Future Cooling Experiments

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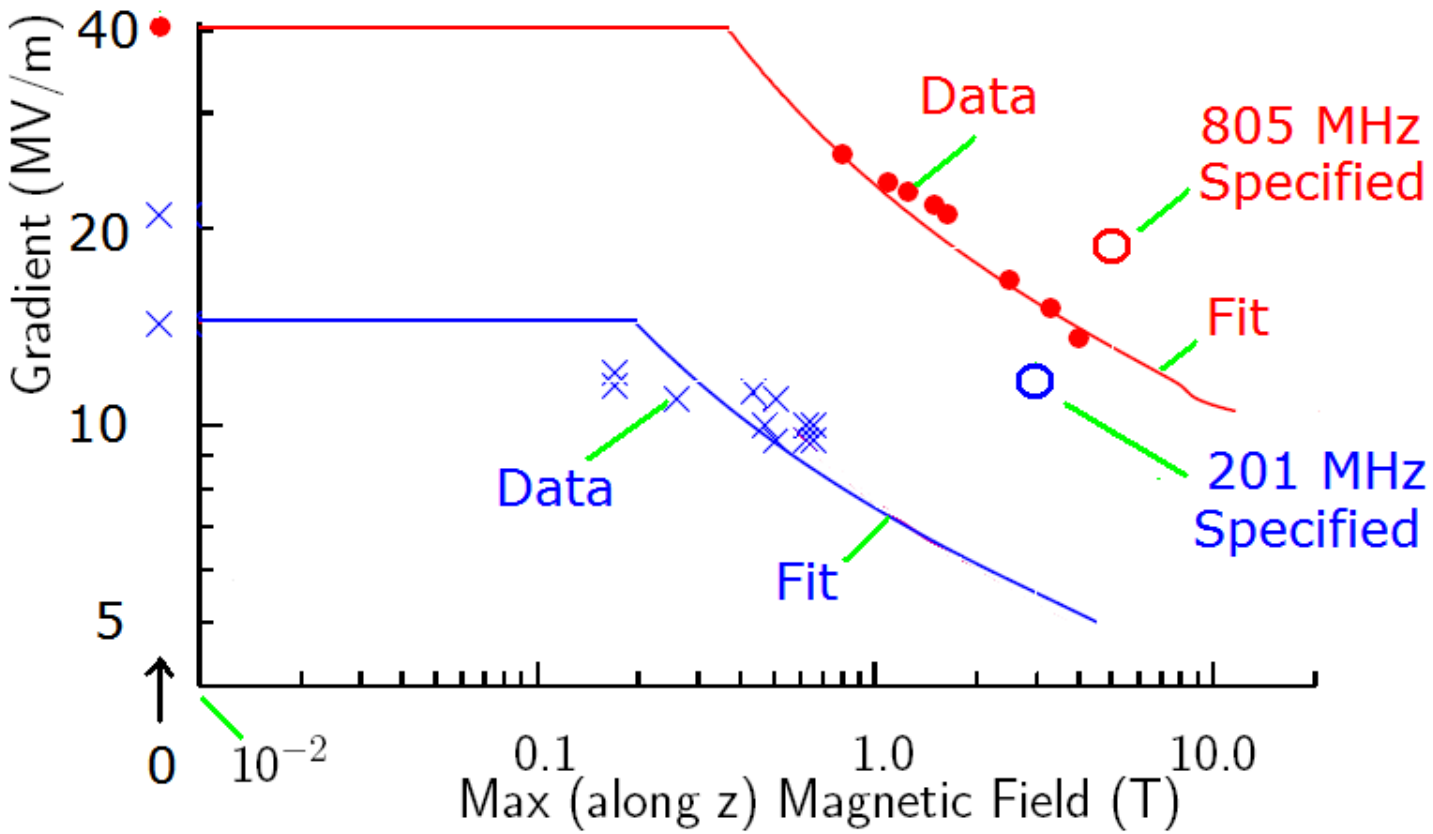
Collab Mtg LBNL

