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Off-momentum cleaning simulations and halo modelling for the LHC

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30th of September 2015

Motivation

- Need to have a good understanding of the off-momentum dynamics.
- In the LHC both betatron and off-momentum loss maps are measured.
- We have a good model for the betatron loss maps but not for off-momentum.
- Unexplained observed phenomena probably related with off-momentum dynamics:
  - Unexplained losses in IR4.
  - Unexplained beam induced background asymmetry in the ATLAS detector.
  - Losses at the beginning of the ramp.
  - Many other scenarios.
- Goals:
  - Understand the physics behind the off-momentum loss maps.
  - Set up simulations to reproduce off-momentum loss maps.
  - Address some of the issues shown above.

Off-momentum cleaning insertion

TCP.6L3.B1

$$s = 6487.671300 \text{ m}$$

$$\beta_x = 131.507865 \text{ m}$$

$$\beta_y = 144.679028 \text{ m}$$

$$D_x = 2.174855 \text{ m}$$

$$n_1[\sigma_\beta/\text{mm}] = 15.0/3.73$$

LHC longitudinal beam parameters

$$\sigma_z = 75.5 \text{ mm}$$

$$\delta = 1.129 \cdot 10^{-4}$$

$$h = 35640$$

$$f_{\text{rev}} = 11245 \text{ Hz}$$

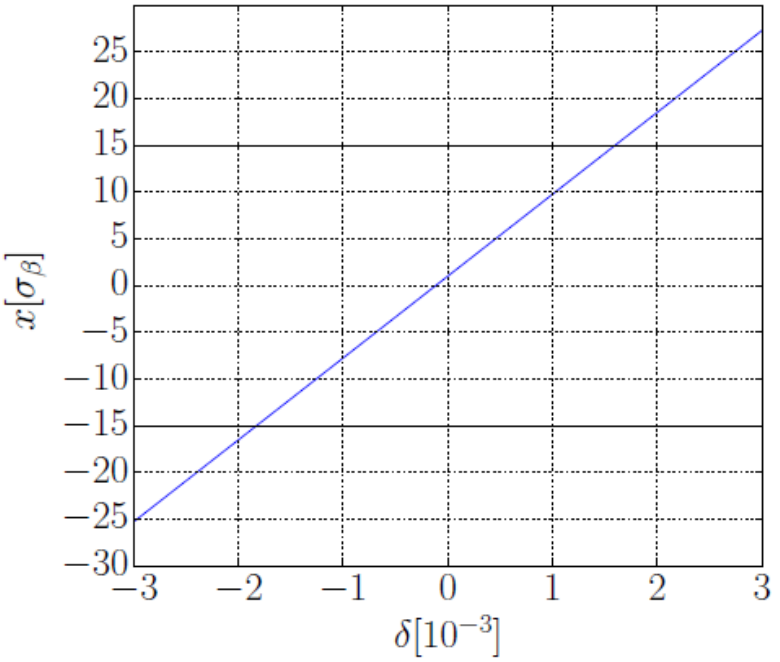
$$f_{\text{rf}} = 400.8 \text{ MHz}$$

$$V = 16.0 \text{ V}$$

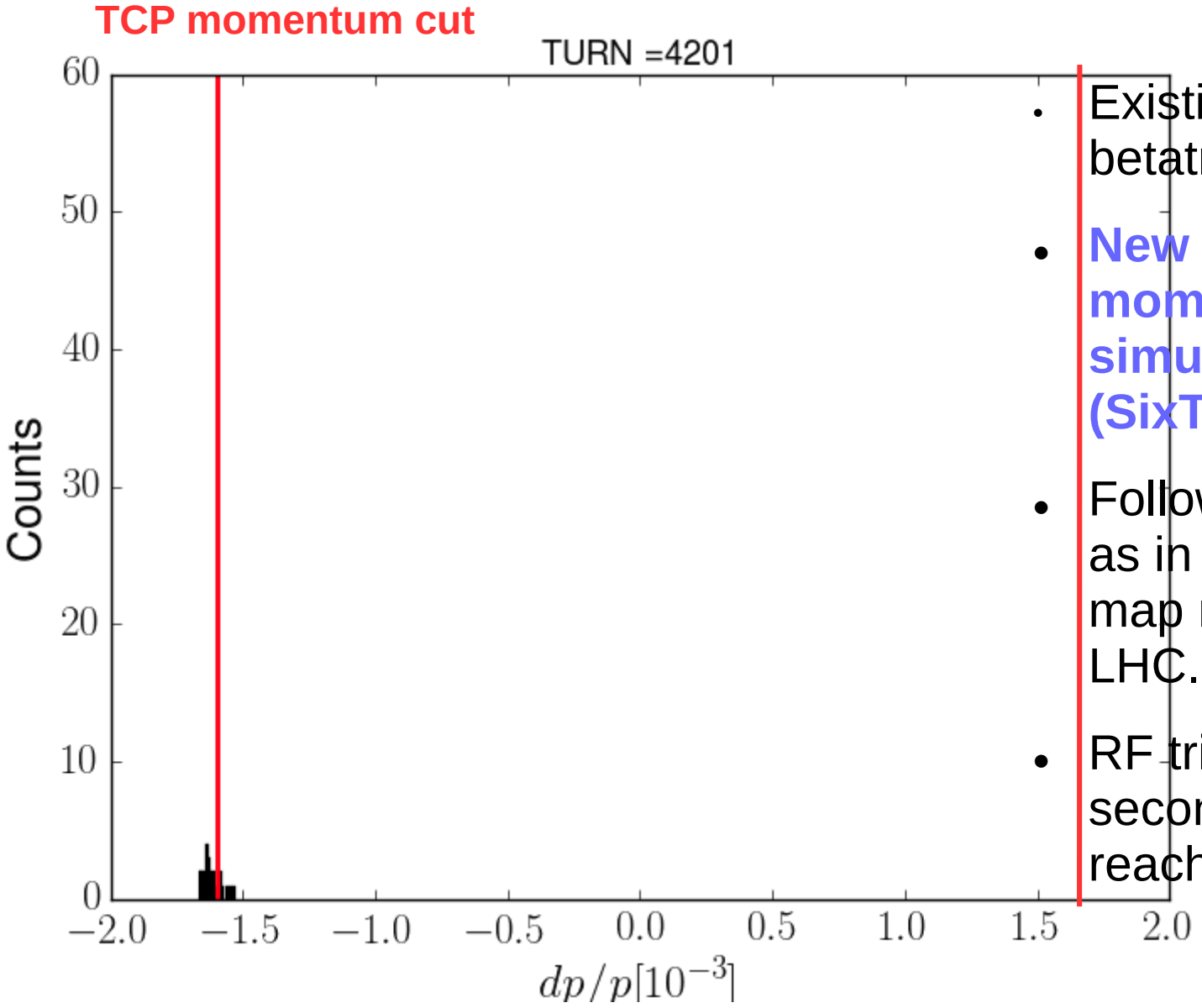
$$x = x_\beta + x_\delta = \sqrt{\epsilon\beta_x} + \delta D_x$$

