3GPP TSG-RAN1 Ad-Hoc on LTE **R1-050643**

Sophia Antipolis, France, 20th-21st June

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Document for: **Discussion**

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On Sub-Channelization for E-UTRA

June 15, 2005

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Introduction

- In recent LTE discussions, two types of sub-channelization were proposed, namely, sub-band based vs. diversified.
- Diversified channel was proposed for open-loop mode. The purpose is exploit frequency diversity and thus improve the system reliability.
- Sub-band channel was proposed for closed-loop mode. The purpose is to exploit frequency multi-user diversity and thus increase the system throughput.
- Sub-band channel with frequency hopping can be used as a diversity channel as well.
- In this contribution, we compare the open-loop performance of these two kinds of sub-channelization in different channel models.
- In addition, we investigate a 3rd kind of sub-band based diversity sub-channelization.
- The purposes is to unify the sub-channel element definition for both diversity and sub-band channelization.

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Diversity sub-channels

All the *sub-carriers* assigned to a particular user are equally (or according to a certain pattern) *distributed* across the frequency domain.

> Advantage:

- **Frequency diversity.**
- **Applicable to open-loop links.**

> Disadvantage:

- **Difficult to exploit multi-user diversity.**
- **High feedback requirement if it was to be used in closed-loop mode**
- **High overhead with dedicated pilots.**

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Sub-band sub-channels

All the *sub-carriers* assigned to a particular user occupy a continuous sub-band.

> Advantage:

- **Easiness in exploiting multi-user diversity in the frequency domain.**
- **Low feedback requirement for closed-loop feedback (provided the UE report the best or a set of best sub-bands).**
- **Small overhead with dedicated pilots.**

> Disadvantage:

- **Lack of frequency diversity.**
- **Poor performance for open-loop links.**

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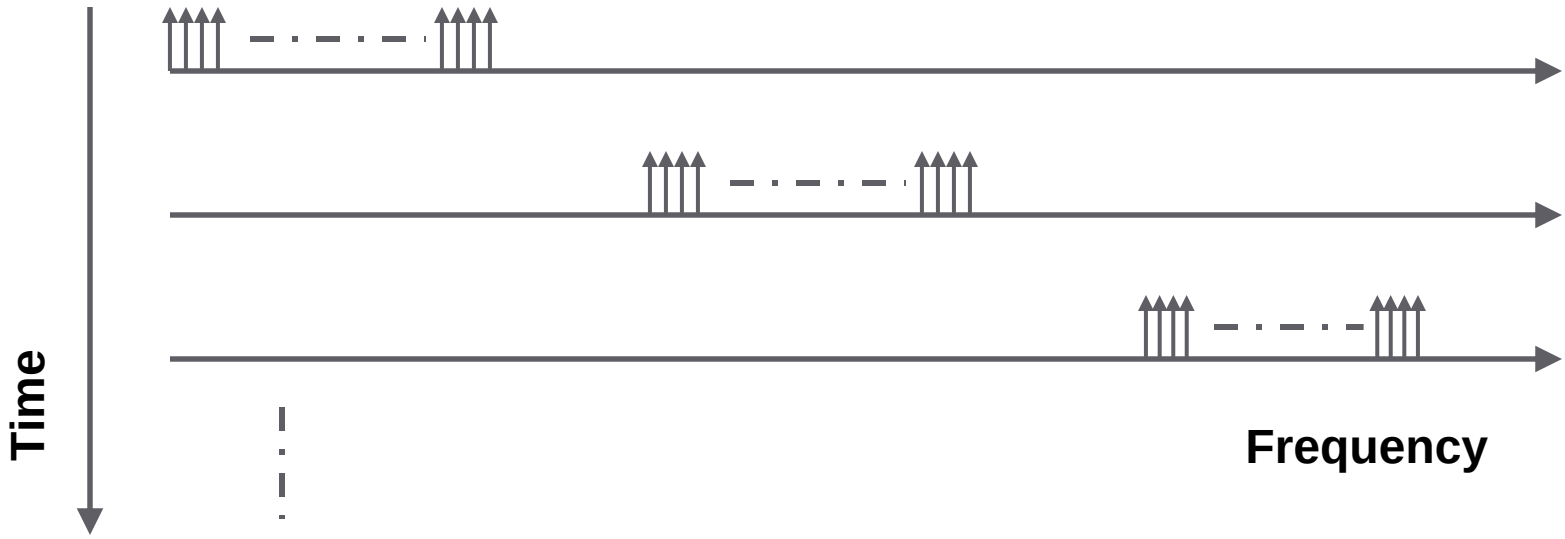
Hopping of sub-band sub-channels

Sub-band sub-channels can hop in the time direction to achieve additional frequency diversity.