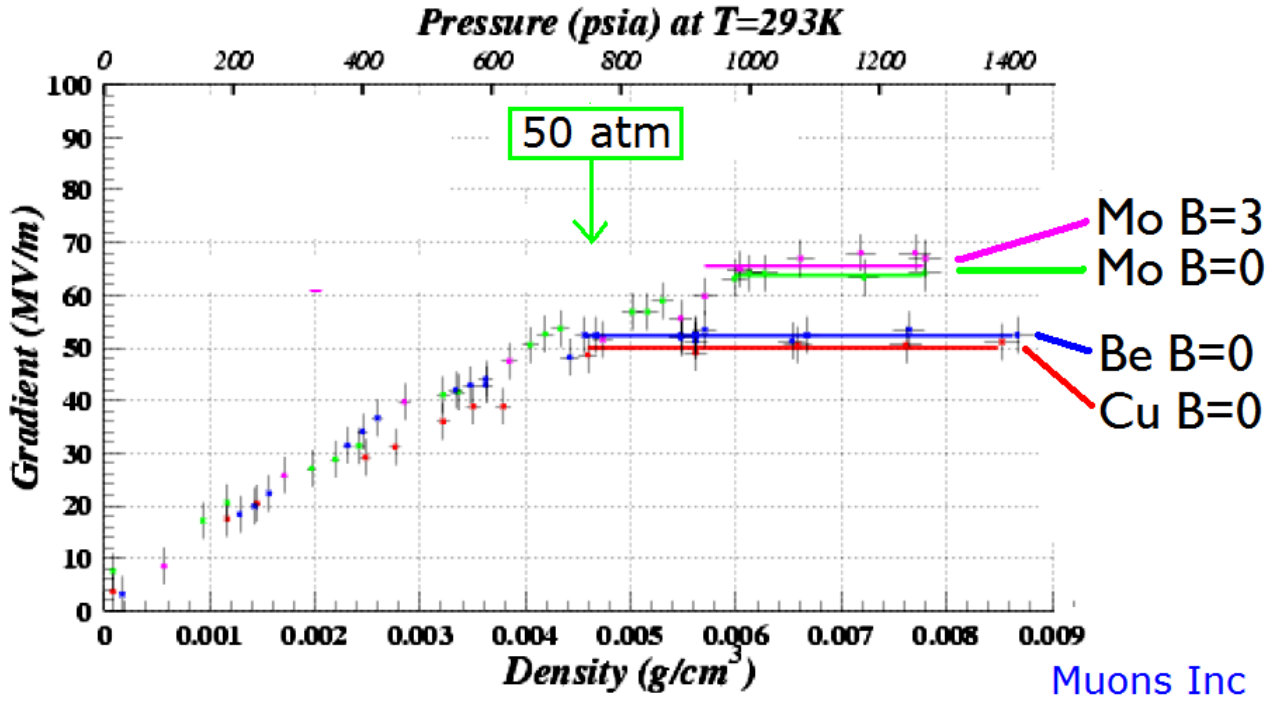
- Cavity damage with magnetic fields
- Possible MICE safety concern
- Alternative lattice to avoid above
- Magnetic insulation
- Future 6D cooling experiments with magnetic insulation
  - 201 MHz Mag Ins 6D Demo
  - Low emittance 6D cooling experiment
- Conclusion

BREAKDOWN WITH MAGNETIC FIELDS



- Breakdowns without field condition gradient higher
- Breakdowns with field progressively reduce achievable gradient and cause visible damage

HIGH PRESSURE GAS INSULATION (Muons Inc)

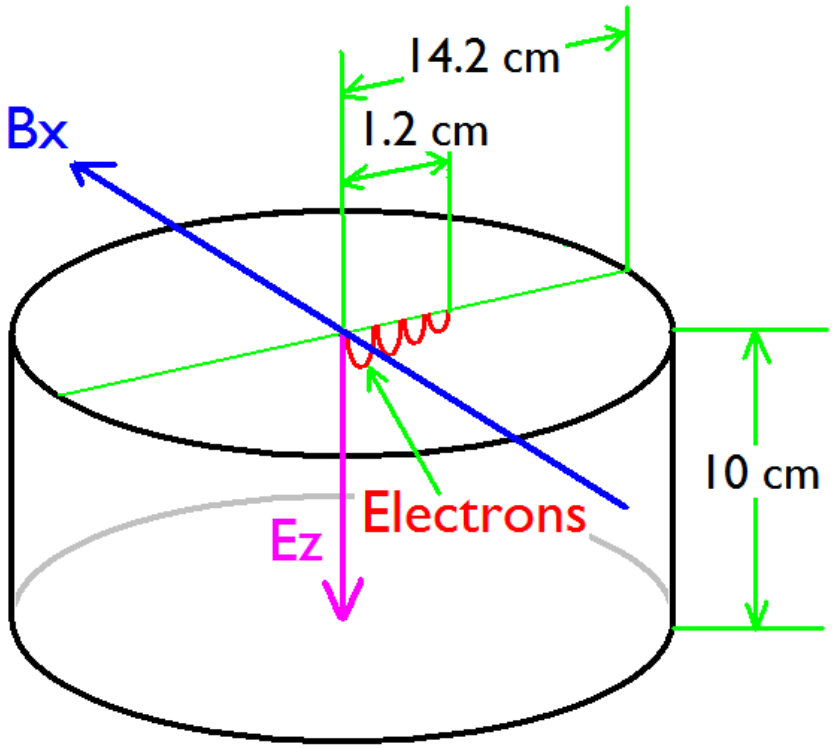


- No magnetic field effect
- Pressure $\geq$ 50 atm at room temp (12 atm at 70 deg)
- Max grad $\approx$ 50 MV/m at 805 MHz
- Probably $\approx$ 25 MV/m at 201 MHz

