DVB-T2:
A second generation digital terrestrial broadcast system

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Presentation Overview

- Background and requirements
- DVB-T2 specification
  - Key Features of the system
  - Related specifications
- Performance & Simulation results
- Implementation & Validation
- UK plans for HDTV service launch
- Conclusions
- Questions

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DVB-T2 – background

- 1st generation system (DVB-T) used for DTT launch in UK (1998) and around the world
- Desire for HDTV on terrestrial platform
  - requires significant increase in capacity
- 2nd generation system (DVB-T2)
  - study mission launched by DVB in 2006
  - to increase capacity, ruggedness and flexibility
- Aim to launch ‘Freeview-HD’ in UK with switch-over roll-out from end-2009
  - an incredibly short timescale!

Commercial Requirements for T2

- Key requirements include
  - Must be able to use existing domestic receive antenna and existing transmitter infrastructure
  - Should provide minimum of 30% capacity increase over DVB-T
  - Should provide for improved SFN performance
  - Should have mechanism for providing service-specific robustness
  - Should provide for bandwidth and frequency flexibility
  - Should provide means to reduce peak-to-average power ratio
- The T2 specification has been compared to these requirements and found to meet or exceed all of them

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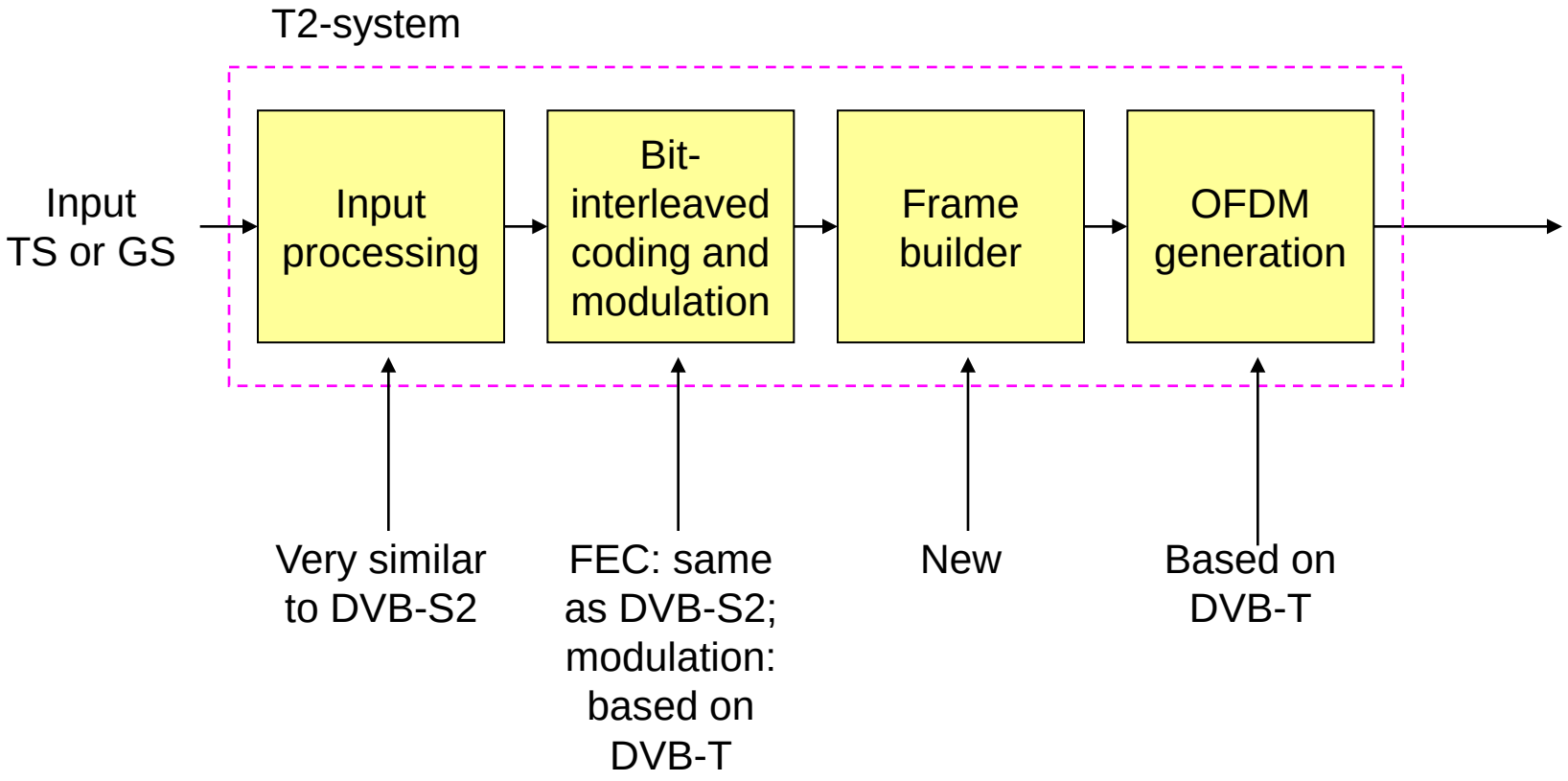
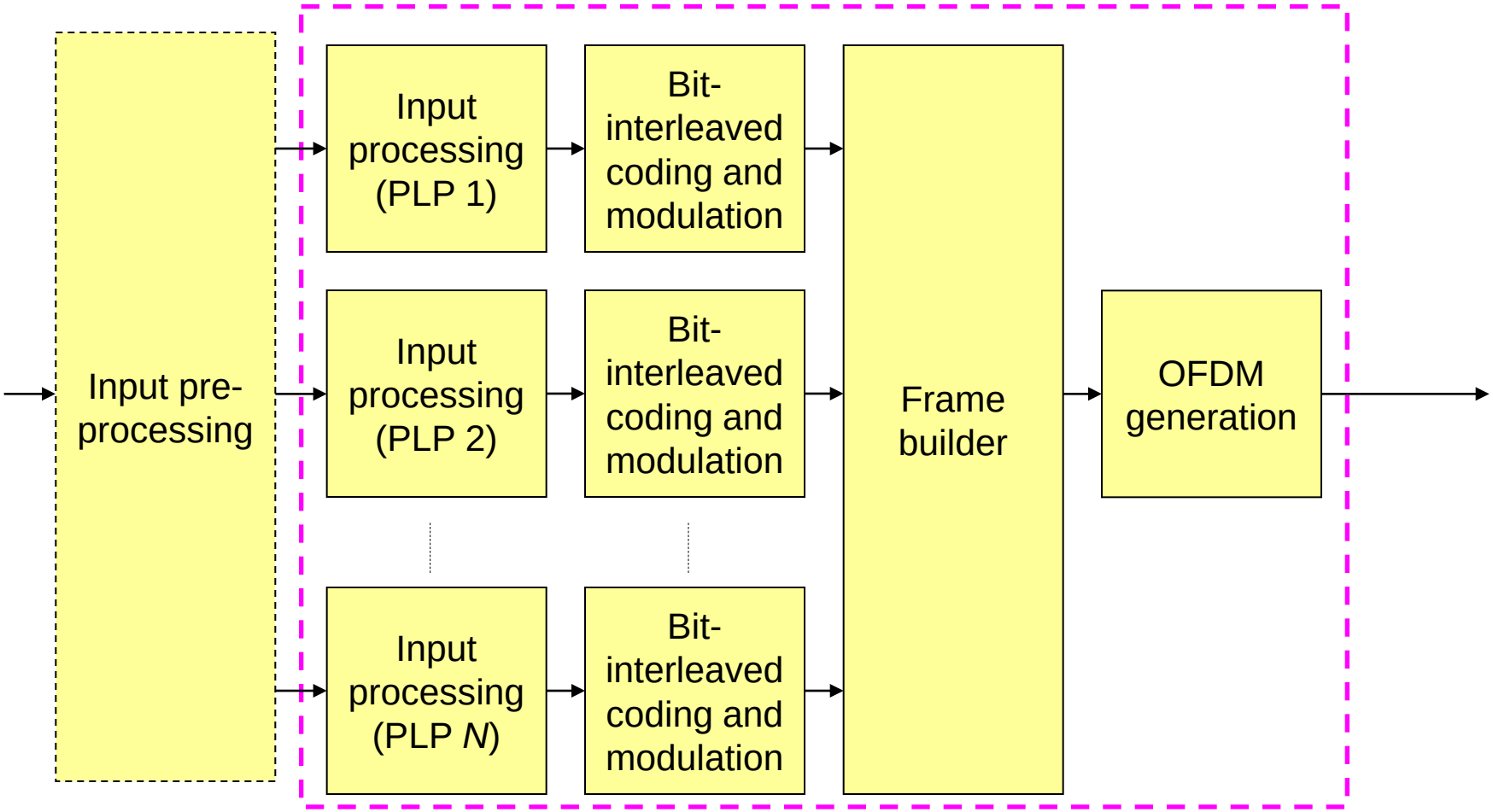
T2 physical layer architecture



