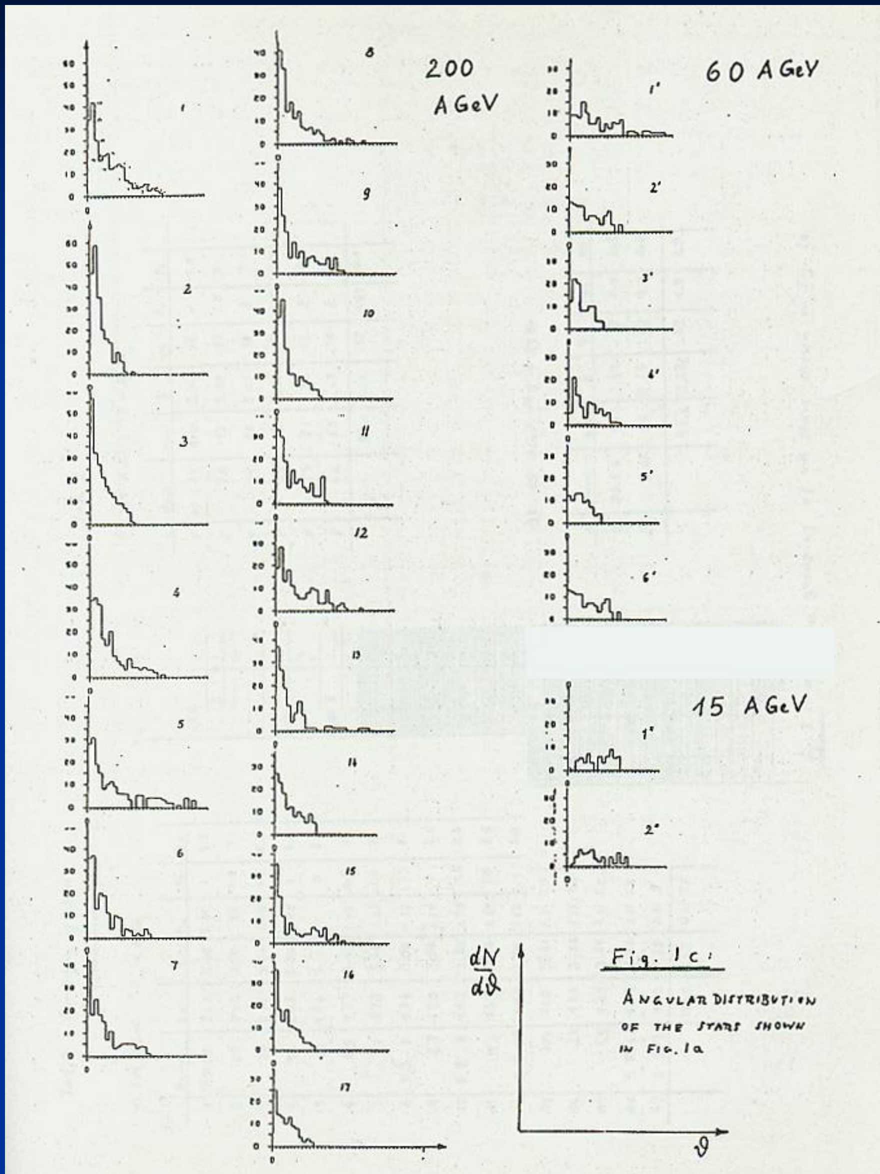

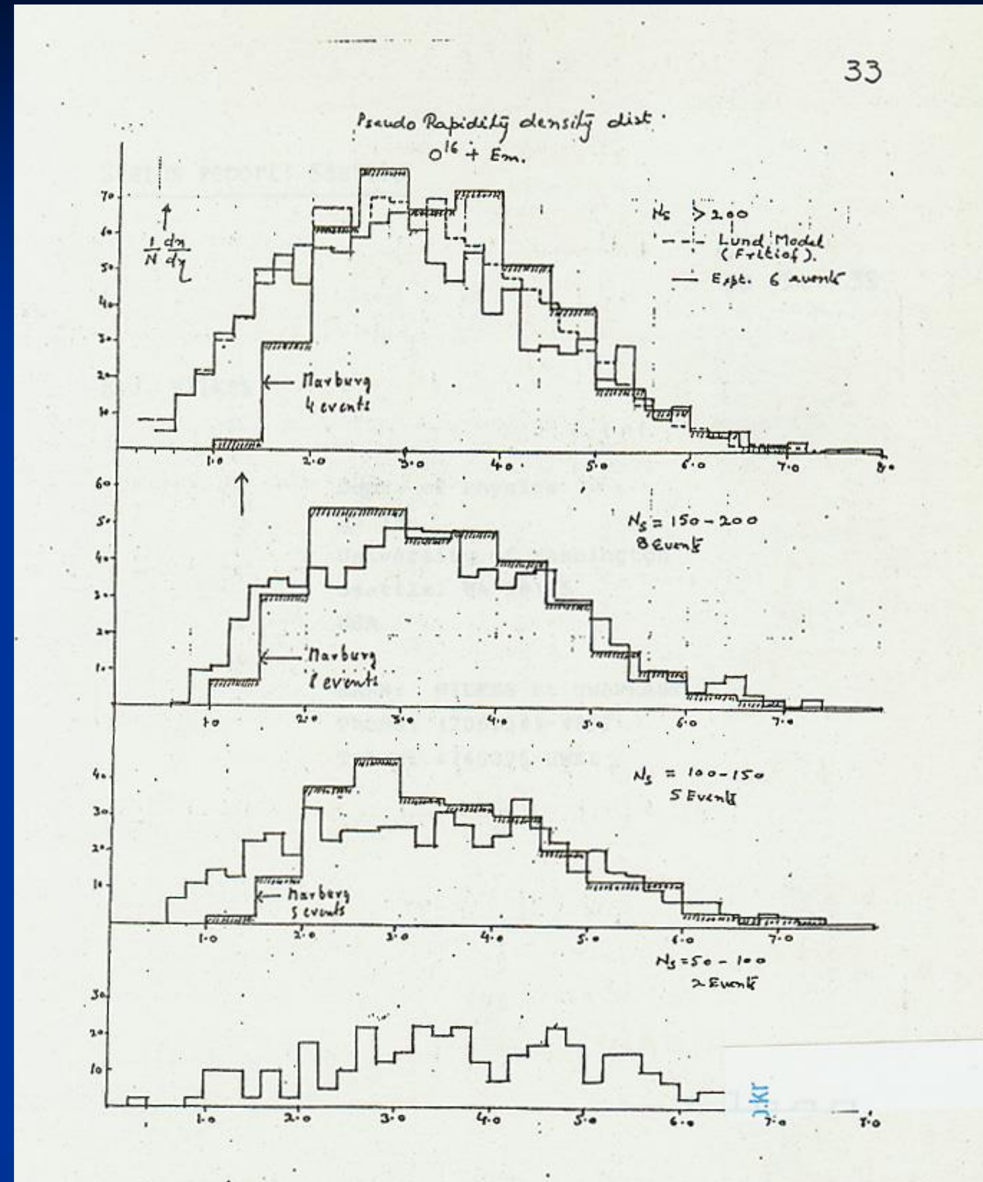

