Hellenic Institute of Nuclear Physics (HINP)

1st one day Workshop on New Aspects and Perspectives in Nuclear Physics

Elastic scattering of $^{20}Ne+^{28}Si$ at near barrier energies

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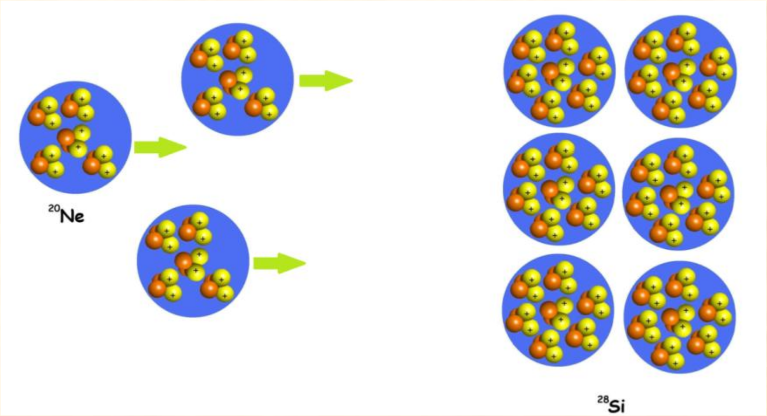
Motivation

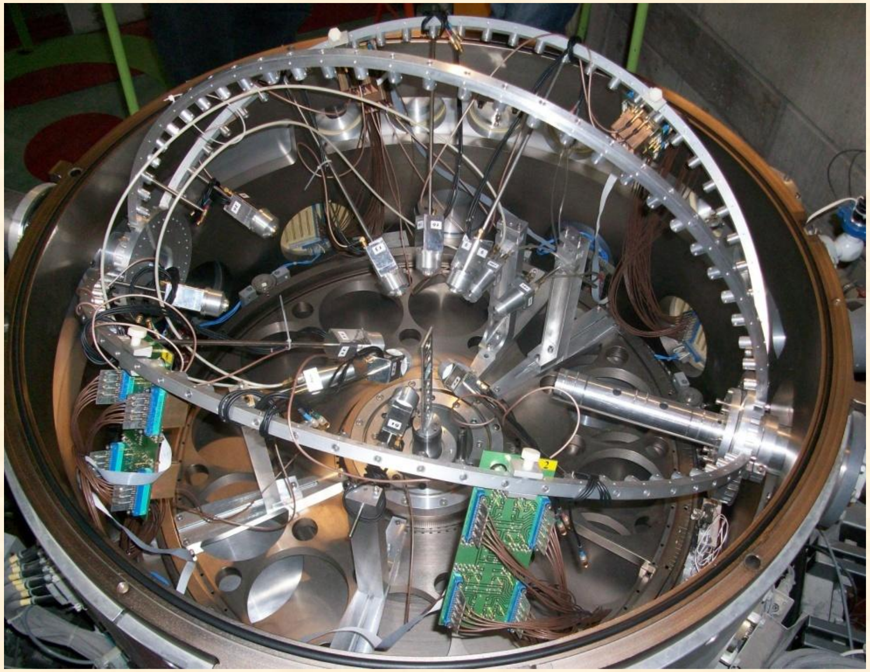
- ✓ Elastic scattering of heavy ions is the main tool for investigating the optical model potential.
- ✓ Especially for projectiles like ^{12}C and ^{16}O, due to clustering, coupling effects to the elastic scattering are significant and appear as an increase in cross sections at backward angles, which for projectiles with a simple structure is not observable.
- ✓ Coupling effects due to cluster of the target are also significant. In that case, it is known that there is a limit on Z where this anomaly stop to exist.

