R1-061721 On the impact of Reference Signal Structures on Localized and Distributed Performance

Agenda Item: 6.4

Introduction

Main topics

- **Performance comparison of Distributed and Localized FDMA with pilots structures in R1-061720 (No channel dependent scheduling)**
  - **Pilot Option 3: FDM pilots**
  - **Pilot Option 1: FDM on SB1, Hybrid FDM/CDM on SB2 (RPF=2)**
  - **Pilot Option 2: Hybrid FDM/CDM on SB1 and SB2 (RPF=2)**
  - **CDM Pilots: On Both SB1 and SB2 (RPF=1)**
- **Benefits of Advanced Receivers**

Simulation Assumptions

- **System Parameters**
  - **DFT-SOFDM parameters included in the EUTRA 3GPP SI Technical Report (TR) – Table 9.1.1-1**

Item	Value/Description
Channel Bandwidth	5 MHz
Number of sub-carriers (LB/SB)	300/150
Sub-carrier spacing (LB/SB)	15/30 kHz
Cyclic prefix length	4.04 μs
Baud/Symbol duration (LB/SB)	66.67/33.33 μs
FFT size (LB/SB)	512/256
Modulation	QPSK, 16-QAM
Coding	R = ½ 1/4, Turbo Max-log-MAP kernel
Channel	GSM TU, Ped B, Veh A, 15kph
Number of Rx Antennas	2

- **Half-length Short Blocks (SB) used for GCL pilot/reference signals**
- **Non-ideal channel estimation**
- **Receivers**
  - **MMSE: Pilot power same as data power**
  - **MMSE + Decision-directed ISI cancellation: Pilot power 3dB higher than data power**
- **Only a single active UE with different effective (Repetition factors) RPFs**
- **Localized Equivalent BW = 5/RPF MHz**

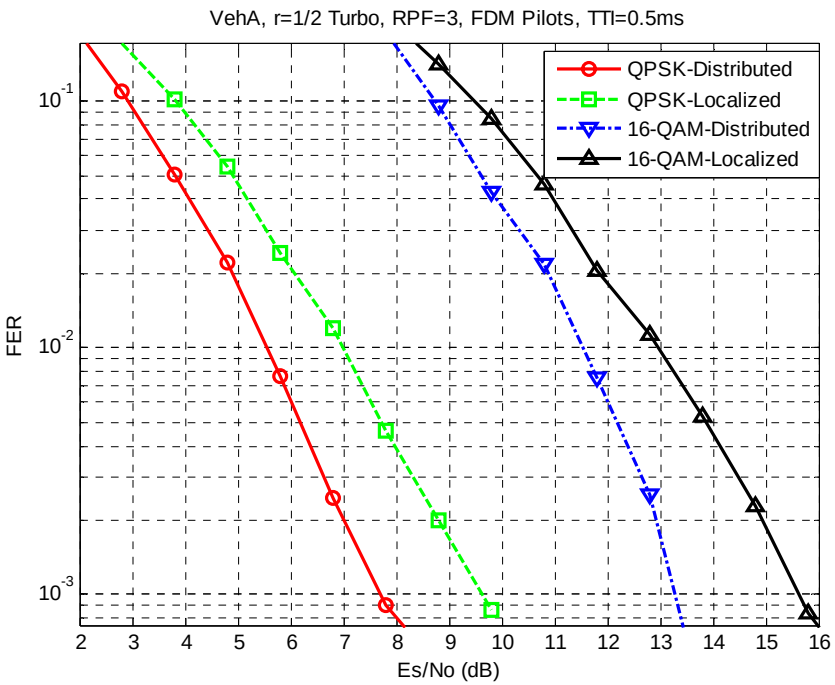
Performance comparison of Distributed and Localized FDMA with FDM Pilots on SB1 and SB2 (Option 3)

Pilot Option 3: FDM on SB1 and SB2

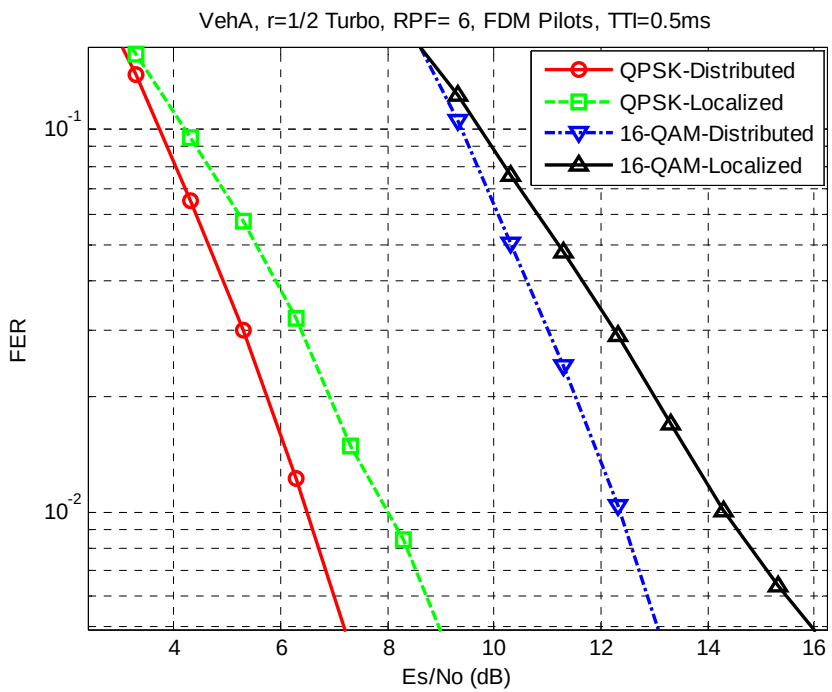
- **FDM on SB1 and SB2**
  - **Localized Data: Localized FDM**
  - **Distributed Data: Distributed FDM with Pilot RPF = Data RPF**
  - **Staggering of the pilot combs**

