
CERN

MD3263

LR beam-beam compensation using DC wires

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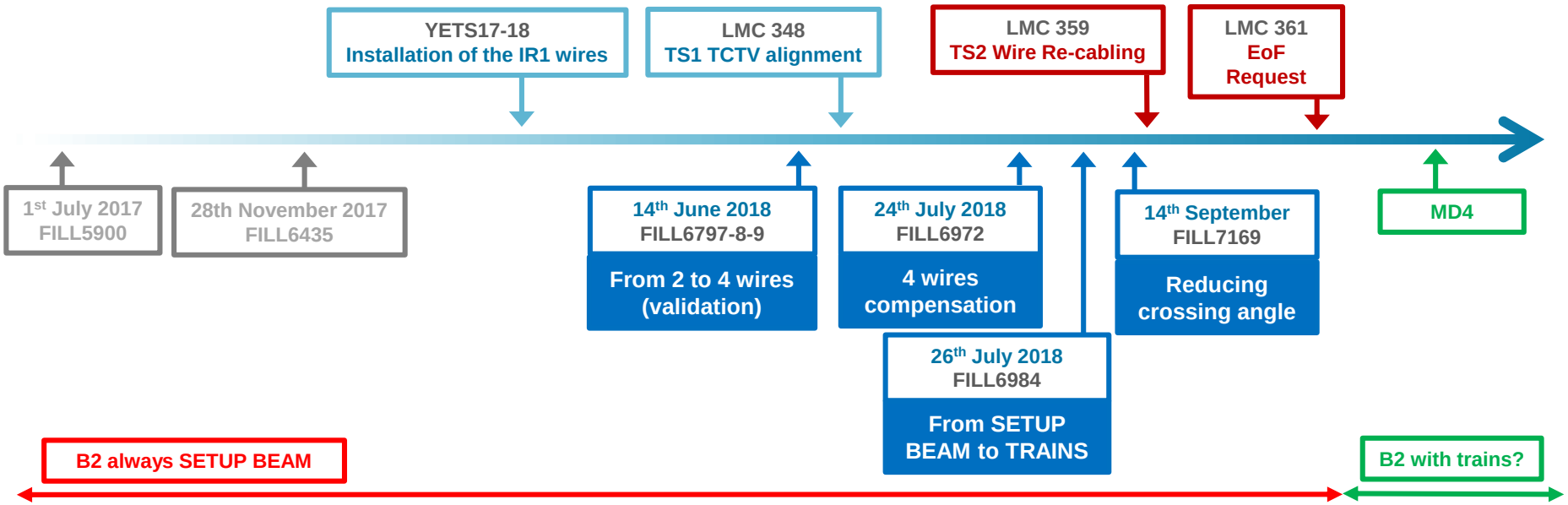
on behalf of the Wire MD team.
Special thanks to the Collimation and OP for the support.

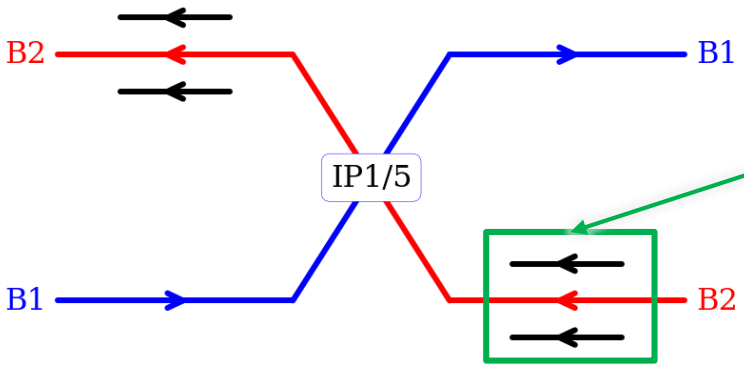
rMPP, 18th October 2018, https://indico.cern.ch/event/765240/
https://asm.cern.ch/md/requests/LHC/3263

MD3263 in MD#4

- **MD Merit:** explore the wires effect in a configuration closer to operation (using only the right wires).

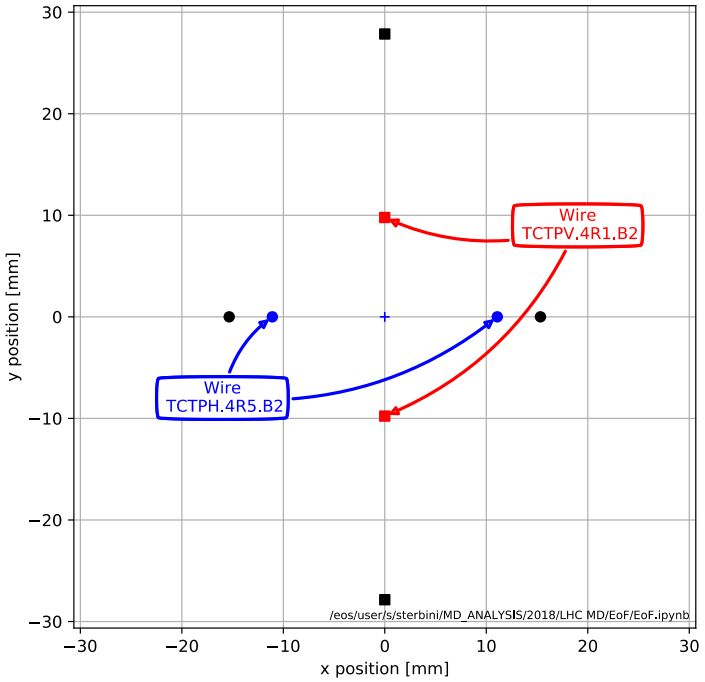


Hardware overview of wire prototypes



- Wires re-cabled during TS2.
- Even multipoles (quadrupoles, octupoles,…) “doubled”.

