Machine Protection Simulations II

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Outline

1. Introduction
2. Simulations Results
3. Conclusions
4. Future work

Introduction

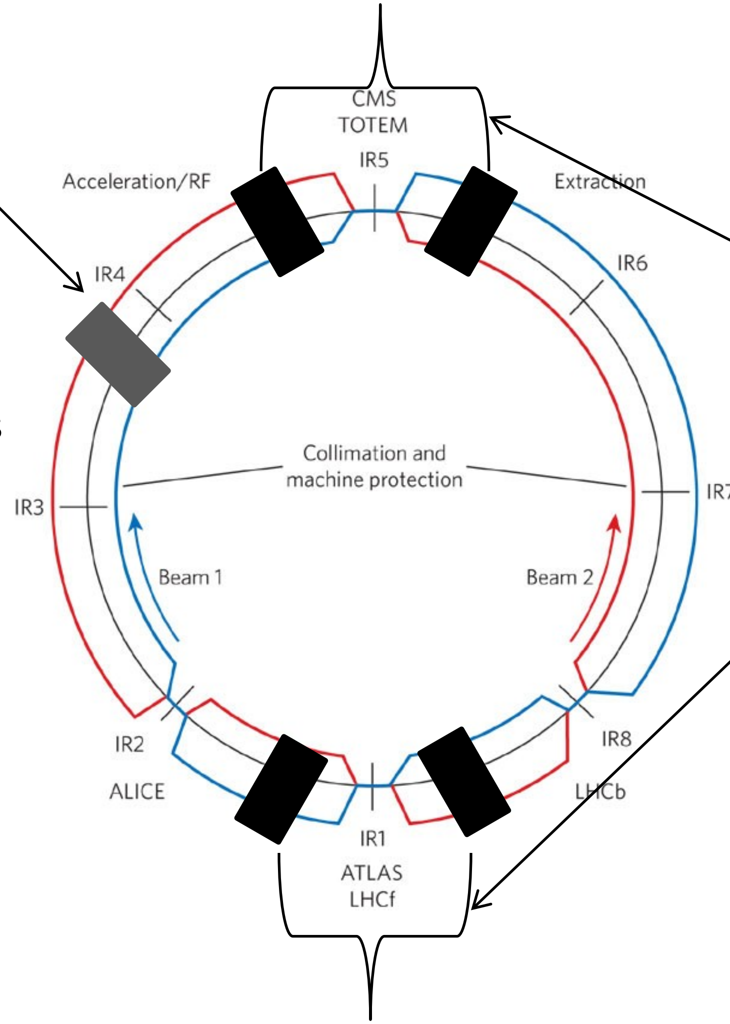
Implementation of Crab Cavities (CC's) in the LHC requires a deep study of Machine Protection [1,2].

Since the energy stored in the LHC beams at 7 TeV is large (350 MJ) fast and safe beam extraction systems are necessary.

Since the CC changes the trajectory of beam particles, an abrupt failure of the CC can produce unwanted beam loss.

Crab Cavity scheme in the Nominal LHC

The Global Crab Cavity Scheme for the CMS (IR5)



The Local Crab Cavity scheme for CMS (IR5) and ATLAS (IR1)

Table 1. LHC Nominal Parameters

Parameter	Unit	Nominal
Energy	[TeV]	3.5-7
Protons per Bunch	[10^{11}]	1.15
$\varepsilon_n(x,y)$	[μm]	3.75
σ_z(rms)	[cm]	7.55
$IP_{1,5}$ β^*	[m]	0.55-1.5
Crossing angle	[μrad]	300

Crab Cavity Fast Failures

We can classify the CC Failures in two [1,2] :

-Fast Failures

Cavity quench or RF breakdown
Sudden discharge in the cavity or couplers
Fast orbit change due to external sources

