- DAΦNE UPGRADE -

PRELIMINARY FEASIBILITY STUDY ON 1.1 – 2.4 *T* RAMPING DIPOLES FOR DAFNE2

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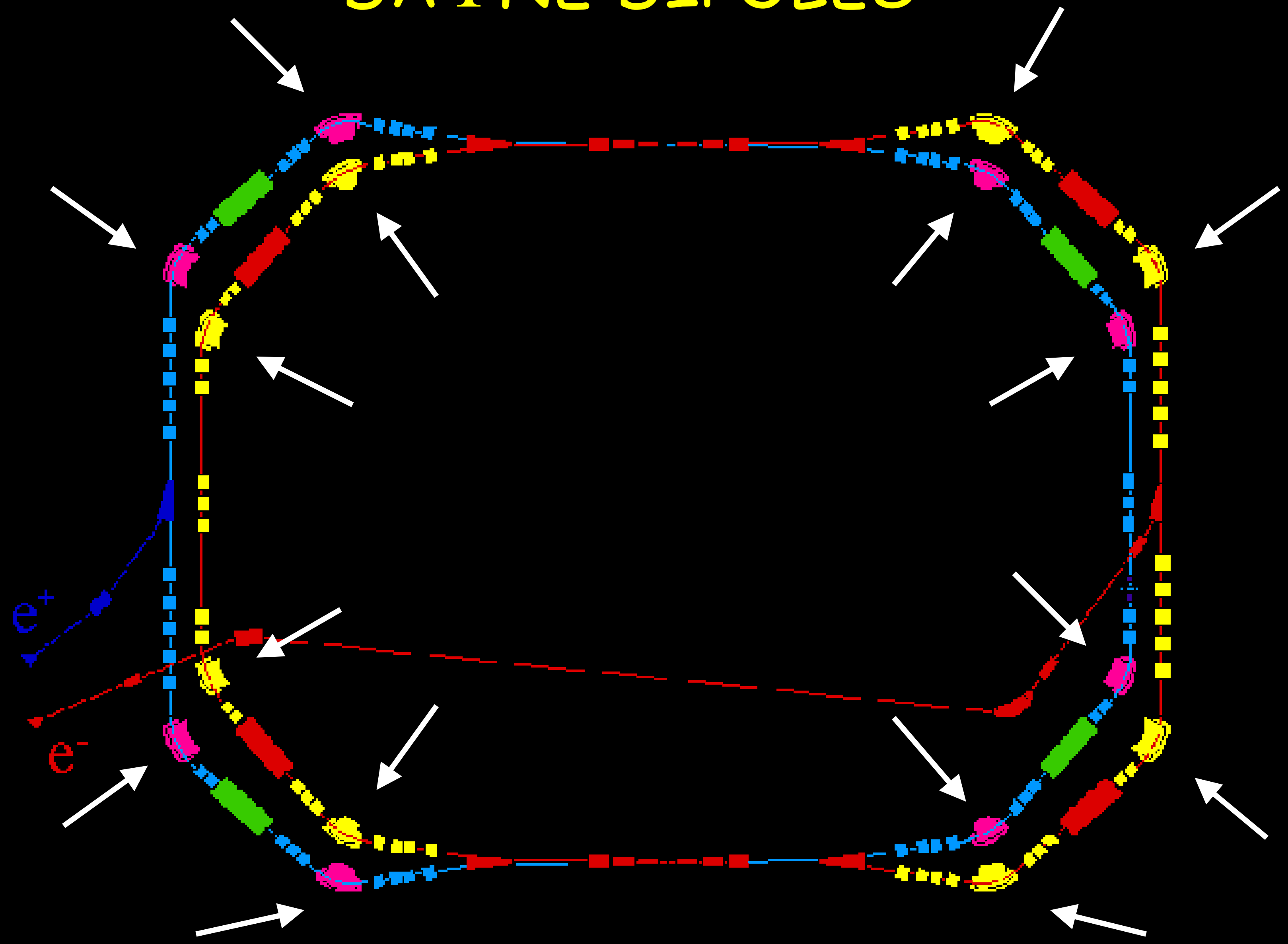
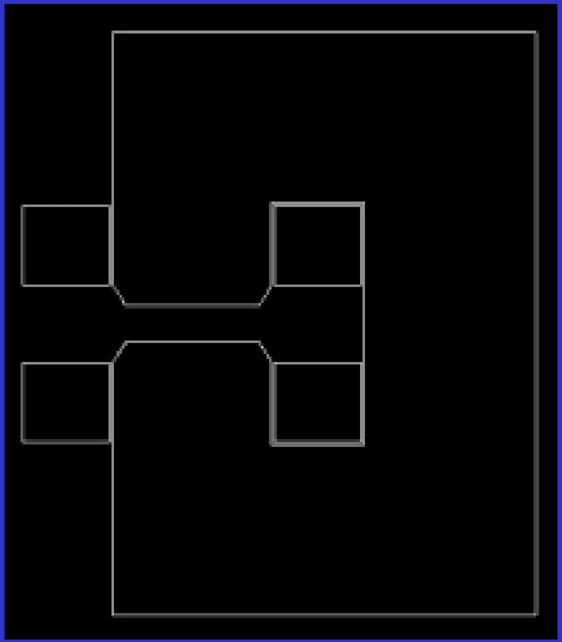
DAΦNE DIPOLES



DAΦNE DIPOLES:

- 8 C-shape bending magnets in each ring, 4 sector like + 4 parallel end

e^+/e^- Energy	510 MeV
Bρ	1.7 T m
Nominal Field	1.214 T
Bending Radius	1.400 m
Nominal Current	262.8 A
Current Density	2.5 A/mm^2
Magnet Gap	75 mm
Good Field Region	± 30 mm



FROM DAΦNE TO DAFNE2

NEW DIPOLES REQUIREMENTS AND CONSTRAINS

- Energy increase to 1.1 GeV

→ Larger fields, up to the saturation for iron magnet

- Ramping magnets from 0.51 to 1.1 GeV

FROM DAΦNE TO DAFNE2

NEW DIPOLES REQUIREMENTS AND CONSTRAINTS

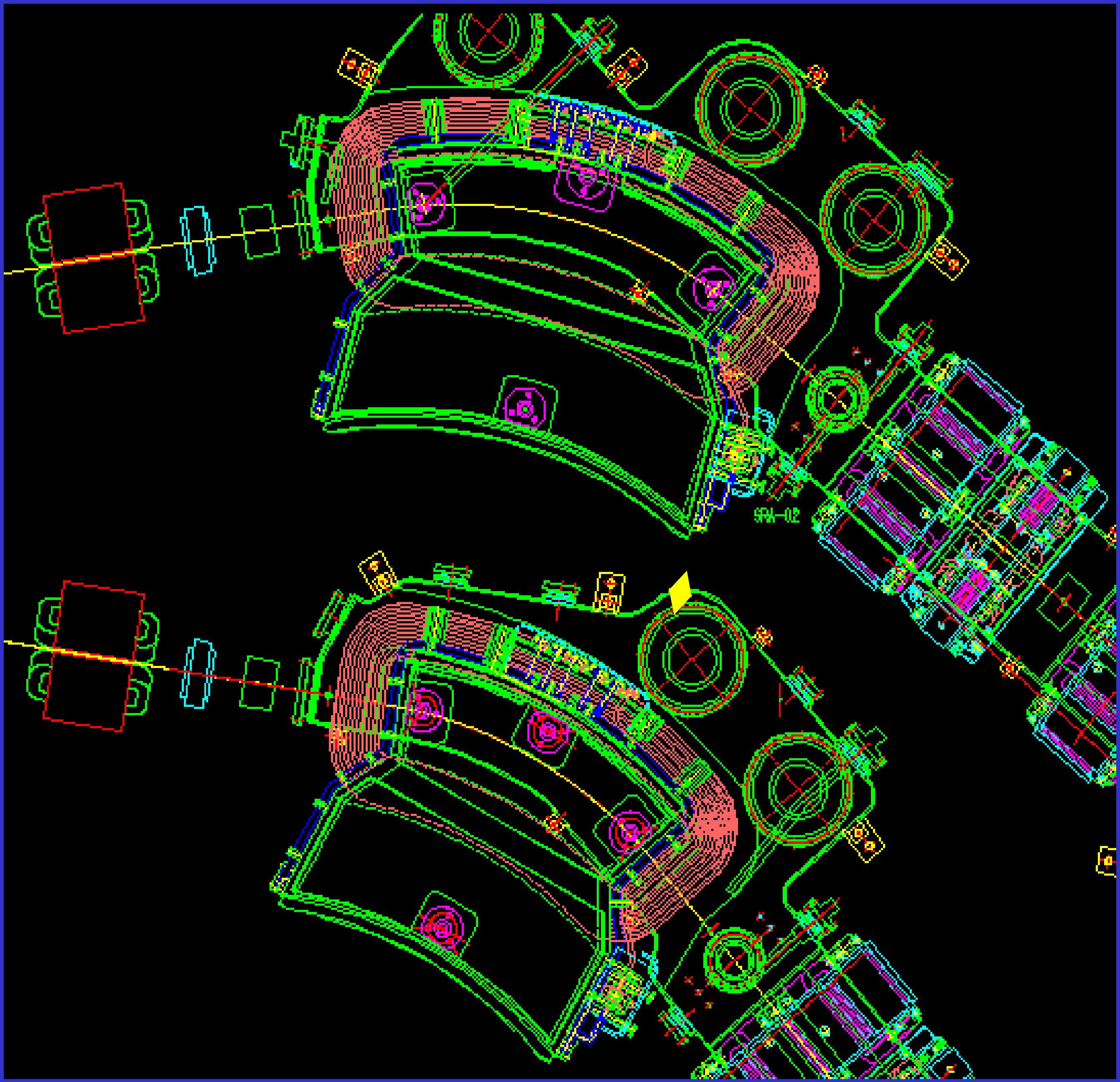
- Same Daϕne vacuum chamber

→ Magnet gap height ≥ 70 mm

→ Same bending angle

- Same Daϕne layout

→ Constraints in the dimension



NEW DIPOLES DESIGN

In order to achieve the field requirement, given the machine layout, it is possible to:

LOWER THE MAGNET GAP

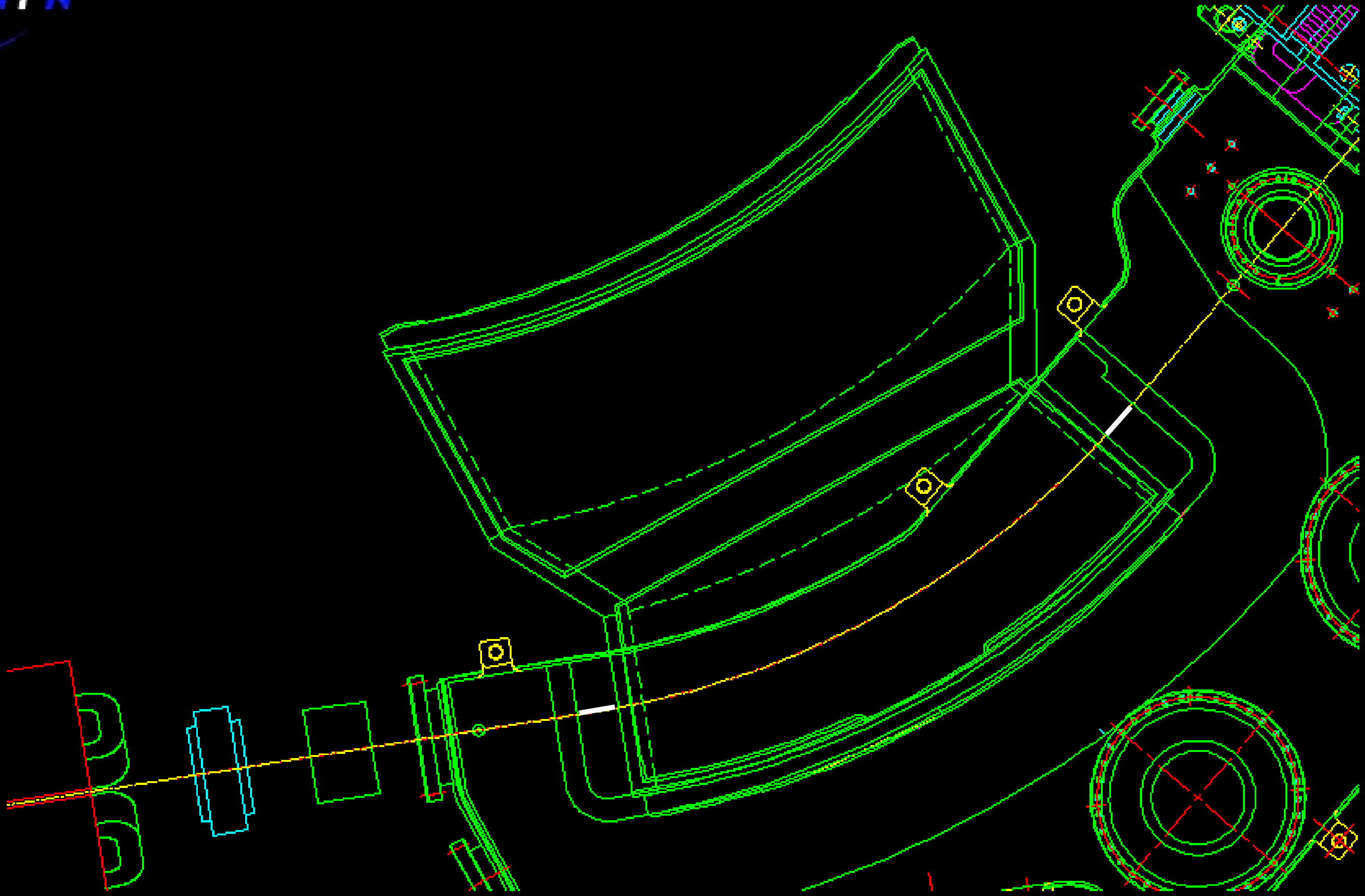
It is possible to reduce the magnet gap from 75 mm to 70 mm, removing the vacuum chamber thermal insulation

NEW DIPOLES DESIGN

In order to achieve the field requirement, given the machine layout, it is possible to:

INCREASE THE BENDING RADIUS

With the Daϕne vacuum chamber it is possible to increase the bending radius from 1.4 m to about 1.53 m, but it involves mechanical complications in the installation.



NEW DIPOLES DESIGN

Also, we should consider the possibility to:

- reduce the good field region
- increase the dipole iron yoke
- accept larger stray fields

NEW DIPOLES DESIGN

Field vs Beam Energy

relative to 1.53 m bending radius

E (GeV)	B (T)
0.510	1.11
1.000	2.18
1.100	2.40
1.150	2.50
1.200	2.61

REQUIREMENTS TABLE

• BEAM ENERGY	0.51 – 1.1 GeV
• Bρ	1.7 – 3.7 T m
• MAGNETIC FIELD:	1.1 – 2.4 T
• MAGNET GAP	70 mm
• BENDING RADIUS	1530 mm
• GOOD FIELD REGION	± 20 mm

WE HAVE TRIED TO SOLVE THE PROBLEM IN TWO DIFFERENT WAYS ...

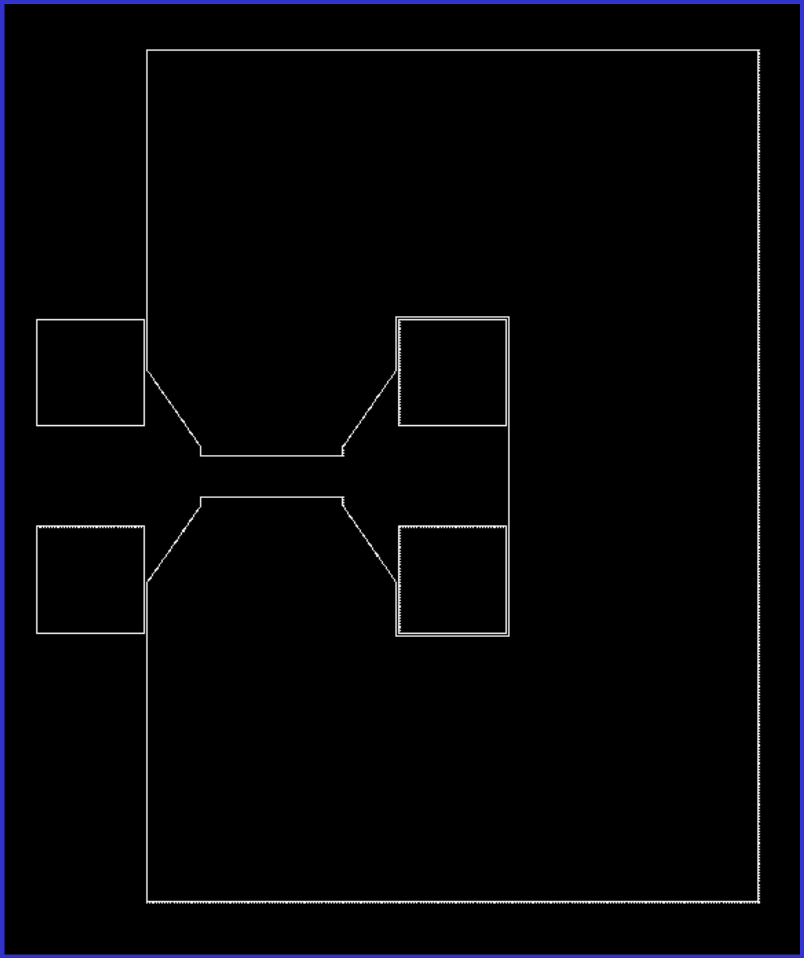
FIRST SOLUTION: CONVENTIONAL IRON MAGNETS

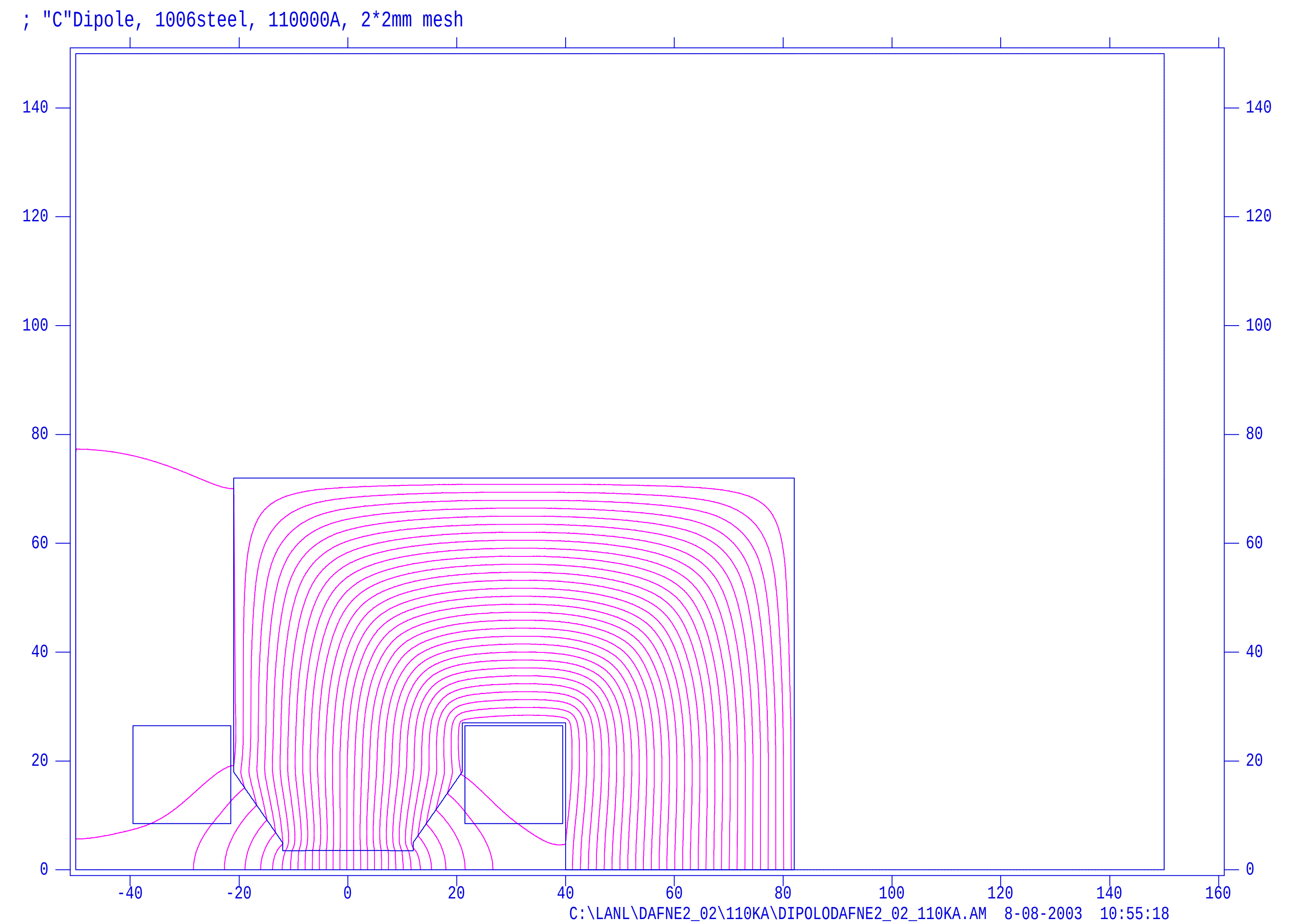
We ran a simulation with POISSON 2D FEM code.