$$x_\beta(\text{TCP.6L3.B1}) = 248.35 \ \mu\text{m}$$

$$x = 3.73 \text{ mm} \Rightarrow \delta = 1.59 \cdot 10^{-3}$$

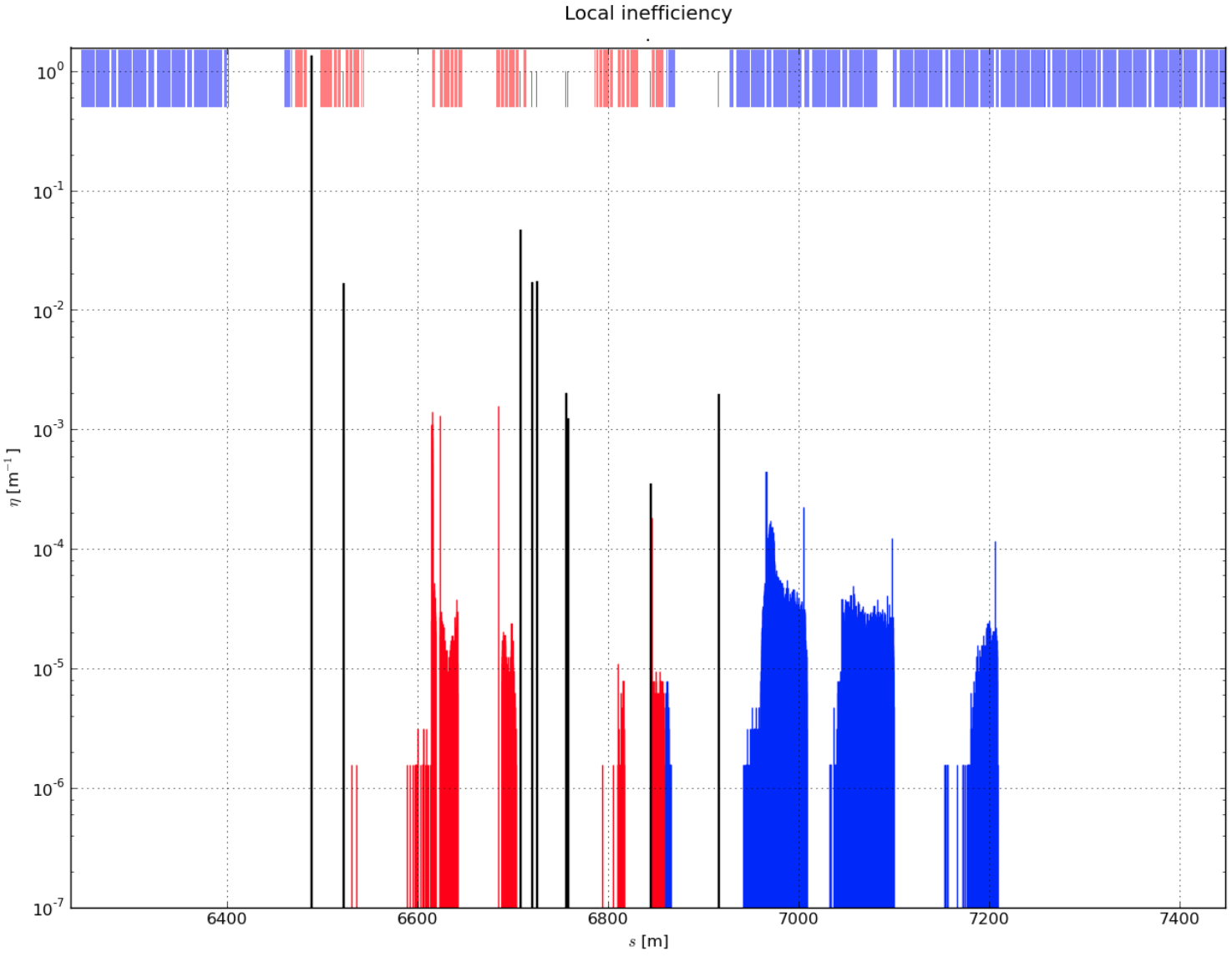


Not a standard simulation



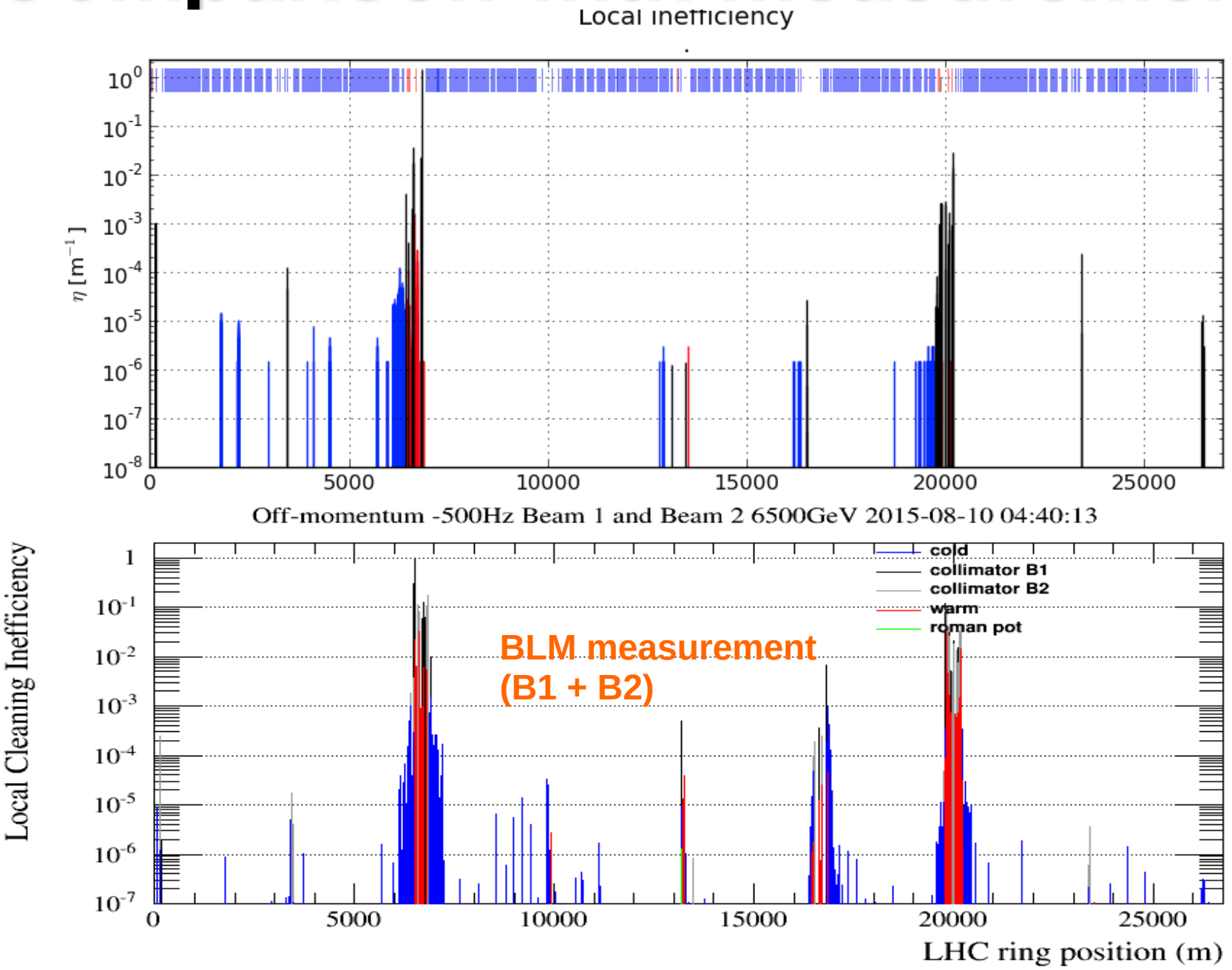
- Existing simulation setup for betatron loss maps.
- **New set of tools for off-momentum loss map simulations (SixTrack/DYNK).**
- Follow the same philosophy as in the off-momentum loss map measurement in the LHC.