Vehicular A, FDM Pilots, MMSE Receiver

RPF = 3



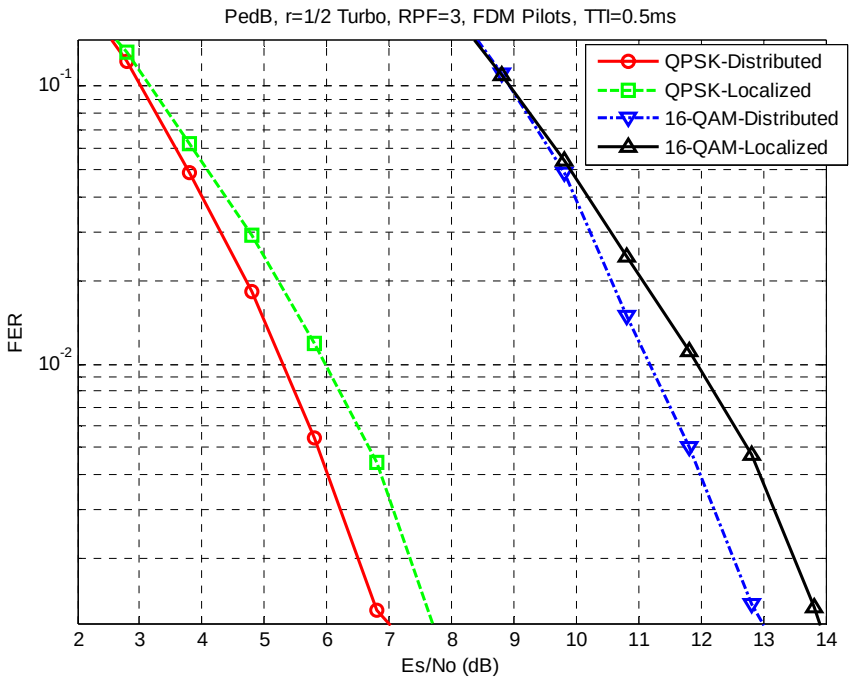
RPF = 6



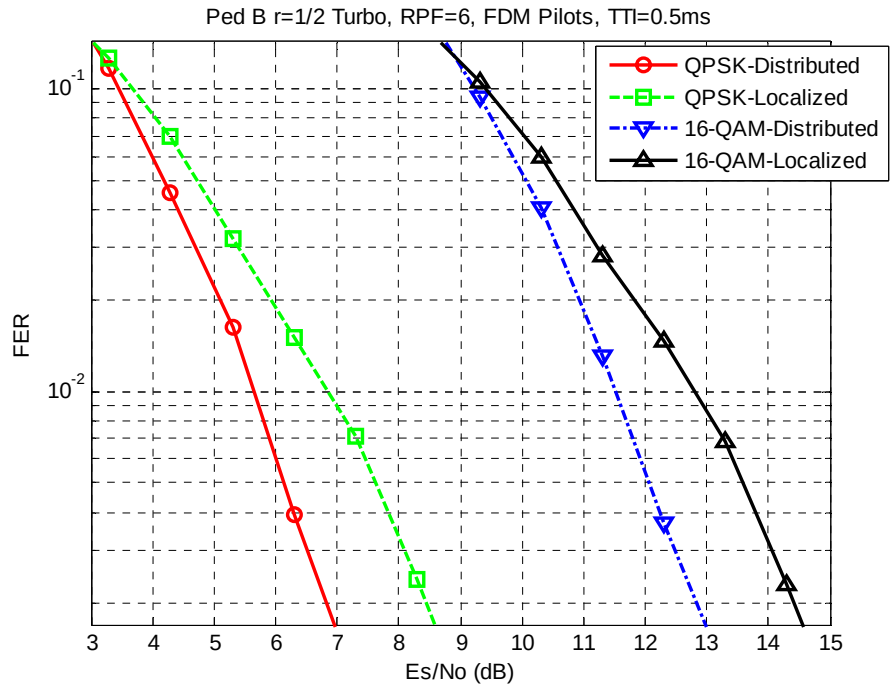
- **Distributed FDMA (5MHz sub-band) out performs localized FDMA due to larger frequency diversity**
- **Performance gains of ~0.7dB @ 10% and ~1.5dB @ 1% FER for RPF=3**
- **Performance gains of ~0.4dB @ 10% and ~1.5-2dB @ 1% FER for RPF=6**
- **D-FDMA performance gains increases for lower FER targets**

Ped B, FDM Pilots, MMSE Receiver

RPF = 3



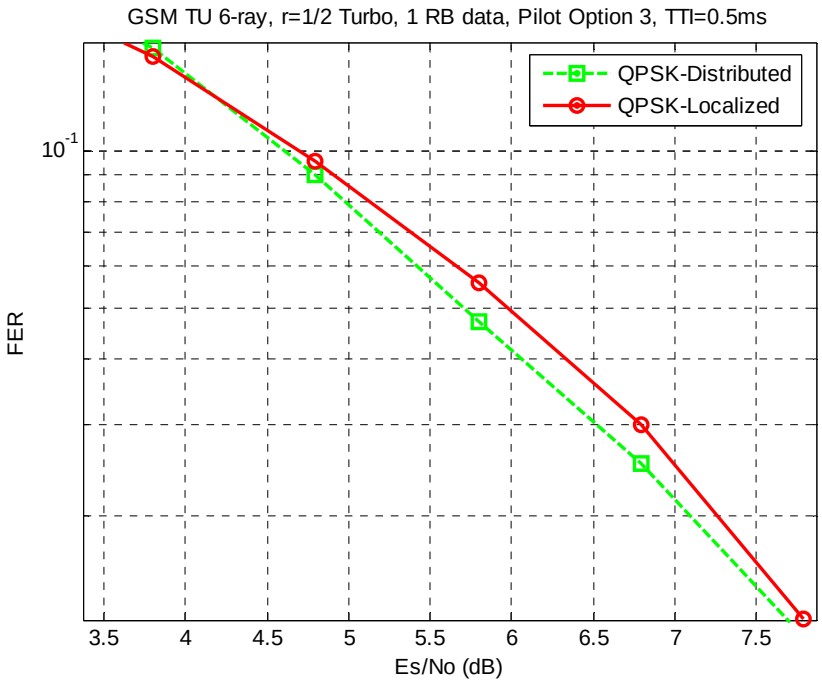
RPF = 6



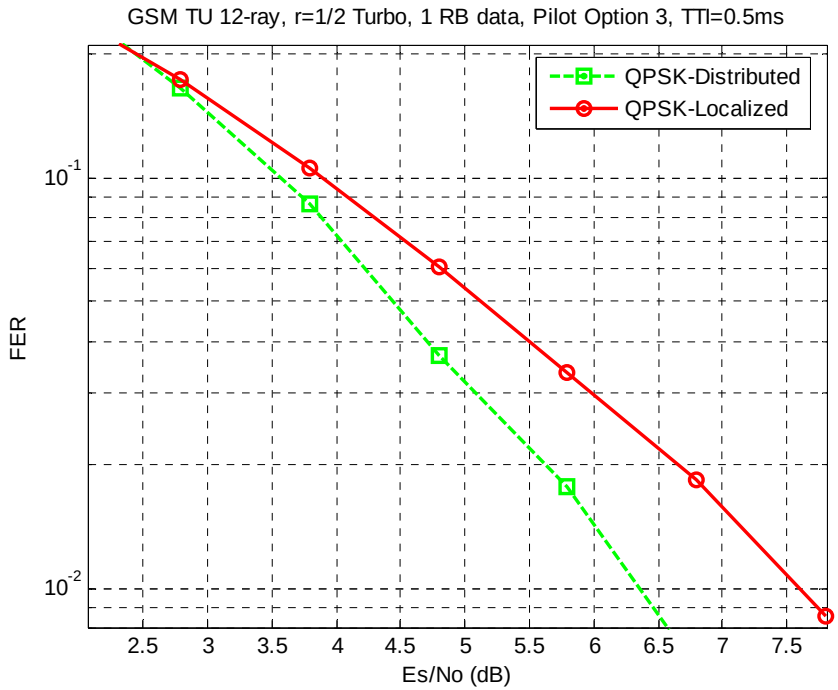
- **D-FDMA (5MHz sub-band) performance similar or better than L-FDMA**
  - **Similar performance at higher FER (10%)**
  - **Better performance at lower FERs**
- **Performance gains of ~0.75dB @ 1% FER for RPF=3 and ~1.25dB @ 1% FER for RPF=6**

