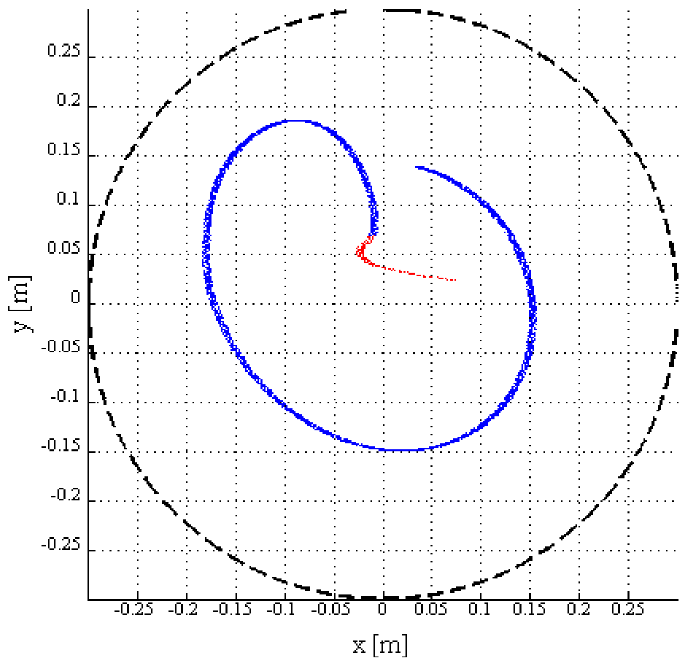
# Consequences of asynchronous beam dump events

Overview of LBDS MADX tracking studies for beam 1




THX to Brennan, Jan, Marcel, Etienne, Kajetan, Alex…

# Outline

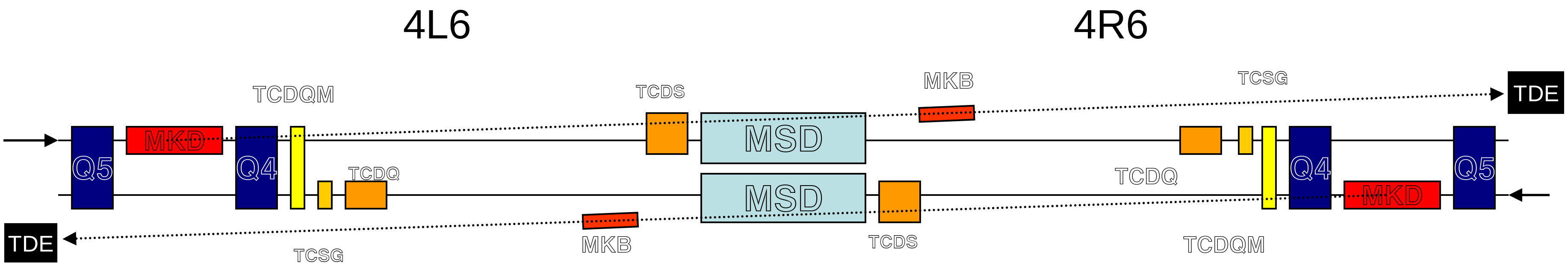
- Methodology
  - Madx setup
  - Particle distributions
  - LHC errors and orbit corrections
  - Aperture model
  - Collimator configuration and settings
  - Asynchronous and pre-trigger failures
  - Post-processing
- Losses for normal/asynch. dumps and failures (dump line & ring)
  - 450 GeV B1 results
    - Asynch, pre-trigger, TCDQ positioning scan, IR7 collimators retracted
  - 7 TeV B1 results
    - Asynch, pre-trigger,TCDQ positioning scan, IR7 collimators retracted
- Conclusions and outlook

# Madx setup

- MadX tracking “thintrack module”

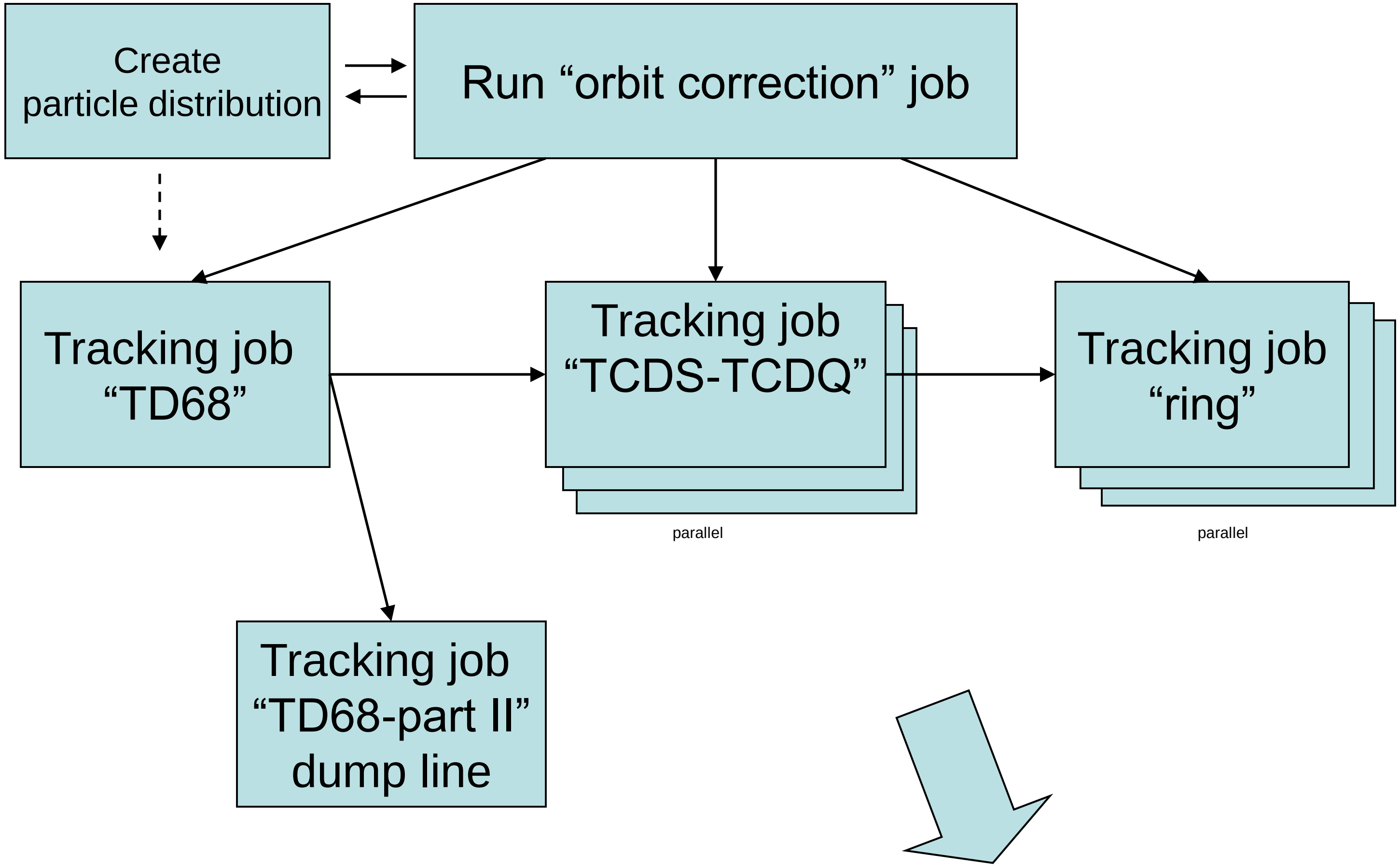
    - Set parameters ( apertures, collimators, errors (MQY,MKD,MSD), orbit, generate particle ensemble)

    - While loop architecture to set time dependent parameters (e.g.kickers)




LBDS - overview

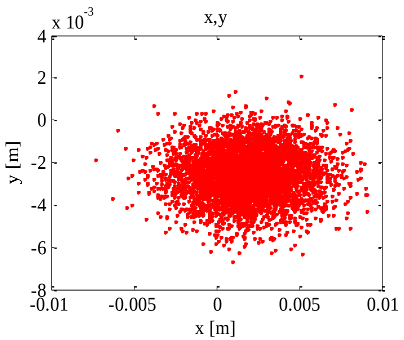
# MADX setup

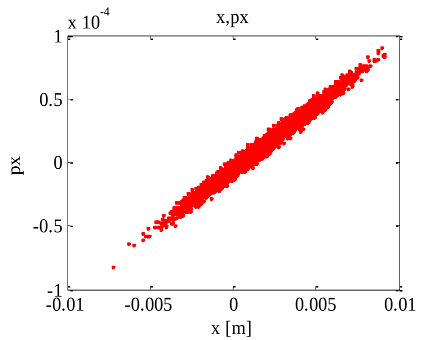


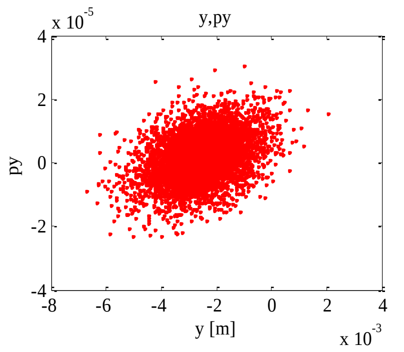

Raw loss data for
post processing

# Initial Particle Distribution

"Gaussian beam"



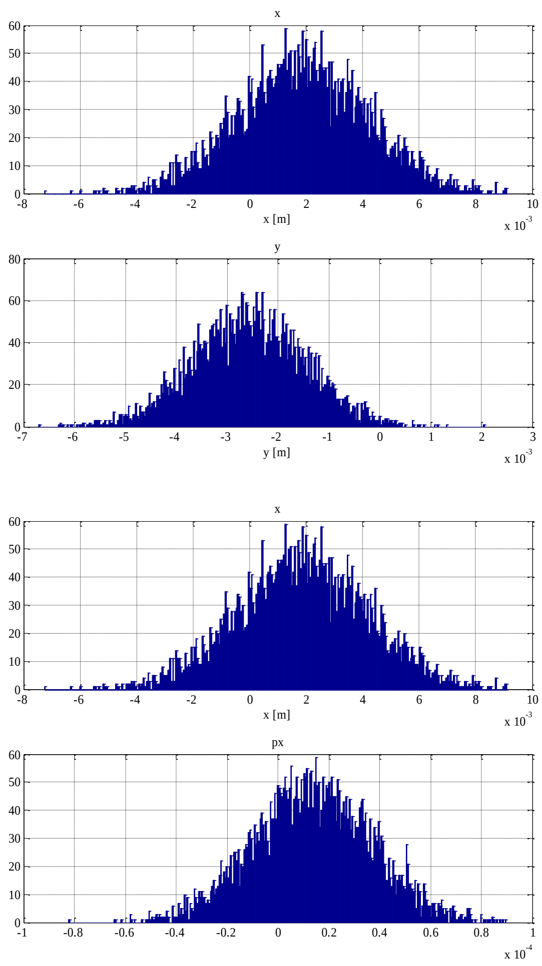




For s= start of TD68

450 GeV

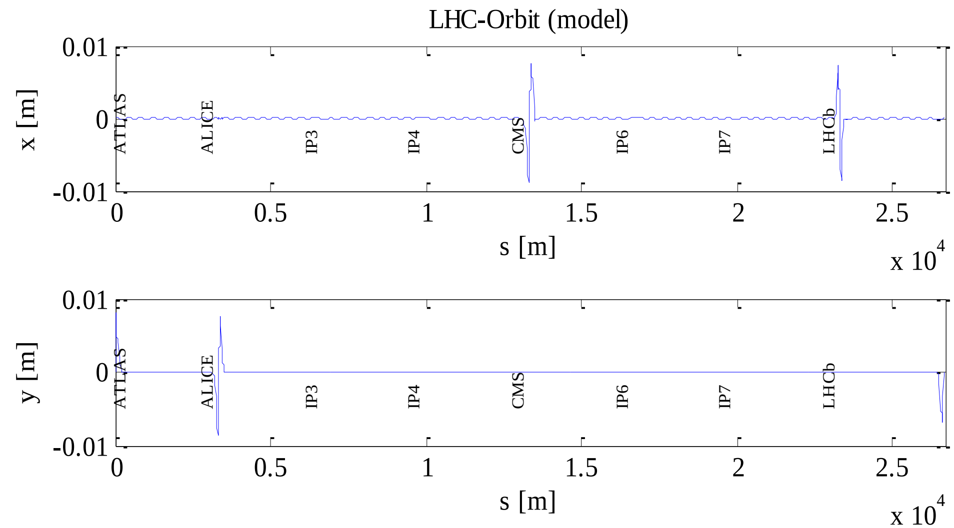
Norm. emittance 3.75E-6

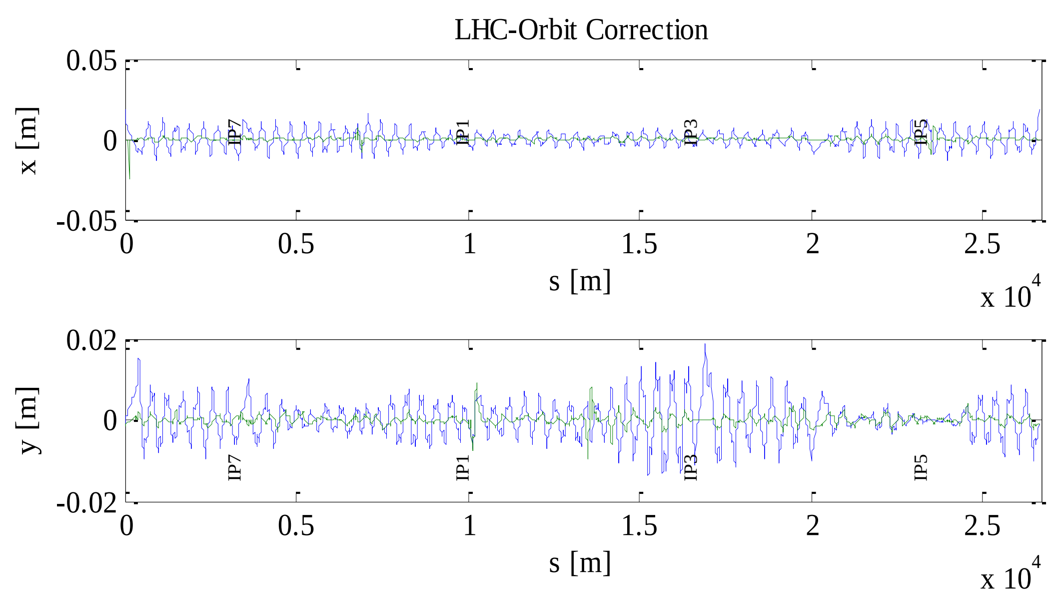



Particle distribution is created in Q5, tracked around the LHC (10 turns), with collimators in place, orbit and all errors included, and then saved as initial distribution

# Assumed errors and orbit correction

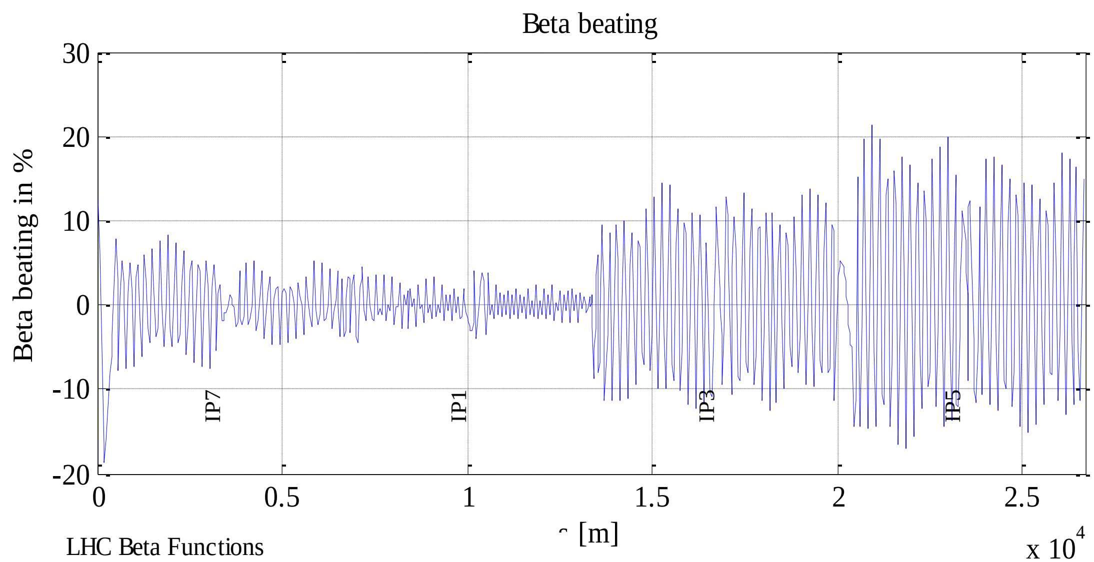
- LHC Orbit
  - Apply random errors
    - Quads (0.37 mm LHC PN 247)
    - MB field error (B0 1E-3 > LHC PR 501)
    - BPM (0.2 mm
      LHC PN 347)
  - Micado orbit correction
    - ~7 mm ptp in x
    - ~8.9 mm ptp in y
    - < 4 mm ptp in LSS6
- LSS6
  - MKD kick error (1%)
  - MQY field errors (0.5%)
  - MSD field error (w.c. power cut)
  - MKB dilution failurs
- Whole ring
  - Aperture & beam screen tolerances

