Magnetic field simulations and measurements on mini ICAL

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INO

December 14, 2020
Overview

- Introduction
- Mini ICAL geometry
- Hall Probe and Search Coil
  - Hall Probe and Search Coil placement
  - Hall Probe and Search Coil comparison
- Experimental data from mini ICAL
- Simulation using MAGNET software
  - Simulation Results
- Conclusion
- Future Plan
**Introduction**

- **ICAL**
  - In ICAL detector (50 k Ton) with $B_{\text{max}}$ 1.5 Tesla.
  - Purpose of making magnetized detector
    - Charge identification
    - Reconstruct momentum of muons not stopping in ICAL

- **Mini ICAL**
  - Mini ICAL is 85 Ton prototype ICAL detector.
  - One aim of the mini ICAL is to compare measured and simulated magnetic field to validate the magnet design.
Mini ICAL
Mini ICAL top view
Hall probe and Search coil

D Type Connector
Drift Adjustment
Reset Button
LCD Display
Flux Meter Box
Placement of Hall probe sensors and search coil in mini ICAL layer
Hall Probe and Search coil comparison

Hall Probe sensors
- Based on hall voltage
- Measures instant Magnetic field (steady state)
- Basic material - Mono-crystal GaAs
- Resolution - 10 Gauss

Search coil
- Based on EM induction
- Measures average magnetic field (ramp up and down)
- Single turn of Teflon coated Cu wire of approximately 0.25 mm$^2$ cross section
- Resolution - 650 Maxwell Turns
Experimental data from search coil-1 (with 2 point calibration)

![Graph showing magnetic field vs current for different current ranges: 0 to 900 amp current (red), 900 to 0 amp current (blue), -900 to 0 amp current (green), and 0 to -900 amp current (black).]
Magnetic field simulation

- Static 3-D simulation using MAGNET 7.4.3 software for 3 & 11 layered model for 600-900 amp.
- In 11 layered model 11 layer geometry is created with 1, 6 and 11 layers having air gap of 3 and 4 mm for Hall probe measurements and rest of the layers are having 2 mm air gap.
- In 3 layer model only 1, 6 and 11 layers are present with air gap of 3 and 4 mm for hall probe measurements.
- One layered model of mini ICAL is made in COMSOL MultiPhysics software to cross check with one layered MAGNET software.
Magnetic field simulation (Results)

Variation in fraction of area $|B| \geq 1$ T with 3 layered model and 11 layered model

| Iron Layer No. | Fraction of Area with $|B| \geq 1$ T |
|----------------|-------------------------------------|
| 0.88           | 11 Layered 600 amp                  |
| 0.89           | 11 Layered 800 amp                  |
| 0.90           | 11 Layered 900 amp                  |
| 0.91           | 3 Layered 600 amp                   |
| 0.92           | 3 Layered 800 amp                   |
| 0.93           | 3 Layered 900 amp                   |

Honey (INO) December 14, 2020
Variation of magnetic field among the layers in simulation (11 layered model 900 amp)
Magnetic field simulation (Results)

Variation of magnetic field among the layers in simulation (3 layered model 800 amp 135 degree 101 points)

Magnetic field (T)

Distance (mm)

layer 1
layer 6
layer 11
Magnetic field simulation (Conclusions)

- Fraction of area of iron plate with magnetic field ($B \geq 1$ T) at different values of current for both the models shows agreement within 5%.
- In 11-layered model
  - D plate - 3% variation in B field in different layers.
  - Edges - 20 – 30% variation in B field in different layers.
- In 3-layered model
  - D plate - 3% variation in B field in different layers.
  - Edges - 10% variation in B field in different layers.
- Sudden decrease in B field values between the air gaps in simulations is to be addressed.
Future plans

- Calibration of the hall probe with 7 points magnetic field.
- Simulations with the measured air gap that is taken as 2 mm (ideal) but measured values are varying from 2 to 3 mm.
- Simulating with smaller (<3 mm) mesh size.
- Comparison between MAGNET software and COMSOL results.
- Study of variation of B field in ICAL GEANT4 simulation.
Thank You