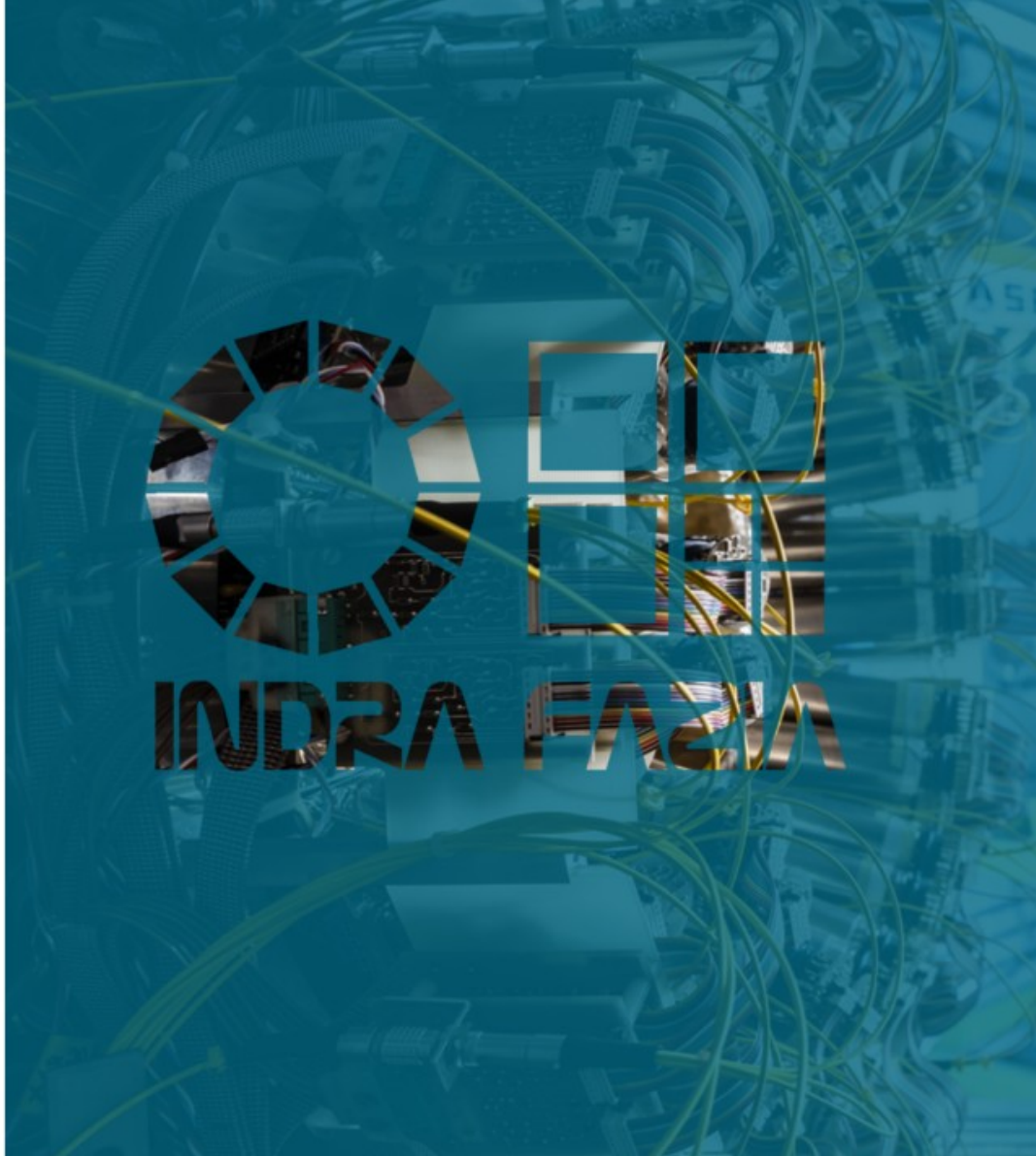
A physics case for $^{12}C+^{12}C$ at 8.75 MeV/nuc : direct reactions and spectroscopy with FAZIA

Diego Gruyer, LPC Caen



Context

During the E818 experiment, we asked for two calibration beams :

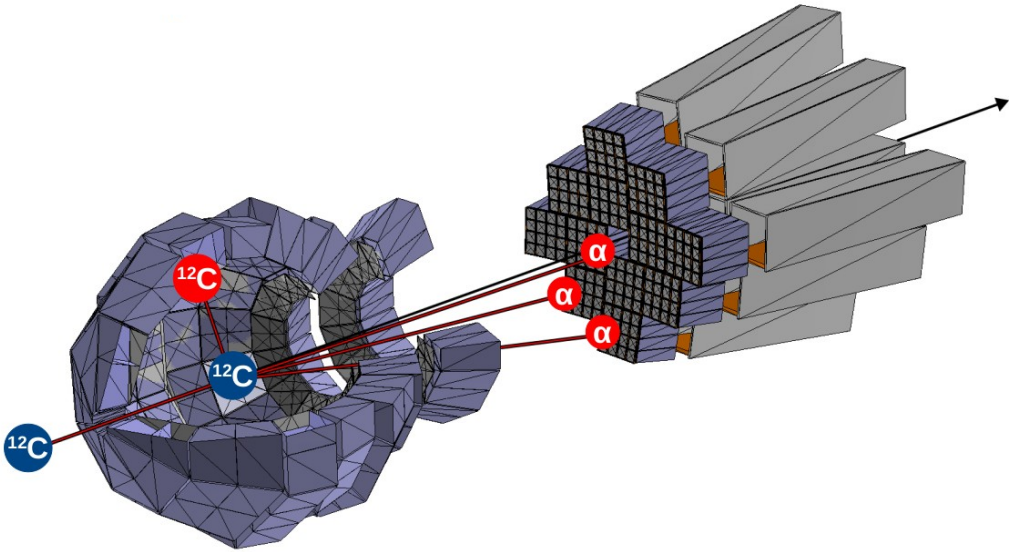
- ^{12}C at 8.75 MeV/nuc to stop in Si1 (CSS1)
- ^{12}C at 13.75 MeV/nuc to stop in Si2 (CIME)

The quality of the CIME beam was excellent.

