INFN
Istituto Nazionale
di Fisica Nucleare

CABIBBO LAB
Laboratorio Nicola Cabibbo

March 26th 2012

(Draft rev.1)

Report on the conclusions of the SuperB magnet costing working group

The working group members are M. Biagini (INFN-LNF), A.Clozza (INFN-LNF), P.Fabbricatore (INFN-Genova) (chair), E.Levichev (BINP), C.Sanelli (INFN-LNF), D.Tommasini (CERN), U.Wienands (SLAC).

Introductory considerations

The questions posed to the working group by SuperB management (see annex A) were triggered by the need to evaluate the proposal of the Budker Institute about the possibility to build some of the Main Rings magnets and the vacuum chamber. This proposal included a list of items that can be provided by BINP and the relative costs.

First of all we have to stress a series of preliminary considerations

- The basic document available to the Working Group is constituted by an excel file (*Magnets_V16.xlsx*) including the main characteristics of all dipoles, quadrupoles and sextupoles of the HER and LER lattices. Namely the field or gradient and the magnetic length are reported for any magnets.
- Some additional information about magnets was coming from PEPII TDR and from the CDR of SuperB.
- This basic information is indeed poor because important parameters such as magnet gap or bore, good field region and beam stay clear are not clearly specified.
- No magnet design exists also at very basic level.
- Under these conditions the mission of the working group appeared very difficult. The only way we could perform, at least partially, our work was to make ourselves

assumptions about the magnet structures if not some simple design exercises on the basis of the existing information.

- An important parameter is the magnet gap or bore. For LER dipoles gaps from 63.3 mm to 100 mm were considered. For HER Dipoles gaps from 60 mm to 100 m were used for evaluation. For quadrupoles, bore radius of 30 mm and 50 mm were considered and finally for sextupoles ~~a~~ bore radius of 30 mm and 50 ~~of 100 mm~~ was used. The reason why we analysed these gap/bore ranges is based on three main considerations:

  a) the lower limits directly were coming from indications given by SuperB responsible for the lattice;

  b) the upper value for the dipoles reflects a worry about the effects on beam pipe dimensions of the needed vacuum pumping rate;

  c) the upper value of the quadrupoles and sextupole bore is an assumption.

Methodologies

Two different methods were used oriented to have as final output a cost evaluation of thee ring magnets:

a) The first method is involving ~~scaling~~ optimization formulae based on a long experience with these kinds of magnets (see annex B for the details) from which the basic geometry of each kind of magnet is calculated and then, using these data, some CERN's Cost Evaluation formulae are applied to each magnet and the cost is evaluated starting from the basic material costs.

b) The second method followed an analytical approach passing through magnetic computations of supposed magnet structures and then evaluating technically and economically the magnets (see annex C for a detailed report).

The vacuum line and ancillary were analysed after some considerations about synchrotron radiation power (see annex D)

Findings

As first general remark we noted that the varieties of magnet appear to be quite large. As an example the HER include dipoles with 7 different lengths with field ranging from 0.067T to 0.319T and 22 different currents involved. For LER quadrupoles we have 3 main magnetic lengths, but more than 100 different currents (ranging from 5 A to 400 A).

A reduction of the number of magnet types and especially of the number of different currents could be helpful later, in view of a better optimization of magnet designs with advantages for the costs of magnets and power supplies.

A second remark is related to the quadrupoles. The HER include many high gradient quadrupoles (16÷20 T/m<G<32 T/m). These magnets are reasonable from the cost point of view if the bore is 60 mm. For larger bore (we looked up to 100 mm bore) the magnets are very massive and expensive. Some re-thinking about the needed gradients by the lattice designers looks necessary.

Costs

The result of the cost (in **k€**) analysis is summarised in the Table 1. The table includes the costs of the magnets as they would be bought new. Both the results of the ~~scaling~~ first and the ~~analytical~~ second approaches are shown. For both methods two different evaluations are reported: one for smaller gaps/bores and a second one for larger dimensions. The table can be used for composing the costs depending on the technical choices. However we can distinguish two main cases depending on the dimensions:

a) Dipole HER 60 mm/68 mm gap. Dipole LER 63.3 mm/64.8 mm gap. Quadrupole 60 mm bore. Sextupole ~~100~~ 60 mm bore. The total cost of the rings magnets is ranging **from € 57234,** first approach, **to 58673**(?? – 58373) to k€ 59100(??), second approach.

b) Dipole 100 mm/ gap. Quadrupole 100 mm bore. Sextupole 100 mm bore. The total cost of the rings magnets is ranging **from € 82086, second approach, to k€ ~~89930~~(?? – 89437), first approach**.

The table 1 also includes the costs of 4 spin rotators and of the final focus quadrupoles. These are all superconducting magnets.

The table also includes the costs of the girders simply considered as a 10% of the total cost. Finally the costs of the vacuum components and equipments is also included

Table 1: Cost evaluation

Item	**Optimization approach**		**Analytical approach**	
HER	Dipole Gap 60 mm Quad Bore 30 mm Sext. Bore 100 mm	Dipole Gap 100 mm Quad Bore 50 mm	Dipole Gap 68 mm Quad Bore 30 mm Sext. Bore 100 mm	Dipole Gap 100 mm Quad Bore 50 mm
Dipole	**16937**	**25893**	**17235**	**21434**
Quadrupole Low Gradient	**1349**	**2500**	**10845**	Not evaluated
Quadrupole High Gradient	**8576**	**16013**		
Sextupole	**2783**	**2783**	**2535**	
LER	Dipole Gap 63.3 mm Quad Bore 30 mm Sext. Bore 100 mm	Dipole Gap 100 mm Quad Bore 50 mm	Dipole Gap 64.8 mm Quad Bore 30 mm Sext. Bore 100 mm	Dipole Gap 100 mm Quad Bore 50 mm
Dipole Low field	**2641**	**3947**	**3153**	**3864**
Dipole High Field	**14034**	**20425**	**11181**	**14776**
Quadrupole Low Gradient	**5626**	**10430**	**10889**	Not evaluated
Quadrupole High Gradient	**2505**	**4663**		
Sextupole	**2783**	**2783**	**2535**	
Spin rotators			**3550**	
Final focus			**3800**	
Girders for magnets rings			**6000**	**8000**
Vacuum pipes				
RF shielded bellows and valves				
Pumps				
Valves				
Gauges				

Reuse of PEPII magnets

In general it is noted that there are two possible modalities for reusing the PEPII magnets. a) Some of the SuperB dipoles fit the length of existing PEPII magnets. In principle these magnets could be used "*as they are*". In facts the PEPII magnets have the windings in aluminum, while for electrical power consumption reasons all SuperB magnets shall involve a copper conductor. So these magnets shall be dismantled, new coils shall be constructed and then integrated into the yoke; finally magnetic test shall be performed.

b) For the magnet with different lengths only the iron yoke can be partially reused after a cutting for meeting the geometrical lengths of SuperB magnets.

Analysing the option *a)* for 40 dipoles of HER (the ones with length 5.4 m) with the analytical approach, one find that the costs to be paid are k€ 1525 for material and k€ 2353 for manpower. If new built, the costs for these 40 magnets is k€ 5047, giving a cost saving of k€ 1169.

Option *b)* for the remaining 154 dipoles of HER implies a cost of k€ 8923 with a cost saving of k€ 2012.

In total the costs saving for HER dipoles seems to be k€ 3190 over a total cost of about k€ 17000. <u>The potential cost saving of 18% is too low to be seriously being considered</u>, because the risks in re-using old equipments.

The same considerations apply to all magnets.

Comparison with proposal of Budker Institute

Comparing the costs reported in this document with the proposal made by Budker Institute, one can see that the costs envisaged by the Working Group are a factor about two higher than the BINP ones. From the analytical analysis it appeared that the manpower costs for the option with smaller gaps/bores is about 37000k€ (see Annex C). Considering that BINP could have these costs 50% lower, the BIMP costs are still 70% lower than the Working Group estimations. This point needs more deep discussions and it is presently post-poned to future developments.

Answer to the questions

On the basis of the studies and analyses done by the working group, the answers to the question posed by SuperB management are:

1. Are the magnet parameters adequate to the SuperB main rings?

Answer: The basic information is presently quite limited (important parameters such as magnet gap or bore, good field region and beam stay clear are not ~~clearly~~ specified) and no magnet design exists also at very basic level. The answer to this question can be only partial. The working group thinks that some work is needed on the lattice optimization aimed to define the dipole gaps taking into account the problems coming from vacuum issues. A high pumping rate could require gaps as large as 100 mm with consequent high cost of the magnets. The quadrupoles of the HER and some quadrupole of LER have too high gradient (> 20T/m) requiring difficult and heavy magnet to be designed and built if the bore is 100 mm. For 60 mm bore no problems are envisaged.

- *Are there clear economic advantages in using the PEP---II rings magnets?*

  The SuperB ring magnets are quite different from PEPII magnets. In facts a lot of SuperB magnets have lengths not matching the PEP magnet lengths. In case gaps of 60 mm are acceptable, PEPII dipole could be reused with a potential cost save of 18%. For the quadrupoles (if bore is 100mm) same considerations apply; in this case cost saving can be even lower because the replacement of all the coils is a driving factor of the costs and the higher gradient quadrupoles shall be procured new. Considering the errors related to the present evaluation and the risks related to involve old components, the reuse of PEPII ring magnets is discouraged.

- *Are there some construction risks and what can be done to mitigate them? (for example: spare parts, maintenance strategy,…)*

  If the magnets are procured as new, there is not particular technical risk, but the high gradient quadrupoles. In general it is found that too many magnets types are presently included in the HER and LER lattices. As remarked above, a reduction of the number of magnet types and especially of the number of different currents could be helpful later for a better optimization of magnet designs with advantages for the costs of magnets and power supplies. Presently there are not the conditions for defining a spare part or maintenance strategy.

- *When and how we can define the main rings layout to evaluate its impact on civil engineering and environmental conditions?*

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2. *What is needed to assess how the solution proposed compares with the one reusing PEPII magnets*.

