
Simulation Overview and Plans

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MUTAC Review
LBNL

8 April 2008

Outline

- “simulations” includes accelerator theory and facility design
- categorize types of simulation activities
- overview of recent NF and MC facility-related simulations
(many topics will be discussed in more detail later)
- list our near- and long-term simulation plans
- NFMCC & MCTF simulation activities are closely coordinated
- thanks to Yuri Alexahin (MCTF) for his help

Simulation categories

- (1) neutrino factory facility design (IDS)
- (2) muon collider facility design
- (3) non-facility simulation efforts
 - MICE experiment (ionization cooling) → Analysis Group
 - MERIT experiment (liquid targetry) → magnetohydrodynamics
 - EMMA experiment (non-scaling FFAG) → beam dynamics
 - breakdown in RF cavities
 - MC detector → new physics & detector group
 - solid target shock
- (4) active collaboration with outside-directed muon collider efforts
 - Muons Inc., SBIR
collider scenario, MANX proposal (6D cooling)
 - Particle Beam Lasers Inc., SBIR
ring coolers, lithium lens cooling

Recent simulations highlights

- **PIC/REMEX** Workshop, May 2007 at FNAL (Muons Inc)
- Muon Collider Design Workshop
December 2007 at Brookhaven
examined status of three 1.5 TeV collider schemes
 - HEMC** $\epsilon_{\text{TN}} = 25 \mu\text{m}$ (NFMCC)
 - LEMC** $= 2 \mu\text{m}$ (Muons Inc)
 - MCTF** $= 12 \mu\text{m}$ (Task Force))
- collaboration funded two new simulation postdoc positions
should help increase simulation efforts
Pavel Snopok joined UC Riverside in October 2007
guggenheim cooling channels, collider rings
offer out now for a position at BNL
accelerator design, cooling ideas
- looking to fill NSF-supported postdoc position for MICE

Facility subsystems

Major facility design areas

- proton driver
- target
 - π collection
- front-end
 - π decay
 - bunching
 - phase rotation (decrease energy spread)
 - ionization cooling
- μ acceleration
- storage or collider ring

Recent activities: neutrino factory

- current NF design work is under auspices of IDS
- shorter bunching & phase rotation channel (Neuffer)
 - likely to give similar performance to Study 2a at lower cost
- gas-filled quad cooling channel alternative (Neuffer)
 - similar performance, less magnetic field in RF cavities
- linear lattice design for linacs and RLAs (Bogacz)
 - longitudinal beam dynamics
 - arc crossing in dogbone RLA, injection chicane lattice
- linear, non-scaling FFAG (Berg)
 - established initial design
 - begun studying injection lattice designs

Recent activities: muon collider

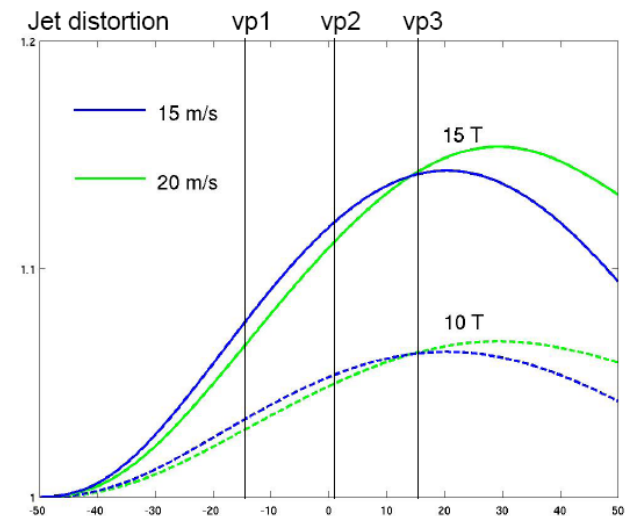
(1) Proton driver

- two new schemes based on upgrades of Project-X linac
 - high rep rate at 8 GeV, 2 MW possible (Ankenbrandt, Popovic)
 - uses accumulator & debuncher rings
 - with MI at 56 GeV, 2-6 MW possible (Neuffer)
 - uses recycler & new rebunching ring

(2) Target (Samulyak)

- cavitation added to hydrodynamics simulations
- studied instabilities of jet leaving nozzle

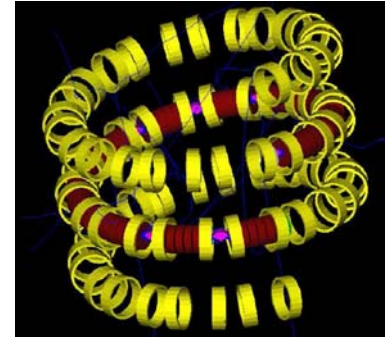
Hg jet transverse distortion
versus longitudinal position



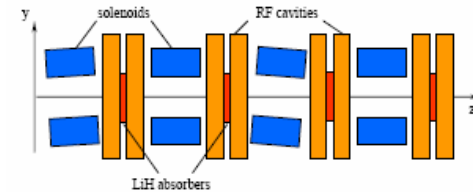
Recent activities: muon collider

(3) Front end (6D cooling)

