Bunch compressor BC2 studies

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Goals:

- **beam based checking of trim coil polarity**
- **find (or check old) coil setting, which minimizes the dispersion produced by BC2 itself**
- **find (or check old) coil setting, which compensates the remnant field (BC2 off)**
- **collect data for comparison and further improvement (if needed) of dipole edge focusing model**

Our strategy how to improve the situation with dispersion in TTF linac:

- **at first, minimize the dispersion produced by main dipole systems (BC2, BC3, Doglegs)**
- **then minimize the residual dispersion by appropriate way of corrector settings**

Method is based on the formula

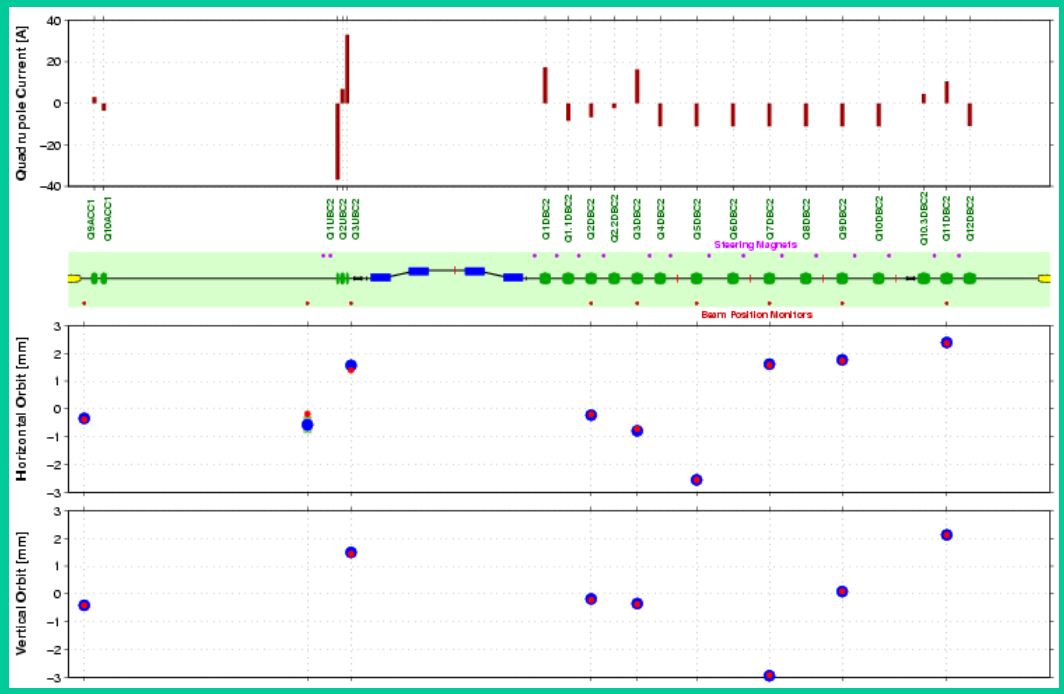
$$\text{dispersion} \approx -\Delta x \quad \text{at BC2 exit}$$

Δx is the shift of trajectory from the field free trajectory

Note that:
Theoretically this approximate equality can become theoretically exact equality only for special cases.
In general case, the precision of this approximation depends on many parameters: energy, entrance beam angle and etc.
The applicability of this approximation has been checked for BC2 case before making an experiment, and has been found that this formula can be used practically with high precision.

Steps :

