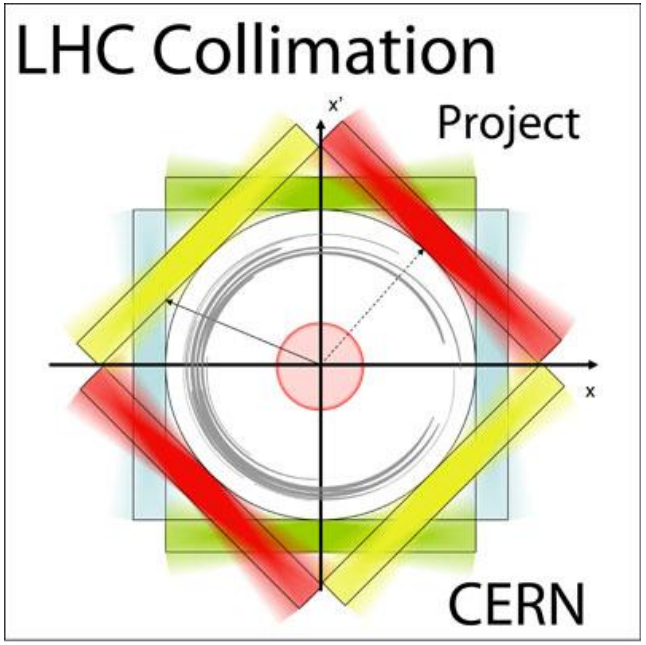
Collimation of encountered losses



D. Wollmann,

R.W. Assmann, F. Burkart, R. Bruce,

M. Cauchi, S. Redaelli, A. Rossi, G. Valentino,

OP-Team, BLM-Team

Outline

- Introduction: Collimator Settings and Qualification of Cleaning
- Examples for breakdown of collimation hierarchy for momentum cleaning (at 450GeV, 3500GeV)
- Change of cleaning inefficiency since last full setup (22.06.2010)
  - Leakage into cold aperture
  - Leakage to tertiary collimators
  - Leakage to dump protection collimators
- Conclusion

Collimator Settings

	Injection optics	Injection optics	Squeezed optics
Energy [GeV]	450	3500	3500
Primary cut IR7 (H, V, S) [σ]	5.7	5.7	5.7
Secondary cut IR7 (H, V, S) [σ]	6.7	8.5	8.5
Quaternary cut IR7 (H, V) [σ]	10.0	17.7	17.7
Primary cut IR3 (H) [σ]	8.0	12	12
Secondary cut IR3 (H) [σ]	9.3	15.6	15.6
Quaternary cut IR3 (H, V) [σ]	10.0	17.6	17.6
Tertiary cut exp. (H, V) [σ]	15-25	40-70	15
TCSG/TCDQ IR6 (H) [σ]	7-8	9.3-10.6	9.3-10.6

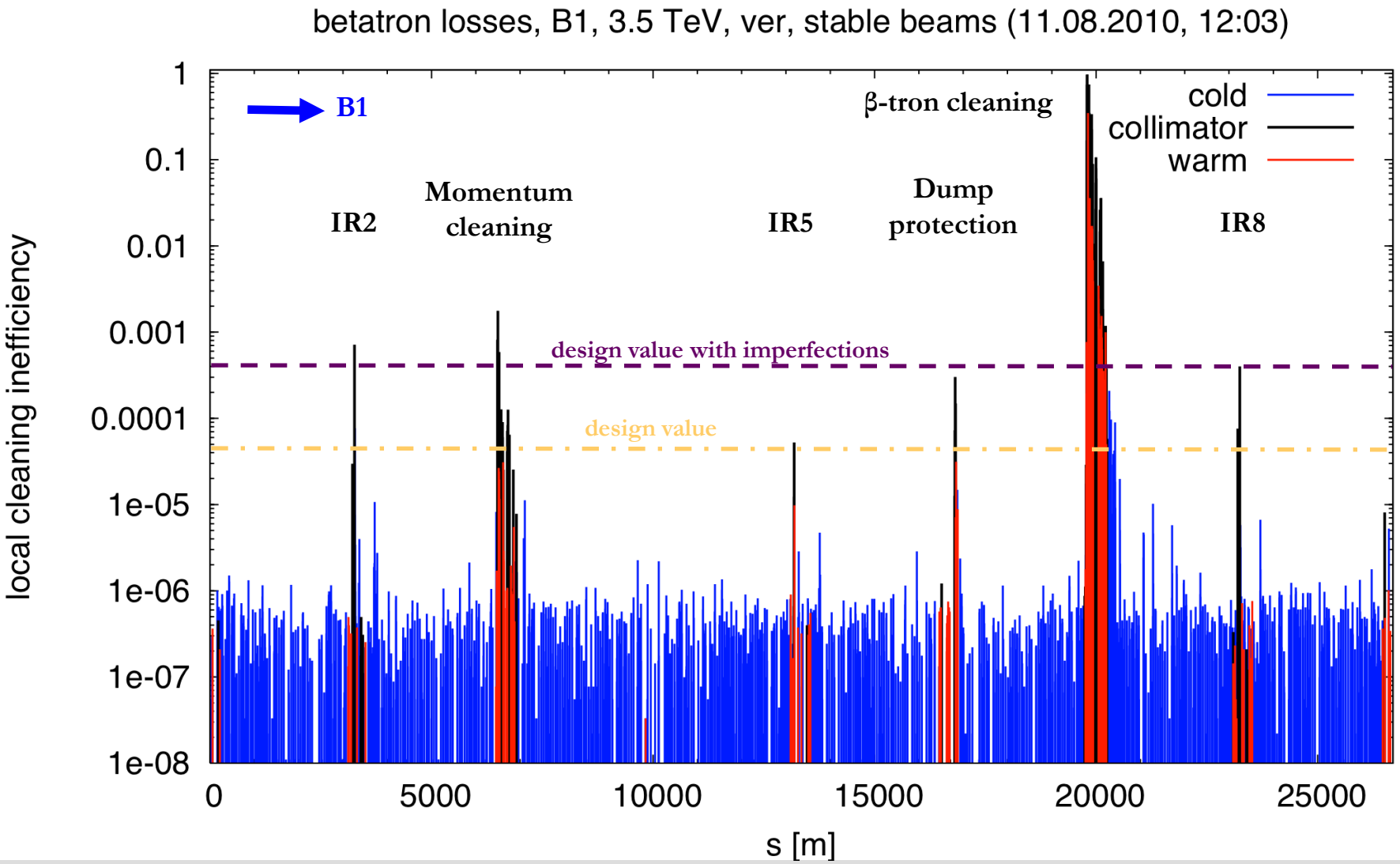
- Beam based setup performed in June 2010

