Energy collimation system insertions and performance evaluation tools

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LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

FCC hh ee he

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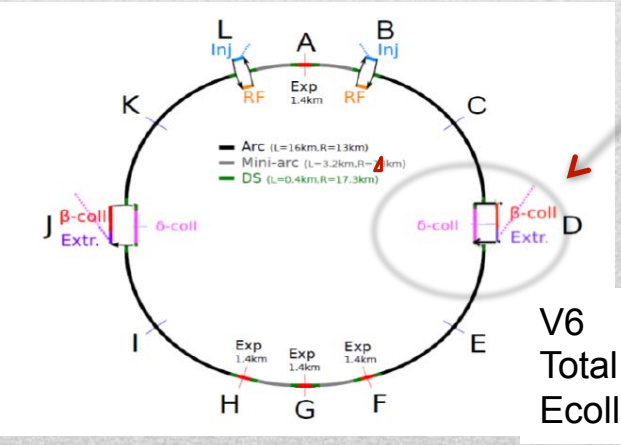
EuroCirCol

Outline

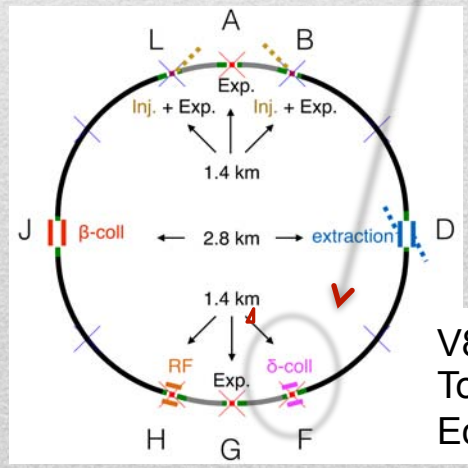
- The “old” energy collimation system
- The tools for performance evaluation
- The ”current” energy collimation system
- The plans for the “new” energy collimation system

FCC parameters

Parameters	LHC V6.503	HL-LHC	FCC V6	FCC V8	Scale LHC
Length [m]	26658	26658	100171	97749	x3.76/3.67
Top beam energy [GeV]	7000	7000	50000	50000	x7.14
Bunch count [25 ns]	2808	2808	10600	10600	x3.77
Bunch particle count [10^{11}]	1.15	2.2	1	1	x0.87
Stored beam energy [GJ]	0.362	0.693	8.4	8.4	x23.2
Normalized emittance [mmrad]	3.75	2.5	2.2	2.2	x0.59
Luminosity [10^{34} cm^{-2} s^{-1}]	1	5	5	5	x5
Beam-collimator interaction [GeV]	114.62	114.62	306.32	306.32	x2.67



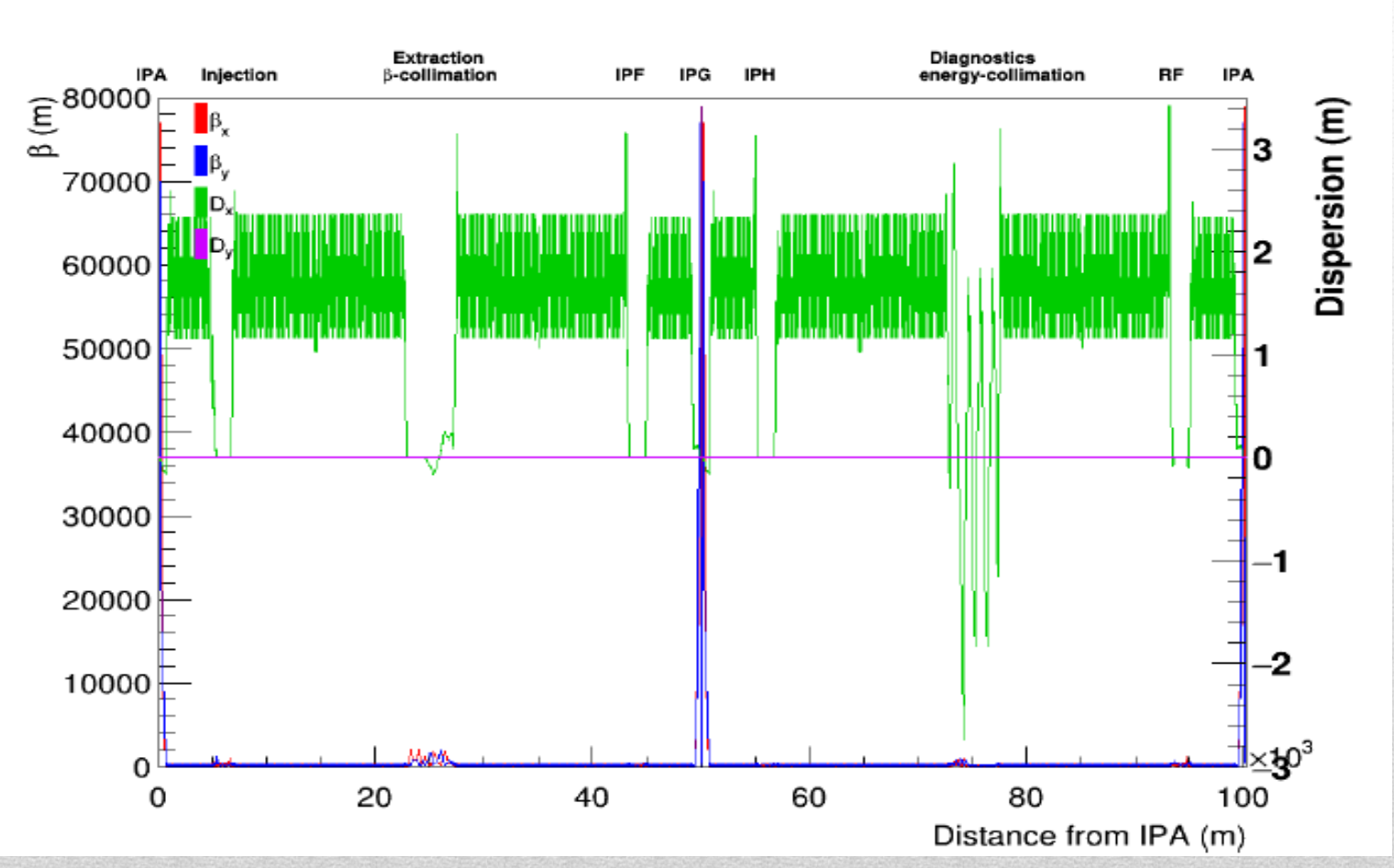
V6
Total length 100171 m
Ecoll length 2800 m



