Charge-particle channels in β decay of ^{11}Li

Proposal E1030: Search for Deuteron Emission in ^{11}Li: DELIS

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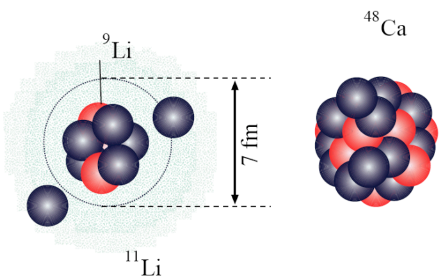


The β-decay of ^{11}Li

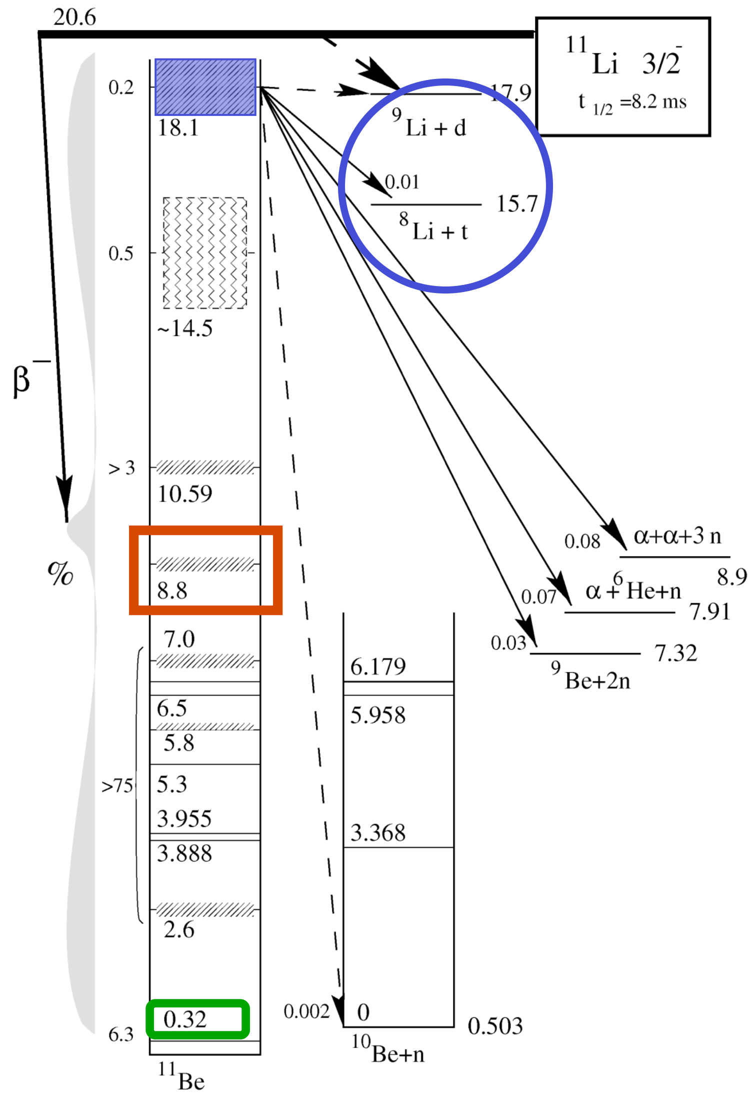
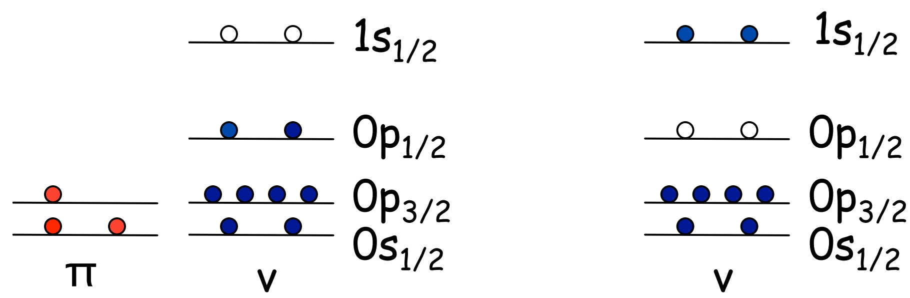