> Advantage: Additional time diversity (for high speed UEs).

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The elements in diversity and sub-band sub-channels

> Diversity sub-channel

- **A sub-channel is defined as a group of *distributed* sub-carriers.**
- **Several sub-channels can be assigned to the same user.**

> Sub-band sub-channels

- **A sub-channel is defined as a group of continuous sub-carriers.**
- **Several sub-channels can be assigned to the same user according to the UE feedback.**

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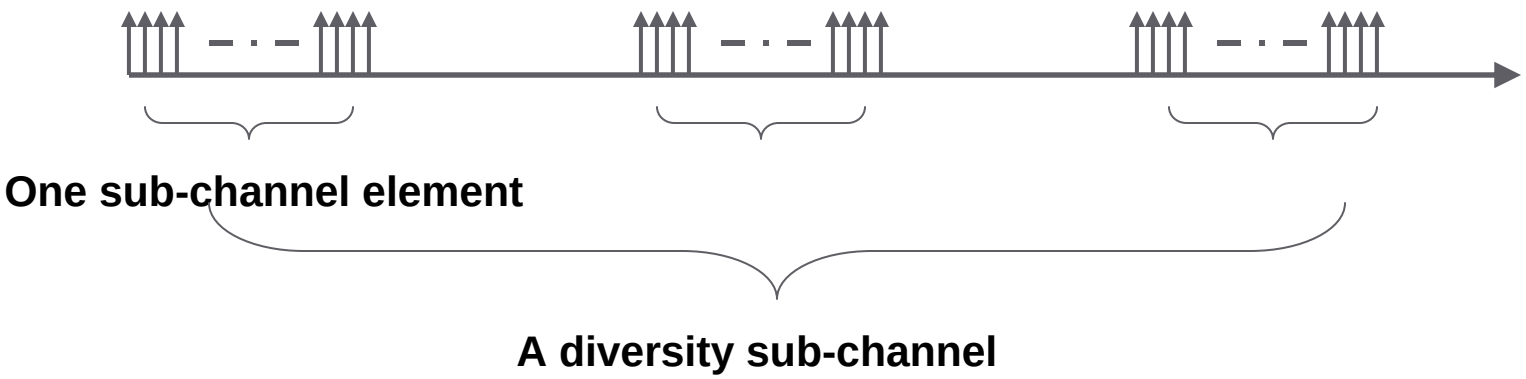
Define a diversity sub-channel based on sub-bands



> Both diversity and sub-band channels use the same sub-channel element (SCE), i.e. a pre-defined number of continuous sub-carriers.

> For a diversity sub-channel based on sub-band, a number of (approximately) equally distributed SCEs is assigned to the UE.

> For a sub-band channel, a number of SCEs can be assigned according to the UE feedback.

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Simulation Conditions

> Channel bandwidth: 5 MHz

> Sampling frequency: 6.72 MHz

> FFT size: 512

> Sub-carrier spacing: 13.125 KHz

> OFDM symbol duration: 83.33 us

> Number of tones per sub-channel: 128

> Number of tones in one SCE: 16

> Open-loop

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Simulated cases

> Sub-carrier based diversity channel *(labeled as distributed in two OFDM symbols)*
  - **64 sub-carriers evenly distributed in one OFDM symbol.**
  - **Two OFDM symbols contain 128 sub-carrier of data, with identical distribution pattern.**

> Sub-band based diversity channel *(labeled as 4 clusters two OFDM symbols)*
  - **4 SCE (Sub-Channel Elements) or clusters are evenly distributed in one OFDM symbol.**
  - **Each SCE contains 16 sub-carriers.**
  - **Two OFDM symbols contain 128 sub-carriers of data, with identical distribution pattern.**

