# Impact of the RC filters on BLM thresholds

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# Motivation

- All BLM monitors on LHC suffer from signal delay effect,
- Up to know the signal delay effects are taken into account when preparing thresholds in a rudimentary way,
- Since this year large RC filters have been introduced the problem needs more study,
- In particular loss evolution in time is an important parameter.

Monitors with small filters, values from Post Mortem analysis.

Table 1: Technical Details for MQM and MSI monitors with small filters

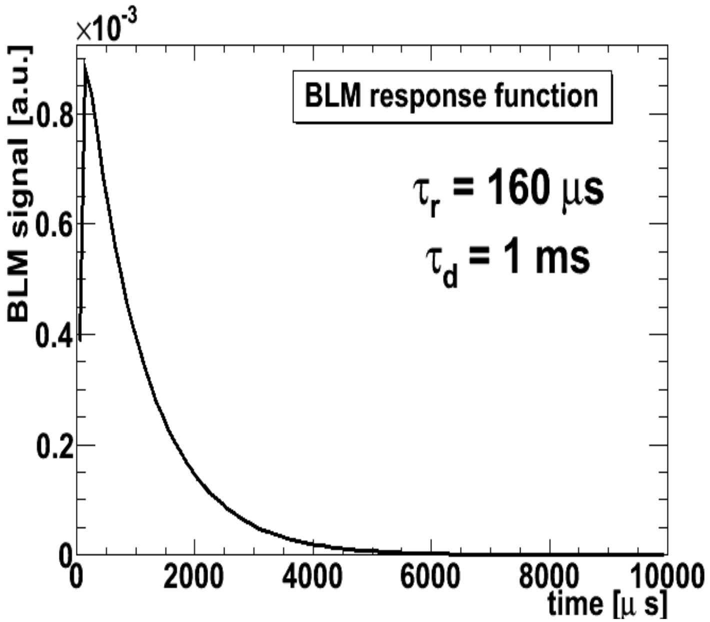
| Expertname | AnalogFE | Cable length | Rise time | Time constant |
|---|---|---|---|---|
| BLMQI.06R8.B2E10 MQML | UA87 BY06 2 2 5 | 55 m | 0.16 ms | 1.453 ms |
| BLMQI.06R8.B2E20 MQML | UA87 BY06 2 2 3 | 55 m | 0.16 ms | 1.326 ms |
| BLMQI.06R8.B2E30 MQML | UA87 BY06 2 2 1 | 55 m | 0.16 ms | 1.076 ms |
| BLMQI.08R8.B2E10 MQML | UA87 BY06 2 6 5 | 55 m | 0.16 ms | 1.521 ms |
| BLMQI.08R8.B2E20 MQML | UA87 BY06 2 6 3 | 55 m | 0.16 ms | 1.470 ms |
| BLMQI.08R8.B2E30 MQML | UA87 BY06 2 6 1 | 55 m | 0.16 ms | 1.134 ms |
| BLMQI.07R8.B2E10 MQM | UA87 BY06 2 3 5 | 40 m | 0.16 ms | 1.366 ms |
| BLMQI.07R8.B2E20 MQM | UA87 BY06 2 3 3 | 40 m | 0.16 ms | 1.307 ms |
| BLMQI.07R8.B2E30 MQM | UA87 BY06 2 3 1 | 40 m | 0.16 ms | 0.964 ms |
| BLMEI.06L2.B1E10 MSIB | UA23 BY07 1 10 1 | - | 0.16 ms | 1.34 ms |
| BLMEI.06L2.B1E20 MSIB | UA23 BY07 1 10 2 | - | 0.12 ms | 1.265 ms |
| BLMEI.06L2.B1E30 MSIB | UA23 BY07 1 10 3 | - | 0.12 ms | 1.249 ms |
| BLMEI.06L2.B1E10 MSIA | UA23 BY07 1 10 4 | - | 0.12 ms | 1.315 ms |
| BLMEI.06L2.B1E20 MSIA | UA23 BY07 1 10 5 | - | 0.16 ms | 1.221 ms |
| BLMEI.06L2.B1E30 MSIA | UA23 BY07 1 10 6 | - | 0.12 ms | 0.978 ms |
| BLMEI.06R8.B2E10 MSIB | UA87 BY06 1 10 6 | 88 m | 0.2 ms | 2.277 ms |
| BLMEI.06R8.B2E20 MSIB | UA87 BY06 1 10 5 | 88 m | 0.12 ms | 1.368 ms |
| BLMEI.06R8.B2E30 MSIB | UA87 BY06 1 10 5 | 88 m | 0.12 ms | 1.895 ms |
| BLMEI.06R8.B2E10 MSIA | UA87 BY06 1 10 4 | 88 m | 0.16 ms | 1.787 ms |
| BLMEI.06R8.B2E20 MSIA | UA87 BY06 1 10 3 | 88 m | 0.12 ms | 1.637 ms |
| BLMEI.06R8.B2E30 MSIA | UA87 BY06 1 10 1 | 88 m | 0.12 ms | 1.189 ms |

