

**Source:**

**Nokia Siemens Networks, Nokia**

**Title:**

**Simulation Results: Linkage between  
PUSCH MCS and amount of resources  
for control on PUSCH**

**Agenda Item:**

**7.1.2**

**Document for:**

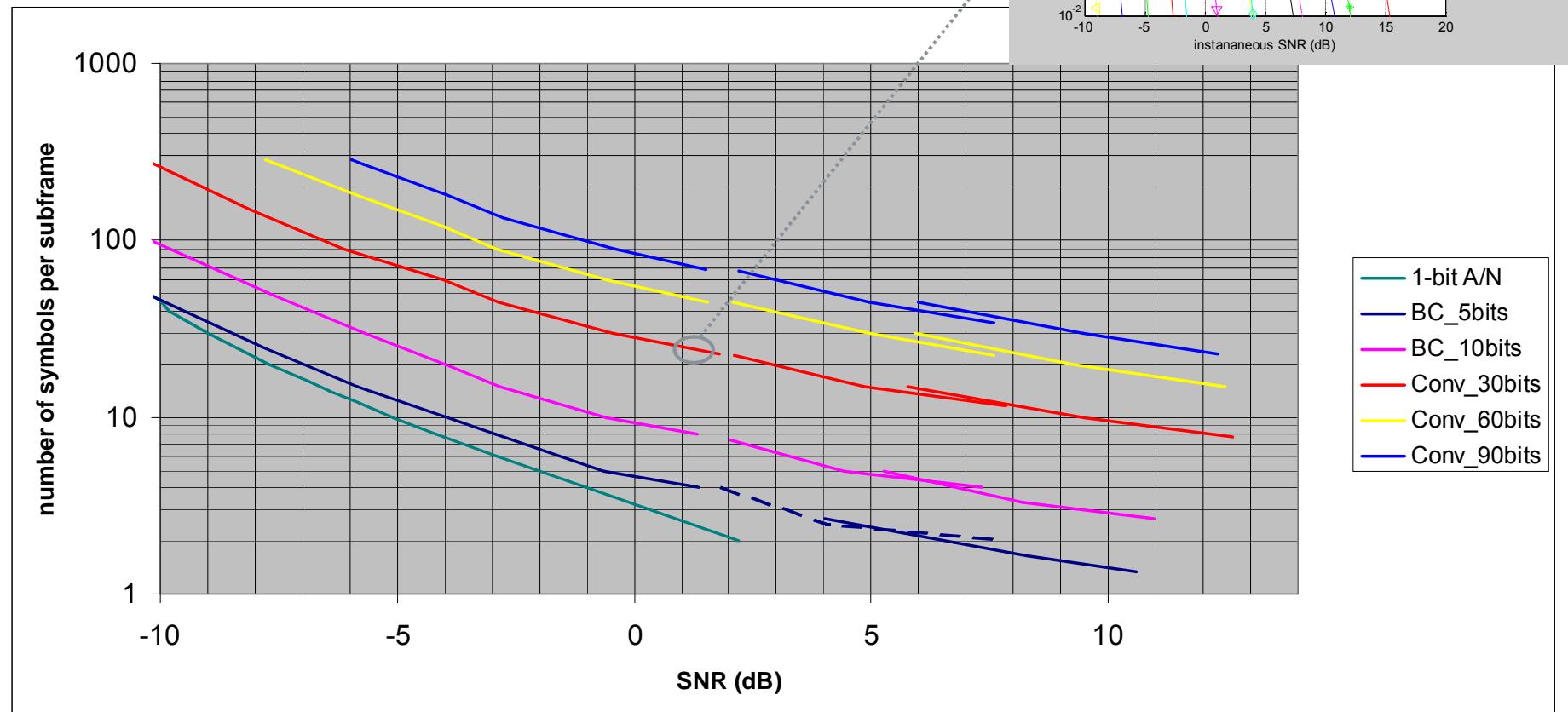
**Discussion**

# Simulation assumptions

- Both short-term (non-persistent scheduling) and long-term performance (persistent scheduling) are considered
  - Frequency hopping OFF
- Bandwidth allocation: [2, 6, 10, 25] RBs
- TU channel,  $v=3$  km/h, 2 receiving antennas
- Channel coding
  - Block coding (32,N) with  $N=5, N=10$
  - Tail-biting convolutional codes (1/3)
  - Simple matching has been used to support variable code rates for CQI
    - Convolutional codes:
      - repetition of every Nth bit
      - puncturing of parity bits only
    - Block codes:
      - Repetition/puncturing for every Nth bit
- Practical receiver assumptions, realistic channel estimation

