

PHY proposal for 802.16.3 systems

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Purpose:

This proposal is offered as part of the PHY layer for the IEEE 802.16.3 task group

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PHY proposal for 802.16.3 systems

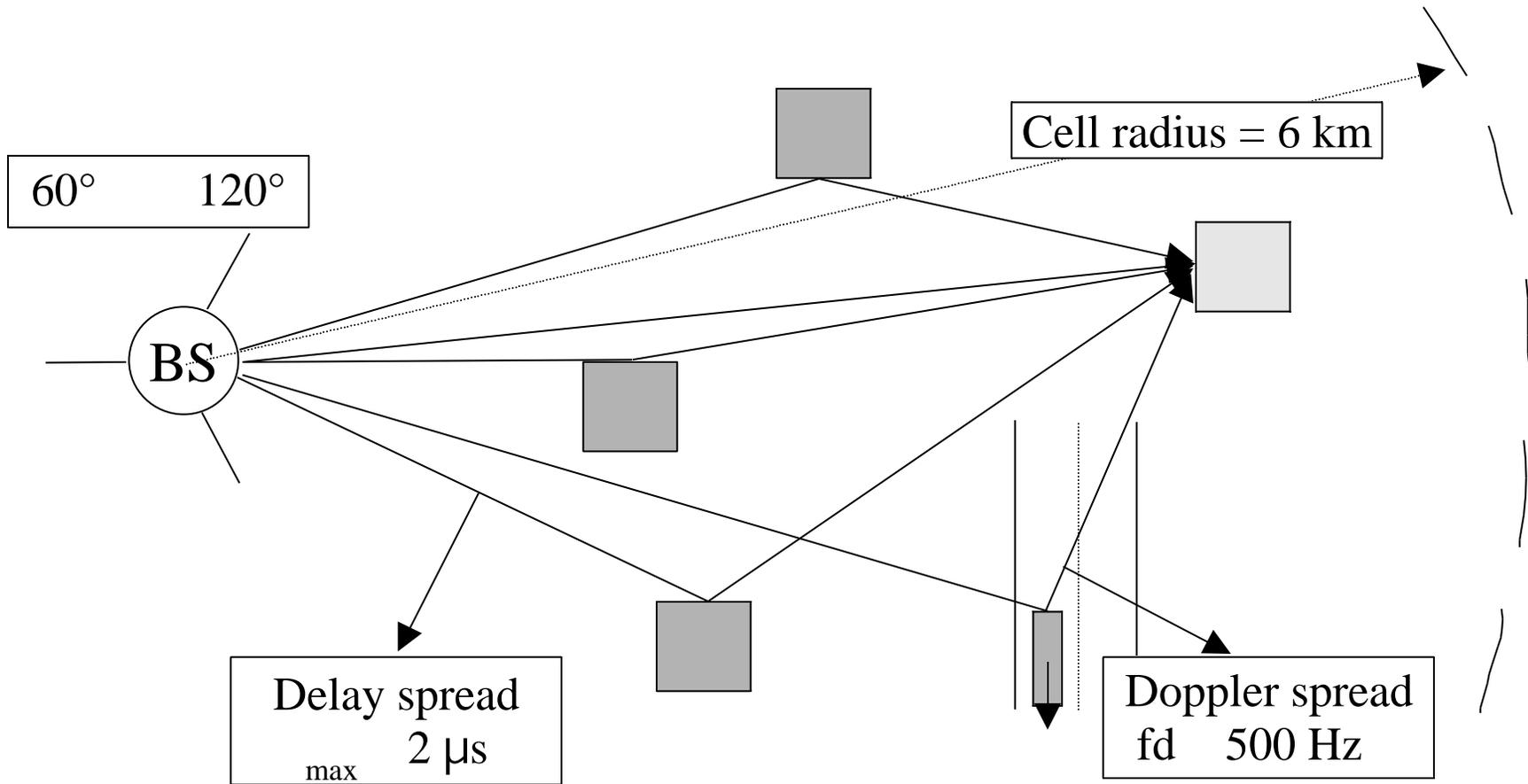
Olivier Seller, SACET.

- _ System overview,
- _ Coding scheme performances,
- _ Low data rates & small packets.

System overview

- _ OFDM,
- _ Space-Time block codes,
- _ High spectral efficiency coding schemes.

