

Muon Accelerator Program Design & Simulations (WBS 2) Monthly Status Review

Sept 6, 2013

Outline



- Introduction
- L2 Manager Updates
- Cary Yoshikawa
 - "A Charge Separation Study to Enable the Design of a Complete Cooling Channel"

Introduction



- Upcoming events:
 - NA-PAC'13, Sept 29 – Oct 4, Pasadena CA
 - Vacuum RF informal mtg on D&S for a start-to-end simulation of 6D cooling, Sept 18-19
 - MuPAC review: Dec 16-18
- Big presence at NA-PAC
 - M. A. Palmer, The R&D Program for a Future Muon Collider
 - R. Samulyak, Algorithms and Self-consistent Simulation of Beam-induced Plasma in Muon Cooling Devices
 - H. Sayed, Applications of Parallel Optimization Algorithms to Muon Collider / Neutrino Factory Design
 - J. Ellison, Advanced Modeling Tools for Muon-Based Accelerators
 - J. Kunz, Progress of the Matter-dominated Muon Accelerator Lattice Simulation Tools Development for COSY Infinity
 - P. Snopok, Space Charge Simulation in COSY Using Fast Multipole Method
 - B. Freemire, High Pressure Gas-Filled RF Cavities for Use in a Muon Cooling Channel
 - A. Bross, nuSTORM: Neutrinos from STORed Muons
 - R. Samulyak, Simulation of High Power Mercury Jet Targets for Neutrino Factory, Muon Collider, and Beyond
 - H. Sayed, Towards a Global Optimization of the Muon Collider / Neutrino Factory Front End Baseline
 - D. Neuffer, A Muon Collider as a Higgs Factory
 - D. Neuffer, The Nustorm Facility-Muon Storage Ring and Injection Design
 - D. Neuffer, A 325 MHz Front End System for a Muon Accelerator
 - M. A. Palmer, A Staged Muon-based Facility to enable Intensity and Energy Frontier Science in the US
 - K. Yonehara, Study Muon Polarization in Muon Collider
 - P. Hanlett, The Muon Ionization Cooling Experiment: Controls and Monitoring System
 - M. Chung, Investigation of Breakdown Induced Surface Damage on 805 MHz Pill Box Cavity Interior Surfaces
 - K. Yonehara, Research and Development of Dielectric Material Loaded High-pressure Gas Filled RF Cavity Tests for Muon Colliders
 - Y. Torun, Assembly and Testing of the First 201-MHz MICE Cavity at Fermilab
 - Y. Torun, Extended RF Testing of the 805-MHz Pillbox "All-Season" Cavity for Muon Cooling
 - D. Bowring, RF Design and Characterization of a Modular Cavity for Muon Ionization Cooling R&D

Introduction



- **Big presence at NA-PAC**
 - T. Luo, Multipacting Study for the RF Test of the MICE 201 MHz RF Cavity at MTA
 - H. Witte, Partial Return Yoke for MICE - Engineering Design
 - H. Witte, Partial Return Yoke for MICE - General Concept and Performance
 - A. Zlobin, Storage Ring and Interaction Region Magnets for a $\mu+\mu-$ Higgs Factory
 - R. Johnson, Helical Muon Beam Cooling Channel Engineering Design
 - S. Kahn, Using Elliptical Magnetic Coils in a Muon Cooling Channel
 - J. Pasternak, Design of the Final Focus of the Proton Beam for a Neutrino Factory
 - J. S. Berg, Linear Analysis for Several 6-D Ionization Cooling Lattices
 - J. S. Berg, A Planar Snake Muon Ionization Cooling Lattice
 - H. Sayed, Optimization of the Capture Section of a Staged Neutrino Factory
 - D. Stratakis, Studies on New, High-Performance, 6-Dimensional Ionisation Cooling Lattices for Muon Acceleration
 - D. Stratakis, Limitations Imposed by Space Charge on the Final Stages of a Muon Collider Ionization Cooling Channel
 - P. Snopok, Analysis of MICE Spectrometer Solenoid Magnetic Field Measurements
 - P. Snopok, Six-dimensional Ionization Cooling Lattice based on 325 and 650 MHz RF Cavities
 - A. Liu, a Muon Beam Line for Cooling Experiments at NuSTORM
 - M. Zisman, Status of the Muon Ionization Cooling Experiment (MICE)
 - C. Yoshikawa, Complete Muon Cooling Channel Design and Simulations
 - J. Maloney, Optimization and Aberration Correction of the Twin Helix Parametric Ionization Cooling Channel for Muon Beams
 - V. Morozov, Recent Developments on Parametric-resonance Ionization Cooling
 - N. Souchlas, Energy Deposition in Magnets and Shielding of the Target System of a Staged Neutrino Factory
 - R. Weggel, Design of Magnets for the Target and Decay Region of a Staged Neutrino Factory
 - X. Ding, Optimization of Particle Production for a Staged Neutrino Factory

More than 40 papers!