Courtesy of Annika Nordt

# Running Sums: reminder

| Name | Duration [μs] | 40-μs steps | Refresh rate 40-μs steps |
|---|---|---|---|
| RS01 | 40 | 1 | 1 |
| RS02 | 80 | 2 | 1 |
| RS03 | 320 | 8 | 1 |
| RS04 | 640 | 16 | 1 |
| RS05 | 2560 | 64 | 2 |
| RS06 | 10240 | 256 | 2 |

# Numerical model



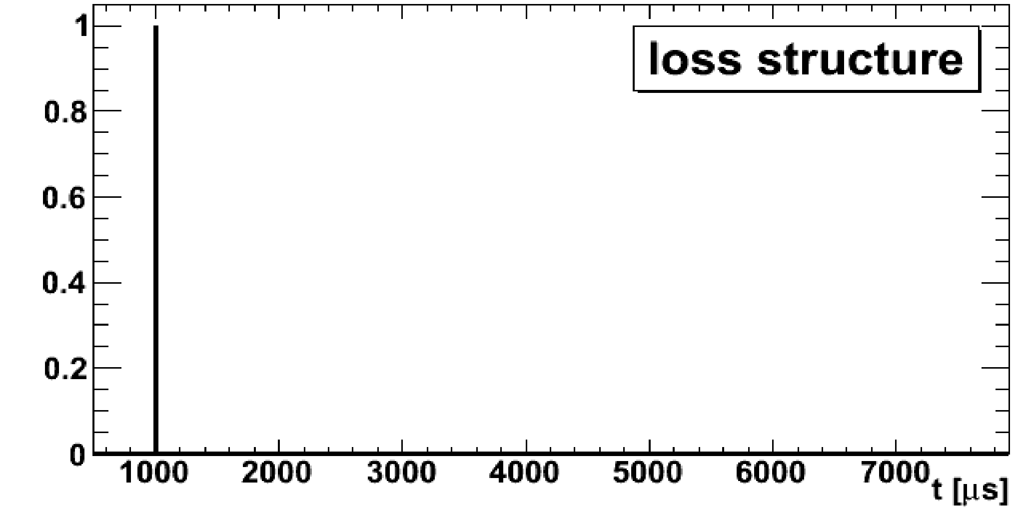

three cases analyzed here:

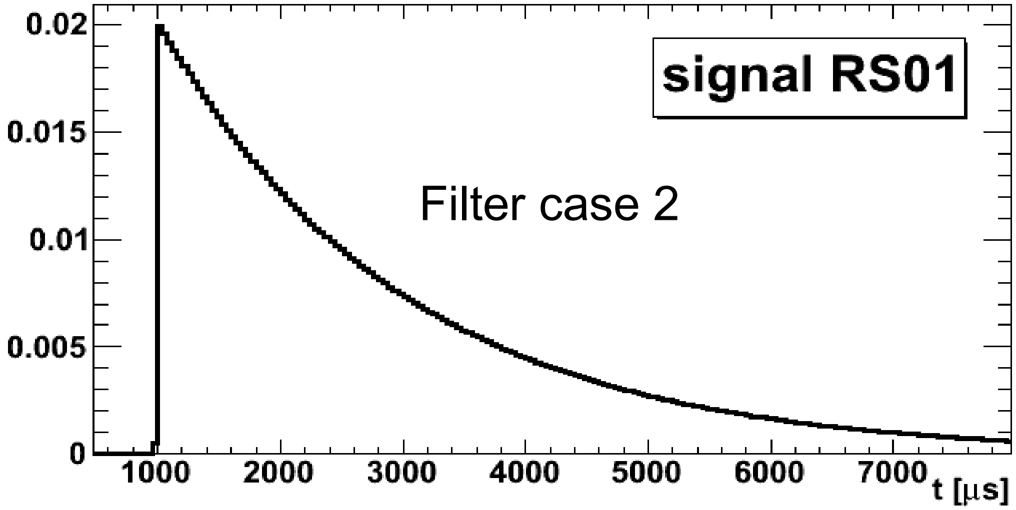
1) very good monitor:
$\tau_r$=40 μs, $\tau_d$=60 μs
2) monitor from Barbara's calculations:
$\tau_r$=0, $\tau_d$=2 ms
3) adding rise time:
$\tau_r$=160 μs, $\tau_d$=2 ms

