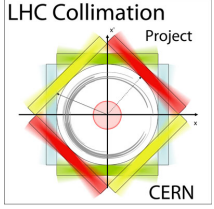




# How to avoid wrong collimator settings after beam-based alignment?

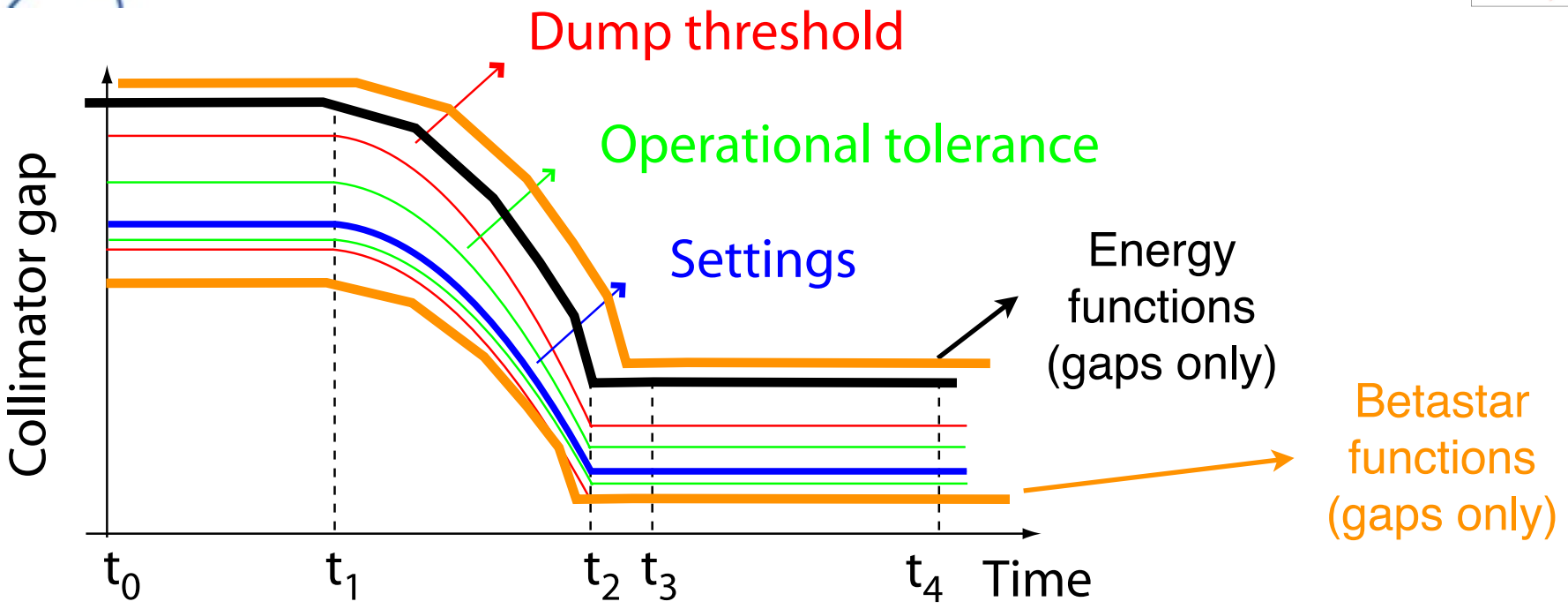
**R. Bruce, S. Redaelli, G. Valentino, B Salvauchua**

Acknowledgements: R. Assmann, M. Cauchi, D. Deboy, L. Lari.

# Introduction

- Collimator settings are heavily interlocked but their necessarily requires **human input**, thus possible errors!
  - "Beam-based" centres established during alignment are not known *a priori*.
- Two problems encountered this year with the collimator settings:
  - TCT collimators in IR2 set at the good gap but wrong centre
    Source: Human error in settings inputs
    ➙ Turned out not to be critical, but caused a lot of worries!
  - 2 collimators in IR3 at the wrong centres
    Source: "bug" in the setting generation tools
    ➙ not critical for operations
- Followed up this problems and tried to improve the setting check!
- General discussion that can also be applied to other systems!

# Recap. of collimator interlocks




- Two regimes: discrete ("actual") and time-functions *(internal clock at 100 Hz )*
- **Inner** and **outer thresholds** as a function of **time** for each motor **axis** and **gap** (24 per collimator). Triggered by timing event (e.g. start of ramp).
- "Double protection" → BIC loop broken AND jaw stopped
- Redundancy: **maximum allowed gap versus energy** (2 per collimator)
- Redundancy: **betastar limits** ensure that the collimators move correctly in squeeze.