The suggestion of this working group is not to reuse PEPII magnets. This conclusion is based on a preliminary analysis done on the information available now. It is clear that an assessment how the option of procure new magnets compares with the reuse of PEPII magnets can be done only after a design of the magnet exists. However this Working Group is not expecting a different conclusion.

APPENDIXA

Charge to the working group

Frascat, Febru ry 14 2012

Biagini, INFN-I.NF, Frascati, ly
Oozza, INF F, Frasca IY
P. Fabbricatore, INFN-Genova, Italy *(chair)*
E. Levichev, BINP, Russia
C. SaMIIi, INF F, FraSGati, taly
O Tommasini CERN,Switzerla d
U. W enandis,SIJ\C. USA

Dear Colle

The IC)o a OIl:nbbo Laboratory, charn o lhe on$IRICIJÌOn ofii'Ie S rE! project at the Roma Tor Vergata Umrersity campus,is plannil1i to collabocate witl1 other international laooratorie:s or the pn:Msion of paru of e accelerator.

I'hl! Bu er stiNte n NOYOSIJ1rsk jRussia) has ev-al the pOSSttì!IJI:Y te bu•ìCl some o! he n :ngs magnets and lhe Ull'l eh mber. A list of item.s that an be providm by BI P, nd relati e coru, has been presented by Prot E. tevidhev.

1- *0«1et* to De a e to correaly evalu.ne me proposal *ot* filNF> we woold hke to 1nYit you. as an I!Jillert n the eld, to parl!c!Qite te en evatua on if'O'.I).

Examples of lc:ey points to be adClressed are reported befow.

1. Arewmai etparametersaclequa.li!to Su eta ma r1n1s?
   Are t111ete cleer economie edvanta es n IJSni the PEP l r1r1es ma ?
   Are thel'e oome CONtruàion risks and what can be done to mitigate mem? (for example: s Te parts, maintenance strategy, –l
   When and now we an defi e main ril1p liayout to uate its att on engjneeril'll and ental concl!'tlons?
2. t is needed to atSsess how me solution proposed cornpares the one reusing FcEPII m gnett

We hope that you will acce this charge looting forward to a *tru* l colla boration, please accept our best rea nti.

Roberto Pe ronm
Director Genera , Ca bibbo La'boratory

Walter Scandale
Director l ab infrastructures, cabibbo Labor.ltOfì'

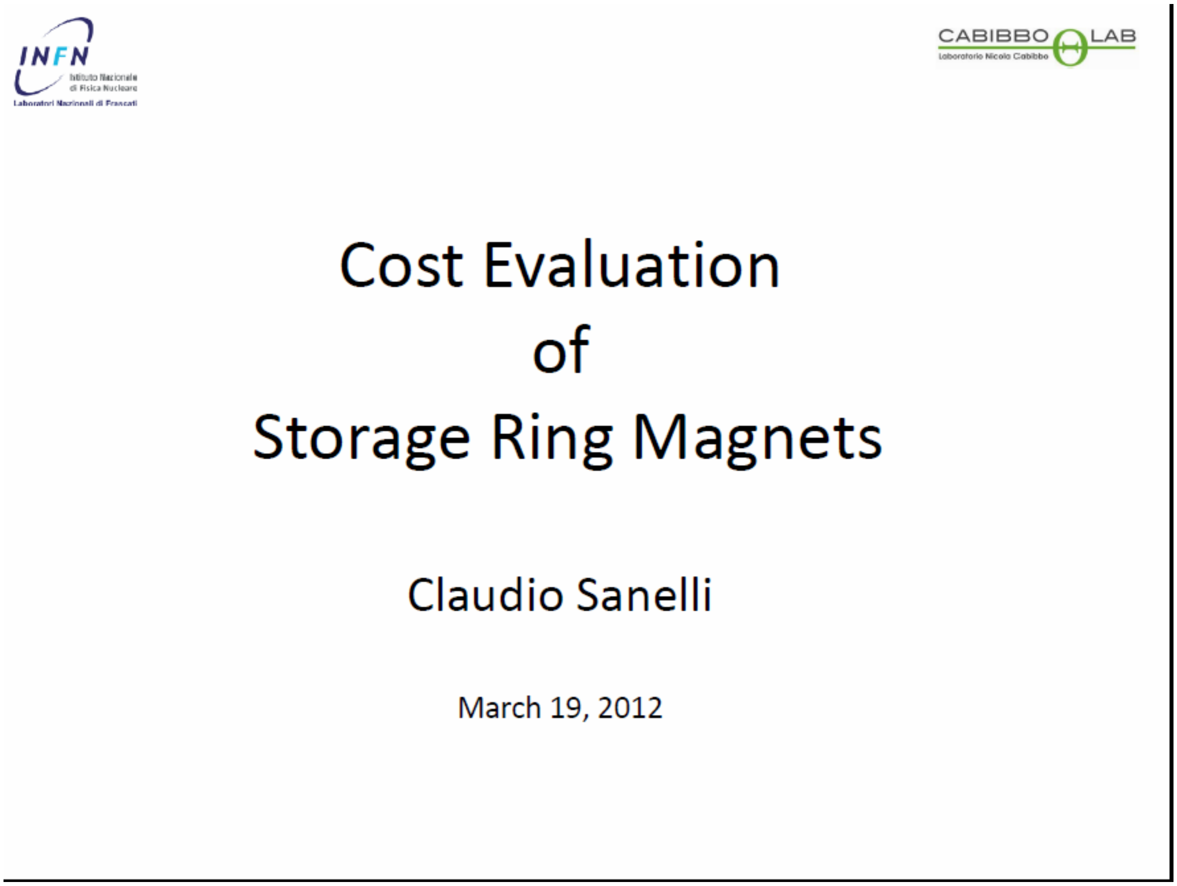
RP-WS/MRf

APPENDIX B

RINGS MAGNETS COST EVALUATION USING OPTIMIZATION FORMULAE APPROACH

C. Sanelli

Presentation given
At 3rd SuperB meeting LNF March 19-23



INFN Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Frascati

CABIBBO LAB Laboratorio Nicola Cabibbo

Cost Evaluation
of
Storage Ring Magnets

Claudio Sanelli

March 19, 2012

Preliminary Questions - 1

Some preliminary questions should be clarified to better understand the problems and to make a more clear and precise cost evaluation. Just as an example:

1) Which are the max beam dimensions (or βmax, $\mathcal{E}$max, $\mathcal{D}$max)?
2) Which are the max beam stay-clears?
3) Is there any impedance budget to be respected for the vacuum chamber? This affects the v.c. geometry, material and dimensions, then the magnet gap and/or the bore radius.

Preliminary Questions - 2

4) Are there special constrains on the vacuum chamber that affect the v.c. encumbrance like, e.g., B.P.M. or e-cloud electrodes, that impose a larger magnet gap and/or bore radius?
5) What about the power deposition due to Synchrotron Light: this again affect the v.c. geometry, the need of absorbers, the materials, etc.. The rough average value of 3 kW/m (A. Clozza) in our case ask for a careful attention and design.

Preliminary Questions - 3

6) Which is the expected Good Field Region and the related magnetic field/gradient tolerance? This again affects the physical dimensions of the magnet (width).

7) Since some magnets are very long (> 5 m), which are the overall vacuum chamber dimensions and tolerances?

8) …..

Preliminary Questions - 4

The answers to these questions (and eventually others I have forgotten) can let us understand if the PEPII magnet gap/bore radius is adequate for Super-B and go ahead with a more precise cost evaluation.

Basic Assumptions - 1

1. L.E.R. Dipoles:

1.1 Two possible gaps: 0.0633 (as per Biagini list) and 0,1 m.

1.2 Two dipole cross-section: a) low field (less than 0,2 T); b) high field (from 0,2 to 0,76 T).

2. H.E.R. Dipoles: Two possible gaps: 0,06 m (as per Biagini list) and 0,1 m, but only one cross-section.

Basic Assumptions - 2

3. L.E.R. Quadrupoles:

3.1 Two possible bore radius: 0,03 m and 0,05 m.

3.2 Two quad cross-section: a) low gradient (less than 16 T/m); b) high gradient (from 16 to 32,11 T/m).

4. H.E.R. Quadrupoles:

4.1 Two posssible bore radius: 0,03 m and 0,5 m.

4.2 Two quad cross-section: a) low gradient (less than 16 T/m); b) high gradient (from 16 to 32,11 T/m).

5. Very high gradient I.R. quads (4): not evaluated.

Basic Assumptions - 3

6. Sextupoles:

6.1 Only one sextupole type.

6.2 Reference design: ANKA sextupole.

6.3 Two possible bore radius: 0,03 m and 0,05 m.

6.4 The 0,05 bore radius sextupole is scaled by the 0,03 one only increasing the bore radius and the current but leaving unchanged the corss-section.

Basic Assumptions - 4

7. Steering magnets:

7.1 The quantities are the same of PEPII.

7.2 The costs are scaled from magnets having similar aperture (CNAO steering magnets), and similar magnetic lenght.

8. No modification, refurbishing, adaptation of the PEPII magnets has been considered

Cost Summary Table

Magnet Type	Gap/Bore Radius (m)	Cost (k€)	PEPII Saving (k€)	Gap/Bore Radius (m)	Cost (k€)	PEPII Saving (k€)
L.E.R. Dipoles (Low field)	0,0633	2641	0	0,1	3947	0
L.E.R. Dipoles (High Field)	0,0633	14034	-5396	0,1	20425	0
H.E.R. Dipole	0,06	16937	-5183	0,1	25893	0
L.E.R. Quadrupoles (Low Gradient)	0,03	5626	0	0,05	10430	-235
L.E.R. Quadrupoles (High Gradient)	0,03	2505	0	0,05	4663	
H.E.R. Quadrupoles (Low Gradient)	0,03	1349	0	0,05	2500	-2500
H.E.R. Quadrupoles (High Gradient)	0,03	8576	0	0,05	16013	-2416
Total Cost (All new magnets)		*51668*	*-10579*		*83871*	*-5151*
L.E.R. Sextupoles	0,03	2783		0,05	2783	Same Sex as 0,03
H.E.R. Sextupoles	0,03	2783		0,05	2783	Same Sex as 0,03
Total Cost (All new magnets)		*5566*			*5566*	
Steering Magnets						
L.E.R. Steering - N. 296 - 30 k€ Each		8880	-8880		8880	-8880
H.E.R. Steering - N. 282 -25 k€ Each		7075	-7075		7075	-7075
Total Cost (All new magnets)		*15955*	*-15955*		*15955*	*-15955*
Grand Total Cost (All new magnets)		**73189**	**-26534**		**105392**	**-21106**
Note: No modification, refurbishing, adaptation of the PEPII magnets has been considered!						

