Transfer reactions using a ^{11}Be beam

The IS430 experiment

Jacob S. Johansen

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Introduction

- Transfer reactions @ REX-ISOLDE.
- Low-energy beams ($<$3MeV/u).
- Single particle excitation.
- Spectroscopical factors.

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- Single particle excitation.
- Spectroscopical factors.

- Two experiments.
  - 2005: without γ-detection
  - 2009: With γ-detection
- 2.25/2.85 MeV/u ^{11}Be-beam.
- Study of bound states in neutron rich Be-nuclei (^{12}Be).

Outline

Energy levels in ^{12}Be

- 0.99 MeV _____ 1^-

- 1.43 MeV _____ 0^+

- 1.57 MeV _____ 2^+

-3.67 MeV _____ 0^+

Cluster description

C. Romero-Redondo et al., Phys Rev. C77 (2008) 054313

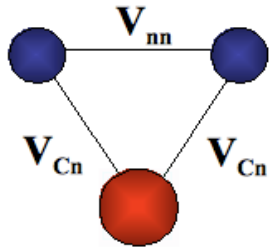
core + 2 neutrons

Inert core (0^+)

Excitations of neutrons

Mainly 2 body interactions

N = 8 shell breaking



S. Shimoura et al., Phys lett B560 (2007) 31

A. Navin et al., Phys. Rev. Lett, 85 (2000) 266

S. Pain et al., Phys. Rev. Lett. 96 (2006) 032502

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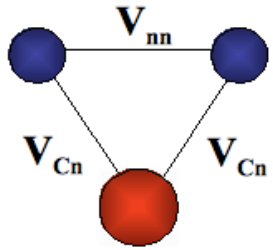

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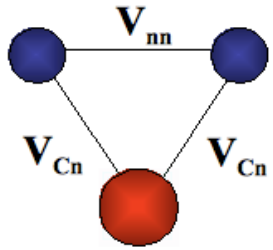

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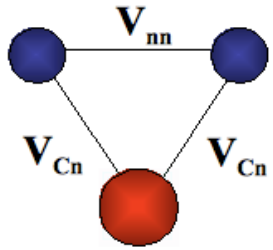

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Excitations of neutrons

Mainly 2 body interactions

N = 8 shell breaking

Break up measurements.

S. Shimoura et al., Phys lett B560 (2007) 31

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S. Pain et al., Phys. Rev. Lett. 96 (2006) 032502

Energy levels in ^{12}Be

$S_{s\text{-wave}}$

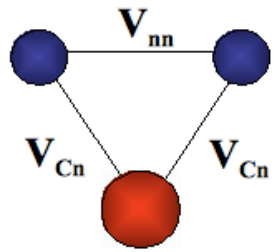
- 0.9 MeV ——— 0^-
- 0.99 MeV ——— 1^-

- 1.43 MeV ——— 0^+ $0.73^{+0.27}_{-0.40}$
- 1.57 MeV ——— 2^+ $0.10^{+0.09}_{-0.07}$

-3.67 MeV ——— 0^+ $0.28^{+0.03}_{-0.07}$

Cluster description

C. Romero-Redondo et al., Phys Rev. C77 (2008) 054313



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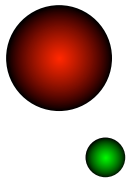
Transfer reactions

R. Kanungo et al., Phys. Lett. B682 (2009) 391

Transfer reactions with ^{11}Be + d



$^{11}\mathrm{Be}_{gs}$: $|^{10}\mathrm{Be}_{gs}\rangle\,|s_{1/2}\rangle$

$1/2^-$ ——————— - 183 keV

$1/2^+$ ——————— - 503 keV

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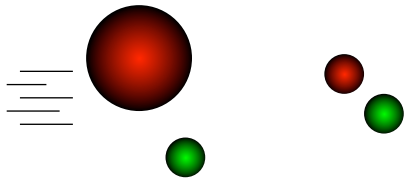

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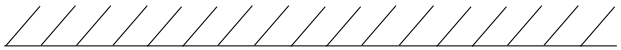

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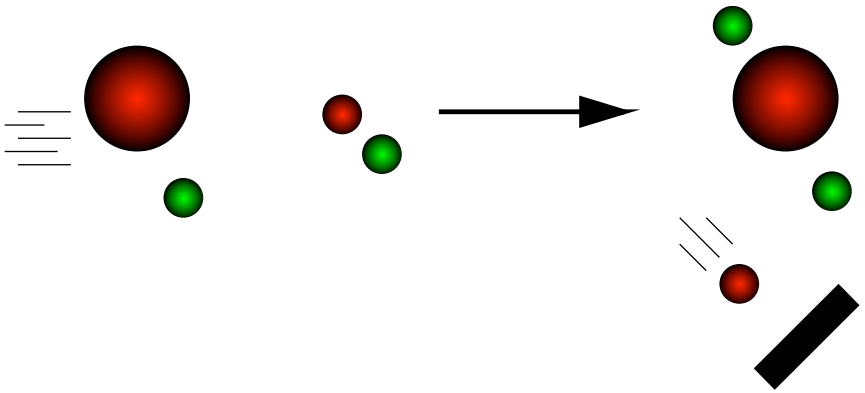
Transfer reactions with ^{11}Be + d

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



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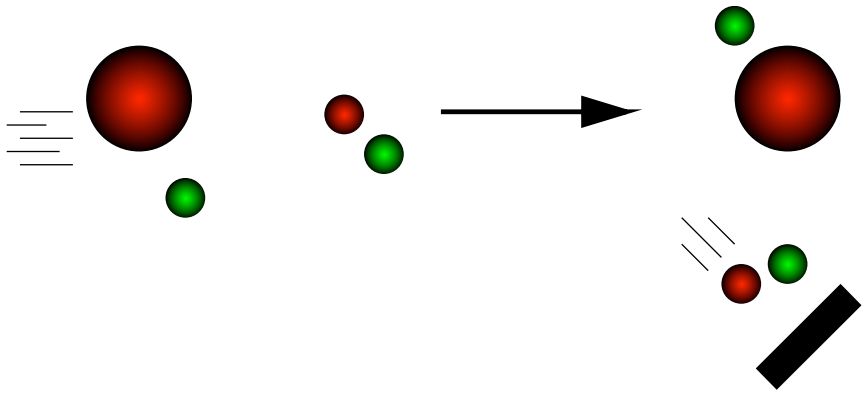

$^{11}Be_{gs}$: $|^{10}Be_{gs}\rangle\,|s_{1/2}\rangle$

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Transfer reactions with ^{11}Be + d

