RFOFO RING in GEANT

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- Overview
- GEANT Simulation
  - **Geometry and Material**
  - **Constant Magnetic Fields**
  - **GRID Magnetic Fields**
- RF Cavities Tuning
- Beam Dynamics
- Summary

Overview

RFOFO in GEANT Team

- R. Godang, D. Summers,
  L. Cremaldi, S. Bracker (Mississippi)

  R. Palmer, R. Fernow,
  S. Kahn, J. Berg (BNL)

  R. Raja, V. Balbekov (Fermilab)

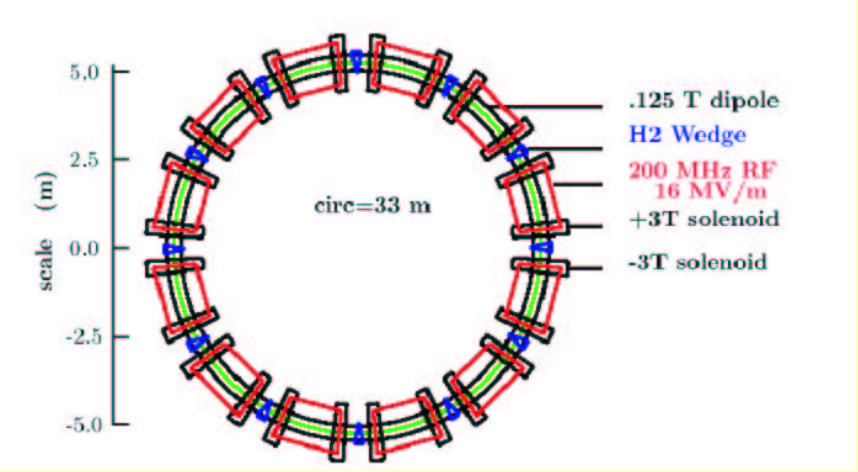
  A. Klier (UC Riverside)

- RFOFO Ring has been designed and simulated using ICOOL simulation

- It is important to simulate RFOFO Ring using GEANT since it is one of a crucial part in a Ring Cooler

- **We are using a modified GEANT at Fermilab that suitable for a Ring Cooler purposes**

RFOFO Geometry in ICOOL

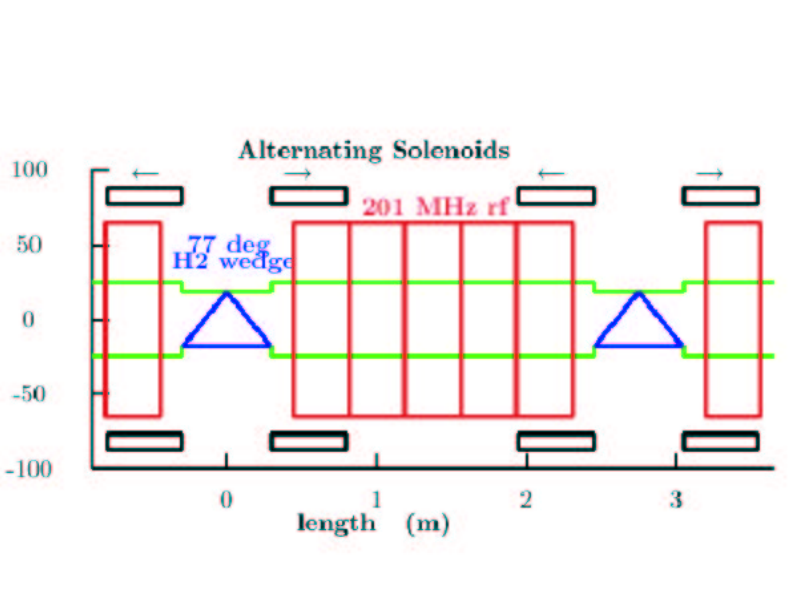


The ring is about 33 m in circumference

- 12 cells and each cell is 2.75 m long
- 1 cell = 1/2 wedge + 6 RFs + 1/2 wedge
- Overall dipole B is 0.125 Tesla
- Alternating Solenoids B is $\pm$3.0 Tesla

