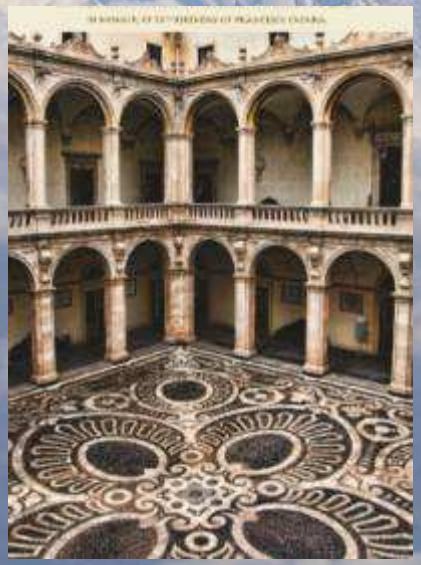
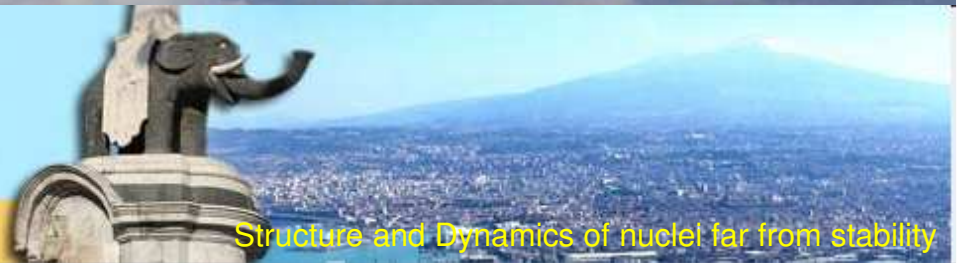
Reactions with exotic beams using the CHIMERA detector at LNS

G.Cardella
For the EXOCHIM collaboration



INFN Istituto Nazionale di Fisica Nucleare
Sezione di Catania



Introduction

Why this talk here?

Francesco was one of the past director of INFN-Sezione di Catania – its help was important at the beginning of this work – He contributed also to create a good atmosphere in Sezione and this was essential for what I will show today

I will speak about:

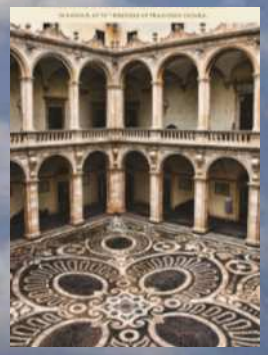
the production system of the fragmentation beam at LNS

some results obtained with such beams

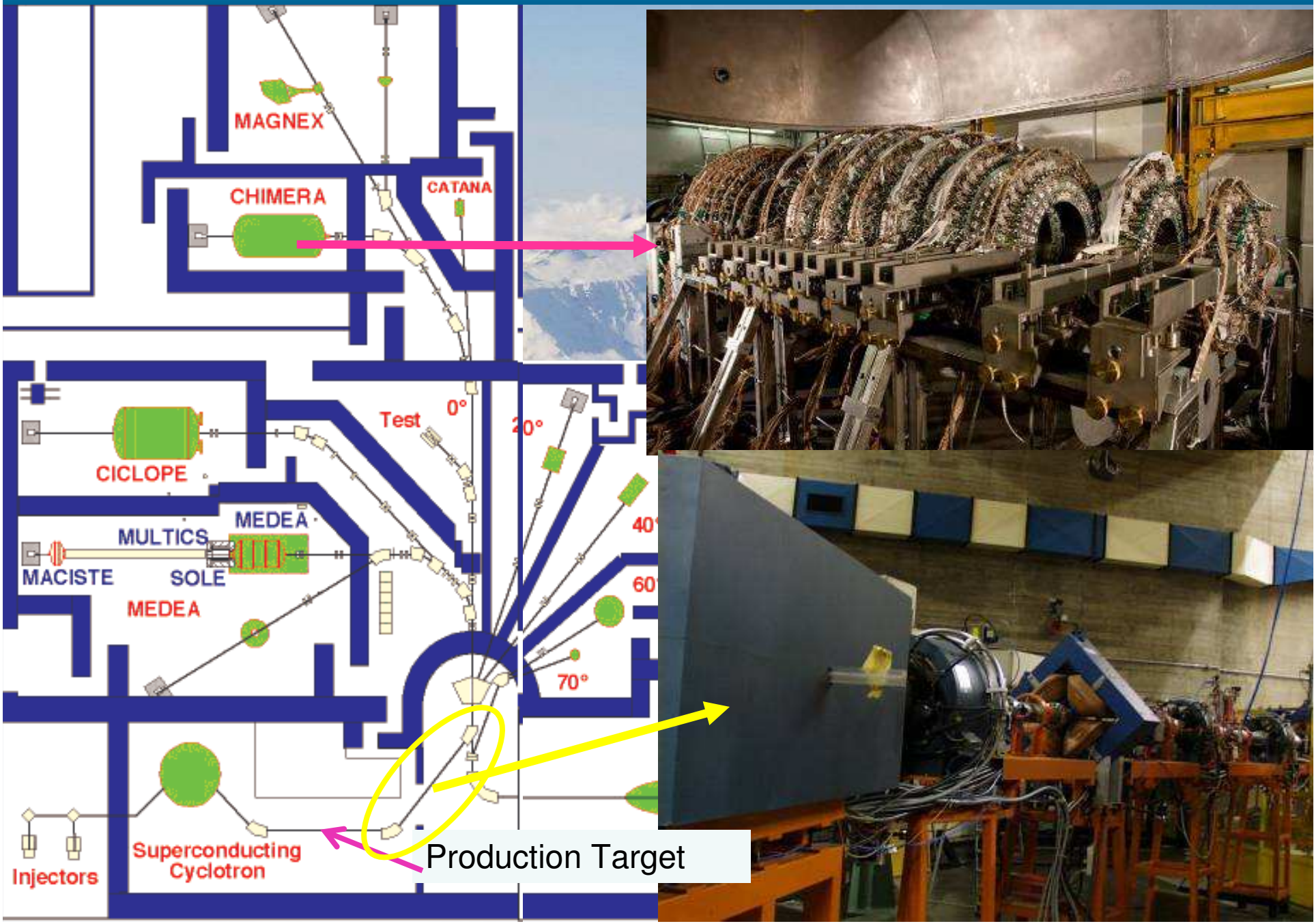
the beam transport and identification

some of the measurements performed with CHIMERA

Future perspectives

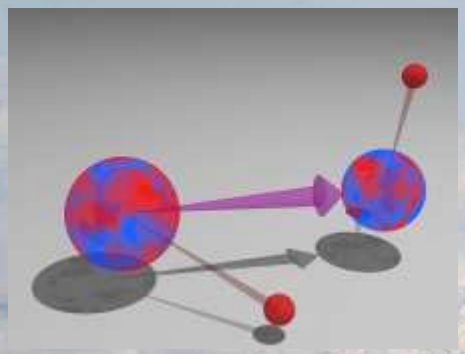


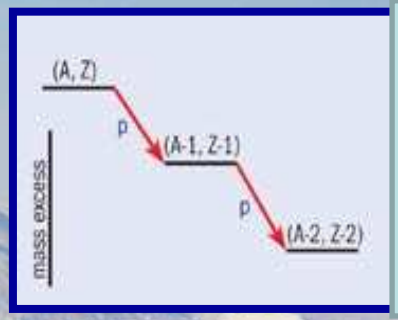
Fragmentation beams at INFN-LNS in Catania