L2 MANAGER STATUS REPORTS: DESIGN & SIMULATION (WBS 2)

Monthly L2 Status Report -

WBS: 02.01 – Proton Driver

6 Sept 2013
Presenter: Keith Gollwitzer



<p><u>Milestone Status (Progress)</u></p>	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <ul style="list-style-type: none">• Assembling team, which has other topics, to look into MASS staging Proton Driver
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• Looking into MASS staging	<p><u>Late Items</u></p> <p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• Develop Accumulator and Compressor Rings (multiple energies)• Develop Compressor Ring extraction line to target for NF• Understanding limitations for different Proton Driver energies and beam power
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• Look at Project X stage 2 as a proton driver (3 GeV/ x GeV).• Investigation of Target Station solenoid field affecting the last transfer line magnetic element(s)	

Monthly L2 Status Report -

WBS: 02.02

06 September 2013
Presenter: Diktys Stratakis



<p><u>Milestone Status (Progress)</u></p> <ul style="list-style-type: none">• Chicane shielding and energy deposition work• Alternative taper schemes for the decay channel• Studies towards a 3 GeV, 1 MW Scenario• Support IDS-NF RDR activities	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <ul style="list-style-type: none">• We restarted the FE meetings on a monthly basis to better evaluate progress
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• FE performance studies for a 3 GeV/ 1 MW scenario• Energy deposition and shielding studies for the chicane	<p><u>Late Items</u></p> <ul style="list-style-type: none">• RDR write-up
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• Optimize buncher/ phase rotator for the 3 GeV proton beam driver case.• Performance studies with chicane integrated• Validate with ICOOL and G4BL. Discrepancy?	<p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• Finish-up global optimization algorithms to maximize the FE performance.• Preparation of a journal paper relevant to the study of different ionization cooling schemes for the FE [BNL/ UK collaboration]

Monthly L2 Status Report -

WBS: 02.03 Cooling

6 Sept 2013
Presenter: Tom Roberts



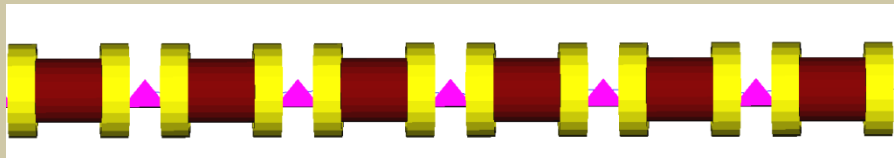
<p><u>Milestone Status (Progress)</u></p> <ul style="list-style-type: none">• Selecting 6-D cooling baseline (1Q2014):<ul style="list-style-type: none">– Progress on Vacuum RF channels– Progress on Helical Cooling Channel	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <ul style="list-style-type: none">• Need funding for Missing Physics Processes• Need engineering study on Vacuum RF channel final stages
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• EPIC: Continuing... (Morozov et al)• HCC: effect of charge separation ~ complete (Yoshikawa)• HCC: charge separator output available at NERSC• Vac: post-merge Gug. complete, 17 sections (Stratakis)• Vac: complete post-merge R_FOFO simul. (Stratakis)• Vac: Snake progressing (Balbekov)• Low-beta FOFO snake simul. (Alexahin)• Bunch merge in G4beamline (Bao and Hanson)• ICOOL bug fixes (Berg)• Physics Processes: Ongoing... (Snopok et al)	<p><u>Late Items</u></p> <ul style="list-style-type: none">• Missing Physics Processes
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• Vacuum RF channel(s) (Stratakis et al)<ul style="list-style-type: none">– Optimize parameters for Gug.– R_FOFO Snake (Balbekov snake)• HCC D&S (Yoshikawa, Yonehara, et al)• Physics Processes (Snopok, Roberts, et al): plasma effects, others, ...	<p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• 6D Baseline Selection<ul style="list-style-type: none">– (Basically on hold awaiting the other 6D D&S tasks)• Vacuum RF channel(s) D&S• HCC D&S• Auxiliary components• Final Cooling D&S• Missing Physics Processes

Rectilinear Channel (Post-Merge)

