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Behind the
Image

DICOM Compression 2002

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Schemes Supported

- RLE
- JPEG - lossless and lossy
- JPEG-LS - more efficient, fast lossless
- JPEG 2000 - progressive, ROI encoding
- Deflate (zip/gzip) - for non-image objects

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In practice mostly …

- Lossless JPEG for cardiac angio
  - multi-frame 512x512x8, 1024x1024x10
  - CD-R and on network
- Lossless JPEG for CT/MR
  - mostly on MOD media rather than over network
  - 256x256 to 1024x1024, 12-16 bits
- RLE/lossless/lossy JPEG for Ultrasound
  - 640x480 single and multiframe 8 bits gray/RGB, text

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But …

- JPEG lossless not the most effective
- JPEG lossy limited to 12 bits unsigned
- Undesirable JPEG blockiness
- Perception that wavelets are better
- Need for better progressive encoding
- Need for region-of-interest encoding

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JPEG Lossless

- Reasonable predictive scheme
  - Most often only previous pixel predictor used (SV1), which is not always the best choice
- No run-length mode
  - No way to take advantage of large background areas
- Huffman entropy coder
  - Slow (multi-pass)

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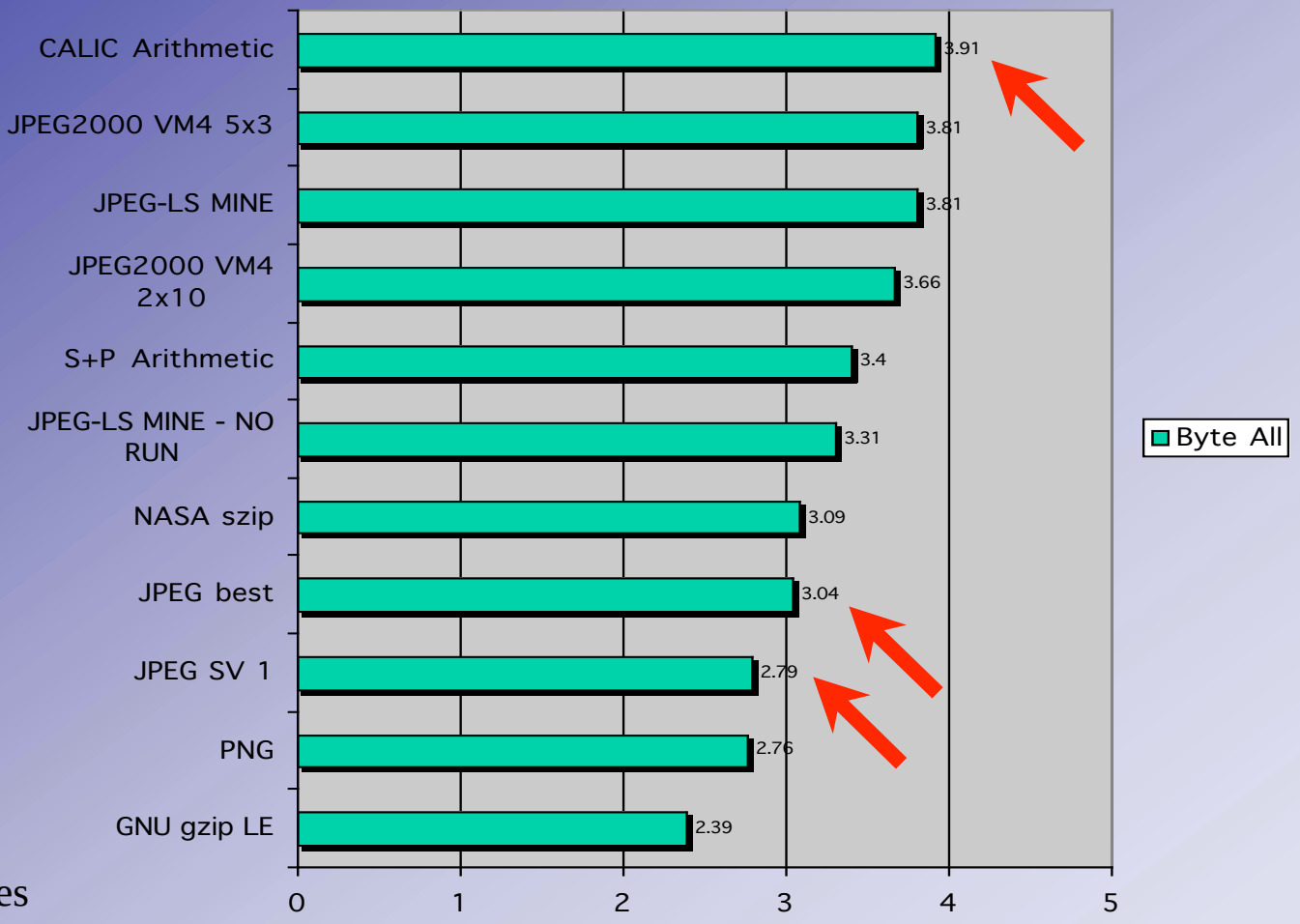
Lossless Compression



