Collimator BPM interlock in SIS

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Collimator BPM Interlock Concept

- Aim of the SIS interlock is to ensure that the beam position is always “well” centred in the collimator BPMs: TCTs and TCSP.6.
  - ‘Easier’ to implement than a HW interlock.

- For TCTs the criticality increases with lower β^*, therefore β^* is used by SIS key input parameter to the interlock logic.

Collimator BPM Implementation

- **Inputs** to the interlock logic (by collimator):
  - Collimator **BPM readings**,
  - **β*** from the timing telegram,
  - **Energy** from the timing telegram,
  - Table with β_{Coll} as a function of β* from LSA (constructed using LSA optics information), **tolerance in sigma** as function of β* and **emittance ε** (= 3.5 μm by default).
- Basic interlock logic:
  - Calculate **beam size @ collimator** : $\sigma_{coll} = \sqrt{(\beta_{Coll}(\beta^*) \ \varepsilon \ m_p / E)}$
  - **Normalize the BPM position** u by σ_{coll} → u/σ_{coll}
    - Assumes of course the nominal position is '0'.
  - Verify if u/σ_{coll} is within tolerance.
  - **Interlock (dump) logic**:
    - If redundant read out (= 4 BPM readings) **interlock raised if at least 2 readings out of tol.**
    - If non-redundant read out (= 2 BPM readings) **interlock raised if at least 1 reading out of tol.**
    - Dump if interlock occurs in **5 consecutive updates** (= 10 seconds).
    - **60 seconds grace period for absence of data**, if longer : **dump.**

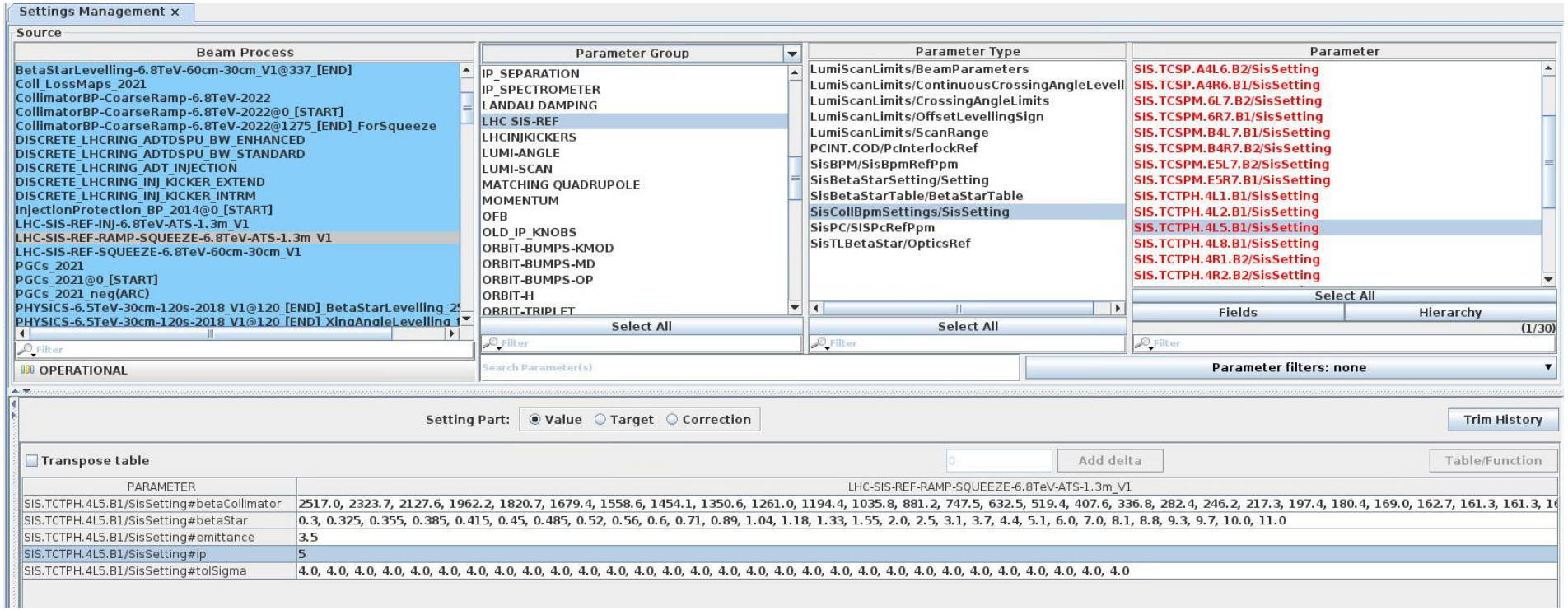
Collimator BPM Implementation (2)

- The logic does not involve the **energy as primary 'variable'**, energy dependent thresholds (injection vs FT) must use the **dependence of β* on the energy** of the CRS.
  - **IR6 + IR7 collimator BPM settings** are associated to the **IP5 β*** (even if the collimator β is constant) to provide room for energy and β* dependent thresholds.

