MICROSCOPIC OPTICAL MODEL FOR PROTON-NUCLEUS INTERACTION

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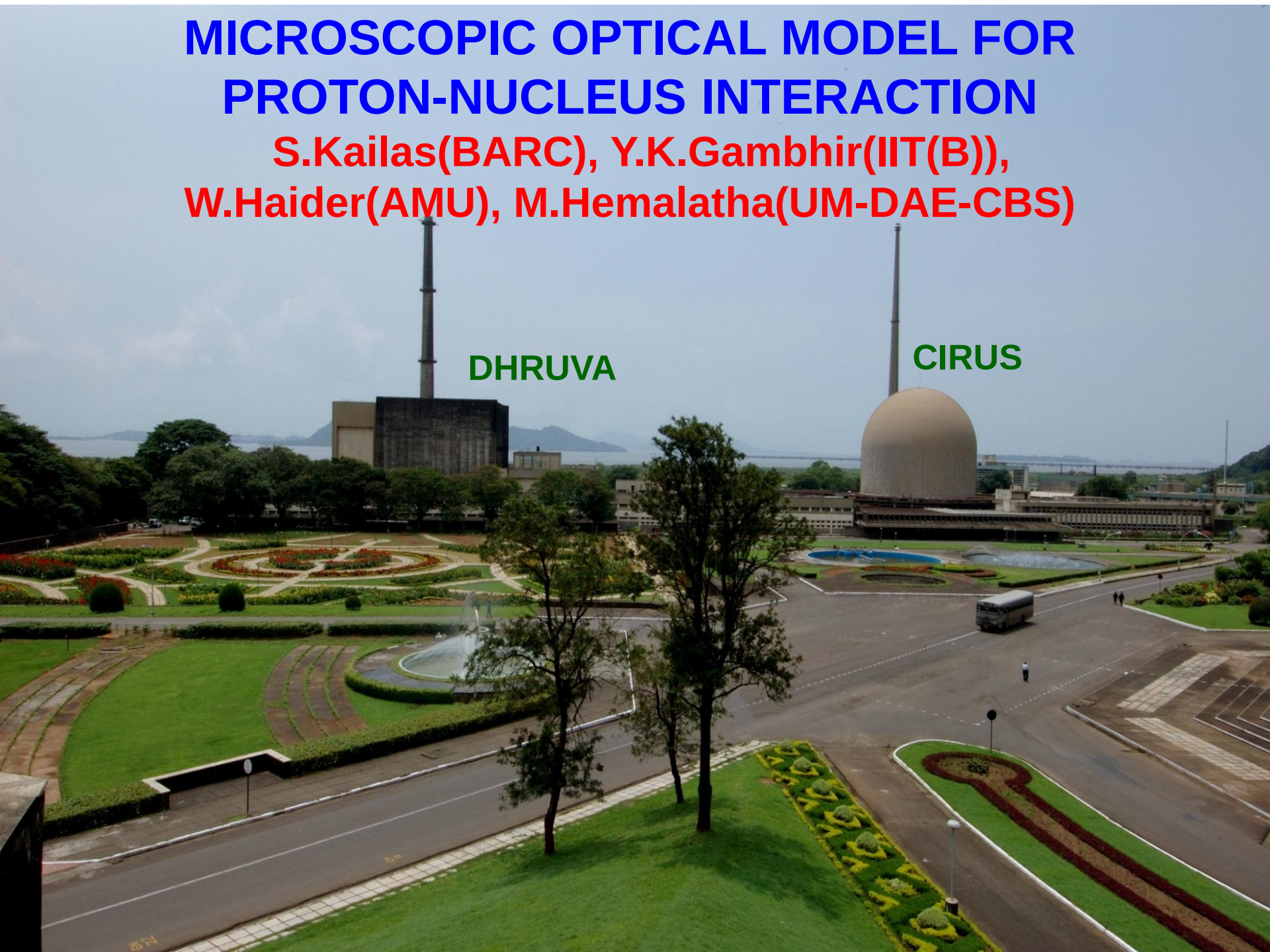


INTRODUCTION

- Nuclear Reactions are strongly influenced by the structure of the interacting Nuclei

- Anomalous Structure of Nuclei inferred from interaction data- lithium isotopes

- Proton – Nucleus data over the isotopes – useful tool to bring out systematic changes in neutron distribution

- Bring out Influence of Target Nucleus structure from elastic and reaction data – proton induced reactions

- Tool employed ------ Microscopic Optical Model constructed from Effective N – N Interaction and
- Nuclear Densities

Groups (Microscopic OM for Nucleon-Nucleus)

1. Leige: C. Mahaux et al (Reid soft core) NM PRC 16,80(1977).

2. Oxford: Brieva and Rook Hamada Johnston (HJ) (Hard Core)
   (NPA 307,493(1978);A291,A297
3. Japan: N. Yamaguchi HJ Prog.T.Phys70,76

4. Hamburg: Von Geramb Paris Int. AIP conf 97(1982)

5. Australia : A. Amos : Bonn Pot. Integral eq. Non-local(PRC70,(2004)

6. INFN, Italy: Baldo: Lombardo: uv-14, av-14, av-18 NM

7. Love & Satchler Phys.Repts.1979 M3Y;Dao et al.PRC56,954(1997)

8. USA: B. D. Day Rev. Mod. Phys. 39(1967)

9. AMU W. Haider,Saliem, Bharti, Manjari, Deepti, Rafi V14,DP
   IIT (B) Y K .Gambhir, A. Bhagwat V14, DP
   BARC S. Kailas, M.Hemalatha, S.K.Gupta: JLM,HJ, V14..
   VECC B.Sinha, D.K.Srivastava, D.N.Basu, A.K.Chaudhari…M3Y
   Sambalpur Behera, Panda….NM

Optical model - microscopic approach

Inputs are effective N-N interaction &

Nuclear densities of the interacting nuclei

V is proportional to veff(N-N) & densities

Glauber model - cross section is directly related to N-N cross section and densities

Both these models can be used to calculate Elastic and reaction cross sections.

METHODOLOGY

- Proton – Target Nucleus reactions – Elastic and Reaction data
- Microscopic Optical Model constructed by folding the Effective N-N Interaction with the Target Nuclear density-
- Proton and Neutron Density distributions from the Relativistic Mean Field (RMF) formalism
- Effective Interaction – different versions- JLM, HJ, V14..
- Density and Energy dependence included
- Both stable and unstable nuclei considered

RESULTS

- P + Zr isotopes - correlation between MSR charge radii and reaction cross sections-
- - Anomalies as a function of Neutron number

- P + Sn isotopes- Elastic & Reaction data- Sensitivity to Neutron Number

- Spin orbit potential – weakening of SO strength with increase in Neutron number-

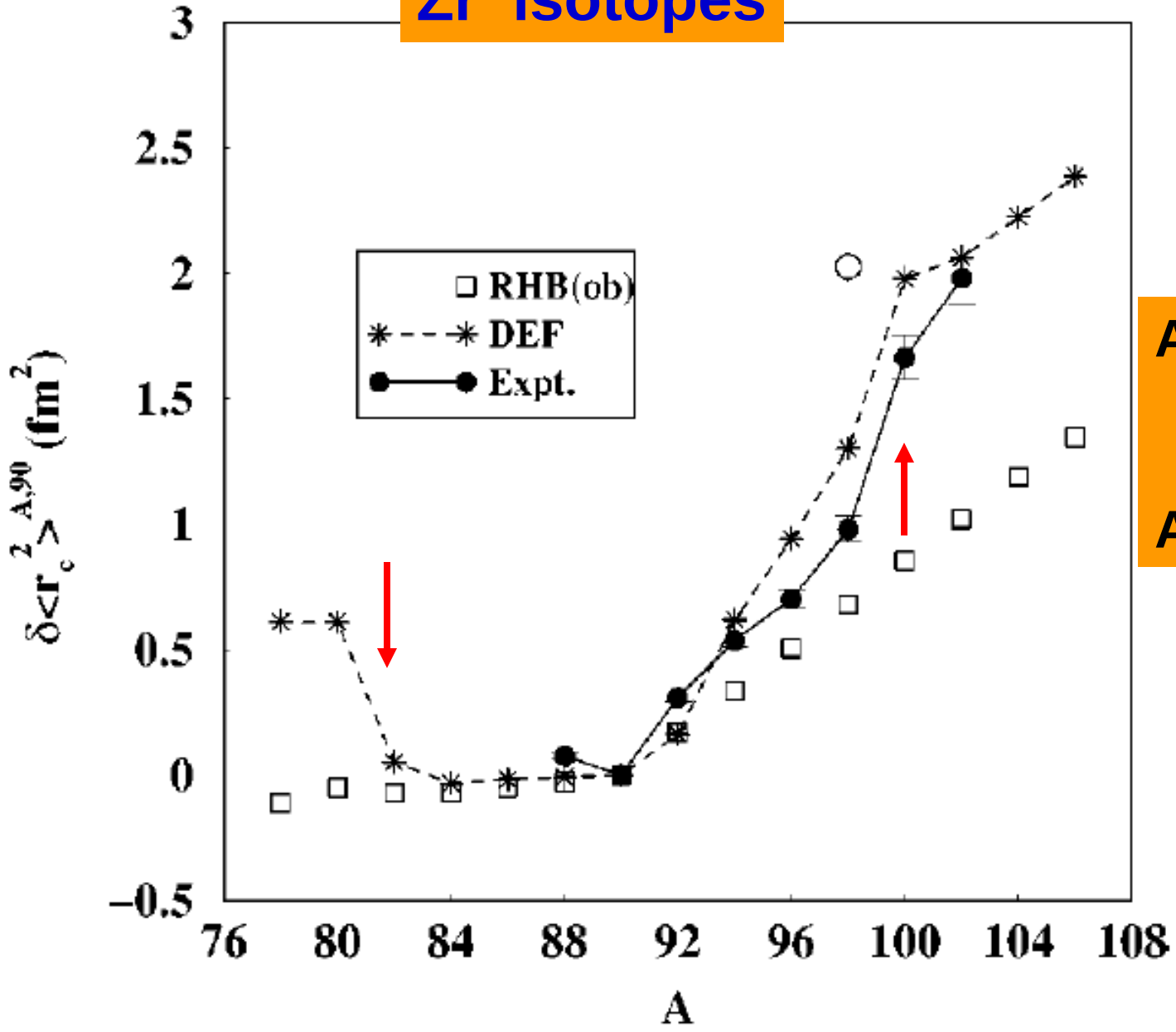
- P + Ca – 40 - comparison between different effective interactions