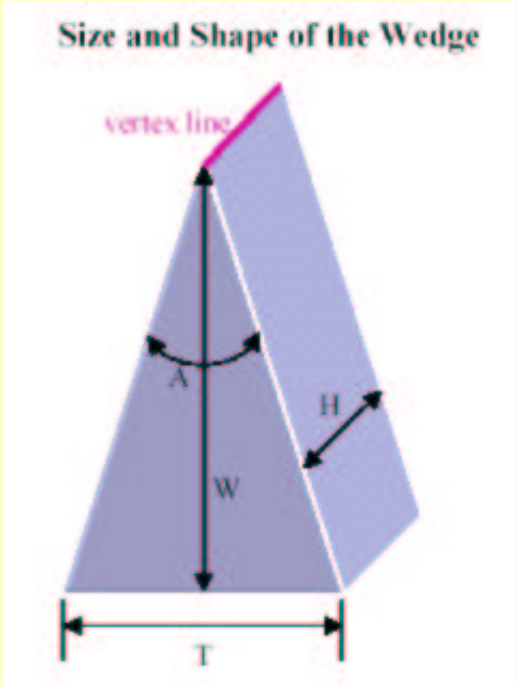
Overview

Alternating Solenoid Coils



- Solenoids coils are located outside the pillbox RF cavities
- RF frequency is 201.25 MHz
- RF gradient is 16 MV/m

Wedges Profile



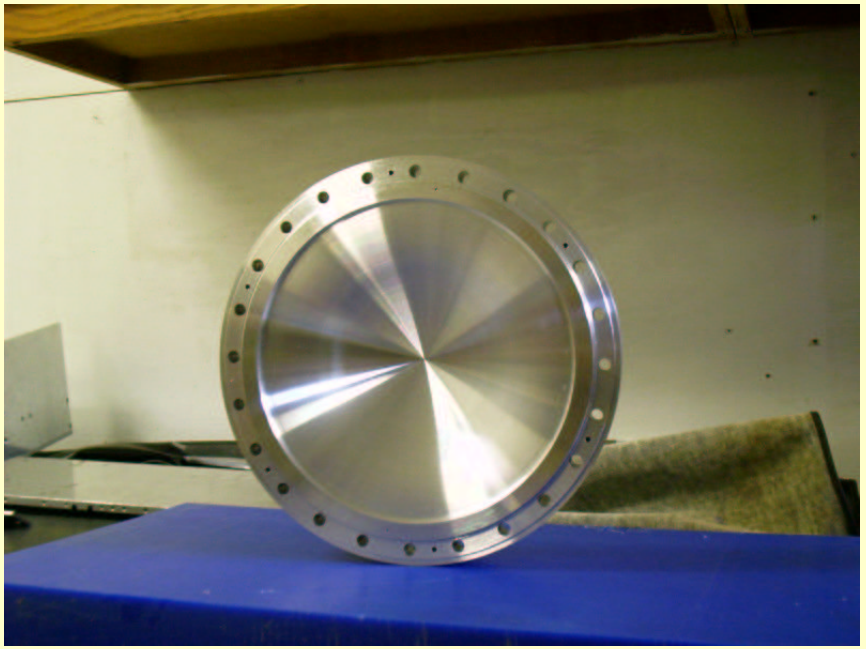
- W = 40 cm, H = 40 cm, T = 62.56 cm
- Wedges are made of liquid hydrogen with a full angle $A = 76.93^{\circ}$ at vertex
- No windows at the moment

RF Cavity and Window

RF Cavities

- 201 MHz RF cavity construction has been started by Berkeley, Mississippi and JLAB

