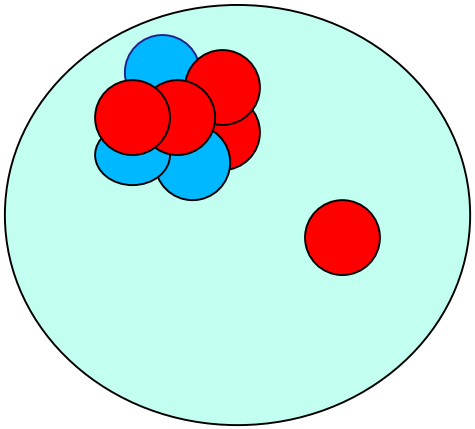
Proposal to the ISOLDE and
Neutron Time of Flight Committee
CERN

Fusion hindrance at sub-barrier energies for weakly bound nuclei on heavy targets: the $^{8}B + ^{208}Pb$ case

collaboration



University of Ioannina and HINP

University of Huelva-Spain

Univ. of Warsaw and NCBJ-Poland

CEA/IRFU – Saclay-France

KU-Leuven- Belgium

MAGNEX group INFN Catania-Italy

EXOTIC group INFN Napoli Padova and University of Padova

Spokesperson: Athena Pakou

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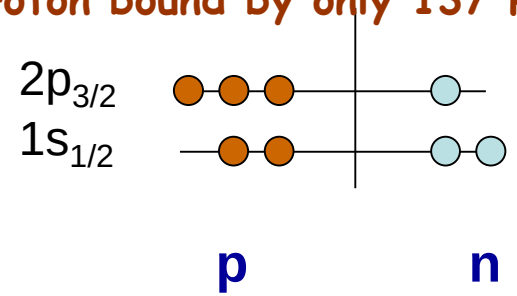
We propose

the study of $^{8}B+^{208}Pb$ below barrier at 43MeV~ 0.8 $E_{c.b.}$

- **^{7}Be production** for determining the breakup cross section for **^{8}B**, and the competition between direct versus compound

- **Elastic scattering** in support of the breakup measurement and as a tool for studying coupling channel effects- deviations off Rutherford scattering below barrier

Last proton bound by only 137 KeV



^{8}B attracted much attention due to

- **Its role in the production of high energy neutrinos in the sun---^{8}B(γ, p)^{7}Be----SSM**
- **A possible proton-halo with strong implications in reaction dynamics**

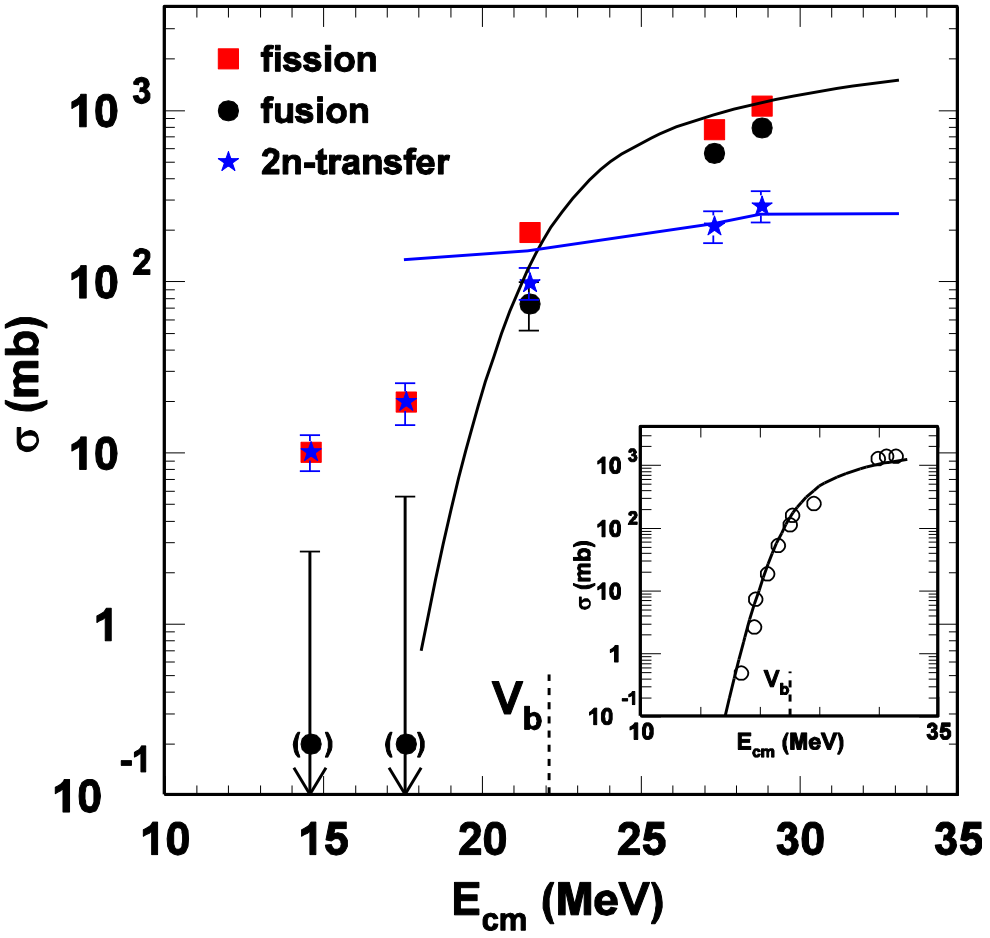
Fusion hindrance below barrier for weakly bound nuclei??

