Rings Magnets Cost Estimate

P.Fabbricatore

INFN Genova

1) Methodology
2) Used parameters
3) Magnets layouts
4) Costs (preliminary)

PRELIMINARY CONSIDERATIONS

- To my knowledge no pre-design of the magnets exists →
- The only way for performing a cost analysis consisted in making by myself some simple design exercises on the basis of PEPII magnets and of existing information
- I personally focused my attention to dipoles, quadrupoles and sextupoles taking as reference the SuperB magnet list provided by Marica in the file Magnets_V16.xlsx
- The information about PEPII magnets were extracted from PEPII TDR and integrated with additional information coming from Uli Wienands.

Methodology

1. A cross section has been supposed. In most cases it is a modified PEPII magnet

2. A magnetic computation is done (using COMSOL) just for checking the magnet layout is reasonable. This allows evaluating the dimensions and the weights on the main materials

3. A cost evaluation was analytically done taking into account a certain number of parameters

4. Analysis of the PEPII magnets potentially usable for SuperB with or without modifications. The associated cost is evaluated.

Parameters for cost evaluation

Materials subdivided into magnetic steel (lamination 1 mm thick were considered for all the magnets), conductor (copper conductor with hole for cooling), insulations (conductor and ground insulation), stiffening structures (longitudinal plates and end yoke flanges), other mechanical components (bolts, rods,), hydraulic circuit with manifolds, alignment components, other materials.

Engineering for constructive design . Indeed I am supposing that the engineering design is done by CabibboLab at level of engineering drawings, not yet at executive level. The constructive drawings are done by the industry as well as the design of the tooling, the material and components procurement and the definition of the constructive methods and the list of tests and controls. (Built under specification)

Cost of dedicated tooling: winding line, impregnation mold, blanking devices for the lamination, assembly and heat treatment of lamination, assembly tools

Cost of generic tooling. tool usable for all magnets such as autoclave, oven, magnetic measurement fixture. I have assumed the firm constructing the magnet partially has in hand this tooling and consequently the associated cost has been considered with a cut of 50%. These cost has been considered one time for all the magnets (In case of orders given to different companies this cost would increase)

Manpower for construction including the following operations: blanking of the lamination, assembly of lamination for forming the yoke, heat treatment of yoke for gluing the lamination, welding of stiffening plates to the yoke, winding of conductor, under vacuum impregnation of the coils, assembly of coil into the yoke, magnet finishing with mechanical, electrical and hydraulic connections, quality controls and engineering follow up. In regarding the lamination it is supposed that no fine blanking is required.

Magnetic measurements on finished magnets

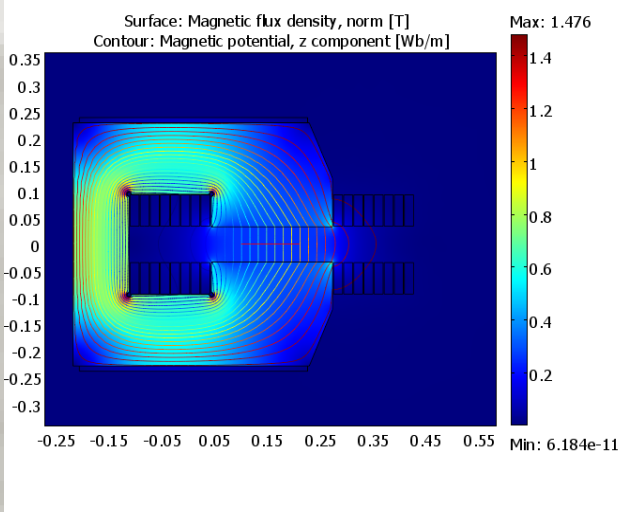
Material costs

Yoke lamination EBG POWERCORE 1200-100 A with Stabolit 70	1.7 €/kg
Copper tube	from 15 to 22 €/kg
Machined ARMCO plates	from 12 to 17 €/kg
Epoxy	7.7 €/kg
Glass	11 €/m

