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Enhancement of accelerating field of rf cavities by magnetic insulation

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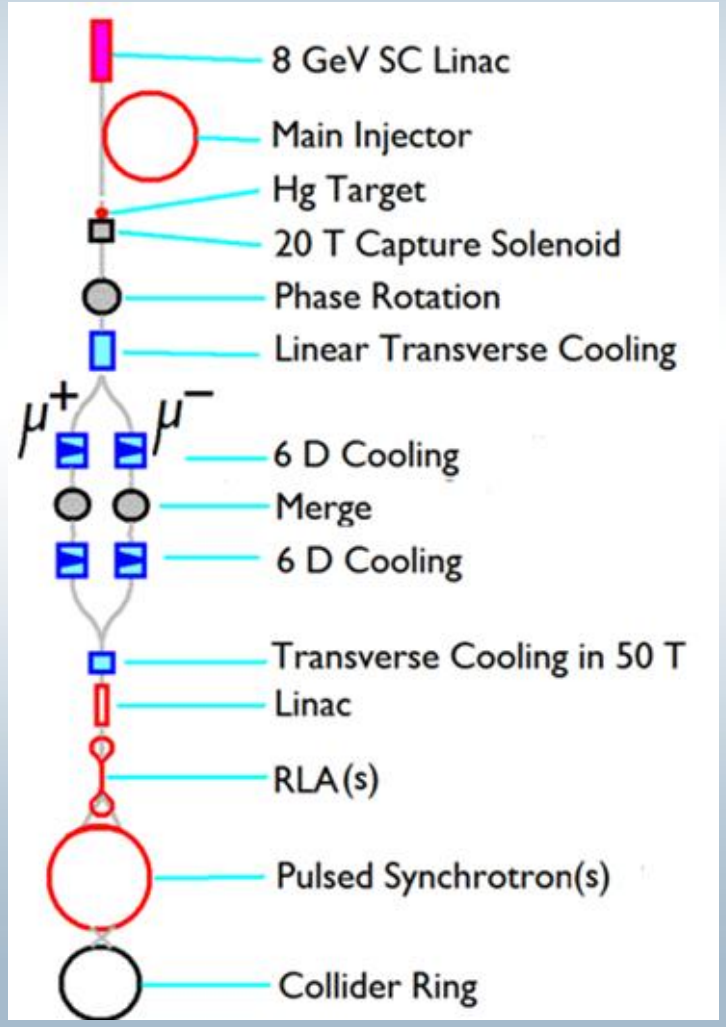
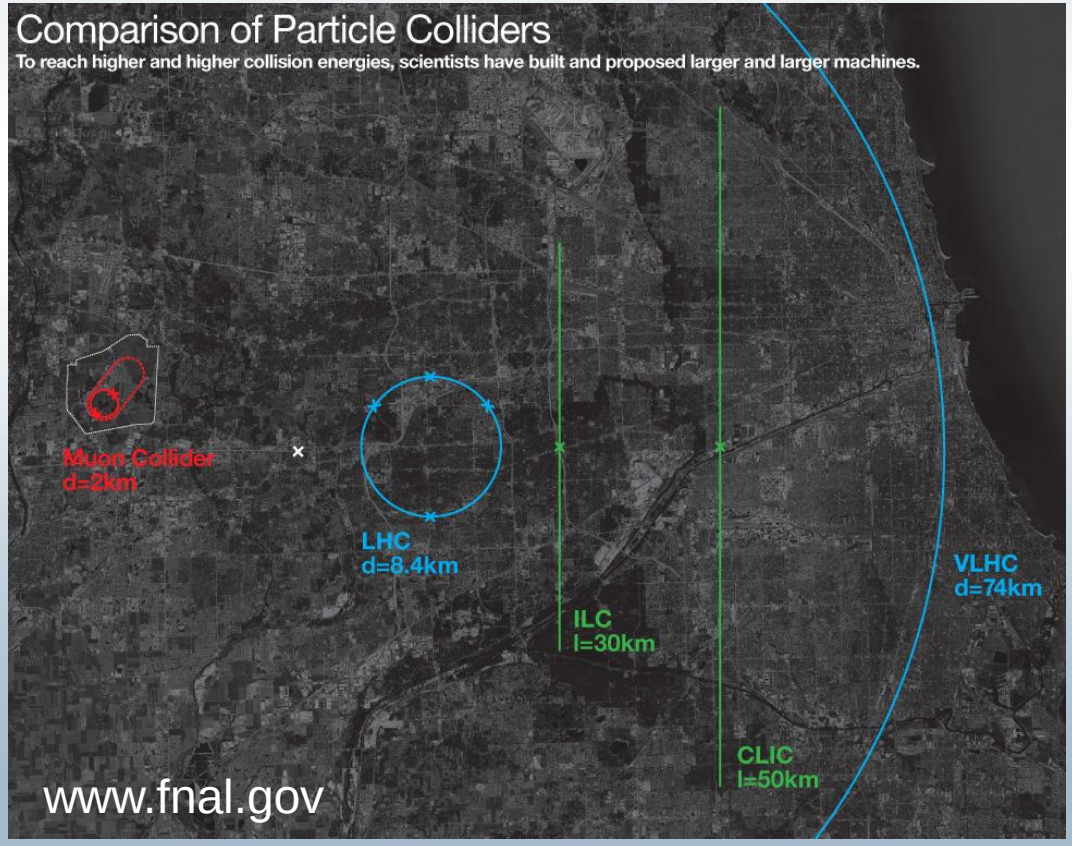
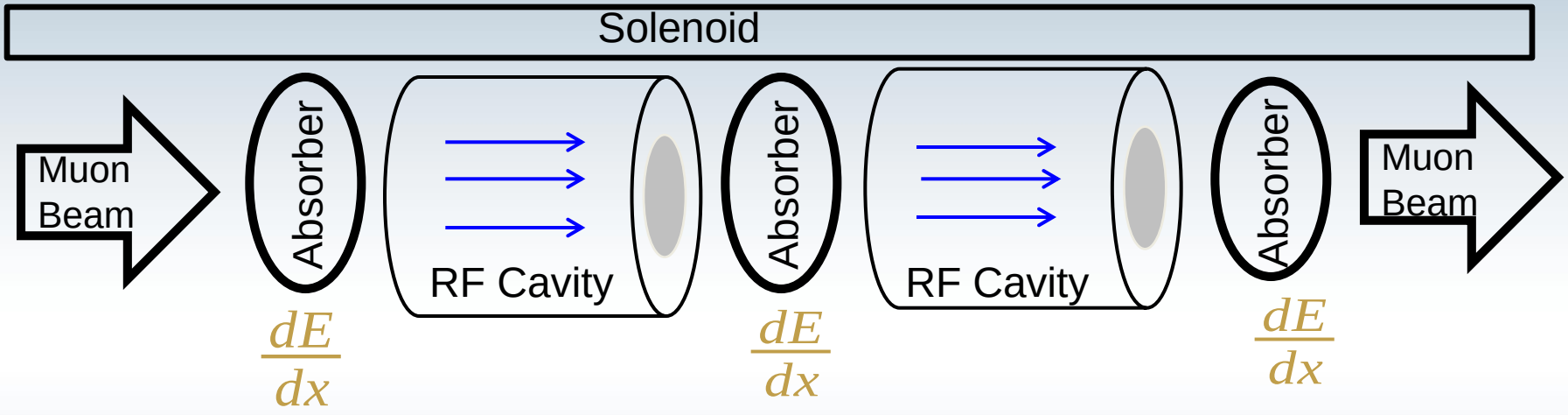
Muon Collider (MC)



