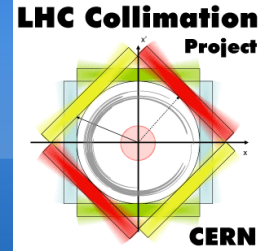


Update on multi-turn particle debris tracking

F. Cerutti, A. Marsili, S. Redaelli



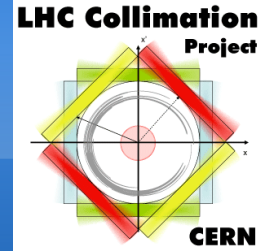
Outline



- Introduction
- Setup of the debris tracking simulations
- Losses at TCL
- TCL measures
- TCL scan
- Normalisation in physical units
- TCLP scan



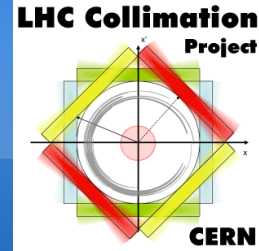
Introduction



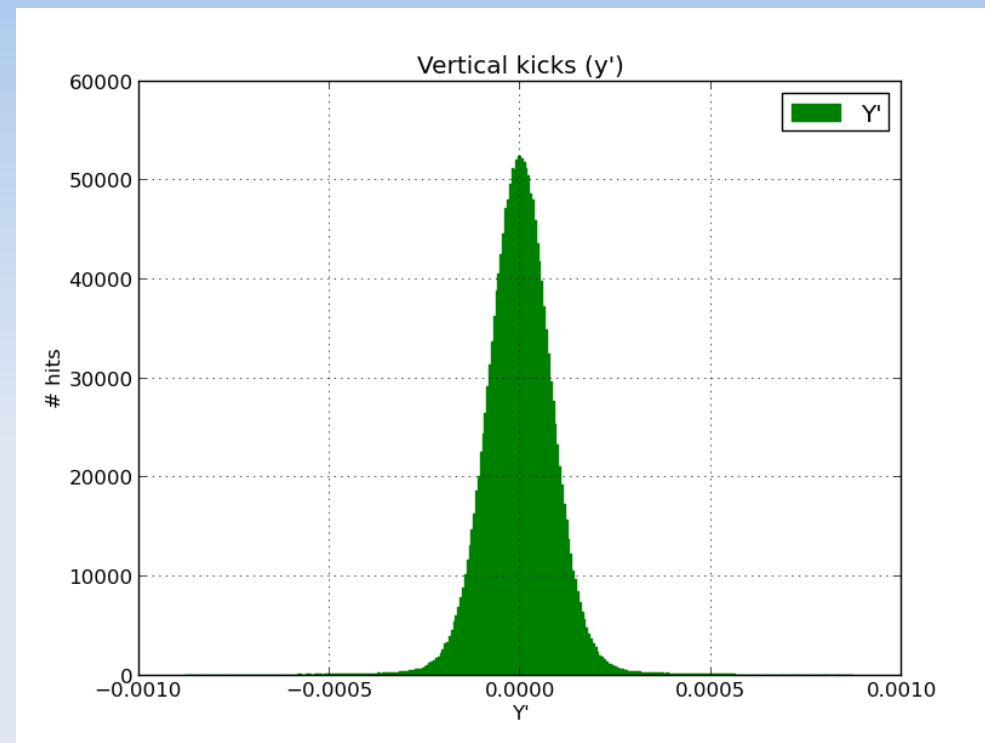
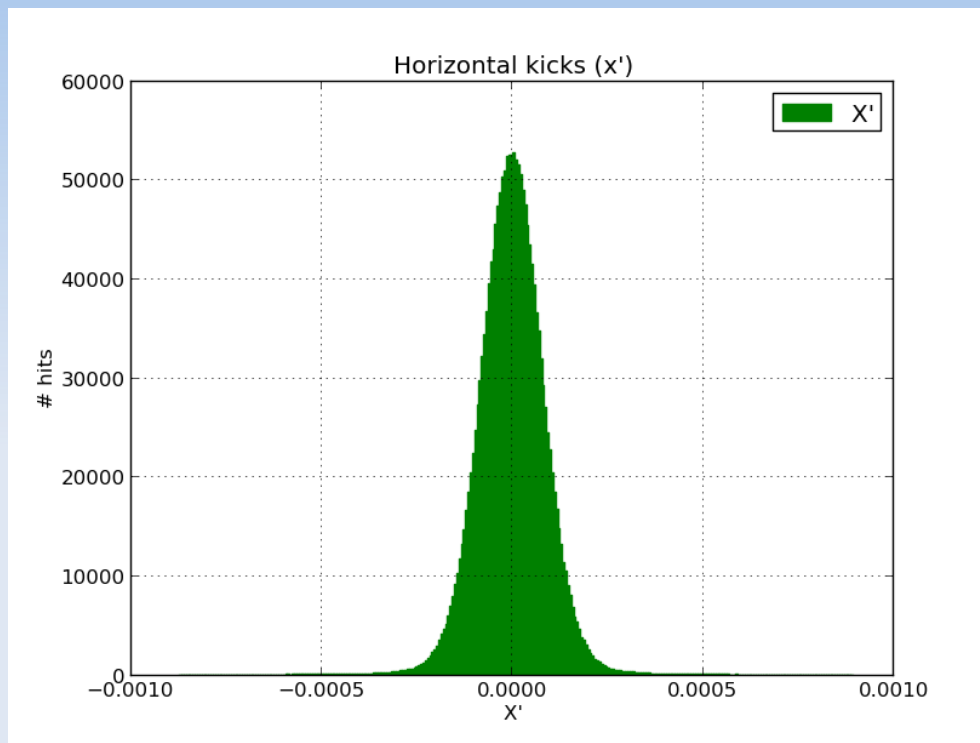
- **Goal:** study the losses due to debris from IPs (instead of regular beam losses) by tracking them around the ring
- Tools are set; first physical results
- Scan with TCL.5R1.B1;
- Comparison with measures;
- scan with TCLP.4R1.B1.



Inputs:

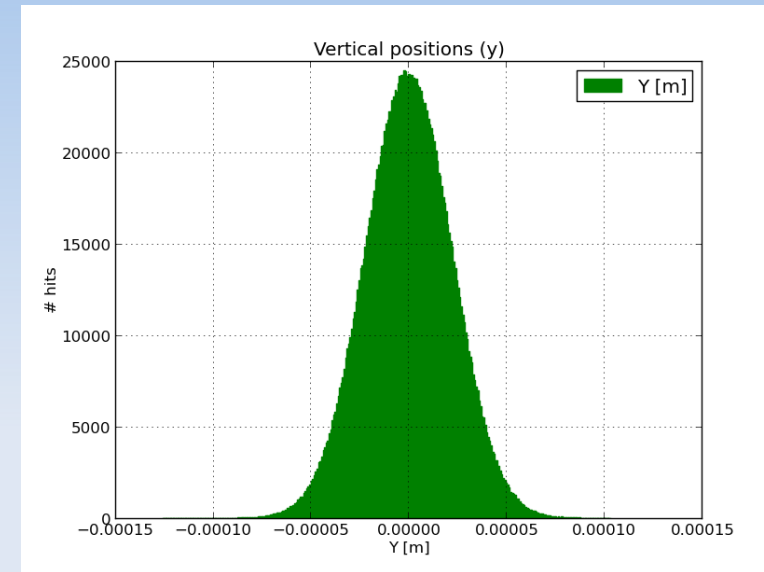
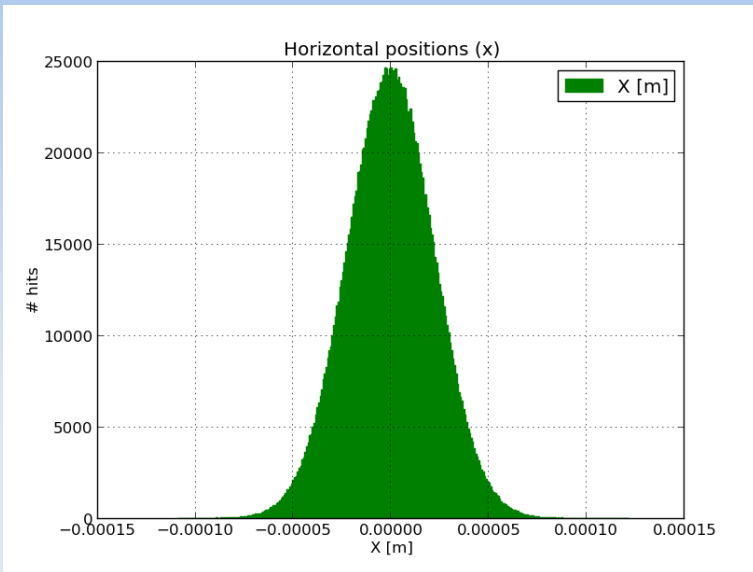


- Generating the output of collisions:
 - Keeping only protons
 - Cut in dp/p (< 0.1) and kicks ($\theta < 0.85$ mrad)
 - Distribution (and help) courtesy of F. Cerutti
 - Tracking only perturbed particles
- Initial beam distribution is generated, then:
- Effect of the collisions is added:
 - Shift in momentum
 - Extra kicks
- Cf. ColUSM #3, ColUSM #11

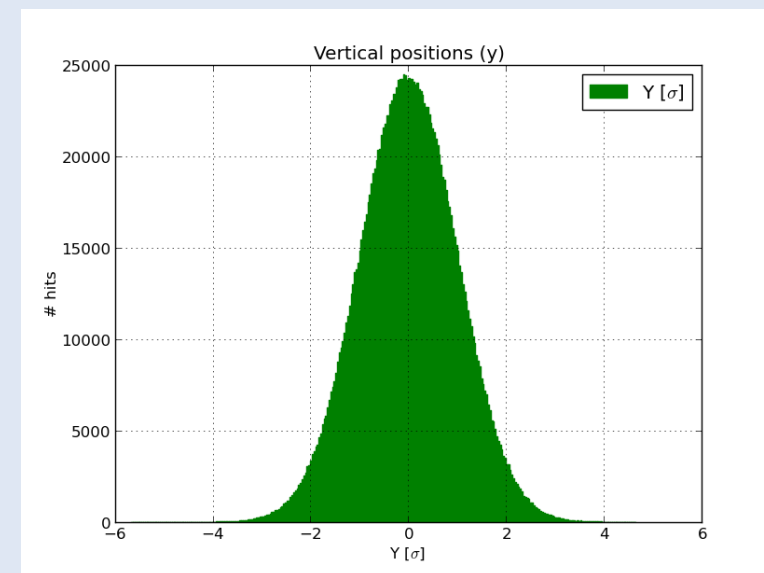
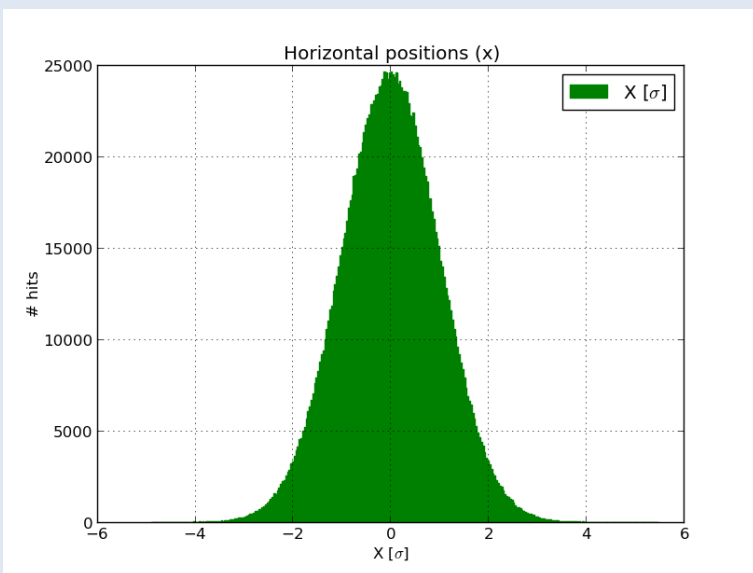


- The distributions of kicks due to collisions are wider than the original distributions of angles
- The kicks are cut at the opening of the TAS

Initial distributions: positions



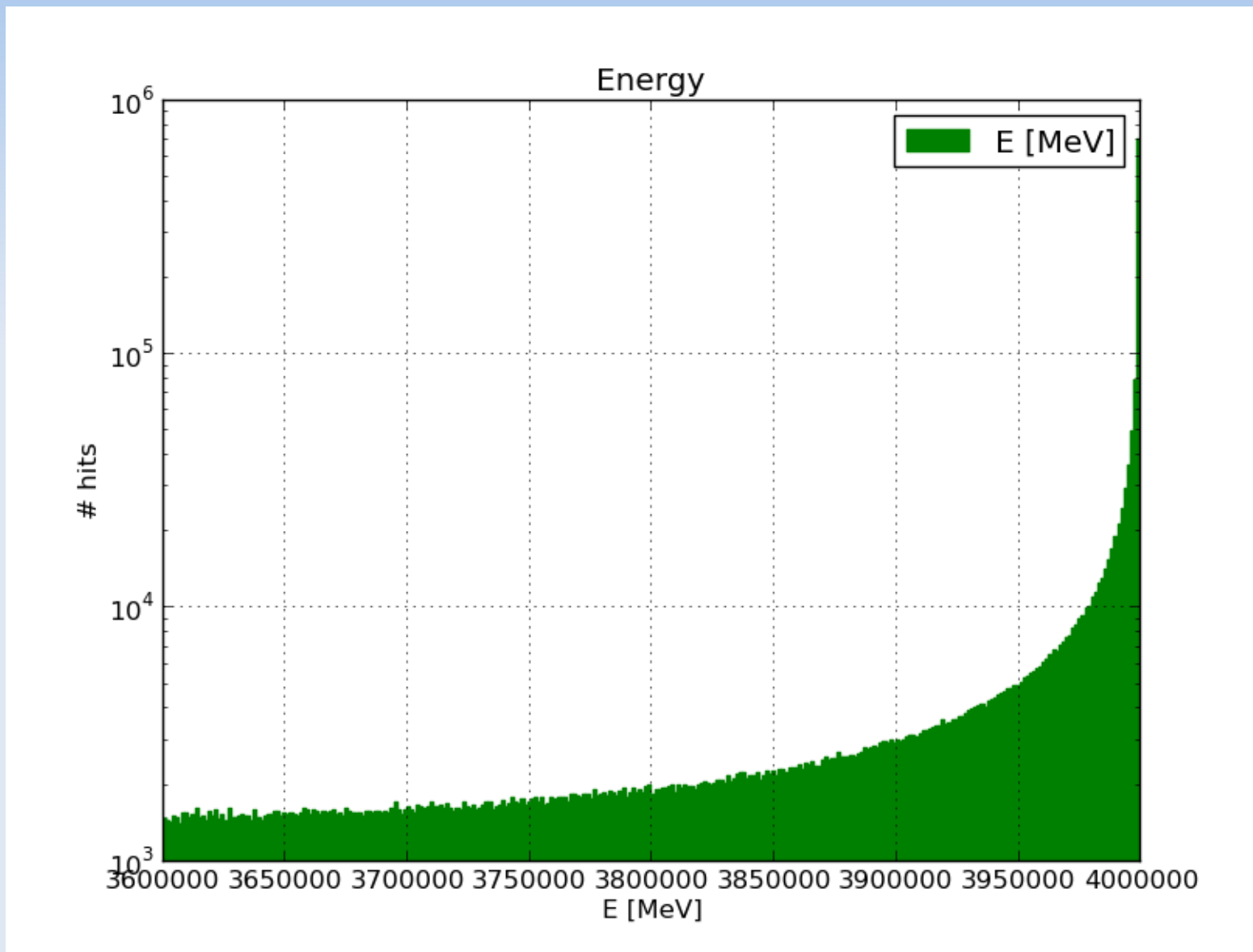
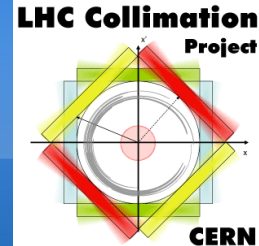
In meters