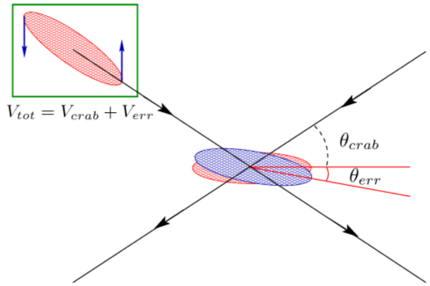
-Slow Failures

Vacuum degradation
IR cavity to cavity voltage and phase drifts

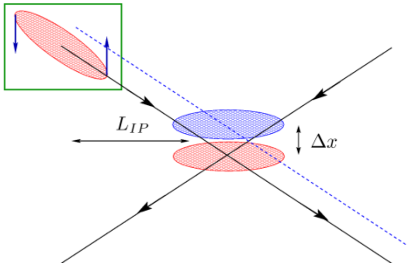
Crab Cavity Failures

The types of CC failures so far simulated are :

- Voltage Change

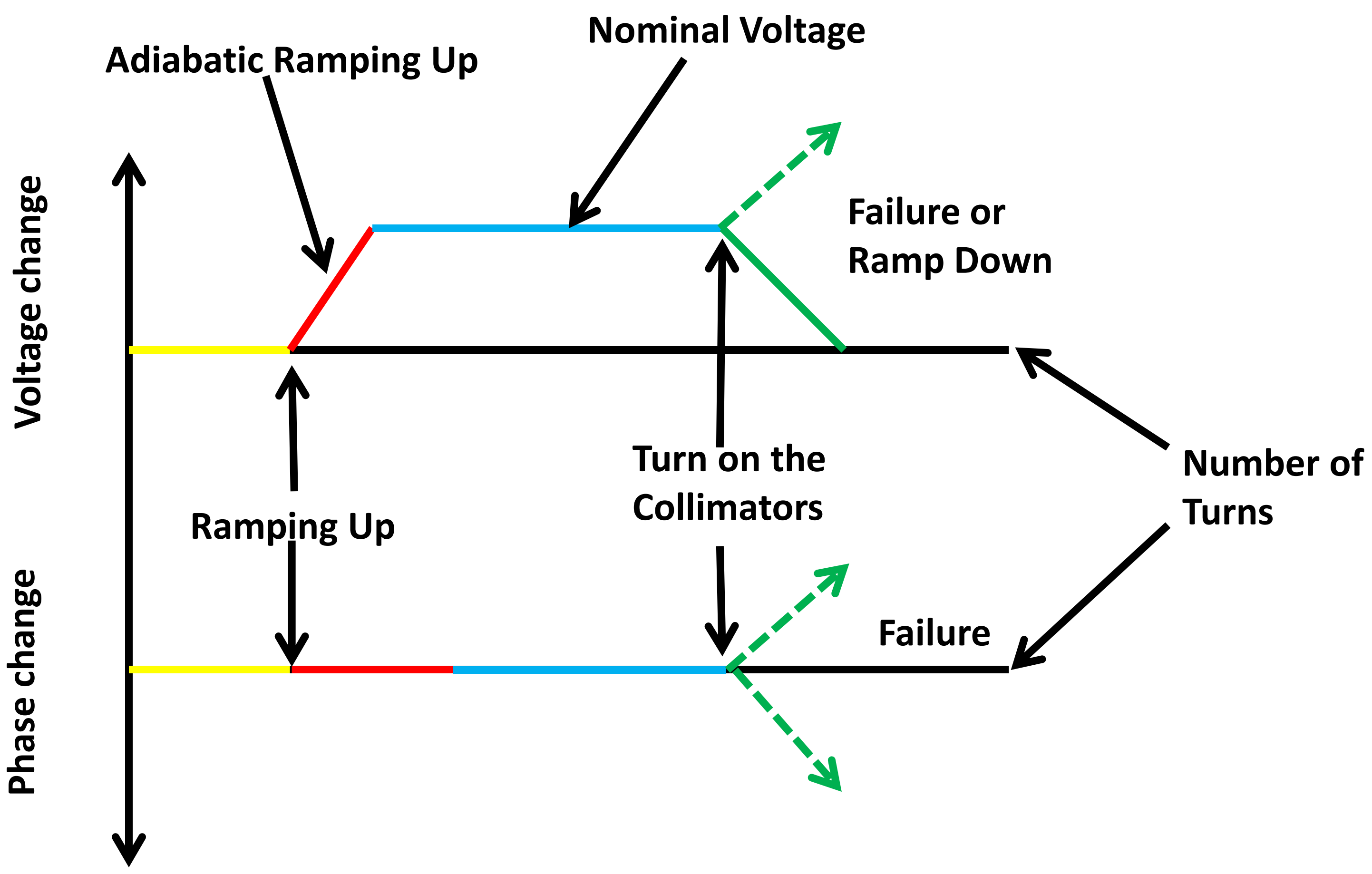


-Phase Change



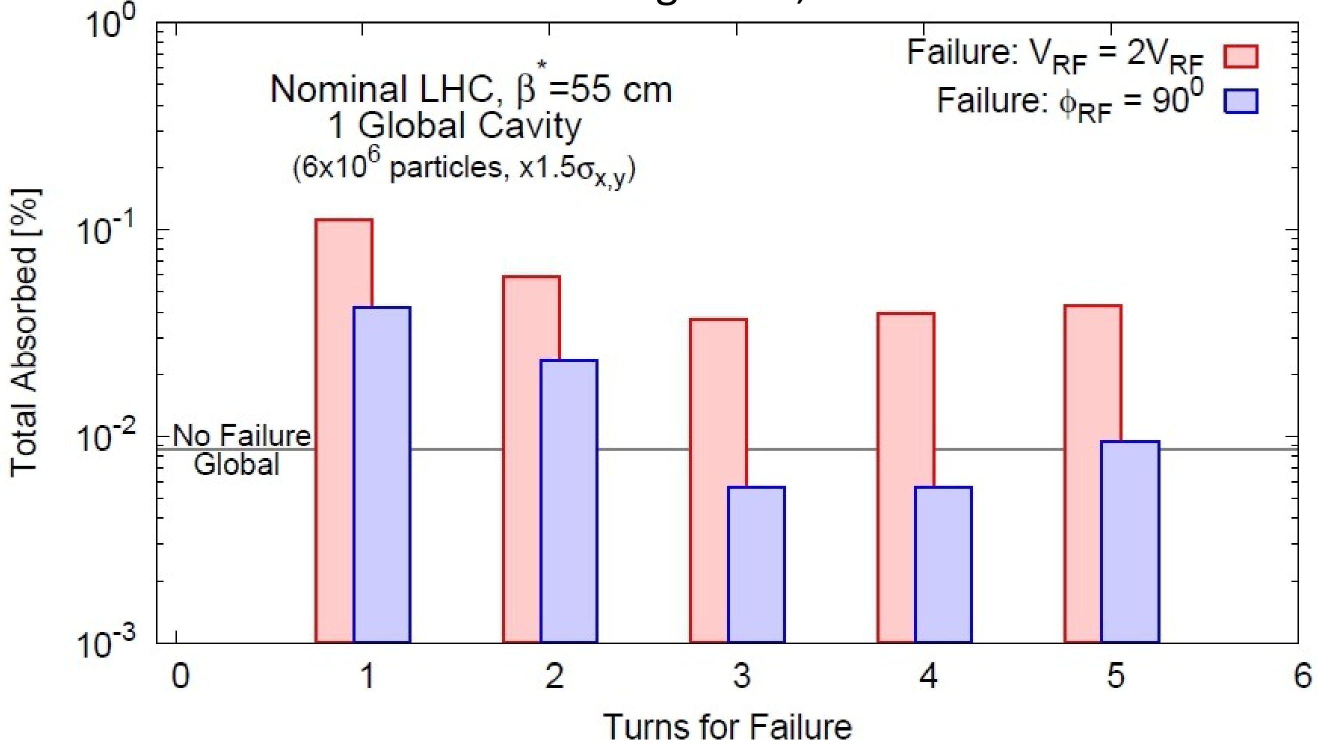
Courtesy, R. Calaga

Simulation set up for changing