# Control channel performance, 2RBs (short-term)

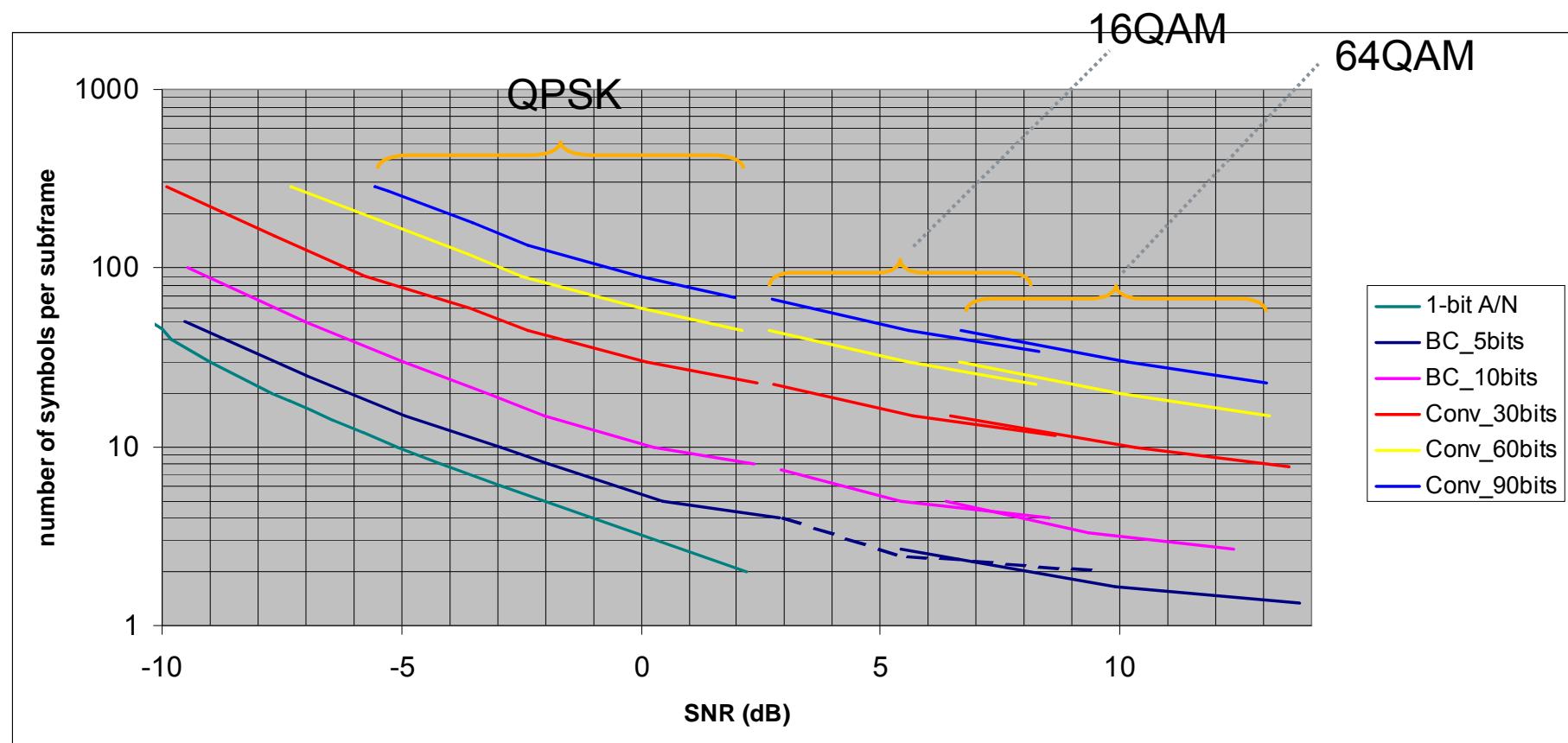
- CQI BLER = 10%
- A/N BER = 0.1%



# Control channel performance, 2RBs (short-term)

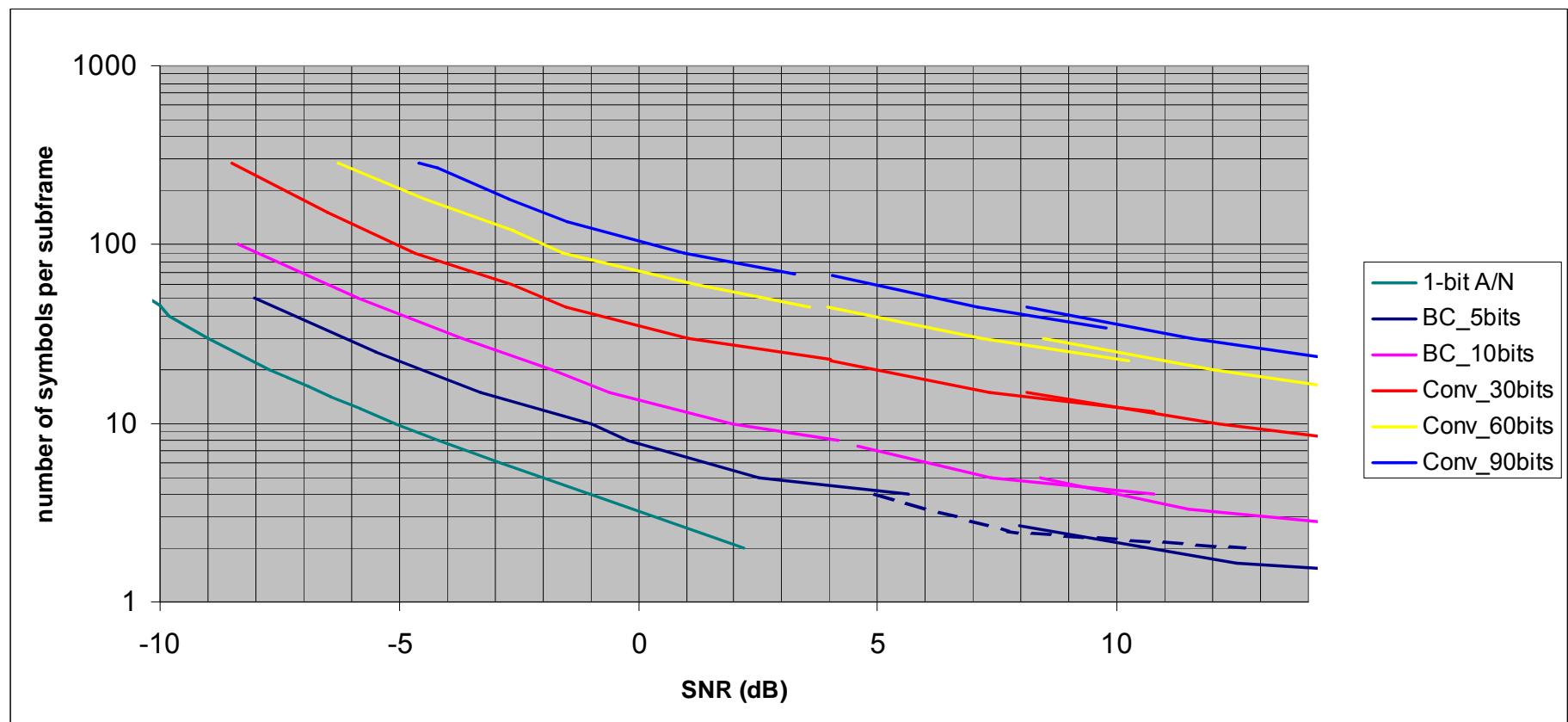
- CQI BLER = 5%
- A/N BER = 0.1%

- RAN1-Shenzhen: CQI/PMI on PUSCH uses the same modulation scheme as data on PUSCH