> Sub-band hopping diversity channel *(labeled as 4 clusters hop in one TTI)*
  - **One SCE or cluster per OFDM symbol.**
  - **The location of the cluster hops every 2 OFDM symbols, with maximum frequency separation.**
  - **Hopping covers 8 OFDM symbols.**

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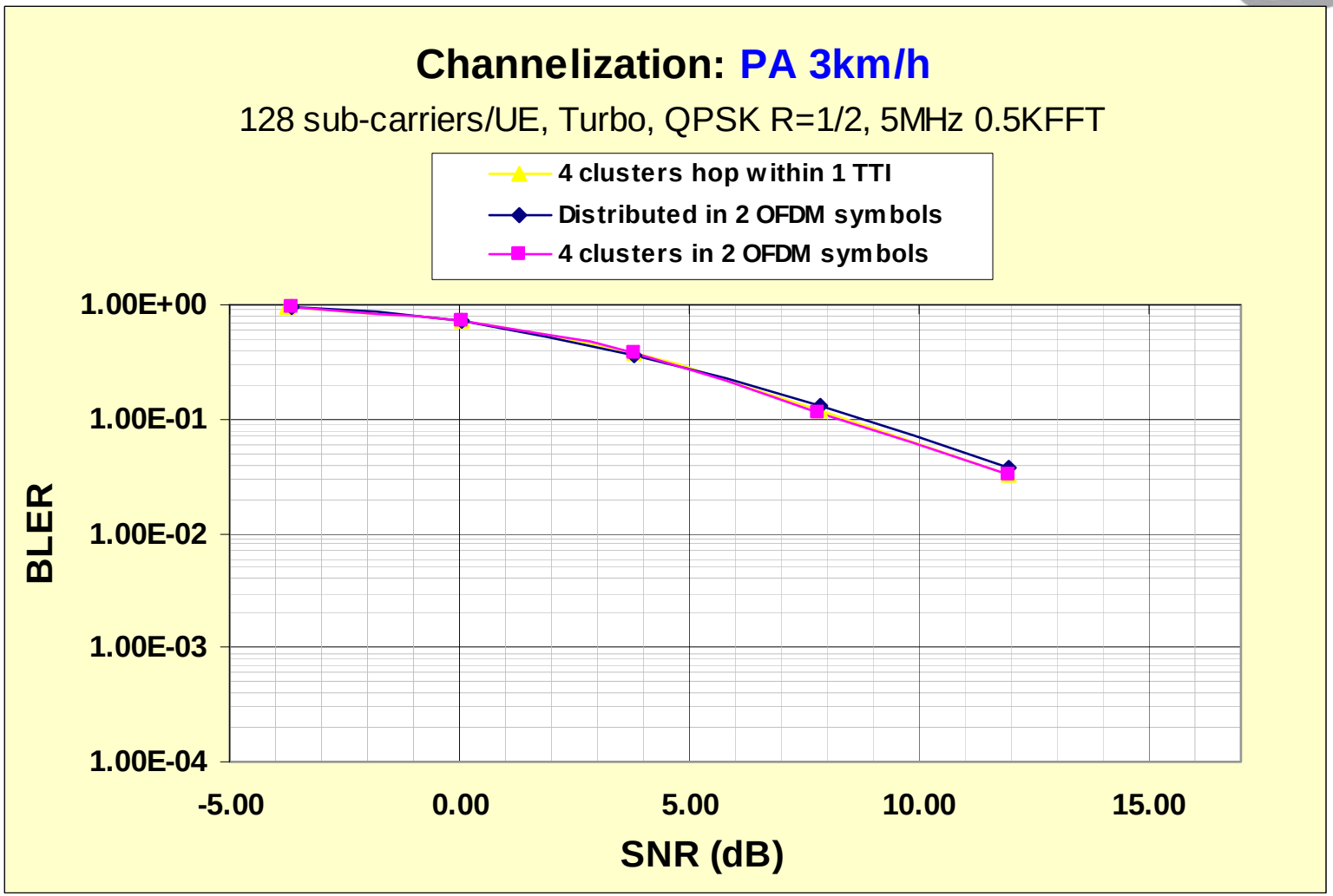
PA 3km/h