The motivation:

Fusion reactions with neutron halo nuclei

While in general it is believed that below barrier we have rather a fusion enhancement;
strong transfer channels have been also observed which if appropriately addressed may change this view

key reaction → $^{6}He + ^{238}U$



Fission is used as a tracer of fusion

M Trotta et al, PRL84,2342(2000)

R. Raabe et al., Nature 431,823(2004)

N. Keeley, R. Raabe, N. Alamanos, J.L. Sida; Progress in Nuclear Physics 59, 579 (2007).

Fusion ^{8}He + ^{197}Au

Lemasson et al.
PRL103,232701(2009)

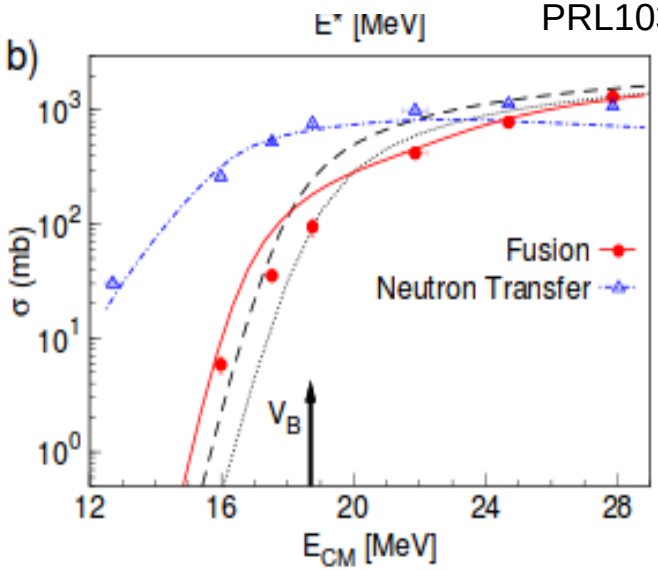
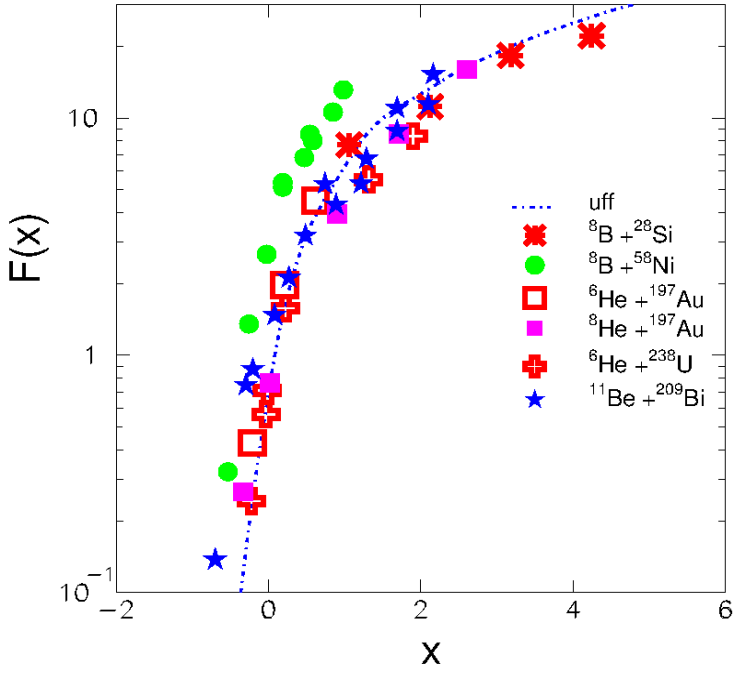


Fig. 2. (a) Cross sections for evaporation residues as

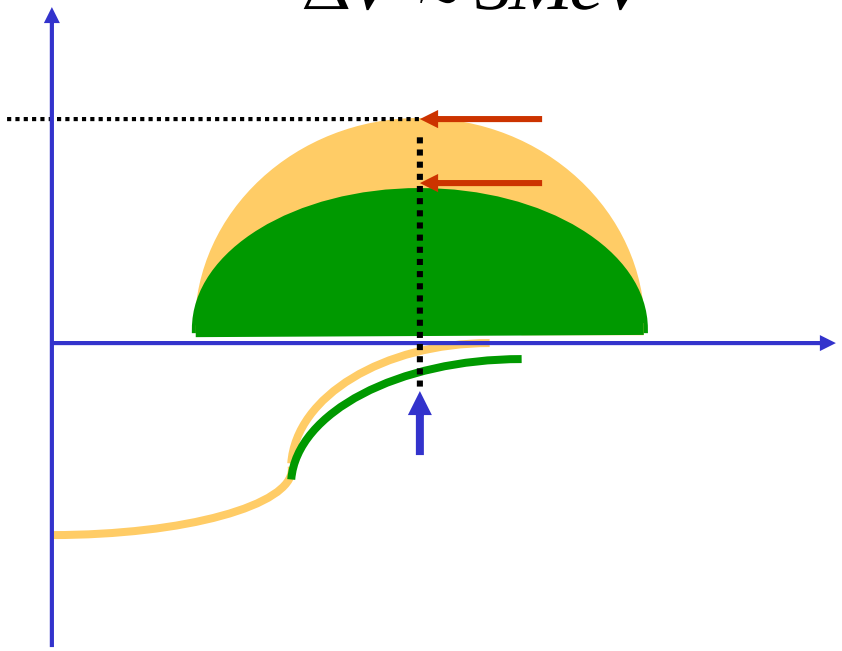
Reduced fusion for various projectiles
from Pakou et al, PRC87,014619(2013).