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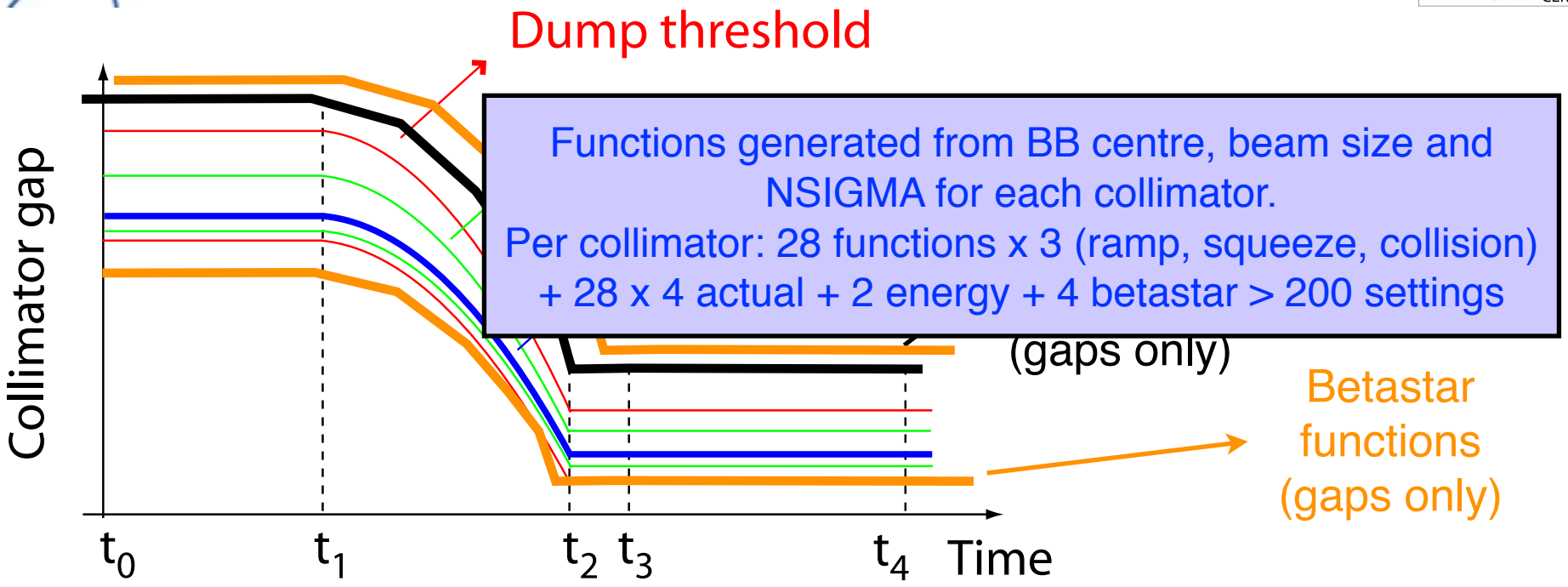


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# Recap. of validation procedures

- Settings established during semi-automated alignment campaigns
- Settings generated with external tools (then import into LSA from files) or within LSA (collimator generation rules)
- Manual verification of generated values by several people in the team
- Systematic checks of the setting transitions (e.g., ramp to squeeze)
- New settings are followed by low-intensity cycles to validate the operation with the sequencer
    - Normally in the shade of fills for loss maps or Q/OFB checks
- All machine configurations are validated by loss maps
    - Ok for cleaning functionality but cannot address completely the cleaning
- Online tools to verify the collimator gaps

