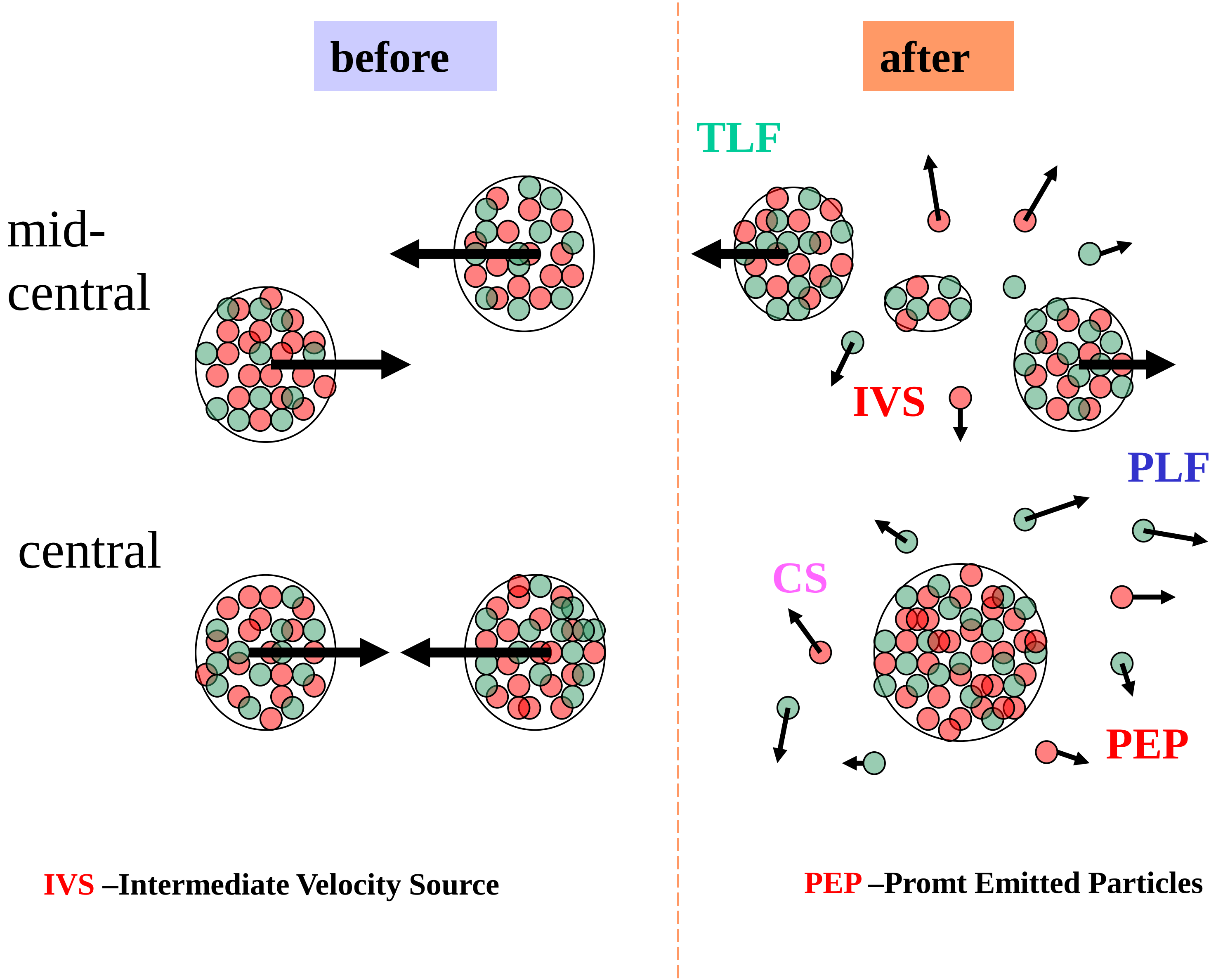
Intermediate bombarding energies



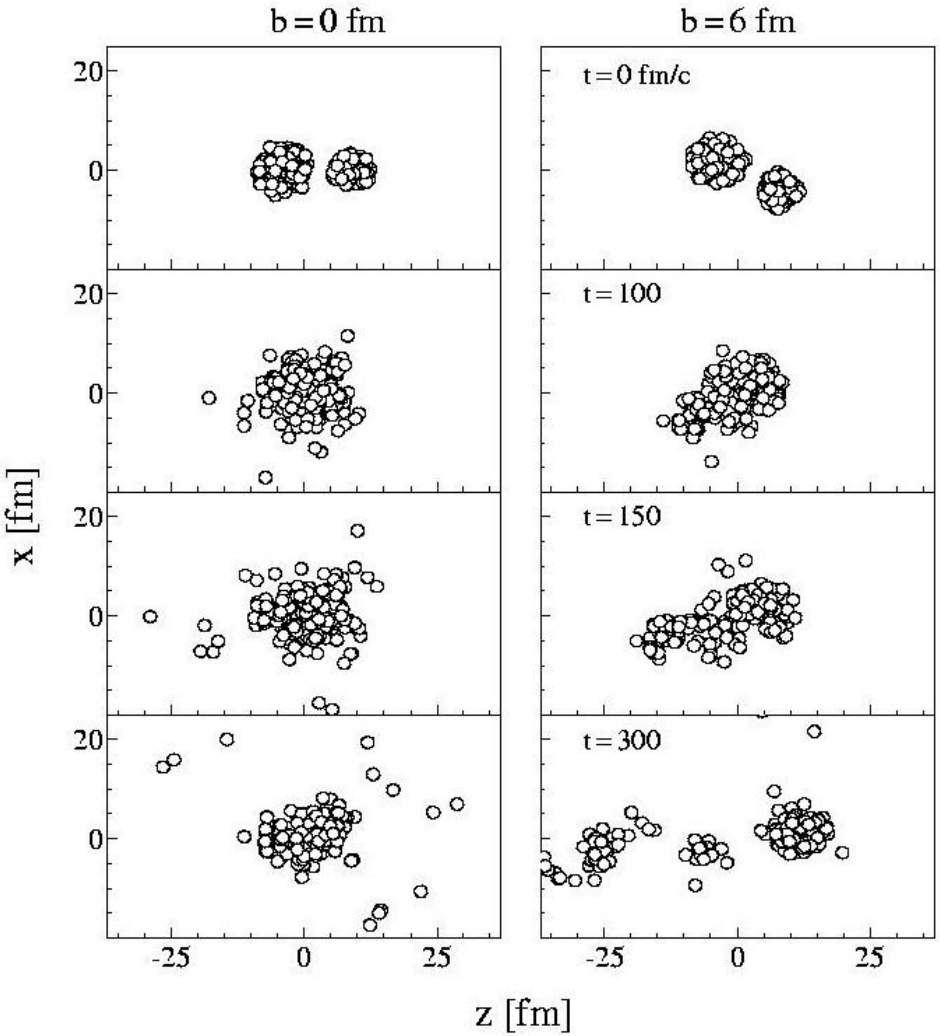
IVS –Intermediate Velocity Source

PEP –Promt Emitted Particles

Time evolution of $^{124}Sn + ^{64}Ni$ reaction at 35 MeV/nucleon

QMD predictions

CHIMERA code
J.Lukasik



fm/c

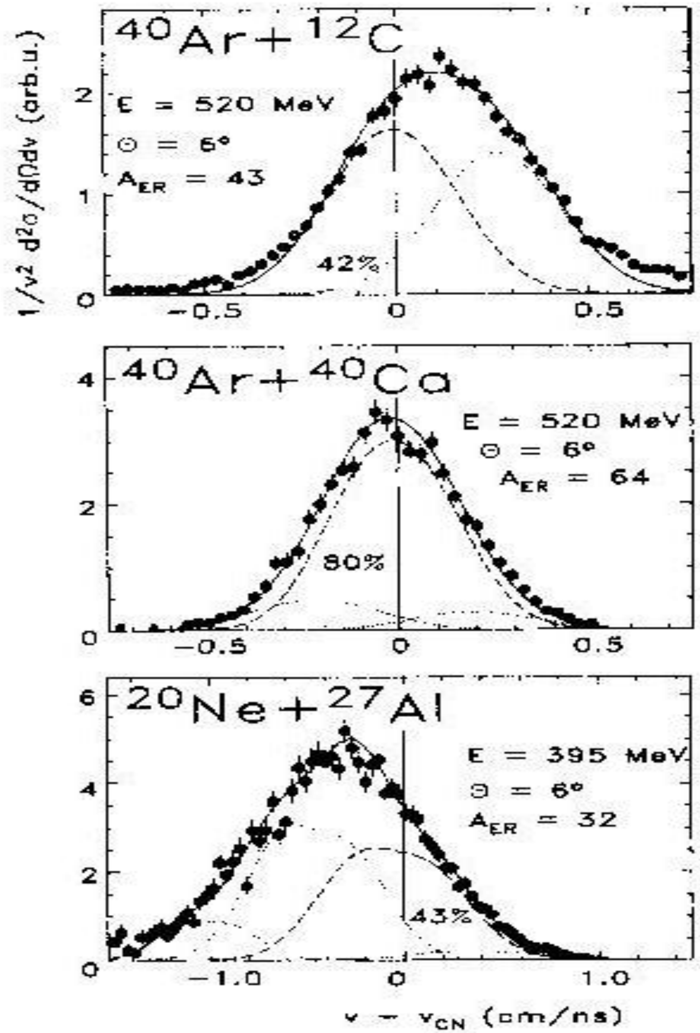
Linear momentum transfer measurements

Factor ρ_{LMT} , a measure of LMT, is defined as:

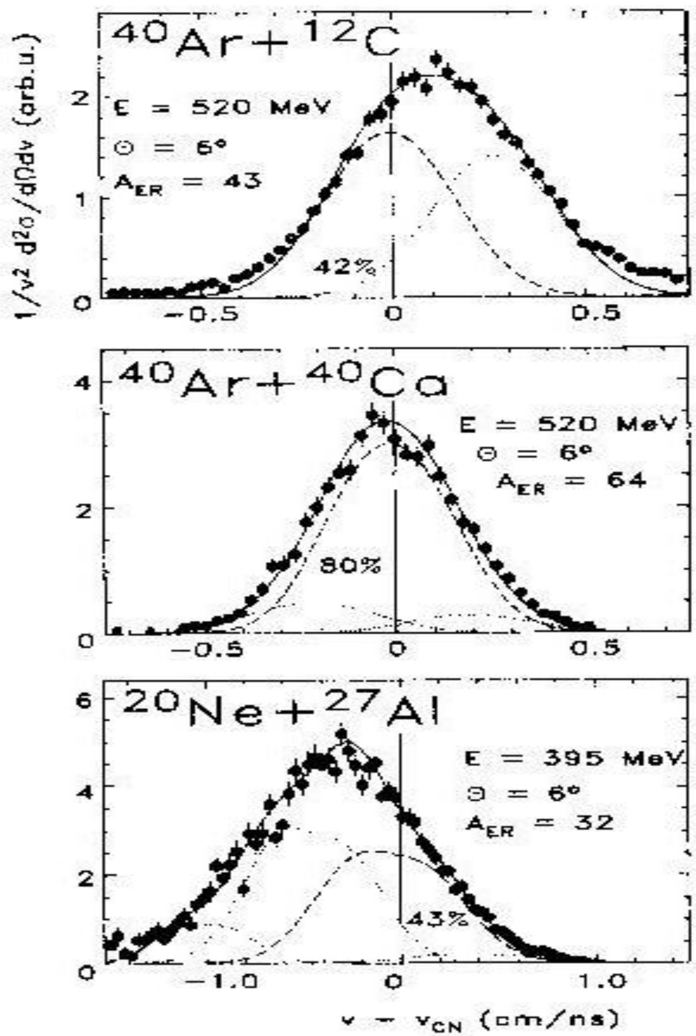