Figure from: I. Mukha et al., NPA 616 (1997) 201c



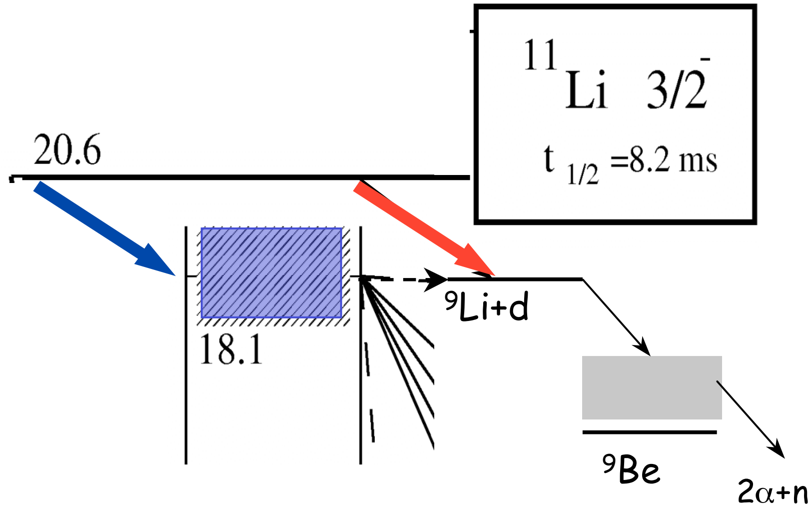
-feeding of the 3/2⁻ state @ 320 keV => measure of the $(0p_{1/2})^2$ content in the halo

-core decay => two halo neutrons survive => excited halo state @ 8.8 MeV (see 8Pi experiment)

-strong GT feeding of the 18.1 MeV resonance

many channels open

E1030 Proposal: β decay to high-lying states and continuum



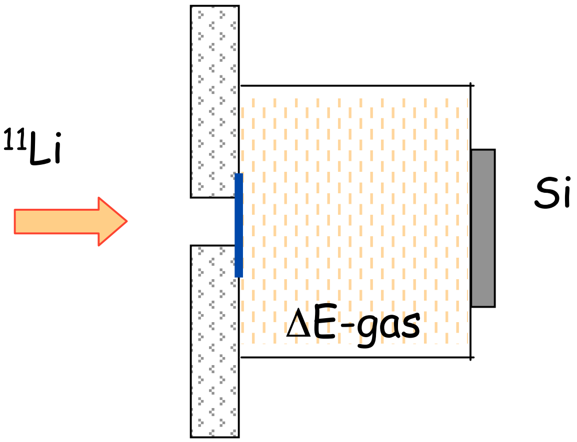
β-decay to high-lying states

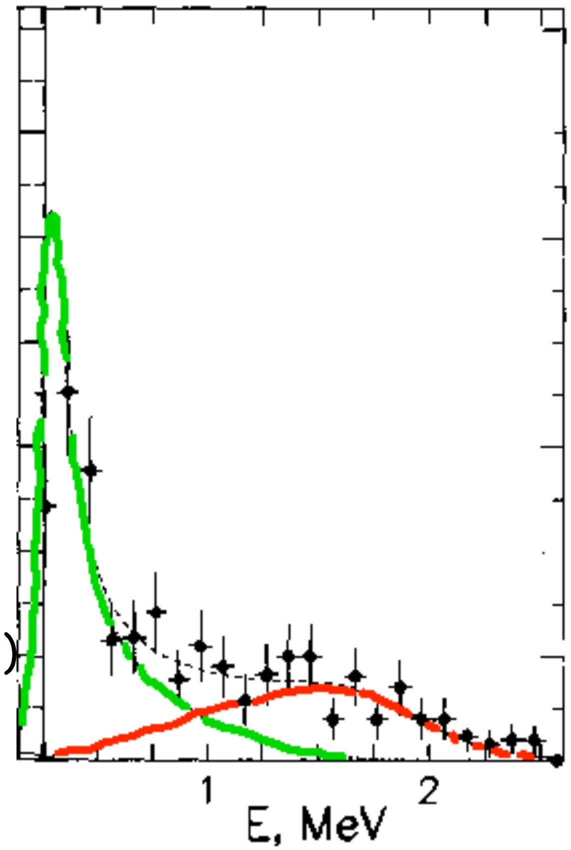
- Large B_{GT} values due to a large overlap of states
  → conclusions are less model-dependent
- One such state suggested in ^{11}Be at E*~18.1 MeV (~18.5 MeV)
  B_{GT}>1.6±0.3. (Presumably it has ^{9}Li+(pn) structure)