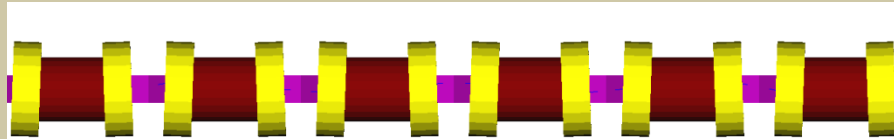


LATTICE DESIGN

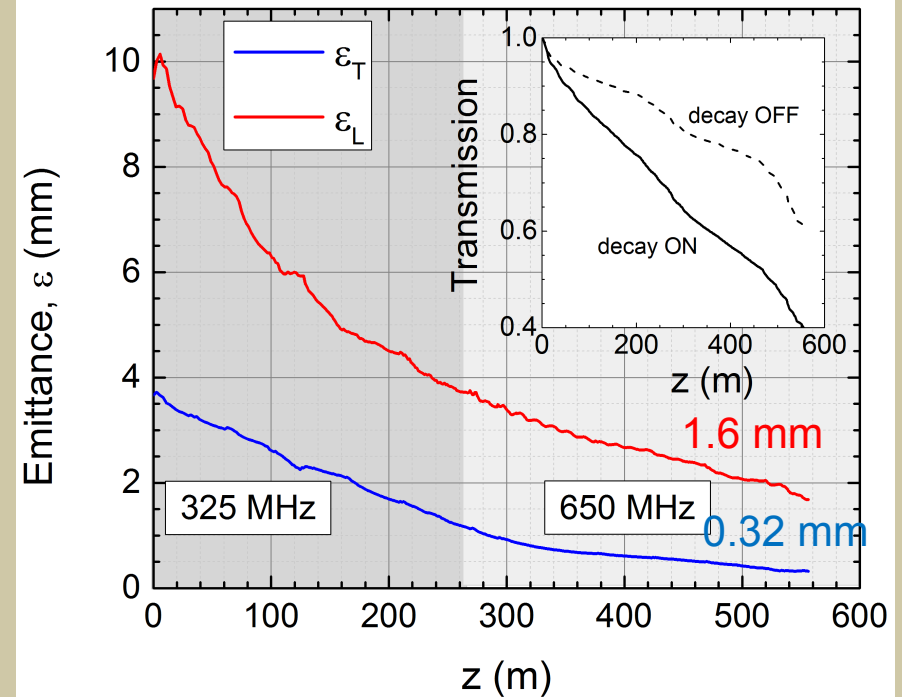
TOP VIEW



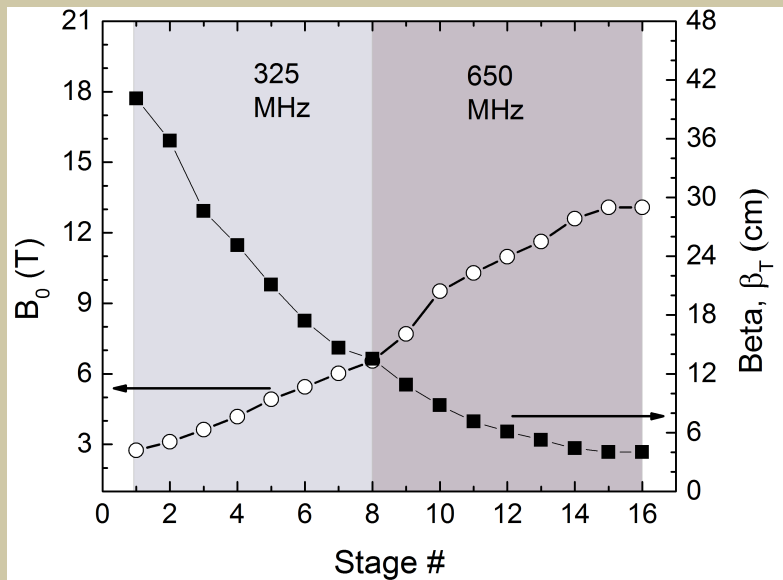
SIDE VIEW



LATTICE PERFORMANCE



FIELD REQUIREMENTS



See Stratakis et al.
See Balbekov et al.

