Nordic Winter Meeting on Physics @ FAIR

21-26 March 2010, Björkliden, Sweden

A complete kinematics approach to study multi-particle final state reactions

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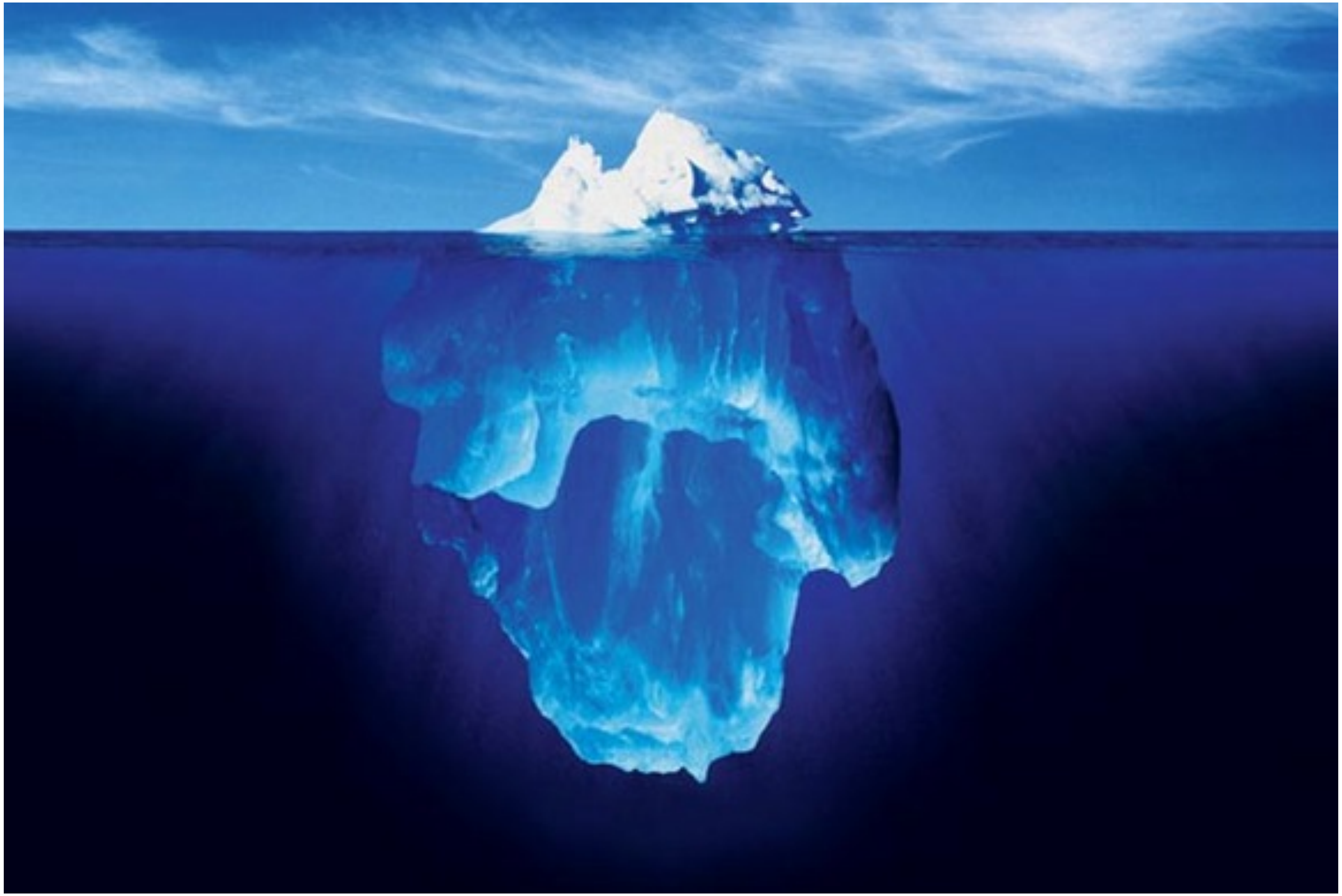
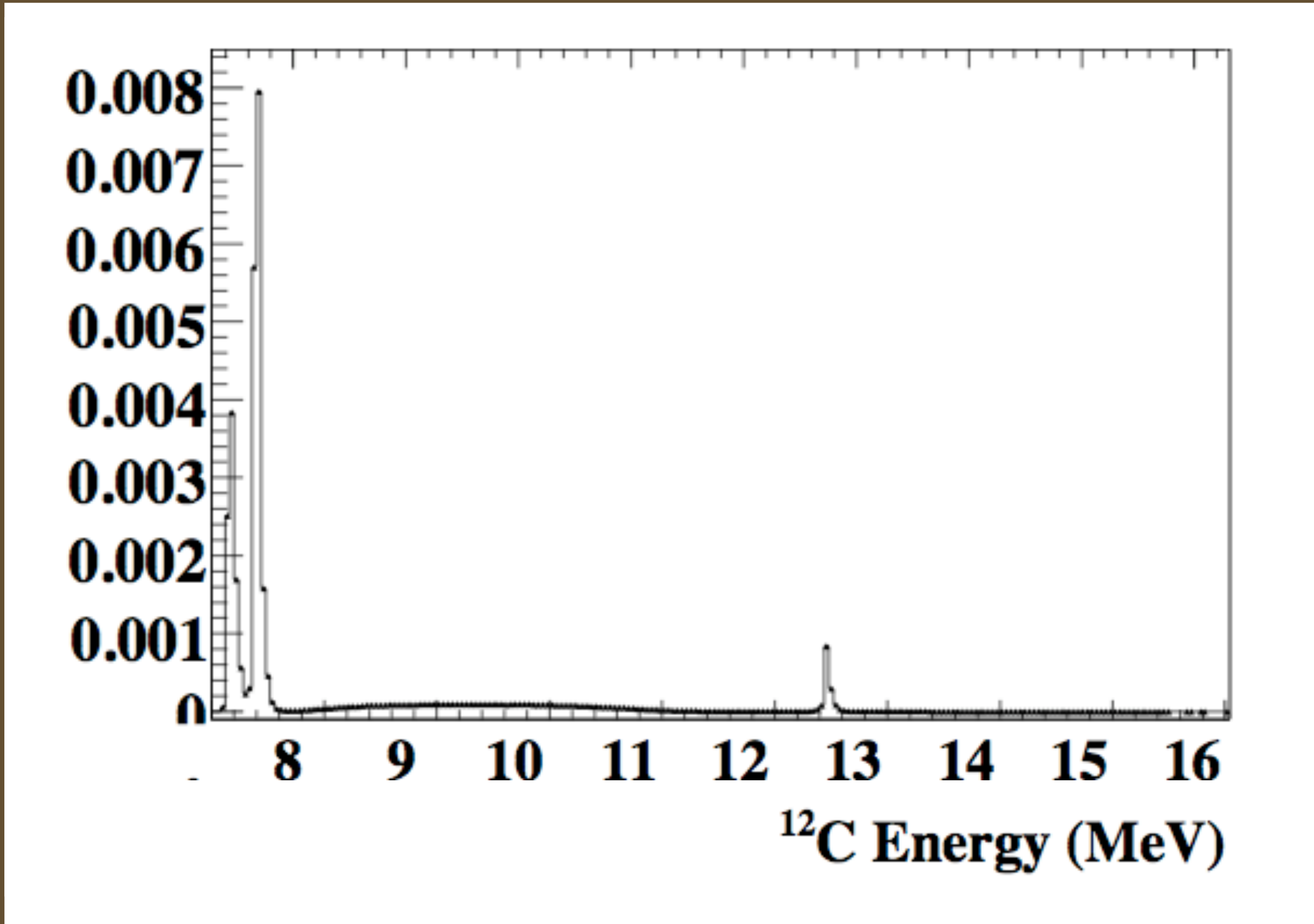
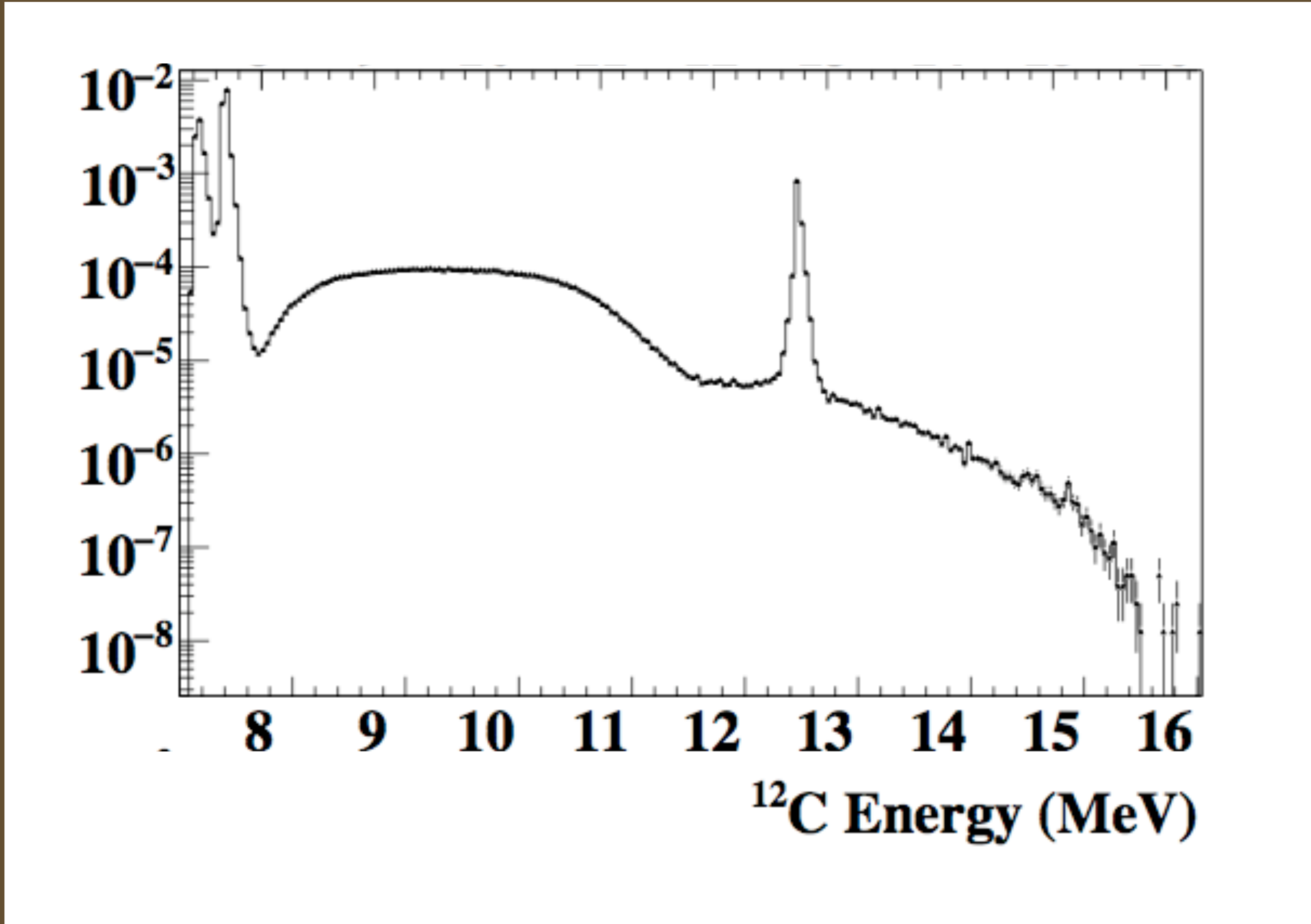