β-decay to the continuum

- Rather simple expressions for the spatial overlap matrix elements describing the decay – easier to interpret results
  Most favorable case: β-delayed deuteron emission
  See also ^{6}He

E1030 Proposal: β decay to high-lying states and continuum





ISOLDE, 1996

deuteron emission measured together with t emission

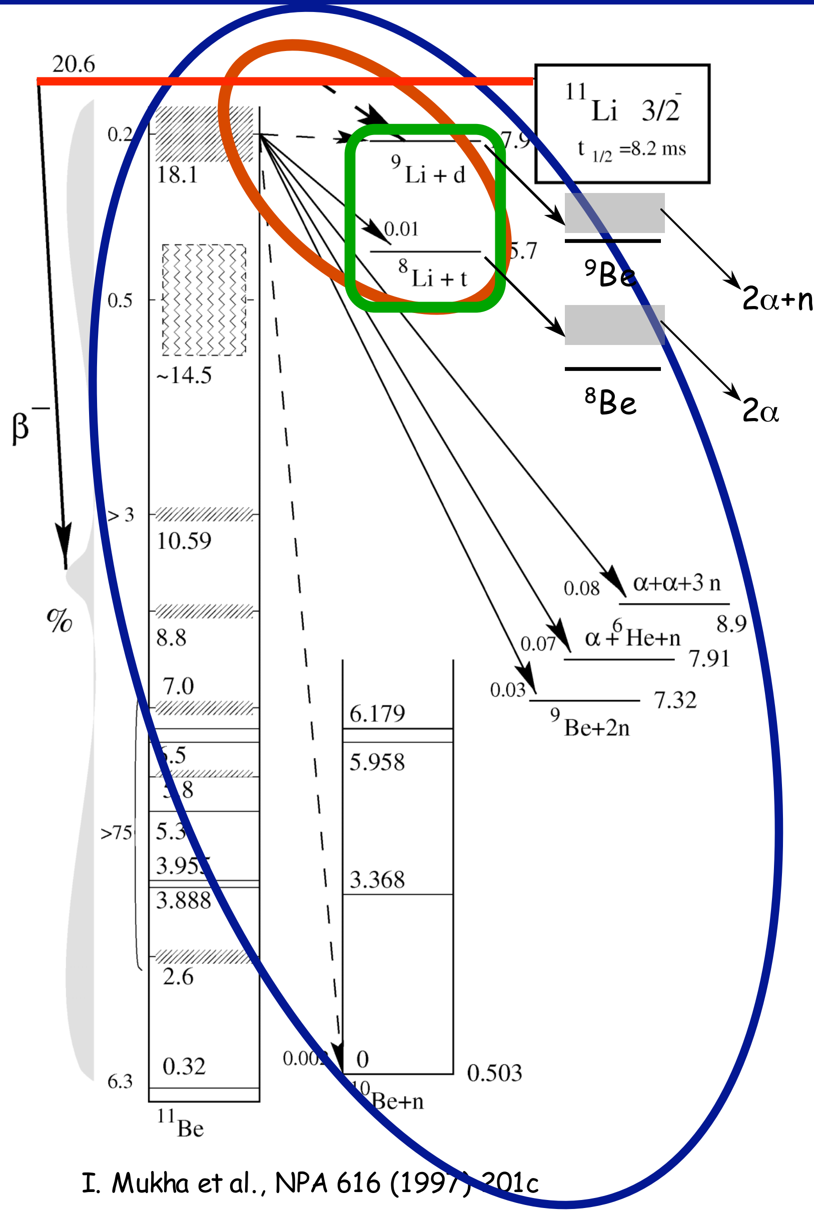
total b.r. (1-3)x10^{-4} (I. Mukha et al., PLB 367 (1996) 65,

M Borge et al, NPA613(1997),199)

- low detection efficiency (2.5%) -> low statistics (~ 250 cts)
- the β background subtracted using ^{9}Li data
- could NOT separate d&t; ^{6}He & α; ^{9}Be and ^{10}Be
- large uncertainties of b.r.: different detectors, recoil out tne target
- high energy threshold

