Status Update: Beam Dump Constraints on HL-LHC Optics

31st HL-LHC TC Meeting, 19th November 2015

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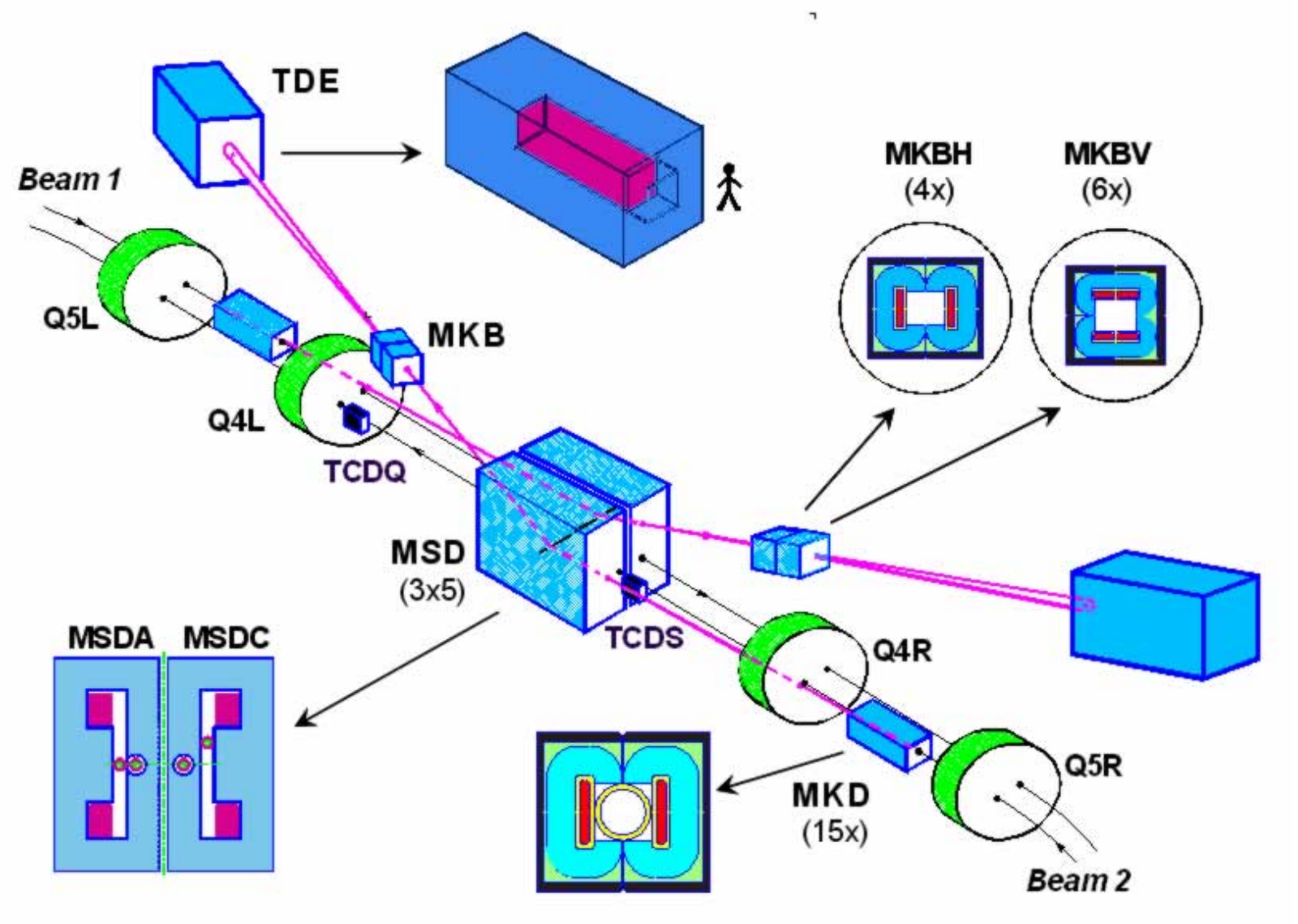
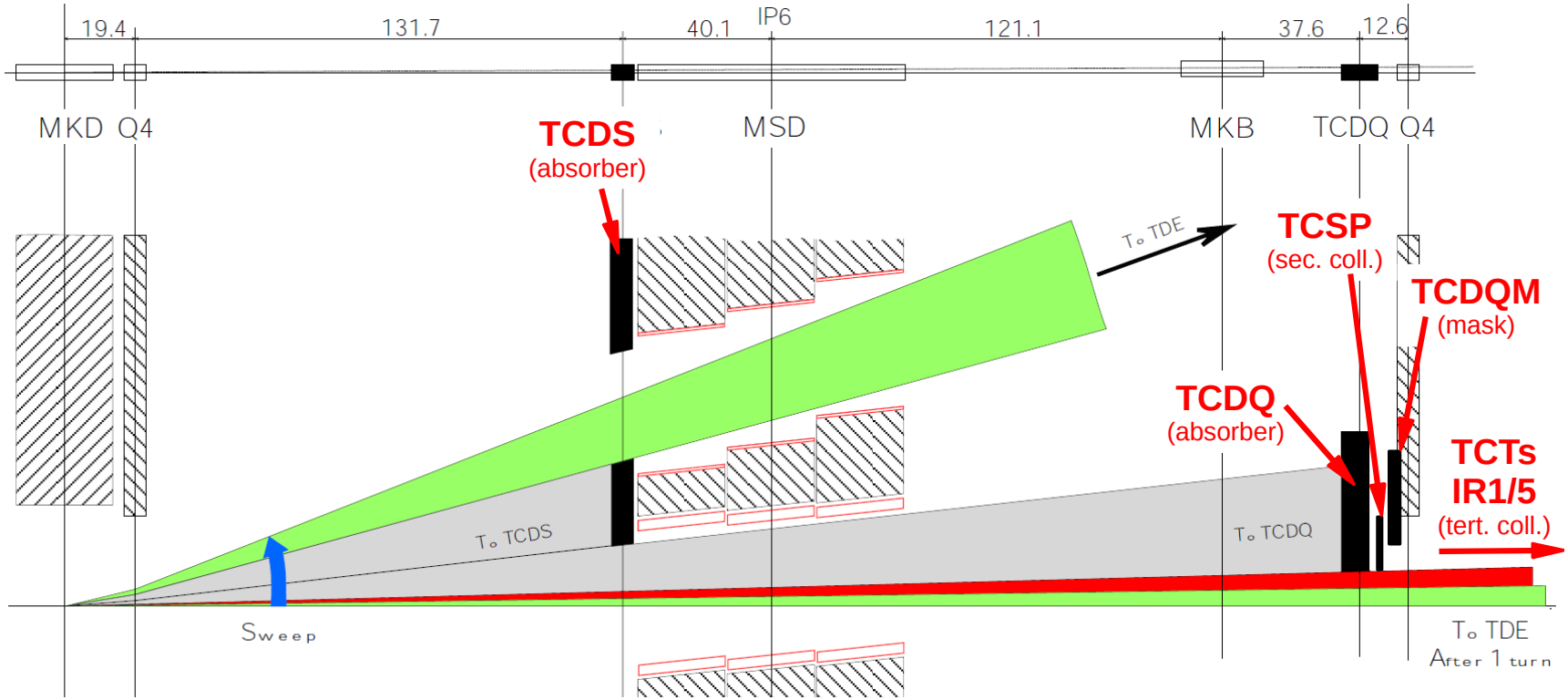
LBDS Overview



