Monte Carlo study of the systematic errors in the measurement of the scattering of ^{15}N ions by $^{10,11}B$

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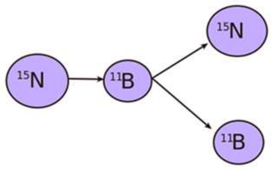
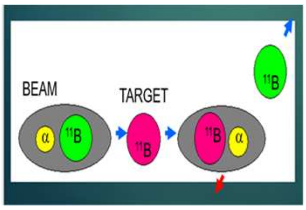
Physical task

There are two most likely mechanisms for the elastic scattering of ^{15}N from ^{11}B.

- The first one is a pure elastic scattering, which is well described by the optical model. It corresponds to the blue line shown in Fig. 1. This mechanism dominates at forward angles.





- The second one is an alpha cluster transfer mechanism, which is described by the Distorted Wave Born Approximation. It corresponds to the red line in Fig. 1. This mechanism dominates at backward angles. The motivation for the experiment is to establish parameters of the interaction potentials.

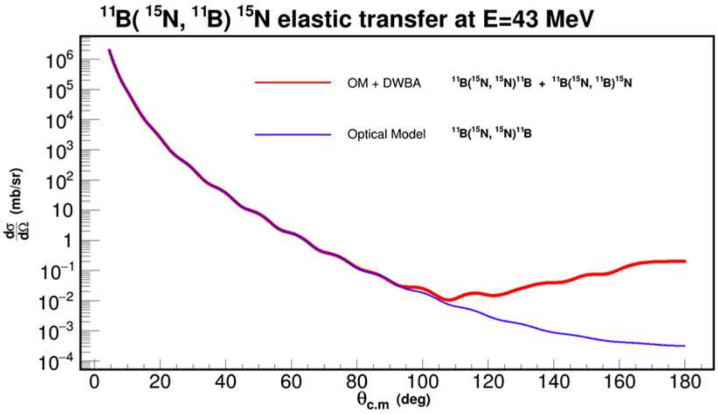


Fig. 1. Angular dependence of the cross-section

Description of the experiment

A series of experiments on the elastic scattering of ^{15}N ions from $^{10,11}B$ has been performed at the U-200P cyclotron in the Heavy Ion Laboratory, Warsaw University, using the charged particles detection system ICARE.

Fig. 2. Experimental setup

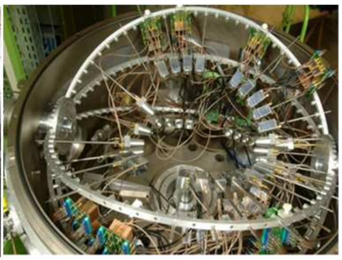


Fig. 3. ICARE system

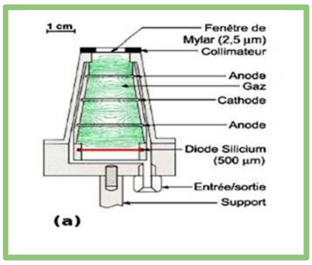
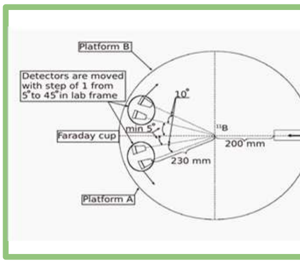


Fig. 4. Detector scheme



The angle of 45 degrees in the Lab covers the angle of 90 degrees in the CM reference frame.

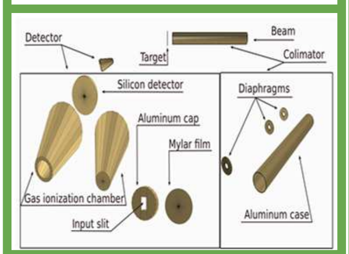
Fig. 5. Experimental scheme

Motivations for simulation

- To study the influence of some physical effects and the geometry of the experiment on:
  - angular resolution.
  - derived angular dependence of the cross-section.
- To understand the systematic errors.
- To make recommendations for future experiments.

The simulations have been done using the ExpertRoot framework.

Geometry for simulation

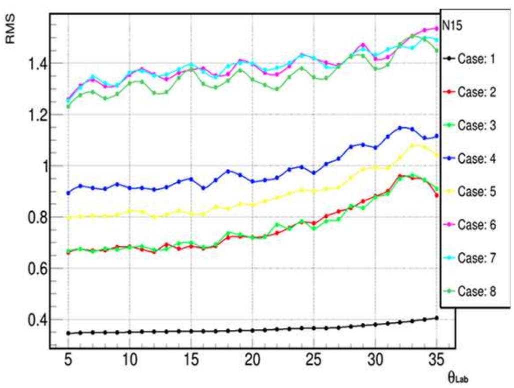


List of factors affecting the results of the cross-section measurement

1. We started from the ideal reaction with the ideal beam, without the target, but with the realistic slit of the detector, and made the following features realistic (step by step):
2. Add the 7-micron-thick ^{11}B target
3. Energy spread of the ^{15}N ion beam (42-43 MeV)
4. Spread of the θ-angle of the ^{15}N ion beam (sigma=5 mrad)
5. Spread of the φ-angle of the ^{15}N ion beam (0-2π)
6. X spread of the beam spot on the target (-0.5-0.5 cm)
7. Y spread of the beam spot on the target (-0.5-0.5 cm)
8. Beam collimator (hole size is 1.5 cm)

Angular resolution

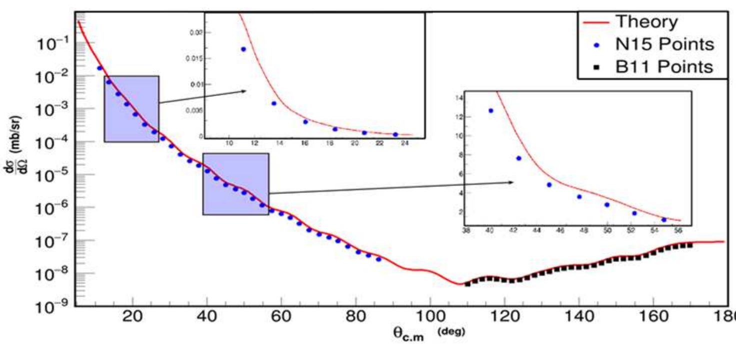
(RMS of the distribution of the detected CM θ-angles)



One can see that the angular resolution deteriorates by the factor almost 4 when all the discussed nonidealities are taken into account.

The statistical error of each point does not exceed ±0.01. The wave-like behavior is statistically significant, but its cause is not clear.

Measured cross-section as a function of the scattering angle in CM



In this figure, the red line corresponds to the input cross-section for the simulation and the blue and black points correspond to the restored one.
There are two main effects:
1) The measured dependence becomes less steep at small angles than the original curve.
2) The wave-like structure of the original curve becomes less prominent.
These effects should be taken into account when interpreting the result.