COMEX5 Conference 2015

Spectroscopic Study of the Intruder S-wave in ^{12}Be via Transfer Reaction

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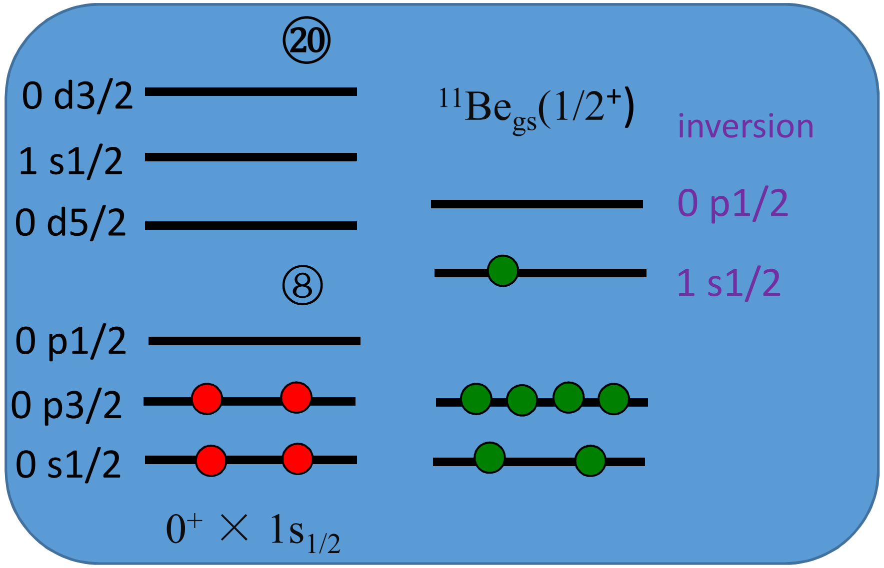
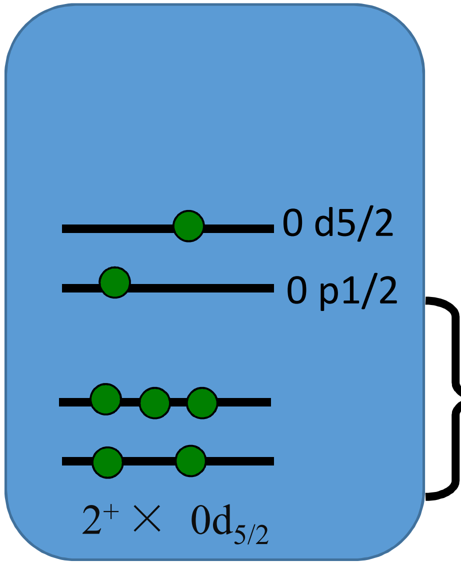
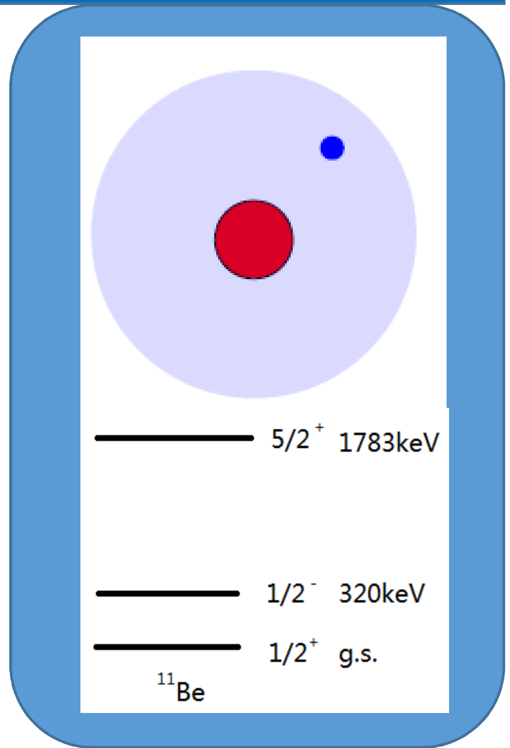
The halo nucleus ^{11}Be

- Neutron loosely bound Sn=0.504 MeV
- Larger radius rms= 2.91 fm
- ^{10}Be core + 1 valance n







PRL 108, 192701 (2012),10Be(d,p)

S~0.71(5)

