Magnet Simulation Activities at Fermilab

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for Vladimir Kashikhin, *et al.*

PAC05

Codes used

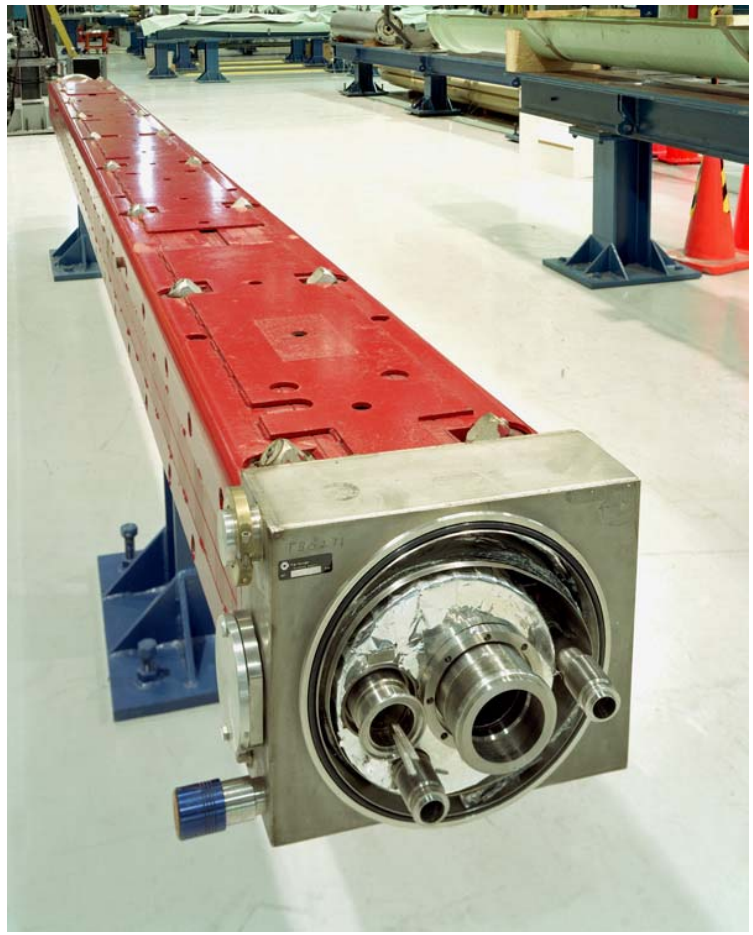
- Vector Fields – 2D, 3D, DC, AC
- Poisson
- ROXIE
- Excel

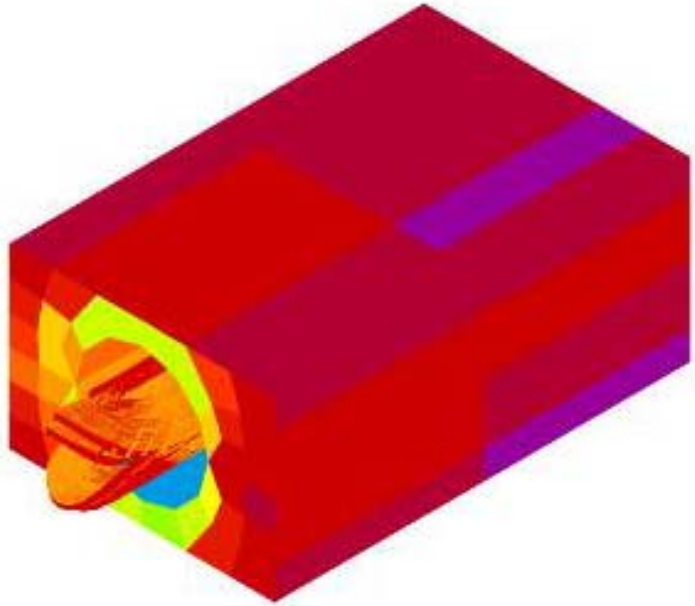
Recent Calculations

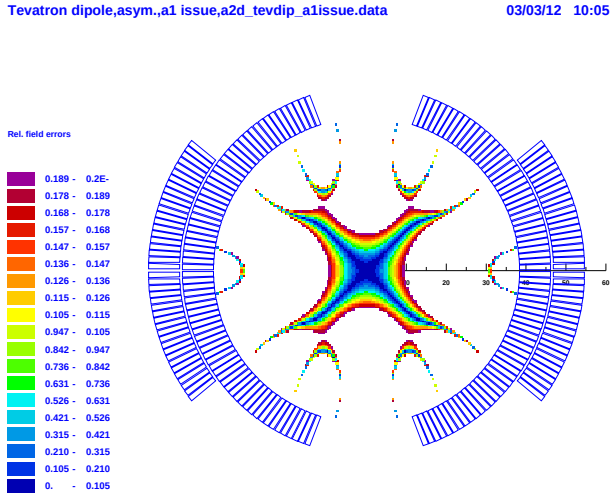
- Tevatron dipole magnets
- Booster Orbit Bump magnets
- WQB wide aperture quadrupoles
- Booster corrector packages
- B-TeV IR quads
- Combined function magnet for FFAG
-
- And more