- step 1 μs
- 10240 steps (max RS06)
- rise: $a(1-\exp(t/\tau_r))$ for $0<t<\tau_r$
- decay: $b\exp(-(t-\tau_r)/\tau_d)$ for $t>\tau_r$
- continuity: $b=a(1-\exp(-1))$
- normalization:

$$\int_0^\infty R(t)dt = 1$$

# Response to δ loss



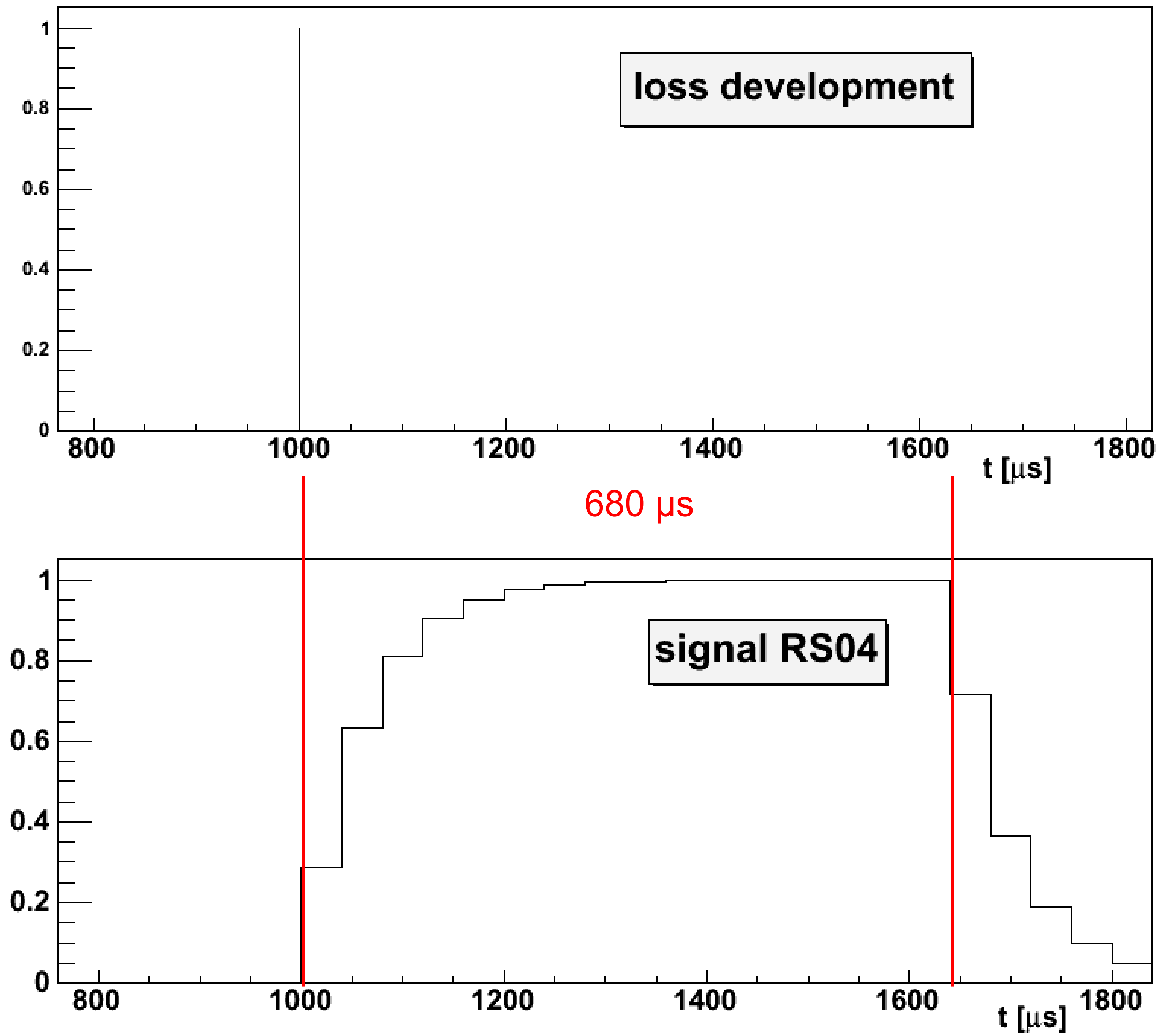

Loss placed 1000 μs after the start of the calculations.

Delay defined as distance from the signal maximum to the loss maximum.

# Response to δ loss in the beginning of RS01- results

| | Case 1 | | Case 2 | | Case 3 | |
|---|---|---|---|---|---|---|
| | max | delay | max | delay | max | delay |
| RS01 | 0.348 | 80 | 0.0199 | 40 | 0.0191 | 200 |
| RS02 | 0.633 | 80 | 0.0395 | 80 | 0.0377 | 240 |
| RS03 | 0.993 | 320 | 0.149 | 320 | 0.143 | 440 |
| RS04 | 1.0 | 680 | 0.290 | 680 | 0.281 | 760 |
| RS05 | 1.0 | 2280 | 0.732 | 2600 | 0.723 | 2600 |

Why so large? See next page.



