Front end simulation tasks

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LEMC Workshop
FNAL

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Background

- NFMCC & MCTF goal: muon collider ZDR in 2012
- simulations will be a major part of the study
- we have begun a study to assess
  - what simulation tasks need to be done
  - how much effort is required (pm = person-months)
  - what is the priority
- we need a plan by August for doing these tasks
  - how to accomplish the tasks with minimum personnel
  - reviewed by Technical Board
  - part of new 5 year NFMCC-MCTF joint planning exercise
  - input to DOE horizontal accelerator review in September
- your input is welcome

Possible schedule

1) explore proposed front end subsystems (2008-2010)
2) examine baseline design (2011)
    - effort should be concentrated on baseline
    - representative matching designs
    - representative tolerance studies
3) detailed study of baseline design (2012)
    - simulations geared towards ZDR requirements
    - design frozen
    - complete all matching sections
    - end-to-end simulation
    - detailed tolerance studies

Effort

- effort assessment for simulating new ideas has **huge** uncertainty
- what to do if something isn't working after initial studies?
  - must make reasonable effort to see how it performs
  - can't spend years trying to understand how to fix it
- effort is directly tied to results of upcoming MuCool experiments
  - effect of B on vacuum RF cavities
  - effect of beam on gas-filled RF cavities
  - probably won't have definite answers for 1 ½ years?

Simulation “WBS”

Simulations

1. Proton driver
2. Target
3. Front end
4. Acceleration
5. Collider ring
6. Physics & detectors

Front end "WBS"

3. Front-end simulations
   - 3.1 decay, bunching & phase rotation
   - 3.2 precooling
   - 3.3 6D cooling
   - 3.4 final cooling
   - 3.5 end-to-end simulation
   - 3.6 general front-end-code development
   - 3.7 breakdown in normal conducting RF cavities

3.1 Decay, bunching & phase rotation

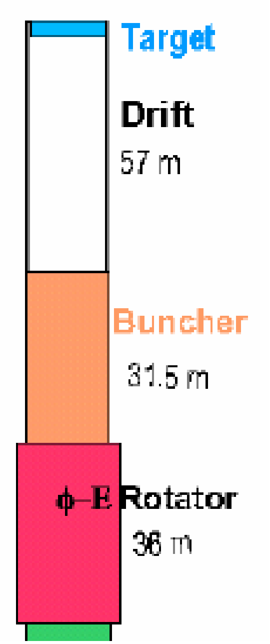
3.1.1 Study 2a

3.1.2 Neuffer 12-bunch scheme

- replace continuous field with coils (1 pm)
- group RF frequencies into families (2 pm)
- absorber & RF windows (1 pm)
- alternate design with magnetic insulation (4 pm)
- sensitivity to errors (1 pm)

3.1.3 LEMC alternative? (4 pm)

- MANX + helical channel?
- low frequency RF near target?
- sensitivity to errors (1 pm)



(D. Neuffer)

3.2 Precooling

3.2.1 Study 2a

3.2.2 Study 2a with LiH → H_2 gas (Neuffer) (1 pm)

sensitivity to errors (1 pm)

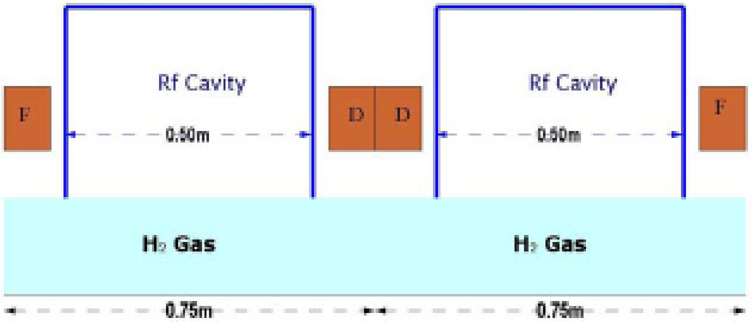
3.2.3 Quad focused channel (Neuffer) (1 pm)

sensitivity to errors (1 pm)

3.2.3 LEMC alternative? (3 pm)

helical channel?

sensitivity to errrors (1 pm)



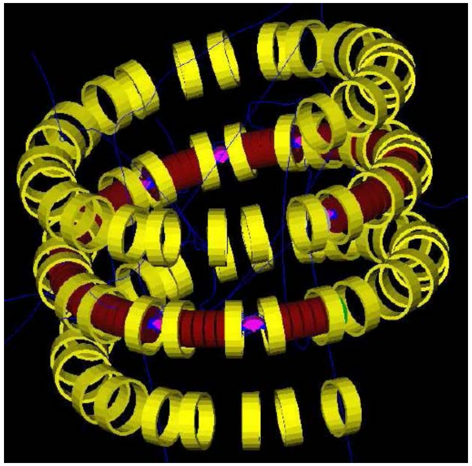
(D. Neuffer)

