Theory and Simulations: Introduction and Plans

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BNL

MUTAC Review
LBNL

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Outline of MC simulation activities

- design simulations for future muon-based facilities
  1) front end
     neutrino factory
       phase rotation optimization (A. Poklonskiy, PhD)
     tabletop ring coolers
     muon collider
  2) acceleration (S. Berg)

- related simulation efforts in the collaboration
  targetry (R. Samulyak)
  MICE (D. Kaplan)
  Muons Inc. (R. Johnson)

- theory

Theory and simulation committee

R. Fernow (BNL)	Chair
H. Kirk (BNL)	Targetry coordinator
D. Neuffer (FNAL)	Front end systems coordinator
S. Berg (BNL) / C. Johnstone (FNAL)	Acceleration coordinators
A. Sessler (LBNL)	Theory coordinator
M. Berz (MSU)	
E. Keil (CERN)	
R. Palmer (BNL)	
S. Koscielniak (TRIUMF)	

Major responsibilities

- consult as necessary on important simulation matters
- organize topical workshops

Simulation activities

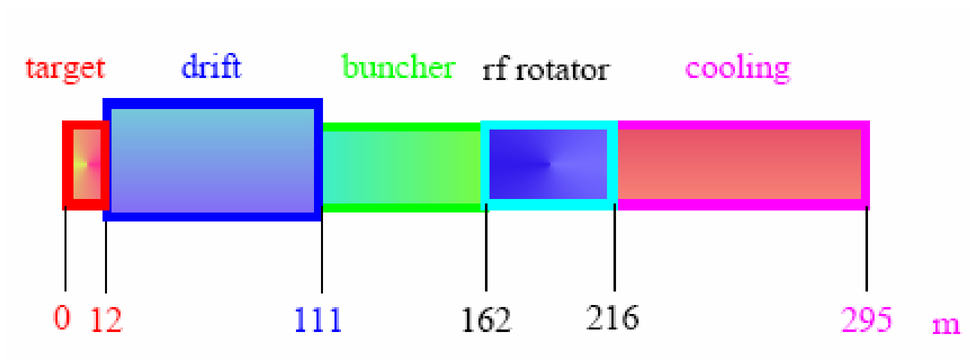
- topical workshops

Gas-filled dipole rings	BNL	June 2004
Ring coolers	UCLA	September 2004
Higgs factory	UCLA	October 2004
FFAG	KEK	October 2004
Muon collider simulations	Miami	December 2004
FFAG	FNAL	April 2005

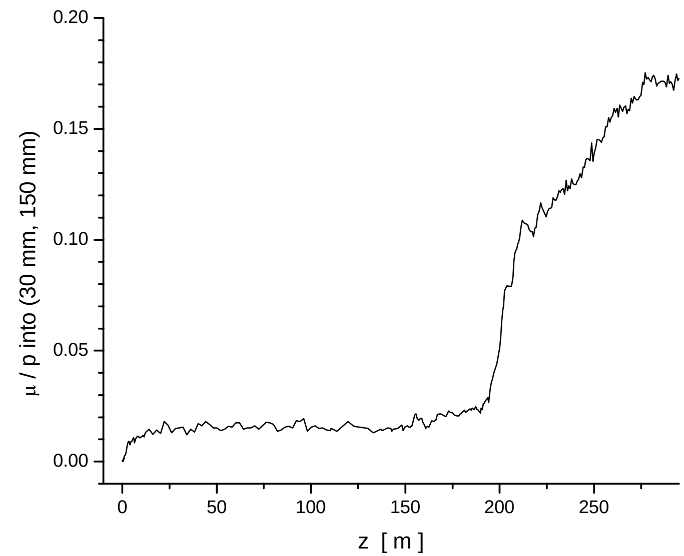
- code development
- MC Friday audio conference
- Collaboration meeting
- talks at conferences
- publications in refereed journals

Study 2a Front End

- objective: significant cost reduction from FS2 neutrino factory
- major new elements
  - (1) adiabatic RF bunching and phase rotation (D. Neuffer, FNAL)
    - eliminate induction linacs
  - (2) new linac front end with A_{TN} = 30 mm acceptance (R. Palmer et al)
  - (3) new simplified cooler design (R. Palmer, BNL)
    - fewer components
    - lower magnetic field