loss development
signal RS04
680 µs
t [µs]
t [µs]

# Response to δ loss in the middle of RS01 - results

| | Case 1 | | Case 2 | | Case 3 | |
|---|---|---|---|---|---|---|
| | max | delay | max | delay | max | delay |
| RS01 | 0.403 | 60 | 0.0197 | 60 | 0.0189 | 220 |
| RS02 | 0.652 | 100 | 0.0391 | 100 | 0.0377 | 220 |
| RS03 | 0.991 | 300 | 0.147 | 340 | 0.143 | 460 |
| RS04 | 1.000 | 660 | 0.287 | 700 | 0.282 | 780 |
| RS05 | 1.000 | 2260 | 0.730 | 2580 | 0.724 | 2660 |

# Response to δ loss at the end of RS01 - results

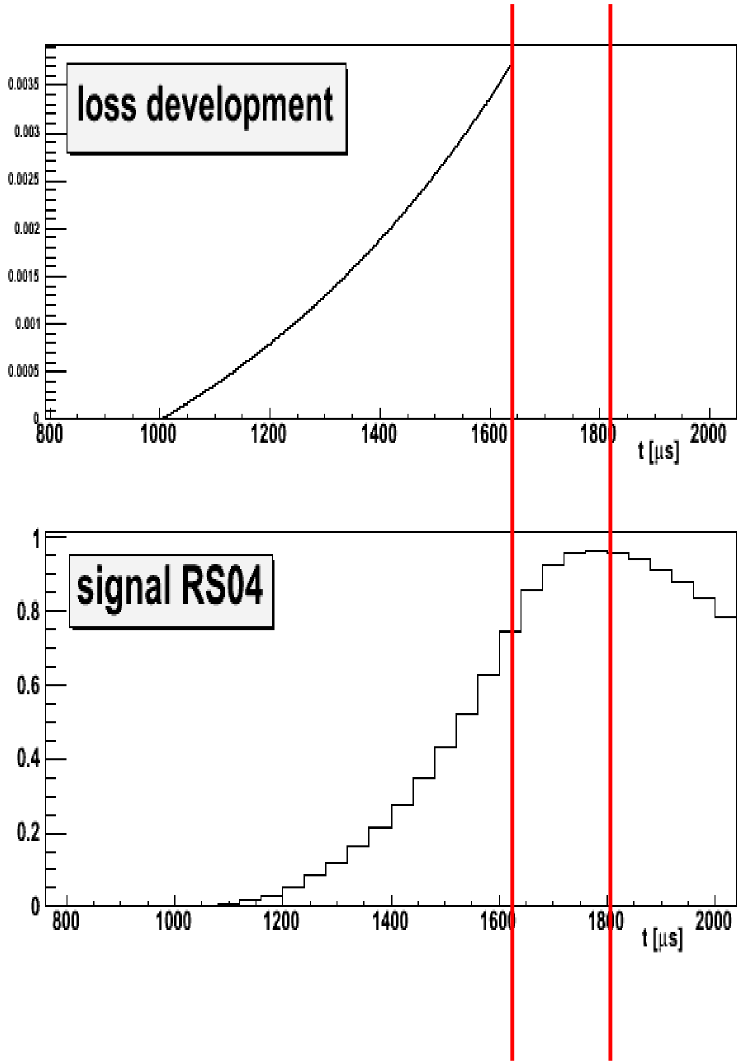
| | Case 1 | | Case 2 | | Case 3 | |
|---|---|---|---|---|---|---|
| | max | delay | max | delay | max | delay |
| RS01 | 0.348 | 80 | 0.0199 | 40 | 0.0191 | 200 |
| RS02 | 0.633 | 80 | 0.0395 | 80 | 0.0377 | 240 |
| RS03 | 0.993 | 320 | 0.149 | 320 | 0.143 | 440 |
| RS04 | 1.00 | 680 | 0.290 | 680 | 0.281 | 760 |
| RS05 | 1.00 | 2320 | 0.727 | 2560 | 0.725 | 2640 |

# Response to exponential loss lasting $t_{RS}$ and with time constant $t_{RS}$

| | Case 1 | | Case 2 | | Case 3 | | |
|---|---|---|---|---|---|---|---|
| | max | delay | max | delay | max | delay | signal at delay 1 |
| RS01 | 0.354 | 40 | 0.0198 | 40 | 0.0190 | 200 | - |
| RS02 | 0.597 | 80 | 0.0390 | 80 | 0.0375 | 200 | 0.0284 |
| RS03 | 0.906 | 120 | 0.142 | 320 | 0.140 | 400 | 0.0879 |
| RS04 | 0.974 | 160 | 0.269 | 600 | 0.267 | 680 | 0.148 |

