Studies of Machine protection for a Crab Cavity in the LHC

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Scheme

- Introduction
- Results
- Summary

CC

A device called “crab cavity” (CC) applies a tiny sideways kick to each particle bunch, in order to changed its dynamics to achieve a head-on collision at the IP. For the HL-LHC the luminosity will increase by factor of 5 (with respect to the nominal).

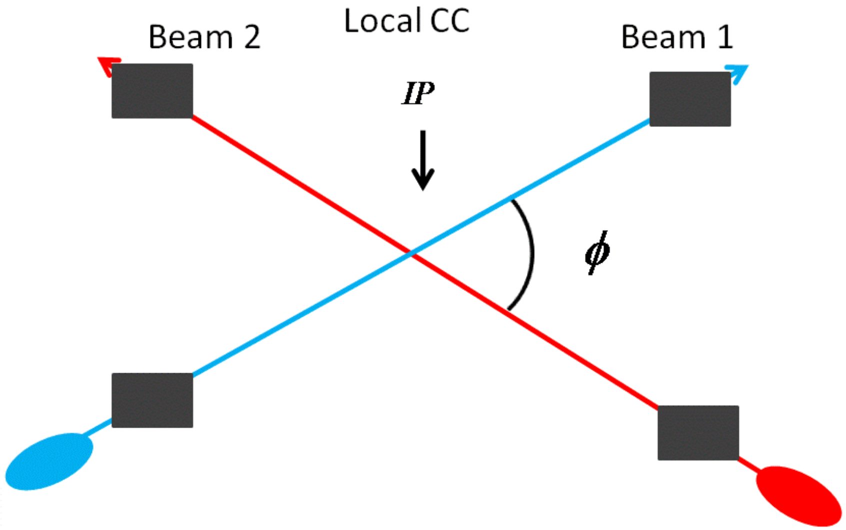


Figure 1: The CC´s effect in the beam at collision point in the LCC scheme.

Layout of the CC

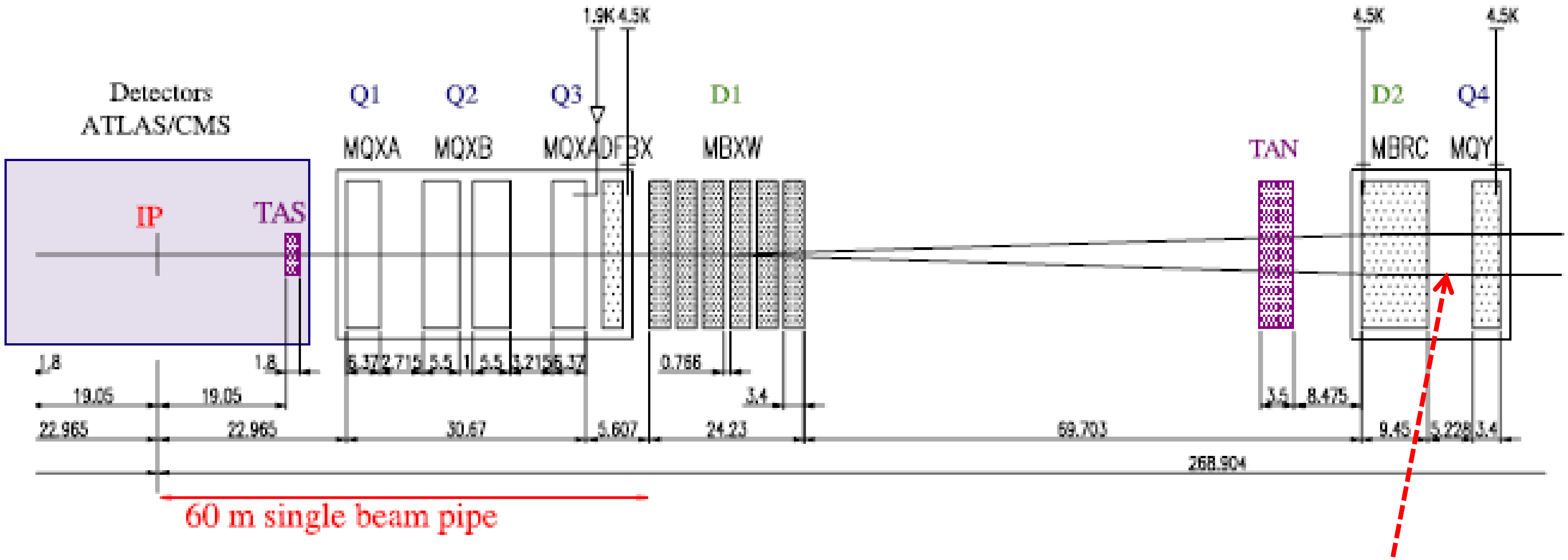
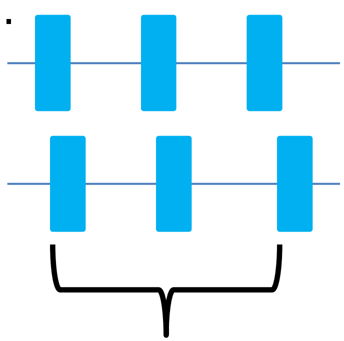


Figure 2 : The scheme layout at right part of the IP for the LHC .