$$\rho_{LMT} = \frac{p_{par}}{p_p}$$

- p_{par} is a parallel component (to the beam direction) of the linear momentum transferred to the quasi-compound nucleus.

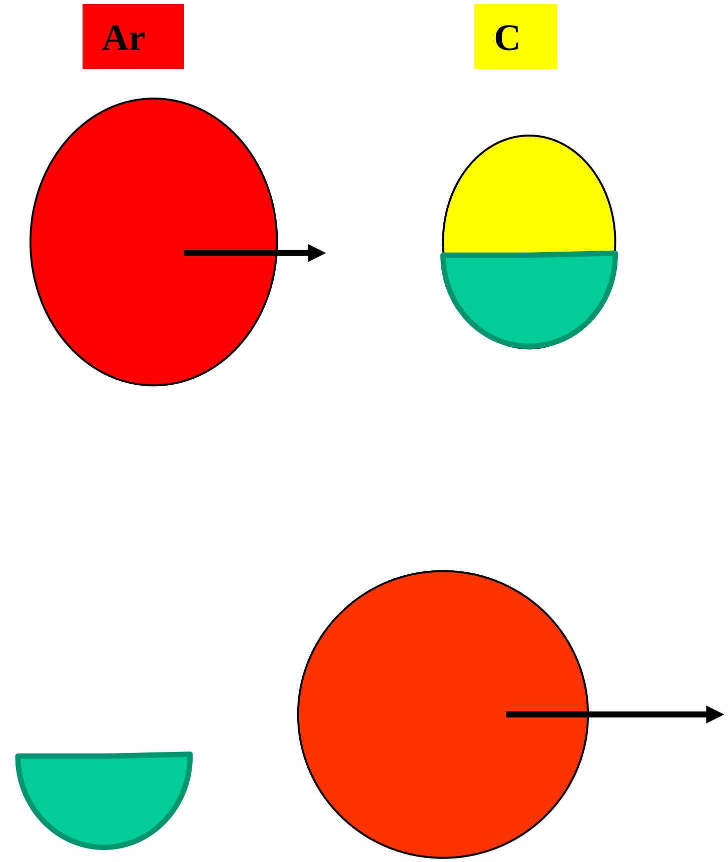
- p_p is the projectile linear momentum.



Velocity spectra of evaporation residues (ER) suggesting that the lighter nucleus loses momentum (mass). Fits are calculations with Gaussian function. The quoted numbers indicate the fraction of complete fusion (dashed curves).