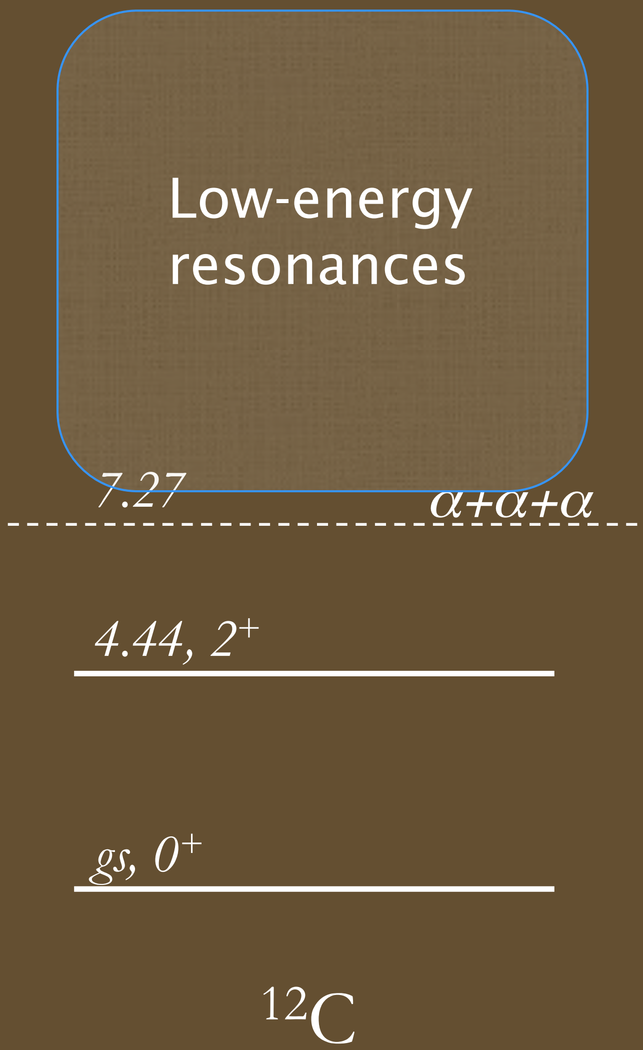
^{12}N β decay

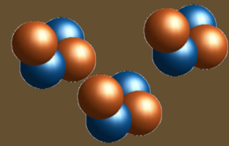


^{12}N β decay



Why study ^{12}C ?

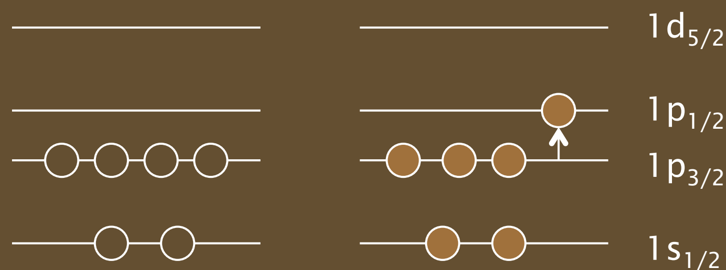




α-cluster states

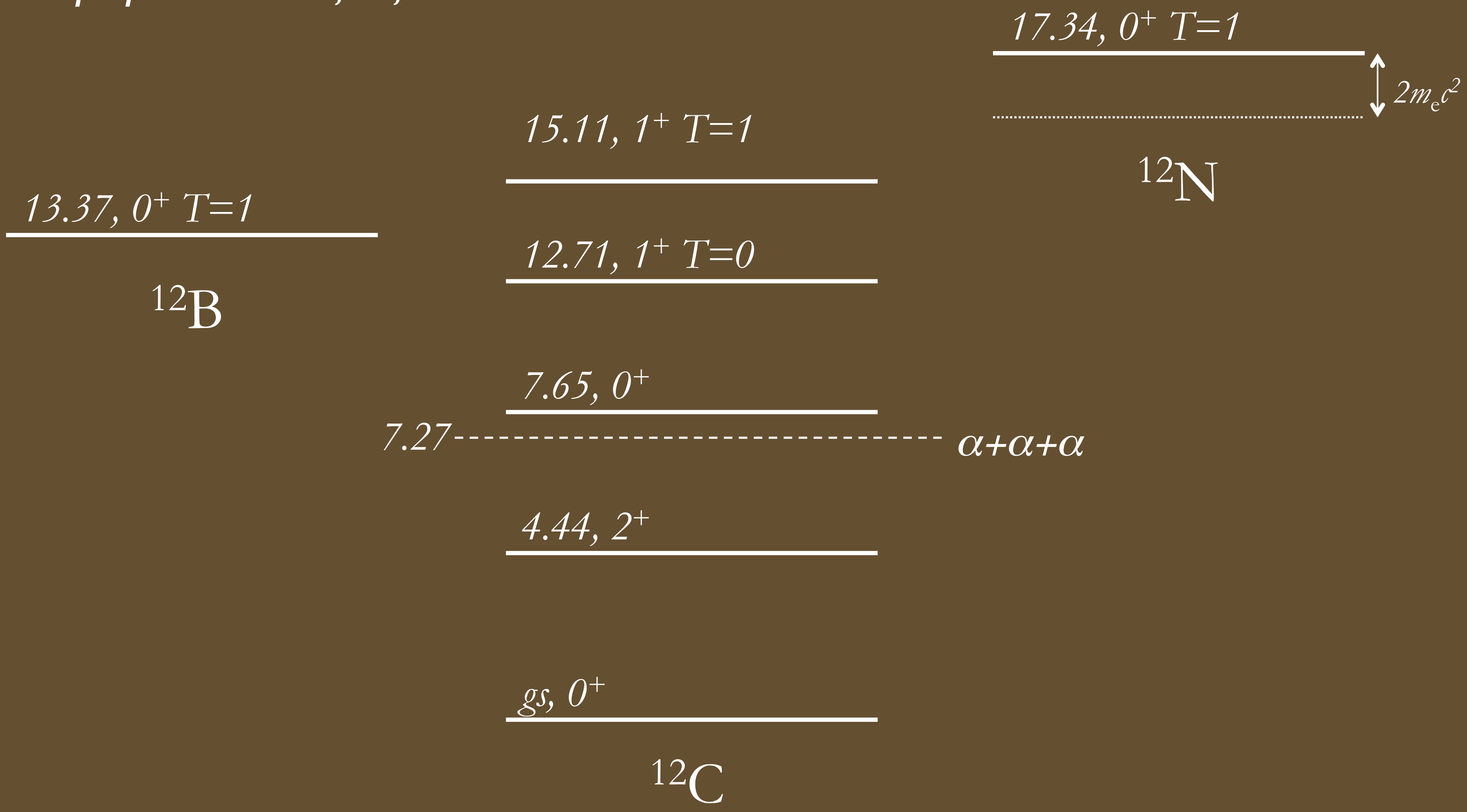
+

shell model states



1st approach: β decay

populates $0^+,1^+,2^+$



S. Hyldegaard *et al.*, PRC 81, 024303 (2010)

2^{nd} approach: Reactions

$$^{3}\mathrm{He} + {}^{10}\mathrm{B} \longrightarrow p + {}^{12}\mathrm{C}^{*}$$

