Collimation loss simulations

J. Molson, A. Faus-Golfe

LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, Fr

October 9, 2017

Thank you to the many people involved:
J. Molson[1], A. Faus-Golfe[1], R. Bruce[2], F. Cerutti[2], A. Ferrari[2], A. Mereghetti[2], S. Redaelli[2], K. Sjobak[2], V. Vlachoudis[2], Y. Zou[3], R. Barlow[4], R. Appleby[5], H. Rafique[5], S. Tygier[5]

[1] LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, Fr

[2] CERN, Geneva, CH

[3] IHEP, Beijing, CN

[4] IIAA, Huddersfield, UK

[5] University of Manchester, Manchester, UK

Overview

- Objective: Simulate and evaluate the FCC-hh collimation system.
- The following talk is an overview of past work at LAL.

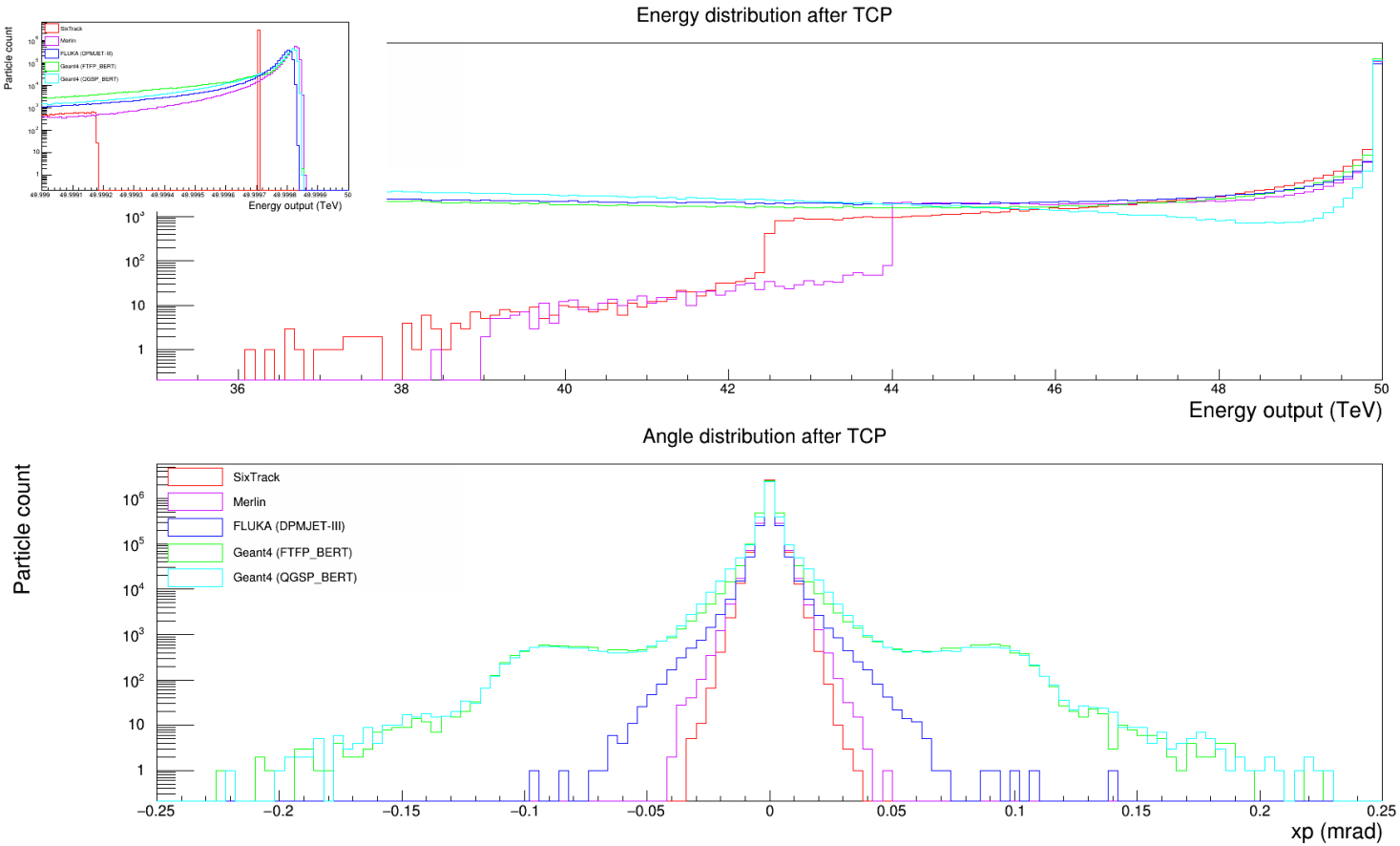
1. Update tools to work with the FCC - a lot of hard coded LHC values existed.
2. Test tool physics at the FCC energy.
3. Evaluate the performace of provided collimator optics and lattices.
4. Suggest changes to enhance the system performance.