Modification, Refurbishing, Adaptation of PEPII Magnets
Some Considerations

Some useful data:

1) LNF Energy Cost – January 2012: 0,178 €/kWh
2) Rough Annual Cost ≈ 1 M€*Year/MW
3) Estimated max electric power: 40 – 60 MW
4) Optimum Current Density: 2 – 2.2 A/mm^2

Expected Electric Energy Cost in operation:

40-60 M€/Year

- Coil Substitution: the PEPII magnets have Al coils:

$$\rho_{Al}/\rho_{Cu} \approx 1,63$$

<u>Only for Storage Rings</u>:

Assuming: a) J= 2.2 A/mm^2; b) gap 0,0633 m

Dipole (very roughly):

H.E.R. ≈ **1 MW** L.E.R. ≈ **0,6 MW**

Quadrupoles:

$$\text{H.E.R. } \langle G \rangle = (\Sigma_i\, G_i * N_i)/\Sigma_i N_i = 19{,}62 \text{ T/m}$$

$$\Sigma_i N_i = 362$$

H.E.R. Quad Power (r=0,03, Lm=0,3 m) ≈ **1 MW**

$$\text{L.E.R. } \langle G \rangle = (\Sigma_i\, G_i * N_i)/\Sigma_i N_i = 12{,}77 \text{ T/m}$$

$$\Sigma_i N_i = 376$$

L.E.R. Quad Power (r=0,03, Lm=0,3 m) ≈ **0,43 MW**

Dipole + Quadrupole total Power: **3,03 MW**

Expected extra cost fro Al coils:

3,03 (MW)*0,63 ≈ 1,9 M€/Year

(Power converter losses, efficiency and power factor cosφ not considered).

Coils have to be built in Cu!

Mechanical (and Magnetic) lenghts have to be adjusted, then one needs:

1) Tools to dismount the magnets (dismount old coils, unsold the external containing and reinforcing plates, etc.)

Question: Are the lamination glued?

If yes, the idea to heat the magnet to unglue the laminations to re-use them appear to me not consistent. In alternative, can the magnet mechanically cut?

To be investigated.

If not, the laminations can be re-used, but:

2) Tools for positioning and packing the new magnets;

3) New containing and reinforcing external plates;

4) New fiducials for correct installation and alignment of the magnet;

5) New ancillary components to assemble the magnet (coil supports, etc.)

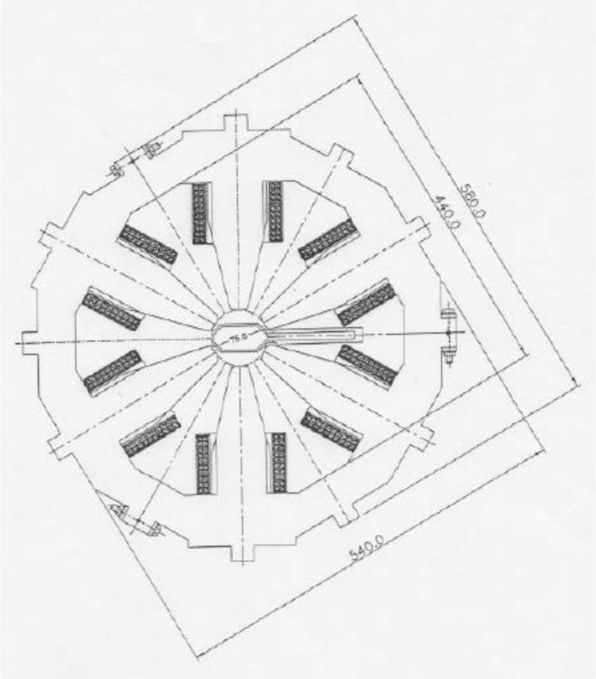
6) New coils (the length is changed)

7) New complete magnet characterization with a complete, iterative set of magnetic measurements, magnet adjustment, magnetic measurements.

8) New magnet supports and adjustment tools.

Question: finally, is the necessary manpower less expensive than the iron lamination?

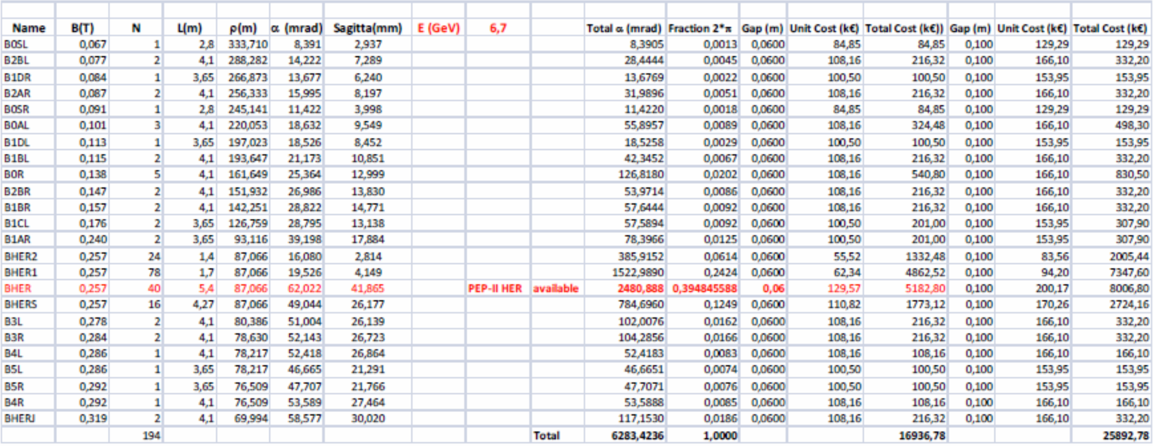
ANKA Sextupole



L.E.R. Bending Dipoles

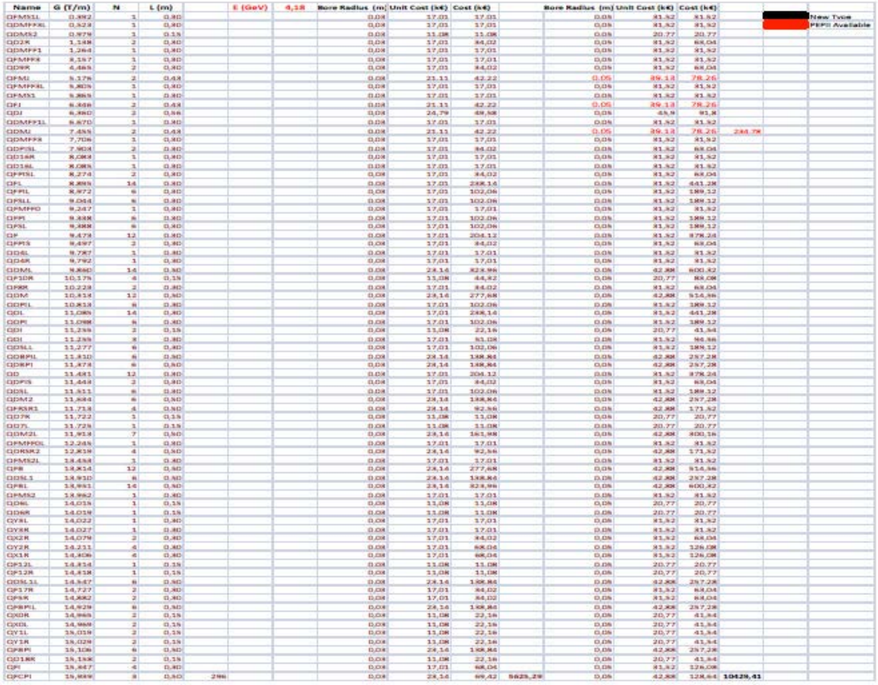
Name	B(T)	N	ρ(m)	L (m)	α (mrad)	Sagitta(mm)	E (GeV)	4,18		Total α (mrad)	Fraction 2*π		Gap (m)	Unit Cost (k€)	Total Cost (k€))		Gap (m)	Unit Cost (k€)	Total Cost (k€)
B0SR	0,042	1	333,719	2,8	8,39	2,94				8,3903	0,0013		0,0633	63,26	63,26		0,100	94,15	94,15
B2BR	0,048	2	288,393	4,1	14,22	7,29				28,4334	0,0045		0,0633	79,92	159,84		0,100	119,52	239,04
B1DL	0,052	1	267,139	3,65	13,66	6,23				13,6633	0,0022		0,0633	74,50	74,50		0,100	111,26	111,26
B2AL	0,0543	2	256,706	4,1	15,97	8,19				31,9432	0,0051		0,0633	79,92	159,84		0,100	119,52	239,04
B0SL	0,0569	1	245,070	2,8	11,43	4,00				11,4253	0,0018		0,0633	63,26	63,26		0,100	94,15	94,15
B0R	0,0633	3	220,060	4,1	18,63	9,55				55,8939	0,0089		0,0633	79,92	239,76		0,100	119,52	358,56
B1DR	0,0707	1	196,993	3,65	18,53	8,45				18,5286	0,0029		0,0633	74,50	74,50		0,100	111,26	111,26
B1BR	0,0720	2	193,652	4,1	21,17	10,85				42,3440	0,0067		0,0633	79,92	159,84		0,100	119,52	239,04
B2AR	0,0858	5	162,372	4,1	25,25	12,94				126,2530	0,0201		0,0633	79,92	399,60		0,100	119,52	597,60
B2BL	0,0918	2	151,822	4,1	27,01	13,84				54,0106	0,0086		0,0633	79,92	159,84		0,100	119,52	239,04
B1BL	0,0980	2	142,211	4,1	28,83	14,78				57,6610	0,0092		0,0633	79,92	159,84		0,100	119,52	239,04
B1AR	0,1099	2	126,763	3,65	28,79	13,14				57,5878	0,0092		0,0633	74,50	149,00		0,100	111,26	222,52
B1CL	0,1497	2	93,090	3,65	39,21	17,89				78,4190	0,0125		0,0633	74,50	149,00		0,100	111,26	222,52
B3R	0,1733	2	80,385	4,1	51,00	26,14				102,0092	0,0162		0,0633	79,92	159,84		0,100	119,52	239,04
B4R	0,1781	3	78,216	4,1	52,42	26,86				157,2573	0,0250		0,0633	79,92	239,76		0,100	119,52	358,56
B5R	0,1781	1	78,216	3,65	46,67	21,29				46,6658	0,0074		0,0633	74,50	74,50		0,100	111,26	111,26
B4L	0,1821	1	76,525	4,1	53,58	27,46				53,5775	0,0085		0,0633	79,92	79,92		0,100	119,52	119,52
B5L	0,182077	1	76,525	3,65	47,70	21,76				47,6971	0,0076		0,0633	74,50	74,50		0,100	111,26	111,26
									Sum	991,7603	0,1578				2640,60				3946,86
BHERSL0	0,421814	24	33,032	0,81	24,52	2,48				588,5208	0,0937		0,0633	76,06	1825,44		0,10	111,04	2664,96
BHERPI10	0,497878	24	27,985	0,45	16,0798	0,90448875	PEP-II LER available			385,9152	0,0614		0,0633	52,9	1269,6		0,10	76,66	1839,84
BHERJ0	0,503805	4	27,656	0,81	29,2882	2,96543025				117,1528	0,0186		0,0633	76,06	304,24		0,10	111,04	444,16
DIP_LER	0,533442	80	26,120	0,81	31,0111	3,139873875				2480,888	0,3948		0,0633	76,06	6084,80		0,10	111,04	8883,2
DIP_LER1	0,604567	78	23,047	0,45	19,5255	1,098309375	PEP-II LER available			1522,989	0,2424		0,0633	52,9	4126,2		0,10	76,66	5979,48
DIP_LERS	0,759264	8	18,351	0,45	24,52	1,38				196,1736	0,0312		0,0633	52,90	423,20		0,10	76,66	613,28
									Sum	5291,6394	0,8422				14033,48				20424,92
									Total	6283,3997	1,0000				16674,08				24371,78
	🟩	Low Field Type																	
	🟦	High Field Type																	
	🟥	PEPII Available																	