- A MC offers high collision energy at a compact size

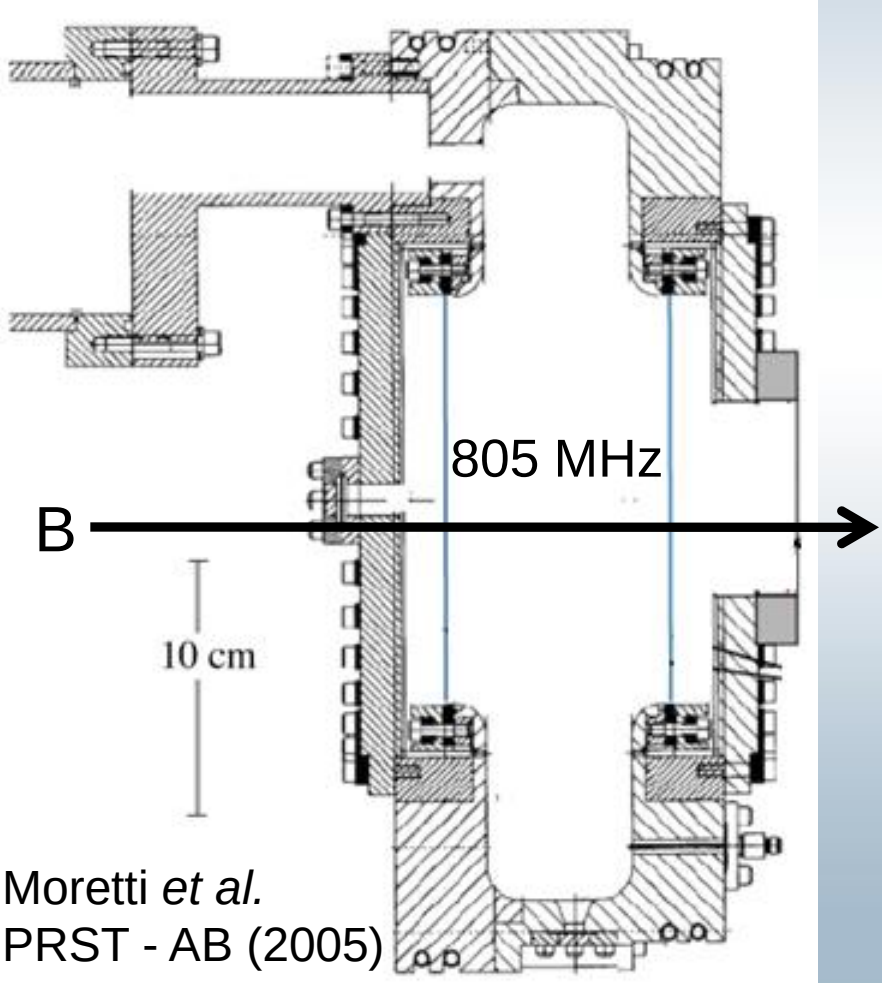


Ionization cooling

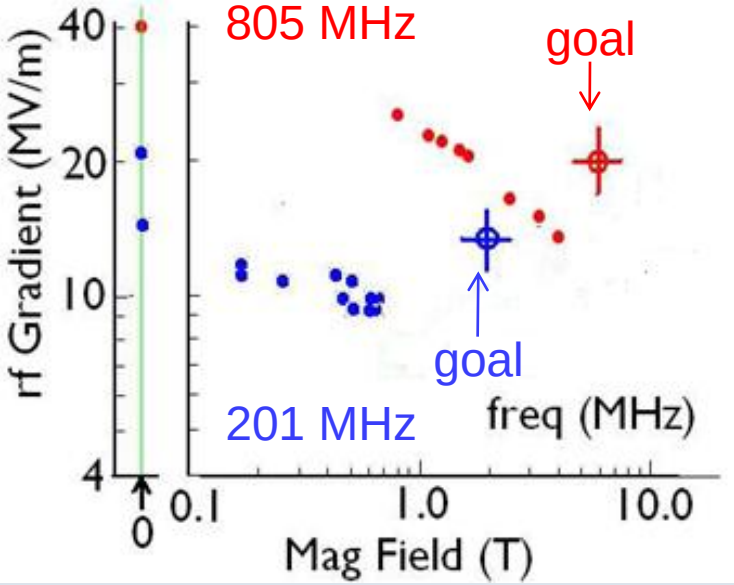


- Muon beam is “born” with high emittance. Beam needs to be cooled.
- In ionization cooling the longitudinal energy lost within the absorber is restored by a rf cavity
- A **multi-tesla** magnetic field is required to confine the muon beam