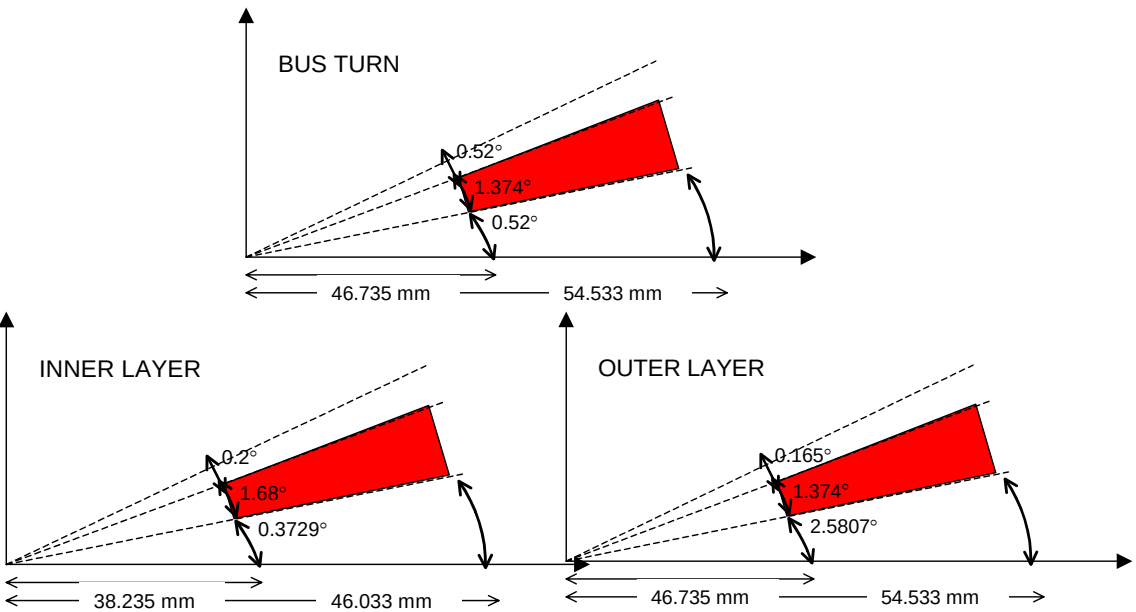
Tevatron dipole magnets

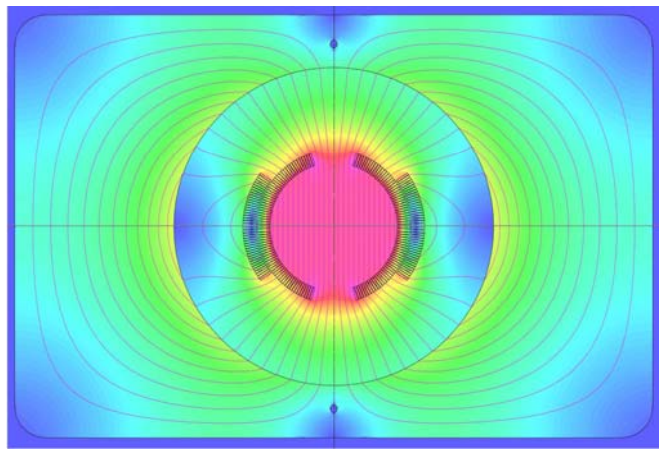
- After 25 years, still trying to understand their behavior
  - Drift and snapback
  - Skew quadrupole





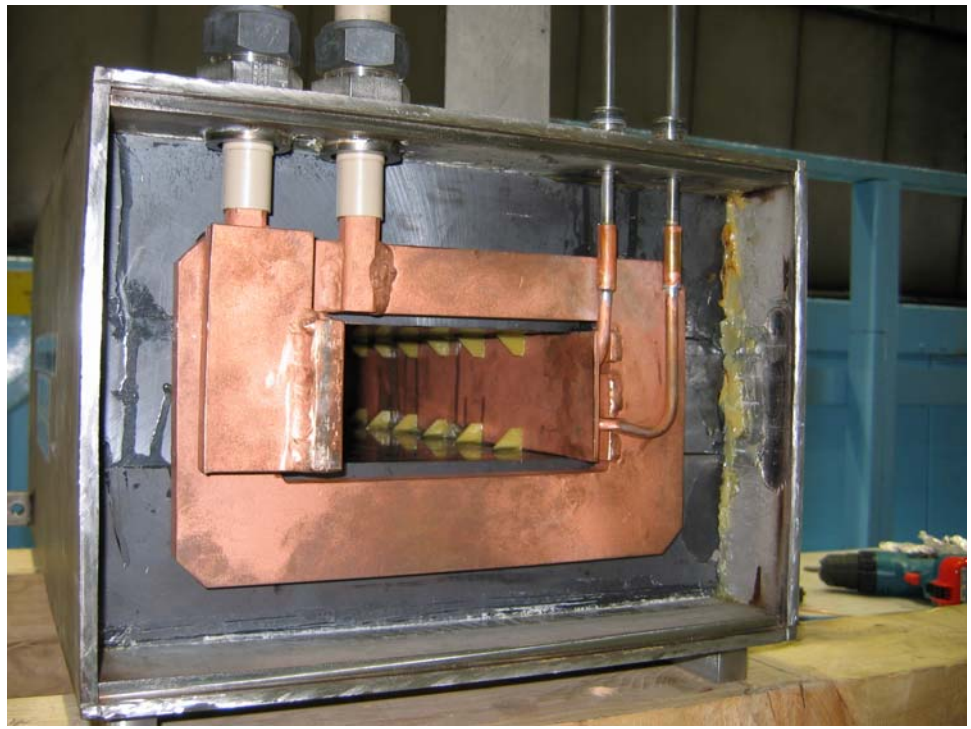

Tevatron dipole,asym.,a1 issue,a2d_tevdip_a1issue.data
03/03/12 10:05
Rel. field errors
0.189 - 0.2E-
0.178 - 0.189
0.168 - 0.178
0.157 - 0.168
0.147 - 0.157
0.136 - 0.147
0.126 - 0.136
0.115 - 0.126
0.105 - 0.115
0.947 - 0.105
0.842 - 0.947
0.736 - 0.842
0.631 - 0.736
0.526 - 0.631
0.421 - 0.526
0.315 - 0.421
0.210 - 0.315
0.105 - 0.210
0. - 0.105
ROXIE 7.0

