FUSTIPEN

French-U.S. Theory Institute for Physics with Exotic Nuclei

In medium fragment breakup of projectile in $^{36}Ar+^{58}Ni$ central collisions

Laura Francalanza
INFN Sez. Napoli

DATA ANALYSIS on the first INDRA campaign (Ganil 1993):

^{36}Ar + ^{58}Ni at 32, 40, 52, 63, 74, 84 95 AMeV (7 incident energy steps)

- What about the system?

  Medium-heavy system; Charge asymmetry;

  Large range of incident energy (little steps);

  Nuclear Stopping & Transparency phenomena ?

- What about the experiment?

  Identification of light charged particles and fragments;

  Completeness of detected events (4pi detector): mandatory for

  a valid Shape analysis

The Experiment

INDRA detector and data

Wide angular coverage: ~90% of 4Pi

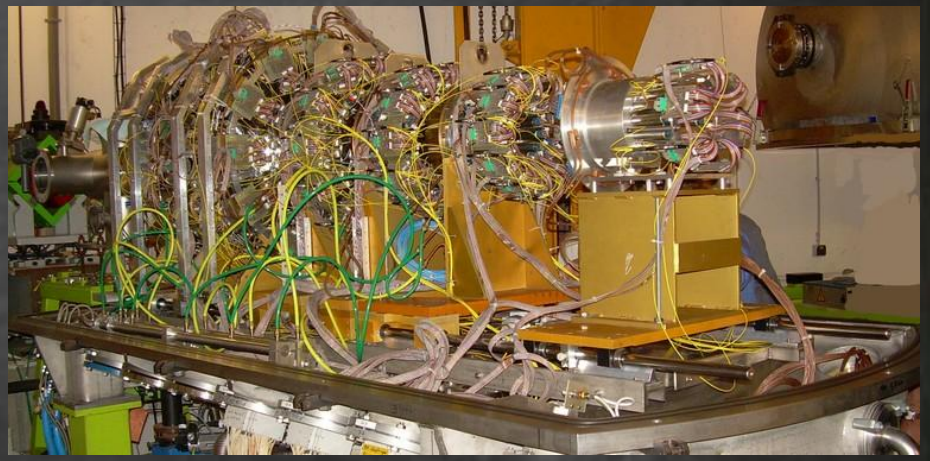
High granularity

High dynamic range in energy,

with small detection thresholds of ~1 MeV/A

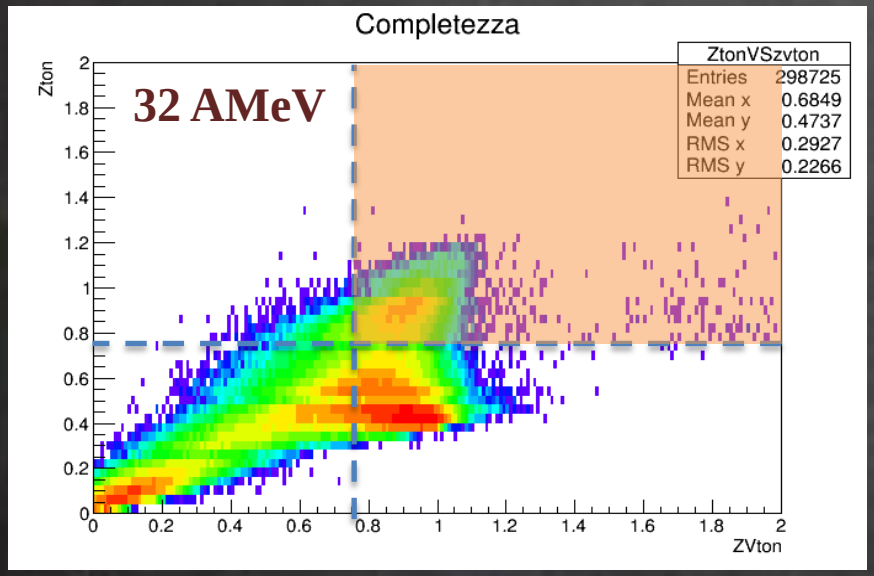
High charge resolution, of up to Z ~ 50

Isotopic identification of light charged particles



- from 2° to 3°: ring 1 is made up of 12 plastic scintillators.
- from 3° to 45°: rings 2-9 have 3 detection stages including one ionization chamber, followed by a wafer with 3 or 4 silicon detectors, behind each of which is placed a cesium iodide (CsI) scintillator.
- from 45° to 176°: rings 10-17 include just 2 detection stages: an ionization chamber coupled to 2, 3 or 5 CsI scintillators.

Data analysis: completeness



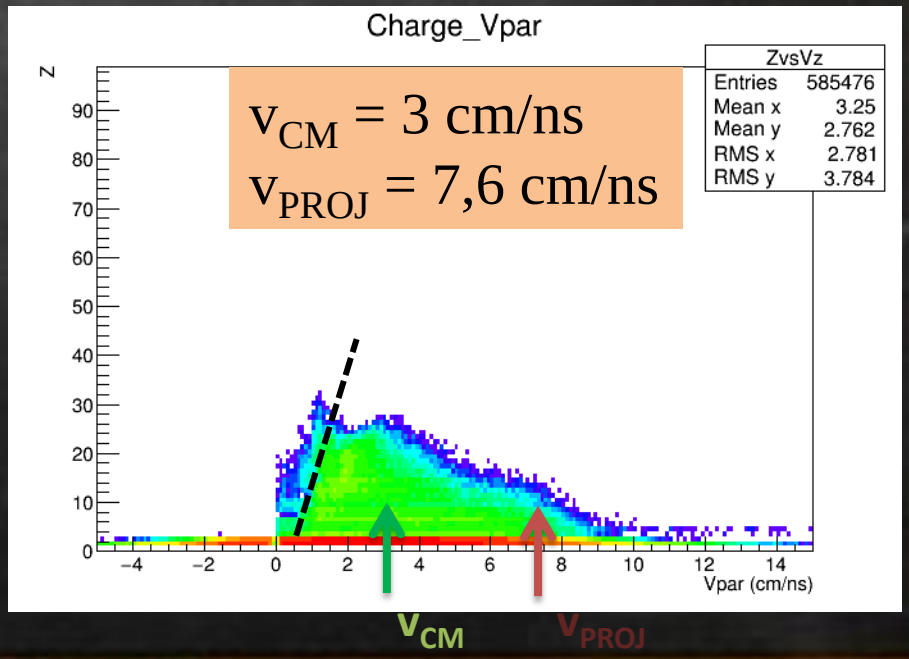
COMPLETE EVENTS:

$$(Z_{ton} \geq 0,75)\ \&\&\ (Zv_{ton} \geq 0,75)$$

vpar Fascio

Different contribution to emission:

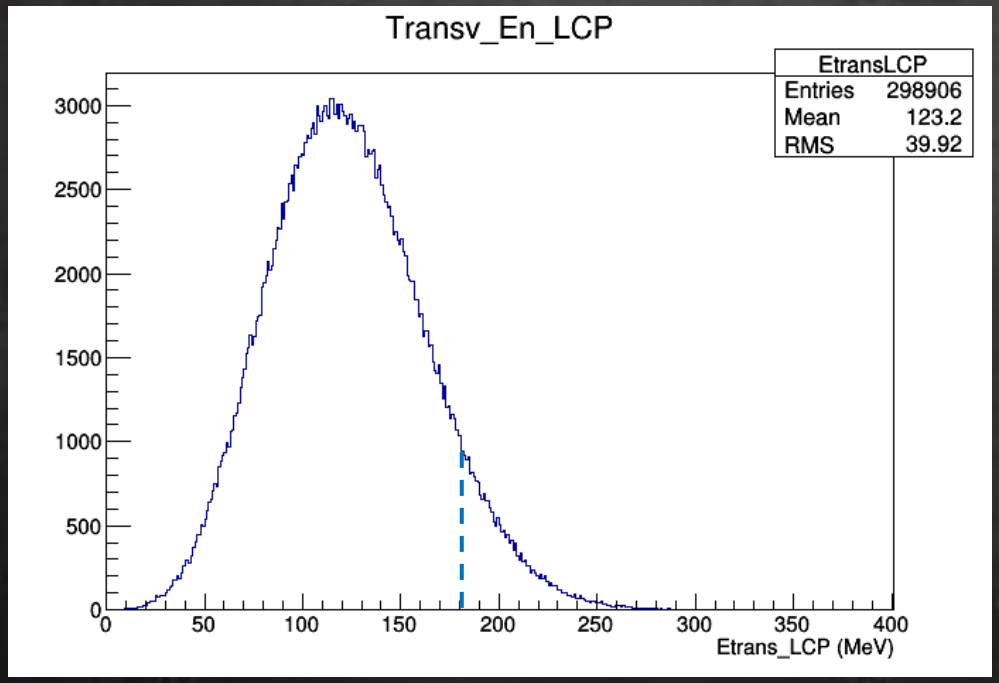
- QT-velocity (= ? cm/ns)
- Mid-velocity (≈ 3 cm/ns)
- QP-velocity (≈ 7,6 cm/ns)



Data analysis: centrality

Multiplicity of charged Particles (MCP); Total Kinetic Energy (TKE); Flow angle or similar Shape Variables; Total transverse Energy (Etr) …

E_{tr12}

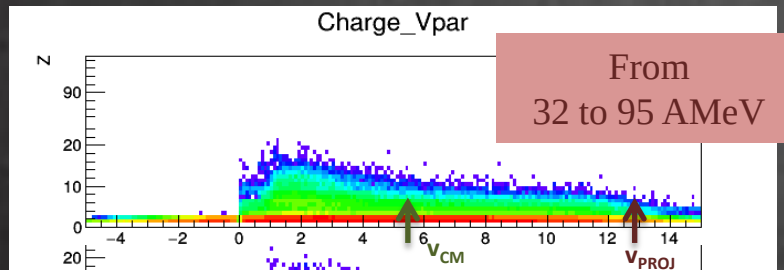


E_{inc} $(AMeV)$	E_{tr12} (MeV)
32	183
40	221
52	285
63	352
74	421
84	479
95	550

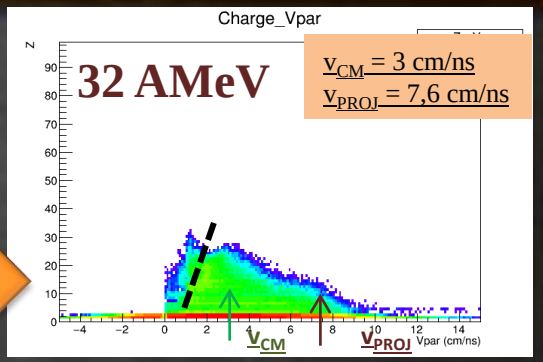
Cavata Method : $\frac{b}{b_{tot}} = \left(\frac{1}{N}\int_{E_{t12MAX}}^{E*_{t12}} Y(E_{t12})dE_{t12}\right)^{1/2}$