V8
Total length 97749 m
Ecoll length 1400 m

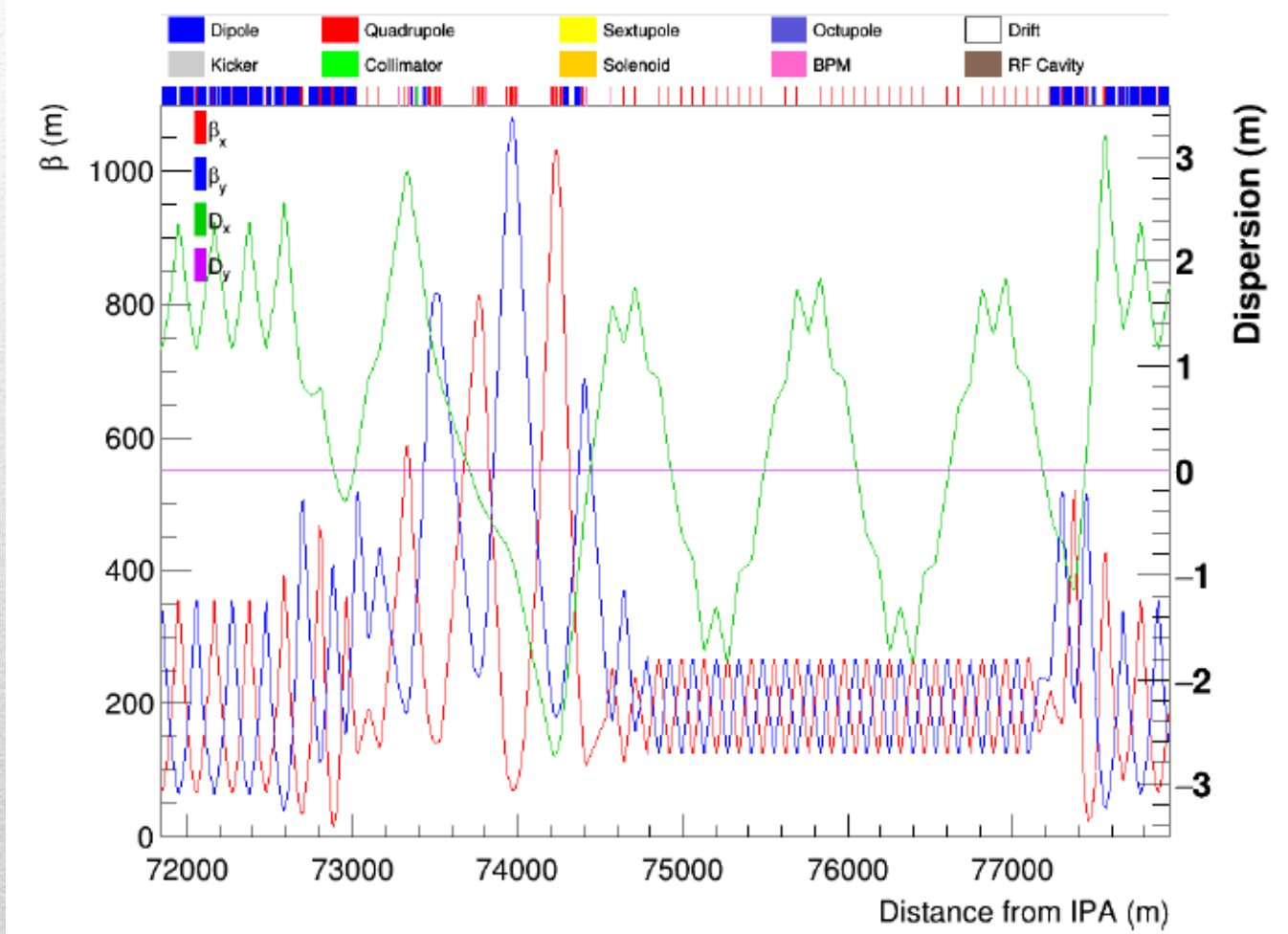
The old energy collimation system

Full ring V6 optics



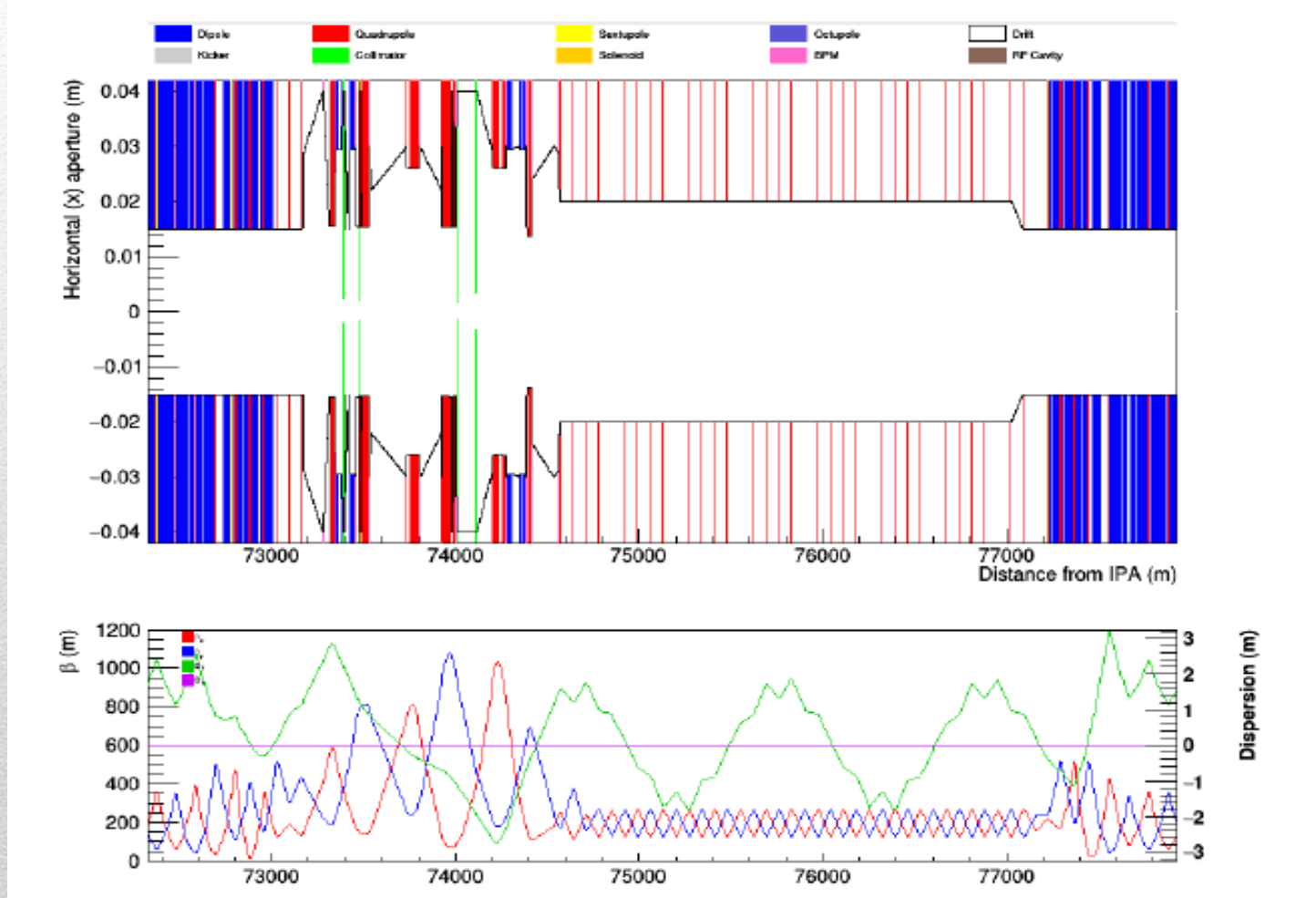
The old energy collimation system

The energy collimation system optics V6



The old energy collimation system

The energy collimation system V6 aperture model



