Ivan Pogrebnyak

Data Scientist

PhD in High Energy Physics

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Data science skills

With over 10 years of experience in experimental particle physics, I have frequently employed data science techniques to analyze datasets ranging in size from tens of points to billions of events characterized by hundreds of variables and occupying terabytes of disk space. My research at the Large Hadron Collider at CERN involved acquiring, processing, and analyzing experimental and simulated datasets. Many of my projects followed a data science workflow of considering a number of models, optimizing their parameters, and selecting the best model based on performance criteria specific to the problem. I have experience working with either framework implementations of data analysis algorithms or programming my own, in cases requiring more flexibility or efficiently.

The specific areas of my expertise are:

- Data preparation, selection, filtering
- Data mining
- Regression modeling, fitting
- Optimization algorithms
- Multivariate analysis
- Machine learning
- Gaussian processes
- Monte Carlo simulations
- Uncertainty analysis
- Development of software for data analysis
- Data visualization and presentation

Scientific expertise

- Experimental high energy physics
- Higgs boson physics
- Hadronic jet physics
- Statistical data analysis
- Monte Carlo event generators

Education

2013 – 2021
Michigan State University
PhD, High Energy Physics

2009 – 2013
University of North Carolina at Chapel Hill
BS with Honors, Physics
BA, Mathematics

Affiliation

2013 – 2021
CERN
Large Hadron Collider
ATLAS detector

Computer skills

- Programming languages: C++, C, Python, Java.
- Scientific and data analysis tools: Mathematica, NumPy, scikit-learn, CERN ROOT, Geant4.
- Web development: JavaScript (D3.js, jQuery), PHP, HTML, CSS.
- Databases: SQLite.
- FPGA programming: VHDL, Xilinx ISE.
- GNU+Linux OS and utilities.
- Version control: Git, SVN

Language fluency

English, Russian, Ukrainian

Research experience

Higgs boson production cross section measurements January 2015 – Present

Affiliation: MSU, CERN, LHC, ATLAS

Advisor: Dr. Joey Huston, MSU

Publications and reports: [1–3, 5–7, 9, 11–15]

This project is a part of the high-profile effort at the Large Hadron Collider at CERN to obtain precision measurements of the properties of the Higgs boson discovered in 2012. In this series of analyses, we measured the Higgs boson production cross sections in the diphoton decay channel. The data was collected by the ATLAS detector in the Run 2 of the LHC at $\sqrt{s} = 13$ TeV. Differential and fiducial cross sections were obtained from the signal yield, extracted via regression analysis using empirical signal and background models. A combination of Monte Carlo event simulations and data-driven techniques were used to optimize the statistical models and to assess uncertainties. This research was the subject of my PhD dissertation [1].

Responsibilities:

- Implementation and application of statistical regression models
- Model optimization
- Background modeling studies
- Uncertainty analysis
- Optimization of data categories
- Monte Carlo predictions
- Interactive web-based analysis tools
- Event displays

Analysis of top quark mass effects in Higgs production January 2018 – Present

Affiliation: MSU

Advisor: Dr. Joey Huston, MSU

This is an ongoing study of the effects of the finite mass of the top quark on the distributions of observables in proton-proton collision events producing the Higgs boson in association with hadronic jets. The integrated luminosity of the LHC data set has become sufficient to explore the phase space outside of the validity range of the commonly used effective field theory approximation for Higgs–gluon coupling, which simplifies calculation by taking the limit $m_t \to \infty$. The aim of the study is to identify kinematic conditions, which define the phase space that is most sensitive to the finite m_t, for use in future measurements testing the Standard Model and new physics searches.

Responsibilities:

- Analysis of large datasets of Monte Carlo simulated events
- Design, implementation, and operation of a database with a web interface of histograms of analyzed variables
- Development of interactive web-based analysis and data visualization tools

ATLAS Tile Calorimeter upgrades September 2014 – December 2017

Affiliation: MSU, CERN, LHC, ATLAS

Advisors: Dr. Joey Huston, MSU; Dr. Giorgi Arabidze, MSU.

Technical report: [4].

As a part of my involvement in the Large Hadron Collider program at CERN, I participated in a number of projects concerning upgrades of the Tile Calorimeter of the ATLAS detector.

