# My* Last** Report on RFOFO and Guggenheim***

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Friday Meeting – 9/8/2006

* Not “The”!
** At least for now

# ***Names, names, names...

I tried to propose “RFOFO Helix,” but some things are stronger than me...

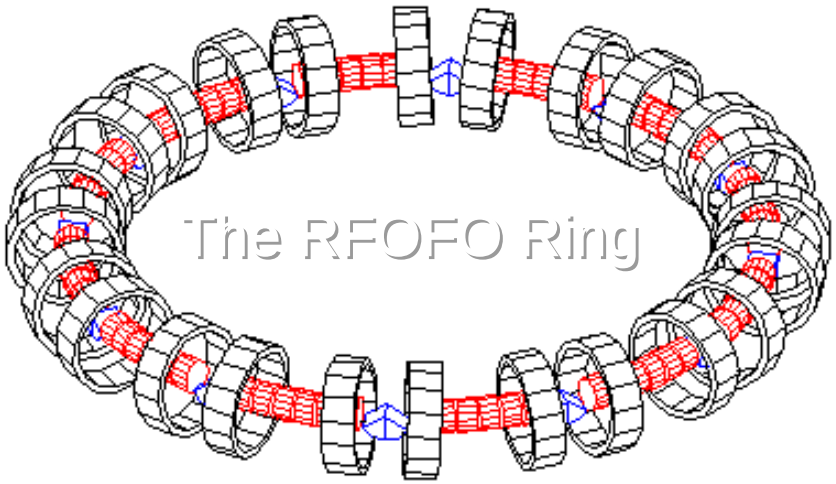
So I give up – Guggenheim shall it be!

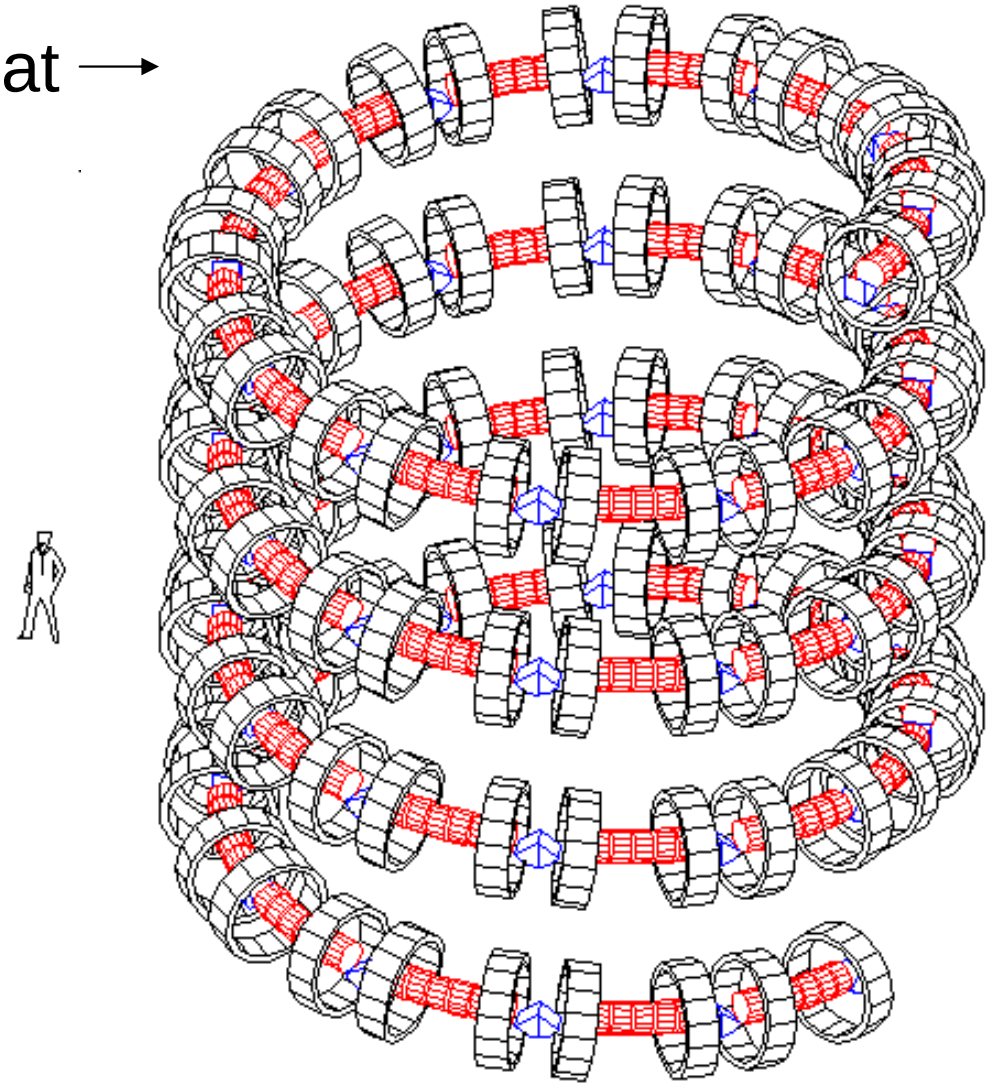
# OUTLINE

- Summary of previous reports (*i.e.* Old News)
  - The idea, why it's good
  - GEANT3 simulation
  - Preliminary "shielding" and "tapering" studies
  - Introducing G4Beamline
- What's New
  - "Full" simulation using G4Beamline
- The future (as I see it)

# The idea

Turn this ↓ into that →



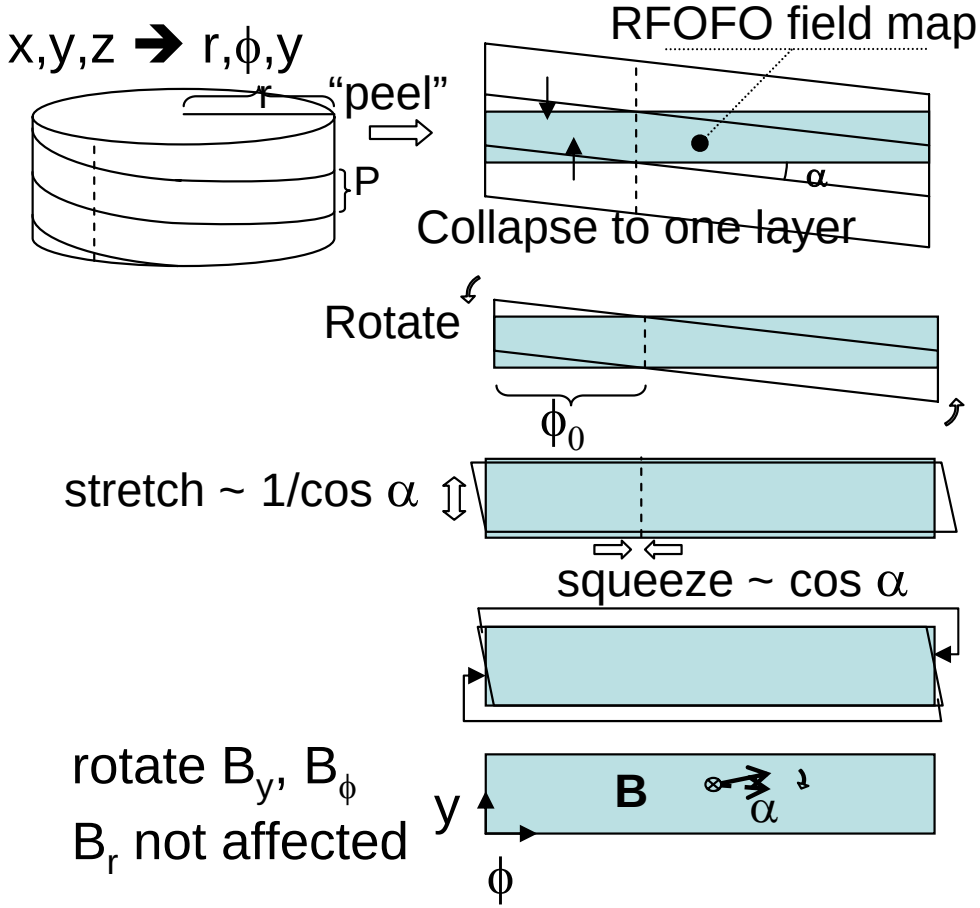
# Why ~~Helix~~ “Guggenheim”?

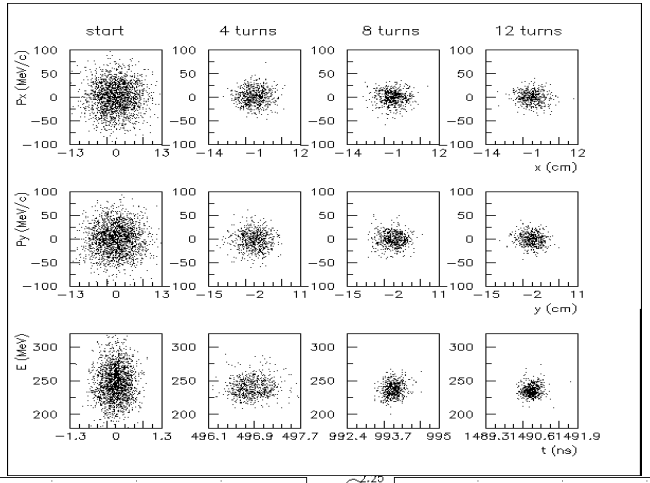
- Injection/extraction – not a problem!
- Unlimited bunch train length
- Less heating in the absorbers
- Tapering ➔ more efficient cooling, cheaper

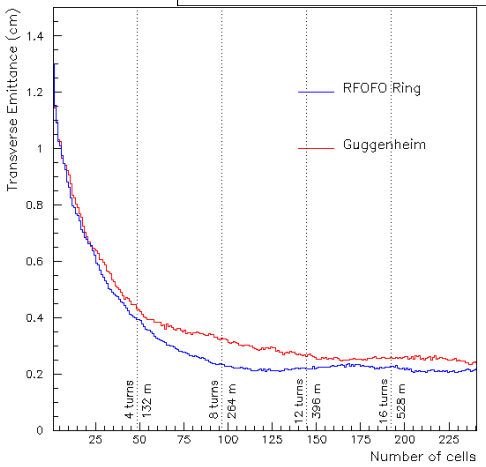
  BUT –
- massive, expensive (many RF cavities)
- Magnetic shielding of some sort is needed
- Last step (805 MHz) may require design change due to very strong magnetic fields on RF cavities

