Updates on MAD-X simulations of slow and fast ADT quench tests

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1. Fast Losses Quench Test

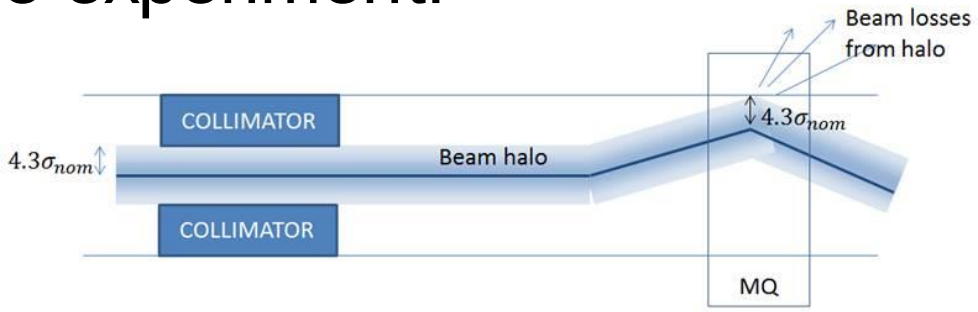
- Fast Losses Quench test aimed to reproduce the UFO-induced beam losses (with duration of a few milliseconds)
- UFO's rate increases with energy and expected to be a major luminosity limitation
- BLM thresholds should be increased to avoid undesirable beam dumps

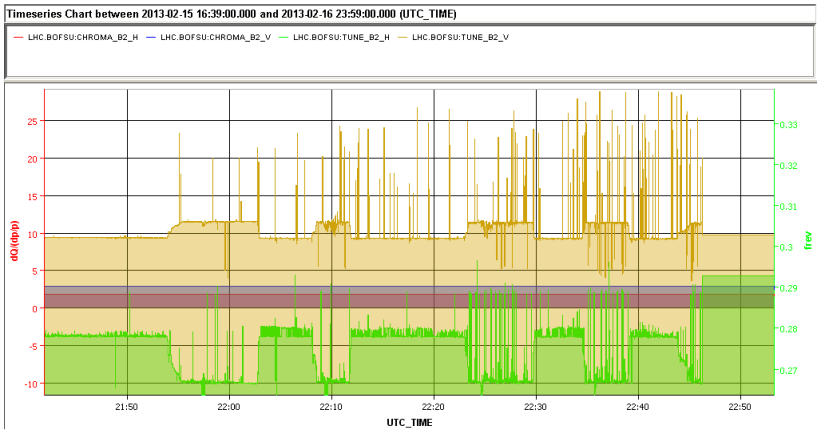
1. Fast Losses Quench Test

	Experiment		MadX
0	Injecting to the LHC	0	Injection optics: β* are **11/10/11/10**, Energy 4 TeV. Beam profile – from BWS measurements.
1	Ramping to the nominal energy		
2	Increasing 3-corr. orbit bump until losses occur, then reducing the bump by 2 mm	1	3-corr. orbit bump with an offset $4.3\sigma_{nom}$ from the beam screen (~21.54 mm from the centre of the BS)
3	Beam scraping on hor. collimators		
4	Measuring the beam profile (BWS)	2	*No matching after applying the bump
5	Opening the collimators	3	MKQ kick (single)
6	Gating the ADT on one bunch	4	ADT excitation (depending on turn)
7	Blowing up the bunch slowly in the vertical plane		
8	Setting the bump to 21.61 mm		
9	MKQ kick and ~11ms later – ADT excitation		

1. Fast Losses Quench Test

- Uncertainties in the experiment:
  - Bump amplitude
  - Beam profile
  - Tune (no information about the tune change during the test)
  - β-function in the MQ.12L6



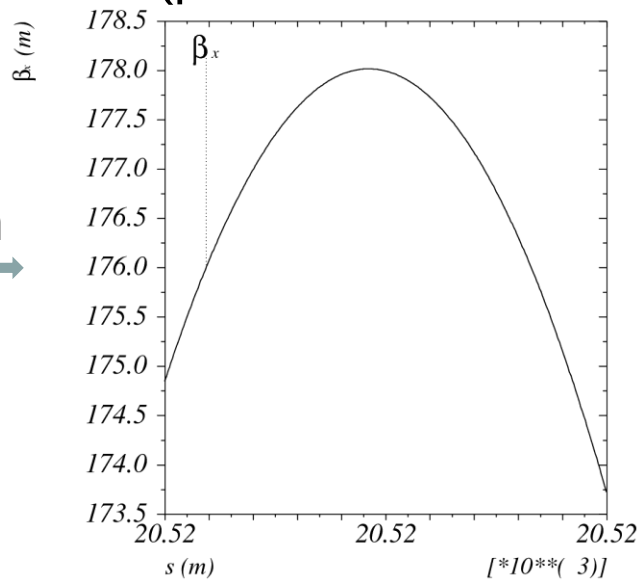


1. Fast Losses Quench Test

β-function at the MQ.12L6

1. Official "thick" LHC sequence + matched injection optics = β-function (at the middle of MQ.12L6): ~ **176.3** m
2. Official "thin" LHC sequence + matched injection optics = β-function (at the middle of MQ.12L6): ~ **181.4** m
3. β-function along the MQ.12L6 when it is sliced into 1 cm thin lenses (β* at the IPs are 11/10/11/10 + nominal tunes)

Beam →



NB! In all the simulations β-function stayed within 10% of the nominal "thick" value

1. Fast Losses Quench Test

- Goal:
  - Integrated (10 ms) spatial distribution (MadX)
  - Time distribution (MadX, BLM measurements)

