Study of Loss Distribution with detailed Aperture Model

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- Beam loss distribution is important input for the BLM-system
- Dilution length of losses: important information for LHC collimation system

Aperture Model + Particle Tracking Environment

- Aperture Information for Dispersion Suppressor and Arc downstream (beam1) of IR7
  - First marker at: ~235 m from IP7
  - Last marker at: ~2845 m from IP7
- Every change of aperture is included (transition pieces, BPMs, beamscreens outside the magnets, locations of bellows,…)
    - At some locations in the order of 5m without aperture element: more markers will be included
- MBs and MQs are sliced

Aperture Model + Particle Tracking Environment

- MAD-X: Aperture Information → LHC sequence.
- MAD-X: Particle Tracking
- Post-processing:
  - longitudinal loss distribution ($N_{lost}(s)$)
  - list of hit elements
  - coordinates of lost particles at each hit element
  - dilution length for losses

Definition of Dilution Length

- Dilution Length and collimation:

  The cleaning inefficiency is determined via tracking programs producing secondary and tertiary halo particles.

  Cleaning inefficiency for N lost particles:

$$\eta_c(a_c) = \frac{1}{N}\sum_{i=1}^{N} H(A_r - a_c)$$

- Local cleaning inefficiency: required local cleaning inefficiency defined via quench limit and maximum loss rate

$$\tilde{\eta}_c = \eta_c / L_{dil} = \frac{R_q}{\dot{N}_{max}}$$

Definition of Dilution Length

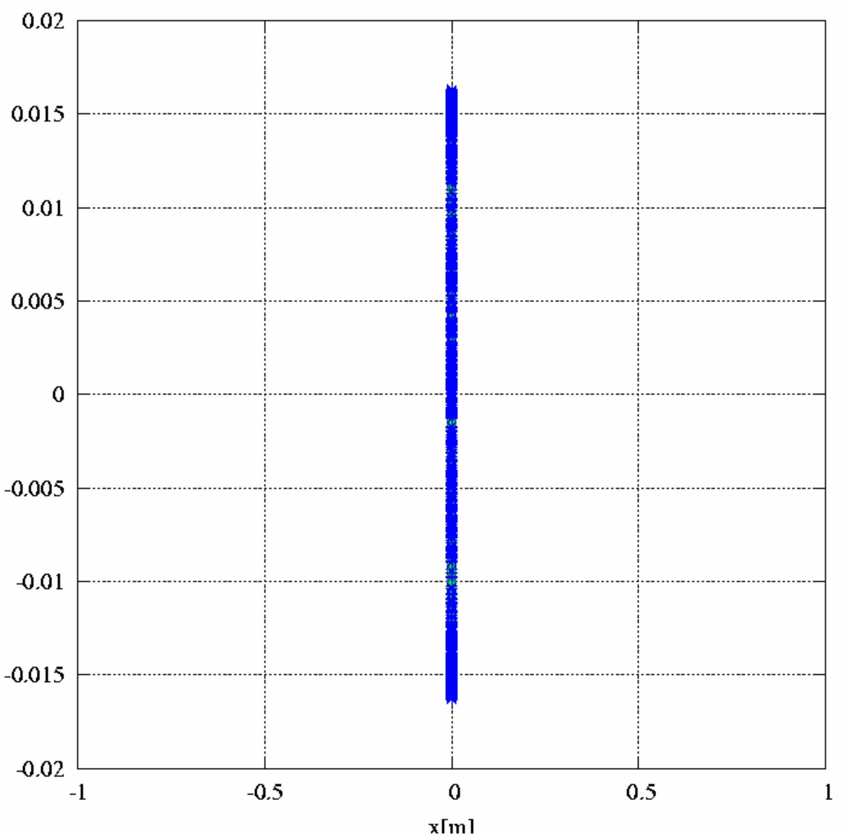
- Assumption on dilution length so far: 50m
- To determine the dilution length from our data:
  - output of simulation: number of lost particles per m: $N_{lost}(s)$
  - dilution length:

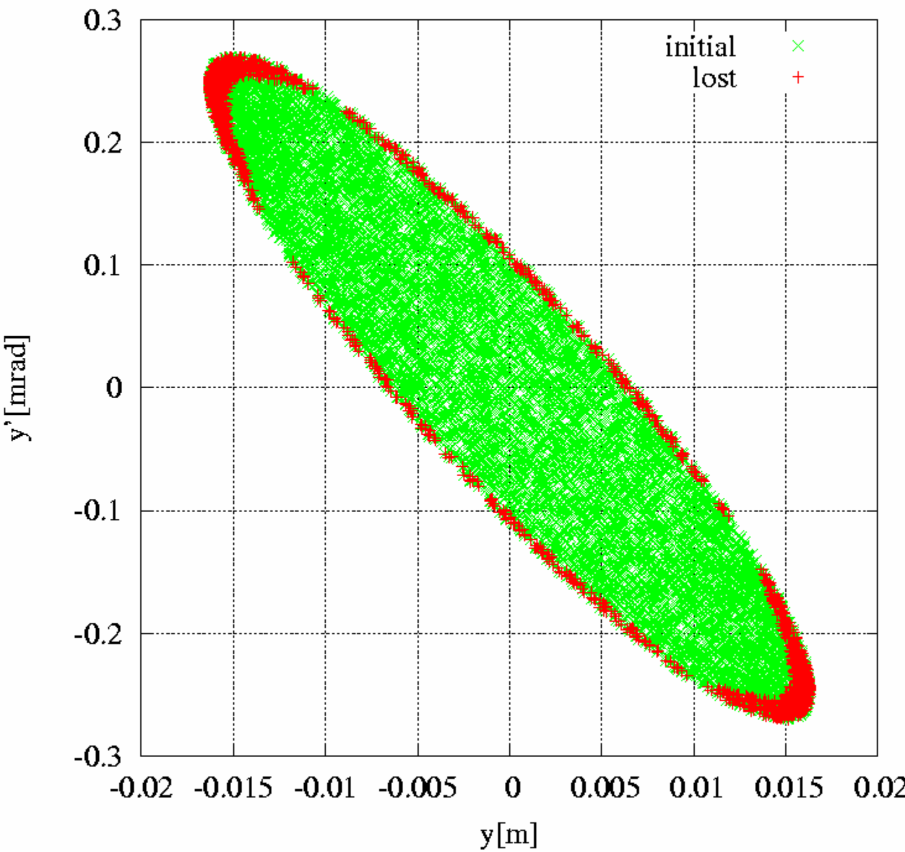
$$L_{dil}^{-1} = \frac{\max N_{lost}(s)}{\sum_s N_{lost}(s)}$$

Testing the Environment …

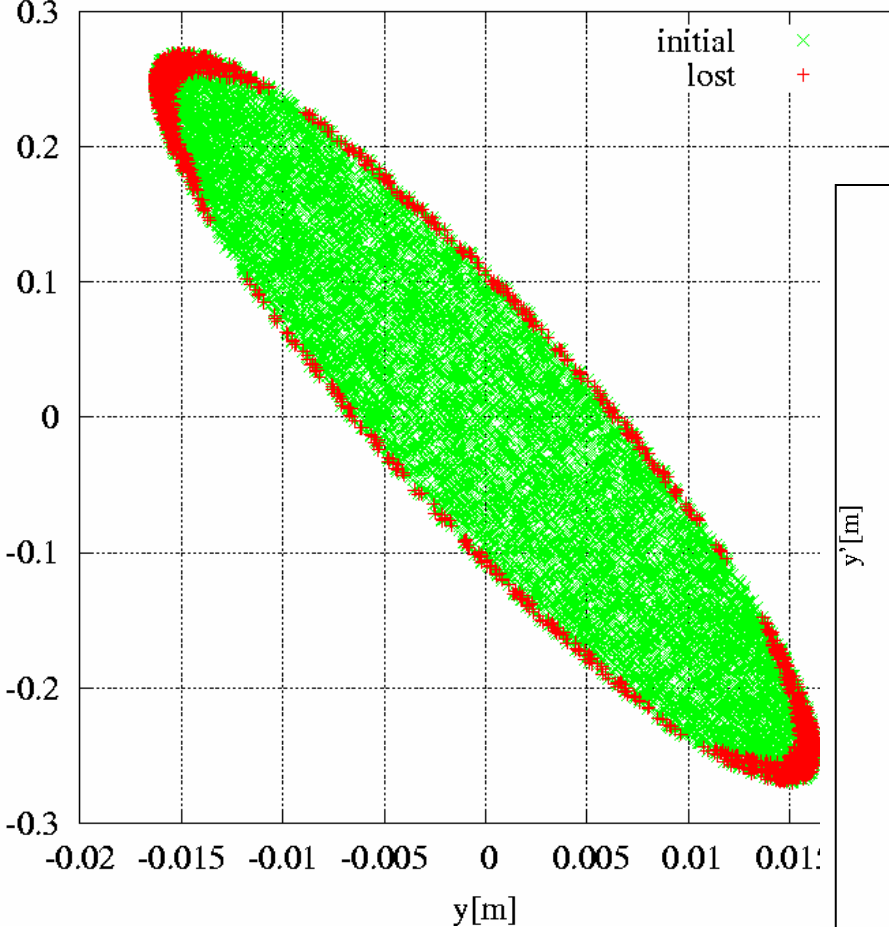
- Loss distributions for test particle configurations (uniform distributions in x and y)
- 7 TeV protons, 10^4 particles
- single pass through the section with detailed aperture
- No errors

