Hellenic Institute of Nuclear Physics (HINP)

4th Workshop on New Aspects and Perspectives in Nuclear Physics (HINPW4)

A global study of the ^{6}Li+p system at near barrier energies in a CDCC approach

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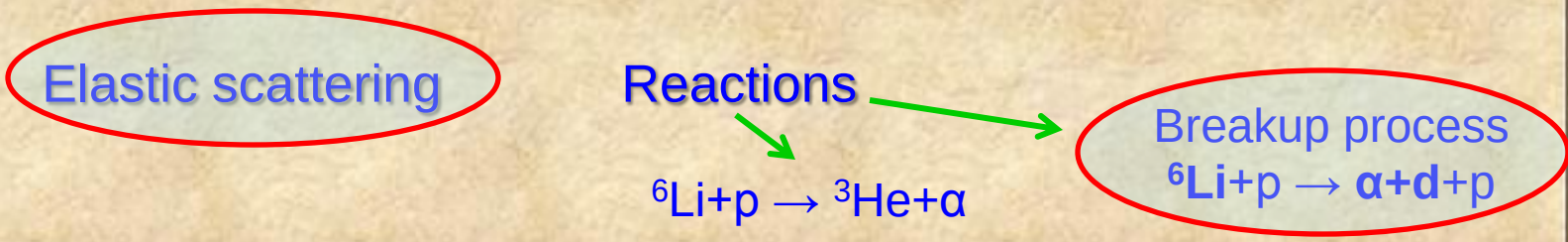
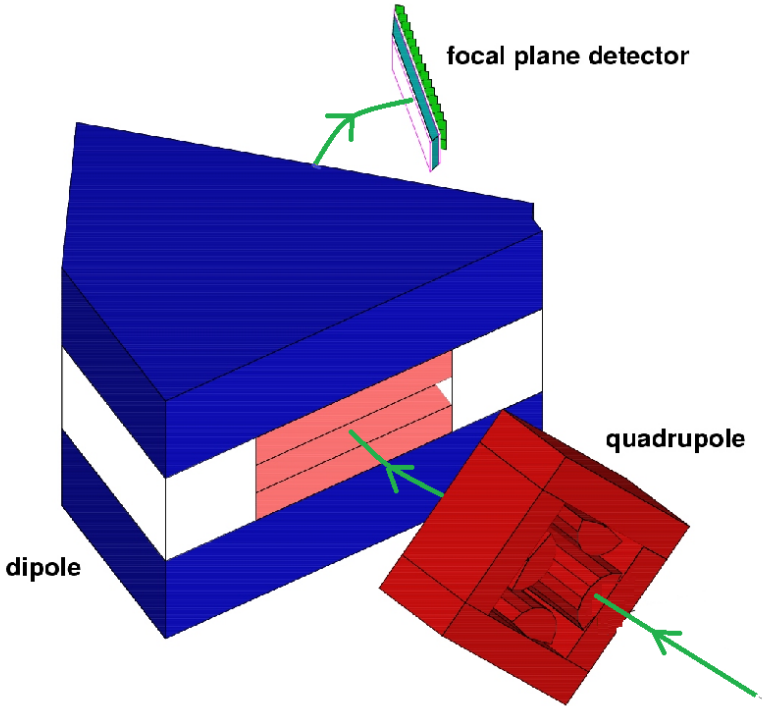
Motivation – Introduction

- ✓ Elastic scattering and reactions of nucleon-nucleus is the main tool for investigating the structure and/or the potential.
- ✓ Measurements via the stable but, weakly bound nucleus ^{6}Li.
- ✓ The goal of the present work for $^{6}Li+p$ is based on a global study of all involved channels in order to probe coupling channels effects on elastic scattering in a CDCC approach.



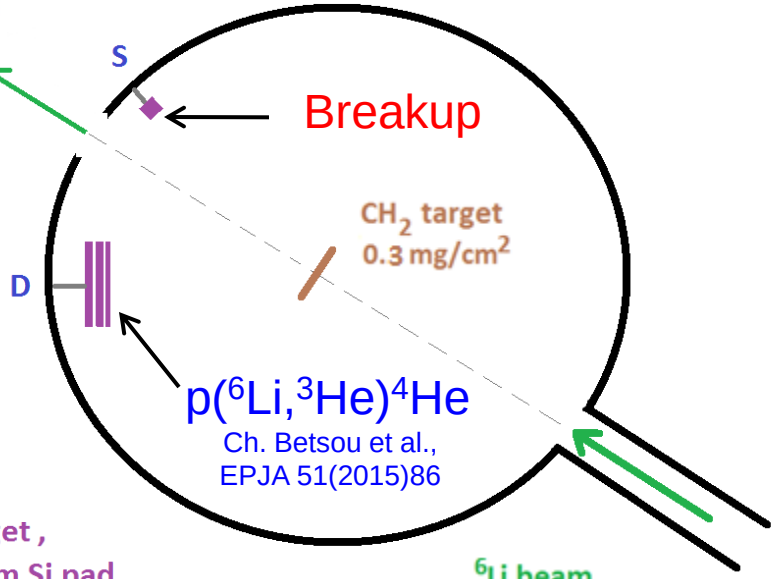
- ✓ Applicability of the JLM potential without coupling for a very light stable weakly bound projectile as ^{6}Li and at very low energies.

Experimental Setup



MAGNEX

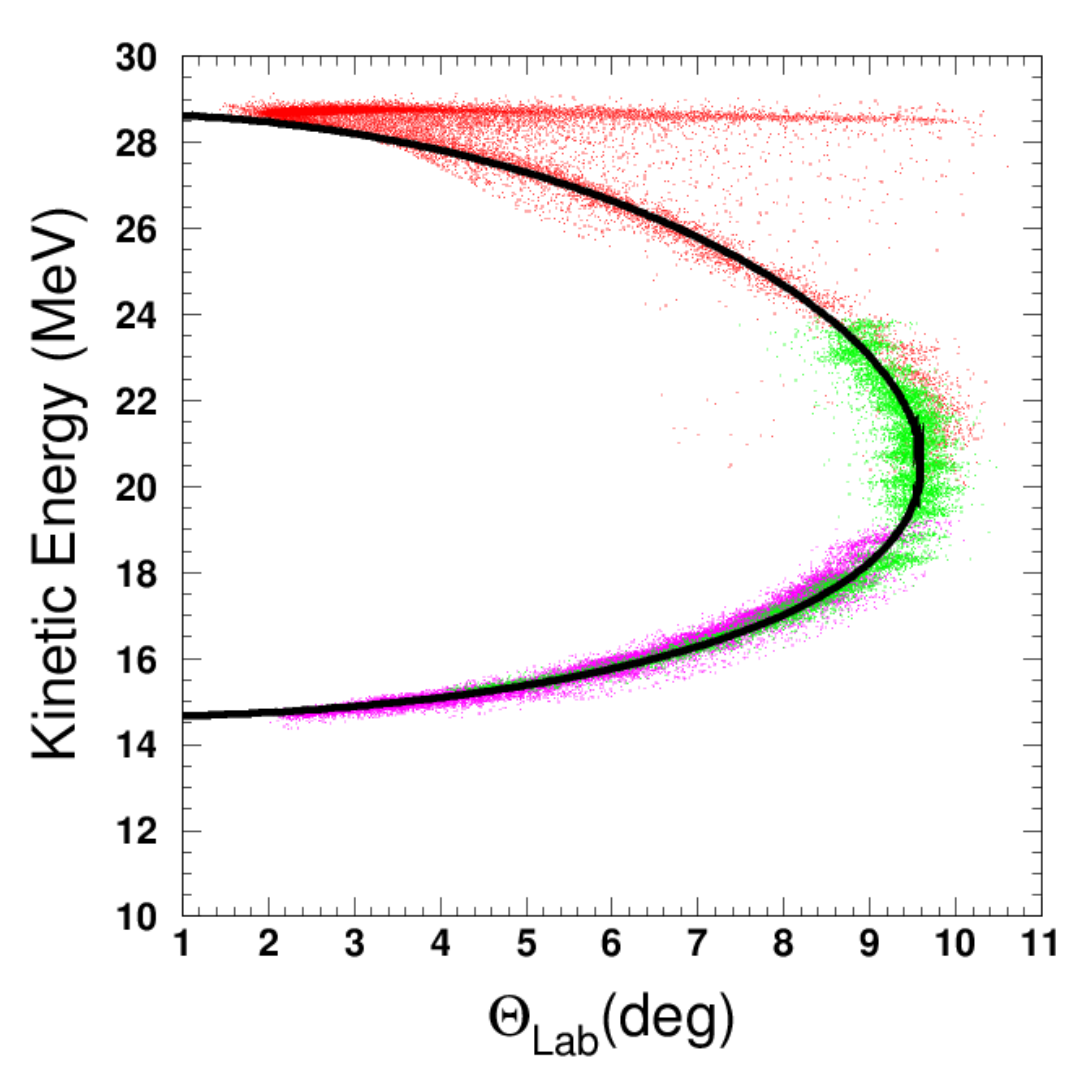
F. Cappuzzello et al.,
Eur. Phys. J. A 52, 167 (2016)