# Recap. of validation procedures

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- D. Jacquet
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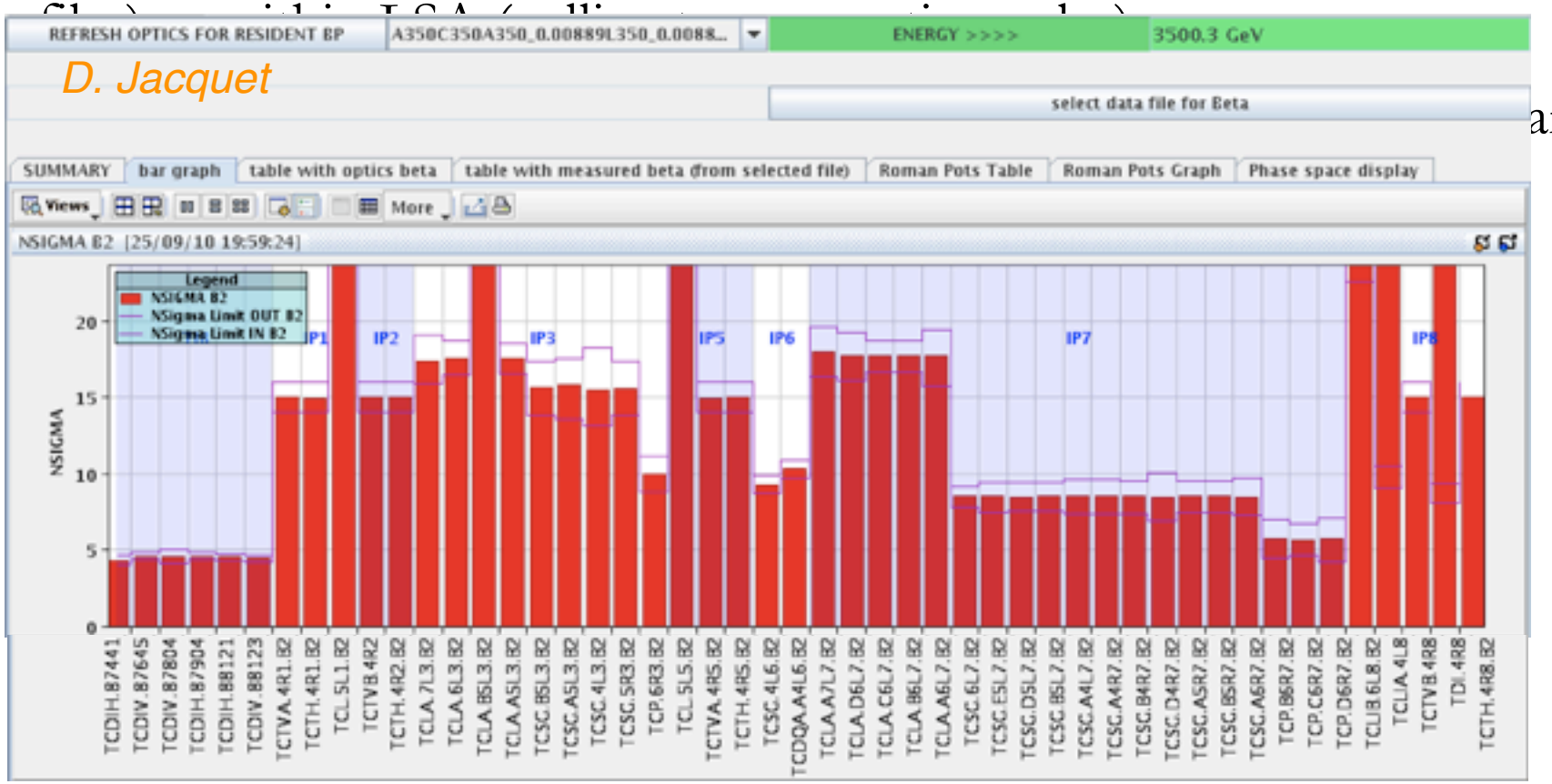
- 

# Error Detection + Recovery

- Collimator setups held towards end of March 2012.
- Error detected on 17.04.2012 during analysis of beam centre variations from logged data.
- March alignment was the last one performed with a manual generation of setup sheets.
- Gap correct but shifted by up to 4 sigmas.

  No issues for cleaning. Aperture could potentially be exposed, but this was not the case.

  Risk for the TCT in case of asynch dump, but error was for TCTV! Operation continued.
- In addition, wrong centers for 2 IR3 collimators, when automatically parsing setup sheet.