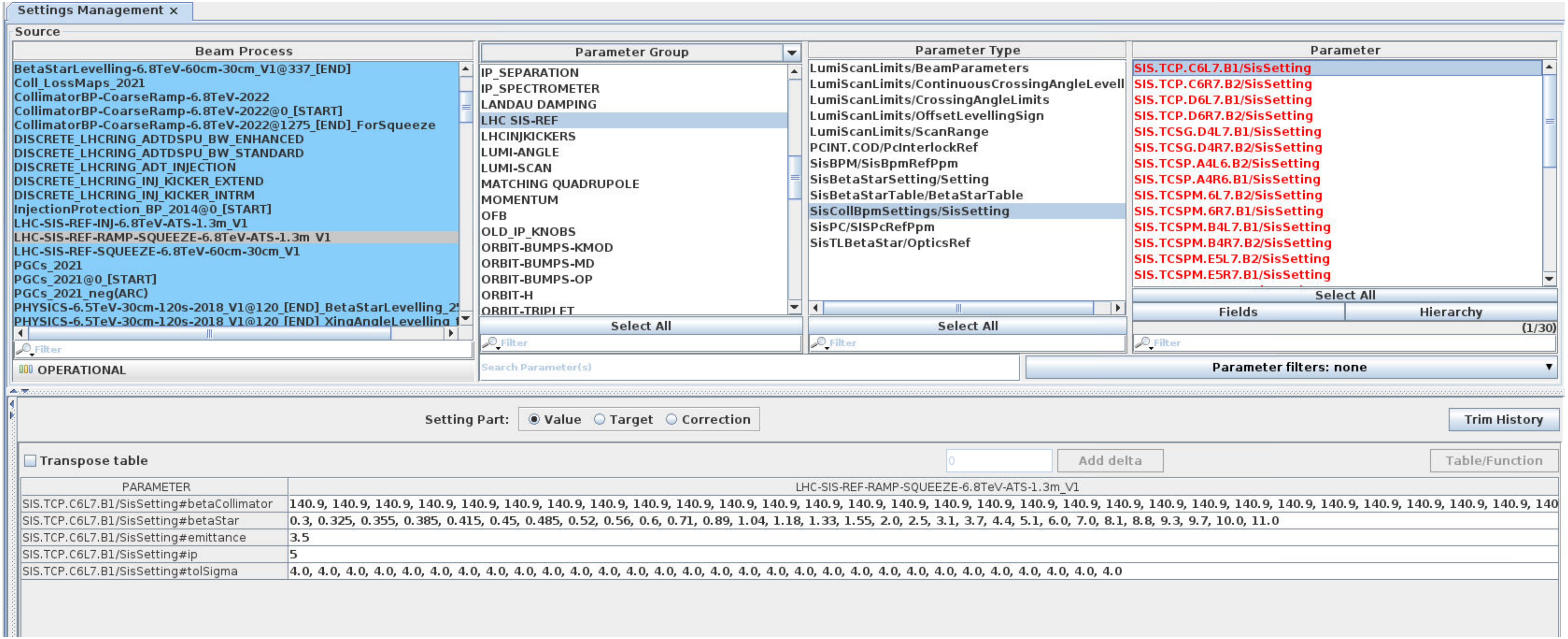
- So far this concept works for all configurations except for non-OP configurations like ballistic optics where it is not needed.
  - Nor does it work for IP2 since there is only one β* value at the IP, although one could use a trick and associate it to IP1 to obtain a better settings granularity.

Collimator BPM SIS settings

- The settings are stored in virtual device/property: **SisCollBpmSettings/SisSetting**
  - Critical settings, role MCS-LHC-SIS-EXPERT.
- There are separate settings for each hypercycle (resp. configuration type), stored in the LHC SIS Ramp settings BP.
  - LHC user: LHC.USER.SIS-RAMP, standard BP name: LHC-SIS-REF-**LSA-RAMP-BP-NAME**



- Example of the IR7 TCP associated to IP 5 β^* to provide flexibility for energy and β^* dependent thresholds.