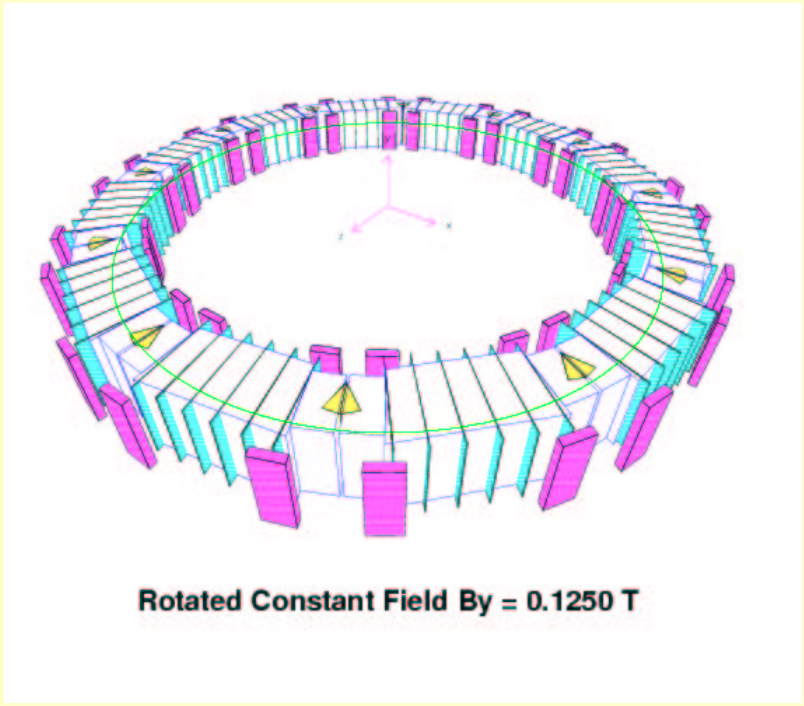
LH_2 Windows



- New double bend window
- Previous absorber windows that were also manufactured in Mississippi have been tested in Illinois

GEANT Simulation

Geometry and Material



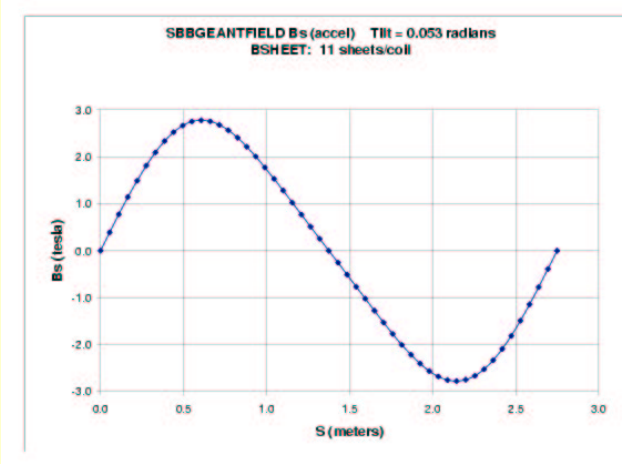
- RFOFO geometry and material in GEANT are identical as in ICOOL
  - Overall dipole B is 0.125 Tesla
  - Alternating Solenoids B is $\pm$ 3.0 Tesla
- **RFOFO's circumference is $\sim$ 33 m**

GRID Magnetic Fields

- We determine the particle closed orbit using constant magnetic fields (shown)
- We generate 1cm x 1cm x 1cm GRID fields map with tilt angle of 53 mrad (S. Bracker, MUCOOL-271)
- Satisfy fundamental Maxwell's equations $\Longrightarrow \nabla \cdot B = 0$ and $\nabla \times B = 0$
- **We use FINT interpolation routine with result of 10^{-4} Tesla differences compared to the real fields**
- $\Longrightarrow$ It is a very good resolution!
- We apply the GRID fields into GEANT with satisfying the geometry boundary condition

