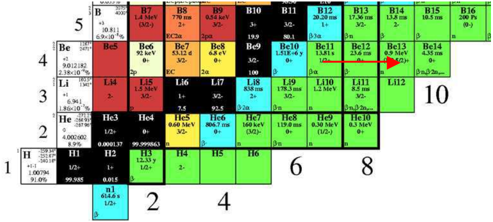
Studies of unbound states in isotopes at the $N = 8$ shell closure

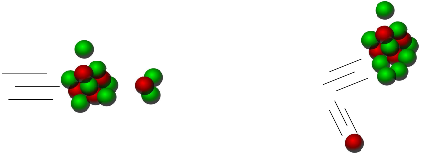
Jacob G. Johansen
on behalf of the T-REX and MINIBALL collaborations
Aarhus University

July 1st 2015



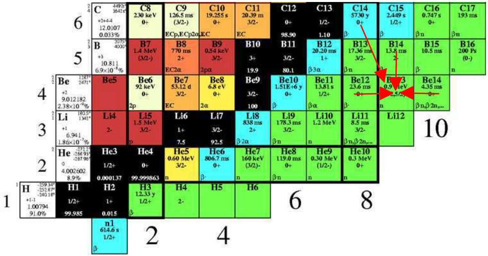
$^{3}H(^{11}Be,p)^{13}Be$ at 5MeV/u

- Resonance energies and widths
- BR for *n*-decay to excited states in ^{12}Be
- Differential cross sections

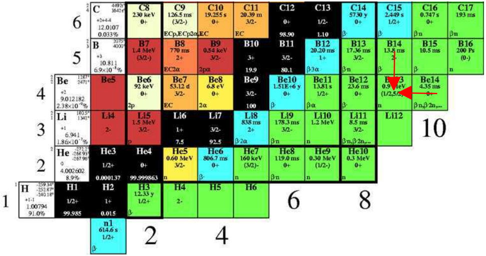


Previous measurements of ^{13}Be

- ^{14}C(^{7}Li,^{8}B)
- ^{14}C($\pi-$,p)
- ^{14}C(^{11}B,^{12}N)
- ^{13}C(^{14}C,^{14}O)
- ^{2}H(^{12}Be,p)
- ^{1}H(^{14}Be,^{12}Be+n)
- C(^{14}B,^{12}Be+n)
- C(^{14}Be,^{12}Be+n)

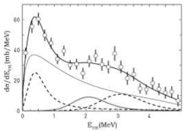


Previous measurements of ^{13}Be

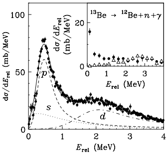


- ^{1}H(^{14}Be,^{12}Be+n)
- C(^{14}B,^{12}Be+n)
- C(^{14}Be,^{12}Be+n)

