Magnetic Field Mapping for Superconducting Cyclotron (SCC) in VECC

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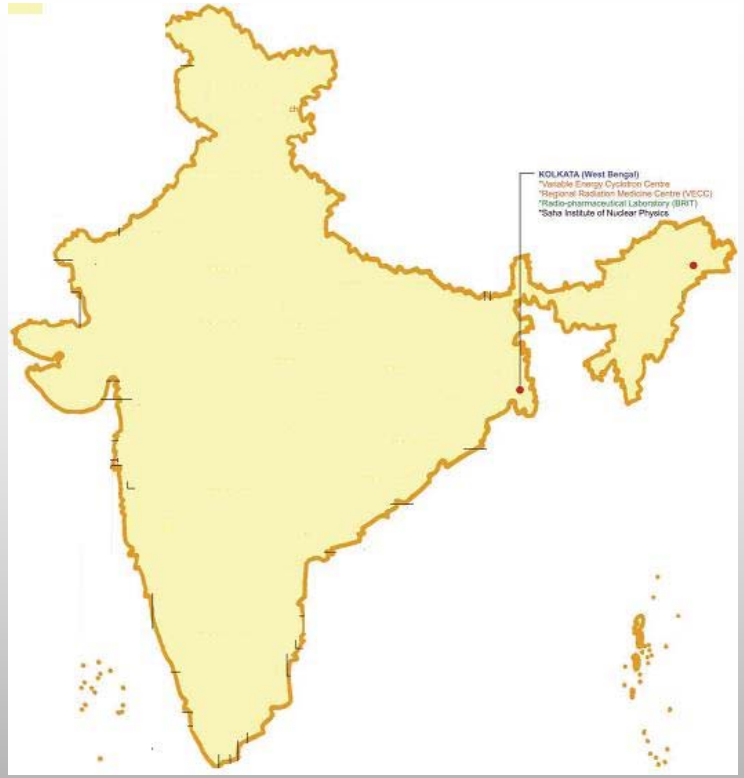
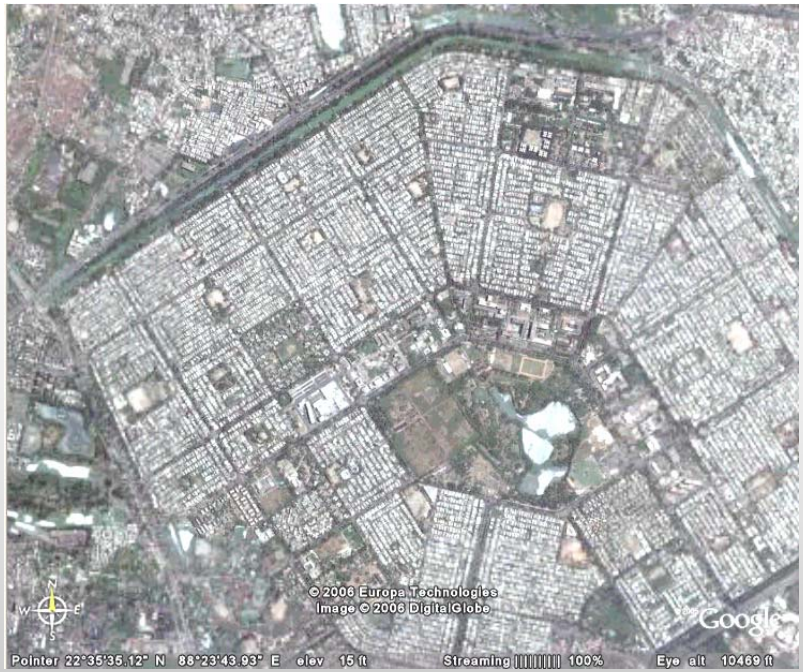
VECC - Kolkata


KOLKATA (West Bengal)
*Variable Energy Cyclotron Centre
*Regional Radiation Medicine Centre (VECC)
*Radio-pharmaceutical Laboratory (BRIT)
*Saha Institute of Nuclear Physics


© 2006 Europa Technologies
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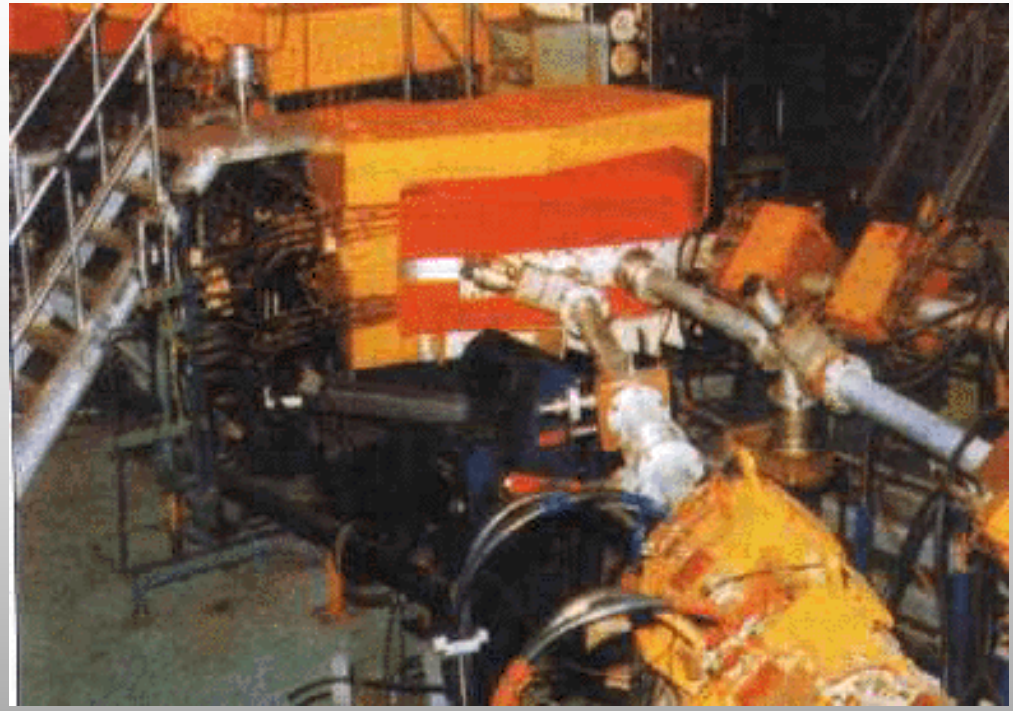
Google
Pointer 22°35'35.12" N 88°23'43.93" E elev 15 ft
Streaming 100%
Eye alt 10469 ft


Rajshahi
INDIA
BANGLADESH
Dacca
Agartala
Barisal
Calcutta

VECC



VECC	*SCC*
224 cm	142 cm
2.1Tesla	5.8 Tesla
450 KW	40KW
K130	K500

SCC

Field Mapping System

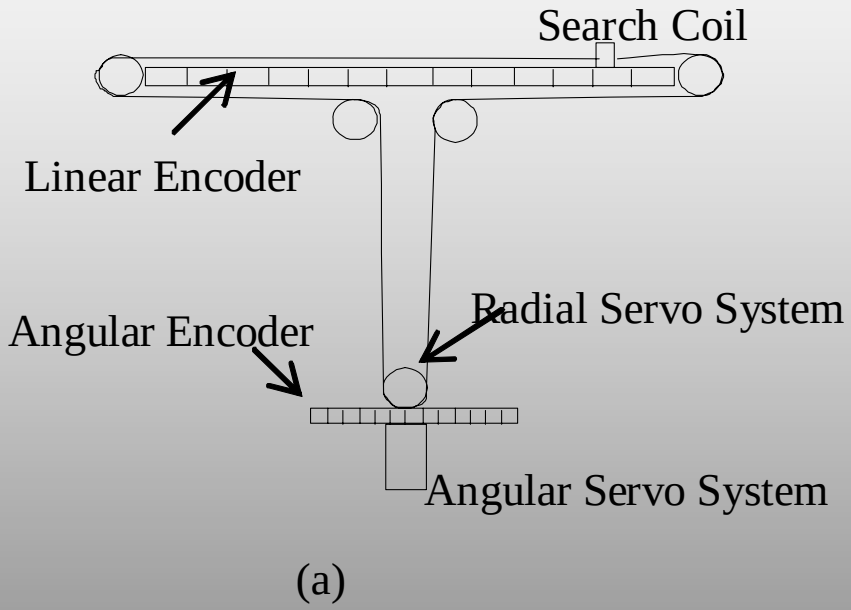
- General requirements
- Module Evolution
  - Digital VFC
  - Bipolar VFC
  - Digital Integrator Module
- Hardware Implementation
- Software Development
- Result
- Conclusion

