



Alpha Clustering Nature of Superradiant States in ^{13}C

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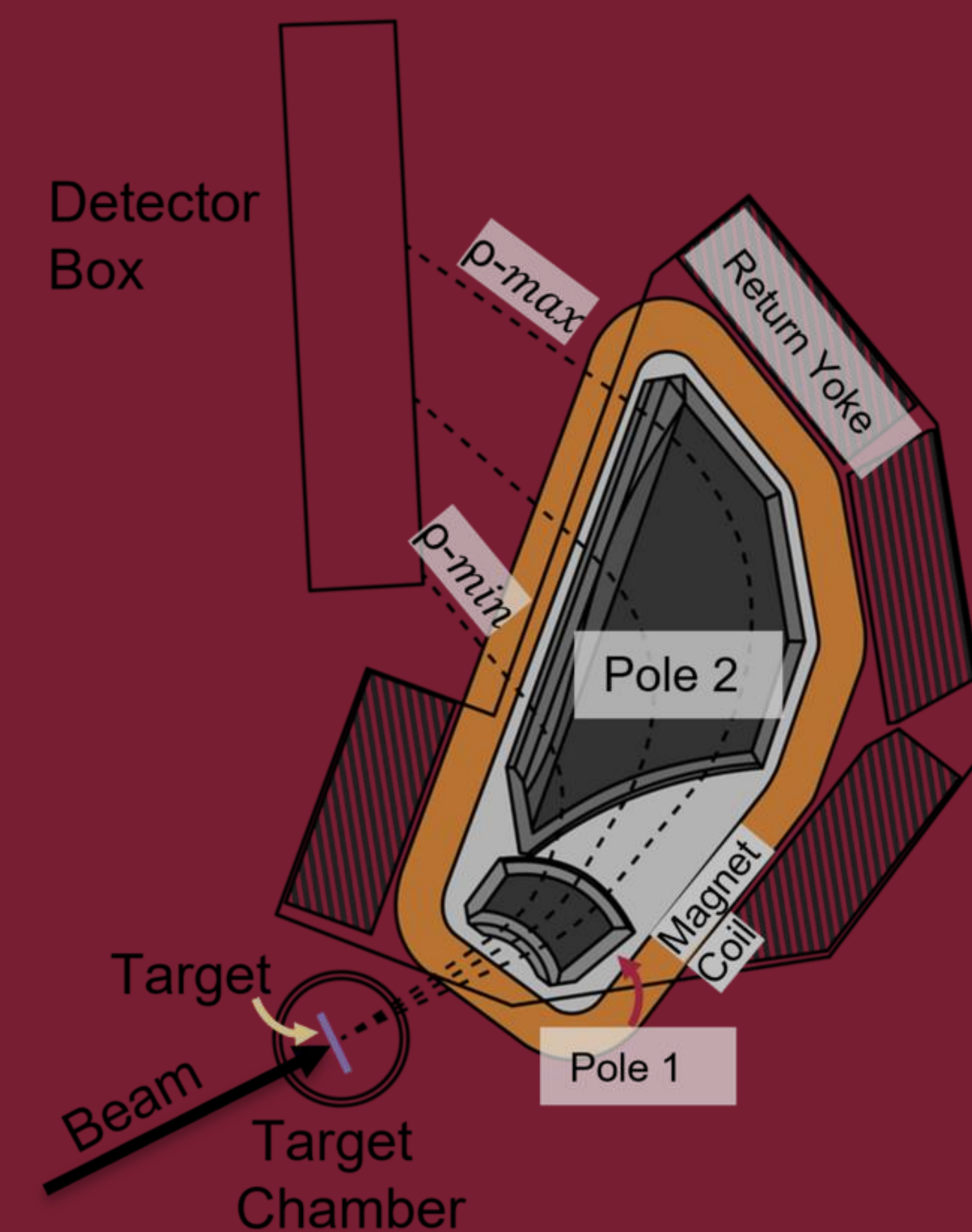
Introduction

- Investigations of exotic nuclei near drip lines and the impact of continuum on nuclear structure are in focus at the Facility for Rare Isotope Beams (FRIB)
- The phenomenon of nuclear superradiance provides a unique workbench to study the influence of the decay continuum on the wave functions of nuclear states in detail.
- Nuclear Superradiance: coupling of nearly degenerate resonances (with access to at least one open decay channel) such that their widths redistribute