3,679 grayscale single frame images

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JPEG-LS (ISO 14495-1)

- Added to DICOM in CP-174 (25Sep2000)
- Two Transfer Syntaxes
- Lossless
  - Predictive, statistical model, Rice-Golomb, run-length
- Near-lossless
  - Prediction error constrained to limit (0 == lossless)
- Simple, fast, low memory requirement
- Approaches state of the art

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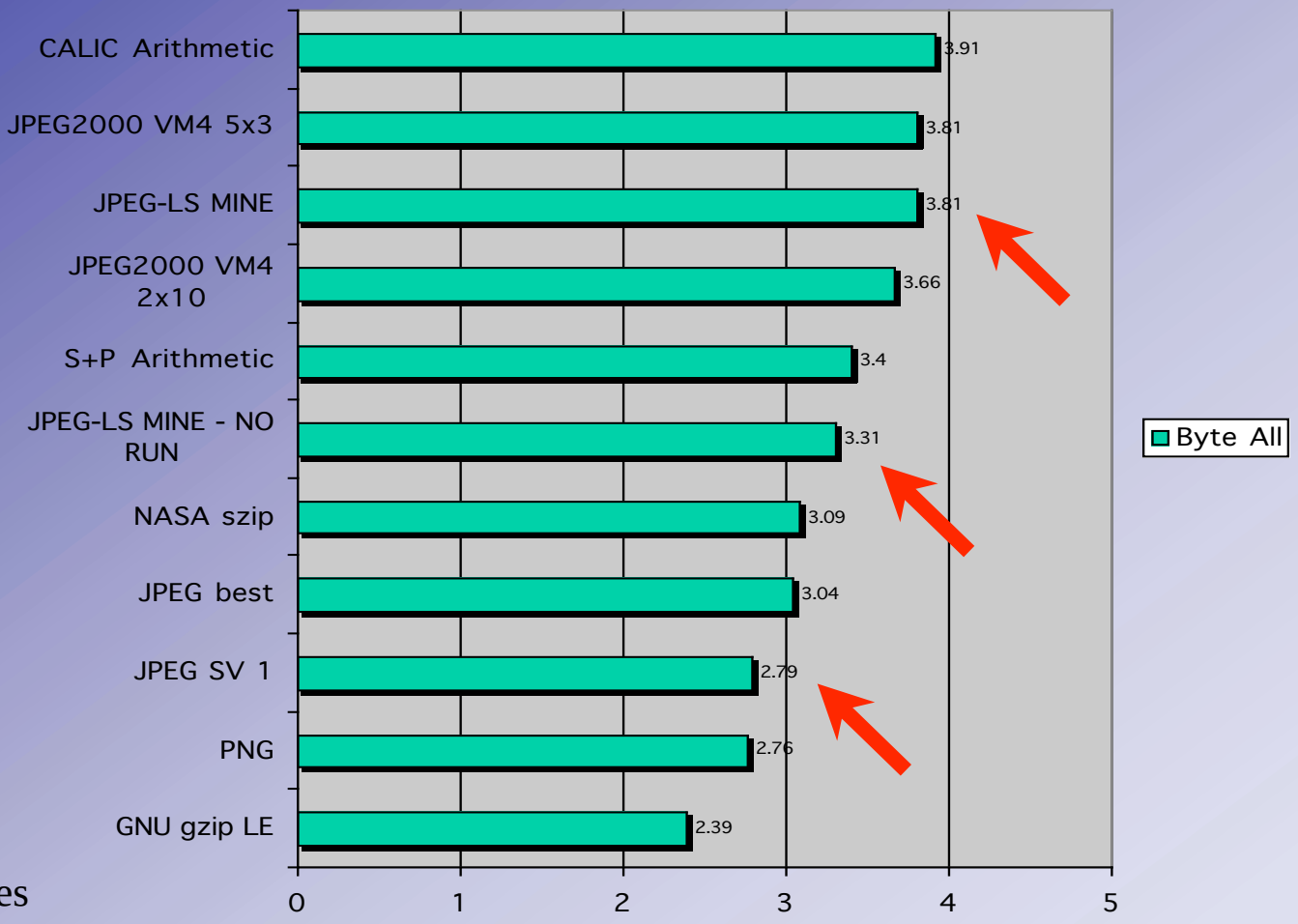
Lossless Compression