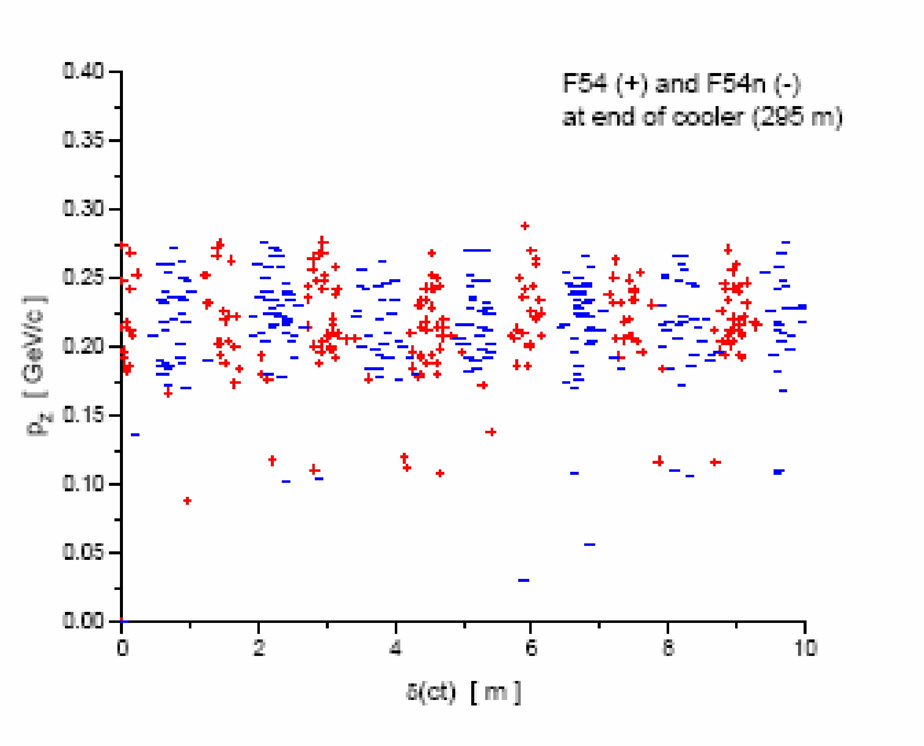


(J. Gallardo, BNL)



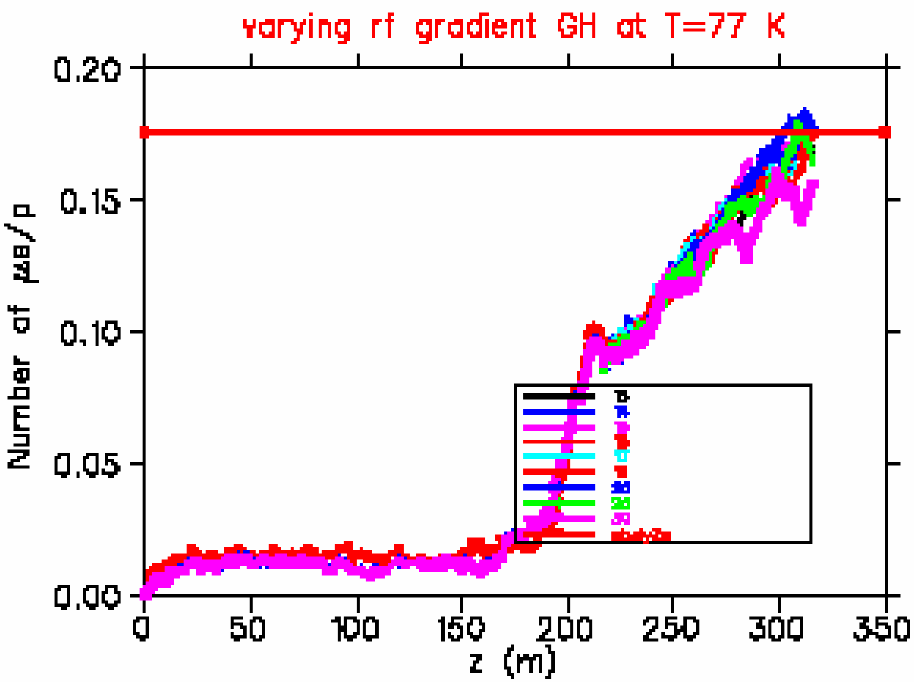
Results of Study 2a

- obtained $\mu / p = 0.170 \pm 0.004$ into accelerator acceptance
- get same number of muons as Study 2
- but this design gives muons of both signs
  - gain of a factor of up to 2 in neutrino flux