PLB 461, 22-27 (1999) 11Be(p,d) S~16%

PRL 84, 35(2000) 11Be 1n removal S~22%

Nearly 100% intruder state in $^{11}Be_{g.s}$

$^{12}Be \sim {}^{11}Be + n$

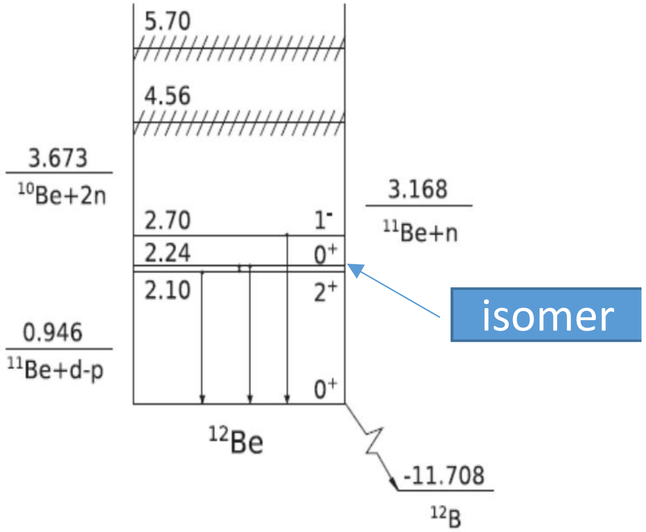
Intruder state

or

Normal state

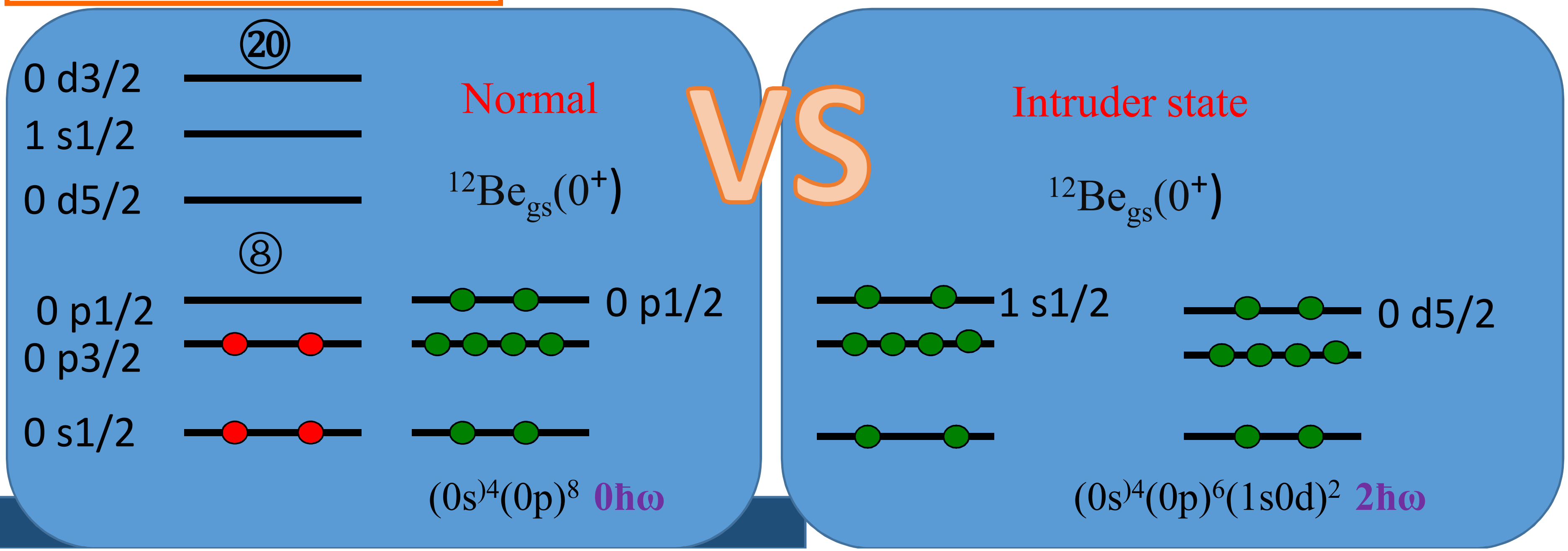
The structrue of nucleus ^{12}Be

- **disappearance** of conventional magic number: N=8
- **Isomeric state**: 0_2^+ 331(12) ns



Two decay modes:
E2 decay: **130 keV and 2.11 MeV** gamma-rays **17(2)**%
E0 decay: internal conversion: negligible
e+e- pair **creation** **511keV** gamma **83(2)**%

Physics Letters B 560 (2003) 31–36;
Physics Letters B 654 (2007) 87-91.



	0_1^+ G.S			0_2^+ Isomer			0_1^+ G.S	0_2^+ Isomer	Reference
	Inutruder		normal	intruder		normal			
	s	d	p	s	d	p			
F.C.Barke	0.33	0.34	0.32	0.56	0.2	0.42	Intruder	Intruder	J.Phys.G 36,038001,2009; J.Phys.G 2, L45,1976
H.T.Fortune and R.Sherr	0.53	0.15	0.32	0.25	0.7	0.68	Intruder	Normal	Phys.Rev.C 74,024301,2006; J.Phys.G36,038002,2009;Phys.Rev.C83,044313,2011.
C.Romero-Redondo Three –body model	0.68-0.77	0.10-13	0.13-19	0.15-0.23	0.08	0.69-0.77	Intruder	Normal	Phys.Rev.C 77,054313,2008.
G.Blanchon pp-RPA	0.25	0.185	0.58	0.74	0	0.19	Normal	Intruder	Phys.Rev.C 82,034313,2010.
M.Dufour NCSM	0.16		0.59	-----			Normal	-----	Nucl.Phys.A 836,242,2010.
Knock -out reaction	0.68		0.32	-----			Intruder	-----	Phys.Rev.Lett 85,266,2000; Phys.Rev.Lett 96,032502,2006.
	S=0.56	S=0.48	S=0.44						
Charge exchange reaction	---	---	0.25	----	---	0.6	Intruder	Normal	Phys.Rev.lett 108,122501,2012.
Transfer reaction	S=0.28 (0.17)	---	---	S=0.73 (0.51)	----	----	uncertain	uncertain	Phys.lett.B 682,391,2010.

Theories

Experiments

Questioned by H.T.Fortune and R.Sherr

Phys.Rev.C 85,051303(R),2012.

Great difference

0_2^+Mix with 2^+ state

-----: no data or no calculation

Normal: Normal state is dominant

Intruder: Intruder state is dominant

Uncertain: no d-wave, could not make sure

Goal of the proposed experiment

- **Main goal:**

Investigate the intruder s-wave strength in the ground state and low-lying excited state of ^{12}Be via the d(^{11}Be,p) transfer reaction at 20-30 MeV/u.

