

# Guide to good practice of Reflectance Transformation Imaging: the Roman coins case study

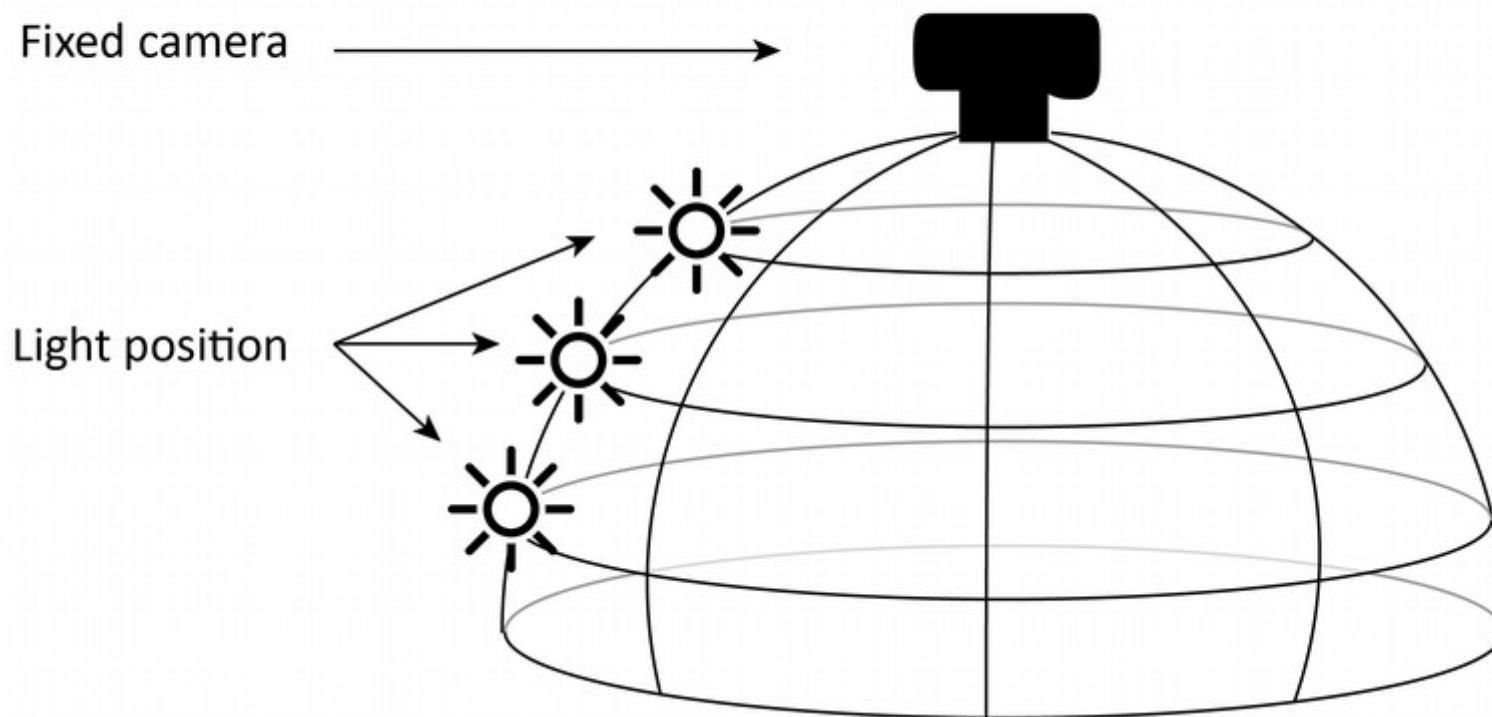
*A. Mathys, RBINS & RMCA*

## Questions addressed

- Numerous research questions could be addressed by experts:
  - Can RTI help id/authenticate coins
  - Help identify provenance/minting marks/etc...
  - Etc. (cf. Case study)
- In this case we focused on methodological questions as not an expert in coins:
  - **Can RTI be an adequate technique to record coins?**
  - **How to compare different equipments?**
  - **What is the impact of the different dome/camera/software/algorithm used on the final result?**

## Technique/Method used: RTI/PTM

- Multiple images with different lighting from one single view point
- Result: one view, but possibility of virtually re-illuminate the object



## Technique/Method used: RTI/PTM

PTM/RTI is a non invasive technique that enables to virtually re-illuminate an object

PTM and RTI are files formats corresponding to different fitting algorithms, they are usually regroup under the large appellation of RTI



## A small history of RTI

- Developed in 2000-2001 by Tom Malzbender and Dan Gelb, research scientists at Hewlett-Packard Labs
- In 2005 researchers from KULeuven developed an alternative approach and viewer and the first version of the minidome
- In 2006 Mark Mudge, Tom Malzbender and their team developed a new method of RTI which didn't require to know the light position but was recovered by specular highlights on a black sphere = H(highlight)-RTI