Gas-filled cooling channel

- looking for further improvements: Study 2b
- β_T is fairly constant in the Study 2a cooling channel
- try replacing LiH with high-pressure H_2 gas as the absorber
- may be possible to find parameters that achieve better performance

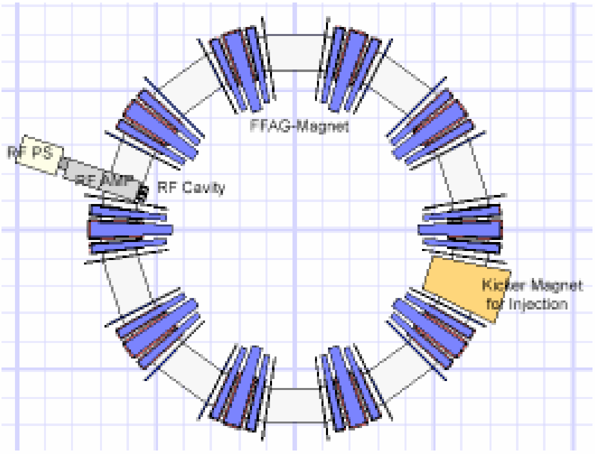


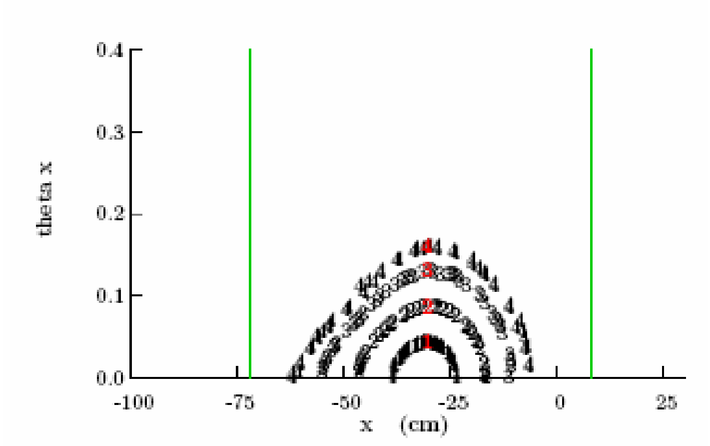
- low temperature allows thinner windows (P = 50 atm)
- used hemispherical steel pressure windows (5.5 mm thick)

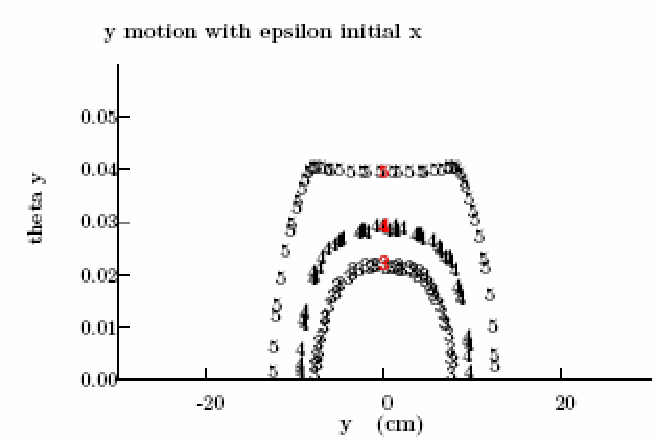
(J. Gallardo, BNL)

Modeling of a scaling FFAG

- can we use systems from other designs?
- simulated PRISM scaling-FFAG in ICOOL
- got flat x and y tunes vs. momentum
- studied effects of different end-field shapes
- studied effects of radial field dependence