Manpower costs

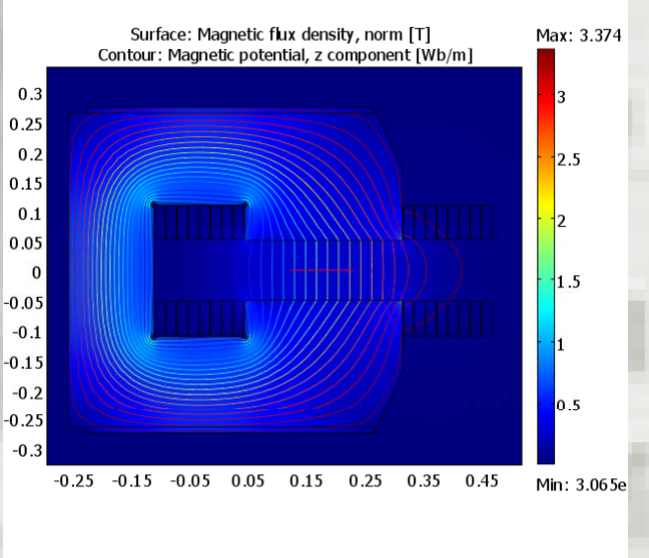
From 60 €/h to 90 €/h

The (assumed) magnets



HER dipole; 68 mm gap; 0.257 T; 877A; 1750 kg/m; 194 magnets; 7 types

Manufacturing Engineering	450
Specific tooling	450
Generic tooling	180
Material and components	7039
Manpower and QA	9116
Total cost	17235 k€



HER dipole; 100 mm gap; 0.257 T; 1250A; 2380 kg/m; 194 magnets; 7 types

Manufacturing Engineering	450
Specific tooling	450
Generic tooling	180
Material and components	8983
Manpower and QA	11371
Total cost	21434 k€

Magnet cost estimate

P.Fabbricatore INFN Genova

HER dipole; 68 mm gap

Name	B(T)	N	L(m)		Material	Man-power	Manuf.
B0SL	0.067	1	2.8		33589	44689	78279
B2BL	0.077	2	4.1		95090	113177	208267
B1DR	0.084	1	3.65		42714	52470	95184
B2AR	0.087	2	4.1		95090	113177	208267
B0SR	0.091	1	2.8		33589	44689	78279
B0AL	0.101	3	4.1		142635	169766	312401
B1DL	0.113	1	3.65		42714	52470	95184
B1BL	0.115	2	4.1		95090	113177	208267
B0R	0.138	5	4.1		237725	282943	520668
B2BR	0.147	2	4.1		95090	113177	208267
B1BR	0.157	2	4.1		95090	113177	208267
B1CL	0.176	2	3.65		85428	104939	190368
B1AR	0.240	2	3.65		85428	104939	190368
BHER2	0.257	24	1.4		445443	764992	1210435
BHER1	0.257	78	1.7		1698892	2700412	4399304
BHER	0.257	40	5.4		2460028	2739520	5199548
BHERS	0.257	16	4.27		789920	930316	1720236
B3L	0.278	2	4.1		95090	113177	208267
B3R	0.284	2	4.1		95090	113177	208267
B4L	0.286	1	4.1		47545	56589	104134
B5L	0.286	1	3.65		42714	52470	95184
B5R	0.292	1	3.65		42714	52470	95184
B4R	0.292	1	4.1		47545	56589	104134
BHERJ	0.319	2	4.1		95090	113177	208267
					0		
Total					7039345	9115681	16155026

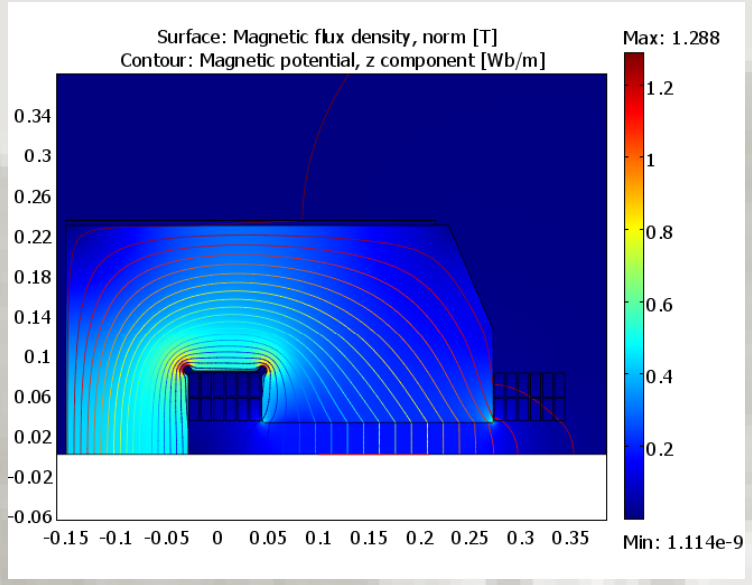
Potential cost saving if taking the 40 PEPII dipoles 5.4m long is 5199 k€, but ..

packing and delivery, replacement of Al coil with Cu coil, QA and test cost shall be added.

