3GPP TSG-RAN WG4 Meeting #53 **R4-094670**
Jeju, Korea, 9th – 13th November 2009

Source: Nokia

Title: Link simulation results for RSTD accuracy

Agenda Item: 7.13.9

Document for: Discussion

1. Introduction

In RAN4 meeting #52bis a proposal for the link simulation frame work was presented [1]. In this contribution, we present initial simulation results for RSTD accuracy to further evaluate the different link simulation assumptions.

2. Link simulation assumptions

In this section the used link simulation assumptions are given. These follow those given in [1] for most parts.

Two different cell ID sets were evaluated, mainly looking the frequency domain orthogonal and non-orthogonal case. It is good to note that different cell ID pairs have different cross correlation properties. Impact of this to the achievable performance would need to be further assessed. Similar evaluations were also done previously when RAN4 worked on RSRP accuracy and cell identification.

The evaluated scenario was assumed to be synchronous and one set of timing offsets between cells was evaluated. It should be further discussed what is reasonable assumption for the maximum offset between the transmission timings of PRS subframes in different cells. In order to be able to benefit from positioning subframes the overlap between them should be maximised. In case of asynchronous networks it would seem reasonable to assume that positioning subframes would overlap at least by 0.5ms (half a subframe). From UE perspective naturally the final received time difference will depend on the maximum ISD to be considered accounting practical limitations for example from sensitivity.

Two cell power offsets were considered. Set1 given is based on a snapshot taken from a system level evaluation, where UE is roughly located halfway between Cell1 and Cell2. Second set is a more arbitrary set emulating case where UE would be located closed to Cell1 and Cell2 and Cell3 would be lower level compared to Cell1.

Simulations were only carried out for system bandwidth and measurement bandwidth of 1.4MHz, but as discussed in RAN4#52bis, it would be useful to evaluate the benefit of wider PRS bandwidth and whether the maximum bandwidth could be limited to some level below 20MHz.

Semi-ideal receiver was assumed, with two uncorrelated receiver branches. RSTD measurements were based on single PRS subframe. Sliding correlation was performed in frequency domain per symbol. The results of these correlations between several symbols were coherently accumulated during 1 subframe. The maximum of the correlation profile was chosen as the strongest multipath path, local maximums at the proximity where evaluated as possible LOS candidates in respect to their relation to maximum and average correlation level.

No threshold to mark measurements as incorrect(false) was implemented. Same sampling rate and instants were assumed at the transmitter and receiver. No frequency error or transmitter impairments were accounted in the eNB.

Furthermore different search window sizes were evaluated to evaluate the impact of different assumption on assistance data. Window sizes ranging from $\pm 50*T_s$ to $\pm 400*T_s$, corresponding to approximately initial uncertainty of ±500m and ±4000m. The window was centred at the time offset of each cell.

Table 1. Link simulation assumptions

Parameter		Value
Cell layout		3 cells at distinct locations as illustrated in Figure 1
Cell ID scenarios		[0, 1, 2] [0, 6, 12]
Network synchronization		Synchronous with different offsets between cells
Cell timing offsets (in relation to cell 1 at the UE location)		[Cell2: 1/3*CP, Cell3: ½*CP]
Cell level offsets (in relation to cell1)		Set1: [Cell2: -1.7dB, Cell3: -8.7dB] Set2: [Cell2: -6dB, Cell3: -12dB]
Duplex mode		FDD
Data and CCH load		100%
Cyclic prefix		Normal
DRX		OFF
Carrier frequency		2 GHz
Channel bandwidth		1.4 MHz
Channel models		AWGN, EPA 3kmh and ETU30kmh
$\hat{E}s/N_{oc}$ for Cell 1 [dB]		Varied
Number of transmit antennas	PRS	1
	CRS	1
Number of receive antennas		2 (Fully uncorrelated)
Positioning subframes		No presence of PDSCH in PRBs containing PRS. Ideal eNB transmitter
Number of positioning subframes used		1
PRS pattern		6-reuse in frequency, v_{shift} = mod(PCI,6)
PRS boost		0 dB
PRS bandwidth		Full carrier bandwidth (e.g. 1.4MHz)
PRS search window (in respect the actual cell timing)		[±50*T_s,±100*T_s,±200*T_s,±400*T_s]

3. Simulation results for RSTD accuracy

In this section we present results for the scenarios and assumption described in previous section. For both of the cells the mean absolute value of the error and the standard deviation of the error are evaluated at different Cell 1 SNR ($\hat{E}_{s1}/N_{oc}$) levels.

