HELLENIC INSTITUTE OF NUCLEAR PHYSICS
1ST ONE DAY WORKSHOP ON NEW ASPECTS AND PERSPECTIVES IN NUCLEAR PHYSICS

# Transfer reactions for the system $^{20}Ne+^{28}Si$ at near barrier energies

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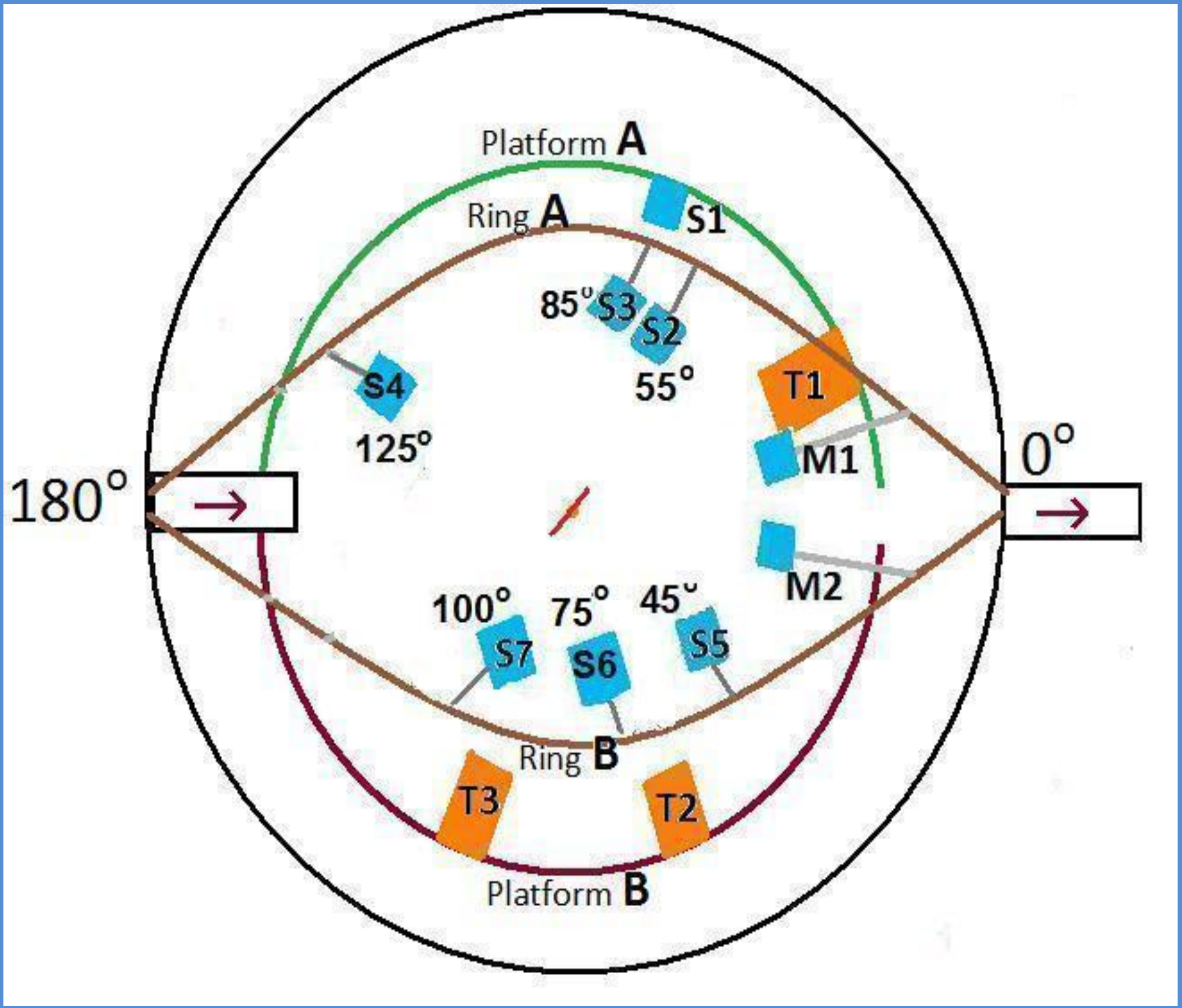
# Motivation

- Transfer reaction mechanisms can be used as a complementary tool to determine the optical potential.
- In this respect, angular distribution measurements of one-alpha and two-alpha transfer reactions for the system $^{20}Ne+^{28}Si$ can be studied as a complementary tool to elastic scattering for deducing the optical potential.