FRAGMENTATION BEAMS: The first experiment - Di-proton

Sequential emission

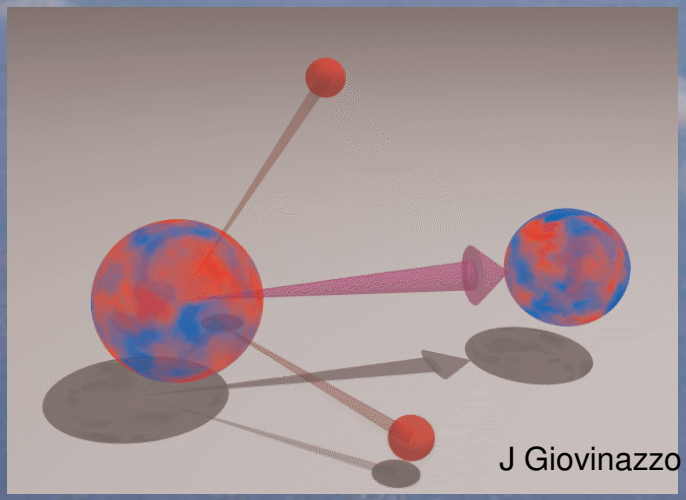




C. R. Bain *et al, Phys. Lett.* **B 373 (1996) 35**

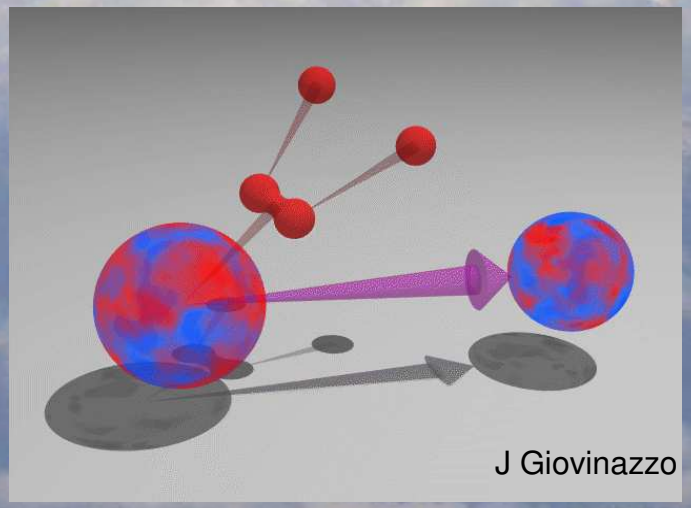
J Giovinazzo

Three body decay

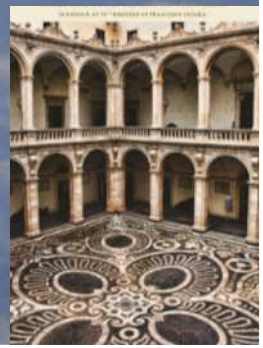


V. Bochkarev *et al., Sov. J. Nucl. Phys.* **55 (1992) 955**

^{2}He decay

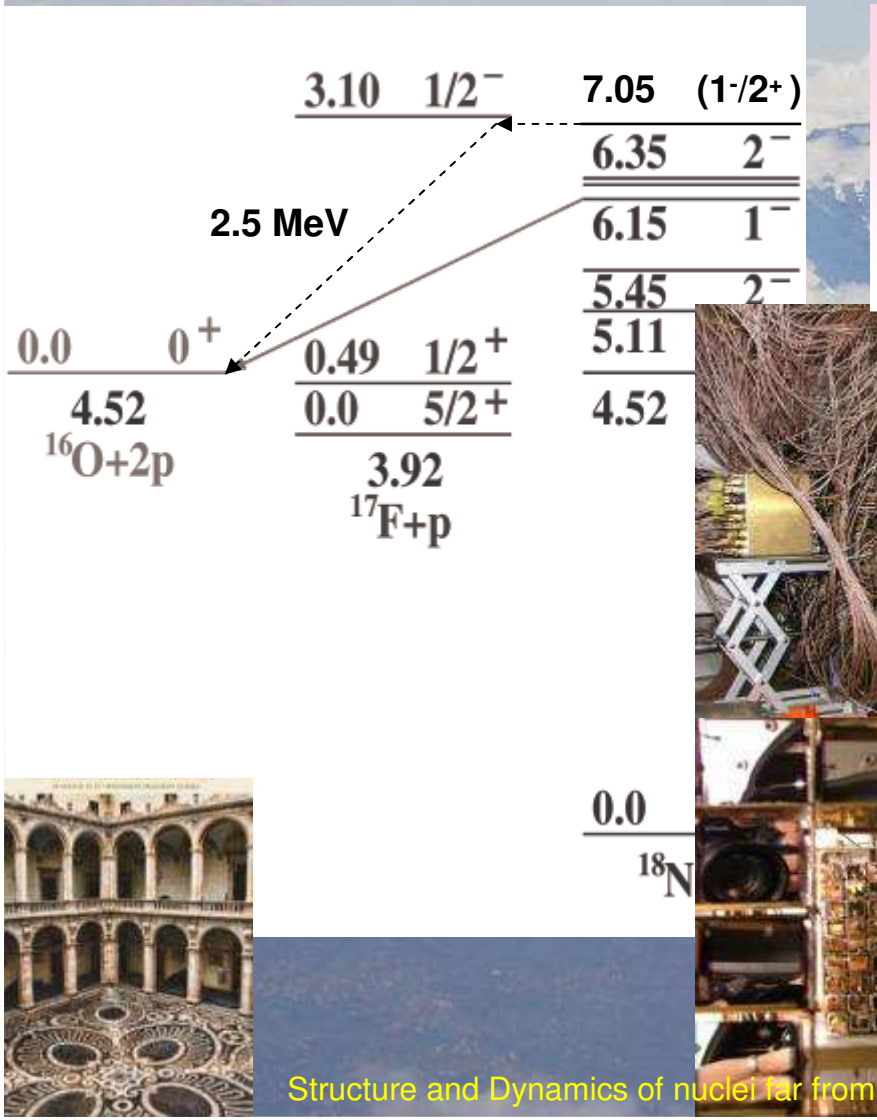


V. I. Goldansky, *Nucl. Phys.* **19(1960)482**

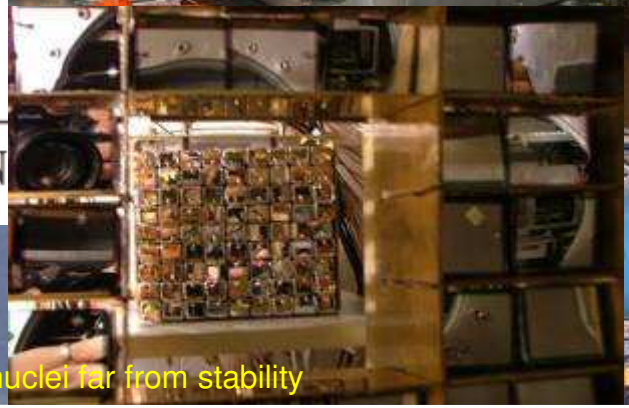


FRAGMENTATION BEAMS: The first results - Di-proton

^{18}Ne* was suggested By Gomez Del Campo(PRL 86(2001)43) as a candidate for the observation of diproton decay from excited level



Study performed in the 20° beam line by using the RACITI ODOSCOPE - because of the low transmission on the CICLOPE chamber where CHIMERA was mounted at that time



FRAGMENTATION BEAMS: The first result - Di-proton

Using ^{18}Ne beam we have studied the excitation and decay of a special state that can decay emitting a diproton

PRL 100, 192503 (2008) PHYSICAL REVIEW LETTERS week ending 16 MAY 2008

Experimental Evidence of ^{2}He Decay from ^{18}Ne Excited States

G. Raciti,* G. Cardella, M. De Napoli, E. Rapisarda, F. Amorini, and C. Sfienti

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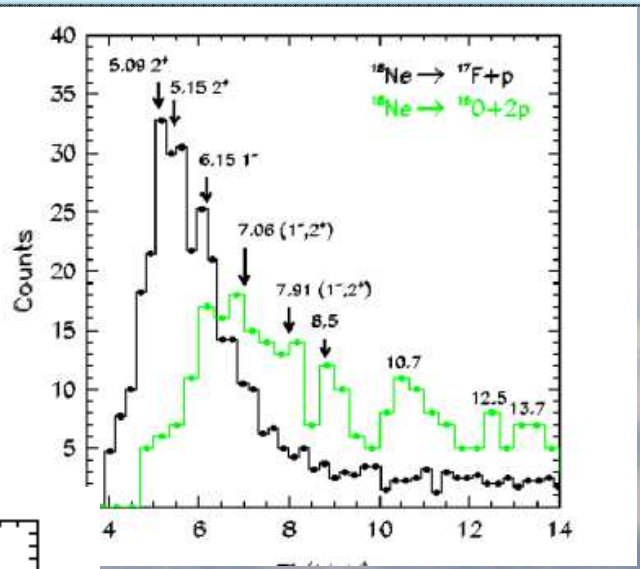
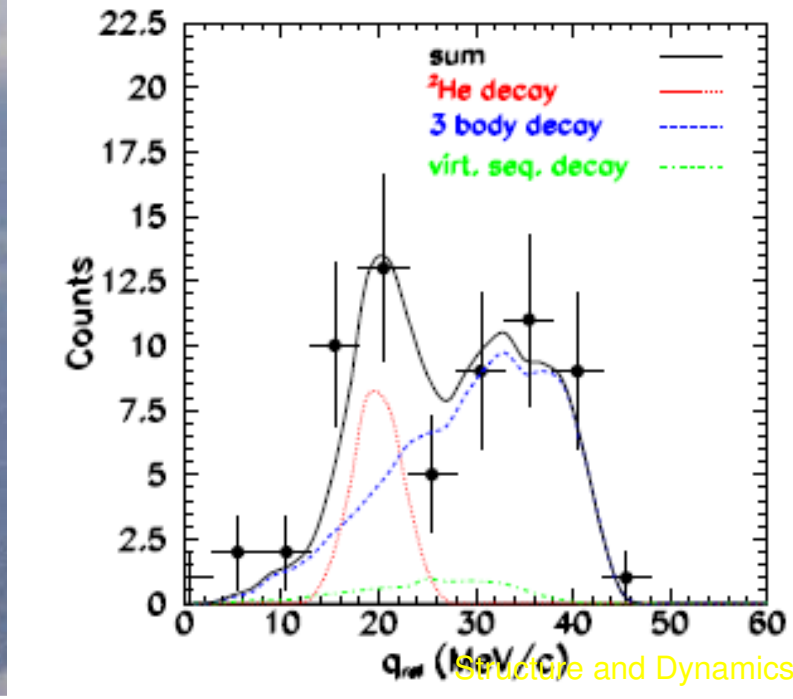
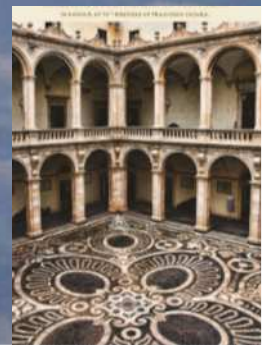
(Received 21 December 2007; published 15 May 2008)

Two-proton decay from ^{18}Ne excited states has been studied by complete kinematical reconstruction of the decay products. The ^{18}Ne nucleus has been produced as a radioactive beam by ^{20}Ne primary projectile fragmentation at 45 AMeV incident energy on a Be target. The ^{18}Ne at 33 AMeV incident energy has been excited via Coulomb excitation on a ^{nat}Pb target. The obtained results unambiguously show that the 6.15 MeV ^{18}Ne state two-proton decay proceeds through a ^{2}He diproton resonance (31%) and democratic or virtual sequential decay (69%). The quoted branching ratio has been deduced from relative angle and momentum correlations of the emitted proton pairs.

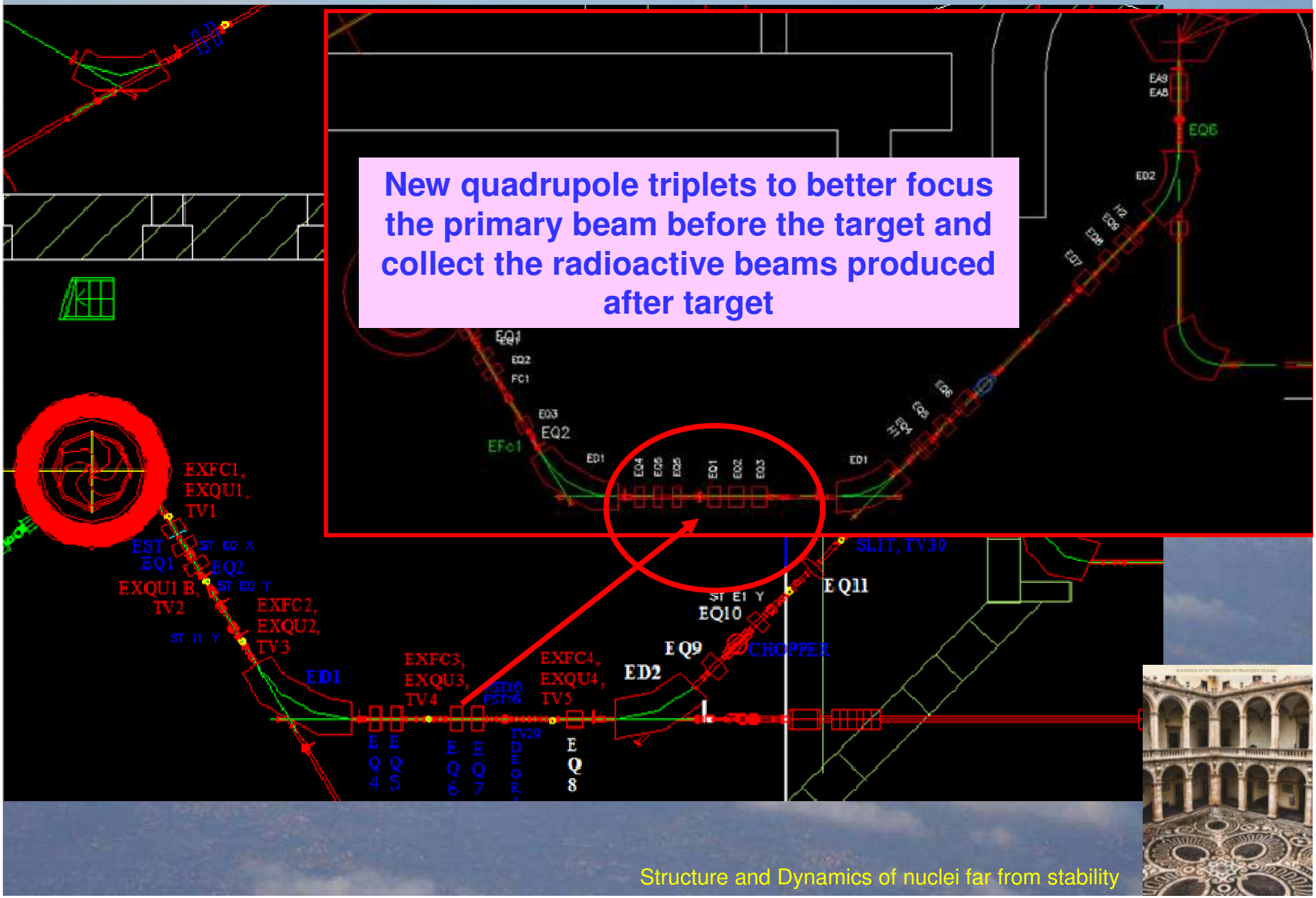






FRAGMENTATION BEAMS: CHIMERA moved in the new scattering chamber to better use these beams

The upgraded LNS Fragmentation beam



Beam diagnostic

The EXCYT diagnostic was essential to improve the beam transport efficiency respect to previous transports based on Pilot beams **A.Amato,..G.Cosentino et al LNS report 2009**

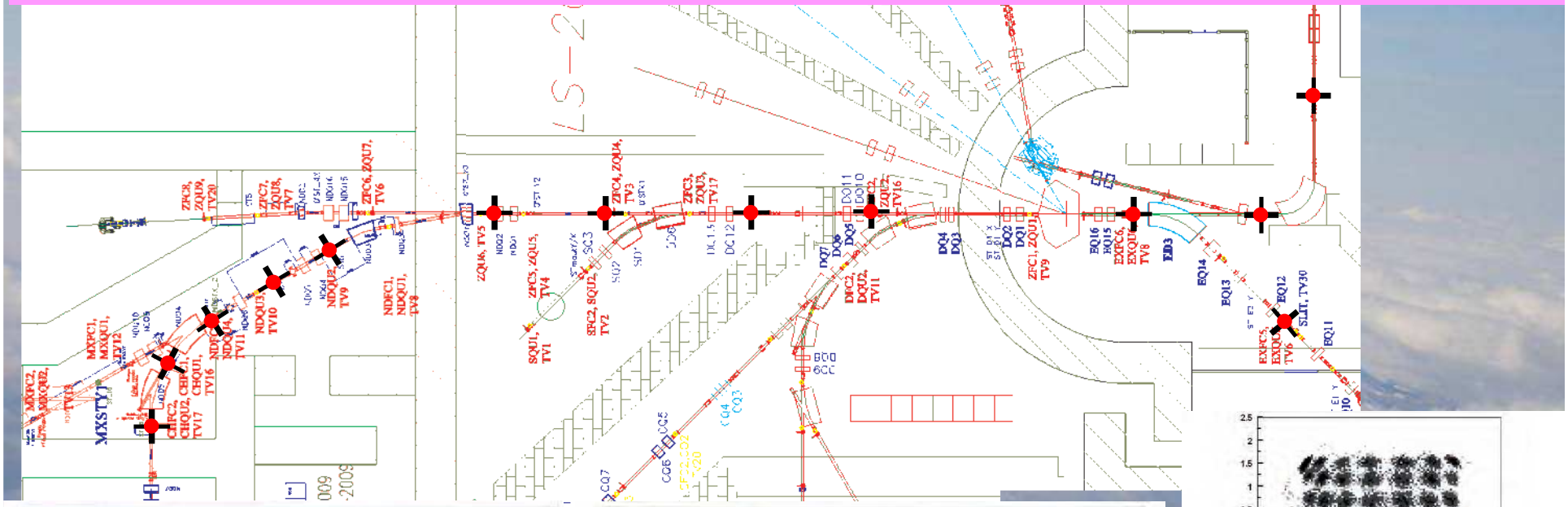


Fig. 2. Beam particle counter, based on a plastic scintillator coupled to a photomultiplier.

