MMF1

MINISTERIO DE EDUCACION Y CIENCIA

Grupo de Física Nuclear Experimental

INSTITUTO DE ESTRUCTURA DE LA MATERIA – IEM

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Grupo de Física Nuclear Experimental

Multiple Particle Break-Up in the ^{11}Li β-decay

M. Madurga

U. Bergmann[3], M.J.G. Borge[5], J. Cederkäll[3] C.Aa. Diget[1], L.M. Fraile[3], H. Frånberg[4], B. Fulton[6], H.O.U. Fynbo[1], S. Grevy[2], H. Jeppesen[1], B. Jonson[4], T. Nilsson[3], G. Nyman[4], M. Meister[4], N. Orr[2], Y. Prezado[5], K. Riisager[1], A. Saban[5], O. Tengblad[5], M. Turrión[5], and the TONNERRE Collaboration[7]

Århus[1]-Caen[2]-CERN[3]-Göteborg[4]-Madrid[5]-York[6]-Collaboration

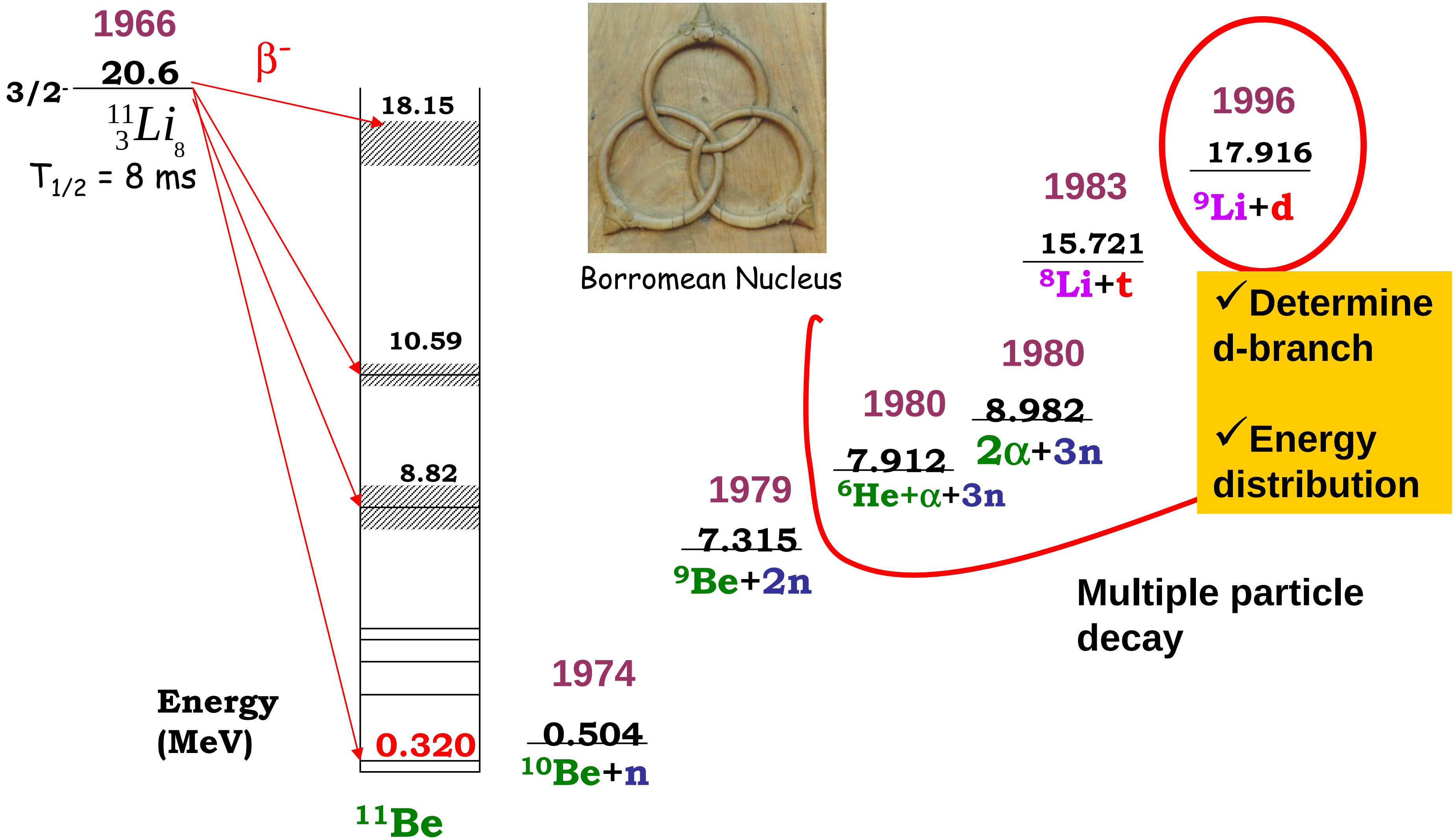
Slide 1

MMF1 I wiil report on the exeperiment on 11Li beta-decay.
This experiment was done in colaboration with Aarhus university, Chalmers unversity, LPC Mirar diapositiva
Miguel Madurga Flores; 2006-02-06

Outline

- Motivation
- Experimental set-up
- Delayed charged particle emission
- Decay of long-lived daughter nuclei
- Outlook

Motivation



Borromean Nucleus

Slide 3

MMF2 Beta decay scheme of 11li that is agood laboratory for nuclear structure as it is the more prolific nucleus in decay modes and has receive a lot of attentio due to its halo structure, that emerged 20 years ago.

We show here the year when the nucleus was discovered and the year of publication of the different decay modes

In this presentation I will concentrate (animacion) in the decay branches that involved charged particles, aiming for the 6He+alpha channel and the 5 particle channel and certainly the final aim will be to get a more precise determination od the d branch and if possible its energy distribution.