3.1 Cell IDs

Figure 1 to **Figure 4** give the results for the cell ID set 1 [0,1,2]. Figure 5 to **Figure 8** show these for cell ID set 2 [0,6,12]. These are shown for different window sizes and propagation conditions.

The impact of different cell ID sets is mostly visible for the Cell3. The impact is minor for Cell2 as it is nearly at equal power level to the Cell1. With cell ID set {0,6,12} the results for Cell2 degrade slightly compared to set {0,1,2} for fading channels at larger window sizes. For AWGN the results even improve slightly for the used cell ID pairs. For cell3 the impact is clearly visible at the larger window sizes, but also reducing the performance at higher SNR levels for smaller window sizes.

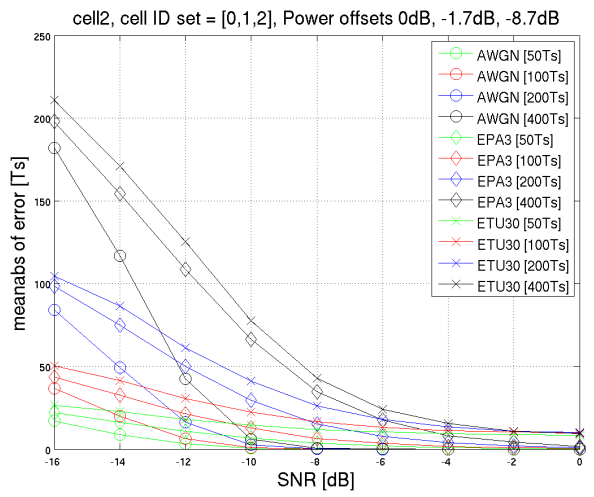

Figure 1. Mean absolute error for RSTD of Cell2 with cell IDs [0,1,2]

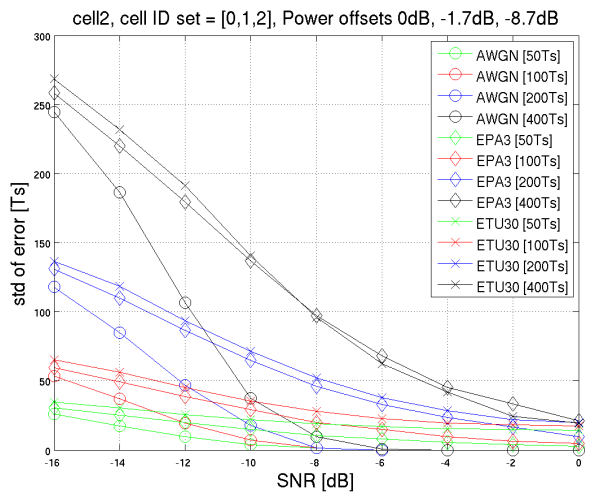

Figure 2. Standard deviation of the RSTD absolute error for Cell2 with cell IDs [0,1,2]

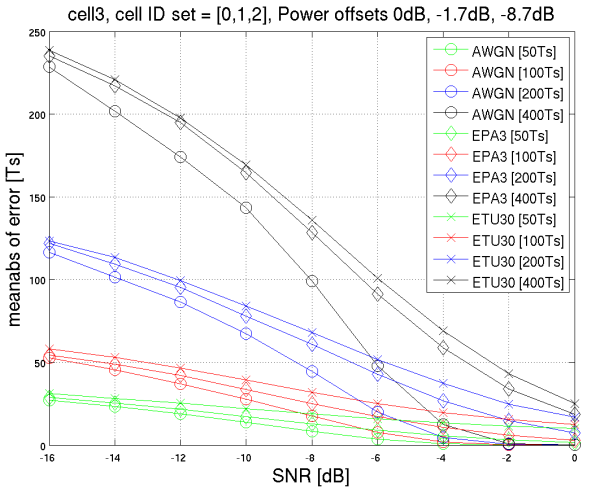

Figure 3. Mean absolute error for RSTD of Cell3 with cell IDs [0,1,2]

