

Production of ${}^8\text{Li}$ with the reaction



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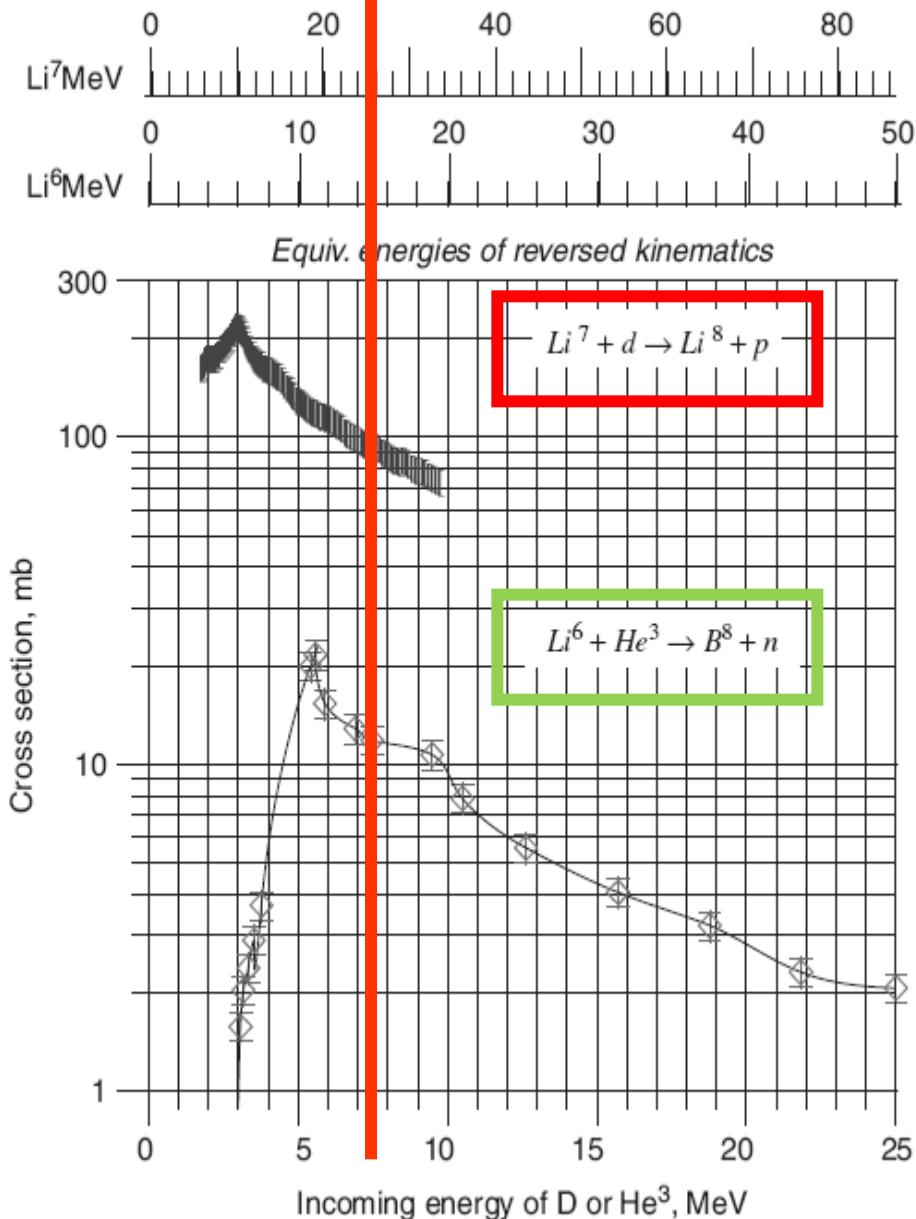
$$\langle \beta^- \rangle = 6243 \text{ keV}$$