Magnet cost estimate

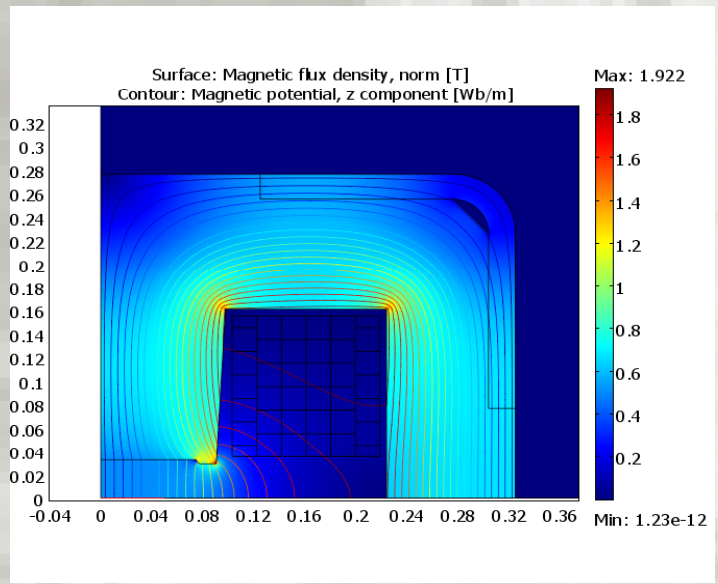
P.Fabbricatore INFN Genova

3nd SuperB Collaboration meeting @INFN-LNF



LER dipole low field; 64.8 mm gap; 0.182 T ; 237A; 1420 kg/m; 34 magnets; 3 types

Manufacturing Engineering	243
Specific tooling	350
Generic tooling	0
Material and components	808
Manpower and QA	1752
Total cost	3153 k€



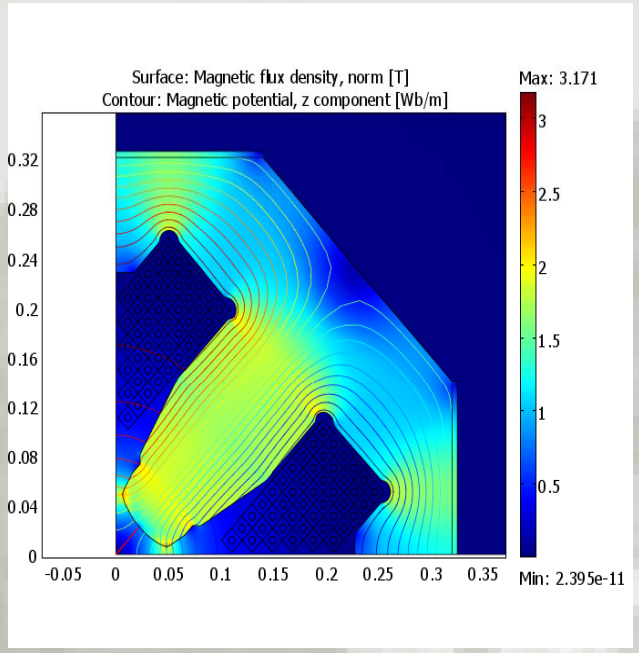
LER dipole high field ; 64.8 mm gap; 0.509 T ; 386A; 2470 kg/m; 210 magnets; 3 types

Manufacturing Engineering	405
Specific tooling	350
Generic tooling	0
Material and components	3293
Manpower and QA	7133
Total cost	11181 k€

