

Source: Nokia
Title: System level evaluation for RSTD accuracy
Agenda Item: 2.9
Document for: Discussion

1. Introduction

In RAN4 meeting #53 we showed link level simulation results for RSTD accuracy [1]. In this contribution, we present system level results evaluating the false alarm threshold setting and neighbor cell list size to the number of detected sites.

2. System simulation assumptions

System simulation assumptions are given in Table 1. These follow mainly those given in [1].

Simulations were done with 10MHz bandwidth and for the scenario of Case 1. UEs were dropped to the centre sector of the network having their serving cell in the middle of the hexagonal grid. 57 neighbouring cells distributed in 19 neighbouring sites signals were fully modelled. Timing offset between cells were evaluated calculating line of sight propagation from different cells to each UE.

In terms of assistance information the following assumptions were made. Search window size of $\pm 200 \cdot T_s$ was considered corresponding to approximately initial uncertainty of $\pm 2000\text{m}$. The window was centred at the exact propagation delay. For cell list different assumptions were used. In the first case all 57 cells from 19 sites belonged to the search cell list. Three other cases with more limited cell list were considered. In these cases the search cell list was limited to 24, 18 or 9 strongest cells (with respect to long term the received power) in addition to the serving cell.

Semi-ideal receiver was assumed, with two uncorrelated receiver branches. RSTD measurements were based on 1, 2, 4 or 6 PRS bursts of 1 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. Same sampling rate and instants were assumed at the transmitter and receiver. No frequency error or transmitter impairments were accounted in the eNB.

Threshold was implemented after the correlation calculation to mark measurements as incorrect (false). Results in this contribution, i.e., detected cells and sites and mean absolute errors, are shown as a function of this threshold.

Table 1. Simulation assumptions

| Parameter | Value |
|---|---|
| Scenarios (ISD, height, UE speed, penetration loss) | Case 1 (500 m, 3 km/h, indoor: 20 dB) |
| Cell layout | Hexagonal grid |
| Number of sites | 19 sites, with 3-sectored antennas at each site |
| Network synchronization | Synchronous |
| Data and CCH load | 100% |
| Cyclic prefix | Normal |
| Carrier frequency | 2 GHz |
| Carrier bandwidth | 10 MHz |
| Channel model | ETU 30kmh, EPA 3kmh |
| Distance-dependent pathloss | $L=128.1+37.6\log_{10}(R)$ (R in km)+20dB |
| Lognormal shadowing standard deviation | 8 dB |

| | | |
|--|-----------------|---|
| Shadowing correlation | Between sites | 0.5 |
| | Between sectors | 1 |
| Minimum distance between UE and BS | | 35 m |
| eNode B antenna gain | | 15 dBi |
| UE antenna gain | | 0 dBi |
| eNode B Tx power | | 46 dBm |
| UE noise figure | | 9 dB |
| Number of transmit antennas | PRS | 1 |
| | CRS | 1 |
| Number of receive antennas | | 2 |
| Positioning subframes | | No presence of PDSCH in PRBs containing PRS. Ideal eNB transmitter |
| Number of consecutive positioning subframes | | 1 |
| Number of positioning occasions used in receiver | | 1,2,4 and 6 |
| PRS burst cycle | | 160ms |
| PRS boost | | 0dB |
| PRS pattern | | 6-reuse in frequency, $v_{\text{shift}} = \text{mod}(\text{PCI},6)$ |
| PRS transmission bandwidth | | Full carrier bandwidth |
| PRS search window | | $\pm 200 * T_s$ |

3. Simulation results

3.1 False alarm threshold

First we look at the false alarm threshold. It is defined as probability of some noise peak in the window exceeding a given threshold. Threshold is defined as some peak level exceeding the noise level after the correlator. In Figure 1 theoretical false alarm rates are shown as a function of false alarm threshold. What is good to note that these are based on assuming window size of $\pm 200 * T_s$. Hence assuming for example wider window would mean that threshold would need to be set to higher level. This would naturally mean that weaker cells would not be heard.

