Hellenic Institute of Nuclear Physics (HINP)

3rd Hellenic Institute of Nuclear Physics Workshop (HINPw3)

Influence of resonance and continuum states on elastic scattering of ^{6}Li+p

Vasileios Soukeras

Nuclear Physics Laboratory

Physics Department, University of Ioannina

8th of April, 2016

Athens, Greece

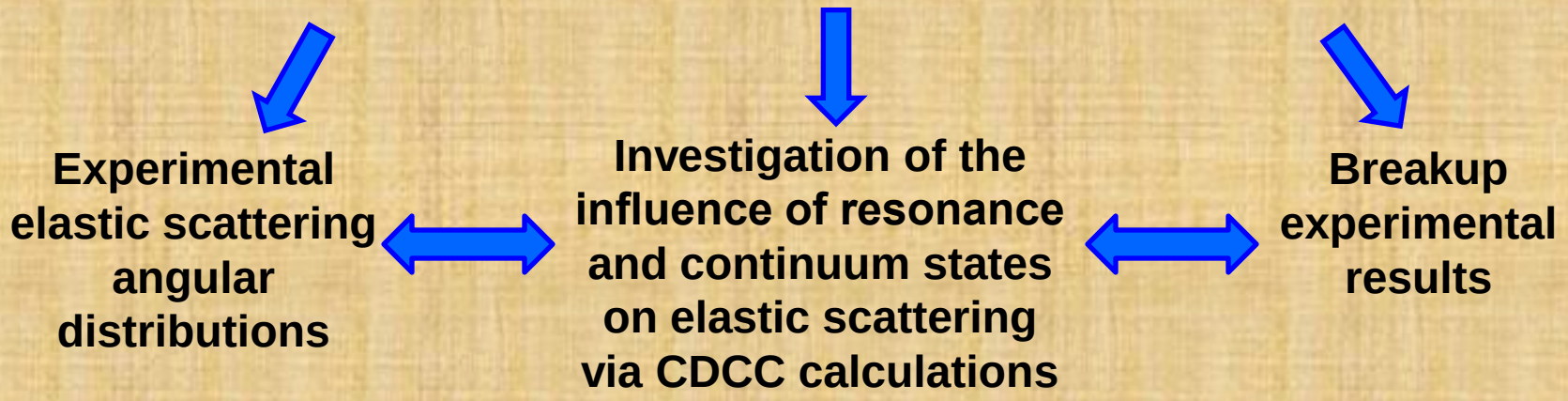
Motivation– Introduction

- ✓ Systematic investigation of the optical potential via elastic scattering and reactions A+p in inverse kinematics.
- ✓ Measurements via the stable but, weakly bound nucleus ^{6}Li.
- ✓ The reactions with ^{6}Li are of great practical and theoretical importance with applications on astrophysical problems.
- ✓ Coupling channel mechanisms for weakly bound nuclei appear to be stronger at near barrier energies.

