How to Guggenheim the RFOFO Ring

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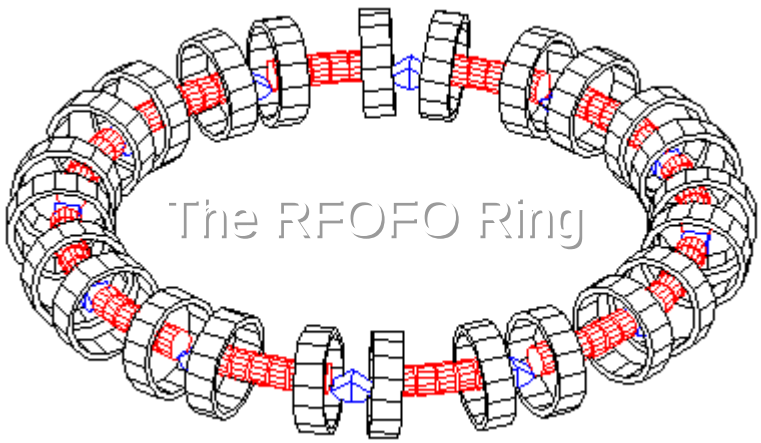
Outline

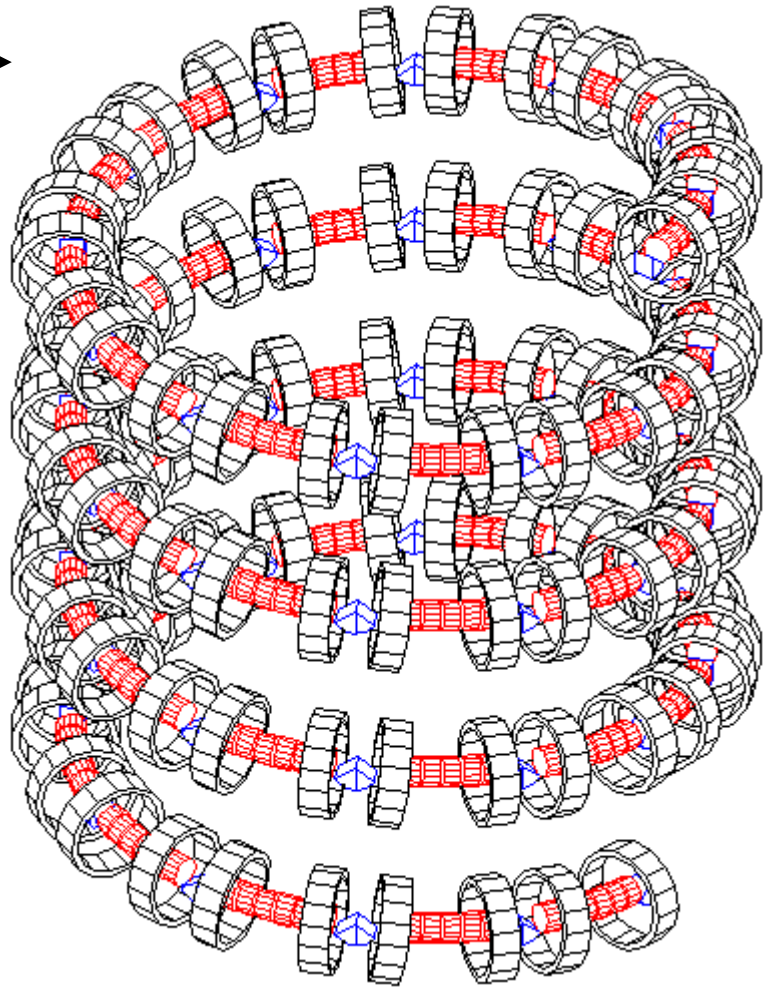
- Why Guggenheim?
- Geometric manipulations
- “Shielding” studies
- Some “Tapering” studies

  All very preliminary

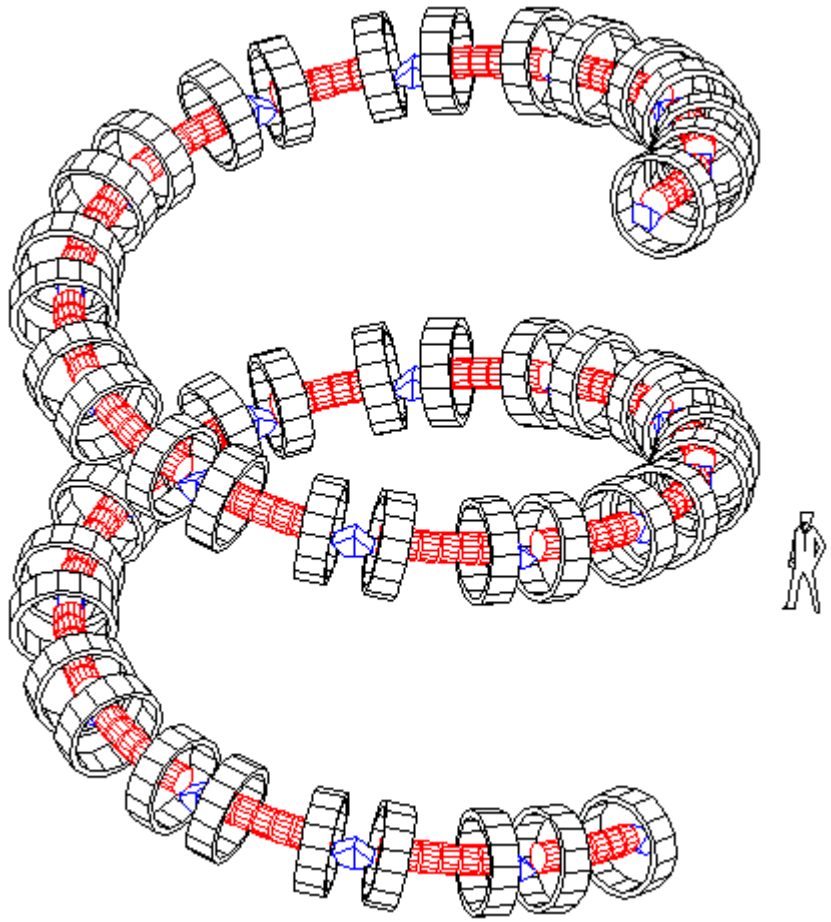
The idea: change the geometry

from this ↓ to this →





A simpler view of the Guggenheim



Why “Guggenheim”?

- Injection/extraction – not a problem!
- Unlimited bunch train length
- Less heating in the absorbers
- Tapering ➔ more efficient cooling, cheaper

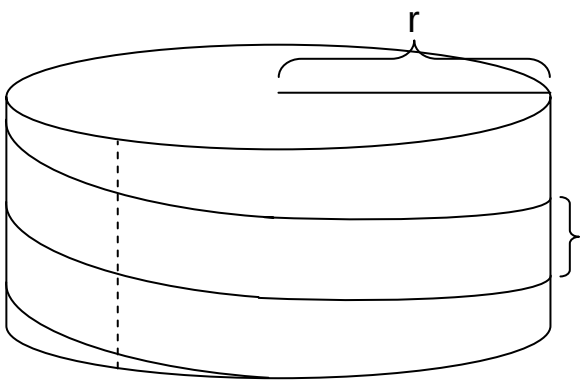
  BUT –
- massive, expensive (more RF cavities)
- Magnetic shielding of some sort is needed
- Can’t cool both signs in the same channel

