

# 3Pi project

## KU Leuven NBMSI Metadata Standard

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Reasons for update from version 1 (<https://doi.org/10.5281/zenodo.3607364>):

- All NBMSI metadata entries received an unique ID.
- Extra insight into the management and handling of the metadata have been added.
- The update provides better tools to allow machine readability of the documented metadata.
- Examples of implementation strings into the EXIF Image Description field.
- Small clarifications and corrections.

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## INTRODUCTION

- 1) The **objective** of the KU Leuven NBMSI Metadata Standard, developed within the framework of the 3Pi project,<sup>7</sup> is to define the required or relevant metadata elements and their parameters for image captures created with a photographic Narrow Band Multi-Spectral Imaging (NBMSI) technology. The determined and selected metadata fields provide information necessary to outline the creation environment and technical infrastructure used in the production of the images. These are not standard included in the basic EXIF or IPTC fields embedded in the image derived from the camera system itself. As such this is metadata pertaining to the image dataset and not to the object being imaged.

The KU Leuven NBMSI Metadata Standard is intended to provide definitions and conventions, allowing users to access documentation for images stemming from a common set of terminology. This will therefore provide a level of consistency for the metadata information.

Therefore, the primary functions of this document are:

- a) Providing users of the images with information about the creation environment of narrow band multi-spectral images.
  - b) Defining standard metadata fields that can be embedded to a multitude of images for consistency and clarity.
  - c) Outlining the values of these standardized metadata fields; how to measure and enter them.
  - d) Allowing independent and long-term interpretation of the images.
- 2) The **scope** of this standard is in the first place aimed at providing coverage to any objects that may be imaged by the narrow band multi-spectral imaging infrastructure deployed by the Imaging Lab at KU Leuven Libraries. This includes the collection held by the University Libraries, as well as collections brought in by external institutions or researchers. Secondly, the standard has also been constructed in the interest of having usability for other institutions, using similar narrow band multi-spectral imaging technology, inside or outside of KU Leuven.
  - 3) **Related Standards:** This standard was developed with direct reference to the Archimedes Palimpsest Metadata Standard. The Archimedes Palimpsest Metadata Standard originally draws from such standards including:

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<sup>7</sup> 3Pi project (*Diagnosis of Papyrus-Paper-Parchment manuscripts through advanced Imaging*, AKUL/17/001, FWO: 1009918N): Promotor-spokesman is prof. dr. Johan Leemans; coordinator is prof. dr. Lieve Watteuw (Head Book Heritage Lab); implementation of the NBMSI system by Bruno Vandermeulen (Head Imaging Lab) & Hendrik Hameeuw (Advanced Imaging, Imaging Lab).

- a) *Dublin Core Metadata Initiative Element Set (ISO Standard 15836)*<sup>8</sup>
- b) *Content Standard for Digital Geospatial Data (FGDS-STD-001-1998)*<sup>9</sup>
- c) *Art Museum Image Consortium (AMICO)*

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<sup>8</sup> Dublin Core Metadata Initiative, DCMI Metadata Terms, 2012-06-14

<https://www.dublincore.org/specifications/dublin-core/dcmi-terms/> also published as IETF RFC 5013 [RFC5013], ANSI/NISO Standard Z39.85-2007 [NISOZ3985], and ISO Standard 15836:2009 [ISO15836].

<sup>9</sup> The Archimedes Palimpsest Metadata Standard, Version 1.0,

[http://archimedespalimpsest.net/Documents/Internal/Image\\_Metadata\\_Standard.pdf](http://archimedespalimpsest.net/Documents/Internal/Image_Metadata_Standard.pdf).

## METADATA DEFINITIONS AND CONVENTIONS

Metadata fields describe different characteristics of the data sets and the environments used to create them. The categories that will be implemented in this particular standard are:

1. Identification Information (IDI)
2. Environmental and Infrastructural Information (EII)
3. Imaging Information (IMI)
4. Data Type Information (DTI)
5. Data Content Information (DCI)
6. Metadata Reference Information (MRI)

The conventions applied to the element fields allow the user to know the parameters for the construction of the metadata in question. The conventions are:

**CORE:** This shows whether the element is required for adequate documentation and will read “Yes” or “No”.

**Type:** This shows whether there can only be one entry (Single) or multiple entries (Compound) of the data field.

**Domain:** This shows the manner in which the data may be entered. Eg. “Text” or “Real Number”

## METADATA MANAGEMENT

The metadata specifications described below must all be embedded in each of the processed image files.<sup>10</sup> The embedding of all this structured information is made in the **EXIF Image Description field**.