Motivation

- ✓ So, the question is if the increase of cross section at backward angles is persistent for heavier projectiles.
- ✓ **Angular distribution measurements of elastic scattering for the system $^{20}Ne+^{28}Si$ were performed at 3 near barrier energies.**

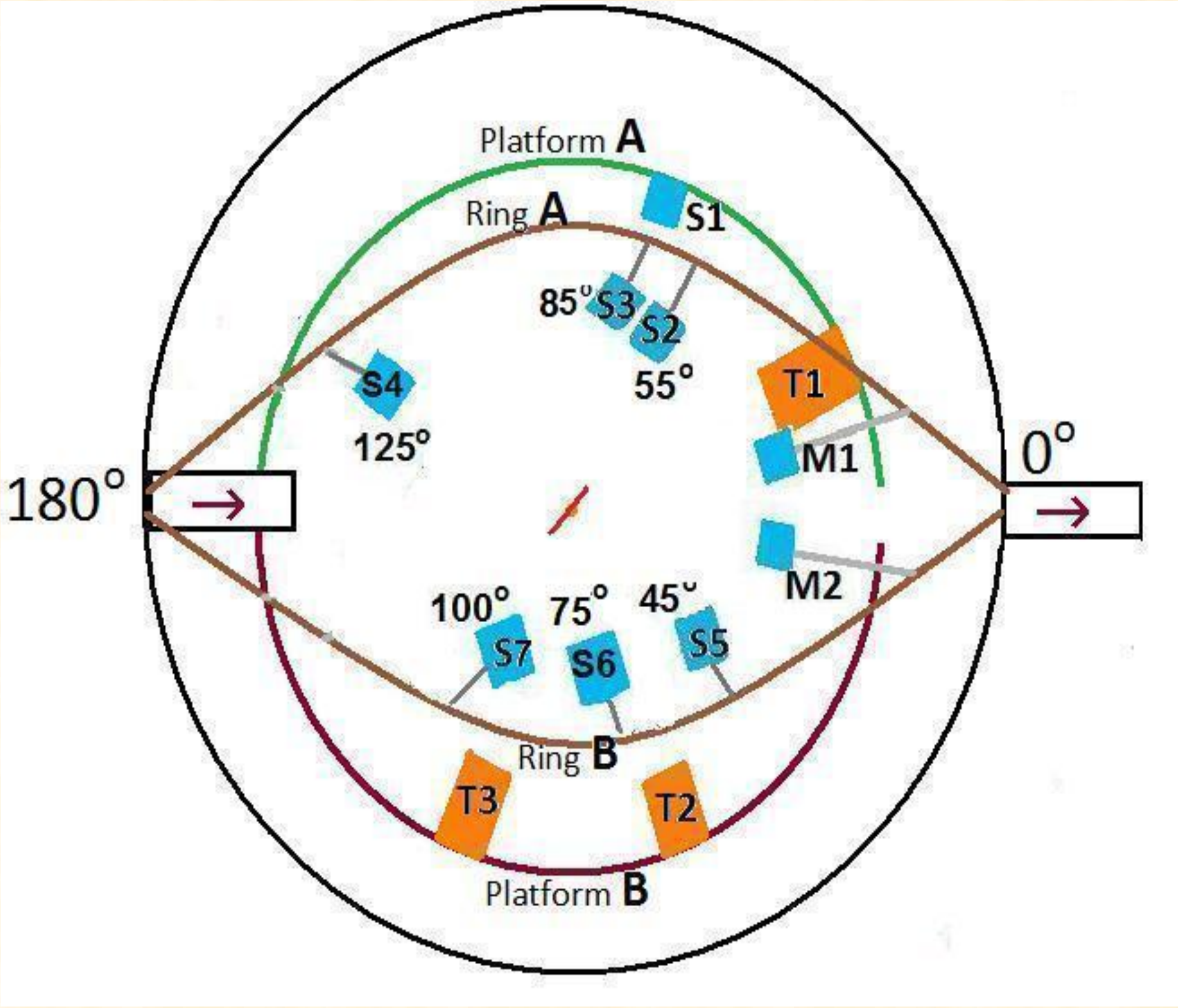


Experimental setup