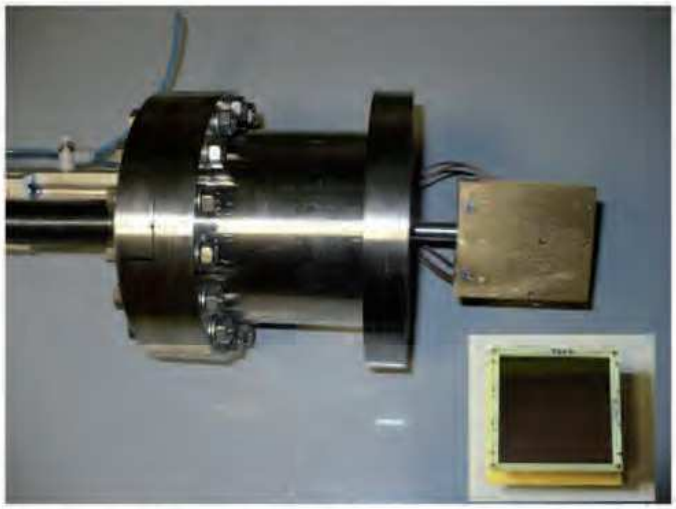


Fig. 3. PSSD mounted in a pneumatic actuator. The mask made by brass is 2mm thick.

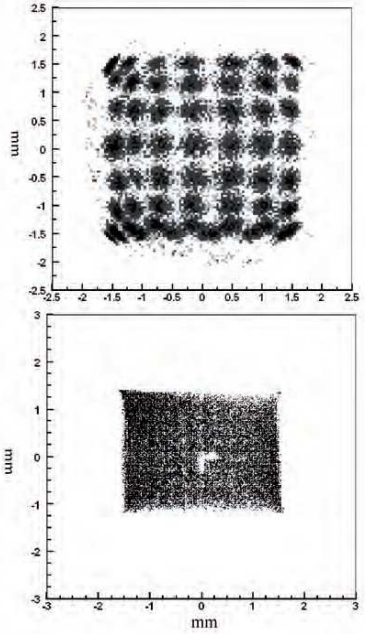
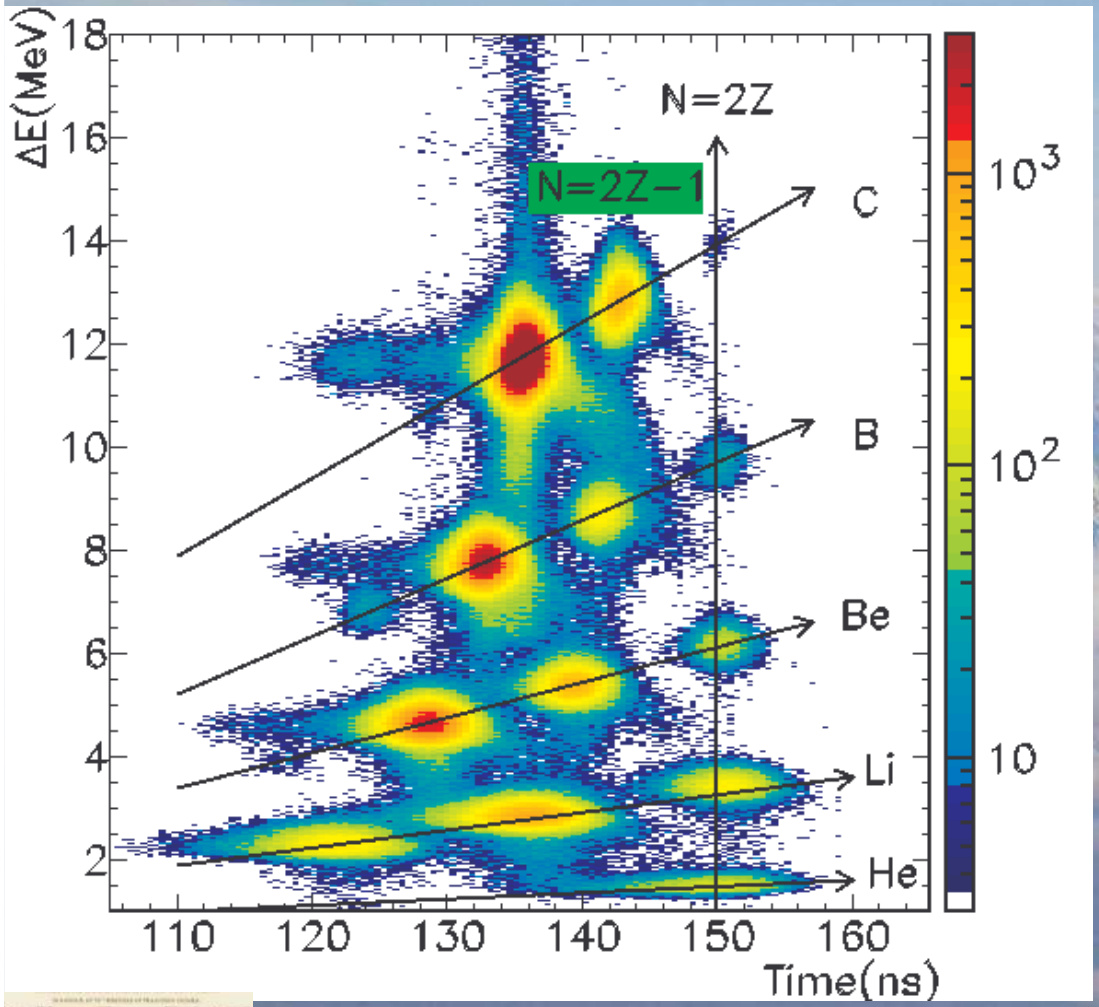


Fig. 4. Corrected beam profiles of a EXCYT (a) and a FRIB (b) beam, acquired by means of the PSSD and using two different masks.

Beam identification



A fragmentation beam is generally a mixed beam and many efforts are devoted to improve its purity

In our case we decided to use another approach – to identify event by event all beam nuclei performing many experiments at the same time

The tagging system is therefore of fundamental importance

Tagging system: flow chart I DSSSD

I cannot change too much the beam characteristics if I want to use it

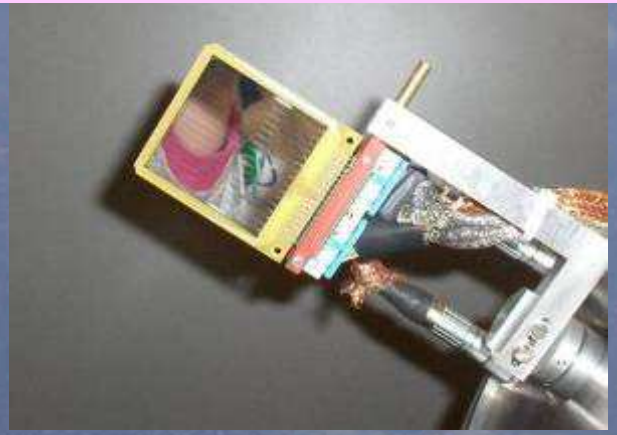
~~ΔE-E?~~

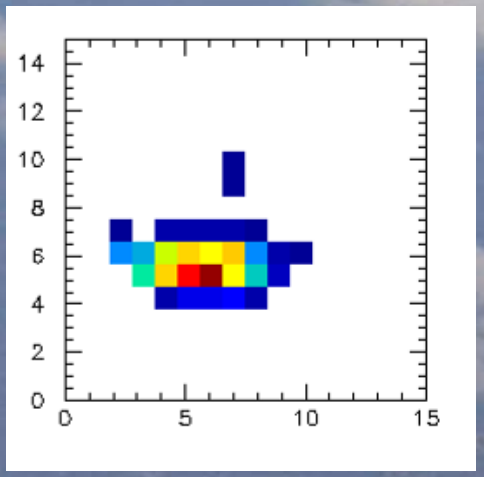
I cannot stop the beam in the tagging detector

ΔE-T?

What can I use for ΔE?

Double side Silicon strip detector





Two main advantages:
From the position of the strip I can also get the XY image of the beam

Many strips can sustain a larger rate than a single detector

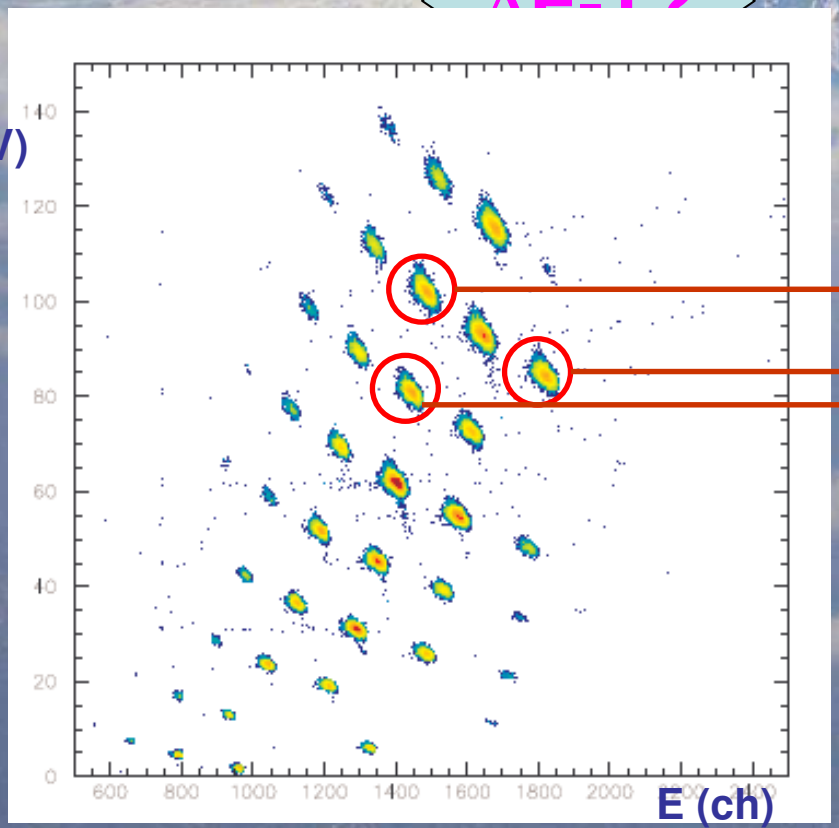
Tagging System: flow chart II - RF-timing

~~ΔE-E?~~

I cannot stop the beam in the tagging detector

ΔE-T?