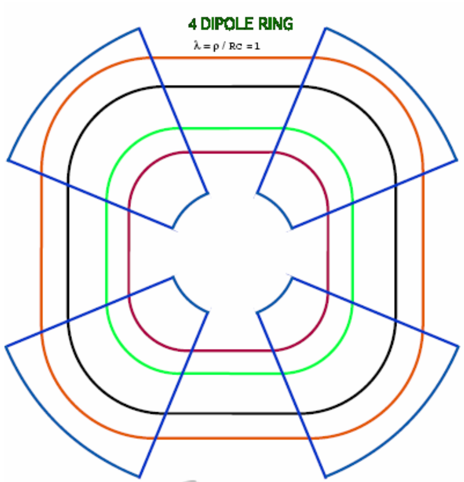
(R. Palmer, BNL)

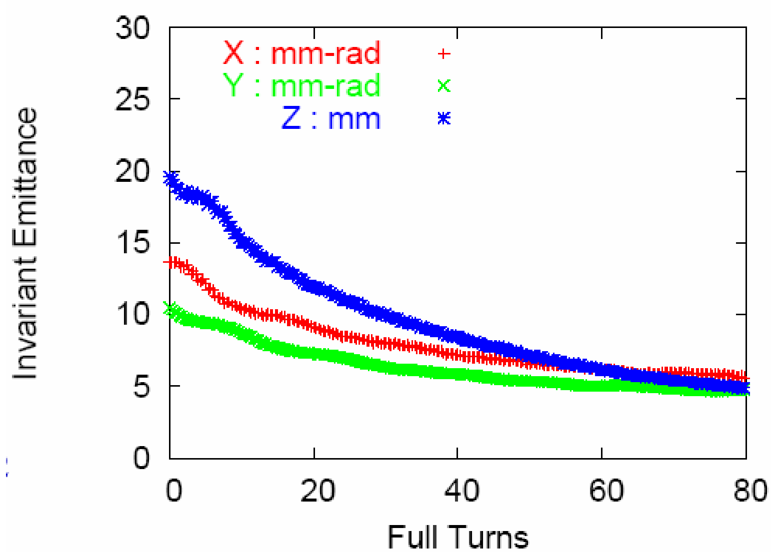
Near-term plans – neutrino factory

- continue investigating refinements to Study 2b
  - e.g. shortening the phase rotator
  - slightly tapering the cooler parameters
  - thermal properties of absorber windows
- try to incorporate any promising new developments
  - e.g. gas-filled channel
- try to incorporate aspects of the European or Japanese designs
- perform "scoping" simulations for World Design Study

Dipole ring cooler (1)

- developed successful design algorithm
  1) design initial lattice using SYNCH
  2) parameter optimization with ICOOL (hard edge mode)
  3) realistic fields with TOSCA, ICOOL (multipole mode)