Qualification of Collimation

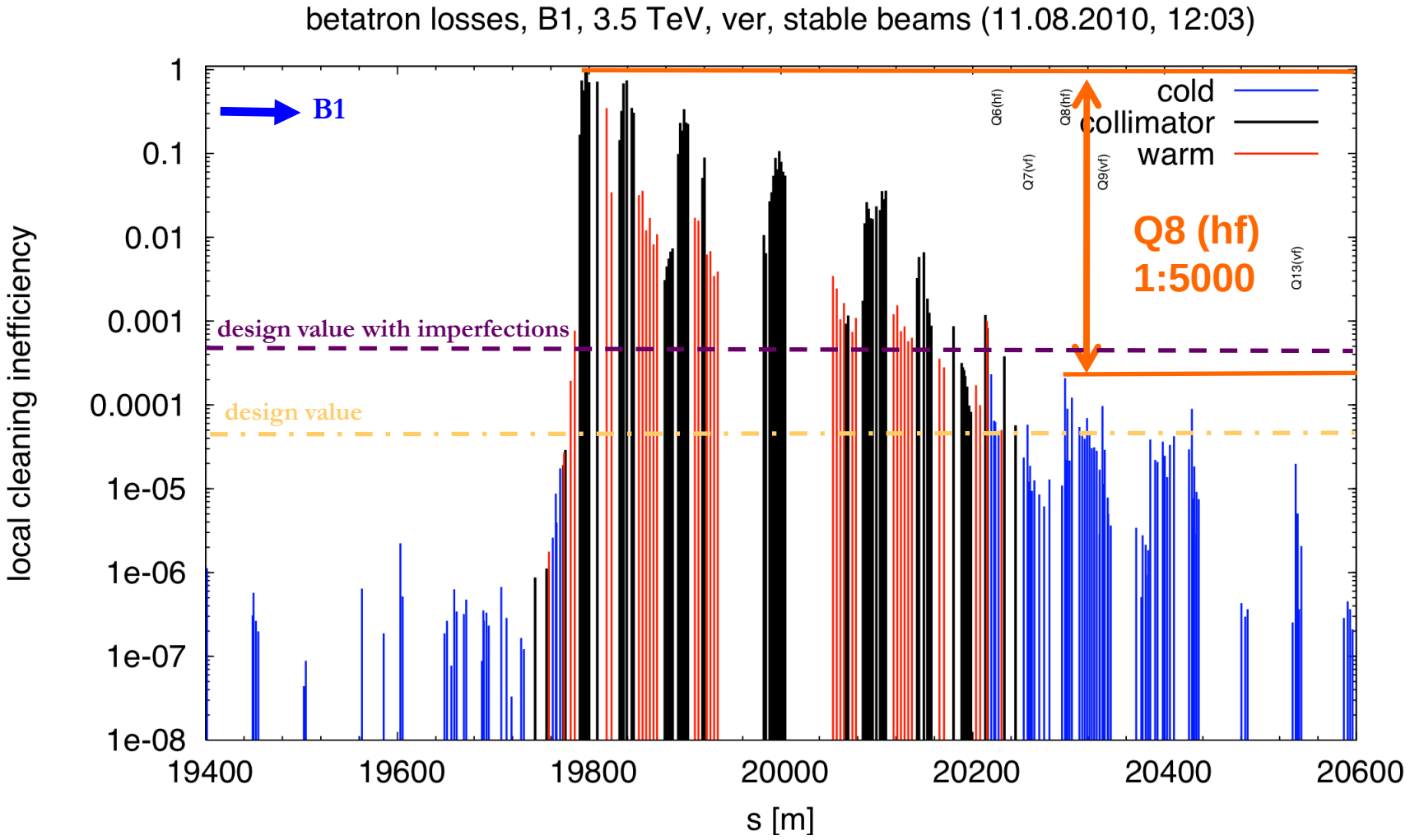
- The cleaning efficiency and the correct hierarchy of the collimation system are regularly qualified by intentionally creating slow losses
- β-tron losses by crossing a third integer tune resonance (B1-h, B1-v, B2-h, B2-v)
- Momentum losses by changing the RF frequency (± 1000 Hz, B1+B2)

- Performed with one nominal bunch at 3.5TeV and stable beams conditions
- Needs dedicated fills (one for β-tron cleaning and two for momentum cleaning)
- Qualification of the collimation system is regularly needed to check the validity of the setup and track the changes in cleaning efficiency over time