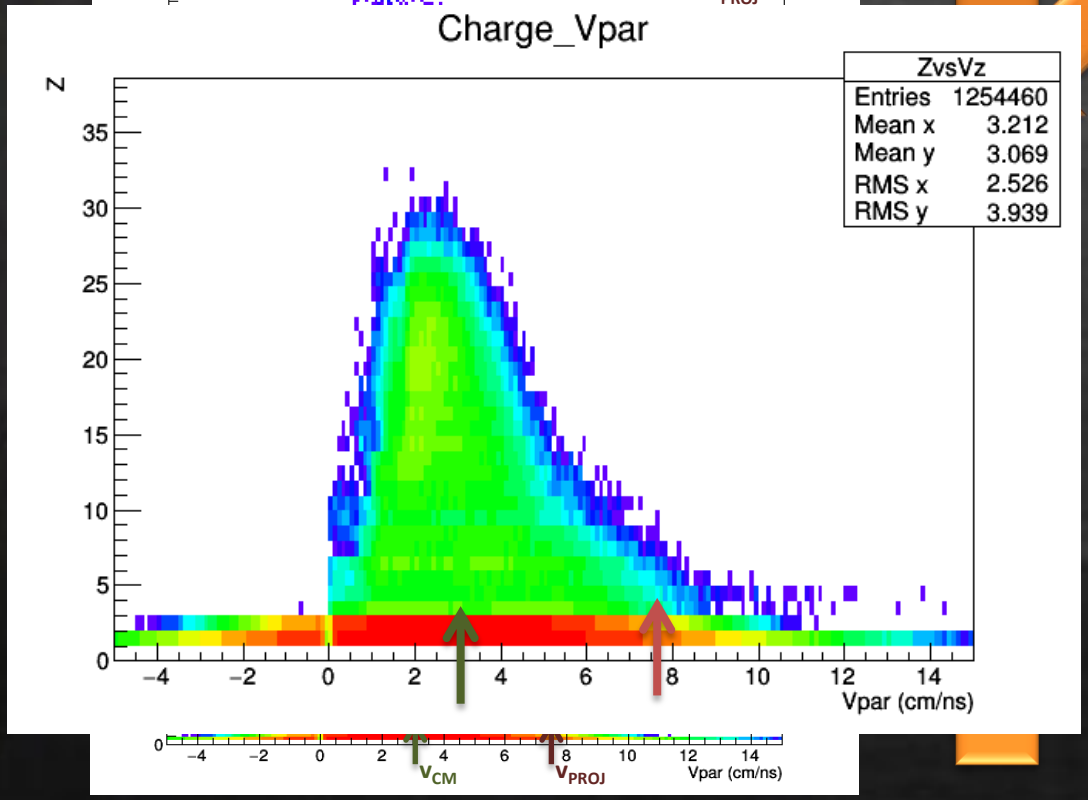
$b \approx [0-2{,}5]\ fm$

Central Events



From
32 to 95 AMeV





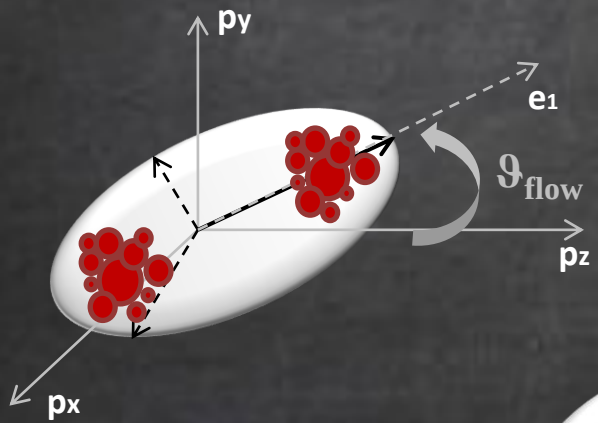
v_{CM} (cm/ns)	v_{proj} (cm/ns)
5,12	12,6
4,8	11,9
4,53	11,3
4,2	10,5
3,8	9,6
3,35	8,5
2,97	7,6

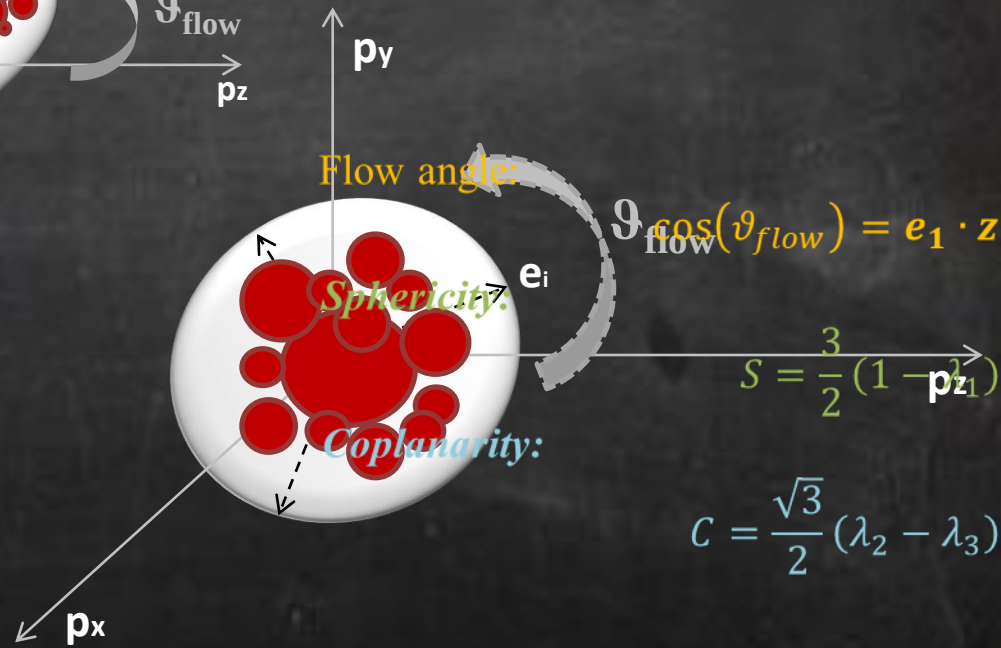
Shape Analysis

$$F_{ij} = \sum_n \frac{p_i p_j}{2m_n}$$

$$\lambda_1 + \lambda_2 + \lambda_3 = 1$$

$$\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq 0$$



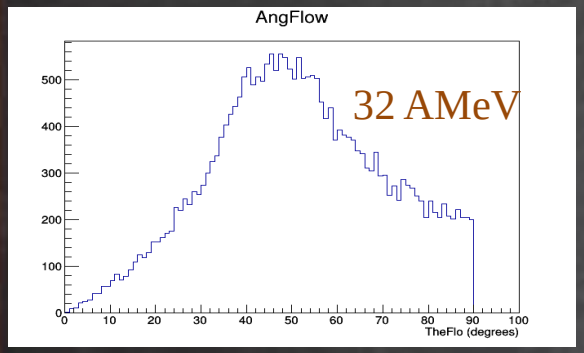


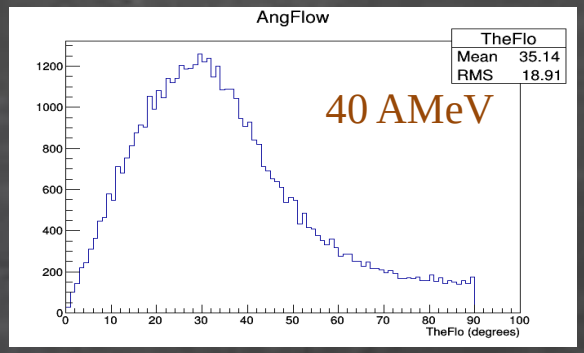
$$\cos(\vartheta_{flow}) = \boldsymbol{e_1} \cdot \boldsymbol{z}$$

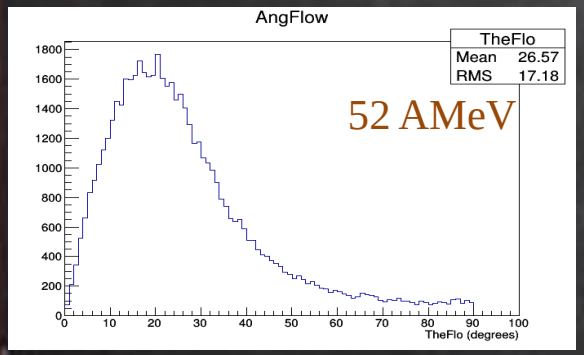
$$S = \frac{3}{2}(1 - \lambda_1^2)$$

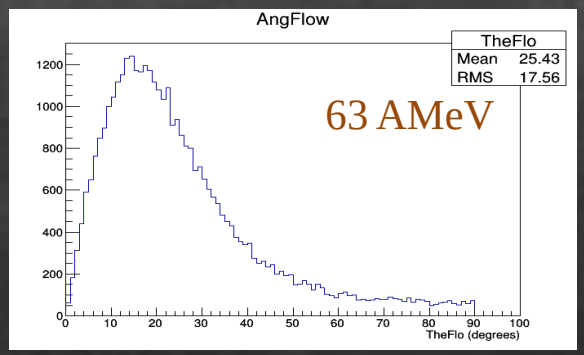
$$C = \frac{\sqrt{3}}{2}(\lambda_2 - \lambda_3)$$

