



# Jefferson Science Associates

Thomas Jefferson National Accelerator Facility

**Proposal:** C12-21-003

**Hall:** B – PRad collaboration

**Title:** A Direct Detection Search for Hidden Sector New Particles in the 3-60 MeV Mass Range

**Contact:** Ashot Gasparian

**Beam time request:** 60 days

**Tune up time and target changes:** 4

**Configuration changes included?** Beam energy change 2.2 GeV to 3.3 GeV

**Electron beam energy:** 2.2 GeV (1-pass) and non-standard 3.3 GeV

**Electron beam current/luminosity:** 100 nA/6.2E32 cm<sup>-2</sup> sec<sup>-1</sup>

**Electron beam polarization:** N/A

**Targets:** Ta

**Basic instrumentation:** HyCal, GEM trackers, and the large vacuum chamber (PRad detector with modifications)

**Non-standard instrumentation?**

**Trigger:** 3-clusters in HyCal with total energy > 4 GeV

**Magnetic field settings:** N/A

The experiment aims to search for hidden sector particles in the mass range from 3 MeV to 60 MeV. This search is motivated by recent claims of a hypothetical particle, X17, observed in atomic nuclear transitions in three different reactions. The resonance search method will be employed to look for a bump in the invariant mass distribution of the decay products of the hypothetical particle,  $e^+e^-$  or  $\gamma\gamma$ , on top of a copious electromagnetic background. The experiment will reach very low couplings of the X17 to the Standard Model electric charge,  $\epsilon^2 \geq 5 \times 10^{-9}$ .

The proposed experiment will conduct the search using the improved PRad setup in Hall-B. Some of the proposed modifications differ from the changes proposed for the PRAD-II experiment, C12-20-004. The target, mounted on the harp ladder, is very close to the collimator (or halo blocker, as cited in the proposal). The tracking system will not have the resolution to distinguish the production from the collimator and the target. While the beam is expected to have a very little halo, production off of the collimator walls may become an issue for the proposed search.

## Technical Comments:

- 1) The required beam parameters do not pose any challenge. Such beams have been delivered for various experiments in Hall-B. The requested beam energy of 3.3 GeV requires a non-standard CEBAF energy setting. We encourage collaboration to calculate the reach in Table 4 for a standard 2-pass beam at ~4.4 GeV to find out how much beam time will be needed for a similar sensitivity.

A Halo blocker upstream of the Hall-B tagger magnet is shown in the rendering in Fig. 8. There is no description of the blocker in the text. Depending on the requirements for the blocker, the existing wire harp and the pair of the Hall-B raster magnets currently mounted in that location may have to be removed or relocated. The wire harp is a crucial device for beam tuning.

- 2) Only the high-resolution part of the HyCal, consisting of more than 1100 PbWO<sub>4</sub> crystals, will be used. The old readout based on NIM modules and Fastbus electronics must be replaced with fADC250 (similar arrangement as for C12-20-004, PRAD-II experiment) to be compatible with the requirements for triggering. On page 21 of the proposal, it is stated that “A large fraction of the electronics needed for the DAQ and trigger, including the high voltage crates and all necessary cabling for the detectors, are available in Hall B from the PRad experiment.” It should



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be clear that PRad in Hall-B does not have the required fADC250, VXS crates, or trigger modules. These are all new equipment that must be either purchased or borrowed.

In the first paragraph of page 19, the energy calibration of HyCal using the Hall-B tagged photon beams during the first PrimEx experiment is described. There is no mention of how HyCal will be calibrated for this run. For 12 GeV operations of CLAS12, we removed the photon tagger focal plane counters. Re-installation is possible, but the photon energy knowledge will not have the same accuracy as it was during the first PrimEx experiment. Also, over time vacuum in the tagger scattering chamber degraded due to the deterioration of the chamber window. This affects the photon beam energy resolution.

- 3) Two new GEM-based tracking detectors are planned for the experiment. These are not the same detectors that have been proposed for PRAD-II (C12-20-004) experiment. Substantial R&D will be needed to make these detectors lightweight, 0.3% r.l.. We strongly advise that the proponents of these three proposals work together to develop one set of tracking detectors for the proposed C12-20-004, C12-21-003, and PR12-22-003.