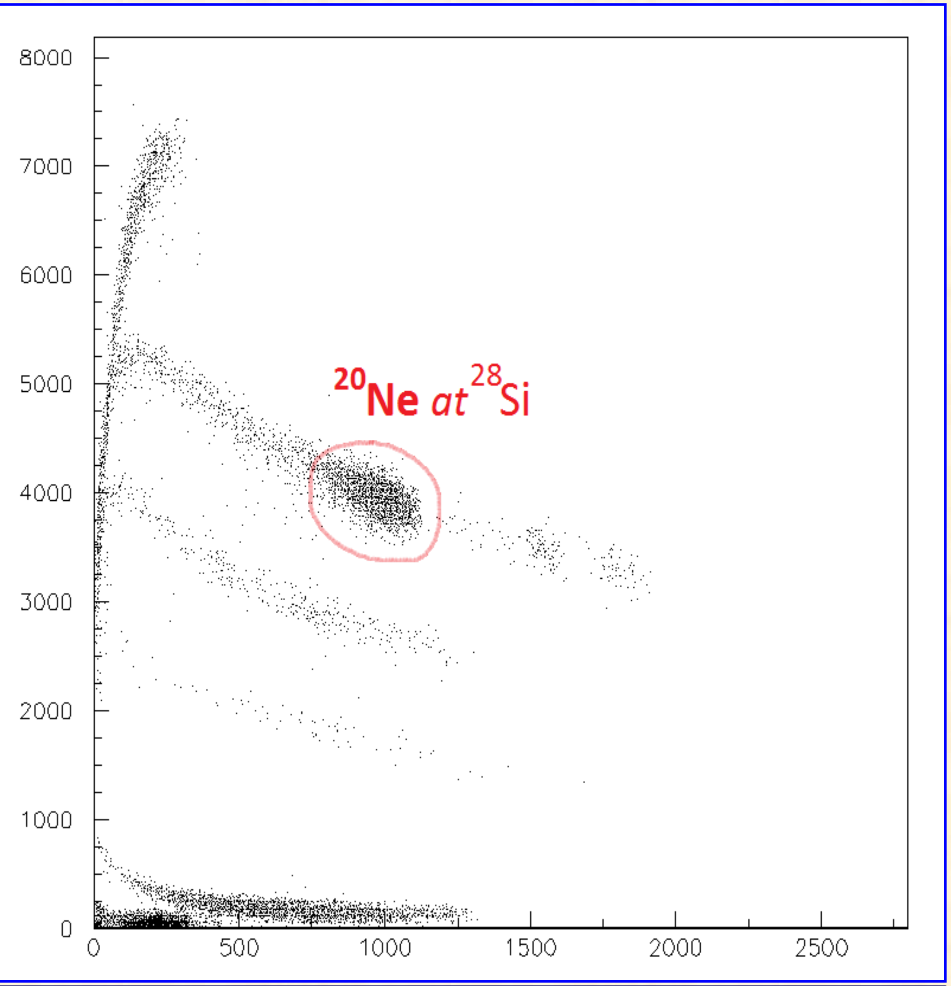
- The experimental setup was visualized in ICARE facility of the H.I.L. (Warsaw).
- ICARE consists of a big chamber with various facilities for setting up numerous detectors. In this respect, the chamber includes two platforms (A,B) and several rings that allow us to place many detectors.

