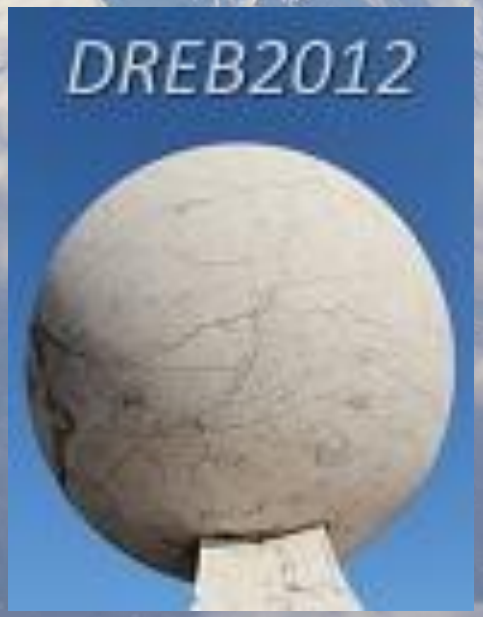
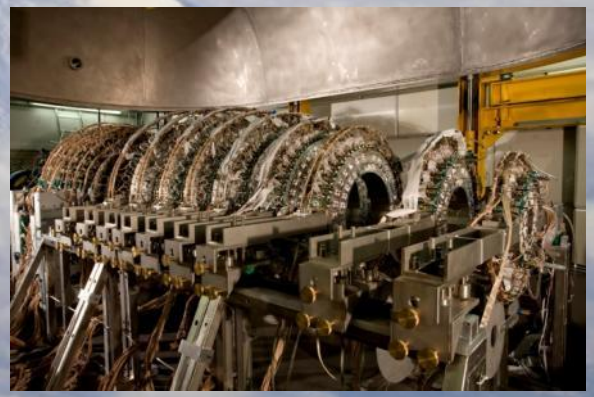
Reactions on light neutron rich nuclei with CHIMERA detector at LNS

G.Cardella
For the EXOCHIM collaboration





INFN Istituto Nazionale di Fisica Nucleare
Sezione di Catania

Summary

- I will speak about:
- the production system of fragmentation beams at LNS
- preliminary results on total cross sections for “elastic” and “transfer” channels
- perspectives

Fragmentation beams at INFN-LNS in Catania

Production Target

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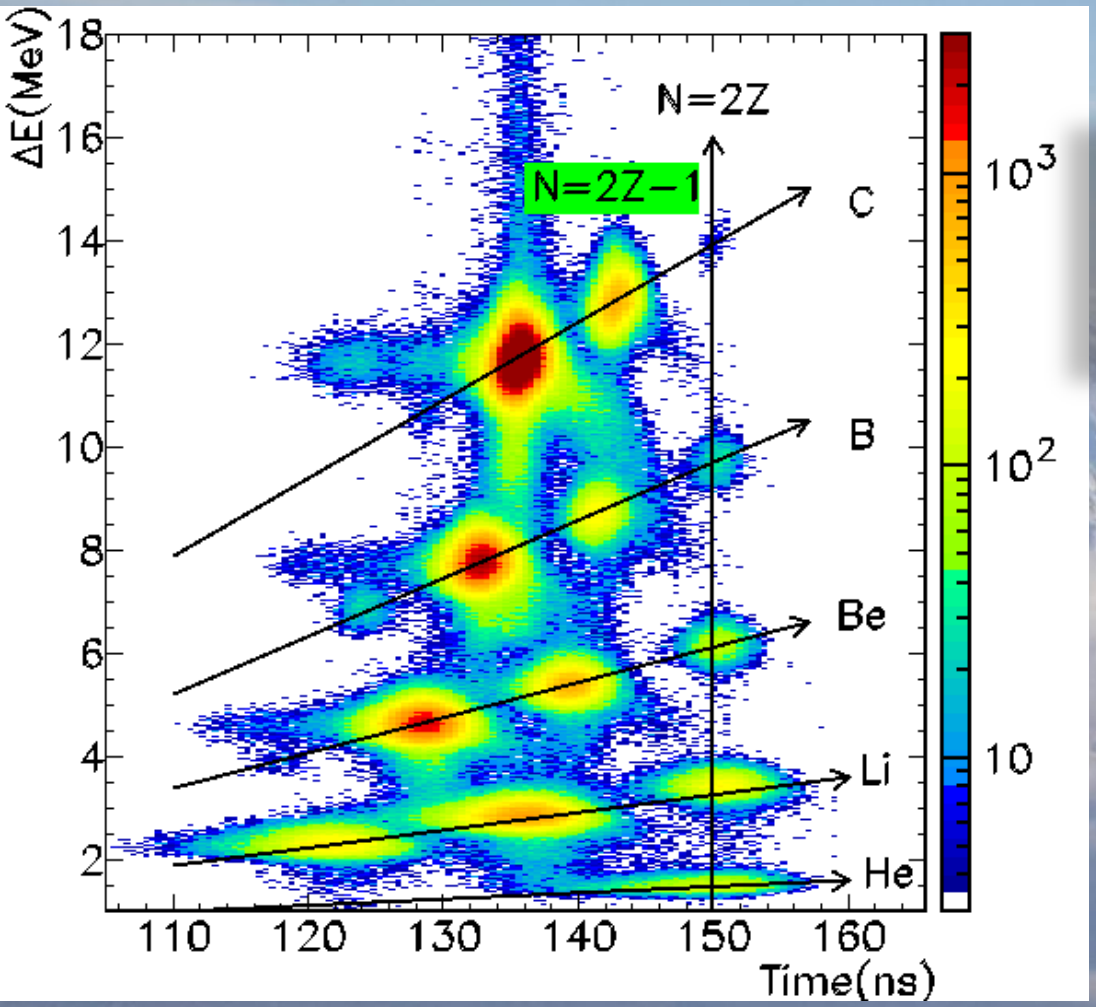
DREB2012

Beam identification

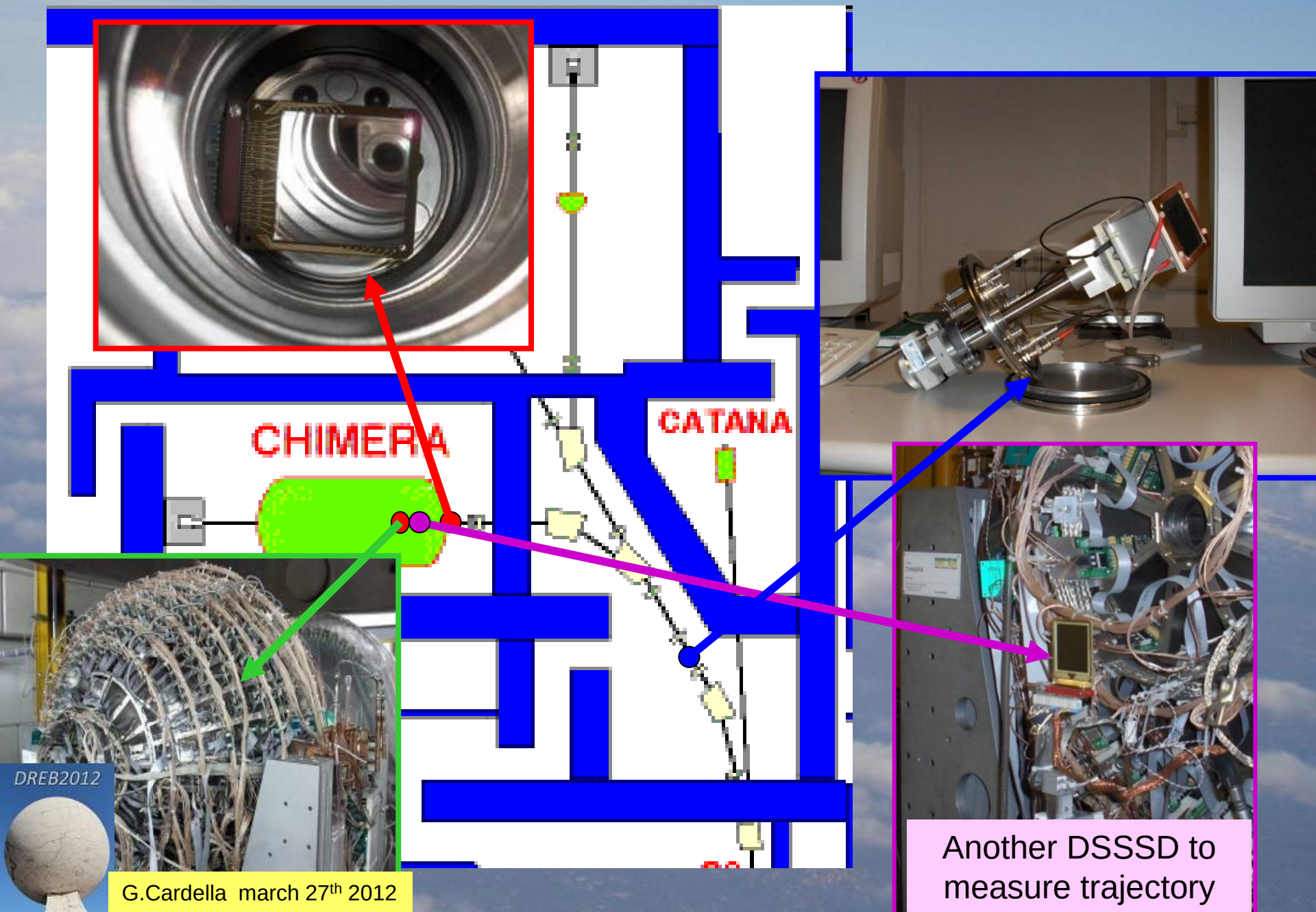


A fragmentation beam is generally a mixed beam and many efforts are devoted to improve its purity