Field Measurement, Analysis and Correction

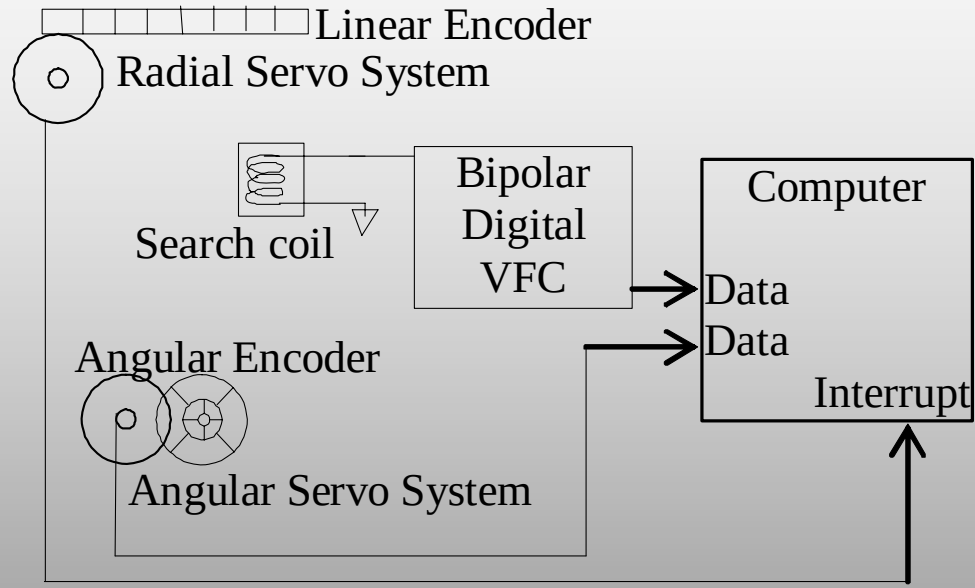
- *Field measurement*
  - *at different excitations up to ~26” radius*
  - *on discrete azimuthal bands beyond 26” radius*
  - *along axial hole*
  - *along extraction path*
  - *Fringing field measurement.*
- *Analysis of the measured raw data for magnet correction*
  - ***Reproducibility** check up*
  - *Finding the **magnetic symmetry** axis*
  - *Correction of average iron field distribution by iron shims*
  - ***Coil centering** by support link force balance*
  - *Coil centering by first harmonic minimization*
  - *Minimization of first harmonic component by **shimming***

DEVELOPMENT

Using Bipolar VFC

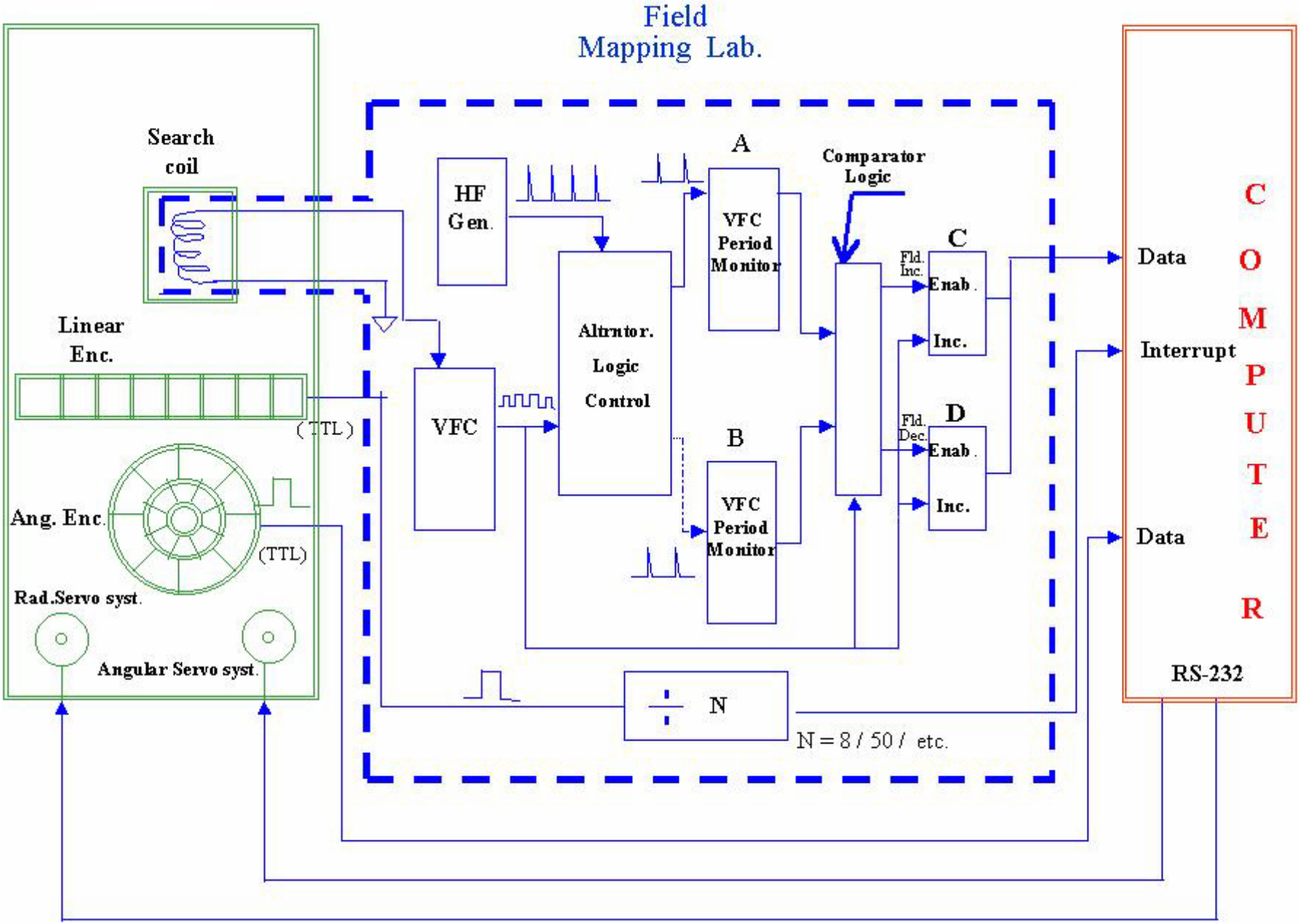


(a)



(b)