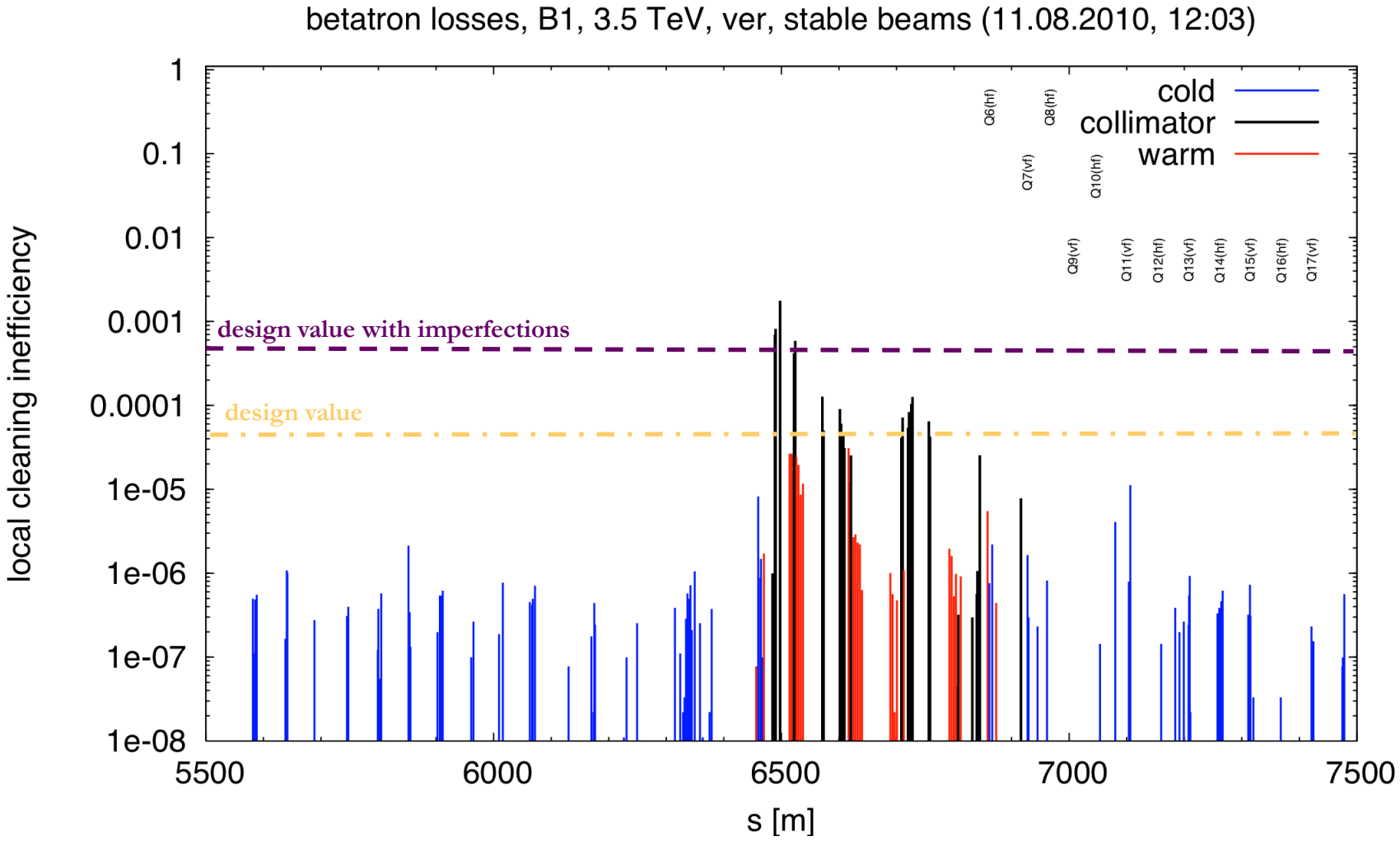
β-tron losses, B1v, 3.5TeV, β*=3.5m



β-tron losses, B1v, 3.5TeV, β*=3.5m IR7



β-tron losses, B1v, 3.5TeV, β*=3.5m IR3



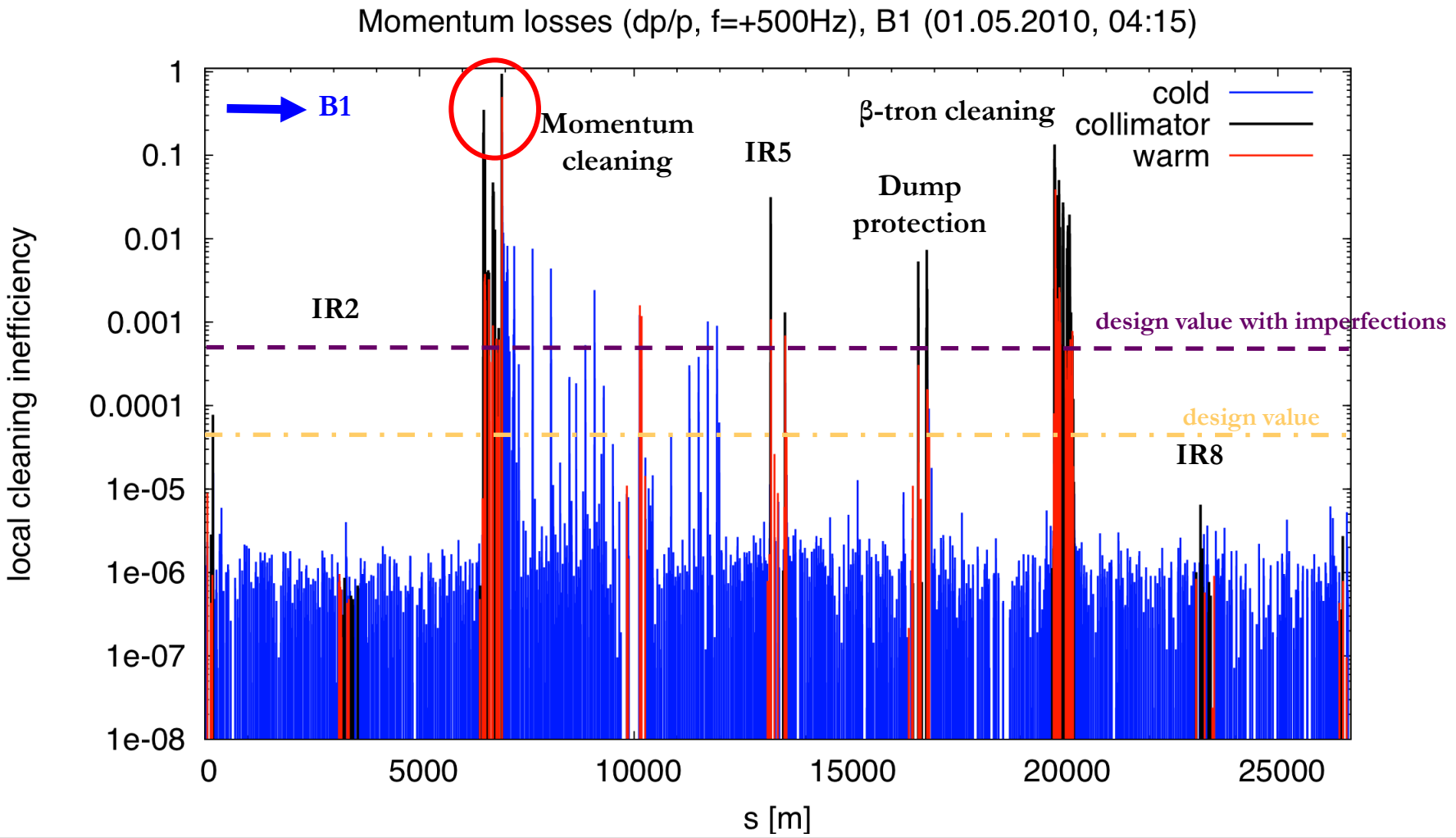
Breakdown of Collimation Hierarchy

Two events observed so far (both in momentum cleaning):

- 1st of May: B1, 450GeV, +500Hz
- 13th of August: B2, 3.5TeV, -1000Hz

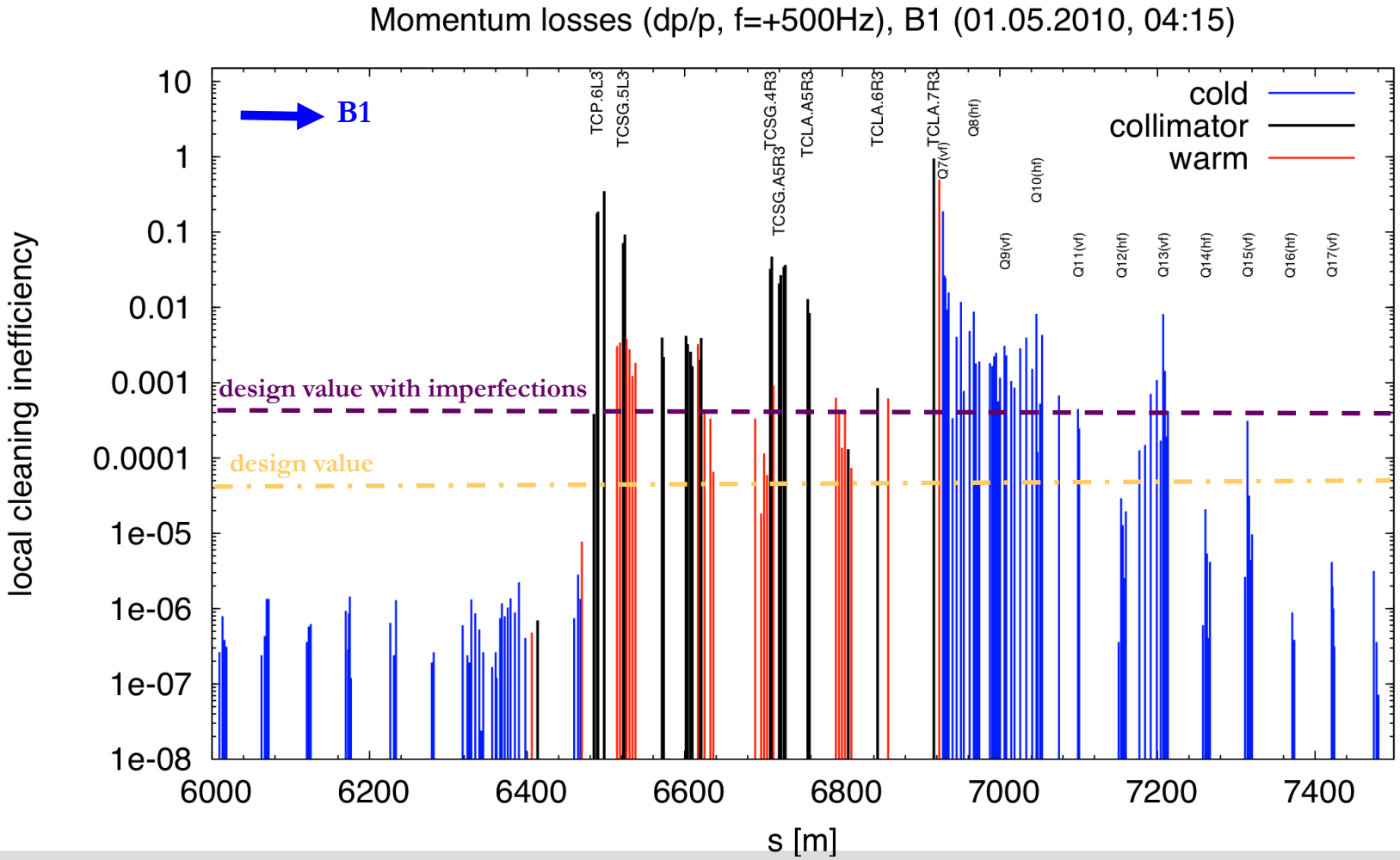
Momentum losses, B1, 450GeV, (+500Hz)