- Only right wires powered with trains.
- All collimation gaps at nominal position.
- 5-th axis of the right wire in IR5 to be moved by 2.9 mm.



4 Phases proposed for the MD

PHASE0	• Before the MD
PHASE1	• During the MD at 450 GeV
PHASE2	• During the MD at 6.5 TeV
PHASE3	• Actual measurements at 6.5 TeV

Phase 0

- Polarity test of the wire series connection in the tunnel. **Done.**
- Test the wires HW interlock. **Done.**
- Perform the thermal test on the wires. **Done.**
- Modify the feedforward taking into account the new wire connections (doubling the Q4/Q5 trim and zeroing the dipolar correction). **Done.**
- Check the PC time constants when a fault occurs. **Done.**
- Do loss maps at top energy with the 5-th axis of TCTPH.4R5.B2 + 2.9 mm. **Done.**
- Check with train 75 bunches the motion of the 5-th axis of TCTPH.4R5.B2. Verify the alignment. **Done.**
- Check the wires polarity with beam at 450 GeV. To be **done ➔ Phase 1**
- Check the feed-forward orchestration at 450 GeV. To be **done ➔ Phase 1**

Phase 1

- Inject the beams according to the PHASE 1 filling scheme
  - 1 LHCINDIV per beam
- **Cycle each single wire WITHOUT the quadrupolar feedback** and measure the tune shift. The cycling will be done by steps up to 350 A and down -350 A. [60 min]
- **Cycle each single wire WITH the quadrupolar feedback** and measure the tune shift. The cycling will be done by steps up to 10 A and down -10 A. [30 min]

Phase 2

- Inject the beams according to the PHASE 2 filling scheme.
  - B1 filling scheme (**strong beam**):
    3x48 bunches (BCMS).
    1x12 bunches.
    1 NOMINAL (2 HO in IP1 and IP5, but no LRBB),
    1 NOMINAL (no HO, no LRBB).
  - B2 filling scheme (**weak beam**):
    Bunch #10 (super-PACMAN): 1 NOMINAL (2 HO in IP1 and IP5, but no LRBB).
    Bunch #390 (regular): 1 NOMINAL (2 HOs in IP1 and IP5, and ~60 LRBB in IP1 and IP5).
    It collides with the third train on B1.

- Measure the H/V emittances at injection energy with the wire scanners. [30 min]
- Trim the B1/2 octupoles to reach FT with 550 A. Ramp. Measure regularly the H/V B2 emittances with the wire scanners during the ramp. [20 min]
- After the squeeze, set the 5th-axis alignment of
  - TCTPH.4R5.B2
    - using the settings found in FILL7206 (+2.9 mm). [20 min]
- Bring the beams into collisions according to the nominal sequence. Lumi-optimization will be done each ~20 min. Put the CO feedback need to be ON. [10 min]
- Reduce the crossing angle to 150 mrad. Check the quadrupole feedforwards for each of the 4 wires by ramping the current up to 350 A and back to 0 in steps (starting from the right wires). Monitor the B2 tunes [1 h 30 min].
- Move back the 5th-axes, dump the beam and rampdown [30 min].

Phase 3

1. Inject the beams according to the PHASE 3 filling scheme [1 h]. **"Symmetric" fill:**
   - 3x48 bunches (BCMS).
   - 1x12 bunches.
   - 1 LHCINDIV colliding HO
   - 1 LHCINDIV not colliding HO
2. Ramp the beams according to the nominal sequence until the squeeze. [30 min]
3. After the squeeze set the 5th-axis alignment of
   - **TCTPH.4R5.B2 using the settings found in FILL7206 (+2.9 mm). [20 min]**
4. Bring the beams into collisions according to the nominal sequence (ATS 30 cm). Lumi-optimization will be done each ~20 min. Put the CO feedback need to be ON. [10 min]
5. Reduce the crossing angle to **150 μrad**.
6. Start the wire compensation on IR1 (only right wires) and IR5 (only right wires) setting the current I_W^{L1}=0 and I_W^{R1}=350 A in IR1, I_W^{L5}=0 A and I_W^{R5}=350 A in IR5. Make 3 ON/OFF cycles to observe the effect of the compensation. The current trims should be performed from the application setup by the OP team [G.-H. Hemelsoet and M. Solfaroli] [1 h].
7. Reduce the crossing angle down to 140 μrad with **compensation ON**. Repeat the previous step [1 h].
8. Reduce the crossing angle down to 130 μrad with **compensation ON**. Repeat the previous step [1 h].
9. It time allows, move B2 to as sub-optimal working point by moving the tune away from the diagonal and repeat the previous step [1 h].
10. If time allows, make a current scan for the wires in IR1 and IR5 [1 h].
11. **As an end-of-MD commutation ON/OFF of the active filter of the MB.**
12. Move back the 5th-axes and dump the beam. [20 min]