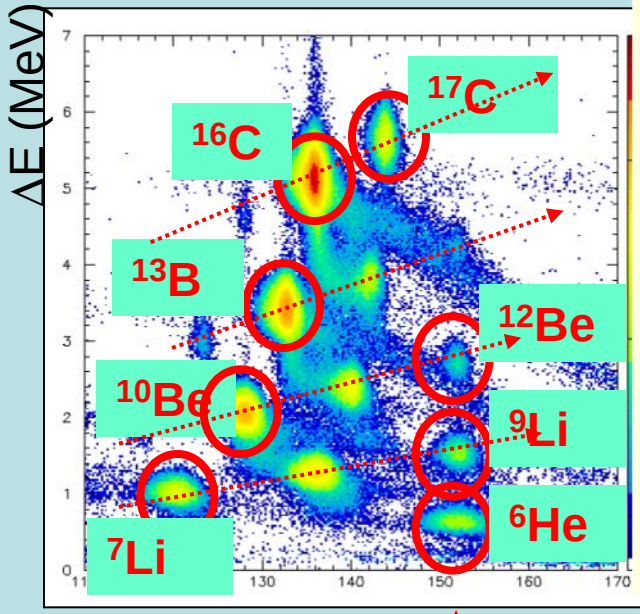
In our case we decided to use another approach – to identify event by event all beam nuclei performing many experiments at the same time

We have developed a tagging system working up to about 500 kHz

Tagging system: layout



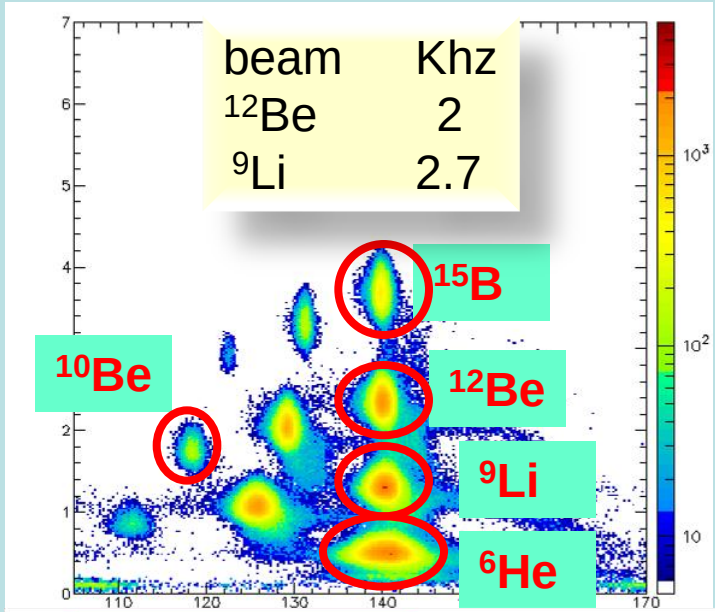
Intensities of some beams available in the CHIMERA Hall



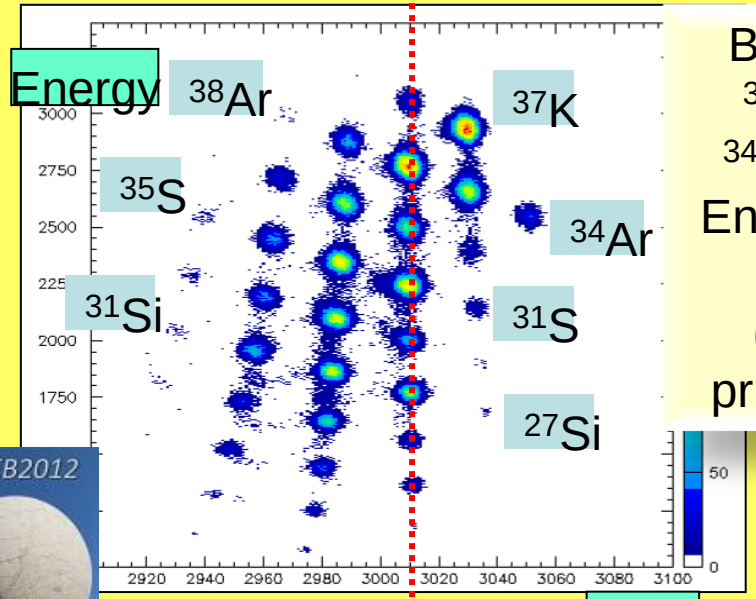
^{18}O 55 MeV/A 100 W primary beam (6.3×10^{11} p/s)

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

E~50 MeV/A
ΔP/P <1%

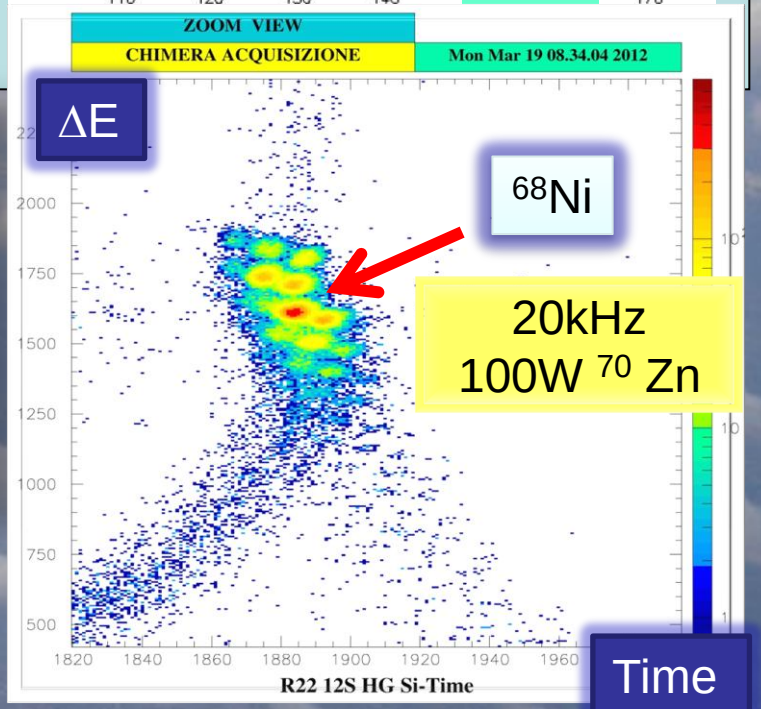


beam	Khz
^{12}Be	2
^{9}Li	2.7



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

Energy ~ 20-25 MeV/A (25 W ^{36}Ar primary beam)



20kHz
100W ^{70} Zn

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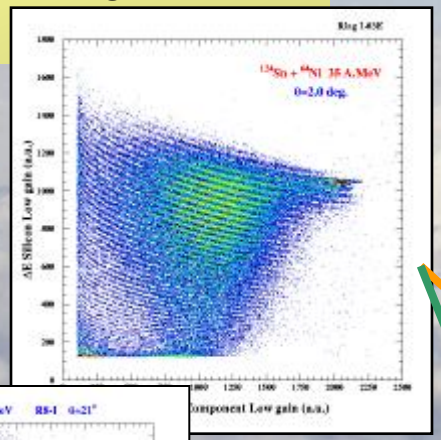
The Detector : built for multifragmentation - useful for many other thinks