Schematic of Control and Measurement System Instrumentation



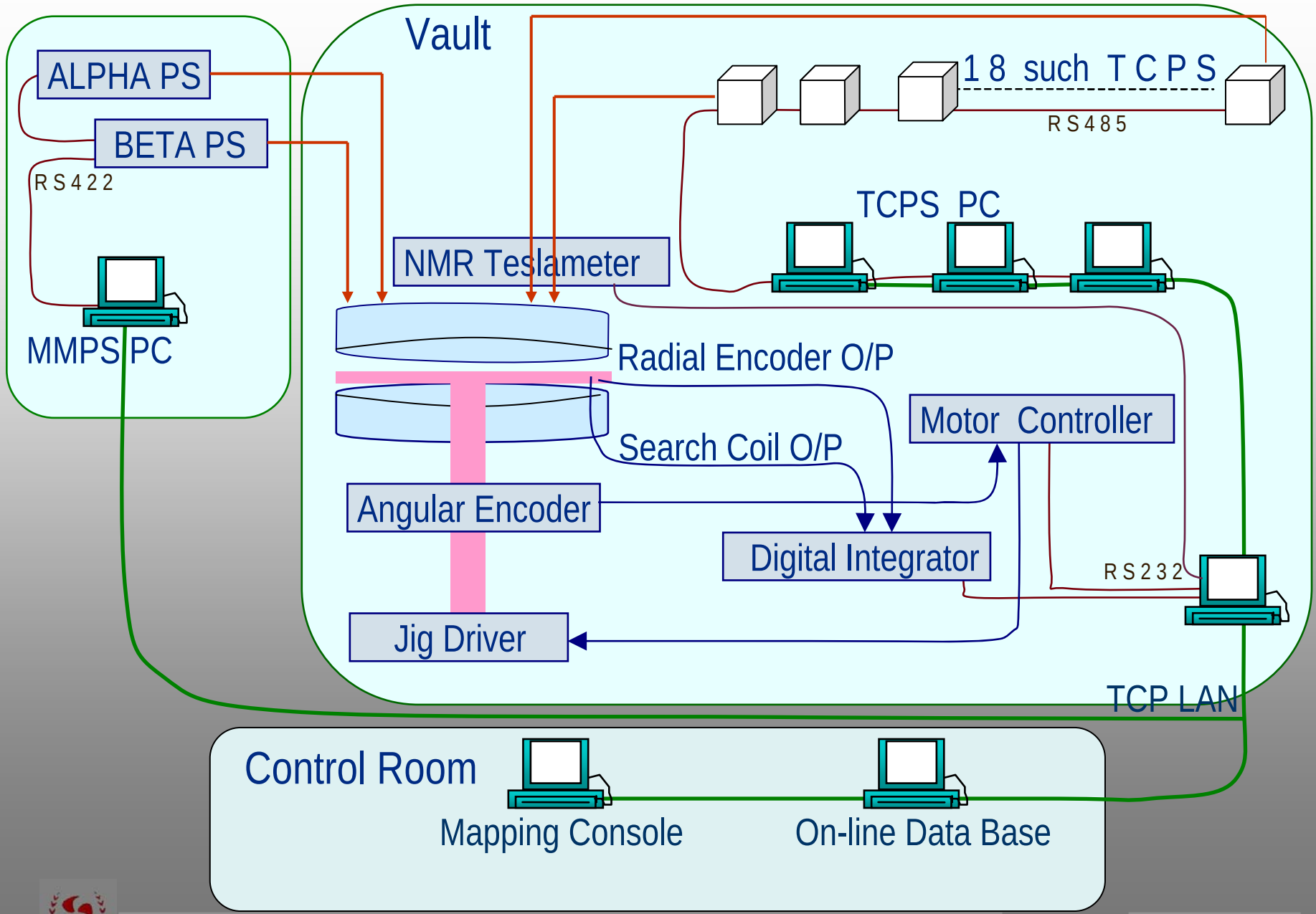
Lab set-up for software development testing

SYSTEM - S/W & H/W

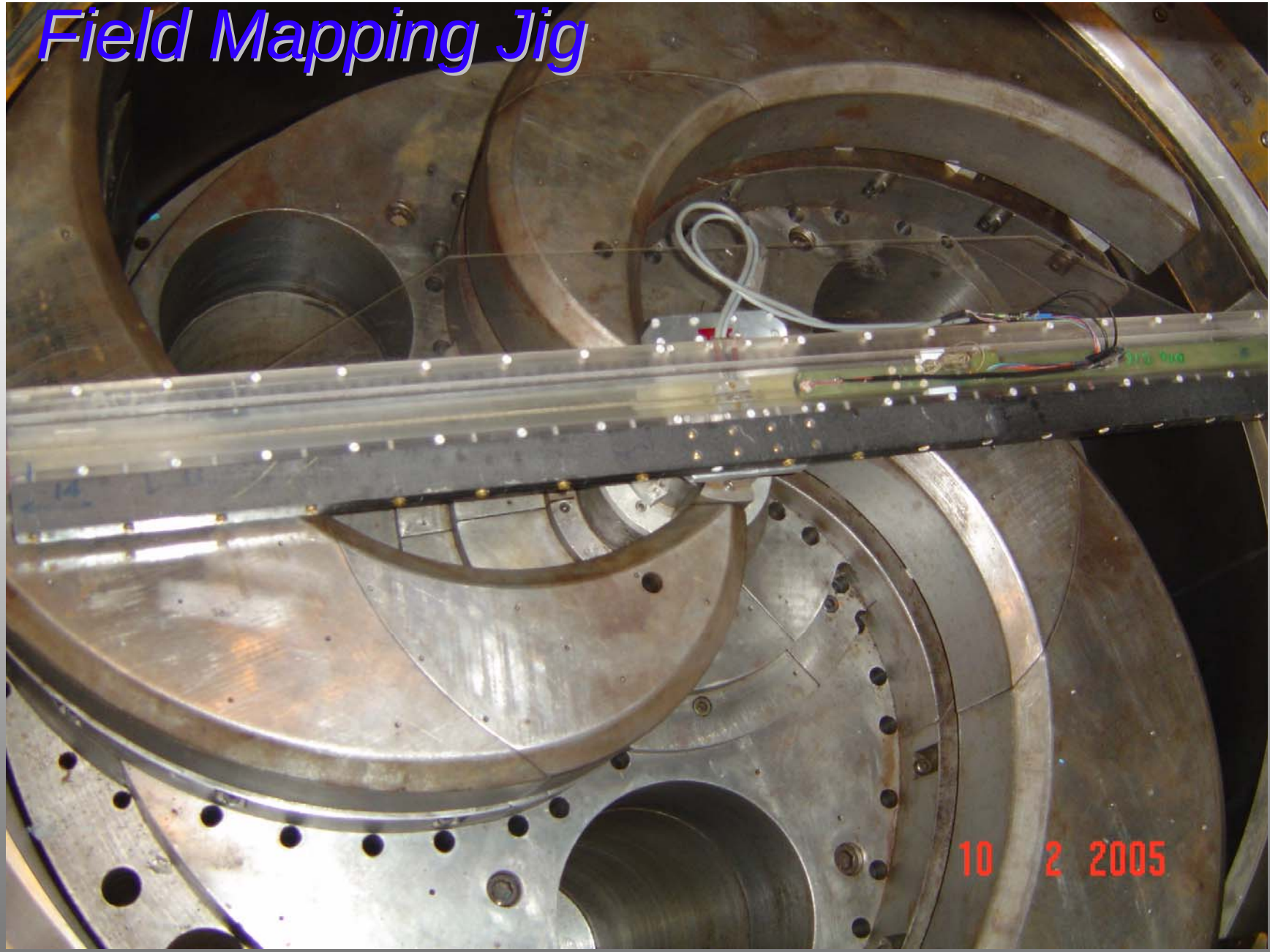
Salient features of Magnetic Field Mapping System

- ~ 100K Data Points per map
- High speed data taking (~90 min. per map)
- 5 micron radial encoder resolution
- 0.004 deg. Angular Encoder resolution
- Special precision electronics (VFC, NMR, Jig controller, smart motors)
- Client-Server architecture
- PC based system & s/w implementation by VC++ & LabVIEW
- On-line plot and harmonic analysis for error correction.