2+ 838 ms

${}^8_3\text{Li}$

β^-

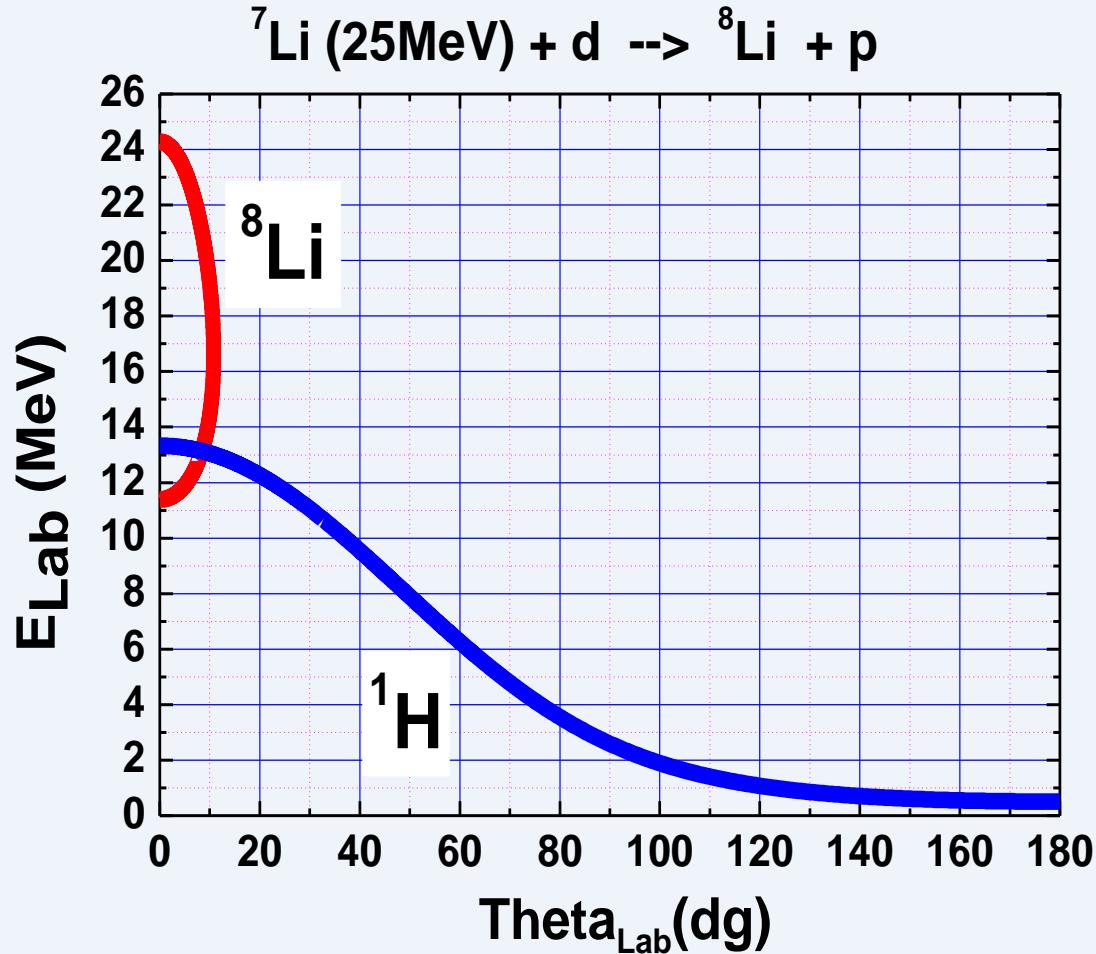
$$E_{\text{lab}} = 25 \text{ MeV}$$



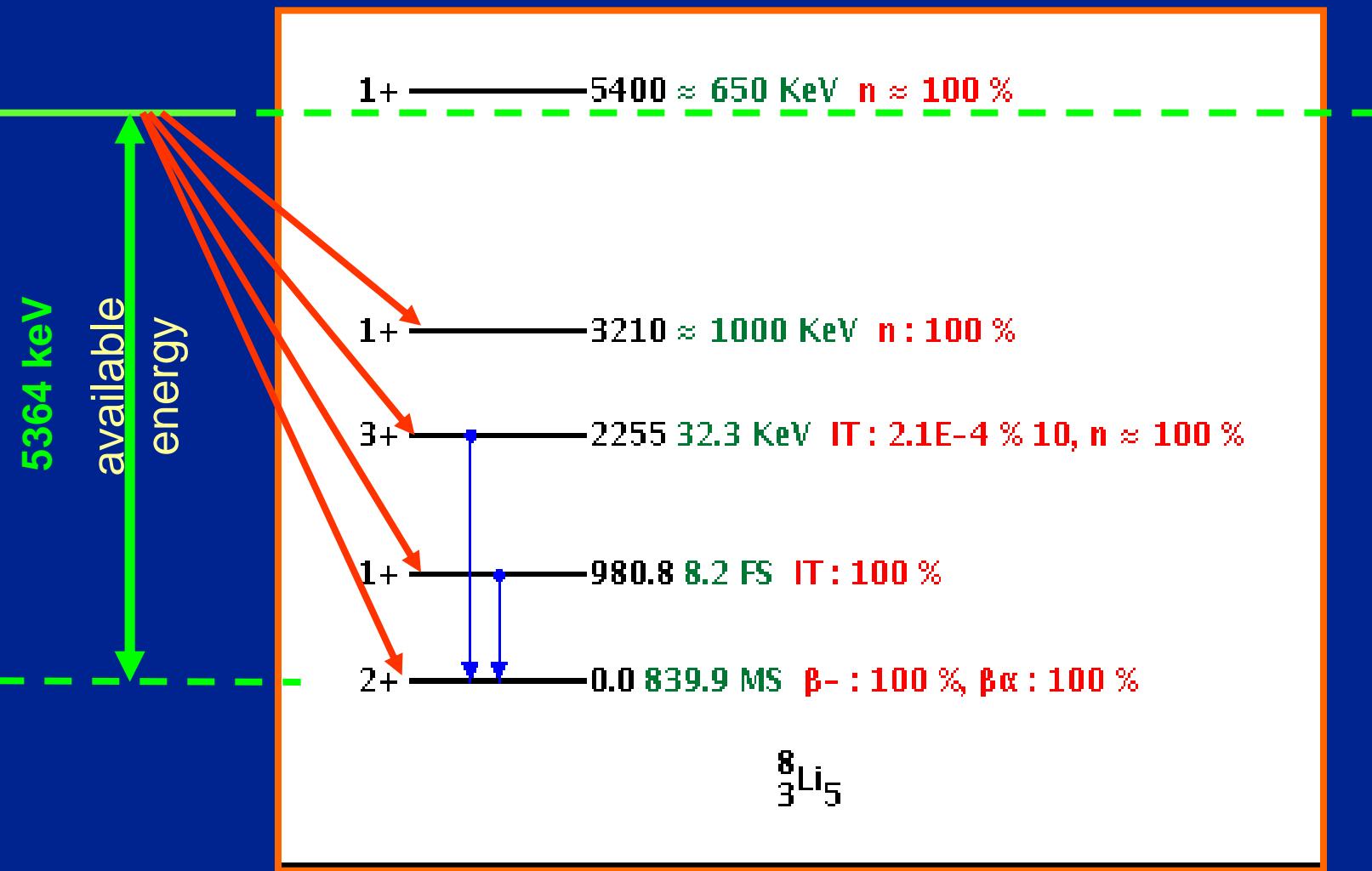
Questions

1. What is the angular distribution of ${}^8\text{Li}$
2. What is the cross section for the ${}^8\text{Li}$ production

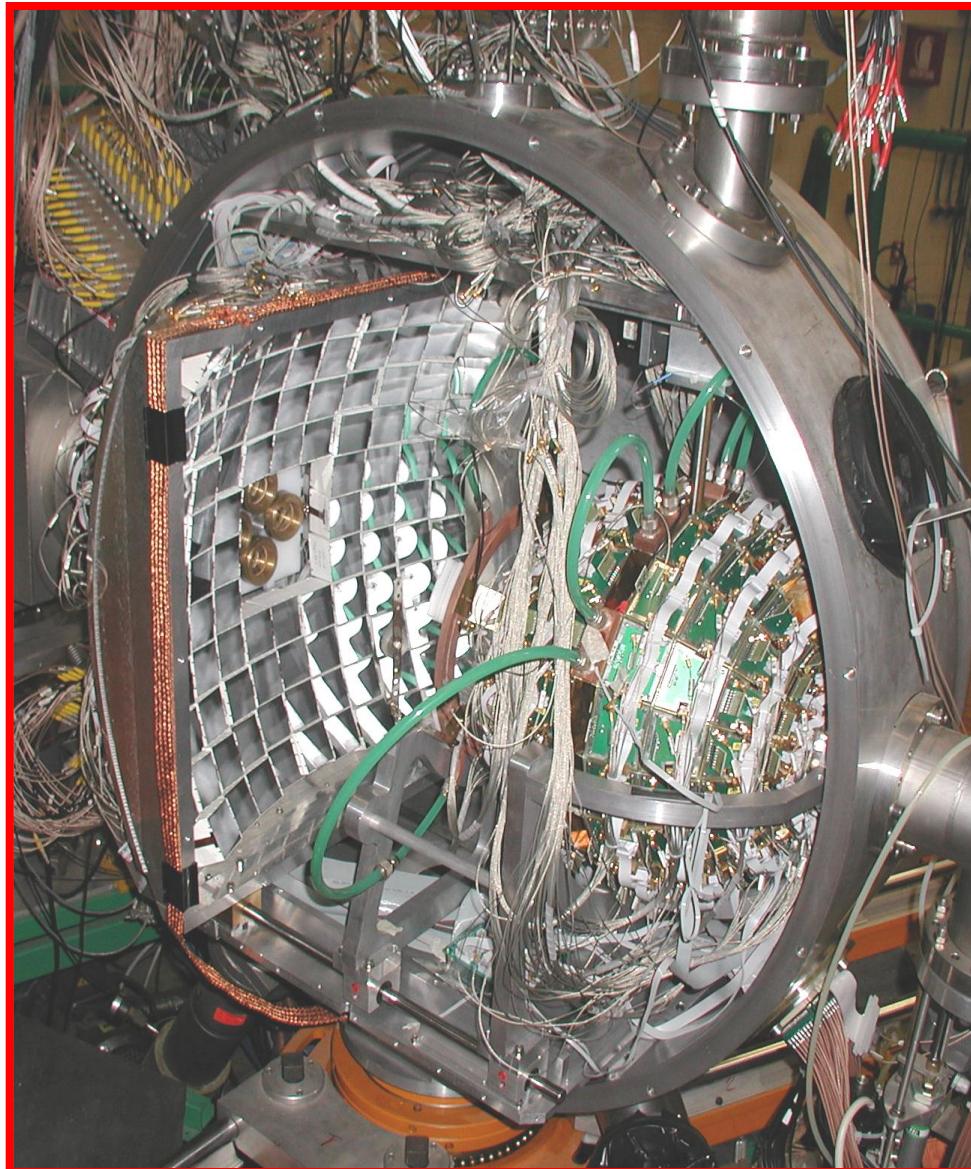
$^7Li + d \rightarrow ^8Li + p$: two-body