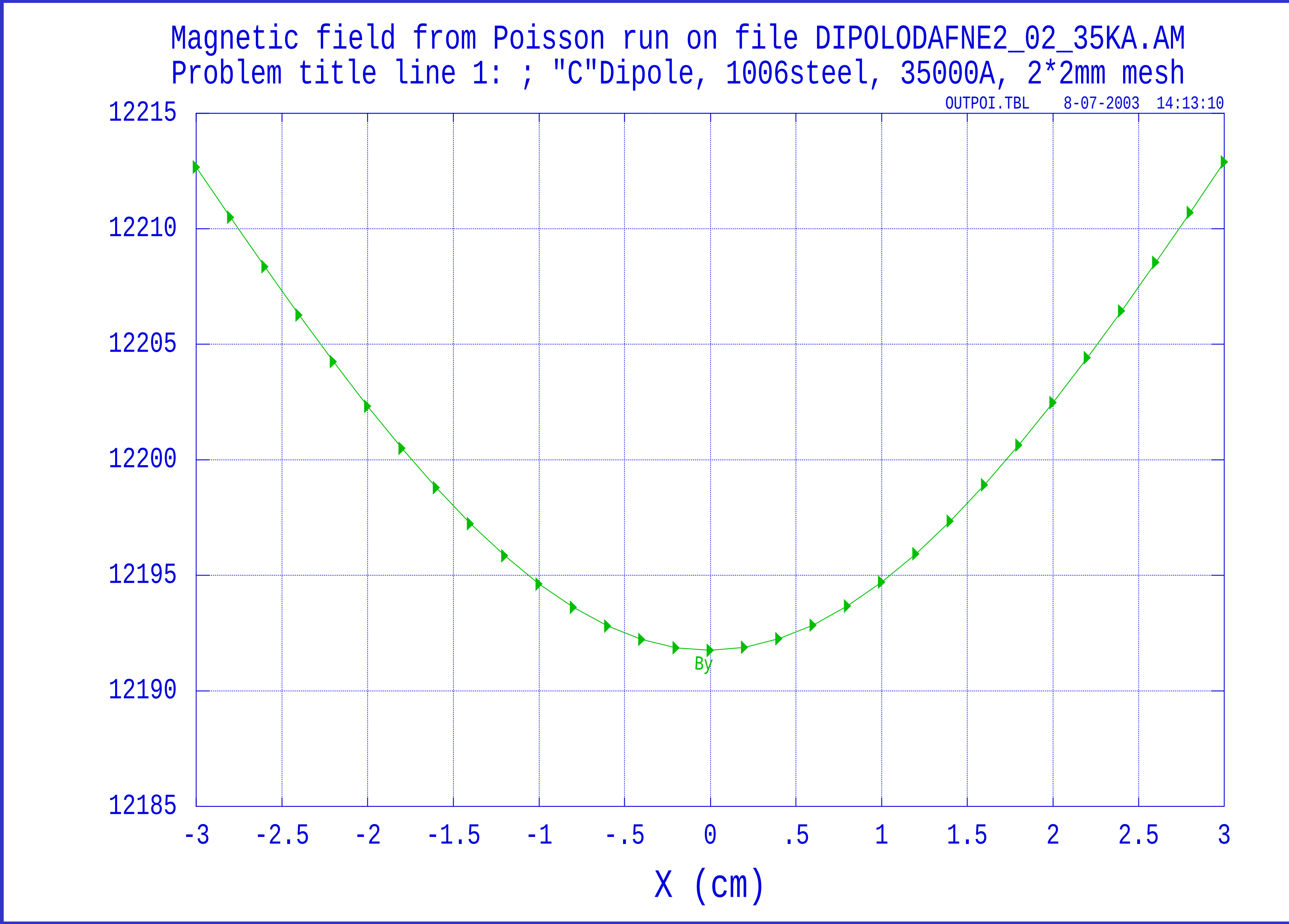
The material considered is the 1006 iron in all the yoke.

The current ranges from 31.5 to 150 kA*turns

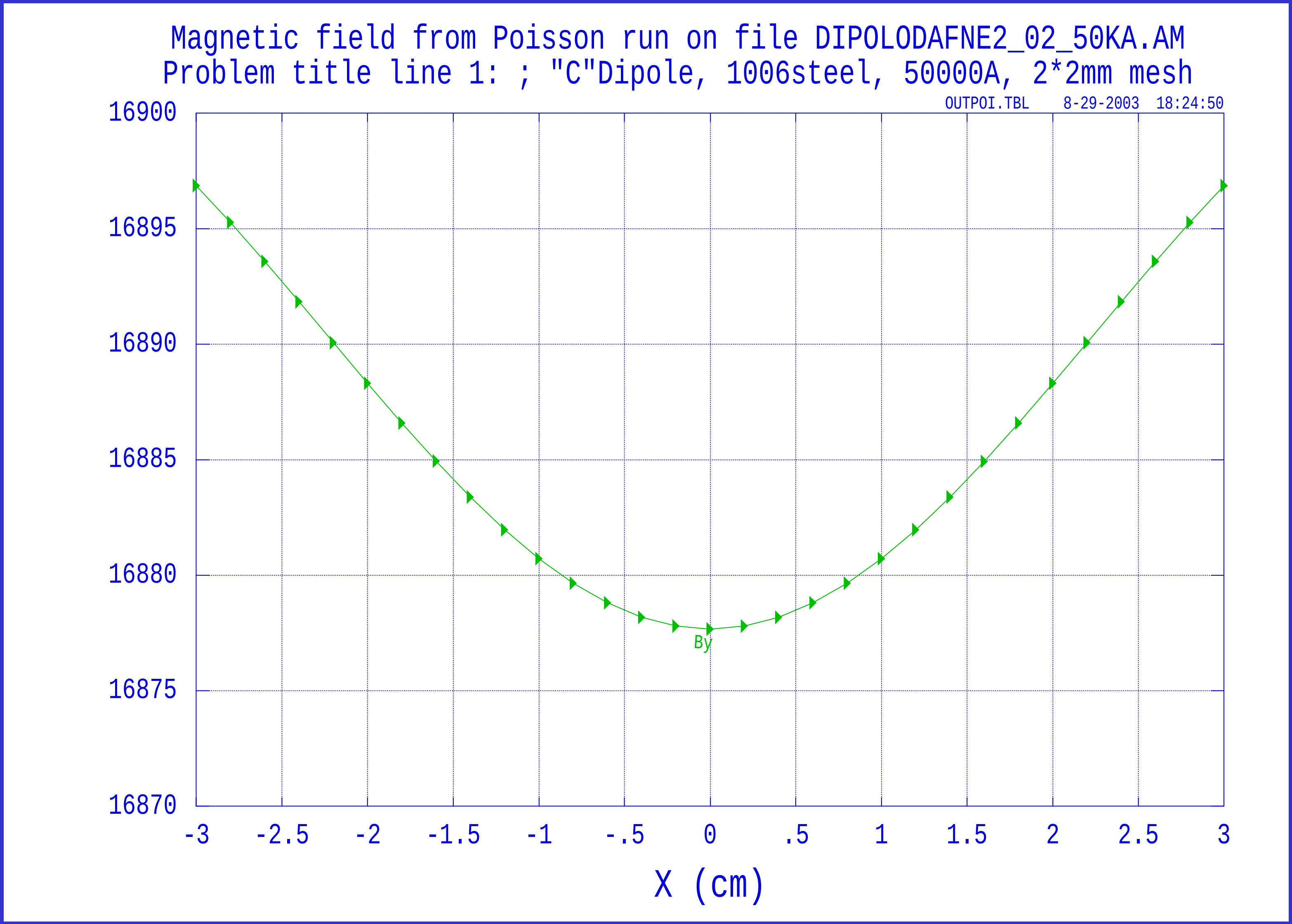
With 32400 mm^2 cross-section coils and a filling factor of 0.55, the current density in the coil ranges from 1.8 to 8.4 A/mm^2

