Guggenheim with realistic fields

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Introduction

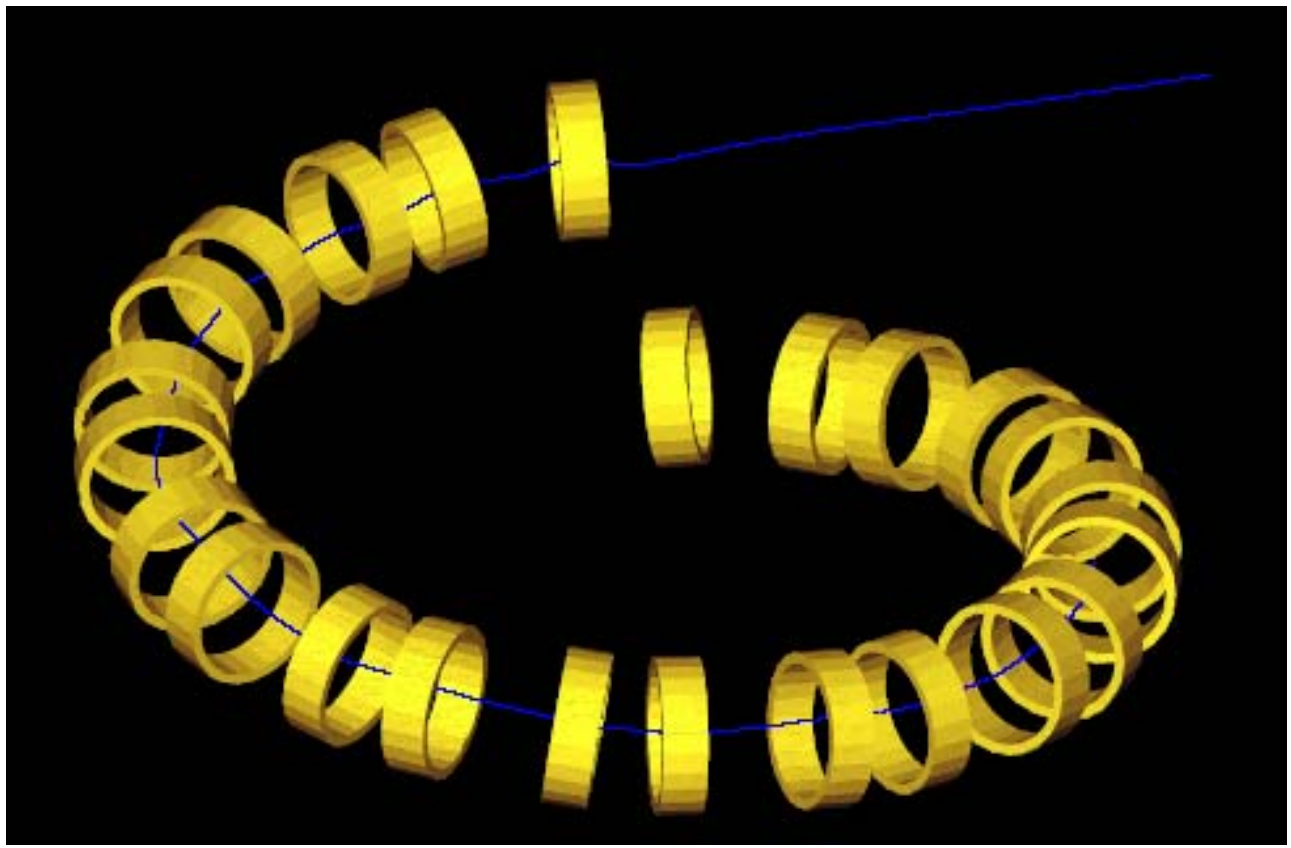
- first realistic modeling of Guggenheim channel
  - done by Amit Klier in 2006
  - using G4Beamline
  - work continued by Pavel Snopok et al
- ICOOL simulations of Guggenheim channels
  - 1) ignore helical nature of channel (assume helix ≈ ring)
  - 2) use skew dipole term in a multipole expansion
- found inconsistencies using multipole expansion technique
- => use 3D map feature in ICOOL
- need procedure for creating accurate 3D map