☑ **Yesterday we found two errors of TCT collimator settings**

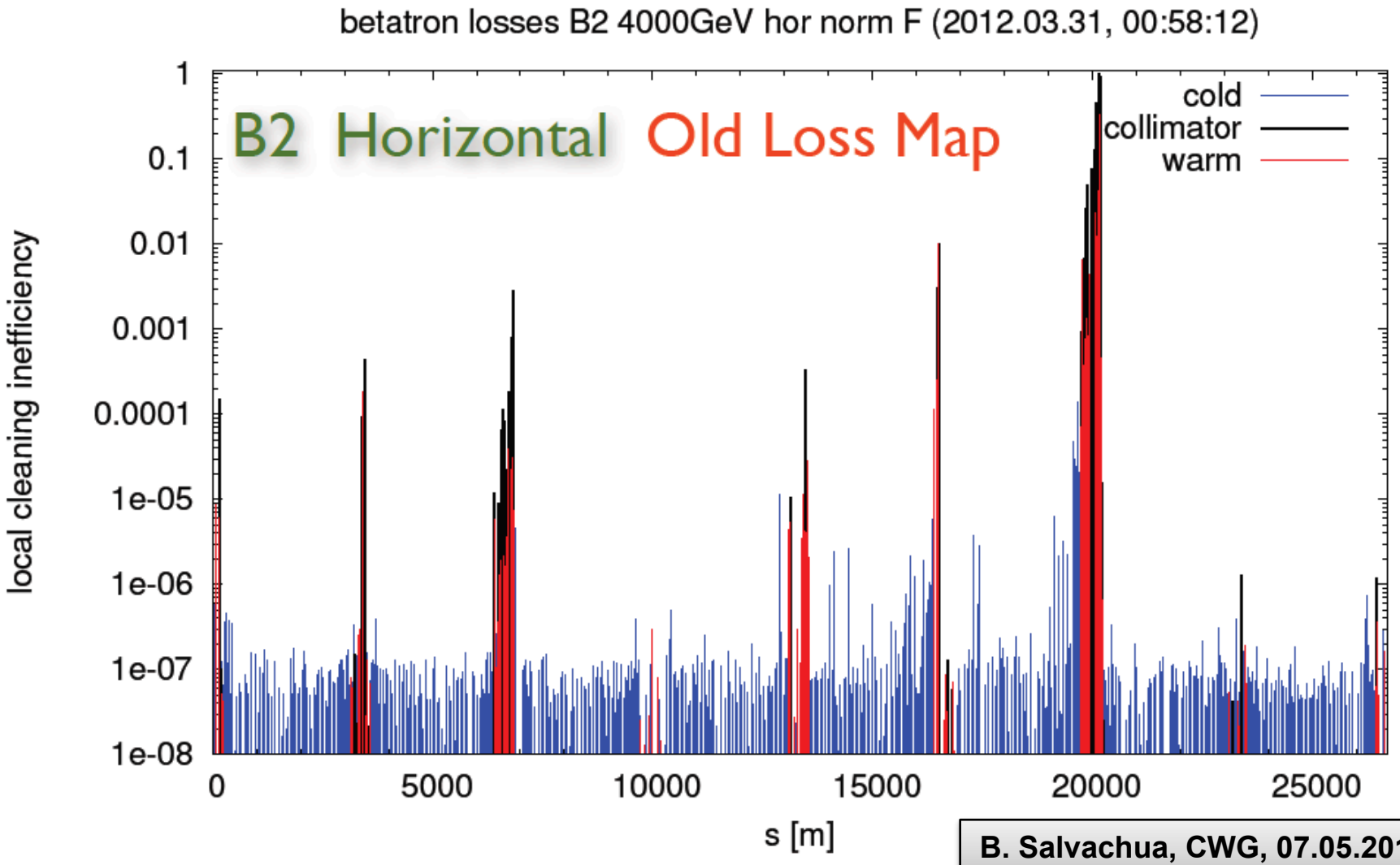
***TCTVA.4R1.B2:*** *Flat-top centre off by 0.46 mm when TCT at ± 6.65 mm*
***TCTVA.4R2.B2:*** *Collision centre off by 1.66 mm = 3.8 sigmas*

☑ **What does this means in practice:**

***TCTVA.4R1.B2:***
*Error of 1.8 σ when TCT at 26 σ. Error goes to zero at the end of the squeeze.*
***TCTVA.4R2.B2:***
*Instead than symmetric 12 σ settings, one jaw is at 16 σ and one at 8 σ.*

☑ **Problem caused by typo while filling Excel tables with the beam-based collimator centres ('-' and '+' exchanged)**

# Loss Map Comparison




B. Salvachua, CWG, 07.05.2012

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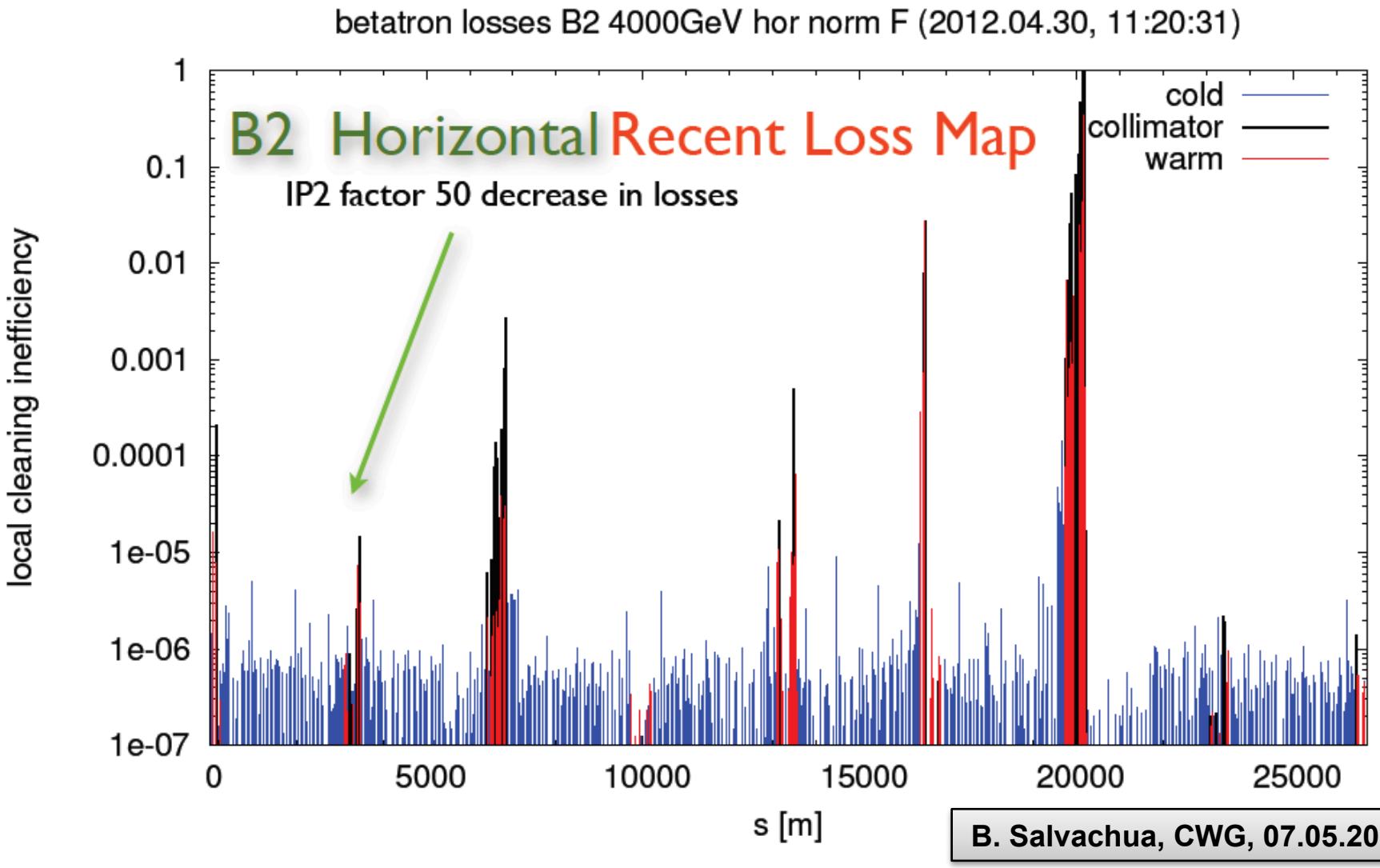