3.3 6D cooling

3.3.1 Guggenheim
3.3.2 HCC
3.3.3 FOFO-snake
3.3.4 charge separation
3.3.5 low energy bunch merging
3.3.6 charge recombination

3.3.1 Guggenheim

modeling field with multipole expansions (4 pm)
matching sections for present 5-part design? (2 pm)
new channel with tapered parameters (4 pm)
study shielding of field from other layers (2 pm)
confirm predicted performance with G4BL (4 pm)
replace RFOFO lattice with magnetically insulated cavities (5 pm)
injection system (1 pm)
space charge at end of 805 MHz channel (1 pm)
sensitivity to errors (1 pm)



(P. Snopok)

3.3.2 HCC

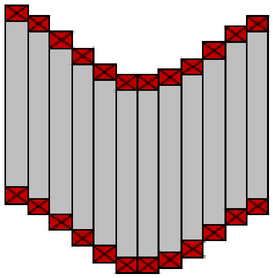
design practical schemes 1-3 (9 pm)
- satisfy engineering constraints on clearances, peak fields
- determine limits of usefulness

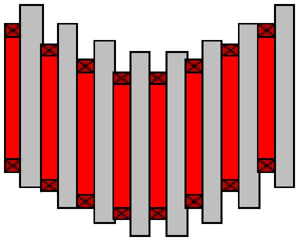
injection system (1 pm)

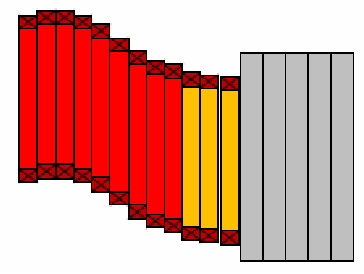
matching sections (3 pm)

space charge at end of channel (1 pm)

sensitivity to errors (1 pm)







(A. Jansson)

3.3.3 FOFO-snake

simulate standard snake performance (5 pm)

determine limits of usefulness

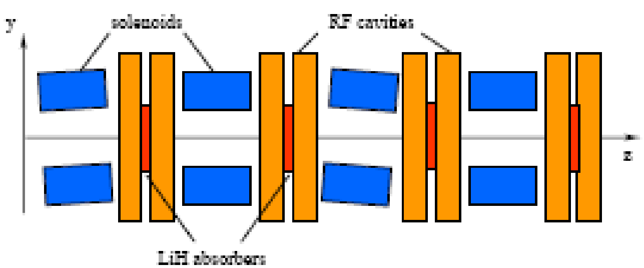
design & simulate lattice with no gas in channel (2 pm)

injection system (1 pm)

matching sections (2 pm)

space charge at end of channel (1 pm)

sensitivity to errors (1 pm)



(Y. Alexahin)

3.3.4 Charge separation

(may not apply to FOFO-snake)

dipole system (2 pm)

bent solenoid system (2 pm)

sensitivity to errors (1 pm)

3.3.5 LE bunch merging

(HEMC scenario only)
merging with planar wiggler (2 pm)
merging with helical wiggler (2 pm)
merging with magnetically insulated cavities (3 pm)
sensitivity to errors (1 pm)

3.3.6 Charge recombination

(may not apply to FOFO-snake)

dipole system (2 pm)

bent solenoid system (2 pm)

sensitivity to errors (1 pm)

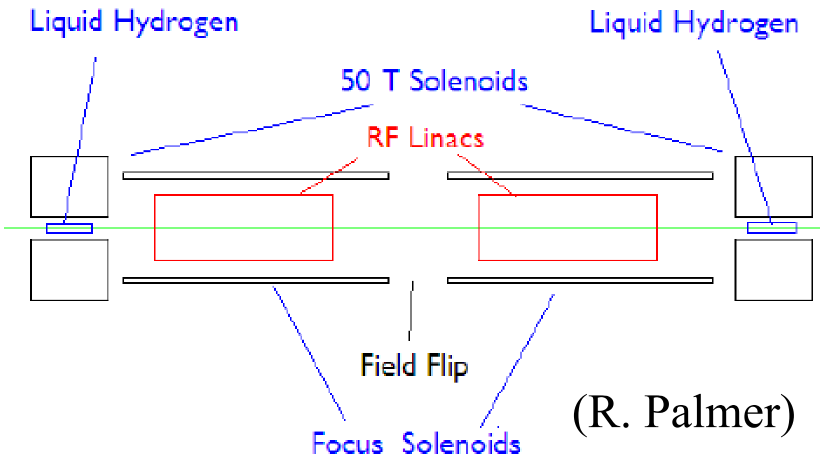
effect of space charge (1 pm)