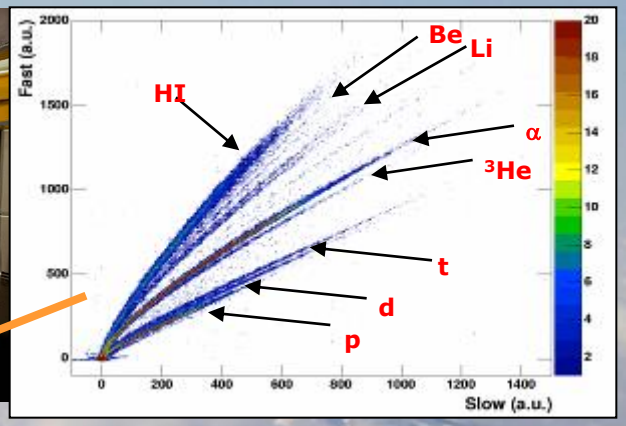
ΔE(Si)-E(CsI)

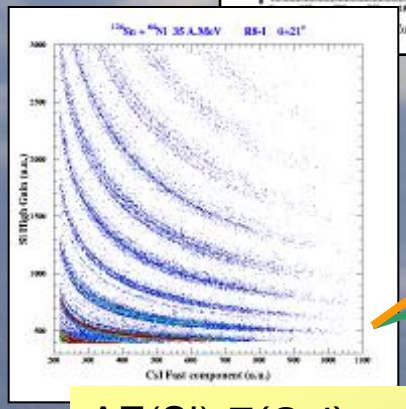
Charge Z for particles punching through the Si detector



PSD in CsI(Tl)

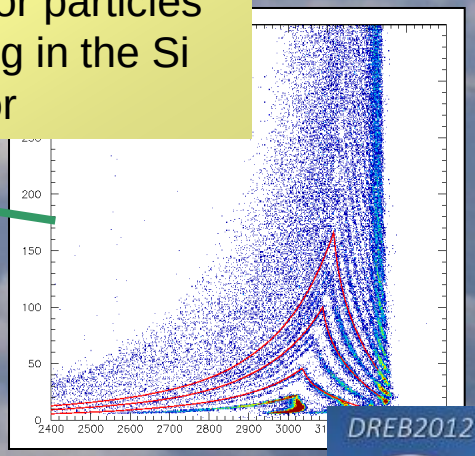
Z and **A** for light charged particles





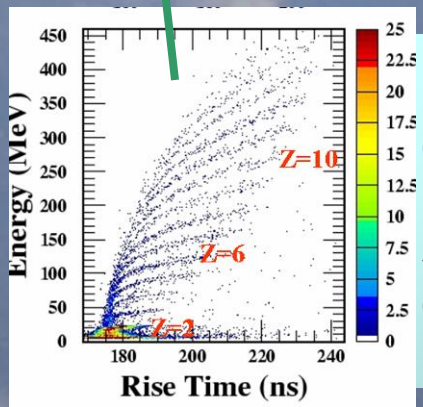
ΔE(Si)-ToF

Mass for particles stopping in the Si detector



ΔE(Si)-E(CsI)

Charge Z and A for light ions (Z<9) punching through the Si detector



E(Si)-Rise time

Charge Z for particle stopping in Si detectors (**NEW**)

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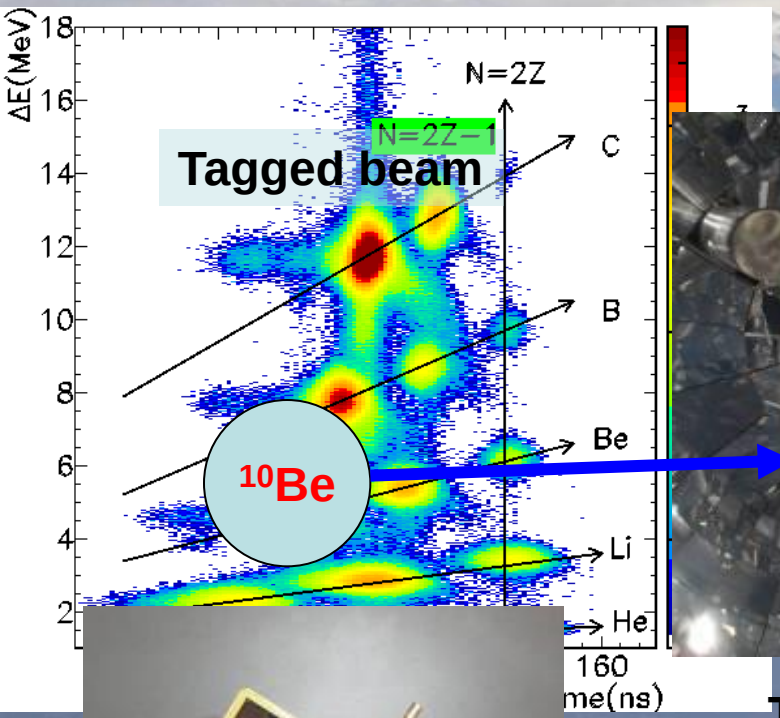
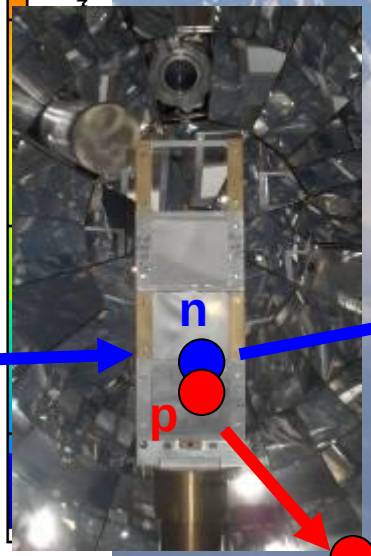
-Neutron transfer reactions near halo nuclei -

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





^{11}Be

p

Target d

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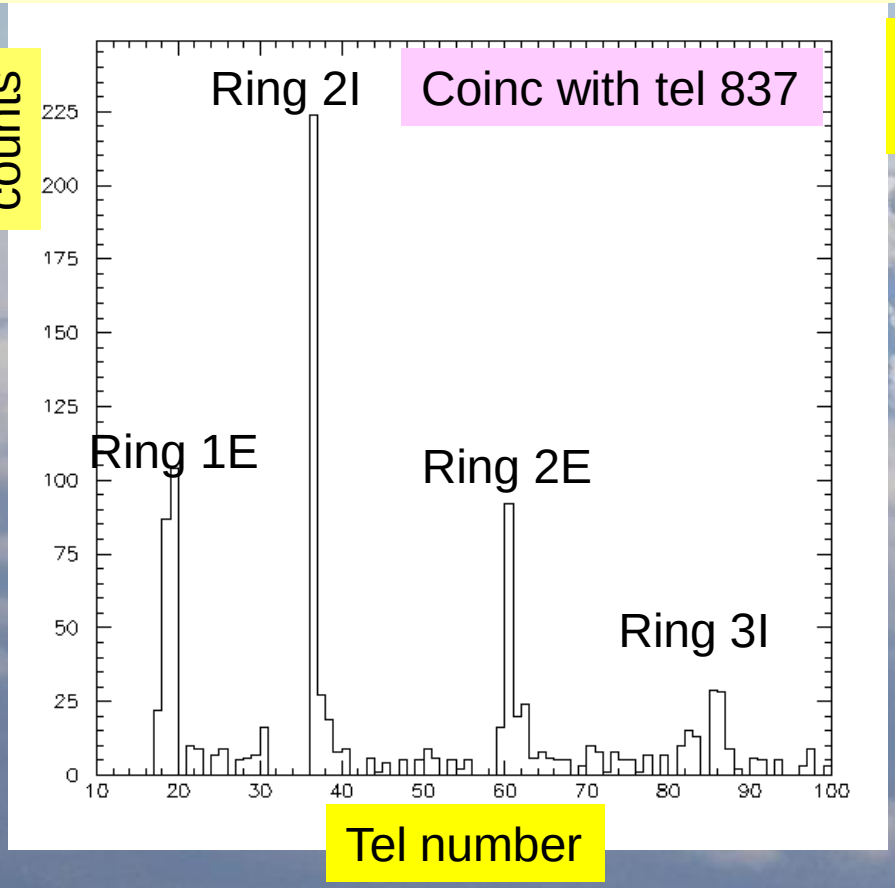
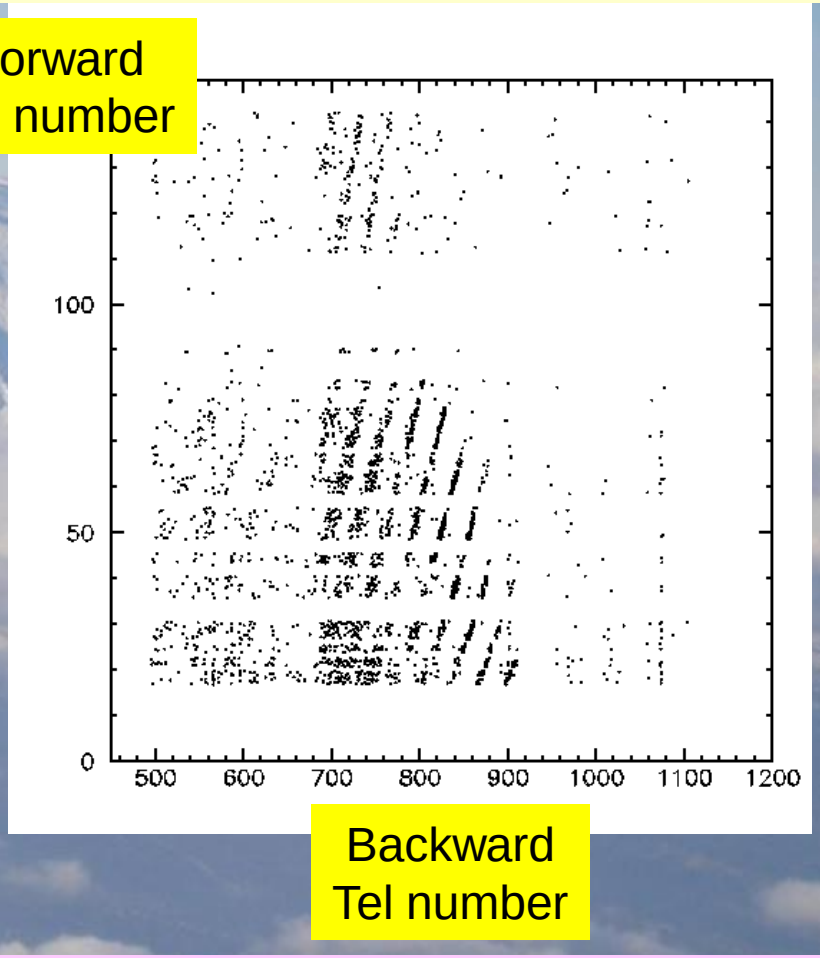
– Some preliminary results on “elastic-inelastic channel”