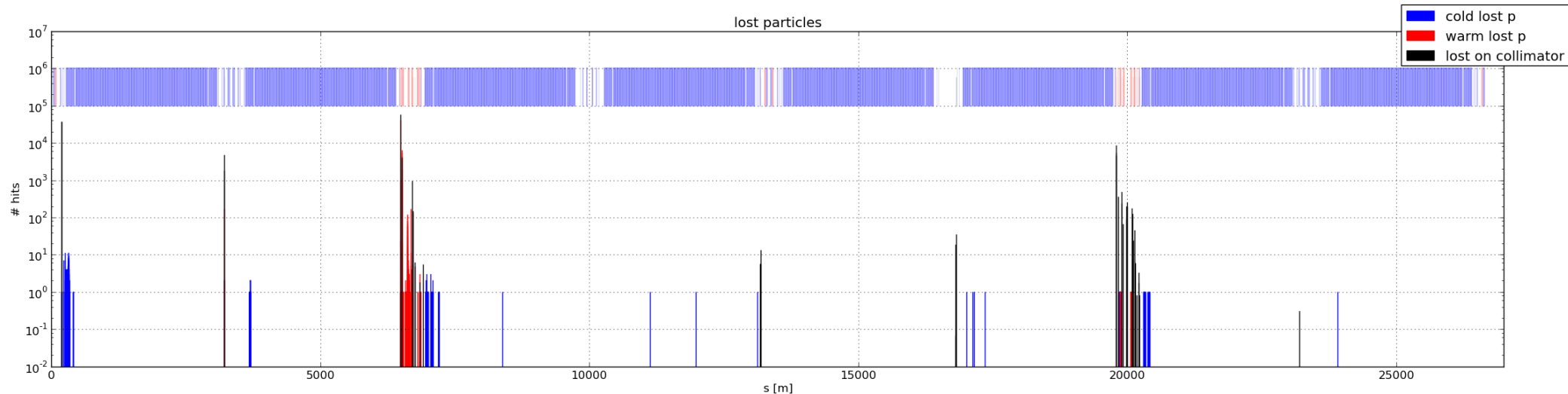


In sigma units



Initial distribution: dp/p

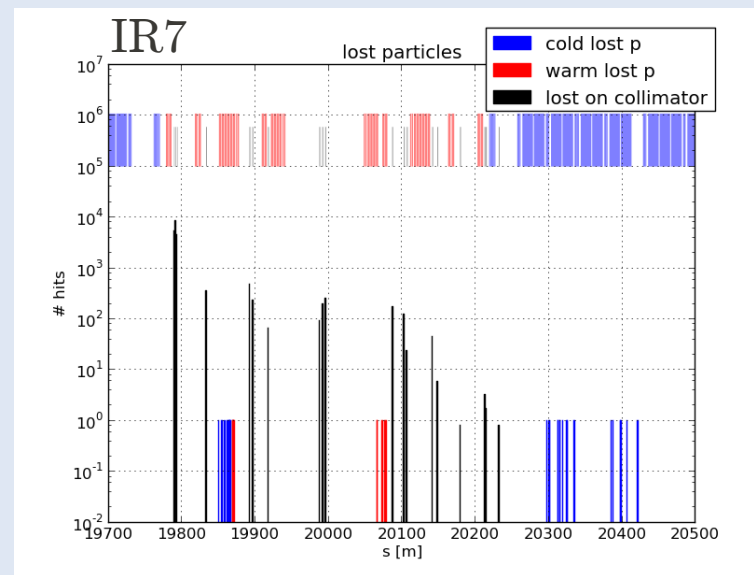
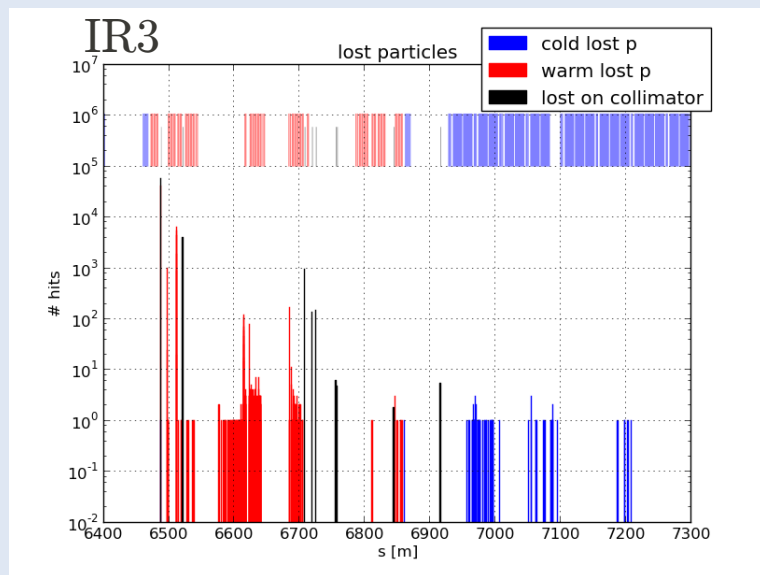
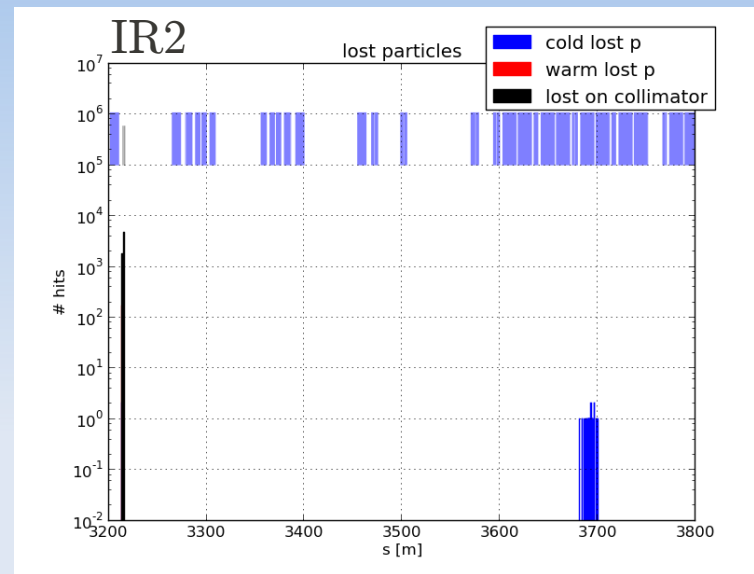
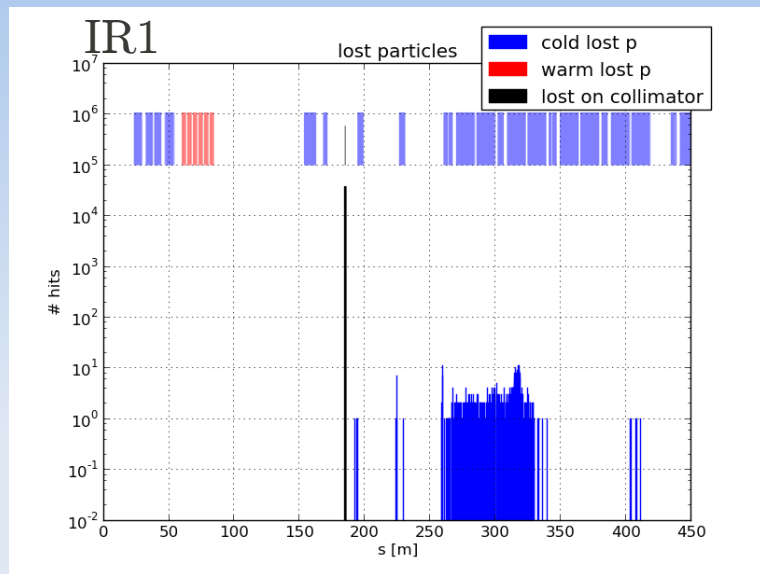
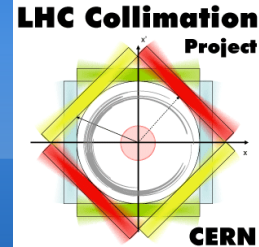


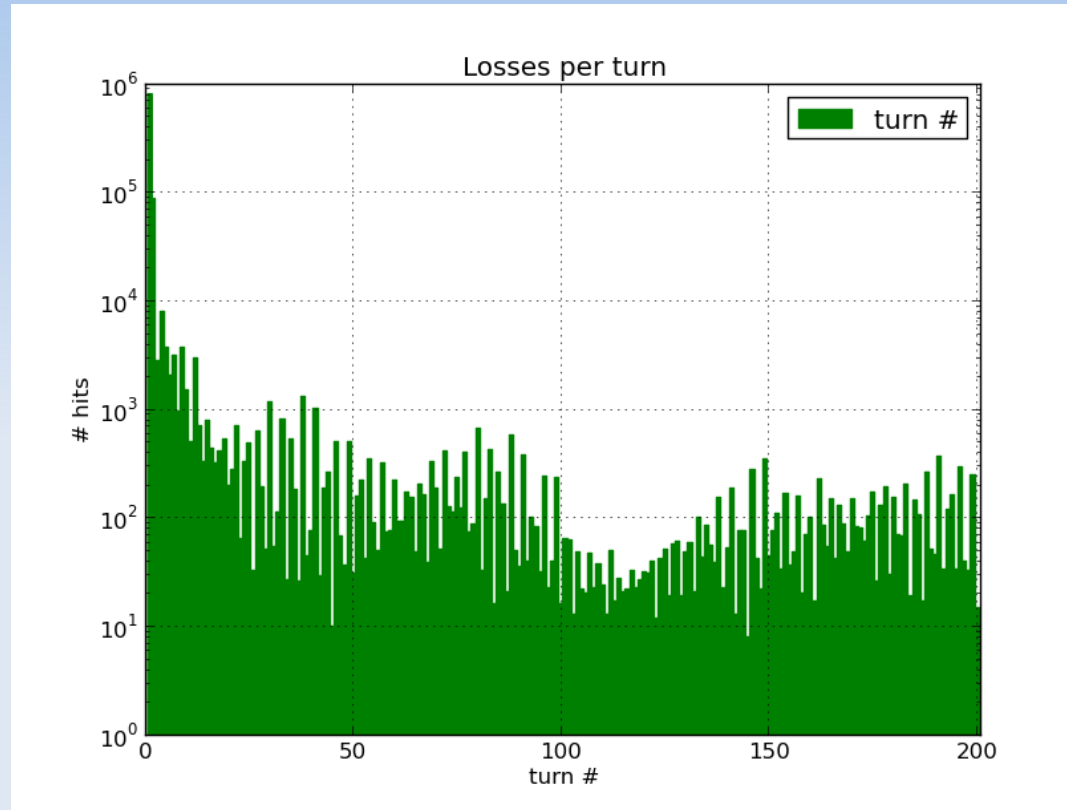


- 4 TeV, nominal settings
- $1.77e6$ p (for $1e7$ collisions, after cut)
- Tracking debris from IP1
- Highest losses at the TCP.6L3.B1 (momentum cleaning)