CC s

Transverse distribution

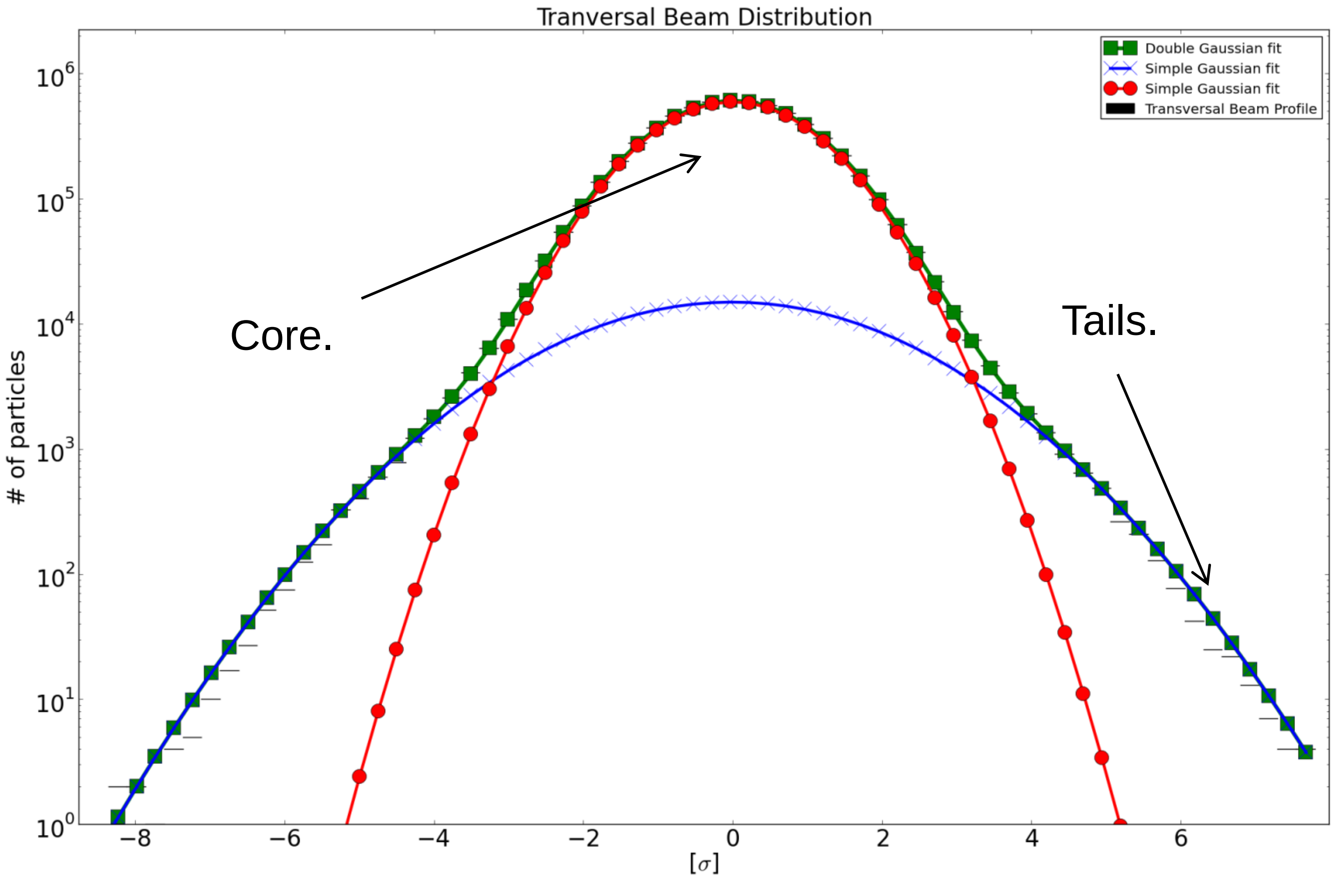


Figure 3: The Transverse beam profile obtained by using the CMS measurements. The sigma of the tails is 1.9 times than the core .

