FRS meeting
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HIGH PRECISION Bρ MEASUREMENTS OF LIGHT URANIUM REACTION PRODUCTS

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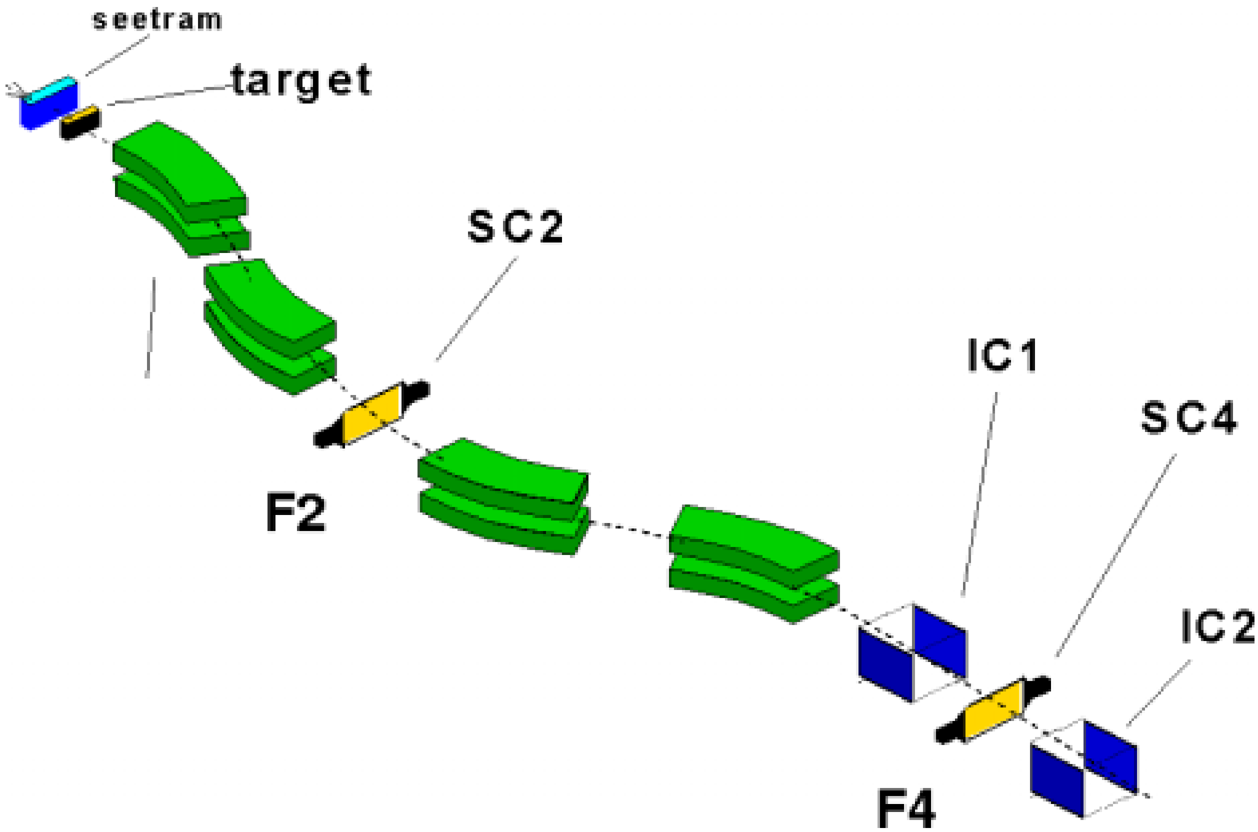
THE FRAGMENT SEPARATOR



- identification of Z from IC: $\Delta E \propto Z^2$

- identification of A/Z from time and position:

$$\frac{A}{Z} = \frac{1}{3.1}\frac{B\rho}{\beta\gamma} \quad \text{with} \quad [B\rho] = Tm \qquad \beta = \frac{v}{c} \quad \text{with} \quad v = \frac{s}{ToF}$$

large flight path → good mass resolution

- once nuclides are identified (i.e. A and Z are integer numbers), velocity is calculated from Bρ:

$$\beta\gamma = \frac{B\rho}{3.1}\frac{Z}{A}$$

very precise evaluation !

