Beam position interlocks

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From discussions with
B. Goddard, J. Uythoven, R. Jones, R. Schmidt and others

- Beam dump aperture.
- Orbit @ TCDQ.
- Fast failures.

General remarks

From Chamonix (and even before…) → seems clear that we need to interlock the beam position in the dump area.

But we should remember that for operation :

- Orbit/injection oscillations at injection may be quite bad before adjustments :

  We should not have to mask the interlocks too often in order to get the first pilot beam in !!!
- Injection oscillations of 2σ amplitude (some 50-100 turns) and tune measurements should not lead to a dump.

Beam dump aperture interlock

Summary of the discussions on position interlocks

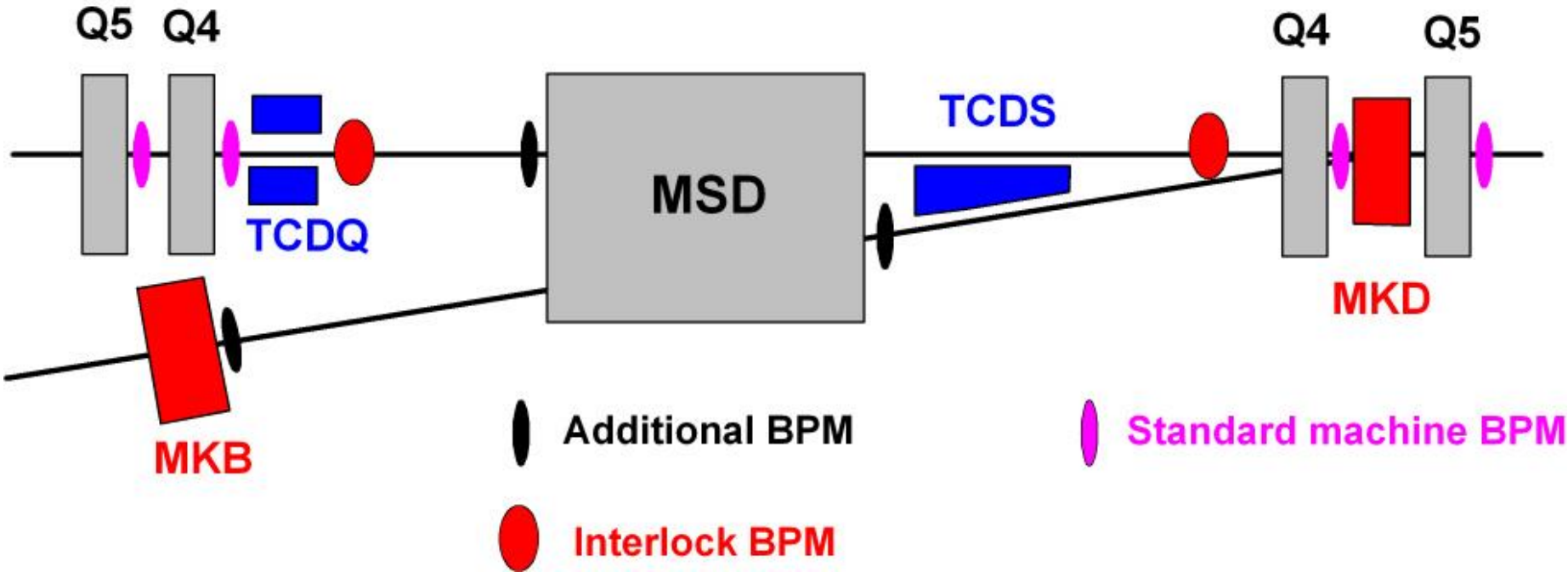
Required interlock level : 4 mm @ Q4 in IR6

Layout & architecture (details to be evaluated) :

- Redundant system of BPMs on the IP side of the Q4s
  → 4 new BPMs / beam.
- Some form of redundancy on the electronics (crates).
- Interlock signal → local BICs.
- Bunch by bunch system seen as simpler :
  auto-trigger – no timing.

BPM layouts

Sketch of the BPM layout in IR6 / one beam.



Thresholds

Thresholds & response : based on D1 failure

- D1 failure → ~60 μm/turn @ TCDQ (V. Kain).
- Response time : 1 turn (detection) + 2 turns (delay, synchro…).
  - 200 μm movement between detection and dump.
  - 200 μm single bunch (pilot) resolution.
  - interlock threshold of 3.6 mm → 4 mm effective threshold.

Other points…

- Position offsets must be introduced…
- False trigger rate has to be evaluated ….