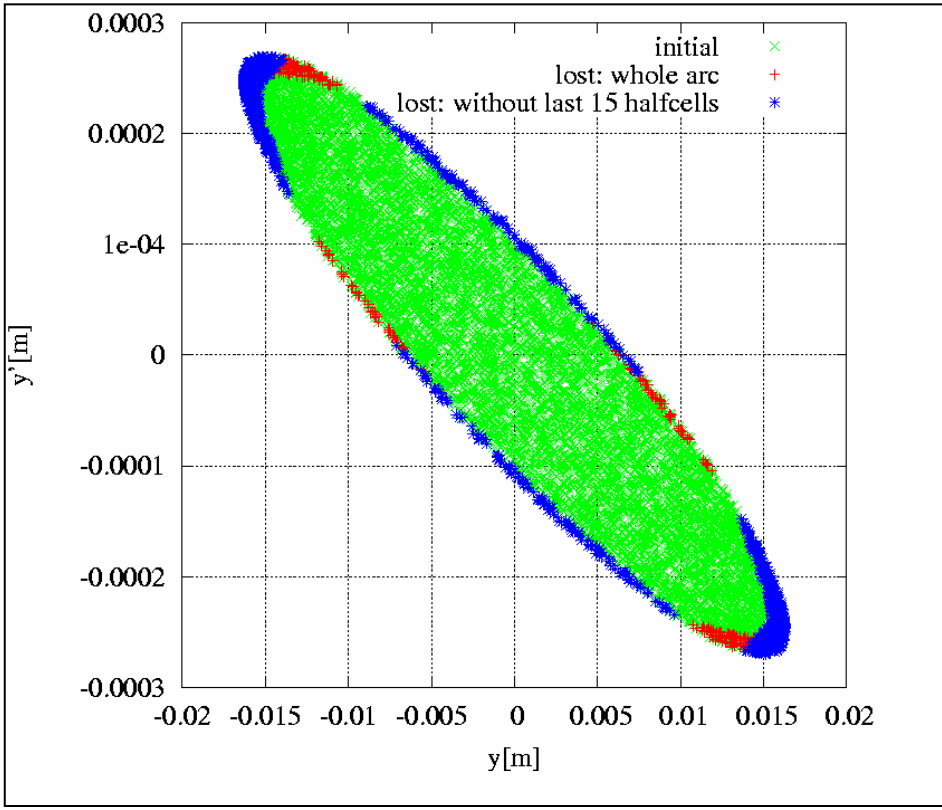
Uniform distribution in y, x = 0



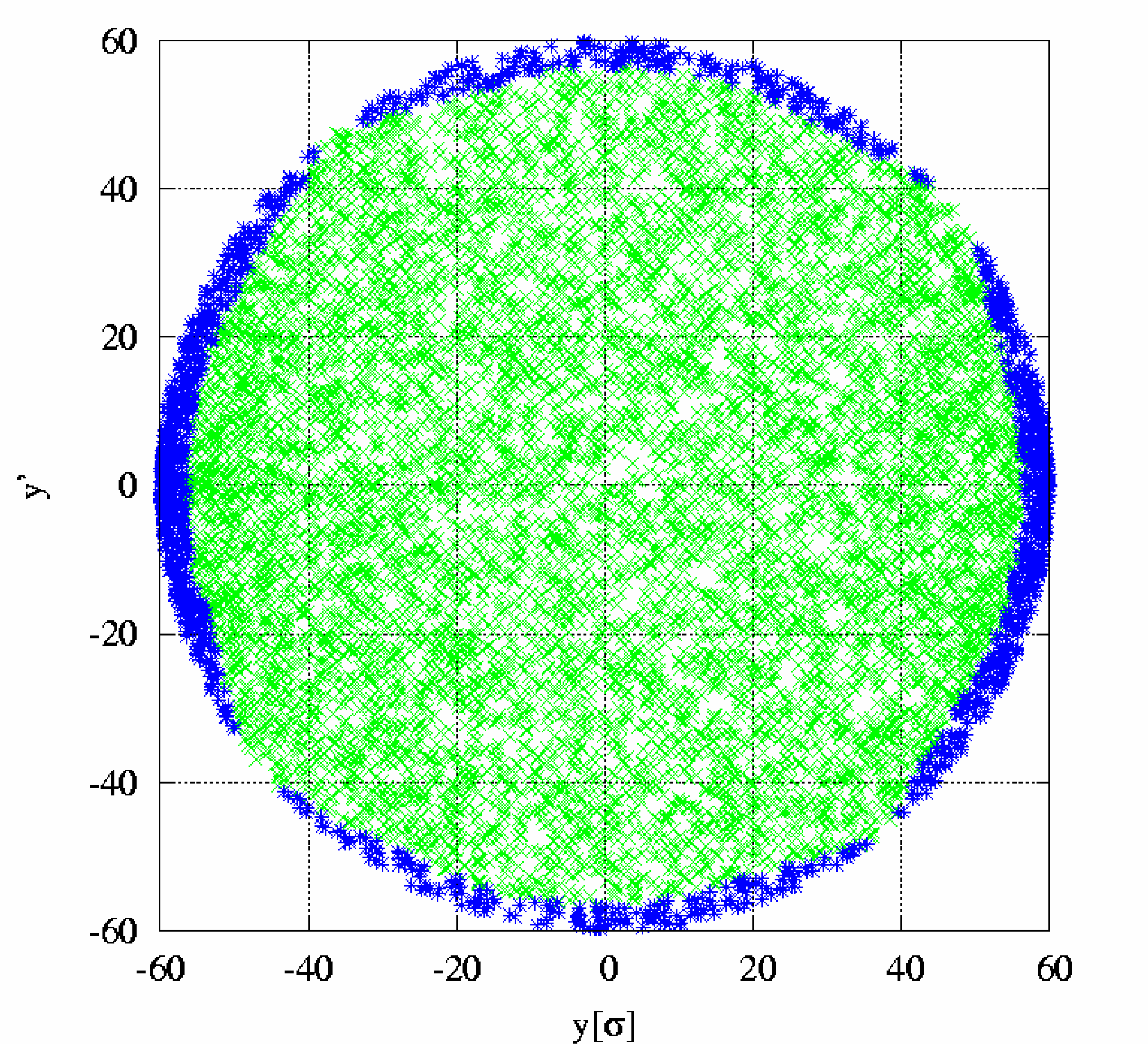


