Bunch intensity Limitations for LBDS intercepting devices and TL steering during fills

C. Bracco

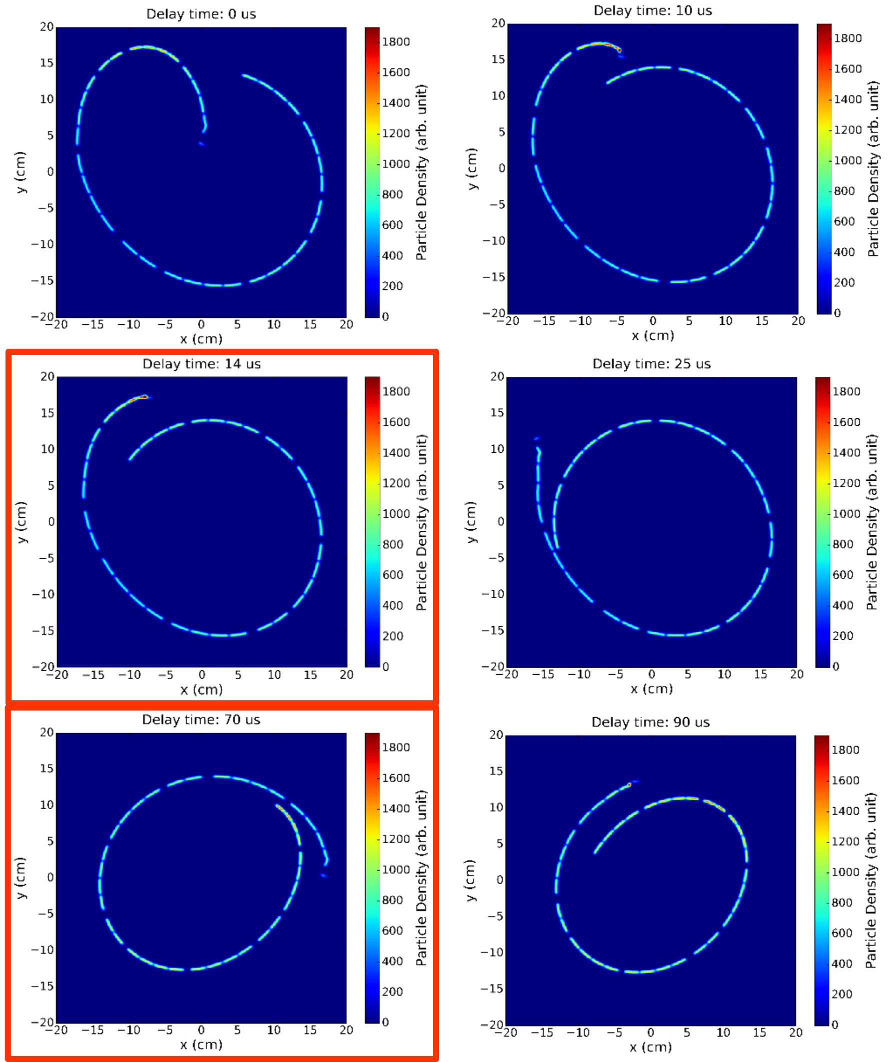
Acknowledgments: M. Calviani, M.I. Frankl, A. Lechner, F-X. Nuiry, T. Polzin, V. Rizzoglio, F.M. Velotti, J. Wenninger, C. Wiesner

