Design study of PRISM-FFAG magnet

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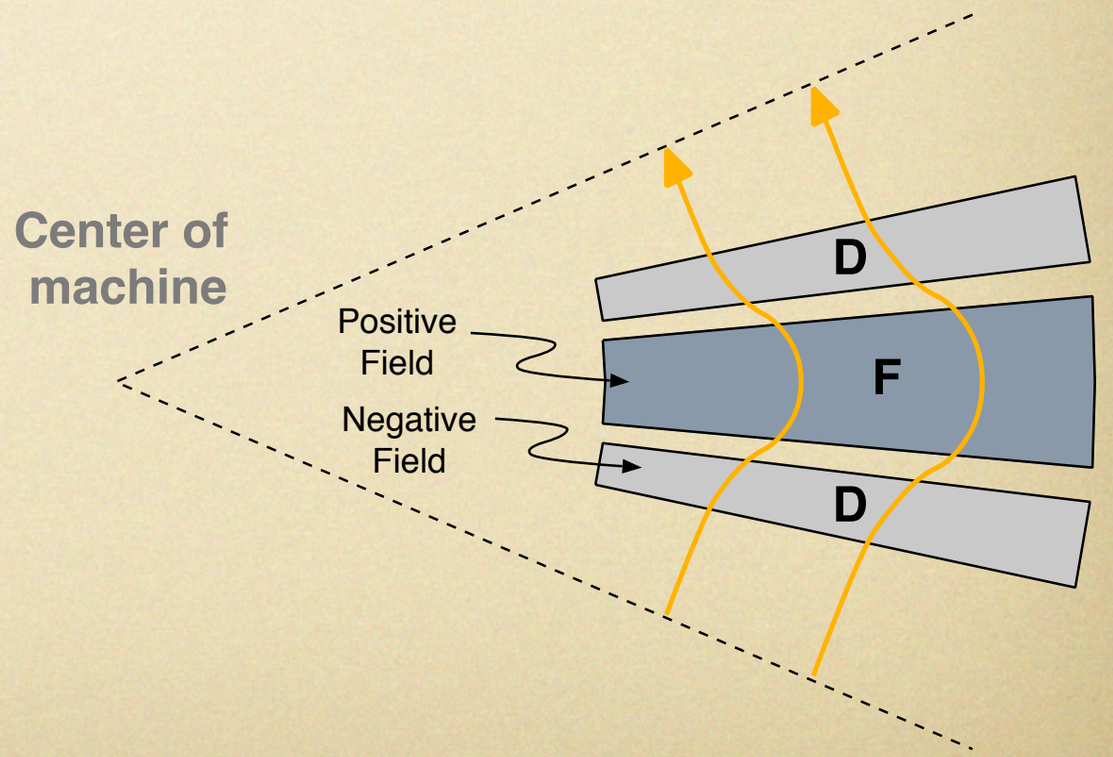
Requirement for PRISM-FFAG

- Scaling FFAG : $B(r) = B_0 \left(\frac{r}{r_0} \right)^k$
- Large momentum & space acceptance
  - Large aperture : 100 cm x 30 cm
- Tunable magnetic field
  - Trim coils : k value +- 0.5 , F/D ratio +- 2
- Extraction toward injection from ring outside
  - Yoke type : C type

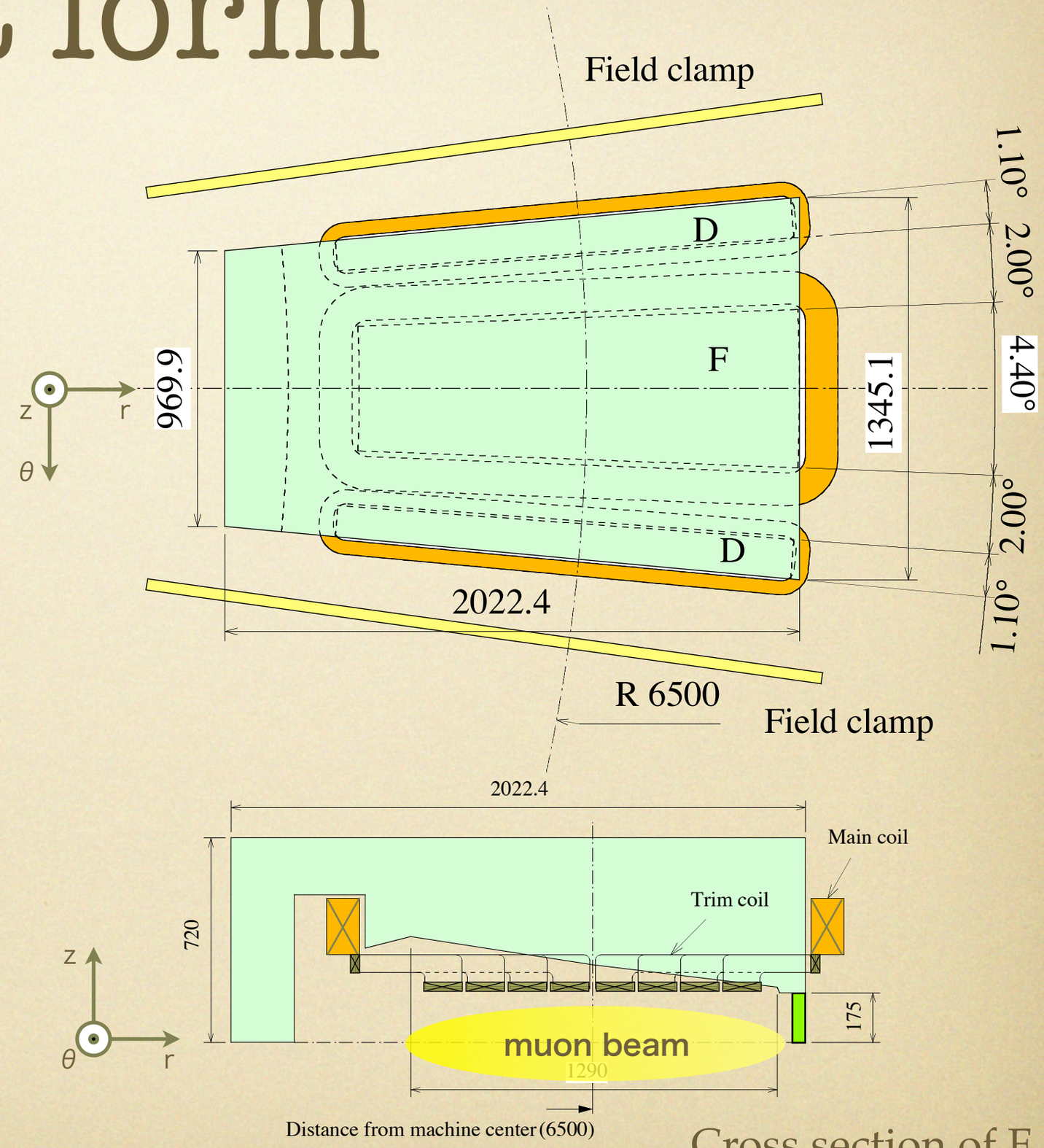
Lattice parameters

- Radial sector DFD Triplet
- Central momentum : 68 MeV/c
- Equilibrium radius : 6.5 m
- Number of cell : 10
- F/D ratio : 6
- Field index (k value) : 4.6