- **20-30 MeV/u :**

1. S_f is independent of the incident energy in large energy range
2. Reduce the effect of complicated reaction mechanism
3. Beam production rate times reaction cross sections

New ideas

- **Decrease the background**

  Coincident measurement of $^{10-12}Be$ and light-charged particles

- **Remove the effect of proton in CD2 target**

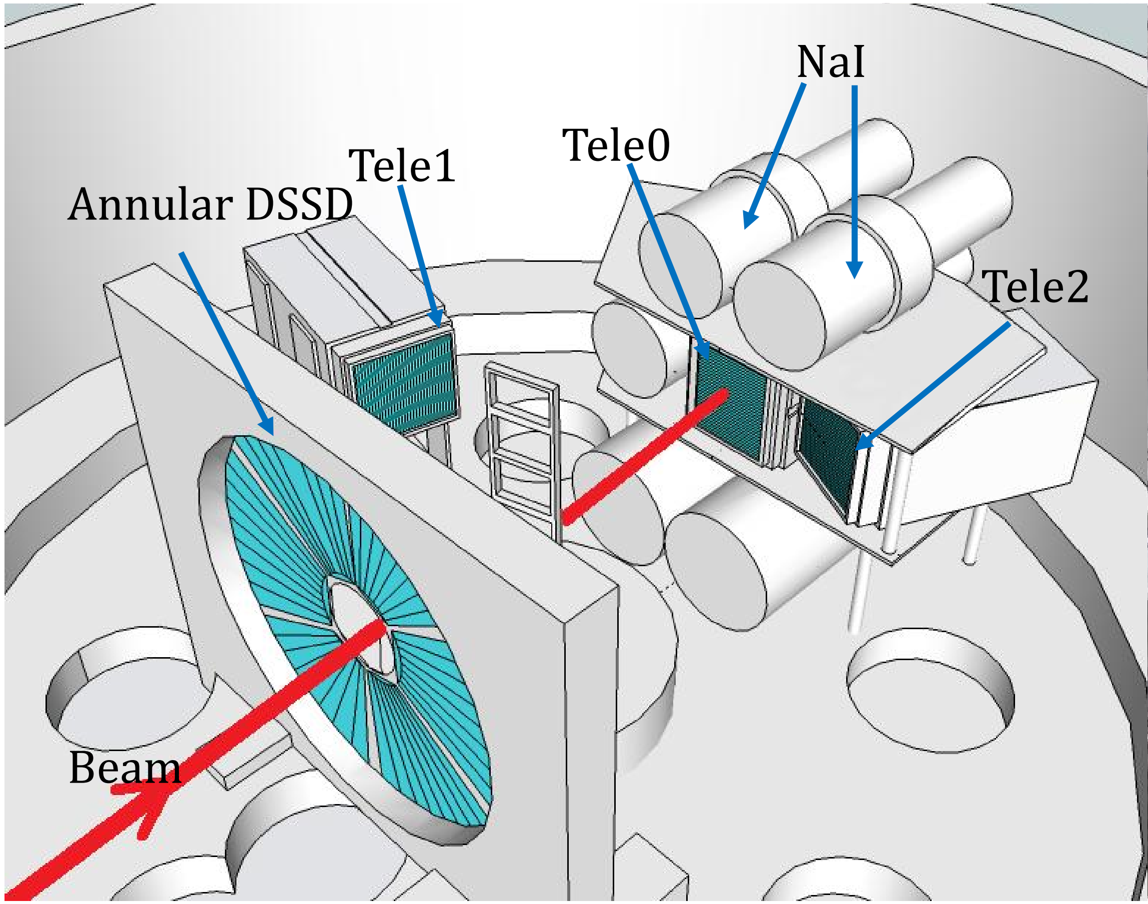
  Compare the elastic scattering data of ^{11}Be+p to ^{11}Be+d to get the proton content in CD_2 target.

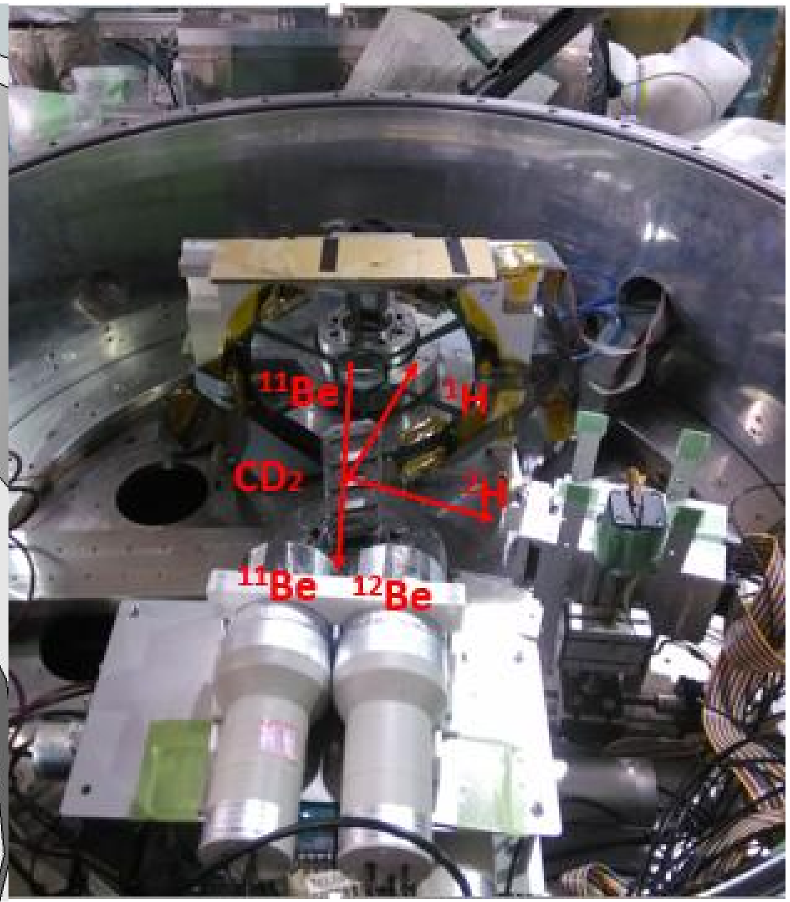
- **New technique to separate 0_2^+, measure Smaller angles data**