Needs to be confirmed/remeasured

E1030 Proposal: goals



I. Mukha et al., NPA 616 (1997) 201c

Our goals:

Measure:

- Branching ratio of the ^{9}Li+d channel
- Branching ratio of the ^{8}Li+t channel
- Energy spectra of d and t

- Branching ratio of all channels from E*~18.1 MeV in ^{11}Be

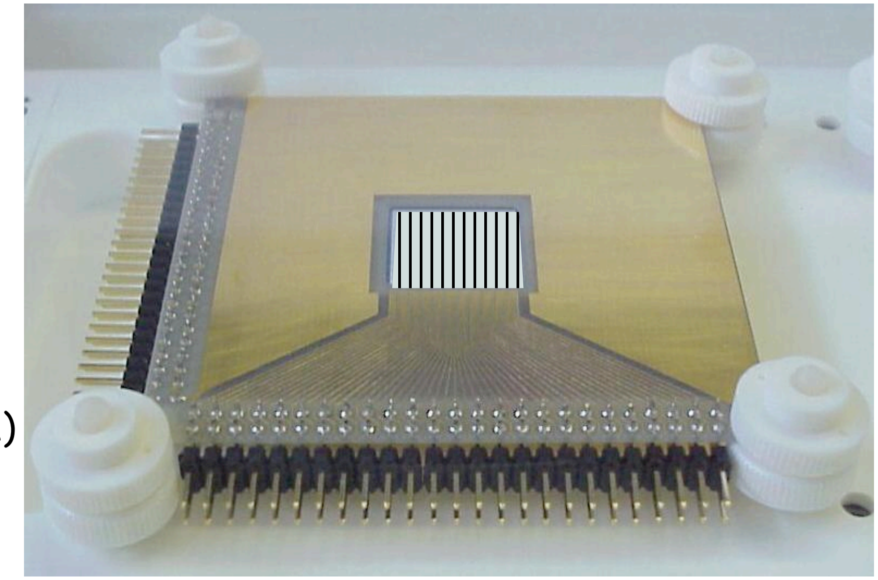
^{11}Li in TRIUMF

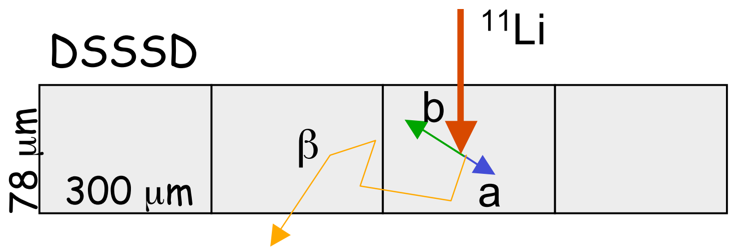
- ^{11}Li beam needed for our implantation technique (15 MeV)
- Intense and pure beam (not available elsewhere)

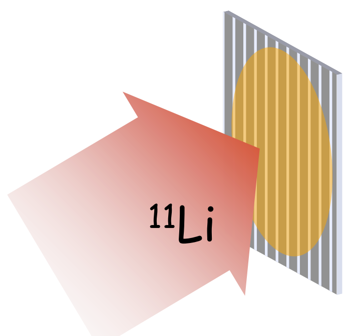
Our method: Implantation & Decay in the DSSSD

IMPLANTATION:

- Segmented double-sided strip detector:
  16x16 mm^2, 78 μm thick
  48x48 strips, 300 μm wide → 2304 pixels of 300 μm x 300 μm in size
- ^{11}Li implantation (E_{beam}~15 MeV):
  - middle plane of the detector (~40 μm, SRIM)
  - uniform profile (as much as possible)





