LHC off-momentum collimation simulation

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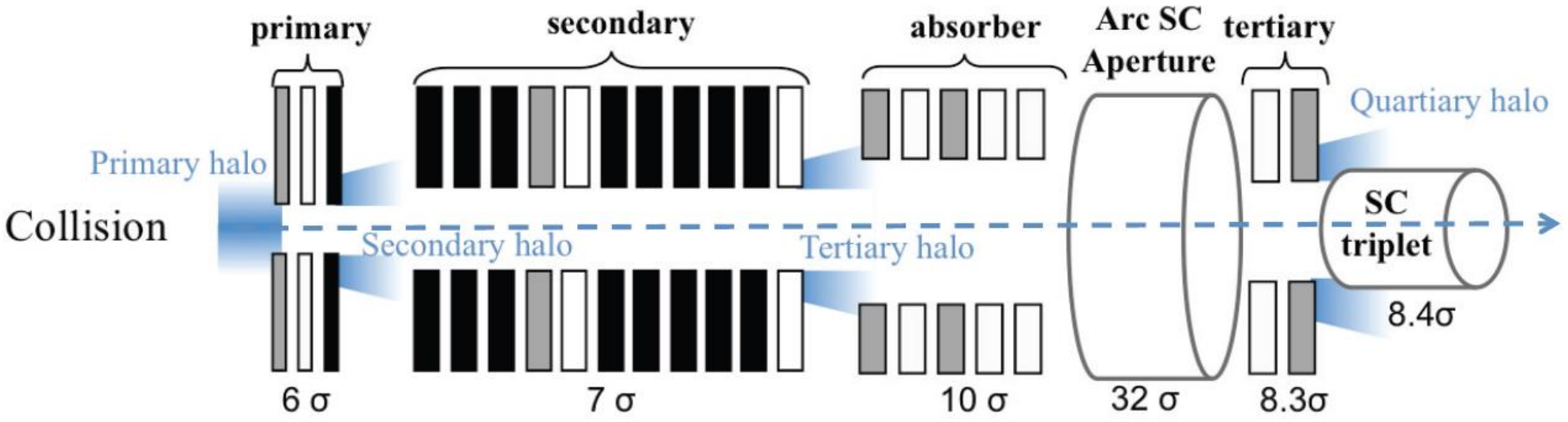
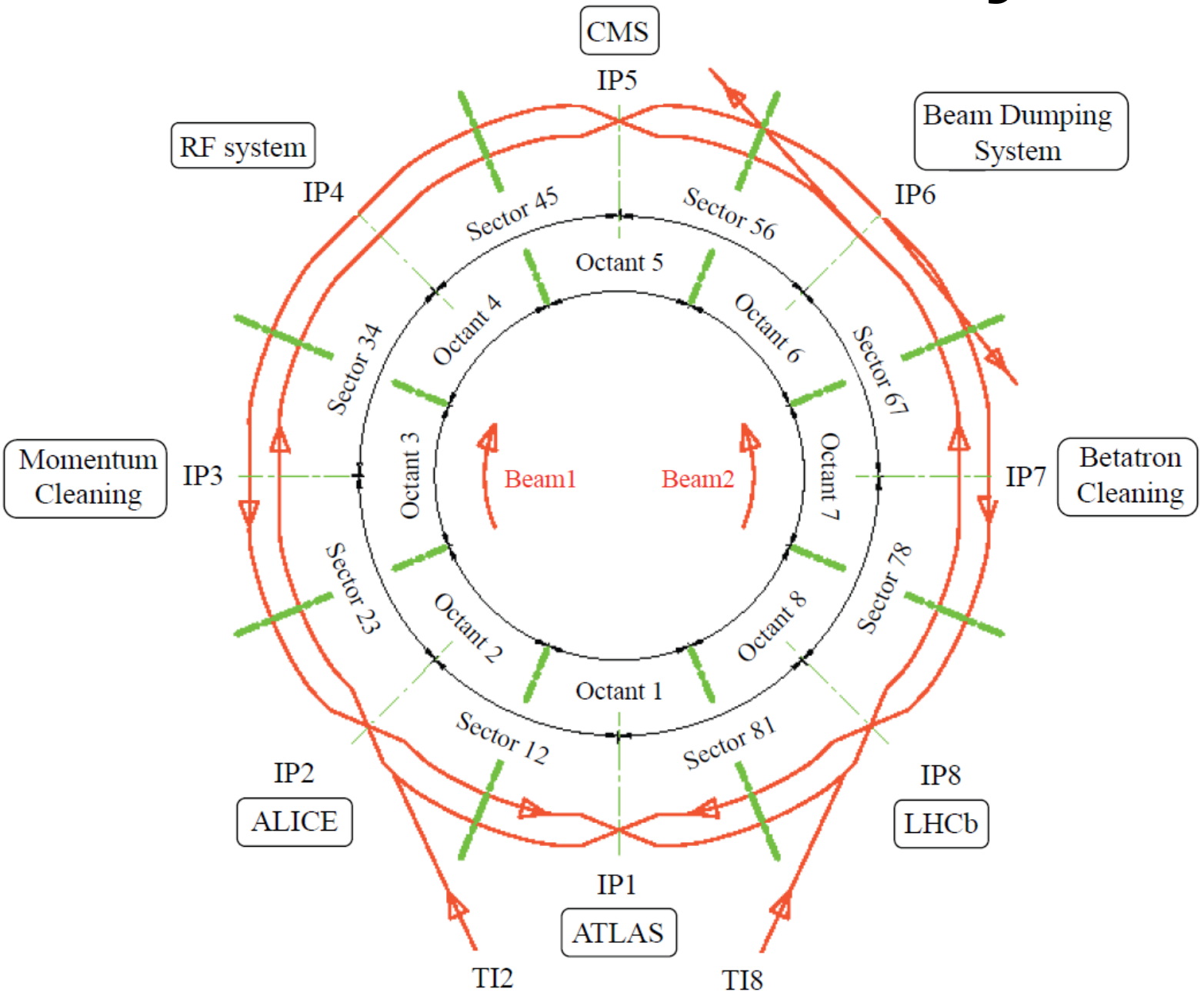
Multi-stage collimation sytem