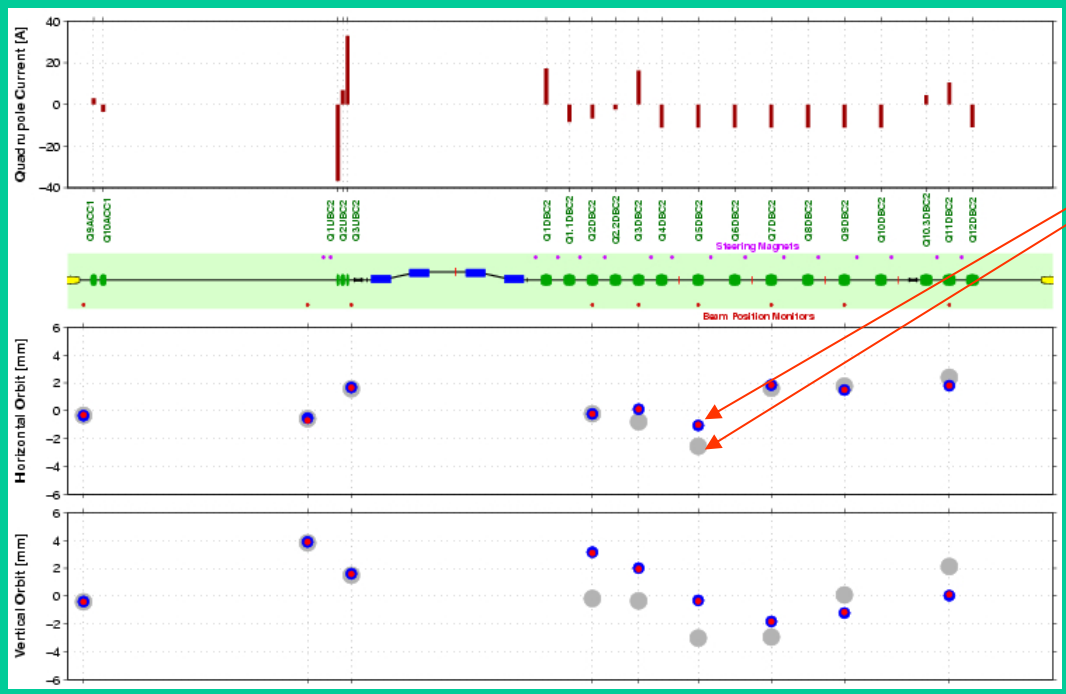
1. Saving the trajectory with BC2 on.
   Cycling to zero field, compare trajectories
   => can be improved.
2. Saving of data for checking of trim coil
   polarities for off-line analysis.
3. Degauss can be chosen as a method to get
   the field free trajectory.
4. After degaussing: with measured remnant fields
   for all 4 dipoles not larger than 0.2 mT
   the residual dispersion is not more than
   (0.8 – 0.9) mm at the BC2 exit.
5. Saving of field free trajectory.
6. Find setting of trim coils with BC2 on
   to restore the horizontal orbit to field free one.
7. Find setting of trim coils with BC2 off
   to compensate the remnant fields.



Step 1: before degauss

BC2 on

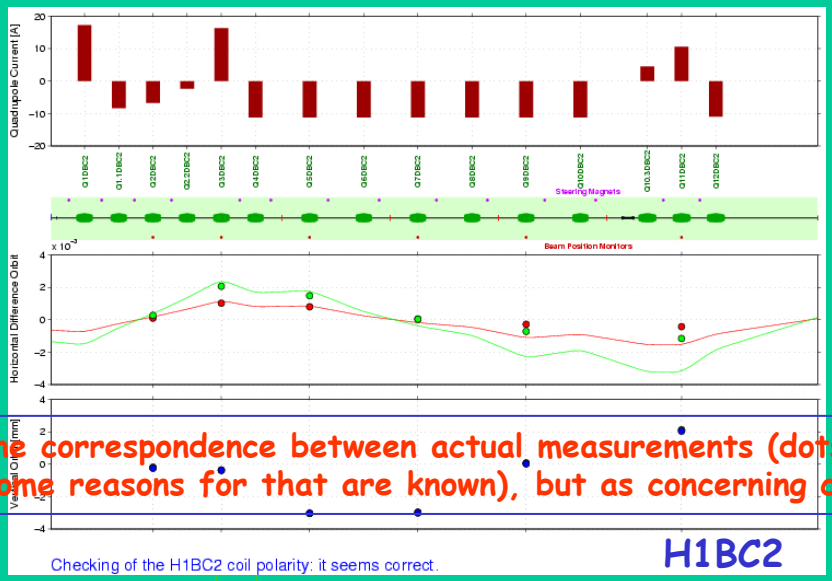
Difference obtained indicates that the current coil setting is not perfect and can be improved