# Experimental Setup

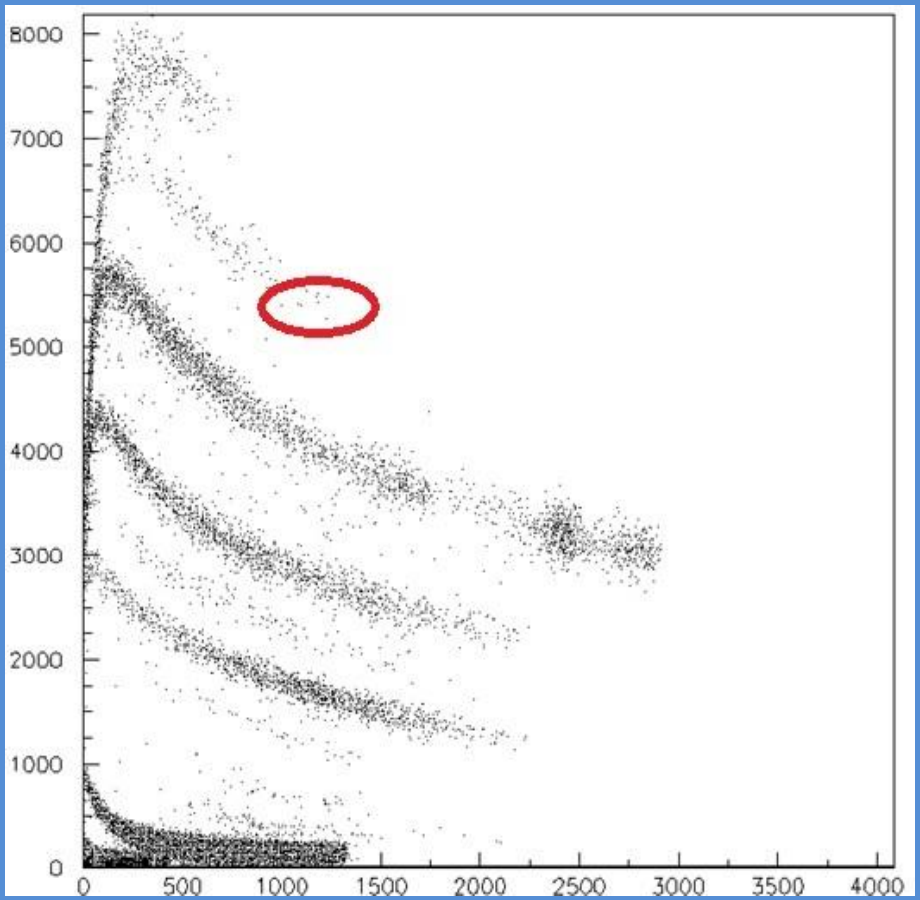



Schematical details of the setup

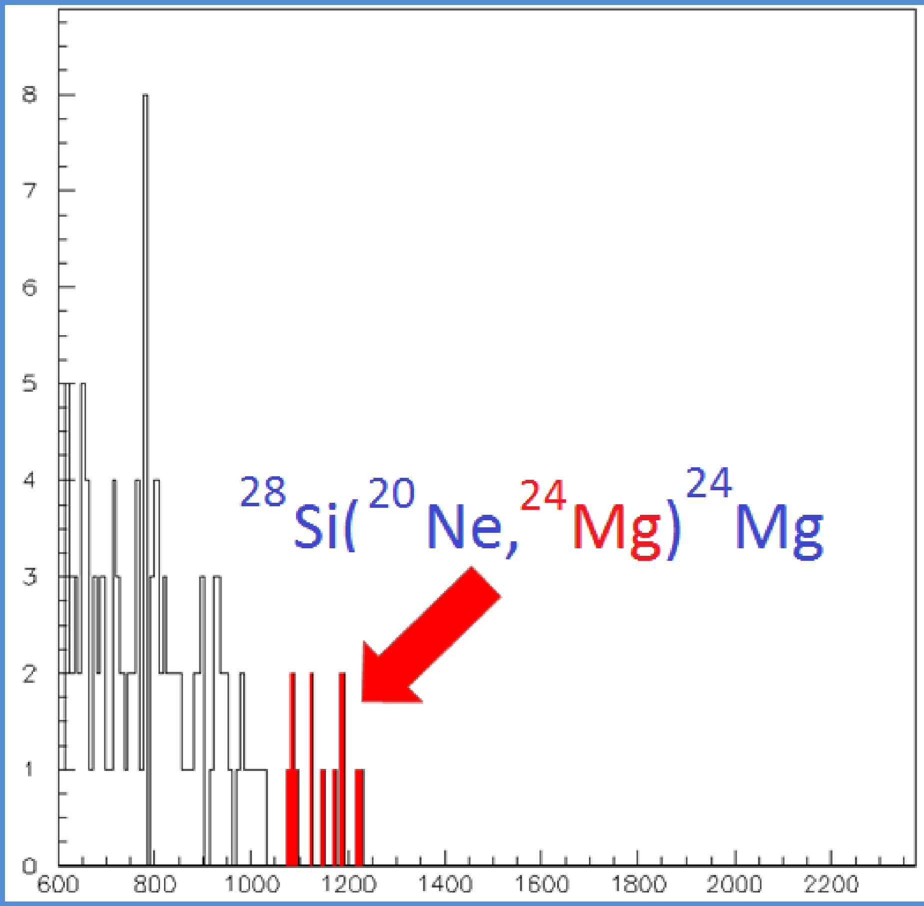
| Detector | Distance from the target (cm) |
|---|---|
| M1 | 31.5 |
| M2 | 31.5 |
| T1 | 11.5 |
| T2 | 11.5 |
| T3 | 11.4 |
| S1 | 11.1 |
| S2 | 11.5 |
| S3 | 11.5 |
| S4 | 11.5 |
| S5 | 11.6 |
| S6 | 13.5 |
| S7 | 11.6 |