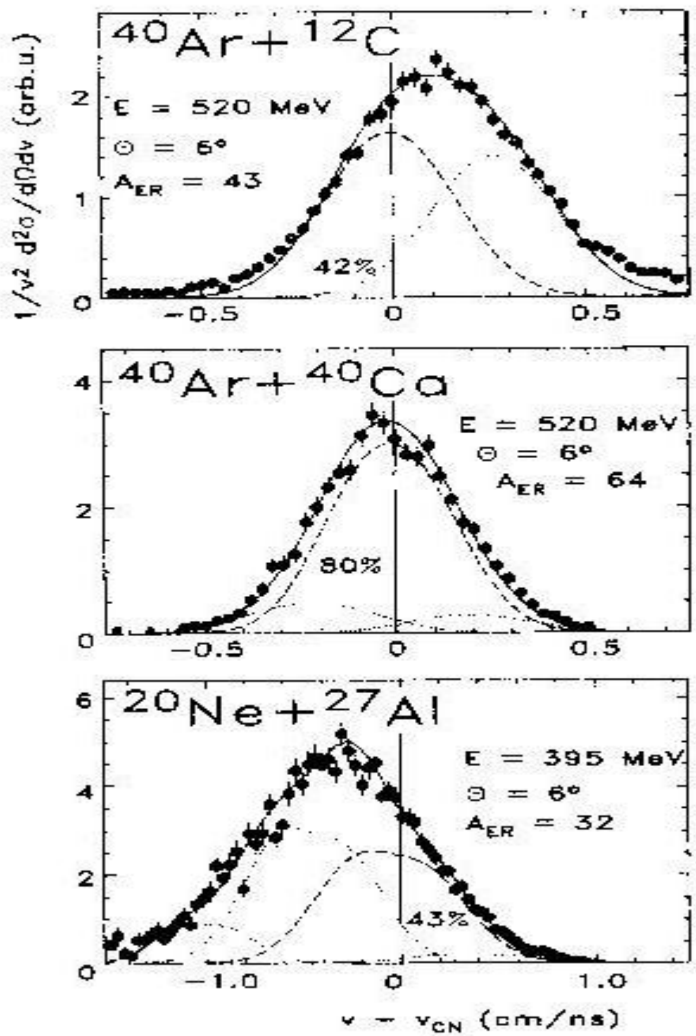


40Ar+12C
E = 520 MeV
Θ = 6°
A_ER = 43
42%
40Ar+40Ca
E = 520 MeV
Θ = 6°
A_ER = 64
80%
20Ne+27Al
E = 395 MeV
Θ = 6°
A_ER = 32
43%
1/v2 d2σ/dΩdv (arb.u.)
v − vCN (cm/ns)



Ar
C

$V > V_{CN}$


$^{40}Ar + ^{12}C$
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Θ = 6°
A_{ER} = 43
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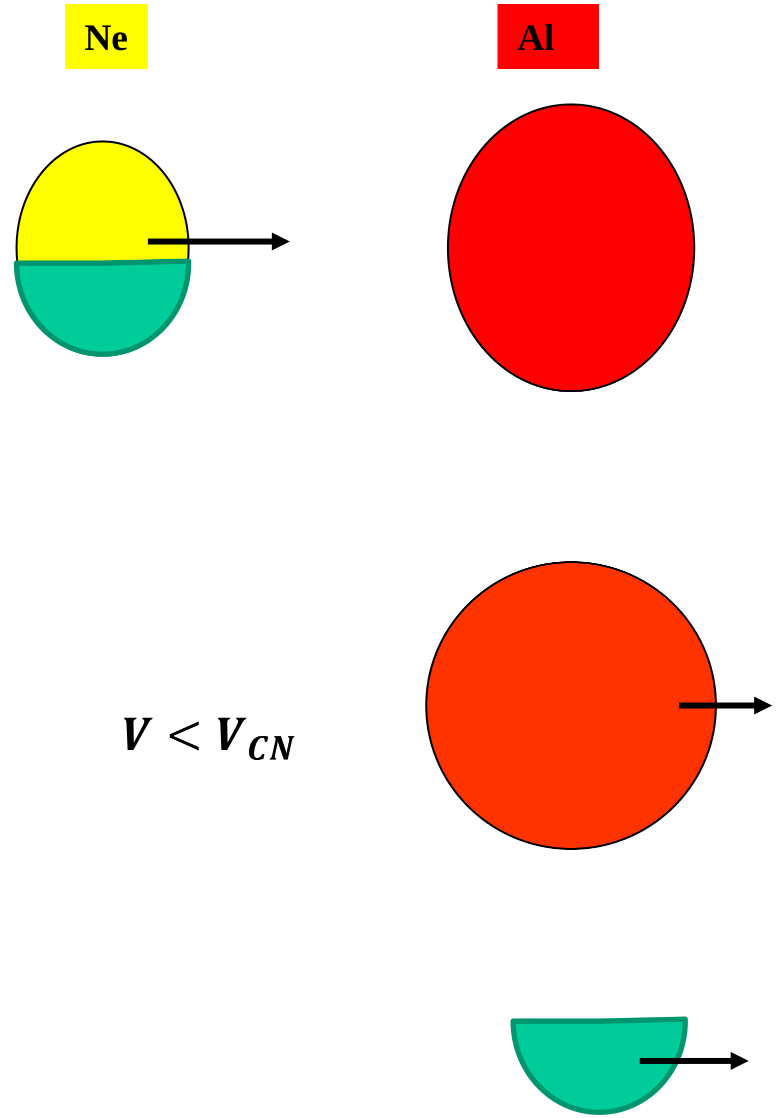
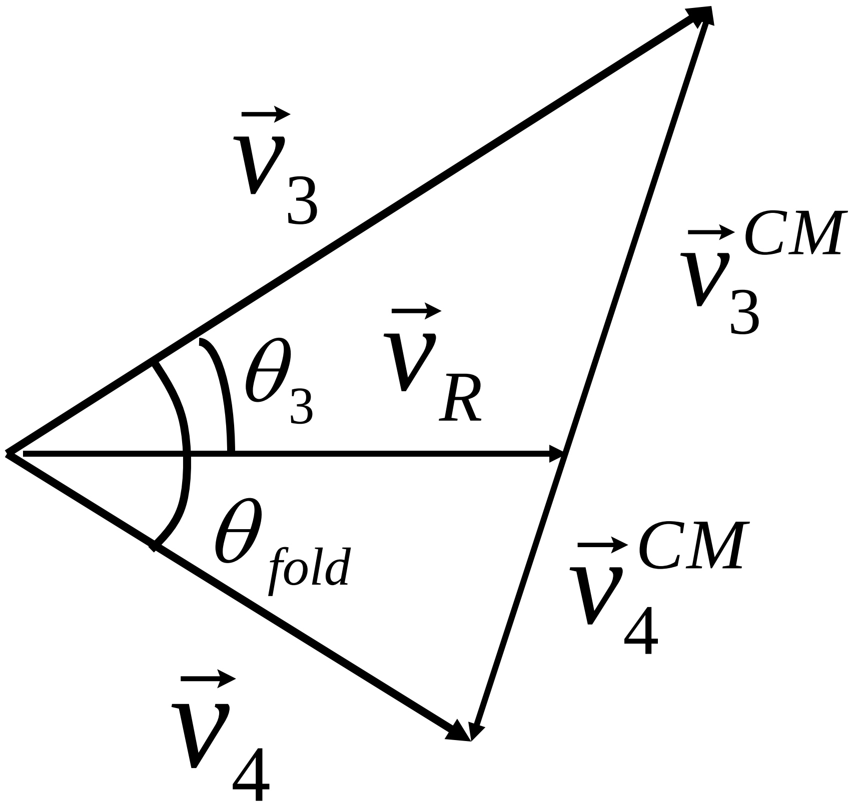
Θ = 6°
A_{ER} = 64
80%
$^{20}Ne + ^{27}Al$
E = 395 MeV
Θ = 6°
A_{ER} = 32
43%
$1/v^2\ d^2\sigma/d\Omega dv$ (arb.u.)
$v - v_{CN}$ (cm/ns)