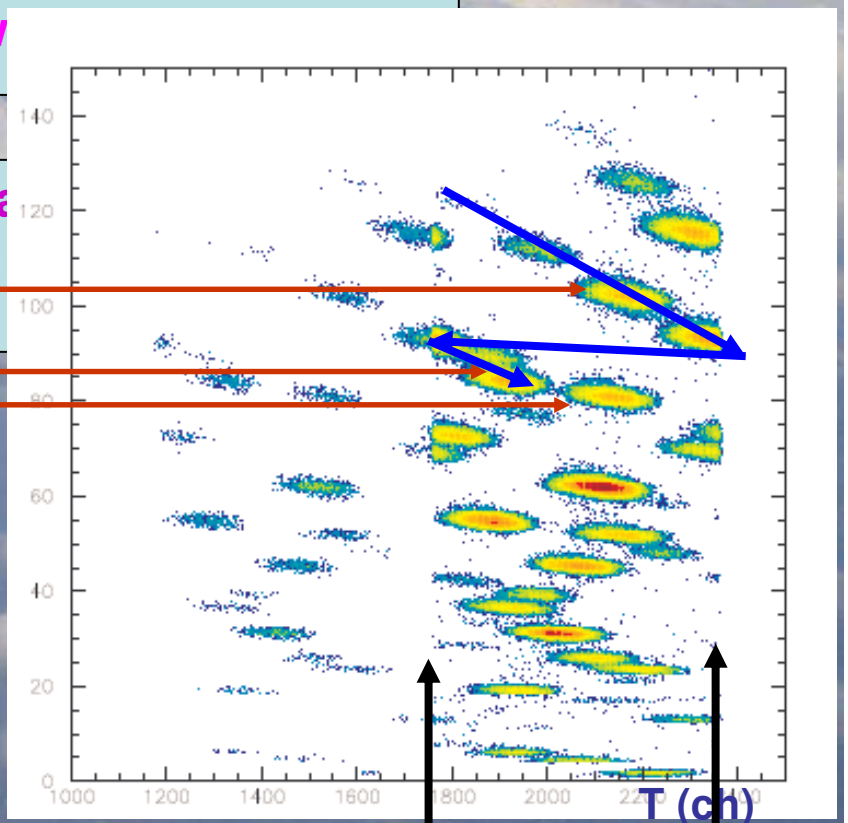
Possible but how



^{20}Ne

^{18}Ne

^{18}F

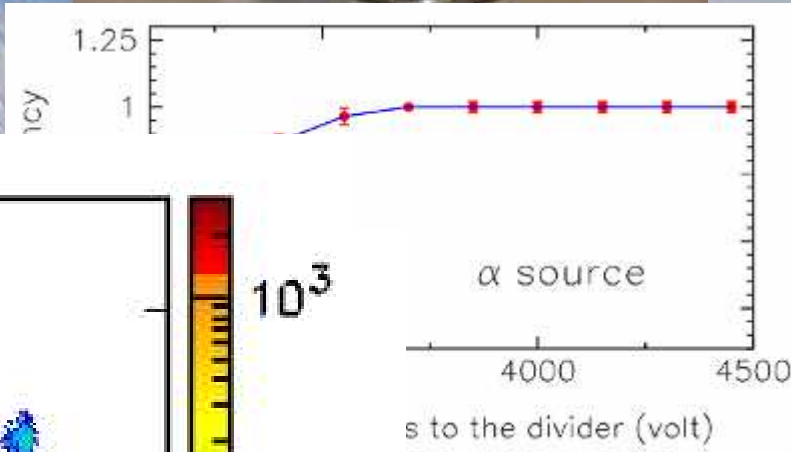


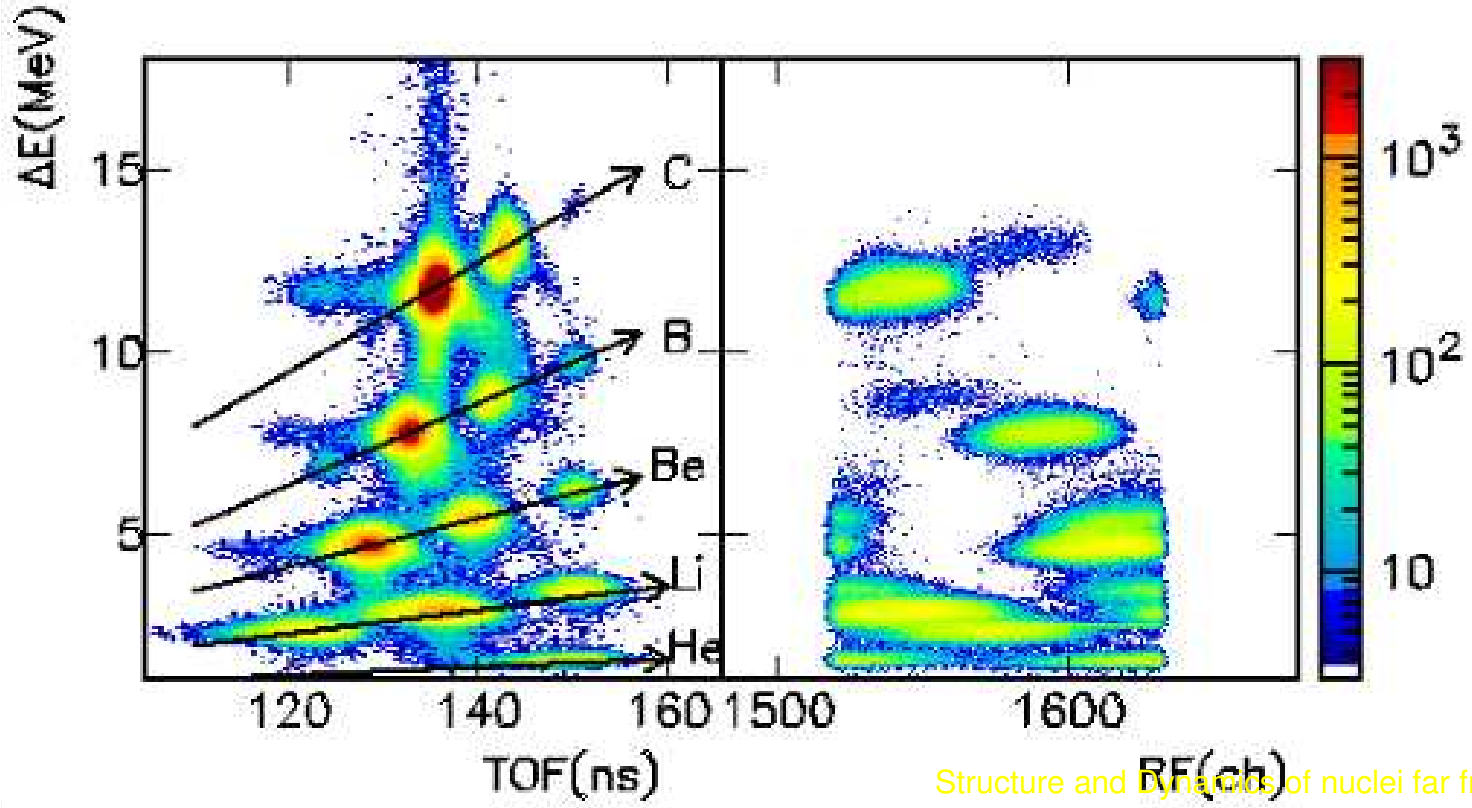
Tagging system : flow chart III MCP timing

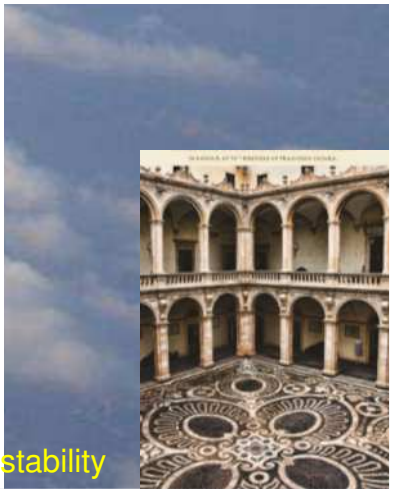
DE-E?

I cannot stop the beam
in the tagging detector

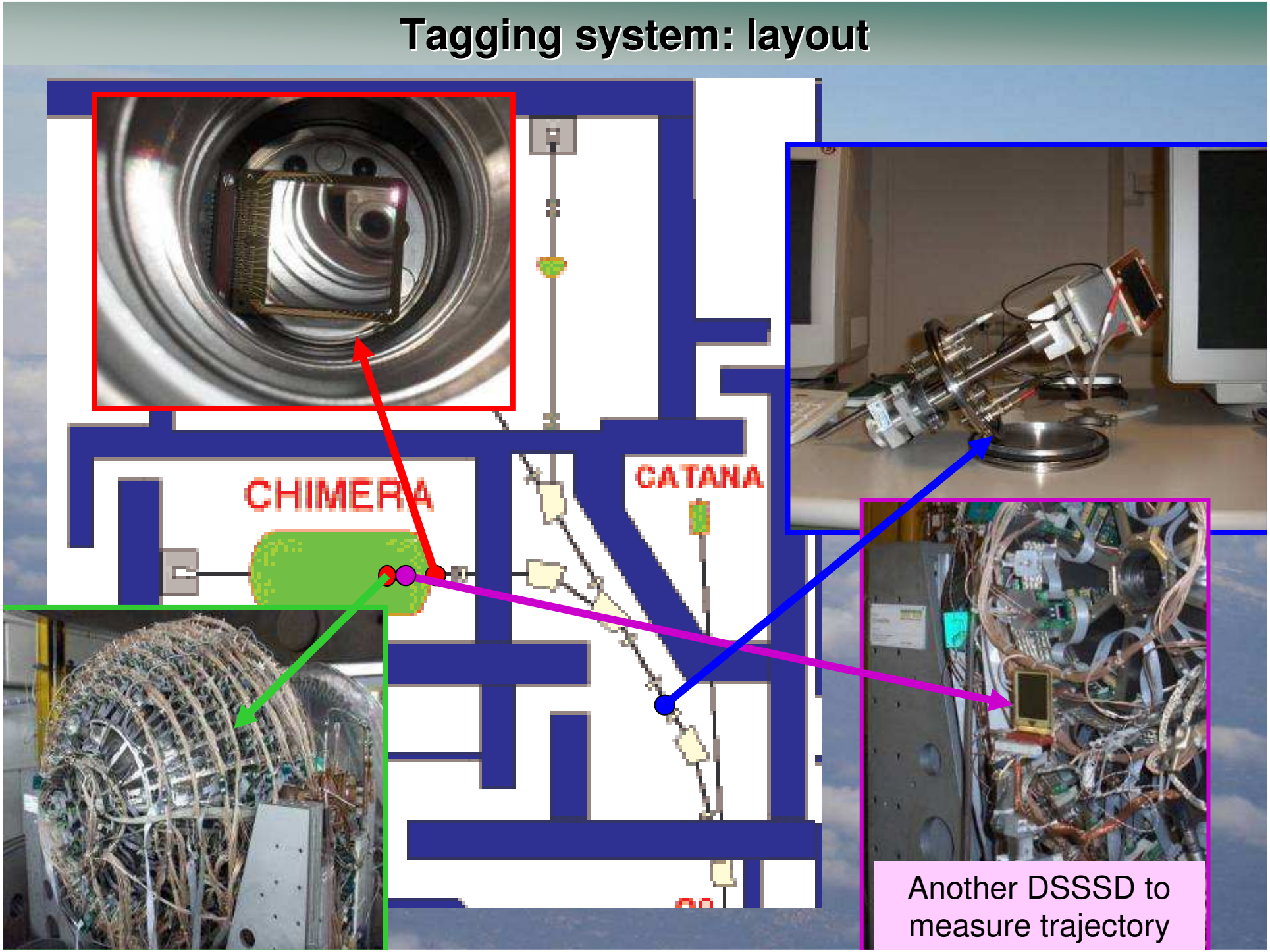
Tagged beam



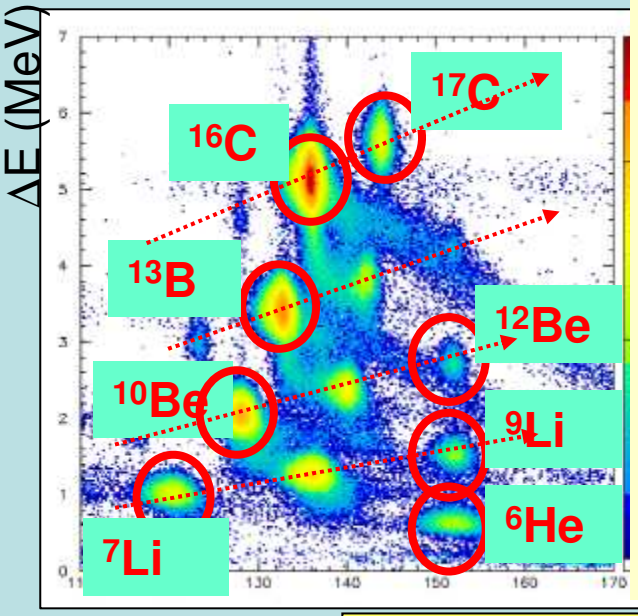




Tagging system: layout



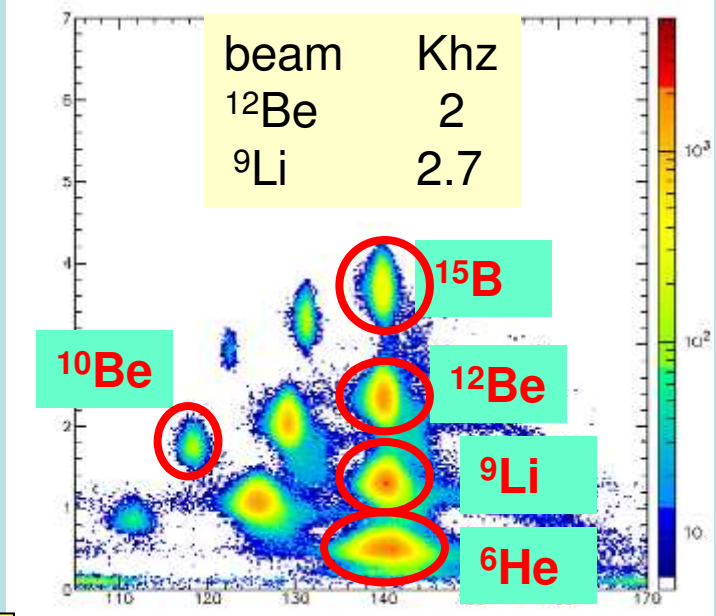
Intensities of some beams available in the CHIMERA Hall