$Q = 19.7$ MeV

$E_{\mathrm{beam}} = 4.9$ MeV

$$^{3}\mathrm{He} + {}^{11}\mathrm{B} \longrightarrow d + {}^{12}\mathrm{C}^{*}$$

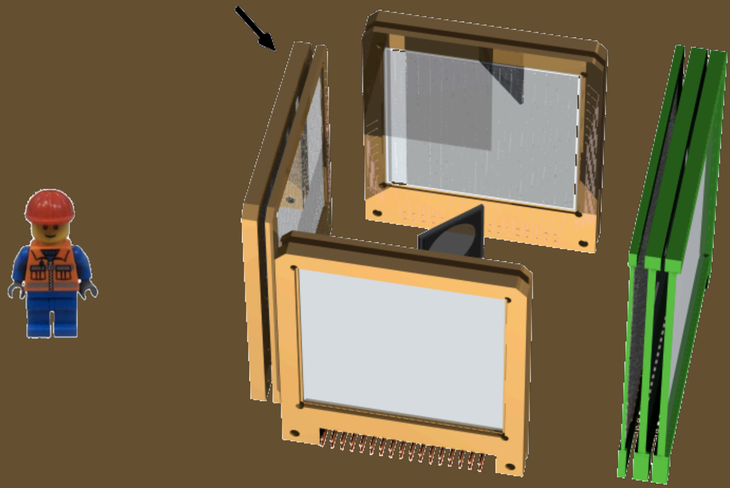
$Q = 10.5$ MeV

$E_{\mathrm{beam}} = 8.5$ MeV

Experimental setup

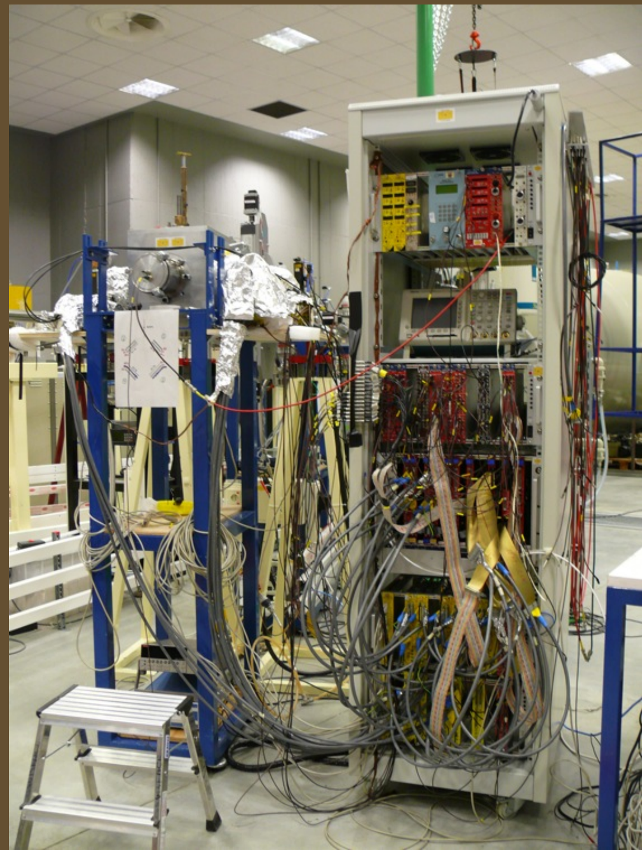
^{3}He beam

60 μm 16x16 DSSSD
+
1.5 mm Si pad



Plaza Major
(March 2008)

Madrid, Spain

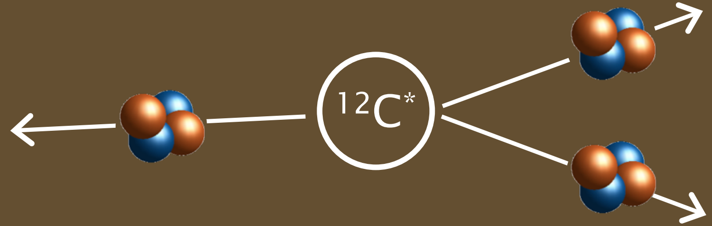


Centro de Microanálisis de Materiales (CMAM)

M. Alcorta *et al.*, NIM A 605, 318 (2009)

3α breakup of ^{12}C

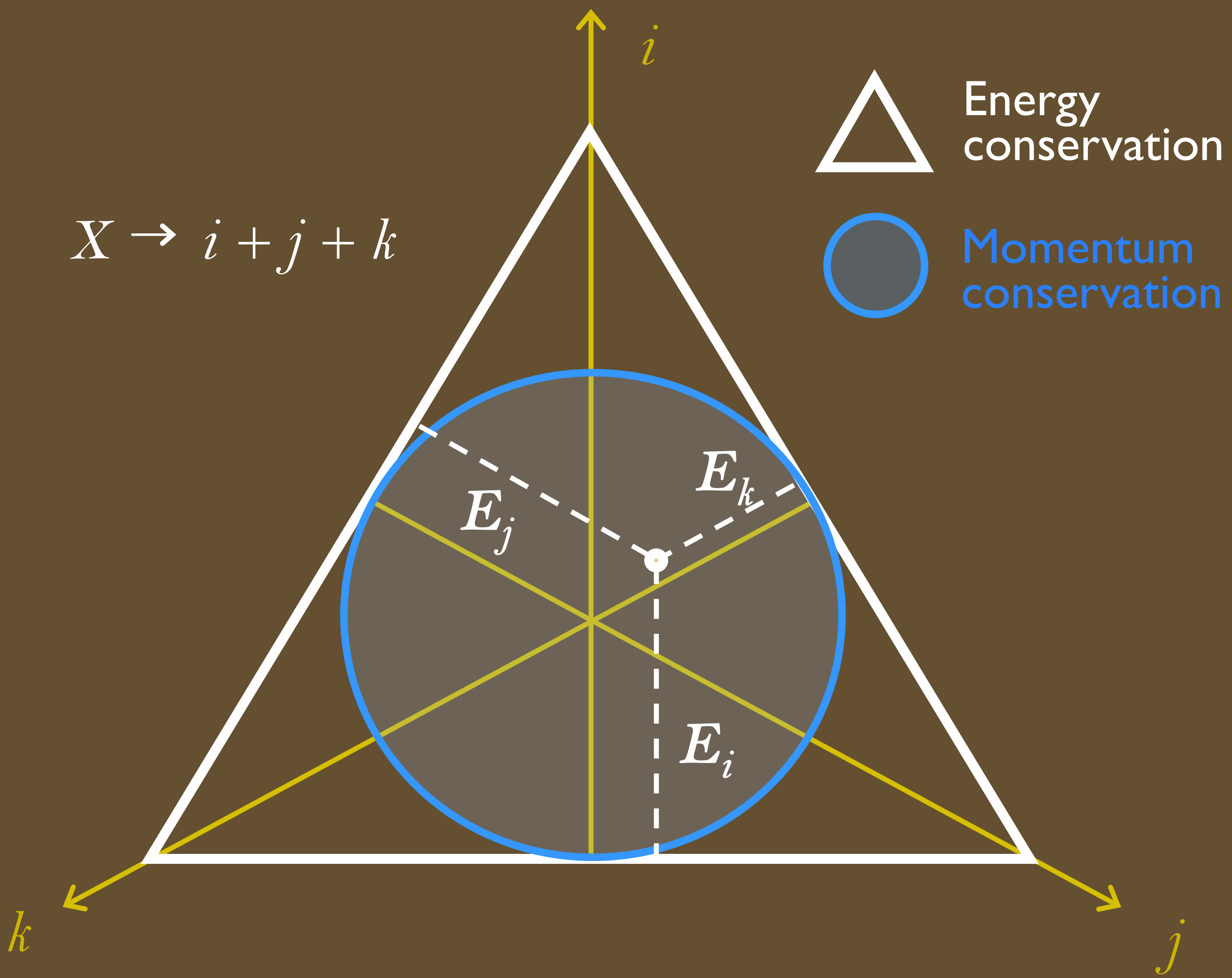
What (if anything) can we learn about the structure of ^{12}C resonances from the energy distribution of the α particles ?



Decay dynamics

- two-body resonances
- interference
- tunneling
- ...