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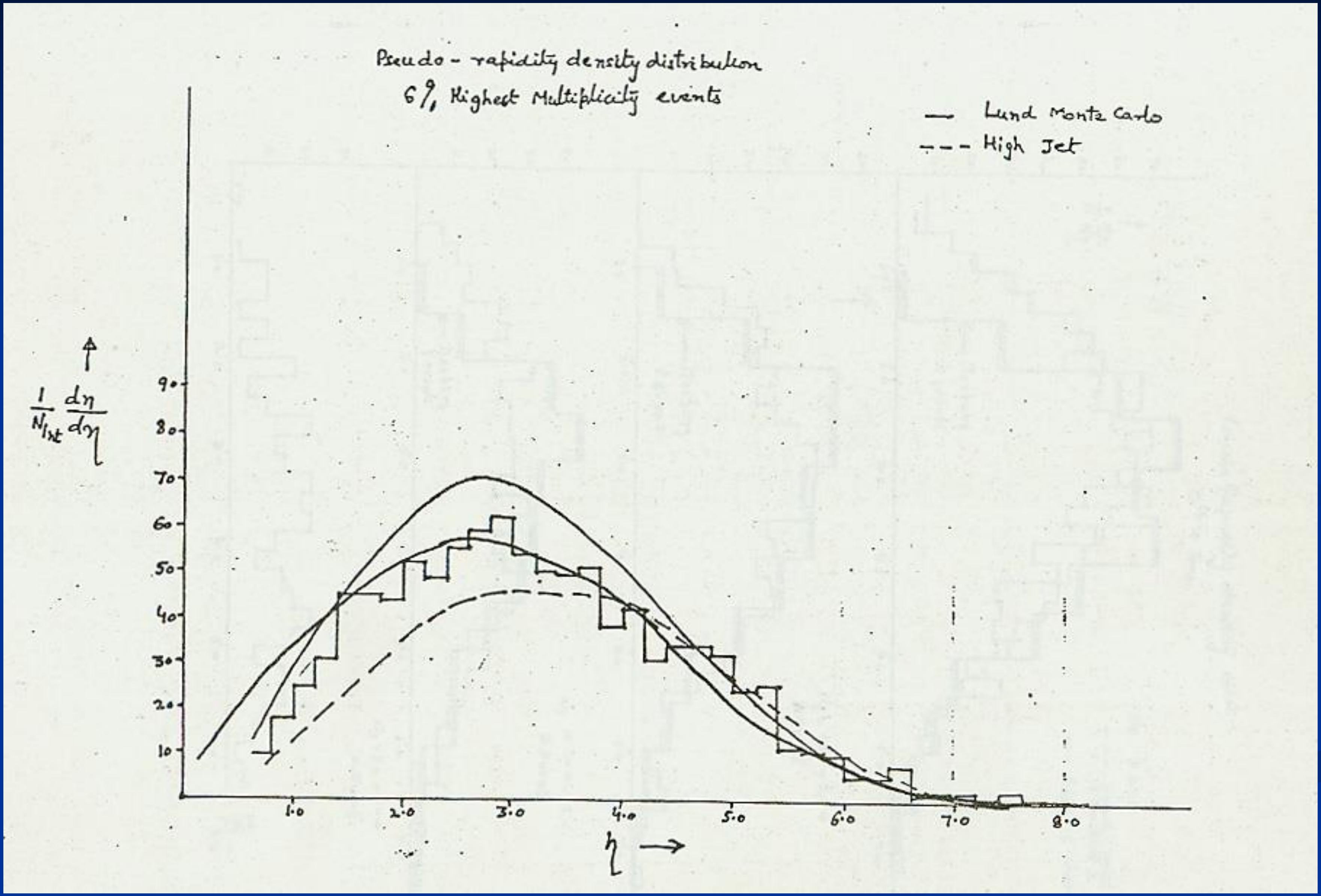

