Enhancement of accelerating field of rf cavities by magnetic insulation

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Muon Collider (MC)

- A MC offers high collision energy at a compact size
Ionization cooling

- Muon beam is “born” with high emittance. Beam needs to be cooled.
- In ionization cooling the longitudinal energy lost within the absorber is restored by a rf cavity.
- A multi-tesla magnetic field is required to confine the muon beam.
Pillbox cavity in a magnetic field

- Large dark current and surface damage
- Maximum rf accelerating field is $B$ depended

Moretti et al.
PRST - AB (2005)
Field emission (FE) in rf cavities

- At 20 MV/m, electrons can reach ~1 Mev on impact
- Focused to 50-100 µm spots when B>0.1 T
- This causes substantial amount of power delivered to very localized regions -> Heating-> Damage
- But, can we suppress the deleterious effects of FE?

Stratakis et al. NIMA (2010)
Scope of this work/ Outline

• Propose magnetic insulation as a tool for suppressing the deleterious effects of FE
• Review an experimental program that could test the concept
• Study numerically the feasibility of magnetic insulation into two potential accelerator applications
  • (1) Muon Collider and (2) Neutrino Factory
Possible solution: Magnetic insulation

- Use of the concept for rf shielding was proposed by Bob Palmer (Palmer et al. PRST-AB 2009).

- Field-emitted electrons do not move far from surface but instead come back with low energies.

- The concept is been currently tested with a box cavity at FermiLab (Poster: TUP289)
Experiment to test magnetic insulation (preliminary data)

Moretti et al. MAP Meeting (7/2010)

- When B, E are normal, the rf performs better

http://mice.iit.edu/mta/
Application to a Muon Collider

- 6-D muon cooling channel with 805 MHz cavities
Application to a Neutrino Factory

- Muon capture front-end with 201 MHz cavities
Magnetically insulated rf vs. pillbox rf

- Similar to a conventional lattice, a MI lattice produces satisfactory cooling.
Requirements and open issues

- **Strength of magnetic field for insulation**
  - For a 805 MHz cavity a 0.2 T field is required

- **Coil misalignments**
  - 1-2 mm coil misalignments can be tolerated

- **Power requirements**
  - MI cavities have two times less shunt impedance.

- **Multipacting**
Summary

• Field-emission from the rf surfaces can cause damage and may initiate breakdown.
• The deleterious effects of field-emission can be suppressed by magnetic insulation.
• A experiment is underway to test the concept
• Application to muon accelerator lattices shows good performance
• There are two important issues with magnetically insulated cavities: (a) power consumption, and (b) multipactoring