The manner in which this information is structured, follows ideally the same order as the proposed NBMSI metadata standard below. But, it is acknowledged not each capturing and/ or processing and/or managing system will allow that. Equally, a best approach is to adopt the titles (i.e. in each ex. the text in front of the colon) attributed to each entry. But again, for practical reasons that might not always be possible. Therefore, each of the NBMSI metadata standard entries has been attributed an ID. These IDs should be imbedded in direct relation to their specific entry of the metadata standard in the IPTC Description field.

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<sup>10</sup> Storing it in a separate file, to facilitate particular practical or system interventions is supplemental. A script can always extract the metadata from the original image file. But, the original image file and the separate (meta)datafile can get separated.

## THE KU LEUVEN NBMSI METADATA STANDARD

- 1. Identification Information (IDI): This category covers the basic information data fields. These should also be in accordance with external standards such as *Dublin Core*.**

**1.1 Resource Identifier [ID0101]:** Any unique, preferable digital, identification number used to reference the imaged resource. That number is preceded by the issuer (in most cases an institute or collection holder) of the identifier. The separator between the ‘issuer’ and ‘identifier’ is a ‘\_’ (i.e. underscore). This entry can be multiplied.

Ex. 1: “IDI\_Resource\_Identifier: KU Leuven Archives\_ScopeID849162”

CORE: Yes TYPE: Compound DOMAIN: Text

**1.1.1 File Name [ID010101]:** A unique identifier for the data file or files assigned to the original image or scanned data. It is good practice to include all image file names captured in one and the same acquisition sequence (stack), in the order they were made. As such one is informed the particular image is part of a broader NBMSI imaging effort. In that case, to know which file name applies to the particular file look at “CDI\_Content\_Description” (see section 5 below). In that case, the recorded or attributed stack number is placed in front of each listed file name between square brackets, no separator; between the listed file names each time an enter command.

Ex. 1:

“IDI\_File\_Name: BE\_MSB\_MS328\_f003r\_01”

Ex. 2:

“IDI\_File\_Name:

[001]LCP\_LCP0118-recto01-365N\_001\_F  
 [002]LCP\_LCP0118-recto01-385N\_002\_F  
 [003]LCP\_LCP0118-recto01-410N\_003\_F  
 [004]LCP\_LCP0118-recto01-420N\_004\_F  
 [005]LCP\_LCP0118-recto01-450N\_005\_F  
 [006]LCP\_LCP0118-recto01-480N\_006\_F  
 ...”

CORE: Yes TYPE: Single DOMAIN: Text

**1.2 Author or Creator [ID0102]:** The individual or individuals responsible for acquiring content for the data set. One individual per entry; this entry can be multiplied.

Ex. 1:

“IDI\_Author\_Creator: Hendrik Hameeuw”

CORE: Yes TYPE: Compound DOMAIN: Text

**1.3 Contributor [0103]:** Others who have contributed to the content of the resource, data set or study. One contributor per entry; this entry can be multiplied. When no additional contributor is to be defined, a ‘/’ (slash) can be entered.

Ex. 1:

“IDI\_Contributor: Lieve Watteeuw

IDI\_Contributor: Bruno Vandermeulen”

Ex. 2:

“IDI\_Contributor: /”

CORE: No TYPE: Compound DOMAIN: Text

## 2. Environmental and Infrastructural Information (EII): This category covers the infrastructure and set up that was used in the capture of multi-spectral images.

Diagram 1 shows the standard setup used for narrow band multi-spectral imaging at KU Leuven. The features on the image are intended to help documentation of the capture environment and will be elaborated on in the definition areas of the data fields. The diagram depicts a movable support table, two light panels, an object (representing the material being scanned) and the camera. The two panels are positioned on either side of the table and can be raised and lowered, as can the height of the table itself. For consistency the light panel on the left – when you are facing the set-up – is to be known as “Light Source 1,” while the panel on the right will be “Light Source 2.” The panels can be moved to angle the light differently depending on how the image is to be captured. In the final image capture the rotation that occurs might result in the light emitted by the left panel to be visible in the right side of the image and the light emitted by the right panel visible on the left in the case the image is rotated 180°. Note that should a transmitting panel be in use the light panels will not be in use at the same time. When the transmitting panel is in use the panel will rest over the object on the table.

