

LHC Injection and Dump Protection

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LHC Beam Commissioning Workshop

Evian, 19-20 Jan 2010

Commissioning Plan: Injection Protection

- Calibration of BLMs
- Centering/beam size of TCDIs and setting to 4.5σ
- Check phase space coverage
- Check local MSI protection
- TDI/TCLI centering/beam size and setting to $\sim 7 \sigma$
- TDI/TCLI check against MKI failure

TCDI set-up

transfer line collimation

- Centering OK for TI2 and TI8 TCDIs
- Beam size: measured only for TCDIs upstream the TED, i.e. 2/6 per TL

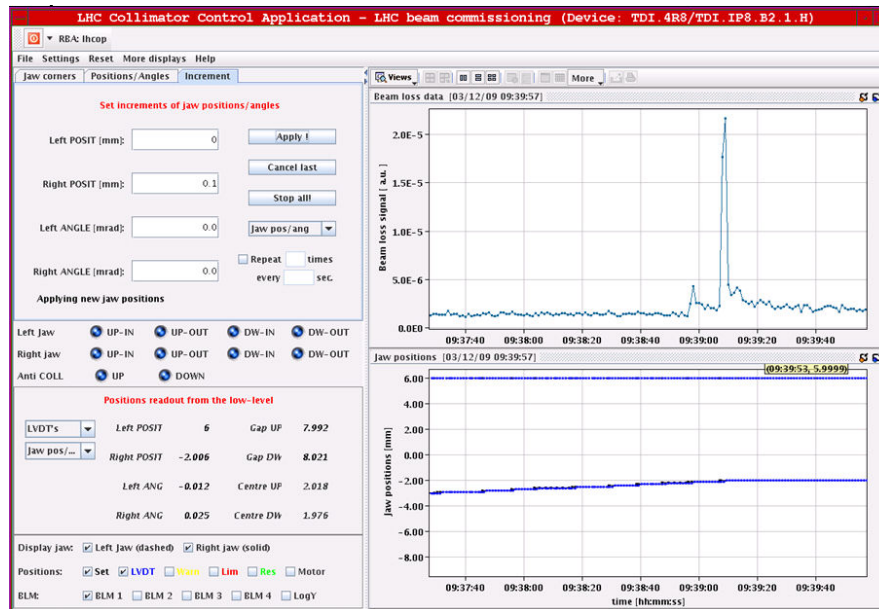
Problems:

- normalization to intensity difficult because of poor BCT resolution in TL
- saturation of BLMs with fastest integration time scale
- crosstalk between BLMs
- Set TCDIs to 4.5σ : DONE for all TCDIs, but theoretical σ taken
- Check phase space coverage: NOT done
- Check local MSI protection: NOT done

TDI and TCL set-up (I)

vertical passive injection protection system

- Set-up no major problem:
 - Beam edge defined at 5.7σ by collimation system
 - few mm jaw asymmetry to understand for B2, beam well centered on adjacent BTVs
 - TDI already protected LHC from overinjection or missing injection kick.
 - Beam size at TDI **NOT measured**



upper jaw: +6 mm

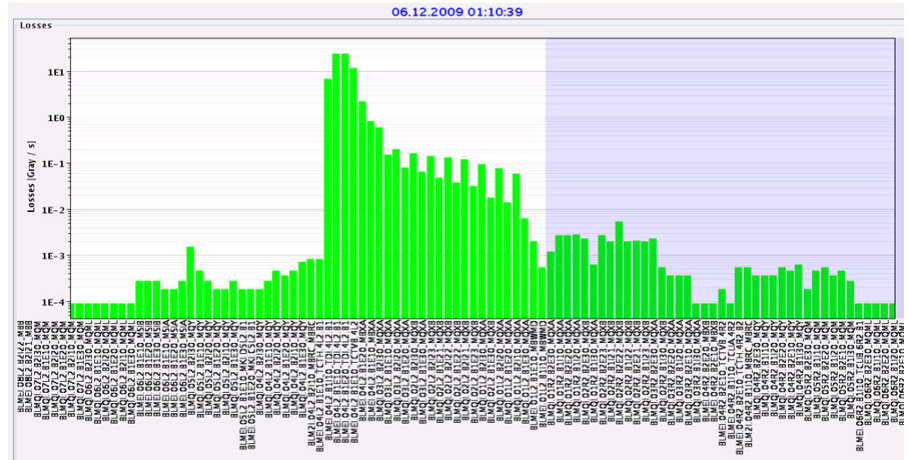
lower jaw: -2 mm

TDI and TCL set-up (II)