H.E.R. Bending Dipoles

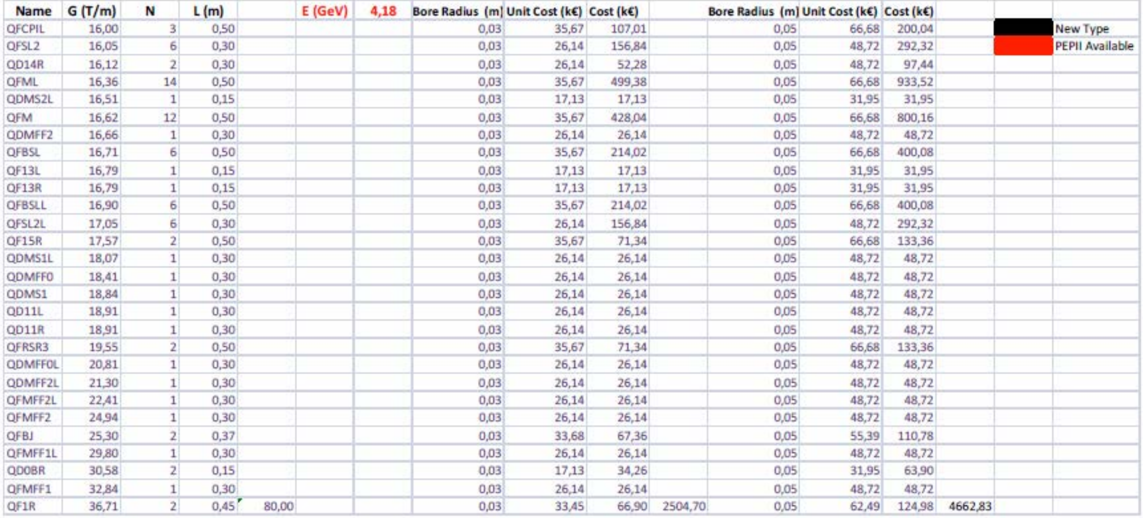


Name	B(T)	N	L(m)	ρ(m)	α (mrad)	Sagitta(mm)	E (GeV)	6,7		Total α (mrad)	Fraction 2*π	Gap (m)	Unit Cost (k€)	Total Cost (k€))	Gap (m)	Unit Cost (k€)	Total Cost (k€)
B0SL	0,067	1	2,8	333,710	8,391	2,937				8,3905	0,0013	0,0600	84,85	84,85	0,100	129,29	129,29
B2BL	0,077	2	4,1	288,282	14,222	7,289				28,4444	0,0045	0,0600	108,16	216,32	0,100	166,10	332,20
B1DR	0,084	1	3,65	266,873	13,677	6,240				13,6769	0,0022	0,0600	100,50	100,50	0,100	153,95	153,95
B2AR	0,087	2	4,1	256,333	15,995	8,197				31,9896	0,0051	0,0600	108,16	216,32	0,100	166,10	332,20
B0SR	0,091	1	2,8	245,141	11,422	3,998				11,4220	0,0018	0,0600	84,85	84,85	0,100	129,29	129,29
B0AL	0,101	3	4,1	220,053	18,632	9,549				55,8957	0,0089	0,0600	108,16	324,48	0,100	166,10	498,30
B1DL	0,113	1	3,65	197,023	18,526	8,452				18,5258	0,0029	0,0600	100,50	100,50	0,100	153,95	153,95
B1BL	0,115	2	4,1	193,647	21,173	10,851				42,3452	0,0067	0,0600	108,16	216,32	0,100	166,10	332,20
B0R	0,138	5	4,1	161,649	25,364	12,999				126,8180	0,0202	0,0600	108,16	540,80	0,100	166,10	830,50
B2BR	0,147	2	4,1	151,932	26,986	13,830				53,9714	0,0086	0,0600	108,16	216,32	0,100	166,10	332,20
B1BR	0,157	2	4,1	142,251	28,822	14,771				57,6444	0,0092	0,0600	108,16	216,32	0,100	166,10	332,20
B1CL	0,176	2	3,65	126,759	28,795	13,138				57,5894	0,0092	0,0600	100,50	201,00	0,100	153,95	307,90
B1AR	0,240	2	3,65	93,116	39,198	17,884				78,3966	0,0125	0,0600	100,50	201,00	0,100	153,95	307,90
BHER2	0,257	24	1,4	87,066	16,080	2,814				385,9152	0,0614	0,0600	55,52	1332,48	0,100	83,56	2005,44
BHER1	0,257	78	1,7	87,066	19,526	4,149				1522,9890	0,2424	0,0600	62,34	4862,52	0,100	94,20	7347,60
BHER	0,257	40	5,4	87,066	62,022	41,865		PEP-II HER	available	2480,888	0,394845588	0,06	129,57	5182,80	0,100	200,17	8006,80
BHERS	0,257	16	4,27	87,066	49,044	26,177				784,6960	0,1249	0,0600	110,82	1773,12	0,100	170,26	2724,16
B3L	0,278	2	4,1	80,386	51,004	26,139				102,0076	0,0162	0,0600	108,16	216,32	0,100	166,10	332,20
B3R	0,284	2	4,1	78,630	52,143	26,723				104,2856	0,0166	0,0600	108,16	216,32	0,100	166,10	332,20
B4L	0,286	1	4,1	78,217	52,418	26,864				52,4183	0,0083	0,0600	108,16	108,16	0,100	166,10	166,10
B5L	0,286	1	3,65	78,217	46,665	21,291				46,6651	0,0074	0,0600	100,50	100,50	0,100	153,95	153,95
B5R	0,292	1	3,65	76,509	47,707	21,766				47,7071	0,0076	0,0600	100,50	100,50	0,100	153,95	153,95
B4R	0,292	1	4,1	76,509	53,589	27,464				53,5888	0,0085	0,0600	108,16	108,16	0,100	166,10	166,10
BHERJ	0,319	2	4,1	69,994	58,577	30,020				117,1530	0,0186	0,0600	108,16	216,32	0,100	166,10	332,20
		194							Total	6283,4236	1,0000			16936,78			25892,78