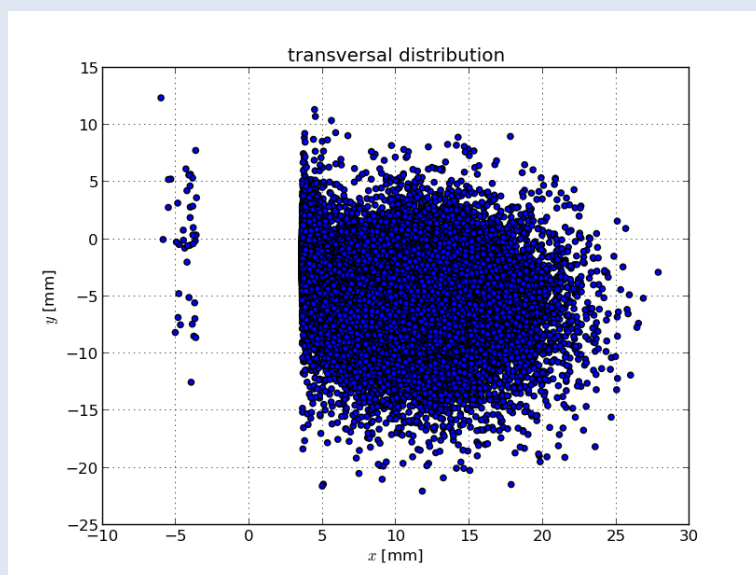
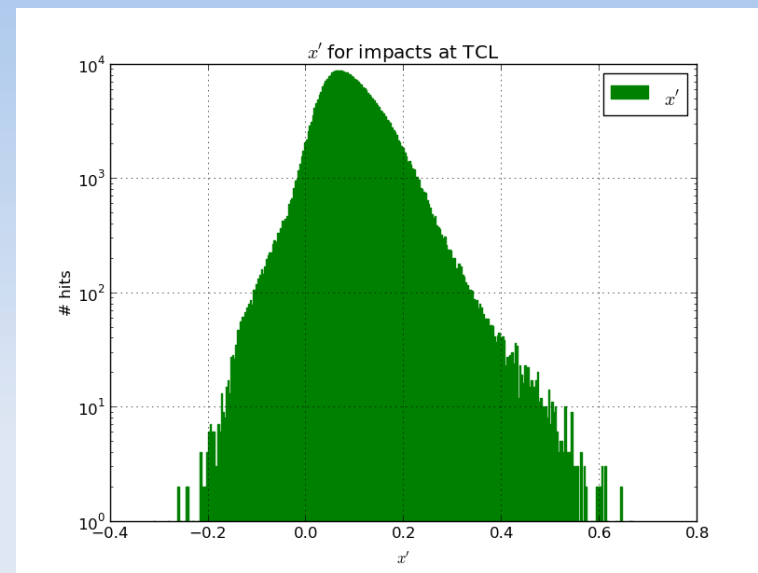
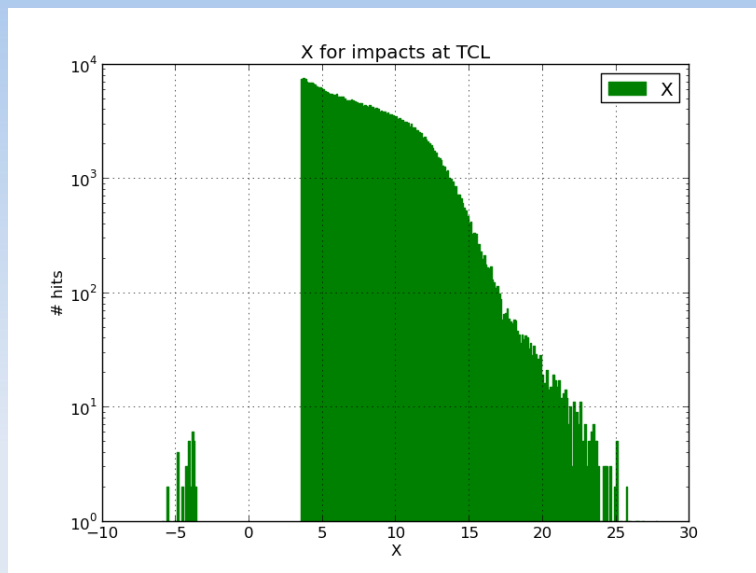


Loss maps 4 TeV nominal zooms



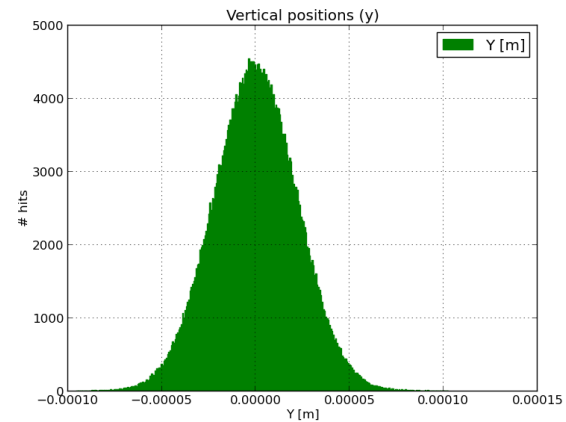
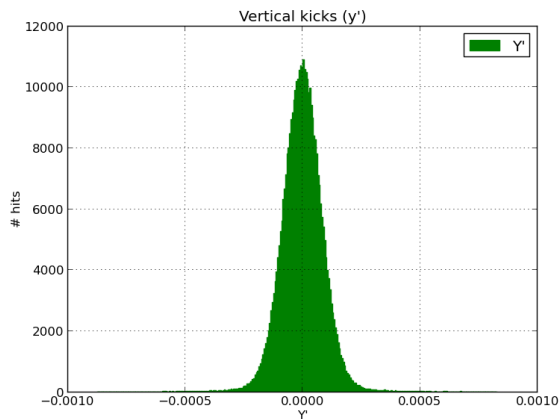
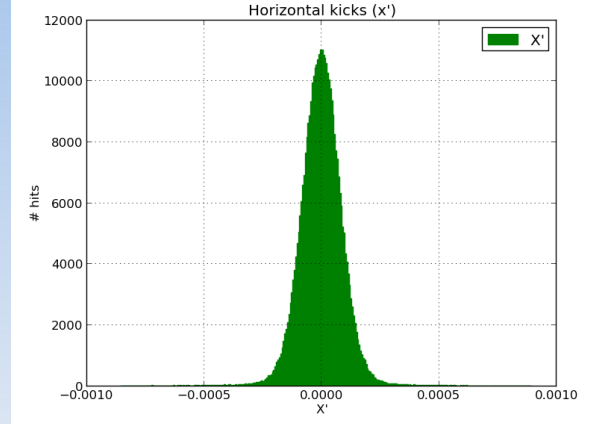
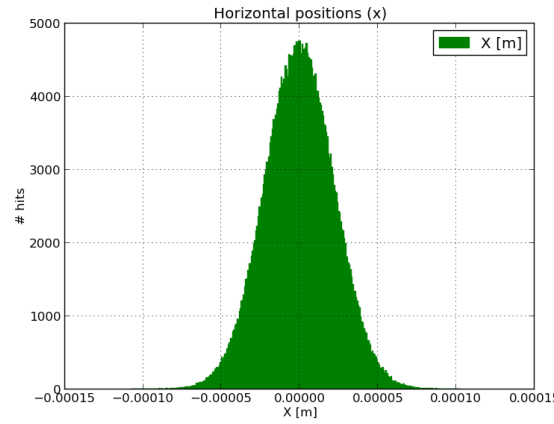
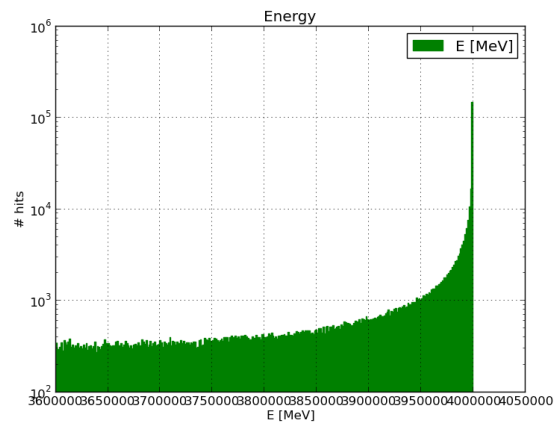


- Most particles are lost in the first 2 turns
- Most likely first turn losses at TCL

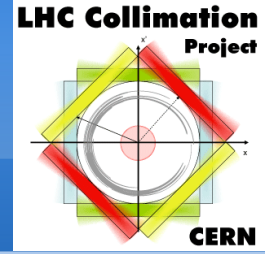


- $\sigma_x = 359 \mu\text{m}$
- TCL setting: 10σ
- Most losses for $x > 0$

Initial distributions of particles hitting the TCL



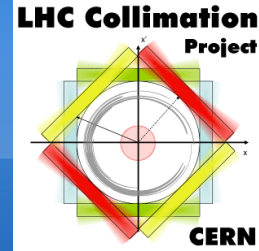
- No obvious difference – just seem like scaled-down initial distr.
- 1/5 of total particles



TCL scan



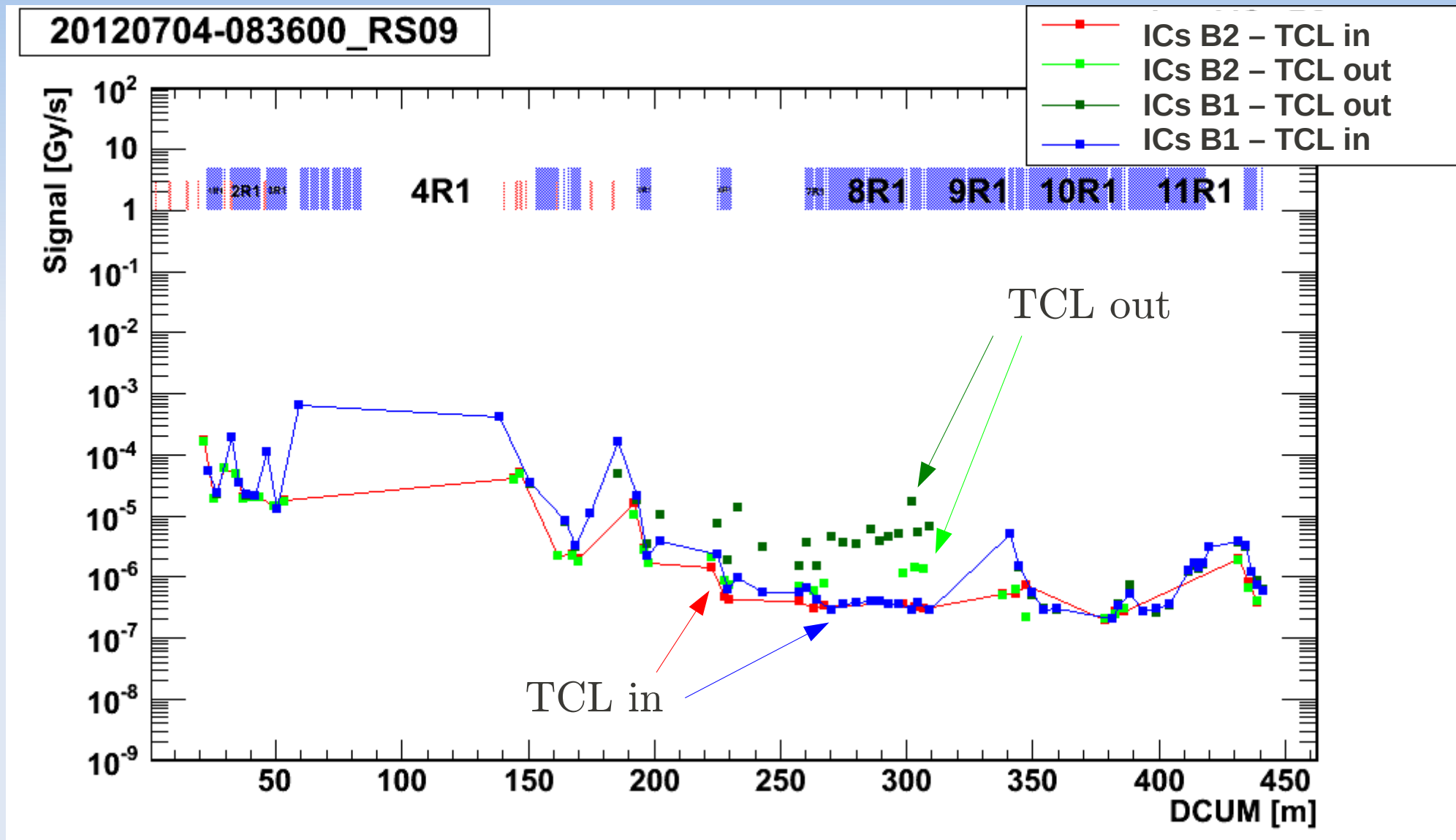
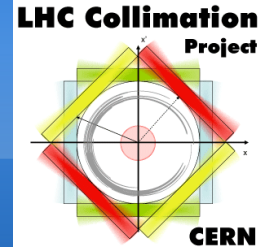
TCL scan