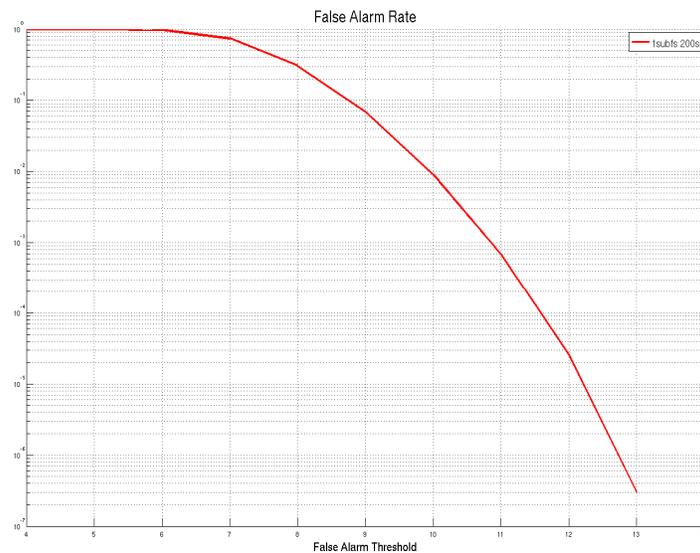


Figure 1. False alarm rate for $\pm 200 T_s$ window size and 1 subframe for a given threshold. X-axis in dBs after the correlator.

Figure 2 and Figure 3 show the mean absolute error of RSTD for the five strongest cells with different false alarm thresholds. These are averaged over all the dropped terminals. It can be seen that with lower false alarm thresholds the

RSTD accuracy gets worse, especially for the weaker cells (4th and 5th cell), but also for the others. The reason for this is two fold. Firstly as could be assumed weaker cells are accounted thus in general their accuracy is worse. Secondly also some cross correlation peaks are judged as proper peaks e.g. cells. This is especially the case when a weaker cell is being attempted to be measured. Also the PRS bursts always occur in the same sub-frame, the cross correlation products also appear at the same time instant, thus aggregating the measurement result over multiple burst does not help this case, even though it generally can be said to improve the hearability. This could of course be compensated by having multiple consecutive PRS sub-frames.

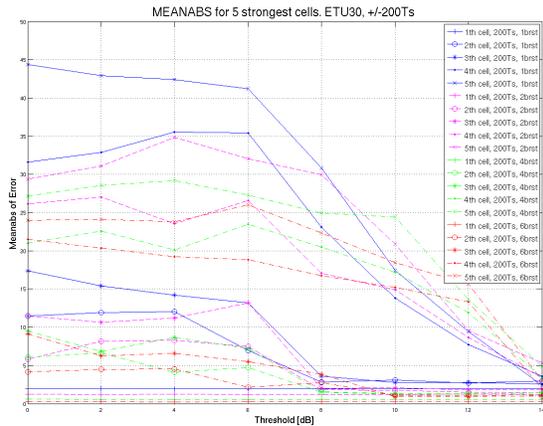


Figure 2 Mean absolute detection errors in ETU30 for five strongest cells.

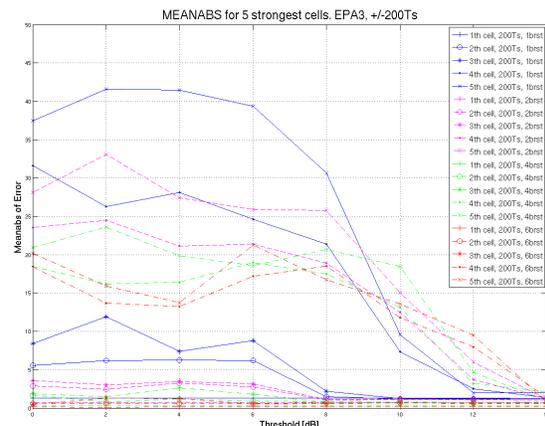


Figure 3 Mean absolute detection errors in EPA3 for five strongest cells.

3.2 Simulation results for RSTD accuracy

In this section we represent results for the scenarios and assumption described in previous section.

Figure 4, Figure 6, Figure 8 and Figure 10 show the average number of detected cells for the four different cases (57, 24, 18 and 9 cells), respectively. Figure 5, Figure 7, Figure 9 and Figure 11 show the respective results for number of different detected sites. Note that no other filter than the threshold was used when plotting these figures to consider a cell as detected or not (please see Annex A at the end of this document).

When considering the results showing the number of detected cells and sites, we can see that the lower the false alarm threshold the higher the number of detected cells or sites is. This is an expected result as weaker correlation peaks are considered to correspond to cell. This could be expected to improve the location accuracy, but on the other hand as show in Figure 2 and Figure 3 in previous section, lowering the threshold will result in bad RSTD accuracy. Thus the threshold setting would needs to be carefully balanced.