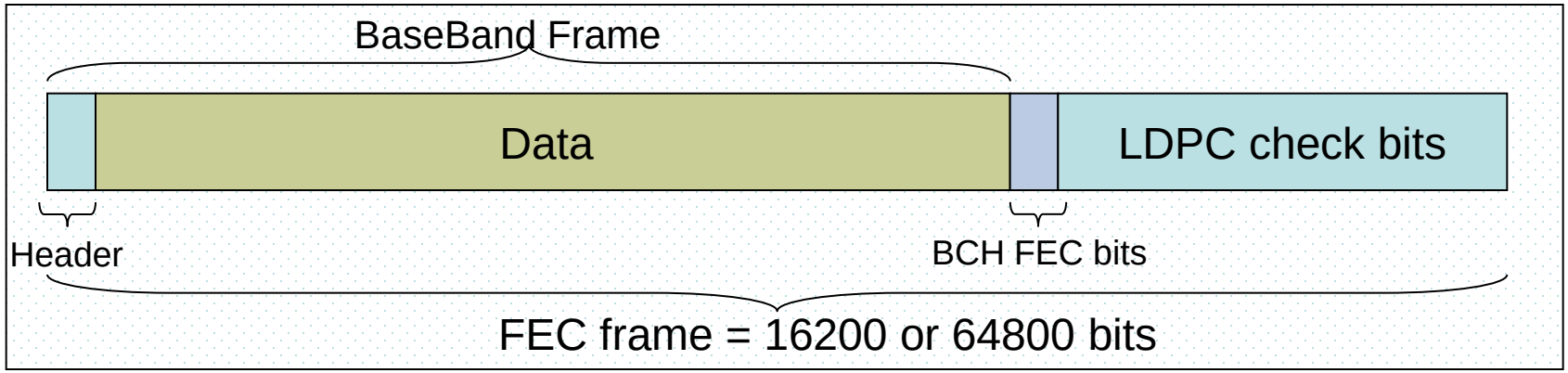
- Common elements from DVB-T and DVB-S2 give:
  - coherent family of DVB standards
  - easy translation between S2 and T2

Multiple services in Physical Layer Pipes (PLPs)



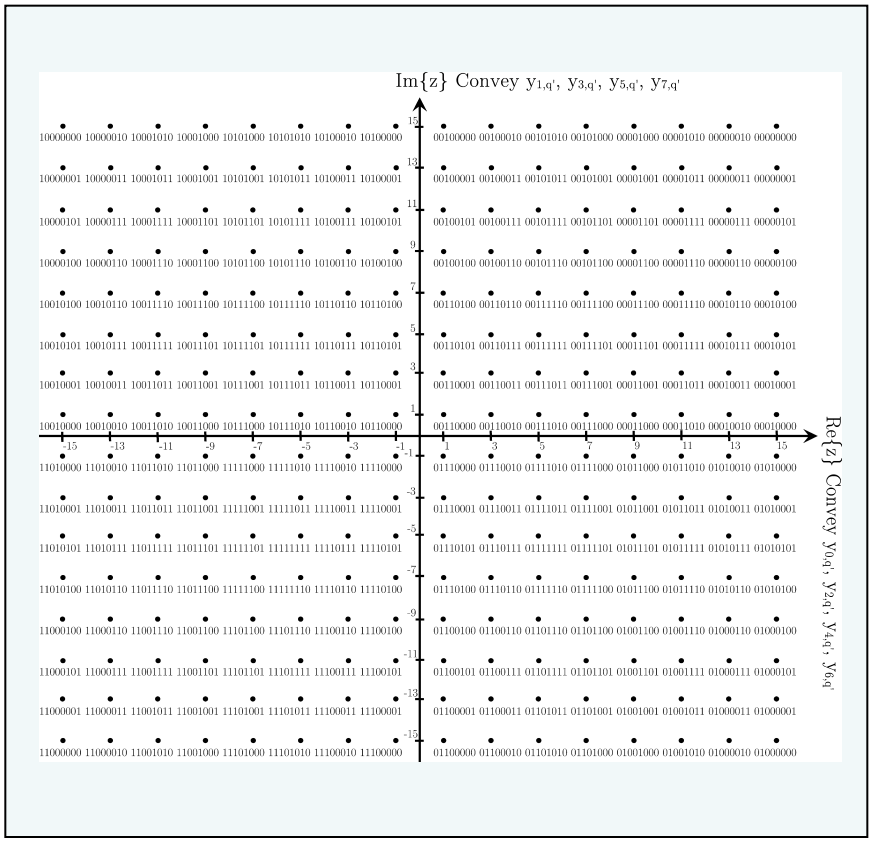
Key features: LDPC

- Protected by the Low Density Parity Check (LDPC) code
  - As in DVB-S2
  - Code rates: 1/2, **3/5**, 2/3, 3/4, 4/5, 5/6
  - Performance is much closer to theoretical limits than convolutional code used in DVB-T



Key Features: Modulation (1)