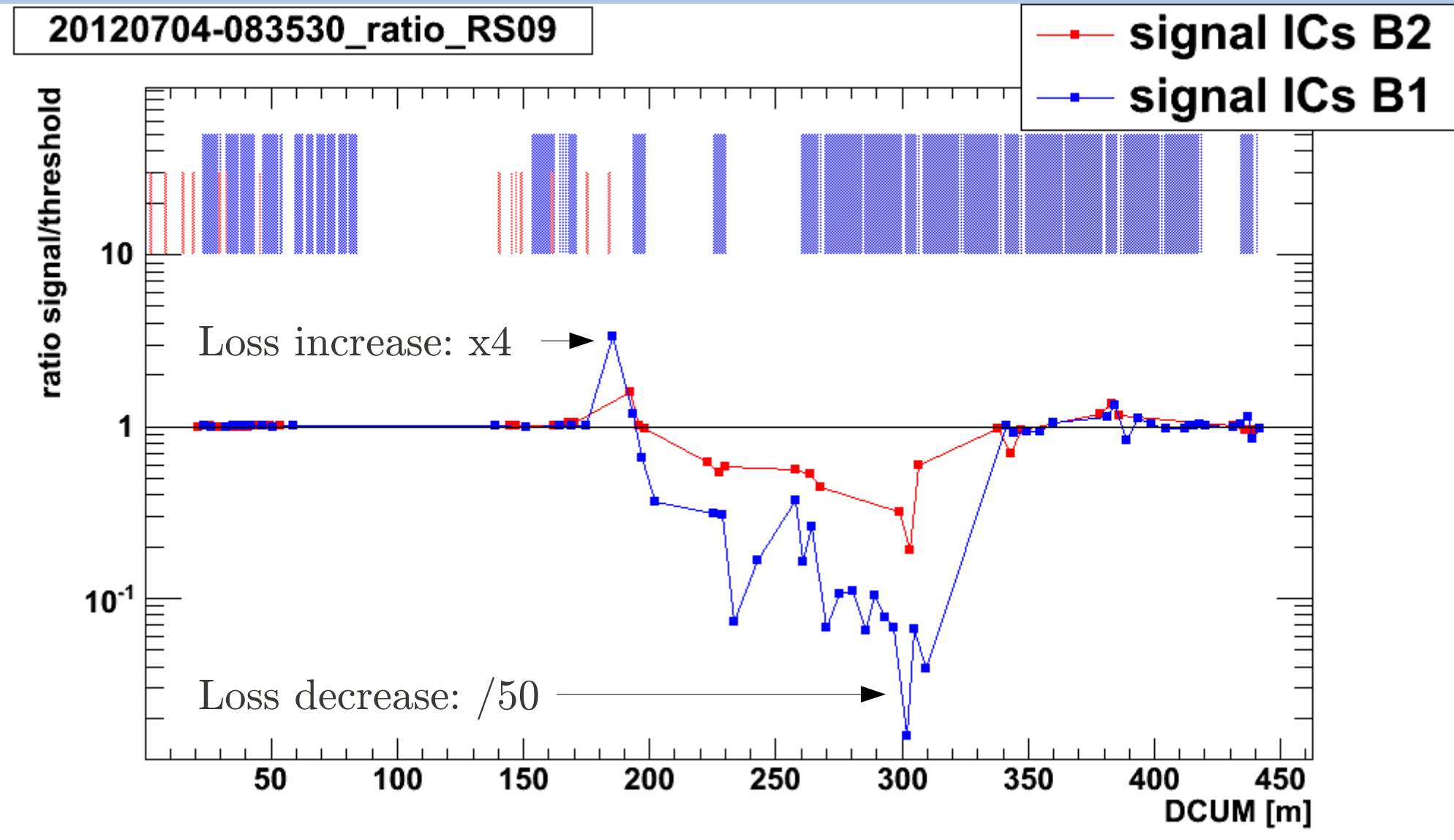


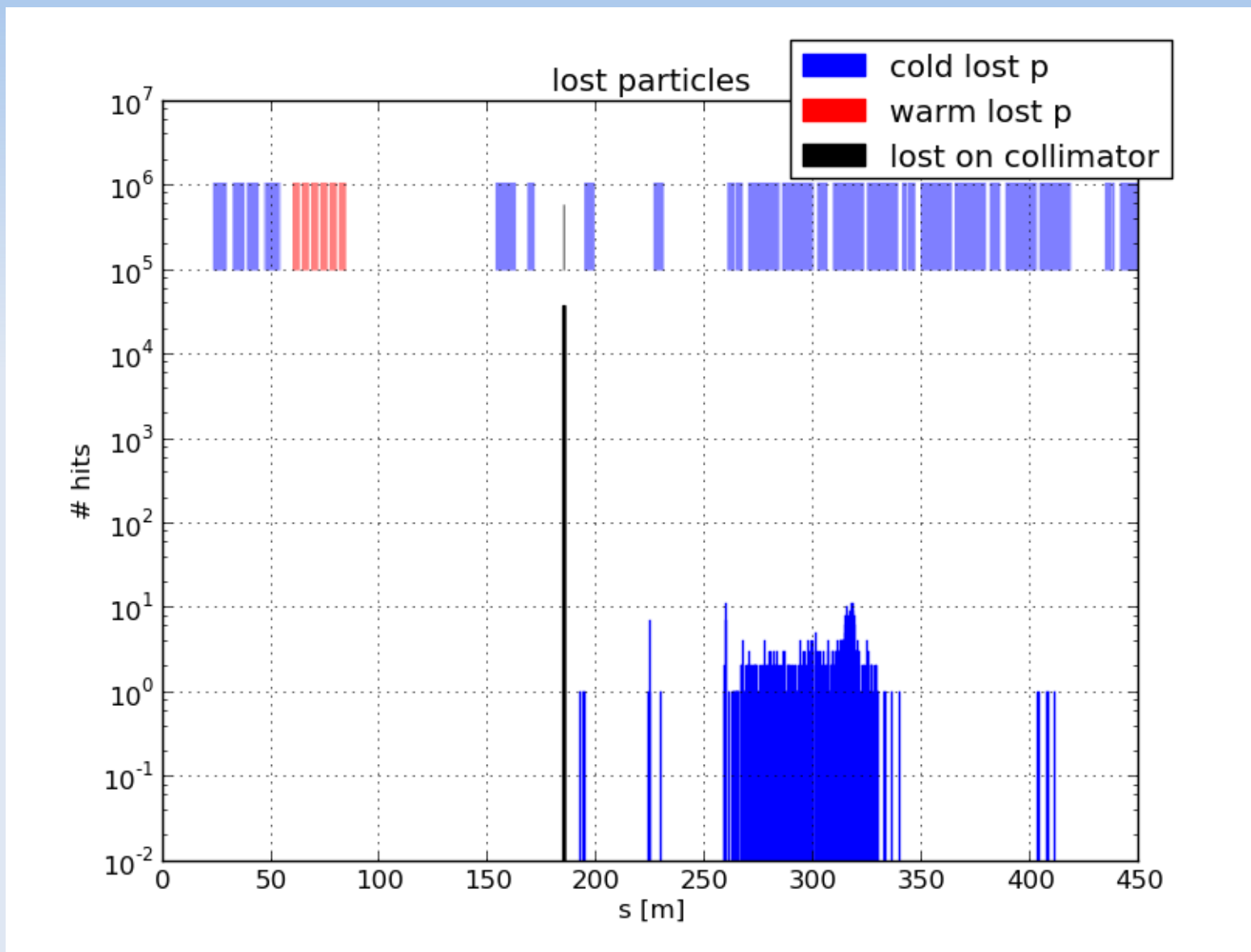
- Real TCL scans **measurements** were taken in the LHC earlier this year.
- TCL starts at 10σ , then is moved out to 60σ (and back in).
- The losses at the TCL are decreasing, while the losses downstream are increasing (protection).
- **Goal**: try to reproduce this effect with the simulations
- Simulation setup: 10σ to 30σ , steps of 2σ
- Before that, a reminder on the measures
- **Movie**

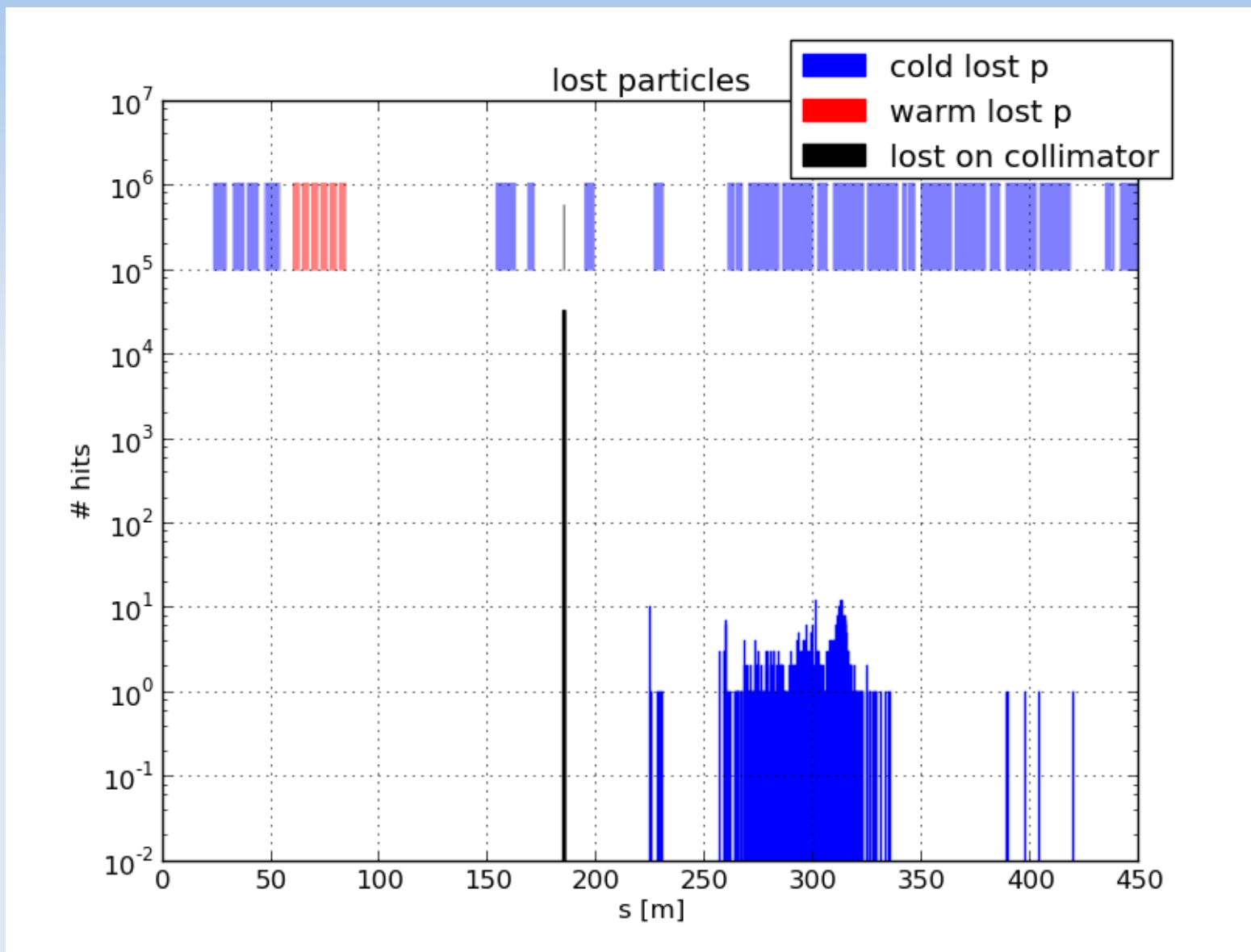


Effect of the TCL in the LHC



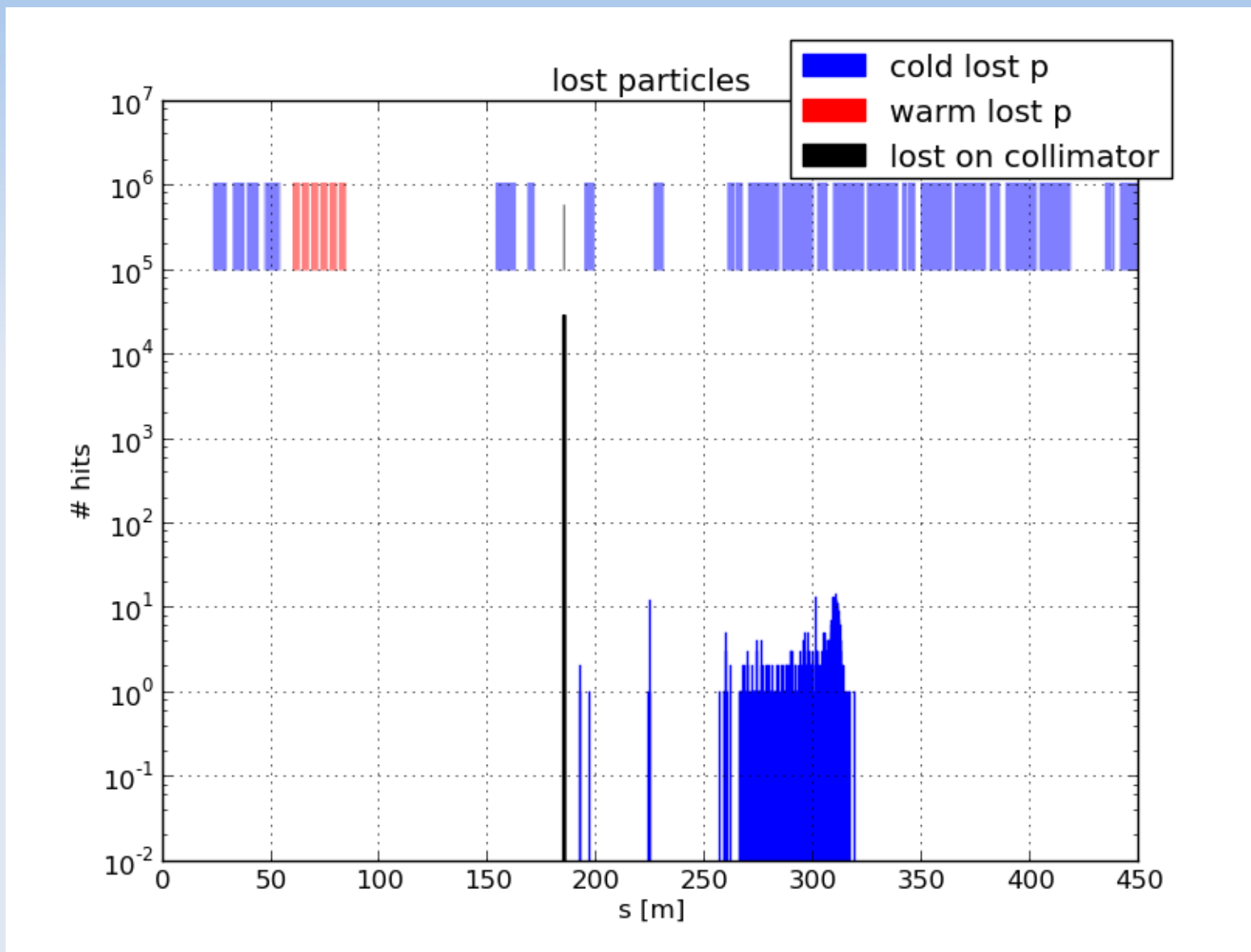
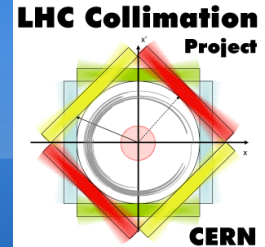