The halo effect

Decrease of the barrier

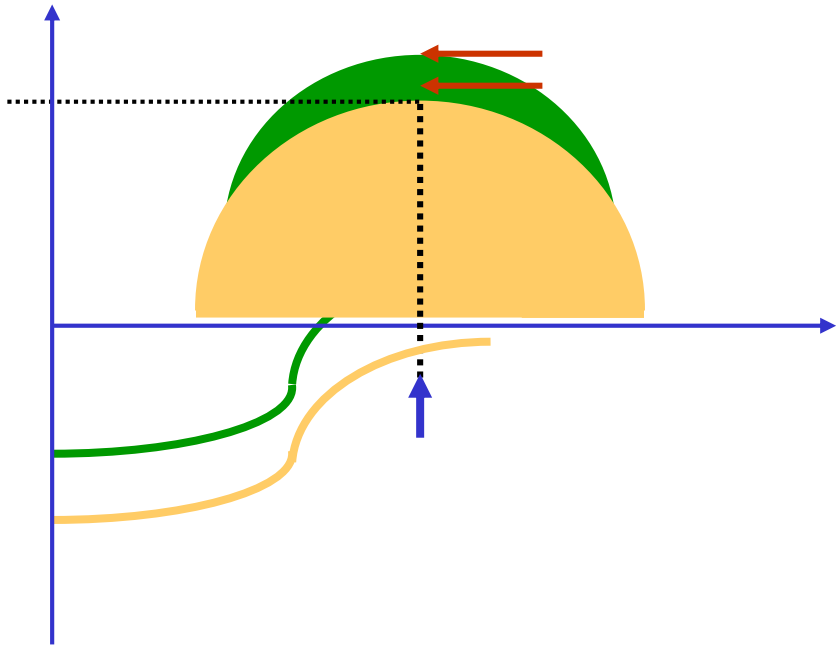
$$\Delta V \approx 3MeV$$



The dynamic polarization Potential

Increase of the barrier

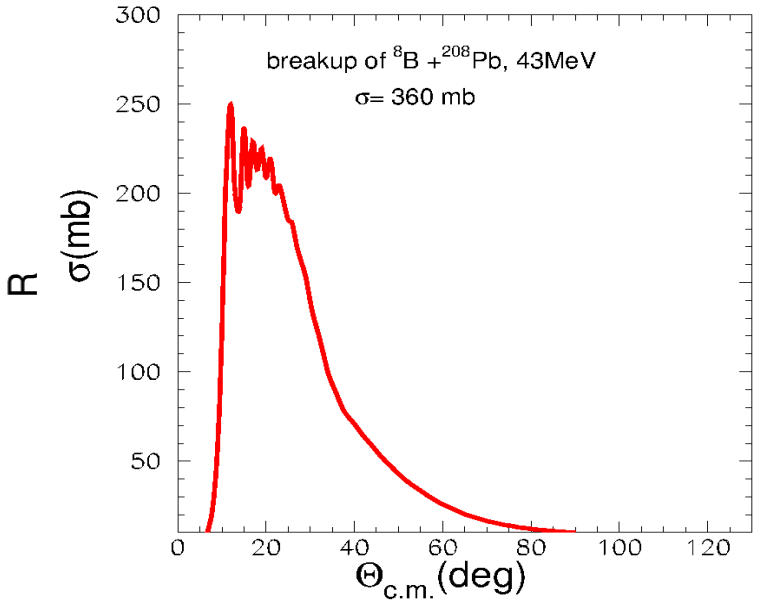
$$\Delta V \approx MeV$$



M. Hussein and R. Satchler N.P 567A (1994) 165

The motivation:

For the ^{7}Be production measurement



The 8B+208Pb case:
'Jnique possibility :

A large breakup cross section 360mb

lajor contributor to total reaction
ross section of 415mb

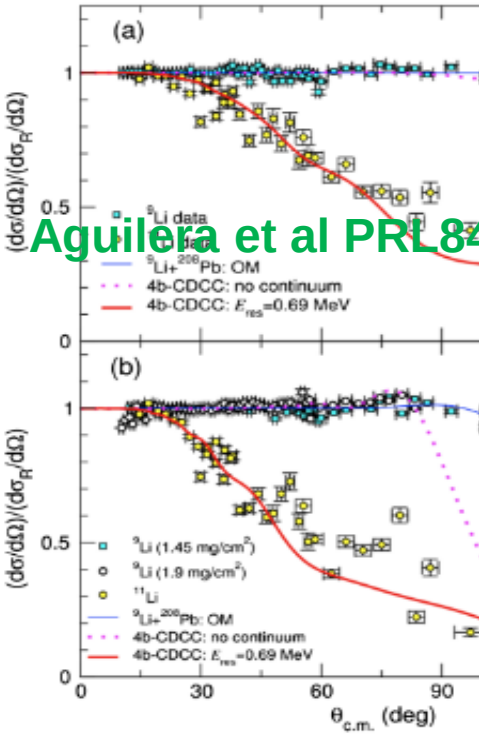
Phenomenological prediction agrees with calculation !