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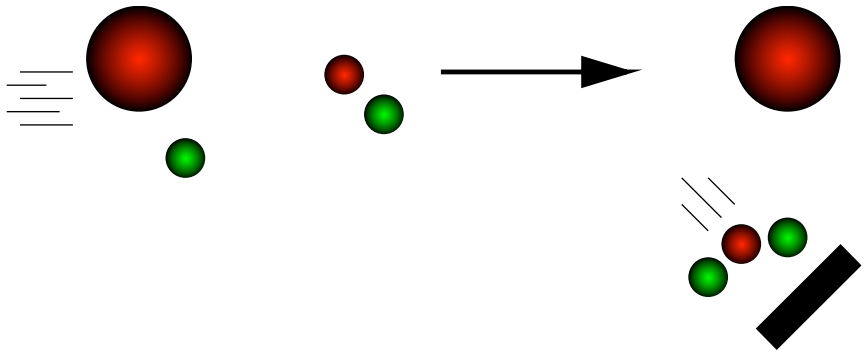

$^{11}Be_{gs}$: $|^{10}Be_{gs}\rangle\,|s_{1/2}\rangle$

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Transfer reactions with ^{11}Be + d

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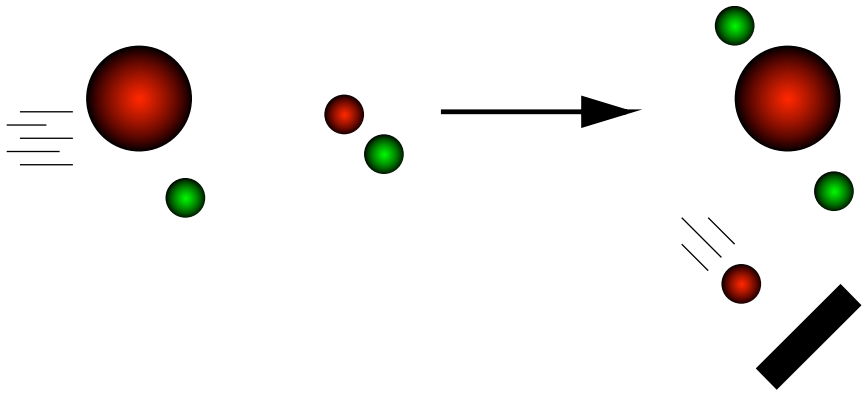

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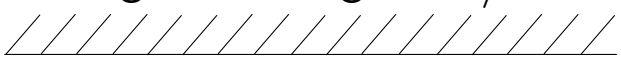


$1/2^-$ ——— - 183 keV

$1/2^+$ ——— - 503 keV

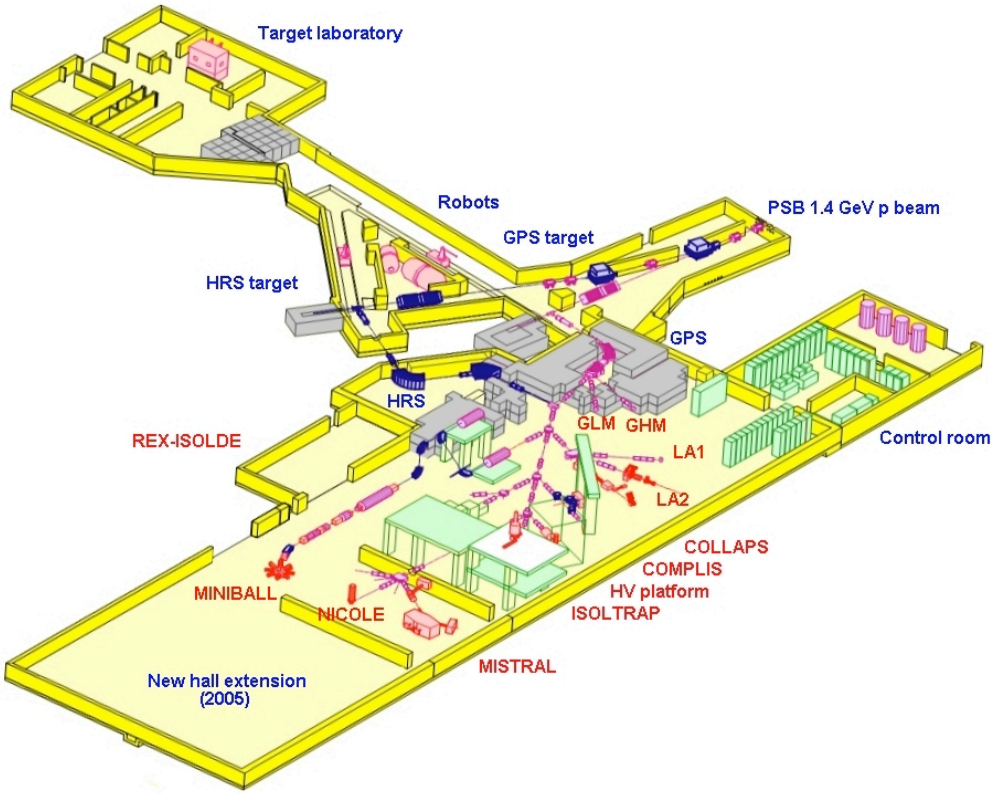
$E_{beam} = 3MeV/u \Rightarrow L_{max} = 3/2$

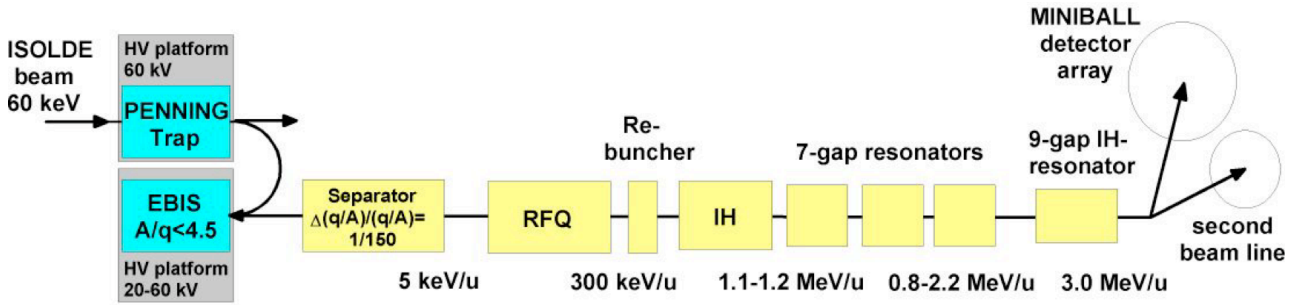
Reaction favours:

$|^{10}Be_{gs}\rangle\,|s_{1/2}\rangle\,|p_{1/2}\rangle\,(1^-$ and $0^-)$

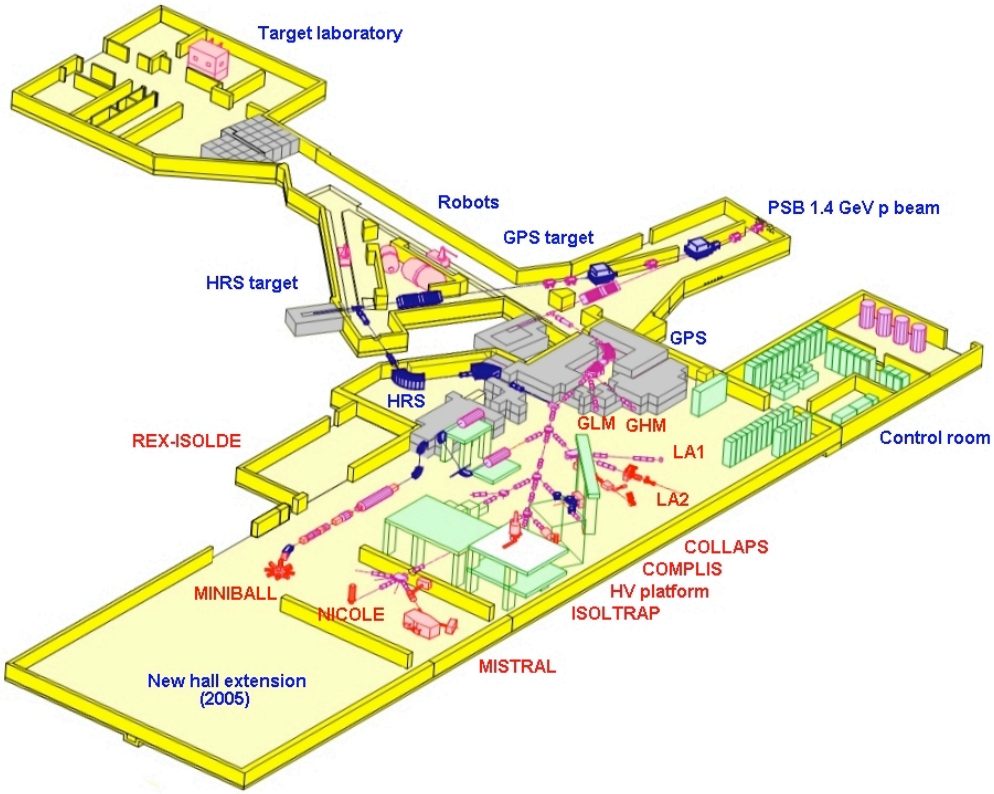
$|^{10}Be_{gs}\rangle\,|s_{1/2}\rangle\,|s_{1/2}\rangle\,(0^+)$

ISOLDE


Target laboratory
Robots
PSB 1.4 GeV p beam
GPS target
HRS target
GPS
HRS
GLM
GHM
LA1
LA2
REX-ISOLDE
Control room
COLLAPS
COMPLIS
HV platform
ISOLTRAP
MINIBALL
NICOLE
MISTRAL
New hall extension
(2005)


ISOLDE
beam
60 keV
HV platform
60 kV
PENNING
Trap
EBIS
A/q<4.5
HV platform
20-60 kV
Separator
Δ(q/A)/(q/A)=
1/150
RFQ
Re-
buncher
IH
7-gap resonators
9-gap IH-
resonator
MINIBALL
detector
array
second
beam line
5 keV/u
300 keV/u
1.1-1.2 MeV/u
0.8-2.2 MeV/u
3.0 MeV/u

ISOLDE

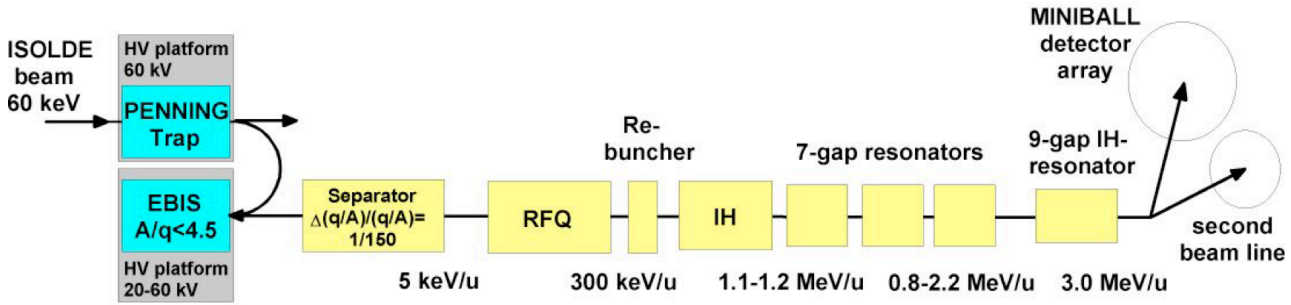


Beam:

- ^{11}Be.
- 2.25/2.85 MeV/u.
- $10^4 - 10^5 / \sim 10^5$ /s

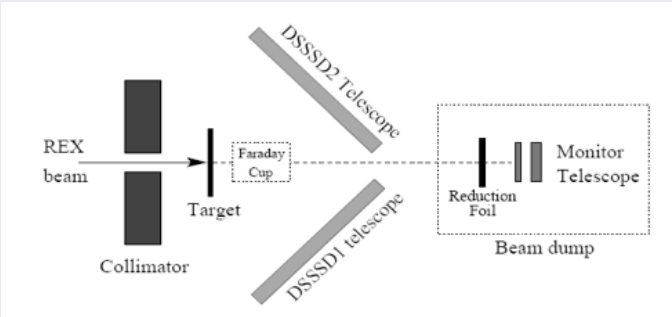
Target:

- Deuterated polyethylene.
- Polyethylene (background).
- Silver (Beam intensity).



Setups

2005



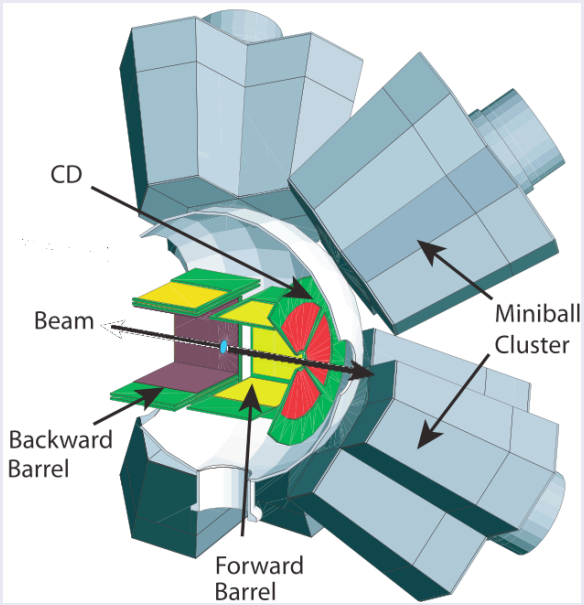
Detectors

32 x 32 DSSSD's (60 μm).

1500 μm Si-detectors.

$\theta_{\text{lab}} = 10^\circ - 80^\circ$ $(130^\circ - 160^\circ$ Kanungo et al.$)$

2009



Barrel

16 strips Si-detectors (140 μm).

1000 μm Si-detectors.

CD

16x16 strips Si-detectors (500 μm).

500 μm Si-detectors.

