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Cooling with magnetically insulated channel

Muon Collider Design Workshop, BNL
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Motivation

- The requirement
  - A muon collider needs the beam emittance to be reduced by a factor of 10^6
- The challenge
  - Muons decay fast
  - One possibility: Ionization cooling

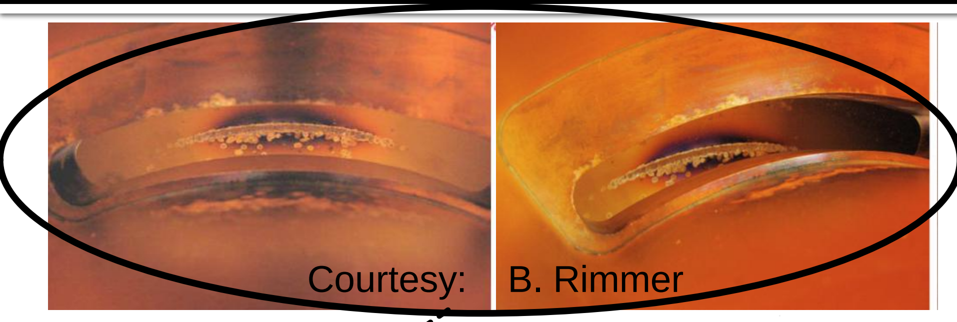
Approach

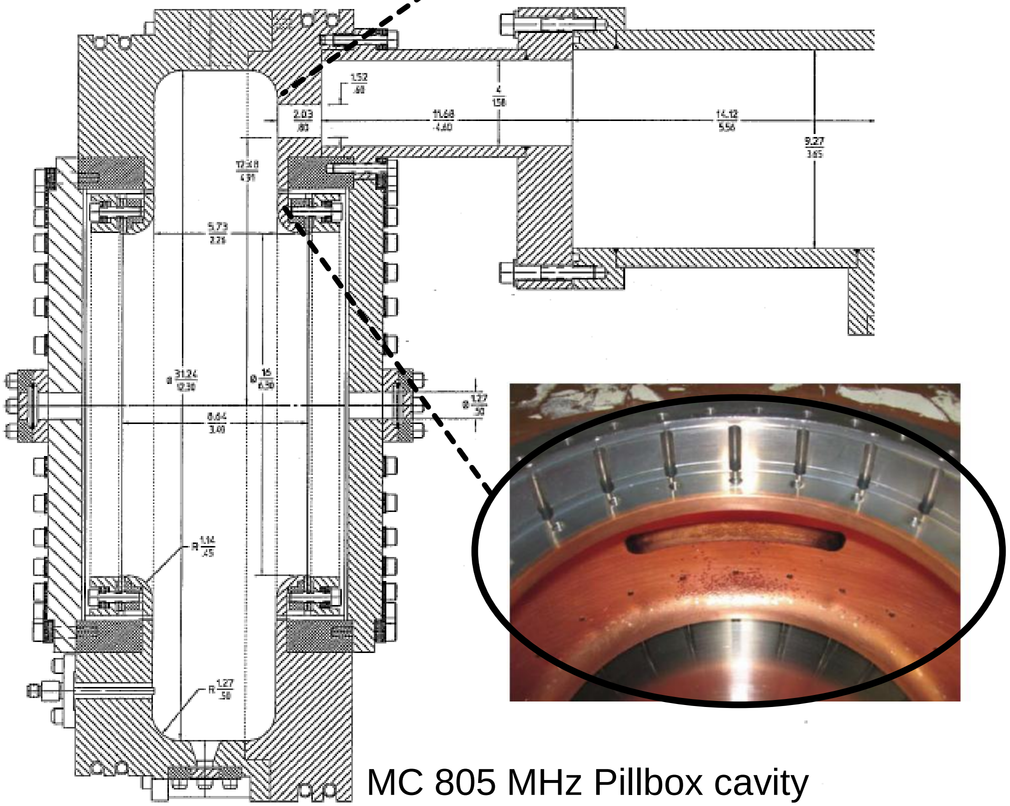
- Ionization cooling requires rf cavities to operate within magnetic fields
- Experiments indicate operational problems when rf cavities are within magnetic fields
- Magnetic insulation can be a solution but has been never tried to rf cavities before
- This study, demonstrates the use of magnetic insulated cavities in cooling lattices