  Implantation-decay-detect gamma(stop and decay)

- **Measure the elastic scattering Channel** in the same experiment

Experimental Setup



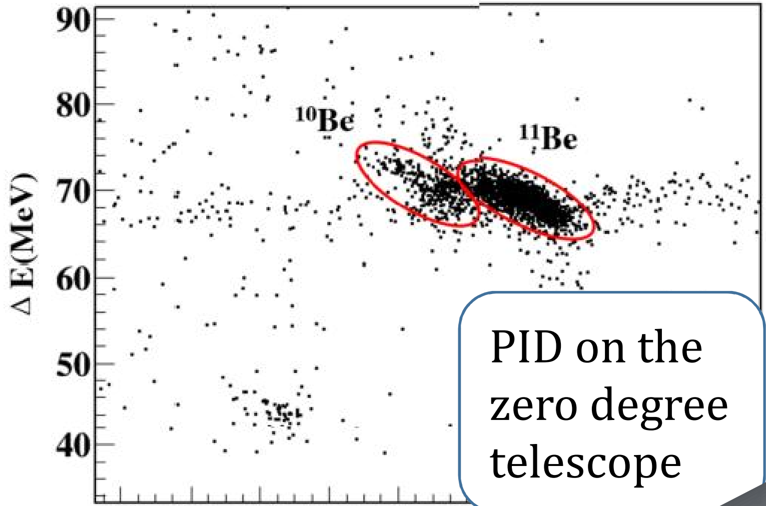


Experimental Data

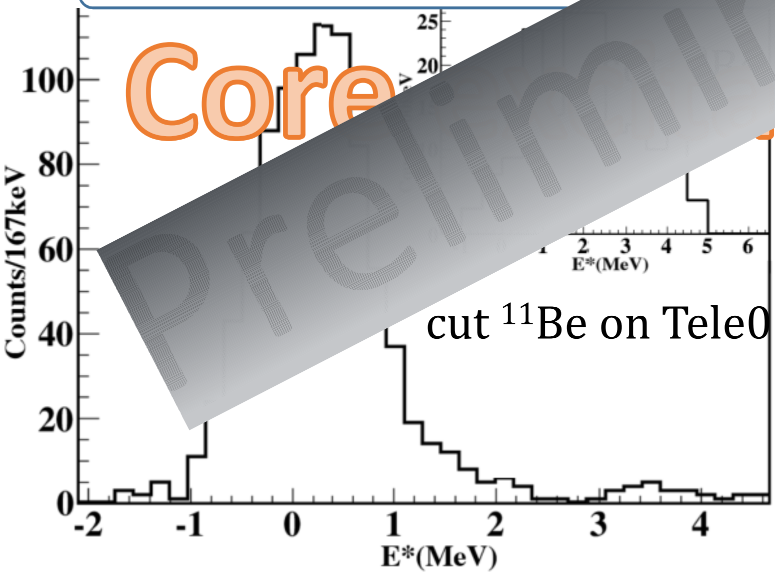
Elastic scattering data of ^{11}Be+p and ^{11}Be + d

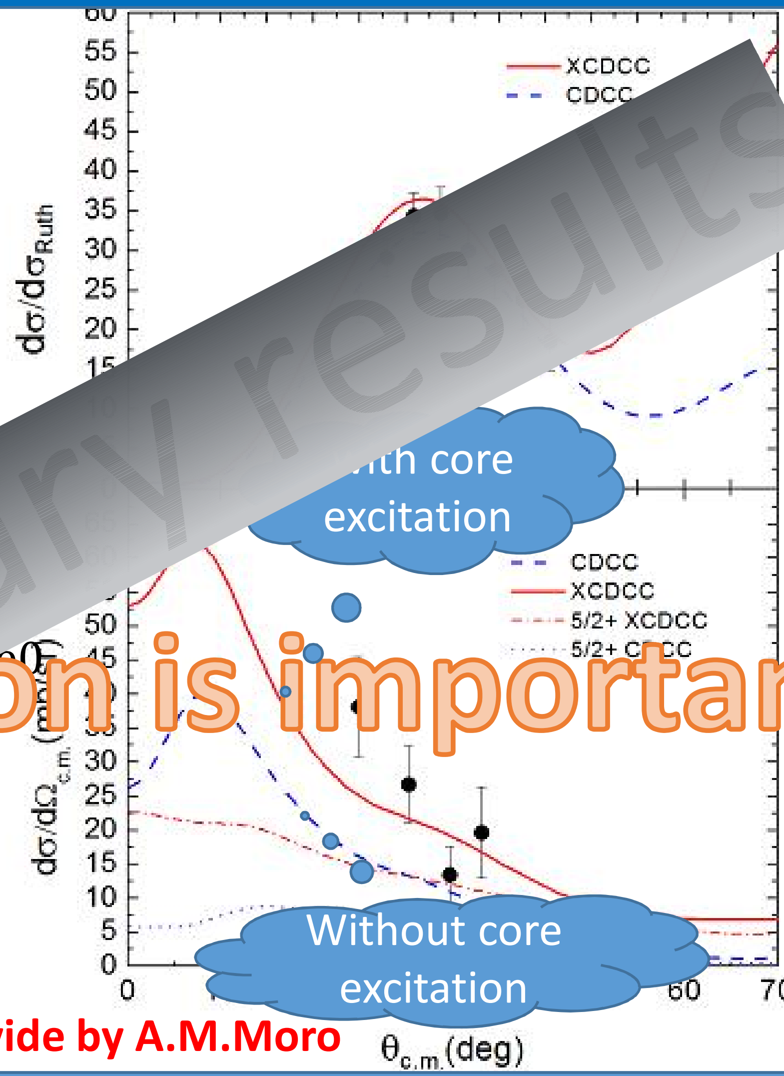
To extract Optical Potential for the entrance channel of transfer reaction

