LHC INJECTION LOSSES
AND
NEED FOR SUNGLASSES?

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MPP, 9th October 2015

Outline

- Types of injection losses
- Recap of longitudinal losses from LIBD on 29th Sept. 2015
- MKI pulse lengthening
- Transverse losses
- Doublets
- Mitigations of longitudinal losses
- Conclusions

Types of injection losses

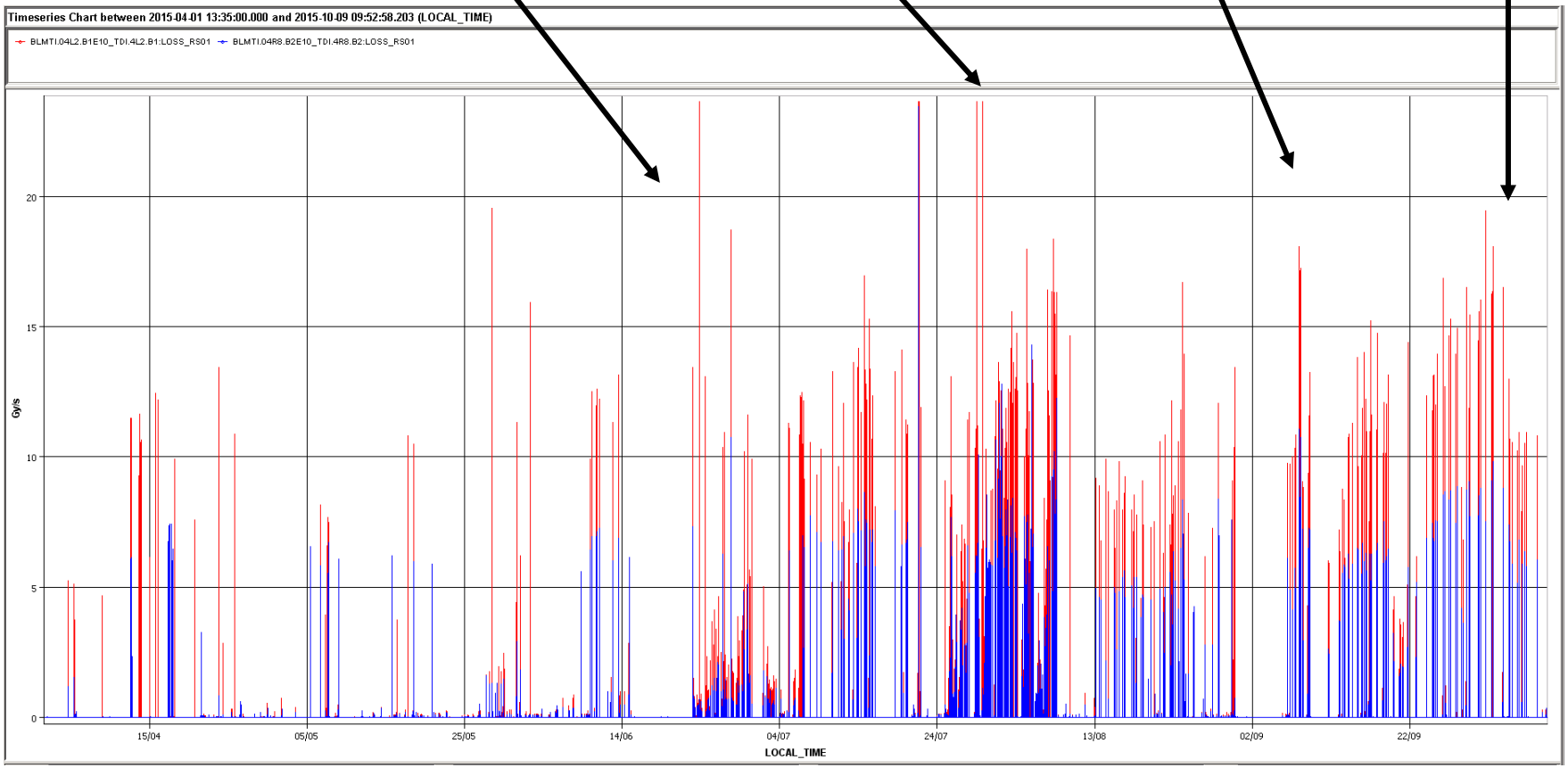
TDI losses since start of beam commissioning