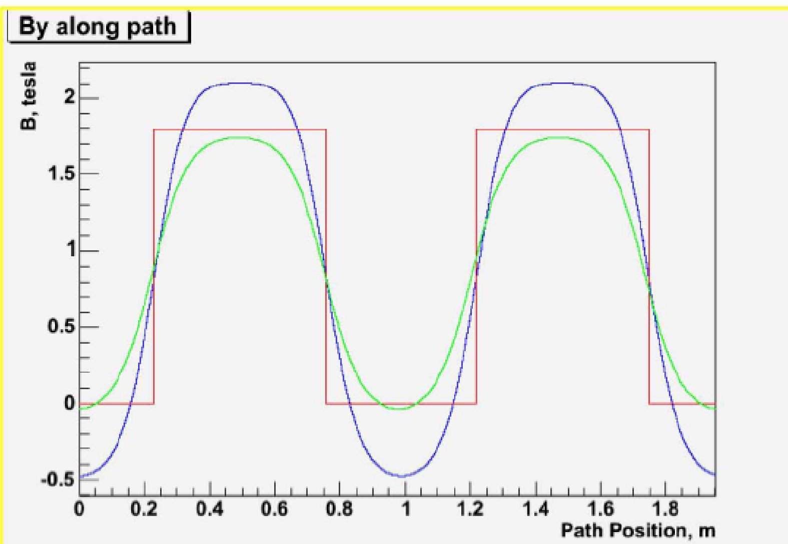


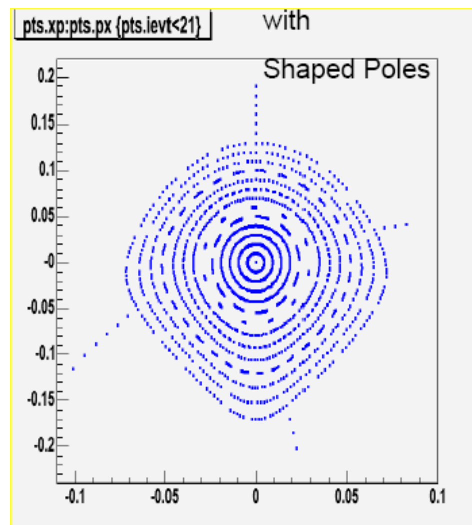


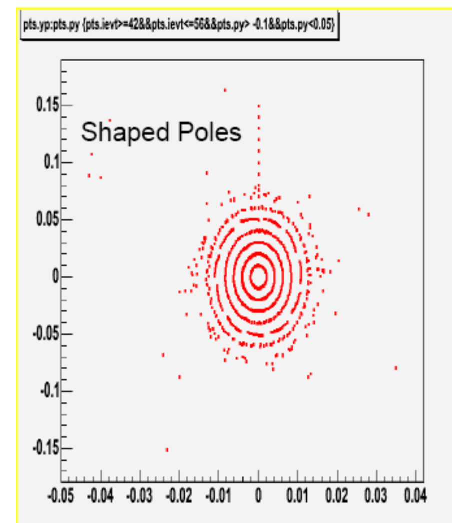
- 4-sector, weak focusing ring (H. Kirk, BNL)
- H_2 gas filled (β_T small and constant)
- f=201 MHz, h=3, C=3.8 m, P=40 atm at room temperature

Dipole ring cooler (2)

- 4-cell weak focus ring was simulated with realistic fields
- shaped pole pieces increase horizontal dynamic aperture
- SBIR phase II for complete engineering design of ring and dipole prototype





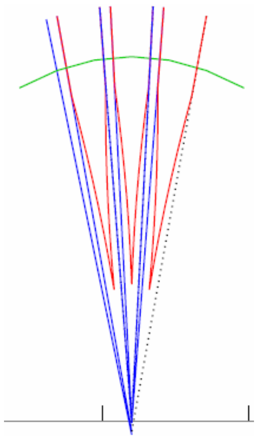


blue –coils only

(S. Kahn, BNL)

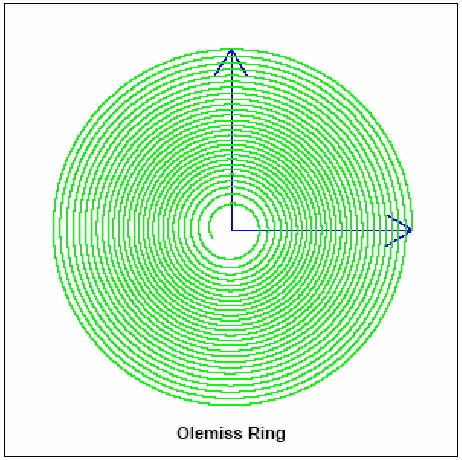
Anti-cyclotron ring

- might be possible to eject low-emittance, stopped beam
- inject muons into gas-filled ring
- let beam cool by spiraling into center
- B=3 T, p=105 MeV/c, P=50 atm
- ionization injection studies with ICOOL underway
- use graded density, higher on outside

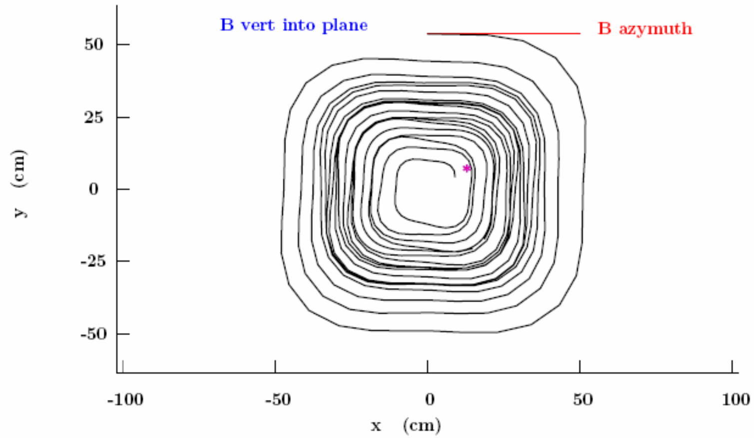


scheme with wedges

(R. Palmer, BNL)