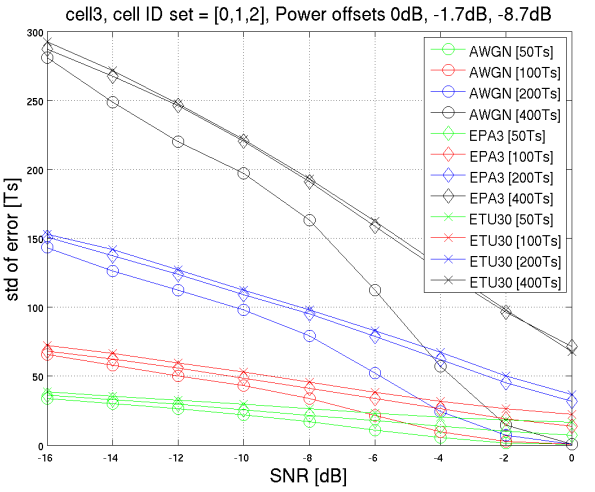

Figure 4. Standard deviation of the RSTD absolute error for Cell3 with cell IDs [0,1,2]

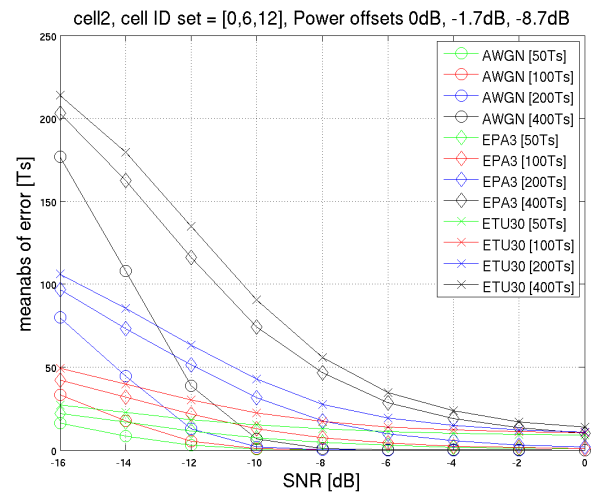

Figure 5. Mean absolute error for RSTD of Cell2 with cell IDs [0,6,12]

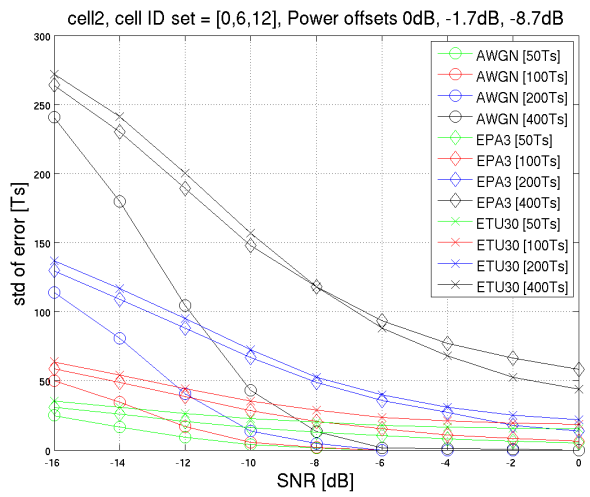

Figure 6. Standard deviation of the RSTD absolute error for Cell2 with cell IDs [0,6,12]

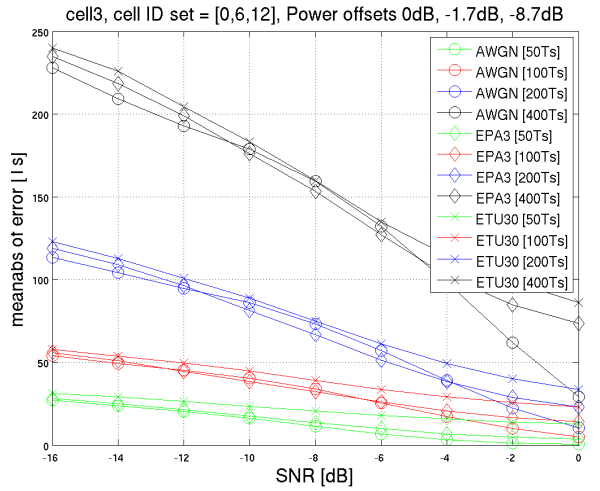

Figure 7. Mean absolute error for RSTD of Cell3 with cell IDs [0,6,12]