Simulating the Guggenheim ring

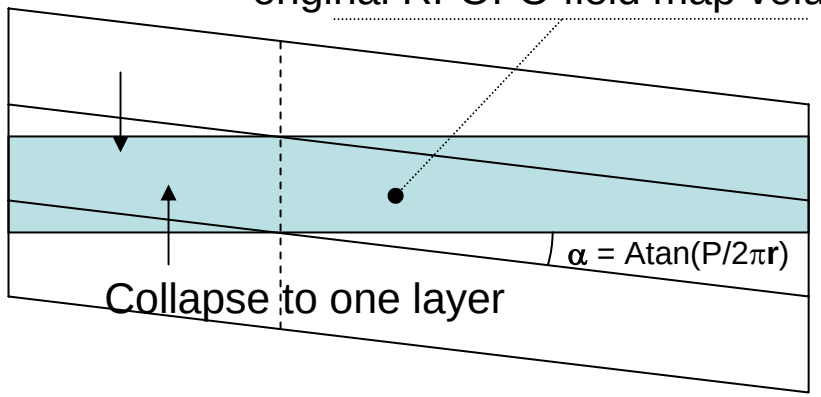
- Starting with:
  - a working GEANT3 simulation of the RFOFO
  - magnetic field map for the RFOFO ring
- Software modification:
  - Turning the existing field map into a "Guggenheim" using 2 parameters: P (pitch) and ϕ_0 (azimuthal angle offset)
  - This modification does not take into account the effects of "ring stacking"

Turning a ring into a helix

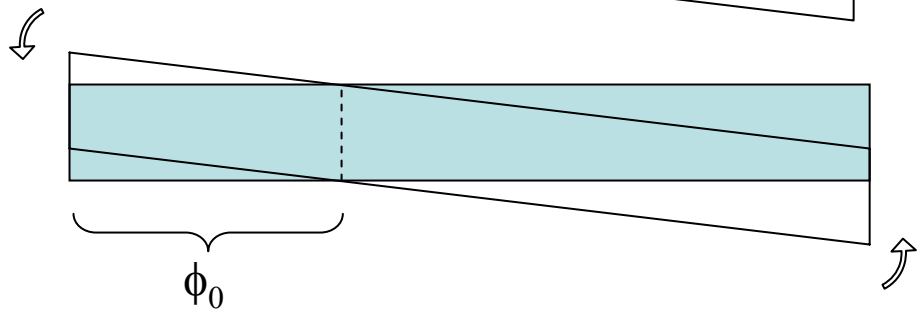
For each point x,y,z ➔ r,ϕ,y



"peel off"



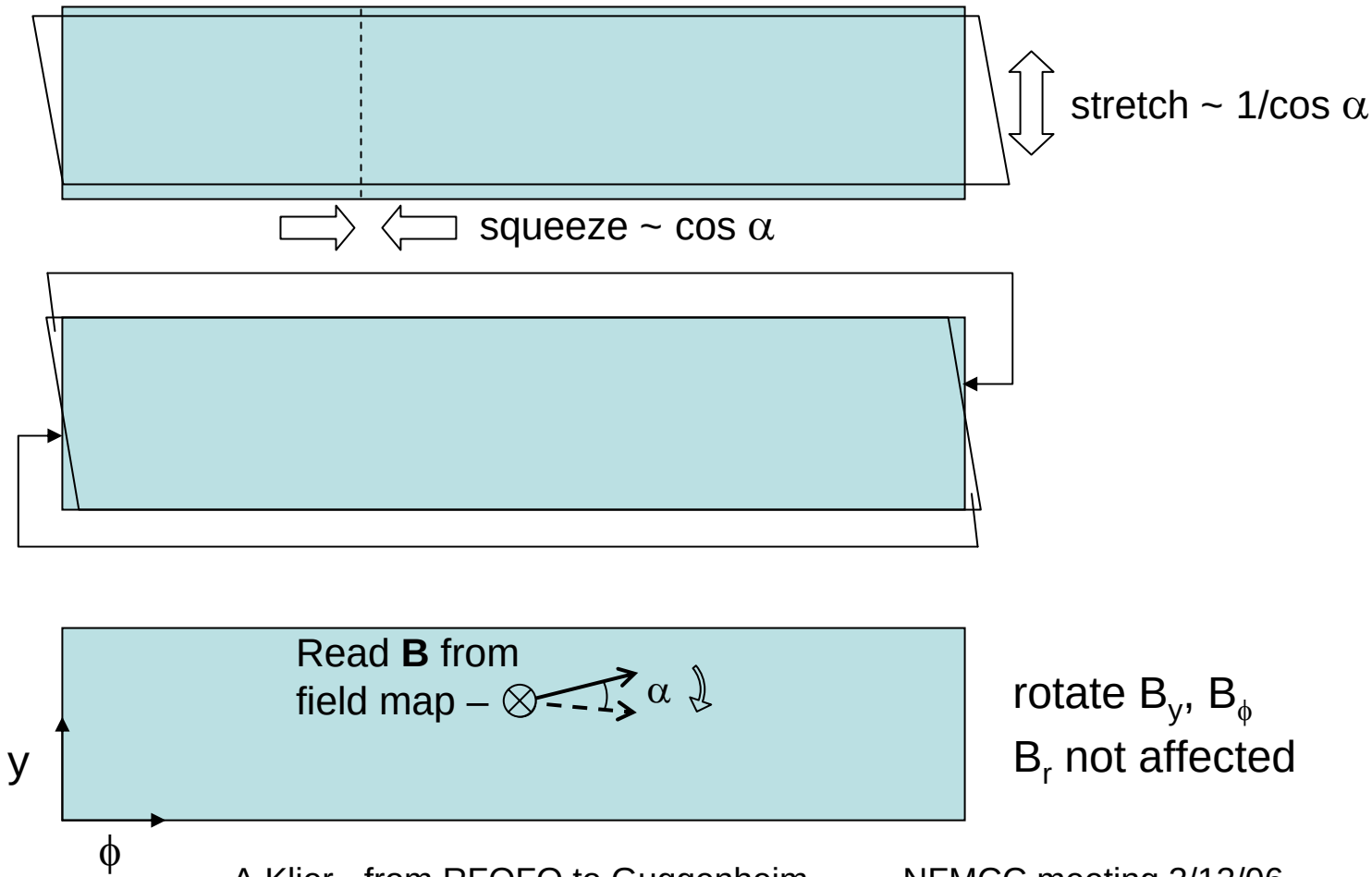
Rotate by angle α



More adjustments needed

Turning a ring into a helix

Exaggerated view of a single “slice”:

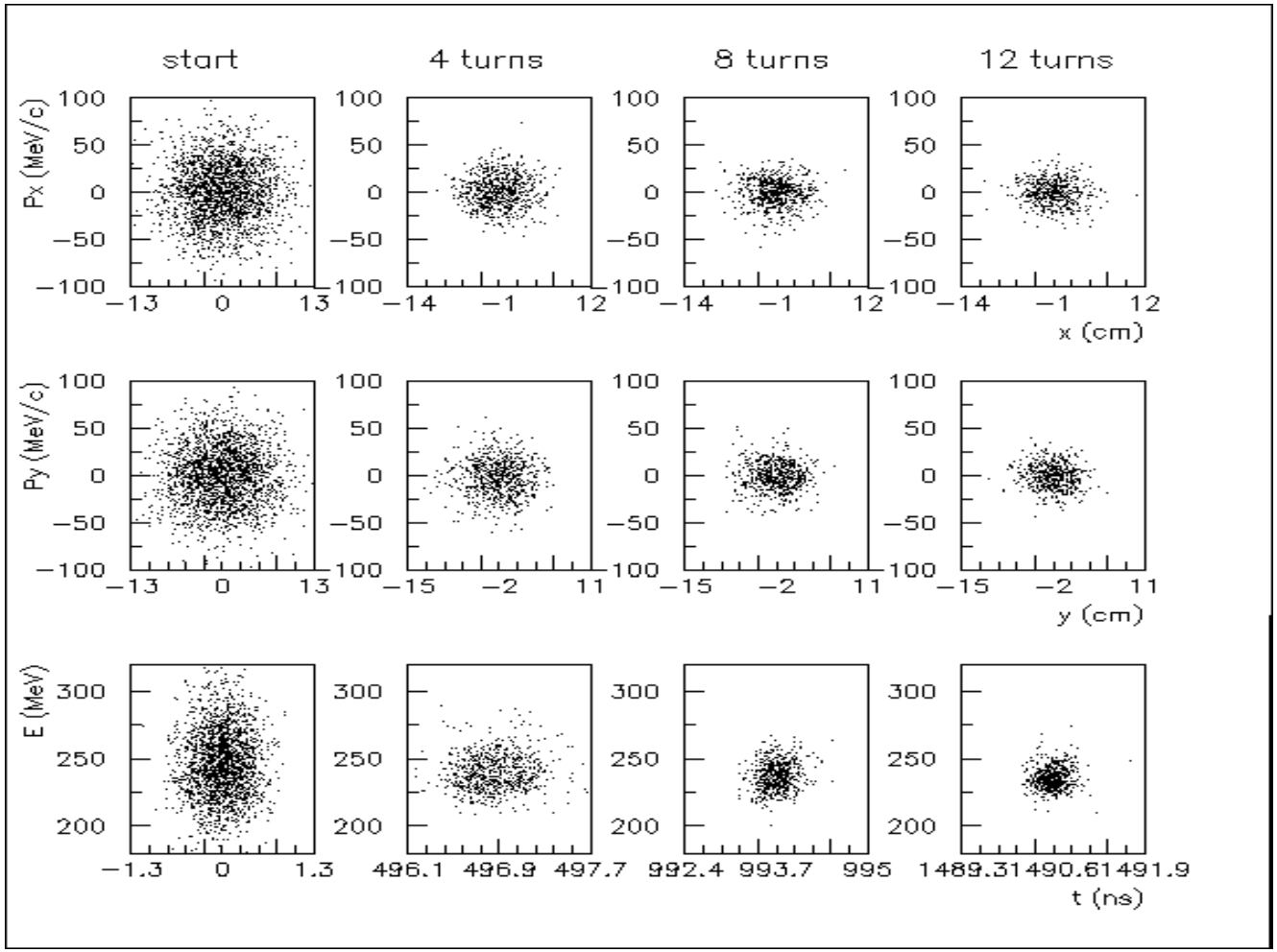


Cooling simulation

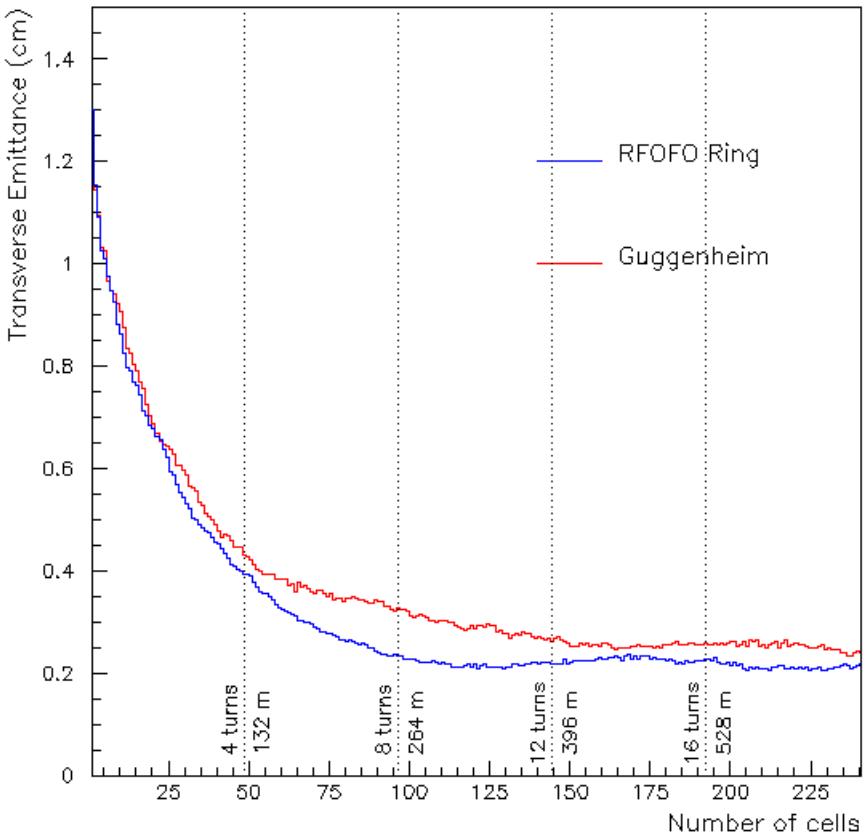
- Pitch = 3 m
- No windows, but otherwise realistic...
- The “reference orbit” – 25th harmonic of the 201.25 MHz (**not necessary!**)
  - Longitudinal momentum = 205 MeV/c, compared to 201 MeV/c for RFOFO

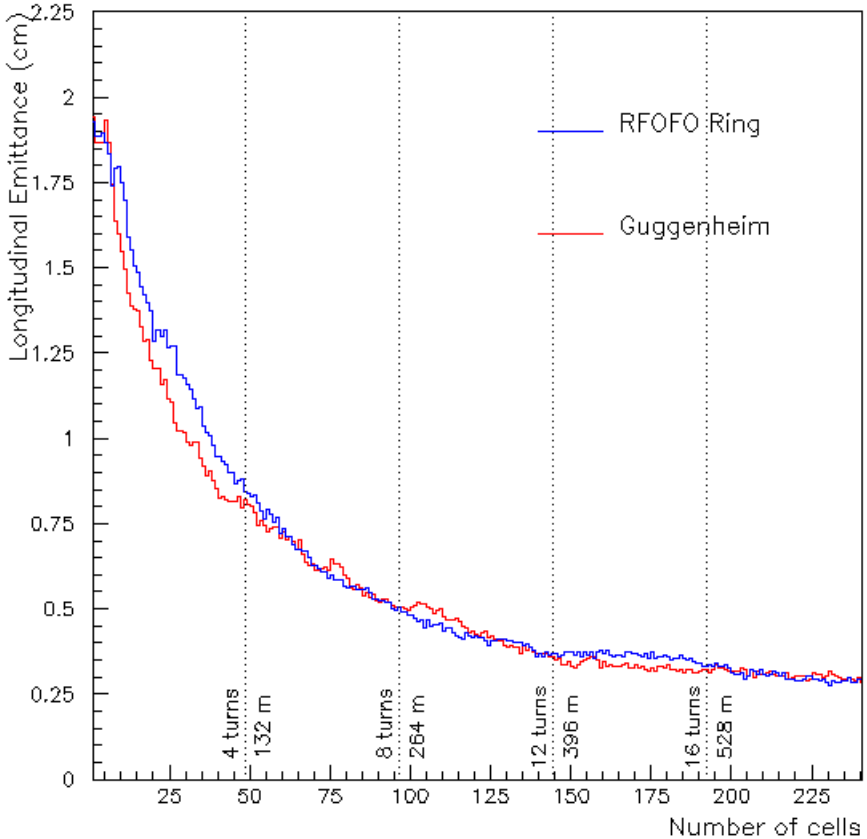
    (longer path requires β ratio = $1/\cos \alpha(r)$)
- Use the same 1000-muon beam as the RFOFO
  - rotate by angle α about the x/r axis at entry

Cooling... seems to work



Comparing results



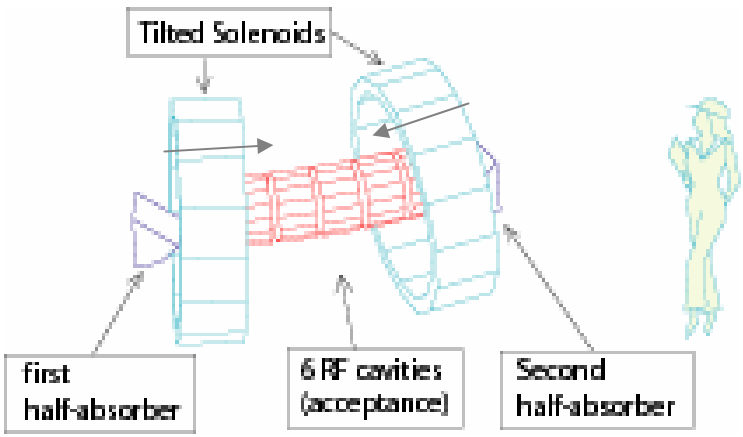


“Guggenheiming” the RFOFO

- Works in principle
- More realistic magnetic fields needed
  - Will be done (hopefully) soon