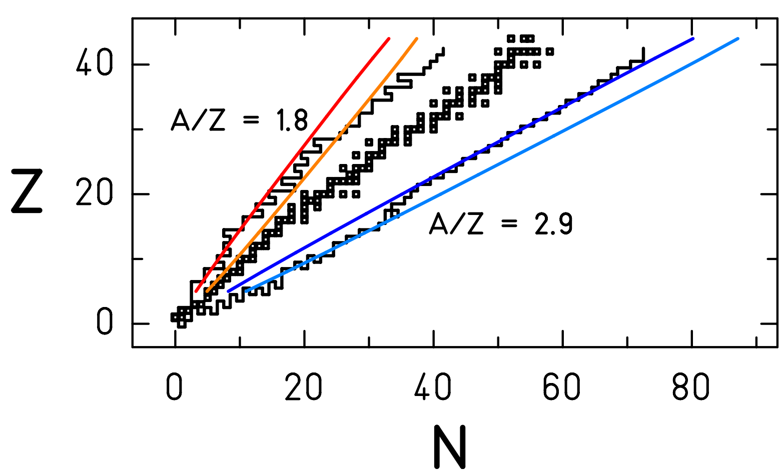
FEATURES OF FRS

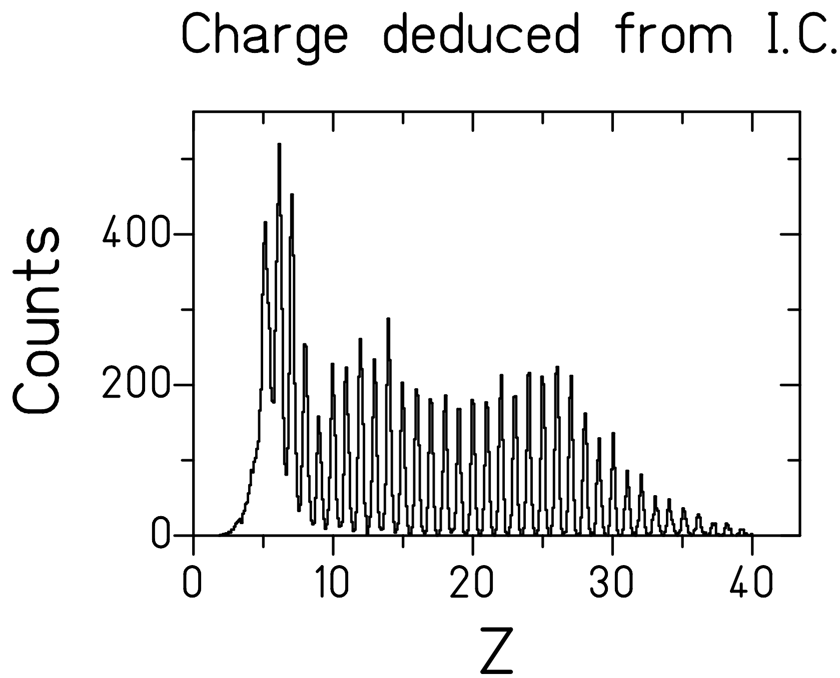
- high resolution in A, Z and velocity
- limited momentum acceptance: needs a combination of several Bρ settings to cover all A/Z and velocity
- limited angular acceptance: only a part of the real production is measured.