Comparison: cuts in phase space: whole arc (46 halfcells) – 29 halfcells

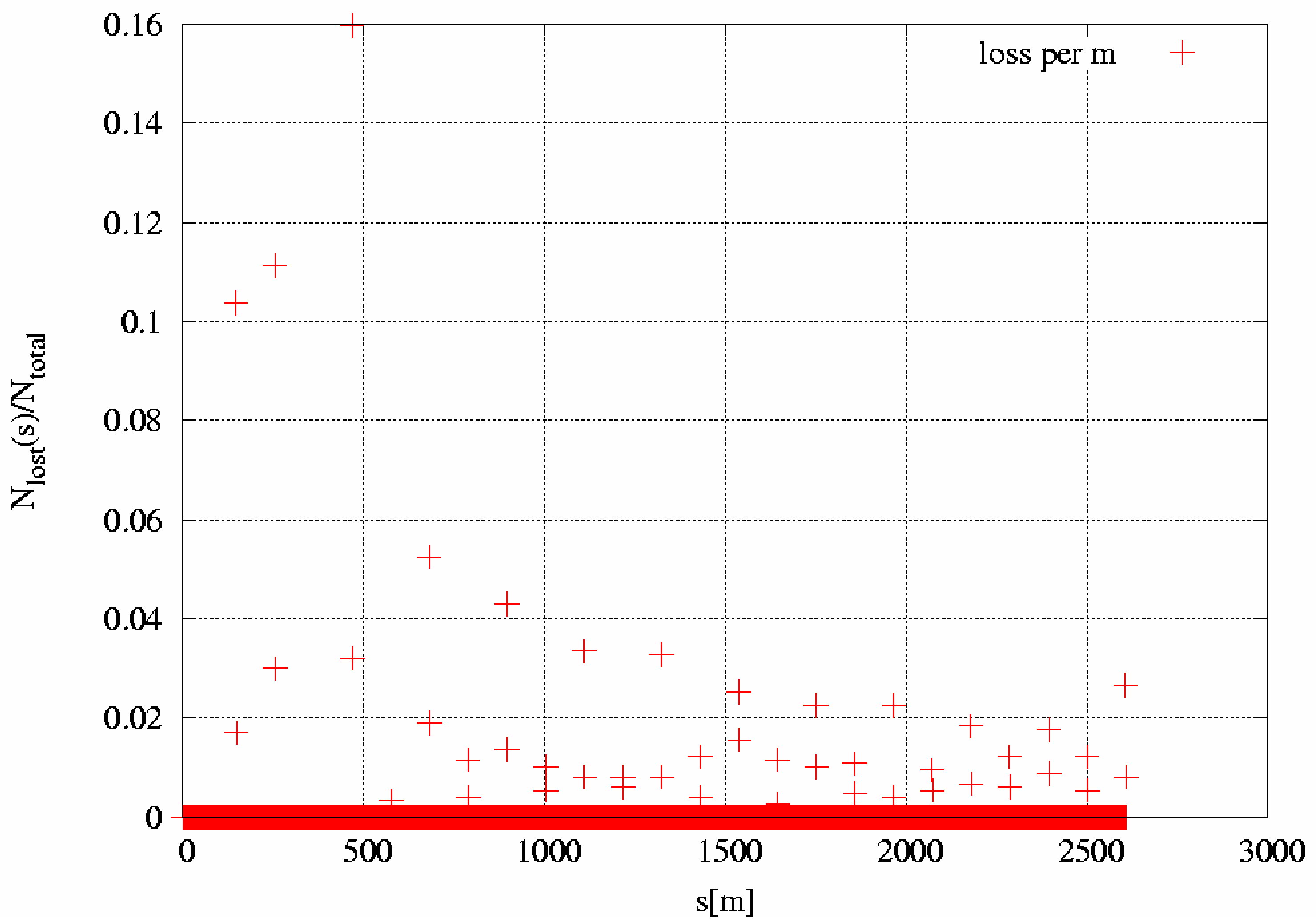




