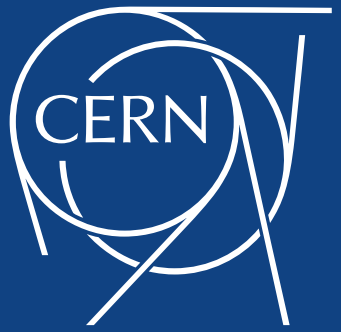

CERN

The crucial role of the **Software Interlock System**

at CERN's
Super Proton Synchrotron

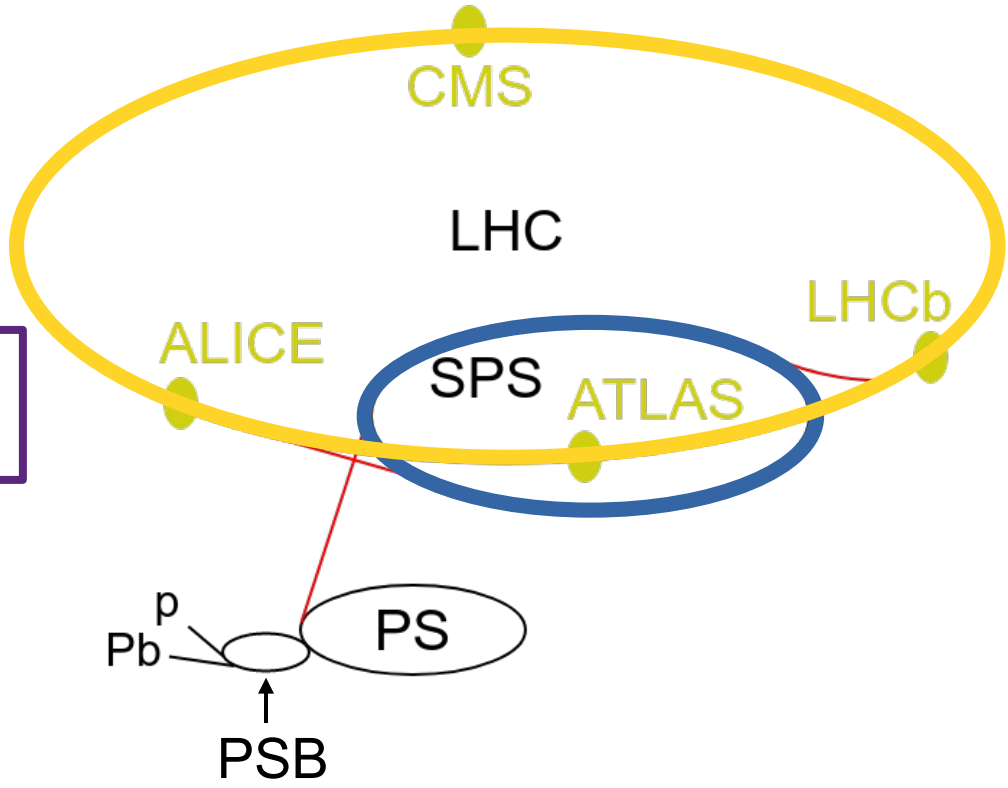
Serge Massot
CERN – SPS Operations

Outline

- **Introduction**
  - CERN injectors chain
  - SPS complex
- **Machine Protection**
  - Damage
  - Machine Protection Synergy
- **Beam Interlock System (BIS)**
  - Beam Interlock Controller (BIC)
- **Software Interlock System (SIS)**
  - SIS - Graphical User Interface (GUI)
  - Used as diagnostic
  - Mask and Latch
  - Configuration
- **Summary**

Introduction

CERN injectors chain:



The accelerated particle types are protons and heavy ions

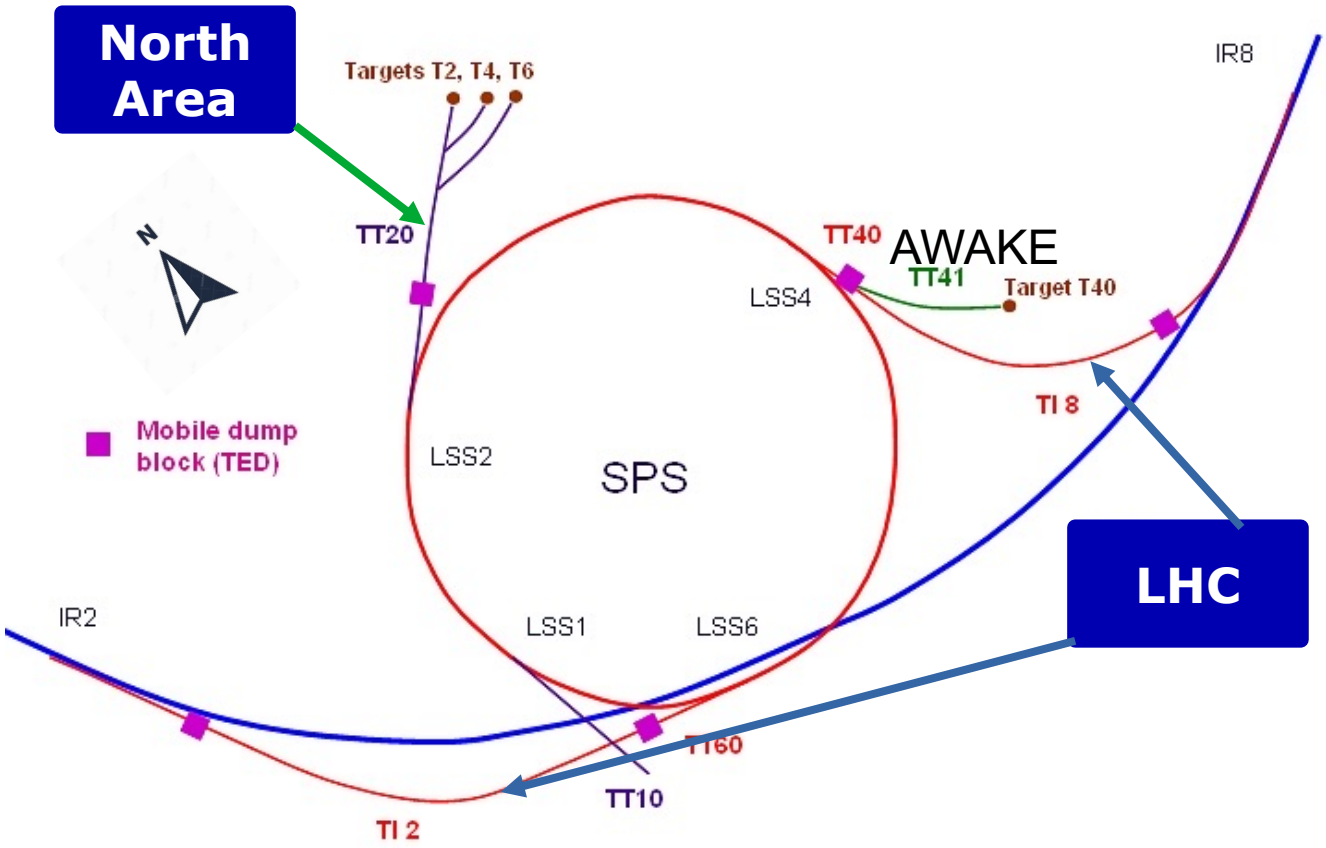
Energy:
- LHC: 6.8 TeV/c
- SPS: 450 GeV/c
- PS: 26 GeV/c
- PSB: 1.4 GeV/c

Intensity per beam:
- LHC: > 35E13 p^+
- SPS: > 4E13 p^+
- PS: > 2E13 p^+
- PSB: > 2E13 p^+

Circumference:
- LHC: 26,659 m
- SPS: 6,912 m
- PS: 628 m
- PSB: 157 m

SPS complex

The SPS is the injector of the Large Hadron Collider (LHC).
SPS is delivering beam to North Area to fullfill Fixed Target physics.
Machine Development Studies are performed for optimisation of new beams.



Machine Protection

- SPS and LHC beam energy can be above the damage level of accelerator components (vacuum chamber, magnets, etc…).

→ Protection by an interlock system:

"interlock" refers to a safety mechanism or control system designed to automatically halt the operation of the accelerator

❒ Designed to detect faults, failures and potentially dangerous situations

❒ To prevent excessive beam losses

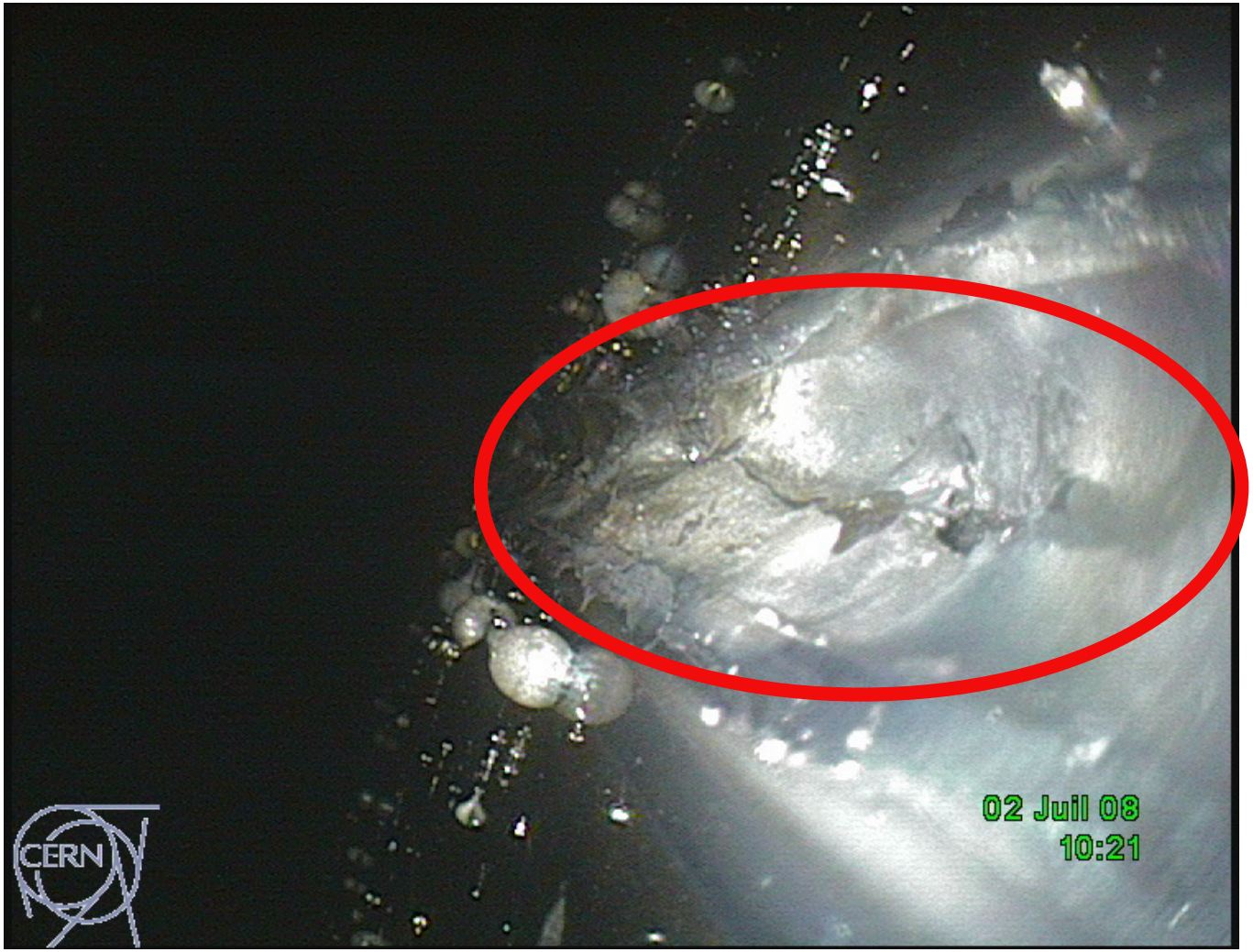
❒ To stop operation when something goes wrong
Caveat: a trade-off between protection and beam availability