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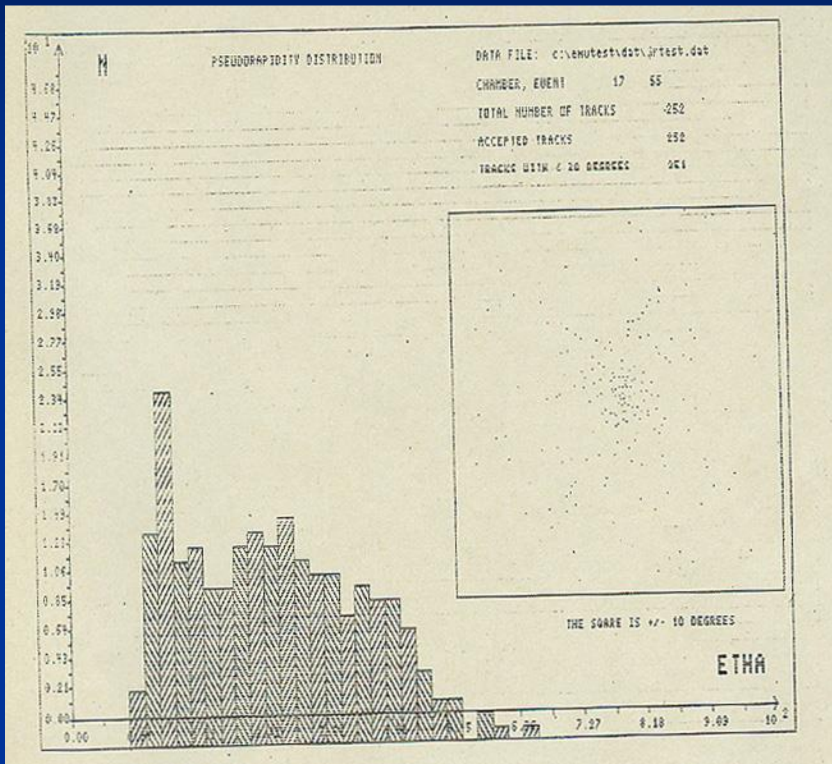

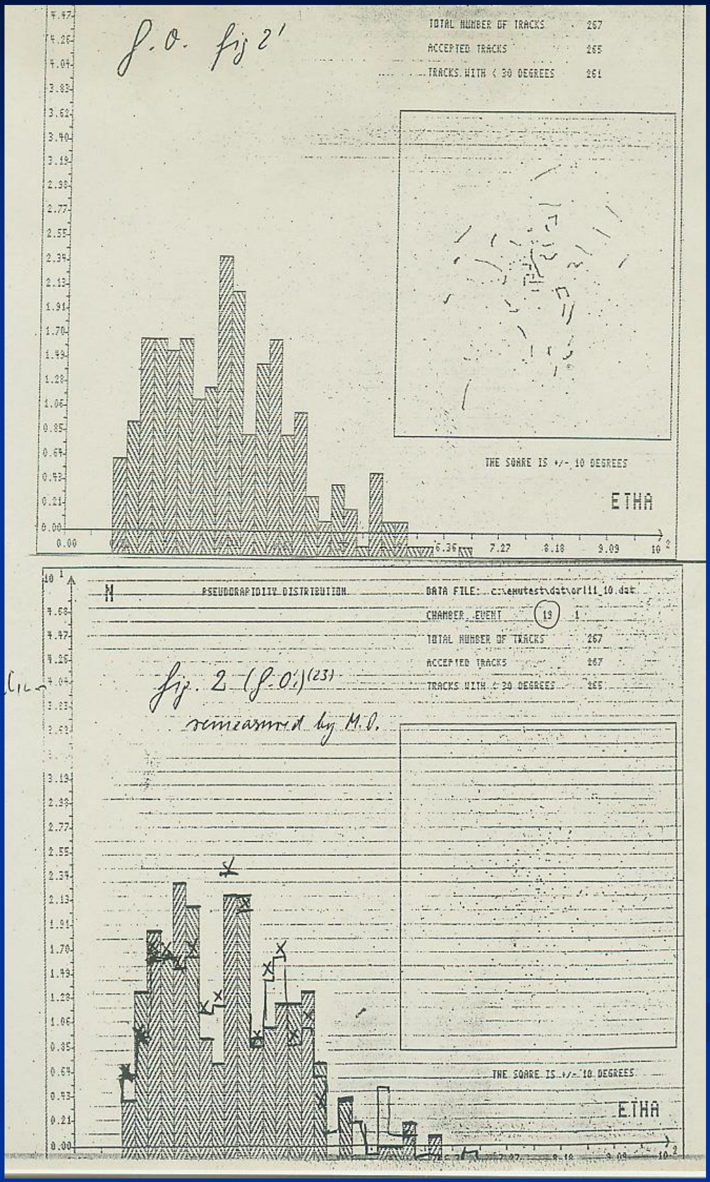

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Entropy and Relative entropy

4 Relative entropy

4.1 Introduction of R and H

Simak, Sumbera and Zborovsky[SIMA89] have investigated the data of experimental multiplicity distributions in hadron-hadron collisions using an information entropy defined as

$$S := -\sum_{n=1}^{k} P(n) \ln P(n) \quad ; \quad P(n) = \frac{N_n}{N} \qquad (4.1)$$

where N_n = multiplicity of charged particles, with the usual normalization

$$\sum_{n=1}^{k} P(n) = 1 \quad and \quad N = \sum_{n=1}^{k} N_n$$

They suggested a variable,

$$Y_{max}^{CMS} = \ln \frac{\sqrt{s} - 2m_P}{m_\pi}. \qquad (4.2)$$

Data base

Table 2: Data base for mesured and simulated data(all min. biased data sets, except S + AU, see the footnotes)

