Identification of multi-nucleon transfer reaction products in $^{50}Ti + ^{249}Cf$

Antonio Di Nitto

on behalf of the TASCA Collaboration

TASCA16 26 August 2016

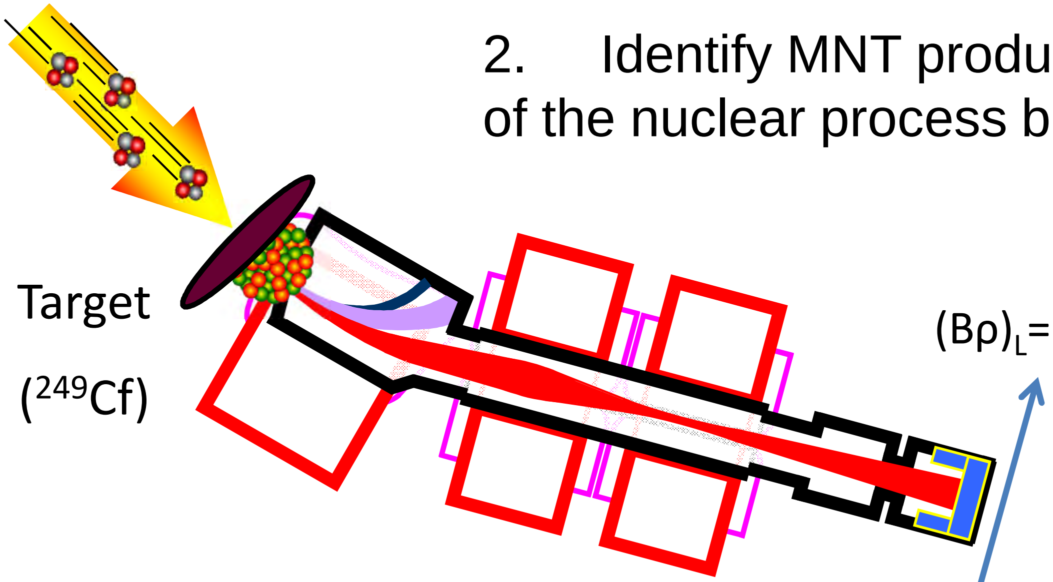
Outline

- Motivation
- Experimental setup
- Data analysis and results
- Discussion and summary

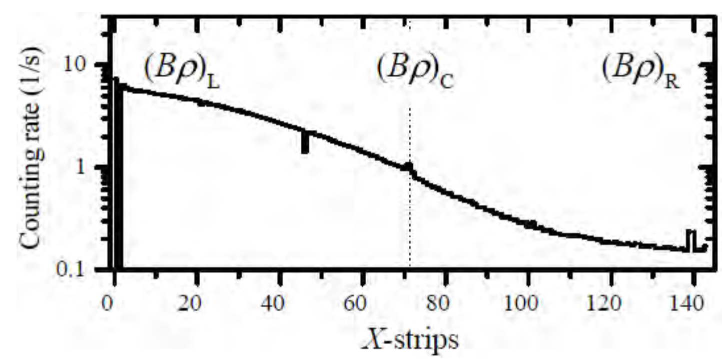
The reaction $^{50}Ti+^{249}Cf$ at TASCA

Pulsed Beam
(^{50}Ti @ 4.9 MeV/A)