(D. Summers, UMiss)

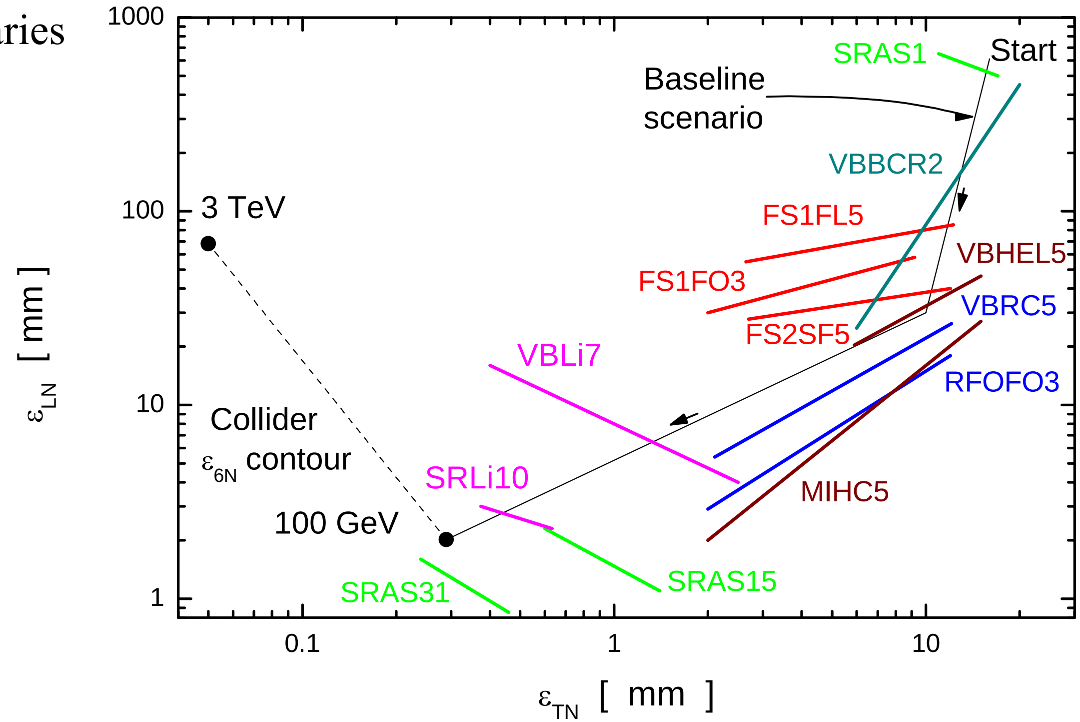


Near-term plans – tabletop cooling rings

- continue studies of small rings
  - gas-filled dipole ring
  - anti-cyclotron ring
- complete the realistic field modeling
- optimize ring and beam parameters
- continue studies of injection (extraction?)