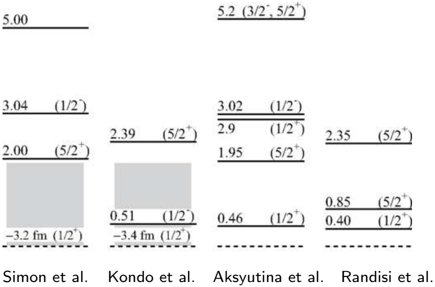
Results from the knock-out reactions

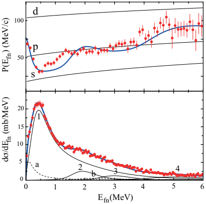


H. Simon *et al.*,
Nucl.Phys. **A791**, 267 (2007)

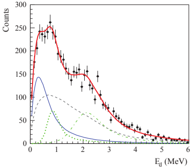


Y. kondo *et al.*,
Phys.Lett. **B690**, 245 (2010)

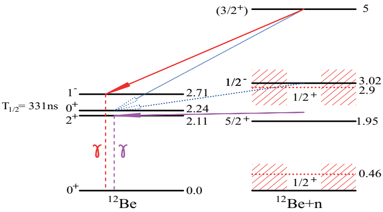




Y. Aksyutina *et al.*,
Phys.Lett. **B718**, 1309 (2013)

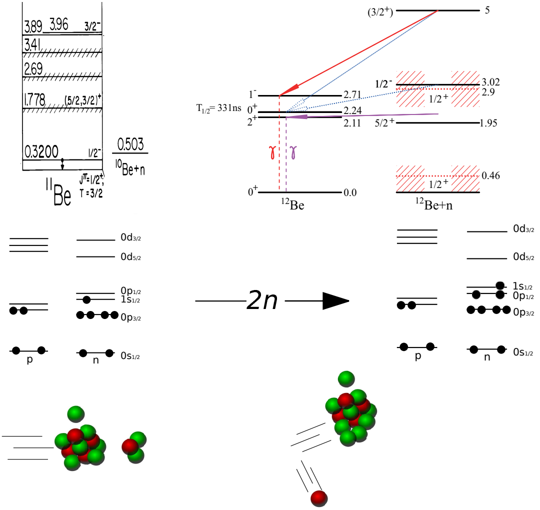


G. Randisi *et al.*,
Phys.Rev. **C89**, 034320 (2014)



The ^{3}H(^{11}Be,p)-reaction

^{11}**Be** ^{13}**Be**

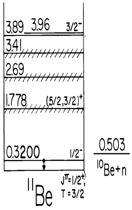


The transfer reaction:

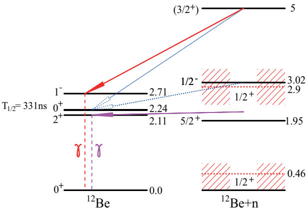
- Complementary reaction
- Different initial state
- Extract E_r independent of n-decay
- γ-measurements from all states in ^{12}Be

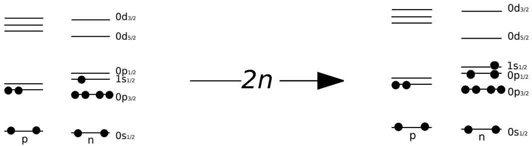
The ^{3}H(^{11}Be,p)-reaction

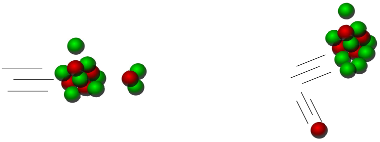
^{11}Be



^{13}Be







Possible transfers:

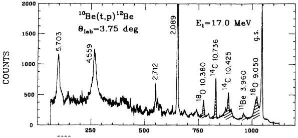
$L = 0$: $J^\pi = 1/2^+$

$L = 0 + E1$: $J^\pi = 1/2^-$

$L = 1$: $J^\pi = 1/2^-$

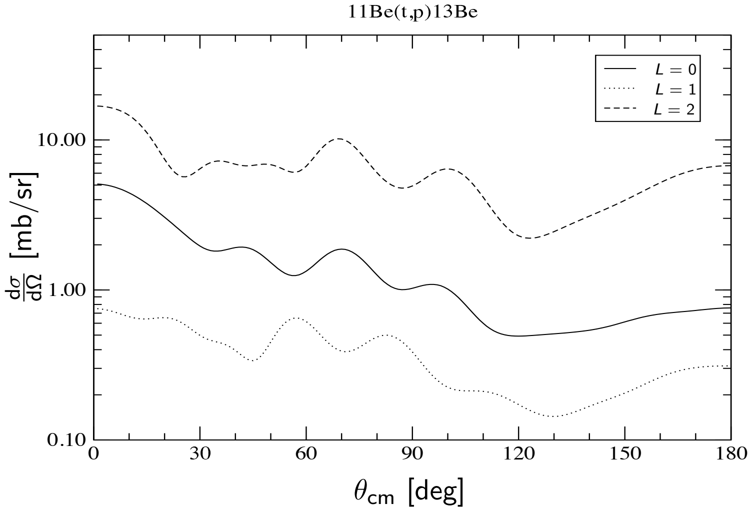
$L = 2$: $J^\pi = 5/2^+$

Example: ^{10}Be(^{3}H,p)^{12}Be



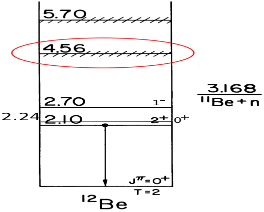
H.T. Fortune *et al.*, Phys.Rev. **C50**, 1355 (1994)

Differential cross sections



Additional channels

^{3}H(^{11}Be,d)