❒ To help diagnose and resolve problems

❒ To check the machine configuration

Damage

Accidental high intensity (4E13 p^+) Fixed Target beam crash at 400GeV/c :



Machine Protection Synergy

Beam Interlock System (BIS):

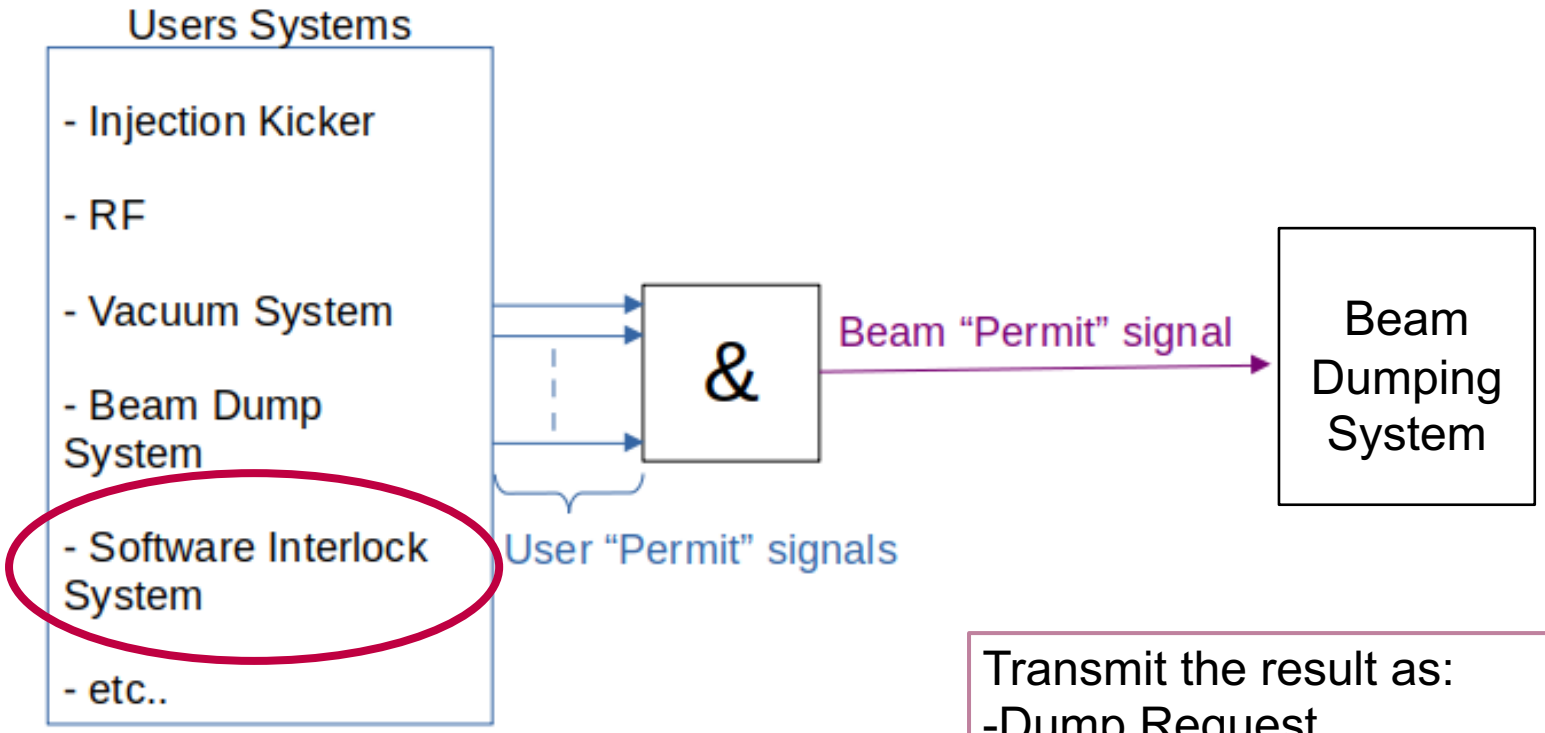
- entirely implemented in **Hardware**
- dumps the beam
- prevents injection or extraction
- fast reaction time (μsec)
- expert authorisation needed to change settings

Software Interlock System (SIS):

- entirely **Software** based
- more flexible
- implements more complex logic
- reaction time rather slow (hundreds msec)
- used also as a diagnostic tool
- SIS is a input of the BIS

Beam Interlock System (BIS)

A number of users or clients provide interlock signals (permits) to the BIS.



