Microscopic spin–orbit potentials for ^{3}He elastic scattering at intermediate energies

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Abstract

- The central part of optical potentials for ^{3}He elastic scattering has been determined from optical model analyses up to E_{lab} = 450 MeV.
- The spin–orbit part of optical potentials for ^{3}He scattering is unknown due to lack of experiments using polarised ^{3}He beams.

  E_{lab} = 33 MeV (Birmingham) only one data

- There is an experimental project using polarized ^{3}He beams at E_{lab} = 450 MeV. (RCNP)

- We analyse the ^{3}He elastic scattering with the optical model using double folding potentials.

Our Analyses

- Elastic scattering of ^{3}He particles

$^{3}He+^{58}Ni$ 33 – 450 MeV $d\sigma/d\Omega$

$^{3}He+^{58}Ni$ E_{lab}= 450 MeV Ay

RCNP (preliminary results)

■Volume integrals of real central potentials

A unique potential family of central part for real optical potentials in ^{3}He elastic scattering has been decided.

- Low incident energies

deep or shallow potentials

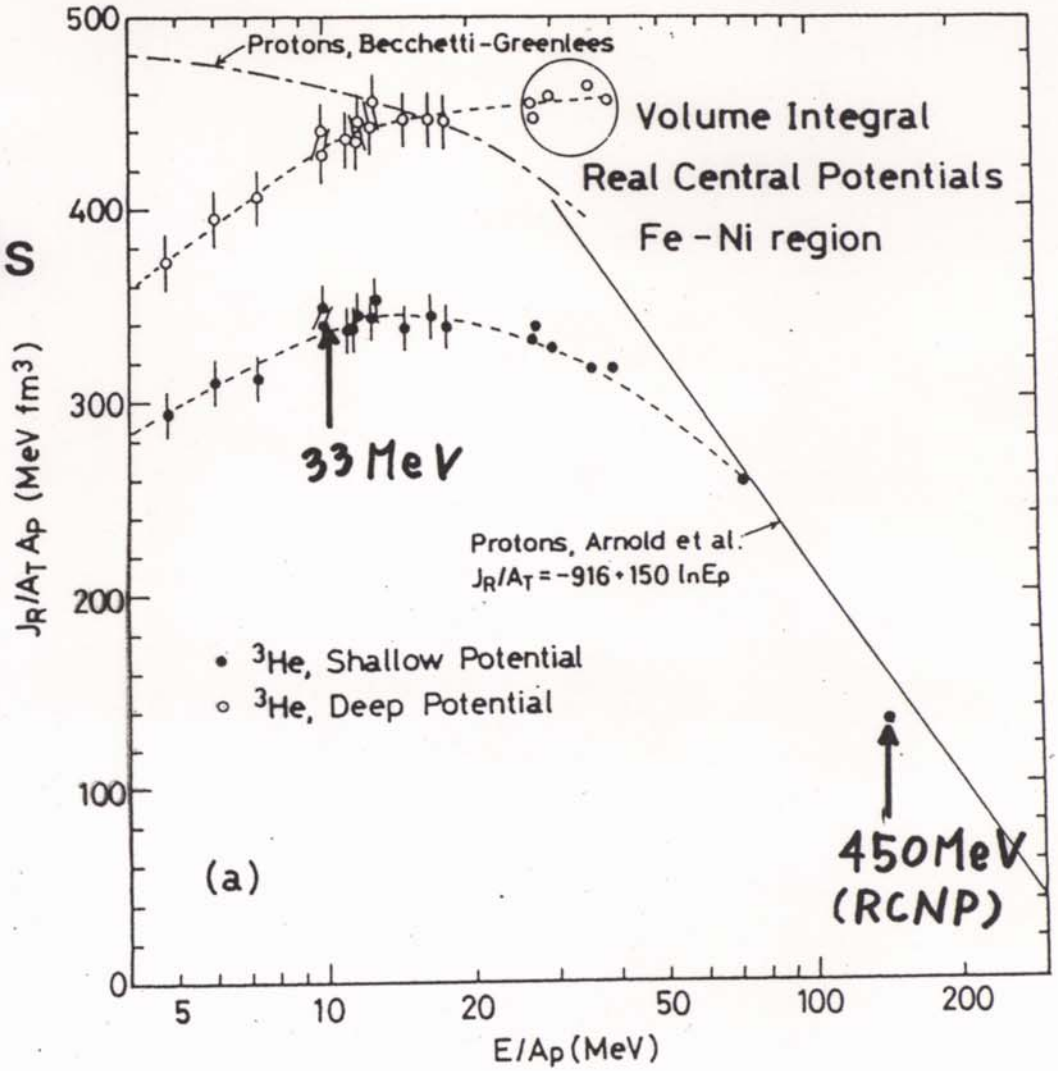
- Energies higher than

40 MeV/N

the shallow potential

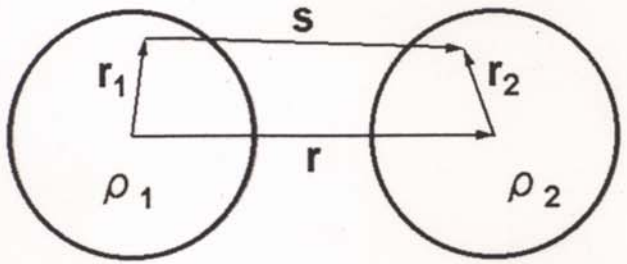
becomes

the best-fit potential.