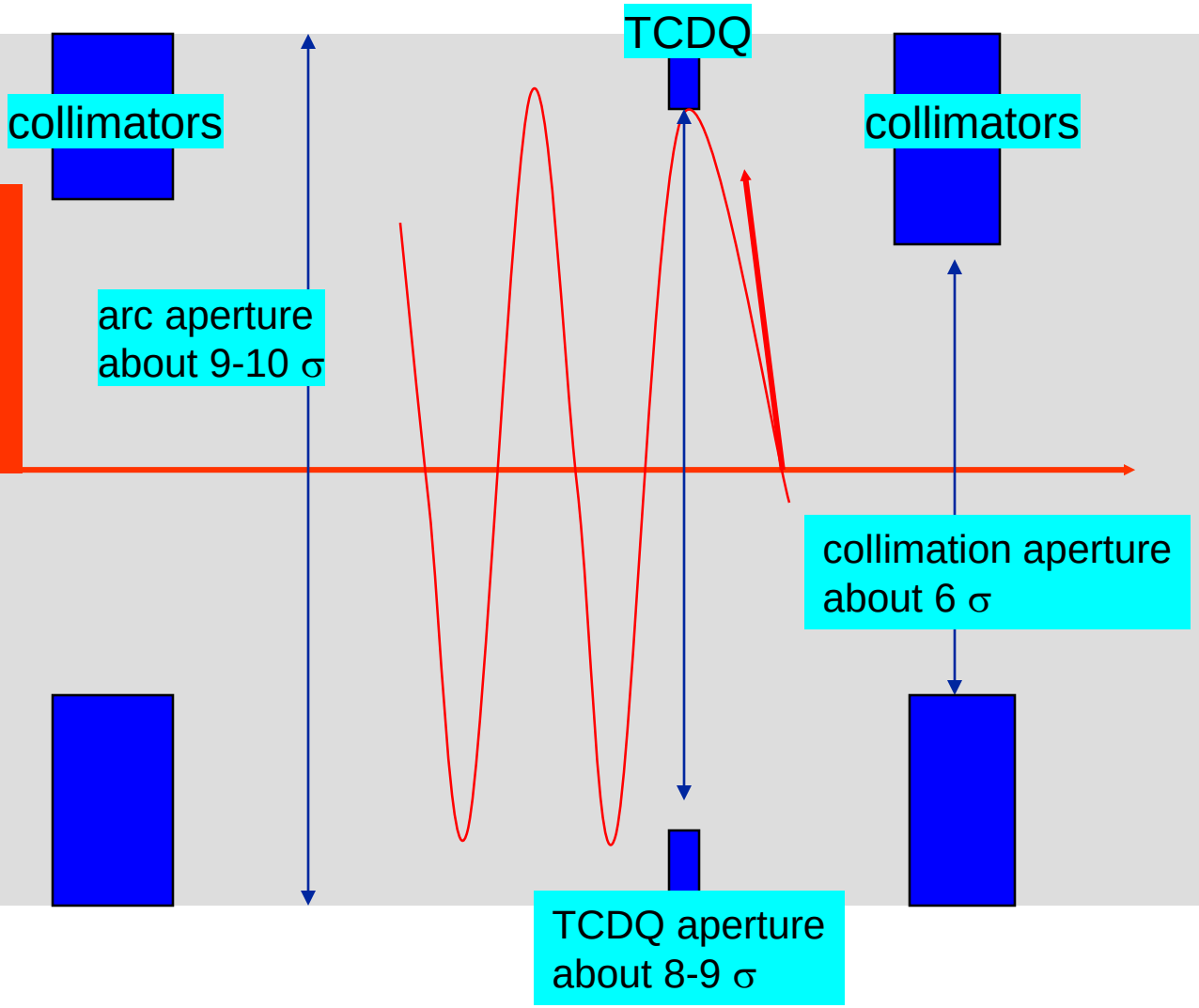
Overall impression : feasible !

Orbit @ TCDQ

@ Injection…

We must protect the arcs against asynchronous beam dumps :
ARCs must be in the shadow of the TCDQ !

TCDQ must sit below 10 σ !



Orbit tolerance @ TCDQ / Injection

- Beam size @ the TCDQ : σ = 2.2 mm.
- Dump aperture interlock → dump @ ~ 2 σ.
- With a CO shift of 2σ + asynchronous dump :

  some bunches reach amplitudes of ~ TCDQ aperture + 2σ

  → TCDQ aperture should be at least 2σ smaller than arc aperture to avoid requiring a tighter position intlk.

- For a 2σ orbit shift :

  TCDQ may become secondary (or even primary) collimator !

