The Jefferson Lab Eta Factory Experiment and Applications of PbWO Calorimeters in Future Experimental Facilities

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The goal of the new JLab Eta Factory (JEF) experiment, conducted with the GlueX detector in Hall D at Jefferson Lab, is to perform measurements of various $\eta^{(\prime)}$ decays with a primary focus on rare neutral modes. The experiment's physics program ranges from precision tests of low-energy QCD to searches for gauge bosons with masses below 1 GeV that could couple the Standard Model (SM) sector to the dark sector. The experiment will collect a high-statistics data sample of $\eta^{(\prime)}$ mesons produced via a beam of tagged photons. The GlueX detector features a large, nearly uniform acceptance for both neutral and charged particles, enabling efficient identification of complex multi-particle final states. To meet the requirements of the JEF experiment, the inner section of the forward lead-glass calorimeter in the GlueX detector has been upgraded with lead tungstate ($PbWO_4$) scintillating crystals. $PbWO_4$ offers exceptional characteristics, such as a small radiation length and Molire radius, and large light yield, that make it ideal for constructing high-granularity, high-resolution, radiation-hard detectors. These properties enable excellent spatial separation and energy resolution of reconstructed electromagnetic showers, establishing $PbWO_4$ as the material of choice for many high-precision experiments. The JEF experiment began data collection in April 2025 and will operate concurrently with the GlueX experiment, whose primary objective is the search for gluonic excitations in the meson spectrum. I will give an overview of the JEF experiment, the GlueX detector, and the feasibility of further upgrades to support future η physics studies. Special attention will be given to the newly constructed $PbWO_4$ scintillating calorimeter and recent advancements in calorimeter instrumentation.

Acknowledgement: Work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under contract DE-AC05-06OR23177.

April 36, 2025