Magnet Design for the PRISM-FFAG

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Type of PRISM-FFAG Magnet

- Radial Sector Type
- DFD Triplet
- C type
- Magnetic Field Distribution

\[ B(r) = B_0 \left( \frac{r}{r_0} \right)^k \]

- \( r \): distance from a center of a machine
- \( r_0 \): average radius of beam orbit
- \( B_0 \): magnetic field density at \( r=r_0 \)
- \( k \): k value

Plan view of radial-sector magnet
Form of PRISM Magnet

- F and D have their return yoke in common.
- Field clamps are installed not to leak magnetic field to RF Core.
Coils of PRISM Magnet

- Coils consist of main coil and trim coils which can adjust field distribution.

![Diagram of Coils]
Form of PRISM Magnet

- Aperture size:
  - 110 cm (horizontal)
  - 30 cm (vertical)
- Gradient of magnetic field is produced by main pole
- Anisotropic inter pole is used
Anisotropic Inter-Pole

- **Structure**
  - Layers of ferromagnetic and paramagnetic material

- **Advantage**
  - Fringe field distribution become uniform at different r-position.
  - Smoothing of fluctuation for field distribution caused by trim coil

\[
\mu_z = \mu_{Fe} \quad \text{Large}
\]
\[
\mu_r \sim 2 \quad \text{Small}
\]
Effect of inter-pole 1

- Uniform fringing magnetic field distribution in different $r$

Without inter-pole

With inter-pole

3D Calculation by TOSCA
Effect of inter-pole 2

- Improvement of field fluctuation of local k caused by trim coils

\[ local\ k = \left( \frac{\partial B_z}{\partial r} \right) \frac{r}{B_z} \]

Without inter-pole

With inter-pole

2D Calculation by PANDIRA
3D simulation of PRISM Magnet

- Main pole shape and main coil current was optimized to meet flowing conditions over the aperture of the magnet.
  - local $k = 4.6$
  - $F/D = 6$
  - BL integral = 8.6 Tm/half cell
- Calculation program: TOSCA (Opera3d Vector field co.)
Calculation Results

Magnetic field distribution

\[ B_{FL} = \int B(r)_{B>0} r \, d\theta \]

\[ B_{DL} = \int B(r)_{B<0} r \, d\theta \]
Calculation results

local \( k = \left( \frac{\partial B_z}{\partial r} \right) \frac{r}{B_z} \)

F/D ratio \( = \frac{B_F}{B_D} \)

\[ B_F L = \int B(r)\bigg|_{B>0} r \, d\theta \]

\[ B_D L = \int B(r)\bigg|_{B<0} r \, d\theta \]
Magnetic Field in RF core

- Saturation of RF core by DC magnetic field is occurred more than 100 Gauss

- Field clamp is installed to clamp magnetic field at RF Core
Effect of field clamp

Magnetic field in the RF core

Without Field Clamp

With Field Clamp
Summary

• PRISM FFAG magnet is DFD radial sector triplet magnet, which have large aperture.

• Anisotropic inter-pole is used, which have following merits
  • Make uniform magnetic field distribution at fringe
  • Damp the undulation of local k due to trim coils

• Magnetic field at RF core is clamped by the field clamp