ELASTIC AND REACTION

CROSS SECTIONS

Sensitivity to Density Distributions

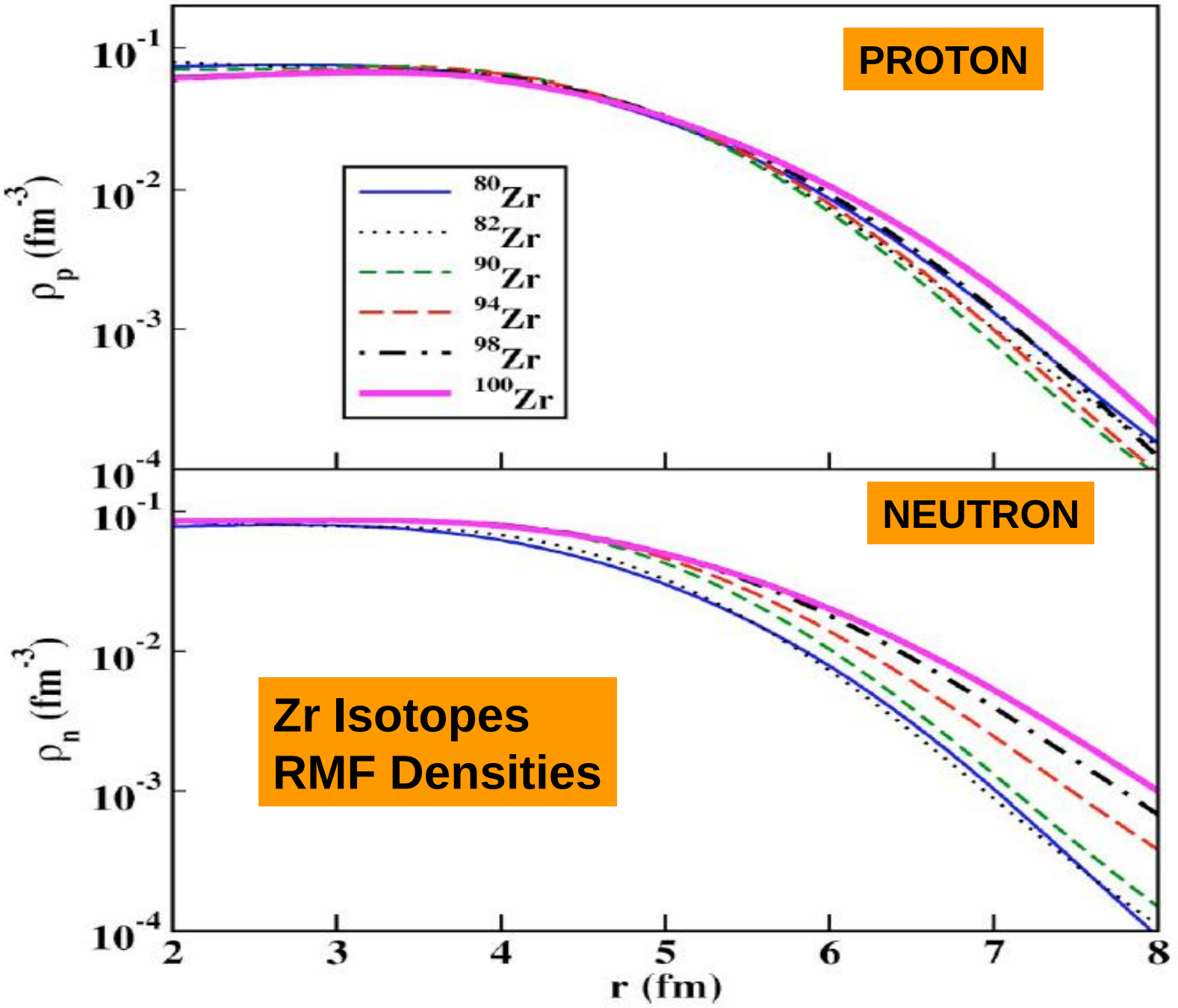
Zr isotopes

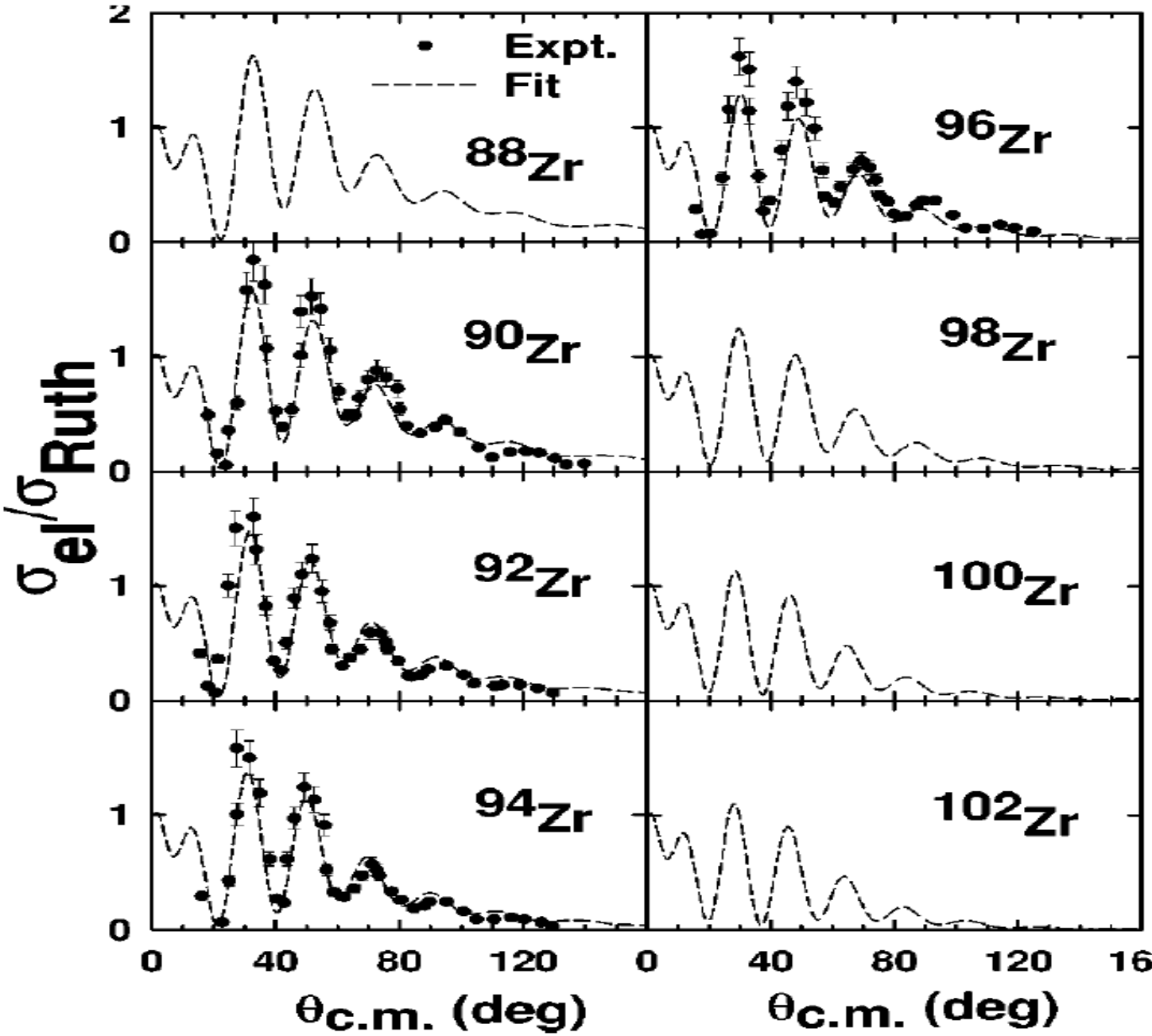


A- 80-82

A - 98-100

PRC 70,044320(2004) Hemalatha et al.


PROTON
NEUTRON
Zr Isotopes
RMF Densities
80Zr
82Zr
90Zr
94Zr
98Zr
100Zr
ρp (fm-3)
ρn (fm-3)
r (fm)
10-1
10-2
10-3
10-4
2
3
4
5
6
7
8