GSM TU, FDM Pilots, MMSE Receiver

1 RB Allocation, TU 6-ray



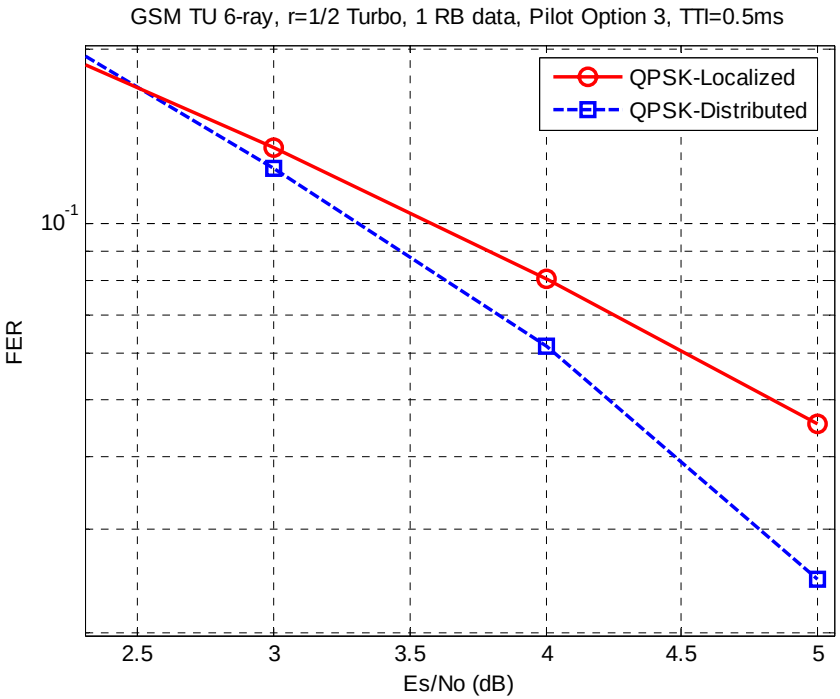
1 RB Allocation, TU 12-ray



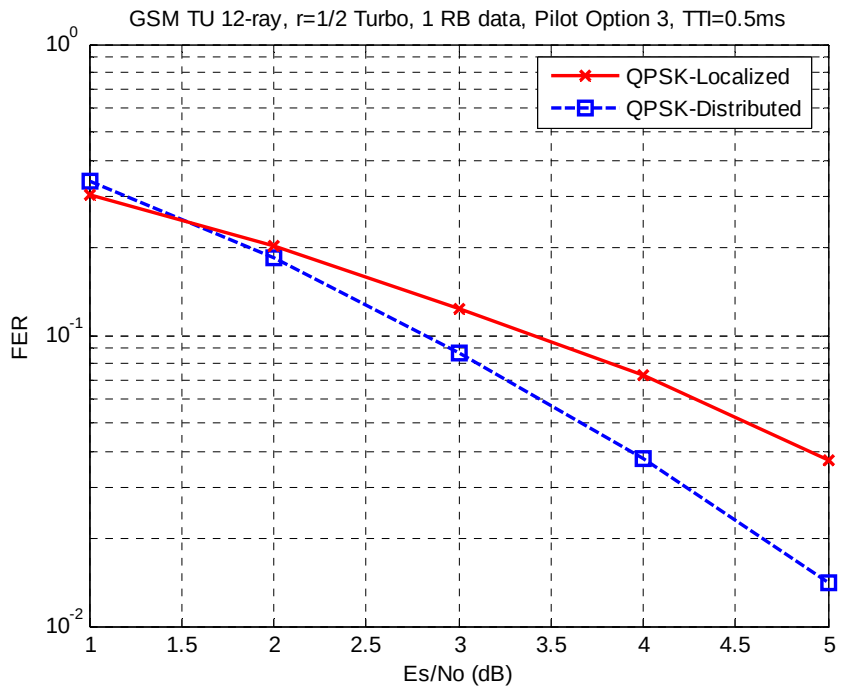
- **D-FDMA (1.25MHz sub-band) performance similar or better than L-FDMA**
  - **Similar performance at higher FER (10%)**
  - **Better performance at lower FERs**
  - **Better performance with larger frequency diversity GSM TU 12-ray channel**
- **Performance gains of ~0.4dB @ 10% FER and ~1.25dB @ 1% FER for GSM TU 12-ray channel**

