

IIPImage & An Analysis of JPEG2000 Encoding Parameters

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1. IIPImage
2. Museum Imaging
4. Multispectral & Hyperspectral Imaging
5. Scientific Applications
6. JPEG2000 Encoding Parameters

IIPImage

Imaging Challenge in Museums

Images getting larger and larger. New imaging technologies, new imaging techniques produce **massive** quantities of data ...



Scientific Imaging in Museums

Scientific imaging techniques can produce quantitative data in 16, 32 bit formats



Xray



Infra-red



Raking Light



UV

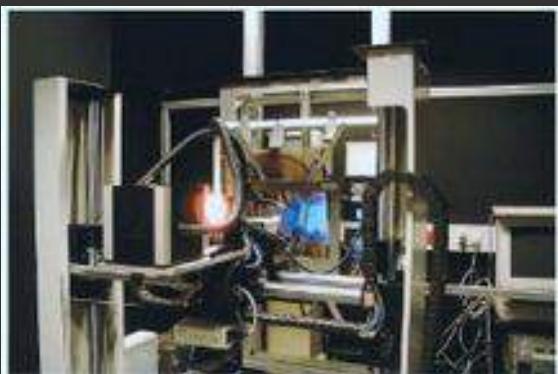


Emmisography

Images Copyright ©C2RMF 2014
Image Credits: Elsa Lambert, Elisabeth Ravaud

Spectral Imaging in Museums

Multi/Hyper spectral imaging can produce gigabytes of data and hundreds of channels per pixel



Multispectral Imaging

Hyperspectral Imaging

Image Visualization Software: IIPIImage

- Open source
- Networked remote viewing
- Single source → multiple uses
- High resolution images – up to terapixel sizes
- Region export / resizing
- Gamma, contrast adjustments, rotation etc.
- Multi-platform
- Images stored in standard *archive formats*: TIFF or JPEG2000



<http://iipimage.sf.net>

Web Services API

- Basic Image Processing Parameters
 - Contrast: CNT=c
 - Gamma: GAM=g
 - Thresholding: MINMAX=c:min,max
 - Band recombination: CTW=[N:M]
 - Profile: PFL=r:x1,y1-x2,y2
 - Spectral reflectance: SPECTRA=r,x,y
 - Color map: CMP=JET
 - Inversion: INV

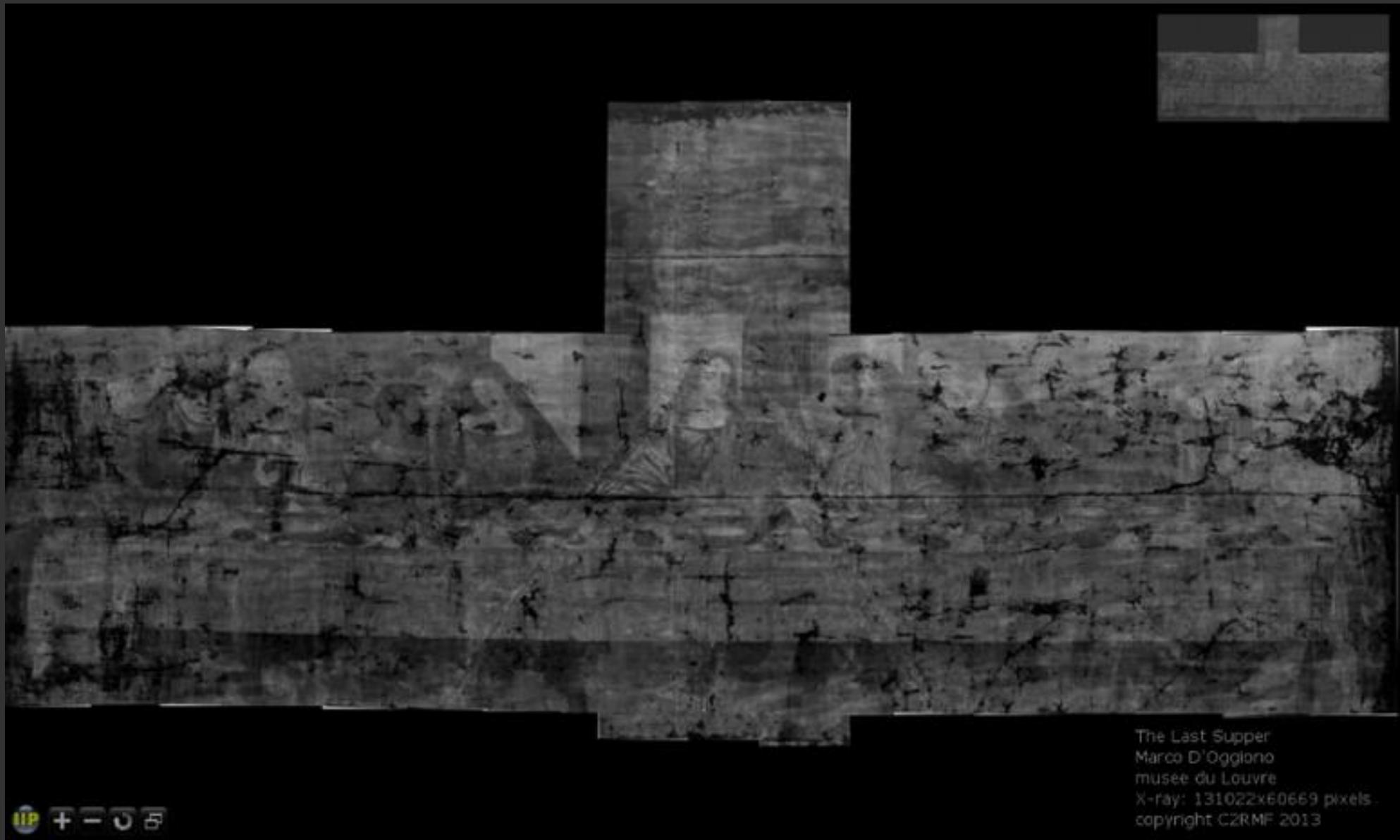
Protocol Support

IIPImage can handle multiple access protocols

- IIP (Internet Imaging Protocol)
- Zoomify
- Deepzoom
- IIIF (International Image Interoperability Framework)

Museum Imaging Examples

Extreme Resolutions



The Last Supper (1506), Marco D'Oggiono: Xray: 131,022 x 60,669 pixels (7 gigapixels)

Image Copyright ©C2RMF 2014
Image Credits: Elsa Lambert, Guy Bazile

Monitoring Change

Images during restoration process



Before Restoration



During Restoration



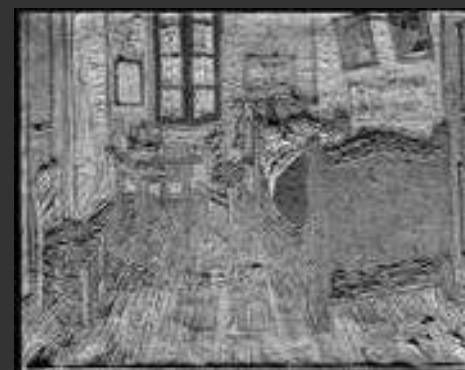
After Restoration

The Virgin and Child with Saint Anne
Leonardo da Vinci
Oil on Panel
1.68 x 1.30 m
Musée du Louvre

Images Copyright ©C2RMF 2014
Image Credits: Ruven Pillay, Jean-Louis Bellec

Comparing Imaging Modalities

Images of same object using different cameras or techniques



The Bedroom at Arles (1889)

Vincent van Gogh

Oil on Canvas

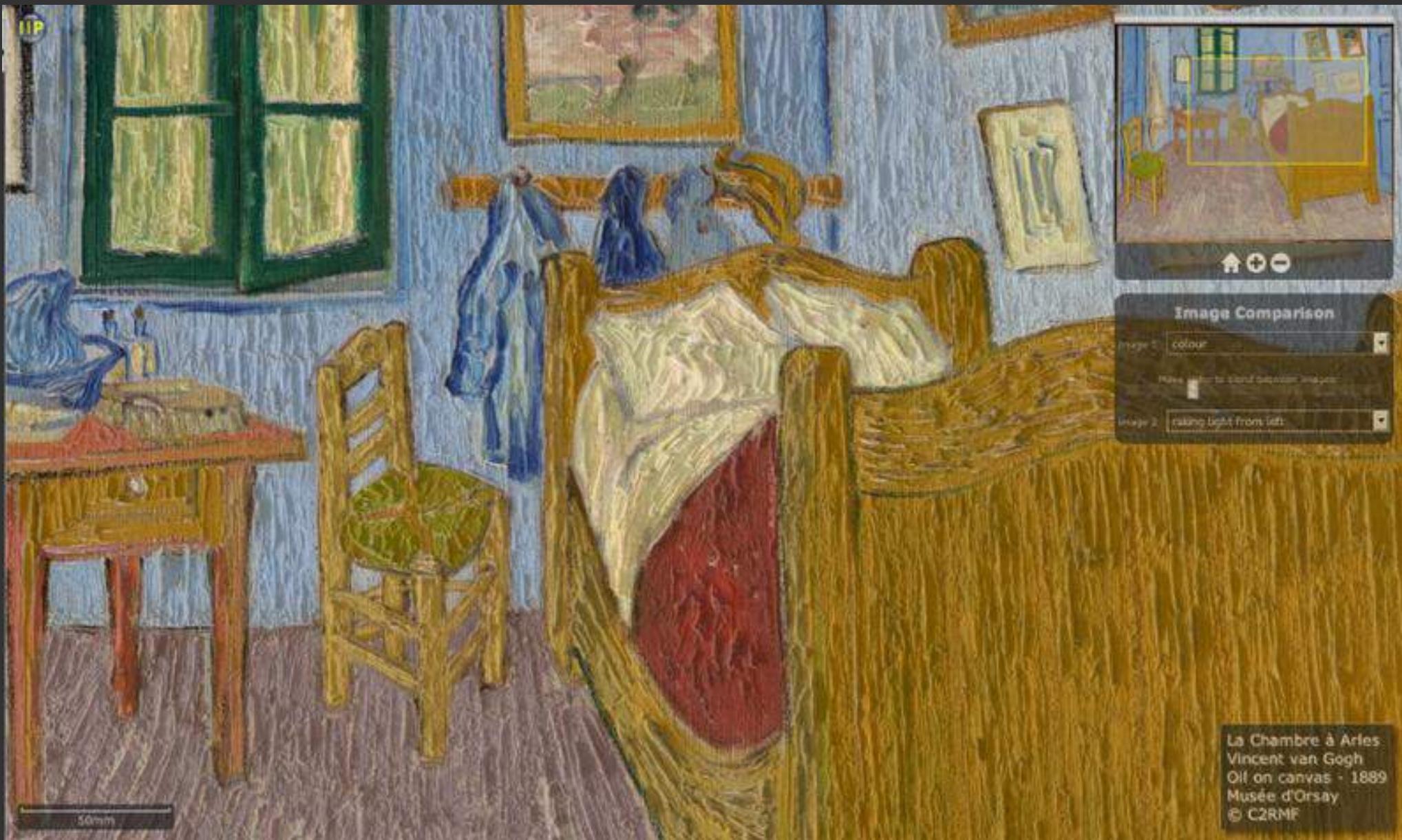
57.5 x 74.0 cm

Musée d'Orsay

Images Copyright ©C2RMF 2014

Image Credits: Ruven Pillay, Elsa Lambert, Elisabeth Ravaud

Image Blending



<http://merovingio.c2rmf.cnrs.fr/iipimage/iipmooviewer-2.0/vangogh.html>

Images Copyright ©C2RMF 2014
Image Credits: Ruven Pillay

Linking Images and Data

- Make images a gateway through which to explore and understand
- Link additional scientific data directly into image



Portrait of a Woman with a Mirror (1515)

Titian

Oil on Canvas

93 x 76 cm

Musée du Louvre

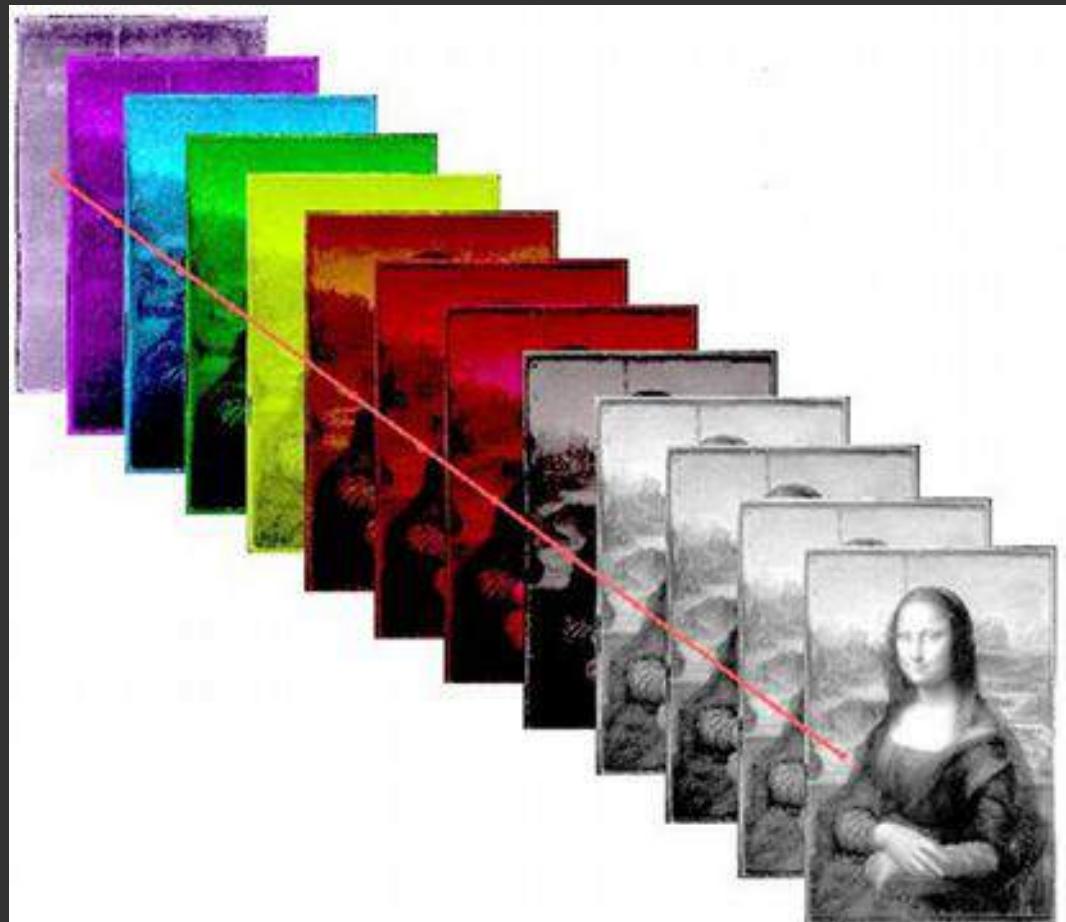
Image Copyright ©C2RMF 2014
Image Credits: Ruven Pillay

High Resolution Multispectral & Hyperspectral Imaging

Multispectral Imaging

Description
independent of
environment

- Acquisition of many colour channels (10's)
- Acquisition of reflectance spectrum
- Quantitative measurements



Spectral Reconstruction



Images Copyright ©C2RMF 2014
Image Credits: Ruven Pillay

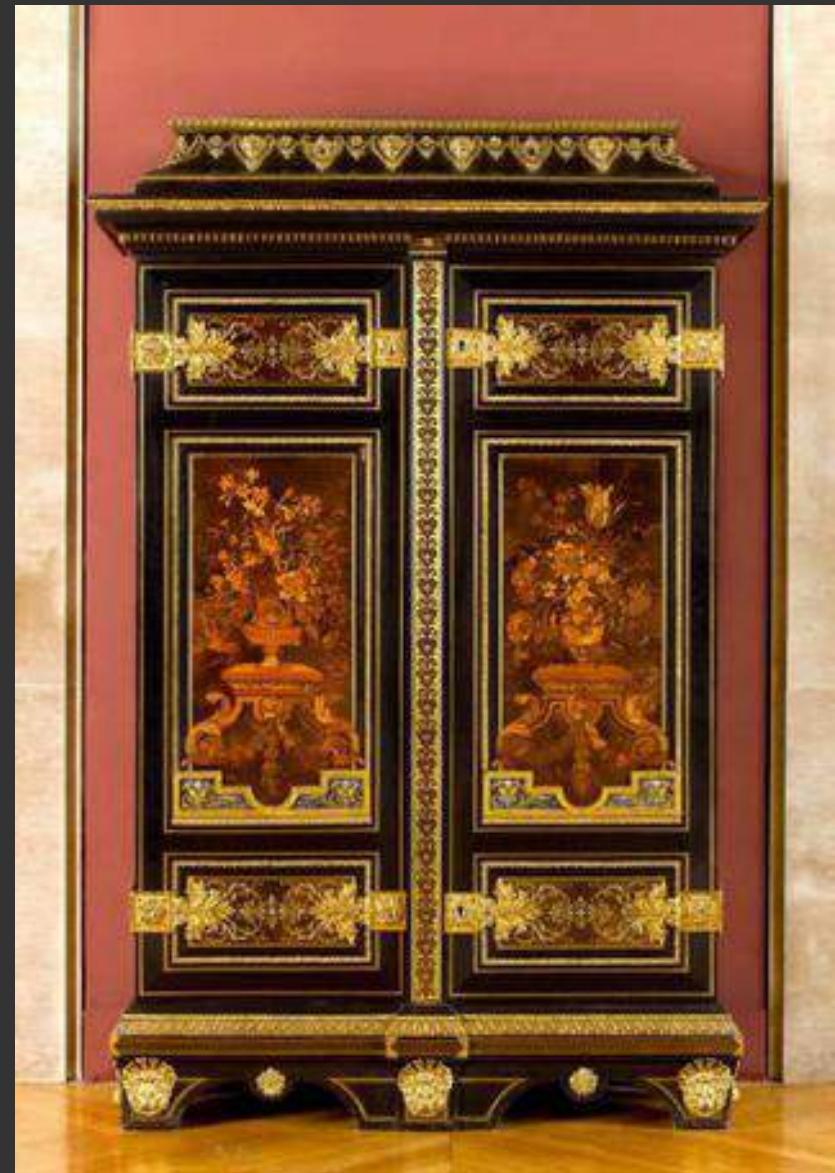
Hyperspectral Imaging at the C2RMF

- Spectral Range
 - Visible – Near Infrared (400-1000nm)
 - Up to 160 bands
- Spatial Resolution
 - 15 pixels / mm
 - 65 microns
 - 385 dpi



Hyperspectral Imaging of Marquetry

- Major study and restoration of Louvre's André-Charles Boulle collection
- Marquetry consisting of multiple types of painted wood



Images Copyright ©C2RMF 2014
Image Credits: Thomas Clot

Inlaid Marquetry



Wardrobe Doors (~1700)
André Charles Boulle
Marquetry (255.0 x 157.0 cm)
Musée du Louvre

Images Copyright ©C2RMF 2014
Image Credits: Ruven Pillay

Technical Imaging



Color



UV Fluorescence



X-ray

Images Copyright ©C2RMF 2014
Image Credits: Thomas Clot, Jean Marsac

Comparing Wavelengths

20GB Data Cube

- 7nm spectral sampling
- 8241 x 16177 pixels spatially

Comparison of Color vs narrow spectral bands:

- 412nm
- 992nm

Wardrobe Doors (~1700)

André Charles Boulle

Marquetry (255.0 x 157.0 cm)

Musée du Louvre



Images Copyright ©C2RMF 2014
Image Credits: Ruven Pillay

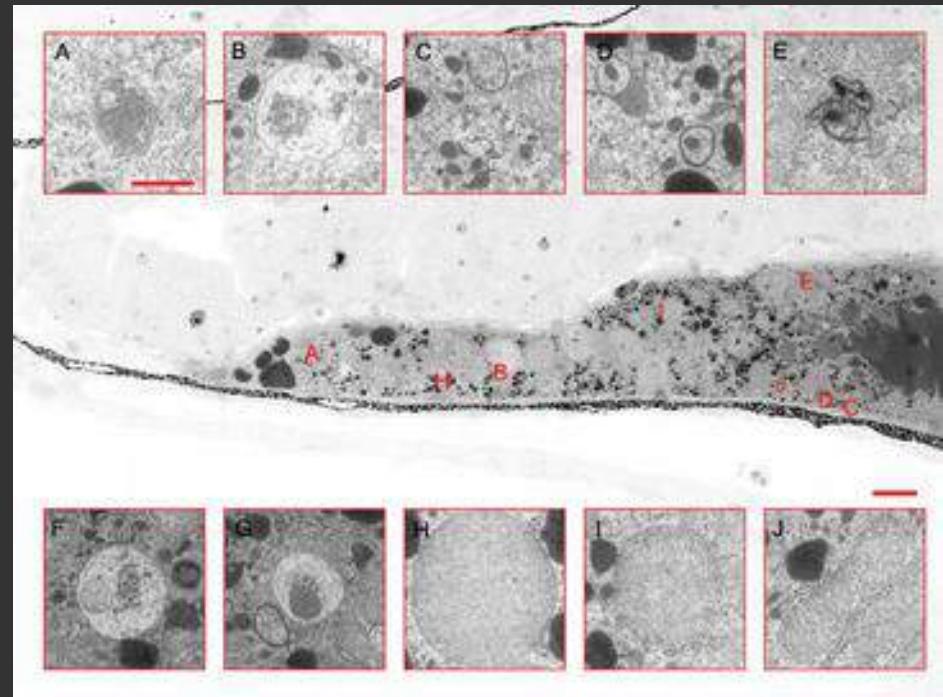
Who Uses IIPImage

- Cultural heritage institutions:
 - Museums: National Gallery of Art, Washington, National Gallery, London, C2RMF / Louvre
 - Libraries: The European Library, BNF, The National Library of Wales, University Libraries
 - UNESCO, Wikimedia Commons, Wellcome Foundation, Mellon Foundation
- Science
 - Micro-biology: Virtual nanoscopy applications, biomedical applications
 - Astronomy: NASA, Institute of Astrophysics: sky surveys, astrophysics data

Biomedical Applications

Biomedical Applications

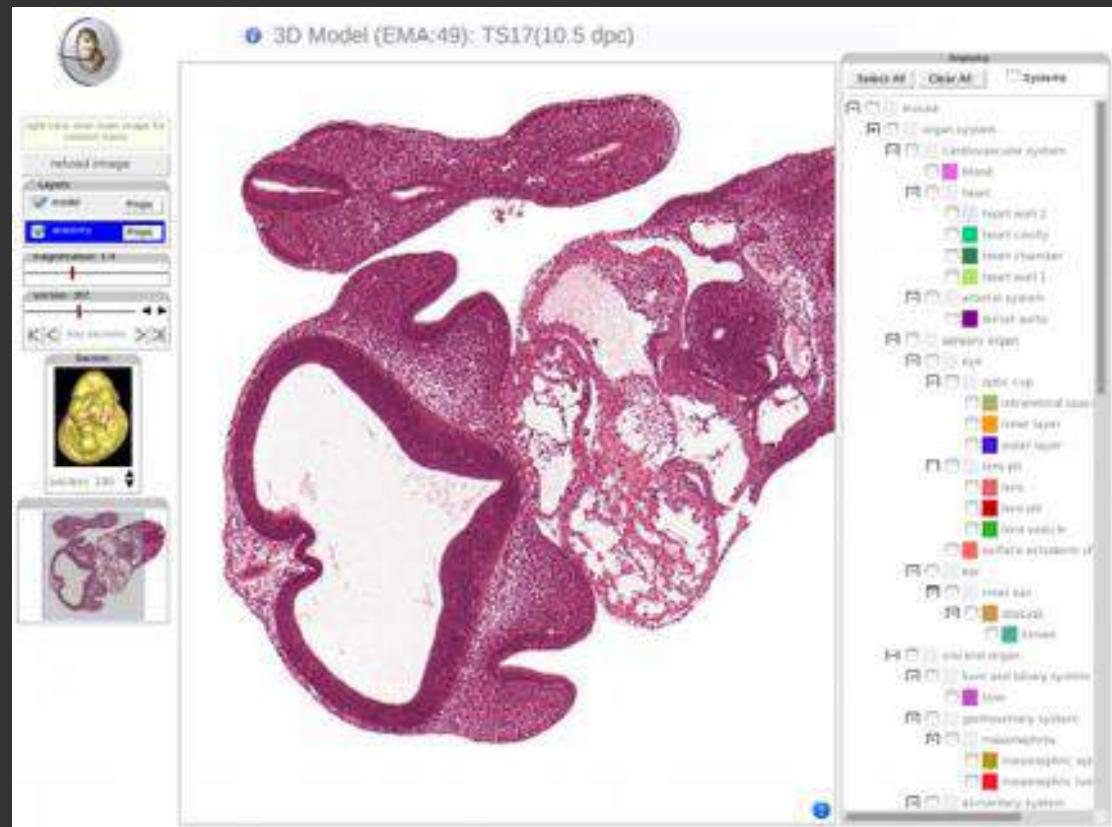
- Virtual nanoscopy - Creation of large virtual slides
 - Regions up to 1 mm² at nm resolution
 - Transmission electron microscopy
 - Resulting slide:
 - $1,461 \times 604 \mu\text{m}^2$ in size
 - $921,600 \times 380,928$ pixels
 - Each pixel 1.6 nm square
 - Total of 281 gigapixels



[1] F. G. A. Faas, M. C. Avramut, B. M. van den Berg, A. M. Mommaas, A. J. Koster, and R. B. G. Ravelli, "Virtual nanoscopy: Generation of ultra-large high resolution electron microscopy maps," *J Cell Biol*, vol. 198, no. 3, pp. 457–469, Aug. 2012.

Biomedical Applications

- MRC Human Genetics Unit, Institute of Genetics and Molecular Medicine, UK
- Woolz 3D data
- IIP3D - extension to IIP protocol for 3D cross-sections
- Atlas of mouse embryo development
- 3D Volumetric Data
- Annotations
- Anatomy ontology



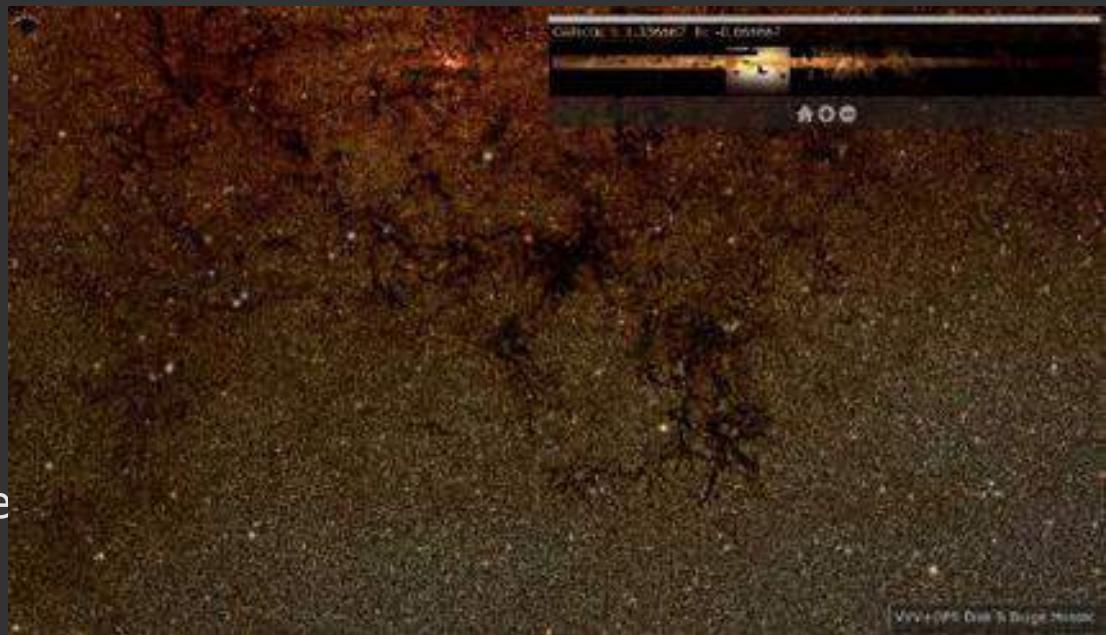
[1] Z. Husz, N. Burton, B. Hill, N. Milyaev, and R. Baldock, "Web tools for large-scale 3D biological images and atlases," *BMC Bioinformatics*, vol. 13, no. 1, p. 122, Jun. 2012.

<http://www.emouseatlas.org/>

Astrophysics Applications

Astronomy

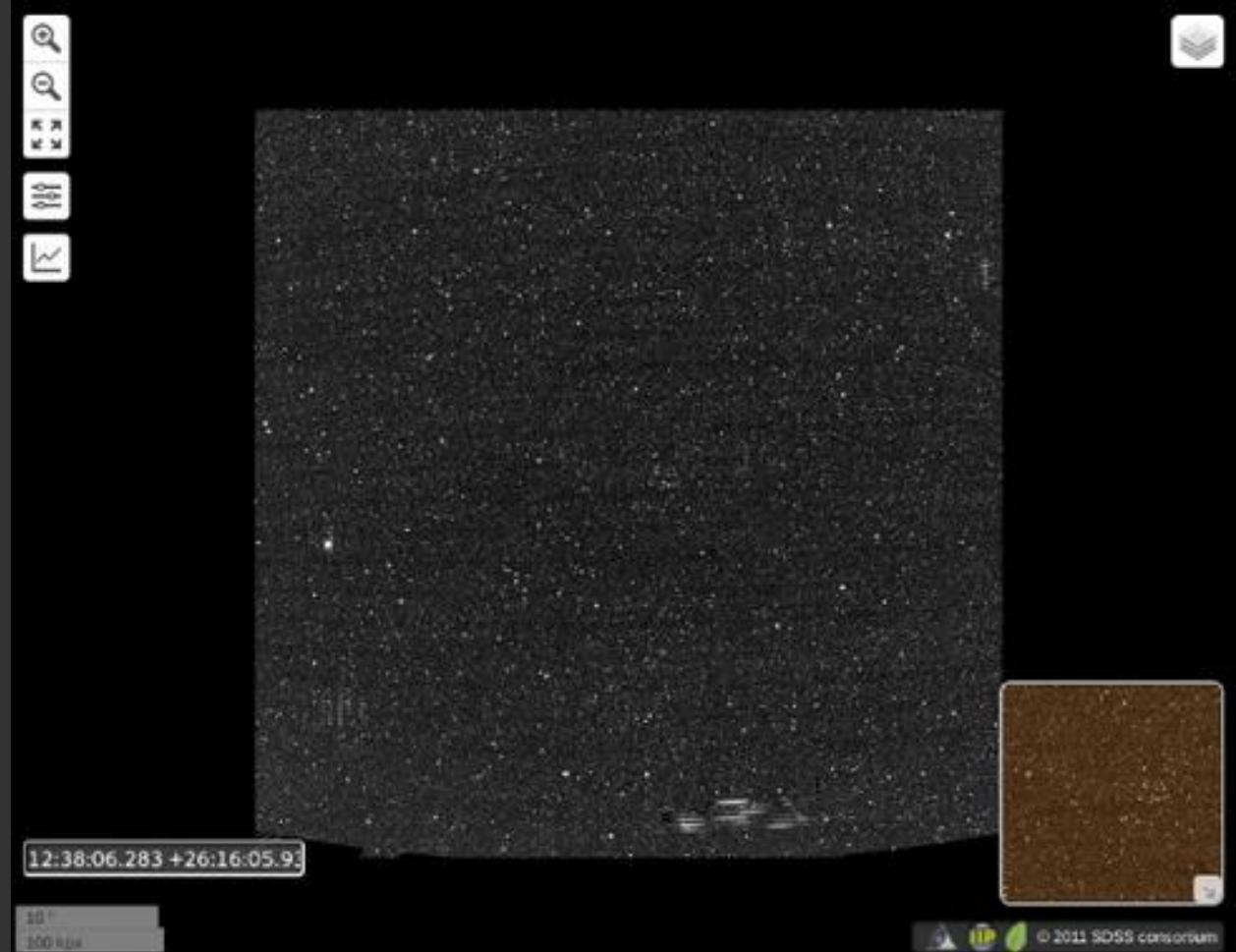
- Sky Surveys:
 - VISTA Variables in the Via Lactea (VVV)
 - Galactic Plane Survey (GPS)
- VISTA (Visible and Infrared Survey Telescope for Astronomy), Chile
 - 3 tonne camera
 - 16 IR detectors
 - 67 million pixels
- Data:
 - 100-200 TB of raw data
 - 3 IR wavelengths combined to create false color image
 - Image containing 1 billion stars
 - 100GB TIFF of entire galactic plane
 - 1,267,500 x 120,000 pixels



<http://djer.roe.ac.uk/vsa/vvv/iipmooviewer-2.0-beta/lb.html>

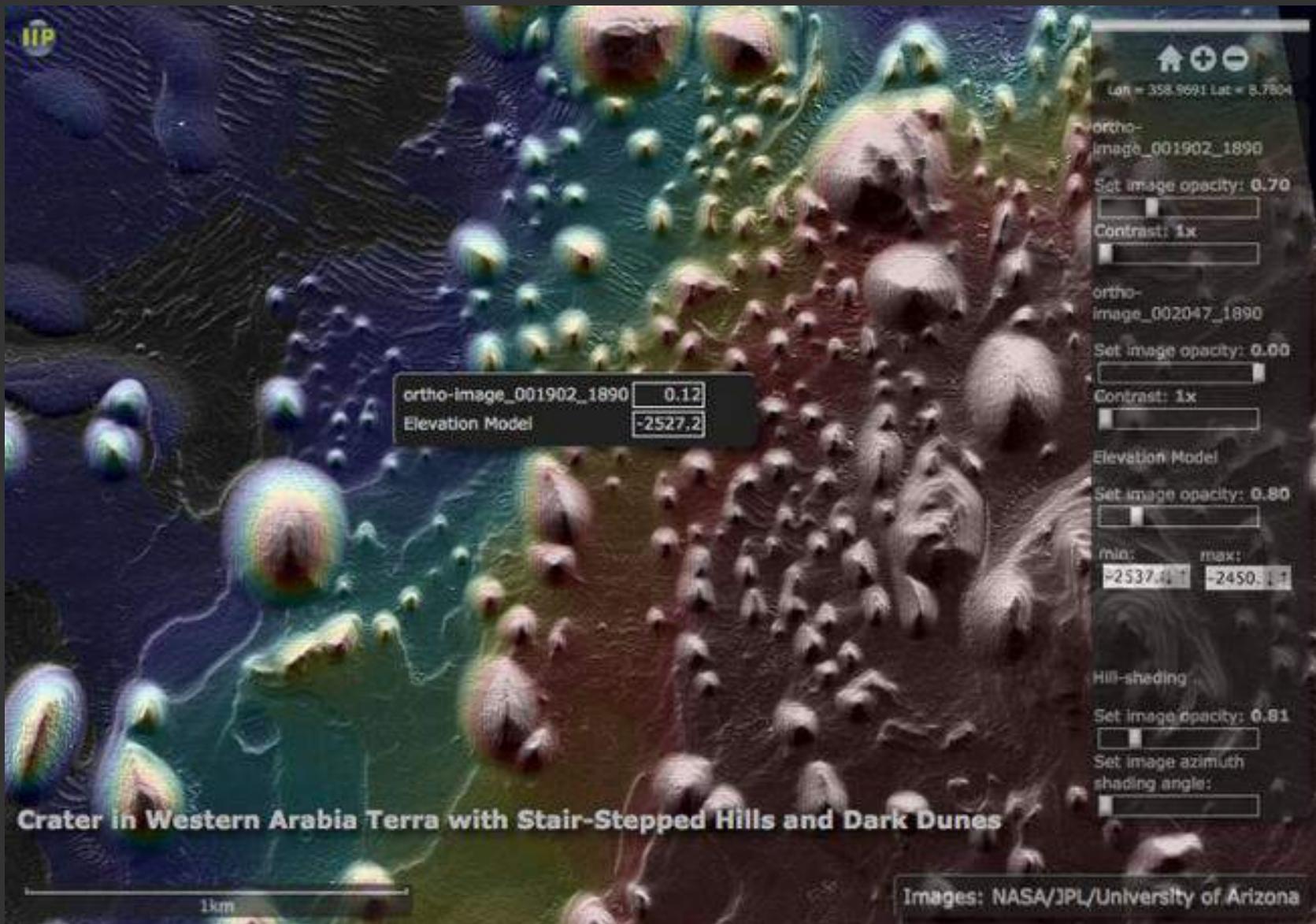
Terabyte Scientific Data

- Calibrated sky survey data
 - Full 32 bit per channel floating point data
 - 1.3TB TIFF file
- Access to line profiles
- Star catalogue integration



Institute of Astrophysics (IAP)
<http://visiomatic.iap.fr/demo/large.html>

Digital Elevation Maps



Dynamically color-mapped DEM data / hill-shading, Mars: HiRISE Project (NASA/JPL/University of Arizona)

Getting and Installing IIPImage

Build & Package Support

- Debian / Ubuntu
 - apt-get install iipimage-server
- Fedora / CentOS / RHEL
 - yum install iipsrv
- Compilation from source
 - Github:
<https://github.com/ruven/iipsrv>
 - Linux, Solaris, Mac OSX, Windows
 - GCC, Clang, VC++
- Web Server Environments
 - Apache, Lighttpd, NginX, Stand-alone



Analysis of JPEG2000 Encoding Parameters

JPEG2000

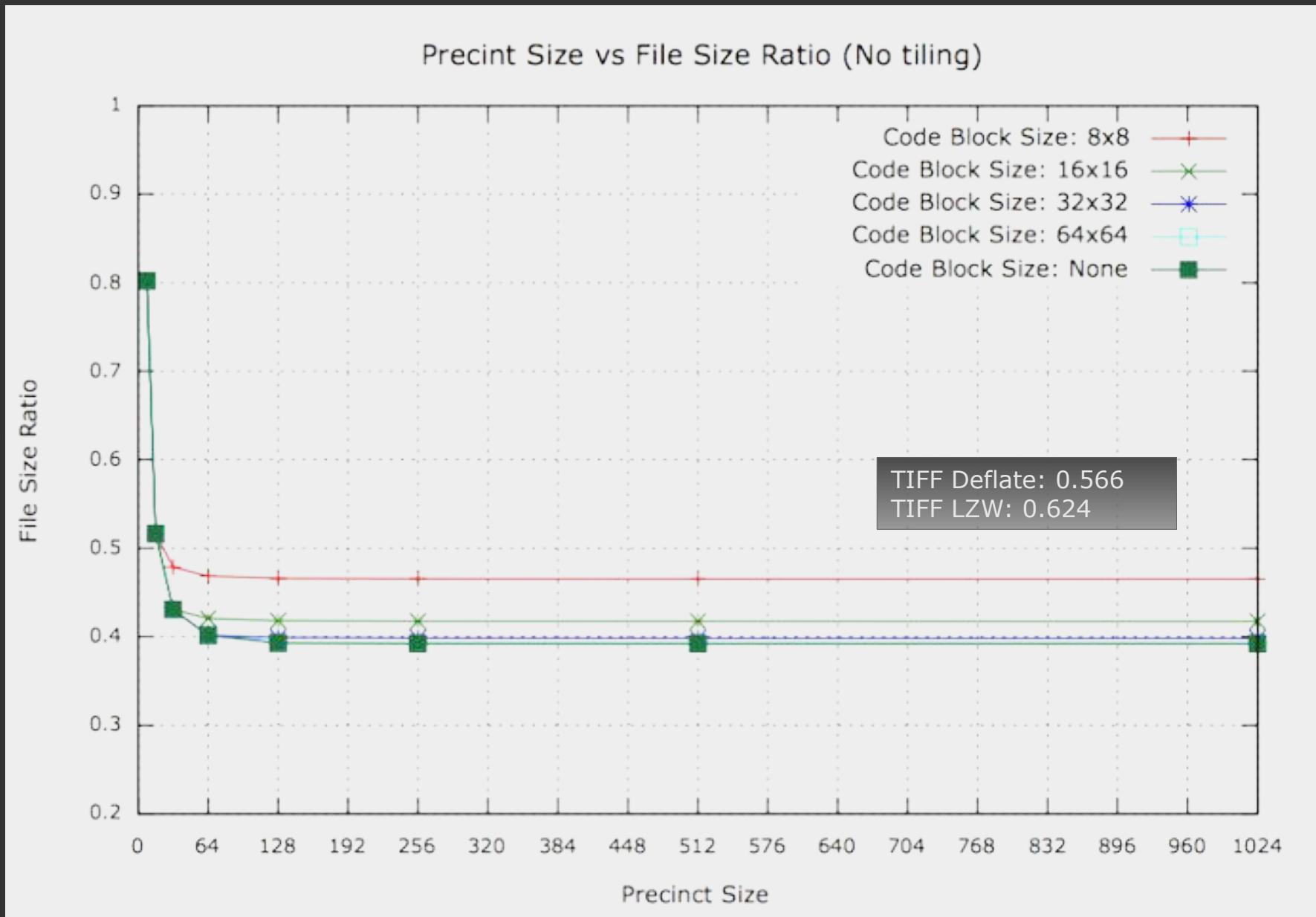
Encoding parameters can make a big difference to image

- Encoding time
 - File size
 - Decoding speed for streaming applications
-
- Can make large difference to IIPIImage performance
 - JPEG2000 parameter choice a dark art

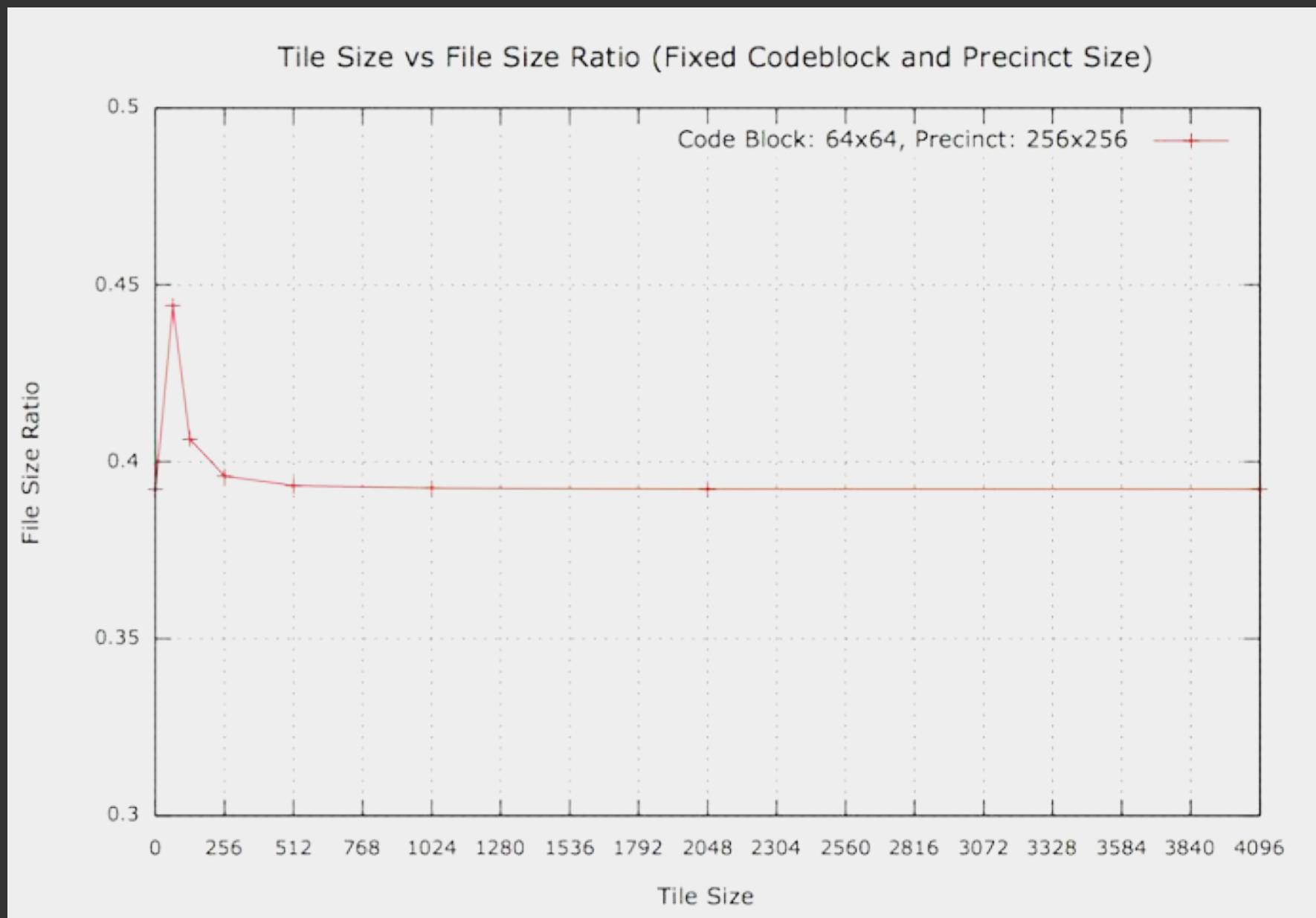
Parameter Analysis

- Parameters
 - Tile sizes ($0 \rightarrow 4096 \times 4096$)
 - Precincts ($0 \rightarrow 1024 \times 1024$)
 - Codeblocks ($0 \rightarrow 64 \times 64$)
 - Software (Kakadu & OpenJPEG)
 - $\rightarrow 864$ combinations
- Test image (505MB)
 - 15016×11741 pixels
 - 3 channel RGB
 - 8 bits per channel