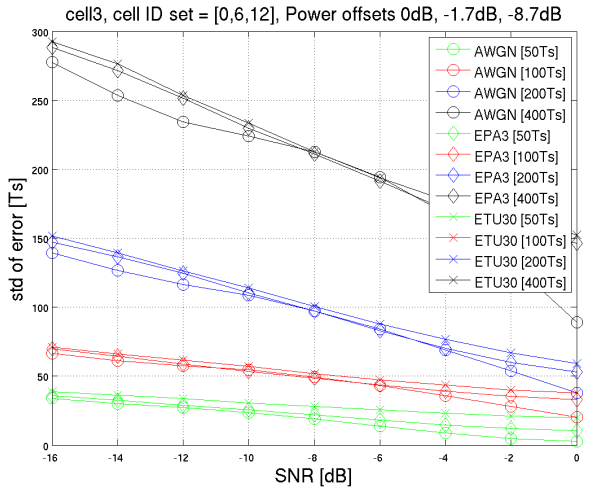

Figure 8. Standard deviation of the RSTD absolute error for Cell3 with cell IDs [0,6,12]

3.2 Window size

In this section the results presented in previous section are presented in different format to look how the effect of window size changes if other parameters are changed. An additional cell level set is also shown e.g. [0dB, -6dB ,-12dB]. Only two propagation conditions shown were limited to two, AWGN and ETU 30kmh. Range of the SNR points shown is also wider, as it could be assumed that in case of cell level set2, [0dB, -6dB ,-12dB], the noise would be lower level compared to cell 1.

Results for different window sizes for cell2 are show in **Figure 9** to **Figure 16**. Corresponding results for cell3 are given in **Figure 17** to **Figure 24**.

It can be seen that depending on the cell ID set and cell levels the limited correlation window size provides improvement to the performance especially in ETU propagation conditions and for weaker cells. For cell2 the mean error reaches zero at higher SNR levels in AWGN regardless of the window size and cell ID and level setting. For cell 3 the low error levels cannot be reached for all setting at larger window sizes than $\pm 50 * T_s$.

The average error saturates and does not reach low error levels even at high SNR levels in ETU. The performance is limited by low amount of samples as only single PRS burst is used to obtain the RSTD result. The impact of window size is still clear in ETU even for cell2, where degradation in both, mean error and deviation can be seen with larger window sizes. Similar findings can be done for cell3. The impact is most evident when cell level is lower compared to cell1.

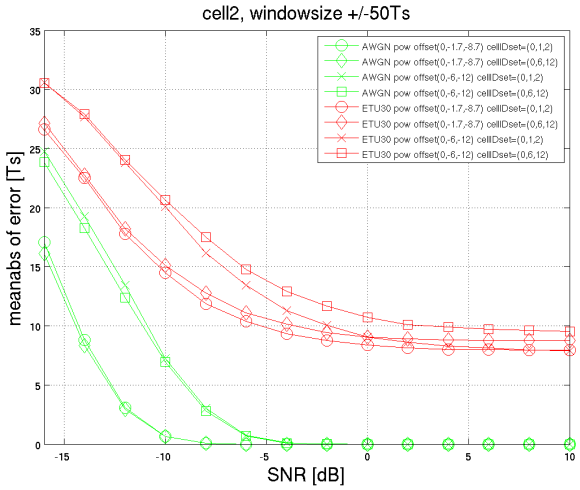

Figure 9. Mean absolute error for RSTD of Cell2 with window size of ±50*T_s for different power levels and cell IDs

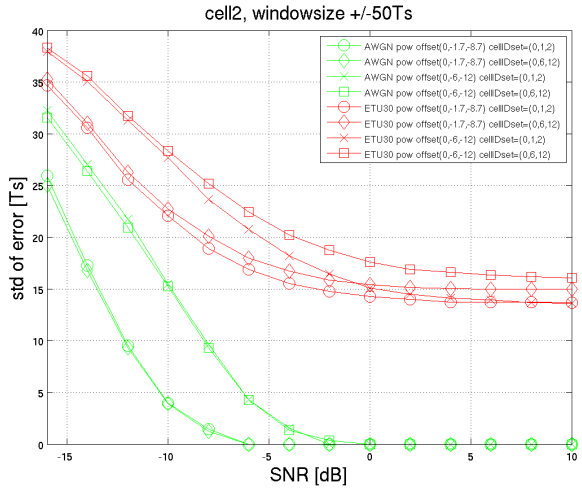

Figure 10. Standard deviation of the RSTD absolute error for Cell2 with window size of ±50*T_s for different power levels and cell IDs