Experimental setup

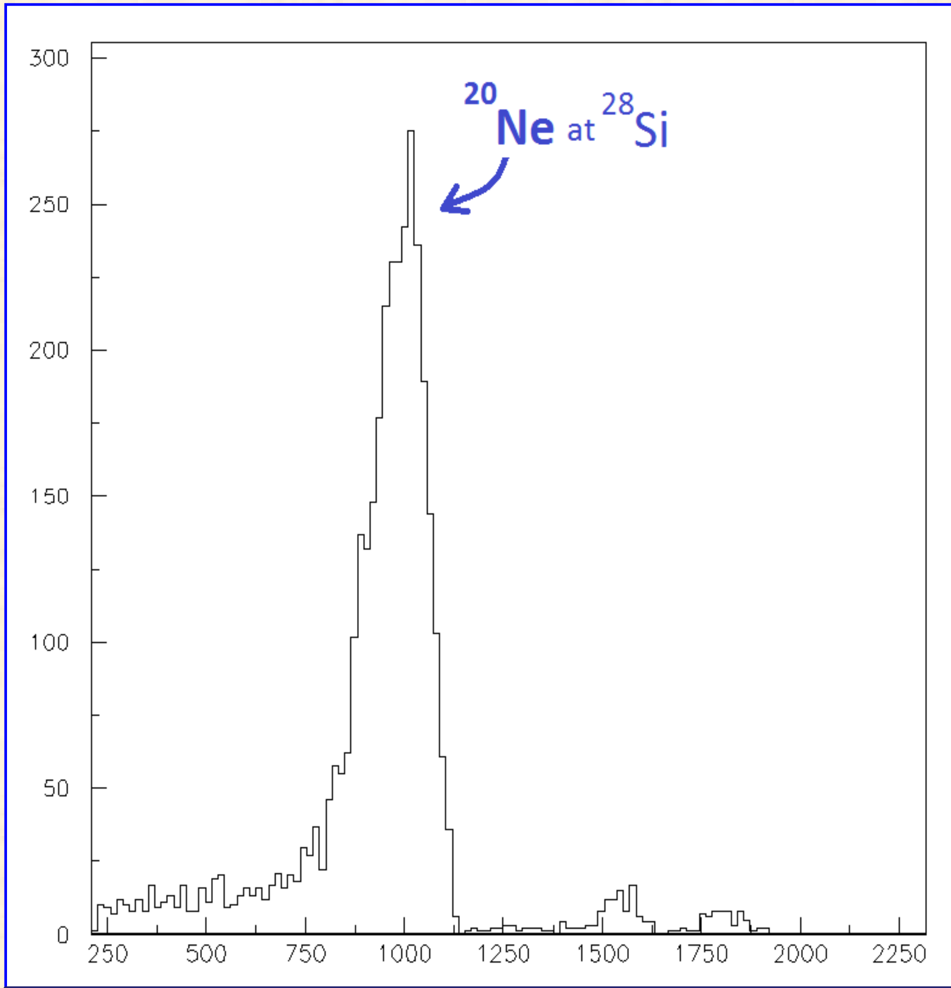


Detector	*Distance from the target (cm)*
M1	**31.5**
M2	**31.5**
T1	**11.5**
T2	**11.5**
T3	**11.4**
S1	**11.1**
S2	**11.5**
S3	**11.5**
S4	**11.5**
S5	**11.6**
S6	**13.5**
S7	**11.6**

Identification of Elastic channel



Run 155, E=52.3MeV, Telescope T1, Angle 45deg, Target vertical 200μg/cm^2



Run 155, E=52.3MeV, Telescope T1-E, Angle 45deg, Target vertical 200μg/cm^2

Cross sections calculations

- The cross section is given by the formula:

$$\sigma = \frac{N}{\left(D\Phi\right)\Omega}$$

- The $\left(D\Phi\right)$ quantity is calculated via monitors' information by the known Rutherford scattering:

$$\left(D\Phi\right) = \frac{N_{monitor}}{\sigma_{Ruth}\Omega_{monitor}}$$

- The Ω quantity was calculated by the known activity of ^{241}Am source that is given by the formula:

$$\Omega = \frac{4\pi}{R}\frac{\mathrm{N}_{\alpha lphas}}{t} = \frac{4\pi}{\left(40000Bq\right)}\frac{\mathrm{N}_{\alpha lphas}}{t}$$