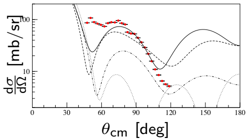


Suggested J^{π}:
$0^{+}, 1^{-}, 2^{+}, 2^{-}, 3^{+}, 3^{-}$

- N-decay to $1/2^{-}$ in ^{11}Be with BR$>10\%$
- $\Gamma = 100 - 650$keV.
- Possibly two resonances

^{3}H(^{11}Be,t)

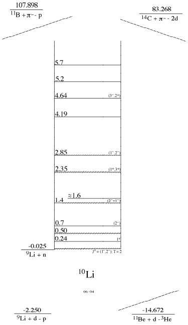
^{2}H(^{11}Be,d) (IS430):



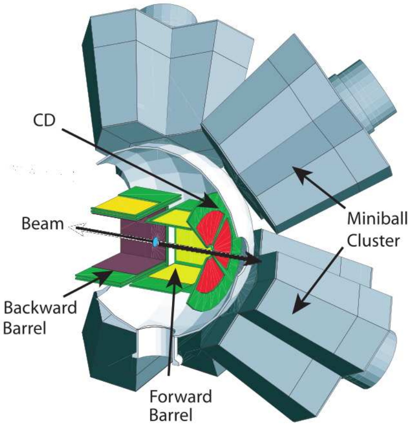
Optical potentials:

Solid	Best fit (xfresco)
Dash	Perey and Perey, Atom.Data.Nucl.Data.Tab, **13**, 293 (1969)
Dot	R. Kanungo *et al.*, Phys.Lett. **B682**, 391 (2010)
Dash-dot	R. Kanungo *et al.*, Phys.Lett. **B682**, 391 (2010)

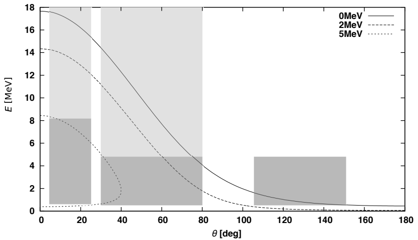
^{3}H(^{11}Be,α^{9}Li)



The setup



- Standard setup
  - 8 HpGe clusters
  - 12 silicon detectors (telescopes)
- Additionally
  - 1 HpGe detector at beamdump
  - Stopper foil after the CD



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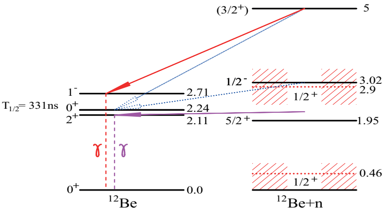

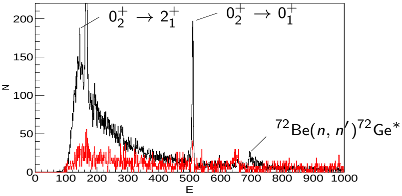

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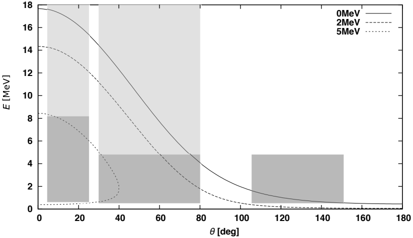


Beam request

15 shifts Primary reaction: ^{11}Be beam and ^{3}H+Ti target

2 shifts Ti-background measurements: ^{11}Be beam and pure Ti-target

2 shifts Beam contamination background measurement: Buffergas beam and ^{3}H+Ti target

2 shifts Beam intensity measurements: ^{11}Be beam and Ag target. (divided into short runs throughout the experiment)

Based on:

- $I_{\text{beam}} \approx 5 \cdot 10^6$/s at 5MeV/u - Feasable with UC_x target.
- $\frac{d\sigma}{d\Omega} \approx 1$mb/sr - DWBA calculations.
- $t_{\text{target}} = 40\mu$g/cm^2.