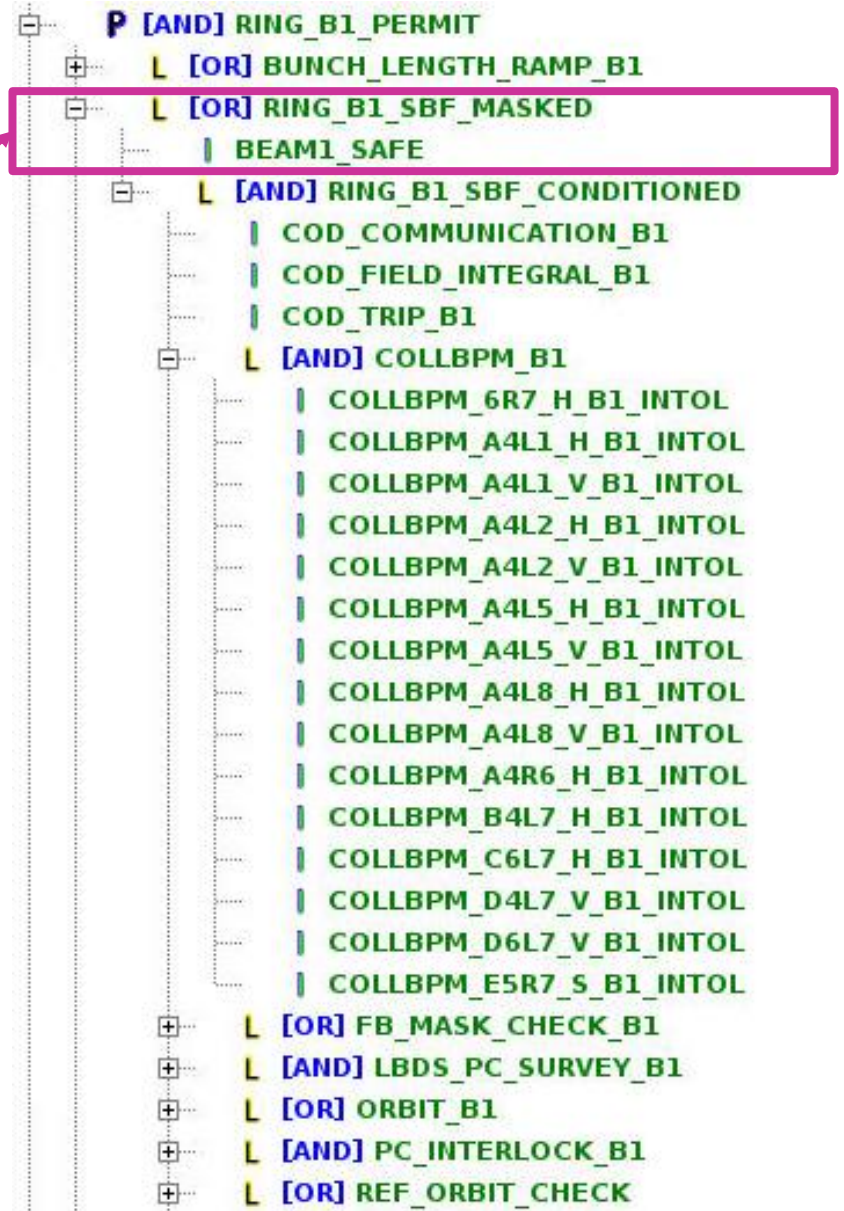


Run 2 settings

- In Run 2:
  - The tolerance were set to **1 sigma** for IR1 and IR5 TCTs @ 30-40 cm, progressively tightened from 4 sigma in the squeeze.
    - 1 sigma ~ 0.7-1 mm.
  - The tolerance was set to **2.5 sigma** for IR8 TCTs @ 3 m.
  - The tolerance was set to **4 sigma** for IR2 TCTs.
  - The tolerance for the IR6 TCSPs was set to **1.5 sigma all along the cycle**.

SIS interlock tree

- Collimator BPM interlocks are part of the RING_B1(2)_PERMIT trees.
- The interlocks are **AUTOMATICALLY masked** when SBF = true.



OR-ed with SBF=true (BEAM1_SAFE)

Some time in the future

- When things calm down again, one could consider to move the SIS interlock processing logic into a UCAP NODE.
  - NODE publishes results and values used in the logic (Ok/notOk, beam size, beta*, tolerance, normalized readings…).
  - Logic results could be used by SIS to act.
  - Full published data could be logged in nxcals to improve the diagnostics.