Looking at the number of detected cells in the different cell list cases, it can be seen that the more cells are detected with larger cell list, as could be expected. The maximum number of detected cells is limited in average to 37.38 cells which is achieved by leaving out the cells with received power under -30dB respect to the thermal noise out of consideration. This is done to reduce the complexity of the simulations since it is not possible to receive those weak cells in practice anyway. When comparing different cell list sizes, it can be seen that 57, 24 and 18 cell list have nearly equal performance when considering the higher threshold settings ≥ 12 dB. With slightly lower threshold setting, the case with 57 cells in the list has much higher number of cells, while 24 and 18 cell lists are nearly equal, and 9 cells starts to saturate.

Similarly, when considering the number of different detected sites, there is no significant difference between the average number of detected sites between 57, 24 and 18 cell list case at higher thresholds ≥ 12 dB. Again at lower thresholds the results start to differ between different cases. It should be noted that, as can be seen from Figure 1 to Figure 3, that using too low thresholds (10 dBs or lower) the number of erroneously detected cells increases.

All results show that when higher number of PRS bursts are considered, more cells or sites can be detected. Time diversity provided by accumulating measurements over multiple PRS bursts facilitates the detection of different cells. This also narrows the difference between the cases.

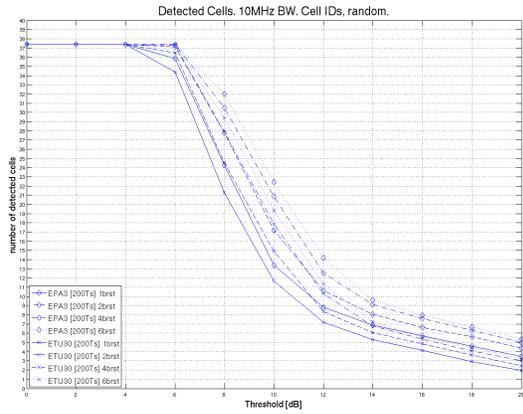


Figure 4. Number of detected cells for the case of 57 cells