GSM TU, FDM Pilots, MMSE+ISI Canceller Receiver

1 RB Allocation, TU 6-ray



1 RB Allocation, TU 12-ray

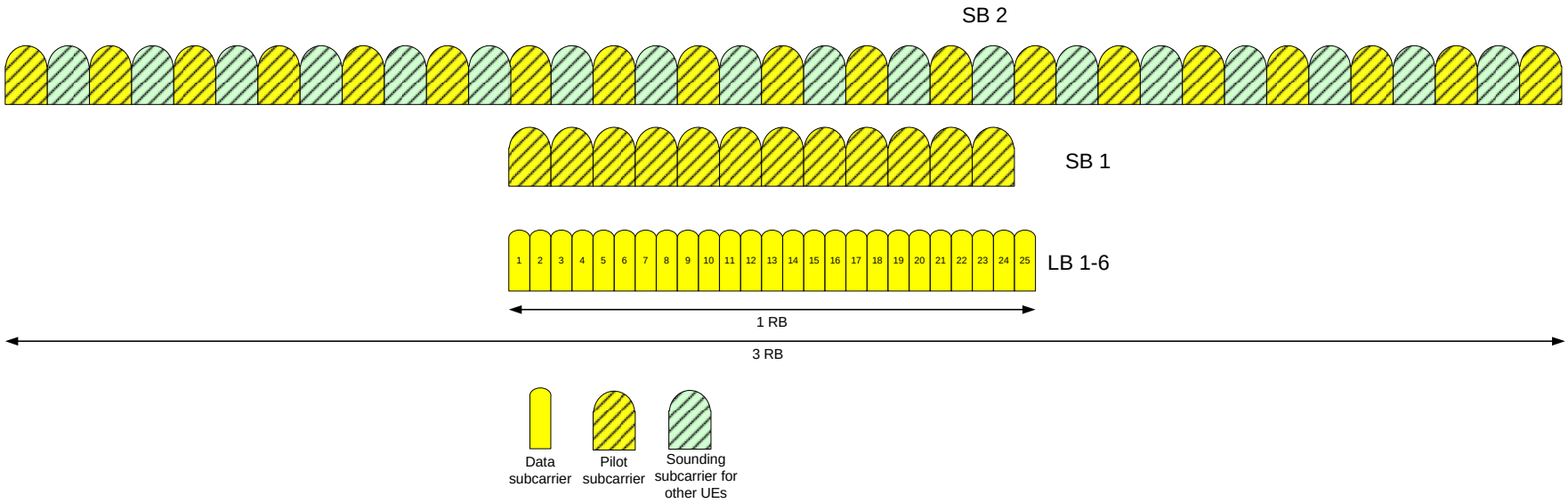


- **D-FDMA (1.25MHz sub-band) performance better than L-FDMA for both TU 6-ray and 12-ray channel**
- **Frequency diversity gains of distributed FDMA enhanced with ISI-cancellation**
- **Gains increase for larger frequency diversity GSM TU 12-ray channel**

Performance comparison of Distributed and Localized FDMA with FDM Pilots on SB1 and FDM/CDM Pilots (RPF=2) on SB2 (Option 1)

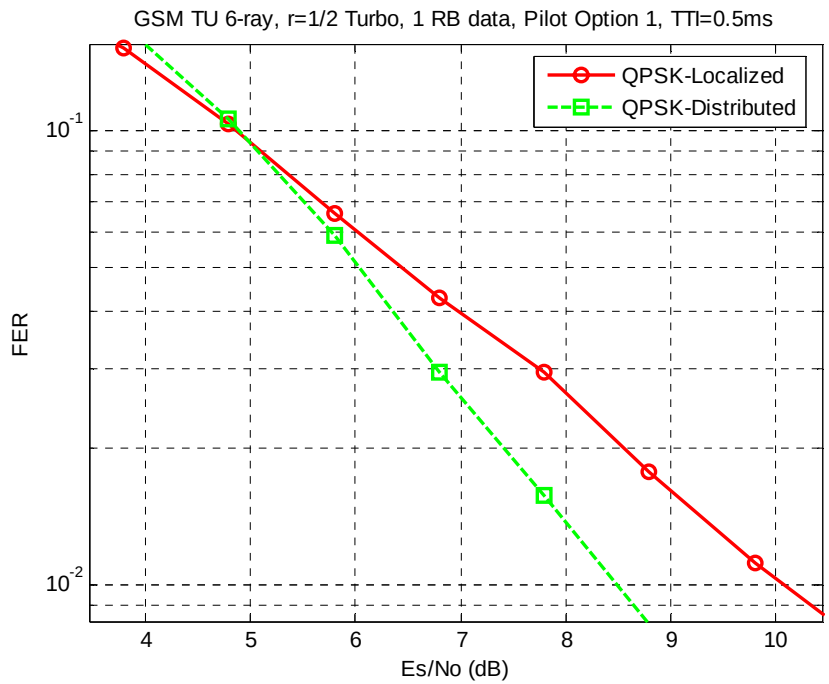
Pilot Option 1: FDM on SB1, Hybrid FDM/CDM on SB2

- **FDM on SB1**
  - **Localized Data: Localized FDM**
  - **Distributed Data: Distributed FDM with Pilot RPF = Data RPF**
- **Hybrid FDM/CDM on SB2**
  - **Pilot RPF=2**
  - **Pilot BW=3 RBs**