Pillbox cavity in a magnetic field

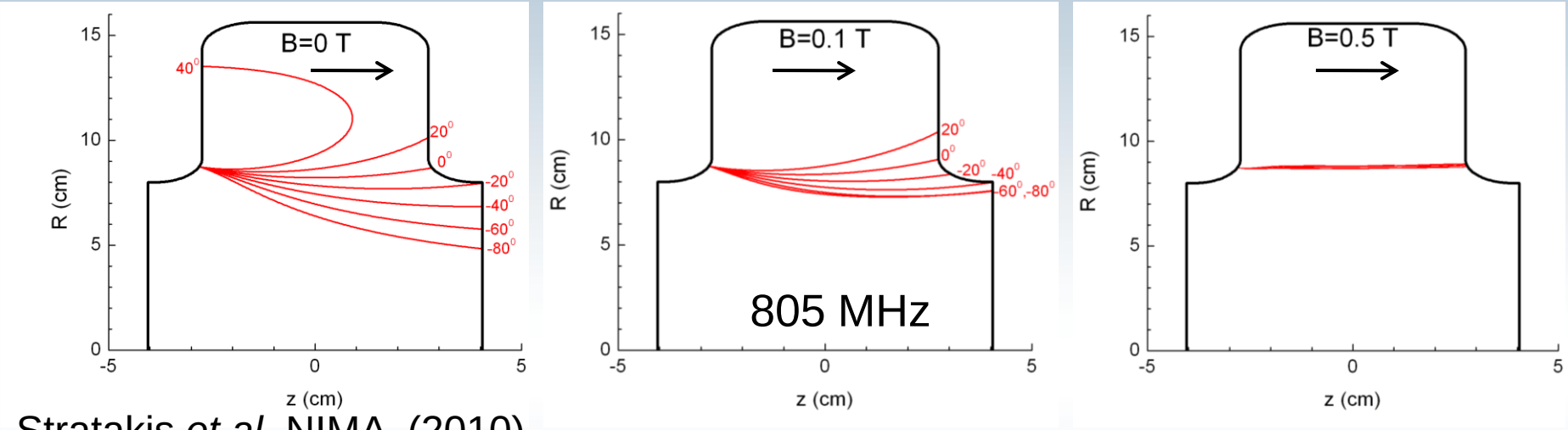


Moretti *et al.*
PRST - AB (2005)



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

Field emission (FE) in rf cavities



Stratakis *et al.* NIMA (2010)

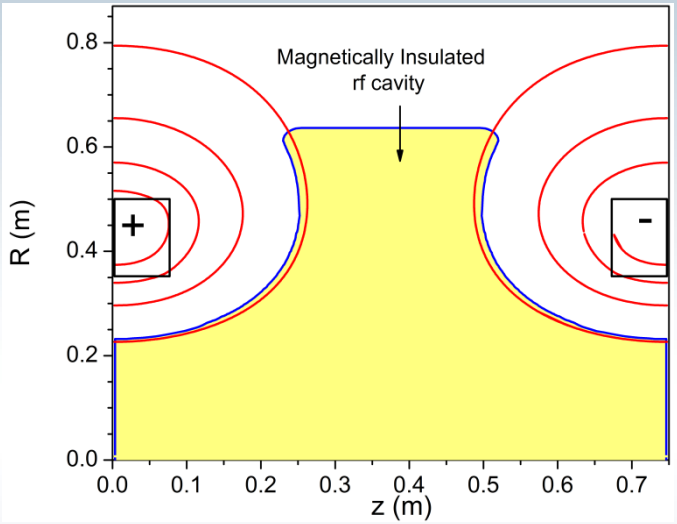
- At 20 MV/m, electrons can reach ~1 Mev on impact
- Focused to 50-100 μm spots when B>0.1 T
- This causes substantial amount of power delivered to very localized regions -> Heating-> Damage
- But, can we suppress the deleterious effects of FE?

