ILC – Main Linac Simulation August 2006 Report.

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ILC-LHC R&D in AMR

Outline

- A proposed plan for CHEF-based studies for the next 6 months
  - my focus: LET results, both “static” and “dynamic”
  - Panagiotis et al: Damping Ring
  - Little new software infrastructure needed for LET.
- Current status on Dispersion Matched Steering in CHEF

Goal of such studies.

- Establish that we have a credible Beam Based Alignment and Steering strategy that preserves the transverse emittance, for the Main Linac (1st priority), if resource available, RTML & BDS
- Study improved performance options, such as adding
  - the capability of moving quadrupoles or cryo-modules, or even individual cavities,
  - and/or additional correctors elements

Assumption on resources.

- Support for CHEF available. (bug fixes...)
- One additional Beam physicist on LET/CHEF studies available.
- If more people become available, writing CHEF documentation should be given higher priority.

Comments of #1 goal

- Based on previous MatLIAR calculation, done!..
  - for Main Linac, at least (RTML still very difficult.)
- But no margin for additional machine imperfections..
  - Dynamic effect while 1st steering..
  - Effect of feedback loops, consistency between static BBA and dynamical steering.
  - Robustness of the solution against small changes in operation.
  - Not yet simulated imperfection of the Linac, (long range wake fields, for instance.)

The Plan, Aug/Sept 06

- Pursue static steering, repeat some but not all previous studies. (Need to think/specify required benchmarks..)
- Consider algorithms with beam elements movers.
- Start on integration of ground motion with existing steering code.
- Start on studies realistic curved Linac (i.e., RDR lattice)

Oct06/Nov 06

- Study 1rst order Beam Based Alignment Steering (i..e, comissioning) with vibration, ground motion and beam jitter, etc... Attempt to estimate how long it will take, on realistic lattices.
  - Main Linac has still priority.
- Study Dynamical Steering algorithm to maintain high luminosity performance, on RDR lattices, once a the beam has been successfully steering
  - include integration of the simple 1 to 1 linear, small corrections.

Oct06/Nov 06, II

- Study realistic (RDR) lattice performance, including matching sections, non-Gaussian beams, effect of missing klystrons and other machine failures.

Later...

- Start on integration issue on RTML/Main Linac integration, focusing on dynamical issues.
- Same with Main Linac/BDS
- Do the Damping Ring to IP integrated, "start to end" simulation.

Comments on Start to End simulation.

- Final goal, but almost always postponed... Why?
  - Makes little sense to do start to end on a simplified version of the machine, once a base line design has been layed out.
  - Requires all the pieces or section to work!!!
  - easily got stuck on local details, that needs to be resolved.
  - Software integration difficulties: some section requires expert software.
- Yet, much needed to give us confidence in a refined baseline design, should be part of a “TDR”

CHEF Tool-kit, requirements.

- Currently missing, but trivial
  - Solenoid
- A bit more work.. (> 3 man-weeks):
  - Spin transport.
  - Undulator.
- Again, maintenance required.
- If to be trusted/used by a broader community, must write documentation!!!

Comments on the plan:

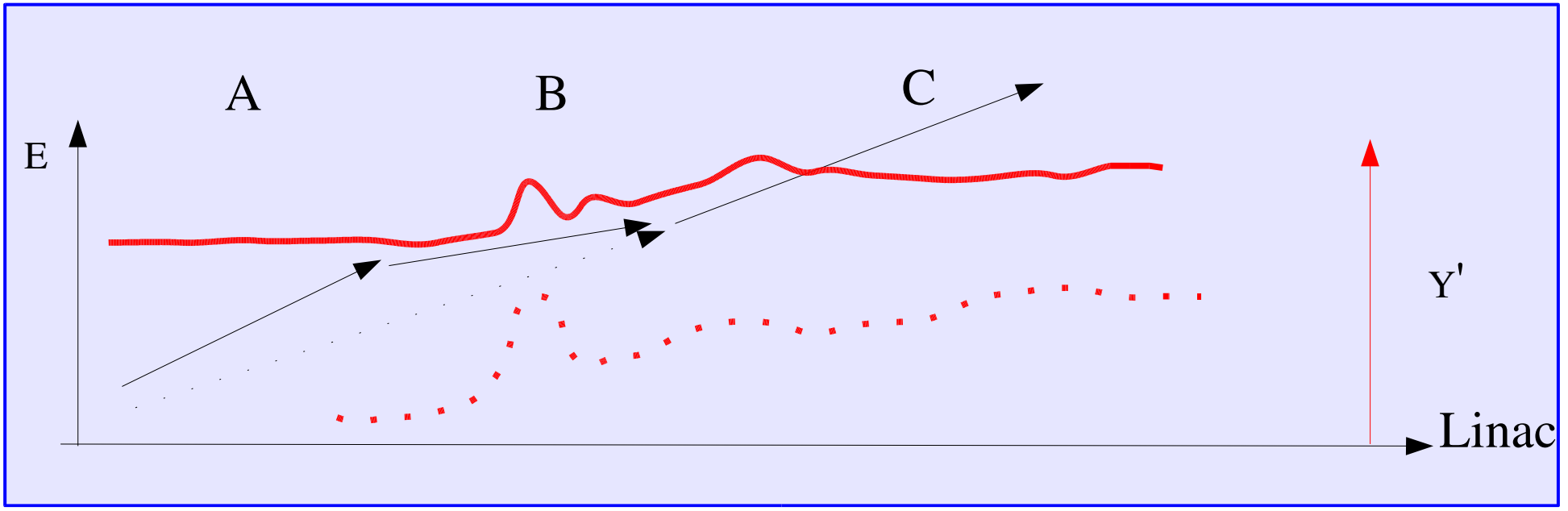
- Uploading the RDR lattices, one by one, into CHEF and check that the perfectly aligned corresponding machine preserves the emittance can start now.
- But this requires one of us to start using CHEF. Perhaps Francois O. or Alex V. can start on this...
- Or conversely, I would have to leave Steering studies and work on this...
- Left aside: Use the Merlin DFS algorithm in the context of Merlin, and vice-versa: Nice infrastructure project, but also very useful if CHEF (or Merlin!) results are disputed: allowing to dissociate between tracking and steering algorithm features or problems.