  → dump via BLM rates before reaching BPM interlock level ?

Orbit @ TCDQ / ramp & squeeze

At end of the ramp – before squeeze :

- Dump aperture interlock → dump @ ~ 8 σ (4 mm)
  Since optics is not changed (except for errors)
- Might be good to reduce the TCDQ aperture to **~ 25σ at end of the ramp.**

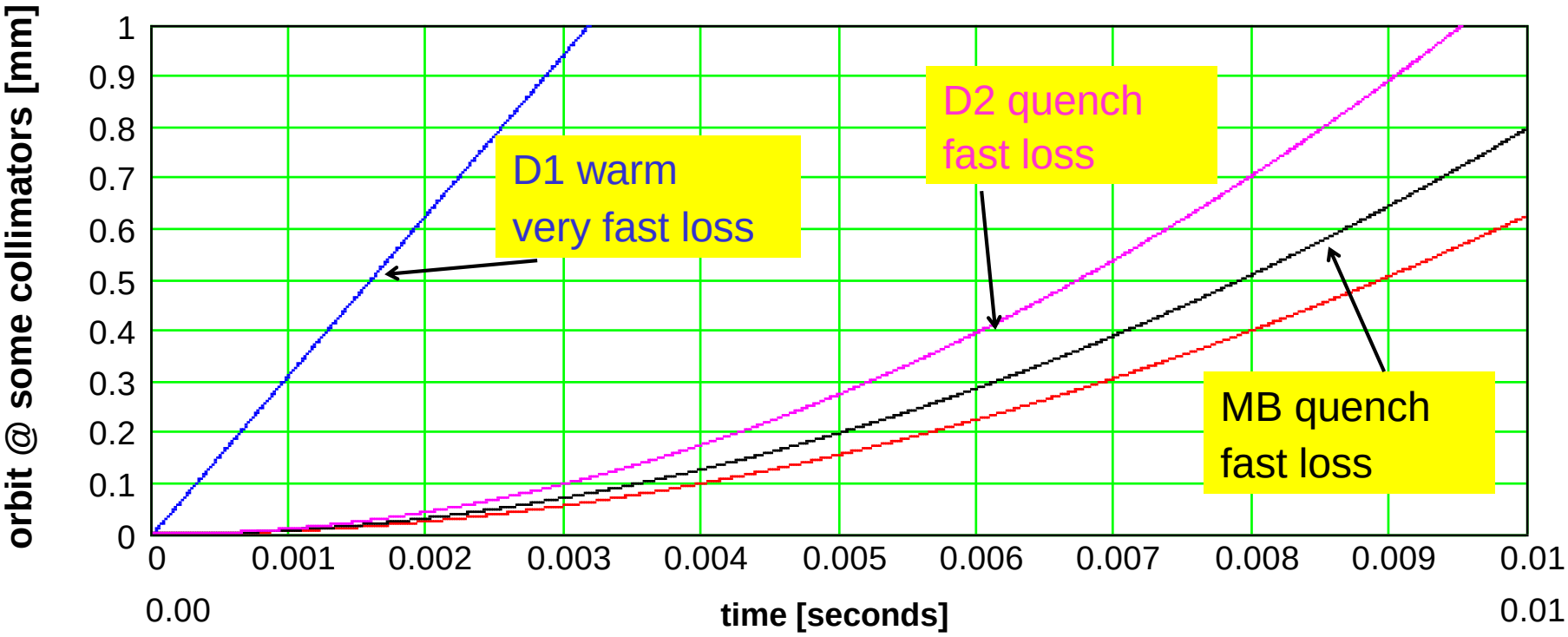
After squeeze (see Rudiger's presentations) :

- If the interlock level is kept constant at 4 mm / 8 σ :
  → The triplets must be protected by absorbers.
- Without triplet protection :
  → Tighter interlock threshold : 2 mm ? Less ?

