Recent Progress on Guggenheim Simulations

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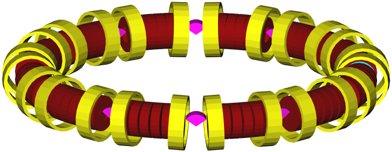
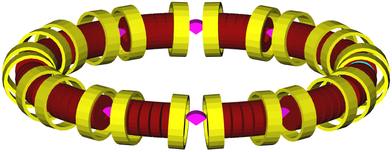
RFOFO ring & helix

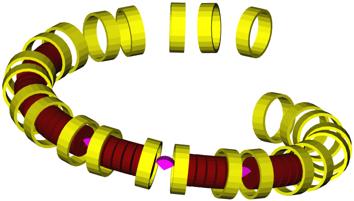


- RFOFO ring

RFOFO ring & helix



- RFOFO ring



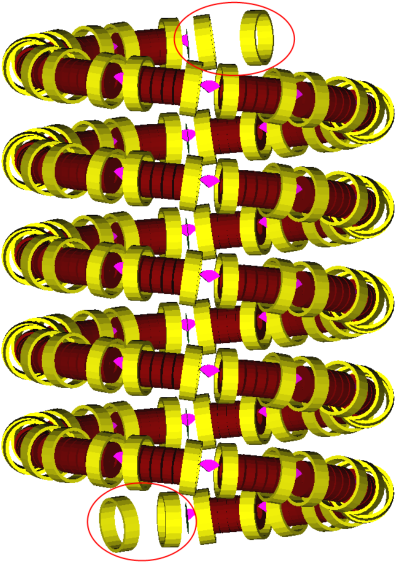
- RFOFO helix

RFOFO ring & helix

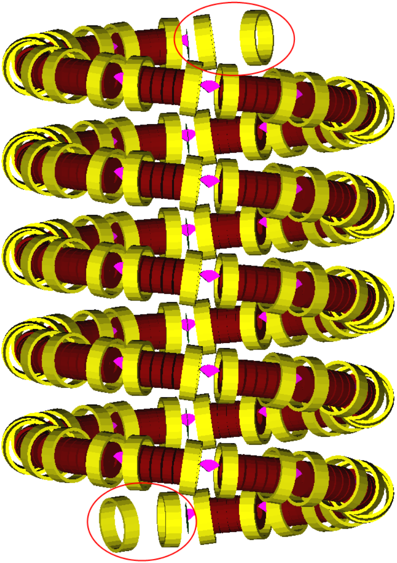
Table: RFOFO and Guggenheim parameters

	RFOFO	Guggenheim
Circumference, [m]	33.00	33.00
Pitch, [m]	0	3.00
Pitch angle, [deg]	0	5.22
Radius, [mm]	5252.113	5230.365
Maximum axial field, [T]	2.77	2.80
Coil tilt (wrt orbit), [deg]	3.04	3.04
Average momentum, [MeV/c]	220	220
Reference momentum, [MeV/c]	201	201
RF frequency, [MHz]	201.25	201.25
RF gradient, [MV/m]	12.835	12.621
Absorber angle, [deg]	110	110
Absorber thickness on beam axis, [cm]	27.13	27.13