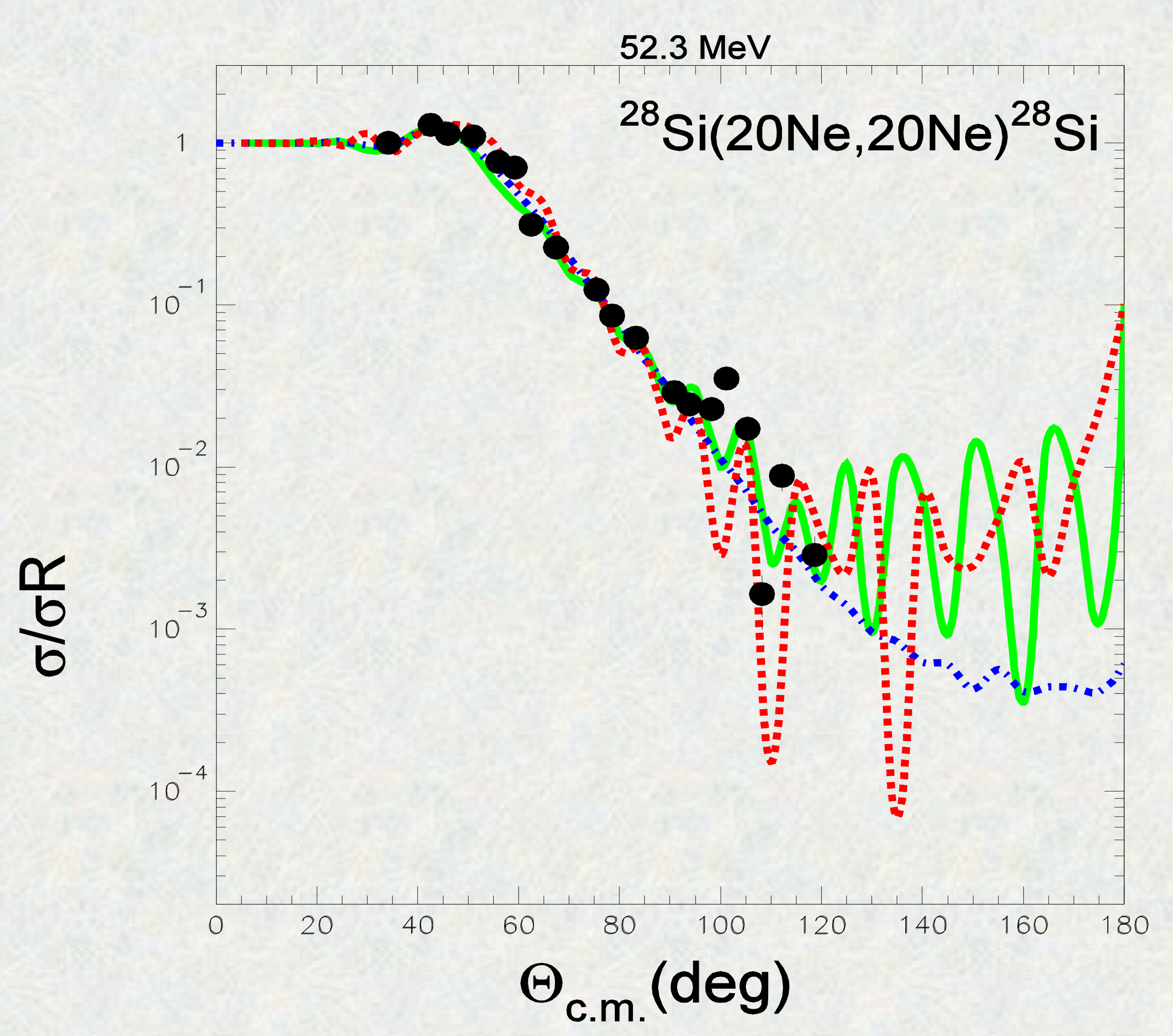
Cross sections calculations

- Define as: f= σ/σ_{Ruth}. Then, the uncertainties were calculated via the following formula:

$$\sigma_{\sigma/\sigma_{Ruth}} = \sigma_f = \left[\left(\frac{\partial f}{\partial \mathrm{N}}\sigma_{\mathrm{N}}\right)^2 + \left(\frac{\partial f}{\partial \mathrm{N}_{monitor}}\sigma_{\mathrm{N}_{monitor}}\right)^2 + \left(\frac{\partial f}{\partial \Omega}\sigma_{\Omega}\right)^2\right]^{1/2} \Rightarrow$$

$$\Rightarrow \ldots \Rightarrow \sigma_{\sigma/\sigma_{Ruth}} = \frac{\sigma}{\sigma_{Ruth}}\left[\frac{1}{N} + \frac{1}{\mathrm{N}_m} + \frac{1 + \mathrm{N}_{\alpha lphas}\left(\frac{\sigma_t}{t}\right)^2}{\mathrm{N}_{alphas}}\right]^{1/2}$$