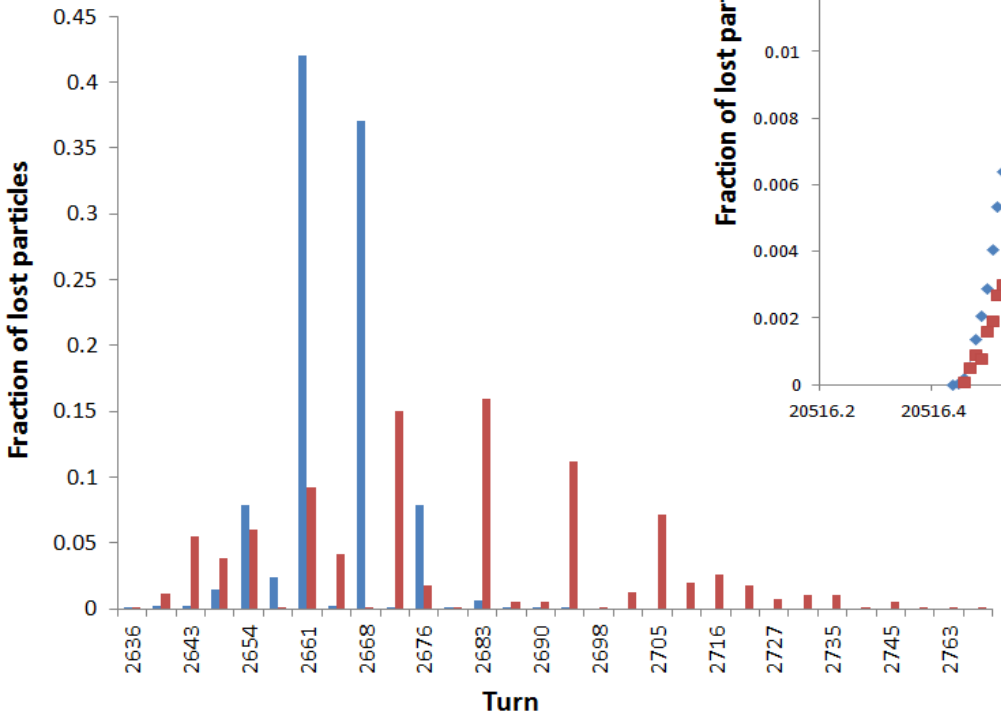
Study the dependence of these distributions on

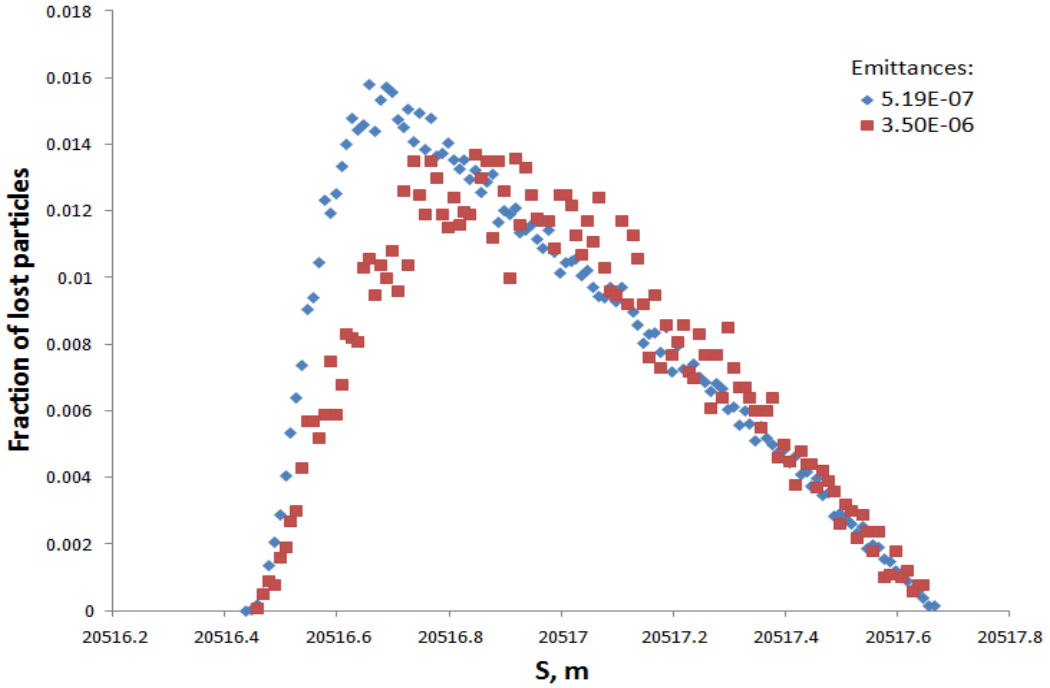
- Bump amplitude
- Beam size
- Tune

1. Fast Losses Quench Test

Dependence on the beam size

Q1 = 64.28
Q2 = 59.31
Offset: 4.3sigma(nominal)