- 26th June 2015
- MKI pulse length reduced for TDI
- Checked bunch train injections up to 72 bpi

Beginning of August:
Scrubbing with up to144 bpi

9th Sept-15
Injection tests

4th Oct-15
MKI pulse lengthening

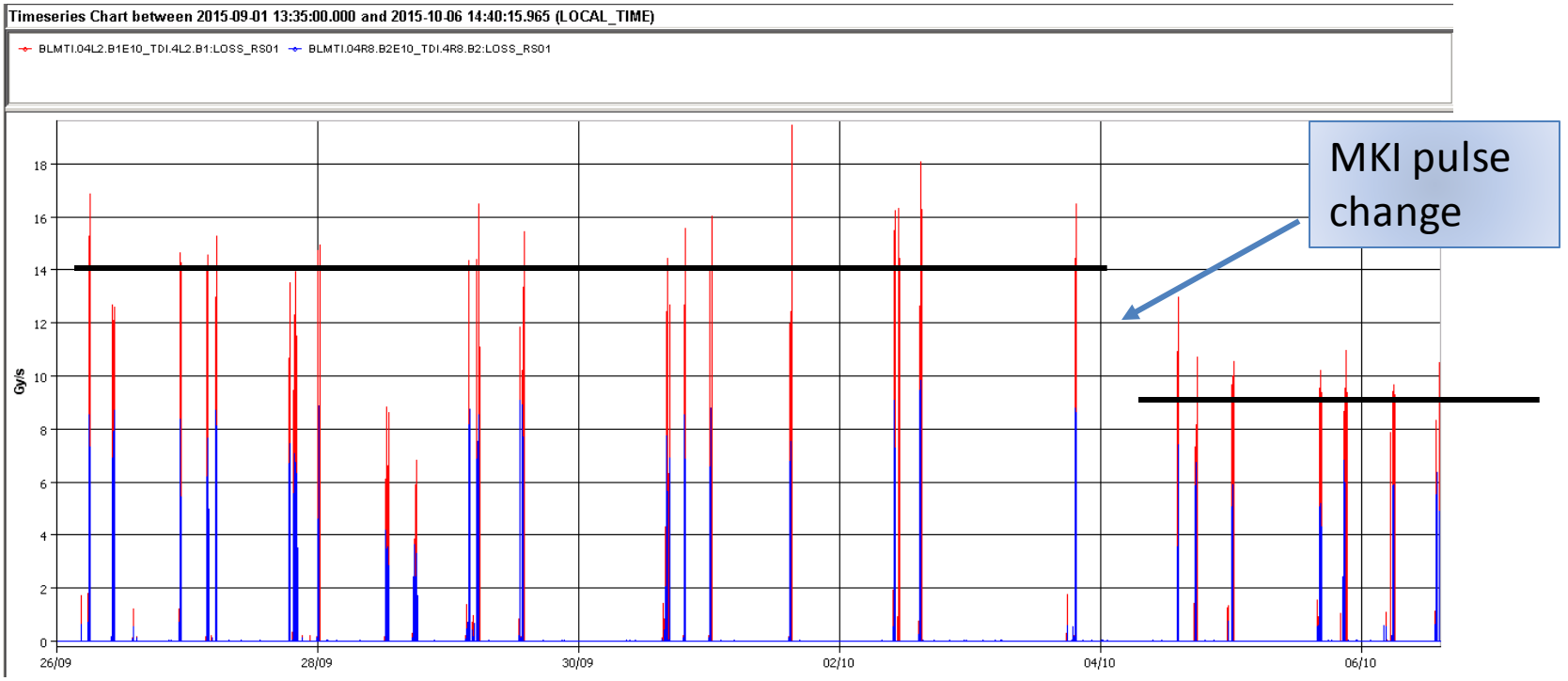


Recap on longitudinal losses from LIBD, 29th Sept. 2015

- B1 144 b injections reached 30-60% of dump threshold on the TDI
- B2 around 10 - 25%
- Factor 25 higher compared to run 1
- Reasonable operational margin should not exceed ~20%
- B1/B2 difference due to different SPS extraction kicker rise times (1 vs 7 us)
- LHC injection gap cleaning successfully setup on Sept. 9th, 2015 – reduces losses from a few percent to below a percent