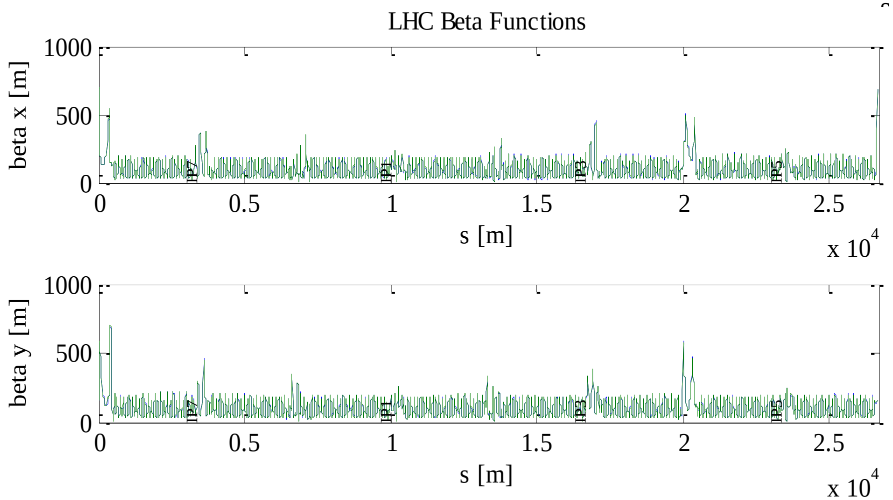


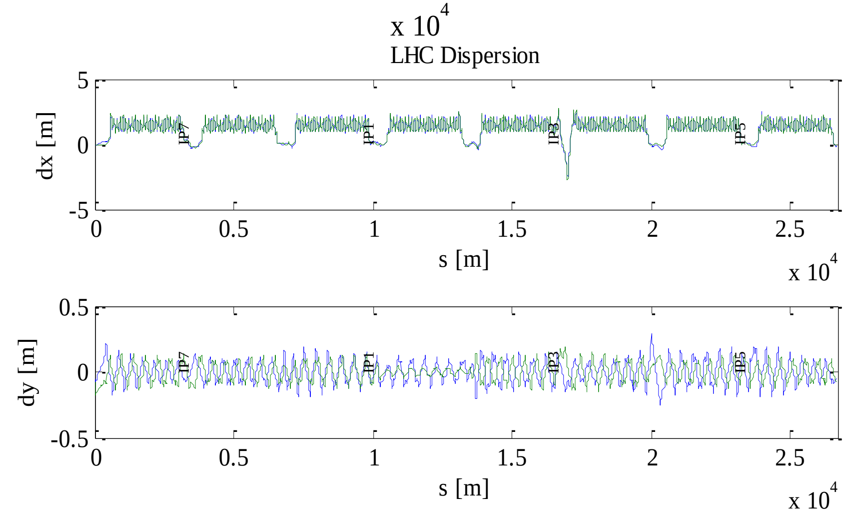



# Optics and beta-beating

- So far not included: quadrupole and higher order field errors



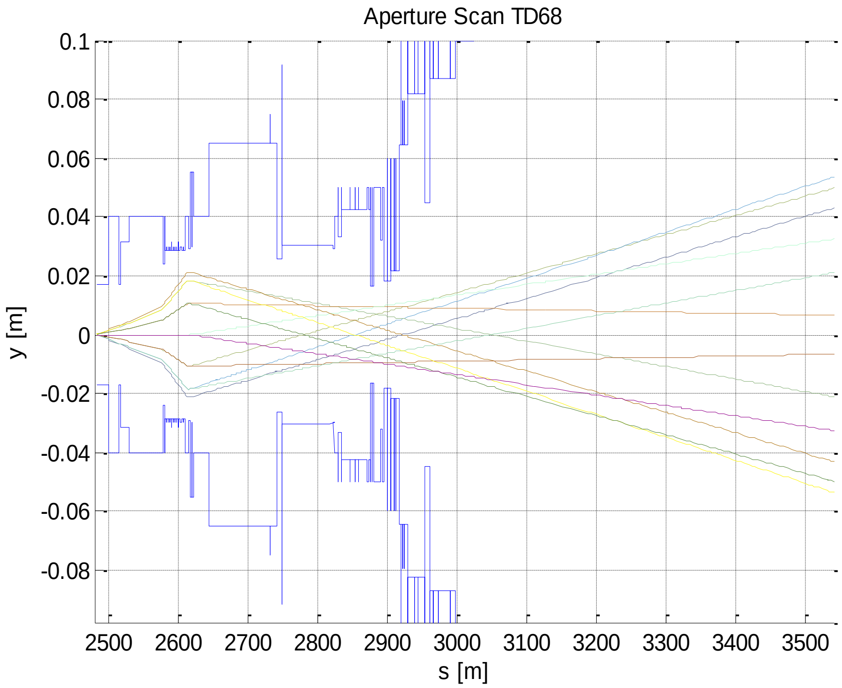



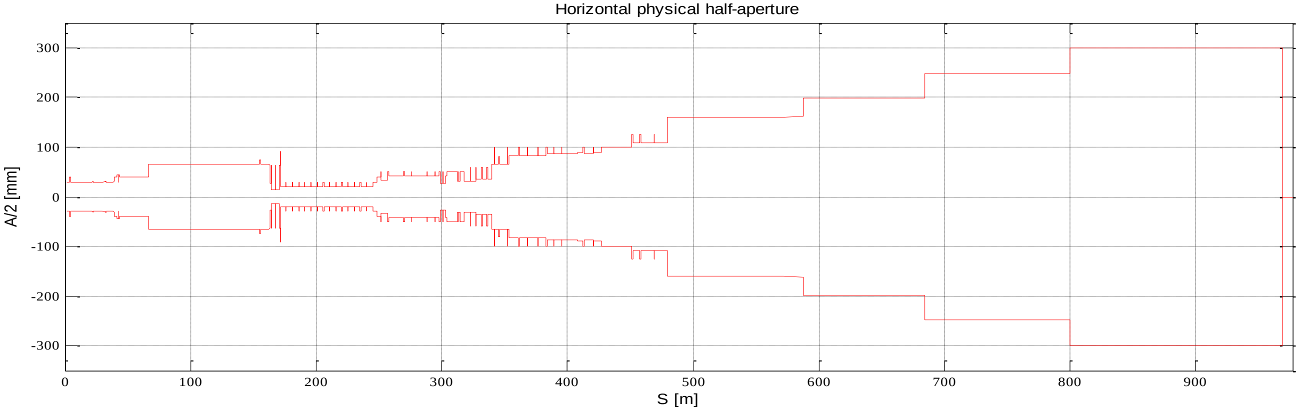



# Aperture model

- Self made aperture model for TD62,TD68 and MQY5L6-MQY5R6

- upgraded “Official LHC aperture”
  - Collimators
  - “some” additional detector apertures ( CMS roman pots, LHCb…)



# Collimator configuration and settings

Aperture for all (phase 2) collimators, masks and protection elements added

Collimators are aligned in respect to the beam orbit & energy

| | 450 GeV | | | 7 TeV | | |
|---|---|---|---|---|---|---|
| | TCP | TCSG | TCLA | TCP | TCSG | TCLA |
| IR3 | 8.0 | 9.3 | 10.0 | 15.0 | 18.0 | 20.0 |
| IR7 | 5.7 | 6.7 | 10.0 | 6.0 | 7.0 | 10.0 |
| | TCSG | TCDQ | | TCSG | TCDQ | |
| IR6 | 7 | 8 | | 7.5 | 8 | |
| | TCLI | TDI | | TCT | | |
| IR2/8 | 6.8 | 6.8 | | 8.3 | | |
| | | | | TCT | TCLP | |
| IR1/5 | | | | 8.3 | 10 | |

LHC PR 1013

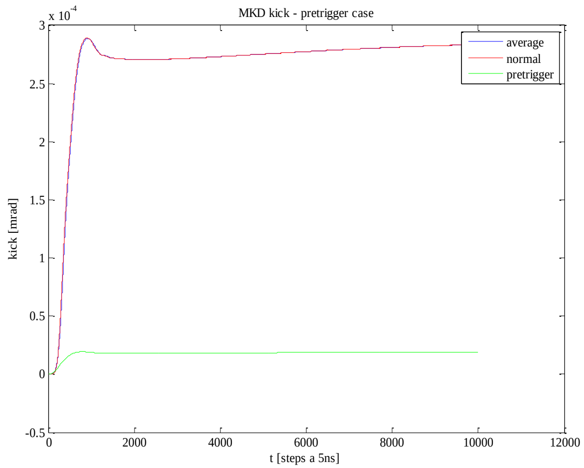
Thesis G. Robert-Demolaize

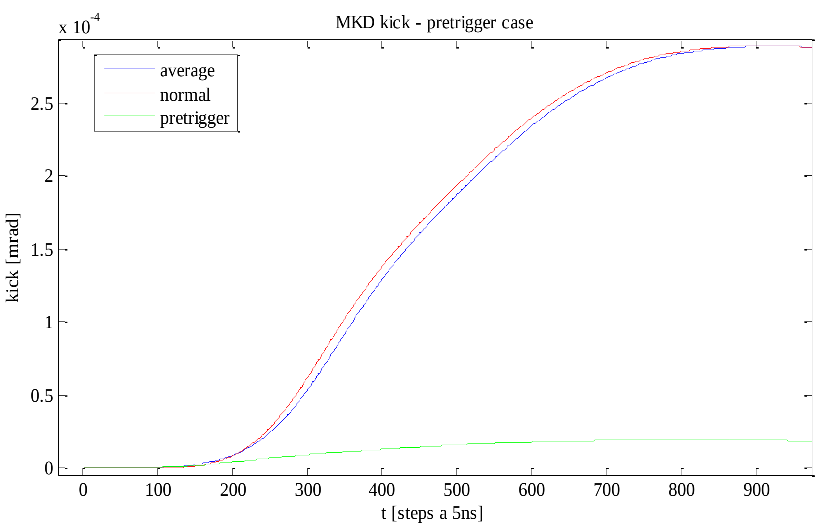
# Treatment of skew elements

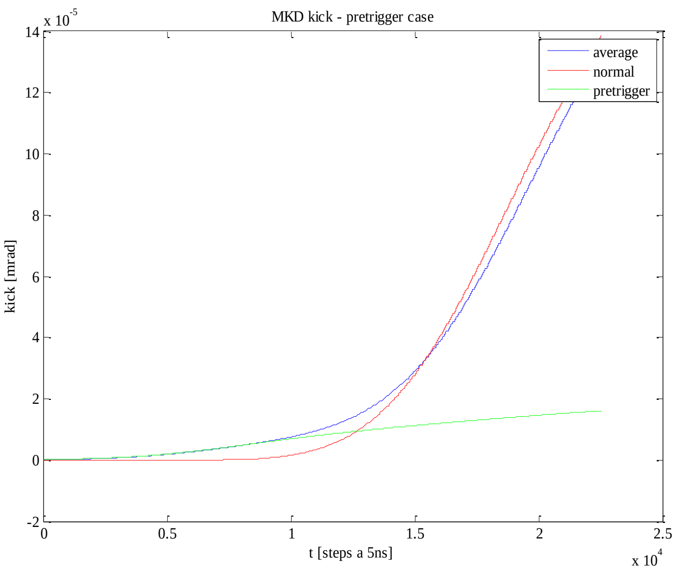
- Skew collimators turned out to be a delicate issue within the MADX simulations
- Thintrack does not support tilted apertures
- An approach using ealign (dpsi) seemed to be the solution but spoiled the whole code ( “tune changing collimators” ) -> never ever use ealign with big angles
- Another meaningful approach is to rotate the whole sequence
- So far not implemented -> thus no IR7 skew collimators have been considered so far

# Asynchronous - pre-trigger failures

- MKD retrigger delays
  - 450 GeV 1 µs + cable delay
  - 7 TeV 0.5 µs + cable delay (5 ns/m)
  - Values from lab, not yet measured in tunnel



# Post-processing

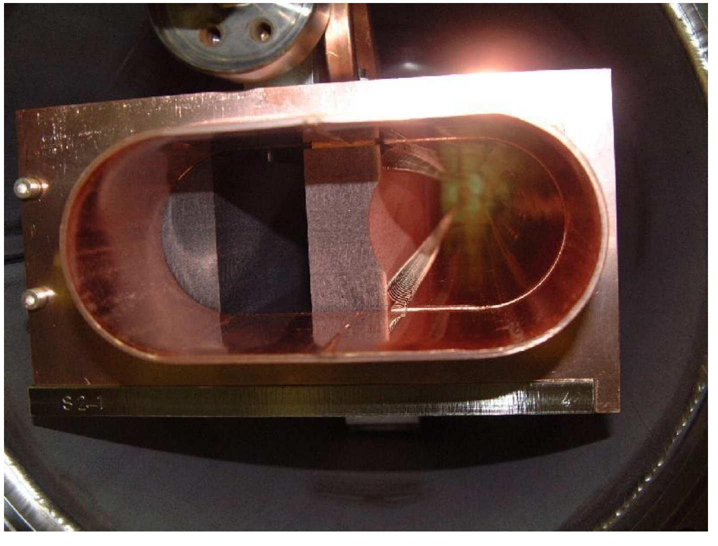
- MADX raw data is read into MATLAB
- tfs tables from jobs are combined to one big matrix which is processed
- Works quite well for single orbit case
- read data routine takes time → 100 different orbits will need several hours CPU time

# Cases covered

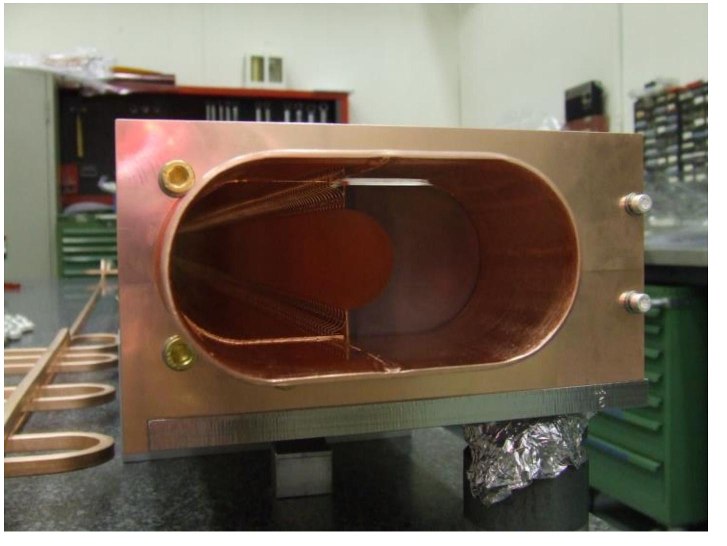
| Case | Failure | Beam | Energy | Emittance | TCDQ/TCS position | Orbit (peak) | Beta-beat (peak) | Collimator positions | TCT positions | Covered |
|---|---|---|---|---|---|---|---|---|---|---|
| Asynch nominal | Asynch | B1 | 450 GeV | 3.75 | Nominal | 4 mm | 20% | Nominal | Nominal | X |
| Pretrigger nominal | Pretrigger | B1 | 450 GeV | 3.75 | Nominal | 4 mm | 20% | Nominal | Nominal | X |
| Asynch TCDQ pos | Asynch | B1 | 450 GeV | 3.75 | 0, 0.5, …10 s error | 4 mm | 20% | Nominal | Nominal | X |
| Pretrigger TCDQ pos | Pretrigger | B1 | 450 GeV | 3.75 | 0, 0.5, …10 s error | 4 mm | 20% | Nominal | Nominal | X |
| Asynch orbit tol | Asynch | B1 | 450 GeV | 3.75 | Nominal | 4, 5, 6, 10mm obit | 20% | Nominal | Nominal | |
| Pretrigger orbit tol | Pretrigger | B1 | 450 GeV | 3.75 | Nominal -0.5s | 4, 5, 6, 10mm obit | 20% | Nominal | Nominal | X |
| Asynch optics tol | Asynch | B1 | 450 GeV | 3.75 | Nominal | 4 mm | 20, 40, 60, 80, 100% | Nominal | Nominal | |
| Pretrigger optics tol | Pretrigger | B1 | 450 GeV | 3.75 | Nominal | 4 mm | 20, 40, 60, 80, 100% | Nominal | Nominal | X |
| Asynch coll out | Asynch | B1 | 450 GeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Nominal | X |
| Pretrigger coll out | Pretrigger | B1 | 450 GeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Nominal | X |
| Asynch coll, TCT out | Asynch | B1 | 450 GeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Retracted | X |
| Pretrigger coll, TCT out | Pretrigger | B1 | 450 GeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Retracted | X |
| Asynch emitt | Asynch | B1 | 450 GeV | 5, 10, 15 | Nominal | 4 mm | 20% | Nominal | Nominal | |
| Pretrigger emitt | Pretrigger | B1 | 450 GeV | 5, 10, 15 | Nominal | 4 mm | 20% | Nominal | Nominal | X |
| Asynch nominal | Asynch | B1 | 7 TeV | 3.75 | Nominal | 4 mm | 20% | Nominal | Nominal | X |
| Pretrigger nominal | Pretrigger | B1 | 7 TeV | 3.75 | Nominal | 4 mm | 20% | Nominal | Nominal | X |
| Asynch TCDQ pos | Asynch | B1 | 7 TeV | 3.75 | 0, 0.5, …10 s error | 4 mm | 20% | Nominal | Nominal | |
| Pretrigger TCDQ pos | Pretrigger | B1 | 7 TeV | 3.75 | 0, 0.5, …10 s error | 4 mm | 20% | Nominal | Nominal | X |
| Asynch orbit tol | Asynch | B1 | 7 TeV | 3.75 | Nominal | 4, 5, 6, 10mm obit | 20% | Nominal | Nominal | |
| Pretrigger orbit tol | Pretrigger | B1 | 7 TeV | 3.75 | Nominal | 4, 5, 6, 10mm obit | 20% | Nominal | Nominal | X |
| Asynch optics tol | Asynch | B1 | 7 TeV | 3.75 | Nominal | 4 mm | 20, 40, 60, 80, 100% | Nominal | Nominal | |
| Pretrigger optics tol | Pretrigger | B1 | 7 TeV | 3.75 | Nominal | 4 mm | 20, 40, 60, 80, 100% | Nominal | Nominal | X |
| Asynch coll out | Asynch | B1 | 7 TeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Nominal | |
| Pretrigger coll out | Pretrigger | B1 | 7 TeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Nominal | X |
| Asynch coll, TCT out | Asynch | B1 | 7 TeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Retracted | |
| Pretrigger coll, TCT out | Pretrigger | B1 | 7 TeV | 3.75 | 0,0.5, 10 s error | 4 mm | 20% | IR7 retracted | Retracted | X |
| Asynch emitt | Asynch | B1 | 7 TeV | 5, 10, 15 | Nominal | 4 mm | 20% | Nominal | Nominal | |
| Pretrigger emitt | Pretrigger | B1 | 7 TeV | 5, 10, 15 | Nominal | 4 mm | 20% | Nominal | Nominal | X |