Monthly L2 Status Report -

WBS: 02.04 – D&S Acceleration

6 Sept 2013
Presenter: J. S. Berg



<p><u>Milestone Status (Progress)</u></p> <ul style="list-style-type: none">• Lattices for IDS-NF acceleration: working out final details• IDS-NF RDR acceleration section: only introduction• 5 GeV 325 MHz neutrino factory: only a first look• Just beginning Higgs factory acceleration chain	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <ul style="list-style-type: none">• Interest in looking at a straight 5 GeV linac for a neutrino factory• Need realistic gradients & apertures for 325 MHz SCRF <p><u>Late Items</u></p> <ul style="list-style-type: none">• Behind target on FFAG acceleration chain• IDS-NF RDR acceleration section
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• Put together beginnings of acceleration section for IDS-NF RDR• Calculations for fast ramped dipole• Initial look at longitudinal dynamics for linac to 1.2 GeV at 325 MHz for neutrino factory	<p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• Q4: IDS-NF RDR Linac/RLA section• FY14Q1: Higgs factory FFAGs• FY14Q1: 5 GeV 325 MHz acceleration for neutrino factory
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• Calculations to support FFAG-based acceleration chain design• Finish acceleration section for IDS-NF RDR	

Monthly L2 Status Report -

WBS: 02 05 Collider Ring Design

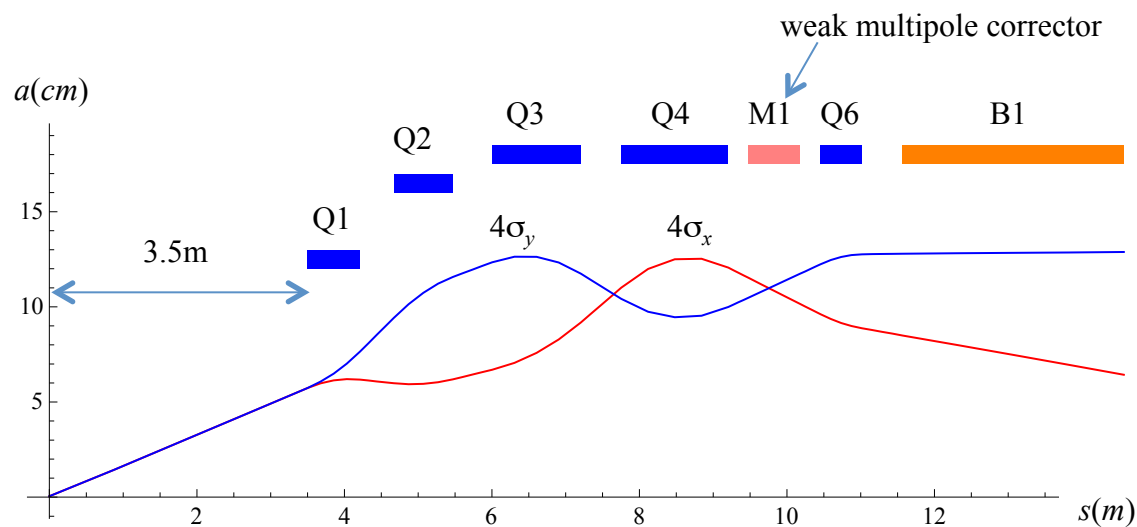
6 September 2013
Presenter: Y. Alexahin



<p><u>Milestone Status (Progress)</u></p> <ul style="list-style-type: none">• Higgs Factory (HF) design with account of detector protection from backgrounds – started 2nd iteration.• Study of effects of field imperfections in wide-aperture IR magnets on beam dynamics in Higgs Factory – DONE.• Longitudinal dynamics studies in Higgs Factory with account of beam-beam forces and wake-fields – started.• Upgrade of the 3TeV collider lattice with combined-function magnets – on hold	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <ul style="list-style-type: none">• All of the studiers were mostly occupied with other tasks or on vacations.
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• New HF IR designed with magnet apertures reduced owing to: increased β^*, increased pole tip field up to 12T, increased number of different apertures from 2 to 3, reduced beam pipe radius from 5 to 4 sigmas.• Weak-strong simulations of the longitudinal beam-beam effect (D.Shatilov) confirmed the strength of the effect, revealed no surprises.	<p><u>Late Items</u></p> <p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• Design of a new version of the HF collider lattice.• Self-consistent longitudinal dynamics simulations for HF• Design of a new version of the 3TeV muon collider lattice
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• Design of a new version of the HF collider lattice.• Longitudinal dynamics simulations for HF - K.Ohmi agreed to perform strong-strong simulations (hopefully this year)• Design of a new version of the 3TeV muon collider lattice.	