GUGMAP

- wrote new code to make maps from RFOFO-like lattices
- starts with simple user input
- positions and orients solenoids along reference helix
- makes superposition of solenoid fields on cylindrical grid
  => no shielding considered
- solenoid field calculated using elliptic integrals
- calculates fields in Frenet and cylindrical coordinates
- has Biot-Savart routine for checking results
- checks Maxwell's equations at all interior grid points
- checked that pitch=0 reproduces RFOFO fields

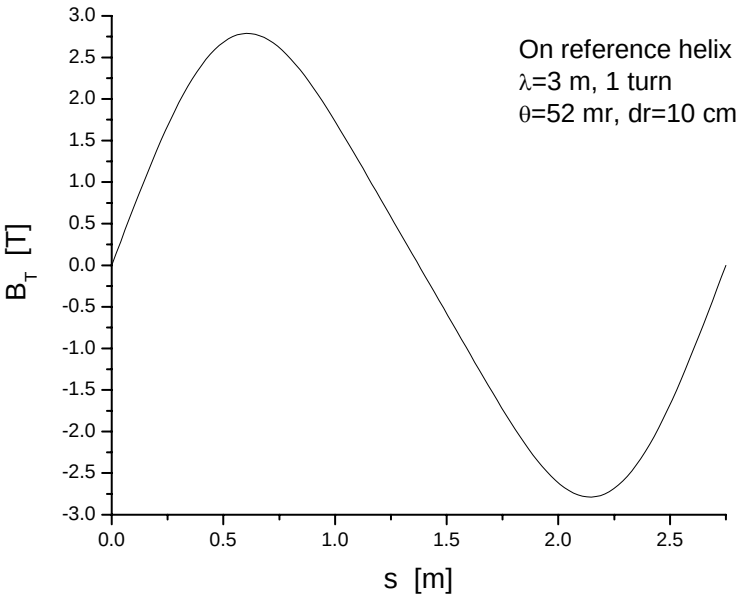
Guggenheim channel

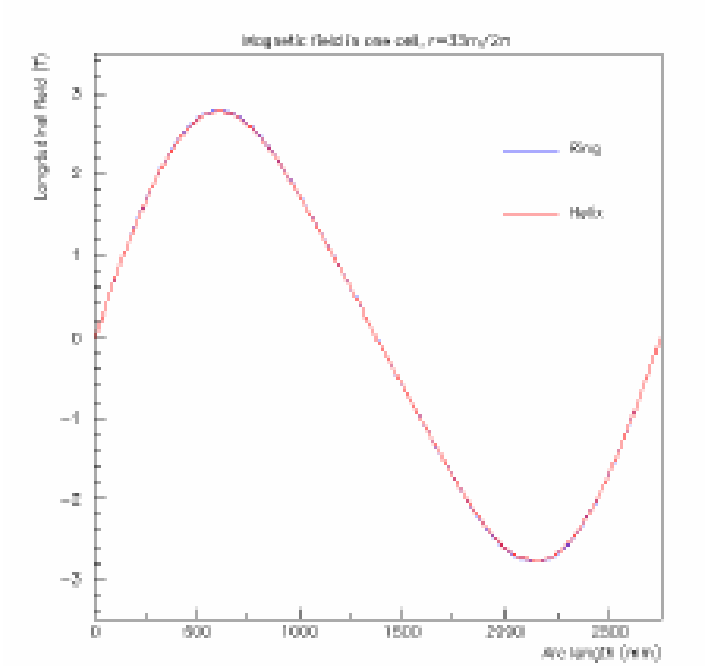
- G4Beamline model of one turn of the channel
- pitch = 3 m