Motivation

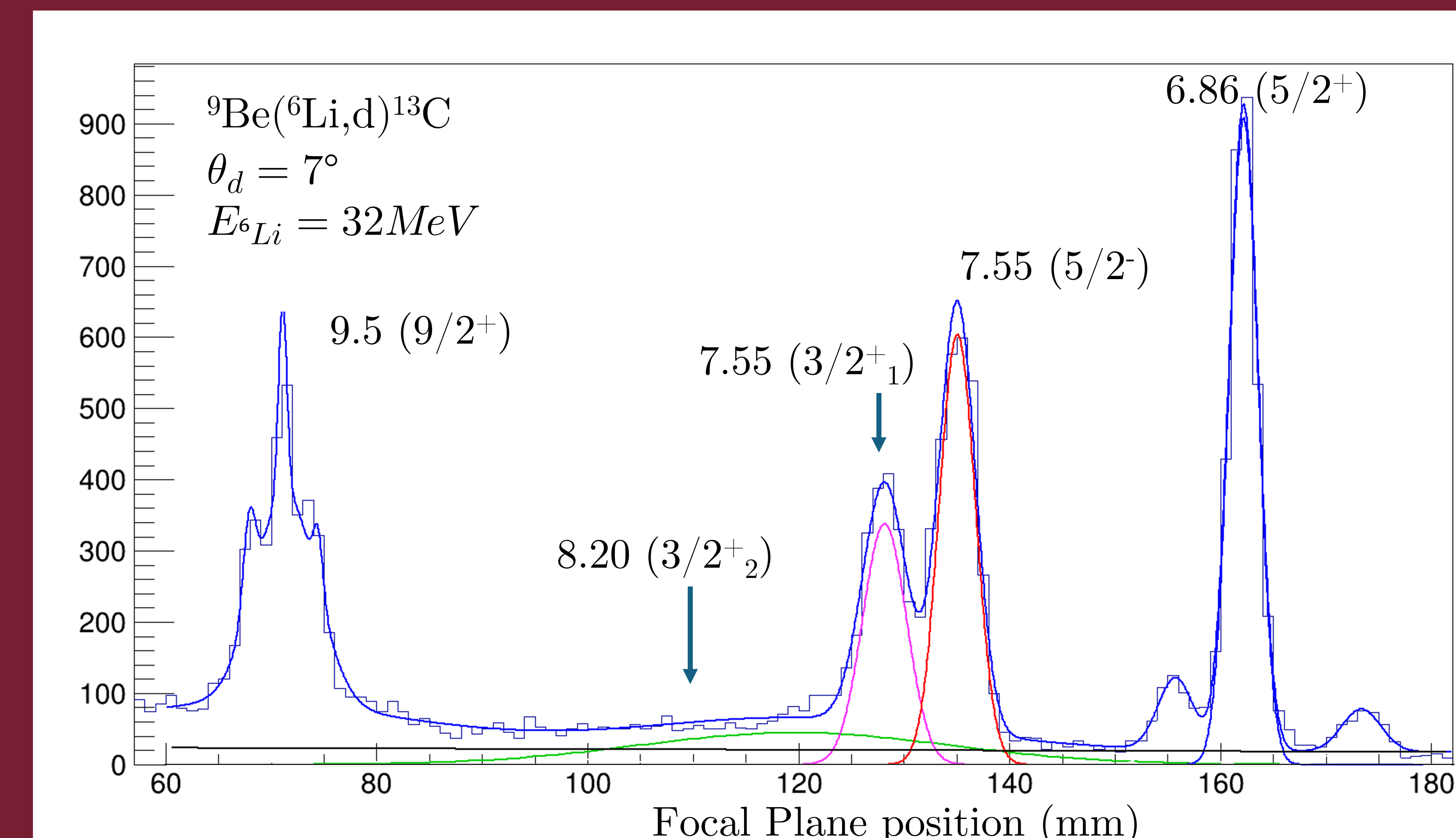
- Previous work by FSU graduate Dr. Ken Hanselman [1] has investigated the superradiant state in ^{13}N in detail and developed the reaction theory needed to determine its wave function in experiments at the John D. Fox Laboratory.
- A good candidate to extend this study is the mirror-nucleus is ^{13}C with respect to the competition of α -clustering and neutron decay in the $3/2^+_{1,2}$ states

Methods



- Compare the population of excited states through the neutron-transfer reaction $^{12}\text{C}(d,p)^{13}\text{C}$ (bottom left) at 16 MeV beam energy to the α -transfer reaction $^9\text{Be}(^6\text{Li},d)^{13}\text{C}$ (right) at 32 MeV, using the Super-Engel Split Pole Spectrograph (SE-SPS).
- For both experiments we focused the broad superradiant $3/2^+_1$ peak and to observe the sharp $3/2^+_2$ state, which in (d,p) appears as an interferent "notch" at 7.69 MeV.
- Gates applied on E-dE timing on ^2H particles to generate spectrum
- Energy calibrated with $^9\text{Be}(^6\text{Li},d)^{13}\text{C}$ using SplitPole Analysis Code (SPANC)

