1. Division Tracking Number: 38588.1

2. Date Prepared: December 9, 2021 Proposal Due Date: January 20, 2022

3. Work Proposal Title: ML designed searches for new physics discovery at the LHC

4. Estimated Period of Performance in number of months: 60

5. Organization issuing the Solicitation, and Solicitation Number. **A copy of the solicitation must be attached to this request.** (Example: Golden Field Office, Number DE-PS36-06-GO96018, or DARPA, BAA-09-69)

DOE Office of Science, DE-FOA-0002563

6. How did you hear about this funding opportunity? (Mark with an X)

Newsletter  Program Manager  Sponsor Website

Industry Partner  Sponsor Announcement  Other

7. Argonne PI: Walter Hopkinss HEP

(Name) (PI Division)

8. Division Director   
 Approval:       \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Name) (Signature) (Date)

9. What unique capability does Argonne have to perform this work, such that this work is not in competition with the private sector?

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| The proposal is for fundamental science research conducted within the ATLAS collaboration at CERN and thus will not compete with the private sector in any way. The private sector doesn't currently perform fundamental particle physics research within ATLAS. The Argonne ATLAS group has been part of the ATLAS collaboration for many years. The established collaboratiton within ATLAS and the Argonne Leadership Computing Facility offers unique capabilities that greatly aid the success of the proposal. |

10. Complete columns B – F as appropriate, or add additional columns

|  | Lead Proposer | Team Member A | Team Member B | Team Member C | Total Amount Requested |
| --- | --- | --- | --- | --- | --- |
| Enter name of business, laboratory, university, etc. | UChicago Argonne, LLC DBA Argonne National Laboratory |  |  |  |  |
| Proposed total share of award in $ | $ | $ | $ | $ | $2,500,000.00 |
|  |  |  |  |  |  |
| Cost sharing if applicable |  |  |  |  |  |

11. Proposal Description: (Approach, anticipated benefits, Argonne’s work scope and role of each team member. Approximately 2-3 paragraphs total, use extra page as necessary). You are encouraged to attach the full proposal if available.

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| The Large Hadron Collider (LHC) experiments have verified the predictions of the highly-successful Standard Model (SM). However, the SM lacks an explanation for several observed phenomena (e.g. dark matter) motivating the search for Beyond the Standard Model (BSM) physics. The current search strategy has been to use simplified BSM models (i.e. models with two to three parameters) to optimize requirements on experimental observables (e.g. missing transverse energy) to enhance BSM physics signatures while rejecting SM background. This simplified approach was driven by the expected large increases of BSM physics sensitivity from the increases of center-of-mass energies during early upgrades of the LHC. Unlike these previous upgrades, future LHC upgrades will no longer include significant increases in energy, instead they will first double (Run~3) and then tenfold (High Luminosity-LHC, HL-LHC) the the current data set.  The lack of large jumps in sensitivity and the fact that the current search methodology has provided no significant evidence for new physics motivates a change in BSM physics search strategy, specifically to move beyond only using simplified models. Broader models, such as the 19-parameter Phenomenological Minimal Supersymmetric Standard Model (pMSSM), have been studied but have not been used to build a BSM search program. This is because the pMSSM can produce thousands of models and inspecting all of these models manually to predict their experimental signature is simply not feasible. Previous attempts at predicting experimental signatures of models that had not been excluded by existing searches only included ~10 models. This proposal presents the development of a novel search strategy for the HL-LHC by probing the experimental signatures of thousands of pMSSM models with machine learning (ML) techniques.To facilitate the research the PI will leverage the computing expertise and resources at Argonne National Laboratory such as the ML expertise at the Argonne Leadership Computing Facility (ALCF) and the upcoming Aurora supercomputer.  An important aspect to developing BSM search regions for discovery is to accurately estimate SM backgrounds with simulations of physics processes and detector responses. ATLAS uses two frameworks for detector response simulations: a fast parameterization (FastSim) and an implementation of GEANT4 (FullSim). The scale of the computational cost for the required SM background simulations at the HL-LHC prohibits the use of the current implementation of FullSim to estimate backgrounds and FastSim has been shown to mismodel the decay products of heavy particles which are likely to be present in BSM physic searches. Therefore, the PI proposes developing an ML-based correction to a modified version of FullSim, altered to be computationally faster, to produce fast and accurate detector simulations. The use of an ML-based correction would allow for a better use of High Performance Computing (HPC) resources (such as the upcoming Aurora supercomputer for which the PI is the lead for an early access proposal) for simulation by performing the ML correction on graphical processing units which are expected to make up a large fraction of the computational power of future HPC resources.  The PI will pursue this work with a team that consists of 57% of the PI's time and an average of 1.5 FTE of postdocs for five years. |

12. Argonne’s level of effort is within that which is allowed under the solicitation: \_\_\_\_\_\_\_

(TCP initial)

13. Manager, Sponsored Research Office  
      

(Name) (Signature) (Date)

\* **If selected for award, the full approved SPP proposal and New Proposal Information Questionnaire will require DOE approval prior to receipt of funds from the sponsor.**