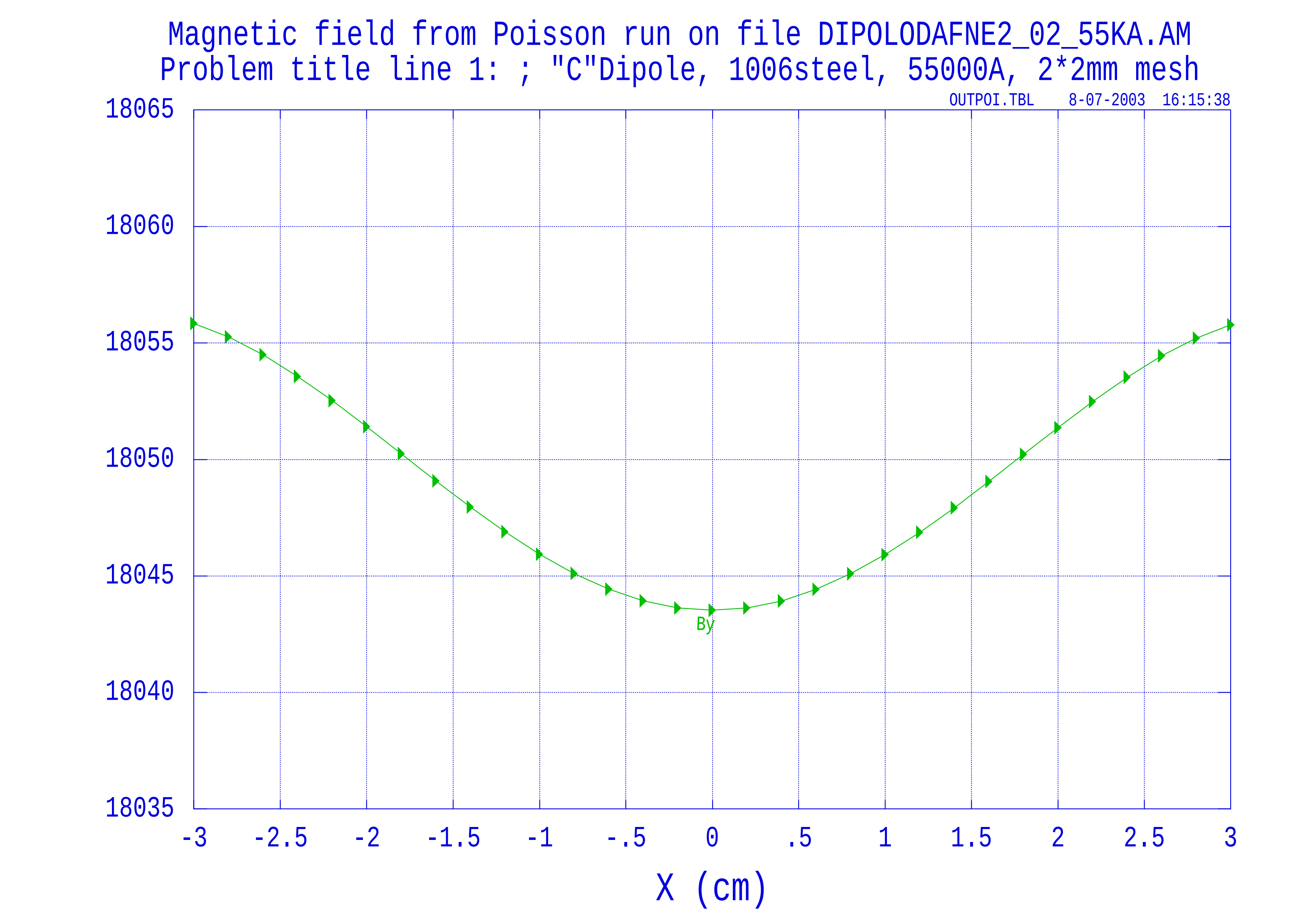


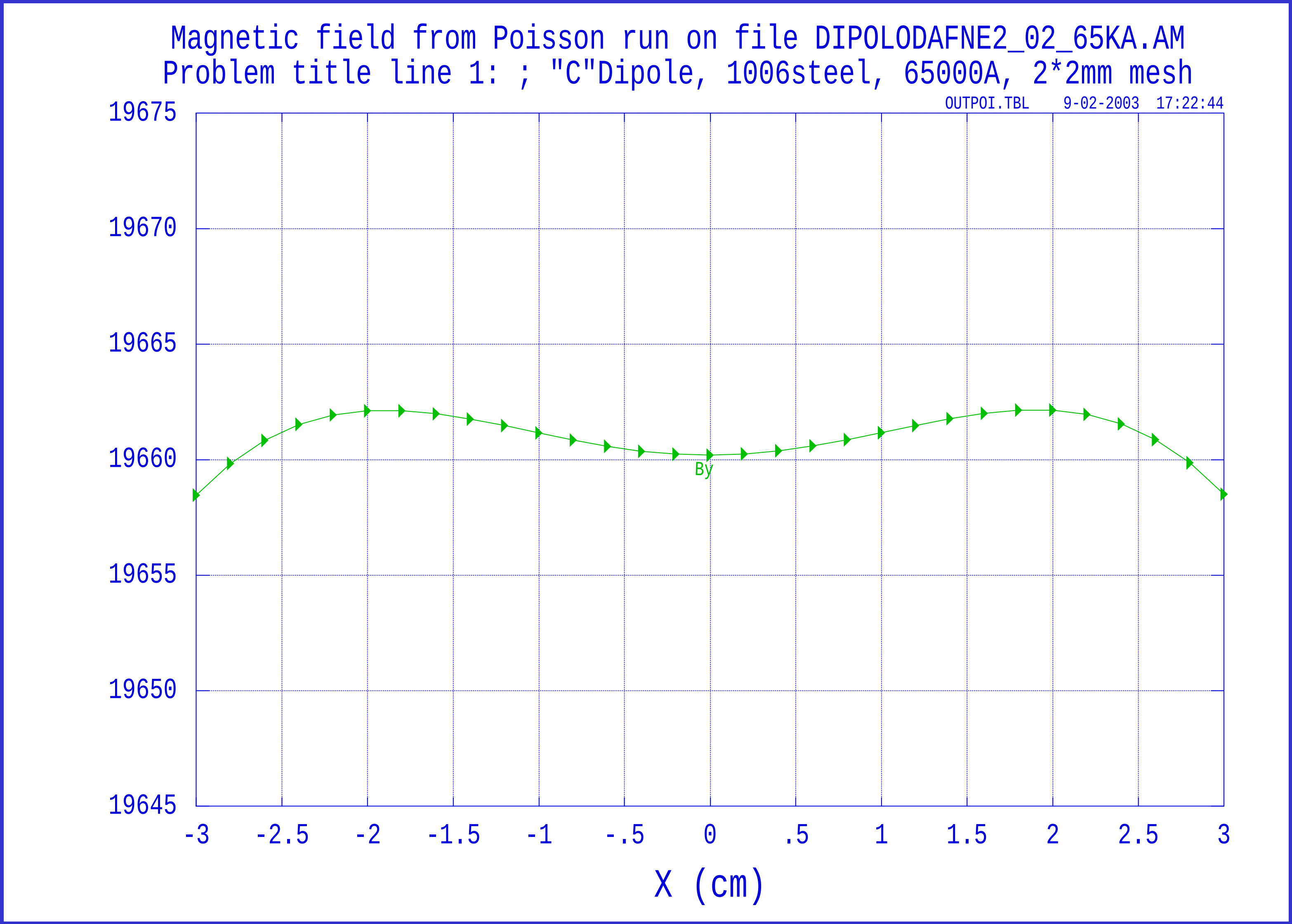

; "C"Dipole, 1006steel, 110000A, 2*2mm mesh
140
120
100
80
60
40
20
0
-40
-20
0
20
40
60
80
100
120
140
160
C:\LANL\DAFNE2_02\110KA\DIPOLODAFNE2_02_110KA.AM 8-08-2003 10:55:18



Magnetic field from Poisson run on file DIPOLODAFNE2_02_35KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 35000A, 2*2mm mesh
OUTPOI.TBL 8-07-2003 14:13:10
12215
12210
12205
12200
12195
12190
12185
By
-3 -2.5 -2 -1.5 -1 -.5 0 .5 1 1.5 2 2.5 3
X (cm)


Magnetic field from Poisson run on file DIPOLODAFNE2_02_50KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 50000A, 2*2mm mesh
OUTPOI.TBL 8-29-2003 18:24:50
16900
16895
16890
16885
16880
16875
16870
By
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
X (cm)


Magnetic field from Poisson run on file DIPOLODAFNE2_02_55KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 55000A, 2*2mm mesh
OUTPOI.TBL 8-07-2003 16:15:38
18065
18060
18055
18050
18045
18040
18035
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
By
X (cm)