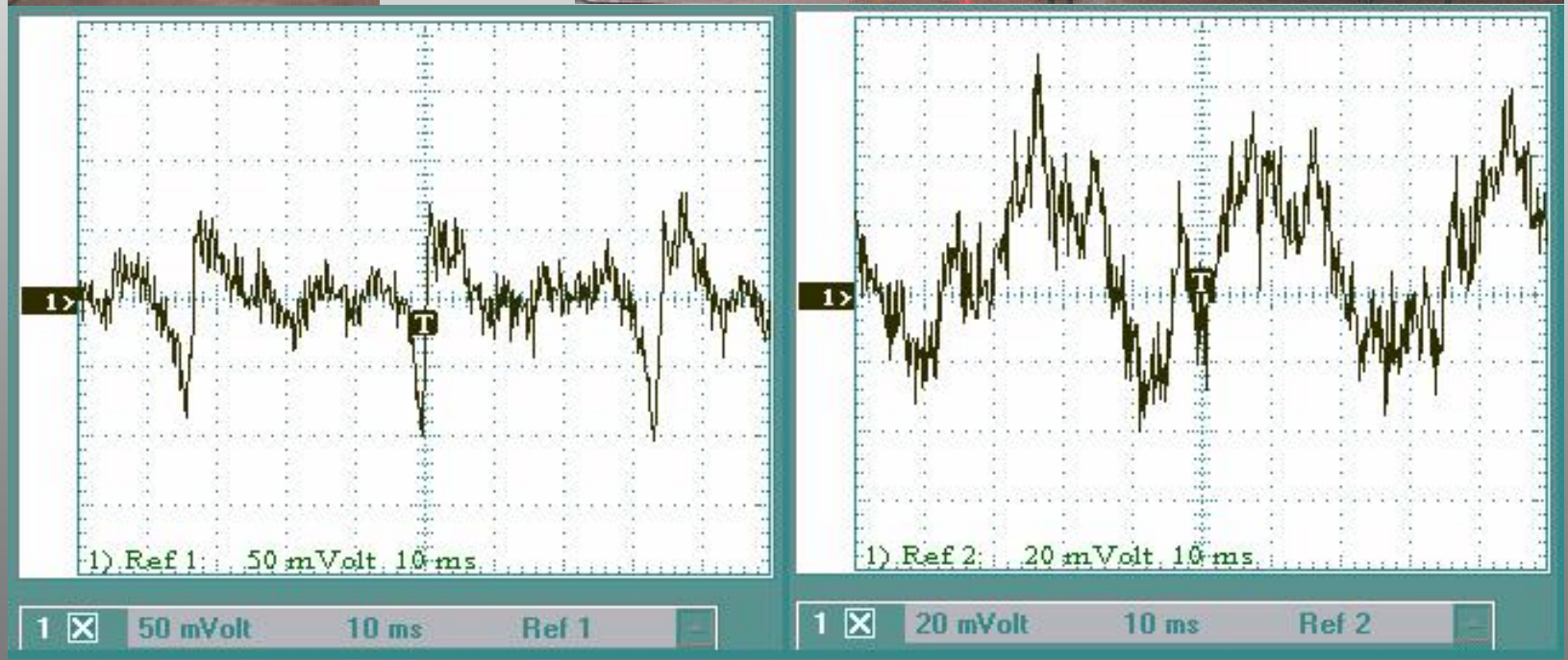
Schematic setup of Magnetic Field Mapping System