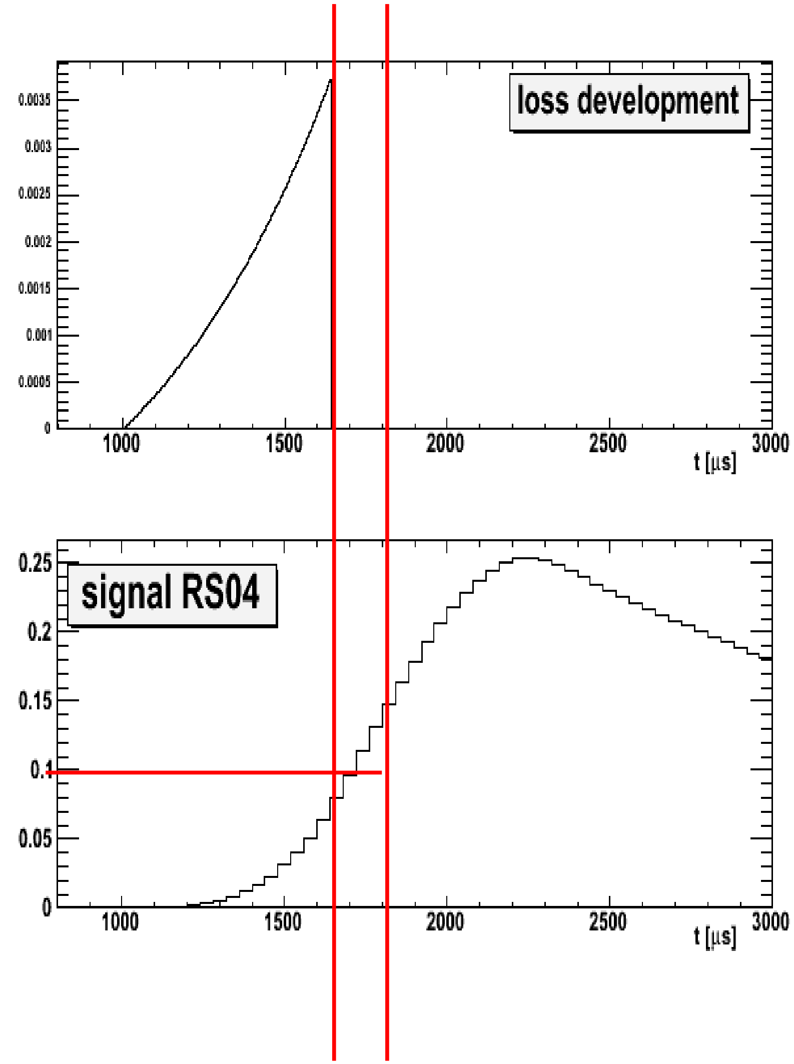
Delay is calculated with respect to the loss end (maximum).
But does it make sense to investigate a loss like that?

Explanation:
next slide



loss development
signal RS04
t [µs]
800
1000
1200
1400
1600
1800
2000
0.2
0.4
0.6
0.8
1