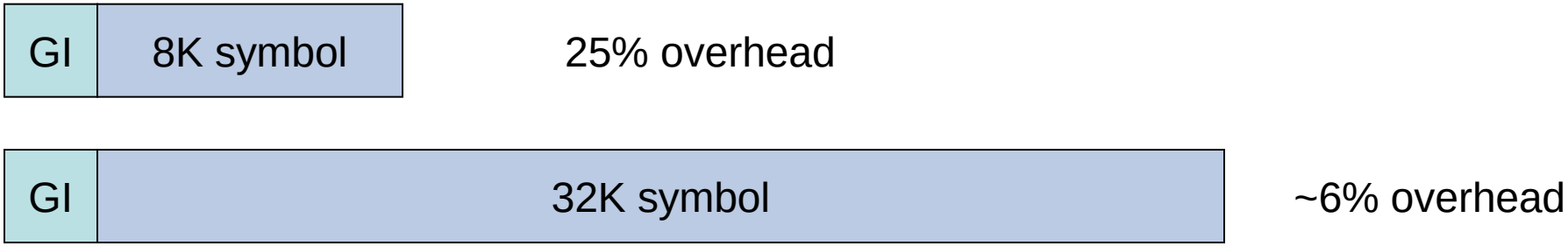
- Constellations:
  - QPSK, 16-QAM, 64-QAM, plus **256-QAM**



- 256-QAM
  - carries 8 bits/data cell
  - cf.6 for 64-QAM
  - improved FEC performance of LDPC makes robustness similar to 64-QAM in DVB-T

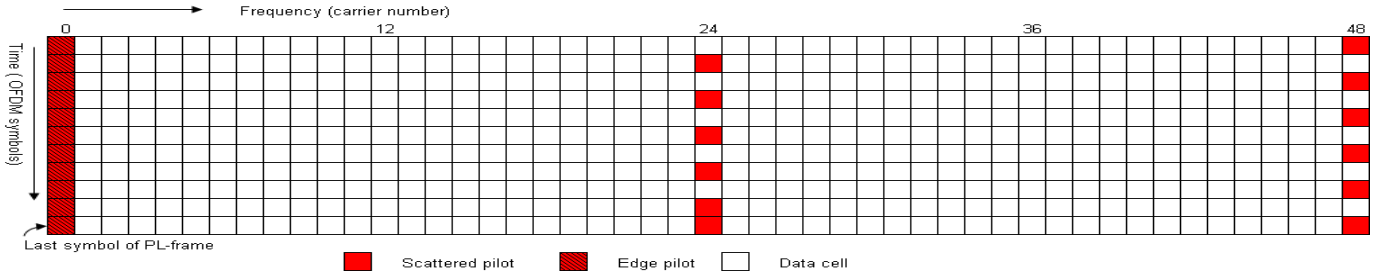
Key Features: Modulation (2)

- T2 uses conventional Guard-Interval OFDM
  - as in DVB-T
- **1K**, 2K, 4K, 8K, **16K, 32K** FFT options are available in T2
- Larger FFT sizes:
  - Can reduce guard interval overhead for given size of SFN
  - Can increase SFN capability for a given fractional GI

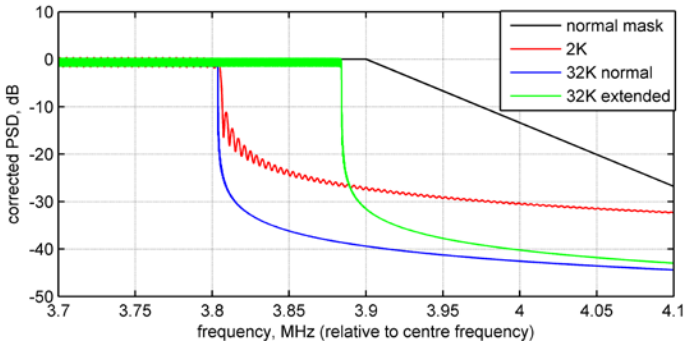


Efficiency improvements

- Lower pilot density where appropriate (1% vs 8%)



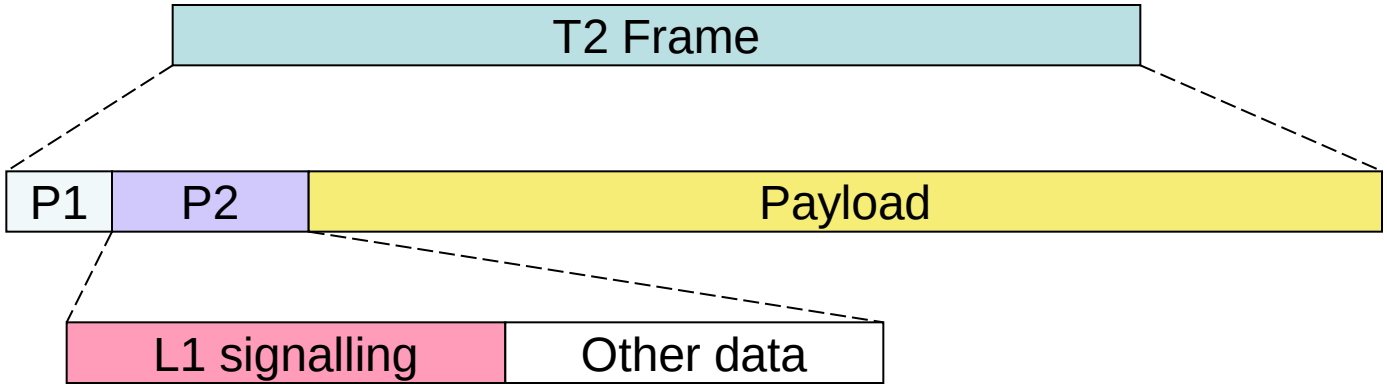
- Extended carrier mode (2% extra capacity)