## The coins

- Roman silver denarii were selected as test object for an interdisciplinary study

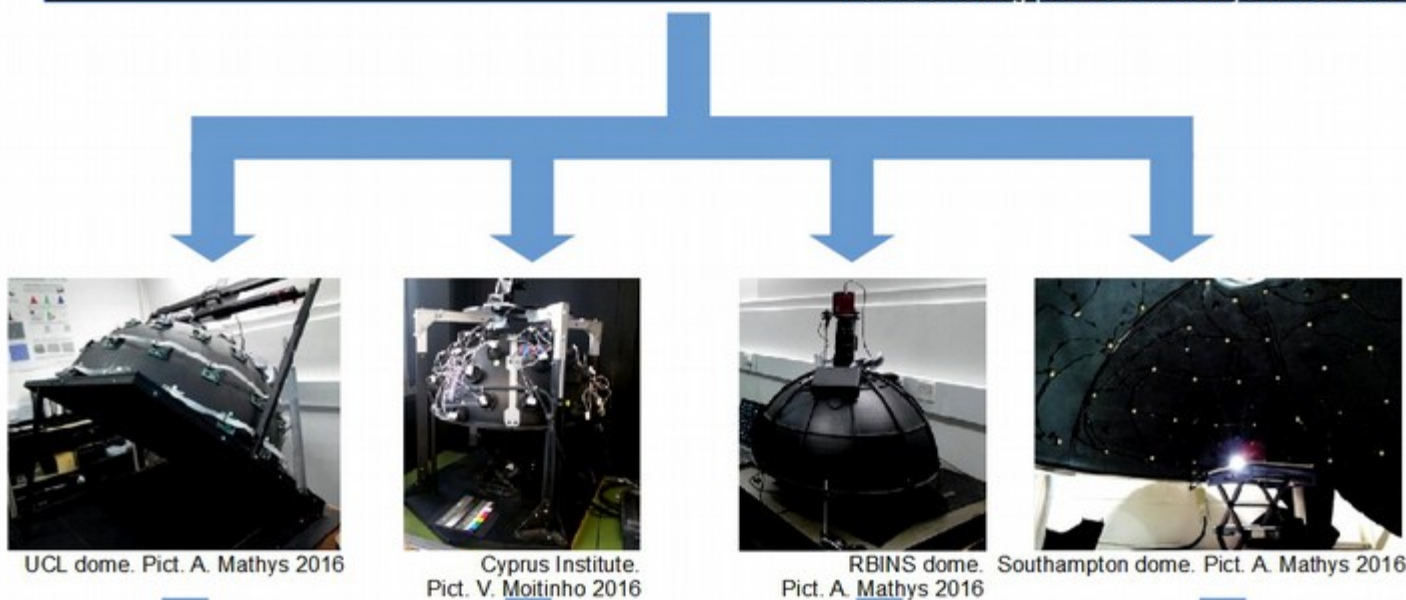


Coin A: Diva Faustina/Aeternitas



Coin B: Diva Faustina/Vesta

# Acquisition



## Acquisition

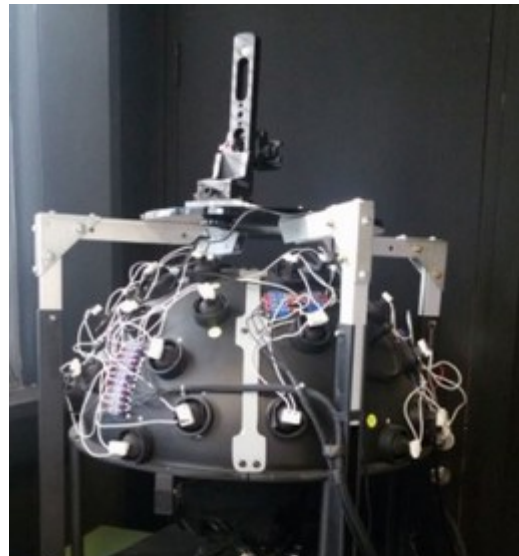
- UCL dome



Dome	Camera
64 lights	DSLR
Flash	DX-Format sensor (24x16)
Dome diameter: 102 cm	200 mm lens
Max. object diameter: 34 cm	10,2 Mp
	3872×2592