Number of MD's	**1**
Time required per MD [h]	11+2
Beams required [1, 2, 1&2]	1&2
Beam energy [GeV]	0.450 and 6.5 TeV
Optics (injection, squeezed, special)	Injection (PHASE 1) ATS **30 cm**, 150 mrad (PHASE 2) ATS **30 cm** from 150 to 130 mrad (PHASE 3).
Bunch intensity [#p]	1.15e11 ppb (see below for details)
Number of bunches	**PHASE 1:** B1/B2: LHCINDIV ========= **PHASE 2:** B1= 3 trains of 48 bunches + 12 bunches train+ 2 NOMINALs B2= 2 NOMINALs (1.15e11 ppb) (<3e11 p) ========= **PHASE 3:** B1/2= 3 trains of 48 bunches + 12 bunches train+ 2 NOMINALs
Transv. emittance [m rad]	We assume 2.2 um rad at collision.
Bunch length [ns @ 4s]	1 ns
Optics change [yes/no]	No.
Orbit change [yes/no]	No.
Collimation change [yes/no]	Yes. **Moving the 5th axis of the TCTPH.4R5.B2 by 2.9 mm.**
RF system change [yes/no]	No.
Feedback changes [yes/no]	No.
Tune changes	Tune scan of ±5e-3 will be performed in PHASE 3.
What else will be changed?	BBCW wire ±10 A interlock (BBLR_ R[L]1[5]_PC_OFF) to be masked. Modify the settings of the "**PC interlock**" to trim the Q4/5 in IR1/5. **As an end-of-MD commutation ON/OFF of the active filter of the MB.**
Are parallel studies possible?	No

What if the wire PCs trips?

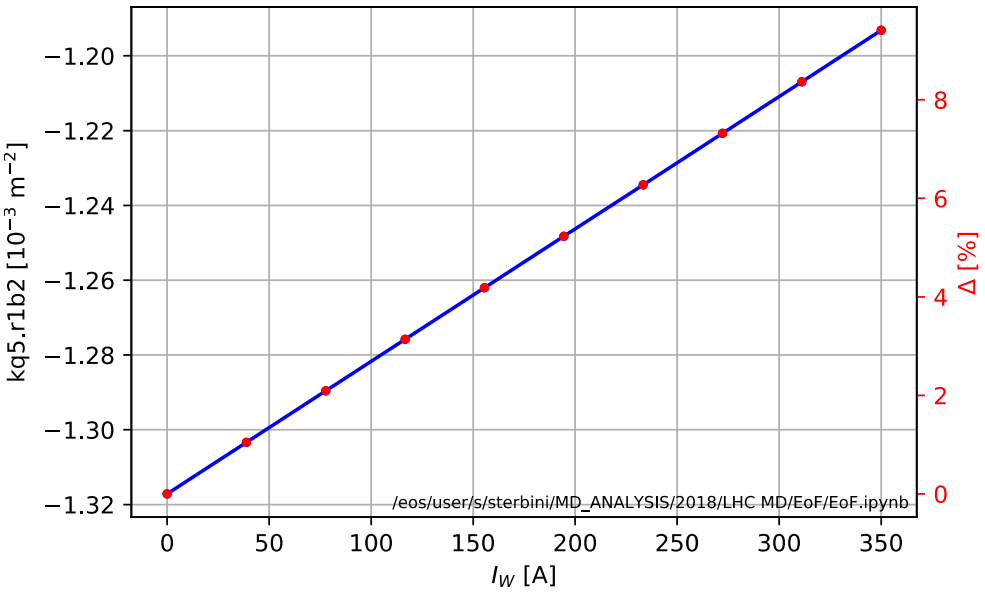
When we trim a wire the Q4/5 close to the wire are trimmed to compensate as close as possible the quadrupolar perturbation of the wire.

IF the PC of the wire trips the beam is **NOT** automatically dumped: the Q4/5 trim will cause tune shift and beta-beating.

From the collimation point of view, the failure scenarios are ok for β*=30 cm.

We will compare in the following the beta beating and the tune shift.