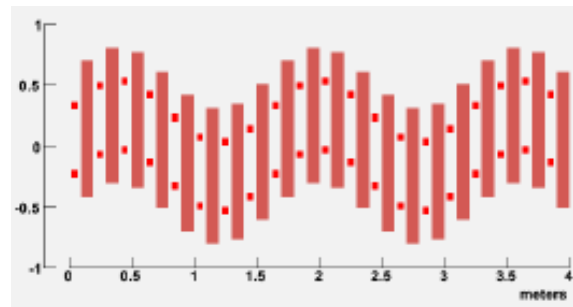
- Guggenheim simulations (Snopok, Fernow)
modeling helical nature of channel in ICOOL & G4BL
- new helical field model in ICOOL (Gallardo)
torsion in multipole expansion & equations of motion
- new cooling lattice design tool, **MICCD** (Alexahin)
Mathematica, handles tipped, displaced solenoids
- 6D cooling in new low- β lattices (Alexahin, Palmer, Fernow)
FOFO-snake, FOFO-helix, bucked coil
- incorporating RF in **HCC** (Yonehara, Kahn)
3 schemes, coil spacing & clearances important
- optimal performance of HCC (Balbekov)
examining period, frequency, & momentum parameter space



Guggenheim



FOFO-snake



HCC scheme 2
(S. Kahn)

Recent activities: muon collider

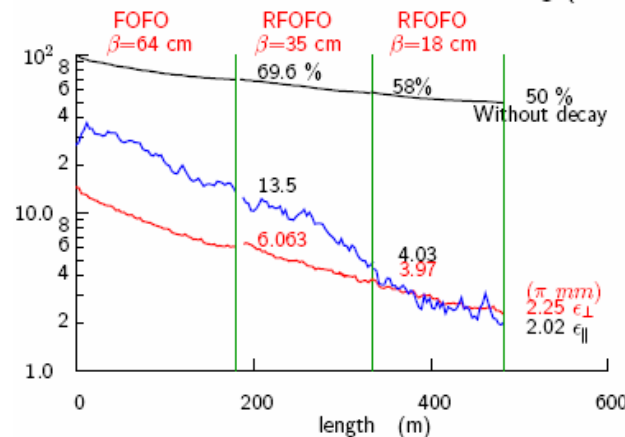
(3) Front end (final cooling, etc)

- low energy bunch merging (Gallardo, Fernow)
RF + {drift, planar wiggler}
Neuffer's shorter bunching should help
- cooling with 50 T HTS channel (Palmer)
7stage, E falls, bunch length grows
- PIC & REMEX cooling lattices (Newsham, Bogacz, Derbenev)
trying to minimize 3rd order aberrations
- improved model for muon scattering and straggling (Striganov)
ICOOL Vavilov model may underestimate straggling

Recent activities: muon collider

(3) Front end (breakdown in RF cavities)

- computations of beam interactions in gas-filled cavities (Tollestrup)
Mathematica, may leave layer of positive ions in cavity
- breakdown in vacuum RF cavities, **CAVEL** (Palmer, Gallardo, Fernow)
studying coil location and cavity shape for magnetic insulation
- breakdown simulations using OOPS code (Tech-X Corp.)
- open-aperture cooling lattices (Palmer)
promising backup if gradients limited by magnetic field



RFOFO cooling slightly better
Transmission slightly worse

Recent activities: muon collider

(4) Acceleration

- 2.5 \rightarrow 33 & 33 \rightarrow 750 RLA preliminary designs (Bogacz)
- 30 \rightarrow 750 GeV rapid cycling synchrotron (Summers)
lower cost alternative to RLAs?
- intense beam interactions in SCRF cavities (Solyak, Yakovlev)
strong but manageable wakefield excitation in ILC-like structures
beam loading, peak power, transverse kicks, emittance growth

(5) Collider ring

- 3 new lattice designs, 1.5 TeV, $\beta^* = 1$ cm
differ in assumed emittances, location of sextupole families
- dipole-first lattice design (Alexahin, Gianfelice-Wendt)
increases dispersion at sextupoles, local chromatic correction
- LEMC ring (Bogacz)
sextupoles outside final focus region
- COSY studies of high-order chromatic effects & corrections
(Snopok, Johnstone, Berz)

Some high-priority near-term plans

- improve realism of Neuffer 12-bunch phase rotation
advantages for both NF & MC
- improve modeling of vacuum & gas-filled RF cavity breakdown
understand upcoming MuCool measurements
- refine design of magnetically-insulated PR & cooling channels
- demonstrate high efficiency in tapered guggenheim cooling lattice
assumed in HEMC luminosity estimates
- simulate performance of FOFO-snake cooling lattice
intriguing 6D cooling alternative
- improve performance of low- β bucked coil cooling lattices
could improve final collider cooling
- find practical design for HCC with RF
could offer more compact 6D cooling

Feasibility Study planning

- NFMCC & MCTF would like to complete a MC feasibility study in 2012
- we have begun a study to estimate
 - the simulation tasks needed
 - the effort required
 - priority of simulation tasks
- this planning exercise needs to be completed by this August
- should help organize simulation work over next few years
- will be discussed further in Mike's R&D plan update talk

Summary

- have active, coordinated program of **simulation work**
- continuing to refine design of a neutrino factory
 - Study 1 → Study 2 → Study 2a → ISS → **IDS**
- pursuing three paths to a 1.5 TeV muon collider design
- working on detailed simulation plans for a MC feasibility study
- have continued to make progress in all areas over last year
- a lot of design and simulation work still needs to be done