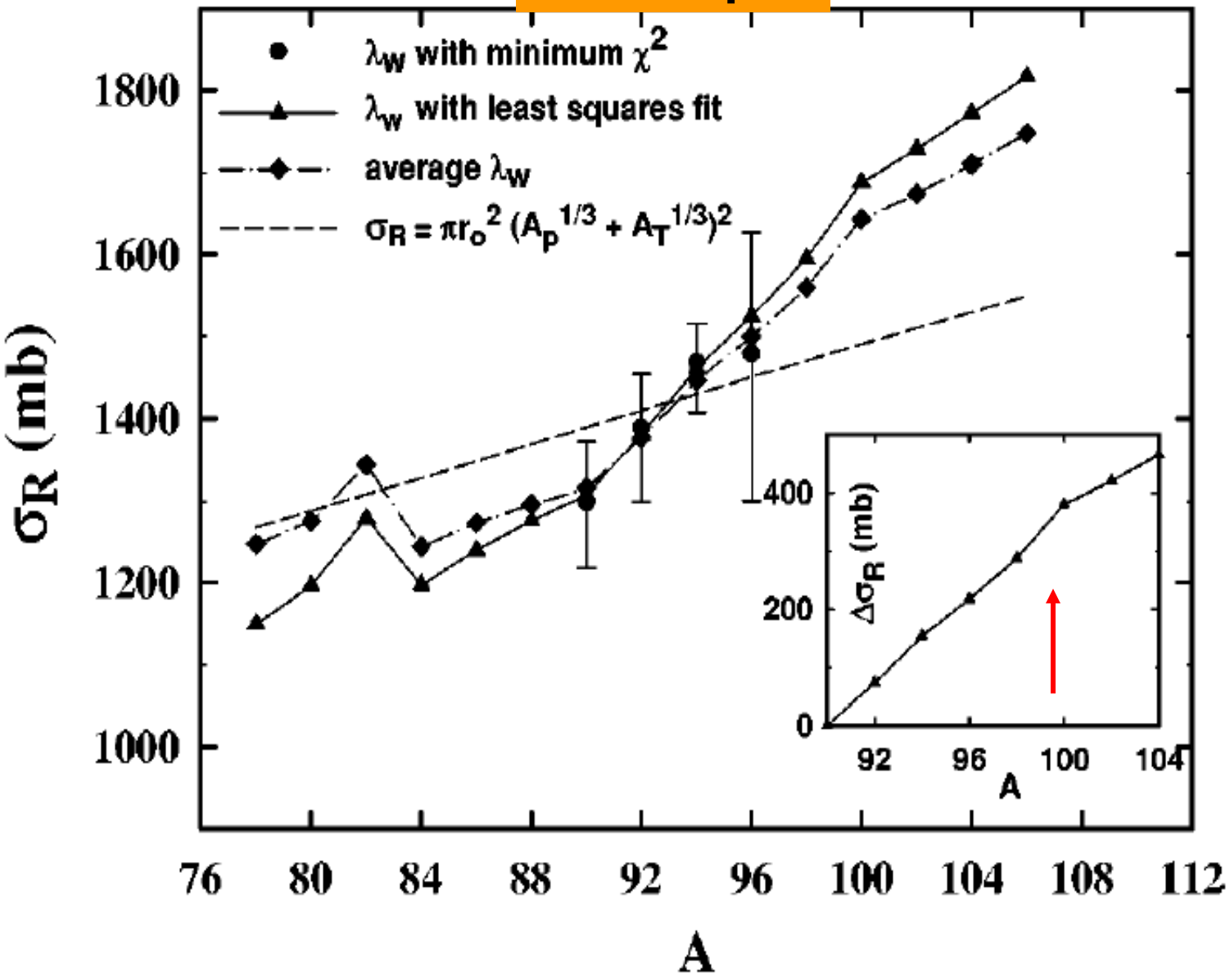
E=50 MeV

JLM , RMF

Change in Magnitudes Of structures

Zr isotopes

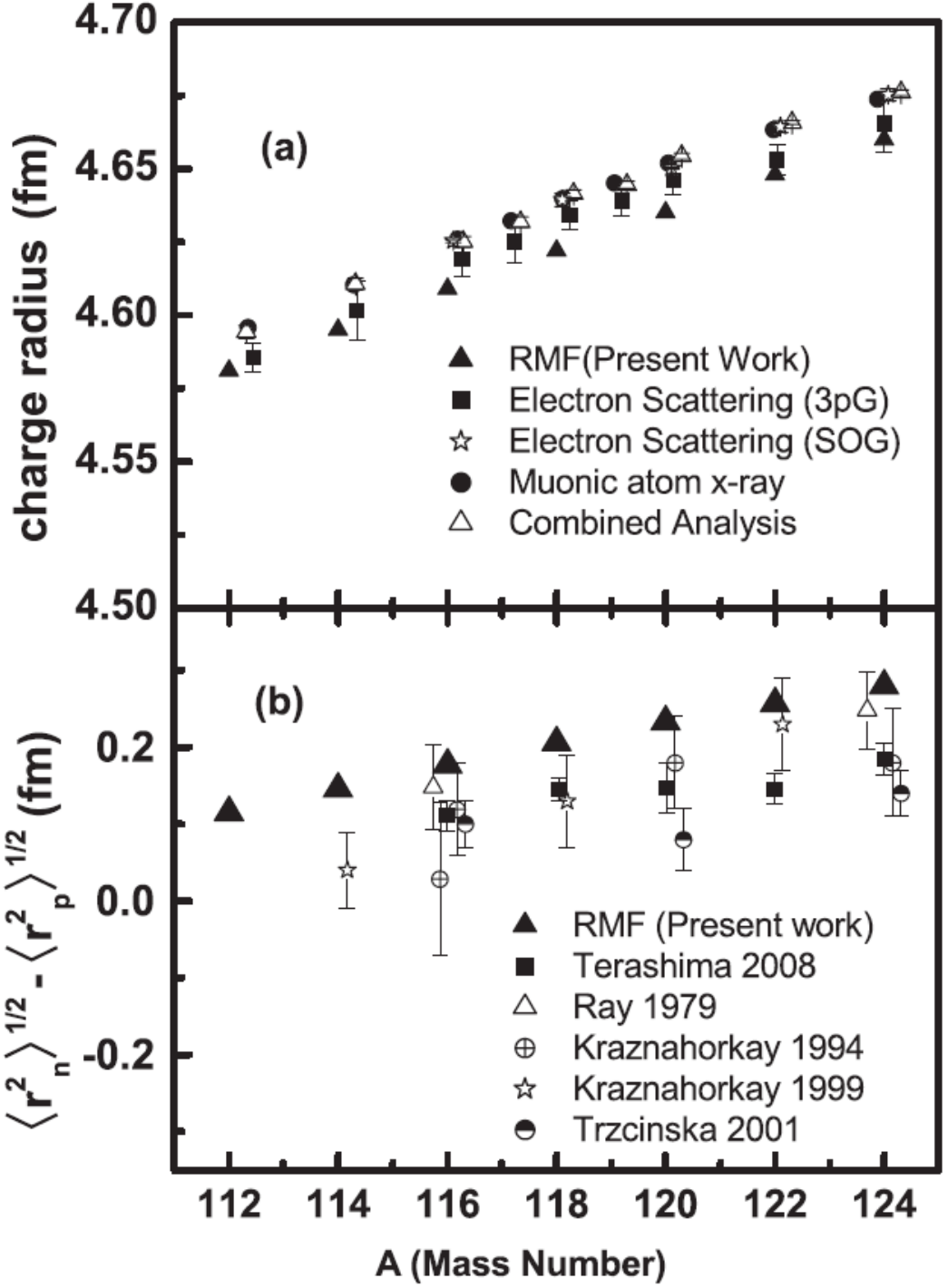
PROTON REACTION CROSS SECTION



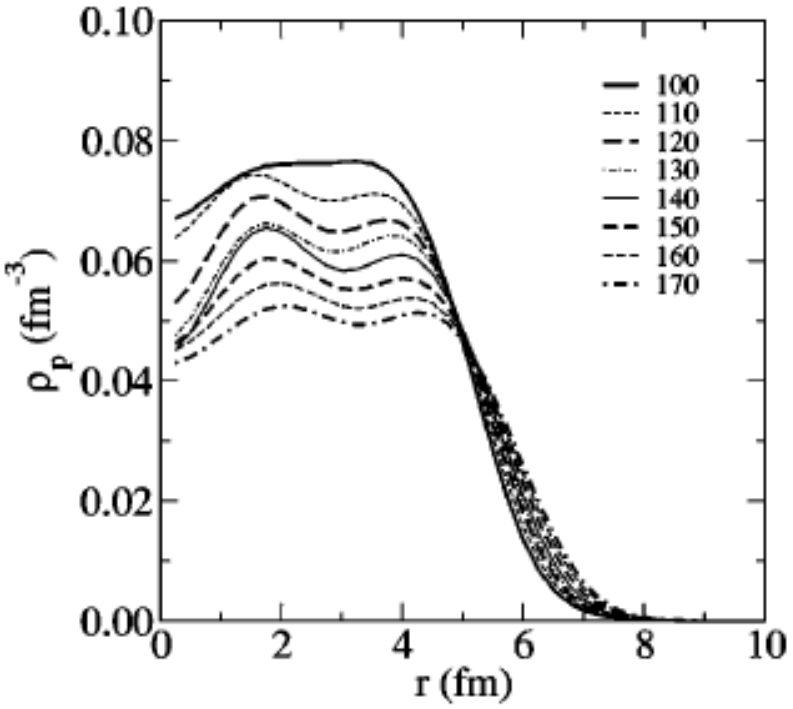
Note the correlation with charge radii

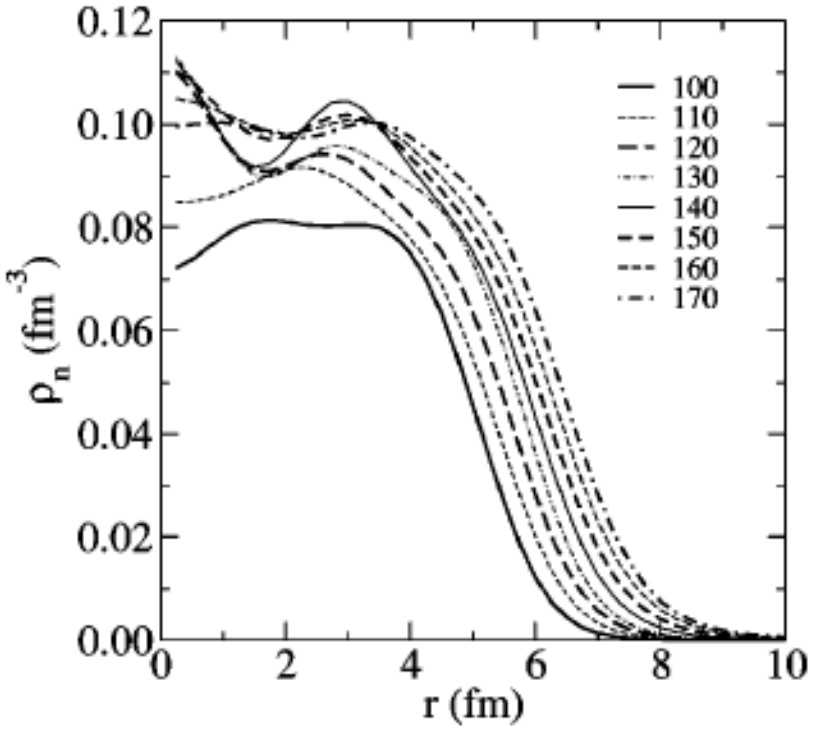
Sn Isotopes

Increase with Increase of Neutron Number



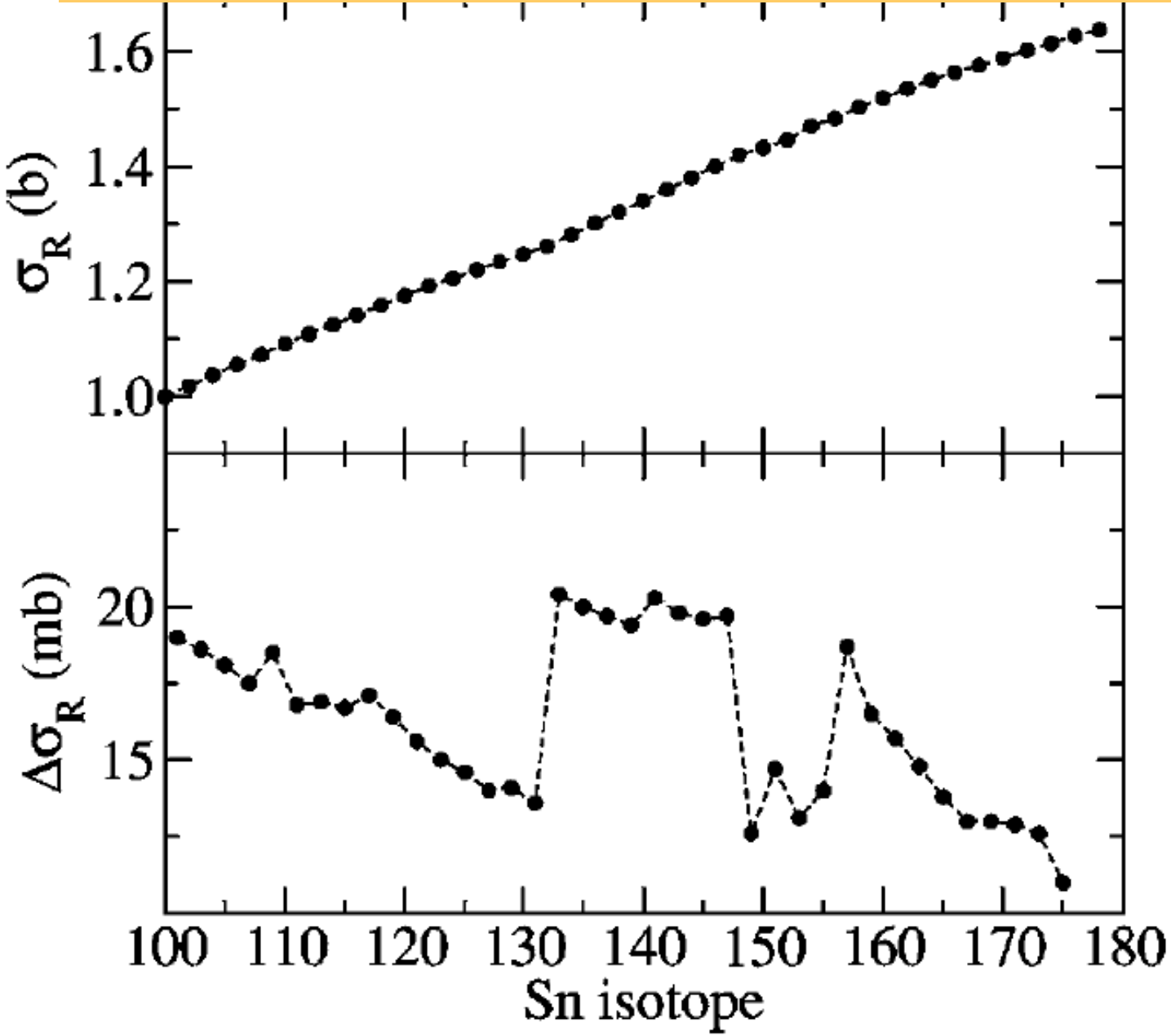
Proton and Neutron Density Distributions
Sn Isotopes



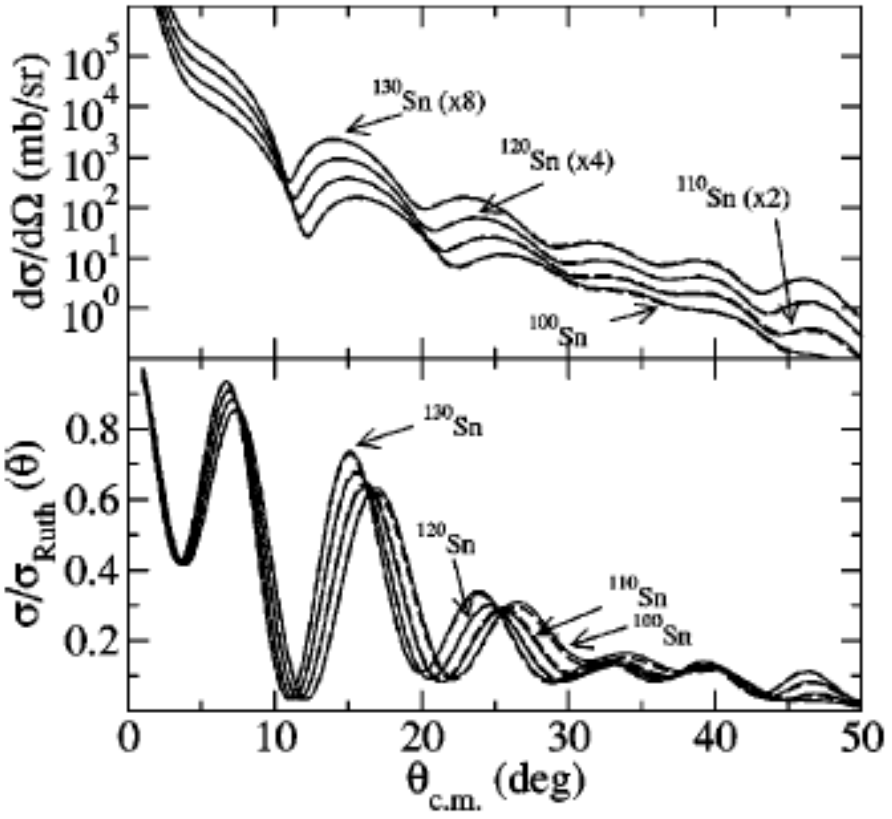


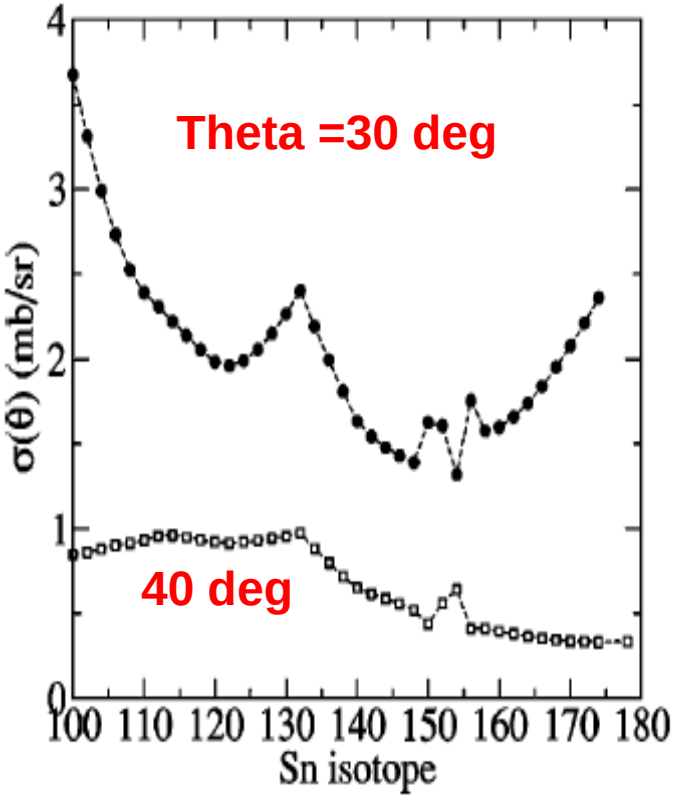
PRC 70, 024607 (2004) Amos et al

Reaction Cross Sections for 200 MeV Protons

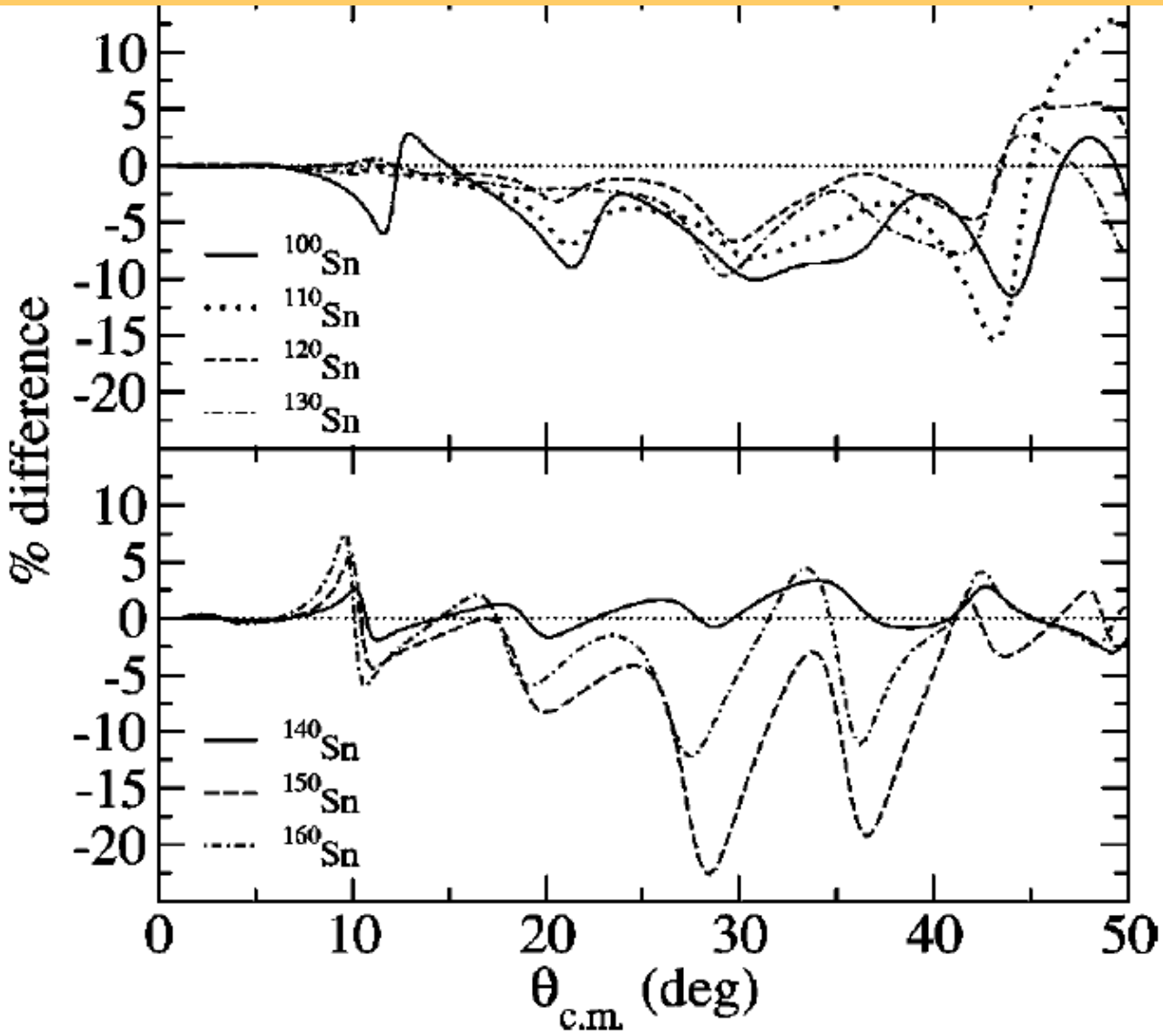


Elastic Scattering Cross sections for 200 MeV Protons





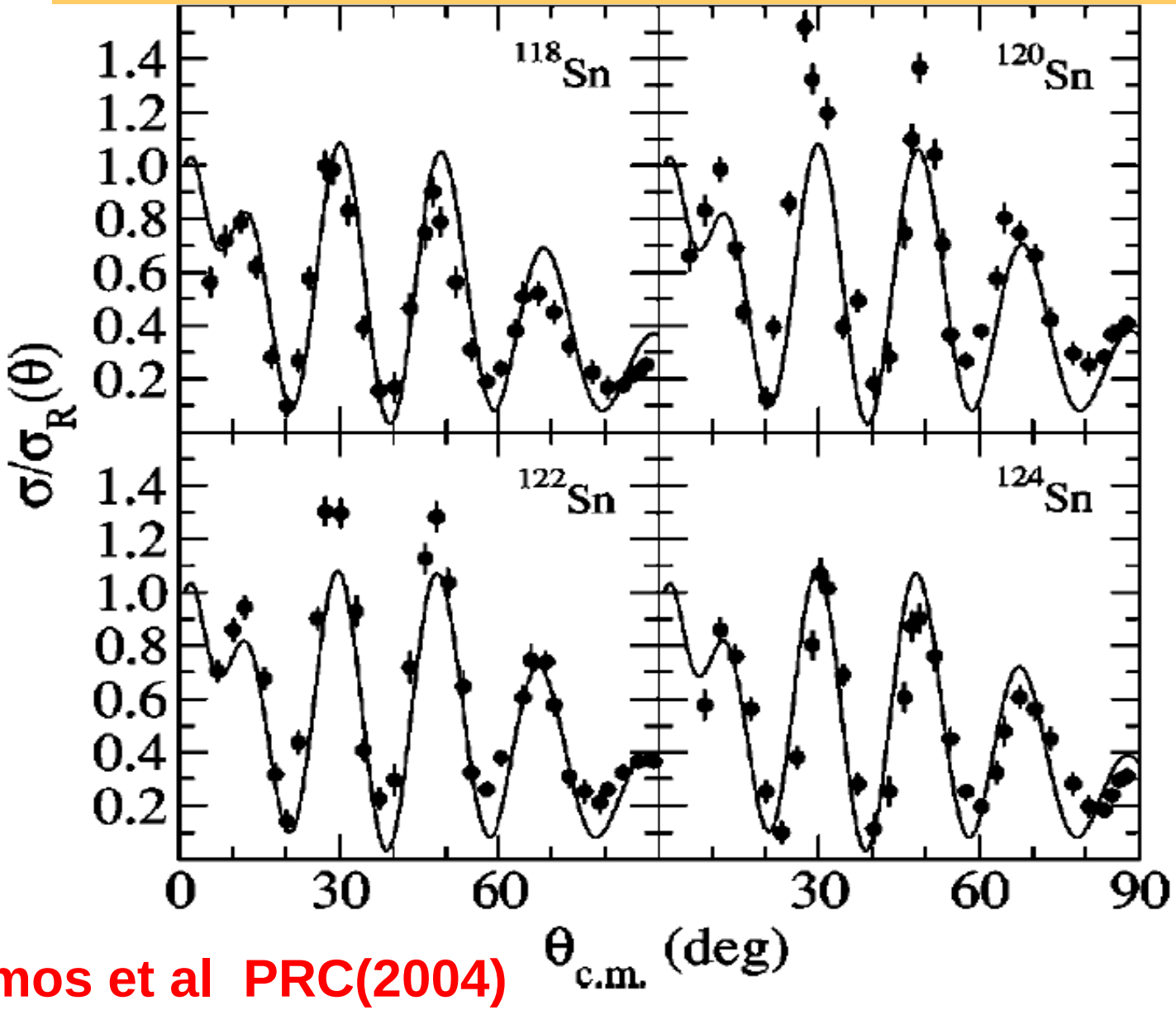
Percentage Differences between Differential cross sections



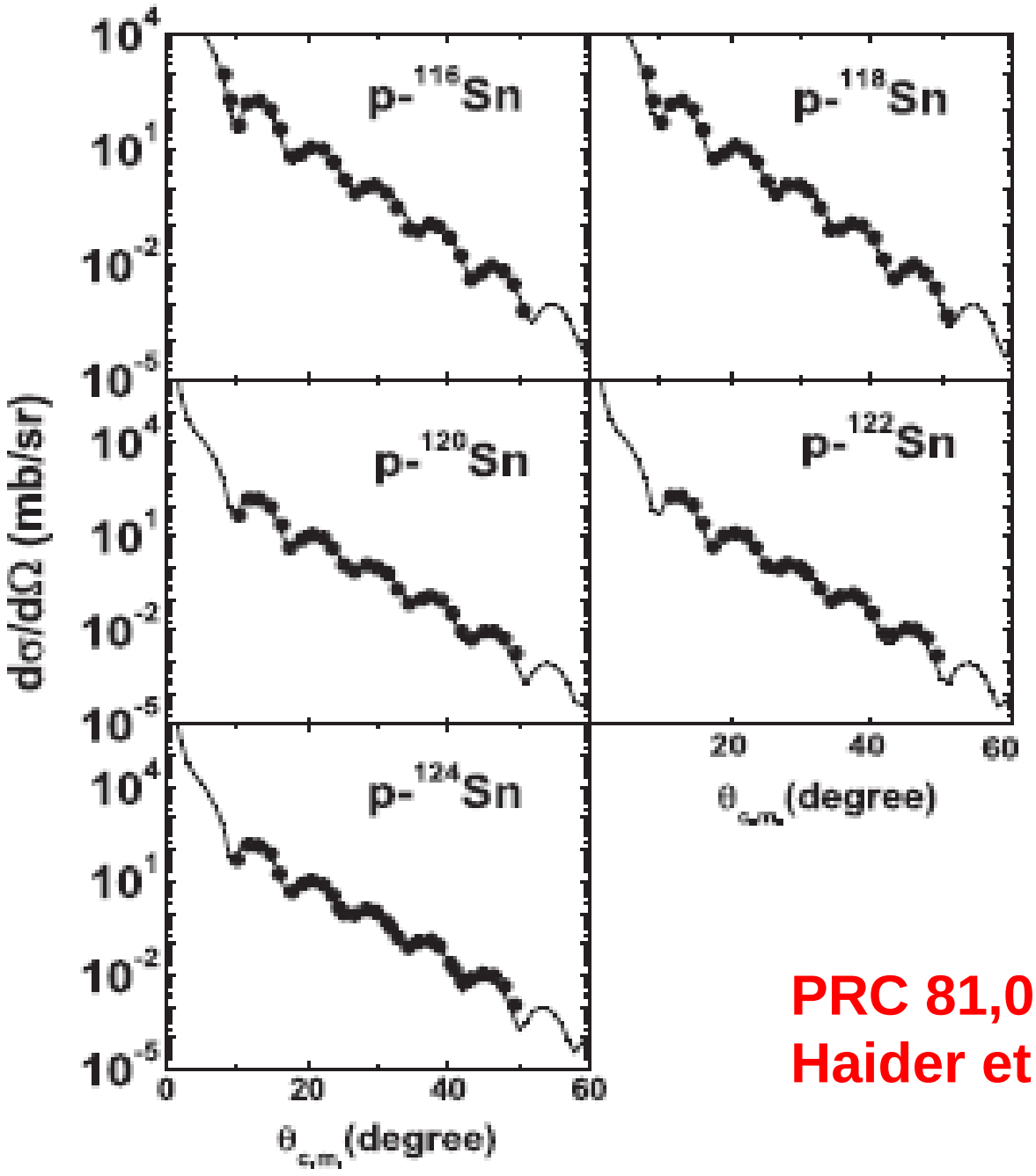
200 MeV

Using two structure model densities

Elastic Cross Sections for 49.35 MeV Protons



Amos et al PRC(2004)



E = 295 MeV

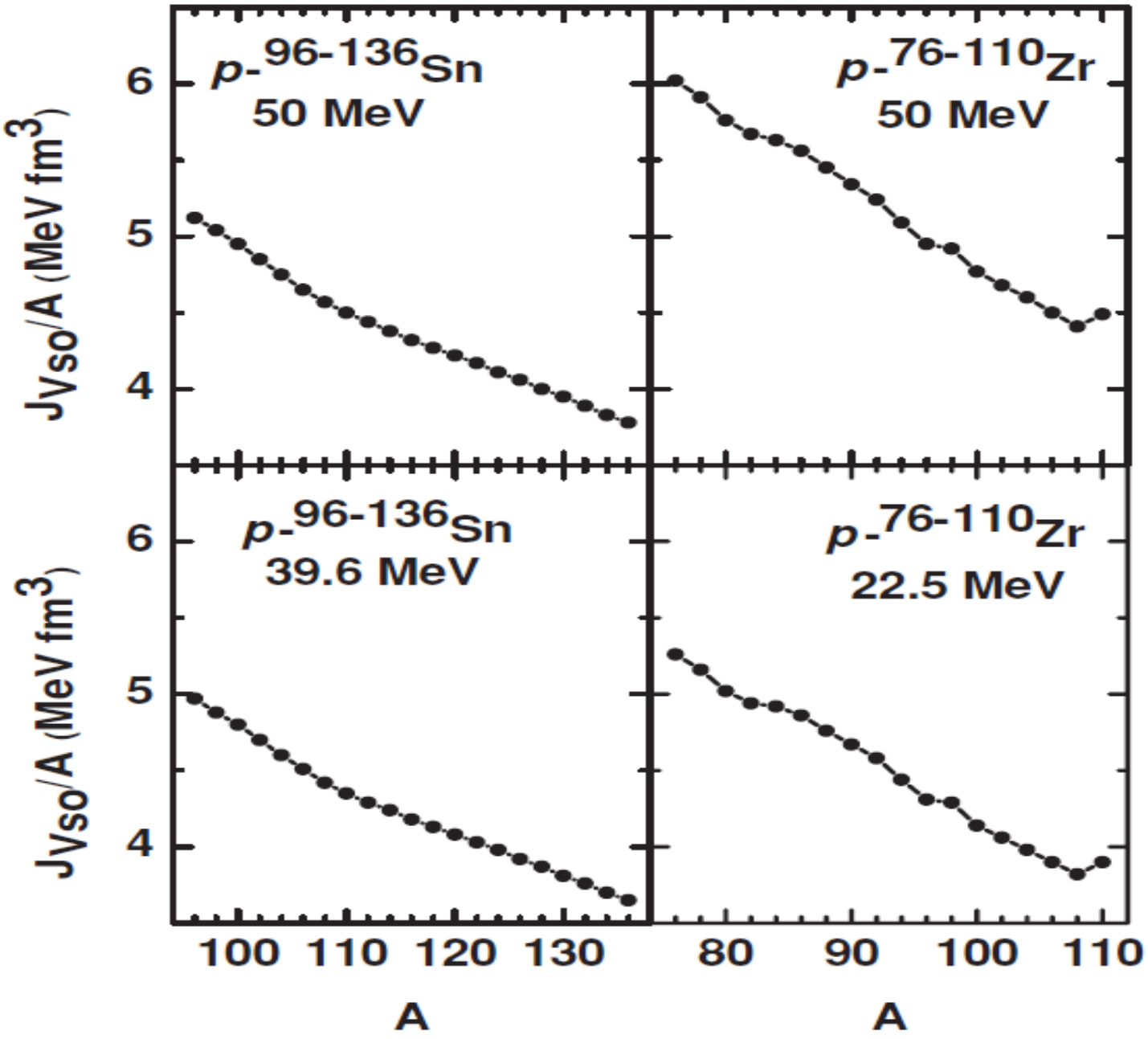
Relativistic Kinematics

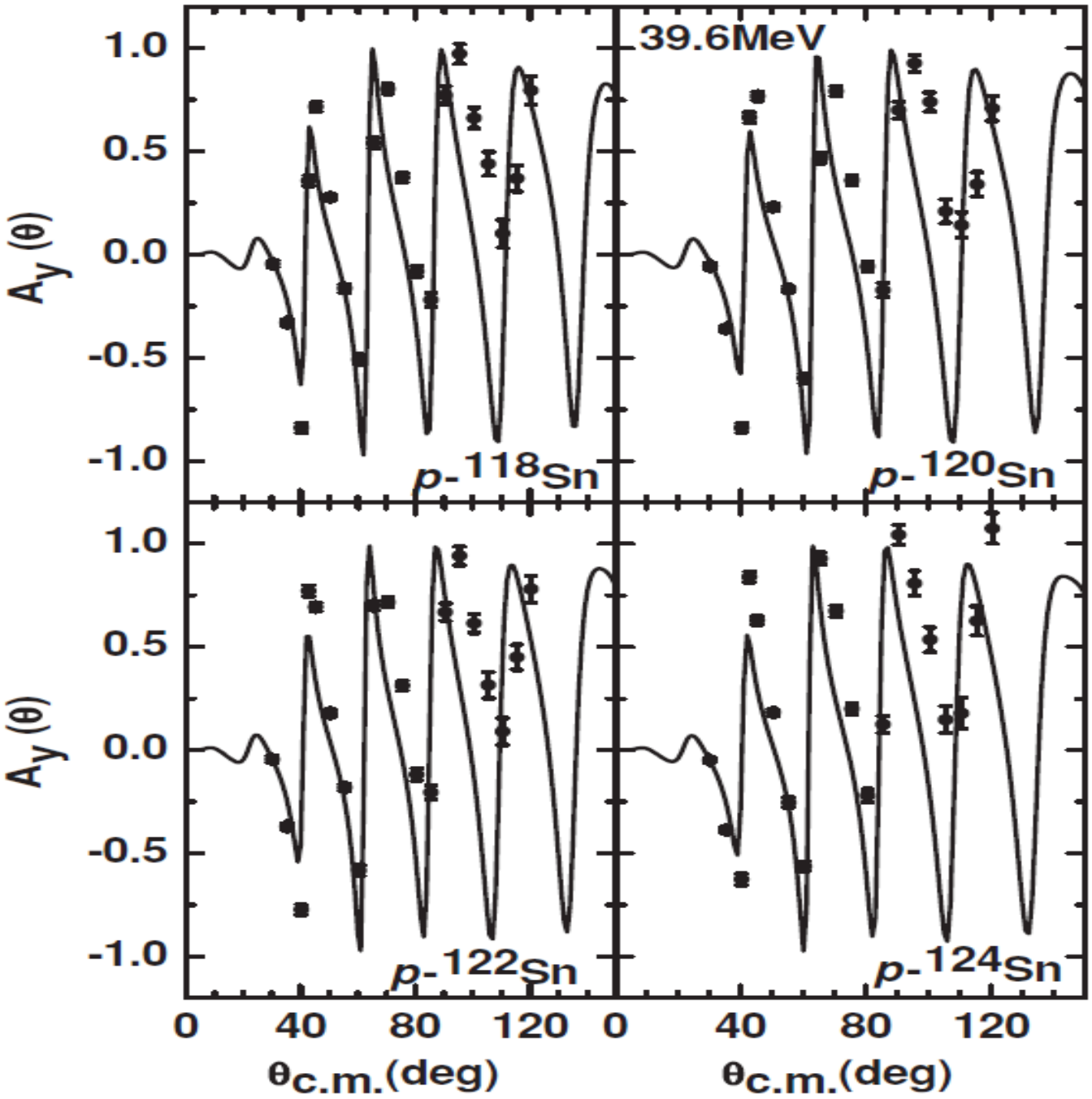
Exact SO

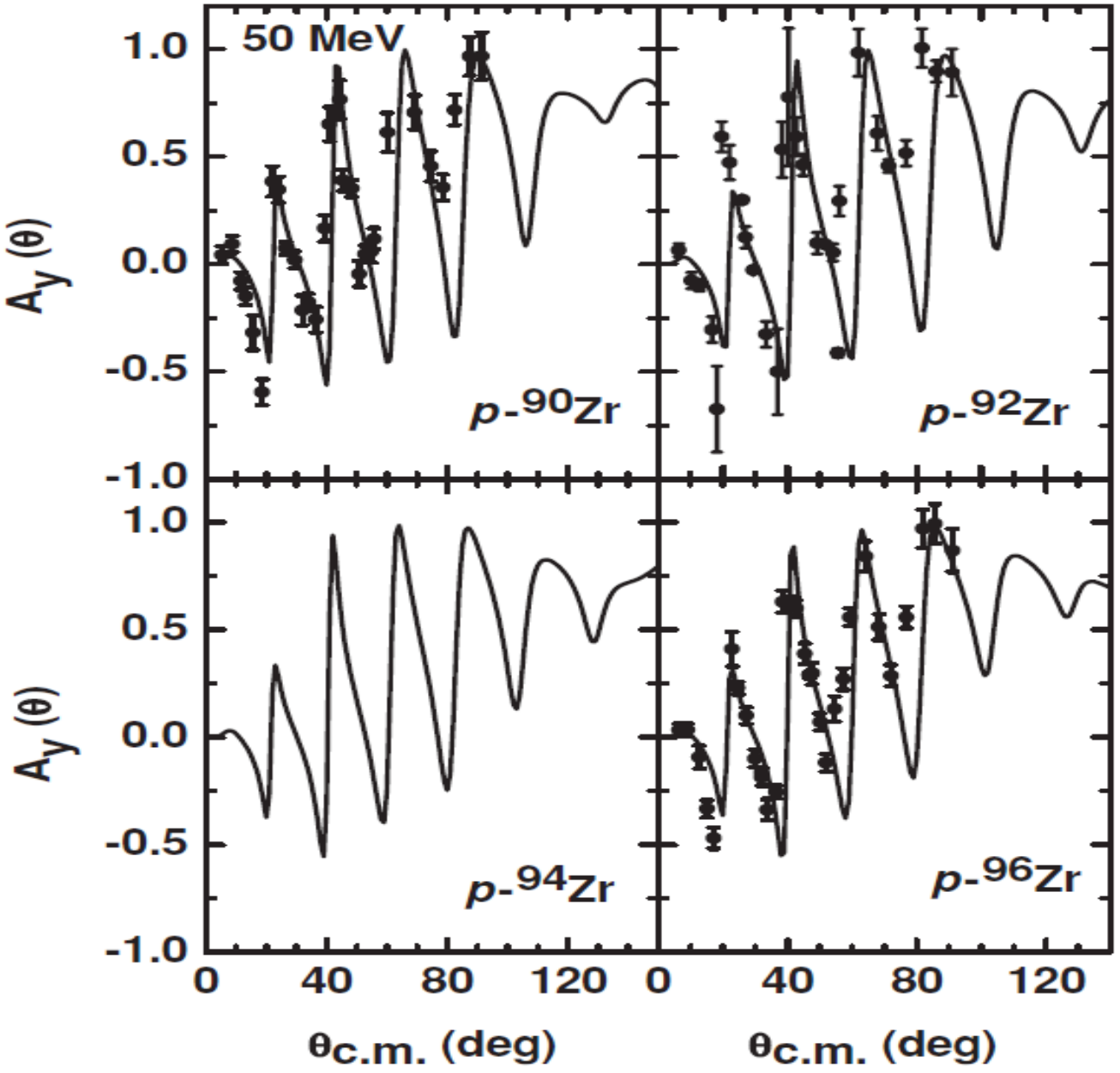
PRC 81,034601 (2010)
Haider et al

VARIATION OF SPIN ORBIT POTENTIAL WITH NEUTRON EXCESS

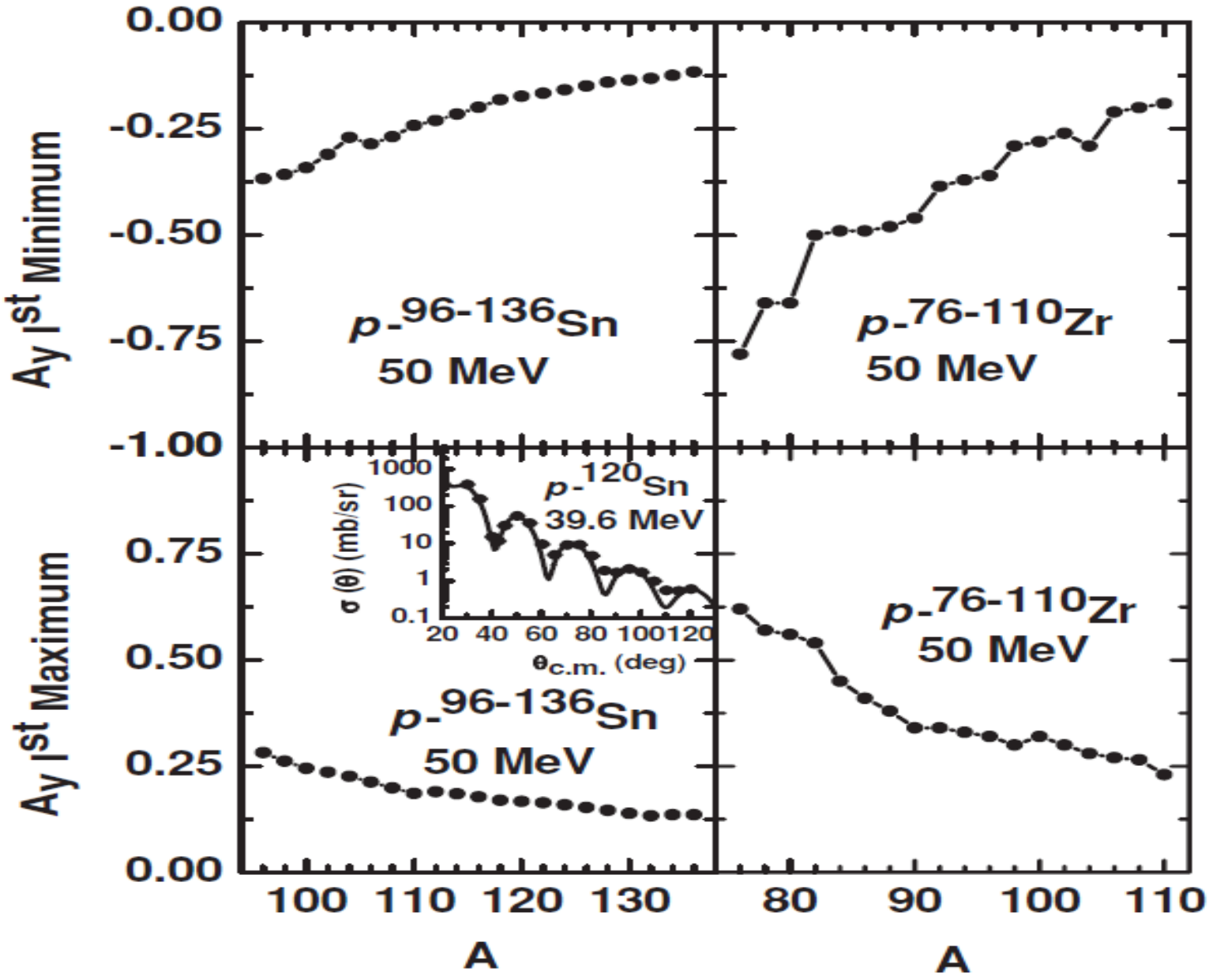
WEAKENING OF SPIN ORBIT STRENGTH

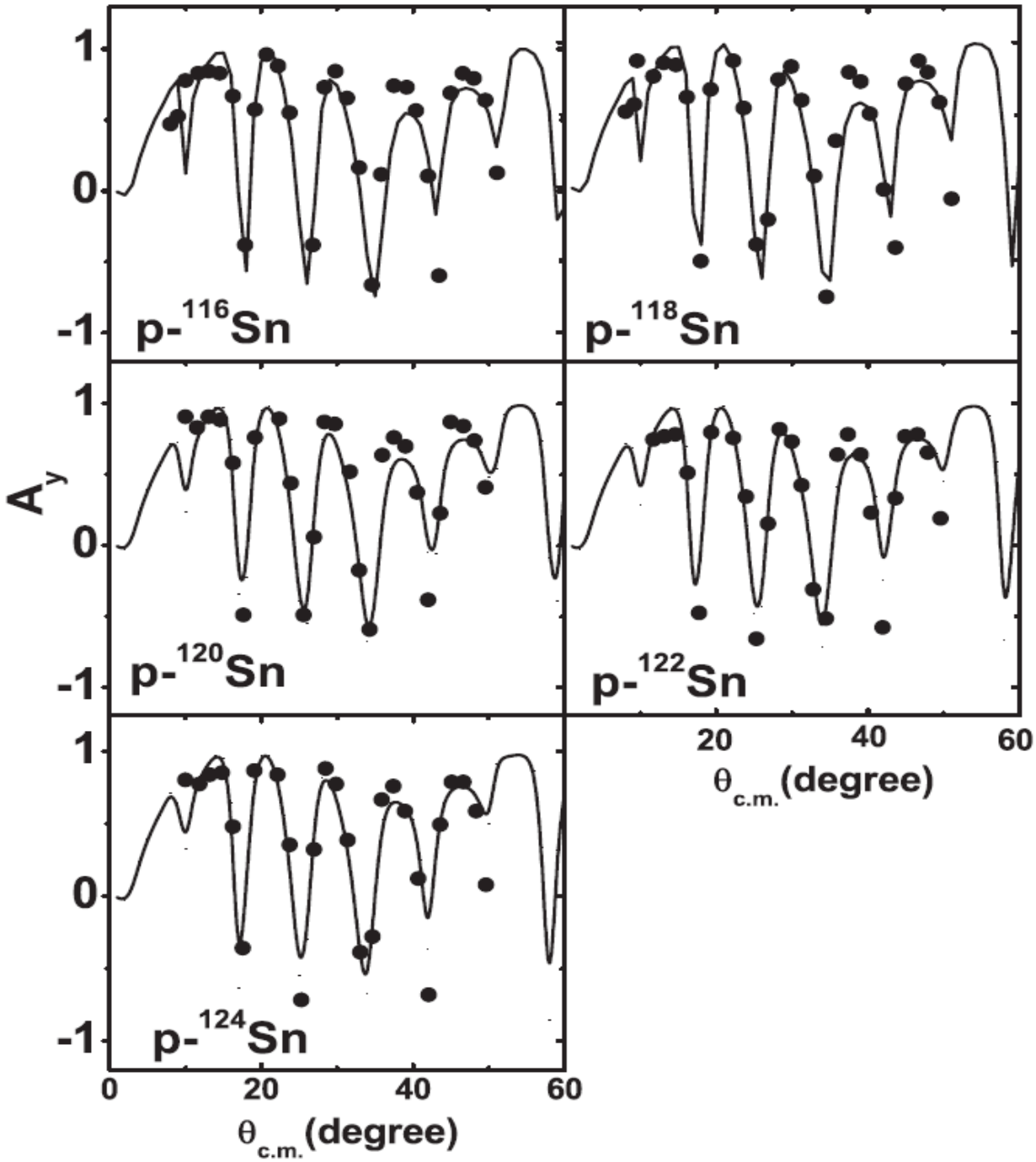

p-96-136Sn
50 MeV
p-76-110Zr
50 MeV
p-96-136Sn
39.6 MeV
p-76-110Zr
22.5 MeV
JVso/A (MeV fm3)
JVso/A (MeV fm3)
6
5
4
6
5
4
100 110 120 130
80 90 100 110
A
A


39.6MeV
p-118Sn
p-120Sn
p-122Sn
p-124Sn
Ay(θ)
Ay(θ)
1.0
0.5
0.0
-0.5
-1.0
0
40
80
120
θc.m.(deg)
θc.m.(deg)


50 MeV
p-90Zr
p-92Zr
p-94Zr
p-96Zr
Ay (θ)
Ay (θ)
1.0
0.5
0.0
-0.5
-1.0
0
40
80
120
θc.m. (deg)
θc.m. (deg)

PRC 79, 057602 (2009) Hemalatha et al.

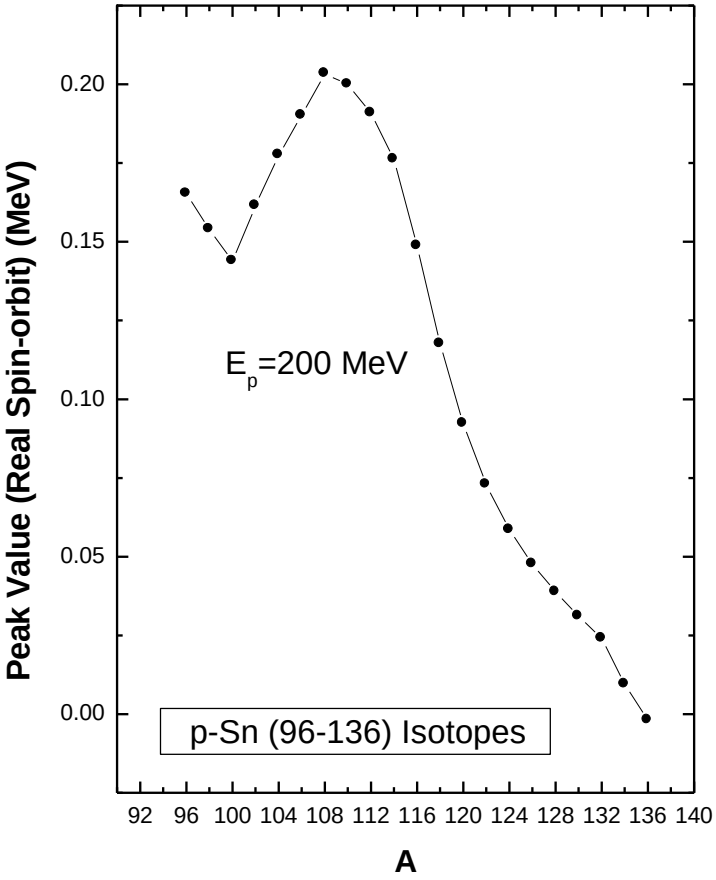


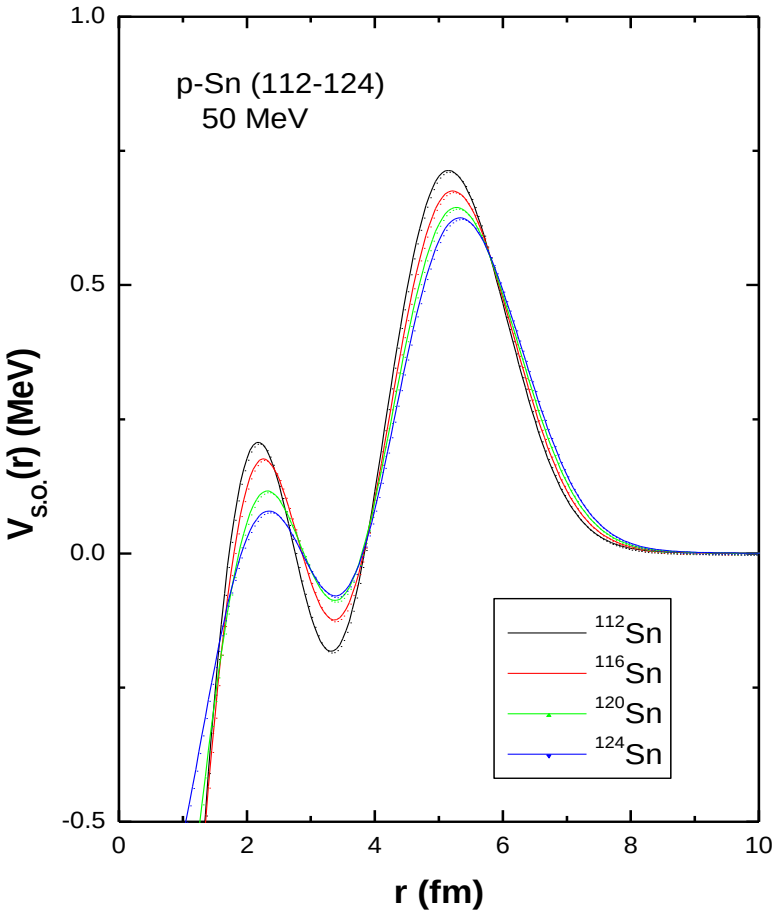


Ep = 295 MeV

1st Max & 1st Min

Sn Isotopes - Behaviour of Spin- Orbit Potential





Haider et al

DIFFERENT PRESCRIPTIONS FOR EFFECTIVE INTERACTION

CROSS SECTION SENSITIVITY TO EFFECTIVE INTERACTION

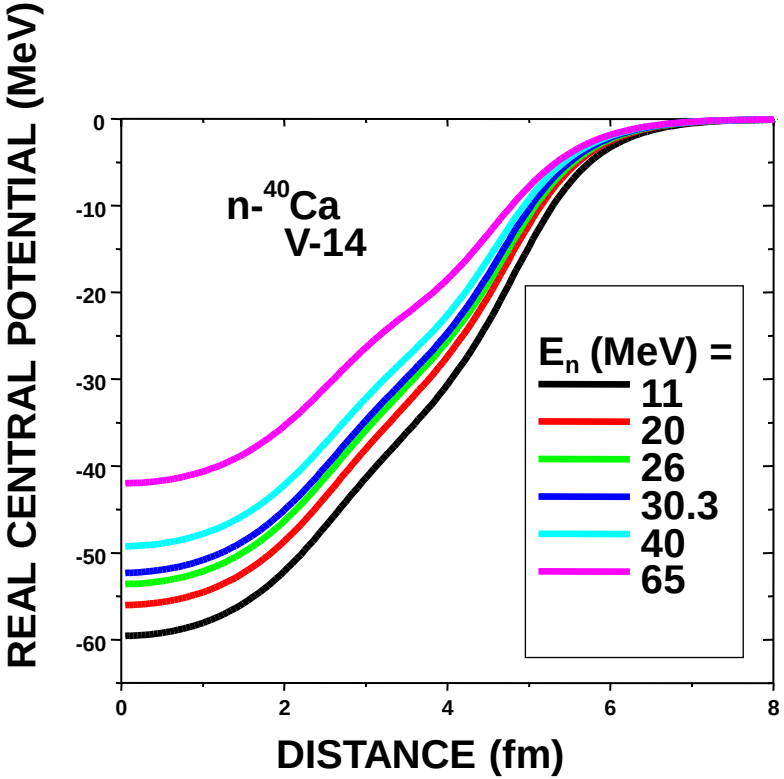


Figure 1 (a)

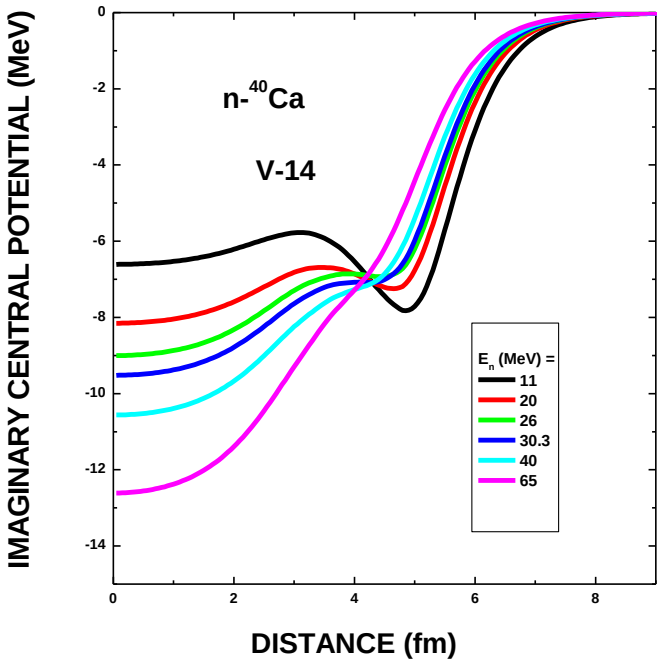
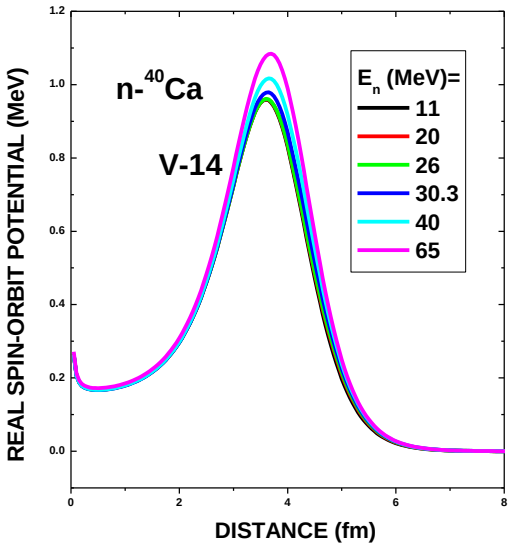
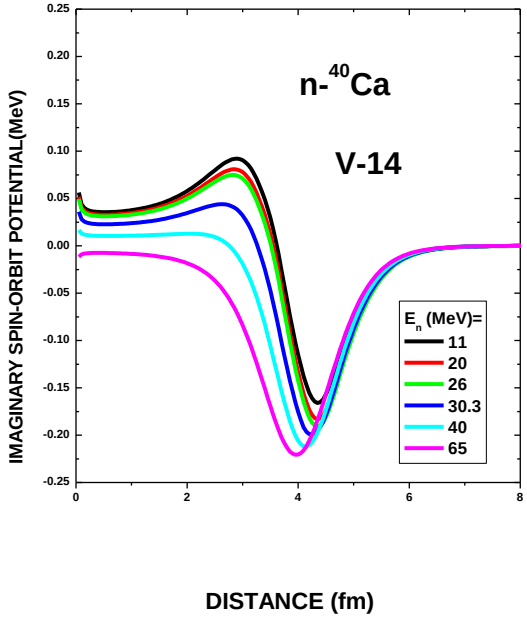
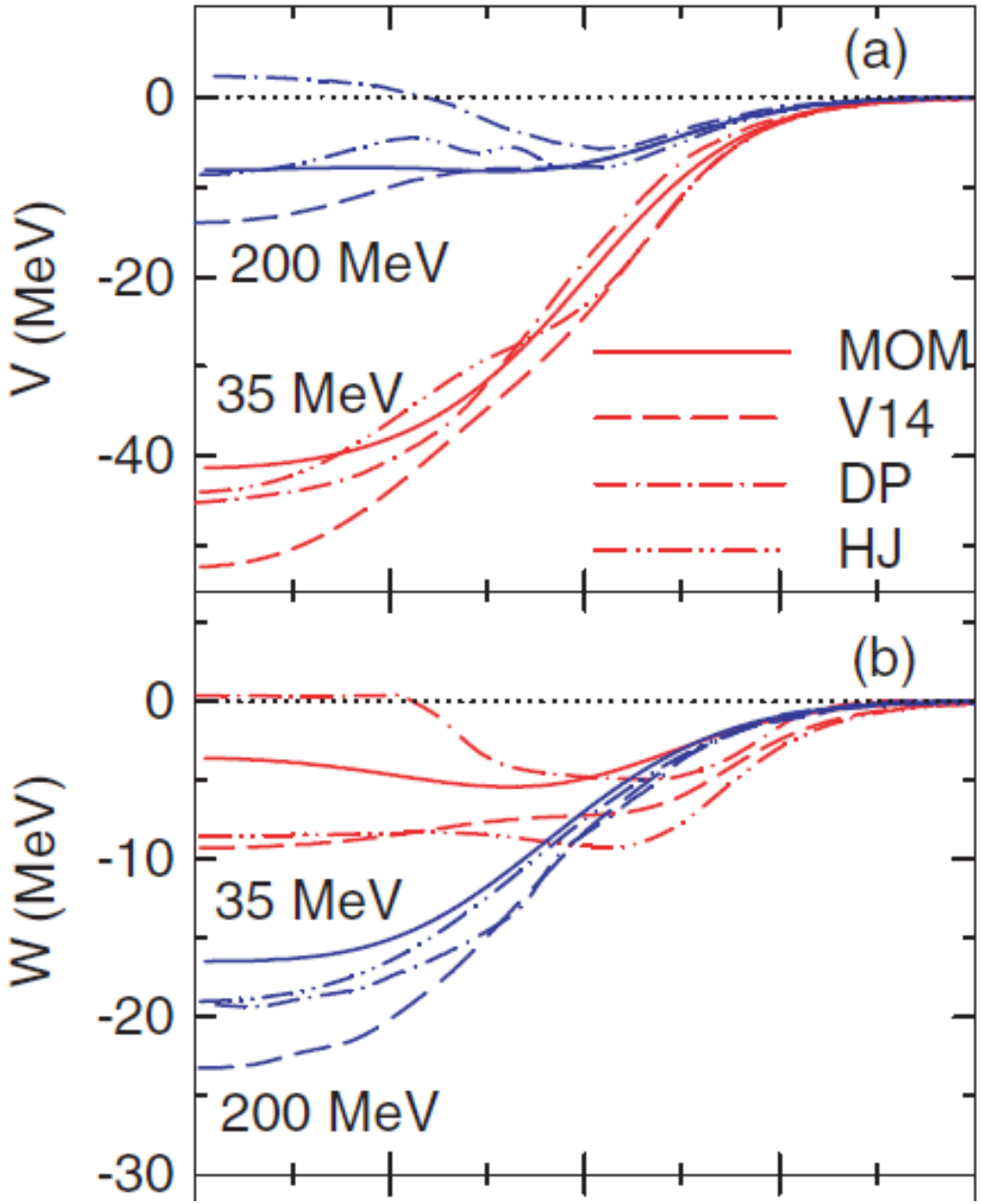


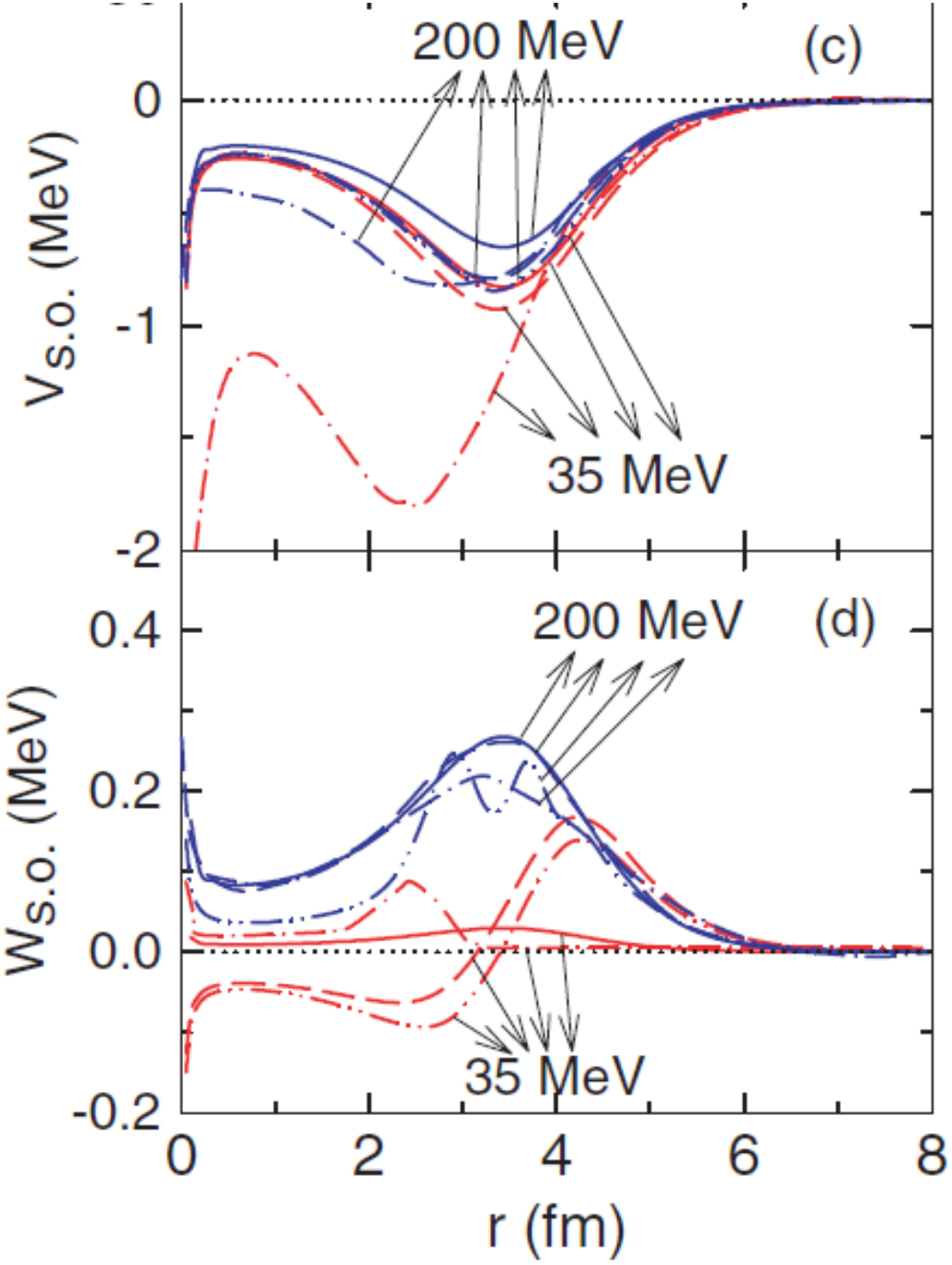
Figure 2 (a)





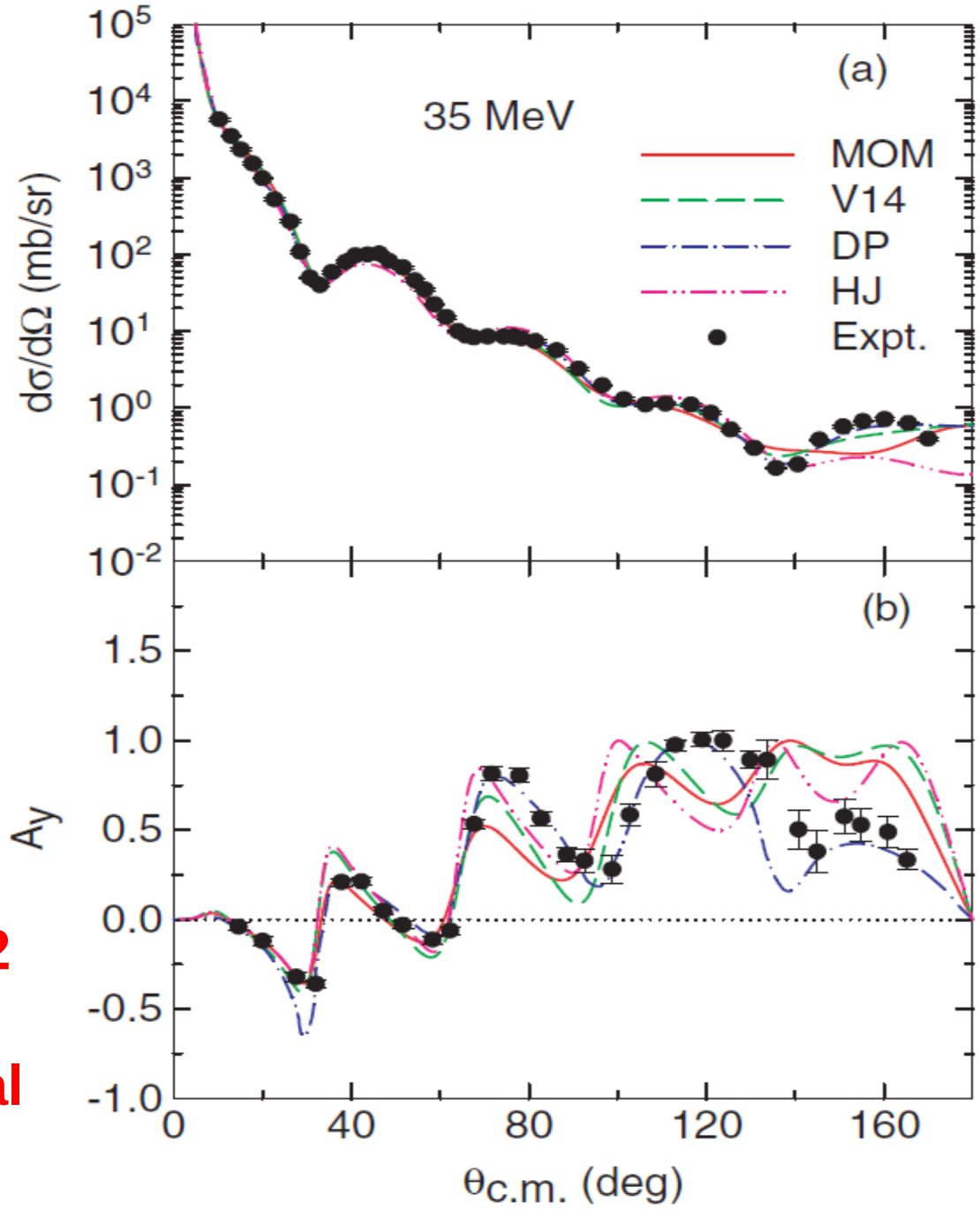

(a)
0
-20
-40
V (MeV)
200 MeV
35 MeV
MOM
V14
DP
HJ
(b)
0
-10
-20
-30
W (MeV)
35 MeV
200 MeV

P + 40 Ca


200 MeV
(c)
0
-1
-2
$V_{s.o.}$ (MeV)
35 MeV
200 MeV
(d)
0.4
0.2
0.0
-0.2
$W_{s.o.}$ (MeV)
35 MeV
0
2
4
6
8
r (fm)

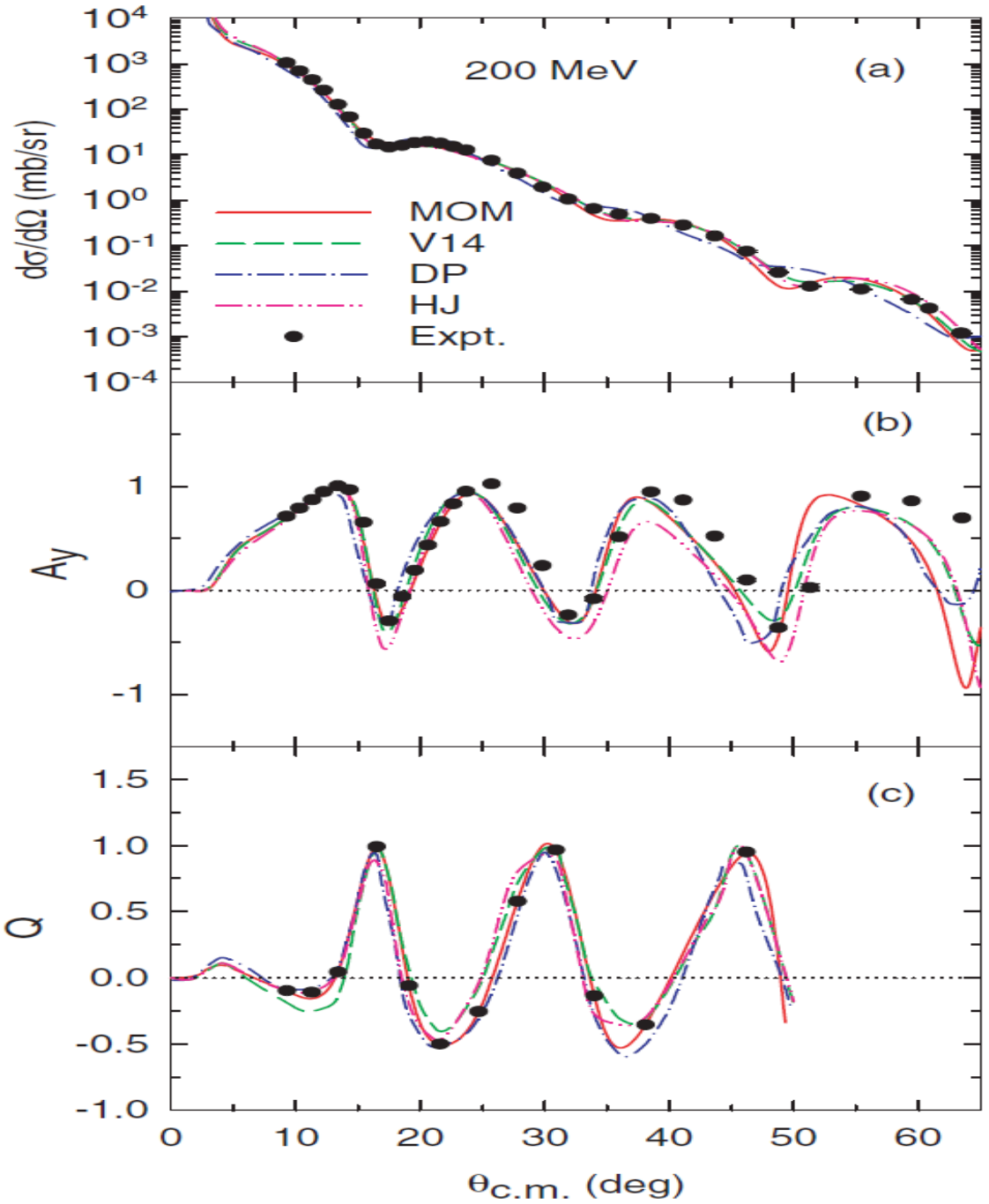
P + 40 Ca

P + 40 Ca

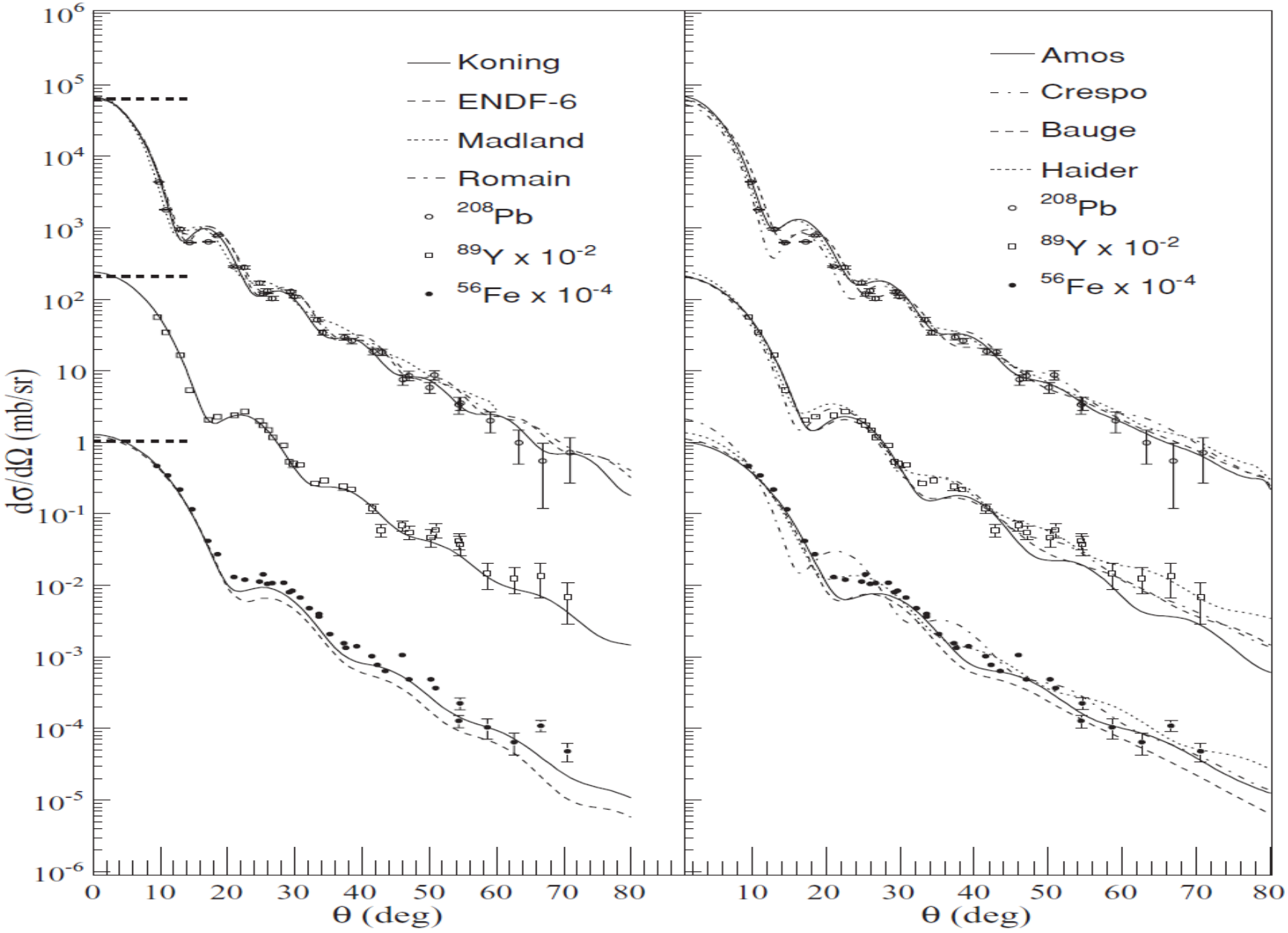


PRC 75,037602 (2007) Hemalatha et al

P + 40 Ca



96 MeV Neutron Scattering from Fe, Y and Pb



Ohrn et al. PRC 77, 024605 (2008)

SUMMARY

- Correlation between MSR Charge Radius & Proton Reaction Cross section – Zr, Sn isotopes;
- Sudden changes at A(Zr)= 82 – 80; 98 – 100.
- A(Sn) = 110, 132, 156

- SO strength decreases with increase of Neutron Number; Correlation with 1st Max and 1st Min in Asymmetry data

- Sensitivity to Effective Interaction - A & E dependence

- Wine bottle bottom shape potential is not necessary to describe Intermediate energy data

- Systematic Reaction and Asymmetry data with Nuclei Away from line of stability will be interesting & will put constraints on various models for nuclear densities