Contents

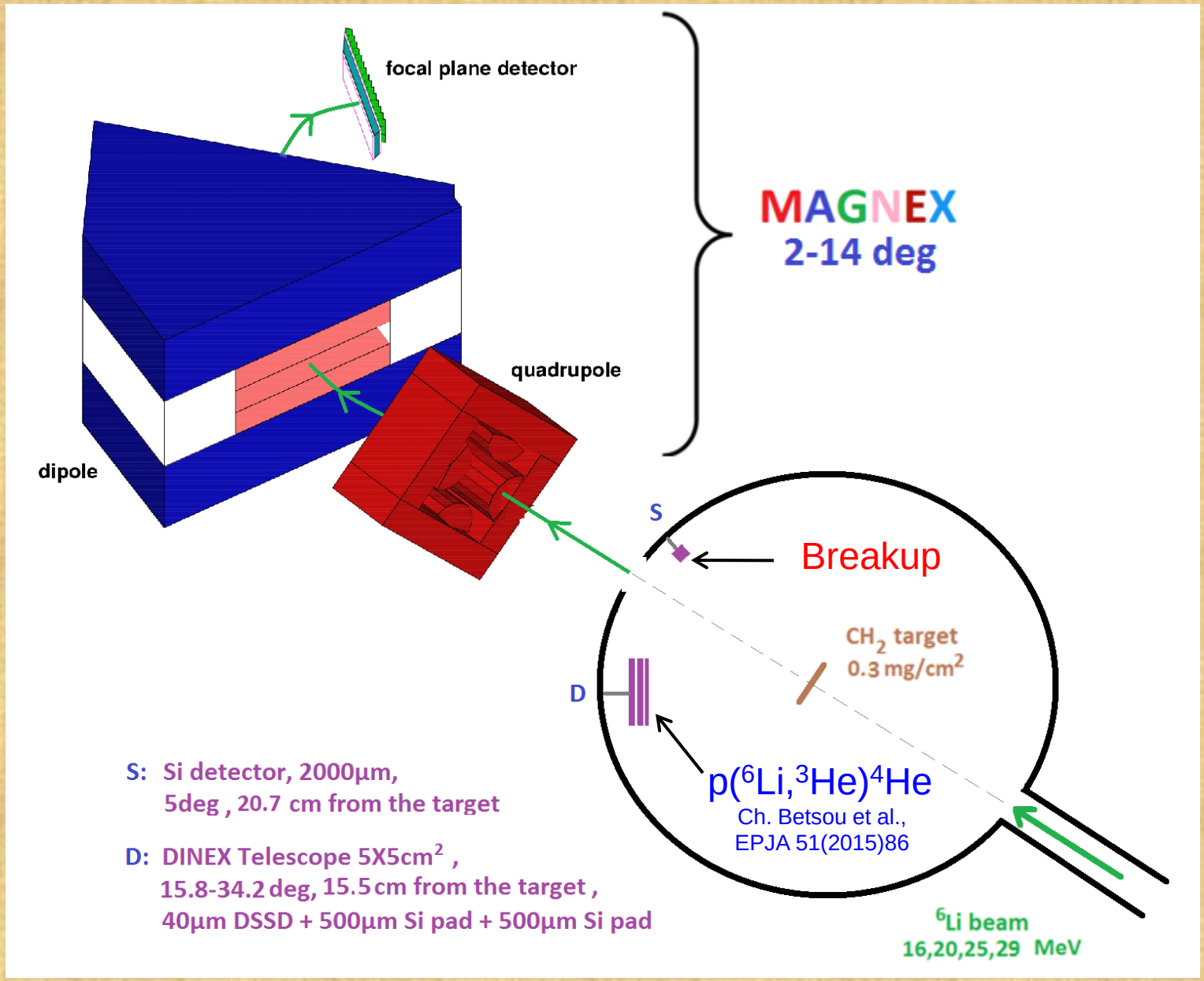
Experimental Setup

Influence of resonance and continuum states on elastic scattering of ^{6}Li+p



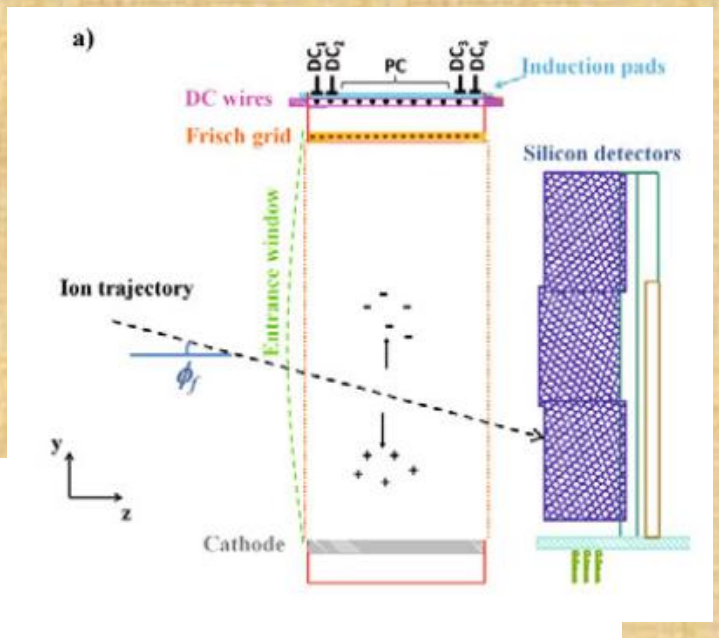
Summary

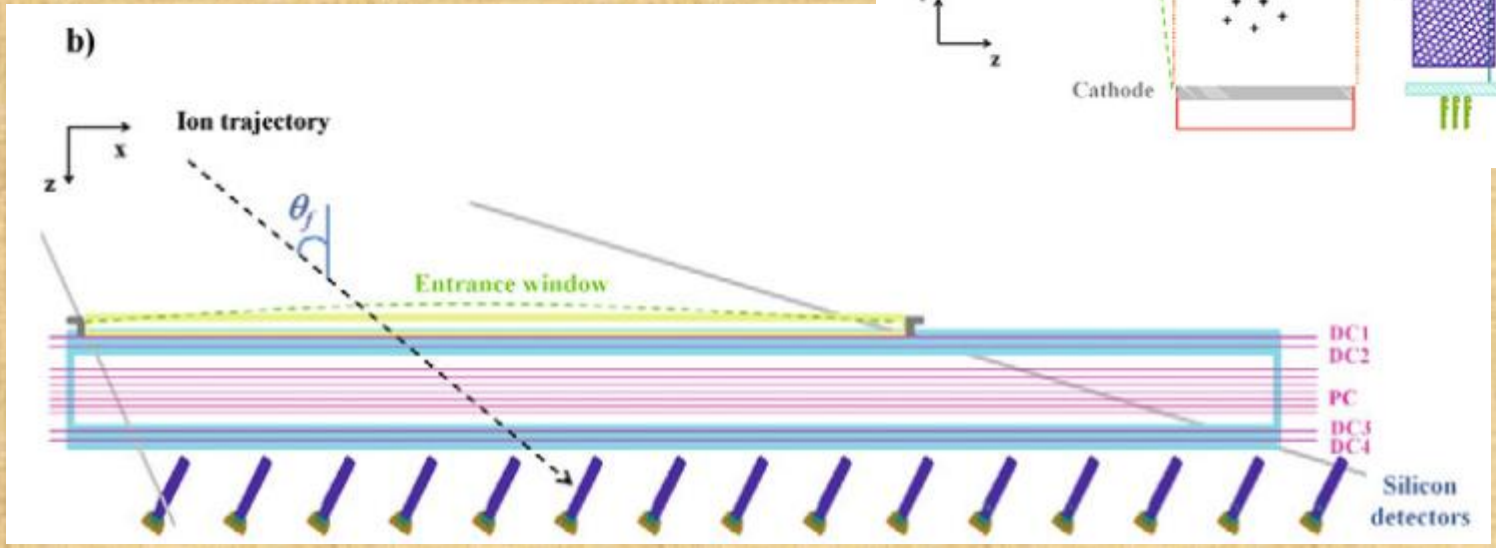
Experimental Setup



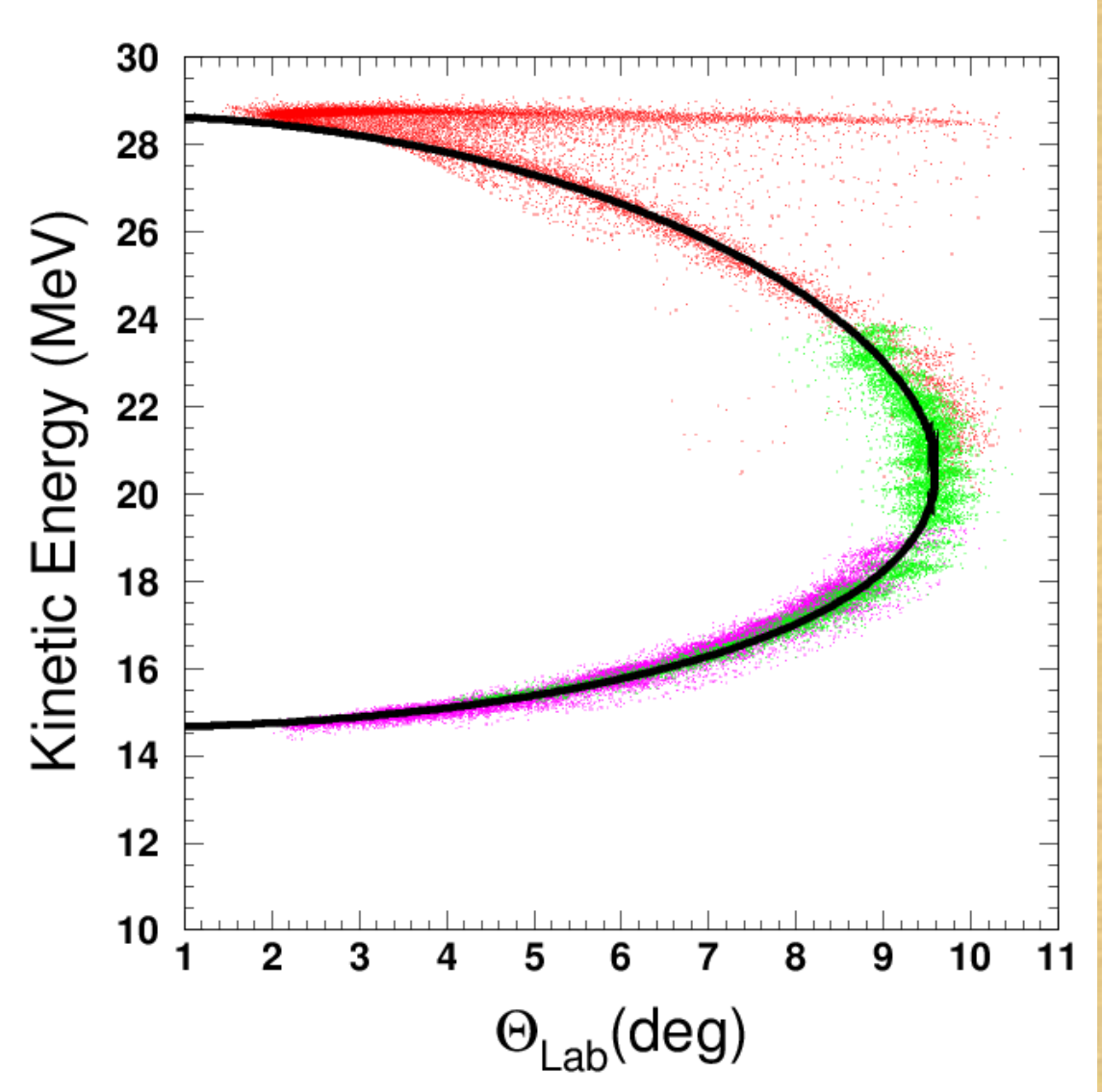
The Focal Plane Detector

M. Cavallaro et al., Eur. Phys. J. A 48 (2012) 59