L.E.R. Quadrupoles – Low Gradient



L.E.R. Quadrupoles – High Gradient

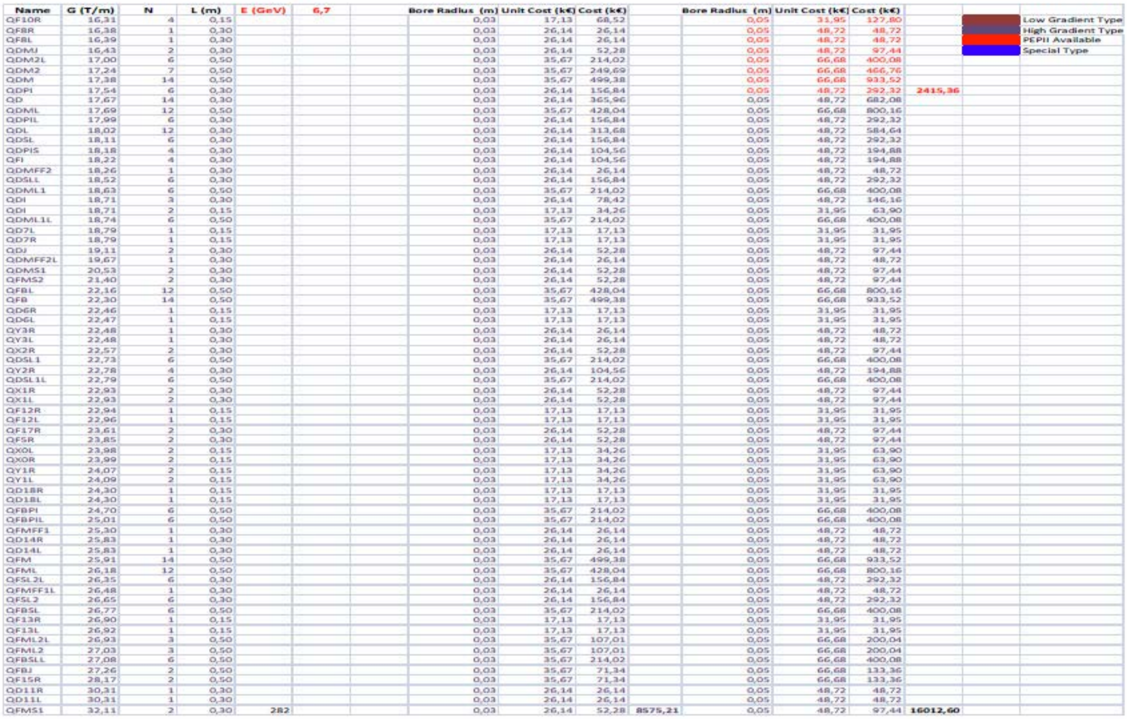


Name	G (T/m)	N	L (m)		E (GeV)	4,18	Bore Radius (m)	Unit Cost (k€)	Cost (k€)		Bore Radius (m)	Unit Cost (k€)	Cost (k€)			
QFCPIL	16,00	3	0,50				0,03	35,67	107,01		0,05	66,68	200,04		■	New Type
QFSL2	16,05	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32		🟥	PEPII Available
QD14R	16,12	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QFML	16,36	14	0,50				0,03	35,67	499,38		0,05	66,68	933,52			
QDMS2L	16,51	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QFM	16,62	12	0,50				0,03	35,67	428,04		0,05	66,68	800,16			
QDMFF2	16,66	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFBSL	16,71	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QF13L	16,79	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QF13R	16,79	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QFBSLL	16,90	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QFSL2L	17,05	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QF15R	17,57	2	0,50				0,03	35,67	71,34		0,05	66,68	133,36			
QDMS1L	18,07	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QDMFF0	18,41	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QDMS1	18,84	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD11L	18,91	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD11R	18,91	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFRSR3	19,55	2	0,50				0,03	35,67	71,34		0,05	66,68	133,36			
QDMFF0L	20,81	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QDMFF2L	21,30	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFMFF2L	22,41	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFMFF2	24,94	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFBJ	25,30	2	0,37				0,03	33,68	67,36		0,05	55,39	110,78			
QFMFF1L	29,80	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD0BR	30,58	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QFMFF1	32,84	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QF1R	36,71	2	0,45	80,00			0,03	33,45	66,90	2504,70	0,05	62,49	124,98	4662,83		

H.E.R. Quadrupoles – Low Gradient

Name	G (T/m)	N	L (m)	E (GeV)	6,7		Bore Radius (m)	Unit Cost (k€)	Cost (k€)		Bore Radius (m)	Unit Cost (k€)	Cost (k€)			
QFMFF5	0,78	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52		🟫	Low Gradient Type
QDMFF4L	0,85	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52		🟪	High Gradient Type
QDMFF6L	1,03	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52		🟥	PEPII Available
QDMFF4	1,15	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52		🟦	Special Type
QFMFF5L	1,75	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD2R	1,82	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD2L	1,82	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QDMFF6	1,88	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QFMFF7	4,27	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QFMFF7L	5,09	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QDMFF8	6,63	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD9R	7,16	2	0,30				0,03	17,01	34,02		0,05	31,52	63,04			
QDMFF8L	7,20	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QFMFF3L	11,22	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QFMJ	11,27	2	0,30				0,03	17,01	34,02		0,05	31,52	63,04			
QFMFF3	11,48	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD16L	12,95	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD16R	12,96	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QFSL	14,51	6	0,30				0,03	17,01	102,06		0,05	31,52	189,12			
QFPI	14,51	6	0,30				0,03	17,01	102,06		0,05	31,52	189,12			
QFPIS	14,52	4	0,30				0,03	17,01	68,04		0,05	31,52	126,08			
QF	14,58	14	0,30				0,03	17,01	238,14		0,05	31,52	441,28			
QFSLL	15,05	6	0,30				0,03	17,01	102,06		0,05	31,52	189,12			
QFPIL	15,08	6	0,30				0,03	17,01	102,06		0,05	31,52	189,12			
QFJ	15,09	2	0,30				0,03	17,01	34,02		0,05	31,52	63,04			
QFL	15,17	12	0,30				0,03	17,01	204,12		0,05	31,52	378,24			
QDMS2	15,64	2	0,15				0,03	11,08	22,16		0,05	20,77	41,54			
QD4R	15,69	1	0,30				0,03	17,01	17,01		0,05	31,52	31,52			
QD4L	15,69	1	0,30	80			0,03	17,01	17,01	1348,94	0,05	31,52	31,52	2500,1		

H.E.R. Quadrupoles – High Gradient



Name	G (T/m)	N	L (m)	E (GeV)	6,7		Bore Radius (m)	Unit Cost (k€)	Cost (k€)		Bore Radius (m)	Unit Cost (k€)	Cost (k€)			
QF10R	16,31	4	0,15				0,03	17,13	68,52		0,05	31,95	127,80		🟫	Low Gradient Type
QF8R	16,38	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72		🟪	High Gradient Type
QF8L	16,39	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72		🟥	PEPII Available
QDMJ	16,43	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44		🟦	Special Type
QDM2L	17,00	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QDM2	17,24	7	0,50				0,03	35,67	249,69		0,05	66,68	466,76			
QDM	17,38	14	0,50				0,03	35,67	499,38		0,05	66,68	933,52			
QDPI	17,54	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32	2415,36		
QD	17,67	14	0,30				0,03	26,14	365,96		0,05	48,72	682,08			
QDML	17,69	12	0,50				0,03	35,67	428,04		0,05	66,68	800,16			
QDPIL	17,99	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QDL	18,02	12	0,30				0,03	26,14	313,68		0,05	48,72	584,64			
QDSL	18,11	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QDPIS	18,18	4	0,30				0,03	26,14	104,56		0,05	48,72	194,88			
QFI	18,22	4	0,30				0,03	26,14	104,56		0,05	48,72	194,88			
QDMFF2	18,26	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QDSLL	18,52	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QDML1	18,63	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QDI	18,71	3	0,30				0,03	26,14	78,42		0,05	48,72	146,16			
QDI	18,71	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QDML1L	18,74	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QD7L	18,79	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QD7R	18,79	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QDJ	19,11	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QDMFF2L	19,67	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QDMS1	20,53	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QFMS2	21,40	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QFBL	22,16	12	0,50				0,03	35,67	428,04		0,05	66,68	800,16			
QFB	22,30	14	0,50				0,03	35,67	499,38		0,05	66,68	933,52			
QD6R	22,46	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QD6L	22,47	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QY3R	22,48	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QY3L	22,48	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QX2R	22,57	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QDSL1	22,73	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QY2R	22,78	4	0,30				0,03	26,14	104,56		0,05	48,72	194,88			
QDSL1L	22,79	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QX1R	22,93	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QX1L	22,93	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QF12R	22,94	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QF12L	22,96	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QF17R	23,61	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QF5R	23,85	2	0,30				0,03	26,14	52,28		0,05	48,72	97,44			
QX0L	23,98	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QX0R	23,99	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QY1R	24,07	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QY1L	24,09	2	0,15				0,03	17,13	34,26		0,05	31,95	63,90			
QD18R	24,30	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QD18L	24,30	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QFBPI	24,70	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QFBPIL	25,01	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QFMFF1	25,30	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD14R	25,83	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD14L	25,83	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFM	25,91	14	0,50				0,03	35,67	499,38		0,05	66,68	933,52			
QFML	26,18	12	0,50				0,03	35,67	428,04		0,05	66,68	800,16			
QFSL2L	26,35	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QFMFF1L	26,48	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFSL2	26,65	6	0,30				0,03	26,14	156,84		0,05	48,72	292,32			
QFBSL	26,77	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QF13R	26,90	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QF13L	26,92	1	0,15				0,03	17,13	17,13		0,05	31,95	31,95			
QFML2L	26,93	3	0,50				0,03	35,67	107,01		0,05	66,68	200,04			
QFML2	27,03	3	0,50				0,03	35,67	107,01		0,05	66,68	200,04			
QFBSLL	27,08	6	0,50				0,03	35,67	214,02		0,05	66,68	400,08			
QFBJ	27,26	2	0,50				0,03	35,67	71,34		0,05	66,68	133,36			
QF15R	28,17	2	0,50				0,03	35,67	71,34		0,05	66,68	133,36			
QD11R	30,31	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QD11L	30,31	1	0,30				0,03	26,14	26,14		0,05	48,72	48,72			
QFMS1	32,11	2	0,30	282			0,03	26,14	52,28	8575,21	0,05	48,72	97,44	16012,60		

L.E.R. Sextupoles (ANKA Type)