S: Si detector, 2000µm,
5deg , 20.7 cm from the target

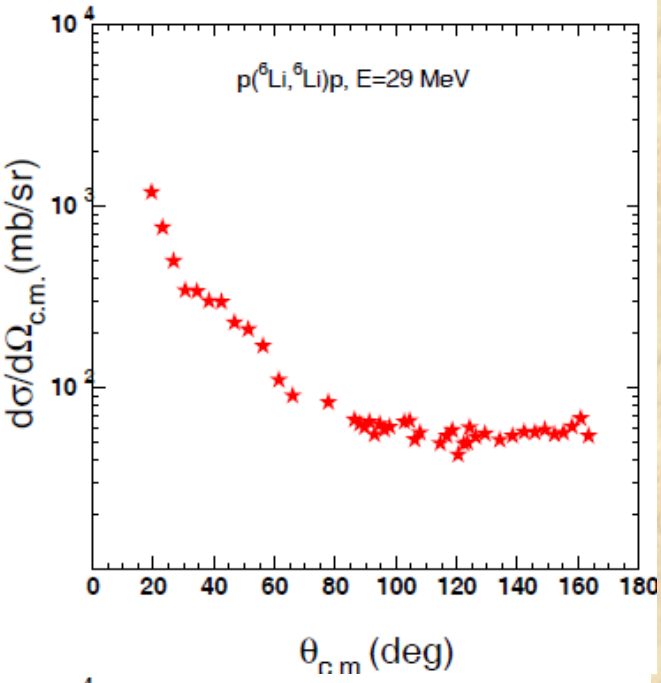
D: DINEX Telescope 5X5cm^2 ,
15.8-34.2 deg, 15.5 cm from the target ,
40µm DSSD + 500µm Si pad + 500µm Si pad

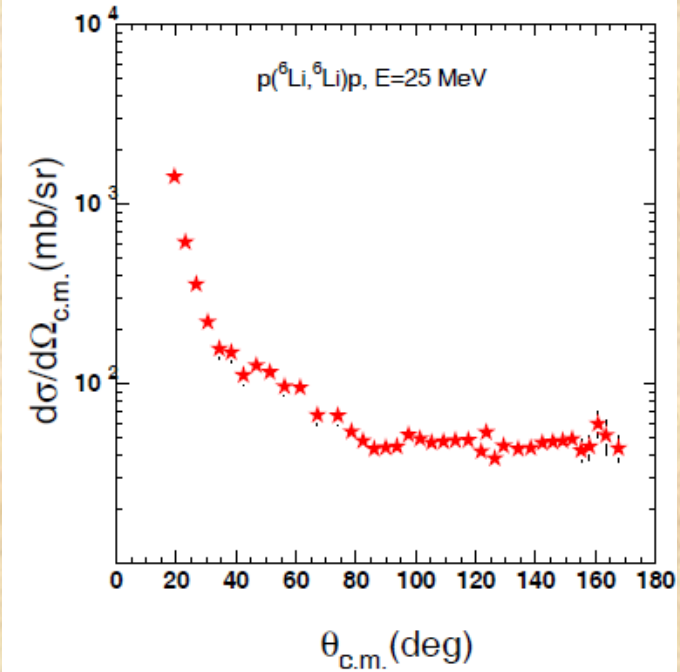
Identification of Elastic channel

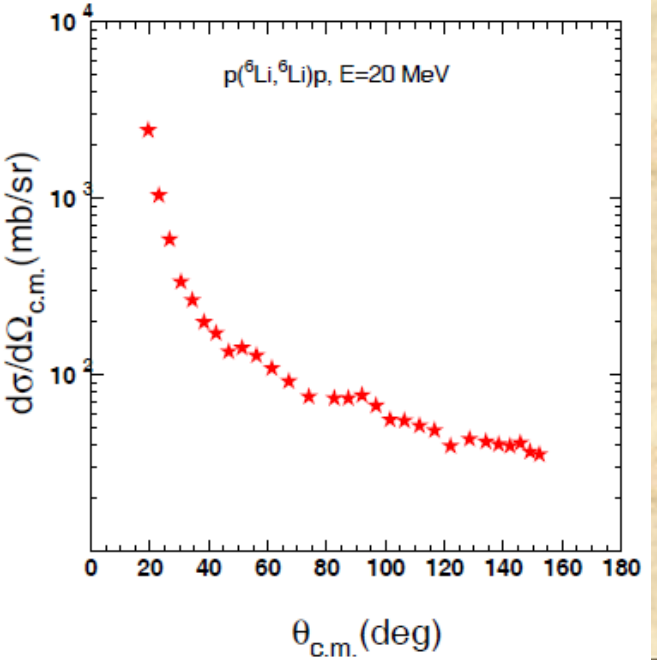


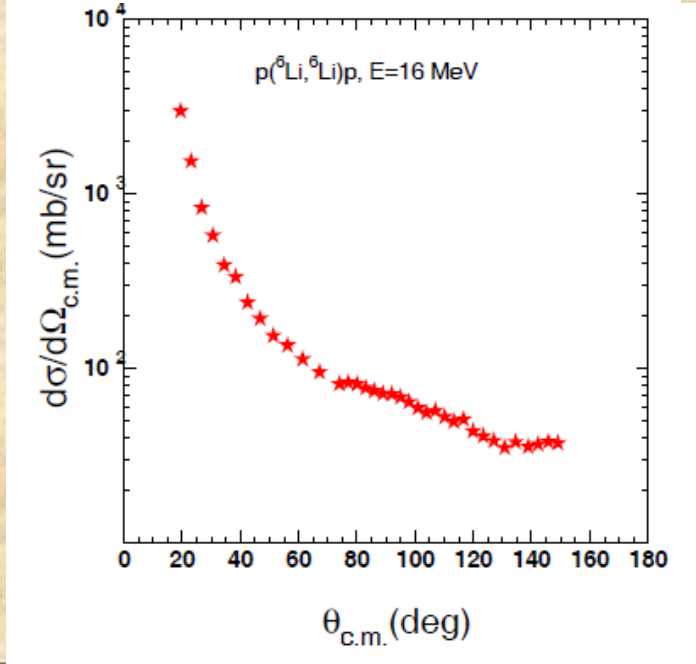
V. Soukeras et al.,
Phys. Rev. C 91, 057601 (2015)