^{18}O 55 MeV/A 100 W primary beam (6.3×10^{11} p/s)

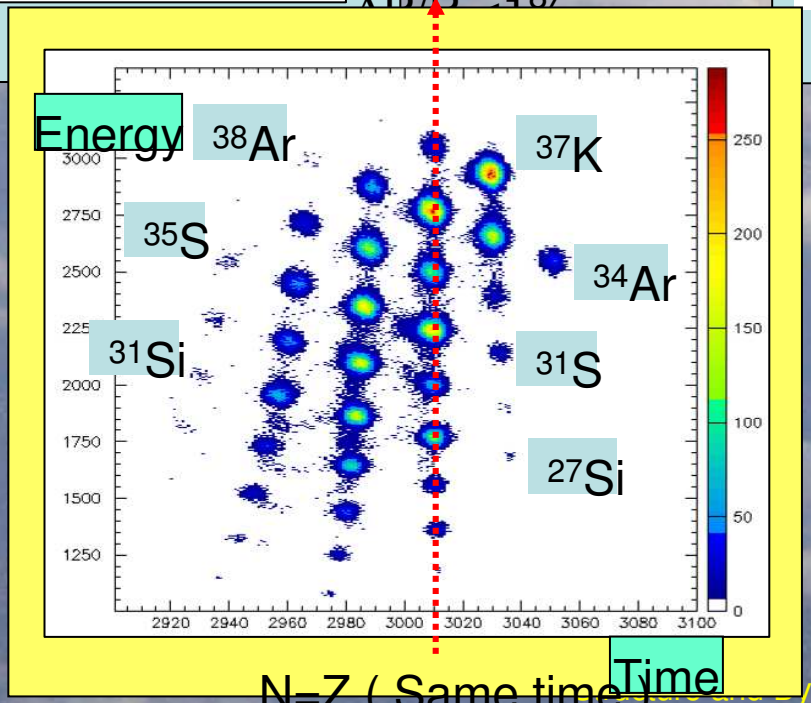
beam	Khz
^{16}C	60
^{13}B	40

E~50 MeV/A



beam	Khz
^{12}Be	2
^{9}Li	2.7

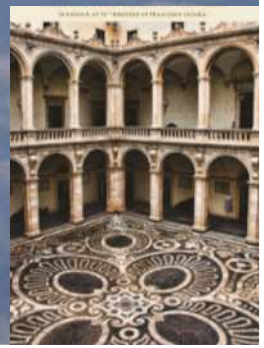
T (ns)



N=Z (Same time)

Beam	Khz
^{37}K	14
^{34}Ar	1.8

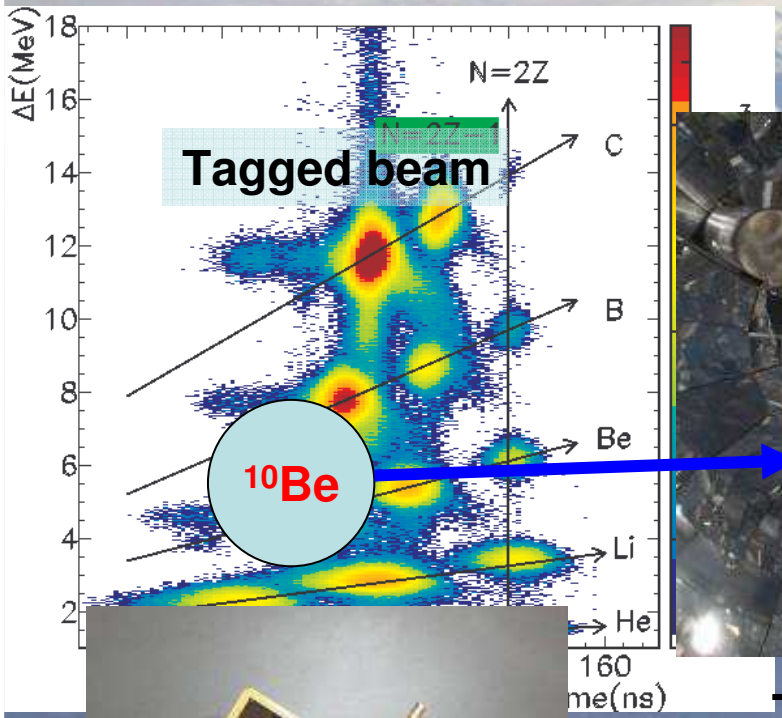
Energy ~ 20-25 MeV/A (25 W primary beam)

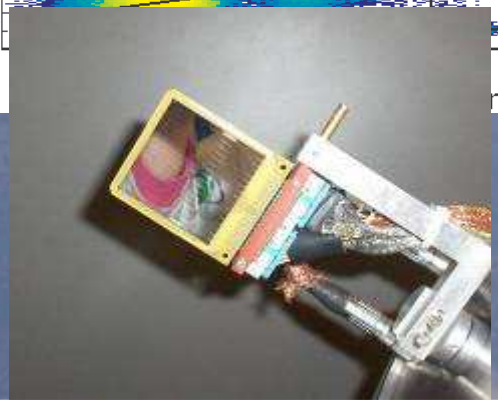


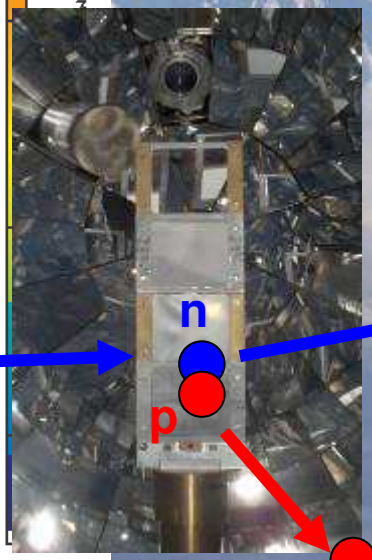
-Elastic scattering and neutron transfer reactions near halo nuclei -

We want study elastic scattering and transfer reactions of light nuclei on p, d targets to look for halo or other nuclear structure effects

EVENT SELECTION performed with kinematic coincidences – we measure in binary reactions both reaction partners cleaning the events