Outline

- Introduction/ Previous work
- Magnetic insulation
- Cooling with magnetic insulation
- Future work
- Conclusion

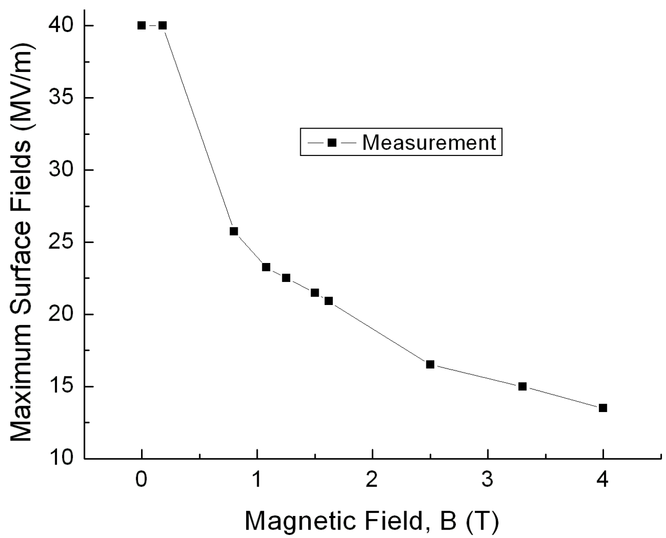
Observed Problems in RF Cavities in a Magnetic Field





MC 805 MHz Pillbox cavity

- When ext. mag. fields exist:
  - Dark currents
  - Surface damage
  - Spread of Cu dust
  - 60% reduction of accel. gradient



Norem et al. PRST-AB (2003)
Moretti et al. PRST - AB (2005)