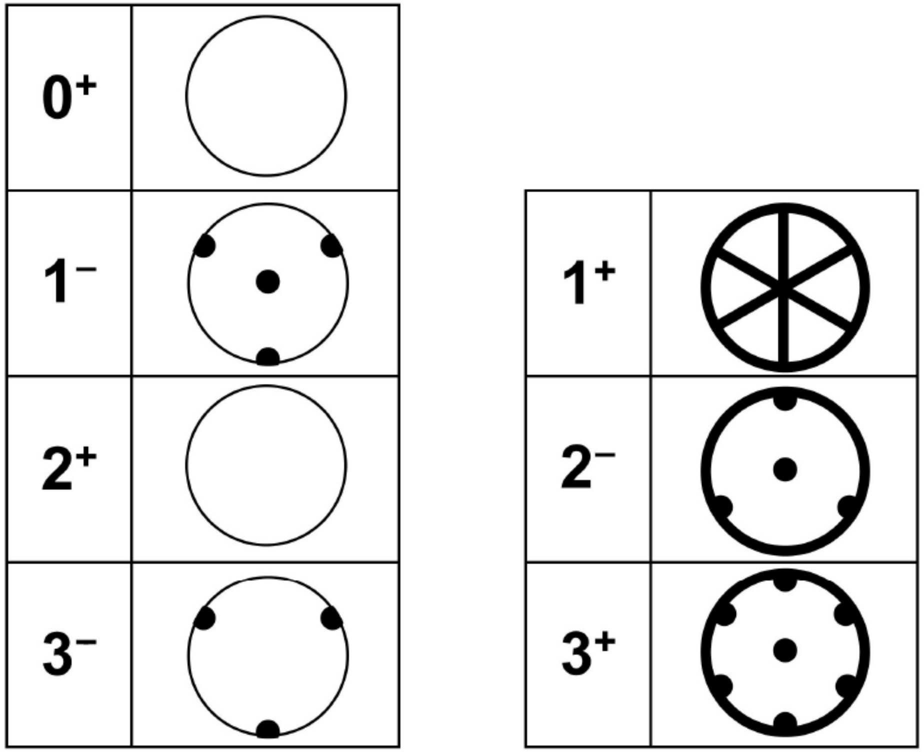
The Dalitz plot



R. H. Dalitz, Philos. Mag. 44, 1068 (1953)

Constraints from symmetries

Regions of vanishing intensity



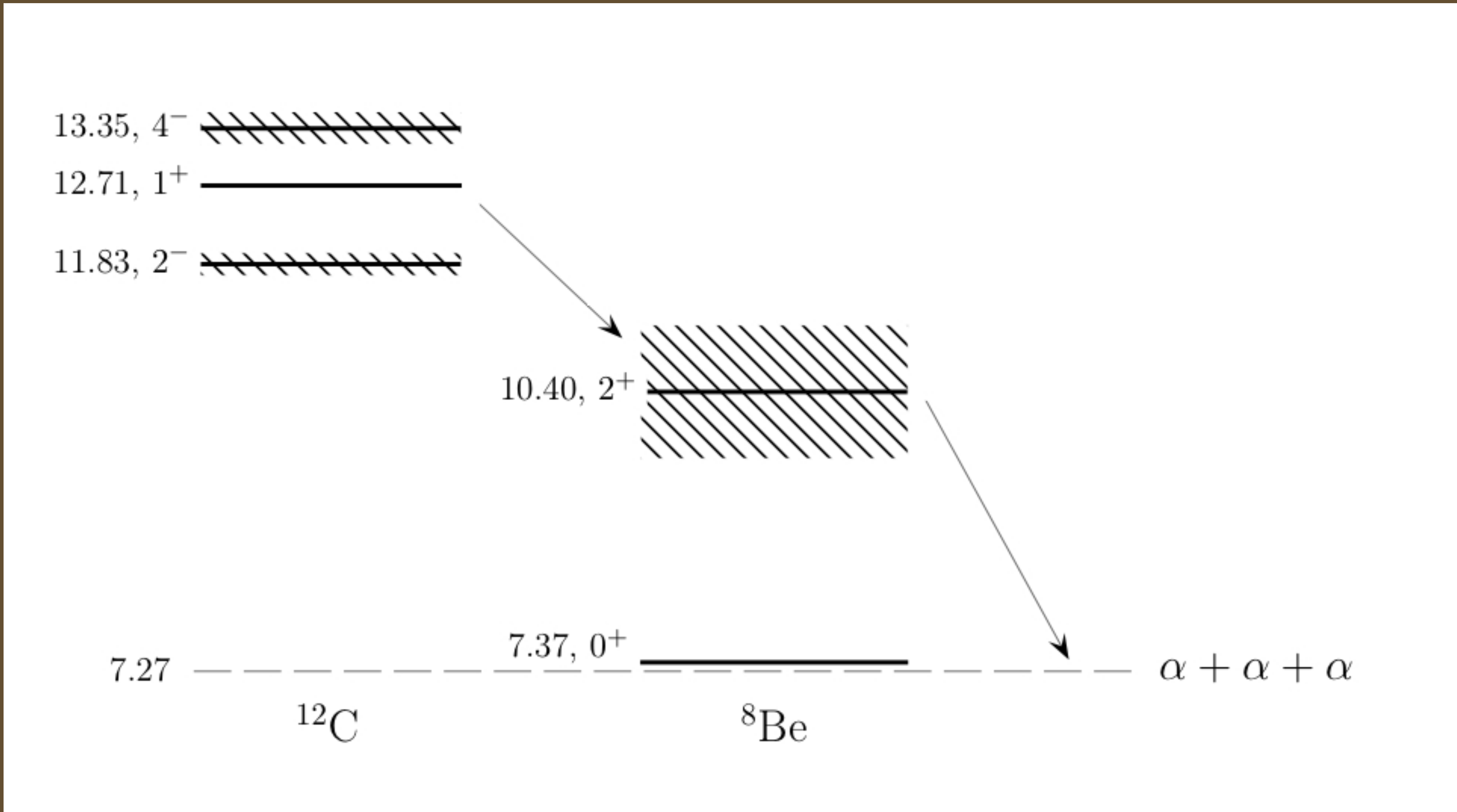
Spin-parity conservation

+

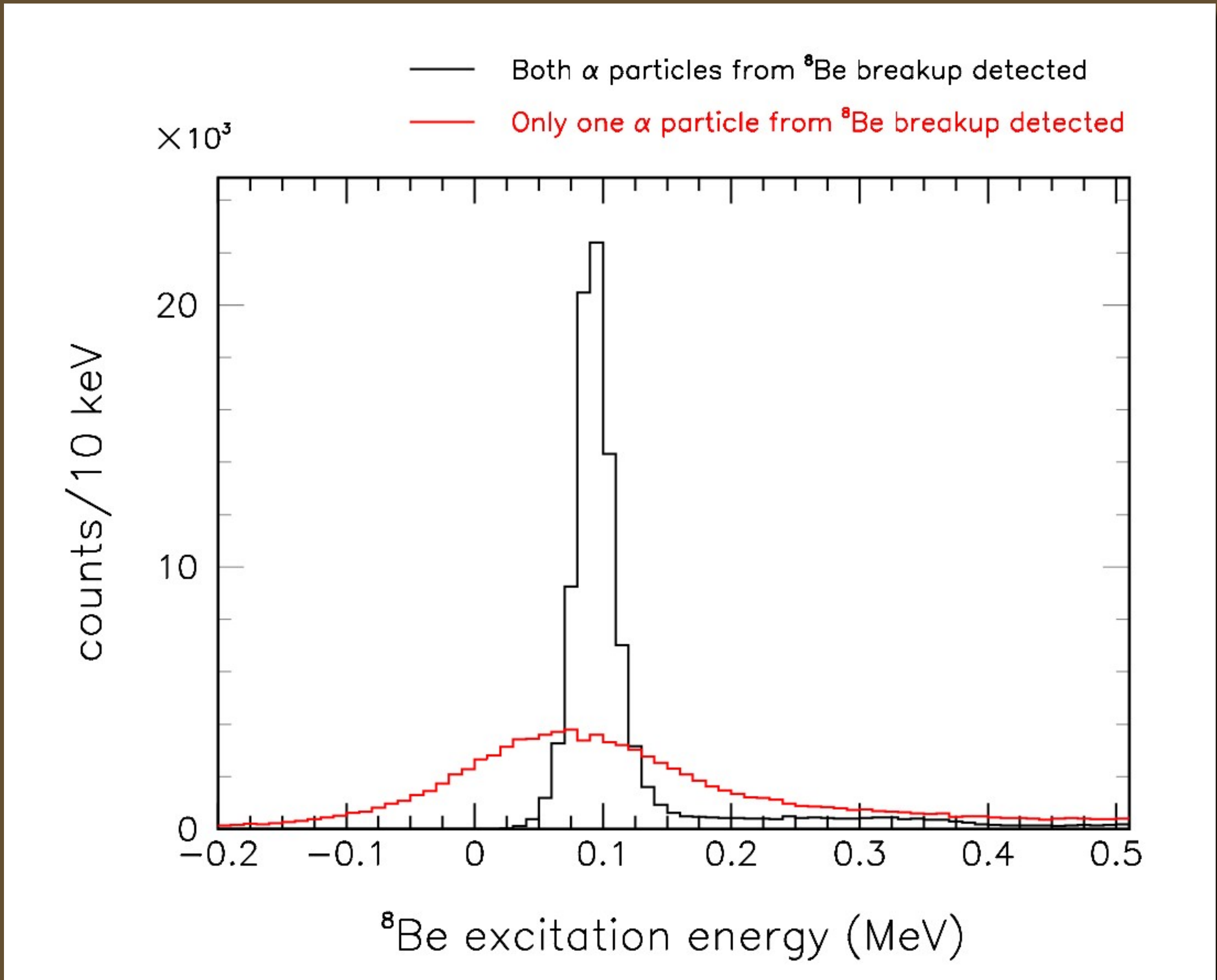
Bose statistics

C. Zemach, Phys. Rev. 133, B1201 (1964)

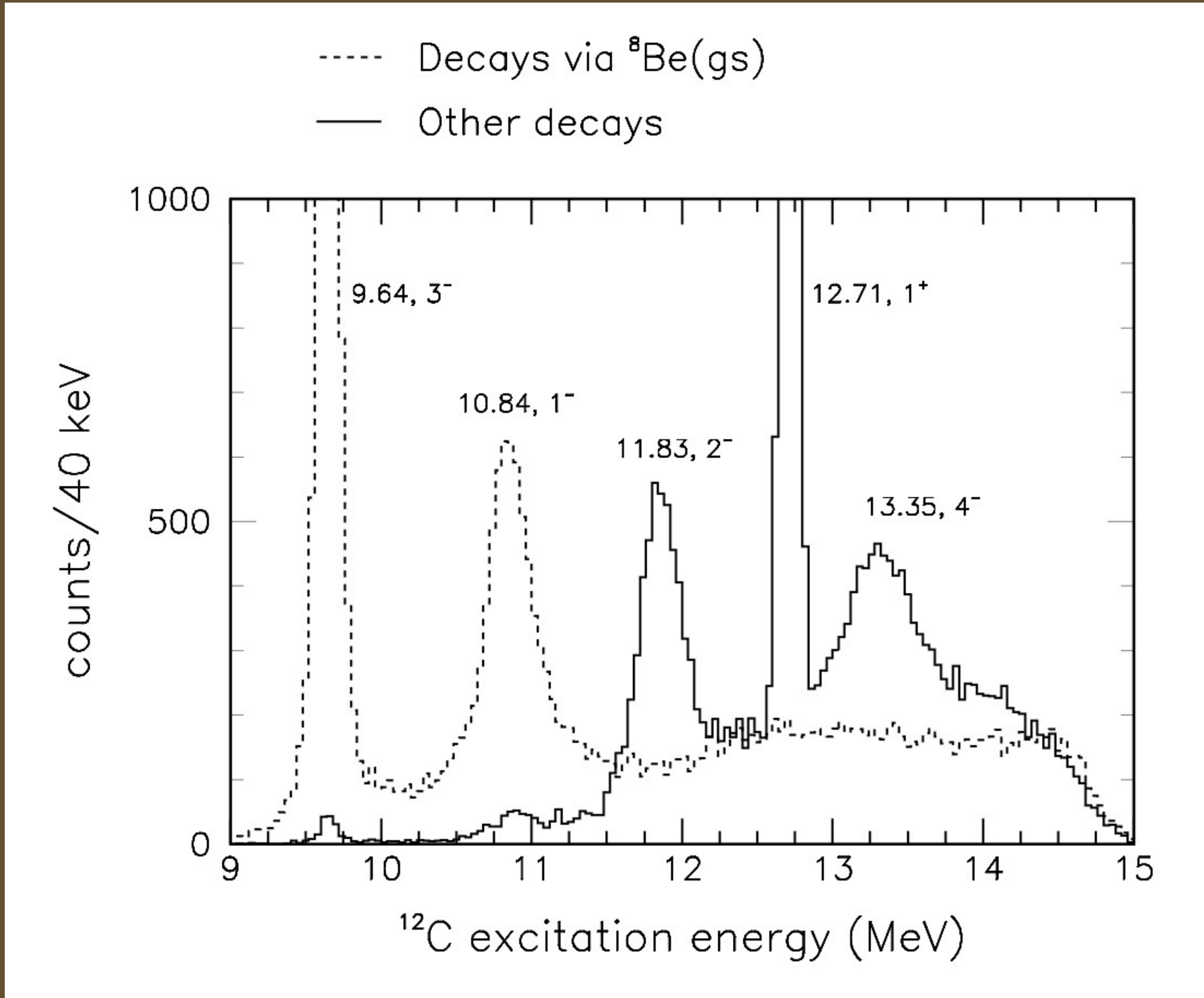