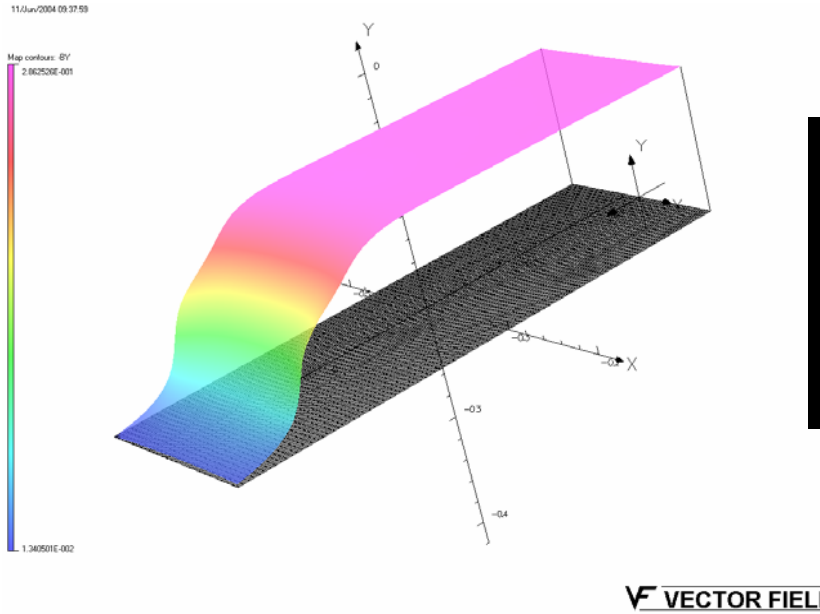

BUS TURN
0.52°
1.374°
0.52°
46.735 mm
54.533 mm
INNER LAYER
0.2°
1.68°
0.3729°
38.235 mm
46.033 mm
OUTER LAYER
0.165°
1.374°
2.5807°
46.735 mm
54.533 mm

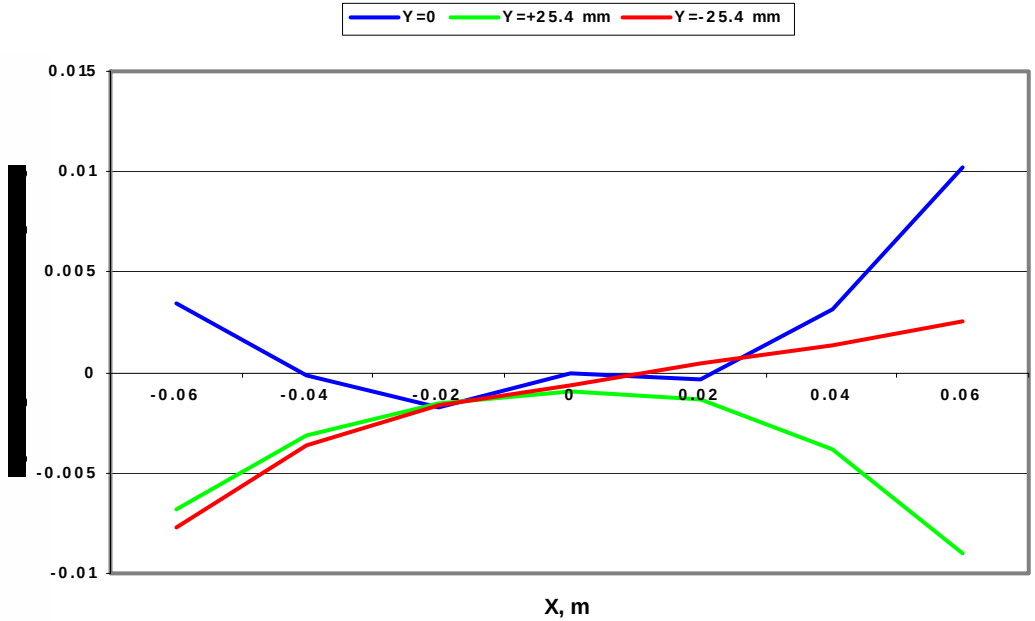


Booster Orbit Bump magnets

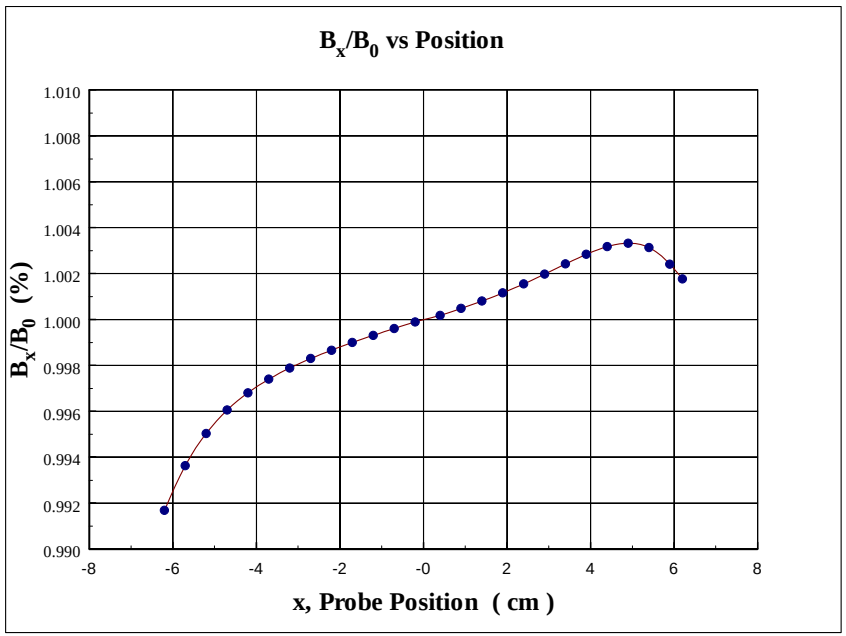
- Pulsed, 15 Hz
  - 20 μs, 35 μs, 20 μs
- 0.28 T peak field
- 0.52 m long
- 65.1 mm gap
- 135 mm width
- NiZn Ferrite core
- Single turn
- ~15 kA