(Amit Klier)

Longitudinal component

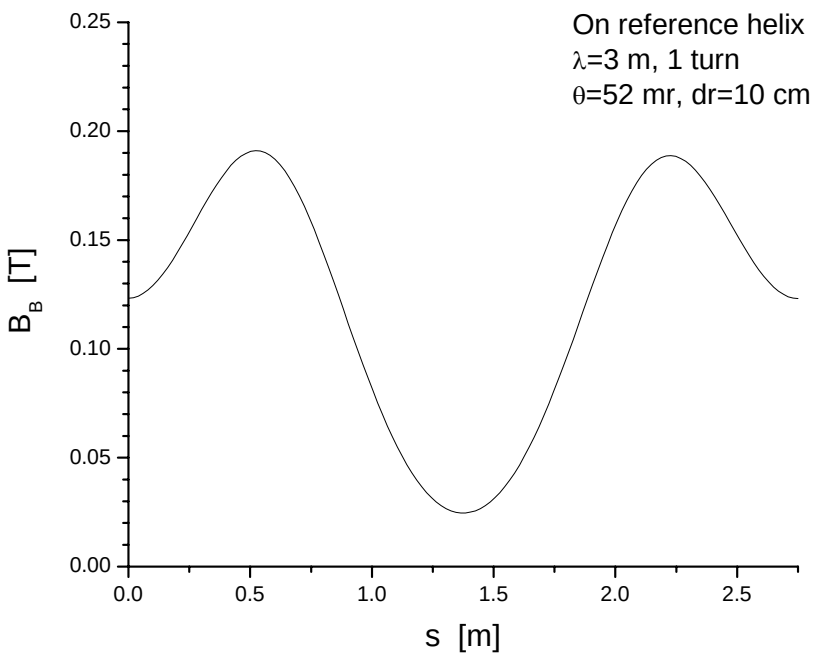


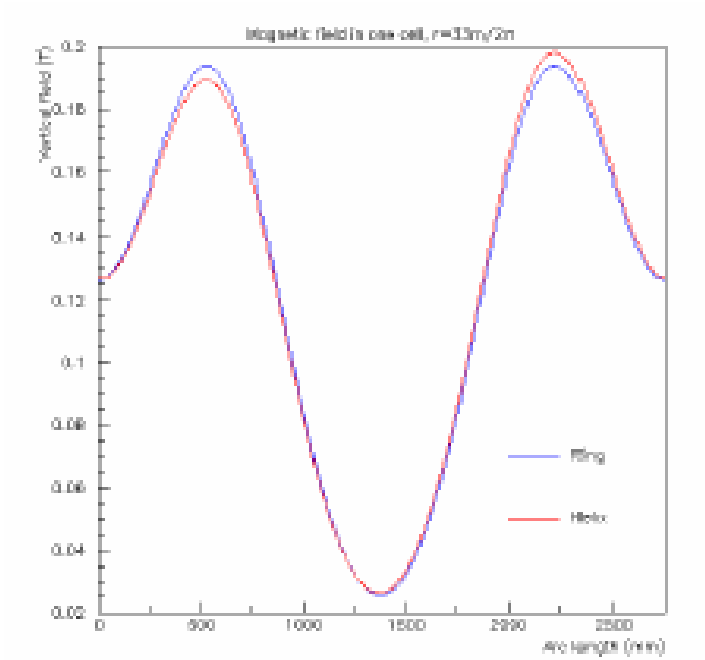


(Amit Klier)