Extra systems

The calibration was fast so we have also measured :

- ^{12}C + ^{12}C at 8.75 MeV/nuc (~6 h, trigger 1)
- ^{12}C + ^{58}Ni at 8.75 MeV/nuc



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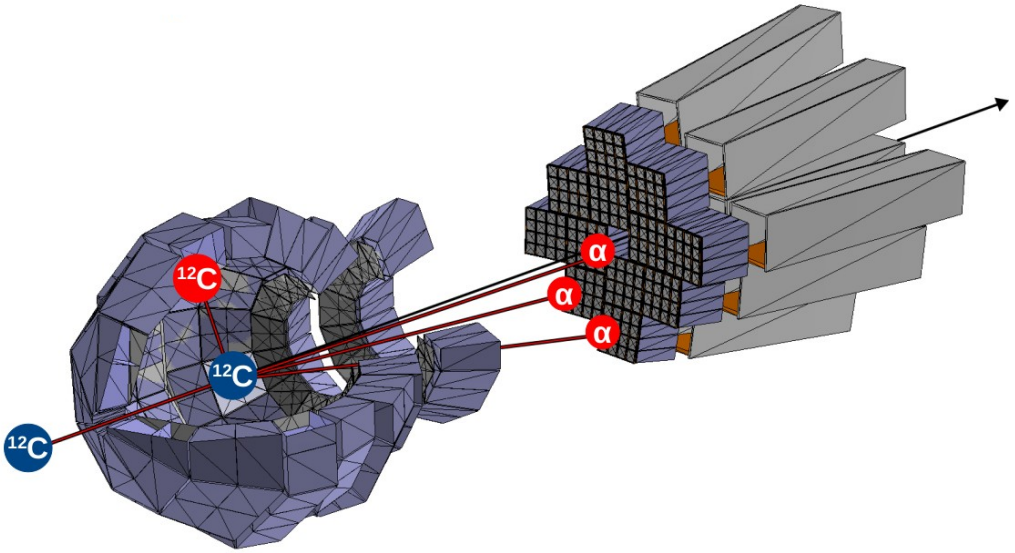
Notes

1. Next time, ask a ^{12}C beam stopping in CsI
2. INDRA and FAZIA data were not merged online but it could be done. I considered only FAZIA data for now.



Pulse Shape Analysis

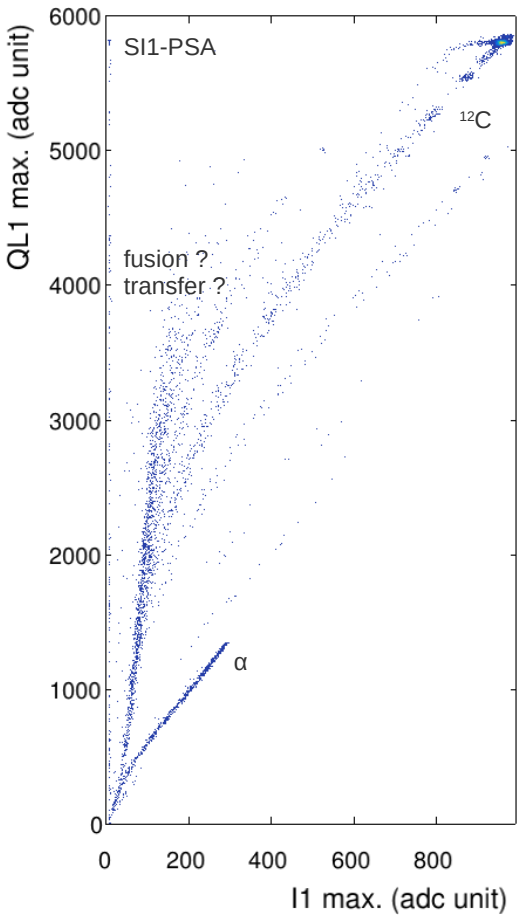
PSA in Si1 grids are ready and implemented in KaliVeda. Identification up to Z=7 with some heavier fragments (not resolved). Will be used to normalize cross sections.

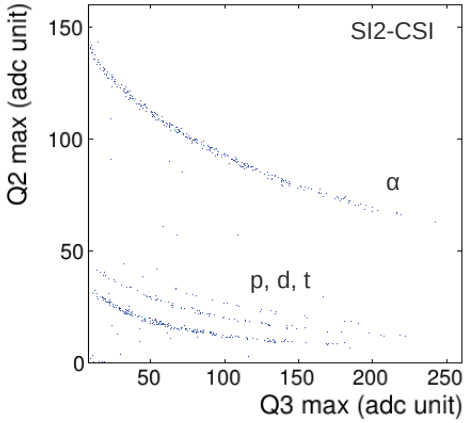
ΔE-E

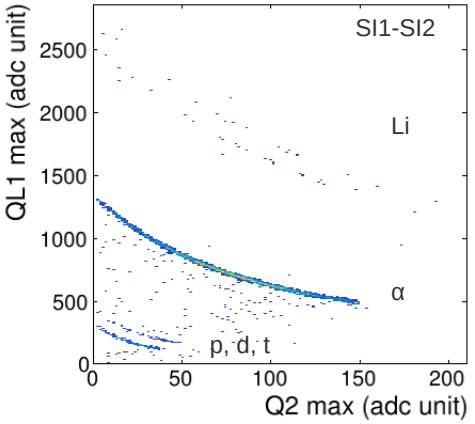
Si1-Si2 and Si2-CsI grids clicked in adc unit. Isotopic identification up to Z=3. Most of the α identified in Si1-Si2.

Calibration

Only the energy loss in Si1 and Si2 are used to compute total energy.







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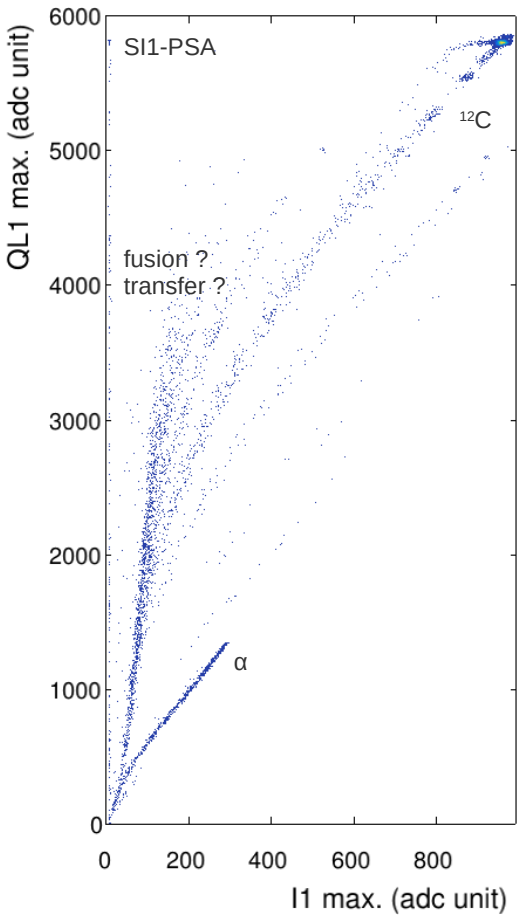
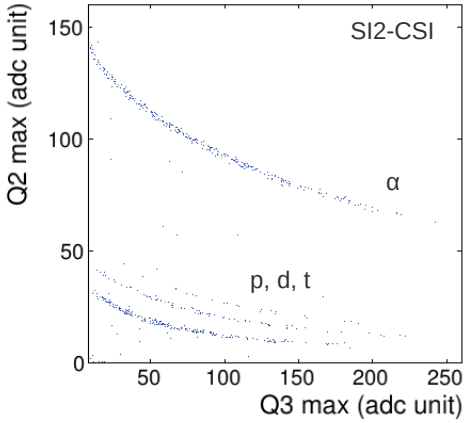
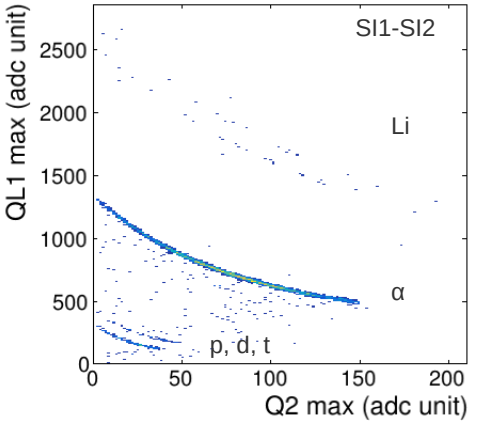
→ 20k 3α events with good identification and energy resolution