PHY constraints

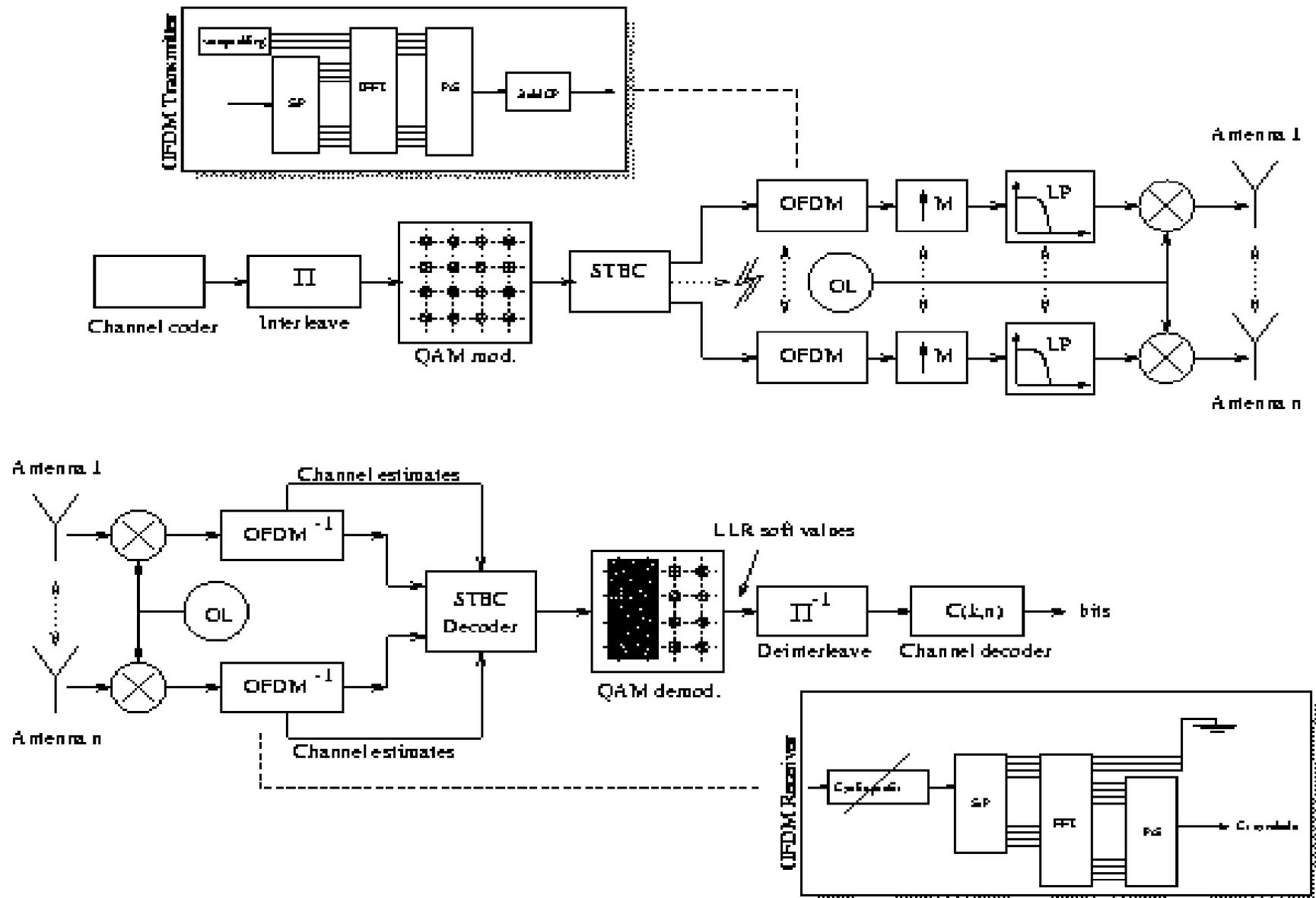


OFDM parameters

- Low ICI subcarrier spacing $100 * f_d$ 50 KHz,
- Cyclic prefix ($\tau_{\max} = 2 \mu\text{s} = 6$ samples at 3 Msymbols / s),
- PSAM for channel estimation,
- Suited OFDM waveforms:

Bandwidth	FFT size	Nb of used Carriers	PSAM Pattern	CP size	CP + PSAM Efficiency
3,5 MHz	64	TBD	4 * 16	10	0.85
7 MHz	128	TBD	4 * 16	16	0.875
14 MHz	256	TBD	4 * 16	28	0.89

System overview



OFDM existing standards

- _ 802.11a, Hiperlan2, DVBT,
- _ OFDM technology already exists,
- _ Development:
 - _ ASIC:
 - _ Use 802.11a or DVBT chips,
 - _ Fast redesign (main change: FFT size, pilots).
 - _ FPGA / DSP:
 - _ Possible since computing power and prices ,
 - _ Software time to market, product evolutivity.

