BNL-114512-2017-TECH
CBETA/003;BNL-114512-2016-IR

Halbach magnets outline construction method

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October 2016

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC), Nuclear Physics (NP) (SC-26)

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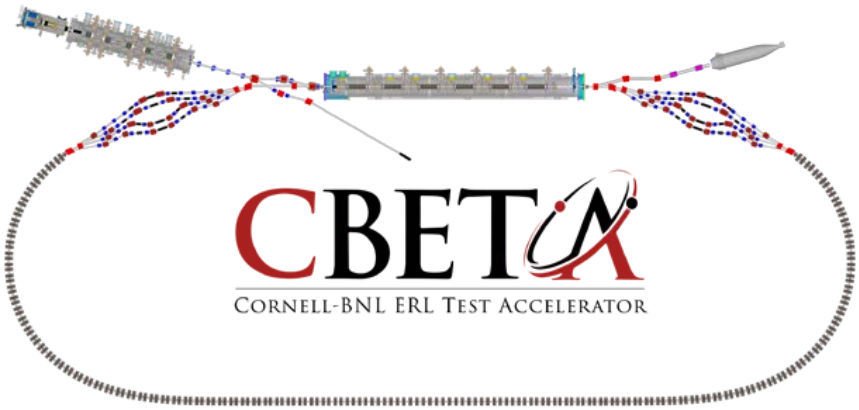

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Funded by NYSERDA contract 102192

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Halbach Magnets Outline Construction Method

Stephen Brooks, Dejan Trbojevic, Nick Tsoupas, George Mahler 2016-Oct-28
CBETA machine note #3

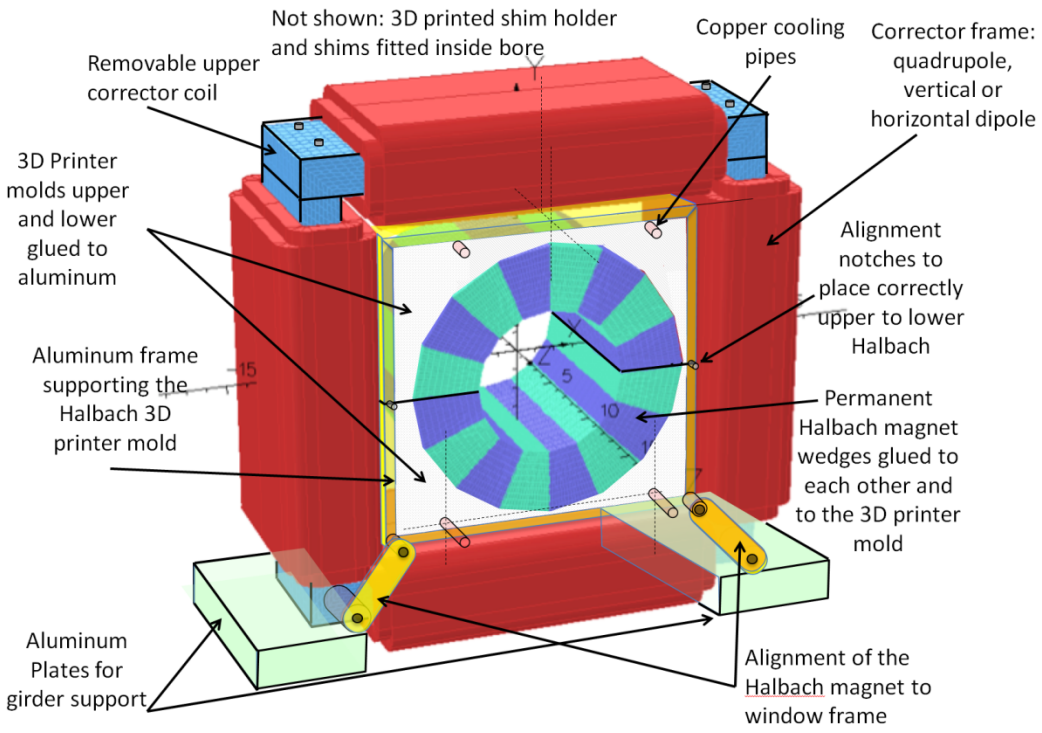
Overall Assemblies and Quantity

There are two types of magnet assembly, QF and BD. These share a common outer frame and also include the same windowframe corrector around them. The differences are only (a) the thickness of the NdFeB permanent magnet wedges, (b) the shape of the 3D printed mould fitting around the wedges inside the aluminium holder and (c) the length of the overall magnet. All assemblies are splittable in order to fit the vacuum pipe through them.