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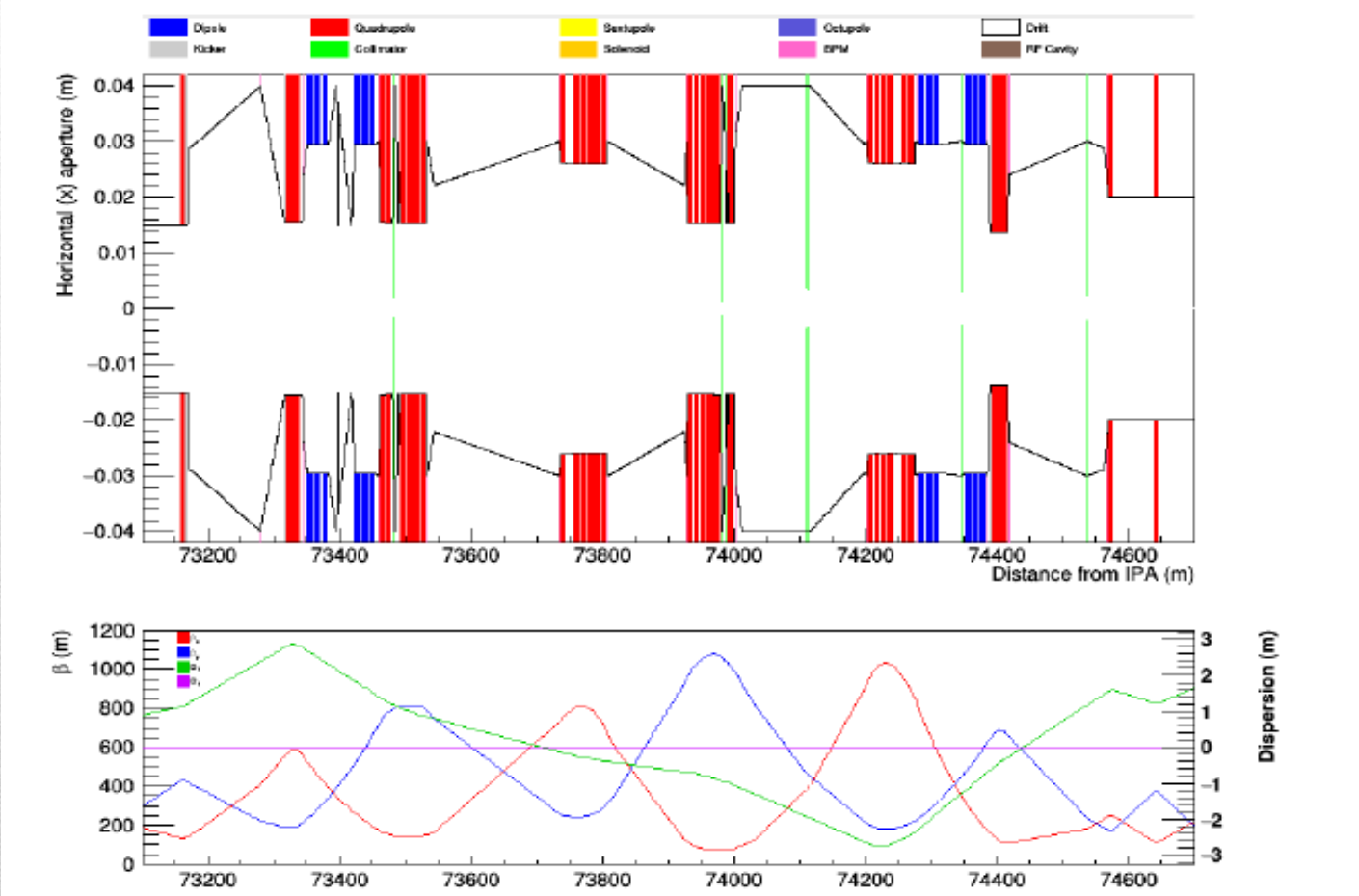
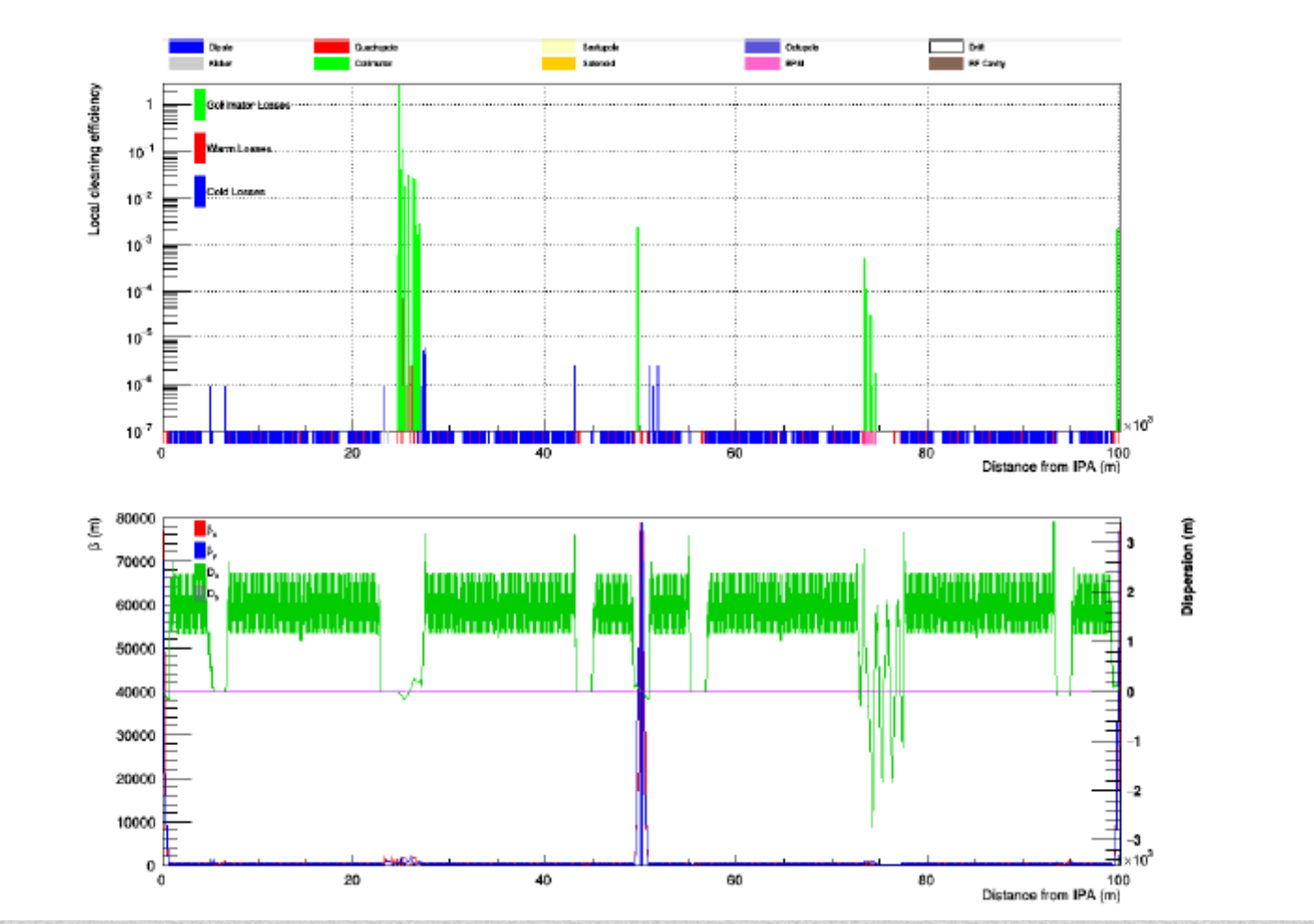


The old energy collimation system

Full ring loss map V6 on-momentum with Merlin



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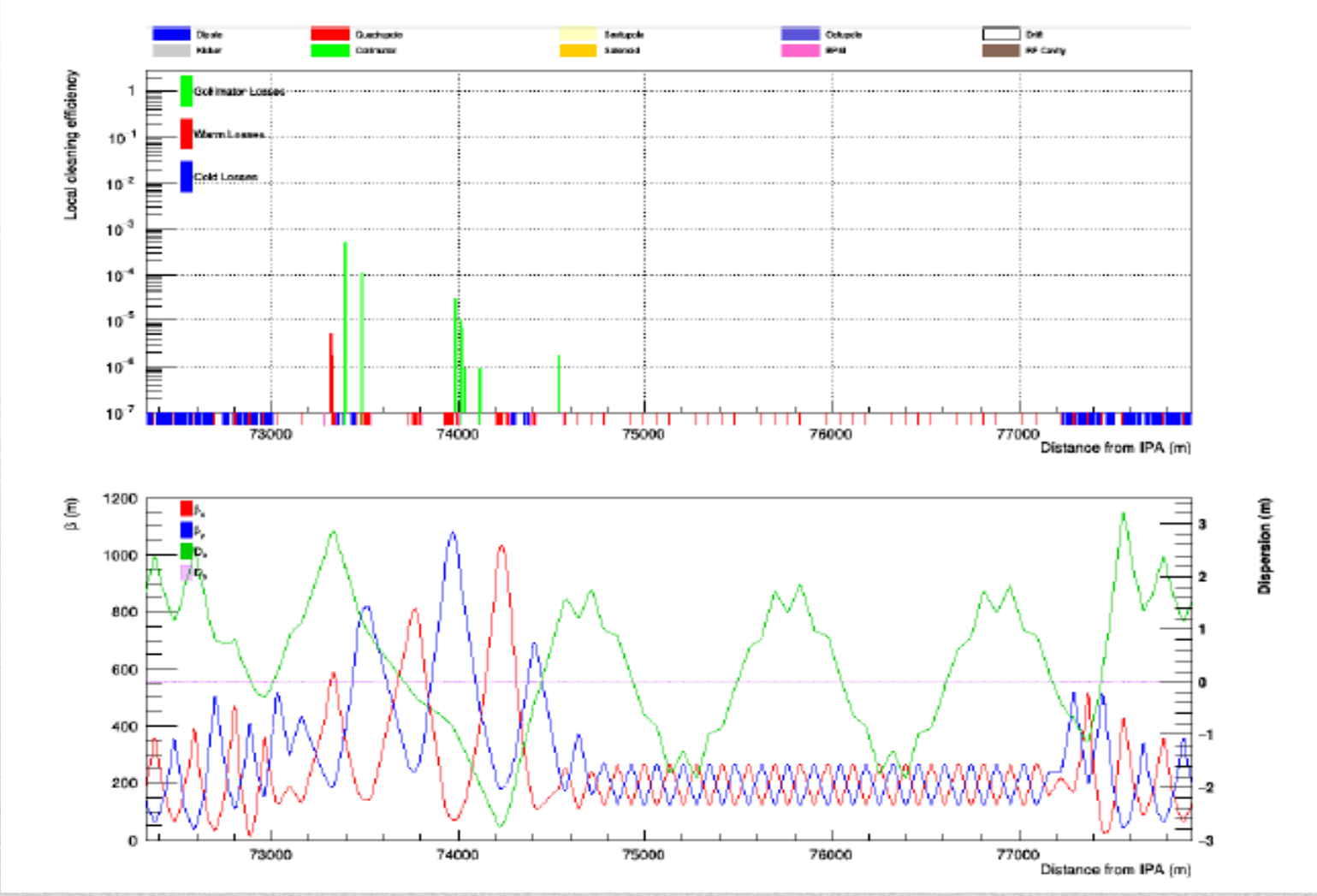
Energy collimation loss map V6 on-momentum with Merlin



