MD4746: BFPP Quench Test 2018

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Goal

Use BFPP beams to induce a quench in a main dipole magnet

Information on **steady state quench limit in a clean loss scenario**:

- Impact point in magnet can be controlled by orbit bumps avoiding magnet ends, what would return less accurate quench level estimates

- Quench limit can be approached gradually by leveling the luminosity of the IP, since the power of BFPP beams is directly depending on luminosity and can therefore be controlled by changing the beam separation

Proposed magnet for MD: MB.B11R1.B1

Motivation

First test performed on Dec 8th 2015 (Fill 4707) on **MB.B11L5.B2**

Location chosen due to observed loss situation

- Losses still in the MB during regular operation with -3mm bump
- Could easily move losses deep into the MB by inverting the bump for QT

Inconclusive results require second test at different location

- Discrepancy between the expected & the actual loss location→ analysis revealed aperture misalignment in this zone
- Quench limit lower than expected
  - Power density reconstructed with FLUKA is ~ factor 2 lower than the quench level predicted by electro-thermal models.
  - Quench happened at 2.3e27 $cm^{-2}s^{-1}$ but max. luminosity reached during the run 3.6e27 $cm^{-2}s^{-1}$ and no other BFPP induced quenches occurred (bump in L5 still left losses inside MB)

Procedure

① BLM MFs =1 at MB.B11R1 (and L1/R5)

② Prepare beam as for **standard physics fill** until collisions.

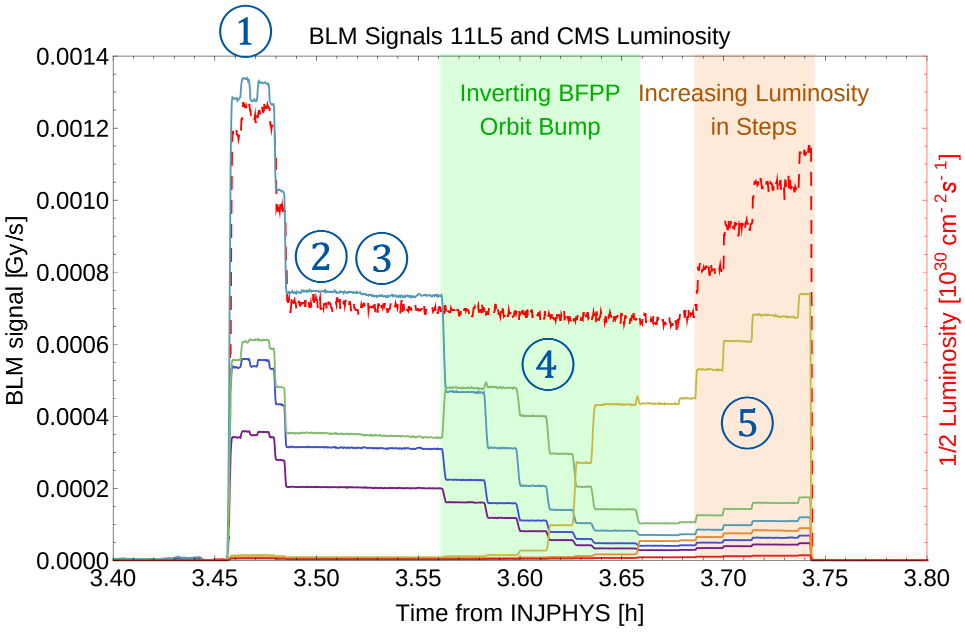
③ Re-separation of the beams to reduce burn-off.

④ Reduce beam separation in IP1 to have enough luminosity to determine the impact point of the BFPP beam in the MB based on the BLM signals.

⑤ **Invert BFPP orbit bump** from operational setting (neg. bump) until losses are fully in the MB (slightly pos. bump around +1mm).

⑥ **Reducing the separation in IP1** in 5μm steps until quench occurred (wait 0.5-1min/step)

Time evolution of the 2015 test



Courtesy of M. Schaumann

Other considerations

QPS crates

New patched nQPS boards installed during TS3 in cell 11 L/R of IR1 & IR5 in anticipation for the ion run.

Losses during intensity ramp up and high intensity EOF tests will be closely monitored to spot potential issues triggered by R2E.