Quadruplet Final Focus v2

$\beta^*=3\text{cm}$, $\varepsilon_{\perp N}=0.3\text{mm}$



	Q1	Q2	Q3	Q4	M1	Q6	B1
bore ID (cm)	24	32	35	35	35	35	35
gradient (T/m)	100	-59.4	-54.3	62.9	0	-51.8	0
dipole field (T)	0	2	2	0	2	2	8
length (m)	0.71	0.8	1.2	1.45	0.7*	0.56	3.0
clearance IR-4σ _{max} (cm)	4.3	4.3	4.7	4.9	>5.0	4.8	4.8

*) Physical length. This multipole must provide octupole gradient $\sim 100\text{T/m}^3$ + some (weak) skew quadrupole and be immersed in 2T dipole field

Monthly L2 Status Report -

WBS: 02.06 - Machine-Detector Interface

6 September 2013
Presenter: Nikolai Mokhov



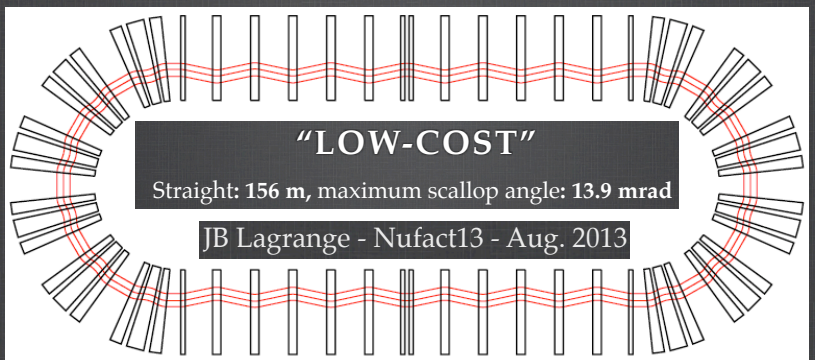
<p><u>Milestone Status (Progress)</u></p> <ul style="list-style-type: none">• Developments of physics and geometry modules of MARS15 for adequate modeling of heat loads in SC magnets and backgrounds in HF and MC detectors.• Development of MARS model of HF IR with large-aperture magnets, MDI and detector as well as of the entire HF ring.• Development of background hit rate reduction techniques.	<p><u>Resource Conflicts, Plan Changes and Issues</u></p> <p>None.</p> <hr/> <p><u>Late Items</u></p> <p>None.</p>
<p><u>Summary of Previous Month</u></p> <ul style="list-style-type: none">• Further tests and fine tuning of the HF MARS model.• Thorough optimization of the MDI configuration with a main focus on the nozzle for further reduction of the backgrounds in the detector.• Extension of the MARS HF IR model to the entire ring with CCS, matching sections and arcs included.	<p><u>Quarterly Plans</u></p> <ul style="list-style-type: none">• Q4: Tests and first background and heat load runs with the MARS model of the entire HF ring.• Q1 (FY14): Production MARS runs on backgrounds to feed the HF detector studies and to minimize heat loads to HF IR and ring magnets.
<p><u>Upcoming Work (Next Month)</u></p> <ul style="list-style-type: none">• After tests, launch HF MARS runs on backgrounds in detector and heat loads on large-aperture SC magnets with the full model of the HF ring.	

Monthly L2 Status Report -

WBS: Decay Rings 02 07

6 September 2013
Presenter: Alex Bogacz



<p>Milestone Status (Progress) Racetrack FFAG</p>  <p>“LOW-COST” Straight: 156 m, maximum scallop angle: 13.9 mrad JB Lagrange - Nufact13 - Aug. 2013</p>	<p>Resource Conflicts, Plan Changes and Issues</p>
<p>Summary of Previous Month</p> <ul style="list-style-type: none">• J-B Lagrange – Mature design of a Racetrack FFAG ring for nuSTORM, with large momentum acceptance ($\pm 20\%$) and limited ‘orbit scalloping’ in the straights was presented at NuFact’13. The design has a comparable cost to the separated function magnet FODO ring (current baseline).• J. Pasternak – Complete lattice design, including injection system using realistic kicker design for 10 GeV NF decay ring, was presented at NuFact’13.	<p>Late Items</p>
<p>Upcoming Work (Next Month)</p> <ul style="list-style-type: none">• A. Liu – nuSTORM FODO ring: Dynamic Aperture studies with newly implemented chromaticity correction scheme (sext + oct)• D. Kelliher – Further optimization of the injection kicker design; smaller aperture magnets.• J-B Lagrange – Explore 4 Tesla PAMELA type magnets to bring down the cost of a Racetrack FFAG ring for nuSTORM, and increase straight/circumference ratio.	<p>Quarterly Plans</p> <ul style="list-style-type: none">• Large acceptance ring design for νSTORM<ul style="list-style-type: none">– Pursue both FODO and FFAG Racetrack designs– Continue lattice optimization and Dynamic Aperture study for both designs• Ring design for NF<ul style="list-style-type: none">– Finalize 10 GeV ring design for IDS-NF– Finalize injection into the ring for both charge species– Adapt 10 GeV ring design (IDS-NF) for 4 GeV L3NF at Fermilab

AOB



- Are there any other issues for today's discussion
- Questions?
- Comments?