LBDS Protection Devices



Status Update (1)

- Initial studies have been made for Run 2 and BCMS:
  - A. Lechner, *Update on machine limitations for the BCMS* beam at the LMC on 15th July 2015:

Beam	$\epsilon^n_{x,y}$	I_b
LHC ultimate	3.5 μm·rad	1.7×10^{11}
Std 25 nsec Run 2	2.6 μm·rad	1.2×10^{11}
BCMS Run 2	1.37 μm·rad	1.3×10^{11}

2 × brightness

similar brightness

- HL-LHC FLUKA and ANSYS analysis not yet carried out and limited conclusions can be made today.

Status Update (2)

- Our strategy for the upcoming studies:
  - We don't have the resources to make a large number of parametric studies with FLUKA/ANSYS to understand all limits/behaviours of each protection device.
  - Propose to study the worst case beam size at each location for ***HL-LHC v1.2*** optics:
    - TDE, TCDQ, TCDS and at MKDs (with R. Bruce) for the TCTs.
  - Results to be discussed as they are analysed next year, which will guide our strategy.
  - We aim to make firm conclusions on the IR6 optics by end of June. At this point we should conclude if elements need to be replaced or if we would require additional elements, e.g. extra mask on Q5.

Status Update (3)

- We are now considering a Type 2 erratic event:
  - An erratic firing of a single MKD in which the current is not conducted by the switch but finds another path to flow through the kicker.
  - Rise-time is very quick for this MKD, moving the beam close to and onto the TCDQ before the re-triggering of the other MKDs extracts the beam.
  - Never occurred with beam, observed in the machine during HV conditioning reliability runs.
  - Discussion on-going within ABT: this failure mode not included in initial LHC studies. Mitigation options to improve the situation are being studied, but failure mode cannot be excluded.