Crab Cavity voltage and phase



Particles absorbed in the Global scheme

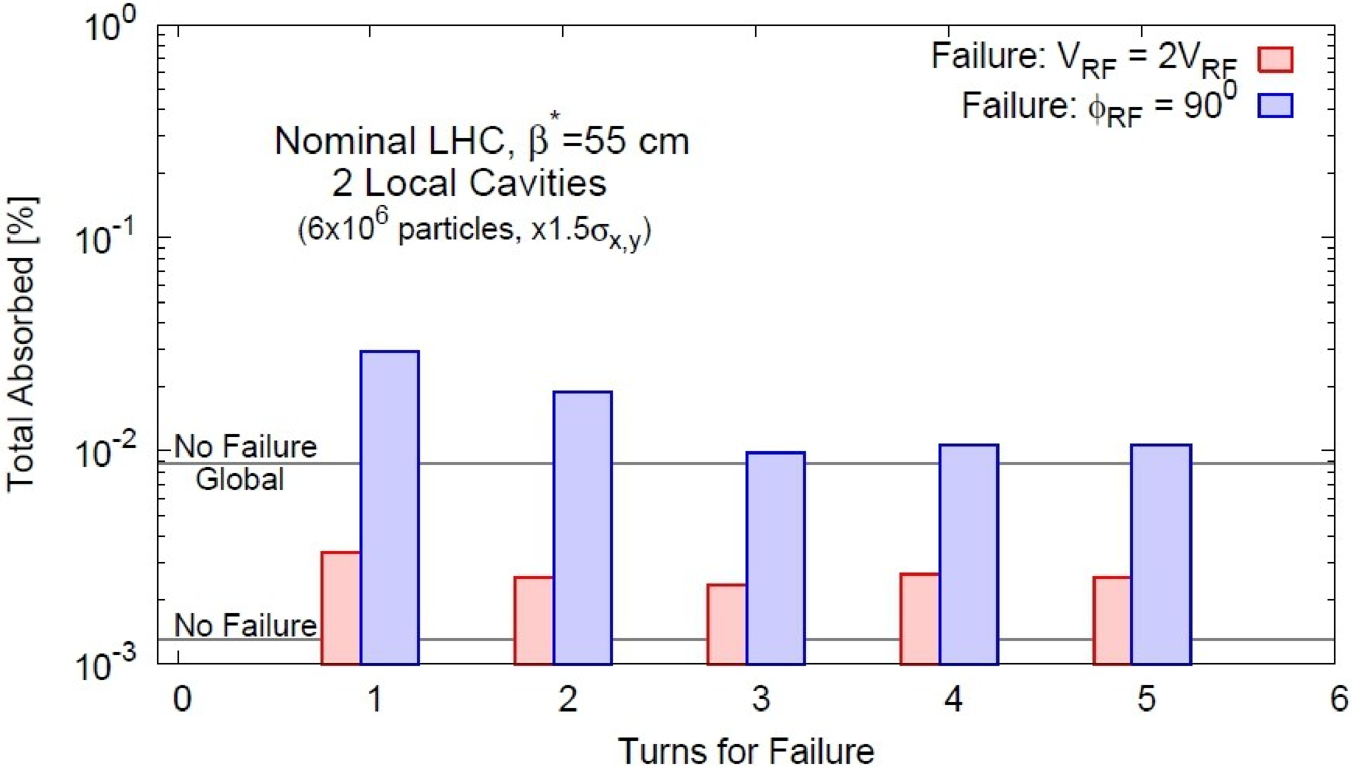
R. Calaga et al, PAC11.



The total number of particles absorbed in the Global Scheme.