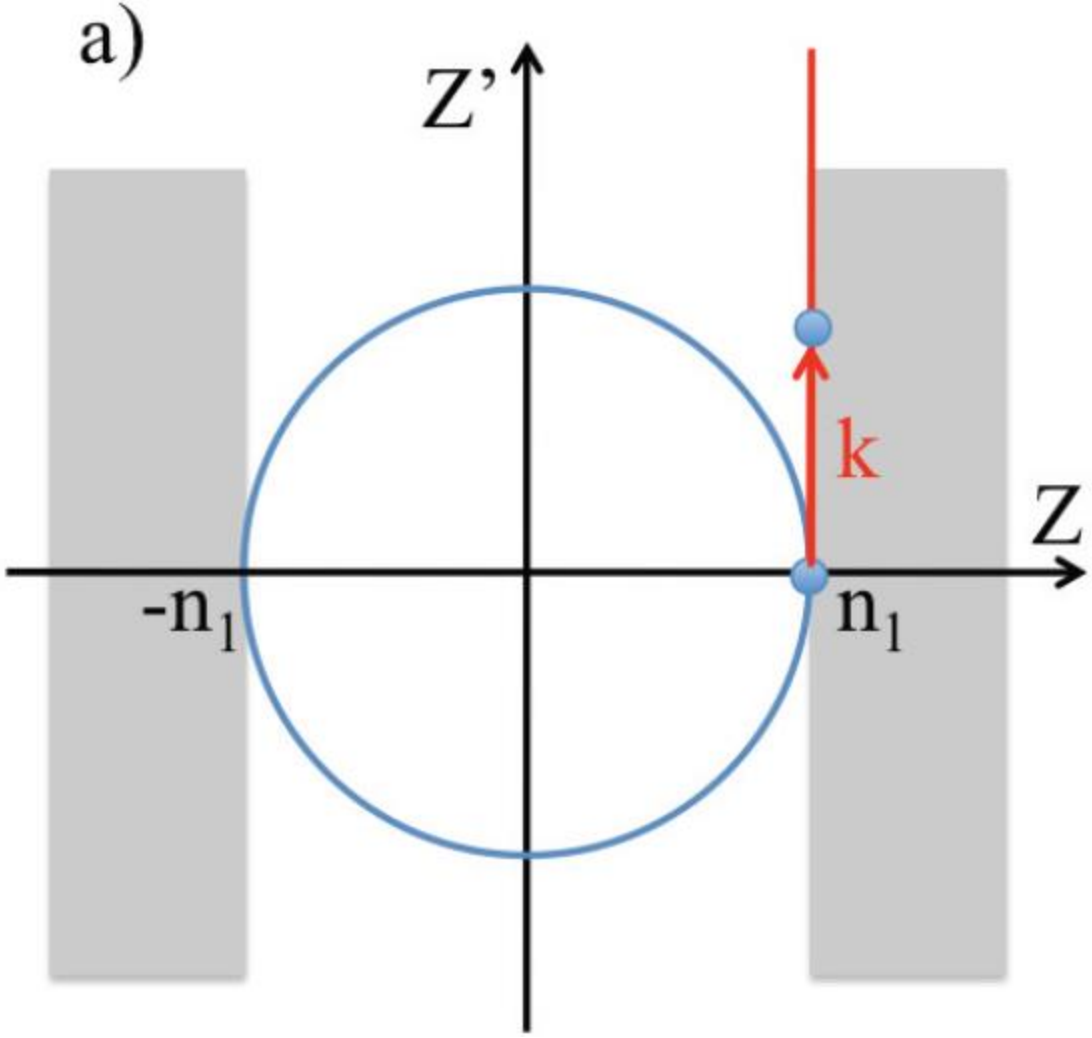
- Primary halo intercepted in Primary Collimators (**TCP**)
- Secondary halo generated in the Primary collimator intercepted by Secondary Collimators (**TCS**)
- Tertiary collimators (**TCT**) protect Inner Triplet and reduce experimental background

The LHC collimation system



Betatron cleaning

- Particles with large amplitude are intercepted by the collimators in IR7.
- High beta and low dispersion sections.