- Fewer Continual Pilots, sync-byte removal, …

T2-Frame Structure

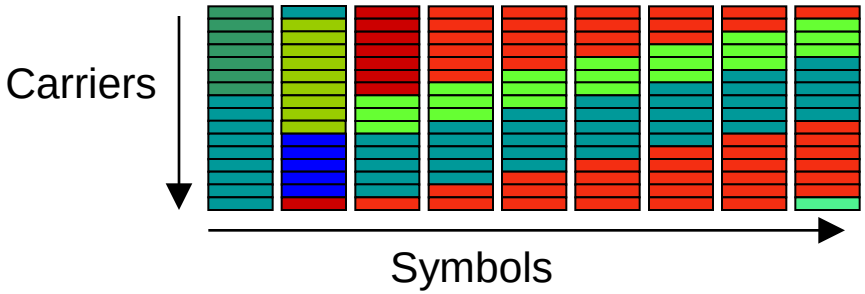
- Typical frame duration: 150 - 250 ms



  - P1 Preamble gives rapid detection and acquisition
  - P2 carries L1 signalling including frame structure data
    - Plus other data if space remaining

Single vs. Multiple PLP

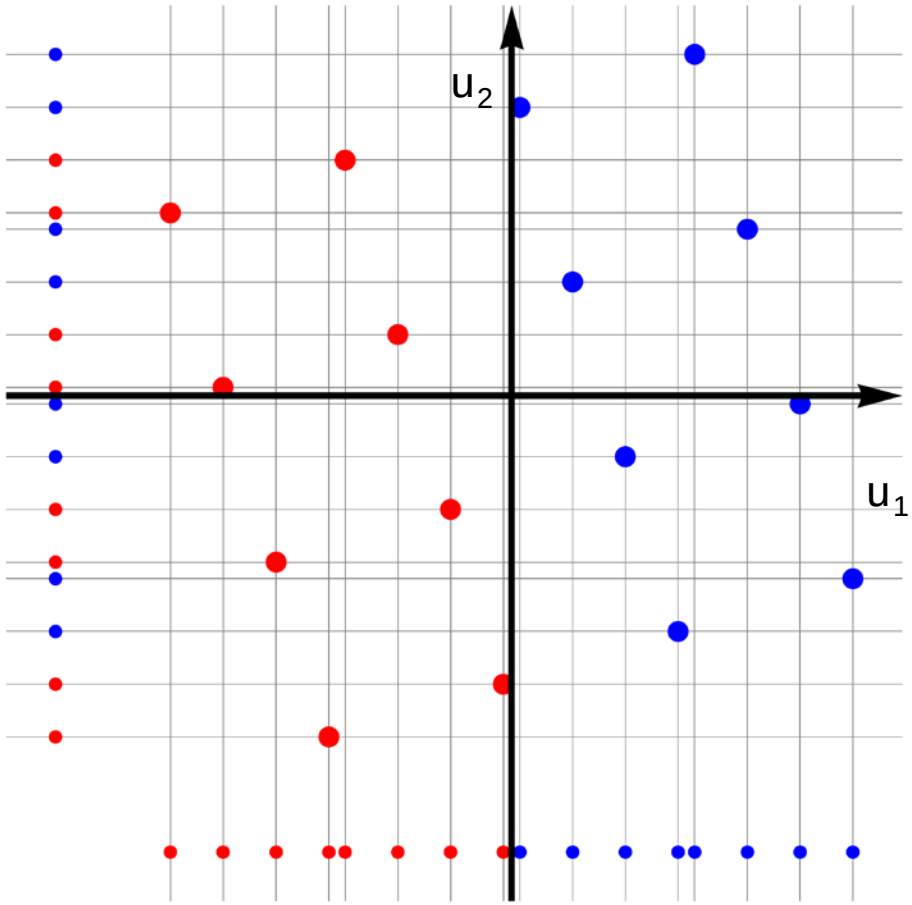
- Single PLP
  - Complete transport stream is contained within single PLP



- Multiple PLP
  - Each data PLP carries a transport stream
  - Information common to a group of PLPs (e.g. EPG) is carried in a ‘Common PLP’
  - Receiver must be able to decode Common PLP & one data PLP
  - Different PLPs can have different modulation/coding
    - Service-specific robustness, e.g. roof-top + portable services