“Shielding” studies

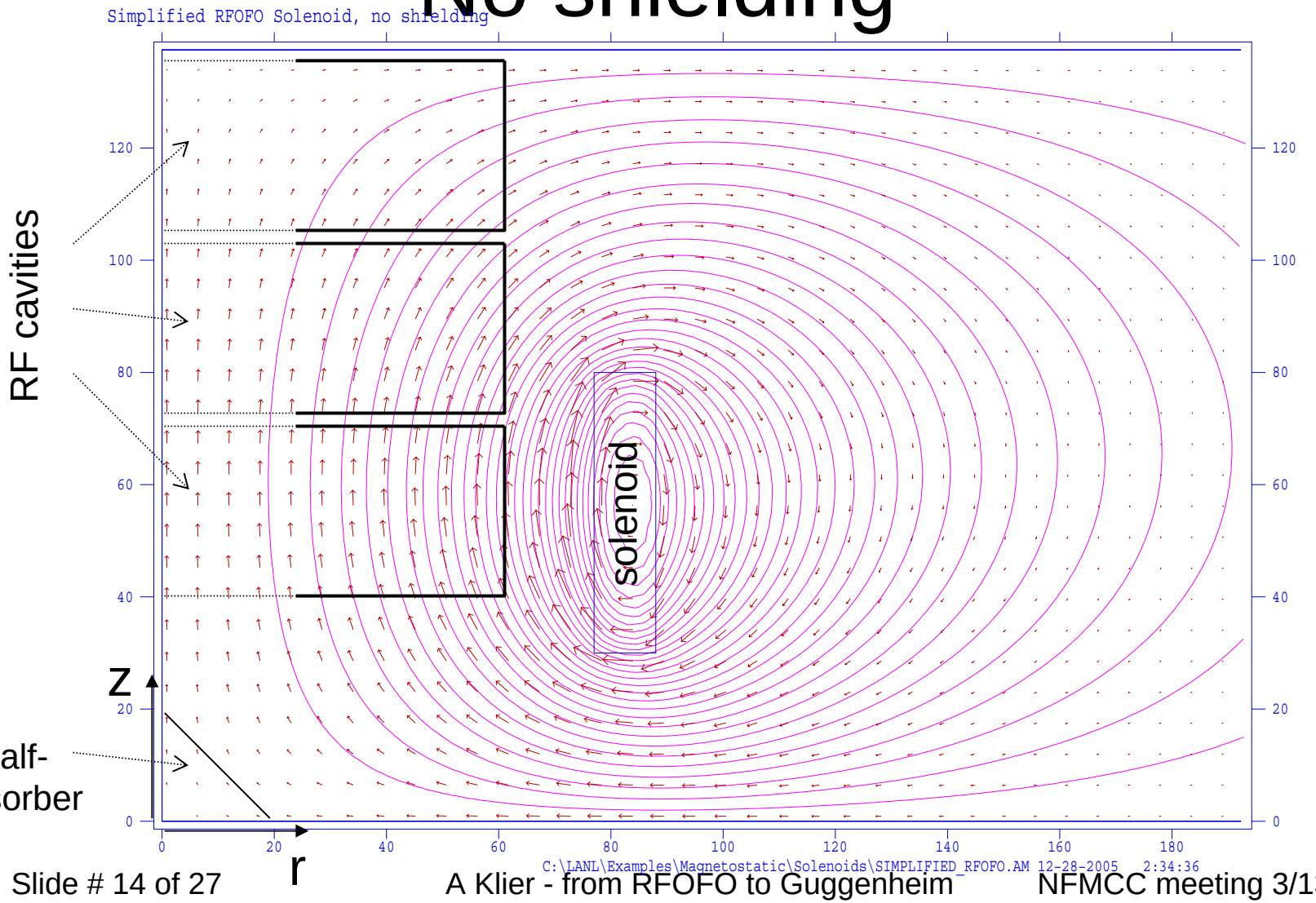
The RFOFO cell:



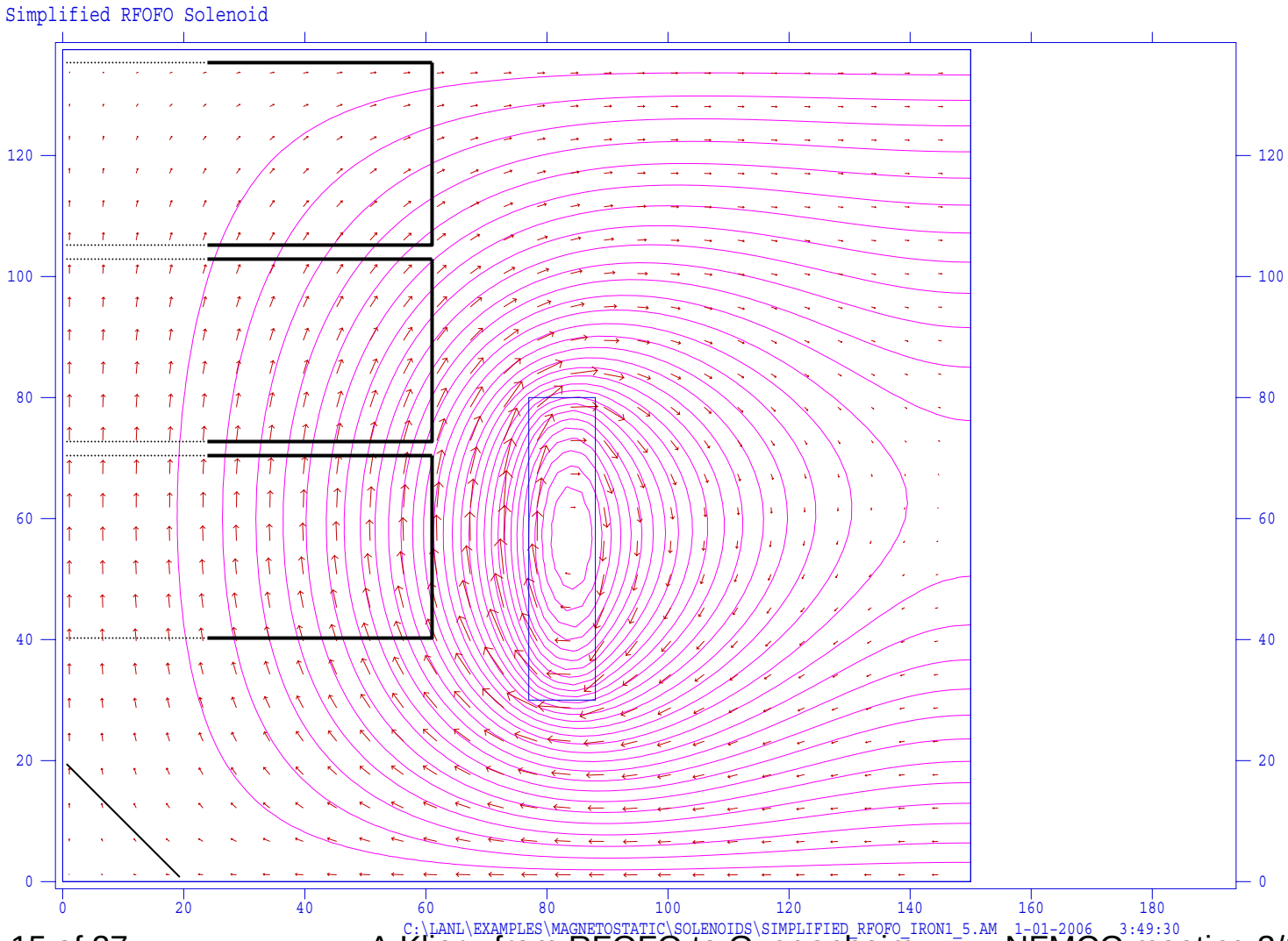
Simplified version:

- “Straighten” the cell (cancel solenoid tilt)
  ➔ 2-dim. problem (r, z)
- Cut in half (at field flip)
- Boundary conditions:
  $B_z = 0$ at edges
  $B_r = 0$ at $r = 0$
- **“Iron” shielding**:
  B $\perp$ surface (i.e. $B_z = 0$)
  at $r = R_{shield}$

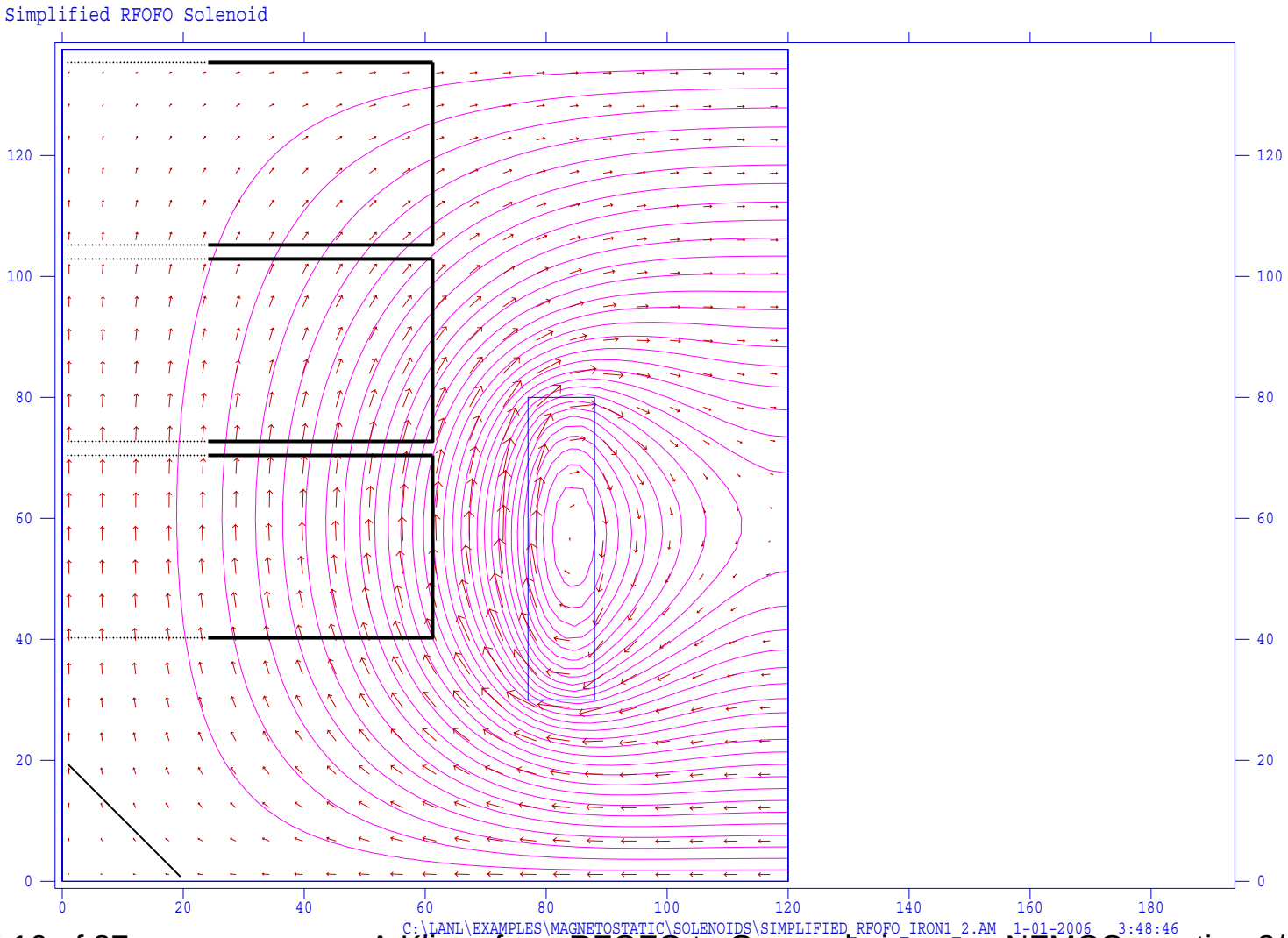
B Field (Poisson-Superfish): No shielding