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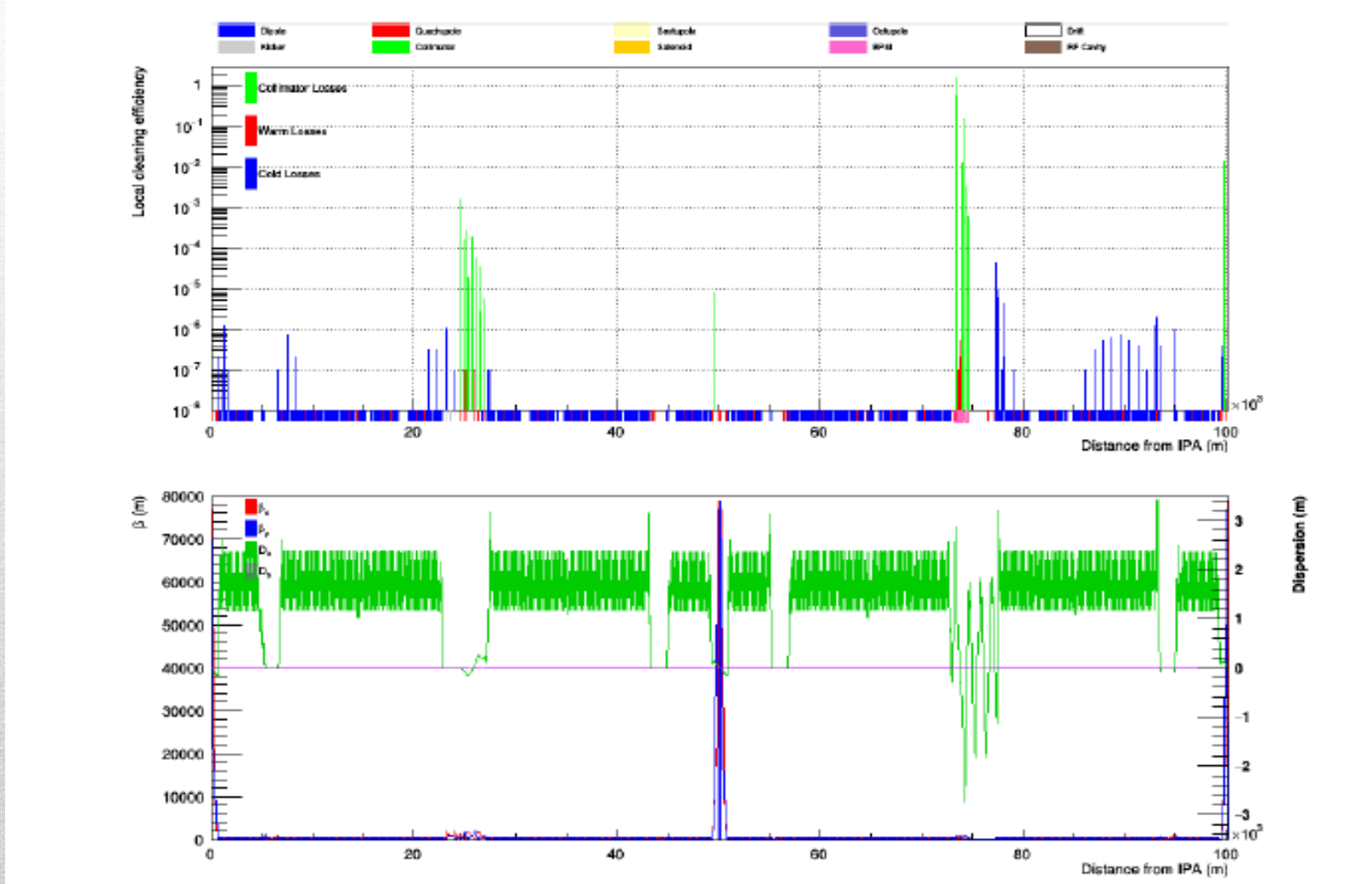

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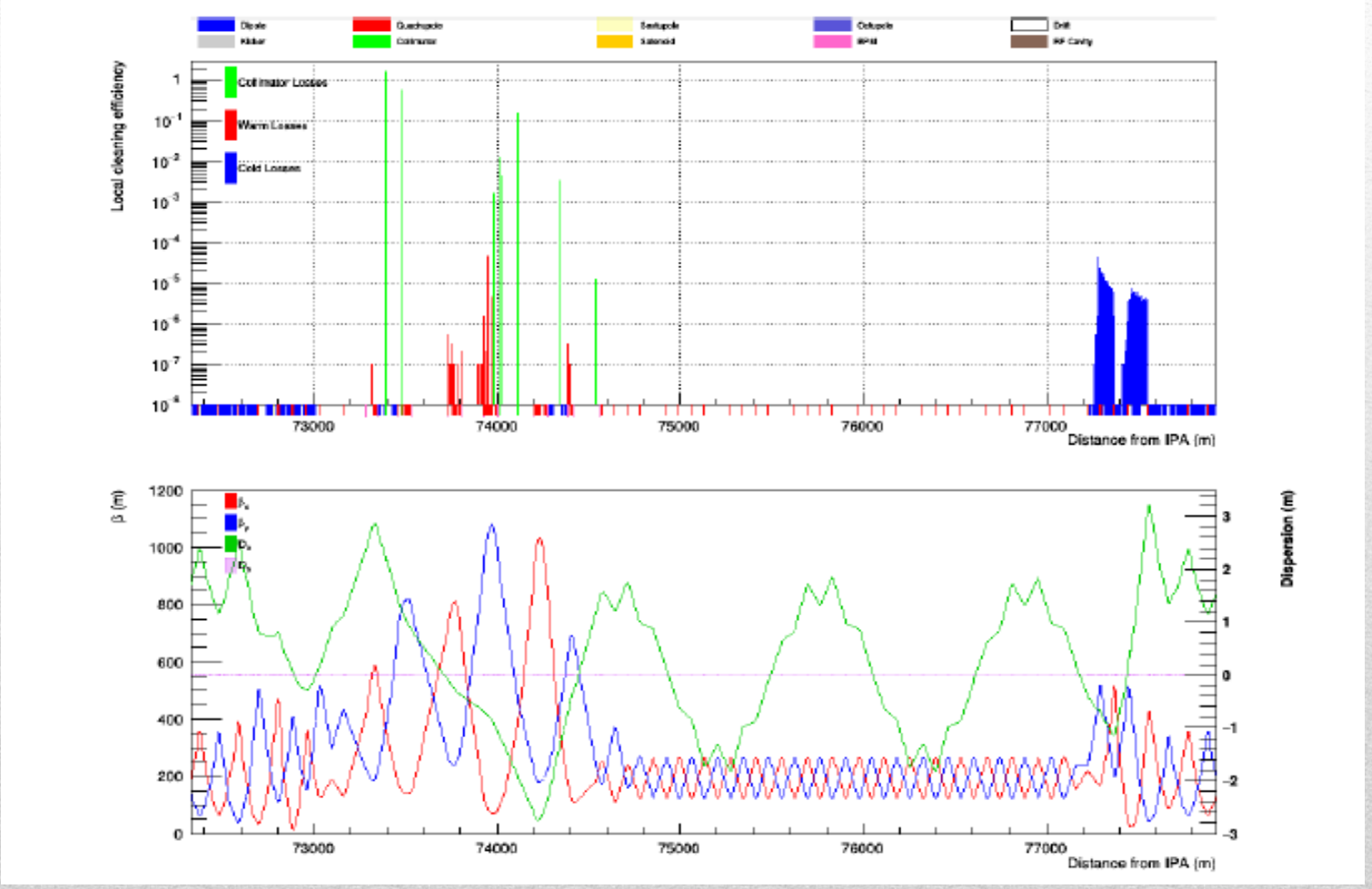


The tools for performance evaluation

A number of codes currently are used for collimation simulations:

- SixTrack/K2
- Merlin
- FLUKA
- BDSIM (Geant4)

Are differences in codes due to tracking or to physics?