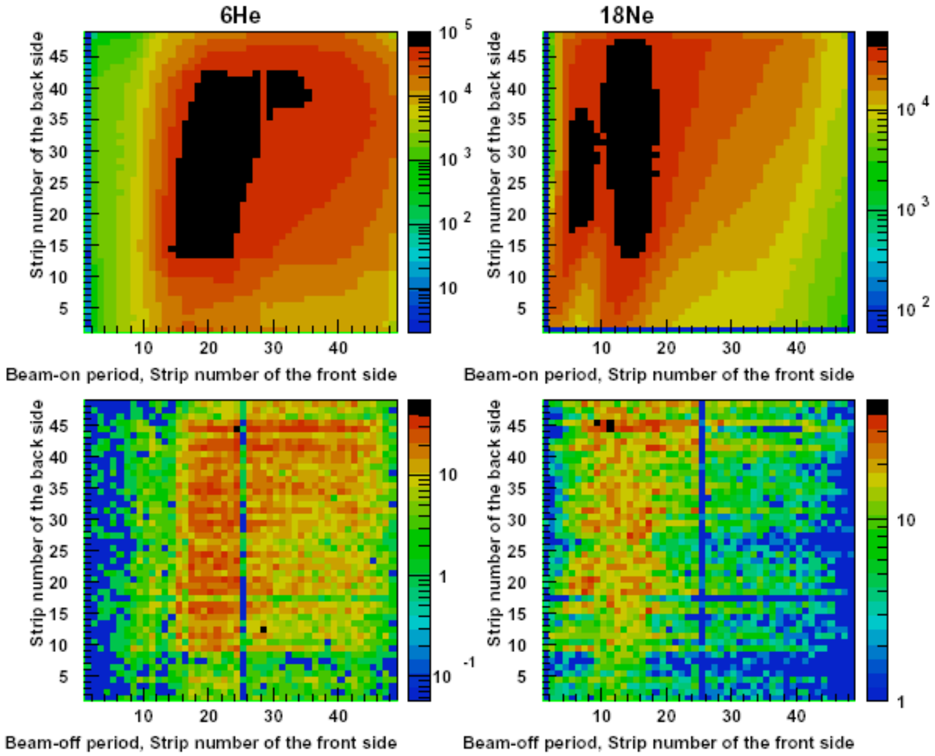


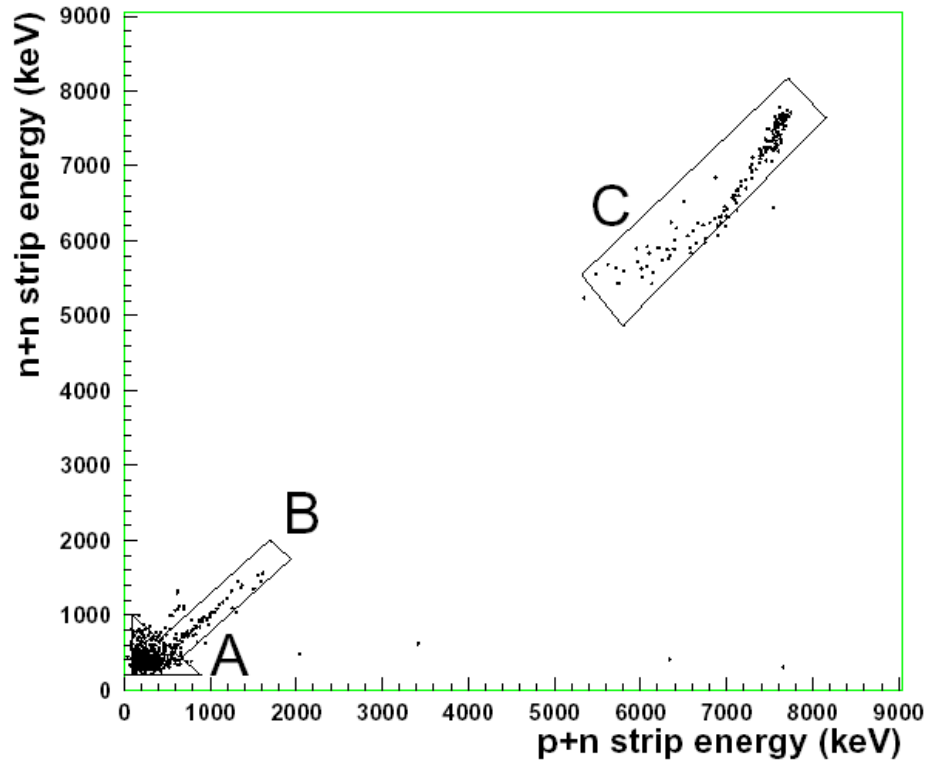
DECAY (time-position correlations):

