Update on proton cleaning studies

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General updates since last time

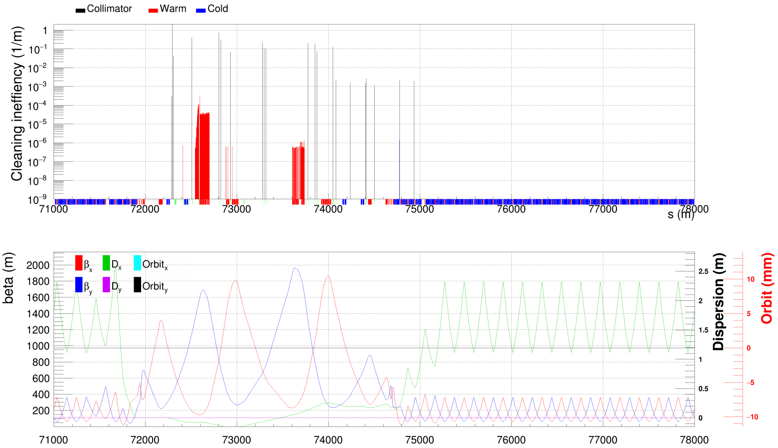
- Now running with the SixTrack - FLUKA coupling (latest versions of each - many thanks to the FLUKA team).
- Slight additions to the lattice from the 'baseline' (master branch in the repository):
- The TCDQ has been added - but using the LHC models (not quite the correct density and length).
- High luminosity IRs have 2 sets of TCTs, 'low' luminosity has 1 set.
- Each experiment and collimation insertion has 2 TCLDs in the dispersion suppressor.
- The beam pipe is the correct octagon shape now - but no photon dump slit.
- Collimator configuration now fully updated: TCPs are 30cm, the first TCSG is CFC with the thicker jaw, and all other TCSGs are MoGr with the low impedance coating.
- Now running at collision, with 30cm β^* and the crossing angle enabled.

Loss map information

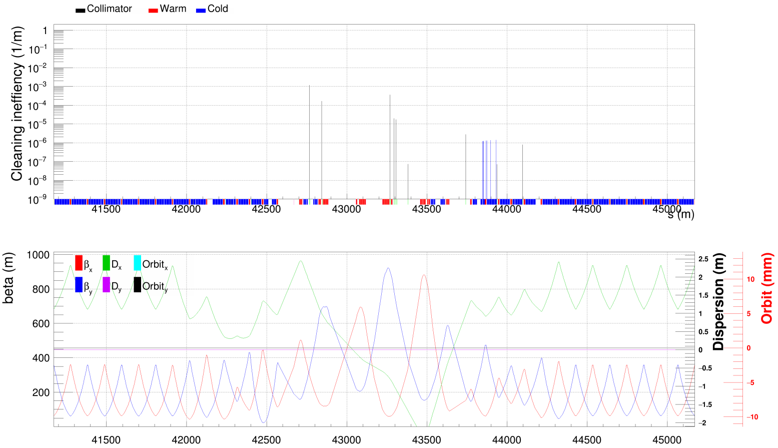
- NOTE: Unlike previous loss maps which showed the numbers of particles lost around the ring, these will all show the energy lost in each bin.
- For example, a 1 MeV lost proton will show a smaller loss spike than a 50 TeV proton.
- The total energy lost in the collimators and aperture is summed, and each lost bin is normalised to this value, so it can be now read as the fraction of the total input energy that is lost at a location (per meter).
- Remember the power load is approximately 11 MW for a 12 min beam lifetime.
- The first simulations have a 30% cut in energy from the reference - i.e. everything below 35TeV is killed.