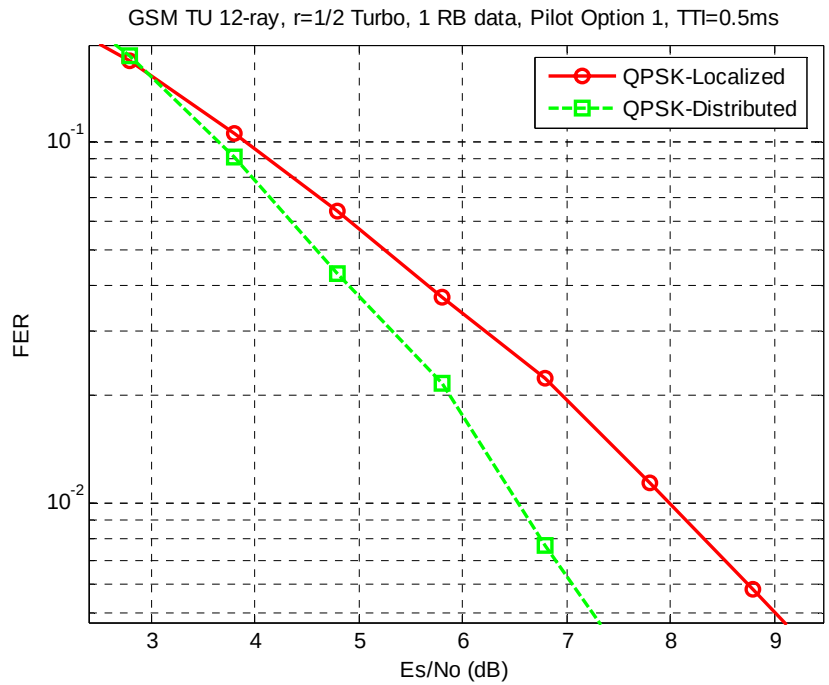


GSM TU, Pilot Option 1, MMSE Receiver

1 RB Allocation, TU 6-ray



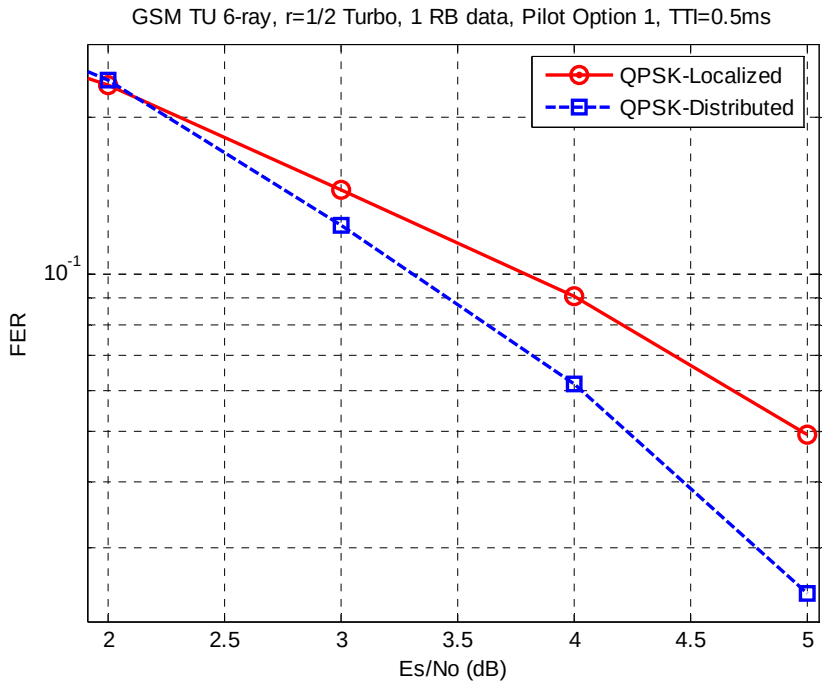
1 RB Allocation, TU 12-ray



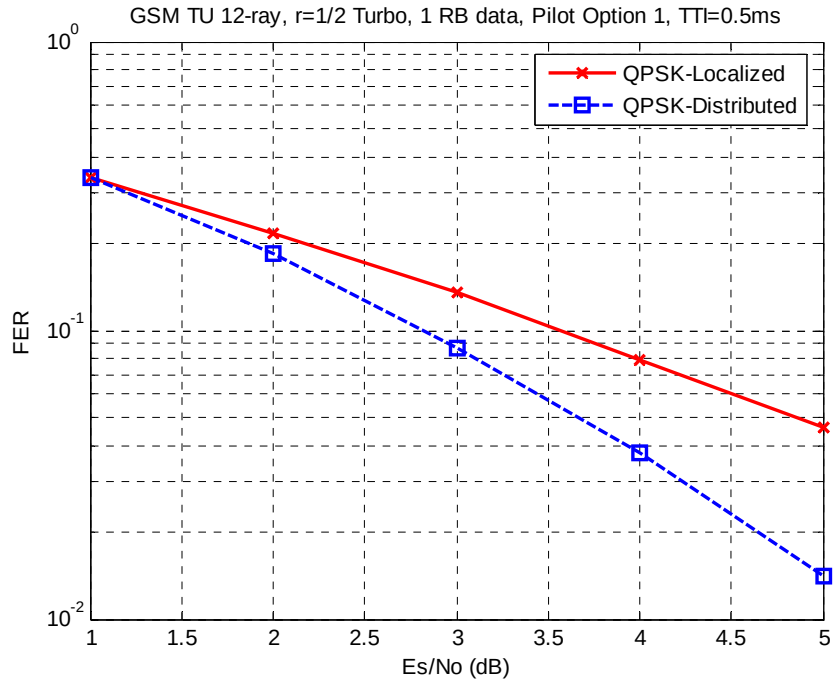
- **D-FDMA (1.25MHz sub-band) performance similar or better than L-FDMA**
  - **Similar performance at higher FER (10%)**
  - **Better performance at lower FERs**
  - **Better performance with larger frequency diversity GSM TU 12-ray channel**
- **Performance gains of ~0.2dB @ 10% FER and ~1.5dB @ 1% FER for GSM TU 12-ray channel, ~1.5dB @ 1% FER for GSM TU 6-ray channel**

GSM TU, Pilot Option 1, MMSE+ISI Canceller Receiver

1 RB Allocation, TU 6-ray



1 RB Allocation, TU 12-ray

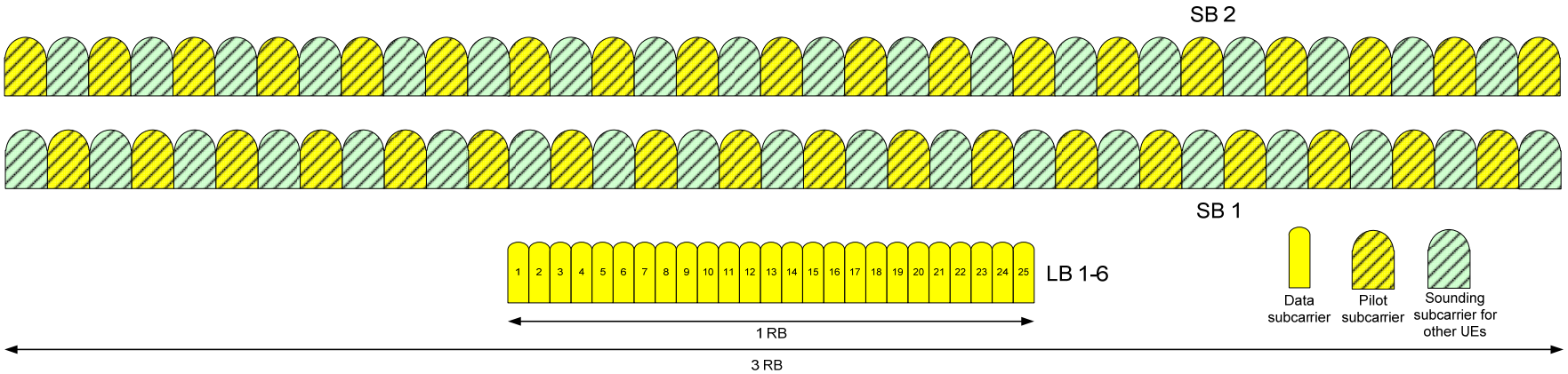


- **D-FDMA performance better than L-FDMA for both TU 6-ray and 12-ray channel**
- **Frequency diversity gains of distributed FDMA enhanced with ISI-cancellation**
- **Gains increase for larger frequency diversity GSM TU 12-ray channel**

Performance comparison of Distributed and Localized FDMA with FDM/CDM Pilots (RPF=2) on SB1 and SB2 (Option 2)