BC2 off: trim coils H1BC2/H4BC2: +1.4 A

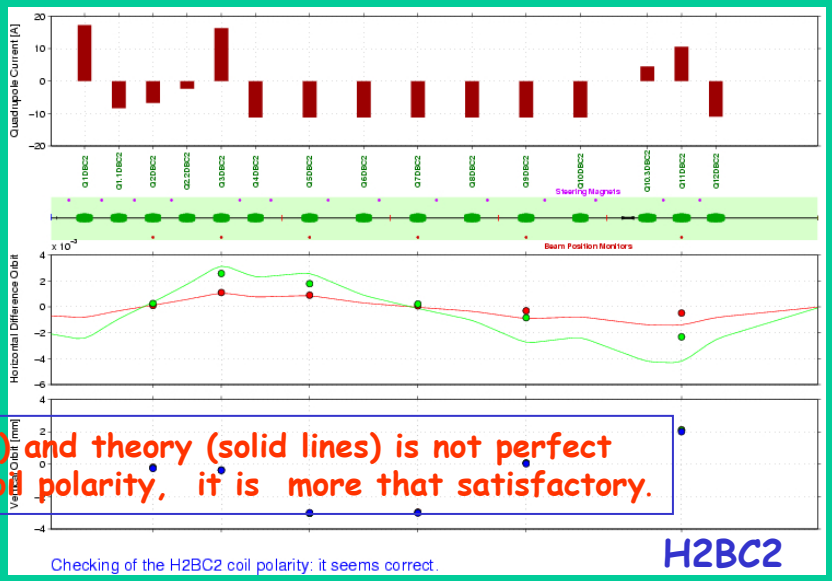
Step 2: Checking of the trim coil polarity

(off-line analysis, difference orbit method): looks correct



Checking of the H1BC2 coil polarity: it seems correct.

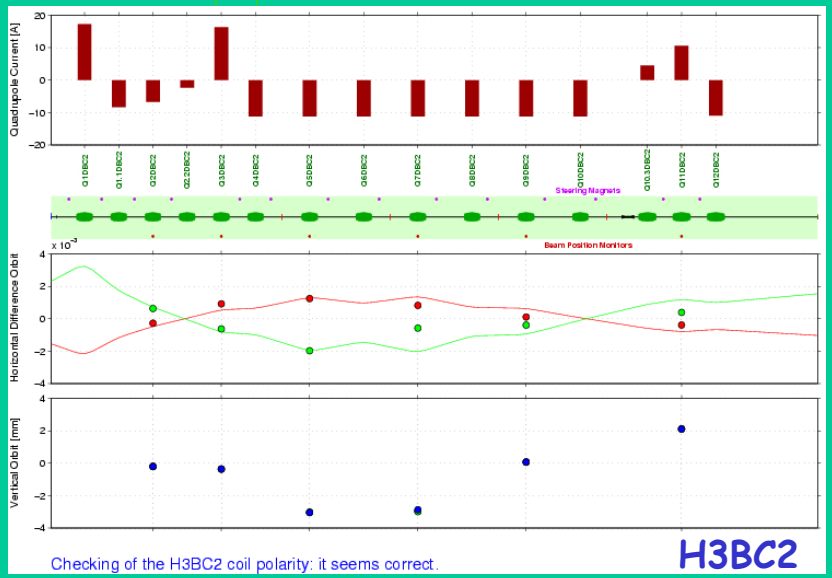
H1BC2



Checking of the H2BC2 coil polarity: it seems correct.

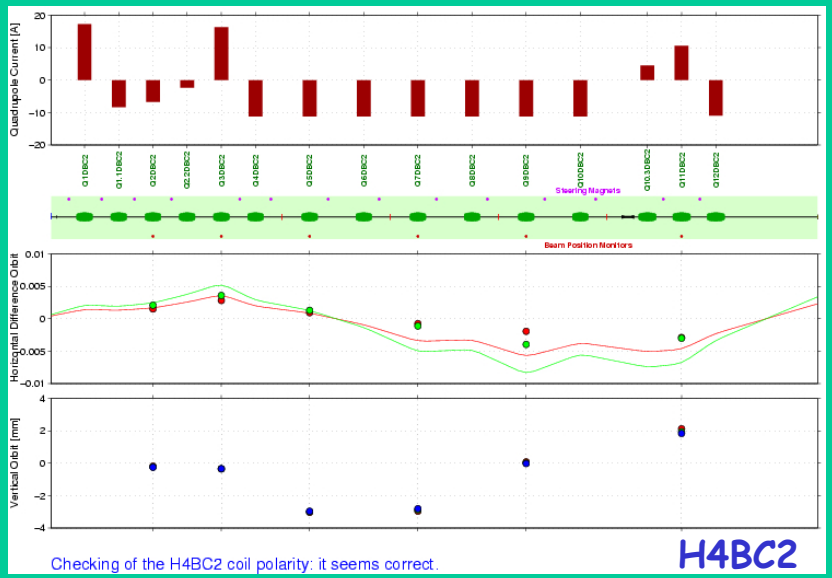
H2BC2

The correspondence between actual measurements (dots) and theory (solid lines) is not perfect (some reasons for that are known), but as concerning coil polarity, it is more that satisfactory.