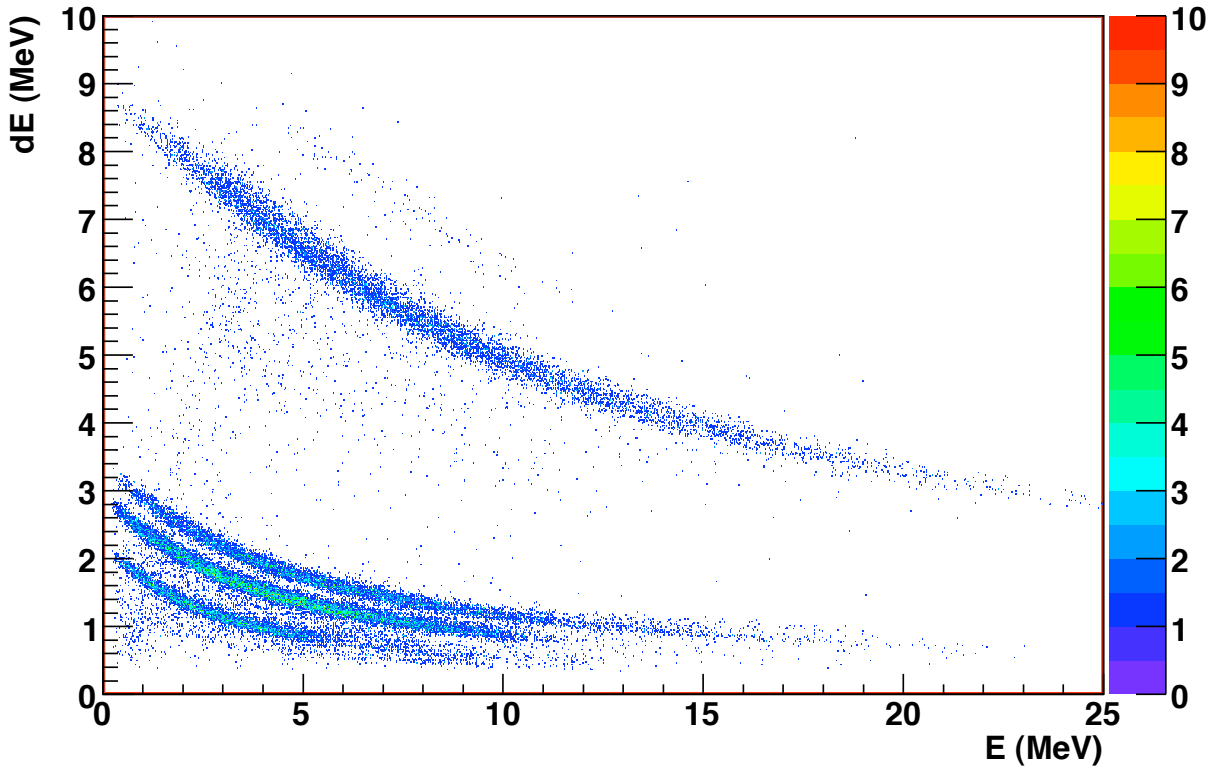
miniball

144 Ge-detectors.

8 clusters. (1 broken)

2005: Particle identification

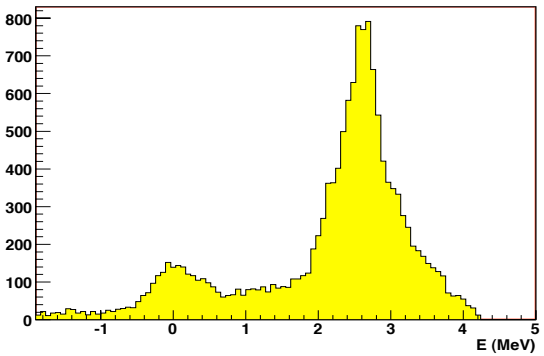
Δ E vs. E



- ^{12}Be + p
- ^{11}Be + d
- ^{10}Be + t
- ^{4}He, ^{6}He

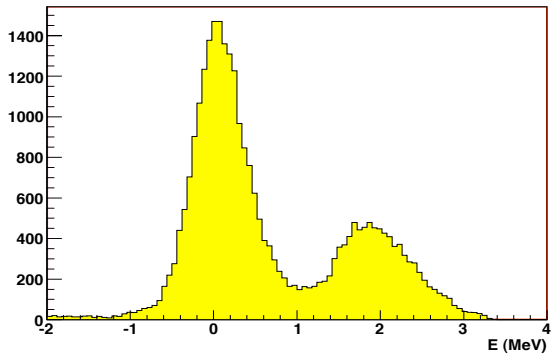
2005: Energy spectra

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



E (MeV)	J^π
0	0^+
2.1	2^+
2.24	0^+
2.68	1^-

$d(^{11}Be,d)^{11}Be$



E (MeV)	J^π
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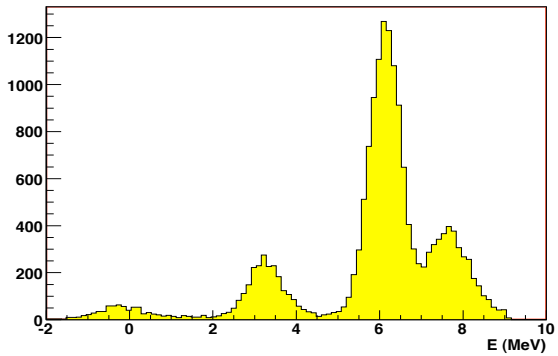
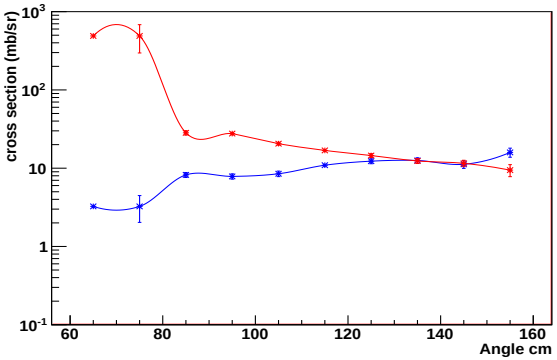
$d(^{11}Be,t)^{10}Be$



E (MeV)	J^π
0	0^+
3.368	2^+
5.958	2^+
5.960	1^-
6.179	0^+
6.263	2^-

2005: Cross sections

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



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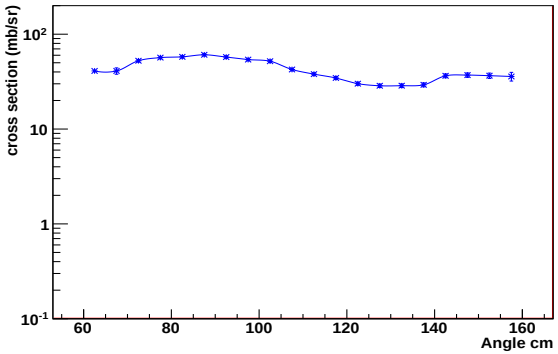