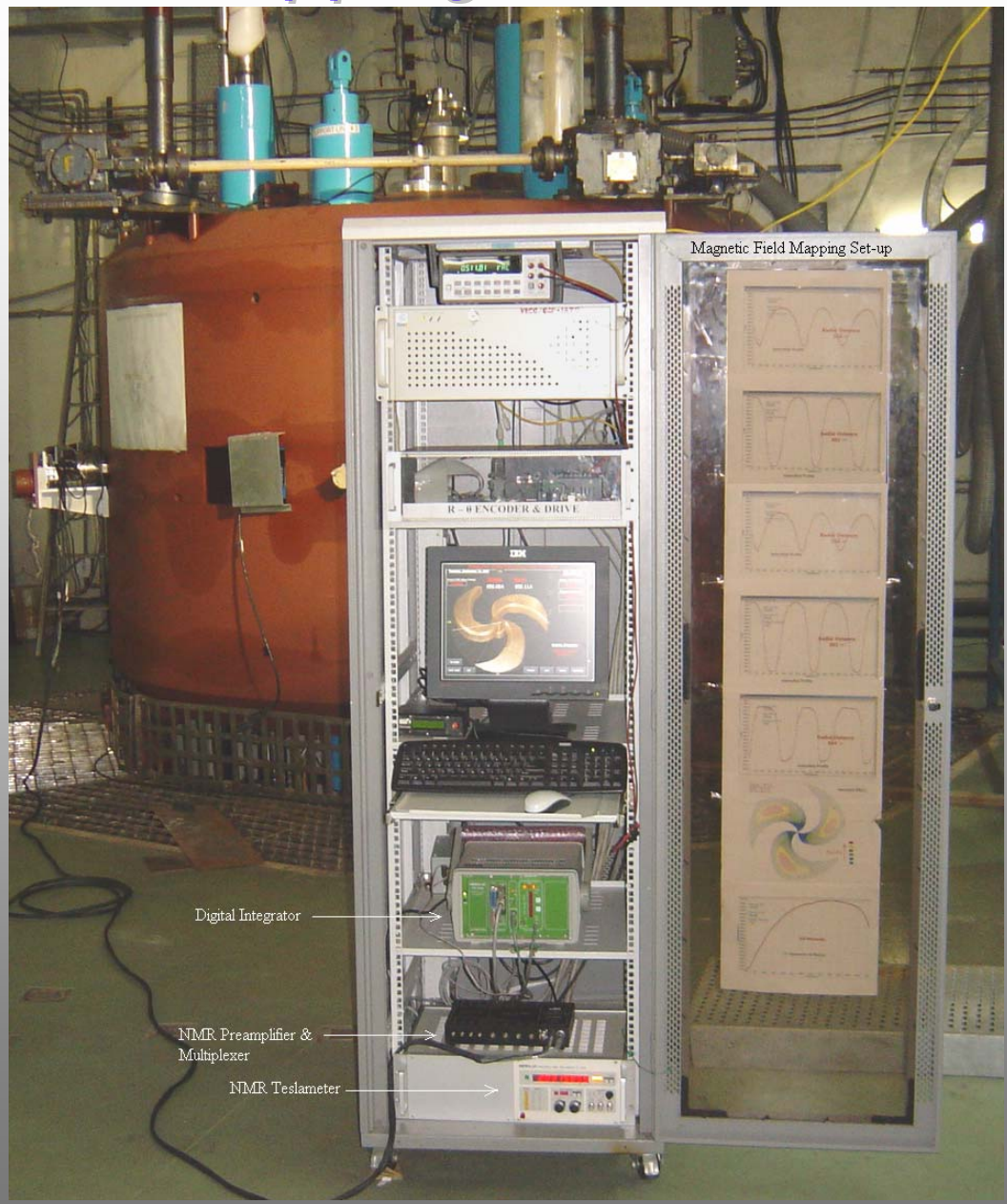
Field Mapping Jig



Absolute field measurement by NMR probe



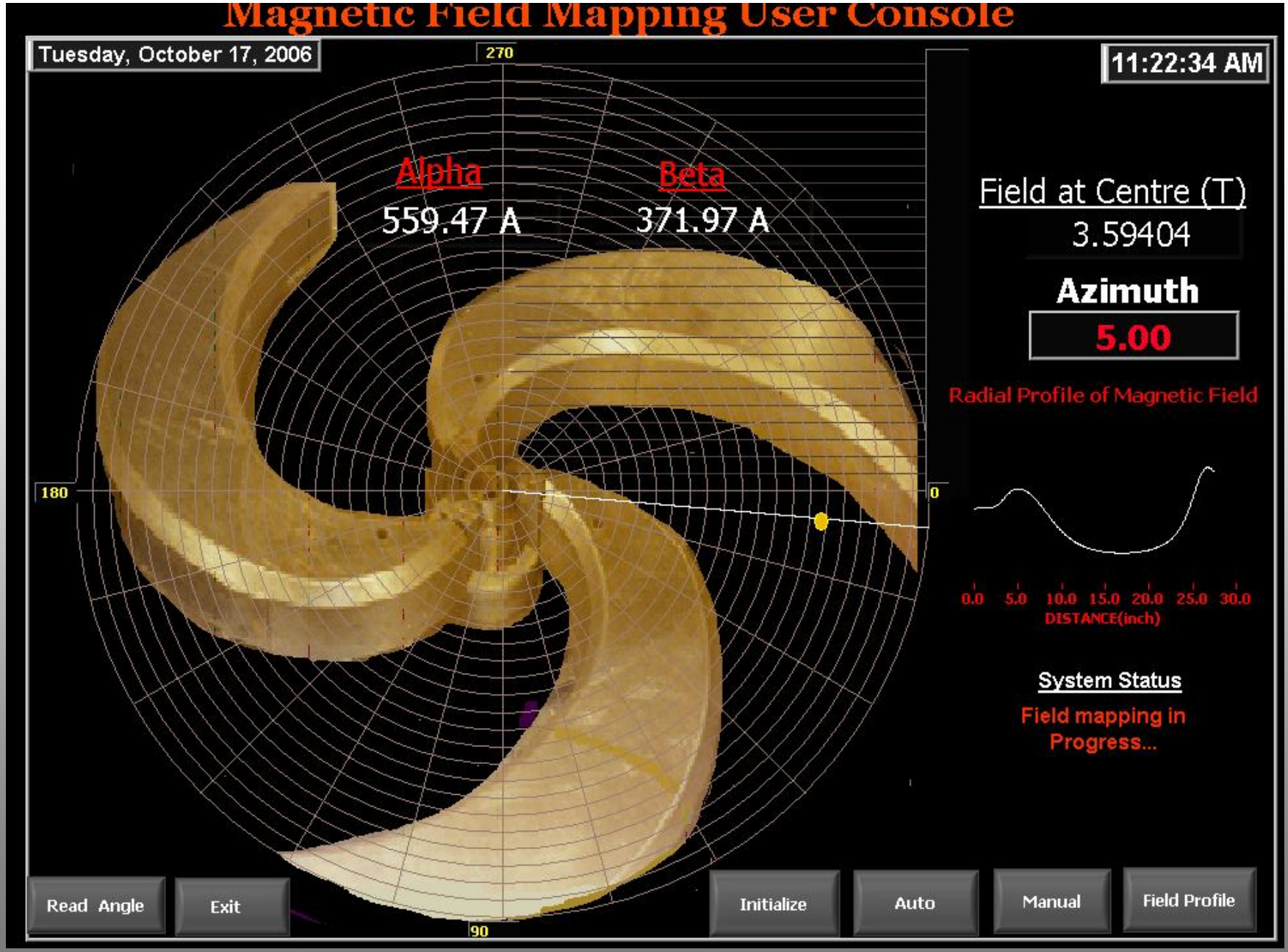
Field Mapping Server Station



Measurement Controller Software

- *A multithreaded C module implemented using Windows API performs following three tasks simultaneously.*
  - ***Receive command** from client program and decode the command to invoke appropriate job.*
  - ***Execute** the current job.*
  - *Execute a watchdog timer independently to **monitor any unacceptable event** and notify the client.*
- *The program is divided into following **five modules**.*
  - *Main server thread initializes the **search coil movement** and positioning system, opens protected TCP socket to communicate with the MFM User Interface. MUI has a predefined IP address to receive command and **accepts command** from the client to invoke the appropriate task. It also generates error message in case of any failure.*
  - *Digital Integrator thread issues commands to digital integrator module for **controlled data acquisition**.*
  - *NMR Gauss Meter thread **reads online NMR** Gauss meter output.*
  - ***Angular movement** thread positions the search coil carrying arm at desired angle by communicating with angular encoder and smart motor driver.*
  - ***Watchdog** as a monitoring thread with a preset time out, facilitates to come out of any deadlock situation.*

Client at Console

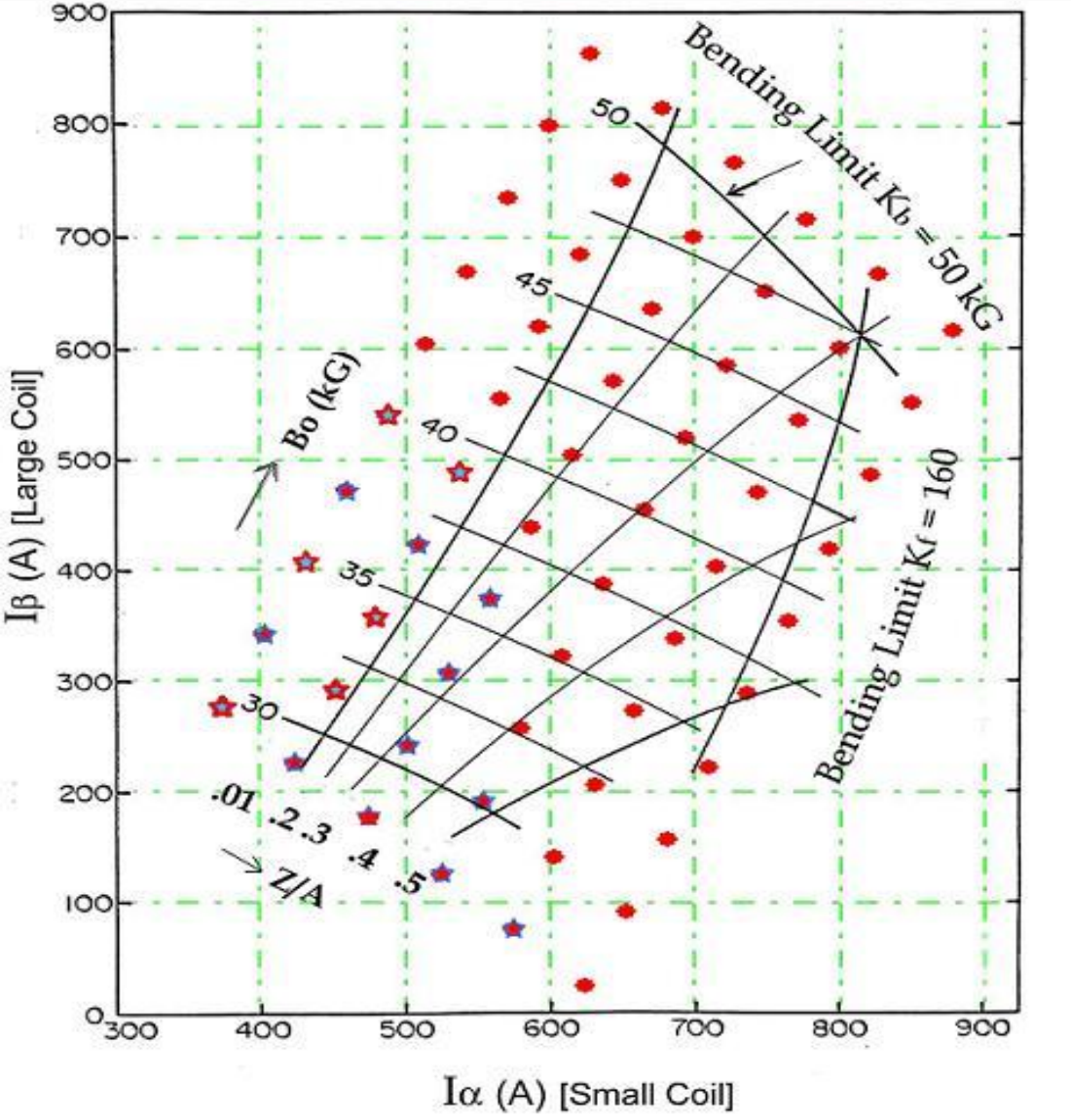

Magnetic Field Mapping User Console
Tuesday, October 17, 2006
11:22:34 AM
270
180
0
90
Alpha
559.47 A
Beta
371.97 A
Field at Centre (T)
3.59404
Azimuth
5.00
Radial Profile of Magnetic Field
0.0 5.0 10.0 15.0 20.0 25.0 30.0
DISTANCE(inch)
System Status
Field mapping in Progress...
Read Angle
Exit
Initialize
Auto
Manual
Field Profile