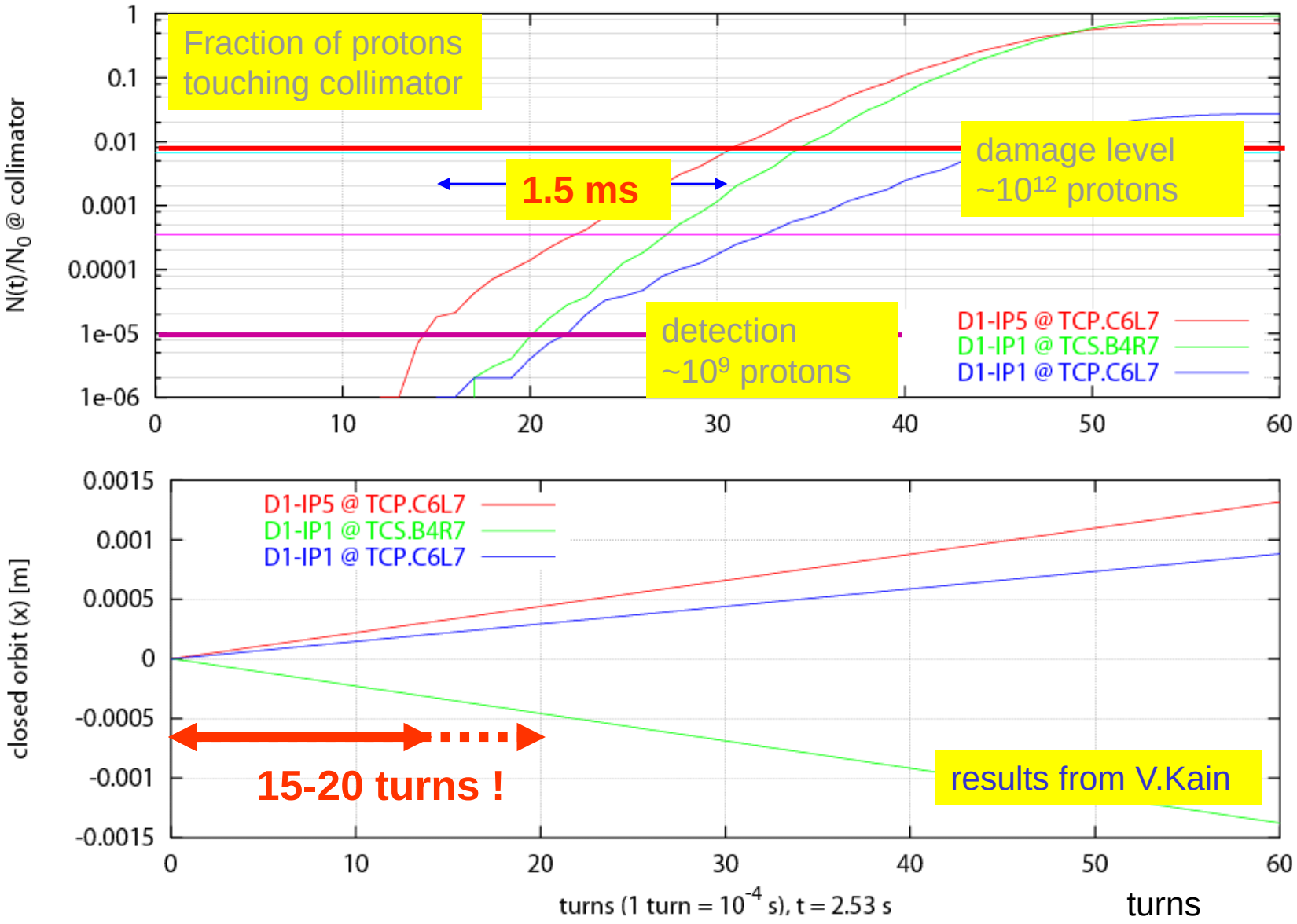
Fast failures I

CO movements from fast failures (LHC V6.4) :

- D1 with squeezed beams : ~ 600 μm / 10 turns @ TCDQ
- D2 quench/ MB quench : ~ factor 2 smaller slope after 5-6 ms



BPMs can start measuring /integrating at an early time !!



Fast failure thresholds

D1 failure – for squeezed beams (~ steady state) :

Threshold :

→ ~ 900-1200 μm in 15-20 turns @ TCDQ !

→ 500 μm in 15-20 turns with safety factor for optics changes..

Failure of D1+solenoid, MB quench... :

Threshold :

→~ 900-1200 μm in 60-80 turns @ TCDQ !

→ 500 μm in 60-80 turns with safety factor for optics changes..

But the later can happen any time in the cycle !!

Interlock summary

- **Beam dump aperture** :
  - Position interlock at 4 mm ~ OK, fast failures are covered.

- **Protection by the TCDQ :**
  - At injection : compatible with the same interlock settings if TCDQ aperture is at least ~2σ tighter than machine aperture. Compromise between TCDQ aperture and interlock threshold.

  - Squeezed beams : triplet protection and/or tighter thresholds (by a factor 2 or so).

- **Fast failures :**
  - Interlock threshold: 0.5-1 mm / 15-20 turns (β ~ 500-600 m).
  - Feasible ? Within the same interlock system ?

- SPS measurements over 26 →450 GeV cycle as test-bed ?