Identification of Elastic channel

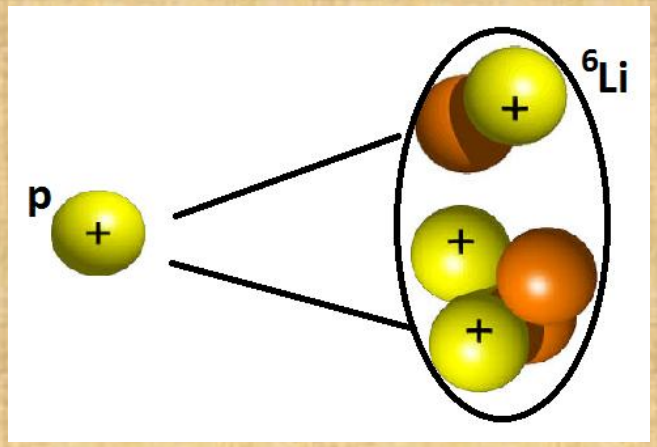


V. Soukeras et al., Phys. Rev. C 91 (2015) 057601

CDCC Calculations

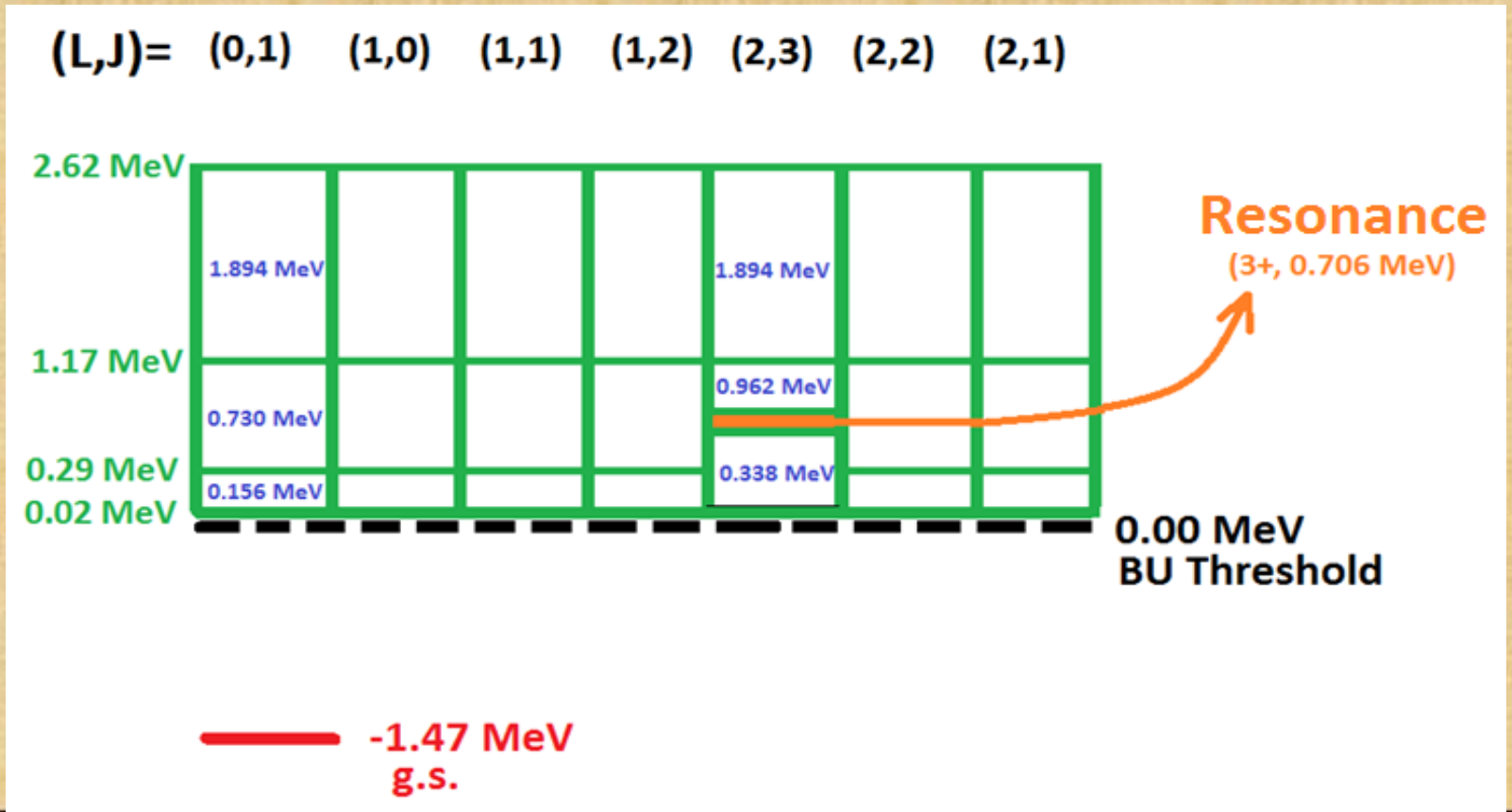
Description of the technique is reported in:

- **K. Rusek et al., Phys. Rev. C 56 (1997) 1895**
- **K. Rusek et al., Phys. Rev. C 64 (2001) 044602**



CDCC Calculations

- ✓ The continuum above the $^{6}Li \rightarrow \alpha + d$ breakup threshold was discretized into momentum bins of equal widths. The discretization of the momentum space was performed for different values of ***L***,***J***=***L***+***S***.
- ✓ The width of a bin corresponding to a resonance was adjusted with respect to the resonance width.