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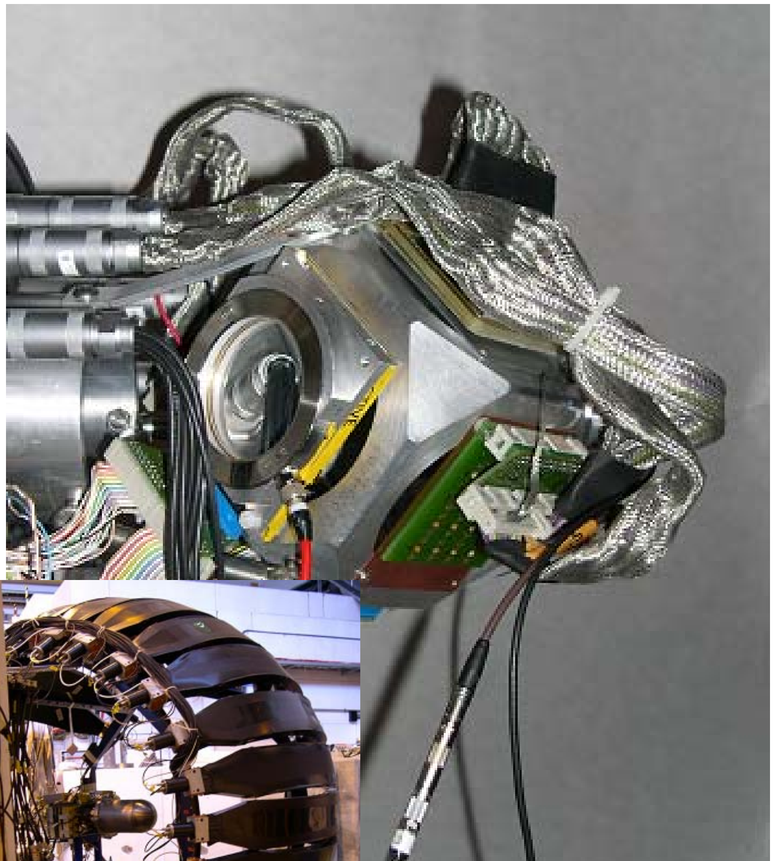
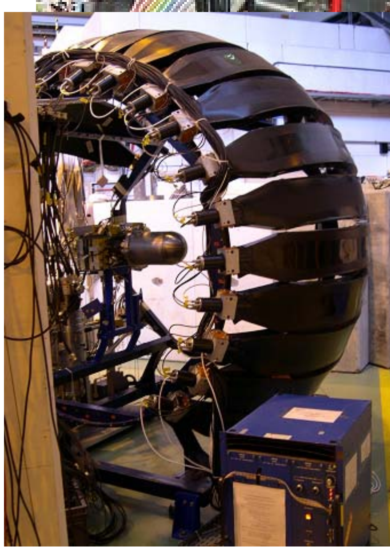
MMF3

Experimental set-up





- **Charged particle detection:**
  - **4 DSSSD's + thick silicon pads**
  - **Compact cubic geometry: 4x 8% 4π**
- **Neutron detection:**
  - **TONERRE time of flight. 20% 4π**

Slide 4

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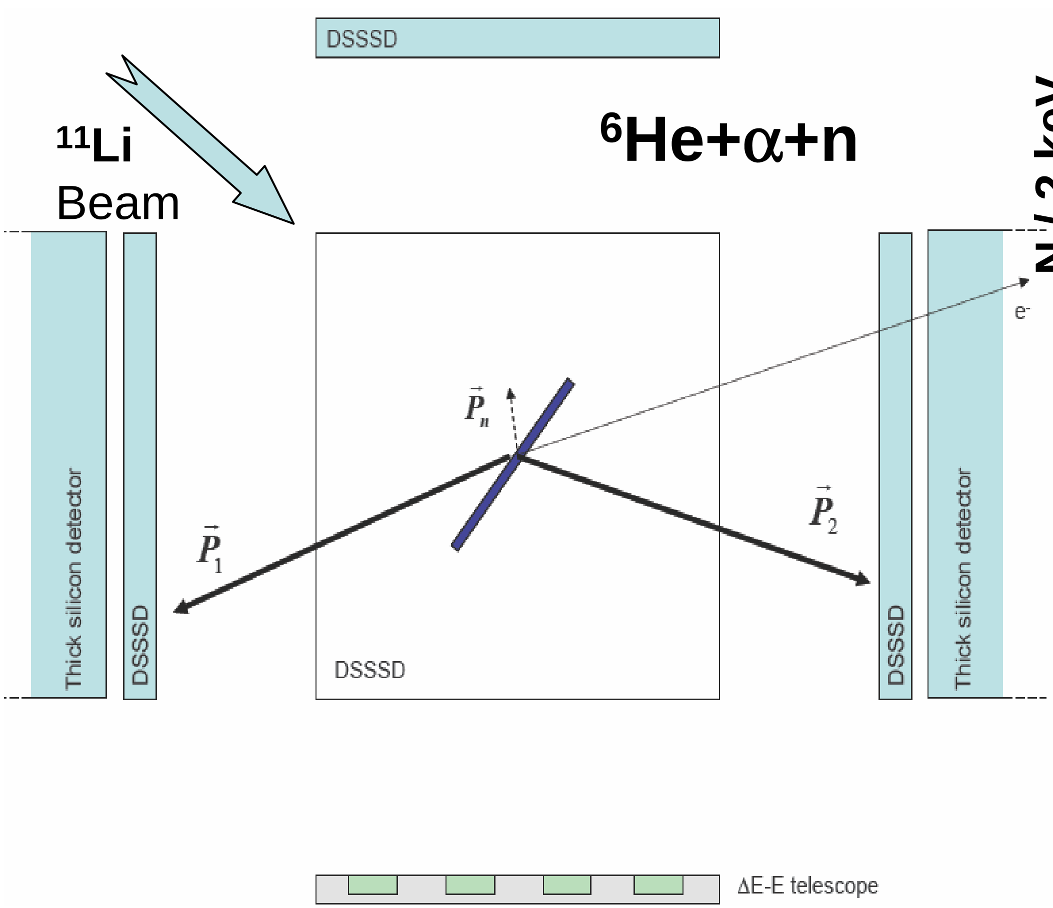
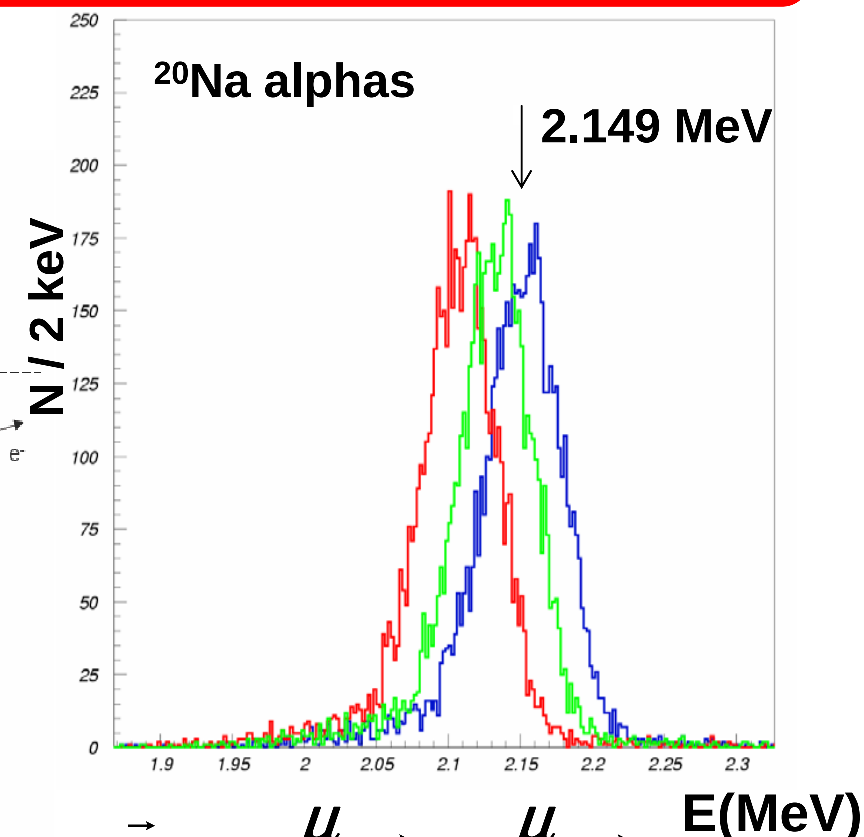
MMF4