Magnetic field from Poisson run on file DIPOLODAFNE2_02_65KA.AM
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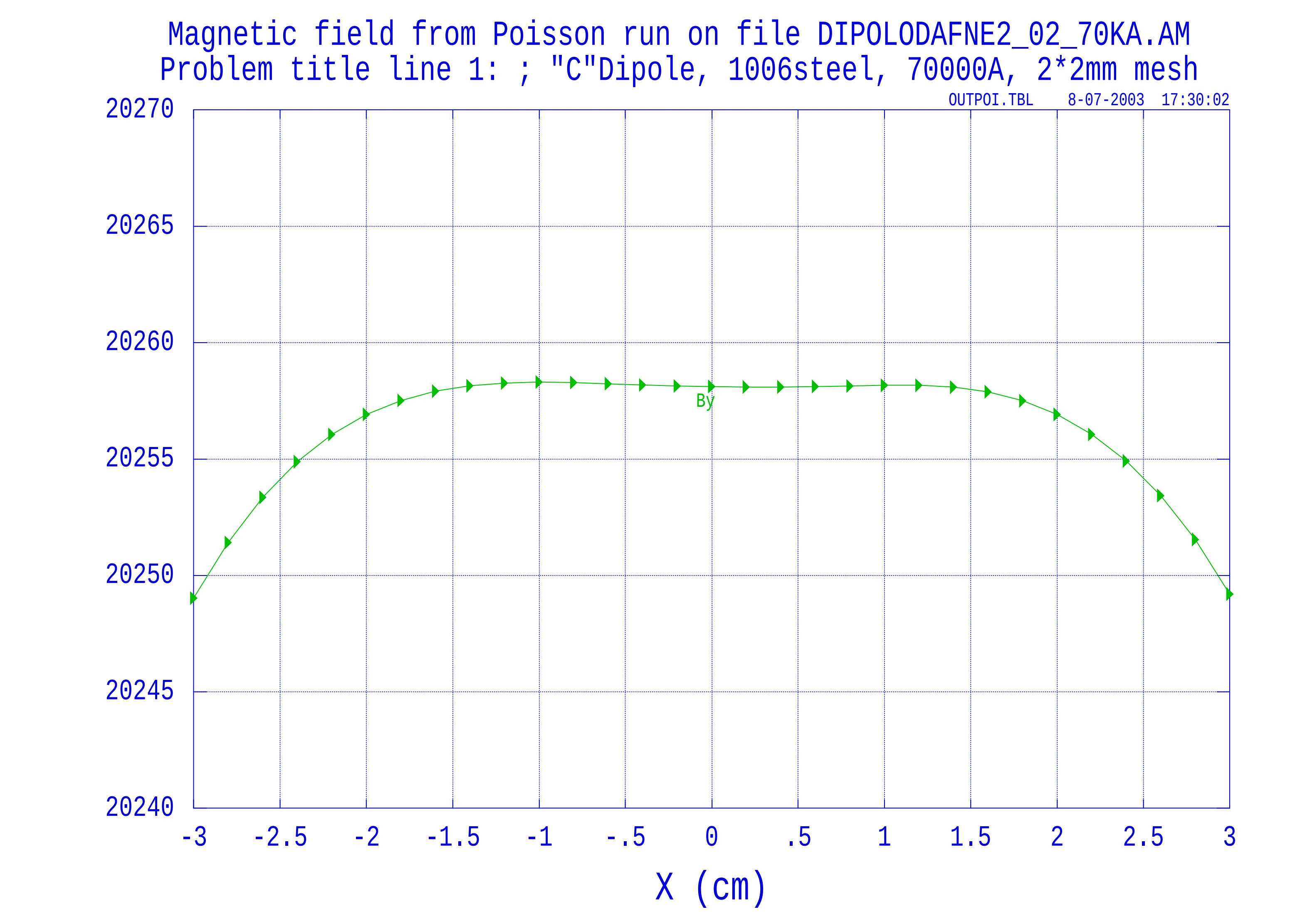
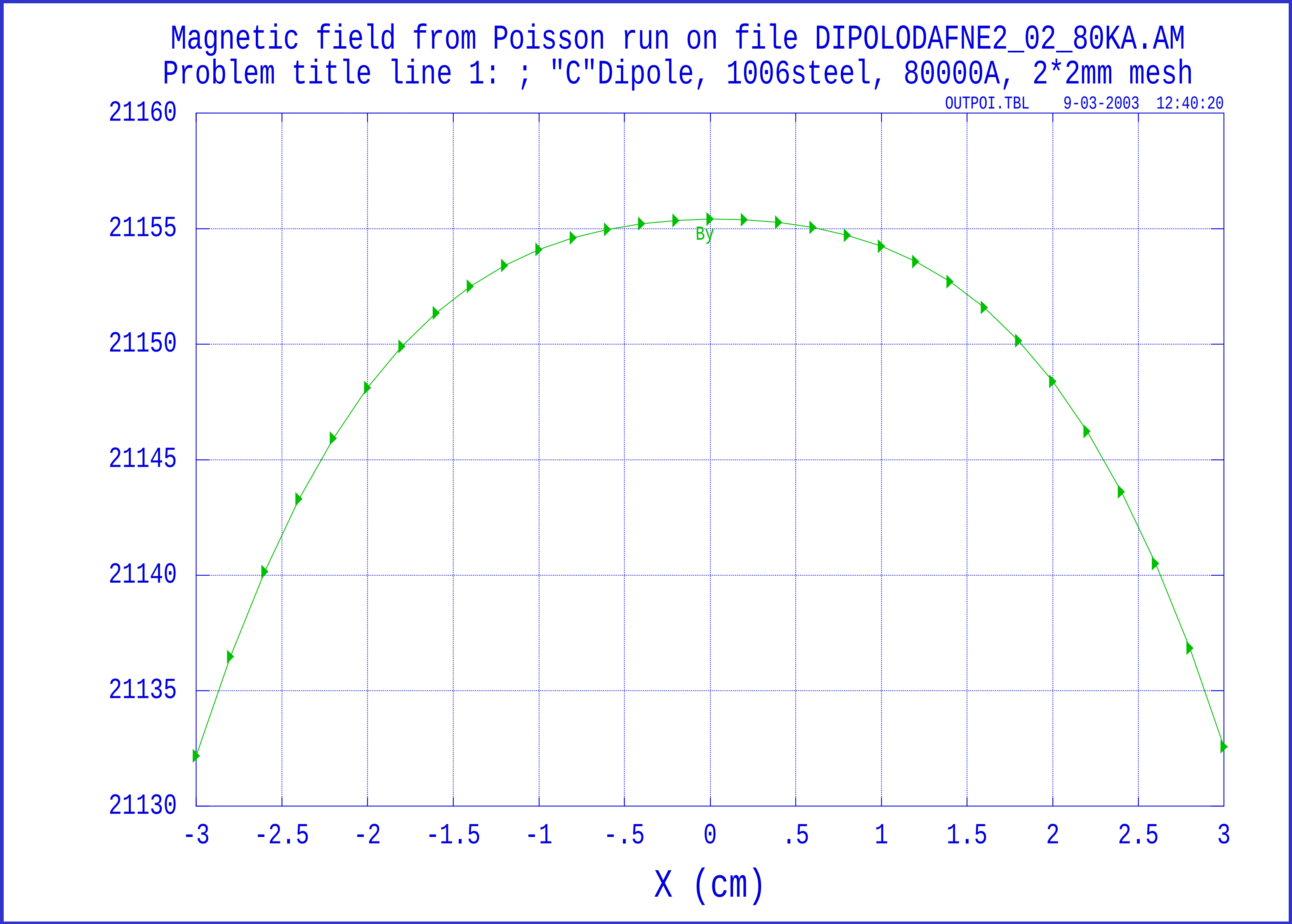
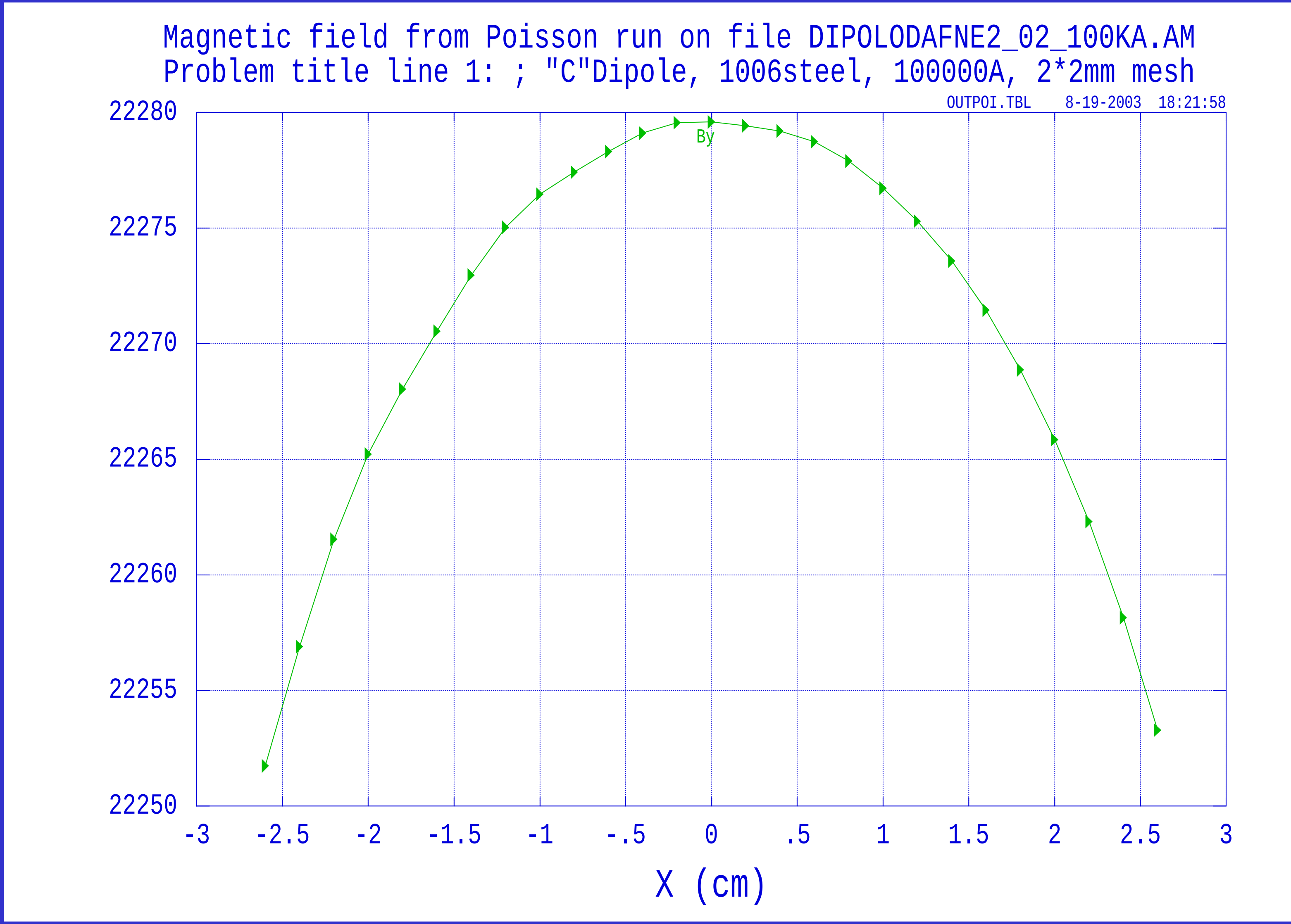
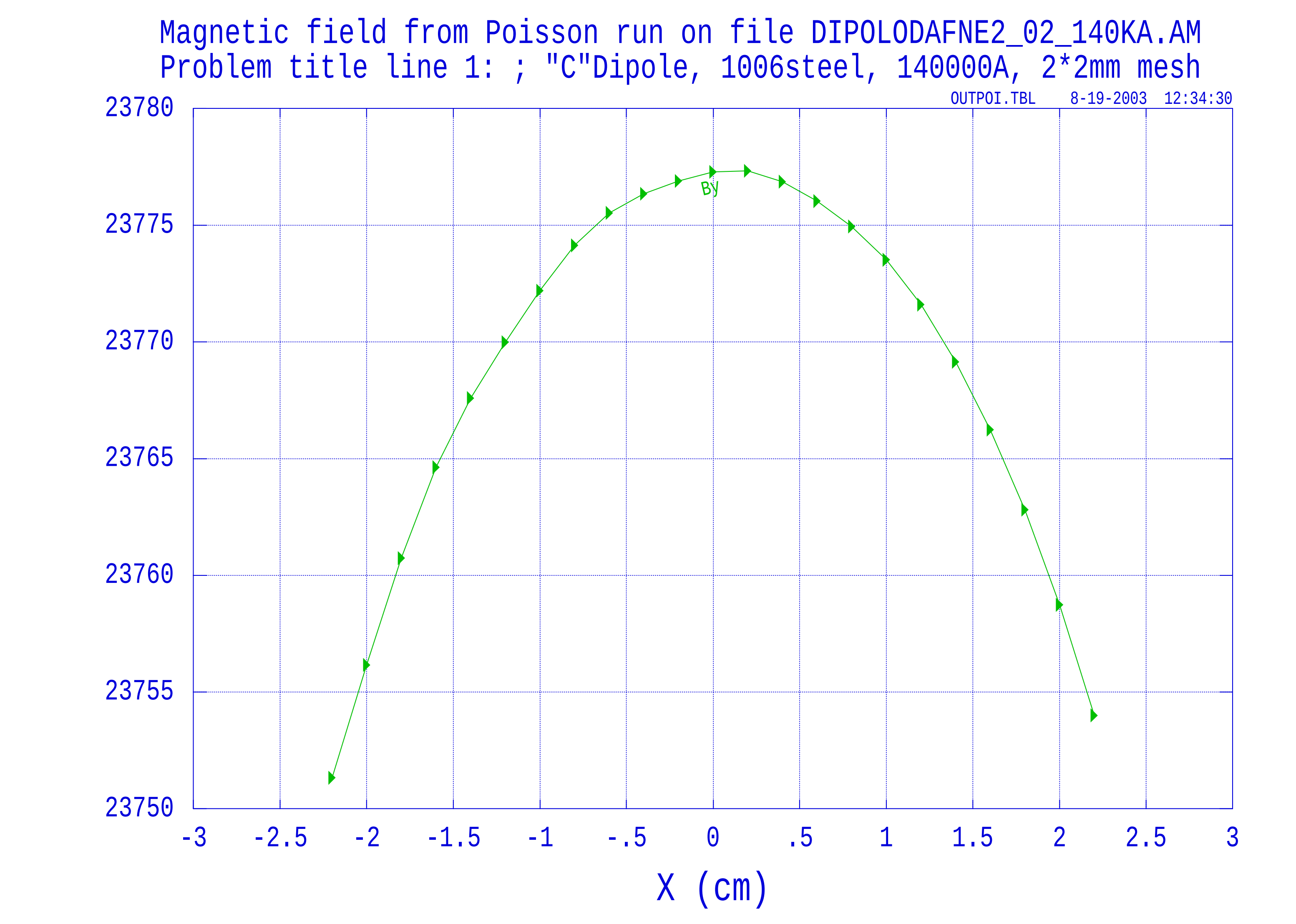
OUTPOI.TBL 9-02-2003 17:22:44
19675
19670
19665
19660
19655
19650
19645
By
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
X (cm)


Magnetic field from Poisson run on file DIPOLODAFNE2_02_70KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 70000A, 2*2mm mesh
OUTPOI.TBL 8-07-2003 17:30:02
20270
20265
20260
20255
20250
20245
20240
By
-3 -2.5 -2 -1.5 -1 -.5 0 .5 1 1.5 2 2.5 3
X (cm)