# Asynchronous beam dump

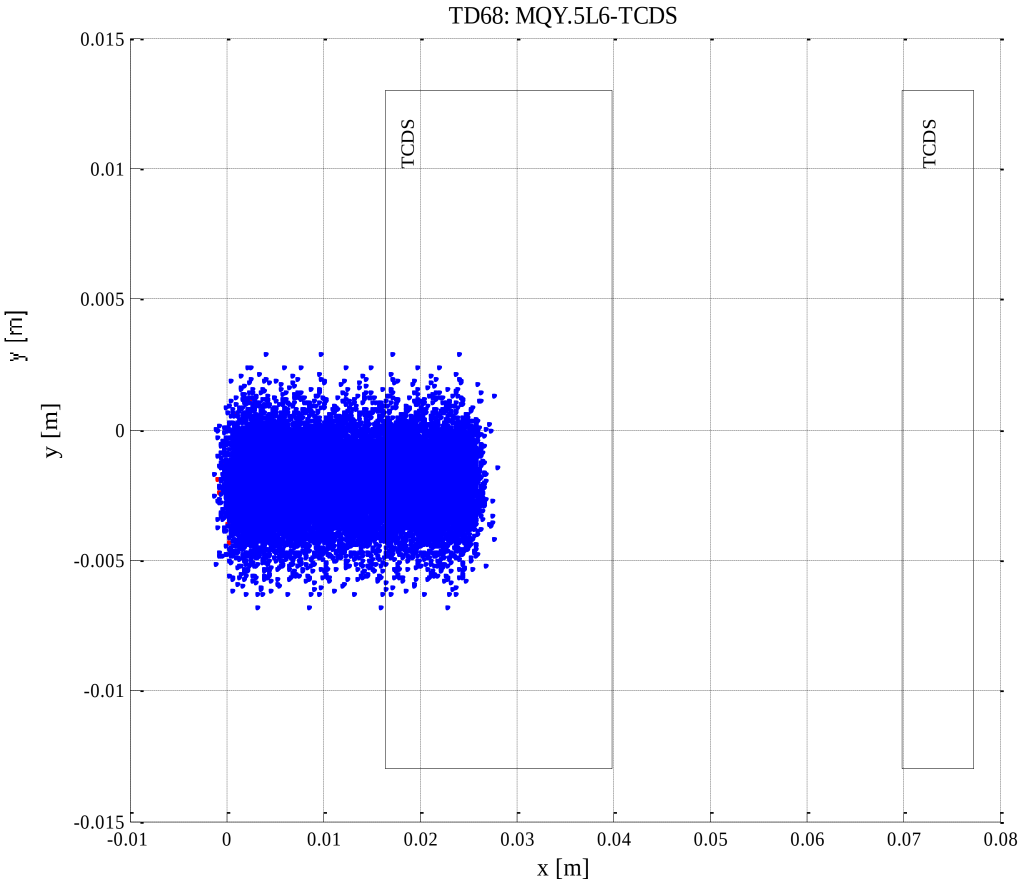
- Kickers are not fired correctly within the abort gap  thus beam is swept over the TCDS aperture
- Fraction of ~1250ns (measured from 1st MKD impact on beam) remains in the accelerator

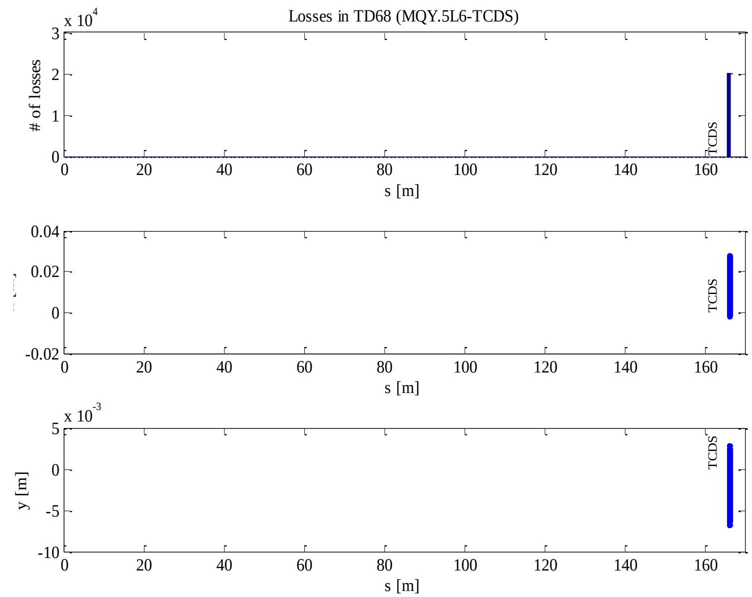


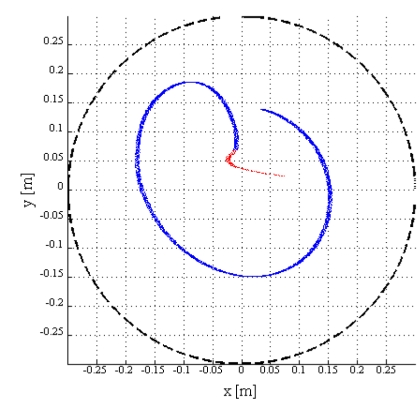
TCDS


TCDQ

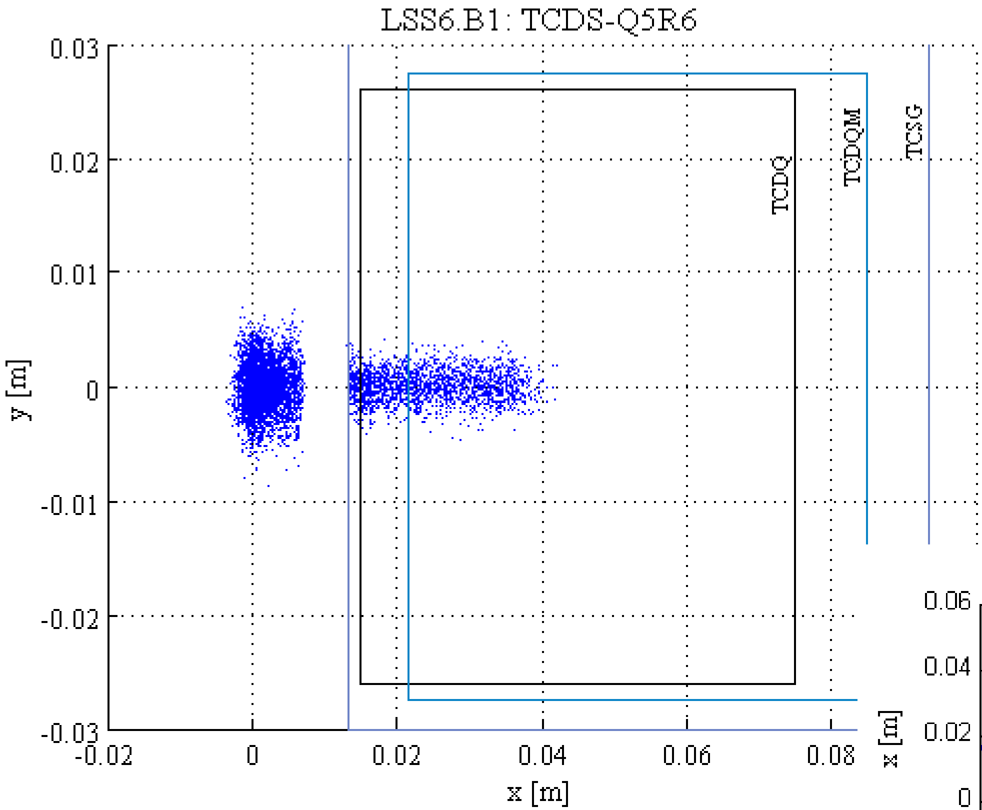
# Results – TCDS and TD68

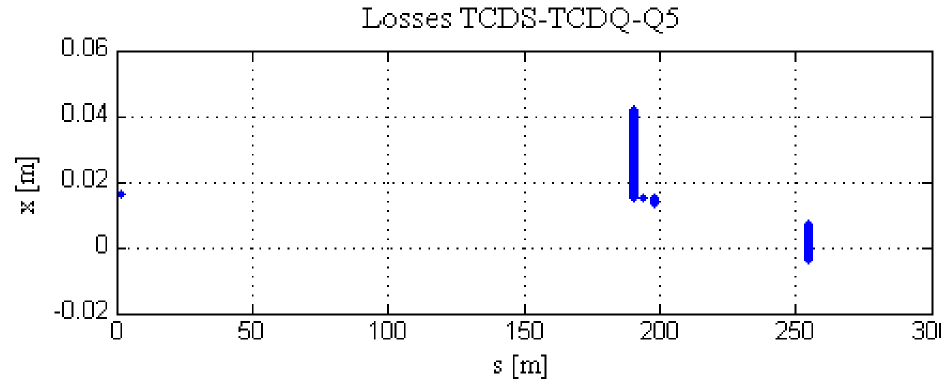


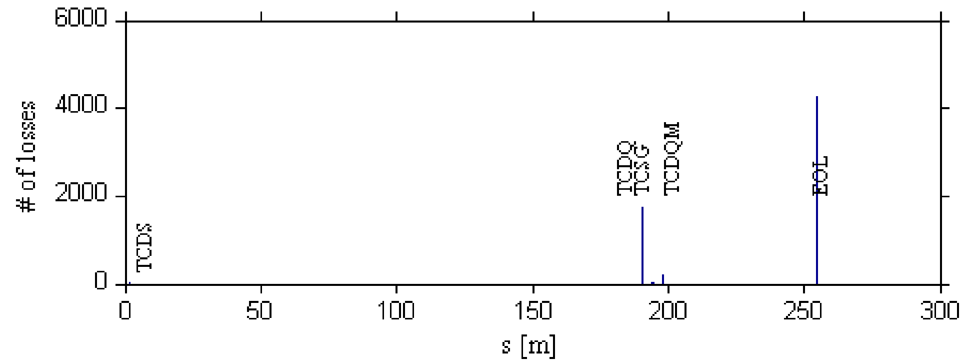



# Results
# TCDS-MQY.5R6



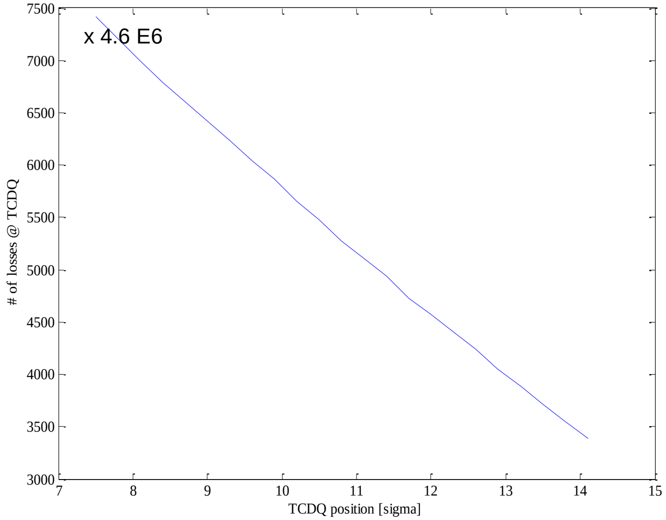



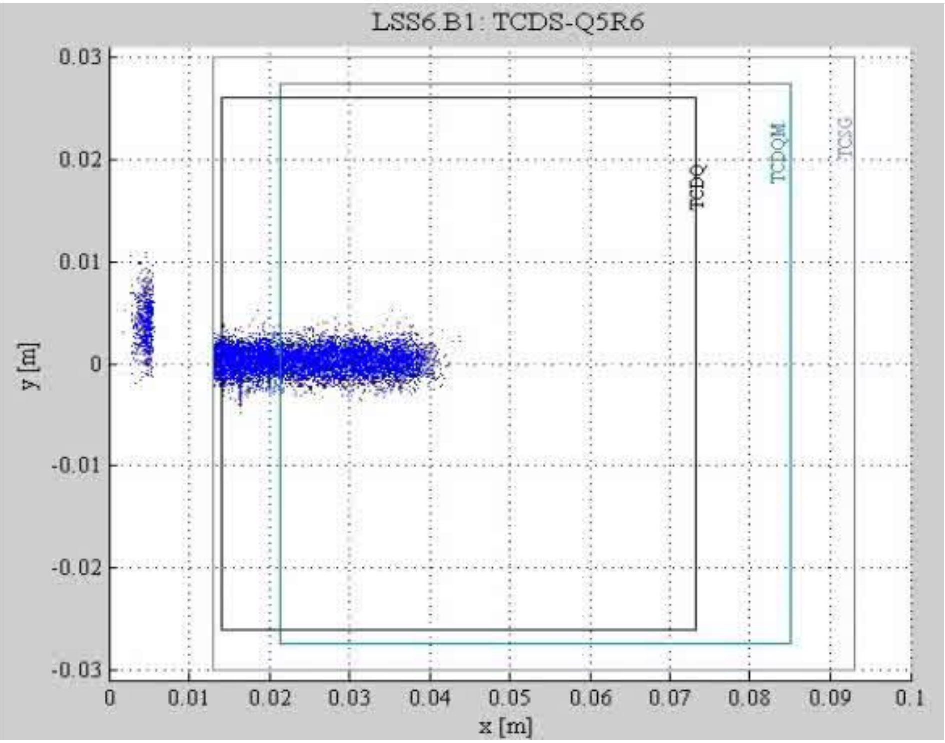

Collimators:

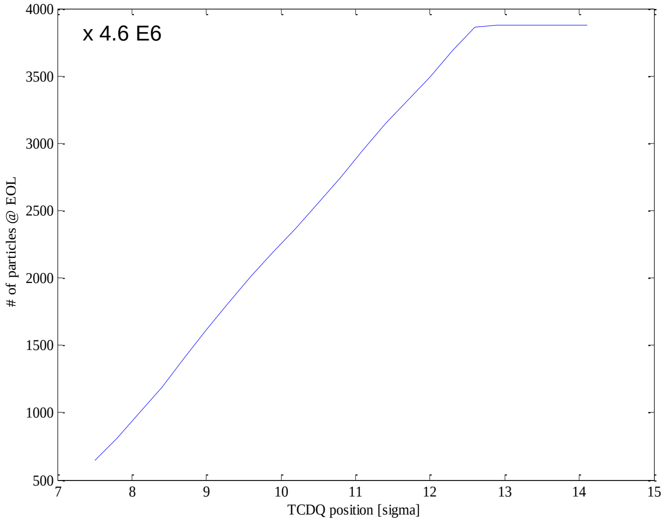
TCDQ 7.5 sigma

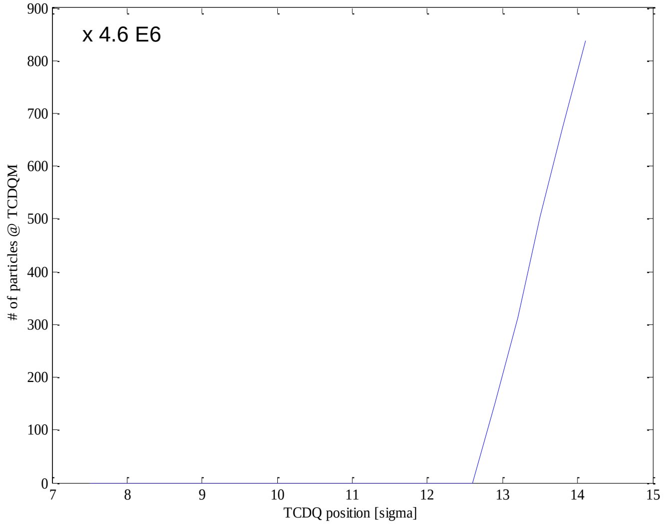
TCDQM 21.5mm

TCSG 6.7 sigma

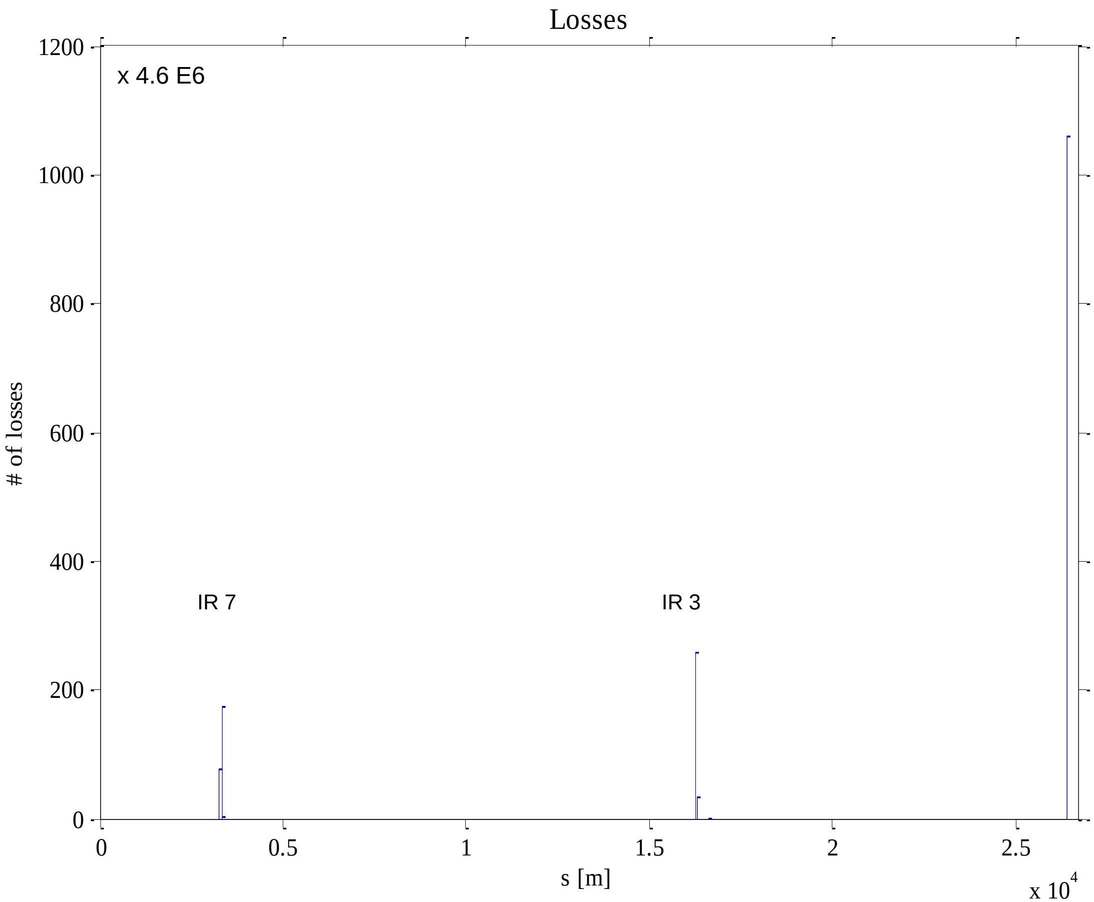

x 4.6 E6
# of losses @ TCDQ
TCDQ position [sigma]