- RF trim during a few seconds until the beam reaches the collimator cut.

Simulated off-momentum loss maps



s [m]

Comparison with measurements



Collected simulated loss maps (LHC)

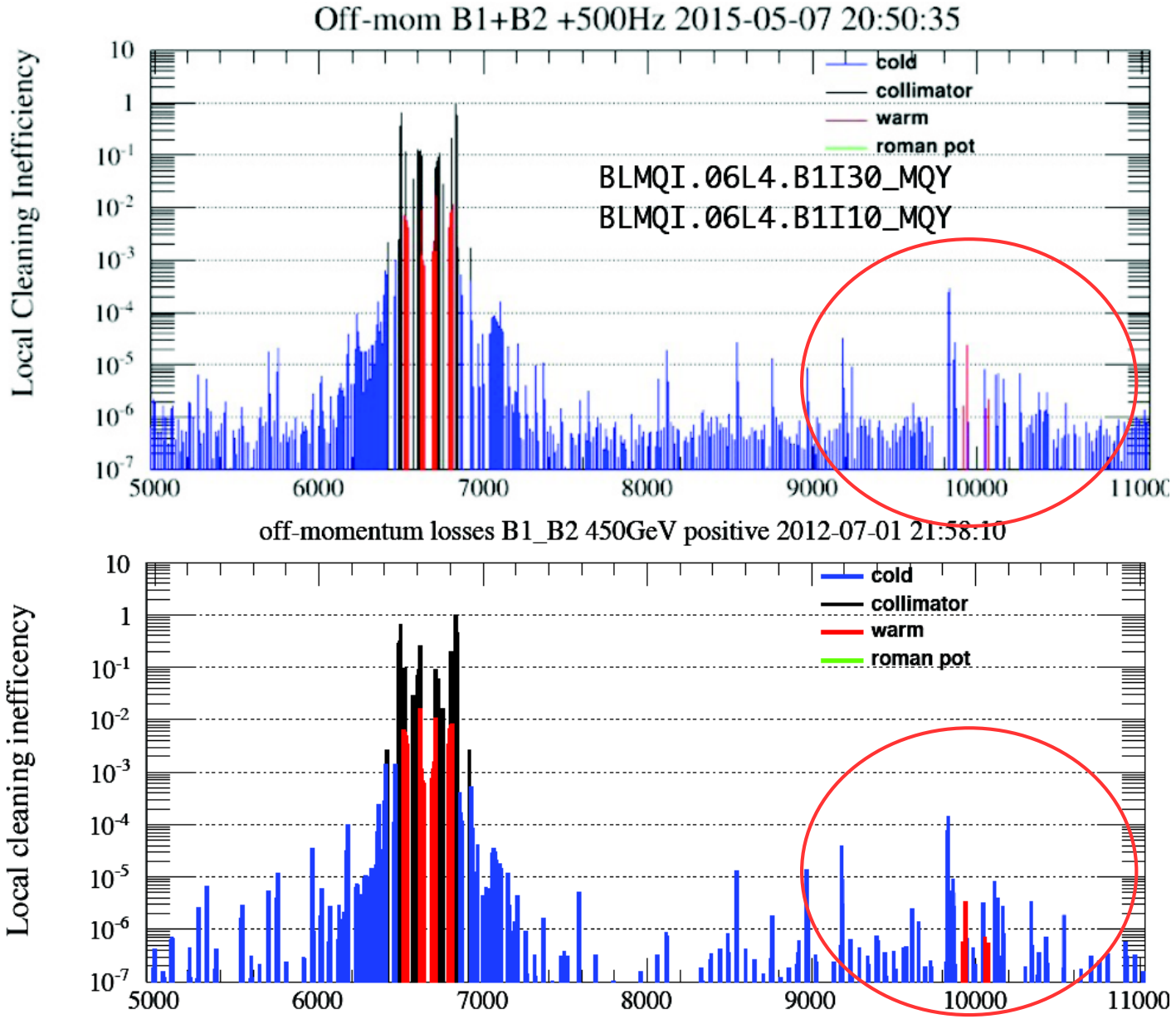
	+ 500 Hz		- 500 Hz	
	B1	B2	B1	B2
4.0 TeV				
6.5 TeV				

Addressing issues

- Losses in IR4.
- ATLAS beam induced background asymmetry.
- Losses at the start of the ramp.

