



# Anomaly Detection Using Machine Learning Techniques for Beam Injections from the SPS to the LHC at CERN

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### **Statement of Originality**

I, the undersigned, declare that this is my own work unless where otherwise acknowledged and referenced.

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## Acknowledgements

## Abstract

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# List of Abbreviations

<b>CERN</b> European Organization for Nuclear Research	
<b>IQC</b> Injection Quality Check .....	2
<b>LHC</b> Large Hadron Collider	
<b>LS</b> Logging Service.....	2
<b>SPS</b> Super Proton Synchrotron	



# Introduction

# Background and Literature Review

## 2.1 Introduction

## 2.2 Understanding the Problem Domain

The LHC is filled to the required maximum intensity by injecting electron bunch trains from the SPS through a transfer line using kicker magnets [CITE HERE]. This is a challenging task given the high energy of the beam, the very small apertures and the delivery precision's tight tolerances, thus multiple sensors are installed around the CERN particle accelerator complex [CITE HERE] which gather readings and data that can be used to check the quality of the injected beam. For this particular study, the sensors around the injection from the SPS to the LHC will be of particular interest. This data is stored using CERN's Logging Service (LS) [CITE HERE]. While many studies have been made using this logged data and lots of statistical tests have been done with regards to injection quality checks for the LHC (such as [CITE HERE] and [CITE HERE]), no literature was uncovered where researchers used unsupervised machine learning methods to analyse this data.

The Injection Quality Check (IQC) software currently installed has a set of hard-coded rules for detecting anomalies in the SPS-LHC injection [CITE HERE], however there are documented cases in the past where situations occurred which were outside the originally foreseen rules and were therefore not caught as anomalies.