



# Block design

CEA

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# Critical current density

*Critical surface*

$$B_{c2}(T) = B_{c20} \cdot (1 - t^{1.52})$$

$$J_C = \frac{C(t)}{B_p} \cdot b^{0.5} \cdot (1 - b)^2$$

$$C(t) = C_0 \cdot (1 - t^{1.52})^\alpha \cdot (1 - t^2)^\alpha$$

Where:  $t = \frac{T}{T_{c0}}$  ;  $b = \frac{B_p}{B_{c2}(t)}$  with  $B_p$  peak field on the conductor

$T_{c0}$ ,  $B_{c20}$ ,  $\alpha$ ,  $C_0$  are fitting parameters computed from the analysis of measurements on the conductor.

For a reasonable estimate of the critical current density of a round wire, magnet designers can assume the following parameters:  $T_{c0} = 16 \text{ K}$ ,  $B_{c20} = 28.8 \text{ T}$ ,  $\alpha = 0.96$ ,  $C_0 = 255230 \text{ A/mm}^2 \text{ T}$ . For the cable degradation we assume 5%.

Bernardo  
Bordini  
CERN

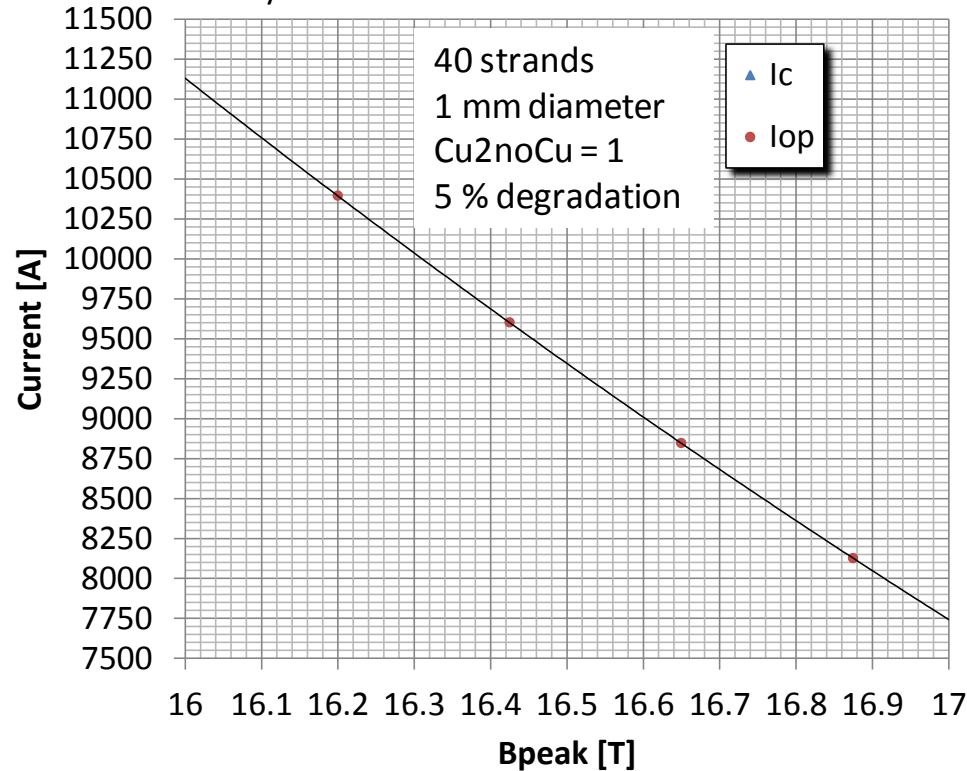
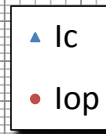
Top = 4.2 K

# Pre-analysis

Operating current with 10% LL margin  
vs  
Bpeak

$$y = -13.003x^3 + 1009.3x^2 - 26071x + 223150$$

40 strands  
1 mm diameter  
Cu2noCu = 1  
5 % degradation



$j_o = 200 \text{ A/mm}^2$  (10000 A/21.4x2.22mm<sup>2</sup> - 5%)