Elastic scattering angular distributions









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

V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

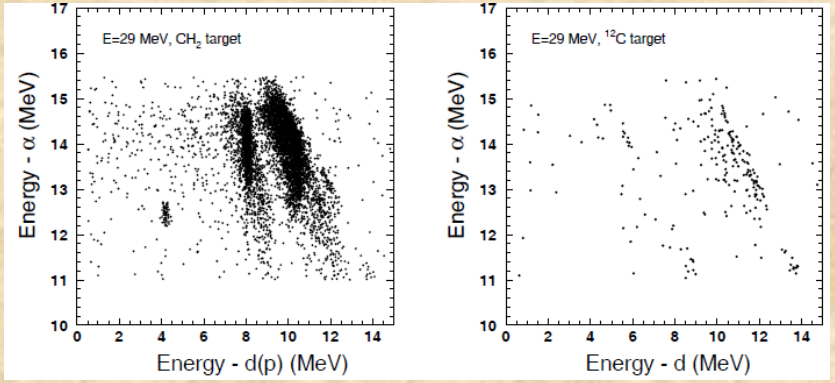
Identification of Breakup channel

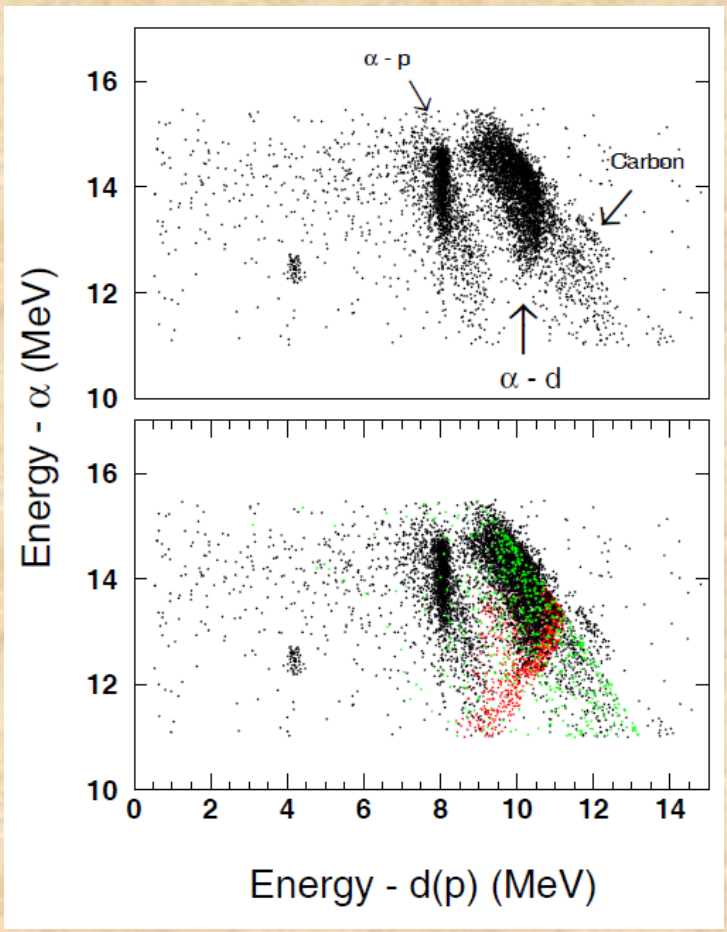
$^{6}Li + {}^{1}H \rightarrow {}^{4}He + {}^{2}H + {}^{1}H$

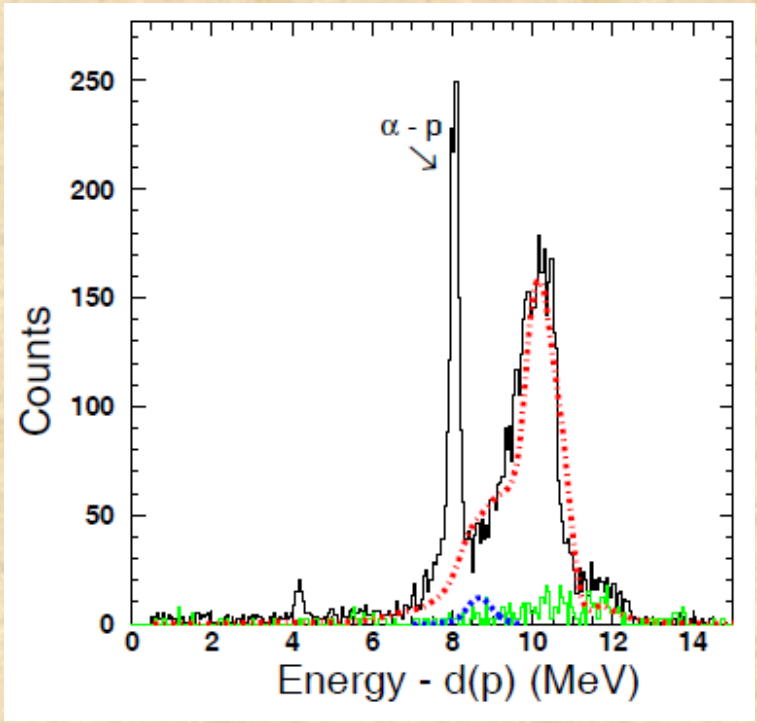
$^{6}Li + {}^{12}C \rightarrow {}^{4}He + {}^{2}H + {}^{12}C$

$^{6}Li + {}^{1}H \rightarrow {}^{4}He + {}^{3}He$

$^{6}Li + {}^{1}H \rightarrow {}^{5}Li + {}^{2}H \rightarrow {}^{4}He + {}^{1}H + {}^{2}H$