- good agreement

“Vertical” component

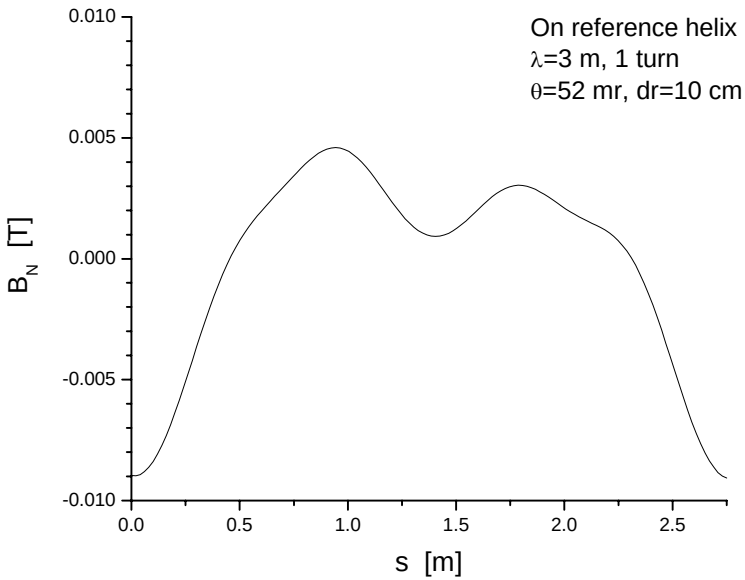


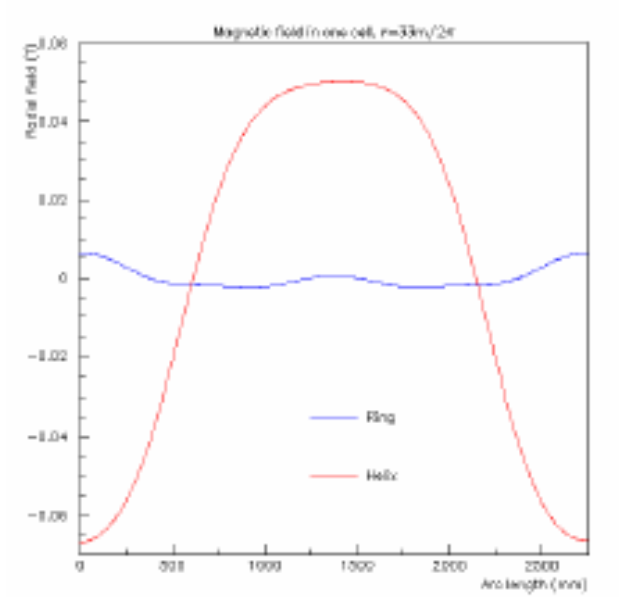


(Amit Klier)

- bi-normal direction in Frenet coordinates
- good agreement

Radial component





(Amit Klier)

- there is disagreement on the magnitude and detailed shape
- both codes agree the magnitude is much smaller than other components

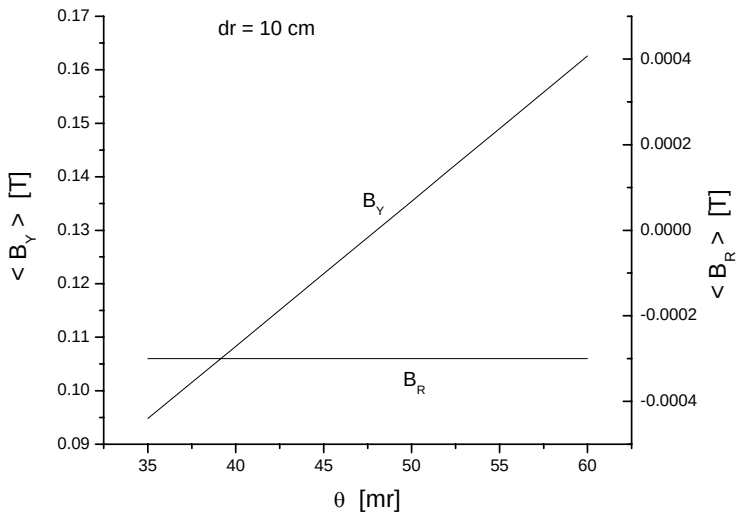
  => hopefully difference only introduces minor uncertainty on performance
- could be due to

