An Update on LHC Wire Compensation Simulation

A. Poyet with the incredible inputs of G. Sterbini, K. Skoufaris, S. Kostoglou, N. Karastathis, S. Fartoukh and Y. Papaphillipou

Beam-Beam and Luminosity Studies Meeting – 25th February 2019

Outline

I. An historical introduction to the problem
II. Simulations results: the inconsistence
III. A useful tool: cpymad
IV. Application: validation of the wire implementation in MAD-X
V. Conclusions and next steps
VI. AOB: experience sharing about job submission (HTCondor)

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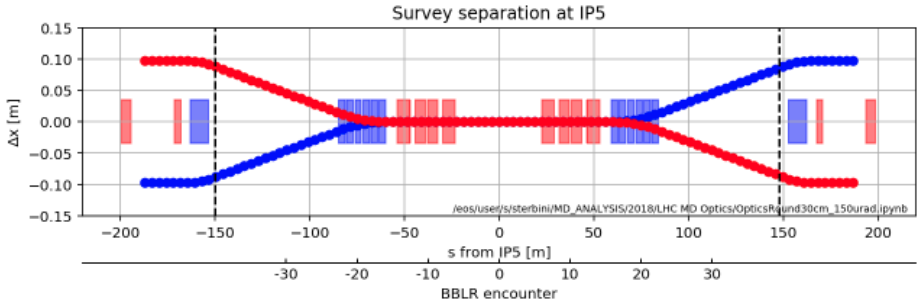
Not all colliders are like LHC…

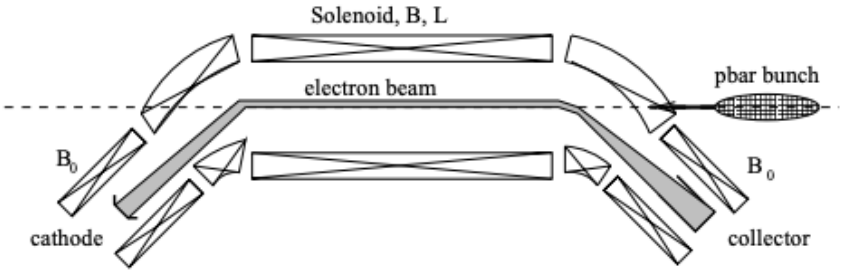
- The ”after the triplet” location of D1 allows a lot of Beam-Beam Long-Range encounters



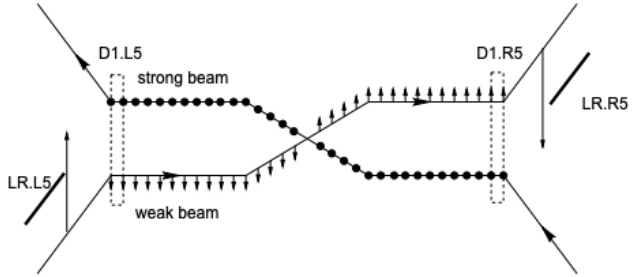
- But with all encounters (almost) in phase…
  - → A local solution for a local issue?

From e-lens to DC wire

- While developing the e-lens in Fermi Lab, V. Shiltsev proposed as application to compress the tune footprint induced by BBLR (1997)
- In 2000, JP Koutchouk proposed instead a **local compensation of the non-linear kicks** induced by the BBLR interaction, using **DC wires**
- The approach was focused on compensating the encounters in between the triplets, installing the wires **at the same beta-functions** (x and y), for **round optics**.



V. Shiltsev and al., *Electron compression of beam-beam tune footprint in the Tevatron*, FERMILAB-TM-2008 (1997)

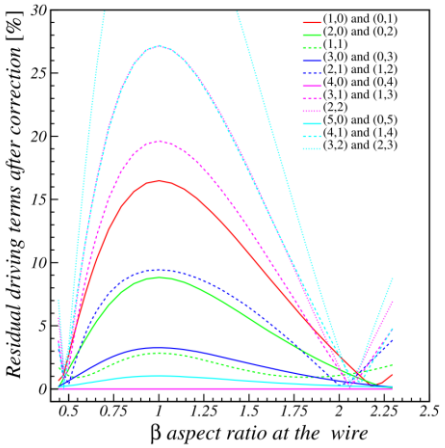


JP Koutchouk, *Principle of a correction of the long-range beam-beam effect in LHC using electromagnetic lenses*, LHC Project Note 223 (2000)