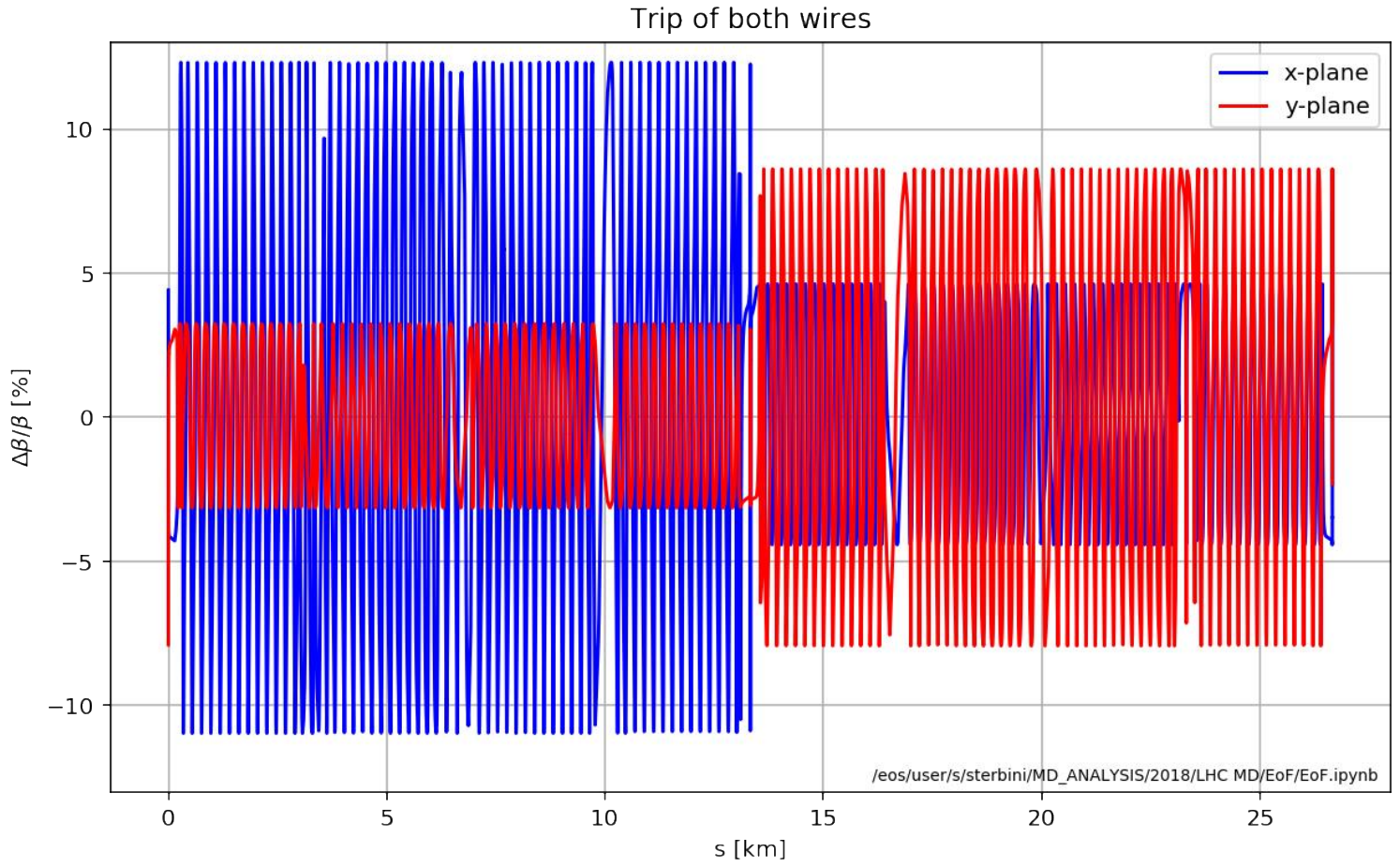
Q5R1



	ΔQH	ΔQV
Trip on both wires	-0.001788	0.002006
Trip on R1 wire	-0.009535	0.006858
Trip on R5 wire	0.008327	-0.005695

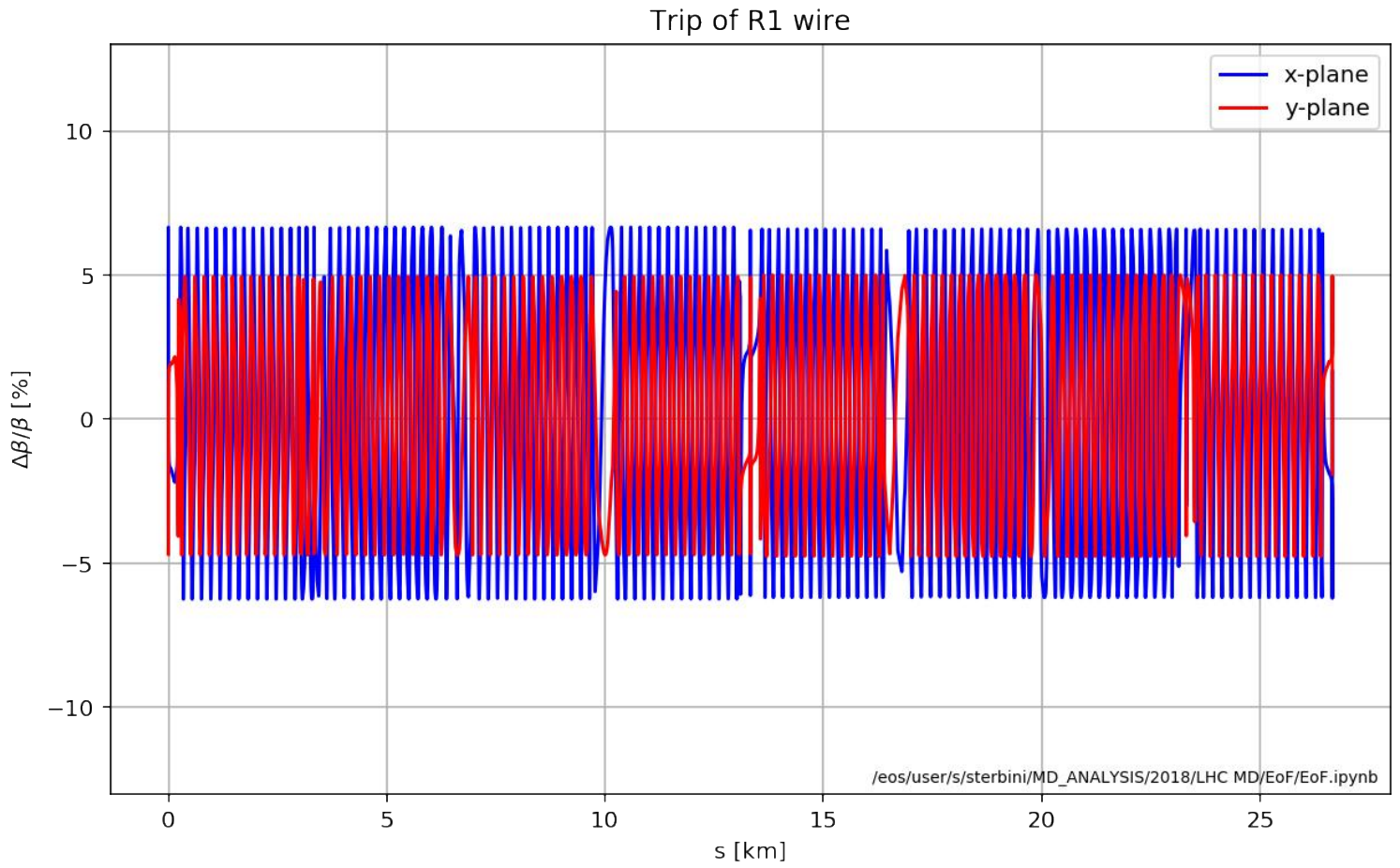
What if the wire PCs trip?