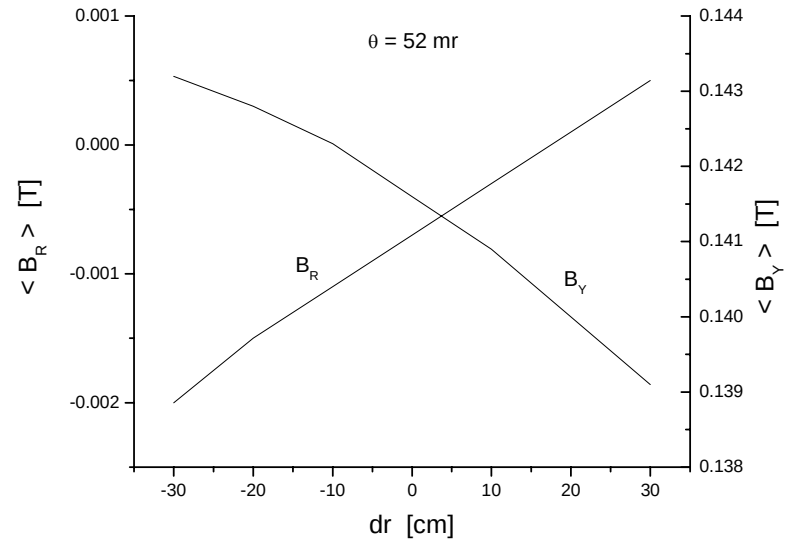
  error in calculating B

  or most likely in the exact layout of solenoids

Tuning the field

- adjust dip angle to get $\langle B_Y \rangle$ to correspond to radius of helix
- adjust radial offset of coils to get $\langle B_R \rangle \approx 0$





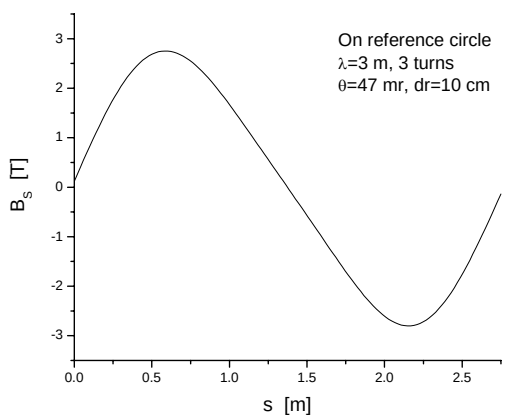
- dip adjustment works fine
- radial offset adjustment

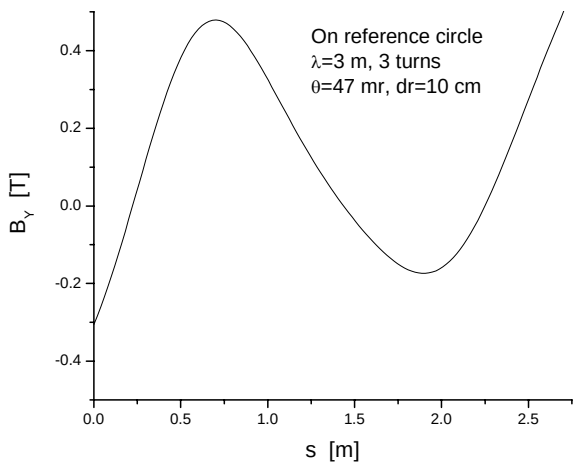
  gives $\langle B_R \rangle$ close to 0