Analysis techniques





$$\vec{P} = \frac{\mu}{\ } \vec{n} + \frac{\mu}{\ } \vec{n}$$

- **Deadlayer and carbon-foil energy losses corrected**

- **Background subtraction:**

E_{front} - E_{back} ≤ 40 keV

Slide 5

MMF4 schematic view of the set up with an example of 2 particles traversing through the c-foil an reaching opposite detectors in what we call back-back geometry.

On the right we see the effect on taking into account the effect of c-foil and deadlayer. In red the original data and in blue the final afeter correction where it a large effect in the cetroid its oberver and together with an imrovement in the resolution.

background was further subtracted by imposing that the nergy difference in the front and back strips is less than 40 keV

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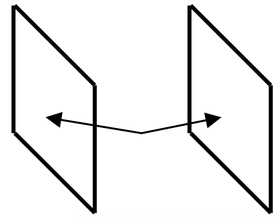
MMF5

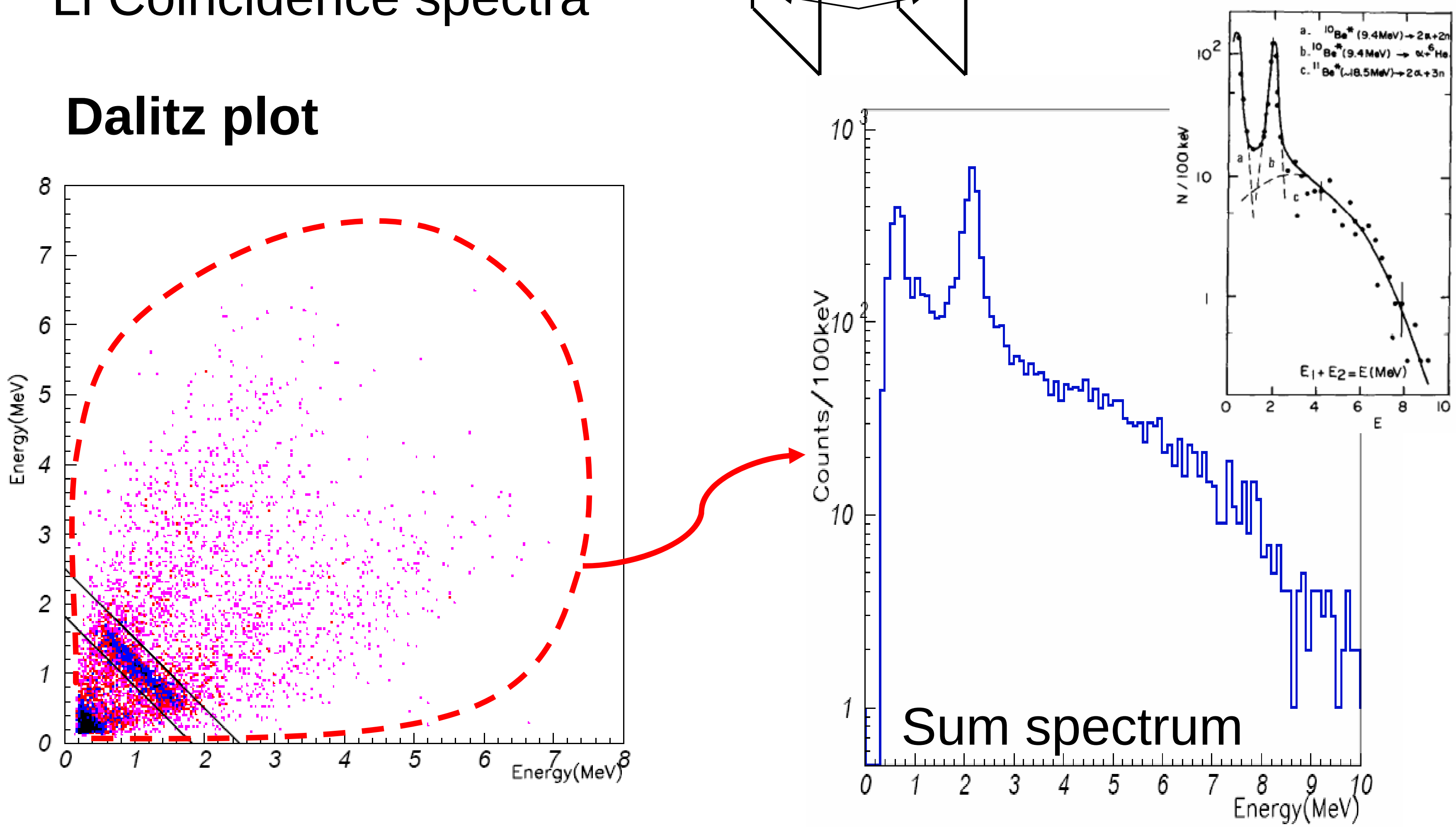
β-delayed charged particle emission

^{11}Li Coincidence spectra



M. Langevin et al., NPA 366(1981) 449

Dalitz plot



27/04/2006

MMF5 In the plot is show the data in the back to back geometry.