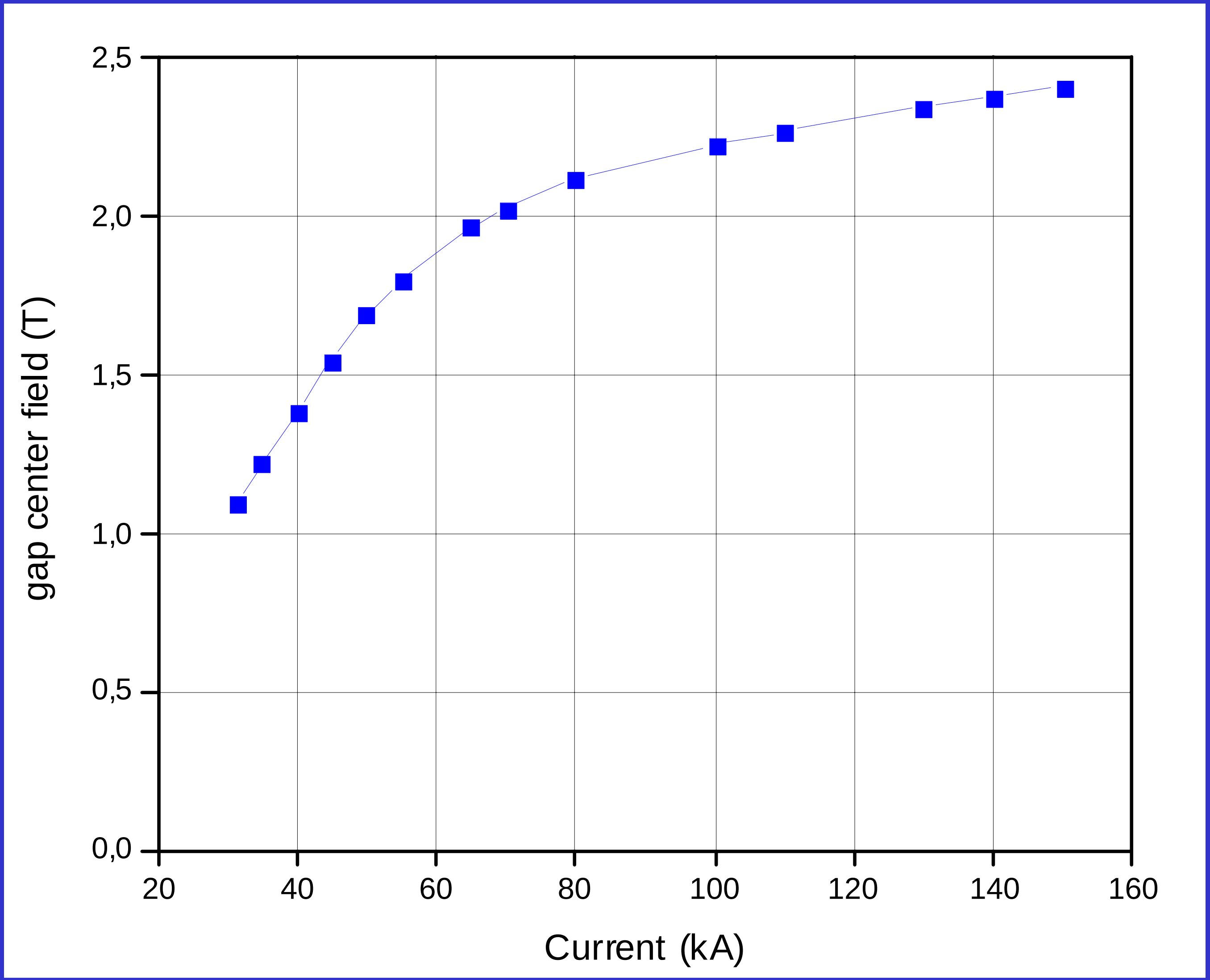

Magnetic field from Poisson run on file DIPOLODAFNE2_02_80KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 80000A, 2*2mm mesh
OUTPOI.TBL 9-03-2003 12:40:20
21160
21155
21150
21145
21140
21135
21130
By
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
X (cm)


Magnetic field from Poisson run on file DIPOLODAFNE2_02_100KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 100000A, 2*2mm mesh
OUTPOI.TBL 8-19-2003 18:21:58
By
22280
22275
22270
22265
22260
22255
22250
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
X (cm)

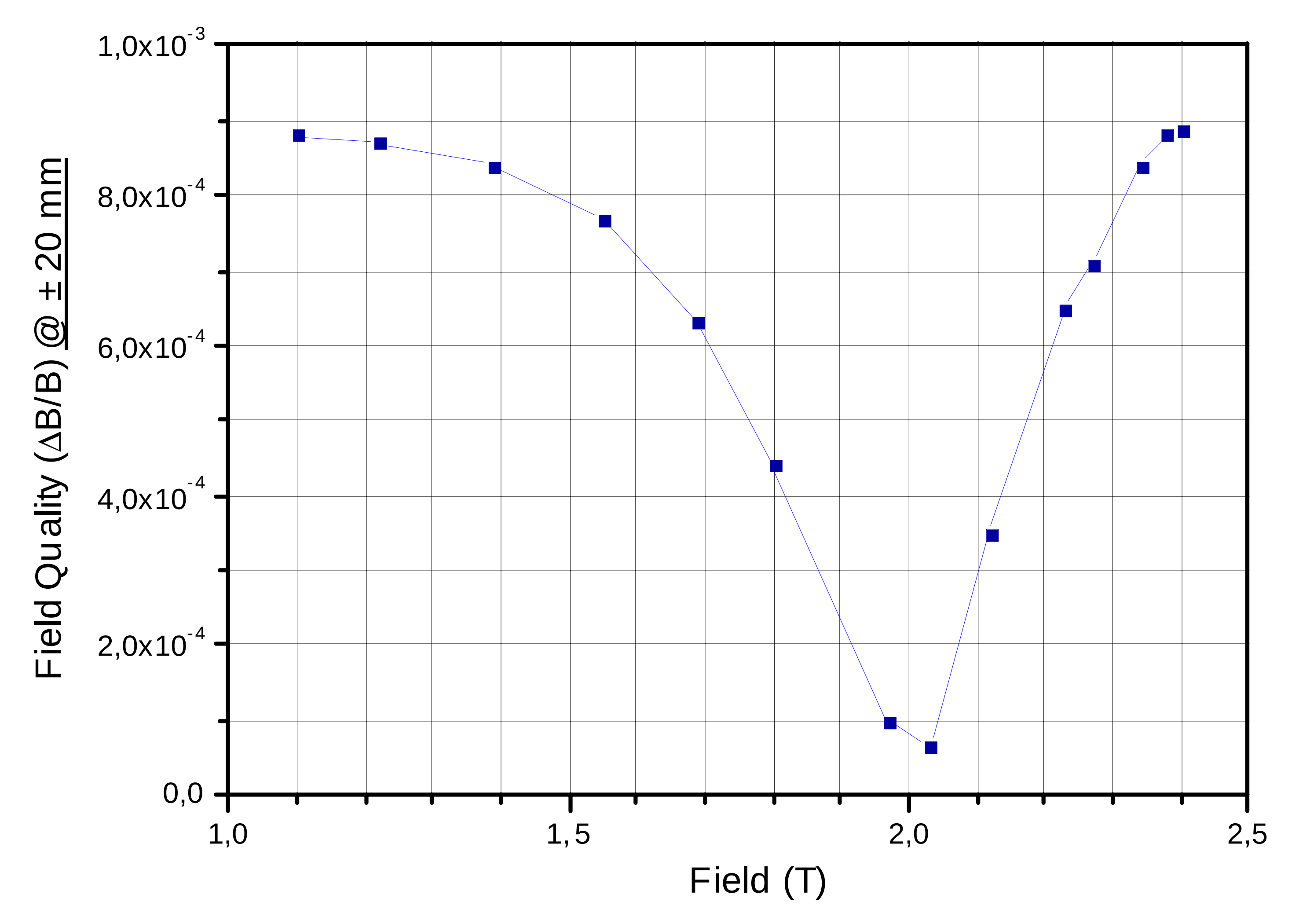


Magnetic field from Poisson run on file DIPOLODAFNE2_02_140KA.AM
Problem title line 1: ; "C"Dipole, 1006steel, 140000A, 2*2mm mesh
OUTPOI.TBL 8-19-2003 12:34:30
23780
23775
23770
23765
23760
23755
23750
By
-3
-2.5
-2
-1.5
-1
-.5
0
.5
1
1.5
2
2.5
3
X (cm)

FIELD vs CURRENT
IN THE GAP CENTER



FIELD QUALITY
IN THE GOOD FIELD REGION



SIMULATION RESULTS

(B = 1.1 ÷ 2.4 T, GFR = ± 20 mm)

- CURRENT DENSITY = 1.8 ÷ 8.4 A/mm^2
- FIELD QUALITY ($\Delta B/B$) = 9 10^{-4} @ 1.1 & 2.4 T
- STRAY FIELDS = 500 G @ 1 m, 2.4 T

CONCLUSIONS
about the first solution – iron dipole

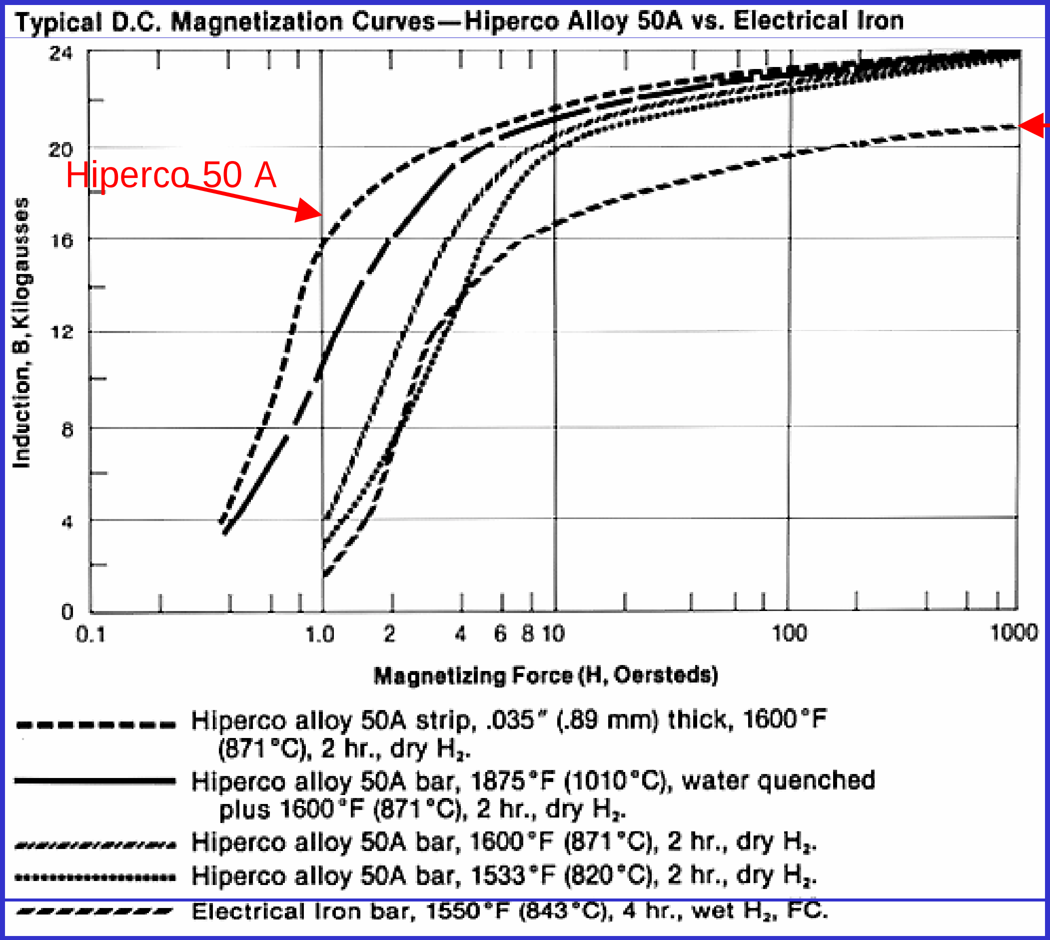
The constrains in the design of the dipoles are so strong.