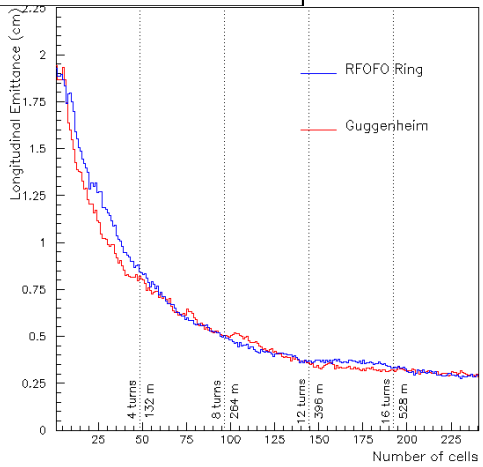
# First attempt: GEANT3 with geometric manipulations

Dec. 2005, BNL (ISS-WS)




Performs well, but unphysical

# Required improvements

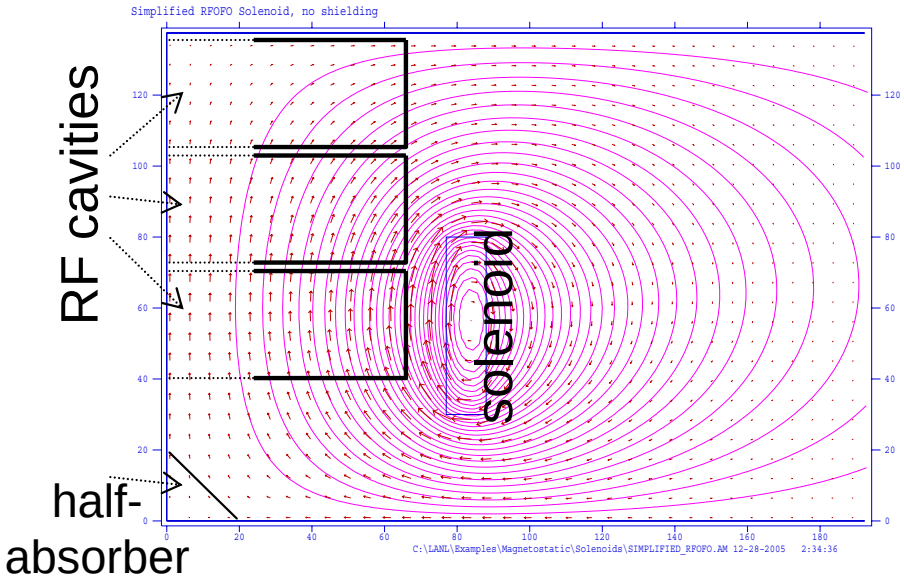
- Create realistic field map for the "Guggenheim" configuration.
  - GEANT3 (MUC_GEANT) can't do that
  - G4Beamline can! OK, I'll do it later...
- Meanwhile I can do other things:
  - Study shielding effects (using Superfish)
  - Study "tapering" using ring simulations
    - Results can be extrapolated if "real Guggenheim" performance is not entirely different than ring...

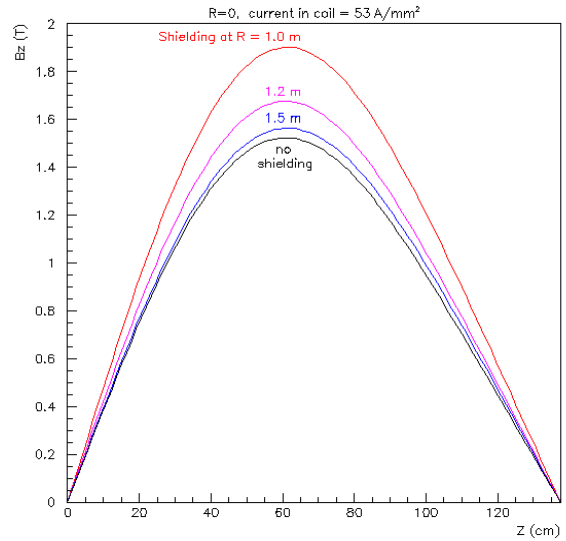
# Shielding Study

Feb. 2006, FNAL (LEMC WS)

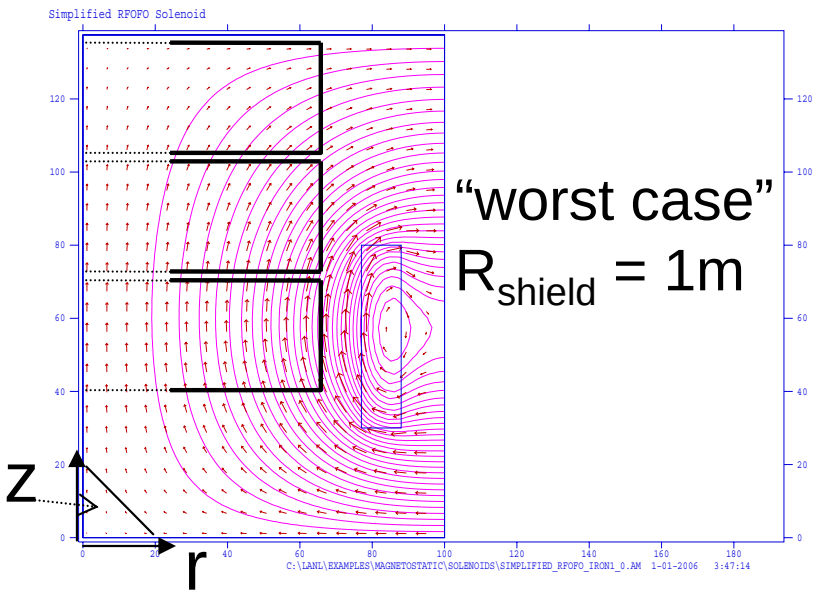
- Use Simplified (straightened) RFOFO **half-cell** (has cylindrical symmetry)
- Impose boundary conditions:
  - $B_z = 0$ at the edge, $B_r = 0$ at $r = 0$
- For shielding use “simplified iron”:
  - **B** $\perp$ surface (*i.e.* $B_z = 0$) at $r = R_{shield}$

# Effect of “shielding”

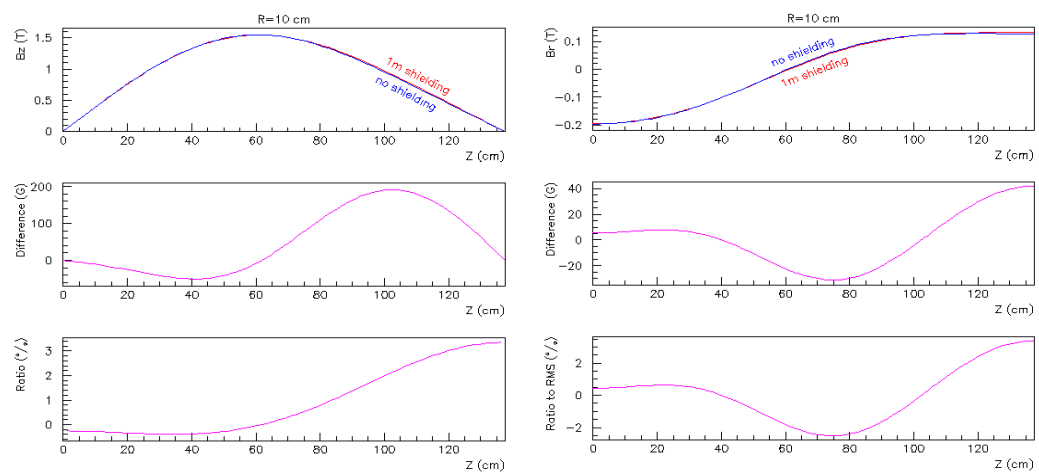



Tighter shielding
➔ less current needed



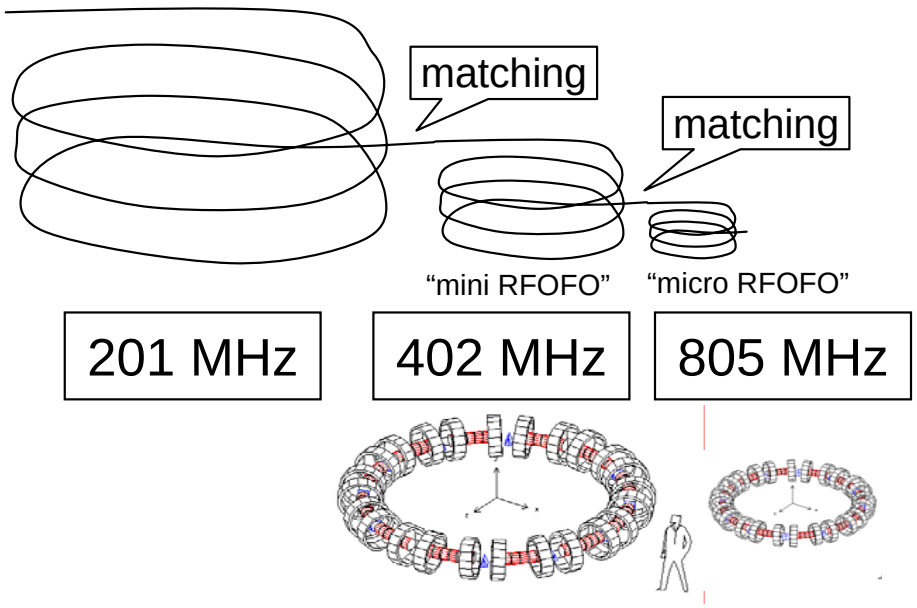

Almost negligible effect on field at the beam



# Preliminary tapering study

Mar. 2006, IIT (NFMCC CM)

- Cooling in 3 stages:

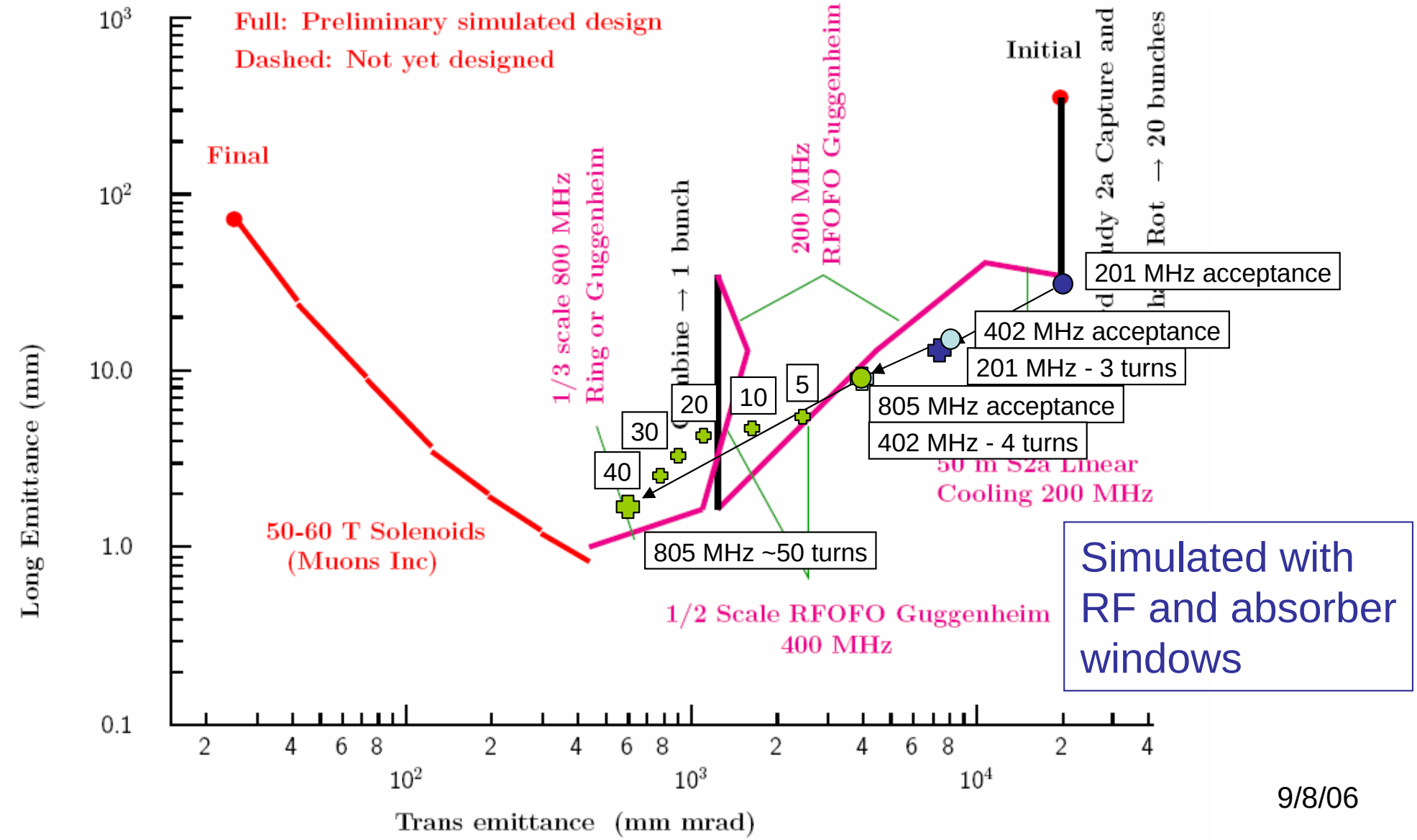



- The way I simulated:
  - Use ring (not "Guggenheim") geometry
  - Scale geometry (1/2, 1/4), field, RF freq.
    (RF Gradient scales by about 1.5 each step)
  - No matching yet

Apr. 2006, FM

# Roadmap to muon collider?

Bob Palmer's "grand scheme" (NFMCC meeting, 3/14/06)

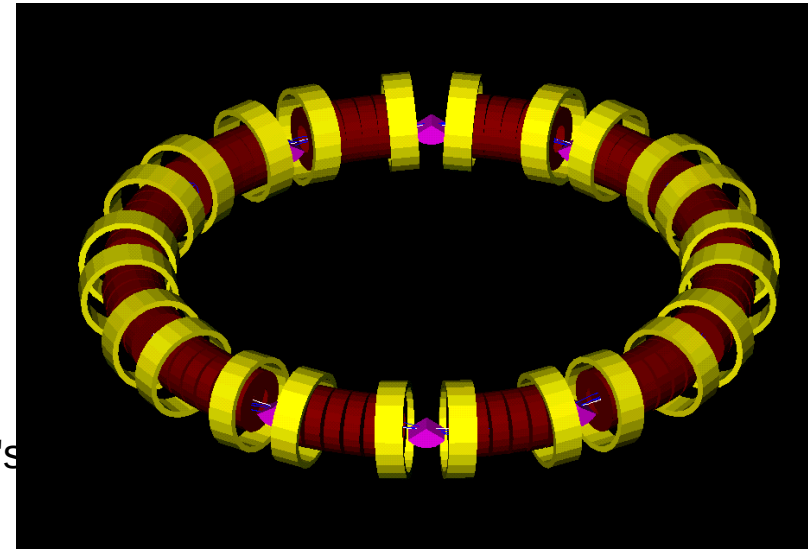



9/8/06

# Introducing G4Beamline

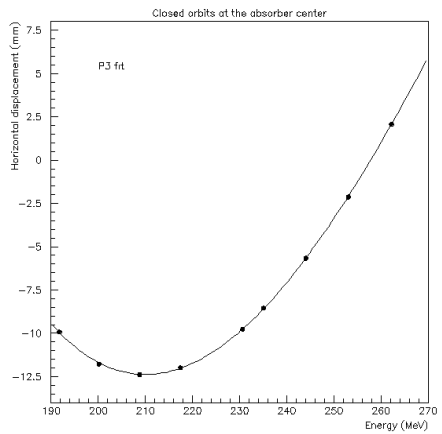
Jul. 2006, FM

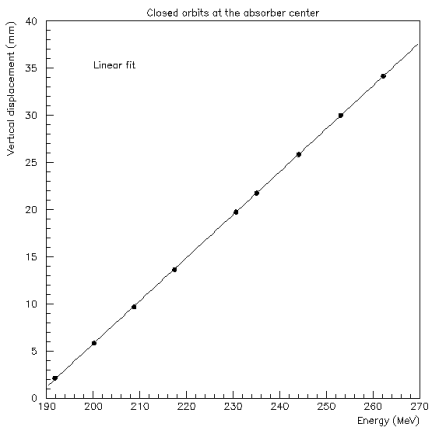
- With G4Beamline it is possible to generate realistic field map using solenoids.
  - Finally - simulate a realistic “Guggenheim”
- OK, but first look at what we already know:
  - The RFOFO ring...



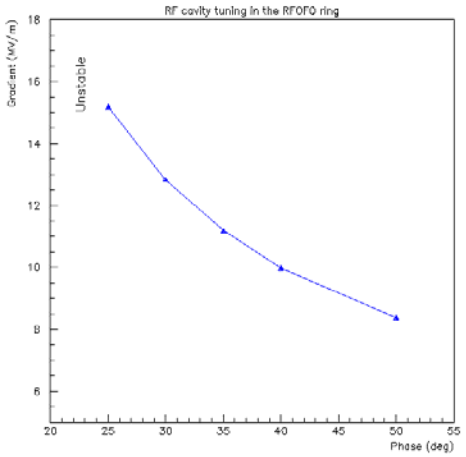
# Compare to GEANT3

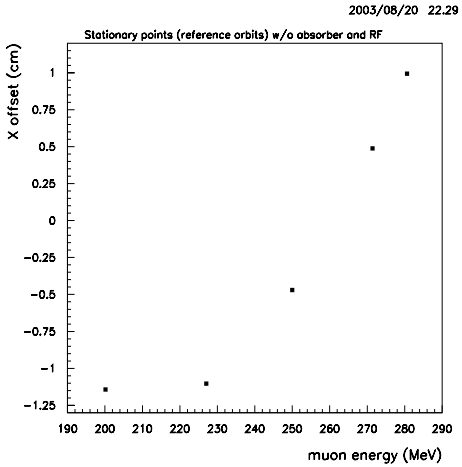
- Closed orbits:

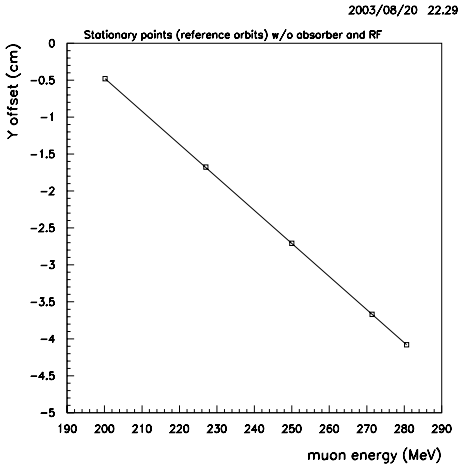



- Gradient vs. RF phase: ↓



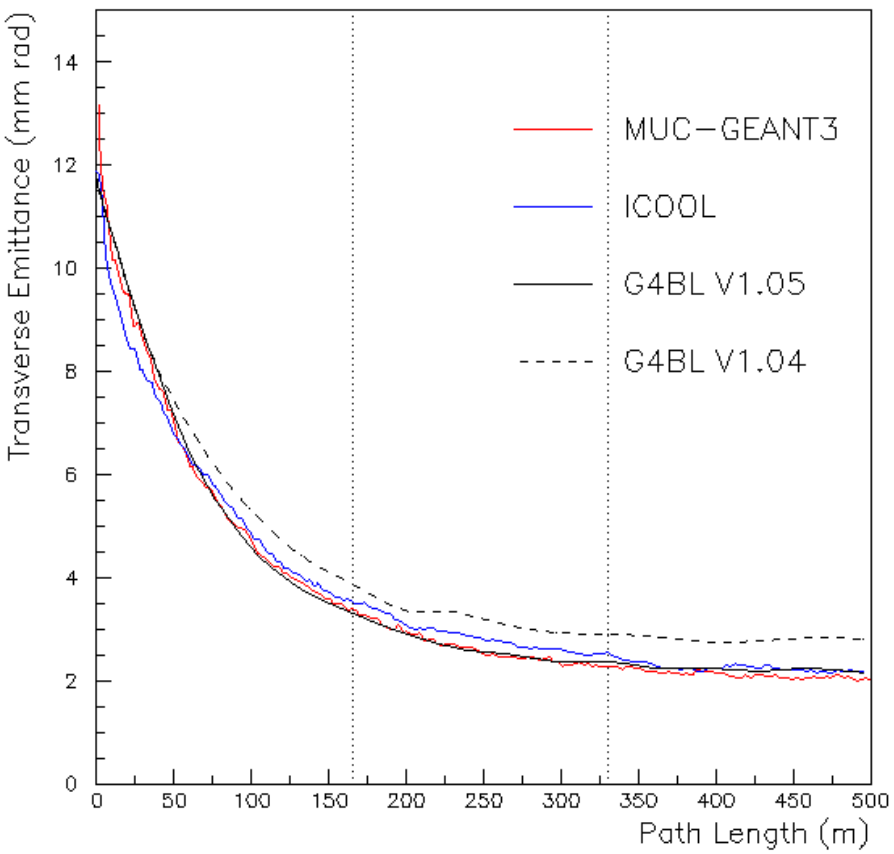



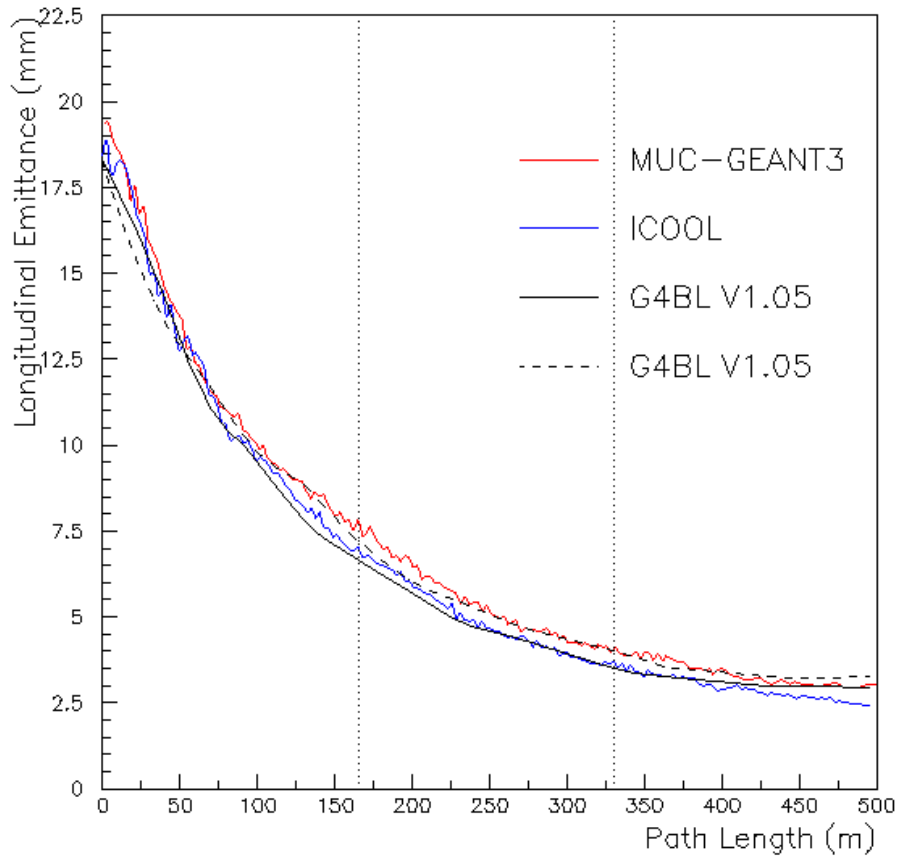

The ring is flipped (doesn't matter)

# Cooling simulation (I)

## The latest Geant4 release agrees with G3

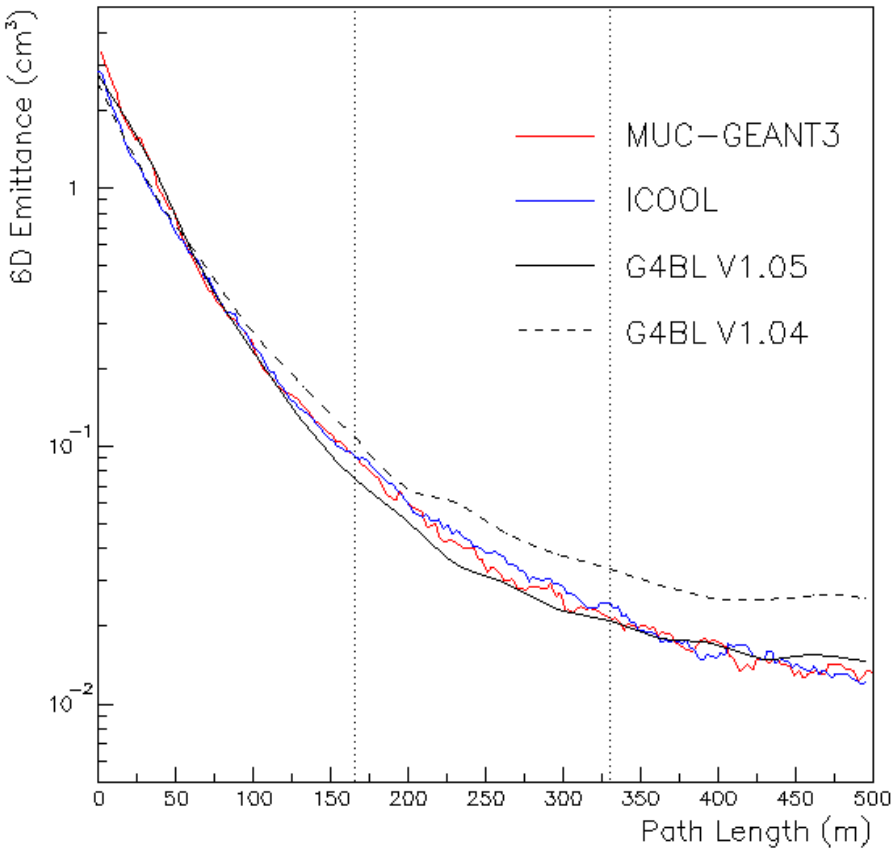
In G4BL run, chose RF phase = 35º ➔ gradient = 11.2 MV/m

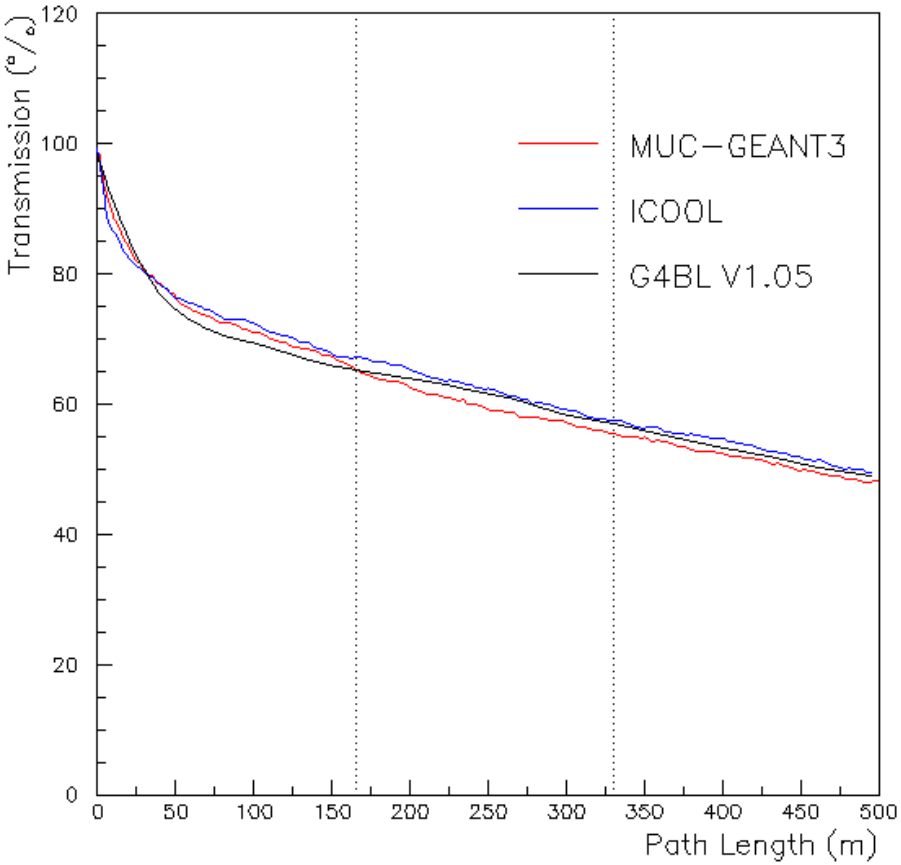


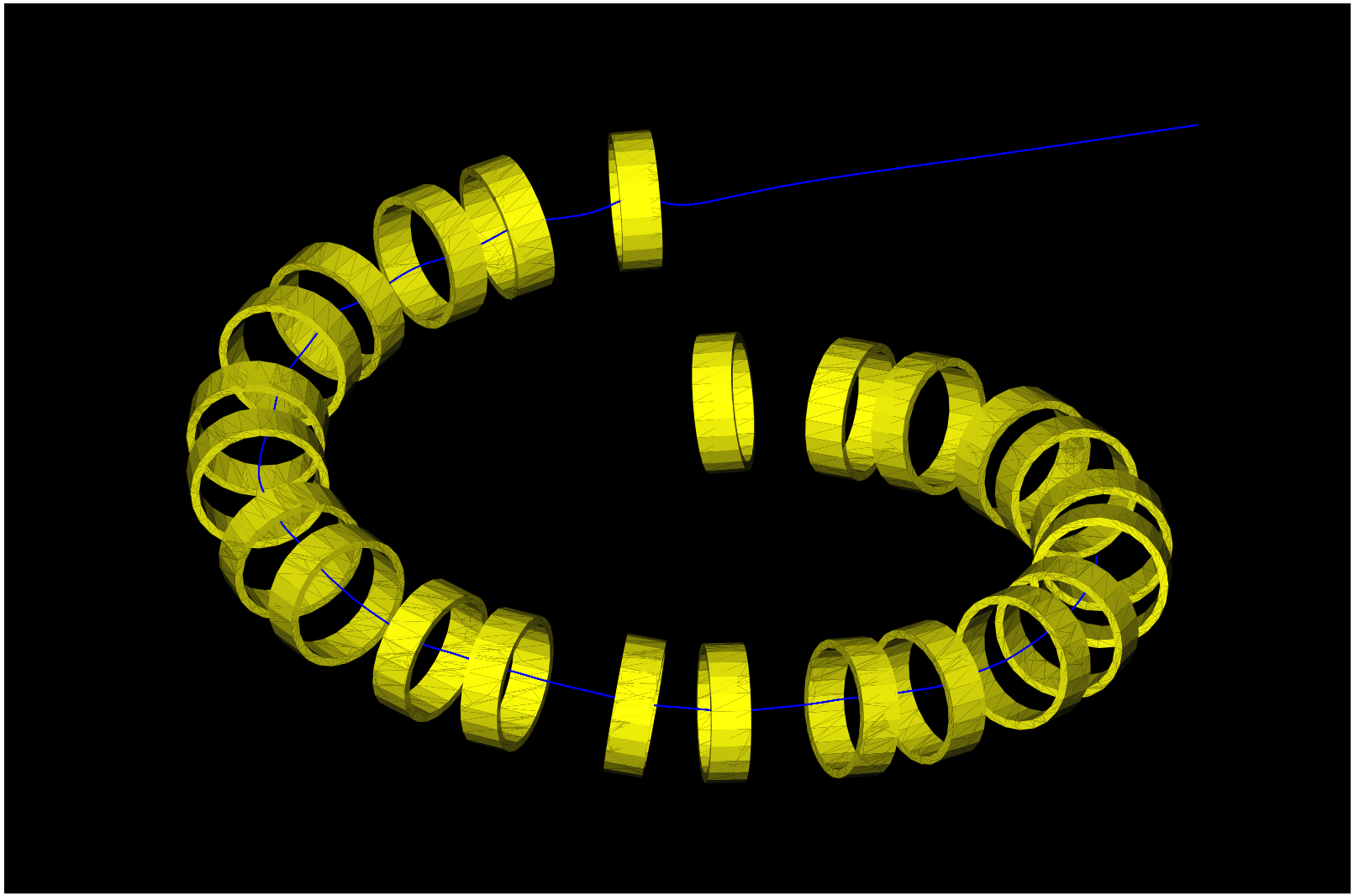
# Cooling simulation (II)