1. Search for 120 element
2. Identify MNT products and study the evolution of the nuclear process behind



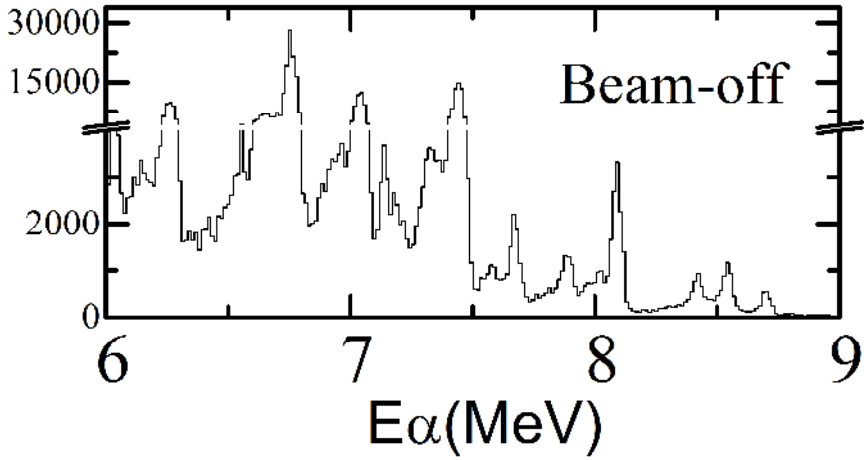
Implantation events with E>3 MeV

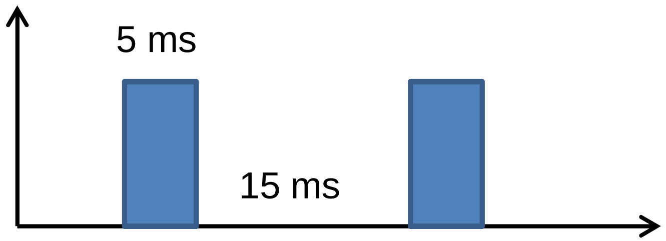


J. Khuyagbaatar et al. PRL 172501 (2015)

- **$(B\rho)_C$=2.01 Tm (set to collect Z=120)**
- **No perfect separator exists → suppression of transfer is not 100%**

Energy spectra





pulsed beam structure

α-like events originated by transfer products and decay of SHE with Z=120

Correlation analysis performed

- ER-AL;
- ER-AL-AL;
- AL-AL;
- AL-AL-AL;

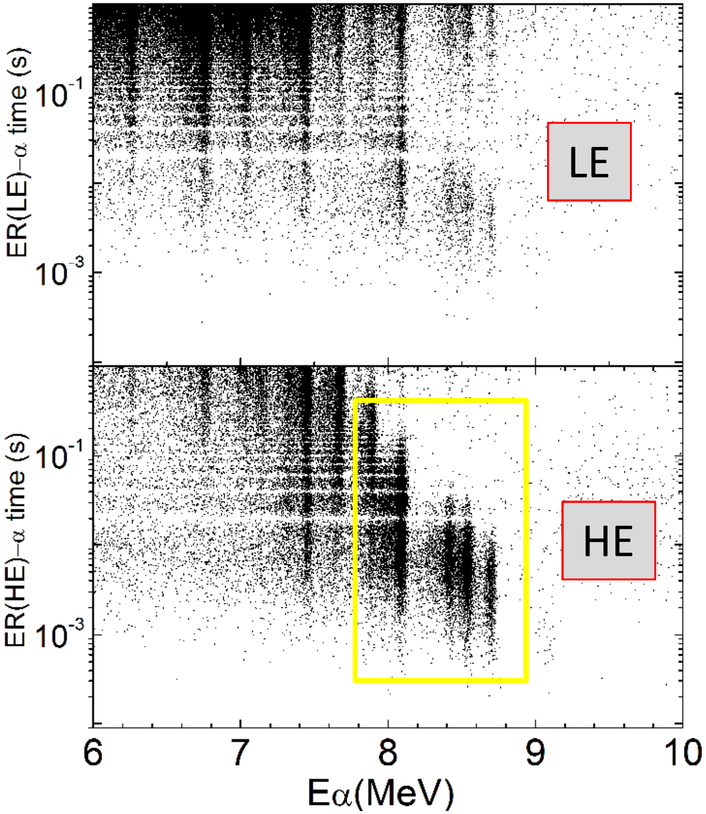
ER: E = 3-90 MeV, Beam ON, coinc. with ToF and anti -coinc. with punch-through det

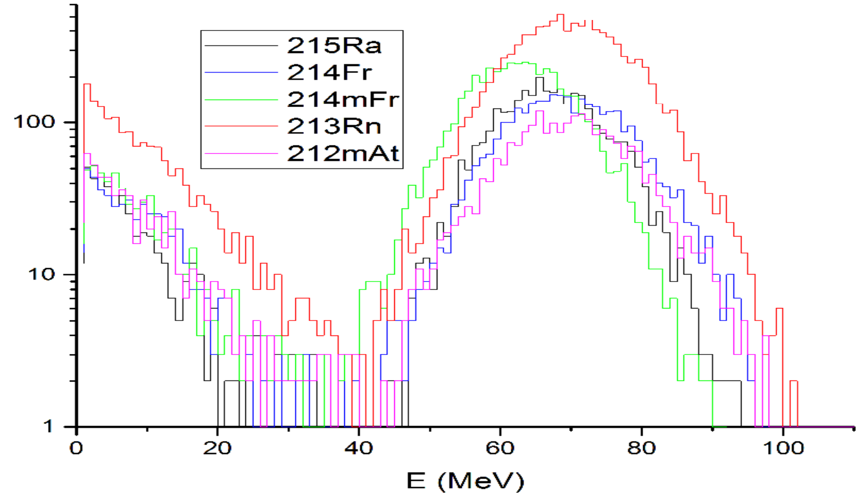
AL : E = =5-10 MeV, anti-coinc. with ToF and anti-coinc. with punch-through det