CC operation

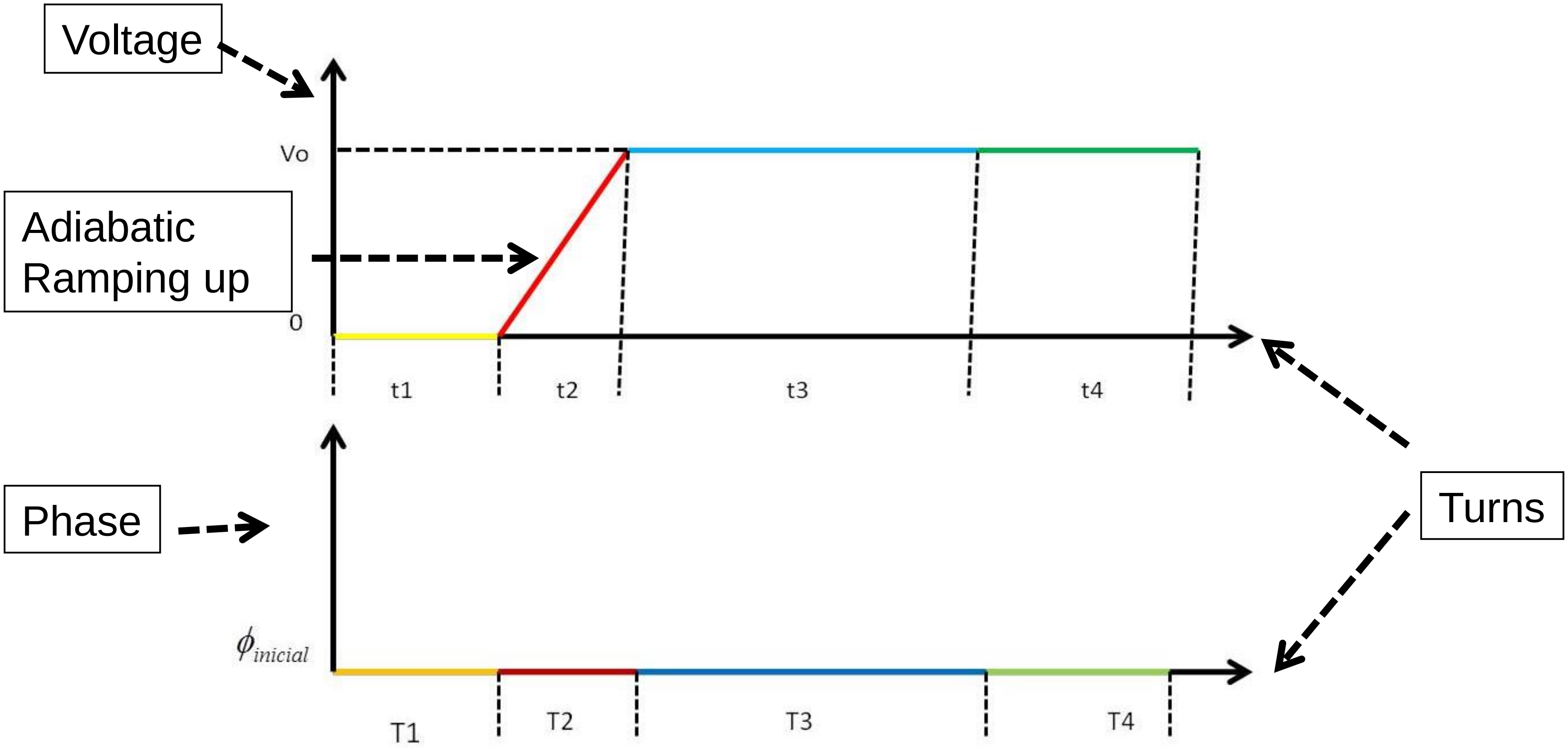
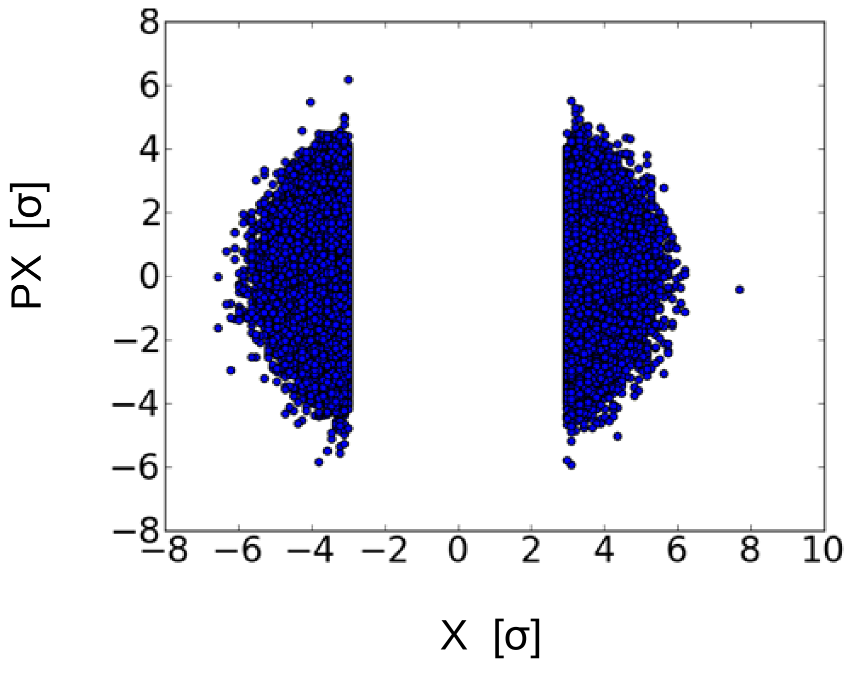


Figure 4: In the Normal operation (NO) represent the ideal performance of the CC.

