
CERN

Data-Driven Risk Matrices for CERN's Accelerators

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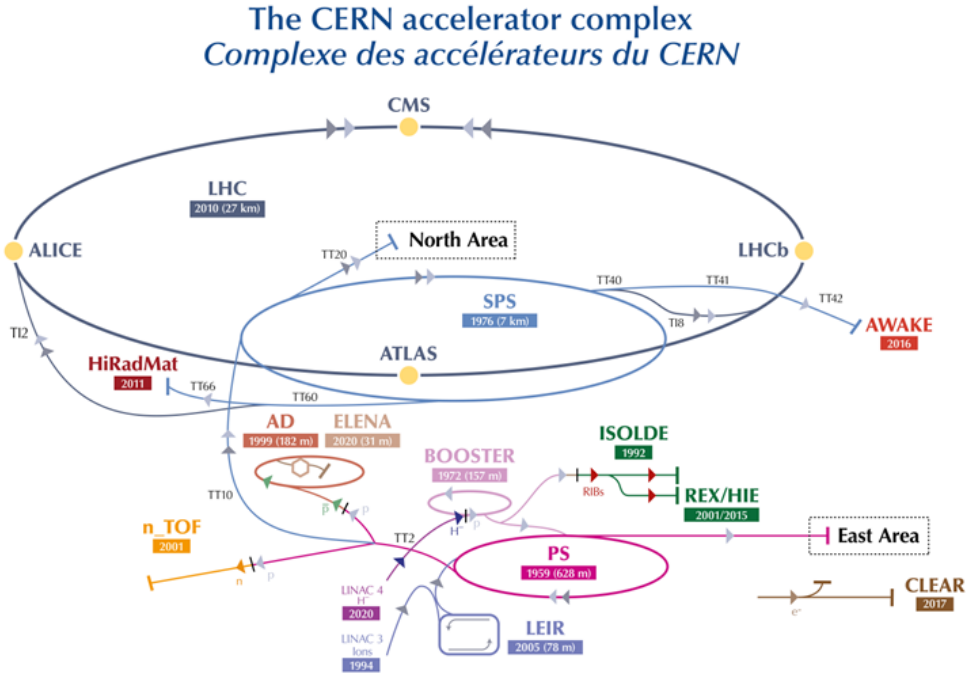
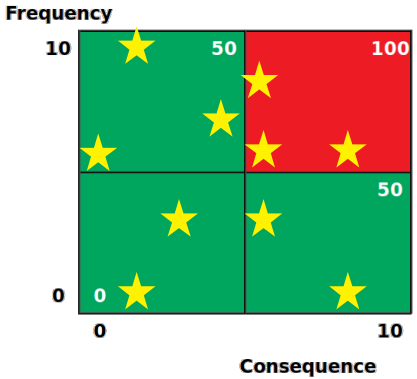


Risk Matrices for Risk Management



- **Risk matrices** =
  tools used to support managerial decisions when dealing with risk
- **Failure mode** = Possible way for a system to fail
- Quantification of the **Risk** of a failure mode = **Frequency** x **Consequence**

- Risk Matrices = tables covering a 2D space: **Frequency** x **Consequence**
  - They can be tailored to any application
  - Likelihood can be expressed by a **frequency**, a probability, …
  - Consequence can be expressed by a financial impact, a **fault duration…**
  - The axes discretization can be **quantitative** or qualitative
  - The progression can be linear or logarithmic…
  - One wants to define a boundary between **acceptable risks** and **unacceptable risks**

- Positioning all the failures modes of a system on its risk matrix helps the allocation of resources dedicated to mitigate them

