DEPARTMENT OF
PHYSICS &
ASTRONOMY

Physics & Astronomy Colloquium

Prof. Ariel Schwartzman (SLAC/Stanford)

(Host: Prof. Nural Akchurin)

3:30 - 4:30 p.m. | Tuesday, Nov. 11

ESB I Building 120

Title: From Colliding Particles to Colliding Light: A new path for the exploration of fundamental physics

The experimental exploration of physics at particle colliders provides a window to probe fundamental and outstanding questions about the nature of our universe. The difficulties of realizing this vision have led to breakthroughs in technology which have given benefits to a wide range of scientific fields.

Advancing the frontier of particle physics will continue to inspire novel ideas for future colliders. One such idea is to collide *light* instead of particles. A photon-photon collider works through inverse Compton scattering of laser beams to convert relativistic electron beams to gamma-rays that then collide to produce new particles. Earlier optical-laser concepts were investigated in the 2000s, but recent breakthroughs in X-ray free-electron lasers (XFELs) have enabled a new type of XFEL photon collider with significantly enhanced physics capabilities.

Because Higgs boson can be produced directly in the s-channel in γγ collisions—but not in e^+e^-—a photon collider can operate at lower electron-beam energies (≈65 GeV versus 125 GeV per beam) and without positrons, yielding a more compact and cost-effective Higgs factory. At 125 GeV, a γγ Higgs Factory achieves the same (or larger) Higgs boson production rate as a 250 GeV e+e− Higgs factory. Down-type

quark backgrounds are particularly suppressed at a γγ collider which improves the measurement of the coupling to b-quarks and may give a photon collider a unique advantage in measuring the Higgs coupling to strange quarks. Photons allow for full control of the polarization of the initial state which could be used to measure CP properties of the Higgs. At 280 GeV CoM energy (as opposed to 550 GeV in e+e-), a photon collider can produce pairs of Higgs bosons and directly measure the Higgs potential. Preliminary studies suggest that an XFEL photon collider could reach Higgs self-coupling sensitivities comparable to that of the 100 TeV FCC-hh collider.

In this talk I will introduce the XFEL Compton Collider (XCC) concept, summarize preliminary physics projections for single Higgs and di-Higgs self-coupling measurements, outline some of the key experimental challenges that require further R&D, and briefly discuss a potential route for photon colliders to reach the 10 TeV scale in the future.

Bio:

Prof. Schwartzman explores the universe at its most fundamental level using the highest energy hadron collider experiment in the world and novel large-scale quantum atomic sensor networks. At the ATLAS Experiment at CERN, his group looks for new exotic decays of the Higgs boson that could be connected with the mystery of dark matter, develop deep learning algorithms for pattern recognition and physics event reconstruction with an emphasis in jets, and investigate ultrafast-timing detectors for future detectors. Prof. Schwartzman also participates in the MAGIS-100 Experiment at Fermilab, the world largest atom interferometer (now under construction) that will search for ultralight wave dark matter, test quantum mechanics at record-breaking distances and times, and serve as a prototype detector for a future Km-scale gravitational wave detector in the mid frequency band which could probe the Higgs boson potential beyond the reach of future particle colliders. His group is developing a novel single-shot light-field 3D imaging system for MAGIS-100, as well as its diagnostic imaging system for atom trajectory control and calibration.