Particles absorbed in the Local scheme

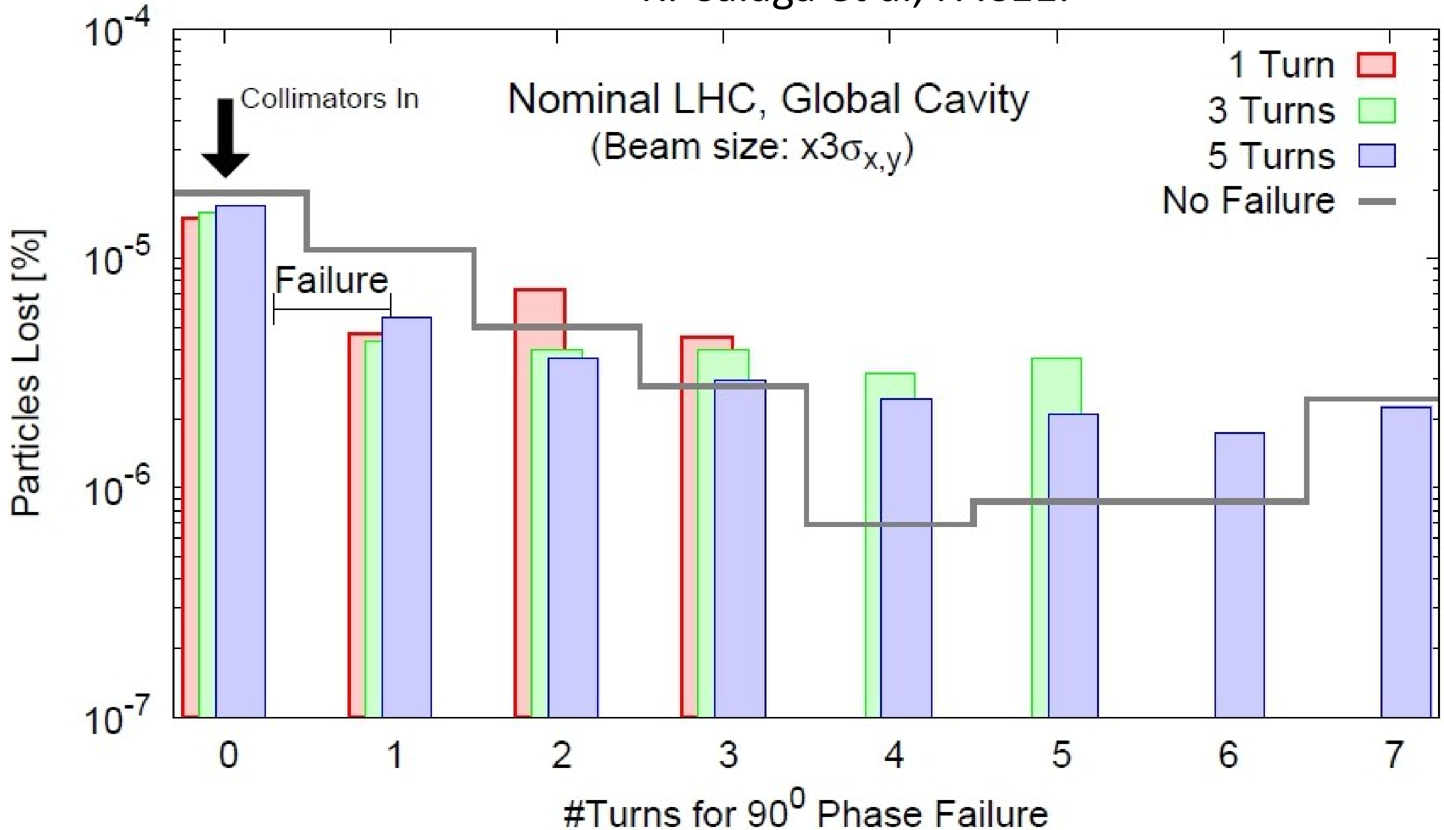
R. Calaga et al, PAC11.



The total number of particles absorbed in the Local Scheme.