Magnet form

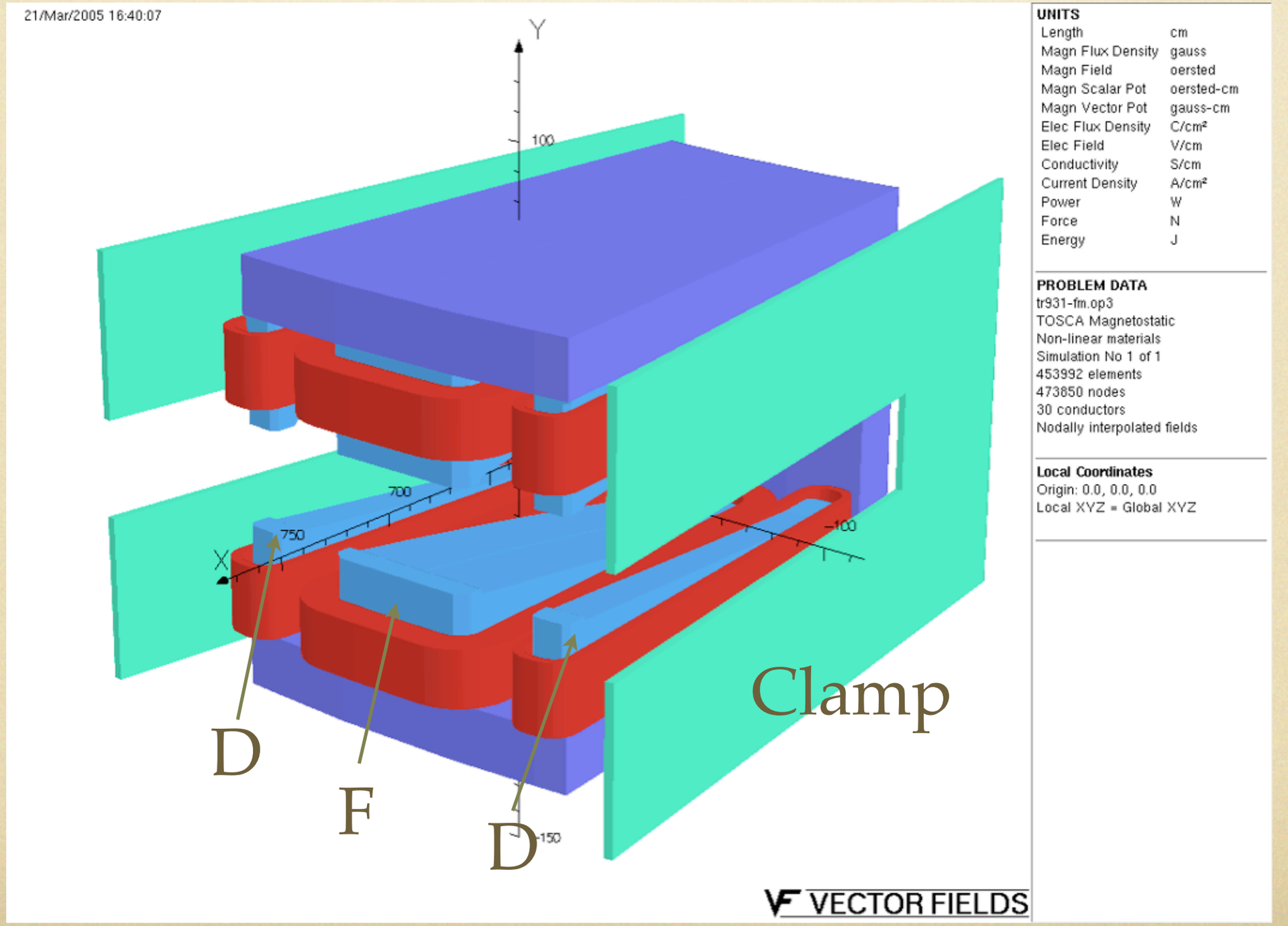
- C type
- Aperture
  - 100 cm (horizontal)
  - 30 cm (vertical)
- Slant pole produce field gradient
- Trim coils are installed to correct magnetic field



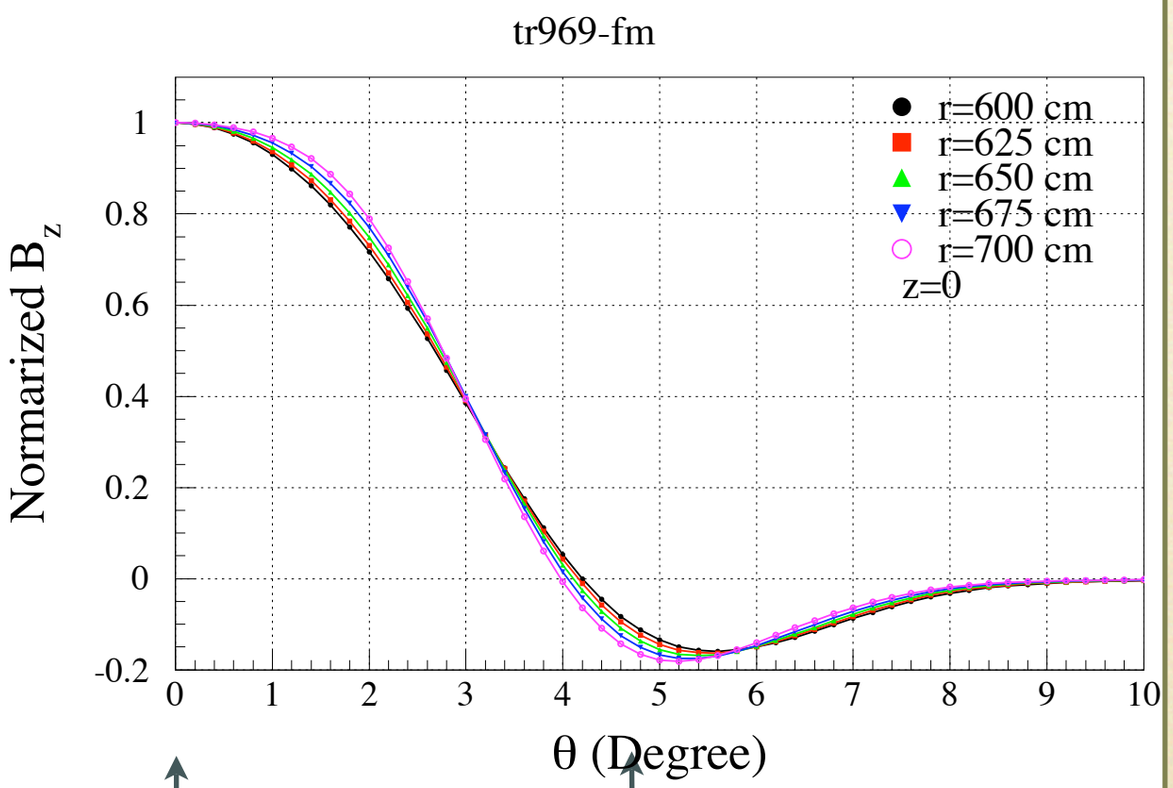
Cross section of F magnet

3D calculation

3D calculation code “TOSCA”