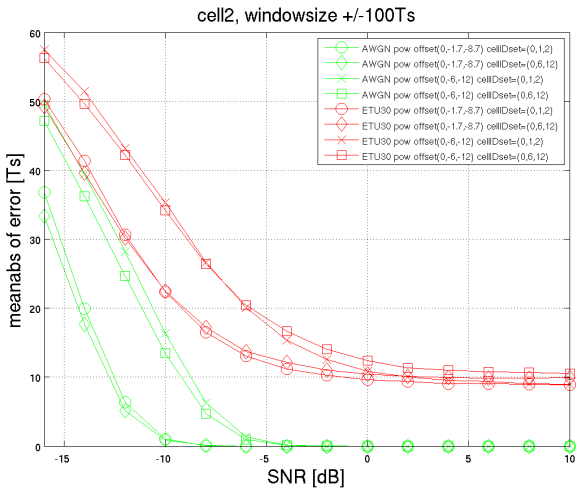

Figure 11. Mean absolute error for RSTD of Cell2 with window size of ±100*T_s for different power levels and cell IDs

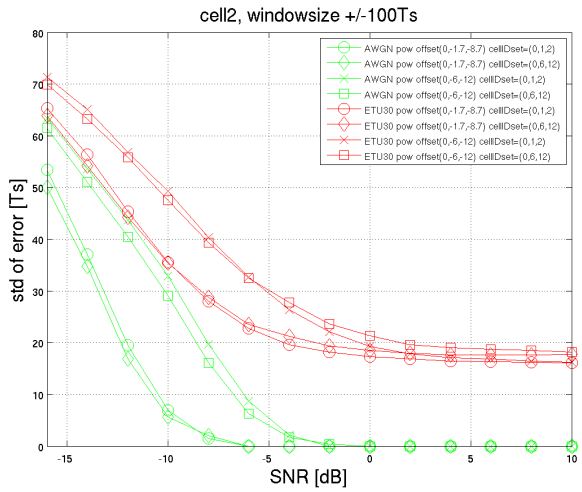

Figure 12. Standard deviation of the RSTD absolute error for Cell2 with window size of ±100*T_s for different power levels and cell IDs

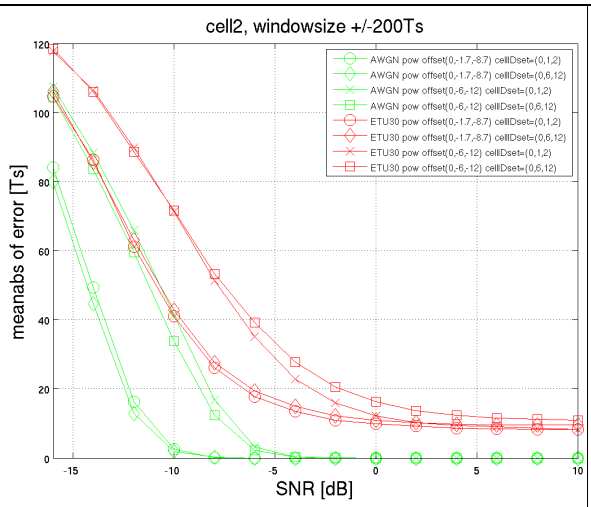

Figure 13. Mean absolute error for RSTD of Cell2 with window size of ±200*T_s for different power levels and cell IDs