- Losses and scraping studied, also with Beam Condition Monitors from LHCb and ALICE

Problem:

- overinjection – now works for B1 but not B2 (losses on MQXA (Q3) R8 which triggers BLMs)

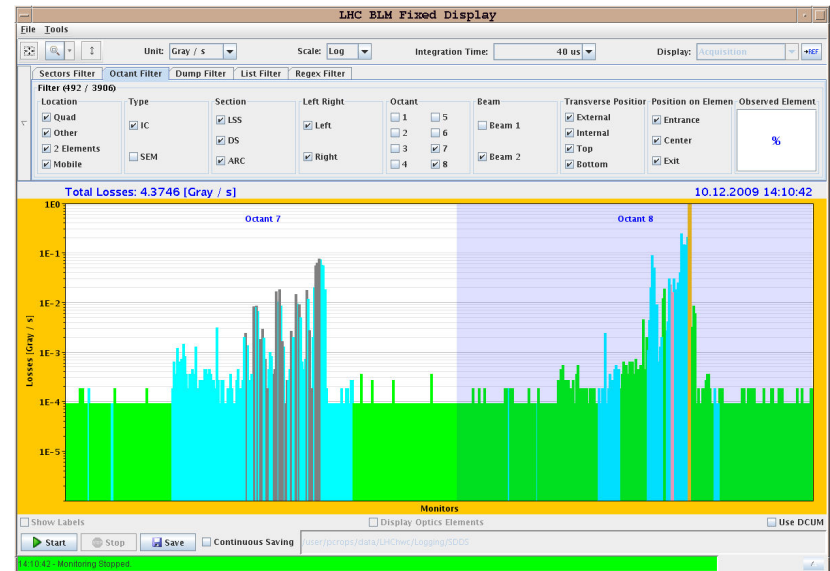
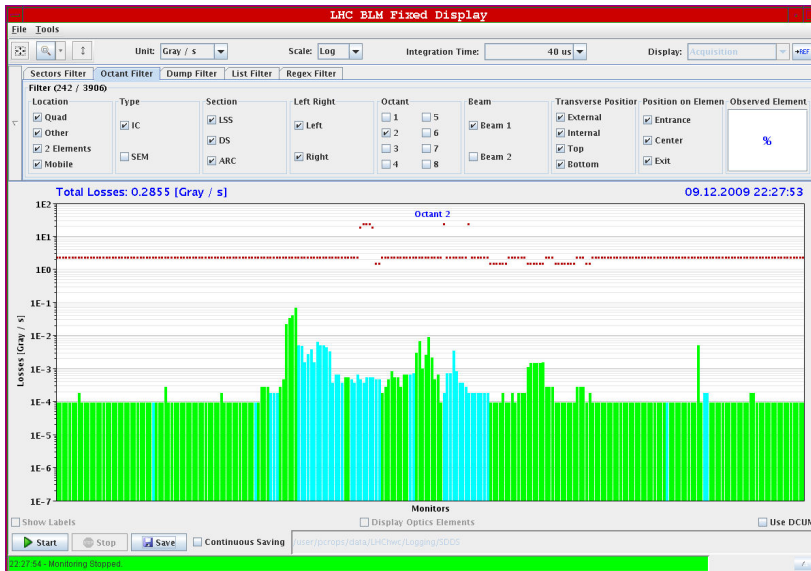


Injection of 1 pilot bunch with TCDIs..

... at nominal 4.5σ settings with losses from tails (no SPS scraper):