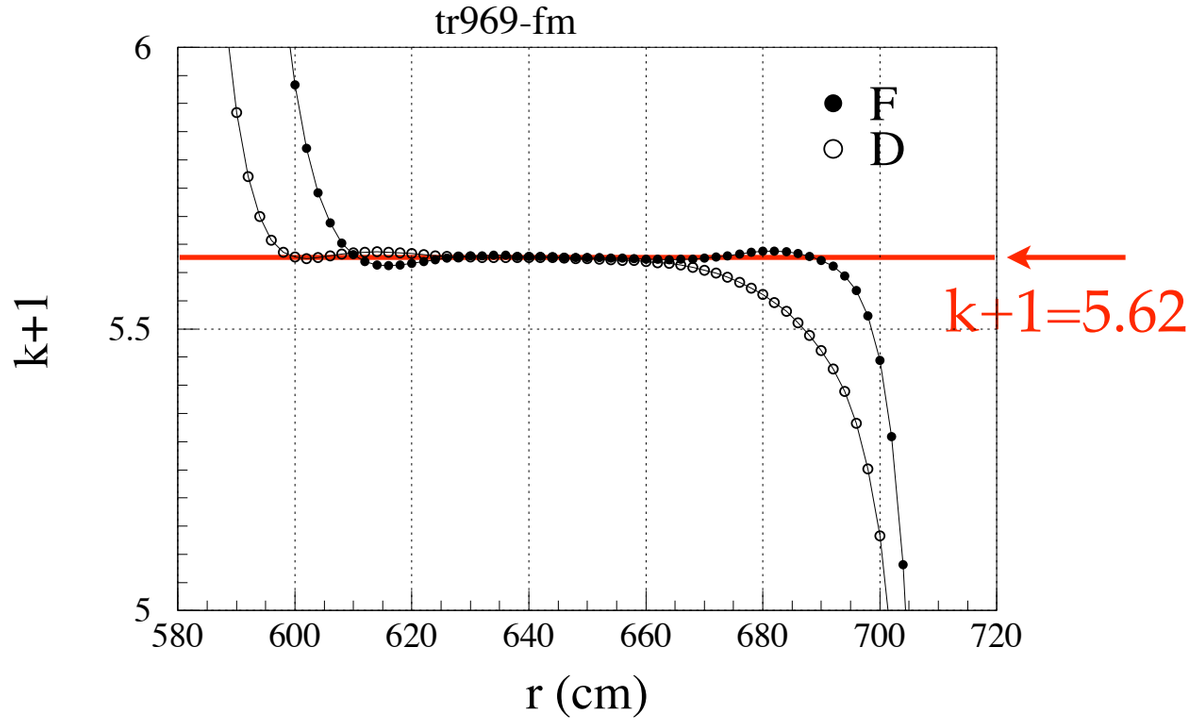


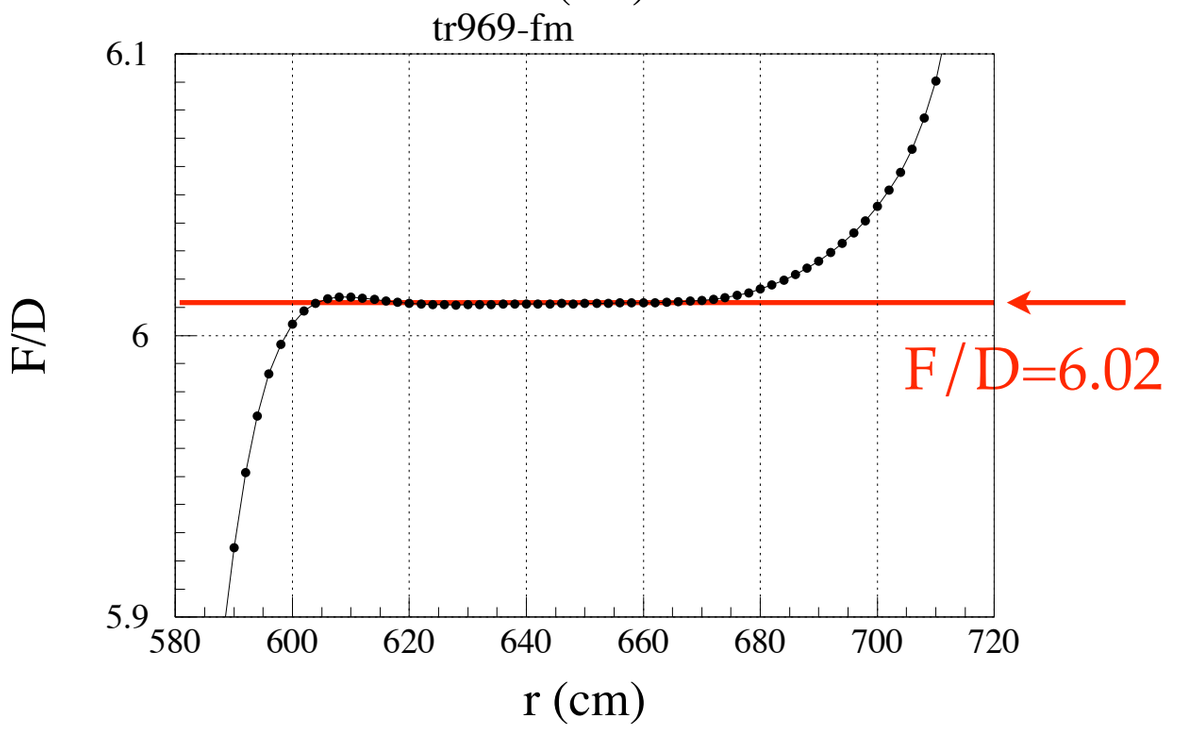
Magnetic field distribution

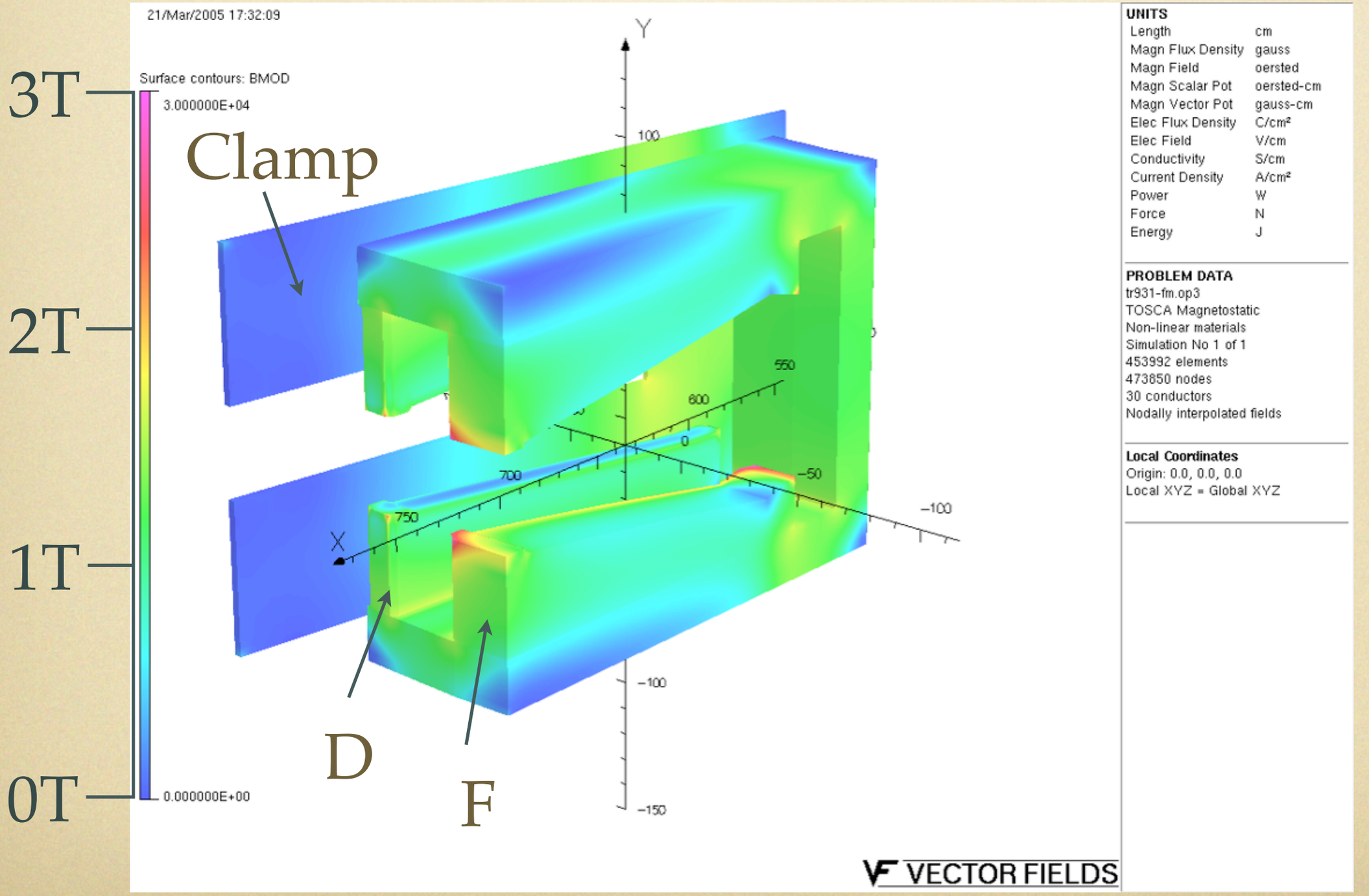


Center of F magnet

Center of D magnet



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3T
2T
1T
0T
Clamp
D
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Y
X
100
550
600
0
700
750
−50
−100
−100
−150
UNITS
Length cm
Magn Flux Density gauss
Magn Field oersted
Magn Scalar Pot oersted-cm
Magn Vector Pot gauss-cm