Population of 8Li

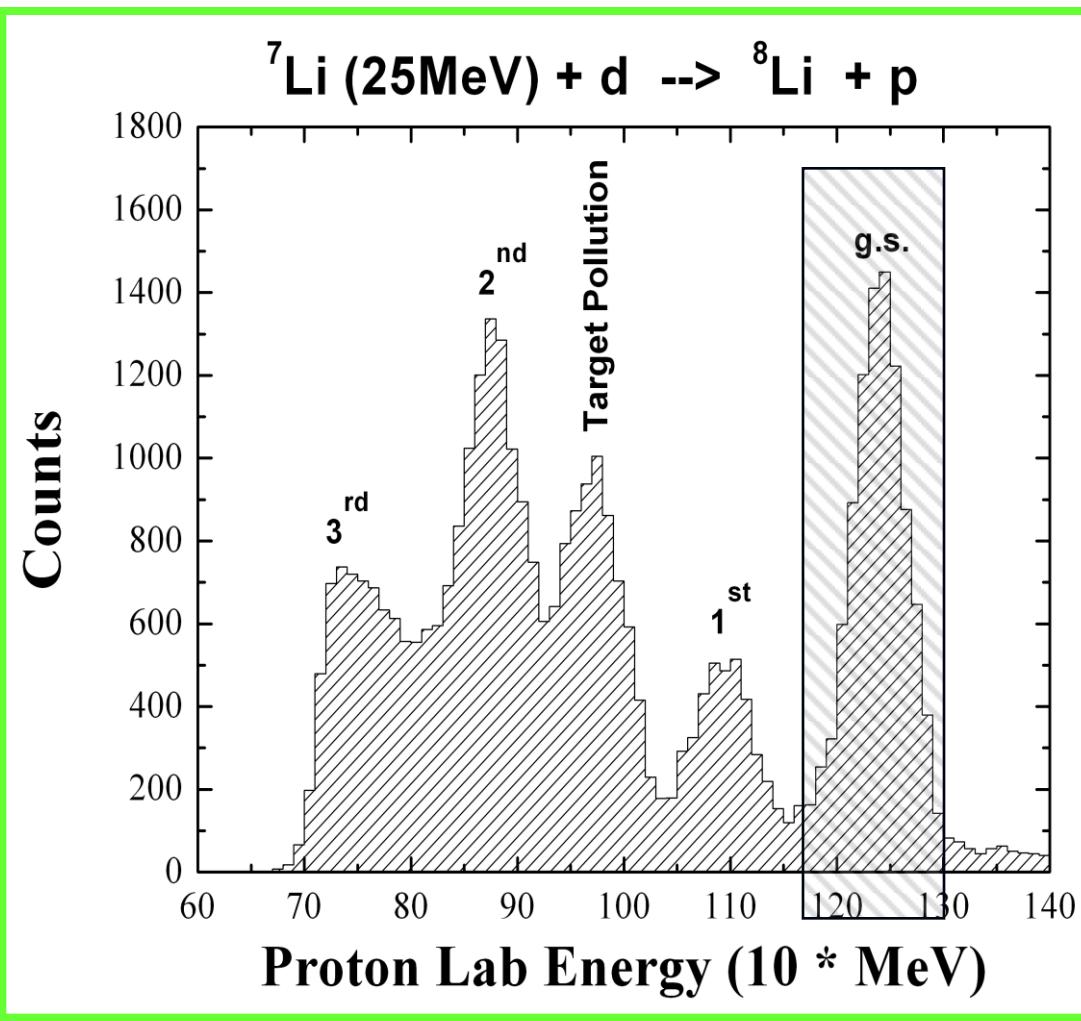


8π LP setup @ LNL



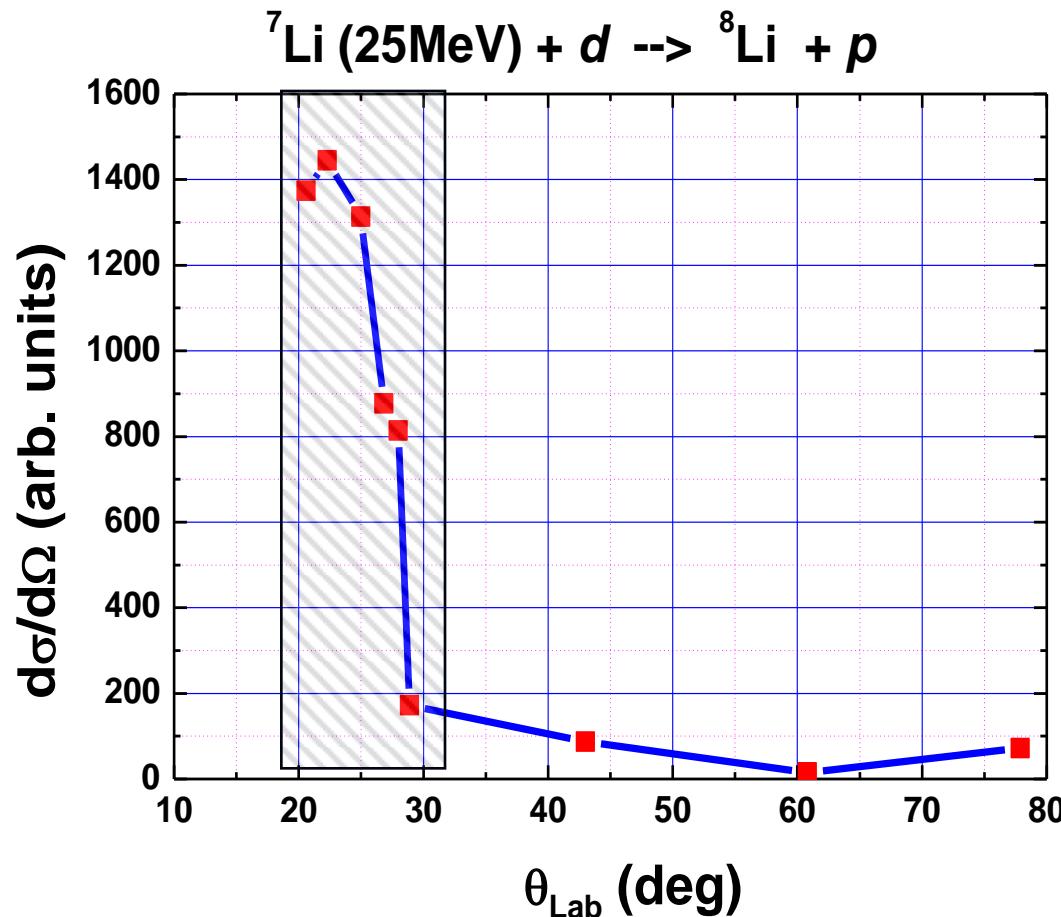
$^7Li + d \rightarrow p$ (Energy)