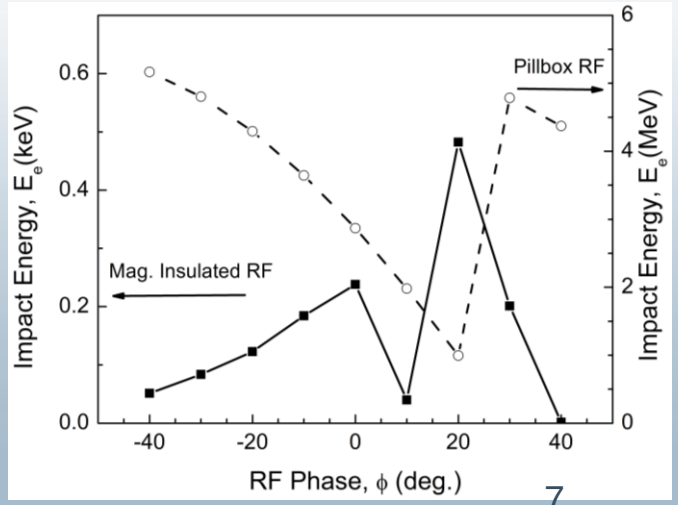
Scope of this work/ Outline

- 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

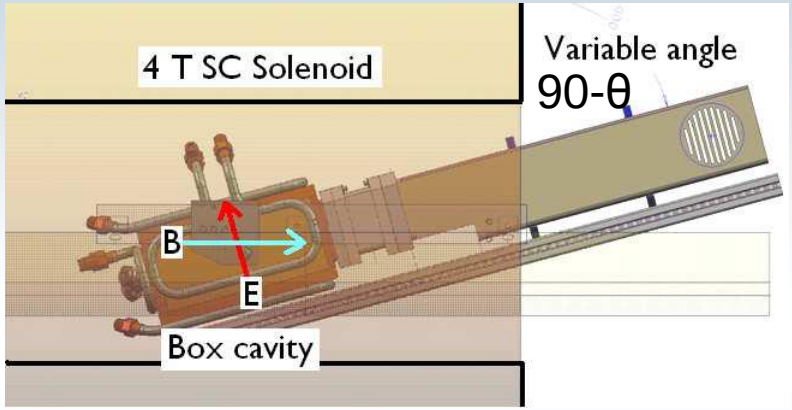
Possible solution: Magnetic insulation

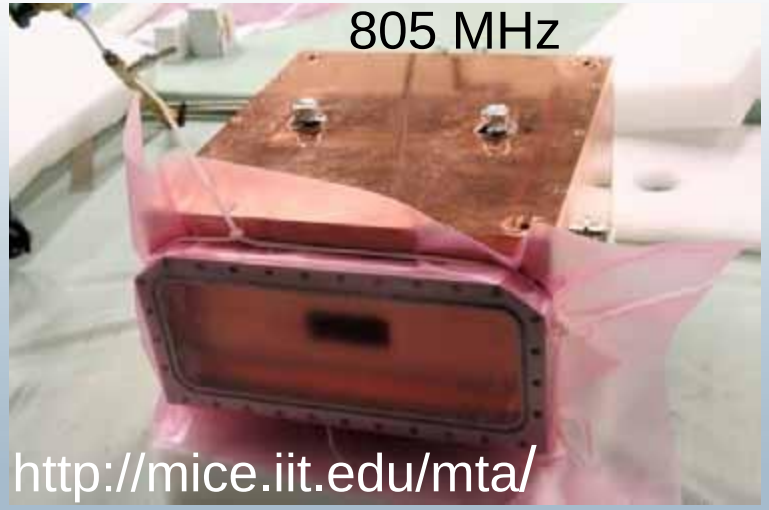
- Use of the concept for rf shielding was proposed by Bob Palmer (Palmer *et al.* PRST-AB 2009).
- Field-emitted electrons do not move far from surface but instead come back with low energies.
- The concept is been currently tested with a box cavity at FermiLab (**Poster: TUP289**)



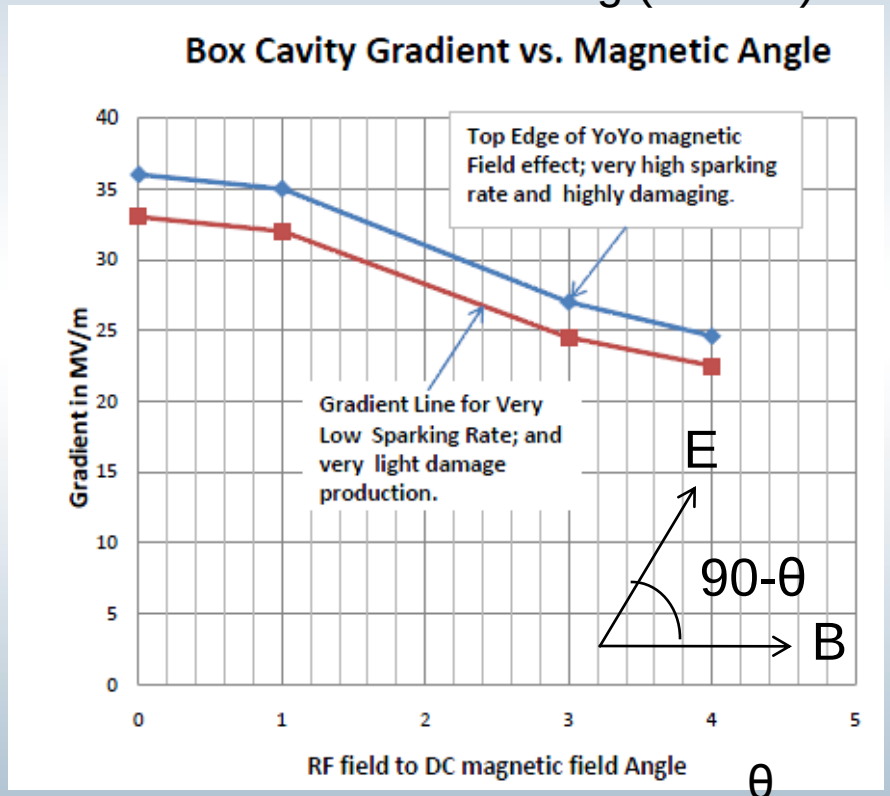


Experiment to test magnetic insulation (preliminary data)





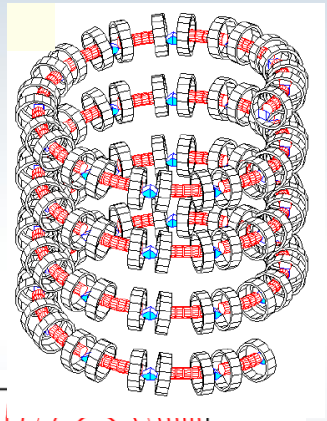
Moretti *et al.* MAP Meeting (7/2010)