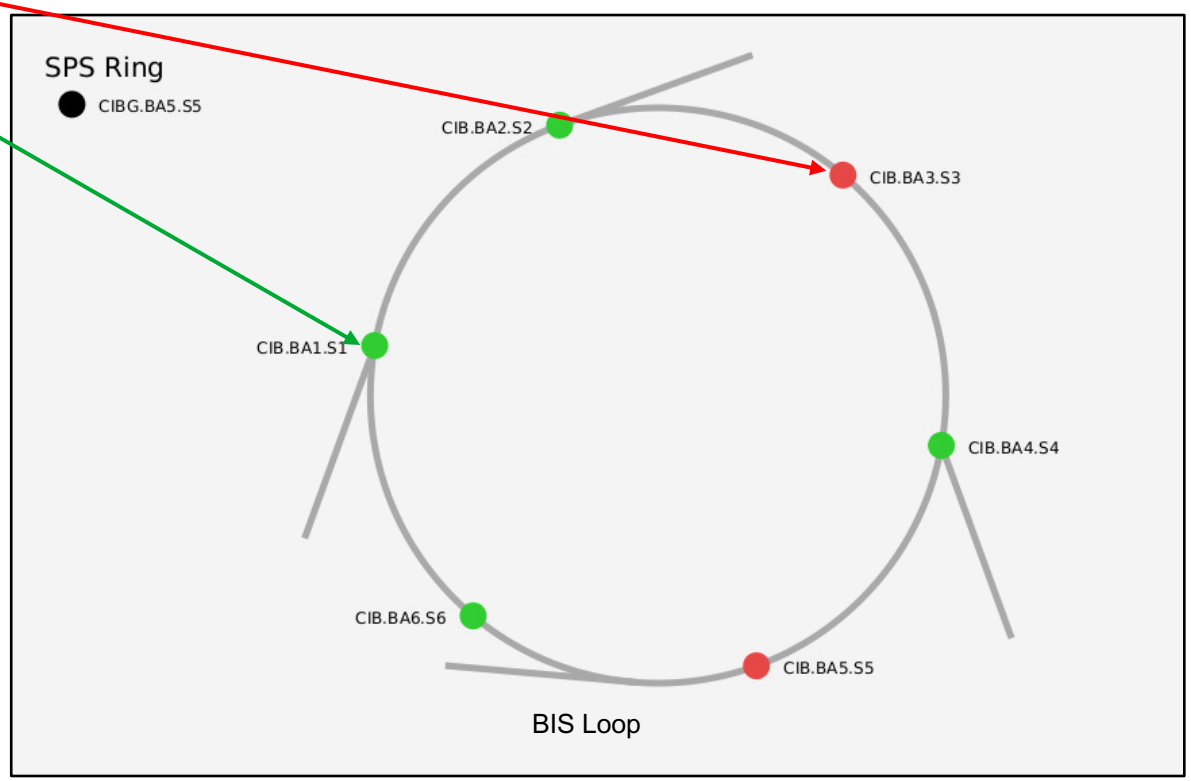
The Beam Interlock System has to:

Collect status or default signals → Perform a summation of all signals → Transmit the result as:
-Dump Request
-Inhibit of injection Permit
-Inhibit of extraction Permit
-OK for beam

Beam Interlock Controller (BIC)

The central element of the Beam Interlock System (BIS) is the Beam Interlock Controller (BIC). Each BIC acts as a local concentrator, collecting User Permit signals.