^{10}Be

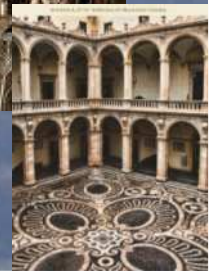
n

p

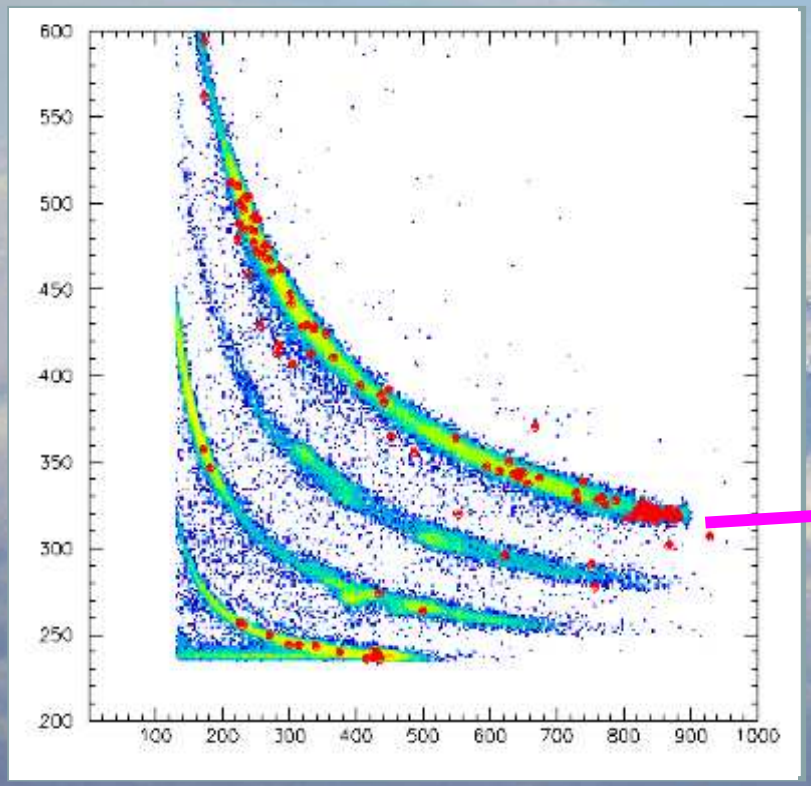
^{11}Be

p

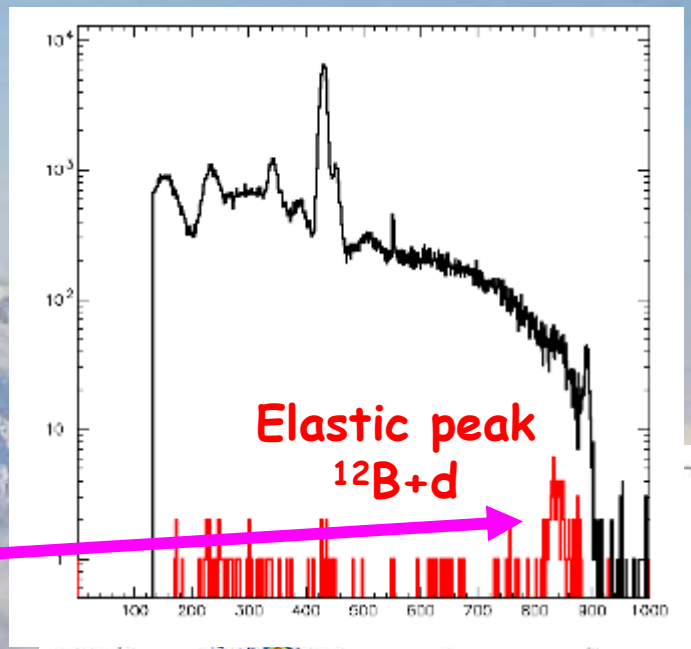
Target d

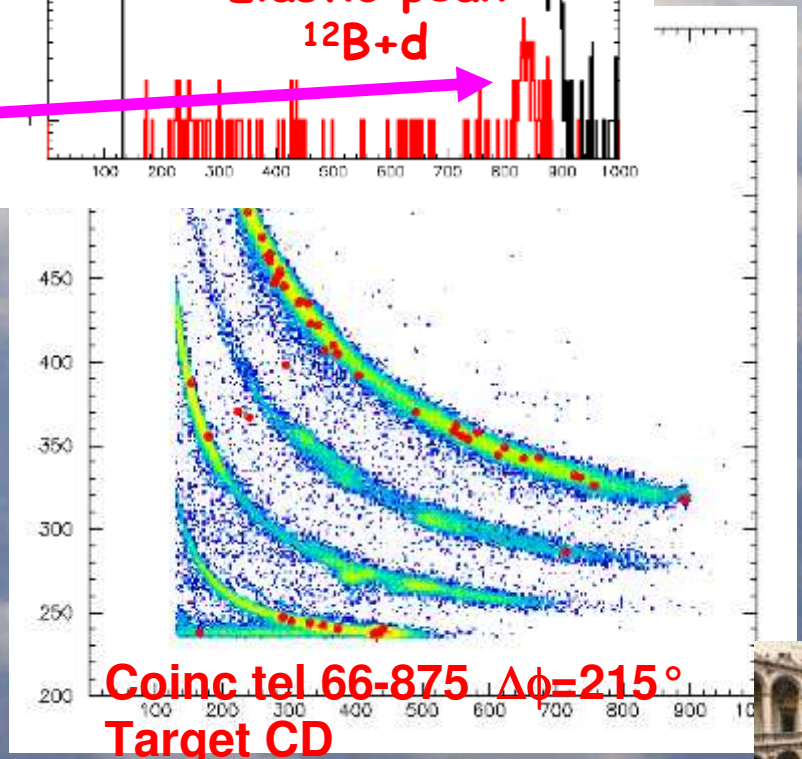


DETECTION : kinematical identification

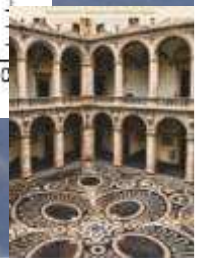


Coinc tel 38(3.1°)-870(66°) Δϕ=180°
Target CD beam 12B

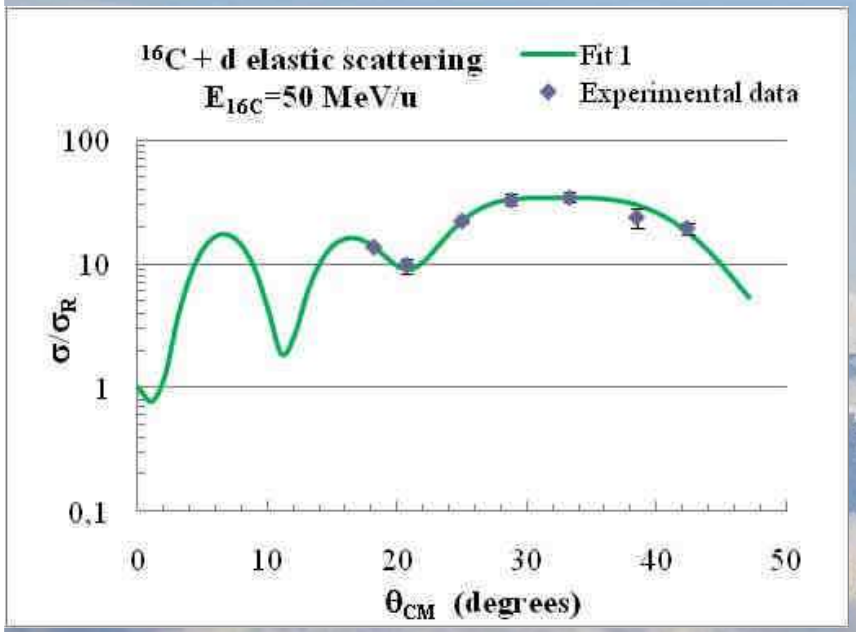


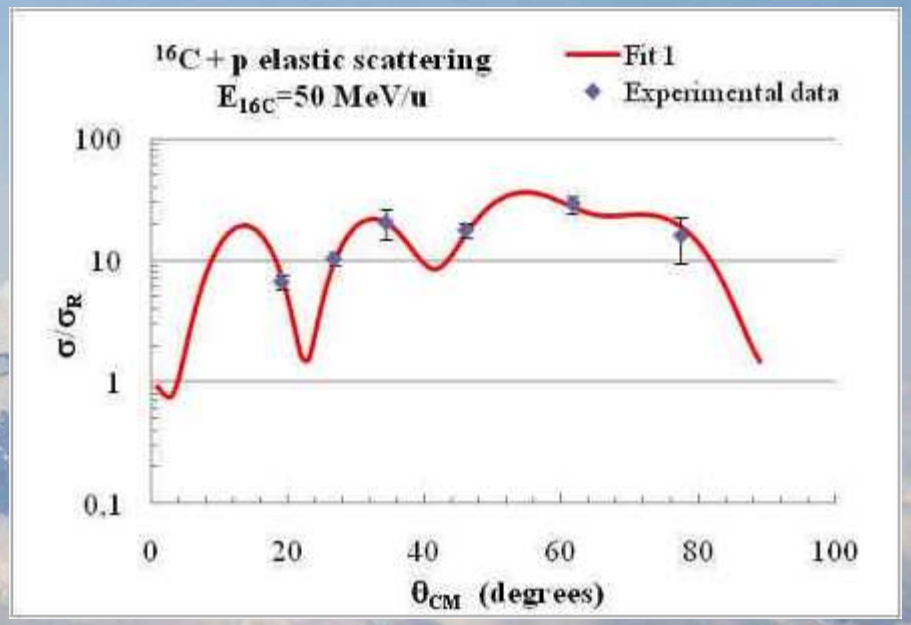


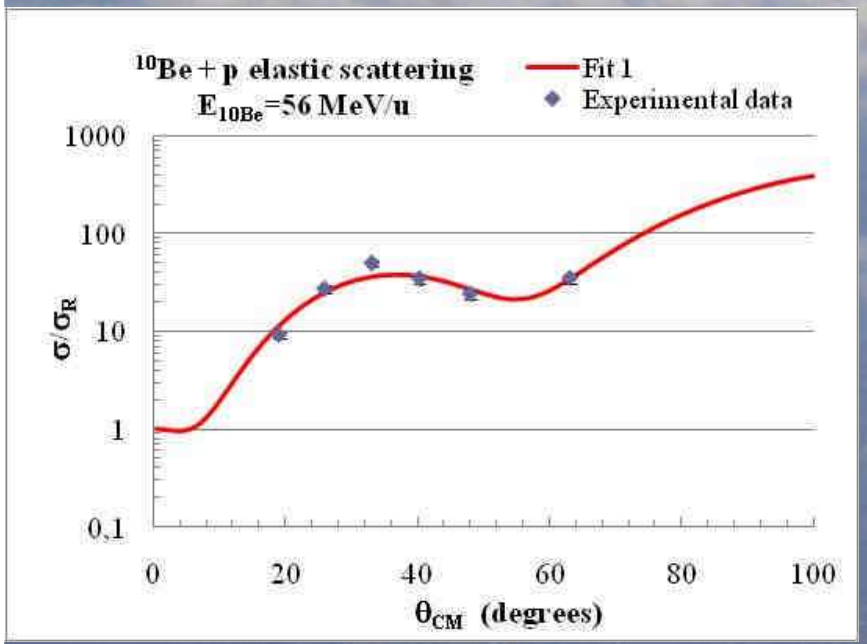
Very clean measurement – coincidences are observed only if Δϕ=180°

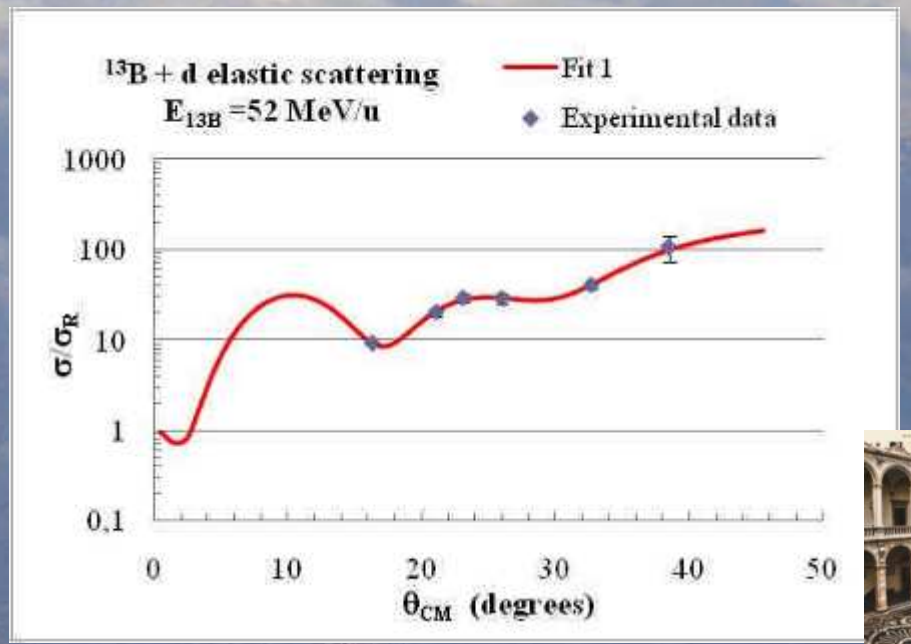


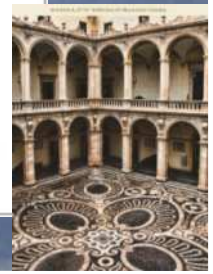
– Some results on elastic scattering -





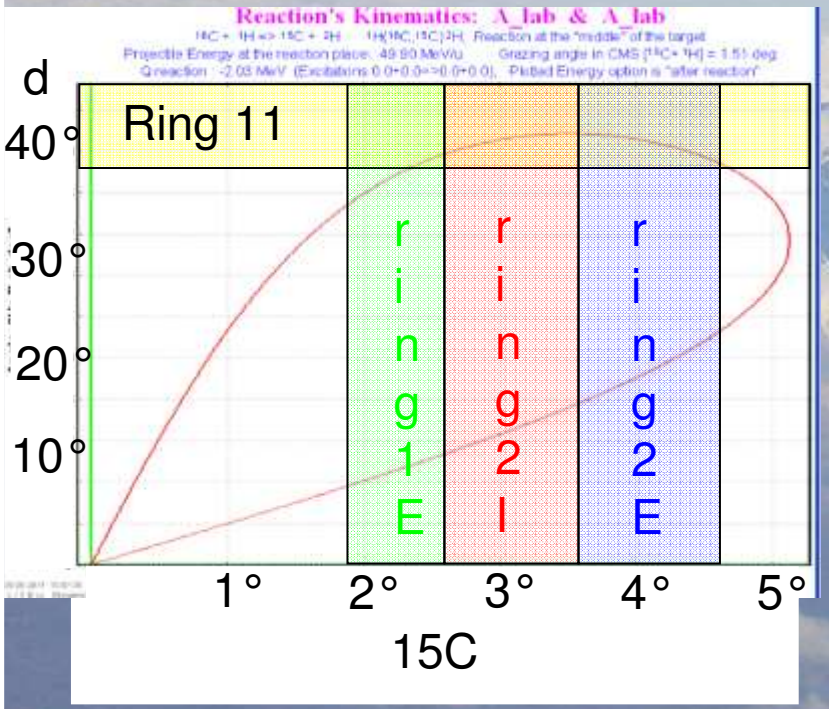




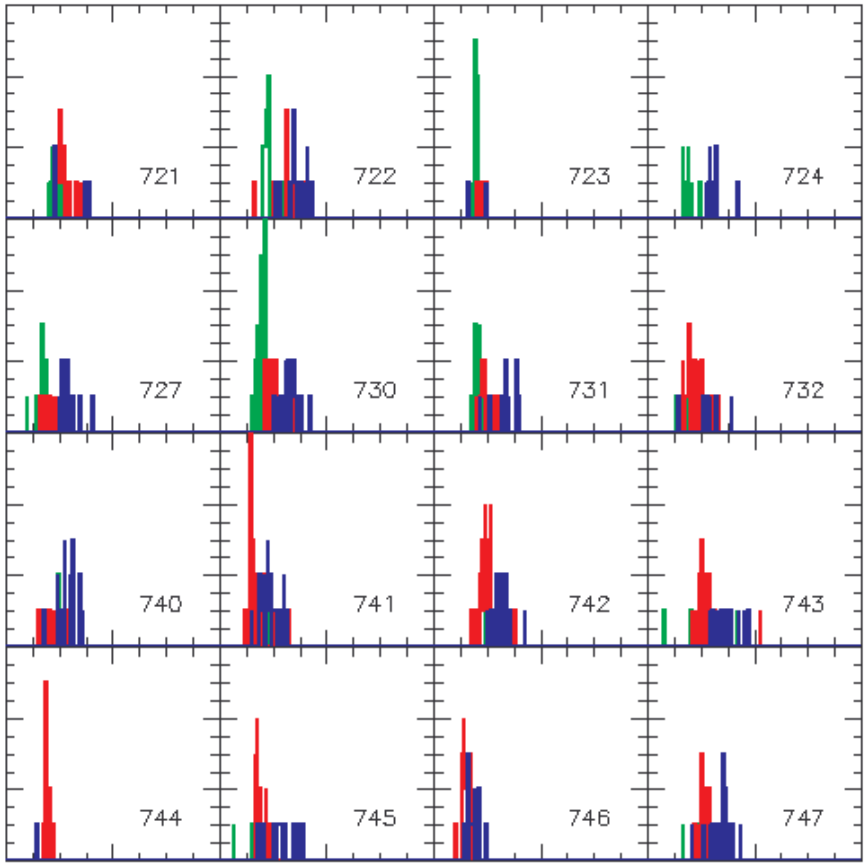


– Some preliminary results on transfer reactions -

We can look the $^{16}C+p->^{15}C+d$ reaction searching deuterons in coincidence with carbon – we look to kinematics and we see that deuterons detected around 40° (ring 11) are in coincidence with carbon from 2 to about 5° (rings1E, 2I, 2E)