LSS6.B1: TCDS-Q5R6
TCDQ
TCDQM
TCSG
y [m]
x [m]

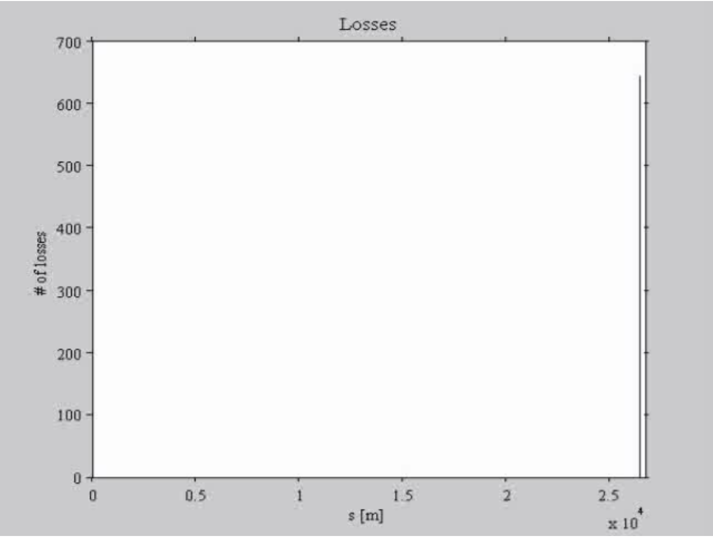

x 4.6 E6
# of particles @ EOL
TCDQ position [sigma]


x 4.6 E6
# of particles @ TCDQM
TCDQ position [sigma]

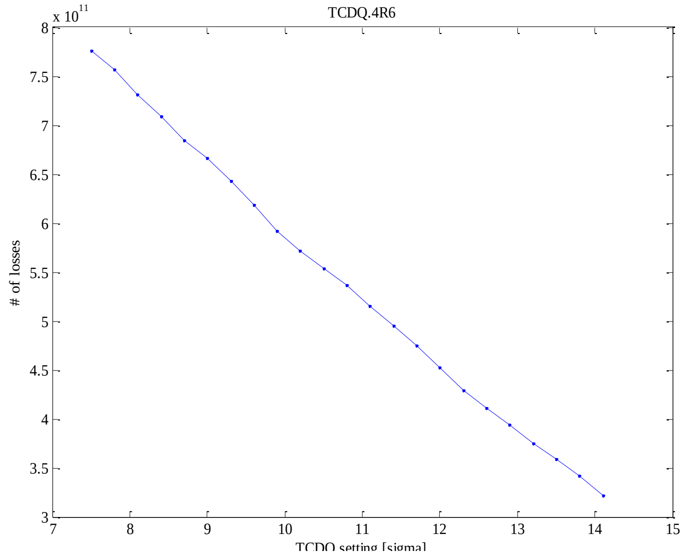
# 450 GeV - nominal



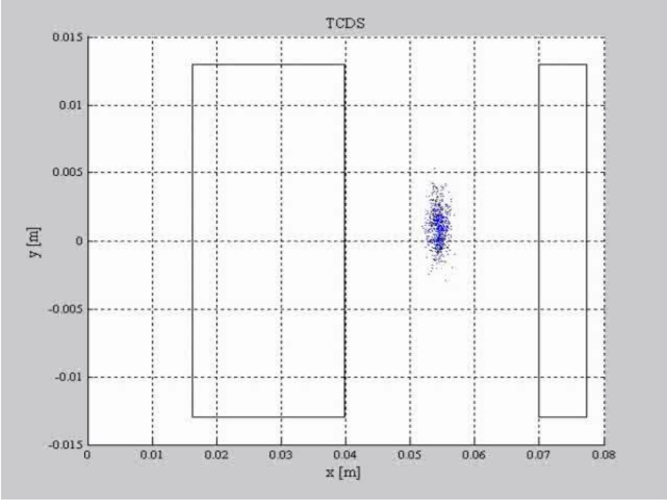

| TCDQ @ 14.1 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 7 |
| 'TCDQM.4R6' | 3.42 |
| TCDSA.4L6.B1'* | 5.31 |
| 'TCLA.6R3.B1' | 0.005 |
| 'TCLA.A7R7.B1' | 0.87 |
| 'TCLA.C6R7.B1' | 0.015 |
| 'TCP.6L3.B1' | 1.3 |
| 'TCSG.4R6' | 1.195 |
| 'TCSG.5L3.B1' | 0.175 |
| 'TCSG.6R7.B1' | 0.39 |
| * no real losses (marker for extr.) | |

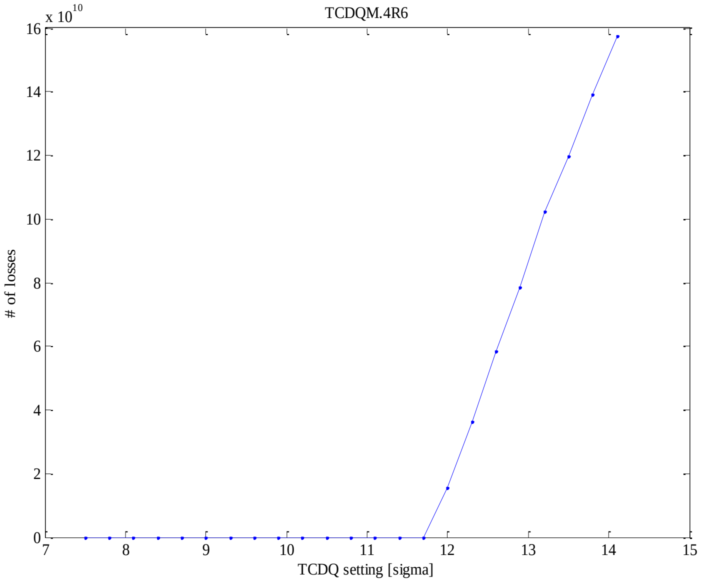


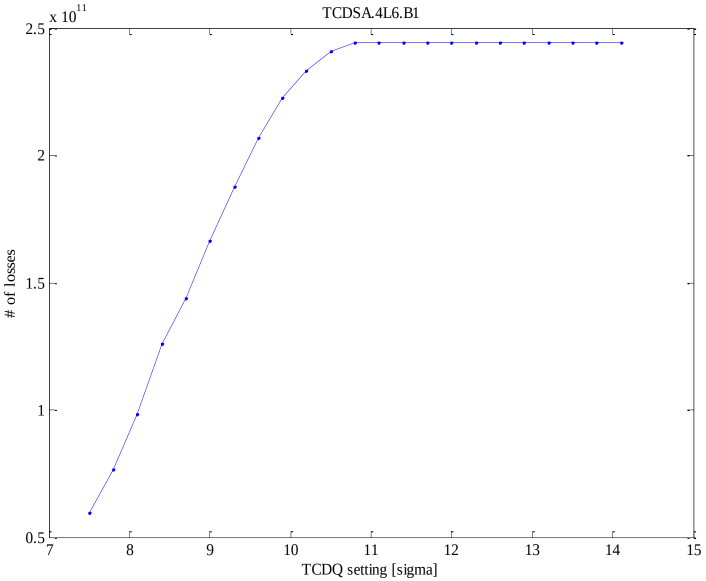
# Losses in IR 6



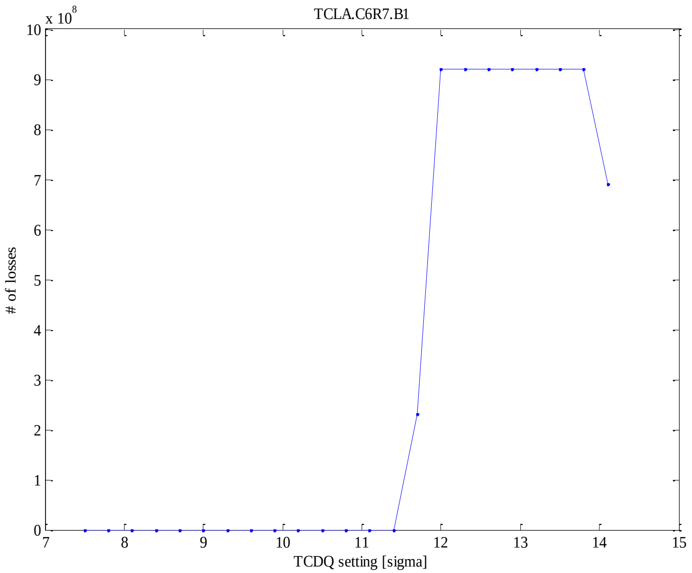

| TCDQ @ 14.1 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 3.22E+11 |
| 'TCDQM.4R6' | 1.57E+11 |
| TCDSA.4L6.B1'* | 2.44E+11 |
| 'TCSG.4R6' | 5.50E+10 |
| * no real losses (marker for extr.) | |

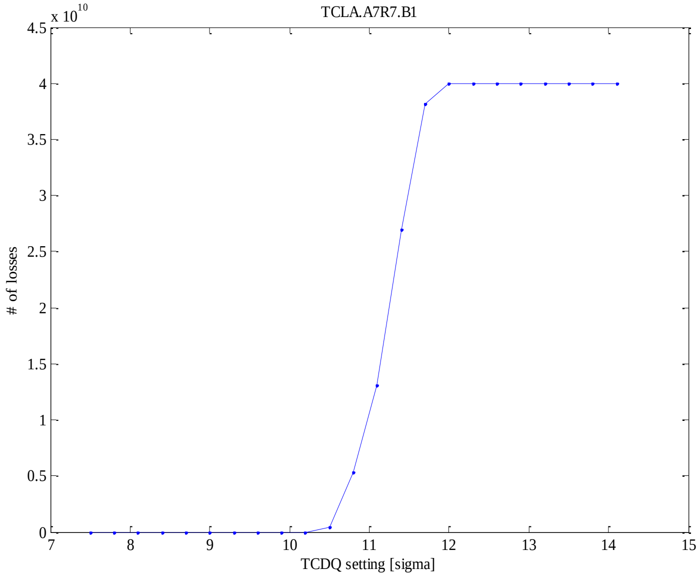


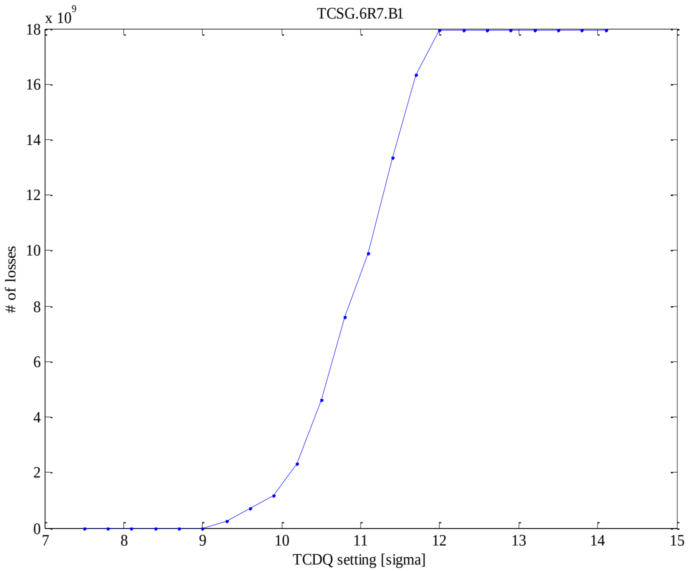



# Losses in IR7

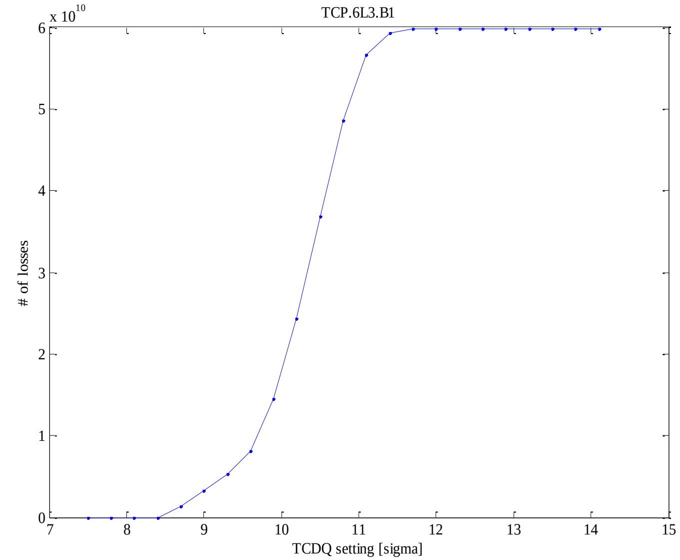


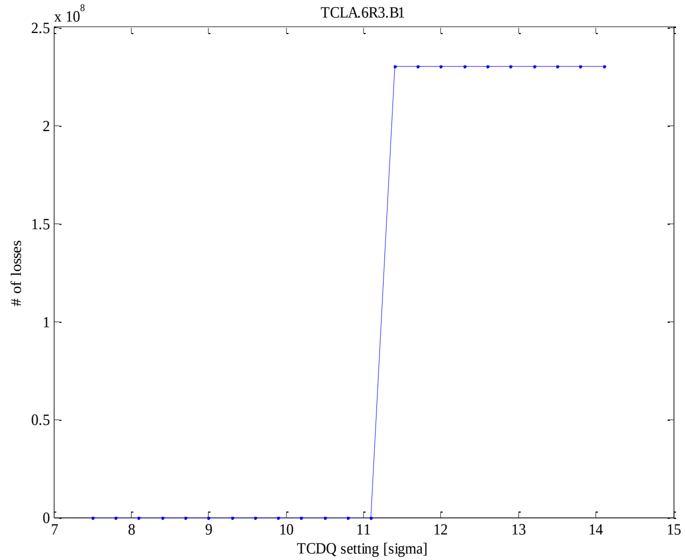



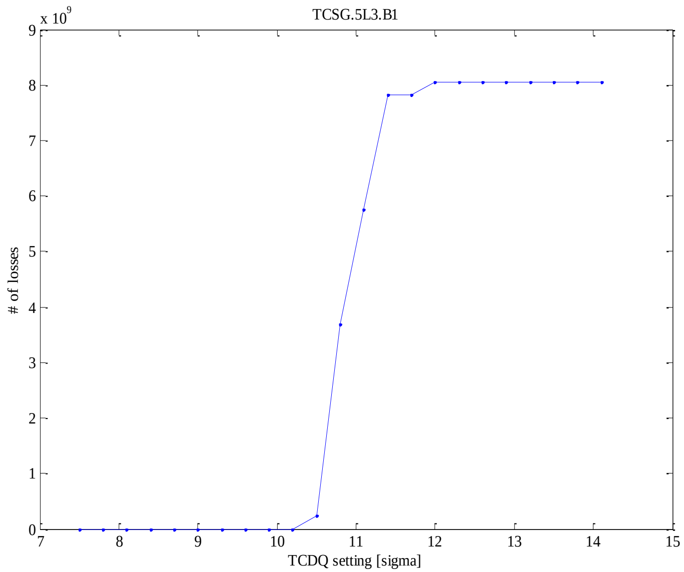




| TCDQ @ 14.1 sigma | |
|---|---|
| Location | % of losses |
| 'TCLA.A7R7.B1' | 4.00E+10 |
| 'TCLA.C6R7.B1' | 6.90E+08 |
| 'TCSG.6R7.B1' | 1.79E+10 |