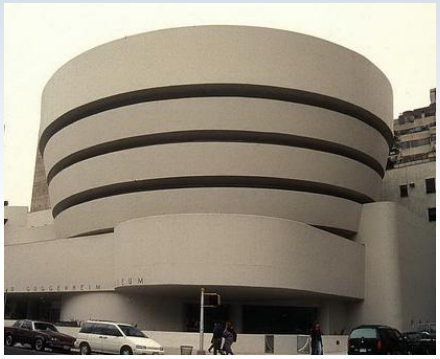


- When B, E are normal, the rf performs better

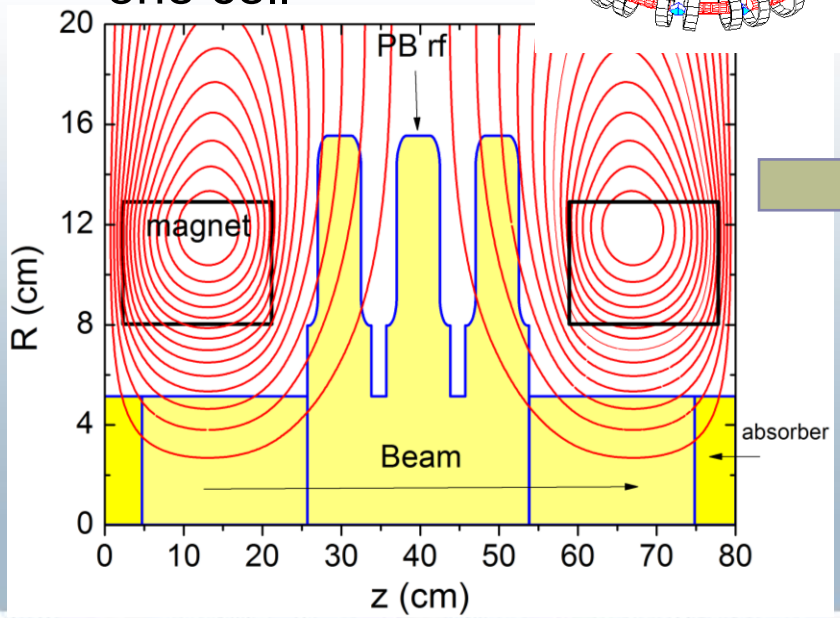
Application to a Muon Collider

- 6-D muon cooling channel with 805 MHz cavities





one cell