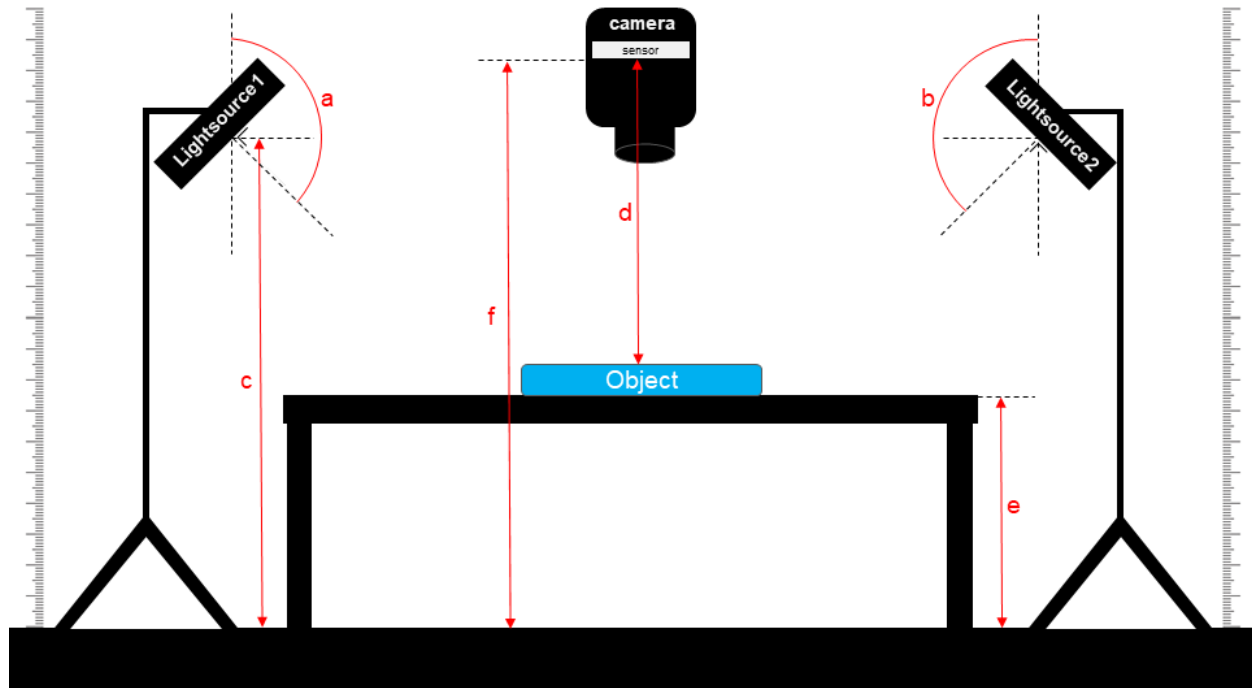
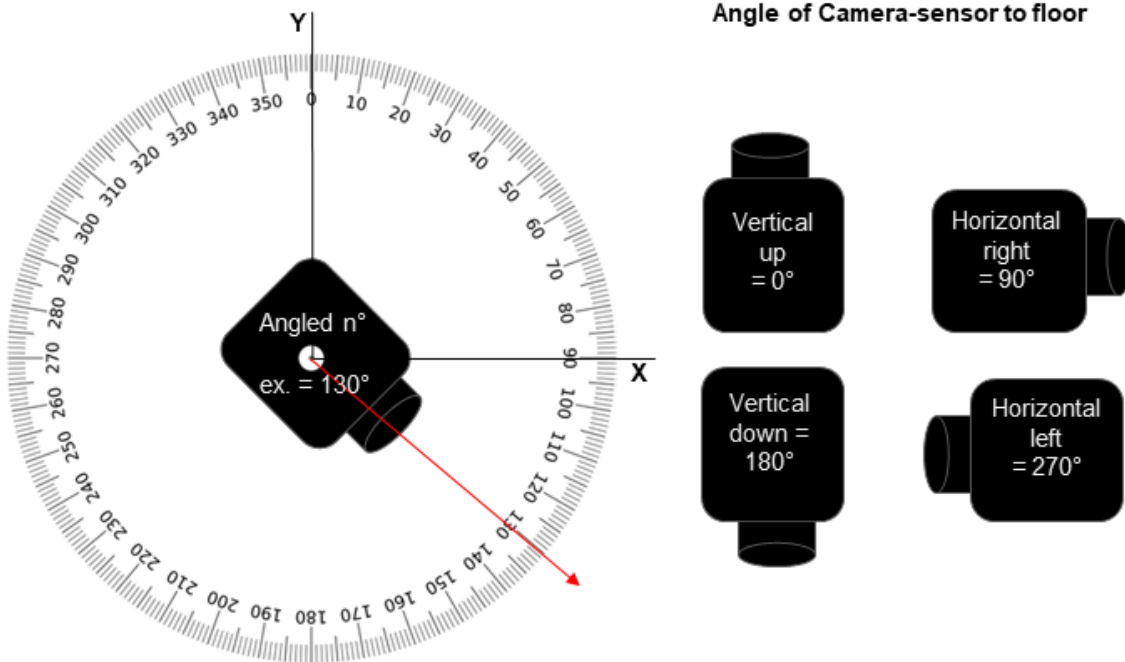