Table 1: numbers of assemblies and lengths

Magnet assembly type	Number in design (CDR)	Number in magnet costing (includes some spares), comparable to iron costing	Length (mm)
QF	106	110	133.3
BD	107	110	121.7
Total	**213**	**220**	

Figure 1: assembly schematic parts



Cross-Sections with Dimensions

Figure 2: BD magnet cross-section

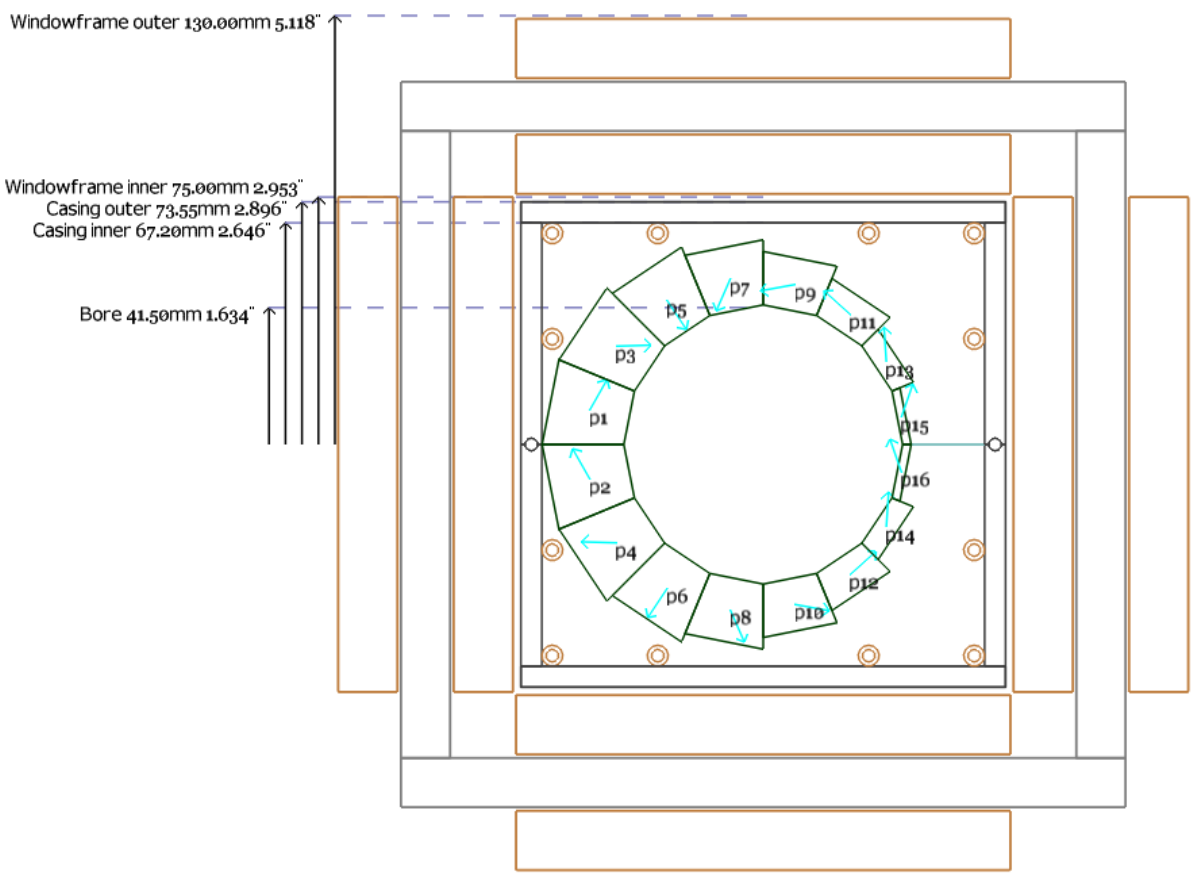
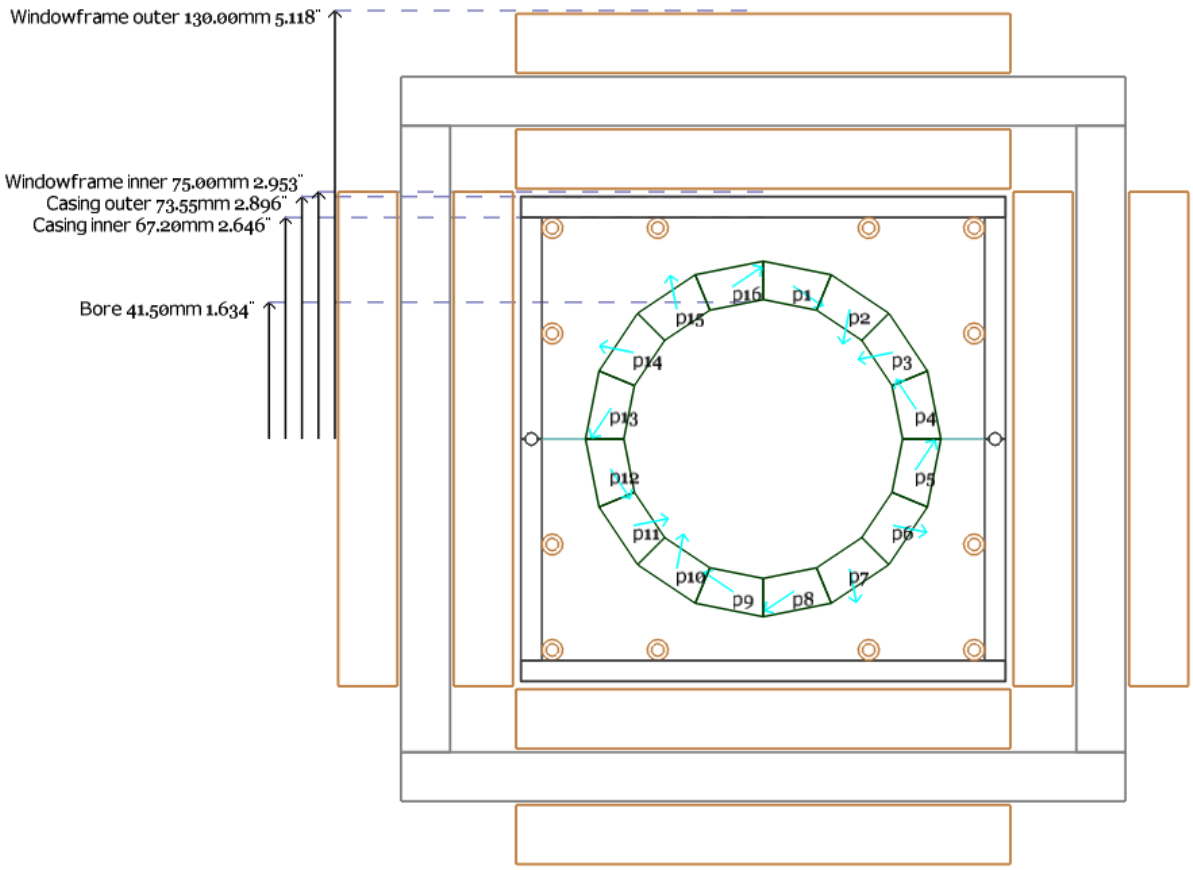
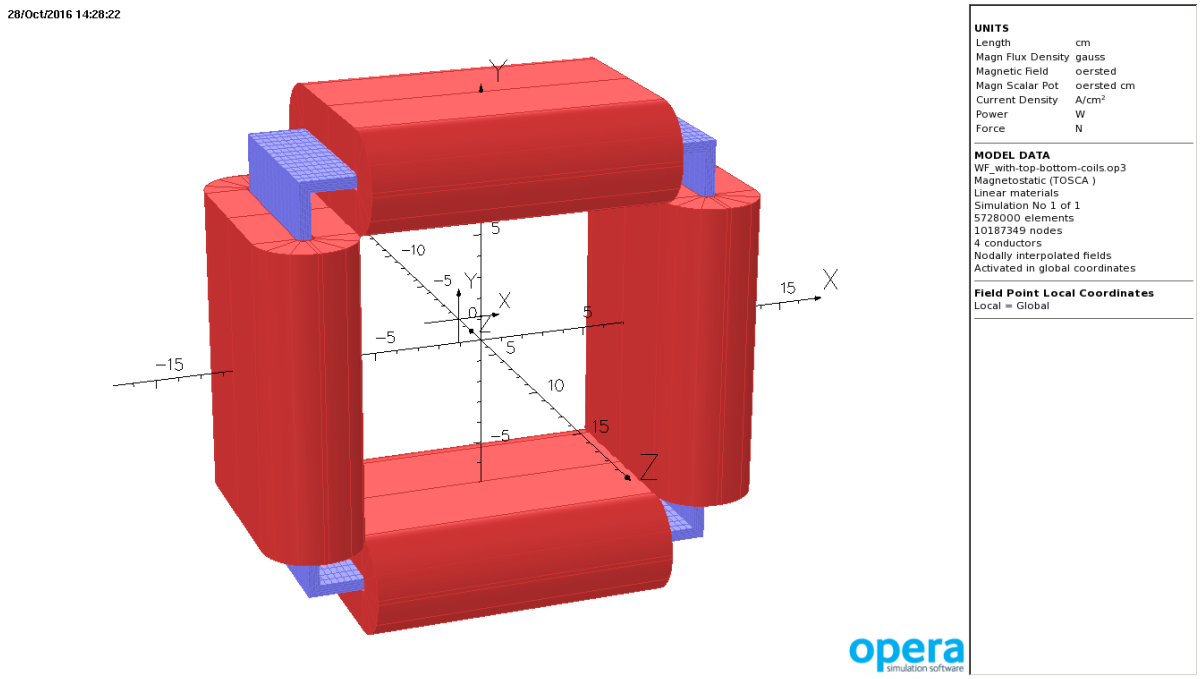


Figure 3: QF magnet cross-section



The windowframe iron is 15mm thick and the coils are 20mm thick on each side. An OPERA-3D model of the corrector is shown in figure 4.