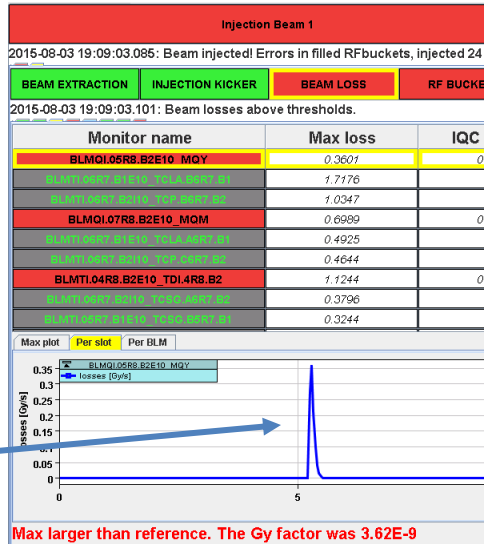
Extension of MKI pulse length

- Lengthening of MKI pulse length to allow for alternative LHC beam production types on 4th October 2015
- 100 ns longer flattop after batch end brings ~30% reduction of TDI losses for both beams (14 Gy/s → 9 Gy/s for B1 and 9 Gy/s → 4 Gy/s for B2)



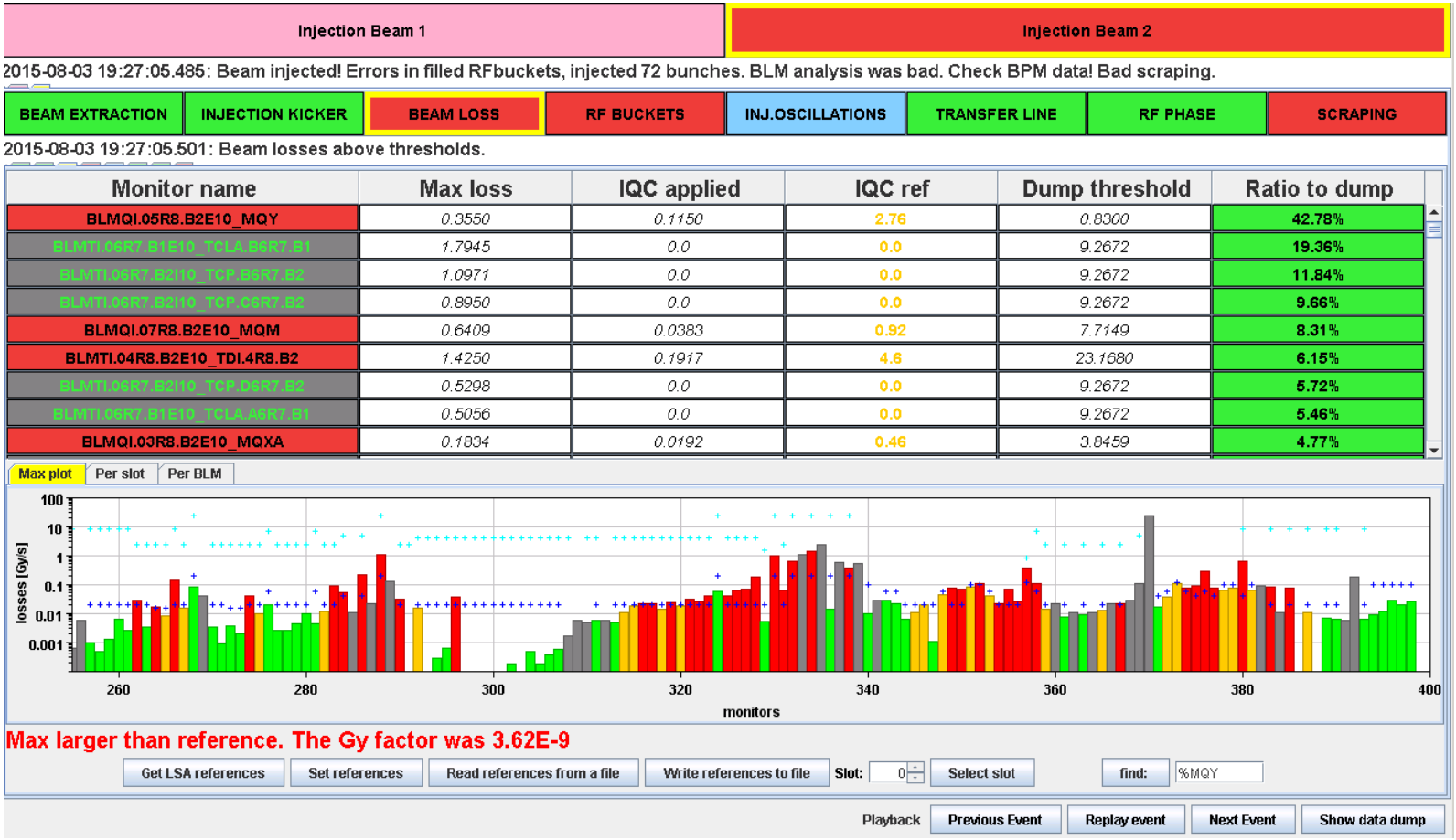
Transverse losses

- Experience with 144 b train injections
- Usual 'hot' spots:
  - P2: Q8, Q5, MSI, Q6
  - P8: Q7, Q5, MSI
- In normal conditions stay below 0.5 - 1 Gy/s
- RS01 thresholds at injection at MQMLs around 7-11 Gy/s
- Q5
  - Q5L2 threshold 13.9 Gy/s while Q5R8 threshold 0.83 Gy/s according to small filter reduction (~17)
  - Loss signals show rather a factor 2 higher for Q5R8
  - Q5R8 has IC+SF ?? Do we have this filter really in?
  - Q5L2 has IC
- Expect increase for 288 b, but should still allow efficient operation
- Mitigations
  - Steering the lines
  - Scraping in the SPS