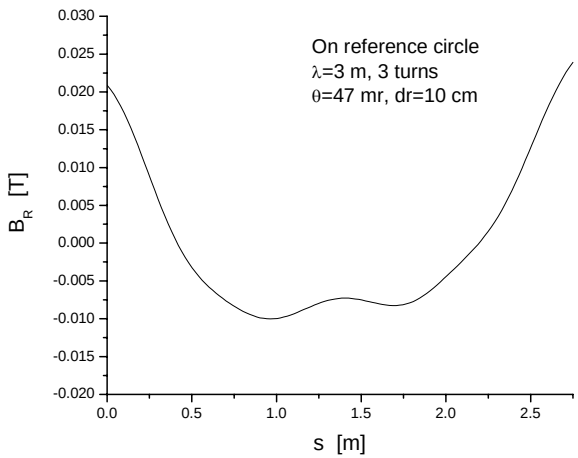
  also affects vertical field

Cylindrical grid

- compute field on 1 cm cylindrical grid
- use field in central cell in middle of 3-turn lattice
- takes ~2 hours to make grid



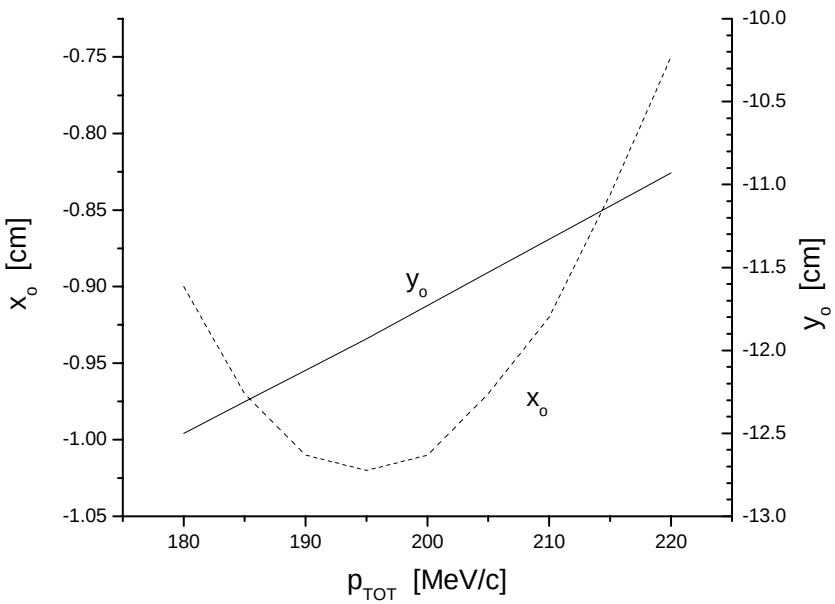


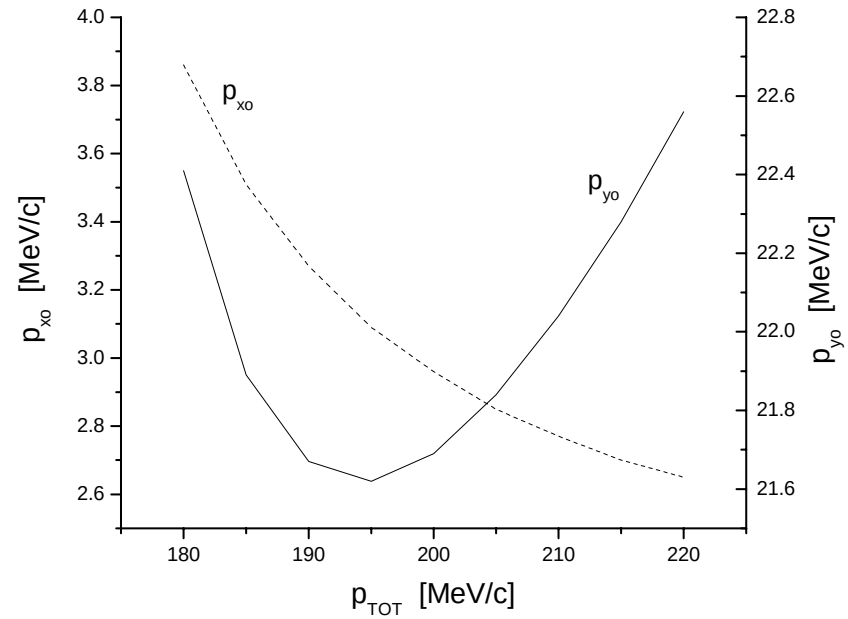


- on-axis components at center of grid

Periodic orbits

- periodic orbits determined with root-finding routine
- routine uses ICOOL tracking with the 3D map