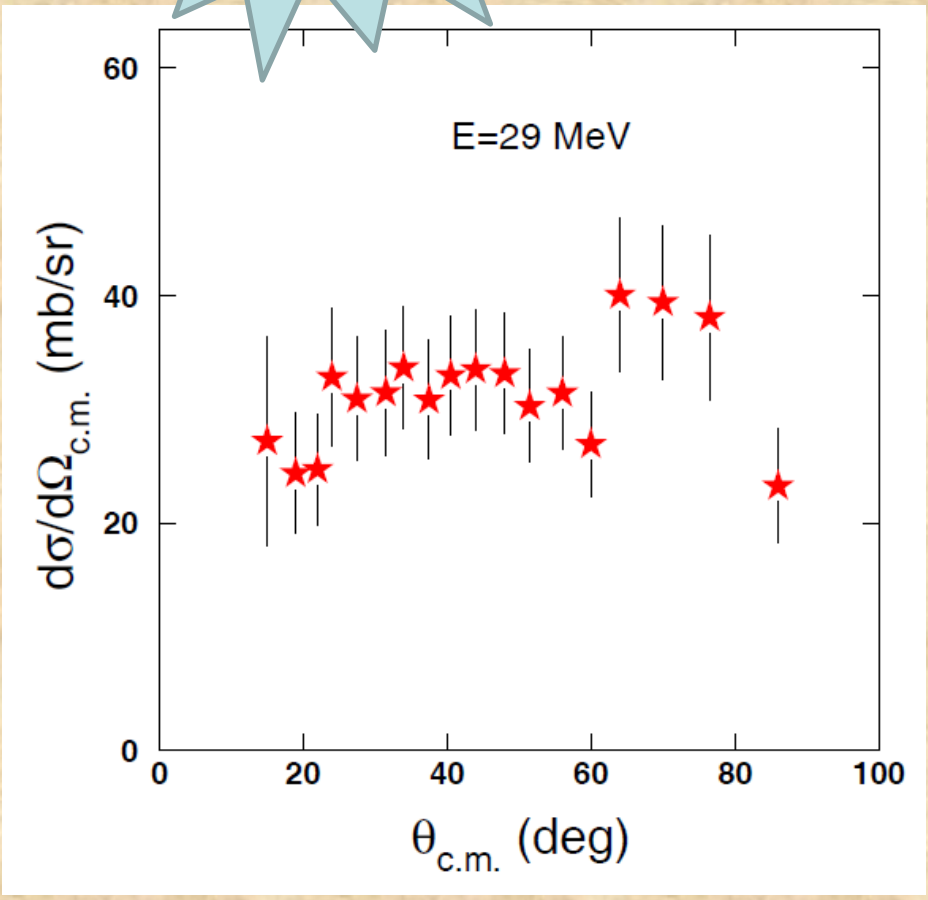


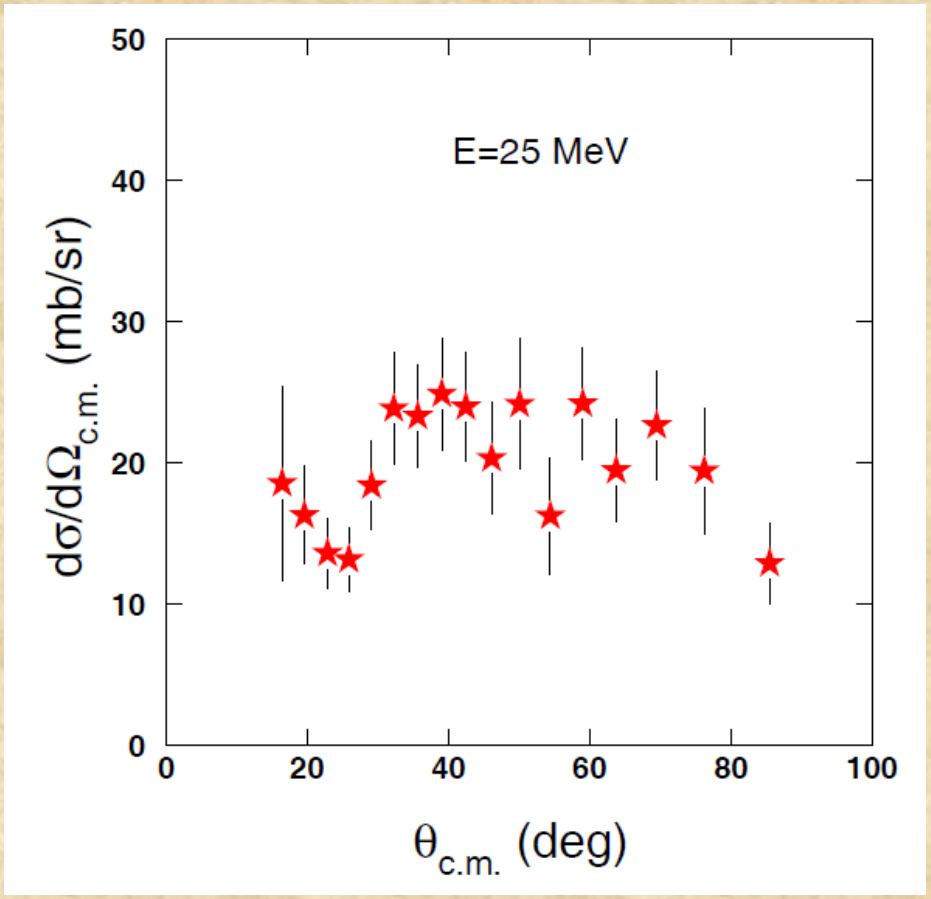


V. Soukeras et al.,
Phys. Rev. C accepted for publication (2017)

Breakup angular distribution

Measured for the first time





V. Soukeras et al.,
Phys. Rev. C accepted for publication (2017)

JLM Calculations

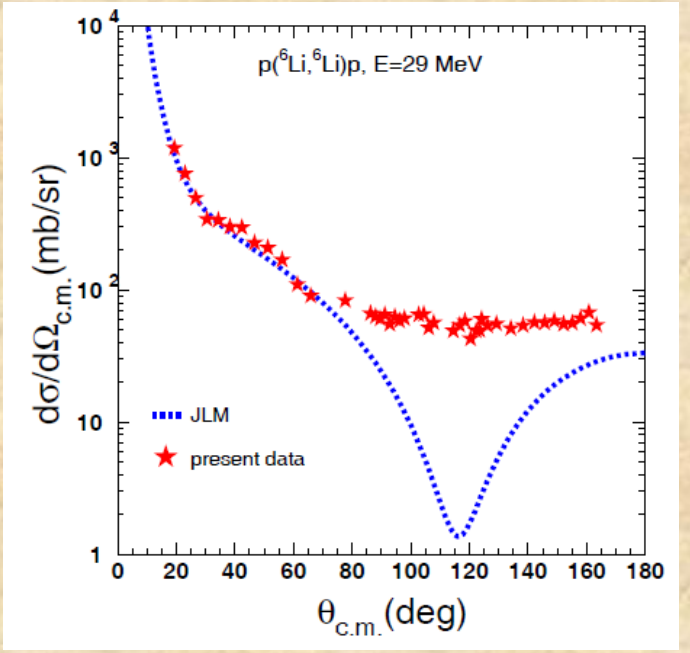
- Potential derived by

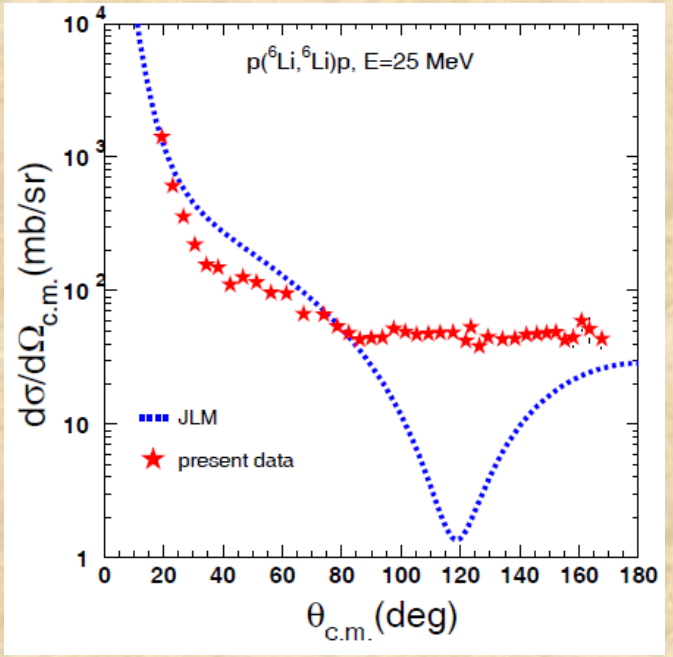
  Jeukenne, Lejeune and Mahaux

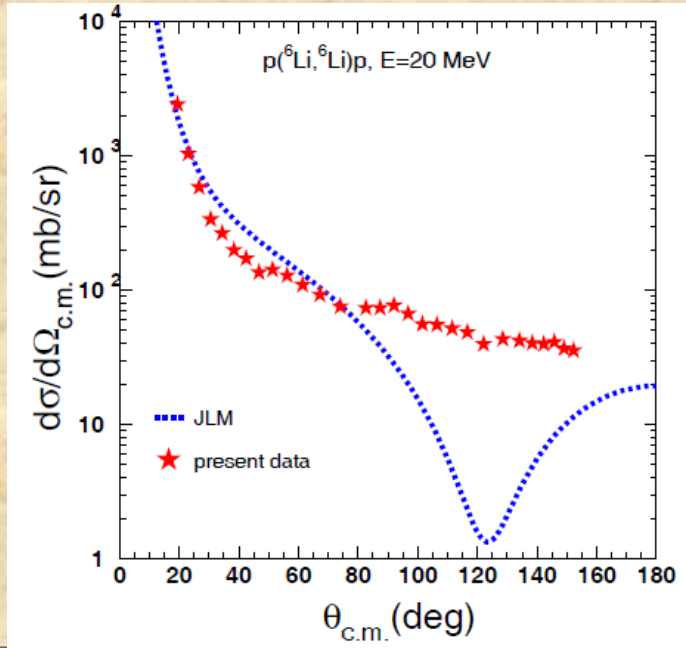
  [**J. P. Jeukenne, A. Lejeune, C. Mahaux, PRC 16, 80 (1977)**]
- Nucleon – Nucleus complex microscopic potential
- Good reproduction of many nucleon – nucleus systems