160 µs

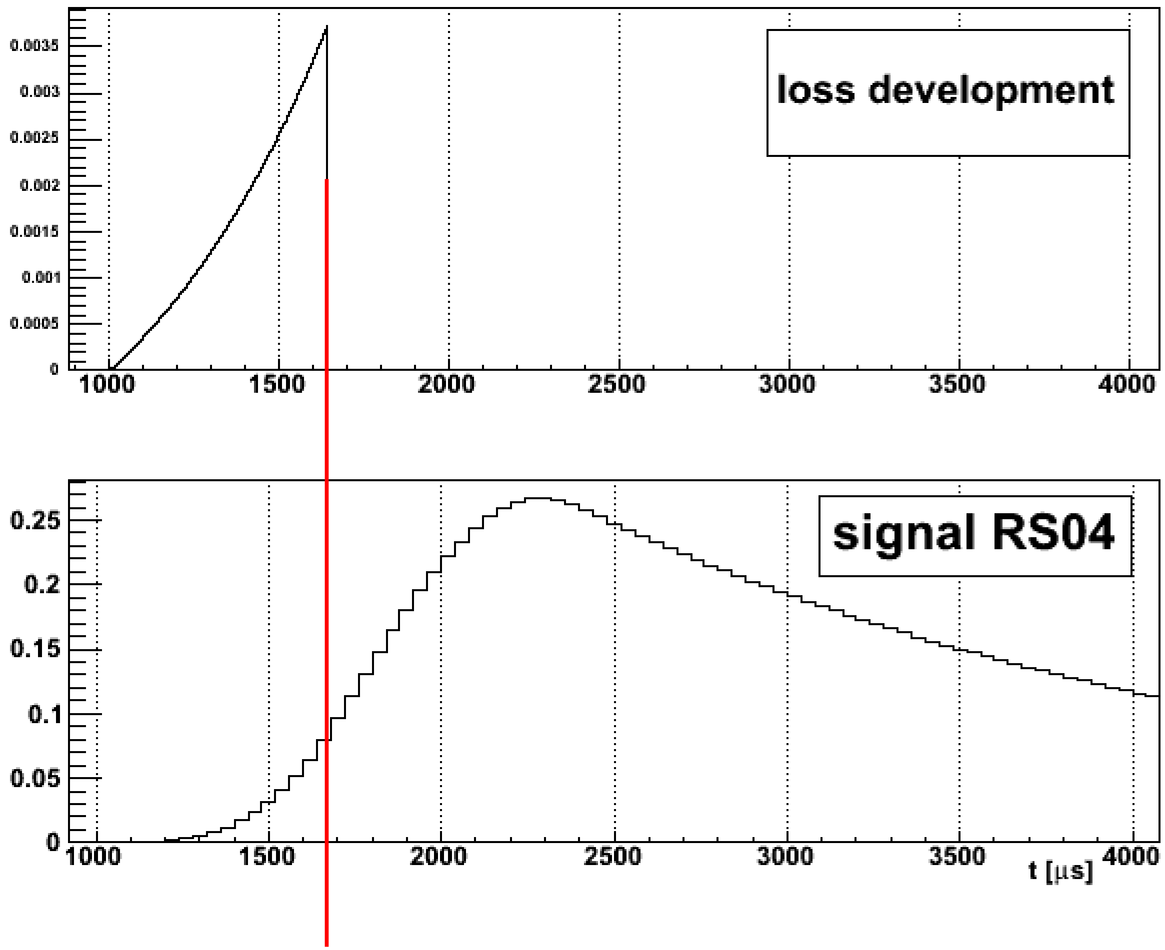


loss development
signal RS04
t [µs]
1000
1500
2000
2500
3000
0.05
0.1
0.15
0.2
0.25


160 µs

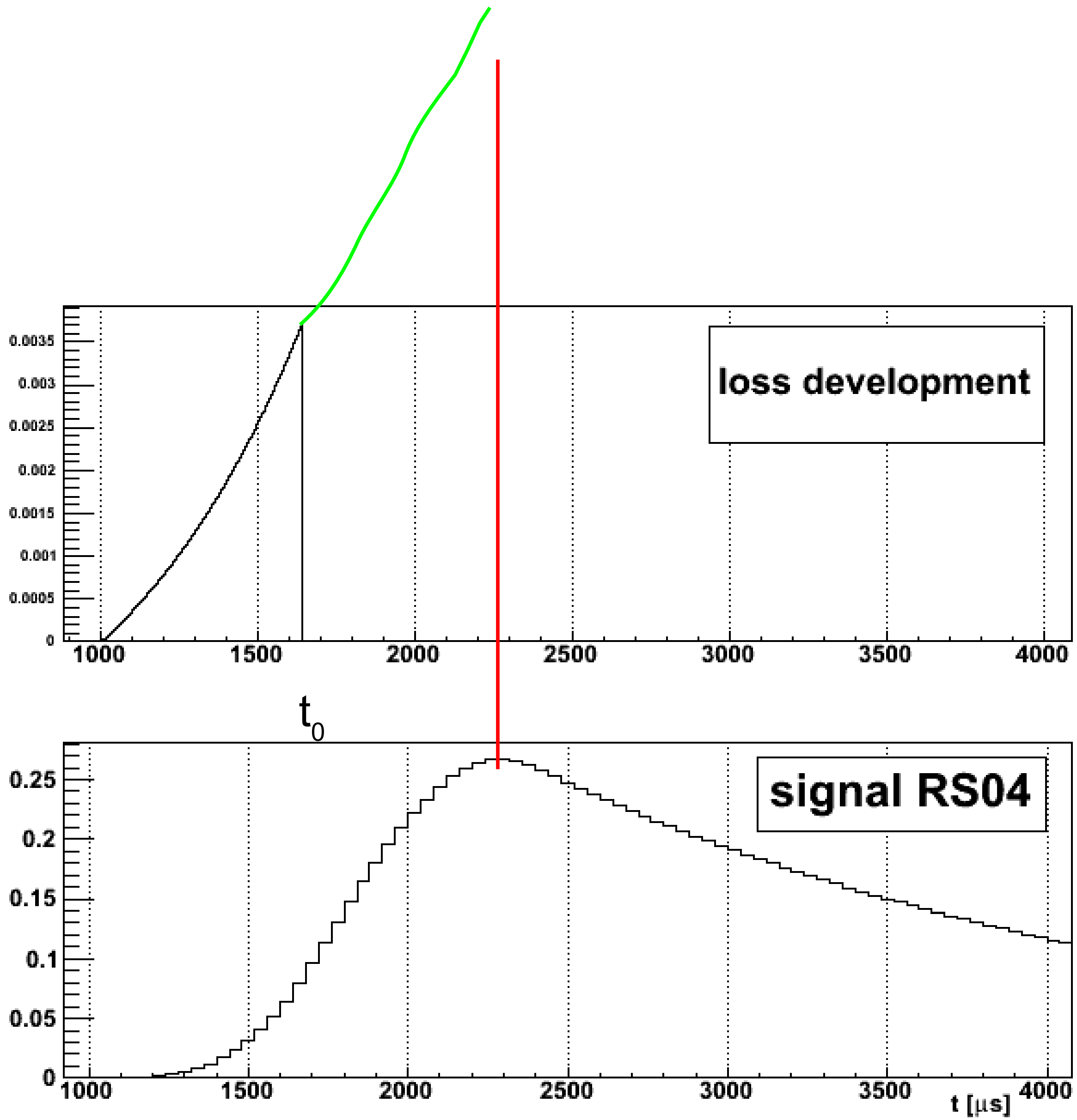
# But does such loss make sense?