Action - Losses IP4

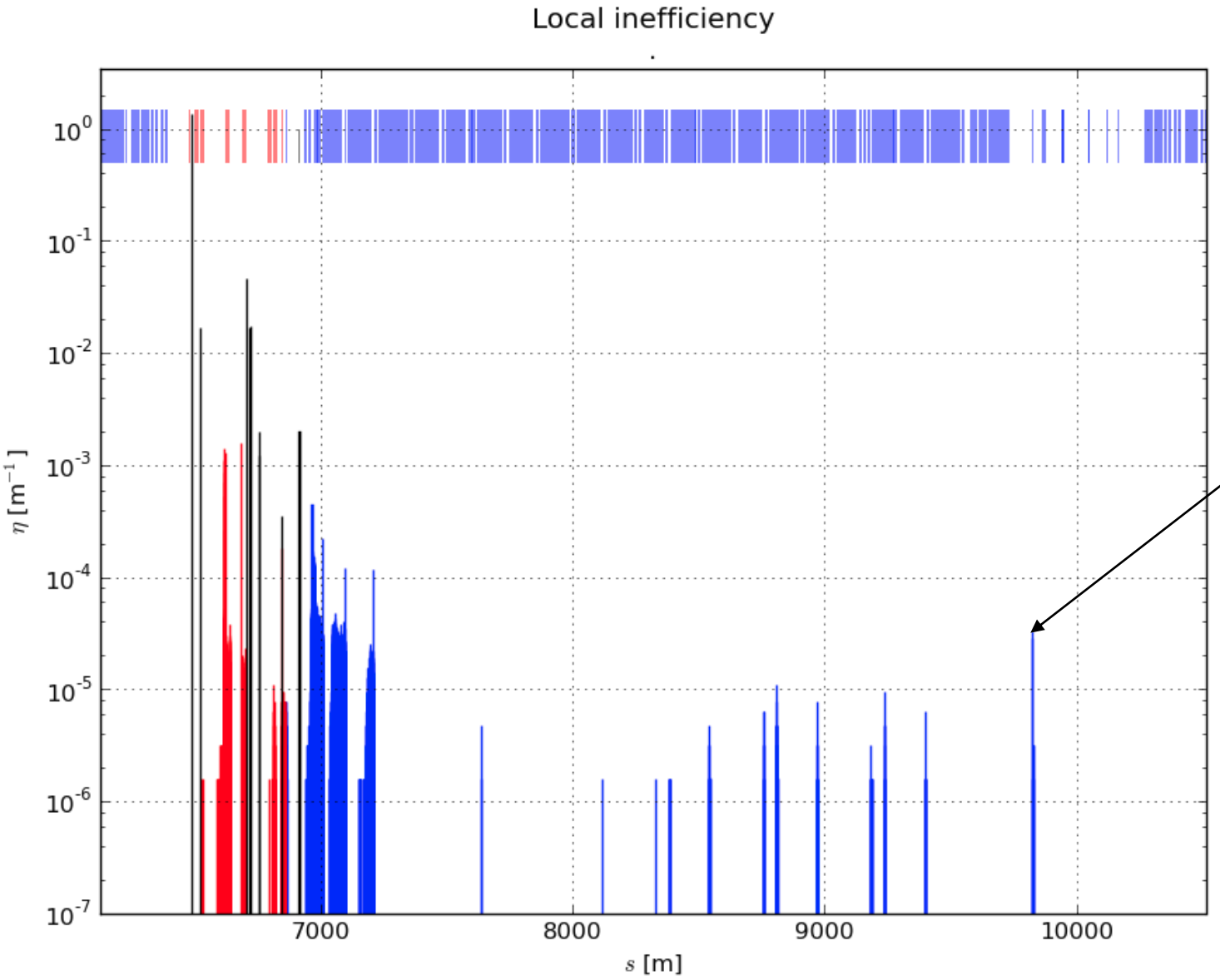
S.Redaelli LMC 20-05-2015



Action: ***Identify the elements in point 4 where the noted losses take place.***