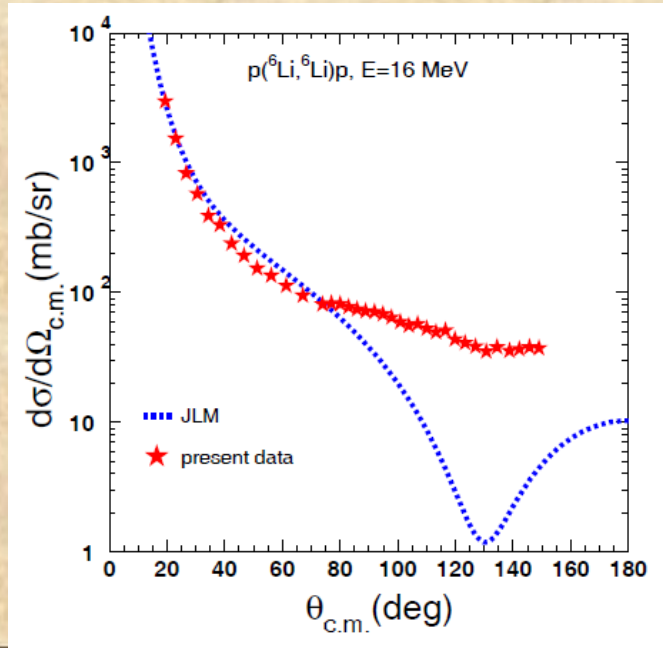
N. Alamanos et al., NPA 660, 406 (1999)
A. Pakou et al., NPA 691, 661 (2001)
N. Alamanos et al., J.Phys.G 24, 541 (1998)
A. De Vismes et al., PLB 505, 15 (2001)
V. Lapoux et al., NPA 722, 49c (2003)
F. Skaza et al., PLB 619, 82 (2005)
A. Gillibert et al., NPA 787, 423c (2007)
N. Patronis et al., PRC 85, 024609 (2012)

JLM Calculations





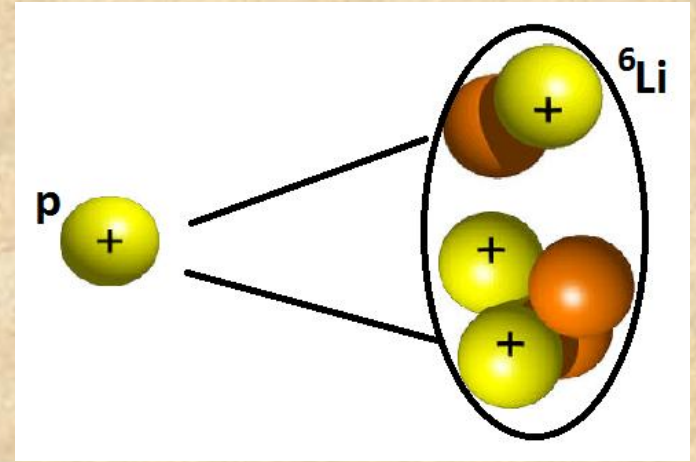




V. Soukeras et al., Phys. Rev. C 91, 057601 (2015)

CDCC Calculations

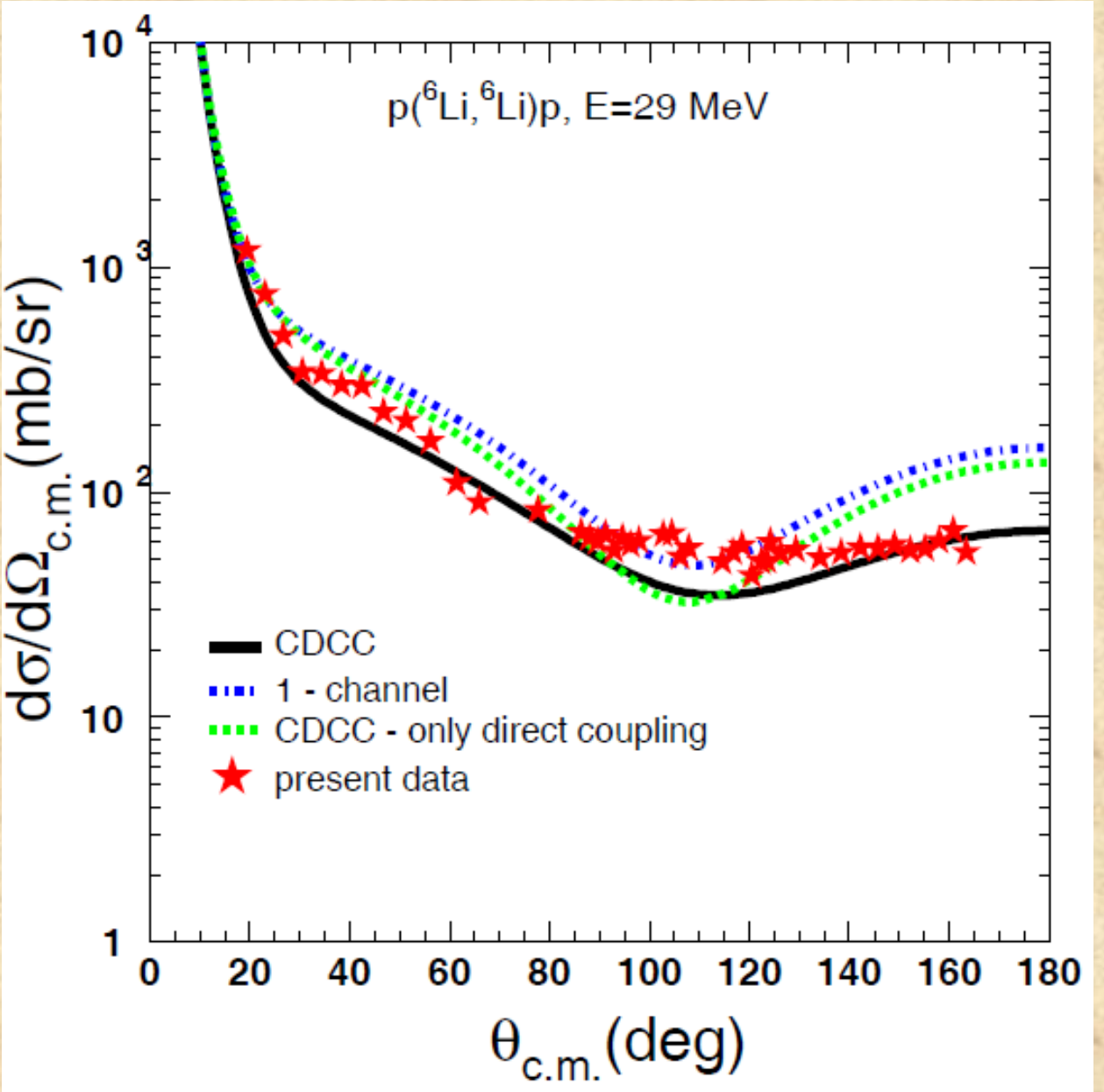
- Discretization of the continuum phase space above the breakup threshold
- Cluster structure of the weakly bound nucleus