B. Salvachua, CWG, 07.05.2012

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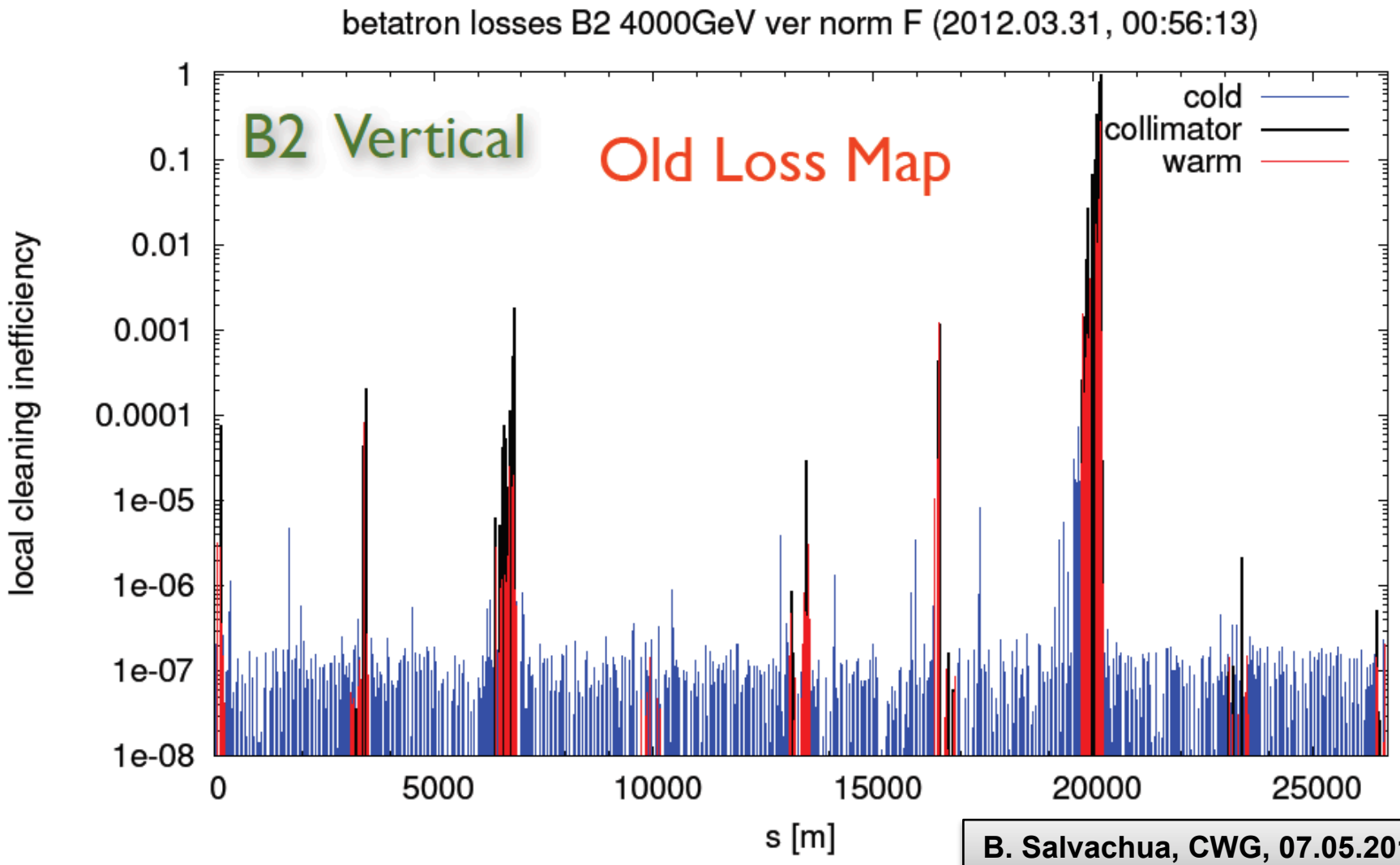