Figure 4: windowframe corrector model in OPERA-3D by Nick Tsoupas



3D issues

The windowframe iron will be shortened in the longitudinal axis so the coils do not “overhang” the nominal magnet length.

Table 2: Parts List (excluding pins, screws etc.)

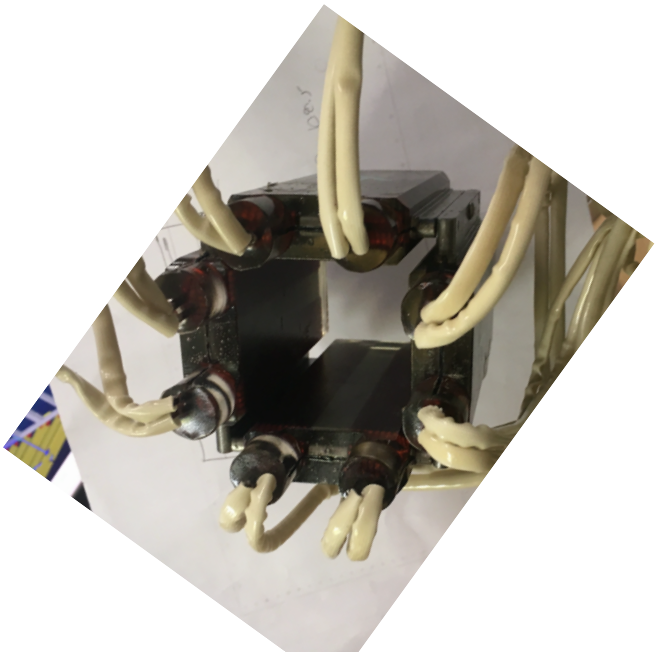
Part	Material	Number per magnet	Total number
Permanent magnet wedges	NdFeB	32 (2 layers of 16)	7040
Shim holder halves	3D printed plastic	2	440
Shimming wires	1006/1008 steel wire	32	7040
Moulds to hold wedges	3D printed plastic	2	440
Copper cooling pipes	Bent ¼” copper tube	2	440
Halbach casing	¼” thick Al plate	6	1320
Halbach-to-windowframe attachment plates	Steel plate	4	880
Windowframe iron	15mm thick 1006 iron	4	880
Windowframe coils	Cu potted in epoxy	4	880

Table 3: Assembly Methods

Part A	Part B	Attachment method
Permanent magnet wedges	Mould to hold wedges	Glue, while hammering blocks into plastic mould
Permanent magnet wedges	Permanent magnet wedges	Glue
Permanent magnet wedges	Shim holder halves	Glue before commencing shimming/rotating coil
Shimming wires	Shim holder halves	They stick there by magnetic force, helped by sockets in the shim holder, but can glue or epoxy in place when done
Moulds to hold wedges	Halbach casing (halves)	Glue, should also be good fit
Halbach casing (Al plates)	Halbach casing (Al plates)	Screws attaching two plates at 90 degrees
Halbach casing (upper half)	Halbach casing (lower half)	Pins in drilled holes to ensure accurate, repeatable alignment
Halbach casing (lower half)	Windowframe iron (lower half)	Via the Halbach-to-windowframe attachment plates, using screws or bolts
Windowframe coils	Windowframe iron	Manufacturer's choice
Windowframe iron (top/lid)	Windowframe iron (lower part)	Manufacturer's choice, probably screws
Windowframe iron (lower part)	Girder	6-axis adjustable mount

Figure 5: Glue tested at C-AD that (when dried) holds permanent magnet wedges together even when they repel.

Figure 6: Example of windowframe magnet with potted coils, similar construction will be used for CBETA's corrector.



Shimming Method

1. Assemble whole magnet including corrector iron
2. Glue shim holder halves into bore
3. 1st rotating coil measurement
4. Run program that outputs wire sizes/lengths (fast)
5. Cut wires to length and insert in shim holder (1hr)
6. 2nd rotating coil measurement
    a. Include survey of coil axis to magnet fiducials this time
7. If harmonics are low enough finish, otherwise re-shim for another iteration (go to step 4).

Typically only 1 or 2 iterations (2 or 3 coil measurements total) are required.