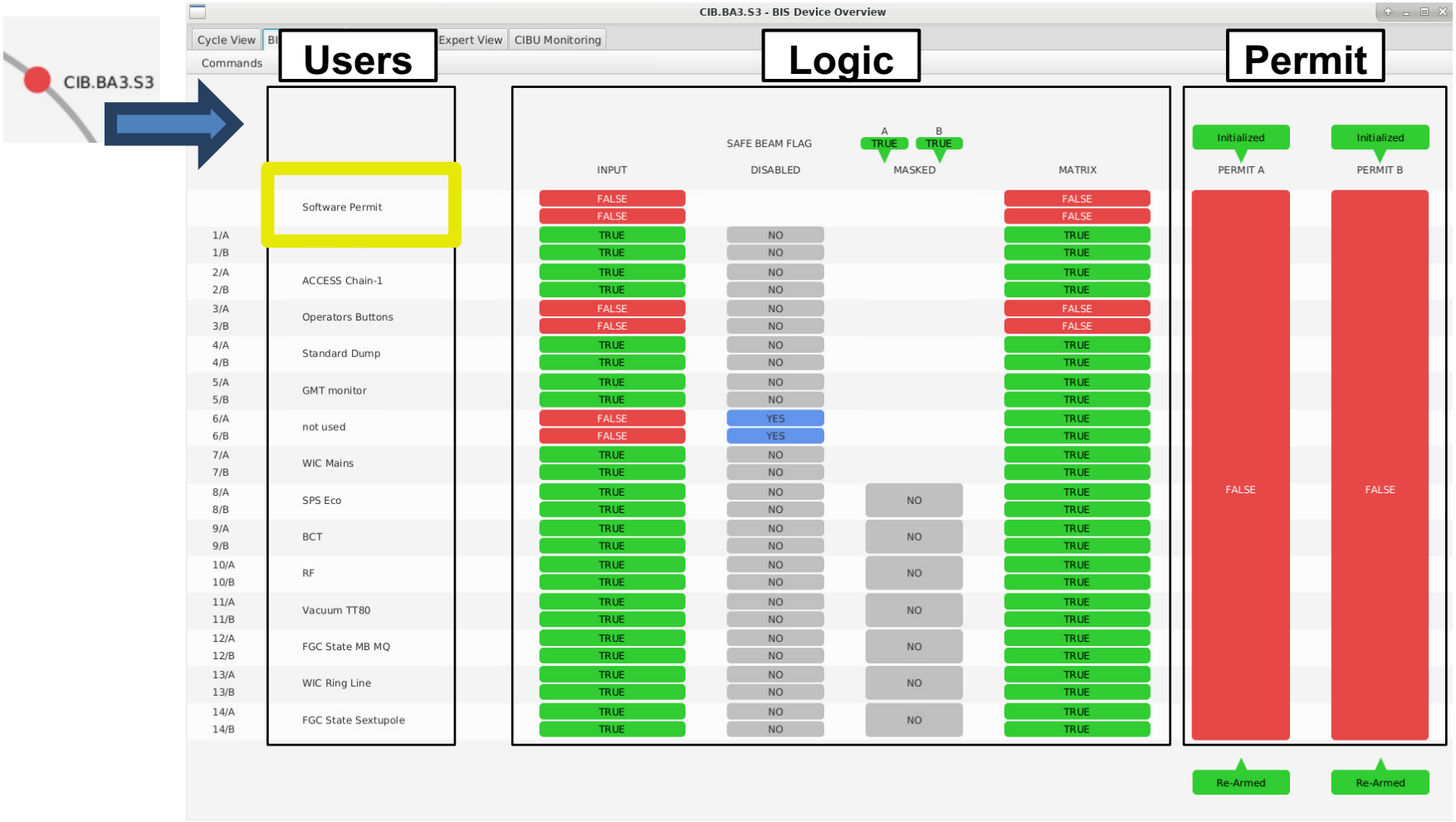
Permits may be TRUE or FALSE:



TRUE → No Interlock , Beam allowed

FALSE → Interlock present, Beam dumped

Beam Interlock Controller (BIC)



Any input can dump the beam through a signal sent to the BIC

Software Interlock System (SIS)

- SIS **monitors** ~ 9500 logic inputs, states and settings covering the SPS and its transfer lines for ~ 1045 devices.

- SIS **acquires** values, analyzes and converts into a logical state.

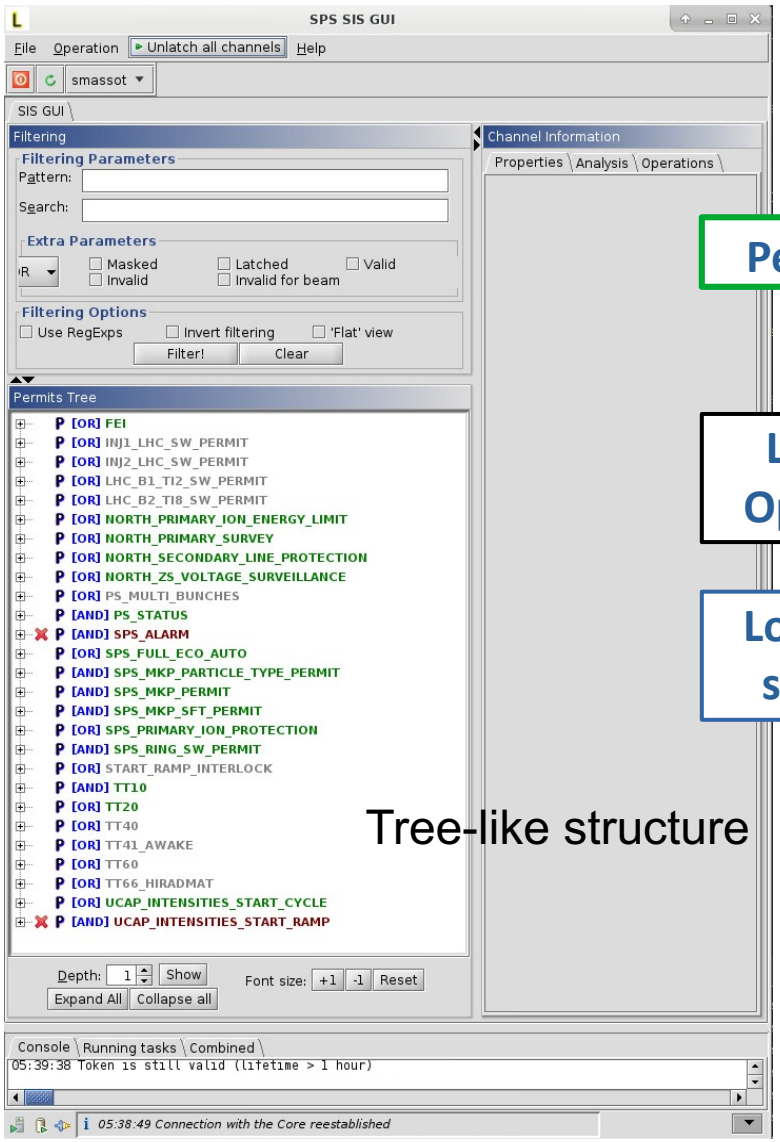
  TRUE or FALSE

- The SIS **logical states** are grouped into tree-like structures and combined using logical operators.