Ratio between LE and HE TLF components at FPD

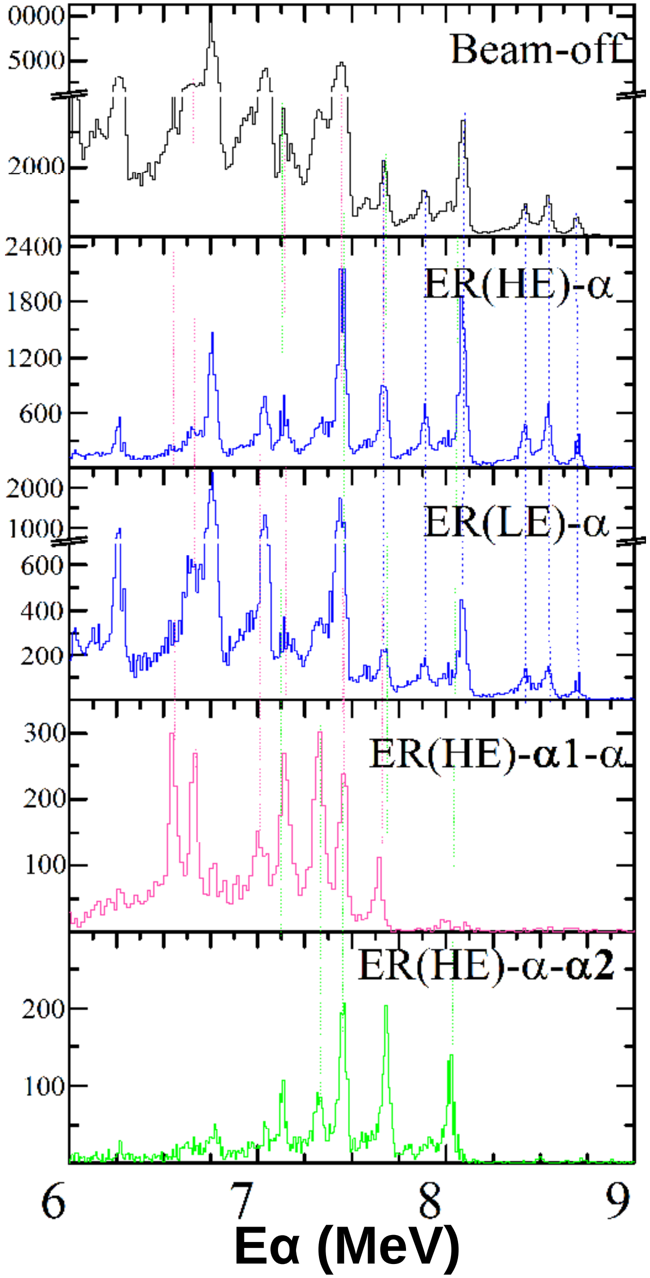
	^{211}Po	^{212}At	^{212m}At	^{213}Rn	^{214}Fr	^{214m}Fr*	^{215}Ra
LE/HE(%)	-	10.1	-	11.4	13.9	10.7	11.4
$T_{1/2}$	0.516s	119ms	314ms	25ms	5 ms	3.35 ms	1.6 ms

Mean Ratio LE vs HE yields = 11.5 %





Energy spectra



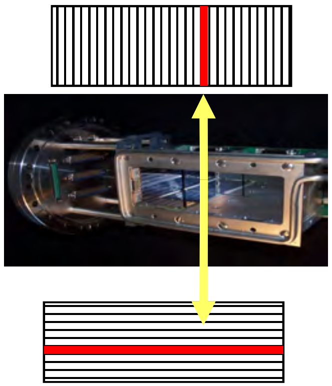
Here are shown 5 α-spectra collected with different correlation conditions:

- during beam OFF period
- correlated with High Energy Transfer-like events
- correlated with Low Energy Transfer-like events
- 1st and 2nd α-particles correlated with High Energy Transfer-like events

The energy spectra of α-α correlation analysis are not presented because very similar to ER-α-α correlation analysis ones (purple and green in the left figure).