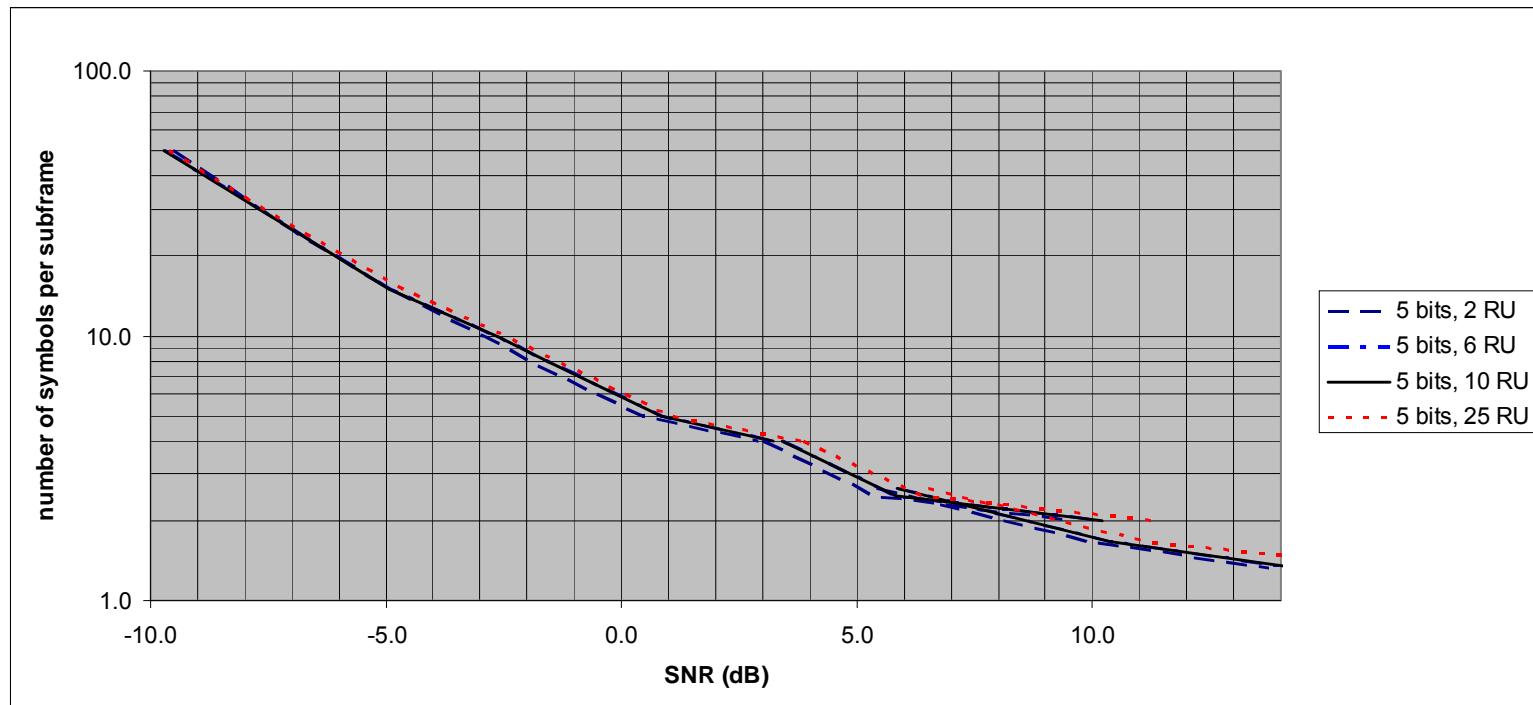
# Control channel performance, 2RBs (short-term)

- CQI BLER = 1%
- A/N BER = 0.1%



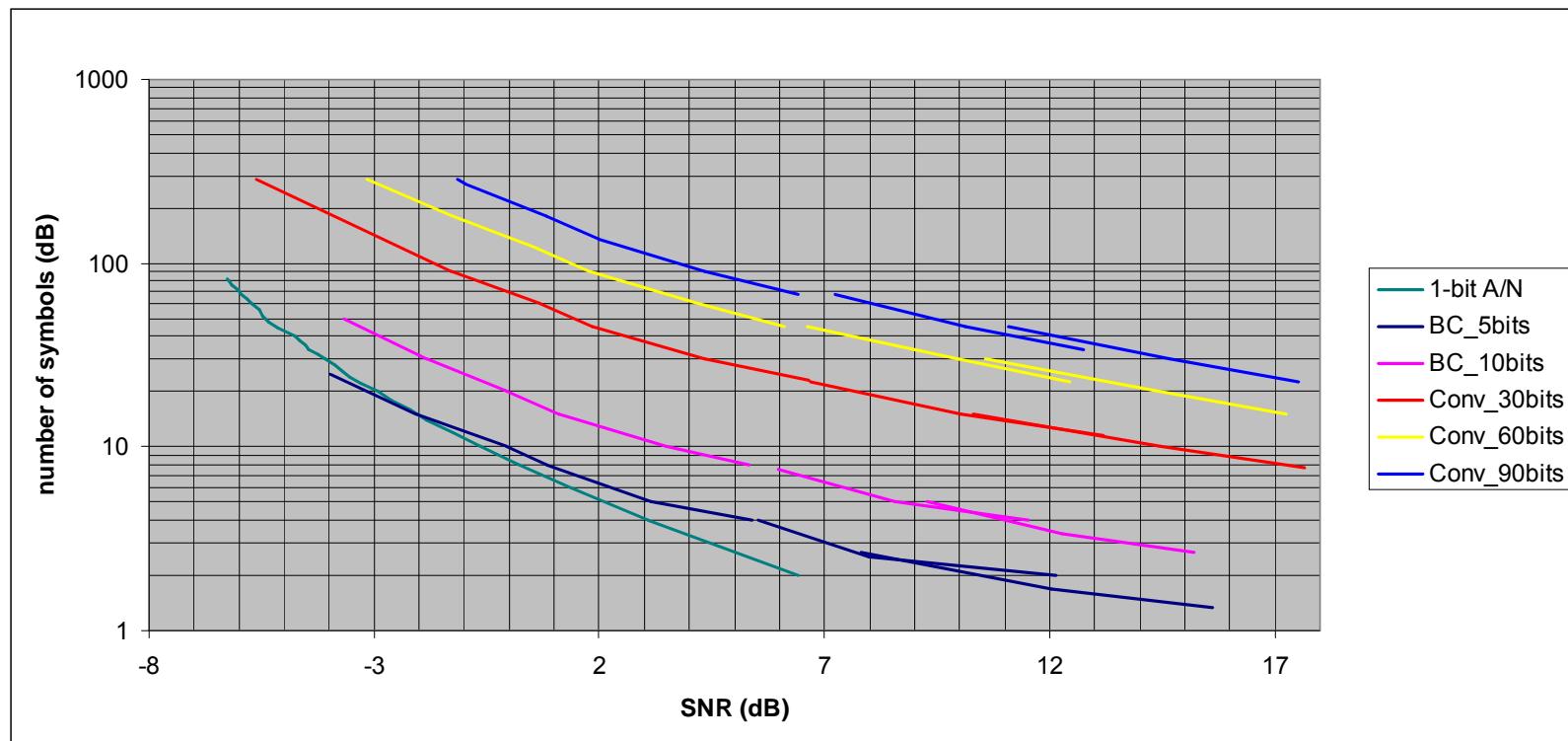
# Control channel performance, (short-term)