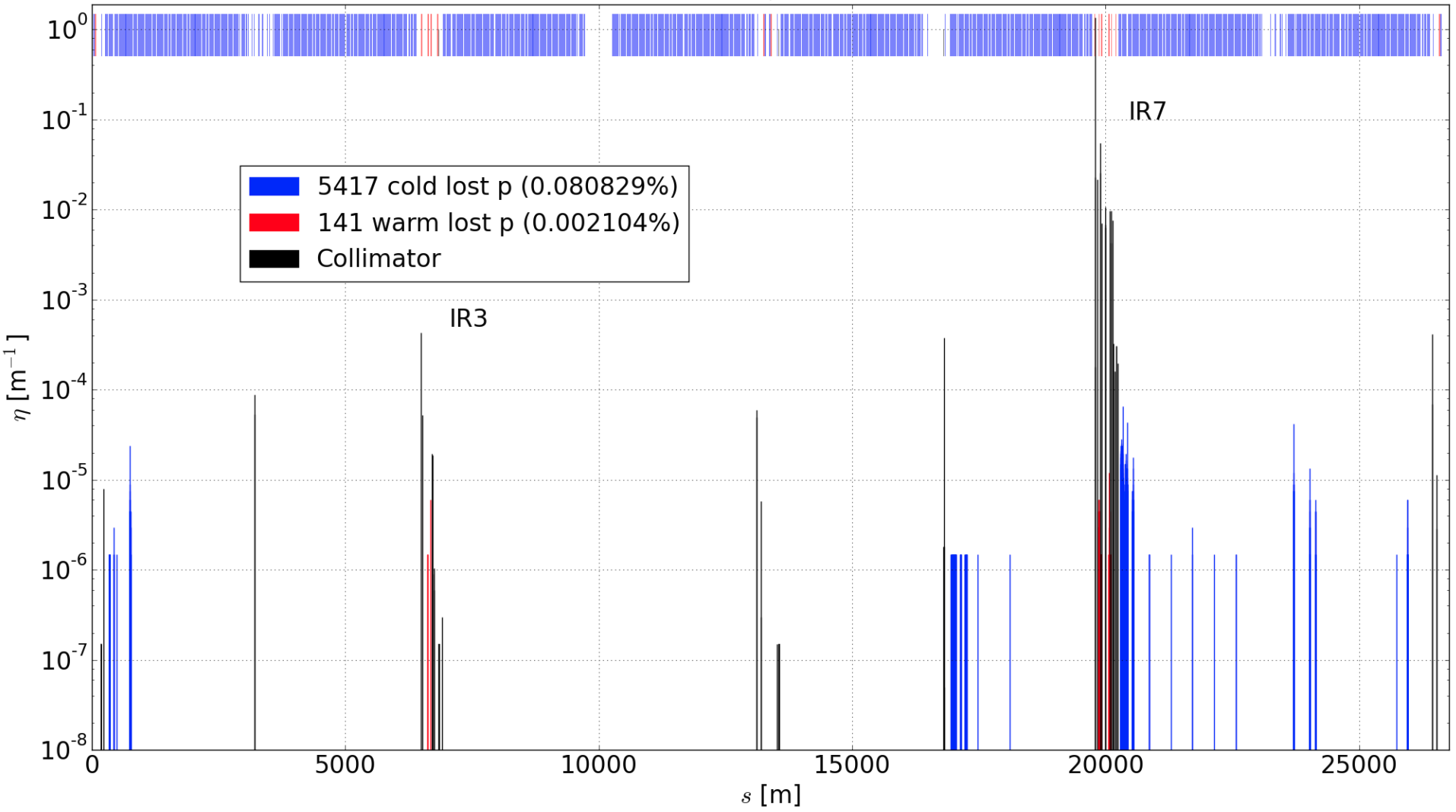


$$u'' + K(s)u = \delta D_u(s)$$

$$x = x_\beta + x_\delta = x_\beta + D_x\delta$$

Interlude: betatron loss map

$$\eta_{\mathrm{ineff}} = \frac{N_{\mathrm{loc}}}{N_{\mathrm{total}}\Delta s}$$

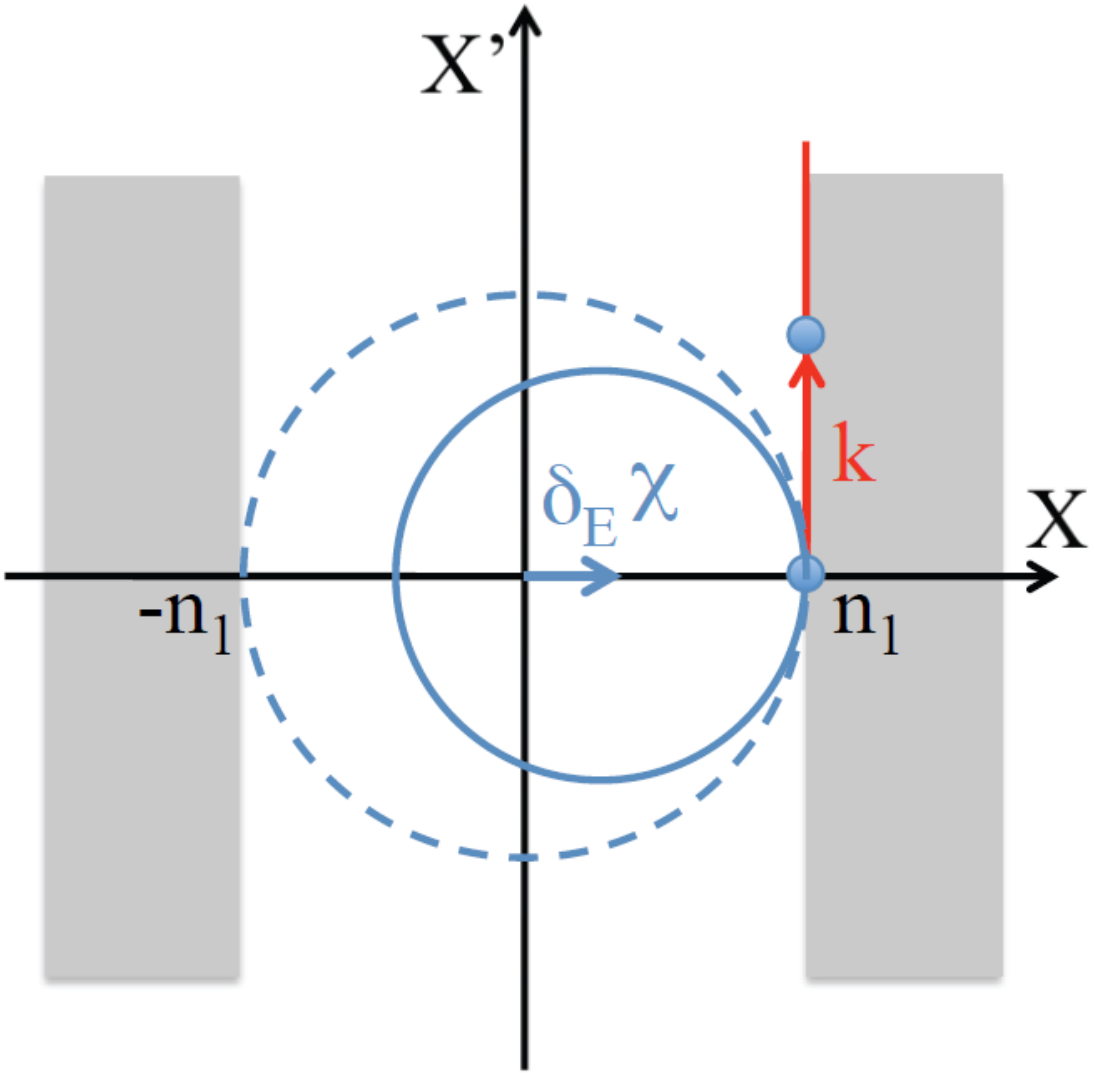