Is that really true???
If yes this could have very important consequences to fusion itself-coupling channel effects and possibly to astrophysical problems

The motivation:

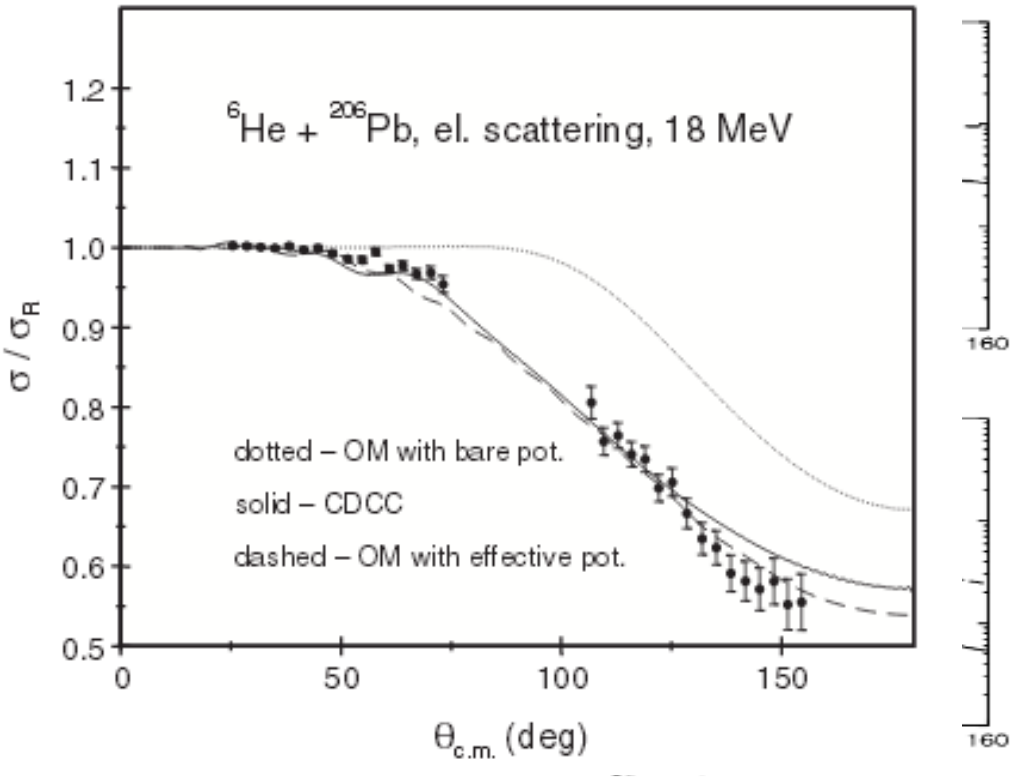
Elastic scattering of $^{8}B+^{208}Pb$ at 43MeV