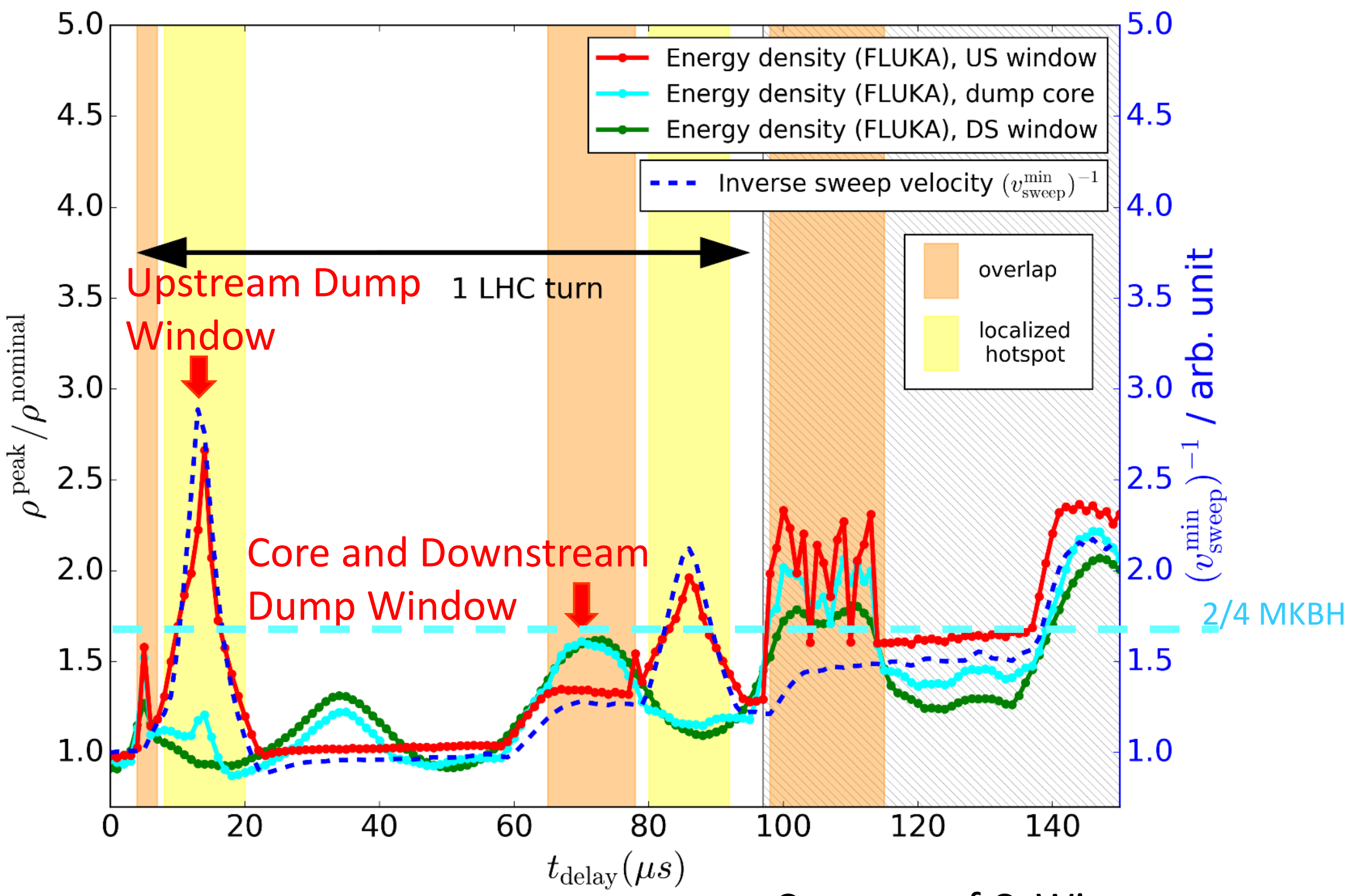
Outline

- MKB
  - Possible missing dilution after LS2 upgrades
  - Effect on dump components and compatibility with Run3 beam parameters
  - Safe ppb beam intensity at top energy
- TL steering during fills
- Conclusions

Possible Missing Dilution After LS2

MKB erratic (lower risk in Run3 after generator upgrade ➔ lower voltage):
MKB re-triggering is being implemented in LS2 to avoid anti-phase in case of erratic ➔ only 1 MKB missing but different sweep pattern depending on erratic and actual beam dump delay (0 ➔ 1 LHC turn ➔ 89 µs + signal propagation)