Multilayer scheme

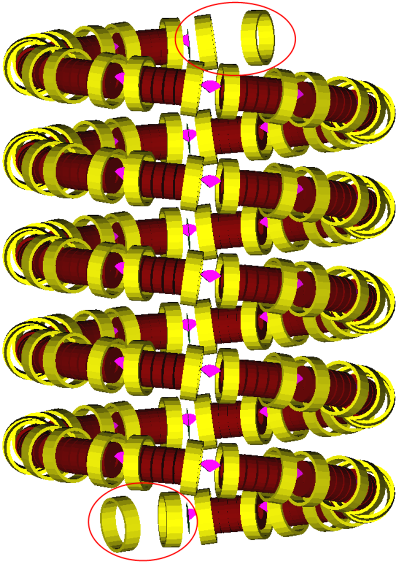


Multilayer scheme



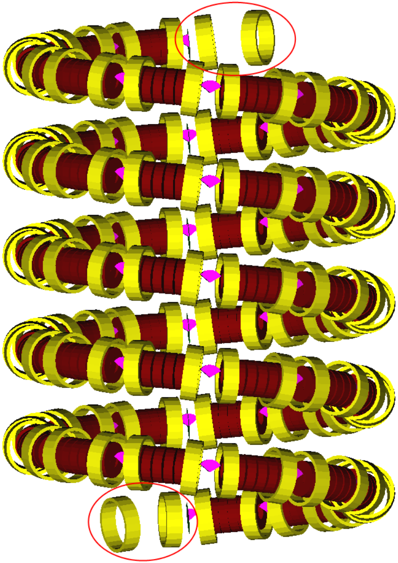
- 5 layers = 165 m

Multilayer scheme



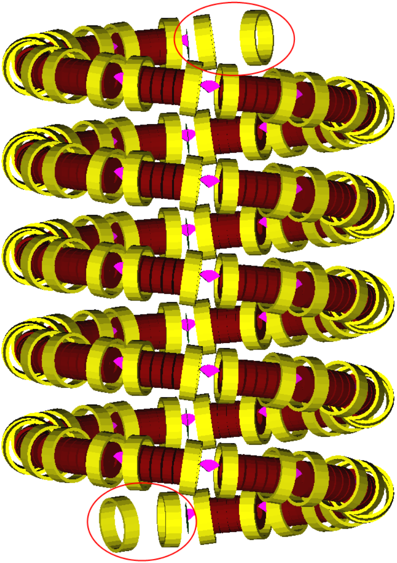
- 5 layers = 165 m
- no shielding between layers

Multilayer scheme



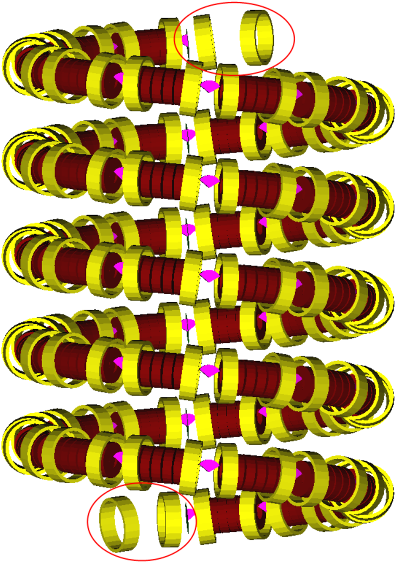
- 5 layers = 165 m
- no shielding between layers
- no shielding of outer layers

Multilayer scheme



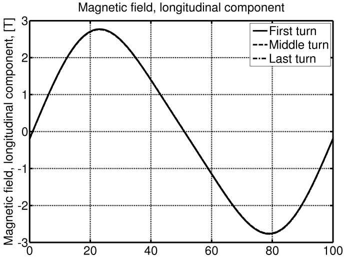
- 5 layers = 165 m
- no shielding between layers
- no shielding of outer layers
- the magnetic field at any point of the trajectory is generated by all the coils

Multilayer scheme

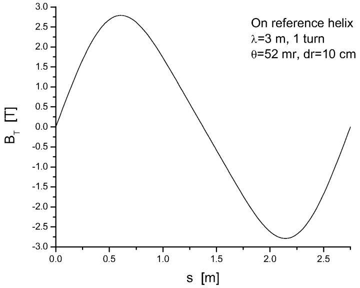


- 5 layers = 165 m
- no shielding between layers
- no shielding of outer layers
- the magnetic field at any point of the trajectory is generated by all the coils
- compared to the case with shielding between layers