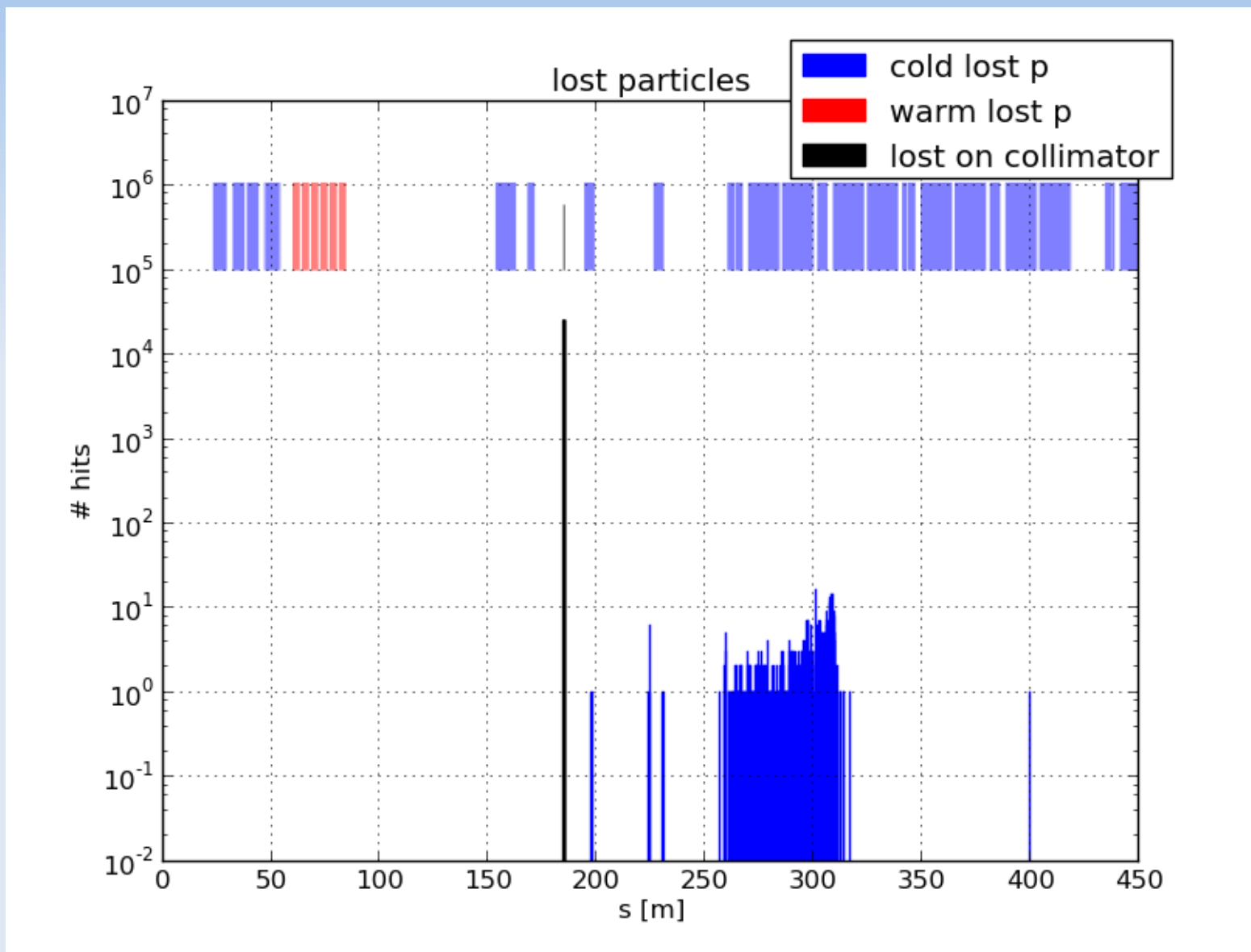


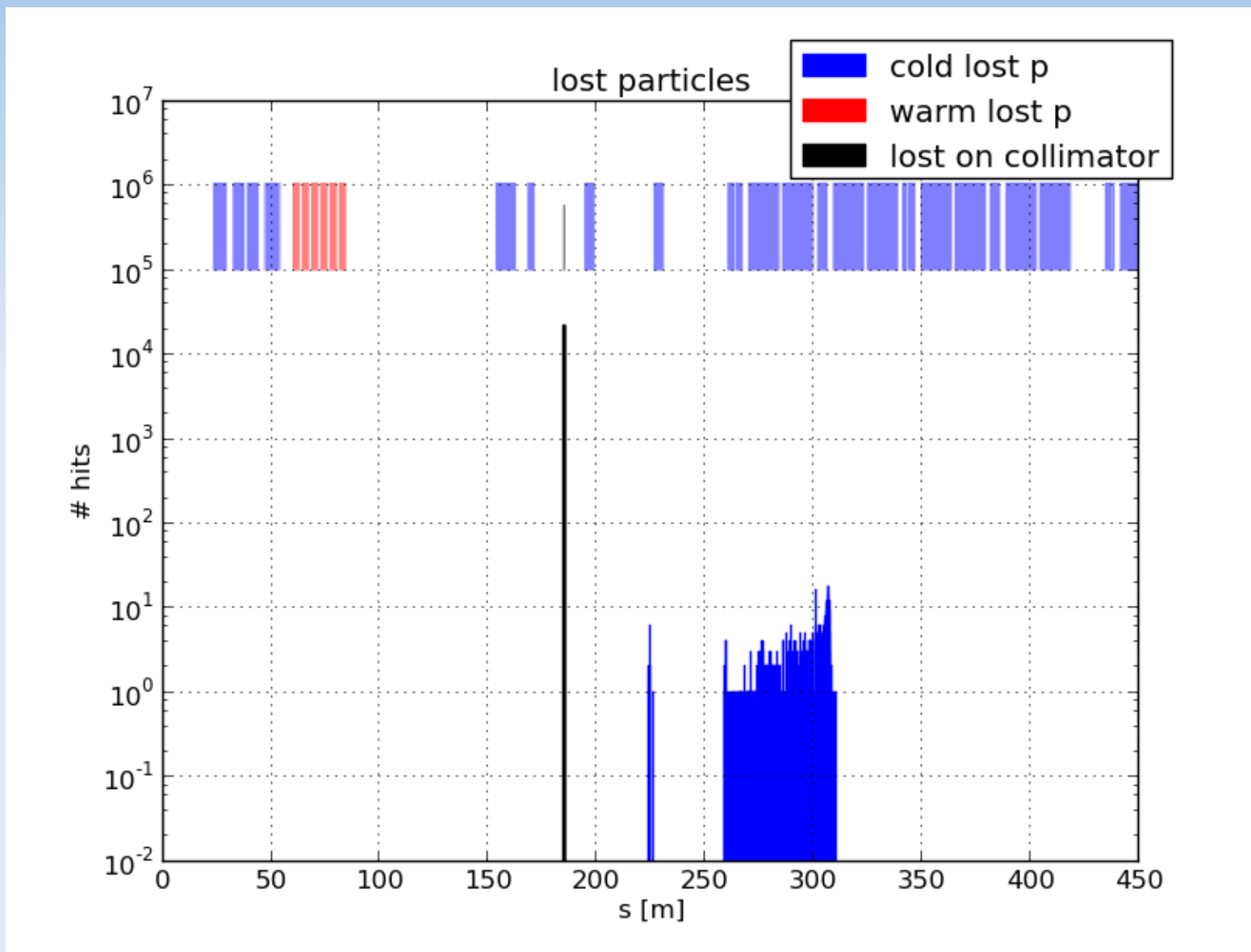


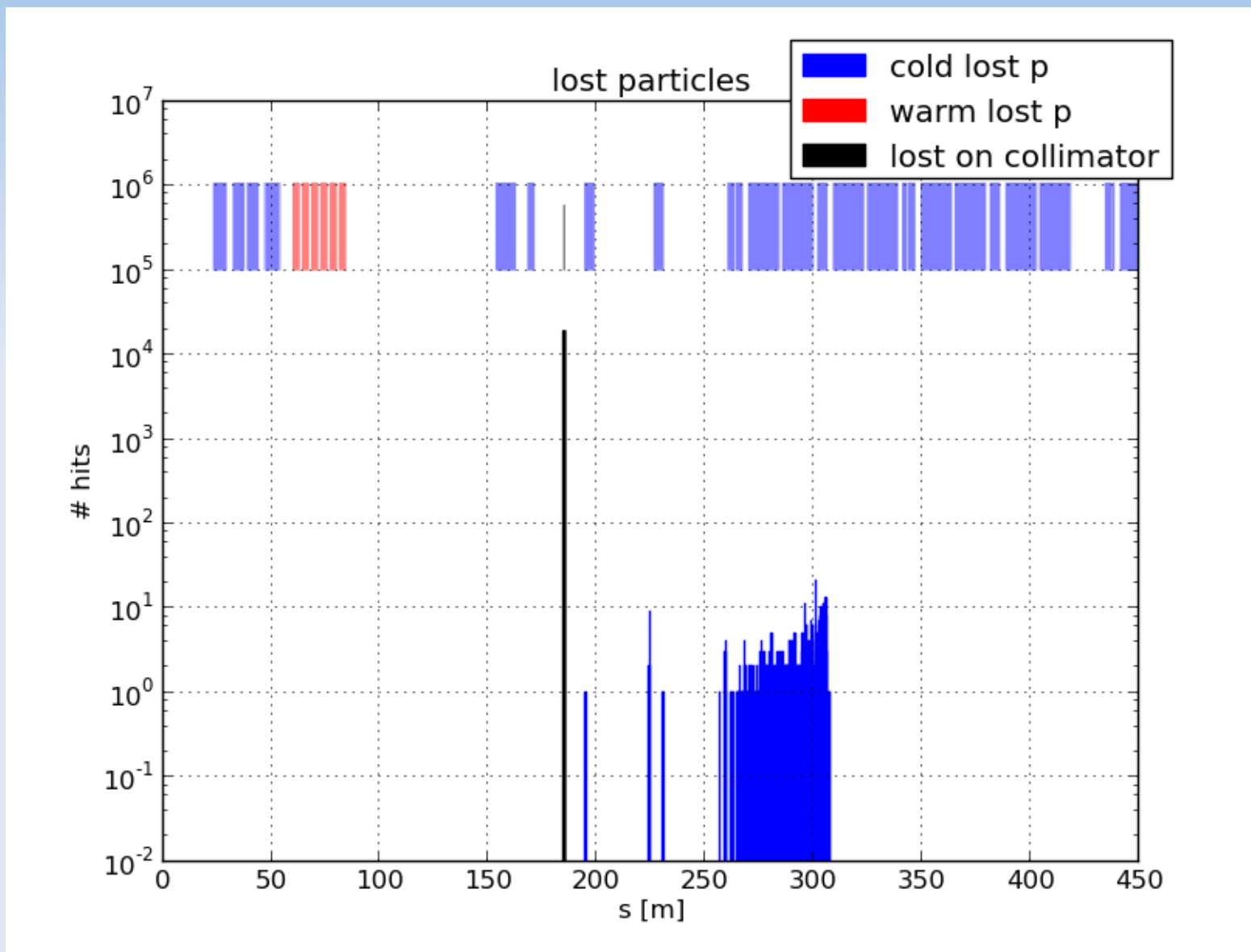


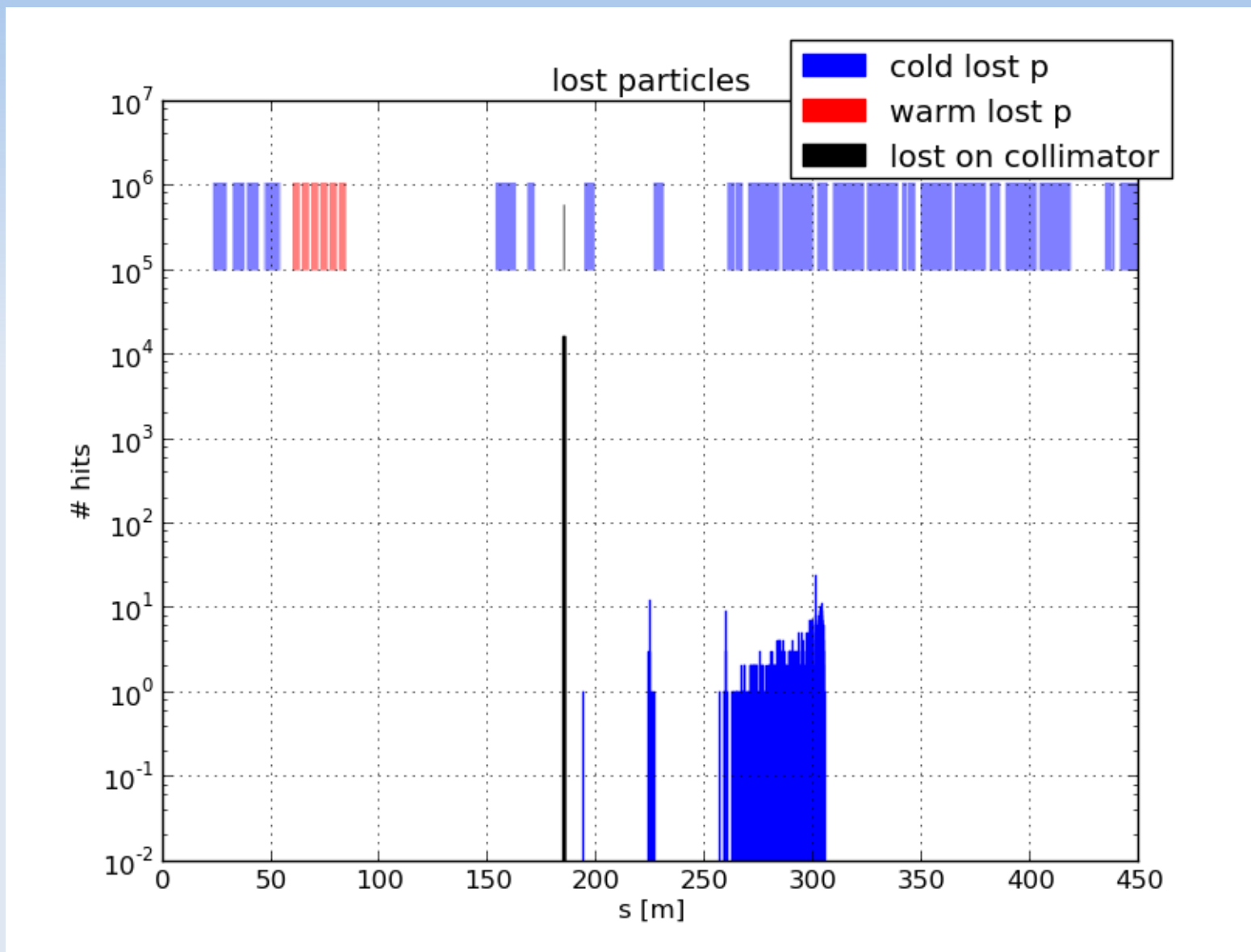
TCL scan 14σ

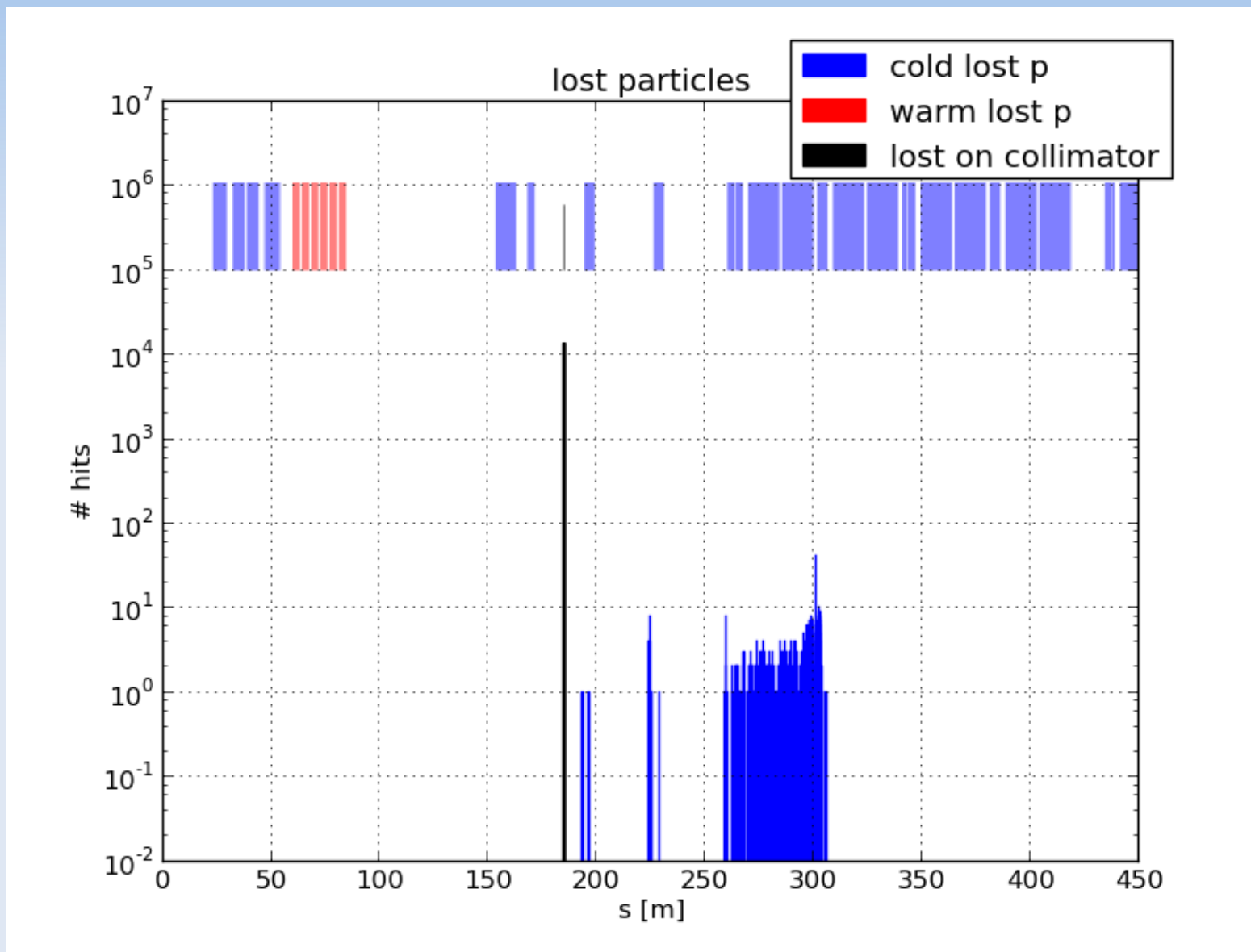


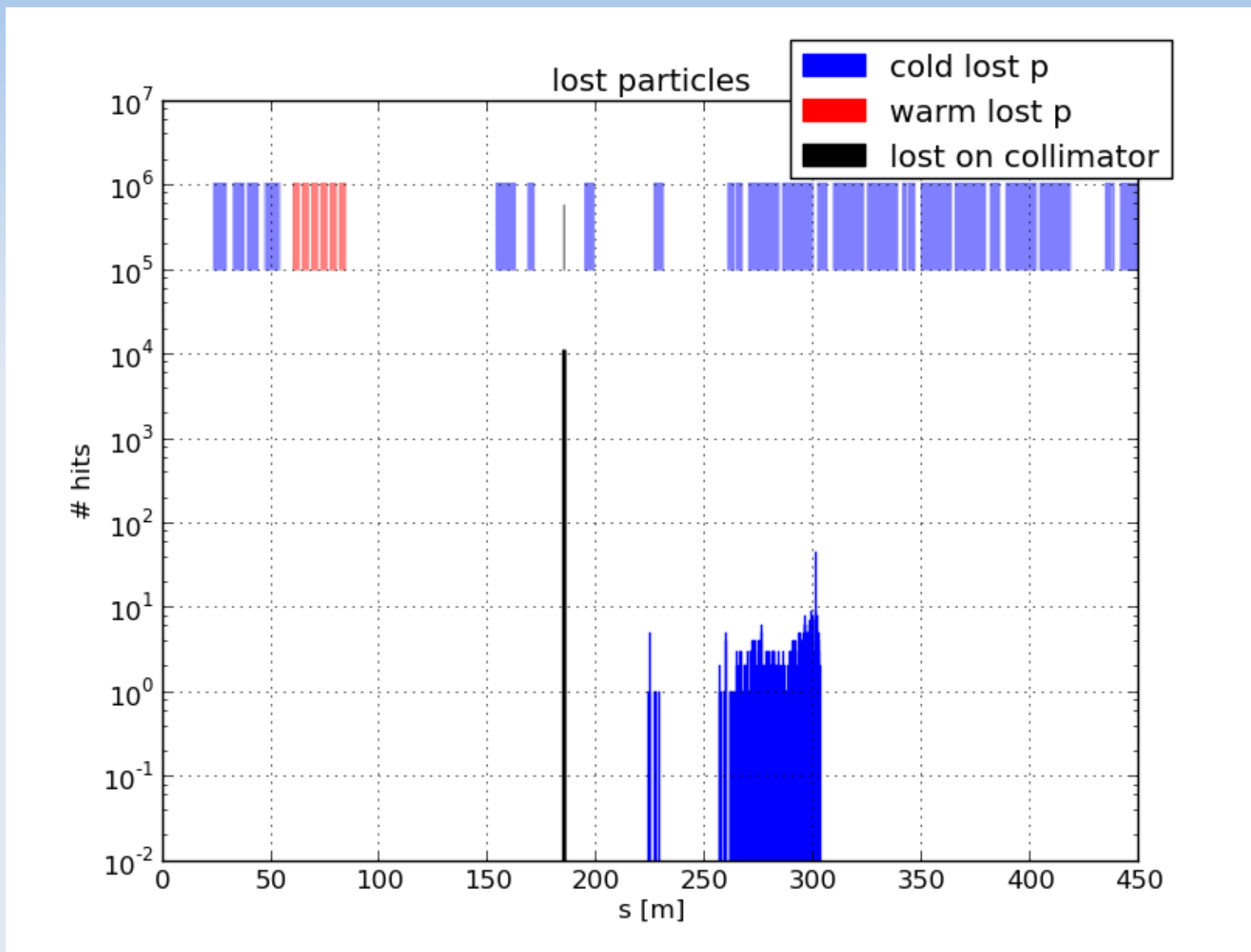


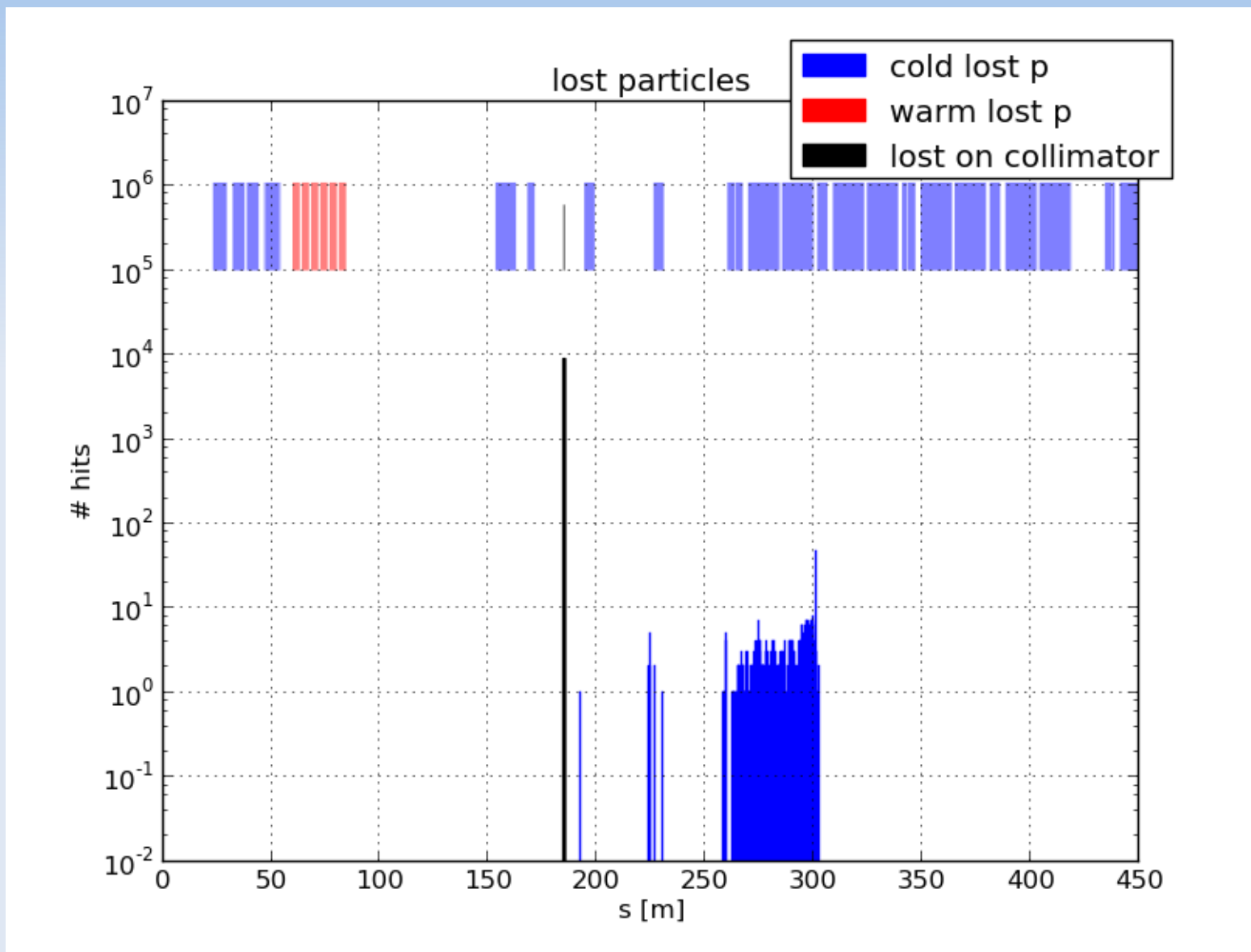


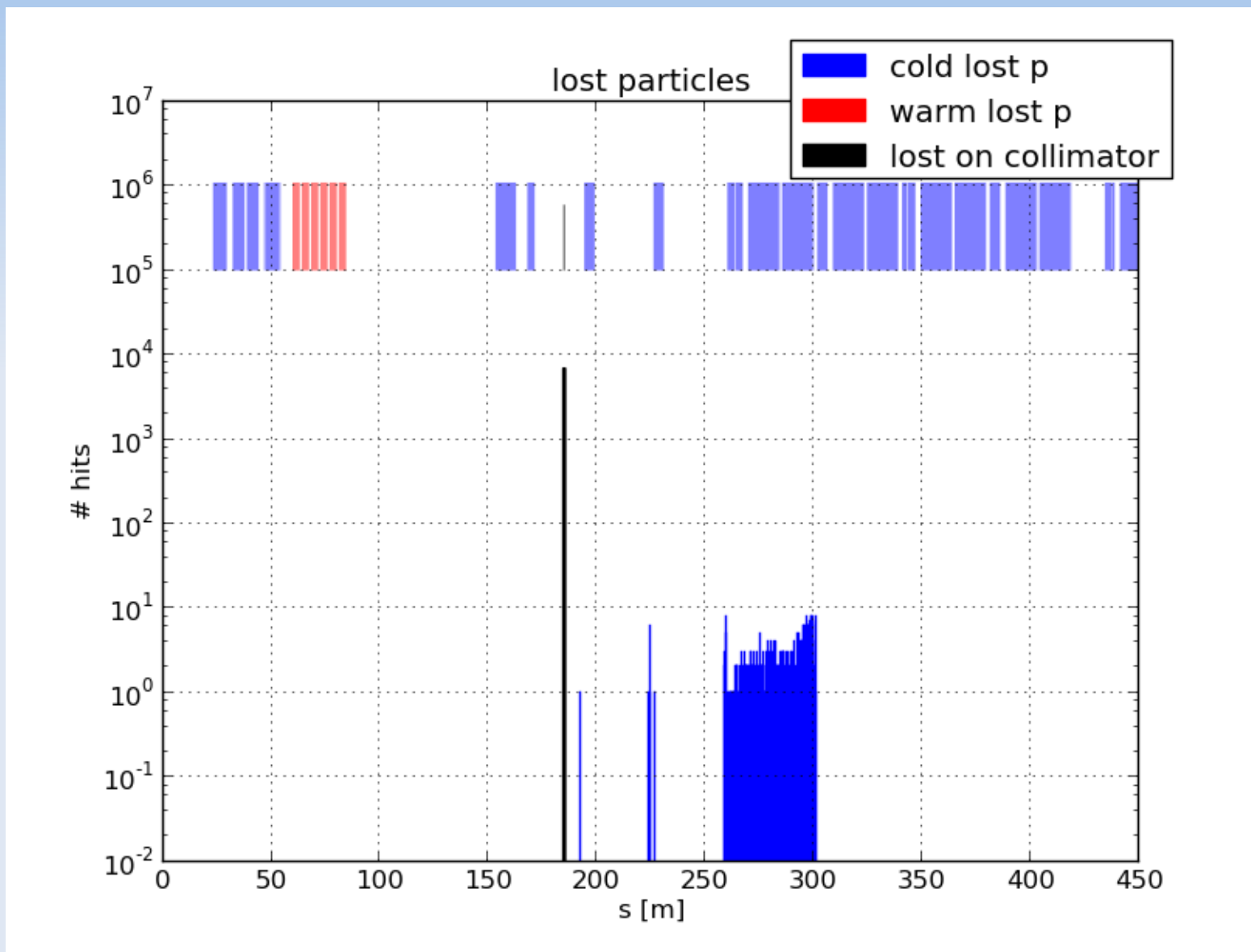






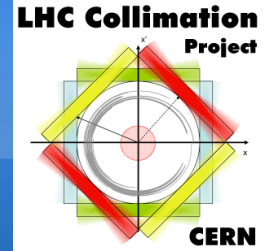








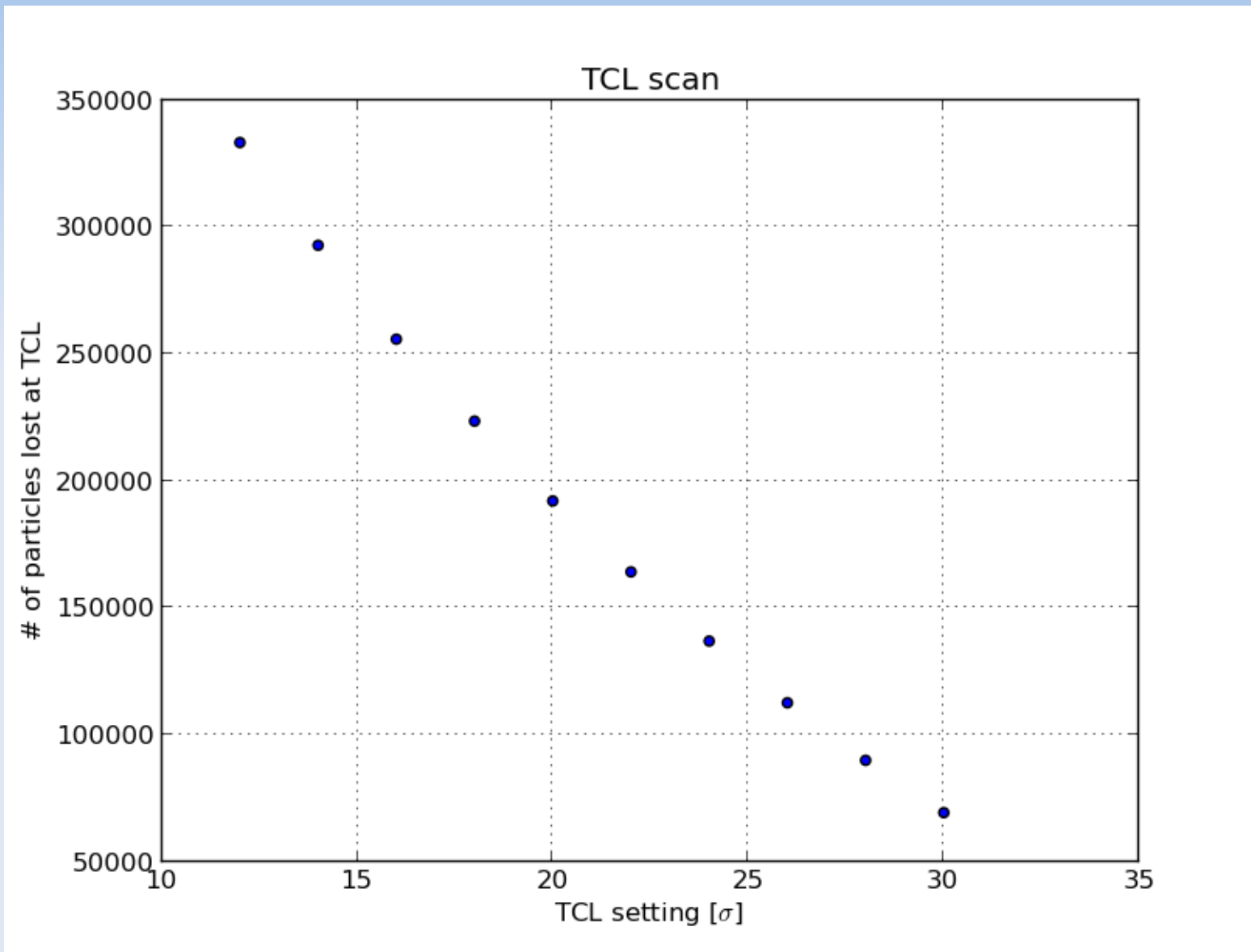
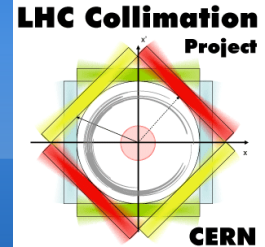
Observations



- The loss **at the TCL** decreases with the increase of the gap (next slide)
- The losses **downstream** the TCL get closer to the TCL with the increase of the gap