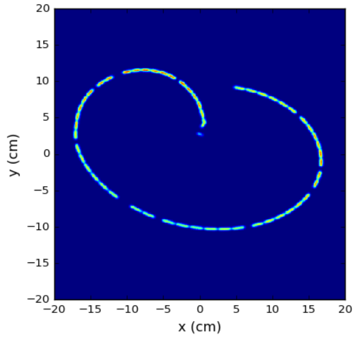


Courtesy of C. Wiesner

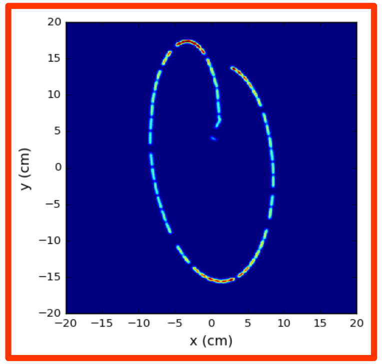
Possible Missing Dilution After LS2

MKB flashover:

1. Simultaneous loss of two MKBs

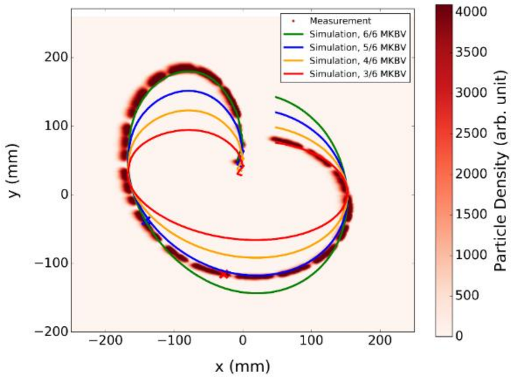


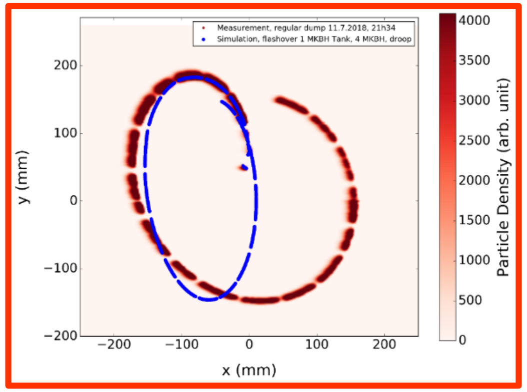
