h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
fbi
FACHBEREICH INFORMATIK

CERN

Anomaly Detection with Artificial Intelligence: Post-mortem analysis of LHC ion beam losses during high-energy beam dumps

Background

The Large Hadron Collider (LHC) at CERN is the world's largest and most powerful particle accelerator – and perhaps the largest machine ever built by humankind. Inside the accelerator with a circumference of 27 km, two high-energy particle beams of protons or ions travel counter clockwise at close to the speed of light before they are made to collide. With this principle collision energies reach above 13TeV which is even extended with the actual High-Luminosity LHC project.

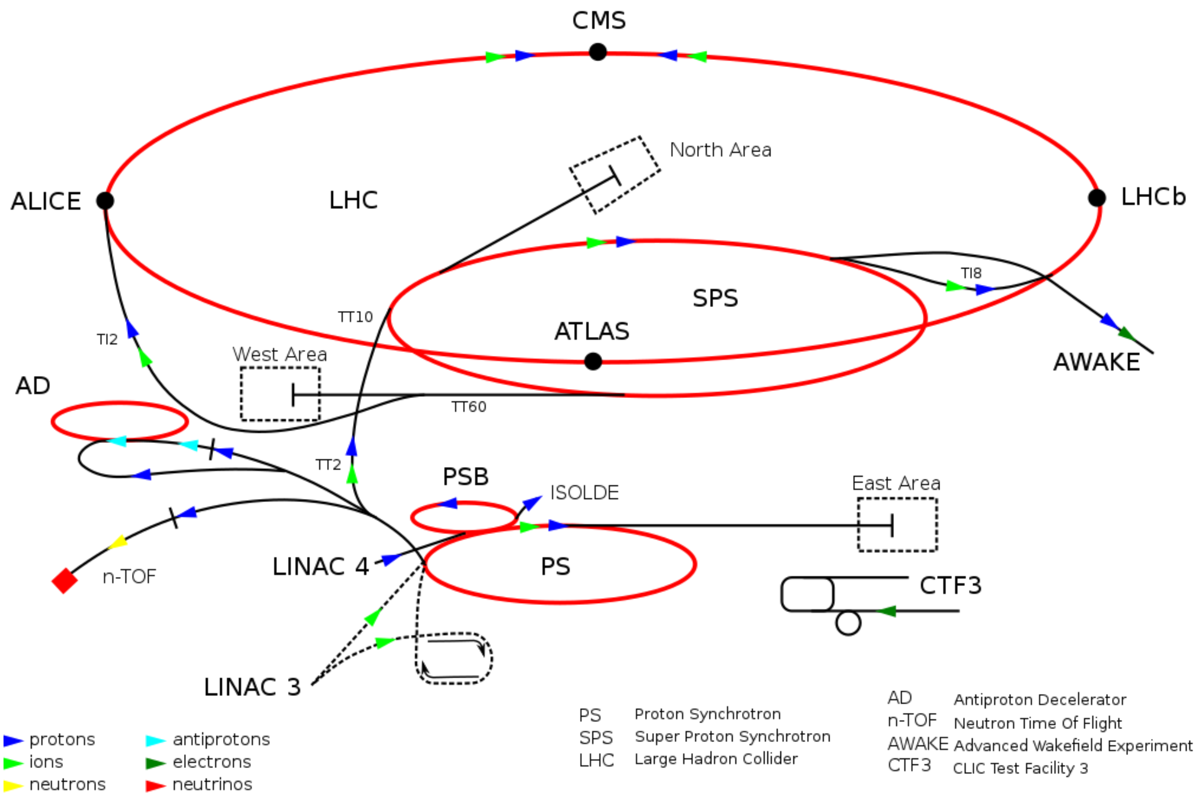

Figure 1 Particle accelerator cascade from injection to collision in the LHC

To avoid damage to accelerator components, a sophisticated Machine Protection and Electrical Integrity System is implemented. The correct functioning of the Machine Protection System includes the analysis of beam dumps and beam losses. Beam dumps or so-called aborts are usually induced by operation in a controlled manner, whereas some beam losses occur uncontrolled and spontaneously. As a parameter for the actual quality of a particle beam the divergence of the beam is continuously measured by so called beam-loss monitors.