MP3

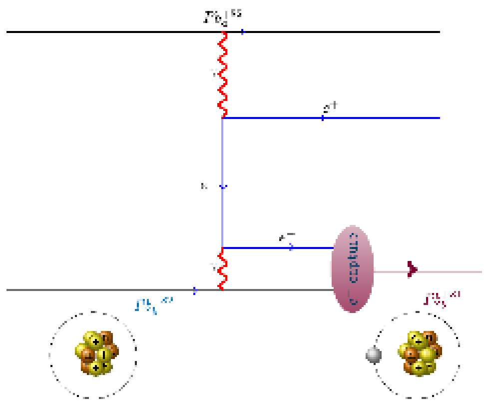
No special constraints for quenching MB.B11 in L1/R1 according to magnet experts

Backup

Secondary Beams created in the Collision

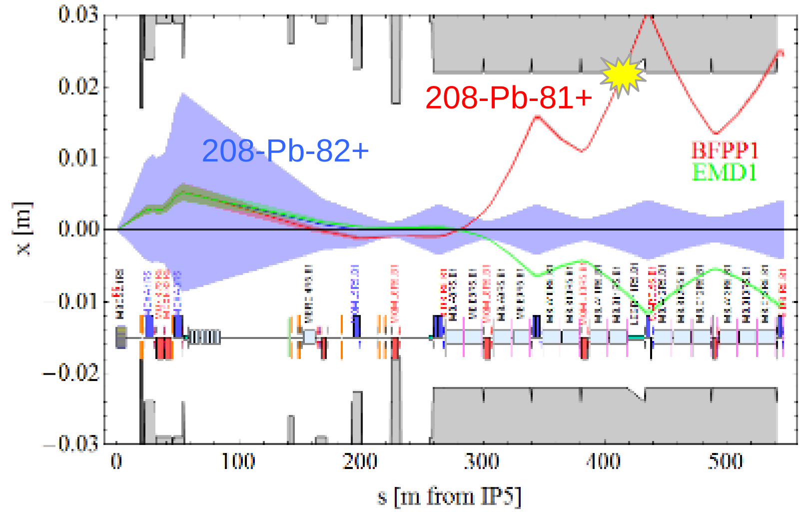
Bound-free pair production (BFPP)

$$^{208}Pb^{82+} + ^{208}Pb^{82+} \longrightarrow ^{208}Pb^{82+} + ^{208}Pb^{81+} + e^+$$



Has large interaction cross-section (>200b) in Pb-Pb collisions and is the main contribution to fast luminosity burn-off.

Secondary beams impact in superconducting magnets downstream the interaction points.

