Stanford Rotation Projects in Heavy Photon Search

The Heavy Photon Search Group at SLAC is collaborating with physicists at Jefferson Lab, Fermilab, UCSC, INFN in Italy, and Orsay and Saclay in France in an experiment aimed at discovering a hidden-sector or "heavy" photon. Such a particle would have mass in the range 0.01 to 0.3 GeV, couple weakly to electrons, and decay to e+e-. It would be produced in electron bremsstrahlung on a heavy target, and be identified as a narrow resonance. The very weak couplings of the heavy photon to electrons account for its not yet having been discovered and would give rise to separated vertices in its decay, providing a spectacular signature.

Heavy photons have become a hot topic because they may be intimately linked to light dark matter, an interesting alternative to the SUSY wimps which no one is finding. If the Dark Matter is lighter than about 1 GeV, there is a strong case that a new force, like the hidden photon, must mediate dark matter decays and interactions. Our primary effort at SLAC is the Heavy Photon Search experiment (HPS). During 2011 and 2012, we built, installed, commissioned, and ran the HPS Test Run Experiment at JLab. Following a successful test run, DOE approved and funded the Heavy Photon Search Experiment. The full experiment was installed and commissioned at JLAB early in 2015, and has taken data in two Engineering Runs, one in 2015 and the second in 2016, which demonstrated its physics readiness and led to full JLAB approval. The bulk of our running is scheduled for 2018-2020.

HPS offers opportunities for rotation students to begin work in a number of areas. We are analyzing our data from the 2015 and 2016 runs, so bump hunt and vertex search analyses are being developed and refined. In addition to searching for heavy photons, we've recently expanded our menu to search for Strongly Interacting Massive Particles (SIMPs) that decay via a heavy photon. As we prepare the data for these analyses, we are putting the finishing touches on calibrations, alignment, and improved tracking algorithms. To prepare for major data taking runs in 2018 and beyond, we are training a new crew to operate the silicon vertex tracker (SVT), the SVT DAQ, and the HPS beamline. We are also building new silicon modules to upgrade the performance of the SVT. This project will offer new students hardware, commissioning, and data taking experience. HPS is a very small experiment by modern standards, but exploits cutting edge detection and readout technologies to address a very fascinating piece of physics. It provides a broad education for a thesis students, including all aspects of experimental work, from design to hardware implementation to data analysis. Rotation Projects are available for Summer 2017 and the 2017-2018 academic year.

The HPS group is also helping to initiate a new experiment, the Light Dark Matter Experiment (LDMX), which would run in 2020 at SLAC. LDMX is a search for invisible decays of a heavy photon, complementary to the direct decays sought in HPS. LDMX will be sensitive to thermally produced light dark matter. A hidden sector is expected to have both force particles, like the heavy photon, and matter particles, like the light Dark Matter. Accelerator experiments like HPS and LDMX may be the key to finding the first evidence of hidden sectors in nature.

John Jaros.

An introduction to HPS for Physics 290 is given here: Physics 290 11.07.2016.pptx

Possible Projects for 2018-2019

Contact information

Project Title	Contact Person	Student
HPS Upgrade	Tim Nelson	
Simulation	Takashi Maruyama	
HPS Analysis	Matt Graham	
Tracking Studies	Norman Graf	

Projects

- Study the performance of the Silicon Vertex Tracker using the 2016 engineering run data and compare it to Monte Carlo. This includes understanding the time resolution, occupancy and resolutions. Skills: C++, Java and ROOT.
- Study how machine learning can be used improve the identification and rejection of background. For example, can a machine learning algorithm making use of hit and timing information be used to reject wide angle bremsstrahlung events. Skills: python, matplotlib, scikit-learn and possibly tensorflow.
- Improve the performance the fit algorithm used to extract information from the raw hit samples readout from the SVT. Skills: C++, Java, Minuit and ROOT.
- Improve the simulation of HPS backgrounds. Skills: C++, Geant4
- Develop a procedure to quickly align the SVT. Skills: Java, python, Millipede