Shape Analysis

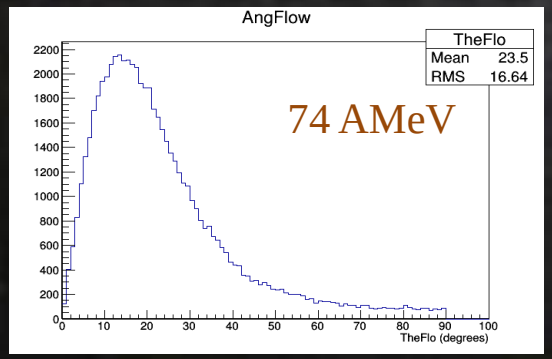


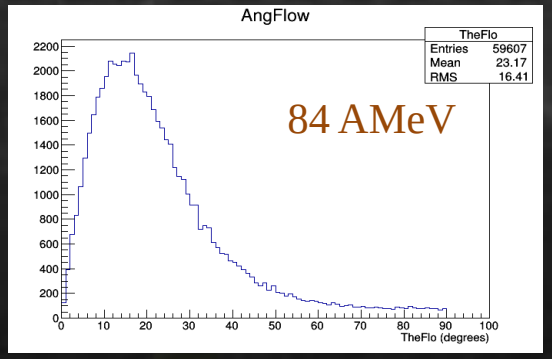


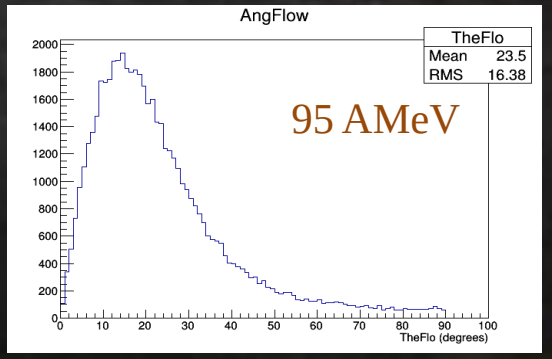




E_{inc} $(AMeV)$	$\langle \vartheta_{flow} \rangle$ $(degrees)$
32	50,85
40	35,14
52	26,57
63	25,43
74	23,5
84	23,3
95	23,5







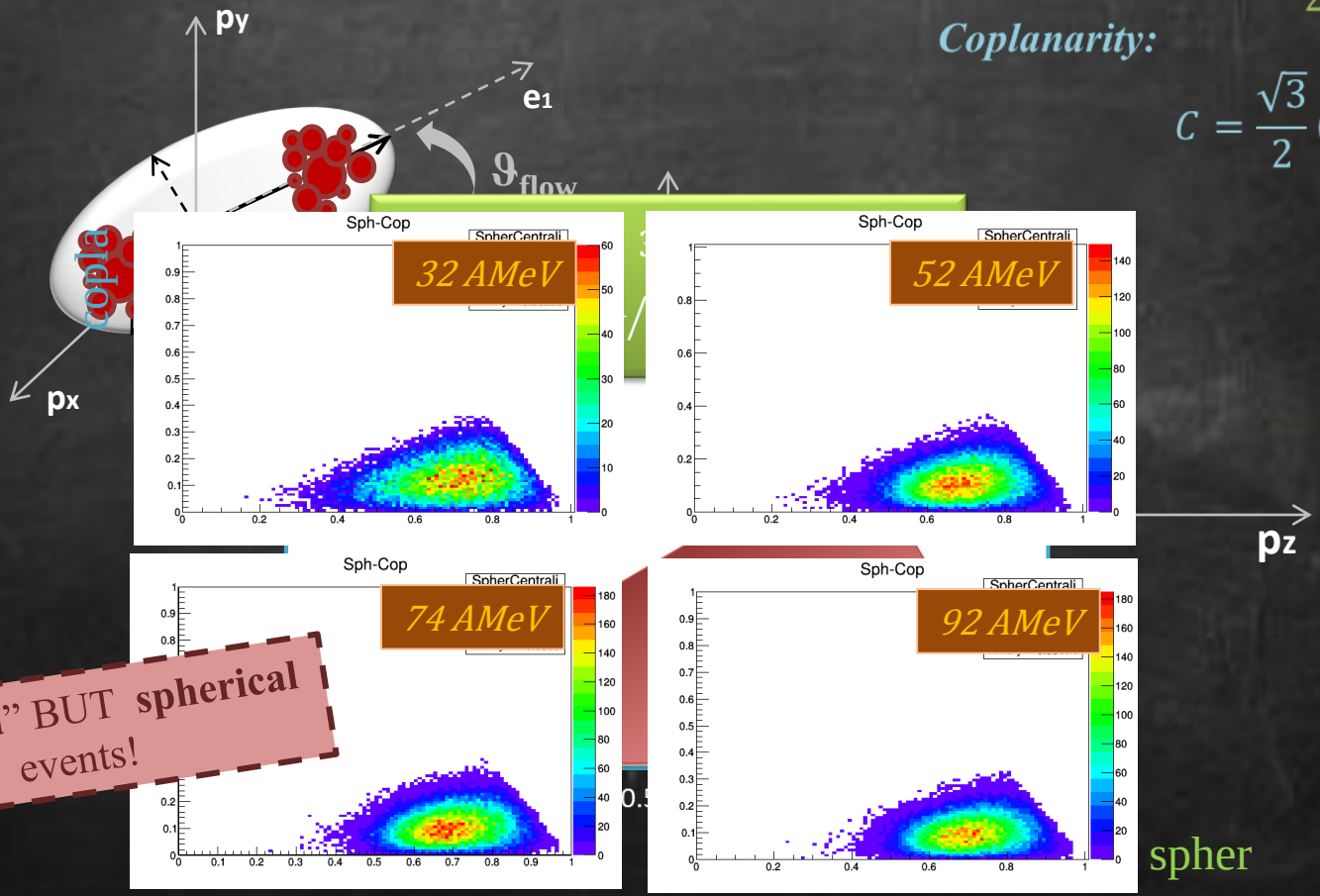
Shape Analysis

Sphericity:

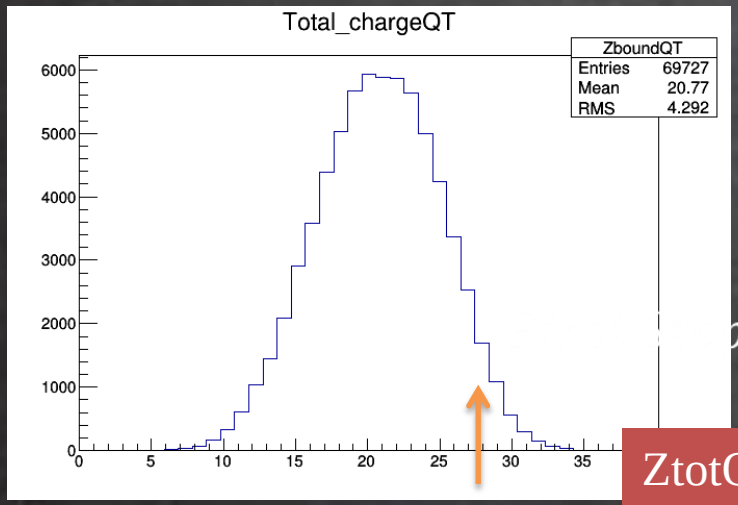
$$S = \frac{3}{2}(1 - \lambda_1)$$

Coplanarity:

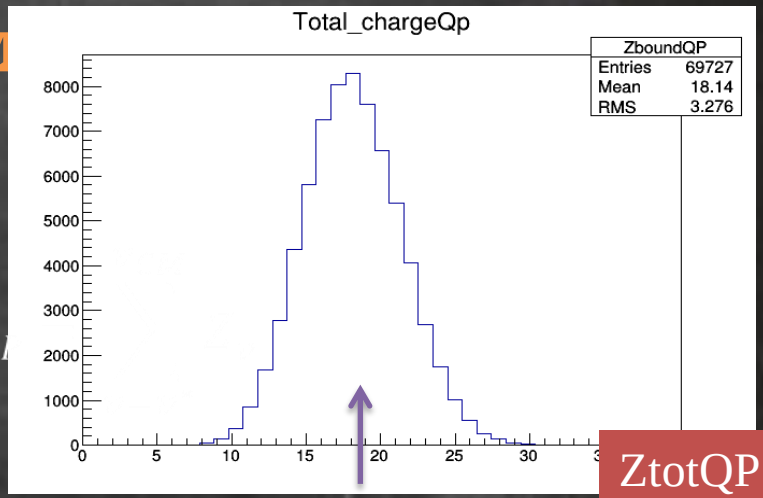
$$C = \frac{\sqrt{3}}{2}(\lambda_2 - \lambda_3)$$



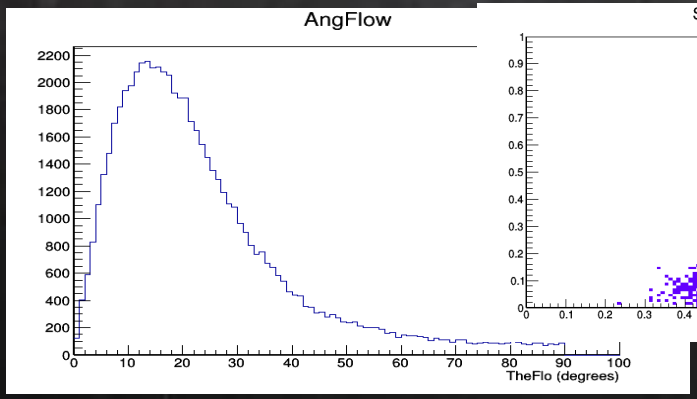
Sources Disentangle:
QT + QP & mid-vel.