Rotated Constellations

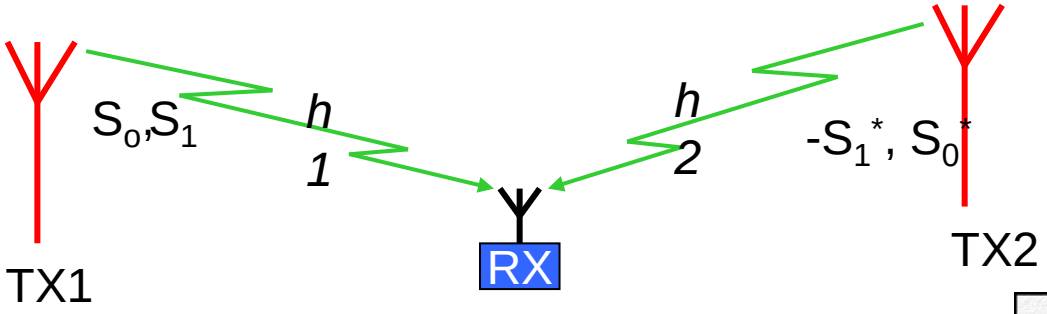
- Map data onto a normal QAM (x,y)
- Rotate constellation (axes now (u1,u2)
- Ensure u1 and u2 travel in different cells
  - So that they fade independently
  - Gather together in receiver
- Each of u1,u2 carries all of the info of original x,y
  - So can decode if one is erased completely
- Simulated gains up to 7dB



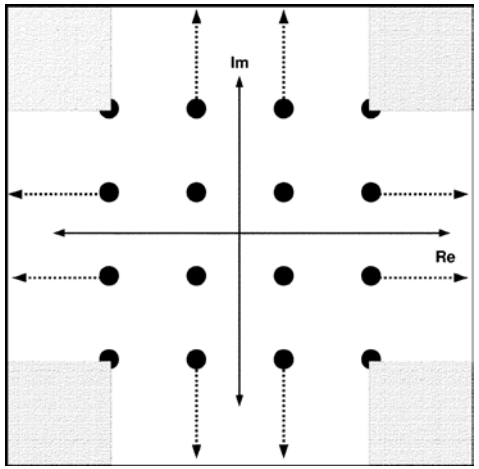
Rotated 16-QAM constellation, showing bit 0 mapping. Blue points represent a 0 and red points represent a 1

Other key technologies

- Transmit diversity (Alamouti)
  - could give 30% increase in coverage



- Peak-to-average power reduction
  - Could reduce peak power by 20%



- Time interleaving
  - At least 70ms
  - Provides protection against impulsive interference

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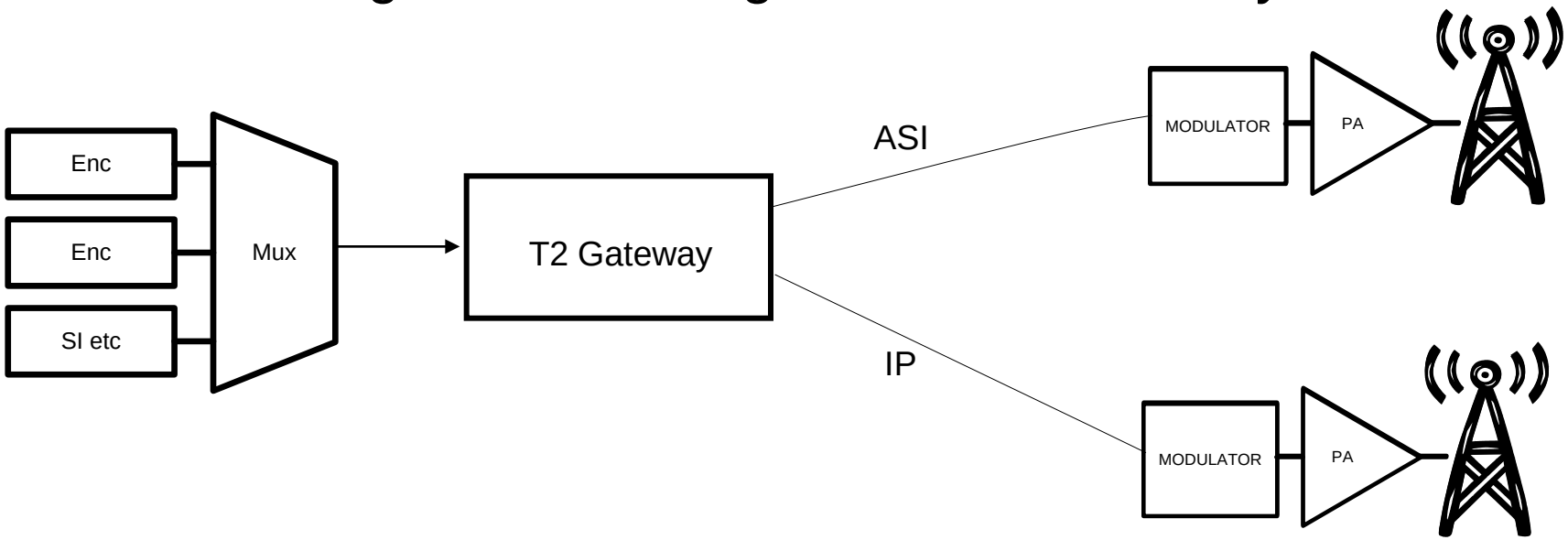
Modulator Interface