Ne
Al
$V < V_{CN}$

As can be seen it is striking that:

- **mass symmetry in the entrance channel leads to mean ER velocities $\upsilon_R = \upsilon_{CN}$;**

- **mass asymmetry for a light projectile and a heavy target leads to $\upsilon_R < \upsilon_{CN}$ and in the oposite case we have $\upsilon_R > \upsilon_{CN}$**



Folding angle, θ_{fold}, between the two fission fragments.
V_R is the velocity of the quasi-compound nucleus.

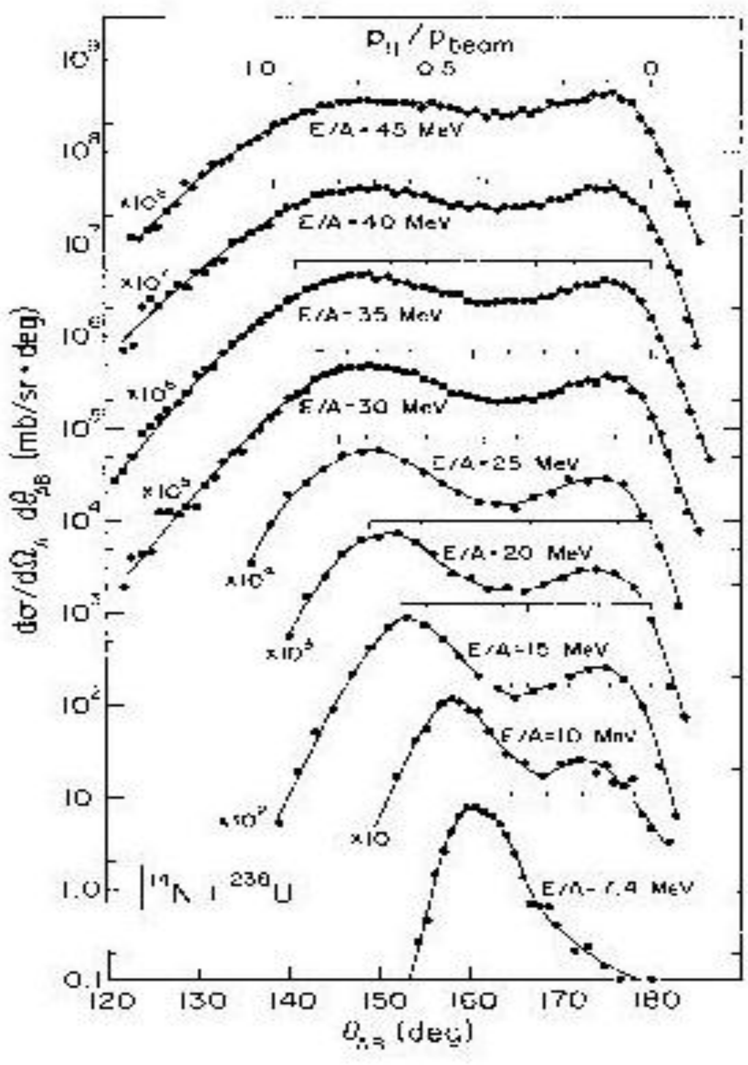
The relationship between θ_{fold} and ρ_{LMT} :

$$\rho_{LMT} = \frac{A_4 \upsilon_4 \sin\theta_{fold}}{A_1 \upsilon_1 \sin\theta_3}$$

where A_1, v_1 are the mass and velocity of the projectile, A_4, υ_4 those of one of the fission fragments before evaporation.

The relationship between θ_{fold} and ρ_{LMT} :

$\rho_{LMT} \rightarrow$ ***0*** $\leftrightarrow$ $\theta_{fold} \rightarrow$ ***180 degrees***

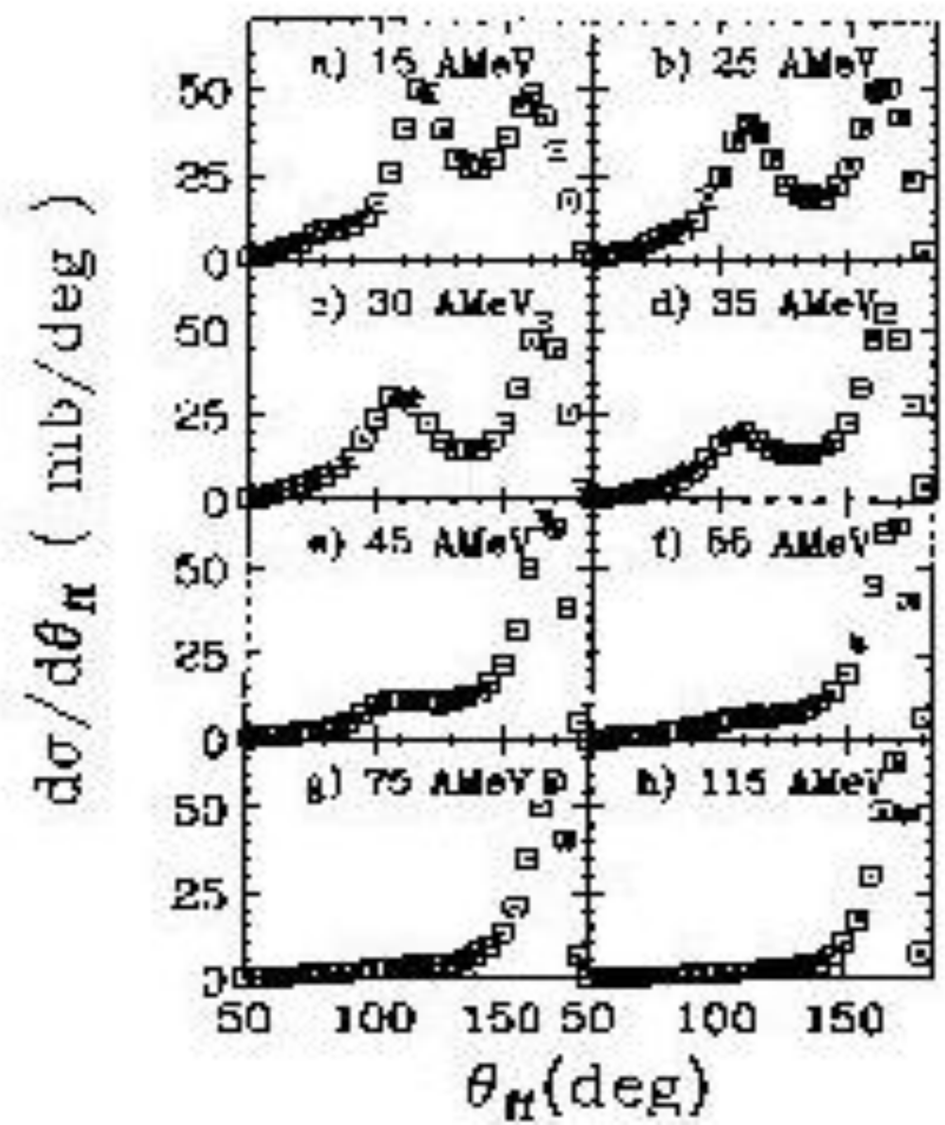


Fission fragment folding angle distribution for 14*N* +238*U* reaction. For each measurement a linear momentum transfer scale, ρ $_{LMT}$, is shown immediately above the data.