Beam 1

Beam 2

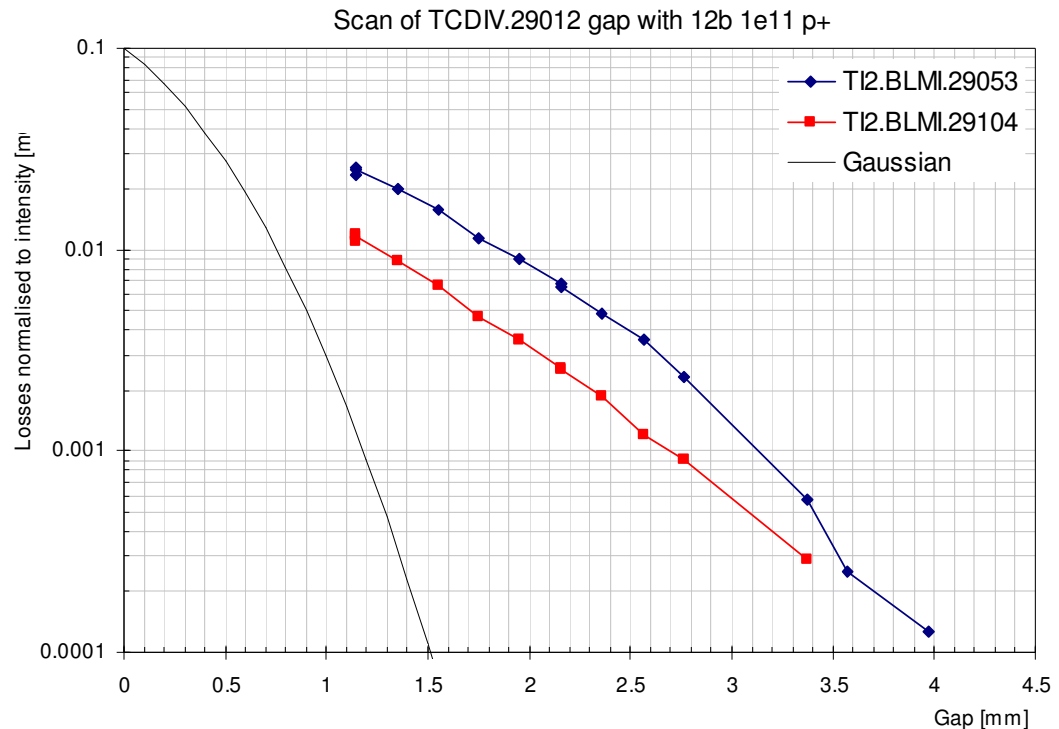


Already close to BLM interlock limit for 40 μ s integration time!

Tail Scan with TCDIs

- Tail Scan in TI2
- Intensity: 1.2×10^{11}
- Jaws set around derived beam centre
- Jaw opening increased in steps
- Very significant exponential beam tails...

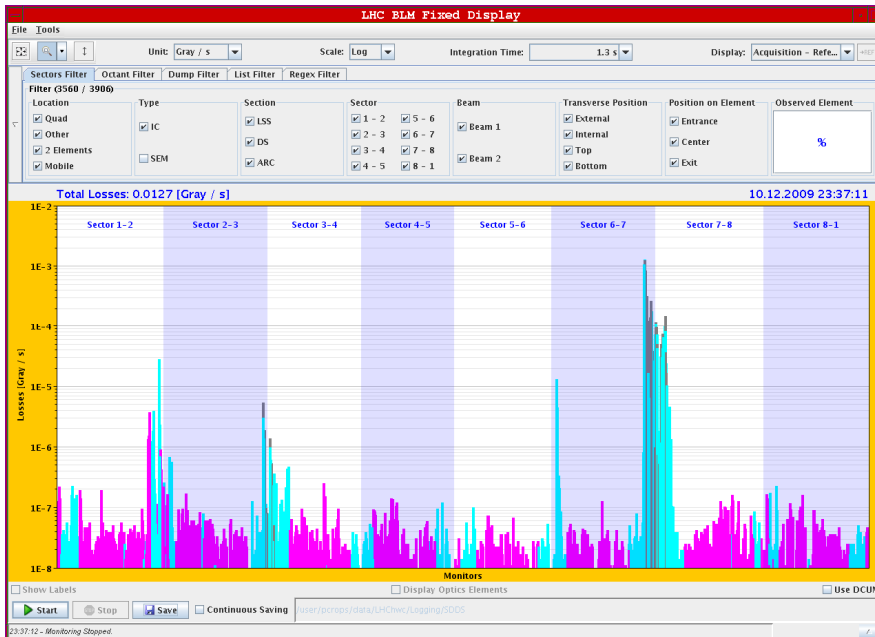
➔ Scraping necessary?!?