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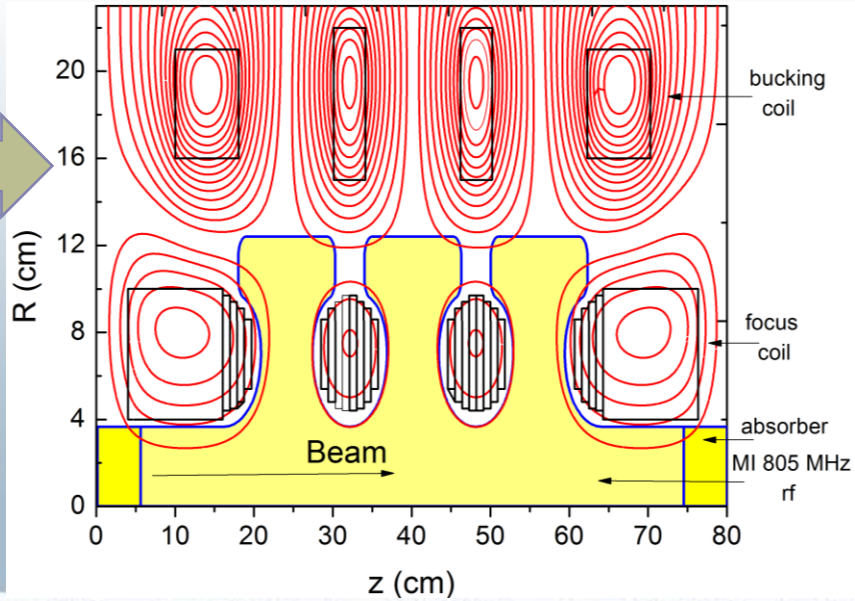
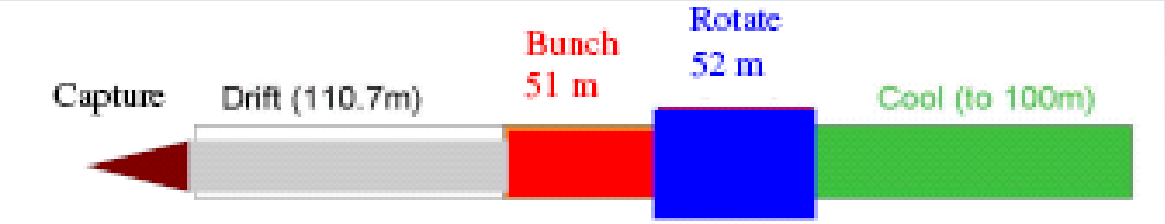
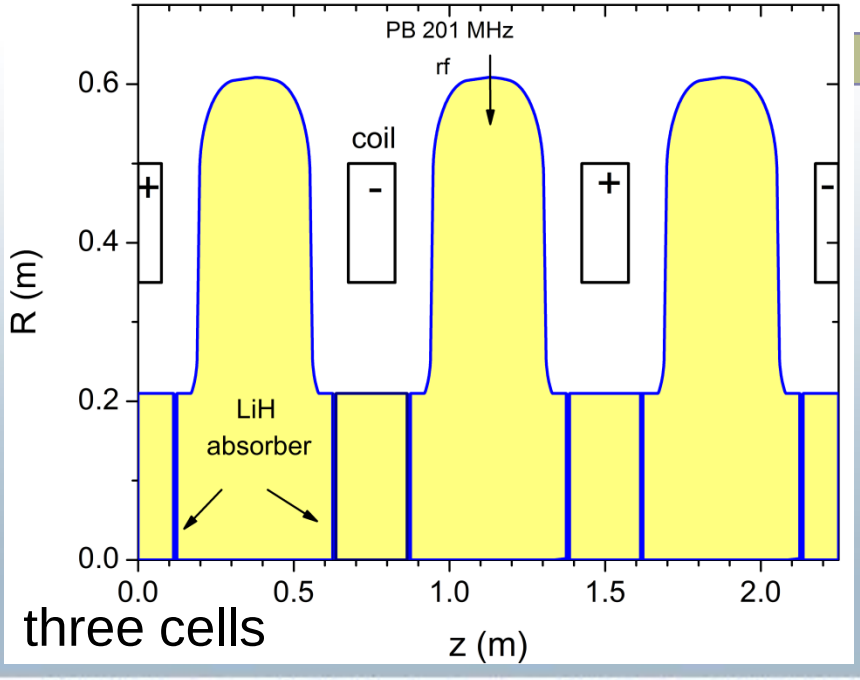
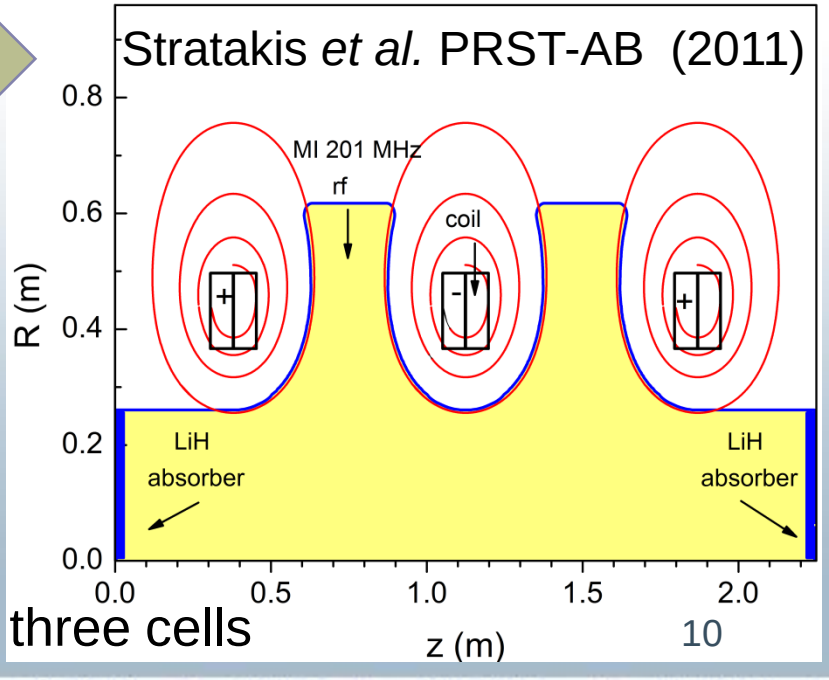