Topic

For prediction of potential issues, an analysis of beam losses that occur during the beam aborts or beam dumps will be performed in this master's thesis. Extensive time data series of all beam-loss monitors are available for the investigation of anomalies.

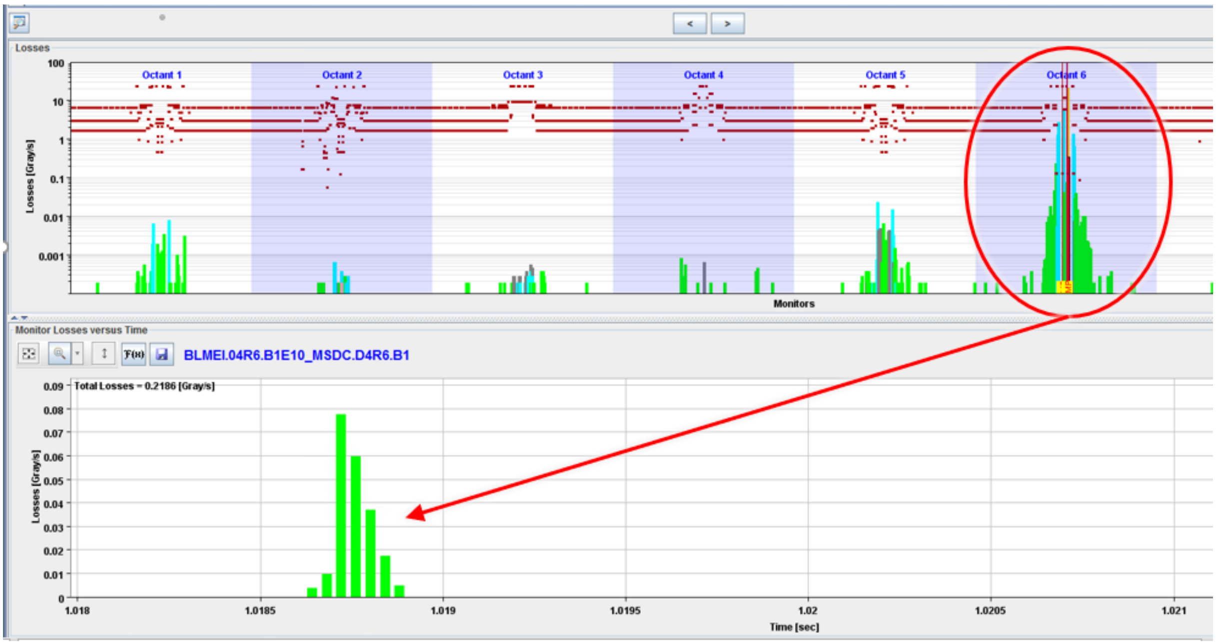

Figure 2 Example of beam losses in the LHC during a nominal beam abort. Higher losses in the extraction region in Octant 6 are visible (top plot). The bottom plot shows the time evolution of the losses for one beam loss monitor located in Octant 6

The successful candidate will screen and classify existing beam-loss data from LHC ion operation. In a first stage, the beam-loss data that is available in the so-called Post-Mortem system will be transfered and cleaned. Afterwards, a search for relevant beam-loss patterns will be performed and anomalies detected, using advanced machine-learning techniques where applicable.

Prerequisites

You have the following knowledge or enjoy acquiring it and closing existing gaps:

- Basic concepts in machine learning and artificial intelligence
- Good Programming skills in Python with standard libraries numpy, matplotlib and pandas, supplemented by keras and tensorflow or similar libraries
- Basic knowledge of data logging architectures (databases, time series data, data exchange between systems and data preprocessing, communication over networks, etc.)
- Knowledge of distributed computing with PySpark is an advantage

- Interest in working in a heterogeneous team of scientists, with a lot of freedom to bring in own ideas
- English language skills to discuss your work with colleagues who cannot communicate confidently in German

The thesis is supervised in cooperation with Dr. Christoph Wiesner and Dr. Daniel Wollmann from the section Controls and Beam Studies for Protection at CERN Geneva, Switzerland.

Contact

Prof. Dr. Andreas Müller
Raum 03.06
Gebäude D14
Schöfferstraße 8b
64295 Darmstadt
+49 6151 1638448
andreas.mueller@h-da.de