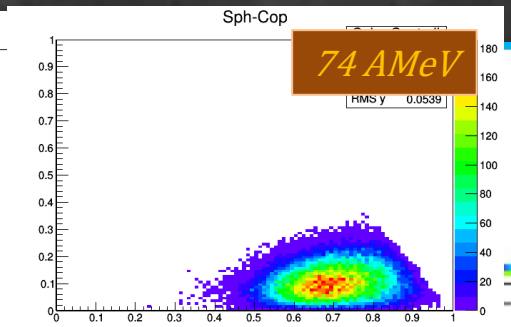


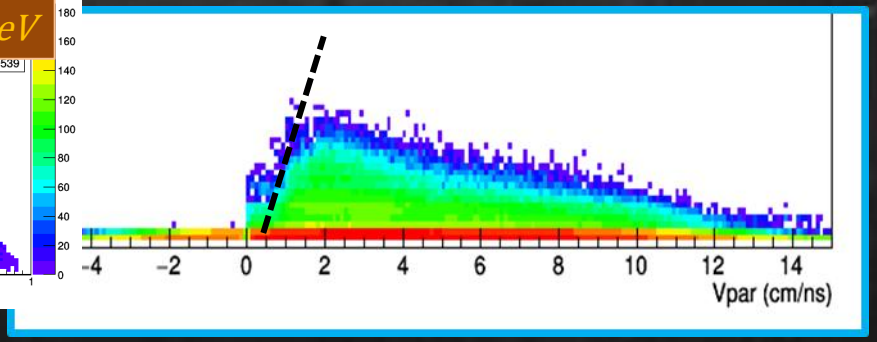
ZtotQT



ZtotQP

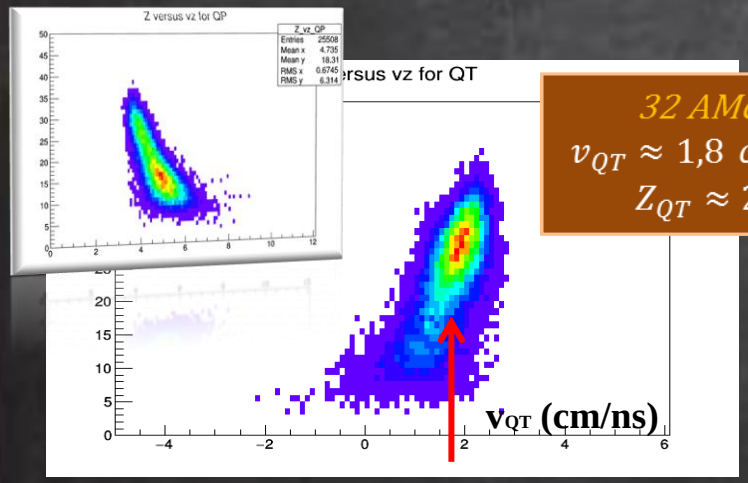




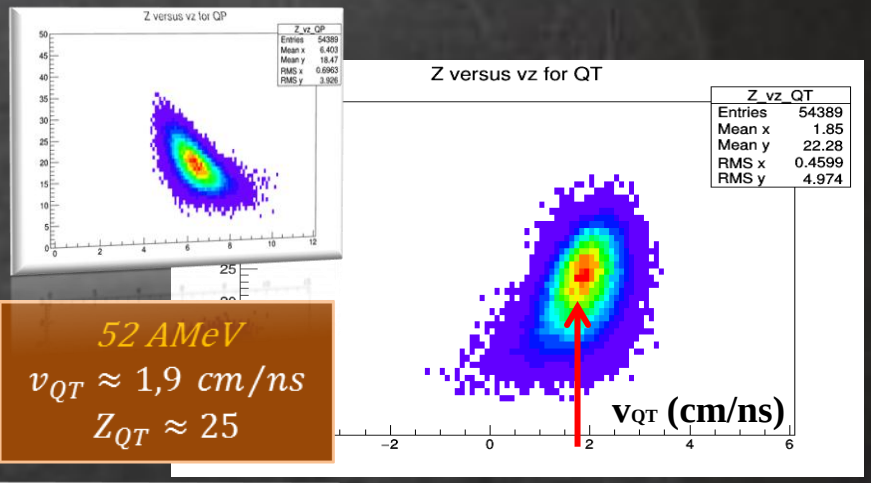


Sources Reconstruction: QT & QP

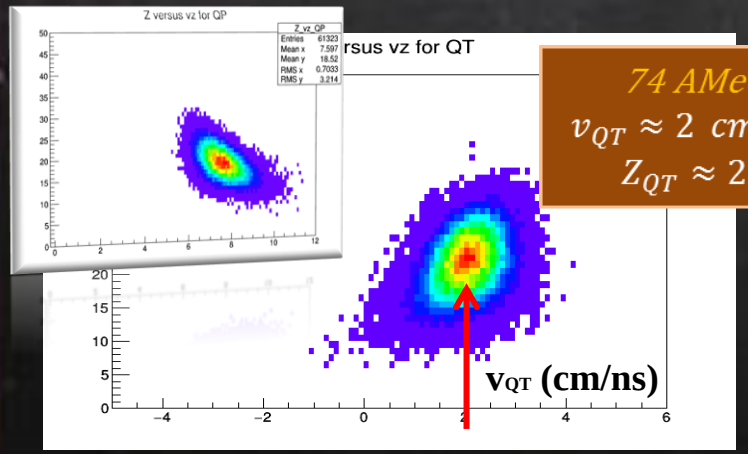
Reconstructed Charge and Velocity of sources (if any)



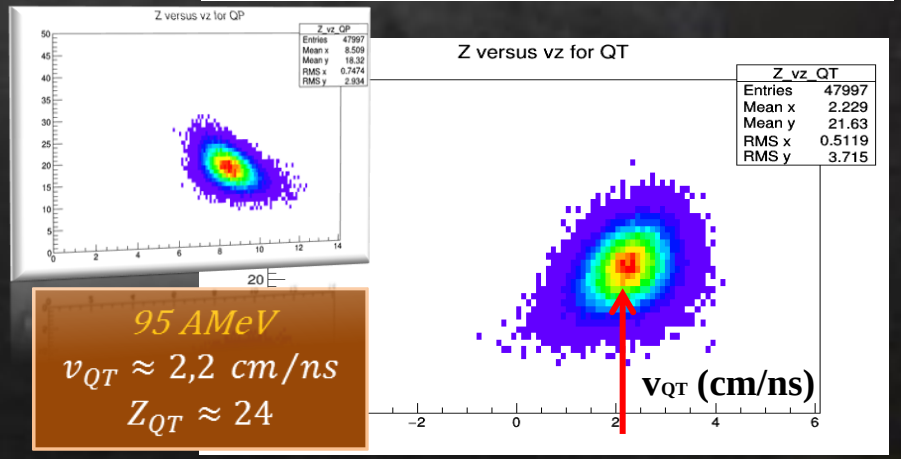
32 AMeV
$v_{QT} \approx 1{,}8\ cm/ns$
$Z_{QT} \approx 28$



52 AMeV
$v_{QT} \approx 1{,}9\ cm/ns$
$Z_{QT} \approx 25$



74 AMeV
$v_{QT} \approx 2\ cm/ns$
$Z_{QT} \approx 24$

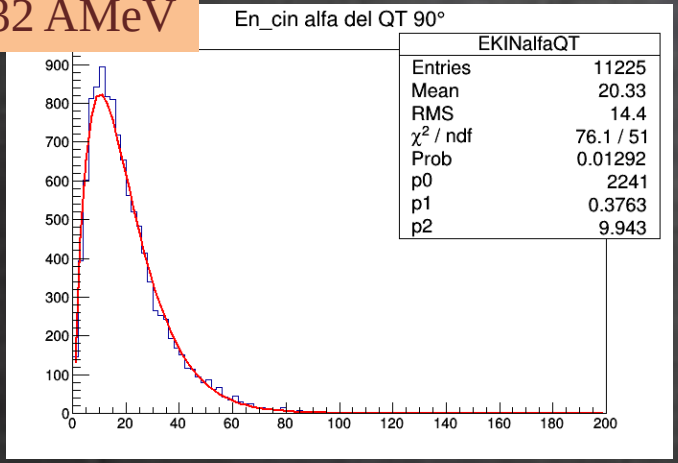


95 AMeV
$v_{QT} \approx 2{,}2\ cm/ns$
$Z_{QT} \approx 24$

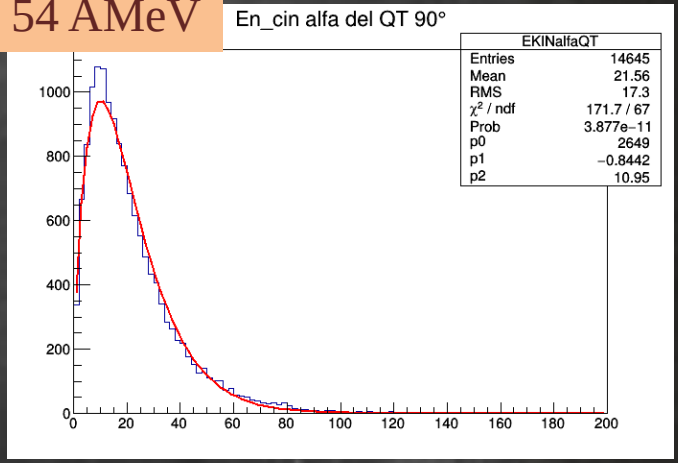
What kind of mechanisms?