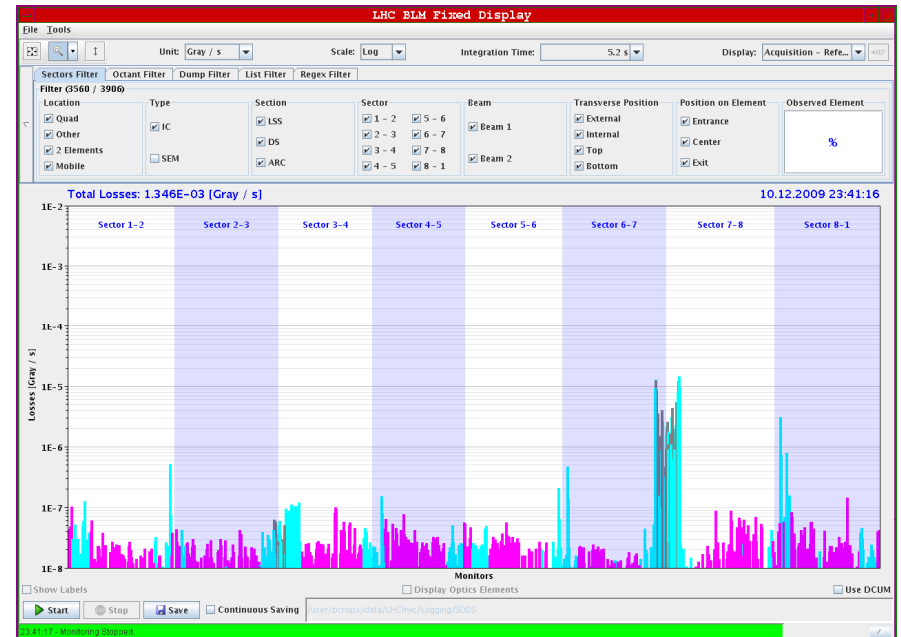
Injection with higher intensity

- 2e10 protons, with SPS scraping, 6 σ horizontal and 4.5 σ vertical collimator settings
 - ➔ very clean for B2
 - ➔ B1 has larger losses

Beam 1



Beam 2



Commissioning Plan: **Dump Protection**

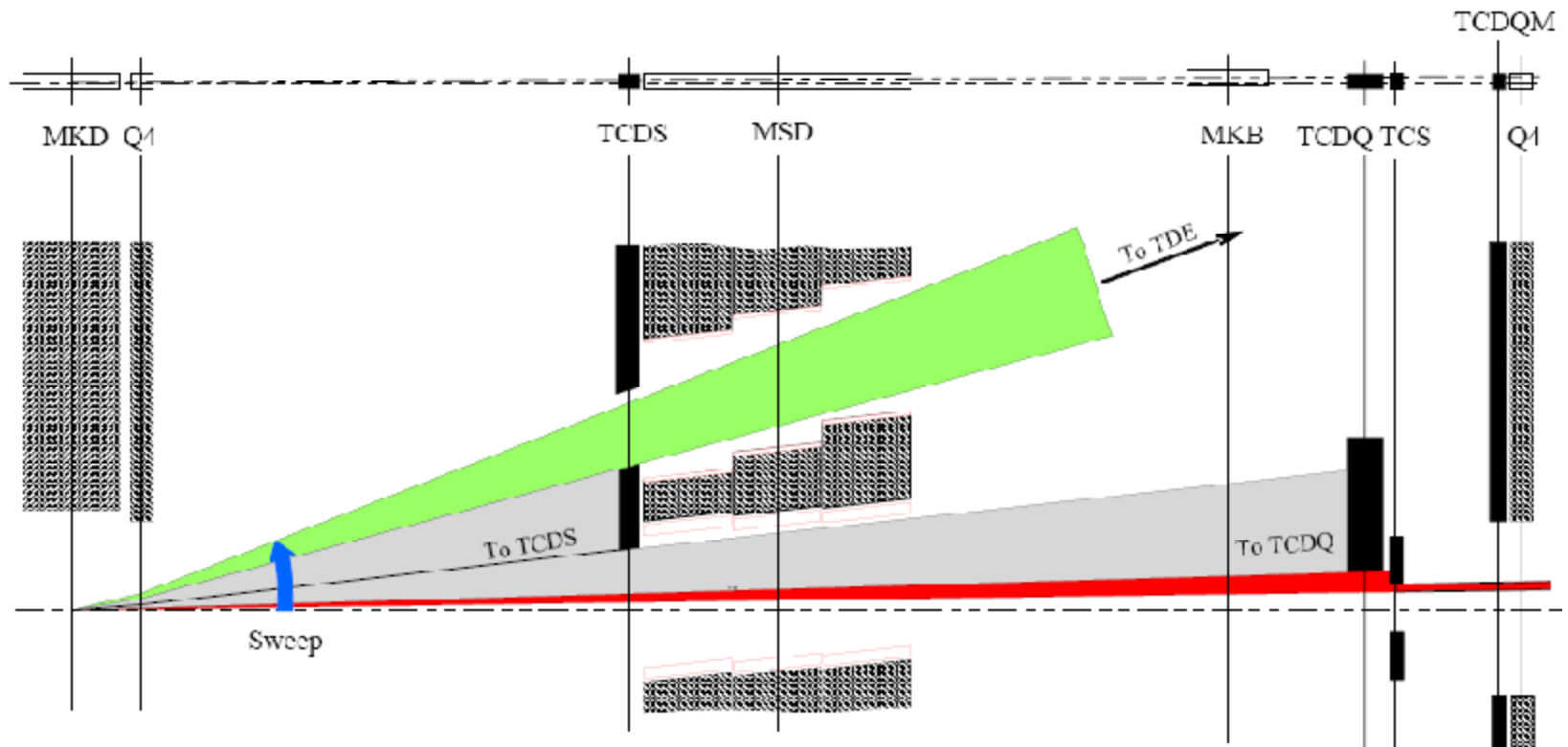
- Correct orbit in point 6
- TCDQ – check SW interlock on beam position wrt TCDQ position
- Set up TCDQ/TCS jaws
- Check of TCDQ protection
- Calibration of beam loss signal and protons lost at TCDQ
- Aperture in P6