GEANT Simulation

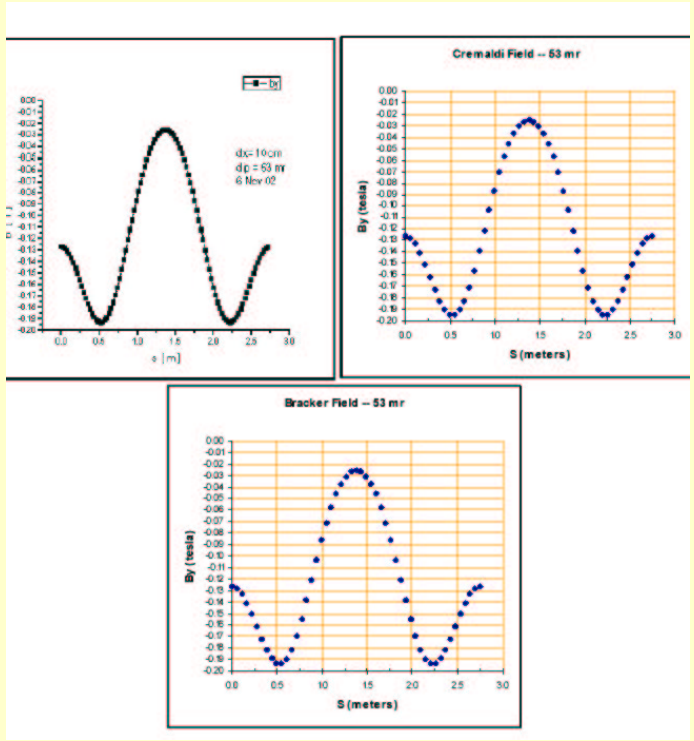
Acceleration Magnetic Fields



- Acceleration magnetic fields (B_s) is in a direction of the particles orbit in the RFOFO Ring
- The fields has a tilt angle of 53 mrad
- **It follows the Biot-Savart's Principles**

ICOOL vs GRID Fields

ICOOL and GRID Fields have a very good agreement into each other now



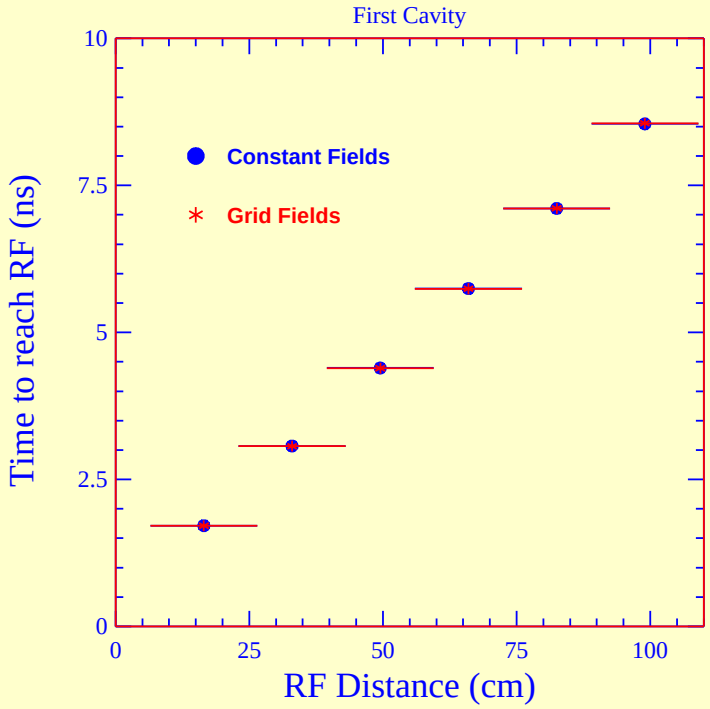
- **There was some disagreement in B_y between Cremaldi's and ICOOL's**
  ↪ It has been fixed properly

RF Cavities

RF Tuning

File: rf_times.dat

ID	IDB	Symb	Date/Time	Area	Mean	R.M.S.
200	0	-41	000000/0000	30.58	70.60	25.14
300	0	-48	000000/0000	30.58	70.62	25.14