Advantages of CANDI

GSI EE CANDI DAQ system for µs-isotopes

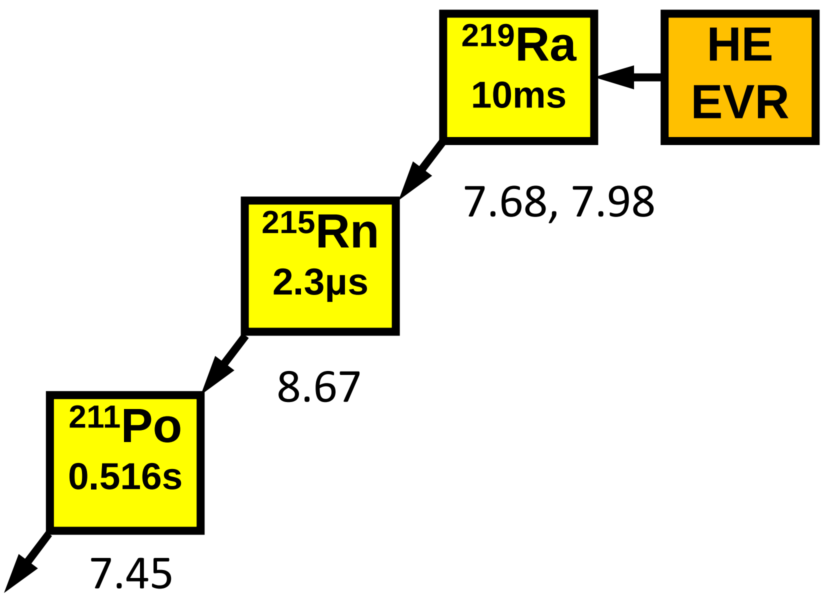


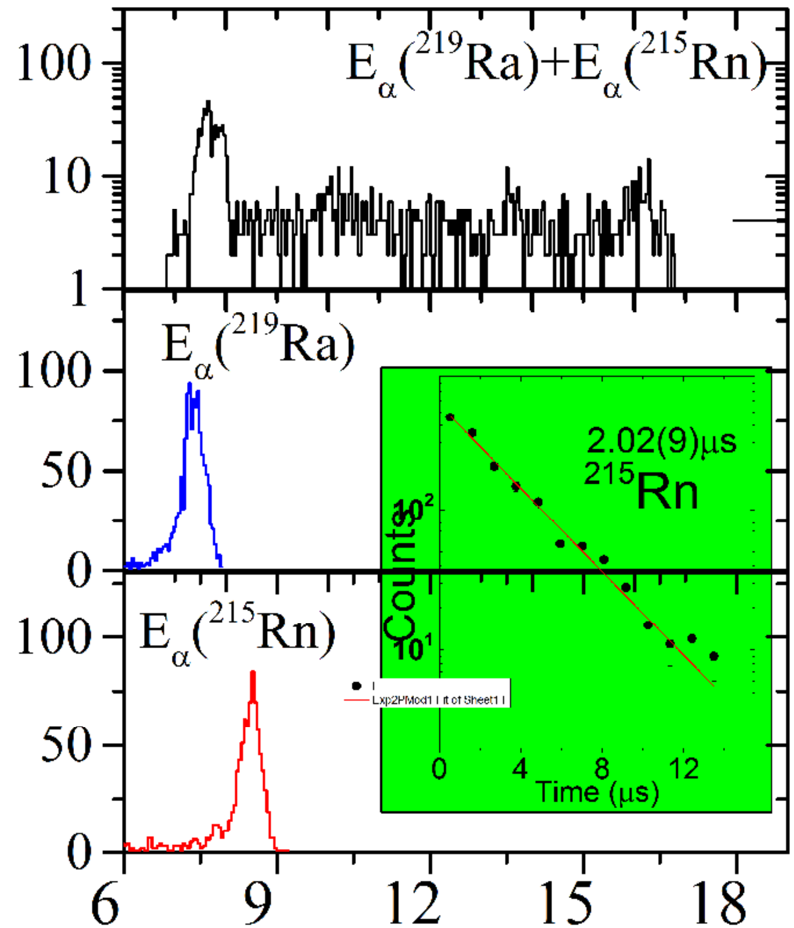
Analog
Energy, X: Deadtime <50 µs

$$E_{FrontX}=E_{backY}$$

Digital
Energy, Y: Trace length 50 µs