- The **highest loss downstream** the TCL seems to increase with the increase of gap
- However, the **sum of all losses** downstream (up to 450 m) is actually decreasing (next slide).

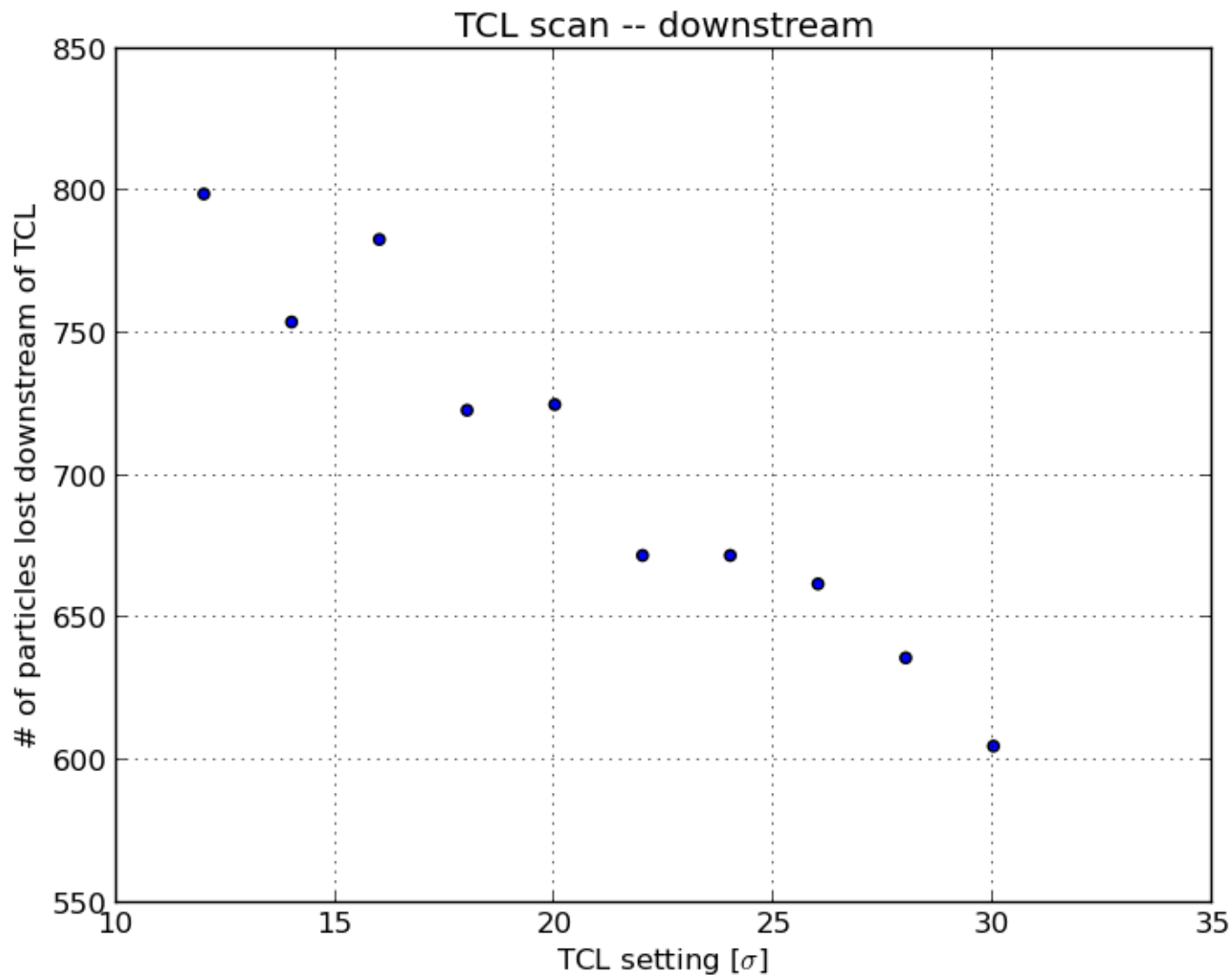
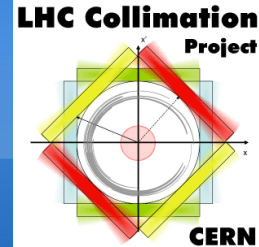


Losses at TCL vs. TCL setting



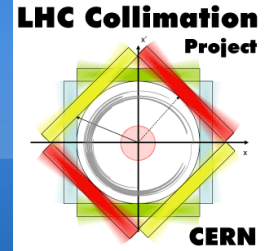


Sum of losses downstream TCL (up to 450 m) vs. TCL setting





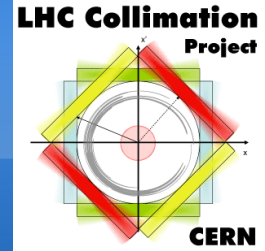
Normalisation factors



- $L_{\text{LHC}} \simeq 6000 \mu\text{b}^{-1} \cdot \text{s}^{-1} = 6 \times 10^{33} \text{ cm}^{-2} \cdot \text{s}^{-1}$