Horizontal halo loss map

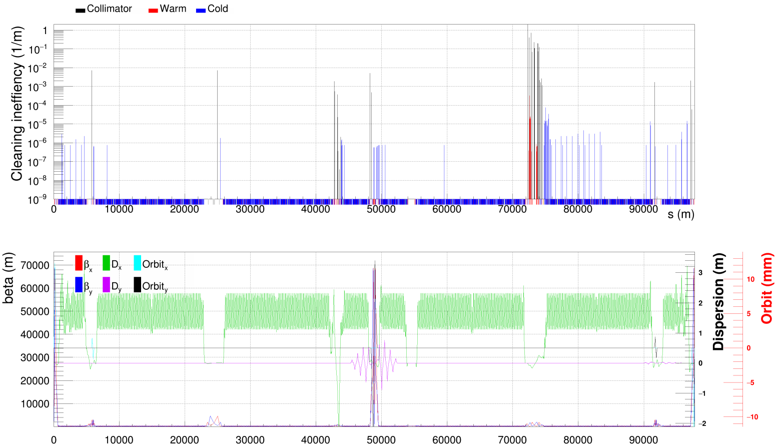
Horizontal halo loss map



Horizontal halo loss map



Horizontal halo loss map - no TCLDs



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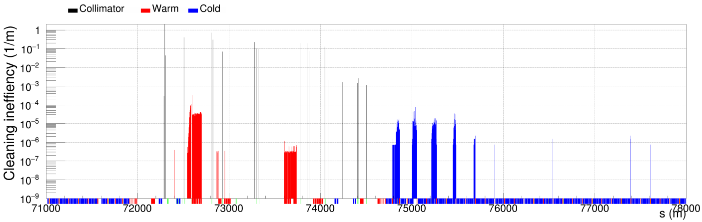
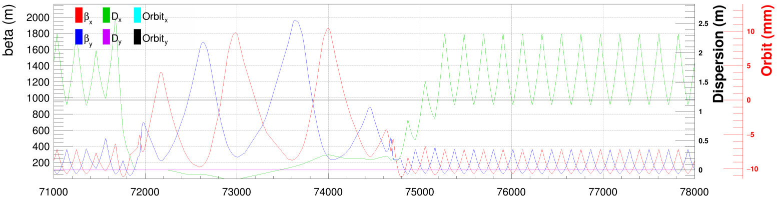
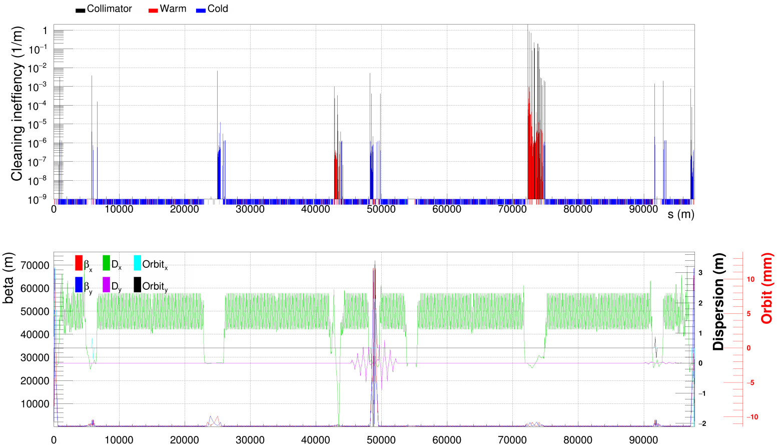




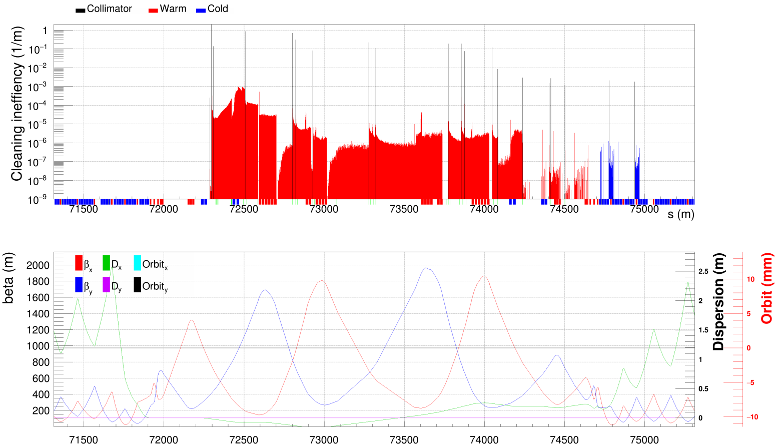
General SixTrack - FLUKA coupling improvements

- The base SixTrack release now has the online aperture check fully implemented.
- All particle count limits in SixTrack have been removed.
- The heavy ion tracking code of P. Hermes has been merged into the main SixTrack release.
- What we really wish to know is the energy flow around the machine - where does the energy end up being deposited?
- Since we can now track all particles from protons through to heavy ions (specifically protons, deuterons, tritium, Helium-3, Helium-4 and 'heavy ions', why not send these back to SixTrack?
- Production and transport cuts of the above particles were removed in FLUKA (as much as is possible to do in the coupling) - both internally, and for particles to be sent back to SixTrack for further tracking.
- Does the previous 30% cut in energy make sense? We can now generate very low energy protons and debris - so check!