TCDQ/TCSG (I)

protects Q4 and downstream elements

...in case of asynchronous beam dump or asynch. firing of MKD kickers where part of beam is not absorbed by TCDS

- TCDS (fixed) – 6 m long diluter protects extraction septum
- TCDQ/TCS (mobile) – 7 m long diluter kept at about 7-8 σ from the beam, at all times

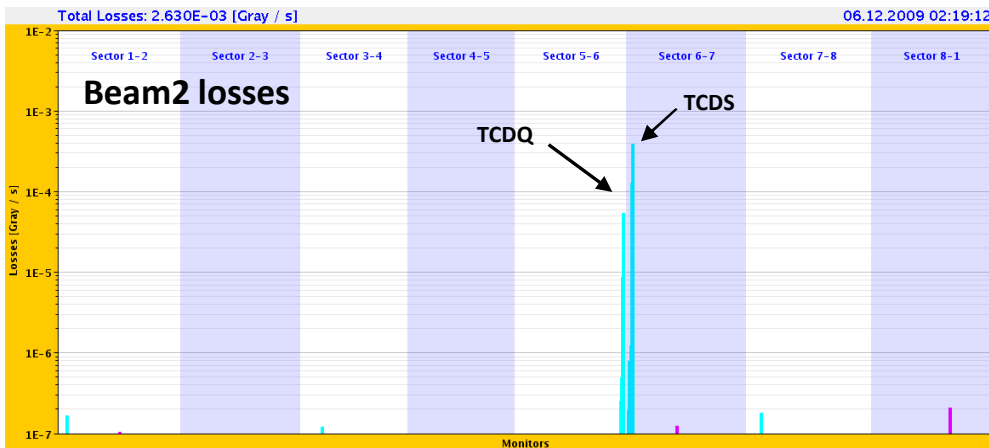
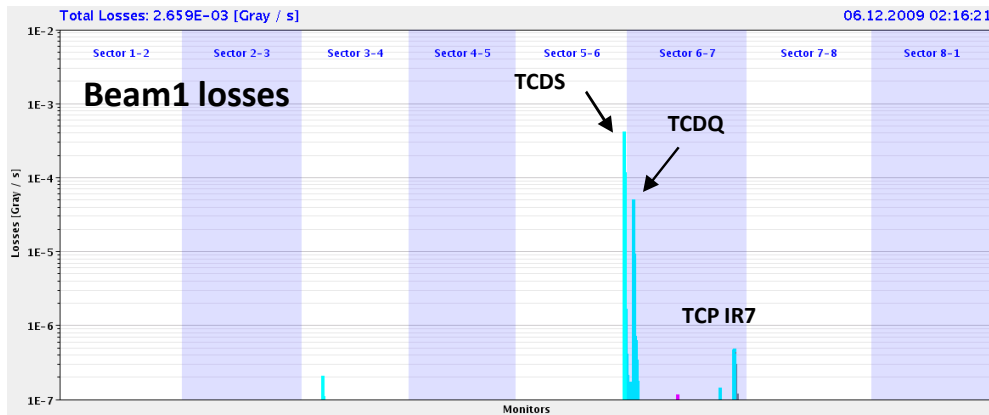