BBLR compensation as a path towards HL-LHC

- 15 years later, thinking about flat optics for HL-LHC, S. Fartoukh realized that the approach was not sufficient and started computing RDTs.
- But, numerically, S. Fartoukh showed that, by compensating 2 RDTs, **it exists a s-position (an aspect ratio) in which the wires would minimize all RDTs**.
- With ATS Optics, this compensation scheme is **optics independent**.
- **This turned the wires into the so-called plan B for HL-LHC.**
- **Objective for HL-LHC: obtaining the same plot, but showing Dynamic Aperture.**

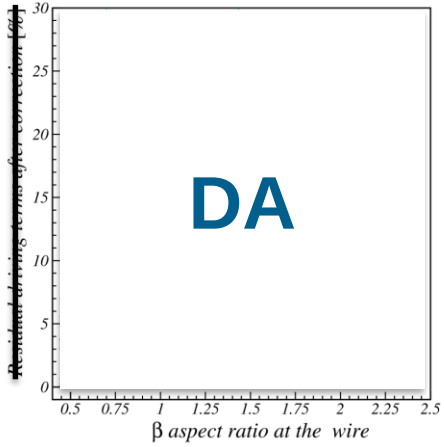
Correction of (40)-(04)-(60)-(06)



$$c_{pq}^{\mathrm{LR}} \equiv \sum_{k\in\mathrm{LR}} \frac{\beta_x^{p/2}(s_k)\beta_y^{q/2}(s_k)}{d_{bb}^{p+q}(s_k)}$$

RDT led by BBLR

OBJECTIVE



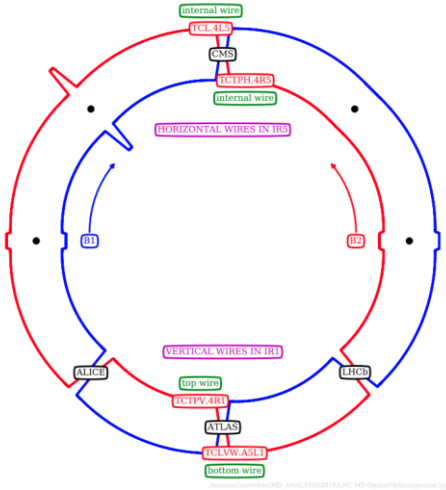
$$\begin{cases} c_{pq}^{w.\mathrm{L}} \equiv N_{w.\mathrm{L}} \times \frac{(\beta_x^{w.\mathrm{L}})^{p/2}(\beta_y^{w.\mathrm{L}})^{q/2}}{(d_{w.\mathrm{L}})^{p+q}} \\ c_{pq}^{w.\mathrm{R}} \equiv N_{w.\mathrm{R}} \times \frac{(\beta_x^{w.\mathrm{R}})^{p/2}(\beta_y^{w.\mathrm{R}})^{q/2}}{(d_{w.\mathrm{R}})^{p+q}} \end{cases}$$

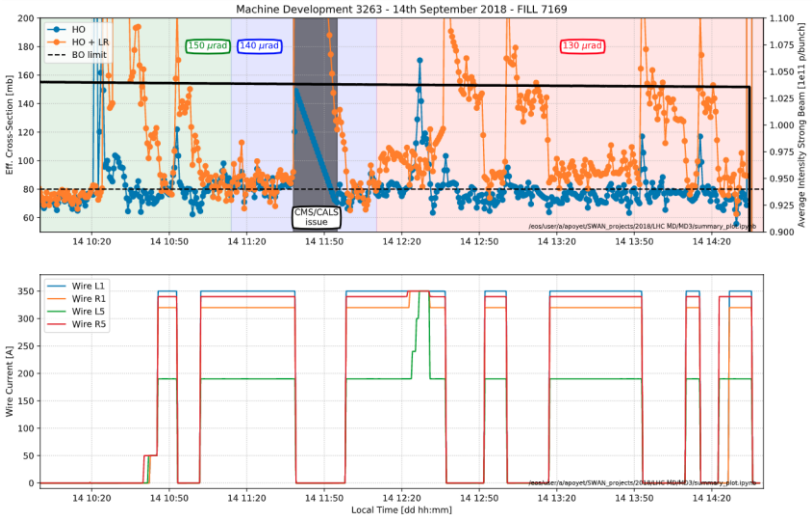
RDT led by the wires

S.Fartoukh and al., *Compensation of the long-range beam-beam interactions as a path towards new configurations for the high luminosity LHC*, Phys. Rev. ST Accel. Beams **18**, 121001 (2015)

