

Observation of a Near-Threshold Proton Resonance in ^{11}B

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Introduction:

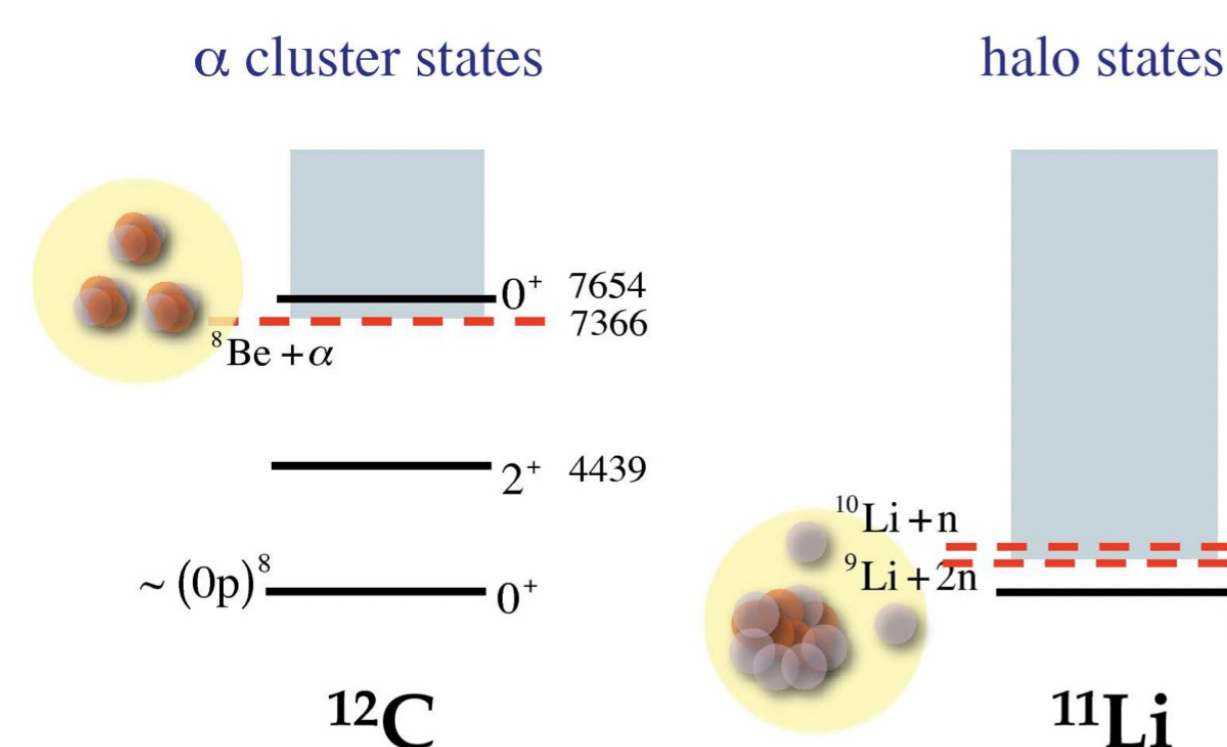


Fig. 1. Examples of known near-threshold resonances

- Nuclear clustering is one of the most puzzling phenomena in subatomic physics.
- Resonances are genuine intrinsic properties of quantum systems, associated with their natural frequencies, and describing preferential decays of unbound states.
- The understanding of these phenomena is critical in the development of a unified nuclear theory.

Experimental studies of the $^{11}\text{Be}/^{10}\text{Be}$ branching ratio obtained unexpectedly high results that raised questions about the decay mechanism and led to speculations about a possible nuclear dark decay channel.