3.4 Final cooling

3.4.1 50 T HTS channel
3.4.2 PIC-REMEX
3.4.3 low-β bucked coil lattice
3.4.4 lithium lens channel
3.4.5 conventional REMEX with wedges
3.4.6 high energy bunch merging

3.4.1 50 T HTS channel

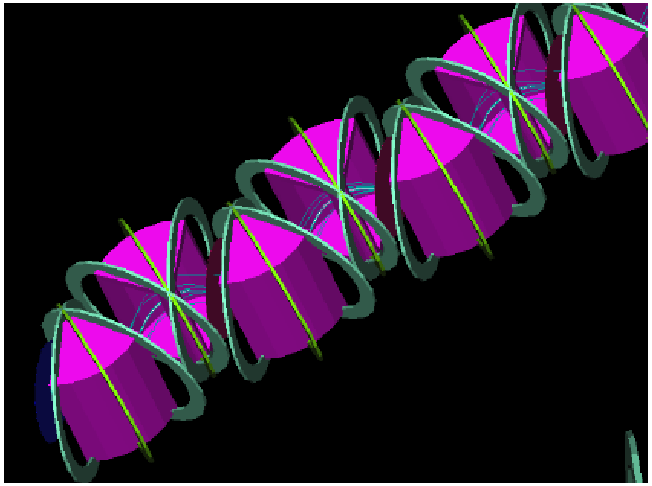
matching between the 7 stages (3 pm)
reacceleration between the stages (2 pm)
reacceleration with mag.ins. RF cavities (2 pm)
final acceleration from ~40 → 200 MeV/c (2 pm)
space charge effects (1 pm)
sensitivity to errors (1 pm)



(R. Palmer)

3.4.2 PIC-REMEX

design aberration-corrected PIC lattice (6 pm)
design PIC lattice with mag.ins. RF (5 pm)
simulation of PIC performance (4 pm)
design aberration-corrected REMEX lattice (6 pm)
design REMEX lattice with magnetically insulated RF (5 pm)
simulation of REMEX performance (5 pm)
space charge effects (1 pm)
sensitivity to errors (2 pm)



(D. Newsham)

3.4.3 Low-β bucked coil lattice

simulation of straight LβBC performance (5 pm)

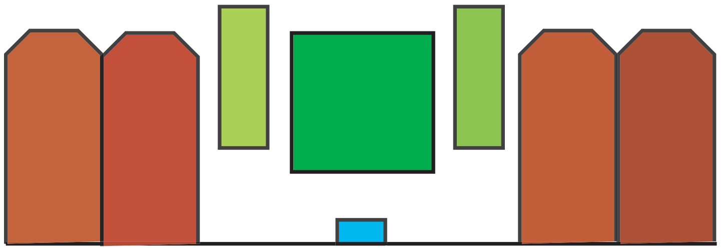
determine limits of usefulness

simulation of dispersive LβBC performance (6 pm)

determine limits of usefulness

space charge effects (1 pm)

sensitivity to errors (1 pm)



3.4.4 Lithium lens channel

simulate straight channel performance (6 pm)
    determine limits of usefulness
injection system (1 pm)
space charge effects (1 pm)
sensitivity to errors (1 pm)

3.4.5 Conventional REMEX with wedges

simulate performance (3 pm)
    determine limits of usefulness
injection system (1 pm)
space charge effects (1 pm)
sensitivity to errors (1 pm)

3.4.6 HE bunch merging

(not used in HEMC scenario)

design bunch merging rings (2 pm)

injection system (2 pm)

extraction system (2 pm)

sensitivity to errors (1 pm)

3.5 End-to-end simulation

design all missing matching sections (4 pm)
ICOOL model of whole channel (3 pm)
G4BL model of whole channel (3 pm)
high statistics runs (1 pm)
understand differences from codes (2 pm)
sensitivity to physics models (1 pm)
  π production, scattering, straggling, …
sensitivity to hardware errors (1 pm)
  fields, gradients, RF phases, …
polarization (1 pm)
dedicated space charge study (4 pm)
  particle-in-cell, boundaries

3.6 General front-end code development

3.6.1 ICOOL

maintenance & minor improvements (4 pm)

3.6.2 G4Beamline

maintenance & minor improvements (4 pm)

3.7 Breakdown in NC RF cavities

- want to understand MuCool measurements

interactions of beam in gas-filled cavities (2 pm)

breakdown of vacuum RF cavities

  CAVEL development (6 pm)

  Tech X code development (2 pm)

  LBNL-SLAC modeling (2 pm)

  ANL plasma studies (2 pm)

design of magnetic insulated cavities (2 pm)