Diagram 1

*Front view on general set-up, heights and angles of various hardware*

Diagram 1 shows the standard image capture setting. In a standard image capture setting the light that is being emitted by the panels is reflected by the object and this reflected light is being captured by the camera sensor. In the capture setting when the transmitting panel is in use the light source is a backlighting system and therefore the light that is being recorded by the camera sensor is the emitted light from the light source transmitted by the object and not light reflected by the object.

In non-standard image capture settings the camera may be mounted differently and therefore the angle may change. Diagram 2 demonstrates the different camera angles that may be measured when using a non-standard setting. Measurements of the camera angles are to be taken from the straight perpendicular line to the floor (the Y-axis). **This measurement will be referred to as “y” in the definitions of the metadata.**



*Diagram 2*  
*Front view on set-up camera-sensor*

Diagram 3 shows how the alignment of light sources can change in non-standard capture environments. The diagram illustrated the horizontal plane and how to measure the alignment of the light sources from that measurement. This is especially important if the alignment is different and the set-up is asymmetrical.



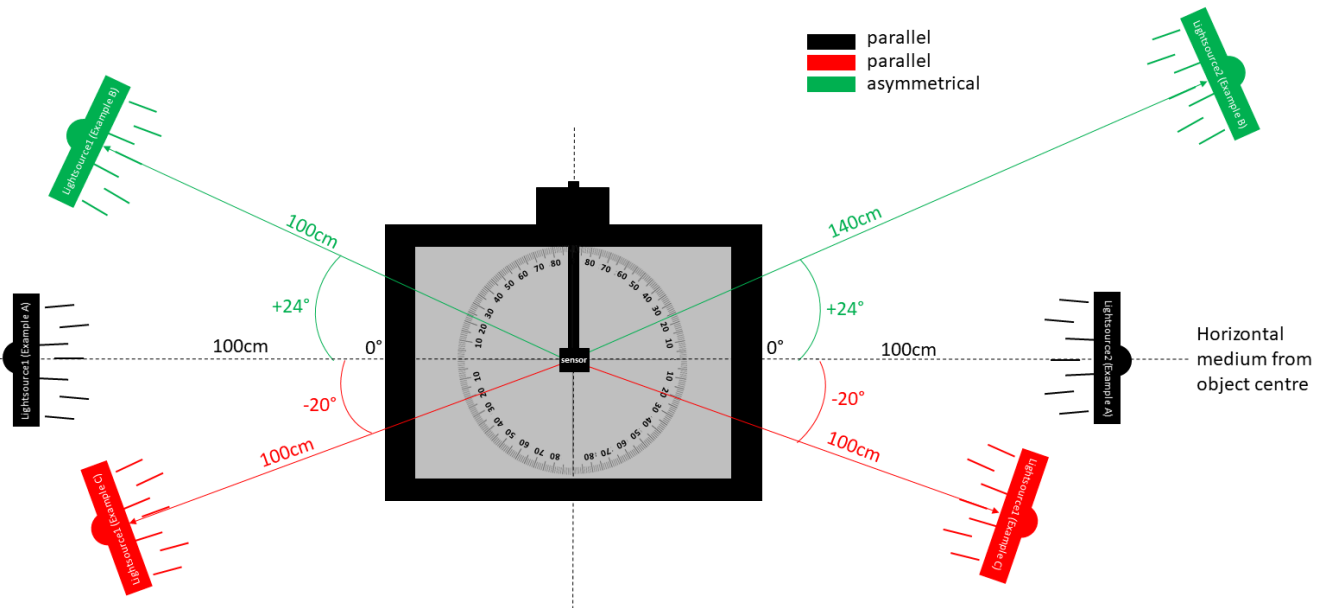


Diagram 3:  
Top view on general setup, multiple examples of positions light sources

**2.1 Camera Angle [ID0201]:** This describes the angle of the camera (i.e. the light sensor) in the general set-up in relation to the orientation of the floor. Diagram 2 shows the different positions of the camera: ‘Horizontal left, 270’ and ‘Horizontal right, 90’ shows the camera lens facing at 90° from the Y-axis perpendicular to the floor. ‘Vertical up, 0’ and ‘Vertical down, 180’ shows the camera lens facing up or down from Y-axis perpendicular to the floor. ‘Angled n°’ shows the camera at any angle ‘n’ in between the vertical up (0°) and the horizontal (90° and 270°) positions. The standard camera angles must be entered (‘vertical up, 0’, ‘vertical down, 180’, ‘horizontal right, 90’, ‘horizontal left, 270’); or the numerical amount in degrees that the angle deviates from 0° (i.e. from the Y-axis, see Diagram 2). The ‘°’ is not included in the entry and the separator between the ‘camera position’ and ‘°’ value is a ‘\_’ (i.e. underscore).

Ex. 1:

“EII\_Camera\_Angle: Vertical\_down\_180”

Ex. 2:

“EII\_Camera\_Angle: Angled\_130”

Ex. 3:

“EII\_Camera\_Angle: Horizontal\_90”

CORE: Yes TYPE: Single DOMAIN: Text

**2.2 Distance camera sensor to the Centre of the Object [ID0202]:** The distance from the center of the camera sensor to the center of the object being photographed as shown in diagram 1 as ‘d’. The value entered reflects a measurement in cm. The ‘cm’ is not included in the entry.

Ex. 1:  
 “EII\_Dist\_to\_Center\_Object: 110”

CORE: Yes TYPE: Single DOMAIN: Real Number

**2.3 Height of Sensor from floor level [ID0203]:** The height (distance) of the camera sensor from the floor measured in cm. This is shown in diagram 1 as ‘f’. The value entered reflects a measurement in cm. The ‘cm’ is not included in the entry.

Ex. 1:  
 “EII\_Dist\_Sensor\_to\_Floor: 178”

CORE: Yes TYPE: Single DOMAIN: Real Number

**2.4 Height of Table [ID0204]:** The height (distance) of the top of the table, or the surface on which the object being imaged rests, from the floor. This is shown in diagram 1 as ‘e’. The value entered reflects a measurement in cm. The ‘cm’ is not included in the entry.

Ex. 1:  
 “EII\_Height\_Table: 82.1”

CORE: Yes TYPE: Single DOMAIN: Real Number

**2.5 Height of Light Source from floor level [ID0205]:** This is the height (distance) of the light panels from the floor on which the light sources stand or have been mounted above. The value is shown in diagram 1 as ‘c’, and is measured from the center of the light panel to the floor. If a transmitting panel is used, this field should be marked as “Transmitting”. The entered values per light source in this entry should be separated by a comma, and reflects a measurement in cm. The ‘cm’ is not included in the entry and the separator between the ‘Light source’ and ‘cm’ value is a ‘\_’ (i.e. underscore).