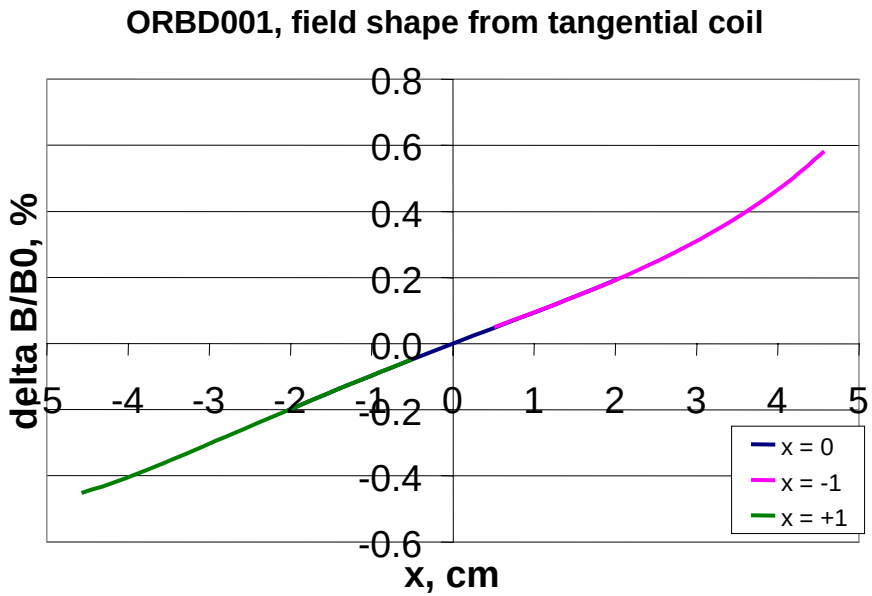






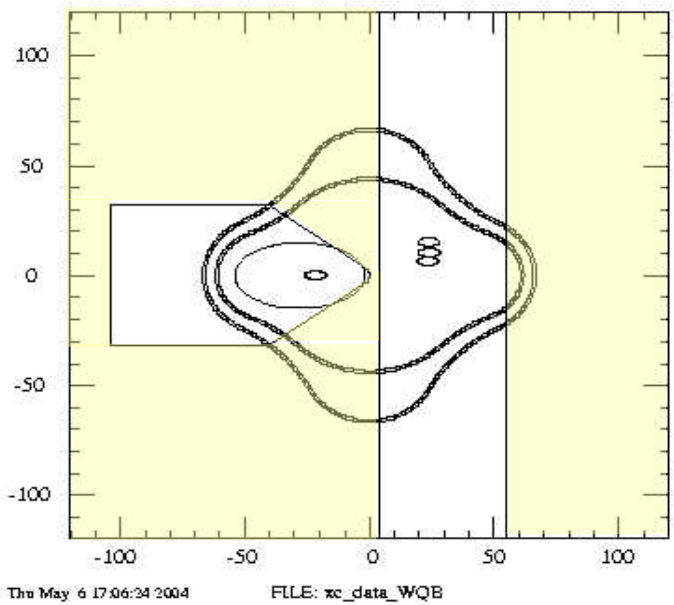
VECTOR FIELDS

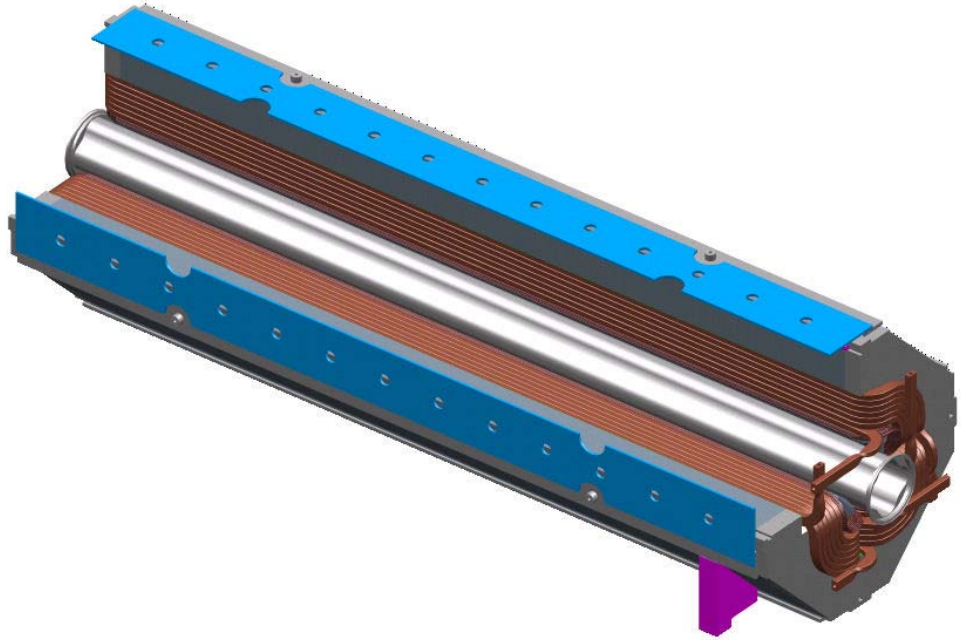


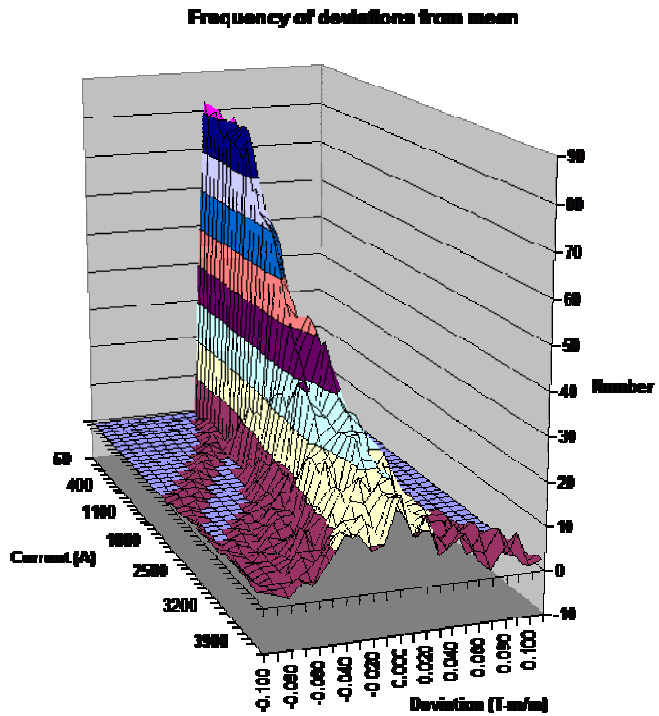


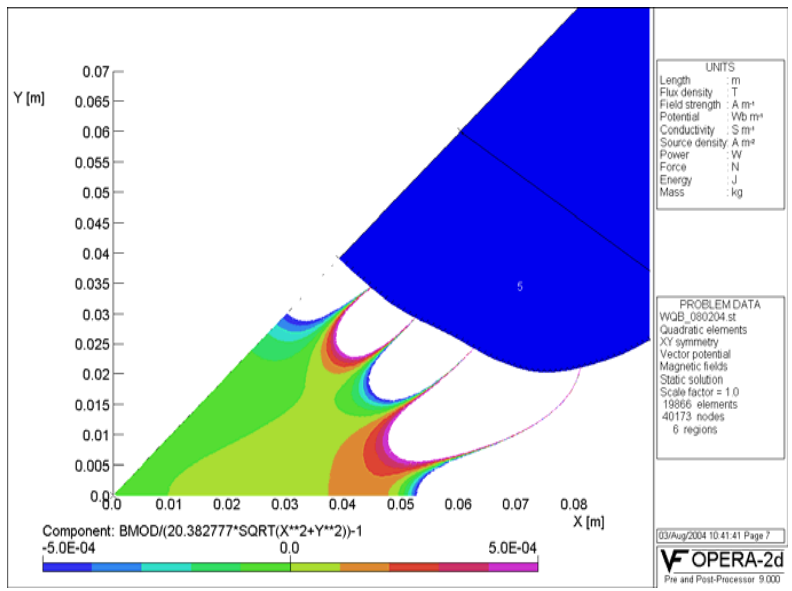
WQB Wide aperture quad

- Replace existing quads
- Same length
  - 2.13 m
- Same current
  - 3600 A
- Same field
  - 20.4 T/m