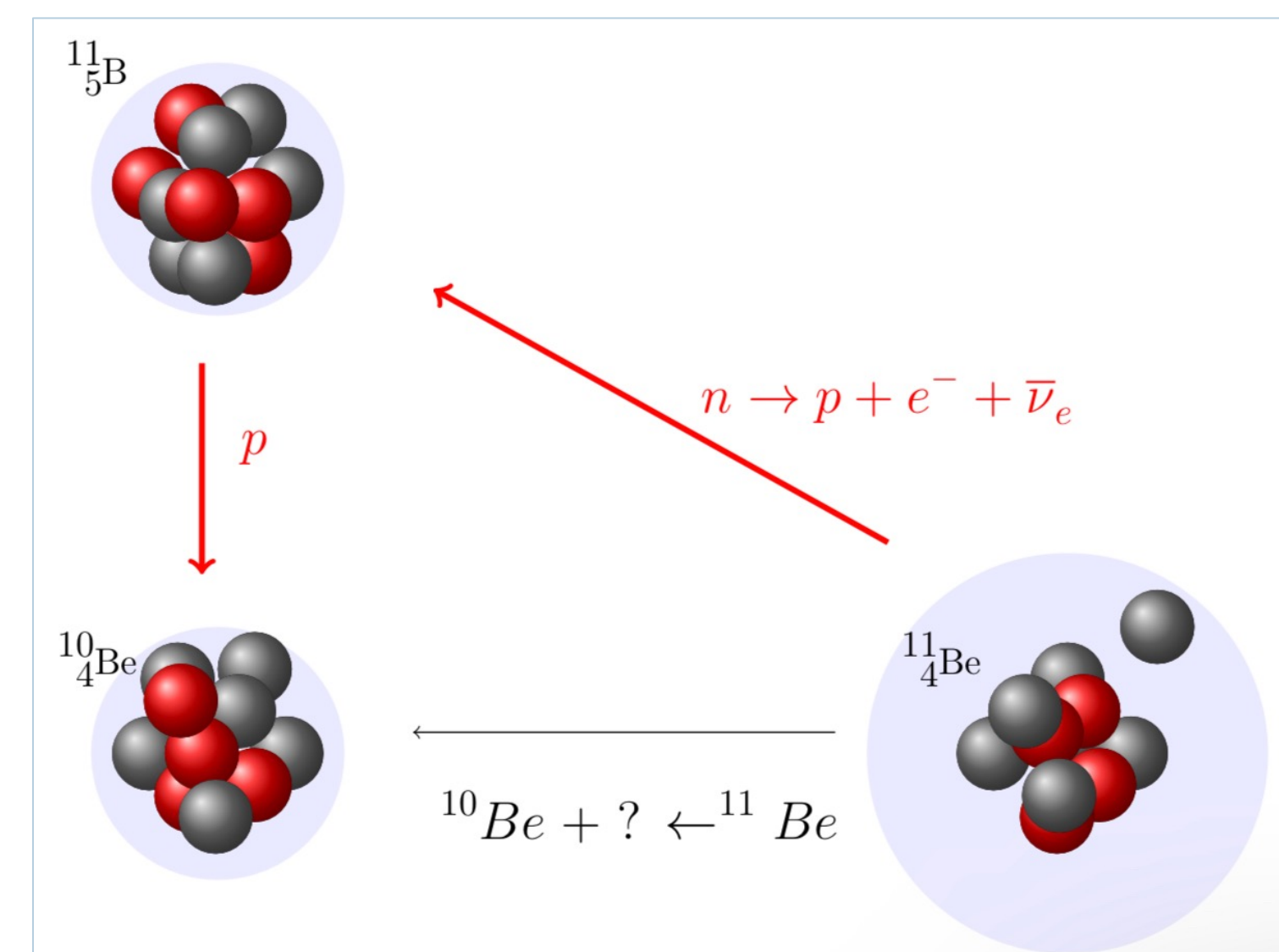


Fig. 2. Possible $^{11}\text{Be} \rightarrow ^{10}\text{Be}$ decay paths.

A non-exotic explanation...