Elec Flux Density C/cm²
Elec Field V/cm
Conductivity S/cm
Current Density A/cm²
Power W
Force N
Energy J
PROBLEM DATA
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TOSCA Magnetostatic
Non-linear materials
Simulation No 1 of 1
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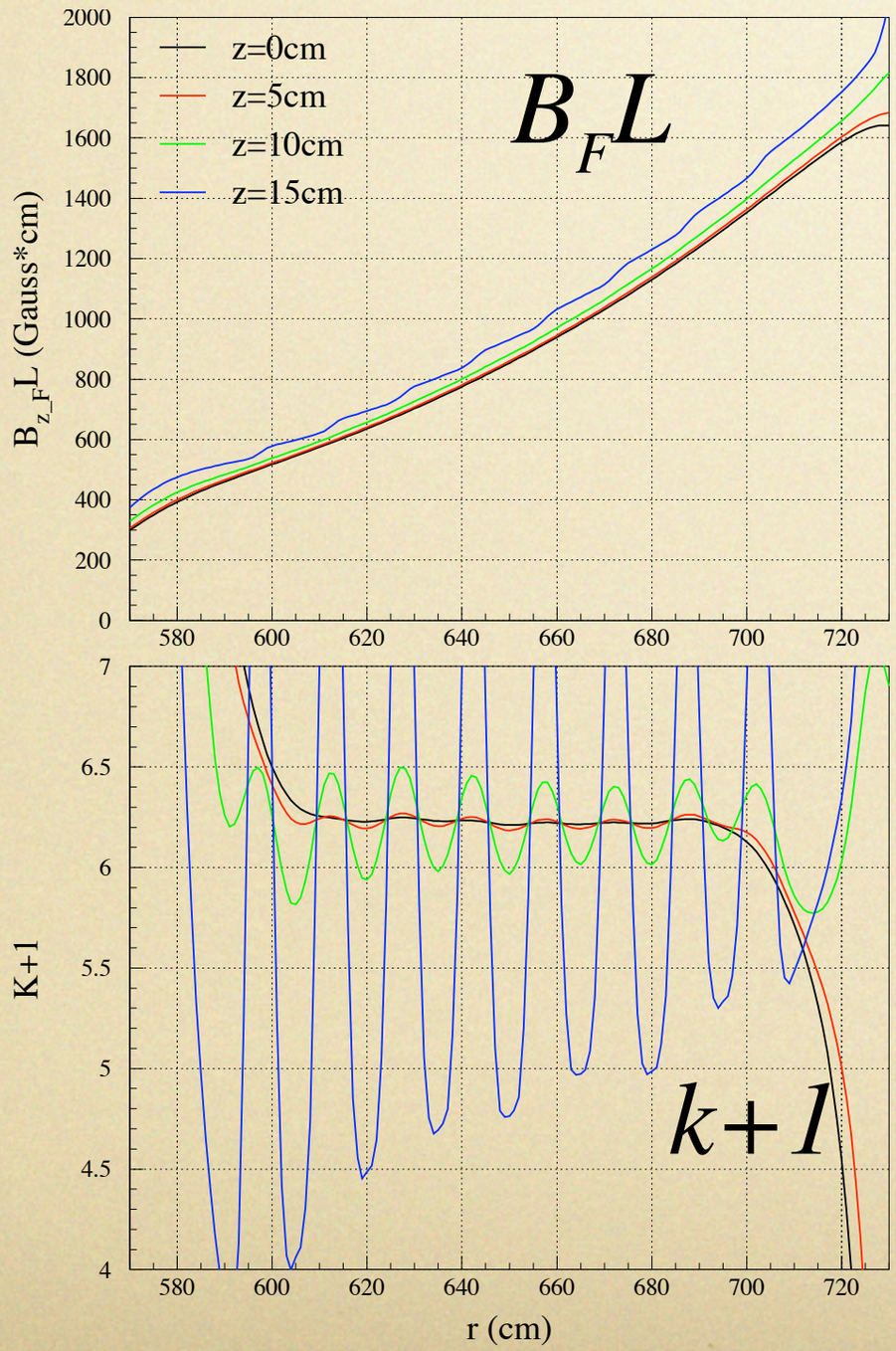
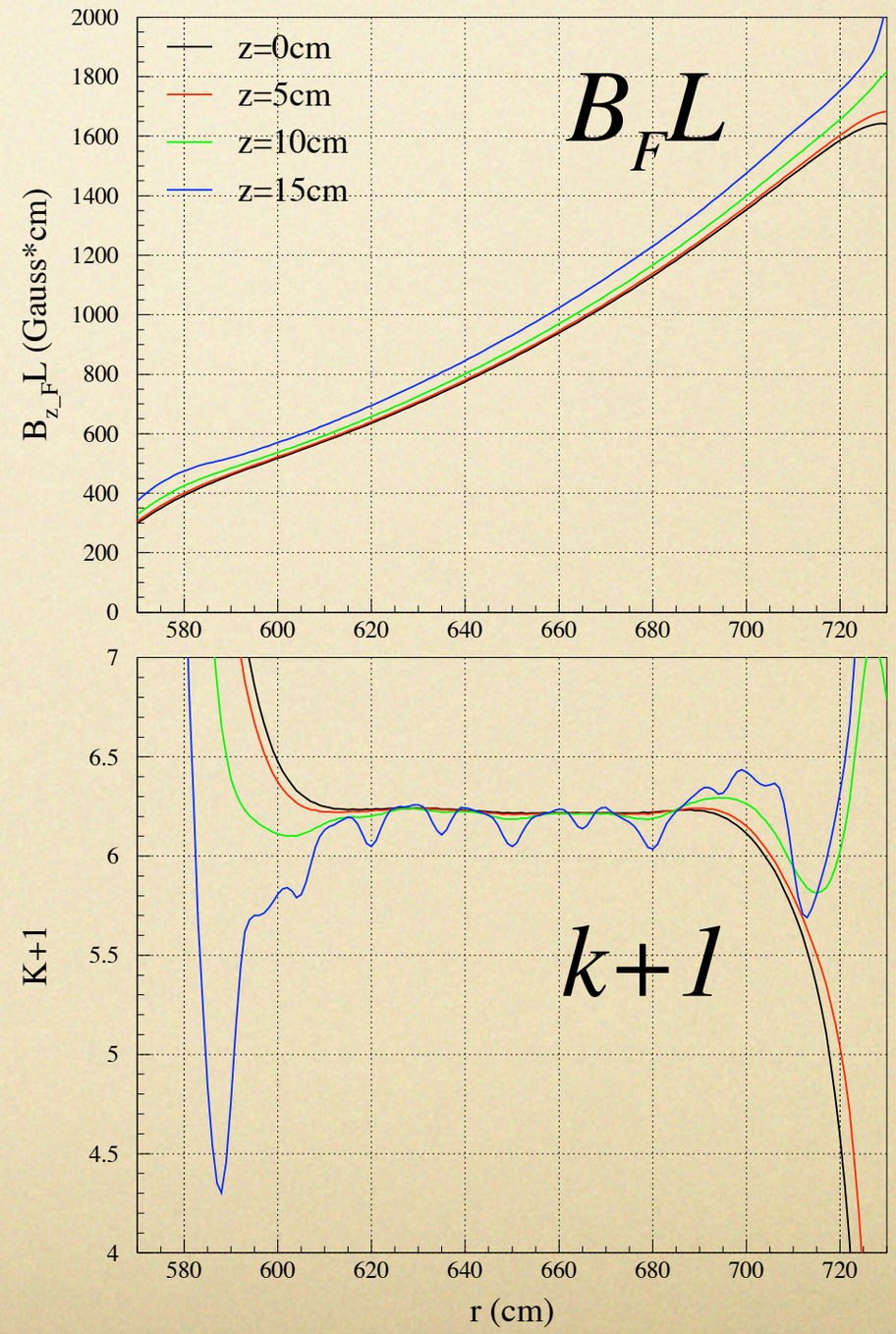
473650 nodes
30 conductors
Nodally interpolated fields
Local Coordinates
Origin: 0.0, 0.0, 0.0
Local XYZ = Global XYZ
VECTOR FIELDS