Breakdown Model Description

Field-Emission from asperities

↓

Electron focusing by the B-field

↓

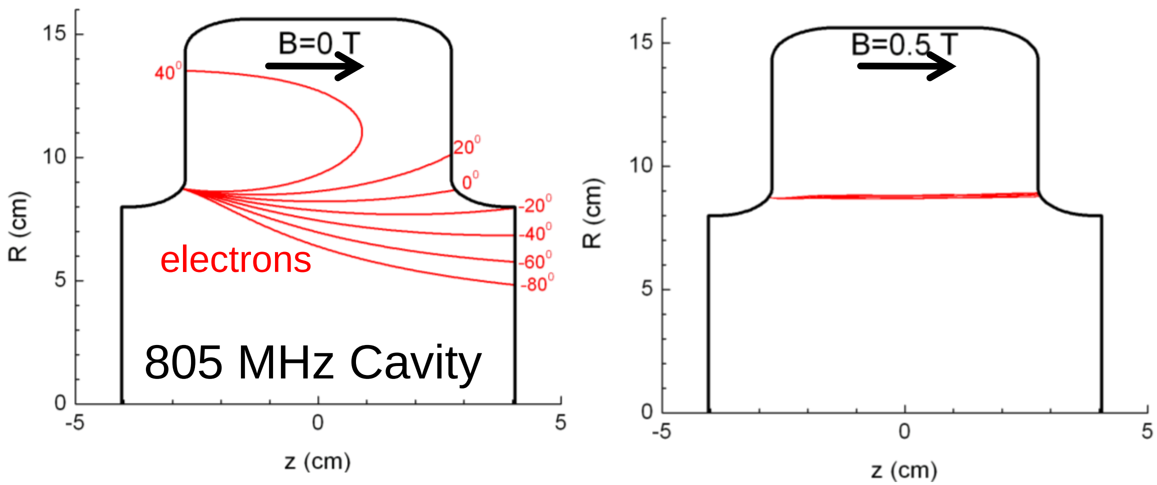
Electron impact on the wall

↓

Damage

↓

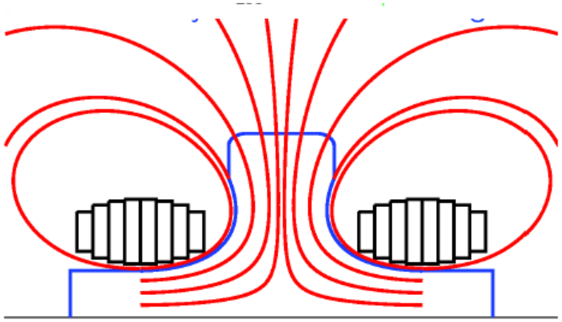
Breakdown



Details: Palmer and Stratakis Nufact09 Presentations

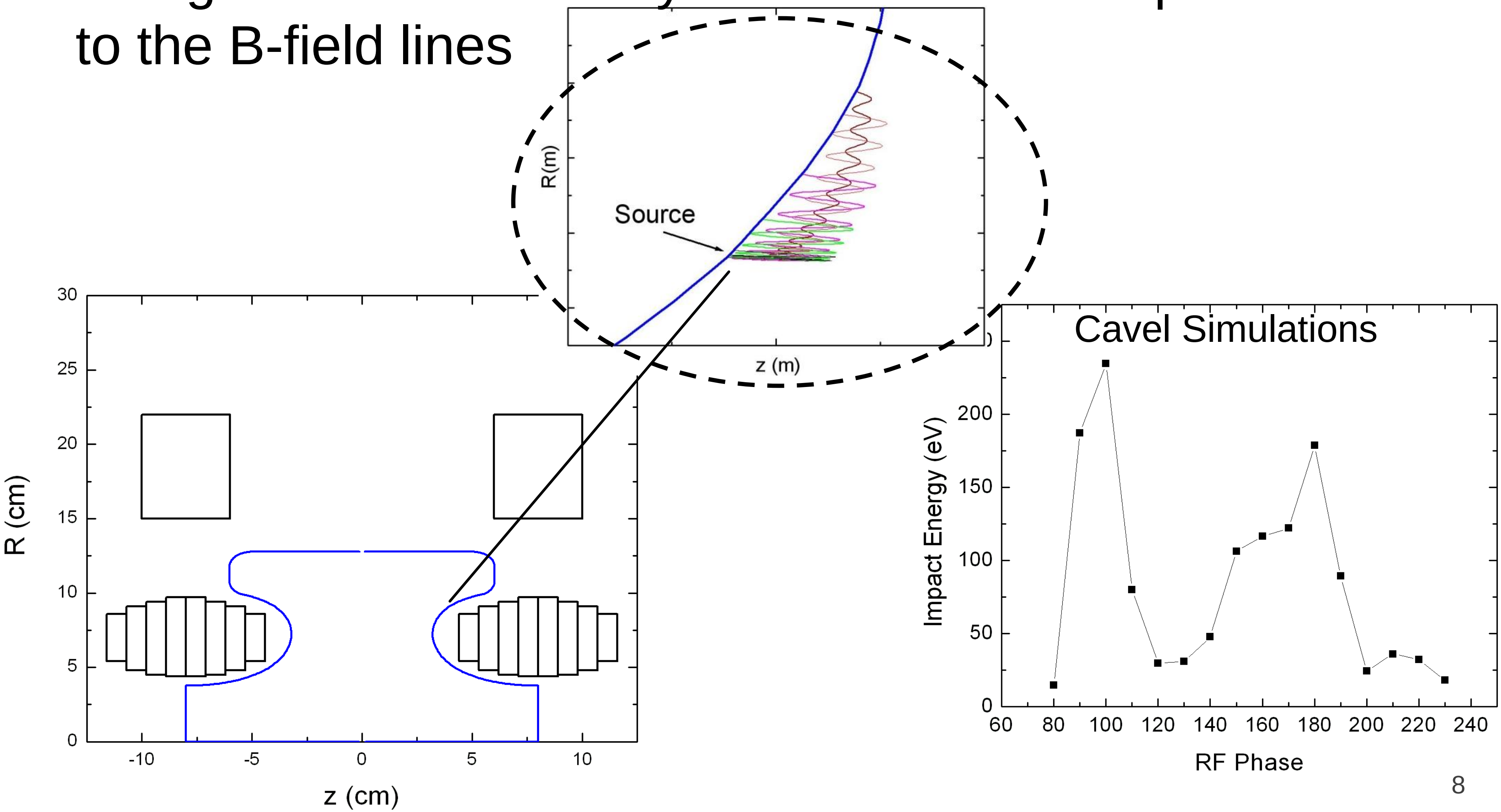
Concept of Magnetic Insulation

- Magnetic insulation is used for high pulsed voltage applications (Winterberg Rev. Sci. Instrum. 1970)
- Use of the concept for rf shielding was proposed by B. Palmer (Palmer et el. PRST AB 2009).
- When $B \perp E_{RF}$ emitted electrons do not move far from surface but instead come back with low energies.