Detectors' distances from the target

# Identification of reaction channels - One alpha transfer

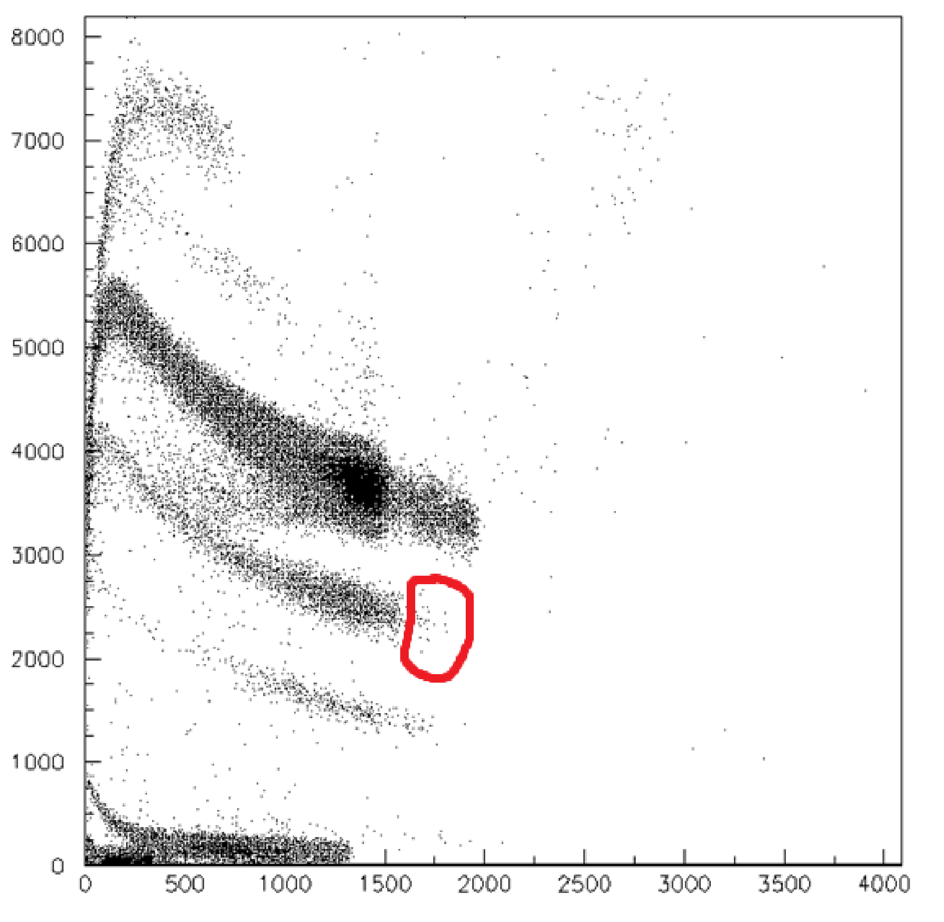



2D Spectrum – $^{24}$Mg contour, T1 at 34 deg, $E_{beam}$= 71 MeV

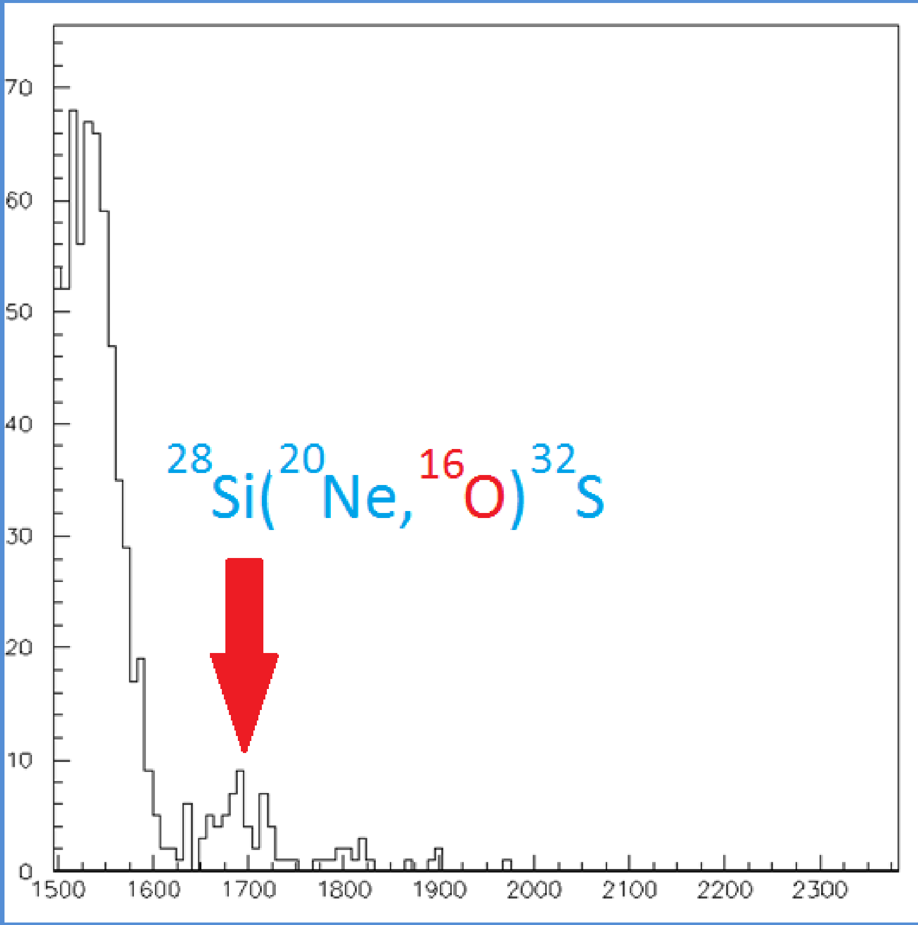



1D Spectrum – Projection on E, T1 at 45 deg, $E_{beam}$= 71 MeV

# Identification of reaction channels - One alpha transfer

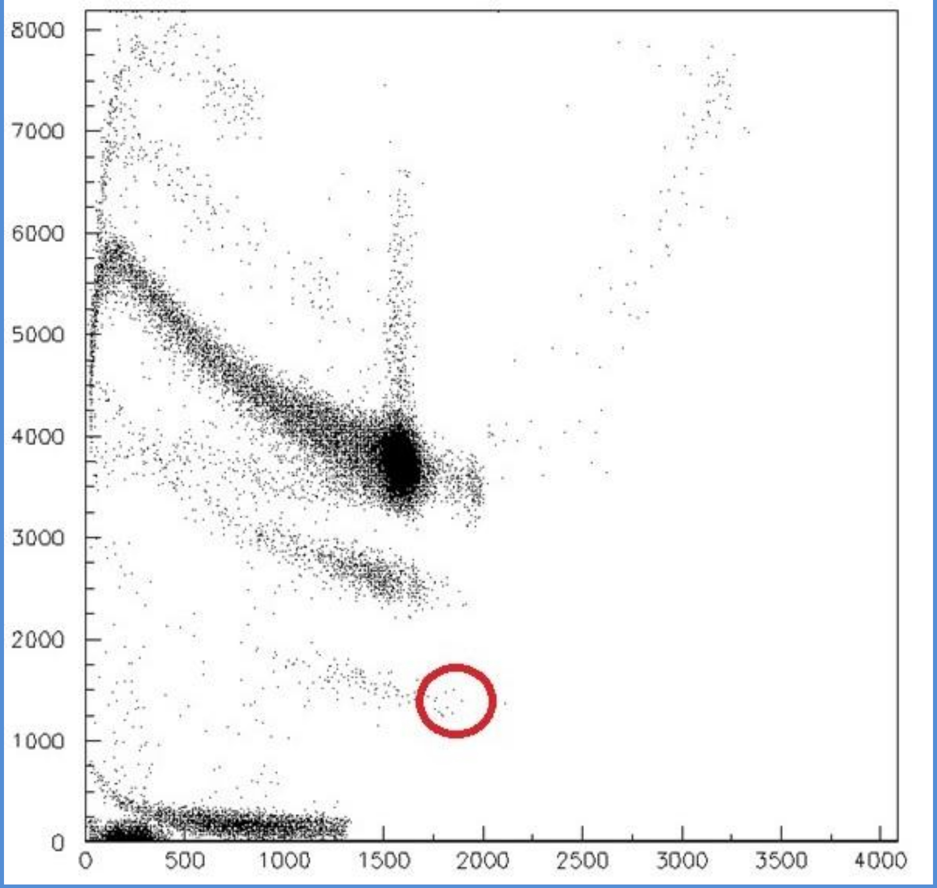



2D Spectrum – $^{16}O$ contour, T1 at 33 deg, $E_{beam}$ = 53 MeV

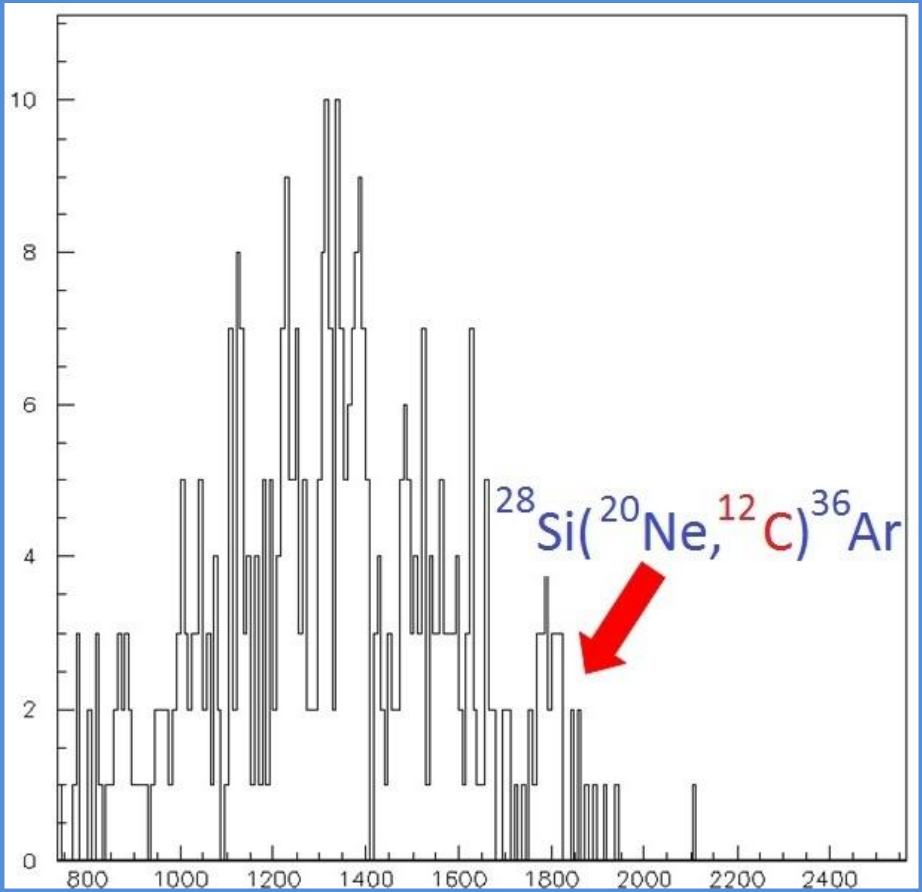



1D Spectrum – Projection on E, T1 at 33 deg, $E_{beam}$ = 53 MeV

# Identification of reaction channels- Two alpha transfer




2D Spectrum – $^{12}C$ contour, T1 at 30 deg, $E_{beam}$= 53 MeV




1D Spectrum – Projection on E, T1 at 30 deg, $E_{beam}$= 53 MeV

# Cross section calculation

- The cross section for each reaction channel was calculated according to the formula:

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

where is the N number of counts, Ω is the solid angle of the detector, Φ is the flux of the beam and D are the scattering centers.

- The "unknown" quantity (DΦ) is calculated via Rutherford scattering: $D\Phi = \frac{N_{monitor}}{\sigma_{Ruth}\Omega_{monitor}}$.