- $\sigma_{\text{p}} = 73.5 \text{ mb} = 73.5 \times 10^{-27} \text{ cm}^2 \text{ (TOTEM)}$
- $L_{\text{LHC}} \times \sigma_{\text{p}} = 4.41 \times 10^7 \text{ collisions/s}$
- Simulations for 10^7 collisions; bin width = 10 cm
⇒ normalisation factor of 44.1 for losses in p/m/s



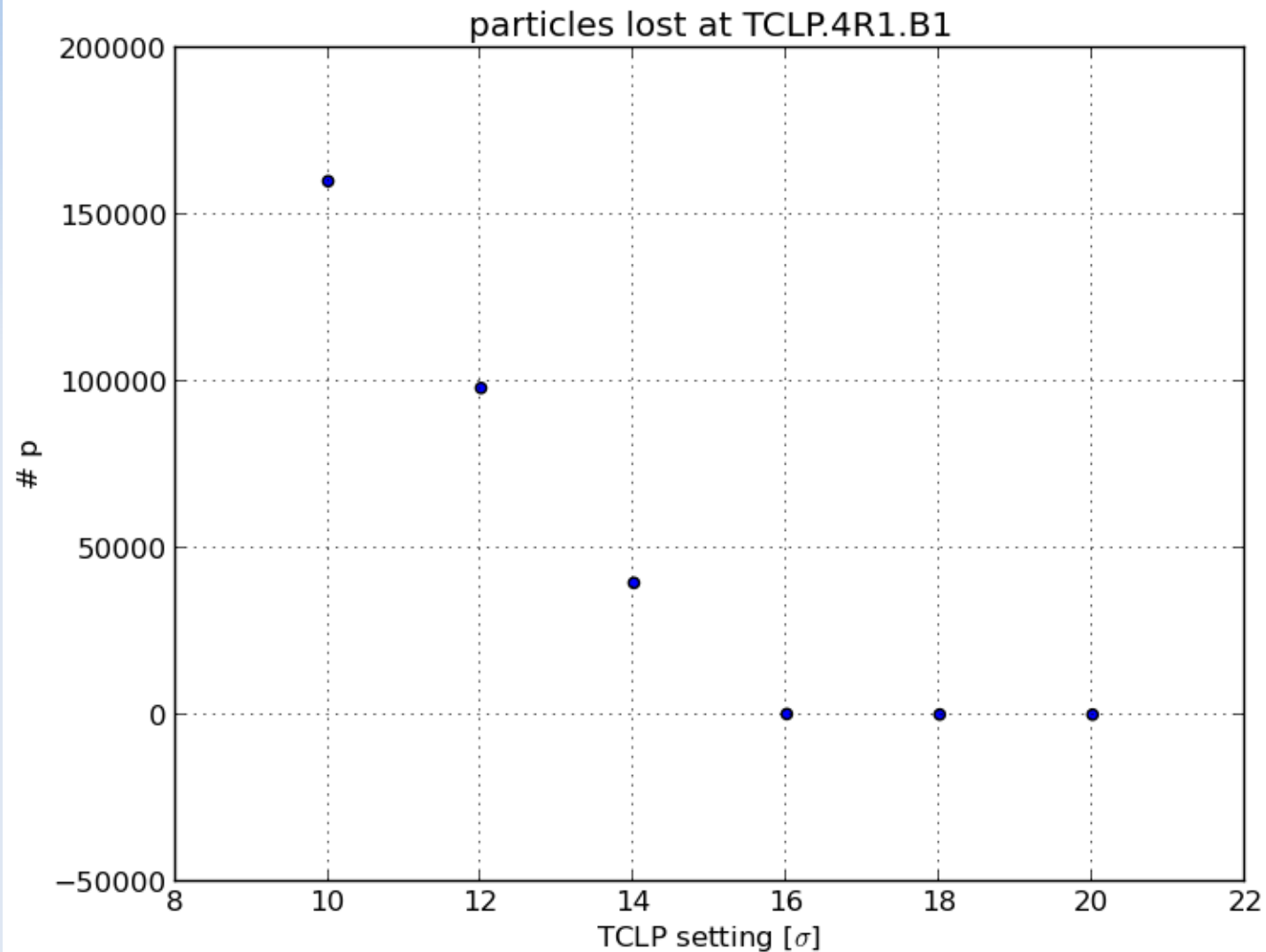
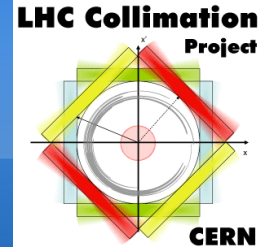
TCLP scans



- Goal: see if the protection of the DS can be achieved by the TCLP.4R1.B1 (instead of TCL)
- `/!\` different optics sequence: V6.5.seq
- Same procedure: 10 σ to 30 σ , with 2 σ steps
- `/!\` The TCL was closed in this case (somehow defeating the point)
- [Movie](#)