Implement all physics models in SixTrack so that the tracking, input files, post-processing will be the same:

- SixTrack is a fast symplectic beam tracking code
- Extensively used for tracking studies at CERN for many years.
- Written in fortran and open source.

A complete simulation study with each model and comparison has been performed with a single jaw test

The tools for performance evaluation

Loss maps:

- We observe that each code produces different output distributions after interactions with a collimator
- Merlin How important it this to the operation and effectiveness of the collimation system?
- Test with the current FCC-hh lattice
- 200 turns, 12.8 million protons at 50 TeV, with a horizontal betatron halo distribution -a ring in $(x,x_{p)}$ that just touches the horizontal primary collimator jaw, normal distribution cut at 3 sigma in (y,y_p)

Loss maps show the distribution of losses around an accelerator ring. In an ideal world all losses will be confined to the collimators, and any normal conducting magnets. Losses into superconducting magnets are to be avoided.

The tools for performance evaluation

Relative loss counts in each named region relative to the default K2 scattering in SixTrack

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

- Qualitatively there is an excellent agreement between each code's loss map
- This gives good confidence in our simulation tools
- When performing a more detailed quantitive comparison this changes

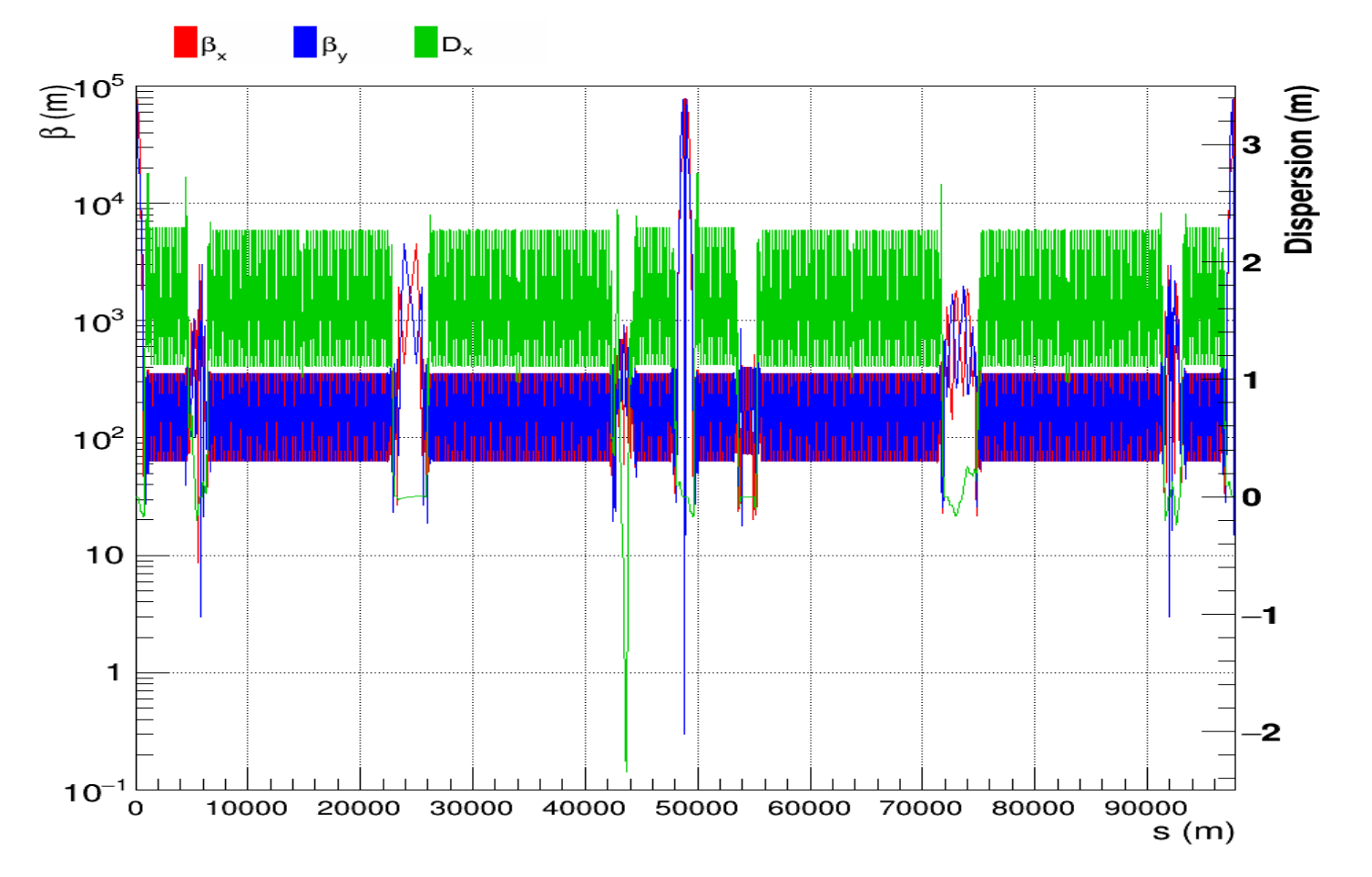
The tools for performance evaluation

- We can now run our simulations with more confidence of the loss locations -all codes generally agree in loss locations, differences are mostly in the magnitude of the losses
- Therefore we know where to focus shielding efforts
- Take care when using simulation tools, they may give unexpected results -see differences between geant4 physics lists
- Always get a second opinion
- More data input needed from the particle physics side