Folding potentials

$$V^N(r) = \int \rho_1(r_1)\ \rho_2(r_2)\ \upsilon_{NN}(s)\ dr_1 dr_2$$



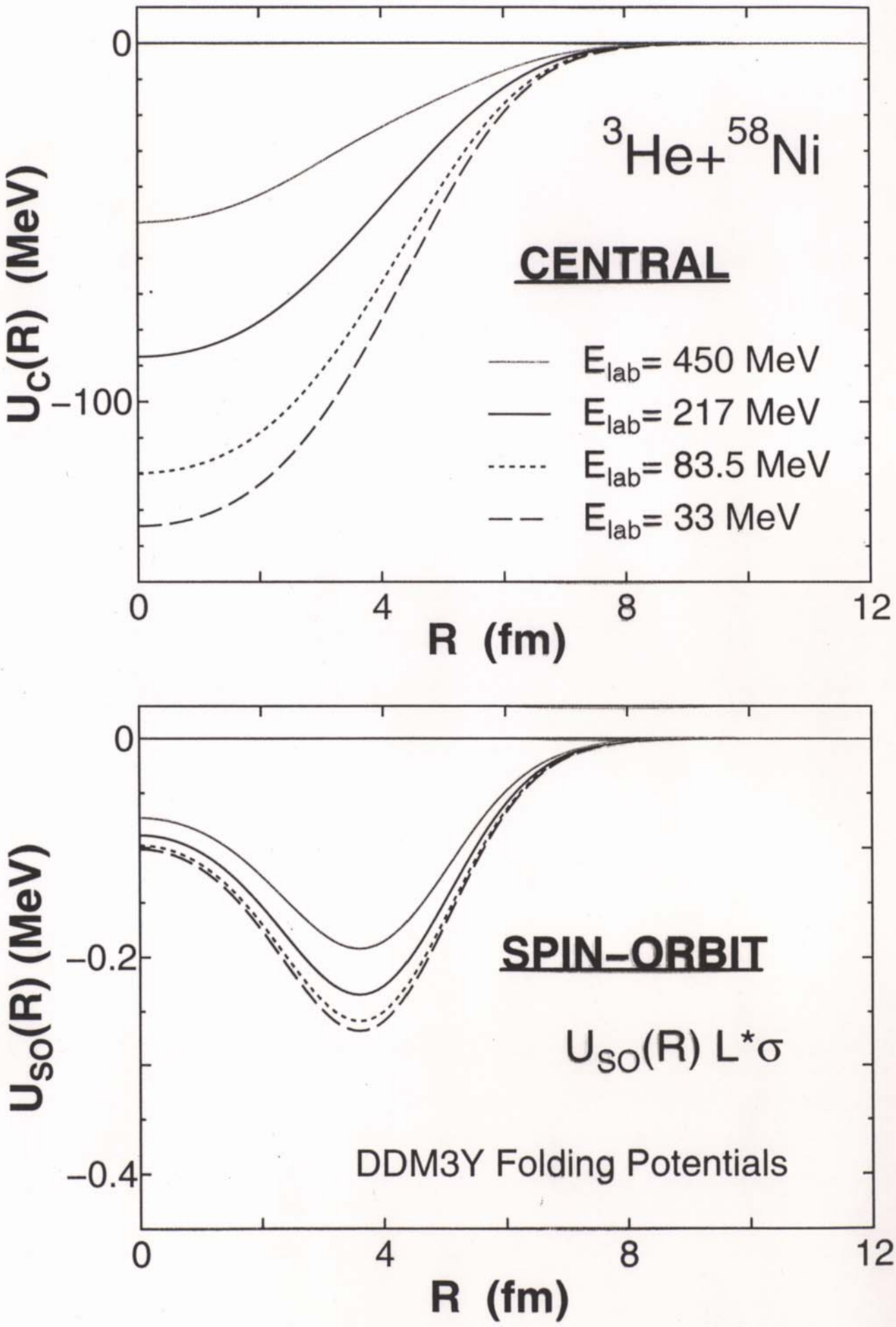
- The effective Nucleon–Nucleon interaction (DDM3Y)

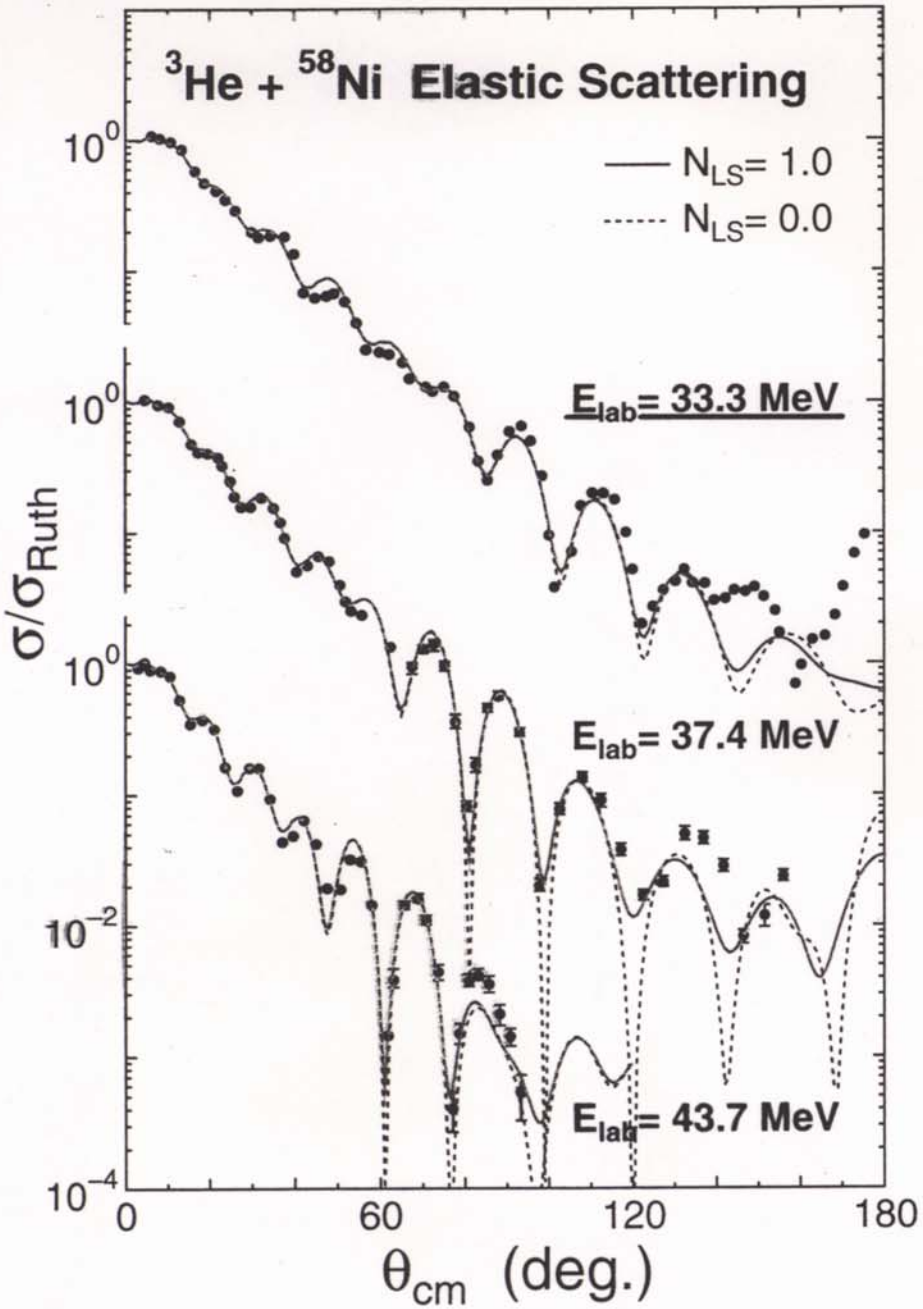
$$\upsilon_{NN} = \upsilon_{CE}(s) + \upsilon_{SO}(s)\ L\cdot\sigma$$