The effect of kinematical coincidences can be seen looking to coincidences as a function of telescope numbers

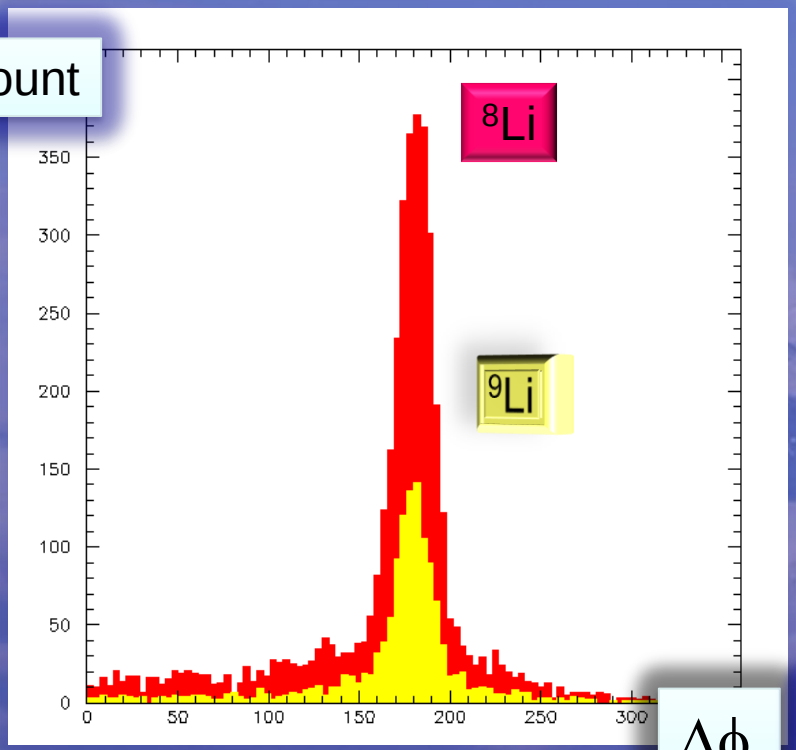


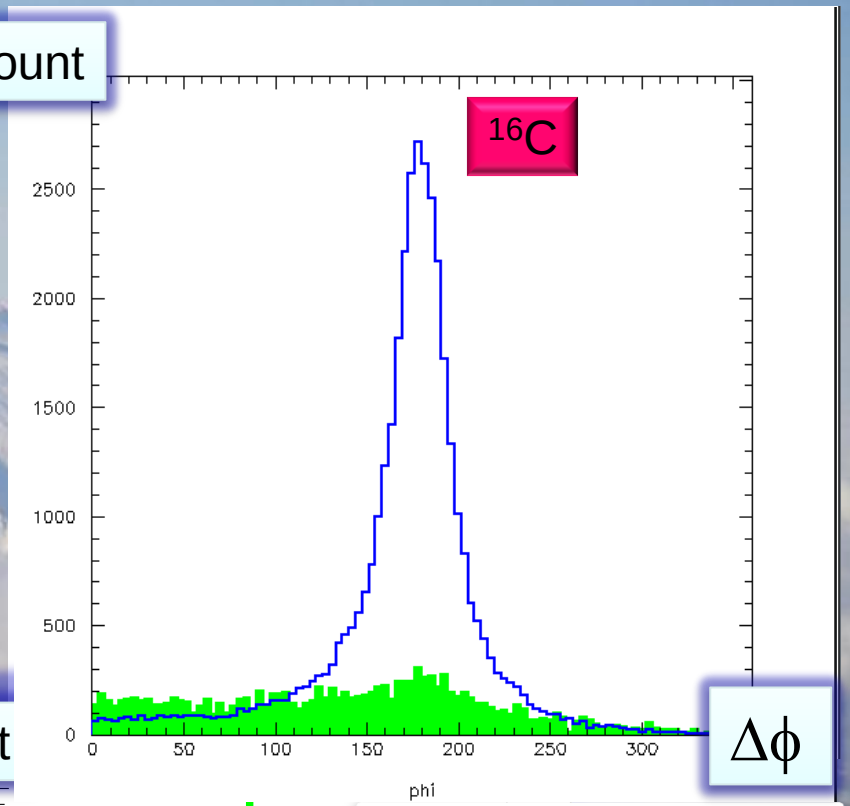


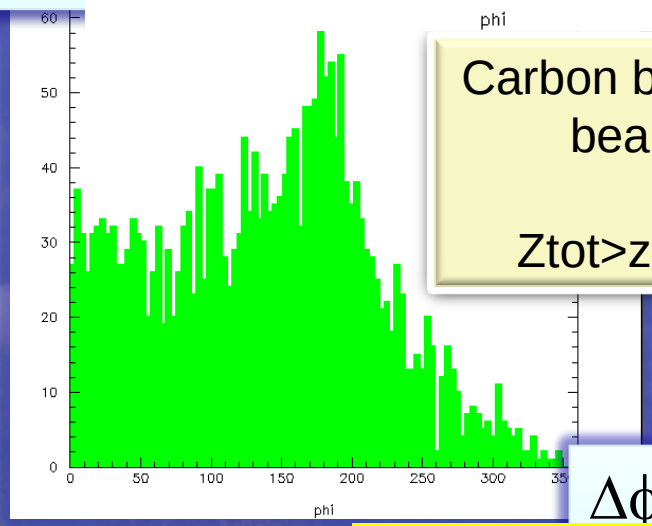
The coincidence rate is enhanced with telescopes at the right azimuthal angle

There is a very precise path between the telescopes in coincidence

– Some preliminary results on “elastic-inelastic channel”







We can plot the Δϕ angle between the two coincidence detectors putting constraints on the complete event reconstruction (Mult=2, ztot = zbeam+1)