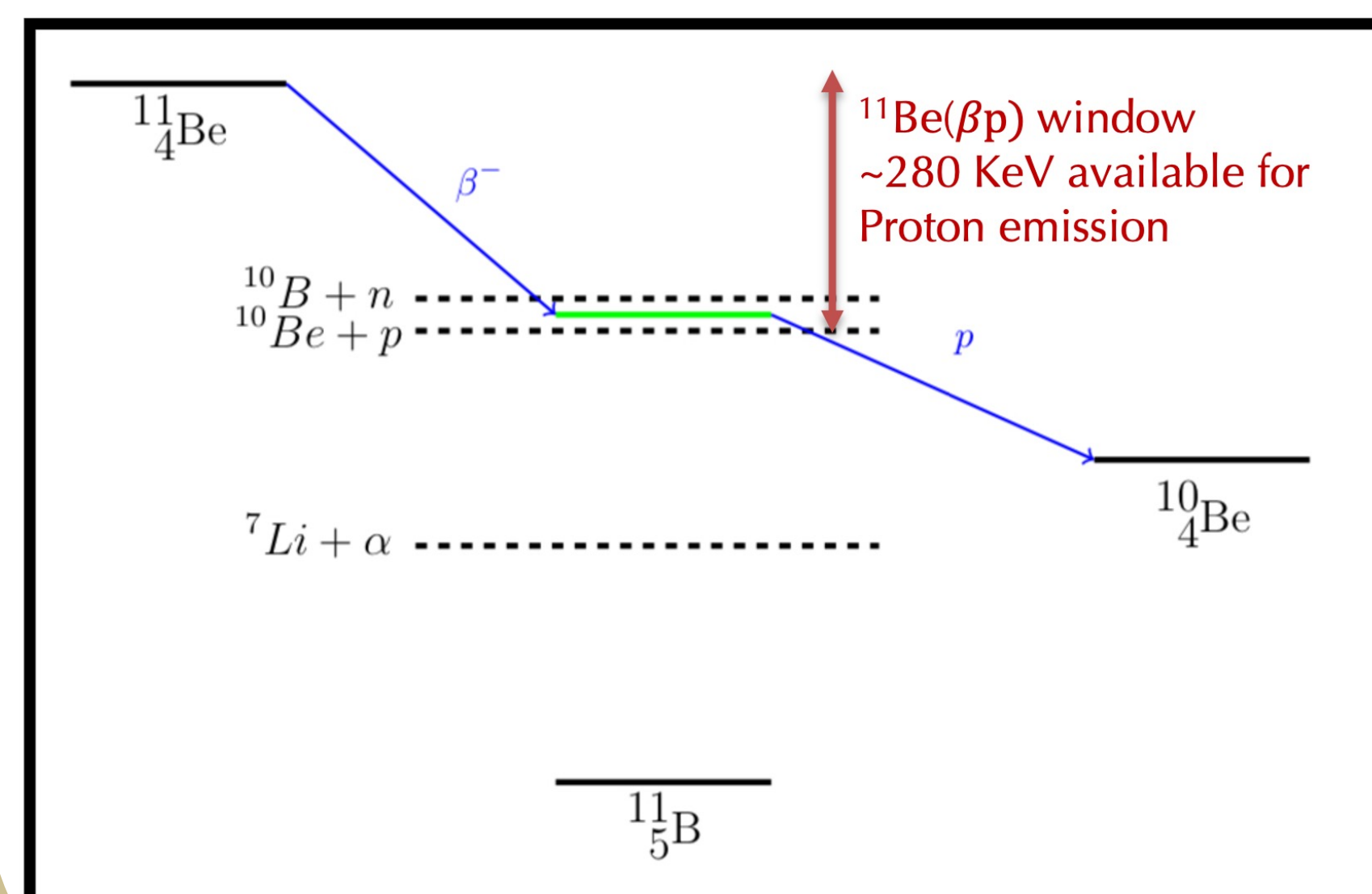


Fig. 3. ^{11}B relevant particle emission thresholds for the proposed proton resonance.

A sharp near-threshold proton resonance in ^{11}B could help explain the $^{11}\text{Be}/^{10}\text{Be}$ experimental results.

Experimentally challenging to detect protons of such low energy in direct kinematics.

Beta-delayed proton emission is a rare decay mode energetically allowed for neutron-rich nuclei with $S_n < 782$ keV.

^{11}Be is also the best candidate for the beta-delayed proton emission decay!

D. Baye, Physics Letters B 696 (2011) 464–467

Does this near-threshold resonance exist?

The $^{10}\text{Be}(d,n)^{11}\text{B}$ experiment in inverse kinematics at FSU:

^{10}Be beam produced in-flight with RESOLUT beam facility.