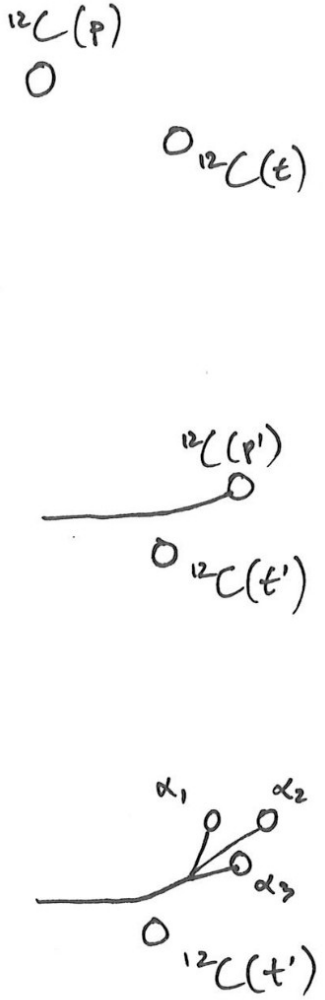






Scenario

The ^{12}C projectile diffuses on the ^{12}C target. Both of them can be excited. The projectile then decay into three alphas.



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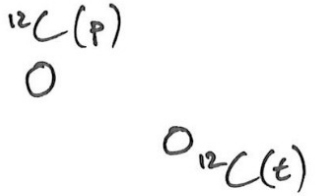
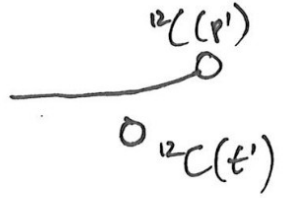
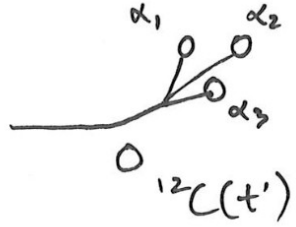


$$\begin{pmatrix} E_p \\ \vec{p}_p \end{pmatrix} + \begin{pmatrix} m_t c^2 \\ \vec{0} \end{pmatrix} = \begin{pmatrix} E_{p'} \\ \vec{p}_{p'} \end{pmatrix} + \begin{pmatrix} E_{t'} \\ \vec{p}_{t'} \end{pmatrix} \quad (1)$$





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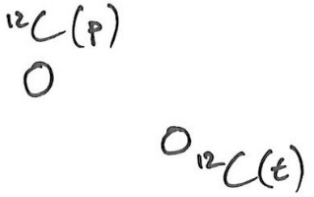

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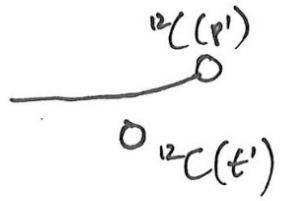

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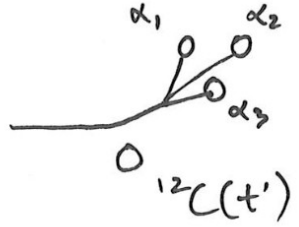

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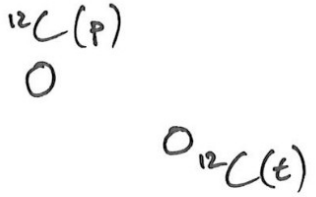
Invariant mass

The $^{12}C(p')$ excitation energy and momentum are reconstructed from the three alpha detected in FAZIA.



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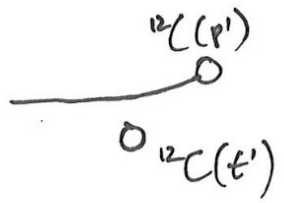

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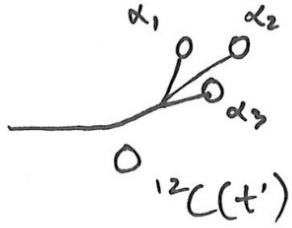

