Resonances of 25,26F Atomic Nuclei

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Resonances of $^{25,26}$F Atomic Nuclei

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National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU)
- National Superconducting Cyclotron Laboratory (NSCL) Lansing, Michigan
- Facility uses two particle accelerators called cyclotrons which produces many radioactive isotopes
- The isotopes are separated by a magnetic fragment separator
- The beam is then directed into a target where collisions cause reactions within the nucleus.

Isotope Separation
- Time-of-Flight (ToF) is the time it takes the charged fragment to get from the target to the fragment detectors
- The energy loss separates the elements and is proportional to $Z$ where $Z$ is the number of protons in the nucleus
- Adjusting the ToF based on charged particle trajectories results in isotope separation
- Nuclides generated from our secondary beam based on their adjusted ToF and energy loss is shown below.

Simulation Description
- The Monte Carlo simulation that we use to simulate our experiment requires a number of inputs:
  - A $^{27}$Ne beam energy (101.305 MeV/amu) along with position and angle distributions at the target
  - Liquid deuterium target thickness (cylinder of diameter of 38 mm and a length of 30 mm) in the simulation we used an equivalent energy loss with $^{28}$Si instead of deuterium
- Identify the reaction product $^{25,26}$F resulting from removing 1p or 2p resulting form removing 1p and 2p
- Reaction model $^{2}$ momentum kick given to the product after reaction
- Neutron sizes, Sweeper magnet neutron window, charged particle and neutron detector dimensions, detector resolutions, and complete detector setup

Simulation Overlay
- This figure (taken from Reference 1) shows the decay energy of $^{25}$F with resonance at (green line) 28 KeV, (thin line) 300 KeV, and (dotted line) 1200 KeV.
- $^{25}$F produces many resonances at (green line) 28 KeV, (thin line) 300 KeV, and (dotted line) 1200 KeV.

Eccentricity of $^{25}$F with simulation overlay:
The three simulation peaks are (red line). 375 MeV peak with a 0.2 MeV width, (pink line) 1.0 MeV peak with a 0.6 MeV width, and (blue line) 3.0 MeV peak with a 2.0 MeV width.

Eccentricity of $^{25}$F with simulation overlay:
The three simulation peaks are (red line). 35 MeV peak with a 0.3 MeV width, (pink line) 1.45 MeV peak with a 0.6 MeV width, and (blue line) 3.5 MeV peak with a 2.0 MeV width.

Neutron Detection
- Neutron Time-of-Flight $^{25}$F
  - Neutron Time-of-Flight is the time it takes the neutron to get from the target to MONA and USA.
  - This is timed right before the liquid deuterium target to the MONA-LISA detectors.
  - First peak is an interaction with the detectors and Gamma-rays.

Interpretation
- The states above the $S_{0}$ line have enough energy to emit a neutron and are still unstable and emit another neutron and ends at a stable $^{25}$F with two emitted neutrons.
- The states above the $S_{+}$ line have enough energy to emit a neutron and ends at a stable $^{25}$F with one emitted neutron.
- Theoretical calculations for the different ways of producing $^{25}$F or $^{26}$F.
- Green lines are for negative parity and red lines are for positive parity.
- A parity is how the state is mathematically represented with a positive parity being a cosine function and a negative parity is a sine function.
- Theory calculation using NuShell

Outlook
- The difference between the prior results and our data will be explored.
- Publish a journal article on the unbound states of $^{25}$F and $^{26}$F.
- We plan to reconstruct a 3-body decay energy spectrum

Acknowledgements
We thank our MONA Collaboration colleagues, especially Jaclyn Brett and Dr. Paul Dehong from the Hope College Nuclear Group. We would like to acknowledge support from NSF grant #1304236 and Augustana College.