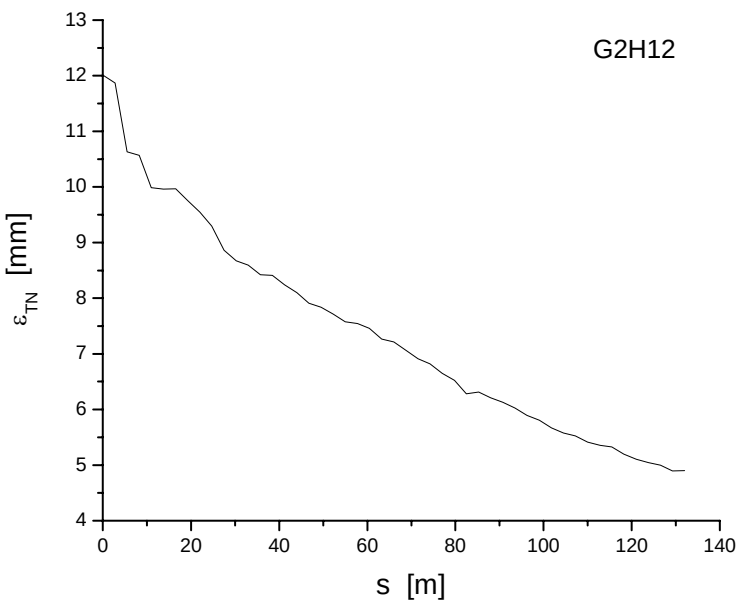


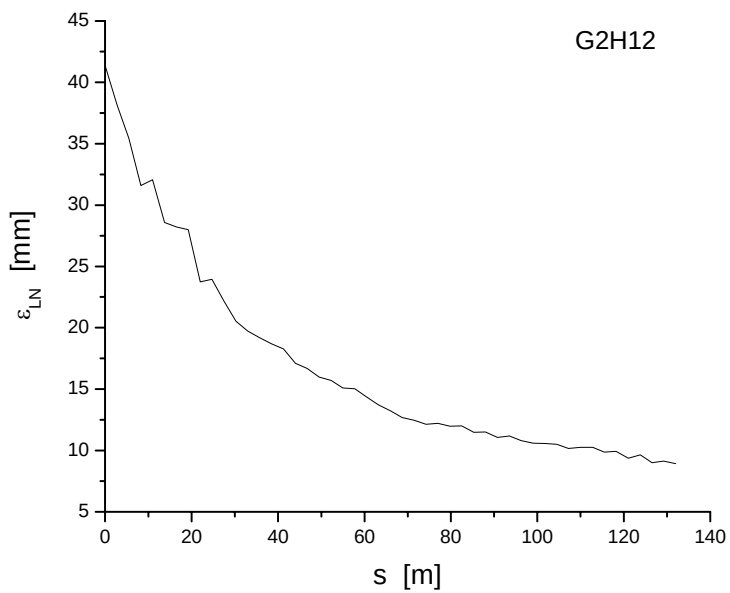


- finds good periodic orbits over wide range of p
- large initial vertical offset ~ -12 cm
- 3 m pitch => 25 cm vertical offset per cell