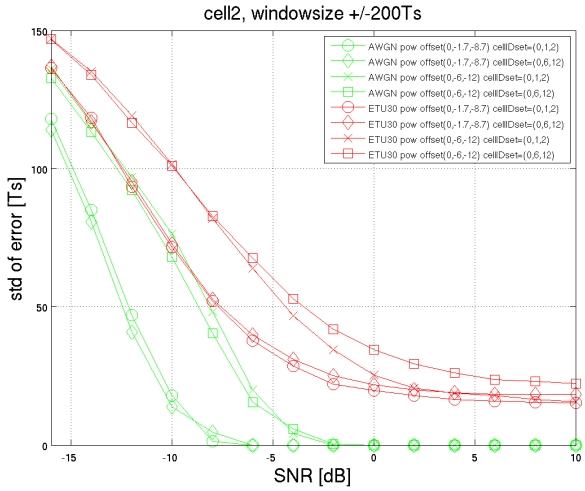

Figure 14. Standard deviation of the RSTD absolute error for Cell2 with window size of ±200*T_s for different power levels and cell IDs

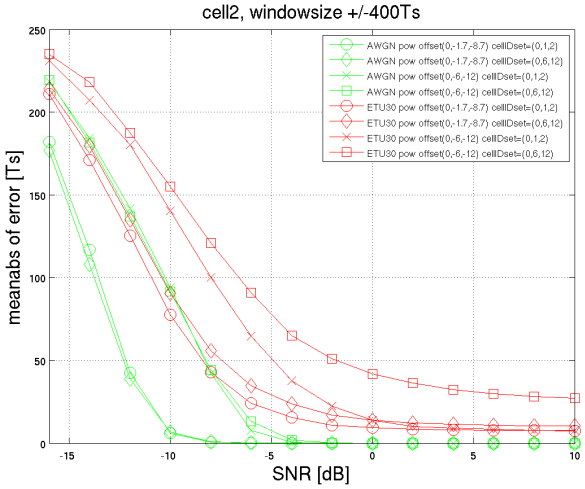

Figure 15. Mean absolute error for RSTD of Cell2 with window size of ±400*T_s for different power levels and cell IDs

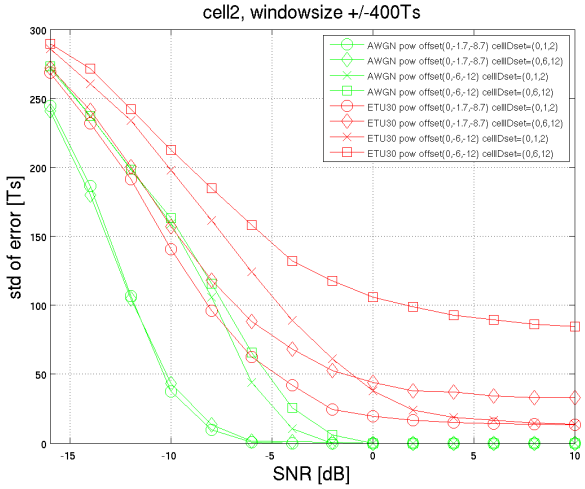

Figure 16. Standard deviation of the RSTD absolute error for Cell2 with window size of ±400*T_s for different power levels and cell IDs

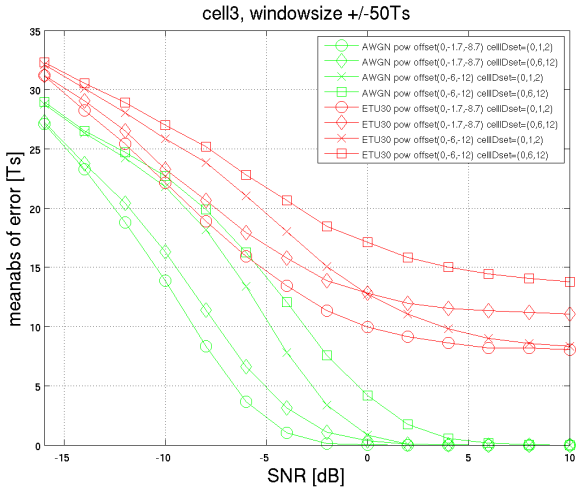

Figure 17. Mean absolute error for RSTD of Cell3 with window size of ±50*T_s for different power levels and cell IDs