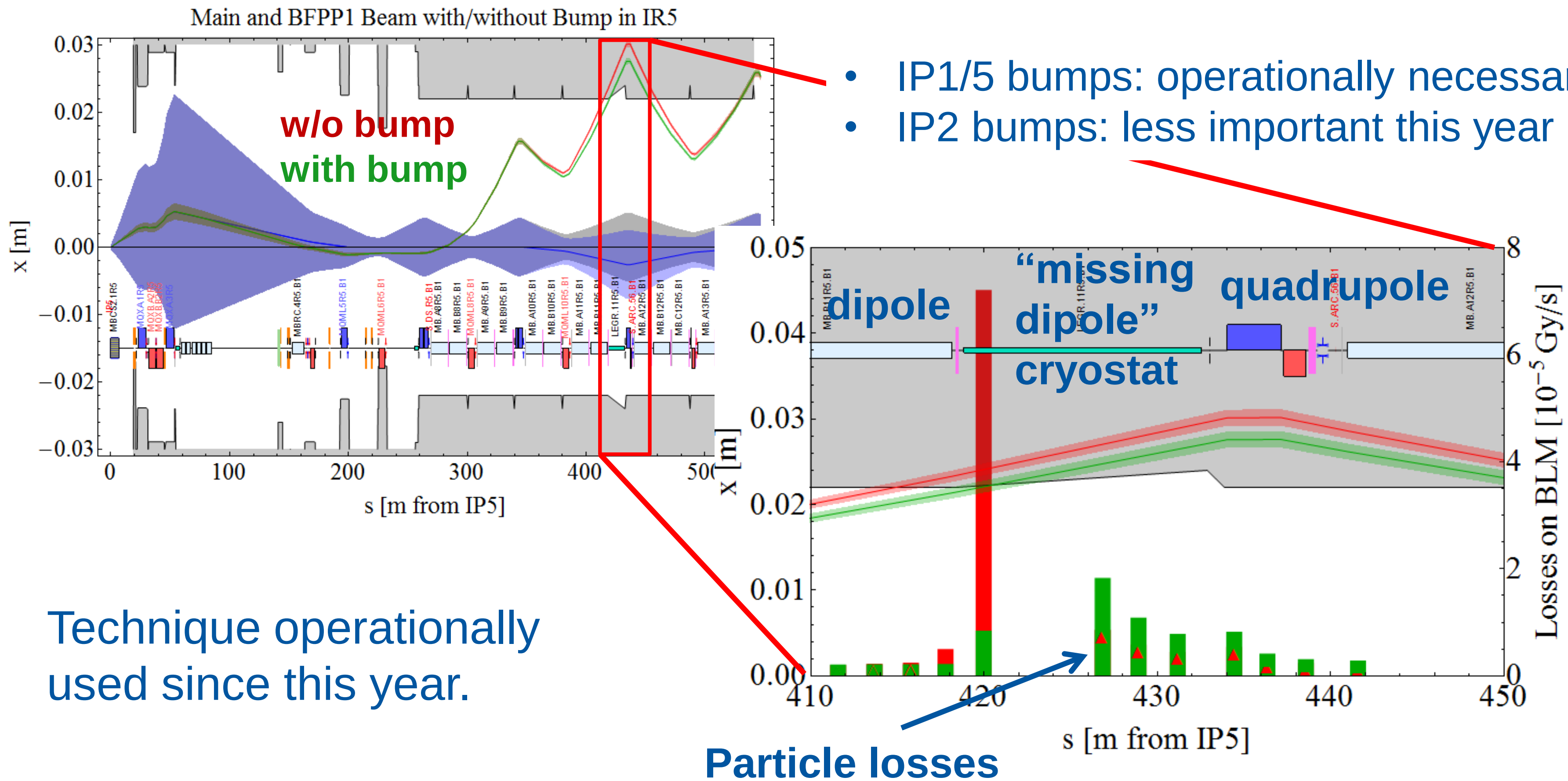


Deposited power exceeds quench limit.

Luminosity limit found at L≈2.3e27cm^{-2} s^{-1} in 2015 quench test (≅40W into magnet)

Quench Risk Mitigation with Orbit Bumps

Orbit bumps are used to move the secondary beam losses to a less vulnerable location in order to reduce risk of quench.

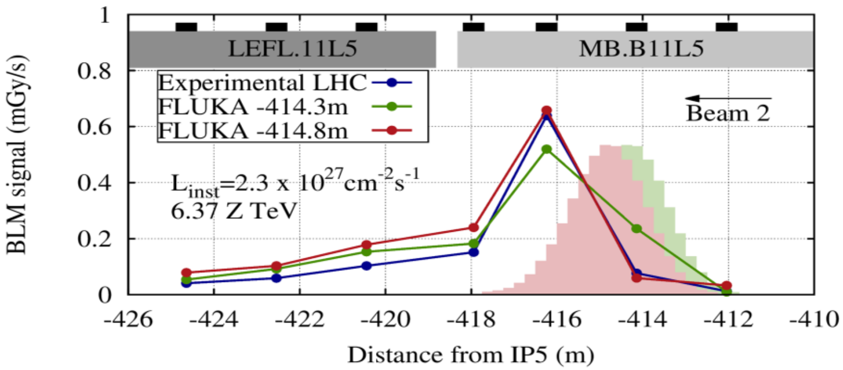


- IP1/5 bumps: operationally necessary
- IP2 bumps: less important this year

Technique operationally used since this year.

FLUKA Results of 2015 test

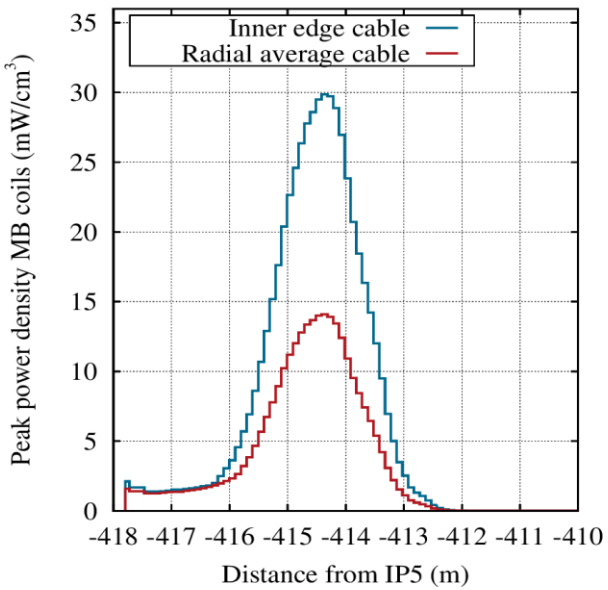
BLM signals can be accurately reproduced with FLUKA, but strongly depend on the longitudinal loss location.



Inconsistencies found. A second test in a different location is required to understand and confirm the results.

Power deposition in the MB coils is **lower than expected***,

- strongly depends on shape of loss distribution
- shape effect is washed out in the BLM signals.



*power density reconstructed with FLUKA is about a factor of two lower than the quench level predicted by electro-thermal models

courtesy of C. Bahamonde