B. Salvachua, CWG, 07.05.2012

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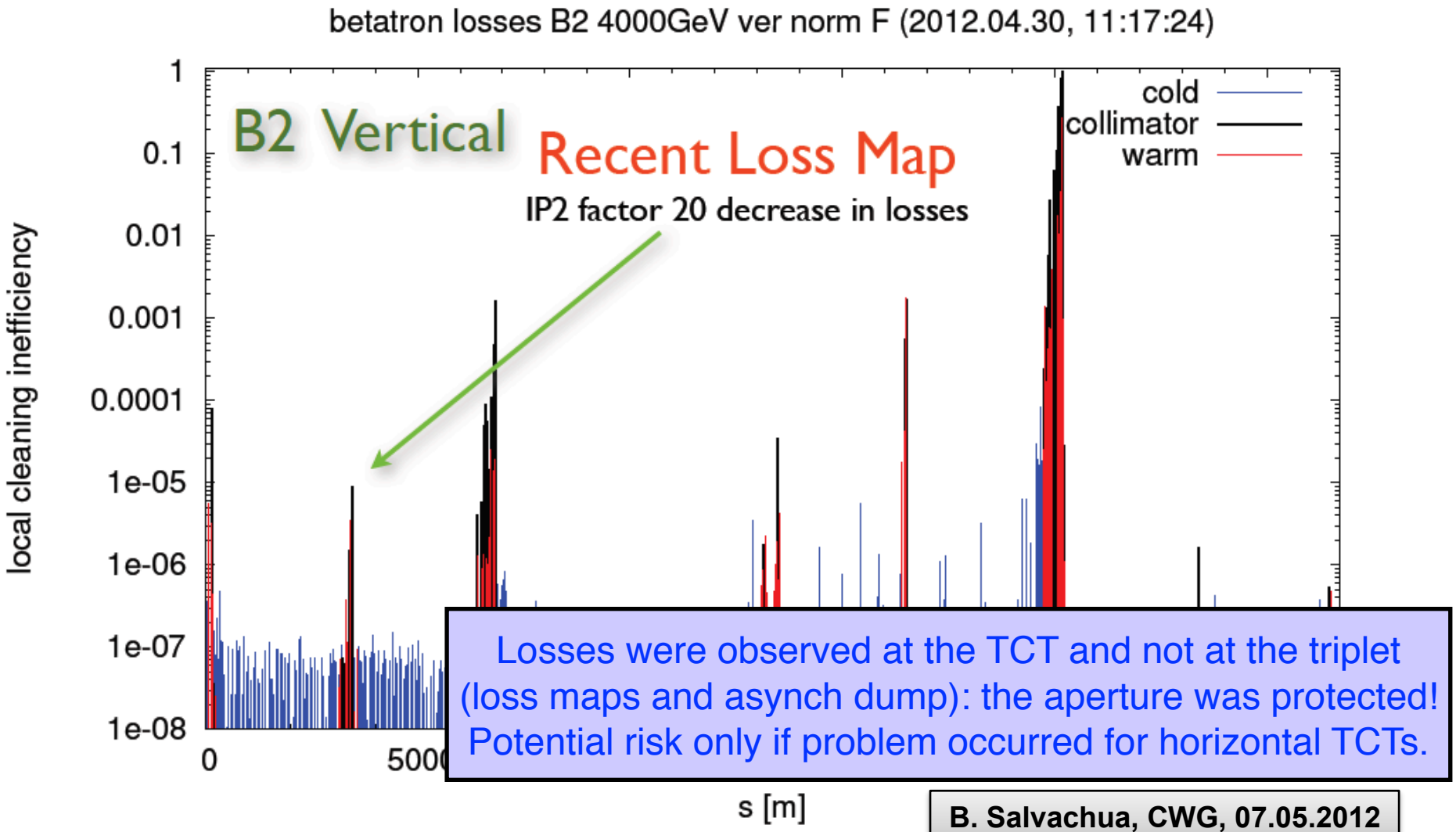
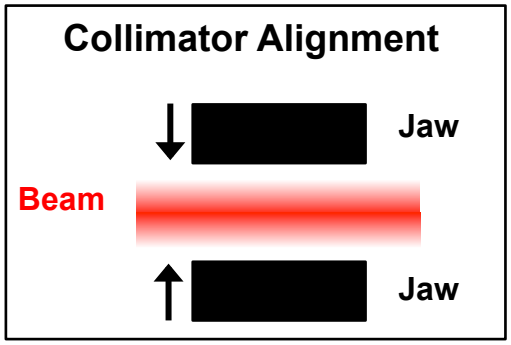



Losses were observed at the TCT and not at the triplet (loss maps and asynch dump): the aperture was protected! Potential risk only if problem occurred for horizontal TCTs.

