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Description of CBETA magnet tuning wire holders

S. Brooks

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Collider Accelerator Department
Brookhaven National Laboratory

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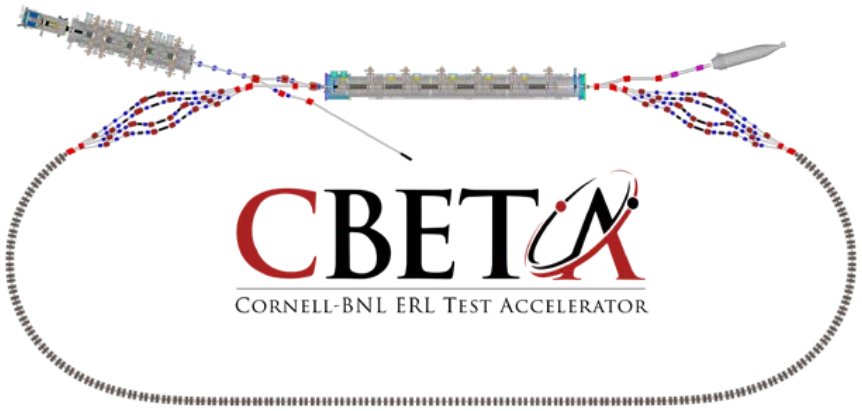

Collider-Accelerator Department, Brookhaven National Laboratory, Upton NY 11973
U.S. Department of Energy
Office of Science, Office of Nuclear Physics

Cornell Laboratory for Accelerator-Based Sciences and Education, Ithaca, NY 14850

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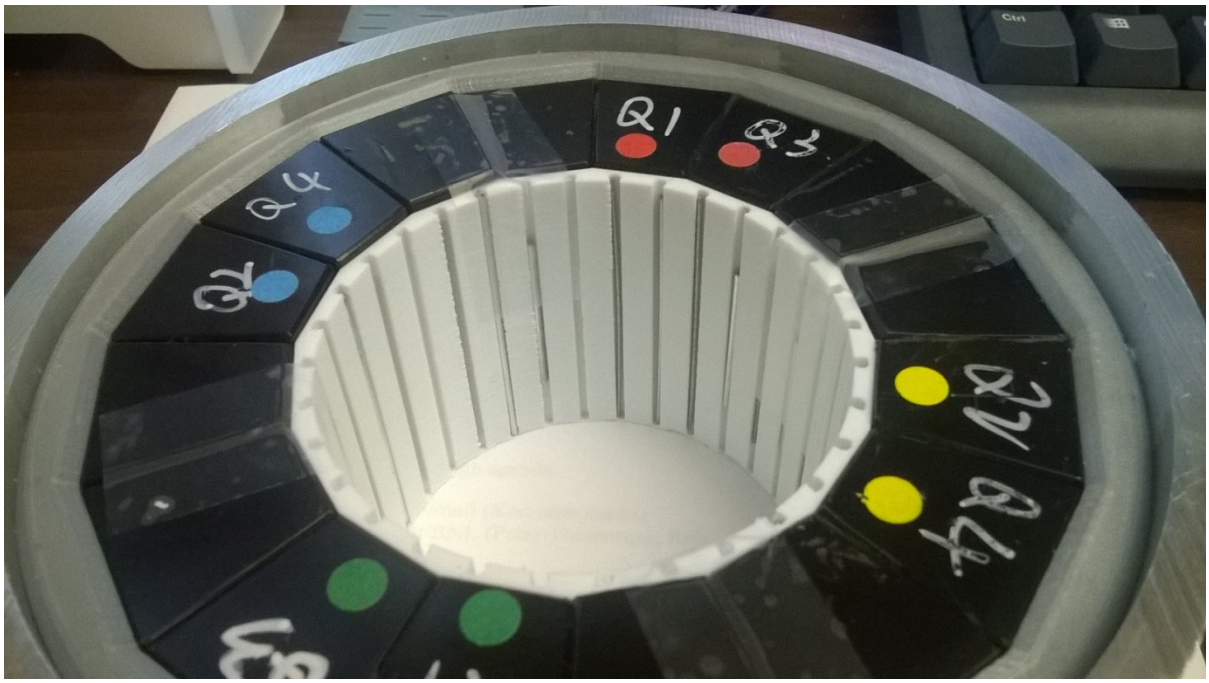
Description of CBETA Magnet Tuning Wire Holders