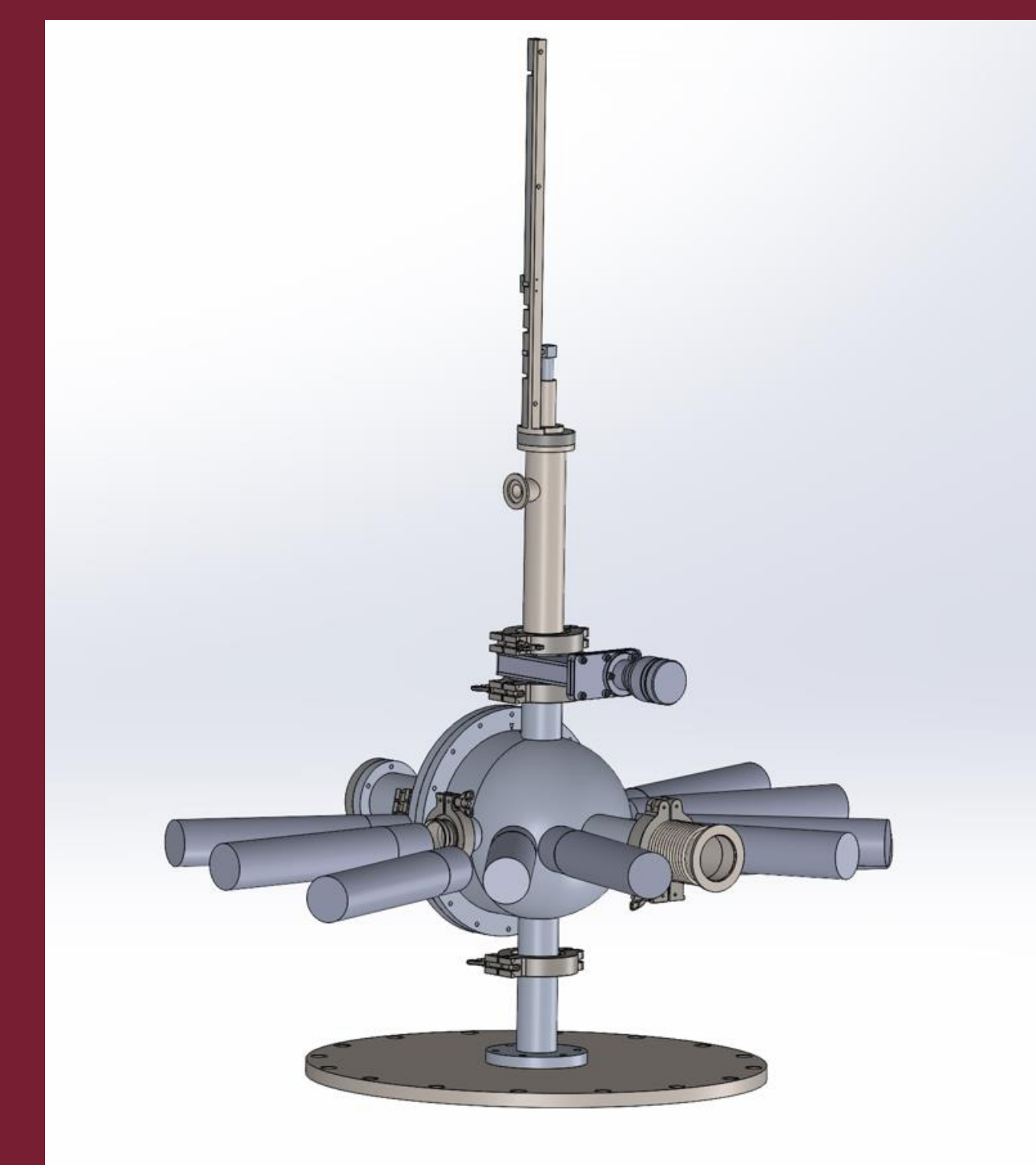
Results



- Good resolution achieved in previously reported states [2].
- No sign of broad superradiant state at 8.20 MeV
- The trapped "notch" state at 7.69 MeV has substantial strength and appears as an isolated peak.
- The α -strength seems to be concentrated in the trapped state, while the neutron-strength is concentrated in the broad state.
- This may be an example of orthogonalization due to the presence of competing decay channels.

Future Work

- Perform both (d,p) and $(^6\text{Li},d)$ experiments with SE-SPS and CATRINA to detect coincident neutrons. This will allow to analyze decay angular correlations and to determine precise wave function components in comparison to Continuum Shell Model calculations.



References:

- [1] Hanselman, K 2022, 'Direct Reactions and Decay Correlations Studying The Proton-Unbound State in ^{13}N ', PhD Thesis, Florida State University, Tallahassee
- [2] X. Aslanoglou, K. W. Kemper, P. C. Farina, and D. E. Trcka Phys. Rev. C 40, 73