It is clearly seen between the two black lines the three body decay through an intermediate state.
If we take now all data and project the sum energy of the two charged particles we get an spectrum similar to the one obtained 25 years ago, expected as langevin had two detectors in close geometry as we have in our set-up.

The two main peaks, coincide with the following regions (show) in the e vs e spectrum.
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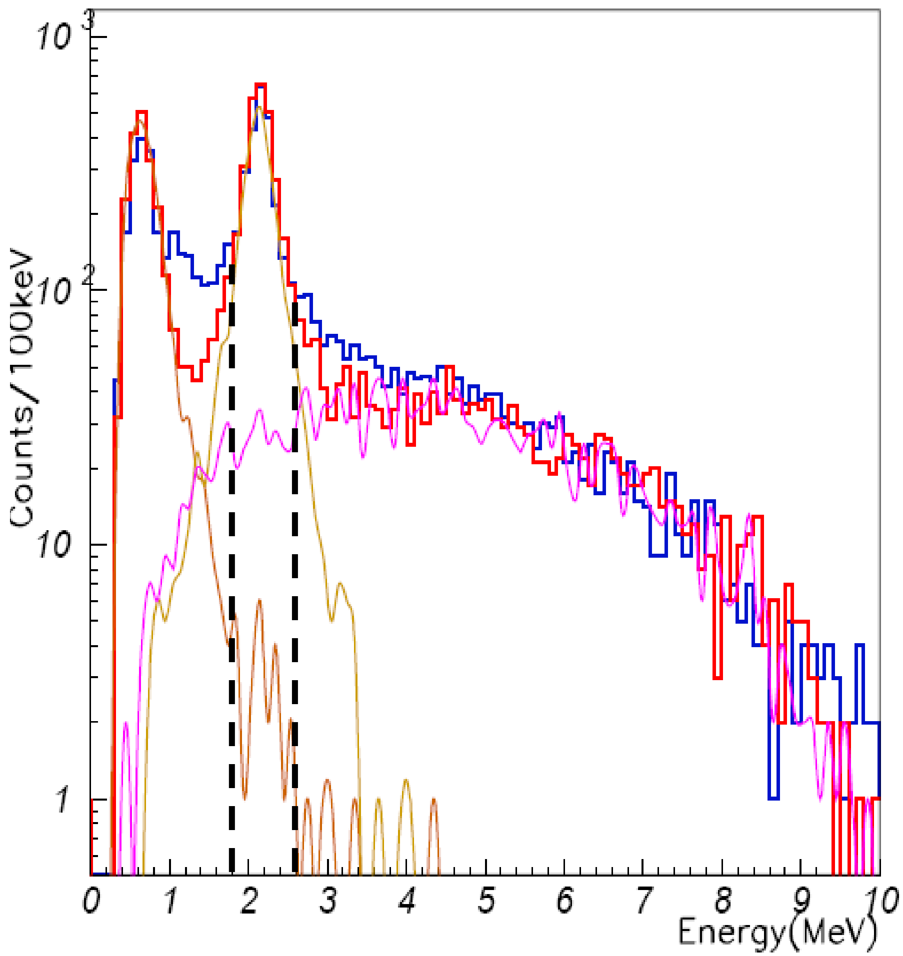
β-delayed charged particle emission

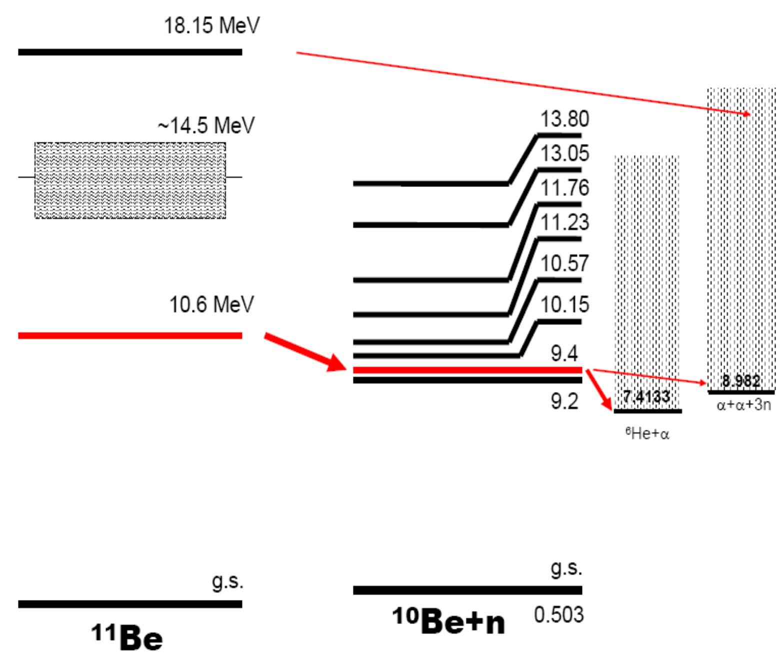


Simulated channels (red)

$^{11}Be^*(10.56) \rightarrow {}^{10}Be^*(9.48MeV)+n \rightarrow {}^{6}He+\alpha+n$

$11Be^*(10.56) \rightarrow 10Be^*(9.48MeV)+n \rightarrow 2\alpha+3n$

$11Be^*(18.15) \rightarrow 2\alpha+3n$



Slide 7

MMF6 with this data we performed a simulation with the known alpha-alpha and 6he and alpha channels.

in ths data we can see the contribution through the 9.5 meV level into 6he+alpha, and the decay of this level into 4 particles.
on the contrary the break-up into 5 particles of the 18.15 level in 11be is this broad (show) distribution.