- Need frequency dependence
- Need volume dependence

MAGNETIC INSULATION

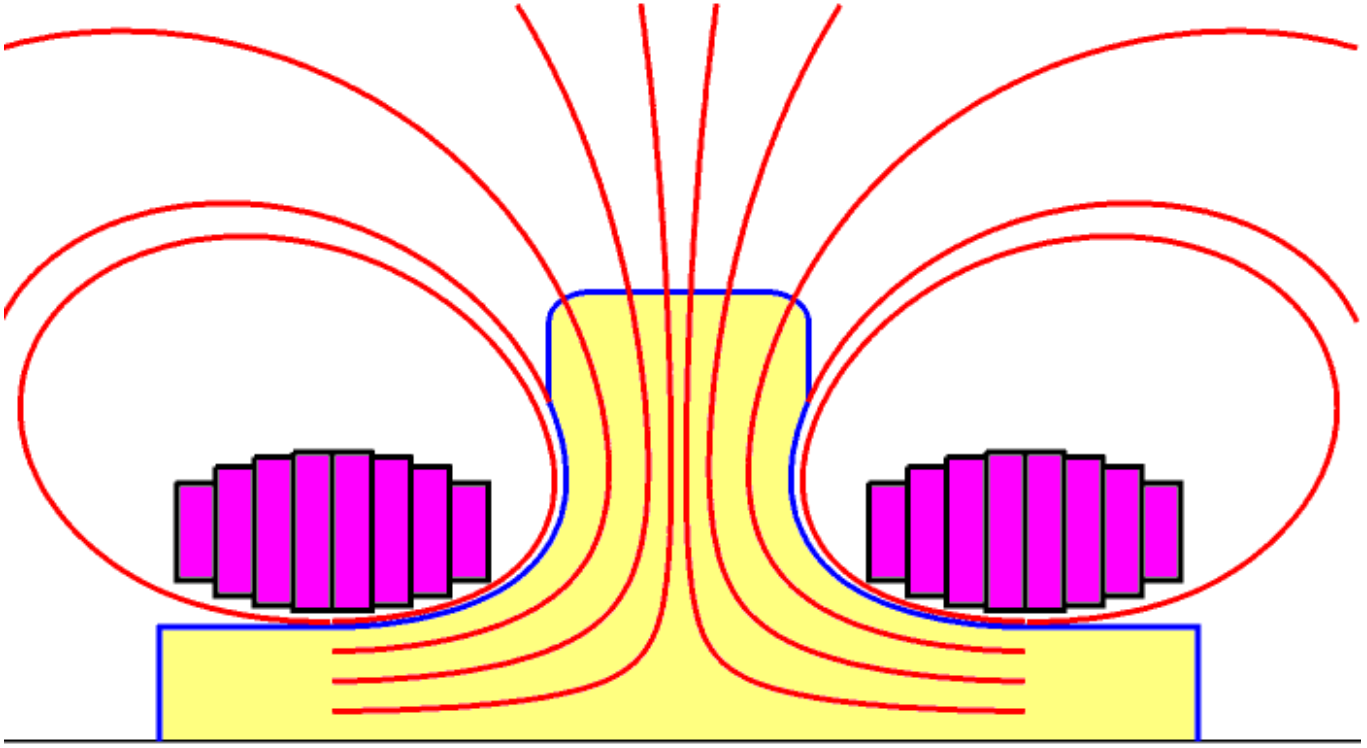
CAVEL Fernow simulation of simple 805 MHz pill-box



- Electrons are returned to surface by B
- Return energies very low
- No damage, no X-Rays, suppressed breakdown
- Multipactor ? Grateful to SLAC for help

Application to rf cavities

Form cavity surface to follow magnetic field lines



FUTURE COOLING EXPERIMENTS

A future experiment should address the known challenges:

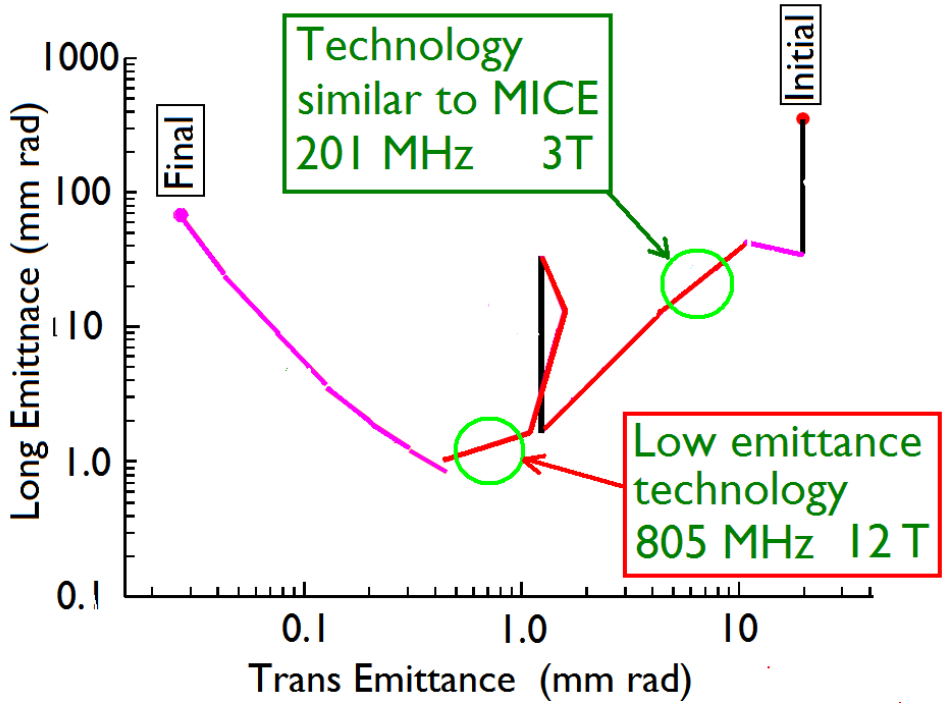
- Integration of RF in a channel with the required focusing.
- Integration of emittance exchange.
- High pressure hydrogen gas with windows and safety considerations or a wedge absorber of the specified material