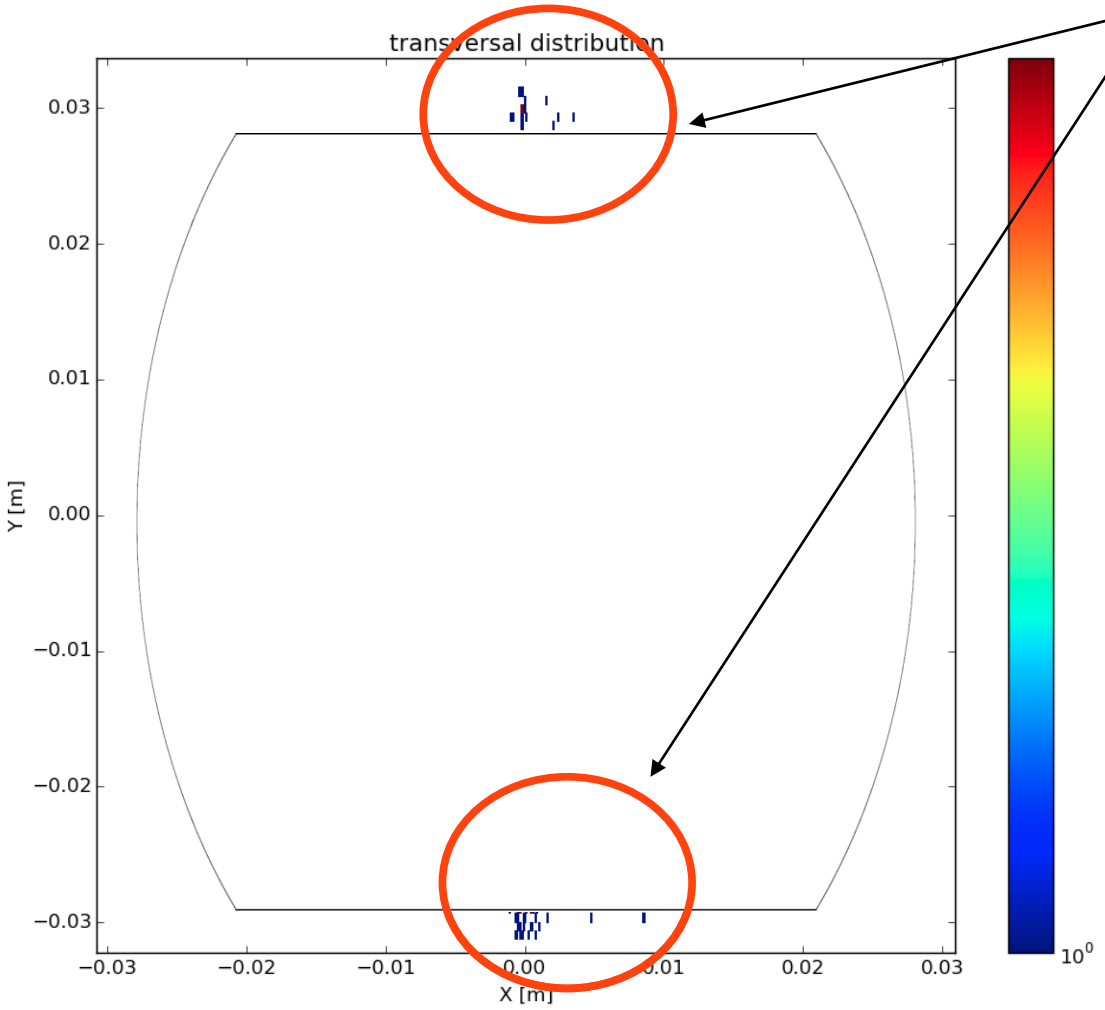
Verify results with simulations

Simulated Loss Map (B1)



MQY.6L4.B1

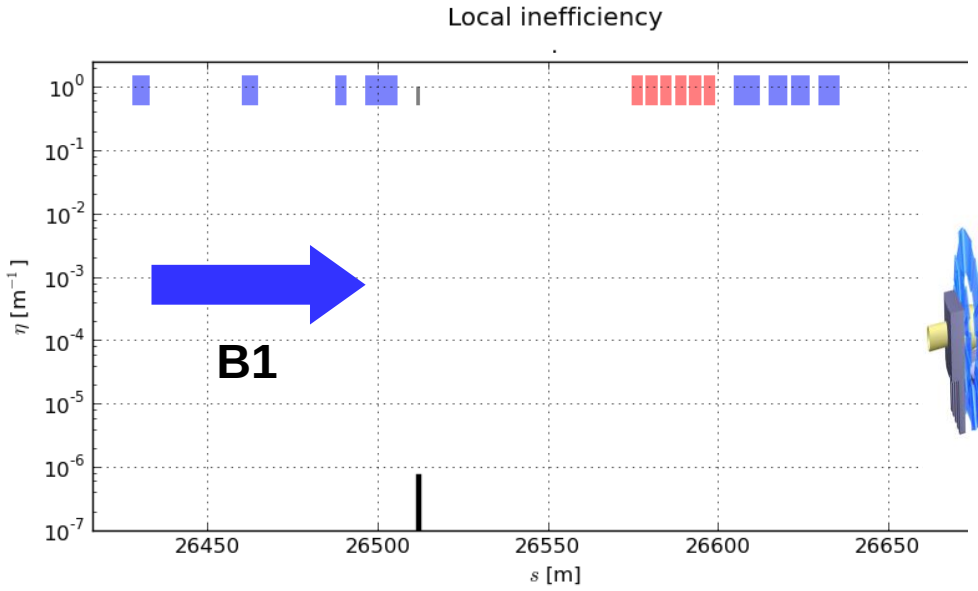
Impact distribution in MQY.6L4.B1

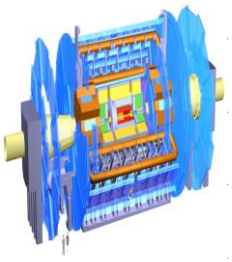


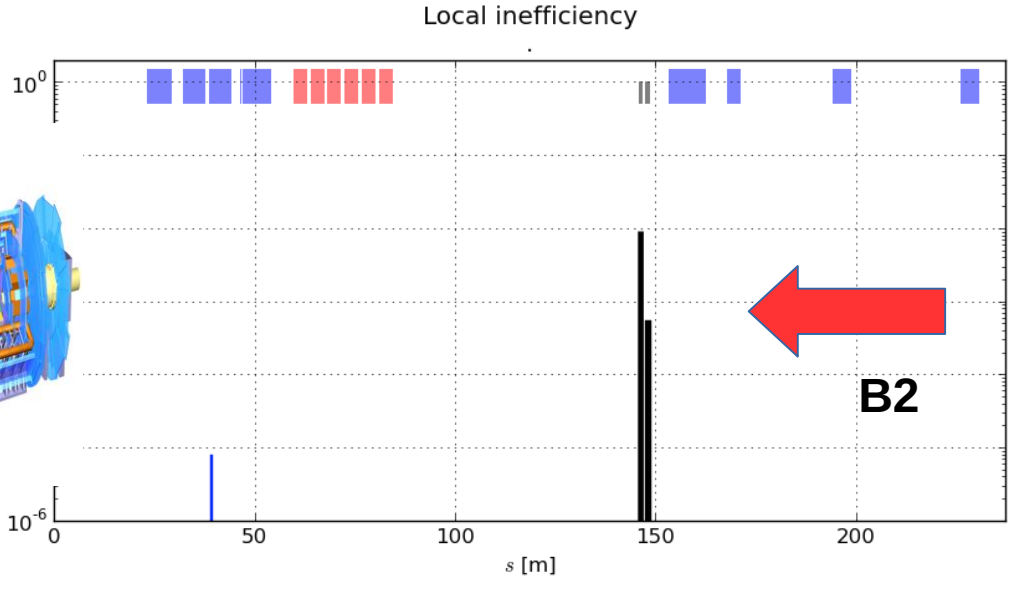
- **Vertical losses consistent from the aperture bottleneck measurements**
- Particles hit **TCP** first and **TCS** after before hitting the magnet aperture.
- Hierarchy is respected.
- Not enough statistics to evaluate a realistic distribution. More time required.