Magnet cost estimate

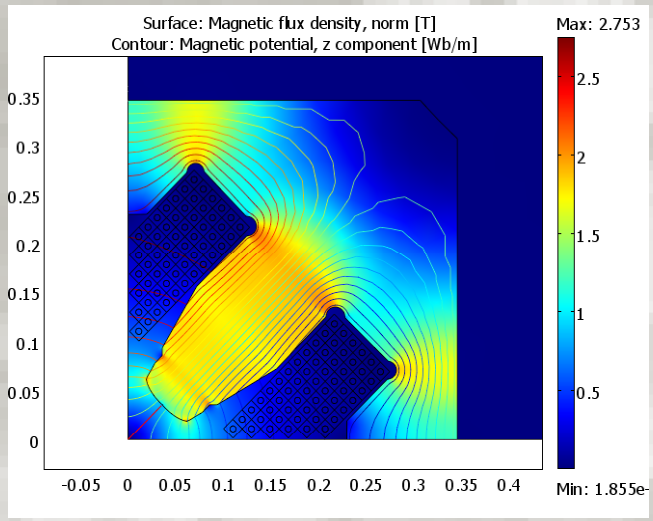
P.Fabbricatore INFN Genova

3nd SuperB Collaboration meeting @INFN-LNF

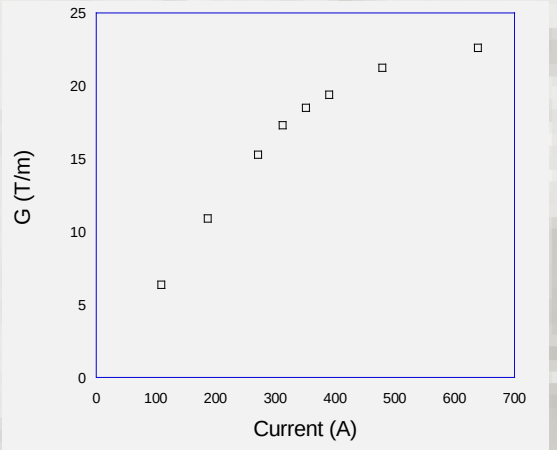


HER&LER quad; 60 mm bore28 T/m ; 350A; 2372 kg/m; 364 + 364 magnets; 3 types

	HER	LER
Manufacturing Engineering	378	108
Specific tooling	290	190
Generic tooling	0	0
Material and components	2477	2583
Manpower and QA	7700	8008
Total cost	10845	10889



HER quad; 100 mm bore (PEPII type).

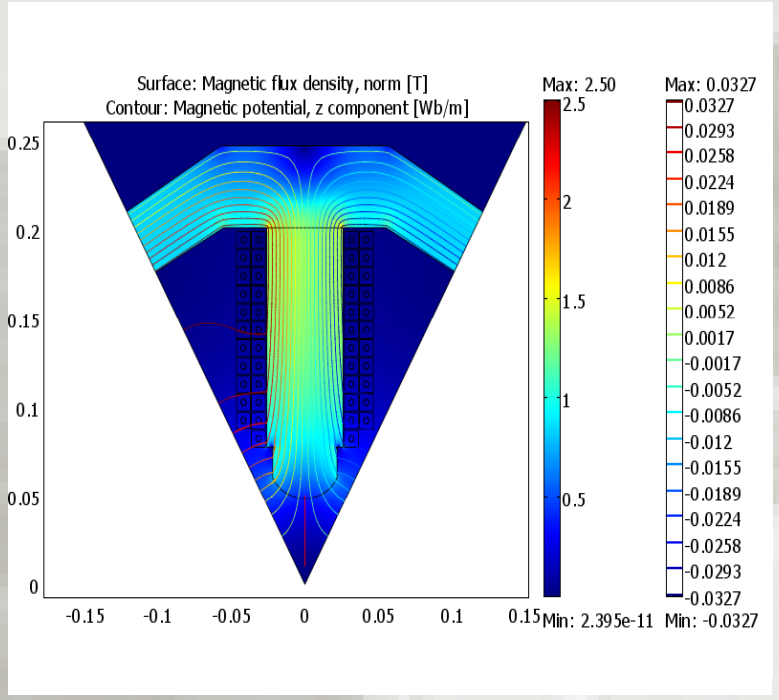


A limitation was found at 22 T/m.

Magnet cost estimate

P.Fabbricatore INFN Genova

3nd SuperB Collaboration meeting @INFN-LNF



HER&LER sextupoles ; 60 mm bore; 170 T/m^2 ; 230 A; 1133 kg/m; 200 magnets; 3 types

Manufacturing Engineering	378
Specific tooling	320
Generic tooling	0
Material and components	679
Manpower and QA	3693
Total cost	5070 k€

Summarising Table (at present time)

Magnet type	Gap/bore (mm)	Cost (k€)	PEPII potential saving
HER dipole (C-shaped)	68	17235	5199
HER quadrupoles	R30	10845	0
LER dipole low field (C-shaped)	64.8	3153	0
LER dipole high field (H-shaped)	64.8	11181	4204
LER Quadrupoles	R30	10889	0
HER & LER Sextupoles	R50	5070	-
Octupoles/Correctors		?	
Spin rotators		3550	
Final doublets		3800	
Girders		-	
Total		65723	

Thank you for your attention