^{11}Be elastic and breakup on protons



Energy spectrum for ^{11}Be





Core excitation is important

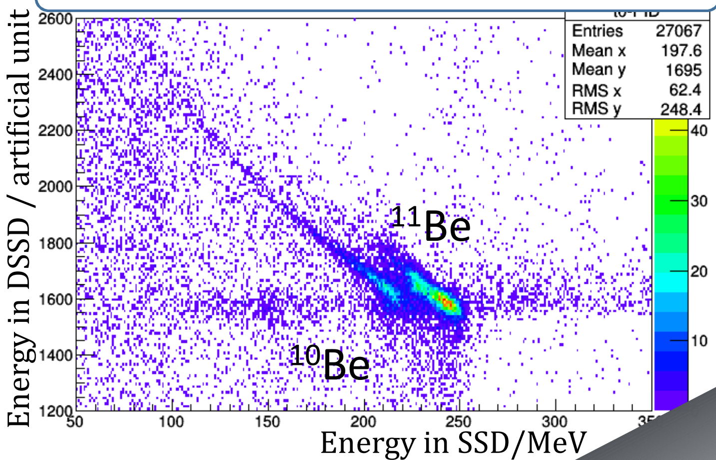
Provide by A.M.Moro

CDCC ➔ considering the effect of breakup channels

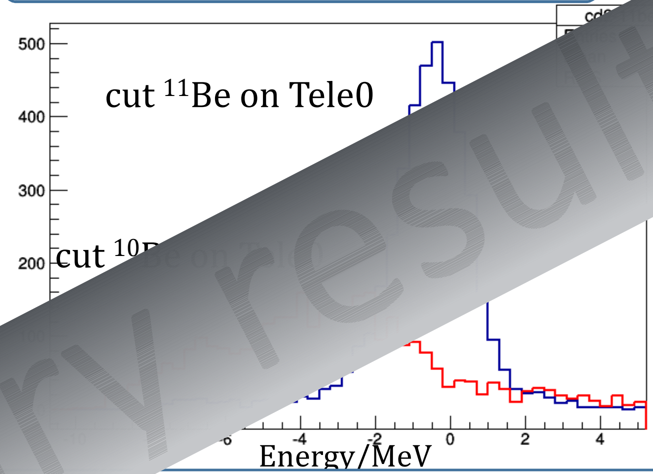
XCDCC ➔ considering the effect of core excitation

^{11}Be elastic and inelastic scattering on deuteron

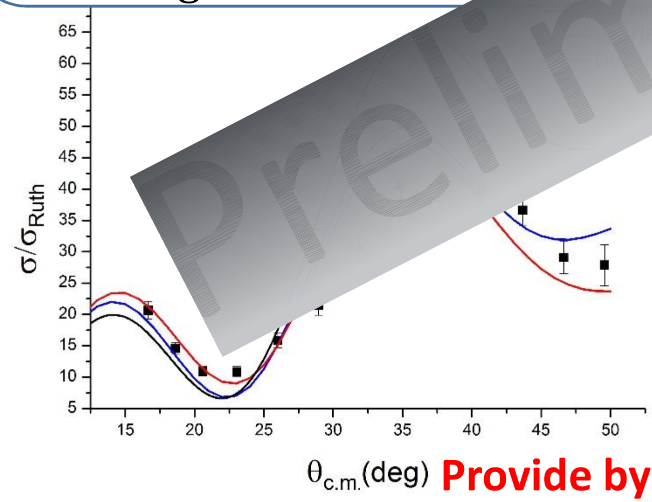
PID on the zero degree telescope



Energy spectrum for ^{11}Be

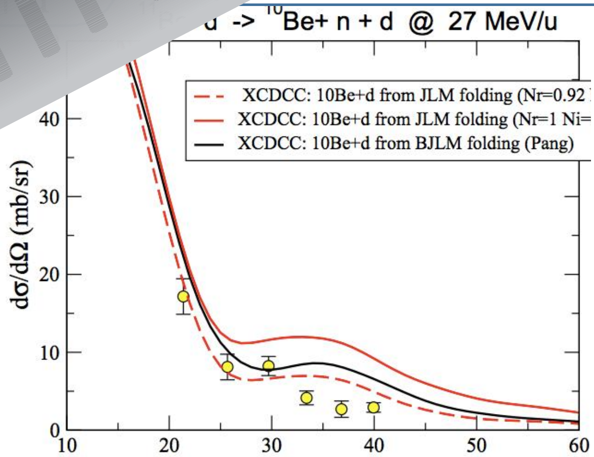


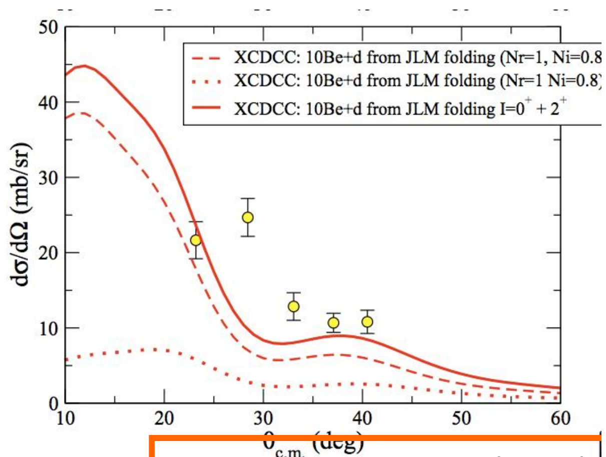
Global JLM potential can reproduce the Angular distribution of ^{11}Be