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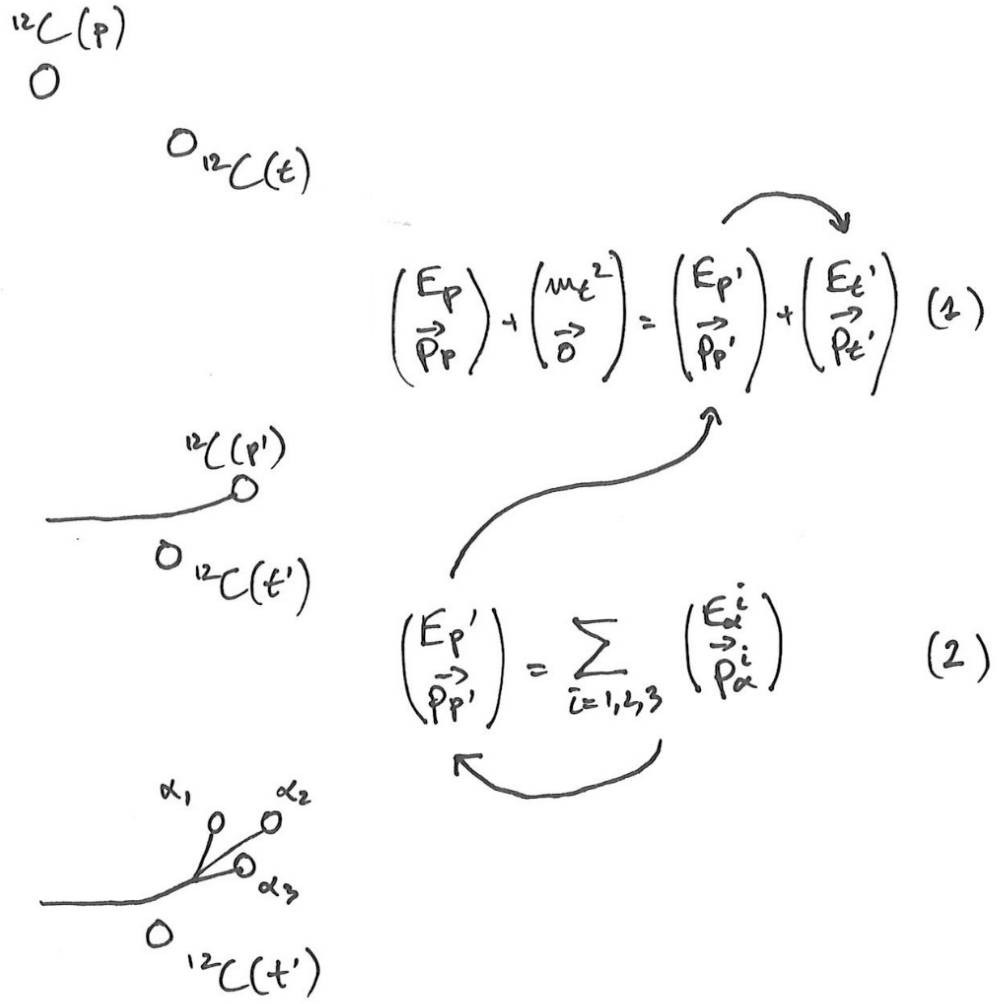
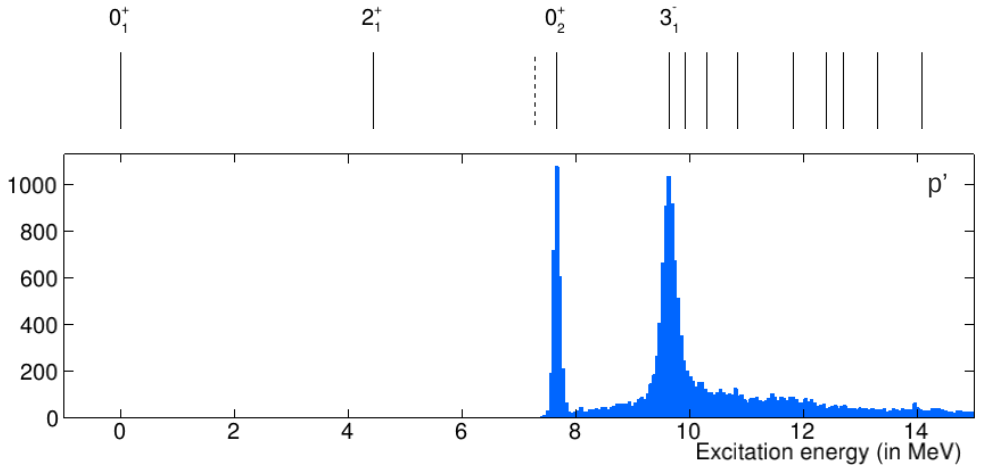
The $^{12}C(t')$ excitation energy can then be deduced from the projectile excitation energy and momentum (binary reaction).



^{12}C(p') excitation energy

The excitation energy spectrum starts above the 3 alpha threshold. It shows two narrow resonances and a broader « background » (higher energy broad states or direct break-up)



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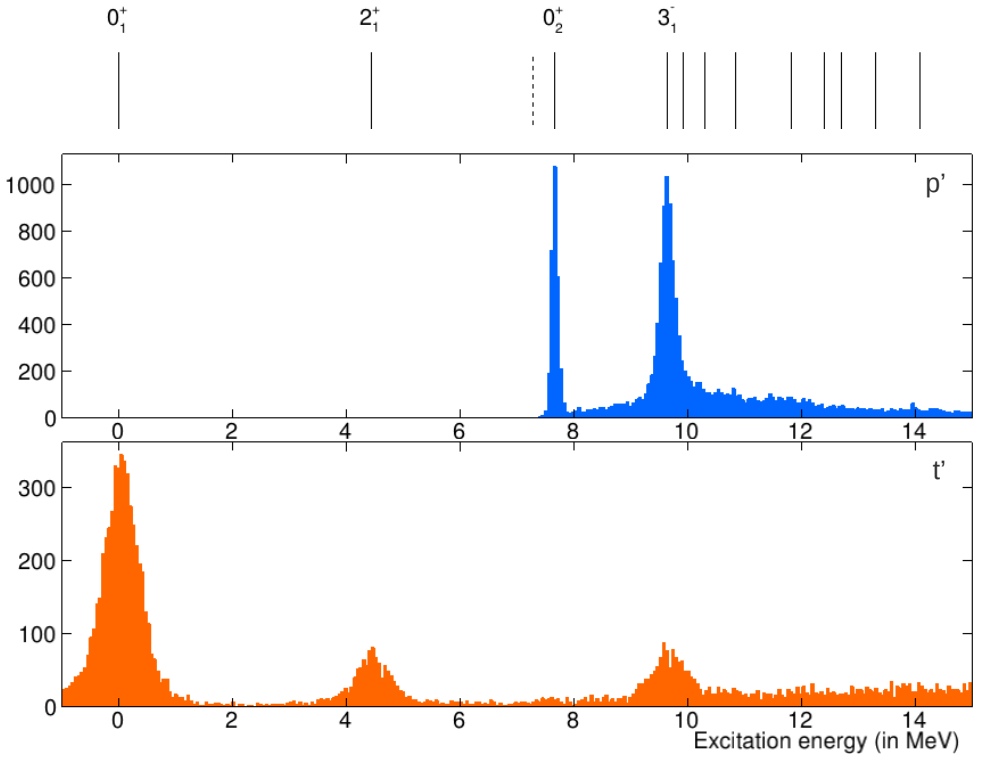