TDE (+ window) Remarks

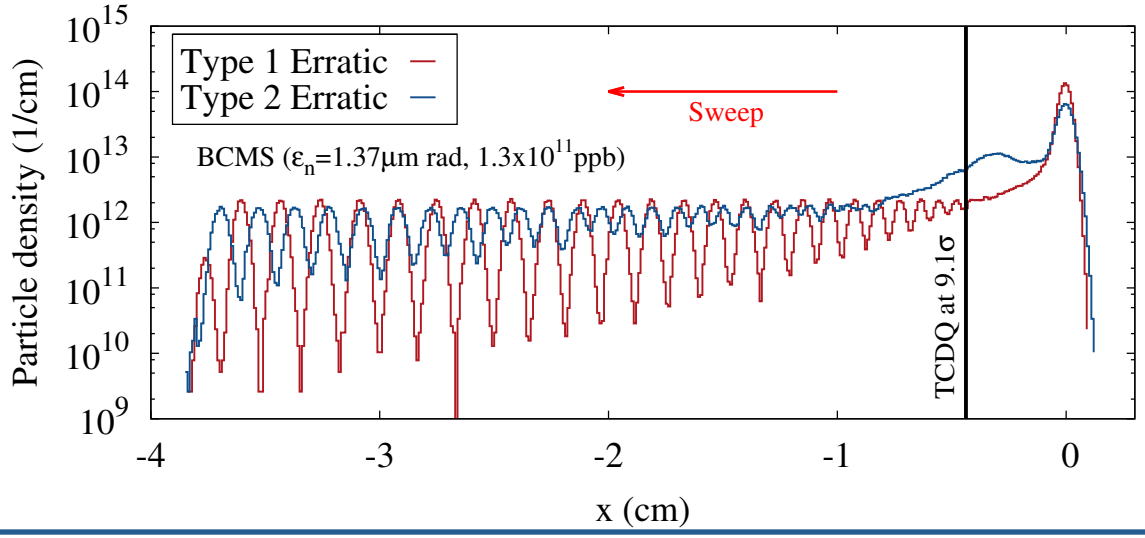
- From Run 2 (BCMS emittance) studies we learnt that we are rather more sensitive to intensity than emittance at 7 TeV.
- Beam sizes on TDE linked directly to beam size on TCDS, TCDQ: without optics in dump line we are coupled.
- Sweep speed is slowest in vertical direction as it turns to come back down the face of the dump:
  - Dilution failure scenarios become more critical: presently consider 2H and 2V failures for Run 2, need to consider if this is satisfactory for HL-LHC.

TCDS Remarks

- This device, as installed, does not and will not move with the squeeze.
- Main issues are vertical beam size (horizontal sweep) and overall beam intensity in the case of an asynchronous event.
- We seem independent to the type of MKD erratic (Type 1 or Type 2): the sweep speed is already quite high at this amplitude as re-triggering has already happened whilst the beam is on the edge of the TCDQ.

TCDQ Remarks

- Main issues are MKD re-triggering time, vertical beam size and of course, overall beam intensity in the case of an async. dump.
- In principle, the TCDQ could move with the squeeze but:
  - BETS interlock and controls will need revising and upgrading.
  - Intensity intercepted by the TCDQ goes exponentially with the absolute distance of the TCDQ from the circulating beam.
  - This may enter as another optics constraint: beta_x at TCDQ
  - OK for Run 2 BCMS (TCDQ at 9.1σ): could be critical for HL-LHC.



Optics Constraints

- Q4 gradient is fixed (we mentioned 1% differences in the past).
- Horizontal phase advance between MKD and TCDQ: close to 90 degrees.
- MKD (status: OK today):
  - Beta_y: aperture constraint at injection.
  - Beta_x and its variation along the 15 tanks: issue for TCTs.
- TCDQ (status: unknown):
  - Beta_y: horizontal sweep imposes more constraint
  - Beta_x: constraint to keep TCDQ away from beam for ATS
- TCDS (status: unknown):
  - Beta_y: horizontal sweep imposes more constraint
- TDE (status: unknown):
  - Coupled to the above constraints, limiting the above.
- Other flexibility: could win by permitting more dispersion but we need to consider the consequences before giving a specification.

Summary

- Studies to move forward with **v1.2** optics based on worst-case betas at each protection device.
- Limits for protection devices for HL-LHC are not known: FLUKA/ANSYS studies are ongoing.
- Depending on results, analysis and discussion of mitigation scenarios, we will present conclusions before end of June next year.
- Presently only the replacement of the TCDS is in the WP14 baseline. Replacement of any other element (or in the worst case the addition of dilution kickers) are not presently foreseen and are not part of the budget.