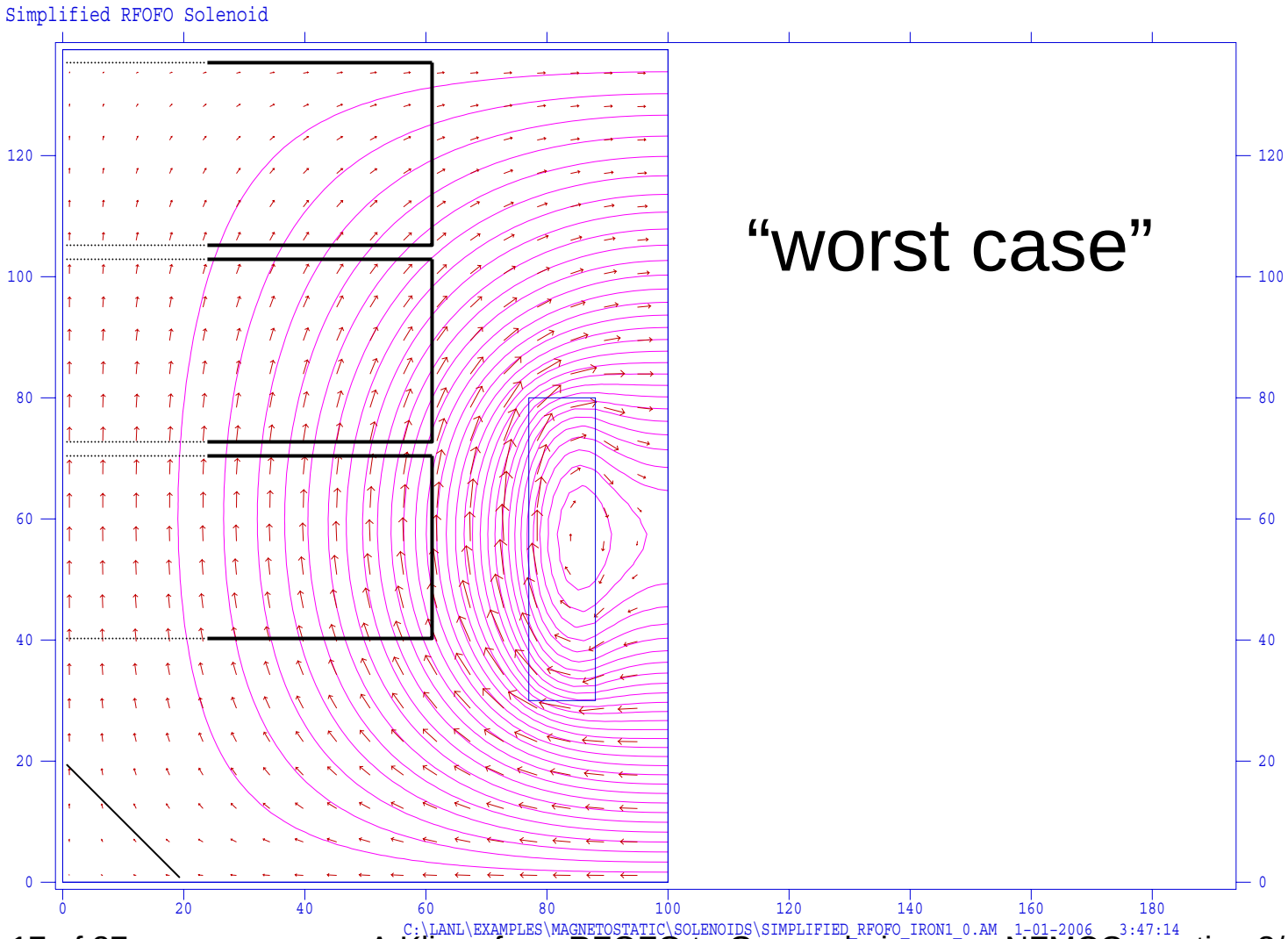
Shielding at r = 1.5 m



Shielding at r = 1.2 m

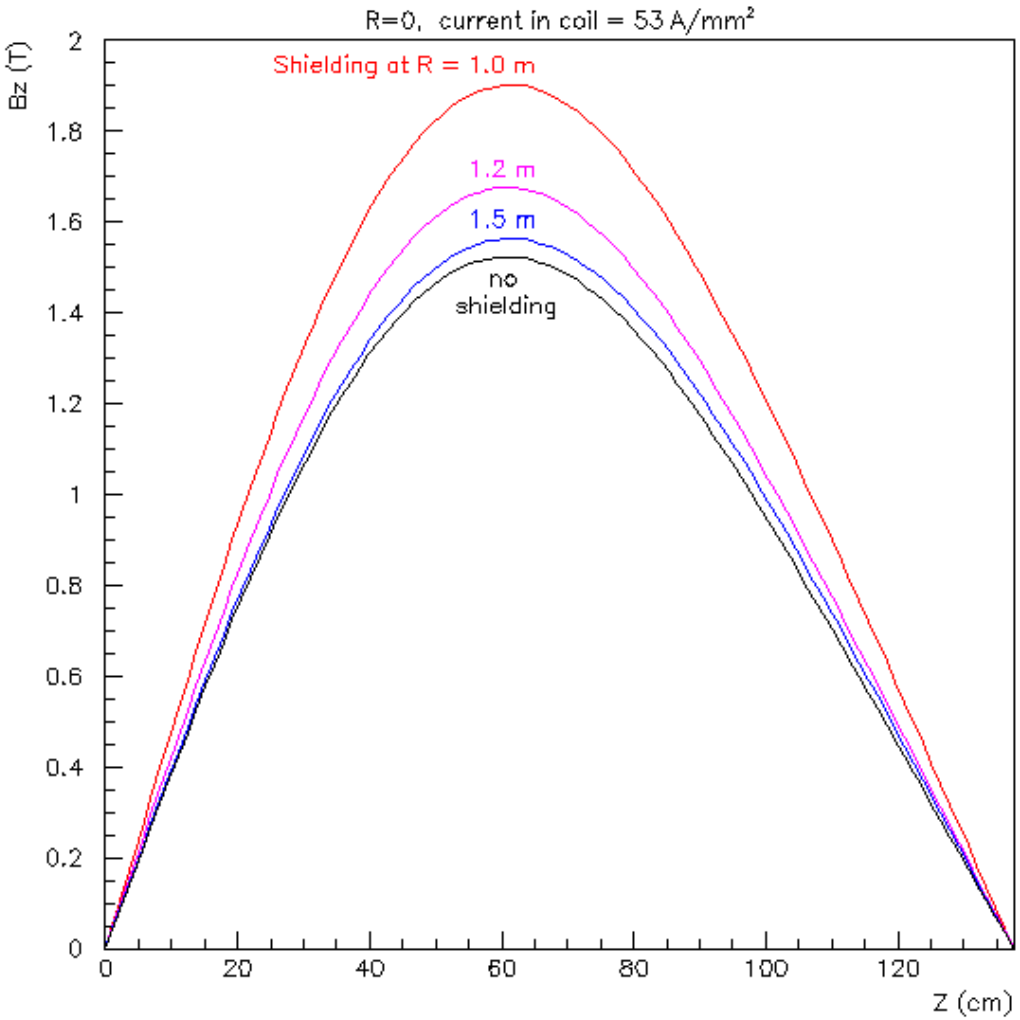


Shielding at r = 1.0 m



"worst case"