# Losses in IR3

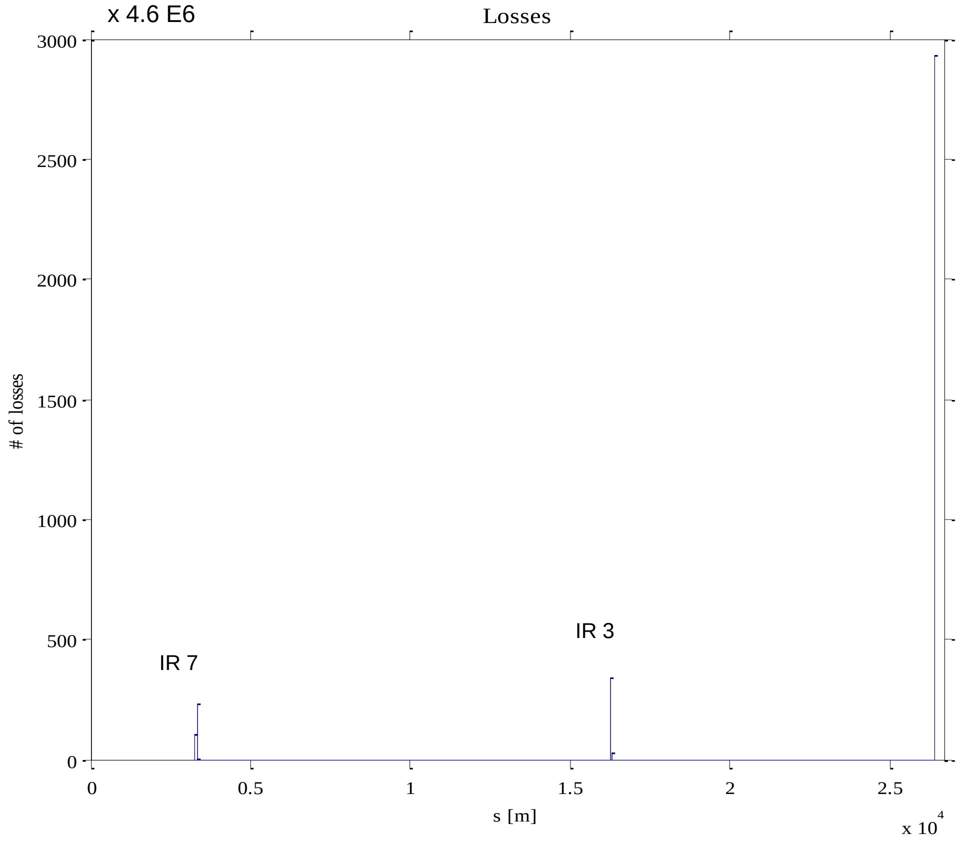


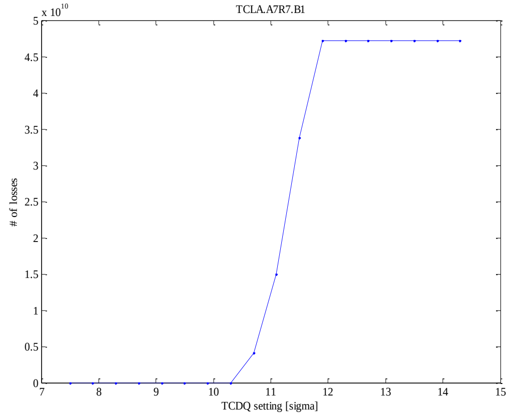



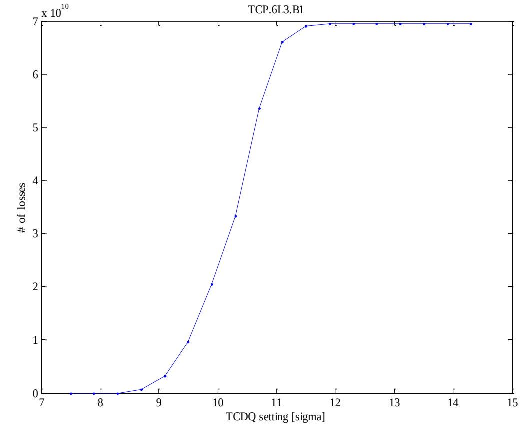

| TCDQ @ 14.1 sigma | |
|---|---|
| Location | % of losses |
| 'TCLA.6R3.B1' | 2.30E+08 |
| 'TCP.6L3.B1' | 5.98E+10 |
| 'TCSG.5L3.B1' | 8.05E+09 |

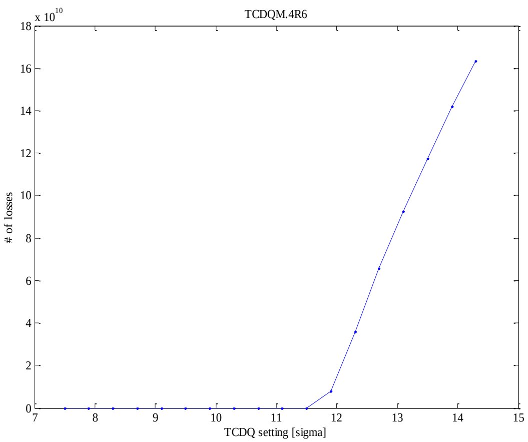
# 450 GeV prefire



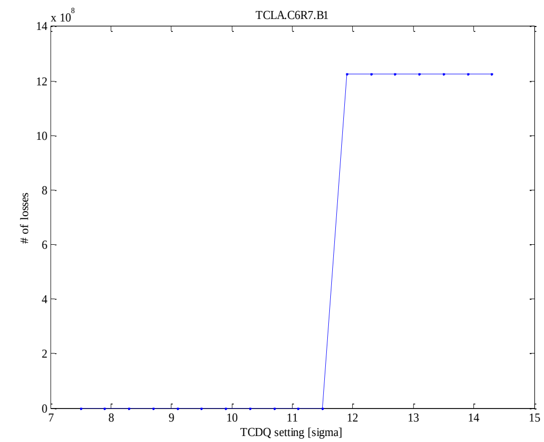

| TCDQ @ 14.3 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 6.2844 |
| 'TCDQM.4R6' | 3.5511 |
| 'TCDSA.4L6.B1' | 13.027 |
| 'TCLA.A7R7.B1' | 1.0267 |
| 'TCLA.C6R7.B1' | 0.026667 |
| 'TCP.6L3.B1' | 1.5111 |
| 'TCSG.4R6' | 1.4089 |
| 'TCSG.5L3.B1' | 0.13333 |
| 'TCSG.6R7.B1' | 0.47556 |
| * no real losses (marker for extr.) | |

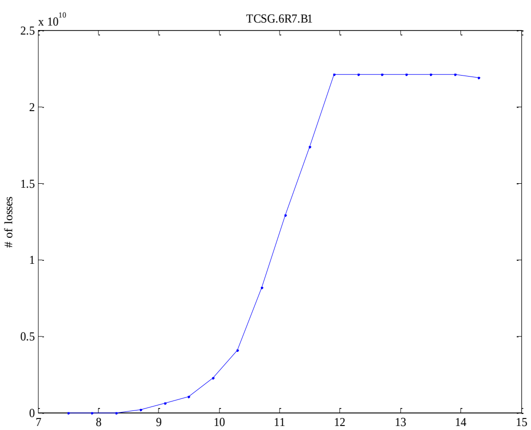


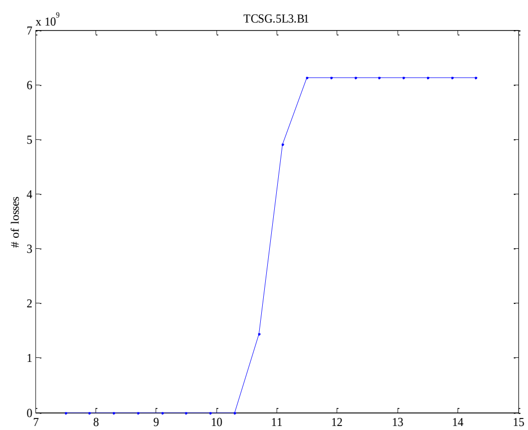



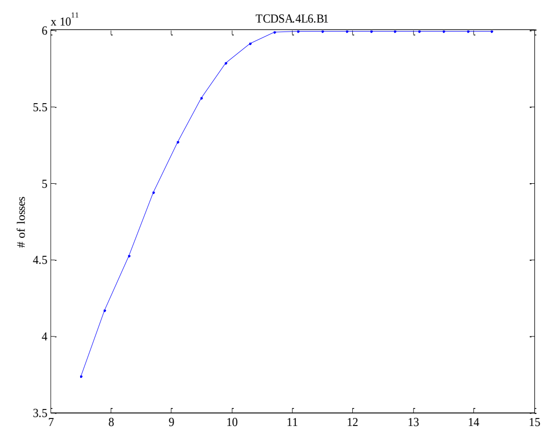




| TCDQ @ 14.3 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 3.25E+11 |
| 'TCDQM.4R6' | 1.84E+11 |
| TCDSA.4L6.B1'* | 6.74E+11 |
| 'TCLA.A7R7.B1' | 5.31E+10 |
| 'TCLA.C6R7.B1' | 1.38E+09 |
| 'TCP.6L3.B1' | 7.82E+10 |
| 'TCSG.4R6' | 7.29E+10 |
| 'TCSG.5L3.B1' | 6.90E+09 |
| 'TCSG.6R7.B1' | 2.46E+10 |
| * no real losses (marker for extr.) | |

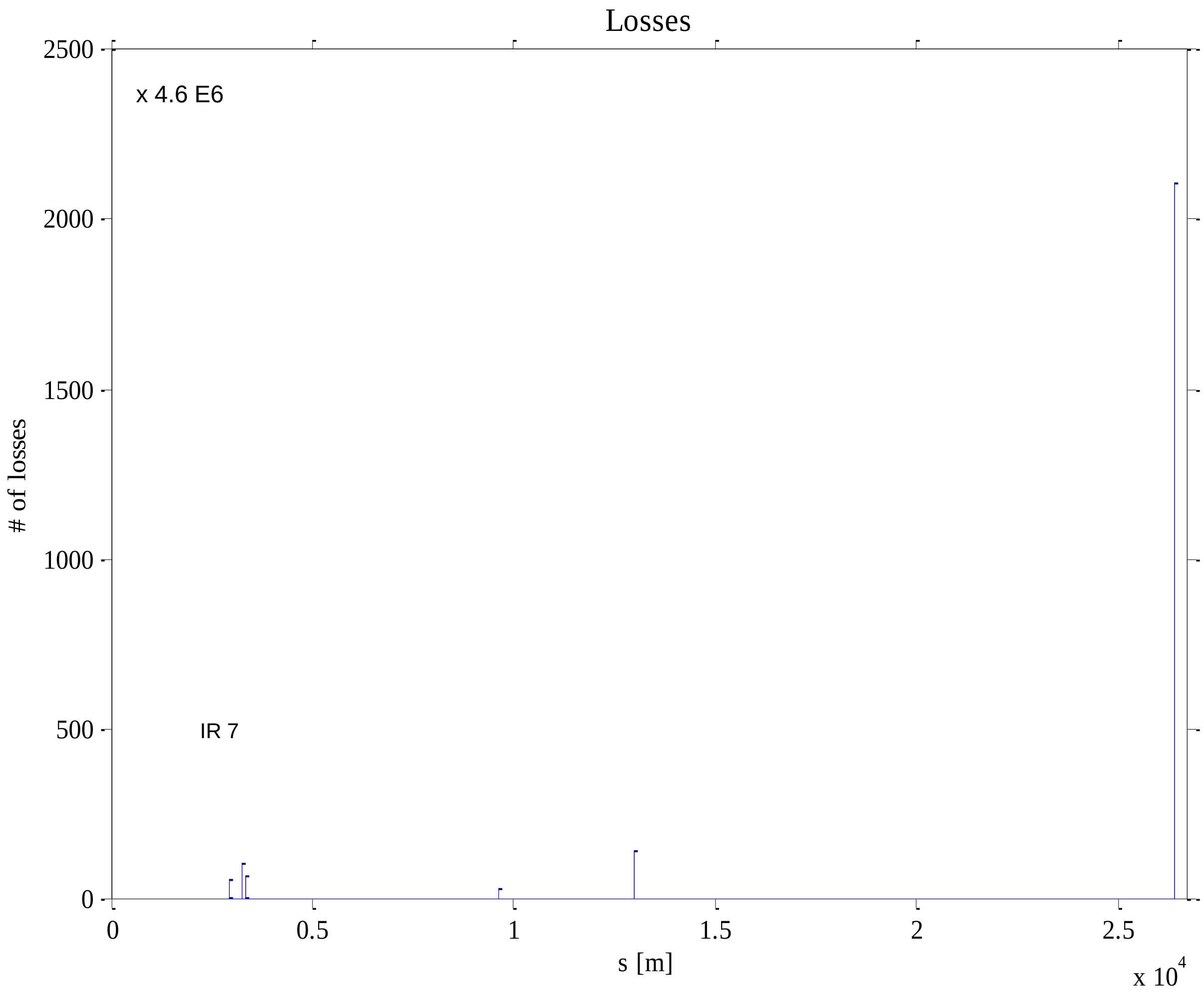


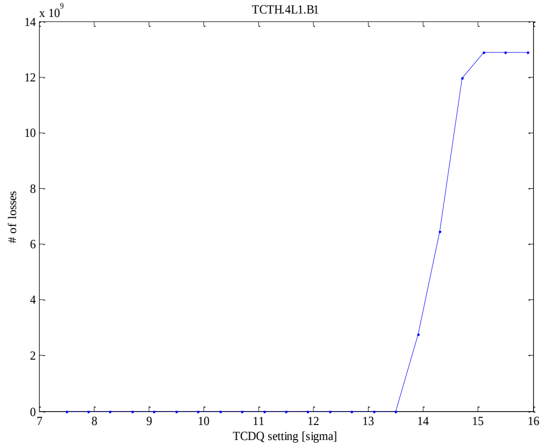



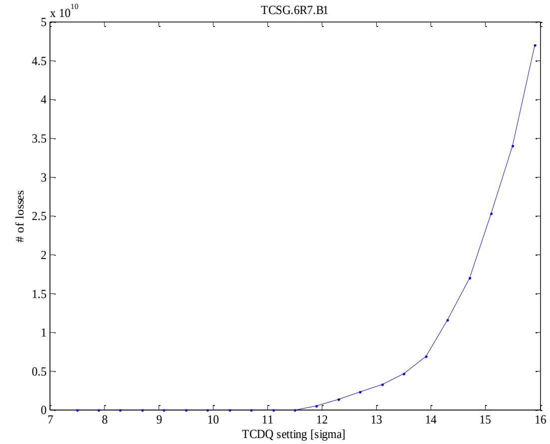



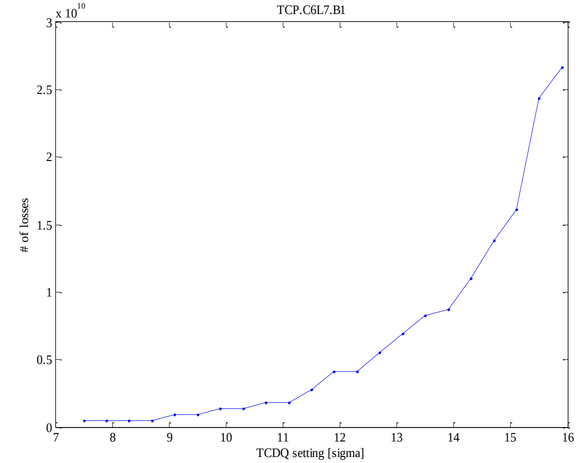
# 7 TeV nominal

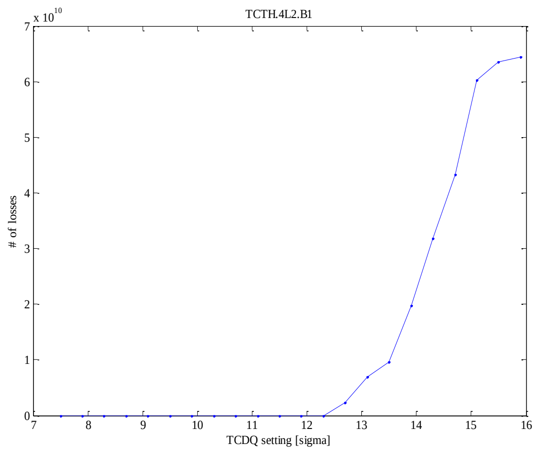



| TCDQ @ 15.5 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 40.624 |
| 'TCDQM.4R6' | 0 |
| TCDSA.4L6.B1'* | 16.88 |
| 'TCLA.A7R7.B1' | 0.336 |
| 'TCLA.C6R7.B1' | 0 |
| 'TCP.B6L7.B1' | 0.04 |
| 'TCP.C6L7.B1' | 0.424 |
| 'TCSG.4R6' | 0.92 |
| 'TCSG.6R7.B1' | 0.592 |
| 'TCTH.4L1.B1' | 0.224 |
| 'TCTH.4L2.B1' | 1.104 |
| * no real losses (marker for extr.) | |