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JPEG 2000 (ISO 15444-1)

- Added to DICOM in Sup 61 (14Jan2002)
- Lossless
  - Integer wavelet (+/- reversible color transformation)
- Either lossless or lossy
  - Integer or floating point wavelet
- Many features
  - <= 16 bits, signed or unsigned
  - Progressive by contrast or spatial, embedded
  - Region-of-interest coding - fewer bits for background

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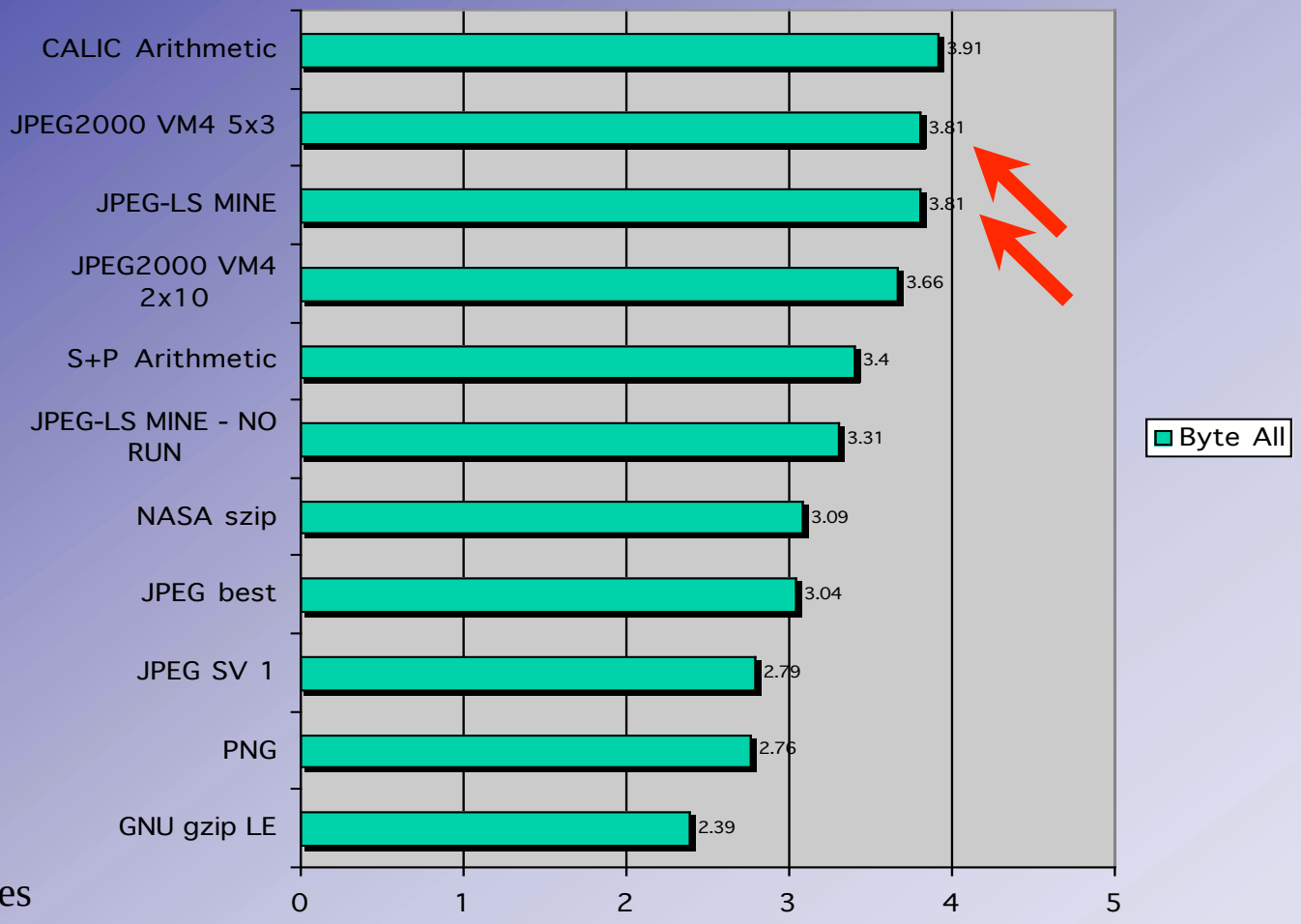
Lossless Compression



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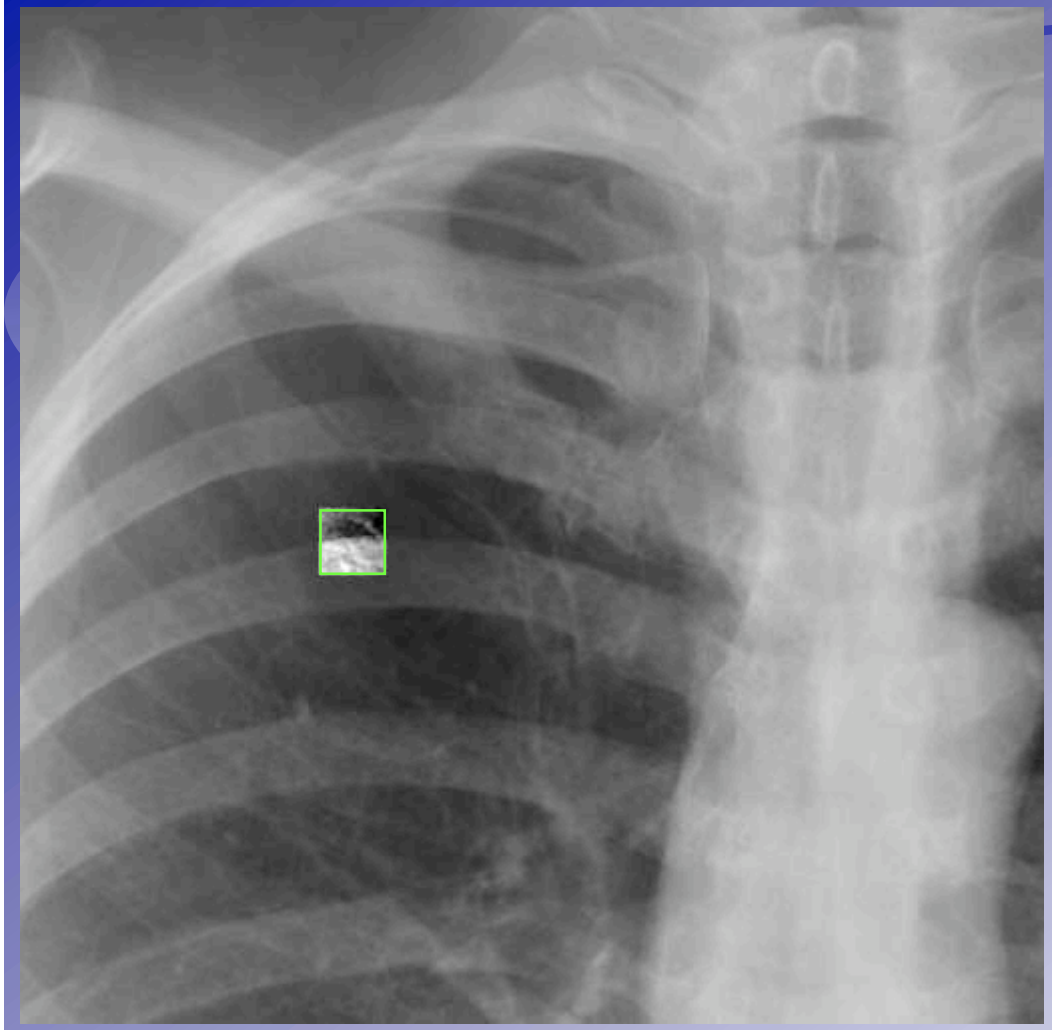
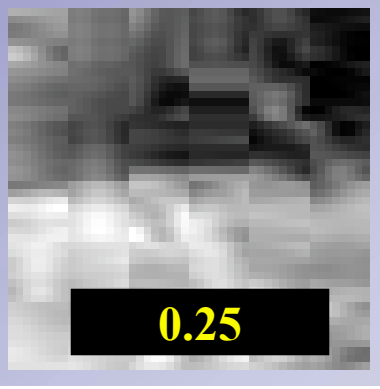
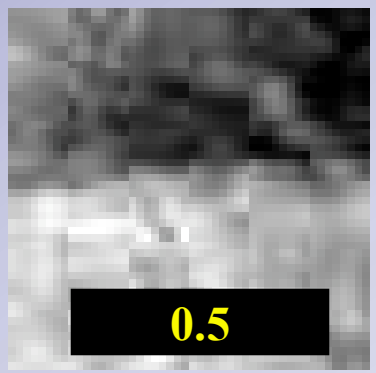
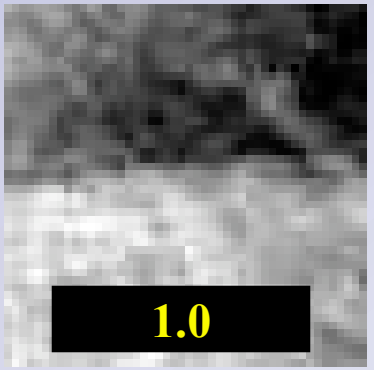


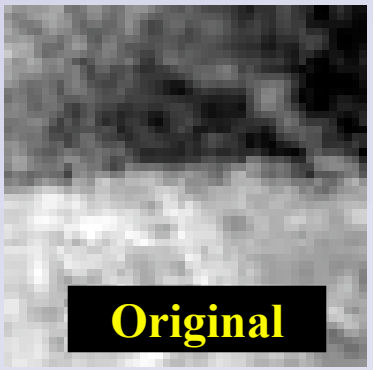
JPEG DCT

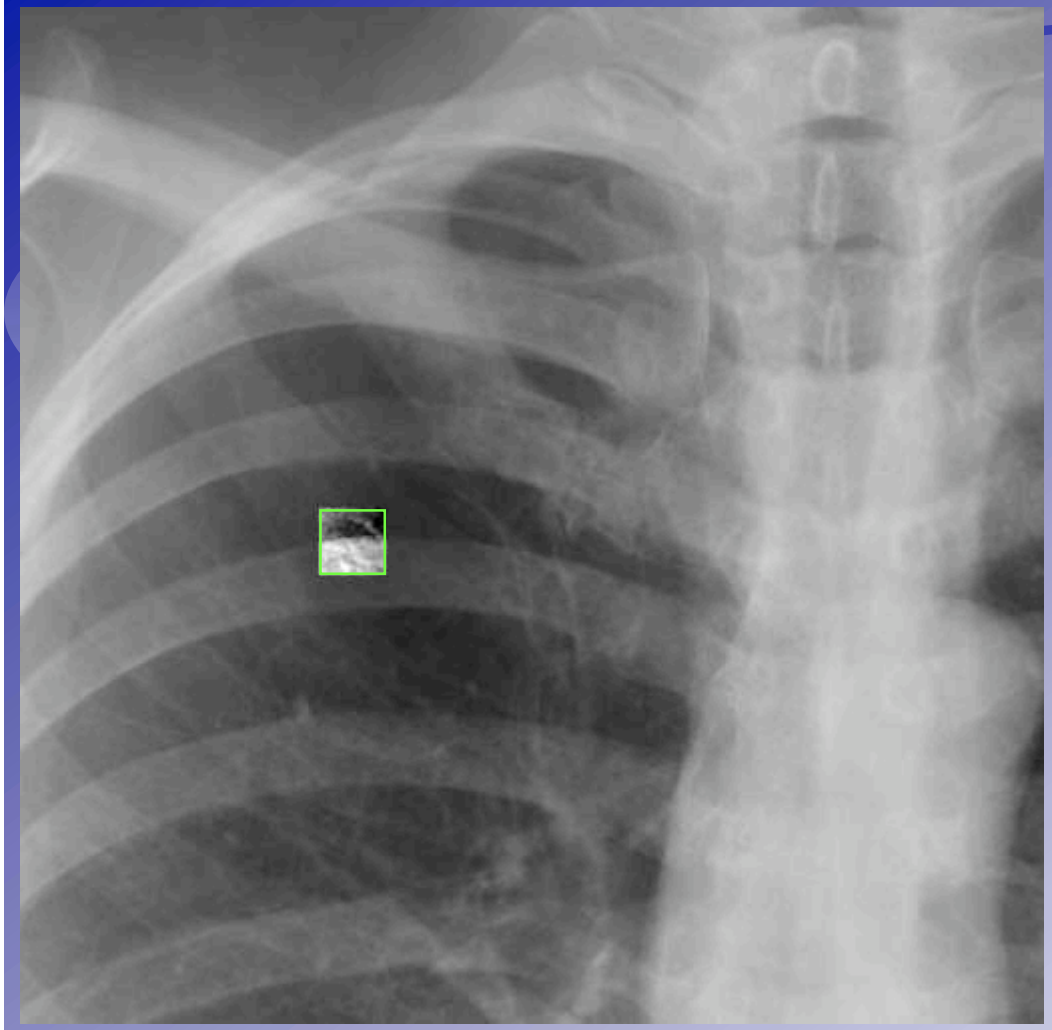
(Foos, Maui, 1999)





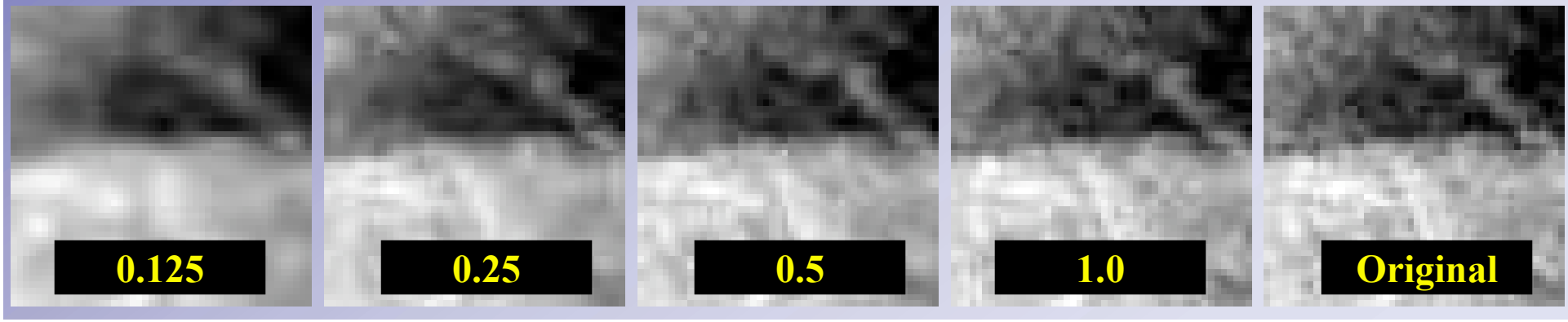






Wavelet

(Foos, Maui, 1999)



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JPEG 2000 - More ?

- ISO 15444-n
- Transform in 3rd dimension
  - Hyperspectral imaging
  - 3D volumes
- M-JPEG2000 - not applicable to DICOM
- Other 3D initiatives, floating-point
- Interactive protocol (JPIP)

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What about MPEG ?

- Initially proposed by US for cardiac echo
- Tests: only superior to M-JPEG at > 50:1
- MPEG X? (1, 2, profile/level, frame size)
- How to take advantage of hardware
- Effect on burned in text at low bit rates
- Lost champion/expert, withdrawn

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What about waveforms ?

- Sup 30 added 26Sep2000
- Audio, ECG, hemodynamic waveforms
- Bulk waveform data in (5400,1010)
  - May be multiple (inside SQ, one per multiplex group)
- Would need new encapsulation mechanism
- Audio specific (".WAV" format question)
- In the interim - use Deflate Transfer Syntax

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Deflate Transfer Syntax

- Added in CP 218 (16May2001)
- Goal: compress all attributes
  - 36,112 byte Structured Report -> 3,014 bytes (11.98:1)
  - 62,450 12-lead ECG -> to 26,139 bytes (2.39:1)
- Algorithm used in zip, gzip utilities
  - Deflated bitstream without file header
- ***Entire*** data-set not just (7FE0,0010)
  - Not the Part 10 meta-header for files, obviously