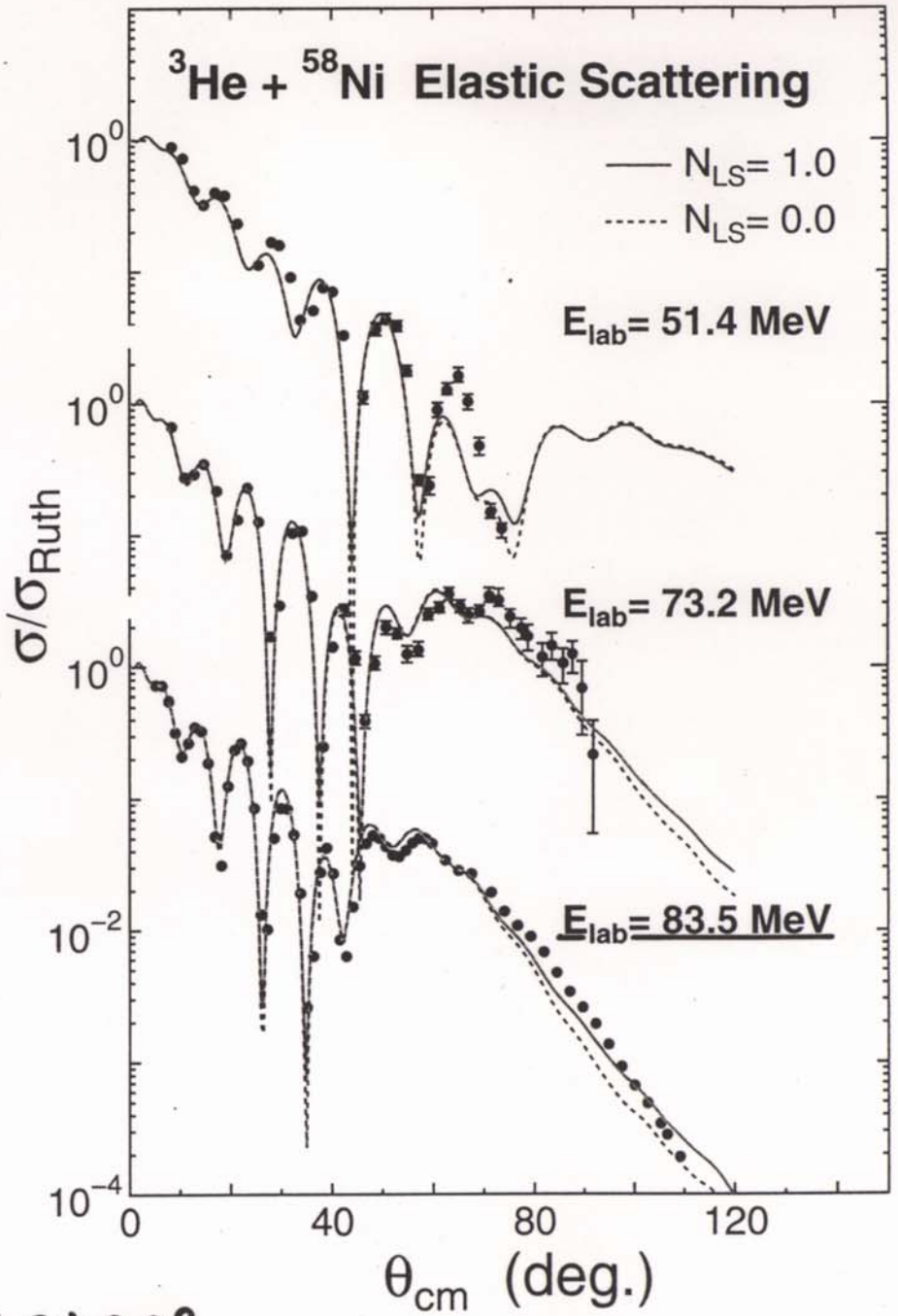
- Optical Potentials

$$U(r) = N_R\ V^N_{CE}(r) + N_{LS}\ V^N_{SO}(r)\ L\cdot\sigma$$

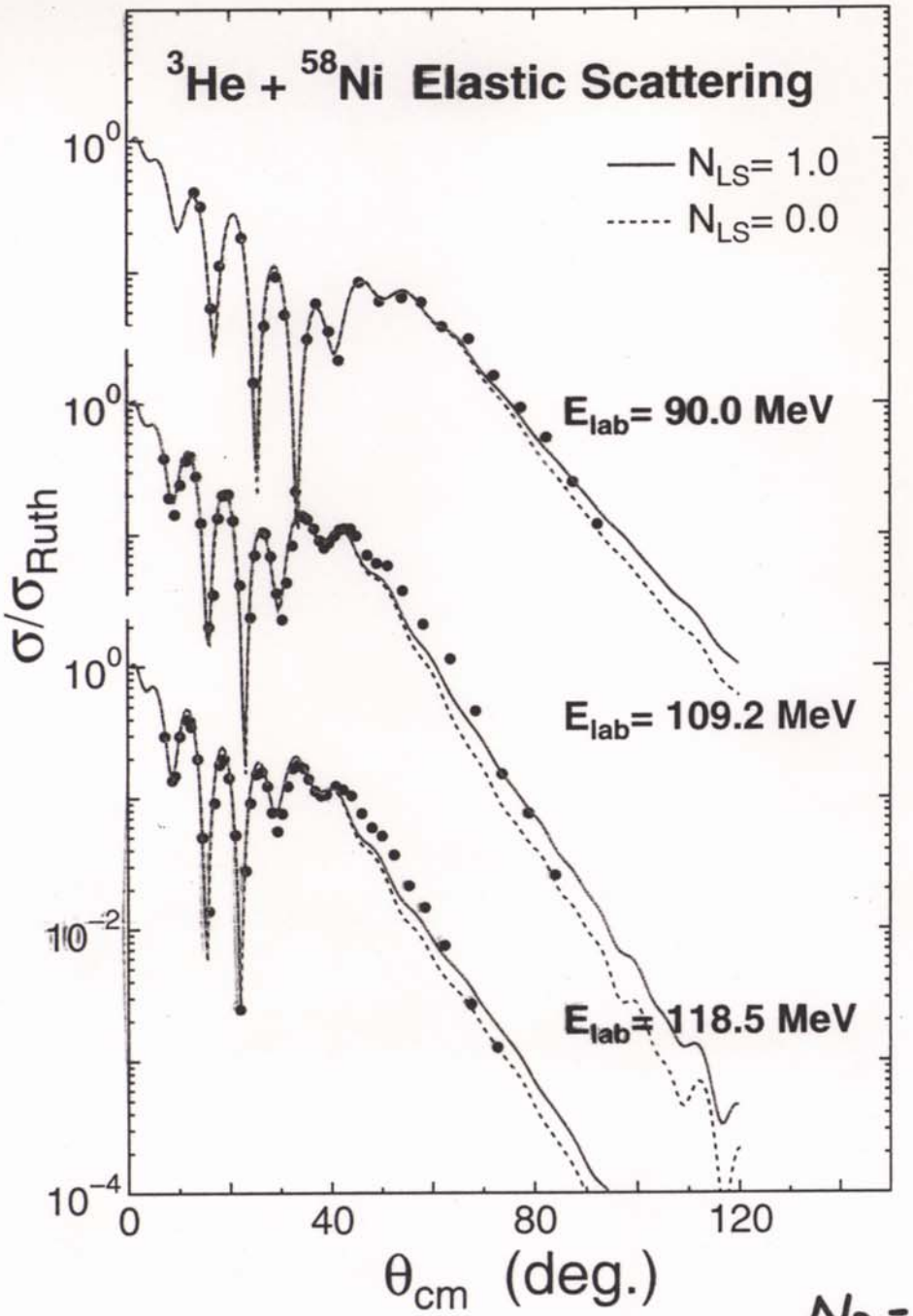
$$+V^C(r) + i\ W_{WS}(r)$$

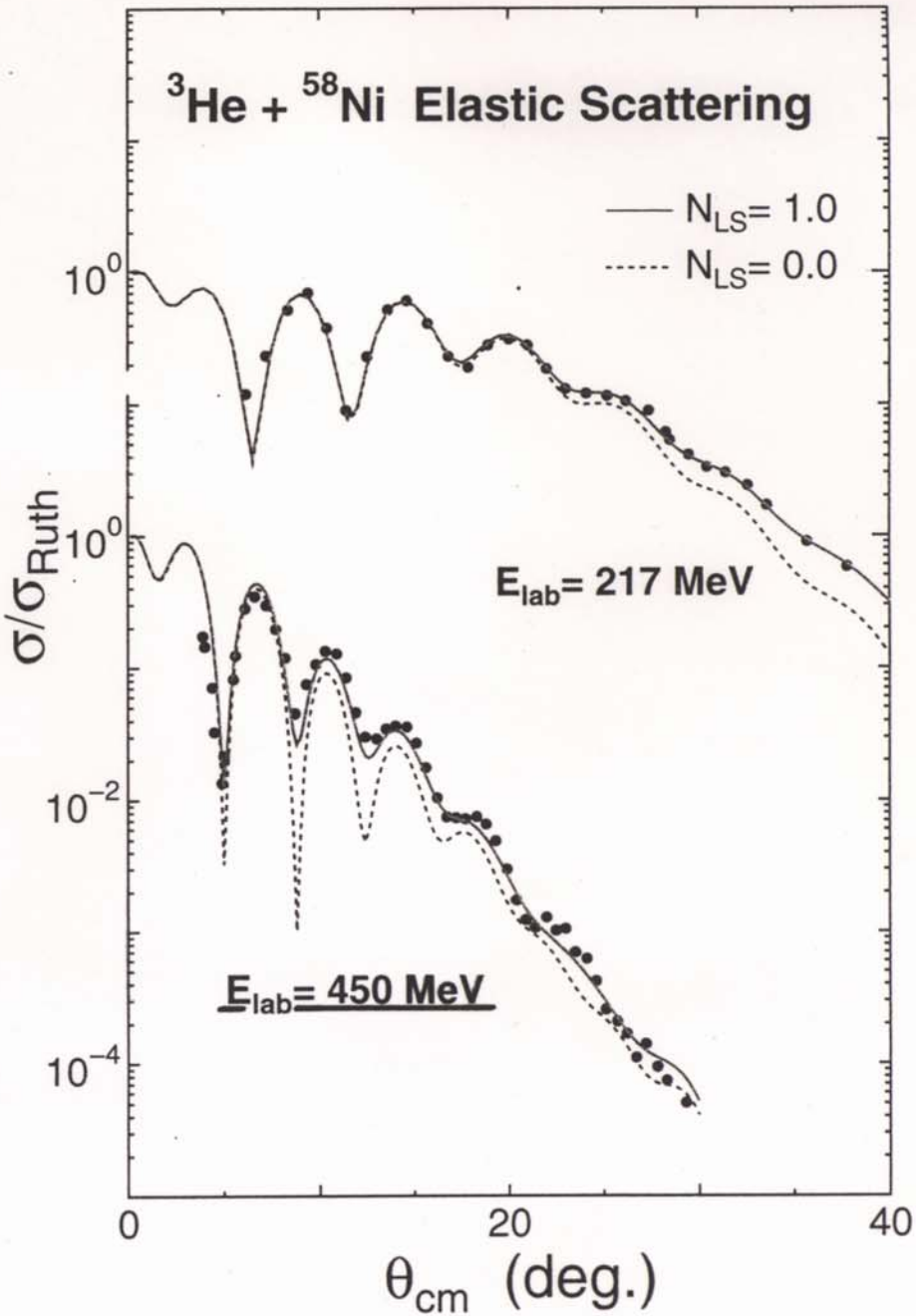

0
−100
$U_C(R)$ (MeV)
$^3He+^{58}Ni$
CENTRAL
E_{lab}= 450 MeV
E_{lab}= 217 MeV
E_{lab}= 83.5 MeV
E_{lab}= 33 MeV
0
4
8
12
R (fm)
0
−0.2
−0.4
$U_{SO}(R)$ (MeV)
SPIN–ORBIT
$U_{SO}(R)$ L*σ
DDM3Y Folding Potentials
0
4
8
12
R (fm)


^{3}He + ^{58}Ni Elastic Scattering
N_{LS}= 1.0
N_{LS}= 0.0
E_{lab}= 33.3 MeV
E_{lab}= 37.4 MeV
E_{lab}= 43.7 MeV
σ/σ_{Ruth}
θ_{cm} (deg.)


^{3}He + ^{58}Ni Elastic Scattering
N_{LS}= 1.0
N_{LS}= 0.0
E_{lab}= 51.4 MeV
E_{lab}= 73.2 MeV
E_{lab}= 83.5 MeV
σ/σ_{Ruth}
θ_{cm} (deg.)