Possibles:

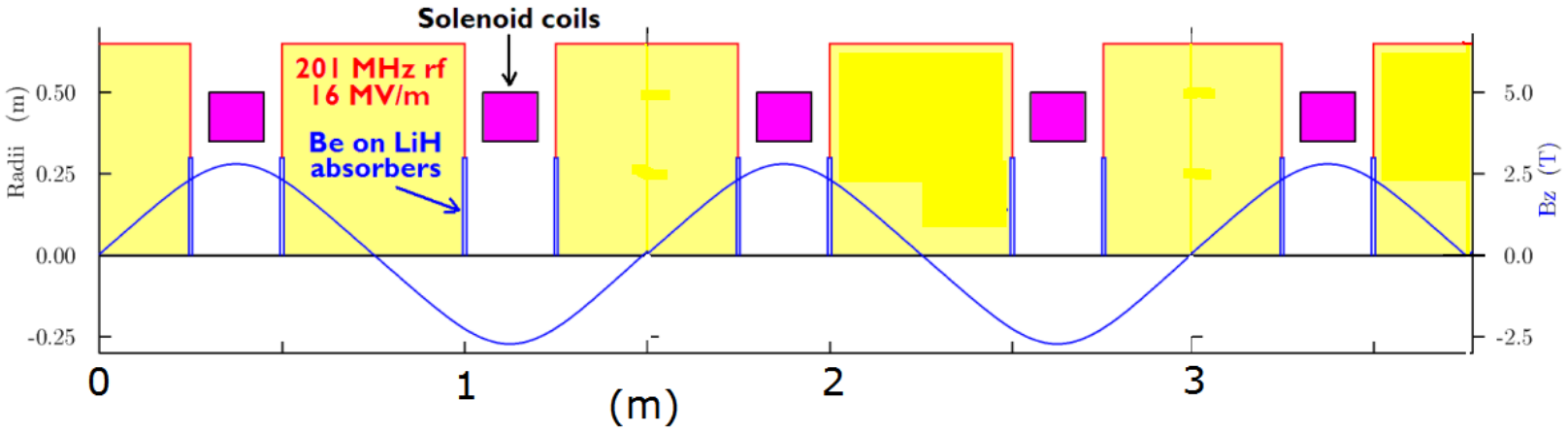
1. Magnetic Insulation at 201 MHz & 3T

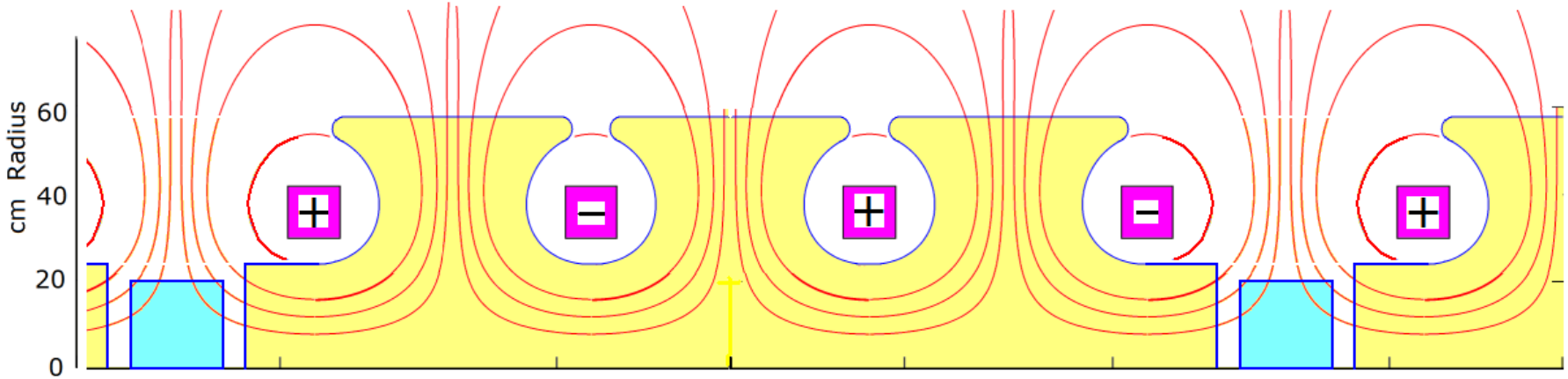
2. Magnetic Insulation at 805 MHz & 12 T
   - Explores a new regime of emittances
   - Is more compact and possibly cheaper