Lost Particles in the Global scheme

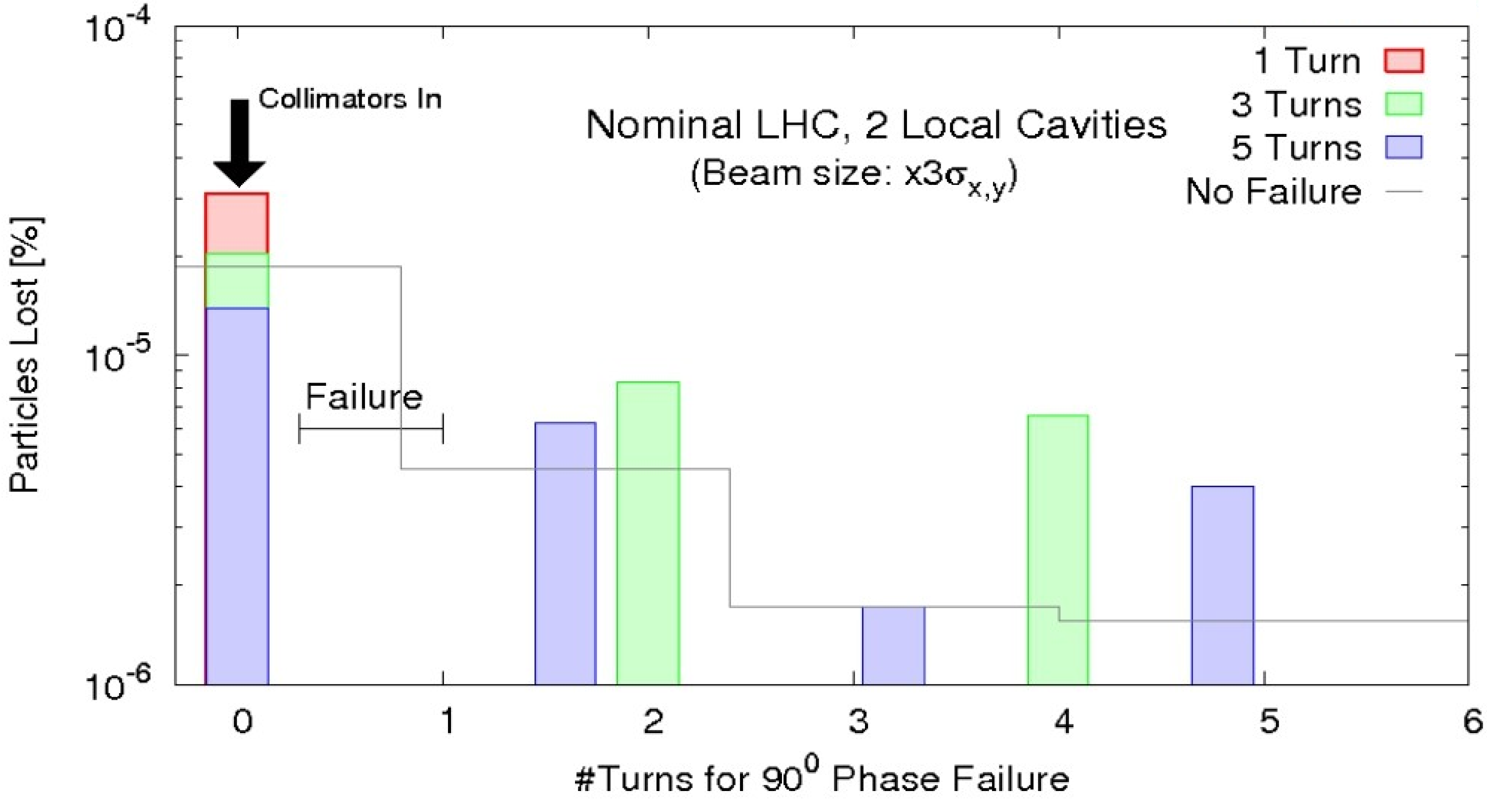
R. Calaga et al, PAC11.



Particles Lost in the Global Scheme in case of a phase failure.

Lost Particles in the Local scheme

R. Calaga et al, PAC11.



Particles Lost in the Local Scheme in case of a phase failure.

Conclusions

These are the last results of the Fast Failures CC in the LHC, which were presented at PAC11 [1,2].

The particle-loss for abrupt changes in both schemes (Local & Global) remains below 10^{-5} of the initial population.

Future work

- Now we are running simulation with a Double Gaussian distribution to include the beam halo using the measured parameters from CMS [3].

- Repeat the analysis for HL-LHC upgrade optics.

References

[1] R. Calaga et al., *Abrupt Crab-Cavity Failures*, PAC11.

[2] T.Baer et al., *BEAM LOSSES DUE TO ABRUPT CRAB CAVITY FAILURES IN THE LHC*, PAC11.

[3] The CMS collaboration, *Absolute Calibration of the CMS Luminosity Measurements: Summer 2011 Update*, CMS PAS EWK-11-001.

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