## Perfect agreement (latest version)



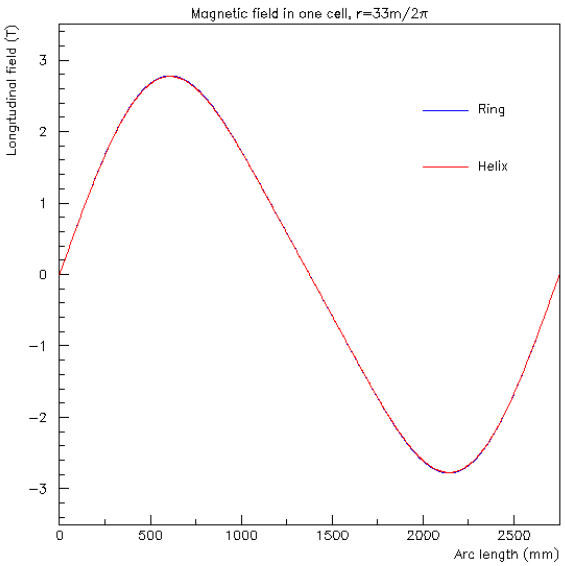
# Guggenheim geometry (solenoids only)



# Changes in magnetic field

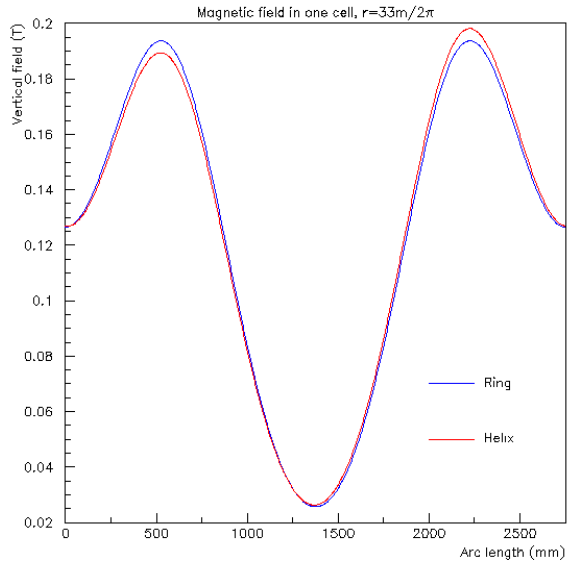
## Longitudinal

agrees well



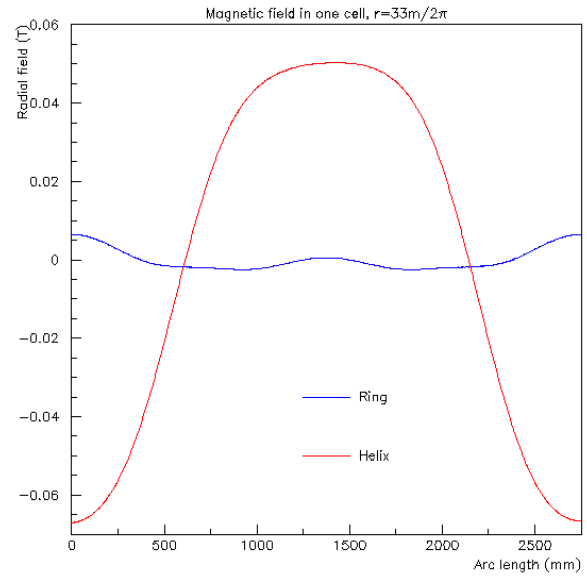

## "Vertical"

asymmetry!




## Radial

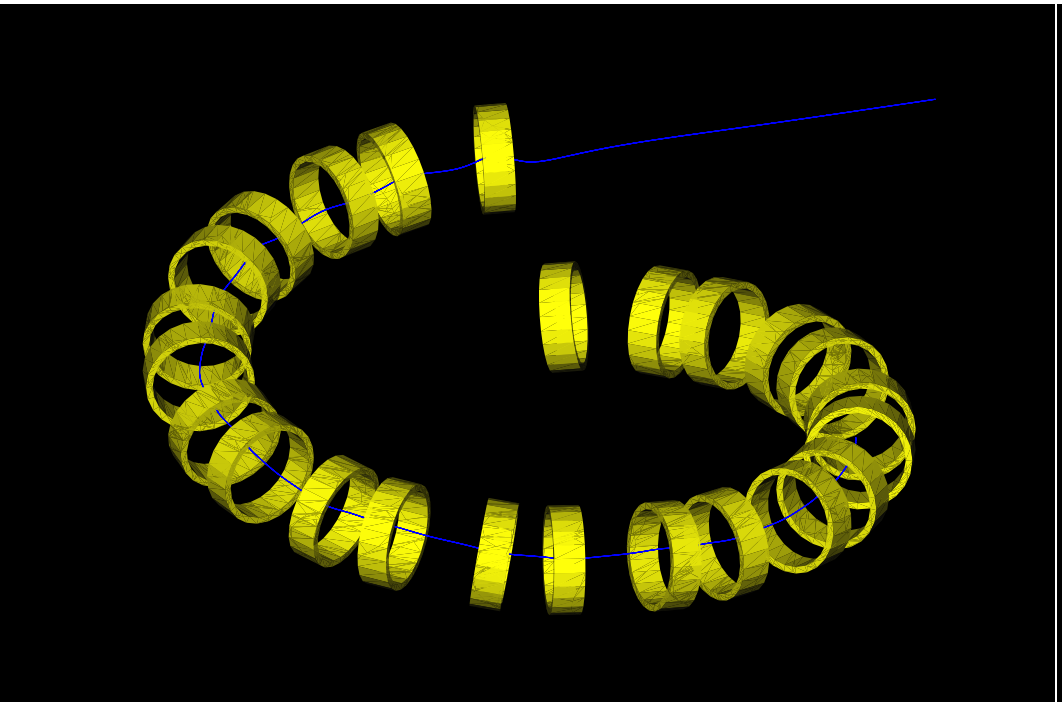
big change!

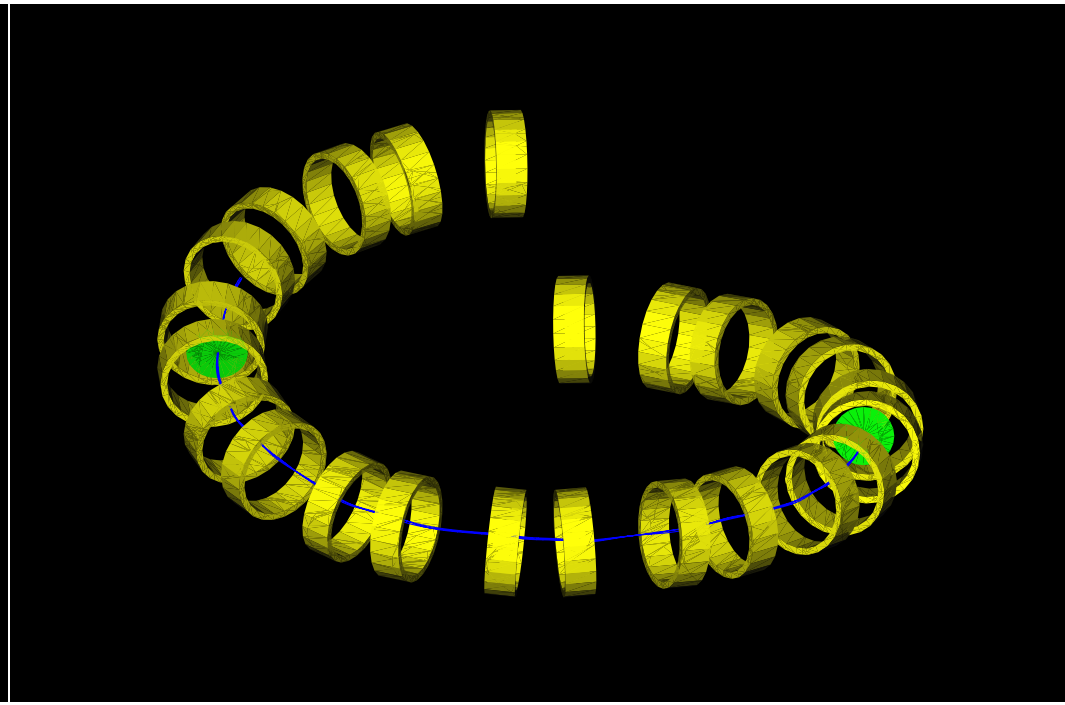



(still very small)