Description of the technique is reported in:

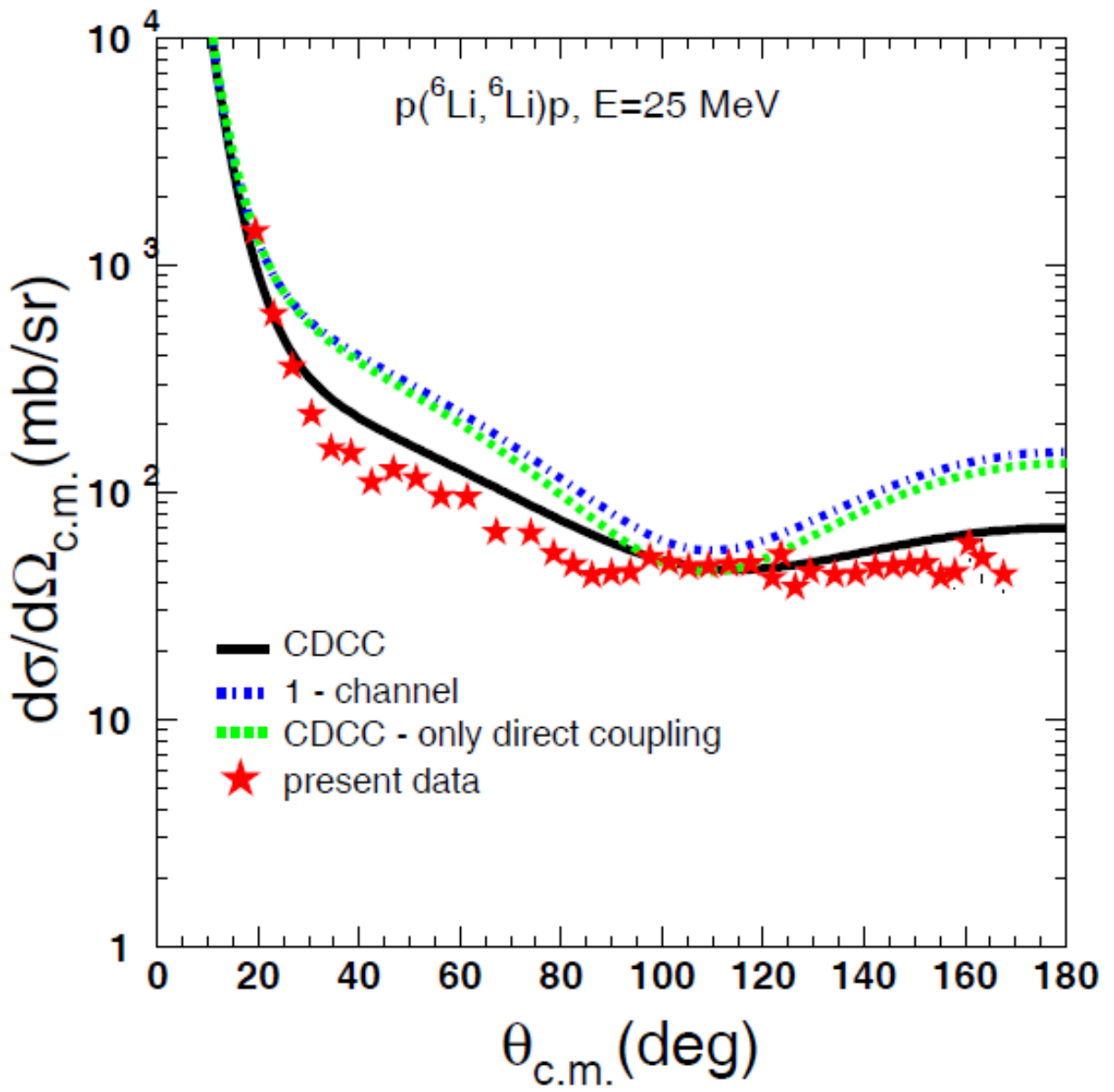
- **K. Rusek et al., Phys. Rev. C 56, 1895 (1997)**
- **K. Rusek et al., Phys. Rev. C 64, 044602 (2001)**

CDCC Calculations versus elastic scattering data at 29 MeV



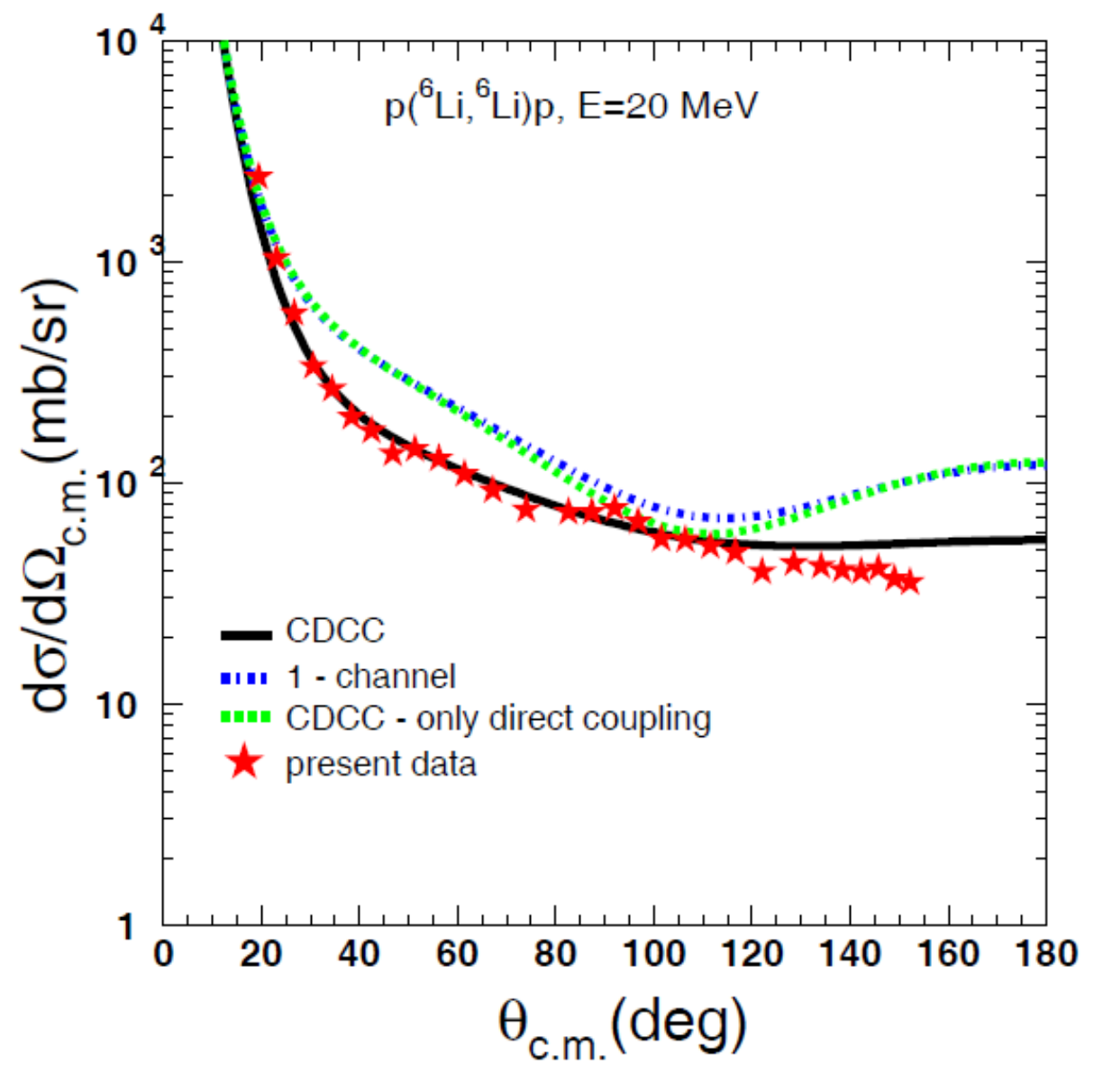
V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