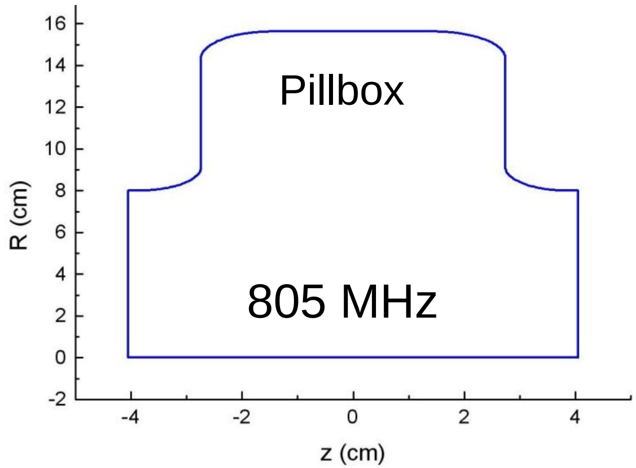


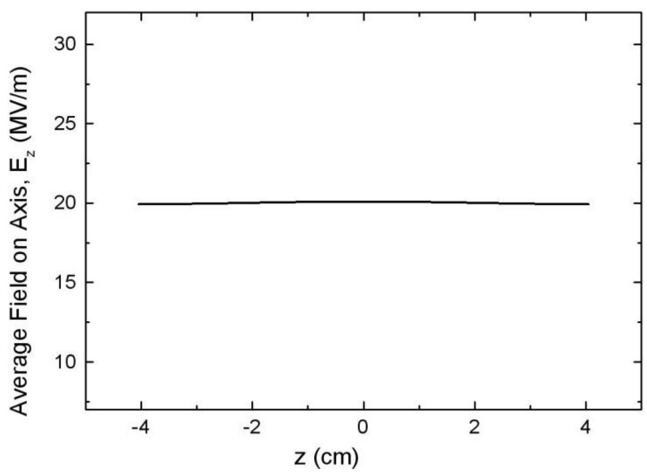
Field Emission in Magnetic Insulated rf cavities

- Design a 805 MHz cavity were its surface is parallel to the B-field lines

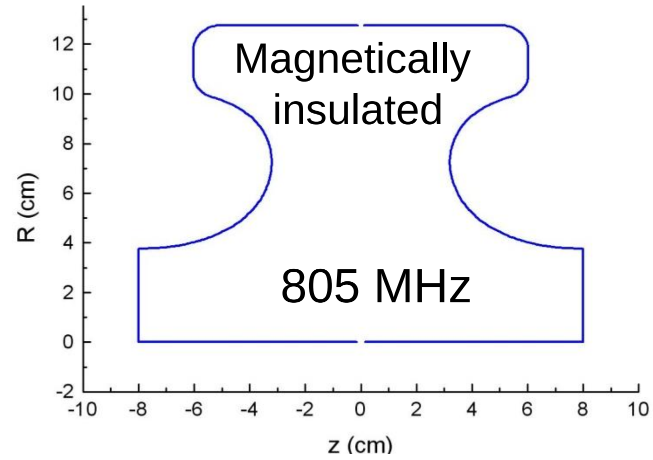


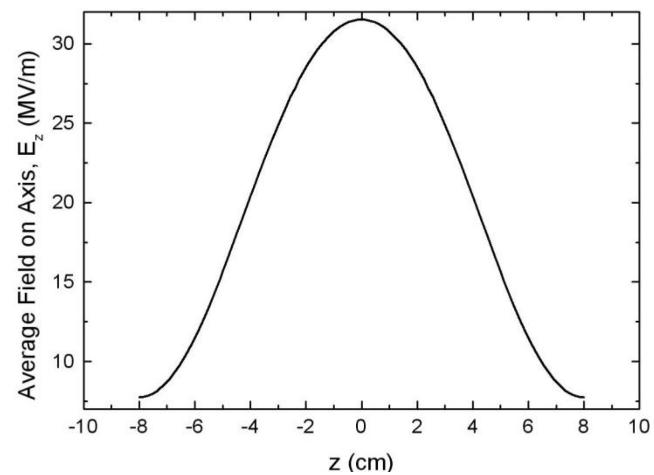
Magnetic insulated vs. pillbox





Peak-to-average ratio Emax/E0 = 1.06
Power=0.76 MW (for 20 MV/m)