# Trying to preserve symmetry

- Use half-ring as basic unit



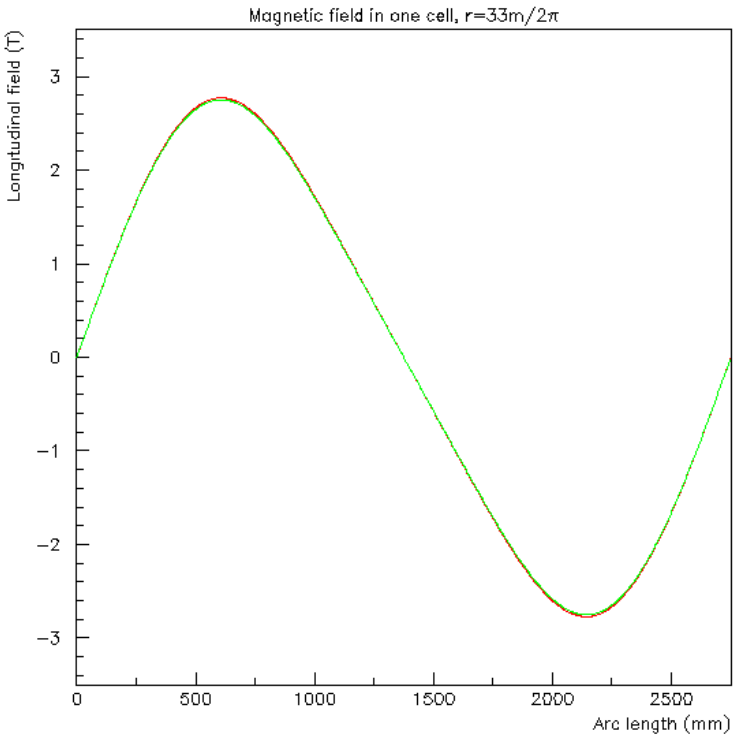


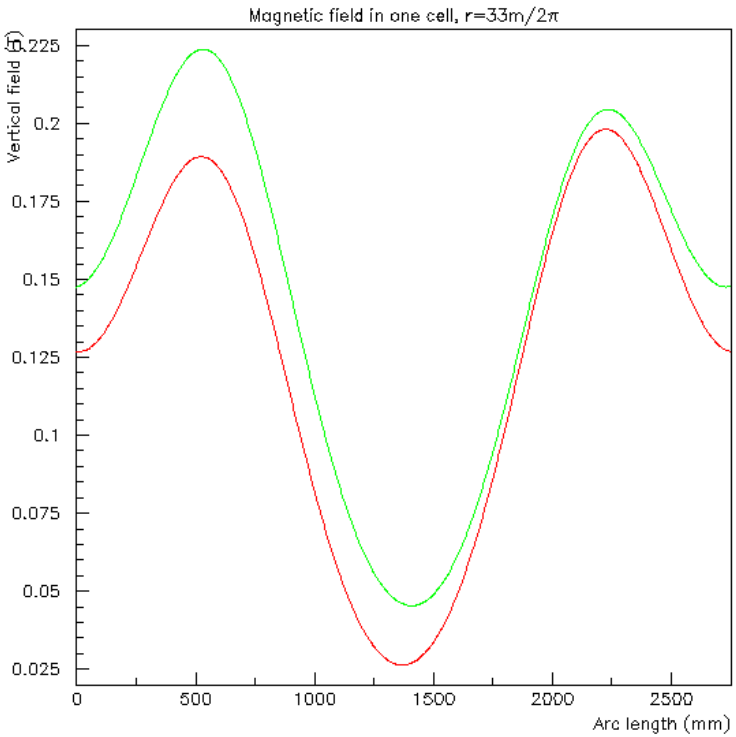
This idea was abandoned (for now)

# The effect of “ring stacking”

- 3-m pitch “stack” vs. single layer

  no shielding (impossible to generate in G4BL)

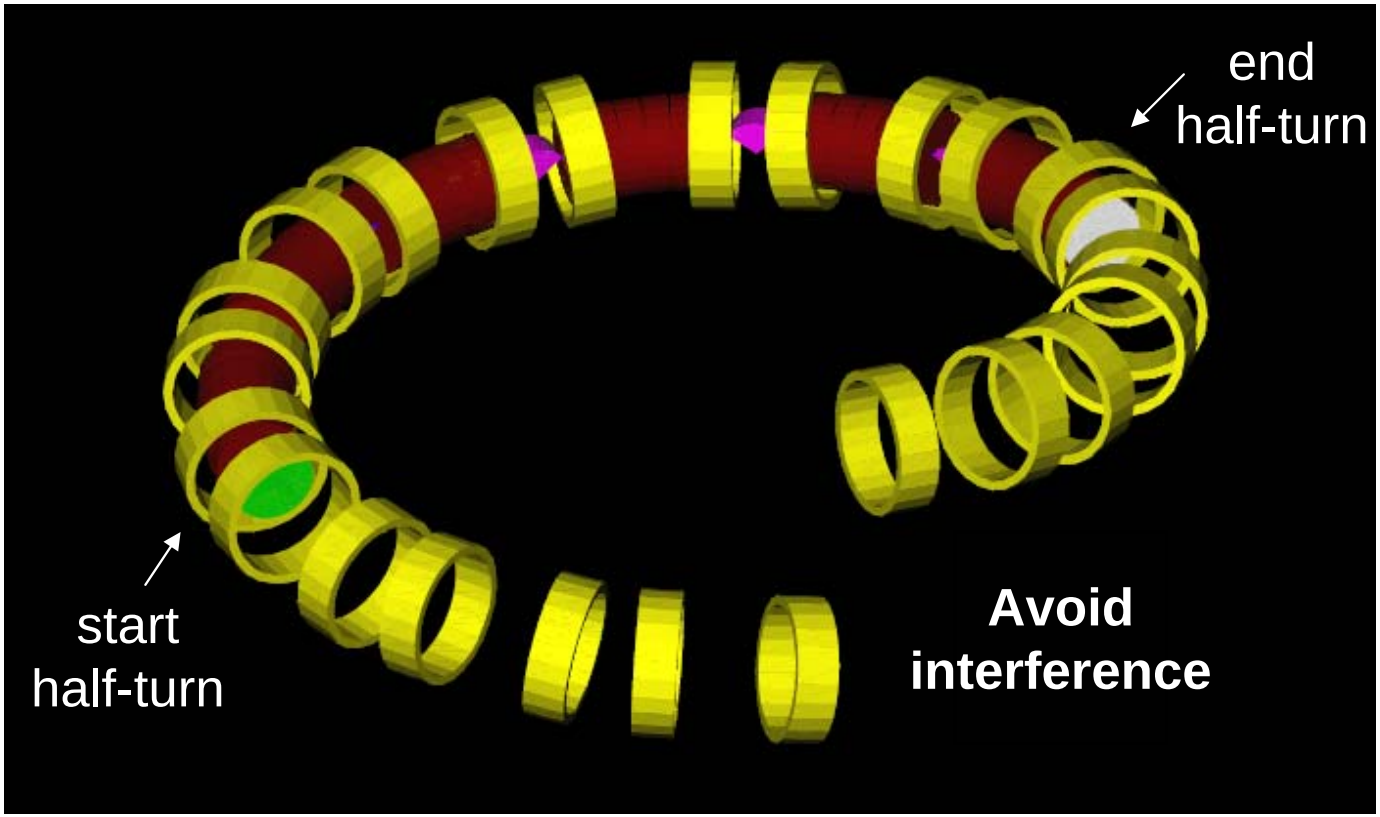


# End of introduction - Now the news

# Introduce RF to Guggenheim

- Simulate a single layer (12 cells), but fill only 6 of them with cavities & absorbers

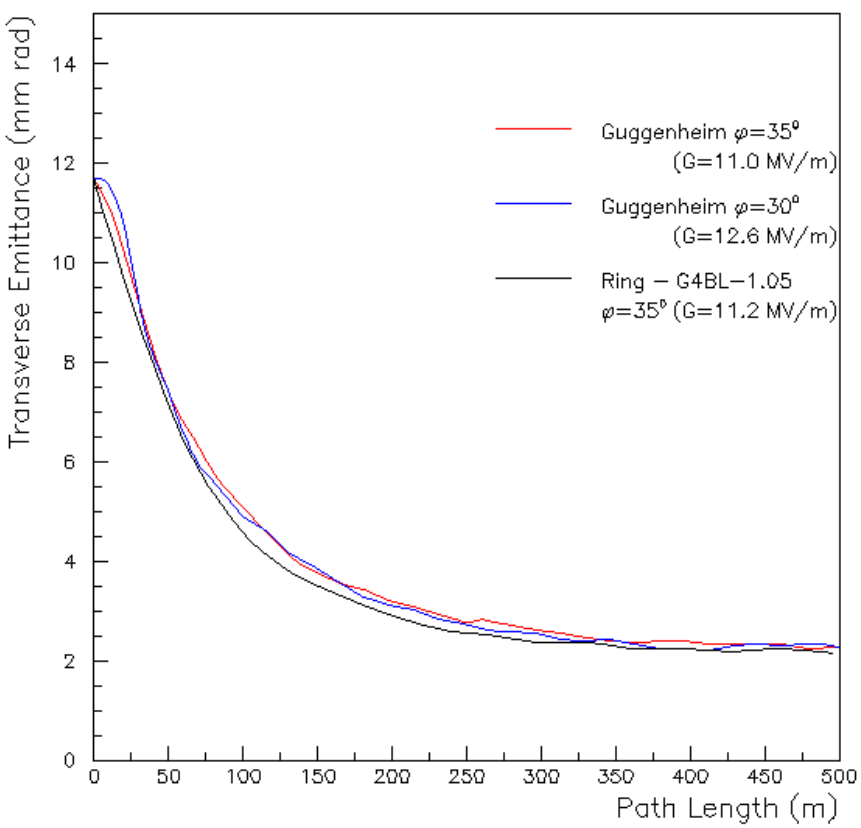


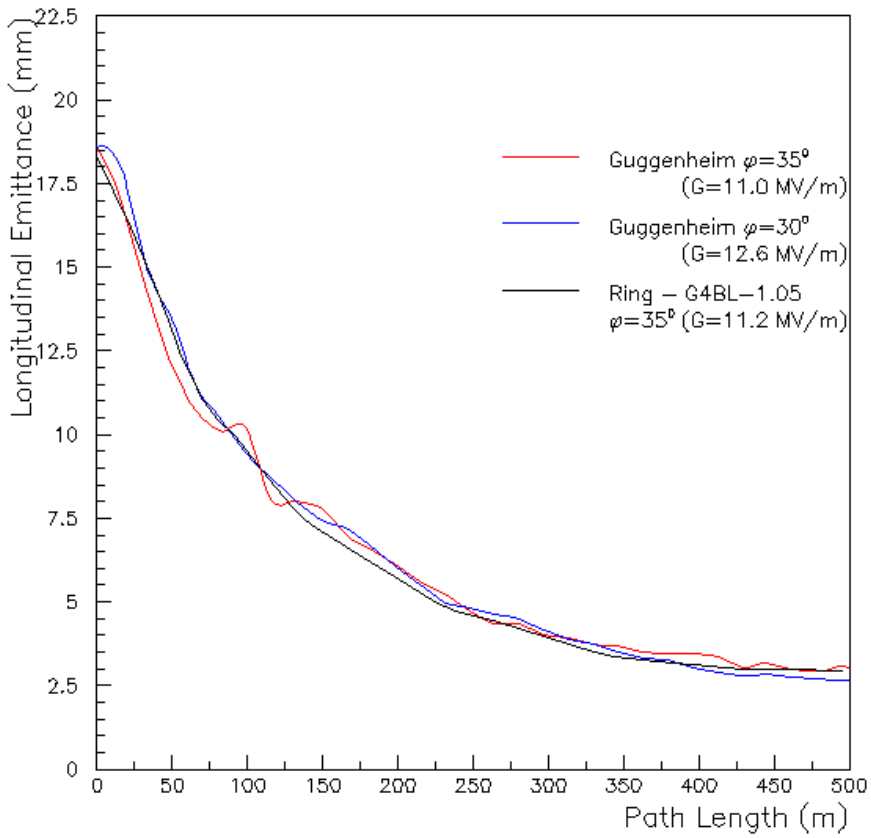

3 m
pitch

(circ.=33m)