Sequential decay via ^{8}Be



Gate on ^{8}Be(gs) peak



$^{3}He + {}^{11}B \longrightarrow d + {}^{12}C^{*}$

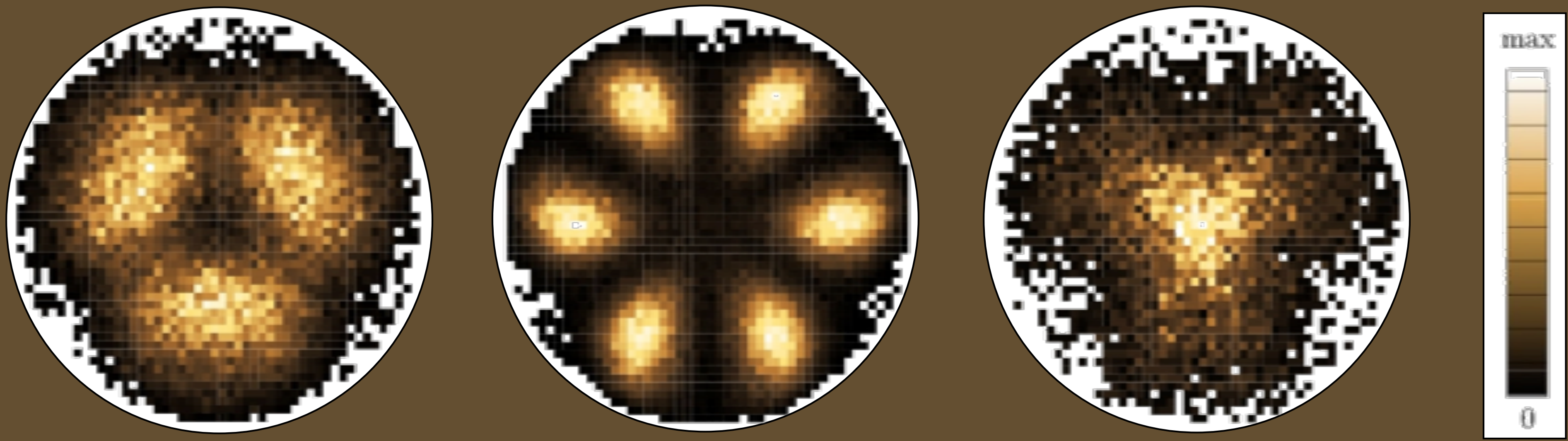


Experimental dalitz plots

11.83 MeV, 2^-

12.71 MeV, 1^+

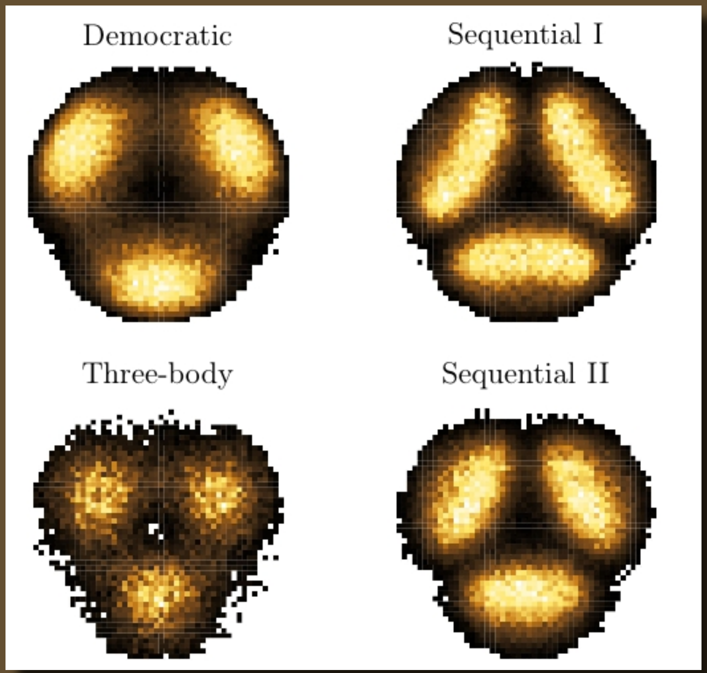
13.35 MeV, ~~(2^-)~~ 4^-



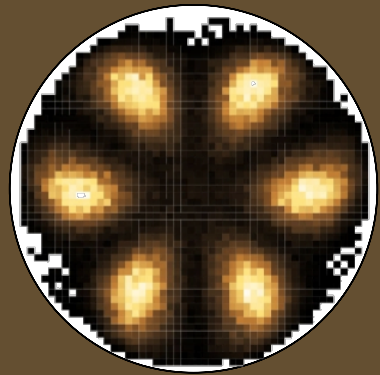
2^- 1^+ 4^-

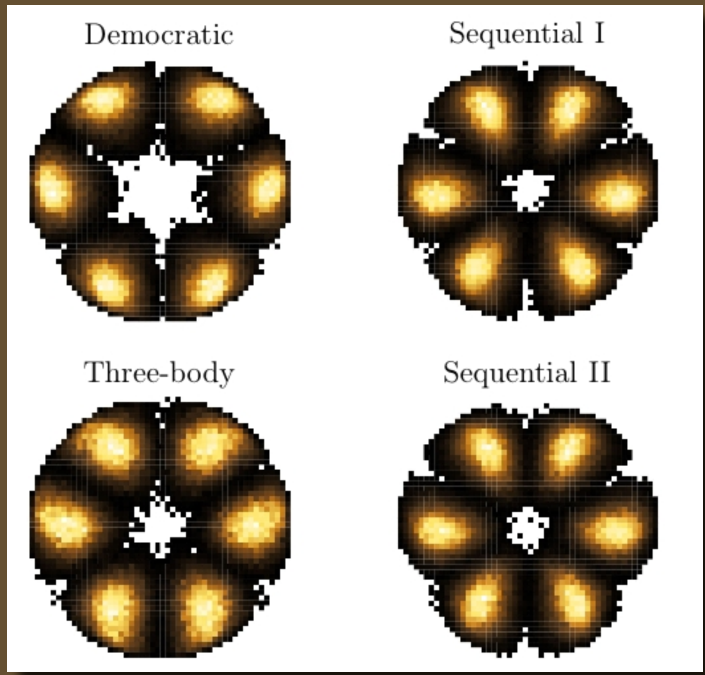
