Electron capture of ^{8}B into the highly excited states of ^{8}Be

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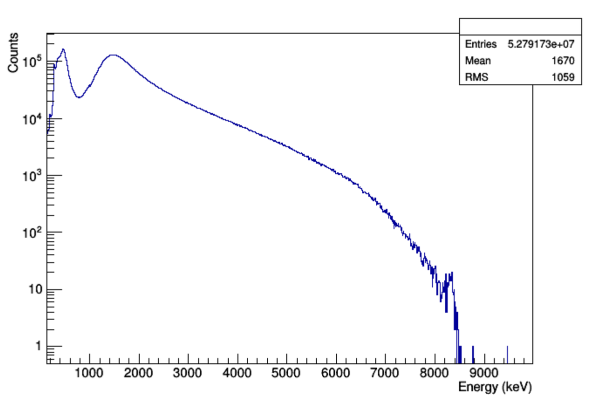
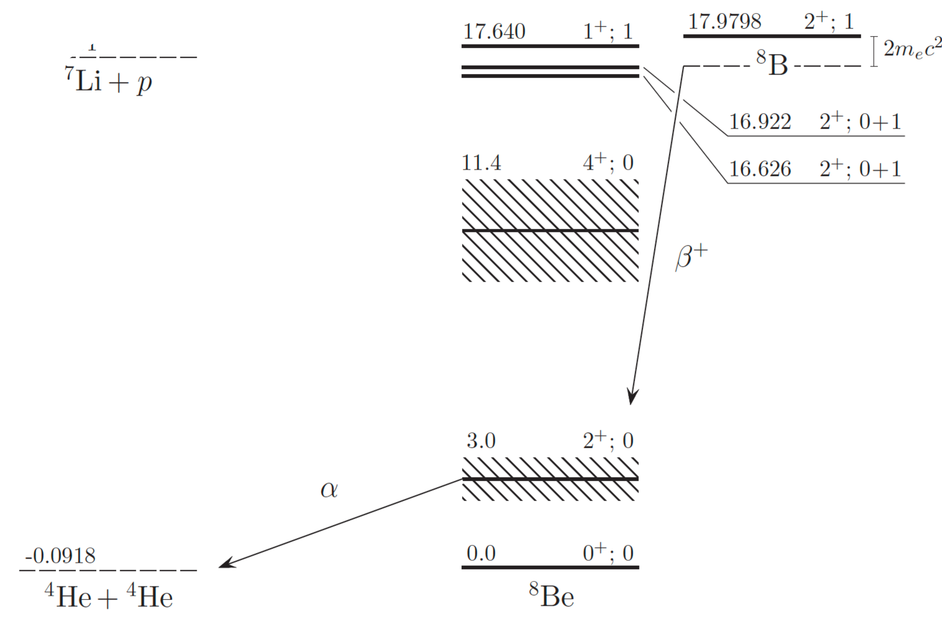
Introduction



Online raw particle spectrum of ^{8}Be fragmentation into 2α in DSSD

^{8}B is very important in astrophysics as is the only source of solar neutrinos above 2 MeV. Predominantly, is β^{+}-decay followed by the fragmentation into 2α particles through 3.03 MeV state and, less probably, through the 11.4 MeV state. These states are broad and produce a continuous α-spectra as seen in the left figure.

The decay of this nucleus is further interesting in nuclear structure because ^{8}B is the only confirmed proton halo nucleus in the ground state [1]. Our interest lies in determining the branching ratios and the properties of the 2+ doublet at 16.6 and 16.9 MeV populated via electron capture (EC) and β^{+}. This doublet has high isospin mixing [2]. Also, we want to detect the so far unobserved EC delayed proton emission via the 17.640 MeV state, which has a theoretical branching ratio of $2.3 \cdot 10^{-8}$ [3].