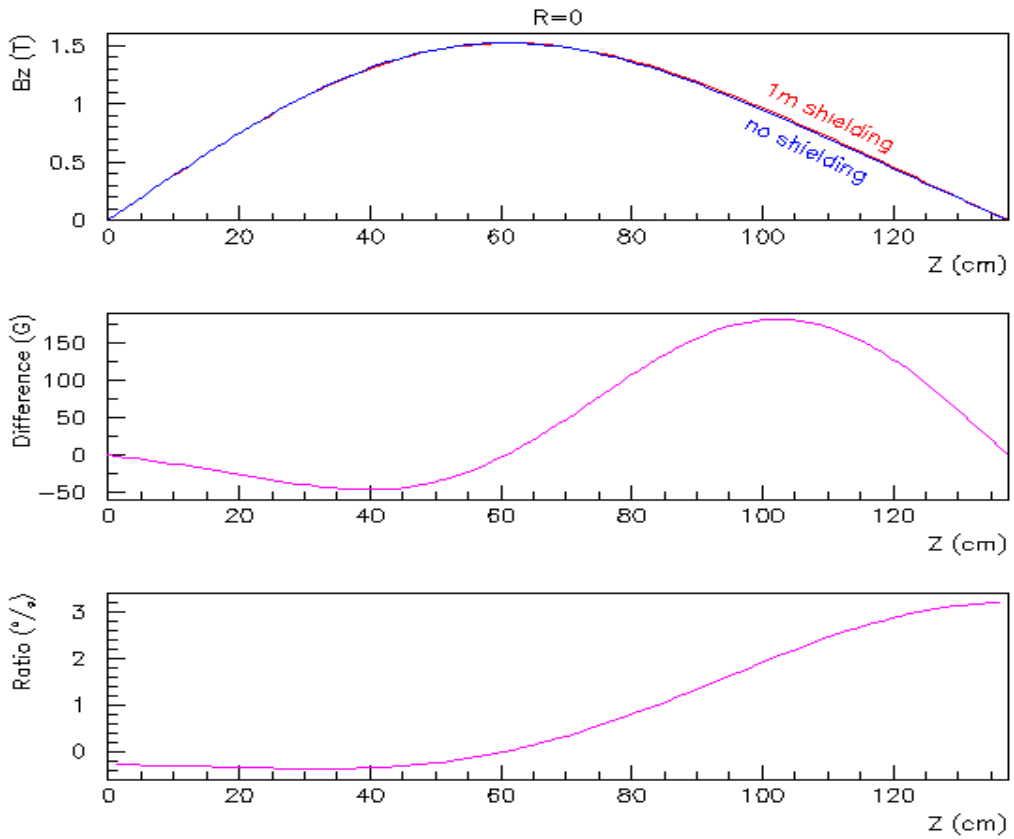
Strength of B field at r = 0



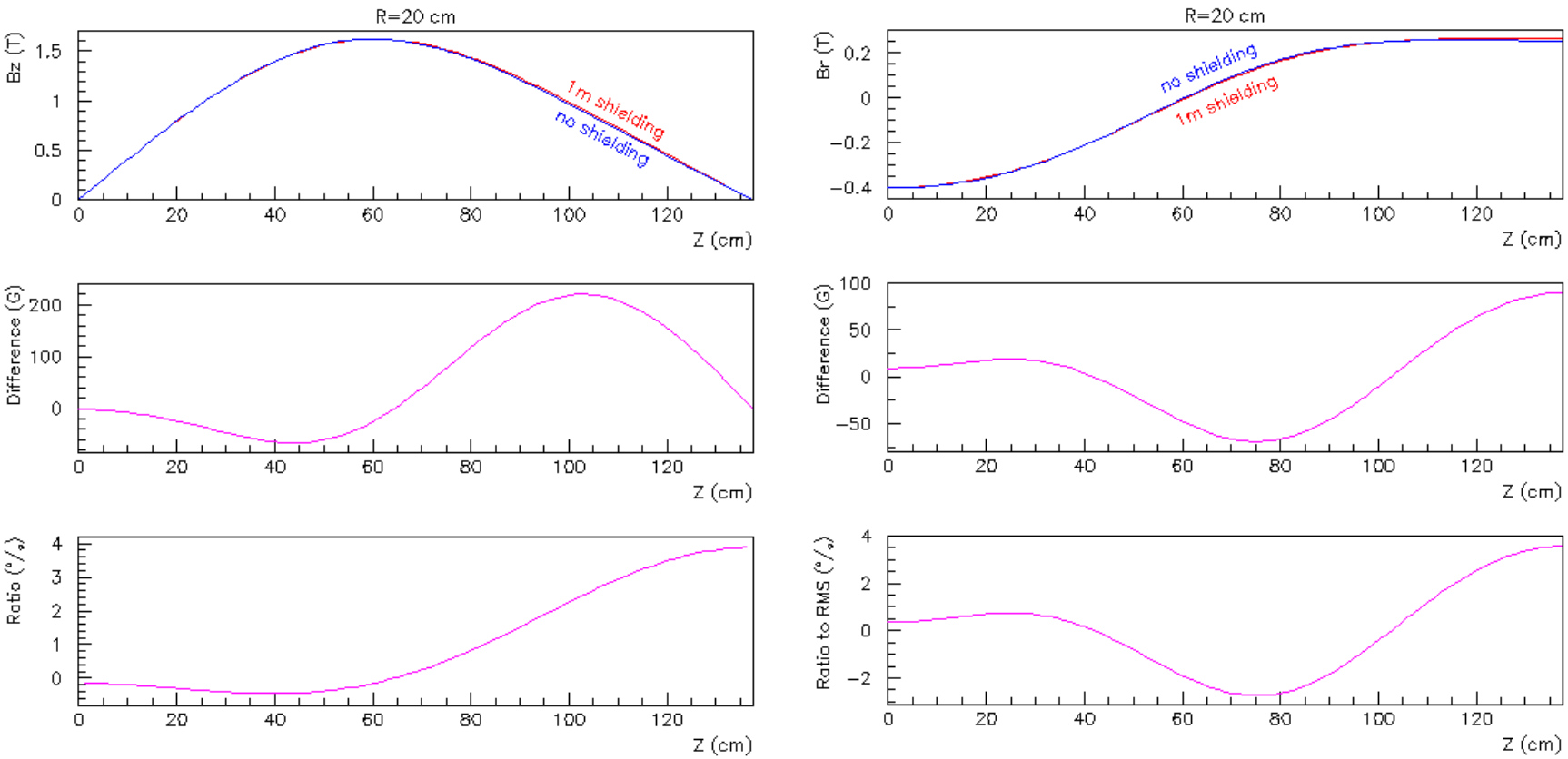
For the comparison
I normalized the currents
to match Bz maximum
at r = 0 without shielding

Shielding	Current (A/mm^2)
none	53.00
1.5 m	51.66
1.2 m	48.18
1.0 m	42.47

Comparing no shielding and “worst case” (normalized) at r = 0



Comparing no shielding and "worst case" (norm.) at r = 20 cm

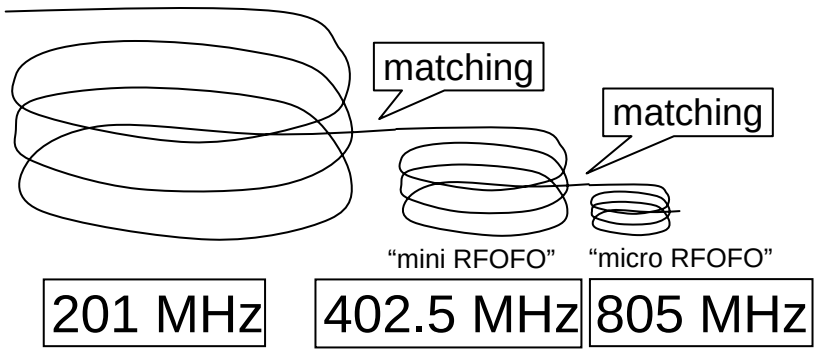


“Shielding” studies

- Shielding seems to have little effect on magnetic field near the beam
- Forces, saturation, engineering design
  - Save it for later...
- Meanwhile we can simulate without iron and **not worry about it**

“Tapering” studies (preliminary)

- Actually, it’s a 3-stage scheme:

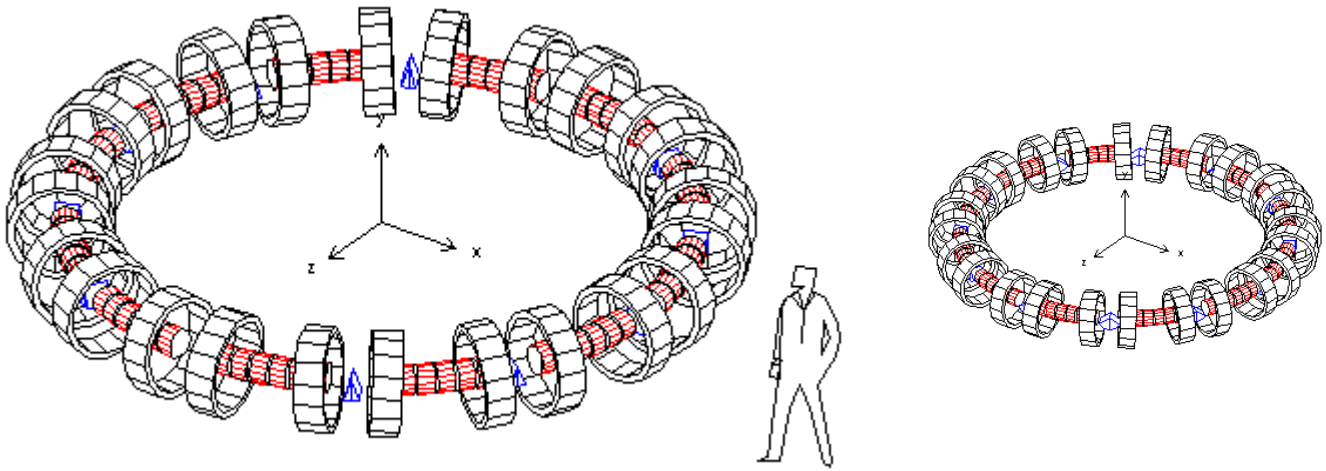


- The way I simulate (for now):
  - Use existing RFOFO (not “Guggenheim”) field
  - Scale geometry (1/2, 1/4), field, RF frequency
  - RF Gradient scales by about 1.5 each step