Projectile	Target	Energy/AGeV	EXP	FRITIOF
Oxygen	Emulsion	14.6	948	1000
Oxygen	Emulsion	60	694	700
Oxygen	Emulsion	200	492	500
Sulphur	Emulsion	200	235	235
Sulphur	Gold	200	188[1]	188[2]

Relative Entropy

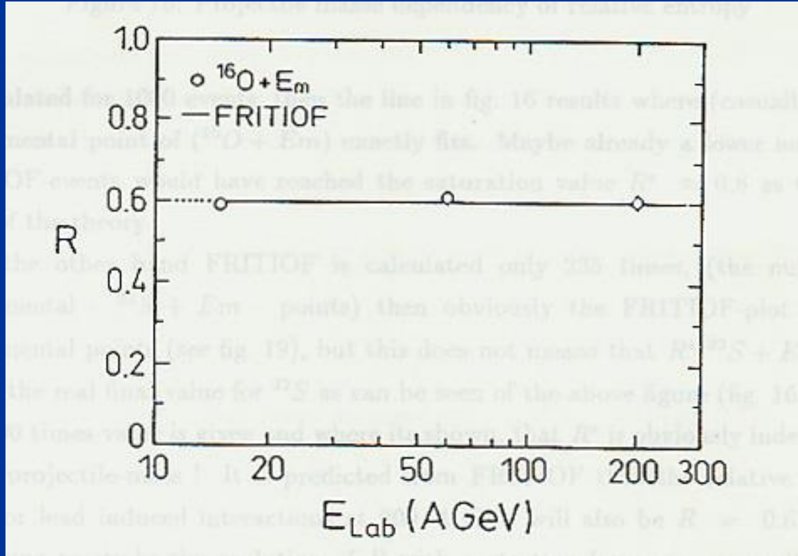

Figure 15: Relativ entropy in full phase space for $^{16}O + Em$

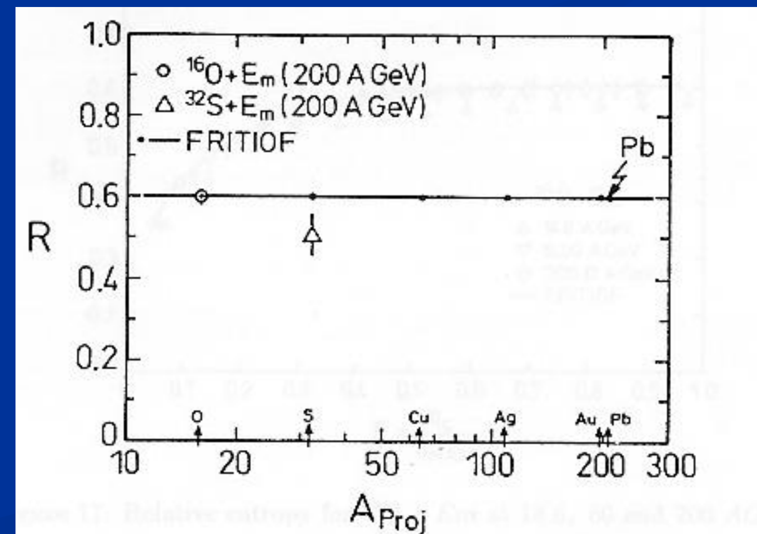

Figure 16: Projectile masse dependency of relative entropy

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Relative Entropy

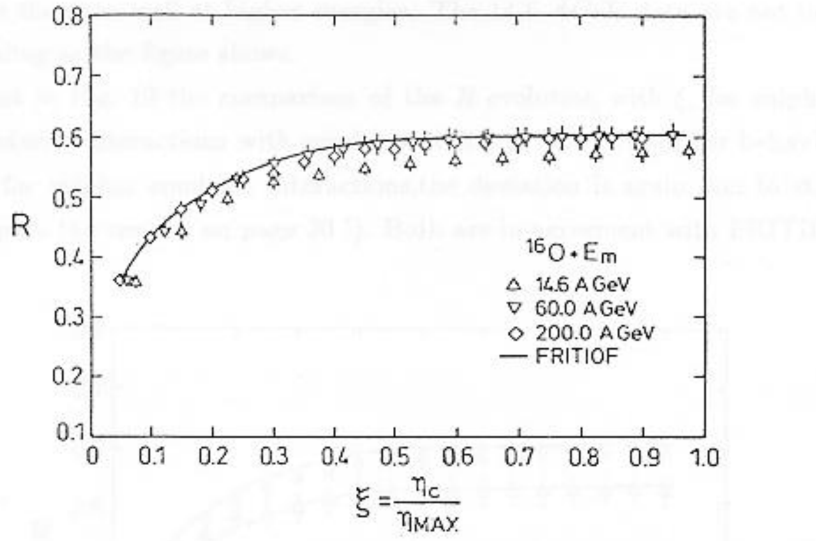

Figure 17: Relative entropy for $^{16}O + Em$ at 14.6, 60 and 200 $AGeV$