Name	G (T/m2)	N	L (m)		E (GeV)	4,18	Bore Radius (m)	Unit Cost (k€)	Cost (k€)		K(m-2)	E (GeV)		Bro			d^2B/dx^2	S
CRABR	0,0	2	0,175				0,03	22,2	44,4		0,00		4,18	13,93333			0	0
SD1_INJ2	7,9	2	0,3				0,03	28,2	56,4		0,17		4,18	13,93333			7,895555556	3,947778
SFX0R	32,7	2	0,35				0,03	30,2	60,4		0,82		4,18	13,93333			32,64380952	16,3219
SDY0R	49	2	0,25				0,03	26	52		0,89		4,18	13,93333			49,60266667	24,80133
SF1	56	1	0,15				0,03	21	21		0,61		4,18	13,93333			56,66222222	28,33111
SF1	56	26	0,3				0,03	28,2	733,2		1,21		4,18	13,93333			56,19777778	28,09889
SD1	63	53	0,3				0,03	28,2	1494,6		1,36		4,18	13,93333			63,16444444	31,58222
SF_INJ	72	1	0,15				0,03	21	21		0,77		4,18	13,93333			71,52444444	35,76222
SDY2L	98	2	0,275				0,03	27,1	54,2		1,93		4,18	13,93333			97,78666667	48,89333
SF1_INJ2	101	2	0,15				0,03	21	42		1,09		4,18	13,93333			101,2488889	50,62444
SFX2L	110	2	0,35				0,03	30,2	60,4		2,77		4,18	13,93333			110,272381	55,13619
SFX1R	113	2	0,35				0,03	30,2	60,4		2,83		4,18	13,93333			112,6609524	56,33048
SDY1R	133,0841	2	0,275				0,03	27,1	54,2		2,63		4,18	13,93333			133,2533333	66,62667
SD_INJ	139,3333	1	0,3				0,03	28,2	28,2		3,00		4,18	13,93333			139,3333333	69,66667
		100							**2782,4**									

H.E.R. Sextupoles (ANKA Type)

Name	G (T/m2)	N	L (m)		E (GeV)	6,7	Bore Radius (m)	Unit Cost (k€)	Cost (k€)		K(m-2)	E (GeV)		Bro			d^2B/dx^2	S
CRABR	0,0	2	0,175				0,03	22,2	44,4		0		6,7	22,33333			0	0
SFX0R	52,5	2	0,35				0,03	30,2	60,4		0,82		6,7	22,33333			52,32380952	26,1619
SF_INJ	53,9	1	0,15				0,03	21	21		0,36		6,7	22,33333			53,6	26,8
SD_INJ	73,1	1	0,3				0,03	28,2	28,2		0,98		6,7	22,33333			72,95555556	36,47778
SF1	75,4	26	0,3				0,03	28,2	733,2		1,01		6,7	22,33333			75,18888889	37,59444
SF1L	75,4	3	0,15				0,03	21	63		0,51		6,7	22,33333			75,93333333	37,96667
SDY0R	79,3	2	0,25				0,03	26	52		0,89		6,7	22,33333			79,50666667	39,75333
SD1	88,9	55	0,3				0,03	28,2	1551		1,19		6,7	22,33333			88,58888889	44,29444
SDY1R	156,6	2	0,275				0,03	27,1	54,2		1,93		6,7	22,33333			156,7393939	78,3697
SFX1R	176,8	2	0,35				0,03	30,2	60,4		2,77		6,7	22,33333			176,752381	88,37619
SFX2L	180,8	2	0,35				0,03	30,2	60,4		2,83		6,7	22,33333			180,5809524	90,29048
SDY2L	213,3	2	0,275				0,03	27,1	54,2		2,63		6,7	22,33333			213,5878788	106,7939
		100							**2782,4**									

APPENDIX C

RINGS MAGNETS COST EVALUATION USING AN ANALYTICAL APPROACH

P.Fabbricatore

Presentation given

At 3rd SuperB meeting LNF March 19-23

CABIBBO LAB

Magnet cost estimate
P.Fabbricatore INFN Genova

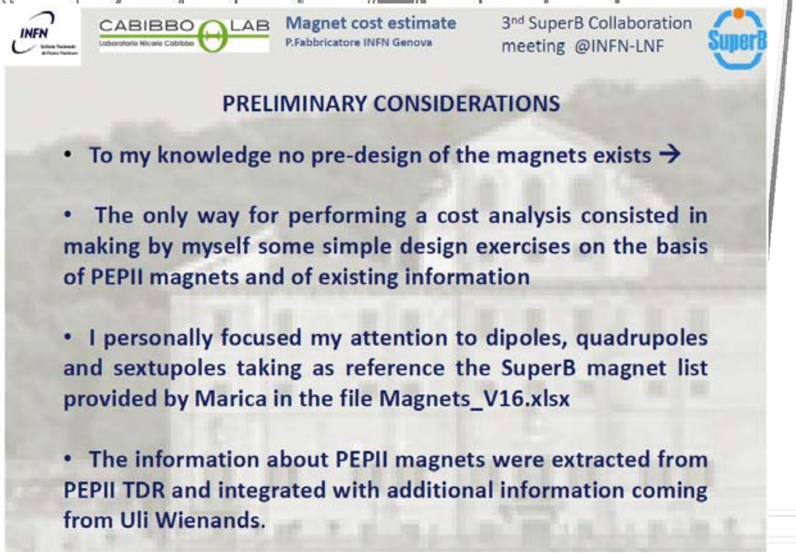
3nd SuperB Collaboration meeting @INFN-LNF

Rings Magnets Cost Estimate

P.Fabbricatore

INFN Genova

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



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Laboratorio Nicola Cabibbo

Magnet cost estimate
P.Fabbricatore INFN Genova

3nd SuperB Collaboration meeting @INFN-LNF

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.

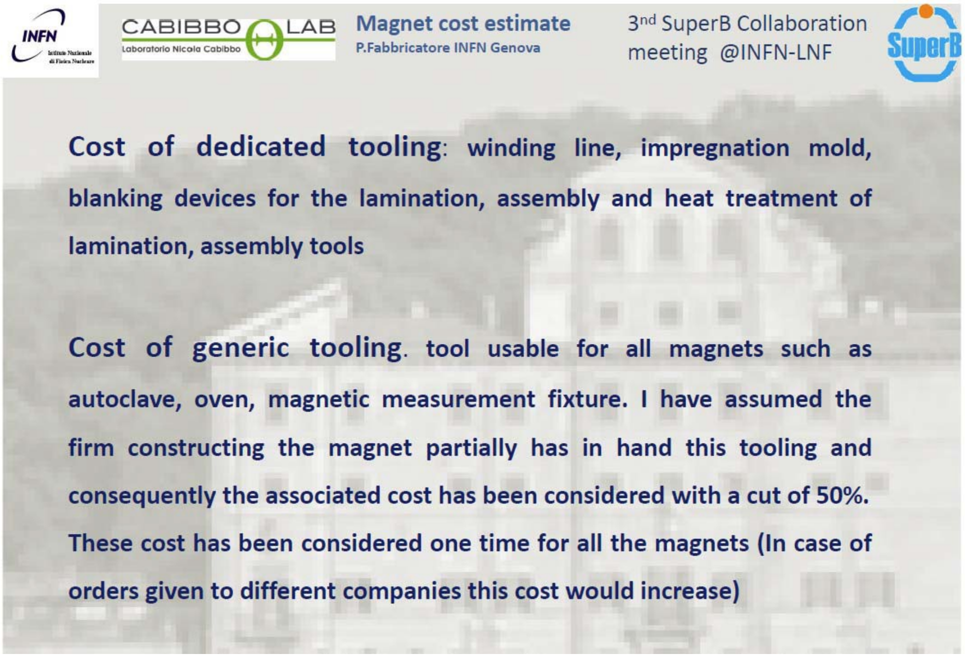
Methodology

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

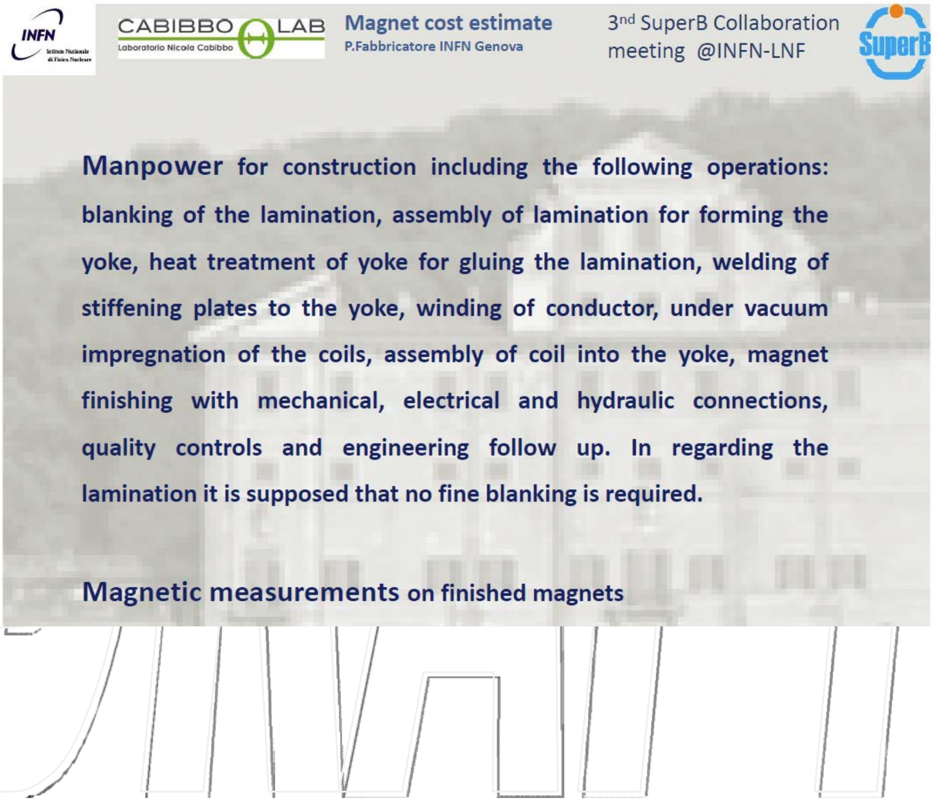
Materials subdivided into magnetic steel (lamination 1 mm thick were considered for all the magnets), conductor (copper conductor with hole for cooling), insulations (conductor and ground insulation), stiffening structures (longitudinal plates and end yoke flanges), other mechanical components (bolts,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