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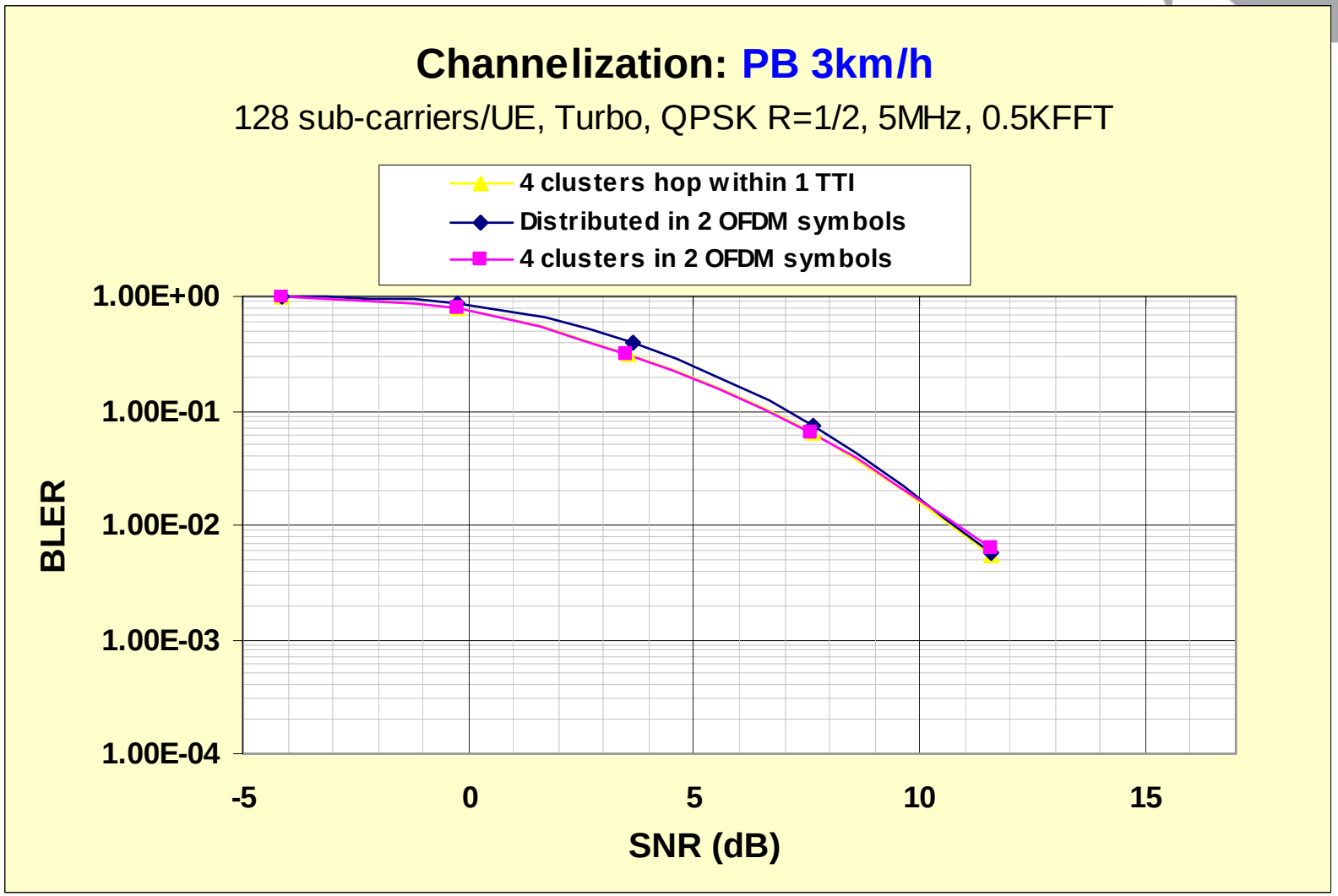
PB 3km/h