Provide by D.Y.Pang

XCDCC calculation for breakup of ^{11}Be +d





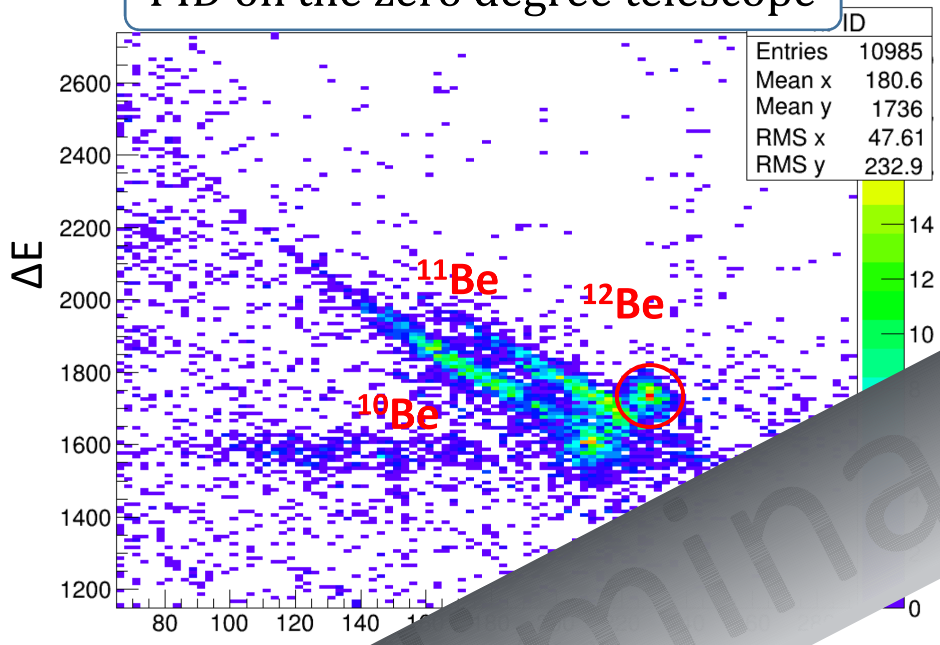
Provide by A.M.Moro

[1] PRC **83**, 064619 (2011)
[2] JPG **39** (2012) 095101

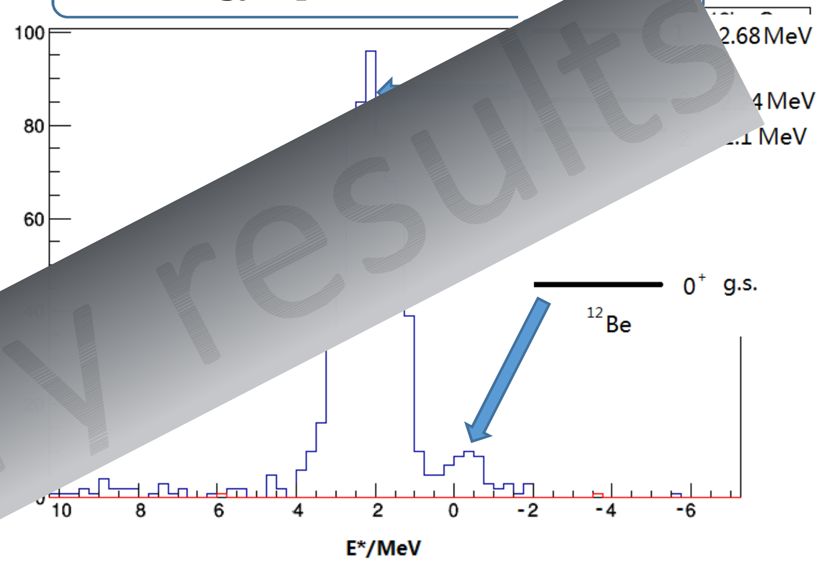
Experimental result of transfer reaction