If both converters trip (R1+R5).



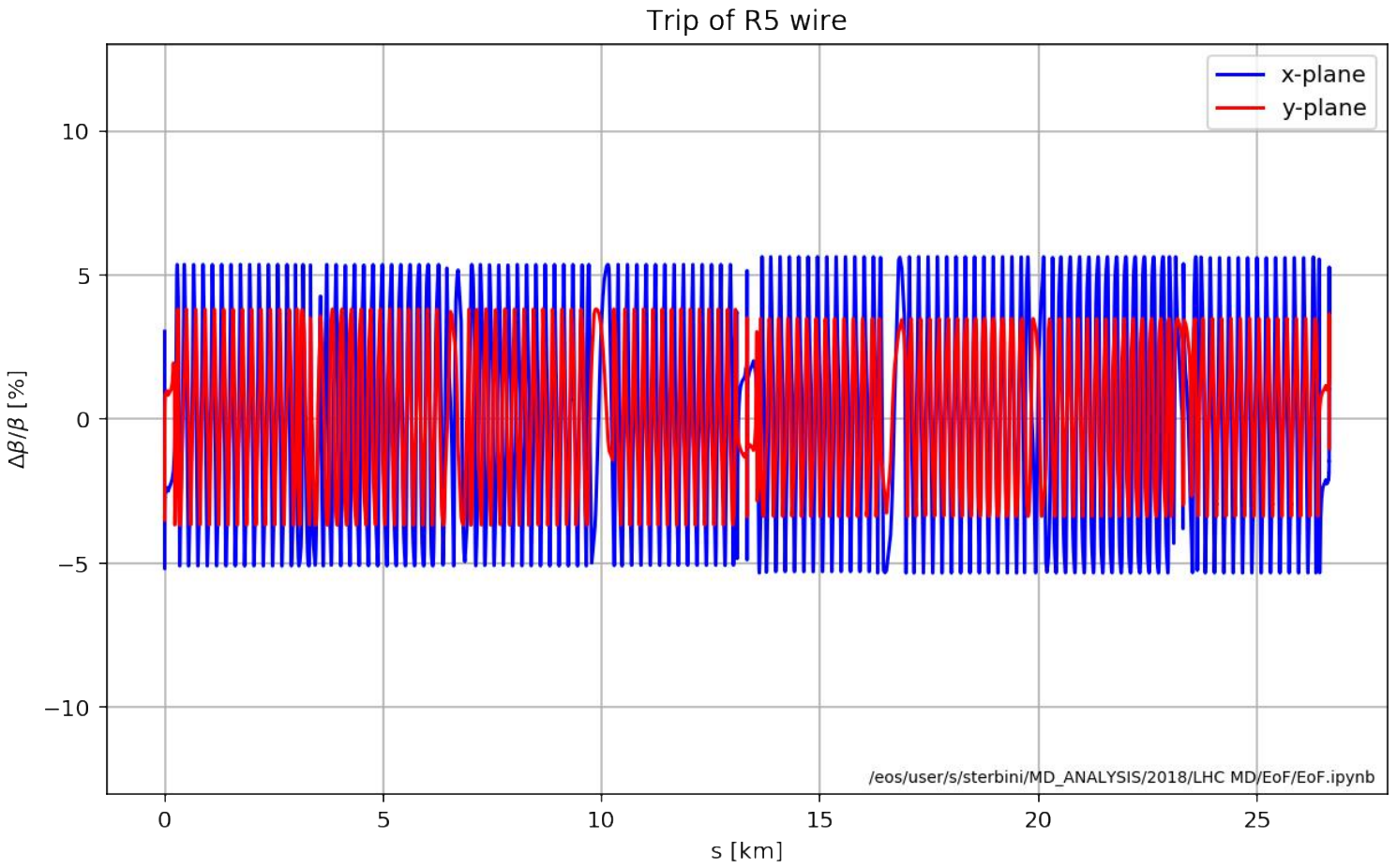
What if the wire PCs trip?

If both R1 converter trips.