Comparison to models

11.83 MeV, 2^-



12.71 MeV, 1^+





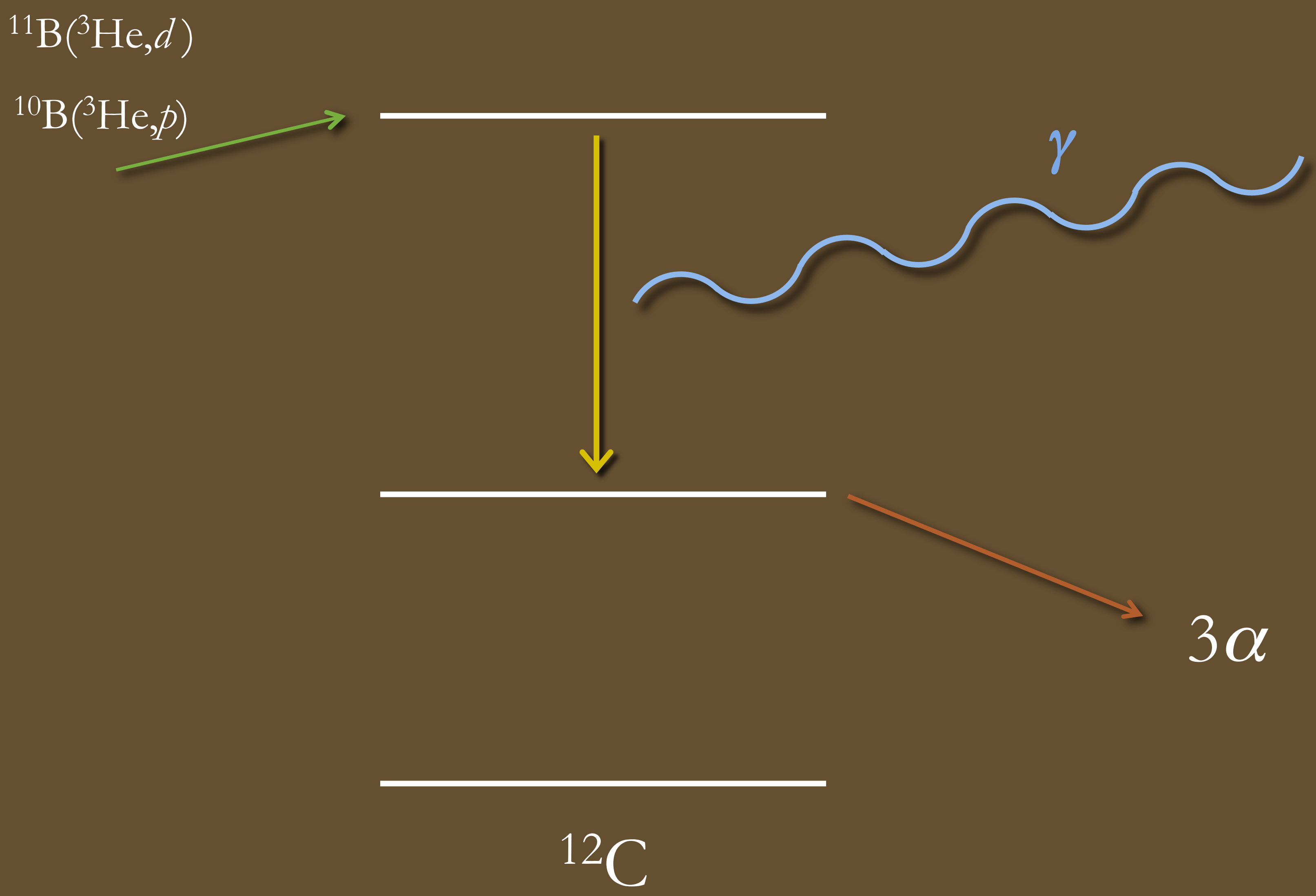
Democratic: A.A.Korsheninnikov, Sov. J. Nucl. Phys. 52 (1990)
Sequential: H.Fynbo *et al.*, PRL 91 (2003)
Three-body: R.Alvarez-Rodriguez *et al.*, PRL 99 (2007)

The *LOSU* factor

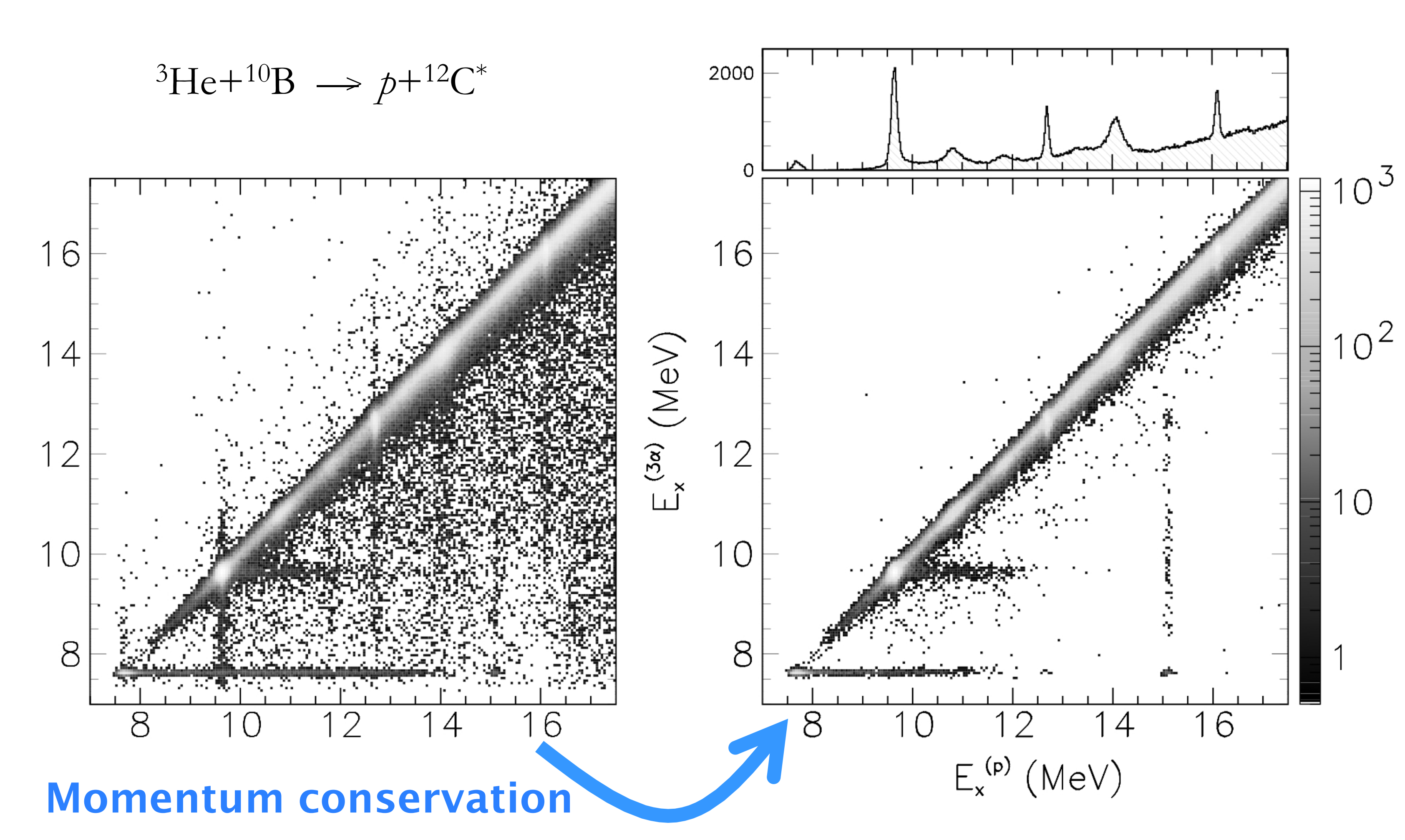
*L*evel *O*f *S*cientific *U*nderstanding