Trim coil

Cross section of Trim coil

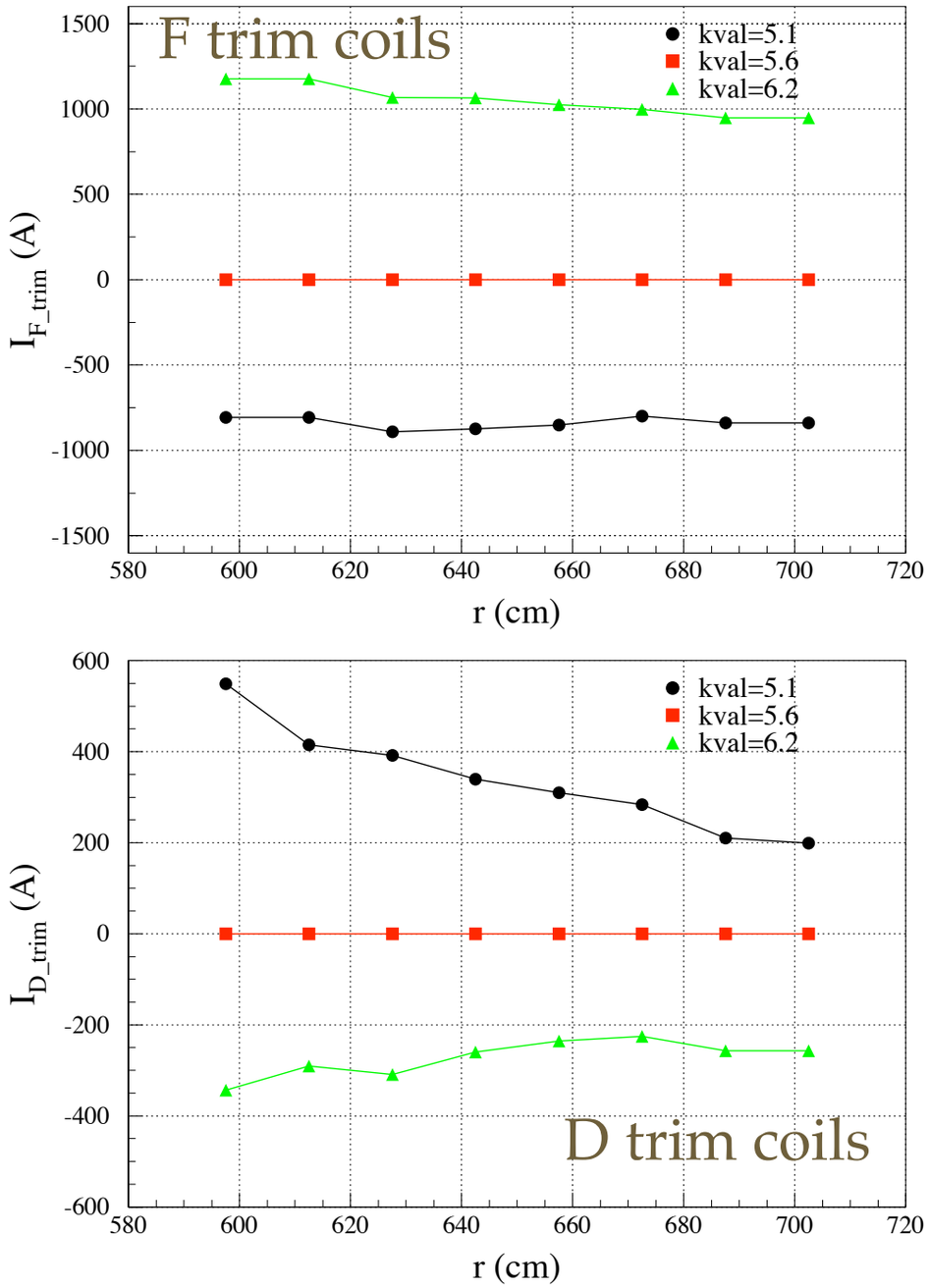
Cross section of Trim coil



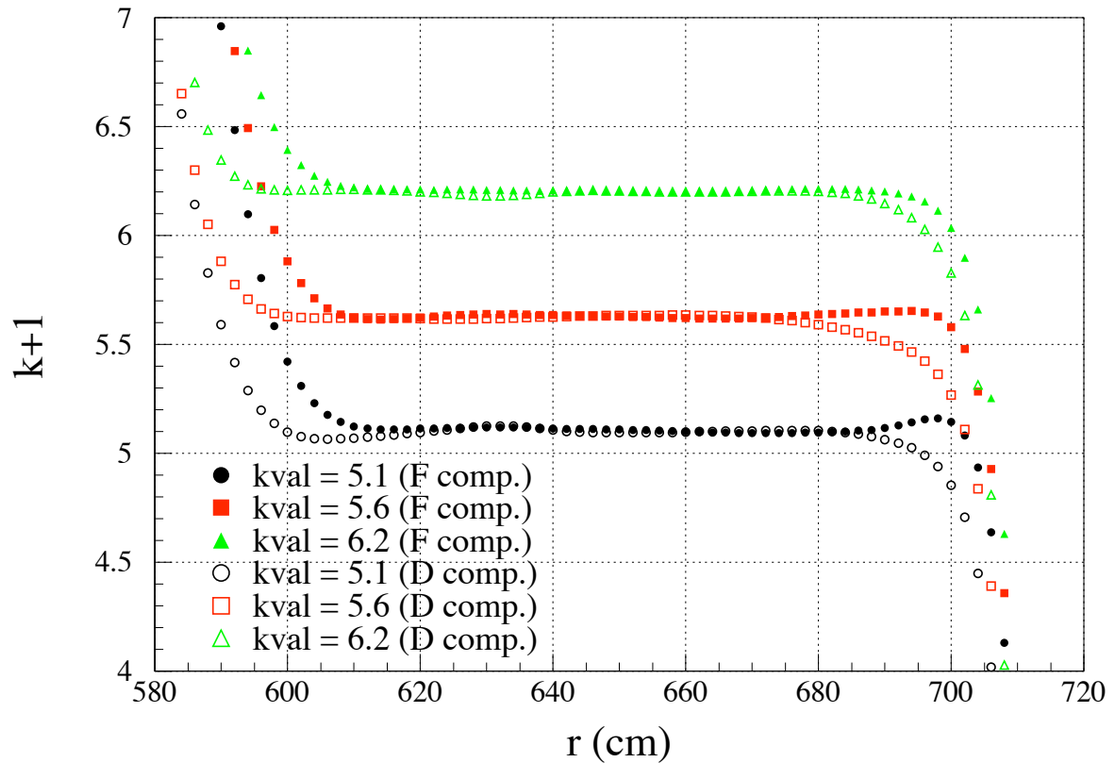


k value changed by trim coils

Current distribution



k+1 value distribution