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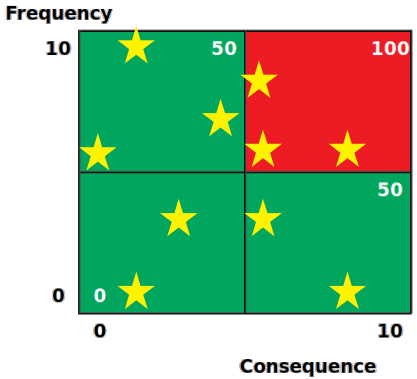
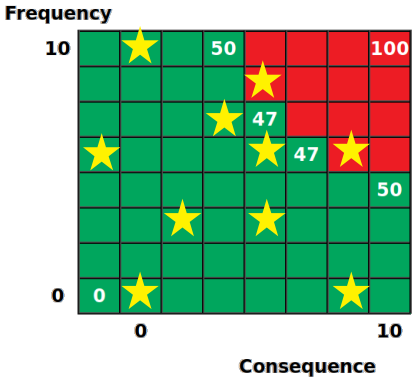
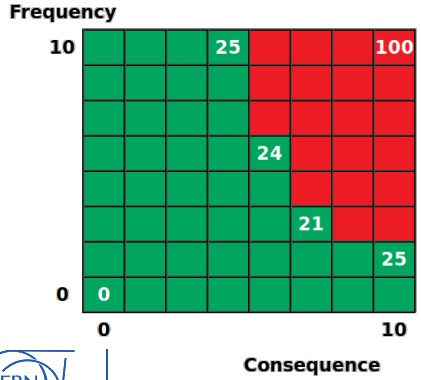
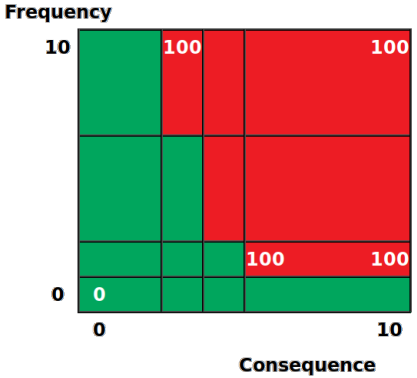
Aim: Building Data-Driven Risk Matrices









- Risk Matrices are usually defined at the design step of a machine
- CERN's accelerators are regularly consolidated / upgraded
- Aim: Using failure data recorded in the last 4 years by the "Accelerator Fault Tracker", an optimization of the CERN's risk matrices is performed

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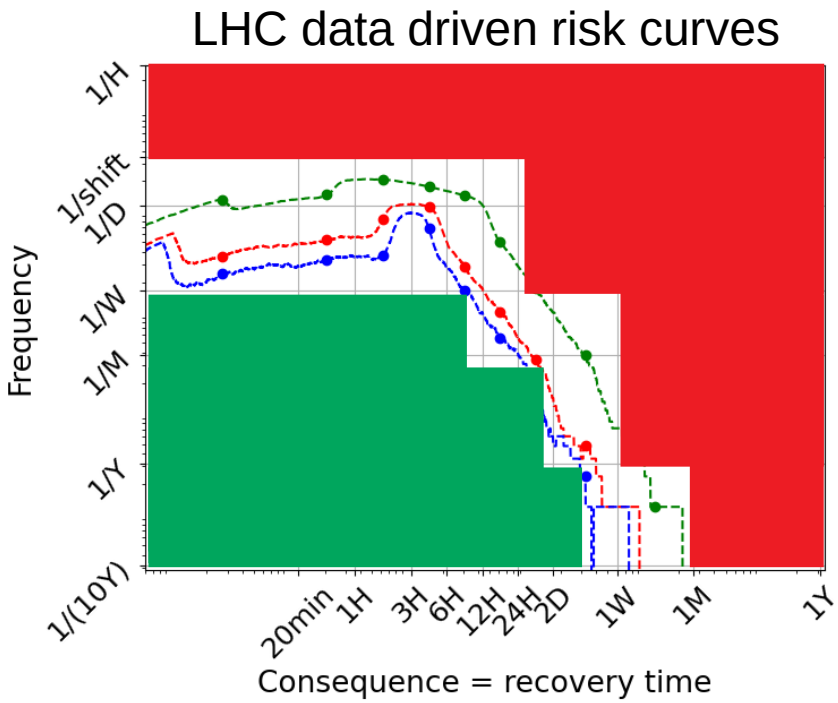
Intermediate step: Data-Driven Risk Curves



* Shift = 8h

- Definition: curve approximating the frequency of faults of a machine with respect to the duration of those faults
- Input = a list of fault durations d_i
- Output = $F_\alpha(d) = \sum_{i=1}^{N} \mathbb{1}_{I_{\alpha,d_i}}(d)/D$

  $I_{\alpha,d_i} = [d_i/\alpha, d_i \times \alpha]$
- If $d \in I_{\alpha,d_i}$ then d is of the order of d_i with a α margin