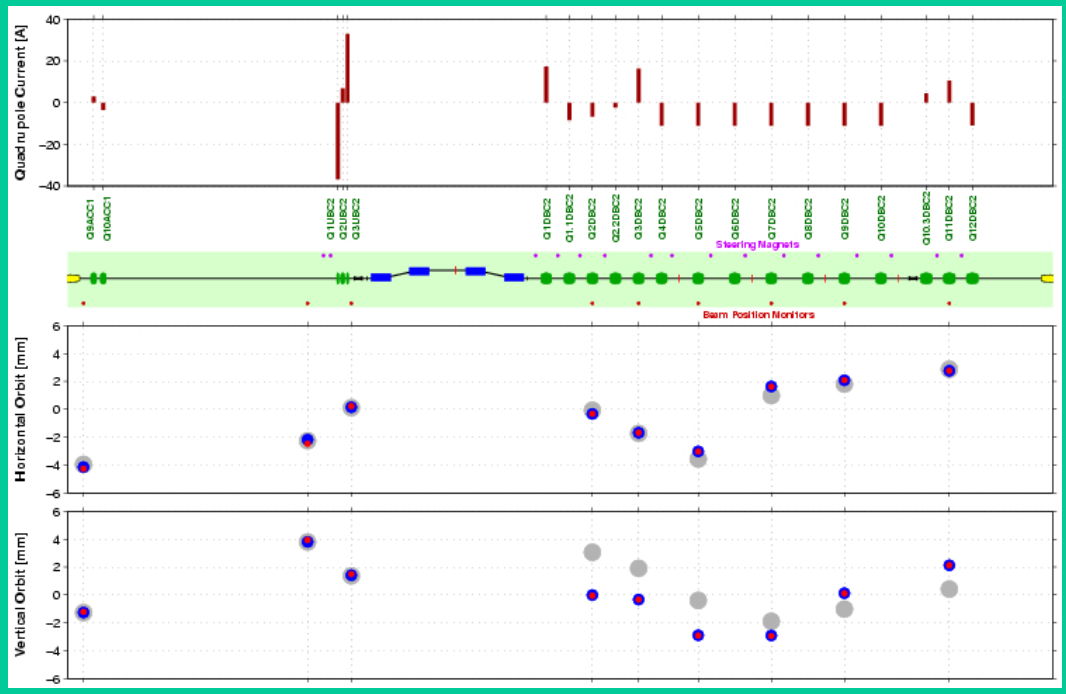
Checking of the H3BC2 coil polarity: it seems correct.