- After implantation, the subsequent ion decays (including possible daughter decays) are detected as events in the same pixel with ~ 100% efficiency (typical d,t,α ranges are <40 μm at E<2 MeV).
- In contrast, β particles deposit very little energy in one pixel but can deposit more energy in a few strips/pixels (multiple-hit events) ⇒ energetic β's are strongly suppressed by multiplicity 1 requirement and energy matching

Experimental example: α+d channel in the β-decay of ^{6}He

D. Smirnov et al., NIM in preparation (IKS, Leuven)





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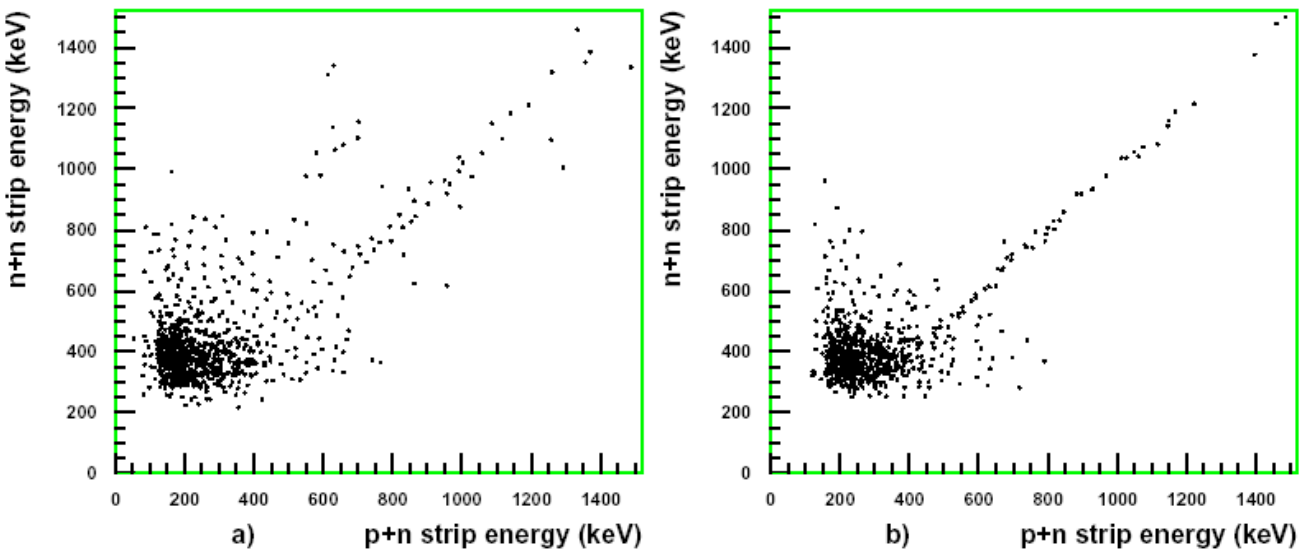
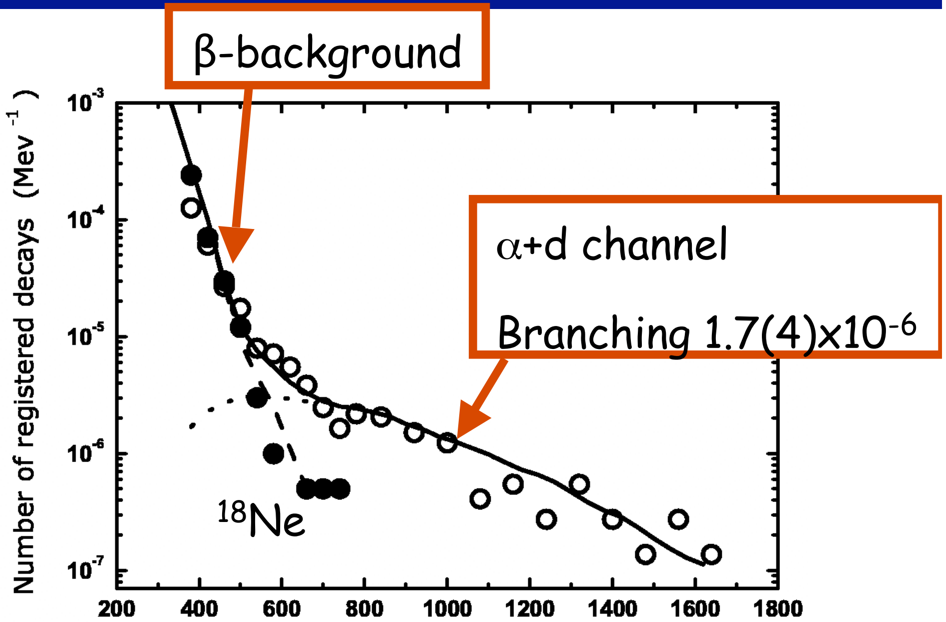
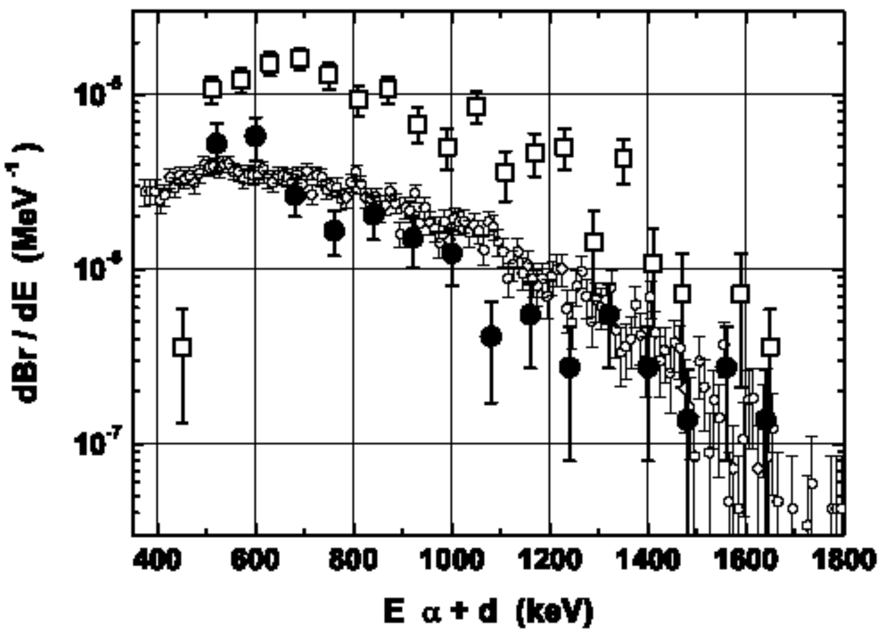


