4 TeV squeeze loss maps with Merlin update

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Modelling the 4 TeV squeeze optics

• Spoke before about comparing Merlin to BLM data and sixtrack for the 4 TeV squeeze
• Merlin did not give the expected losses in IR1, IR2 and IR5.
Can also compare with Sixtrack.

SixTrack

BLM

Merlin

S (m)

Loss/\max(Loss)

\eta (m^{-1})
Checks

- Lots of checks to inputs, optics files, and code functions
- Adjusting the IR2 TCTs.
  - Reducing from 12 to 6 or 7 sigma shows losses, so they are functional in the code.
- Checking aperture
  - Some differences between merlin and sixtrack apertures. Fixed some issues in merlin. But does not appear to be the cause of discrepancy
Trajectory comparison

• By comparing a single particle trajectory between sixtrack and merlin we can see why it survives in one code and is lost in the other
• Roderik extracted the trajectory of particles that are lost in IR2 in sixtrack
  – $dp \sim 5e^{-3}$
• I took the initial coordinates of those particles and ran them in merlin
Starts well
Large deviation on entrance IR8
Not good in IR1
Misses the TCT in IR2
Optics

• Looks like the optics disagree in IR8
• Found that Sixtrack simulations have been using -220 μrad horizontal cross angle, where as the madx optics file had this disabled
• Also sixtrack is using -90 μrad in IR2 where the madx files had 145
• The IR8 change made a significant improvement
Small remaining difference

- There was a difference in the optics in IR8 and IR2. This is fixed now.
- The remaining difference looks like a small drift between the codes. Which appears amplified at the IRs due to the high beta
- Check by starting the particle close to IR1
Other checks

- Imported particle coordinates have truncated precision
  - Checked that results are not sensitive to small changes in initial position/energy.

- Tracking model
  - Merlin has 2 (now 3) trackers
  - Made these runtime switch-able
    - `tracker->SetIntegratorSet(new ParticleTracking::TRANSPORT::StdISet());`
    - `tracker->SetIntegratorSet(new ParticleTracking::THIN-LENS::StdISet());`
    - `tracker->SetIntegratorSet(new ParticleTracking::SYMPLECTIC::StdISet());`
  - Subtle differences between trackers don't explain tracks

- Momentum vs energy, $x'$ vs $p_x$
  - Careful audit, but too small to effect tracks

- Optics, possibly a subtle optics difference
  - Perhaps due to thick->thin conversion for SixTrack
  - Sixtrack optics files would be useful (Just received these)
Rerun loss maps

- Apart from small remaining difference, now good for loss map runs
- Rerun loss maps with the fixed optics
Code merge

• We have long been talking about merging all the merlin development into a single codebase

• This is now done:
  – New scattering (Elastic and SD), with clean modular code
  – Hollow electron lens
  – General clean up (Spoiler->Collimator)
  – Error models
  – Improved performance
  – Bug and memory leak fixes
  – Test suite
  – Git history
Conclusion

- Comparing trajectories between Merlin and sixtrack has highlighted differences.
- Some optics configuration difference, now fixed
  - Better reproduction of losses in IR1 and IR2
  - But still short on losses in IR2
- Looks like there is still a small drift between codes
  - I can keep looking for a solution
  - Could implement Sixtrack thin lens tracker in Merlin
- Code merged
- Ready for HiLumi production runs