- $\Omega = \frac{4\pi}{R}\frac{N_a}{t}$ , where R is the activity of $^{241}Am$, $N_a$ are the counts from the alpha source and t is the record time.

# Error calculation

- Cross section was calculated according to the formula :

$$\sigma = \frac{\mathrm{N}}{(D\Phi)\Omega} = \ldots = \alpha \frac{\mathrm{N}}{\mathrm{N}_m \Omega}$$

, where "α" is a constant.

- The error in cross section was calculated via:

$$sigma = \left[ \left( \frac{\partial \sigma}{\partial \mathrm{N}} \sigma_{\mathrm{N}} \right)^2 + \left( \frac{\partial \sigma}{\partial \mathrm{N}_m} \sigma_{\mathrm{N}m} \right)^2 + \left( \frac{\partial \sigma}{\partial \Omega} \sigma_{\Omega} \right)^2 \right]^{1/2} =$$

$$= \left[ \left( \frac{a\sigma_{\mathrm{N}}}{\mathrm{N}_m \Omega} \right)^2 + \left( \frac{a\mathrm{N}\sigma_{\mathrm{N}m}}{\mathrm{N}_m{}^2 \Omega} \right) + \left( \frac{a\mathrm{N}\sigma_{\Omega}}{\mathrm{N}_m \Omega^2} \right)^2 \right]^{1/2} \Rightarrow \ldots$$

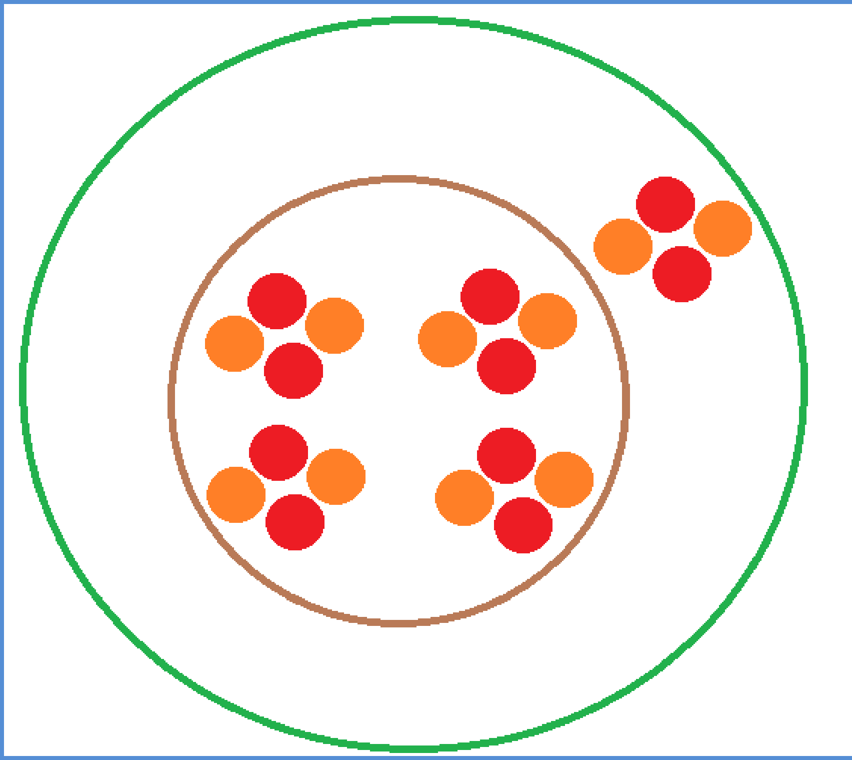
$$\ldots \Rightarrow sigma = \sigma \left[ \frac{1}{\mathrm{N}} + \frac{1}{\mathrm{N}_m} + \frac{1 + (1.269 \times 10^{-3})\mathrm{N}_a}{\mathrm{N}_a} \right]^{1/2}.$$

# D.W.B.A

- D.W.B.A uses distorted instead of plane waves.
- Necessary condition: The elastic scattering should be dominant compared to other possible reactions.
- All the reactions can be treat as weak transitions between elastic scattering states.