Experimental example: α+d channel in the β-decay of ^6He

- 1.86×10^8 ^6He ions implanted in the DSSD
- 10^4 β particles detected (single pixel/hit)
- suppression factor 2×10^{-4}
- good agreement with literature data, e.g. TRIUMF: $1.8(9)\times10^{-6}$ for E>525 keV D. Anthony et al., PRC65(2002), 034310)
- well-understood technique and detector response (including simulations)





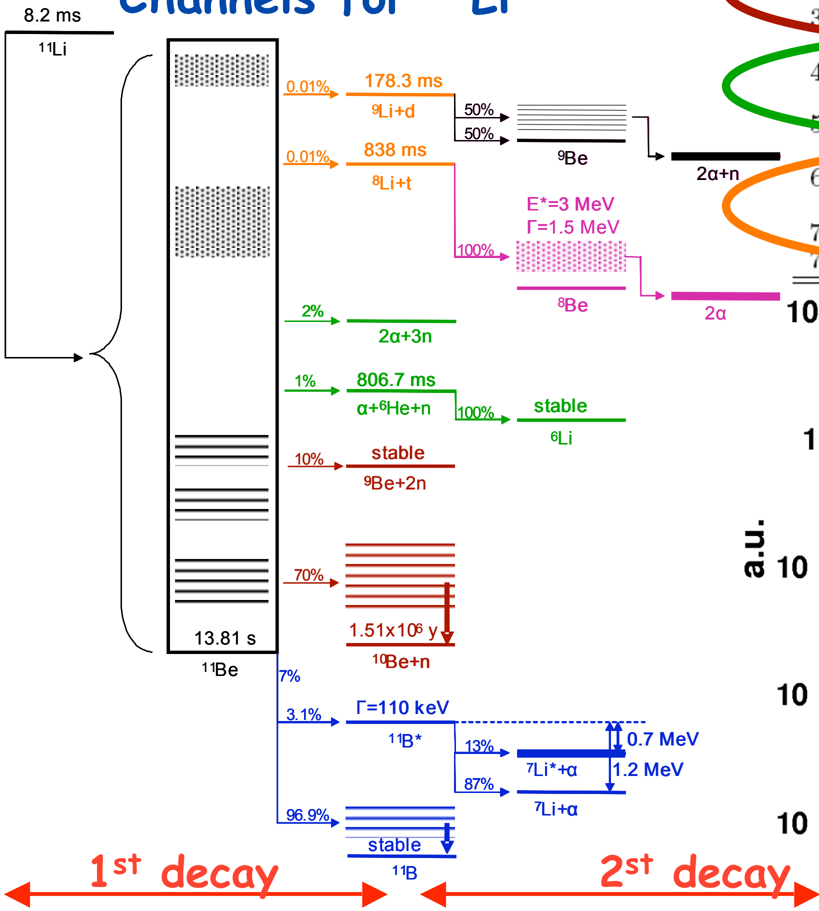
Experiment: Channel selections in the ^{11}Li decay