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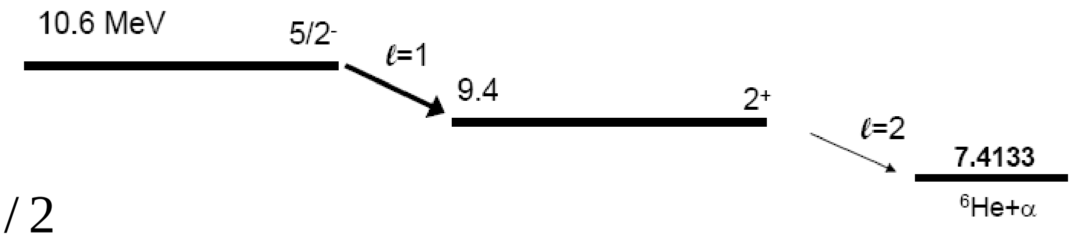
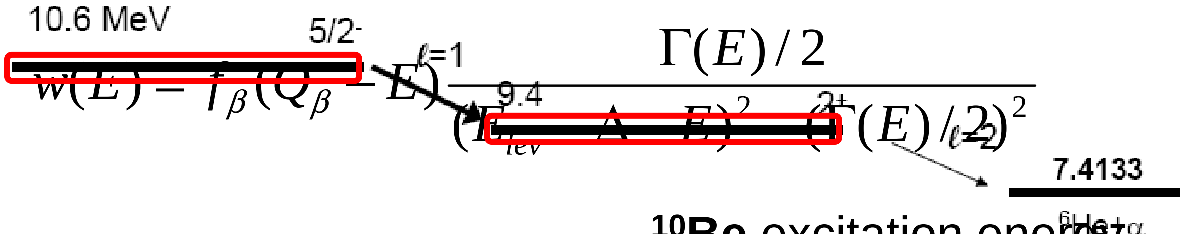
The ^{6}He+α+n channel

Two single-channel resonances





$$w(E) = f_\beta(Q_\beta - E)\frac{\Gamma(E)/2}{(E_{lev} - \Delta - E)^2 + (\Gamma(E)/2)^2}$$

Parameters:

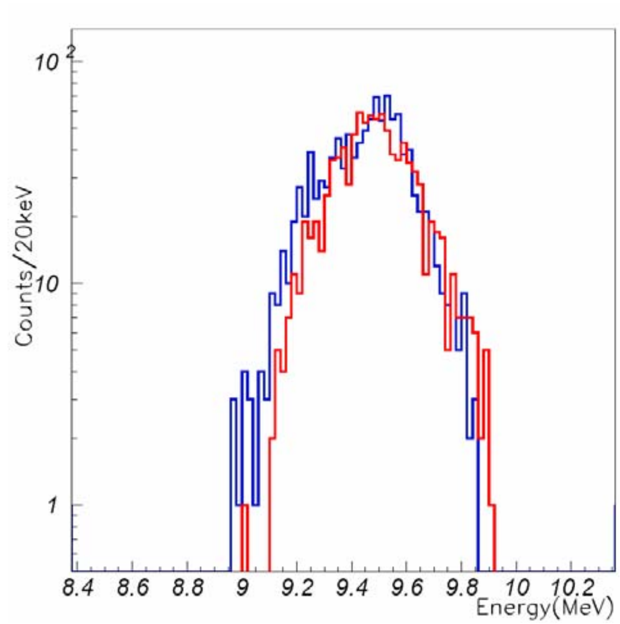
ℓ_n=1[1]

Γ(E)=2P(E)γ²

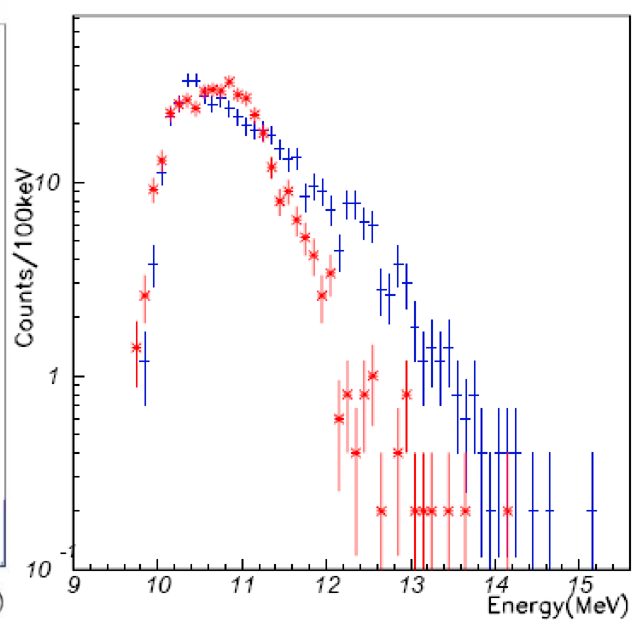
γ(10.56) = 0.210 MeV$^{1/2}$

γ(9.48) = 0.045 MeV$^{1/2}$

^{10}**Be** excitation energy



^{11}**Be** excitation energy



1 Y. Hirayama et al., Phys. Lett. B 611(2005)239

Slide 8

MMF7 using two resonances in the single-channel aproximation of R-matrix theory

The transition probablity depends on the

The fitting for the 9.5 MeV sate in 10Be is good, and if we implement the neutron energy to reconstruct the 11be energy the fit is not as good and we can see a contribution at high energies that must be due to feeding from levels at energies above the 10.6 considered in this analysis.

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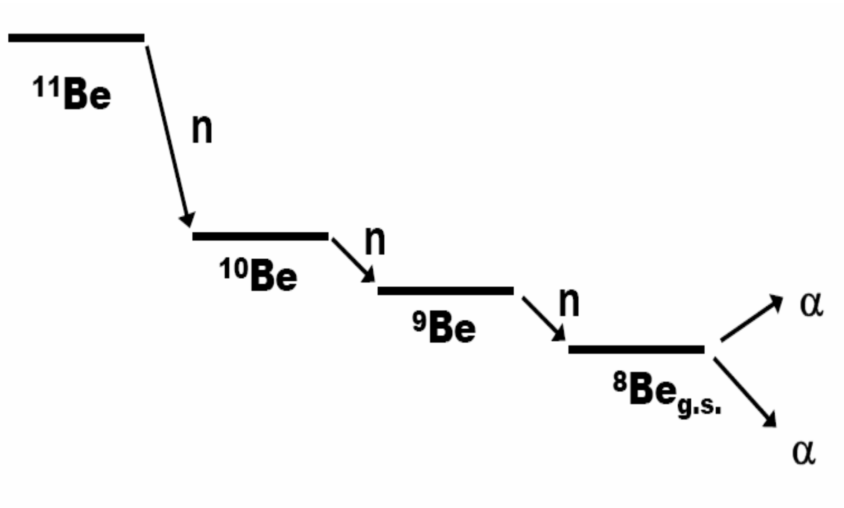
MMF8