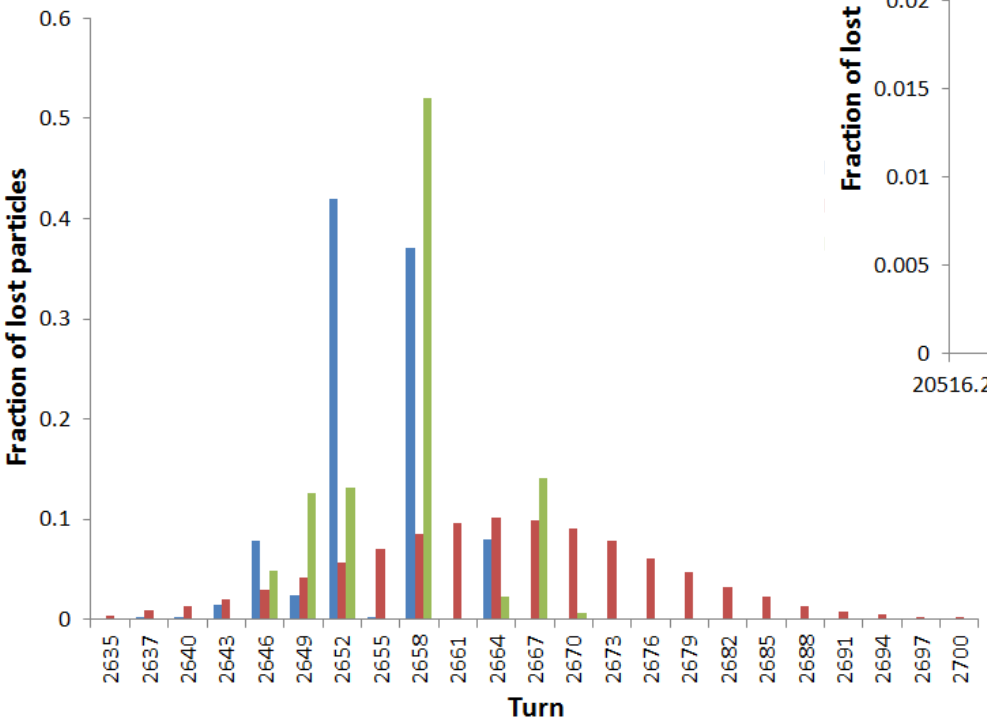
$\varepsilon_{n,x} = 5.19e\text{-}7$

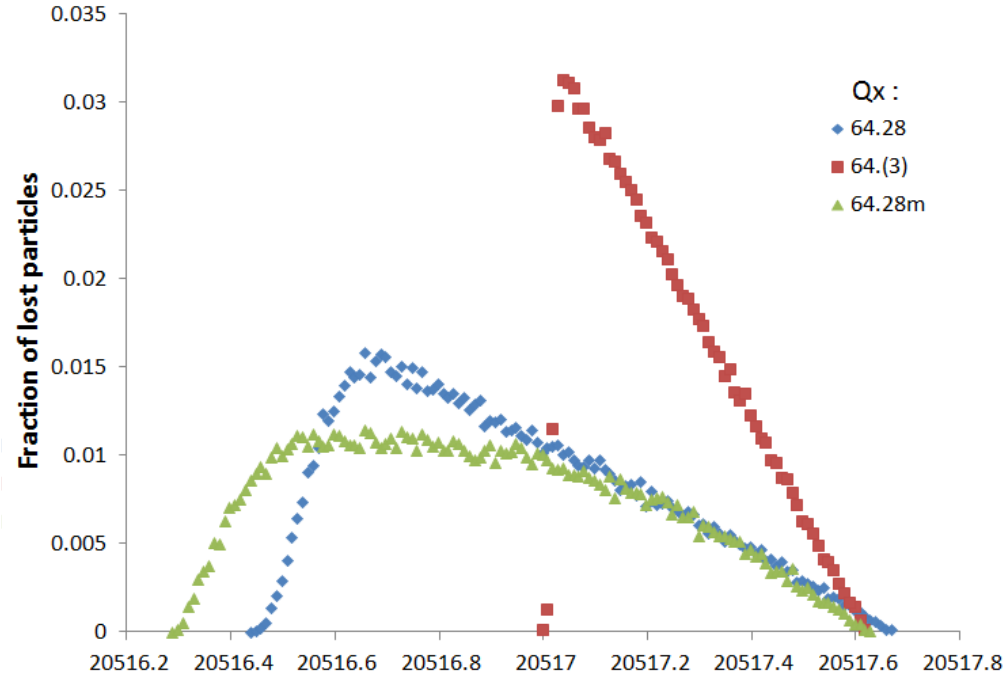
$\varepsilon_{nom,x} = 3.5e\text{-}6$

1. Fast Losses Quench Test

Dependence on the tune

εx = 5.195e-7
εy = 1.409e-5
Offset: 4.3sigma(nominal)





$Q_x = 64.28$ → (3CB) → $Q_x = 64.274$

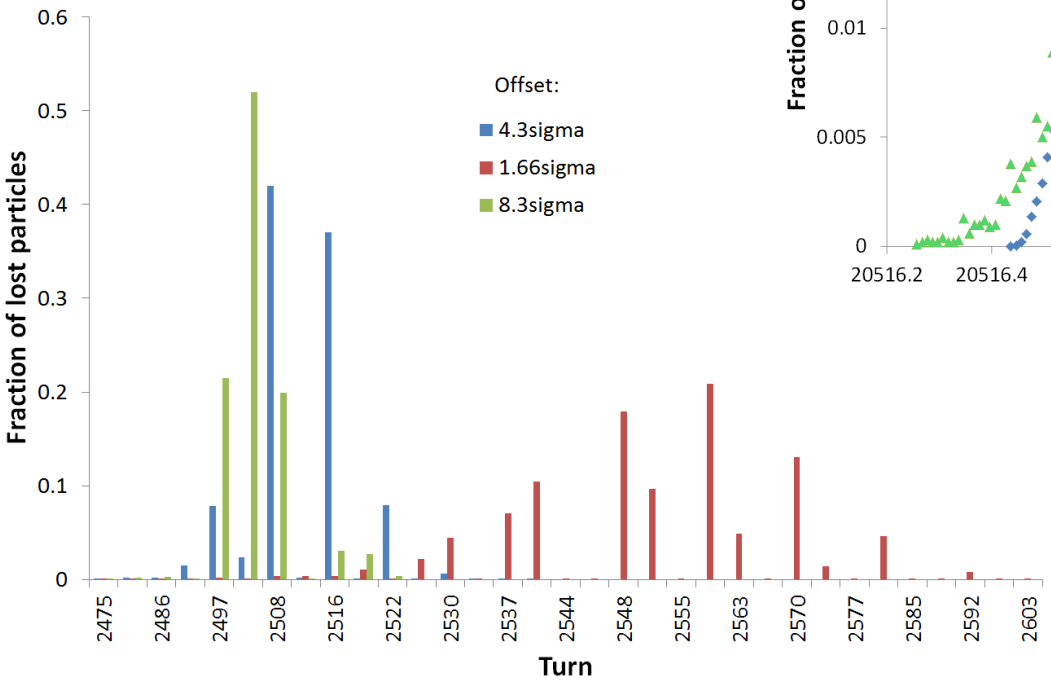
$Q_x = 64.28$ → (3CBm) → $Q_x = 64.268$

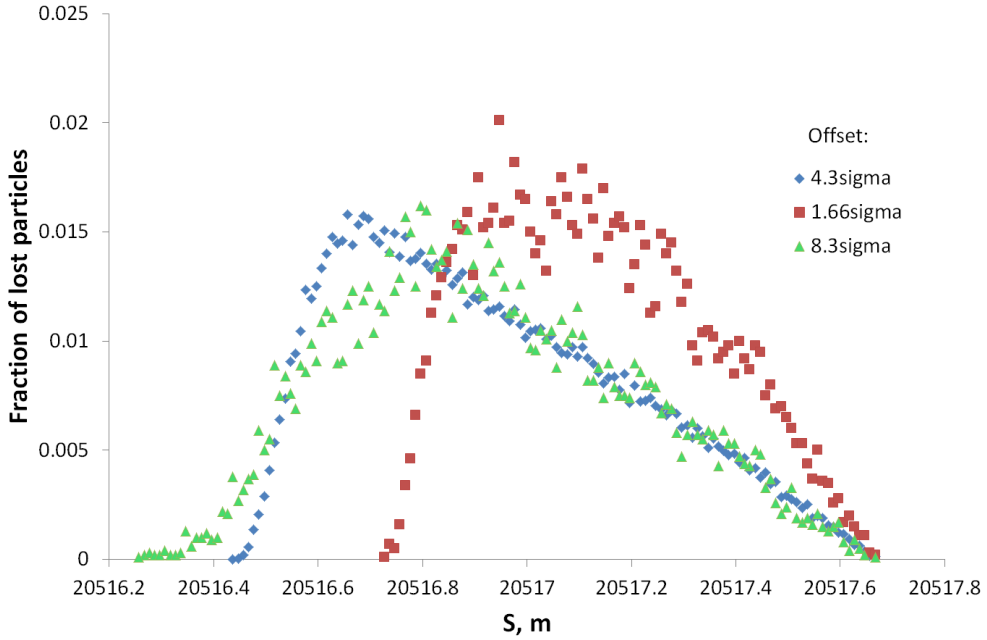
$Q_x = 64.(3)$ → (3CB) → $Q_x = 64.3330$