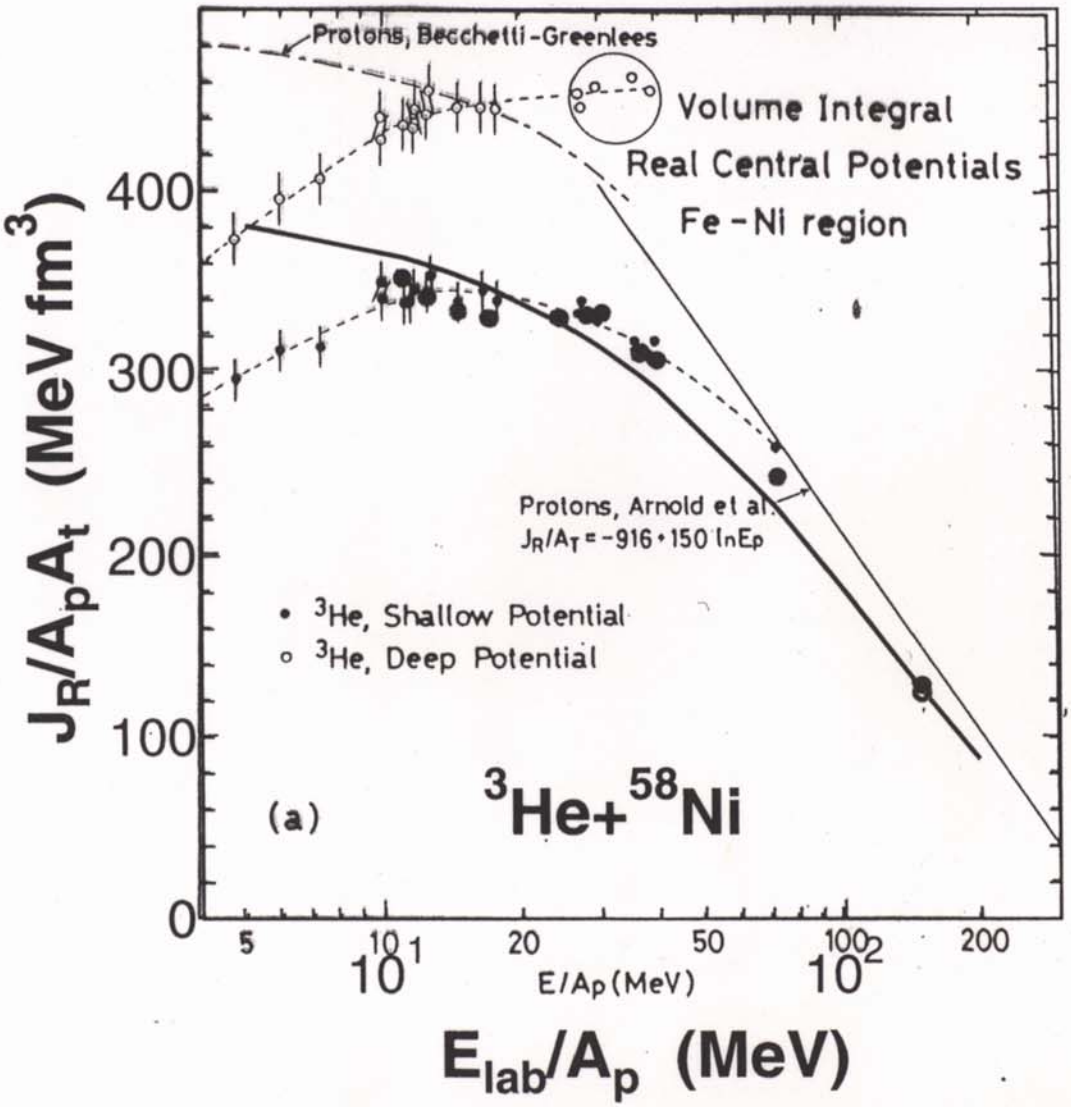
$N_R = 1.0 \pm 0.08$

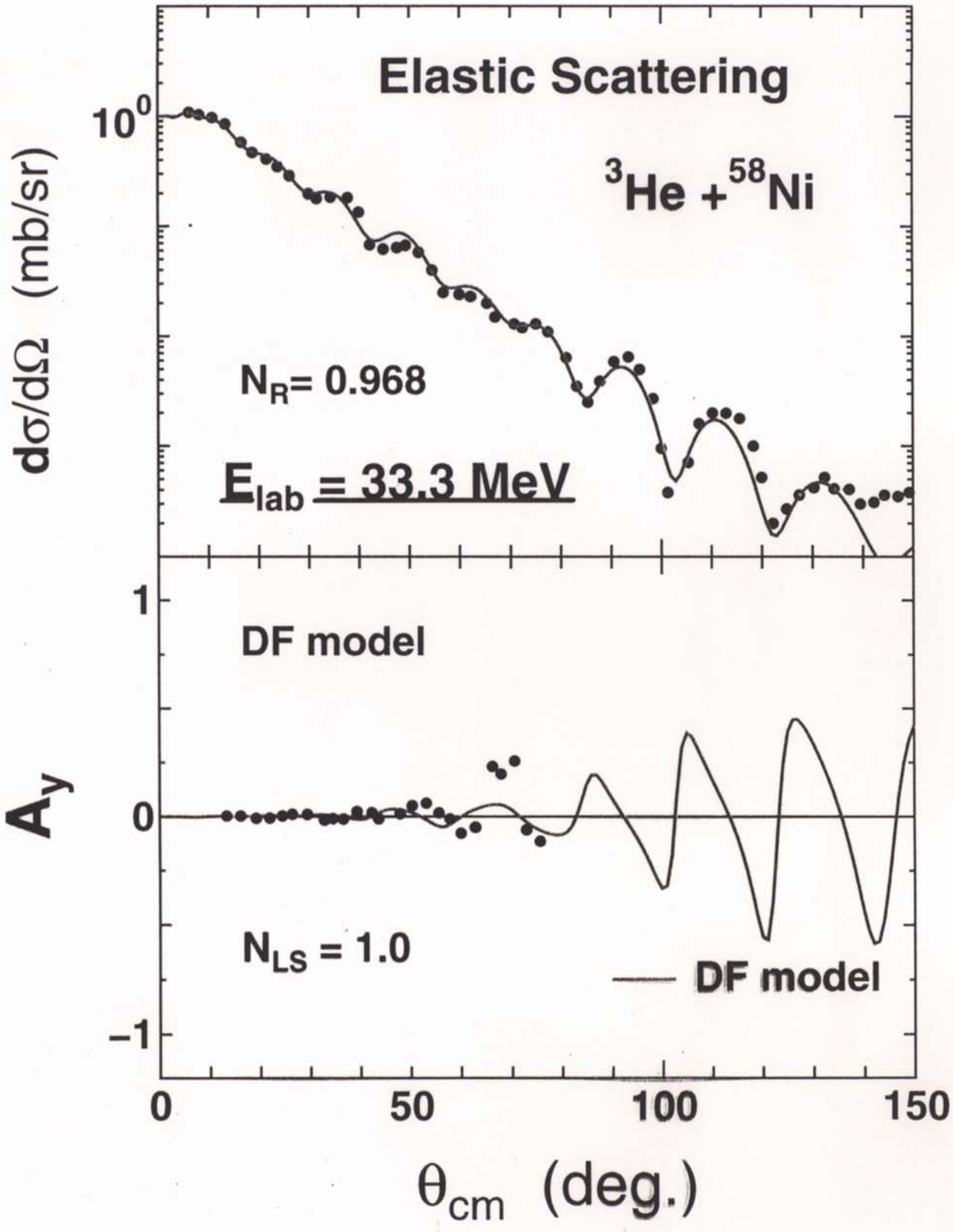

^{3}He + ^{58}Ni Elastic Scattering
N_{LS}= 1.0
N_{LS}= 0.0
E_{lab}= 90.0 MeV
E_{lab}= 109.2 MeV
E_{lab}= 118.5 MeV
σ/σ_{Ruth}
θ_{cm} (deg.)

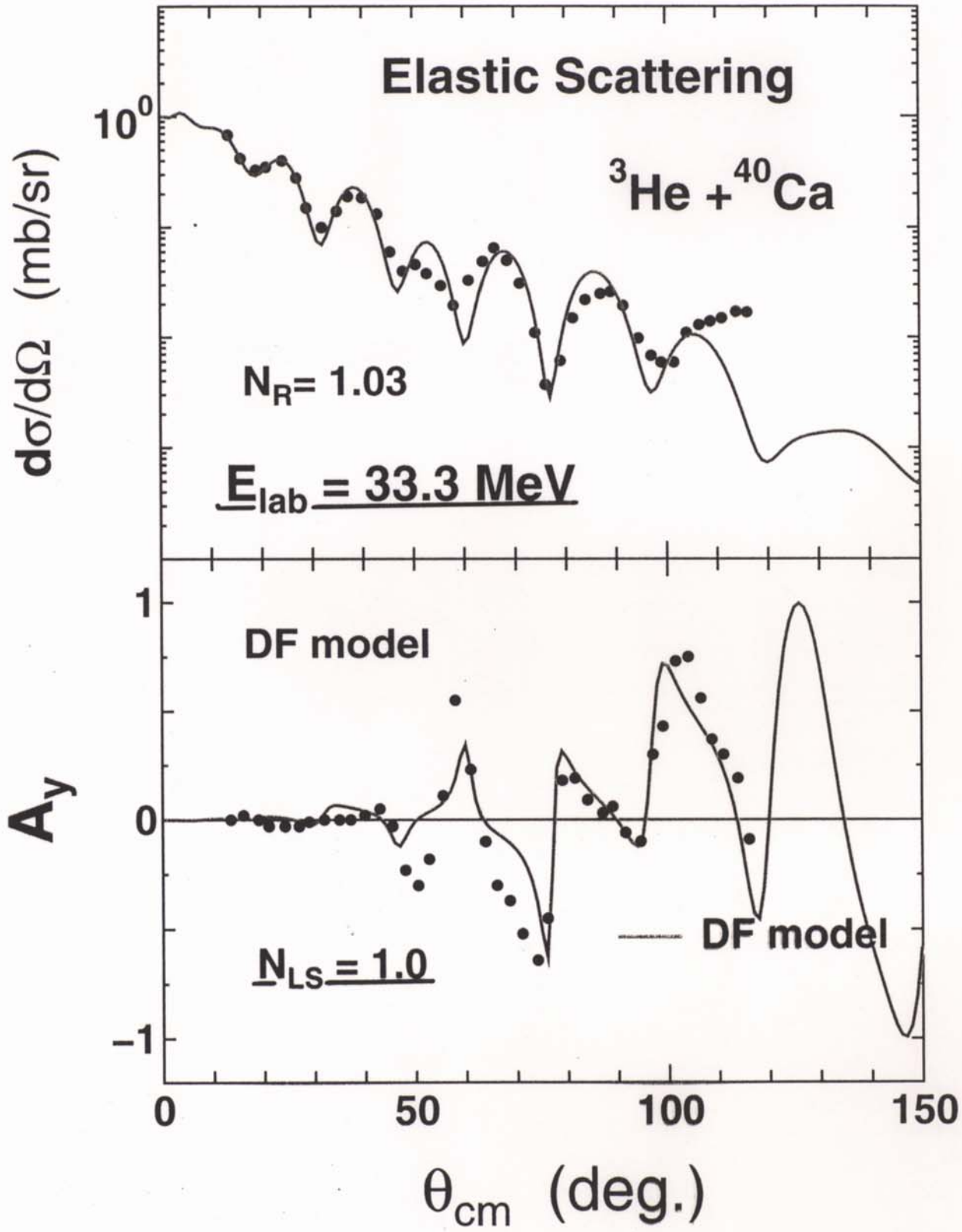

^{3}He + ^{58}Ni Elastic Scattering
N_{LS}= 1.0
N_{LS}= 0.0
E_{lab}= 217 MeV
E_{lab}= 450 MeV
σ/σ_{Ruth}
θ_{cm} (deg.)

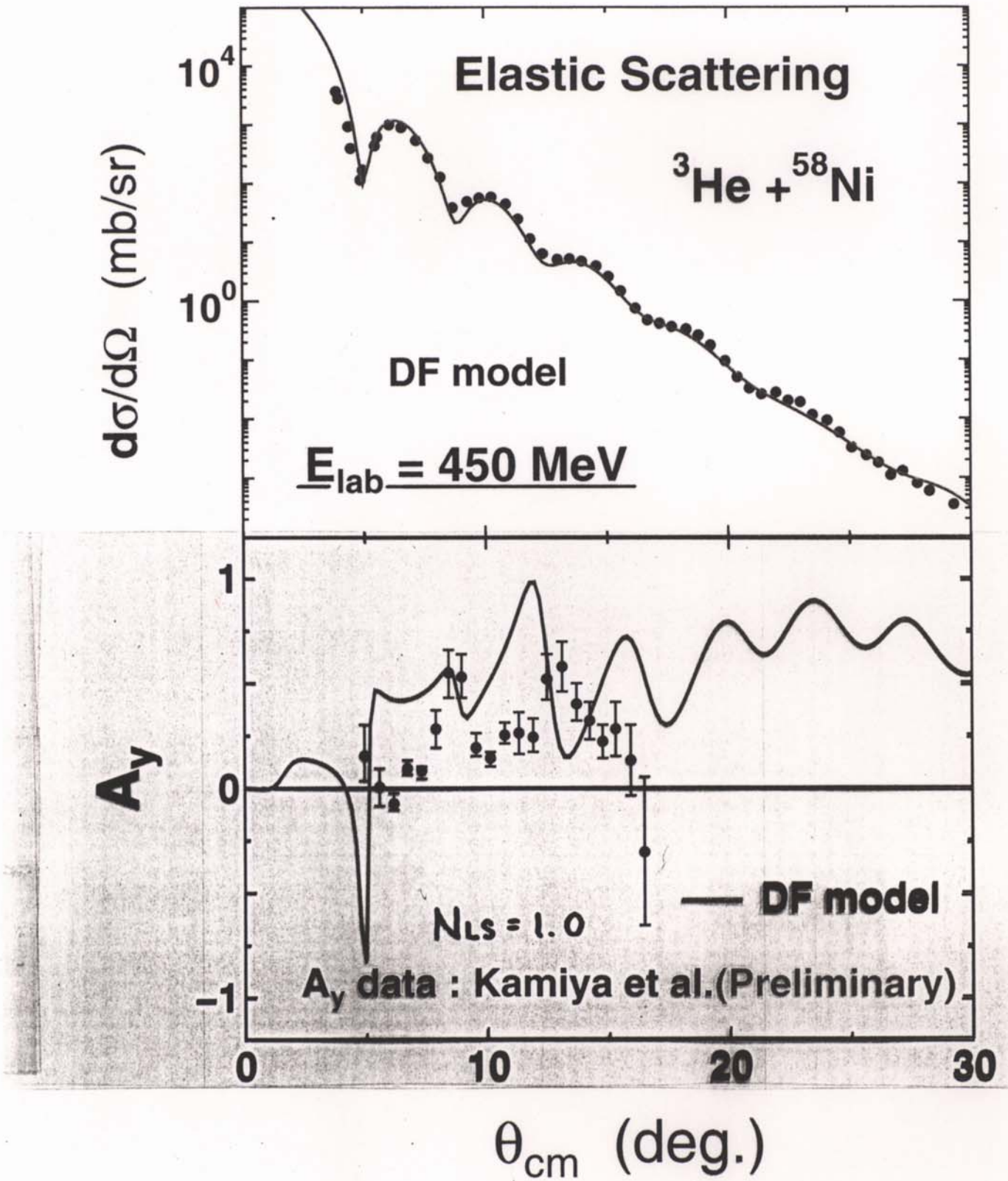
$N_R = 1.0 \pm 0.08$

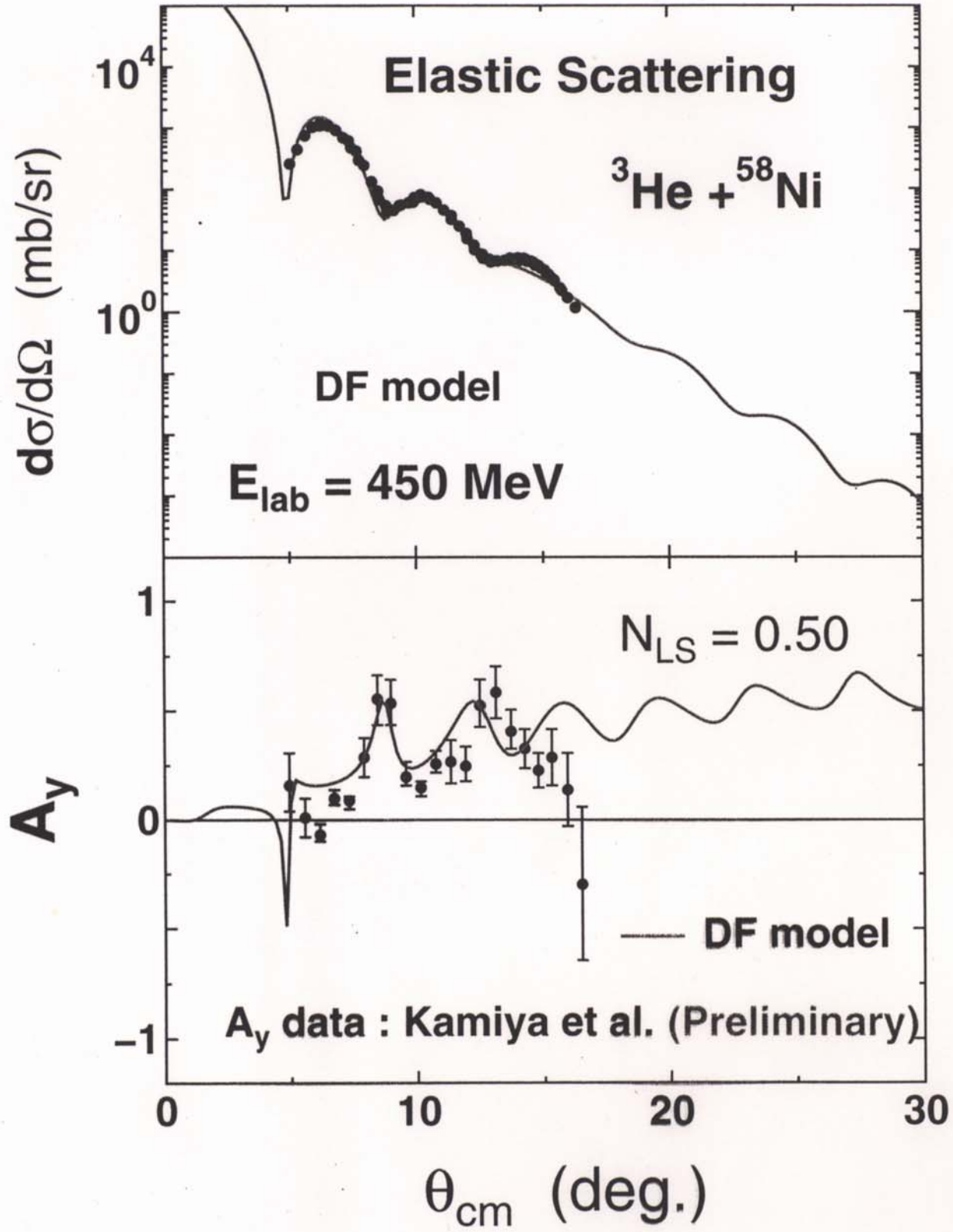
Volume integrals per nucleon pair




Elastic Scattering
$^{3}He + ^{58}Ni$
10^{0}
$d\sigma/d\Omega$ (mb/sr)
N_R= 0.968
E_{lab} = 33.3 MeV
DF model
A_y
1
0
−1
N_{LS} = 1.0
DF model
0
50
100
150
θ_{cm} (deg.)


Elastic Scattering
$^{3}He + ^{40}Ca$
10^{0}
$d\sigma/d\Omega$ (mb/sr)
N_R= 1.03
E_{lab} = 33.3 MeV
DF model
A_y
1
0
−1
N_{LS} = 1.0
DF model
0
50
100
150
θ_{cm} (deg.)


Elastic Scattering
^{3}He + ^{58}Ni
DF model
E_{lab} = 450 MeV
$d\sigma/d\Omega$ (mb/sr)
10^4
10^0
A_y
1
0
−1
N_{LS} = 1.0
— DF model
A_y data : Kamiya et al.(Preliminary)
0
10
20
30
θ_{cm} (deg.)


Elastic Scattering
^{3}He + ^{58}Ni
DF model
E_{lab} = 450 MeV
dσ/dΩ (mb/sr)
10^4
10^0
N_{LS} = 0.50
A_y
1
0
−1
DF model
A_y data : Kamiya et al. (Preliminary)
0
10
20
30
θ_{cm} (deg.)

Summary

We analyses elastic scattering for the $^{3}He+^{58}Ni$ system at incident energies from 33 MeV to 450 MeV with the double folding potentials using M3Y interaction.

- The cross-section data for ^{3}He elastic scattering are reproduced by our folding potential without the large modification of real central potentials, i.e. $N_R \sim 1.0$.
- The double folding model predicts large analyzing power compared with the recent experimental data at E_{lab}= 450 MeV (RCNP).
- The renormalization factor N_{LS} of spin-orbit potentials is 0.5 to reproduce the experimental data.