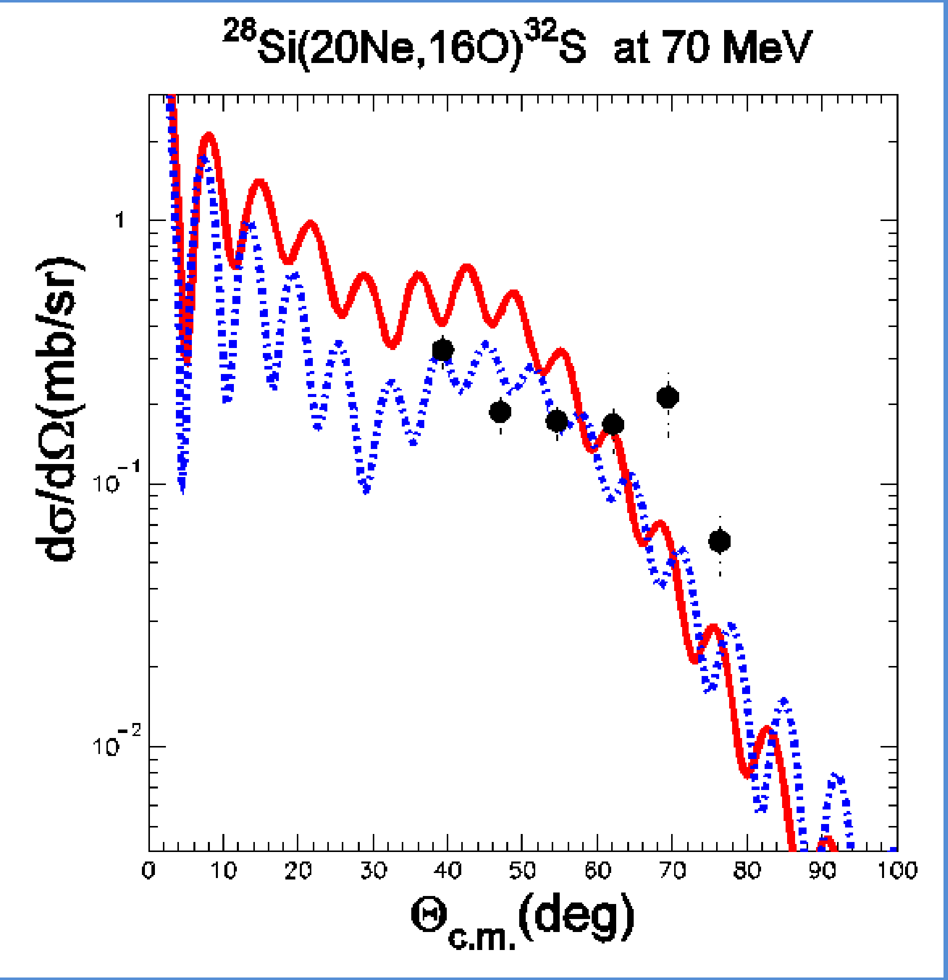
# Our D.W.B.A calculation

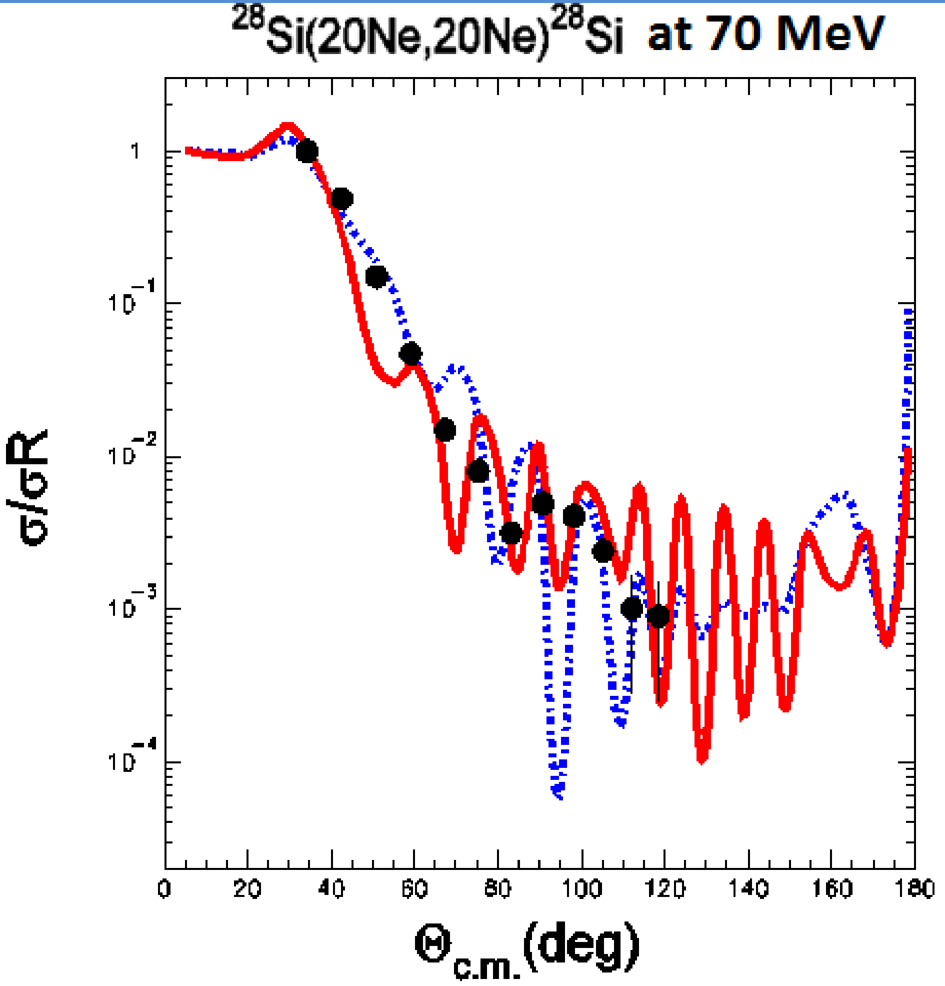
- Some nuclei permit an approximate description of their structure in terms of cluster. In our calculations we assumed cluster structure for the projectile.
- In this respect, vital for our calculation were: the binding potential between $^{16}O$-$^{4}He$, the $^{16}O$-$^{28}Si$ potential and the $^{4}He$-$^{28}Si$ potential.
- In addition, for the different reaction channels, we assumed that the valence is a pure single particle state.
- In a more accurate calculation, we have to take the valence state coupled to all the possible core states. That's why our calculation is the simplest one.