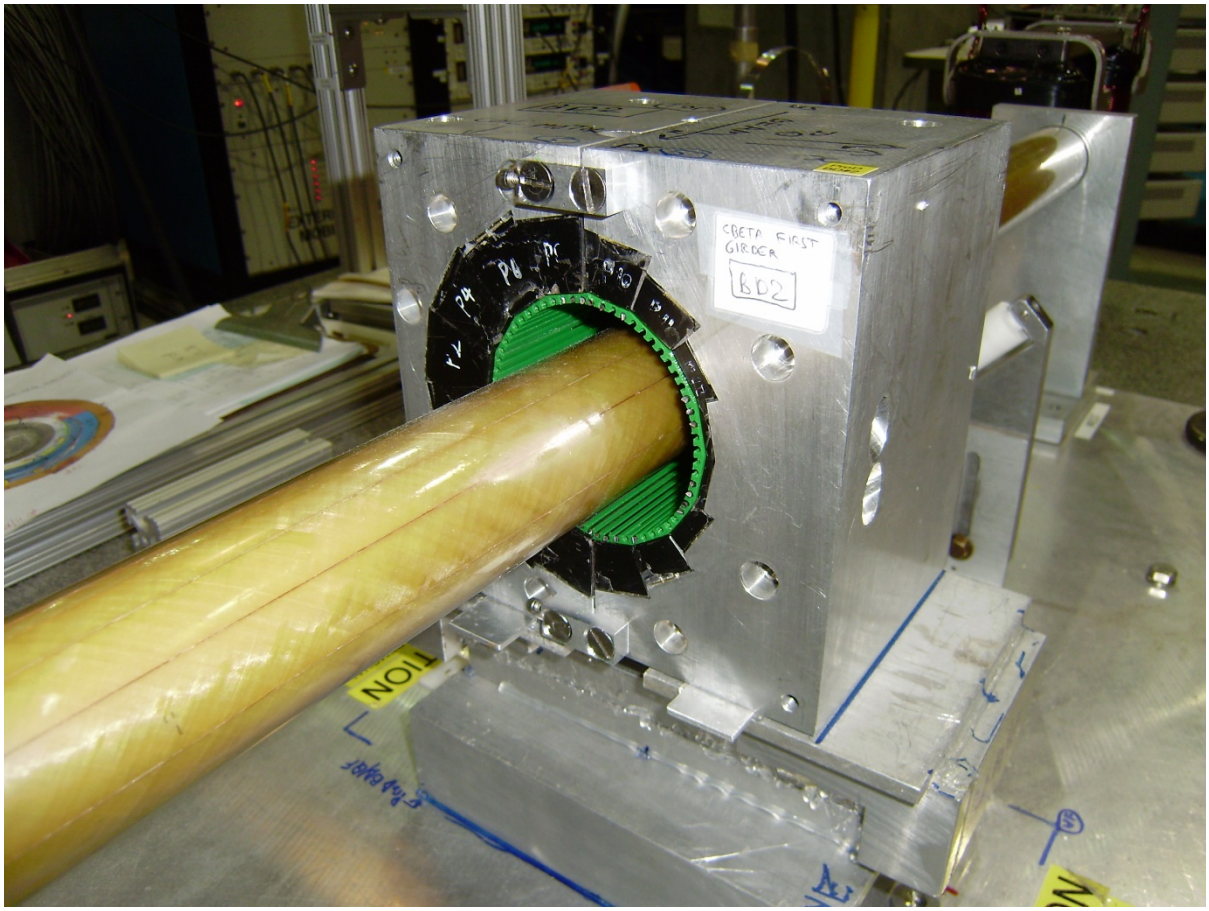
Stephen Brooks 2017-Jul-19 CBETA machine note #018

1. Introduction

A non-magnetic insert will be placed directly inside the permanent magnet blocks in every CBETA Halbach magnet in order to hold a set of iron "tuning wires". These wires have various lengths around the perimeter of the aperture in order to cancel multipole field errors from the permanent magnet blocks. An example of such a wire holder made of 3D printed plastic is shown below.