Longitudinal component

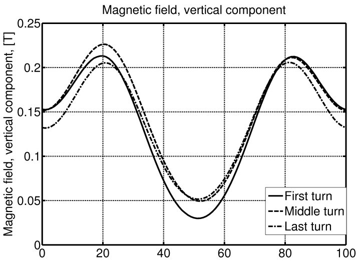


- G4Beamline

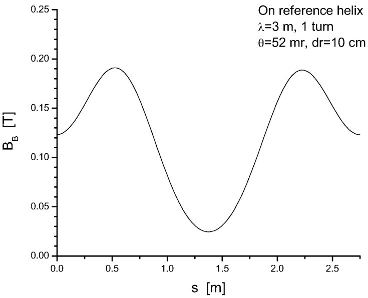


- ICOOL

Vertical component

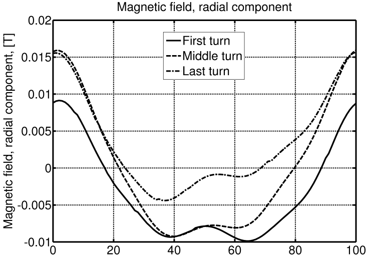


- G4Beamline

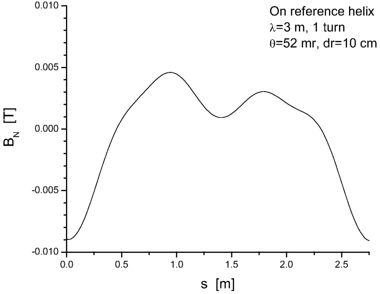


- ICOOL

Radial component

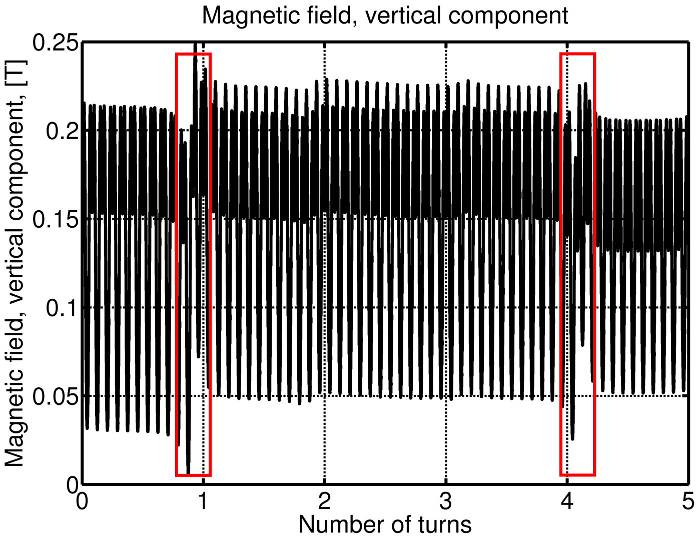


- G4Beamline



- ICOOL

Multilayer vertical component

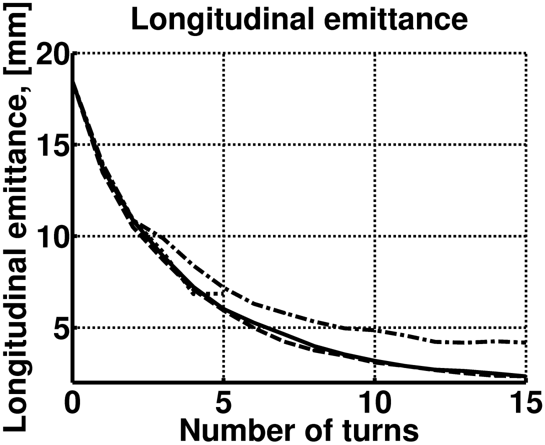


Performance characteristics compared

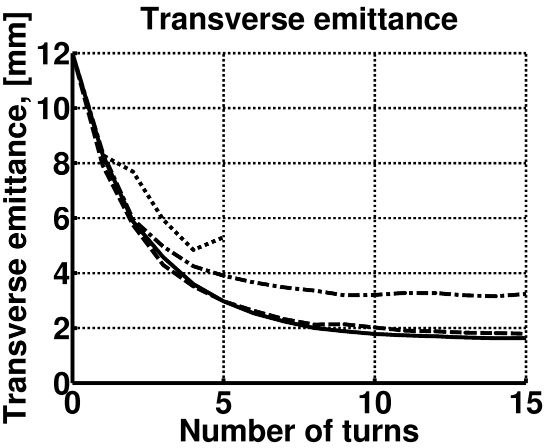
Four simulations are considered:

- Original RFOFO lattice
- Ideal Guggenheim (shielding between layers, single turn)
- "Realistic" Guggenheim (shielding between layers, single turn, RF cavities with windows, absorbers with windows)
- 5-layer Guggenheim (no shielding, all 5 layers contributing, all windows)