Collimation physics codes

- Collimation tools have been tested at LHC energies, but the FCC-hh is much higher.
- Are the models in the current codes used valid at the FCC-hh energy?
- Are differences in simulation codes due to tracking or due to physics?
- Implement diifferent physics models directly into sixtrack to perform a comparison - therefore all use the same tracking.
- If all is good, all results will be the same.
- K2, and FLUKA were already added - have since added Merlin and Geant4 FTFP and QGSP.

See IPAC 2017 talk, "A Comparison of Interaction Physics for Proton Collimation Systems in Current Simulation Tools", (WEOBA1).

Codes comparison: Test collimator physics



Codes comparison: betatron loss map

Codes comparison: loss map - betatron collimation

Loss levels relative to K2

Region	Merlin	FLUKA	G4 FTFP	G4 QGSP
β TCP	1.00	1.01	0.92	0.94
β TCSG	1.00	1.27	1.45	1.32
β TCLA	0.92	1.50	2.37	1.91
β DS1	0.51	0.57	0.68	0.066
β DS2	0.44	0.45	0.52	0.032
β DS3	0.41	0.43	0.51	0.027
β DS4	0.41	0.45	0.47	0.086
δ TCP	0.45	1.39	1.12	0.69
δ TCSG	0.49	1.36	1.24	0.79
δ TCLA	0.51	1.3	1.22	0.92
Total	1	1.05	0.99	0.99