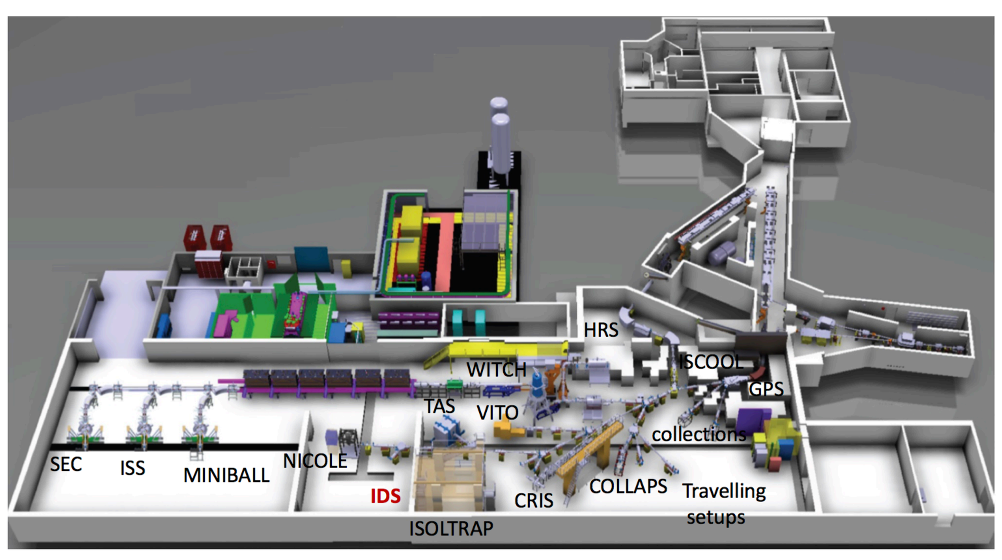


Decay scheme of ^{8}B into ^{8}Be. All the energies are in MeV. Taken from [4]

Experimental set-up

Facility ISOLDE and IDS (CERN)

The experiment was performed at the ISOLDE (Isotope Separation On-Line Device) facility, in concrete at the Isolde Decay Station (IDS).



General overview of the ISOLDE facility. IDS can be seen in red letters.

ISOLDE produces exotic beams with the ISOL technique and the produced fragments are mass separated by A/Q selection. In our case, ^{8}B, which has a half-live of 770ms and it's send to IDS as a molecule of $^{8}BF_2$.

In the figure is shown the layout of the ISOLDE hall. It shows several fix experimental setups as IDS. It can be separate in low energy stations (ISOLTRAP, IDS, COLLAPS,…) and the high energy stations on the left (SEC, ISS and MINIBALL)

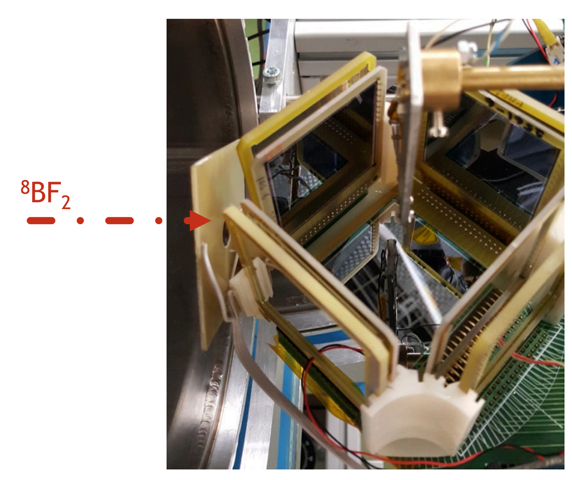
IDS is a experimental setup operational since 2014. It includes flexible arrays of γ, charged particles and neutrons for β-decay spectroscopic studies of the low-energy radioactive beams.