Responsibilities:

- Programming FPGA logic for data acquisition and communication between electronic components of the detector
- Radiation testing of the upgrade electronics at CERN

ATLAS TileCal monitoring system upgrades January 2015 – December 2015

Affiliation: Argonne National Laboratory, CERN, LHC, ATLAS

Advisor: Dr. Alexander Paramonov, ANL.

Award: DOE award from Science Graduate Student Research (SCGSR) program.

Technical report: [16].

This project focused on investigation of requirements and solutions to improve monitoring and diagnostics of the low-voltage distribution system of the ATLAS Tile Calorimeter. The on-detector electronics has high radiation hardness requirements. Improved monitoring was necessary to expedite future repairs.

Responsibilities:

- Assessment of points of failure and insufficiency of the existing monitoring system
- Research of feasible solutions
- Formulation of new requirements and documentation of solutions to achieve them

Electromagnetic simulation of particle accelerator January 2013 – May 2013

Affiliation: UNC, Triangle Universities Nuclear Laboratory

Advisors: Dr. Thomas Clegg, UNC; Dr. Arthur Champagne, UNC.

Publication: Rev. Sci. Instrum 89.8 [8].

Working on this project, I developed an electromagnetic simulation of a new low energy charged particle accelerator for the Laboratory for Experimental Nuclear Astrophysics (LENA) at the Triangle Universities Nuclear Laboratory (TUNL).

Responsibilities:

- Implementation of the accelerator geometry in the simulation software
- Collection and analysis of data from the simulation
- Optimization of the provisional accelerator geometry

Research experience

Statistical analysis of nuclear partial width distributions May 2012 – May 2013

Affiliation: UNC, Triangle Universities Nuclear Laboratory

Advisor: Dr. Christian Iliadis, UNC.

Publication: Phys. Rev. C **88**, 015808 [17].

In this project I performed statistical analysis of distributions of partial widths of (p, p) and (p, α) nuclear reactions for target nuclei from Ne to Cr. The distribution parameters were extracted from the data for charged-particle elastic scattering and reactions that were measured at the Triangle Universities Nuclear Laboratory (TUNL) over several decades.

Responsibilities:

- Compilation of data from previous publications and dissertations
- Data processing
- Regression modeling

Particle detector simulation May 2011 – September 2011

Affiliation: UNC, Triangle Universities Nuclear Laboratory

Advisor: Dr. Christian Iliadis, UNC.

In this project I developed and collected data from a Geant4 Monte Carlo simulation of high-purity germanium gamma-ray detectors for the low energy particle accelerator of the Laboratory for Experimental Nuclear Astrophysics (LENA) at the Triangle Universities Nuclear Laboratory (TUNL). The goal was to optimize the size, number, and positioning of the detector elements for a tentative upgrade of an older detector setup.

Responsibilities:

- Implementation of the Geant4 simulation
- Collection, analysis, and interpretation of the data from the simulation
- Optimization of the provisional detector geometry

Fellowships

- 2015: DOE Office of Science Graduate Student Research (SCGSR) fellowship.
- 2020: Michigan State University Dissertation completion fellowship.

Conference talks

US ATLAS Workshop July 2018

Measurements of Higgs boson properties in the diphoton decay channel with the ATLAS detector

US ATLAS Workshop June 2015

Low-voltage monitoring upgrade for ATLAS Tile Calorimeter

Publications and articles

[1] I. Pogrebnyak. "Higgs boson cross section measurements in the diphoton decay channel in proton-proton collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector at the LHC". PhD Diss., Michigan State U., 2021. URL: https://cds.cern.ch/record/2766569.

[2] J. Adelman et al., ATLAS Collaboration. "Measurement of fiducial and differential cross sections in the $H \to \gamma\gamma$ decay channel with 140 fb^{-1} of 13 TeV proton–proton collision data with the ATLAS detector". ATL-COM-PHYS-2019-035 (Jan. 2019). URL: https://cds.cern.ch/record/2654897.

[3] ATLAS Collaboration. "Measurements and interpretations of Higgs-boson fiducial cross sections in the diphoton decay channel using 139 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV with the ATLAS detector". ATLAS-CONF-2019-029 (July 2019). URL: https://cds.cern.ch/record/2682800.