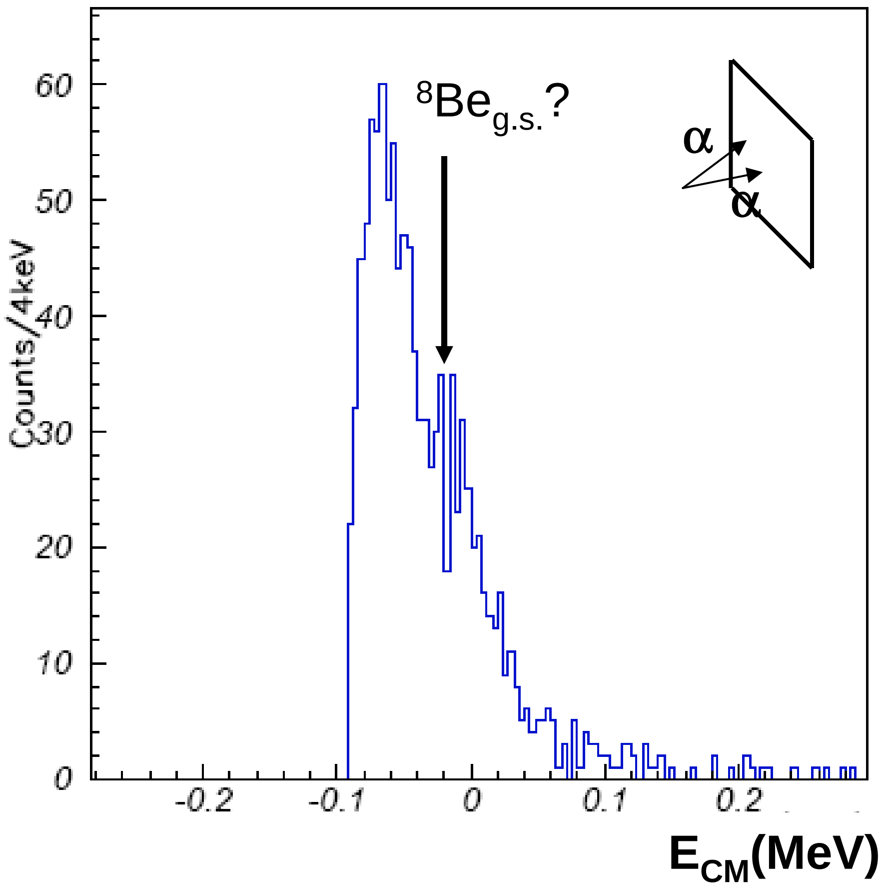
Sequential decay

Observation of decay through the ^{8}Be g.s.

The ^{8}Be ground state is a fingerprint of a 3n sequential decay



E_{CM} – 0.092 MeV



Slide 9

MMF8 Now we also searched for channels with the two charged particles were ging to the same detectro and reconstruct the erngy of the original state.

The right figure shows the C.M. energy of the 2 detected particles minus the 8be g.s. energy.

The observation of the 2 particles within an angle of 40 deg is because one of the neutrons is very energetic.

one possible scenario is decay from the 18 mev into 10.6 mev in 10be and 3 mev in 9be.

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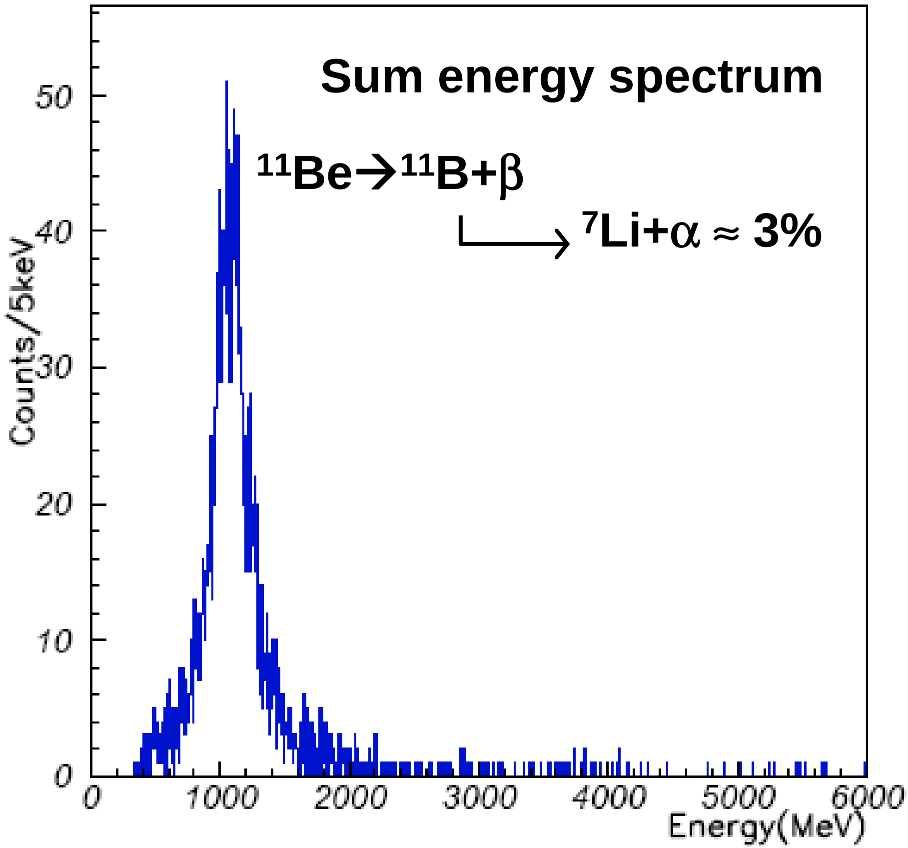
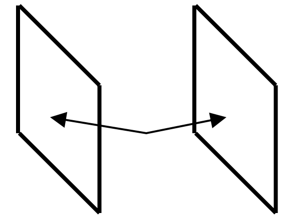
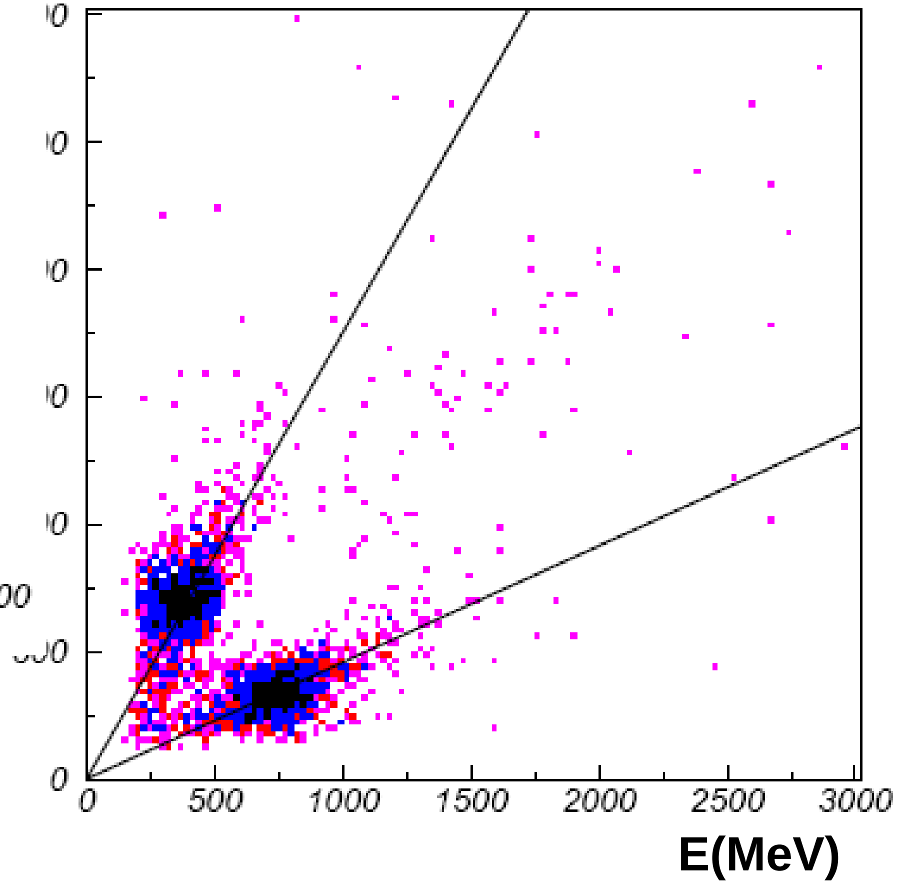
MMF9