Experimental result of $^{11}Be(d,p)^{12}Be$

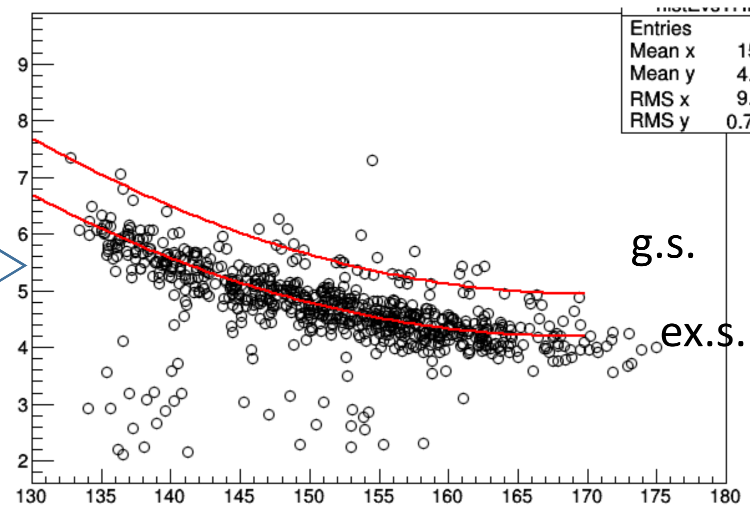
PID on the zero degree telescope



Energy spectrum for 12Be

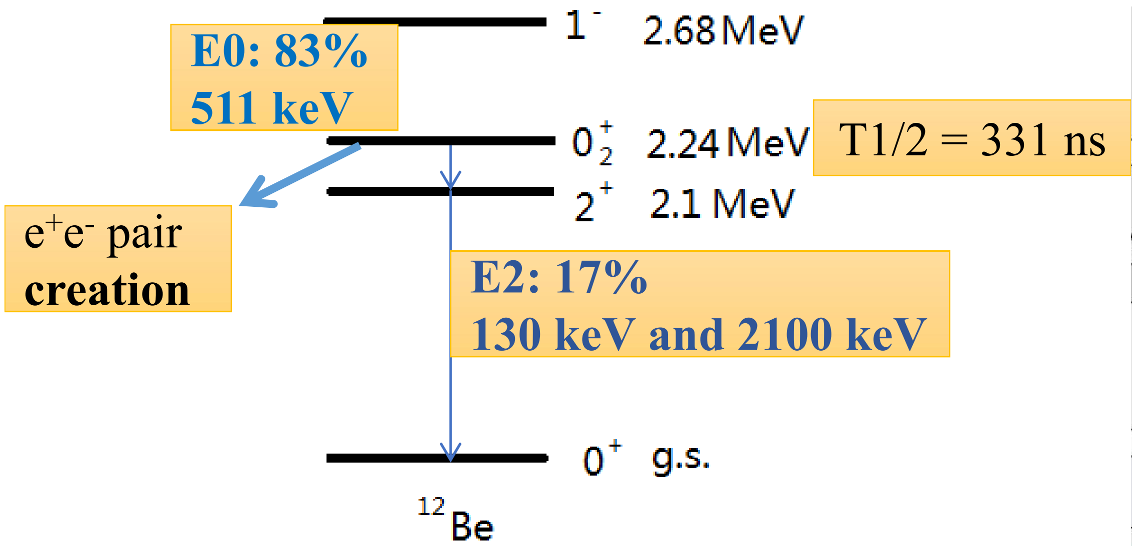


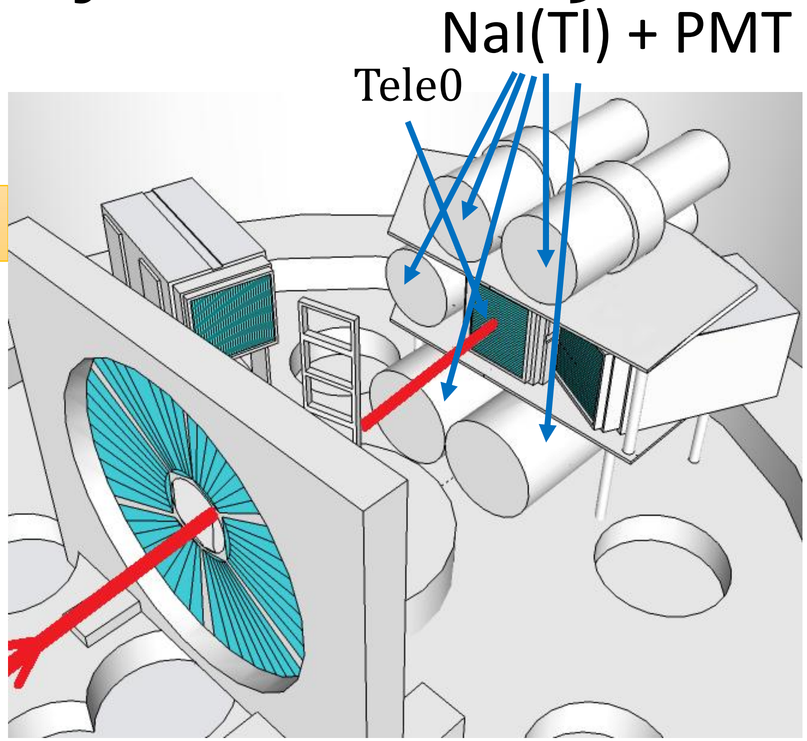
Kinematic loci for protons in coincidence with ^{12}Be on Tele0



Experimental result of $^{11}Be(d,p)^{12}Be$

Isomeric state(E0 decay was used)