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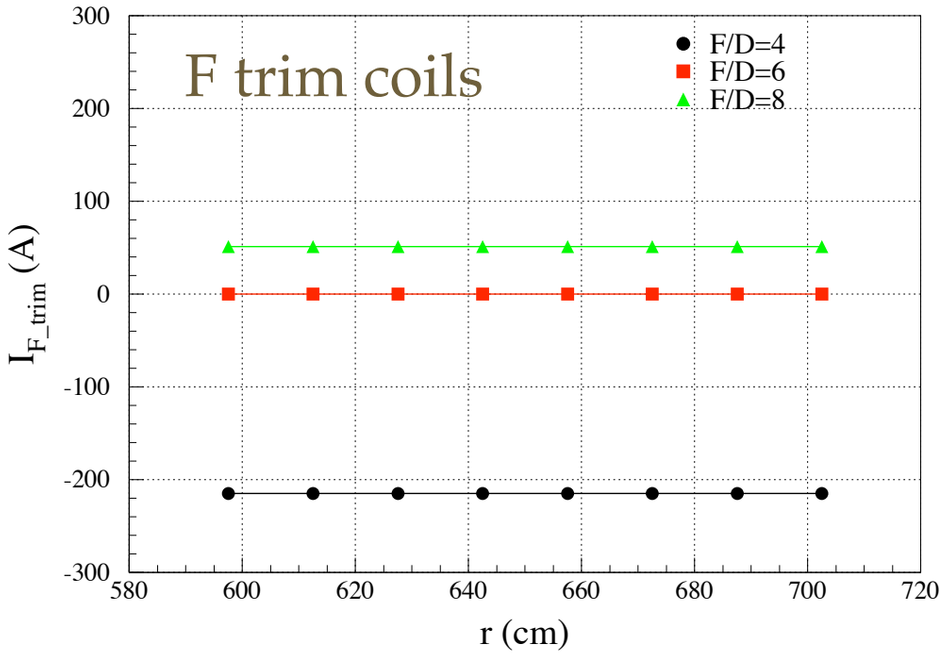
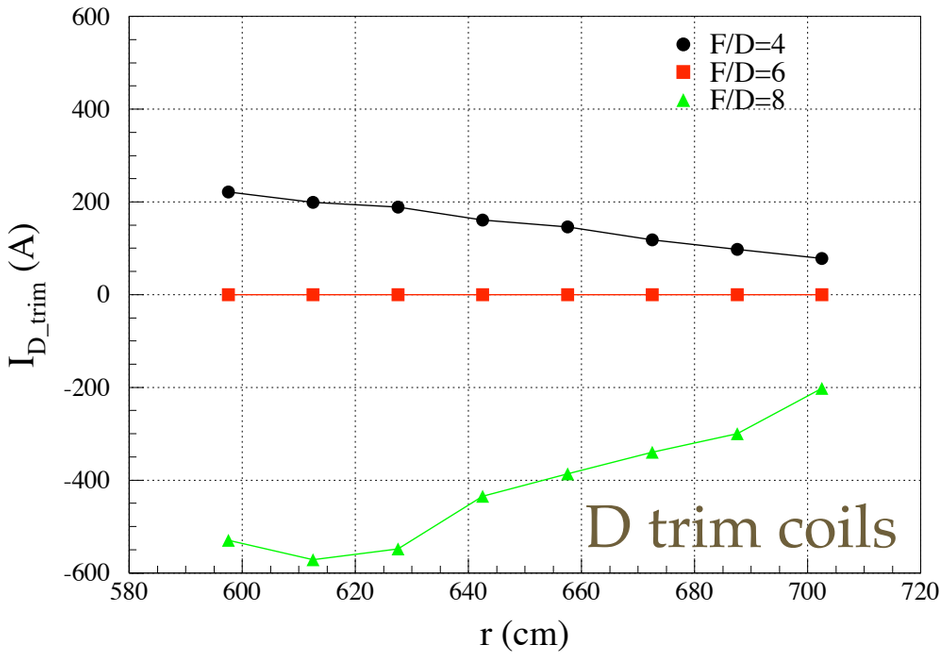
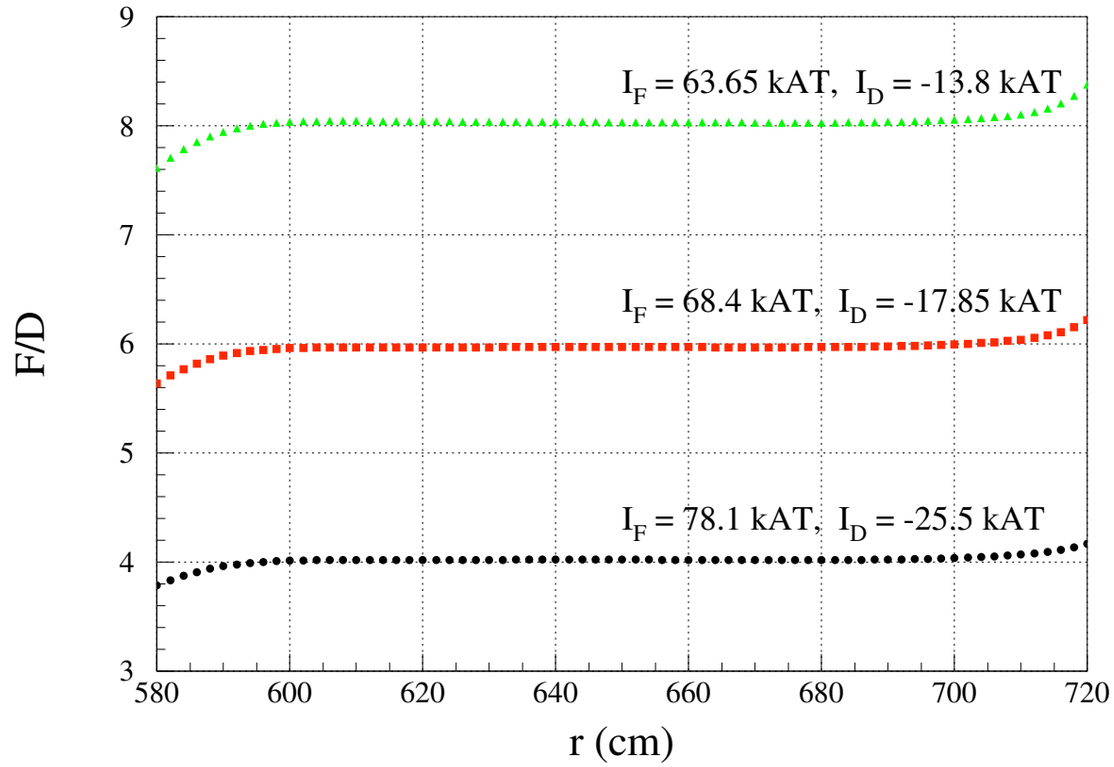
F/D ratio changed by main coils and trim coils

