Cooling Channel Magnet Mapping Plan

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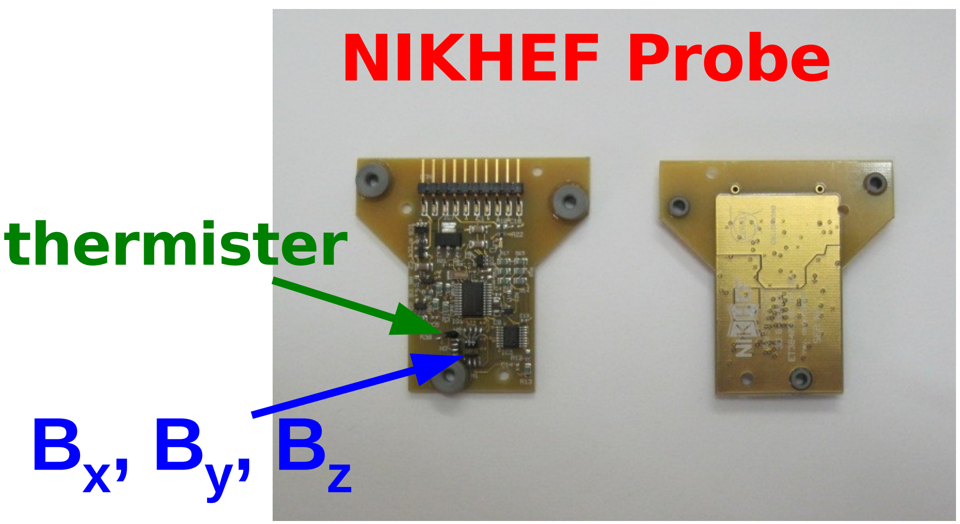
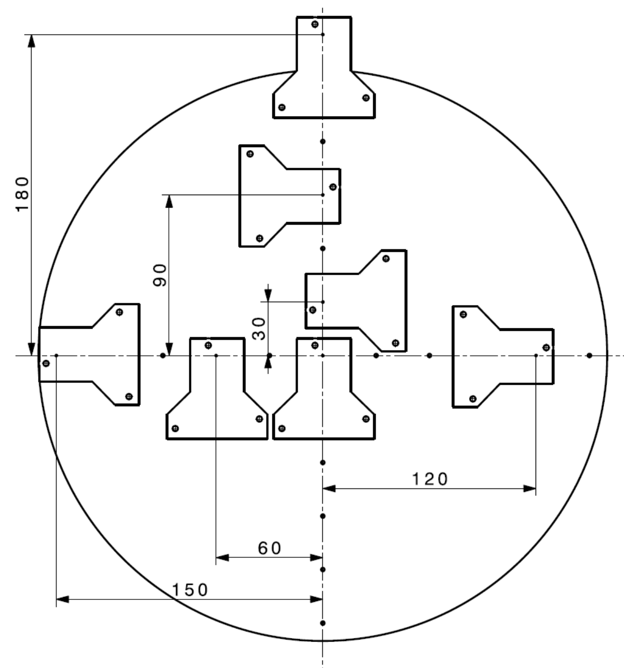
Outline

- Introduction
- Motivation
- Tasks
- Configurations
- Mapping Grids

Introduction

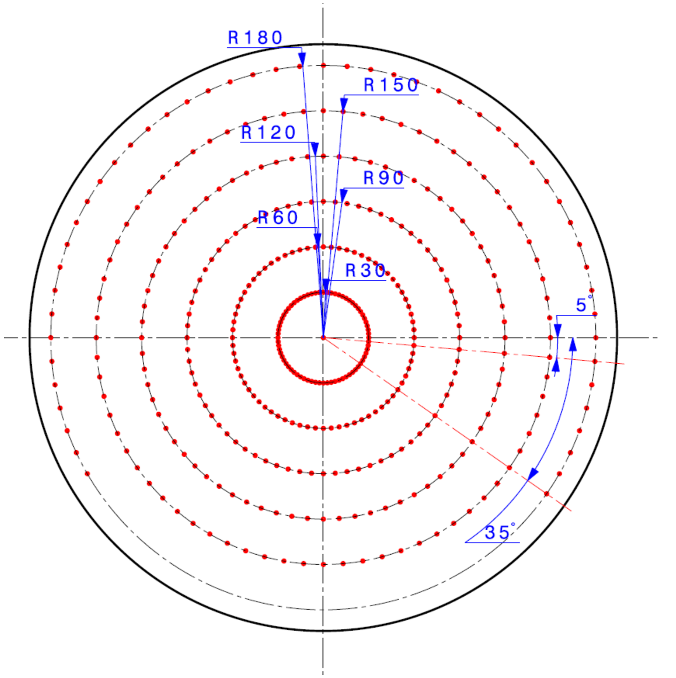
- **"Mapping" magnets: measuring magnetic field components on a 3D spatial grid**
- **Performed using Hall probes: B_x, B_y, B_z, T**
- **NIKHEF probes mounted on disk**