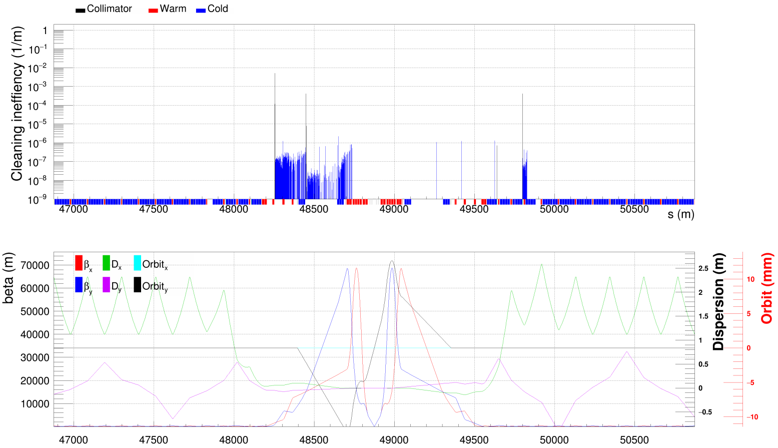
Horizontal halo loss map - no cuts



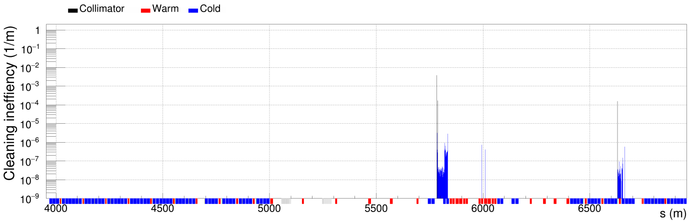
Horizontal halo loss map - no cuts

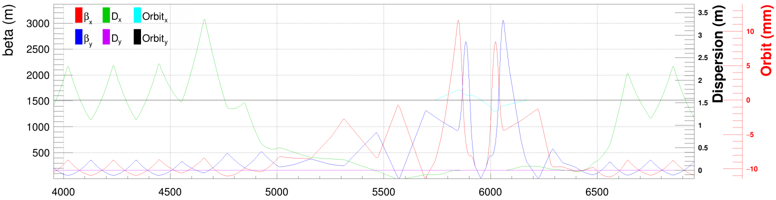


Horizontal halo loss map - no cuts

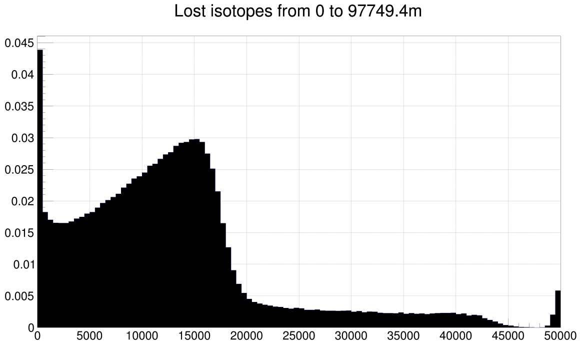


Horizontal halo loss map - no cuts



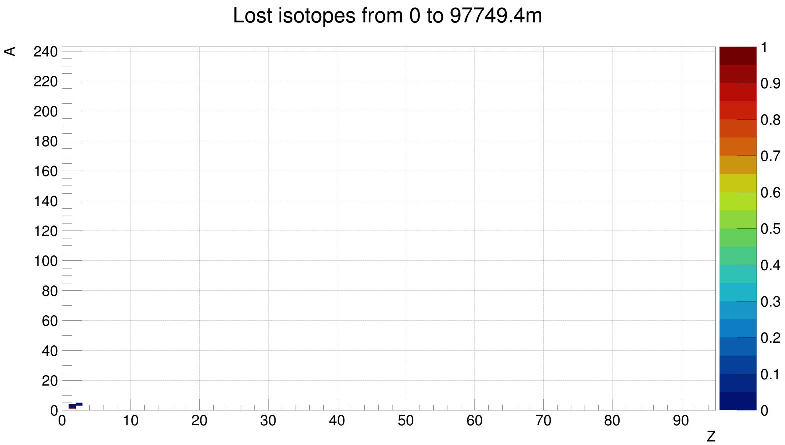


Aperture hit energy fractions



- Each bin is scaled to the bin energy and then normalised to the total energy deposited in the aperture.
- The majority of the energy deposited on the aperture is low energy debris, but it is confined to the warm regions.

Particle species lost in the aperture



- No heavy ions escape, but some light fragments up to He-4 escape. They do not contribute a significant fraction of the energy.

Summary of cut removal

- Even with no TCLDs, no low energy debris escapes the collimation insertion into the cold areas.
- With TCLDs (shown previously), debris does escape the TCLDs - and the quantity is significant.
- Previous simulations by A. Krainer showed this, and the real machine will have absorption masks added.
- This same problem also occurs in all areas where there are lone collimators - e.g. TCTs, the TCDQ, and TCLDs.
- Local energy deposition studies would be useful, and absorption masks are needed.
- Debris coming from the TCTs could generate a large background for the experiments!