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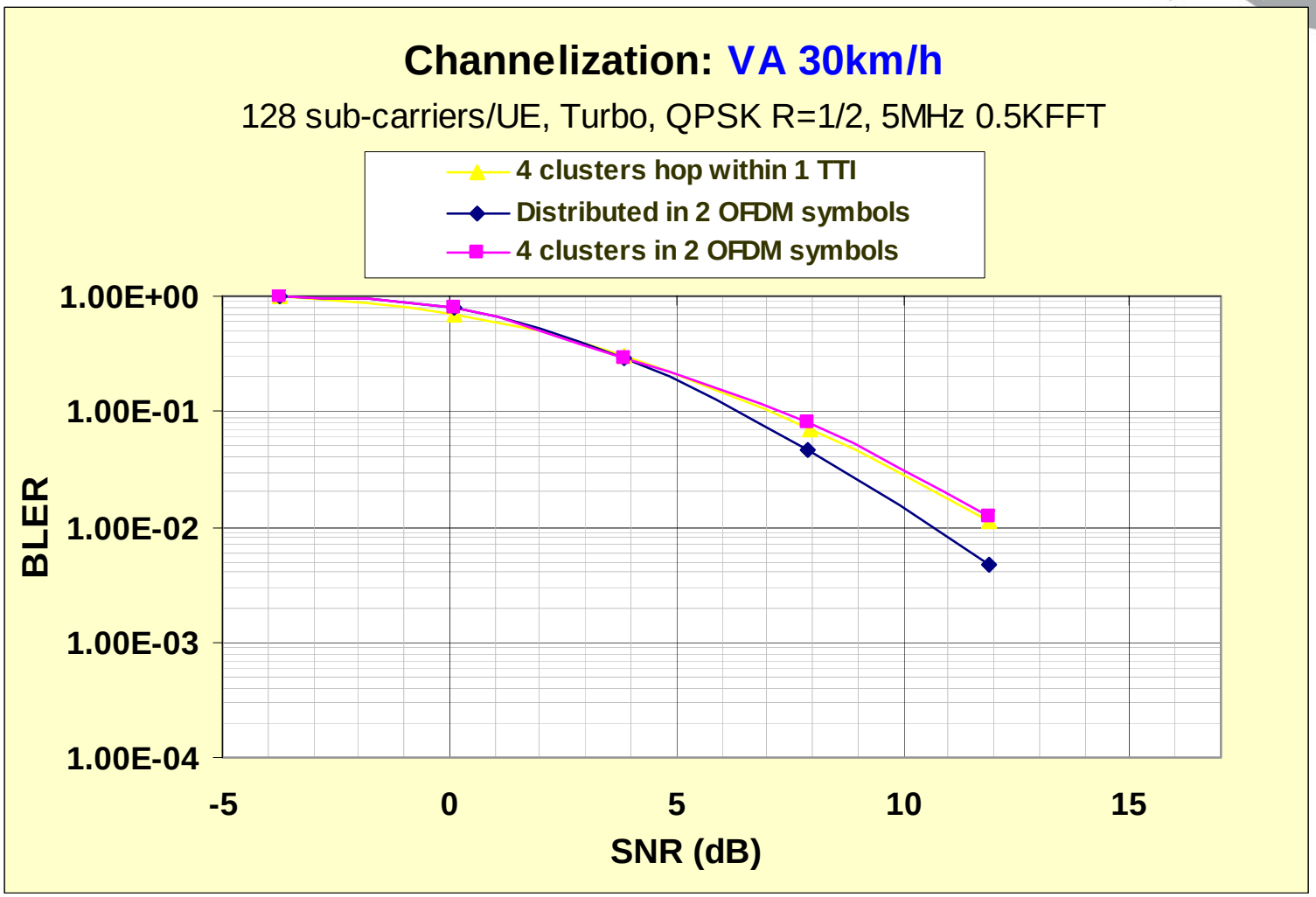
VA 30km/h