Momentum cleaning

- Particles with large momentum deviation are intercepted by the collimators in IR3.
- Low beta and high dispersion sections.

$$u'' + K(s)u = \delta D_u(s)$$

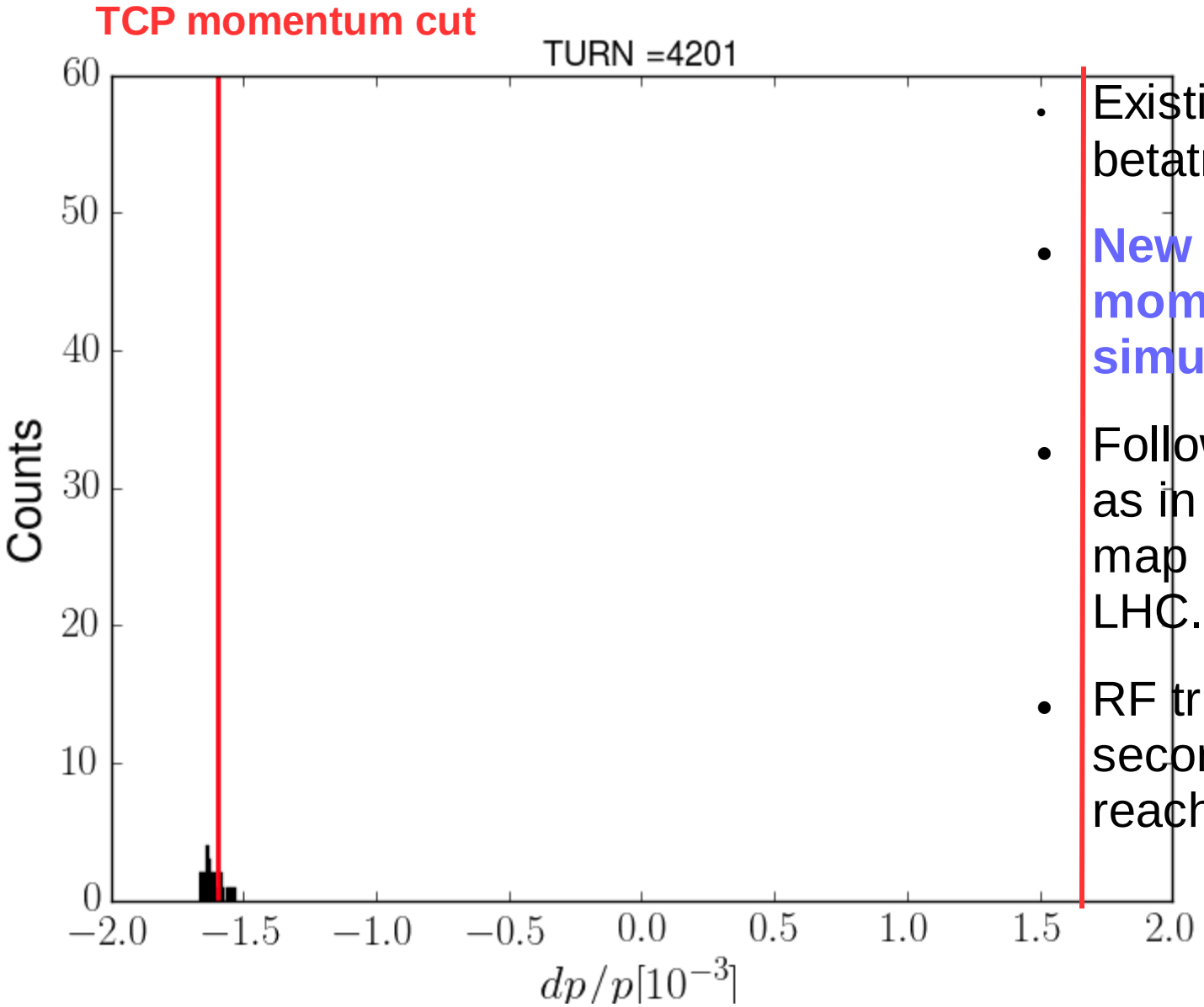
$$x = x_\beta + x_\delta = x_\beta + D_x\delta$$