- In a Single Frequency Network must ensure that all modulators generate identical T2 frames
- T2-MI generated by central ‘T2 Gateway’
- Transmitters generate T2 signal deterministically from T2-MI



- Specification published as DVB BlueBook in Feb 09
- Interoperability tests planned for late 2009

Transmitter Identification

- Requirements for professional monitoring receiver
  - Identify if Tx within SFN has incorrect timing
  - Identify if Tx within SFN has incorrect frequency
  - Monitor channel to check for anomalous propagation
- Several techniques have been investigated
  - Use of low-level additive signal
  - Use of existing reserved parts of T2 signal
  - Use of future extension frames (FEFs)
- Progress:
  - First draft of specification produced

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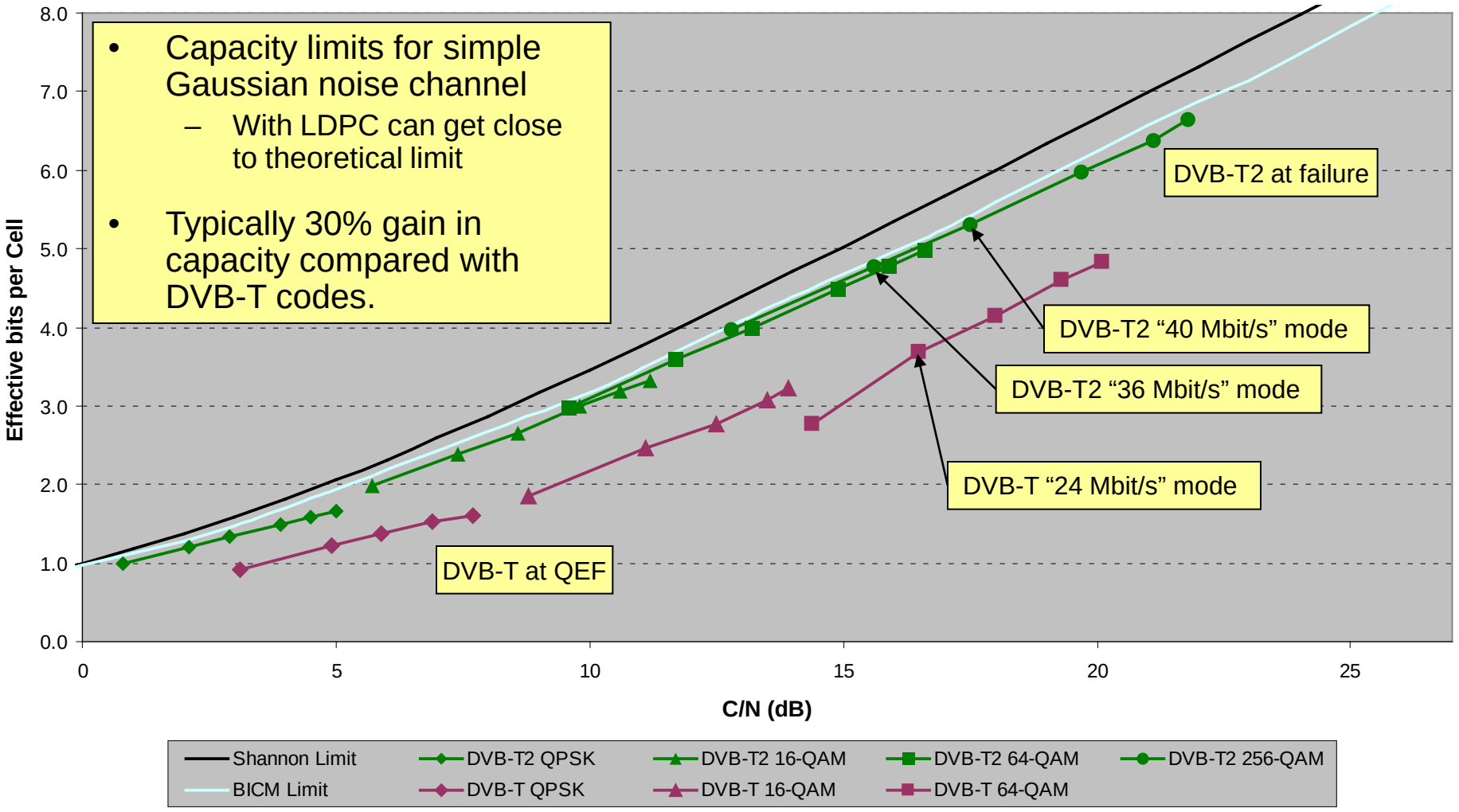
Modulation and Coding Performance