L. Standylo et al. PRC87,064603(2013)



Aguilera et al PRL8

^{11}Li+^{208}Pb



^{6}He+^{209}Bi

Deviations from Rutherford

well understood for neutron rich nuclei with

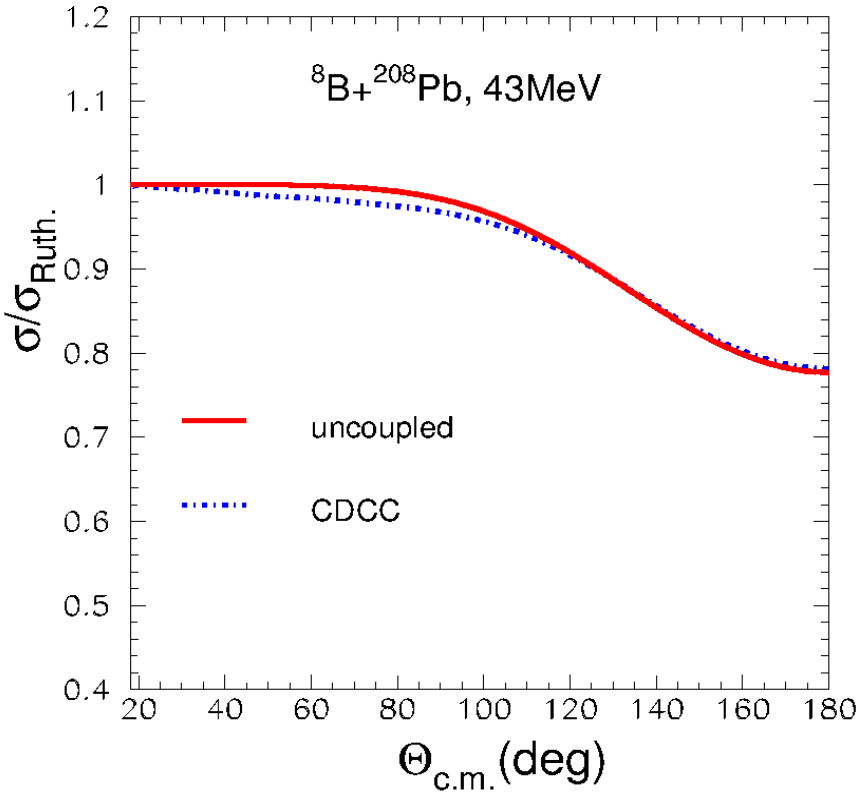
couplings to continuum

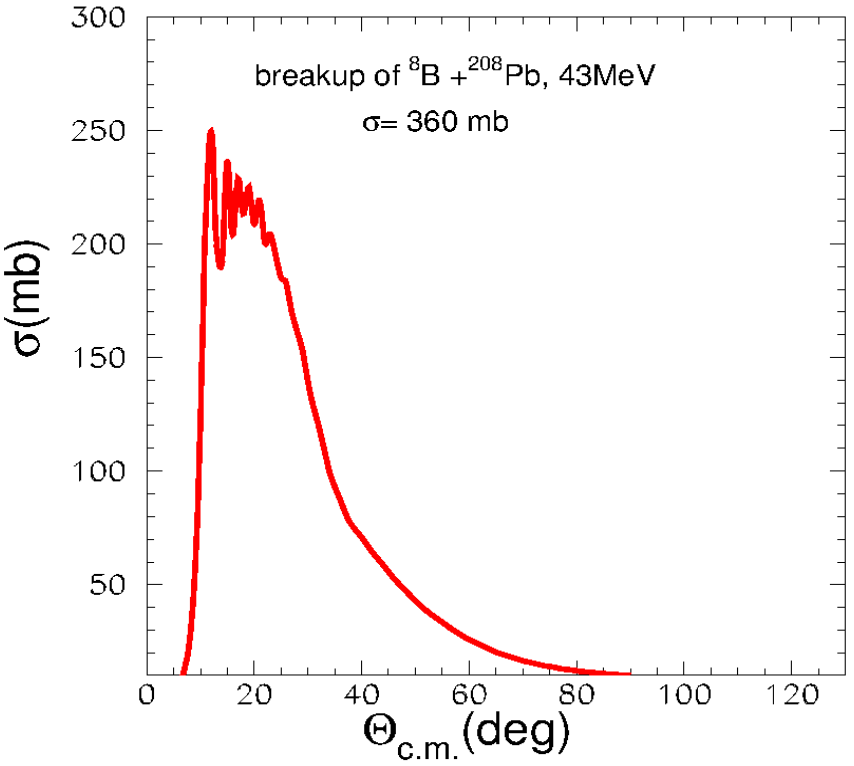
questions

Is that true for proton rich nuclei?
The coupling effect is it directly connected with the breakup magnitude ?

Keeley, Alamanos,Kemper, Rusek,

Prog. Part. Nucl. Phys. 63, 396 (2009)

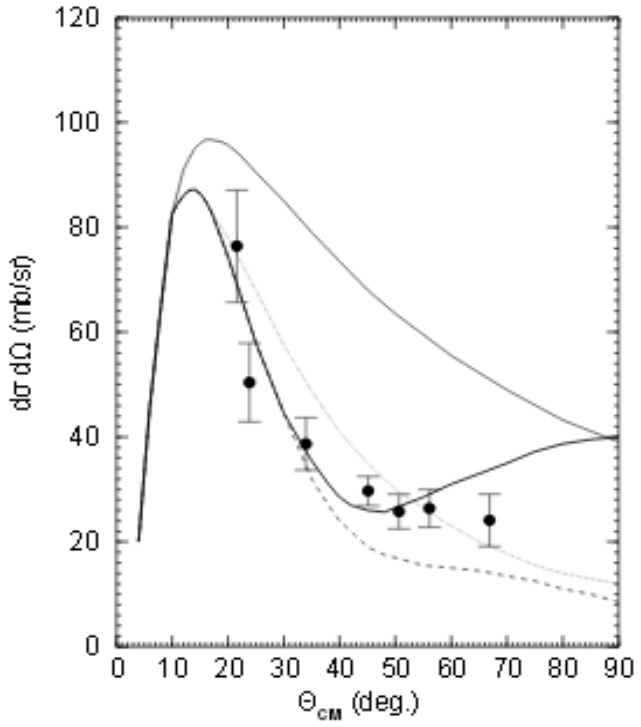




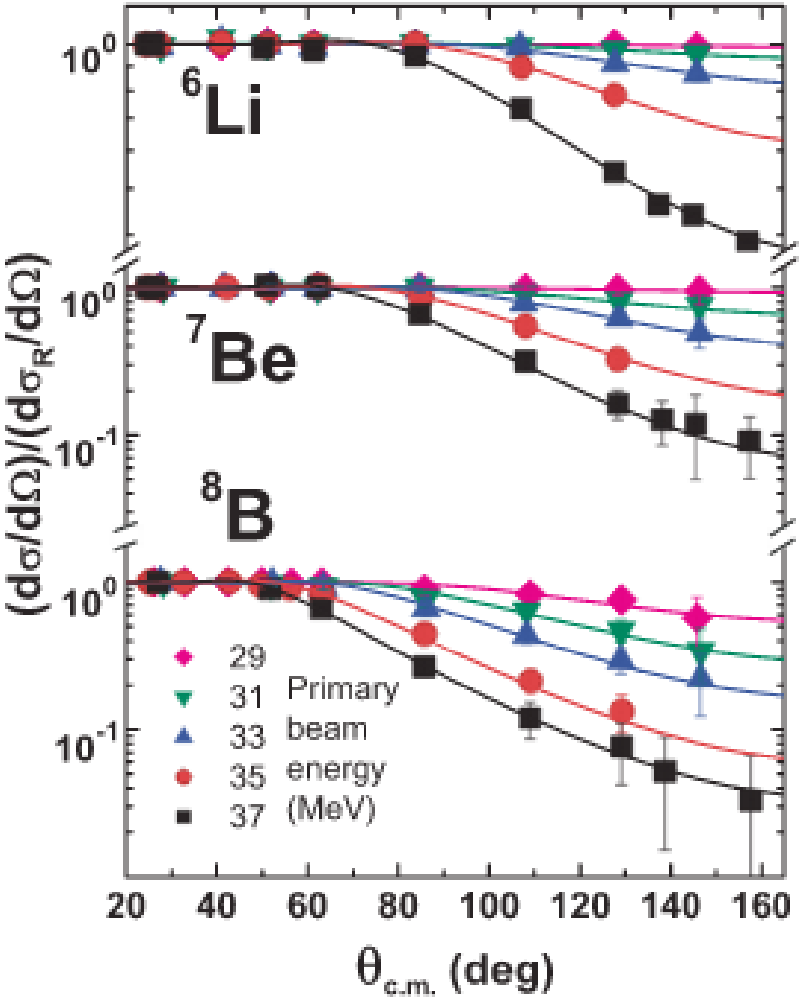
Previous measurements

$^{8}B+^{58}Ni$ breakup, E_{beam}=25.7MeV ($E_{C.b.}$ =23.7 MeV)