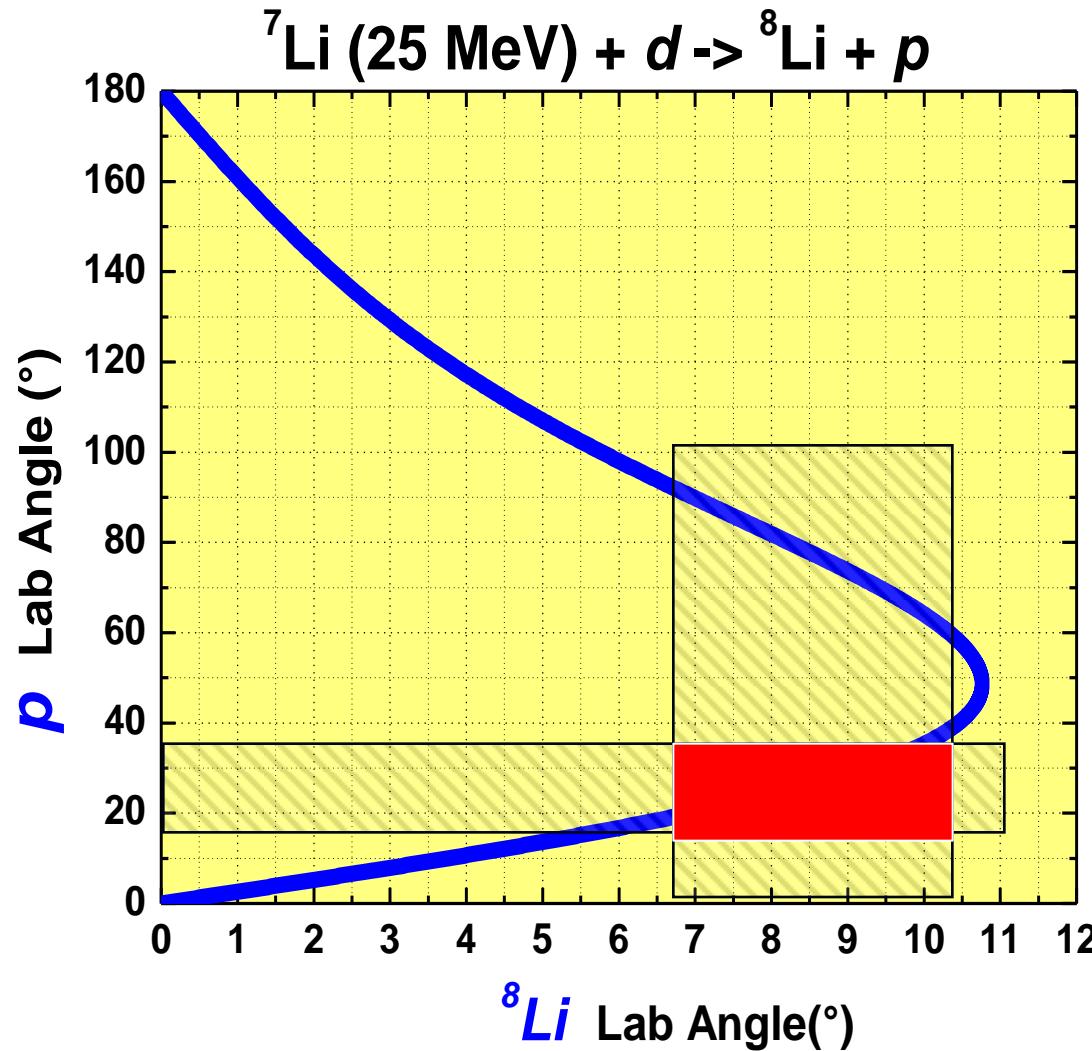
Lab Angle = 20.6°

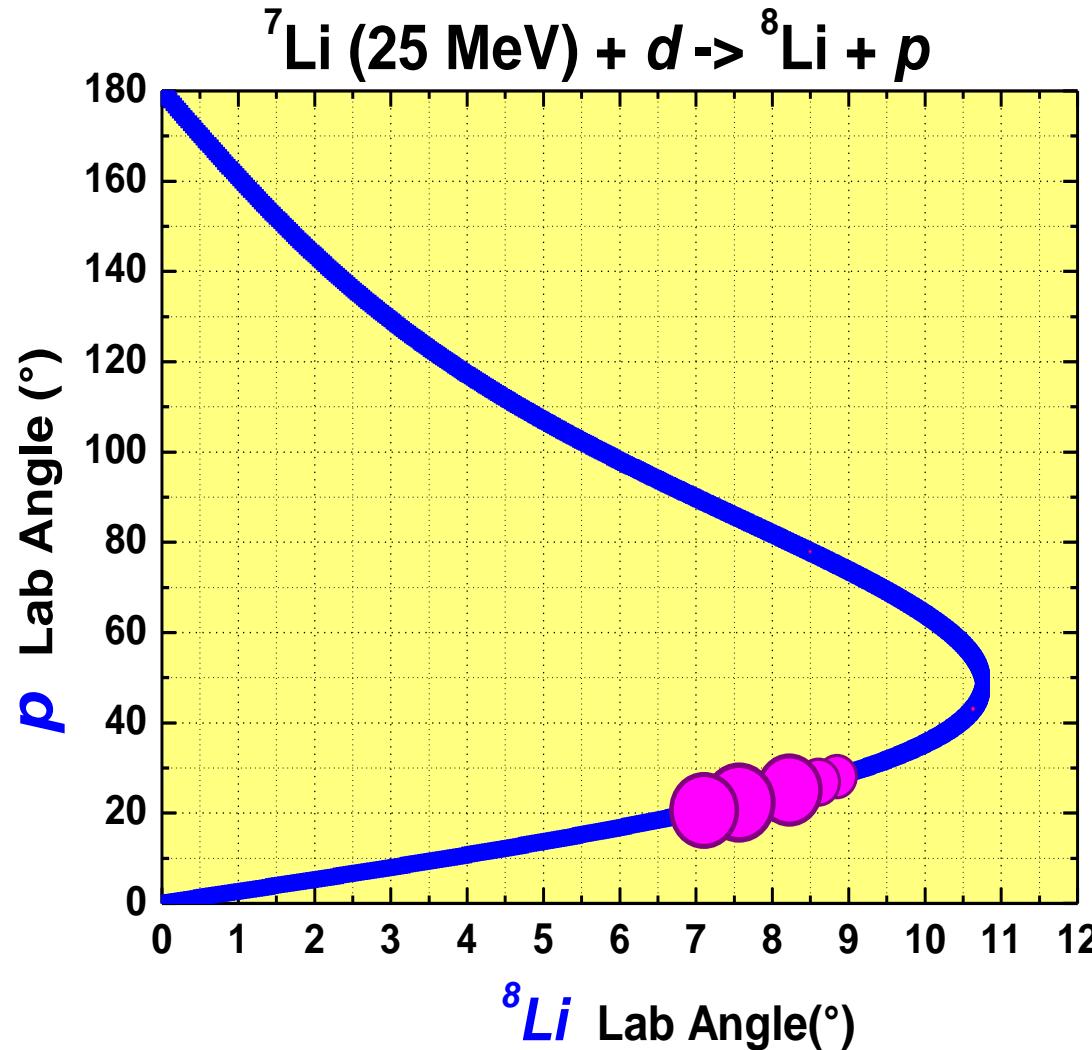




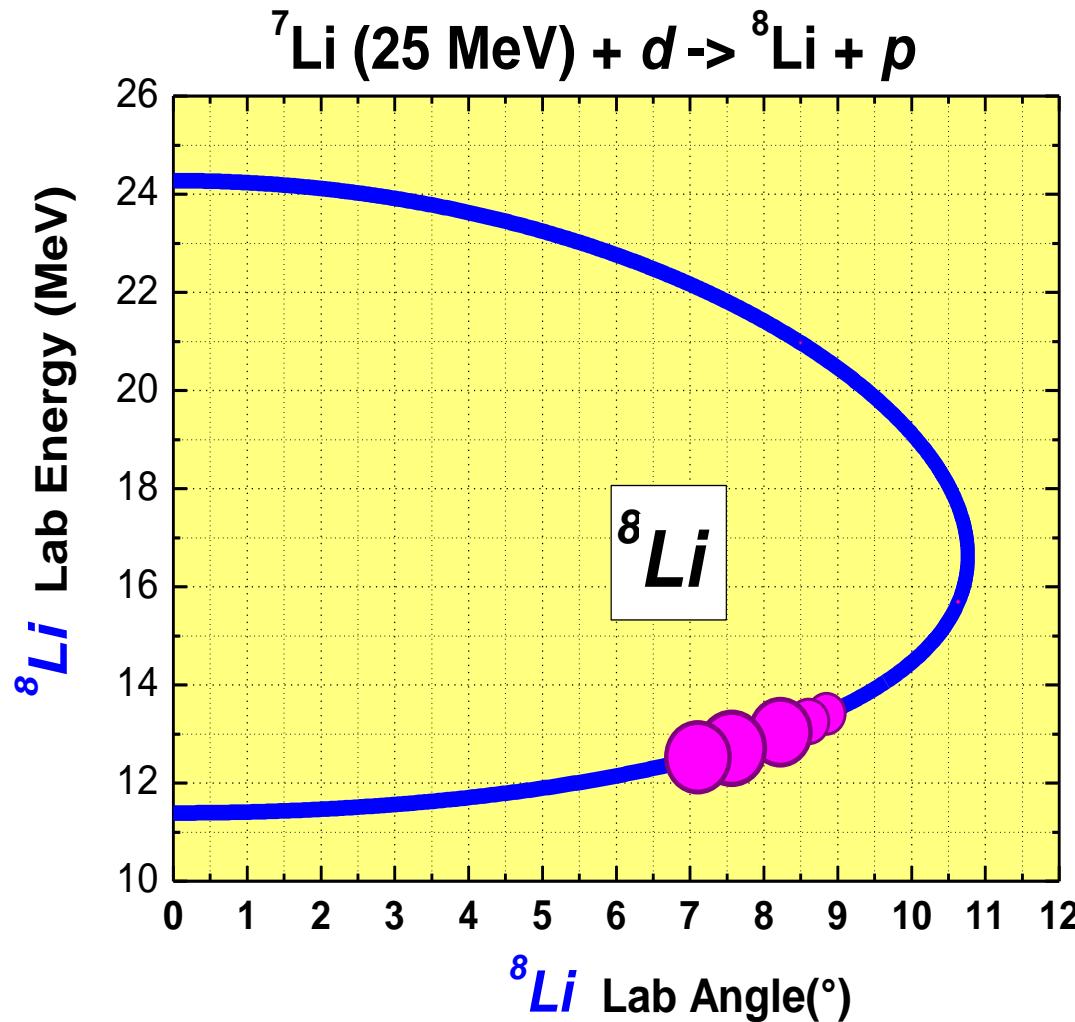
Lab Angular Distribution for g.s.