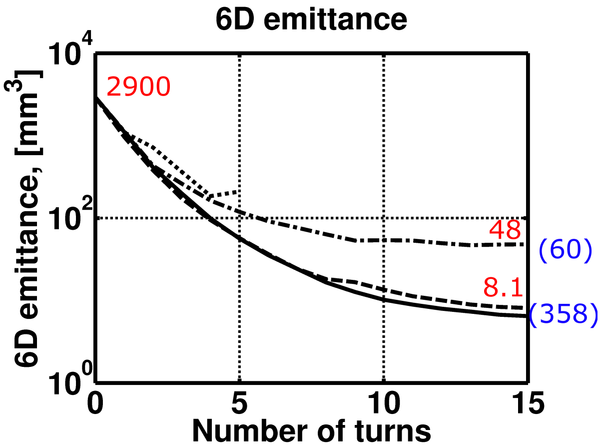
Longitudinal emittance



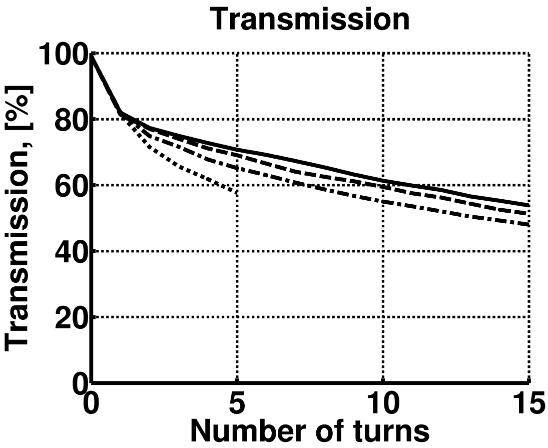
Transversal emittance



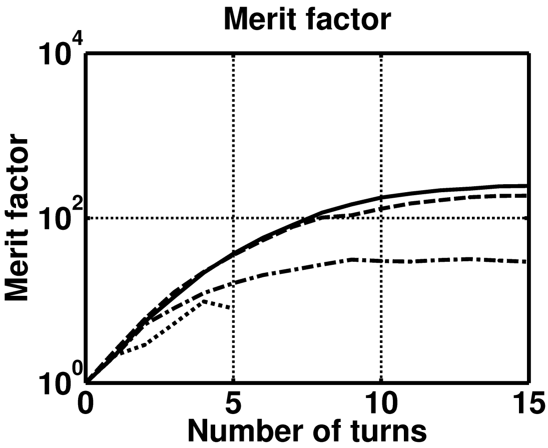
6D emittance



Transmission



Merit factor



		Structure			
Parameter	Turn #	RFOFO ideal	Guggenheim ideal	Guggenheim realistic	Guggenheim 5 layers
σ_x [mm]	0	41.79	41.79	41.79	41.79
	5	25.48	27.05	28.81	30.72
	10	19.62	20.74	25.58	-
	15	18.71	19.47	26.60	-
σ_y [mm]	0	42.86	42.86	42.86	42.86
	5	24.14	27.72	30.10	38.08
	10	18.61	21.74	27.77	-
	15	18.24	20.81	26.73	-
σ_p [MeV/c]	0	27.85	27.85	27.85	27.85
	5	11.80	12.00	13.58	12.79
	10	7.98	8.40	11.55	-
	15	7.37	7.45	10.83	-
σ_t [ns]	0	0.298	0.298	0.298	0.298
	5	0.235	0.237	0.261	0.364
	10	0.171	0.166	0.201	-
	15	0.143	0.144	0.185	-

Table: Decrease in variance for different models

6D Cooling

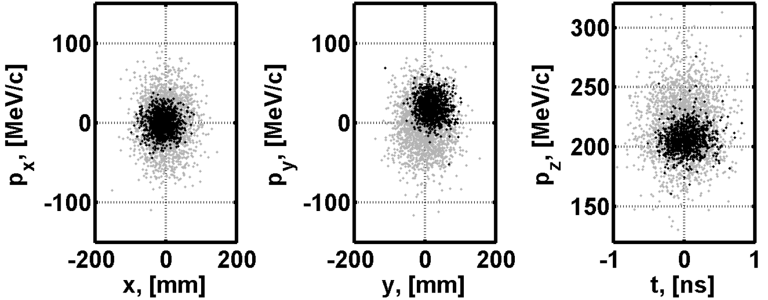
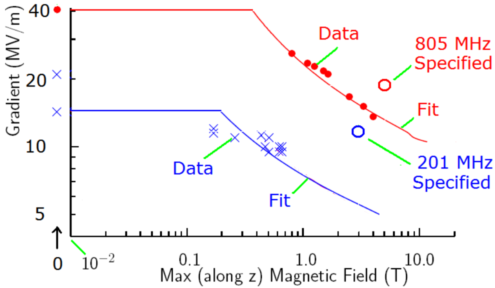