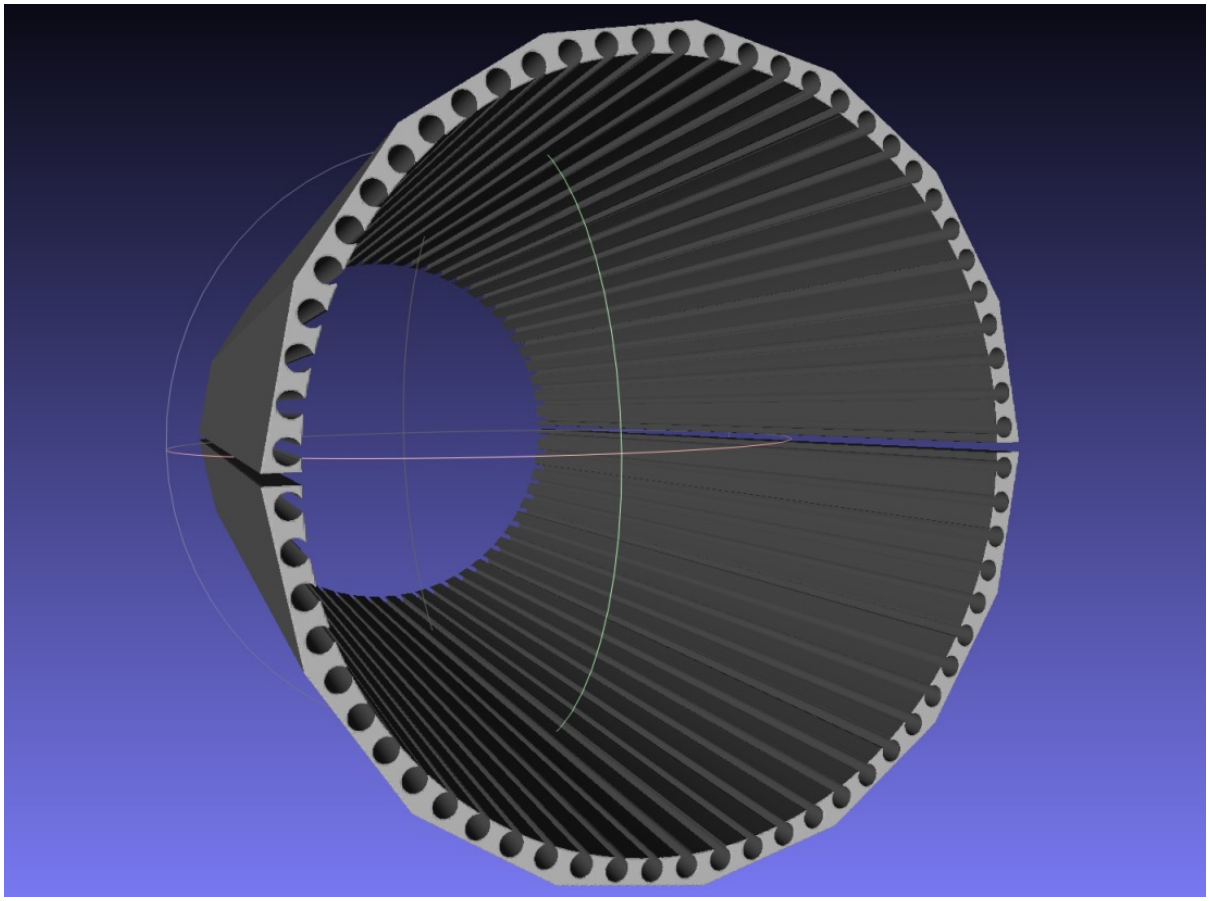


Note that the holder can be made of any non-magnetic material and that the holder pictured above has only 32 slots for wires, fewer than in the final version. The picture below shows a CBETA "first girder" magnet undergoing rotating coil measurement while containing a plastic wire holder.



2. Geometry Description and Dimensions

The interior of each Halbach magnet is a 16-sided regular polygon in cross-section. The CBETA magnets split into two halves, so the shim holders will be made in halves too (both halves are shown in the 3D model below). Each shim holder half has a large circle removed from the centre of the polygon, which becomes the final usable magnet bore, as well as 64 equal-sized, equally-spaced holes all at the same radius. The holes are offset by half of a gap so a hole does not interfere with the place the two holder halves join. The holes are placed so that the holder is continuous on the outside but the wires can be seen on the inside (this will help with removing wires if needed). However, the holes must be sufficiently indented into the plastic so that the wires do not fall out.



There are two types of Halbach magnet bore in CBETA: 108 QF-type magnets and 108 BD-type magnets. Their dimensions are shown in the table below, consistent with v6/v6.5 of the CBETA Halbach magnet designs.

Parameter	QF-type wire holder	BD-type wire holder
Associated magnet types	QF	BD, BDT1, BDT2, QD
Magnet length	133.0mm	122.0mm
Radius to corner of 16-gon	~47.105112mm	~44.046339mm
Radius to side of 16-gon	46.2mm	43.2mm
Radius of bore circle removed	43.3mm	40.3mm
Radius to centre of wire holes	44.484mm	41.484mm
Number of wire circles	64	64
Radius of wire*	0.080”	0.080”

* It is possible a larger radius e.g. 0.105” may be used depending on magnet quality, which would probably also thicken the holder and reduce the overall bore circle.

3. Fits

The shim holder should fit within the magnet bore ideally with a small amount of friction; it can be glued in place once the wires are inserted correctly. For 3D printed plastic, the radius was reduced by 0.2mm to account for plastic roughness (3D printer layers) and any magnet construction errors.

The wires should fit within the holes so that they can slide in longitudinally with a small applied force, but ideally with enough friction so that they do not fall out of place if the holder containing

wires is picked up and turned over. Again, 0.2mm was added to the wire radius to give the hole radius in the case of 3D printed plastic (fast print on Ultimaker 2).

Wires may be glued in place to prevent them moving when the holders are being placed in the magnet (the magnet will strongly attract the wires).

4. Automated Wire Placement

The wires may be inserted robotically in the future, in which case the ends of the wire holes facing the robot should be flanged outwards – for instance growing by 1mm in radius over 5-10mm length – to better guide the wires into the holes.