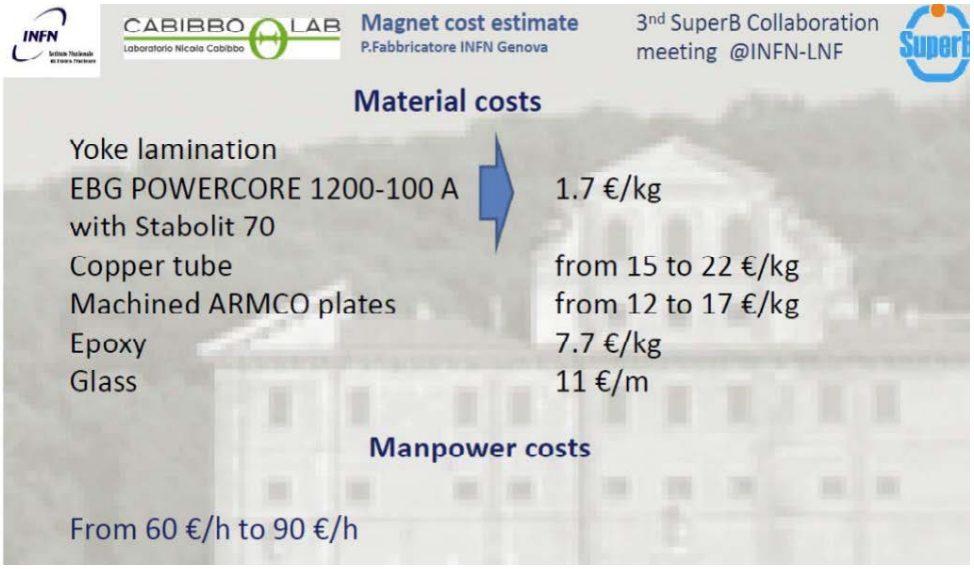
Cost of dedicated tooling: winding line, impregnation mold, blanking devices for the lamination, assembly and heat treatment of lamination, assembly tools

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

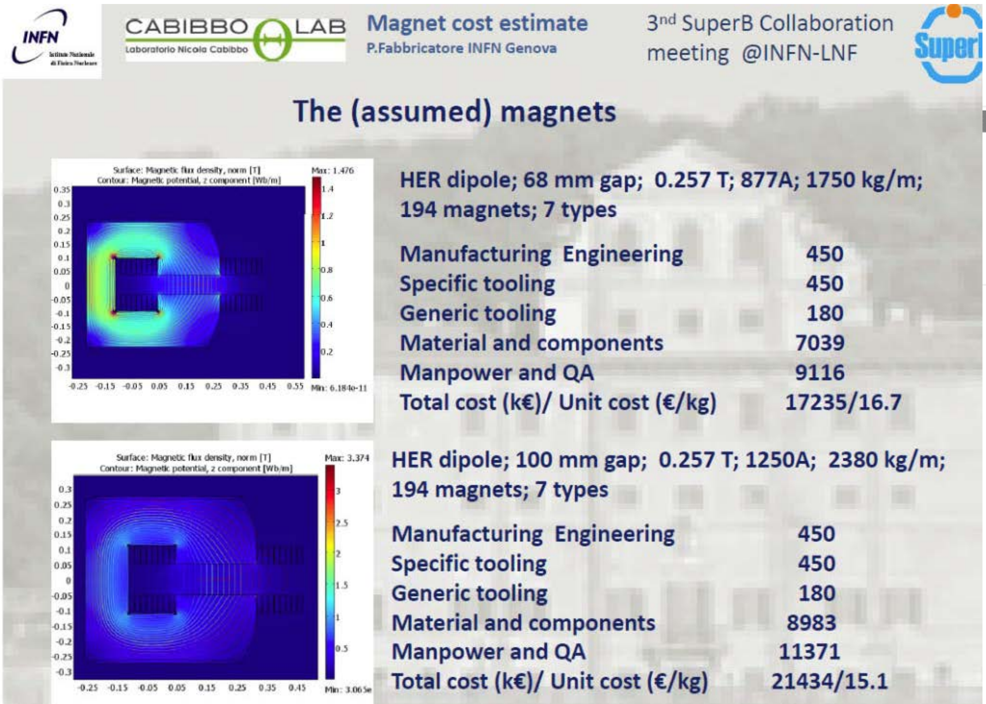


Material costs

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



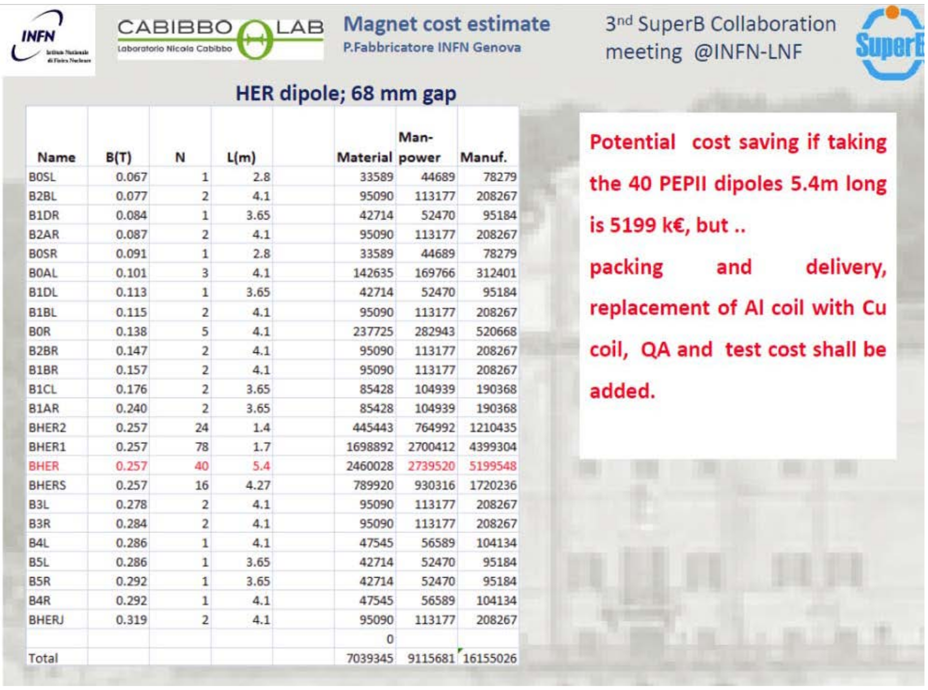
The (assumed) magnets

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 (k€)/ Unit cost (€/kg)	17235/16.7

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 (k€)/ Unit cost (€/kg)	21434/15.1



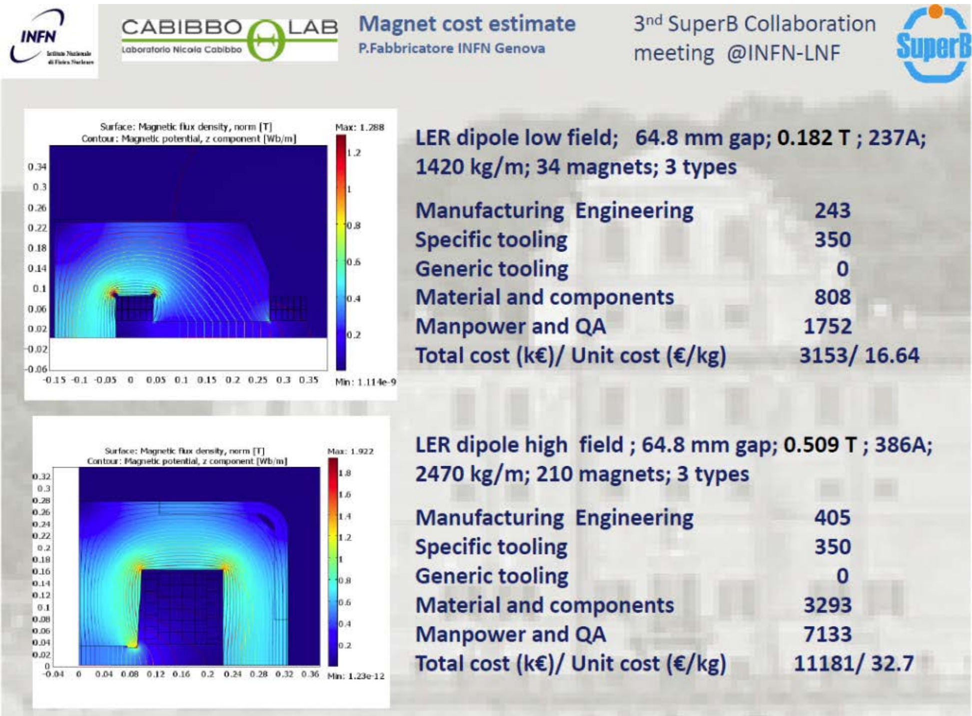
Magnet cost estimate
P.Fabbricatore INFN Genova

3rd SuperB Collaboration meeting @INFN-LNF

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

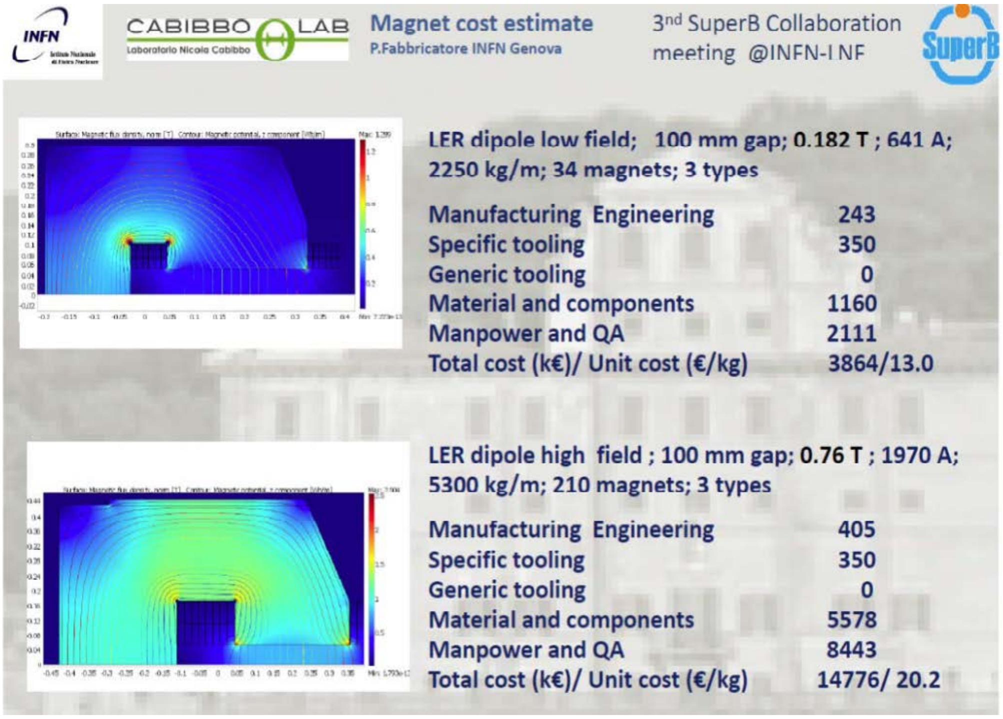
3rd SuperB Collaboration meeting @INFN-LNF