Cluster structure of $^{20}Ne$ nucleus

# D.W.B.A analysis

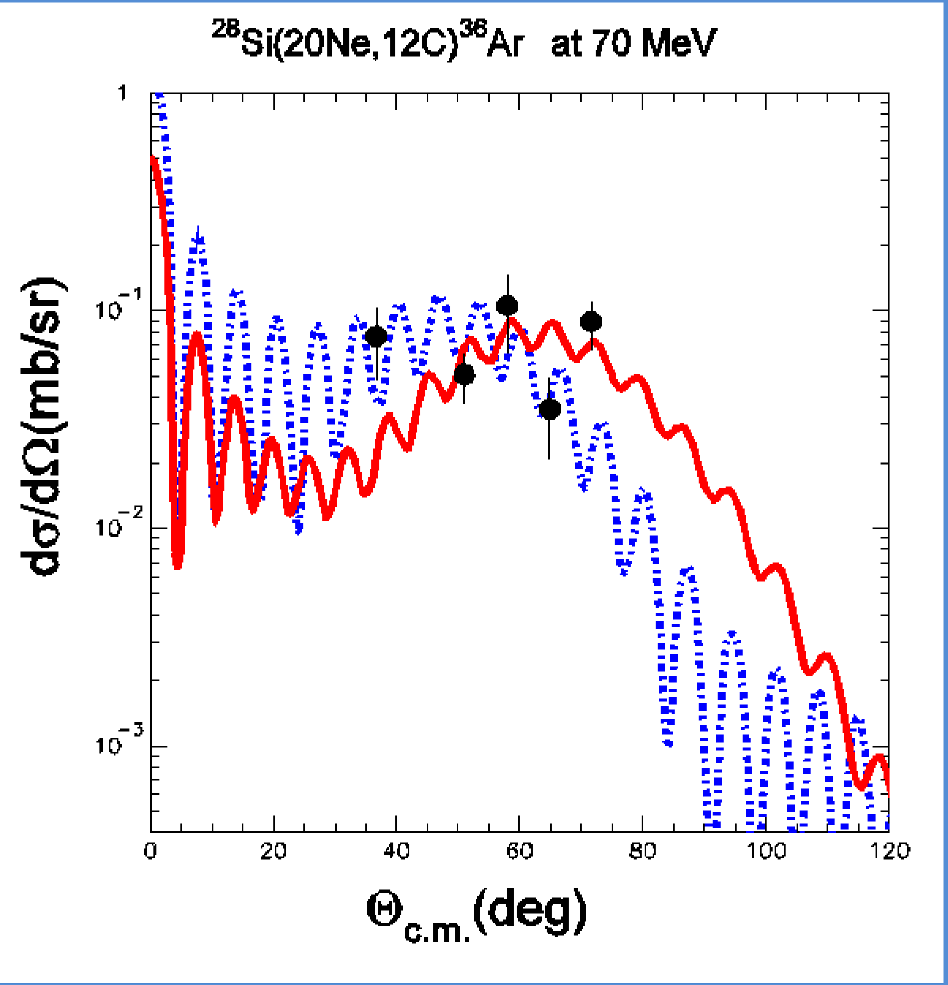


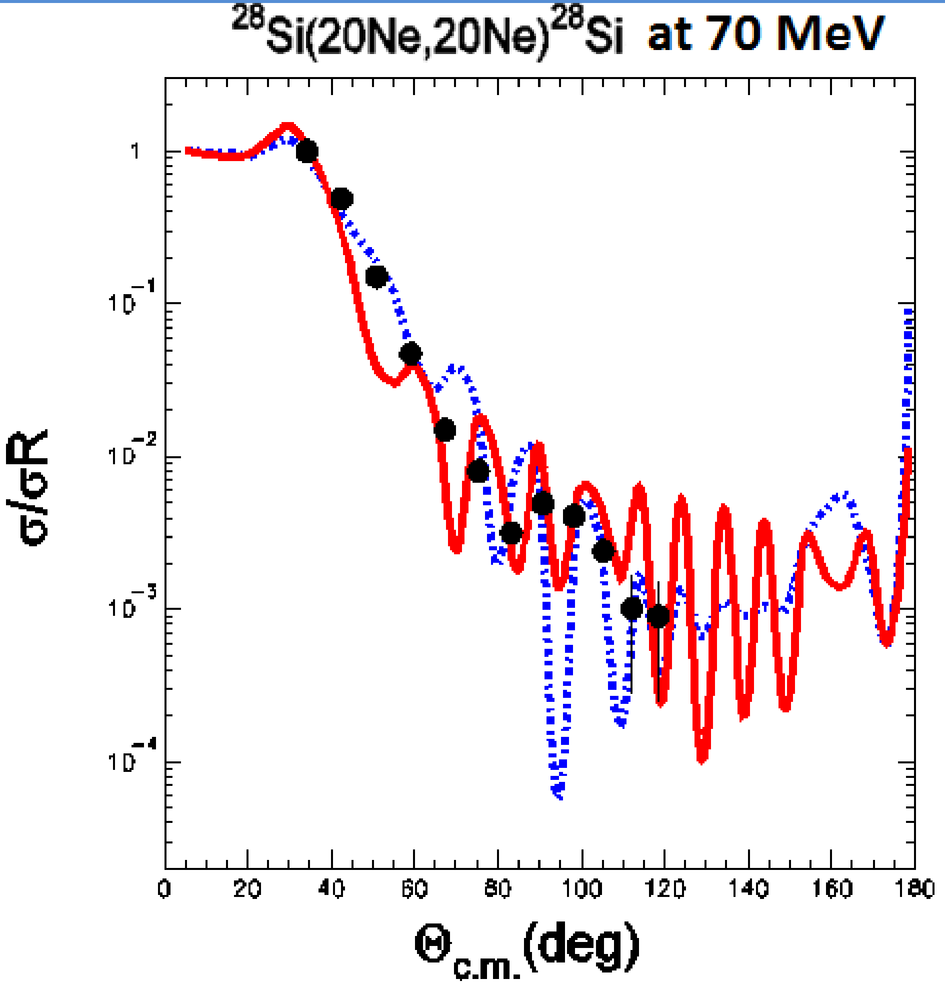

Data for the reaction $^{28}Si(^{20}Ne,^{16}O)^{32}S$ at 70 MeV. A simple DWBA calculation.

Data for the elastic scattering $^{28}Si(^{20}Ne,\ ^{20}Ne)^{28}Si$ at 70 MeV.

# D.W.B.A analysis

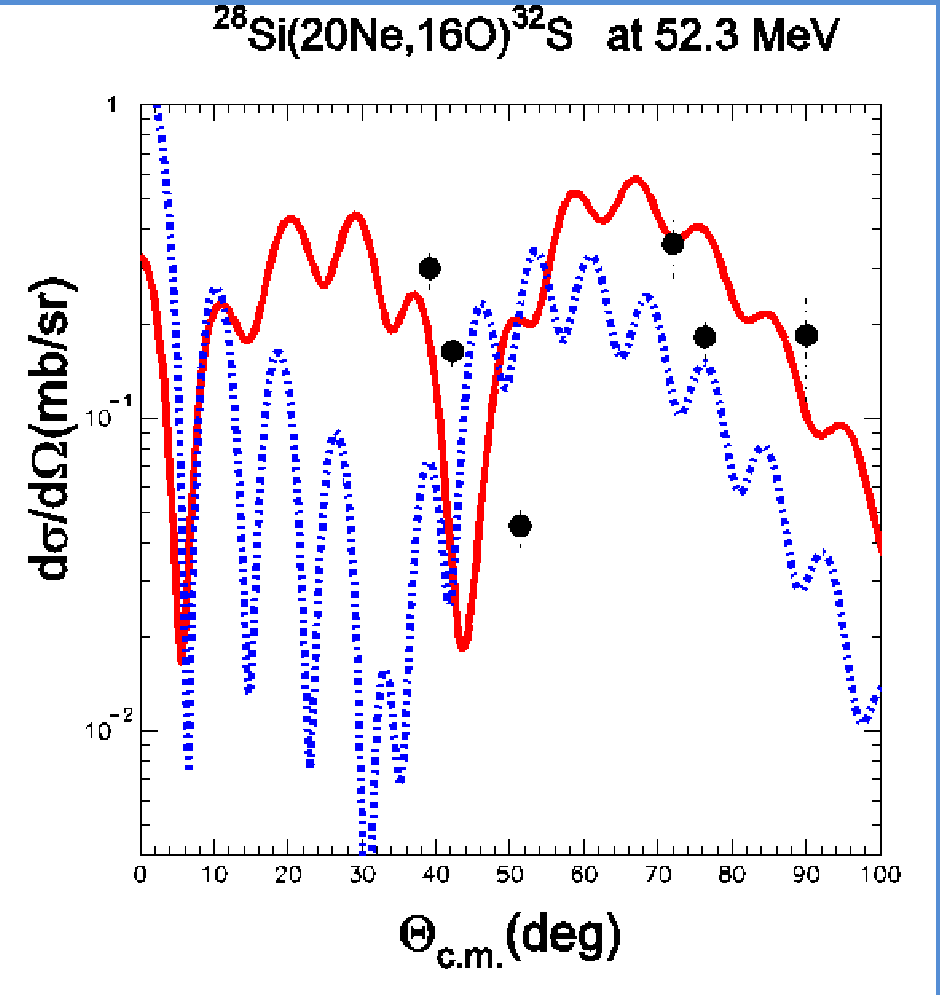


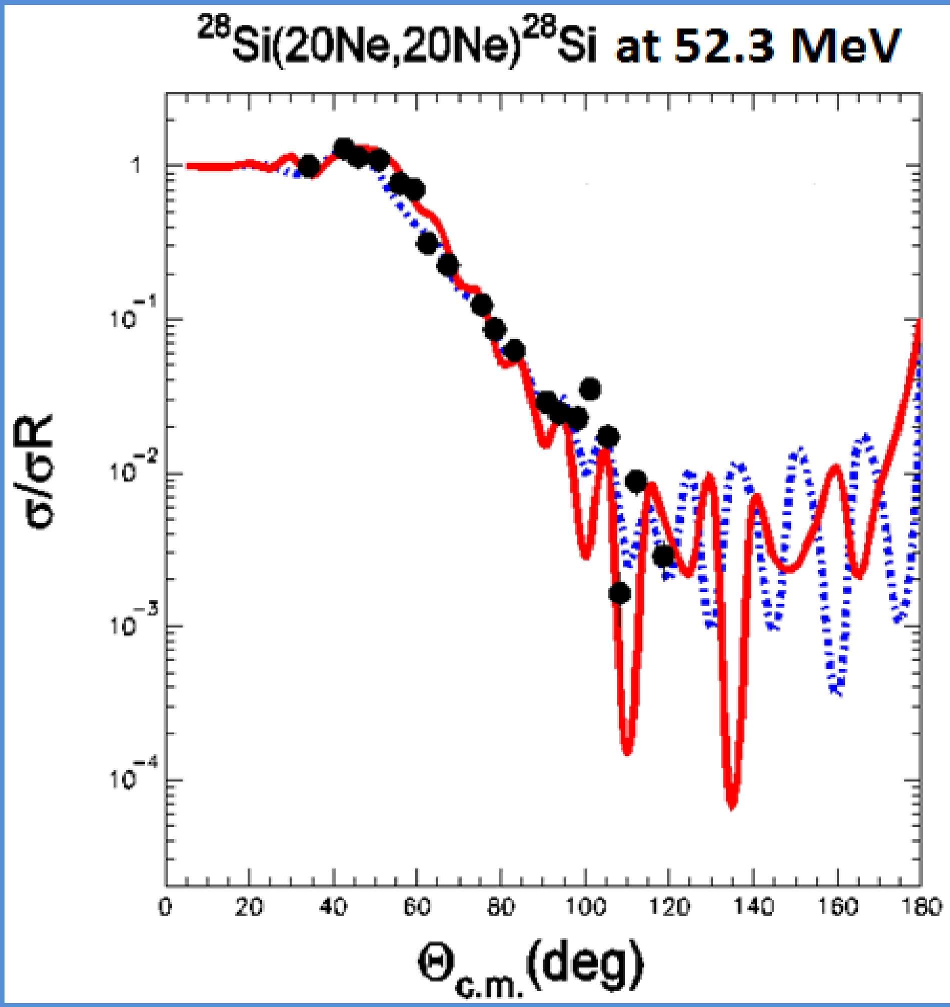

Data for the reaction $^{28}Si(^{20}Ne,^{12}C)^{36}Ar$ at 70 MeV.
A simple DWBA calculation.