evaporative, dynamic …

32 AMeV

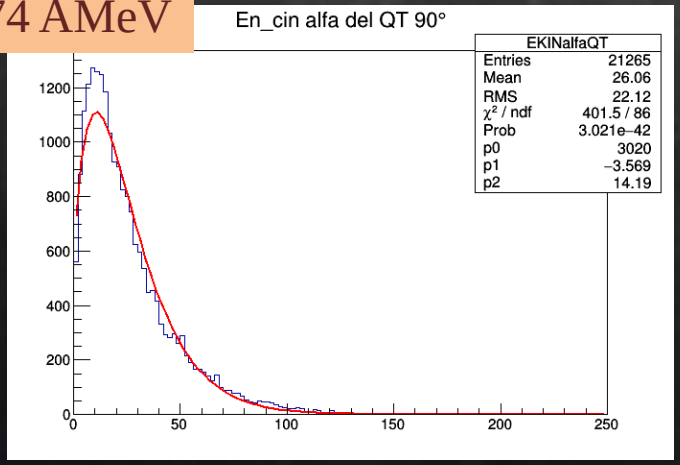


54 AMeV

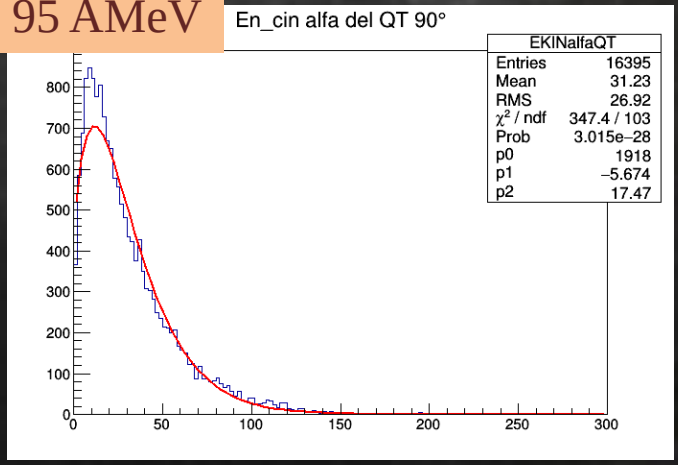


QT

74 AMeV



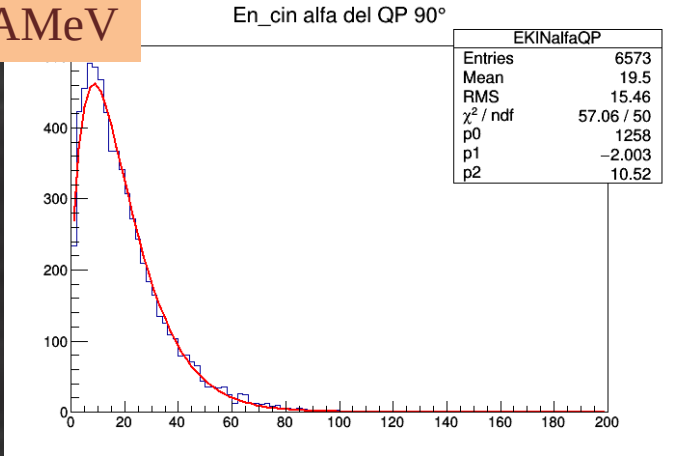
95 AMeV



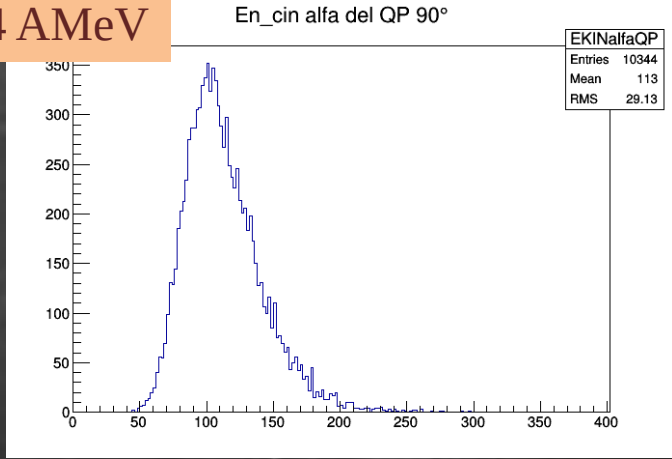
What kind of mechanisms?