## Acquisition

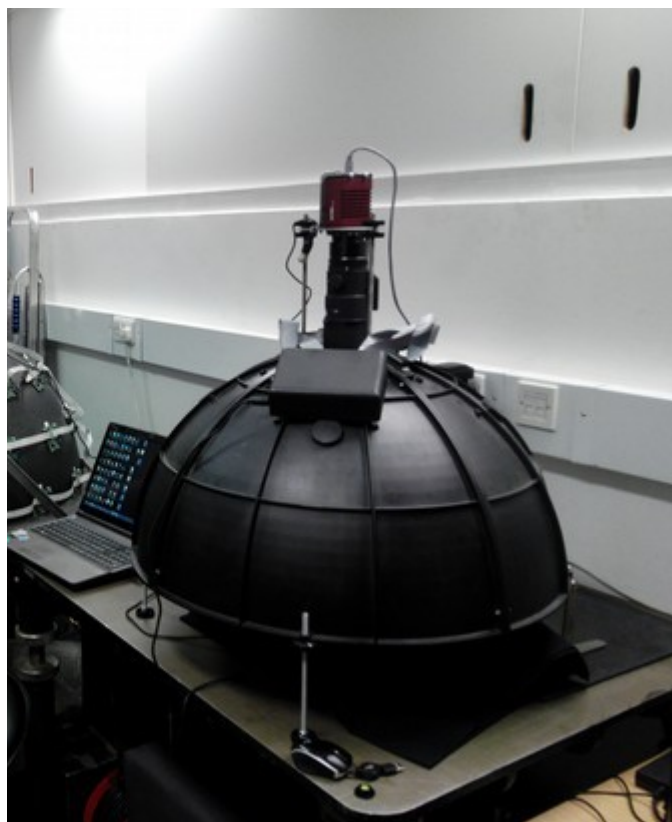
- Cyprus Institute dome



*Picture V. Moitinho de  
Almeida, Cyl*

Dome	Camera
36 lights	DSLR
Halogen	CMOS sensores (36 x 24 mm)
Dome diameter: 60 cm	100 mm lens
Max. object diameter: 20 cm	21,1 Mp

# Acquisition



## •Minidome RBINS

Dome	Camera
260 lights	Machine vision
LED	OnSemi KAI-29050 (36x24)
Dome diameter: 72 cm	200 mm lens
Max. object diameter: 24 cm	28,8 Mp
	6576×4384

# Acquisition

- Southampton dome



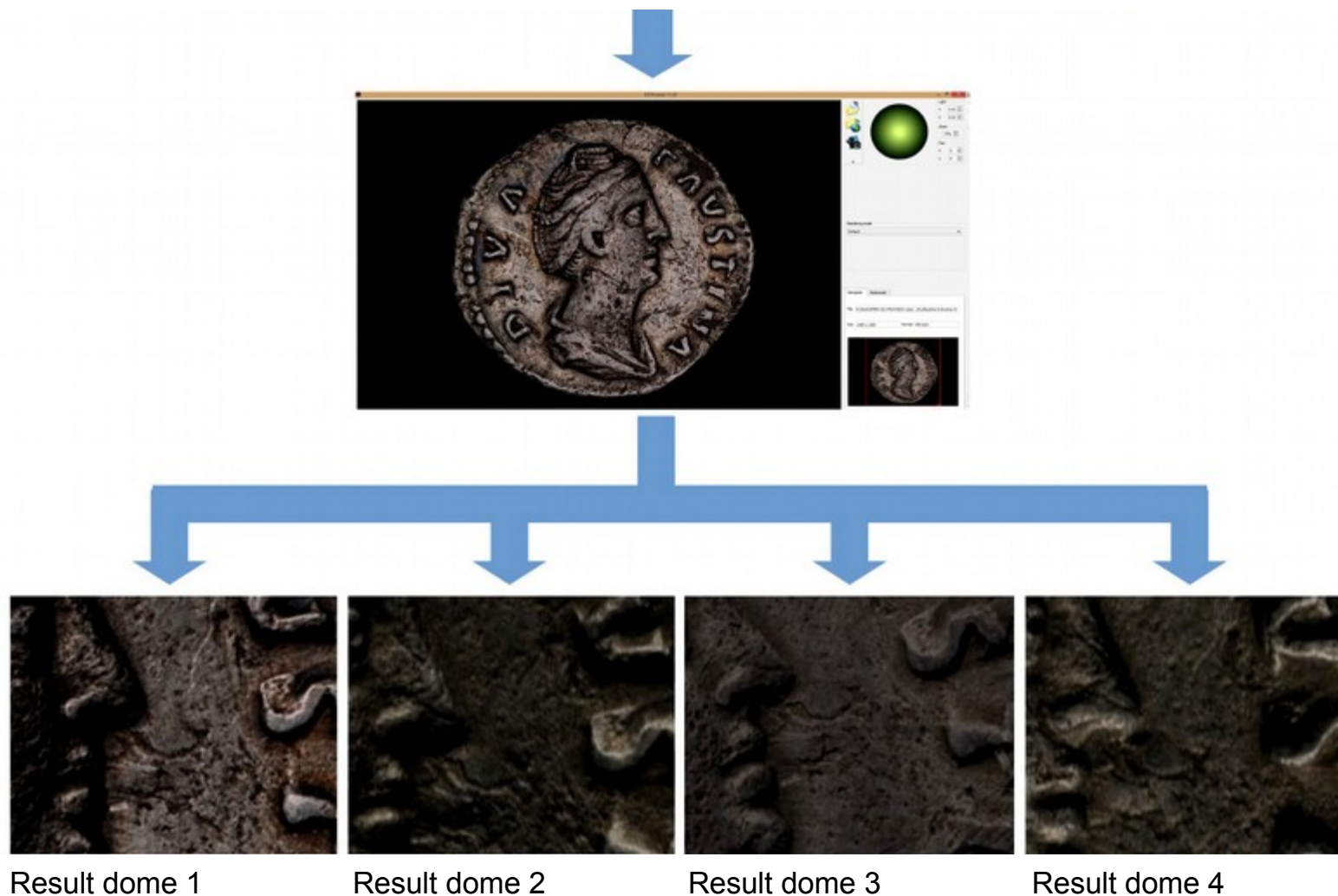
Dome	Camera
72 (76) lights	DSLR
Flash	FX-Format sensor (36x24)
Dome diameter: 100 cm	200 mm lens
Max. object diameter: 33,3 cm	36,3 Mp
	7360x4912