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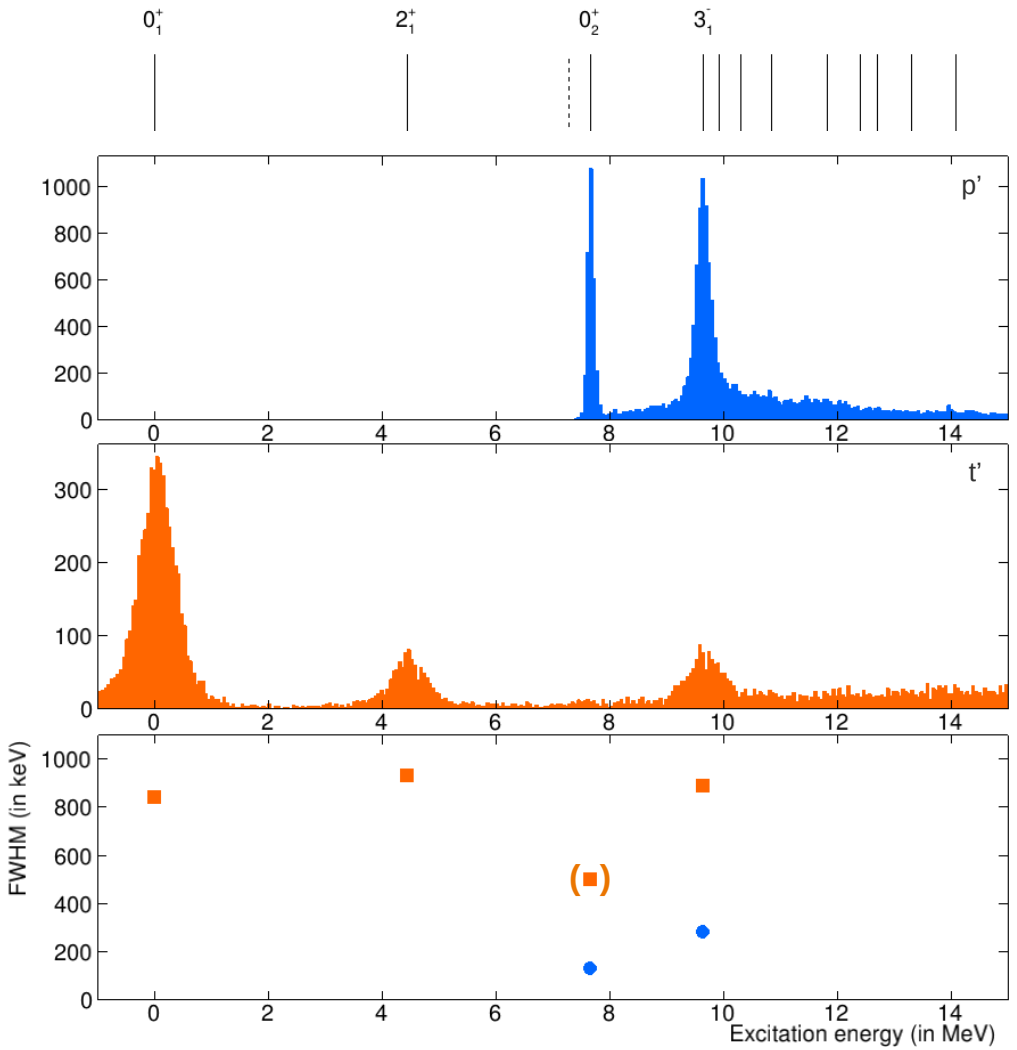
Resolution

The E* resolution using invariant mass increases with increasing E* from 130 keV to 280 keV FWHM. For the missing mass method, the resolution is almost constant arround 900 keV FWHM.



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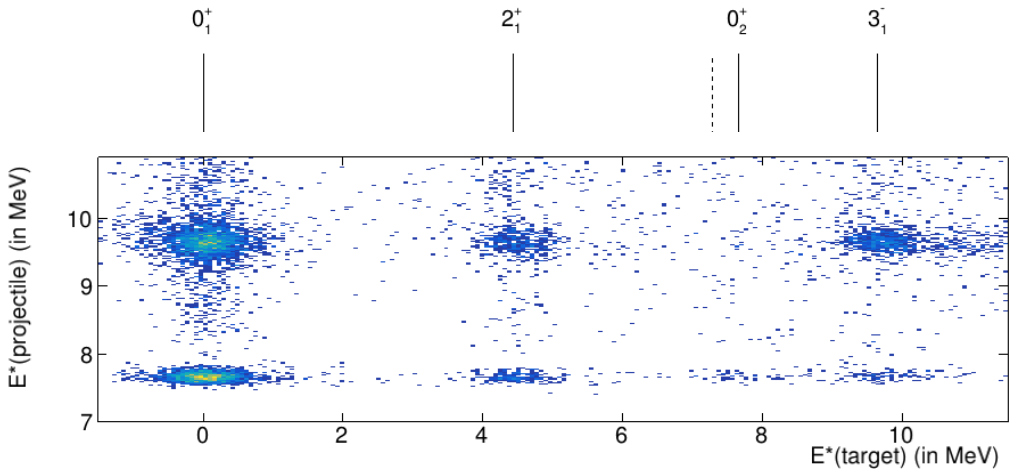

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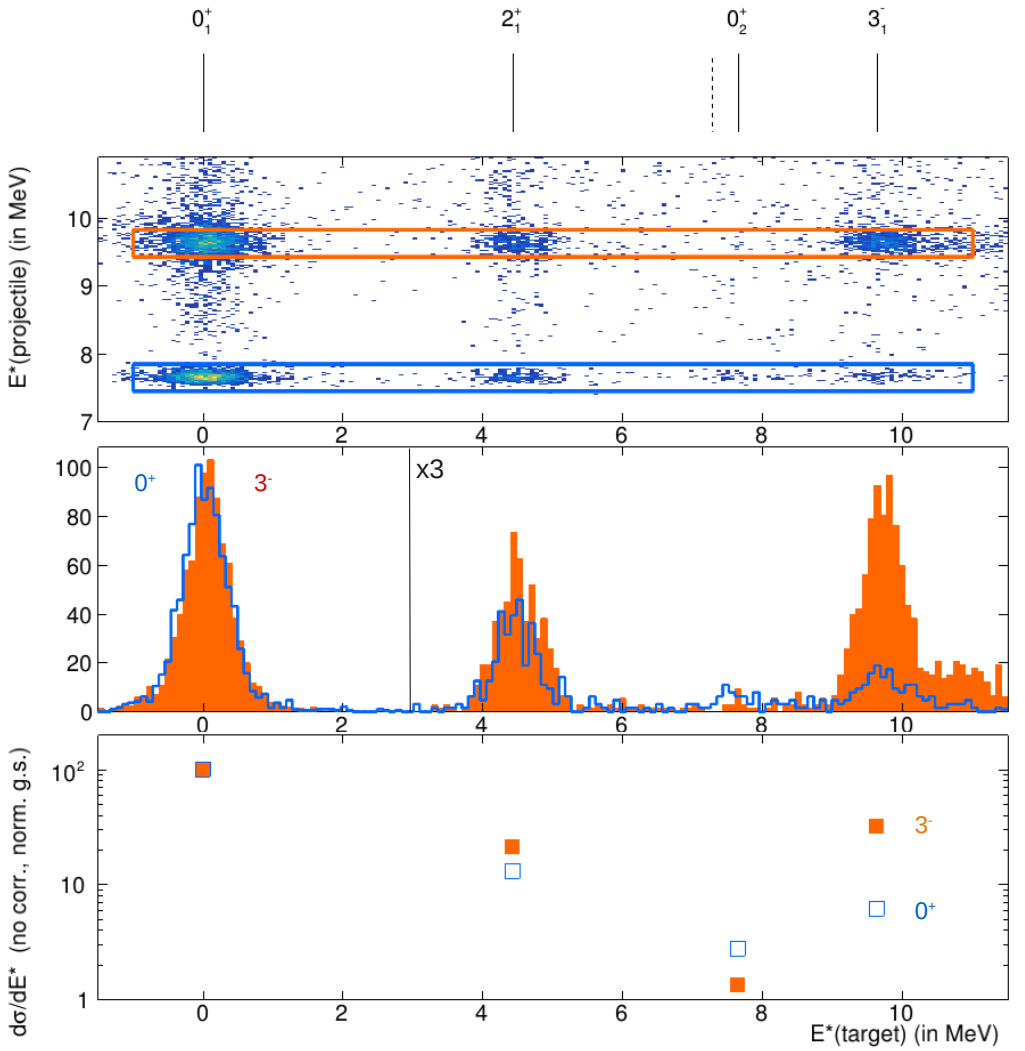
Gate on p’ state