The need of Dynamic Aperture studies

- Being plan B, prototypes of wire compensator were built, installed in the LHC and tested during MDs in 2017/2018.
- The beneficial effect of the wires on the beam lifetime has been observed, using the settings predicted by S. Fartoukh paper.
- We were however experiencing some hiccups with simulations, not being able to observe an improvement of DA using the wire
- **Goal of this presentation: show you that now, we can!**





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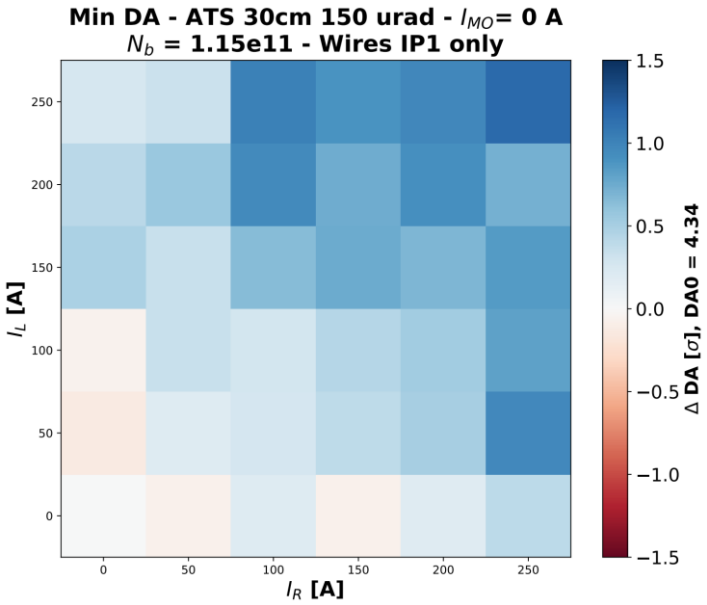
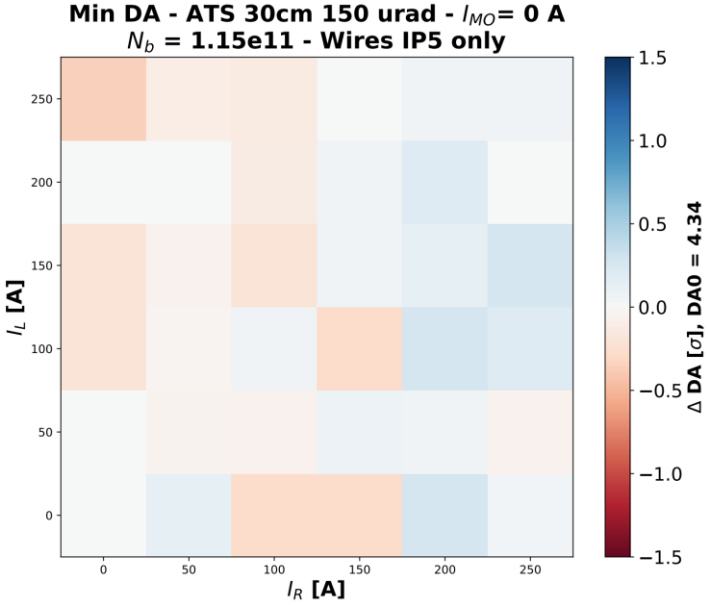
Simulation Results

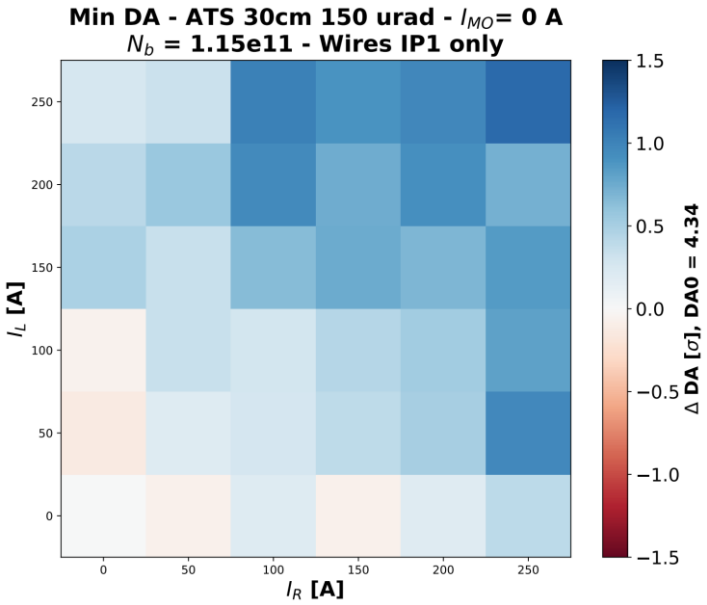
- Scanning each wire independently led to the following plots.
- Inconsistency with the experiment: the wires in IP1 are very efficient
- Inconsistency with the theory: the wires in IR5 do not work!