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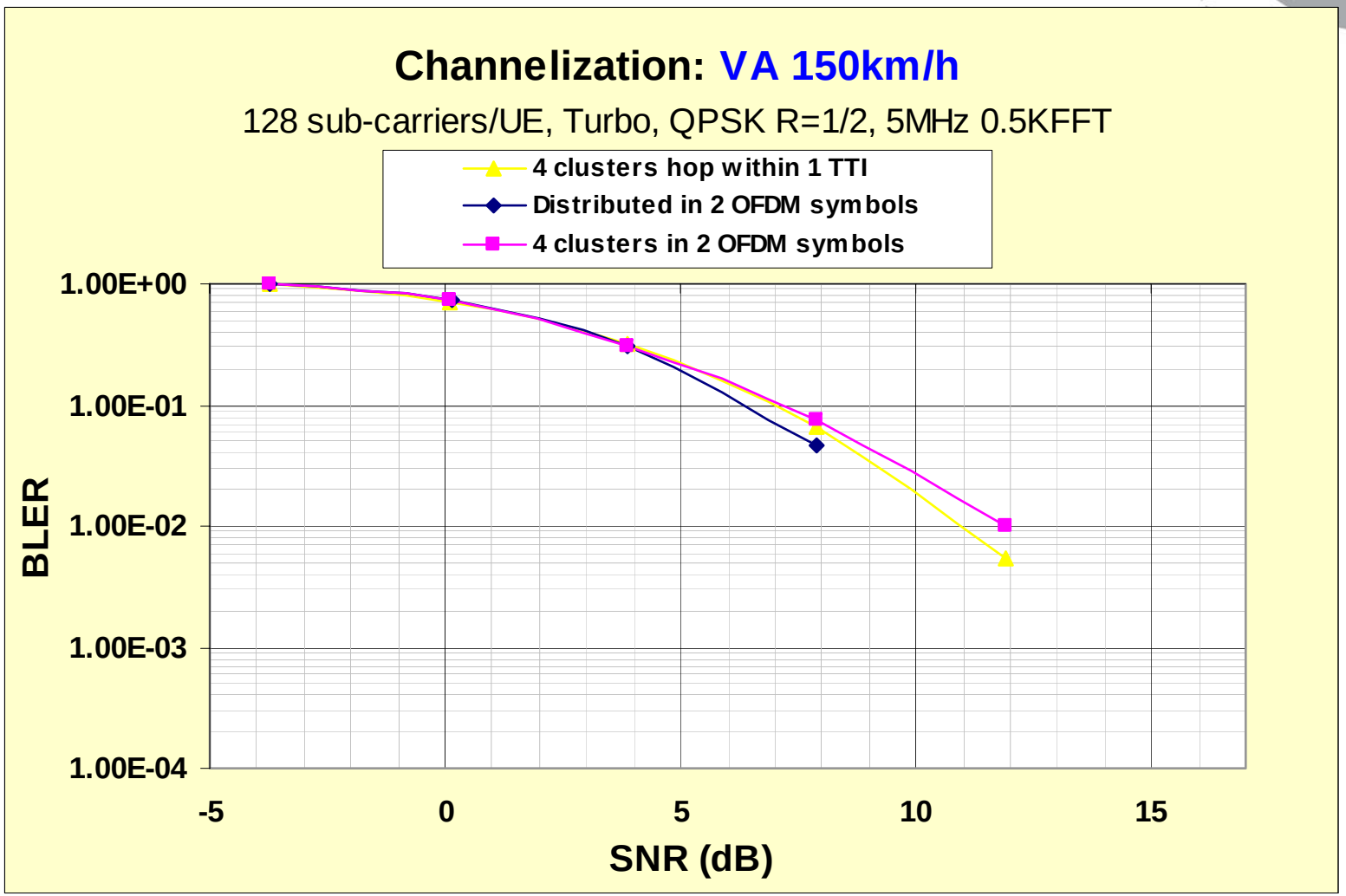
VA 150km/h