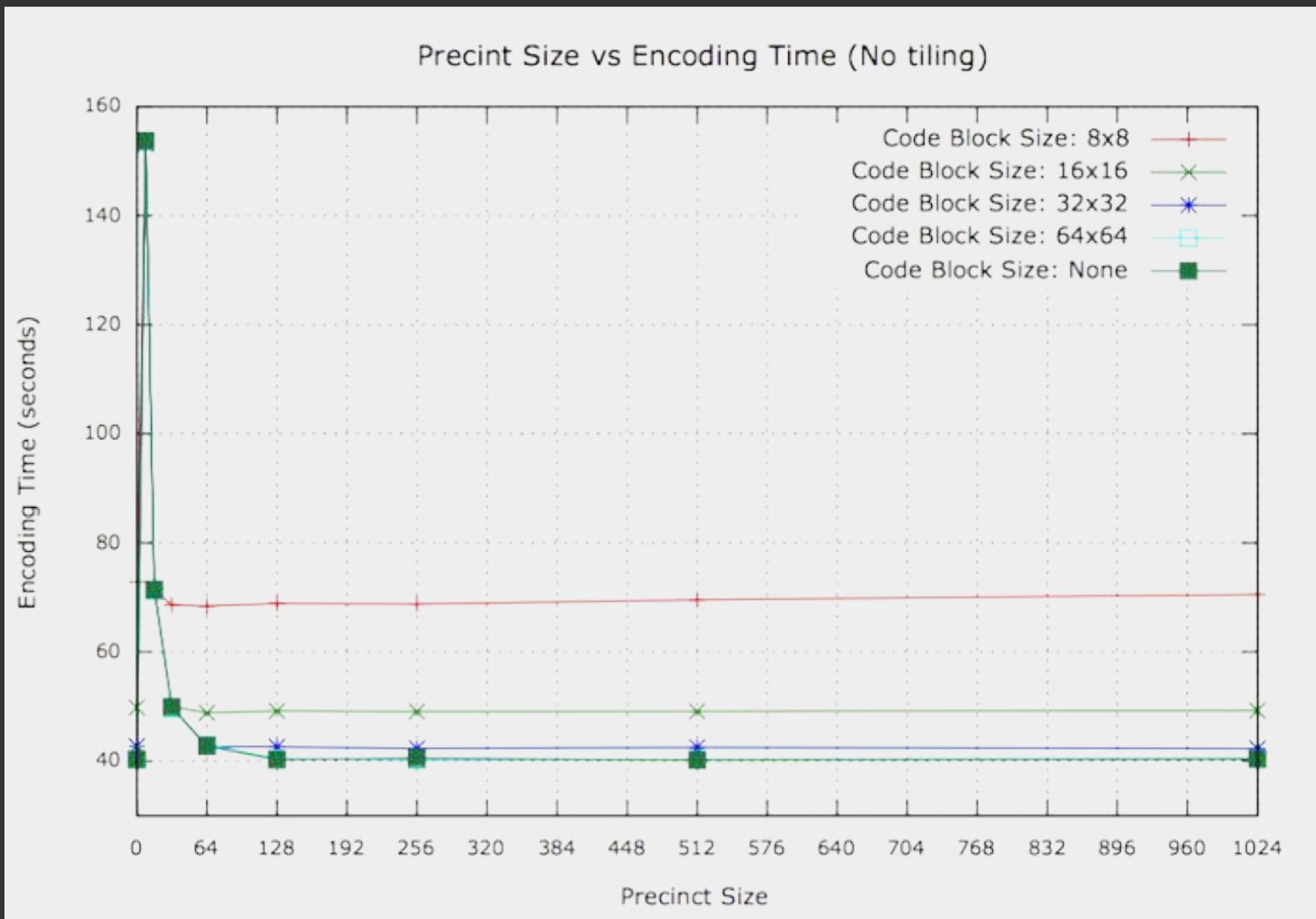
Encoding: File Size



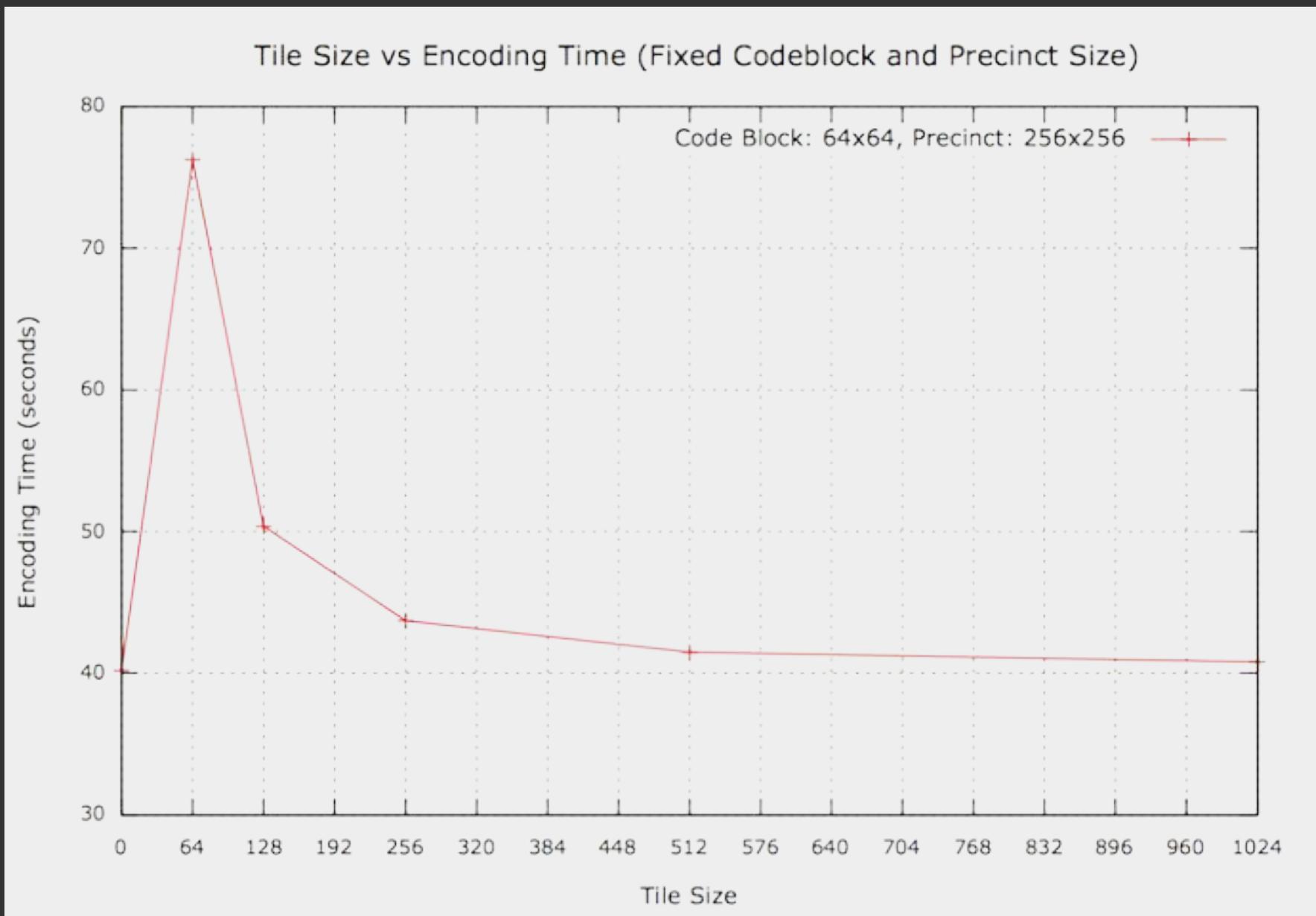
Encoding: File Size



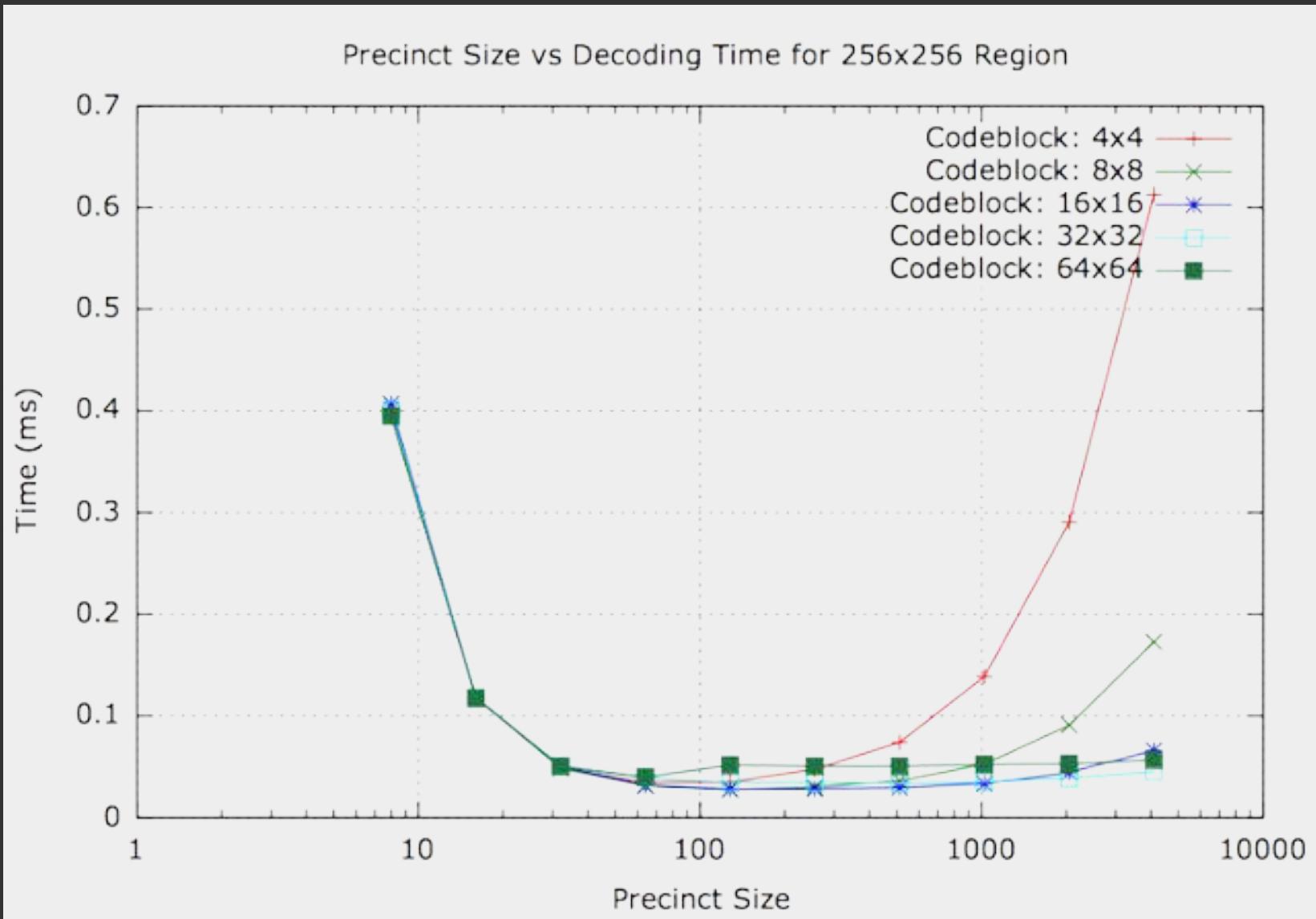
Encoding: Speed



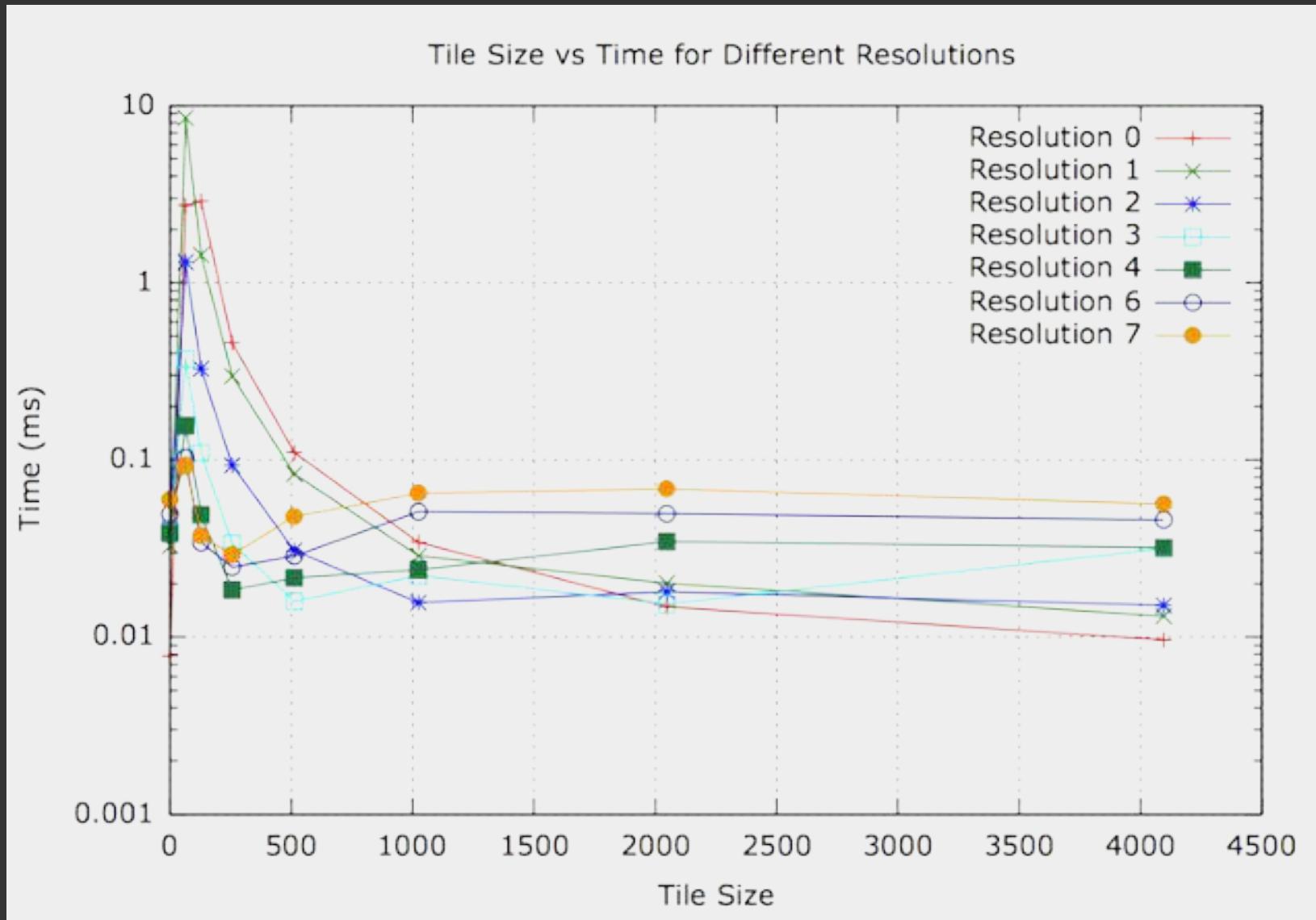
Encoding: Speed



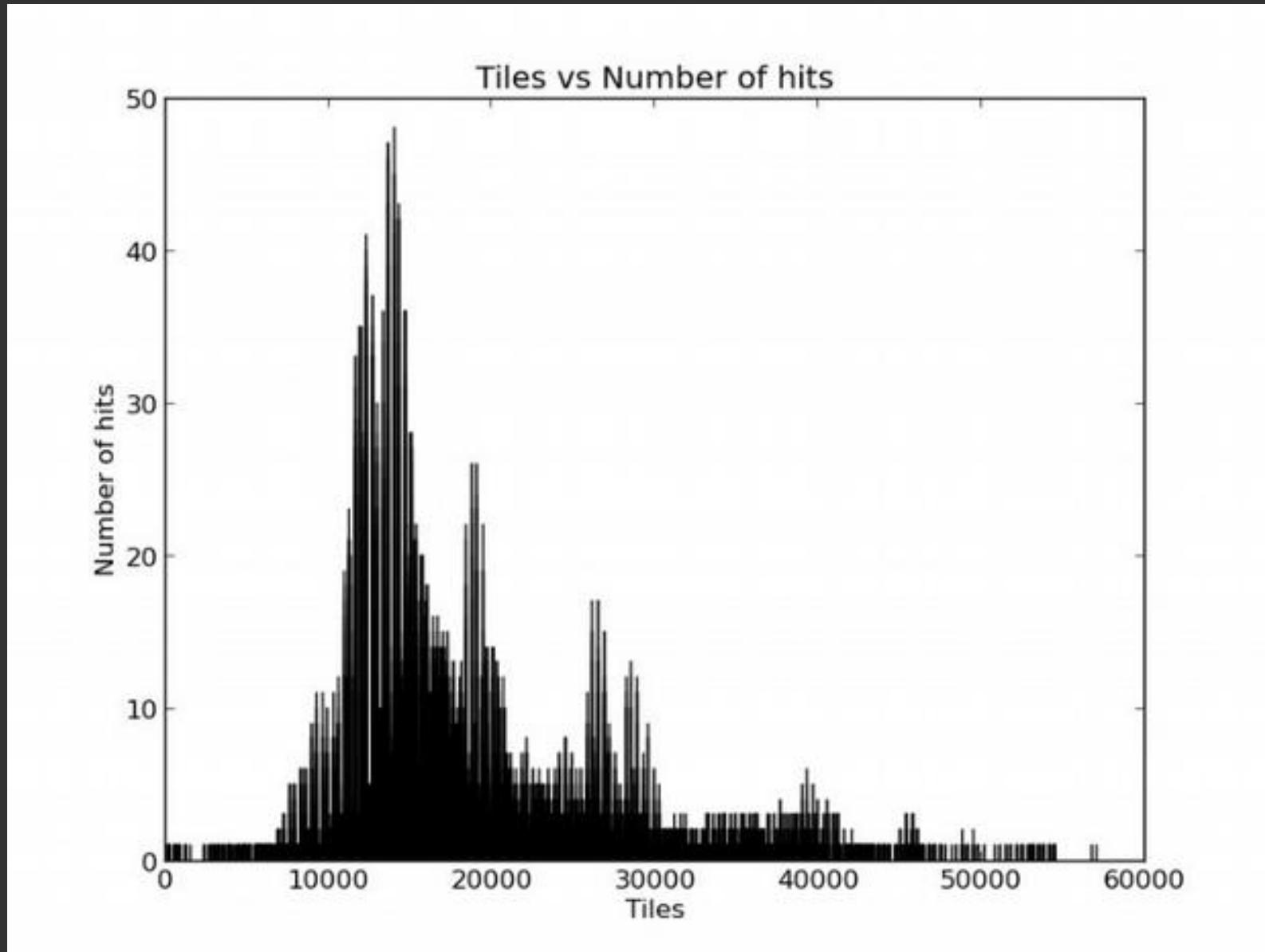
Decoding Time vs Precinct Size for Various Code Block Sizes



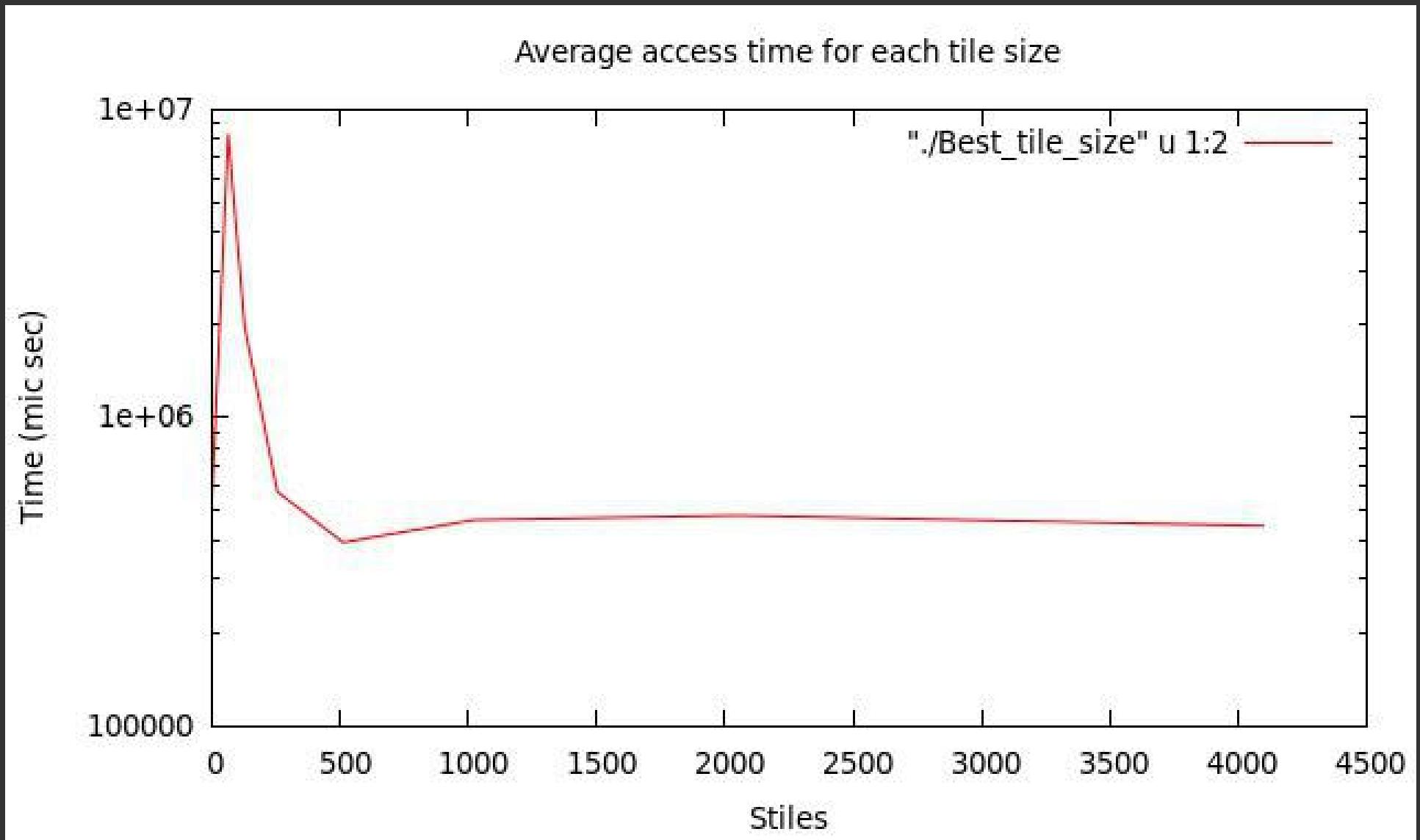
Tile Decoding Time vs JPEG2000 Tile Size Using Ideal Precinct/Code Block Sizes at Different Resolutions



Access Analytics: Tile Index vs Number of Hits for Demo Image on IIPImage Website



Averaged Tile Decoding Time Across All Resolutions vs JPEG2000 Tile Encoding Sizes Using Ideal Precinct / Code Block Sizes





[About](#)

About

IIPImage is an advanced high-performance feature-rich image server system for web-based streamed viewing and zooming of ultra high-resolution images. It is designed to be fast and bandwidth-efficient with low processor and memory requirements. The system can comfortably handle gigapixel size images as well as advanced image features such as both 8 and 16 bit depths, CIELAB colorimetric images and scientific imagery such as multispectral images.

Streaming is tile-based, making it possible to view, navigate and zoom in real-time around gigapixel size images that would be impossible to download and manipulate on the local machine. It also makes the system very scalable as the number of image tile downloads will remain the same regardless of the size of the source image.

Source images can be in either TIFF or JPEG2000 format. Whole images or regions within images can also be rapidly and dynamically resized and exported by the server from a single source image without the need to store multiple files in various sizes.



<http://iipimage.sourceforge.net>

Thank You

Website: <http://iipimage.sourceforge.net>
Github: <https://github.com/ruven/iipsrv>



Facebook: <http://www.facebook.com/IIPImage>



Twitter: <http://twitter.com/iipimage>



Email: ruven@users.sourceforge.net