# Processing

- Software used:

- RTI Builder (Southampton)
- Matlab (UCL)
- PLDDigitize (Minidome)
- Train Brain (Cyprus Institute)

# Visualisation



## Evaluation

Two **methods** were considered when comparing the data:

- a statistical method using the value of the extracted normals
- a visual comparison

## Challenges:

- the coins were captured with different equipment: different domes, camera, lenses, light sources, etc.
- the orientation of the coins is different between the different measurements (fig. 3, e.g. you cannot use the same light coordinate between the different acquisition to view the coins with the same light angle)
- the coins weren't measured at the same time: the appearance had evolved between the different acquisitions (silver get oxidized with time, coins were coated and cleaned for 3D measurements)
- some of the output format were proprietary so we weren't able to view all the output in a same and unique viewer.

# Evaluation



*Different orientation and exposure of the same view of the coins (on the left image from dome 2; on the right image from dome 1).*

## Evaluation

Parameters for visual comparison:

- colour realism: is the colour appearance rendered alike the real coins?
- specular realism (Specularity is amount of reflections rendered): are the reflections rendered alike the real coin?
- impression of dimension: does the result look flat or does it provide an impression of 3D?
- overall impression of realism: does the overall result look realistic?
- visibility of surface texture (as in topographical texture): detail of the surface
- sharpness: are the results sharp?
- assessment of geometry details

# Evaluation of the viewers

- Multiple possibilities:
  - RTIViewer = can view both ptm and rti files
  - HP PTM viewer = can only view ptm files
  - PLDViewer = can only view cun files

	PTM Viewer	RTI Viewer	PLD Viewer
<b>Regulate intensity in default mode</b>	x		x
<b>Several lights</b>	9	1	2
<b>Annotations</b>		x	
<b>Specular enhancement</b>	x	x	
<b>Normals</b>	x	x	x
<b>Supported formats</b>	ptm	ptm, rti	cfp, cun

# Evaluation of the viewers

-  
Not realistic  
No specular  
Proprietary format

+  
2 lights sources  
Measurements  
Export 3D  
Profiles  
Metadata  
Several filters  
Several views  
in same file