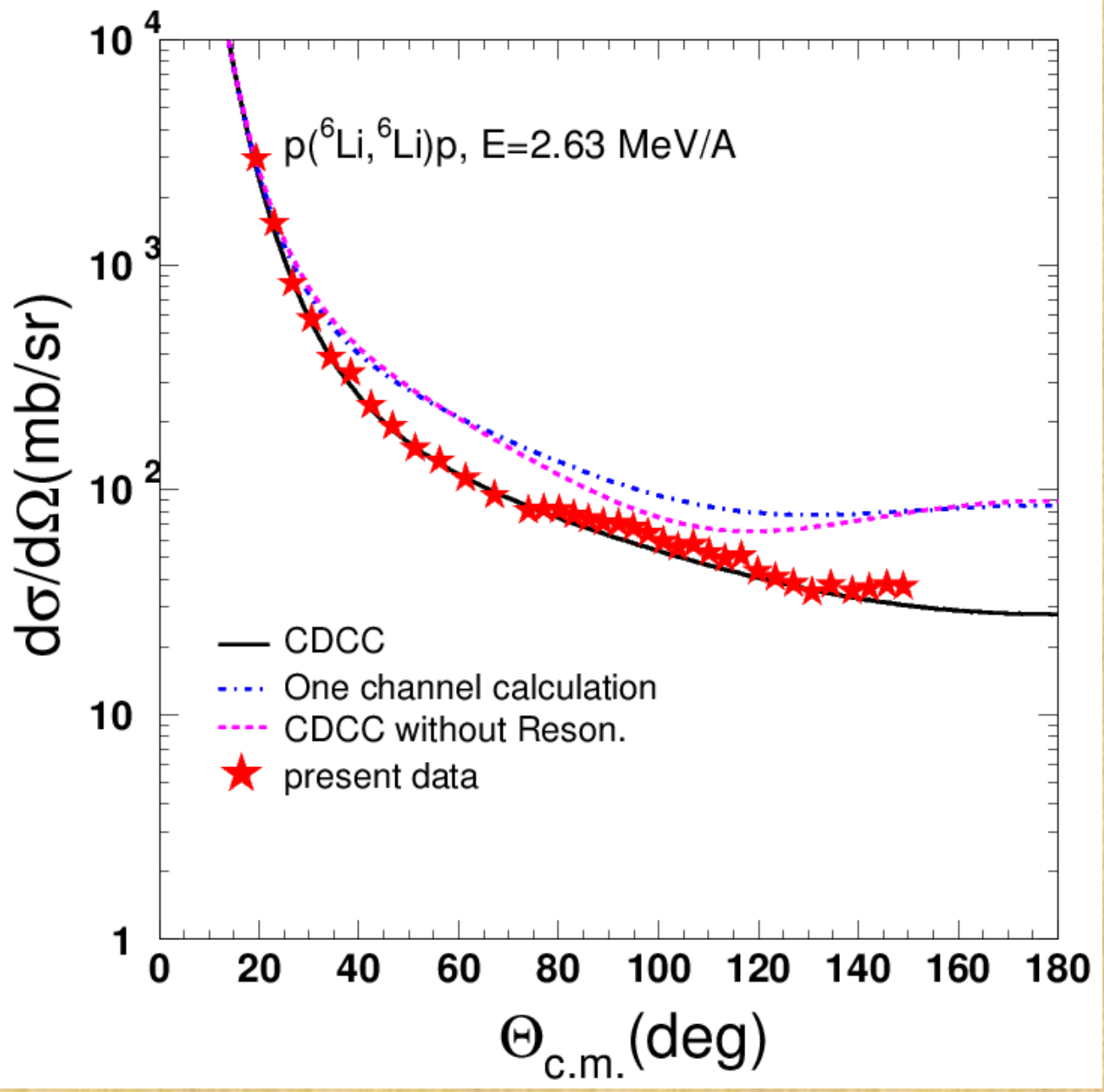


CDCC Calculations

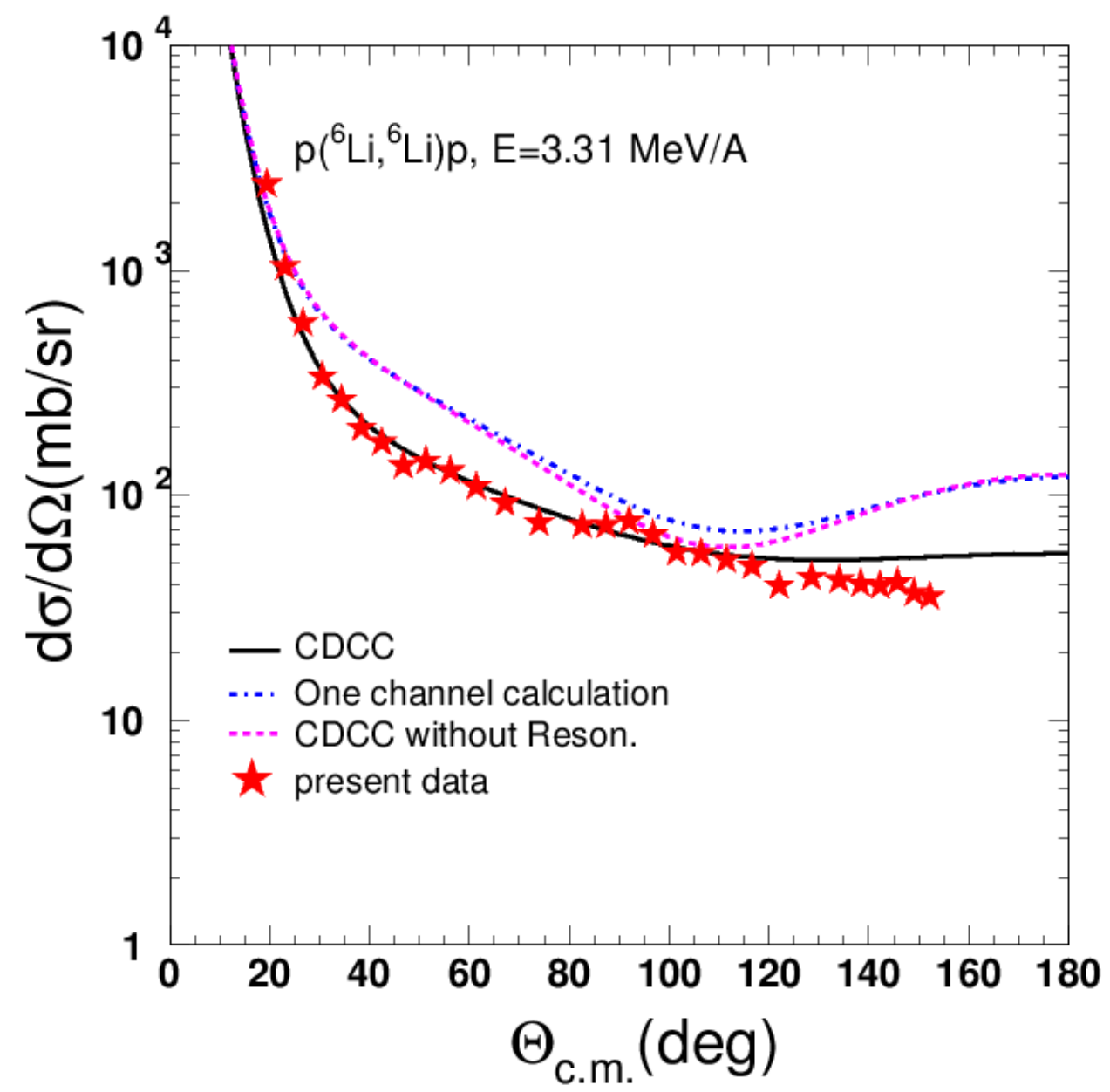
- ✓ The continuum above the $^{6}Li \rightarrow \alpha + d$ breakup threshold was discretized into momentum bins of equal widths. The discretization of the momentum space was performed for different values of $\boldsymbol{L}, \boldsymbol{J}=\boldsymbol{L}+\boldsymbol{S}$.
- ✓ The width of a bin corresponding to a resonance was adjusted with respect to the resonance width.
- ✓ The resonance and continuum states, the nuclear properties of the involved nuclei and the appropriate interactions were fed to a FRESCO code [I. J. Thompson, Comput. Phys. Rep. 7 (1988)167].
- ✓ Special care was given for the potentials of each nucleus of the cluster and the target: ^{4}He-^{1}H και ^{2}H-^{1}H .
- ✓ The influence of the binding potential ^{4}He-^{2}H is also important.

Which is the influence of resonance and continuum states on elastic scattering of $^{6}Li+p$?