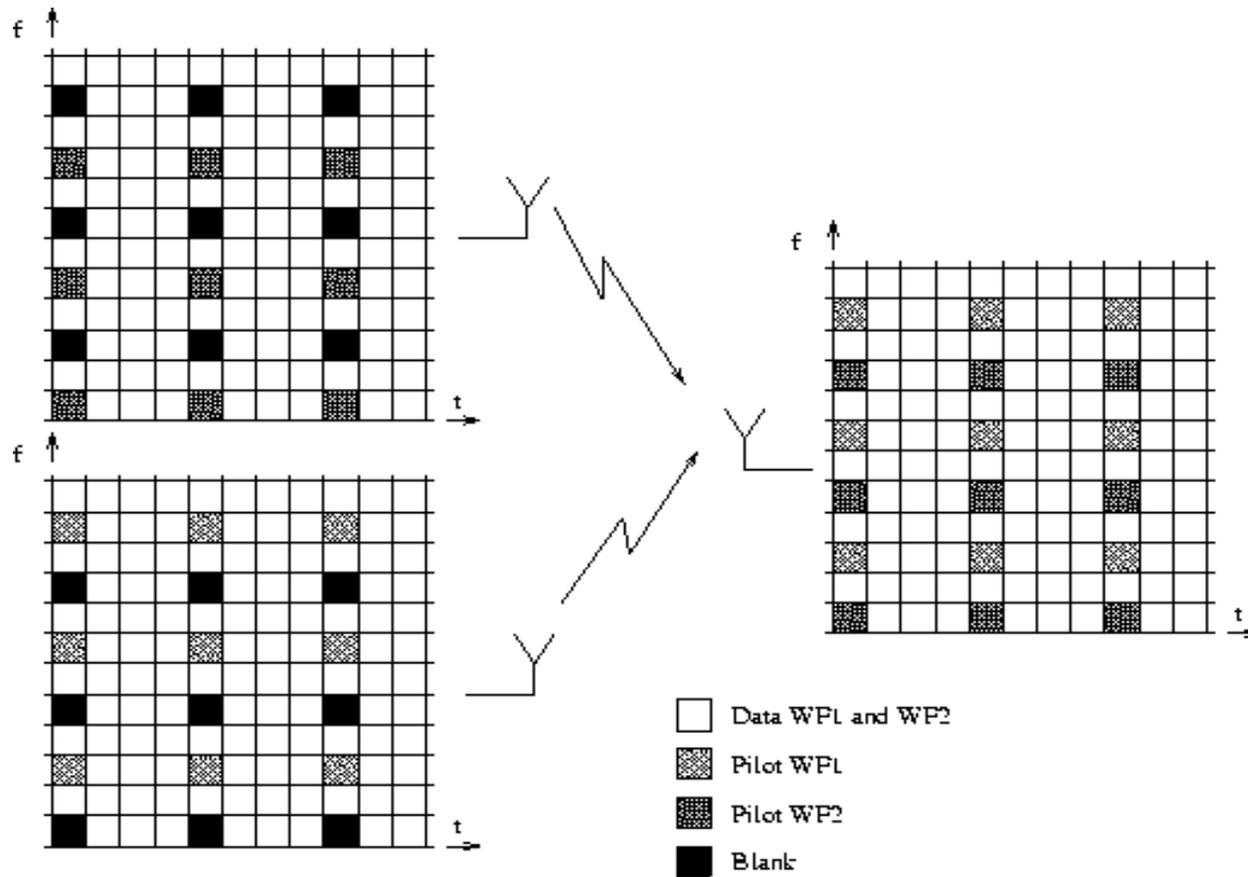
Improving spectral efficiency

- _ Channel estimation: slow fading channel
low density PSAM,
- _ Channel coding: non binary (TCM),
TurboBICM, Turbo Product Codes,
- _ Space-Time block codes:
 - _ $R_{ST} < 1$ increases throughput,
 - _ $R_{ST} > 1$ increases diversity R_c can be higher.