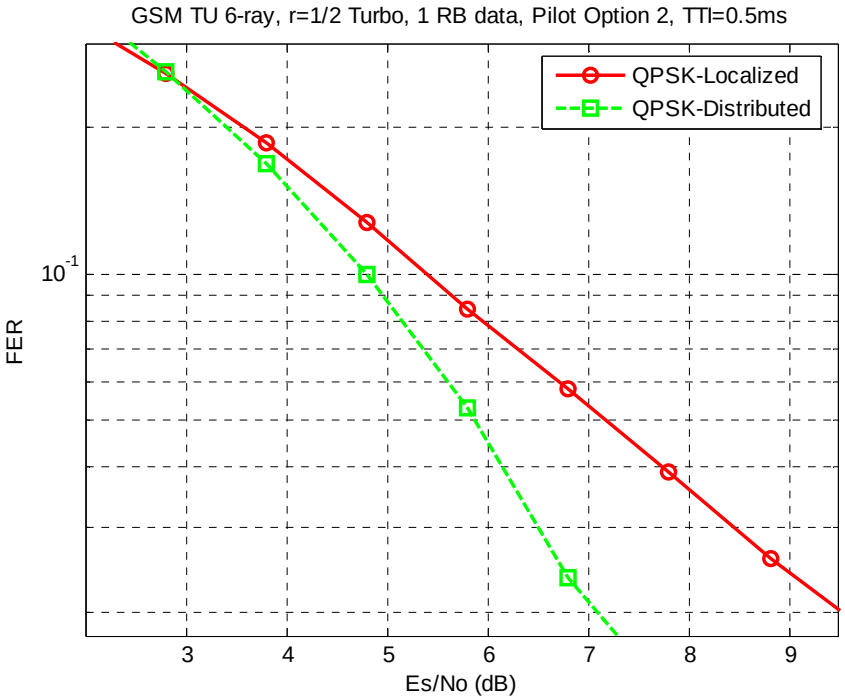
Pilot Option 2: Hybrid FDM/CDM on SB1 and SB2

- Hybrid FDM/CDM on SB1 and SB2
- Pilot RPF=2 on SB1, SB2
- Pilot BW = 3RB
- Staggering of the pilot combs

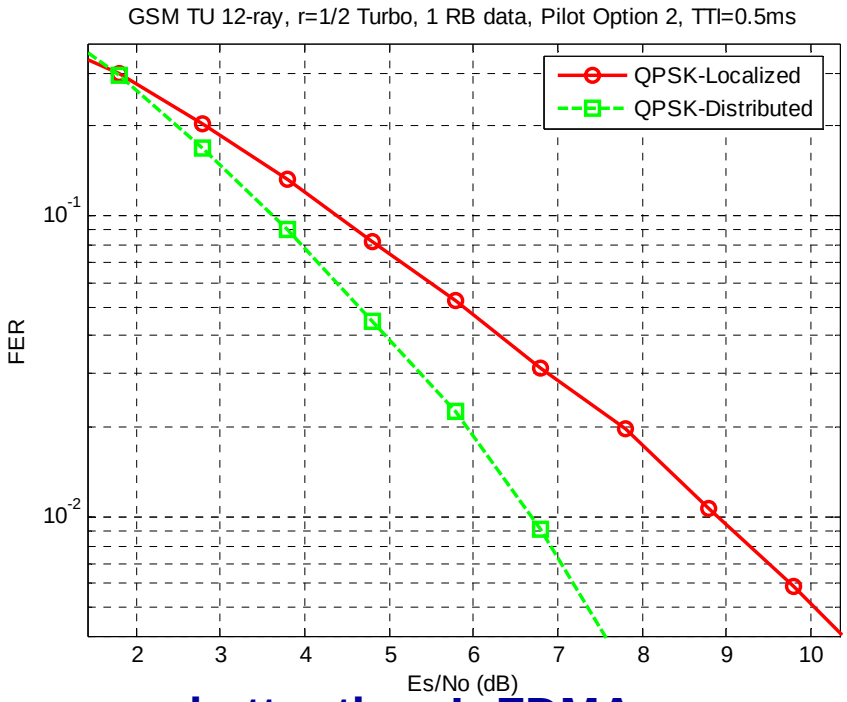


GSM TU, Pilot Option 2, MMSE Receiver

1 RB Allocation, TU 6-ray



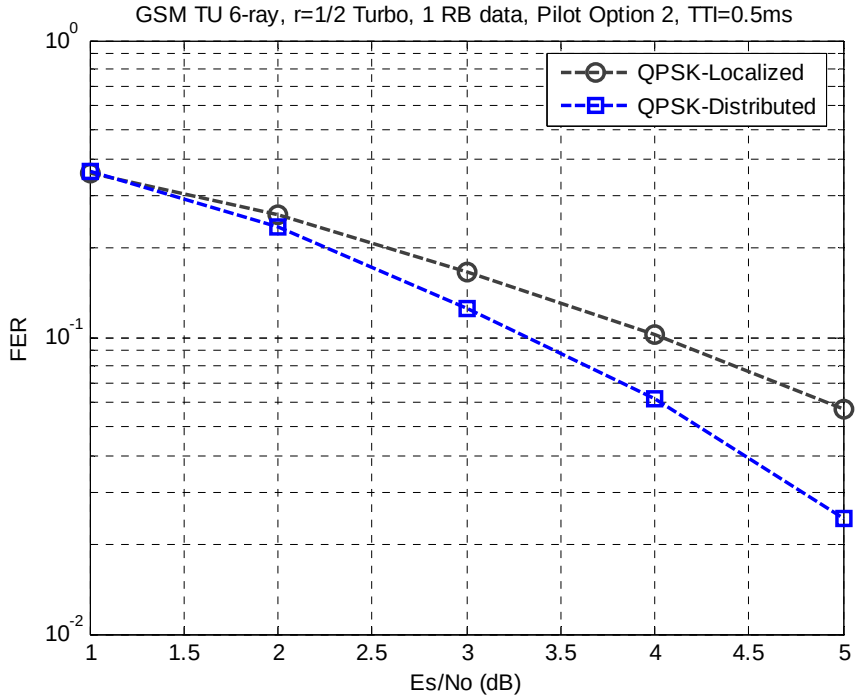
1 RB Allocation, TU 12-ray



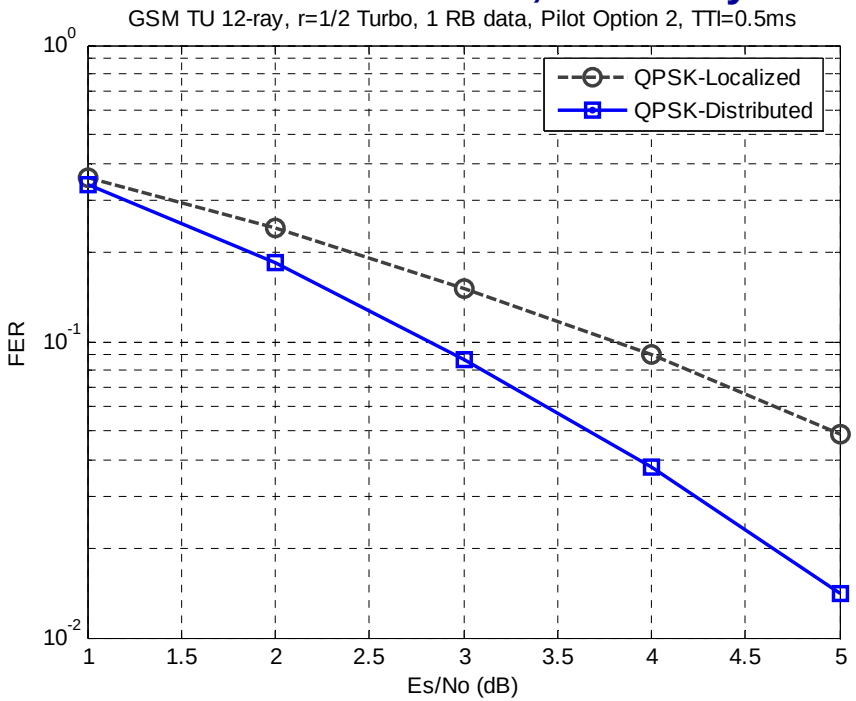
- **D-FDMA (1.25MHz sub-band) performance better than L-FDMA**
  - **Better performance with larger frequency diversity GSM TU 12-ray channel**
- **Performance gains of**
  - **~0.6dB @ 10% FER and >2dB @ 1% FER for GSM TU 6-ray channel**
  - **~0.8dB @ 10% FER and >2dB @ 1% FER for GSM TU 12-ray channel**