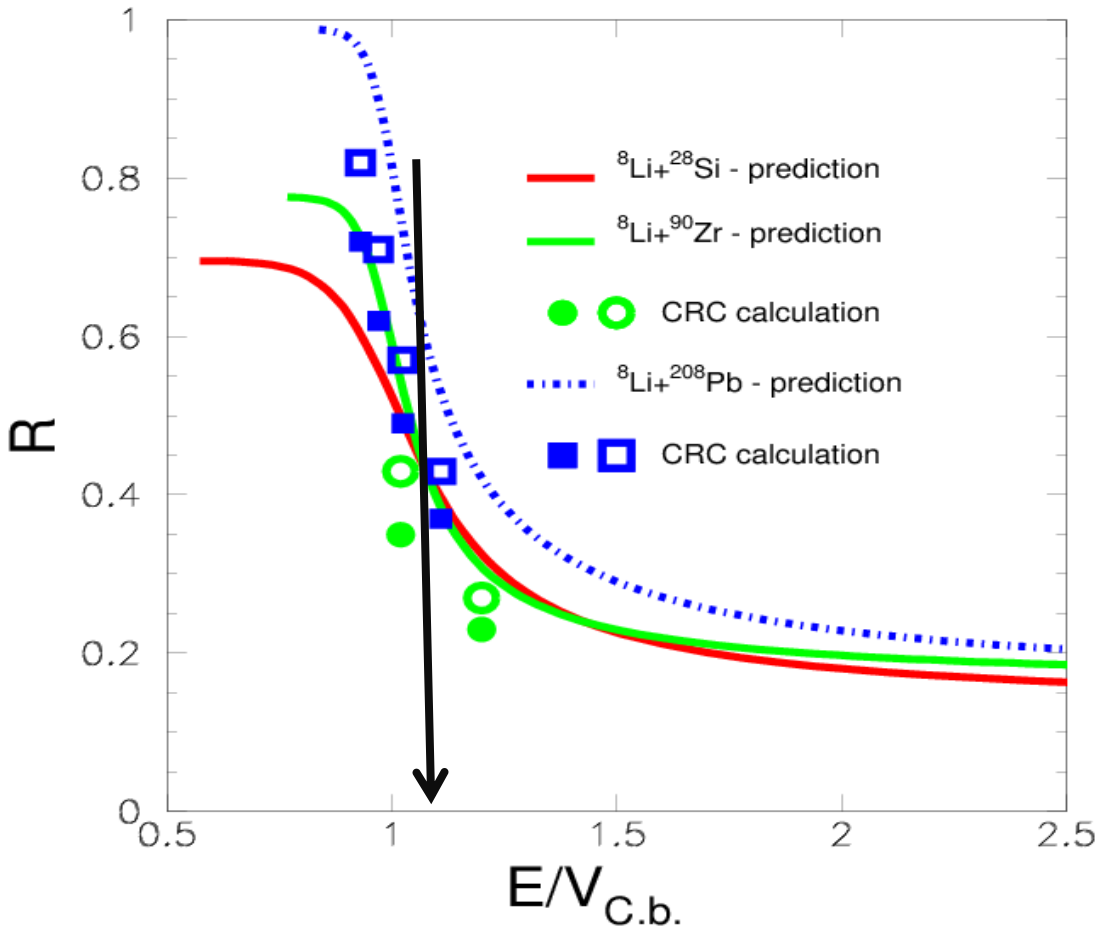
Guimarães et al. PRL 84,1862(2000)



Elastic scattering - PRC79(1999)021601

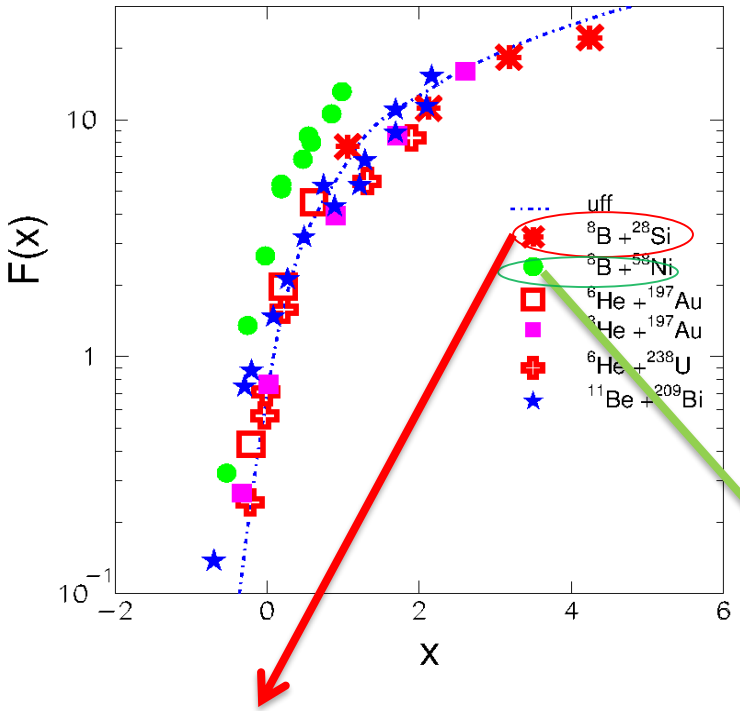


R = direct/total ~ 0.50


R
E/V C.b.
0
0.2
0.4
0.6
0.8
1
0.5
1
1.5
2
2.5
8Li+28Si - prediction
8Li+90Zr - prediction
CRC calculation
8Li+208Pb - prediction
CRC calculation