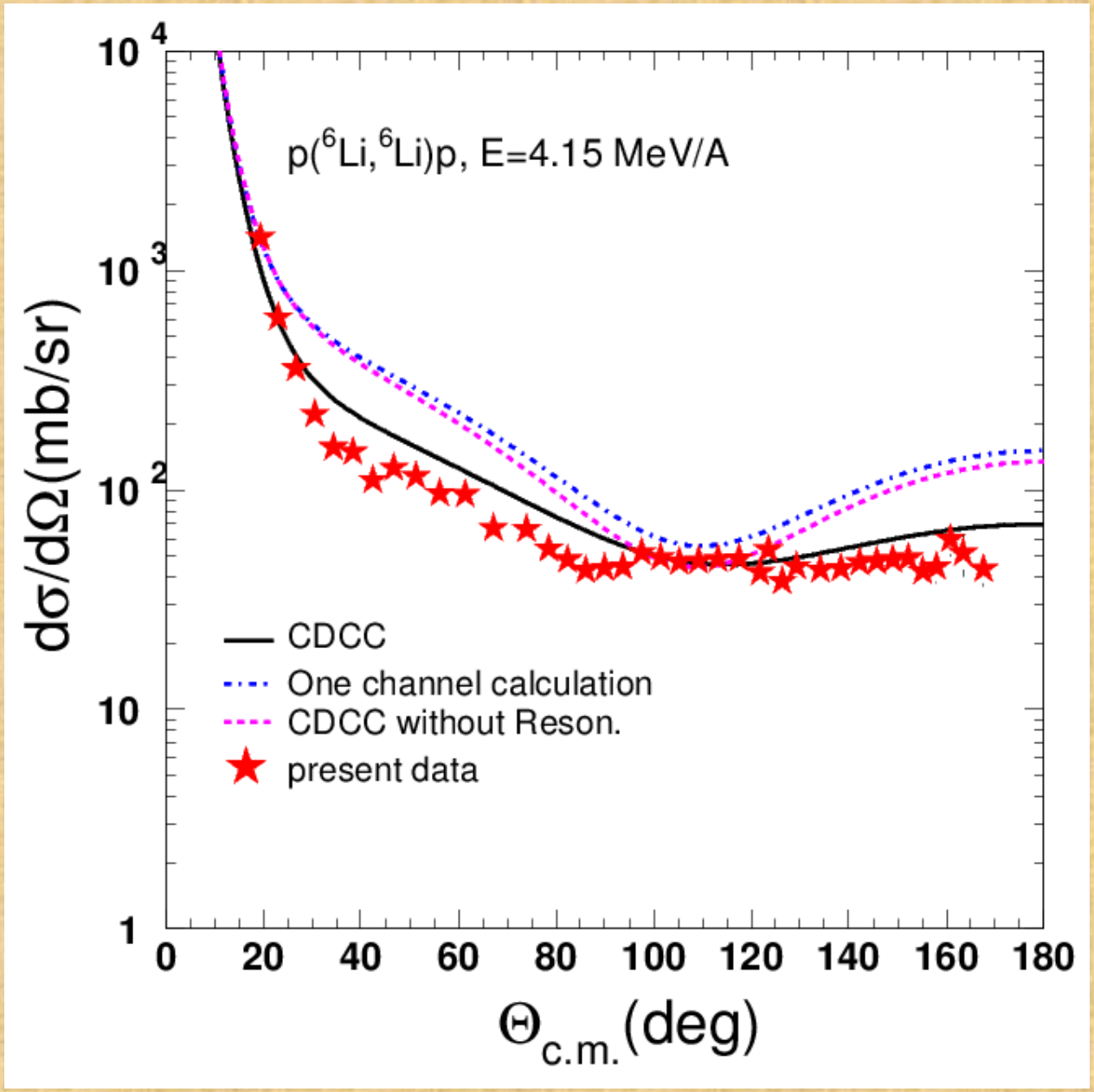
Elastic scattering angular distribution at 16 MeV



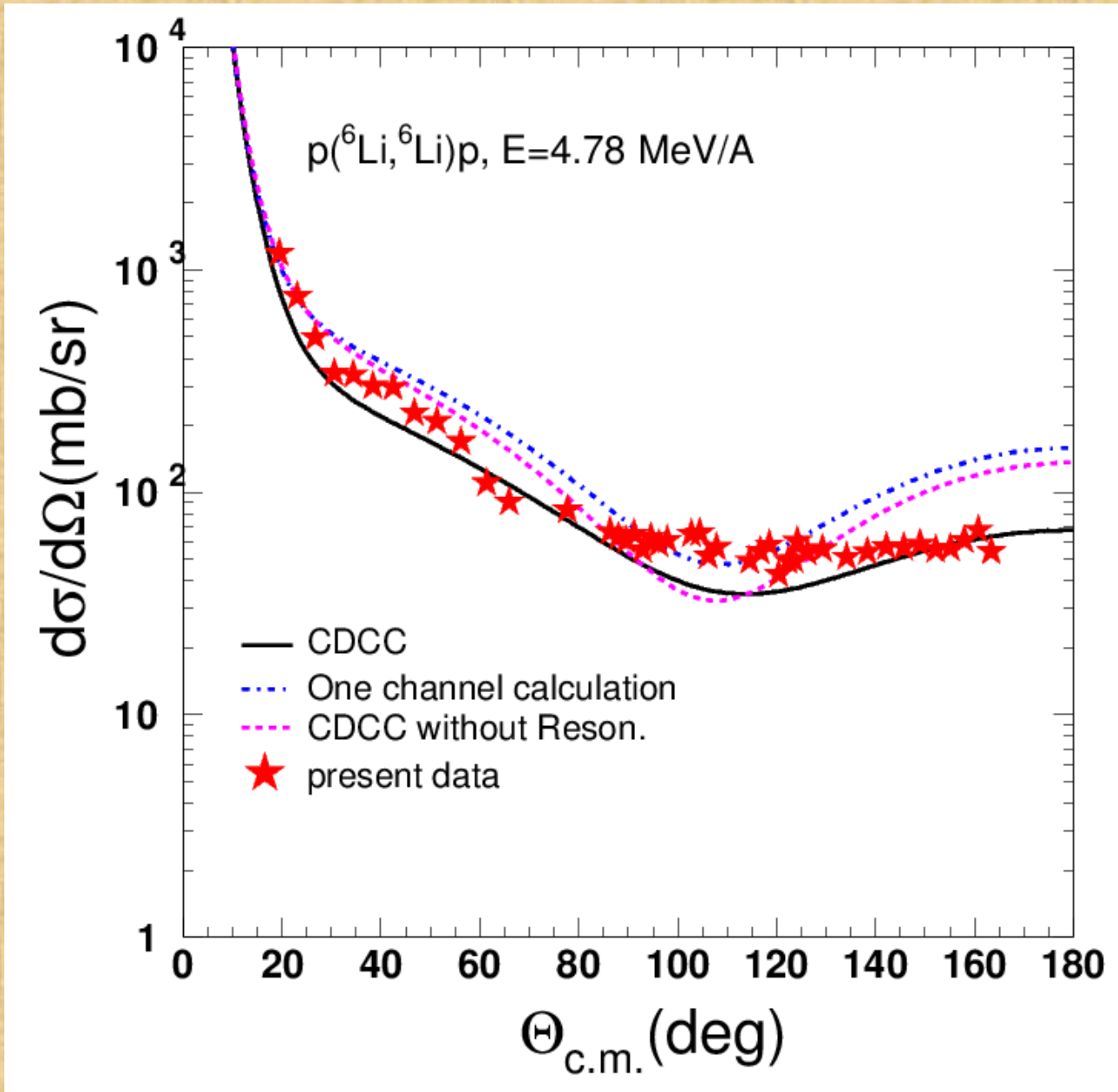
Elastic scattering angular distribution at 20 MeV