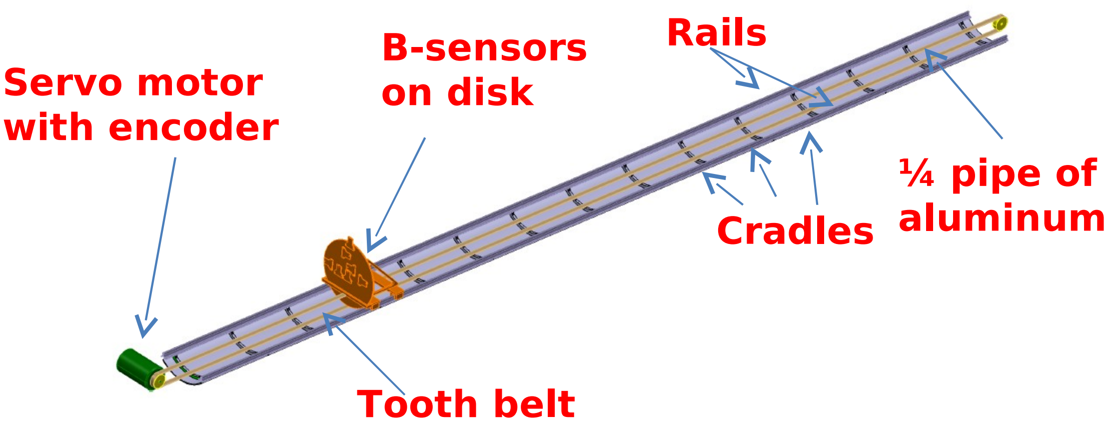




Introduction

- **Disk rotated**
- **measures B at 7 radii**
- **maps transverse plane**
- **5° yields 1.5cm @ largest radius**





- **disk moved**
- **longitudinally**
- **3cm steps**

Purpose

Guiding Principle:

Errors in field map *must not* contribute significantly to emittance measurement errors.

- **Transverse momentum measured from radius of curvature (tracker) and magnetic field**
- **Position and p_t used to compute emittance**
- **Measured field map will be converted to G4MICE field map for analysis**

Purpose

Characterization of magnets

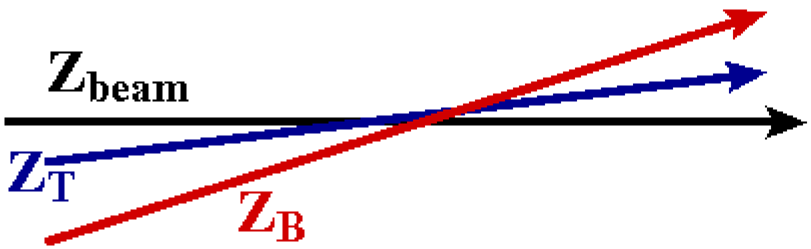
Two Sets of Measurements

- At vendors:
  - Determine magnets operate according to specifications
- In situ in MICE hall
  - real configurations & real environment
  - check field alignment
  - check field uniformity
  - check field consistent with Maxwell
  - fringe fields

Purpose

Additional reasons:

- Determine if simulation matches data
- Fringe fields
  - Force models
  - Nearby equipment (pumps, electronics, ...)
  - Global tracking
- Relative and global alignment



- Scale with fixed hall probes

Tasks – before mapping

Software readiness:

- Convert map to G4MICE map
- Tests for map:
  - Superposition
  - Relative alignment of magnetic and geometric axes
  - Field uniformity
  - Field consistency with Maxwell's equations
  - Emittance errors introduced

Tasks – before mapping

What do we need to know?