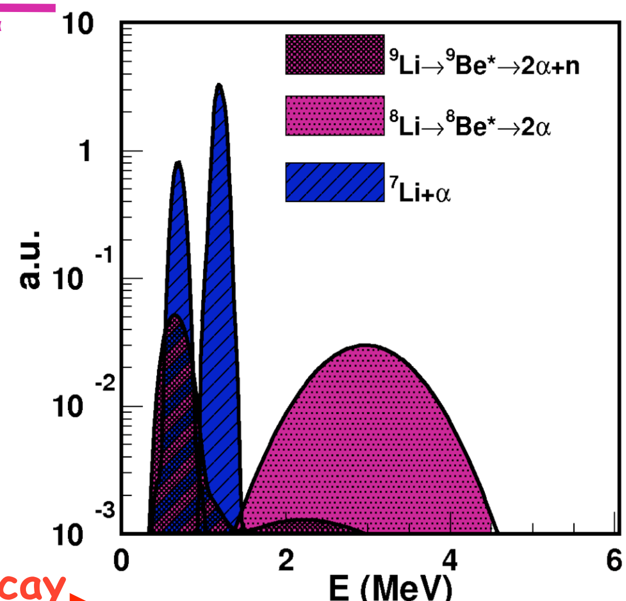
KEY IDEA: use time-position correlations with the daughter products!

- 1st decay is ALWAYS of ^{11}Li (8ms)
- only 3 channels have 2nd ion decay!

^{11}Li channel ($T_{1/2} = 8.2$ ms)			Spectrum	Daughter channel			Spectrum
1a.	~ 7%	^{11}Be (320 keV)	pure β	13.81 s	96.9%	^{11}B	pure β
1b.				13.81 s	3.1%	^{7}Li+α	
2.	~75%	^{10}Be+n	β; ions	10^6 y	–	–	–
3.	~15%	^{9}Be+2n	β; ions	stable	–	–	–
4.	~1%	^{6}He+α+n	β; ions	806.7 ms	100%	^{6}Li	pure β
5.	~2%	2α+3n	β; ions	stable	–	–	–
6.	~10^{-4}	^{8}Li+t	ions	838 ms	100%	2α	
7a.	~10^{-4}	^{9}Li+d	ions	178.3 ms	50%	^{9}Be	pure β
7b.				178.3 ms	50%	2α+n	

Channels for ^{11}Li





- ^{8}Li+t – no problems!
- ^{9}Li+d: use short time gate (<0.3 s) for the second decay to suppress ^{7}Li+α
- Measure directly spectra for ^{8,9}Li in a dedicated run

Beam time request

^{11}Li at 15 MeV

- We want ~ 2500 events in the ^{9}Li+d spectrum (c.f. previous studies <250 cts)
- With ~200 pps and the identification efficiency given above

→ **10 12-hour shifts**

^{9}Li at 13.5 MeV + ^{8}Li at 12 MeV (can work with up to 10^4 pps)

(to measure the energy spectra for 'pure' $^{8,9}Li$ – desirable in the analysis)

→ **1 12-hour shift**

Beam handling, preparation

→ **1 12-hour shift**