1. Fast Losses Quench Test

Dependence on the bump amplitude

εx= 5.195e-7 Q1 = 64.28
εy= 1.409e-5 Q2 = 59.31





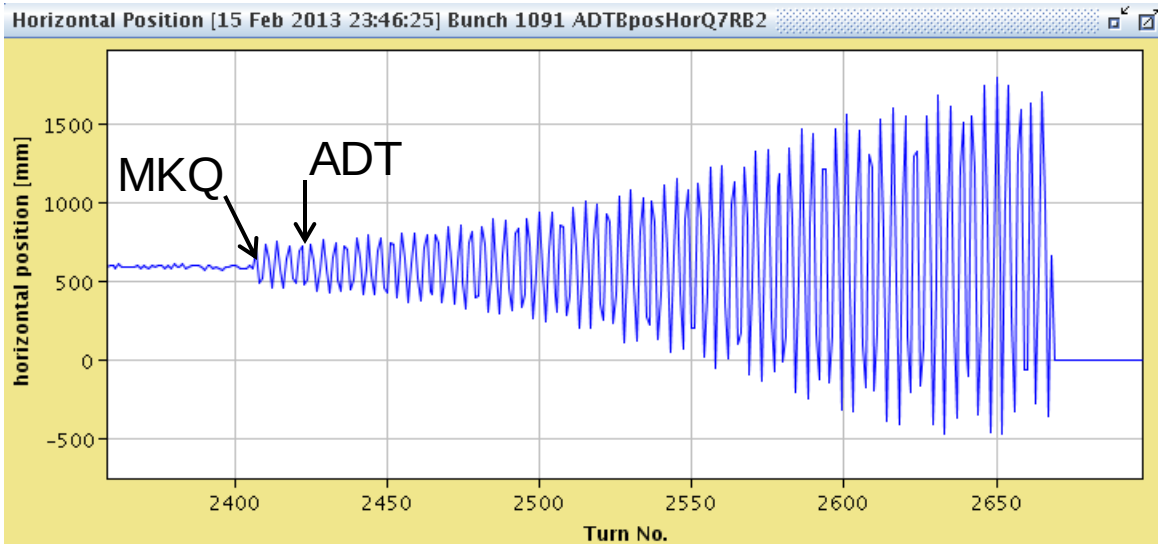
Offset = 4.3sigma

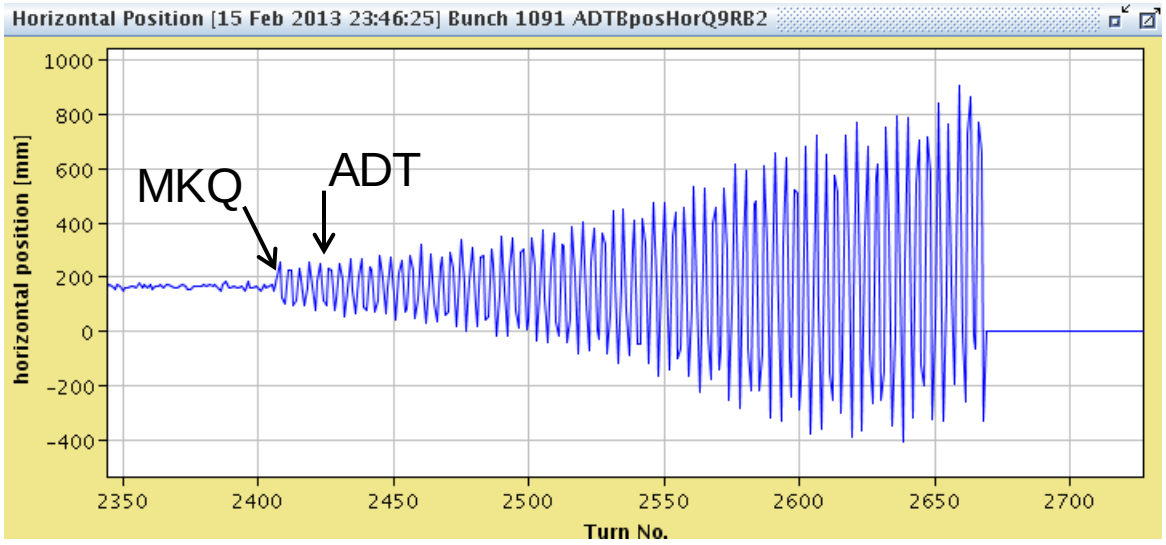
Offset = 1.66sigma

Offset = 8.3sigma

1. Fast Losses Quench Test

- Beam position at ADT pickups:
  - BPMCA.7R4
  - BPMC.9R4
- MKQ kick (1 turn)
- ~1 ms after the MKQ kick:
  - ADT kicks