Elastic scattering 52.3MeV

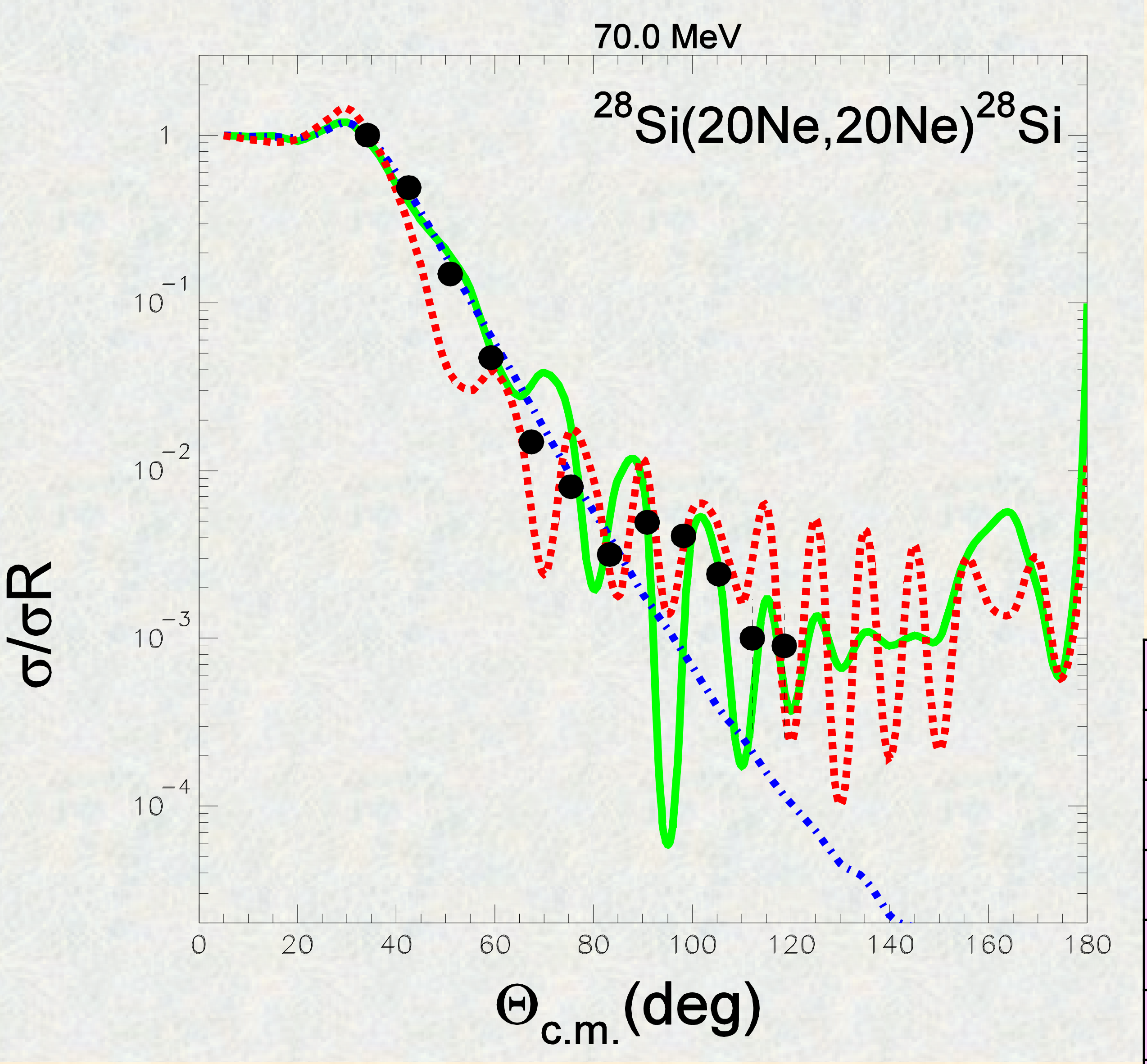


- ❖ **Elastic scattering data for ^{20}Ne + ^{28}Si at energy of 52.3 MeV.**
- ❖ **A FRESCO calculation is performed, where Set 1 and Set 2 are the sets by a phenomenological Woods-Saxon potential without and with oscillations respectively. The Set 3 is a set with Christensen potential as the real part.**

Optical potential parameters

	Set 1	Set 2	Set 3
V (MeV)	24.63	23.76	20.41
r_{0R} (fm)	1.432	1.402	1.268
α_R (fm)	0.361	0.419	0.570
W (MeV)	11.43	7.25	2.44
r_{0I} (fm)	1.250	1.111	1.190
α_I (fm)	0.361	0.160	0.160