Experimental set-up

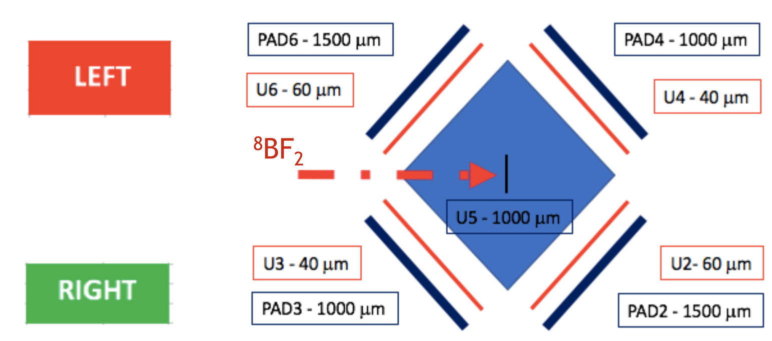
We used a set of 4 particle-telescopes formed by 1 double sided silicon striped detector (DSSD) plus 1 thicker Si-detector. Also, another DSSD on the bottom to maximize the β detection.

The center of this setup is the catcher of carbon foil of 31μg/cm^2 where is implanted the ^{8}B beam. This is surrounded by the particle-telescopes to optimize the detection. They are put face to face with the same thickness to detect the α-α coincidences at 180°.

The thickness of the detectors has been fixed to stop all the α-particles of the ^{8}Be fragmentation (60μm) and to have good resolution at low energies (40μm).



Setup configuration outside the decay chamber



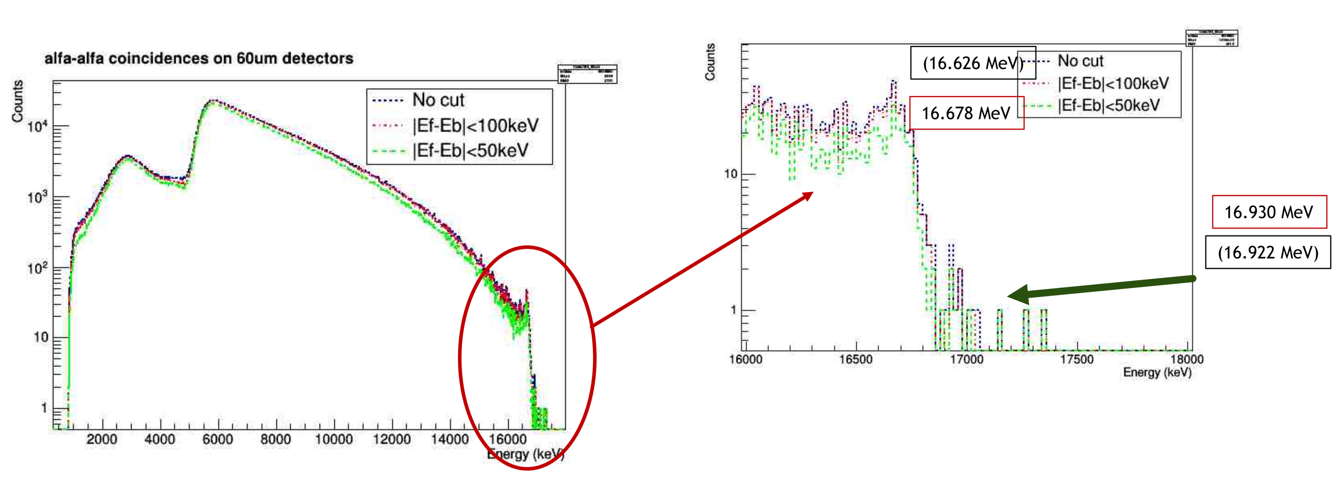
Setup scheme and thickness of each detector

Data analysis and preliminary results

2+ doublet - High energy part of the spectrum

As the interesting branch is not even a 1% of the decays, we put high thresholds to emphasize the high energy part of the spectrum increasing the thresholds. The figure shown is disturbed at low energy due to this cut.

To reach a 4% of statistical error in 16.9 MeV state we need at least 500 events in this peak. Extrapolating the statistics from the 2% of the set of data we should have enough statistics. Still in progress to analyze.



On the **left**, the α-α sum-spectrum between the 60μm detectors spectra with high thresholds and a 15% of dead time. The difference in the spectra are due to a filter reducing random coincidences.