Recent progress on Steering in CHEF

- Polished a bit the Dispersion Matched Steering, and kept testing in DFS mode.
- Good performance if cavity tilts/offsets are ignored!.. In fact, emittance growth can be made less than 1 nmRad for the first ~144 cryo-modules
- Real difficulties when cavity tilts: gained a better appreciation of limits of DFS, started to document a (probably known!) feature of the algorithm.
- And started to implement an algorithm based on moving sets of cavities, to fix or improve the above problem...

On Dispersion in misaligned LINAC

- The dispersion in a given section C depends on how the beam has been accelerated in previous section A & B. If section A is perfectly aligned and rans at higher than nominal voltage, section B is misaligned runs at a lower than nominal voltage, the transverse kicks in section B will be reduced compared to the case where section A runs at higher voltage than section B.



Observed this in Benchmark 2 lattice...

- Conditions:
  - Section length where steering occurs: 8 dipoles (short!)
  - Overlapping by 7 dipoles (tedious!) That is, moving from one section to the next, I simply shift section B & C by one dipole/BPM, or 24 cavities.
  - A always at nominal accelerating gradient, B reduced. But section B moves as we keep steering sections after sections.
- Observation:
  - Starting Section C at dipole 4, optimum steering for dipole 6 was found to be -0.000258426 T.m. On section 5, this value changed only by less then 1% , to -0.000260542. But, on section 6, the DFS algorithm changed for this dipole to ~+1 10^{-5}

And...

- Setting for other dipole are also widely different than in the previous section -> different solution emerge.
- In practice, one tend to verify previous solution, i.e., go back and forth and check things. If we find different solutions, this tends to be very confusing. => bad algorithm behavior.

Current Fixes...

- Jeff S. retuned the orbit in such a way that, entering section C, being steered, the trajectory matches at given energy. (I think that what he does).
- A clever patch, which hides the following difficulty: suppose we steer with a given set of working klystrons. Next day, one must use a different set, as a few have been repaired and new ones. A different pattern of dispersion(s) values will emerge, does this mean we'll have to re-steer?
- Other algorithm distinguish between bad and even worse solution by minimizing a combined dispersion + deviation chi-square.
  - (not yet implemented in CHEF, but easy to do now..)

A better fix ?

- Re-align the machine, instead of steering the beam!
- Not currently possible, no movers on beam line elements. Too challenging from the mechanical engineering standpoint.
- Even if we do have movers on cavities, how do we do BBA with them?
  - Easy, based on the previous observation: one must have the same dispersion in section C independently of the E(s) functions in upstream section.

Compromise

- Move a cryo-module ! Prior to DFS section C, re-align cryo-module upstream such that the trajectory w/o energy reduction in section B gives the same dispersion measurement.
  - Coded up, started to test it out...

Outlook

- Meanwhile, must improve the speed of the DFS algorithm, not compromising on its accuracy.. (not too much !...)
  - Not re-tracing though steered sections.
  - Not re-computing response matrices..
  - reduce overlap between section.
  - number of iteration
- Started to run on ilcsim again, and get ready for the farm..
  - Condor Script ready.
  - Awaiting to get re-certified at getting certificates.