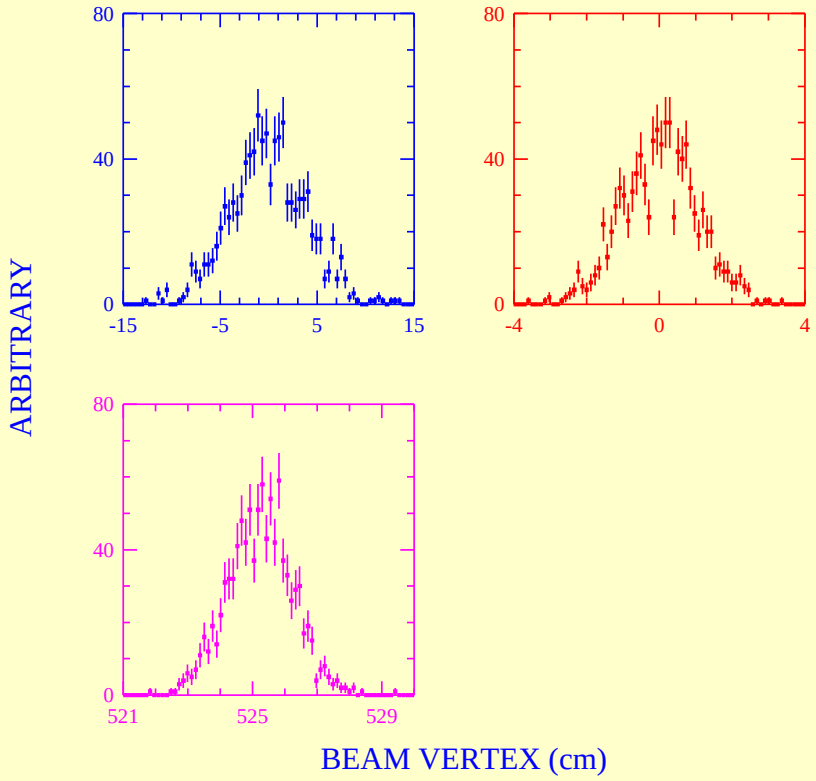


- Time to reach the first RF cavity is 1.7 ns
- Constant B fields gives the same result in timing compared to the GRID fields as we expected

μ-Beam Dynamics

File: stdmake_rfofo.plt

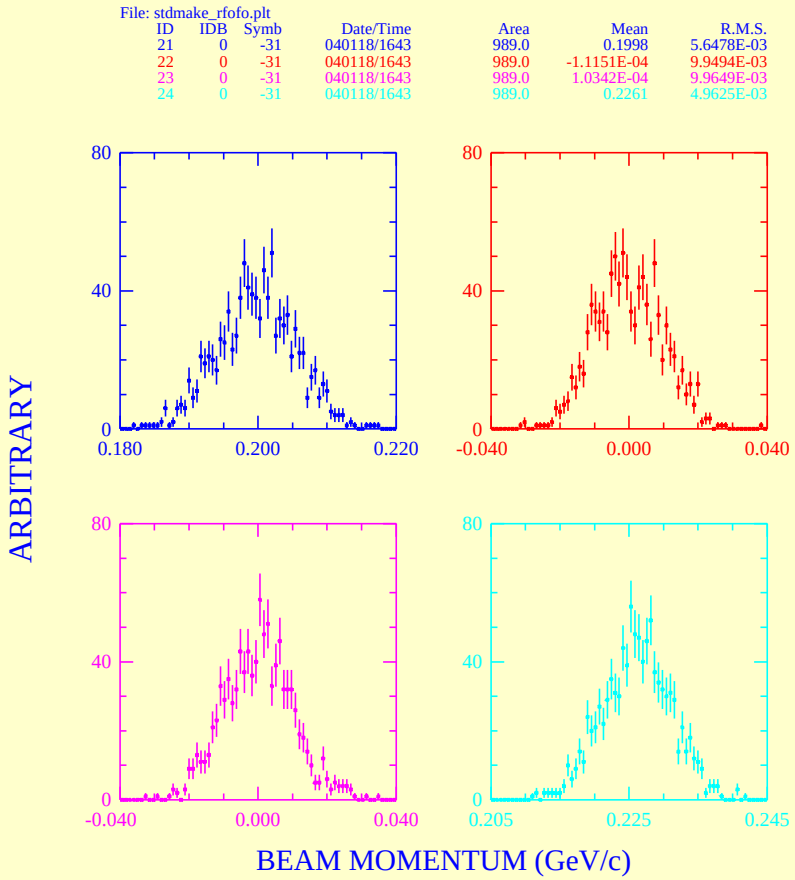
ID	IDB	Symb	Date/Time	Area	Mean	R.M.S.
11	0	-32	040118/1643	989.0	-6.4351E-02	3.956
12	0	-32	040118/1643	989.0	5.3734E-03	1.045
13	0	-32	040118/1643	989.0	525.2	1.008