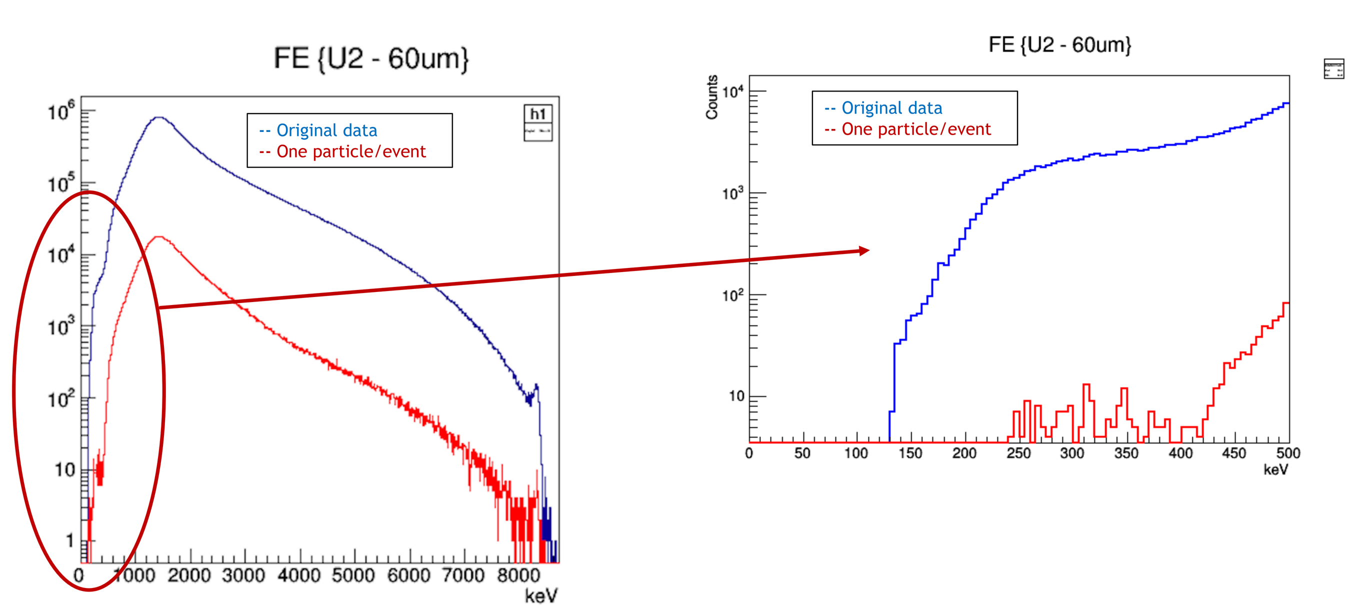
On the **right**, same spectra zoomed in on the range where we are interested. Values in black show the theoretical energy of each peak. The red ones show the peak fitted with the calibration.

Searching for the proton - Cleaning the low energy part of the spectrum

When the 17.6 MeV state is populated by EC, a 337keV proton in coincidence with a non-detectable X-ray is emitted and remains a ^{7}Li nucleus.

Due to the extremely low branching ratio ($2.3 \cdot 10^{-8}$) of the emission of the proton, we have to clean the low energy part of all possible contaminants.

As the main activity is $\beta^{+}\alpha\alpha$ (multiplicity 3), by choosing multiplicity 1, i.e. hit in only 1 of the detectors, a reduction of a factor of 1000 in the low energy part is obtained.



On the **left**, blue line is a α-spectrum of a 60μm detector. Red line spectrum is when multiplicity=1. Due to the the efficiency of the detector, there are still some α-α events where only one of the α is detected. On the **right**, same spectra but zoomed in.

Summary and outlook

1. **The 2+ doublet:** after having analyzed 2% of the data it points to that we will determine the 16.9 MeV state within a 4% statistical error.
2. **The 17.6 MeV state and the proton:** the low energy part of the spectrum can be cleaned enough in order to detect a 10^{-8} event branching. This part of the experiment will take place in spring.
3. Further, as **bonus** the statistic will allow for an improvement on the half-live determination of the ^{8}B. Present accepted value is (770 ± 3) ms [5].

References

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