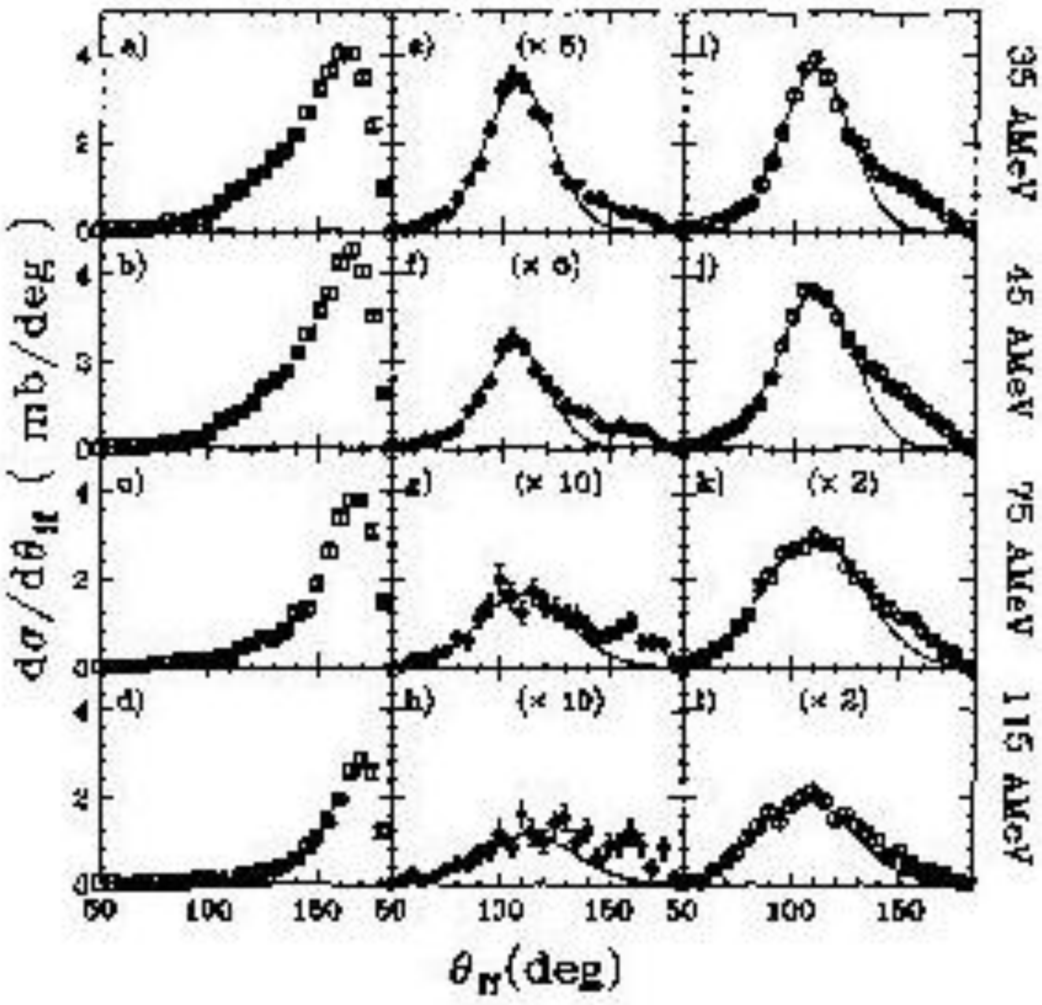
Two remarks may be stressed:

- the central collision bump exists for any bombarding energy up to 45 MeV/nucleon

- the LMT is complete up to 10 - 15 MeV/nucleon and is more and more incomplete above.



Inclusive fission fragment folding angle distributions for Ar + Th reactions from 15 to 115 MeV/nucleon.



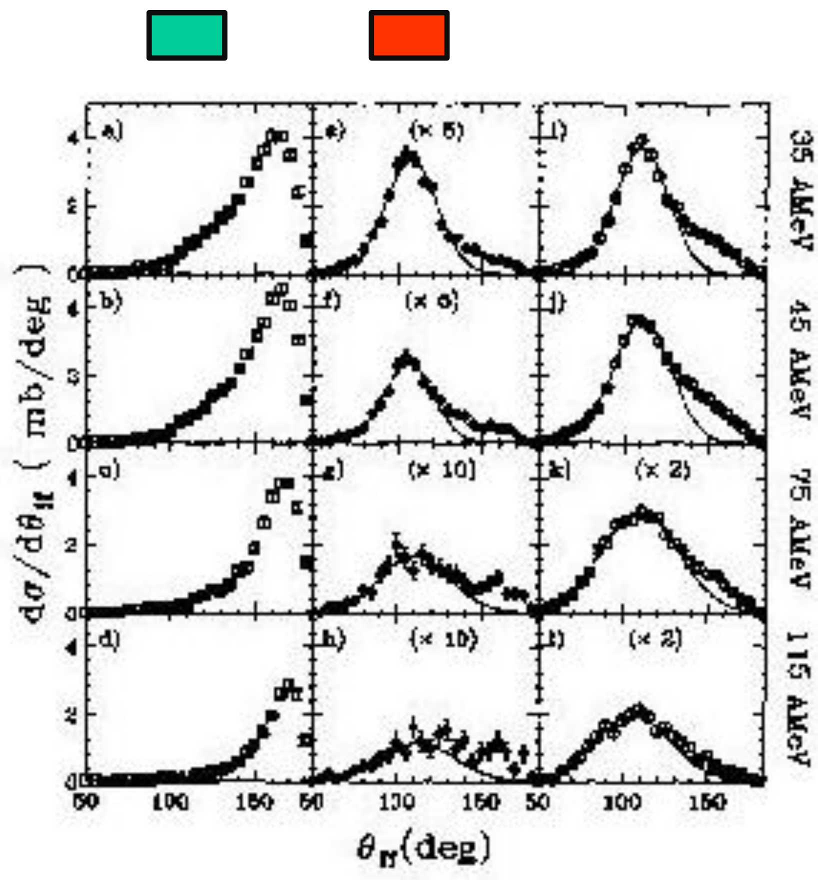
Fission fragment folding angle distributions for Ar + Th reactions