t’ excitation energy (normalised to g.s.) for different p’ states. Population of 2^+ almost equivalent. Hoyle-hoyle diffusion observed (~30 events). No 3^--hoyle and low hoyle-3^- while 3^-–3^- is strongly populated.



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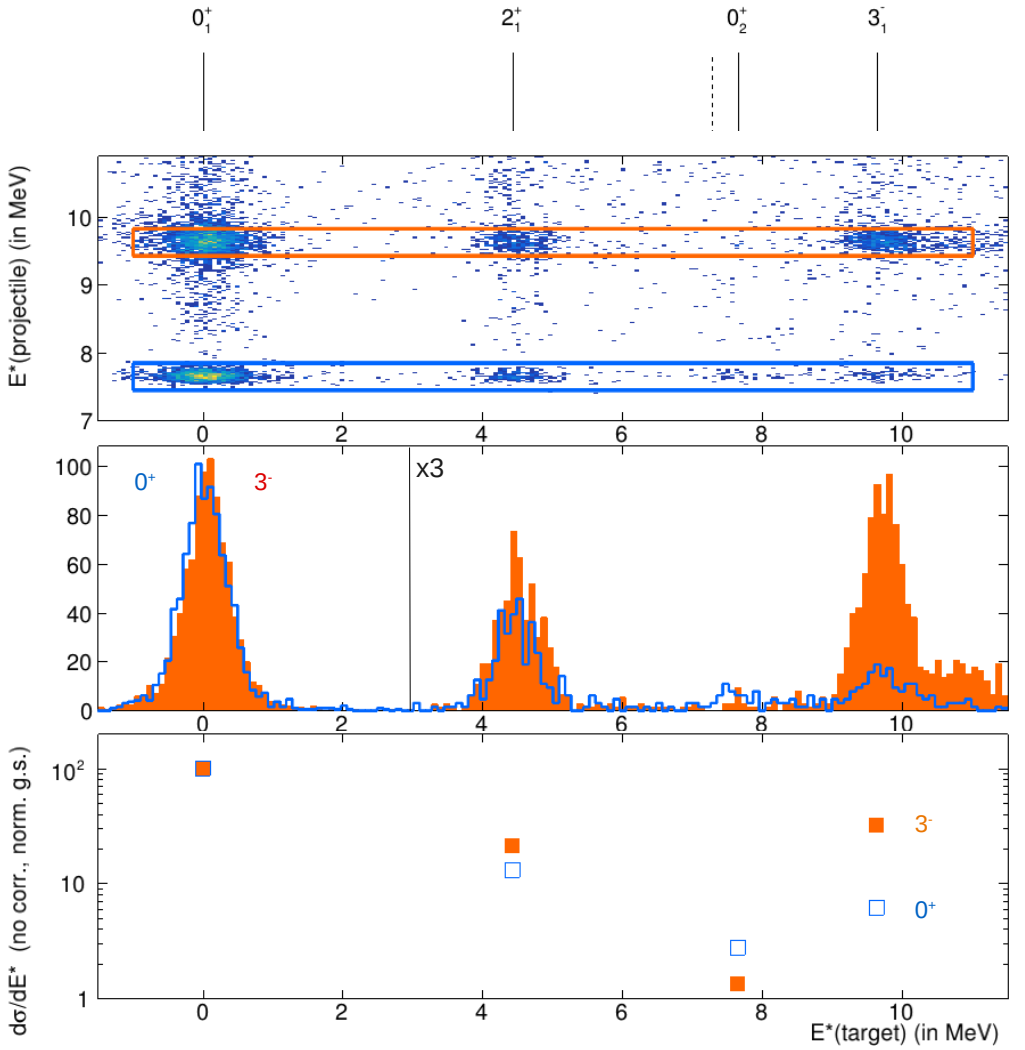
Next steps

Differential cross-section will be corrected for reconstruction efficiency and normalised to elastic cross-section.