T2 Capacity – UK-like example

	Current UK mode	T2
Modulation	64QAM	256QAM
FFT size	2K	32K
Guard Interval	1/32	1/128
FEC	2/3 CC + RS (8%)	3/5LDPC + BCH (0.3%)
Scattered Pilots	8.3%	1.0%
Continual Pilots	2.0%	0.53%
Frame structure overhead	1.0%	0.53%
Bandwidth	Normal	Extended
Capacity	24.1 Mbit/s	36.1Mbit/s

Capacity = DVB-T + 50%

T2 Capacity – SFN example

	Current mode	T2
Modulation	64QAM	256QAM
FFT size	8K	32K
Guard Interval	1/4	1/16
FEC	2/3 CC + RS (8%)	3/5LDPC + BCH (0.3%)
Scattered Pilots	8.3%	4.2%
Continual Pilots	2.0%	0.39%
Frame structure overhead	1.0%	0.65%
Bandwidth	Normal	Extended
Capacity	19.9 Mbit/s	33.2Mbit/s

Capacity = DVB-T + 67%

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On-going T2 activities within DVB

- Validation and Verification
  - 8 independent implementations compared in software
  - More than 30 different modes tested with full agreement
  - Hardware plug fest (March 09) demonstrated interoperation between 5 modulators and 6 demodulators in several modes

Photo-montage of PlugFest, thanks to RAI

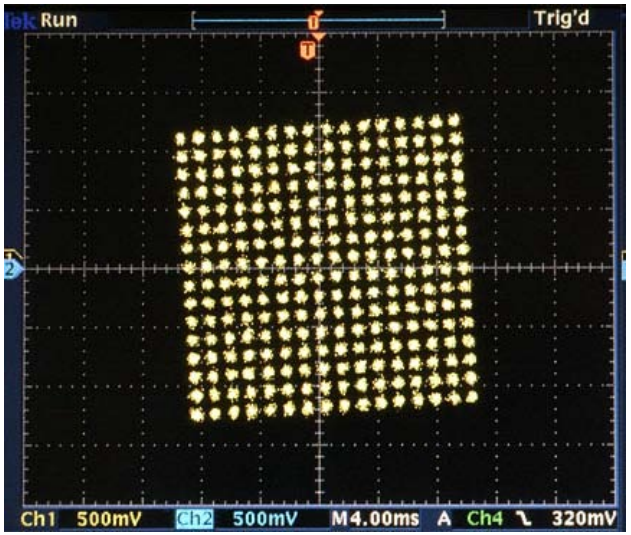
On-going T2 activities within DVB

- Simulation
  - Many simulations performed and results included in Implementation Guidelines document
  - Good agreement between different simulation models
  - Common Simulation Platform
    - MATLAB model
    - Can act as open reference implementation
    - Supports most options of the specification

T2 Implementations

- Software simulation platforms
  - Common Simulation Platform
  - Several independent company implementations
- FPGA prototypes
  - Modulator: BBC, DekTec, R&S, Enensys, SSBT, Teamcast
  - Demodulator: BBC, Dektec, Panasonic, SIDSA, Sony
- VLSI
  - Several large VLSI companies are developing T2 demodulator chips

T2 Implementations



- BBC has had T2 signals on-air since June 2008

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T2 Service Plans in UK

- UK regulator, Ofcom, has announced the UK will launch HDTV services from December 2009
  - Starting in North West of UK as part of Switch Over
  - Around 5 additional stations likely to be added in advance of switch-over
  - initial coverage in early 2010 around 50% of UK

- Single public-service MUX to be used for HD services
  - Starting with 3 HD services
    - BBC, ITV, Ch4/S4C
  - Channel 5 HD service to be added during 2010

UK Planning for HD services

- Ofcom coordinating UK-HD Pilot planning project
- Participants include HD broadcasters, Arqiva, TV/STB manufacturers
- Lab and field trials currently underway,
  - using manufacturers' prototype equipment
- Technical goals:
  - To verify performance using real hardware (in comparison with simulations)
  - To verify planning parameters and choice of mode
  - To provide test bed with real signals to assist manufacturer developments
- Pilot is just one part of the implementation work

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Conclusions

- T2 specification and documentation process approaching completion
- Commercial requirements easily exceeded
- Validation & Verification activities making very good progress
- FPGA-based hardware prototypes already demonstrated
- VLSI design well underway
- Lab tests and field trials underway
- Intense planning activity in UK
- Launch of T2 “Freeview-HD” services in December 2009 in UK

Thanks for your attention!

Any questions?

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