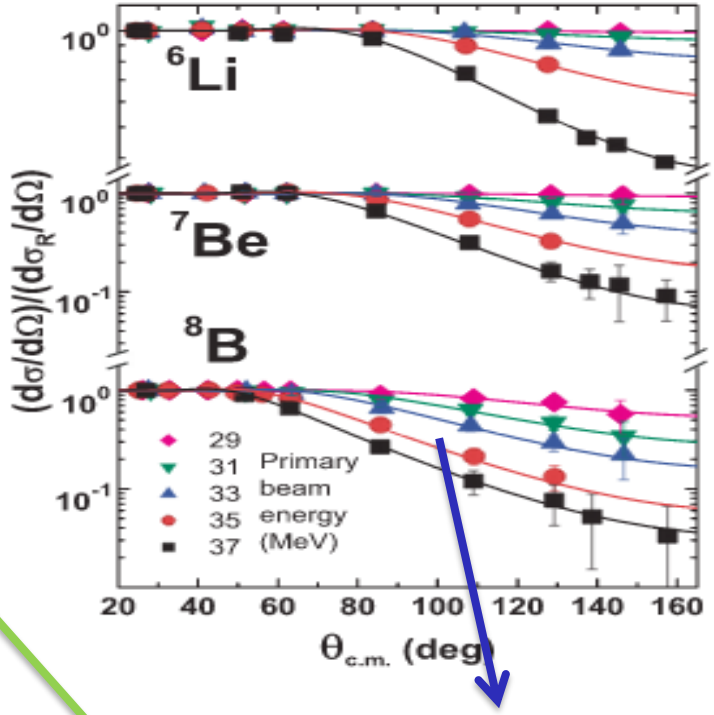
Does ^{8}B behaves as a standard nucleus or as a unique nucleus?

FUSION -systematic



Pakou et al., PRC 87, 014619(2013)