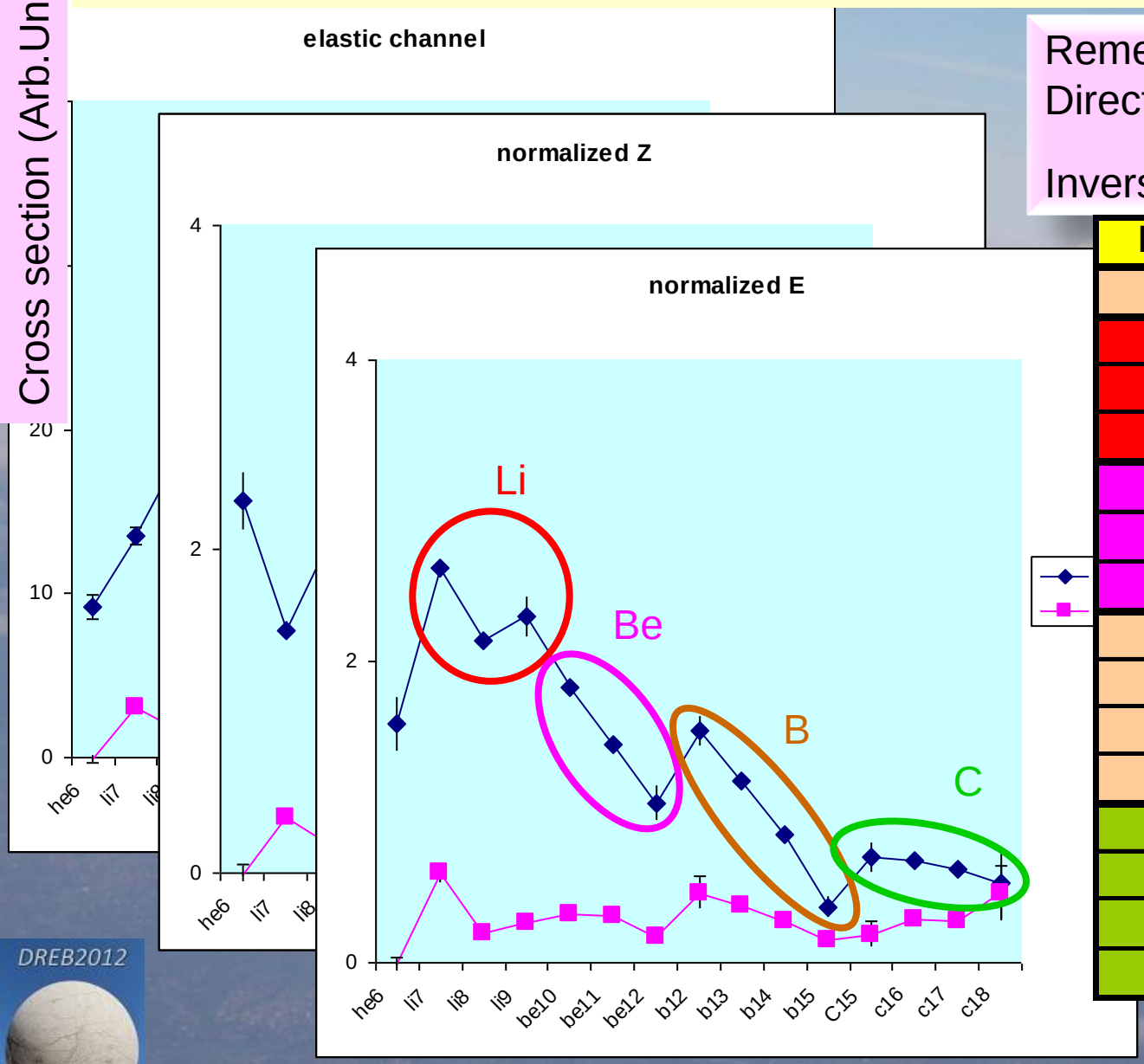
Δϕ width for elastic channels due to the finite opening of the detectors + effects of reactions + background

Carbon background beam ^{16}C

Ztot>zbeam+1

– Some preliminary results on "elastic-inelastic channel"

We can get some preliminary total cross section integrating the $\Delta\phi$ correlation peak



Remember Rutherford
Direct dependence on Z^2

Inverse dependence on E^2

BEAM	MeV/A	count
6He	41.6	8.26E+07
7Li	66.0	1.60E+08
8Li	50.9	3.46E+08
9Li	41.9	7.72E+07
10Be	56.3	7.35E+08
11Be	48.2	2.15E+08
12Be	40.4	2.80E+07
12B	62.7	1.40E+07
13B	52.1	9.36E+08
14B	47.0	8.78E+07
15B	40.4	1.90E+07
15C	57.9	5.41E+06
16C	49.5	1.81E+09
17C	46.4	1.75E+08
18C	40.4	1.42E+06

To be corrected for the efficiency

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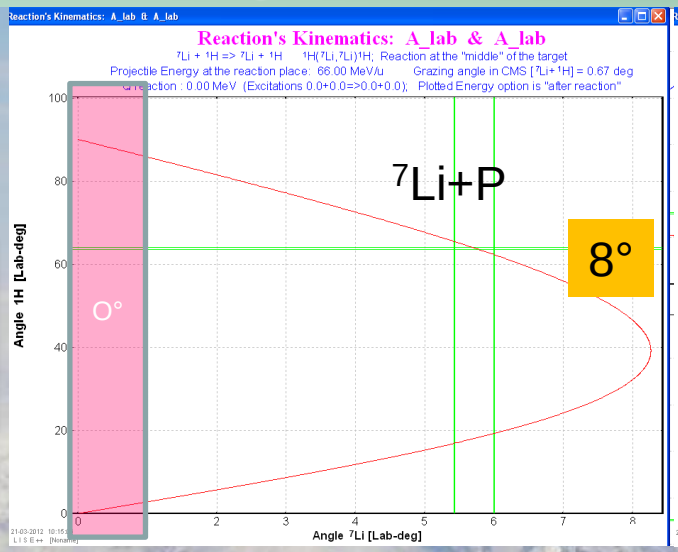
Efficiency – the kinematics effect -

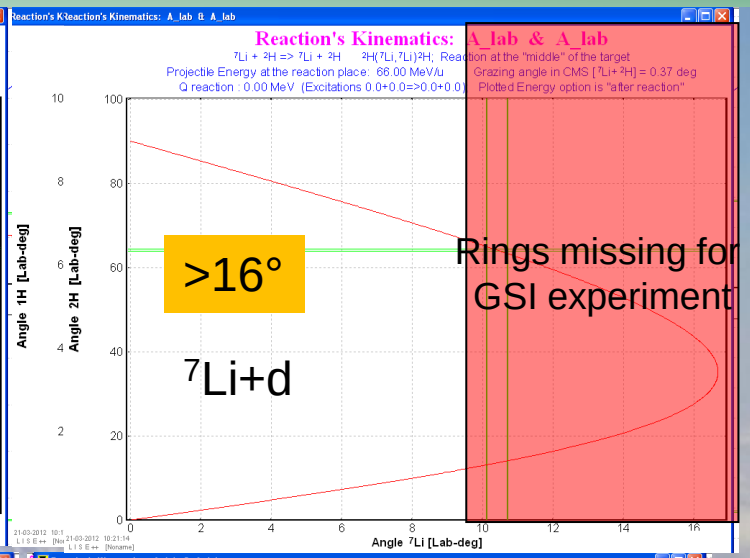
Less efficiency for heavy on p

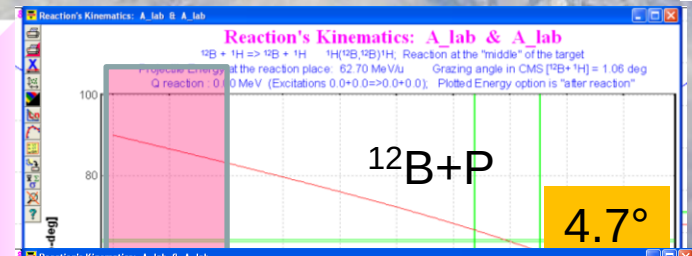
Due to missing rings less efficiency for light on d

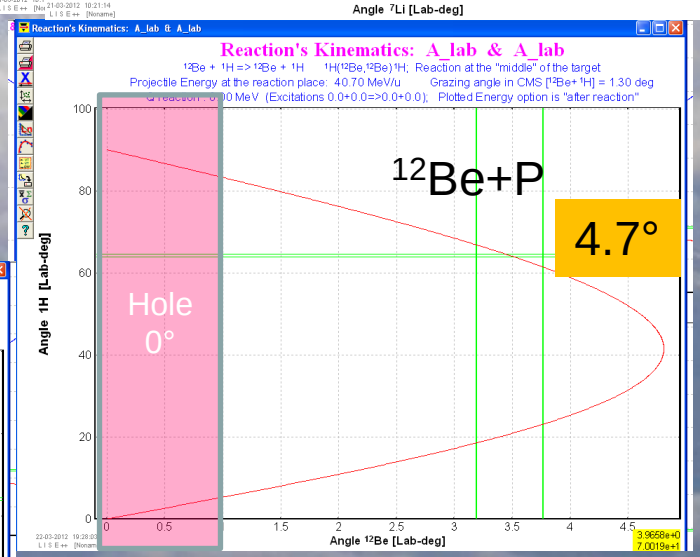
Same efficiency for same mass ^{12}B and ^{12}Be (even if with different beam energy)