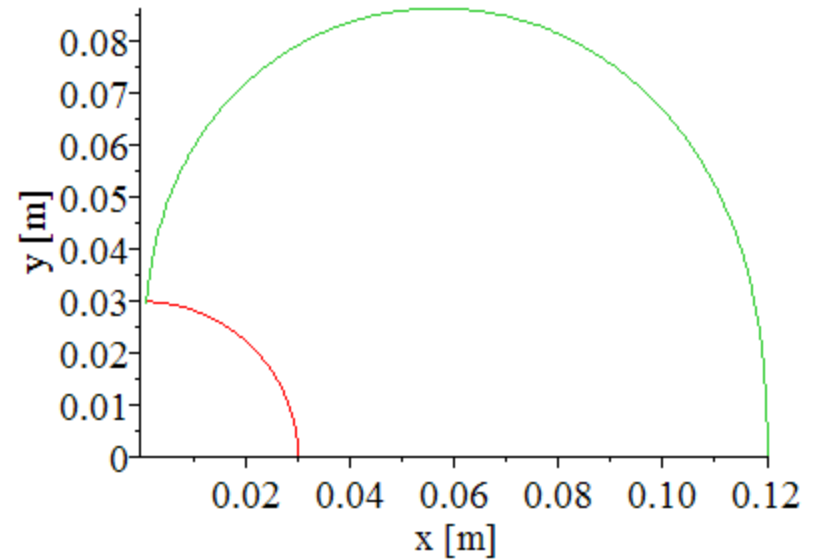
$B_o = 13.1 \text{ T}$  ( $b_3 = 0$ )

(approximately what is needed to reach 16 T with yoke)

X max = 119 mm

Turns = 158 (1.58e6 ampère.turn)

Aperture  $\Phi = 30 \text{ mm}$  (support needed for block coil)

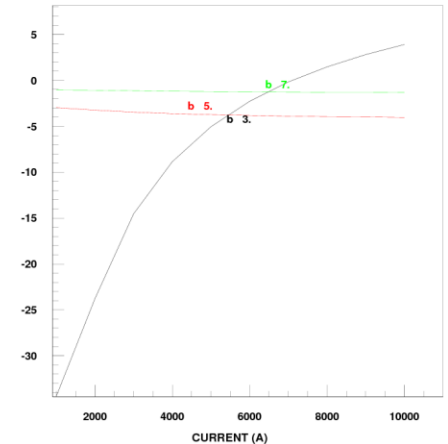
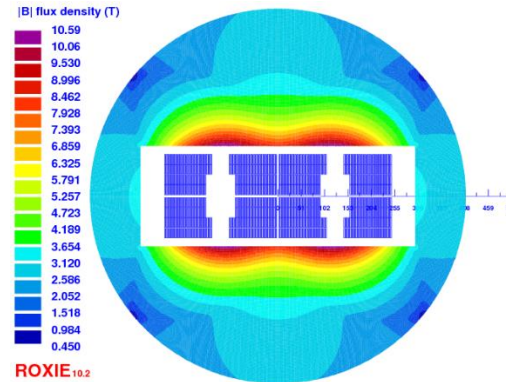
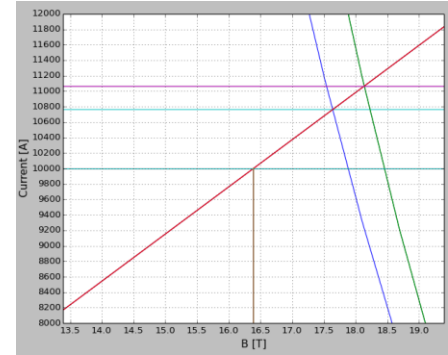
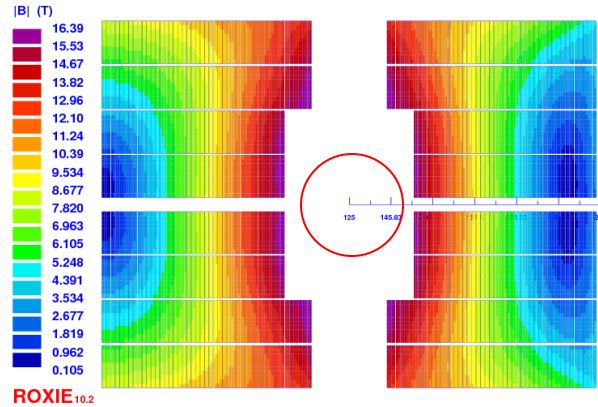


