Reactions on light neutron rich nuclei with CHIMERA detector at LNS

G. Cardella
For the EXOCHIM collaboration
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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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.
Another DSSSD to measure trajectory

Tagging system: layout

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Intensities of some beams available in the CHIMERA Hall

- **^{18}O**: 55 MeV/A 100 W primary beam (6.3x10^{11} p/s) beam
- **^{12}Be**: 2 Khz
- **^{9}Li**: 2.7 Khz
- **^{16}C**: 60
- **^{13}B**: 40
- **E~50 MeV/A**
- **ΔP/P <1%**

- **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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- **^{38}Ar**
- **^{35}S**
- **^{34}Ar**
- **^{31}S**

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- **^{68}Ni**
- **^{27}Si**

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**Time**
\[ \Delta E(Si) - E(CsI) \]

**Charge Z** for particles punching through the Si detector

\[ \Delta E(Si) - \text{ToF} \]

**Mass** for particles stopping in the Si detector

\[ \Delta E(Si) - E(CsI) \]

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

**PSD in CsI(Tl)**

**Z** and **A** for light charged particles

\[ E(Si) - \text{Rise time} \]

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

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We want to 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.
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.

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Some preliminary results on “elastic-inelastic channel”

We can plot the $\Delta \phi$ angle between the two coincidence detectors putting constraints on the complete event reconstruction ($\text{Mult}=2$, $\text{ztot}=\text{zbeam}+1$)

$\Delta \phi$ width for elastic channels due to the finite opening of the detectors + effects of reactions + background

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

Remember Rutherford Direct dependence on $Z^2$

Inverse dependence on $E^2$
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)

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Preliminary results on “d-p channel”

Li\textsubscript{8} \rightarrow Li\textsubscript{9}

Li\textsubscript{9} \rightarrow Li\textsubscript{10} \rightarrow li\textsubscript{9}+n

Be\textsubscript{12} \rightarrow Be\textsubscript{13} \rightarrow Be\textsubscript{12}+n
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)
\[ \Delta E \] (energy loss in tagging detector)
\[ B_\rho \] (from trajectory measurements after a magnet)

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

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

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

Deuteron energy released in CsI
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 \(4\pi\) 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.

\[\Delta\text{E}_{\text{strip}} - \Delta\text{E}_{\text{strip}} - E\text{ CsI} \]

Strip 32x32
300 \(\mu\)m + 1500 \(\mu\)m + 6cm

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