Current distribution





F/D ratio distribution



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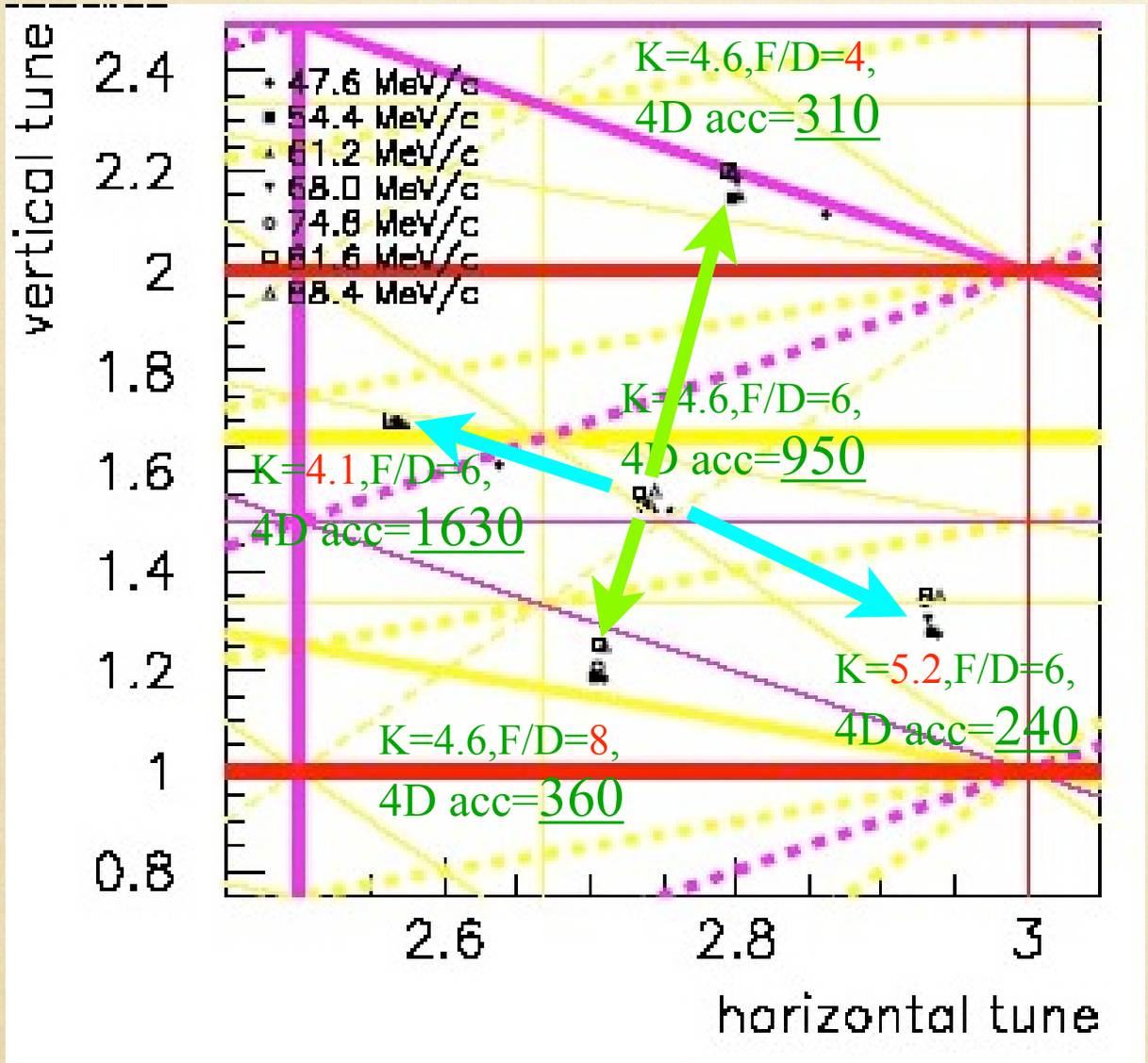
Change of tunes



- Horizontal tune change from 2.55 to 2.95 by changing k value
- Vertical tune change from 1.2 to 2.2 by changing F/D ratio

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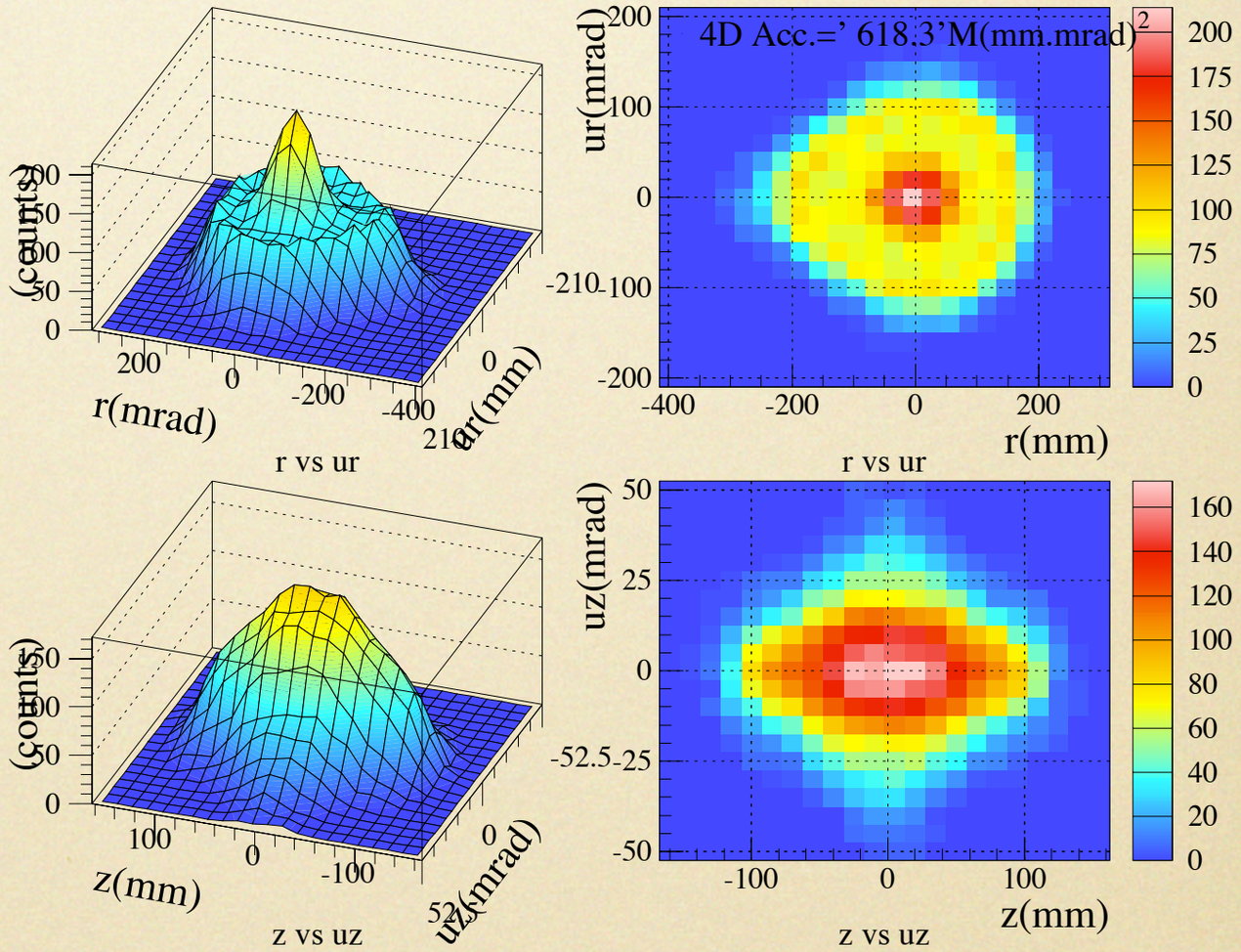
Phase space acceptance

$P = 68\ \mathrm{MeV}/c$ Gap height = ± 15 cm

Horizontal phase space

(@center of straight section)