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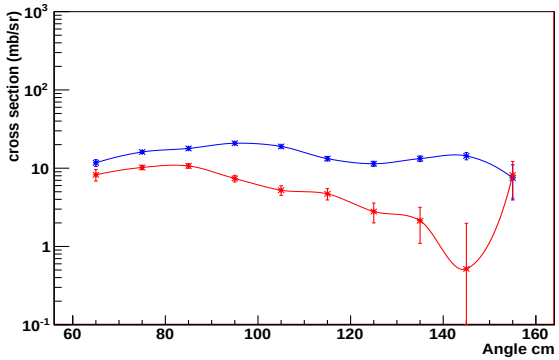

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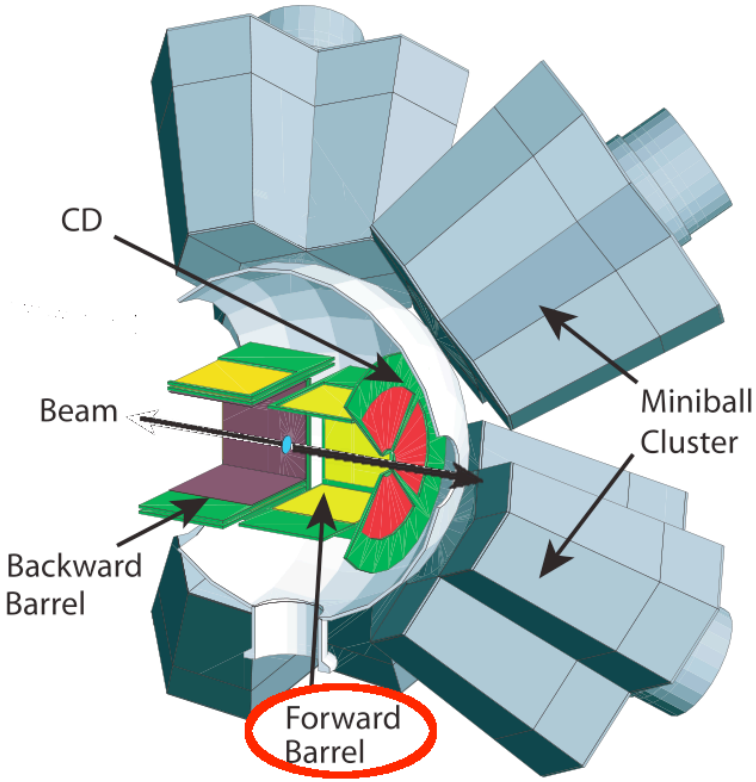
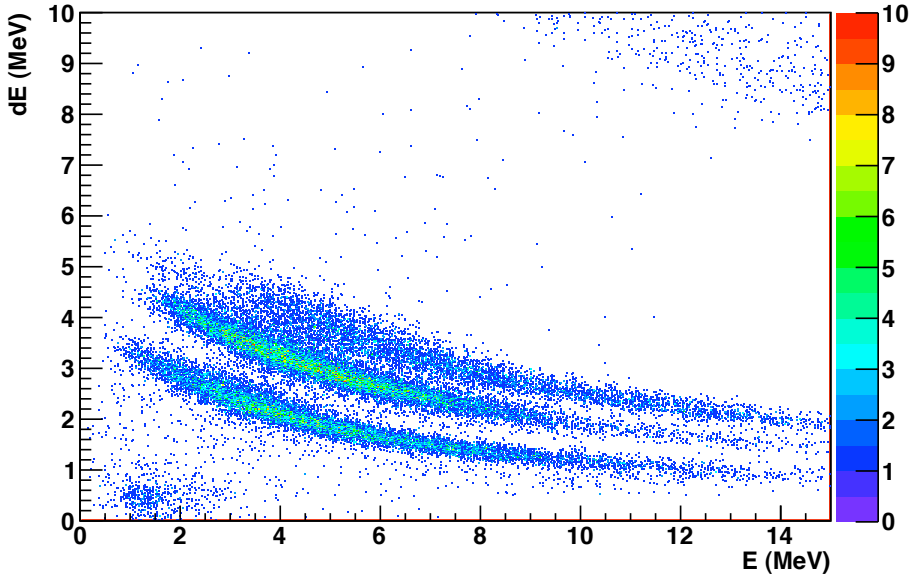
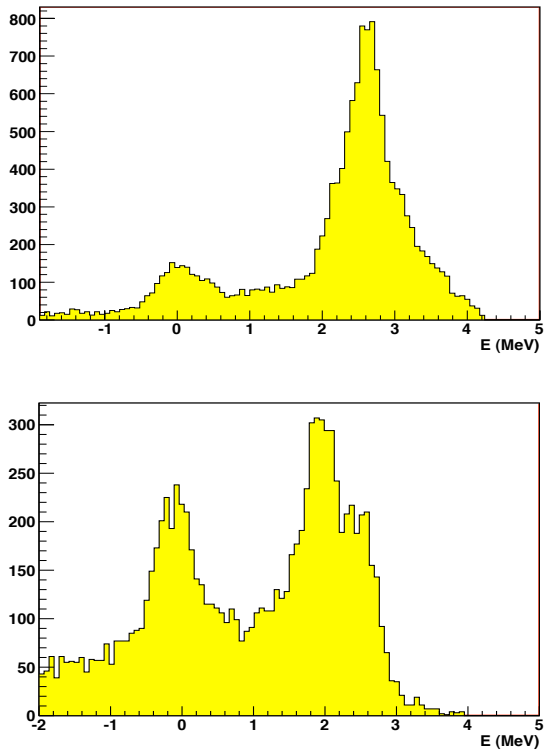