Elastic scattering 70.0MeV



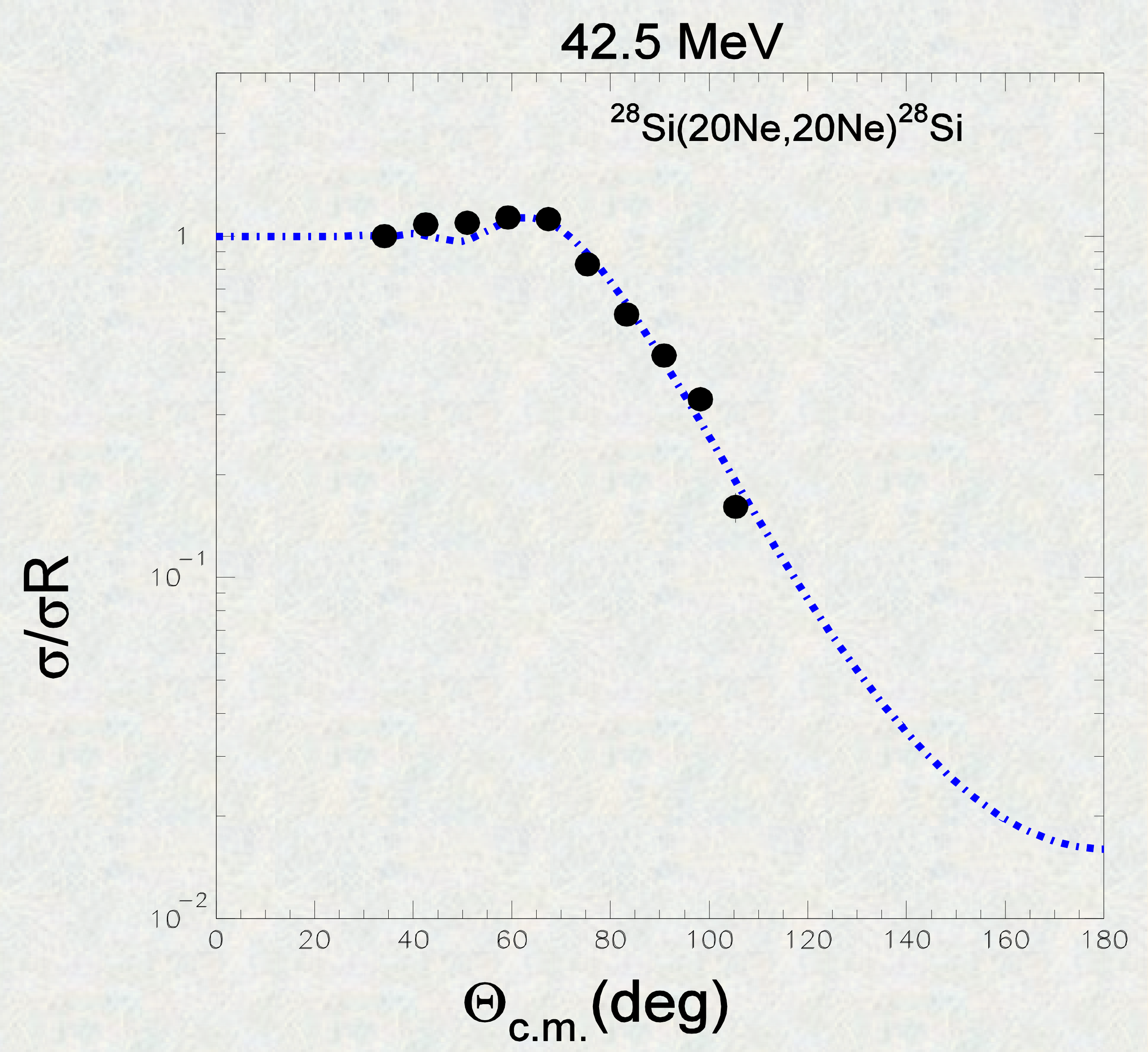
❖ **Elastic scattering data for $^{20}Ne + ^{28}Si$ at energy of 70 MeV.**

❖ **A FRESCO calculation is performed, where Set 1 and Set 2 are the sets by a phenomenological Woods-Saxon potential without and with oscillations respectively. The Set 3 is a set with Christensen potential as the real part.**