**B. Salvachua, CWG, 07.05.2012**

# Collimator Settings Generation Flow




When problem occurred, an automatic generation of setup sheet was deployed but not used as under debugging

**Potential Errors!**

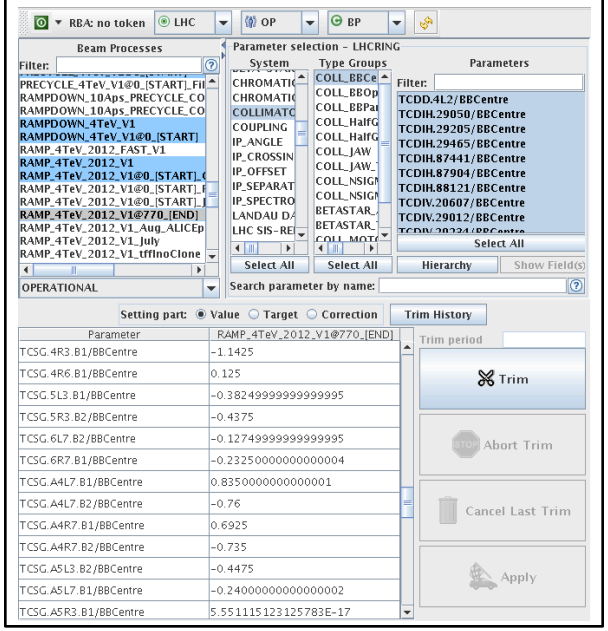
## Excel Setup Sheet

*Block 2: Perform beam-based alignment of all collimators sequentially*

| | Collimator Name | IN angle [deg] | MEAS JAW L calib [mm] | MEAS JAW R calib [mm] | MEAS LVDT gap | RES Gap Offset [mm] | RES Half Gap Meas [mm] | RES Eff sigma in coll plane [mm] | OUT JAW L setting [mm] | OUT JAW R setting [mm] | IN/RES Target HALF GAP [sigma] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | TCP.C6L7.B1 | 0 | 4.420 | -4.805 | | -0.193 | 4.613 | n/a | n/a | n/a | 4.40 |
| 8 | TCP.6L3.B1 | reduce gap by 25% (reduce energy tails) | | | | | | | | | |
| 9 | TCP.C6L7.B1 | 0 | 3.295 | -3.530 | | -0.118 | 3.413 | n/a | n/a | n/a | 3.26 |
| 10 | TCSG.4R6.B1 | 0 | 5.670 | -5.450 | | 0.110 | 5.560 | 1.793 | 12.663 | -12.443 | 7.00 |
| 10 | TCP.C6L7.B1 | 0 | 2.960 | -3.210 | | -0.125 | 3.085 | n/a | n/a | n/a | 2.94 |
| 11 | TCP.C6L7.B1 | 0 | 2.960 | -3.210 | 0.000 | -0.125 | 3.085 | n/a | n/a | n/a | 2.94 |
| 12 | TCDQA.B4R6.B1 | 0 | 4.900 | | | 2.450 | 2.450 | 0.858 | 14.280 | 0.000 | 8.00 |
| 13 | TCP.C6L7.B1 | 0 | 2.760 | -3.035 | | -0.138 | 2.898 | n/a | n/a | n/a | 2.77 |
| 13 | TCP.C6L7.B1 | 0 | 4.340 | -4.540 | 0.000 | -0.100 | 4.440 | n/a | n/a | n/a | 4.24 |
| 14 | TCL.5R5.B1 | 0 | 4.205 | -4.325 | | -0.060 | 4.265 | 1.039 | 25.916 | -26.036 | 25.00 |
| 15 | TCP.C6L7.B1 | 0 | 3.990 | -4.335 | | -0.173 | 4.163 | n/a | n/a | n/a | 3.97 |
| 15 | TCP.C6L7.B1 | 0 | 4.380 | -4.670 | 0.000 | -0.145 | 4.525 | n/a | n/a | n/a | 4.32 |
| 16 | TCTH.4L5.B1 | 0 | 1.030 | -8.270 | | -3.620 | 4.650 | 1.105 | 10.739 | -17.979 | 13.00 |
| 17 | TCP.C6L7.B1 | 0 | 4.155 | -4.440 | | -0.143 | 4.298 | n/a | n/a | n/a | 4.10 |
| 17 | TCP.C6L7.B1 | 0 | 4.155 | -4.440 | 0.000 | -0.143 | 4.298 | n/a | n/a | n/a | 4.10 |
| 18 | TCLA.7R3.B1 | 0 | 3.095 | -3.065 | | 0.015 | 3.080 | 0.757 | 7.589 | -7.559 | 10.00 |