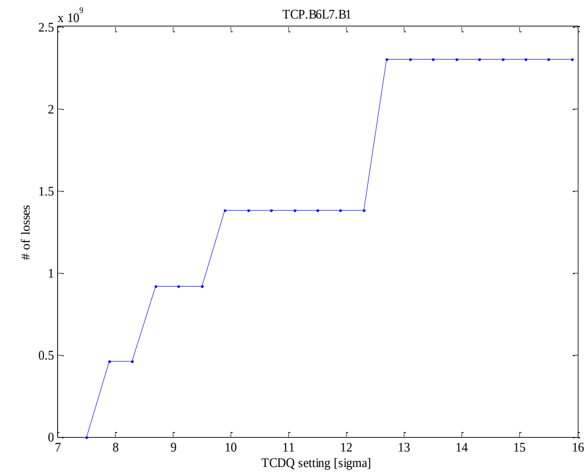


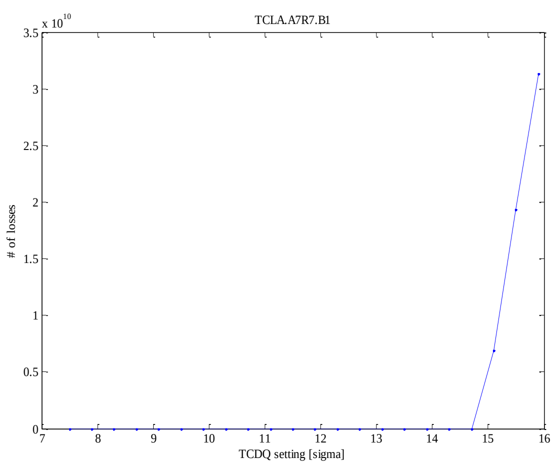



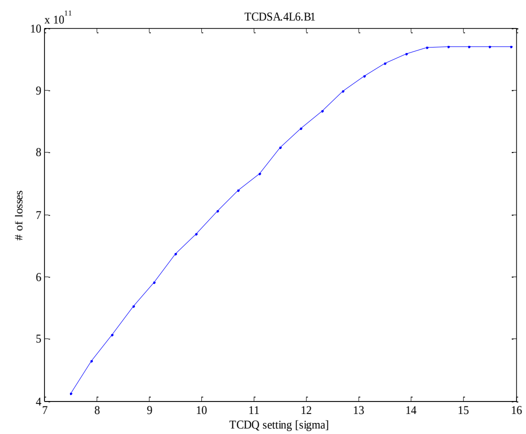



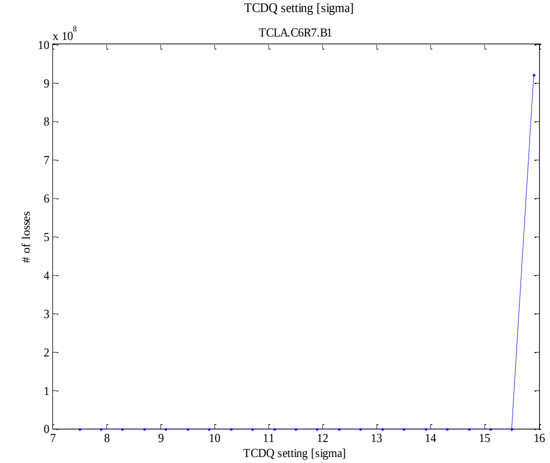




| TCDQ sigma | 15.5 | 15.9 |
|---|---|---|
| Location | # of losses | |
| 'TCDQ.4R6' | 2.34E+12 | 2.31E+12 |
| 'TCDQM.4R6' | 0 | 0 |
| TCDSA.4L6.B1'* | 9.71E+11 | 9.71E+11 |
| 'TCLA.A7R7.B1' | 1.93E+10 | 3.13E+10 |
| 'TCLA.C6R7.B1' | 0 | 9.20E+08 |
| 'TCP.B6L7.B1' | 2.30E+09 | 2.30E+09 |
| 'TCP.C6L7.B1' | 2.44E+10 | 2.67E+10 |
| 'TCSG.4R6' | 5.29E+10 | 5.15E+10 |
| 'TCSG.6R7.B1' | 3.40E+10 | 4.69E+10 |
| 'TCTH.4L1.B1' | 1.29E+10 | 1.29E+10 |
| 'TCTH.4L2.B1' | 6.35E+10 | 6.44E+10 |
| * no real losses (marker for extr.) | | |

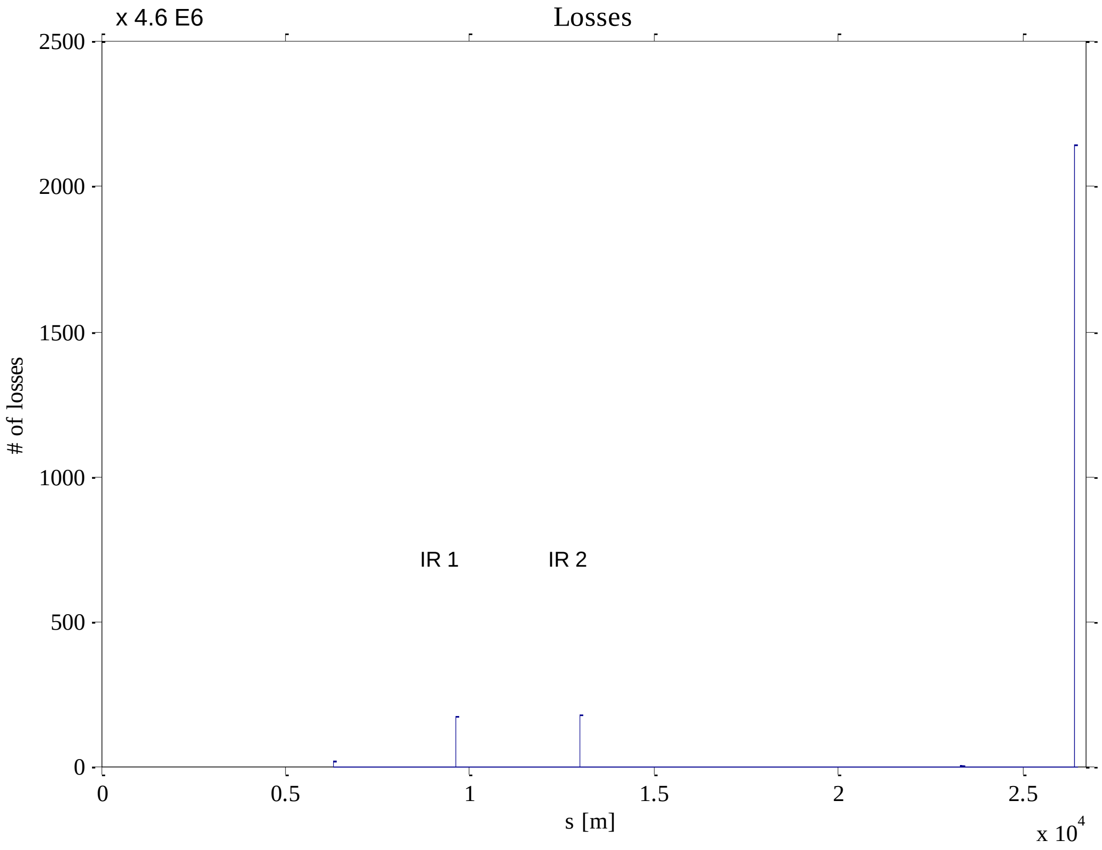


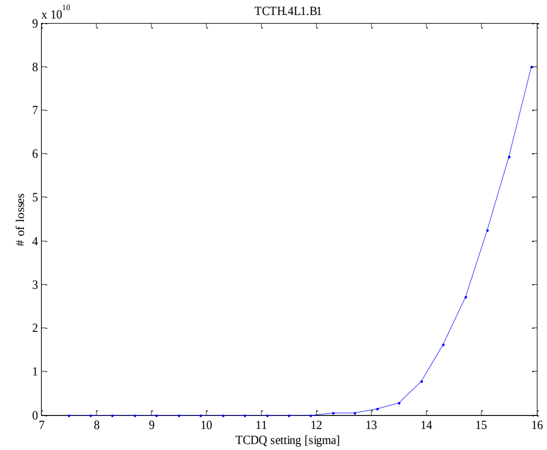



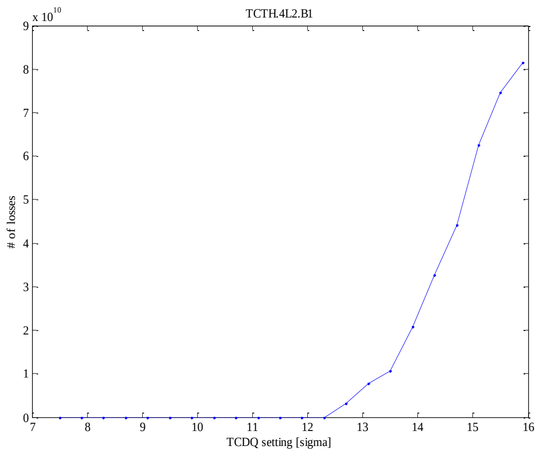



# 7 TeV - no collimation in IR7

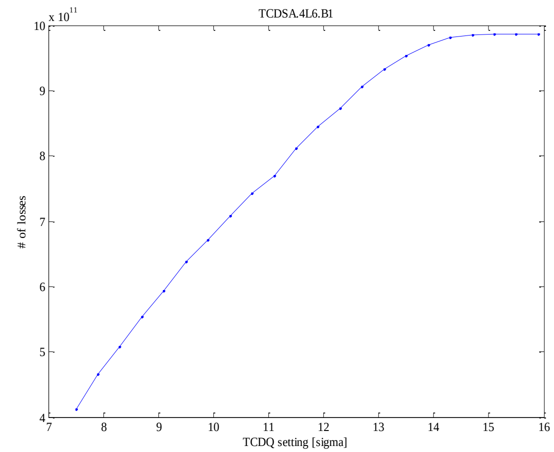


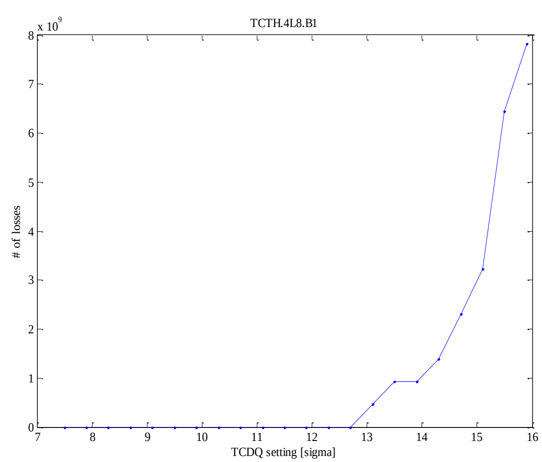

| TCDQ @ 15.5 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 40.624 |
| 'TCDQM.4R6' | 0 |
| TCDSA.4L6.B1'* | 17.152 |
| 'TCSG.4R6' | 0.92 |
| 'TCTH.4L1.B1' | 1.032 |
| 'TCTH.4L2.B1' | 1.296 |
| 'TCTH.4L8.B1' | 0.112 |
| 'XRPH.B6R5.B1' | 0.008 |
| * no real losses (marker for extr.) | |

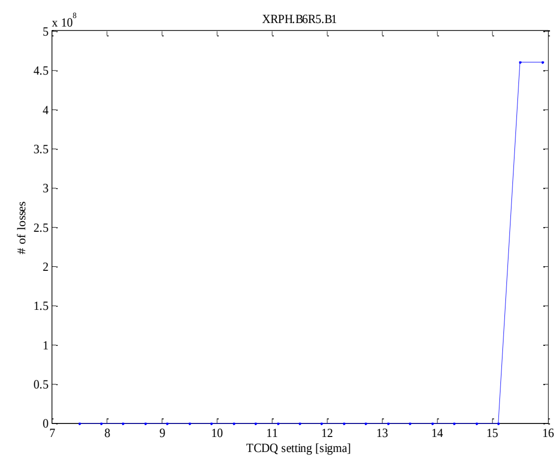


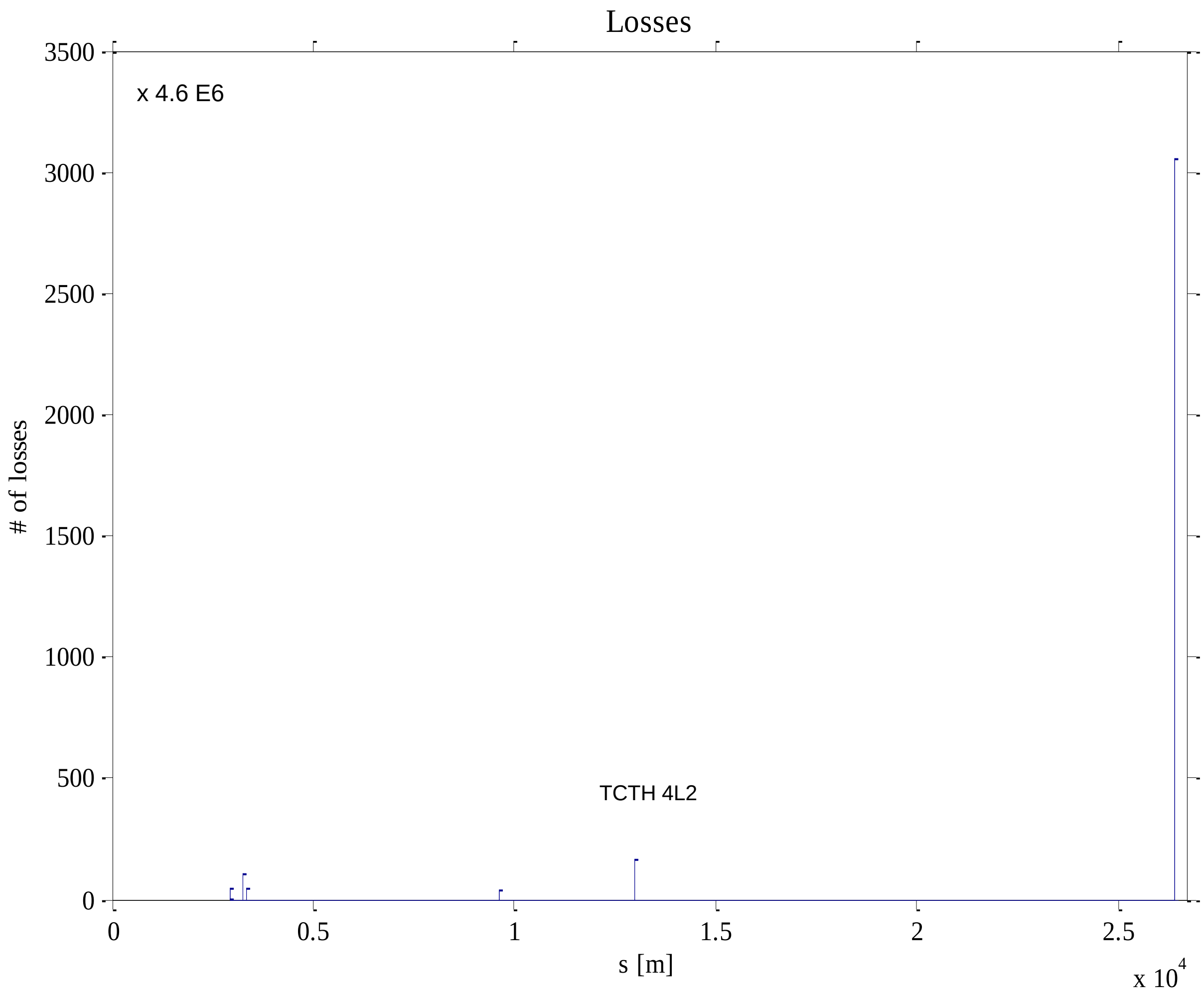

| TCDQ sigma | 15.5 | 15.9 |
|---|---|---|
| Location | # of losses | |
| 'TCDQ.4R6' | 2.34E+12 | 2.31E+12 |
| 'TCDQM.4R6' | 0 | 0 |
| TCDSA.4L6.B1'* | 9.86E+11 | 9.86E+11 |
| 'TCSG.4R6' | 5.29E+10 | 5.15E+10 |
| 'TCTH.4L1.B1' | 5.93E+10 | 8.00E+10 |
| 'TCTH.4L2.B1' | 7.45E+10 | 8.14E+10 |
| 'TCTH.4L8.B1' | 6.44E+09 | 7.82E+09 |
| 'XRPH.B6R5.B1' | 4.60E+08 | 4.60E+08 |
| * no real losses (marker for extr.) | | |



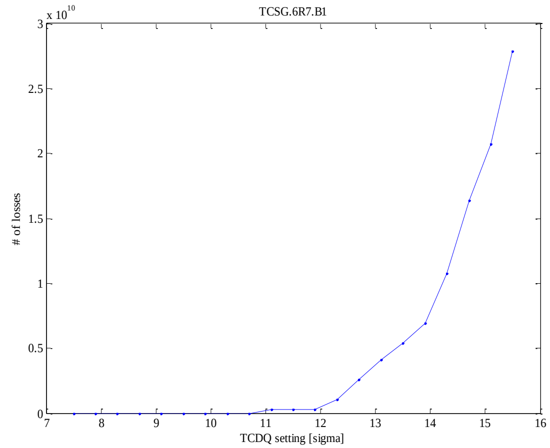



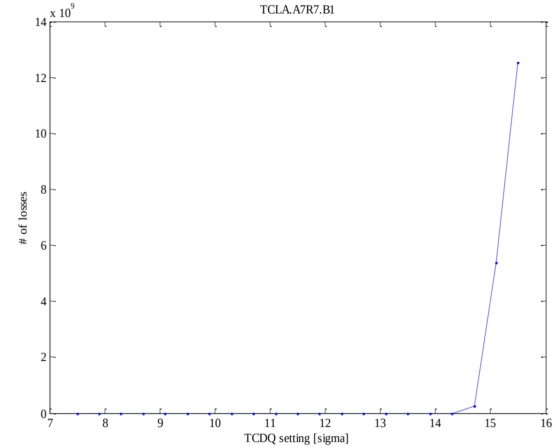



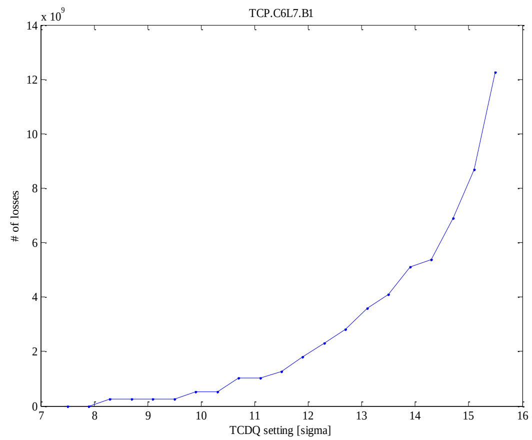
# 7 TeV prefire



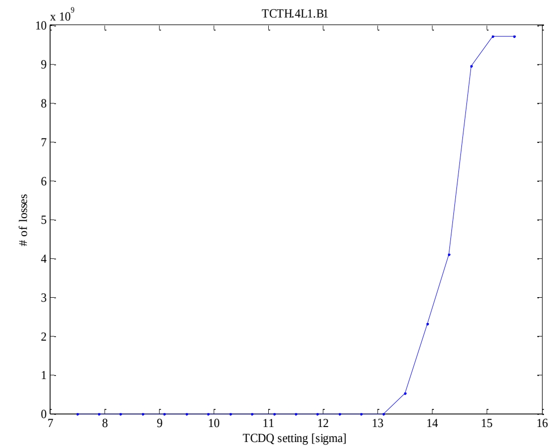

| TCDQ @ 15.5 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 24.64 |
| 'TCDQM.4R6' | 0.00 |
| TCDSA.4L6.B1'* | 13.60 |
| 'TCLA.A7R7.B1' | 0.22 |
| 'TCP.B6L7.B1' | 0.02 |
| 'TCP.C6L7.B1' | 0.21 |
| 'TCSG.4R6' | 0.57 |
| 'TCSG.6R7.B1' | 0.48 |
| 'TCTH.4L1.B1' | 0.17 |
| 'TCTH.4L2.B1' | 0.76 |
| * no real losses (marker for extr.) | |