- Performance comparison for different PUSCH BW options
  - 5-bits CQI, block code
- Different BW options perform almost equally, in terms of CQI BLER
  - The same applies for PUSCH data (short-term performance)



# Control channel performance, (long-term)

- 2 RBs, FH OFF
- CQI BLER=5%,
- A/N BER=0.1%



- Control signaling on PUSCH
  - Modulation scheme
    - CQI/PMI on PUSCH uses the same modulation scheme as data on PUSCH
  - Offset
    - Semi-statically configured offset between the data MCS and the code rate of the control signaling (A/N and CQI)
    - Next steps: Define the offset values. Discuss whether multiple offsets are needed e.g. when multiple services with different QoS are time multiplexed
- Open issues
  - Formula to determine the size of control region based on data MCS
  - Offset values

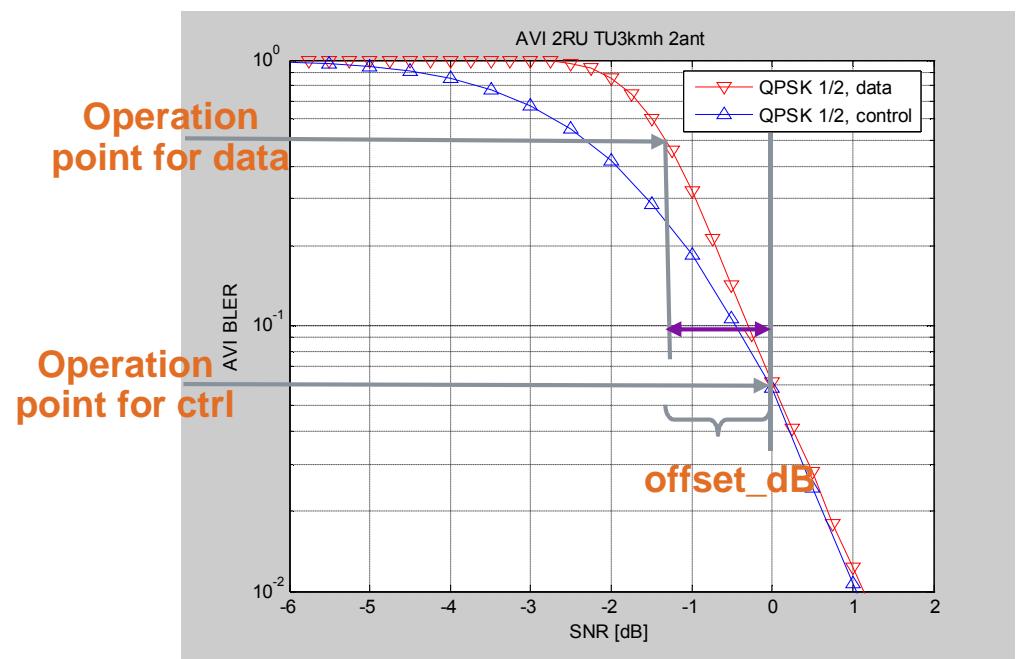
# Proposed formula to determine the size of control region based on data MCS

$$M_{ctrl} = \left\lceil \frac{N \cdot \frac{CR}{M_{Mod}}}{10^{\frac{-offset\_dB}{10}}} \right\rceil$$

- $M_{ctrl}$  : Number of control symbols for given control type
- $N$  : Number of control signalling bits (for given control type)
- $CR$  : coding rate of given PUSCH MCS, e.g., 3/1
- $M_{mod}$  : number of (uncoded) bits/symbol  $M_{mod} \in \{2, 4, 6\}$
- $offset\_dB$  : quality difference between given control type and PUSCH data
  - S(I)NR requirement for control – S(I)NR requirement for data
  - Configured/signalled via RRC
- $\lceil \rceil$  : ceil operation
  - rounds the control channel size to the nearest supported integer value, towards (plus) infinity.

# offset\_dB (cont')

- *offset\_dB*: Compensates the performance difference between control and data channel
  - Different BLER operation point (data & control)
  - Different packet size & coding gain
    - No coding (A/N)