- How do we quantify field error contributions to emittance?
  - Uniformity, positions, magnitudes
- What can we do analytically?
- What simulations do we need?
- How to convert map to G4MICE map?
  - Introduce conversion errors?
  - What grid step size?
- What configurations do we map?

Tasks – at vendors

At vendors (coarse grid):

- Measure each coil separately
- Measure at 0.25, 0.5, 1.0, 1.1 xI_{max}
- Measure 5 coils (at 0.25, 0.5, 1.0, 1.1 xI_{max})
  - Convert map to G4MICE
  - Checks:
    - Superposition
    - Alignment of magnetic and geometric axes
    - Field uniformity
    - Verify Maxwell's equations

Tasks – in MICE hall

In MICE hall (fine grid):

- Magnets in situ – real environment and realistic running configurations
- Fringe fields
- Fixed hall probes
- Convert map to G4MICE
- Checks:
  - Superposition
  - Relative alignment: geometric & magnetic
  - Verify Maxwell's equations
- Use to compute errors from real map

Configurations

- **Spectrometer solenoids**
  - **9 measurements X 4 FC configurations=36**
  - **Needs further study/input**

- **Focusing coils**
  - **++**
  - **--**
  - **+-**
  - **-+ (will we need this also?)**

- **Coupling coils (1 ?)**

Mapping Grids

At vendor (coarse grid):

- 10cm longitudinal steps
- 20° angular steps
- 5 coils at 4 currents + all coils
  - 24 configurations

- 4 measurements (B_x,B_y,B_z,T) 4/15s
- Longitudinal travel v=10mm/s
- Will use $\Delta t=\Delta z/v+0.5s$ (Δz is step size)

Mapping Grids

SS at vendor (coarse grid: Δz=10cm):

- **Movement and measurement is 10.5s**
  - **SS – 5m longitudinal**
    - **50 longitudinal steps – 525s (in z)**
    - **18 angular steps – 525sX18=9,450s**
    - **3 hours/configuration – 3/day**
    - **24 configurations – 8 days**

Mapping Grids

CC/FC at vendor (coarse grid: Δz=10cm):
Movement and measurement is 10.5s

- FC – 3.5m longitudinal
  - 35 longitudinal steps – 368s (in z)
  - 18 angular steps – 368sX18=6,624s
  - 2 hours/configuration – 4/day
  - 10 configurations – 2.5 days

- CC – 3.5m longitudinal, 1 configuration
  - 4 configurations – 1 day

Mapping Grids

At MICE (fine grid):

- **3cm longitudinal steps**
- **10º angular steps**
- **9 (ε,p) measurements**
- **4 FC configurations**

- **4 measurements (B_x,B_y,B_z,T) 4/15s**
- **Longitudinal travel 10mm/s**

Mapping Grids

SS in MICE hall (fine grid: Δz=3cm):

- Movement and measurement is 3.5s
  - SS – 5m longitudinal
    - 167 longitudinal steps – 585s (in z)
    - 36 angular steps – 585sX36=21,060s
    - 6 hours/configuration – 2/day
    - 36 configurations – 18 days

Mapping Grids

CC/FC in MICE hall (fine grid: Δz=3cm):

Movement and measurement is 3.5s

- FC – 3.5m longitudinal
  - 117 longitudinal steps – 410s (in z)
  - 36 angular steps – 410sX36=14,760s
  - 4.1 hours/configuration – 2/day
  - 4 configurations – 2 days

- CC – 3.5m longitudinal, 1 configuration
  - 1 configurations – 1 day

Tentative Schedule

In all that follows, I propose 2 sets of rails:

- **1 at RAL and 1 to move between vendors**

- **Beginning August SS1 at Wang NMR**
- **End August at FC1 at Tesla**
- **Beginning September SS1 at MICE**
- **Beginning November SS2 at Wang NMR**
- **Beginning January SS2 at MICE**

Very preliminary – need lots of input

Note manpower intensive!!!

Conclusions

- **Mapping is necessary**
- **Required tasks identified (preliminary)**
- **Significant preliminary work**
- **Measurements differ: (vendor & MICE)**
- **Configurations identified (CC and FC)**
- **SS missing configurations(investigating)**

Conclusions

- **Initial grids proposed – must be optimized**
- **Manpower intensive – needs thought**
- **Optimization and MICE note to follow**