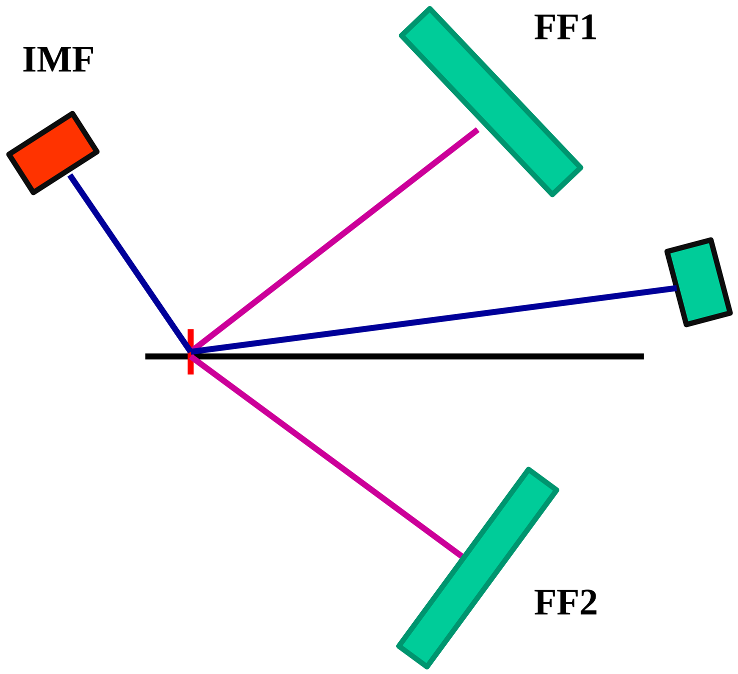
• gated on IMFs at forward angles (left column),

•IMFs at large angle (center column),

•and central collision impact parameter obtained by the total transverse kinetic energy.

Solid lines are Gaussian to guide the eye.





IMF – Intermediate Mass Fragment

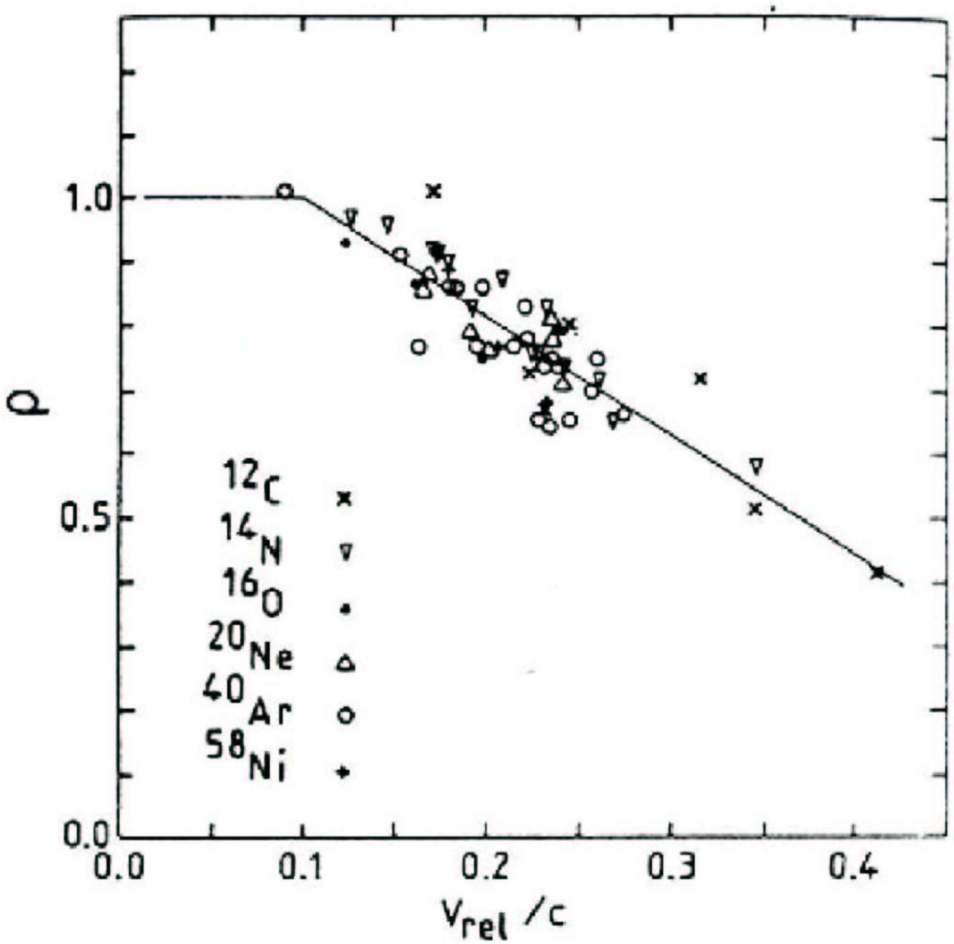
FF- FissionFragment

The υ_{rel} is defined as:

$$\upsilon_{rel} = \sqrt{\frac{2\left(E_{CM} - V_C\right)}{\mu}}$$

where E_{CM} is the center of mass energy,

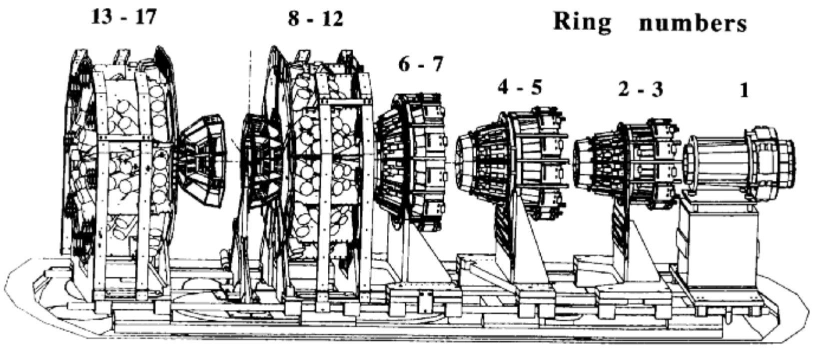
V_C the Coulomb barrier and μ the reduced mass.



Most probable values of ρ_{LMT} measured in various reactions as a function of the relative velocity of the incoming ions. The line corresponds to the fit.