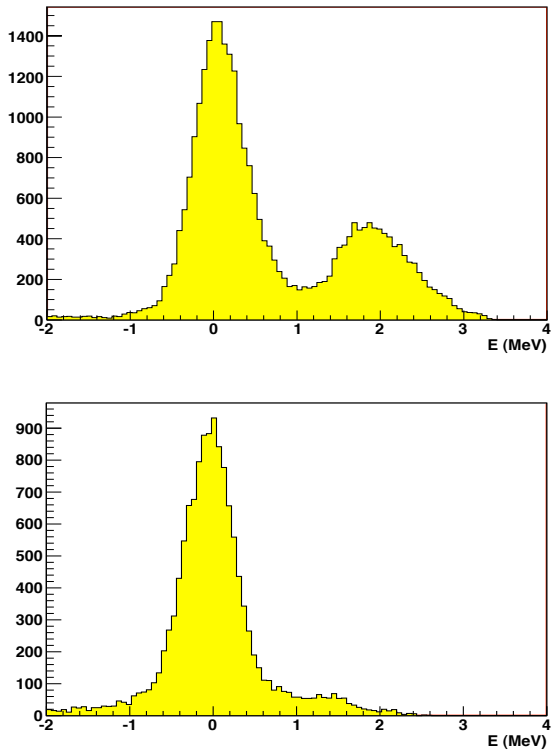


Excitation spectra. PRELIMINARY

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



$d(^{11}Be,d)^{11}Be$



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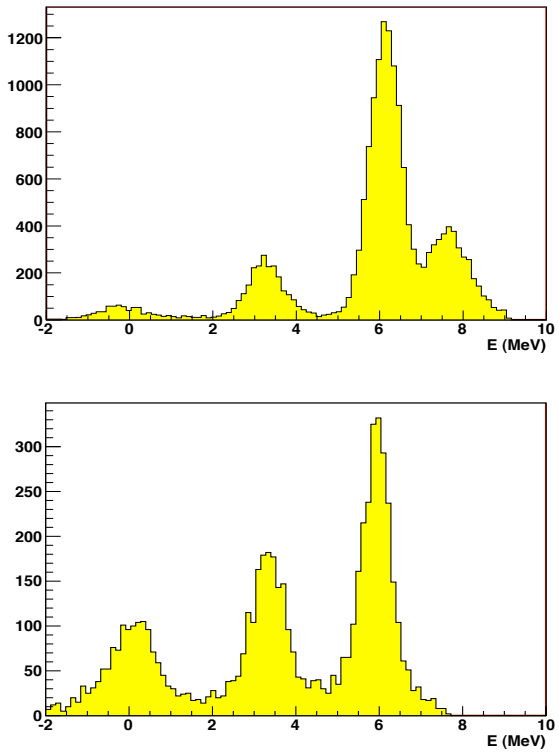
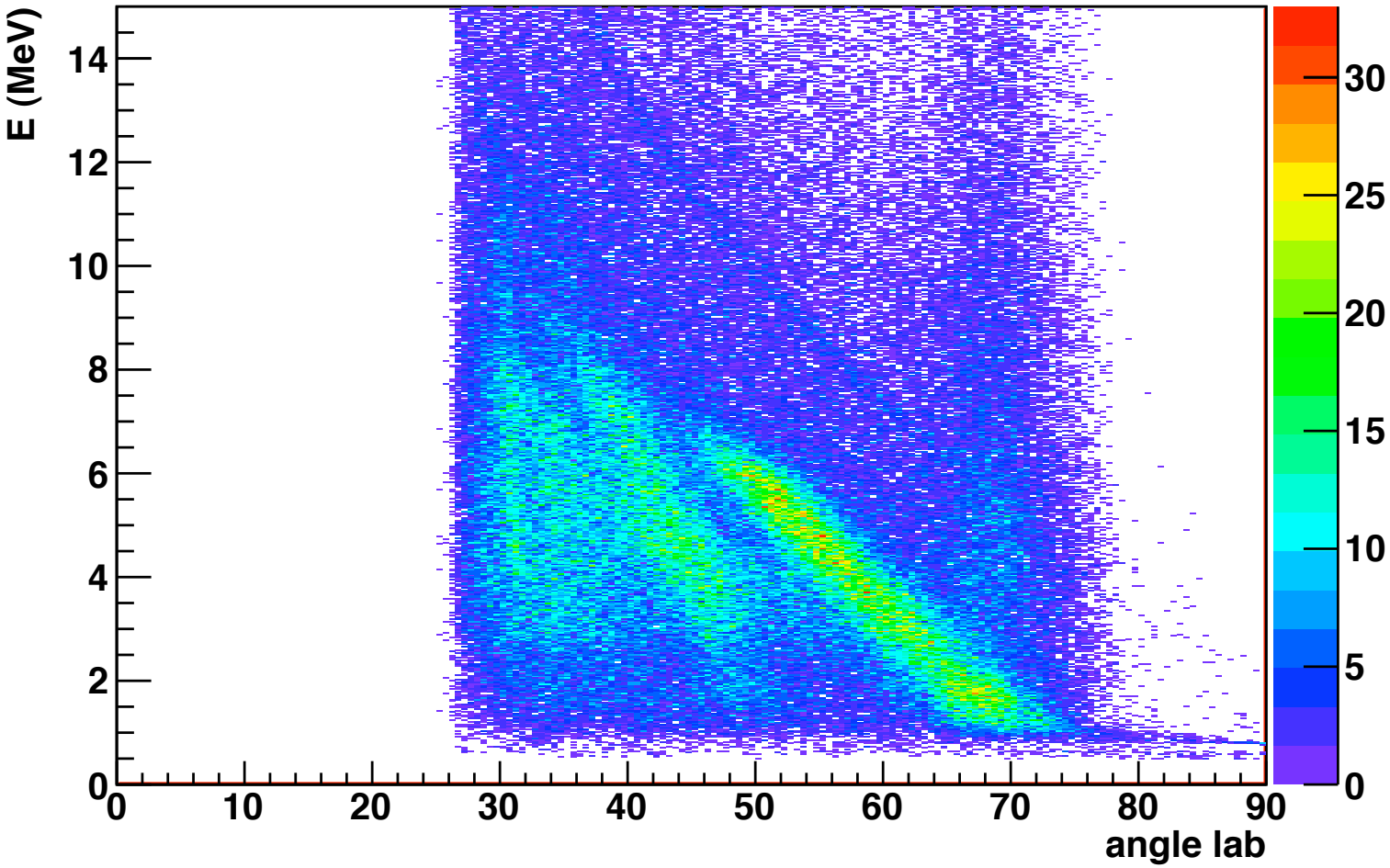
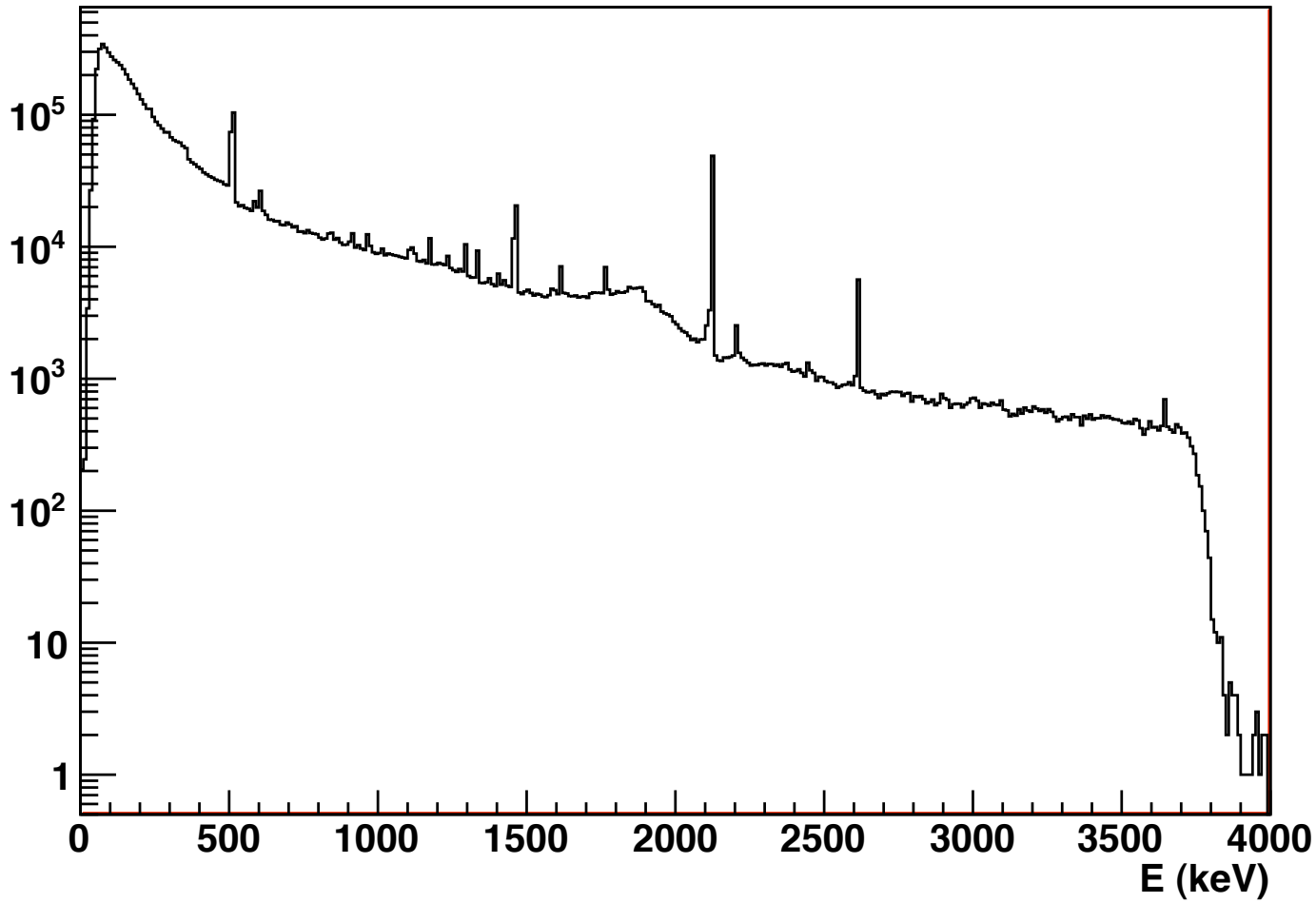