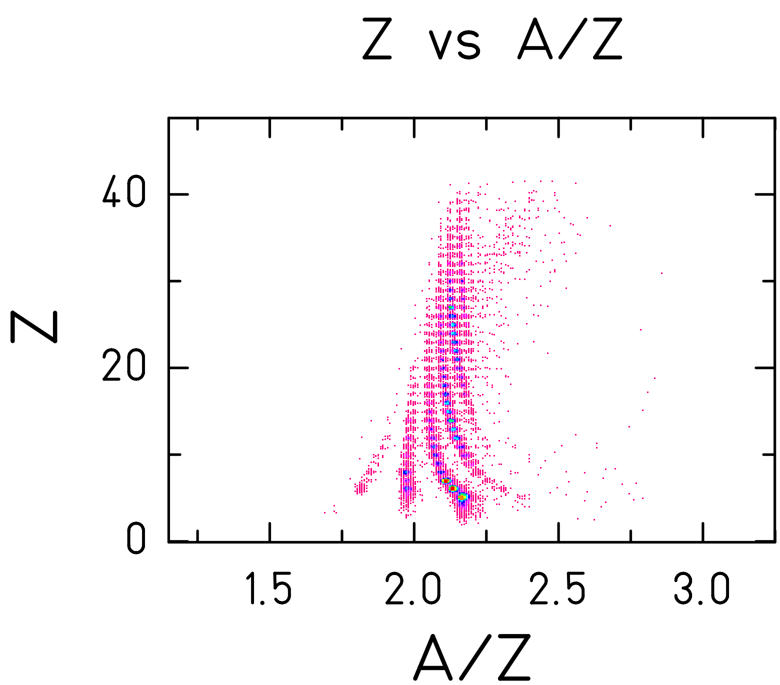
OUR DATA: ^{238}U (1 A GeV) H_2 (+ Ti)

Preliminary analysis of light masses:

H_2 + Ti → 11 settings (from A/Z = 1.8 to A/Z = 2.9)
Ti (dummy) → 6 settings (from A/Z = 1.8 to A/Z = 2.9)

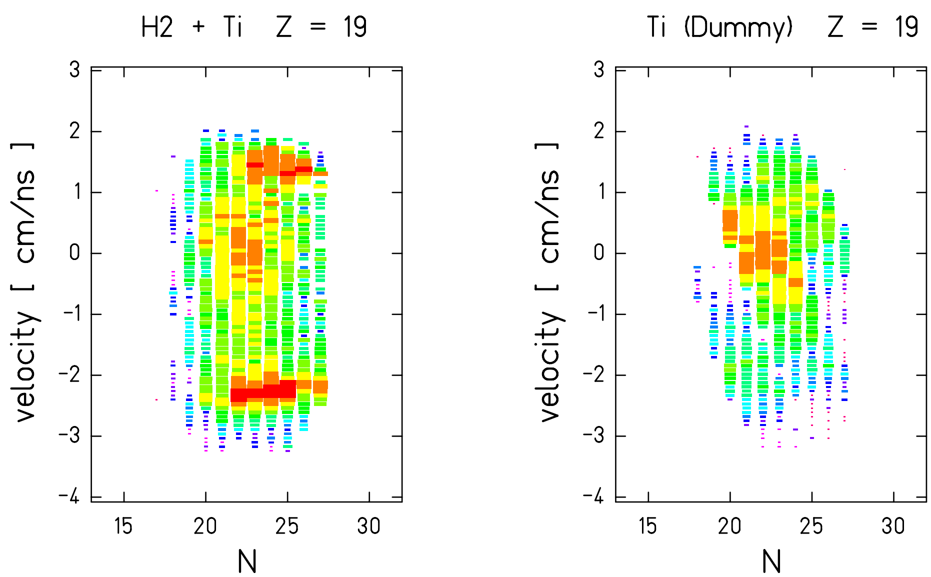



Charge deduced from I.C.
Counts
400
200
0
0
10
20
30
40
Z


Z vs A/Z
Z
40
20
0
1.5
2.0
2.5
3.0
A/Z

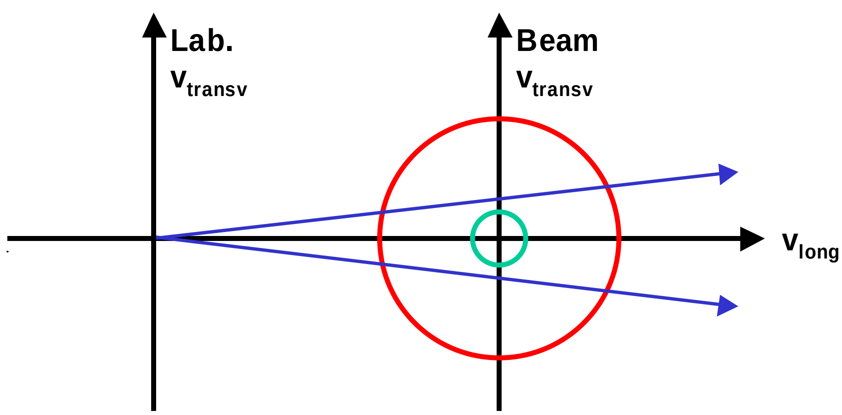
Combining appropriately all the setting together finally we have the velocity spectrum of every isotope.

All isotopes of one element: potassium



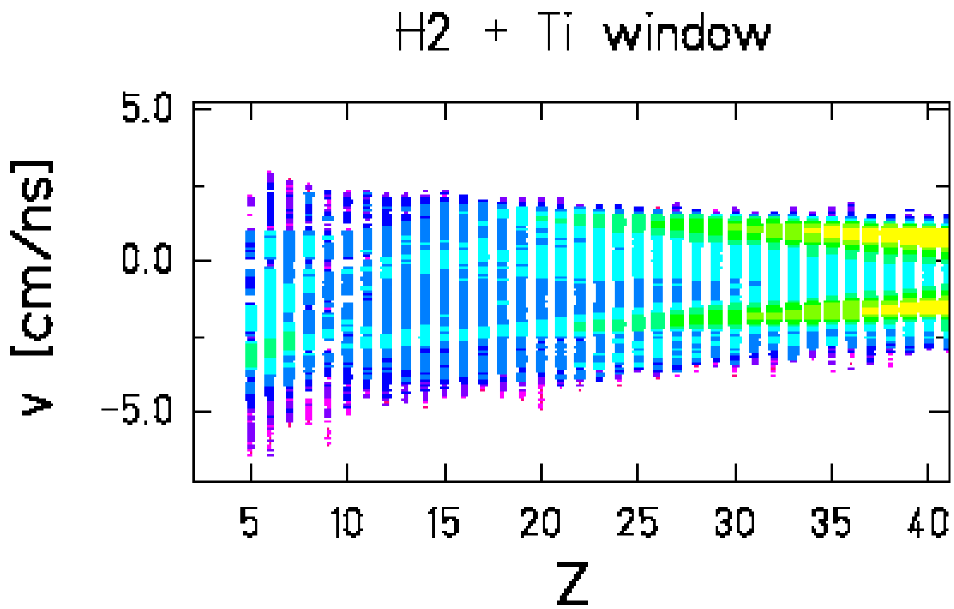
What do we learn from these pictures?

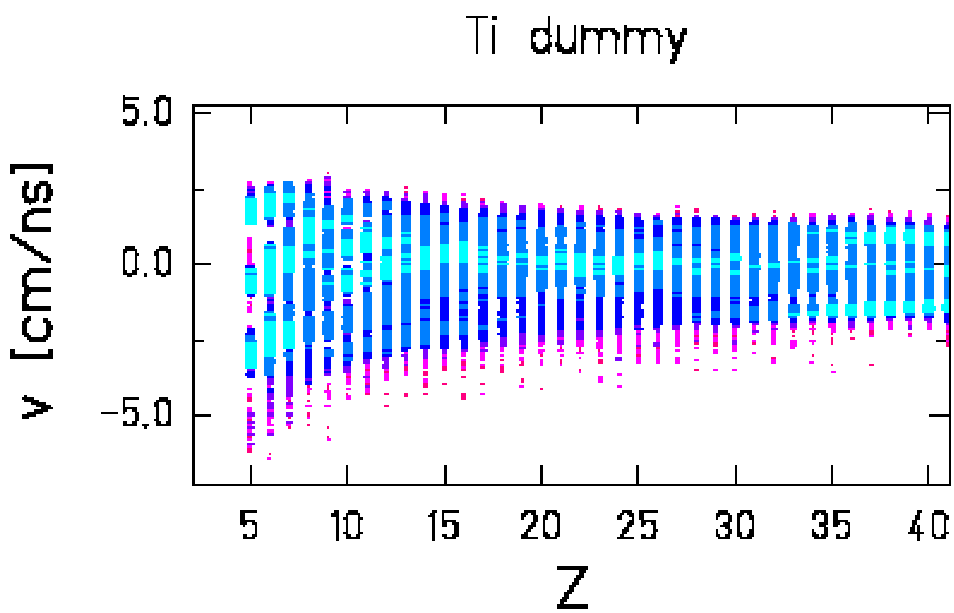
We observe three bumps in velocity, but the FRS transmits only a small part in angle…



All the pictures refer to the longitudinal component of the velocity of transmitted fragments in the beam center-of-mass frame.

All elements together



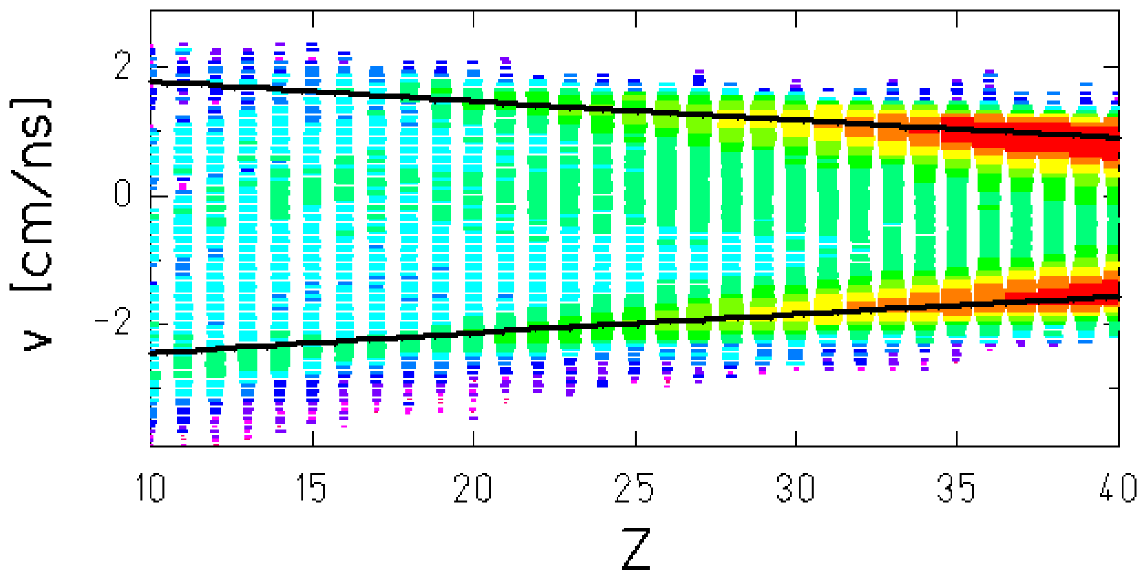


- evidence of FISSION
- evidence of FRAGMENTATION
- evidence of a 3rd process (MULTIFRAGMENTATION?)

FISSION

1) very asymmetric fission can produce very light nuclei (Z = 10 (or less?))

2) velocity of fission products: it is consistent to what expected from theory (→ we can deduce the partner)



Lines: calculated velocities of fission fragments from the compound nucleus Z = 84, A = 214

3) isotopic distribution shifted towards the neutron rich side

COMPARING WITH OTHER RESULTS…

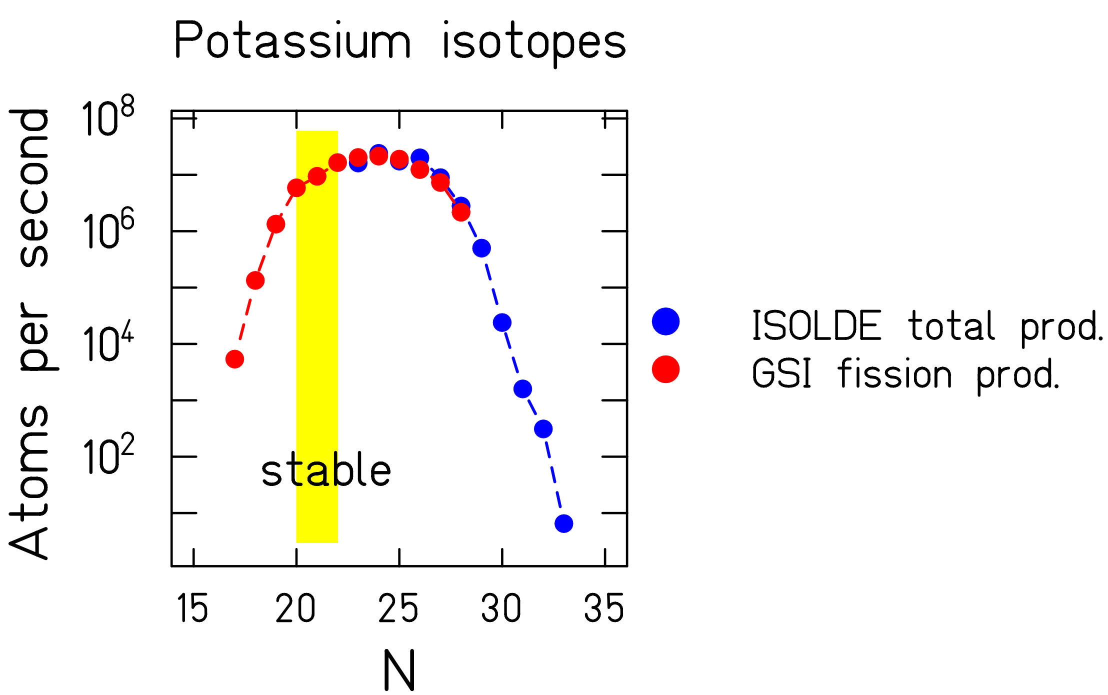
The production of light isotopes (10<A<40) from 600 MeV proton on ^{238}U has been also observed at ISOLDE[(*)] (CERN).

ISOLDE: 0.6 GeV p → ^{238}U

- no velocity measurements → no knowledge of the reaction mechanism
- production of very neutron-rich nuclei

GSI: 1 A GeV ^{238}U → H_2

- precise velocity measurements → fission is the reaction mechanism
- production shifted to the neutron-rich side



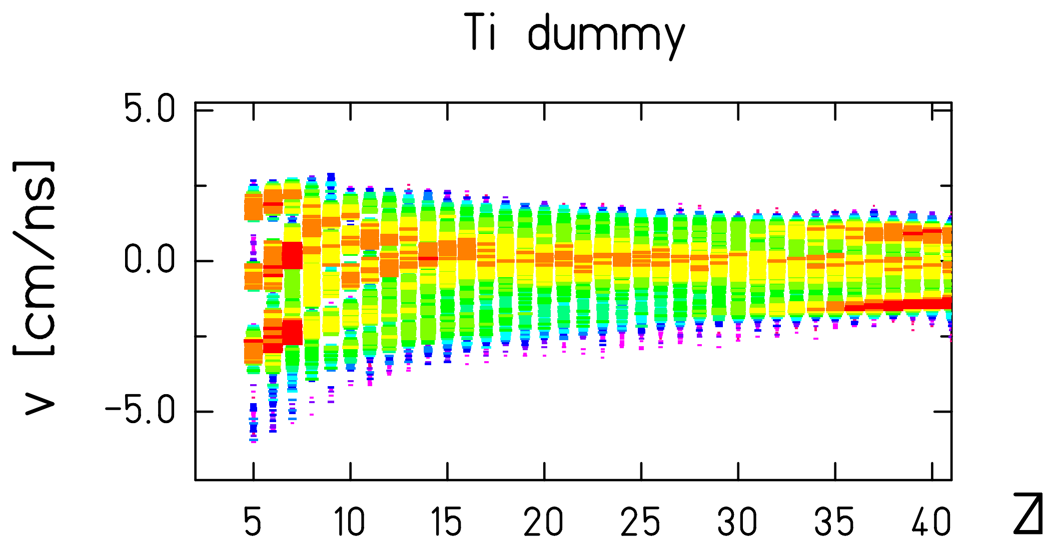
(*) H.-J. Kluge, ISOLDE user's guide, CERN 86-05 (1986)

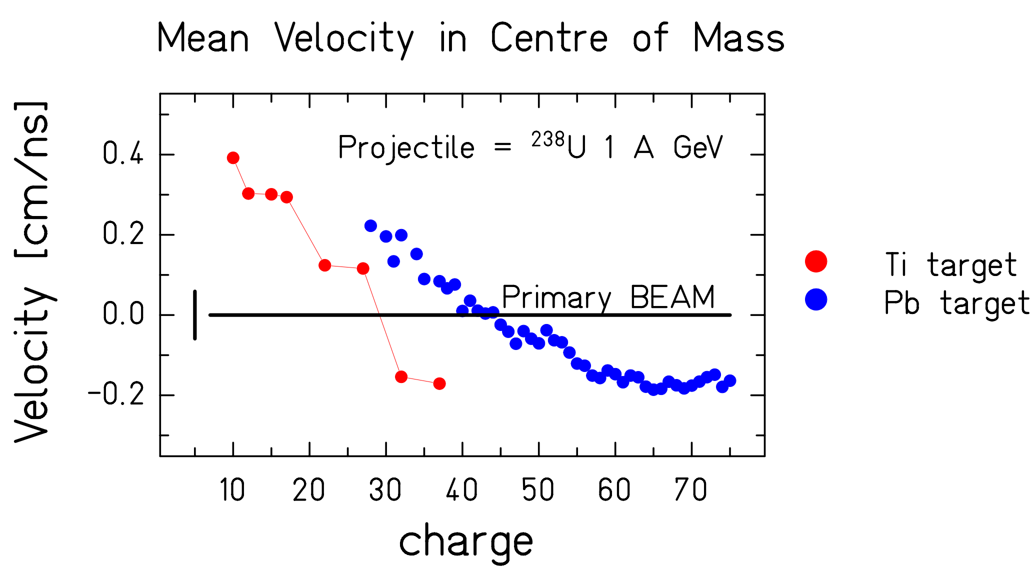
FRAGMENTATION

1) velocity spread around zero

2) isotopic distribution shifted towards the neutron-deficient side

3) velocity increases as the mass of the fragment decreases (!)





CONCLUSIONS

THE FRS

1) high resolution in Z and A → isotope identification

2) precise evaluation of velocity → kinematic properties of products

THE EXPERIMENT

Preliminary analysis of ^{238}U 1A GeV → H2 + Ti shows that different processes occur.

FISSION of ^{238}U in H_2

Fission is a very important method for the production of very light neutron-rich isotopes (down to neon)

FRAGMENTATION of ^{238}U in Ti

The acceleration of light nuclei can give new information on the dynamics of the fragmentation process