$d = 0.144$   
 $\lambda = 0.00205$

# Design no-grading

Quantity	Unit	Value
H_bare	mm	21.0
W_bare	mm	1.82
Isol.	mm	0.2
Cu/nonCu	.	1.0 – 1.4
N strands	.	40
Φ	mm	1.0

Quantity	Unit	Value
Iop	kA	10.0
N turns	.	176
Bpeak	T	16.39
Margin LL	%	9.6 – 7.1
Cu/nonCu	.	1.0 – 1.4
Outer dia	mm	820
Fx per ½ coil	kN/m	11,400



MAIN FIELD (T) ..... -16.004463  
MAGNET STRENGTH (T/(m<sup>2</sup>(n-1))) ..... -16.0045

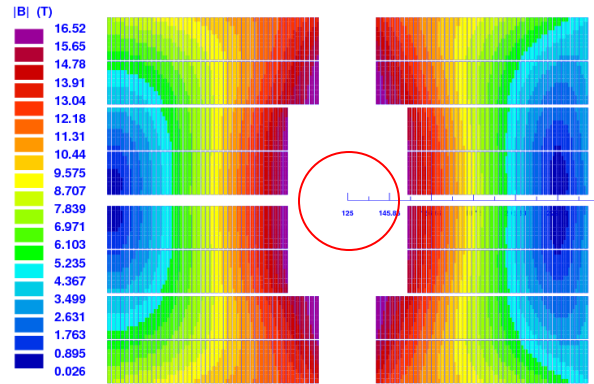
NORMAL RELATIVE MULTIPOLES (1.0-4):  
b 1: 10000.00000 b 2: -77.69922 b 3: 3.90151  
b 4: -0.79713 b 5: -4.02275 b 6: -0.00114  
b 7: -1.30850 b 8: 0.00004 b 9: -0.27461

Definition of geo/sat for harmonics? 1 aperture/2 aperture/low current/operating current.4.?

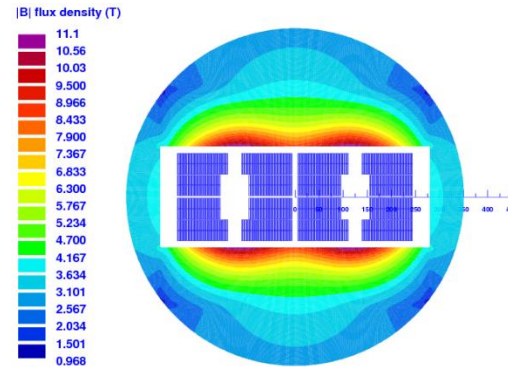
# Design grading (v12)

Quantity	Unit	Value
H_bare	mm	21.0
W_bare	mm	2 / 1.82
Isol.	mm	0.2
Cu/nonCu	.	1.0 / 1.9
N strands	.	36 / 40
Φ	mm	1.1 / 1.0

Quantity	Unit	Value
Iop	kA	10.15
N turns	.	174
Bpeak	T	16.52
Margin LL	%	10.0
Cu/nonCu	.	1.0 / 1.9
Outer dia	mm	750
Fx per ½ coil	kN/m	11,310