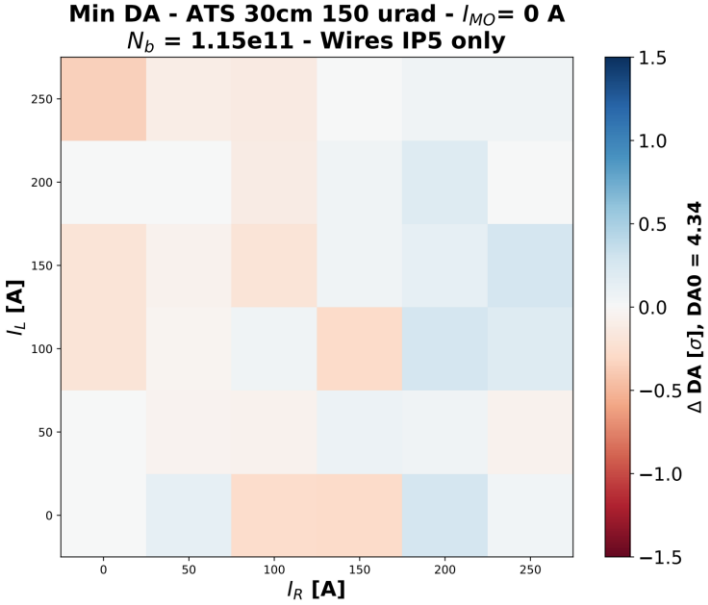




Simulation Results

- Sanity checks are needed to validate
  - Wire implementation in MAD-X
  - Interface between MAD-X and SixTrack





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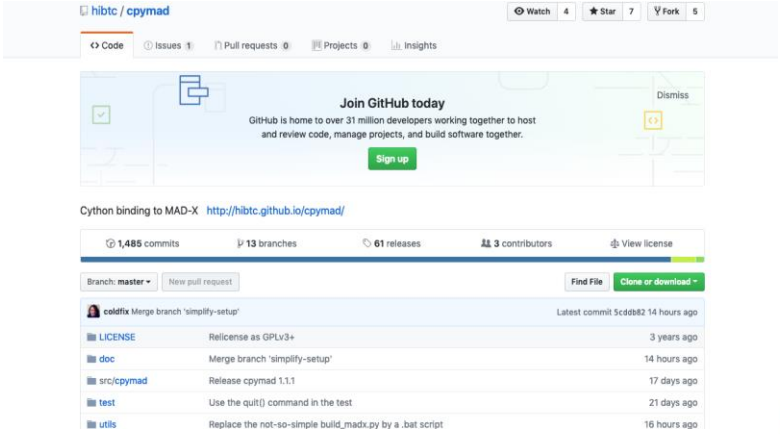
A useful tool: cpymad

- In order to have a ‘step-by-step’ approach, we will use the **cpymad package** in a **SWAN notebook** environment
- Link to SWAN: https://swan.cern.ch
- Historically: https://github.com/pymad
- Link to cpymad project: https://github.com/hibtc/cpymad
- To demonstrate the power of this tool, we will go through all the sanity checks needed for the wire, in a notebook.



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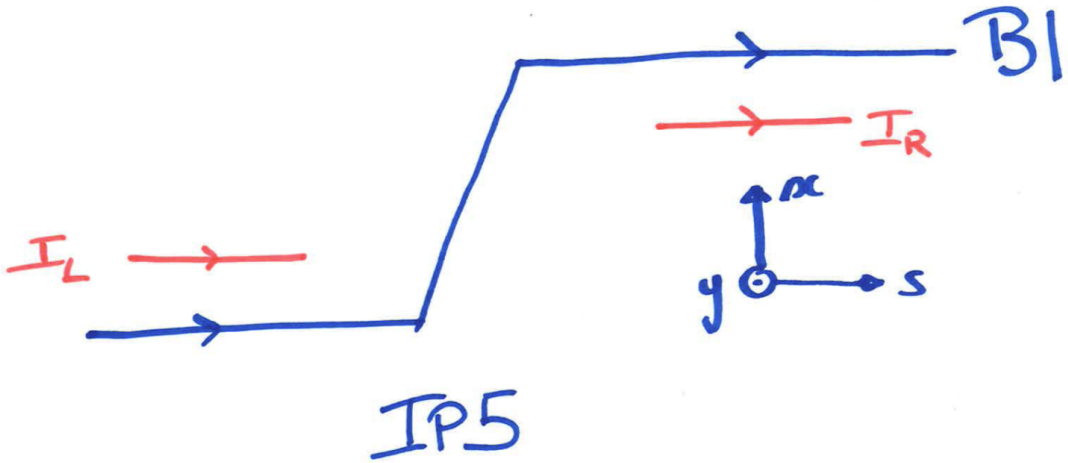
LET'S GO!