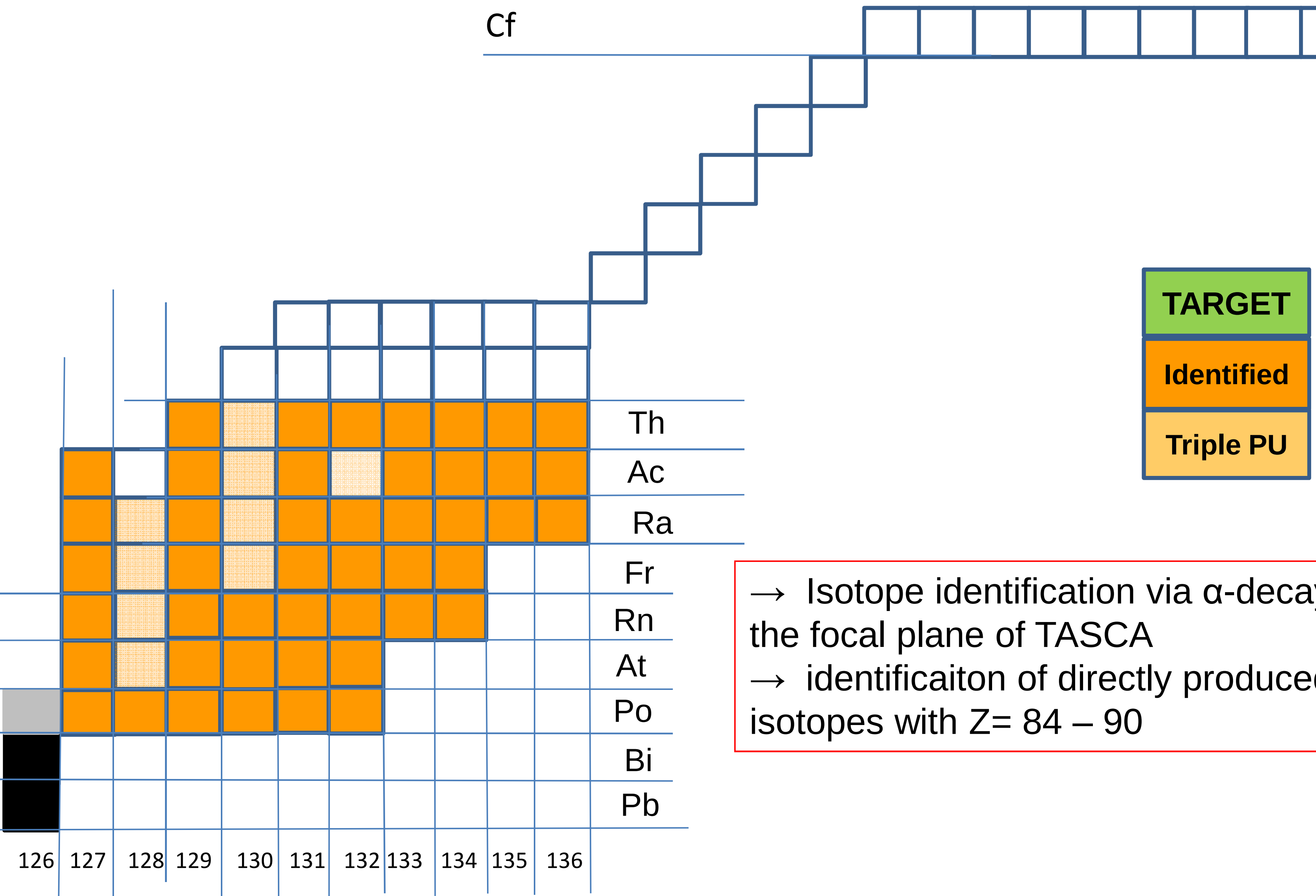
J. Khuyagbaatar et al. PRL 242502 (2015)





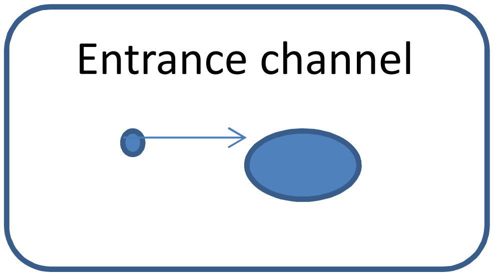
Conditions:
HE conditions for signal 1
Pile up for signal 2
Eα3 and beam off for signal 3