  AND or OR

  - TRUE : OK for beam operation.
  - FALSE : one or more tests indicate an abnormal situation.

SIS - Graphical User Interface (GUI)



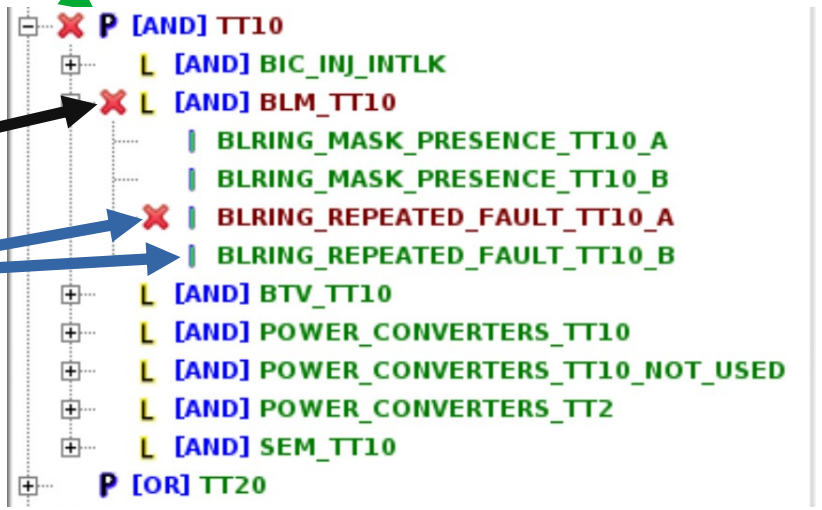
Tree-like structure

The top of the tree corresponds to a SOFTWARE PERMIT (SW_PERMIT)