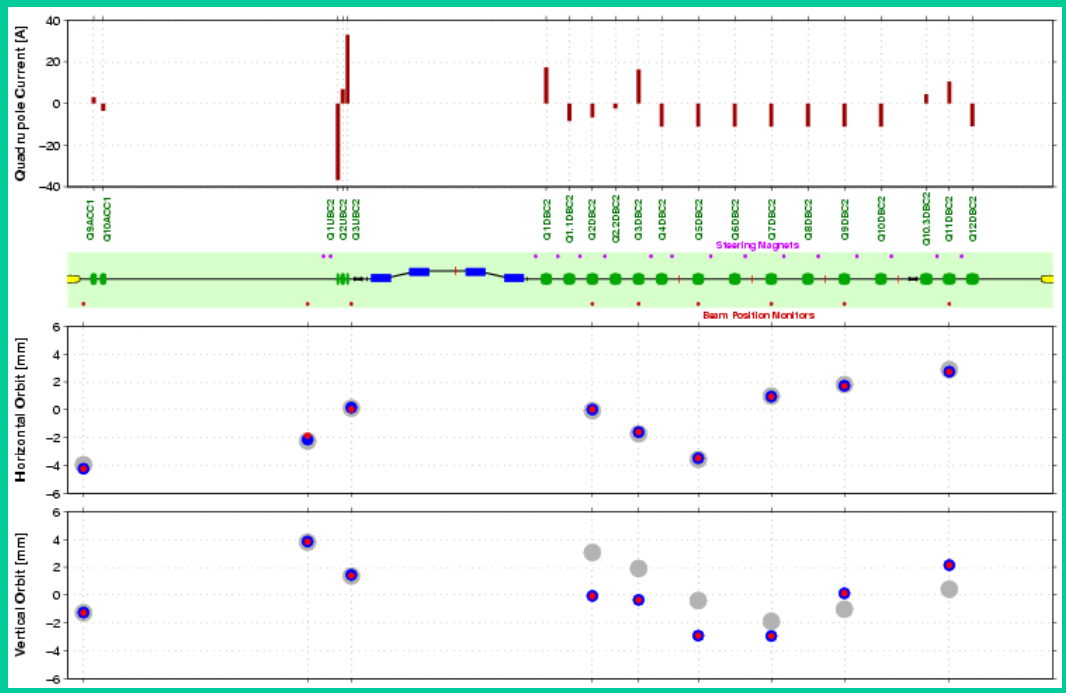
H3BC2



Checking of the H4BC2 coil polarity: it seems correct.

H4BC2





Step 6: BC2 on after degauss

old setting (P.Castro)