Example for RS04




Loss finished after 640 mus?
Or beam dumped?

# Lets prolongate it with the same time constant and see when we collect whole signal?

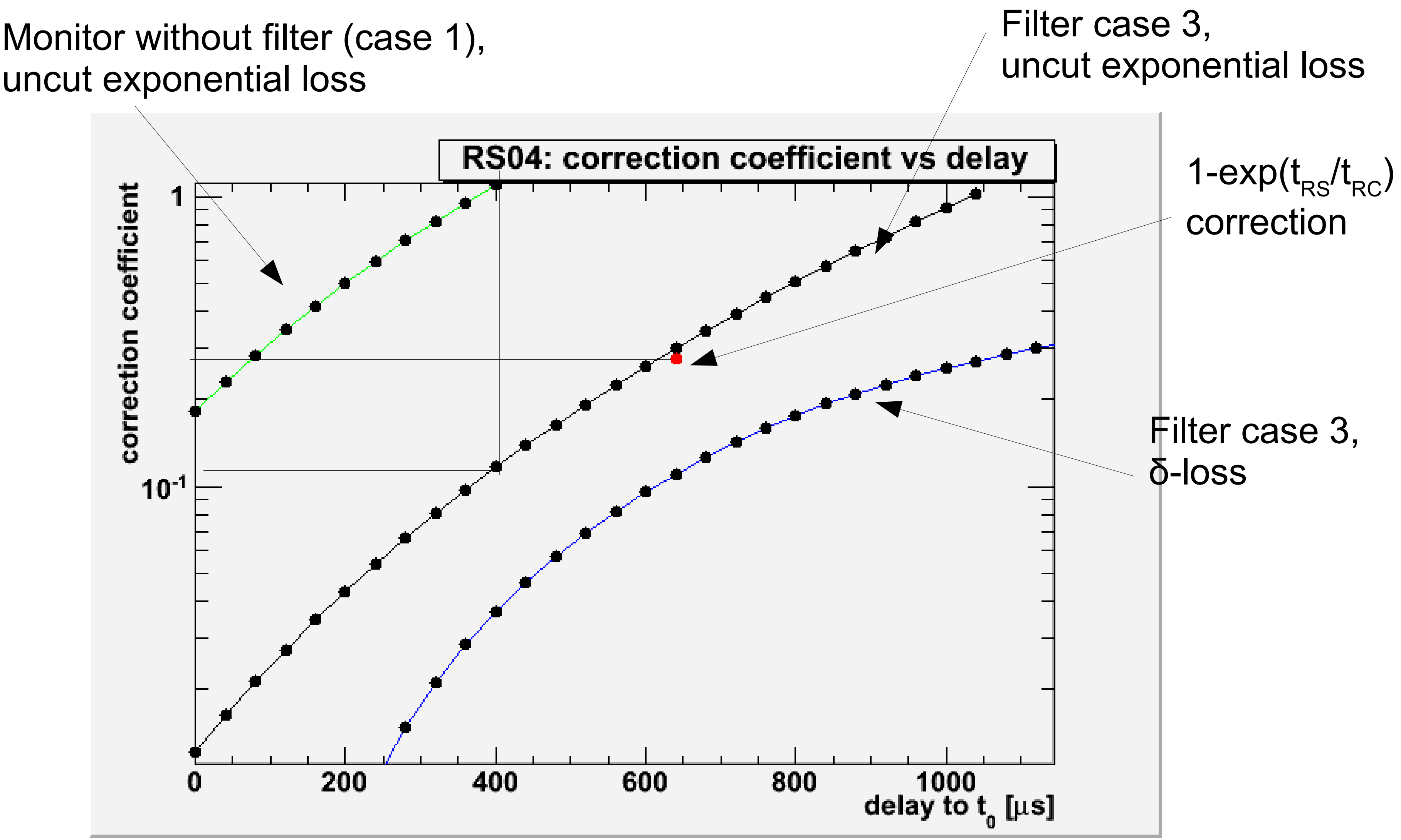


# Response to exponential loss lasting time constant $t_{RS}$ but prolongated – delays to get whole signal

Time after which whole signal is integrated [μs]

| | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| RS03 | 240 | 640 | 720 |
| RS04 | 400 | 1000 | 1040 |

