MD2202: LRBB compensation
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LSWG, 17th August 2017
Foreword: >20 years of studies BBC experiments

- 1996: V. Shiltsev et al., idea to use electron (elens) to compensate BB in hadron machine
- 2001: J.-P. Koutchouk: idea to use a DC wire
- 2004: J.-P. Koutchouk, F. Zimmermann, J. Wenninger: SPS wire experiments campaign (lasted >10 year and involving a lot of people)
- 2008: U. Dorda PhD on wire compensation LHC (F. Zimmermann supervisor)
- 2012: T. Rijoff Msc on wire compensation for the HL-LHC (F. Zimmermann supervisor)
- 2013: F. Zimmermann and R. Steinhagen: specification for the LHC wire prototypes
- 2015: S. Fartoukh et al.: Compensation of the long-range beam-beam interactions as a path towards new configurations for the high luminosity LHC
- 2016: F. Zimmermann and H. Schmickler, Long-range beam–beam compensation using wires

Synergic effort of Collimation Team, BE-BI, EN-STI, EN-MME and TE-EPC to transform an idea in real HW!

From the idea to the BBCW prototype in LHC
Introduction

After the installation of the BBCWs (prototypes of the beam-beam wire compensators) during last EYETS and parasitic tests at injections of top energy, an MD took place on the 1\textsuperscript{st} July.

Layout of the BBCW compensation: use 2 DC wires to compensate on the B2 the effect of the B1.
Objectives of the MD

1. Test with beam the different setting-up procedures.
2. Prove the beneficial effect of the wires compensation on the bunches suffering long-range beam-beam (partial compensation due to the presence of wires only in IP5 and to the limit of the beam-wire distance due to the collimator constraints). Privileged observable: the effective total cross-section of the p-p interaction ($\sigma_{\text{EFF}}$).

$$\sigma_{\text{EFF}} = - \frac{1}{\sum_{IP} L_{IP}} \frac{dN}{dt}$$
- 10 h MD.
- The FILL5898 was dumped (RF on B1, not clear the reason, RF experts suggest a glitch on the interlock). Half-RF detuning.
- The observations we report concern the FILL5900. Full-RF detuning.
Asymmetric filling scheme

To approach the wire to the beam the B2 has to be \(<3e11\) p (safe limit). We will mainly concentrate on the two bunches of B2 (Only HO and HO+BBLR).
STEP 1: Alignment of the two wires

Important vertical offset (up to 5 mm) to be taken into account with the vertical alignment procedure. This is not a trivial procedure (no V PU).
STEP 2: H emittance blow-up

To increase the LRBB effect, the B2 was blown up to 5-6 mm mrad and tunes were set to (0.31, 0.32).
STEP 3: Crossing angle reduction

To increase the BBLR the X-ing angle was reduced. Great synergy with the OP tools developed for the crossing angle anti-leveling.
During the powering of the wires the tunes of the beam (and its position) has to be controlled. The wires can move the $Q$ of 0.01: dipolar and quadrupolar contributions of the wires are compensated with feed-forward trims.
Sanity checks on H-position

- The H-position of the beam is under control.
Sanity checks on V-position

- The wires are vertically aligned.
Sanity checks on tunes

- Very good control of the tunes when powering the wires.
Result on the compensation (I)

- From the FBCT signals compensation on the losses [credit to M. Hostettler].
- **Clear effect of the BBWC.**
Result on the compensation (II)

- Compensation on the burn-off losses [credit to N. Karastathis].
- Clear effect on the BBCW when switching-off.
- We need a long integration time…
Result on the compensation (III)

- Using dBLM signals to compute the cross-section [credit to A. Poyet].
- Improved time resolution.
- Further checks on calibration needed.
Summary

- During the MD2202 it was observed for the first time the effect of a direct compensation of the BBCW. The setting-up procedures were tested and validated.

- The HW (interlock, PCs, jaws temperature/cooling, collimators…) worked smoothly.

- There are still margin of improvement: beta-beating/tune feedforward and a smoother orchestration of the feedforward trims (looking forward MD3).

Thank you for your attention.
BACK-UP SLIDES
The wires are embedded in tertiary collimators. There are precise limits in the positioning of the wire with respect to the beams.
Optimizing HO collision
Positioning the collimation jaws

- H-centering the beam up/downstream
- B1/B2 Xing angle reduction
- B2 Xing angle reduction
- at 5.5 $\sigma_{\text{coll}}$
- at 6 $\sigma_{\text{coll}}$
- same distance in mm

1st July 2017

H-position of TCL/TCTPH jaws [mm]

time [hh:mm]
MD2202: Q trims
MD2202: dipolar trims

![Graph showing dipolar trims with two lines representing ACBYHS4.R5B2 and ACBYHS4.L5B2 over time.]
MD2202: instability of B2

[Graphs showing the instability of B2]

Pilot

Beam 1

Bunch #224
no HO, no BBLR

HO

HO

1st July 2017

B1 and B2 from 338 to 375 A

Intensity [10^11 ppb]

[Intensity scale]

[Time scale for graphs]

[Graphs showing the variation of B1 bunch intensity over time]

[Graph showing the current fluctuations over time]
## MD2202: Optics

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<th>Y</th>
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End of FILL test