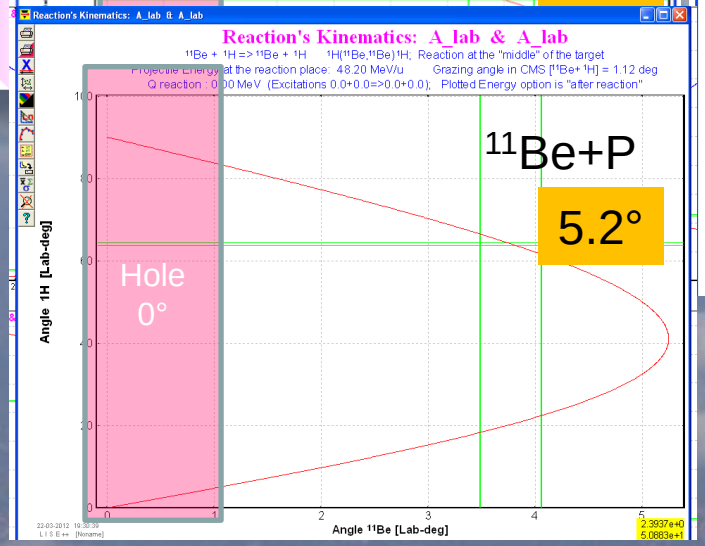
Slightly better efficiency decreasing the mass (the hole at 0° is less important)











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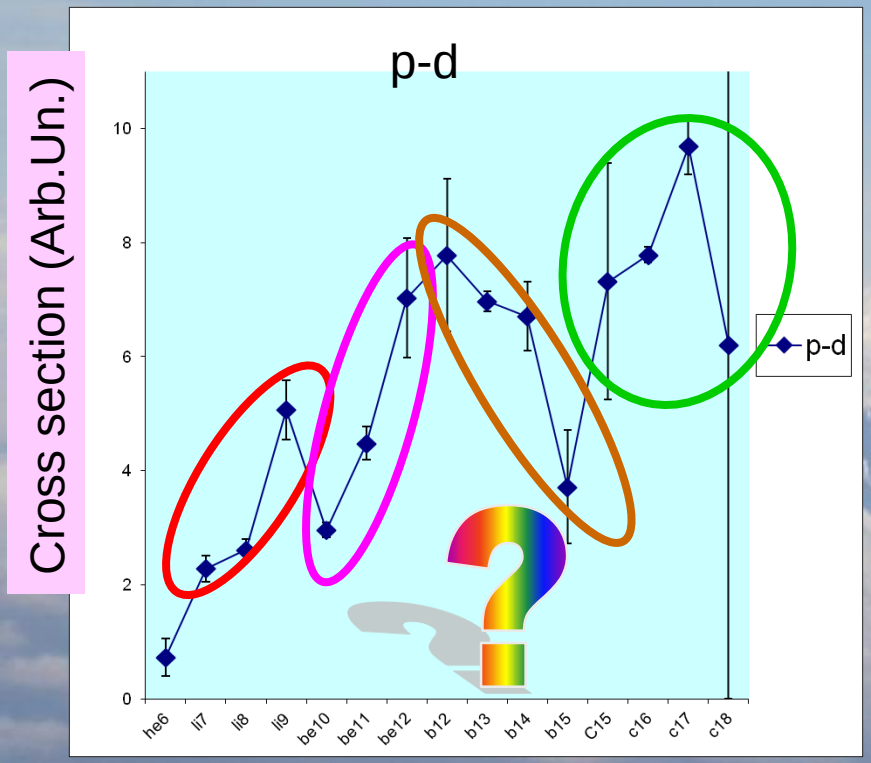
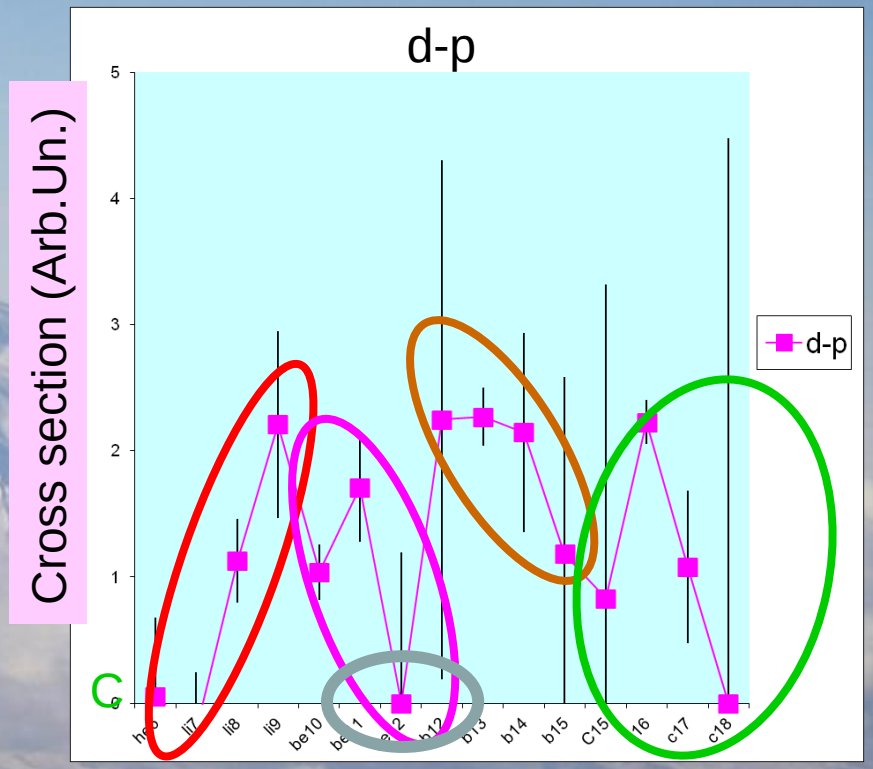
– Preliminary results on “1n channel”





Cross section p-d grows increasing the neutron number
Odd even effects can be seen
why B decreases?

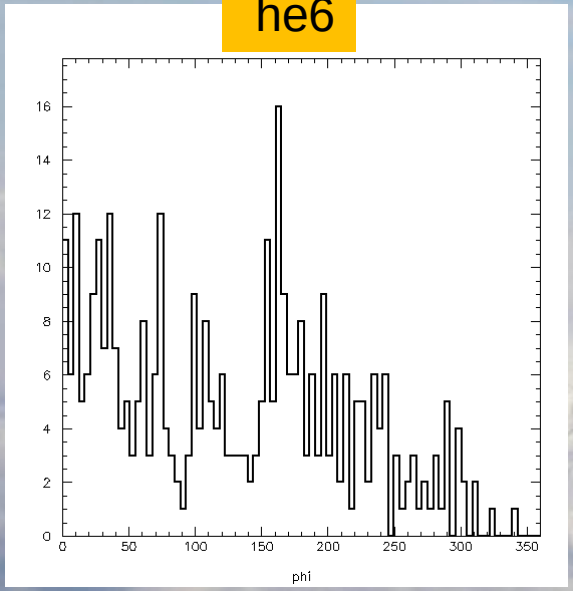
Cross section d-p decreases increasing the neutron number with some fluctuations
mostly odd-even effects

Interesting high ^{9}Li d-p cross section (formation and decay of ^{10}Li)

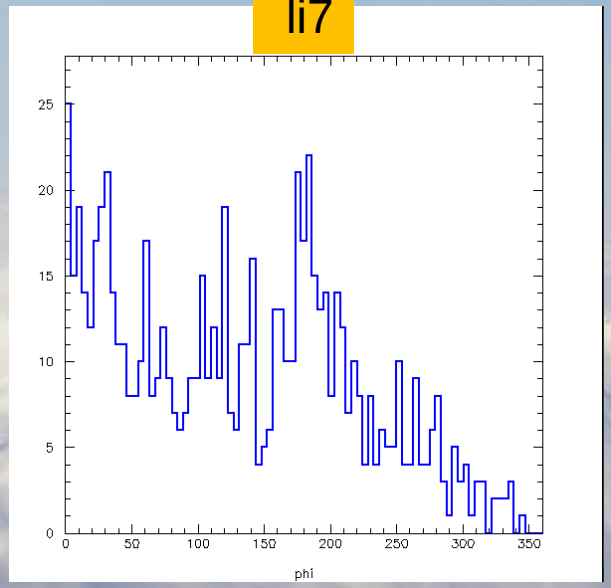
No? cross section for ^{12}Be d-p cross section (no? ^{13}Be formation and decay)

– Preliminary results on “d-p channel”