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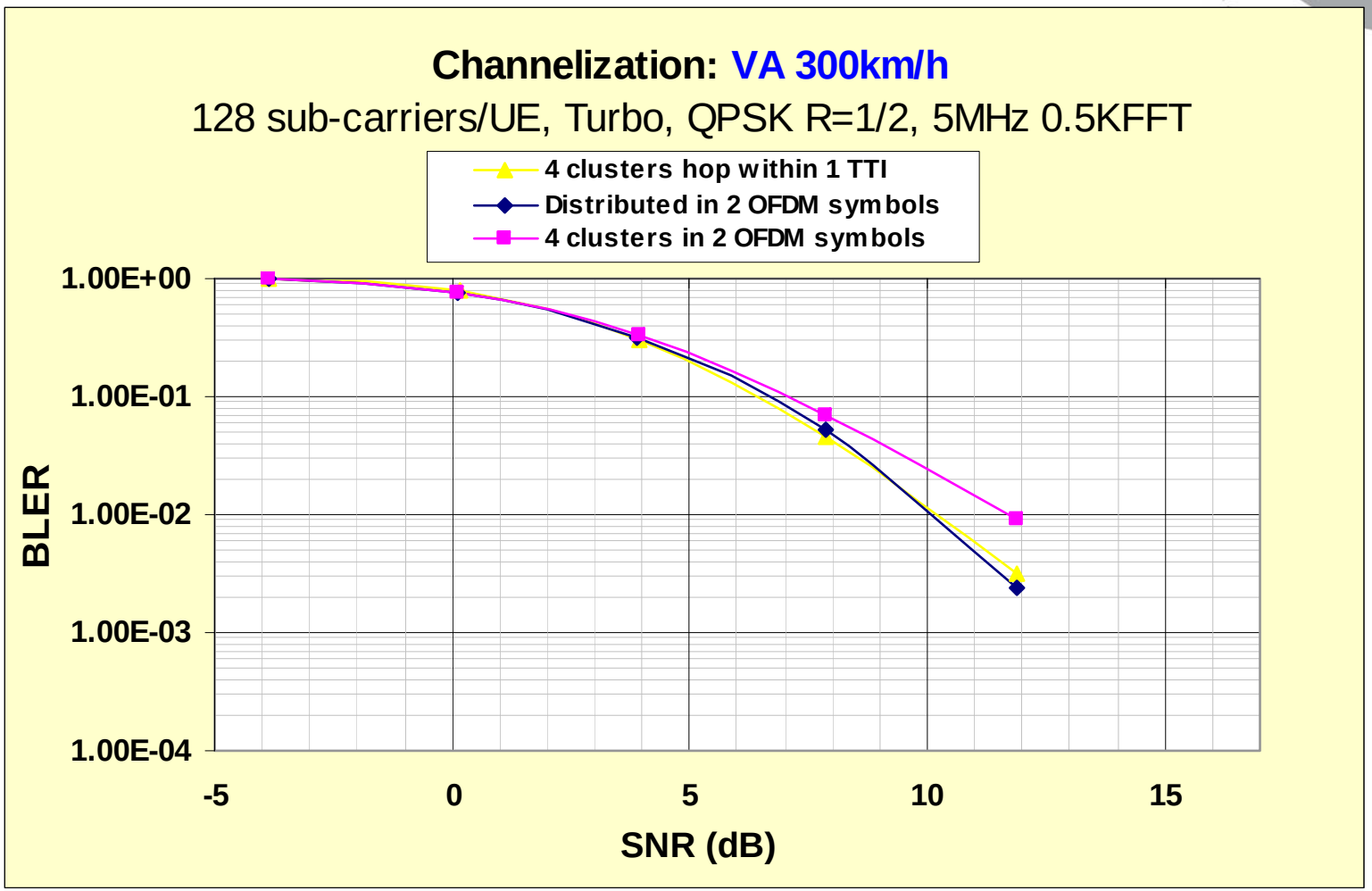
VA 300km/h