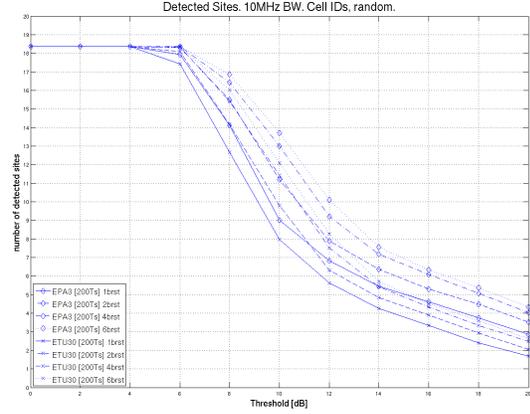


Figure 5. Number of detected sites for the case of 57 cells

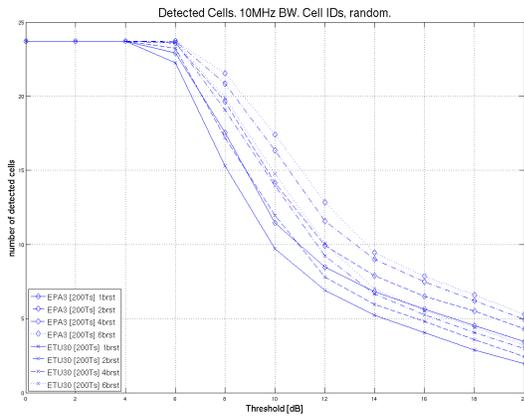


Figure 6 Number of detected cells for the case of 24 strongest cells

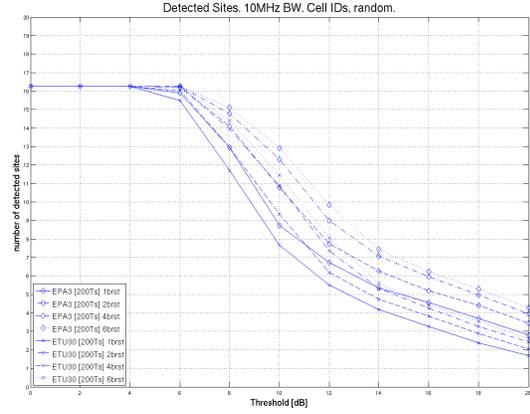


Figure 7. Number of detected sites for the case of 24 strongest cells

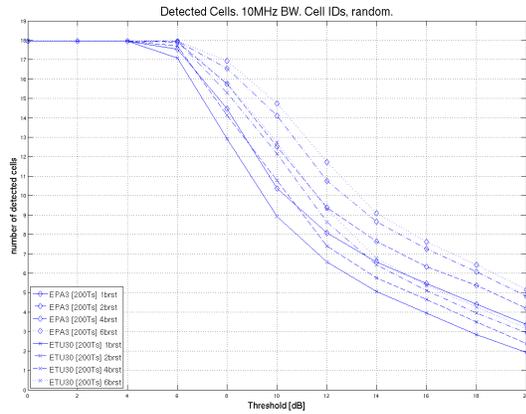


Figure 8. Number of detected cells for the case of 18 strongest cells

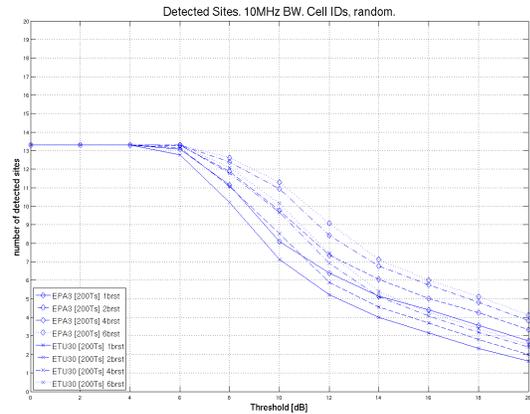


Figure 9. Number of detected sites for the case of 18 strongest cells

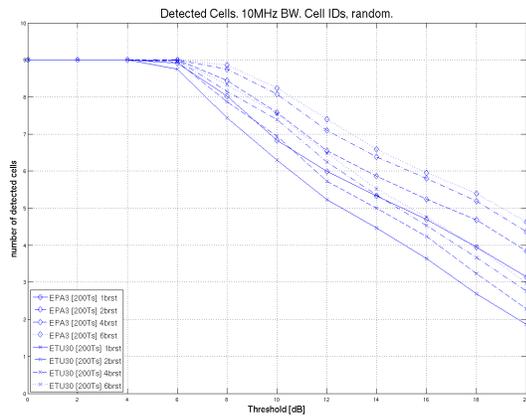


Figure 10. Number of detected cells for the case of 9 strongest cells

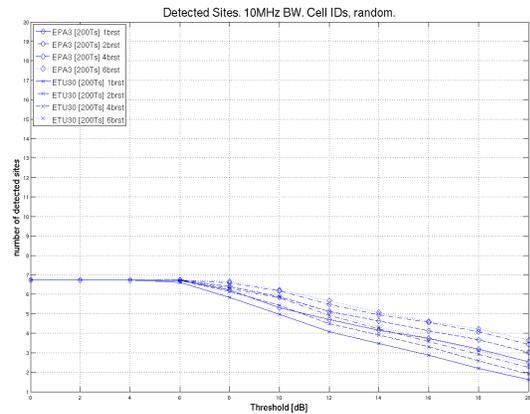


Figure 11. Number of detected sites for the case of 9 strongest cells

As noted in earlier discussion the threshold setting has also effect to the RSTD accuracy. How much practical benefit a RSTD STD estimation and reporting would provide for the network positioning algorithms would need to be further assessed [3]. However as also noted cross correlation peaks may result in errors when weak cells are considered, it would seem practical to consider reasonably low false alarm probability (e.g. high threshold) to prevent negative implications. This is also shown when comparing Figure 18 and Figure 19 in the Annex A. To further evaluate the impact of different neighbour cell list sizes, the probability of detecting equal number or more than 3 or 5 sites was studied for few thresholds. Selected thresholds were 12dB, 14dB and 16dB. Based on Figure 2 and Figure 3 these thresholds should give sufficiently good RSTD accuracy even for 5 cells.