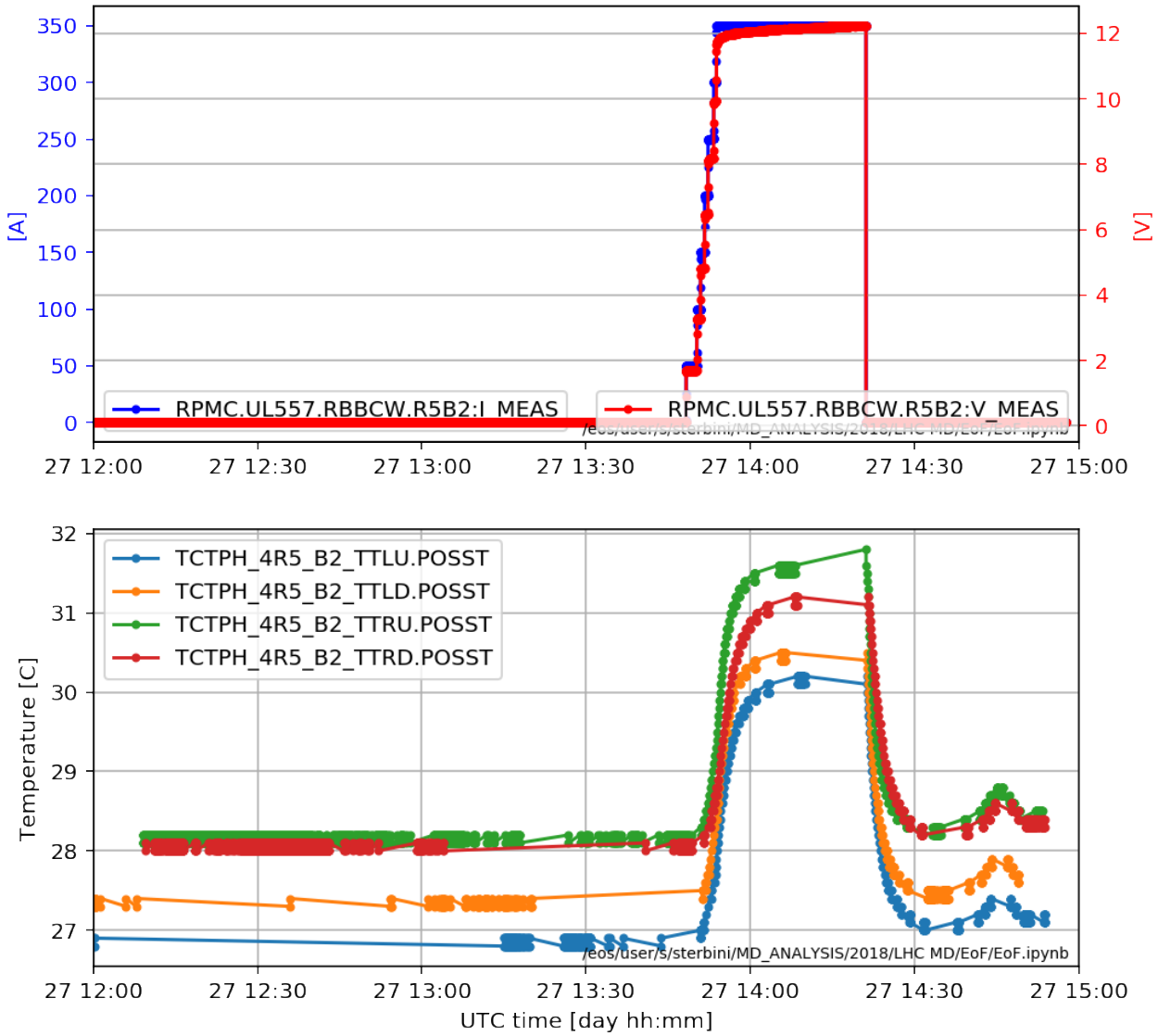
What if the wire PCs trip?

If both R5 converter trips.