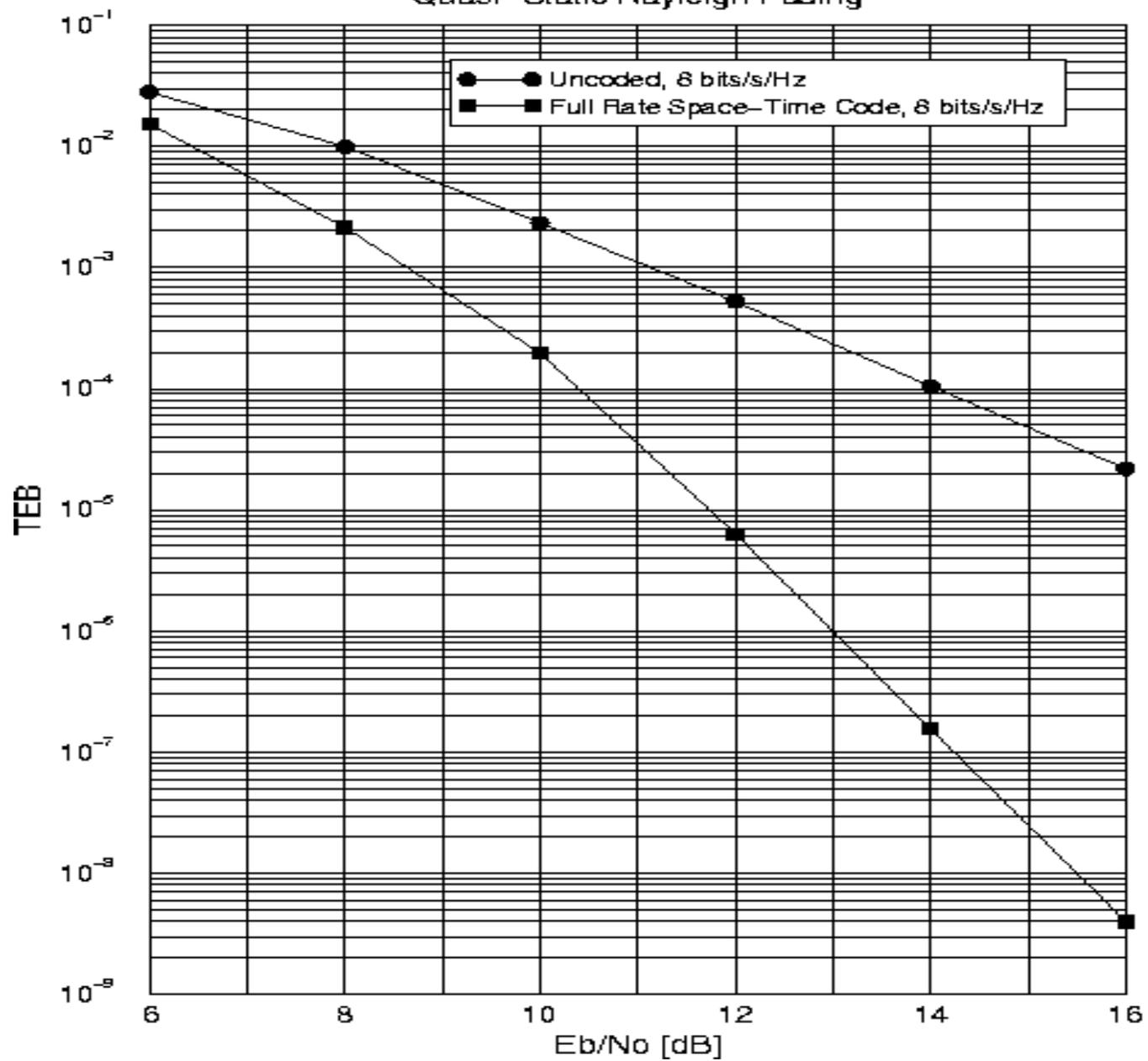
Space-Time block codes

- Multiple antennas reduce power on each amplifier cheaper and more linear amplifiers,
- « Interspaced » PSAM: nominal performances, simple MIMO channel estimation (next figure),
- OFDM can shift Space-Time to Space-Frequency codes, within B_c : slow frequency varying channel slow time varying channel.

Space-Time block codes: interspaced PSAM



Full Rate Space-Time Code, 4 TX, 4 RX, 4-QAM, 8 bits/s/Hz
Quasi-Static Rayleigh Fading