Detailed information on IPAC17 WEOBA1

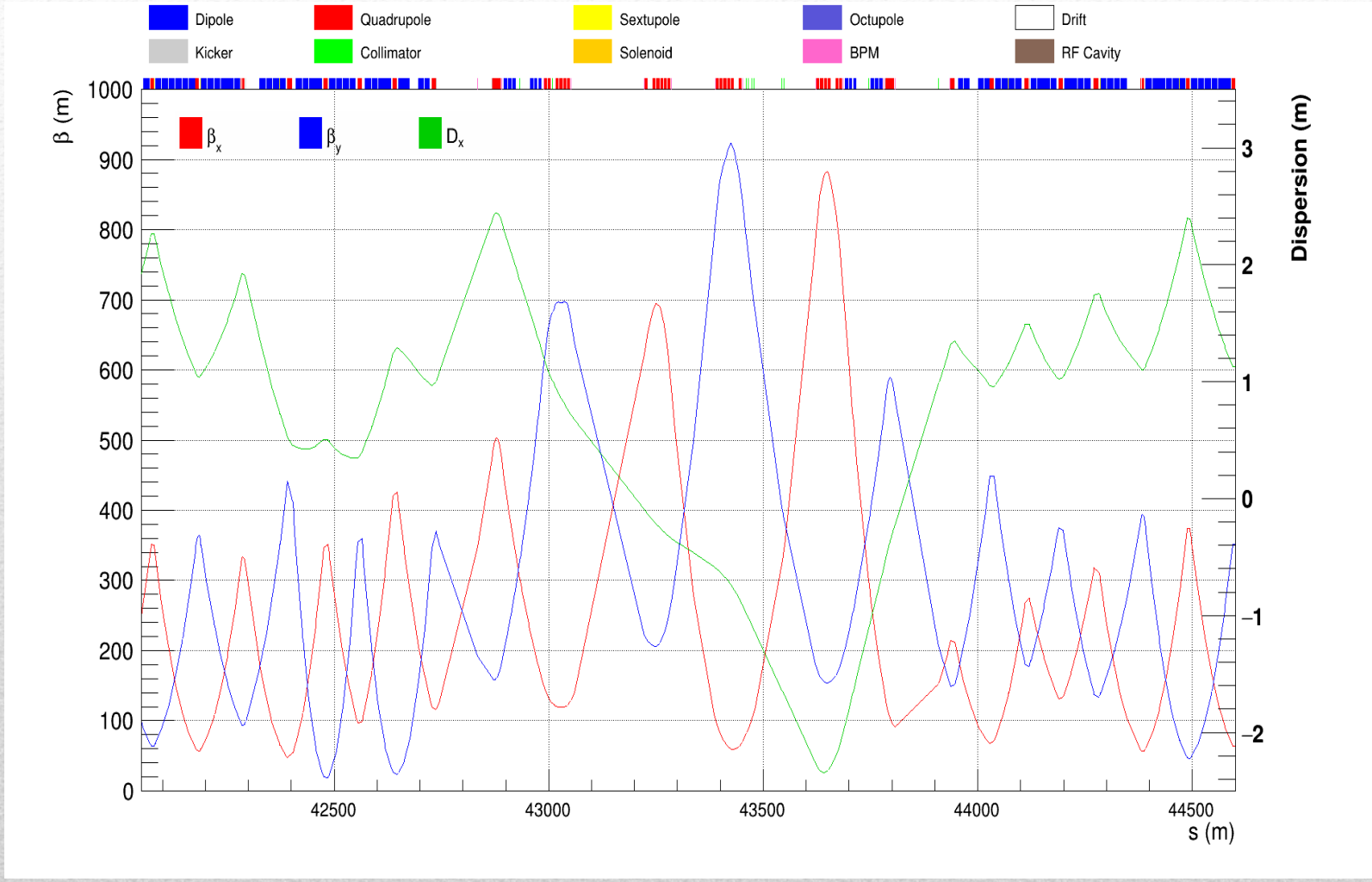
The current energy collimation system

Full ring V8 optics



The current energy collimation system

Energy collimation loss V8 optics

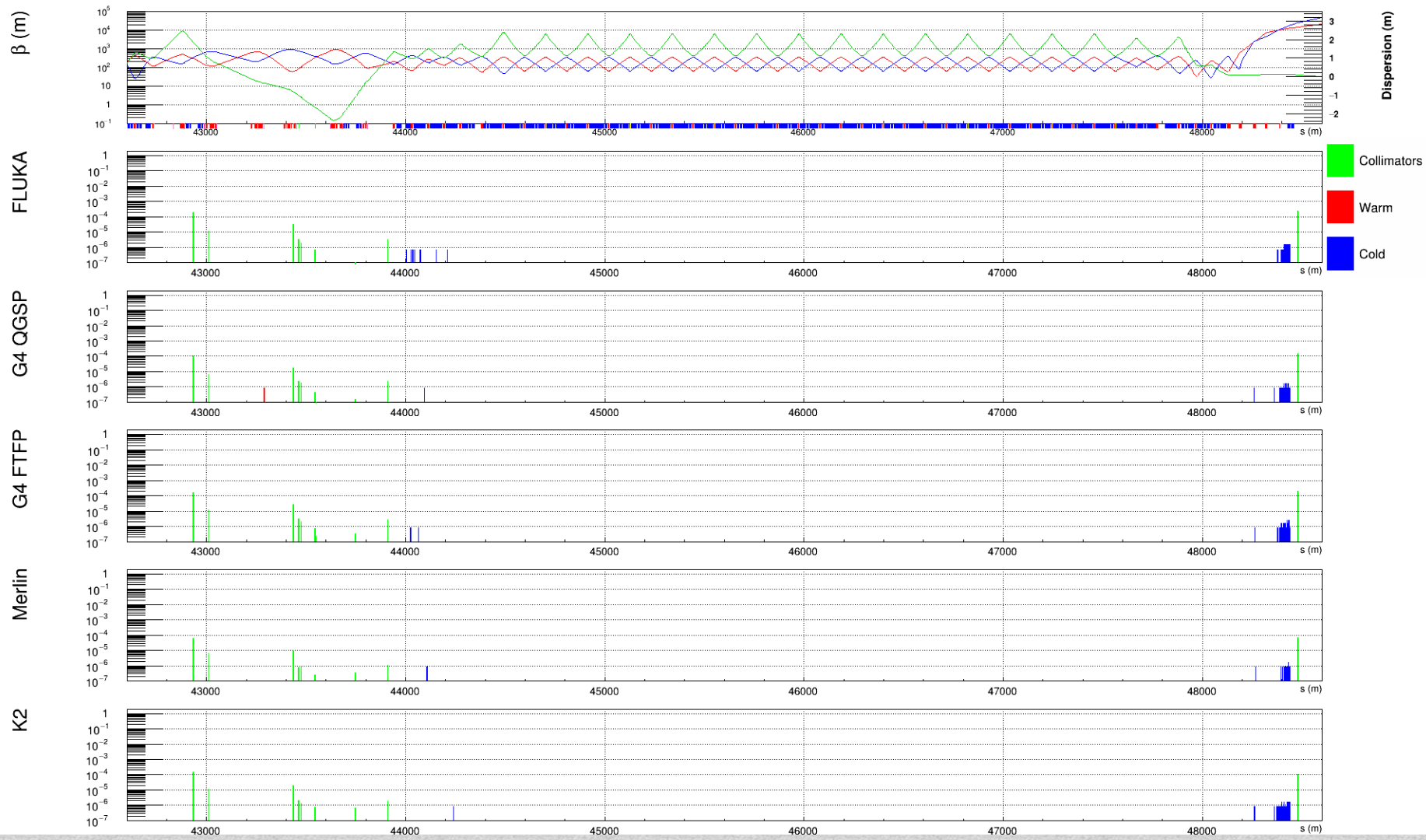


The current energy collimation system

Full ring loss map V8 on-momentum

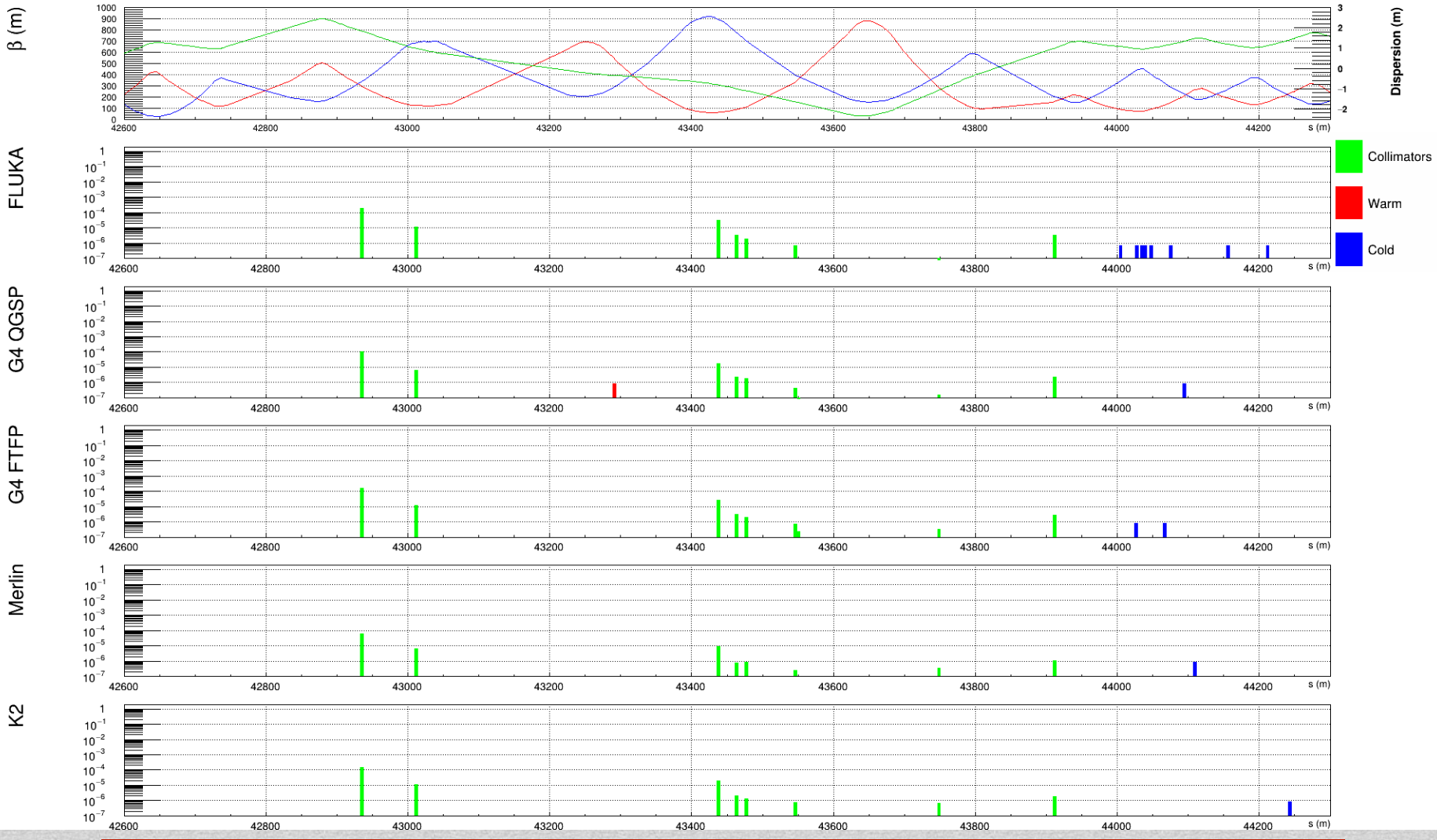
The current energy collimation system