3. High pressure gas HCC at 201 MHz $\approx$ 6 T
   - Short section of HCC (eg 180 deg)
   - With rf
   - With hydrogen and windows



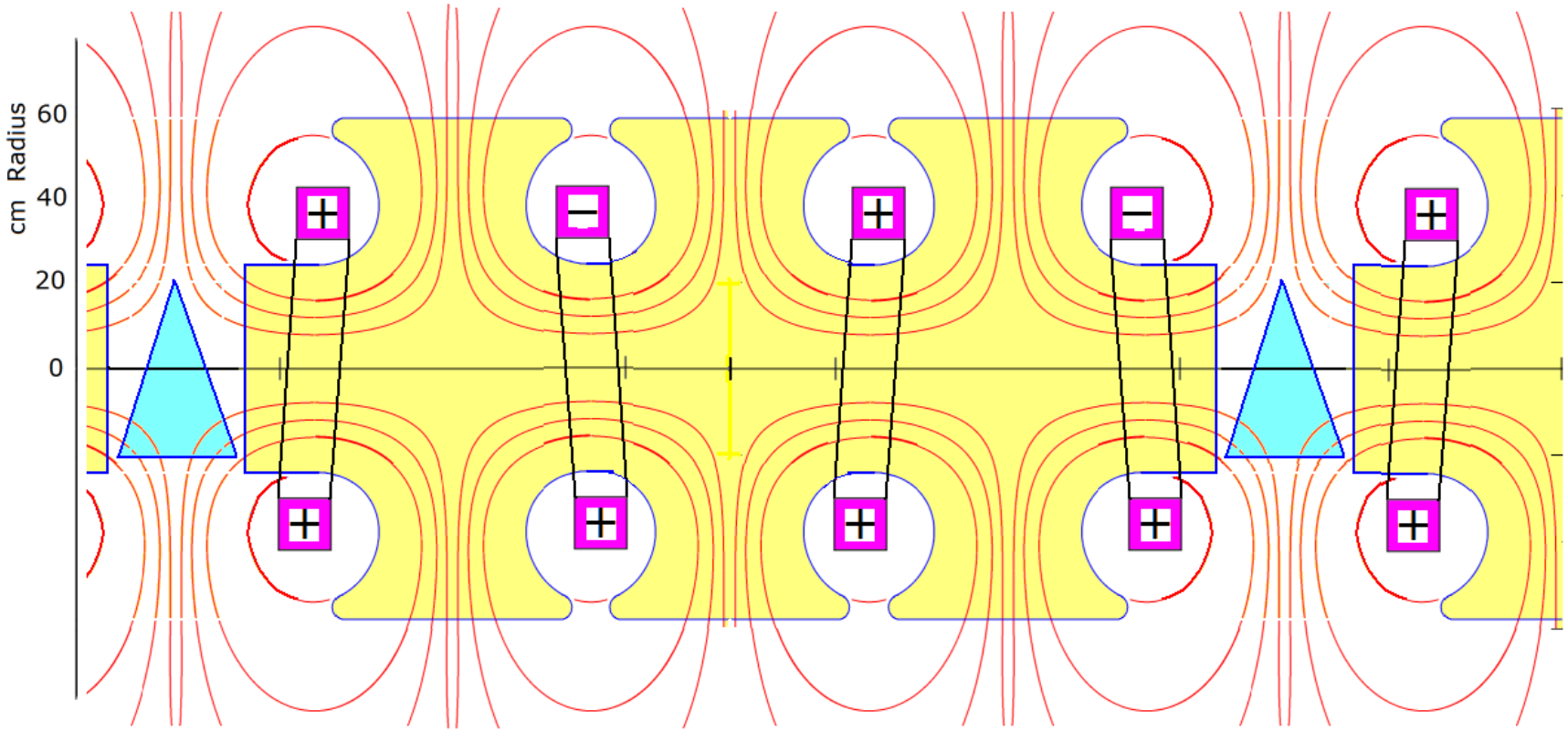
1a) Mag insulated Pre-cooling Lattice





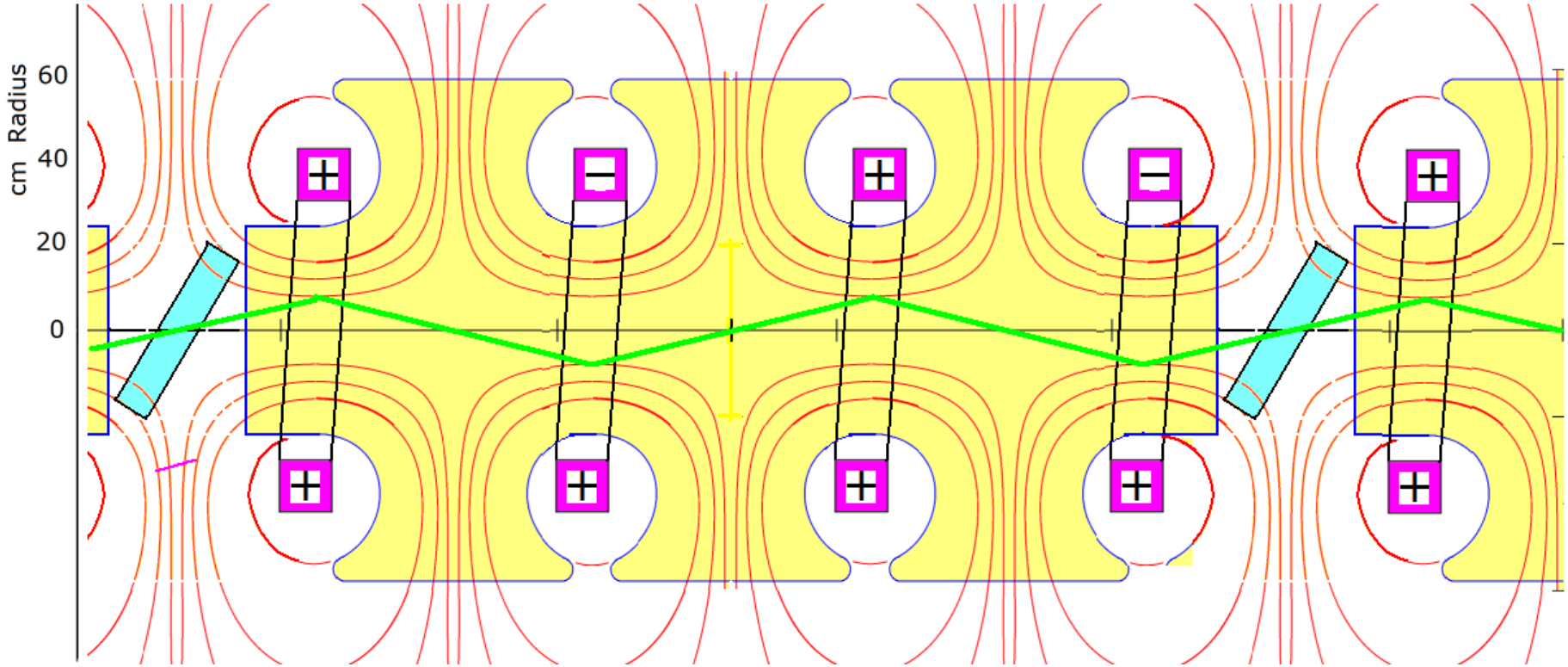
- Fields on axis are identical
- So losses expected to be the same