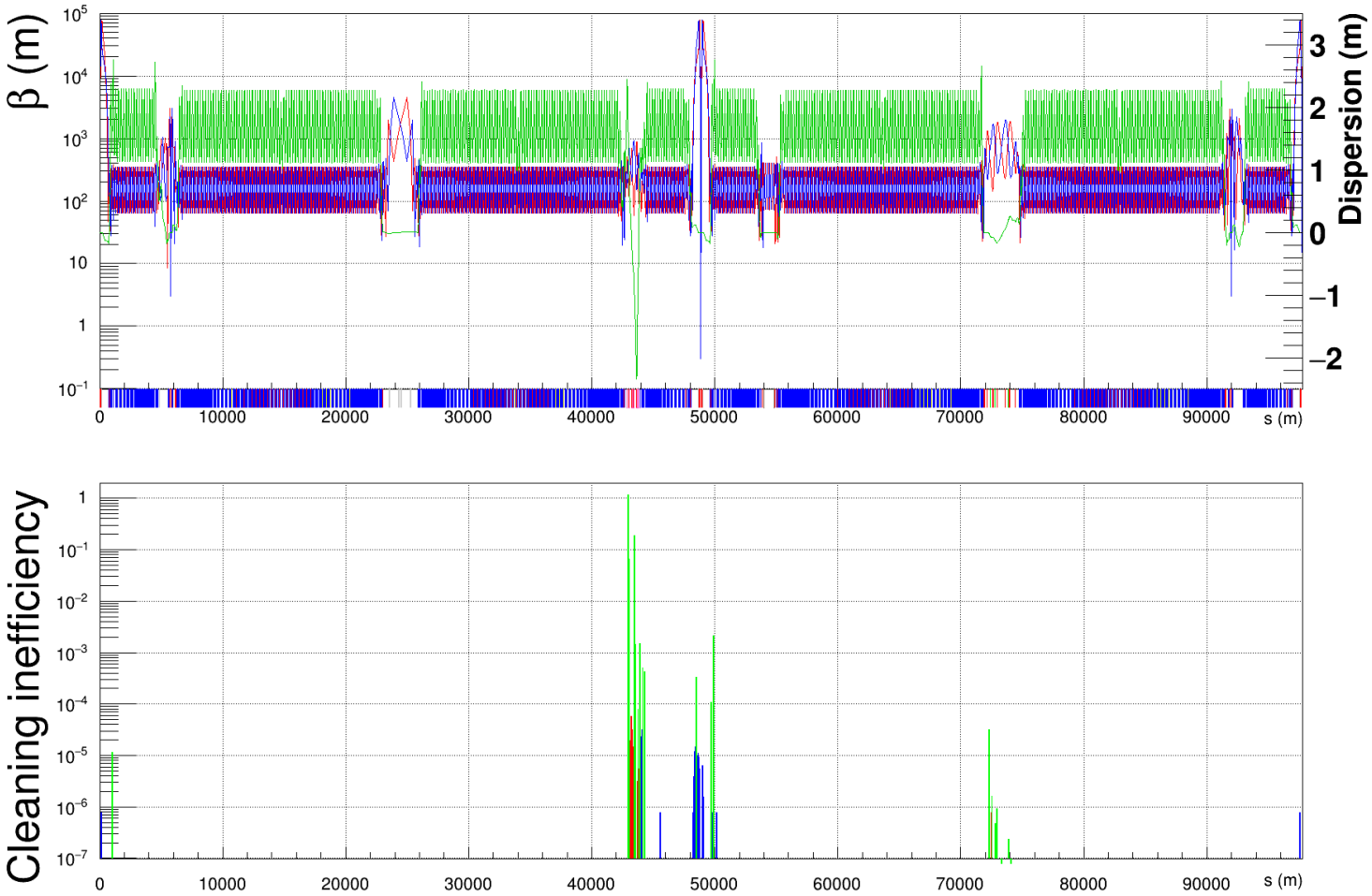
- Good agreement - losses are observed in similar locations, but differences occur in the quantity of losses at each peak.
- Exclude codes that are clearly incorrect - will not use K2 or G4 GQSP.