- Bigger aperture
  - r=55.2 mm









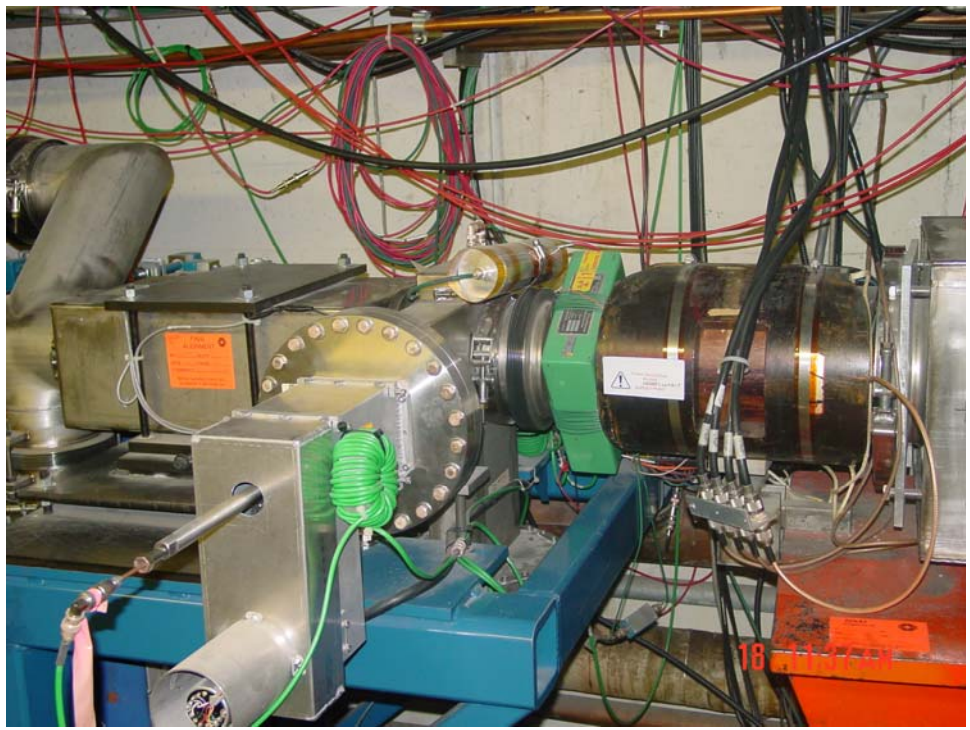
Field quality at maximum current 3600 A. Gradient is 20.3828T/m.

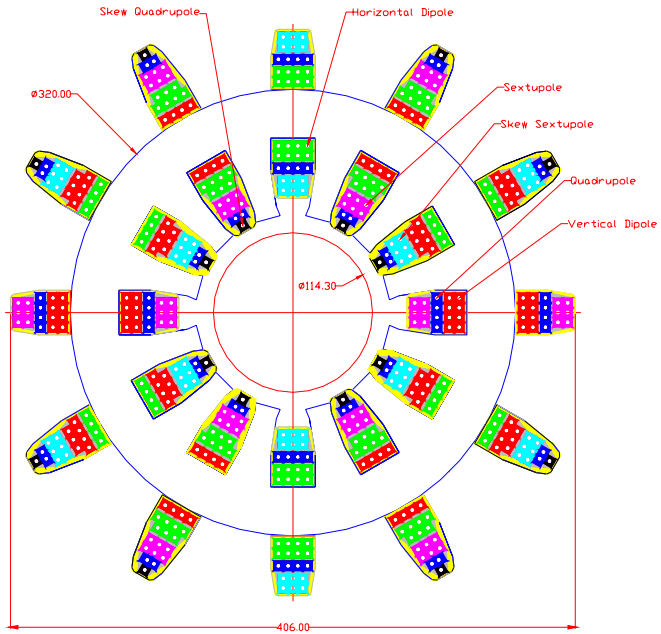
Booster corrector packages

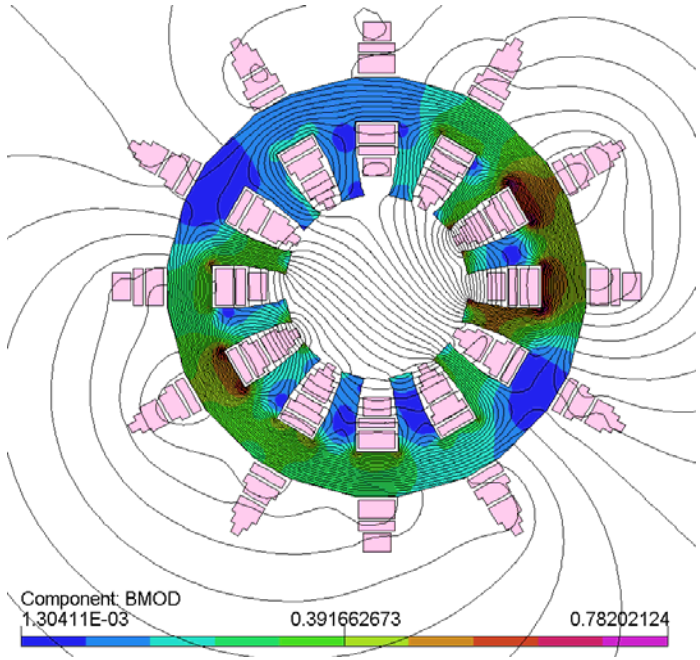
- Horizontal dipole
- Vertical dipole
- Normal quad
- Skew quad
- Normal sextupole
- Skew sextupole