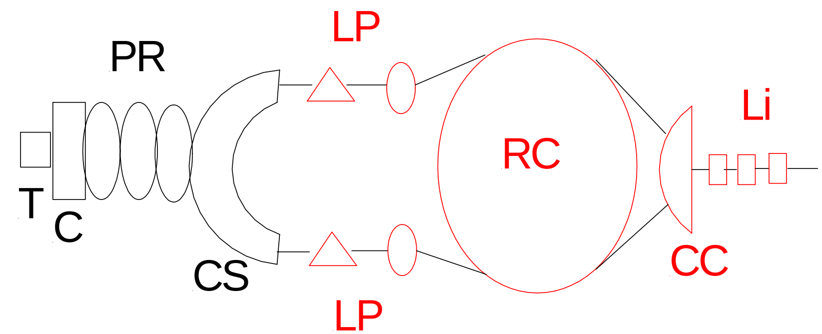
Muon collider simulations

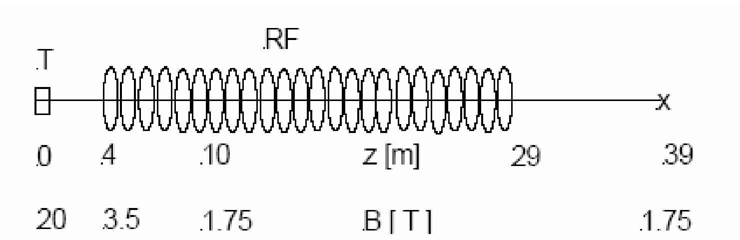
- there is no complete, self-consistent design for front-end of muon collider
- *caveat emptor*
  - doesn't show transmission losses
  - technical feasibility varies
  - quality of simulations varies

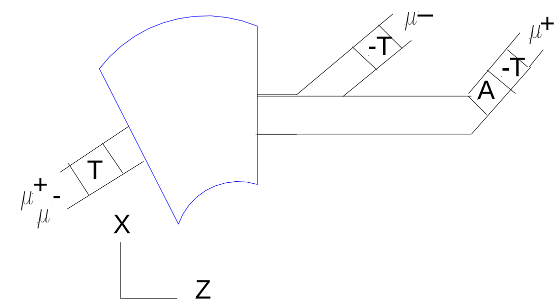


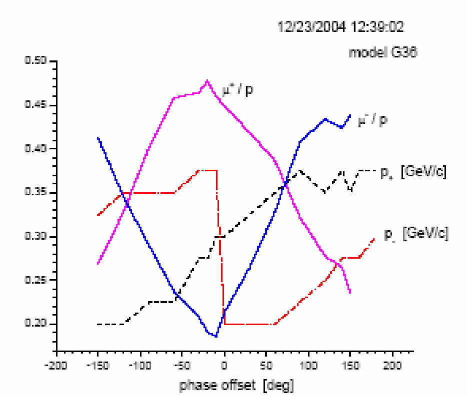
Collider front-end studies

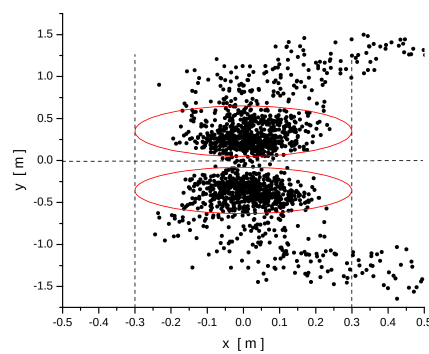
- looking at front-end designs with ring coolers
- maximize transmission in ring acceptance
- equal numbers of μ^+ and μ^-
- use bent solenoids to separate charged beams
- get 0.28 μ/p for both charge beams

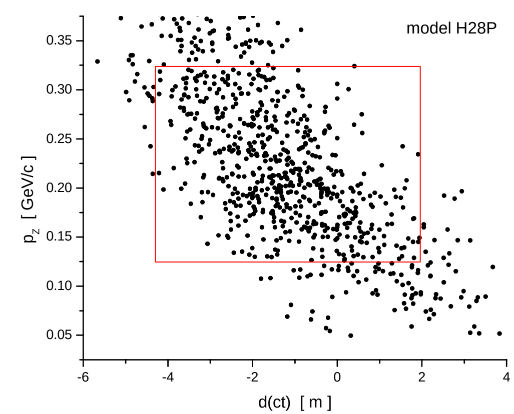












Near-term plans – muon collider

- study collider system design based on using ring coolers
  - e.g. study realistic injection/extraction systems for rings
  - design required 6D precooler
  - study thermal issues for ring absorbers
  - study lithium lens cooling
  - bunch train coalescence
- available manpower to work on this is limited

Summary

- have active program of front-end simulations
- major thrust: neutrino factory
  - Study 1 → Study 2 → Study 2a → Study2b → WDS
- tabletop ring cooler
- muon collider
- made progress in all areas last year
- have plans for continuing this work in the coming year