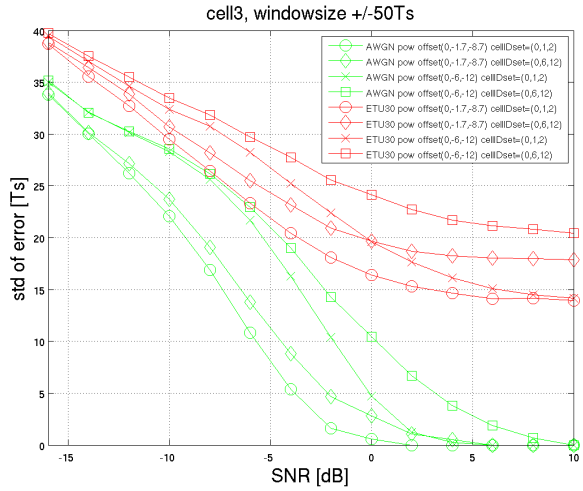

Figure 18. Standard deviation of the RSTD absolute error for Cell3 with window size of ±50*T_s for different power levels and cell IDs

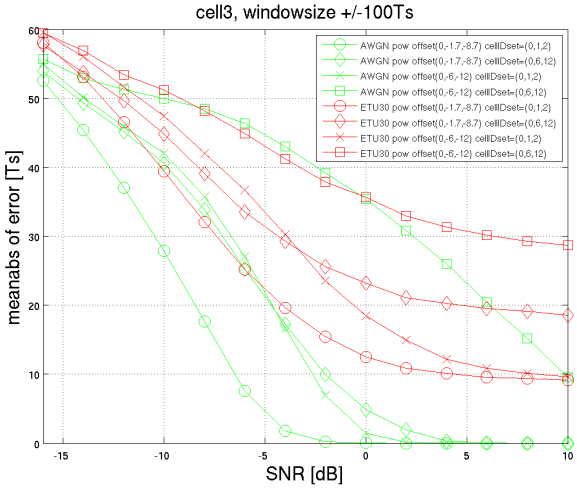

Figure 19. Mean absolute error for RSTD of Cell3 with window size of ±100*T_s for different power levels and cell IDs

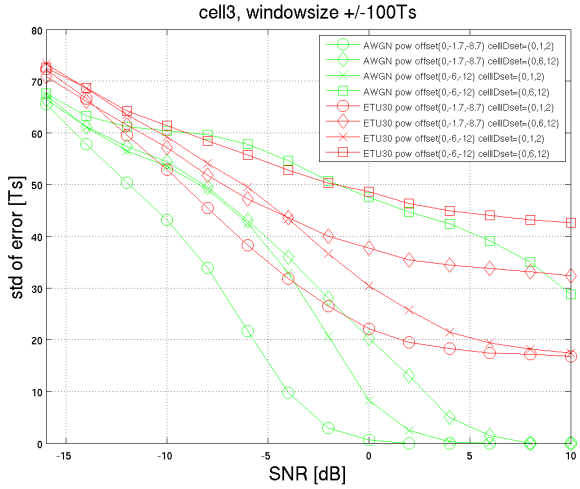

Figure 20. Standard deviation of the RSTD absolute error for Cell3 with window size of ±100*T_s for different power levels and cell IDs

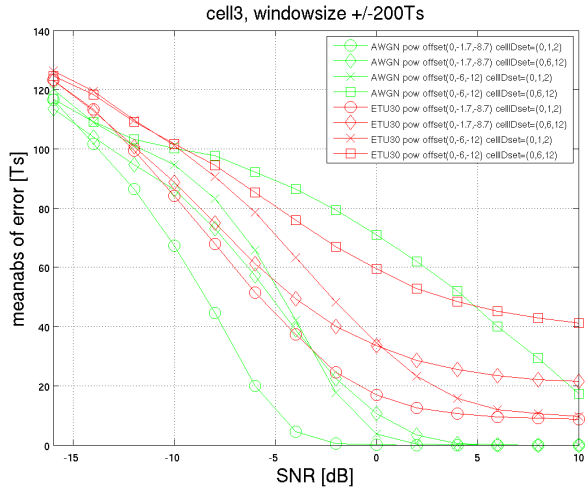

Figure 21. Mean absolute error for RSTD of Cell3 with window size of ±200*T_s for different power levels and cell IDs