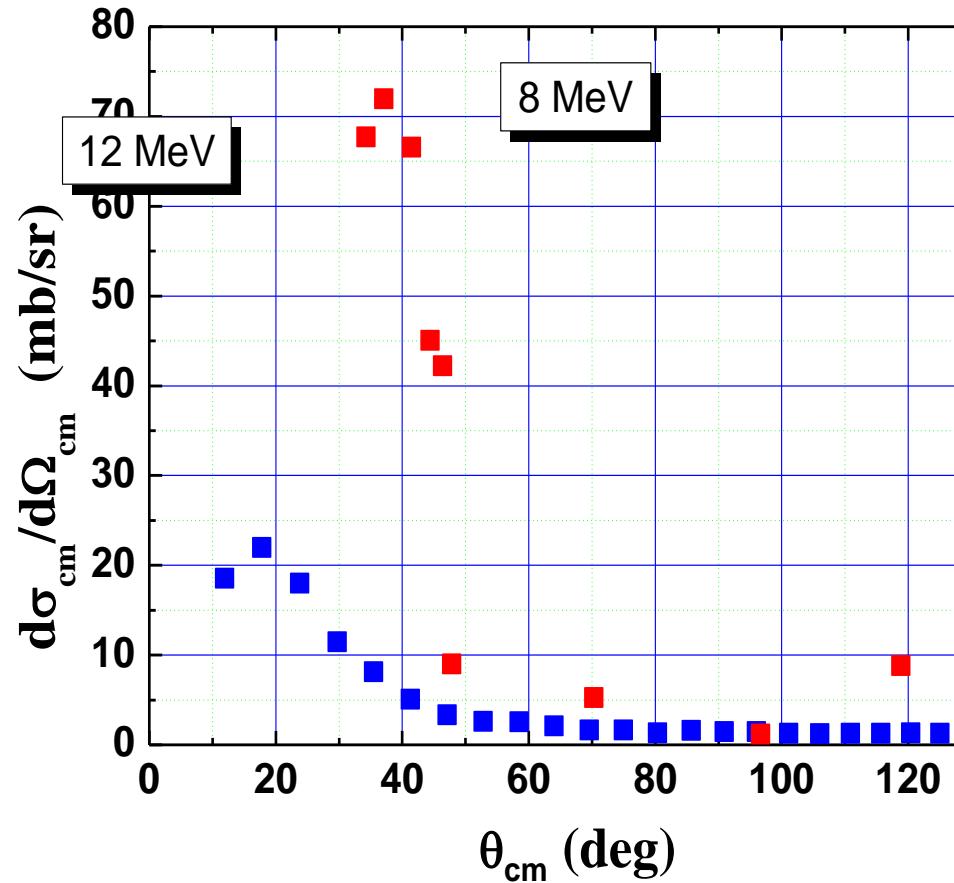


Production of 8Li

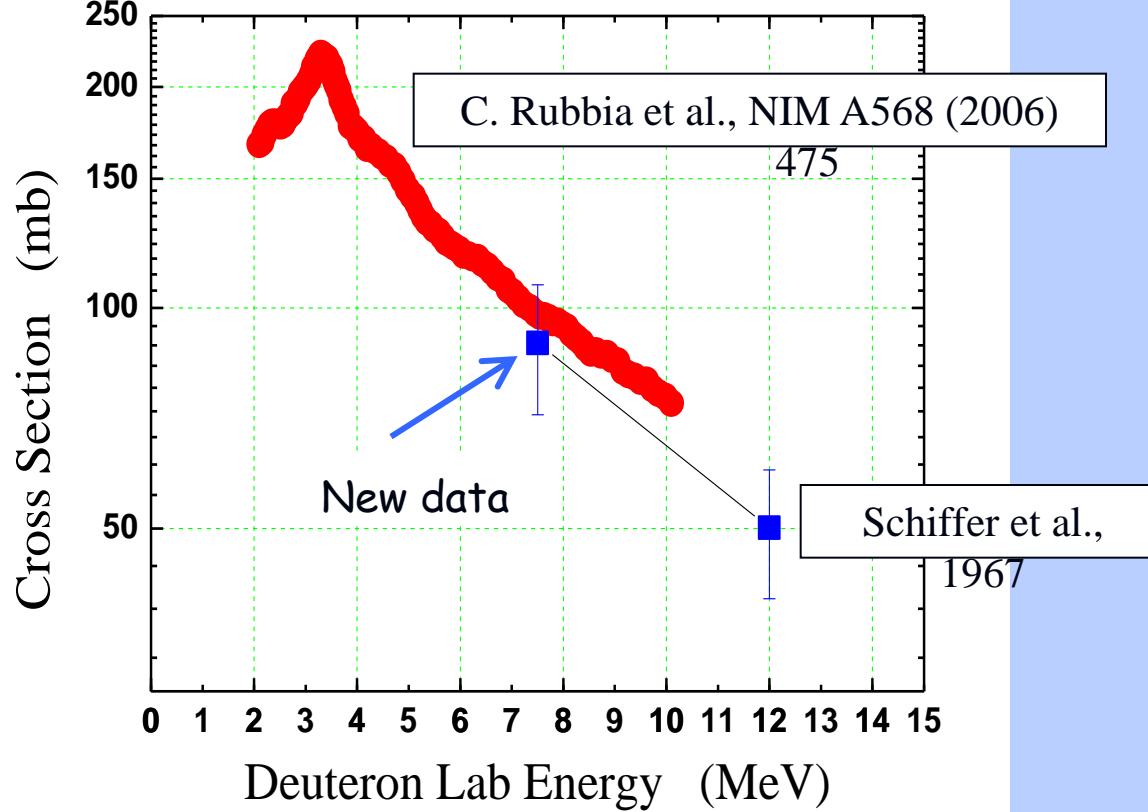




CM Angular Distribution for g.s.



${}^8\text{Li}$ production cross section



Main results

1. The angular distribution of ${}^8\text{Li}$ is focused between 6° and 10° in the lab frame
2. The cross section for the ${}^8\text{Li}$ production is 90 ± 18 mb at $E_{\text{lab}}({}^7\text{Li}) = 25$ MeV

^8B production in the reaction $^6\text{Li}(\text{He}^3, \text{n})^8\text{B}$ via neutron angular distribution measurement

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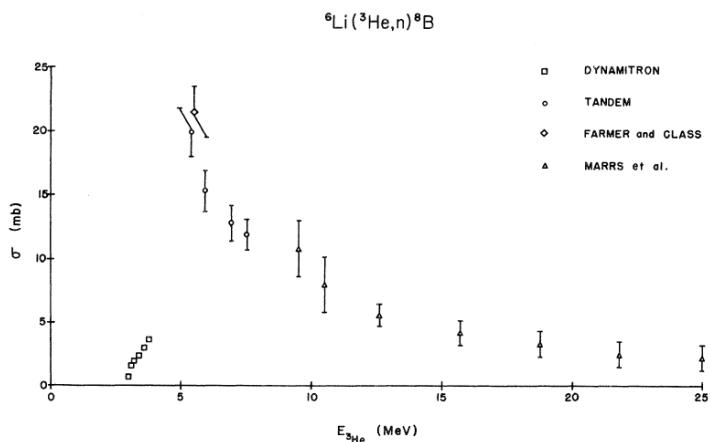
The Problem: ^8B production cross section

C.R. McClenahan and R.E. Segel PRC 11 (1975) 370
R.E. Marrs D. Bodansky, E.G. Adelberger, PRC 8 (1973) 427

Cross sections for the $^7\text{Li}(d,p)^8\text{Li}$, $^6\text{Li}(^3\text{He},n)^8\text{B}$, $^6\text{Li}(d,\alpha)^4\text{He}$,
 $^6\text{Li}(d,p)^7\text{Li}$, and $^6\text{Li}(d,n)^7\text{Be}$ reactions

Charles R. McClenahan* and Ralph E. Segel
Northwestern University, Evanston, Illinois 60201†
and Argonne National Laboratory, Argonne, Illinois 60439‡
(Received 19 August 1974)

The $^7\text{Li}(d,p)^8\text{Li}$, $^6\text{Li}(^3\text{He},n)^8\text{B}$, $^6\text{Li}(d,\alpha)^4\text{He}$, $^6\text{Li}(d,p)^7\text{Li}$, and $^6\text{Li}(d,n)^7\text{Be}$ reactions have been studied, chiefly at bombarding energies below 3.8 MeV. All five of these reactions have potential applications in controlled thermonuclear systems. Total cross sections, believed to be accurate to 15%, which is sufficient for reactor design, have been determined in all cases. Residual activity was counted in the $^7\text{Li}(d,p)$ and $^6\text{Li}(^3\text{He},n)$ studies while the yield of the ^7Be 428-keV γ ray was measured in the $^6\text{Li}(d,n)$ investigation. Extensive angular distribution measurements were made for the $^6\text{Li}(d,\alpha)$ and $^6\text{Li}(d,p)$ reactions and some discussion is given of the reaction mechanisms. Wherever possible, detailed comparisons are given to previously reported results.



From Positron Counting Technique

P. Van Der Merwe et al., NPA 103 (1967) 474

THE $^6\text{Li}(^3\text{He}, n)^8\text{B}$ REACTION MECHANISM

P. VAN DER MERWE †, W. R. McMURRAY and I. J. VAN HEERDEN
Southern Universities Nuclear Institute, Faure, C.P., South Africa

Received 3 July 1967

Abstract: The $^6\text{Li}(^3\text{He}, n_0)^8\text{B}$ reaction has been studied in the bombarding energy range 4.0 to 5.7 MeV. The absence of structure in the excitation curve and the gradual variation of the forward peaked angular distribution suggest a dominant direct reaction mechanism in this energy range. The angular distributions indicate that there is a considerable contribution from the forward knock-out mode to the direct process. The results are discussed in relation to the cluster structures of ^6Li and ^8B .