Transverse phase space



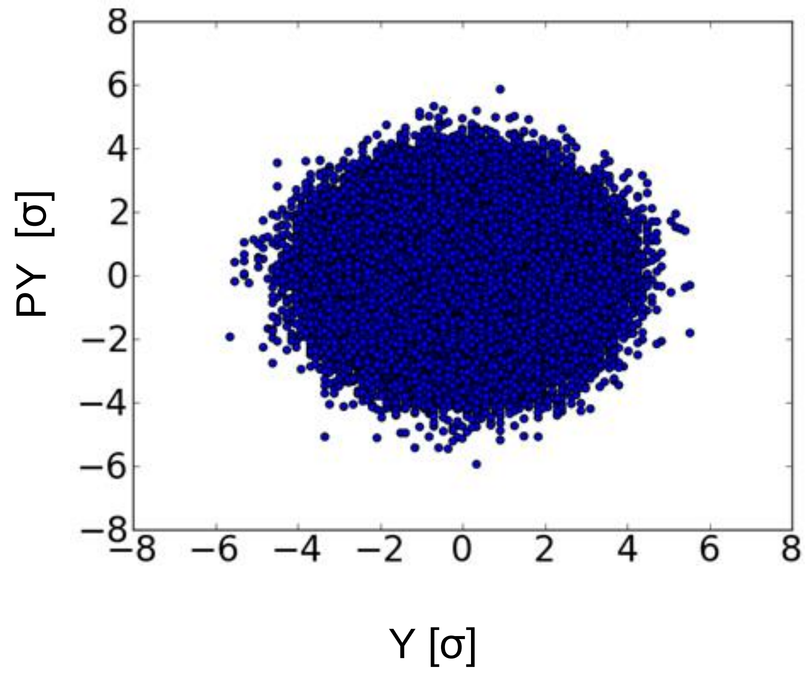


Figure 5: The phase space in X (left) with a cut at 3 σ and Y (right) without cut.