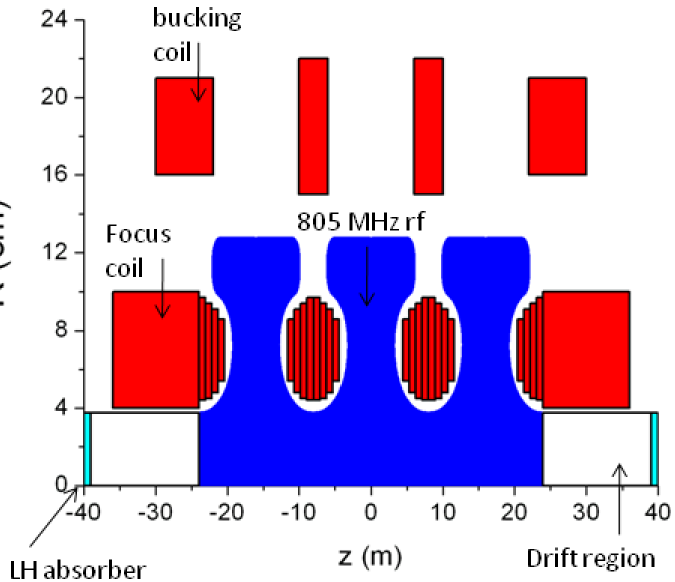




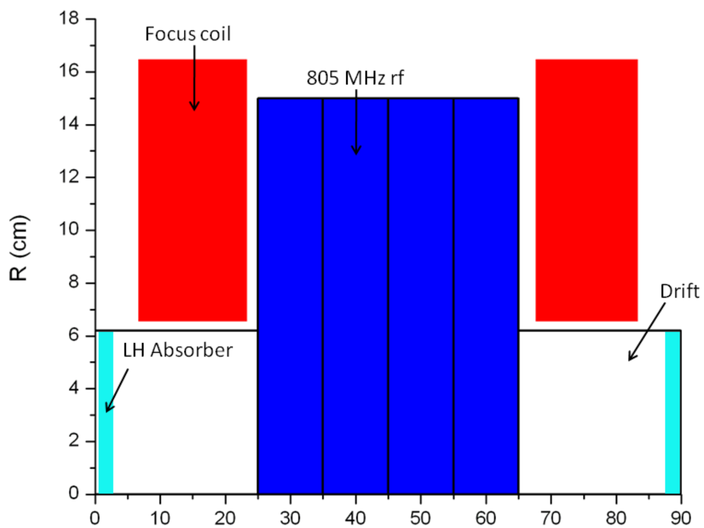
Peak-to-average ratio Emax/E0 = 2.39
Power=3.0 MW (for 20 MV/m)

Cooling Lattice Cell (1)

Magnetic Insulated (MI)