Data for the elastic scattering $^{28}Si(^{20}Ne,\,^{20}Ne)^{28}Si$ at 70 MeV.

# D.W.B.A analysis

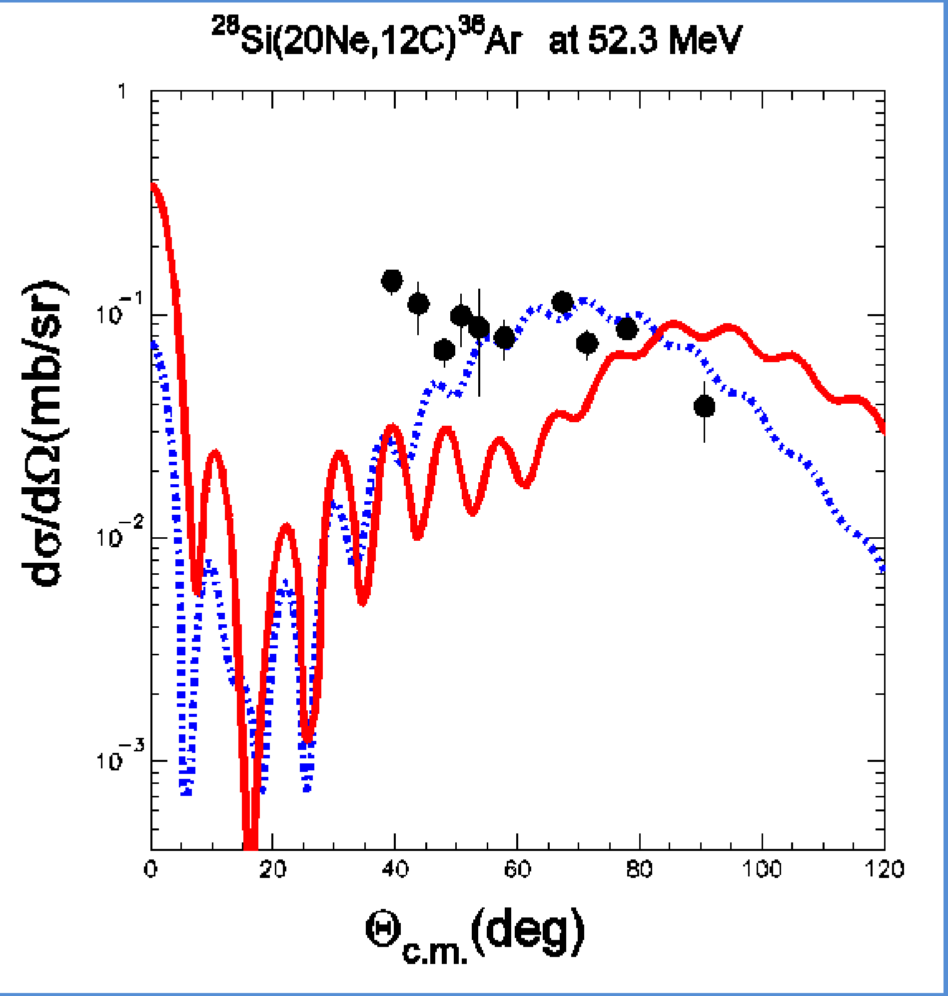


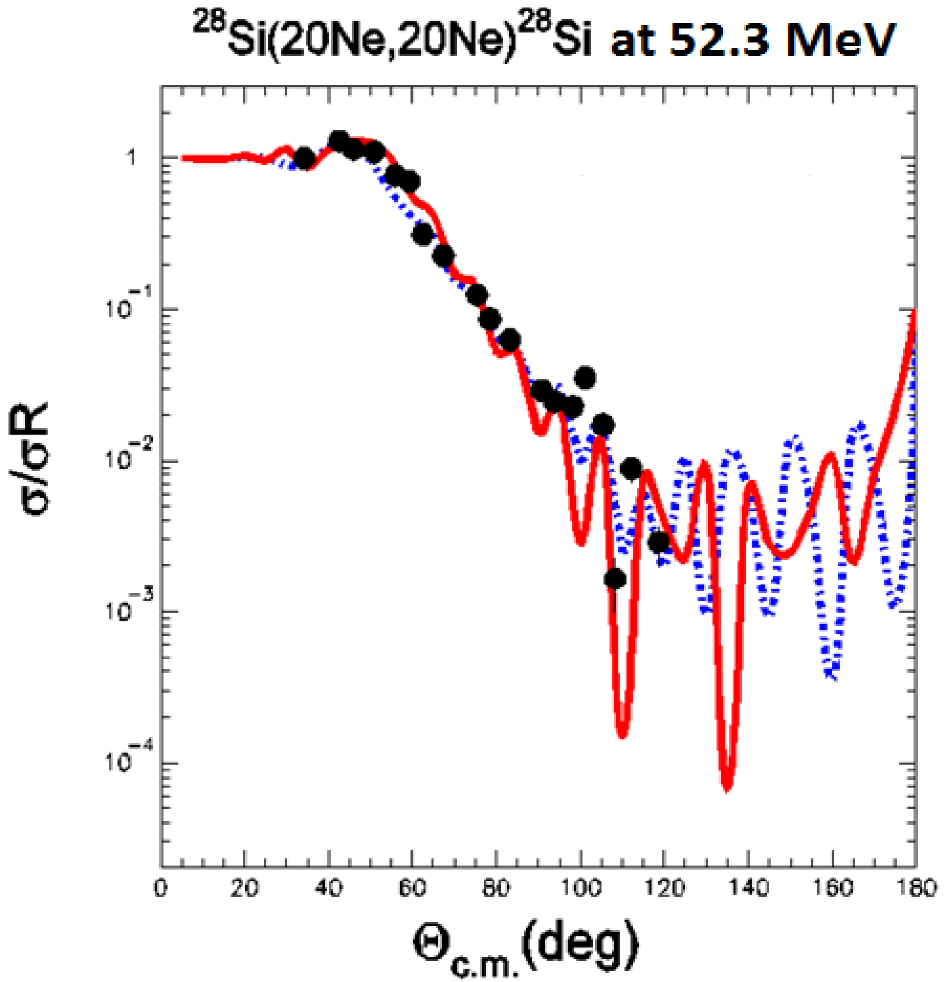




Data for the reaction $^{28}$Si($^{20}$Ne,$^{16}$O)$^{32}$S at 52.3 MeV. A simple DWBA calculation.