- Mean vertex (z direction) is 525 cm as a radius of the RFOFO Ring

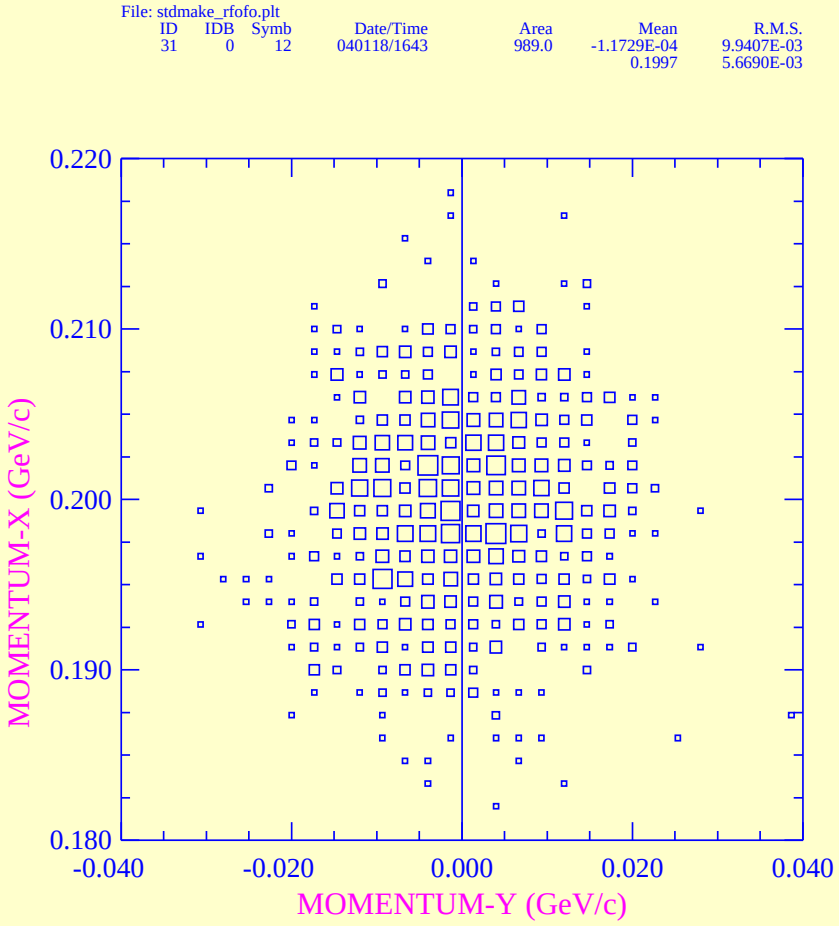
μ-Beam Dynamics

μ-Beam Momentum



- We has been studied the RFOFO Ring acceptance
- Mean μ-beam momentum is 200 MeV/c with momentum spread $\pm$20 MeV/c