H1BC2: 0

H2BC2: -0.762 A

H3BC2: -0.970 A

H4BC2: +1.029 A

after tuning

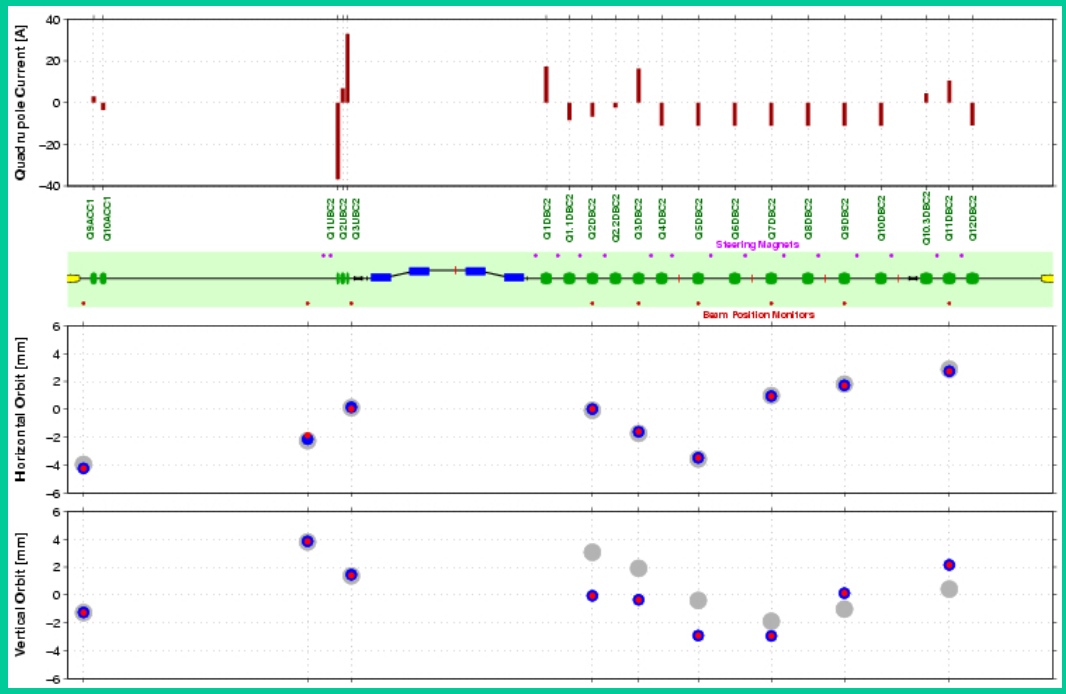
H1BC2: +0.015 A

H2BC2: -0.652 A

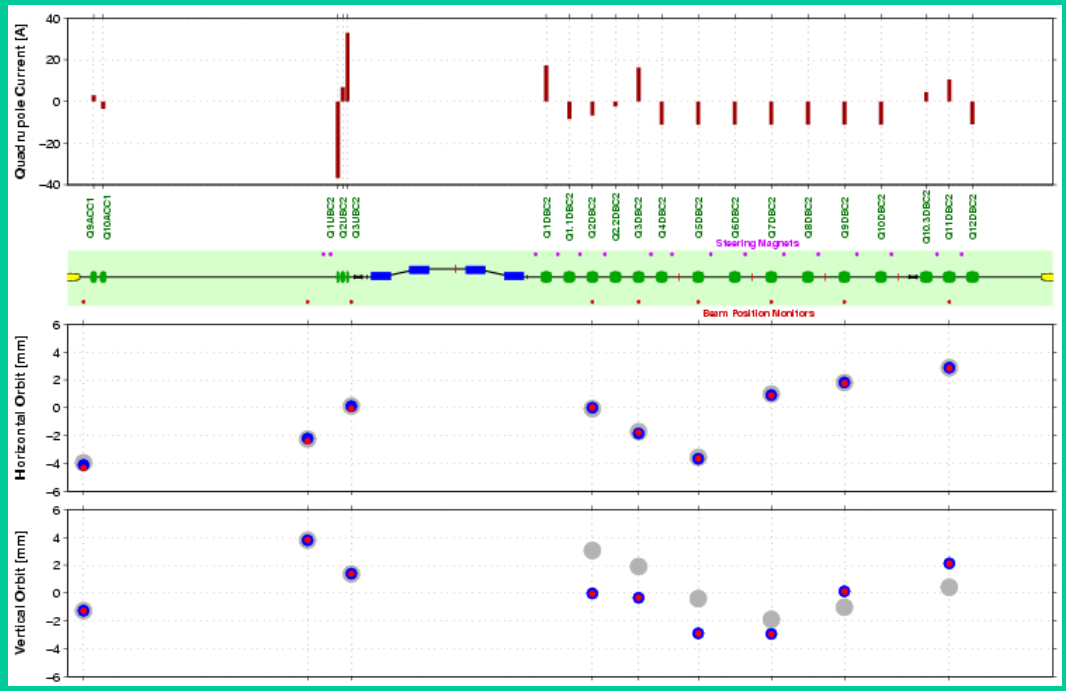
H3BC2: -1.077 A

H4BC2: +1.209 A

Step 6: BC2 on after degauss

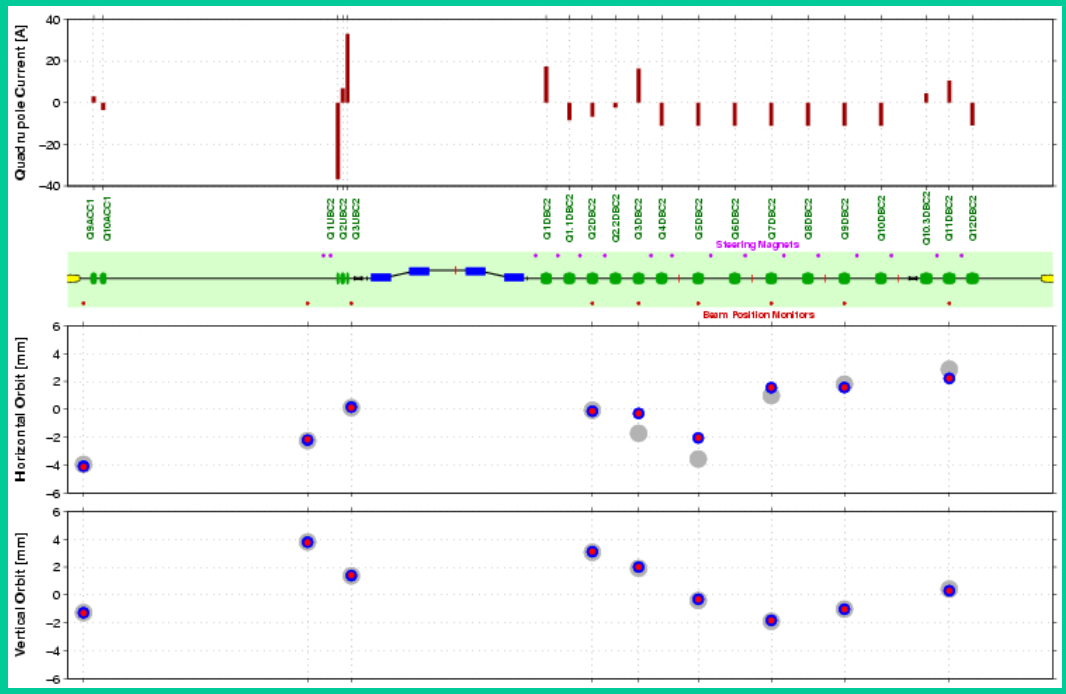


Setting 1
H1BC2: +0.015
H2BC2: -0.652
H3Bc2: -1.077
H4BC2: +1.209

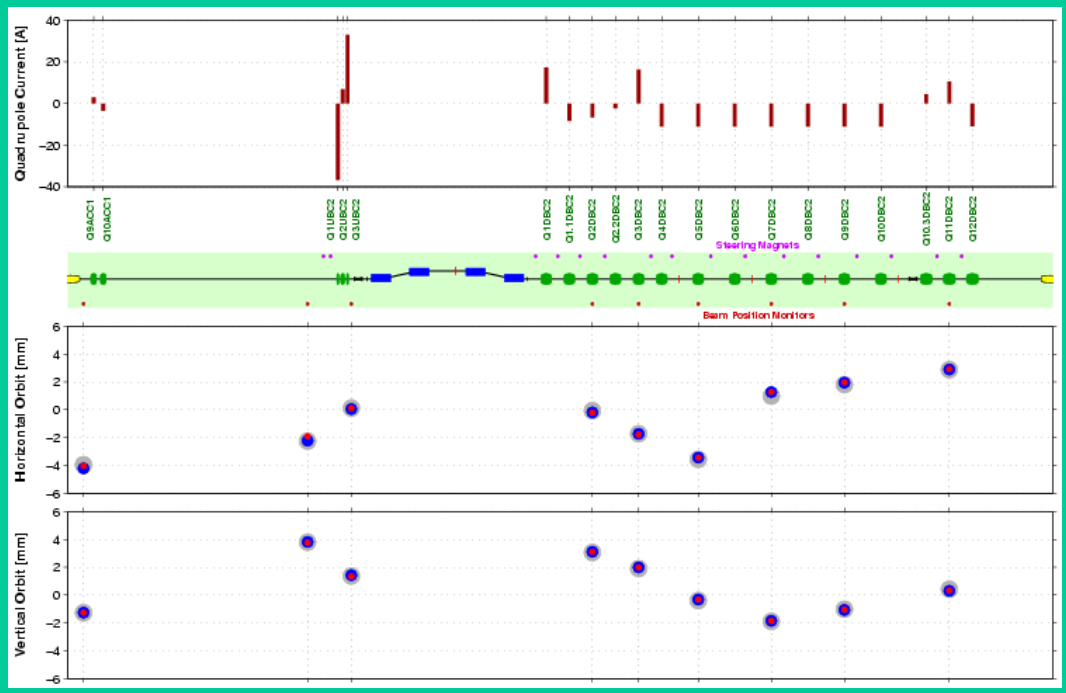


Setting 2: min sum of | I |
H1BC2: +0.136
H2BC2: -1.062
H3BC2: -0.070
H4BC2: +0.612

Step 7: BC2 off after degauss



old setting
H1BC2: +1.4 A
H4BC2: +1.4 A



after tuning
H1BC2: +1.523
H4BC2: +1.465

One can argue that due to some factors, which have not be taken into account (dipole tilts, …), the dispersion produced by BC2 is still large, but as with a part of our general strategy we are satisfied by results because

1. One can easily check: Is something wrong (with PS, …) by comparing trajectory with BC2 on and BC2 cycled to zero field.
2. If the difference appears to be un-appropriate (exact sense has to be defined), the full procedure (due to its simplicity) can be repeated by any operator with the help of software prepared.
3. It is clear that difference in vertical orbits with bunch compressor on and off (BC2 and BC3) has to be used to remove the large vertical offset and angle at bunch compressor entrance. Since cycling to zero and back is time expensive (≈ 6 min) and iterations could be needed, an efficient algorithm has to be developed.

Developed method looks to be a new approach to the bunch compressor correction coils setup and works!

Many thanks to all colleagues who helped us to make this experiment successful.