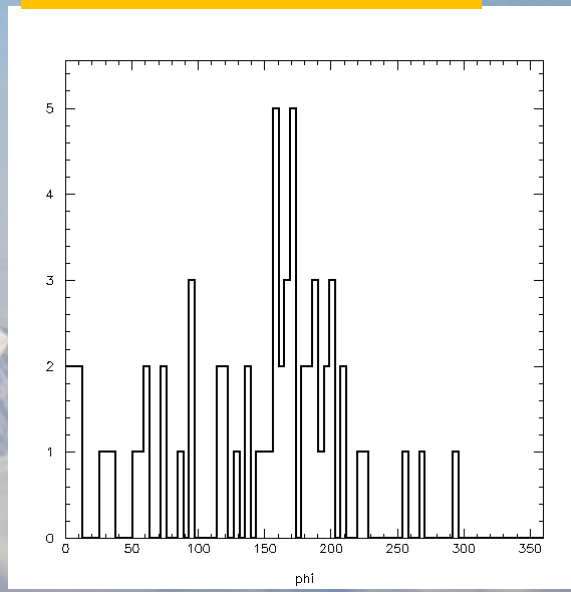
he6



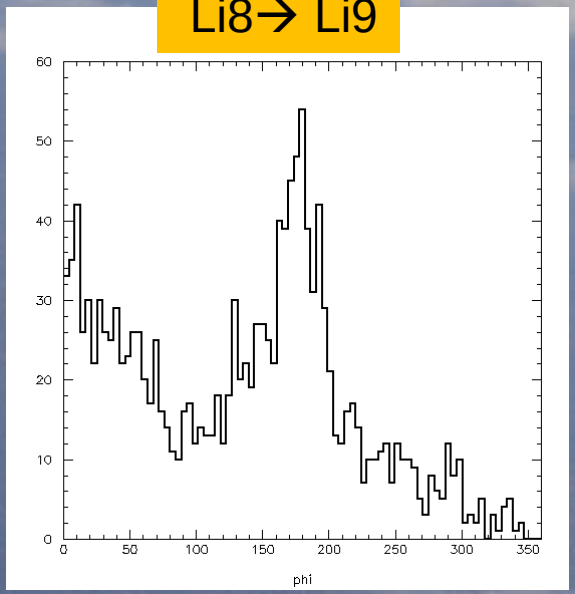
li7



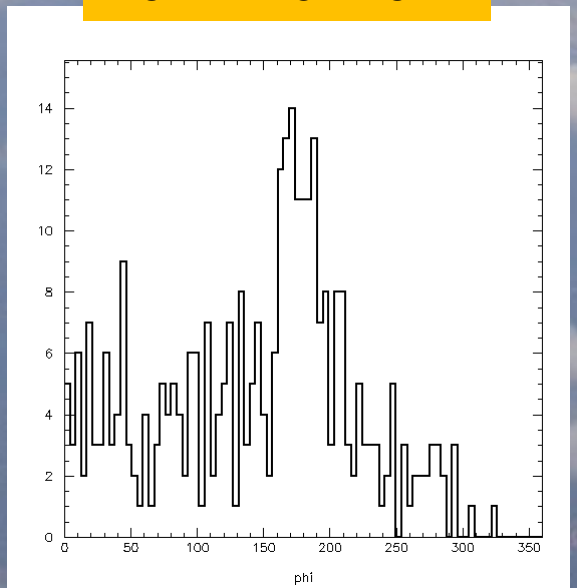
B15→ B16→B15+n



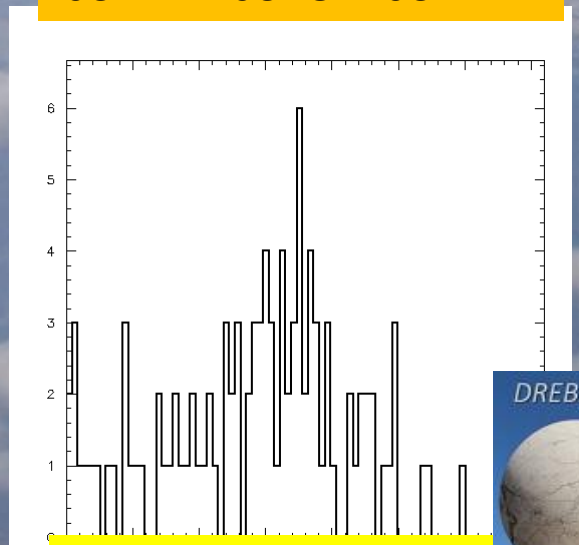
Li8→ Li9



Li9→ Li10→li9+n



be12→ be13→be12+n



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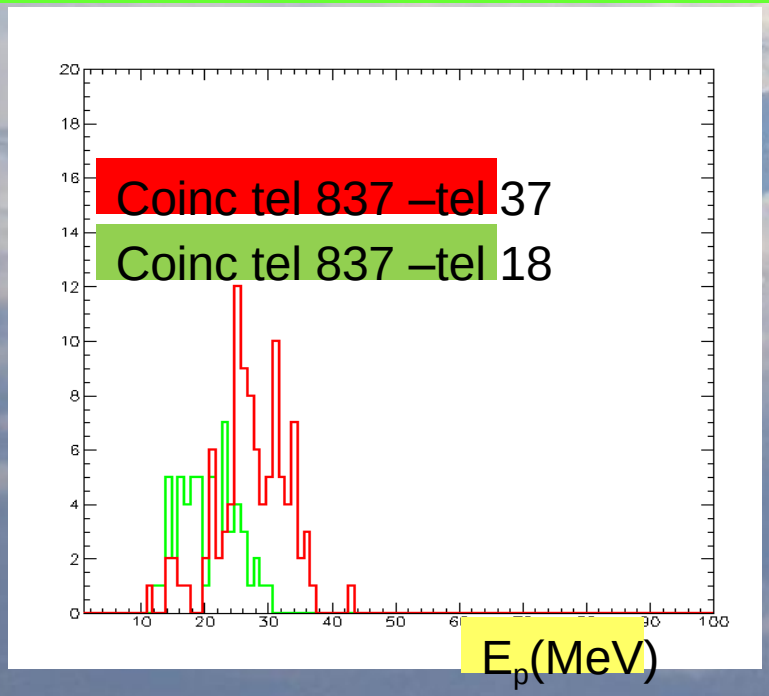
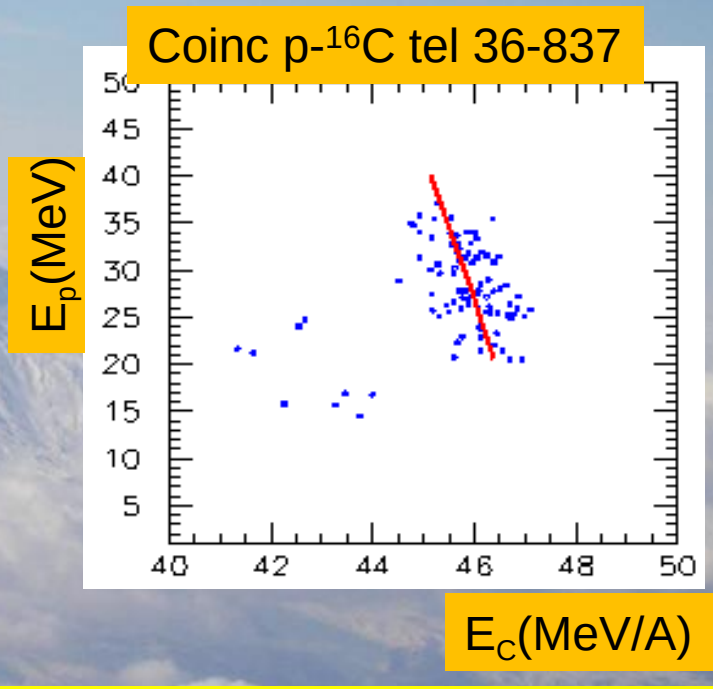
– Some preliminary results on elastic scattering –energy correlations

Now we must improve our results using the energy information

Looking the energy spectrum we have a large spread in the elastic channel due to kinematics and….