Metadata
Display
Measure
Params

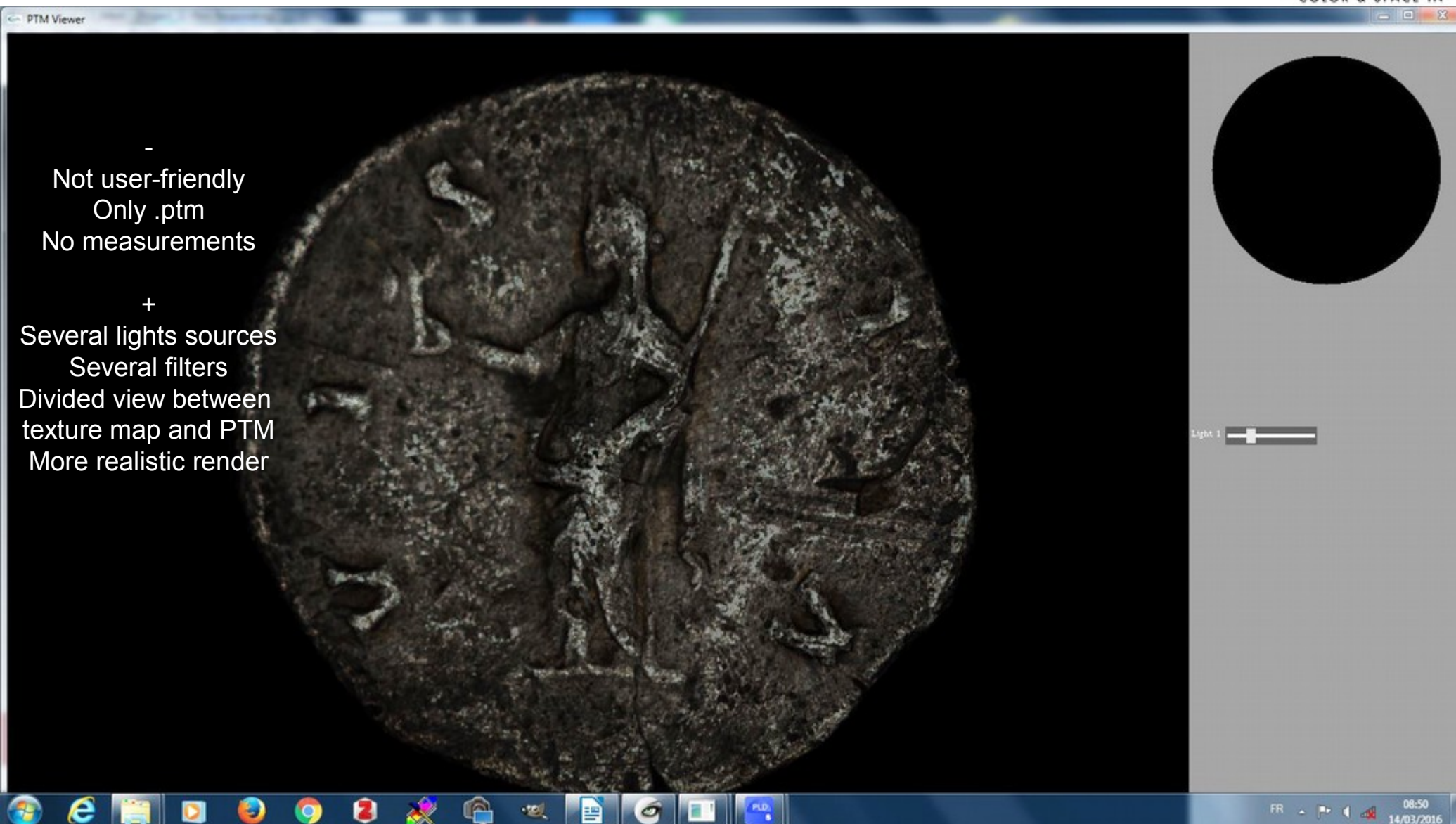
Display Settings
Color source: Ambient
Albedo
Ambient
Shader: color
color
sharpen
shaded
shaded exaggerated
sketch 1
sketch 2
curvature
normals
color specular
BRDF materials
Intensity 1
Intensity 2
Display 1:1
Fit to Window

Screenshots
Zoom
Dimension: 1194x727
Background Color:
Take screenshot
Take 1:1 snapshot
Print screenshot
Create movie

## Evaluation of the viewers

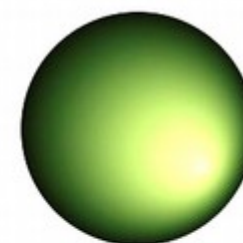
-  
Not user-friendly  
Only .ptm  
No measurements

+  
Several lights sources  
Several filters  
Divided view between  
texture map and PTM  
More realistic render



## Evaluation of the viewers

RTIViewer 1.1.0



Light  
x 0,57  
y -0,34  
Zoom  
60%  
Pan  
x 0  
y 0

Rendering mode

Default

Navigator

Bookmarks

File J:\Work\STSM UCL RTI\COSCH coins - UCL\Faustina B reverse.ptm

Size 1430 x 1360

Format LRGB PTM



-  
No measurements  
1 light source

+  
More realistic  
Specular  
Several filters  
.ptm and .rti files  
Annotations