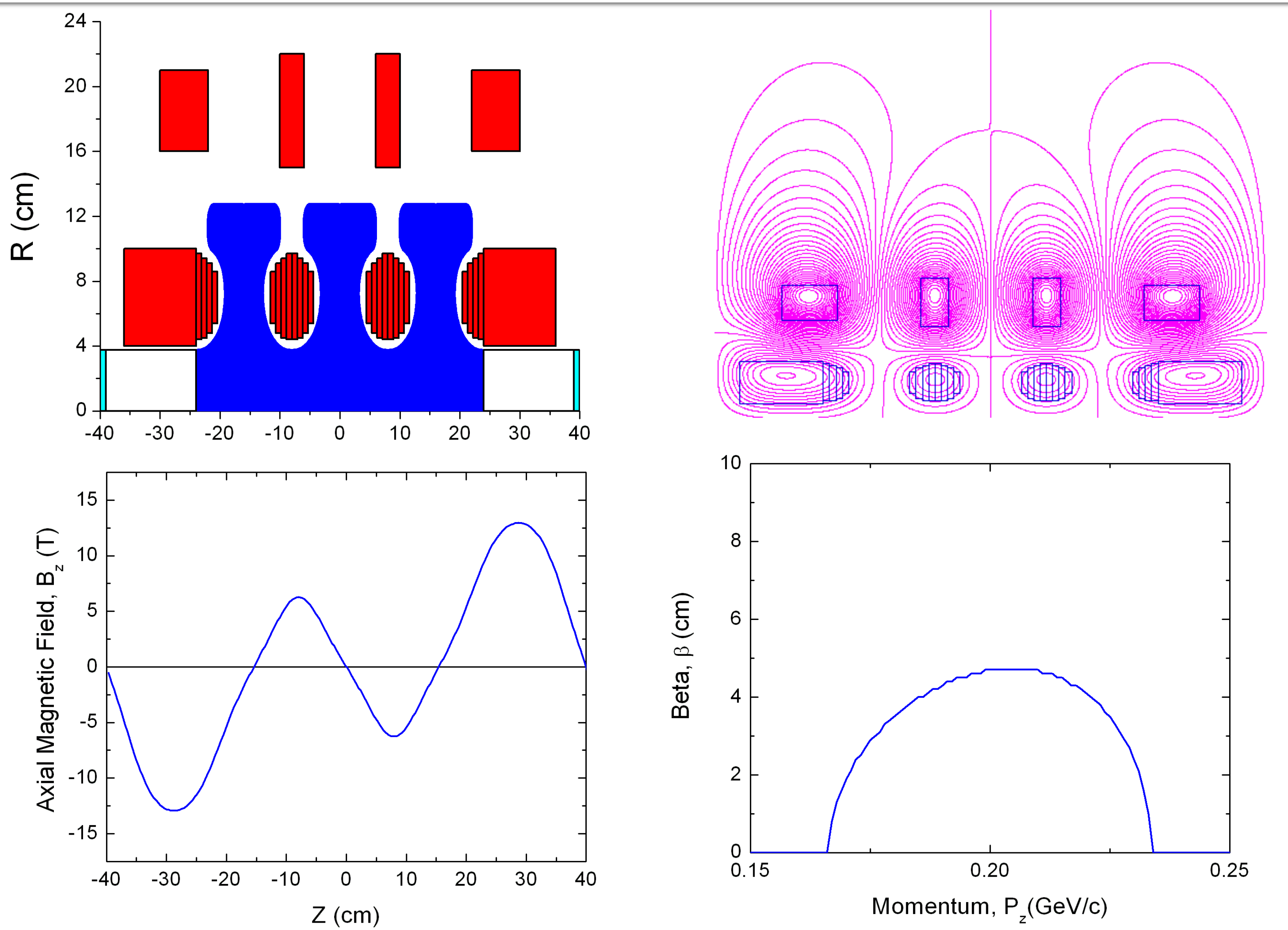


Pillbox Cavities (OLD)

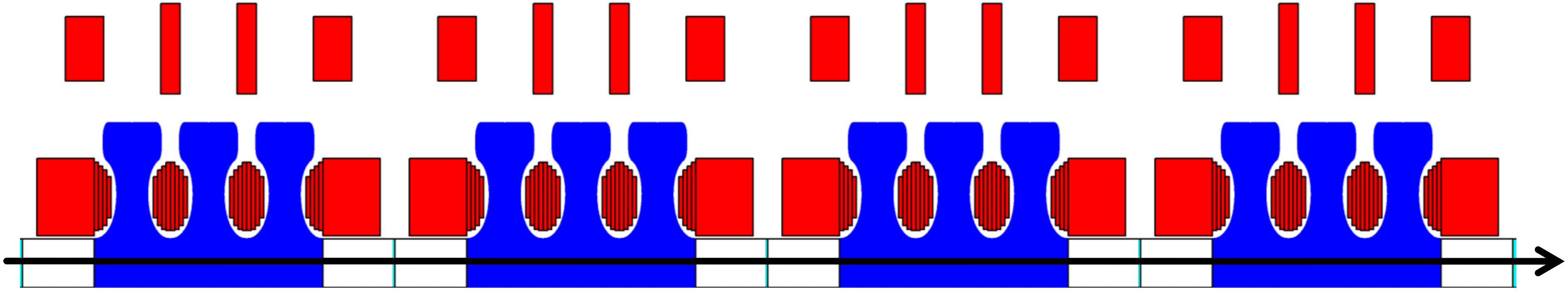


	MI	Old
Period	80 cm	90 cm
RF frequency	805 MHz	805 MHz
RF gradient	20 MV/m	20 MV/m
Maximum axial field	13.0 T	10.6 T
Central momentum	0.199 GeV/c	0.195 GeV/c
Beta minimum at central momentum	4.6 cm	5.4 cm
Width of passband	0.068 GeV/c	0.060 GeV/c
RF phase	30 deg.	30 deg.