In total 21 shifts requested

Summary

We want to measure:

- ^{13}Be
  - Resonance energies and widths
  - Differential cross sections for the lowest resonances
  - Branching ratios for the neutron decay of the higher resonances

We will be using:

- Standard ISOLDE setup (T-REX + MINIBALL)
- Target used in several previous experiments (tritium target)
- High intensity beam used in previous transfer reaction (^{11}Be)

In addition we will get information on states in:

- ^{12}Be
- ^{11}Be
- ^{10}Li

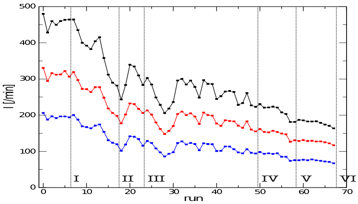
Thank you for your attention

The beam - Based on measurements in IS430 (2010)

Expected intensity

- ^{11}Be + Ag

	I	II	III
I [10^6 /s]	3.92	6.12	5.52
	IV	V	VI
I [10^6 /s]	6.06	5.23	4.46



black: Measured deuterons

red: Measured protons

blue: Measured tritons

The beam - Based on measurements in IS430 (2010)

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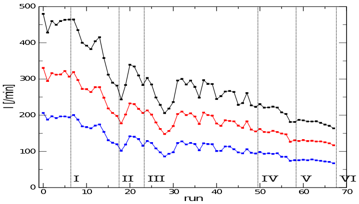

black: Measured deuterons

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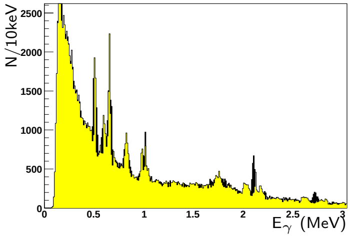
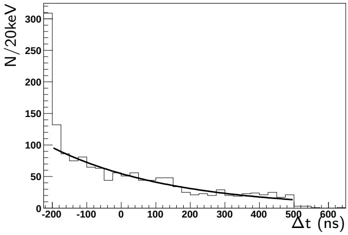
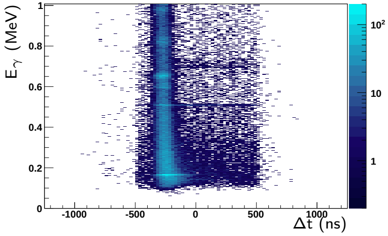
Beam contamination

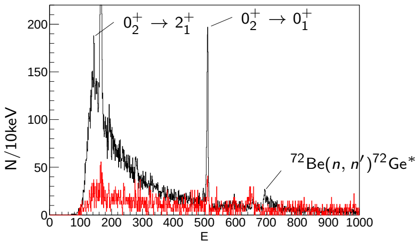
- ^{11}B - No indication in 2010
- ^{22}Ne - A possible contamination in 2010
- Isotopically enriched ^{20}Ne buffer gas
- Background runs without ^{11}Be