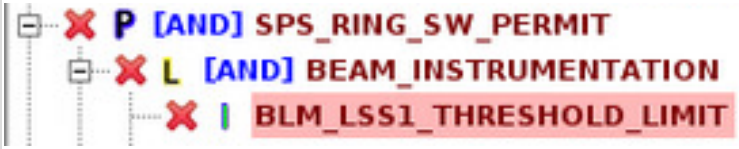
Permit

Logical Operator

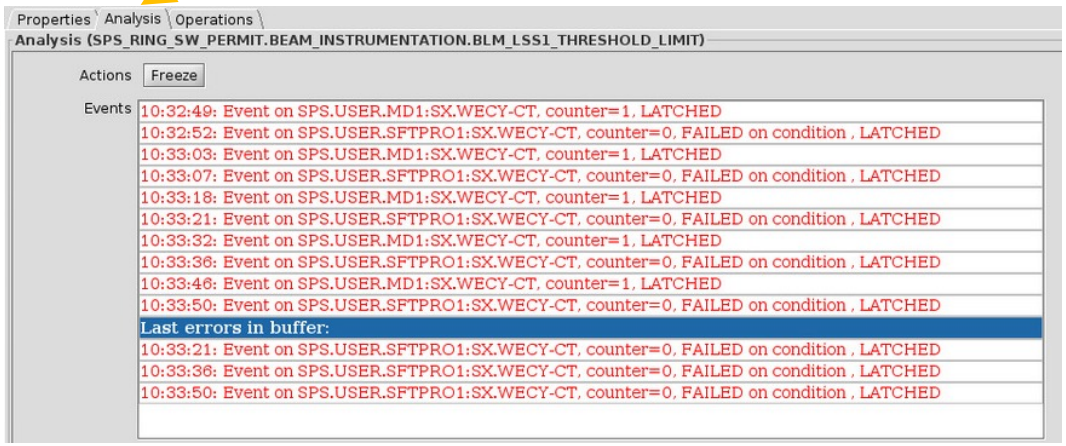
Logical state



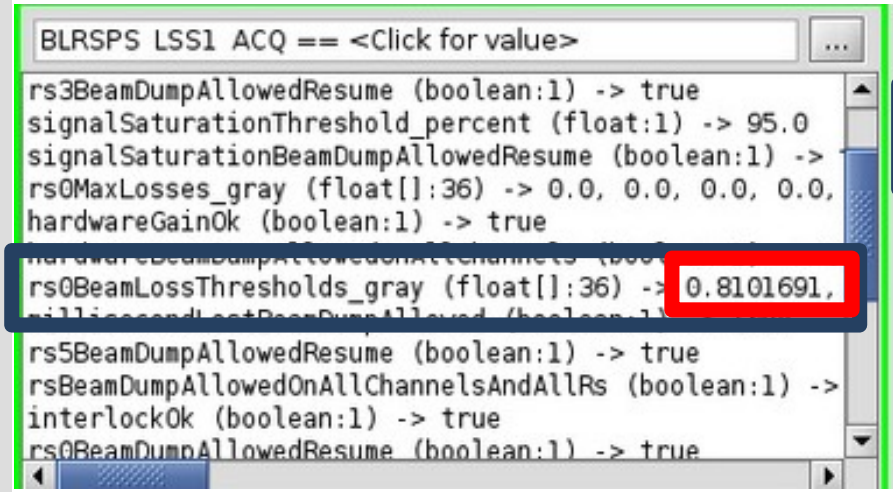
Used as diagnostic



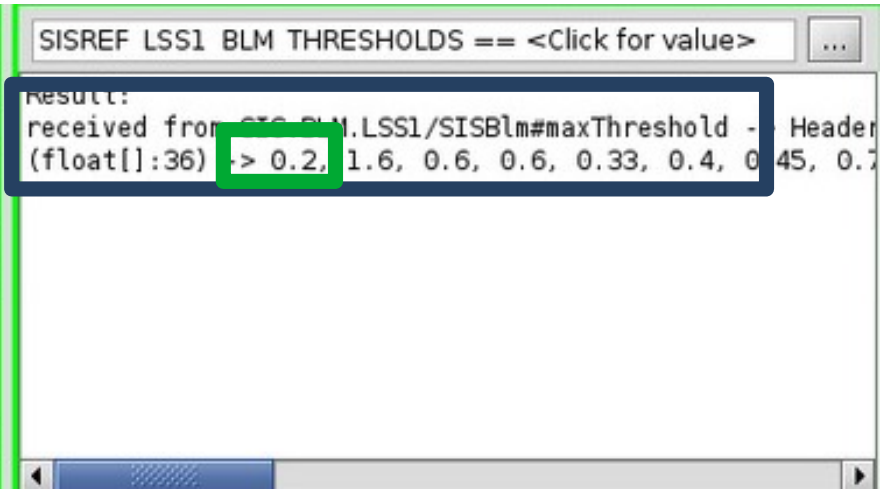
Analysis



Acquisition



Reference

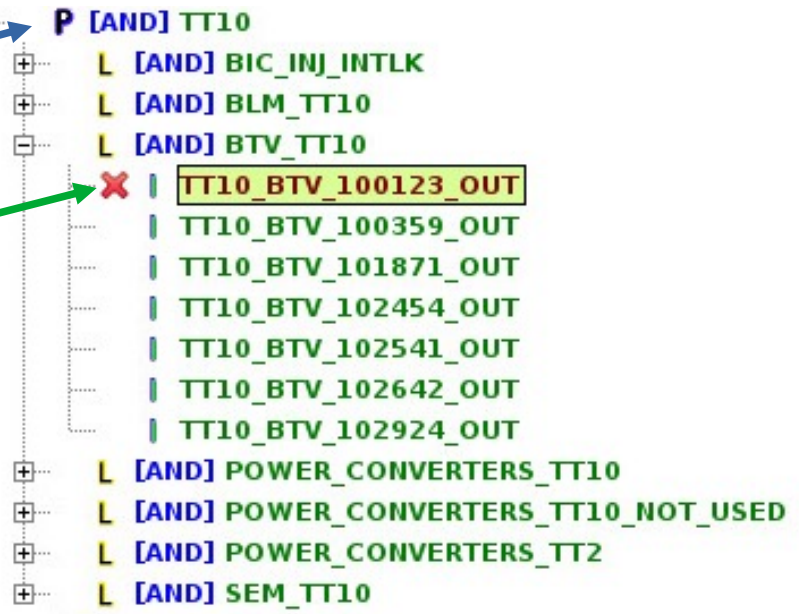


Mask

- Input Masking:

- Allows operators to ignore logical input
- Access privileges required
- Means evaluating always to TRUE
- Permit signals are not maskable