Motivation for off-momentum cleaning simulations

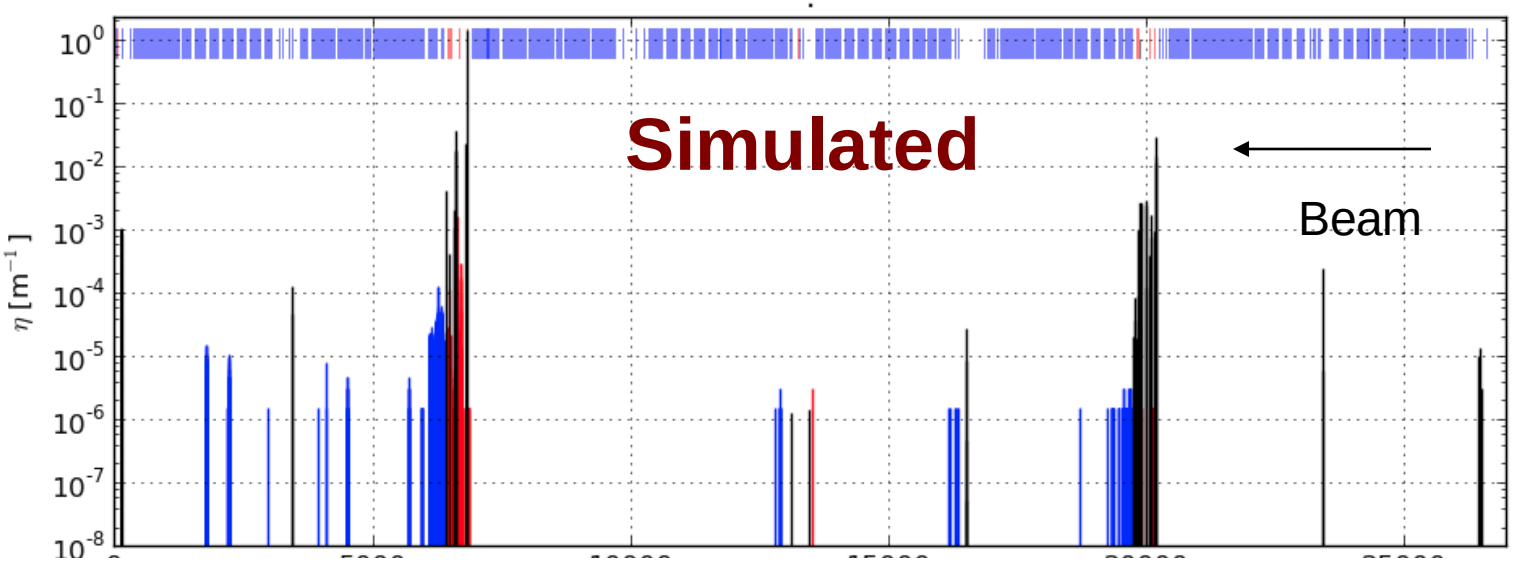
- Off-momentum dynamics is not fully understood.
- We already have a tool for betatron loss map simulation.
- We can measure but we cannot simulate/predict/understand what happens.
- It can potentially explain the origin of some unexplained losses observed in the LHC.

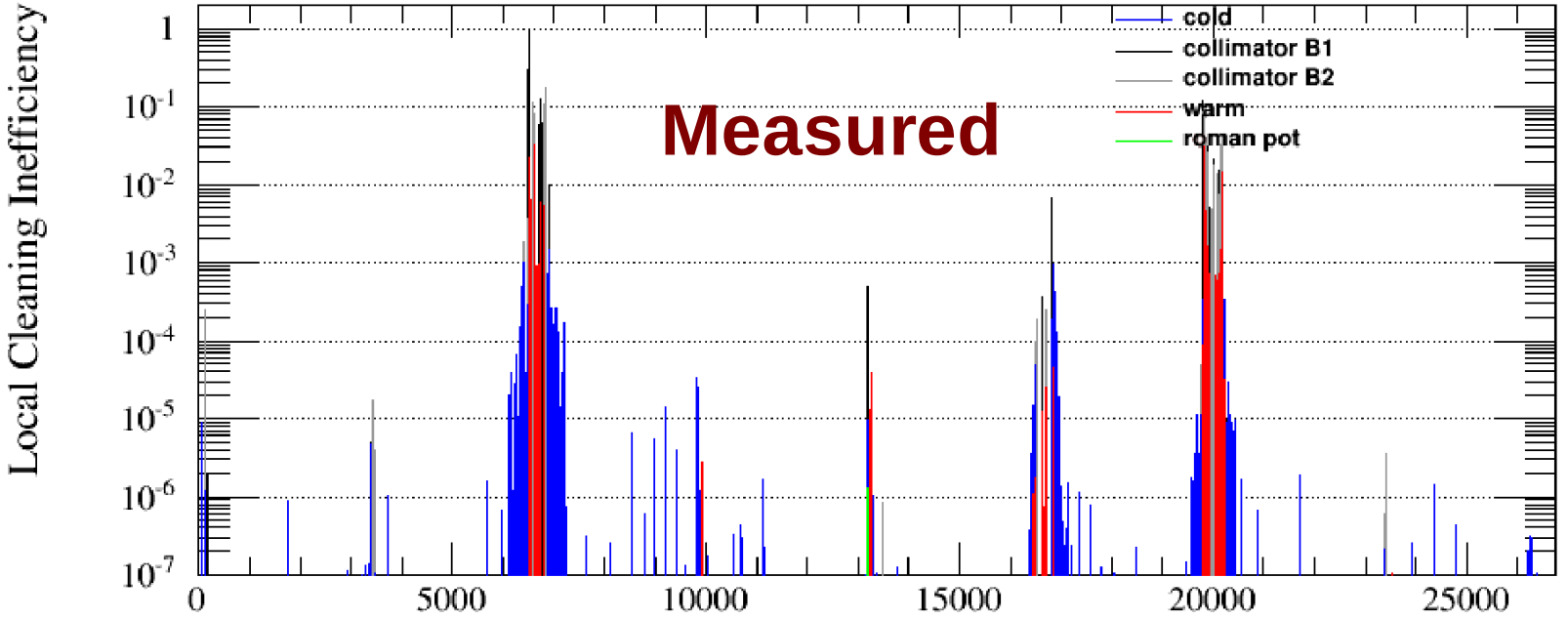
Not a standard simulation



- Existing simulation setup for betatron loss maps.
- **New set of tools for off-momentum loss map simulations.**
- 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.