Beam induced background asymmetry in ATLAS

- ATLAS observes more particles coming from one beam compared to those coming from the other.
- Not explained with betatron halo.
- Off-momentum halo?
- First distributions in TCTs already obtained.
- FLUKA simulations of secondaries to see the impact (R.Kwee)

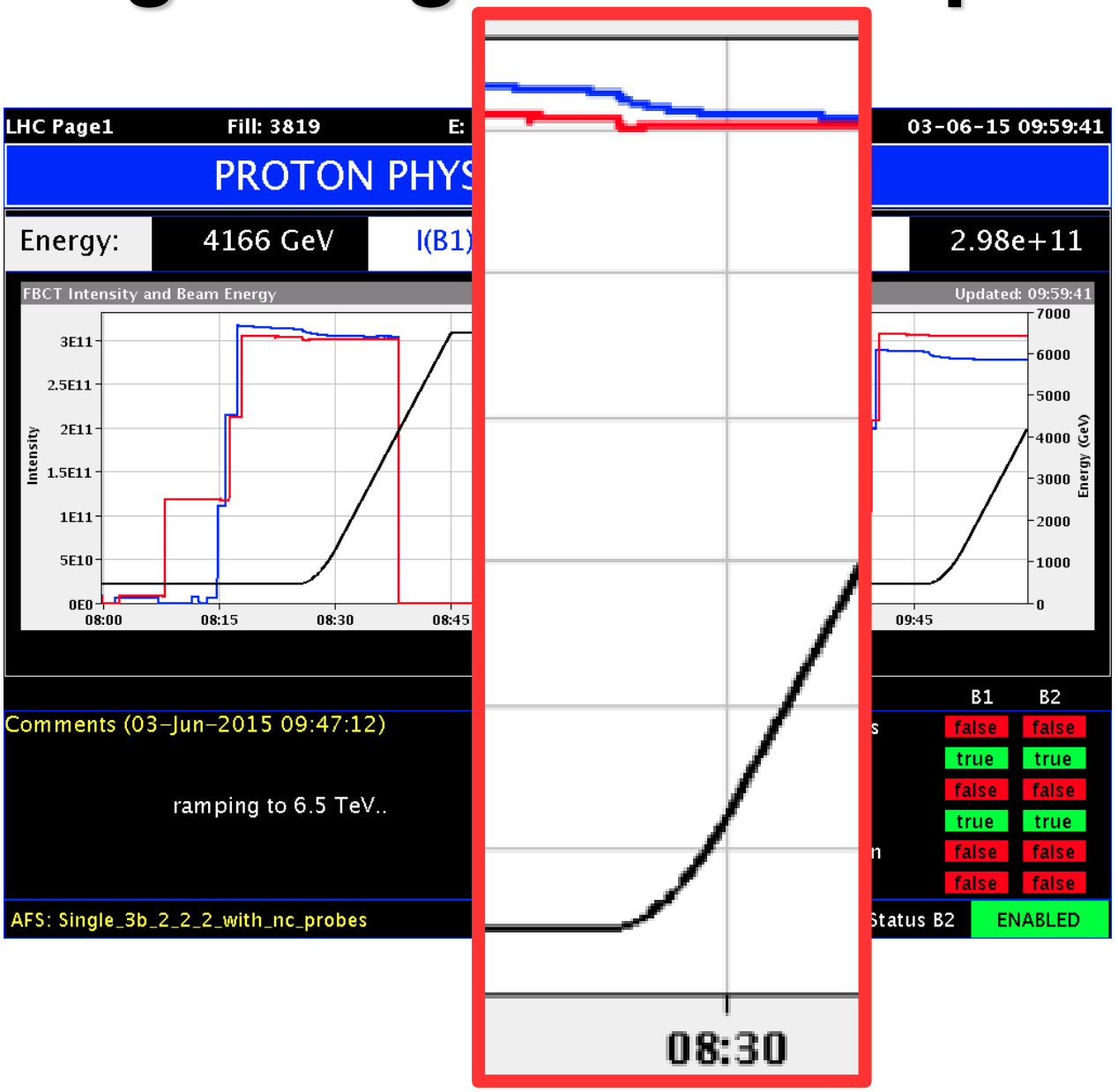






Losses at the beginning of the ramp

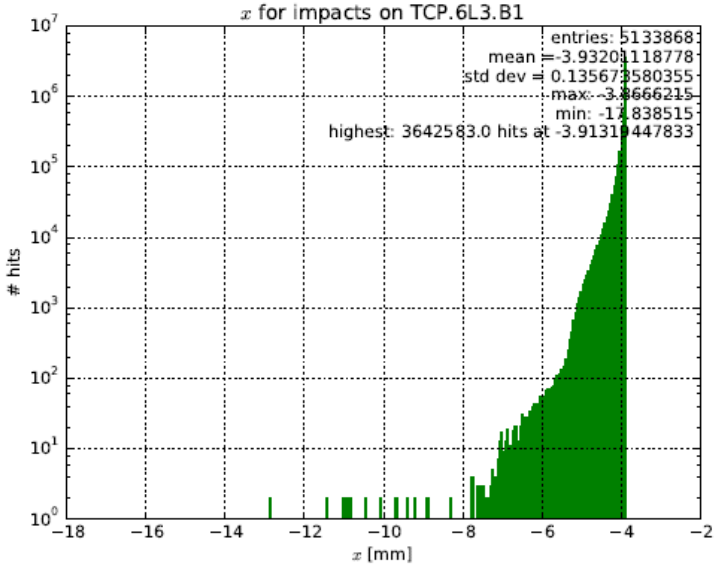
- Losses in IR3 are observed during the start of the ramp.
  - Unbunched beam lost when acceleration starts.
- Most important off-momentum losses during standard operation.
- Starting simulation setup for ramp.