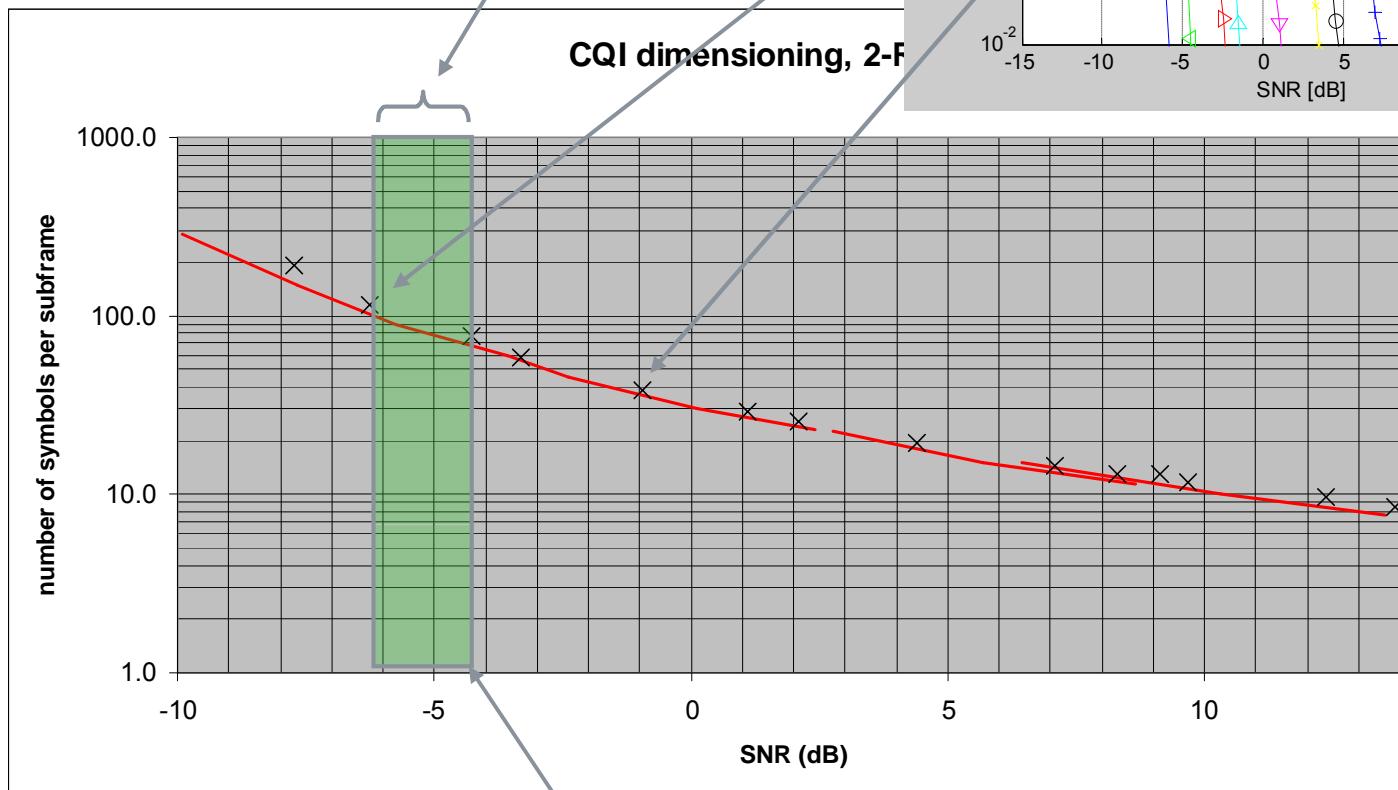
# Size of control channel, (short-term)

- BLER\_data < 30%
- BLER\_CQI < 5%
- Offset\_dB = 1.1 dB

PUSCH:

- QPSK 1/6 used here
- BLER (w/o HARQ) < 30%

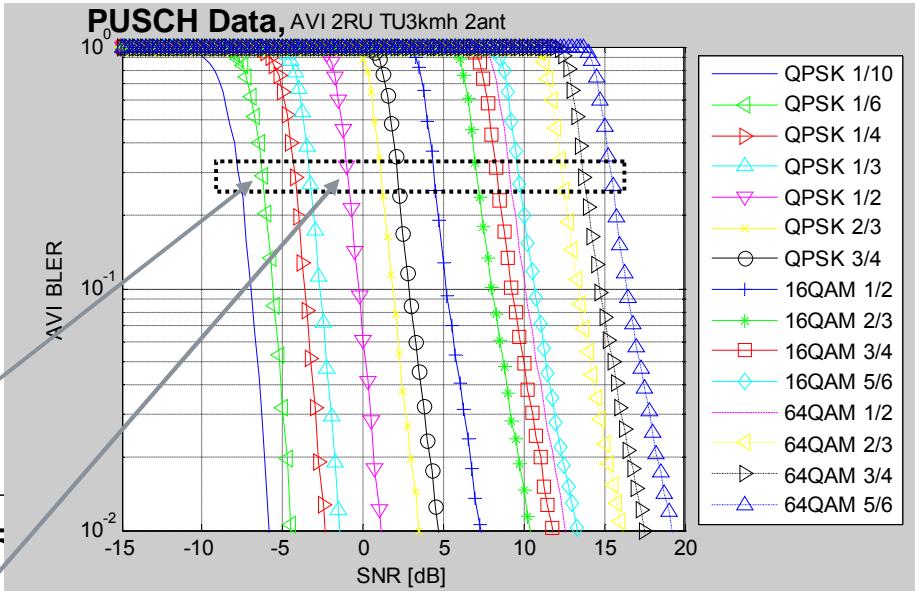
CQI dimensioning, 2-F



$$M_{ctrl} = \frac{N \cdot \frac{CR}{M_{Mod}}}{10^{\frac{-offset\_dB}{10}}}$$

Conv\_30bits  
x Conv\_30bits

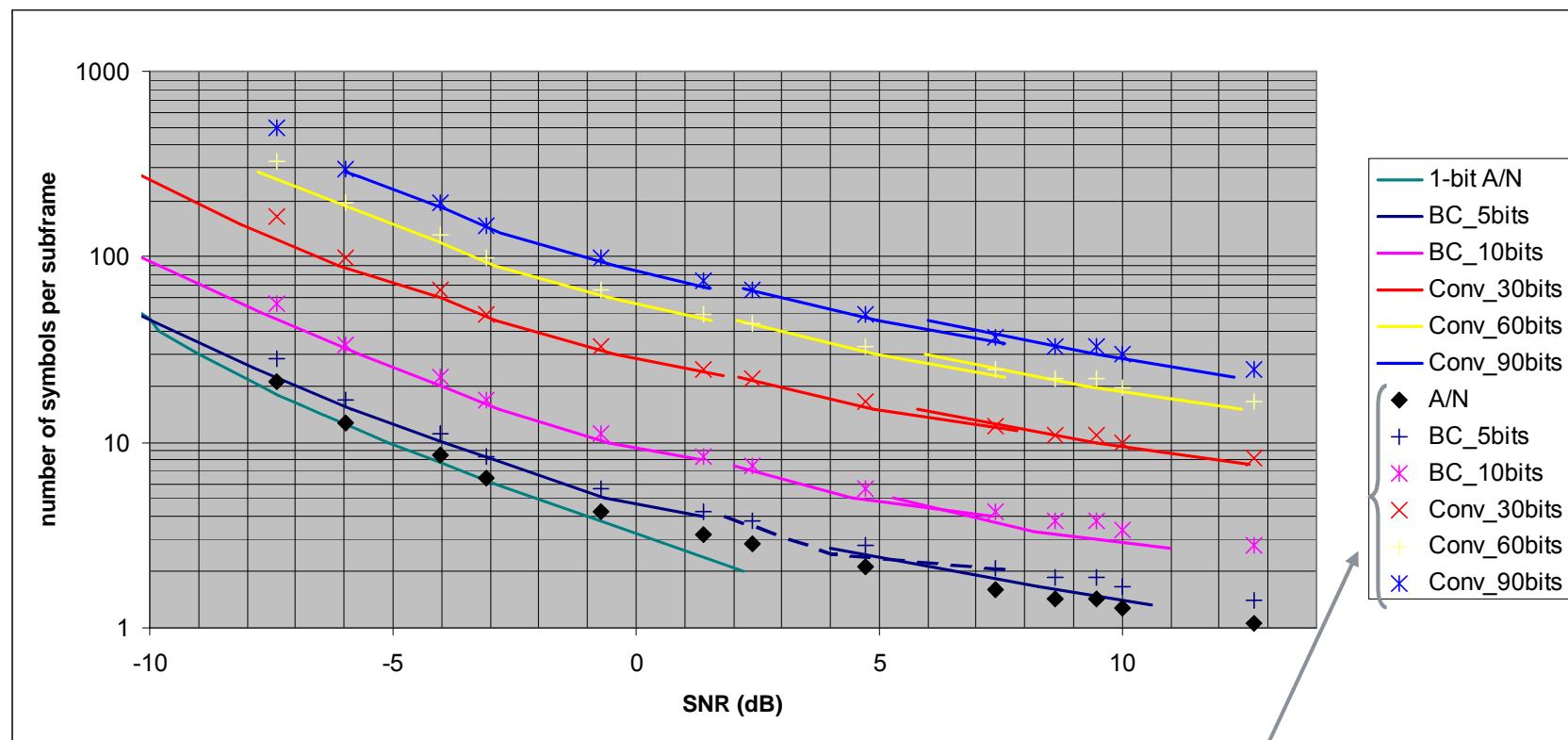
no quantization for  
 $M_{ctrl}$  applied here