evaporative, dynamic …

32 AMeV

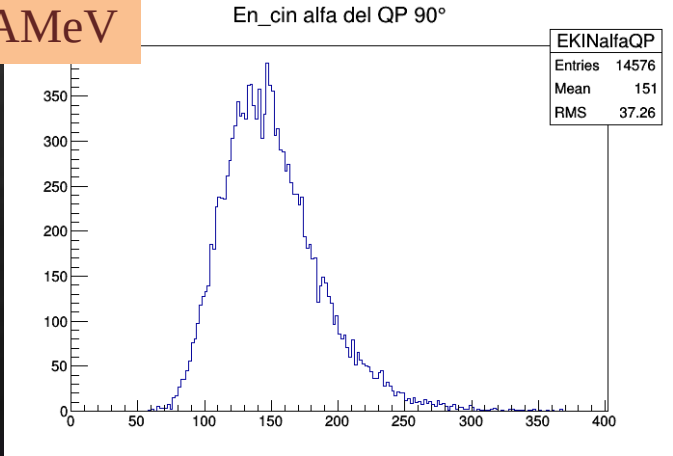


54 AMeV

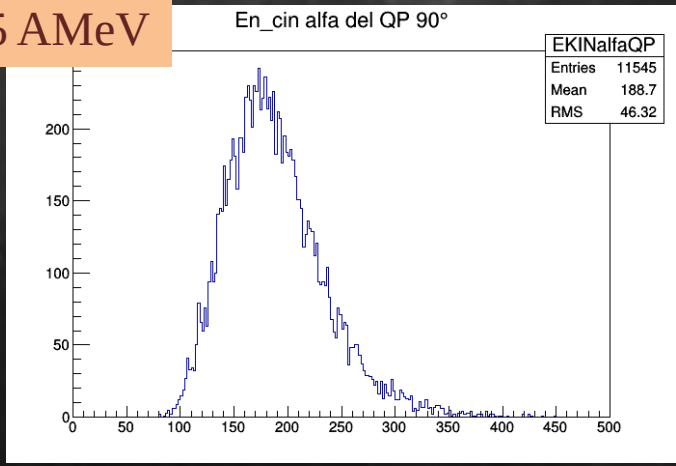


QP

74 AMeV



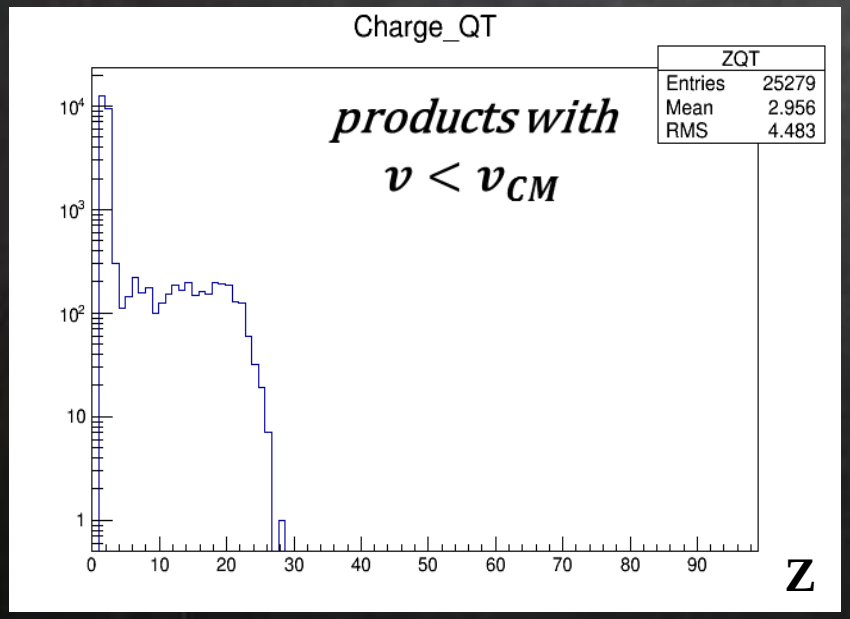
95 AMeV

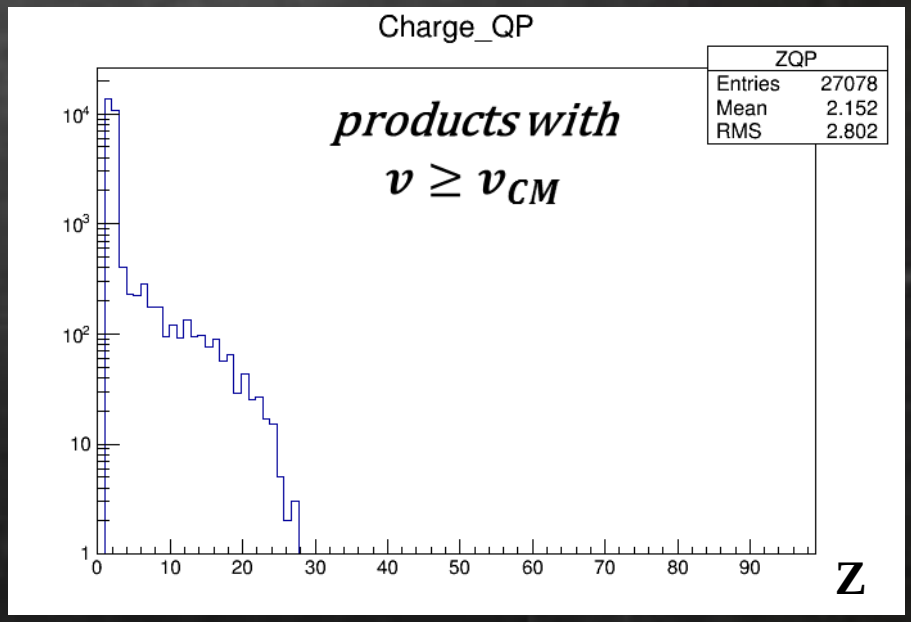


What kind of mechanisms?
evaporative, dynamic …

QT*: Typical U-shape of Fusion-Evaporation processes + MF distribution

QP: Charge distribution indicative for not-statistical emission from single source, dynamical Multifragmentation





in summary …

-fusion

Evaporation

amical MF.

In medium «crumbling»

Vaporization

Participant-spectator

THANK YOU ALL !

To the perspectives…

Transparency like: is favoured by such a system? (Size, asymmetry., internal structures…)

Is the structure of the projectile responsible for such a in medium break-up?

What about alpha abundance [**Bacri et al., PLB 1995, 353, 27-31**] ?

It could be interesting to look at system with the same mass, but different N/Z ratio of projectile… or systems with a different mass asymmetry….

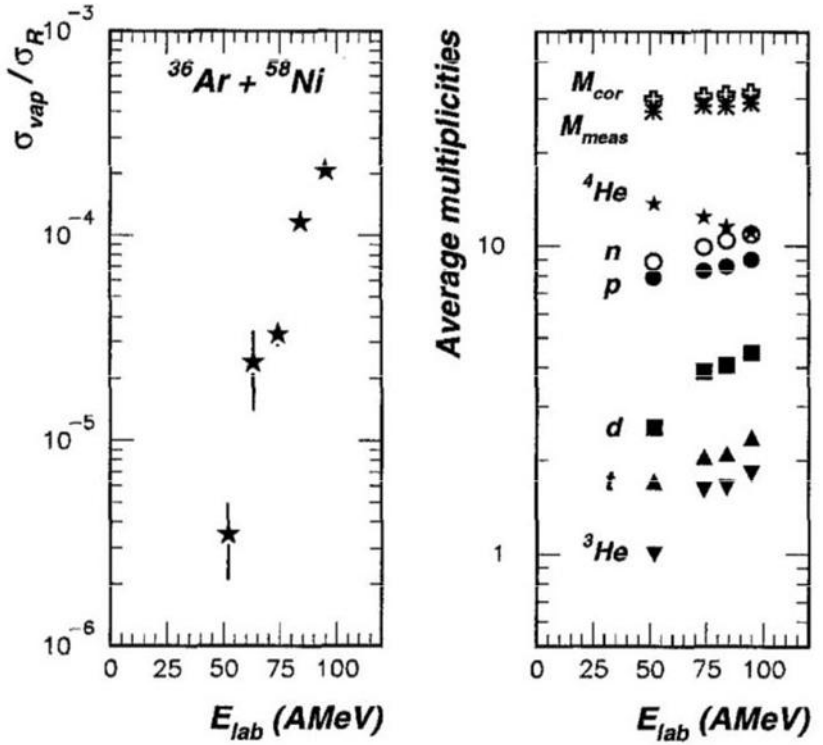


Fig. 2. Left: Excitation function for vaporization. Cross-sections are normalized to calculated reaction cross-sections [10] and are not corrected for detection probability (see text). Right: average multiplicities of the different particle species in the vaporization events. Full (open) symbols refer to measured (corrected) values.

Bacri et al., Physics Letters B, Elsevier, 1995, 353, pp.27-31