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 (k€)/ Unit cost (€/kg)	3153/ 16.64

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 (k€)/ Unit cost (€/kg)	11181/ 32.7



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Magnet cost estimate

P.Fabbricatore INFN Genova

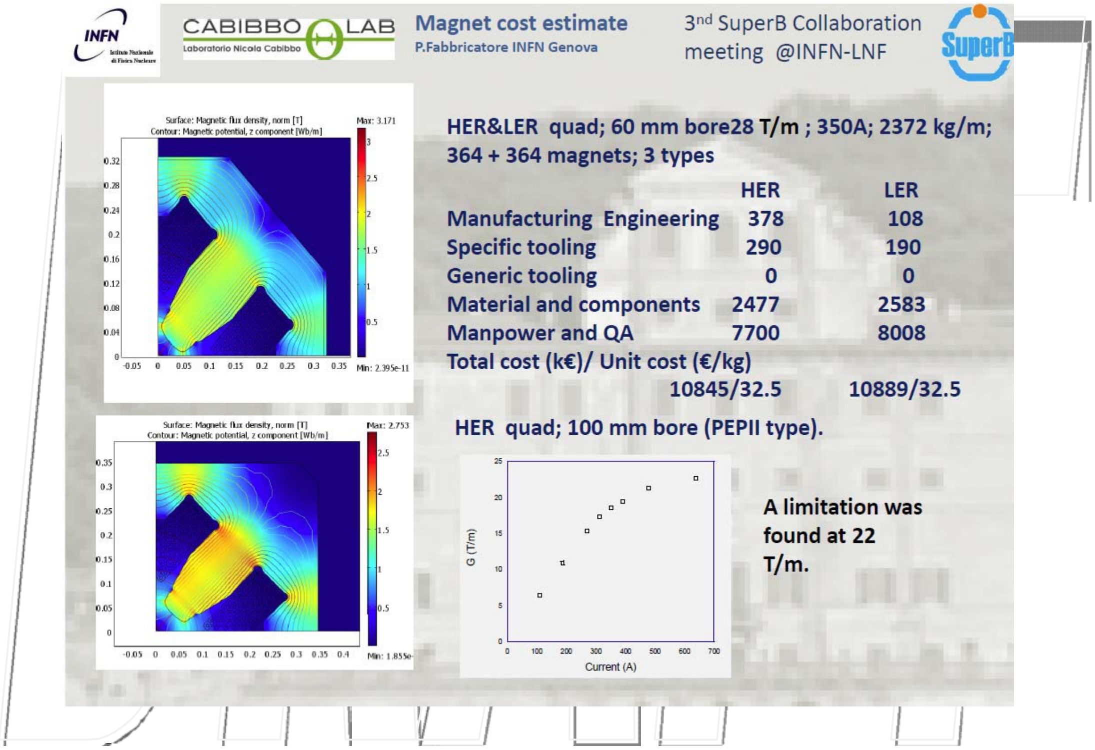
3rd SuperB Collaboration meeting @INFN-LNF

LER dipole low field; 100 mm gap; 0.182 T ; 641 A; 2250 kg/m; 34 magnets; 3 types

Manufacturing Engineering	243
Specific tooling	350
Generic tooling	0
Material and components	1160
Manpower and QA	2111
Total cost (k€)/ Unit cost (€/kg)	3864/13.0

LER dipole high field ; 100 mm gap; 0.76 T ; 1970 A; 5300 kg/m; 210 magnets; 3 types

Manufacturing Engineering	405
Specific tooling	350
Generic tooling	0
Material and components	5578
Manpower and QA	8443
Total cost (k€)/ Unit cost (€/kg)	14776/ 20.2



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Magnet cost estimate

P.Fabbricatore INFN Genova

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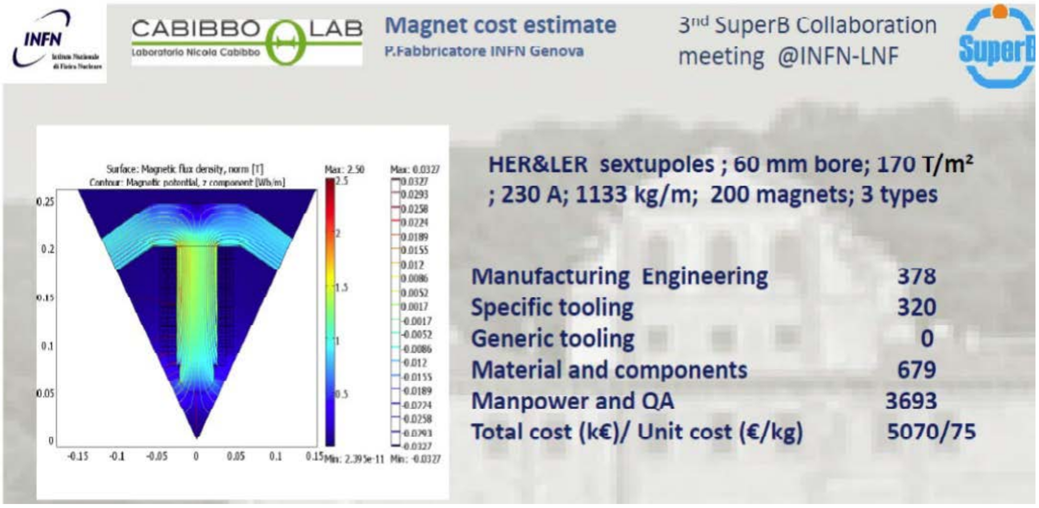
HER&LER quad; 60 mm bore28 T/m ; 350A; 2372 kg/m; 364 + 364 magnets; 3 types

	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 (k€)/ Unit cost (€/kg)	10845/32.5	10889/32.5

HER quad; 100 mm bore (PEPII type).

A limitation was found at 22 T/m.



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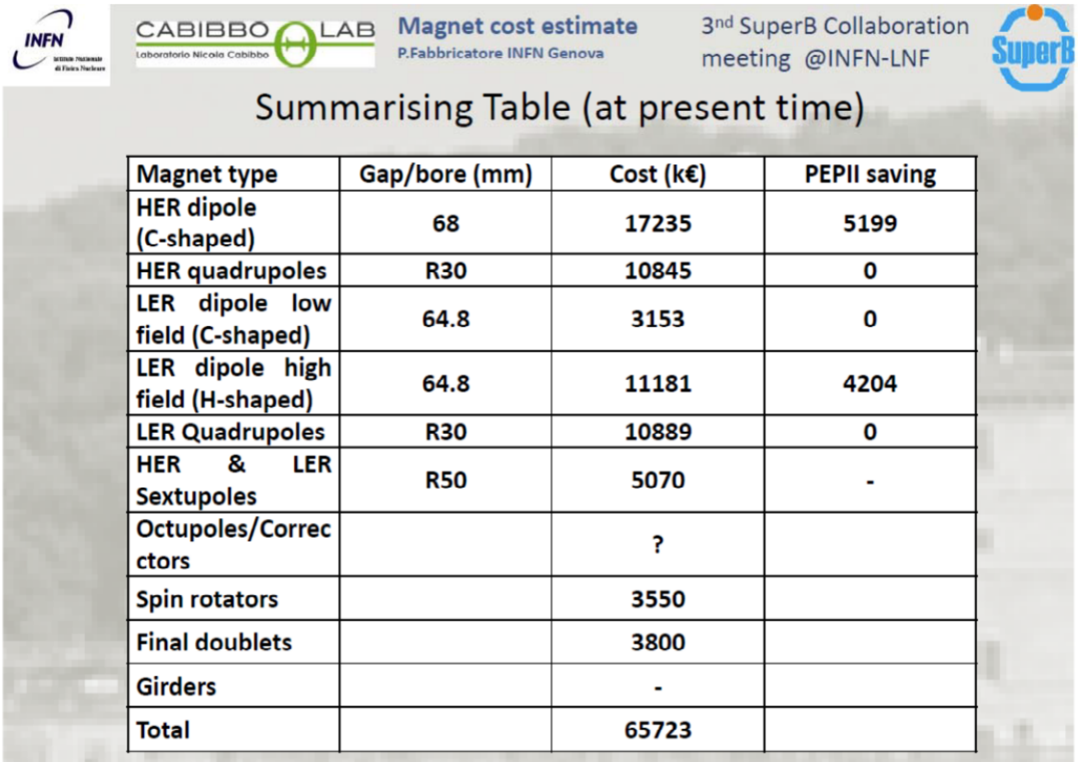
Magnet cost estimate
P.Fabbricatore INFN Genova

3^{rd} SuperB Collaboration meeting @INFN-LNF

HER&LER sextupoles ; 60 mm bore; 170 T/m² ; 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 (k€)/ Unit cost (€/kg)	5070/75



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Magnet cost estimate
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Summarising Table (at present time)

Magnet type	Gap/bore (mm)	Cost (k€)	PEPII 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	

APPENDIX D VACUUM

ISSUES AND COSTS A.Clozza

Presentation given
At 3rd SuperB meeting LNF March 19-23