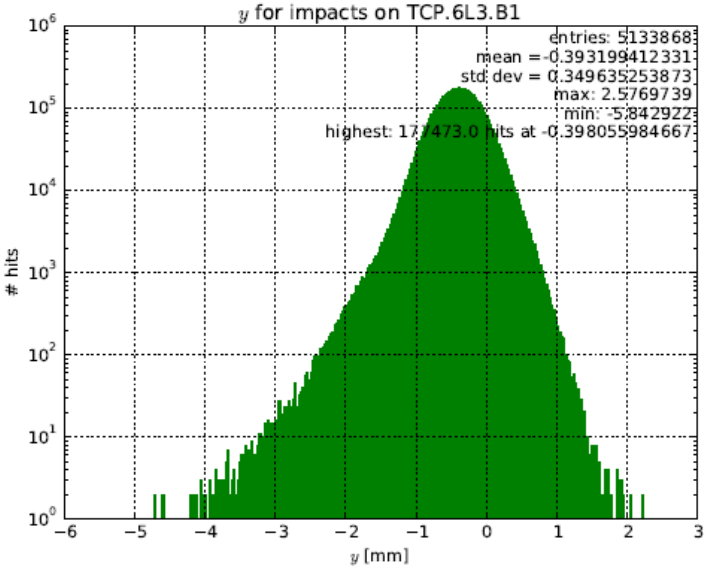


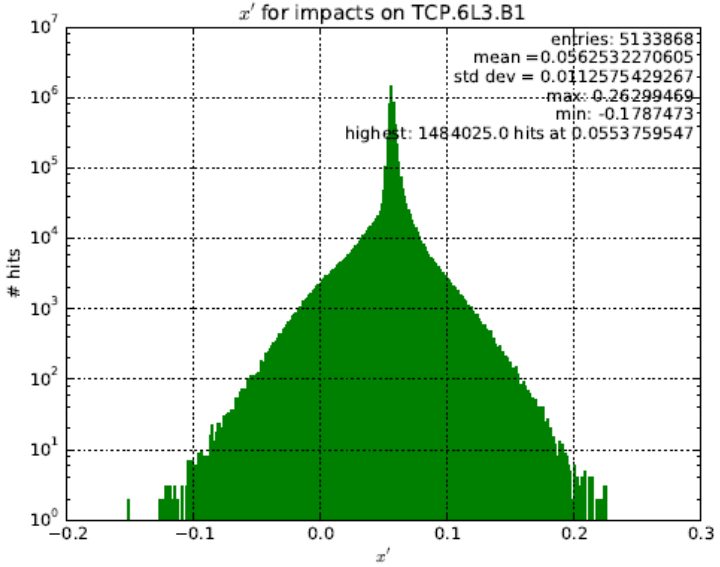
Off-momentum halo modelling

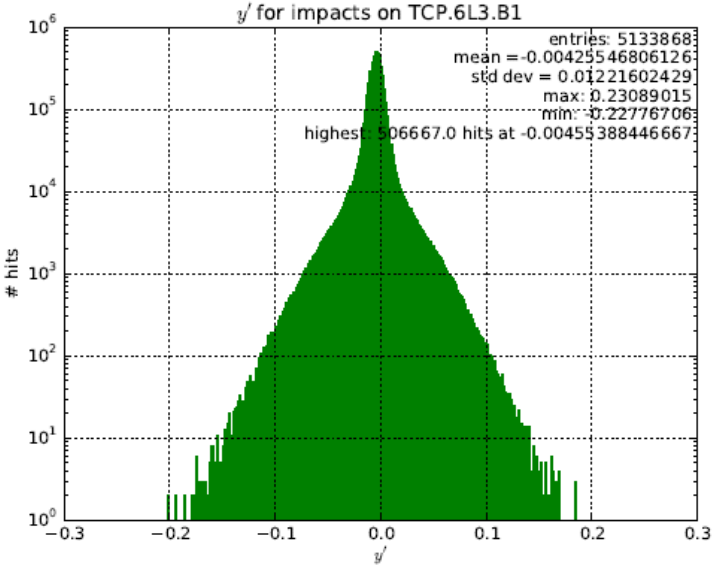
- The initial motivation of the study was (and still is) to have a reliable model of the off-momentum beam halo.
- This will give us a deeper understanding of the off-momentum dynamics…
- … and a faster way to perform simulations.
- The idea is to extrapolate a model from the impacts on the TCP in IR3.
- General halo model for all cleaning loss scenarios in the LHC.

TCP hits distribution (after RF trim)