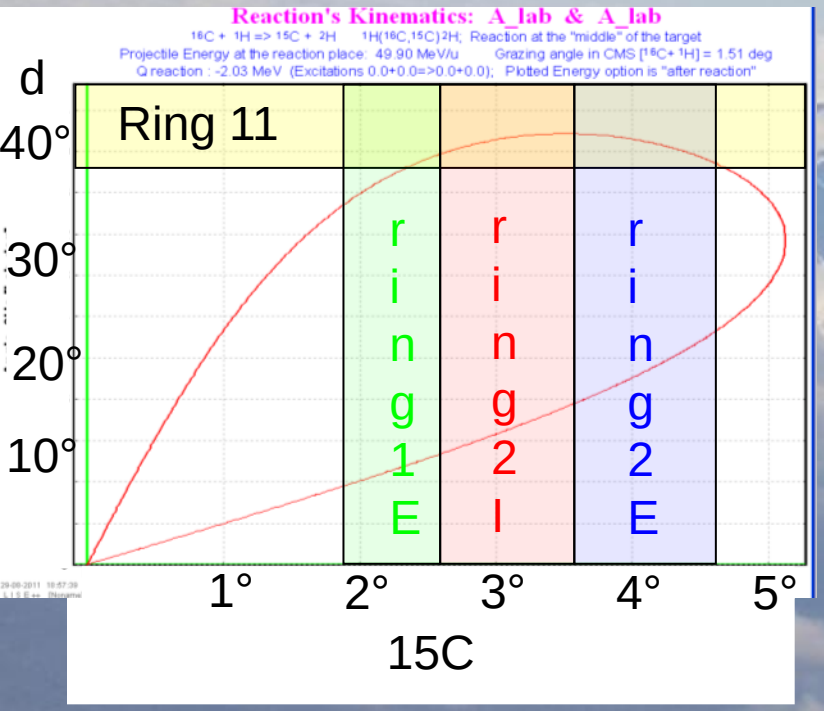


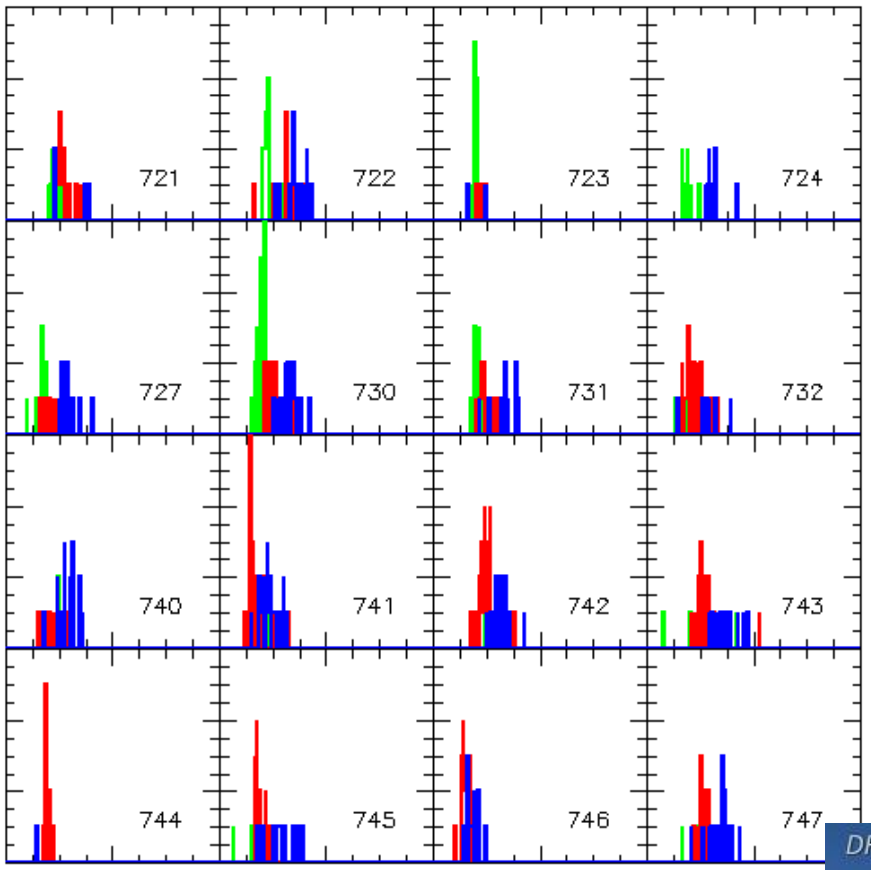
We must remember that the fragmentation beam has a momentum spread of about 1%

TOF (beam TOF from mcp to tagging detector)
ΔE (energy loss in tagging detector)
Bρ (from trajectory measurements after a magnet)

– Some preliminary results on “p-d channel” - energy/angular correlations

We can look the $^{16}C+p \rightarrow ^{15}C+d$ reaction searching deuterons in coincidence with carbon





Deuteron energy released in CsI

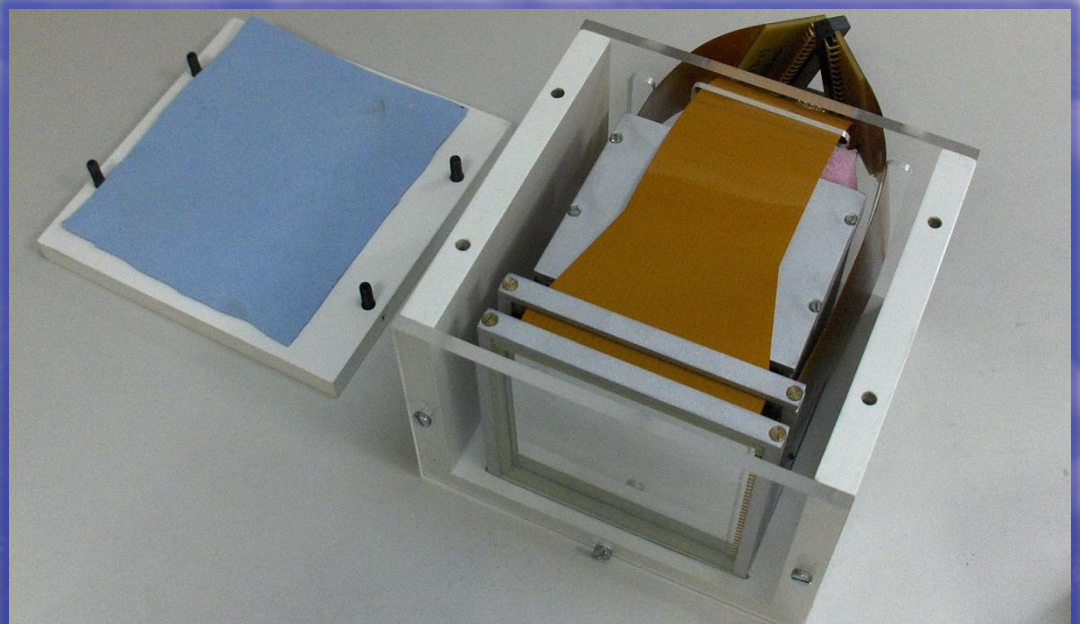
Using energy information we will better clean $\Delta\phi$ spectra obtaining also angular distributions

Conclusions and perspectives

Using cocktail neutron rich beams with the CHIMERA detector we are able to compare total channel cross sections for many ions searching for halo or other structure effects

The 4π detection efficiency is very useful and allow the extensive use of the kinematical coincidence technique

For the future activities we are working to improve our detection capabilities and resolutions coupling CHIMERA to a new high efficiency strip telescope array FARCOS and to neutron detectors – see the discussion on future experimental devices - S. Pirrone



ΔEstrip-ΔEstrip-E CsI
Strip 32x32
300 μm + 1500 μm + 6cm

L.Acosta1, C.Agodi1, A.Amato1, F.Amorini1,3, A.Anzalone1, L.Auditore4, I.Berceanu9, L.Calabretta1, C.Calì1, G.Cardella2,*, S.Cavallaro1, M.B.Chatterjee10, L.Cosentino1, M.D'Andrea2, B.Diana1, A.Di Stefano1, E.De Filippo2, N.Giudice2, L.Grassi2,3, A.Grimaldi2, N.Guardone2, E.La Guidara2,5, F.Ferrera1, E.Furia1, G.Lanzalone1,6, P.Litrico1, I.Lombardo1,6, D.Loria4, S.Marino1, A.Maugeri1, T.Minniti4, A.Pagano2, M.Papa2, A.Pappalardo1, S.Passarello1, G.Passaro1, S.Pirrone2, G.Politi2,3, F.Porto1,3, S.Pulvirenti1, C.Rapicavoli2, D.Rifuggiato1, G.Rizza2, F.Rizzo1,3, A.Rovelli1, P.Russotto1,3, G.Saccà2, S.Salamone1, S.Santoro4, F.Sarta1, A.Seminara1, A.Trifirò4, M.Trimarchì4, G.Verde2, M.Vigilante8

1) INFN Laboratori Nazionali del Sud, Catania, Italy

2) INFN, Sezione di Catania, Catania, Italy

3) Dipartimento di Fisica e Astronomia Università di Catania, Italy

4) INFN gruppo collegato di Messina & Dipartimento di Fisica e Astronomia Università di Messina, Italy

5) Centro Siciliano di Fisica Nucleare e Struttura della Materia, Italy

6) Università Kore di Enna, Enna, Italy

7) INFN Sezione di Milano & Dipartimento di Fisica e Astronomia Università di Milano, Italy

8) INFN Sezione di Napoli & Dipartimento di Fisica e Astronomia Università di Napoli, Italy

9) Institute for Physics and Nuclear Engineering, Bucharest, Romania

10) Saha Institute of Nuclear Physics, Kolkata, India