

Reactions to the presentations on GammeV – 12/3/08

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The committee heard three presentations; one on the successful GammeV experiment, one on an idea to modify the GammeV apparatus to extend the sensitivity to “chameleon” particles, and one on the status of plans for a new experiment that would have much greater sensitivity to axion-like particles than GammeV. The effort required for the proposed chameleon search is similar to the original GammeV experiment. The new experiment, provisionally referred to as GammeV Reconstituted and Instrumented Magnets for Resonantly Enhanced Photon Regeneration (GRIM REPR), would be much more challenging and much more expensive. The proponents envision mounting the chameleon search during 2009. They also envision prototyping key components of the apparatus required for the GRIM REPR during 2009. Their goal is to submit a proposal to the Fermilab PAC for this experiment in 2010.

The only issues associated with the proposed chameleon search are the availability of the engineers and technicians needed to make the necessary modifications to the vacuum system and to design and fabricate the “dish rack” that will hold chameleon-reflecting “plates.” The committee did not understand the physics of the chameleon regeneration into detectable photons well enough to understand the requirements for the dish rack. We wonder how flat and parallel to one another the plates need to be. We also could not tell how precisely the positions of the plates need to be known. It was also unclear how transparent (to laser photons) the plates need to be and exactly how this requirement constrains the vacuum system. The first step in determining the resources required will be to develop a detailed list of requirements for the upgrade to the vacuum system as well as the “dish rack” system.

The GRIM REPR concept takes advantage of the existence at Fermilab of a large number of high field dipole magnets (Tevatron magnets) and associated cryogenics and control infrastructure as well as expert personnel. However, it also includes a very challenging laser system of a type never before constructed or operated at Fermilab. The experiment calls for two high finesse (LIGO-caliber) tuned matched cavities and optical heterodyne measurement with single photon sensitivity. The proponents have appropriately planned to build a prototype of this system at the earliest practical date.

The proponents believe that the GRIM REPR will have approximately ten times better sensitivity to axion-like particles than any other existing or planned experiment. This alone is a strong argument for approval of the proposal. However, since the experiment will not have sufficient sensitivity to detect the axion proposed as the solution to the strong CP problem (QCD axion), it is important for the proponents to continue to strengthen the physics motivation for the proposal. The possibility that observable meV axion-like particles might explain the observation of anomalous fluxes of high energy cosmic ray photons is intriguing, but needs further work. For example, a question was raised during the review and not answered of the relationship between the location of photon sources in the sky and the galactic magnetic field.

The committee suggests that planning for the GRIM REPR include a review of the results of ground motion testing that has previously been done at E4R. We also suggest that the proponents explore the availability of magnets that are not included in the list of Tevatron spares, such as those installed in the Proton area right bend. These magnets might provide sufficient magnetic field at normal operating temperature, and these or other “lower quality” magnets might provide sufficient magnetic field if operated at lower temperature using a cold helium compressor. We note that standard interconnects between Tevatron magnets do not allow easy polarity changes, as seems to be assumed. New devices would have to be designed and built to provide this capability.

As plans are devised for the prototype system we suggest that a detailed list of requirements be developed in order to ensure that the R&D addresses the highest priority technical concerns in the design of the laser system and to ensure that E4R is an appropriate location for the

experiment considering factors such as expected ground motion, existing climate control, and possible sources of background from nearby accelerators and beam lines.

Finally, the committee believes that the proponents would benefit from the identification of milestones, both as a means of focusing their efforts and to help management understand the progress of the R&D. It will become increasingly important during 2009 for planning of the GRIM REPR to include a credible cost envelope and estimate of the resources that will be required.

The committee has the following response to the "R&D Workshop Charge" sent to the proponents:

- What is the R&D you are doing and why should it be supported?

The proponents have conducted searches for axion-like particles and for chameleons. They are now working on plans for more sensitive searches that will require development of additional equipment.

- What are the prospects for its use in future detectors?

The work is directed at detectors for two specific experiments, one a chameleon search and one an axion-like particle search.

- What is the current status?

The initial experiments have published. The follow-on chameleon search requires a modest amount of engineering and construction to be executed. The follow-on axion search requires much more extensive R&D and design.

- What is the plan for the next year?

The proponents hope to execute the new chameleon search this year. They also plan to design and build a prototype optical system for the future axion search. Work will begin on a formal proposal for the axion search.

- Where could this lead, on the ~five year time scale, or in what experiment?

The plan is to execute the axion search on a time scale of three to five years after an engineering run in about two years.

- At what point would this transition to detector specific or project work?

The work is currently detector-specific.

- What is the level of financial and personnel resources needed for the next year and longer term?

The proponents did not have a detailed estimate of financial and personnel needs, except to say that the chameleon search would be of the same scale as last year's axion search and that the new axion search would be substantially larger. The tasks for the chameleon search were identified, but specific individual and time estimates were not available. A reasonable guess would be one month each from a vacuum engineer and a mechanical design engineer. Further R&D and design will be required to establish the needs of the axion search, but even the resource needs for the R&D and design had not been estimated.