Breakdown of hierarchy for momentum cleaning



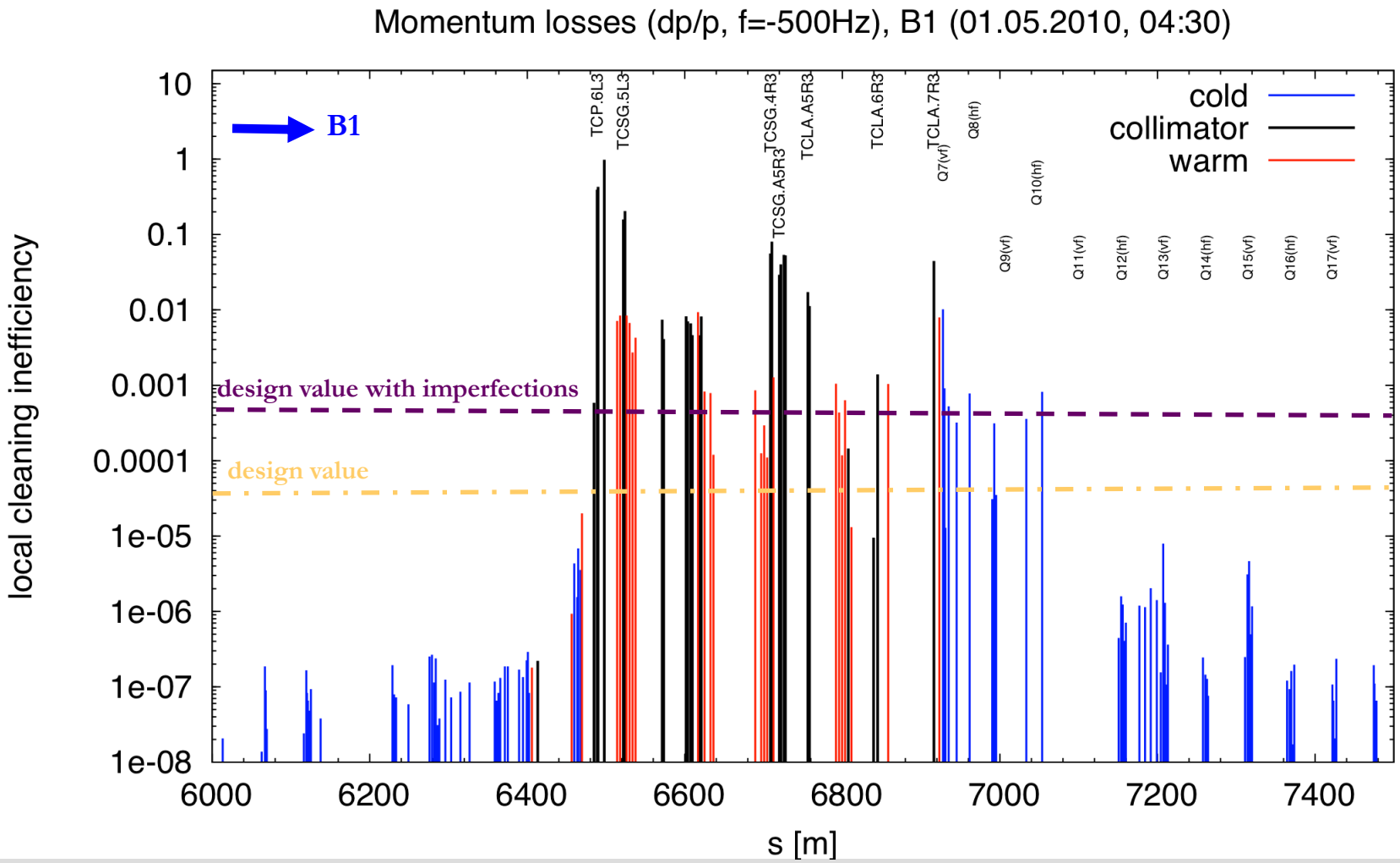
Momentum losses, B1, 450GeV, (+500Hz) IR3

- **Breakdown of hierarchy in B1 for particles with lower momentum**
- **loss of two σ margin between TCP and TCLA**



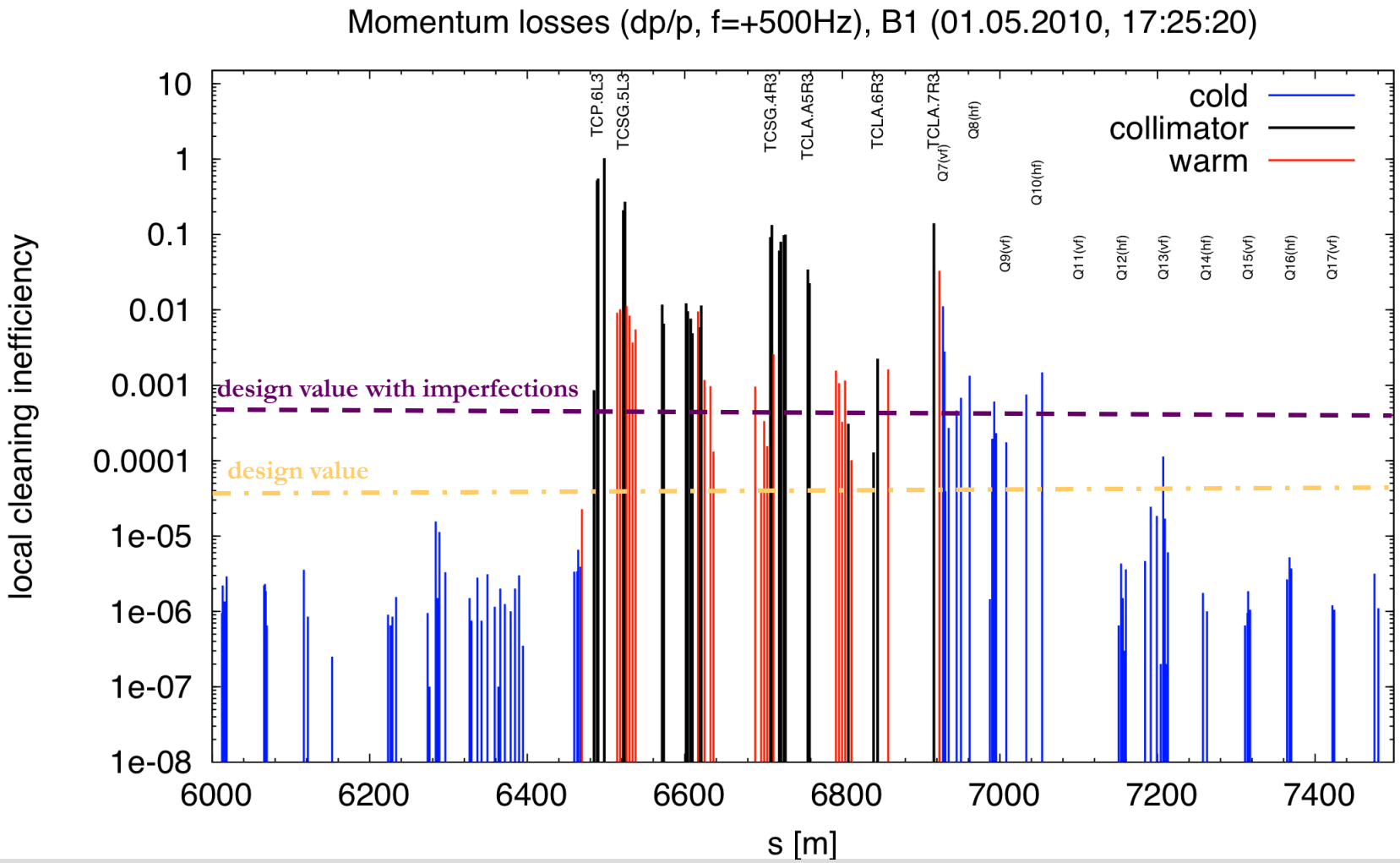
Momentum losses, B1, 450GeV, (-500Hz) IR3