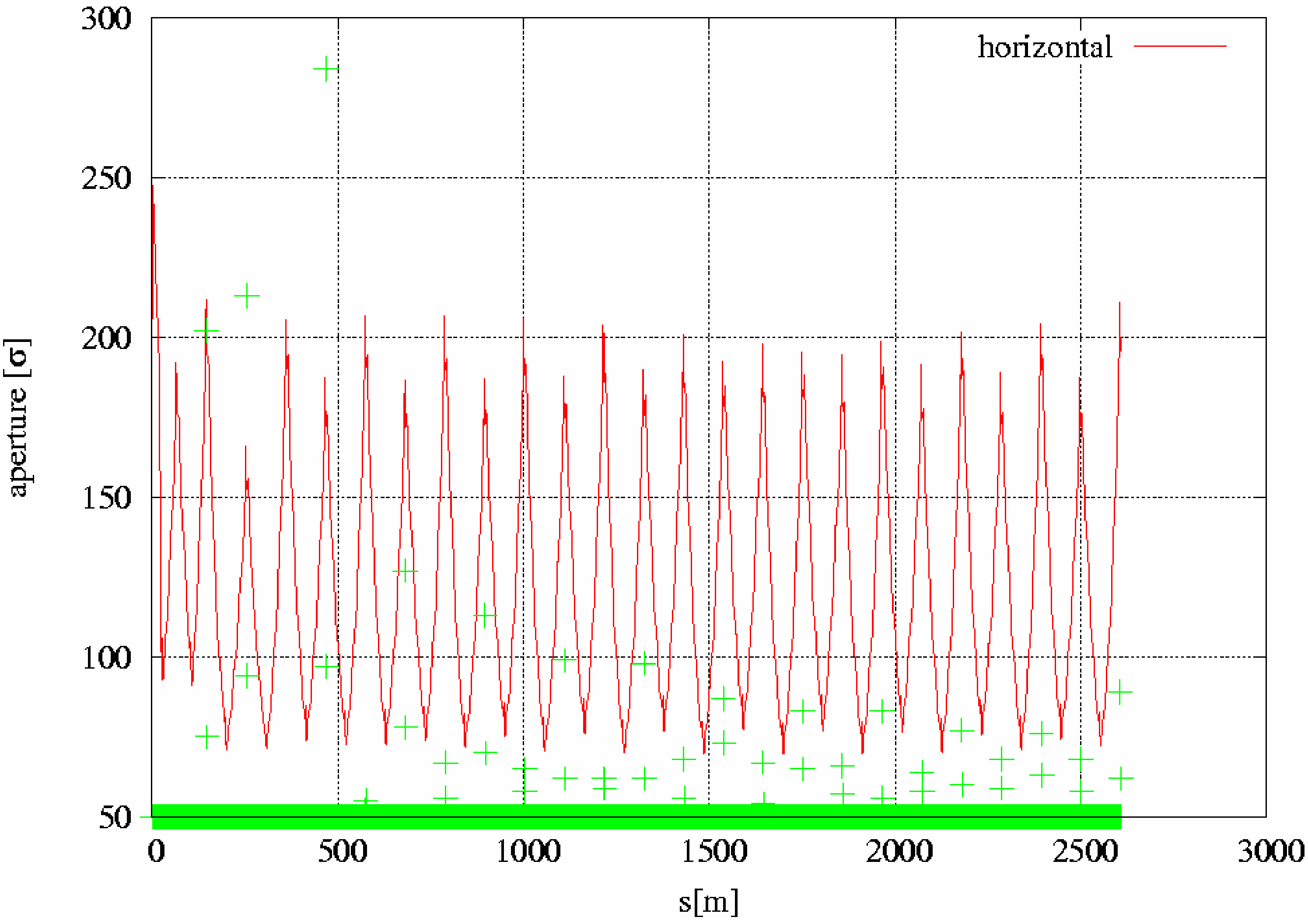
Uniform distribution in y, x=0: normalized phase-space: cut at ~55σ