MFM User Interface Software

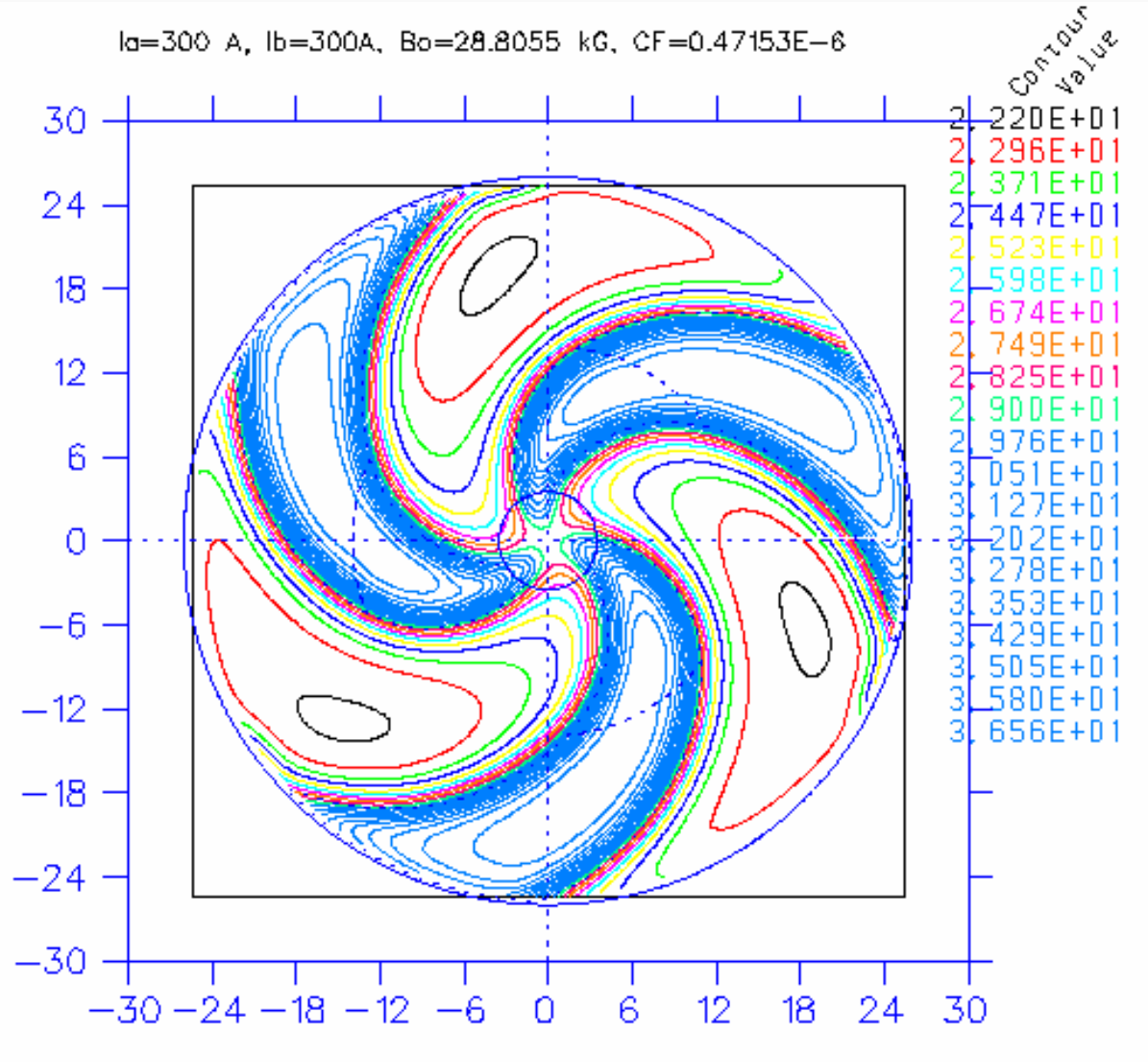
- *This **client software** developed in **LabVIEW** incorporating multi-threaded architecture, performs following tasks simultaneously.*
  - *Communication with Measurement Controller s/w for **automatic and manual mode of operation**, control and monitoring the MFM procedure and field data acquisition and storing.*
  - *Transaction with a centralized **Oracle Database** server through SQL to read and **display** different subsystem (Main magnet power supply System, Trim coil power supplies system, Cryogen delivery system) parameters to ensure the magnetic **field stability** during the mapping.*
  - ***Online visualization** of the acquired field data for comparing the actual and theoretical profile the magnetic field.*
  - *Offline **Fourier Analysis** of MFM data stored in database for the analysis of azimuthal field modulation.*