- **No problem for particles with higher than nominal momentum**

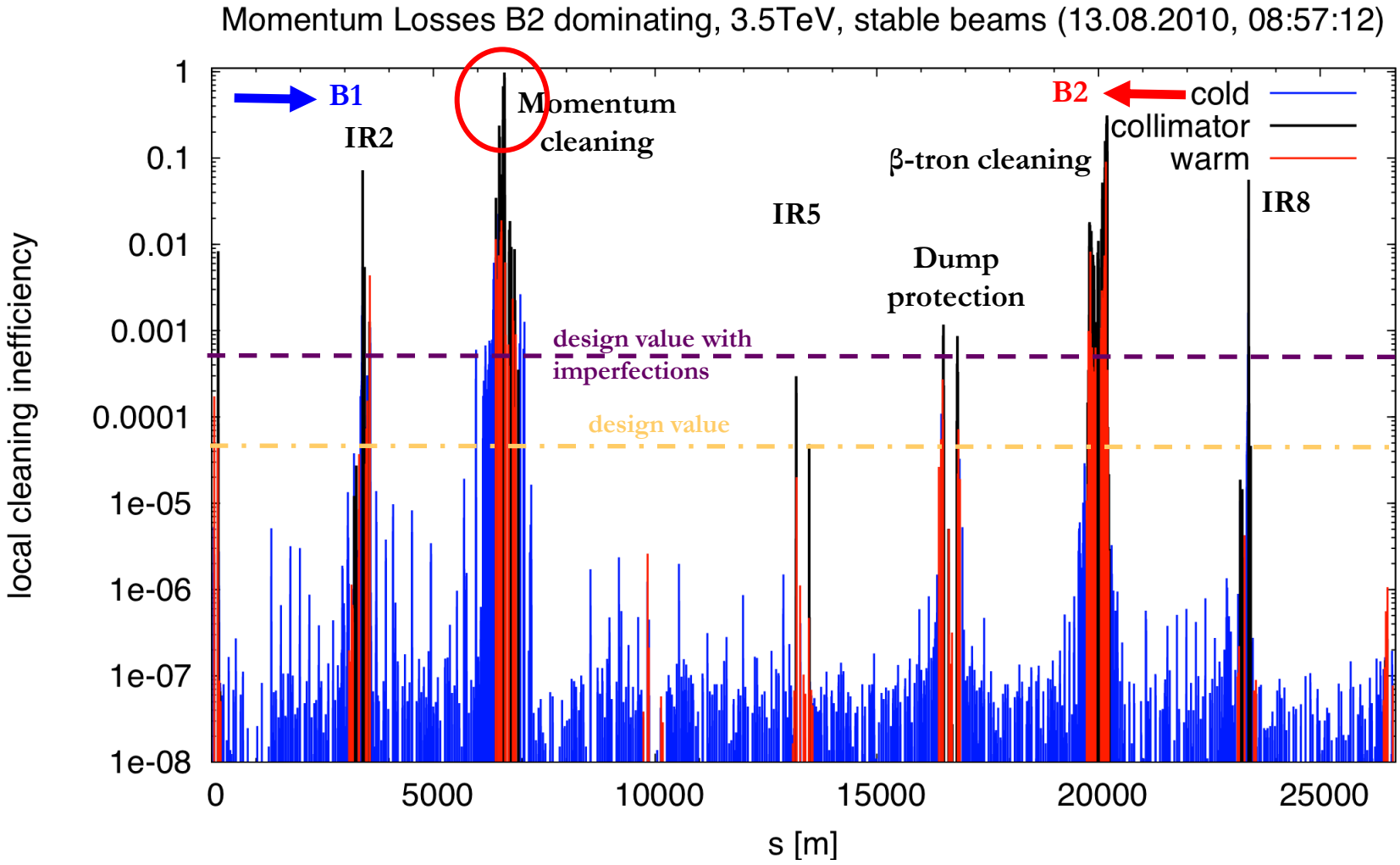


Momentum losses, B1, 450GeV, (+500Hz) IR3

Problem solved by adjusting orbit to correct reference orbit



Momentum losses, B2 dominating, 3.5TeV, β*=3.5m (-1000Hz)