CDCC Calculations versus elastic scattering data at 25 MeV



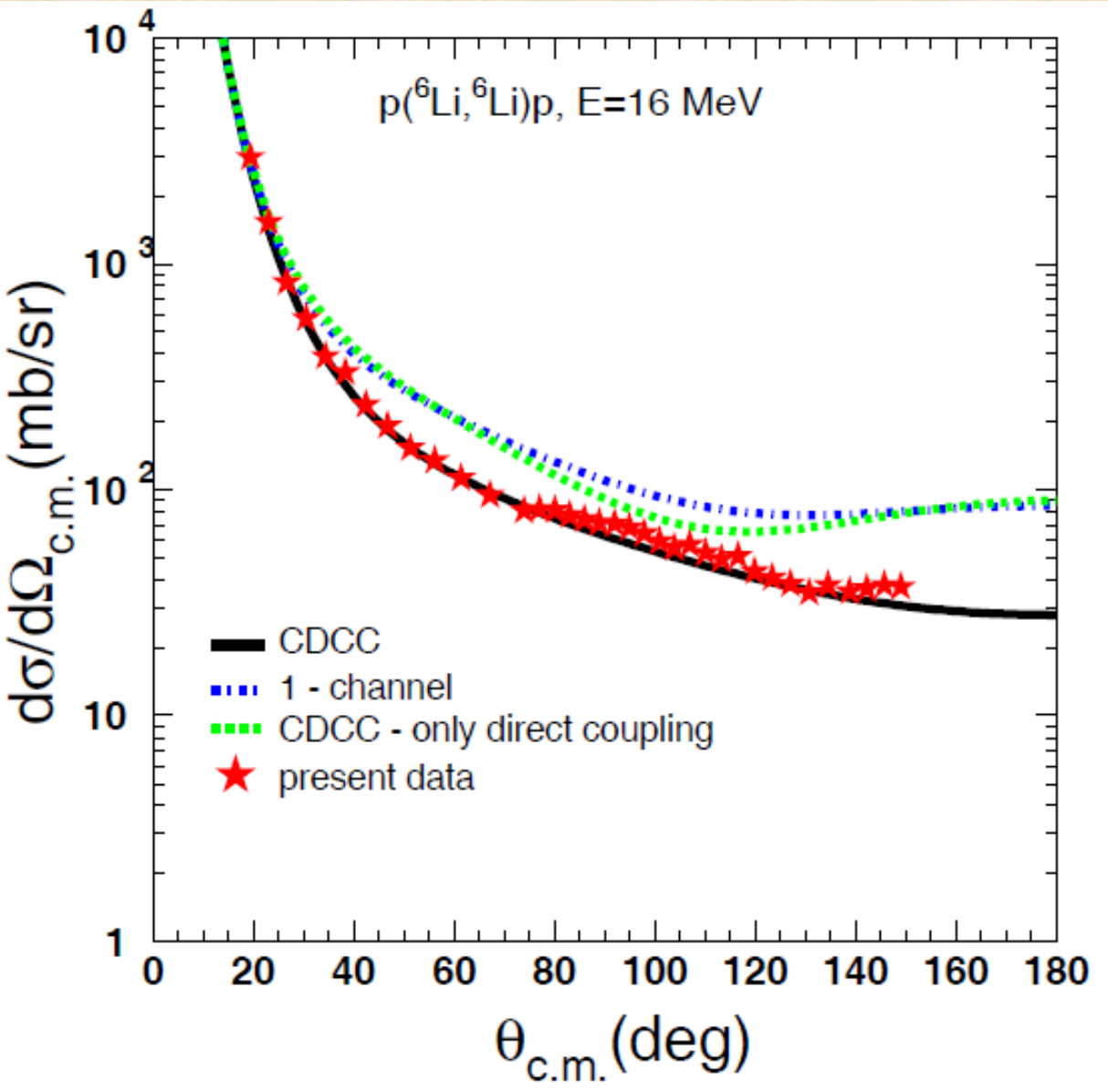
V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

CDCC Calculations versus elastic scattering data at 20 MeV



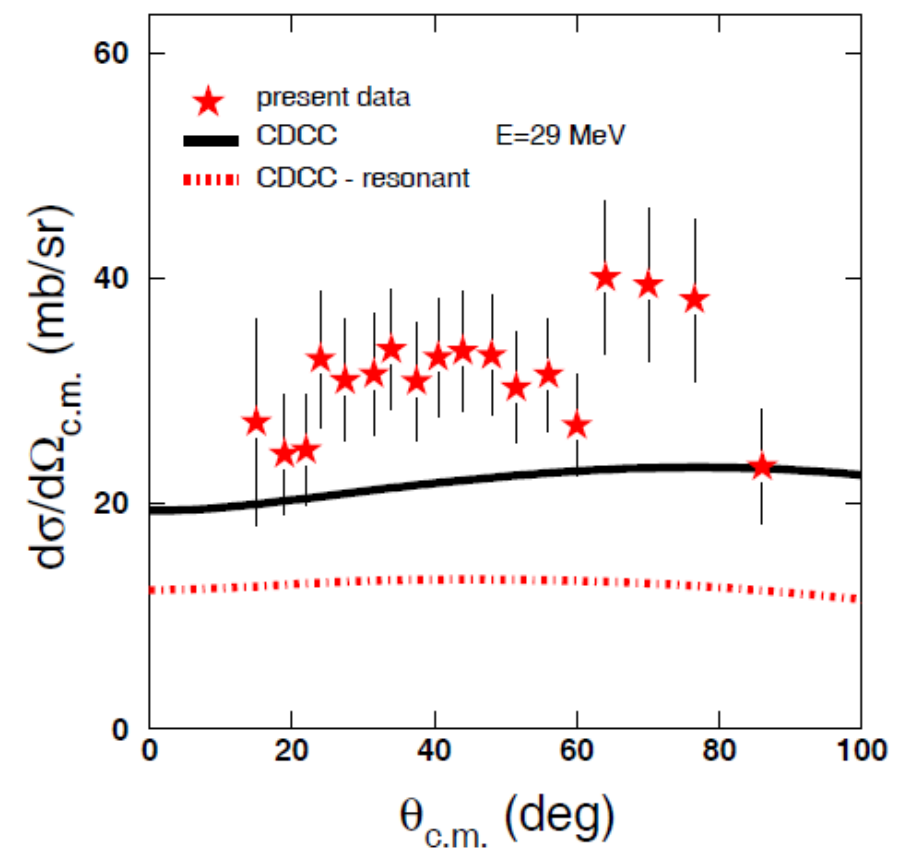
V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