# Performance (I)

- Beam from R. Fernow (1000 muons used)
  - beam is rotated by helix “slope”

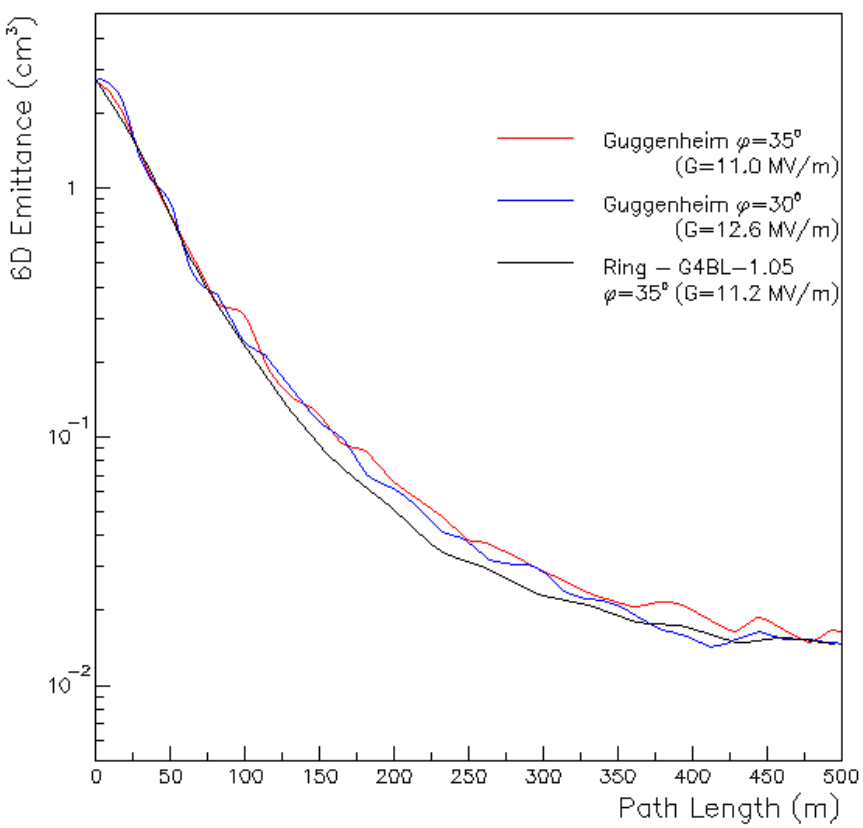


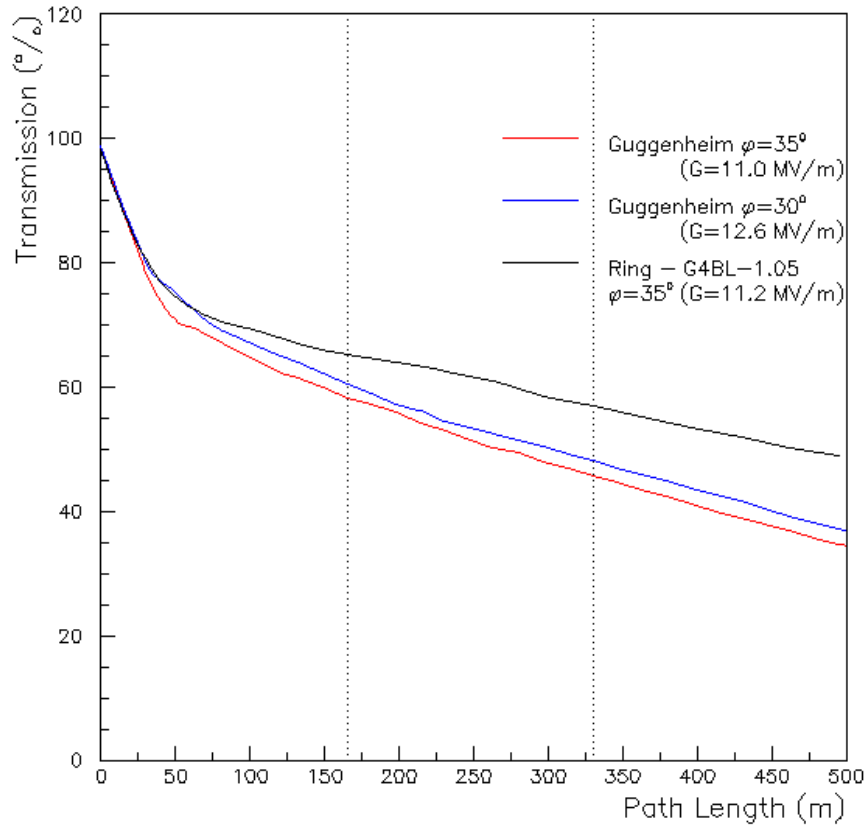



# Performance (II)

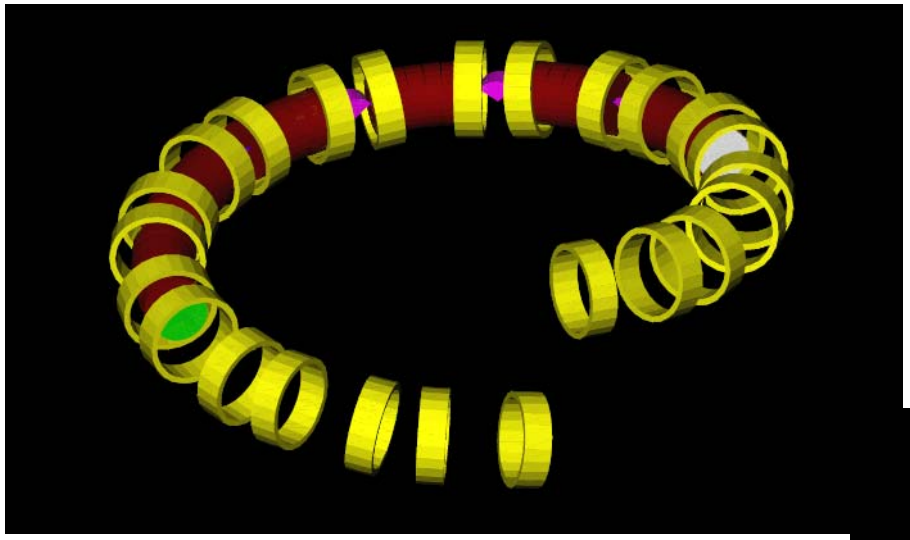
transmission falls!

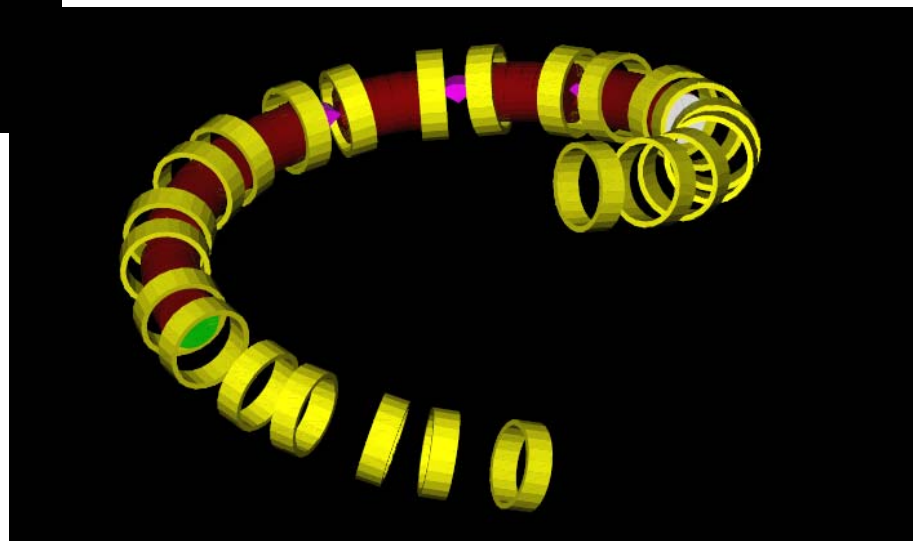
(higher gradient seems a little better)