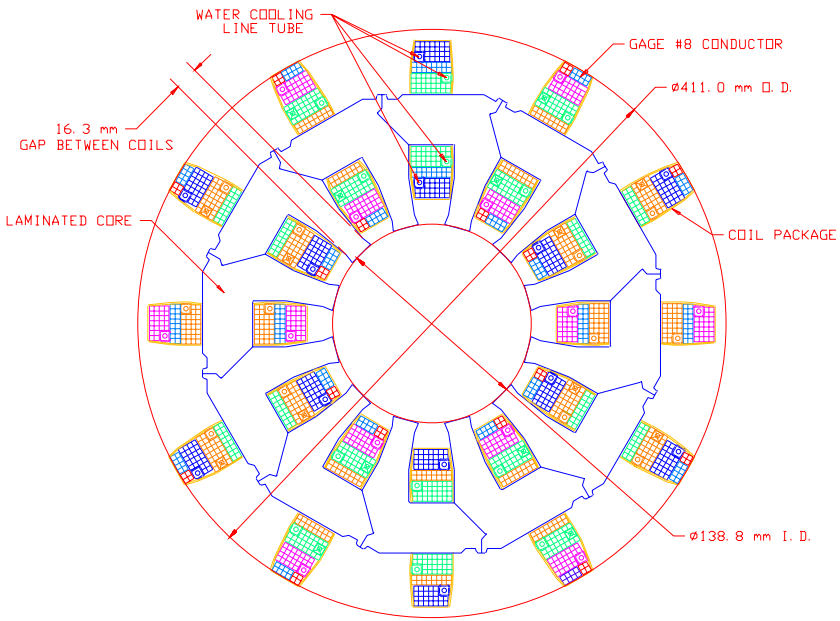
- BPM

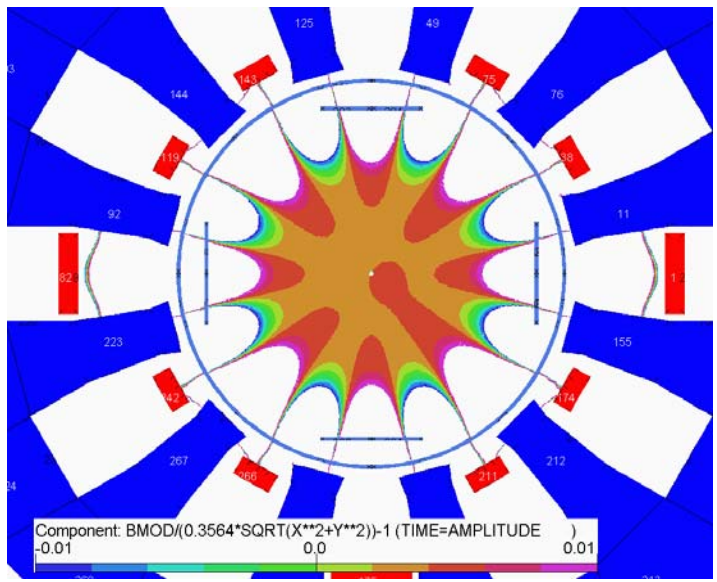
- Stronger
- Faster
- Same space




Skew Quadrupole
Horizontal Dipole
Sextupole
Skew Sextupole
Quadrupole
Vertical Dipole
ø320.00
ø114.30
406.00