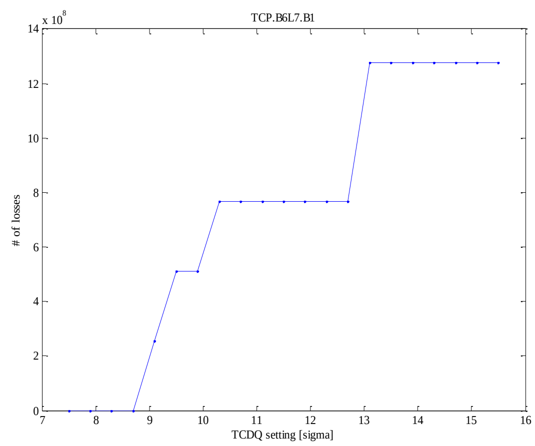


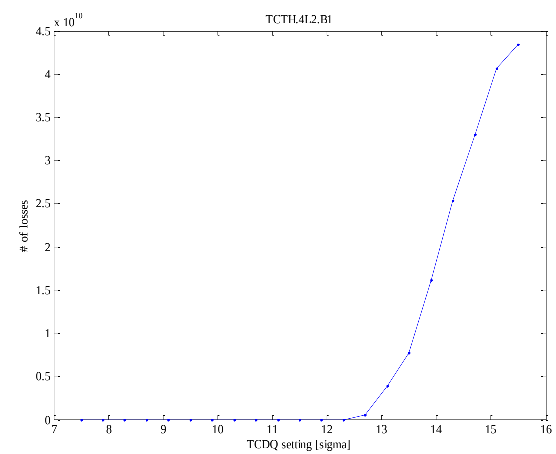



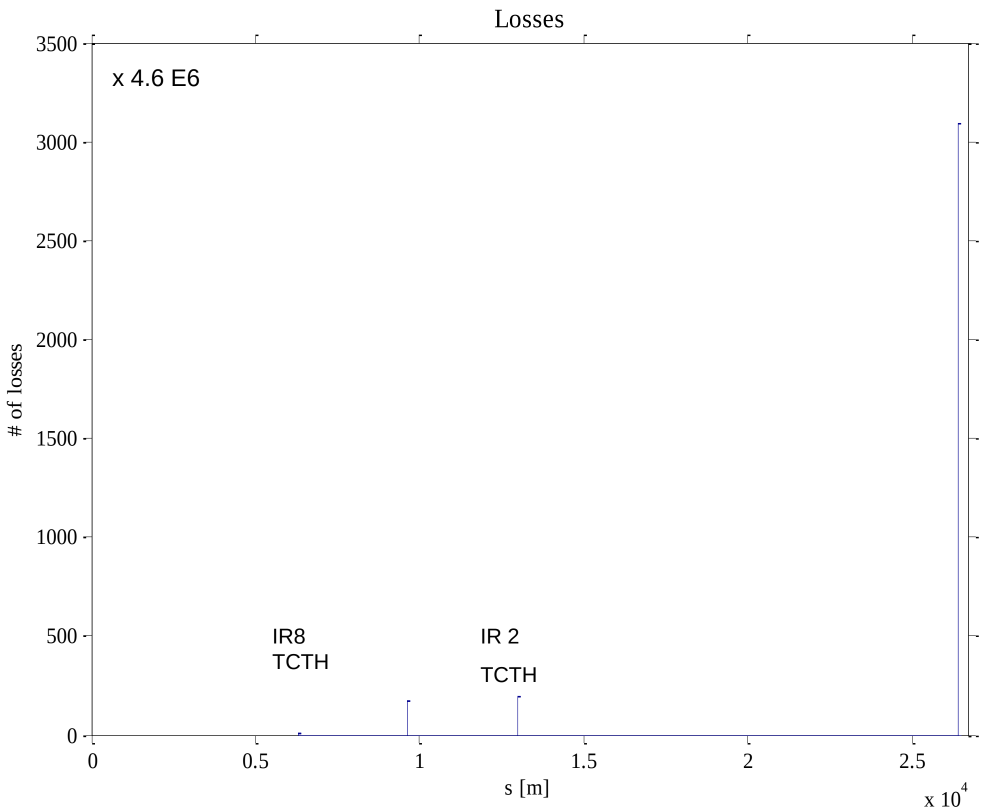

| TCDQ @ 15.5 sigma | |
|---|---|
| Location | # of losses |
| 'TCDQ.4R6' | 1.42E+12 |
| 'TCDQM.4R6' | 0 |
| TCDSA.4L6.B1'* | 7.82E+11 |
| 'TCLA.A7R7.B1' | 1.25E+10 |
| 'TCP.B6L7.B1' | 1.28E+09 |
| 'TCP.C6L7.B1' | 1.23E+10 |
| 'TCSG.4R6' | 3.27E+10 |
| 'TCSG.6R7.B1' | 2.79E+10 |
| 'TCTH.4L1.B1' | 9.71E+09 |
| 'TCTH.4L2.B1' | 4.34E+10 |
| * no real losses (marker for extr.) | |



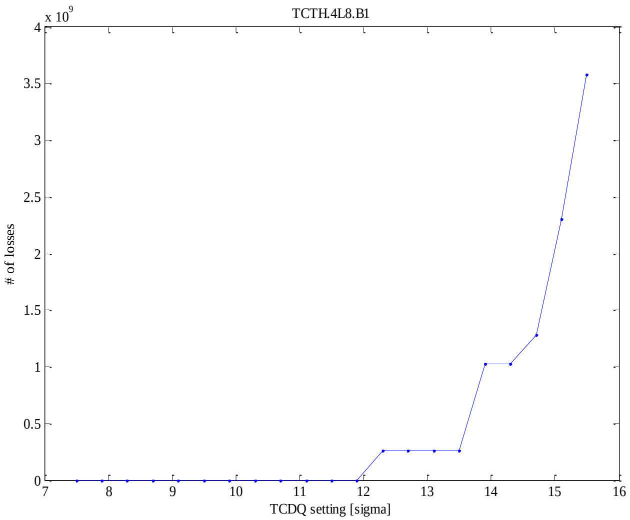



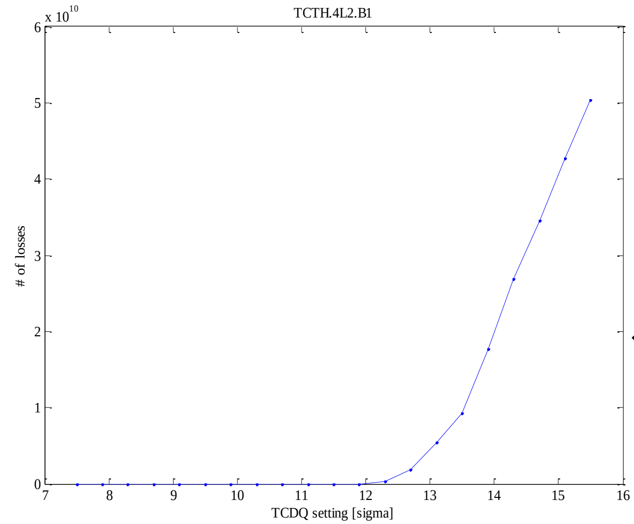



# 7 TeV prefire - no collimation in IR7

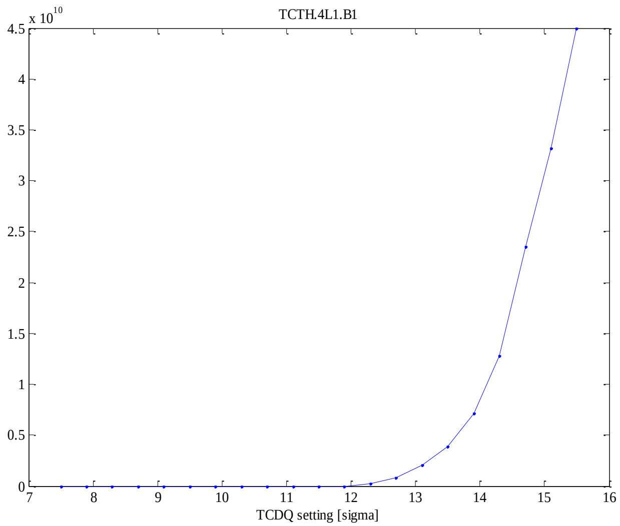


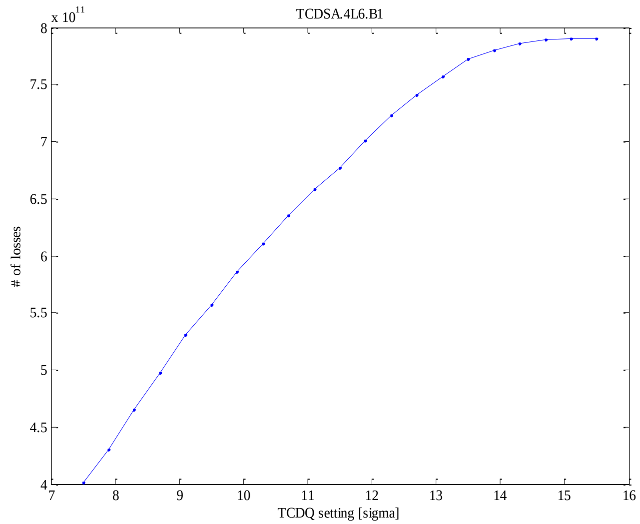

| TCDQ @ 15.5 sigma | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 24.64 |
| 'TCDQM.4R6' | 0.00 |
| TCDSA.4L6.B1'* | 13.74 |
| 'TCSG.4R6' | 0.57 |
| 'TCTH.4L1.B1' | 0.78 |
| 'TCTH.4L2.B1' | 0.88 |
| 'TCTH.4L8.B1' | 0.06 |
| * no real losses (marker for extr.) | |

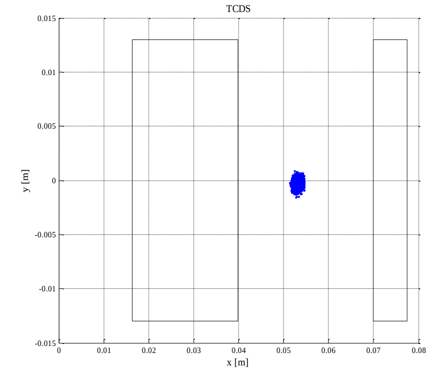



| TCDQ @ 15.5 sigma | |
|---|---|
| Location | # of losses |
| 'TCDQ.4R6' | 1.42E+12 |
| 'TCDQM.4R6' | 0 |
| TCDSA.4L6.B1'* | 7.90E+11 |
| 'TCSG.4R6' | 3.27E+10 |
| 'TCTH.4L1.B1' | 4.50E+10 |
| 'TCTH.4L2.B1' | 5.03E+10 |
| 'TCTH.4L8.B1' | 3.58E+09 |
| * no real losses (marker for extr.) | |



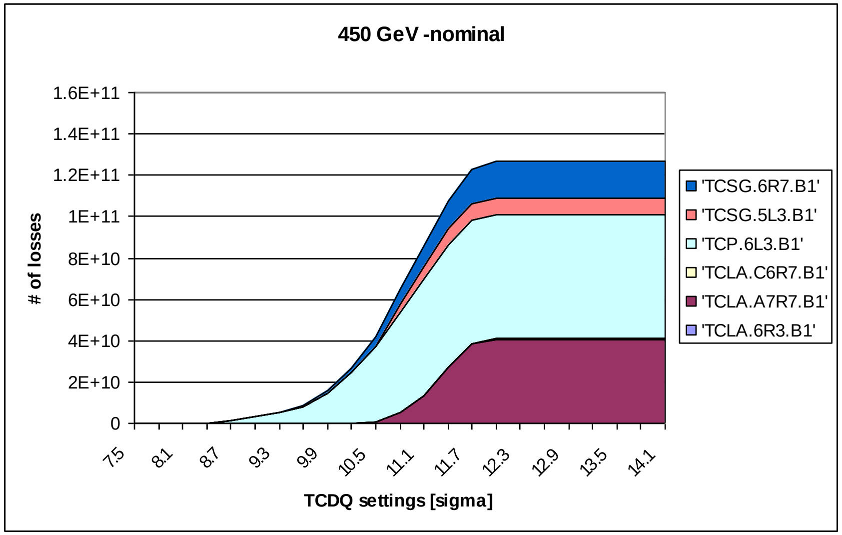



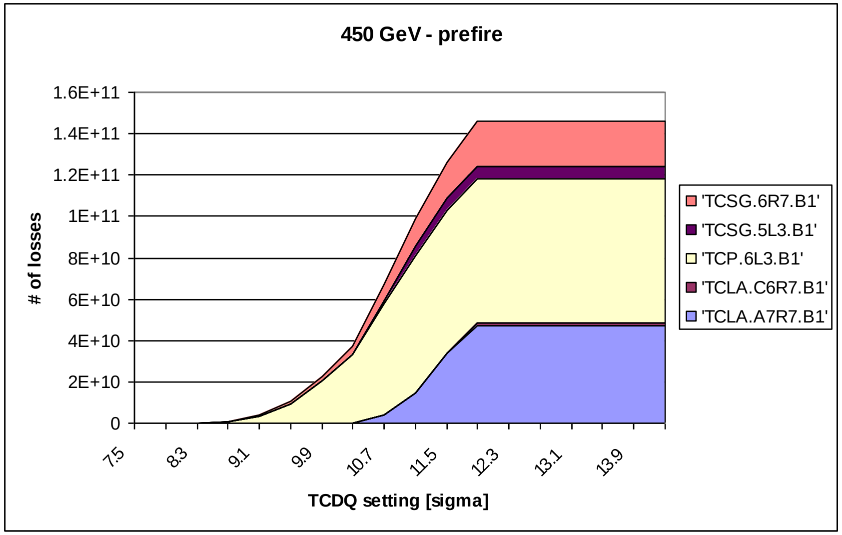

Although for the prefire case the remaining part of the beam seems to be properly extracted:

# Summary 450 GeV cases

| 450 GeV nominal | |
|---|---|
| Location | % of losses |
| 'TCDQ.4R6' | 3.22E+11 |
| 'TCDQM.4R6' | 1.57E+11 |
| TCDSA.4L6.B1'* | 2.44E+11 |
| 'TCLA.6R3.B1' | 2.30E+08 |
| 'TCLA.A7R7.B1' | 4.00E+10 |
| 'TCLA.C6R7.B1' | 6.90E+08 |
| 'TCP.6L3.B1' | 5.98E+10 |
| 'TCSG.4R6' | 5.50E+10 |
| 'TCSG.5L3.B1' | 8.05E+09 |
| 'TCSG.6R7.B1' | 1.79E+10 |
| * no real losses (marker for extr.) | |

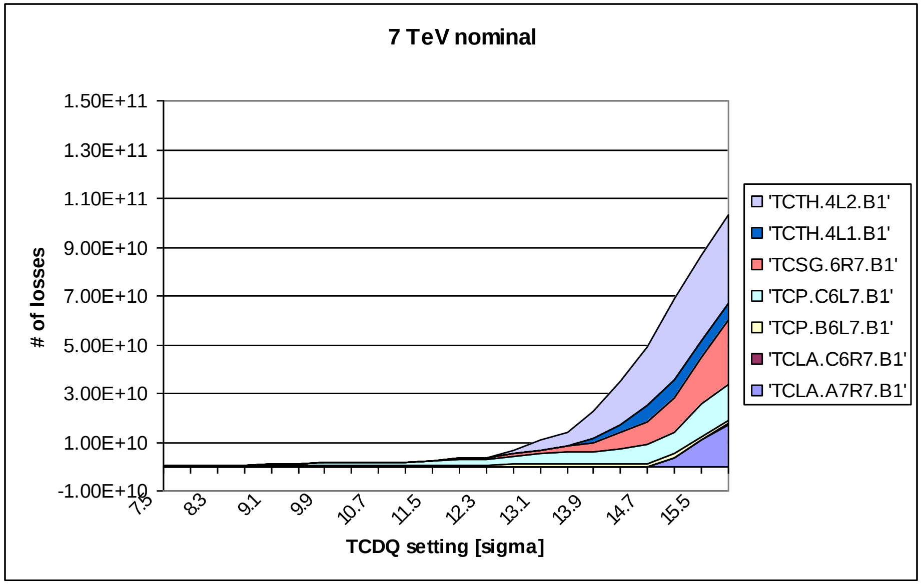



| | prefire | prefire no IR7 |
|---|---|---|
| Location | % of losses | % of losses |
| 'TCDQ.4R6' | 2.89E+11 | 2.89E+11 |
| 'TCDQM.4R6' | 1.63E+11 | 1.63E+11 |
| TCDSA.4L6.B1'* | 5.99E+11 | 5.99E+11 |
| 'TCP.6L3.B1' | 1.40E+11 | 6.95E+10 |
| 'TCSG.4R6' | 6.48E+10 | 6.48E+10 |
| 'TCSG.5L3.B1' | 6.13E+09 | 6.13E+09 |
| 'TCSG.6R7.B1' | 0.00E+00 | 2.19E+10 |
| 'TCLA.A7R7.B1' | 0.00E+00 | 4.72E+10 |
| 'TCLA.C6R7.B1' | 0.00E+00 | 1.23E+09 |
| * no real losses (marker for extr.); TCDQ @ 14.3 sigma | | |