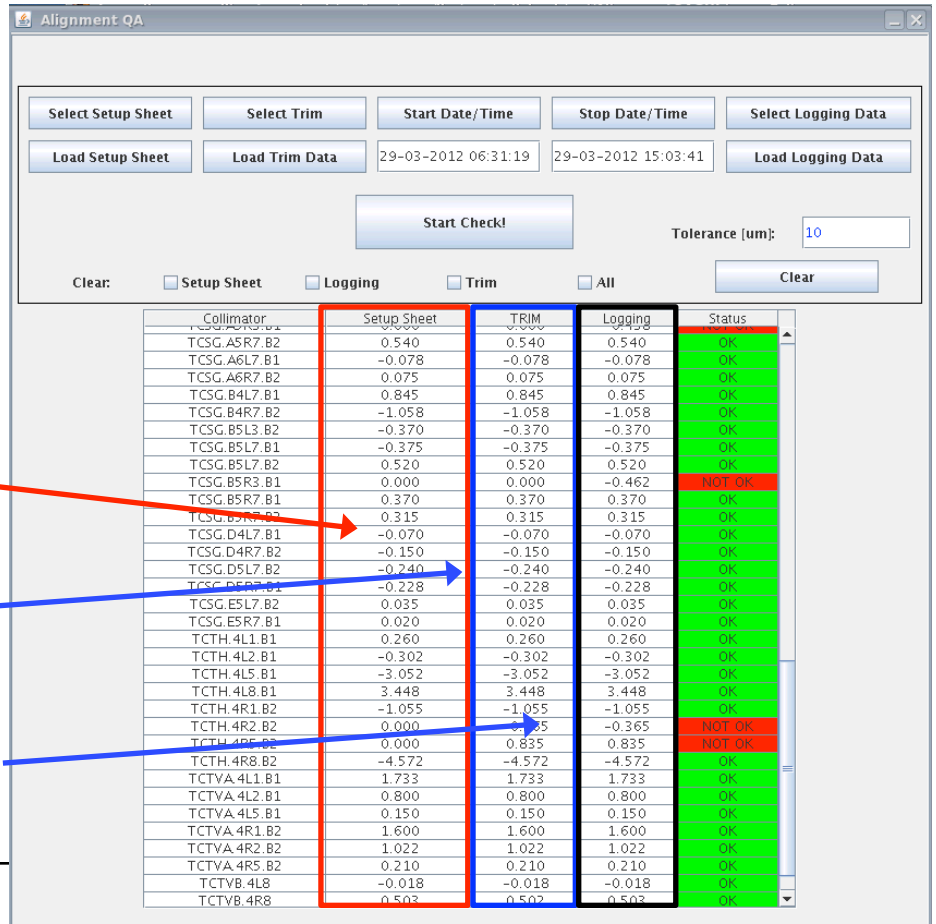
**Potential Errors!**

## Beam Process Settings



# Measures taken to avoid further issues

- Setup sheet is now automatically generated by collimator application during alignment: no more need to input manually the gap positions
- **Settings checker software** tool developed for post-alignment checks:
  1. Reads the centres from the Excel sheet
  2. Automatically calculates from the logged data the collimator centre at the time of the alignment (independent)
  3. Exports the LSA settings used by the operational sequence for the appropriate beam process
  4. Compares the different values




Setup Sheet

BP Settings

MDB Logging

# Future development

- Comparison also between the beam centres calculated from the left and right jaw settings in LSA, the excel sheet and the logging datasets.
  Use the "external parameters" that are sent to the hardware.

- Possibility to select between MDB and LDB for the logging source.
  Enables the possibility to check previous fills.

- Will be extended for online checks: compare machine at a time with reference setup sheets.

- Tables will be implemented in LSA to store directly the measured aligned jaw position (LS 1).
  By-passes the step of storing the intermediate data in the setup sheets.

- Tool could also be used to compare the LSA and Timber jaw settings after power cuts.

# Conclusion

- Errors were detected in the TCTVA.4R1.B2 and TCTVA.4R2.B2 settings (+ 2 IR3 collimators).
- Typo when inputting the aligned jaw positions ('+' exchanged with '-').
- The effect of the incorrect settings was observed in loss maps after solving the issue, but it is not easy to find out this typo of problems.
- The automated alignment setup sheet saving is now fully tested and operational, and a settings checker software tool was developed for post-alignment processing.
- Future work is envisaged to extend the capabilities of the tool.