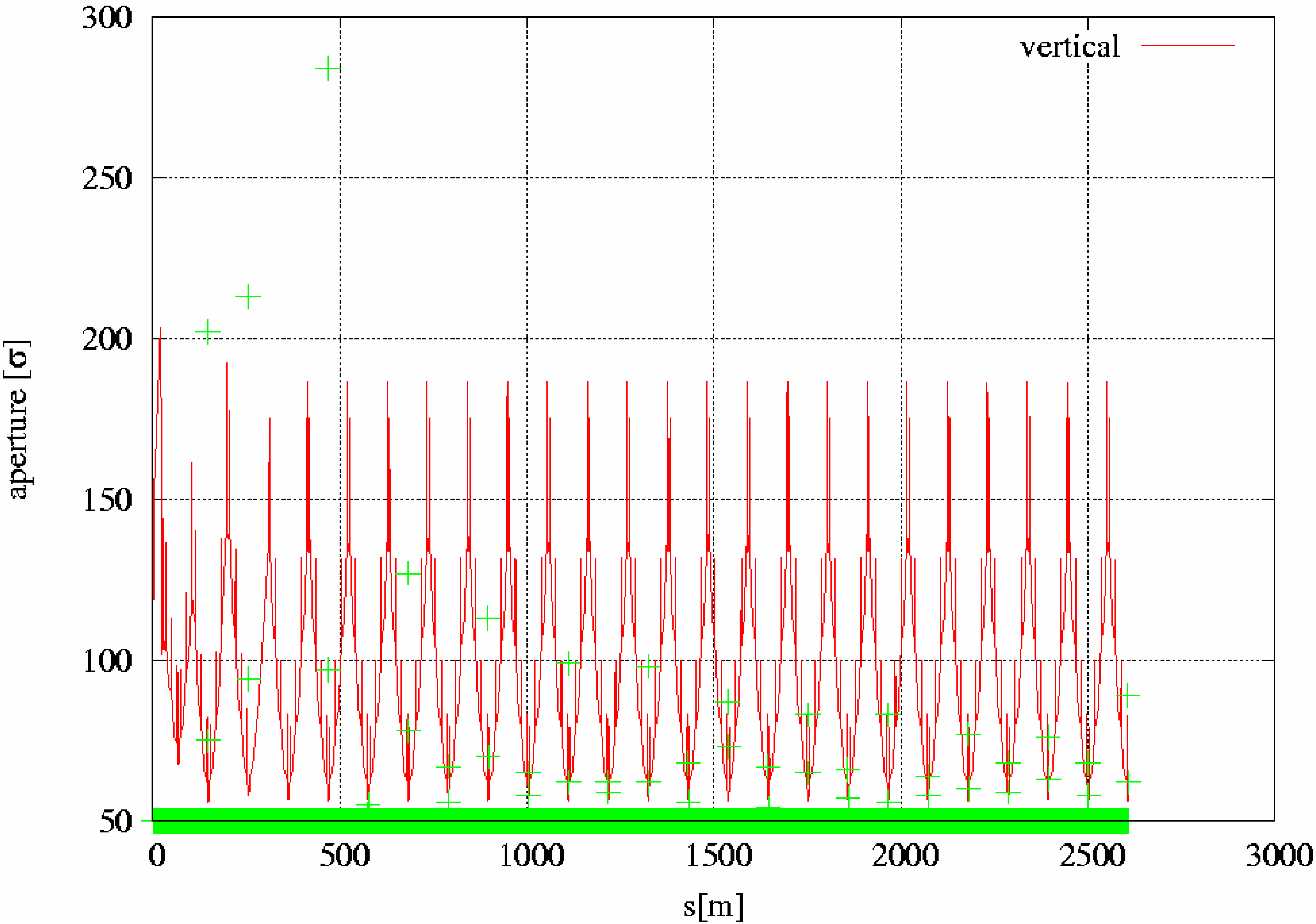
Lost Distribution: uniform distribution y, x=0. Losses occur only at quads.



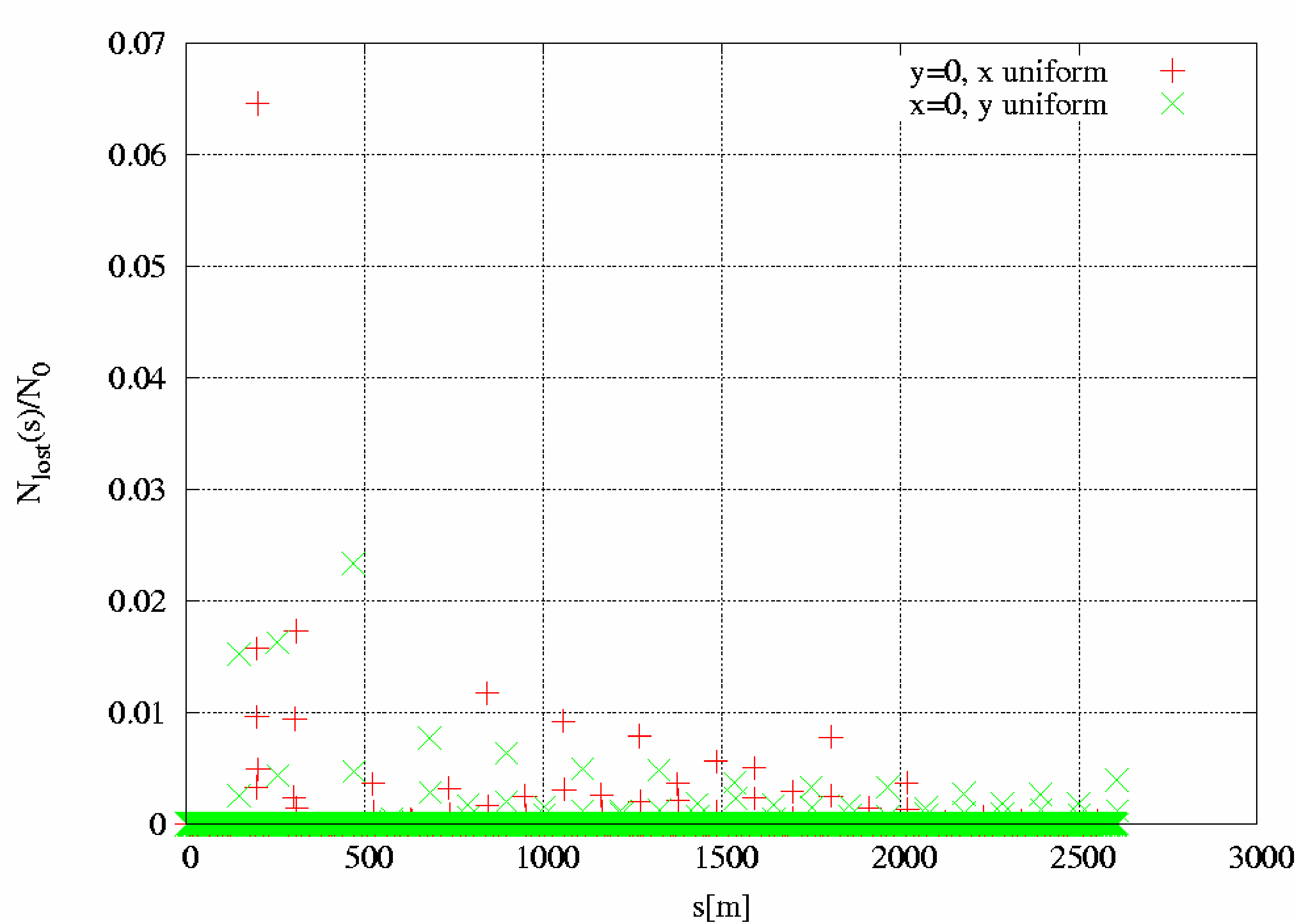
Comparison: loss locations - horizontal aperture limits …



