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Direct Search for a BSM Gauge Boson using High-Resolution Angular-Correlation Measurements of High-Energy IPC Decay in ^{8}Be

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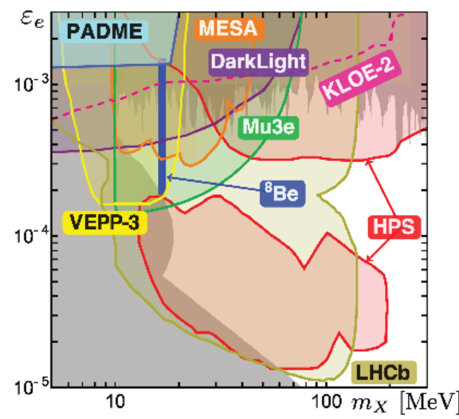
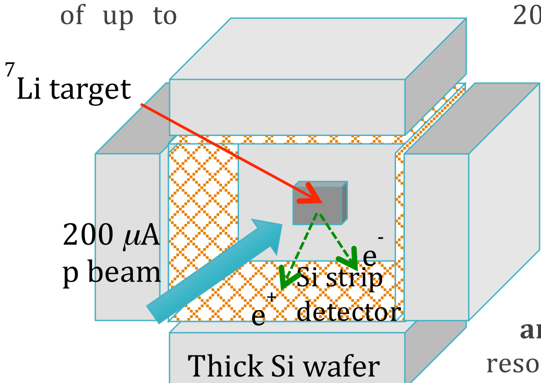


With the recent measurement of internal pair creation (IPC) decay from a high-lying 0^+ state in ^{8}Be, an anomalous enhancement in the IPC rate was found at large *e+e-* correlation angles by the group at MTA Atomki in Hungary [PRL 116, 042501 (2016)]. This anomaly was observed in an isoscalar transition between the 18.15 MeV (J=1^+,T=0) state and the ground state (J=0^+,T=0) in ^{8}Be at a level of nearly 7σ. This observation may in fact represent the first evidence of a new vector gauge boson (X) with a mass of 16.7(6) MeV that decays via X -> *e+e-* and could mediate a fifth force of nature [PRL 117, 071803 (2016)]. Obviously such an observation would be tremendously important for searches into our understanding of physics beyond the Standard Model (BSM), as a new vector (or axial-vector) boson could couple to the dark sector, as has been suggested previously. Light nuclei provide a unique environment for performing these measurements to high precision in a relatively unexplored sector (see image above). **Our initial goal is to confirm the ^{8}Be measurement using higher resolution and statistics through a different experimental technique.**

We propose to perform this measurement using radiative proton capture on a ^{7}Li target at the University of Notre Dame Nuclear Structure Laboratory (NSL). The NSL has a 5 MV single-end 5U accelerator that is typically dedicated to similar radiative proton capture experiments, and can provide proton beams with intensities of up to 200 μA. **This represents a factor of 200 increase in beam intensity relative to the previous measurement.**



To provide the improvement in *e+e-* correlation detection, we plan on using a simple array of silicon strip detectors in a cubic configuration to provide high position resolution, followed by thick Si wafers to provide total energy information for the emitted leptons (see schematic image left). **The Si strip detectors have a very high granularity, and will be configured in such a way as to increase the angular resolution by up to an order of magnitude.** If γ-ray tagging is required, we will employ high-resolution and high-efficiency HPGe clover detectors that we have access to through the DOE clover-share program.

The proposed setup is almost entirely achievable with existing equipment at the NSL, and can be used to perform the confirmation experiment. **For this initial setup, we estimate that $750k would be necessary for construction and operation,** consisting of one PDF for two years, two PhD students (one at Mines and one at UND), and associated electronics, mechanical structure, and design work.

We are currently in the design stage for this project, however given the availability of our equipment and facility (no program advisory committee (PAC) is used at the NSL), we estimate that we could have our equipment constructed, commissioned, and ready for our first physics run in less than 2 years after the money is available. This work is not currently covered under the existing DOE-NP grant of K.G. Leach or the NSF grant of M. Brodeur. If this work is successful, and the measurement has been confirmed, we have plans for continuing these measurements to other light nuclei with a more sophisticated setup.