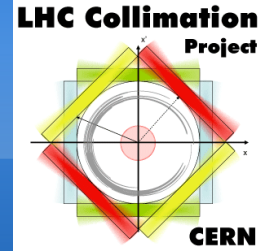


Losses at TCLP vs. setting

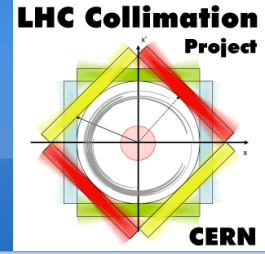




Conclusions

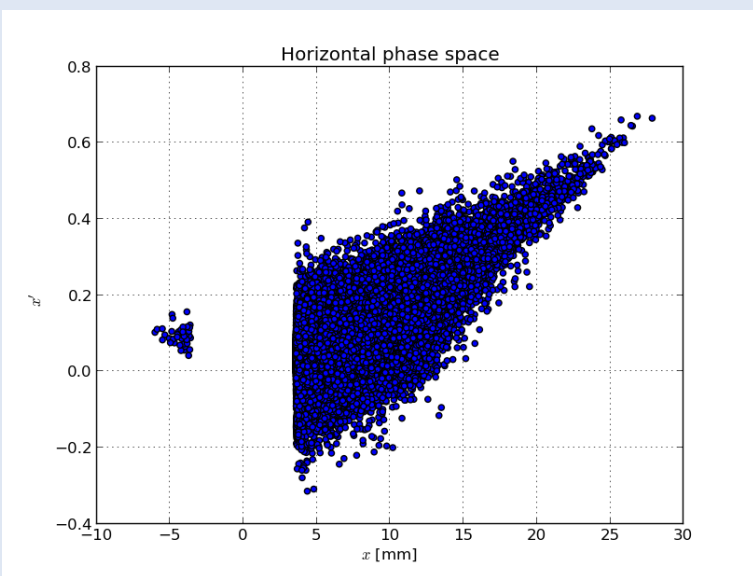
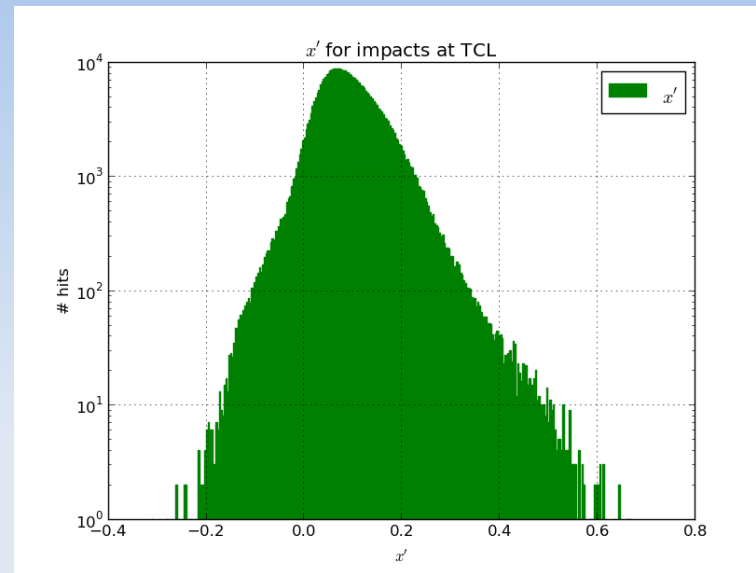
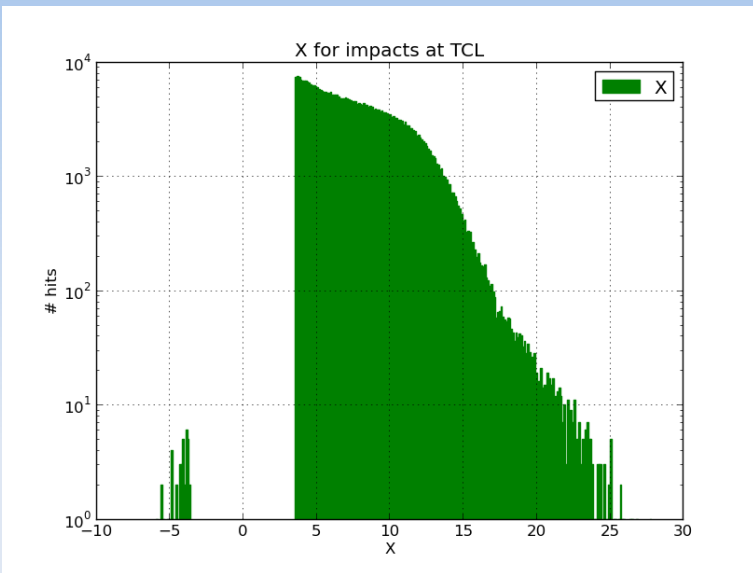


- Whole debris tracking simulation chain is set-up.
- We managed to reproduce some observations;
- But some points are still not understood.
- New input distributions will be provided.
- B2 simulations seem OK as well.
- Further work:
 - Plot loss maps in physical units? [p/m/s]
 - Start simulations at other IPs

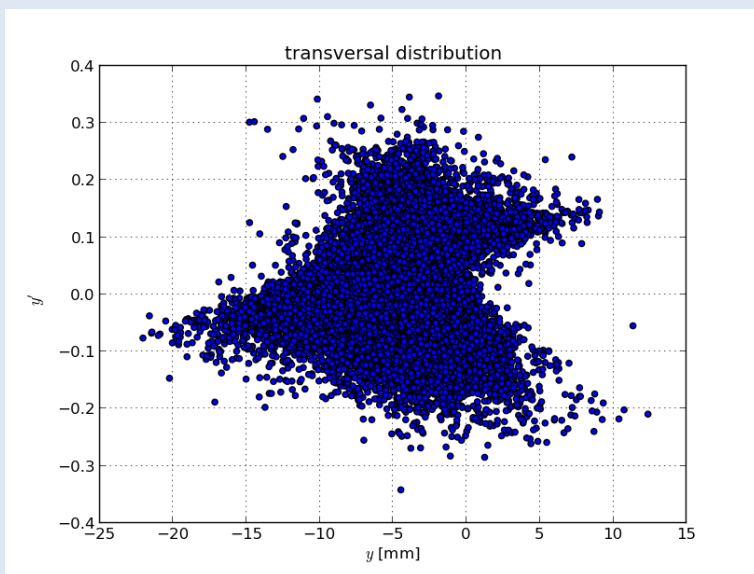
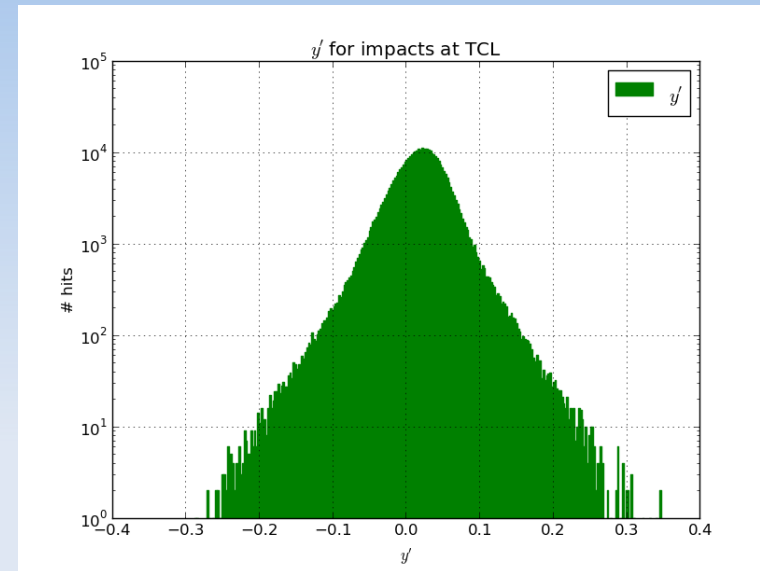
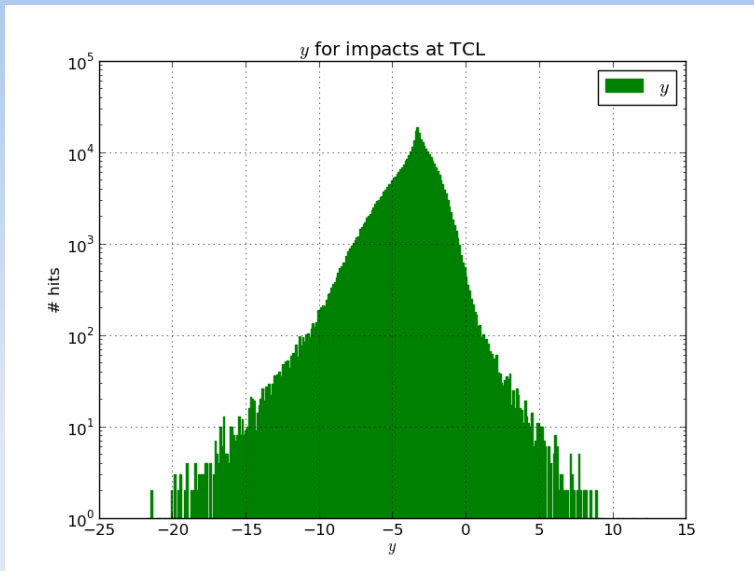


Spare slides

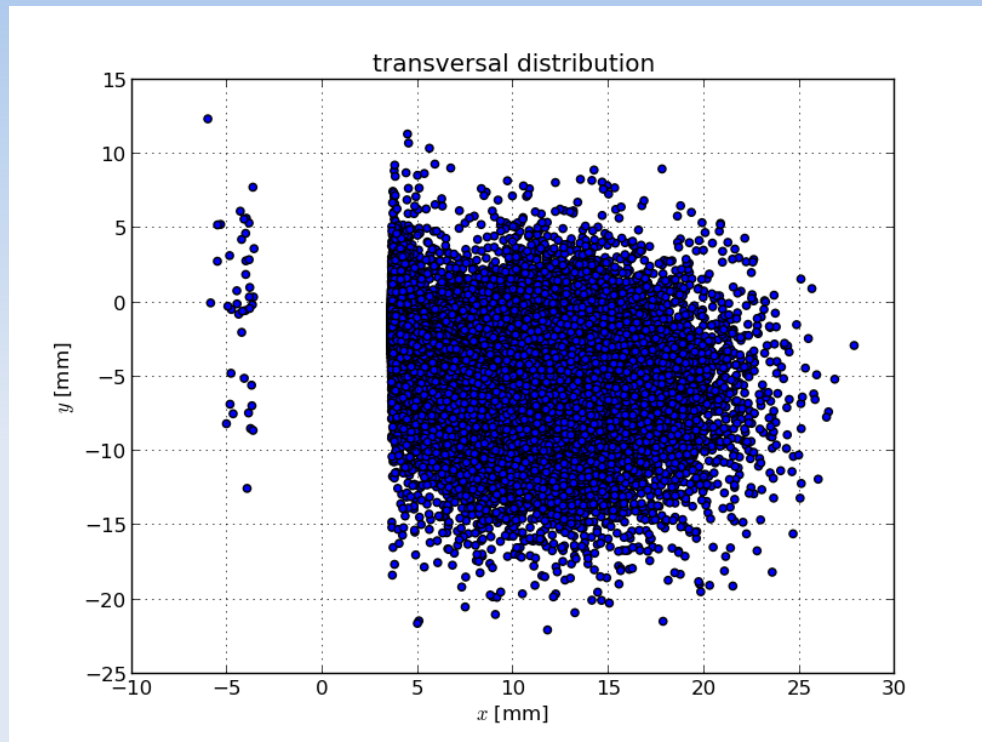
Particles lost on TCL: horizontal phase space



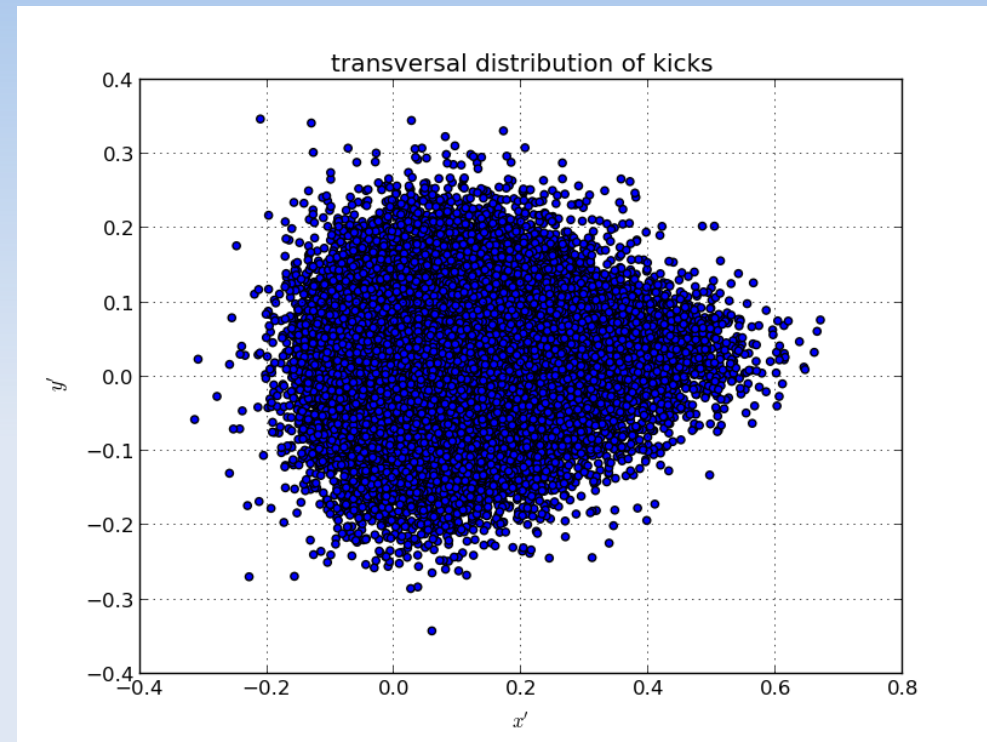
- $\sigma_x = 359 \mu\text{m}$
- TCL setting: 10σ
- Most losses for $x > 0$



- $\sigma_y = 82.8 \mu\text{m}$
- Usual asymmetric y distribution



Physical space



kicks

- Seems to be made of two separated distributions
- Not centered around $(0, 0)$



Losses downstream of TCLP vs. TCLP setting

