Institute for Spatial Information
and Surveying Technology
Mainz University of Applied Sciences

COLOR & SPACE IN
CULTURAL HERITAGE

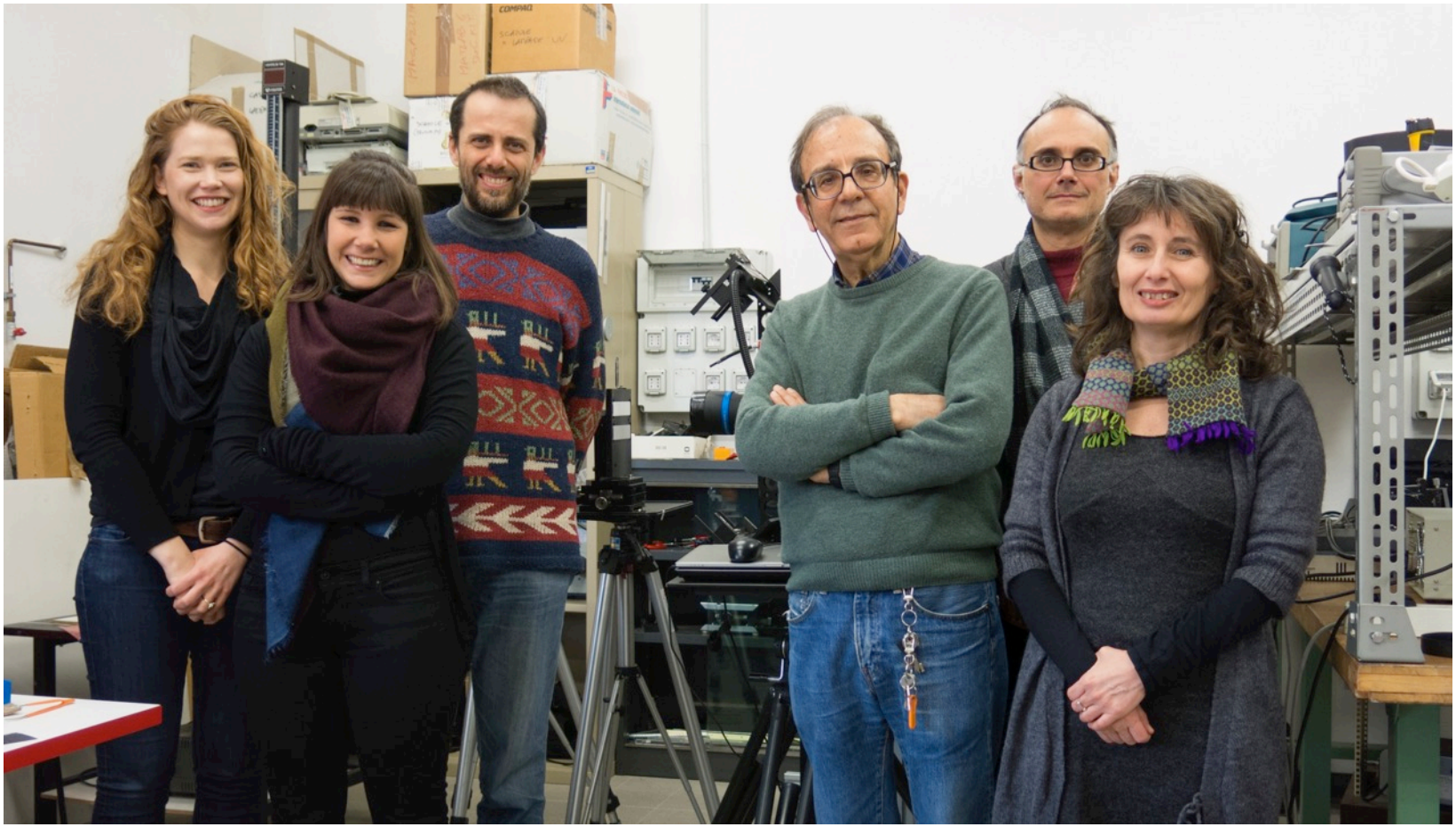
COSCH STSM WG1:
Summarizing coordinated and collaborative research on hyperspectral imaging devices and methods for cultural heritage documentation

E. Keats Webb
University of Brighton, Science & Engineering Arts Heritage & Archaeology (SEAHA) Centre for Doctoral Training

March 2016
Host: Marcello Picollo
Instituto di Fisica Applicata “Nello Carrara”—Consiglio Nazionale delle Ricerche (IFAC-CNR)
Florence, Italy

COST is supported by the EU Framework Programme Horizon 2020

Instituto di Fisica Applicata “Nello Carrara”— Consiglio Nazionale delle Ricerche (IFAC-CNR)



E. Keats Webb, Tatiana Vitorino, Lorenzo Stefani, Andrea Casini, Marcello Picollo, and Costanza Cucci

Colour & Space in Cultural Heritage (COSCH)

Promotion of research, development and application of optical measurement techniques adapted to heritage documentation

Working Groups (WG):

- WG 1—Spectral Object Documentation
- WG 2—Spatial object documentation
- WG 3—Algorithms and procedures
- WG 4—Analysis and restoration of CH surfaces and objects
- WG 5—Visualization of CH objects and its dissemination

WG 1—Spectral Object Documentation

Identification, characterization and testing of spectral imaging techniques in the visible and near IR field

DEFINITIONS

From M. Picollo WG1 presentation in Mainz COSCH meeting, October 2016

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Multi-band imaging. The process of acquiring a set of images in a wide spectroscopic range (UVa; R/G/B; photographic IR; IRFC; IRR; X-ray radiography; etc.) at each spatial point of a sample with diverse imaging systems/devices.

Multi-spectral imaging. The process of measuring a spectrum at each spatial point of a sample with a multispectral imaging system/device. These devices are designed to acquire a sequence of images on a limited number of spectral bands, usually selected by means of suitable set of filters, with bandwidths of tens to hundreds of nanometers.

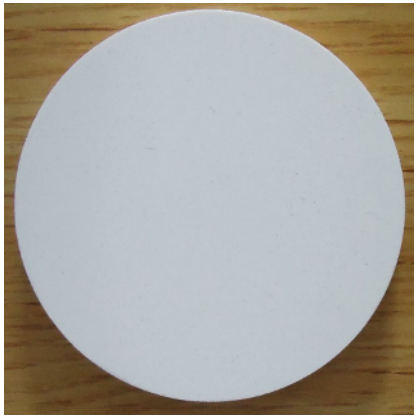
Hyper-spectral Imaging. The process of measuring a complete spectrum at each spatial point of a sample with a hyperspectral imaging system (www.middletonresearch.com). These devices are designed to acquire a fine spectral selection of **almost contiguous spectral-bands** in the investigated spectral region and a separate image for every band can be extracted from the acquired image-cube / cube-file. A sensor is classed as hyperspectral if it is capable of imaging a line / an area in many (e.g. hundreds) bands simultaneously with bandwidths of a few nanometers or less.

From:

Glossary of Terms – SpecTIR: http://www.spectir.com/tools-resources/glossary-of-terms);

Riccardi et al. 2013, Journal of the American Institute for Conservation. 2013 (52), 13-29.

Round Robin Test (RRT)



SphereOptics Zenith Polymer Wavelength Standard

X-Rite ColorChecker® CLASSIC

Painted test panel

Russian Icon

Round Robin Test (RRT)

Objectives:

To work towards standardised methodologies and best practices for spectral imaging in the CH field

To better understand:

- instrumentation
- elements of data acquisition
- the effects of the instruments and methodology to the accuracy and reliability of the data

COSCH Short Term Scientific Mission (STSM)

March 2016

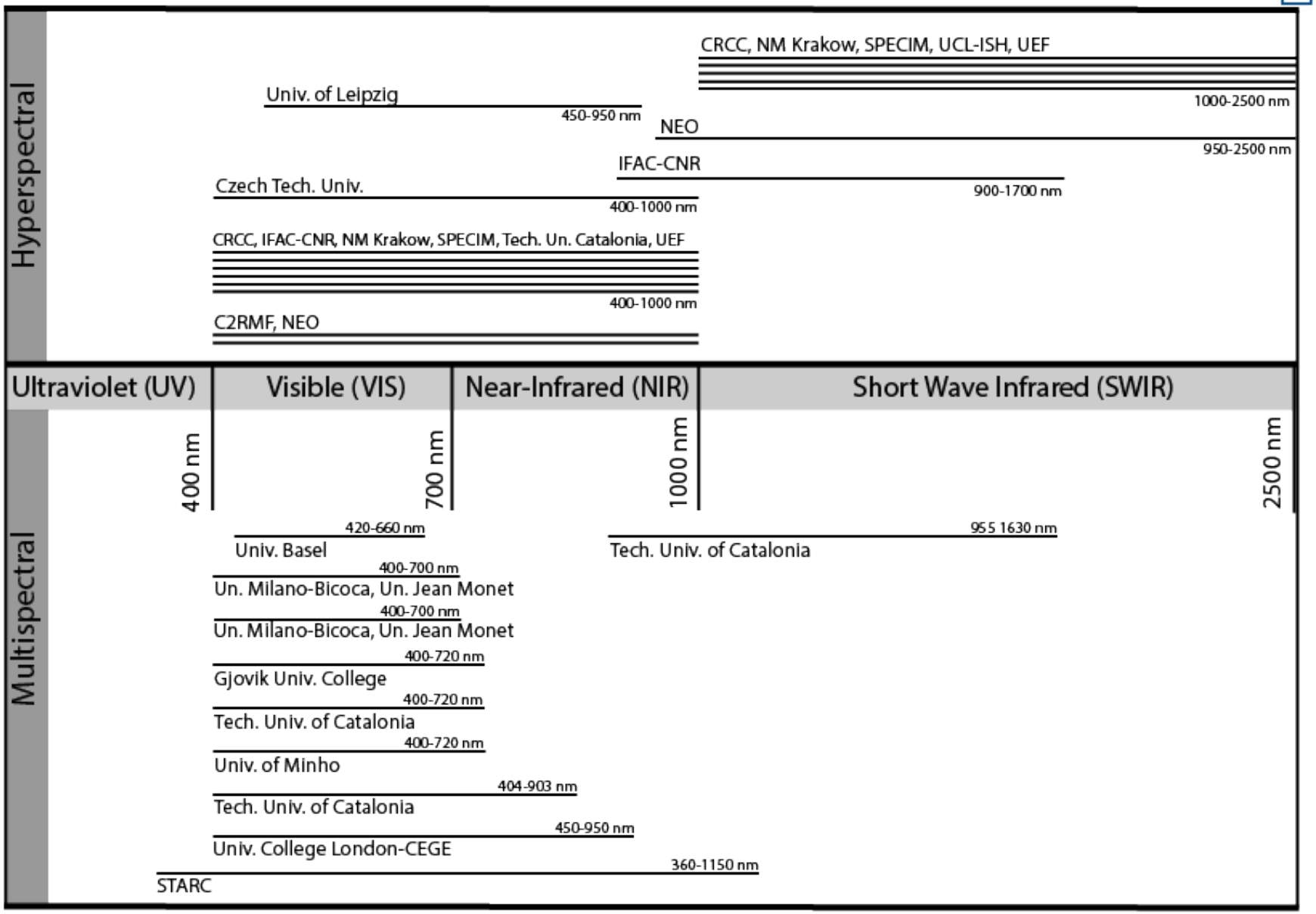
Host: Dr. Marcello Picollo, IFAC-CNR, Florence, Italy

Objectives:

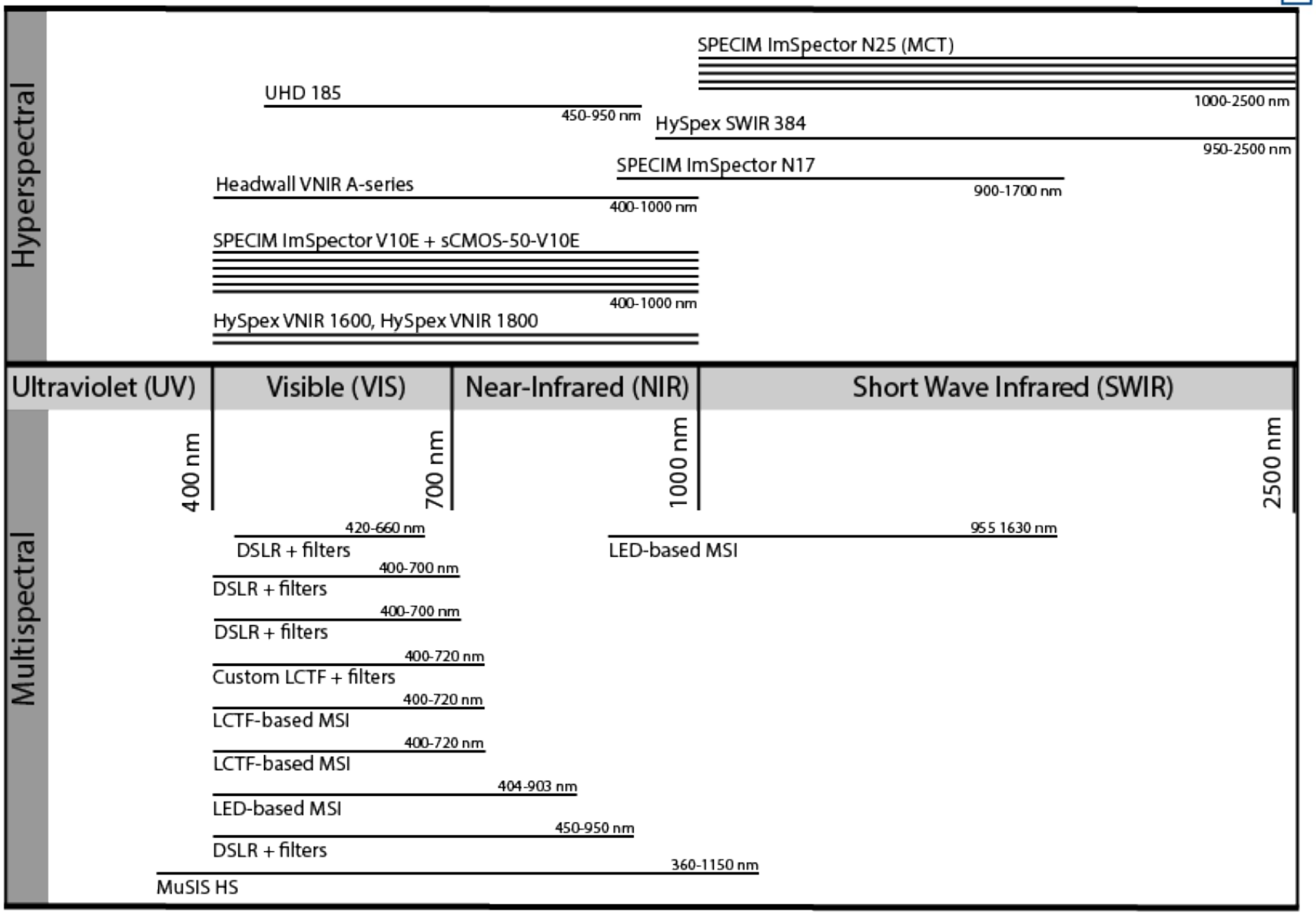
- Summarize to-date results and findings of RRT
- Assess the variability of the received RRT data sets and determine why initial data sets were unfit for elaboration and comparison
- Establish what further evaluation and comparison needs to be conducted to conclude RRT initiative

RRT Participating Institutions
Sweden
Finland
Norway
Baltic Sea
Estonia
Latvia
Lithuania
Moscow
Москва
North Sea
Denmark
United Kingdom
Ireland
Netherlands
Poland
Belarus
Germany
Belgium
Prague
Czechia
Vienna
Slovakia
Ukraine
Austria
Moldova
Hungary
France
Romania
Croatia
Serbia
Black Sea
Italy
Rome
Bulgaria
Portugal
Madrid
Spain
Tyrrhenian Sea
Istanbul
Greece
Turkey
Syria
Mediterranean Sea
GoogleMaps

RRT Data—Institutions and Wavelength Range of Devices



RRT Data—Devices and Wavelength Range



Percentage of MSI vs HSI

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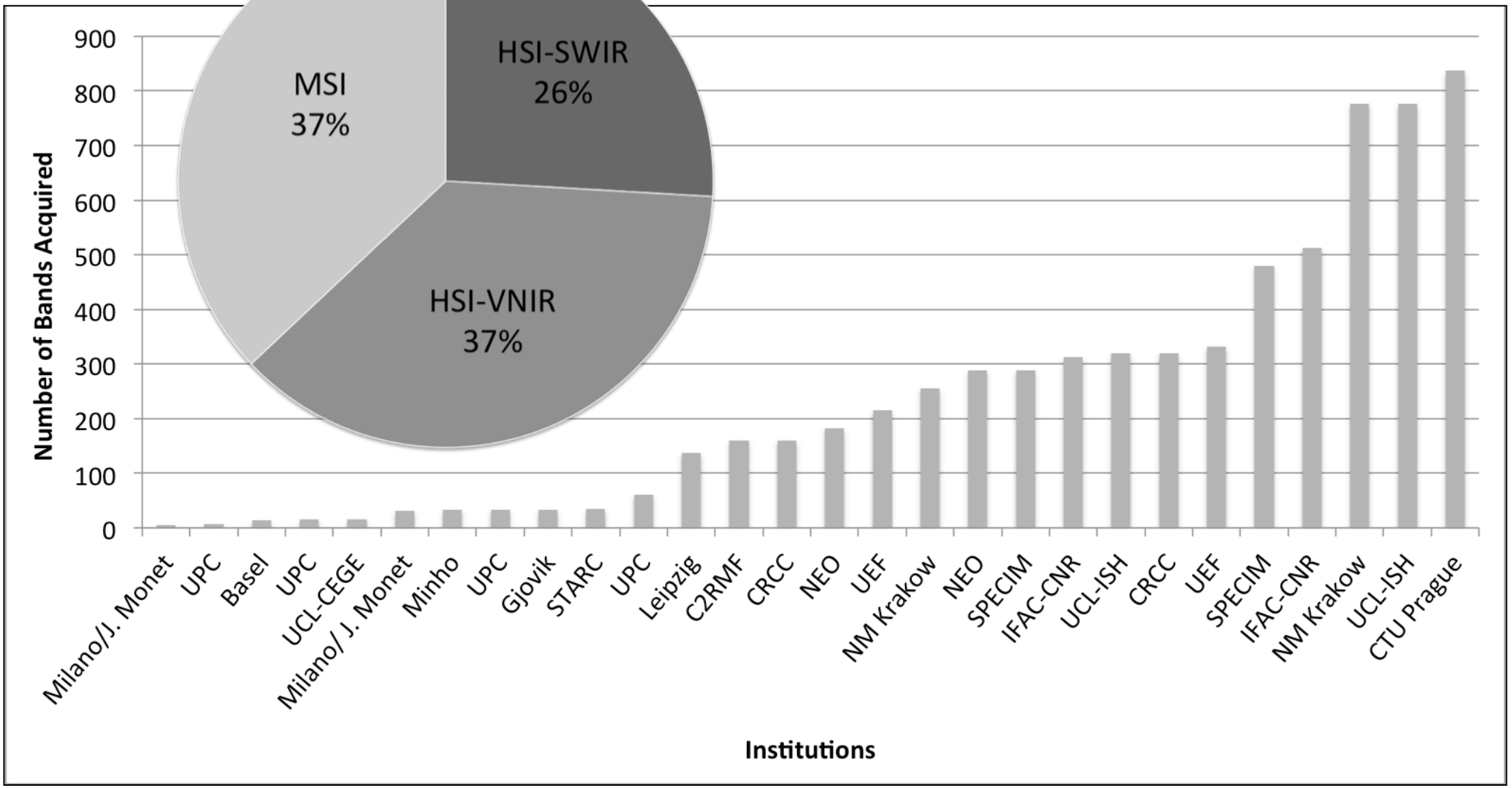
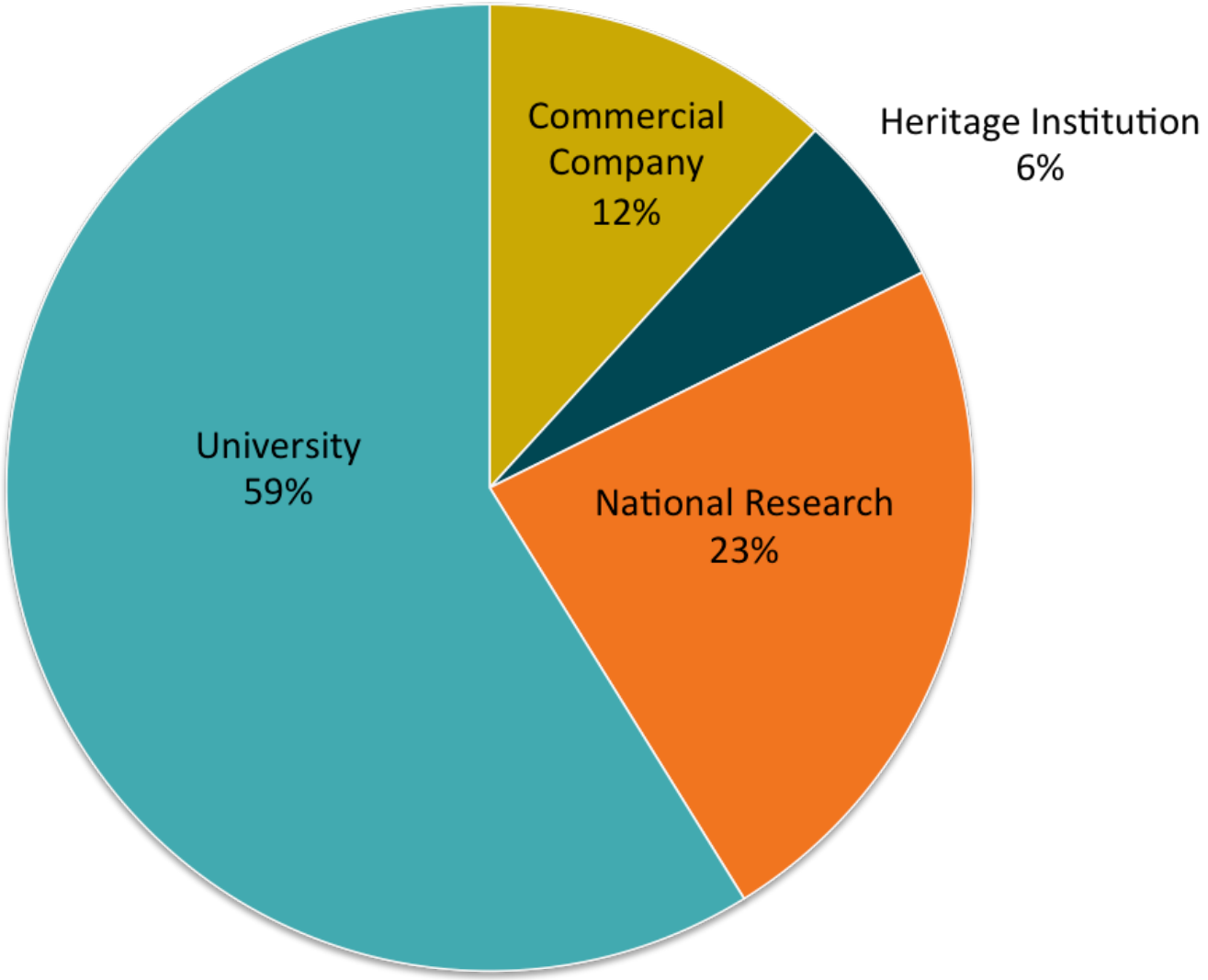
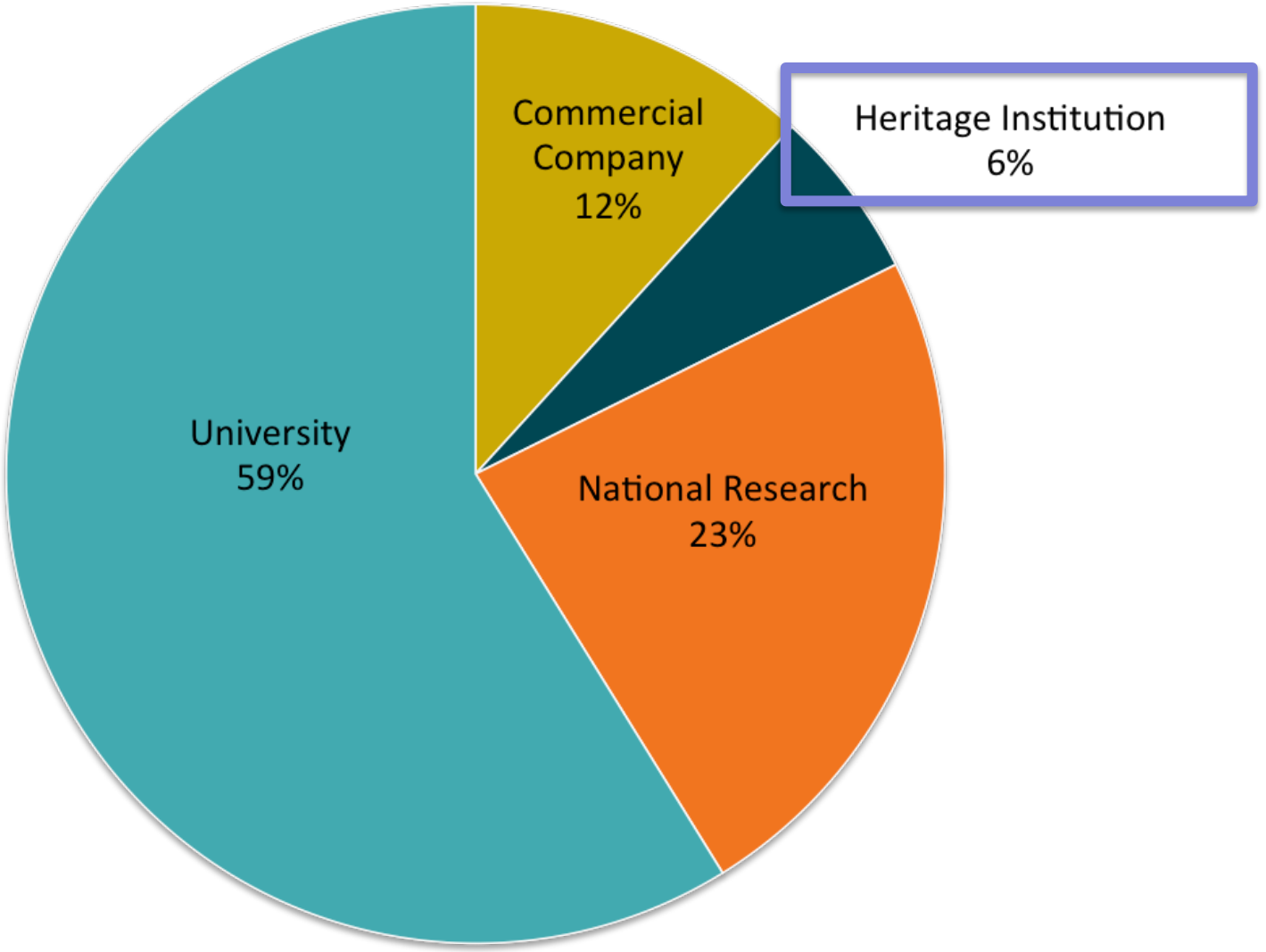
Number of Bands Acquired by Institutions



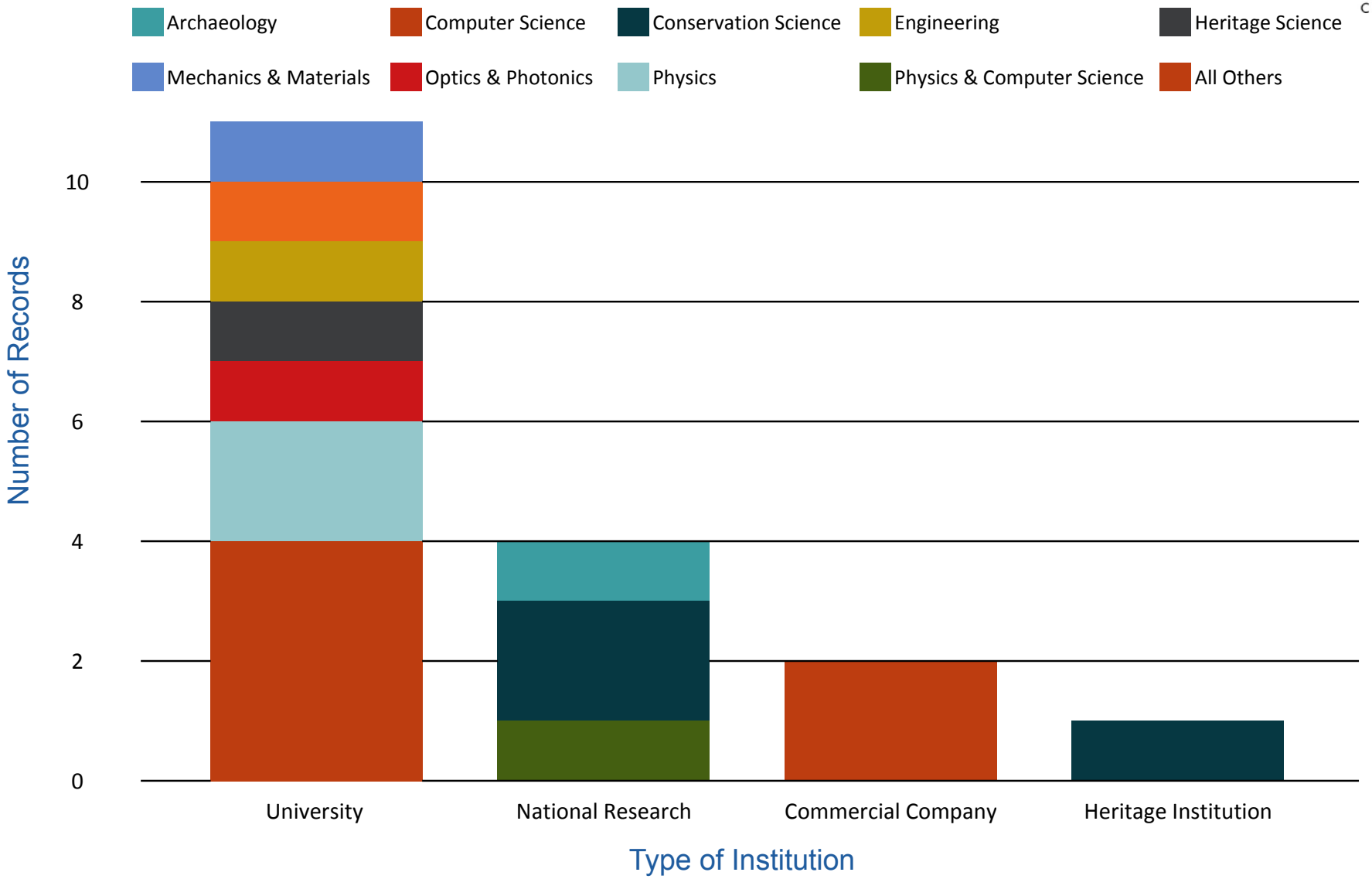
RRT Participating Institutions



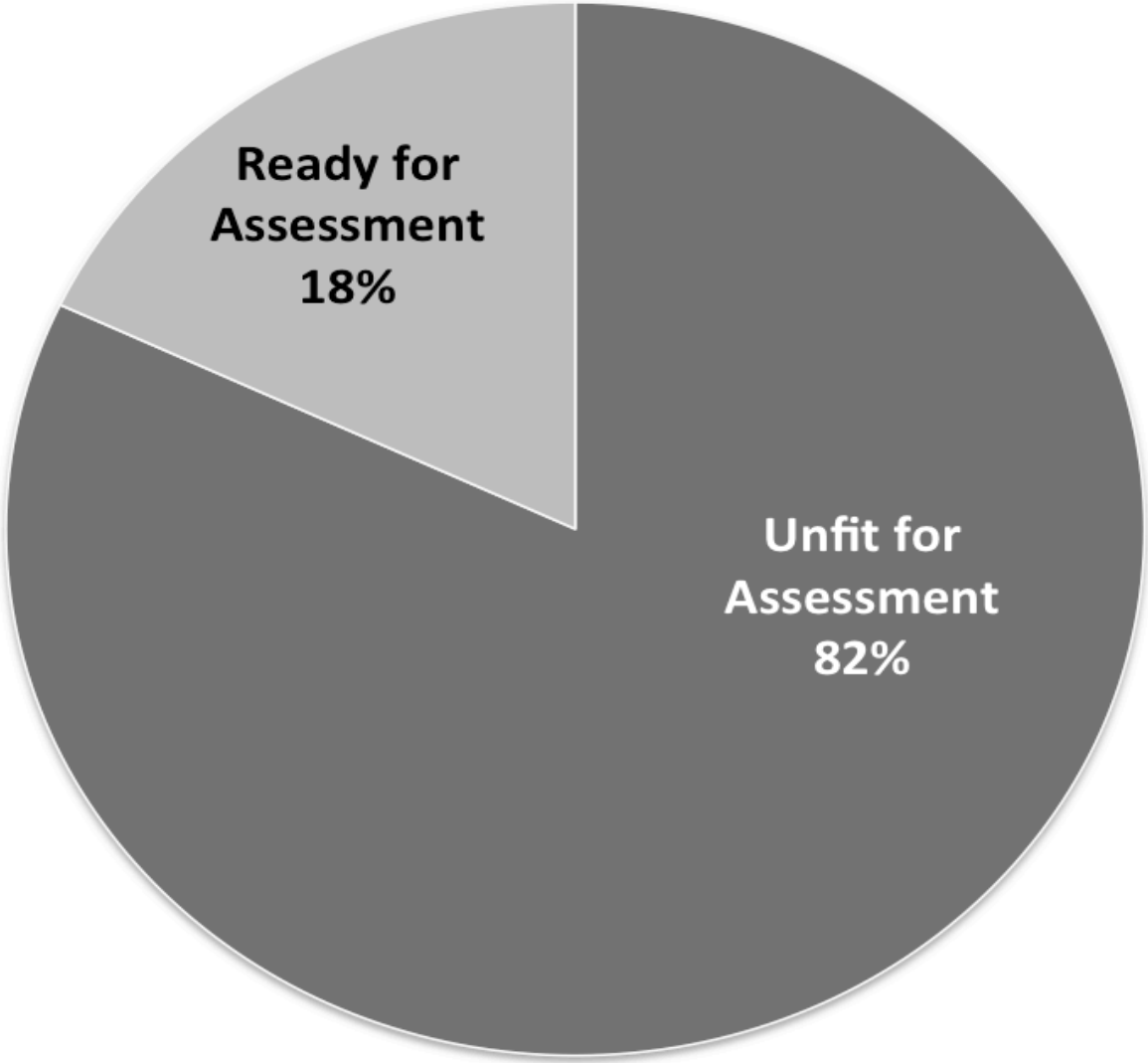
RRT Participating Institutions



RRT Institutions and Users



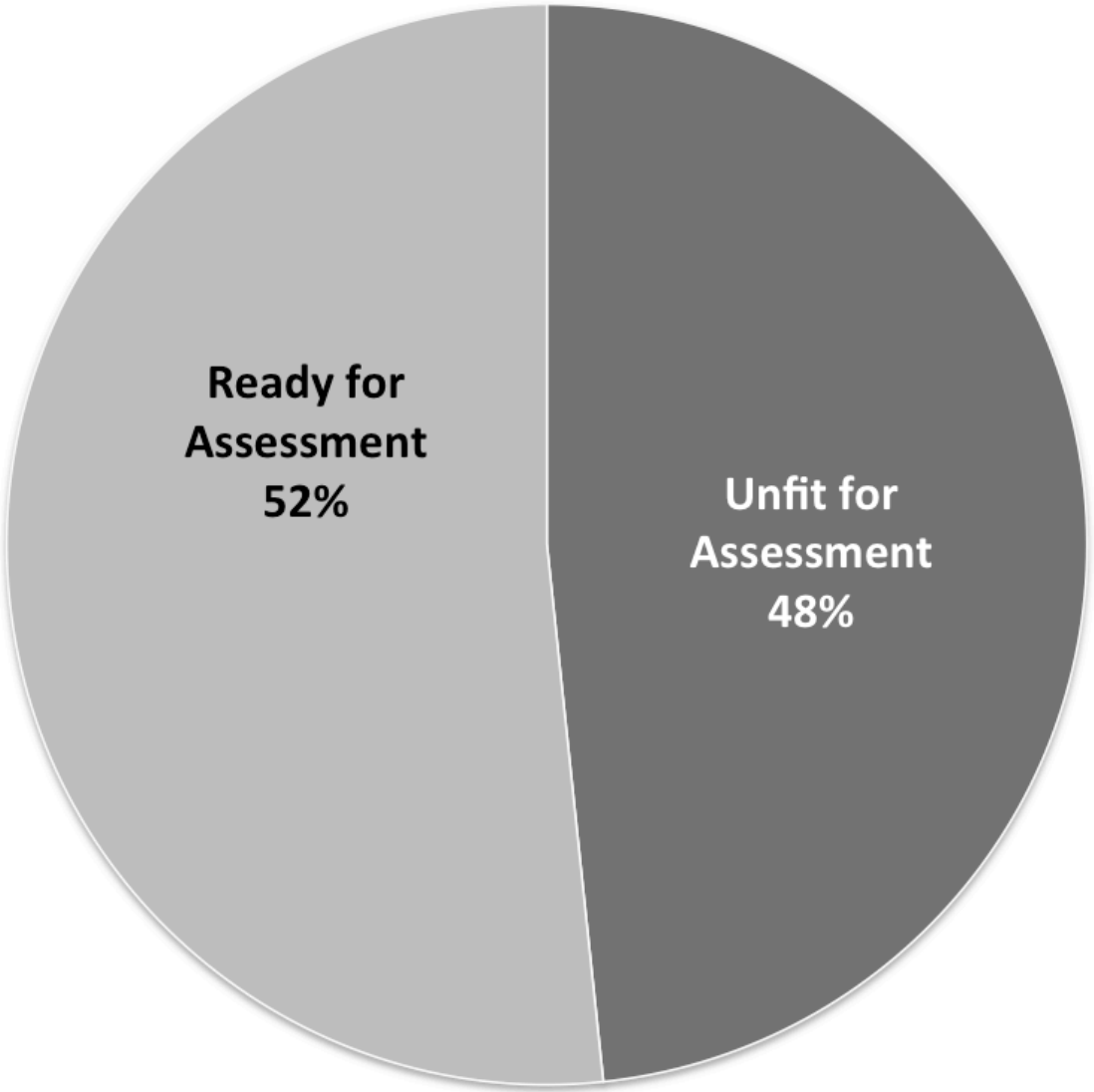
December 2015



Findings from December Data Assessment

- Data incomplete
- Images need to be registered
- Need correct header files
- Images need to be assembled in a cube
- Lack of metadata and information about processing and calibration to understand the received data
- Spatial distortion
- Color images and not monochrome
- Matlab format—not compatible with ENVI
- Questions about 100% reflectance values
- Files could not be opened

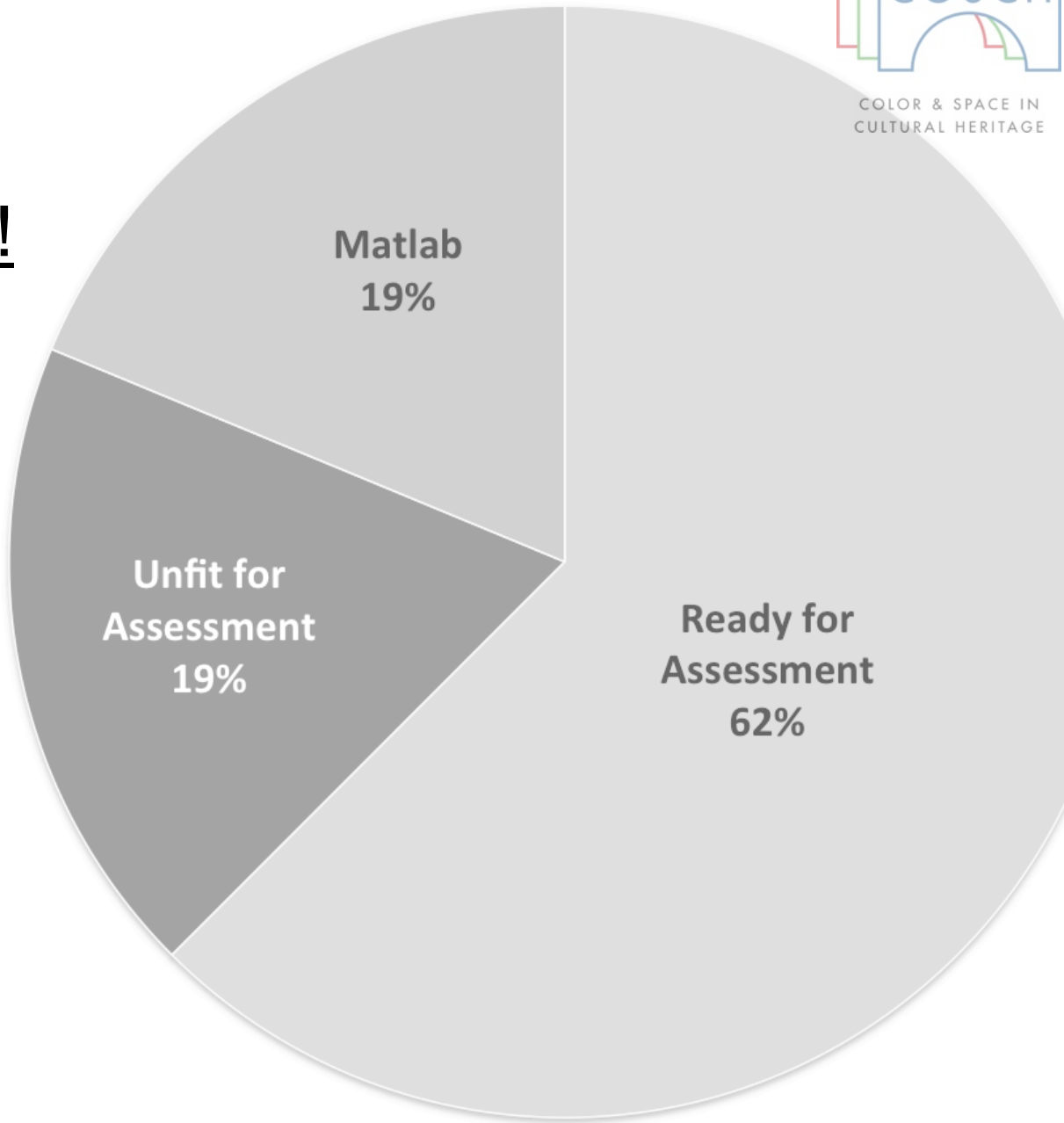
February 2016



March 2016

Over 300 GB of data!!

- 16 institutions
- 5 test objects
- 26 systems used
- ~150 datasets



Challenges and Issues with RRT Data

- Receiving the data from participating institutions
  - Fit for assessment
- Receiving reports—metadata
- Organizing and checking data—file management

- Software and processing
- File Format
- Calibration and normalization

Challenges and Issues with RRT Data

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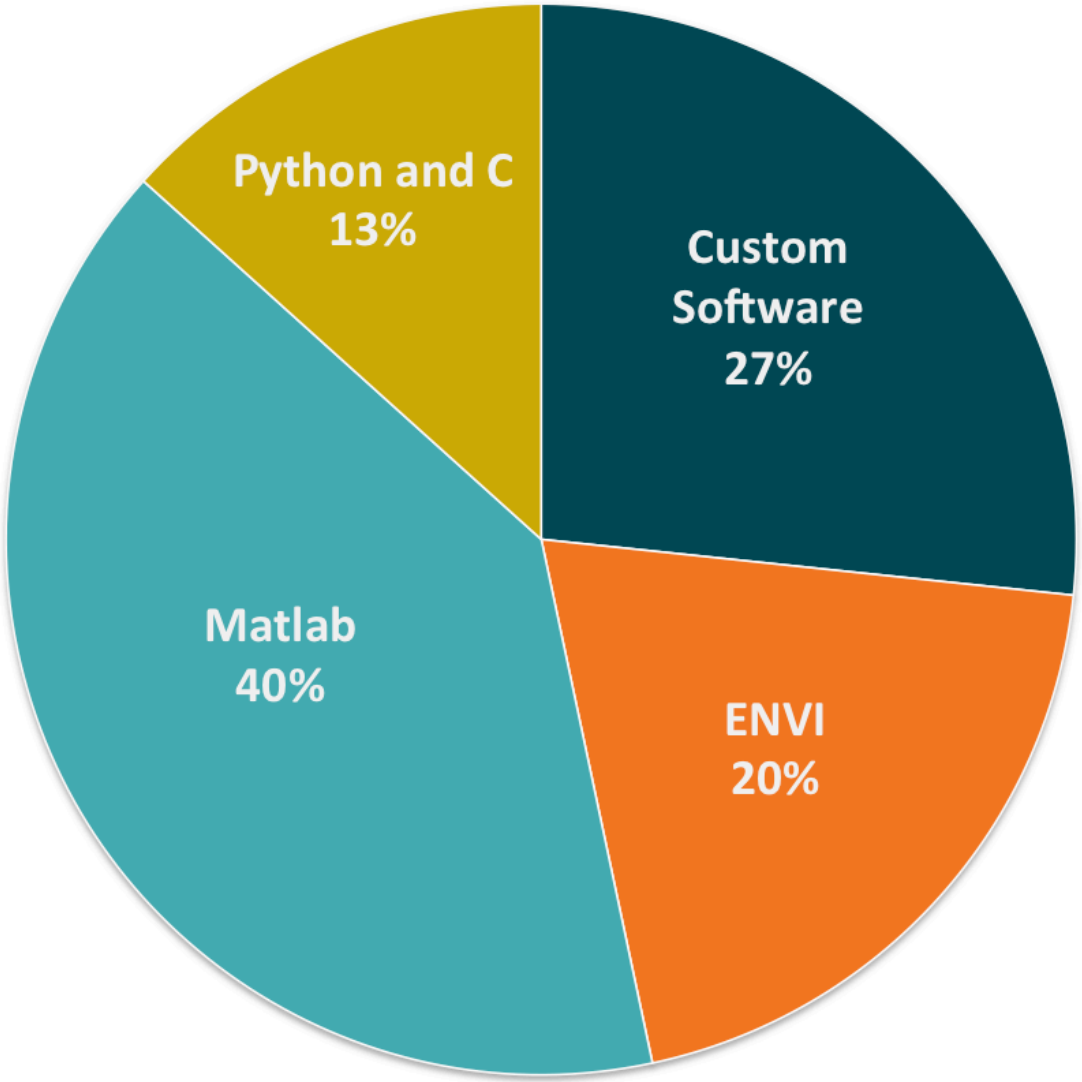
RRT Data—Software and Processing



Percentage of software used to process data for RRT initiative.

Software and Processing

Licensed Options

- ENVI
- Matlab

Equipment Software

Open Source Options

- ImageJ
- Python
- Gerbil
- R
- C
- SAOImage DS9

Software and Processing

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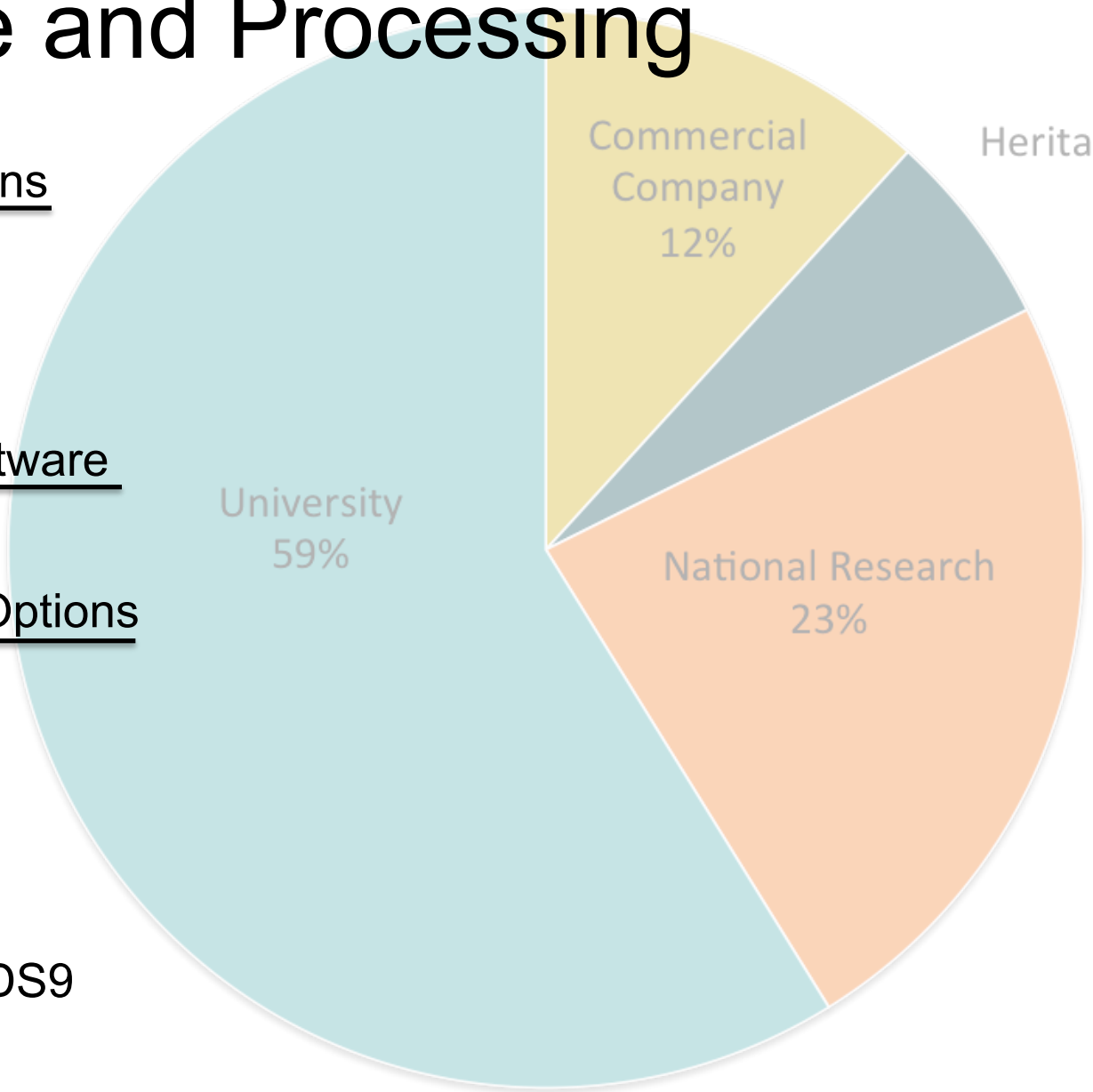

Software and Processing

COLOR & SPACE IN CULTURAL HERITAGE

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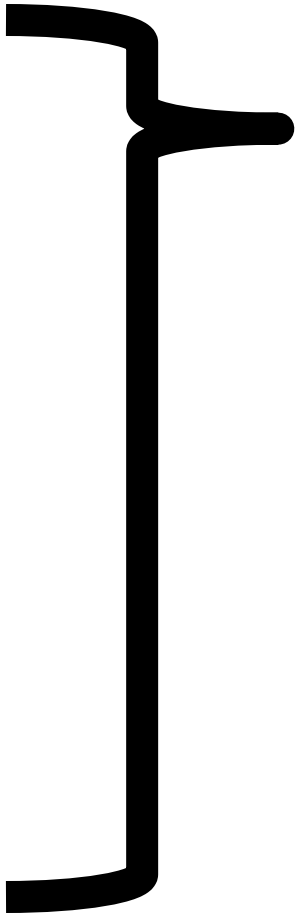

File Formats

*.cue	*.dat
*.img	*.mat
*.raw	*.tif

Software and Processing

COLOR & SPACE IN CULTURAL HERITAGE

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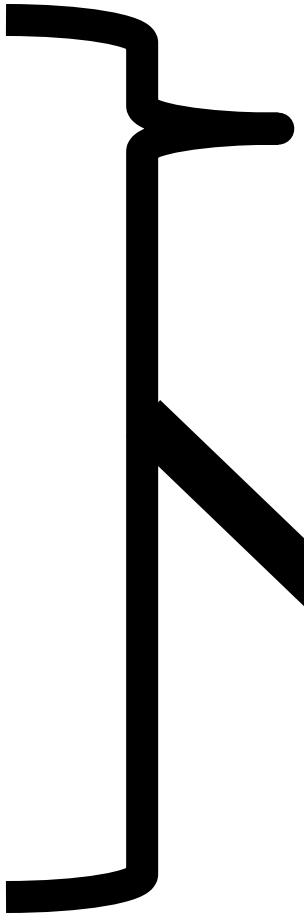

File Formats

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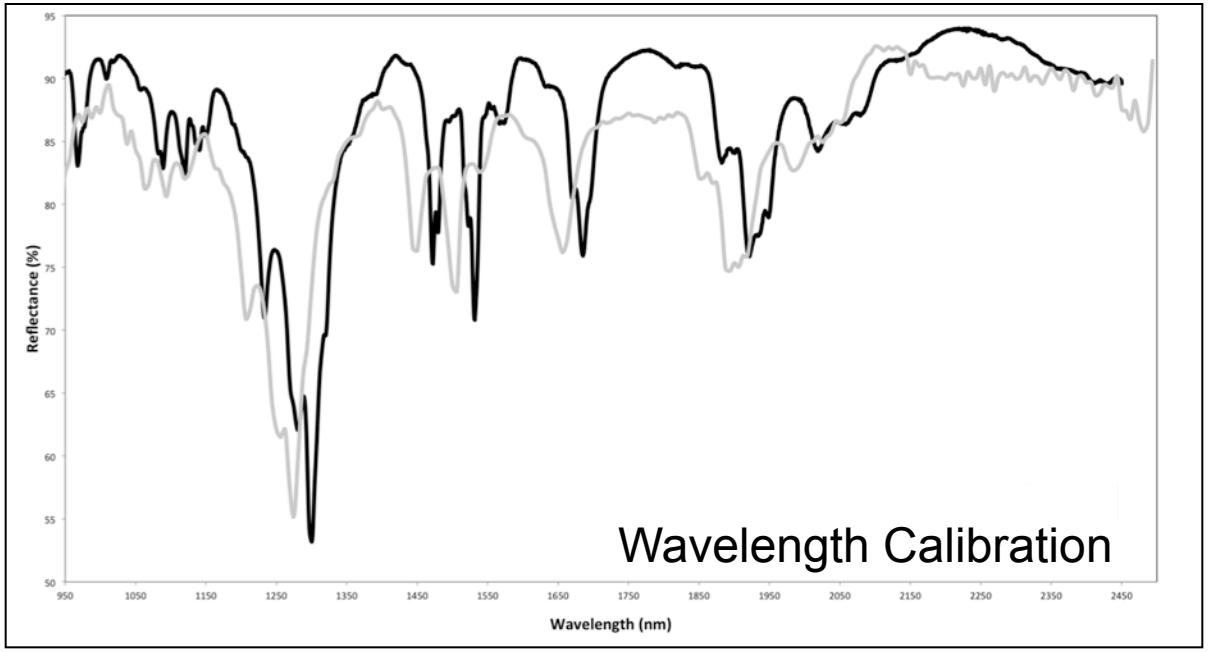
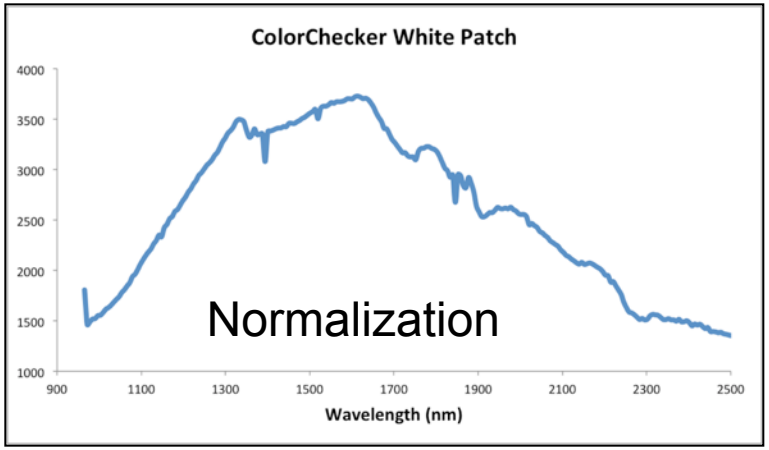
Comparability

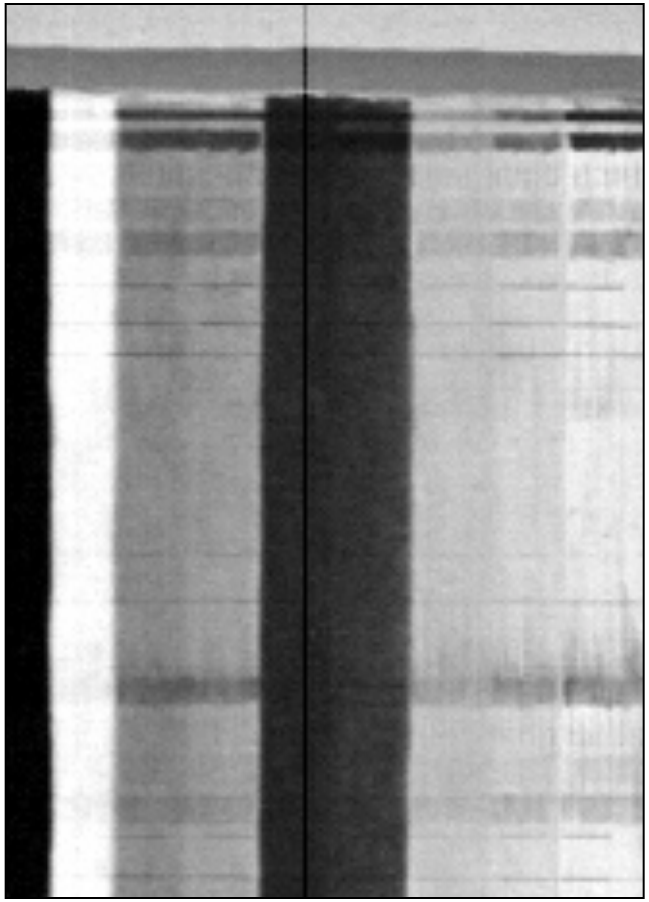
Calibration and Normalization



Flat fielding

Pixel intensity





Dark Calibration

Differences between the same system

- Illumination source
  - Spatial inhomogeneities
  - Spectral density
  - Distance (illumination to object)

→ Normalization
→ Flat Fielding

- Optics
  - Focal length
    - Working distance (sensor to object)
  - Performance—MTF
  - Chromatic aberration
  - Geometric distortion

→ Calibration?

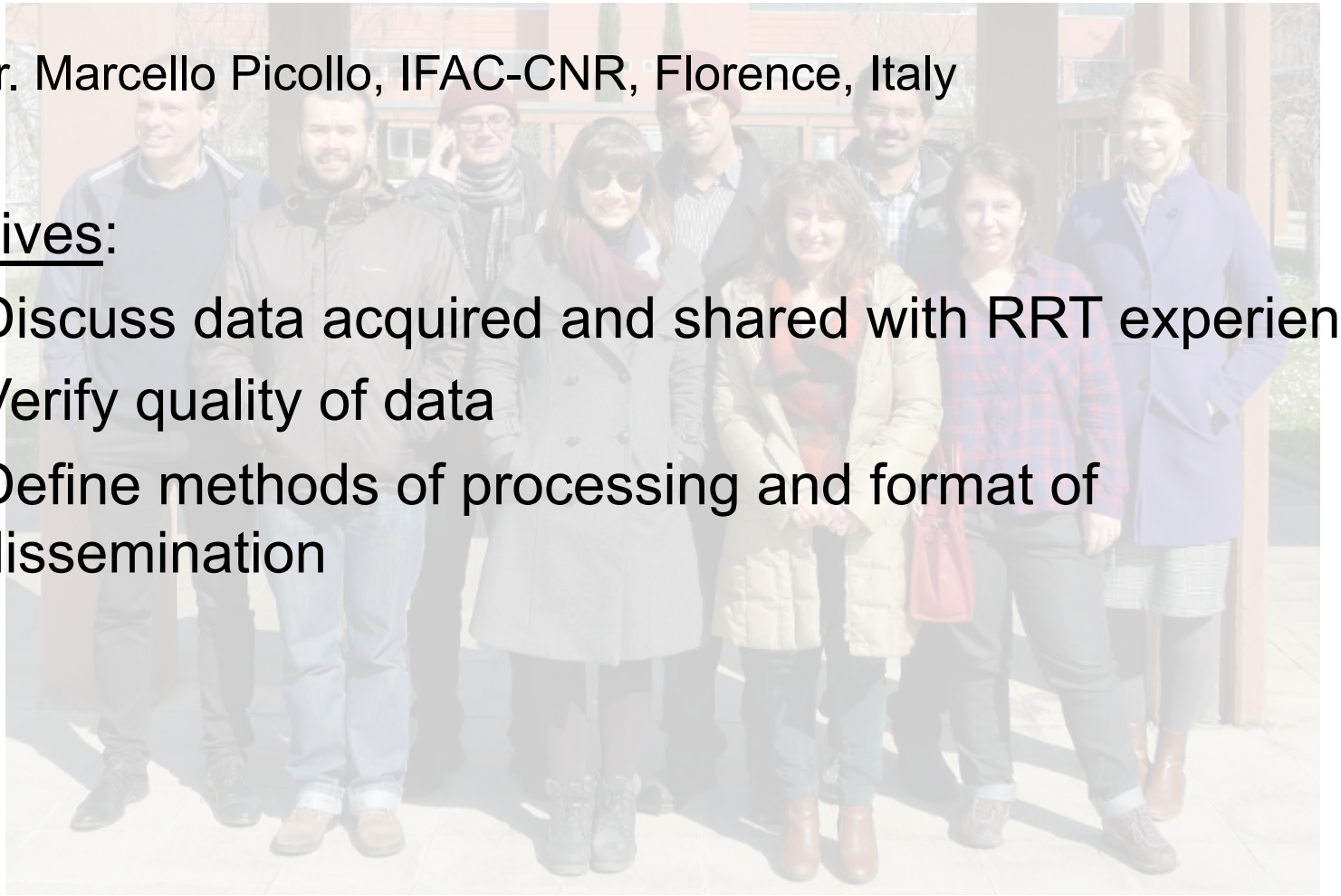
- Pixel response → Calibration for some systems
- Calibration—software and/or workflow → User-dependent

WG1 Task Force Meeting

March 2016

WG1 Task Force Meeting

March 2016



Host: Dr. Marcello Picollo, IFAC-CNR, Florence, Italy

Objectives:

- Discuss data acquired and shared with RRT experience
- Verify quality of data
- Define methods of processing and format of dissemination

Color Checker

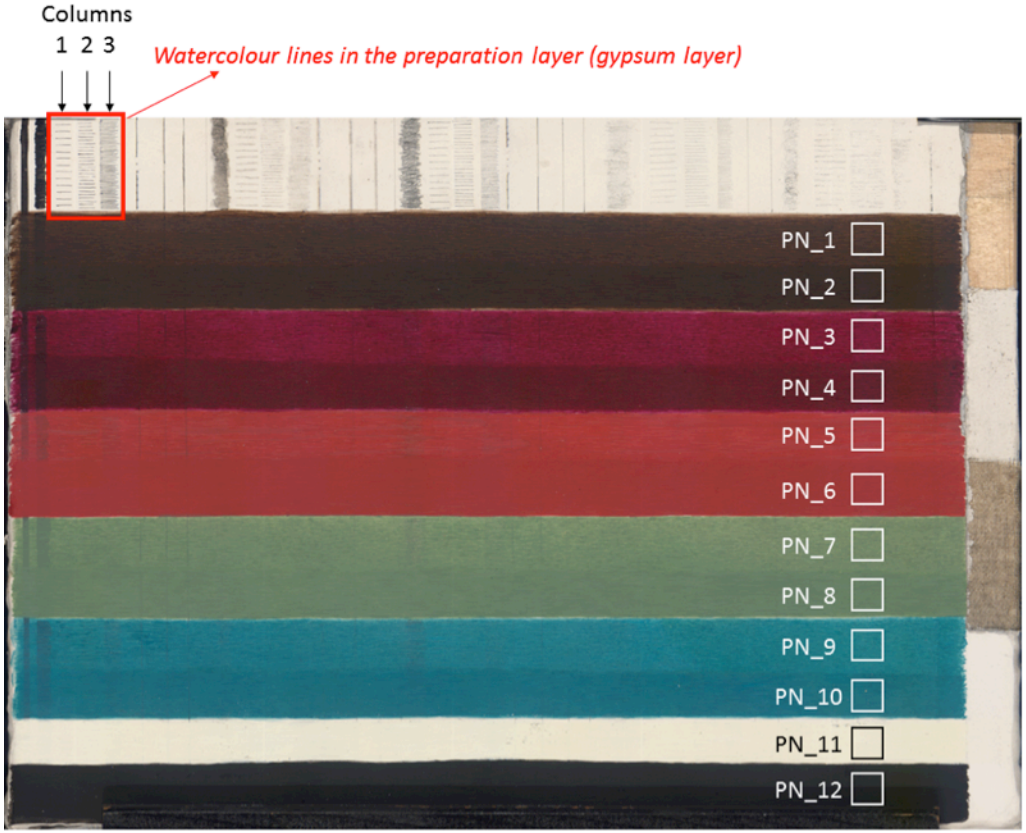
- Average L*a*b*
- Average reflectance spectrum

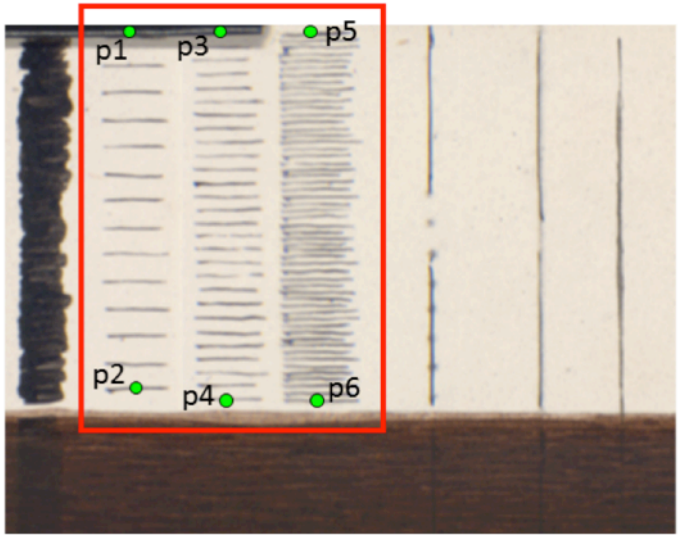
Russian Icon

- Average L*a*b*
- Average reflectance spectrum
- Full resolution color image (TIFF) of the detail area

Painted Panel

- Average L*a*b*
- Average reflectance spectrum
- Indicate of visibility if the watercolour lines in the preparation layer (gypsum layer) are visible or not





Summary

- RRT Test resulted in:
  - Over 300 GB of data
  - 19 participating institutions
  - 5 test objects
  - 26 systems used
  - ~150 datasets
- Challenges in:
  - Receiving data and reports
  - Organizing and assessing data
- Variation with:
  - Software and processing
  - File Format
  - Calibration and normalization

Acknowledgements

- COSCH
  - Supported by the COST Action TD1201 as an STSM
- IFAC-CNR
  - Marcello Picollo, Andrea Casini, Costanza Cucci, Lorenzo Stefani, Tatiana Vitorino
- SEAHA CDT
  - Smithsonian's Museum Conservation Institute
    - Dr. Robert Koestler, Paula DePriest, and Janet Douglas
  - University of Brighton, Cultural Informatics Research Group
    - Karina Rodriguez Echavarria and Roger Evans
  - Analytik Ltd.
    - Ian Laidlaw