Decay of long lived daughter nuclei







MMF9 We take events that happens after 100 ms, where is no 11li left and we look at the double charged particle coincidences. (animacion)

In the 2d plot we can apreciate two bumps lying on digonals with slopes 7/4 and 4/7 respectively, corresponding to the 2-body break-up 11B into alpha+7li, that correspond to 3% of the 11be beta-decay.

Here we show the sum energy projection where we see the lorentzian shape corresponding two the decay of a narrow resonance.
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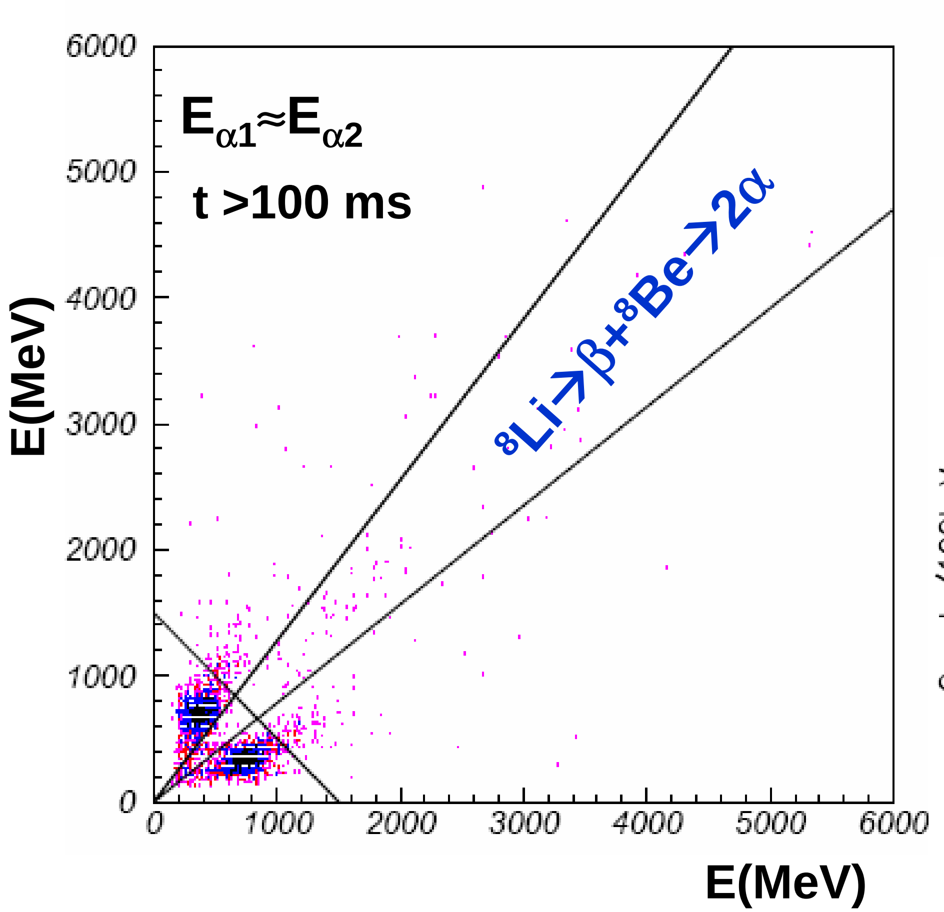
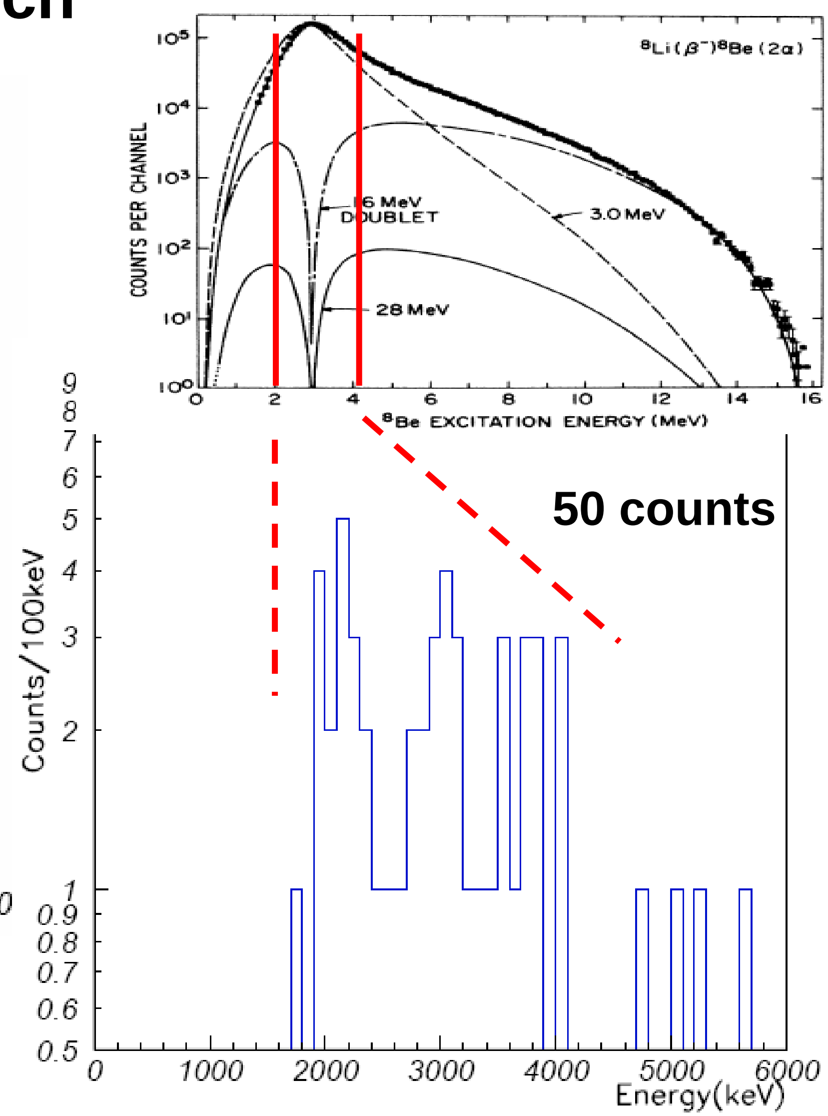
Decay of long lived daughter nuclei

