Reaction mechanisms in collisions induced by a $^8\text{B}$ beam close to the barrier

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Motivation: effects of halo structure on reaction dynamics

Halo nuclei:
small binding energy, low break-up thresholds
coupling to break-up states (continuum) important \( \rightarrow \) CDCC

The n-halo case: e.g. \(^{11}\text{Li},^{11}\text{Be},^{6}\text{He}\)
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Elastic scattering

$^{11}\text{Be}^{+}\text{64Zn}$ ISOLDE experiment

At low bombarding energy coupling between relative motion and intrinsic excitations important.

Coulomb and nuclear long range absorption effects because of the halo.

The $p$-halo case: $^8B$

Weakly bound $Sp=0.137$ MeV (easy to break-up)

Scarce data in the literature.
Only in-flight beams used so far

(ISOLDE has the only ISOL $^8B$ beam)
The p-halo case: $^8$B

$^8$B+$^{58}$Ni elastic scattering

Weakly bound $S_p=0.137$ MeV (easy to break-up)

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Some details of this experiment:

- In-flight produced $^8$B beam
- Beam divergence = 6°
- Large angular detector opening $\Delta \theta = 12°$
- No particle discrimination
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M. Mazzocco et al. PRC 100 024602 (2019)

Large $\Delta R$ with respect to other weakly bound nuclei

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Proposed experiment

Is the total-reaction cross-section enhanced as for n-halo?

CDCC calculations foresee small effects on the elastic cross-section.
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\(^7\text{Be}, ^8\text{B}+^{64}\text{Zn} \text{ at } E_{\text{lab}} \approx 4.5 \text{ MeV/u}
\text{elastic scattering, elastic and non-elastic break-up cross-sections @INTC 2016, but } ^7\text{Be was not approved}

Angular distribution steps:
- for \(\theta \leq 40^\circ\) at steps of \(\theta \leq 2^\circ\)
- for \(\theta > 40^\circ\) at steps of \(\theta = 3^\circ - 5^\circ\)
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CDCC calculations

Improvements:
- $^8\text{B}$ post-accelerated ISOL beam
- Large solid angle + high granularity → good angular resolution
- Coincidence measurement
Beam diagnostics

SEC
(inside)
F-cup @ target position
Beam diagnostics

SEC (inside)

F-cup @ target position

DOWNSTREAM (outside)
- F-cup on exit
  - Current measure
  - 2 pepper-pots
  - empty

Manipulator

DE+E Si-telescope

CROSS
2x ISO100
2x ISO160
Beam diagnostics

**UPSTREAM (outside)**
- F-cup on entrance to chamber
- Current measure
- Different collimators 12, 10, 8 mm

**SEC**

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- F-cup on exit
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**F-cup @ target position**

- 6 way CROSS
- Turbo Pump
- DE+E Si-telescope
- CROSS
  - 2x ISO100
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6 way CROSS
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CROSS 2x ISO100 2xISO160

$^{12}$C beam
Telescope A moved at smaller angles (5.5°<θ<23°) using an extension
Gloria

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Detection system:

- 2 \( \Delta E_1 - \Delta E_2 - E_{pad} \) telescope \( \theta < 60° \)
- 4 \( \Delta E_1 - E \) Si telescopes at \( \theta > 60° \)

with:

- \( \Delta E_1 \): 40 \( \mu \)m DSSSD detector (16+16 strips)
- \( \Delta E_2 \): 1000 \( \mu \)m DSSSD (16+16 strips)
- \( E_{pad} \): Si PAD detector 1000 \( \mu \)m
- \( E \): 1000 \( \mu \)m DSSSD (16+16 strips)
Geometry determination

detectors geometry definition = main part of the data analysis (precise angle and solid angle evaluation)

long time dedicated to $^{12}$C @ 4.9 MeV A on Au (300 $\mu$g/cm$^2$ thick)

geometry optimization has been done with a Montecarlo code considering:

- beam spot
- beam offset
- beam angle
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Low statistics for $\theta > 90^\circ$ because we had half of the BTU approved

Linear scale and zoomed!
Angular distribution steps:
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for $\theta > 25^\circ$ at steps of $\theta = 2^\circ$
Anyway better than foreseen

Test calculations ($^7$Be no spin), now under definition

For $^8$B 1/10 of the expected intensity (300 pps)!!
Very preliminary results

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data-calculation

\[ \frac{\sigma}{\sigma_R} \]

\[ \theta_{\text{c.m.}} \text{ (deg)} \]
$^{8}\text{B very preliminary results}$

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No suppression of the elastic cross section opposite to $^{11}\text{Be}$
→ as foreseen, the halo effect on the rainbow peak is SMALL
Is it a candidate p-halo?

\[
\frac{\sigma}{\sigma_{\text{Ruth}}} \quad \begin{align*}
{^{11}\text{Be}} + {^{64}\text{Zn}} @ E_{\text{c.m.}} &/ V_B \approx 1.45 \quad \sigma_R = 2.7 \text{ b} \\
{^{8}\text{B}} + {^{64}\text{Zn}} @ E_{\text{c.m.}} &/ V_B \approx 1.55 \quad \sigma_R = 1.5 \text{ b}
\end{align*}
Is it a candidate $p$-halo?
$^7$Be events

Break up evaluation now under analysis
Conclusions

Positive

- Despite of the very low statistics we got a better resolution than expected

- Contrary to what observed in in-flight beam measurements there is NO EVIDENCE of a great diffusivity for $^8$B (Coul. Barrier) ($\sigma_{R^8B} \sim 0.5 \sigma_{R^{11}Be}$)
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Negative

- We could not measure coincidences ($^7\text{Be} - p$) because of the very low beam intensity $\Rightarrow$ we will not distinguish break up different components

...anyway we expect to end up with very interesting results ...