- θ_{lab}: 10° - 80°/25° - 75°
- Detector thickness: 60 μm/140 μm

Particles stopped in strip detectors. PRELIMINARY

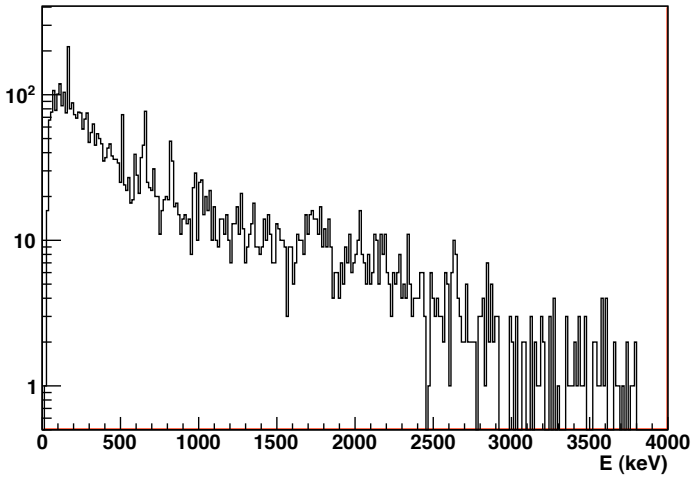


γ-spectra. PRELIMINARY

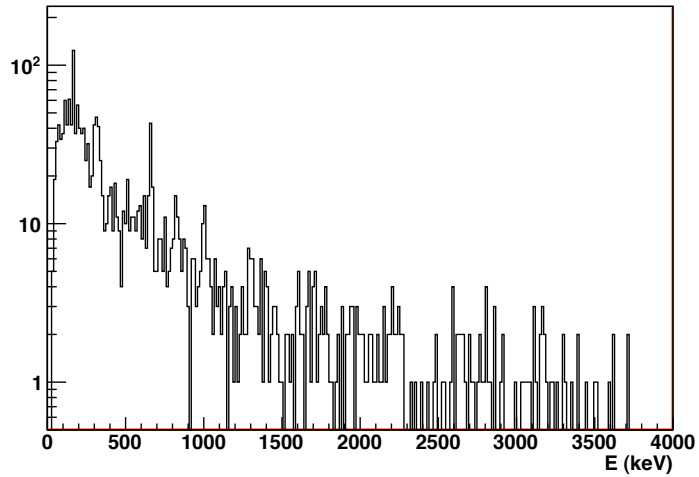


γ-spectra. PRELIMINARY

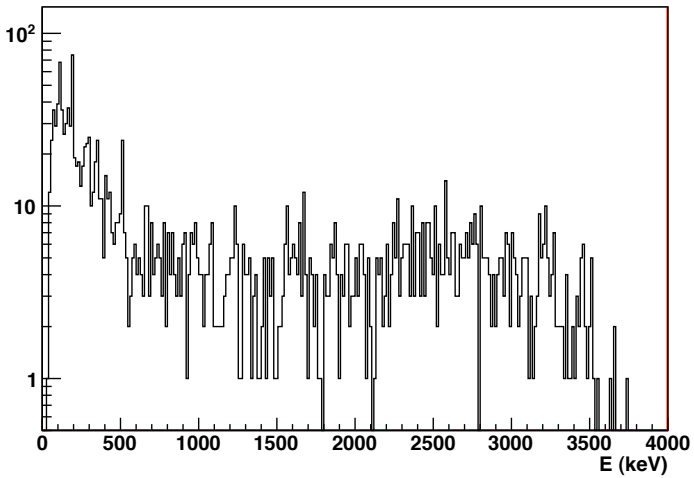
^{12}Be



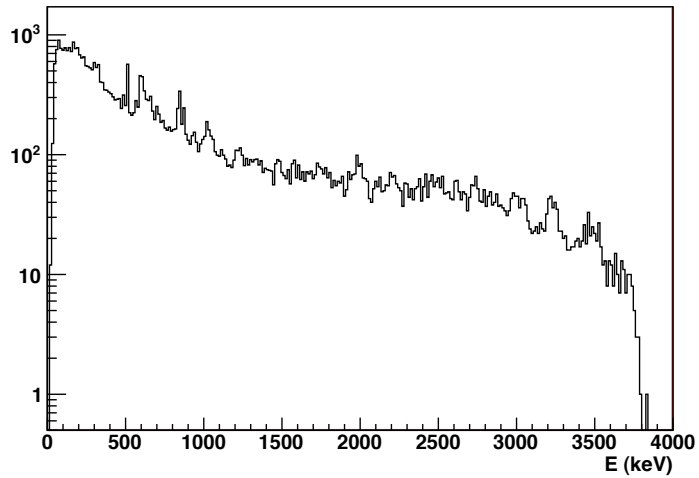
^{11}Be



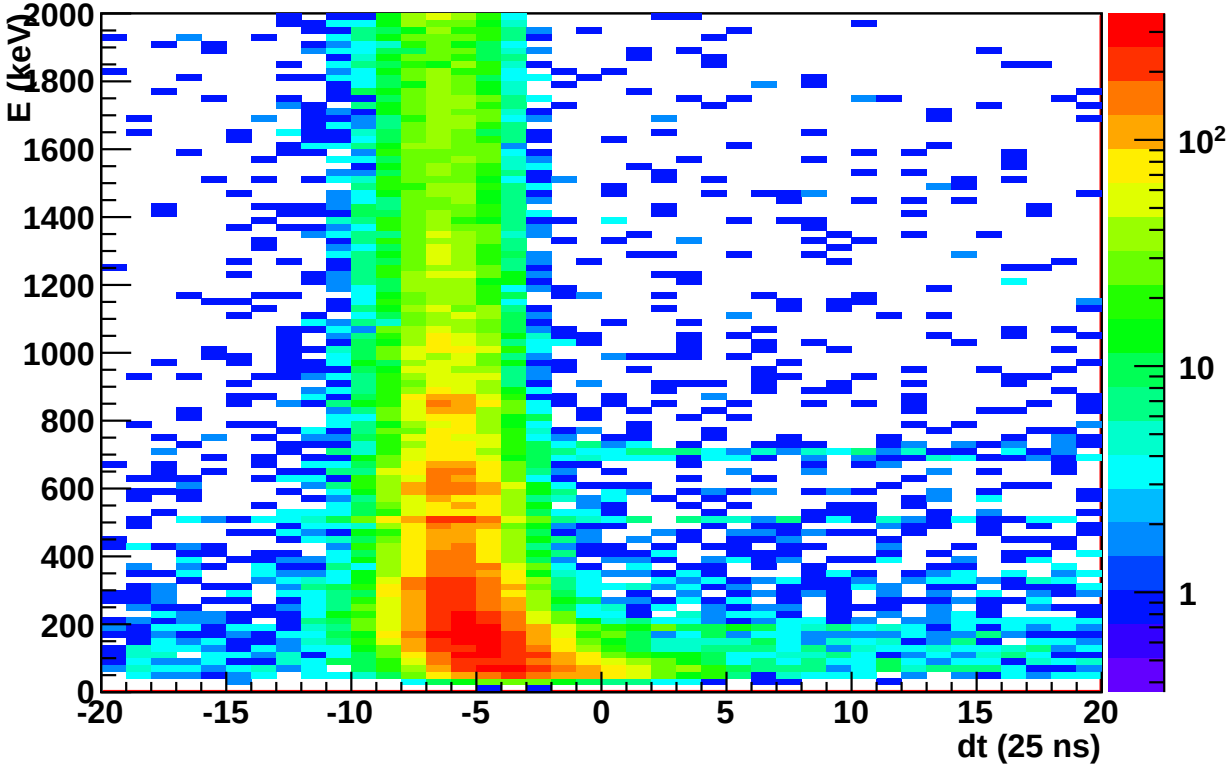
^{10}Be



Particles stopped in strip detectors



Neutron detection. PRELIMINARY

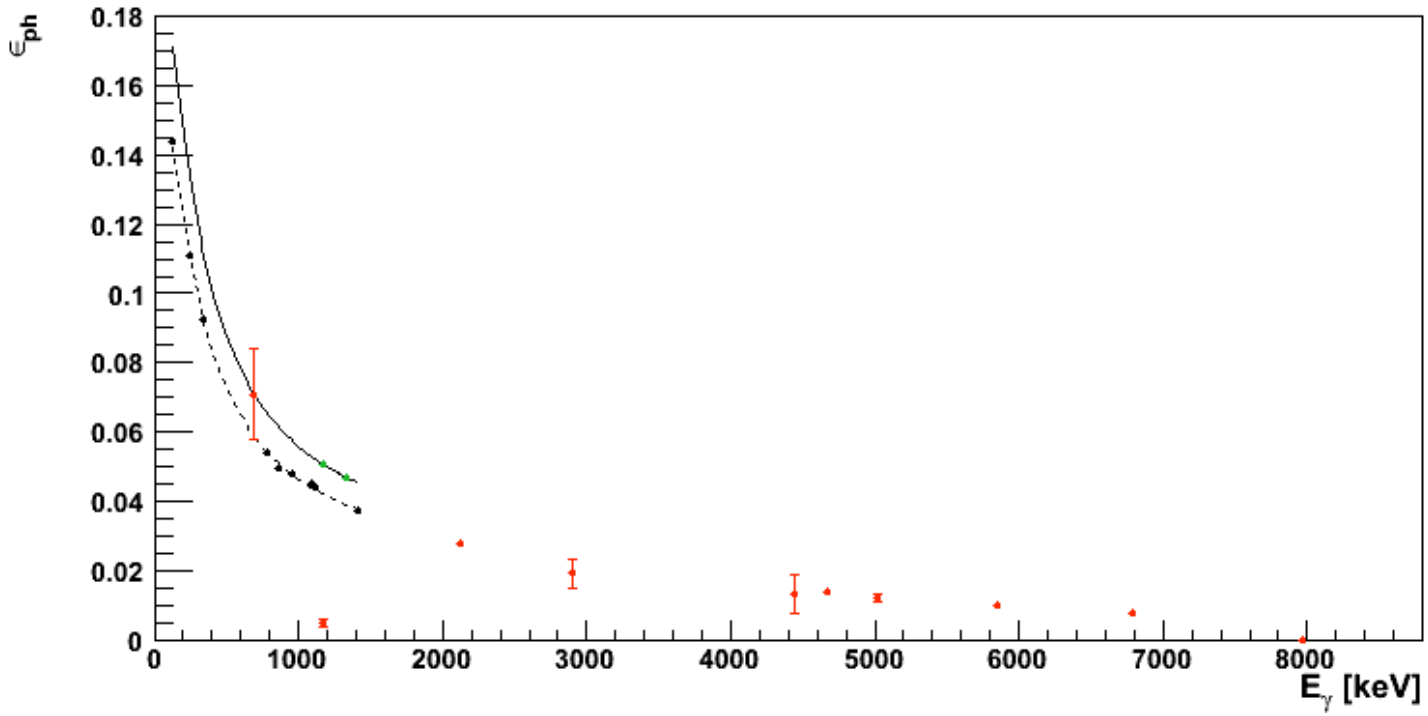


$^{72}\mathrm{Ge}(n, n'e^-)$

D. G. Jenkins et al., Nucl. Instr. A602 (2009) 457-460

Efficiency calibration. PRELIMINARY

- Target: 200 μm Al.
- γ-decay of ^{11}B.



Black: ^{152}Eu. Green: ^{60}Co. Red: ^{11}Be.

Summary and outlook

Summary

- 1p + sd degeneracy in ^{11,12}Be.
- Low energy transfer reactions.
  - Single particle excitations.
  - Distinction between 0^+_1 and 0^+_2.
- 2005:
  - Cross sections.
- 2009:
  - Preliminary results.
  - Neutron detection with MINIBALL.
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Summary and outlook

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Outlook

- Repeat Miniball experiment.
- ^{13}Be
  - ^{12}Be + d
  - ^{11}Be + t (t(^{30}Mg,p)^{32}Mg (IS470))

The is430 collaboration

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Thanks to the MINIBALL collaboration

Thank you