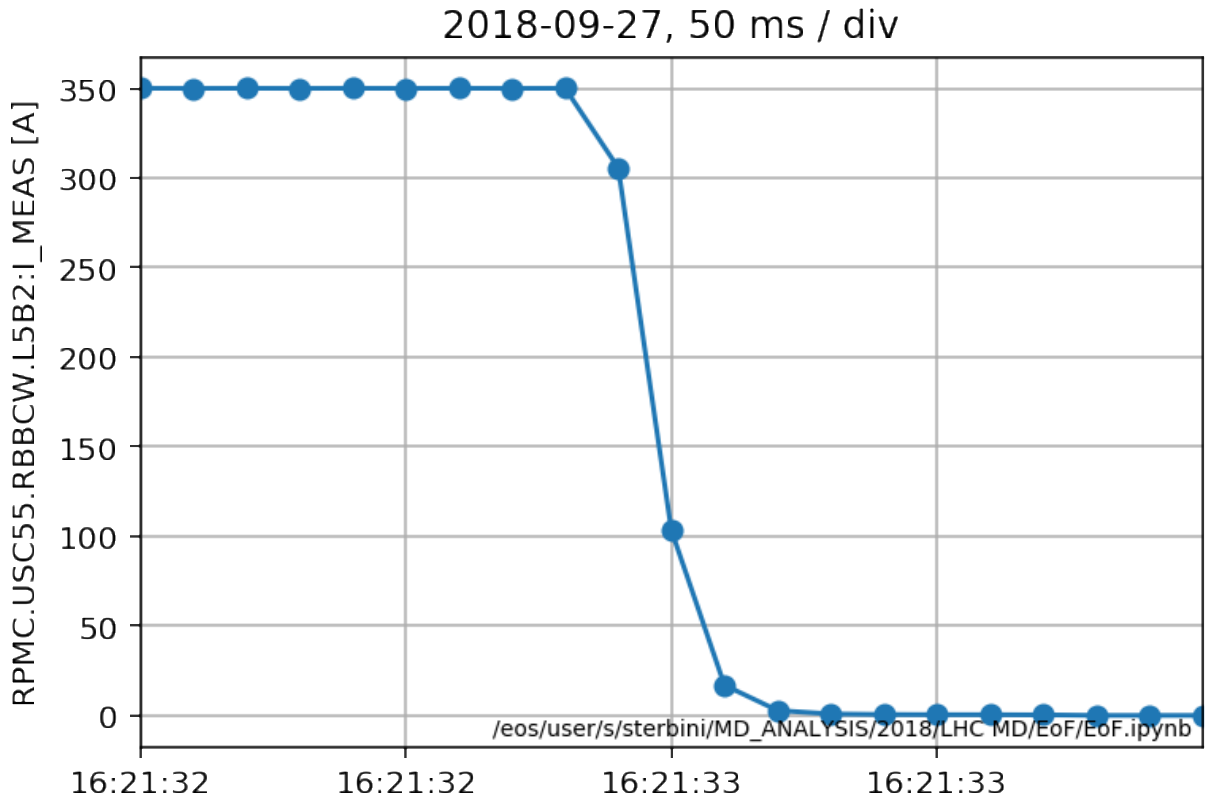


Thank you.