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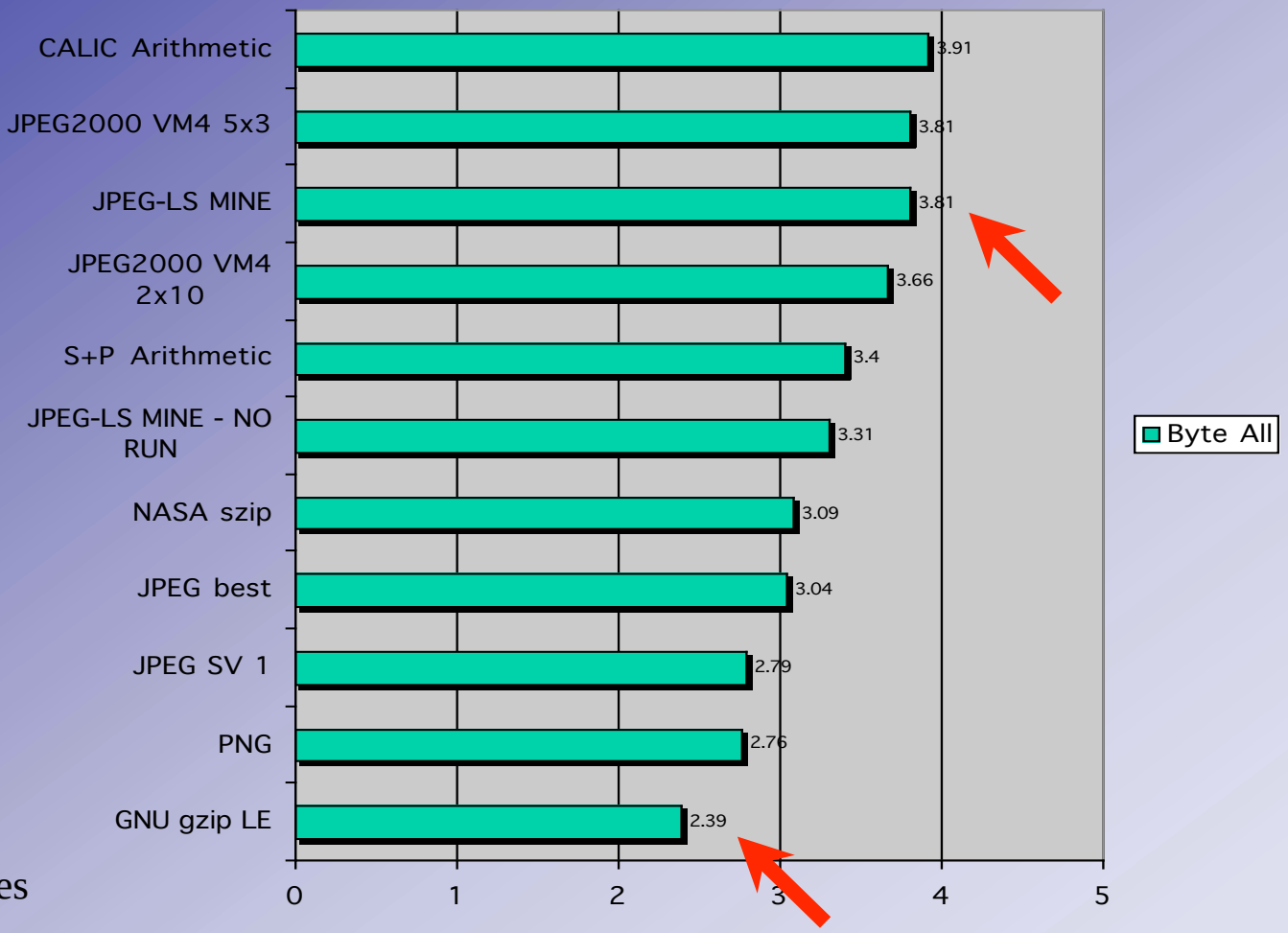

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Other DICOM Initiatives

- Add quality attributes to Query/Retrieve
  - Degree of loss acceptable
  - Contrast and/or spatial resolution required
- Adopt interactive protocol of some kind ?
  - DICOM-specific or leverage JPIP ?
- Icon images
  - Compressed/not, independent of main image (CP 165)
  - In Query response with compression ?

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Reality Check

- Industry slow to adopt new schemes
  - Good enough lossless schemes (2.8 vs. 3.8 ?)
  - Lack of market acceptance of lossy schemes
  - Lack of expertise, past bugs/incompatibilities
  - Unwilling to license toolkits/libraries
  - Few true color DICOM applications
- Network applications
  - Ease of negotiation of proprietary schemes
- Media applications
  - Need to limit # of profiles to maximize interoperability

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Reality Check

- New pressures
  - Proliferation of creative proprietary schemes
  - Acquisition technology advances
    - multi-detector CT, MR flouroscopy, full-field digital mammo
  - Interactive delivery over moderate (DSL) bandwidth
- Media opportunities
  - Take-home patient CD or DVD with built-in viewer
  - DVD-R or -RAM with good lossless compression
  - >25-fold increase in capacity vs. uncompressed CD-R

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Finally ....

- DICOM does not, and will never, "approve" compression schemes for any particular use
- Professional practice standards, scientific literature, regulatory approval (product specific)
- Just because it is in DICOM doesn't mean it is any good; just because it is not, doesn't mean it isn't !

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DICOM Working Group 4 (Compression)

Wednesday, 27 February

7.00pm -10.00pm, Golden West Room

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