Missing 2 MKBHs

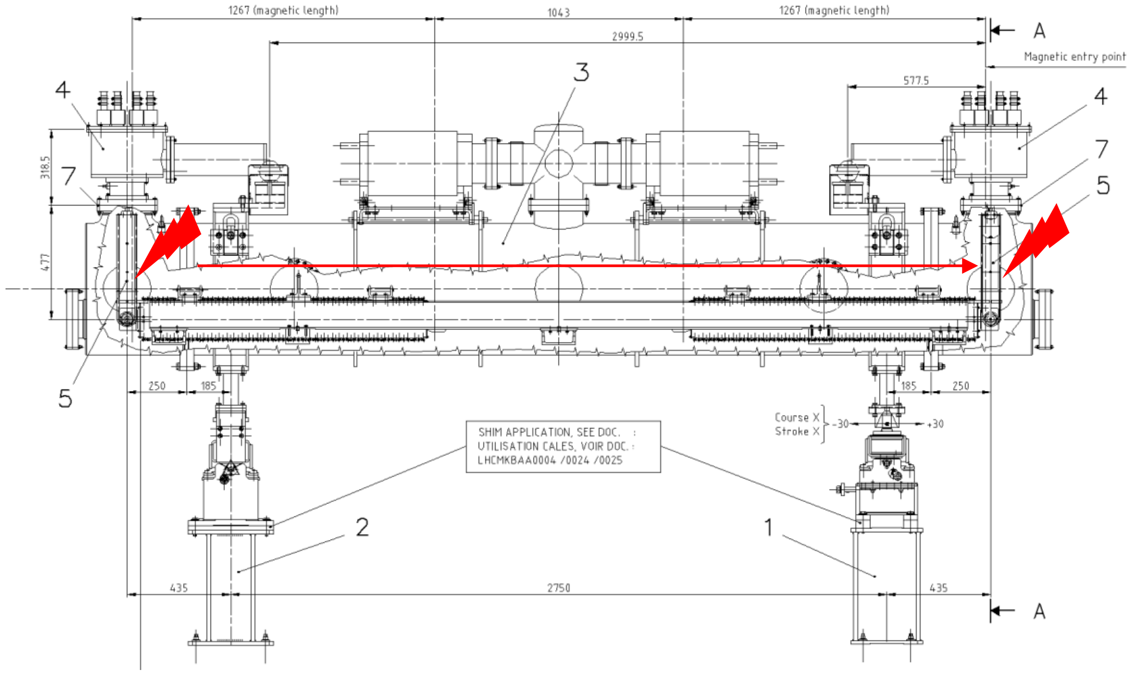


Missing V dilution

2. Loss of >2 MKBs due to delay in flashover propagation







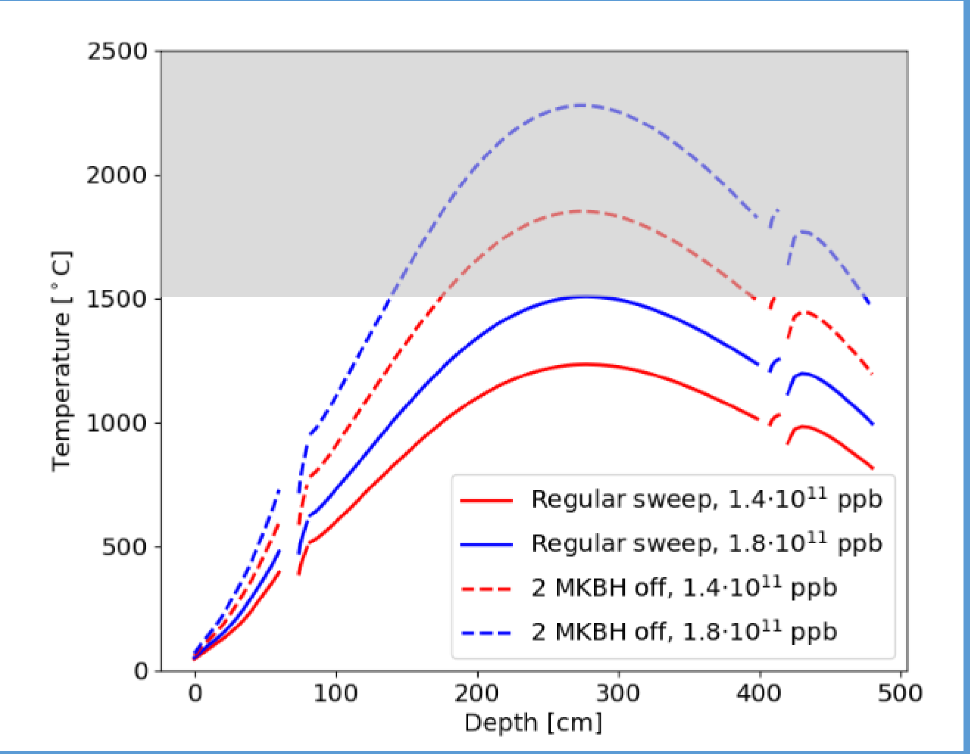
Courtesy of C. Wiesner

Expected Effects on Dump Core (no upgrade in LS2)