In principle, it is possible to use traditional iron dipoles, but:

- The simulations indicates that at energy above 1 GeV the dipole is saturated from the corresponding magnetic field, not just in the pole tips, but also in the iron yoke. This also implies very high stray fields!
- At high fields the current density is very high. This involves very high electric power cost and new power supply.
- The field quality is about 10^{-3}, even in a good field region of ± 20 mm. It can be better without the ramping.

SECOND SOLUTION:
HIGH PERFORMANCE MATERIAL

Permendur (Hyperco 50 A)



Material	B_{sat} [Tesla]	Coercitive Force [Amp/m]
Hiperco 50A	2.40	79.6
Pure Iron	2.15	79.6
1008 Steel	2.09	64

Design Criteria

Target: Use the same section of Dafne Dipoles

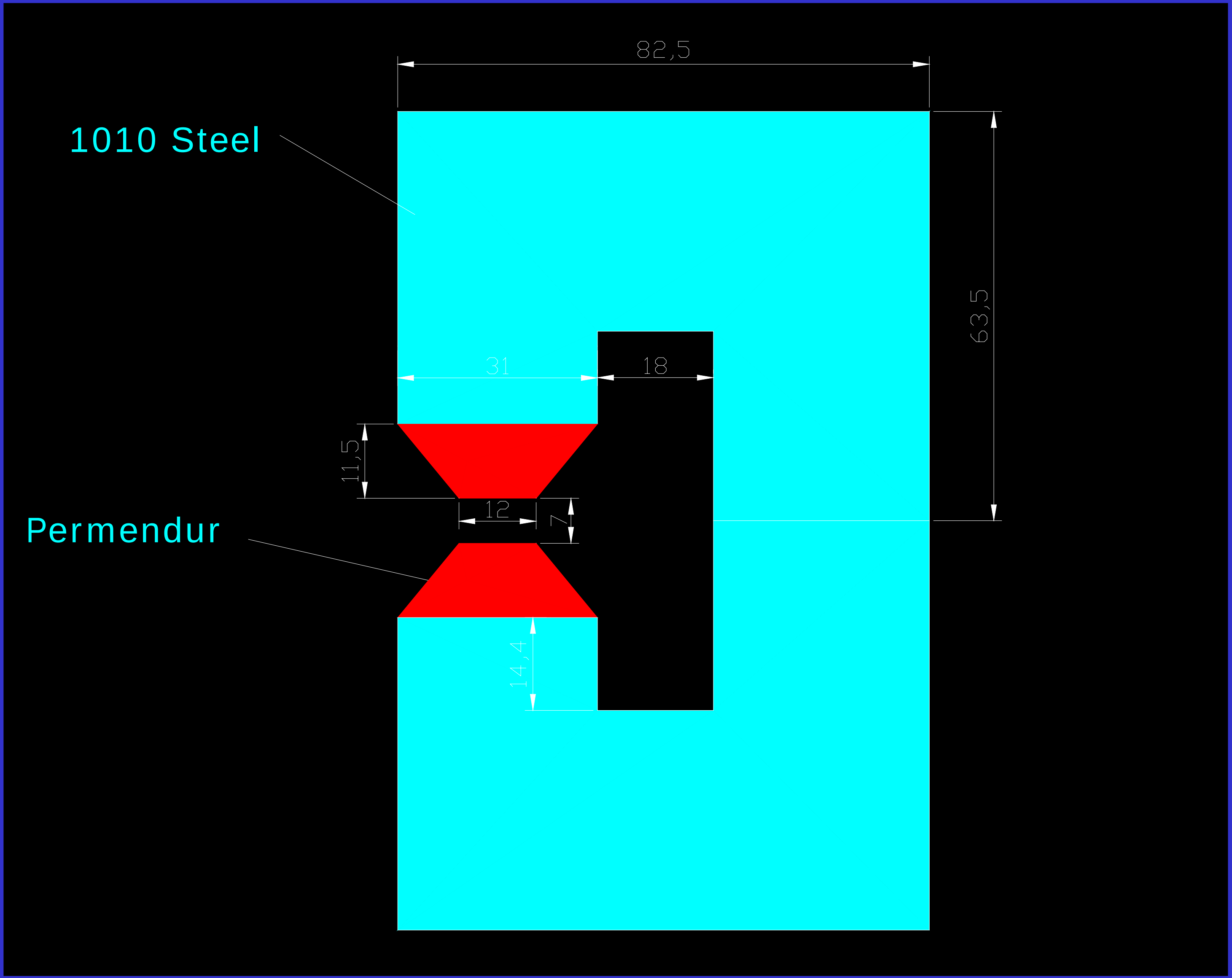
- Concentrate the flux reducing the tip pole section
- Reduce NI