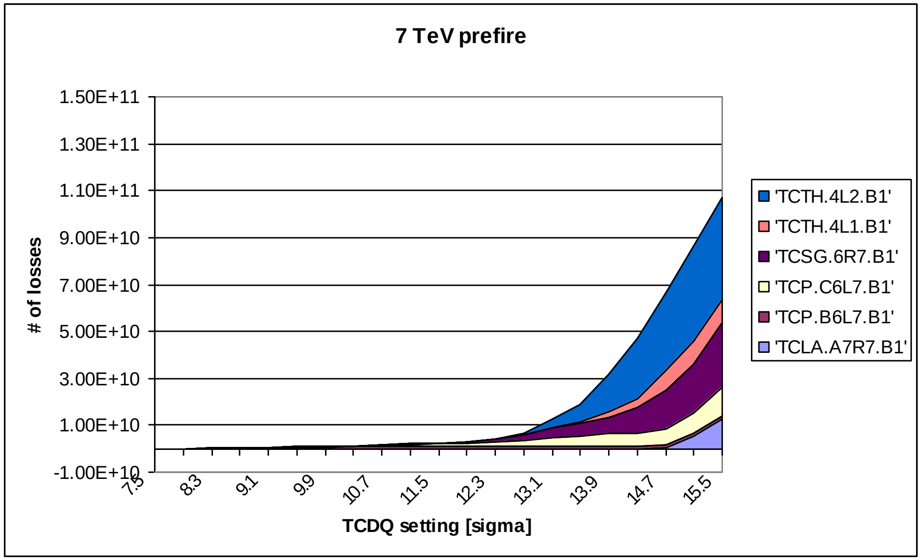


# Summary 7 TeV cases

| | nominal | no IR7 |
|---|---|---|
| Location | # of losses | # of losses |
| 'TCDQ.4R6' | 2.34E+12 | 2.34E+12 |
| 'TCDQM.4R6' | 0.00E+00 | 0.00E+00 |
| TCDSA.4L6.B1'* | 9.71E+11 | 9.86E+11 |
| 'TCLA.A7R7.B1' | 1.93E+10 | 0.00E+00 |
| 'TCP.B6L7.B1' | 2.30E+09 | 0.00E+00 |
| 'TCP.C6L7.B1' | 2.44E+10 | 0.00E+00 |
| 'TCSG.4R6' | 5.29E+10 | 5.29E+10 |
| 'TCSG.6R7.B1' | 3.40E+10 | 0.00E+00 |
| 'TCTH.4L1.B1' | 1.29E+10 | 5.93E+10 |
| 'TCTH.4L2.B1' | 6.35E+10 | 7.45E+10 |
| 'TCTH.4L8.B1' | 0.00E+00 | 6.44E+09 |
| 'XRPH.B6R5.B1' | 0.00E+00 | 4.60E+08 |

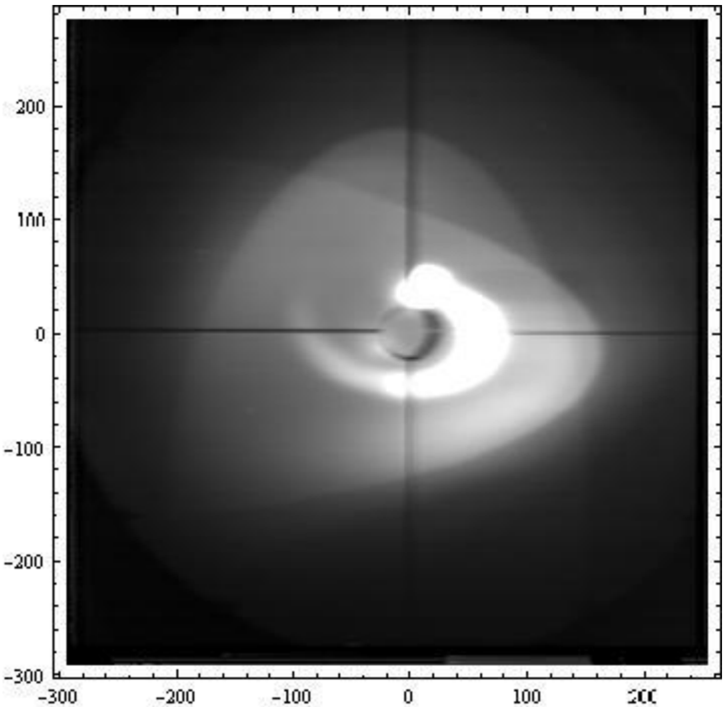



| | prefire | prefire no IR7 |
|---|---|---|
| Location | # of losses | # of losses |
| 'TCDQ.4R6' | 1.42E+12 | 1.42E+12 |
| 'TCDQM.4R6' | 0.00E+00 | 0.00E+00 |
| TCDSA.4L6.B1'* | 7.82E+11 | 7.90E+11 |
| 'TCLA.A7R7.B1' | 1.25E+10 | 0.00E+00 |
| 'TCP.B6L7.B1' | 1.28E+09 | 0.00E+00 |
| 'TCP.C6L7.B1' | 1.23E+10 | 0.00E+00 |
| 'TCSG.4R6' | 3.27E+10 | 3.27E+10 |
| 'TCSG.6R7.B1' | 2.79E+10 | 0.00E+00 |
| 'TCTH.4L1.B1' | 9.71E+09 | 4.50E+10 |
| 'TCTH.4L2.B1' | 4.34E+10 | 5.03E+10 |
| 'TCTH.4L8.B1' | 0.00E+00 | 3.58E+09 |
| 'XRPH.B6R5.B1' | 0.00E+00 | 0.00E+00 |
| * no real losses (marker for extr.) / TCDQ @ 15.5 sigma | | |

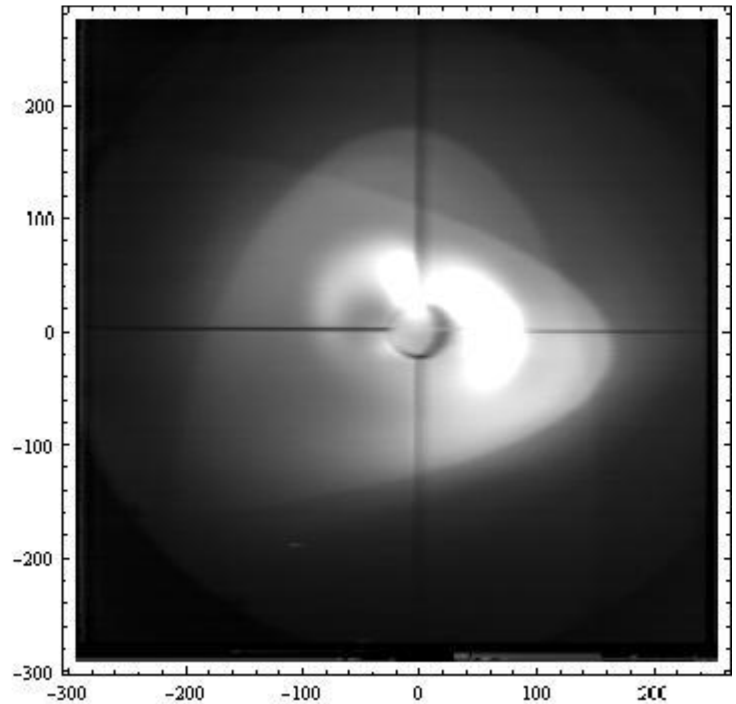


# Night from 11th Sept. to 12th Sept. 2008

02h34 debunched beam 2 was dumped → particles in abort gap

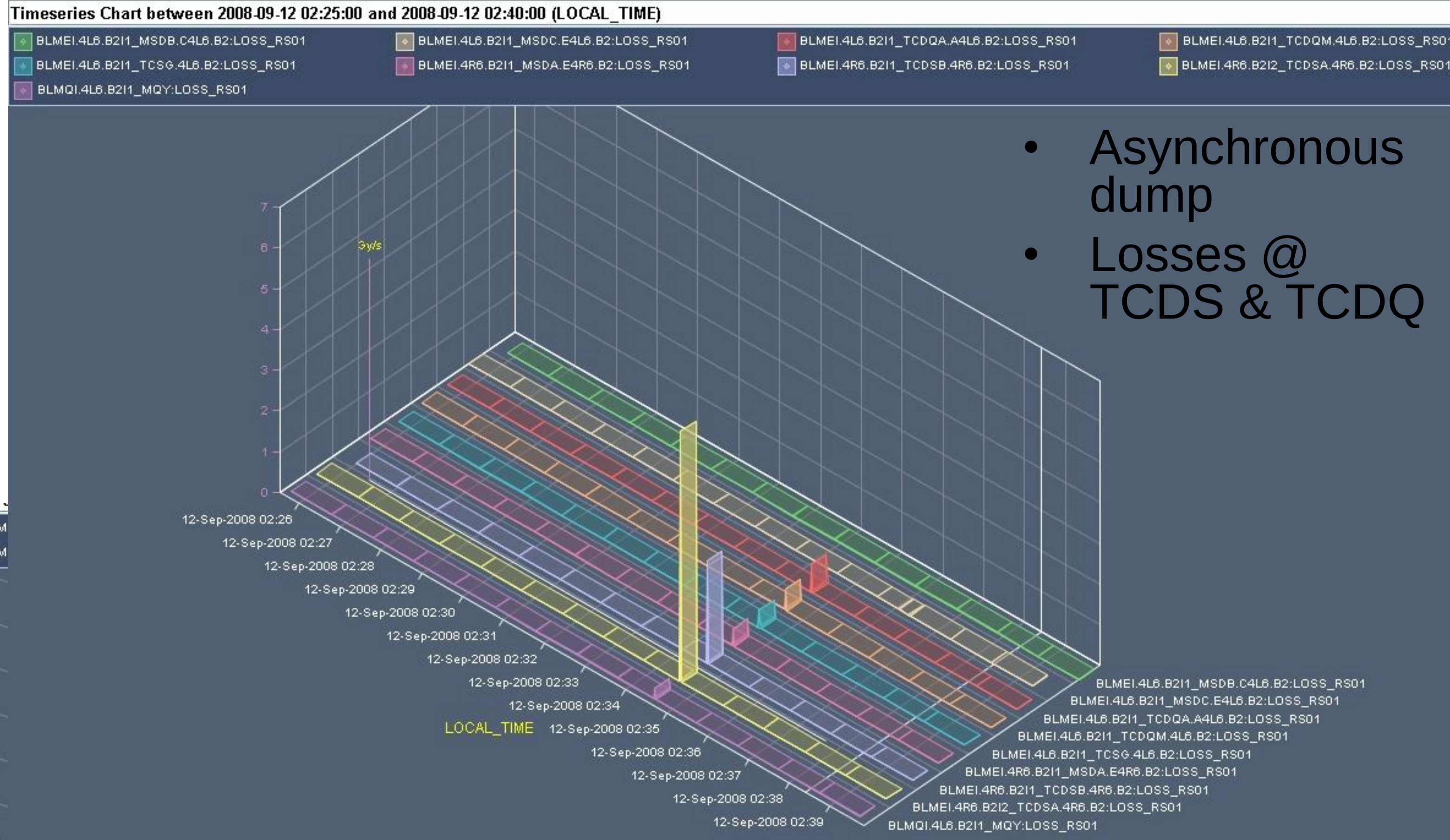



21h14

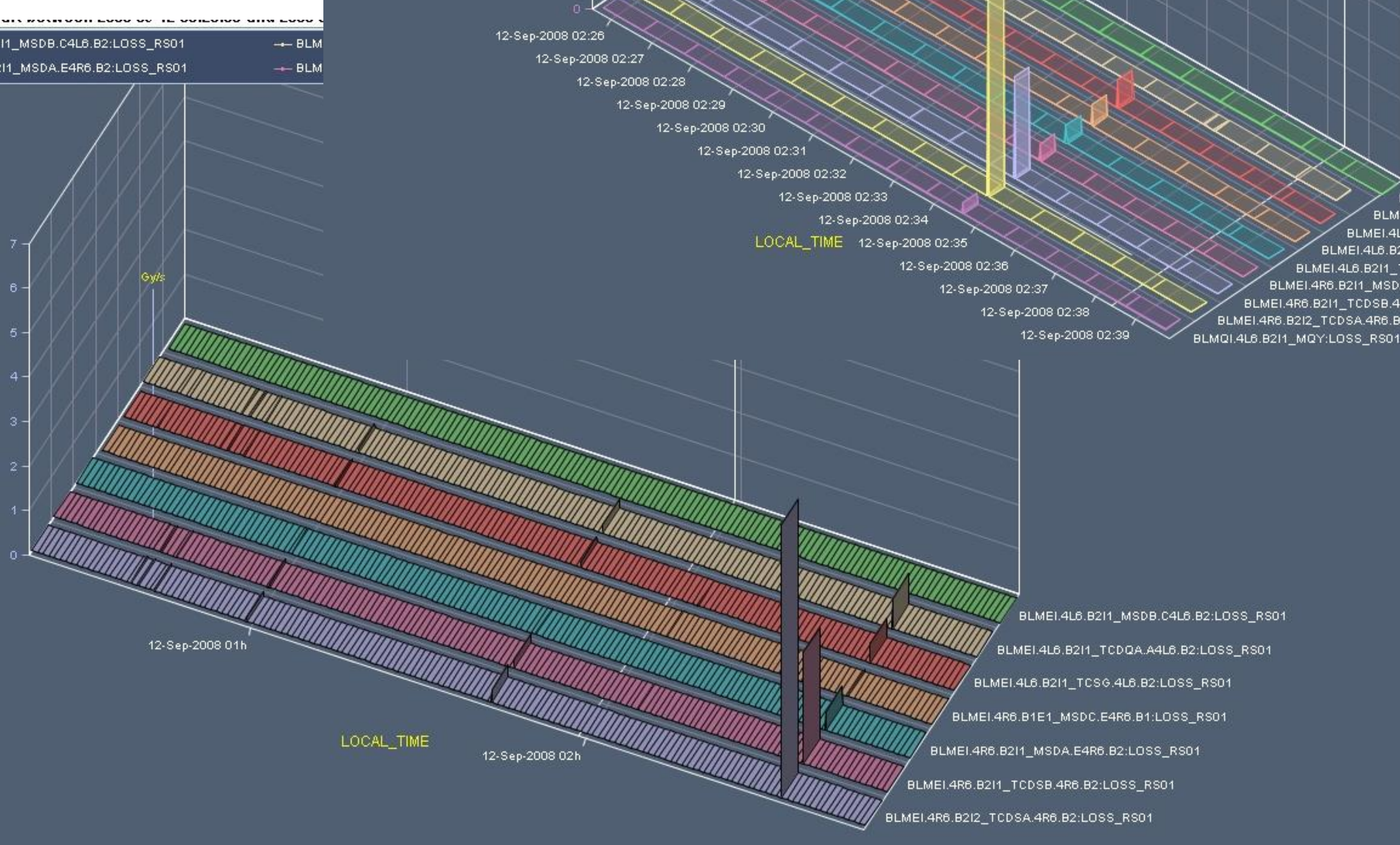



02h34

BTVD (in front of TDE)




- Asynchronous dump
- Losses @ TCDS & TCDQ




TCDQ settings ??

# Conclusions

- Madx tracking model built with errors, updated apertures, measured dump kicker waveforms, corrected orbit and collimator/protection device settings. So far B1 only!
- Dump line aperture checked with tracked beam: OK for nominal dumps, 14/15 MKD
- Losses OK in LHC ring and at collimators for 450 GeV & 7 TeV asynch. Dump and pretrigger when systems in tolerance (orbit, TCDQ position, beta-beating)
- Investigating error cases - preliminary tolerances for TCDQ position
  - 450 GeV: no losses seen below 8.7 sigma (TCP in IR3); losses start to increase dramatically as TCDQ is retracted to more than 10 sigma (2.5 $\sigma$ error)
  - 7 TeV: small losses seen in IR 7 (TCP); progressive increase from 12 sigma on
  - With TCDQ retracted TCDQM seems to protect the arc for 450 GeV
  - Losses on TCLA and TCT collimators at 7 TeV can be several e10 p+
- TCTs: losses start in IR1, 2 and 8 for TCDQ position above about 13 $\sigma$ (with IR7 collimators all retracted). Totals of 5e10 p+ lost.
- TCLAs: losses seen for very open TCDQ position above 15 $\sigma$. Totals of 2e10 p+ lost.
- Experiments and triplets: So far only tiny losses (<5e8 p+) seen on the roman pots for 7 TeV & TCDQ settings above 15 sigma
- Extending cases with different orbit conditions, optics errors and beam emittance is mandatory to find safe element tolerances

# Outlook

- Model now operational and producing results
  - Further improve with quadrupole and higher order field errors
- To complete this study (next 2 months)
  - Finish catalogue of cases
  - Run Monte Carlo of few hundred different cases at tolerance limit with random errors
  - B2 to be included – especially for CMS (TCT positioning tolerances)
  - Use expected abort gap distribution to look at *quench* limits
  - Local bumps combined with asynch dump - quantify danger zone (no losses for circulating beam, damage for asynch dump)
  - Produce maps of losses expected for the TCDQ setting-up measurements with beam
  - Loss density maps for collimators
- For the future…..
  - To what extent should combined failures be considered? e.g. orbit + emittance
  - Use of ‘real’ halo distribution would be nice (how to get this? Information on equilibrium halo distribution…?)