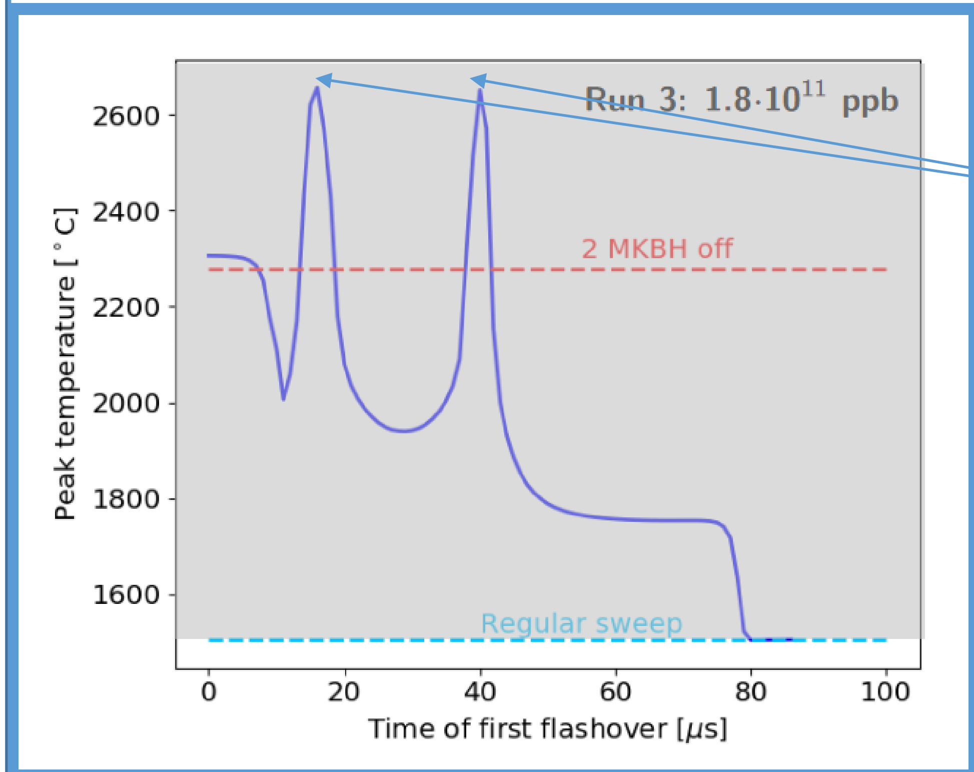
Run3: 2748 bunches of 1.8E11 ppb (1.8 μm emittance)

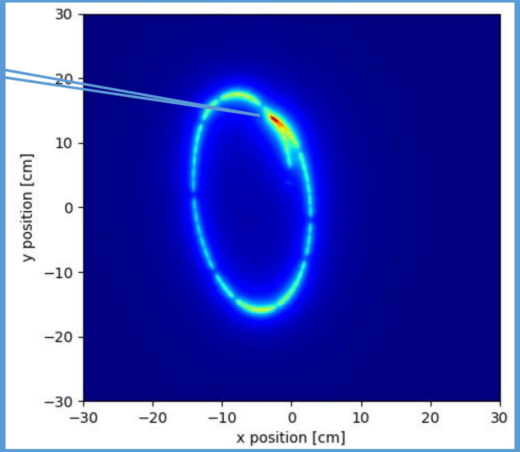
Nominal and worst failure cases for dump core

Possible reducing only by reducing ppb intensity



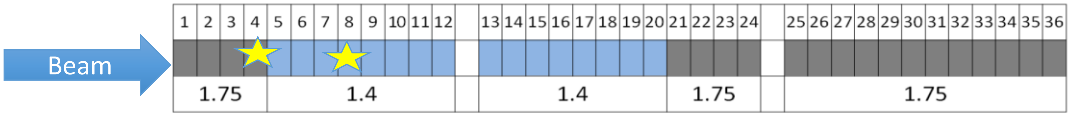
Possible reducing either by reducing ppb intensity or not injecting last train

