Comments on Alignment table

General

Not covered... BPM placement and D1 and D2 alignment

Table arrangement:

Rows are arranged by alignment events, which have a direct correspondence to the assembly of the inner triplet. It is arranged in order of assembly, starting with single components and working towards integrated triplet. See the enclosed diagram

1a) Single MQX cold mass This deals with the local imperfections of the cold mass. The average harmonic imperfections are assumed to be corrected by the local correctors. Average offsets are dealt with in steps 2-4

1b) Single multilayer corrector field The relative angles and offsets of the nested coils are here. This is assumed to be performed at CERN prior to Fermilab assembly.

2a) Relative alignment of MQX magnets in composite Q2

For the case of the Q2 only, there will be two MQX magnets rigidly joined in one cold mass. The relative alignment cannot be modified once in the cryostat. In practice, the magnetic center of Q2a , Q2 b and the combined Q2a-Q2b magnet will be separately measured and the best magnetic axis will be determined Based on these determinations, the location of the Q2a-b cryostat in the tunnel should be adjusted as per AP requirements.

2b) Relative alignment of corrector in a composite Q2 and Q3

The corrector packages will be mounted on the front face of MQX magnets.

3) Placement of composite coldmass into cryostat and relating magnetic axis to external fiducial

This deals with the placement into cryostats of Q1, Q2, Q3, complete with correctors, absorbers etc. The magnetic axis will be determined warm and, for most magnets, cold and this axis will be related to external fiducials on the cryostat.

Since not all of the magnets will be measured cold, it is important to understand the correlation between warm -cold measurements. How stable are the internal magnets supports so that the position does not shift with thermal cycle and transport? How does the supports affect sag?

4) Alignment and Survey into IR

This is largely the domain of the installers. What are the accuracies for the tunnel installation and how does this effect the AP requirements? In the case of Q2, how should the Q2a/Q2b misalignments be handled? What effect, if any, is the tunnel cryostat mounts on the sag and otherwise deformation of the cold mass.

Columns are arranged by three criterion for alignment: AP requirements, mechanical tolerances and measurement and survey accuracy.

The **AP requirements** are goals set by the AP community for achieving the accelerator luminosity and dynamic aperture requirements.

Mechanical tolerances refer to how well the various components can be aligned as a consequence of the construction process.

Measurement and survey refers to the ability to measure by any means the specified alignment

The general idea is to see which column is the limiting factor. If for example, the AP requirement is much tighter than the practical achievable mechanical tolerance, then we have to either revisit the AP goals or search for new ways to build the cryostat. Also, it doesn't make sense to achieve a mechanical tolerance that is beyond the measurement capabilities.