Dispersion suppressor collimators

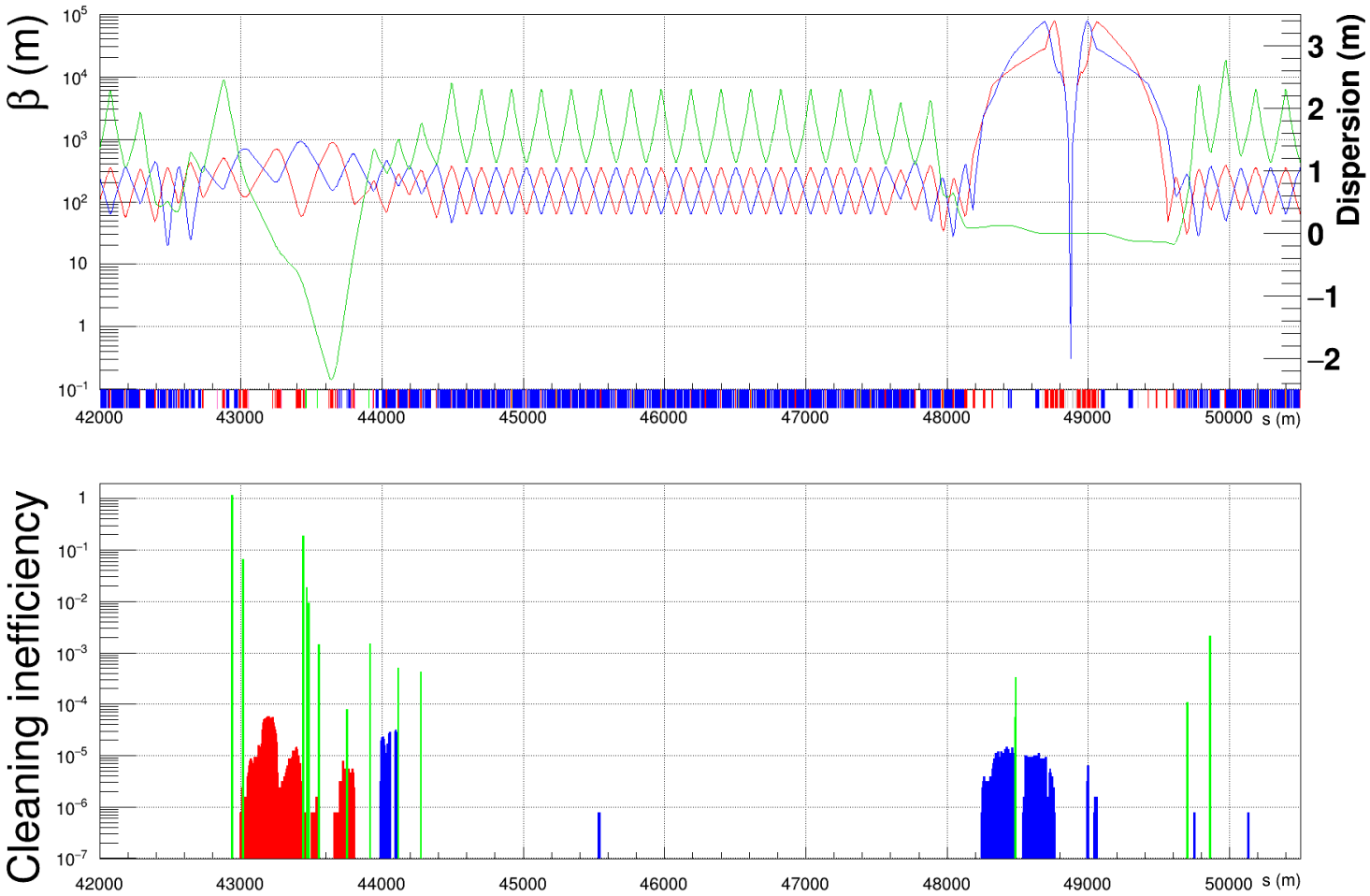
Energy collimation

- The collimation system has been taken as a scaling from the LHC.
- Following loss map uses the Berlin/IPAC lattice.
- DS collimators are in and enabled.
- TCP - 18.06σ, TCSG 21.67σ, TCLA 24.08σ, TCLD 35.14σ.
- 6.4 million protons, fixed $dp = -0.0015$. Tracking starts at IPA, 200 turns.
- TCP is at $dp \approx 0.001$.