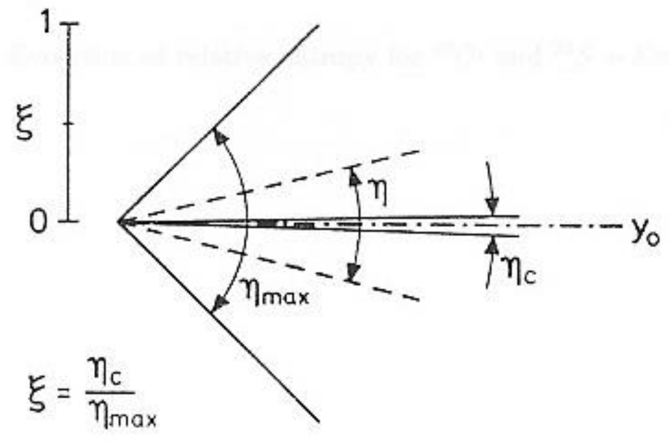

Figure 18: scaled pseudorapidity windows and full phase space

Long range correlation

Consideration of particles in Forward and Backward window gaps

Long range correlation

Gaps between Forward & Backward -Pseudorapidity windows

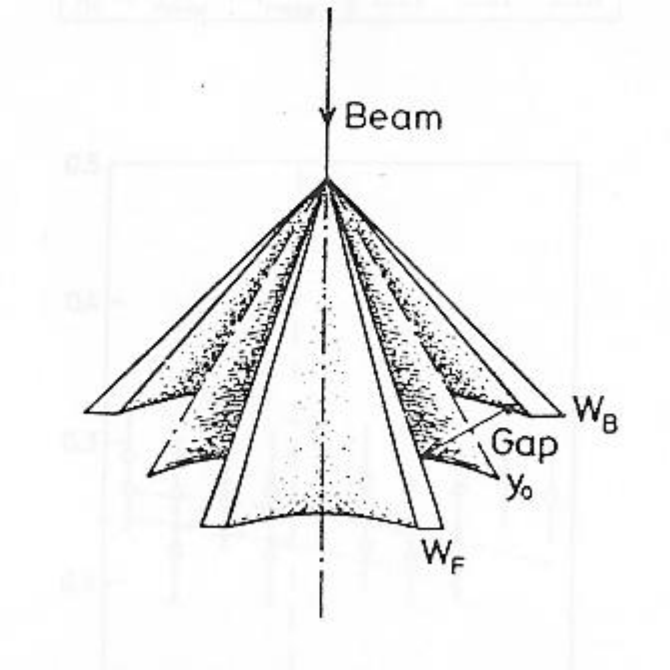

Figure 25: The windows and gap

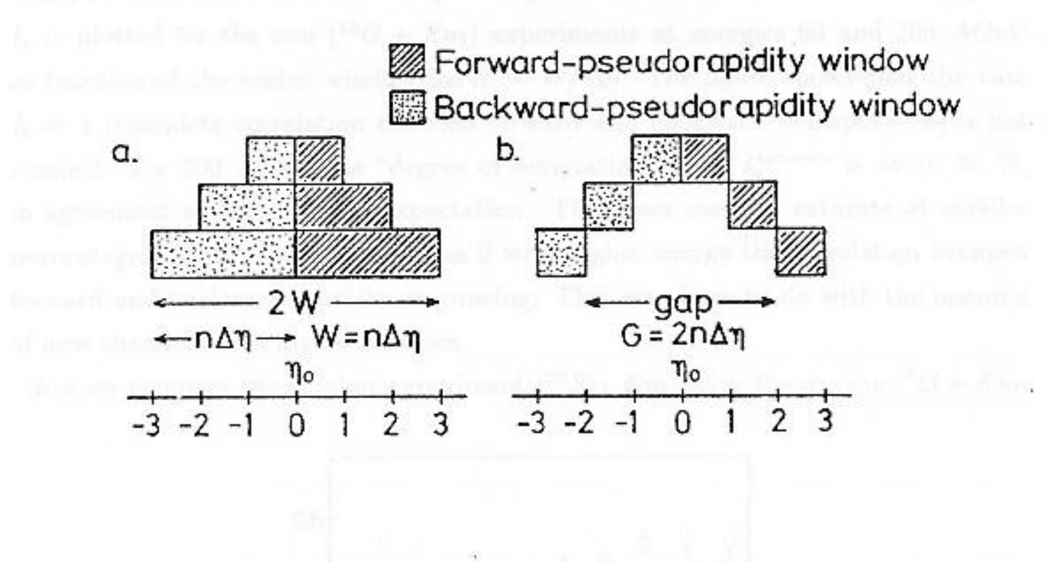

Figure 21: Pseudorapidity windows for F, B regions: a) without gap, b) with gap.

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Entropy without Rapidity Gaps