ROXIE10.2

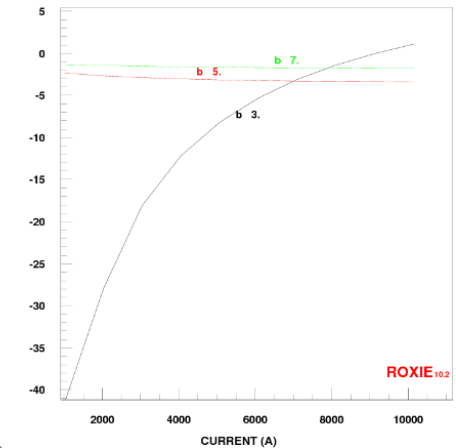
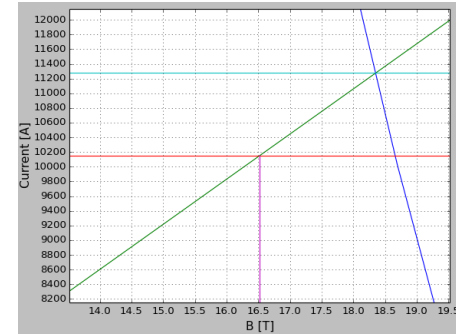


ROXIE10.2

MAIN FIELD (T) ..... -16.036746  
 MAGNET STRENGTH (T/(m^(n-1))) ..... -16.0367

NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	10000.00000	b 2:	-82.06470	b 3:	1.11746
b 4:	-0.77115	b 5:	-3.39512	b 6:	-0.00076
b 7:	-1.77079	b 8:	0.00003	b 9:	-0.40654

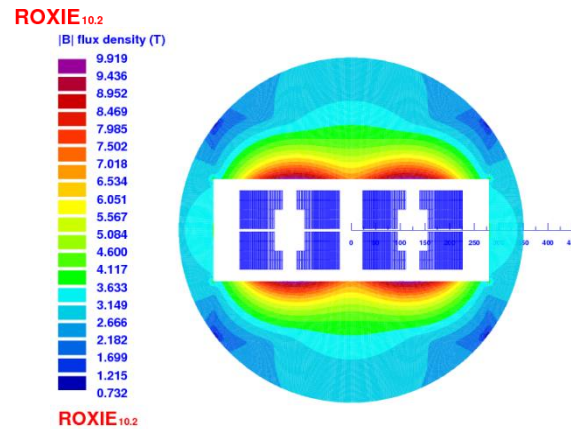
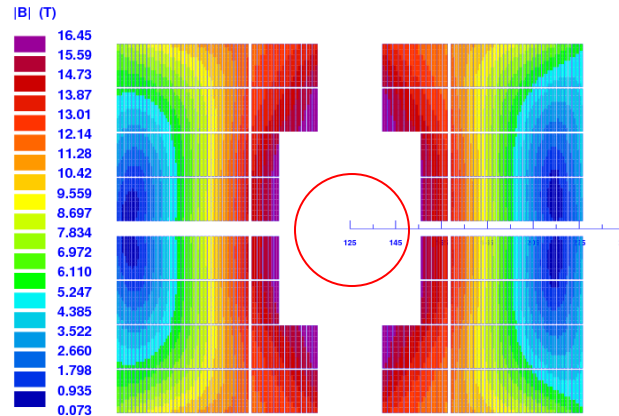


X1<sub>v12</sub> = 29.5 mm  
 X2<sub>v12</sub> = 119.3 mm

# Design grading (v10)

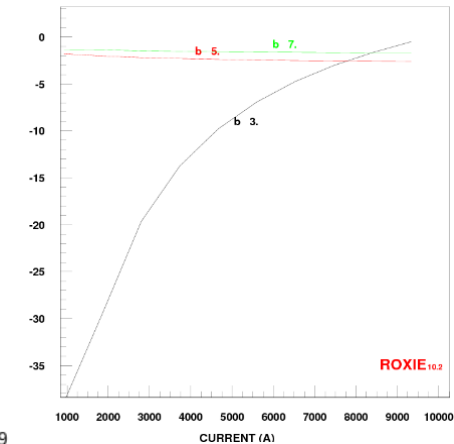
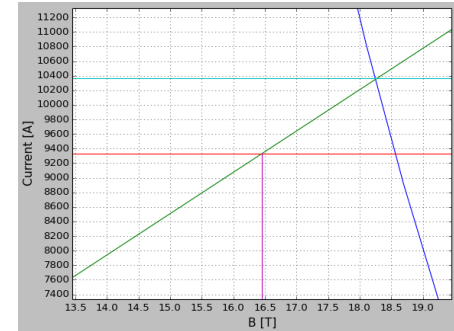
Quantity	Unit	Value
H_bare	mm	18.5
W_bare	mm	2 / 1.25
Isol.	mm	0.2
Cu/nonCu	.	1.0 / 1.7
N strands	.	32 / 50
$\Phi$	mm	1.1 / 0.7