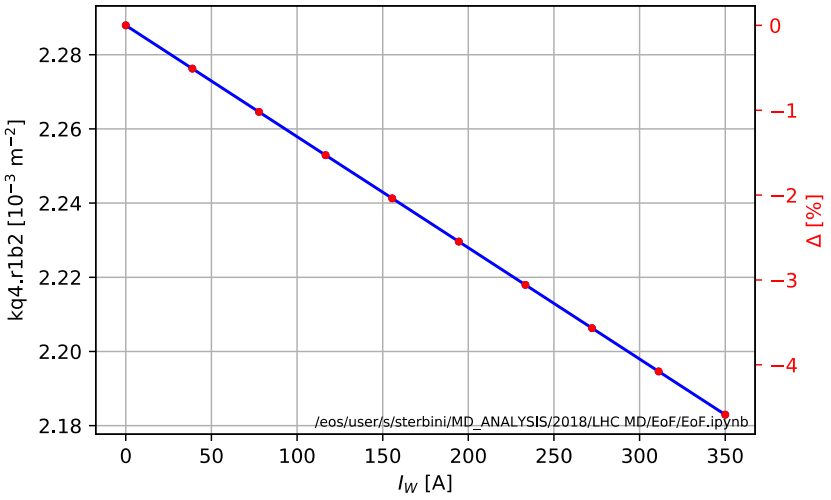
An example of thermal test

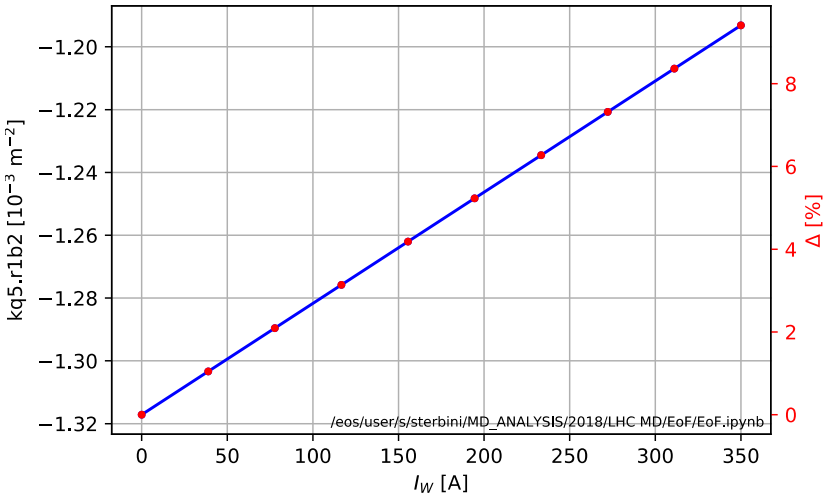


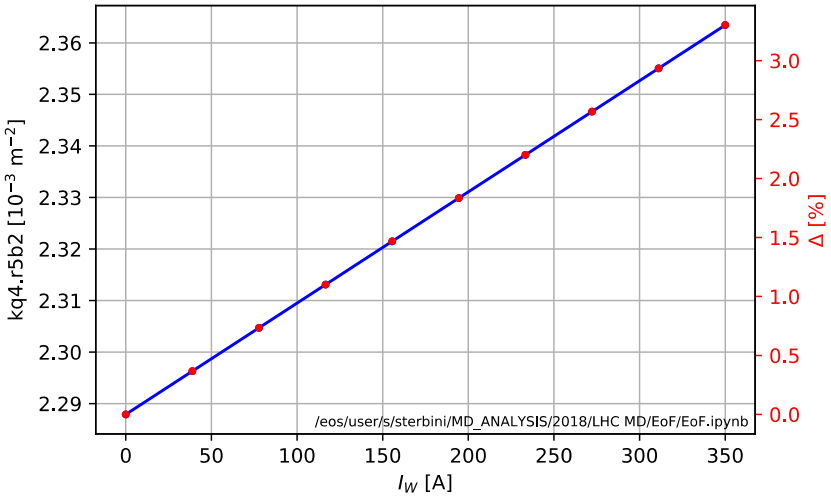
Time constant of the wire trip

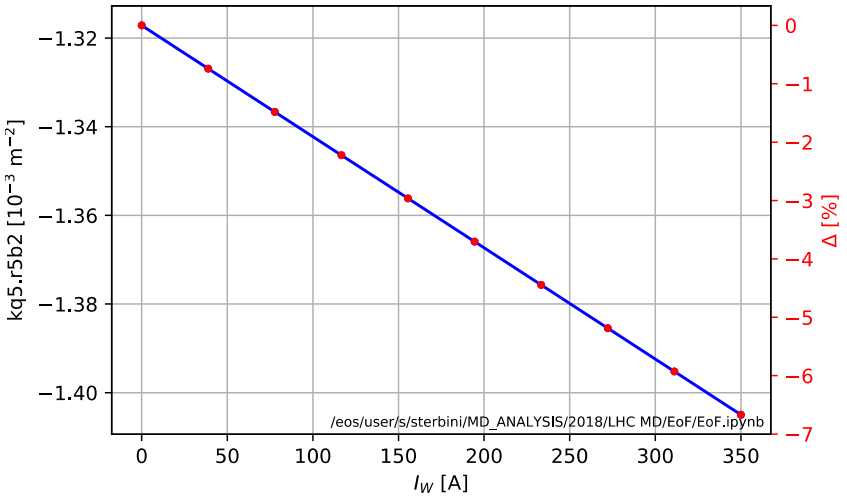


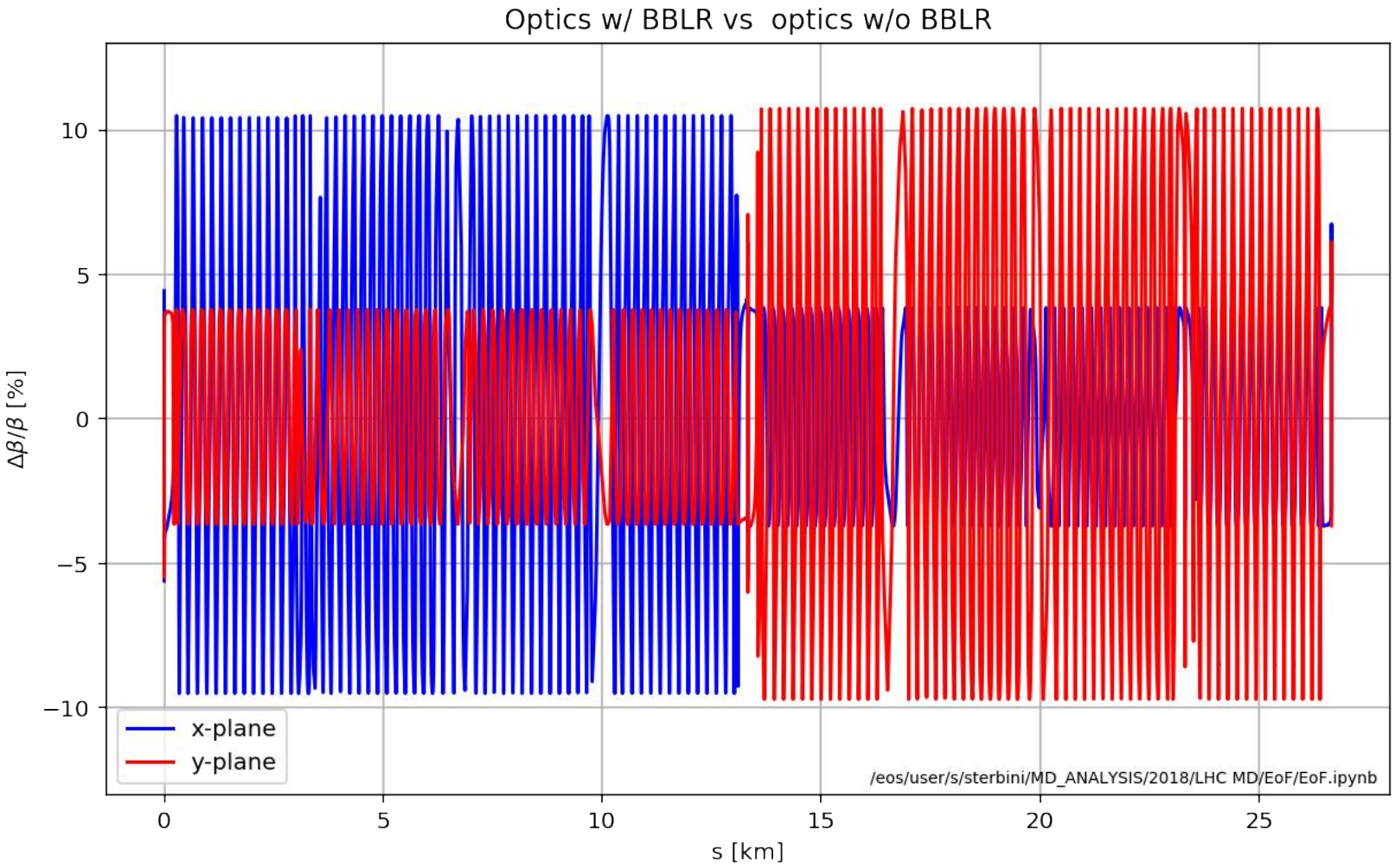
Q-feedforward










Optics w/ BBLR vs optics w/o BBLR
10
5
0
−5
−10
Δβ/β [%]
0
5
10
15
20
25
s [km]
x-plane
y-plane
/eos/user/s/sterbini/MD_ANALYSIS/2018/LHC MD/EoF/EoF.ipynb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