Ex. 1:  
 “EII\_Height\_Light\_Source: Lightsource1\_153, Lightsource2\_153”  
 Ex. 2:  
 “EII\_Height\_of\_Light\_Source: Transmitting”

CORE: Yes TYPE: Compound DOMAIN: Lightsource1 = n Lightsource2 = n

**2.6 Light Sources IDs [ID0206]:** This is the unique identification number of one particular light source. This information can possibly be found when the light source is connected to a computer and recognized by accompanying image capture software (for ex. Spectral XV recognizes the Eureka light panels with their unique IDs). The Entries into this field should be written as: Lightsource1[or 2]\_Device ID\_[and when possible, an additional]Device Name. The Light Source ID makes it possible to identify the type of light source used for the imaging and should give the potential to find their technical documentation form/sheet.<sup>11</sup> The entered values per light source in this entry should be separated by a comma and the separator between the ‘Light source’, ‘Device ID’ and ‘Device Name’ is a ‘\_’ (i.e. underscore).

Ex. 1:

“EII\_Light\_Source\_IDs: Lightsource1\_reflective0205-20181208-equi\_Left-0205-Light1, Lightsource2\_0206-20181208-equi\_Right-0206-Light1”

Ex. 2:

“EII\_Light\_Source\_IDs: Lightsource1\_0205-20181208-equi\_Left-0205-Light1, Lightsource2\_0206-20181208-equi\_Right-0206-Light1, Lightsource3\_0302\_TX20190516\_equi\_TX-0302-Light3”

CORE: Yes TYPE: Compound DOMAIN: Text

**2.7 Angle of Light Source [0207]:** This describes the angle of the light sources in the general set-up in relation to the orientation of the floor. If a transmitting panel (backlight) is the light source the entry should be ‘Transmitting’. In diagram 1 the ‘a’ and ‘b’ mark the angles which should be entered. In general, the same principles as used for “2.1 Camera Angle” are followed. When the light source is perpendicular to the floor and pointing up that is 0°; when pointing down 180°. For all angles between 0° and 180° the center point is the imaged object/surface (i.e. the left light source and its determination of the angle is mirrored compared to the right light source: for all light sources the protractor is oriented towards the imaged object). Thus, when the left or the right light source are in a straight angle perpendicular to the floor-axis (in a diagram the Y-axis), and in the direction of the imaged object, for both light sources the angle is 90° (and not for the left 90° and for the right 270°). The values for the light sources in this entry should be separated by a comma. The ‘°’ is not included in the entry and the separator between the ‘Lightsource’ and the ‘angle’ value is a ‘\_’ (i.e. underscore). When multiple light sources have been used throughout the NBMSI stack, the same numbering of the light sources should be followed as used under 2.6.

Ex. 1:

“EII\_Angle\_Light\_Sources: Lightsource1\_134, Lightsource2\_134”

<sup>11</sup> For ex. for the Eureka light panels that is the “KU Leuven - 3Pi Project NBMSI Hardware Document” (<https://doi.org/10.5281/zenodo.3607302>); for the Fabrizio ultraviolet lamp that is <https://chsopensource.org/ultraviolet-lamp/> (visited 2020-04-06)

Ex. 2:

“EII\_Angle\_Light\_Sources: Lightsource1\_134, Lightsource2\_134”,  
Lightsource3\_Transmitting”

CORE: Yes TYPE: Single DOMAIN: Text

**2.8 Position of Light Sources [ID0208]:** The position of the light panels relative to the object. If the distance from the center of the object is the same they should be marked as “parallel” and the measurement from the center of the object in cm should be entered. If the panels are at different distances they should be marked as “asymmetrical” and the distance of Light Source 1 and Light Source 2 to the object should be entered in cm. If a transmitting panel (backlight) is used this field should be marked as “transmitting” and the distance in cm of the transmitting panel to the object should be given. If the light source is not aligned with the object at 0° on the horizontal medium from the object center – as shown in diagram 3 – the angle in degrees (0° to 90°) that the light source is positioned ‘above’ (+) and ‘below’ (-) the horizontal medium from the object center should also be included; when aligned mark as 0. This entry should also include the relative position of the light source in relation to the object: “left”, “right”, “behind”, “above”. The entered values in this field should be separated by a comma. The ‘cm’ nor ‘°’ is included in the entry and the separator between the ‘dist/pos’, ‘light source’ and ‘°’ or ‘cm’ values is a ‘\_’ (i.e. underscore). When multiple light sources have been used throughout the NBMSI stack, the same numbering of the light sources should be followed as used under 2.6.