Elastic scattering angular distribution at 25 MeV



Elastic scattering angular distribution at 29 MeV



Absorption cross section and Breakup cross section

✓ CDCC calculations can also provide information about:

- Absorption cross section

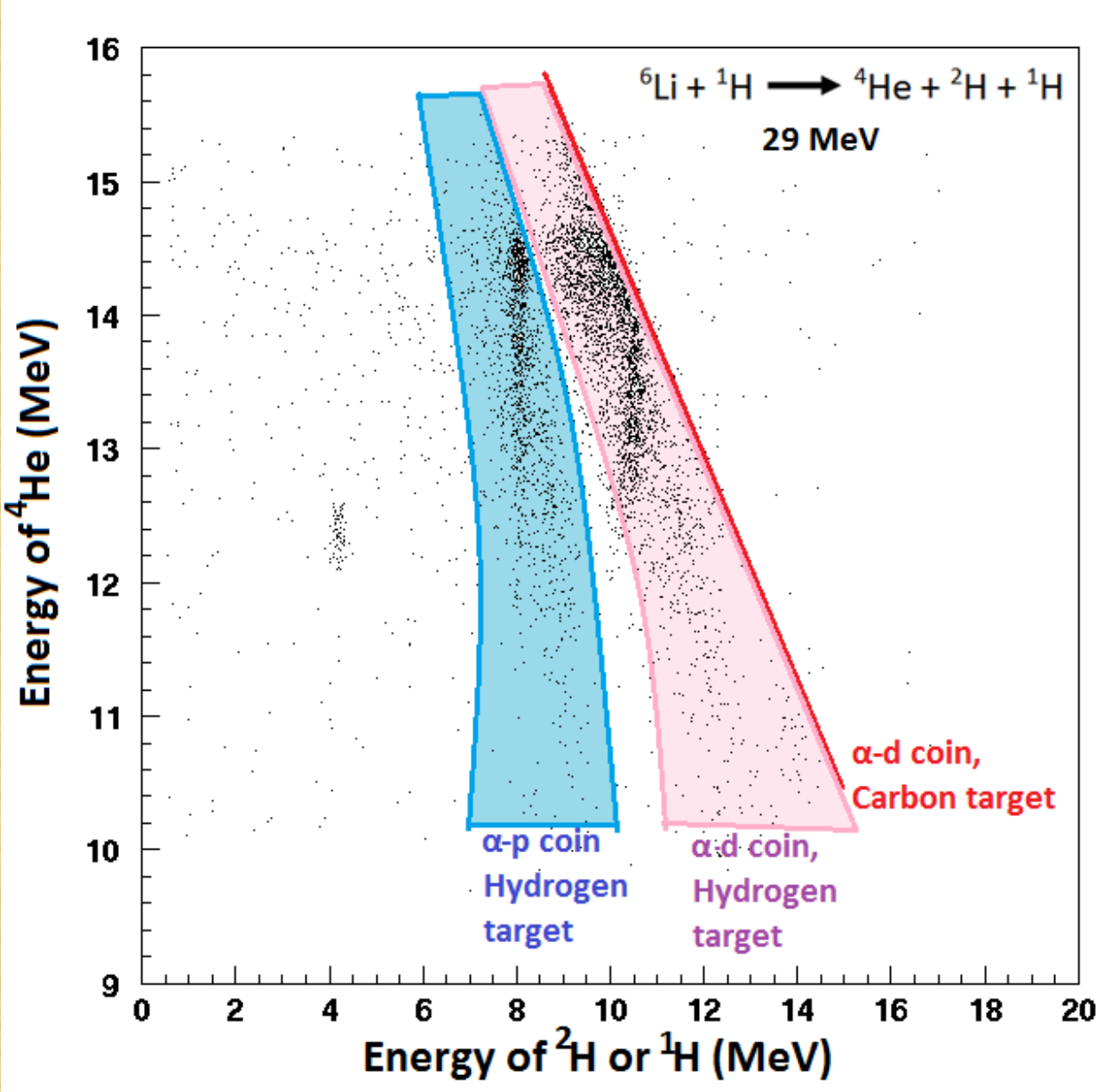
Excellent agreement with the results of the reaction $p(^{6}Li,^{3}He)^{4}He$

[Ch. Betsou et al., Eur. Phys. J. A 51 (2015) 86,

Ch. Betsou, MSc Thesis – University of Ioannina, http://www.uoi.gr/HINP/theses/Pakou_Betsou_MSc.pdf]