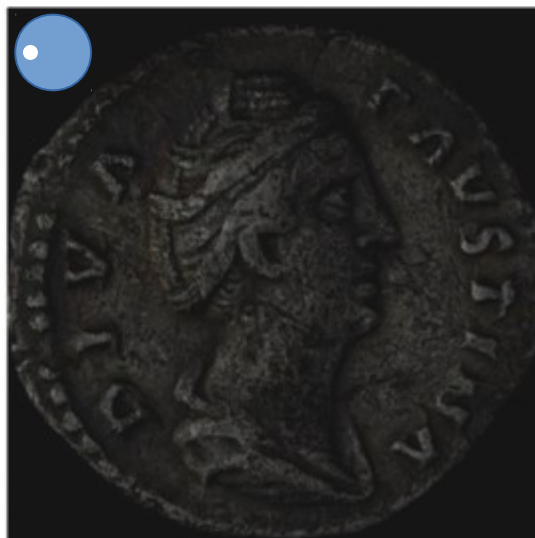
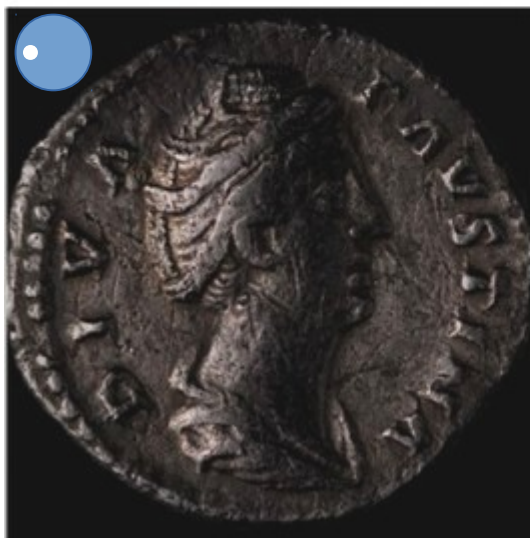
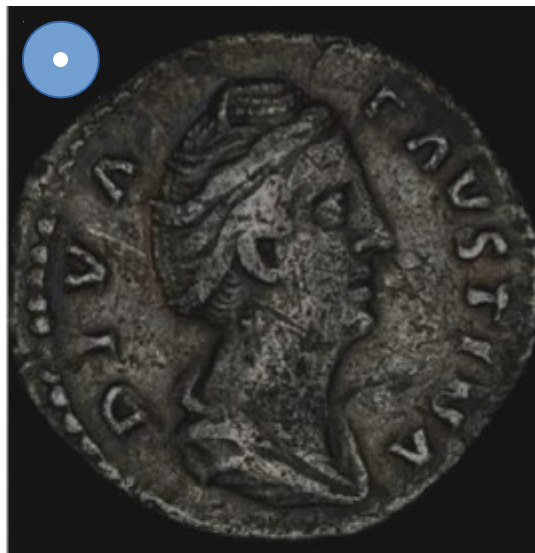
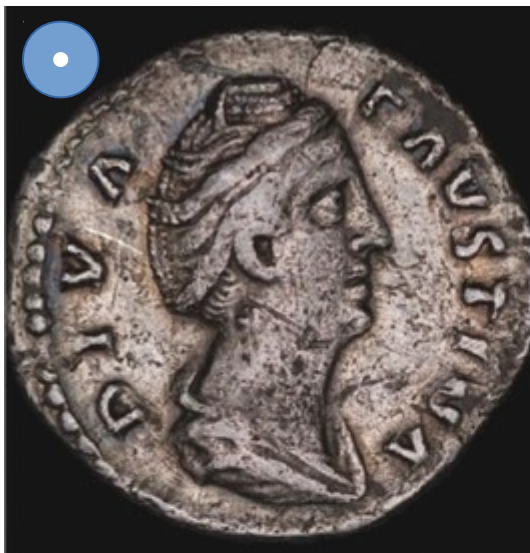


## Evaluation of the viewers

Multiple possibilities:

- **RTIViewer** = **polyvalent** between .rti and .ptm, **user friendly, work-tool** (annotations)
- **HP PTM** viewer = can only view .ptm files, less user friendly, but **more realist rendering, best specular rendering**
- **PLDViewer** = can only view proprietary files (.cun), doesn't render specular, **allow creation of 3D and create profiles**