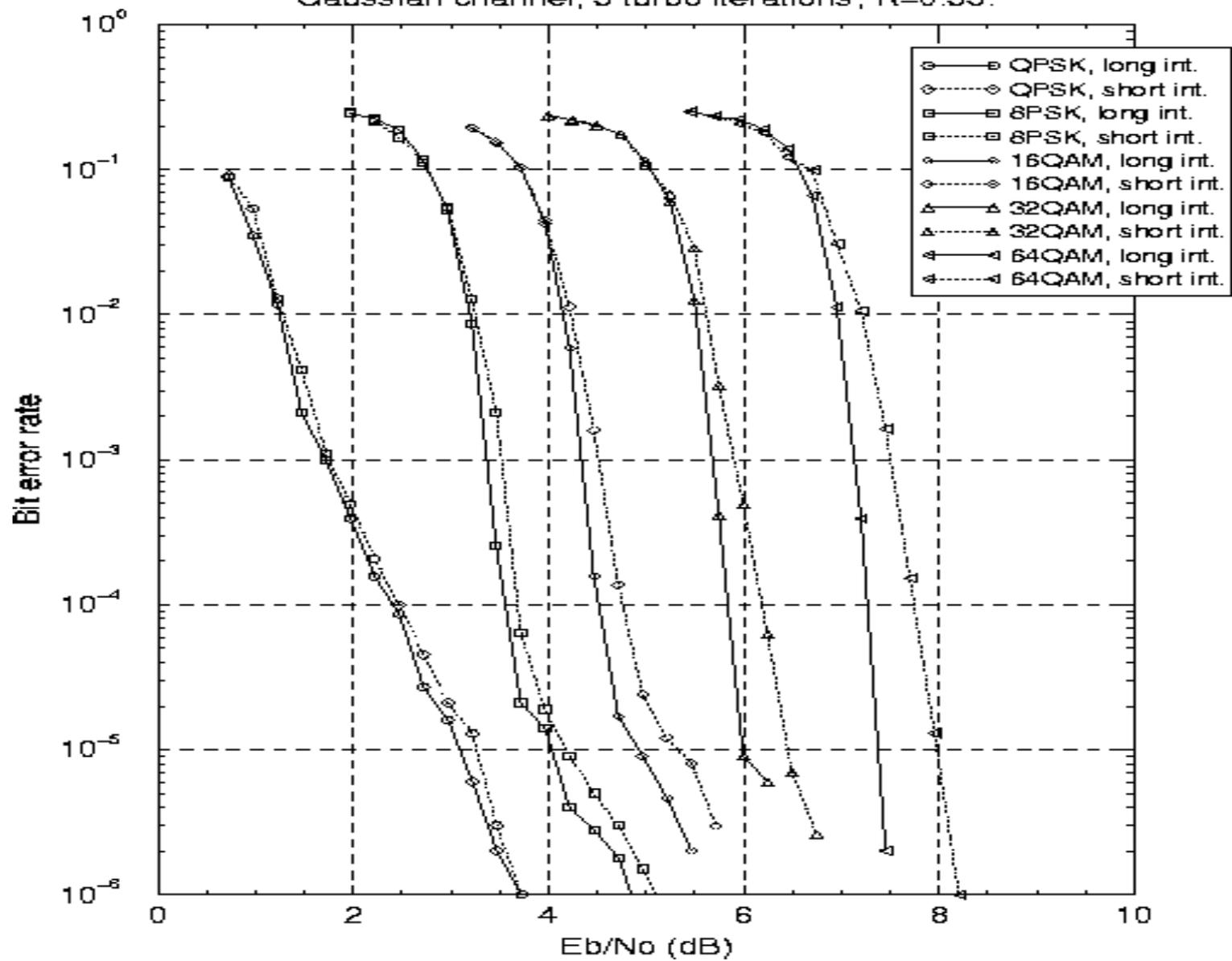


Turbo BICM

- _ New coding scheme which combines Iterative decoding (Turbo) and Bit Interleaved Coded Modulations (BICM),
- _ High spectral efficiency at low SNR:
 - _ Block code, rates from $\frac{1}{2}$ to $\frac{2}{3}$,
 - _ Works at constellation level (like TCM).
- _ Lower complexity than turbo-codes:
 - _ 1 turbo-iteration is only one decoding (instead of 2),
 - _ Short constituent codes: e.g. RS (15,8) over GF (2^4).