INDRA AT GANIL, FRANCE

Isotopic resolution	Z≤4
Charity evaporation attractor line	5≤Z≤24
N/Z of system (1.07)	Z≥25

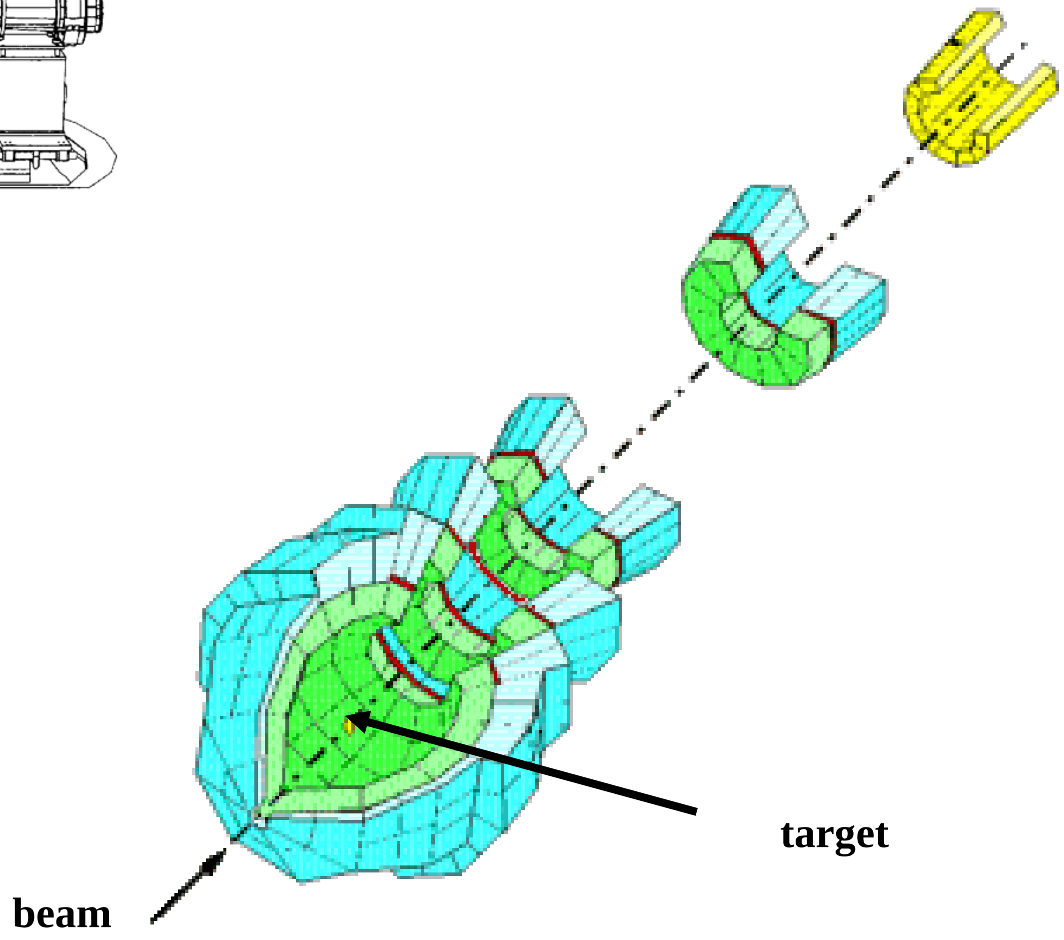


Plastics (phoswichs)

Ionisation chambers

Silicons

CsI (Tl)



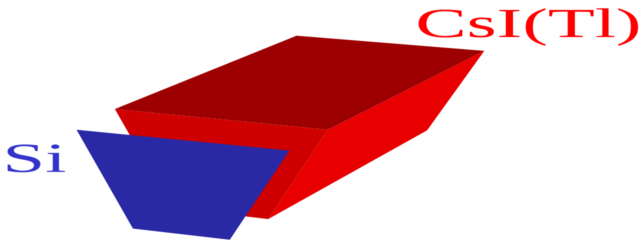
CHIMERA

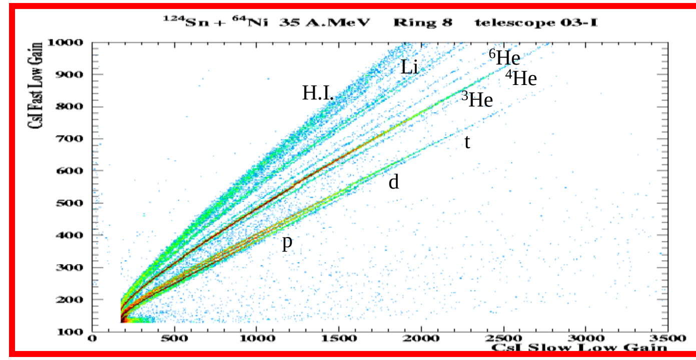
Charged **H**eavy **I**on **M**ass and **E**nergy **R**esolving **A**rray

Istituto **N**azionale di **F**isica **N**ucleare **L**aboratori **N**azionali del **S**ud

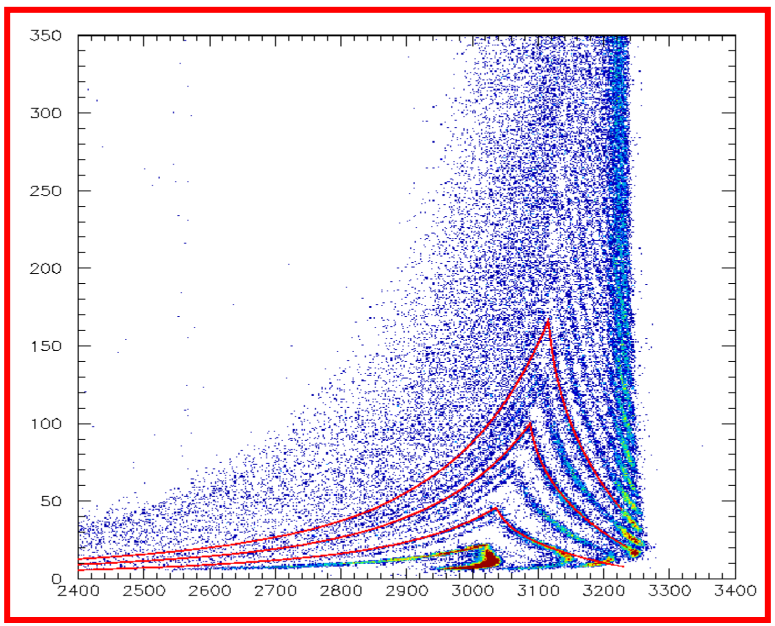
- 35 rings
- 1192 telescopes Si-CsI
- $1° \leq \theta \leq 176°$
- Identifications: 3 methods
  - E-ΔE, TOF, PSD

Experimental methods

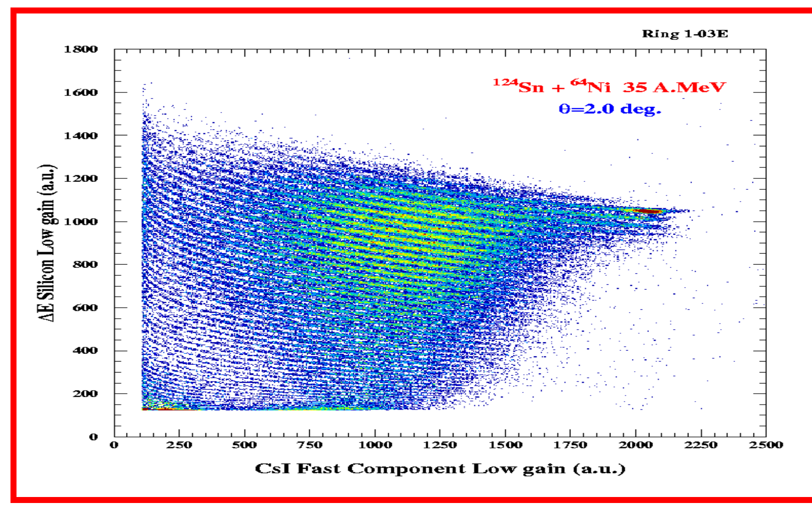




PSD ⟶ **LCP**



ΔE-TOF ⟶ **M,E**



ΔE-E ⟶ **Z, E**

Four-π Identification Array (FAZIA)