- Demonstrates Transverse cooling with specified gradients
- Also demonstrates technology for Phase Rotation

1b) Mag Insulated 6D Pre-cooling Lattice



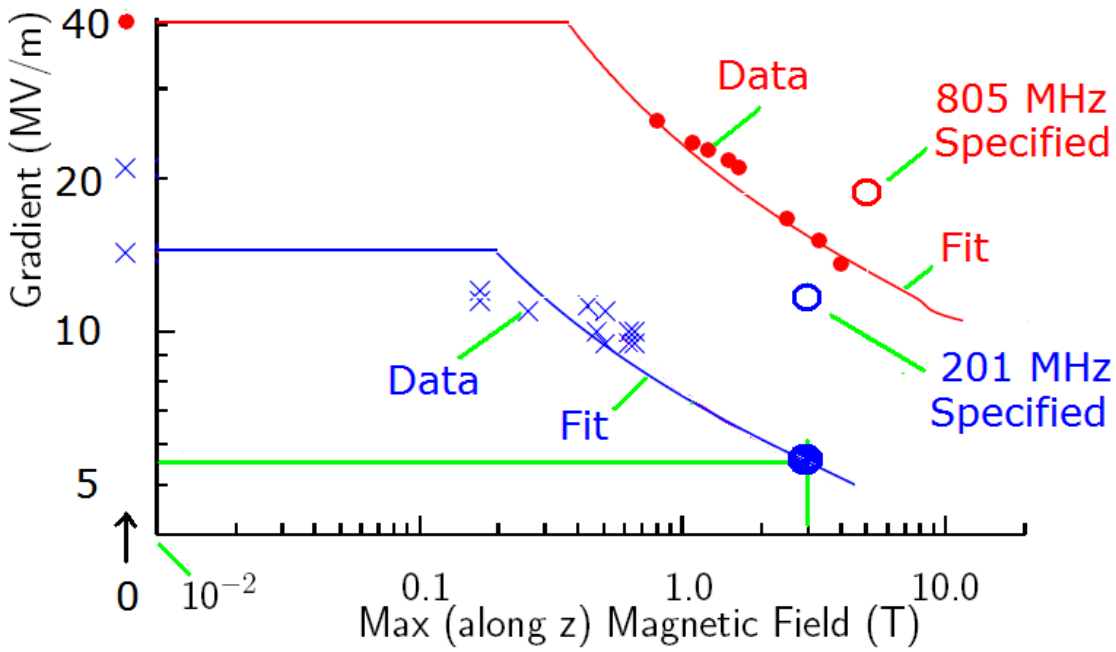
- Alternating tilts of 2-3 deg
- Question if mag insulation still ok ???
- Generates approx 0.125 T transverse field
- Gives dispersion and bend for Guggenheim