Application to a Neutrino Factory

- Muon capture front-end with 201 MHz cavities

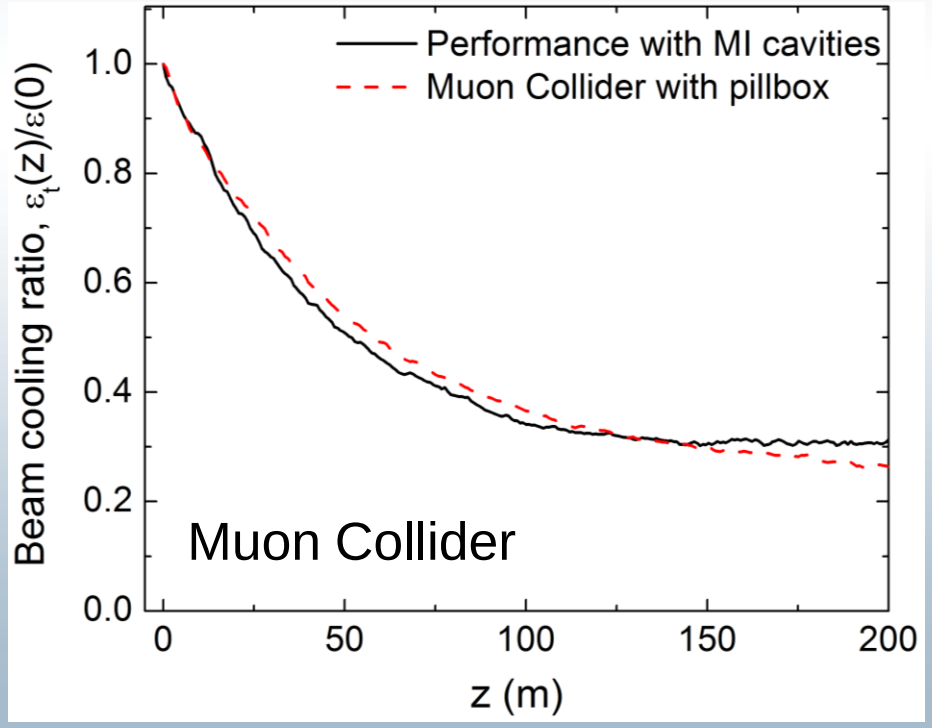


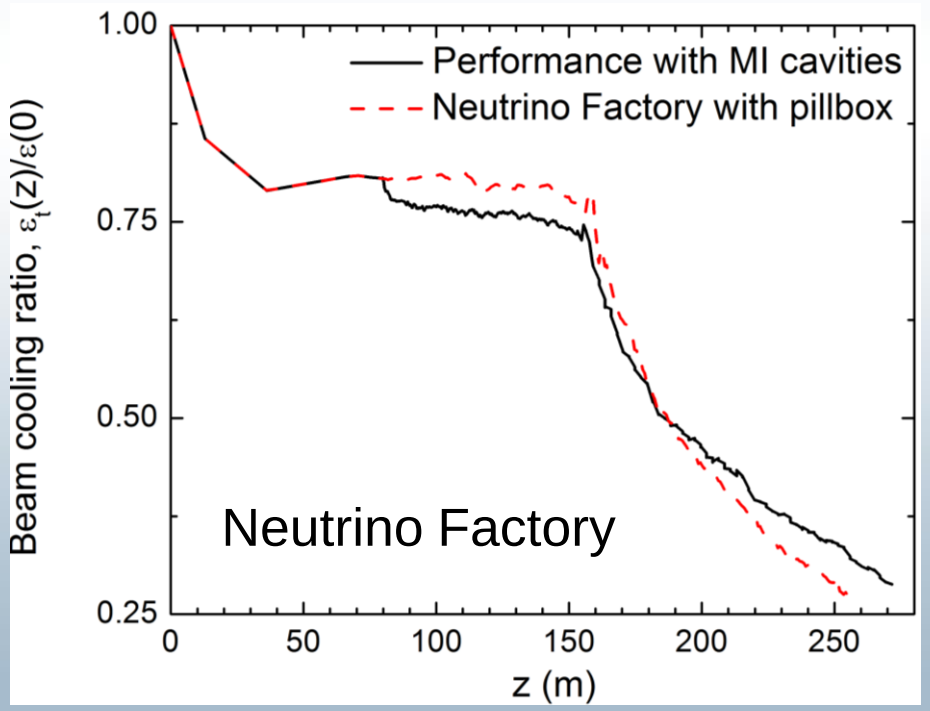




Magnetically insulated rf vs. pillbox rf

- 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.
- Multipactoring

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