Absorbed particles on Collimators

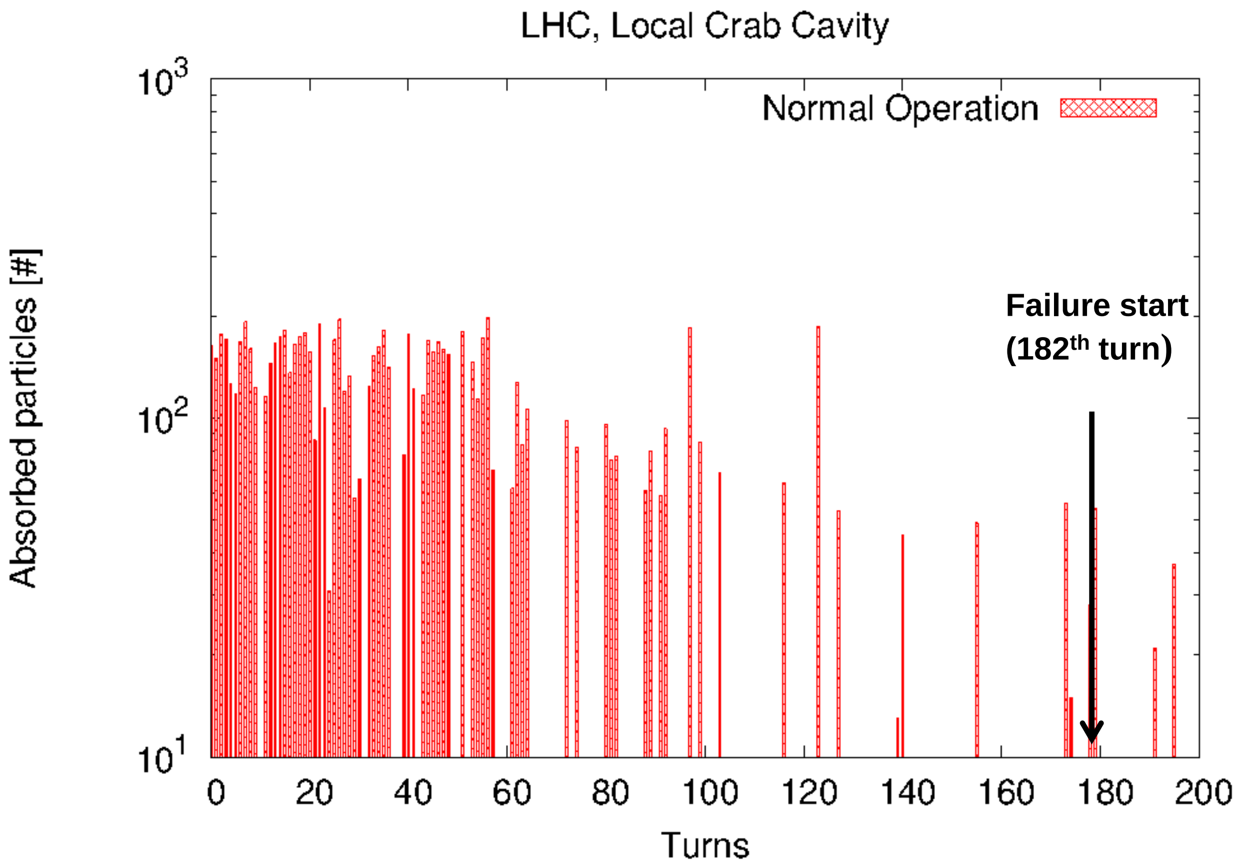


Figure 6. The numbers of particles absorbed on collimators when the CCs work in the normal operation case. Most of the particles are absorbed on TCP.C6L7.B1.

Absorbed particles

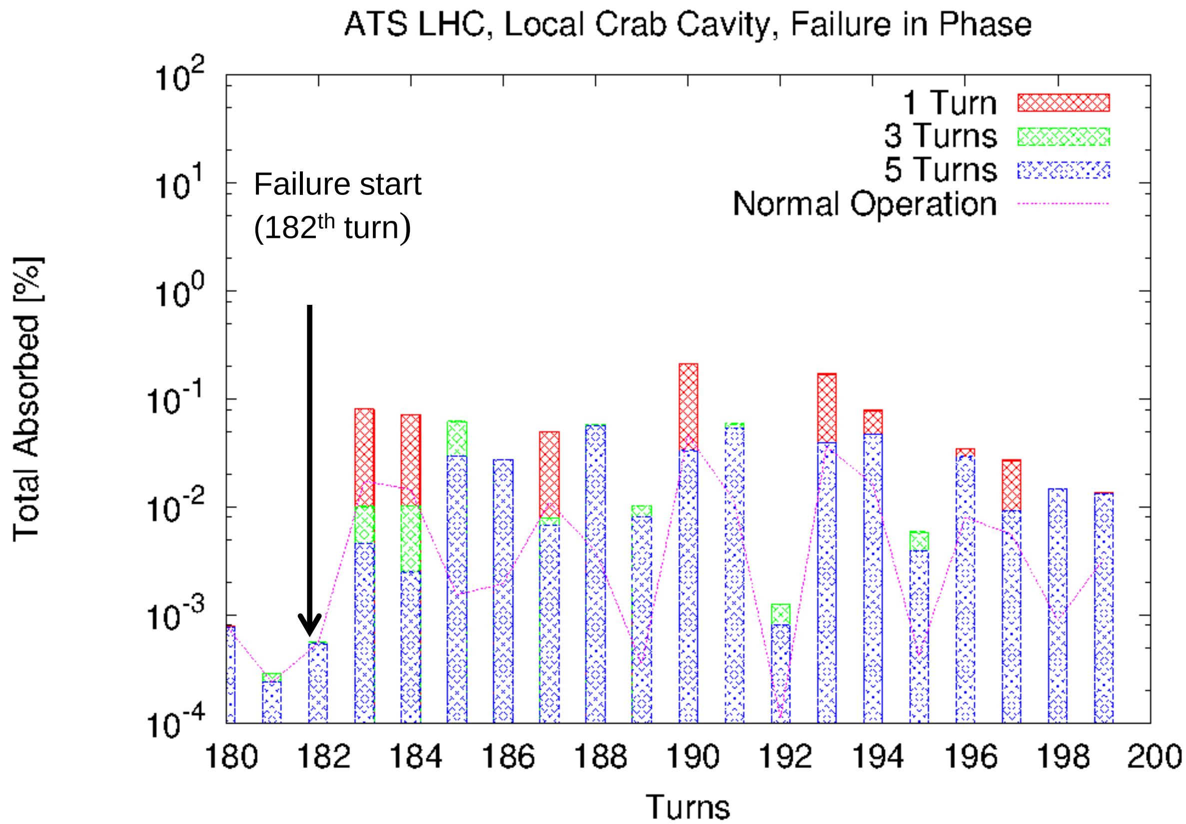


Figure 7. The Percentage of particle lost in the aperture for the failures case of phase. The numbers of particles more than 6x 10^6 .