Energy collimation and IPG loss map V8 on-momentum



The current energy collimation system

Energy collimation loss map V8 on-momentum

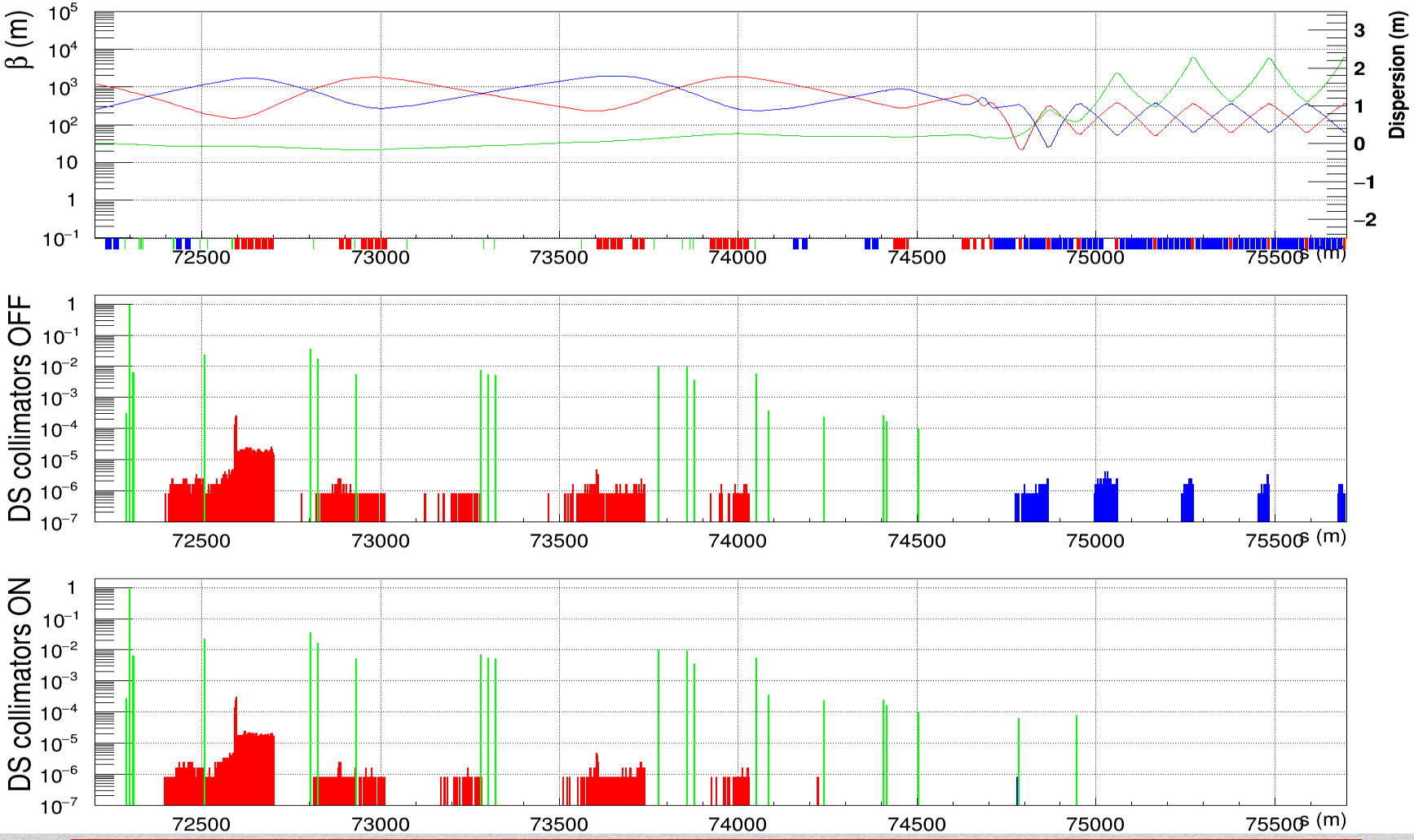


The current energy collimation system

Full ring loss map V8 on-momentum wo/w DS collimators
geant4 FTFP_BERT

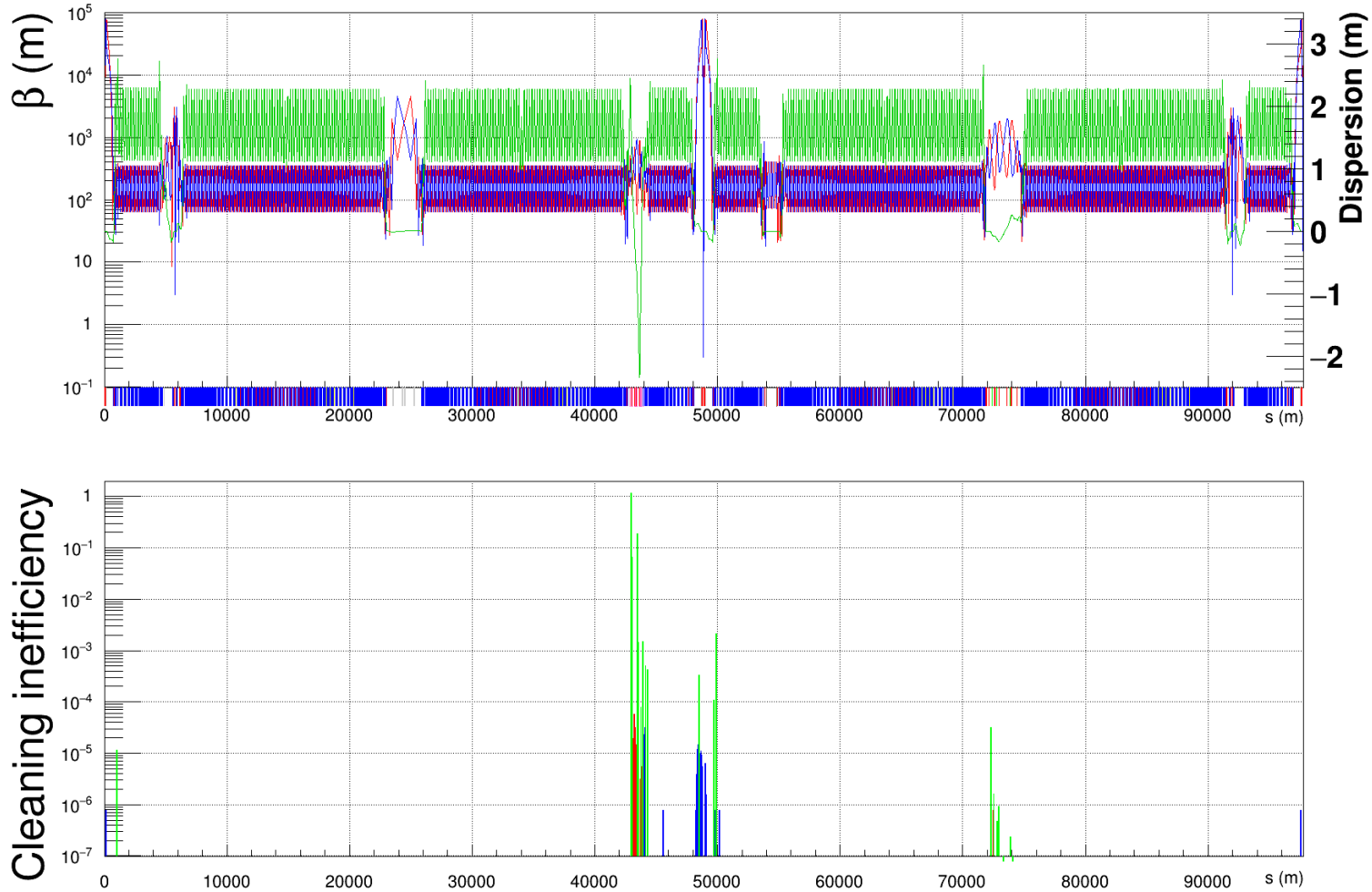
The current energy collimation system

Betatron collimation loss map V8 on-momentum wo/w DS collimators
geant4 FTFP_BERT



