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Undergraduate Research Symposium **May 15, 2015 Mary Gates Hall**

Online Proceedings

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SUB-ATOMIC PARTICLES, ROCKETS AND PLASMAS

Session Moderator: Robert Winglee, Earth And Space Sciences
026 JHN
3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

The Search for Hidden Valley Particles

Andrew Sprincin (Andrew) Arbogast, Senior, Physics: Biophysics
Jiasheng (Stanley) Xie, Senior, Physics: Applied Physics
William H. Li, Senior, Physics: Comprehensive Physics, Computer Science
Mentor: Gordon Watts, Physics

The Hidden Valley is a new theory that extends the Standard Model, our current best description of particles and forces that make up our universe. The Hidden Valley theory, along with others, extends the Standard Model in an attempt describe phenomena like dark matter not yet included in the Standard Model. Hidden Valley particles do not interact with Standard Model particles, and are therefore impossible to directly detect. But by using their predicted decay products, we may be able to prove their existence. We are currently running simulations to try to give us an idea of what we should be looking for when we use data from the Large Haddon Collider at CERN. Features of the model and the search strategy will be presented.

Stability of IBL Upgrade for the ATLAS Inner Detector

Tun Sheng Tan, Senior, Applied & Computational Mathematical Sciences (Engineering & Physical), Physics: Comprehensive Physics
Mary Gates Scholar
Mentor: Shih-Chieh Hsu, Physics

ATLAS, a Toroidal LHC Apparatus underwent an upgrade from 2013 to 2014 as the first phase of the preparation for High Luminosity LHC. An additional beam layer called the Insertable B-Layer (IBL) is installed between the existing pixel detectors and is situated at a radius of 3.2 cm. This new layer increases the performance of the tracking at high luminosity. In order to reconstruct the path of the particles in the detector, the position of the detectors must be determined precisely. Present work involves the use of cosmic muons that provide different topology in accessing the stability of the new geometry and the alignment software. The final determination of the geometry of the detector would be used as the reference geometry for the real collision data collecting. This project prepares the ATLAS inner detector for the upcoming runs in May 2015.

Disrupting Rocket Science: 3D Printing for High Altitude Rockets and Instrumentation

Erin Mary (Erin) Mc Lean, Senior, Human Centered Design & Engineering
NASA Space Grant Scholar
Mark E Stamnes, Senior, Human Centered Design & Engineering
David Jamison Foulds, Senior, Mechanical Engineering: Mechatronics
Nathan Briley, Non-Matriculated,
Michelle Vega, Senior, Electrical Engineering
Mentor: Robert Winglee, Earth And Space Sciences
Mentor: Chad Truitt, Earth and Space Sciences

Traditional manufacturing processes for high altitude rockets are time consuming and vulnerable to a high degree of human error. Currently, in Professor Robert Winglee's Rockets and Instrumentations lab, a rocket and its scientific payload can be built in ten weeks but without a guarantee that the system will have a successful flight. Additive manufacturing is the process of joining materials to create a 3D model (i.e. 3D Printing). With the rise of 3D printing in the public conscience, and the variety of new printer filaments coming on to market, incorporating additive manufacturing processes into our build cycles could benefit high altitude rocketry research. With 3D printing, we are able to build multiple rocket frames and internal components in a fraction of the time as traditional processes and with fewer labor hours. For this research project, we tested the viability of Polyactic Acid (PLA) filament printed rocket airframes for transonic flights. We used Kilo print, a large format 3D printer built by the WOOf 3D printing club on the University of Washington campus. The airframe has embedded sensors to record data on stress, strain, flex, and temperature. This data, combined with a flight post-mortem has helped us determine if PLA printed rocket components are viable for future flights. The rocket, nicknamed Ctrl+P, was launched in late April from the Black Rock Desert in Nevada.

Super Dart Research Rocket

Karl Eugene (Karl) Mitchell, Senior, Earth & Space Sciences (Physics)
Caleb Dale Moore, Senior, Physics: Applied Physics
Mentor: Robert Winglee, Earth And Space Sciences
Mentor: Chad Truitt, Earth and Space Sciences

This project aims to use a variety of techniques to create a high performance system for relatively low cost, on a short build schedule. Taking inspiration from several different sounding rocket configurations, the Super Dart aims to achieve an altitude of 32 km, and a maximum velocity of 900 m/s. Early design inspiration primarily comes from the Loki Super Dart. Designed in the early 1960's, the Loki sounding rocket consists of a 4.5 in diameter booster, which burns out at 5000 ft, moving at Mach 5, after which an unpowered 2 in dart separates and coasts to 340,000 ft due to low drag, high inertia and extreme velocity. Applying the techniques that streamlined the Loki, the Super Dart is a multistage powered dart. Using two boost stages takes advantage of the exponentially decreasing atmosphere to improve output from the motors, and avoids the difficulty and cost of larger engines. Powering the dart adds more thrust and inertia. To decrease cost from individual components and ensure reliable performance, we use off-the-shelf motors and components. Despite using pre-made components, a significant portion of constructions was left, from fabricating carbon-fiber and Kevlar enforced fins, to integrating motors and building custom electronics. The boost portion of the rocket will deliver 22 kN-s of impulse to the rocket, and boost it to 8500 m and 600 m/s, where the dart will separate. After separation and a brief coast, the dart motor will ignite, providing a final 1000 N-s of impulse, coasting to apogee 60 s after final burn-out, and 90 s after lift-off. To control the flight events, a custom flight computer was designed and implemented. Additional functions acquiring and relaying flight and GPS data in real-time. The Super Dart aims to be the highest and fastest rocket ever launched by the UW, and will be tested at Black Rock, NV. in March 2015.

