# FIELD MEASUREMENT OF PRISM-FFAG MAGNET

Y. Arimoto 13th, Apr. 2007@FFAG 2007 CNRS

#### CONTENTS

- PRISM-FFAG Magnet
- Field Measurement Apparatus
- Measurement Results
  - Current correction
  - Comparison of three magnets
  - Comparison to TOSCA calculation
- Summary



#### MEASUREMENT

- Alignment tool Theodrite and Autolevel Measurement tool • 3D axis robot
  - Hall probe : MPT-141 (Group3)

# 3D AXIS FIELD MEASUREMENT TOOL



#### MEASUREMENT REGION





- Inclusion of mechanical distortion for 3d axis robot
- Correction of current fluctuation of power supply for main coil

# DISTORTION OF MEASUREMENTTOOL

- Measurement Tool have mechanical distortion.
- The position in x,y,z axis is deviated from expected position from motor pulse.
- The deviated position is corrected with measured Hall probe position by Auto-level and Theodorite.

#### EXAMPLE OF DISTORTION : HALL PROBE HEIGHT VARIATION



Autolevel Hall probe

• We measured Hall probe height by autolevel changing x-y position of Hall probe

Height variation is ~ 1 mm

Upper left : 3D plot of Height variation of Hall probe Upper right : Contour plot Lower left : Height variation as a function of x Lower right : Height variation as a function of y

# ANGULAR DISTORTION

- Angular Distortion was measured by Laser set up on Hall probe arm
- This data is used to correct Bx and By data
- Hall probe angle change from 0 to 1 mrad while measurement tool is moving from 0 mm to 800 mm.



# CURRENT FLUCTUATION

- Unfortunately coil current power supply have current fluctuation
- The fluctuation is 1 ~ 2 %
- Magnetic field is fluctuating due to coil current fluctuation.
- Correction will be done by using offset current run and monitor Hall probe.

### FIXED HALL PROBE



### CURRENT FLUCTUATION

#### • Trend of Monitoring Hall probe



### CURRENT OFFSET RUN

• To obtain correction coefficient at each position, magnetic field has been measured changing coil current by 1 %.

Run	I <sub>F</sub>	ID
1	I <sub>F0</sub>	I <sub>D0</sub>
2	I <sub>F0</sub> +dI <sub>F</sub>	I <sub>D0</sub>
3	I <sub>F0</sub>	I <sub>D0</sub> +dI <sub>D</sub>

$$\begin{split} I_{F0} &= 1444 \text{ A (F coil current)} \\ I_{D0} &= 602.1 \text{ A (D coil current)} \\ dI_F &= 0.01 \text{ x } I_{F0} \\ dI_D &= 0.01 \text{ x } I_{D0} \end{split}$$

### CORRECTION FUNCTION

$$dB(\boldsymbol{x},\boldsymbol{I}) = \alpha \left(\frac{\partial B(\boldsymbol{x},\boldsymbol{I})}{\partial I_F(\boldsymbol{x})} - \gamma \frac{\partial B(\boldsymbol{x},\boldsymbol{I})}{\partial I_D(\boldsymbol{x})}\right) dM_F + \beta \frac{\partial B(\boldsymbol{x},\boldsymbol{I})}{\partial I_D(\boldsymbol{x})} dM_D$$
(25)

 $dB(\boldsymbol{x},\boldsymbol{I}) = C_F(\boldsymbol{x})dM_F + C_D(\boldsymbol{x})dM_D$ (26)

$$C_{F}(\boldsymbol{x}) = \alpha \left( \frac{\partial B(\boldsymbol{x}, \boldsymbol{I})}{\partial I_{F}(\boldsymbol{x})} - \gamma \frac{\partial B(\boldsymbol{x}, \boldsymbol{I})}{\partial I_{D}(\boldsymbol{x})} \right)$$

$$C_{D}(\boldsymbol{x}) = \beta \frac{\partial B(\boldsymbol{x}, \boldsymbol{I})}{\partial I_{D}(\boldsymbol{x})}$$
(27)
$$(27)$$

A corrected magnetic field is obtained as

$$B_{\rm corr}(\boldsymbol{x}) = B_{\rm meas}(\boldsymbol{x}) - C_F(\boldsymbol{x})dM_F - C_D(\boldsymbol{x})dM_D, \qquad (29)$$

here,  $B_{\text{meas}}$  is a measured value by 3D measurement tool.

Obtained from the measurement where coil currents are changed by 1 %.

# CORRECTION RESULTS : F

- $\mathbf{x} = \mathbf{0} \, \mathbf{mm}$ 
  - Region where F component is dominant





#### CORRECTION RESULT (BL INTEGRAL)

#### **Correction ON**

#### **Correction OFF**



#### COMPARISON WITH OTHER MACNETS (13481)

- Magnetic field of the three magnets has been measured.
- These magnets are compared at red lines shown in right figure.



#### MAGNETS COMPARISON(Z=0MM)



# 4D ACCEPTANCE WITH FIELD ERROR

4D acceptance was calculated when different random factors are applied to each triplets.

- $B_i(r) = (1 + \delta B_i)B(r)$ 
  - i : cell ID number (1~10)
  - δB<sub>i</sub> : random errorfactor within error tolerance



Error tolerance < 0.5 %

Shown at FFAG 2004 at FNAL

### TOSCA VS MEASUREMENT



Difference between TOSCA and measurement is about 0.5 %.

#### SUMMARY

- The distortion of magnet measurement tool was measured.
- The coil-current fluctuation is successfully corrected.
- Difference between three magnets is less than 0.2 % for F component. This value is smaller than required difference to avoid acceptance decrease.
- Difference between TOSCA is about 0.5 %.
- Next study
  - Errors of magnetic field should be estimated.
  - Tracking with measured map