Figure 12 to Figure 17 give the probability for detecting ≥ 3 or ≥ 5 sites with different false alarm thresholds in EPA 3kmh and ETU 30kmh and also with either 1 PRS burst or 6 PRS bursts. As noted in earlier results the probability of detecting more cells decreases as the threshold is increased. Allowing more PRS burst to be used for cell detection, improves the probability of detecting. As also shown by previous results, the probability of detecting ≥ 3 or ≥ 5 sites is practically equal for cell list sizes of 57, 24 and 18, especially if 6 PRS bursts are considered.

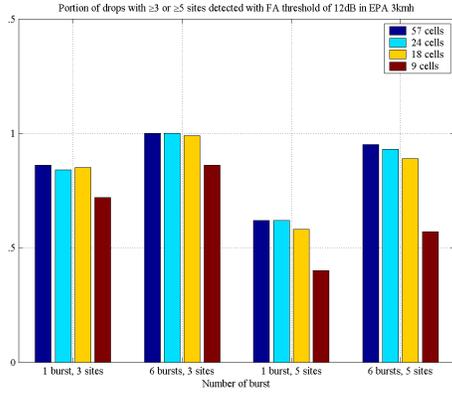


Figure 12. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 12dB in EPA 3kmh

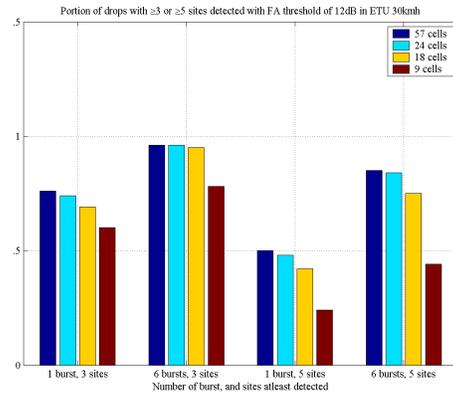


Figure 13. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 12dB in ETU 30kmh

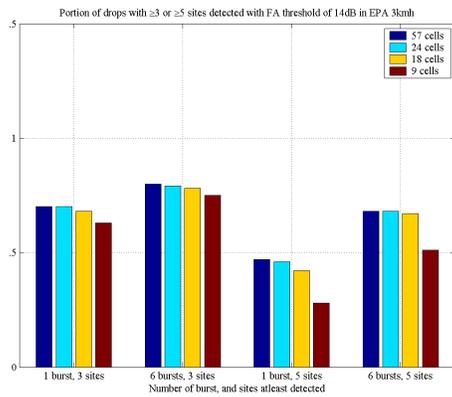


Figure 14. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 14dB in EPA 3kmh

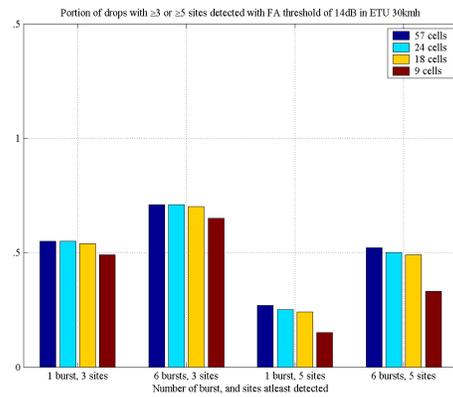


Figure 15. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 14dB in ETU 30kmh

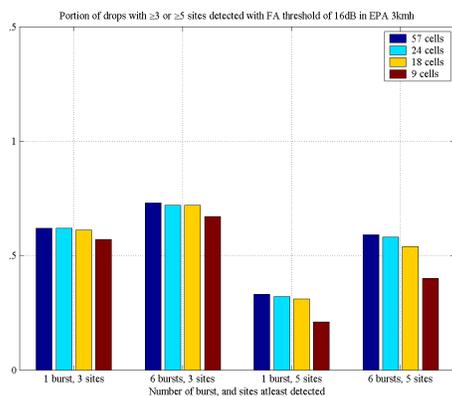


Figure 16. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 16dB in EPA 3kmh

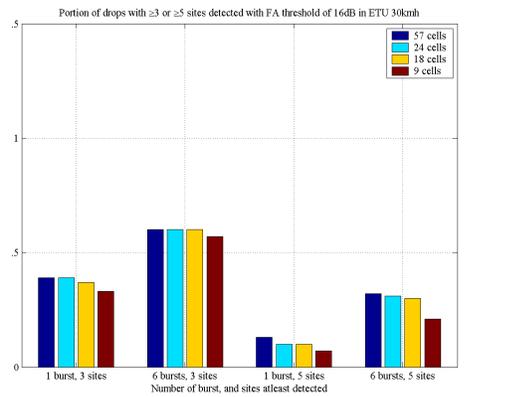


Figure 17. Probability of detecting ≥ 3 or ≥ 5 sites with FA threshold of 16dB in ETU 30kmh