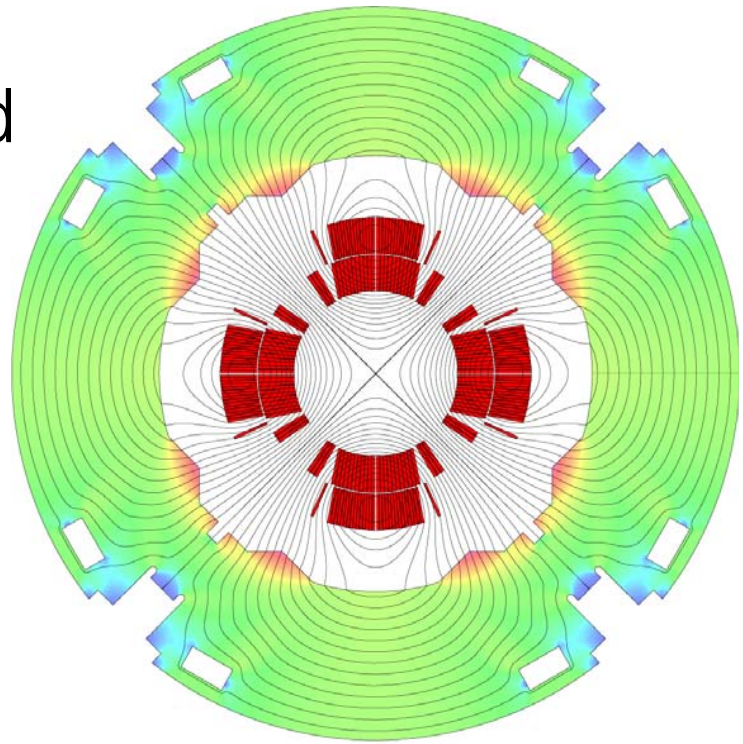

Component: BMOD
1.30411E-03
0.391662673
0.78202124

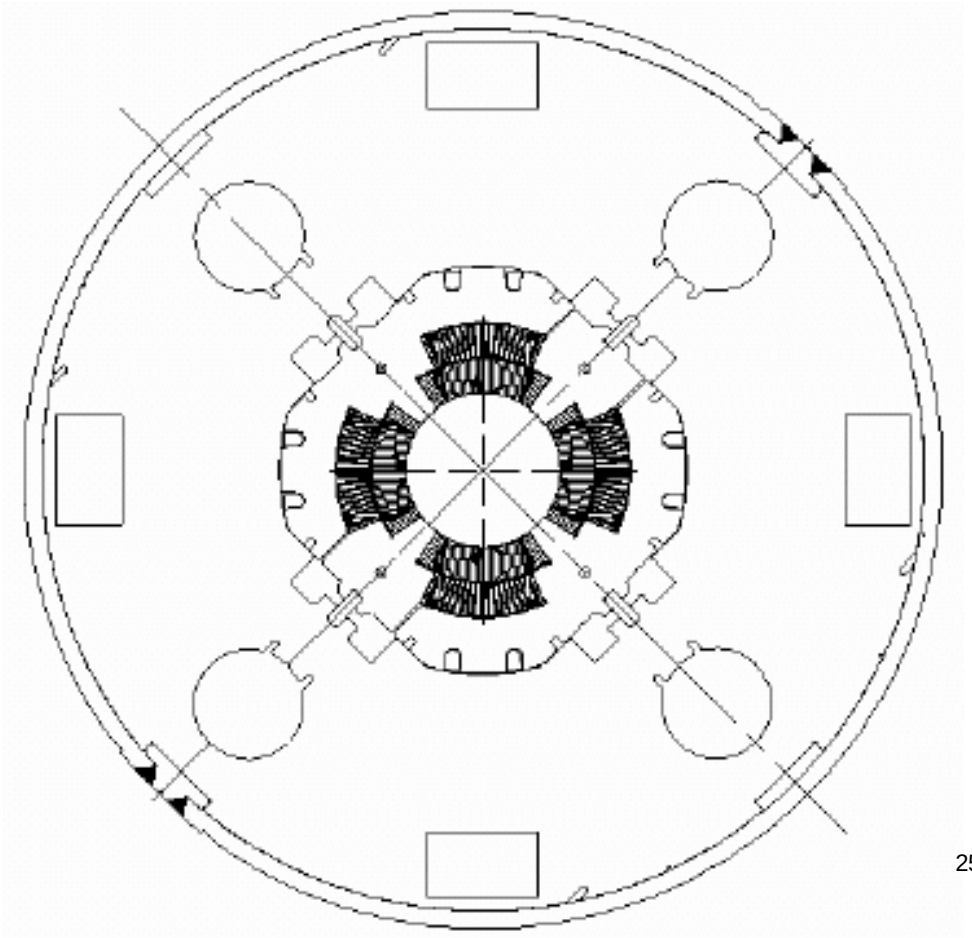

WATER COOLING
LINE TUBE
GAGE #8 CONDUCTOR
ø411.0 mm O.D.
16.3 mm
GAP BETWEEN COILS
LAMINATED CORE
COIL PACKAGE
ø138.8 mm I.D.