Lost particles

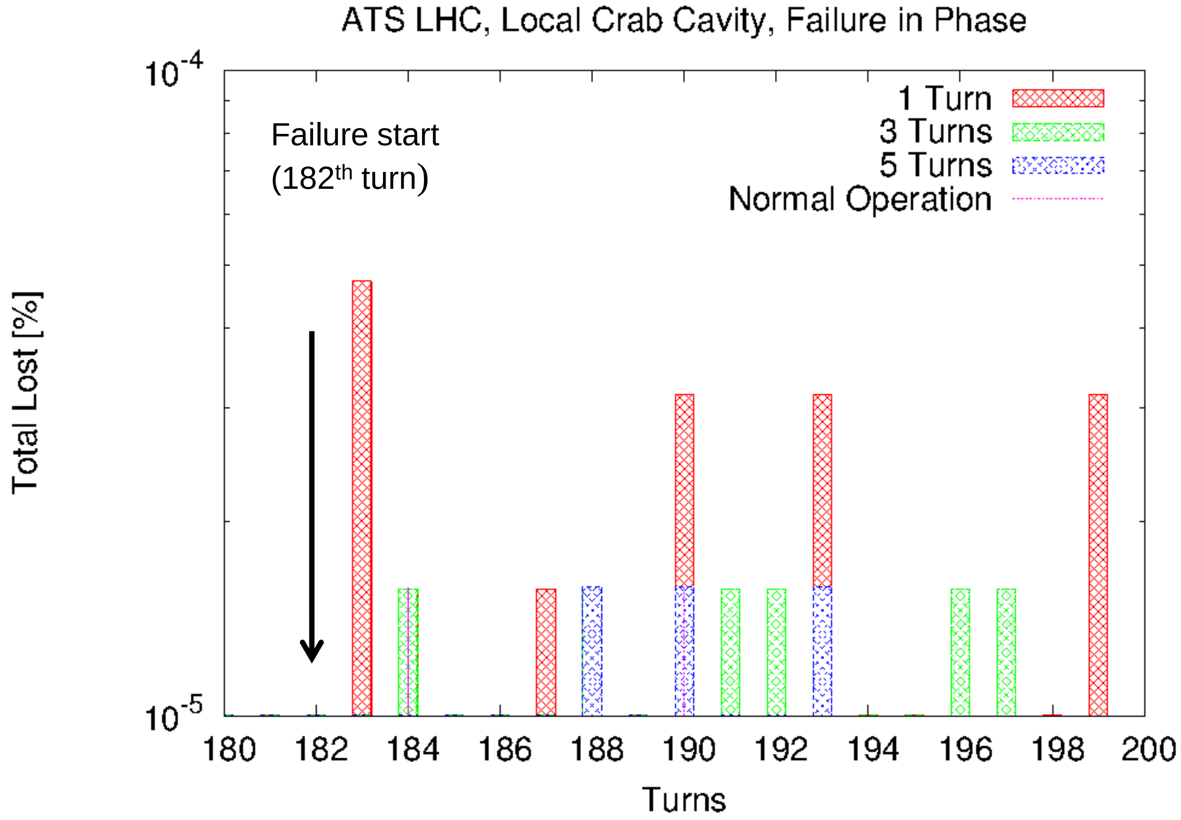


Figure 8. The Percentage of particle lost in the aperture for the failures case of phase. The numbers of particles more than 6x 10^6 .