After complete calibration we will be able to follow the kinematics of the peak and extract an angular correlation with relatively good angular resolution

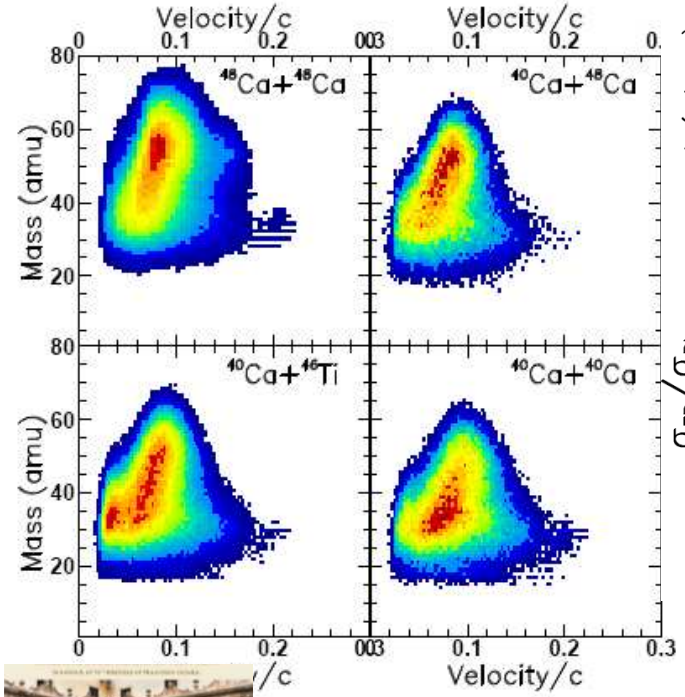


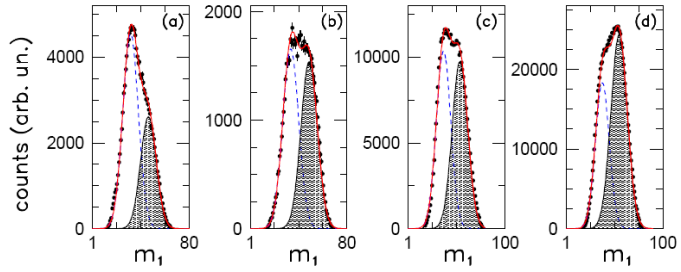
Deuteron energy released in CsI

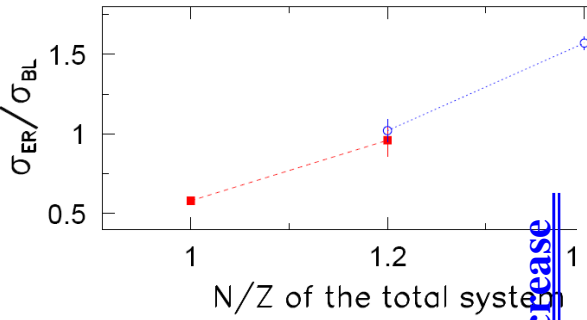
Experiment in progress - Isospin dependence of reaction mechanisms

In past years we measured with CHIMERA detector [1] reactions induced by ^{40,48}Ca at 25MeV/A on ^{40,48}Ca,^{46}Ti.

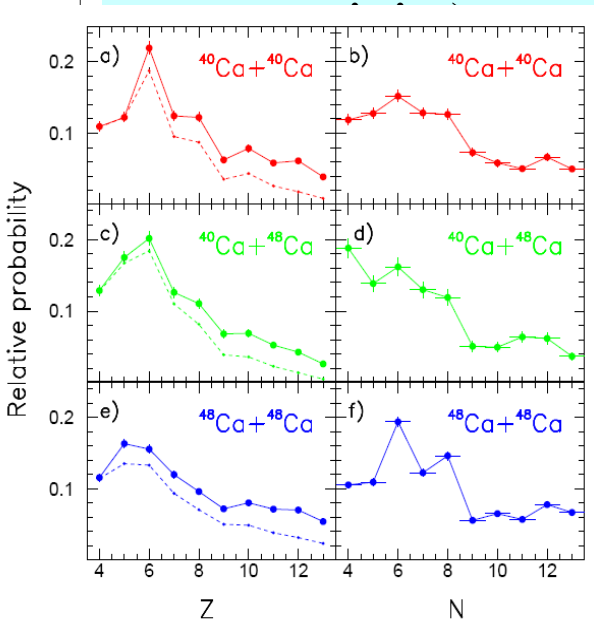
The mass–velocity correlations (m_1,v_1) of the largest nucleus emitted show that in the most neutron rich system ^{48}Ca+^{48}Ca heavy residues are more probably populated than in N=Z systems [2-6]







By increasing the N/Z of the entrance channel increases the ratio between ER production and other mechanisms (such as binary-like and multi-fragment



N/Z increase

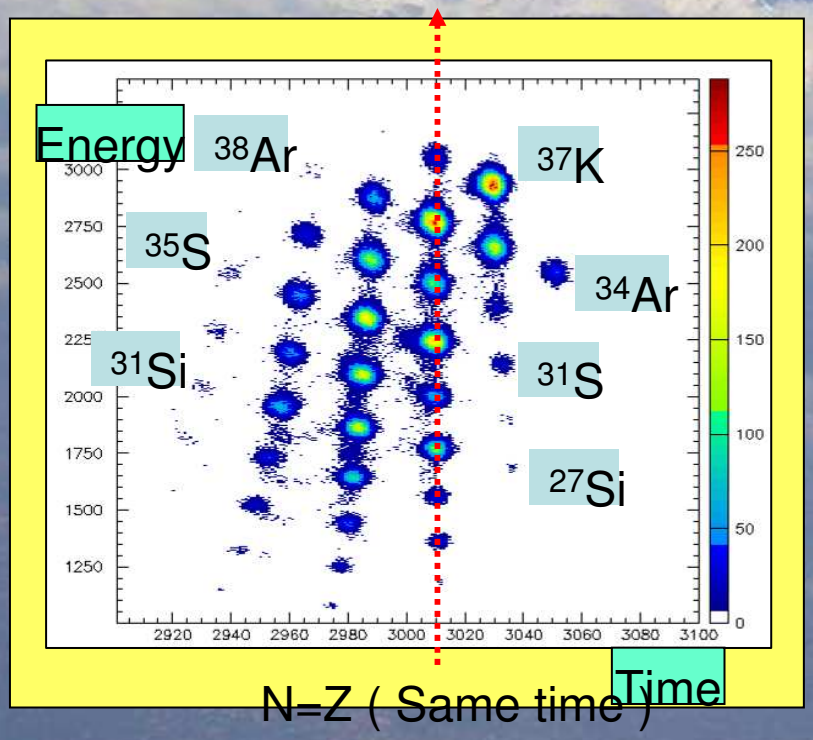
Z/N increase

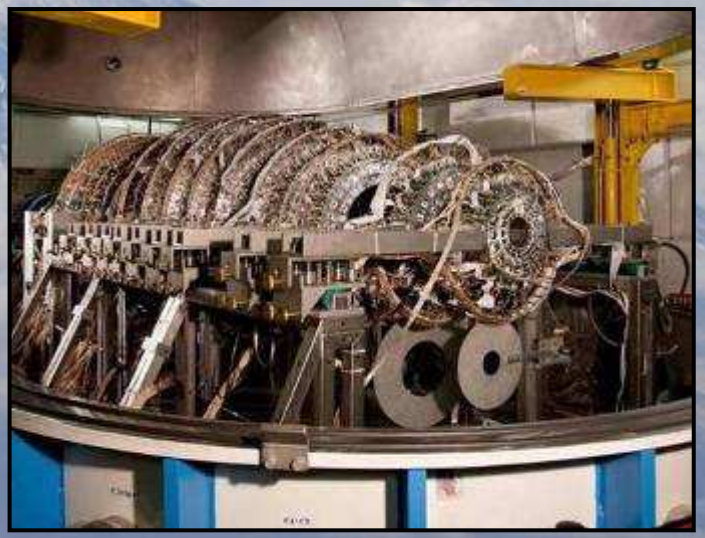
Width of even odd staggering in Z and N distribution depending on the N/Z of the system

Experiment in progress - Isospin dependence of reaction mechanisms

Following these results we decided to extend the investigations to a larger range of N/Z of the total system.

A first attempt was performed on February this year. The exotic mixed beams produced by fragmentation of ^{36}Ar was sent on a ^{27}Al target and reaction products where detected with CHIMERA