Optical potential parameters

	Set 1	Set 2	Set 3
V (MeV)	32.88	32.48	20.41
r_{0R} (fm)	1.275	1.328	1.268
α_R (fm)	0.415	0.347	0.570
W (MeV)	21.50	7.25	8.06
r_{0I} (fm)	1.235	1.111	1.190
α_I (fm)	0.415	0.160	0.160

Elastic scattering 42.5MeV



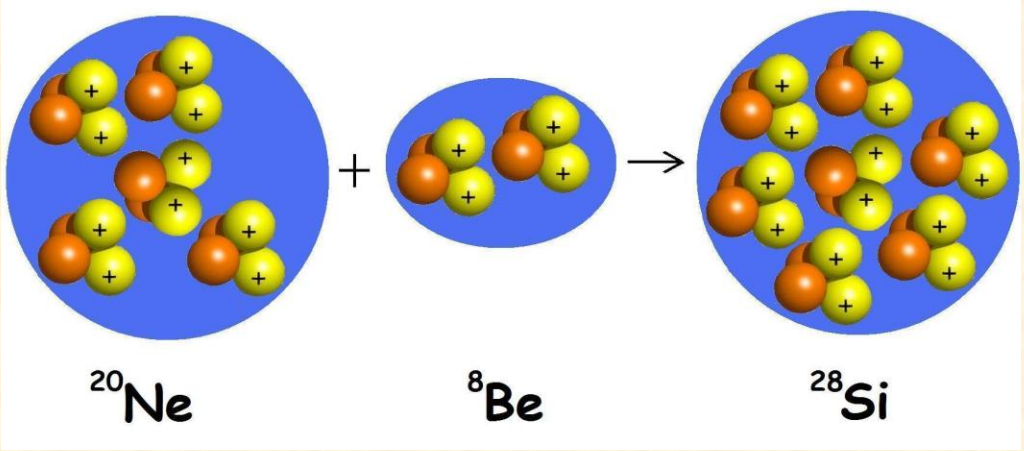
- ❖ **Elastic scattering data for ^{20}Ne + ^{28}Si at energy of 42.5 MeV.**
- ❖ **A FRESCO calculation by a free phenomenological Woods-Saxon potential is designated with the dotted-dashed line.**

Optical potential parameters

V (MeV)	**24.63**
r_{0R} (fm)	**1.432**
α_R (fm)	**0.361**
W (MeV)	**11.43**
r_{0I} (fm)	**1.250**
α_I (fm)	**0.361**

Explanation of the oscillations through coupling mechanisms

- Assuming that 2 sequential alphas are transferred from the target to projectile, the results were not satisfactory.
- On the other hand, a whole ^{8}Be transfer between ^{20}Ne and ^{28}Si can explain such a behavior.
- These advanced calculations are still in progress by N.Keeley.



Conclusions

From the study of the elastic scattering of ^{20}Ne + ^{28}Si at energies of 42.5, 52.3 and 70MeV, the following conclusions can be drawn:

1. The cross section at backward angles and at near barrier energies appear an anomalous increase, as the lighter projectiles ^{12}C and ^{16}O do.

2. This increase can be explained by assuming elastic transfer of a ^{8}Be cluster between ^{20}Ne and ^{28}Si.

3. Phenomenological Woods-Saxon potentials were determined for the lower energies.

4. We can’t ignore the fact that: the statistical errors were significant and the angular distribution was limited to a selected angular range. So, it is necessary a further investigation of that system principally at backward angles, using inverse kinematics to increase the cross section.

Collaborators

- ✓ *Department of Physics and HINP, The University of Ioannina, Ioannina, Greece*
- ✓ *Heavy Ion Laboratory, University of Warsaw, Warsaw, Poland*
- ✓ *The Andrzej Soltan Institute for Nuclear Studies, Warsaw, Poland*
- ✓ *Institute of Accelerating Systems and Applications and Department of Physics, University of Athens, Greece*
- ✓ *CEA-Saclay, DAPNIA-SPhN, Gif-sur-Yvette, France*
- ✓ *Departimento di Fisica and INFN - Sezione di Padova, Padova, Italy*
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