↓

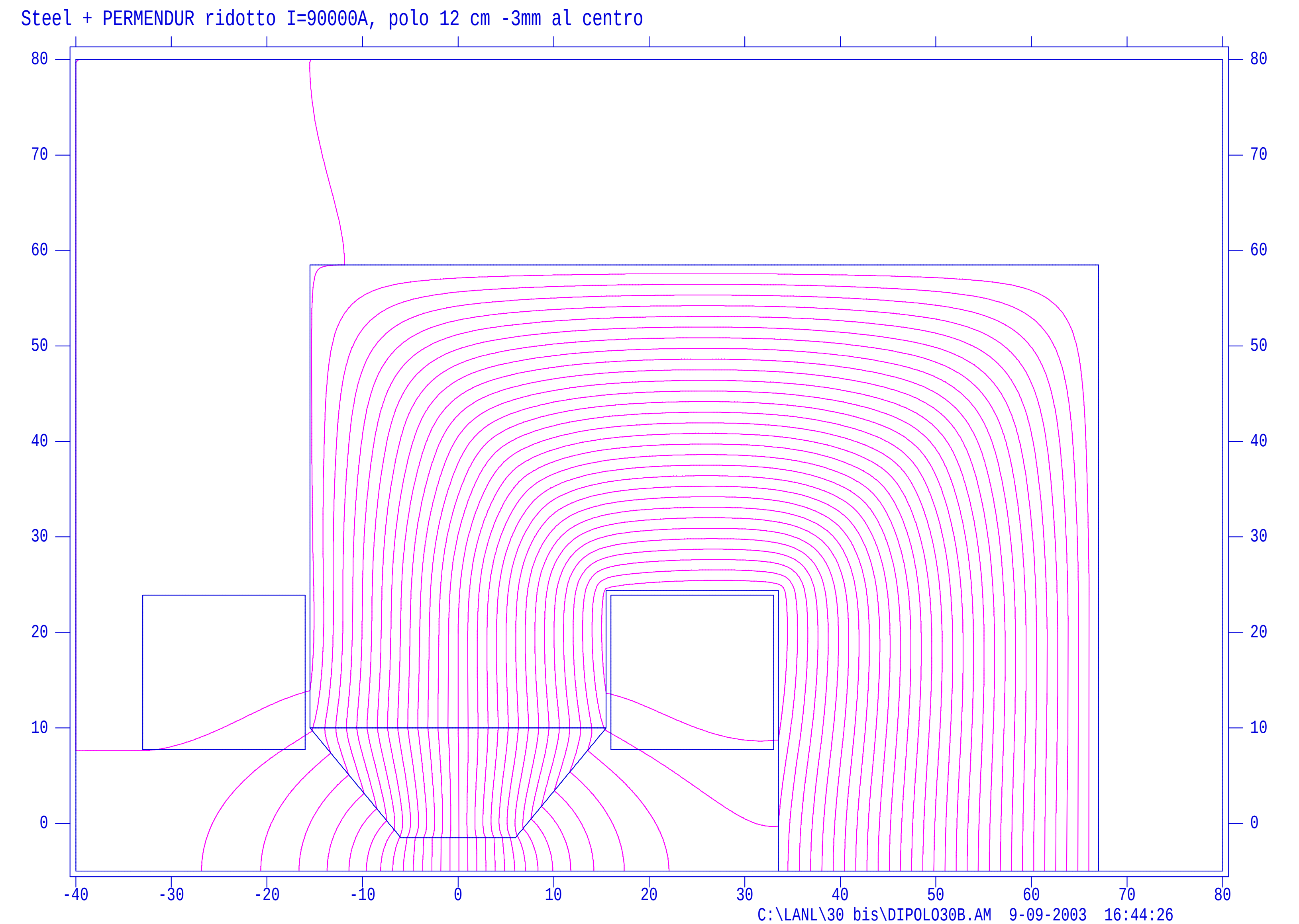
Normal flux density in yoke → Steel

High flux density in tip poles → Permendur

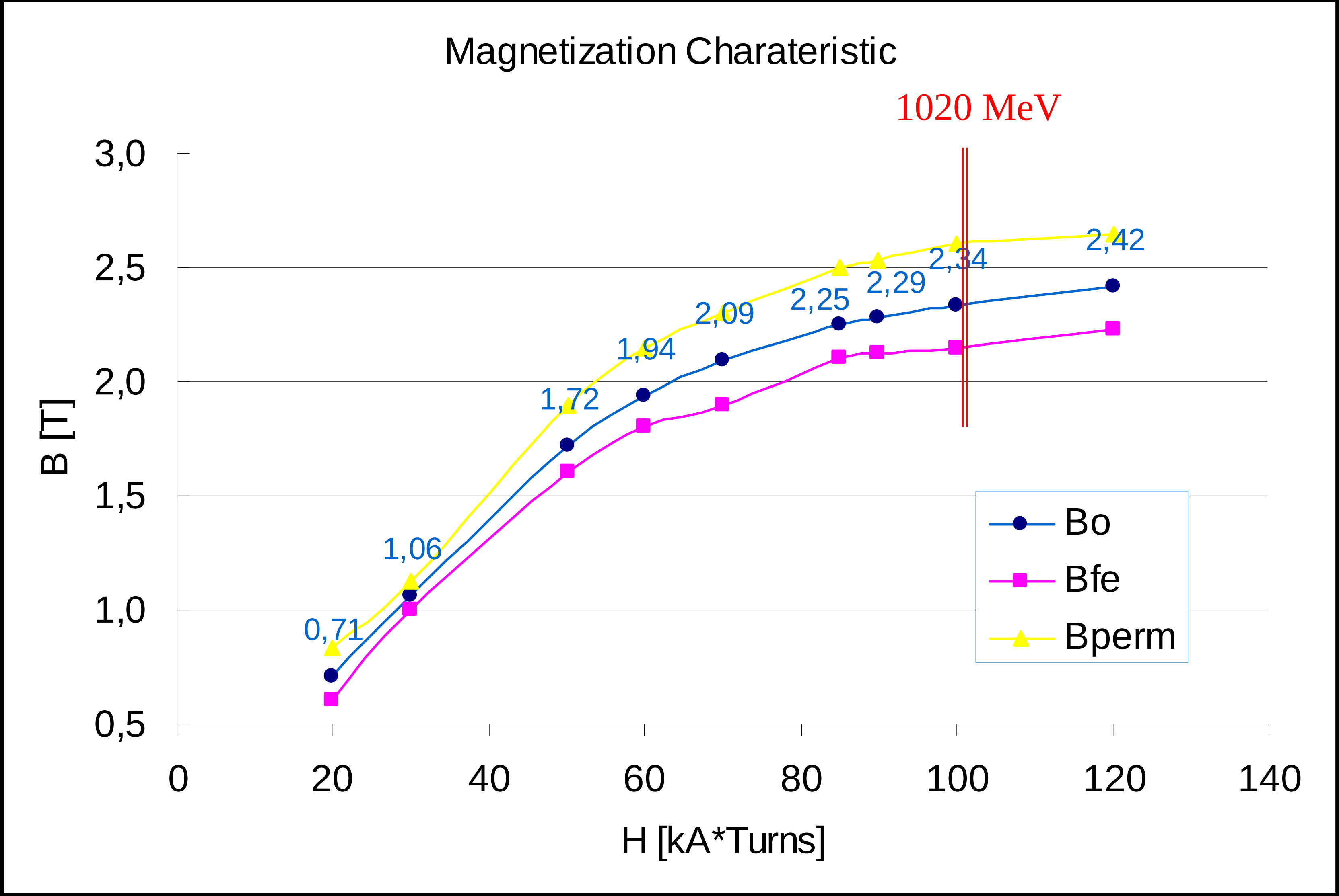
Dipole Section

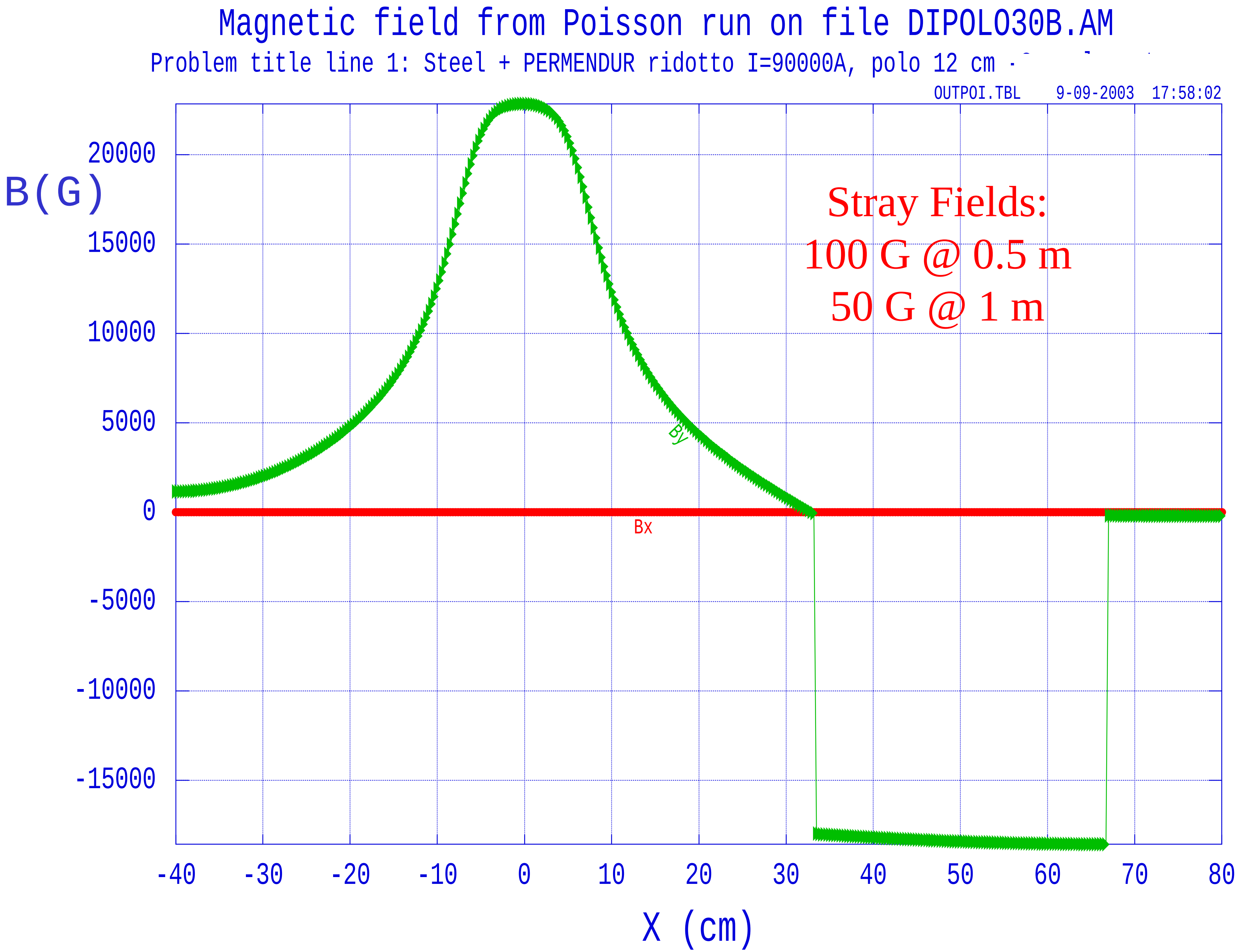


Poisson 2d Output

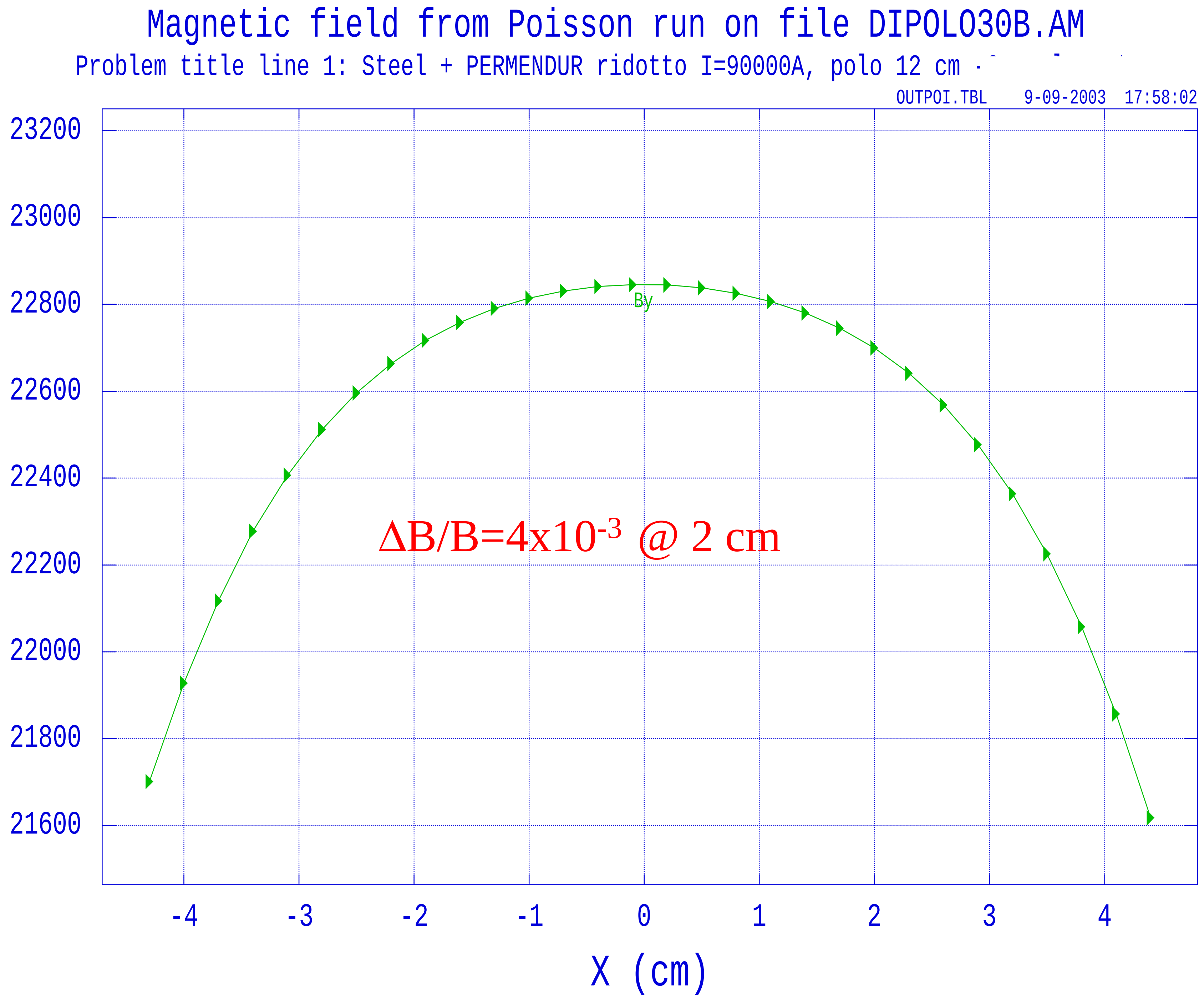


Magnetization Curve





Magnetic field from Poisson run on file DIPOLO30B.AM
Problem title line 1: Steel + PERMENDUR ridotto I=90000A, polo 12 cm
OUTPOI.TBL 9-09-2003 17:58:02
B(G)
20000
15000
10000
5000
0
-5000
-10000
-15000
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
X (cm)
By
Bx
Stray Fields:
100 G @ 0.5 m
50 G @ 1 m


Magnetic field from Poisson run on file DIPOLO30B.AM
Problem title line 1: Steel + PERMENDUR ridotto I=90000A, polo 12 cm
OUTPOI.TBL 9-09-2003 17:58:02
23200
23000
22800
22600
22400
22200
22000
21800
21600
-4
-3
-2
-1
0
1
2
3
4
X (cm)
By
ΔB/B=4x10-3 @ 2 cm

Steel/Permendur Dipole Summary

B= 2.22 T @ 1020 MeV

NI=90kA J= 6 A/mm^2

	Dipole Type		Total
Volume [m^3]	Long	Short	**Dafne 2**
Steel	1,05	0,88	15,45
Permendur	0,07	0,06	0,98
Copper	0,10	0,09	1,52
Weight [kg]			
Steel	8260	6974	122000
Permendur	537	454	7926
Copper	891	776	13336
Tot Type	9688	8203	143130
Power [kW]	78	68	1173

Permendur Cost estimate: 950 k€ (120 €/kg)

Same Power Supply of Daϕne

Work to do

- Pole profile optimization on 2D in order to increase field quality
- 3D analysis