



Automatic Angular Alignment of LHC Collimators



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Introduction

The LHC makes use of a collimation system to protect its sensitive areas from unavoidable beam losses. Collimators are positioned close to the beam using an alignment procedure. Until now they have always been aligned assuming no tilt between the collimator and the beam, however tank misalignments or beam envelope angles at large-divergence locations could introduce a tilt limiting the collimation performance. Three different methods have been implemented to automatically align collimators at various angles in order to determine the best one. These methods are based on a semi-automatic alignment algorithm which has been used in operation these past years, and is able to correctly align the collimators with minimal error, given that the user is present.

1 Angular alignment with reference

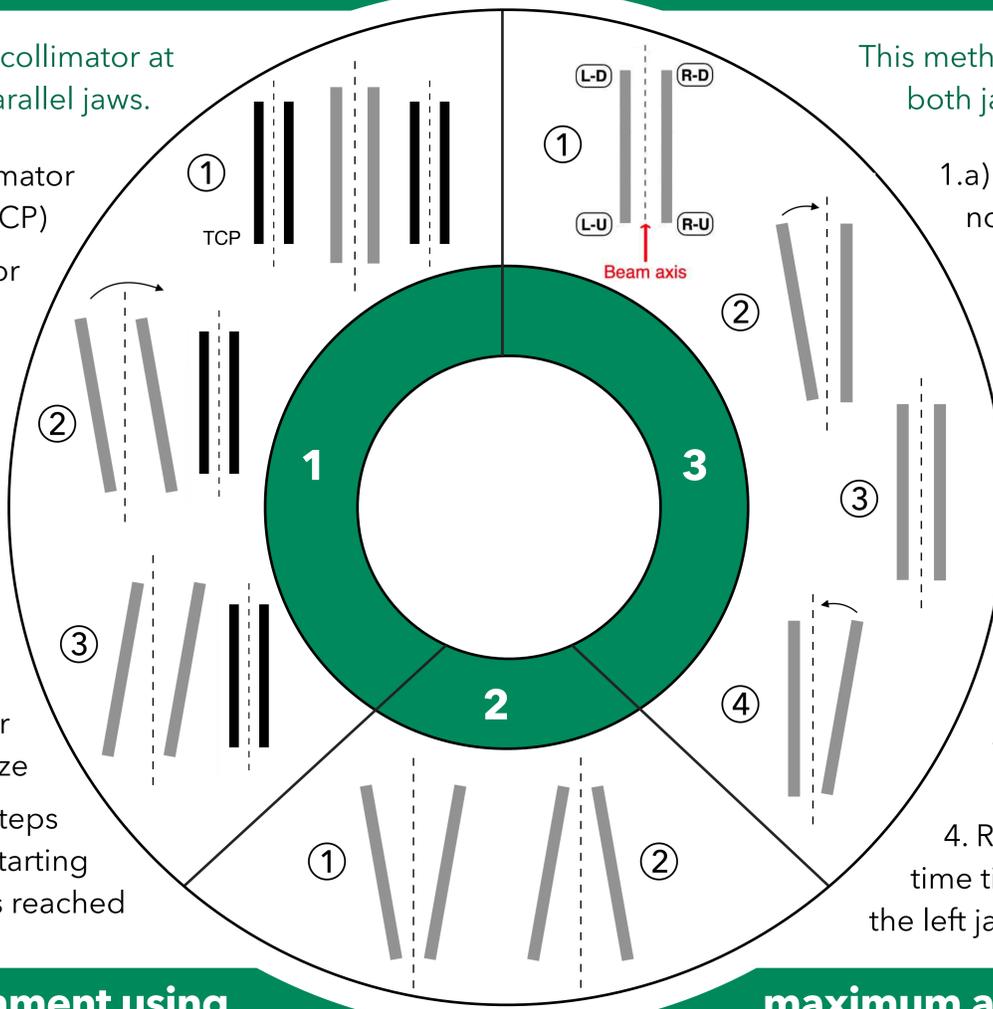
This method aligns the collimator at various angles with parallel jaws.

- 1.a) Align reference collimator (TCP)
- b) Align angular collimator
- c) Align reference collimator
- 2.a) Retract and tilt angular collimator at the largest angle
- b) Align angular collimator
- c) Align reference collimator
- 3.a) Retract and tilt angular collimator by a step size
- b) Repeat the above 3 steps until the negation of the starting angle is reached

3 Angular alignment using single jaw

This method independently aligns both jaws at various angles.

- 1.a) Align angular collimator with no tilt
- 2.a) Retract and tilt the left jaw at the largest angle
- b) Align both jaws
- c) Retract and tilt the left jaw by a step size
- d) Repeat the above 2 steps until the negation of the starting angle is reached
3. Tilt the left jaw back to its initial angle
4. Repeat the entire procedure, this time tilting the right jaw and keeping the left jaw as a reference



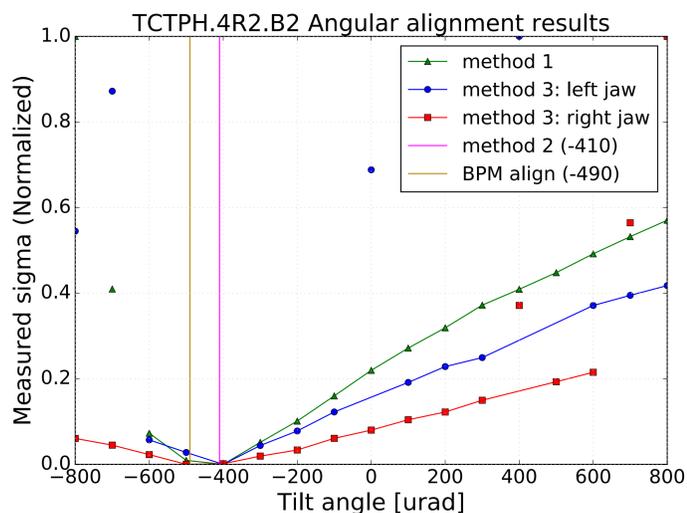
2 Angular alignment using maximum angles

This method aligns the collimator's upstream and downstream corners individually.

- 1.a) Retract and tilt angular collimator at maximum angle with upstream corners closest to beam (1900 μ rad)
- b) Align angular collimator

- 2.a) Retract and tilt angular collimator at maximum angle with downstream corners closest to beam (-1900 μ rad)
- b) Align angular collimator

Results



The TCTPH.4R2.B2 which is a tertiary horizontal collimator in IP2 beam 2, was aligned using the three angular methods, and the results are shown in the plot on the left. The time taken for each of the three methods are: 22 minutes for method 1, 5 minutes for method 2 and 15 minutes for method 3.

The results indicate that the most optimal angle is approximately -450 μ rad which is also similar to the result obtained using the BPM (-490 μ rad).

The plot shows a number of outliers which are misalignments due to the semi-automatic alignment algorithm used. A more robust and fully automatic alignment algorithm based on spike recognition is planned to improve it.

Conclusion

The implementation was successful as it worked automatically and, as intended, no human intervention was required. The results obtained indicate that the most optimal angle can indeed be calculated using each of the methods. Selecting which method to use depends on the situation: Method 1 when there is a real offset in the tank, Method 2 to quickly calculate the upstream and downstream centers and Method 3 in the case of asymmetries within the collimator itself.