ELASTIC SCATTERING

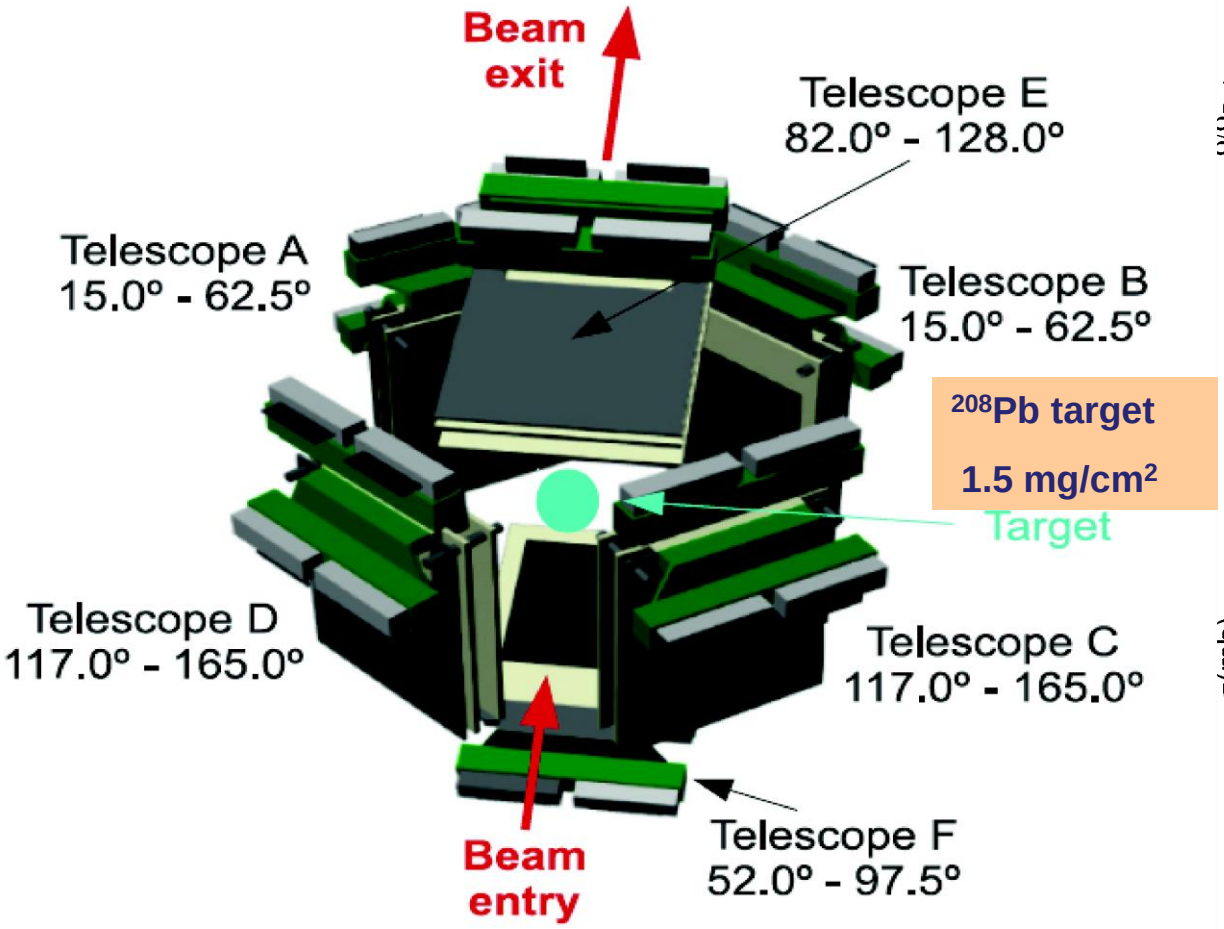


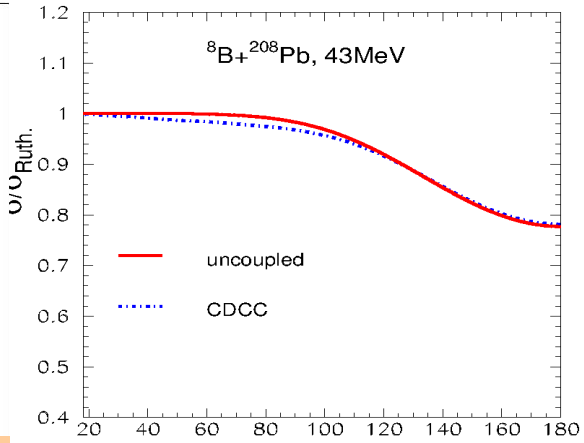
Aguilera et al., PRC79(1999)021601

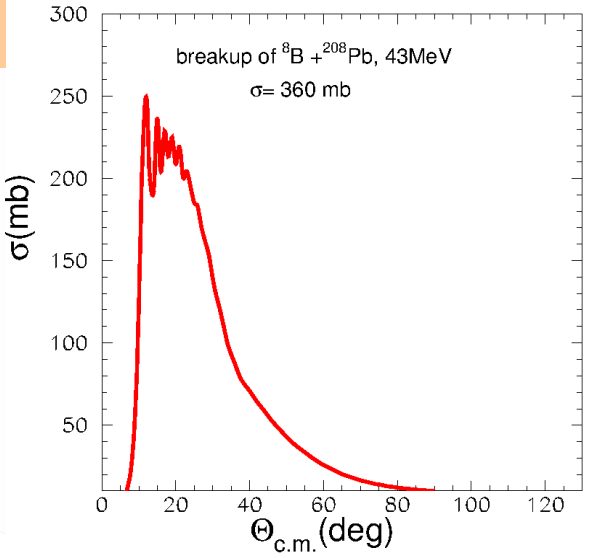
Aguilera et al, PRL107,092701(2011)

3D schematic view of our setup

GLORIA array



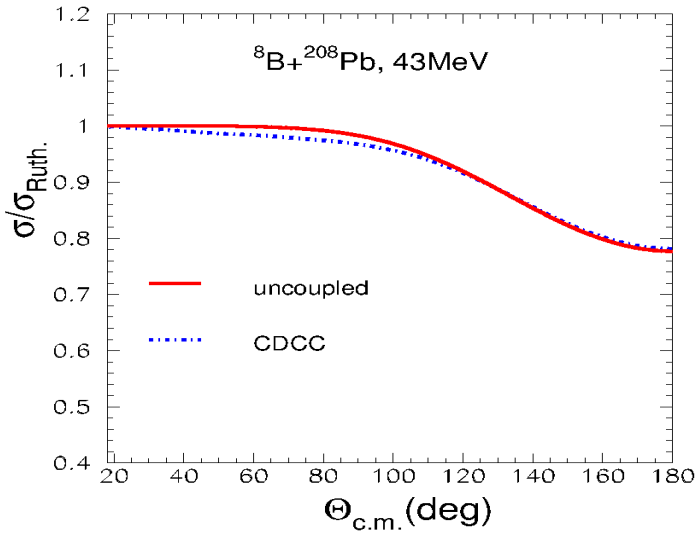




Beam time request : 17 + 4 = 21shifts

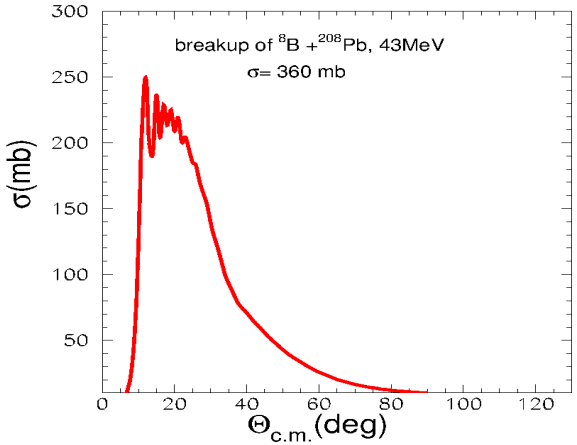
Elastic scattering

At 43 MeV, for beam flux **5x10^3 pps** **t = 1.5mg/cm^2**



θ <38^0	N >10000counts	error < 1%	
θ =90^0	N~ 200 counts	error ~ 7%	
θ =130^0	N ~ 70 counts	error ~12%	8%
θ = 160^0	N ~ 45 counts	error ~15%	10%

Breakup-7Be production



θ=15^0	N ~ 110	error~ 10%	7%
θ=29^0	N ~ 70	error ~12%	8.5%
θ =47^0	N ~ 23	error ~ 21%	15%

Disentangling elastic breakup from inelastic breakup (transfer breakup)

- **favorable kinematics ???**
- **too small to be considered**

Simulated energy profile of 7Be –breakup fragments in ΔE+E detectors