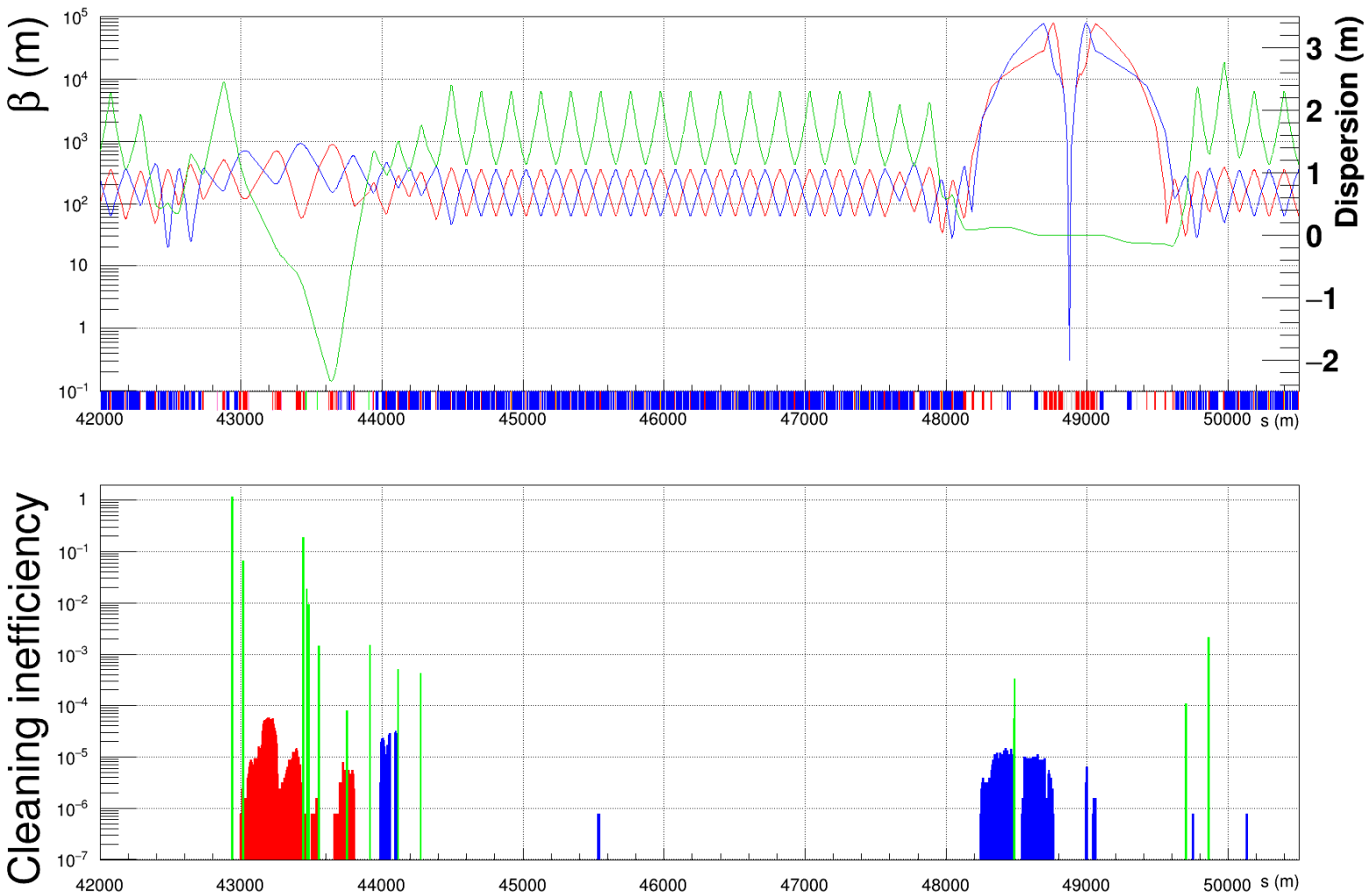
The current energy collimation system

Full ring loss map V8 off-momentum



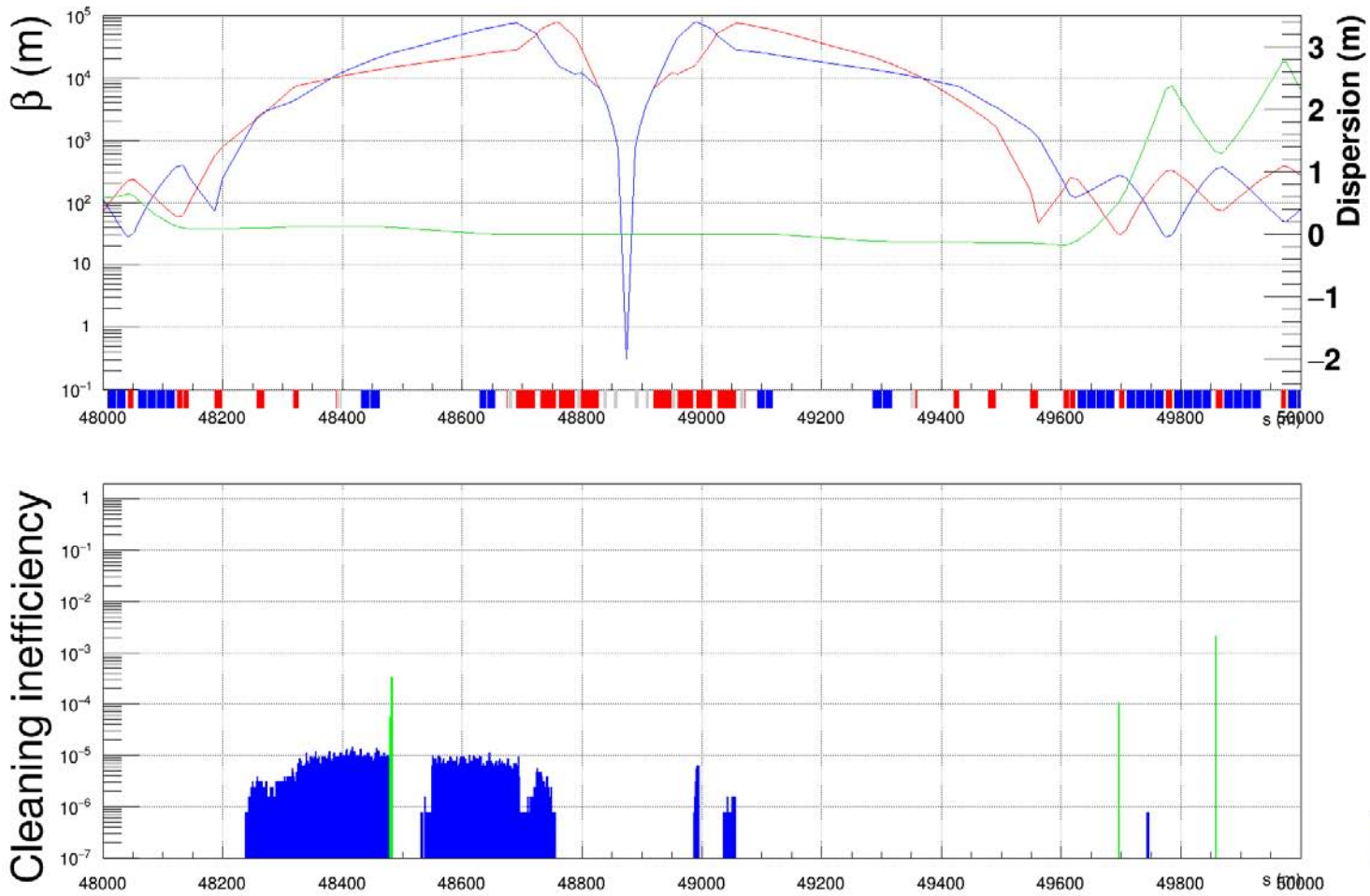
The current energy collimation system

Energy collimation and IPG loss map V8 off-momentum



The current energy collimation system

IPG loss map V8 off-momentum



The current energy collimation system

On-going work:

- Finishing the energy collimation loss maps wo/w DS collimators
- Off-momentum loss maps
- Optimisation of phases advances and collimator locations
- Fermilab will be working on this subject over the upcoming months

The plans for the “new” energy collimation system

- The LHC collimation system has been designed with many compromises because a “predefined” tunnel
- The current FCC-hh energy collimation system is a scaled version of the LHC and present the same problems
- The new proposed solutions will require some innovative solutions
- FCC being design from the scratch there is quite some opportunity for improved collimation system: new magnet designs, strong dogleg bends, combined betatron-energy systems with less collimators and tighter phase space coverage,…

Thank you to the many people involved.

Some material has been taken from:

R. Assmann (FCC week 2015)…