# Numerical values for offset, (short term)

- BLER\_data<20%
- BLER\_CQI<10%

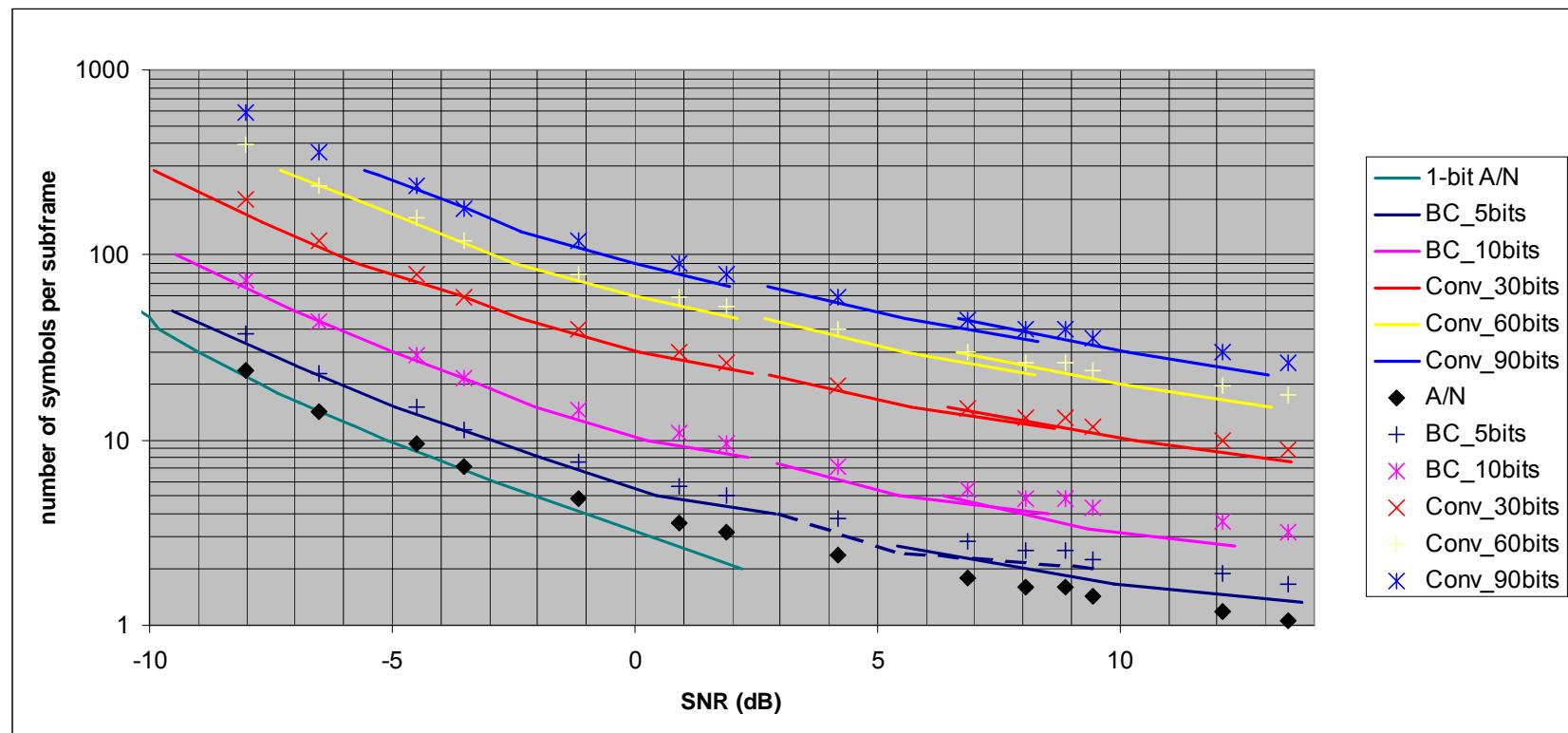
$N$	1	5	10	30	60	90
Offset_dB	6.3	0.5	0.5	0.4	0.4	0.4