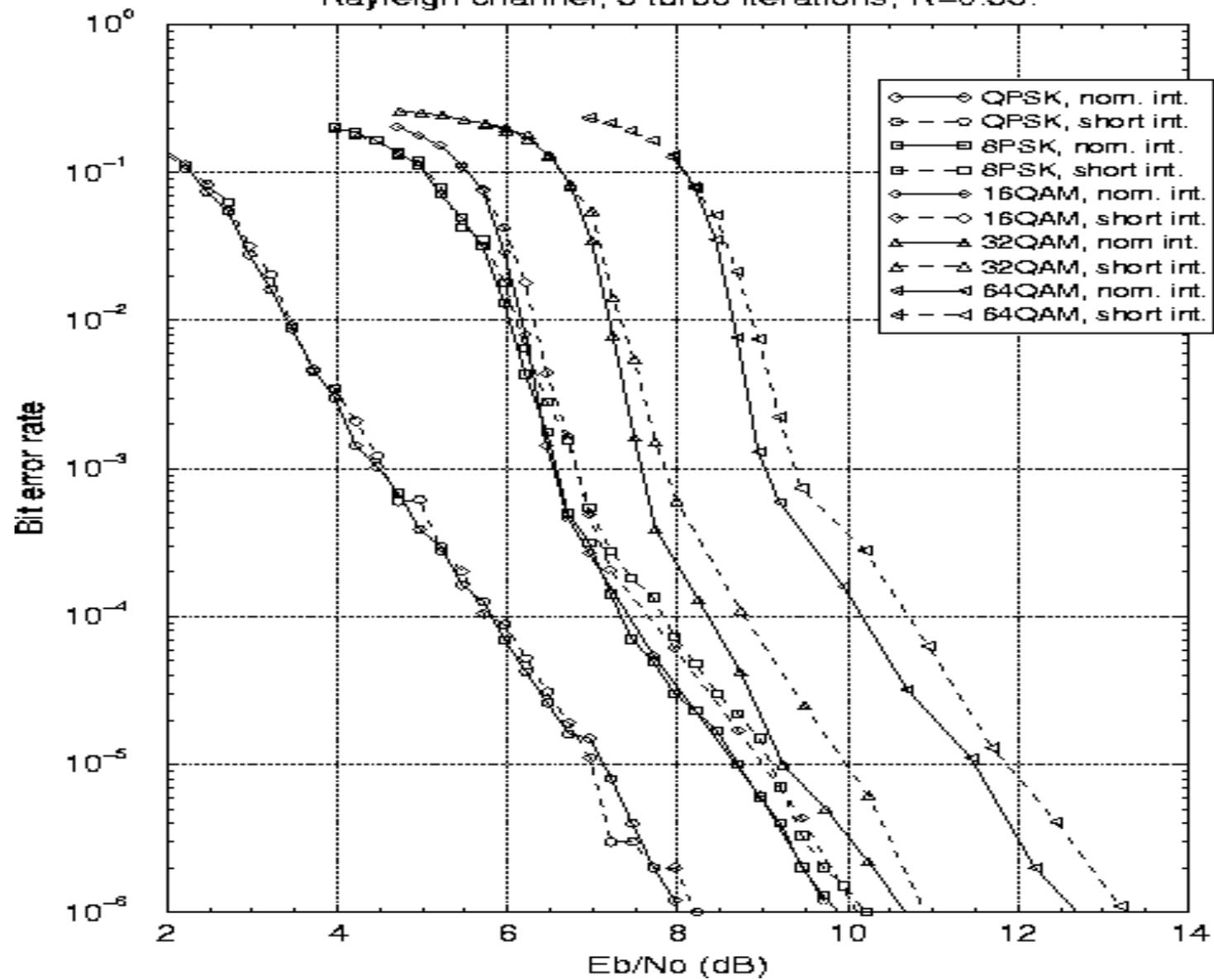
Turbo BICM performances

Gaussian channel, 5 turbo iterations, R=0.53.



Turbo BICM performances

Rayleigh channel, 5 turbo iterations, R=0.53.