# Increase pitch to 6 m

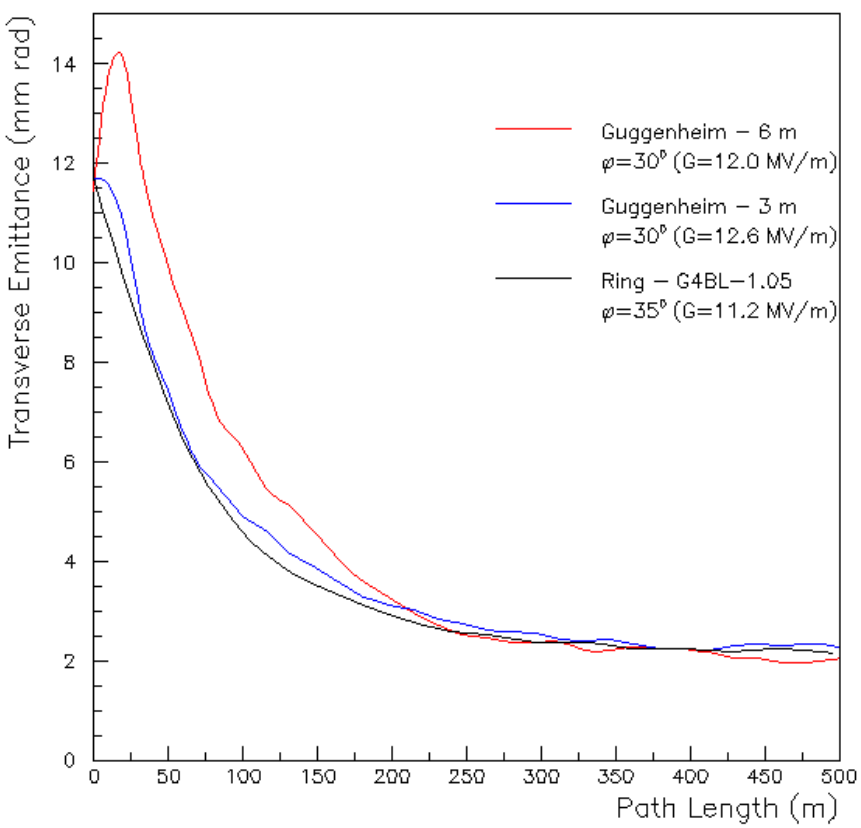


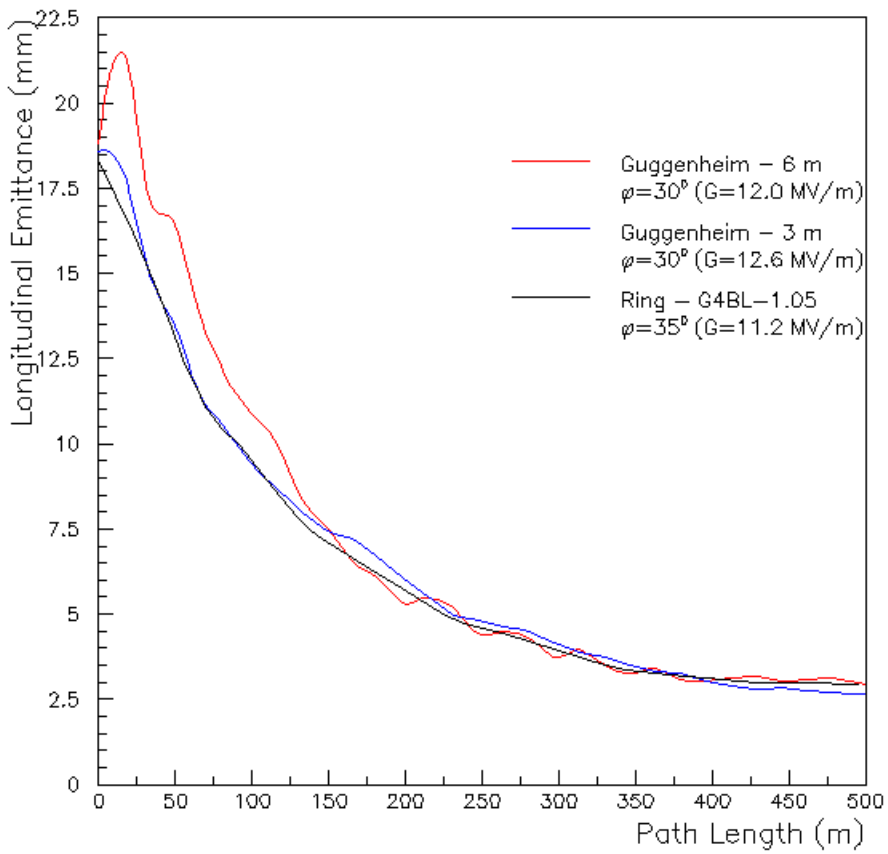


6 m

# Results – 6 m

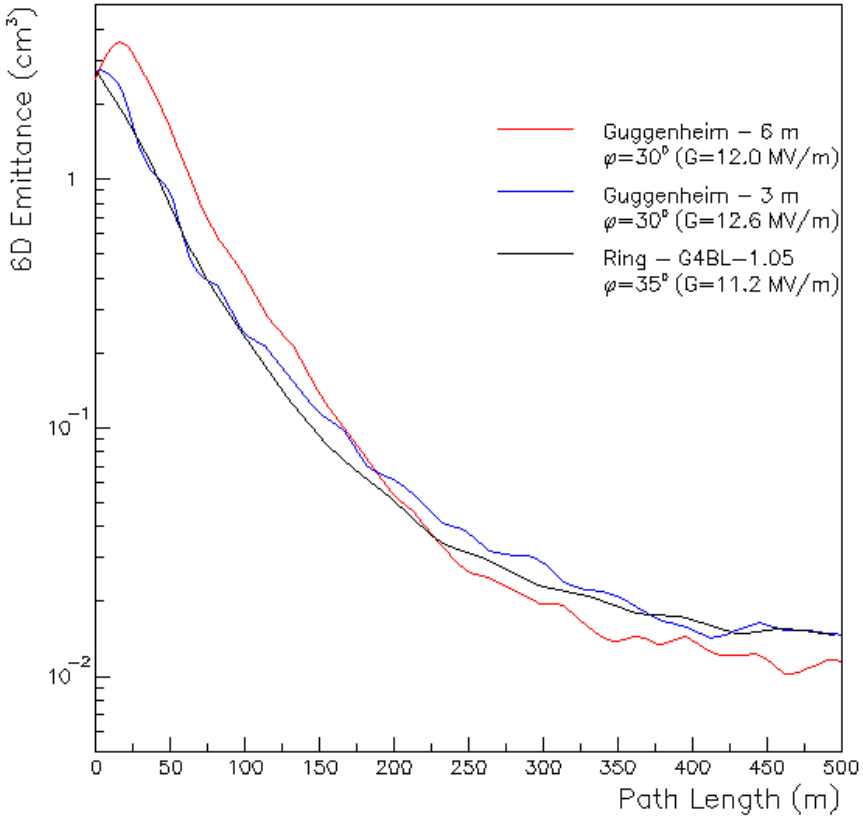
Looks like a mismatch (both transverse & long.)

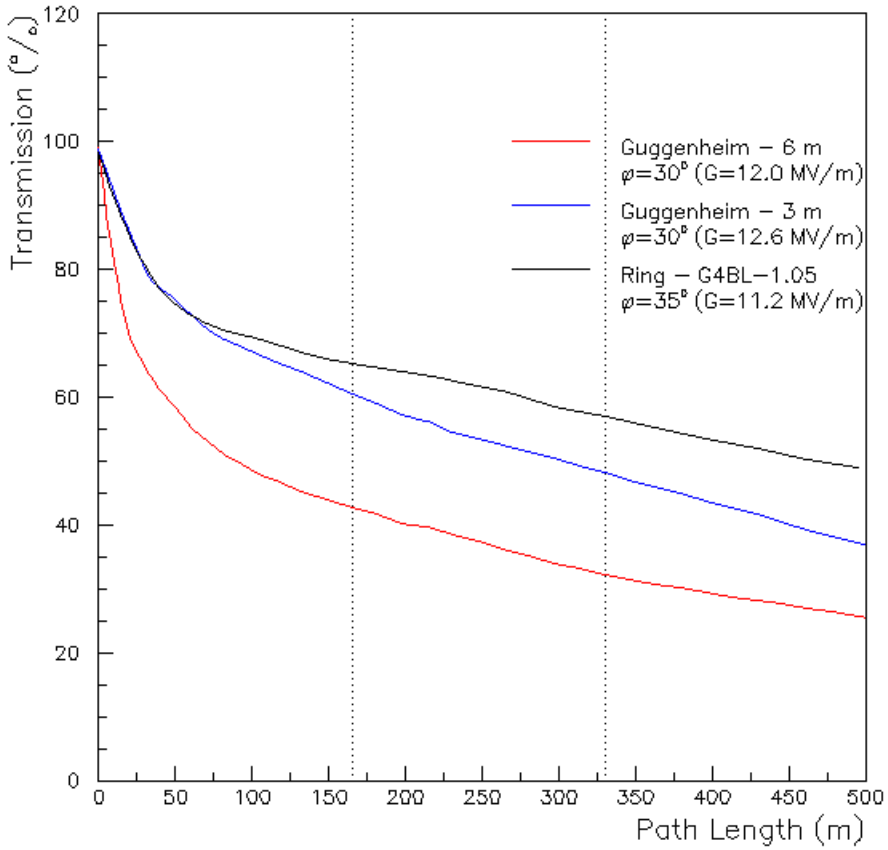


# More results – 6 m

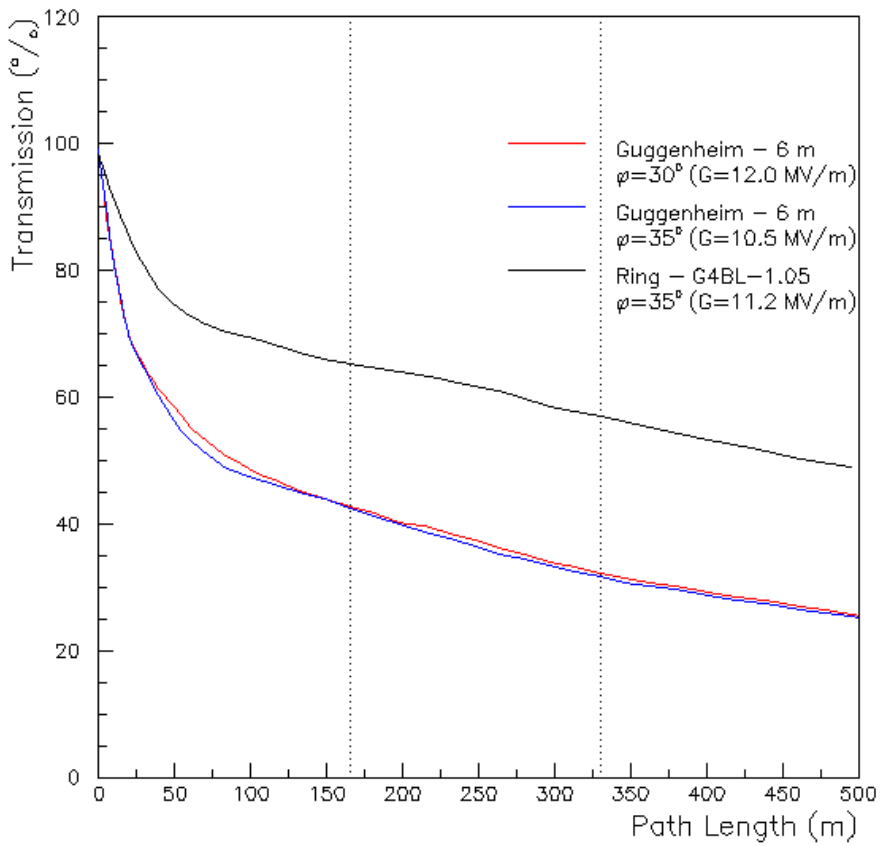
transmission even worse!



# Some more 6-m results

Changing gradient has little effect on transmission here



# Software problems

- Things take too long...
  - I experience difficulty feeding output as input, and have to do it manually (quite distressing)
    - TJR is aware of the problem and trying to fix it
  - Due to complex fields and the fact that each coil has to be felt **everywhere**, running is very slow – Average muon takes ~1 sec to complete **half turn**
  - ...and that's without windows

# The future

- Understand (solve!) transmission/matching problem
- Use G4BL simulation to design a complete cooling channel
  - More realistic: include RF & absorber windows
  - Simulate smaller helixes (402, 805 MHz) and match between stages (incl. bunch merging)
  - Design a realistic 805-MHz helix (R.Palmer?)

# The future (my perspective)

- I'm  leaving in a week, but the work isn't done...
- I intend to write documentation in a note/paper
- My future job in Israel is in ATLAS, but I would like to work on muon cooling, if time permits
  - Not clear yet how much time, if at all, I'll be able to spend on it, and in what framework (MICE?)
- Even if I'm unable to continue, I will help whoever takes over the job
- The future (as in muon collider) seems brighter now than it was when I started this job 3 years and 9 months ago. Keep on the good work!