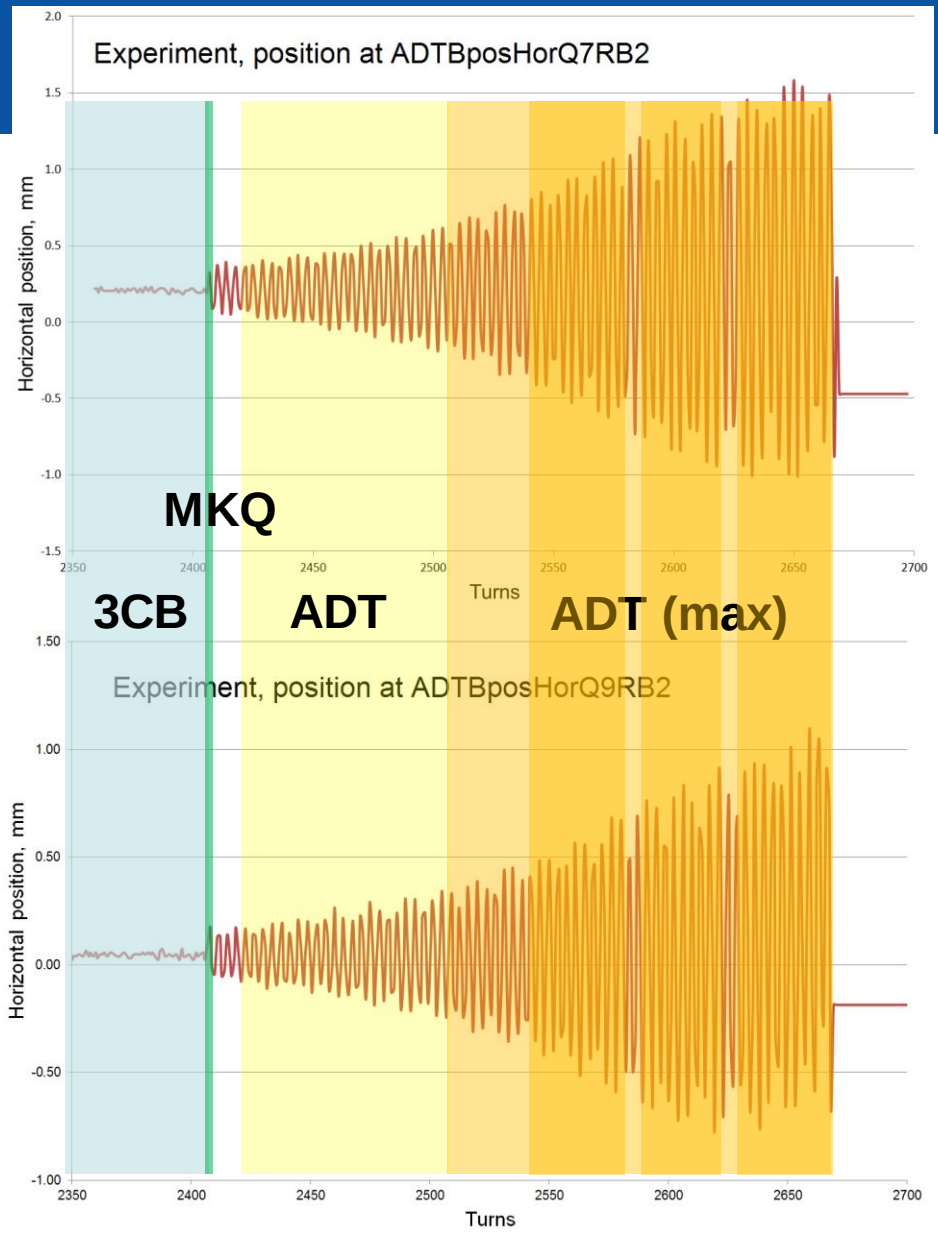
1. Shift the curves in such a way that the beam position during the 1st phase (3CB) oscillates around zero.

2. Fit the position of the beam at the pickups

MKQ kick - constant

ADT = ADT(max)*K*(1-exp(-λ*t))

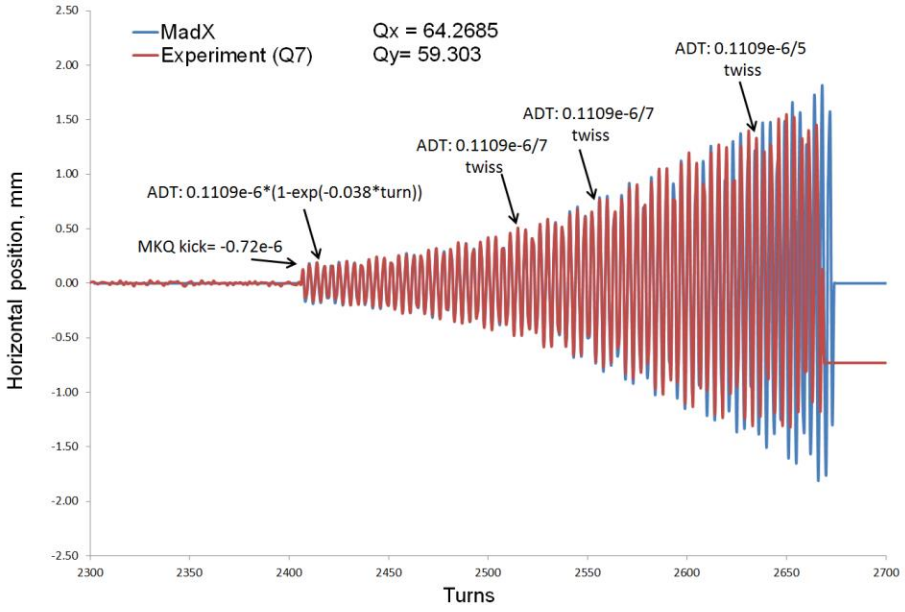
K – fitting coefficient
λ – “time constant”
t – turn