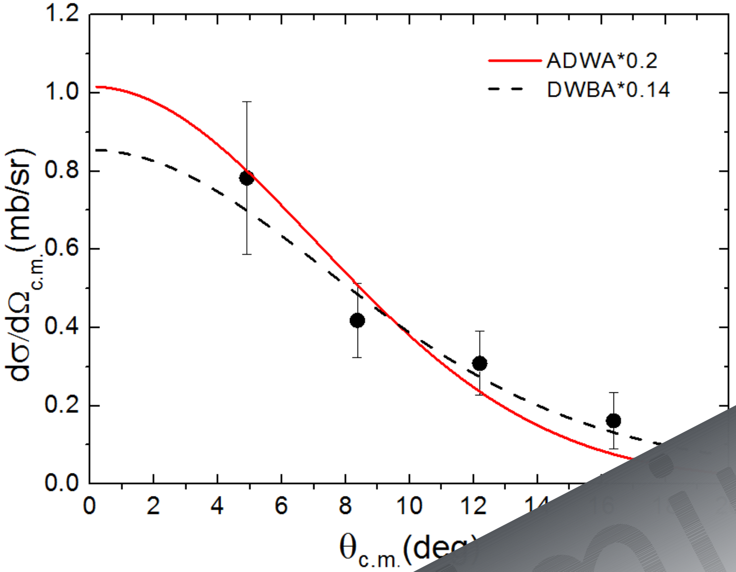


S. Shimoura et al., Physics Letters B 560 (2003) 31–36;

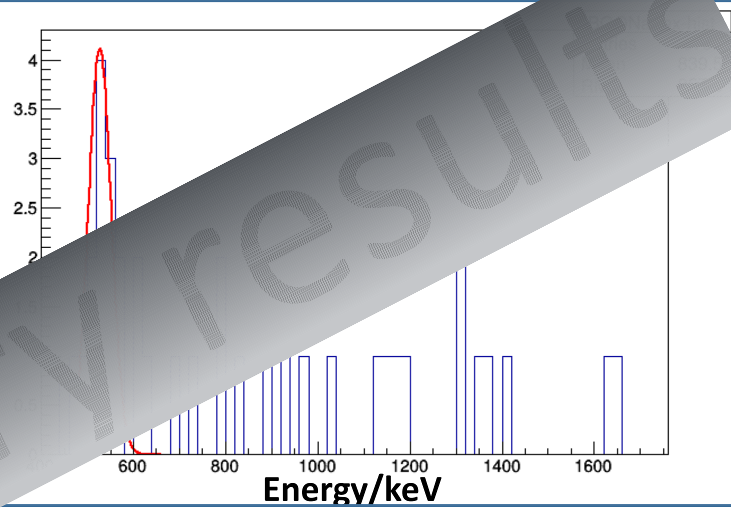
S. Shimoura et al., Physics Letters B 654 (2007) 87-91.

Experimental result of ^{11}Be(d,p)^{12}Be

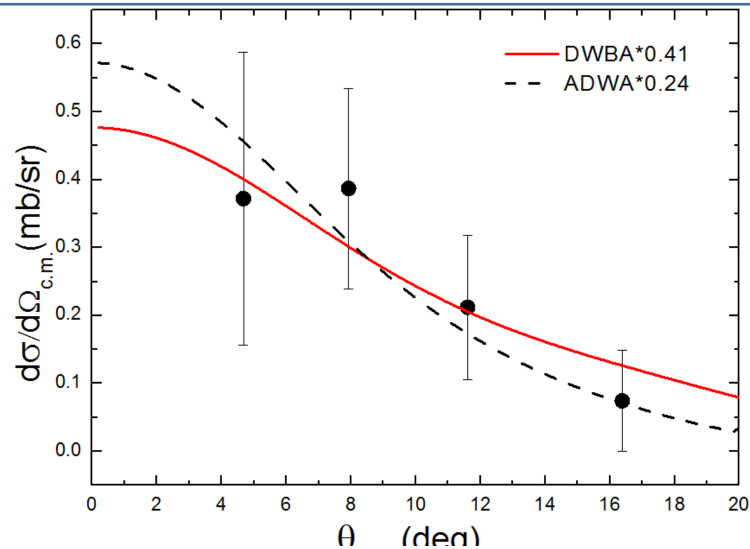
Angular distribution of ^{11}Be(d,p)^{12}Be(g.s.)



γ spectrum in coincidence with ^{12}Be on Tele0



Angular distribution of ^{11}Be(d,p)^{12}Be(e.x.)



Preliminary results

	[illegible]	ADWA
27A [illegible]	[illegible] $_{-0.02}$	$0.20^{+0.03}_{-0.03}$
27A M[illegible]	$0.24^{+0.07}_{-0.07}$	$0.41^{+0.11}_{-0.12}$

Error： 68% confidence

Experimental result of $^{11}Be(d,p)^{12}Be$

	0_1^+ G.S			0_2^+ Isomer			0_1^+ G.S	0_2^+ Isomer	Refere[illegible]e
	Inutruder		normal	Intruder		normal			
	s	d	p	s	d	p			
Knock -out reaction	[illegible].68 S=0.56	S=0.48	0.32 S=0.44	-----			Intru[illegible]	[illegible]	[illegible]ett 85,266,2000; [illegible]Rev.Lett 96,032502,2006.
Charge exchange reaction	---	---	0.25	----	--[illegible]	[illegible]	[illegible]	[illegible]al	Phys.Rev.lett 108,122501,2012.
Transfer reaction1	S=0.28 (0.17)	---	--[illegible]	[illegible]	[illegible]	[illegible]	[illegible]ertain	uncertain	Phys.Lett.B 682,391,2010.
Our result	S=0.14 (0[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

Preliminary results

(1) G.[illegible] consistent with another transfer experimental results within error bar

(2) Isomeric state: Determine the s-wave SF from Direct measurement

Summary

- O.P. for ^{11}Be+d is extracted from the same experiment

  Global OP including ^{11}Be density can reproduce angular distribution

  Core excitation of ^{11}Be is important

  the effect of H percent in CD_2 target are removed

- New experimental technical to detect isomeric state

  implant----stop-----decay

  get the angular distributions in smaller C.M system

- ADWA method is used to extract the s-wave SF

  G.S : $S_f = 0.20^{+0.04}_{-0.04}$, confirm transfer experimental results

  Isomeric state: $S_f = 0.41^{+0.08}_{-0.08}$, determined from direct measurement

- More theoretical calculations to explain our results

Intruder state **or** Normal state

Collaborators

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Thank you for attention!