Off-momentum loss maps (6.5 TeV)

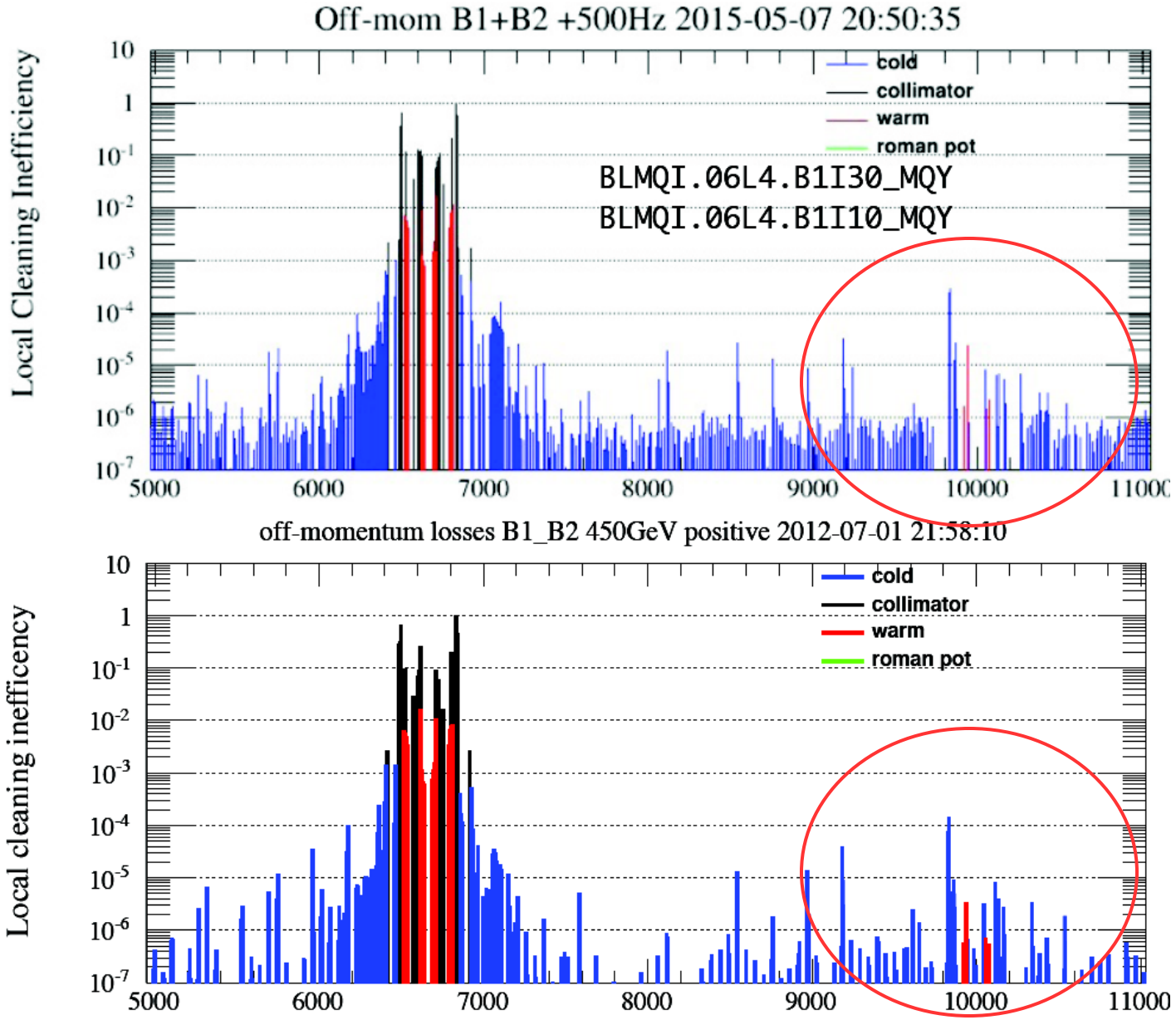




First issue addressed: Losses in IR4

Action - Losses IP4

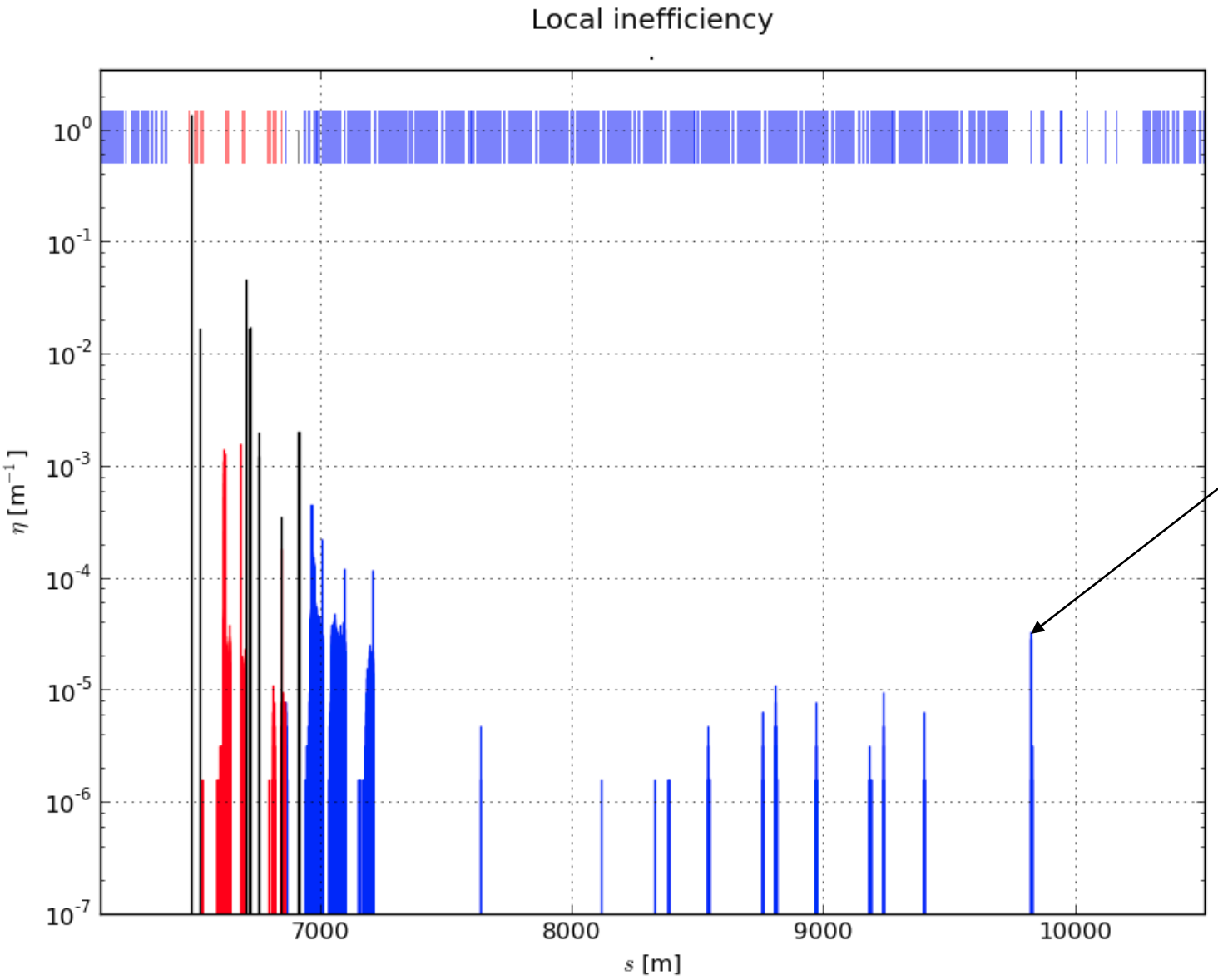
S.Redaelli LMC 20-05-2015



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

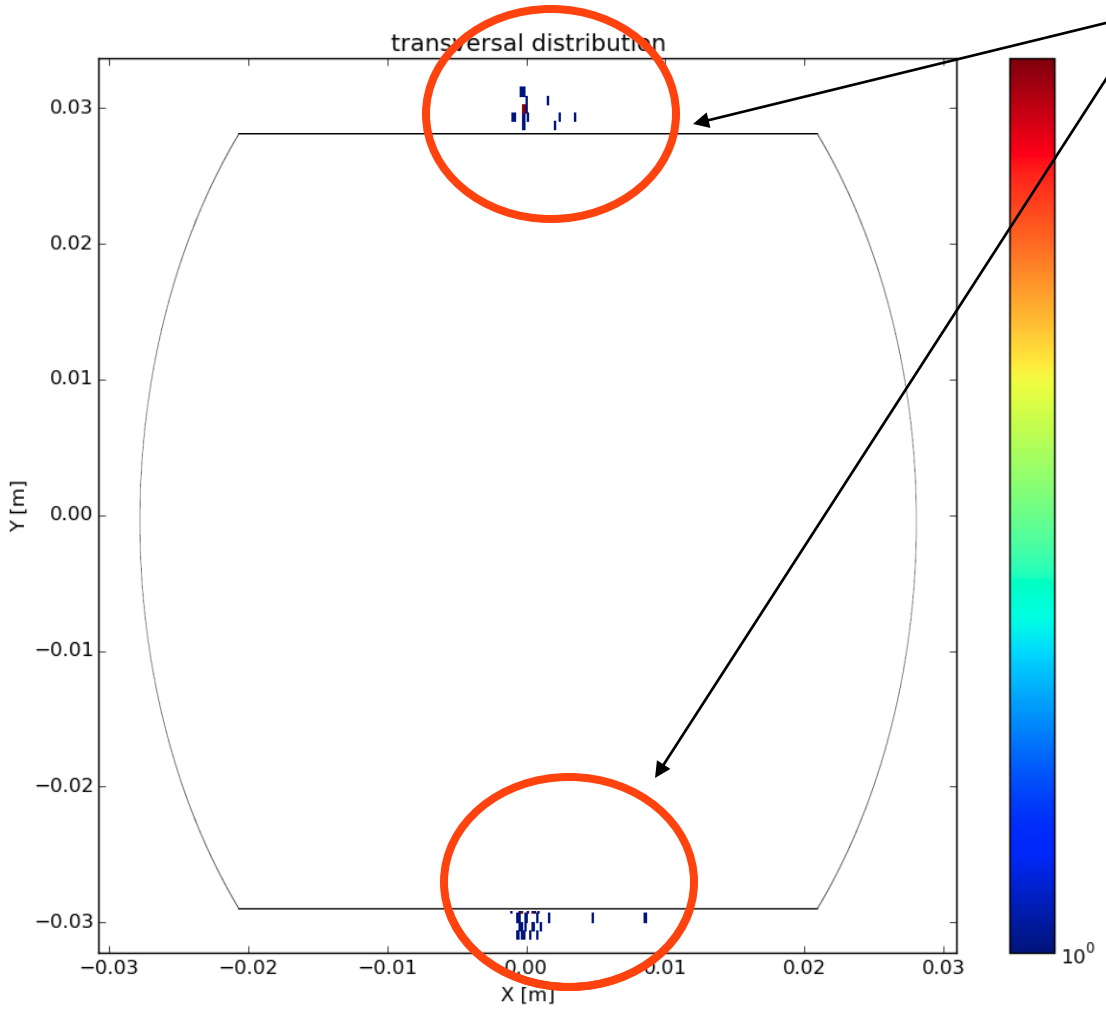
Verify results with simulations

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.

Conclusions so far