1c) Mag Insulated 6D Snake Lattice



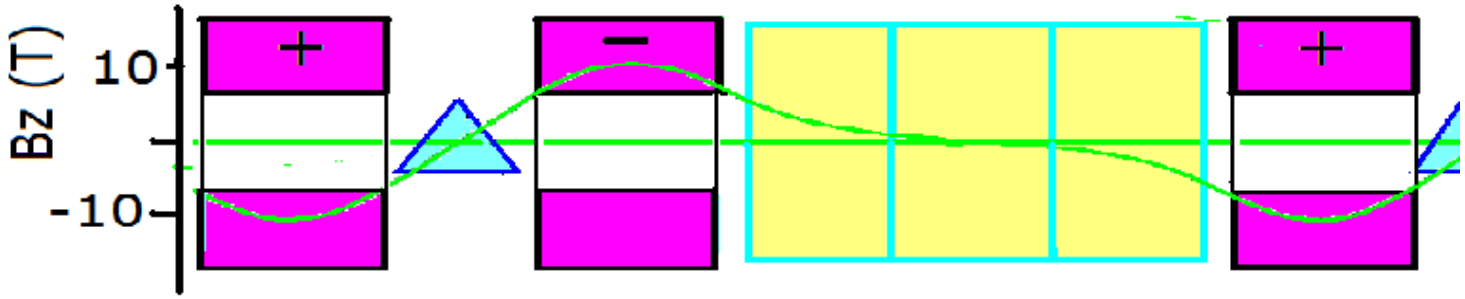
- Fixed tilts of 2-3 deg
- Generates approx 0.125 T alternating field
- Gives bending to form Snake
- Generates angular dispersion
- Emittance exchange with tilted plate

Summary of Exp 1

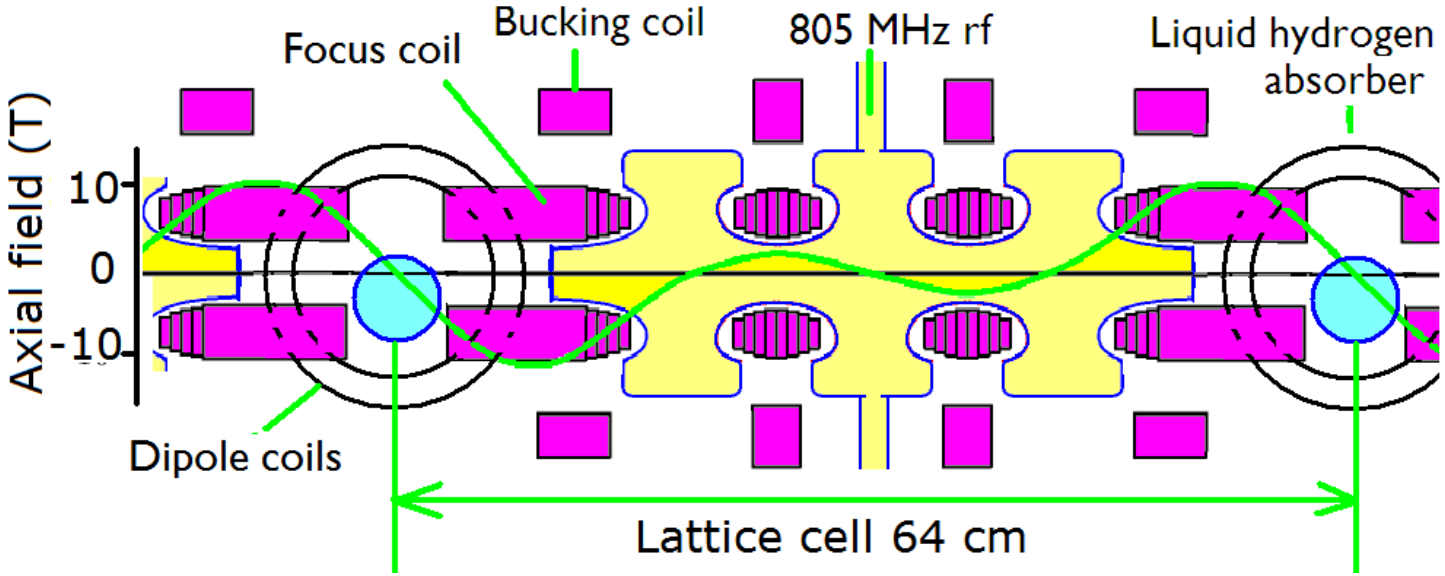


- MICE may well achieve maximum gradients of $\approx$ 5.5 MV/m compared with Study 2 specification of $\approx$ 12 MV/m
- Not showing a solution to this problem is uncomfortable
- Exp 1a) should address this concern
- Exp 1b) demonstrates 6D cooling with LiH wedges
- Exp 1c) demonstrates 6D cooling with LiH angled slabs

2) Guggenheim at 805 MHz and 12 T
Lattice as simulated in 2006



Magnetically insulated version



Summary of option 2

- Demonstrates 6D cooling with acceleration
- Establishes cooling in a new regime of emittances
- Challenges for Detectors: Measure 400 pi mm mrad to 0.5 %