# Delay versus integrated signal



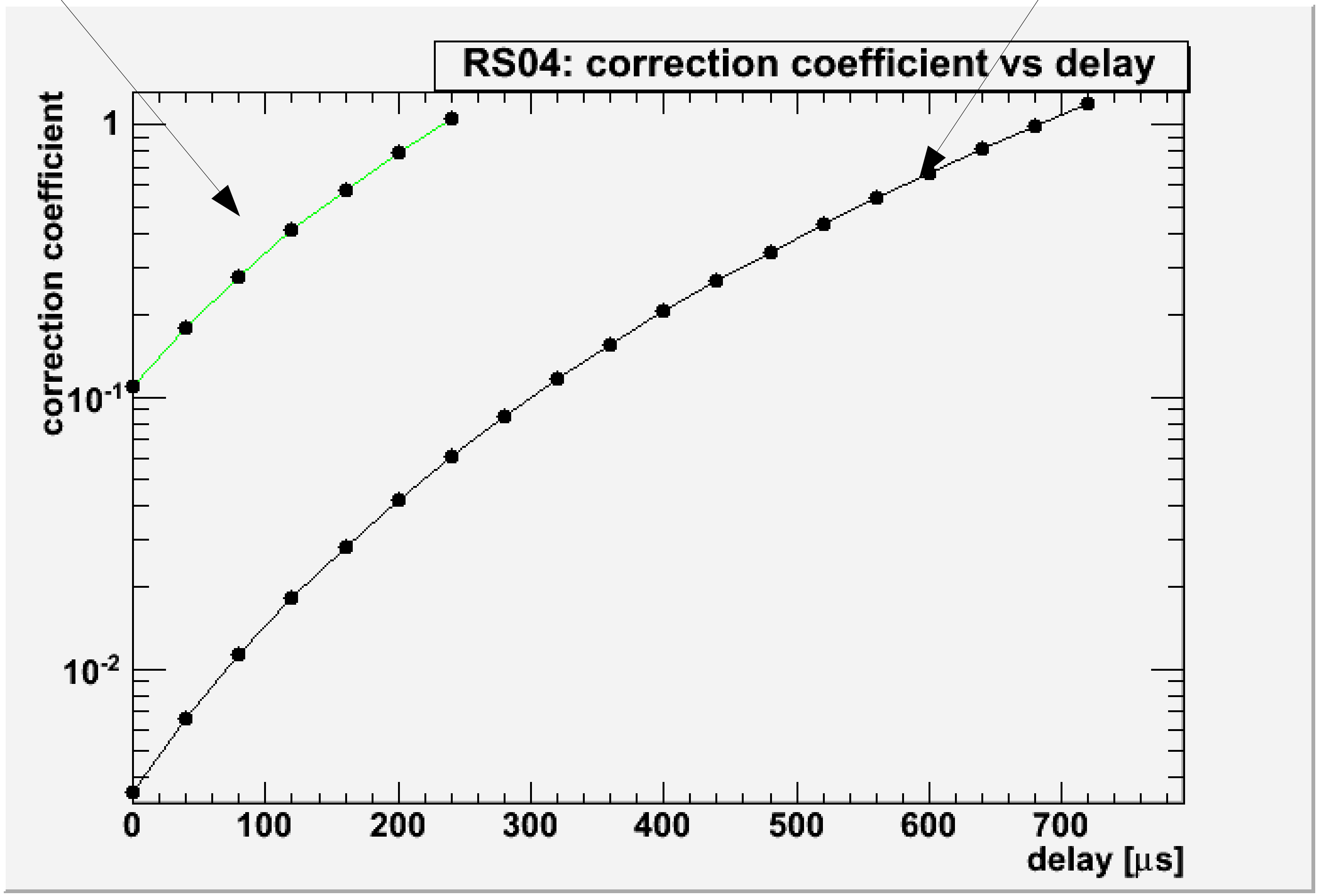
# Conclusions

- 1-exp($t_{RS}/t_{RC}$) correction gives delay of $t_{RS}$ (for delta loss, but similarly for uncut exponential)
- Without any filter the delay is also substantial, so the loss due to 1-exp() correction is not so large (RS04, uncut exponential loss: 240μs)
- Reducing correction factor in order to have the same delay as for monitor without filter is feasible, factor 2-4 (depending on the loss evolution)
- Reducing correction factor in order to have no delay would affect all thresholds and would bring them to noise levels in many cases (about factor 100 down).

# Delay versus integrated signal

Monitor without filter (case 1), uncut exponential loss

Filter case 3, uncut exponential loss




RS03