- A need tracking simulation tool has been implemented.
- First comparison with measurements is really good.
- First issue resolved: Understanding of the losses in IR4.

What's next?

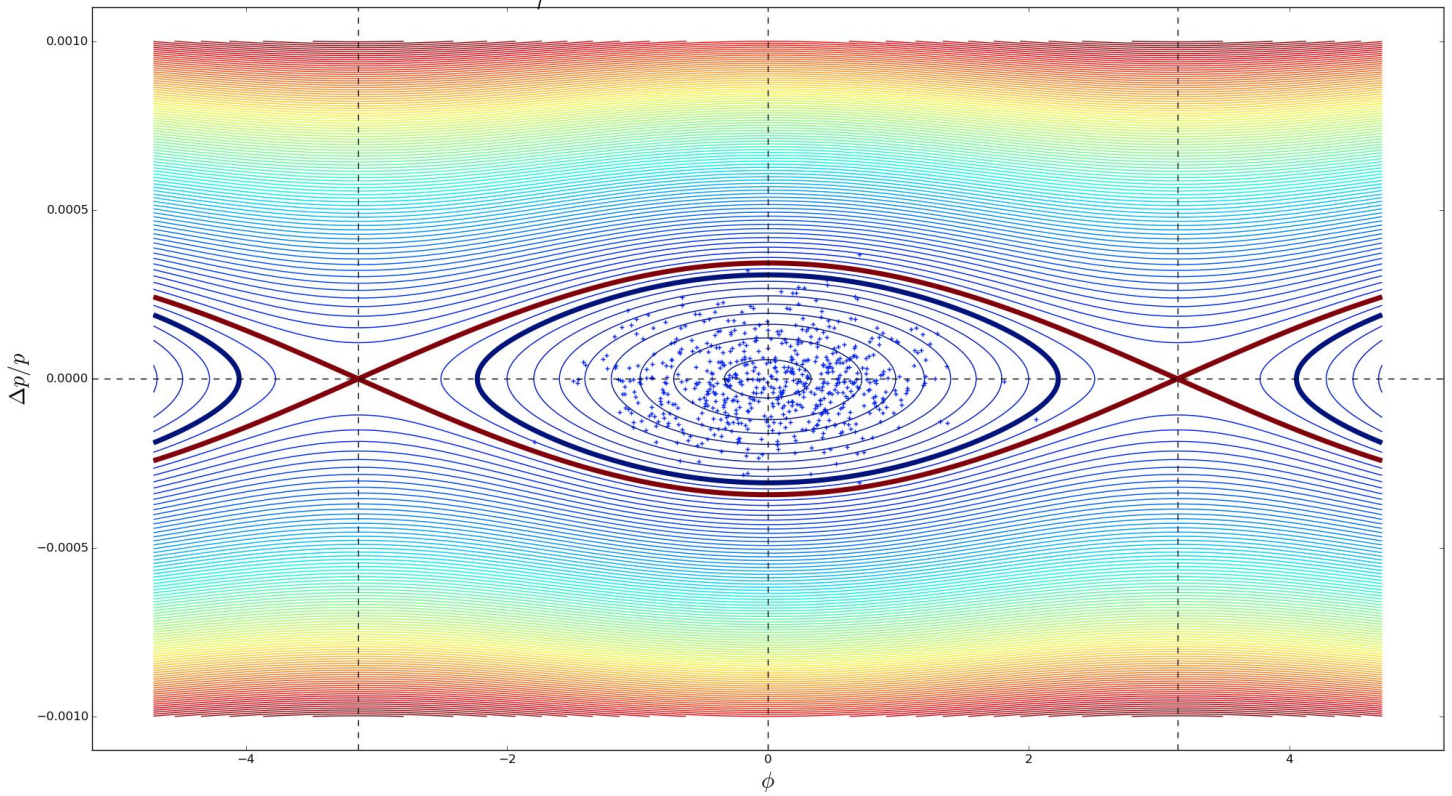
- Explore further in detail the power of such new tool and figure out what can be predicted.
- More data to get a good distribution of losses in IR4.
- Address ATLAS B1/B2 background asymmetry issue.
- General goal: better understanding of the off-momentum dynamics in the LHC.

Thank you!

Backup

Longitudinal motion: a theoretical minimum

$$H = \frac{1}{2}\omega_{RF}\eta\delta^2 + \frac{eV\omega_{rev}}{\beta^2 E}(\cos\phi - \cos\phi_s + (\phi - \phi_s)\cos(\phi_s))$$



$$\phi_{n+1} = \phi_n + 2\pi h\eta(\delta_{n+1})\delta_{n+1}$$

$$\delta_{n+1} = \delta_n + \frac{eV}{\beta^2 E}(\sin\phi_n - \sin\phi_s)$$