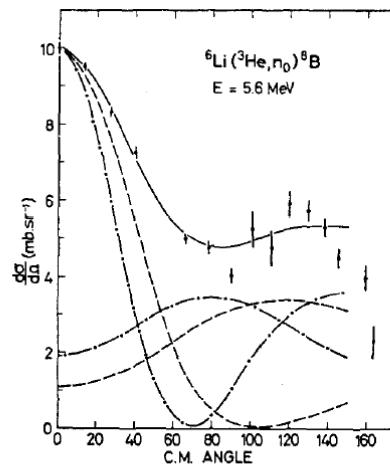


Fig. 4. Angular distribution of the $^6\text{Li}(^3\text{He}, n_0)^8\text{B}$ reaction at 5.6 MeV. The dashed curves are from PWBA calculations for the forward knock-out reaction with $r_0 = 5.6$ fm (for $L = 0$ and $L = 2$). The dot-and-dash curves are PWBA calculations for the double stripping reaction with $r_0 = 5.6$ fm. The solid curve is given by a linear combination of $L = 0$ and $L = 2$ for the forward knock-out reaction.

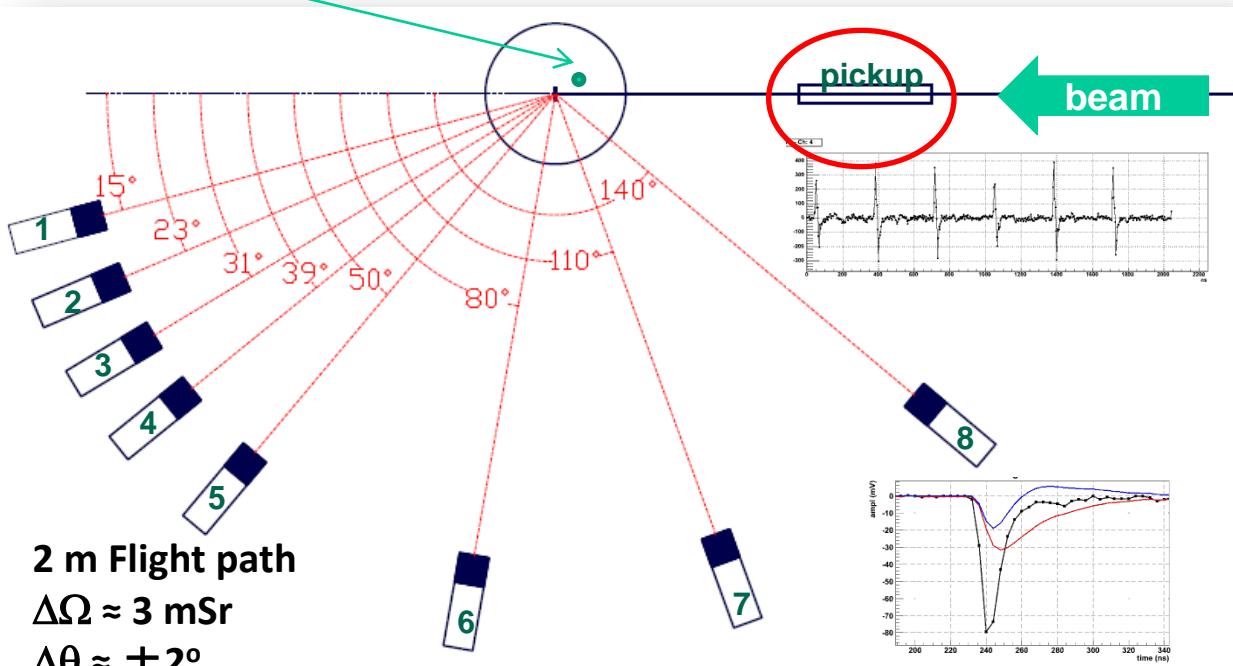
From Neutron Time-of-Flight measurement

The Experimental set-up: The TOF Apparatus



40 pnA, pulsed beam 333 ns rep. rate with 2 ns resolution

ΔE (15 μm) – E (200 μm) Silicon Telescope



2 m Flight path

$\Delta\Omega \approx 3 \text{ mSr}$

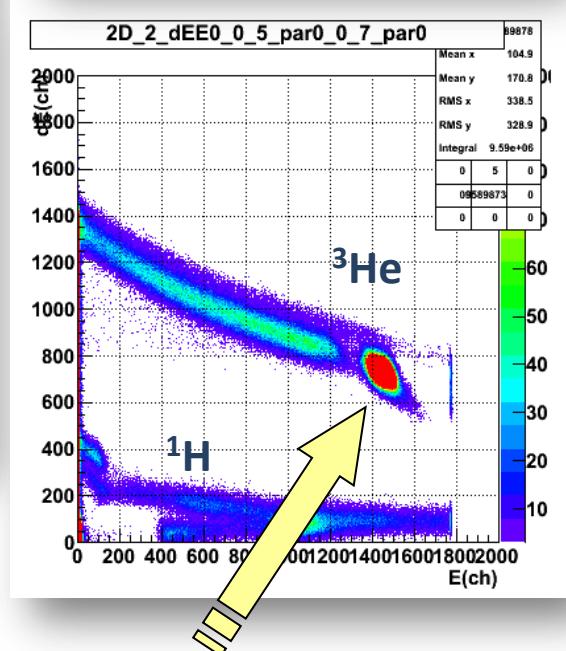
$\Delta\theta \approx \pm 2^\circ$

8 BC501 detectors covering angles from 15° to 140° in LAB

${}^6\text{LiF}$ (500 $\mu\text{g}/\text{cm}^2$) on Au (500 $\mu\text{g}/\text{cm}^2$)

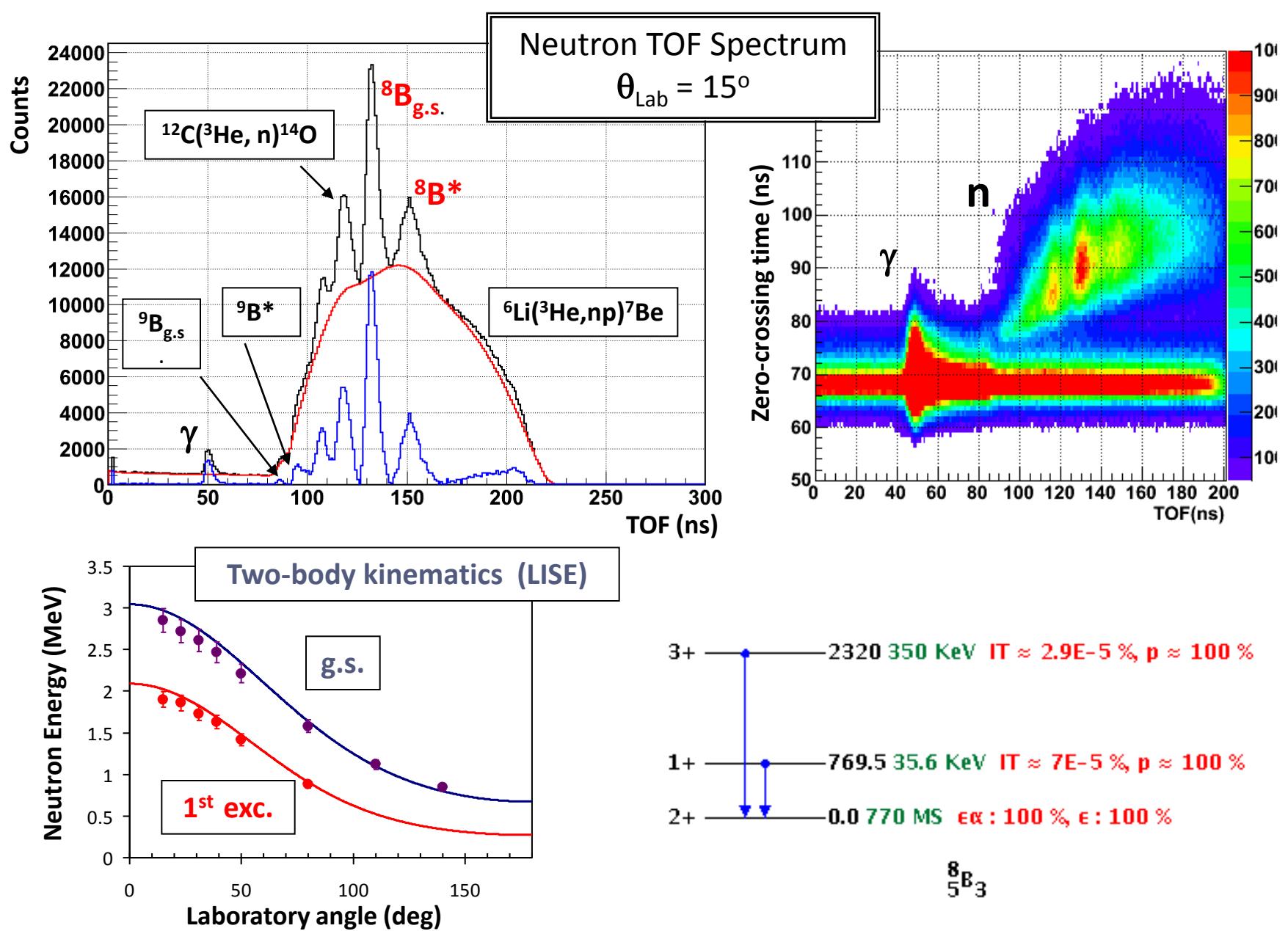
Background measurements:

- 1) ${}^7\text{LiF}$ (500 $\mu\text{g}/\text{cm}^2$) on Au (500 $\mu\text{g}/\text{cm}^2$)
- 2) ${}^{12}\text{C}$ (70 $\mu\text{g}/\text{cm}^2$) & 3) without target



Rutherford scattering of the beam on the Au backing is used as normalization to determine the ${}^8\text{B}$ production absolute cross section

The Data Analisys: Neutron Spectra Analisys

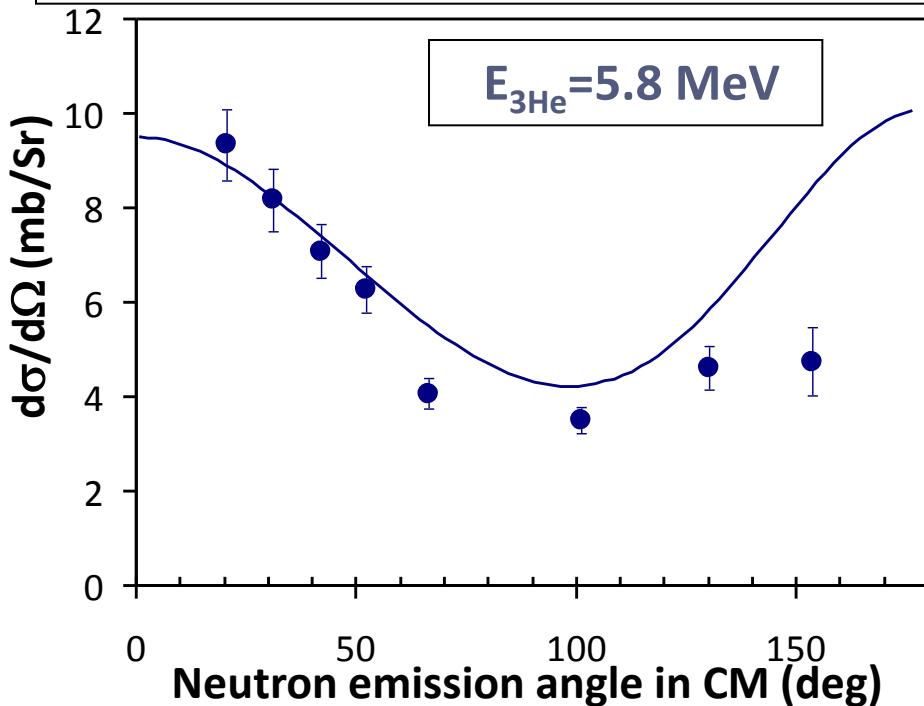


The Data Analisys: Angular distribution and total cross section

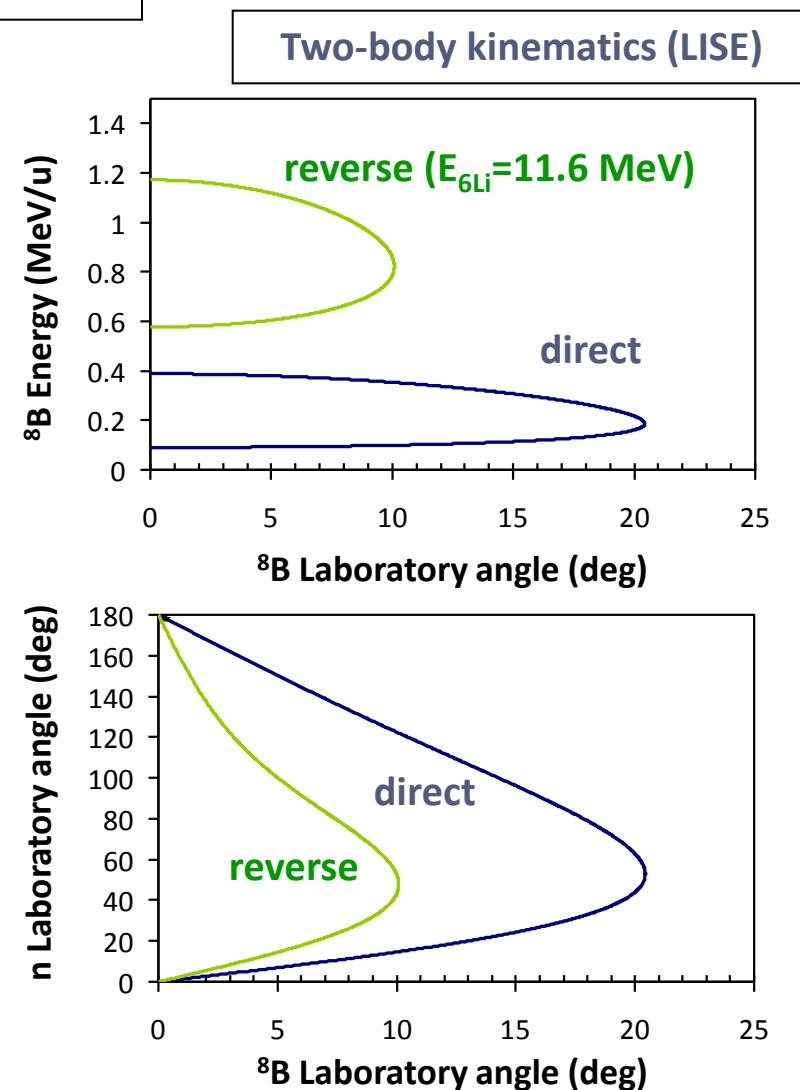
Theoretical Calculations with code DWUCK4

"Zero Range Knock-out Distorted Wave Born Approximation"

S.A. Goncharov, Moscow State University, Russia



Total cross section	Reference
$(58 \pm 7) \text{ mb}$	Our result
75 mb	DWUCK4 calculation
$\approx 65 \text{ mb}$	$E_{^3\text{He}} = 5.6 \text{ MeV}$ (neutron TOF)