$$d \in I_{\alpha,d_i} \Rightarrow \mathbb{1}_{I_{\alpha,d_i}}(d) = 1$$

$$d \notin I_{\alpha,d_i} \Rightarrow \mathbb{1}_{I_{\alpha,d_i}}(d) = 0$$

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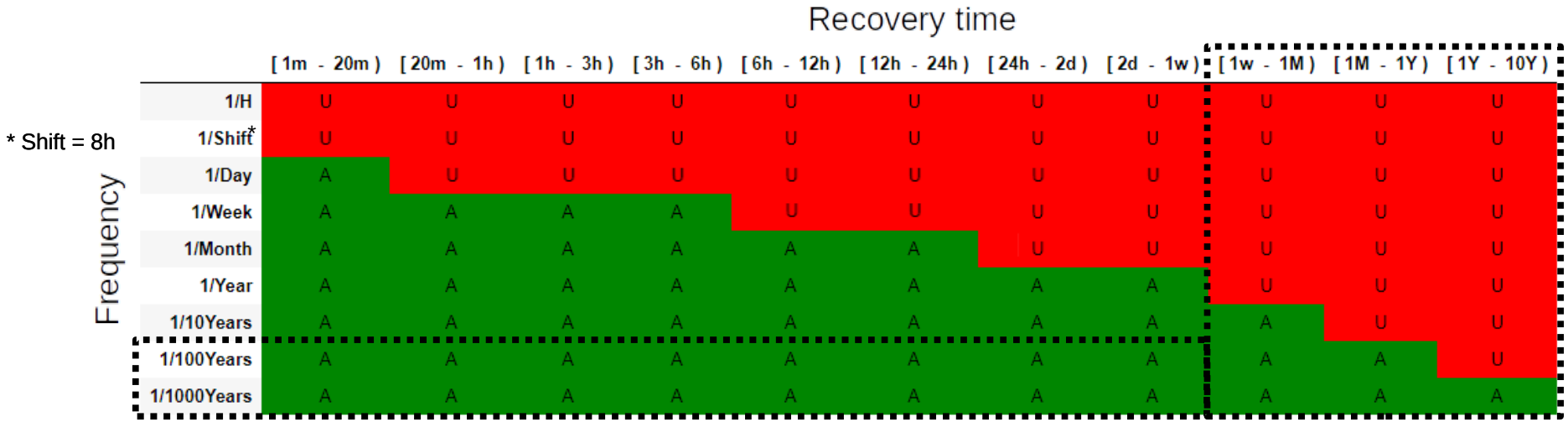
Analytical extension of Risk Matrix for LHC



- Using only a Data-Driven approach does not provide knowledge on very rare events / extreme events
- Still Reliability/Availability targets in those ranges is needed

- Analytical extension of risk curves:
- U_{OE} "Observed Events" Unavailability
- f_{RE} acceptable factor for the "Rare Events"
- $U_{RE} = U_{OE} \times f_{RE}$ Unavailability due to the "Rare Events"

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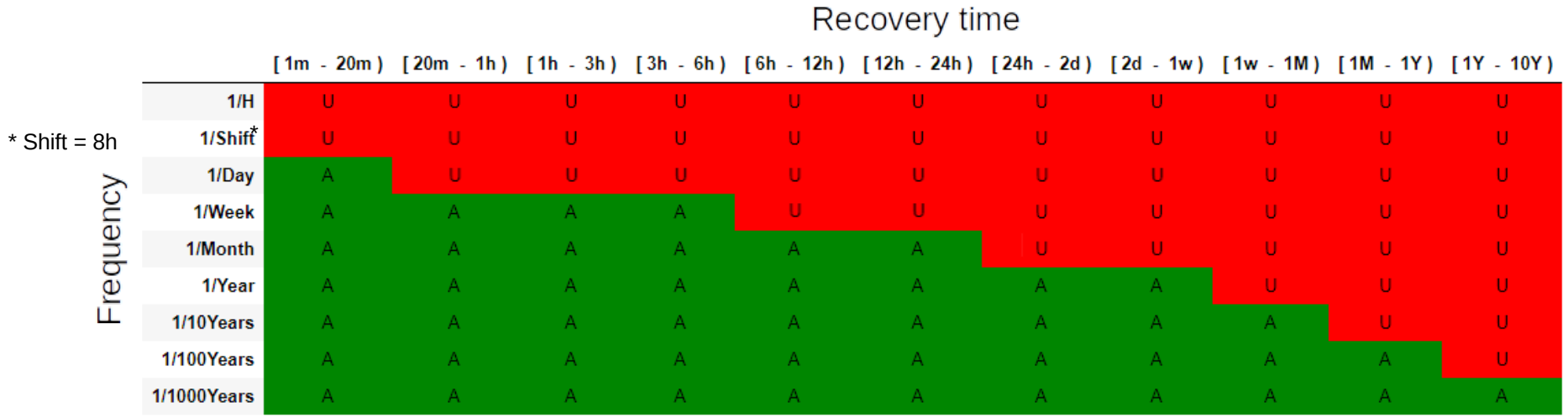
Results: Data-Driven Risk Matrix for LHC



- Data-Driven creation of a tailored Risk Matrix for LHC (and for each accelerator of the injector complex)
- Optimization of the discretization and the frontier between **acceptable failures** and **unacceptable failures**
- Matrix already in use for LHC upgrades

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