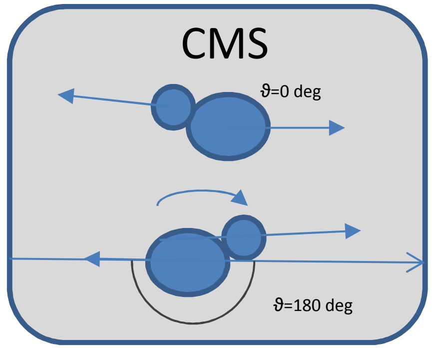
Identified nuclei

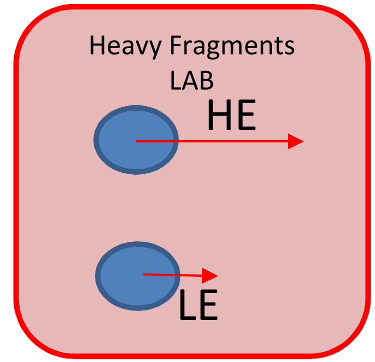


→ Isotope identification via α-decay in the focal plane of TASCA
→ identificaiton of directly produced isotopes with Z= 84 – 90

Multi-nucleon transfer described by Nuclear Molecule formation







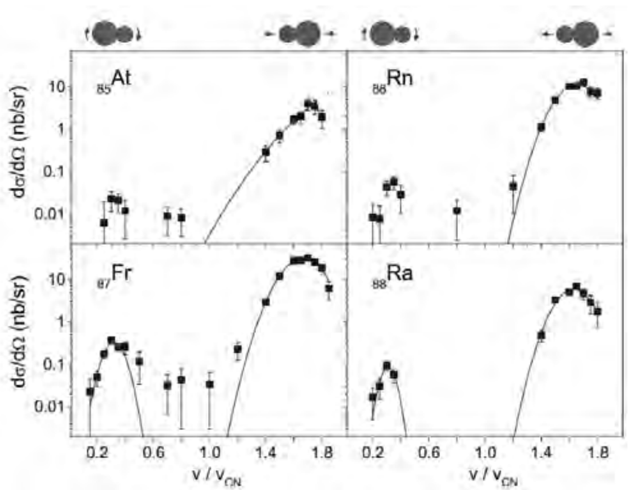
$v_{HE}=v_{CN}+v_{TKE}$

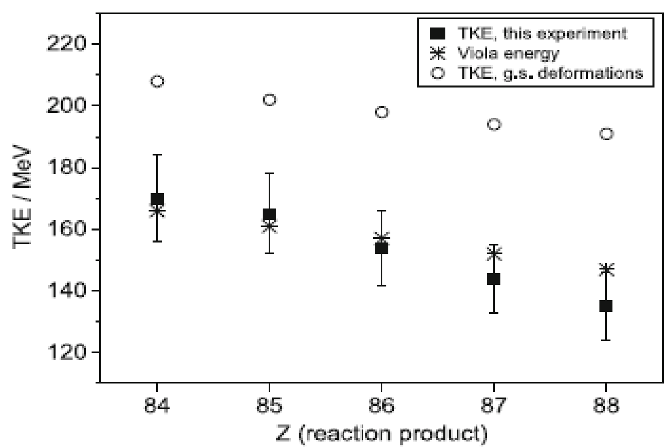
$v_{LE}=v_{CN}-v_{TKE}$

Trajectories selected by the TASCA opening angle 0 ± 90 mrad

Measurements performed at velocity filter SHIP

$^{64}\mathrm{Ni} + {}^{207}\mathrm{Pb}$ at $5.92\,\mathrm{MeV}/u.$

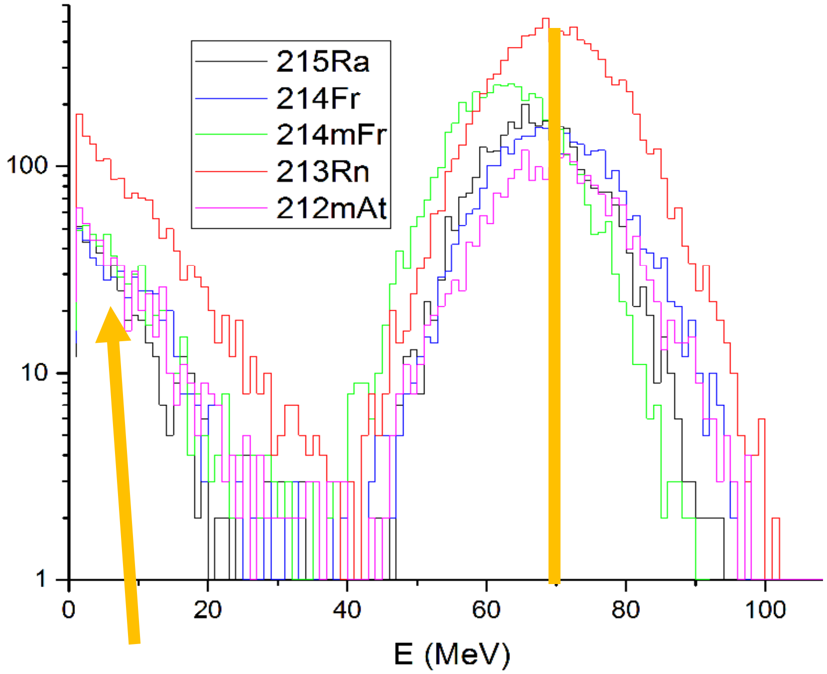




$$E_{\text{Viola}} = \left(0.1189\frac{Z^2}{A^{1/3}} + 7.3\right)\frac{4Z_1Z_2}{(Z_1+Z_2)^2}\ \text{MeV}$$

S. Heinz et al., EPJA 51 (2015)

Kinetic Energies of Transfer Products



Considering enegy loss in passive layers and PHD

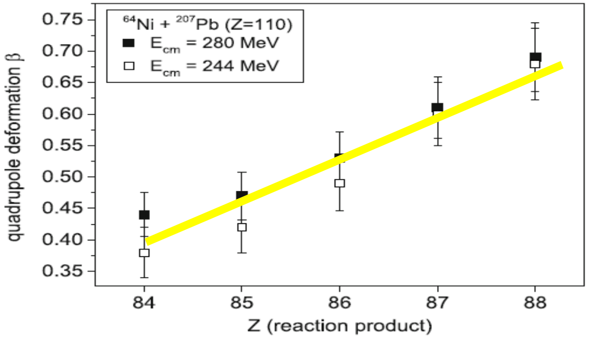
E_{si} (MeV)	E_{CoT} (MeV)
5	**45**
70	**150**

TKE formula for very asymmetric scission and nuclear molecule formation

$$E_{\text{Viola}} = \left(0.1189\frac{Z^2}{A^{1/3}} + 7.3\right)\frac{4Z_1Z_2}{(Z_1+Z_2)^2}\ \text{MeV}$$