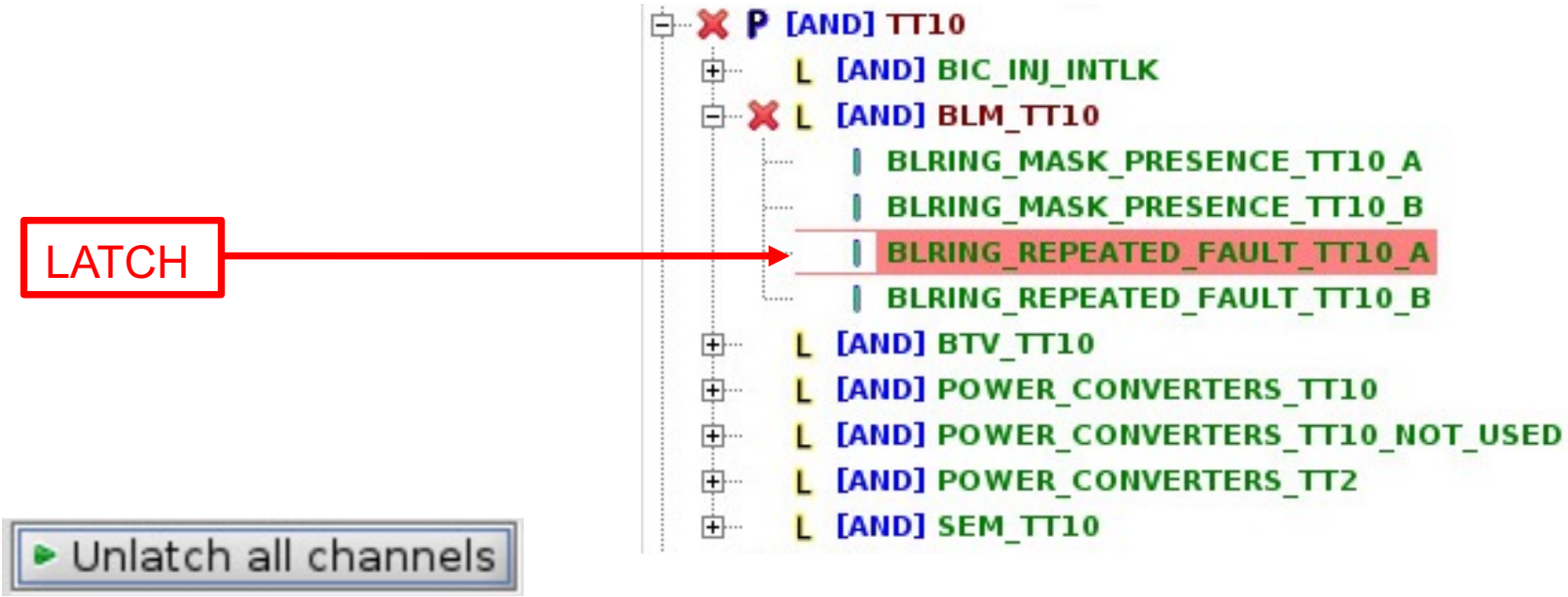
MASK



Latch

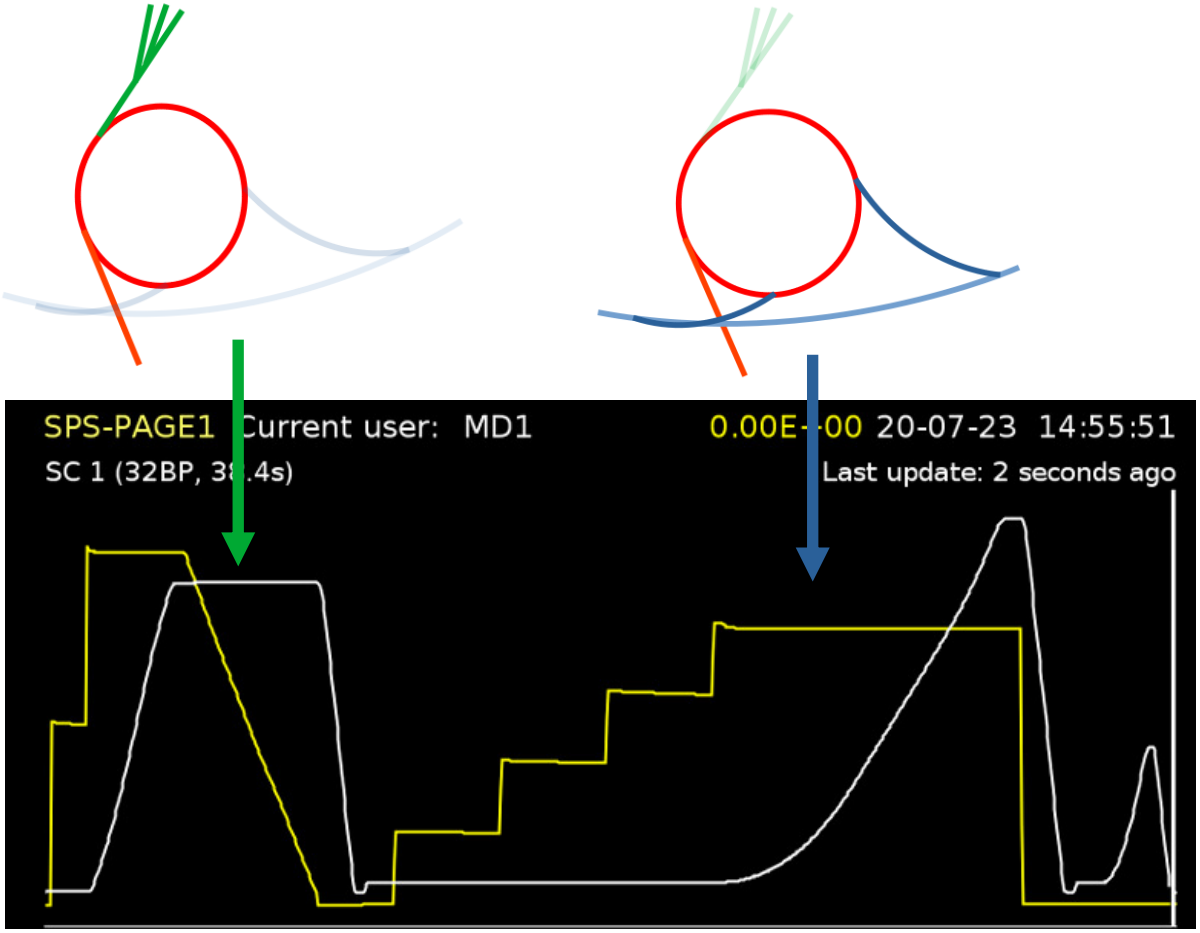
- Input Latching:

- Situation that requires further investigation
- Must be manually unlatched



Configuration

SIS is structured by geographical zone (transfer lines, extractions, ring,…)



Summary

- SIS is a crucial tool for every day operation.

- SIS offers strong flexibilty; changes can be made rapidly.

- The operations team carries out all changes related to the SIS.

- SIS complements the BIS, highlights configuration problems or minor issues.

One of the most powerful tools that guarantees a safe machine for reliable physics

Acknowledgment

ご清聴ありがとうございました

Thank you for your attention

Merci de votre attention

Special thanks to SPS team