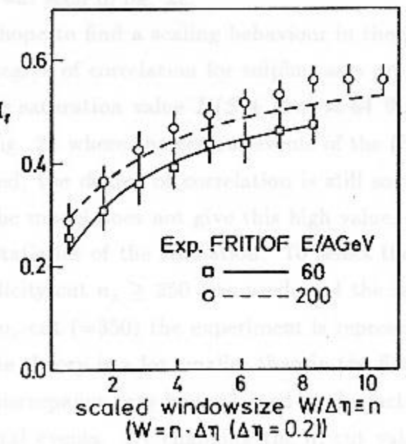


Figure 22: I_r for $^{16}O + Em$ at 60 and 200 $AGeV$ *no gap*

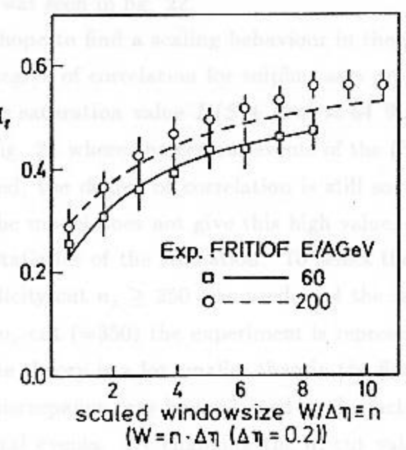


Figure 22: I_r for $^{16}O + Em$ at 60 and 200 $AGeV$ *no gap*

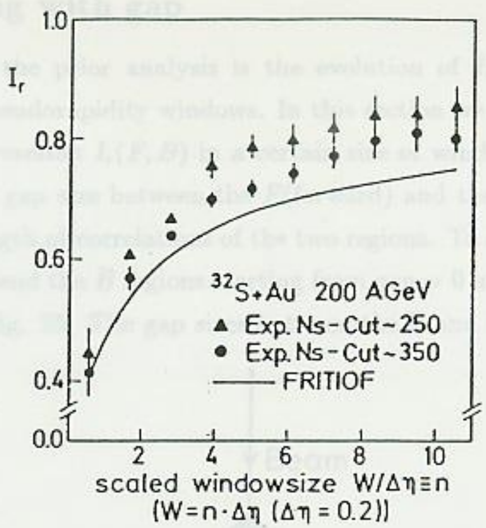


Figure 24: I_r for $^{32}S + Au$ at 200 $AGeV$ *no gap*

n_s-cut in SAU200

n_s-cut	$I_r^s(EXP)$	$I_r^s(FRIT)$	$I_r^s(EXP)/I_r^s(FRIT)$
250	0.855 ± 0.034	0.751 ± 0.022	1.14 ± 0.03
350	0.803 ± 0.026	0.726 ± 0.019	1.11 ± 0.02
400	0.818 ± 0.035	0.727 ± 0.022	1.12 ± 0.07

Entropy with Rapidity Gaps

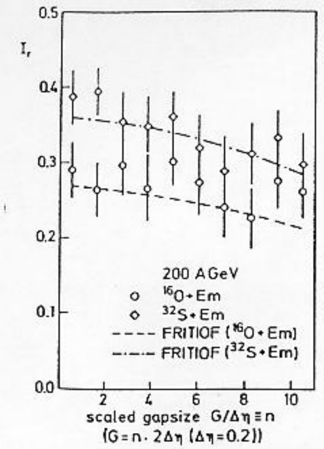


Figure 27: I_r for ^{16}O and $^{32}S + Em$ at 200 $AGeV$ *with gaps*

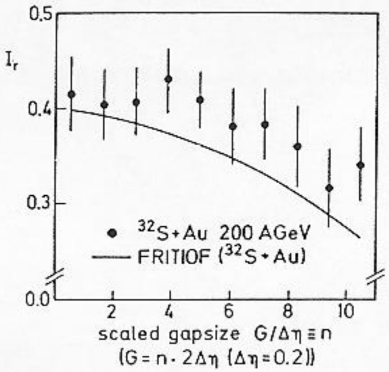


Figure 28: I_r for $^{32}S + Au$ at 200 $AGeV$ *with gaps*

Table 3: # pseudorapidity windows and gaps

Energy(AGeV)	14.6	60	200
# windows	6	8	10
Gap_{max}	2.0	2.8	3.6
$\eta_0 = \eta_{max}^{LAB} - \eta_{max}^{CMS}$	2.11	2.61	3.13

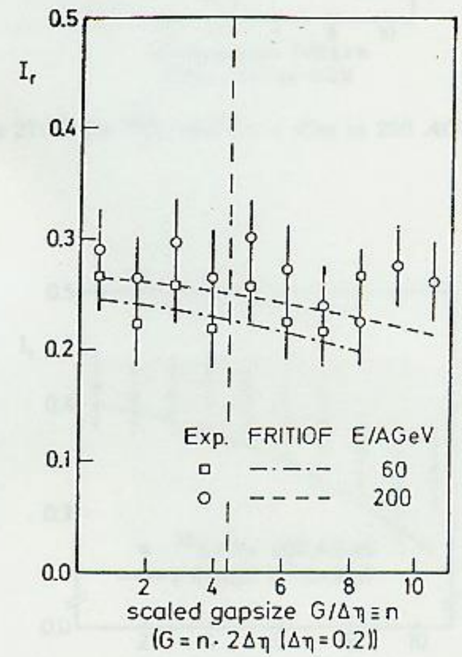


Figure 26: I_r for $^{16}O + Em$ at 14.6, 60 and 200 $AGeV$ *with gaps*

Discussion

Discussion in the Central & Fragmentation Region

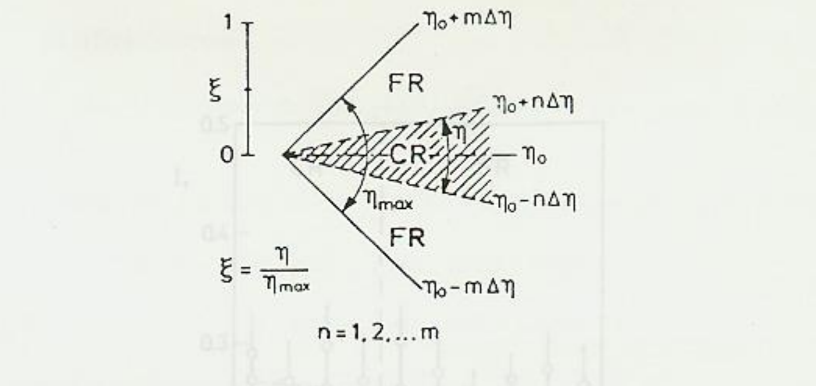


Figure 29: Central rapidity region (CR) and fragmentation region (FR).