# Numerical values for offset, (short term)

- BLER\_data < 40%
- BLER\_CQI < 5%

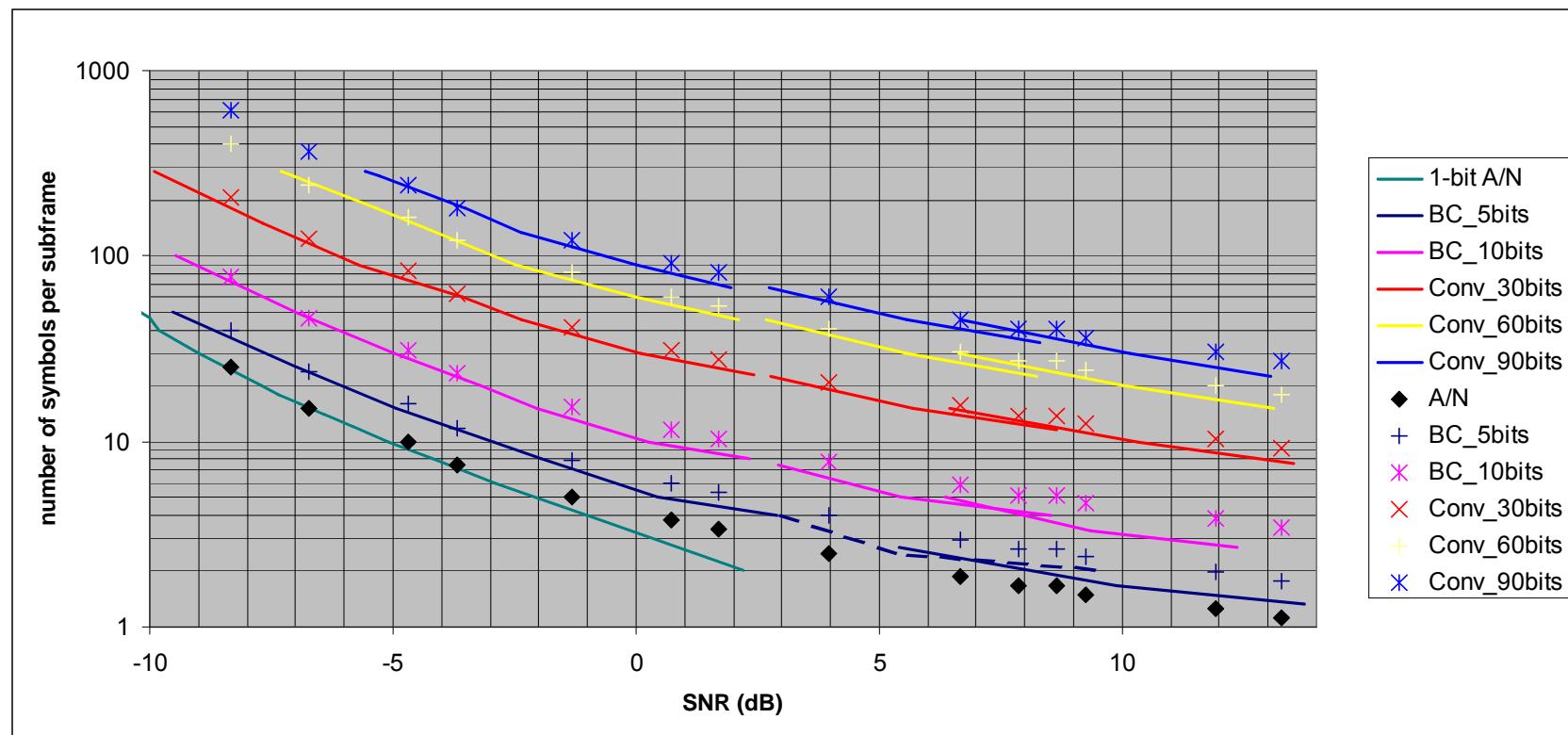
$N$	1	5	10	30	60	90
Offset_dB	6.8	1.8	1.6	1.2	1.2	1.2



# Numerical values for offset, (short term)

- BLER\_data < 50%
- BLER\_CQI < 5%

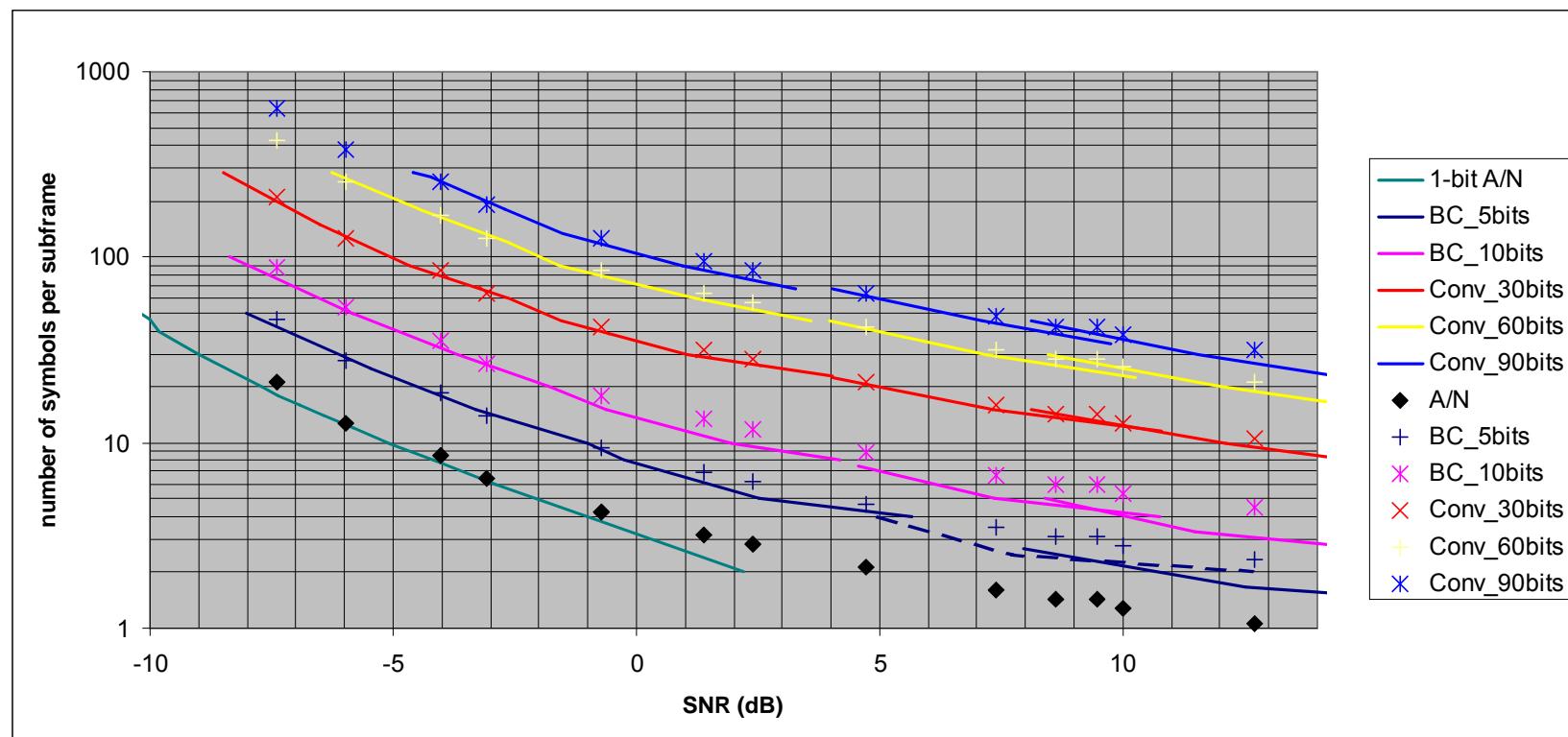
$N$	1	5	10	30	60	90
Offset_dB	7.0	2	1.9	1.4	1.3	1.3