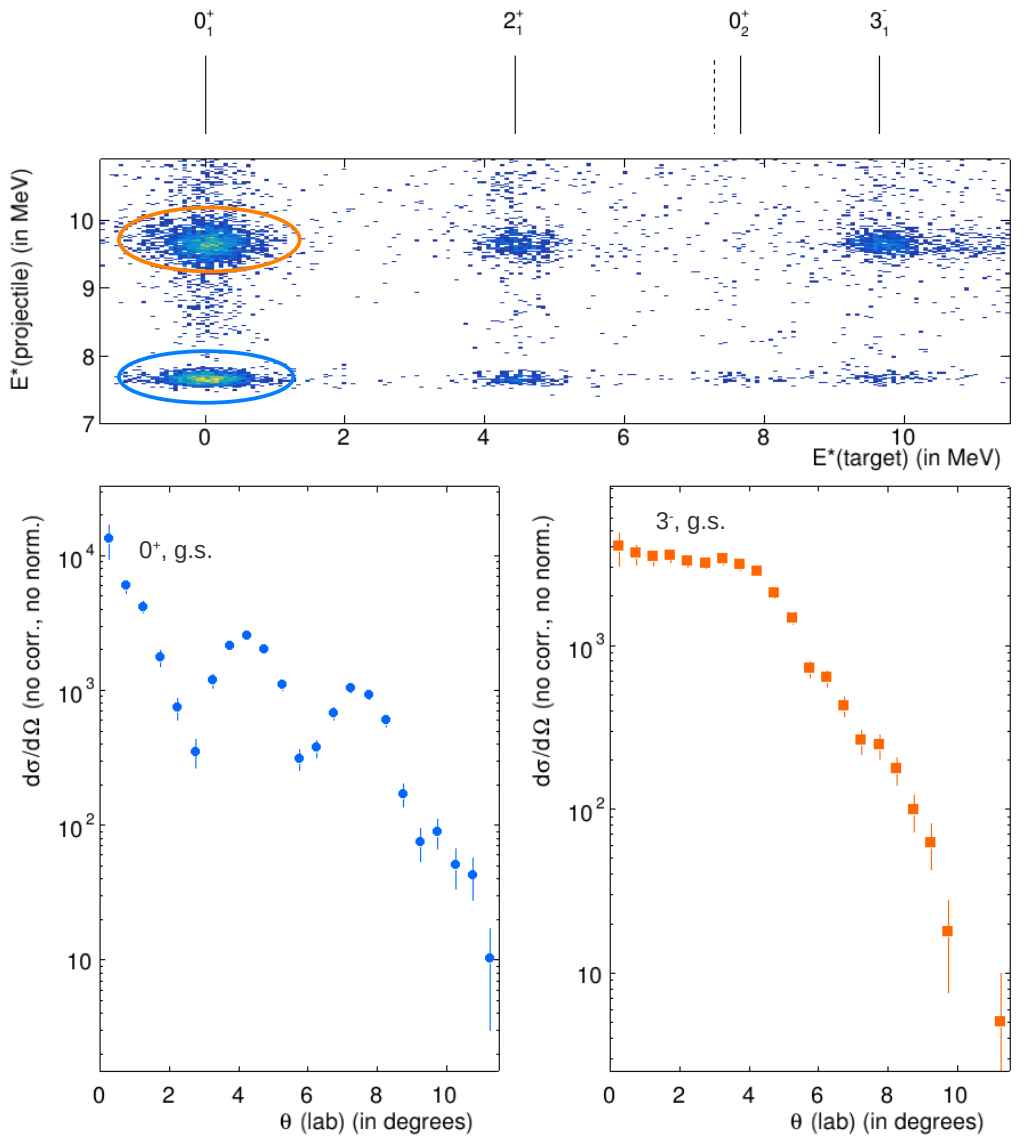


Gate on p’ and t’ states

We can now select both p’ and t’ states : we know everything about the reaction and the background drops significantly.

Diffusion on groundstate

The angular distribution of hoyle and 3^- diffusion on t’ groundstate are typical of $\Delta l=0$ and $\Delta l=3$ momentum transfer.



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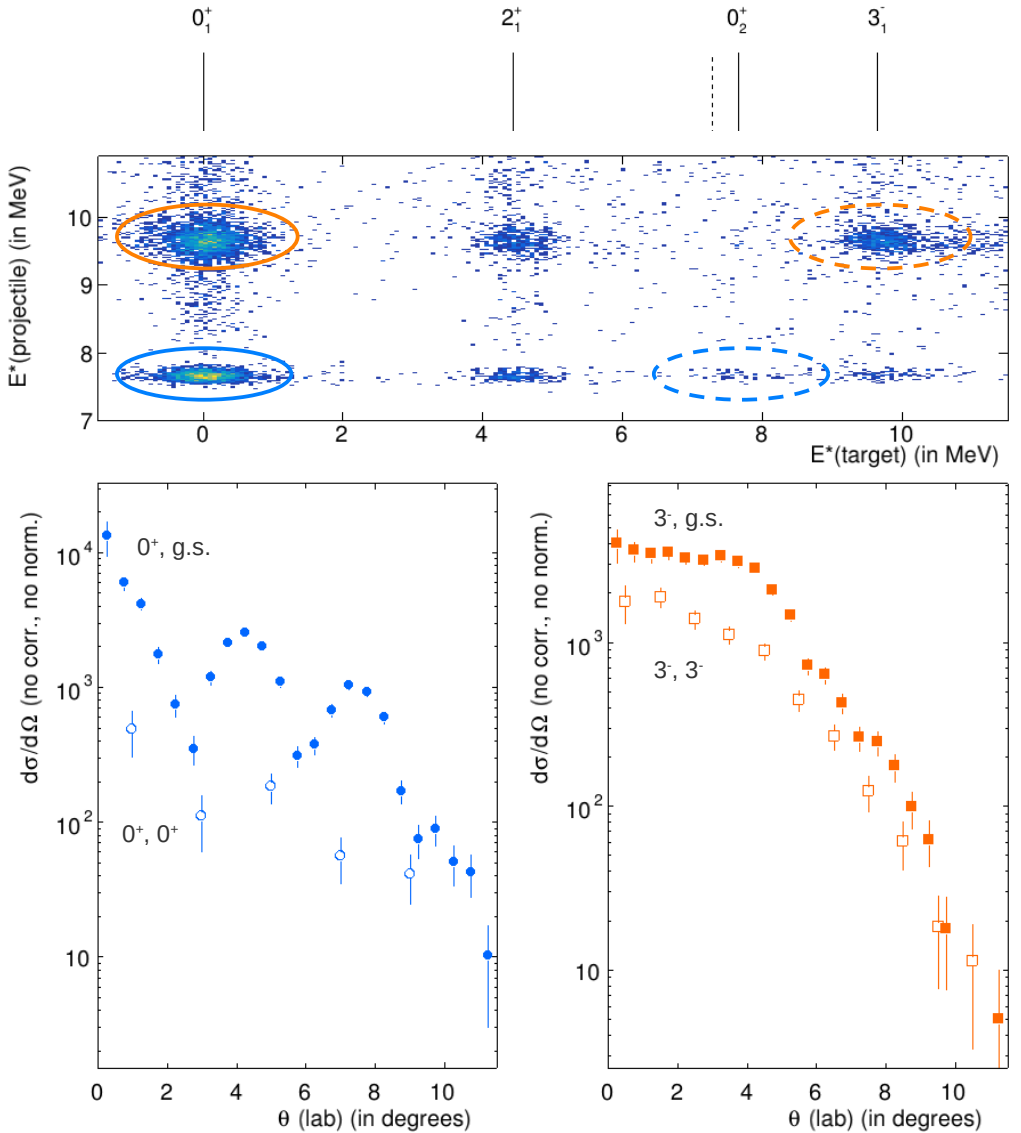
Double excitation

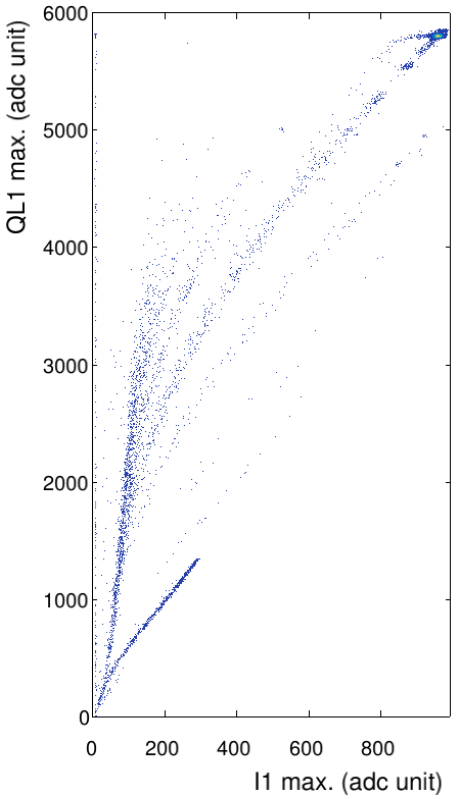
For hoyle and 3^- diffusing on themself we have less statistics but similar patterns. Not sure how to interpret this... It has already been measured ?