TCDQ/TCSG set-up (II)

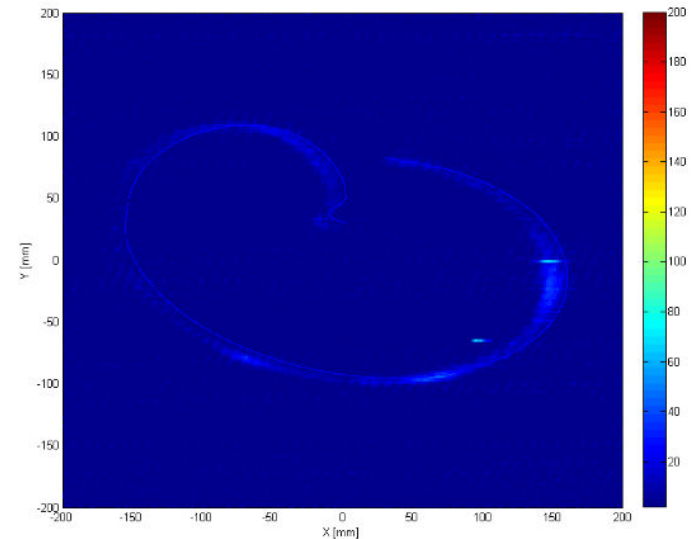
- Centering of TCSG and TCDQ:
 - DONE
 - Problems:
 - movement sense inversion for B2 → solved (Mechanical inversion in tank)
 - setting resolution of 0.1 mm, but change of 0.11 mm in setting was necessary?
 - position reading problem → solved by mechanical fix to reduce the friction of the spring on LVDT
 - change to potentiometer to avoid transducer problems → being considered
- Beam size and jaw tilts: NOT measured
- Set to nominal protect settings: DONE (theor. σ retraction)
- Relative setting of TCDQ to TCSG: DONE

TCDQ/TCSG set-up (III)

- Check of TCDQ protection (dump of debunched beam):
 - Losses concentrated on dump protection devices, with 0.1% on collimators



Asynchronous dump tests:
4 bunches, B2



Sweep shape on BTVDD as
expected

How far did we get...

Injection Protection

- Calibration of BLMs
- Centering/**beam size** of TCDIs
- Set TCDIs to 4.5σ
- **Check phase space coverage**
- **Check local MSI protection**
- TDI/TCLI centering/**beam size** with circulating beam
- Set TDI/TCLI to $\sim 7 \sigma$
- TDI/TCLI check against MKI failure

Dump Protection

- Correct orbit in point 6
- TCDQ – check SW interlock on beam position wrt TCDQ position
- Set up TCDQ/TCS jaws
- Check of TCDQ protection
- **Calibration of beam loss signal and protons lost at TCDQ**
- Aperture in P6

Problem Summary

- TCDI set up:
 - losses in the ring already close to BLM interlock limit for pilot bunch...scraping in the SPS
 - Ratio of one pilot bunch to one nominal SPS batch: $6.4e3$

TCDIs at..	BLM: threshold/losses B1/B2		
	5e9 (B1/B2)	1.6e10	Nominal
4.5 σ hor/vert	10/20		$1 \cdot 10^{-3} / 2 \cdot 10^{-3}$
6.0 σ hor / 4.5 σ vert	30/60		$3 \cdot 10^{-3} / 6 \cdot 10^{-3}$
6.0 σ hor / 4.5 σ vert + SPS scraping		$10^3 / 10^5$	$10^{-1} / 10$

- BLM saturation and dump thresholds for fastest integration time scale – general issue for fast loss
- BLM crosstalk while set-up

Problem Summary (II)

- TDI asymmetry
 - 2mm offset in P8, to be understood, tank opening required
- TCDQ
 - reading problem → fix in shutdown
 - 7 mm misaligned for B1, being checked by experts
- Overinjection B2: losses at MQXA (P8)
 - to be solved...

3.5 TeV? Higher intensity?

- NOT ready
- Injection protection needs to be fully operational for maximum intensity of $1e12$ per injection
- Needs adequate setting-up time
- TCDQ system should be tested for different β^* squeeze steps
- TCDQ system needs to be operational for stable beam

2010 Strategy

- Refine procedure in view of what we learnt
- Need to solve the issues listed
- Get adequate commissioning time