RESULTS

Measurement grid current

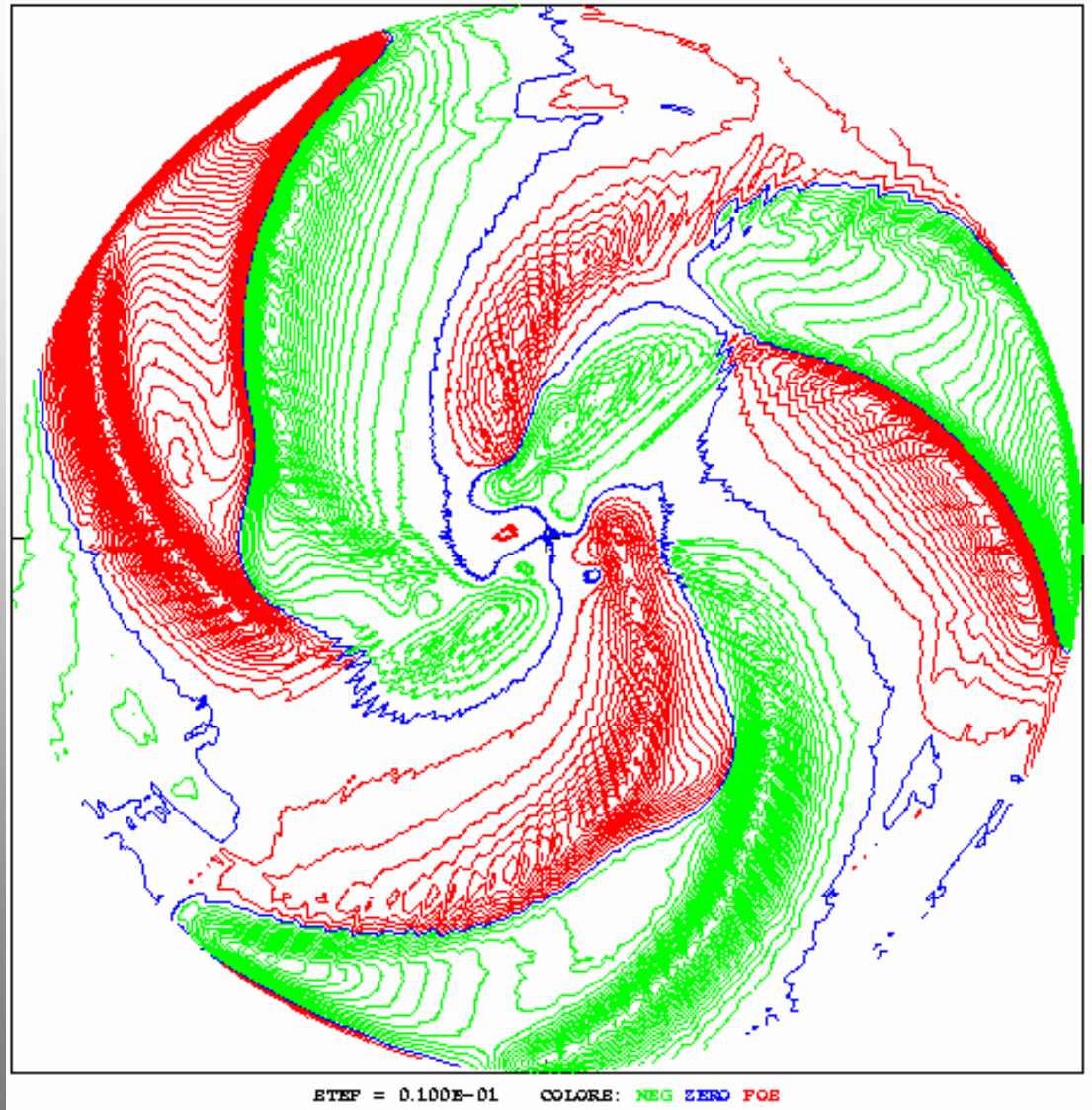


Isogauss Contour Plot of Measured Field



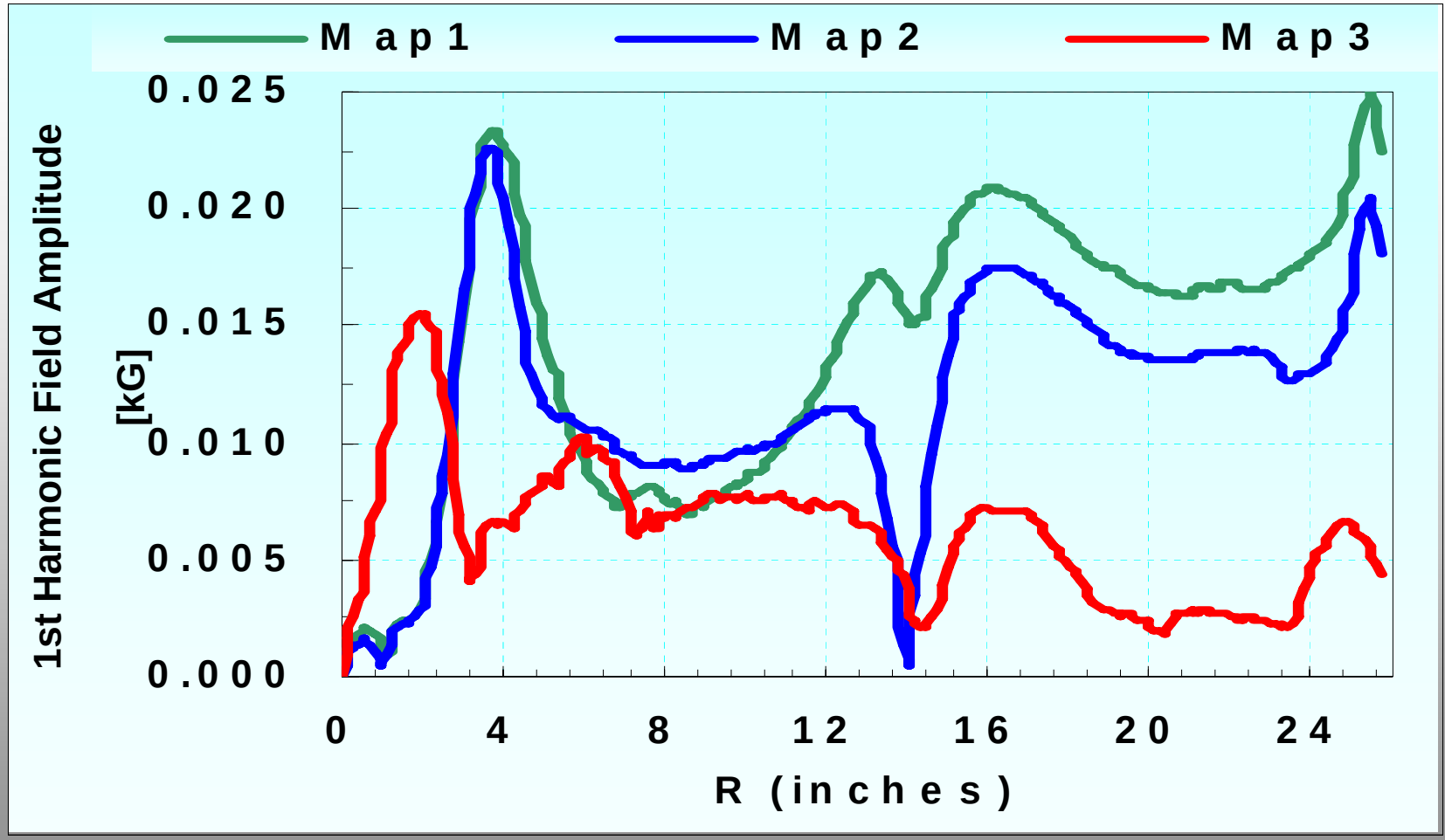
Three-fold symmetry dominated magnetic field distribution is characteristic feature of the three-sector geometry of the VECC K500 superconducting cyclotron

Contour Plot of Deviation from 3-Sector Average



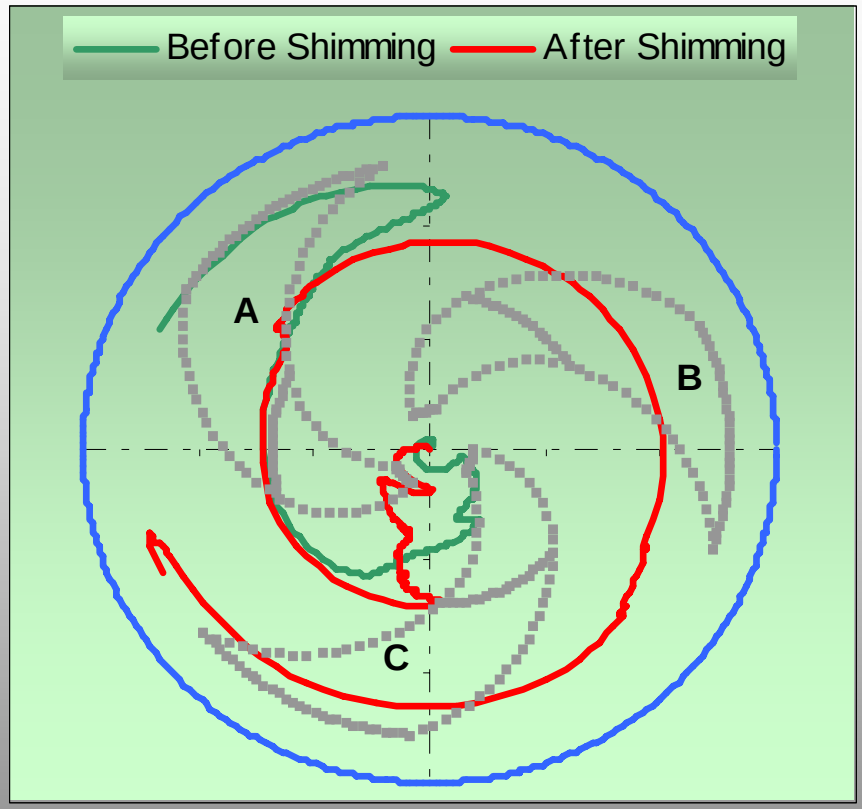
- *Deviation from perfectly three-fold symmetry arises out of manufacturing tolerances and assembly errors. The **blue** contour is of zero deviation, i.e. perfectly three fold symmetric data points, the red and **green** contours are of positive and negative deviations respectively with 10 gauss steps. This includes all harmonics other than 3rd harmonic and integral multiple of 3.(at I_alpha= I_beta = 300 Amperes)*

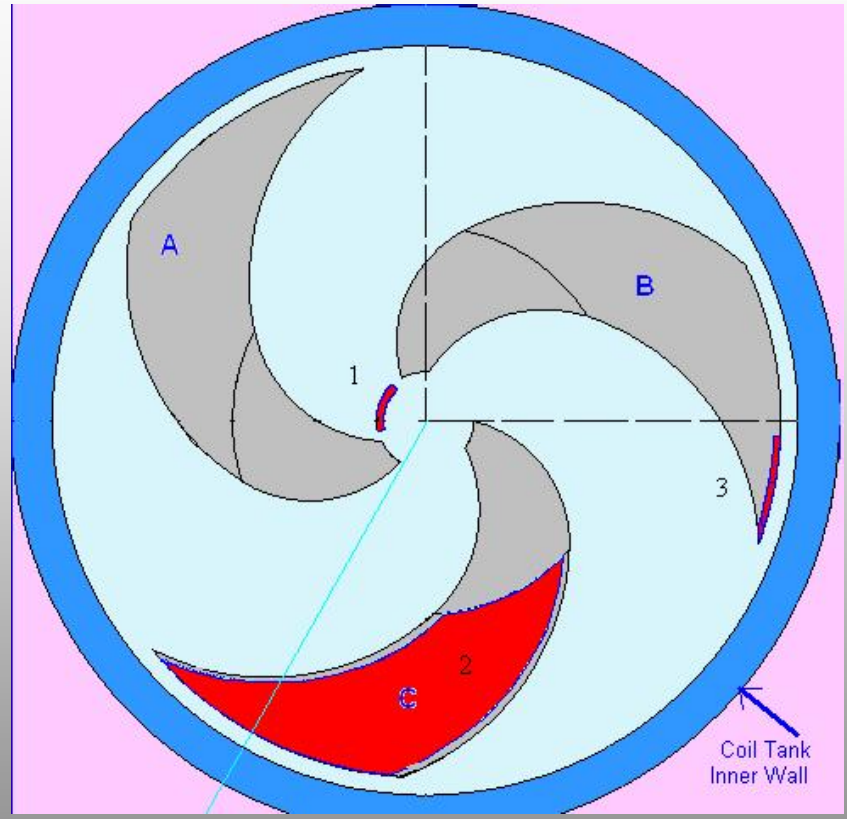
Minimization of First Harmonics Field



The aim was to reduce the error harmonics to manageable proportions at the important places by adding iron shims, however, to minimize the 1st harmonics at the extraction region was the most important issue.