GSM TU, Pilot Option 2, MMSE+ISI Canceller Receiver

1 RB Allocation, TU 6-ray



1 RB Allocation, TU 12-ray



- **D-FDMA performance better than L-FDMA for both TU 6-ray and 12-ray channel**
- **Frequency diversity gains of distributed FDMA enhanced with ISI-cancellation**
- **Gains increase for larger frequency diversity GSM TU 12-ray channel**

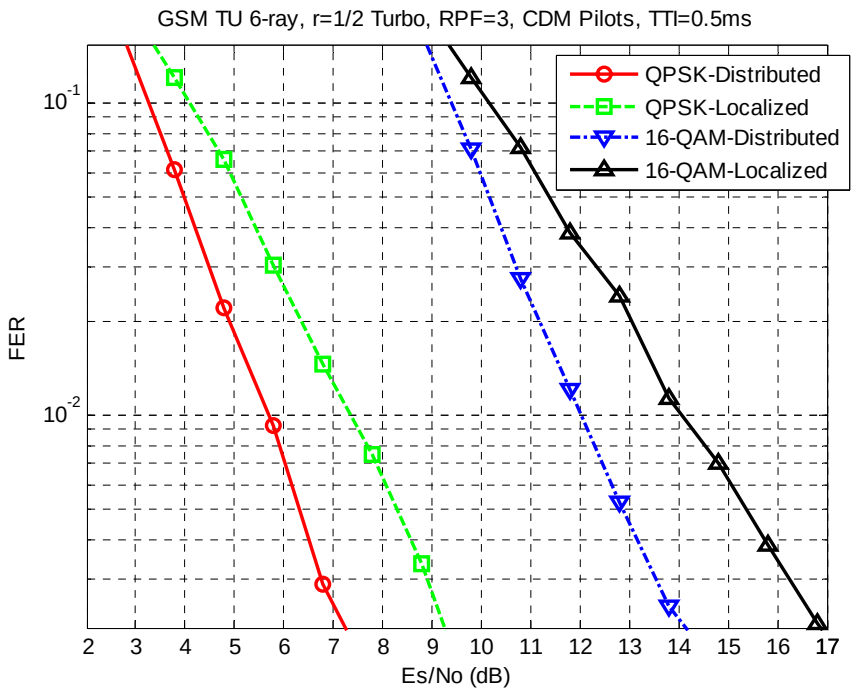
Performance comparison of Distributed and Localized FDMA with CDM Pilots

CDM on SB1 and SB2

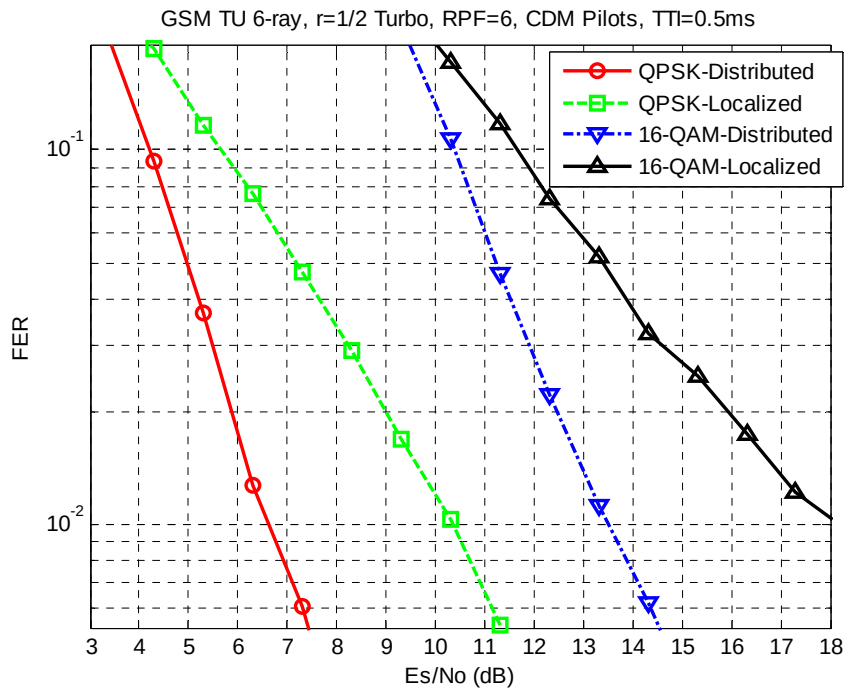
- CDM on SB1 and SB2
- Broadband continuous pilot (Pilot RPF = 1) for localized and distributed
- Pilot BW = 5 MHz (12 RB)