LLM

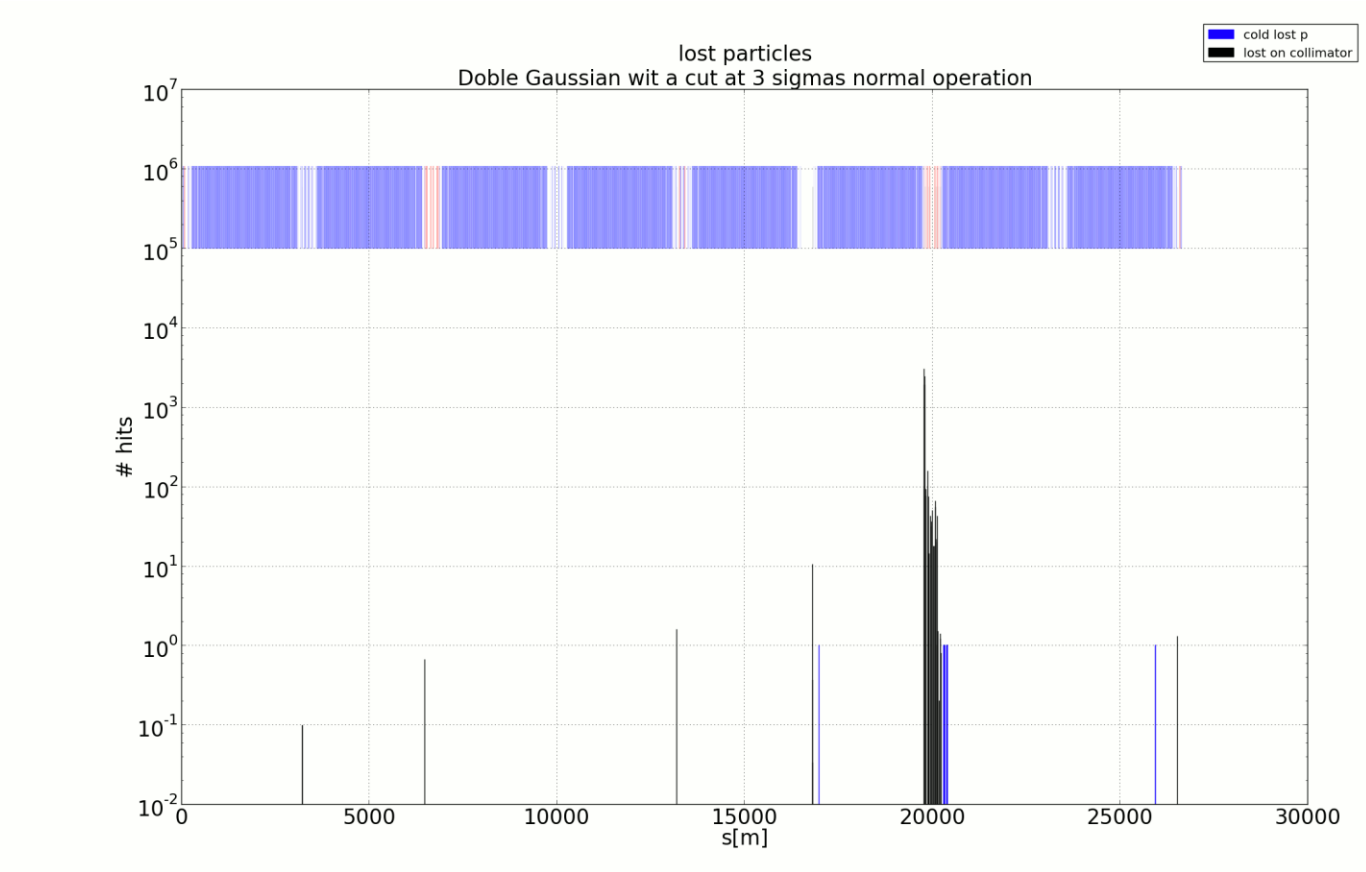


Figure 9 The Local loss Map, obtained by tracking the double Gaussian beam distribution beyond of 3 sigma cut in the Normal operation and failure in phase in one turn.

Tracking results

Table 1: The Summary of the beam lost for the studies using a double Gaussian . The initial FP Failure in phase for the last 18 turns.

CASE	Absorbed particles		Lost particles	
	[%]*	Energy (kJ)**	[%]	Energy (J)**
Normal Operation	0.17	9.14	$3.18X10^{-5}$	1.25
PF in 1 turn	0.81	41.93	$18.87X10^{-5}$	7.47
PF in 3 turns	0.40	20.87	$11.00X10^{-5}$	4.36
PF in 5 turns	0.37	19.45	$4.75X10^{-5}$	1.88

*Percentage with respect the total survival particles (around the 99.35% remains) before start the failure .
**Assuming the total store energy at 7 TeV is 692.84MJ, thus, the fraction of the equivalent deposited energy is 5.12MJ=(0.0074)692.84 MJ, .

Summary

- The percentage of absorbed particles and lost particles after the failures are 0.65 and 1.7×10^{-4} for the distribution beyond 3 σ.

- The phase failure in one turn represents the most dangerous cases, i.e. the FP1 case.

- The different in the amount of losses produced for the failures in 3 and 5 turns are similar.