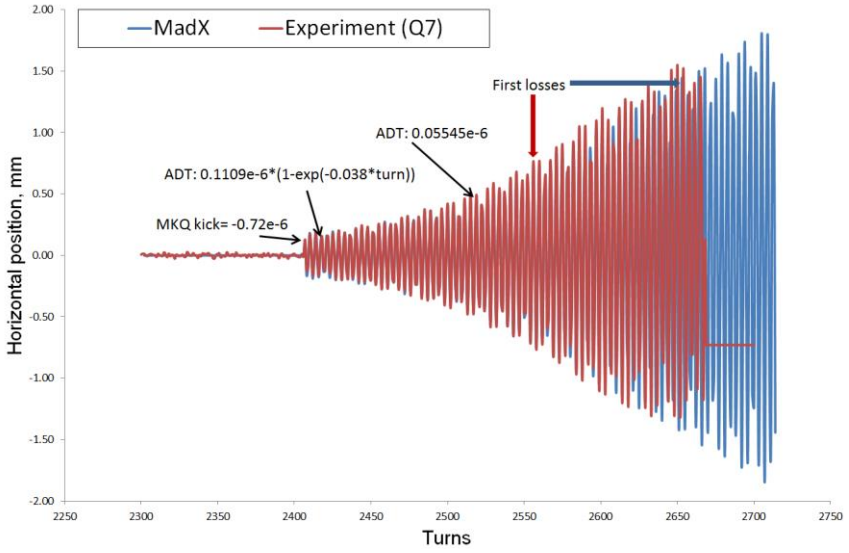


1. Fast Losses Quench Test

Tune correction during the ADT excitation

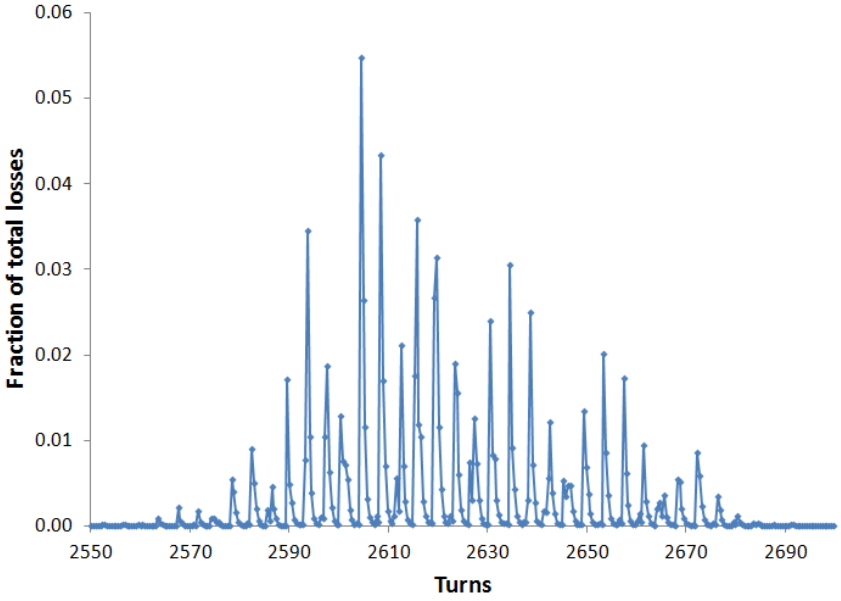
Smaller steps for ADT excitation: Calculations of the tunes when the discrepancies occur





1. Fast Losses Quench Test

BLM signal

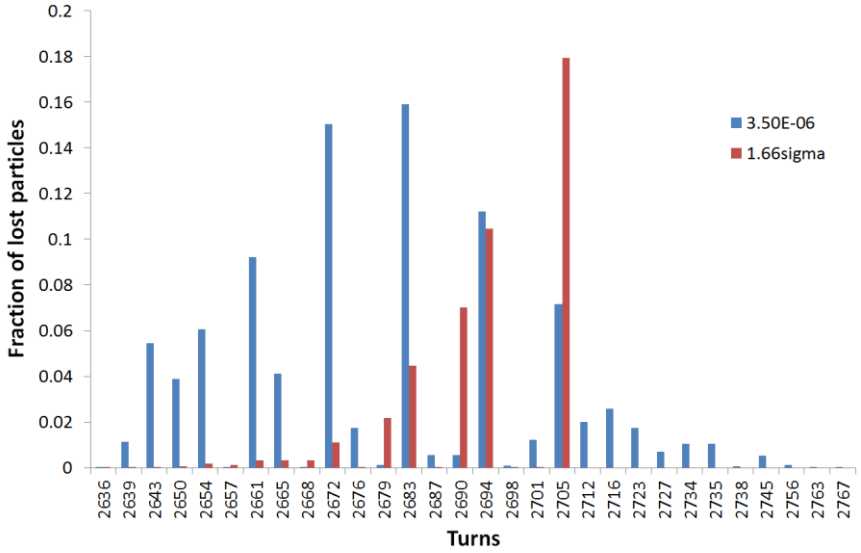


Qx = 64.28, Qy = 57.31

Blue: ε = 3.5e-6, offset = 4.3 sigma

Red: ε = 5.2e-7, offset = 1.66 sigma

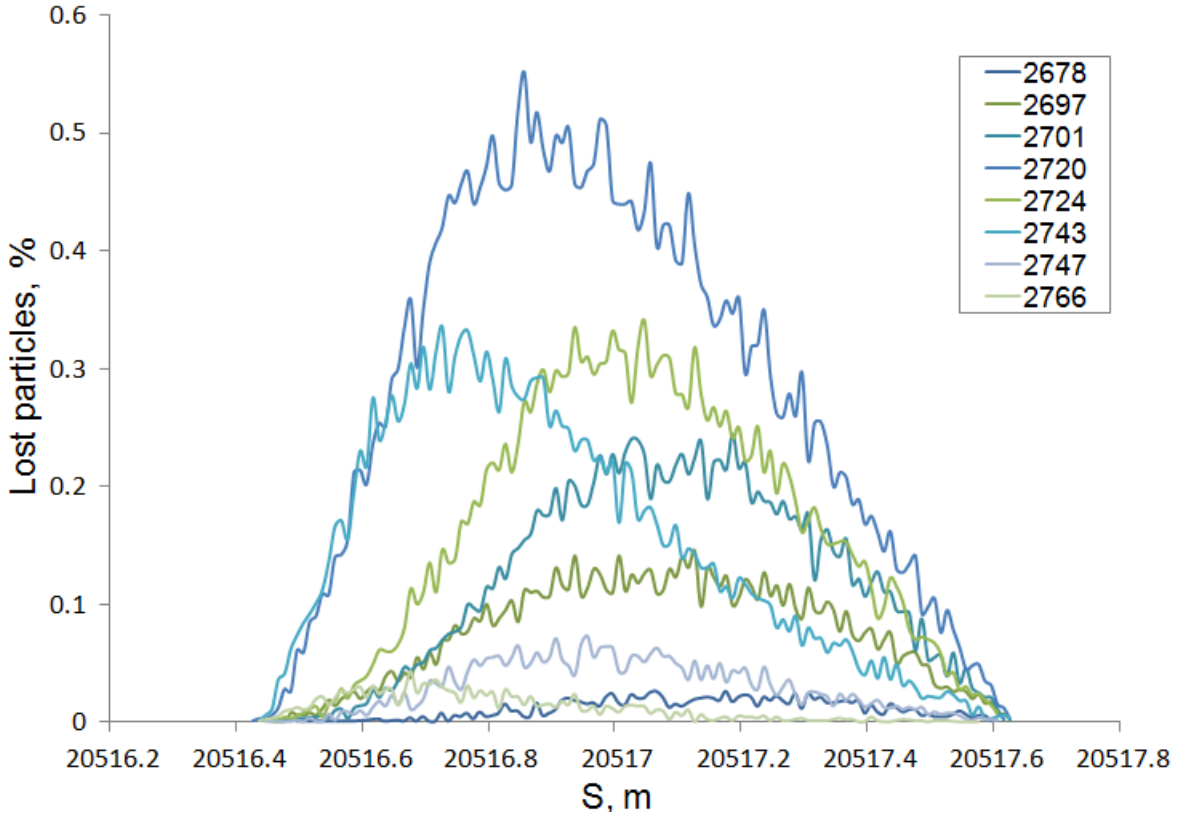
MadX



Combination of larger beam size and smaller offset provides better description of the time distribution