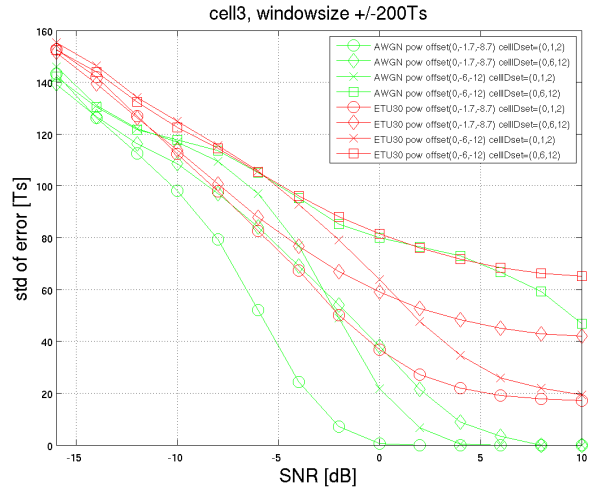

Figure 22. Standard deviation of the RSTD absolute error for Cell3 with window size of ±200*T_s for different power levels and cell IDs

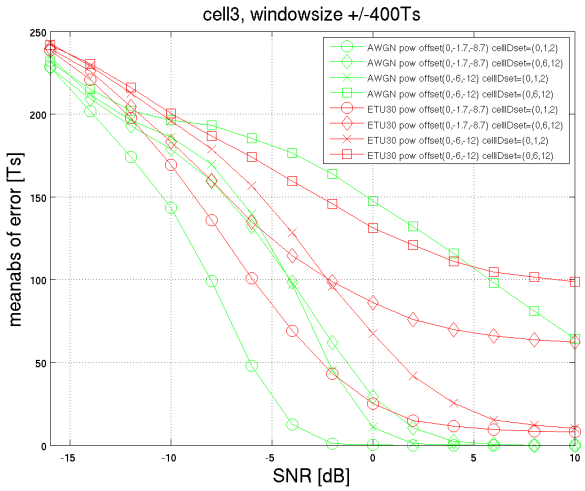

Figure 23. Mean absolute error for RSTD of Cell3 with window size of ±400*T_s for different power levels and cell IDs

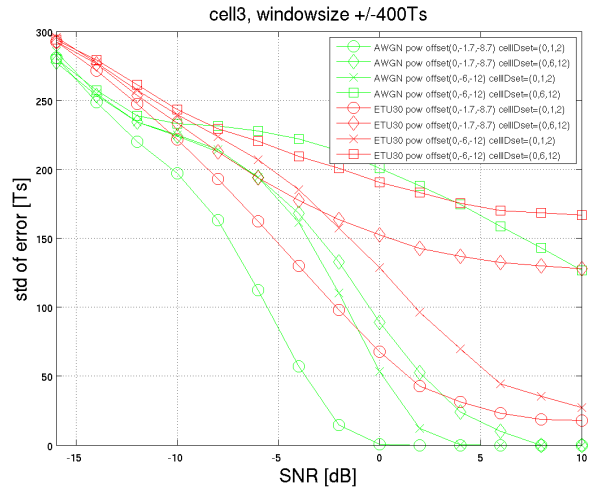

Figure 24. Standard deviation of the RSTD absolute error for Cell3 with window size of ±400*T_s for different power levels and cell IDs

4. Conclusion

In this contribution we have presented preliminary results for the RSTD accuracy. The assumptions used are similar to those proposed in [1], with some modifications. The RSTD mean error and standard deviation were evaluated in scenario with 3 cells, with two different cell ID and cell levels sets. Different propagation conditions were evaluated together with different search window sizes. Impact of different cell ID sets and levels was show in different propagation conditions. Furthermore it was shown that by enabling the UE to focus its correlation search by providing a small window, better RSTD accuracy can be reached, especially for weaker cells and when cell ID planning does not ensure orthogonality. Therefore the range and accuracy of the coarse timing difference assistance information should be carefully considered.

To progress the accuracy RSTD requirement evaluation, in similar manner as for RSRP and cell identification requirements in the past, impact of PRS sequence cross correlation properties would need to be evaluated. It would also

need to be agreed what is the maximum transmit timing difference for PRS subframes and/or correspondingly what is the maximum time difference to be supported by the UE. Also it would be good to evaluate the whether there is possibility to limit the maximum PRS transmission bandwidths or whether all the Channel bandwidth ($BW_{Channel}$) need to be covered with individual configuration.

References

[1] R4-093775, Discussion Link-Level simulation assumptions for OTDOA positioning requirements, Ericsson, ST Ericsson

[2] R4-093861, Discussion on OTDOA positioning assistance information, Nokia