Performance

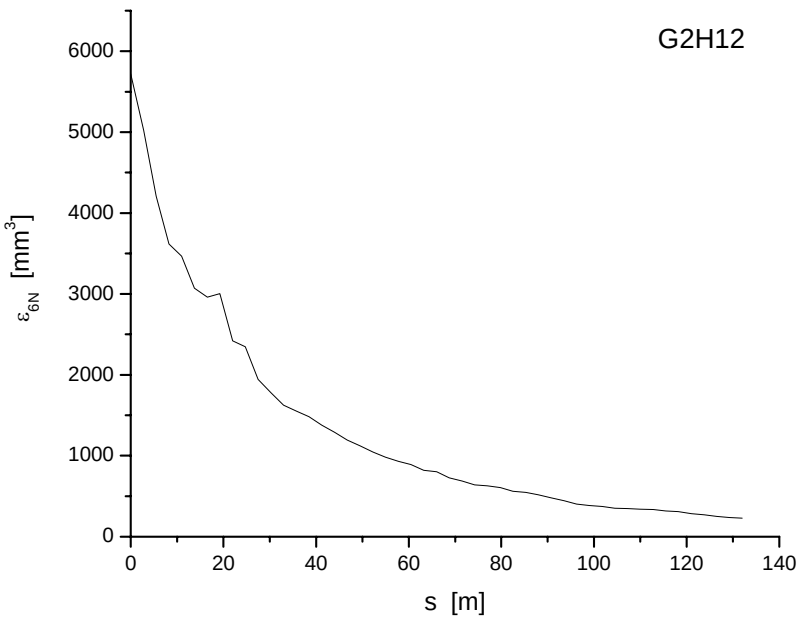
- look at 1st Guggenheim channel in Bob Palmer's collider scenario
- run ICOOL by repeatedly using new 3D map
  OK for interior of long channel, but ignores differences in end-cell fields
  the G4Beamline procedure of using all coils is more realistic
- adjust vertical position of all particles by 25 cm after each cell

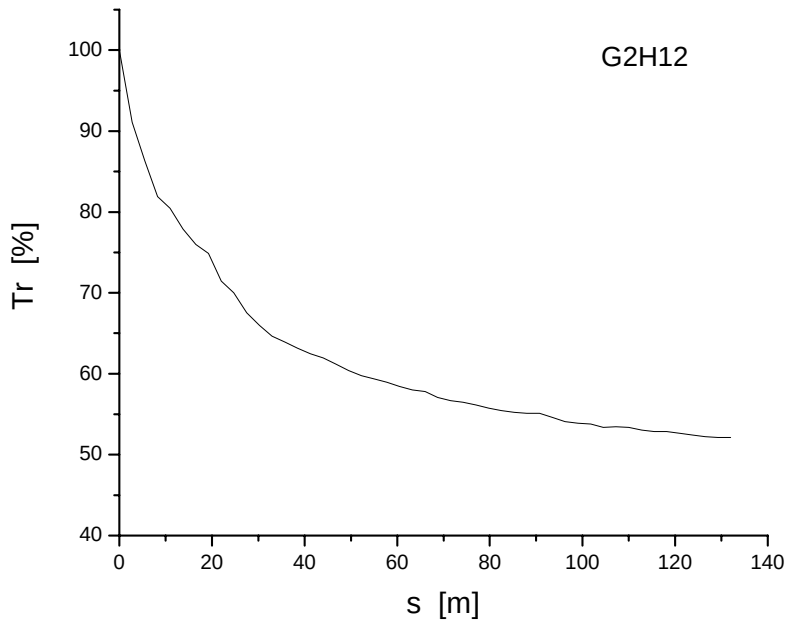




- transverse and longitudinal emittances reach scenario goal

Performance





- 6D emittance reduced by factor of ~25
  => good cooling
- overall transmission is ~50%
  => needs improvement

Summary

- can now study Guggenheim performance in ICOOL with realistic fields
- good agreement with G4Beamline on longitudinal and "vertical" components
- small discrepancy with G4Beamline on the radial component
- found periodic orbits over wide range of momenta using 3D field map
- found good cooling for 1st Guggenheim channel in Palmer collider scenario
- overall transmission (~50%) needs improvement