Vertical phase space

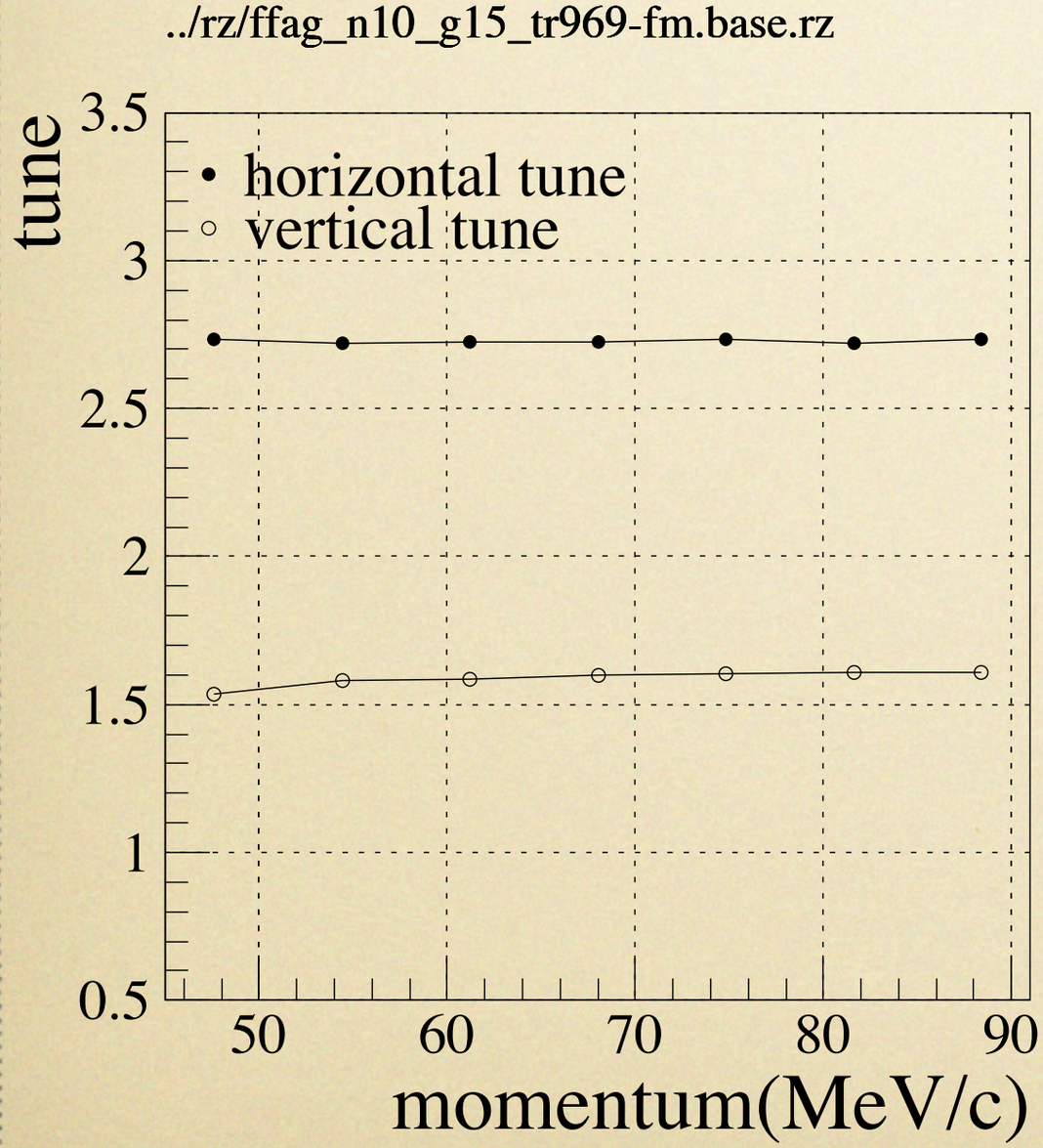
(@center of straight section)

Horizontal acceptance : 35,000 π mm mrad

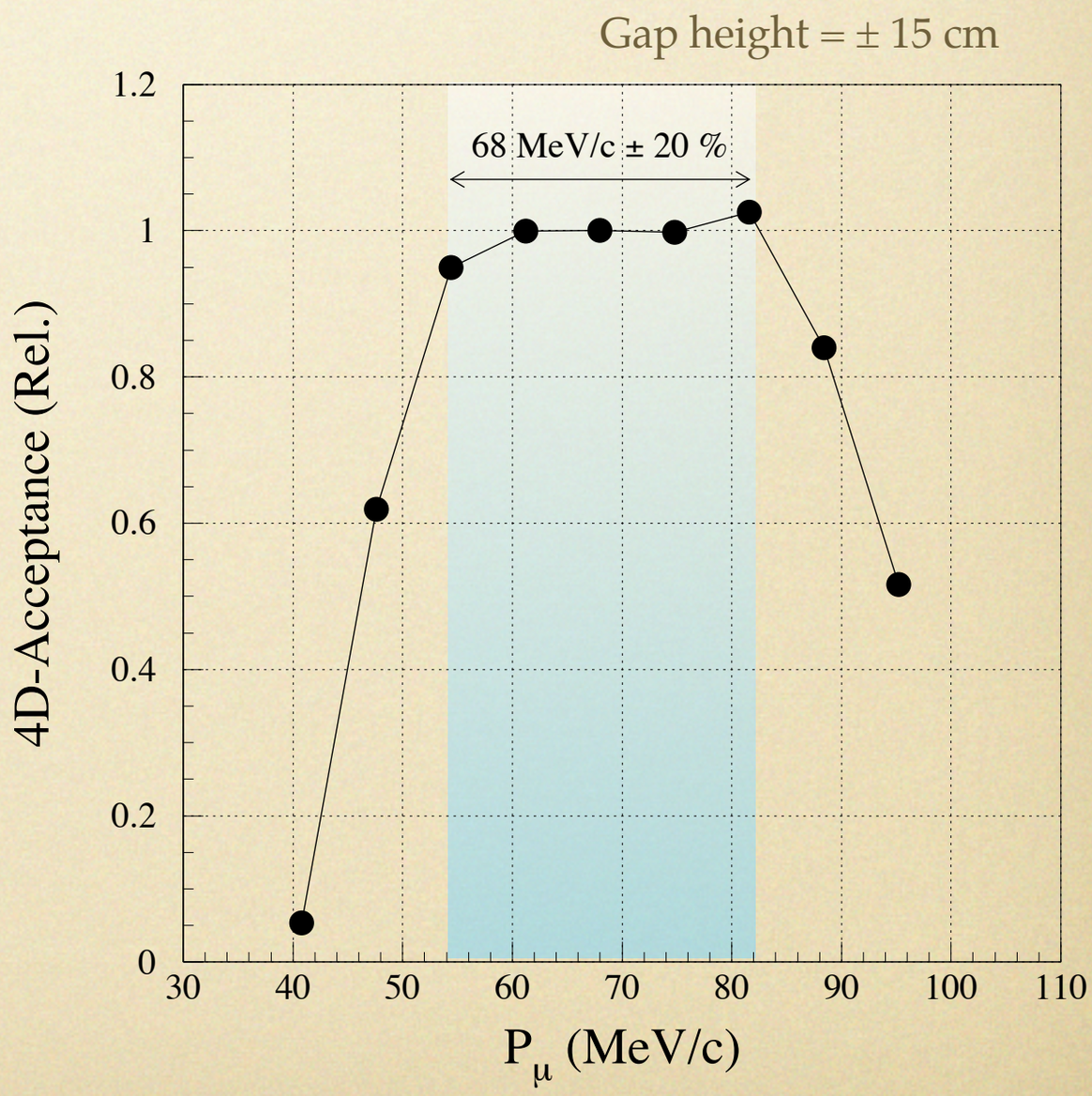
Vertical acceptance : 5,000 π mm mrad

Zero-chromaticity

Tune



4D Acceptance



Magnet parameters

Weight of magnet		17 t/1 cell
Current (per 1 coil)	F magnet	1750 A/ 84000 A*T
	D magnet	1034 A/ 30000 A*T
Power		100 kW/ 1 cell
Flow rate of cooling water	F magnet	61.7 ℓ /min
	D magnet	38.3 ℓ /min
Pressure drop (per 1path)	F magnet	4.8 kg/cm^2
	D magnet	1.9 kg/cm^2

Construction schedule

- JFY 2004 :
  - Production of 40 set of D coils
  - Production of 3 set of F coils
- JFY 2005 :
  - Production of 17 set of F coils
  - Production of 3 set of magnet body
  - Measurement of magnetic field
- JFY 2006:
  - Production of 7 set of magnet body
  - Measurement of magnetic field
  - Construction of PRISM-FFAG ring

Summary

- The design of the magnet have been almost completed, and following performances are confirmed.
  - k value and F/D ratio can be varied.
  - Large phase space acceptance : 35000 π mm*mrad x 5000 π mm*mrad
  - Zero-chromaticity
  - Large momentum acceptance: 68 MeV/c ± 20 %
- Construction of the magnets have been started from JPY 2004 and will be finished in JPY 2006.