**FCC Availability Studies**

A. Niemi, A. Apollonio, V. Begy, J. Gutleber, P. Sollander CERN  
J.-P. Penttinen Ramentor Oy, E. Rogova TU Delft

---

**Motivation**

Availability is a measure of the useful time of beam delivered to physics experiments.

\[
L_{\text{int}} = \int_{0}^{t} L(t) \, dt
\]

Integrated luminosity \([\text{fb}^{-1}]\) is the key performance indicator for particle colliders.

For a set target integrated luminosity, operation costs decrease with increasing availability. However, the cost to achieve higher availability requires higher capital expenses.

It is important to address availability and requirements from conceptual design across the entire accelerator lifecycle.

**Scope of the Study**

The study evaluates the suitability of industrial reliability methods for the domain of particle accelerators taking the LHC as a case study. The goal is to identify and analyse possible design and operational scenarios for the FCC-hh and assess the potential of methods for the LHC High Luminosity upgrade. The study aims to identify key impact factors on availability and luminosity production. However, the study does not intend to give specific guidelines for individual system design and optimization.

**LHC Availability Model**

A detailed fault tree was developed for the LHC Cryogenics system to better understand and be able to scale fault distributions. The control room operators will now capture data and classify faults according to this fault tree.

The model accuracy was validated against the 2012 luminosity production. The actual production was 23.27 fb\(^{-1}\). Taking 2012 failure rates and beam parameters as inputs, the model reproduces the production amount within 1 % accuracy. Calculating 1 000 simulation rounds takes about 10 minutes on a laptop.

**Exploring the Potential of Condition-Based Maintenance**

The data from a slide valve shows the start of the fault in March 2015. However, the failure was recorded after the beam operations started in April. The fault could have been corrected before that.

A dedicated database collaboration was started with CERN IT department. Data availability, quality and consistent monitoring of the signal trends are necessary to derive useful reliability figures.

**Collaboration Contributions**

Join us in the FCC RAMS study!  
FCC-RAMS@cern.ch

---

**Conclusions & Outlook**

Availability is one of the key performance indicators for the integrated luminosity production of a collider. Estimates of the achievable availability of the FCC-hh will be one of the main factors for the feasibility assessment. Future studies should focus on:

- Definition of an FCC cycle duration
- Analysis of different injector options
- Identify strategy for scaling number of components (e.g. number of power converters, redundancy in cryogenic system,...)
- Data quality management

Extending the study to the FCC-ee would require expertise and data on lepton machines.