^{213}Rn	Exp.	Theor.	Vel.
E_{CoT_HE} (MeV)	150	**187**	V: ->
E_{CoT_LE} (MeV)	**50**	**4**	V: <-

Deformation of the separating system



- It is observed deformation increasing the amount of nucleon exchange, up to (2:1) for ^{214}Ra.

S. Heinz et al., EPJA 51 (2015)

$$\beta = \sqrt{\frac{4\pi}{5}} \left(\frac{Z_1 Z_2 e^2}{r_0 TKE(A_1^{1/3} + A_2^{1/3})} - 1 \right)$$

Exp. TKE=144 MeV for ^{213}Rn indicates β_2=1.49 (axis ratio 1:2.9 hyperdeformation)

	^{64}Ni+^{207}Pb	^{50}Ti+^{249}Cf
entrance channel	^{207}Pb β_2=-0.00824 (spherical)	^{249}Cf β_2=0.24 (deformed)
nucleon exchange	(^{214}Ra) 7 Proj. → Target	(^{213}Rn) 30 Targ. → Proj.
nuclear matter	Large overlap (E>>Bc)	Small overlap (E~Bc)

These differences can motivate the presence of larger deformation in the exit channel.

? No Way to explain the low energy peak in fact $\mathbf{V_{TKE} > V_{CN}}$

Summary

- Identification of transfer reaction product of the system $^{50}Ti+^{249}Cf$;
- Nuclei originated by Pb contamination;
- Large deformation at the separation stage required to reproduce the HE peak

Outlook:

- Physical origin of the LE component
- Filling the gap investigating triple pile up