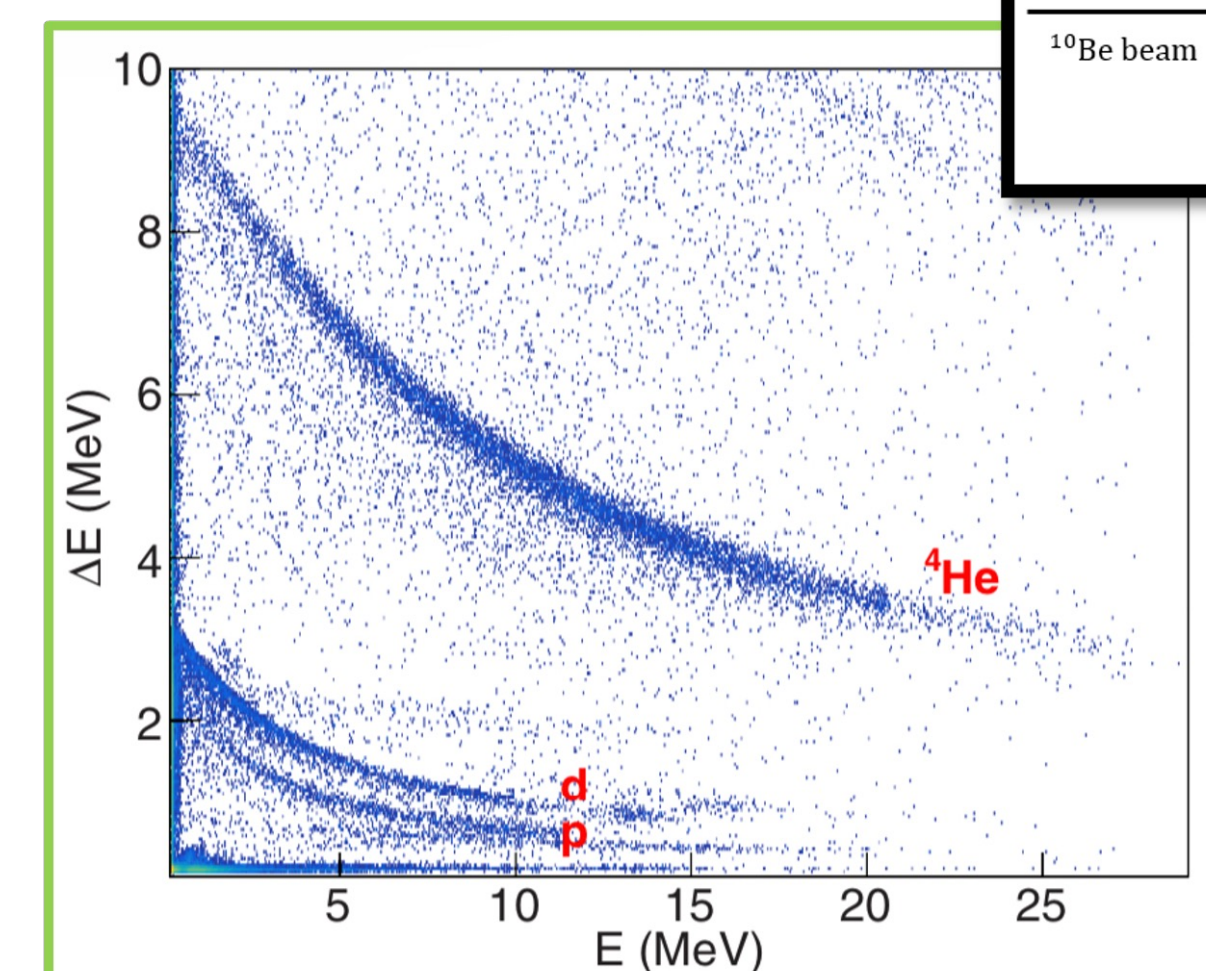


Fig. 5. Particle identification in the Si-telescope array

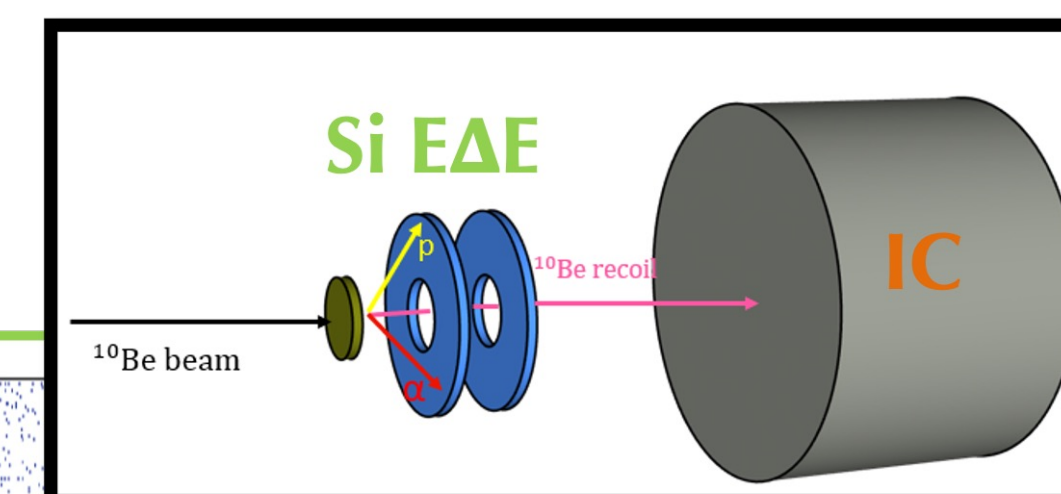


Fig. 4. Experimental setup

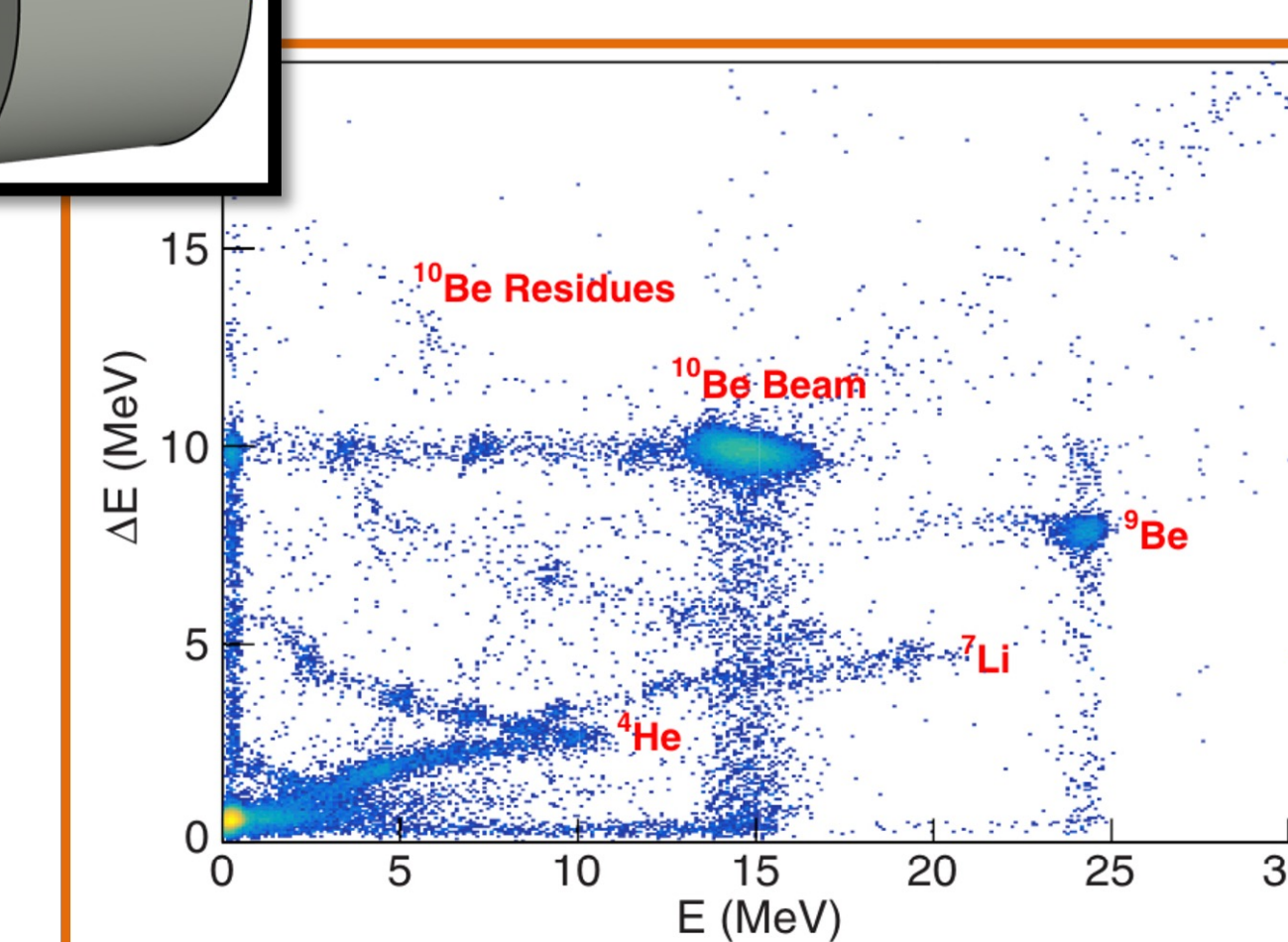


Fig. 6. Particle identification in segmented position-sensitive ionization chamber.

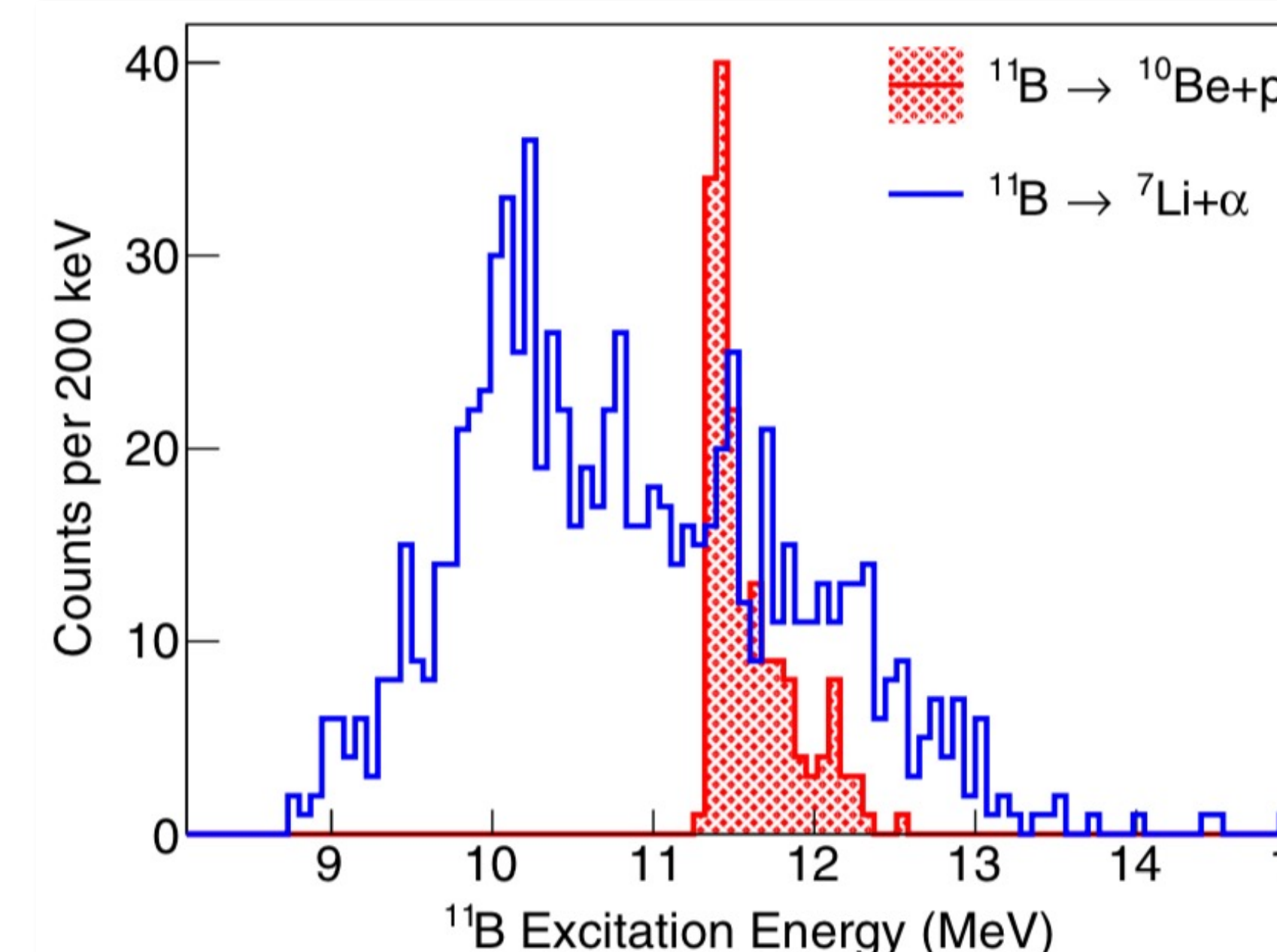
- Events from the $^{11}\text{B} \rightarrow ^7\text{Li} + ^4\text{He}$ and $^{11}\text{B} \rightarrow ^{10}\text{Be} + p$ were identified by requiring coincidences between the Si-EDE and IC
- The position and energy signals from the Ionization Chamber and Silicon-array were used to reconstruct their four-vectors and calculate excitation energy:

$$P^\mu(^{11}\text{B}^*) = P^\mu(^{10}\text{Be}) + P^\mu(p),$$

$$P^\mu(^{11}\text{B}^*) = P^\mu(^7\text{Li}) + P^\mu(\alpha).$$

$$E_{ex} = \sqrt{P^\mu(^{11}\text{B}^*)P_\mu(^{11}\text{B}^*)} - M(^{11}\text{B}_{g.s.})$$

We report the presence of a sharp proton resonance in ^{11}B at $E_{res}=211(40)$ keV!



Experimental characteristics of Proton resonance:

- $E_{ex} = 11.44 \pm 0.04$ MeV
- $\sigma_{exp} = 9\text{mb}$
- $\Gamma_{sp} = 20$ keV
- $C^2S \sim 0.27(6)$ (IF BR(p)=100%)
- $\Gamma_p = 5.4$ keV

Fig. 7. Reconstructed excitation energy spectrum for the proton and alpha decay channel of ^{11}B .

Presence of prominent structure in the alpha spectrum at similar energy as the proposed p-resonance. In this experiment, we can't conclude whether both structures come from the same state in ^{11}B . **New Measurements are needed to study both decay channels!**

Our Results favor the non-exotic decay path for $^{11}\text{Be} \rightarrow ^{10}\text{Be}$!

"Observation of a near-threshold proton resonance in ^{11}B ", Phys. Rev. Lett., 129, 012 502, (2022).

Looking for the alpha channel ...

The $^7\text{Li}(^7\text{Li},t)^{11}\text{B}$ experiment:

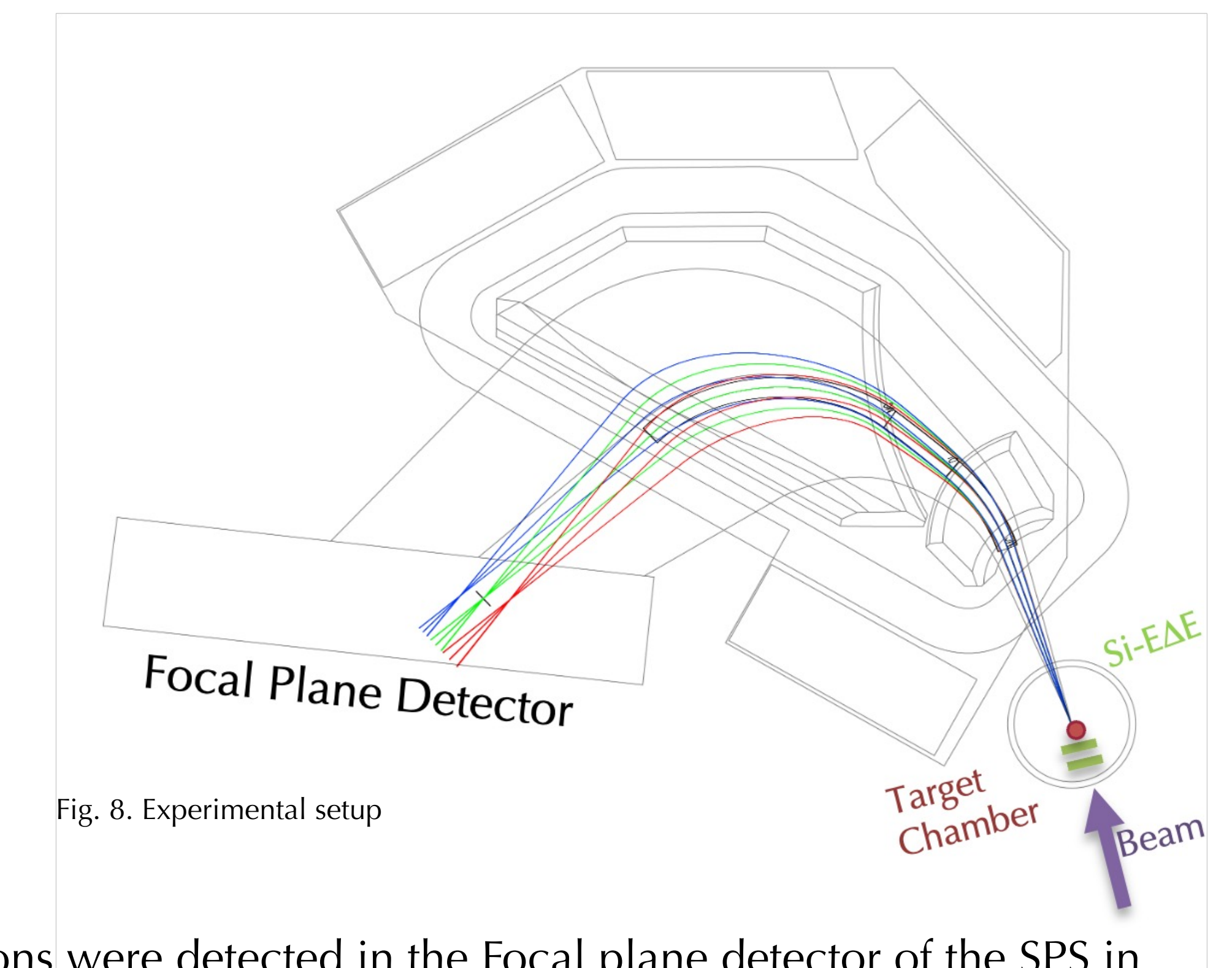


Fig. 8. Experimental setup

Tritons were detected in the Focal plane detector of the SPS in coincidence with the charged particles detected in the Si-telescope array placed at forward angles.

The analysis is ongoing!