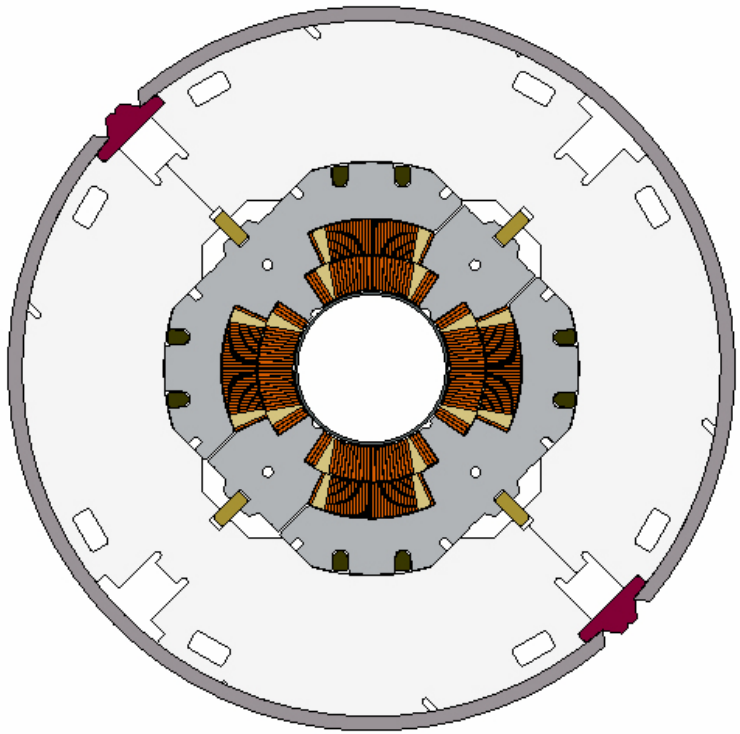

Component: BMOD/(0.3564*SQRT(X**2+Y**2))-1 (TIME=AMPLITUDE)
-0.01
0.0
0.01

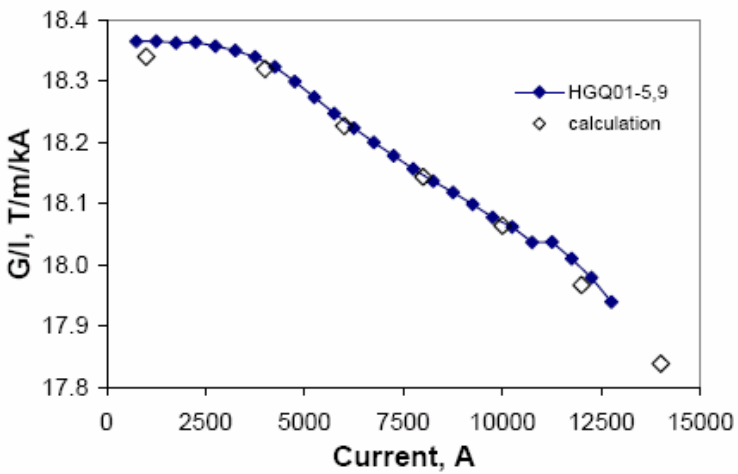
B-TeV IR quads

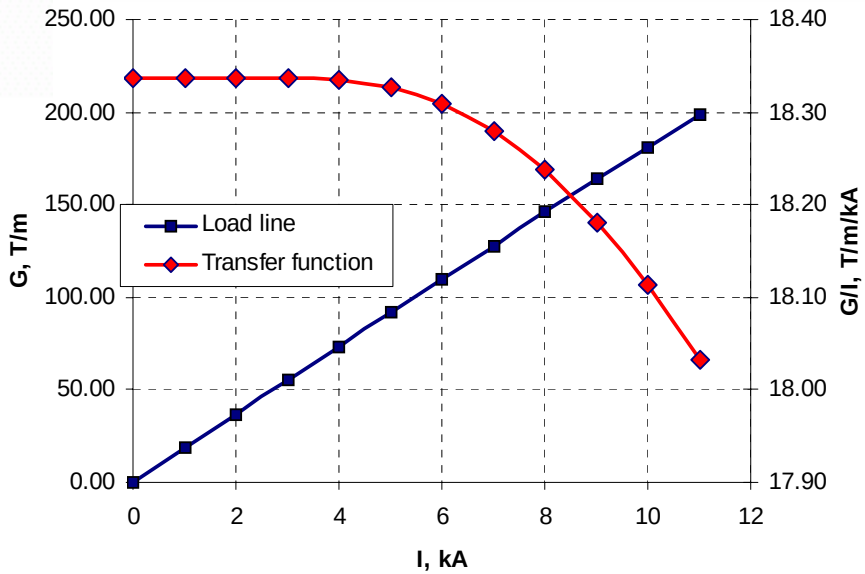
- Inside
  - Same as LHC IR quad
- Outside
  - Smaller
- 170 T/m







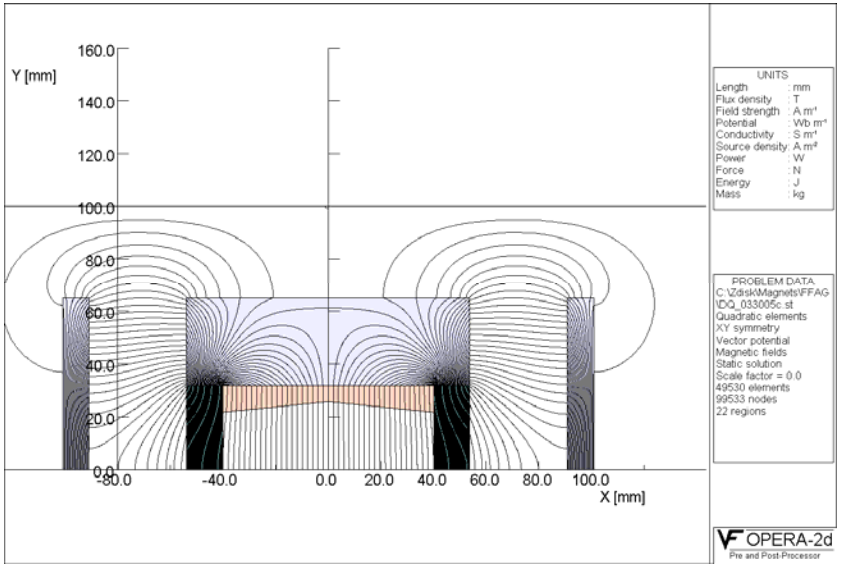

18.4
18.3
18.2
18.1
18.0
17.9
17.8
G/I, T/m/kA
0
2500
5000
7500
10000
12500
15000
Current, A
HGQ01-5,9
calculation

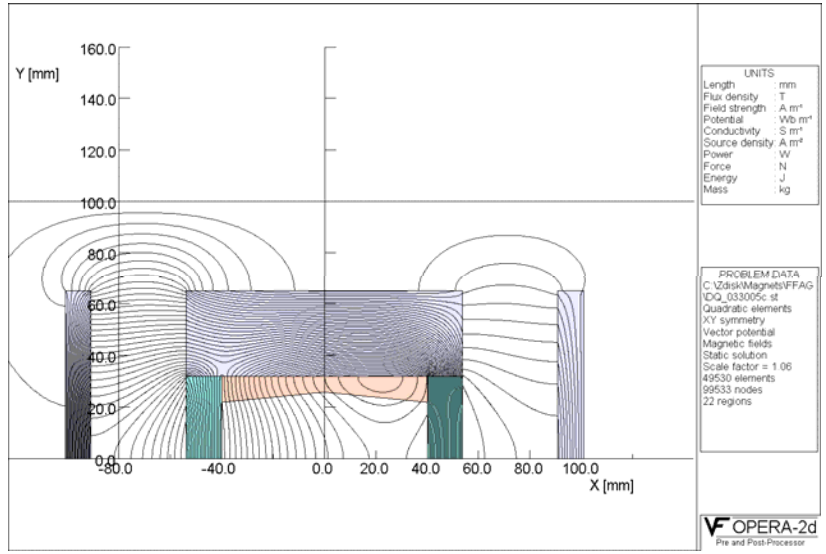

250.00
200.00
150.00
100.00
50.00
0.00
G, T/m
18.40
18.30
18.20
18.10
18.00
17.90
G/I, T/m/kA
0
2
4
6
8
10
12
I, kA
Load line
Transfer function

Combined function magnet FFAG

- Dipole
  - Fixed strength
  - 5 T-mm
- Quadrupole
  - Variable
  - Up to 0.2 T-mm/mm
- 5 cm yoke length

- Concept
  - Permanent magnet dipole
  - Panofsky coil quadrupole


Y [mm]
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-80.0
-40.0
0.0
20.0
40.0
60.0
80.0
100.0
X [mm]
UNITS
Length : mm
Flux density : T
Field strength : A m-1
Potential : Wb m-1
Conductivity : S m-1
Source density : A m-2
Power : W
Force : N
Energy : J
Mass : kg
PROBLEM DATA
C:\Zdisk\Magnets\FFAG\DQ_033005c.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 0.0
49530 elements
99533 nodes
22 regions
OPERA-2d
Pre and Post-Processor


Y [mm]
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-80.0
-40.0
0.0
20.0
40.0
60.0
80.0
100.0
X [mm]
UNITS
Length : mm
Flux density : T
Field strength : A m-1
Potential : Wb m-1
Conductivity : S m-1
Source density : A m-2
Power : W
Force : N
Energy : J
Mass : kg
PROBLEM DATA
C:\Zdisk\Magnets\FFAG\DQ_033005c.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.06
49530 elements
99533 nodes
22 regions
OPERA-2d
Pre and Post-Processor

And more…

- Nb_3Sn magnets
- Lithium lens
- Magnetic shielding
- Adjustable strength permanent magnet quadrupoles
- Adding a sextupole component to existing quadrupoles