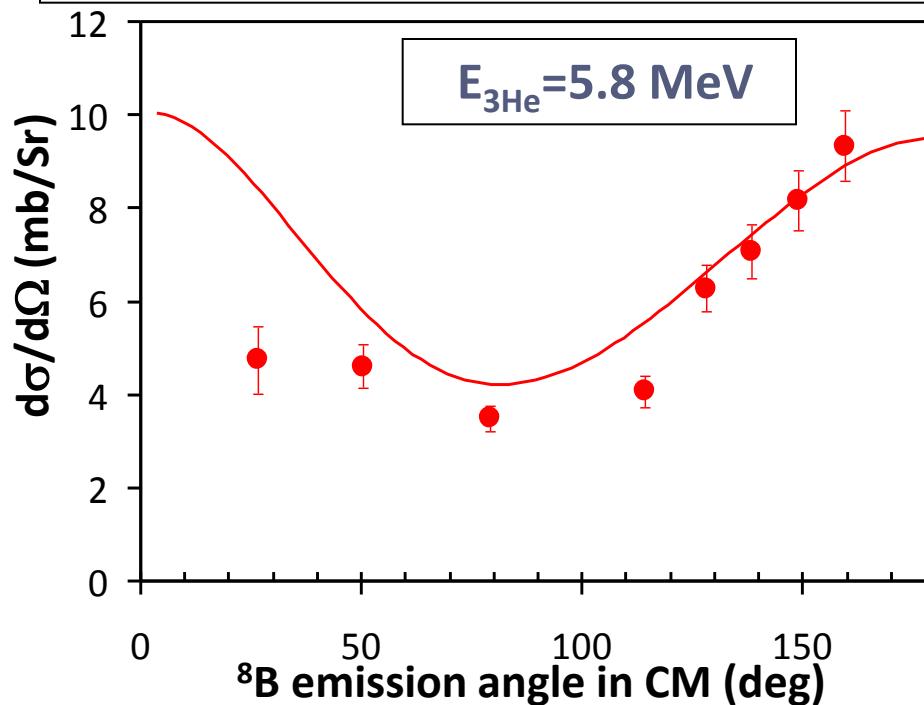


The Data Analisys: Angular distribution and total cross section

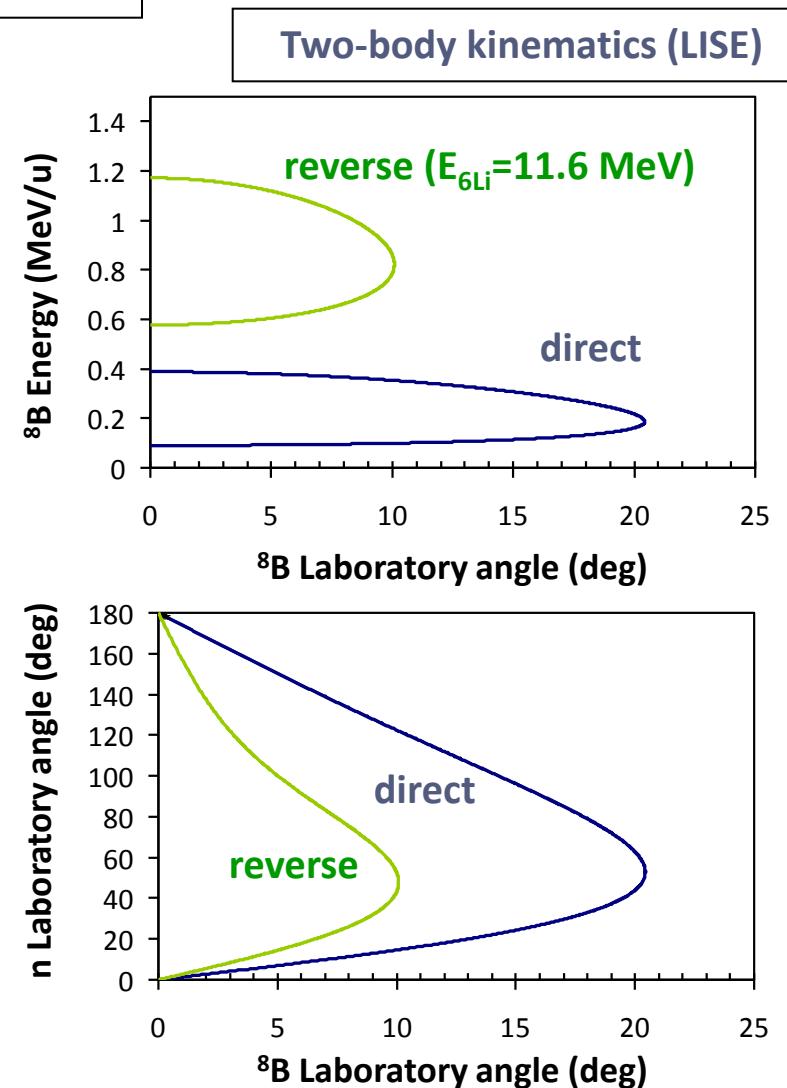
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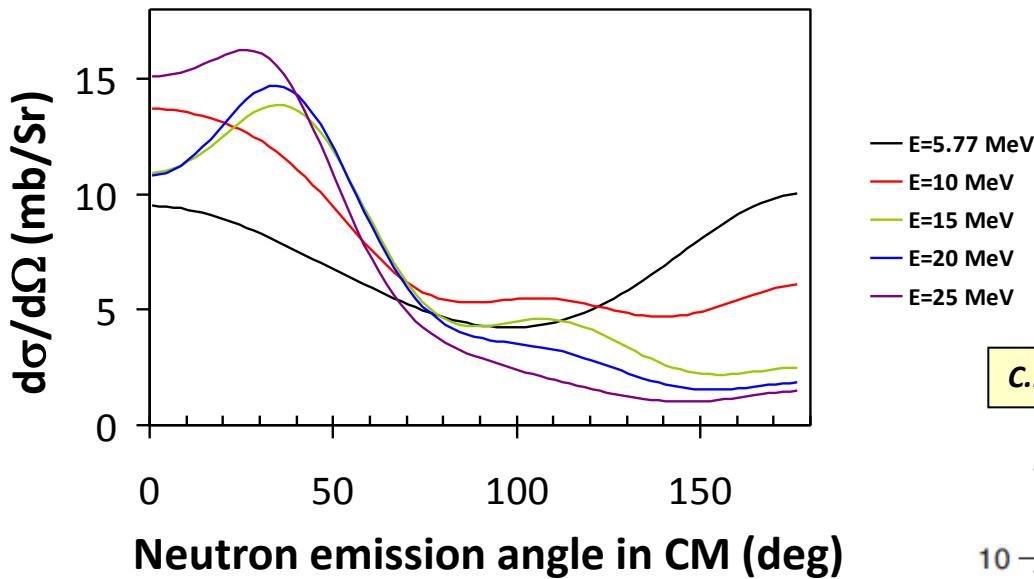


Total cross section	Reference
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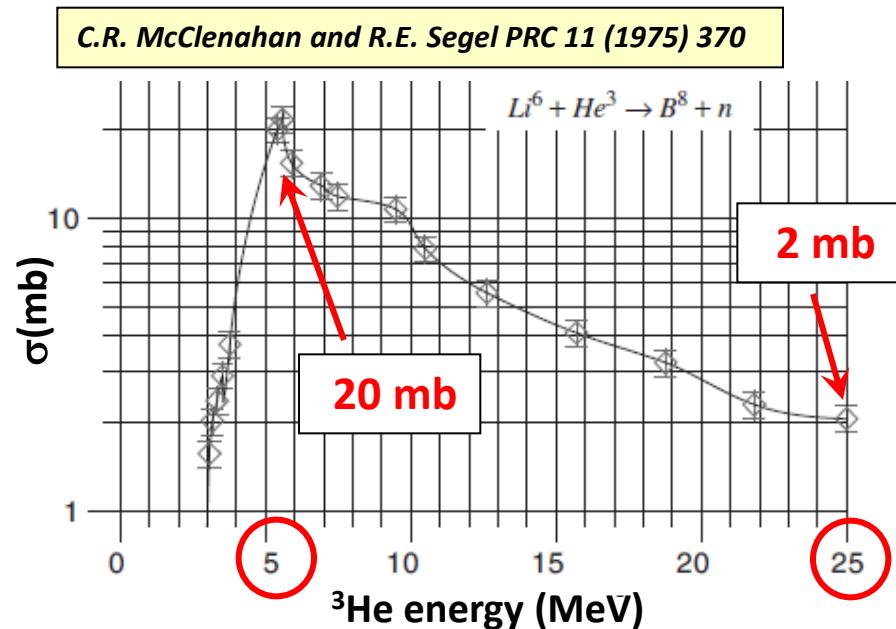
Theoretical predictions: Evolution of the cross section with the beam energy

Predictions of the DWUCK4 code at different ${}^3\text{He}$ beam energies



Neutron emission angle in CM (deg)

Total cross section	${}^3\text{He}$ energy
75 mb	5.77 MeV
85 mb	10 MeV
79.5 mb	15 MeV
74 mb	20 MeV
66 mb	25 MeV



- We have performed High-Statistic Experiments measuring absolute cross section and angular distribution of the ${}^6\text{Li}({}^3\text{He},\text{n}){}^8\text{B}$ reaction
- The results show a cross section value 3 times higher than the one obtained using the positron counting technique.
- Our results are in agreement with theoretical DWBA calculations and with older experimental results obtained with the same Time of Flight technique
- DWBA calculations were also performed for ${}^3\text{He}$ bombarding energies of 10, 15, 20 and 25 MeV suggesting a small variation of the total cross section in contrast with the positron counting technique experimental results
- Experiments with neutron Time of Flight technique at higher beam energies are needed to clarify the discrepancies between the cross section obtained with the positron counting technique