Ex. 1:

“EII\_Position\_Light\_Source: Lightsource1\_parallel\_left\_dist\_100\_pos\_0,  
Lightsource2\_parallel\_right\_dist\_100\_pos\_0; Lightsource3\_transmitting\_behind\_dist\_0”

Ex. 2:

“EII\_Position\_Light\_Source: Lightsource1\_asymmetrical\_Left\_dist\_102\_pos\_35,  
Lightsource2\_asymmetrical\_right\_dist\_130\_pos\_45”

CORE: Yes TYPE: Single DOMAIN: Text

**2.9 Applied Light [ID0209]:** The specific light that is applied to the object. The type of light emitter use for the particular captured image must be indicated. These can be one of a variety of lighting systems and the examples below are to be referred to only to demonstrate the manner of recording the values of the system in place, not as the only options for values. Secondly, insights in the spectral behavior of the applied light should be included in this entry. Light emitters with a single peak wavelength must indicate this wavelength in nanometer (the ‘nm’ is not included in the entry). Emitters which emit a range of wavelengths should specify the range in nm (for ex. 450-1000, the ‘nm’ is not included in the entry); that is also the case when white light emitted (for ex. 390-710). Thirdly, part of the entry must also be how the applied light has been used for the captured image (how the light source is being recorded by the camera sensor), three examples:

Reflection, Transmitting, Fluorescence. The three requirements for entries of values in this field should be separated by a comma.

It is good practice to include all applied lights used in one and the same acquisition sequence (stack), in the order they were made. As such one is informed the particular image is part of a broader NBMSI imaging effort. In that case, to know which type of light applies to the particular file look at “CDI\_Content\_Description” (see section 5 below). In the case, the recorded or attributed stack number is placed in front of each listed file name between square brackets, no separator; between the listed applied lights each time an enter command.

Ex. 1:

“EII\_Applied\_Light: Reflection, LED, 450”

Ex. 2:

“EII\_Applied\_Light: Reflection, Flash bulb, 400-950”

Ex. 3:

“EII\_Applied\_Light: Transmitting, LED, 850”

Ex. 4:

“EII\_Applied\_Light: Fluorescence, TL tube, 365”

Ex. 5:

“[001]Reflecting, LED, 365

[002]Reflecting, LED, 385

[003]Reflecting, LED, 410

[004]Reflecting, LED, 420

[005]Reflecting, LED, 450

[006]Reflecting, LED 480

[007]Reflecting, LED, 510

[008]Reflecting, LED, 530

...”

CORE: Yes TYPE: Single DOMAIN: Text

**2.9.1 Intensity of Light Source [ID020901]:** Depending on the type of light source the intensity of the light can be controlled according to a scale. When that scale is a percentage of a full power the entry should include ‘percent’ and the applied percentage used during the capture of the image (the ‘%’ is not included in the entry). When another scale is used for the power distribution the entry should include ‘value’ and the numeric value as indicated by the power system of the light source system used for that capture of the image is given. When the intensity cannot be controlled when the light source is illuminated, that can be seen as an entry in ‘percent’ with a percentage of 100. The entered values per light source in this field should be separated by a comma and the separator between the ‘Lightsource’, ‘percent or value’ and ‘real number’ is a ‘\_’ (i.e. underscore).

Ex. 1

"EII\_Intensity\_Light\_Source: Lightsorce1\_percent\_100, Lightsorce2\_percent\_100"

Ex. 2

"EII\_Intensity\_Light\_Source: Lightsouce1\_value\_7.5, Lightsorce2\_value\_7.5"

CORE: Yes TYPE: Single DOMAIN: Real Number

**2.10 Filters Lens [ID0210]:** These are any filters applied in front of the lens (i.e. between the lens and the imaged object) during image capture. When the filter is a 'band pass' or a 'long pass', that must be indicated in this entry. Also the spectral wavelength specifications for that filter must be entered. For 'band pass' filters the peak wavelength must be indicated or the range of wavelengths must be indicated in nanometer (for ex. '365' or '450-560'; the 'nm' is not included in the entry). For 'long pass' filter the wavelength value in nanometers at the fifty percent point of transmittance must be recorded (again, the 'nm' is not included in the entry). If a 'circular' or 'linear polarization' filter is used this must be included in the entry. For a 'linear polarization' filter the angle of rotation that the filter has been placed at must be recorded. This can be measured from the Y value (axis going up, i.e. orientated towards the top of the light sensor) in a diagram and is in increments of 90° (0°, 90°, 180° and 270°) rotating clockwise (the '°' is not included in the entry). If the capture is conducted with a 'neutral filter' this must also be recorded in the entry, without further numeric value; equally when no filter is applied, enter 'No filter'. The entered values in this field should be separated from the type of filter by a comma.