Comparison: loss locations - vertical aperture limits …



Comparison: uniform distributin in x (y=0) and unifrom distribution in y (x=0)



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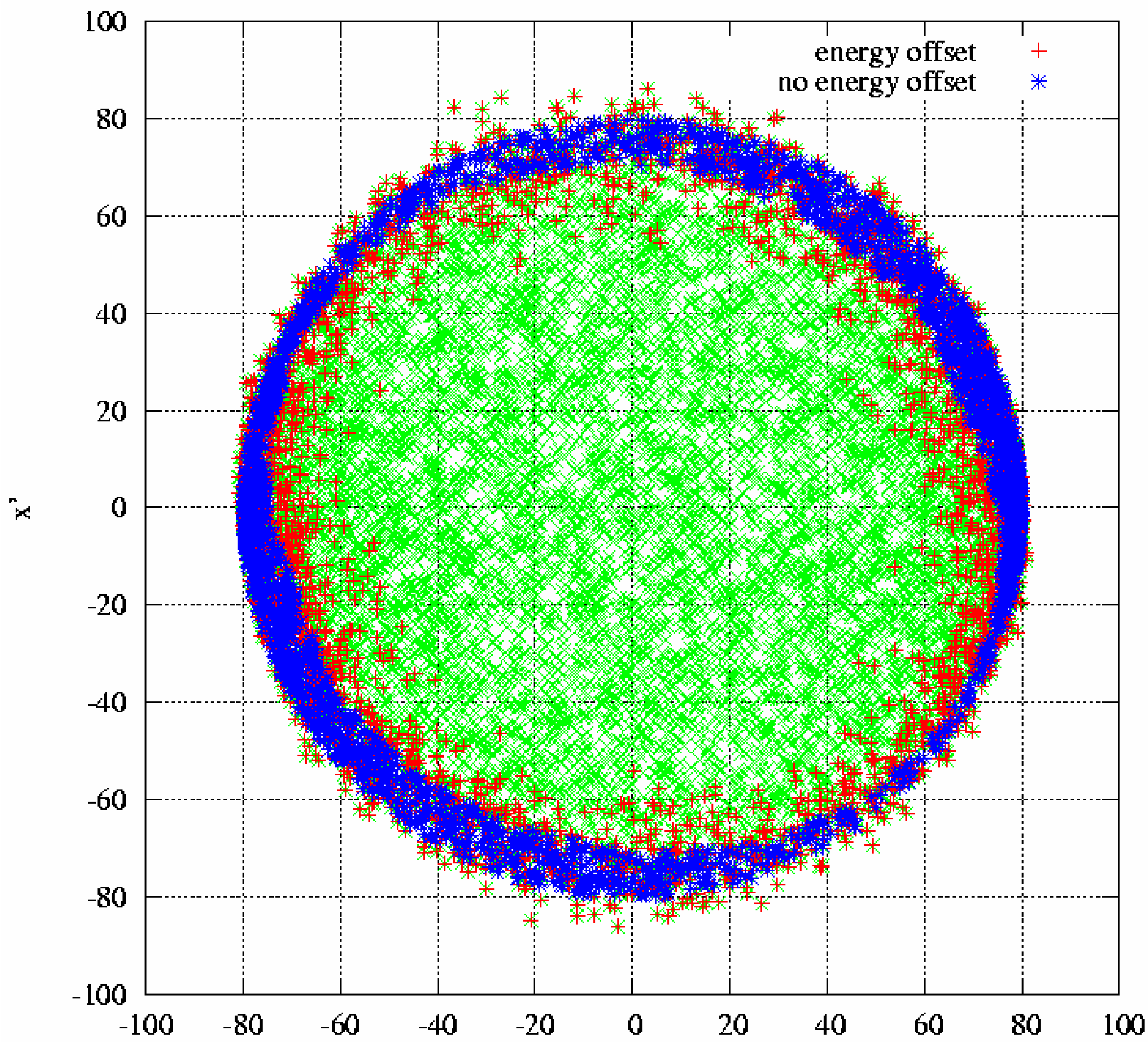
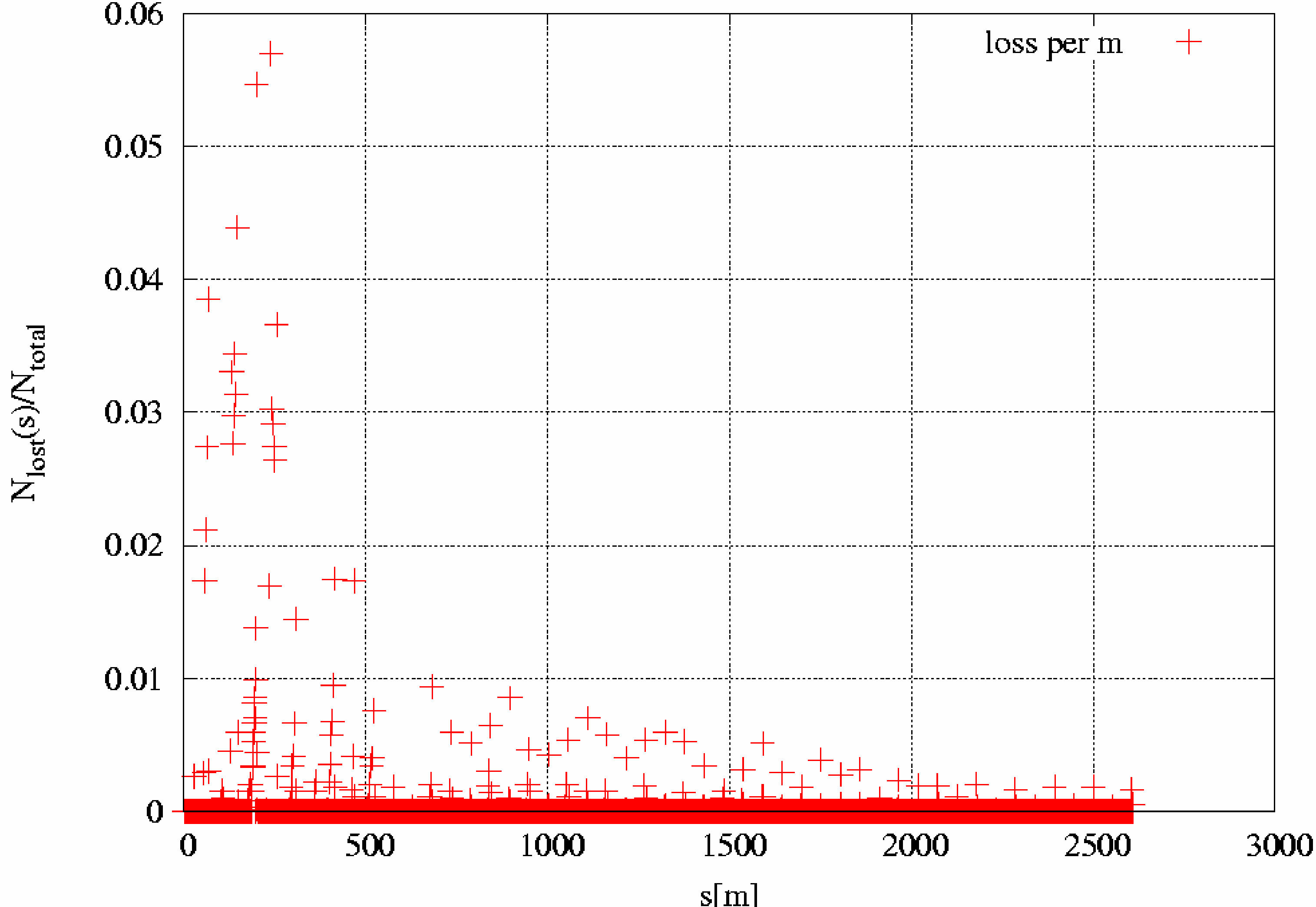
Uniform distribution in x (80σ), y=0; Energy offset: σ_δ=0.001



Uniform distribution in x and y (80σ); Energy offset: σ_δ=0.001



Some numbers …

Uniform distribut.	L_{dil}	cut	loss@ quads	loss@ bends	else
	[m]	[σ]	%	%	%
x, y=0	3.4	~75	83	4	13
x, δ≠0 σ_δ=0.001	7	~60	38	39	23
y, x=0	6.3	~55	100	0	0
x, y	13.7		63.3	29.3	7.3
x, y, δ≠0 σ_δ=0.001	17.6		52	40	8

Conclusion

- We now have a tool to study longitudinal beam loss distributions.
- As it is based on MAD, errors in the machine (orbit, misalignments,…) can be easily included

- For the next step (**dilution length for collimation system**) we need realistic initial particle coordinates: Halo data from Ralph