Gamma detection



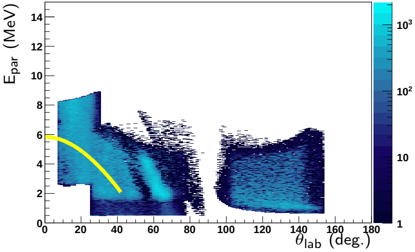


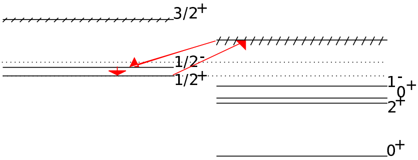




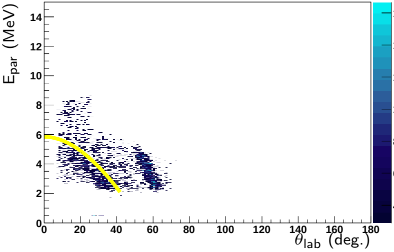
Neutron decay of ^{12}Be*

d(^{11}Be,p)^{12}Be

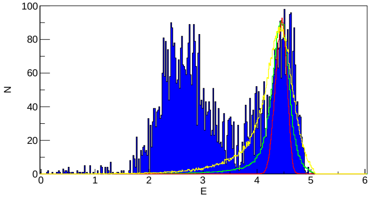




d(^{11}Be,pγ)^{12}Be

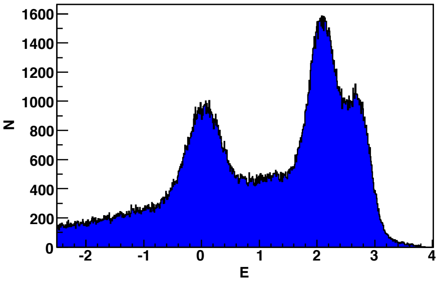


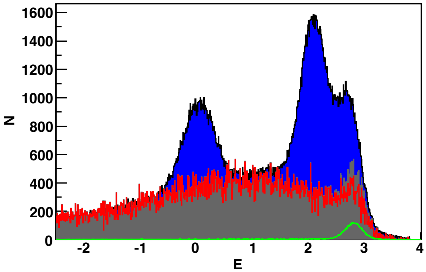
E^*



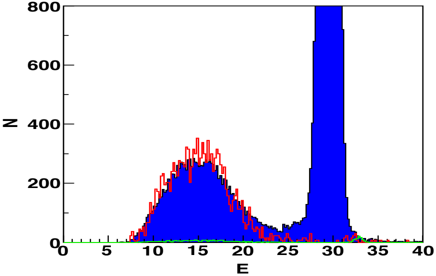
Beam contamination

E^*





E_{in} - coincidence

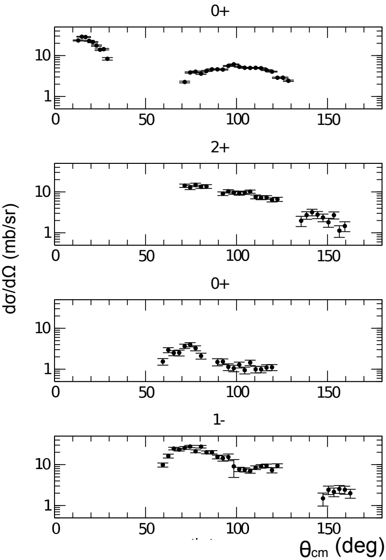


blue: CD_2 target

red: Pure C-target x 8.43/7.5

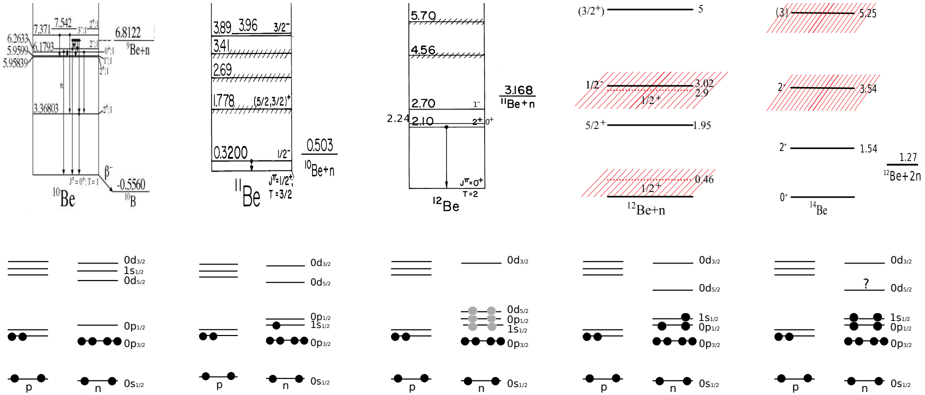
Beam intensity

- $N_{\text{tot}} = 1.11 \cdot 10^{12}$
- $I = 5 \cdot 10^{6}\ /s$
- $t = 2 \cdot 10^{5}$ s
- $t = 55.5$h
- $t = 7$ shifts



Neutron rich beryllium isotopes

^{10}**Be** ^{11}**Be** ^{12}**Be** ^{13}**Be** ^{14}**Be**



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- ^{2}H(^{12}Be,p)
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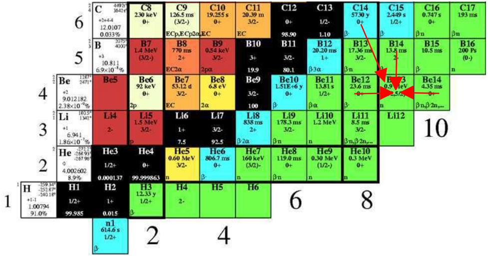

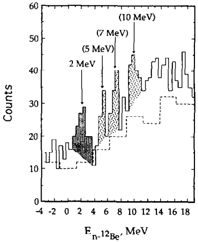

A.A. Korsheninnikov *et al.*, Phys.Lett. **B343**, 53 (1995)