GSM TU, CDM Pilots, Non-ideal channel estimation

RPF = 3, 6-ray TU



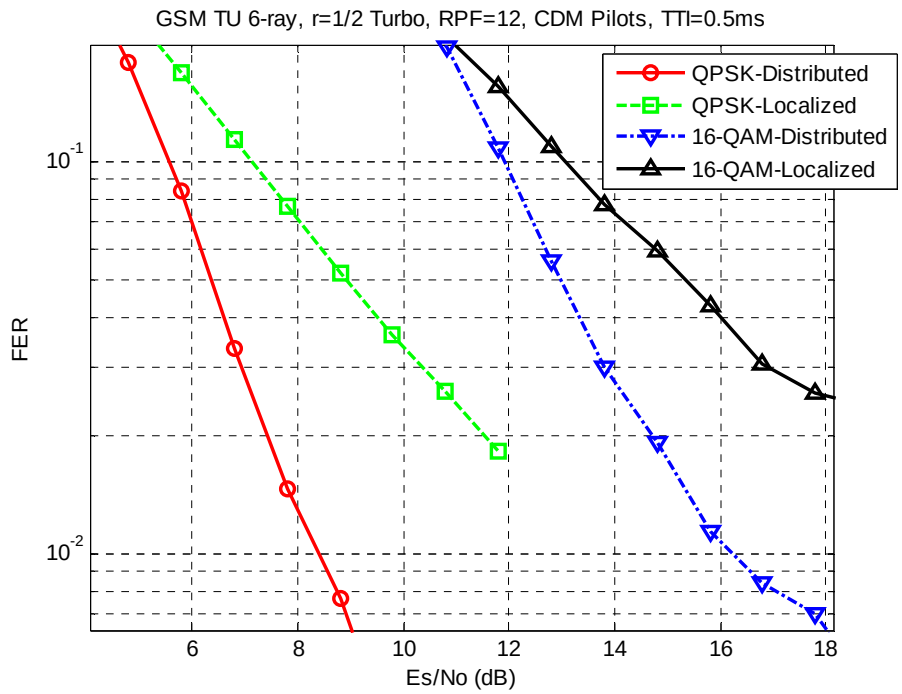
RPF = 6, 6-ray TU



- **Distributed FDMA out performs localized FDMA with CDM pilots (Pilot BW=5MHz)**
- **D-FDMA performance gains increase with RPF due to larger frequency diversity**
- **Performance gains of ~0.7dB @ 10% and ~1.5-2dB @ 1% FER for RPF=3**
- **Performance gains of ~1.5dB @ 10% and >3.5dB @ 1% FER for RPF=6**

GSM TU, CDM Pilots, Non-ideal channel estimation

RPF = 12, 6-ray TU

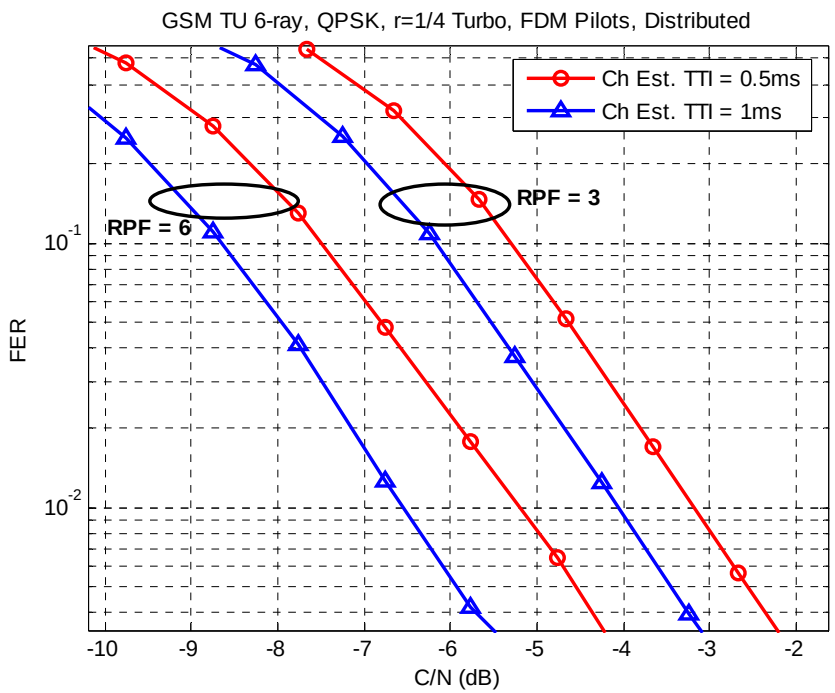


- **Distributed FDMA clearly out performs localized FDMA with CDM pilots due to increased frequency diversity**
- **For channels with larger frequency diversity such as GSM TU 12-ray channel, the gains of distributed FDMA will be even larger**

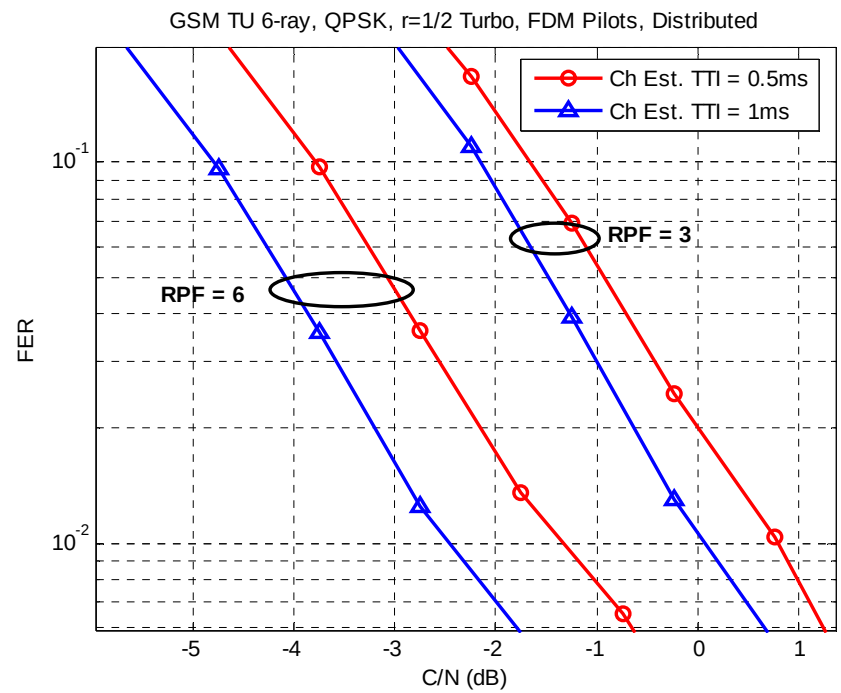
Benefit of longer TTI on channel estimation for D-FDMA

- **Channel estimation (FDM Pilots, 5MHz sub-band)**
  - **TTI = 0.5ms: 2 pilot short blocks**
  - **TTI = 1ms: 4 pilot short blocks**
- **Turbo code-word size = 0.5ms (6 long blocks) for fair comparison**

r=1/4, 6-ray TU



r=1/2, 6-ray TU



- **More accurate channel estimation and performance gains for longer TTI**
- **Further performance gains achievable with longer turbo code-words**

Conclusion

- Performance of Distributed FDMA is similar or better than that of localized FDMA with FDM Pilots (option 3)
- Distributed FDMA better than localized FDMA for pilot options 1 and 2
  - At least one SB has pilot BW > data BW
- Frequency diversity gains of distributed FDMA can be enhanced with advanced receivers
- Distributed allocations should be used to achieve diversity scheduling when channel dependent scheduling is not possible due to lack of reliable CQI information at the Node-B (e.g., VoIP users, high mobility etc.)