Quantity	Unit	Value
Iop	kA	9.33
N turns	.	174
Bpeak	T	16.46
Margin LL	%	10.0
Cu/nonCu	.	1.0 / 1.7
Outer dia	mm	750
Fx per 1/2 coil	kN/m	10,280



MAIN FIELD (T) ..... -16.004349  
 MAGNET STRENGTH (T/(m^(n-1))) ..... -16.0043

NORMAL RELATIVE MULTIPOLES (1.0-4):  
 b 1: 10000.00000 b 2: -66.24351 b 3: -0.51544  
 b 4: -0.73863 b 5: -2.59033 b 6: -0.00231  
 b 7: -1.68871 b 8: 0.00001 b 9: -0.36318

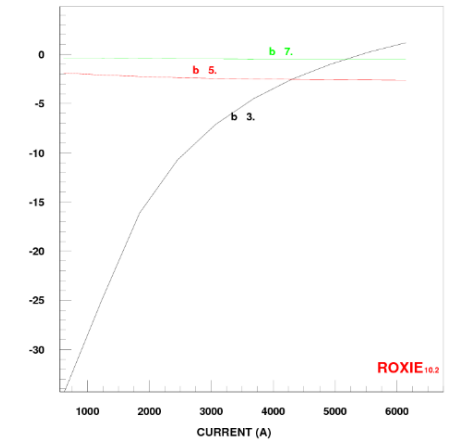
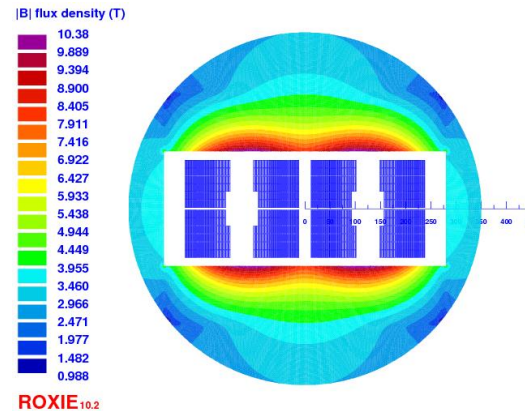
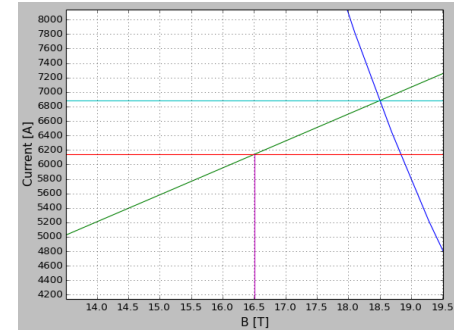
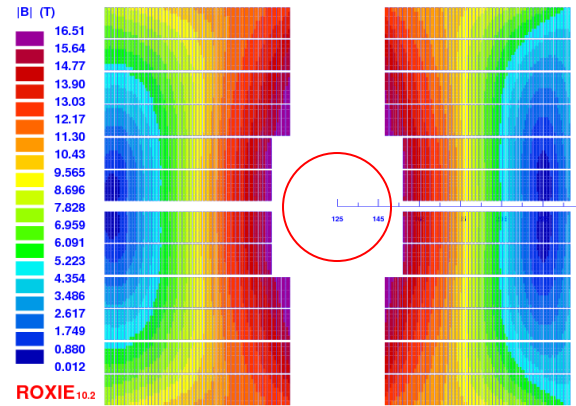