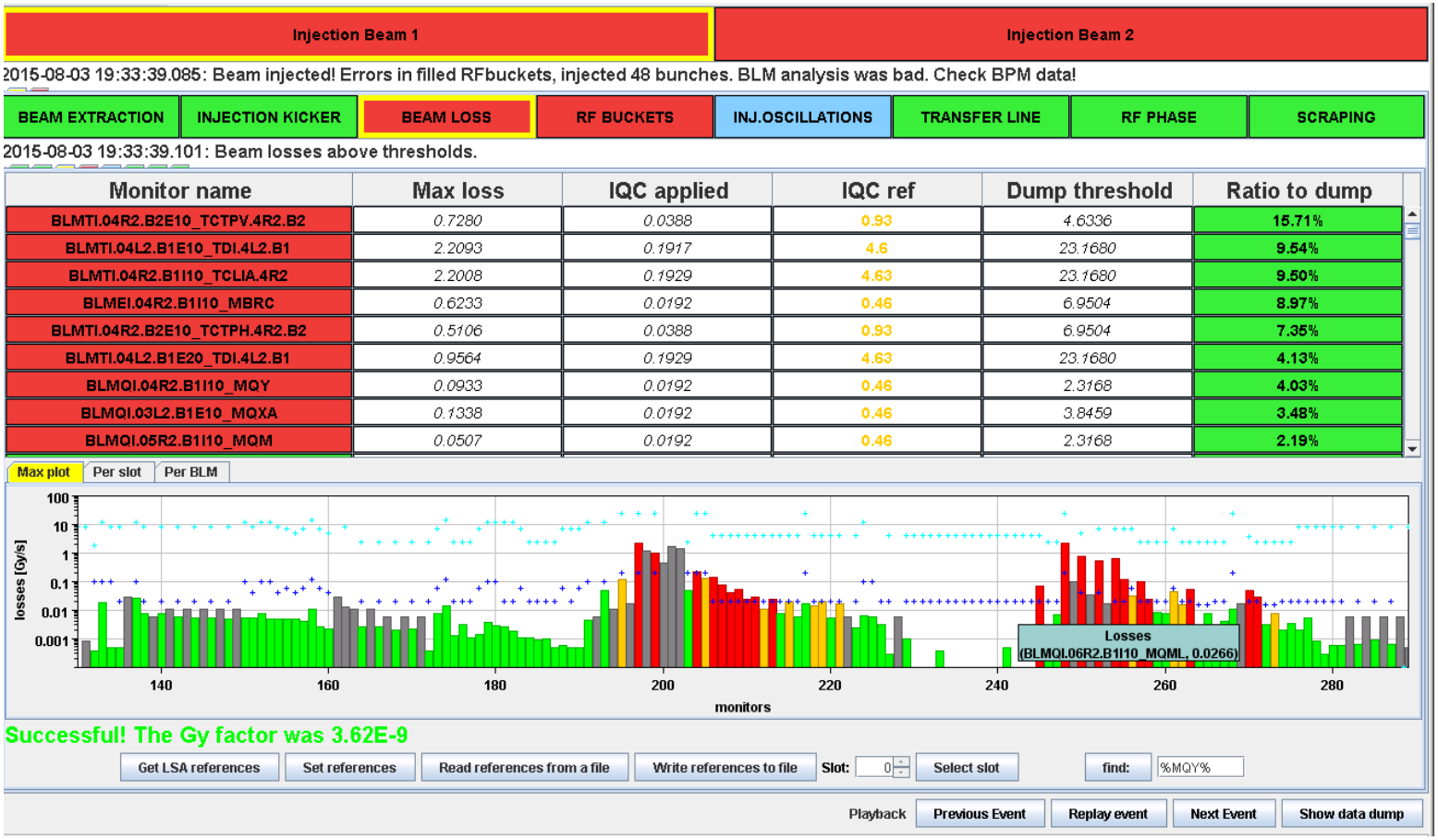
Doublets

- 72 b, no scraping, 43% on Q5



Doublets

- 48 b, 7.2% scraping, only longitudinal losses



Possible mitigations of longitudinal losses

- Losses from LHC unbunched beam
  - Injection gap cleaning in LHC
  - Was set up on 9th Sept-15
  - Reduces losses on TDI from a few percent to below a percent
  - Marginal gain compared to satellite loss level

- Losses from satellites injected into LHC
  - LHC
    - Increase MKI pulse length
      - Can be done immediately within TDI limits
      - Inject satellites close to the batch in a clean way into LHC
      - Possibility to clean them before next injection with injection gap cleaning
      - Should make the losses on ALICE/LHCb BCMs cleaner
      - TDI limit until exchange
      - 100 ns longer pulse gave ~30% reduction of losses on TDI
    - Sunglasses
      - Blind out dump trigger during injection
      - Hides the problem
      - Does not improve for ALICE/LHCb BCMs
  - SPS
    - B2 losses will be similar to B1 after SPS MKE4 modifications in the coming YETS
    - Ramp program optimisation – can be done immediately, but not a huge gain expected
    - Transverse damper to clean the machine around the batch – longer term
  - PS
    - Optimisation of bunch length and extraction kicker flattop at extraction – already fairly optimised

Conclusion

- In recent operation longitudinal losses were dominant
  - There are short term (tweak bunch rotation in PS, longitudinal settings during ramp re-capture in SPS, increase MKI pulse length) and longterm (transverse damper in SPS) mitigation possibilities
  - Sunglasses are less preferred to mitigate longitudinal losses
- Transverse losses mainly due to TCDI shower from the outside at acceptable levels with up to 144 b trains
- Expect an increase with 288 b, but should still stay within limits that allow efficient operation
  - In case we go above levels of 20% dump threshold have the means of steering the lines and scraping in the SPS
  - **No need for activating sunglasses in 2015/16 for normal operation**
  - This comes in a big part from adding filters at critical monitors
  - Have to check Q5 where the loss/threshold ratio is a factor ~30 different, filter?
- In case doublets are needed, transverse (emittance increase) and longitudinal losses (production in the SPS) will be increased
  - When we first tested them the only way of injecting into LHC was by increasing the BLM master threshold!
  - Can heavily scrape in the SPS (factor 2-3 more than usual) to define a clear transverse beam edge and reduce the TCDI shower or blind out the dump trigger at injection
- Should test the sunglass functionality at the startup in 2016
- Which blind out length?
  - As long that the running sums of the blinded BLMs reach 50% of the dump threshold