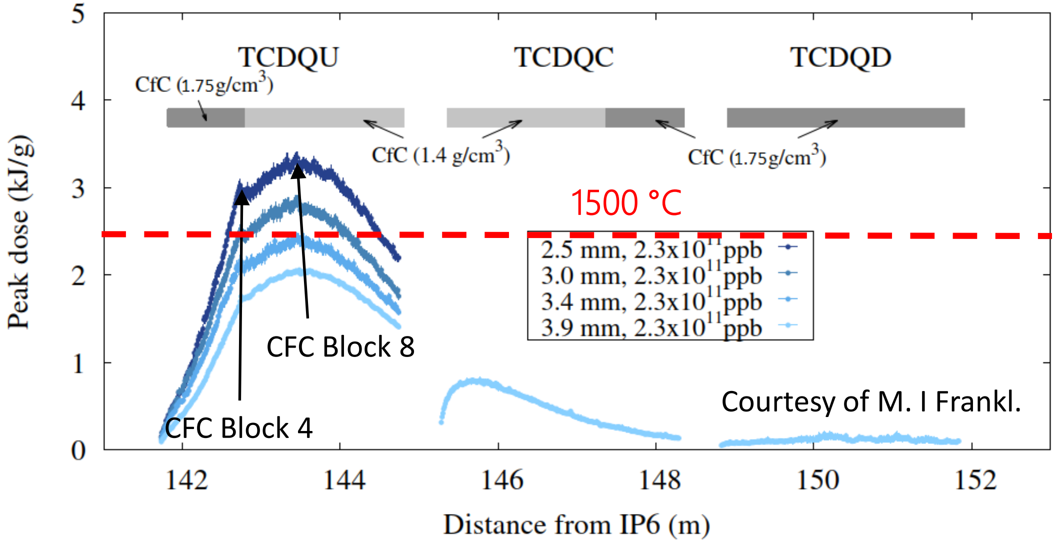


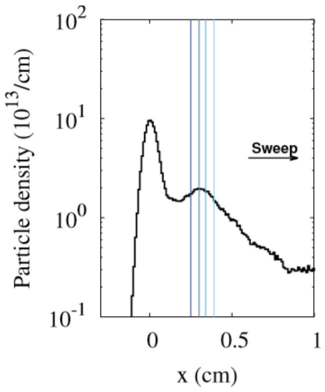


Courtesy of V. Rizzoglio

TCDQ Energy Deposition







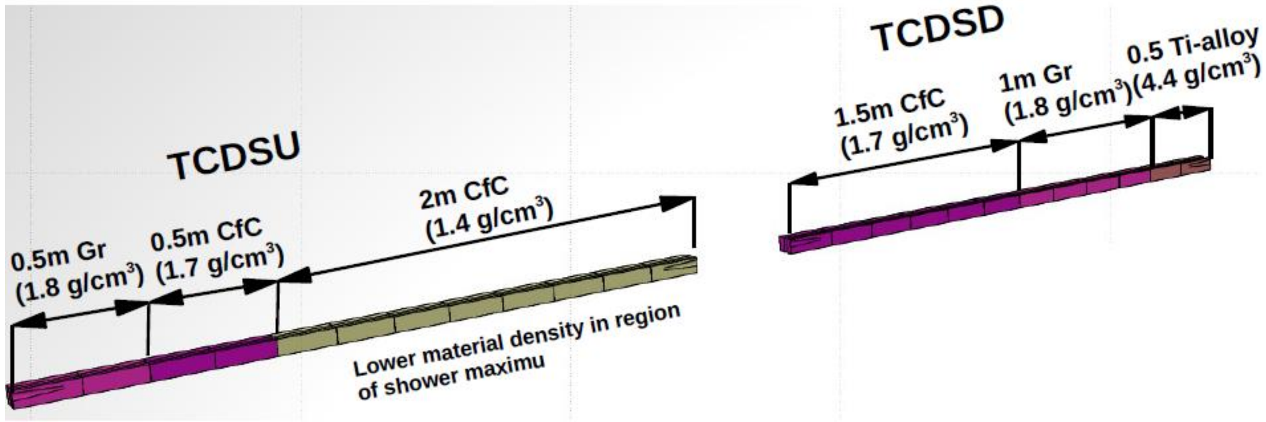
Present Run 3 optics foresees a gap of 3.5 mm (1mm to subtract for tolerances → down to 2.5 mm) so intensity ppb should stay ≤ 1.8E11

	1.4×10^{11}	1.7×10^{11}	2.0×10^{11}	2.3×10^{11}
2.5 mm	2.0 kJ/g (1300°C)	2.4 kJ/g (1500°C)	2.8 kJ/g (1700°C)	3.3 kJ/g (1900°C)
3.0 mm	1.7 kJ/g (1100°C)	2.0 kJ/g (1300°C)	2.4 kJ/g (1500°C)	2.7 kJ/g (1600°C)
3.4 mm	1.5 kJ/g (1000°C)	1.8 kJ/g (1200°C)	2.1 kJ/g (1300°C)	2.4 kJ/g (1500°C)
3.9 mm	1.3 kJ/g (900°C)	1.5 kJ/g (1000°C)	1.8 kJ/g (1200°C)	2.1 kJ/g (1300°C)

Table 2. Peak doses as function of the gap and beam intensity

- The TCDQ energy deposition depends on the gap.
- From the mechanical point of view, the 4th and 8th blocks (high and low density CFC blocks, respectively) are the most affected.
- Material characterization only up to 1500 °C

TCDS



Plastic deformation of Ti block expected for ≥ 1.7E11 ppb (upgrade in HL-LHC baseline, not before LS3)

Proceedings of EPAC 2006, Edinburgh, Scotland TUPLS012

DYNAMIC STRESSES IN THE LHC TCDS DILUTER FROM 7 TEV BEAM LOADING

B.Goddard, A.Presland, W.Weterings, CERN, Geneva, Switzerland.
L.Massidda, CRS4, Sardina, Italy.