4. Conclusion

In this contribution we have presented system level results for the RSTD accuracy. Simulation assumptions mainly followed the ones given in [2] with little modifications. Theoretical false alarm rate together with the RSTD mean absolute errors were also presented and discussed. System level simulation results for four different cell list sizes were considered. Detected cells and sites were shown as a function of false alarm threshold in different propagation conditions. Number of detected cells was shown to be higher with smaller false alarm threshold but in proportion it was shown that with higher false alarm threshold better RSTD accuracy is reached. When comparing detected sites there was no significant difference between different cell list sizes with reasonably high threshold values. With smallest list size and higher number of positioning subframe accumulations nearly the same number of sites were detected as when detecting the whole list with one subframe.

Based on the results, two conclusions can be drawn. Firstly, using multiple PRS bursts improves the cell detection performance, as could be expected, and therefore PRS measurement period should be multiple of PRS periodicities as proposed earlier. Number of periodicities (bursts) considered in this contribution was 6. This would seem as a reasonable value, although further verification would be needed once the false alarm probability related discussion has been concluded. Secondly it was shown that in terms of detecting different sites reliably, there is practically no difference with the maximum considered neighbour cell list of 24 [5] and 18. Thus to reduce the UE complexity it is proposed to limit the assistance information on 18 measured cells.

References

- [1] R4-094670, Link simulation results for RSTD accuracy, Nokia
- [2] R4-093039, System Level simulation assumptions for OTDOA positioning studies, Ericsson, ST Ericsson, Qualcomm, Motorola
- [3] R4-100082, Discussion on RSTD STD requirements, Nokia
- [4] R4-093861, Discussion on OTDOA positioning assistance information, Nokia
- [5] R4-094989, Response on Assistance Information for OTDOA Positioning Support for LTE

Annex A. Additional results

Figure 18 and Figure 19 show the number of detected cells for 57 cell list with two assumptions. In Figure 18 all the peaks exceeding the false alarm threshold are considered as cells and not additional filtering is done, similarly as shown in Figure 5. In Figure 19 the same statistics are plotted in slightly different manner, so that only those cells which RSTD estimate is within $\pm 5 \cdot T_s$ of the ideal timing are accounted as cells. It can be seen that especially at the lower thresholds the amount of sites detected is dramatically decreased. This also highlights the fact that if the threshold is used for judging a cell to correct, it should not be set too low.

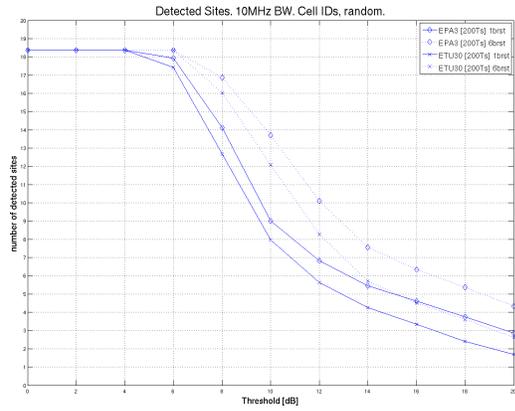


Figure 18. Number of detected sites for the case of 57 cells (re-plot of Figure 5)

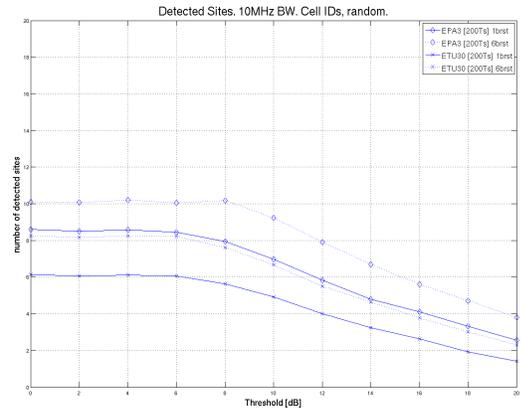


Figure 19. Number of detected sites within $\pm 5 * T_s$ of the ideal timing for the case of 57 cells