My research interests lie in exploring the Standard Model (SM) of particle physics through measurements of known and rare processes to test the validity of the SM in new energy regimes and at the same time addressing questions not answered by the SM. These include questions such as the nature of dark matter (DM) and of the electroweak symmetry breaking (EWSB) mechanism, among others. Answering these questions is made more possible by improving detector capabilities to enhance the precision of our measurements and to maximize the discovery potential of the ATLAS detector.

During my fellowship at DESY, I tackled these challenges by leading a search for DM in invisible Higgs boson decays, setting the strongest existing limit to date, and building a module loading station for the new all-silicon Inner Tracker (ITk) upgrade planned for the High-Luminosity LHC (HL-LHC). I would like to come to ANL to work on new physics analyses and the ITk, benefiting from and contributing to the expertise of the group in physics analysis and detector development.

The rate of invisible Higgs boson decays may be significantly enhanced beyond its SM value of $\sim 0.1\%$ if the Higgs couples to DM particles. To test this hypothesis, I coordinated the most sensitive search that drives the ATLAS direct probe of Higgs boson decays to invisible particles via the vector boson fusion (VBF) production mechanism [1, 2]. The VBF signature is a powerful probe for new physics as it exhibits a striking signature of two forward jets that have large invariant mass. This signature can be exploited to reject large SM backgrounds while retaining signal. I established a collaboration between theorists and the ATLAS analysis team to improve filtering algorithms used in the Monte Carlo generator, which resulted in the reduction of the largest uncertainty in the previous publication by 35%. This work also enhanced the theoretical accuracy and precision of the simulation, which allowed us to better control the main $Z\,(\nu\nu)$+jets background. I also oversaw the optimization of the event selection and analysis object definition to increase the Higgs boson signal acceptance by 50% and reduce the background in the signal regions by 31%. Through these improvements, my team and I significantly increased the sensitivity to this fundamental probe of dark matter by 54%. In the upcoming months, I would like to continue leading the effort of this search to complete a legacy Run-2 paper and contribute to the combination effort of my analysis with other direct and indirect searches for invisible Higgs boson decays.

Looking ahead, the next years are of great importance to prepare for Run-3 in terms of new analysis strategies and reconstruction techniques of physics object. As there has been no definitive sign of new physics yet, it is important to fully exploit the LHC by looking in experimentally hard-to-reach locations that haven't been probed. One potential avenue that offers excellent sensitivity for well motivated scenarios is the search for long lived particles [3]. In analogy to the SM that have particles spanning a wide range of lifetimes, models beyond the SM also predict new particles with a variety of lifetimes, many of which can lead to macroscopic displacements from the primary interaction with lifetimes of $c\tau \geq \mathcal{O}\,(1\text{ mm})$. While the long lived particles in the SM, such as B-hadron decays, have well-understood experimental signatures, BSM long lived particles offer unusual signatures that may be rejected by standard reconstruction algorithms that are predominantly designed for prompt decays. For instance, tracks corresponding to these hypothetical particles are reconstructed with a dedicated tracking configuration that only runs on a filtered part of the main physics dataset due to significantly larger computing cost and data size. This cost can be significantly reduced by employing novel machine learning techniques to make a better track seed selection, and thus enabling long lived particle tracking to run with the standard reconstruction algorithms to benefit from the full available dataset. Another avenue in which to improve upon these searches is to extend signatures typically done in prompt searches and re-interpret them in the context of long lived searches. For instance, the exotic decays of the Higgs boson to two long lived neutral particles can proceed via the decay chain of $H \to aa \to f\bar{f}f'\bar{f}'$ [4]. While this signature can be probed in the associated production of the Higgs boson with a Z boson and displaced hadronic vertices, a search can also be performed with the VBF production mode with large transverse momentum. I would be interested in re-intrepretting the search for Higgs to invisible I performed in the context of long lived particles.

The VBF production of the Higgs boson characterized with jets in the forward regions of the detector, will benefit from the extended angular coverage of the ITk by enabling an improved jet reconstruction and better rejection of pile-up interactions. DESY is deeply involved in the research and development of the silicon strip modules of the ITk and is responsible for constructing one full end-cap with ~ 30 m^2 of silicon. The local support structures of the end-cap are disks built from petals with modules of different types and geometries. I led the DESY project to successfully develop a fully automated petal assembly system in a newly commissioned clean room. This system consists of mounting modules onto a petal core using a robotic gantry as a pick-and-place machine with advanced vision for identification of the sensor fiducial markers. I oversaw the purchasing of the equipment needed to build the station that totaled over \$200k, and exchanged with industry providers to test new solutions. I collaborated closely with other loading sites, in particular TRIUMF, to standardize the loading procedure and adapt a common interface to streamline production. In the process, I gained substantial knowledge of detector development such as building and testing modules, operating industrial robotic assembly, and applying computer vision for pattern finding, and in parallel improved my leadership and management skills when supervising a team of 5 including a PhD student, engineers, and technicians. In February 2020, I successfully presented the first fully loaded petal built at DESY using this automated procedure to the end-cap local support Final Design Review, showing the petal assembly meets the desired specifications with high repeatability and increased capacity to make up for production delays that may arise.

My work in the strip ITk community has prepared me well to join the ANL group to work on the assembly and testing of the silicon pixel modules. I have already performed some of the tasks that will be required at ANL as part of the module loading procedure: for instance, prior to loading the modules on the local support structure, I verified that modules are qualified for assembly through visually inspecting the modules and facilitating the wire-bonds repairs prior to electrically testing the modules. With this experience, I want to learn from and contribute to ANL's work to prepare for production of the ITk pixel modules expected to ramp up during the upcoming years. I want to expand my detector experience to building and testing modules, as well as characterizing them in test beams.

I hope to leverage my expertise in new physics searches and detector work to continue searching for BSM physics and prepare for ITk module production at ANL. I also aim to assume more responsibilities within ATLAS physics and upgrade communities. The work I have done in my DESY fellowship as well as my PhD work have prepared me well to take on new challenges. ANL plays a central role in both searches for new physics and hardware upgrades, and I would be delighted to work, learn, and grow as part of the group.

References

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