[4] I. B. Belean et al. "Firmware Prototype for HVopto slow control in TileCal Phase-II Upgrade". ATL-COM-TILECAL-2019-014. Mar. 2019. URL: https://cds.cern.ch/record/2666886.

[5] ATLAS Collaboration. "Measurements of Higgs boson properties in the diphoton decay channel using 80 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV with the ATLAS detector". ATLAS-CONF-2018-028 (July 2018). URL: https://cds.cern.ch/record/2628771.

[6] ATLAS Collaboration. "Measurements of Higgs boson properties in the diphoton decay channel with 36 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV with the ATLAS detector". *Phys. Rev. D* **98** (Sept. 2018), 052005. DOI: 10.1103/PhysRevD.98.052005. arXiv: 1802.04146.

[7] L. Brenner et al., ATLAS Collaboration. "Measurement of fiducial and differential cross sections in the $H \to \gamma\gamma$ decay channel with 80 fb^{-1} of 13 TeV proton–proton collision data with the ATLAS detector". ATL-COM-PHYS-2018-202 (Mar. 2018). URL: https://cds.cern.ch/record/2306798.

[8] A. L. Cooper et al. "Development of a variable-energy, high-intensity, pulsed-mode ion source for low-energy nuclear astrophysics studies". *Rev. Sci. Instrum.* **89**.8 (Aug. 2018), 083301. DOI: 10.1063/1.5024938.

[9] ATLAS Collaboration. "Measurements of Higgs boson properties in the diphoton decay channel with 36.1 fb^{-1} pp collision data at the center-of-mass energy of 13 TeV with the ATLAS detector". ATLAS-CONF-2017-045 (July 2017). URL: https://cds.cern.ch/record/2273852.

[10] S. Chekanov, I. Pogrebnyak, and D. Wilbern. "Cross-platform validation and analysis environment for particle physics". *Comput. Phys. Commun.* **220** (2017), 91–96. DOI: 10.1016/j.cpc.2017.06.017. arXiv: 1510.06638.

[11] ATLAS Collaboration. "Measurement of fiducial, differential and production cross sections in the $H \to \gamma\gamma$ decay channel with 13.3 fb^{-1} of 13 TeV proton-proton collision data with the ATLAS detector". ATLAS-CONF-2016-067 (Aug. 2016). URL: https://cds.cern.ch/record/2206210.

[12] F. U. Bernlochner et al., ATLAS Collaboration. "Measurement of fiducial and differential cross sections in the $H \to \gamma\gamma$ decay channel with 36 fb^{-1} of 13 TeV proton-proton collision data with the ATLAS detector". ATL-COM-PHYS-2017-145 (Feb. 2016). URL: https://cds.cern.ch/record/2252597.

[13] F. U. Bernlochner et al., ATLAS Collaboration. "Measurement of the fiducial and differential cross sections of the Higgs boson in the diphoton decay channel using 2015/2016 13 TeV pp data". ATL-COM-PHYS-2016-433 (May 2016). URL: https://cds.cern.ch/record/2150683.

[14] F. U. Bernlochner et al., ATLAS Collaboration. "Measurement of the fiducial cross section of the Higgs boson in the diphoton decay channel using 13 TeV pp data". ATL-COM-PHYS-2015-1244 (Oct. 2015). URL: https://cds.cern.ch/record/2056804.

[15] S. Laplace et al., ATLAS Collaboration. "Measurement of the Higgs boson production cross section at 7, 8 and 13 TeV center-of-mass energies in the $H \to \gamma\gamma$ channel with the ATLAS detector". ATLAS-CONF-2015-060 (Dec. 2015). URL: https://cds.cern.ch/record/2114826.

[16] I. Pogrebnyak et al. "Requirements for the Low Voltage Monitoring Upgrade of ATLAS Hadronic Calorimeter". ATL-COM-TILECAL-2015-067 (Sept. 2015). URL: https://cds.cern.ch/record/2055254.

[17] I. Pogrebnyak et al. "Mean proton and α-particle reduced widths of the Porter–Thomas distribution and astrophysical applications". *Phys. Rev. C* **88** (July 2013), 015808. DOI: 10.1103/PhysRevC.88.015808.