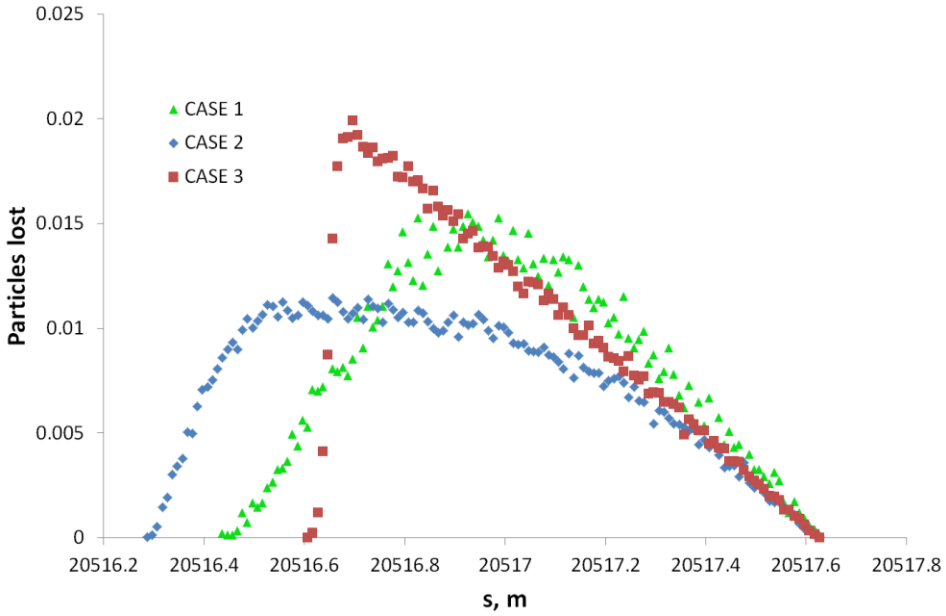
1. Fast Losses Quench Test

Longitudinal distribution vs. turn



1. Fast Losses Quench Test

1. Small Beam Screen in MADX (2.2cm) and large BS in FLUKA (2.325cm), no tune correction during the simulations.
2. 2.325cm Beam Screens in MADX and FLUKA + tune correction
3. 2.325cm Beam Screens in MADX and FLUKA, no tune correction



* Results of the "old-concept" simulations: Matching of the tune was done after the orbital bump was applied

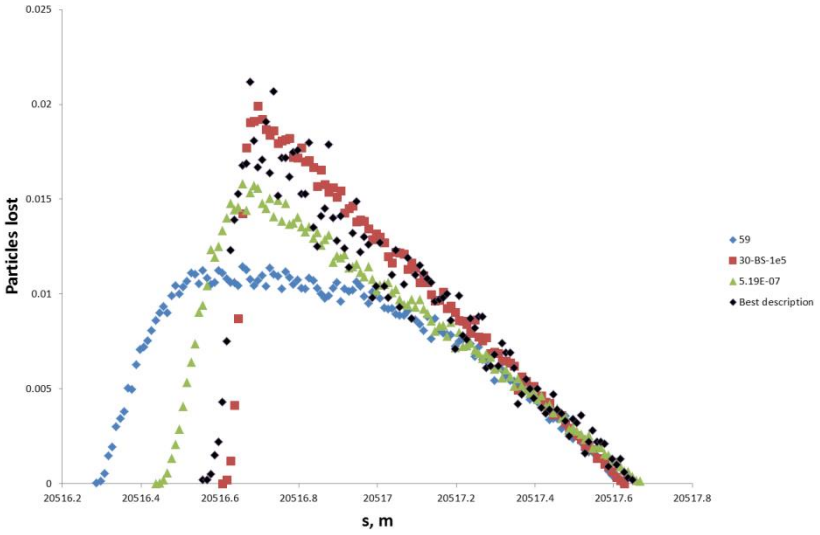
Initial Qx(MadX) = 64.261 smaller than Qx(exp)=64.278

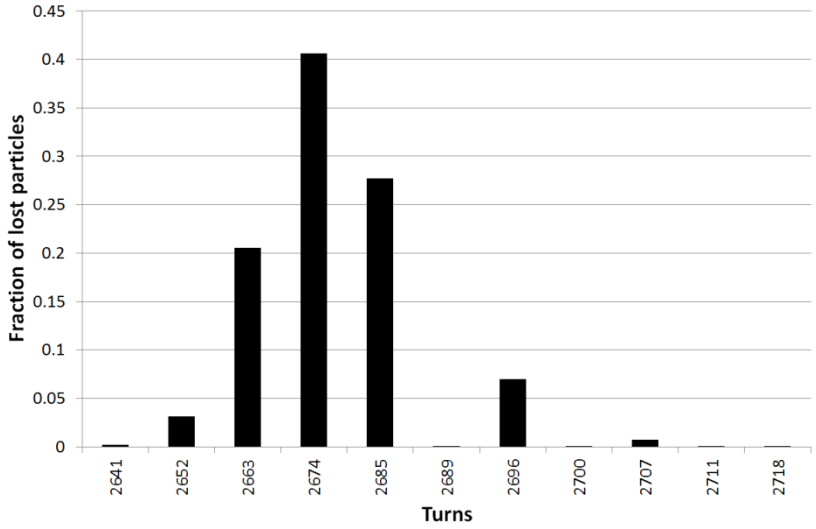
1. Fast Losses Quench Test

CONCLUSIONS

"Best" distribution according to the latest concept:

- Initial tunes Qx= 64.278, Qy = 59.3019
- No matching after applying the orbital bump
- Beam size and offset as in the experiment
- Correcting for the tune during the excitation





1. Fast Losses Quench Test

CONCLUSIONS

1. Tune, beam size/profile and amplitude of the bump influence the longitudinal- and the time- distributions.

2. The longitudinal location always stays within front ~1.5 m (first half) of the MQ.

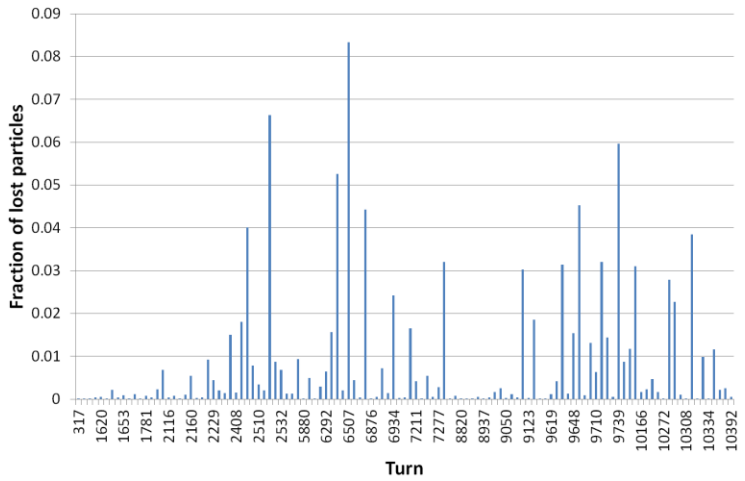
3. The experimental time-distribution of the losses could not be used for the verification of the simulations, because the longitudinal distribution already depends on the turn within one excitation scenario.

2. Steady-State-Loss Quench Test

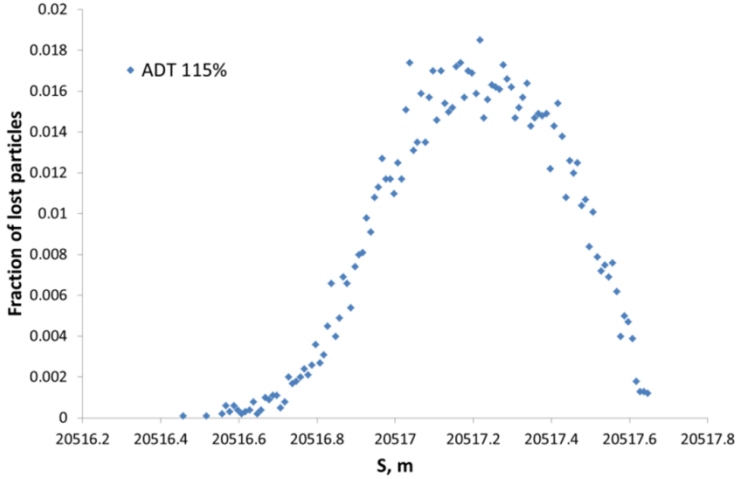
	Experiment		MadX
0	Injecting 24 bunches to the LHC	0	1 bunch at the LHC. Injection optics: β* are **11/10/11/10**, Energy 4 TeV. Beam profile – from BWS measurements.
1	Ramping to the nominal energy		
2	Increasing 3-corr. orbit bump until losses occur, then reducing the bump	1	3-corr. orbit bump with an offset $4.3\sigma_{nom}$ from the beam screen (~21.54 mm from the centre of the BS)
3	Gating the ADT on 8 bunches (bunch spacing 1250 ns, therefore ADT could distinguish separate bunches)		
4	Blowing up the gated bunches in the horizontal plane	2	ADT excitation (random kick)

2. Steady-State-Loss Quench Test

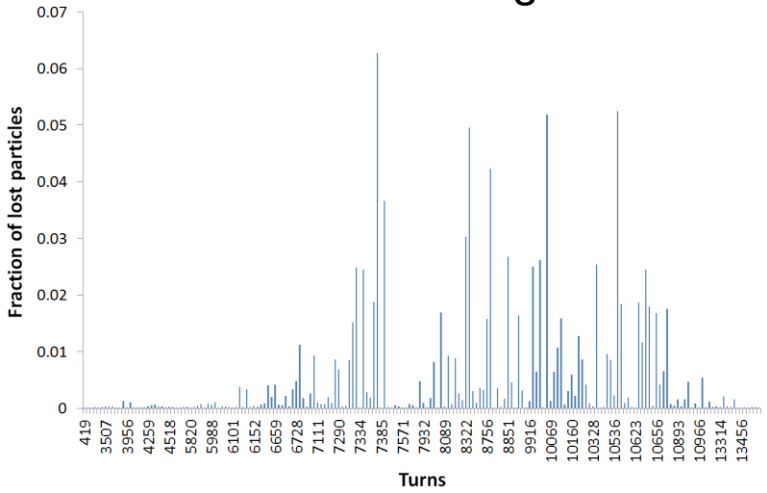
*ADT strength: 115 %



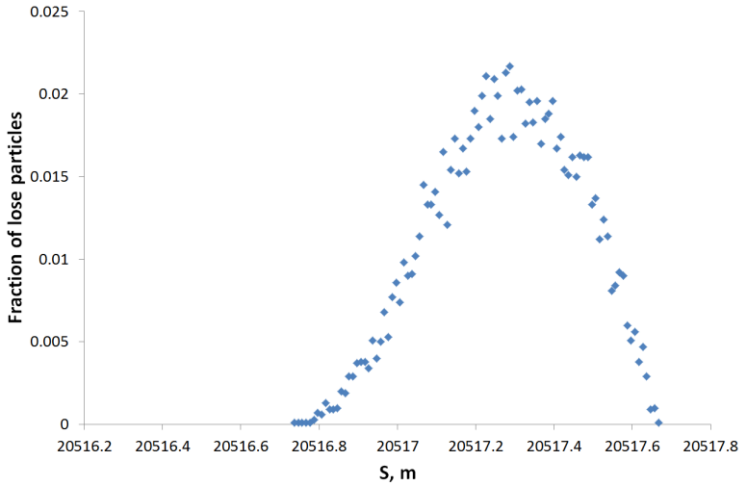
Total loss duration ~ 0.897 s



*ADT strength: 75 %



Total loss duration ~ 1.16 s



The study is still on-going