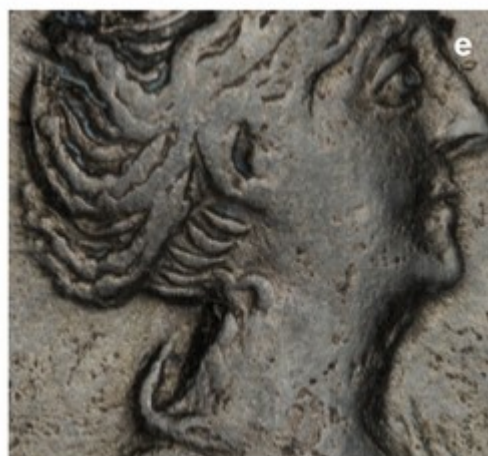
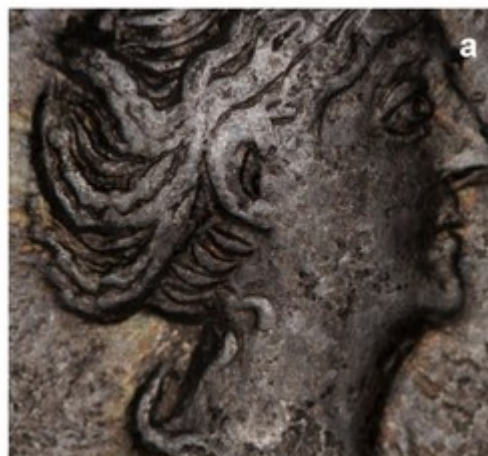
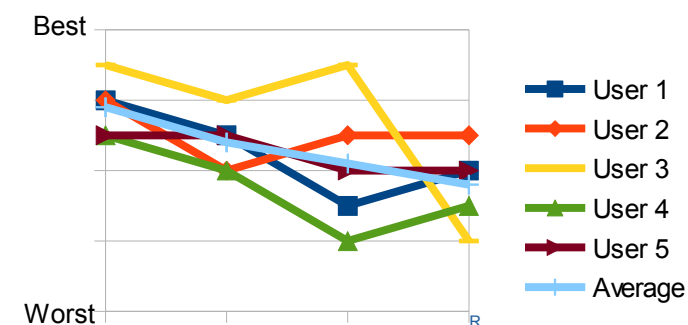
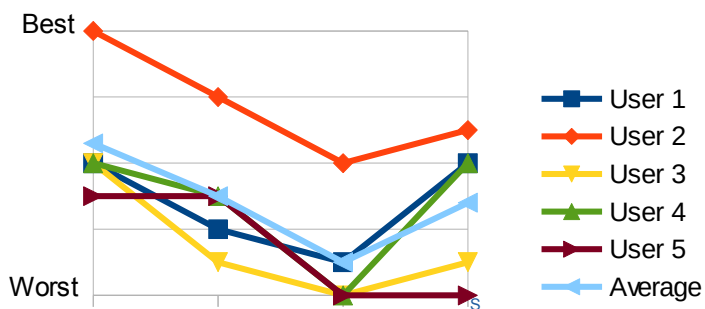
## Evaluation of ptm vs rti



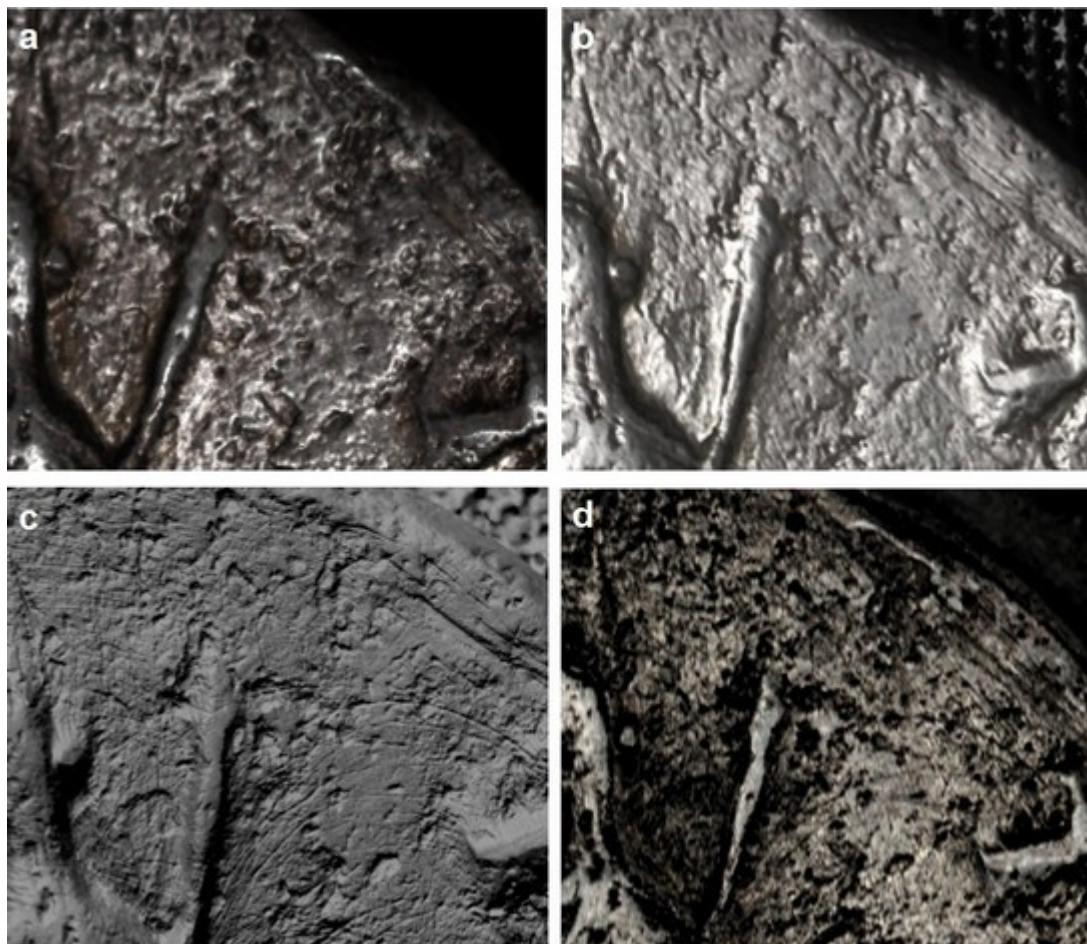
*Coin B observe, dome 1 images. In the same viewer an .rti (left) and a .ptm (right) file of the same set of images with 2 light position. The same coordinates are used for both .ptm and .rti.*