→ Double differential cross-section should be efficiency corrected and normalised



Experiment

- Correct/normalise the cross sections
- Publish experimental data
- Other channels also visible (^{11}C, ^{13}C, ^{10}Be...)
- Also adding particles in INDRA



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Theory

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- Proposal for FAZIA@GANIL !
- Article on exp-theo ?

Transition densities and form factors in the triangular α-cluster model of ^{12}C with application to ^{12}C + α scattering

A. Vitturi,[1,2] J. Casal,[1,2] L. Fortunato,[1,2] and E. G. Lanza[3,4]
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[4]*Dipartimento di Fisica e di Astronomia "Ettore Majorana", Università Catania, Italy*

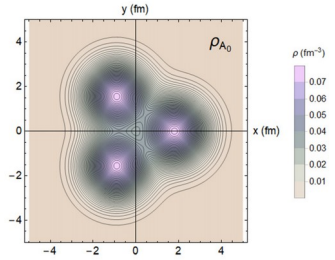
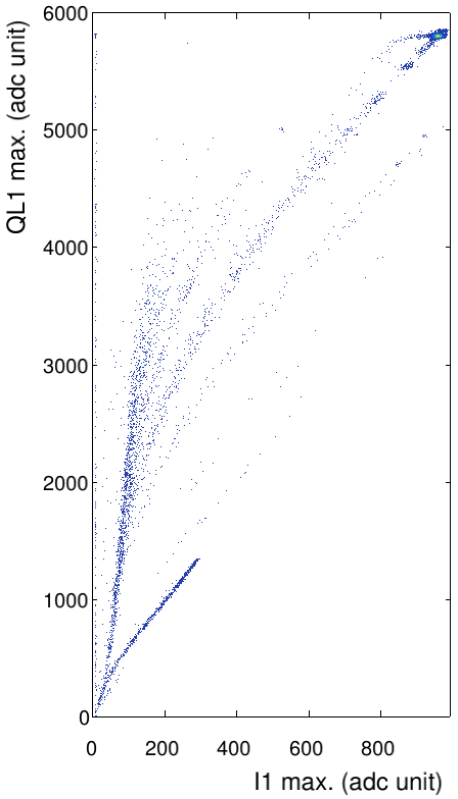


FIG. 2. Contour plot of density in fm^{-3} (cut on the $z = 0$ plane), ρ_{A_0} in Eq. (2), of the ground-state static triangular configuration (with A symmetry).



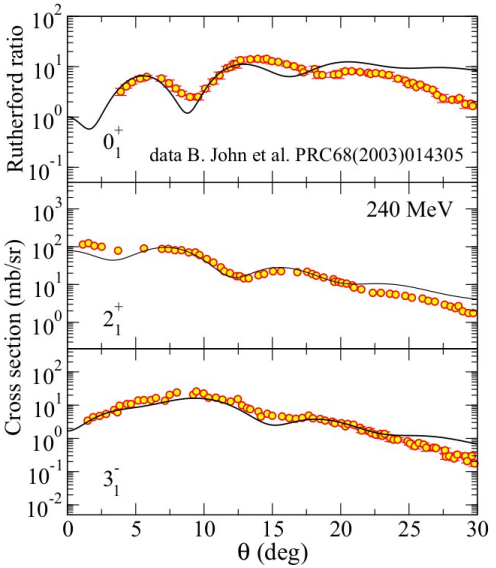


FIG. 16. Differential cross section for the elastic scattering and the transitions $0_1^+ \to 2_1^+$ and $0_1^+ \to 3_1^+$ at 240-MeV bombarding energy. Data are from Ref. [41] (retrieved through EXFOR).

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Future possibilities

- FAZIA + position sensitive detector
- FAZIA with Si arround target (I. Martel)
- FAZIA + ACTAR (identification + resolution)

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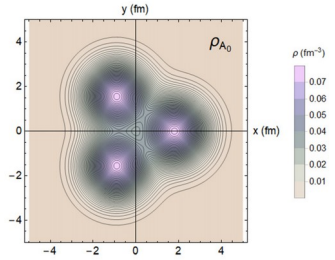

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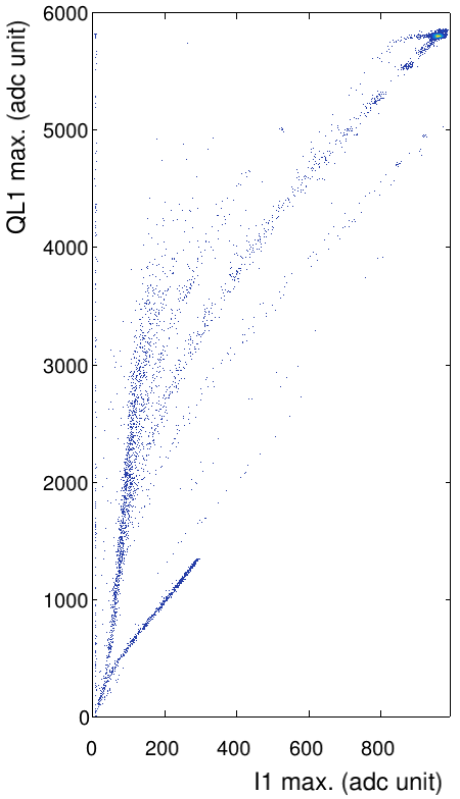

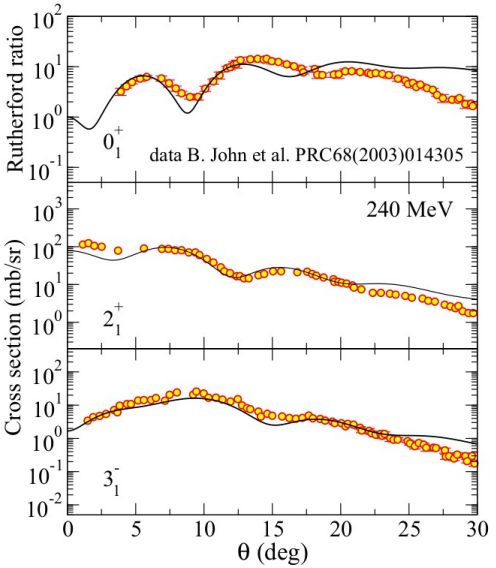

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Correlations

Now we can correlate the projectile and target ejectile excitation energy. All combination of projectile and target are observed except (3^-, hoyle)

Projectile 0^+

The ^{12}C target excitation energy can then be deduced from the projectile excitation energy and momentum (binary reaction). Most ^{12}C states (including g.s.) are visible.

Differential cross section