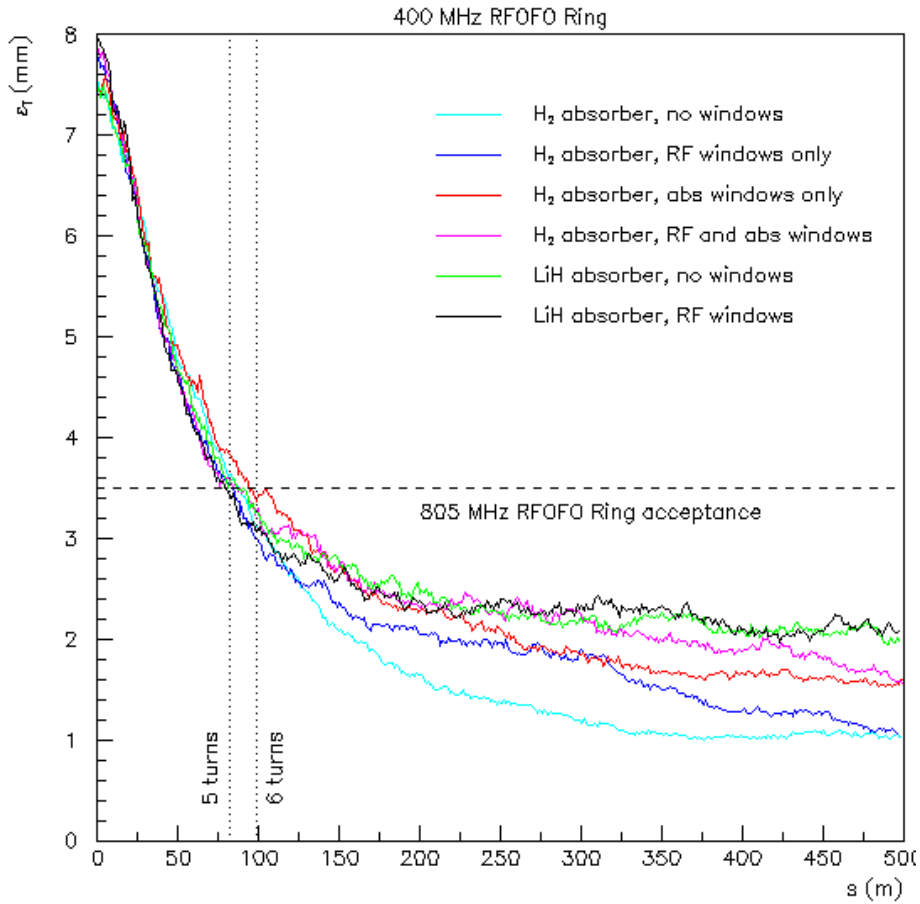
Geometry

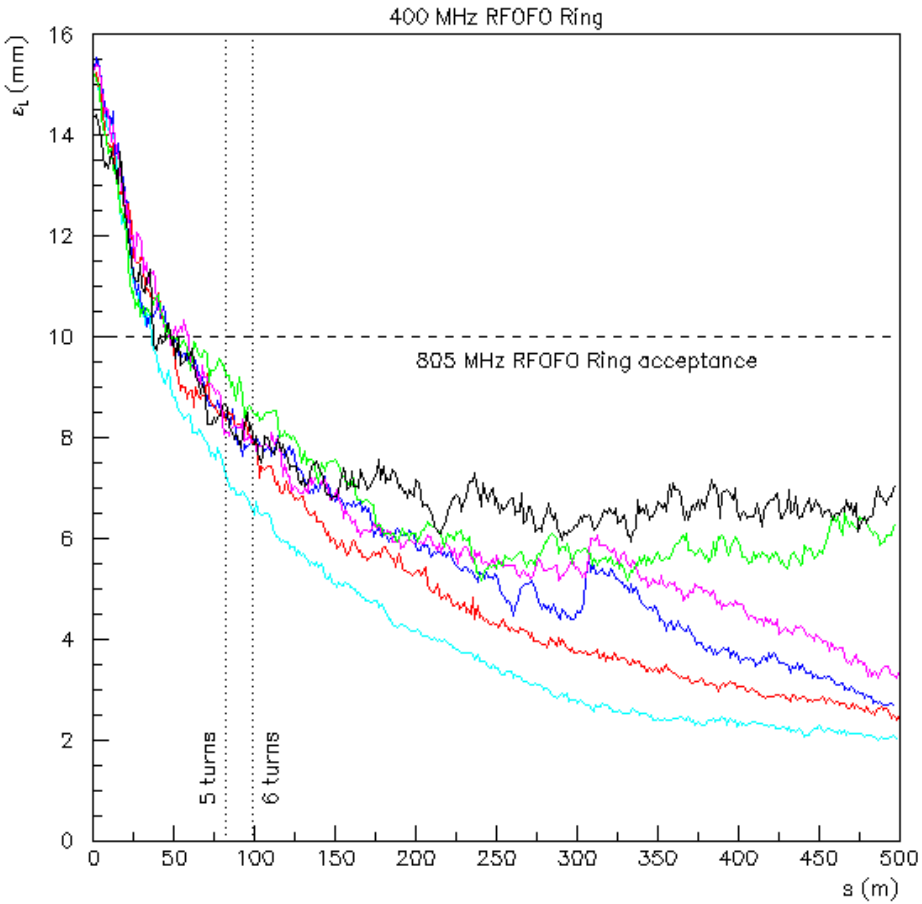
402.5 MHz ring

805 MHz ring



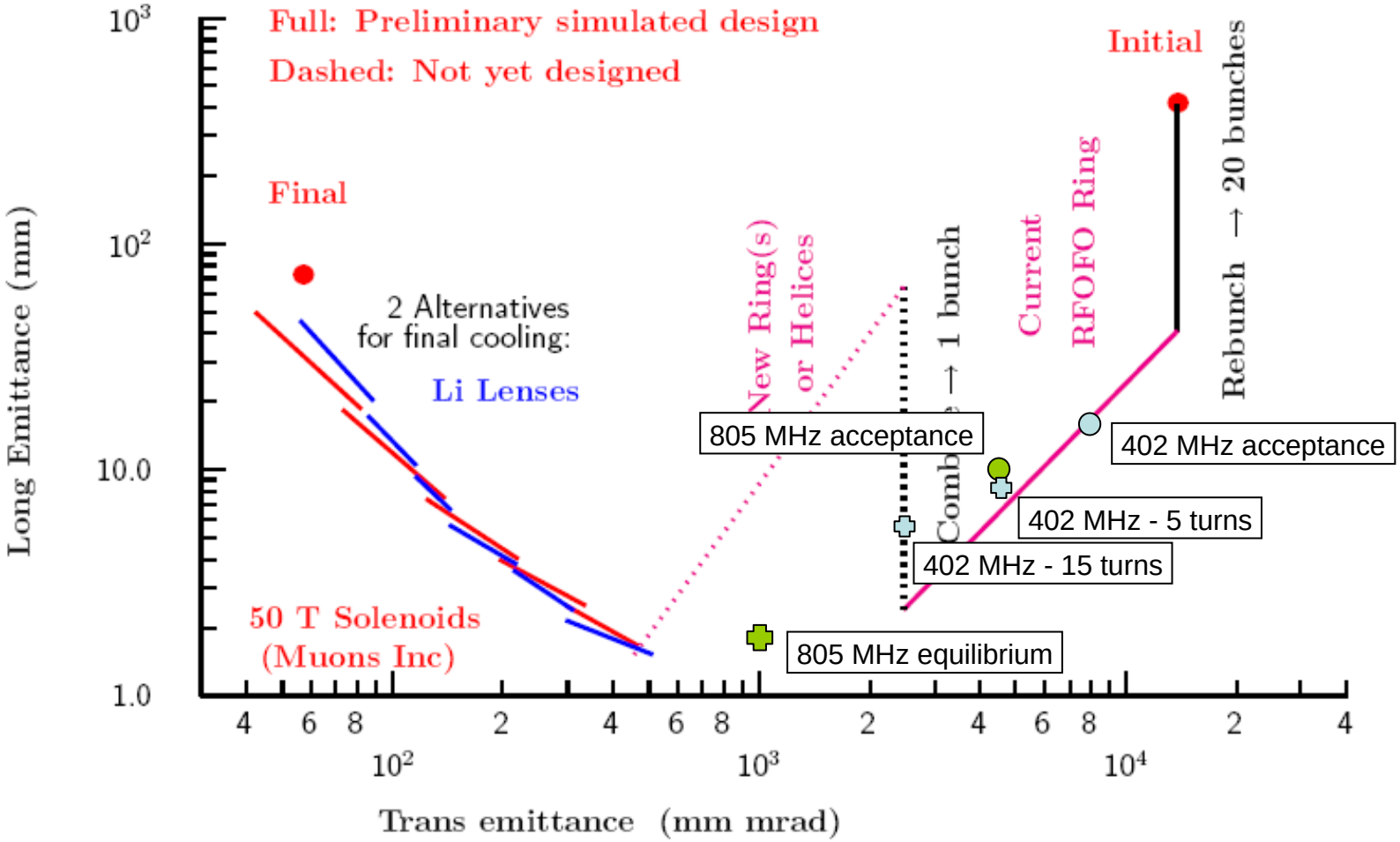
Some results





Roadmap to a muon collider

Bob Palmer's "grand scheme" (Friday meeting, 2/17/06)



To do

- Simulate with “Guggenheim” instead of ring
  - need realistic fields
- Other improvements
  - Absorber shape/material, magnet arrangement
  - Matching to a complete cooling channel...
- Concerns
  - Smallest ring too small, B too high (peak ~15T)

Conclusion

- Based on simplifying assumptions – the Guggenheim RFOFO works well
- Still a lot of work to do