Magnetic Field Studies in the ISAC - II Cryomodule

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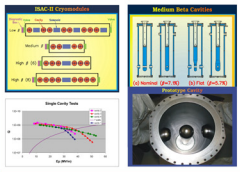
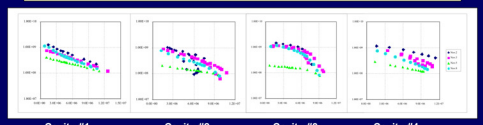
ABSTRACT

The medium β section of the ISAC-II Heavy Ion Accelerator consists of five cryomodules each containing four quarter wave bulk niobium resonators and one superconducting solenoid. The 9T solenoid is not shielded but is equipped with bucking coils to reduce the magnetic field in the neighbouring rf cavities. A prototype cryomodule has been designed and assembled at TRIUMF. The cryomodule vacuum space shares the cavity vacuum and contains a mu-metal shield, an LN2 cooled, copper, thermal shield, plus the cold mass and support system. Several cold tests have been done to characterize the cryomodule. Early operating experience with a high field solenoid inside a cryomodule containing SRF cavities will be given. Of note are measurements of the passive magnetic field in the cryomodule and estimations of changes in the magnetic field during the test due to trapped flux in the solenoid and magnetization of the environment. Residual field reduction due to hysteresis cycling of the solenoid has been demonstrated.

ISAC - II SC Linac

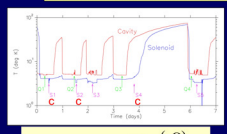


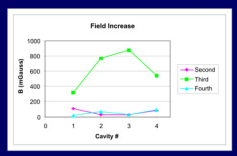
TEST3: Q –curves of the cavities in the Cryomodule during four days rf test



Cavity #1 Cavity #2 Cavity #3 Cavity #4

Day 3: Cavities warmed but solenoid didn't – trapped flux gives large field near solenoid





$$\Delta B\,(mGauss) = \frac{\Delta R_{res}(n\Omega)}{0.3\cdot\sqrt{f\,(GHz)}}$$

Cryomodule Cold Tests

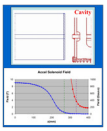
❑ First Cooldown
- > April 2004
- > Alignment and Cryogenic studies

❑ Second Cooldown
- > June 2004
- > RF studies (alignment check)

❑ Third Cooldown
- > Oct. 2004
- > 3 load of studies
- > Remote operation
- > alpha acceleration

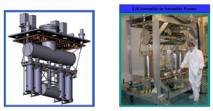
Solenoid - Test 2

- Base Q's measured before solenoid test
- Ramp up solenoid to 9T
  - Cavities 2 and 3 on
  - No quench of cavities or solenoid
  - No change in cavity Q
- Cold mass warmed above transition
- Q's measured after second cooldown
  - No change; Q>1e9
  - Residual field tolerable
- Field measurements after test showed that some magnetization of environment occured



Medium Beta Cryomodule

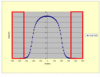
- 2x2x1m stainless steel box vacuum vessel
- LN2 cooled copper sheet used as thermal shield
- Mu metal between vacuum tank and LN2 shield
- Cold mass suspended from lid on three support pillars
- Four cavities Ep<30MV/m
- One SC solenoid @ 9T
- V_{acc}=4.3MV



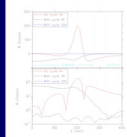
Superconducting Solenoids

- Focussing in the SC Linac is provided by superconducting solenoids (B≤9T)
- End fringe fields controlled with active bucking' coils (B_{comp}≤0.1T)
- Production Medium and high beta solenoids in fabrication at Accel
  - See table for specifications

	Low β	Med β	High β
Field	9T	9T	9T
Bore	26mm	26mm	26mm
Number	4	5	3
Eff. Length	16cm	34cm	45cm



Frozen Flux



Mapping data* for ISAC-II Solenoid

❑ Solenoid is brought to 9 T and

a) Ramped to zero with no cycle at 4K

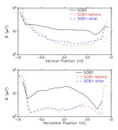
b) Taken to zero through hysteresis cycle at 4K

c) Ramped to zero and warmed to 20K

Frozen flux in solenoid produces a large (20G) field in cavity region when no hysteresis cycle is used. Cycling the magnet does reduce the field at the cavity but only warming the solenoid can eliminate the field.

* Data taken by Accel

Magnetic Mapping of Cryomodule



Mapped the internal magnetic field for

1. SCB1 after solenoid powered then warmed (no hysteresis cycle)
2. SCB1 before powering the solenoid
3. SCB1 after powering the solenoid and with hysteresis cycle

Hysteresis cycle required to reduce memory of solenoid