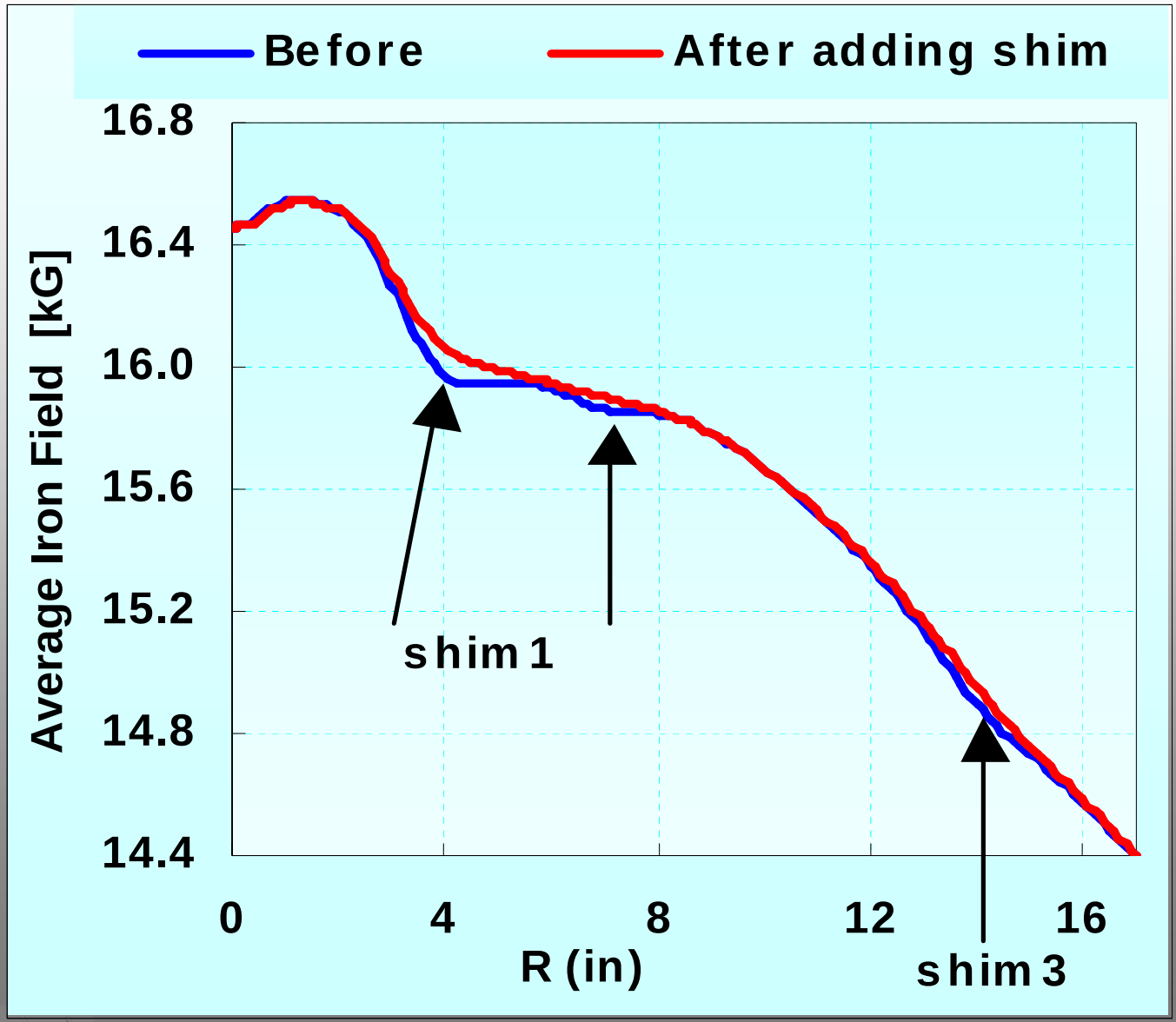
First Harmonic Phase Distribution and the Position of Iron Shims





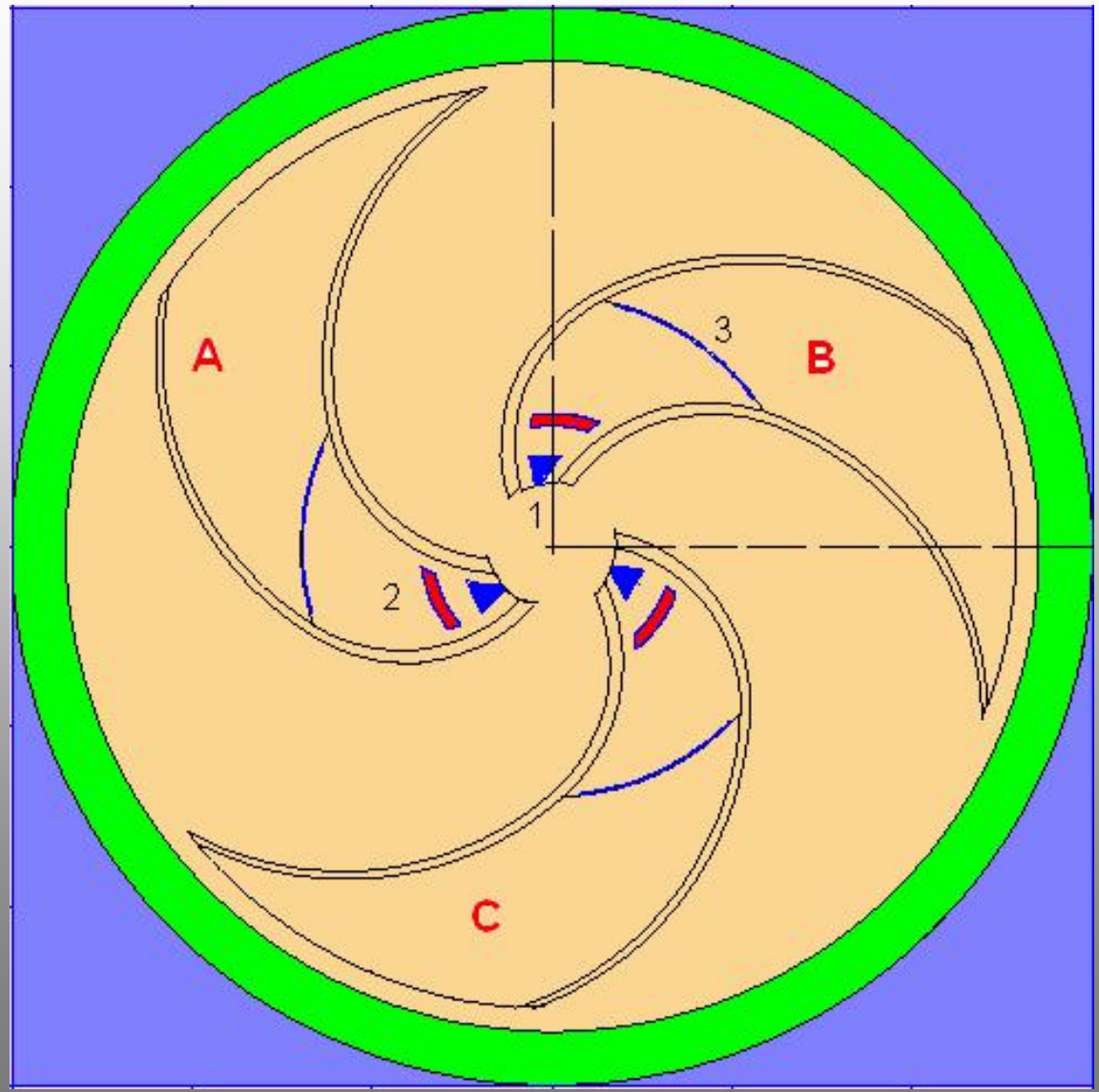
The positions of iron shims to be added are determined by the phase distribution of first harmonic component of the field.

Error Correction in Average Field Distribution



Iron shims were added to remove unwanted dips in the average iron field distribution at about 4", 7" and 14" radii

Iron Shims for Bavr Error Correction



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Thanks!

For

Your Kind Attention!