For the 3α breakup :   *LOSU* = medium

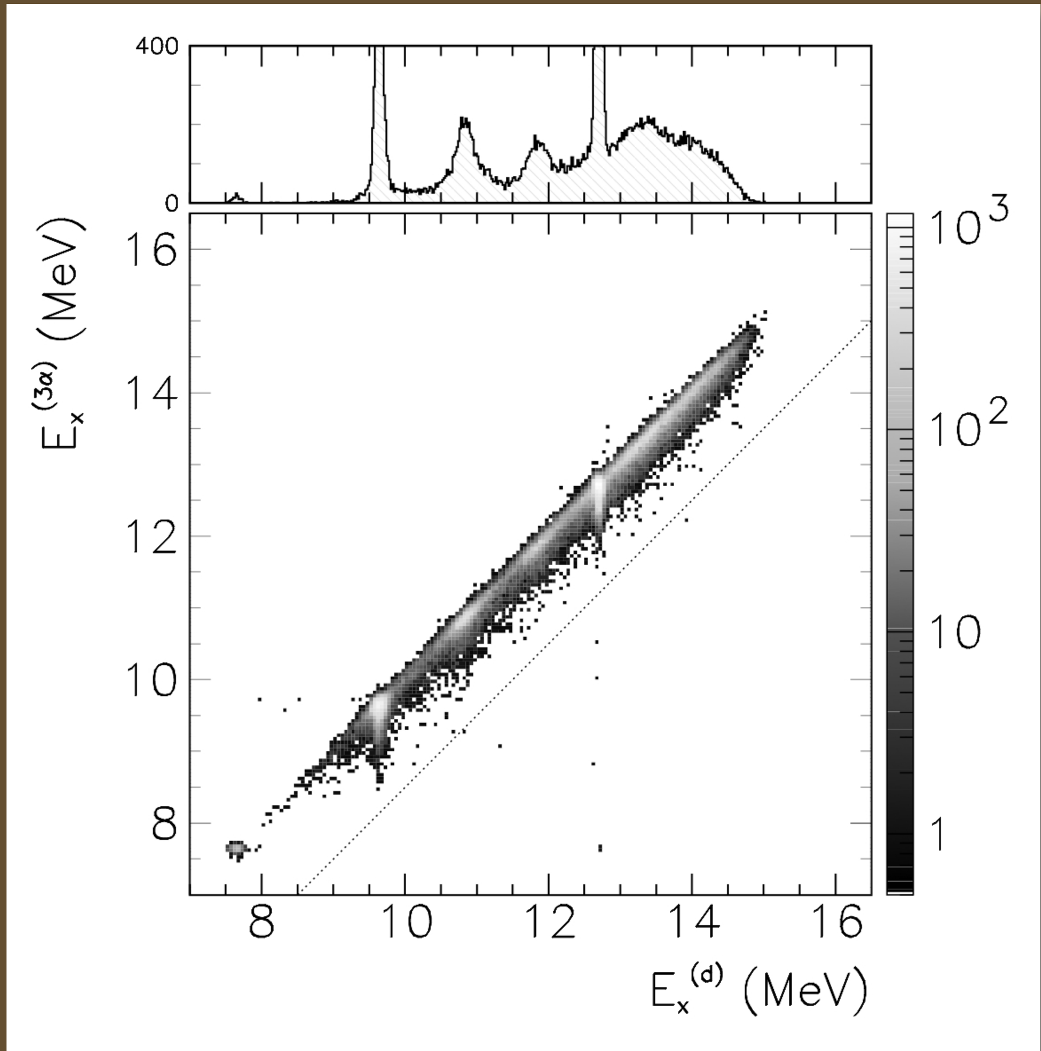
Indirect detection of γ transitions between unbound states in ^{12}C



γ transition from the 15.11 MeV state (1^+, $T=1$)



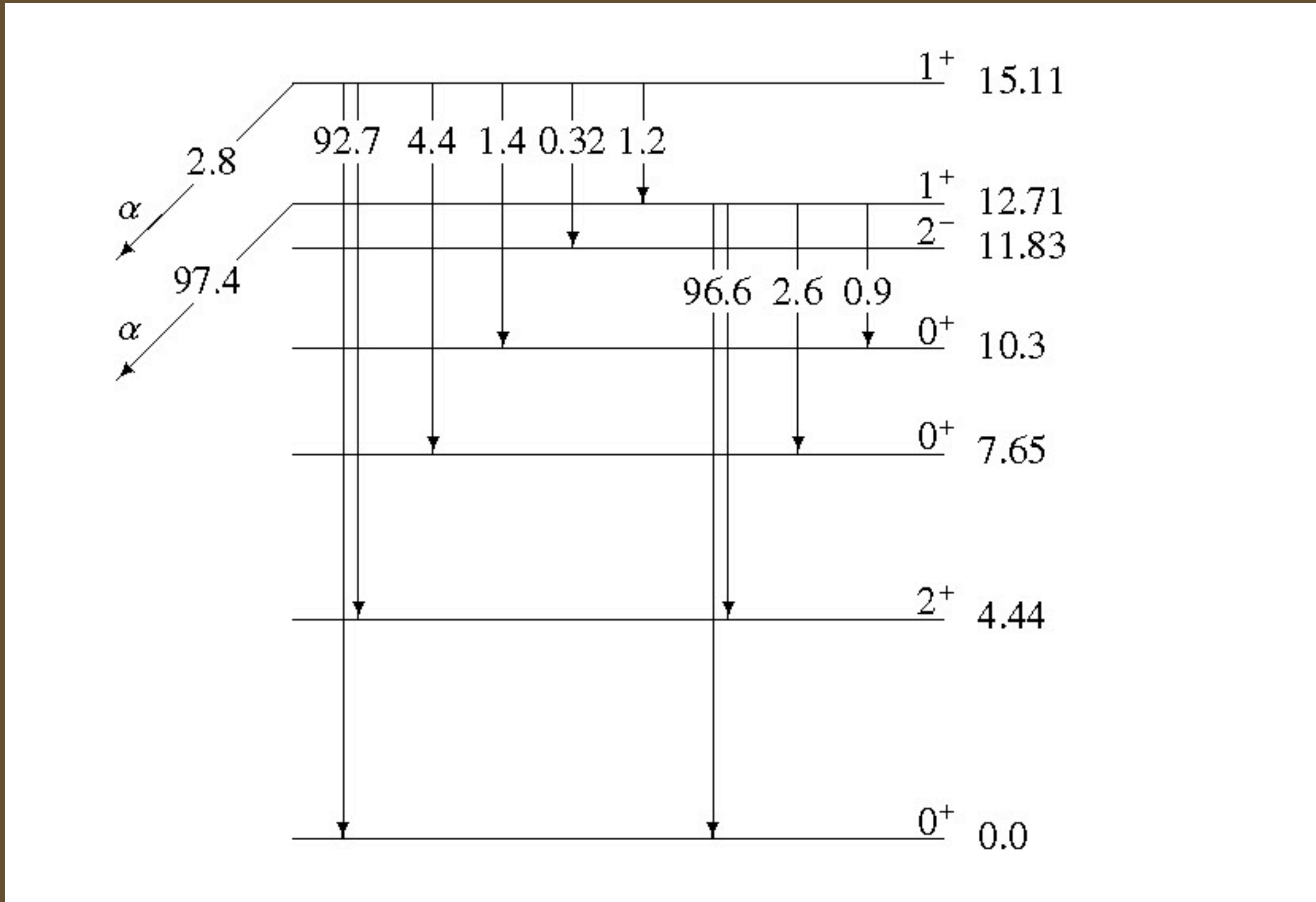
γ transitions from the 12.71 MeV state (1^+, $T=0$)