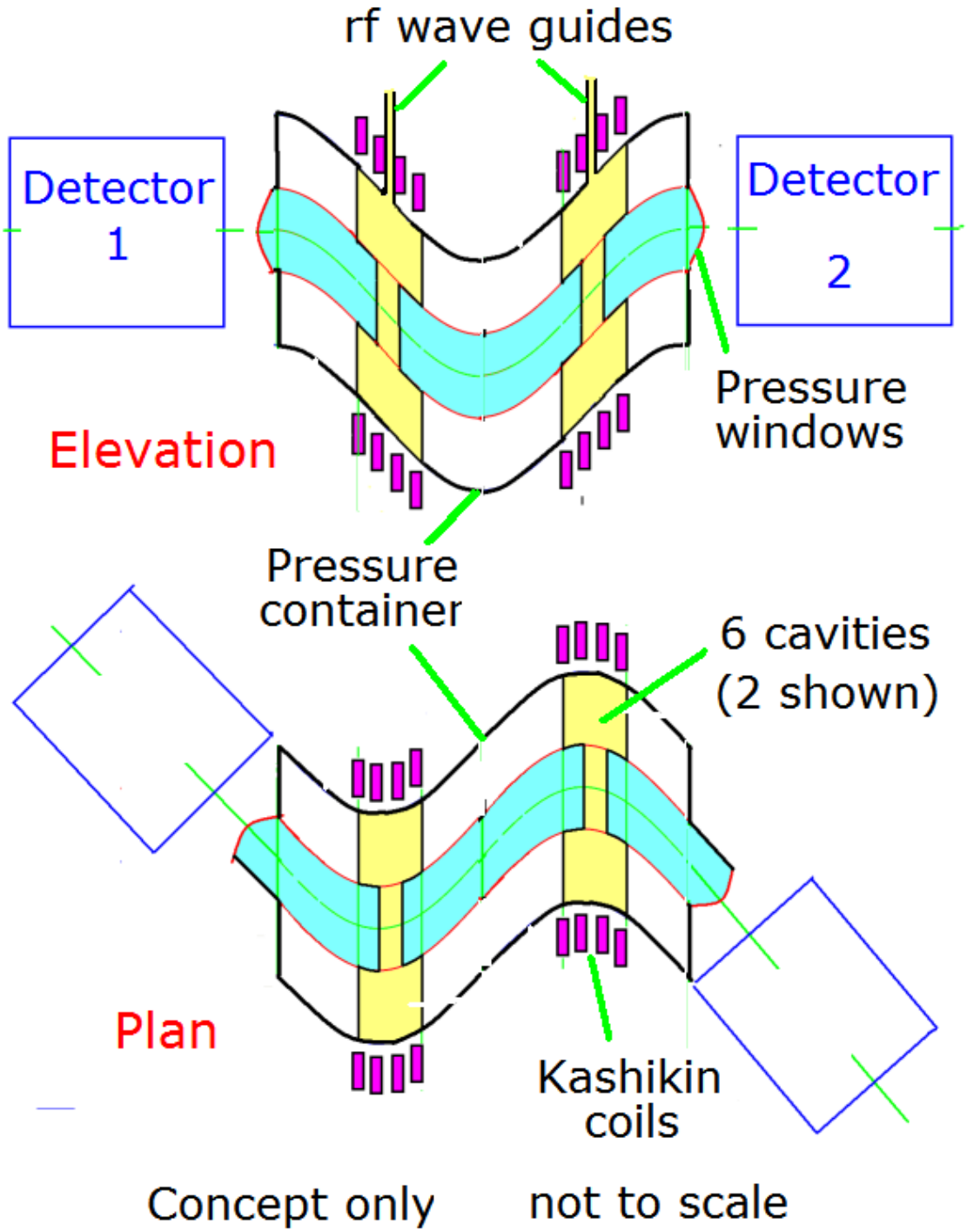
Cell length	80	cm
Cells	6	
Momentum	200	MeV/c
$\beta_\perp$	5	cm
Absorber thickness	10	cm
dE/cell	2.8	MeV
$\Delta\epsilon_\perp$/cell	1.5	%
$\Delta\epsilon_\perp$(total)	9	%
frequency	805	MHz
Phase	30	deg
Minimum rf grad over 48 cm	12	MV/m

3) HCC Exp

(Muons Inc. Balbekov, Yonehara)

- 201 MHz rf as at MICE
- 110 atm H2 at room (27 atm at 70 deg)
- Pressure windows and safety demo
- Ave acceleration 8.6 MV/m
- MICE Detectors and beam
- Off line matching

- Ceramic cavities, if developed, would increase cooling rate



CONCLUSION

- Experiments have shown damage and reduced gradients in required fields
- Solutions include:
  - Magnetically insulated cavities
  - High pressure gas cavities
- Possible cooling experiments include:
  1. A magnetically insulated experiment at 201 MHz
  2. A section of 201 MHz Guggenheim with high pressure hydrogen (not discussed)
  3. A section of 201 MHz Helical Cooling with hydrogen and integrated rf
  4. A demonstration of 805 MHz final collider 6D cooling
- # 1-3 use much of MICE equipment
  #4 would use somewhat less and requires more new equipment and rf sources