Backup

Initial distribution

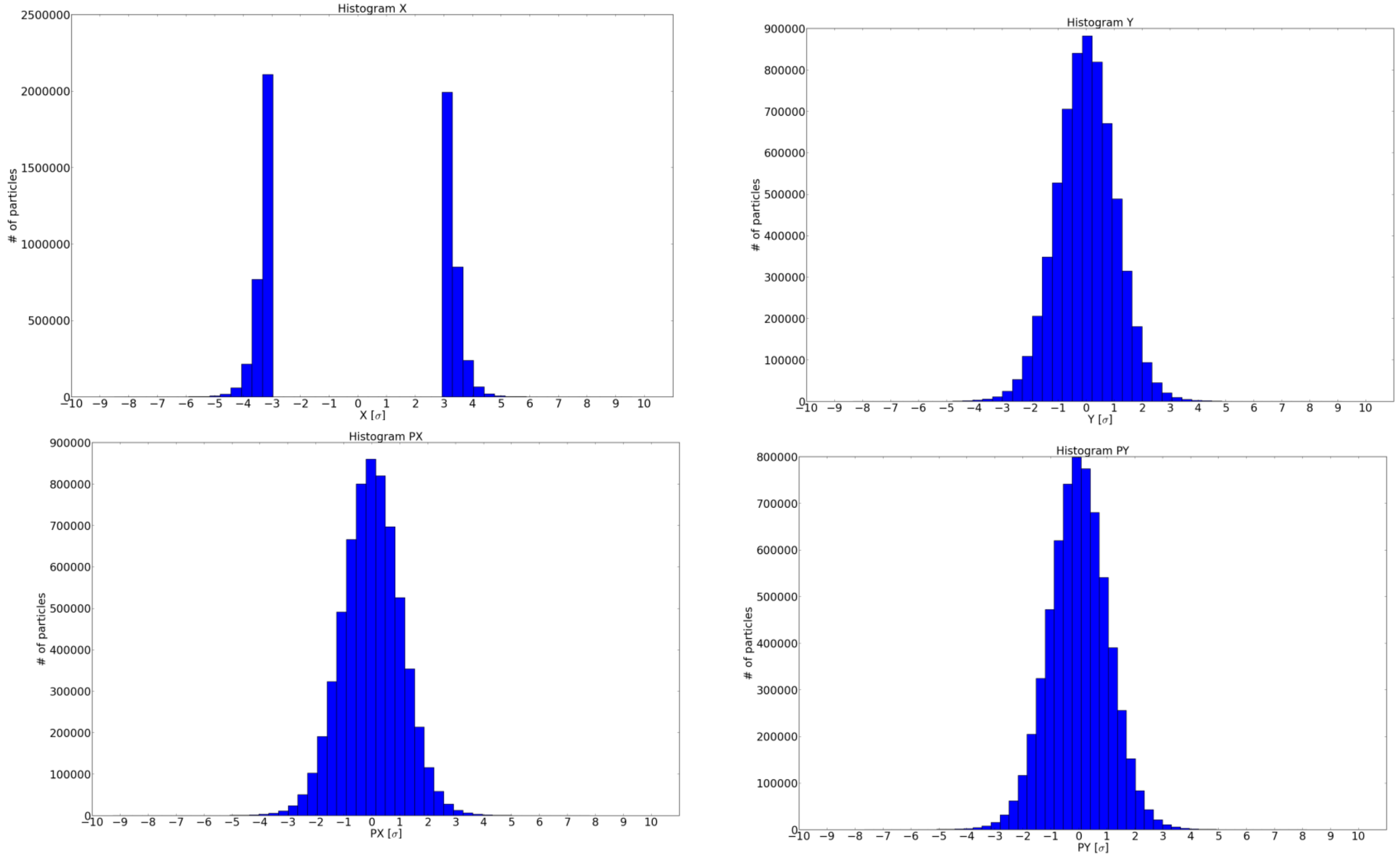
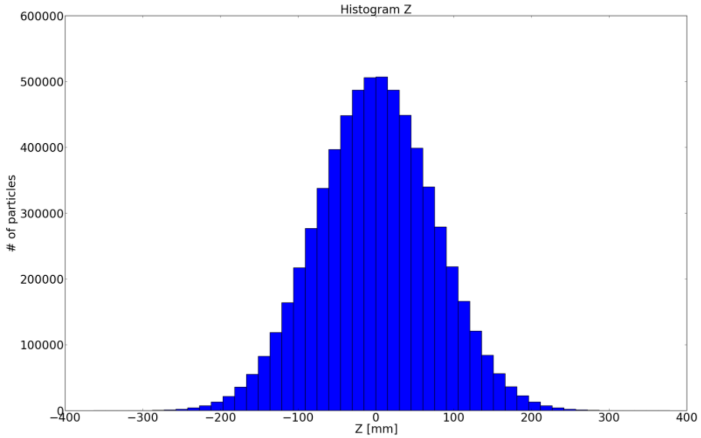


Figure 10. The transverse beam distribution used for these simulations .The numbers of particles more than 6 x 10^6 .

Initial distribution



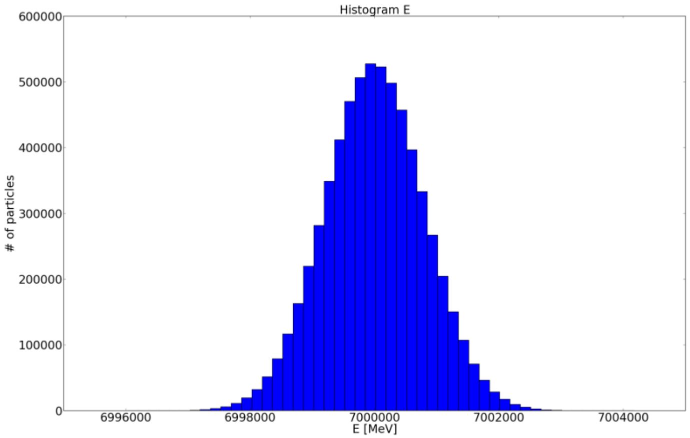


Figure 11. The longitudinal beam distribution used for these simulations .The numbers of particles more than 6×10^6 .

Percentage of the population

Table 2 : The percentage of particles of the double Gaussian distribution beyond the numbers of σ.

Cut (σ)	Percentage of the population [%]
1	33.04
2	5.66
3	0.74
4	0.13
5	0.02