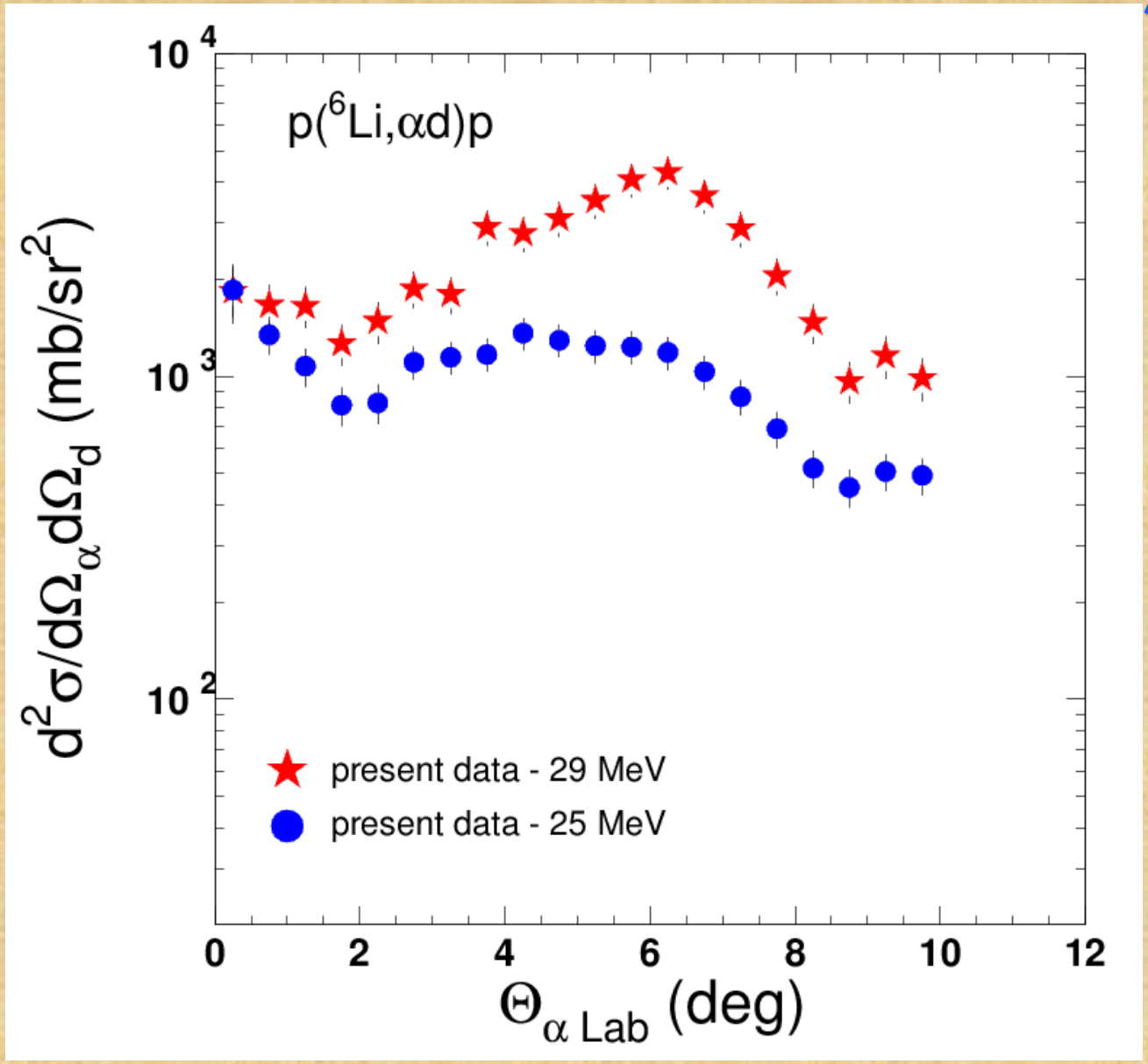
- Total Breakup cross section
- Differential Breakup cross section as a function of center – of – mass angle

Breakup


$^{6}Li + {}^{1}H \rightarrow {}^{4}He + {}^{2}H + {}^{1}H$
29 MeV
α-d coin,
Carbon target
α-p coin
Hydrogen
target
α-d coin,
Hydrogen
target
Energy of ^{4}He (MeV)
Energy of ^{2}H or ^{1}H (MeV)
16
15
14
13
12
11
10
9
0
2
4
6
8
10
12
14
16
18
20

Breakup

Preliminary



Summary

1. Elastic scattering and breakup measurements for the system ^{6}Li+p were performed at 16, 20, 25 and 29 MeV, in inverse kinematics with MAGNEX spectrometer.
2. A software ray-reconstruction was performed for the elastic scattering data and the angular distributions were deduced at the energies 16, 20, 25 and 29 MeV.
3. Theoretical calculations were performed in the CDCC framework and the results were compared with the experimental data. In particular, the CDCC calculations:
   i. Exhibit an excellent agreement with the experimental elastic scattering data
   ii. Indicate a strong influence of the 3+ resonance
   iii. Indicate that the continuum states have a small impact on the calculations
   iv. Give an excellent prediction for the absorption from other reactions channels
4. The analysis of the breakup experimental data is in progress.
5. This measurement establishes our technique which can be applied to new measurements in MAGNEX with other radioactive or stable nuclei.

Collaborators

- ✓ *Department of Physics and HINP, The University of Ioannina, Greece*
- ✓ *Laboratori Nazionali Del Sud (LNS), Catania, Italy*
- ✓ *Dipartimento di Fisica e Astronomia, Universita di Catania, Italy*
- ✓ *Heavy Ion Laboratory, University of Warsaw, Poland*
- ✓ *National Center for Nuclear Research, Otwock Warsaw, Poland*
- ✓ *INFN – Sezione di Catania, Italy*
- ✓ *Departamento di Fisica Aplicada, Universidad de Huelva, Spain*
- ✓ *Departimento di Fisica and INFN – Sezione di Padova, Italy*
- ✓ *INFN – Sezione di Napoli, Italy*
- ✓ *CEA – Saclay, DAPNIA-SPhN, Gif-sur-Yvette, France*

Thank you very much for your attention!