Experimental High-Powered Rocket Motor Design

Jalen I. (Jalen) Son, Senior, Chemical Engineering
Dylan Karl Gustafson, Senior, Chemical Engineering
NASA Space Grant Scholar
Mentor: Robert Winglee, Earth And Space Sciences

This project seeks to produce a cheap and reliable design for high-powered amateur rocket motors. A series of tests were performed over the past year, culminating in the successful launch of a motor during October 2014. In 2015, three motors, two of which are currently in production, are being tested for reusability, safety and performance. They employ a 3 layered gas containment system and are expected to produce roughly 500 pounds of thrust for two to three seconds. Challenges include optimizing designs for given propellant geometry, cost/weight reduction, and ease of manufacture. Another ongoing challenge is the reliable production of fuel using tools ranging from old kitchen appliances to custom 3D-printed molds. All components and fuel are being designed and manufactured by students. The fuel and two nozzles are currently complete. Results from March 2015 live firings in Black Rock Desert, Nevada will be shared.

Monte Carlo Generator Study of Vector Boson Scattering in the Zgammajj Channel

Firdaus Soberi, Senior, Physics: Comprehensive Physics, Economics
Mary Gates Scholar, UW Honors Program
Mentor: Shih-Chieh Hsu, Physics

The Standard Model of particle physics is an extremely successful theory in explaining vast phenomena, and almost all of its predictions have been verified up to date, most recently with the finding of the Higgs. One of the predictions is that the gauge bosons or vector bosons in the electroweak sector can interact with each other through quartic vertices. The goal of the study is to search for such interactions which can occur in many decay channels. Using Madgraph Monte Carlo generator, the quartic interaction is simulated using the vector scattering process and probed for the Zgammajj channel in which the Z can decay into either two leptons or neutrinos. The simulated events are compared with Standard Model predictions and the so called ”anomalous quartic gauge coupling” interpretation, in which the Standard Model is extended. The signal events is carefully selected using information of the resulting particles and the quarks jet information. The event generator study will be useful in helping background estimation that can ”fake” or obscure the real signals coming from the detector since the signal process is rare and hard to detect while the background is usually more common. Study of the gauge coupling process can lead to better understanding of electroweak symmetry breaking which gives the gauge boson mass and at the same time can serve as a tool or probe to find the new heavier Higgs described beyond Standard Model.

Validating Predictions for Imposed Dynamo Current Drive in Plasma Diagnostics

Roy Kenneth (Roy) Taylor, Senior, Political Science, Physics: Comprehensive Physics
Mary Gates Scholar
Mentor: Brian Nelson, Electrical Engineering
Mentor: Kyle Morgan, Aeronautics and Astronautics

Imposed Dynamo Current Drive (IDCD) is a theoretical and well-grounded mechanism for circulating a confined and sustained Spheromak (smoke-ring shaped) plasma. Current drive mechanisms in general have proven crucial in most attempts at controlled fusion, but existing techniques—such as radiofrequency current drive or neutral beam injection—are limited in their effectiveness; additionally, most research focuses on Tokamak reactor configurations. Imposed Dynamo Current Drive grew from previous successes in Steady Inductive Helicity Injection (SIHI), refined under the HIT-SI group at the University of Washington. HIT-SI tests formation and sustainment of a Spheromak in both Deuterium (heavy Hydrogen) and Helium plasmas, and in this context Imposed Dynamo methods were first considered for driving current without disrupting confinement. IDCD posits that perturbations along otherwise closed magnetic flux surfaces within the plasma-confining volume can induce a plasma current through electron drag, and was first theorized in 2012 with additional refinements in 2014 to account for a previously unnoticed SIHI frequency dependence. This study aims to validate and refine the basis of IDCD through comparison of measured electromagnetic impedance across helical magnetic field injectors ('helicity injectors') to predicted and simulated behaviors. Past work validated the overall profile and frequency dependence of IDCD predictions, as well as demonstrated that impedance across a three-injector configuration is lower than the impedance across a two-injector configuration. Present work focuses on distilling information from finite element simulations to be compared with IDCD predictions, and on addressing whether or not relative phase differences between helicity injectors contributes to overall impedance behavior. Future work aims to synthesize the results considered here in a revision of Imposed Dynamo theory by more accurately determining empirical fitting constants and establishing definitively whether or not additional dependencies, such as phase difference, contribute to overall impedance profiles.