DILUTER OPTIMISATION

The results and method were used to optimise the TCDS design. All the highly stressed graphite blocks were replaced with high density C-C, which has much better mechanical properties. An additional C-C block was placed in front of the two Ti blocks, and the final steel block was dropped altogether. The performance of the new configuration was calculated using the same method, and also checked concerning the protection of the MSD septum. The comparison in the maximum stress ratios for the old and new configurations is shown in Fig. 8. All the graphite and C-C blocks are now below the design limit of 1.0 – however, the first Ti block (23) still has a stress ratio of about 1.5. This means that the material may exhibit plastic deformation for the impact of beam intensities above LHC nominal (1.15×10^{11} p+ per bunch); however, the resulting mechanical deformation will remain below the ±0.05 mm level, and can be tolerated for a few such failures.

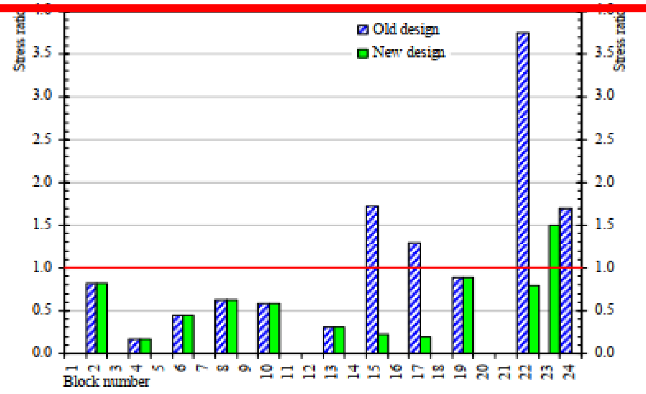


Figure 8. Comparison of maximum stress ratios between old and new designs.

Courtesy of F.X. Nuiry

Safe ppb Intensity at Top Energy?

- EN-STI has to provide final numbers for dump core (LMC action), present known limit: 1.4E11 ppb (to be confirmed/ updated)

- TCDQ:
  - No limitation in minimum gap if ≤1.8E11 ppb
  - No limitation in intensity if gap > 3.5 mm (including tolerances, i.e. 4.5 mm settings)

- TCDS: Ti plastification for ≥1.7E11 ppb but acceptable deformation since very far from circulating beam (ok with 1.8E11 ppb)

Steering during Fills

- Before LS2: 12 bunches to be injected after any steering ➔ fills delayed by steering procedure.
- Recommended procedure is still steering with 12 bunches (two trains to be foreseen in each filling scheme)
- New FGC implemented in all TI2 and TI8 PC during LS2 ➔ transactional behavior fixed (to be tested) ➔ consider option of allowing steering with trains IF AND ONLY IF inside FEI tolerances.
- 12 bunches mandatory if FEI limits have to be re-centered
- Interlock on LHC injection oscillations preventing injecting more than 12 bunches if above thresholds stays (required to insure that tolerances for apertures are respected)
- Studies being performed to calculate/apply required steering before starting the fill:
  - Measure SPS orbit for LHC beam during ramp down
  - Extrapolate position and angle of beam at extraction point
  - Compute and apply required corrections
  - Test with 12 bunches ➔ ideally only one train needed if it works

Conclusions

- Need to limit ppb intensity and not only total number of bunches when operating at high energy
- A software interlock on bunch population as a function of the beam energy could be envisaged
- If transactional behavior for PC of all correctors fixed ➔ possible do steering during fill if corrections within FEI limits
- 12 bunches always required if above injection oscillations limits
- Possibility of pre-correcting trajectories based on measured SPS orbit is being studied