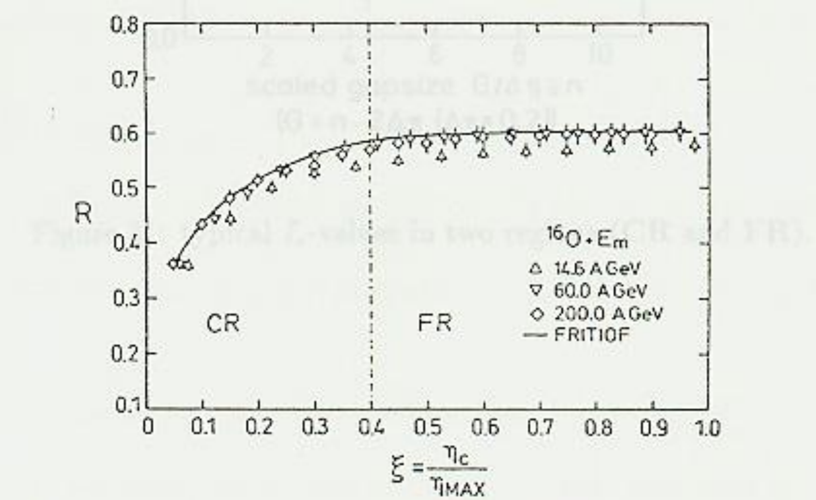


Figure 30: typical R-values in two regions (CR and FR).

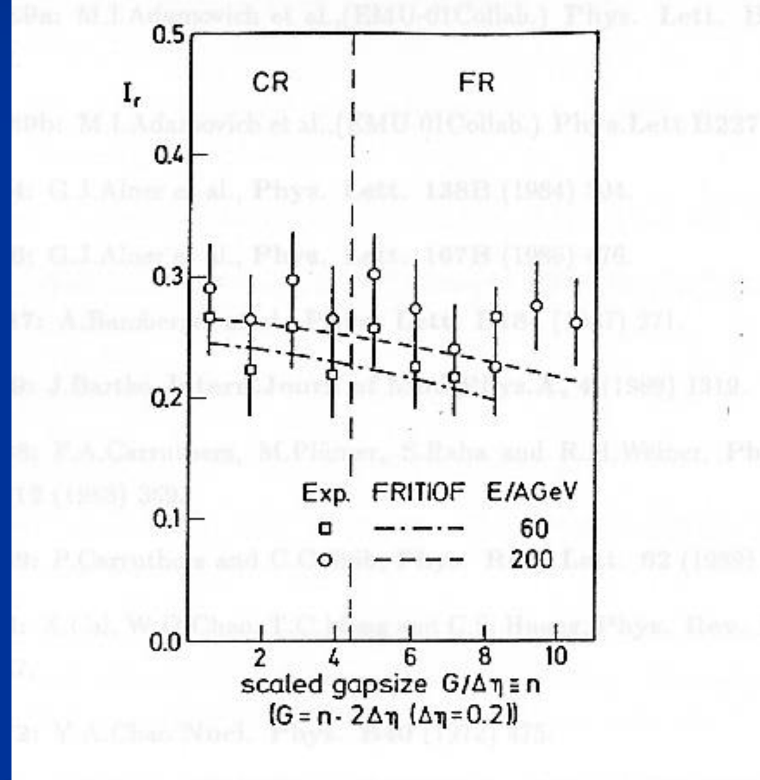


Figure 31: typical I_r-values in two regions (CR and FR).