# Numerical values for offset, (short term)

- BLER\_data < 20%
- BLER\_CQI < 1%

$N$	1	5	10	30	60	90
Offset_dB	6.3	2.7	2.5	1.5	1.5	1.5



# Summary of Numerical Offset values, 2RBs, (short term)

QoS			Offset (dB)					
Data BLER	CQI BLER	A/N BER	N					
			1	5	10	30	60	90
50%	5%	0.1%	7.0	2.0	1.9	1.4	1.3	1.3
40%	1%	0.1%	6.8	2.5	3.1	2.2	2.2	2.2
40%	5%	0.1%	6.8	1.8	1.6	1.2	1.2	1.2
30%	10%	0.1%	6.8	1.1	1.1	0.8	0.8	0.8
20%	5%	0.1%	6.5	1.5	1.5	1.0	1.0	1.0
20%	1%	0.1%	6.3	2.7	2.5	1.5	1.5	1.5
20%	5%	0.1%	6.3	1.2	1.2	0.8	0.8	0.8
20%	10%	0.1%	6.3	0.5	0.5	0.4	0.4	0.4
10%	1%	10.0%	5.8	2.4	2.2	1.3	1.3	1.3

The diagram illustrates the mapping between the A/N offset (5.8 dB to 7.0 dB) and the CQI offset (0.4 dB to 3.1 dB). An arrow points from the A/N offset box to the CQI offset box, indicating that the A/N offset is converted into a CQI offset.

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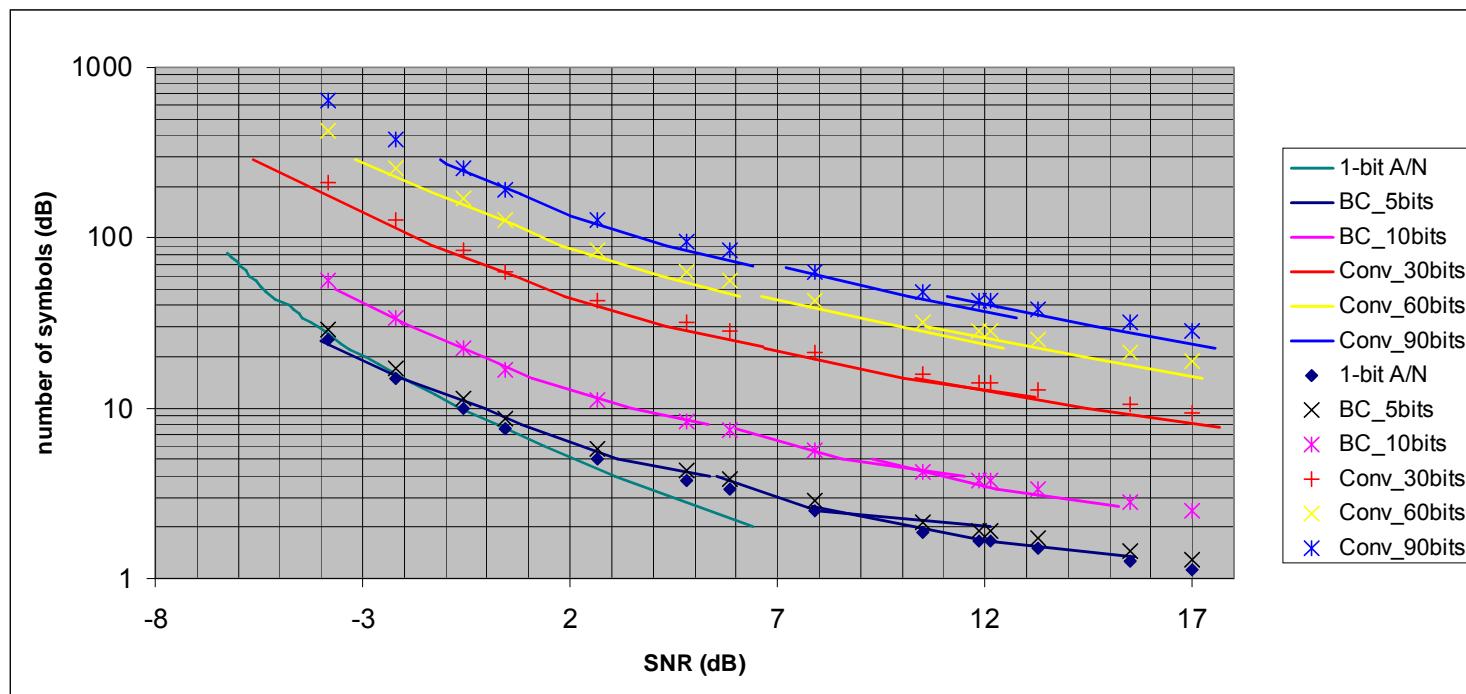
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# Numerical values for offset, 2RBs, (long term)

- BLER\_data<20%
- BLER\_CQI<5%

$N$	1	5	10	30	60	90
Offset_dB	7.0	0.6	0.5	1.5	1.5	1.5



# Conclusions

- We have presented a robust scheme to size the PUSCH control channel
  - Calculated control size reflects well the true control performance
- The proposed scheme is applicable for all situations
  - Both ACK/NACK and CQI
  - Both dynamically scheduled and persistently scheduled data
- We propose that the equation below is adopted as method to size the control channel on PUSCH

$$M_{ctrl} = \left\lceil \frac{N \cdot \frac{CR}{M_{Mod}}}{10^{\frac{-offset\_dB}{10}}} \right\rceil$$