Evidence of the ^{8}Li+t branch



E. K. Warburton, PRC 33 (1986)303



Slide 11

MMF10 As we know that 8li decays into the 8be states that break-up in two alphas whith equivalent energy, we selected the events defined from this lines.

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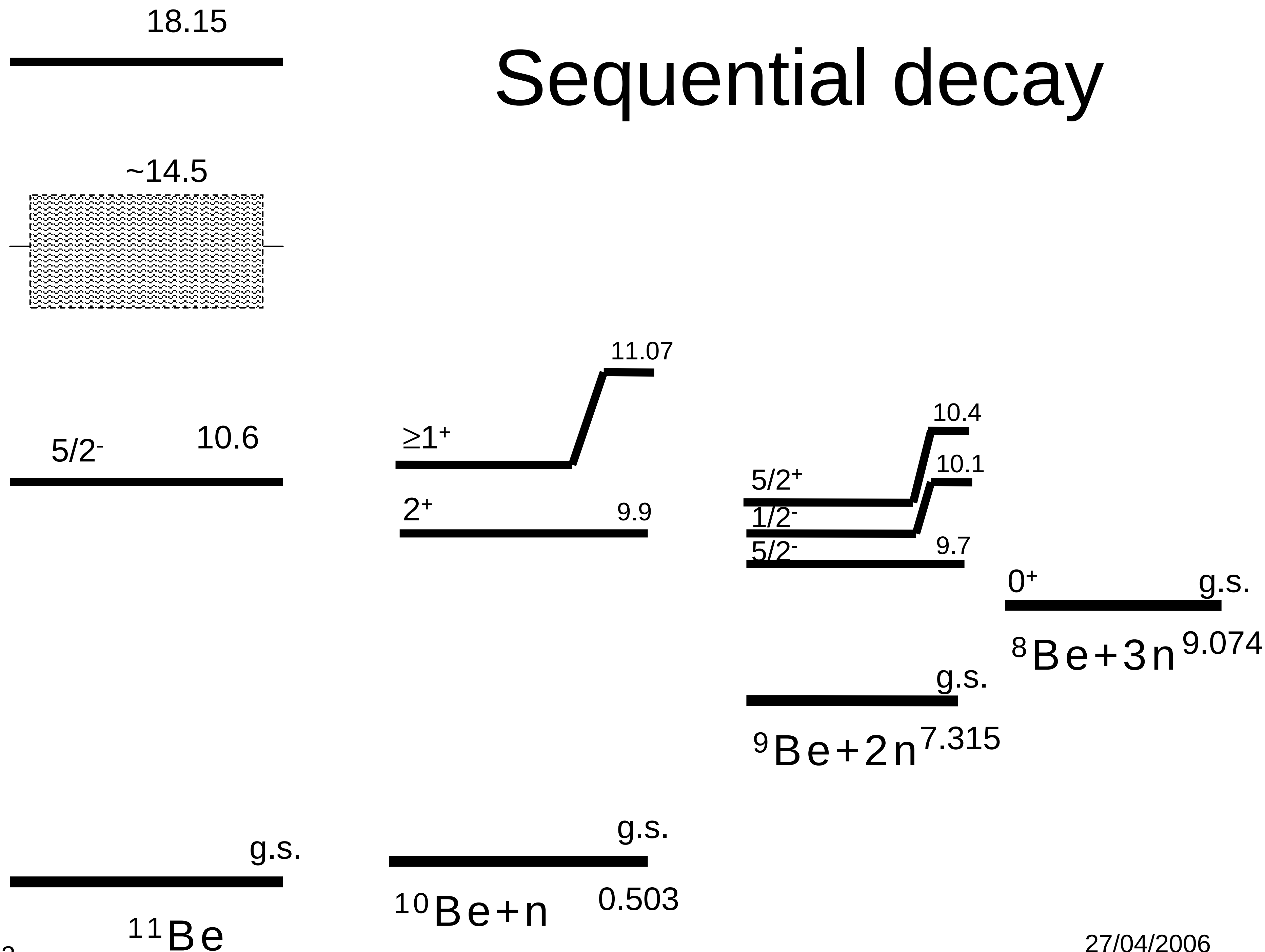
Summary and Outlook

- Decay through the ^{10}Be 9.5 MeV resonance: hint of high energy feeding in ^{11}Be.
- Observation of decay through the ^{8}Be 0^{+} ground state. → $2\alpha+3n$
- The technique used to extract the $^{8}Li+t$ branch can be applied to the decay of the daughter nuclei ^{9}Li. Estimate of the d branch
- Coincidences between neutrons and charged particles.

Sequential decay



Given 3060 counts in the 7Li+α resonance:

P(^{11}Be→^{11}B+β

^{7}Li+α) ≈ 3%

P(^{11}Li→^{11}Be*(320keV) ≈ 7%[1]

P(11Li→11Be*(18.15MeV)→^{8}Li+t) ≈ 0.012%[2]

W(E)(1900keV→4100keV) ≈ 68%[3]

115 expected ^{8}Li decay counts