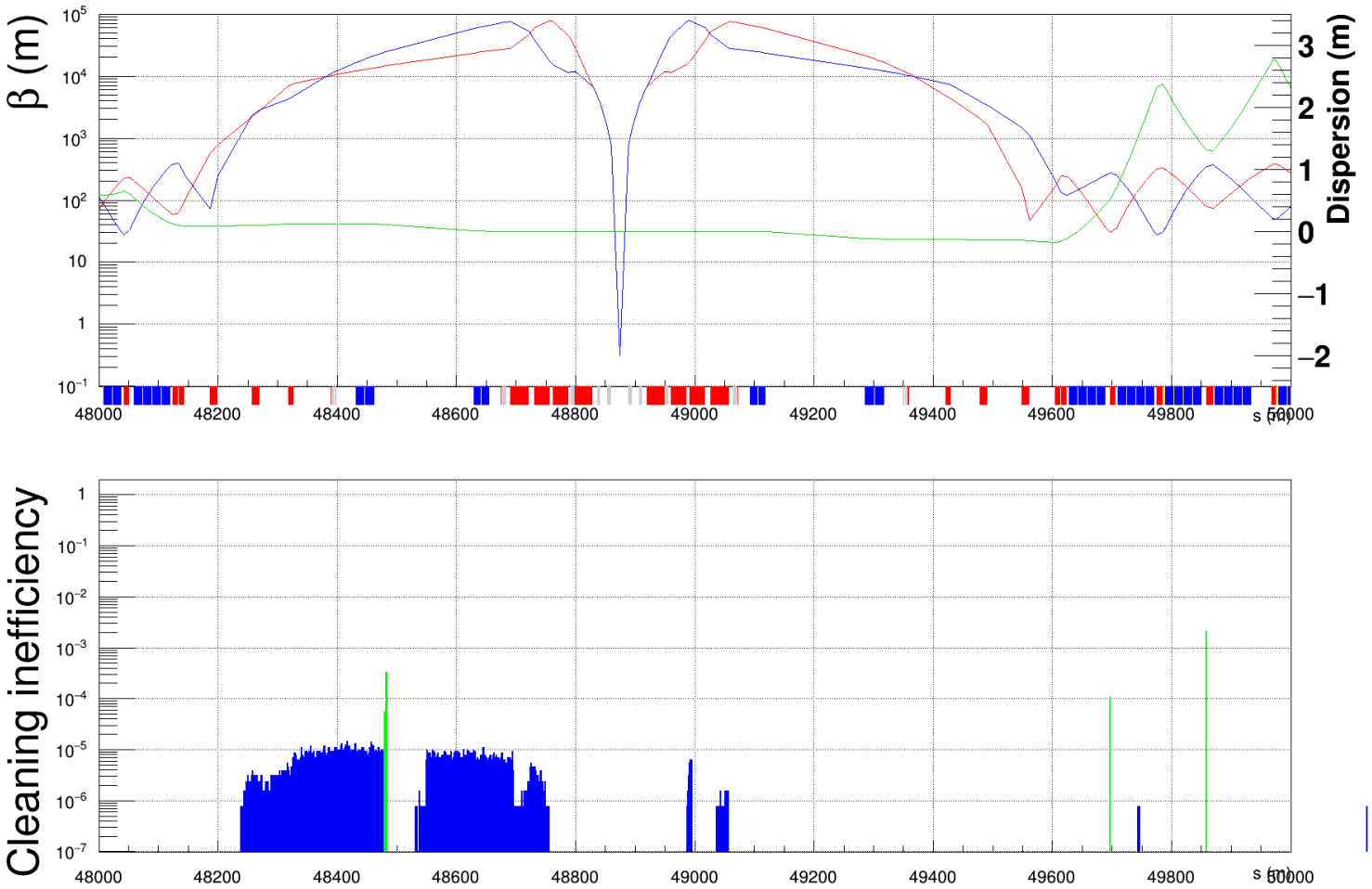
Energy loss map - full ring



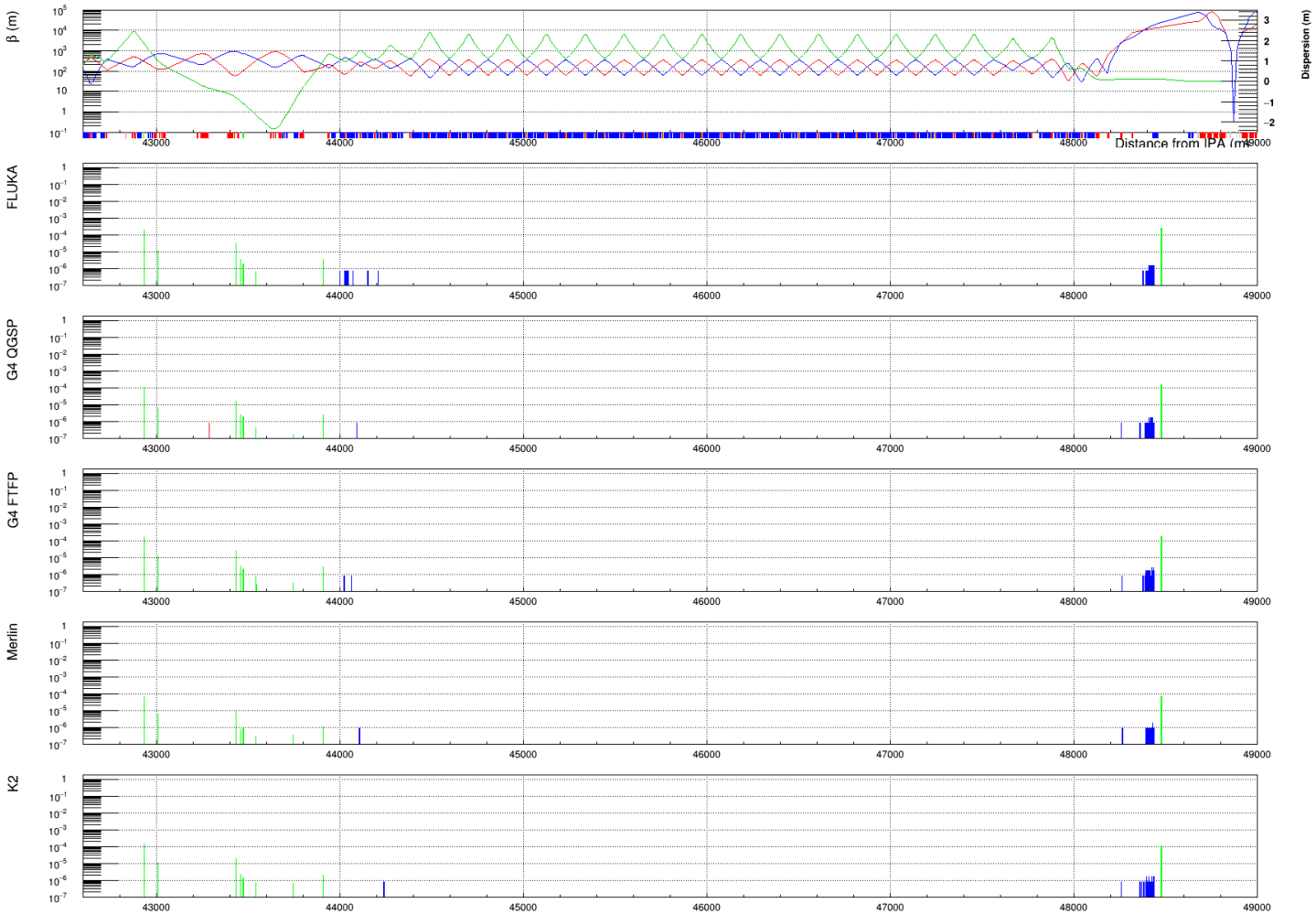
Energy collimation insertion



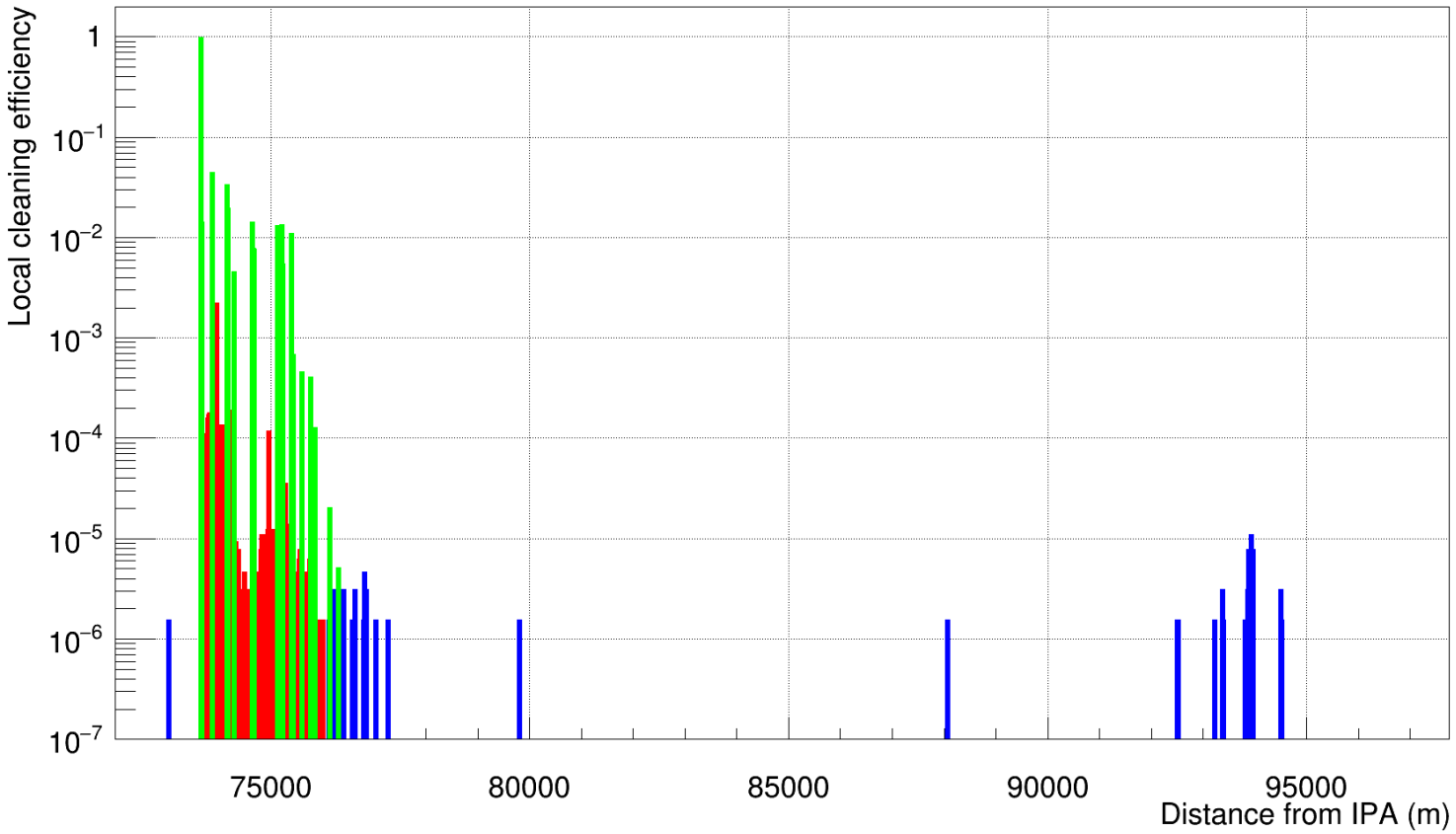
Energy loss map - IPG



Betatron loss map - energy collimation insertion



Injection


Local cleaning efficiency
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
75000
80000
85000
90000
95000
Distance from IPA (m)

Energy collimation summary

- Is the lattice fully corrected (chromatically)?
- The current collimator jaws are placed in the unstable region of the longitudinal phase space.
- These should be placed closer - but much closer could cause the system to interact with the betatron collimators.
- Possibly should switch to the alternate energy collimation layout with higher normalized dispersion.
- Move the energy collimation dispersion suppressor collimators back a cell - currently they do not function sufficiently well.
- Care required with energy loss into the IR - perhaps extra TCT collimators are required?