Cooling Lattice Cell (2)

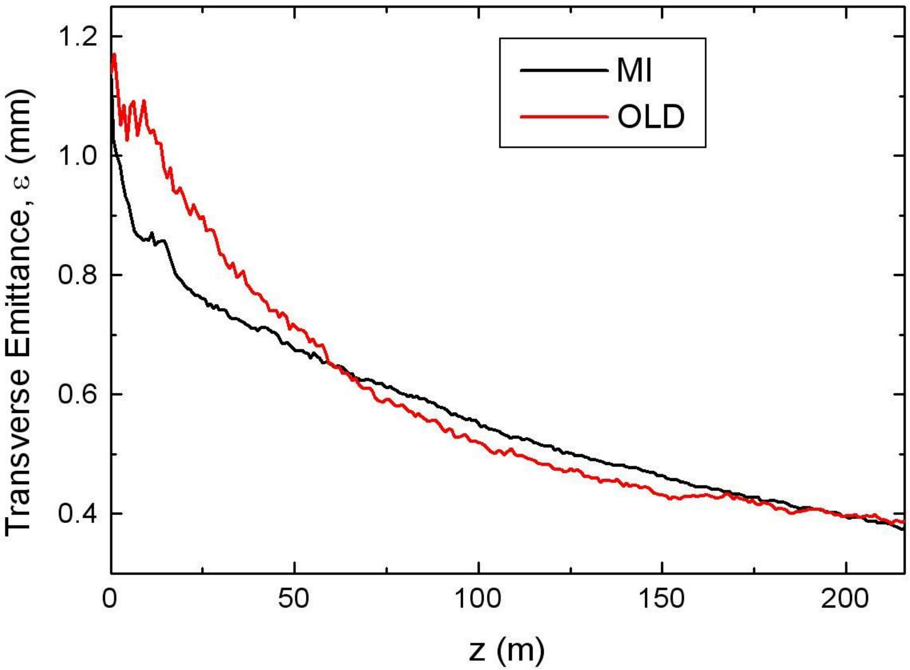


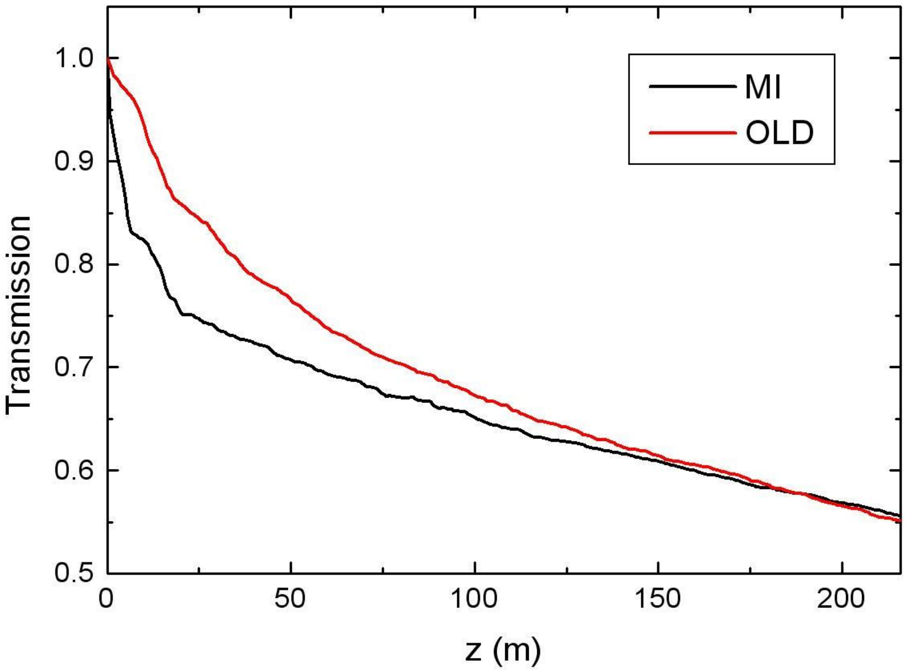
Simulation Details



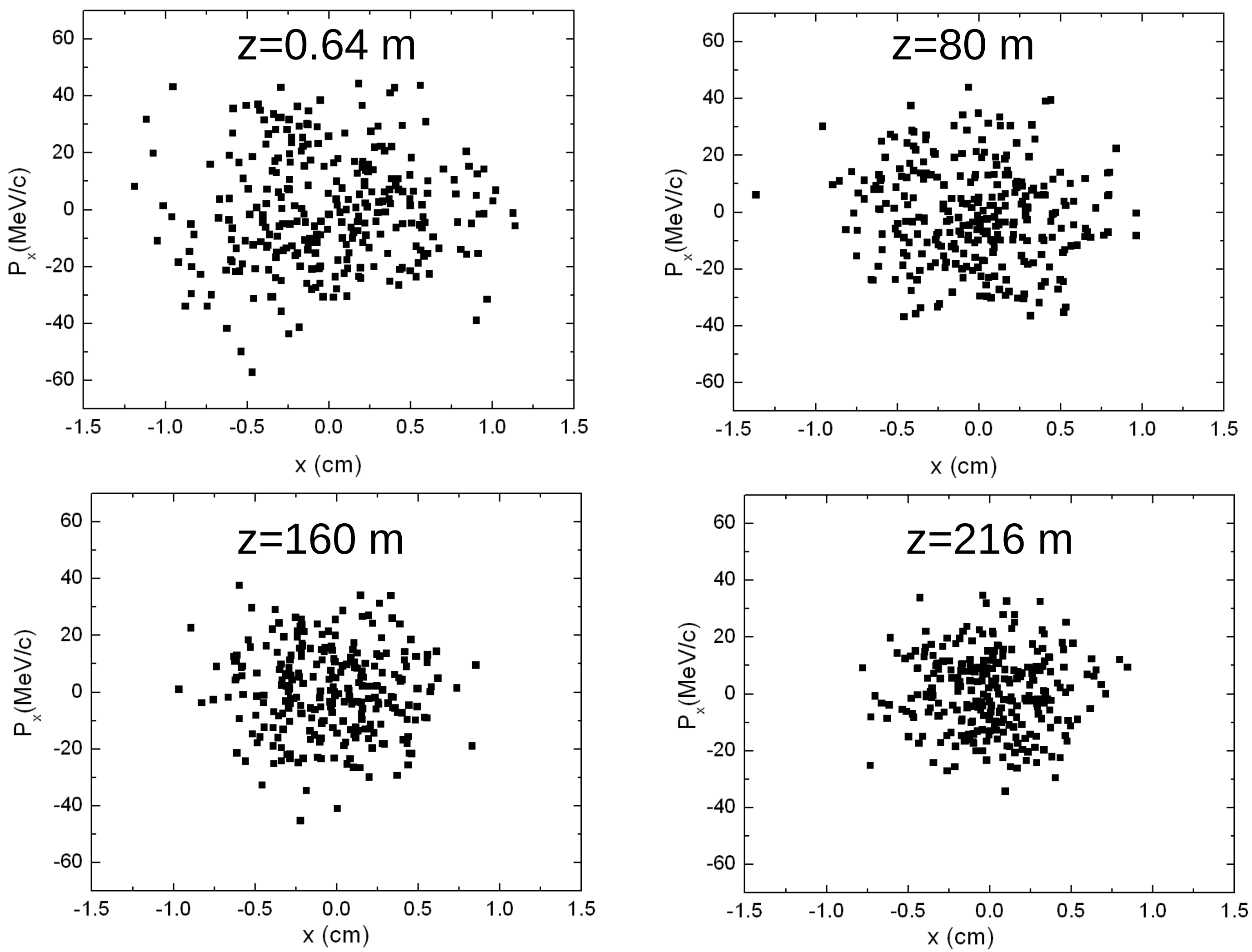
- Simulation details:
  - Linear channel
  - Only transverse cooling
  - Use real shape of insulated cavities
  - 270 cells=216 m
  - We use ICOOL version 3.22

Cooling with MI Cavities





Cooling with MI Cavities



Future work

- There are plenty things to do:
- Simulate a realistic RFOFO ring
- Include longitudinal cooling
- Systematic study of transmission increase
- Refine cavity shape

Summary

- I was demonstrated numerically that cooling with magnetic insulated cavities is feasible
- Transmission is comparable to that of a RFOFO
- Work is in progress and more results will be presented later