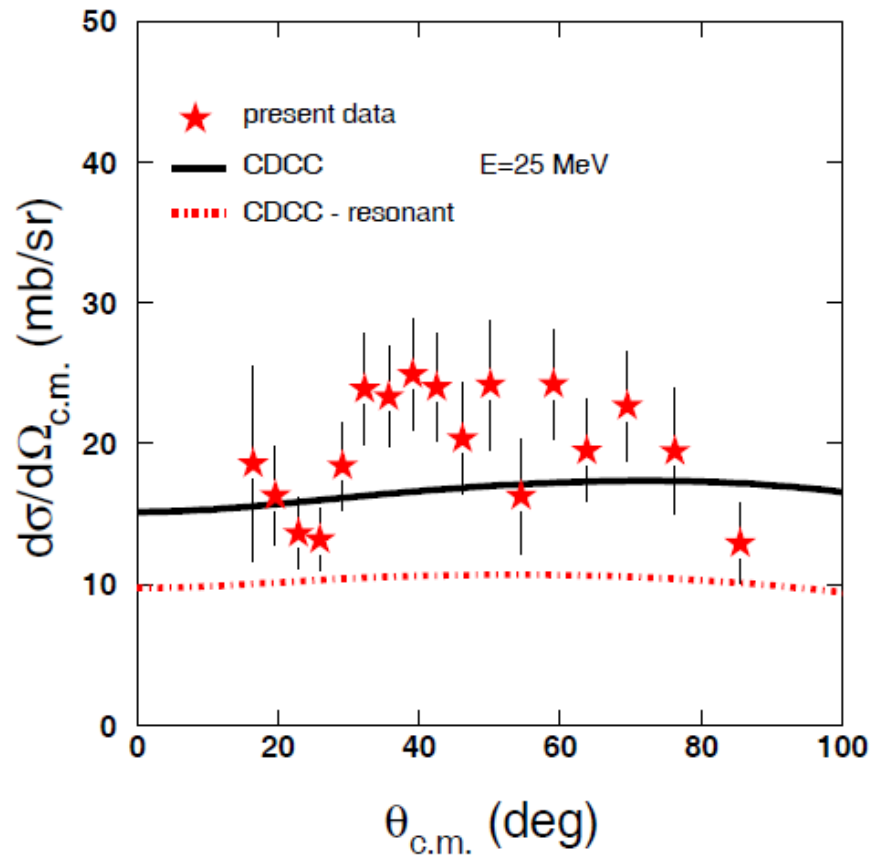
CDCC Calculations versus elastic scattering data at 16 MeV



V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

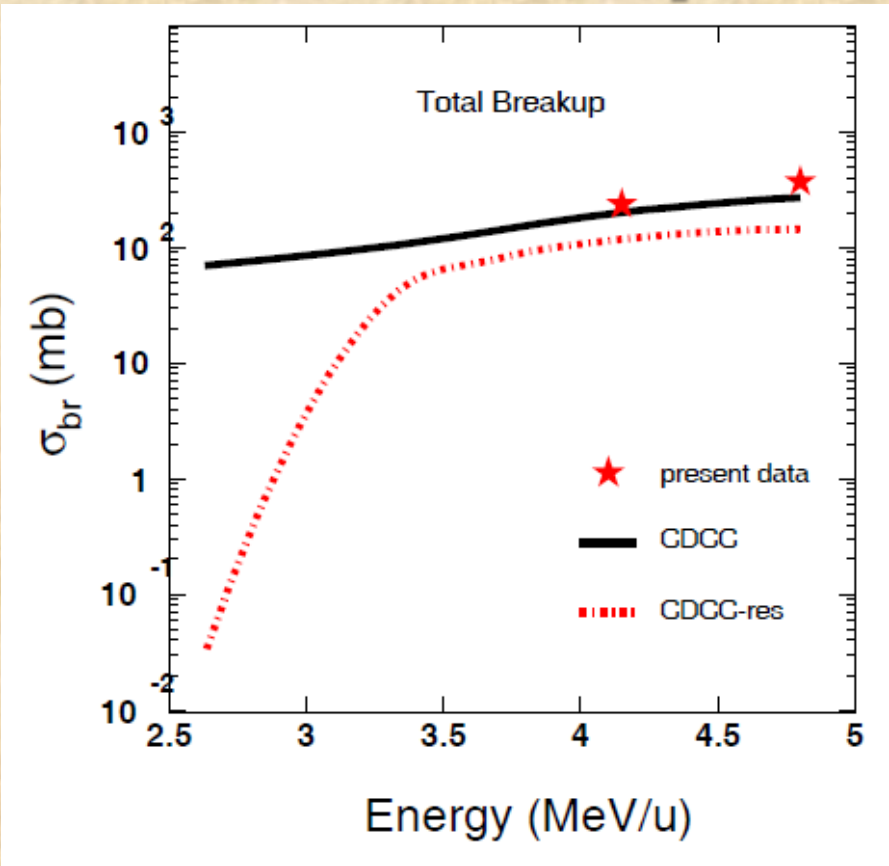
Breakup





V. Soukeras et al., Phys. Rev. C accepted for publication (2017)

Breakup



E (MeV)	σ_{br}	σ_{br}^{CDCC}	σ_{resbr}^{CDCC}	σ_{abs}	σ_{abs}^{CDCC}
29	370±64	269.4	143.3	95±2	109.5
25	235±46	200.0	117.0	131±6	133.0
20	-	102.9	37.5	140±8	162.0
16	-	69.7	0.03	111±2	130.7

$^{6}Li+p \rightarrow {}^{4}He+{}^{3}He$

Ch. Betsou et al.,

Eur. Phys. J. A 51, 86 (2015)

Summary – Conclusions

✓ **A global investigation of elastic scattering and breakup was performed for the system ^{6}Li+p at 16, 20, 25 and 29 MeV, in inverse kinematics with MAGNEX spectrometer and angular distributions were deduced in the center of mass frame.**

✓ **Both elastic scattering and breakup results combined with the reaction ^{6}Li+p$\rightarrow$^{3}He+^{4}He measured in the same experiment found to be described very well in a CDCC framework.**

Summary – Conclusions

1. In particular, CDCC calculations:
   i. Exhibit an excellent agreement with the experimental elastic scattering data
   ii. Exhibit a satisfactory agreement with the experimental breakup data
   iii. Indicate a strong coupling to the 3+ resonance
   iv. Indicate that the coupling to direct breakup has a small impact on the calculations
   v. Give an excellent prediction for the absorption from other reactions channels

2. At the lower energies, according to the CDCC calculations, the coupling to 3+ resonance is very strong although, the resonant breakup cross section seems to be very low.

   ^{6}Li+p 16MeV → σ_{BU}=69.7 mb, $\sigma_{Res.\ BU}$=0.03 mb

   Such a striking situation was recently reported for the elastic scattering of ^{7}Li + p.

   ^{7}Li+p 38MeV → σ_{BU}=66 mb, $\sigma_{Res.\ BU}$=0.5 mb

3. Monte Carlo simulations imitating the CDCC model seem to describe very well the experimental energy distributions of the breakup fragments, validating the philosophy of the continuum discretization behind the CDCC approach.

4. The elastic scattering data were also considered in the microscopic approach of the JLM potential without any coupling which fails to reproduce the data.

5. This measurement establishes our technique, which can be applied to new measurements in MAGNEX with other radioactive or stable weakly bound 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*
- ✓ *CEA – Saclay, DAPNIA-SPhN, Gif-sur-Yvette, France*
- ✓ *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*
- ✓ *Institute of Accelerating Systems and Applications and Department of Physics, University of Athens, Greece*

Thank you very much for your attention!