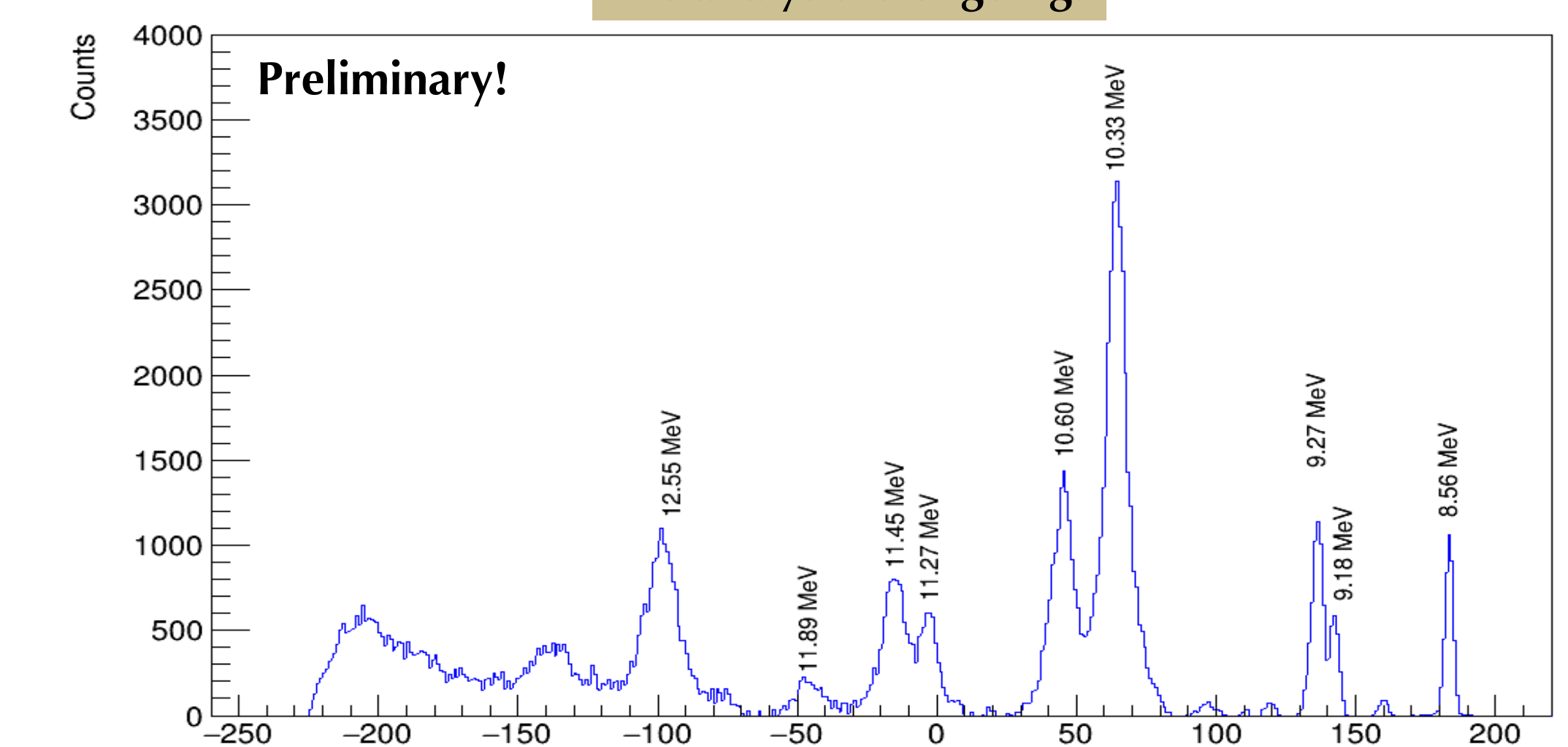


Fig. 9. ^{11}B states identified in the focal plane.

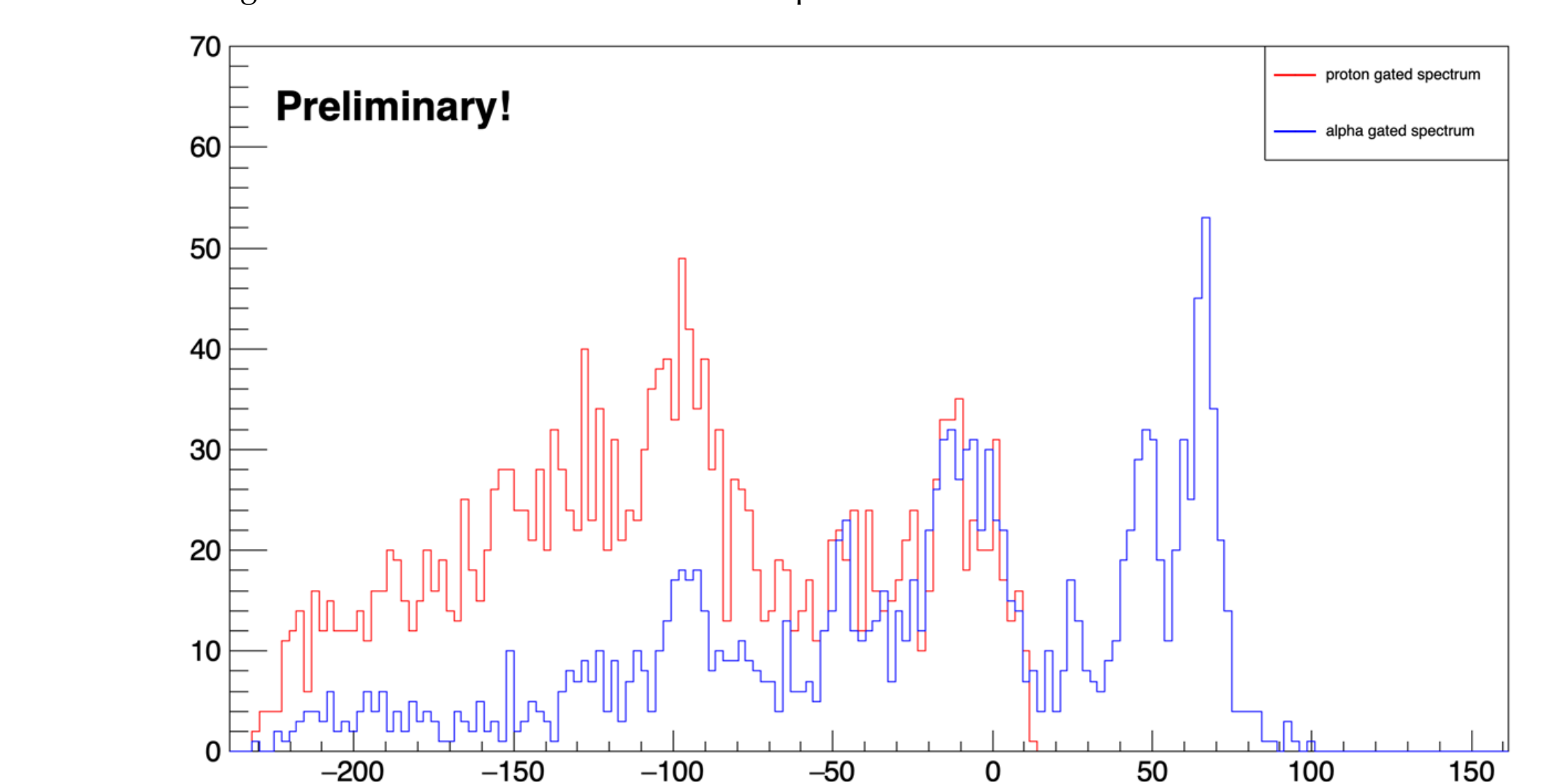


Fig. 10. Events in the focal plane in coincidence with the protons/alphas in the Silicon Array.

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