Figure: Reduction in the 6D phase space due to cooling. Gray – initial distribution, black – after 15 turns in the realistic Guggenheim cooling channel (495 m).

rf Breakdown problem

- Current design will not work
- High pressure gas HCC may work
  - Effect of beam unknown
  - Integration of rf still a problem



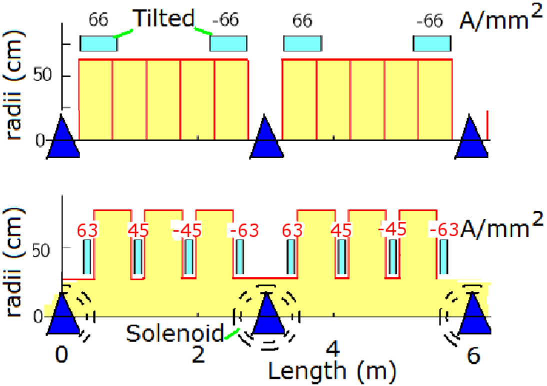
For Vacuum rf

- Bucking the field at rf should work
  - Are losses a problem ? see below
- Magnetic insulation should work
  - Are losses a problem ? see below

Magnetically insulated RFOFO lattices

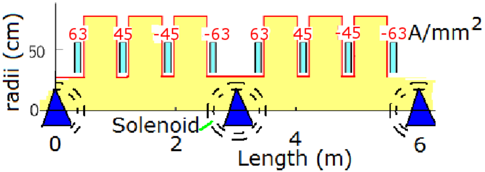
Old RFOFO
with coils outside

Approximated
lattice using
coils in open irises

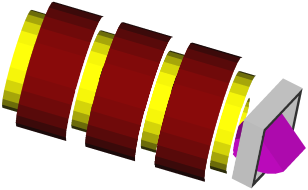


This is not quite the magnetically insulated lattice, since it does not have the outer reverse coils, but the fields on axis will be very similar

One cell of the open cavity lattice as simulated

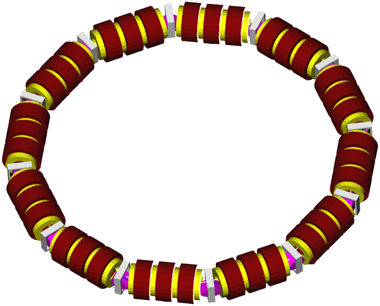


- Scheme



- G4BL Simulation

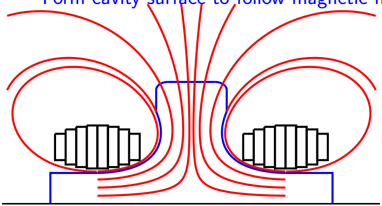
Local bending vs uniform bend

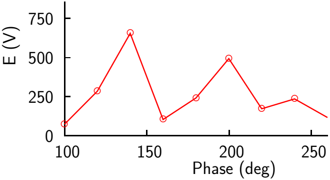


- Straight cells + 30 deg bend
- Curved cells + uniform bend

Magnetic Insulation

Form cavity surface to follow magnetic field lines





- All tracks return to the surface
- Energies are very low
- No dark current, No X-Rays !
- No danger of melting surfaces
- But secondary emission $\longrightarrow$ problems ?
- Grateful to SLAC for help
- This cavity is inefficient $\mathcal{E}_{\text{surface}} \approx 4 \times \mathcal{E}_{\text{acc}}$
  Not acceptable

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Summary

- "Classical" Guggenheim: 50% transmission, 60 times 6D emittance reduction with shielded layers + RF windows + absorber windows.
- RF breakdown problem.
- Open cavity + eventually magnetically insulated lattice = possible solution.
- Open cavity lattice performance is being studied in G4Beamline.
- Prospective: simulate magnetically insulated cavity lattice using Superfish-generated field map for RFs.