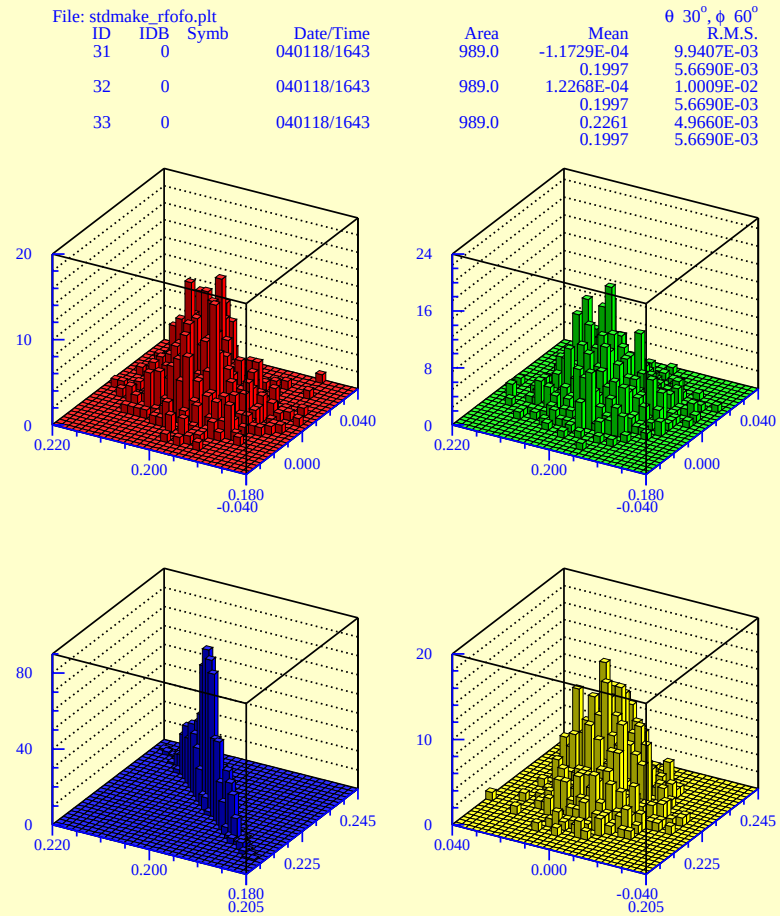
μ-Beam Scatter Plot



- **μ-beam momentum in P_x vs P_y**

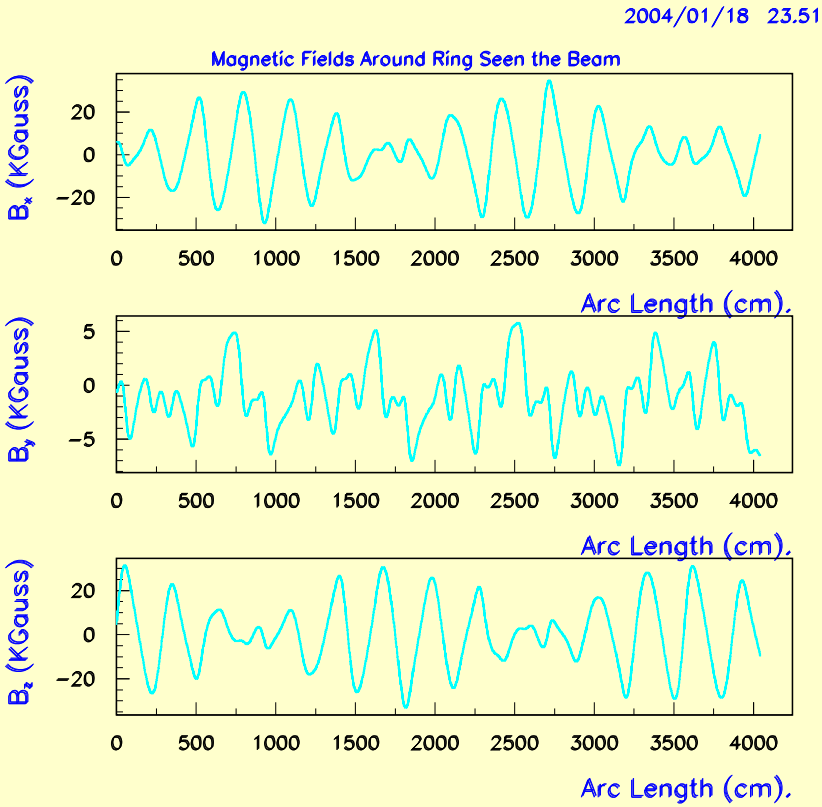
μ-Beam Dynamics

μ-Beam Momentum



- P_x vs P_y and P_x vs P_z,
  P_x vs P and P_y vs P

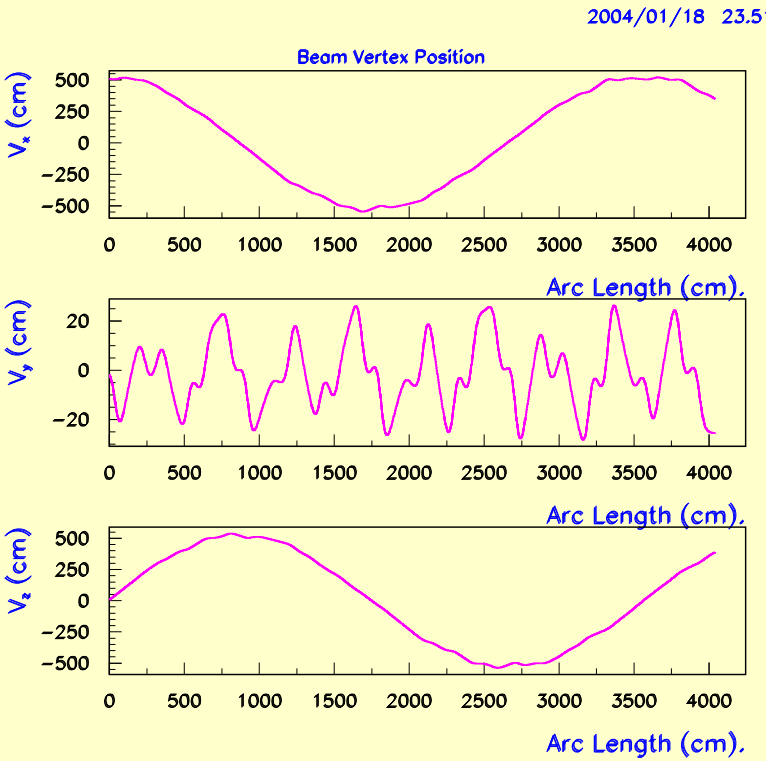
B Fields Seen by μ-Beam



- B_x, B_y and B_z seen by μ-beam

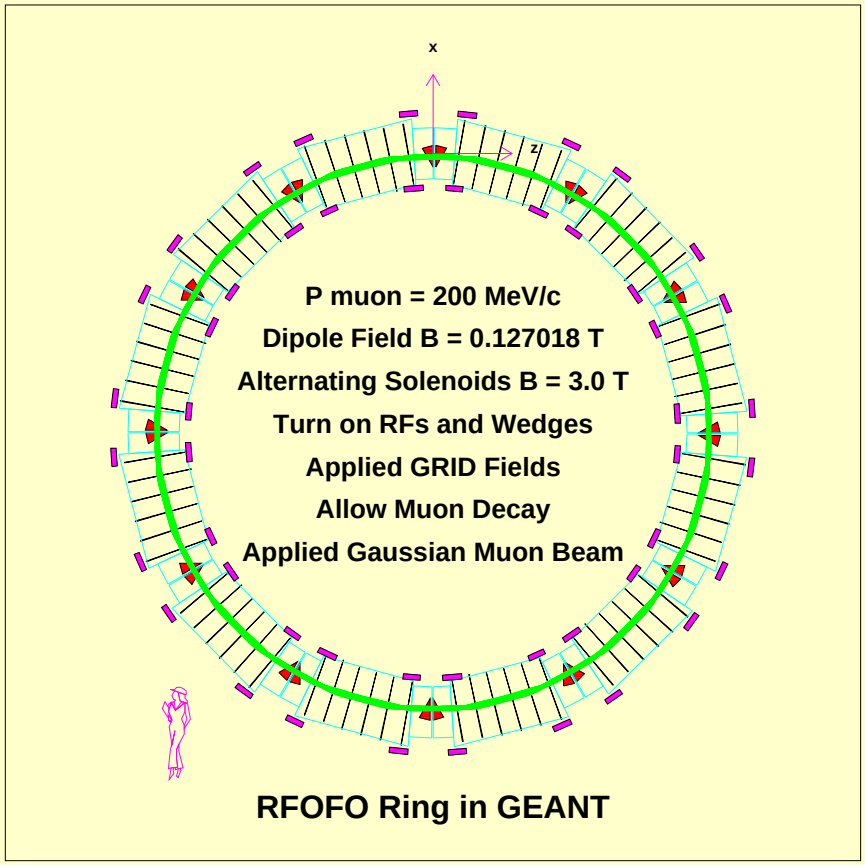
Vertex μ-Beam

μ-Beam Vertex Position



- μ-beam vertexes in x,y and z direction

μ-Beam in RFOFO Ring



- μ-beam is circulating in the RFOFO Ring with the RF, wedges and B fields on!

Summary

We generated the GRID fields with a very high resolution

We applied the B fields into GEANT simulation.
The B fields are correctly seen by the μ-beam

We had been studied the RFOFO Ring acceptances

We generated the μ-beam with a vertex and momentum spread

We are circulating the μ-beam in the RFOFO Ring
with RFs, wedges and B fields on

Need to calculate the cooling merit factor using 6D emmittances

- Work with ECAL9 is in progress to allow a standard μ-beam input

(Thanks to Steve Kahn for his help on ECAL9)