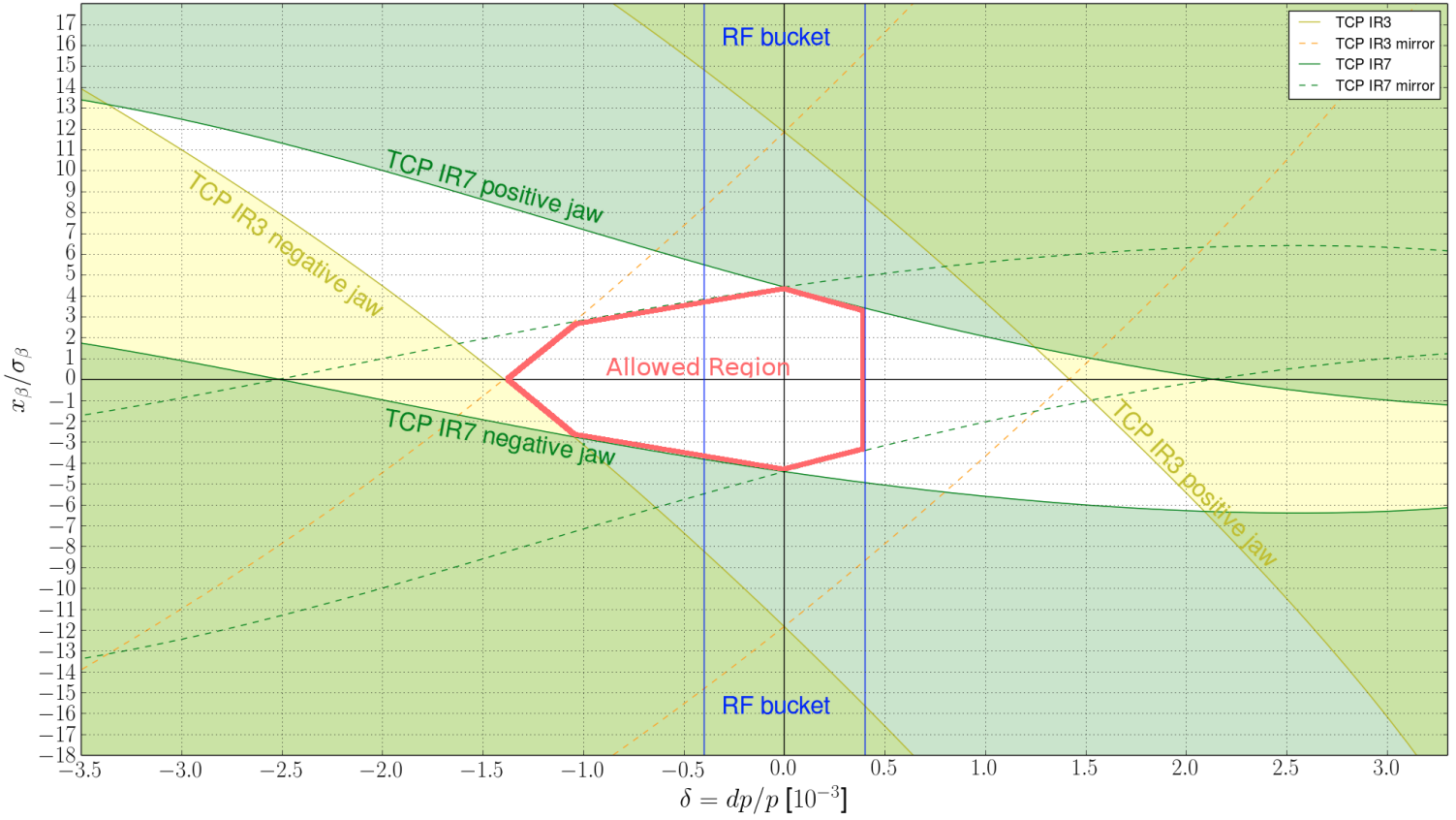






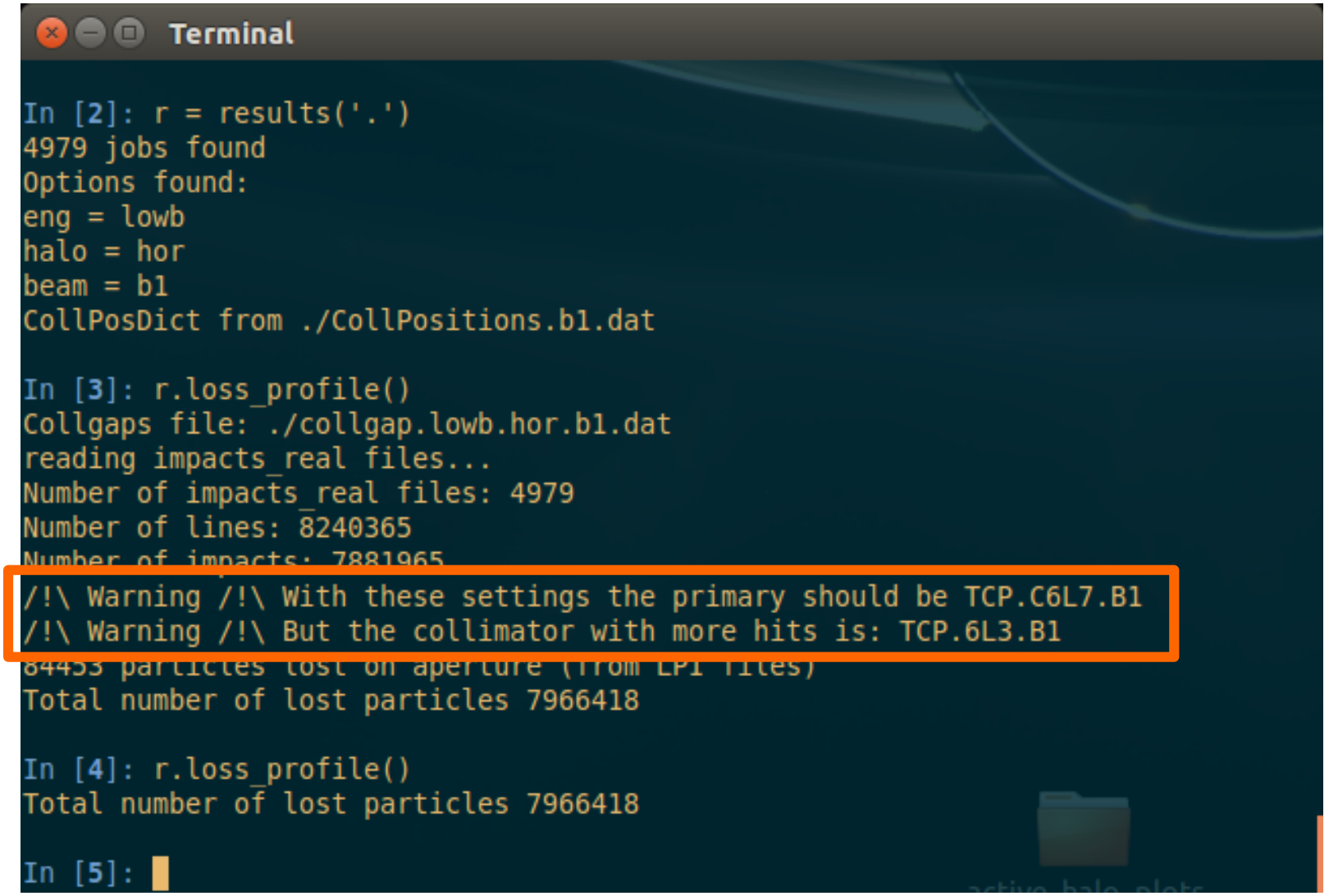
Off-momentum halo modelling

- There is a lot of information waiting to be known.
- Currently extracting longitudinal distributions at the entrance of the TCP in IR3.



Conclusions and prospects

- A new set of simulation tools has been developed to reproduce off-momentum loss maps.
- Already some issues have been addressed and others are ongoing.
- Need to fully exploit the potential of the model.
- Next week MDs for fully validating the simulations in different scenarios.
- Final goal: obtain a model for the off-momentum halo in the LHC.


Terminal
In [2]: r = results('.')
4979 jobs found
Options found:
eng = lowb
halo = hor
beam = b1
CollPosDict from ./CollPositions.b1.dat
In [3]: r.loss_profile()
Collgaps file: ./collgap.lowb.hor.b1.dat
reading impacts_real files...
Number of impacts_real files: 4979
Number of lines: 8240365
/!\ Warning /!\ With these settings the primary should be TCP.C6L7.B1
/!\ Warning /!\ But the collimator with more hits is: TCP.6L3.B1
Total number of lost particles 7966418
In [4]: r.loss_profile()
Total number of lost particles 7966418
In [5]: