HIGH PRECISION B_ρ MEASUREMENTS OF LIGHT URANIUM REACTION PRODUCTS

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

- identification of $A/Z$ from time and position:

$$\frac{A}{Z} = \frac{1}{3.1} \frac{B_\rho}{\beta \gamma}$$

with $[B_\rho] = Tm$  \hspace{1cm} $\beta = \frac{v}{c}$ \hspace{1cm} with \hspace{1cm} $v = \frac{s}{ToF}$

large flight path $\rightarrow$ good mass resolution

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

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

very precise evaluation!
FEATURES OF FRS

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

OUR DATA: $^{238}\text{U}$ (1 A GeV) / $^{2}H_2$ ( + Ti )

Preliminary analysis of light masses:

$^{2}H_2$ + Ti $\rightarrow$ 11 settings (from $A/Z = 1.8$ to $A/Z = 2.9$)
Ti (dummy) $\rightarrow$ 6 settings (from $A/Z = 1.8$ to $A/Z = 2.9$)
Charge deduced from I.C.

Counts

Z

Z vs A/Z

A/Z

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.
- 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 (\(\rightarrow\) 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
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 $p \rightarrow ^{238}$U
- no velocity measurements $\rightarrow$ no knowledge of the reaction mechanism
- production of very neutron-rich nuclei

**GSI:** 1 A GeV $^{238}$U $\rightarrow$ H$_2$
- precise velocity measurements $\rightarrow$ 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 \( A \) \( \rightarrow \) isotope identification

2) precise evaluation of velocity \( \rightarrow \) kinematic properties of products

THE EXPERIMENT

Preliminary analysis of \( ^{238}\text{U} \) 1A GeV \( \rightarrow \) H2 + Ti shows that different processes occur.

FISSION of \( ^{238}\text{U} \) in H2

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

FRAGMENTATION of \( ^{238}\text{U} \) in Ti

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