Skew halos and skew collimators

- Some older outstanding points still remained for simulations with the skew collimation system.
- Due to the high load on the skew primary collimator from debris generated by the vertical and horizontal primaries, it has been proposed to remove the skew TCP.
- Is this possible?
- Inject skew halos up to the aperture restrictions - with the TCP: 5.353σ in each plane.
- Without - The aperture restriction becomes the horizontal/vertical TCP: 7.57σ in each plane.

Skew halo loss map - with the skew primary

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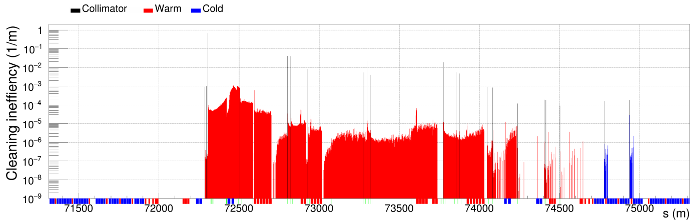
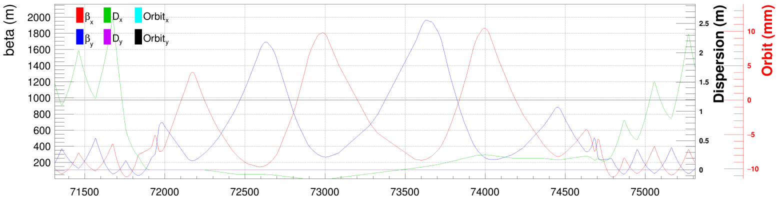
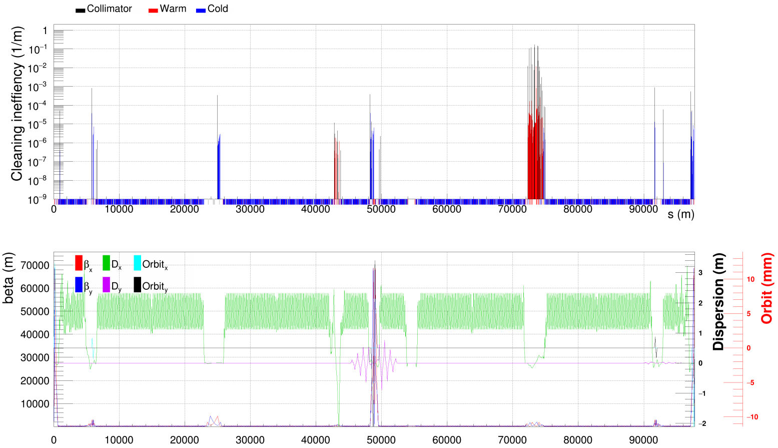
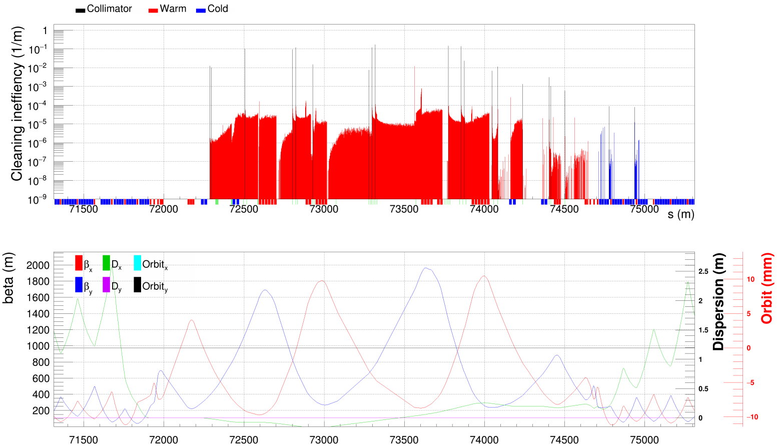




Skew halo loss map - without the skew primary



Skew halo loss map - without the skew primary



Summary

- Can now perform more detailed simulations using the SixTrack-FLUKA coupling to get a more realistic feel for the energy flow around the machine, and using a more up to date lattice configuration.
- In general the cleaning is good, but some areas potentially will need more study - e.g. TCTs - as show by the removal of cuts.
- Removal of the skew TCP could be possible, but only if an additional limit is placed on the beam lifetime in the skew plane.
- Next steps: Update the TCDQ and take into account the rectangular dipole shape for the aperture checking.
- Then re-run all simulation cases to finish the CDR chapter.