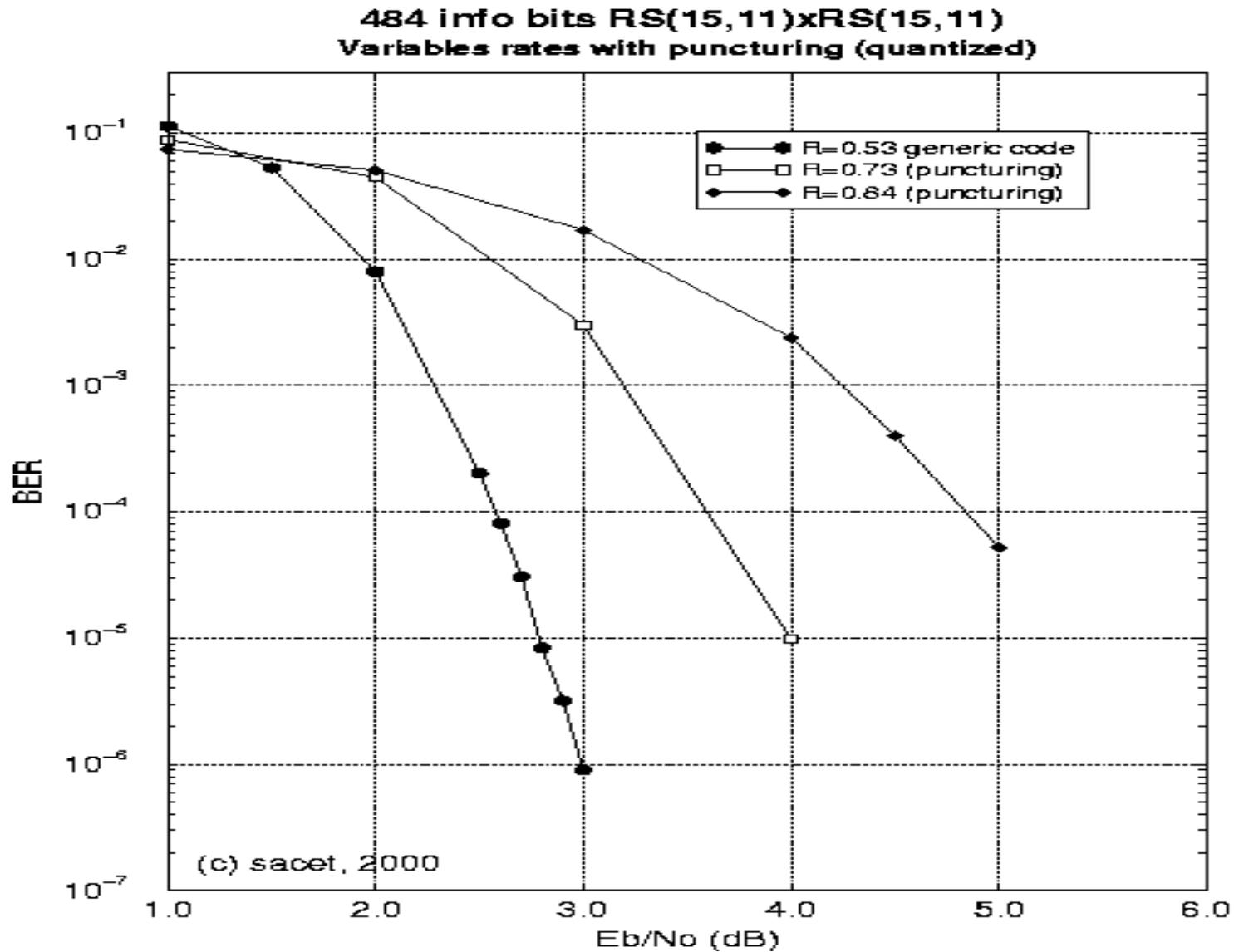


Coding options with Turbo BICM and STBC

OFDM waveform + Turbo BICM channel coder					
Bandwidth	QPSK	8PSK	16QAM	32QAM	64QAM
3,5 MHz	3,17 Mb/s	4,76 Mb/s	6,34 Mb/s	7,93 Mb/s	9,52 Mb/s
7 MHz	6,53 Mb/s	9,80 Mb/s	13,07 Mb/s	16,33 Mb/s	19,60 Mb/s
14 MHz	13,29 Mb/s	19,94 Mb/s	26,58 Mb/s	33,23 Mb/s	39,87 Mb/s

OFDM waveform + STBC (4+4 antennas) + Turbo BICM					
Bandwidth	QPSK	8PSK	16QAM	32QAM	64QAM
3,5 MHz	12,68 Mb/s	19,04 Mb/s	25,36 Mb/s	31,72 Mb/s	38,08 Mb/s
7 MHz	26,12 Mb/s	39,20 Mb/s	52,28 Mb/s	65,33 Mb/s	78,40 Mb/s
14 MHz	53,16 Mb/s	79,76 Mb/s	106,32 Mb/s	132,92 Mb/s	159,48 Mb/s

Turbo Product Code performances



Coding schemes comparison

Scheme	Implementation	Performances
Conv 7,1/2	Simple, exists	Average
Turbo BICM	Dev. Needed	Very good
TPC	Dev. Needed	Very good

Low data rates, small packets

Low SNR, high spectral efficiency required:

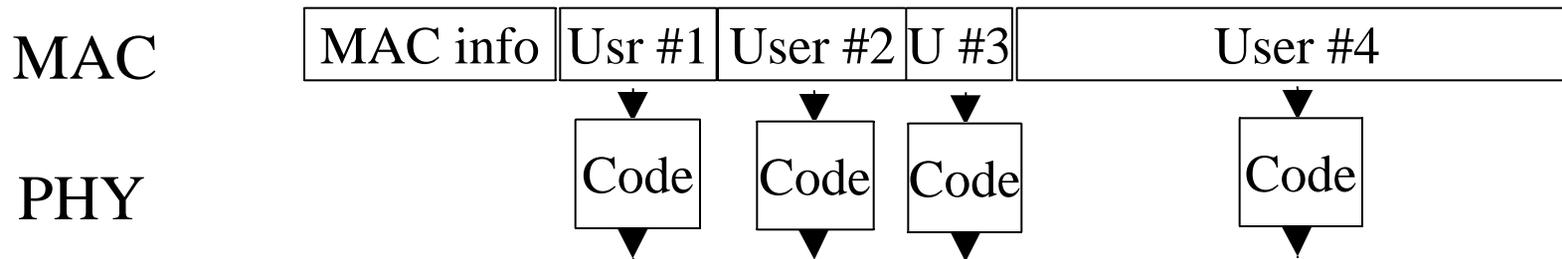
- _ Long codes or long interleavers (Shannon's capacity: BER $\rightarrow 0$ with size $\rightarrow +\infty$.)
 - _ Turbo codes (e.g. NASA's : 65536 bits),
 - _ Turbo BICM: interleaver size is critical,
 - _ Turbo Product Codes: long interleaving.
- _ Problem: long delay for low rate connexions, small packets get poor BER,
 - Proposed solution: « interleaved » TDM.

« Interleaved » TDM

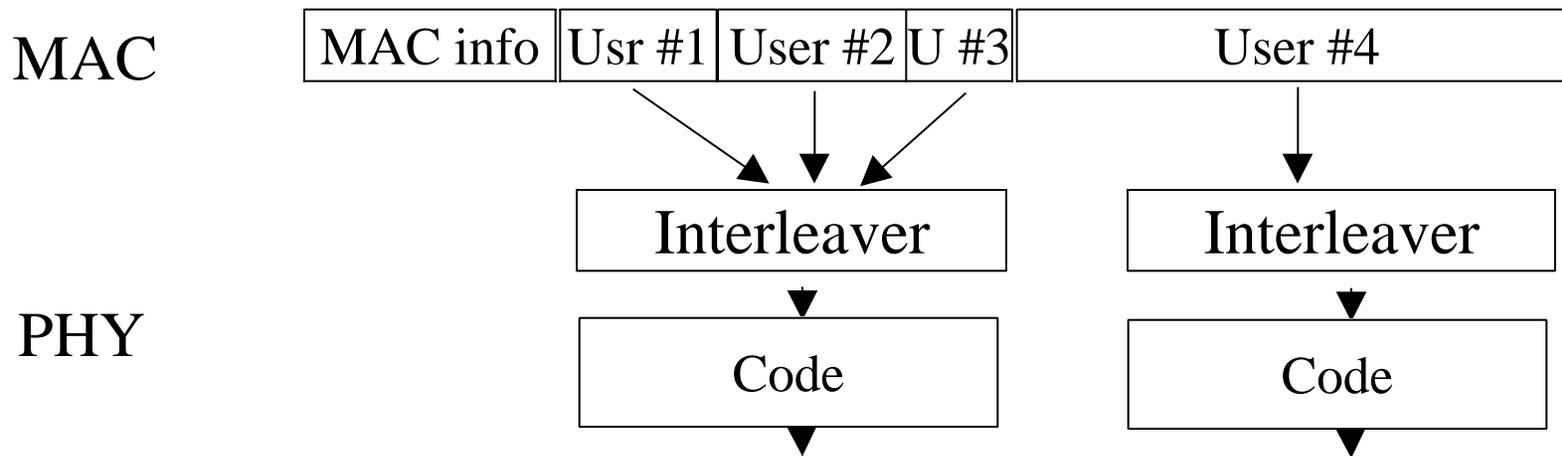
- _ On DownLink only,
- _ Small packets are interleaved together inside one (long) coding or interleaving block,
- _ Interleaved packets share the same constellation,
- _ Keeps high spectral efficiency for small packets,
- _ Small modification of MAC.

« Interleaved » TDM

TDM:



Interleaved TDM:



Conclusion, remarks

- _ NLOS channel OFDM,
- _ High spectral efficiency coding schemes,
- _ Systems uses TDM/TDMA MAC, but OFDMA is possible with more carriers,
- _ OFDM raises PAPR problem. Some work to do, but solutions exist.