# Evaluation

*Coin A observe, detail. a) RTI from dome 1; b) RTI from dome 2; c) RTI from dome 3, albedo mode; d) RTI from dome 3, ambient mode; e) RTI from dome 4; f) Focus stacked picture.*



## Evaluation



*Coin B, reverse, detail of surface texture, un-textured. a) captured and processed by dome 1; b) captured and processed by dome 2; c) captured and processed by dome 3; d) captured and processed by dome 4.*

## Constraints

- Flat objects
- Depth of field
- Stability of the system

## How did the data of the recording technique(s)/method(s) support the cultural heritage tasks?

- ♦ relevant (characteristics of) content, which is inevitable to answer CH question:
    - RTI relevant to coins recording
  - ♦ identified factors having impact on the content
  - ♦ measures to be taken helping to assure required content
- } cf. following slides

## What are the limitations and sources of error?

- Limitations of size and shape:

- Technique adapted to flat object
- Issues with depth of field
- Size of the object depend on the size of the dome and the lens used, while H-RTI has no limitation of size.

- Source of error:

- Light position => when processing the picture make sure that the light position (either in the naming of the picture for the LP file, or in the position of the panels and camera when you dismount and remount a dome) are correct otherwise you won't be able to correctly relight virtually. This error shouldn't occur in H-RTI.

## The DO's and the DON'Ts

### ♦ DON'T...

- Use different software's to compare different data set
- Inverse panels of the domes or mix light position
- Don't use different lenses for comparison, specially different magnification

### ♦ DO...

- Plan you workflow in advance
- Use different software to compare a same set of data
- Use a same software to compare different data-sets
- Make sure your camera is stable, specially using large magnification
- Play with aperture and shutter speed in order to obtain better depth of field

## What are the benefits of the recording technique(s)/method(s)/data in comparison to traditional methods?

- RTI has the advantage over traditional method to **enable virtual relighting** of the object allowing to see details not visible in usual 2D photography  
Virtual relighting enable to enhance details and dimensionnality, therefore RTI can help preserve and monitoring of objects
- RTI can record detail of surface. **Colour can be removed** in order to view only the surface
- In the case of coins, the virtual relighting of the surface can **help identifying** a coin with a damage/corroded surface (cf. Kotoula E. & M. Kyranoudi, 2013. *Study of coins using reflectance transformation imaging*. E-conservation)
- Photometric stereo can produce high definition 3D models
- Dome RTI compared to H-RTI provide an automated method, repeatable, decreases time of acquisition and processing

## Which COSCH Primary Tasks (PT) and sub-tasks (st) are addressed (see COSCH MoU)?

This STSM addressed WG2 (Spatial documentation); WG3 (Algorithms); WG4 (Analysis); and WG5 (Visualisation).

## Conclusions

- **Can RTI be an adequate technique to record coins?**
  - Yes
- **How to compare different equipments?**
  - More careful planning
  - Capture in similar conditions
  - Use same lens for all captures
  - Visual comparison is subjective to the user
  - One data-set for different software and one software to compare different data-set
- **What is the impact of the different dome/camera/software/algorithm used on the final result?**
  - Differences in surface detail, in resolution, in smoothness of re-lighting, in rendering, in realism, in specularity, in sharpness, etc.

## Acknowledgment

- COSCH COST Action TD1201
- Prof. S. Robson, Dr. L. MacDonald, Dr. M. Hess, D. Garside, A. Shah and all the people who hosted me and help me during my stay at UCL
- Prof. K. Martinez and Dr. J. Mills from Southampton University
- Dr. P. Semal, Dr. D. Van den Spiegel and J. Brecko from RBINS and RMCA
- Dr. V. Moitinho de Almeida and Cyl
- Dr. A. Bentkowska-Kafel, E. Bunsch, Dr. M. Hain, Dr. J. del Hoyo Melendez, Dr. D. Rieke-Zapp, Prof. R. Sitnik, Dr. J. Valach from the roman coins case study
- Dr. H. Hameeuw from RMAH
- Prof. M. Proesmans
- Dr. J. Russell from the British Museum