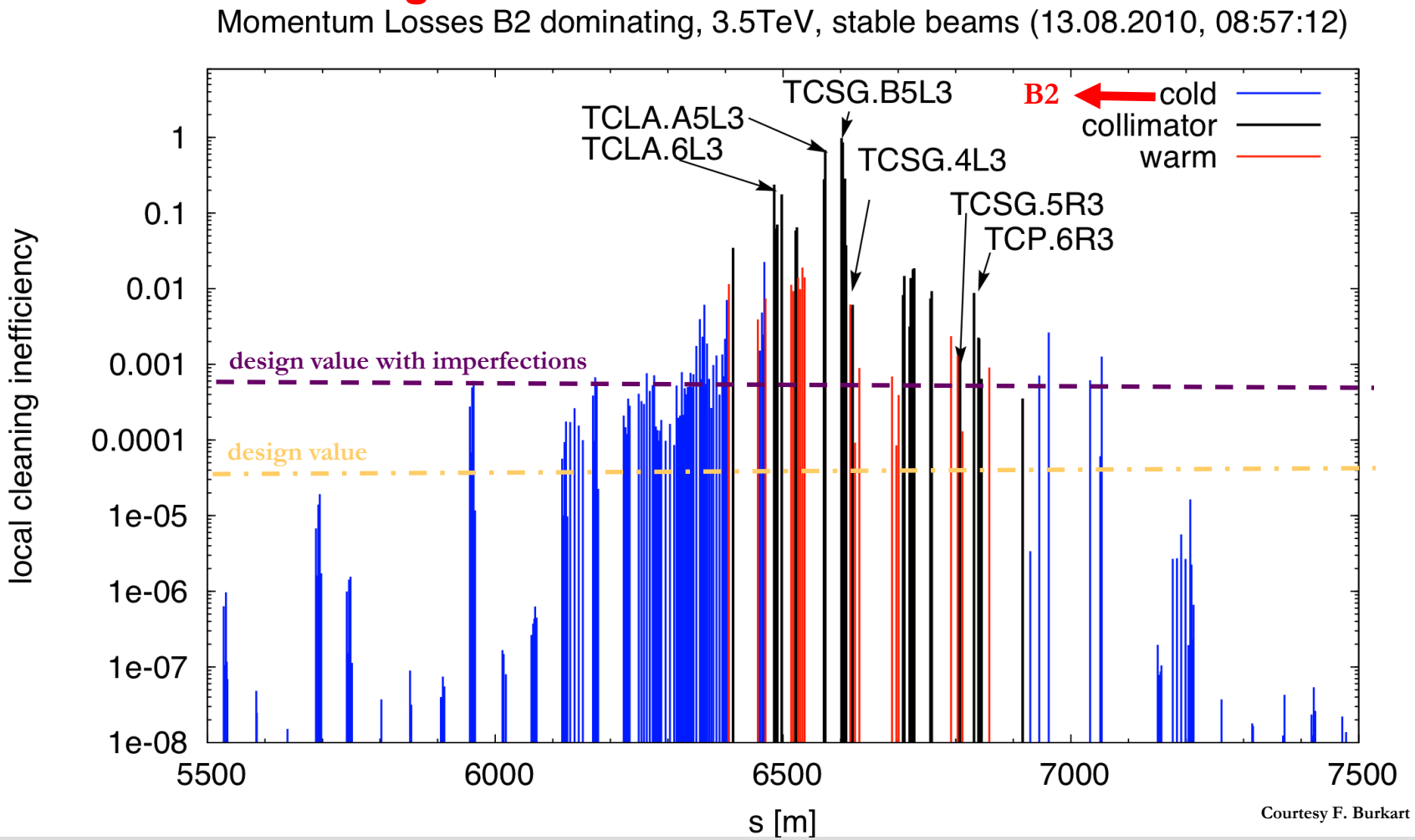


Courtesy F. Burkart

Momentum losses, B2 dominating, 3.5TeV, β*=3.5m (-1000Hz)

IR3

- **Breakdown of hierarchy in B2 for particles with higher momentum**
- **loss of 3.6 σ margin between TCP and TCSG**



Change of cleaning performance over 10 weeks

Performed measurements:

- 4 x qualifications with β-tron losses since last full setup of collimation system (22.06.2010)
- 2 x qualification with losses of particles with higher momentum (1x -1000Hz B1+B2, 1x -1000Hz only B2)
- 2 x qualification with losses of particles with lower momentum (+1000Hz B1+B2, +900Hz mainly B2)

Change of cleaning for β-tron losses qualified by:

- Leakage into cold aperture (Q8, IR7)
- Leakage into tertiary collimator in experimental IRs
- Leakage to dump protection collimators in IR6 (TCSG)

Not enough measurements to qualify the changes within momentum cleaning

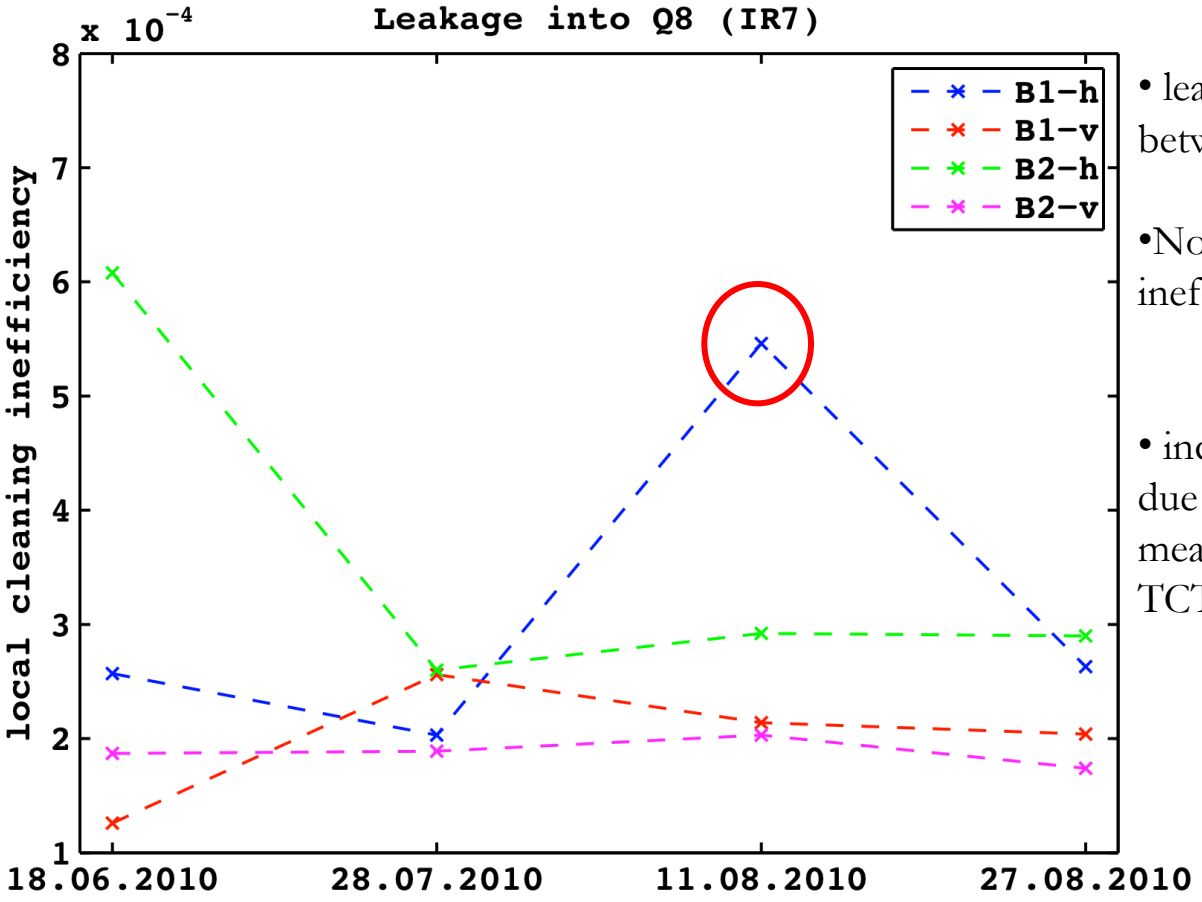
Development of β-tron local cleaning inefficiency (1.3s integration)

Leakage into cold aperture (Q8, IR7)

β-tron losses (cleaning inefficiency)	18.06.2010	28.07.2010	11.08.2010	27.08.2010
B1-H (Q8.R7)	2.57e-4	2.03e-4	5.46e-4	2.63e-4
B1-V (Q8.R7)	1.26e-4	2.56e-4	2.14e-4	2.04e-4
B2-H (Q8.L7)	6.08e-4	2.60e-4	2.92e-4	2.90e-4
B2-V (Q8.L7)	1.87e-4	1.89e-4	2.03e-4	1.75e-4

- Design cleaning inefficiency for phase I: 4.5e-5, with imperf. 5e-4

Development of β-tron local cleaning inefficiency (1.3s integration)