Data for the elastic scattering $^{28}$Si($^{20}$Ne, $^{20}$Ne)$^{28}$Si at 52.3 MeV.

# D.W.B.A analysis

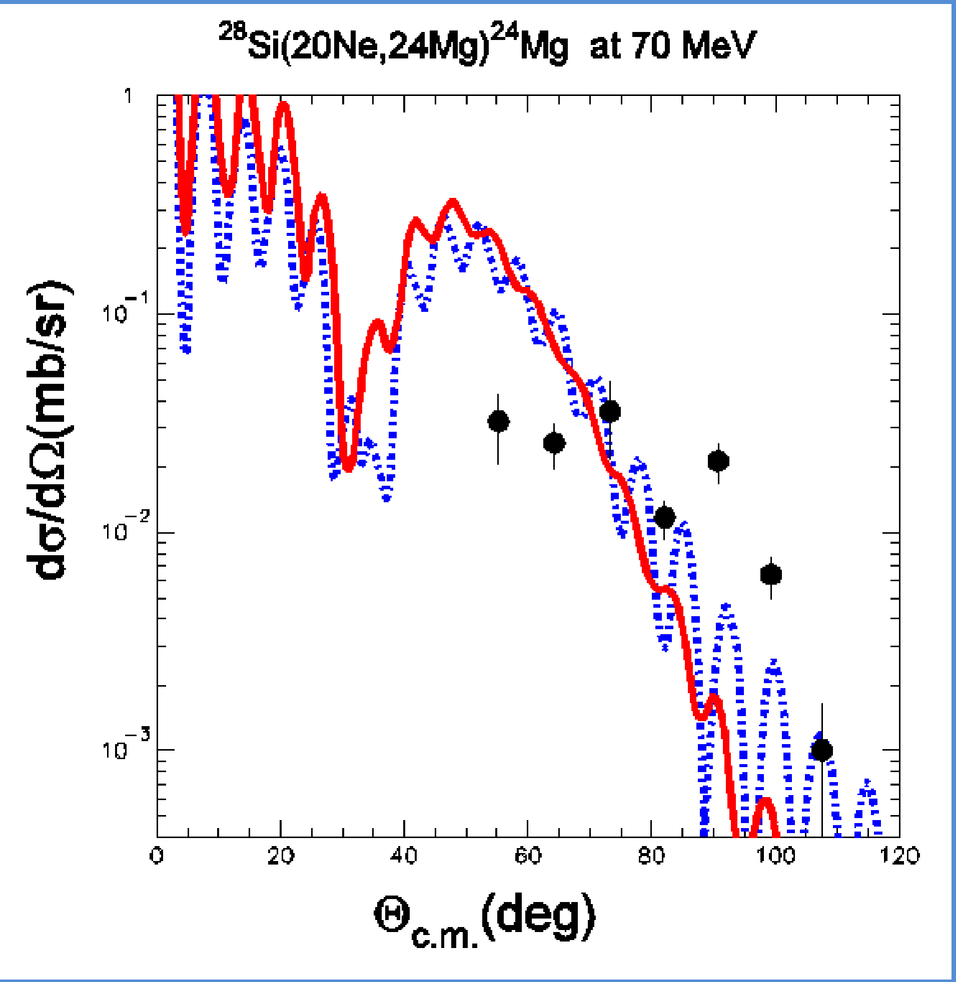


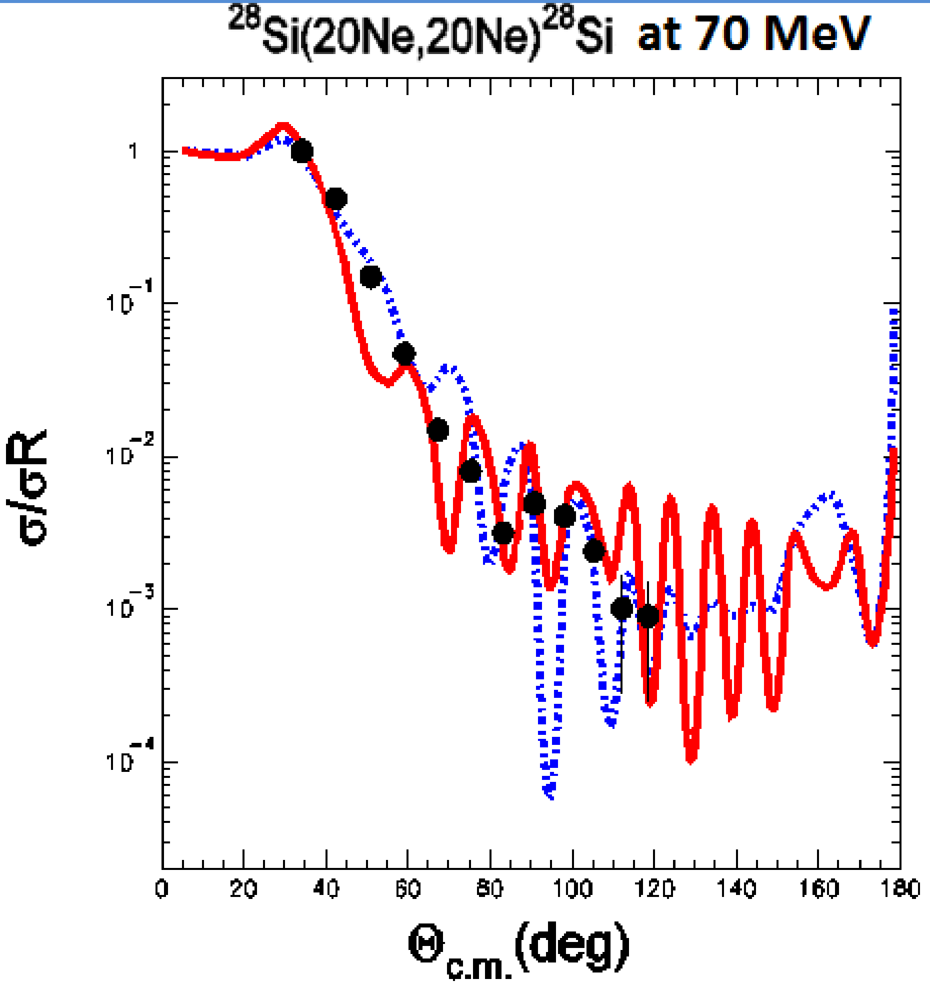




Data for the reaction $^{28}$Si($^{20}$Ne,$^{12}$C)$^{36}$Ar at 52.3 MeV. A simple DWBA calculation.

Data for the elastic scattering $^{28}$Si($^{20}$Ne, $^{20}$Ne)$^{28}$Si at 52.3 MeV.

# D.W.B.A analysis




Data for the reaction $^{28}$Si($^{20}$Ne,$^{24}$Mg)$^{24}$Mg at 70 MeV. A simple DWBA calculation.

Data for the elastic scattering $^{28}$Si($^{20}$Ne, $^{20}$Ne)$^{28}$Si at 70 MeV.

# Conclusions

- Angular distribution measurements of one-alpha and two-alpha transfer reactions for the system $^{20}Ne+^{28}Si$ were performed at near barrier energies.
- One and two alpha transfer reaction products were observed.
- The data were analyzed in a DWBA framework. The agreement with the data is good for both energies, indicating the validity of the proposed potential.
- ***Future aspects:*** Study $^{20}Ne+^{28}Si$ transfer reactions using a mass spectrometer.

Good energy resolution

Good angular resolution

# 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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