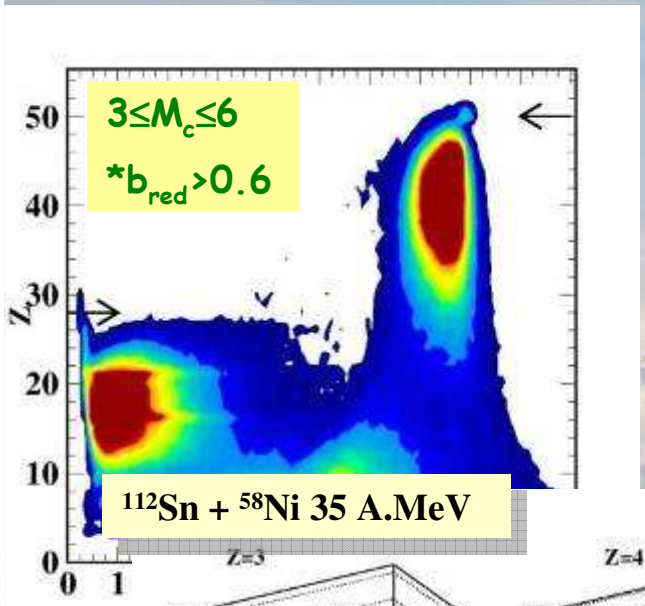


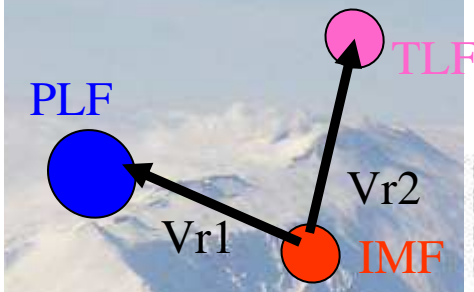


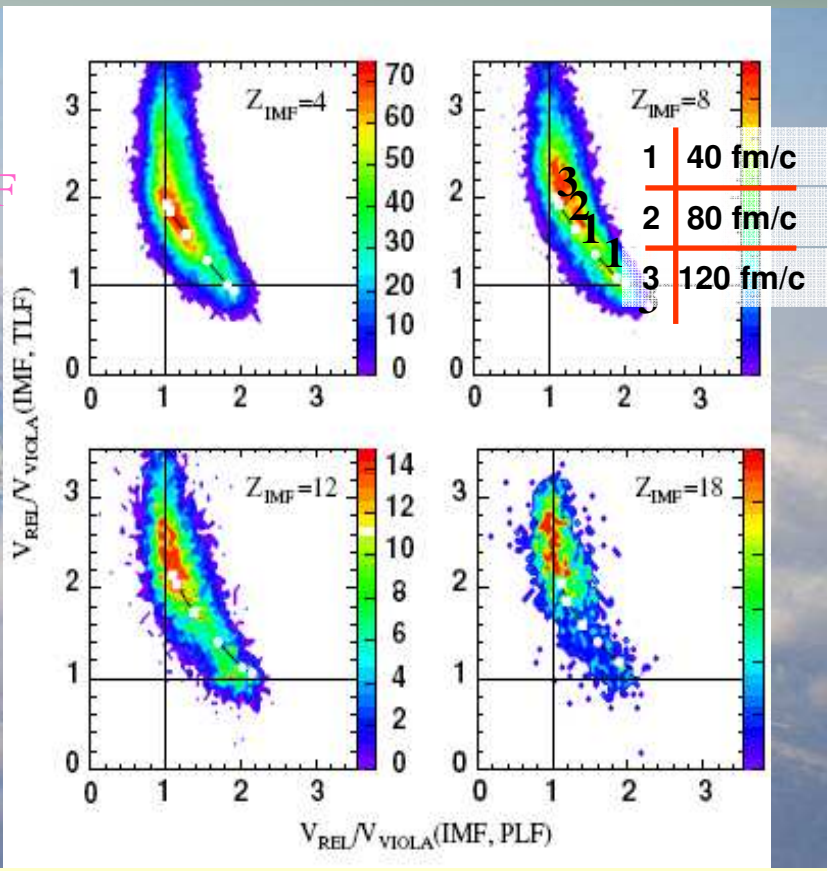
X+ ^{27}Al
~25MeV/A

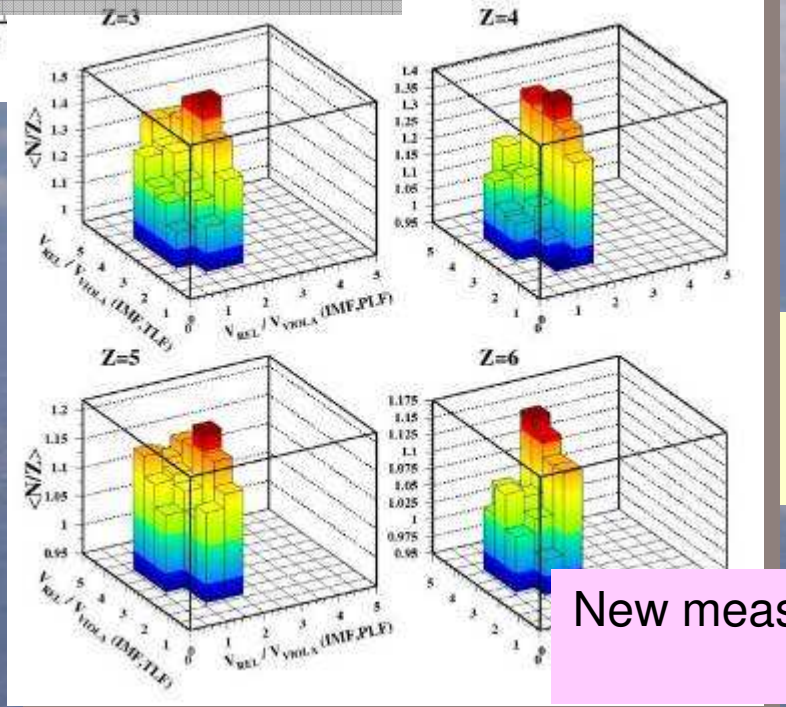
The analysis is going

Experiment in program: - IMF Emission Timescale in reactions induced by Ni ions on Sn – Isospin dependence -





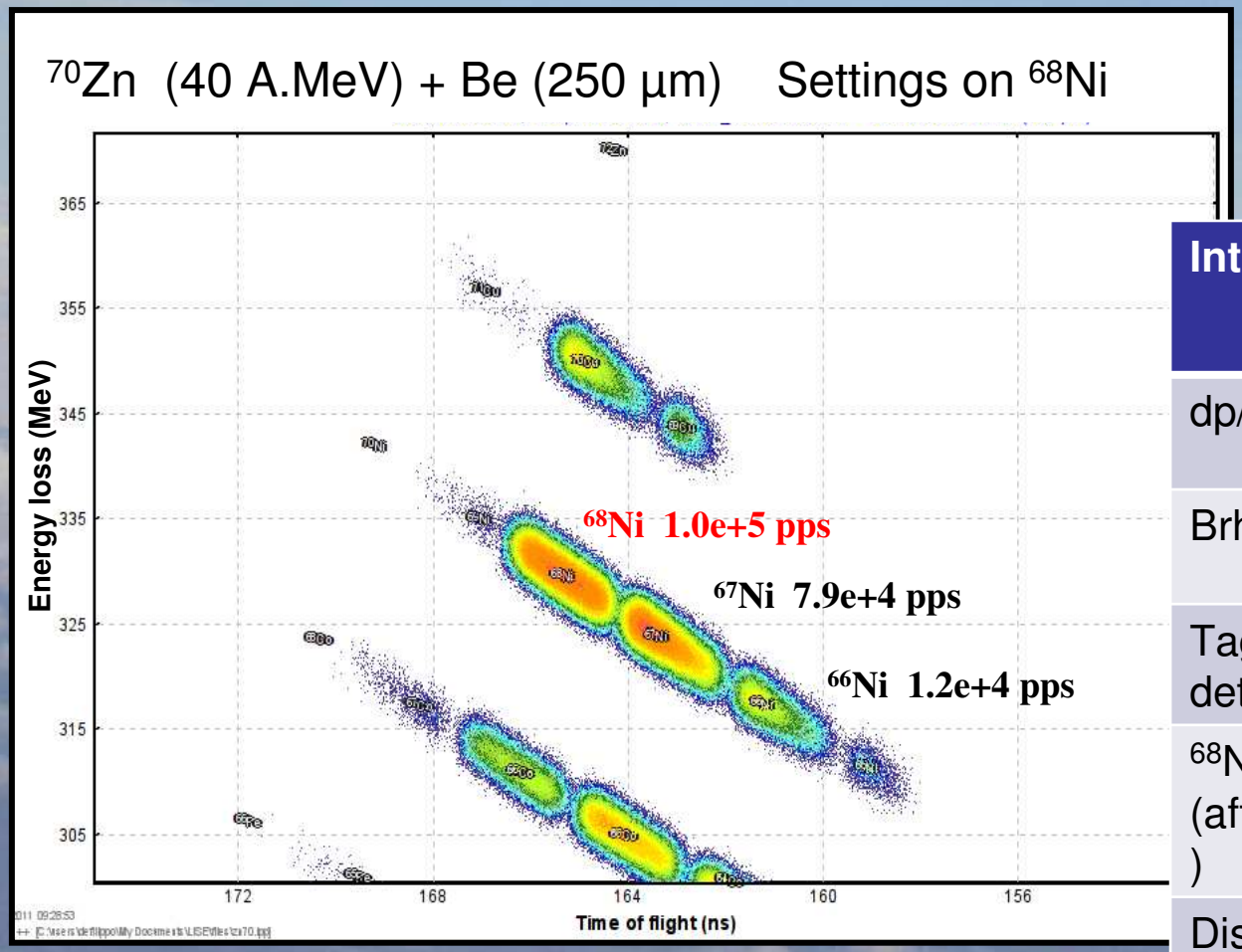




Measurements already performed with $^{64,58}Ni+^{112,124}Sn$ (direct and inverse kinematics)

New measurements with beams of ^{68}Ni (fragmentation of ^{70}Zn)

LISE++ simulations for ^{70}Zn primary beam at 40 A.MeV



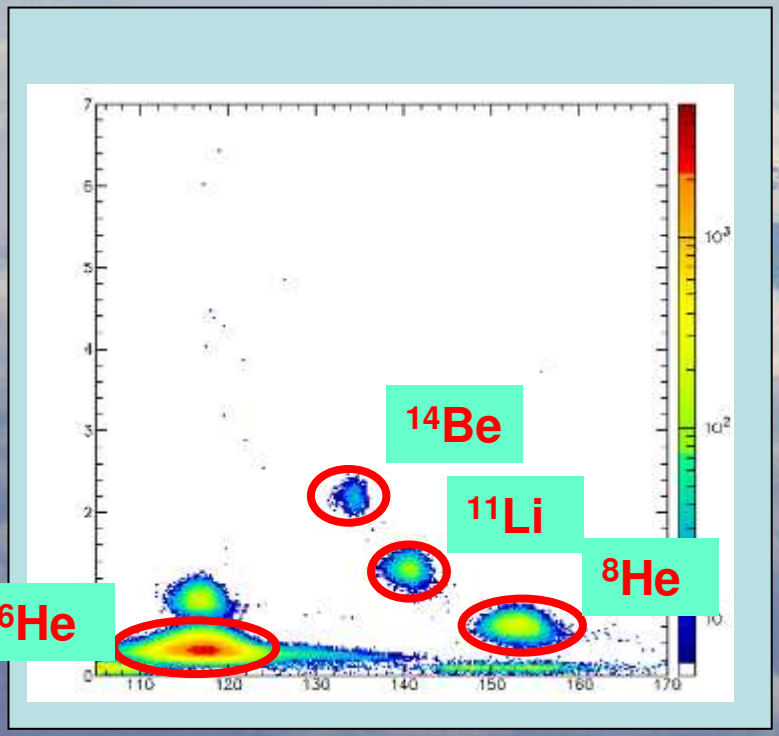
Intensity	0.1 kW (1071 enA)
dp/p	≈1.0%
Brho	2.03Tm
Tagging detector	Si 140 µm
^{68}Ni Energy (after tagging)	≈ 28 A.MeV
Distance MCP-DSSSD (time of flight path)	12.9 m

Lise++ settings for IFEB@LNS simulating the TOF-DE scatter plot of the tagging system for the chosen ^{68}Ni isotope

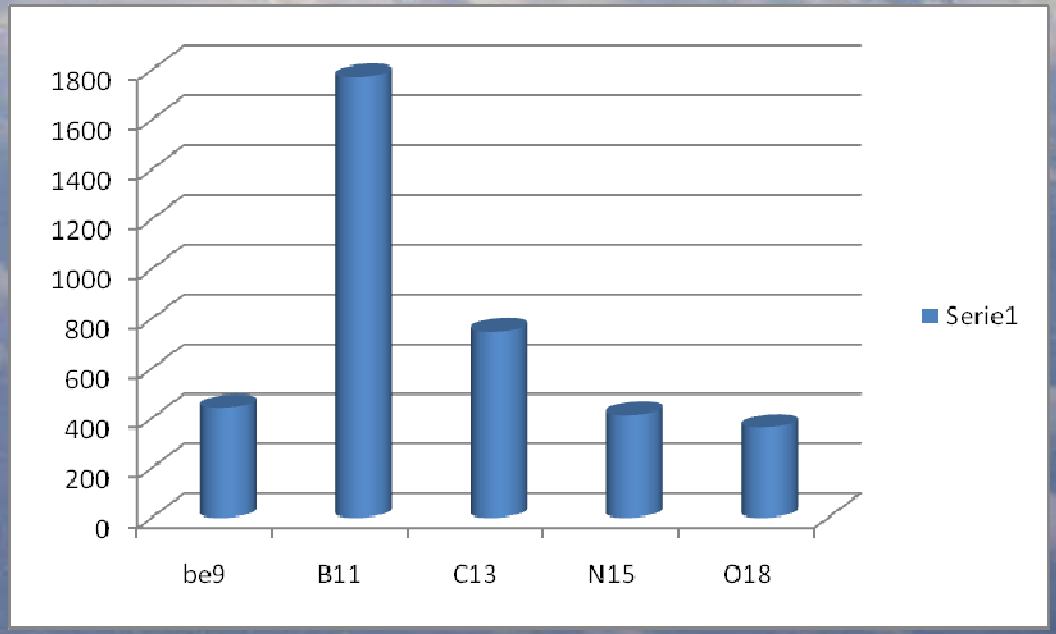
Lise++: O.B. Tarasov, D. Bazin, NIM B266 (2008) 4657.

Other test experiment coming

It is also in program to test 8He production by using a 11B primary beam



8He was already observed with 18O as primary beam – with 11B a much larger production is foreseen – 2kHz are expected by simulations



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