- leakage into cold aperture varied between 1.26e-4 and 6.08e-4

- No clear trend of increasing cleaning inefficiency

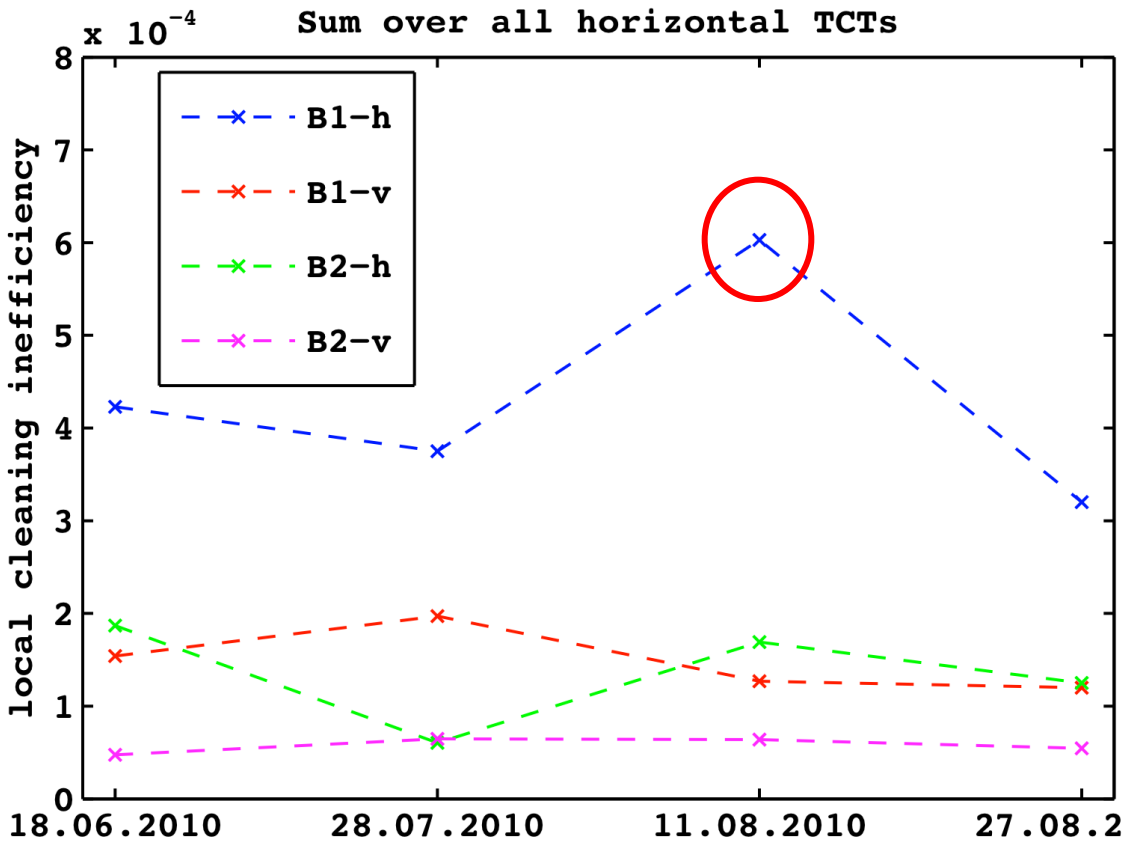
- increase in B1-h for 11.08.2010 maybe due to dump a few seconds after this measurement (seen also in TCTH and TCTV)

Change of β-tron local cleaning inefficiency (1.3s integration)

Leakage into tertiary collimator in experimental IRs

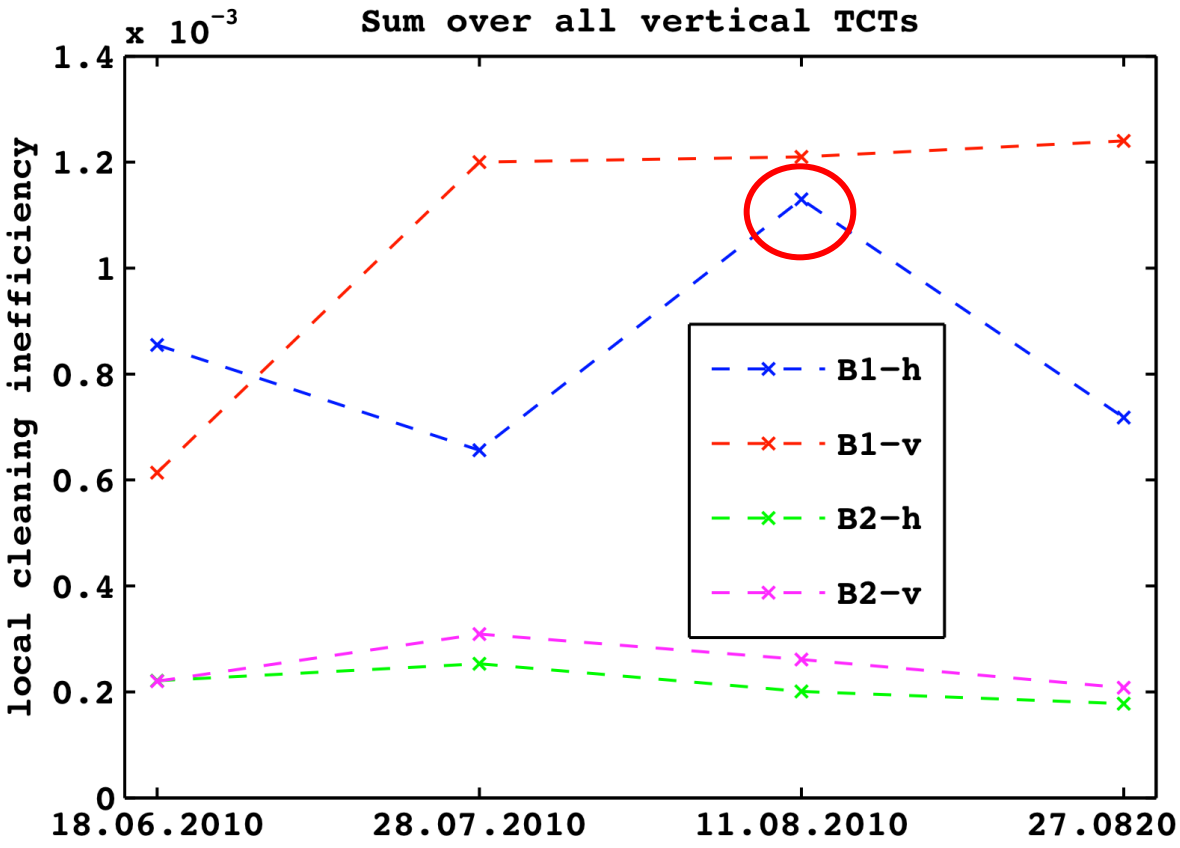
β-tron losses (cleaning inefficiency)	18.06.2010	28.07.2010	11.08.2010	27.08.2010
B1-H				
Σ TCTH	4.23e-4	3.75e-4	6.03e-4	3.20e-4
Σ TCTV	8.55e-4	6.56e-4	1.13e-3	7.18e-4
B1-V				
Σ TCTH	1.54e-4	1.97e-4	1.27e-4	1.20e-4
Σ TCTV	6.14e-4	1.20e-3	1.21e-3	1.24e-3
B2-H				
Σ TCTH	1.87e-4	6.03e-5	1.69e-4	1.25e-4
Σ TCTV	2.21e-4	2.53e-4	2.01e-4	1.78e-4
B2-V				
Σ TCTH	4.76e-5	6.47e-5	6.40e-5	5.44e-5
Σ TCTV	2.20e-4	3.09e-4	2.61e-4	2.08e-4