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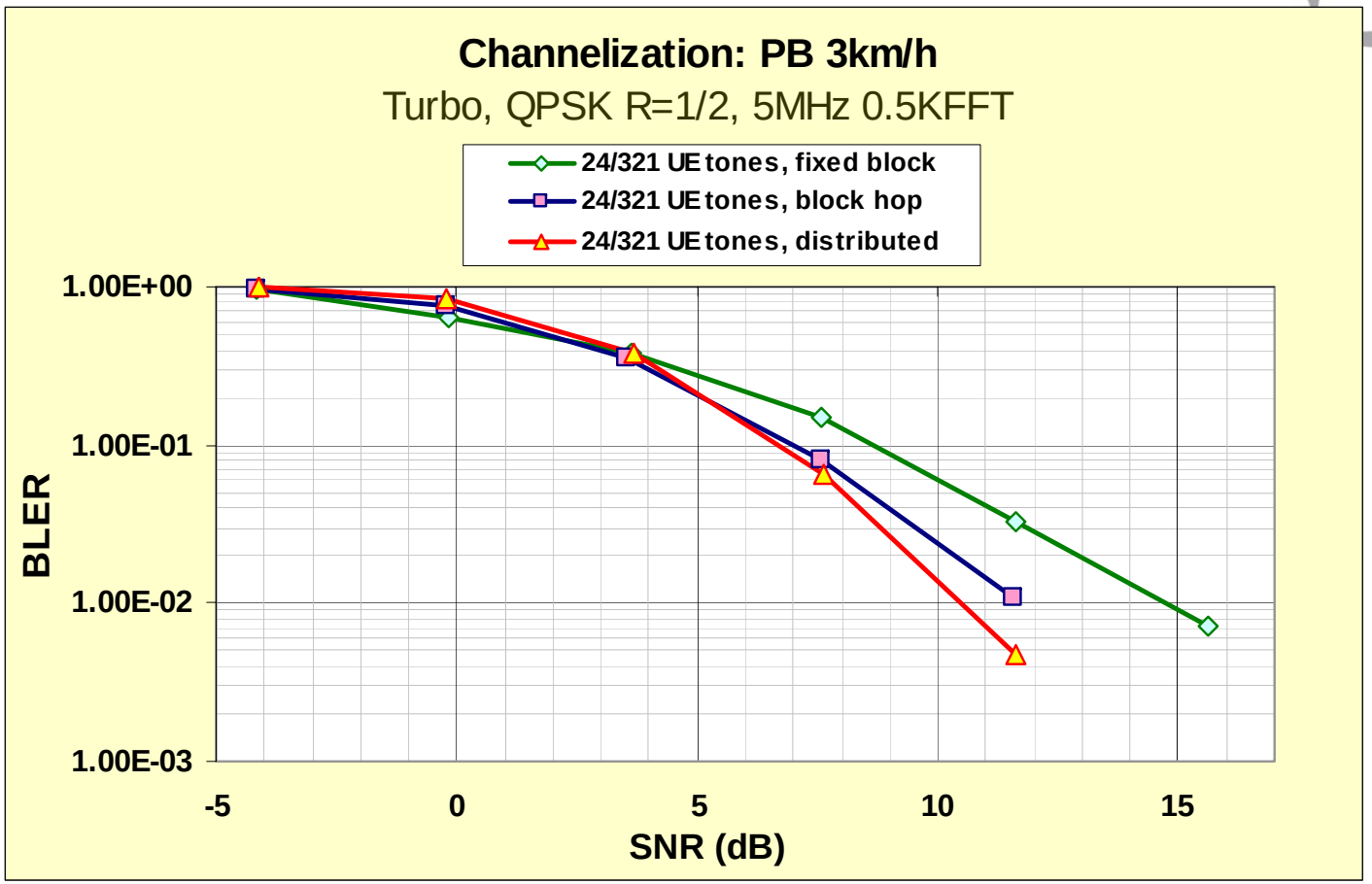
The performance of a localized channel



As a reference, localized channel without frequency hopping provides poor performance in a open-loop link.

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Observations and discussions

> Three different types of sub-channelization were investigated.

> Performance-wise the three sub-channelisation exhibit the following characteristics at the link level for the simulated case (QPSK, Rate ½, 64 used sub-carriers, SCE of 16 tones)
  - For PA and PB channels, SCE based diversity sub-channels achieve similar performance as distributed channel.
  - For VA channel, distributed (sub-carrier based) sub-channel provides additional frequency diversity gain (about 1.5 dB at FER=10^{-2}).
  - For the PA, PB and VA channels at speed 30km/h, sub-band based diversity channel can achieve the same level of performance as the frequency hopping approach.
  - However, for VA channel at high mobile speed, hopping in frequency provides additional gain for SCE based diversity sub-channels:
    - **The higher is the speed, the larger is the diversity gain;**
    - **It achieves the same level of performance as distributed sub-channel at 300 km/h.**

> In terms of resource management :
  - Using SCE (Sub-channel element) allows for the support of sub-band sub-channels and allows for some level of diversity thanks to the SCE based diversity sub-channels.
  - SCE based diversity sub-channels can be easily mixed with SCE sub-band channels in one cell, whereas mixing sub-band channels and sub-carrier based diversity channels may be more complicated (this depends of course on the exact diversity scheme (equal distribution or something else))
  - Depending on the set of numbers of sub-carriers to allocate to a UE, in terms of sub-carrier management by the Node B scheduler (like code tree management in WCDMA) a SCE based allocation rather than a sub-carrier based allocation (also considering the mix of sub-band and diversity channels) may be easier to operate. This should be further analysed.

> We would like to suggest to continue the discussion on the merits of a sub-channel element notion that would be the common point between sub-band and diversity type of channels

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