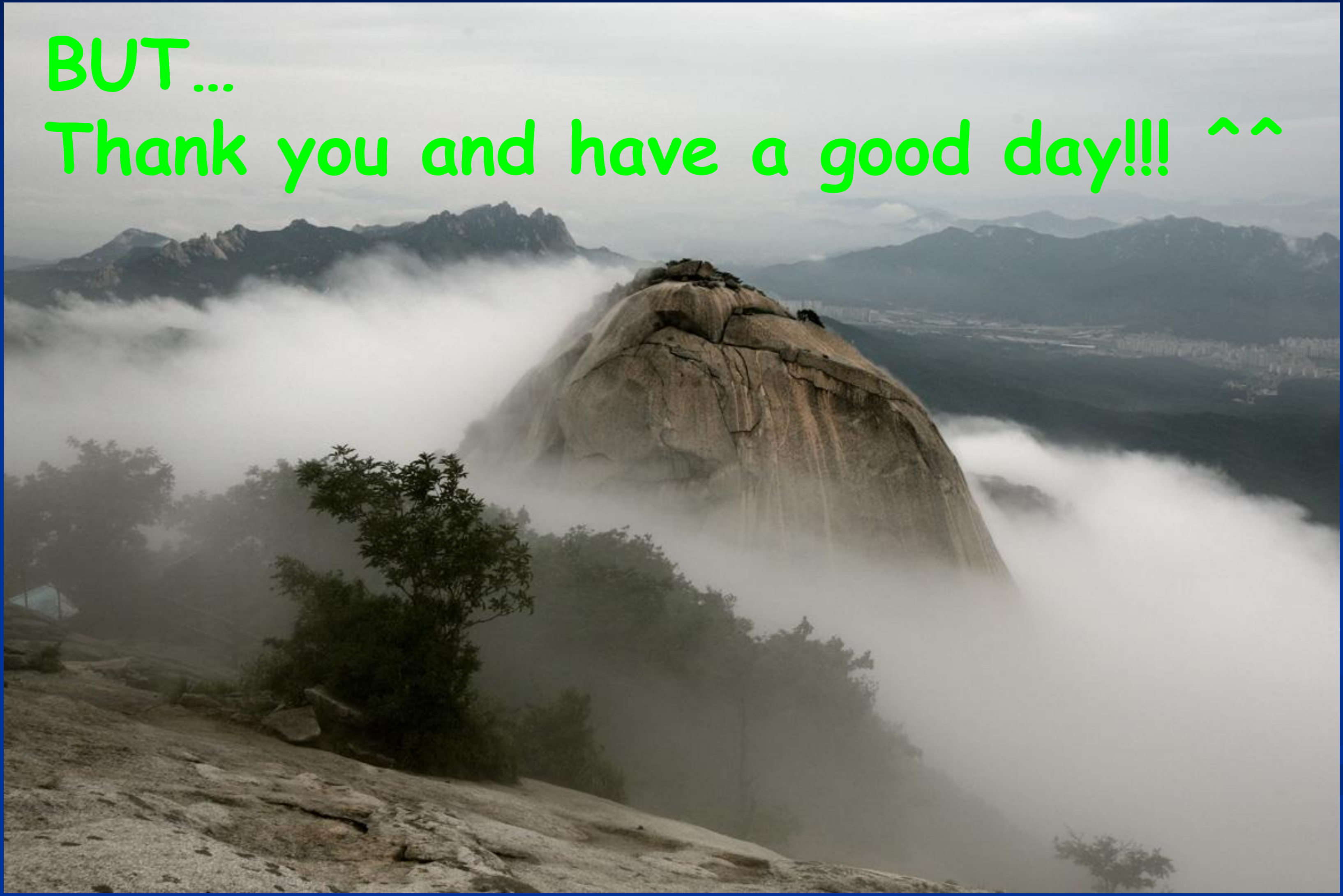
Relative entropy analysis

- Both in full phase space and in different symmetric pseudorapidity windows R is insensitive to energy
- R increses with the scaled window size and tends to saturate
- Compare to Oxygen and Sulpher induced unbiased interactions with emulsion, a faster saturation of R is found in central Sulpher-Gold collisions

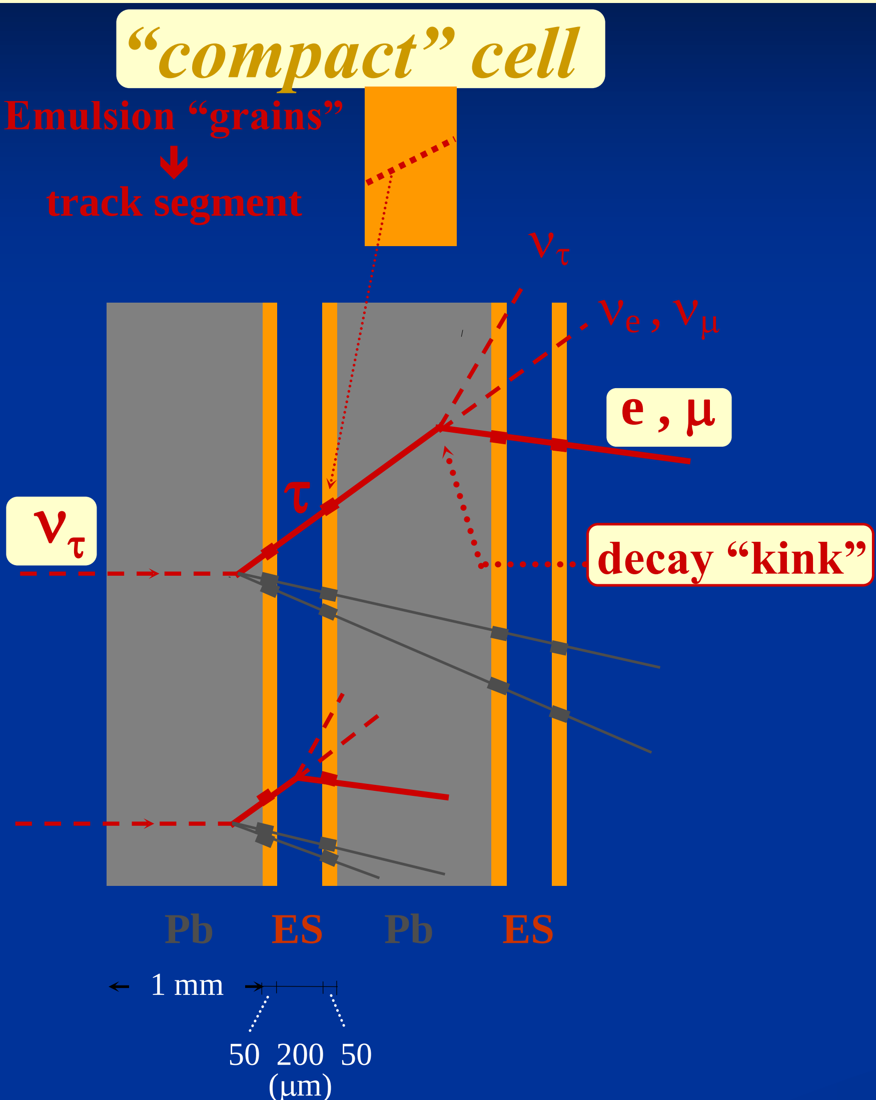
Long-range correlations

- Analyzing without gap: I_r increases with the size of the scaled windows and shows clearly energy dependence.
- Analyzing with gaps: I_r decreases with the gap size between the forward and backward pseudorapidity windows.

(And again one day is finished, and again is produced Bull Sheet only.
Good Night, sleep well you troubles, lick on my Ass till the morning! – And …)


BUT…
Thank you and have a good day!!! ^^

The cell : detection of the primary and of the secondary vertex(OPERA)



- Lead ® large M_{target}
- Emulsion sheets (ES)
  ® tracking in space
- Each (double-sided) ES
  - 50 μm emulsion layers on both si des of
    200 μm plastic base
  - μm detection granularity
  ® high quality track segments
- τ decays <u>downstream of the vertex lead plate</u>
  ® observation of decay kink
  (not simply impact parame ter)