$^3He+^{11}B \longrightarrow d+^{12}C^*$

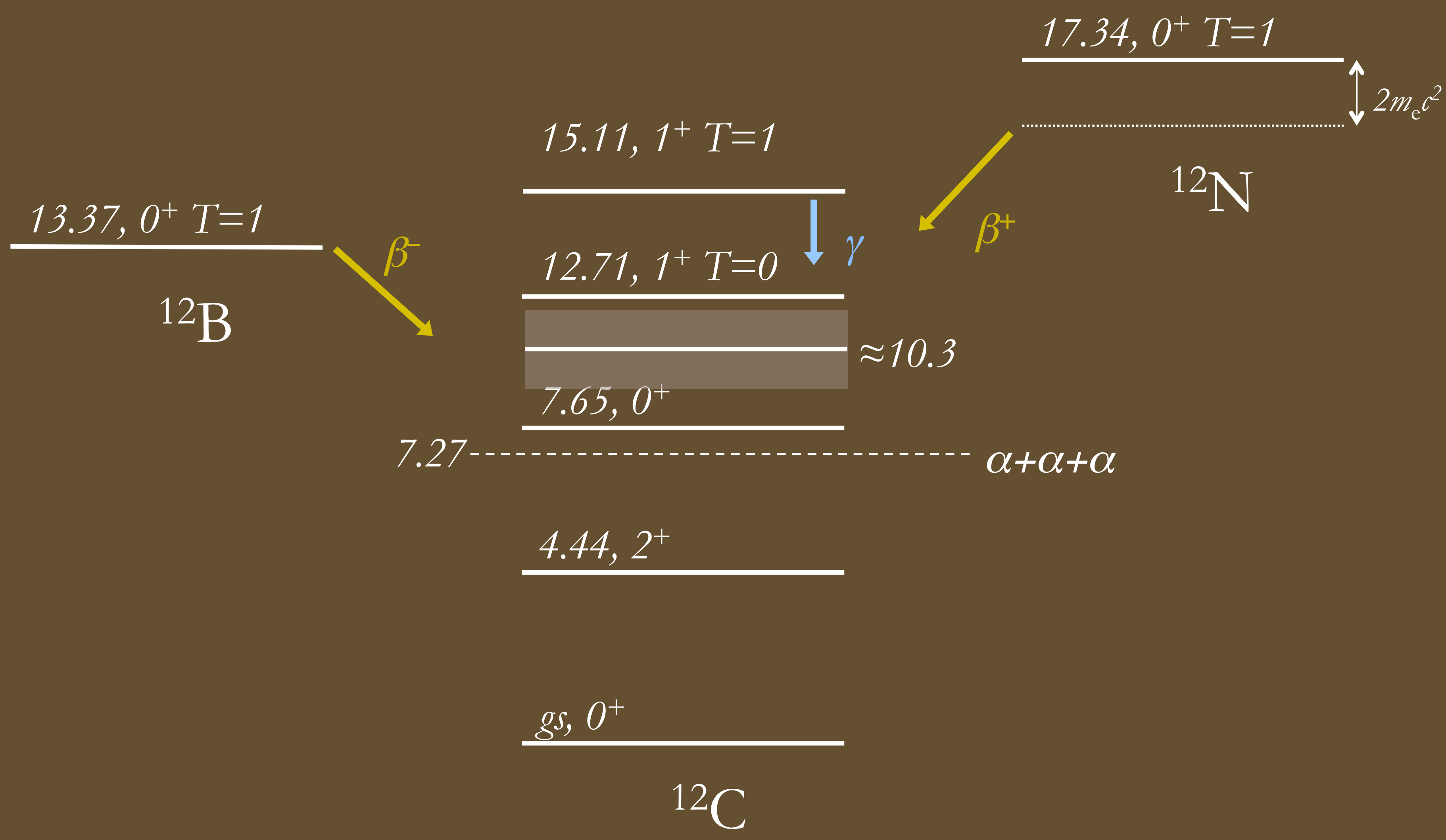
Decays scheme

Numbers give branching ratios in percent



O. S. Kirsebom *et al.*, PLB 680, 44 (2009)

Comparison of B(M1) and B(GT) values



Comparison of B(M1) and B(GT) values

$$B(\mathrm{M1}) = 2.643\mu_{\mathrm{N}}^2 \left[M(\sigma) + M(l) + M_\Delta + M_V^{\mathrm{MEC}}\right]^2$$

$$B(\mathrm{GT}) = \left[M(\sigma) + M_\Delta + M_A^{\mathrm{MEC}}\right]^2$$

$$R(\mathrm{M1/GT}) = \frac{B(\mathrm{M1})/2.643\mu_{\mathrm{N}}^2}{B(\mathrm{GT})}$$

i) For the 15.11→12.71 transition we get R=2.5±0.5

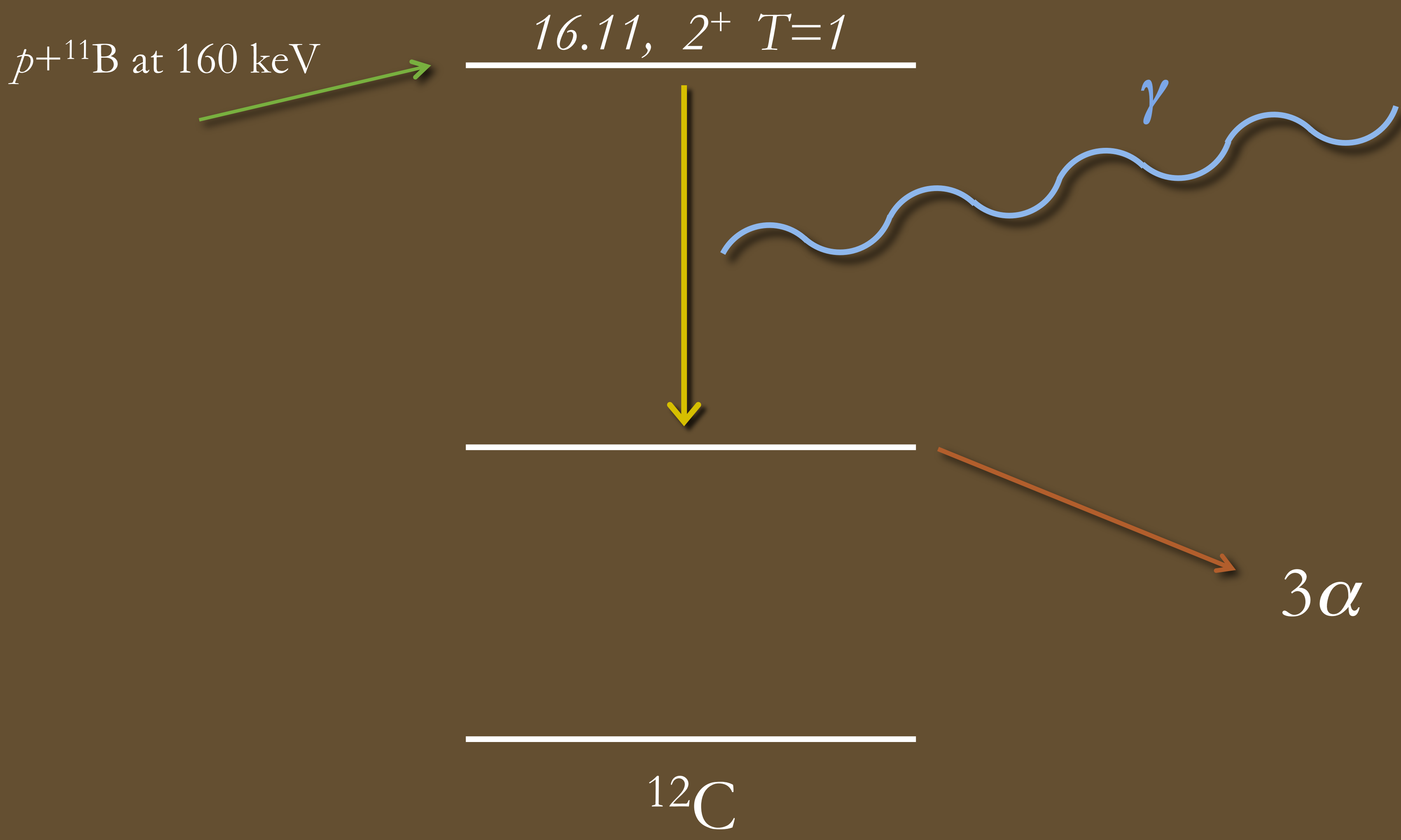
Is NCSM able to reproduce this value ?

ii) For the 15.11→7.65 transition we measure B(M1)=0.37±0.07

while AMD* predicts B(M1)=0.014

* Y. Kanada-En'yo, Prog. Theor. Phys. 117, 655 (2007)

On-going experiment in Århus



Perspectives

Experimental studies of multi-particle breakups and γ trasitions between unbound states are of great interest.

What happens to the low-lying collective (α-cluster) states as we move towards the driplines ?

Possibilities at FAIR:

- Inelastic scattering of relativistic radioactive beams on light targets e.g. proton with subsequent multi-particle breakup.
- Non-relativistic beams (HISPEC/DESPEC).

With the inclusion of neutron detectors a wider range of physics cases will become accessible.