X1<sub>v10</sub> = 30.8 mm  
 X2<sub>v10</sub> = 101.75 mm

# Design grading (v11)

Quantity	Unit	Value
H_bare	mm	14.7
W_bare	mm	1.82 / 1.25
Isol.	mm	0.2
Cu/nonCu	.	1.0 / 3.7
N strands	.	28 / 40
$\Phi$	mm	1.0 / 0.7

Quantity	Unit	Value
I <sub>op</sub>	kA	6.14
N turns	.	292
B <sub>peak</sub>	T	16.51
Margin LL	%	10.8
Cu/nonCu	.	1.0 / 3.7
Outer dia	mm	750
Fx per ½ coil	kN/m	11,160





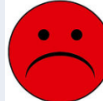



MAIN FIELD (T) ..... -16.022402  
 MAGNET STRENGTH (T/(m<sup>2</sup>(n-1))) ..... -16.0224

NORMAL RELATIVE MULTIPOLES (1.D-4):  
 b 1: 10000.00000 b 2: -82.50209 b 3: 1.18069  
 b 4: -0.70220 b 5: -2.62386 b 6: -0.00032  
 b 7: -0.49283 b 8: 0.00003 b 9: -0.22983

X1<sub>v11</sub> = 31.8 mm  
 X2<sub>v11</sub> = 113.4 mm

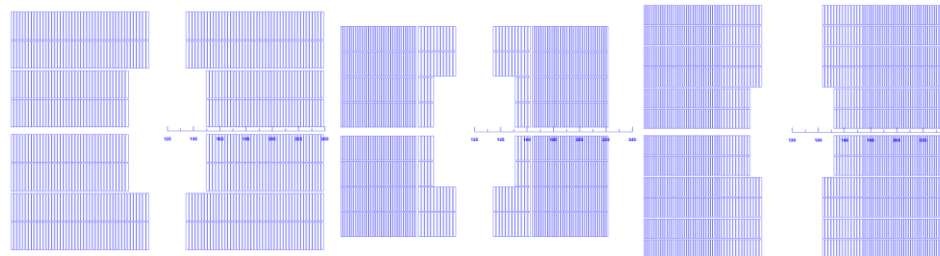
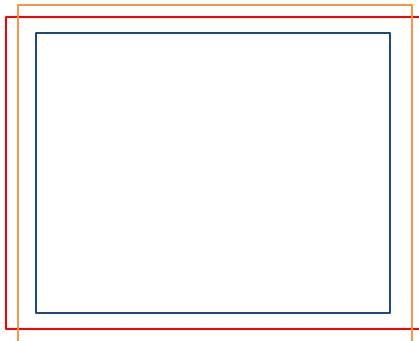
# Conclusion - Cables

Quantity	Unit	~cable Fresca2	~cable QXF	cable 1	cable 2	cable 3	cable 4
# strands	-	40	40	36	32	50	28
diameter	mm	1	0.7	1.1	1.1	0.7	1.0
thickness	mm	1.82	1.25	2.0	2.0	1.25	1.82
width	mm	21.0	14.7	21.0	18.5	18.5	14.7
isolation	mm	0.2					
Bernardo's face							
Magnet version		no-grad v12	v11	v12	v10	v10	v11



# Conclusion - Magnets

Quantity	Unit	v12	v10	v11
Iop	kA	10.15	9.33	6.14
Bpeak	T	16.52	16.46	16.51
Margin LL	%	10	10	10.8
Nturns	-	174	174	292
NDP	-	2	2	3
Inner coil	mm	29.6	30.8	31.8
Outer coil	mm	119.3	101.8	113.4
Fx	kN/m	11310	10280	11160
Cu/nonCu	-	1.0 / 1.9	1.0 / 1.7	1.0 / 3.7
Cable	-	☹️ 😊	☹️ 😞	😊 😊



Same scale