http://fazia.in2p3.fr

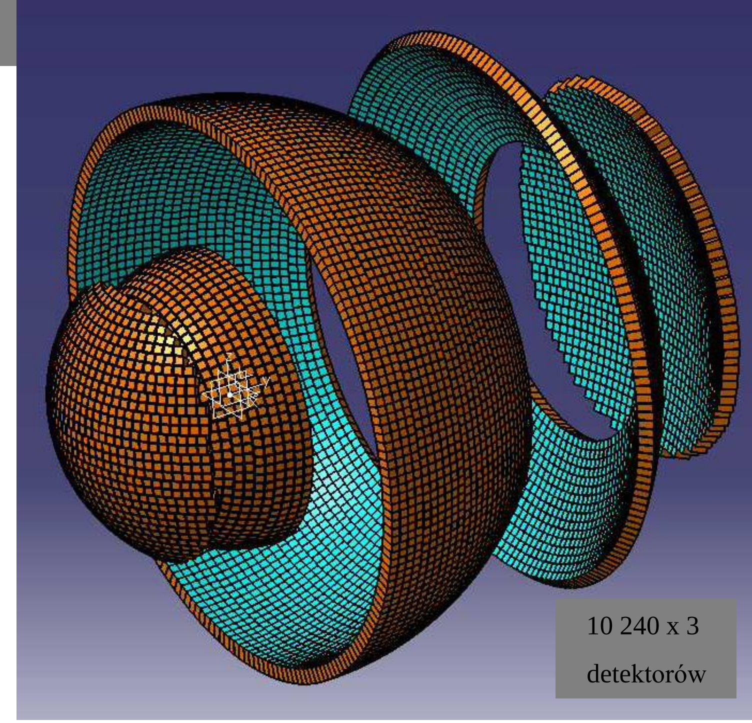
GANIL/SPIRAL/SPIRAL2 Caen

GSI/FAIR/NUSTAR Darmstadt

LNL/ALPI/SPES Legnaro

LNS/EXCYT/FRIBS Catania

2012-2015 2012-2015

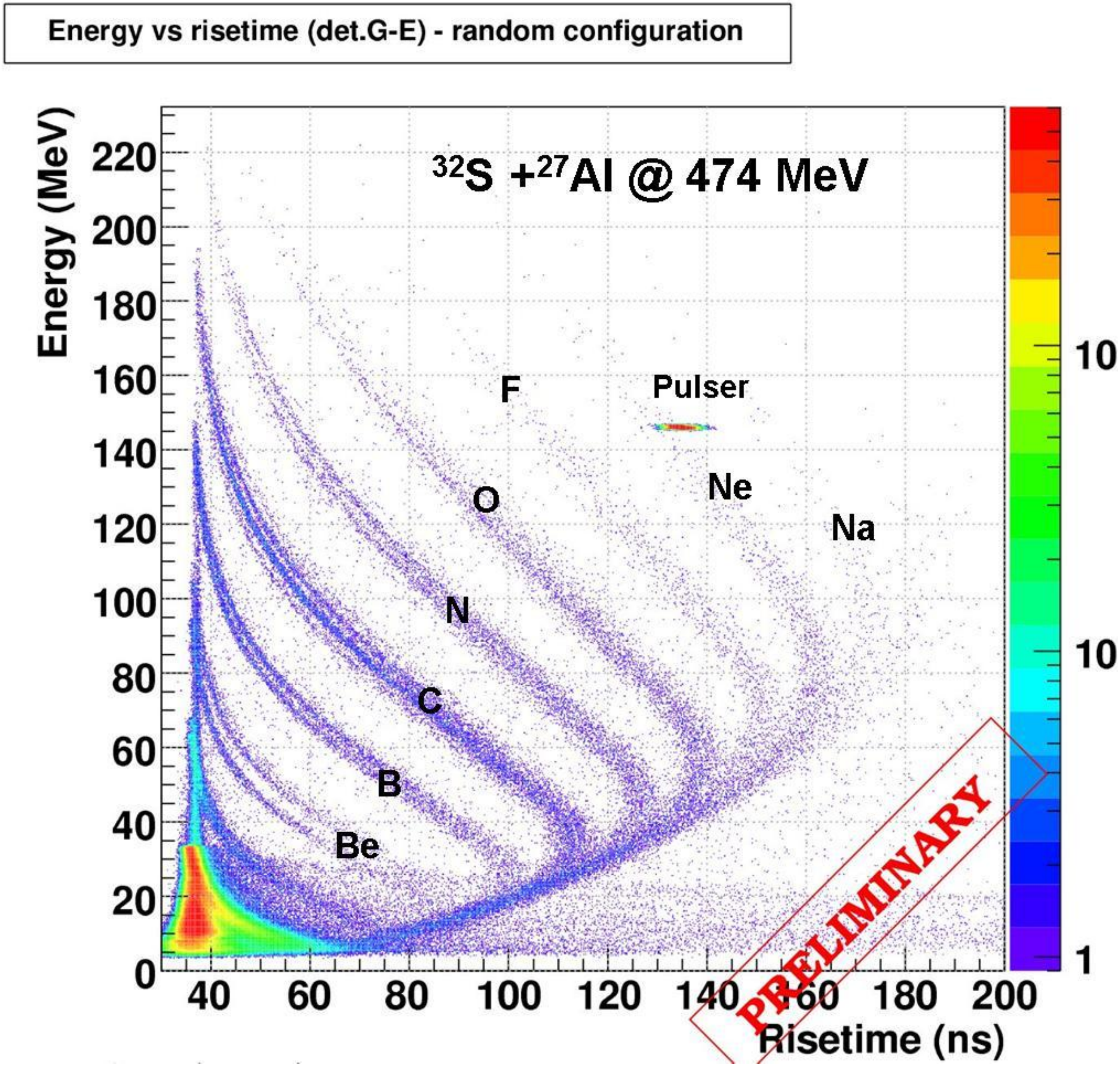


FIZYKA - GLOBALNE WŁASNOŚCI MATERII JĄDROWEJ (MJ)

- TERMODYNAMIKA MJ
- RÓWNANIE STANU MJ (NEOS)
- ASTROFIZYKA JĄDROWA
- TESTY MODELU STANDARDOWEGO
- FUNDAMENTALNE SYMETRIE

TECHNOLOGIE CYFROWE

- ULTRASZYBKA ELEKTRONIKA CYFROWA
- ASIC
- DETEKTORY MONOLITYCZNE
- DIGITALIZACJA SYGNAŁU (2 Gs/s, 14 bit)
- ANALIZA KSZTAŁTU IMPULSU
- MATEMATYCZNE ALGORYTMY IDENTYFIKACYJNE


Energy vs risetime (det.G-E) - random configuration
$^{32}S + ^{27}Al$ @ 474 MeV
Energy (MeV)
Risetime (ns)
0
20
40
60
80
100
120
140
160
180
200
220
40
60
80
100
120
140
160
180
200
1
10
10
Pulser
F
O
N
C
B
Be
Ne
Na
PRELIMINARY

,