- All the material needed from now, is available from the indico page of this fabulous event: https://indico.cern.ch/event/801929/

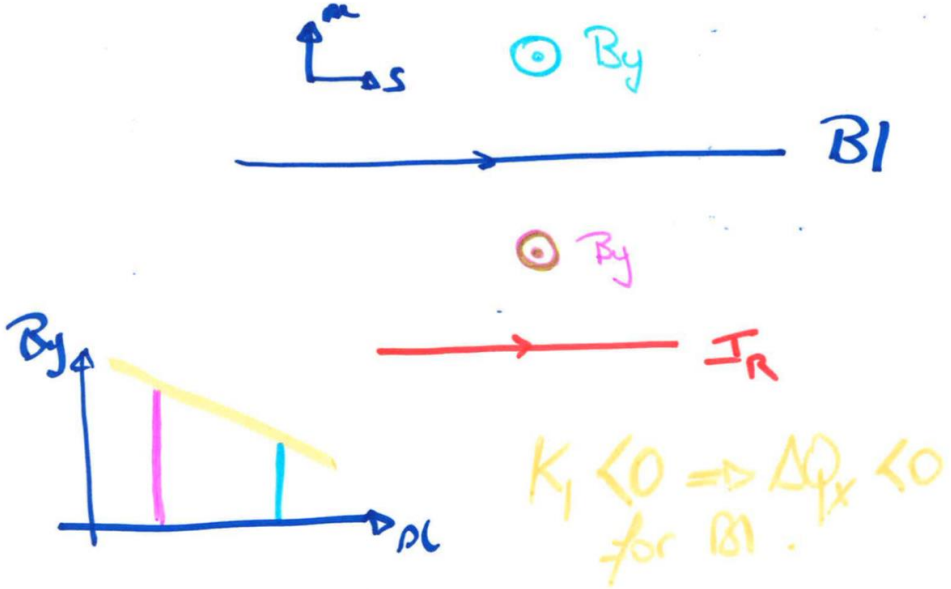
MAD-X reference system

- In MAD-X, the reference system is the one of B1.



Gradient of a wire?

- Using the correct reference system, one gets that the gradient of the wire R5 on B1 has a negative gradient → negative H tune shift



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Conclusions

- Using cpymad in a notebook, we went step-by-step, through **a whole validation of the wire implementation** in MAD-X:
  - Validation of the beam-beam element meaning
  - Validation of the positioning and the polarity of the wire
  - Validation of the tune shifts and detuning with amplitude
  - Validation of the possible multipolar decomposition
- Using cpymad as an alternative of scripts **saved a lot of time.** We can only encourage the usage of this tool in a more systematic way (→ mask writing)
- **Now: need to validate the interface MAD-X/SixTrack, reproducing the footprint using FMA (many thanks in advance to Sofia)**

Thanks for your attention, but don't leave there is an AOB ☺

AOB: optimize the usage and the communication around HTCondor

- Many of us are using HTCondor on a daily basis
- Many of us are experiencing issues, sometimes you don't feel confident enough to open a ticket:
  - Could we create/use an e-group (linked to ABP, ABP-CW?) to address first our doubts/issues? Ideally with a responsible that would be in charge, in case, to be in contact with the batch team.
  - Can we improve our knowledge about HTCondor? Documentation and trainings are available.
  - Can we improve the awareness of the available resources for our group? Improve the way we are sharing them?

AOB: optimize the usage and the communication around HTCondor

- Some useful links:
  - https://twiki.cern.ch/twiki/bin/view/ABPComputing/
  - Documentation: http://batchdocs.web.cern.ch/batchdocs/index.html
  - Tutorial: http://batchdocs.web.cern.ch/batchdocs/tutorial/introduction.html
  - https://indico.cern.ch/event/635217/attachments/1458551/2252370/HTCondor-Presentation.pdf