Leakage into horizontal tertiary collimators



- leakage into TCTHs stays below about 2.0e-4 for B1-v, B2-h, B2-v
- B1-h varied between 3.2e-4 and 6.08e-4
- No clear trend for a increase in cleaning inefficiency
- increase in B1-h for 11.08.2010 maybe due to dump a few seconds after this measurement (seen also in Q8 and TCTV)
- leakage to TCTs at 3.5TeV as simulated by A. Rossi (β^*: 2m-10m-2m-3m):
  B1H: ≈ 4.6e-4; B1V: ≈ 2.6e-4;
  B2H: ≈ 1.3e-4; B2V: ≈ 1.03e-4;

Leakage into vertical tertiary collimators



- leakage into TCTVs stays below 3.1e-4 for B2-h and B2-v
- leakage into TCTVs varies between 6.14e-4 and 1.24e-3 for B1-h and B1-v
- tendency of an increase in B1-V, to be understood if this is caused by only one IR
- increase in B1-h for 11.08.2010 maybe due to dump a few seconds after this measurement (seen also in Q8, TCTH and TCSG.IR6)
- leakage to TCTs at 3.5TeV as simulated by A. Rossi (β^*: 2m-10m-2m-3m):
  B1H: ≈ 4.6e-4; B1V: ≈ 2.6e-4;
  B2H: ≈ 1.3e-4; B2V: ≈ 1.03e-4;

Change of β-tron local cleaning inefficiency (1.3s integration)

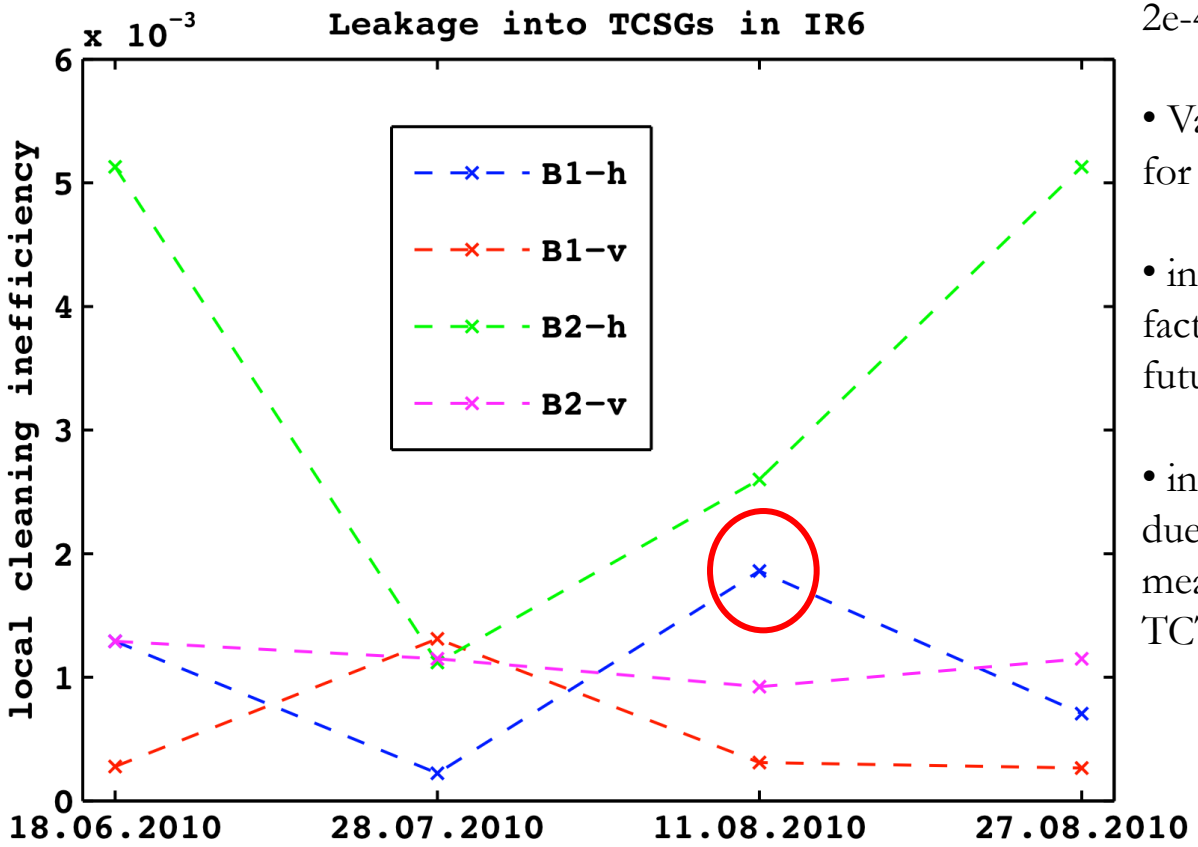
Leakage into dump protection (TCSG, IR6)

β-tron losses (cleaning inefficiency)	18.06.2010	28.07.2010	11.08.2010	27.08.2010
B1-H (TCSG.4R6.B1)	1.29e-3	1.24e-4	1.86e-3	7.06e-4
B1-V (TCSG.4R6.B1)	2.78e-4	1.31e-3	3.09e-4	2.65e-4
B2-H (TCSG.4L6.B2)	5.13e-3	1.12e-3	2.60e-3	5.13e-3
B2-V (TCSG.4L6.B2)	1.29e-3	1.15e-3	9.23e-4	1.15e-3

- leakage to TCSG-IR6 at 3.5TeV as simulated by A. Rossi (β*: 2m-10m-2m-3m):

  B1h: 7.5e-6 B2h: 1e-4 B2v: 6e-4

Leakage into dump protection (TCSG-IR6)



- leakage into TCSG in IR6 stays below 2e-4 for B1-h, B1-v, B2-h
- Variation between 5.2e-3 and 1.2e-3 for B2-h
- increase in B2-h since 28.07. by a factor of 4.6 to be understood and future changes to be tracked
- increase in B1-h for 11.08.2010 maybe due to dump a few seconds after this measurement (seen also in Q8 and TCTs)

Conclusion

- Loss maps have to be performed for all cases to verify and regularly validate the settings of the collimation system (B1, B2, hor, ver, +1000Hz, -1000Hz)
- Limitation in dispersion suppressor: Q8 (cleaning inefficiency < 6.1e-4, i.e. cleaning efficiency > 99.939%; design values phase-I with imperfections: 5e-4, i.e. 99.95%)
- Hierarchy for current setup broken in B2 for particles with too high momentum
- Broken hierarchy causes additional losses into the TCTs of IR1, IR2 and IR8 and leakage to the cold aperture in the case of a momentum gain of the particles
- No clear general trend of decreasing cleaning efficiency to cold aperture or tertiary collimators since last full setup (only B1-v for TCTVs shows a slight tendency, which needs to be further analyses and monitored)
- Leakage to TCSG-IR6 varied by a factor of 4.6 and needs to be further monitored to exclude a systematic increase.
- Cleaning efficiency for faster BLM integration times (currently 1.3s) still to be analyzed

END