It is good practice to include all applied filters used in one and the same acquisition sequence (stack), in the order they were made. As such one is informed the particular image is part of a broader NBMSI imaging effort. In that case, to know which type of filter applies to the particular file look at "CDI\_Content\_Description" (see section 5 below). In that case, the recorded or attributed stack number is placed in front of each listed filter between square brackets, no separator; between the listed applied filters each time an enter command.

Ex. 1:

"EII\_Filters\_Lens: Long pass, 450"

Ex. 2 :

"EII\_Filters\_Lens: Band pass, 400-700"

Ex. 3:

"EII\_Filters\_Lens: Linear polarization, 270"

Ex. 4

"EII\_Filters\_Lens: No filter"

Ex. 5: "EII\_Filters\_Lens:

[001]No filter

[002]No filter

[003]No filter

[004]No filter  
 [005]No filter  
 [006]No filter  
 [007]No filter  
 [008]No filter  
 [009]No filter  
 [010]No filter  
 [011]No filter  
 [012]No filter  
 [013]No filter  
 [014]No filter  
 [015]No filter  
 [016]No filter  
 [017]Band pass, 370  
 [018]Long pass, 515  
 [019]Long pass, 515  
 ...”

CORE: Yes TYPE: Compound DOMAIN: Text

**2.11 Filters Light Source [ID0211]:** Any additional filter that is placed between the light source and the object. When the filter is a ‘band pass’ or a ‘long pass’, when possible or known, that should be indicated in this entry. Also the spectral wavelength specifications for that filter must be entered. For ‘band pass’ filters the peak wavelength must be indicated or the range of wavelengths must be indicated in nanometer (for ex. ‘365’ or ‘450-560’; the ‘nm’ is not included in the entry). For ‘long pass’ filter the wavelength value in nanometers at the fifty percent point of transmittance must be recorded (again, the ‘nm’ is not included in the entry). If a ‘circular’ or ‘linear polarization’ filter is used this must be included in the entry. For a ‘linear polarization’ filter the angle of rotation that the filter has been placed at must be recorded. This can be measured from the y value (axis going up, i.e. orientated towards the top of the light source) in a diagram and is in increments of 90° (0°, 90°, 180° and 270°) rotating clockwise (the ‘°’ is not included in the entry). If the capture is conducted with a ‘neutral filter’ this must also be recorded in the entry, without further numeric value; equally when no filter is applied, enter ‘No filter’. The entered values in this field should be separated from the type of filter by a comma.

It is good practice to include all applied filters used in one and the same acquisition sequence (stack), in the order they were made. As such one is informed the particular image is part of a broader NBMSI imaging effort. In that case, to know which type of filter applies to the particular file look at “CDI\_Content\_Description” (see section 5 below). In that case, the recorded or attributed stack number is placed in front of each listed filter between square brackets, no separator; between the listed applied filters each time an enter command.

Ex. 1 "EII\_Filters\_LightSource: Long pass, 450"  
 Ex. 2 "EII\_Filters\_LightSource: Band pass, 400-700"  
 Ex. 3: "EII\_Filters\_LightSource: Circular polarization"  
 Ex. 4: "EII\_Filters\_LightSource: No filter"  
 Ex. 5: "EII\_Filters\_LightSource:  
 [001]No filter  
 [002]No filter  
 [003]No filter  
 [004]No filter  
 [005]Circular polarization  
 [006]Band pass, 400-700  
 [007]Band pass, 400-700  
 [008]No filter  
 ...

CORE: Yes TYPE: Compound DOMAIN: Text

3. **Imaging Information (IMI): A portion of this information is registered in the element fields (EXIF) that is embedded in the image file by the image capture software.<sup>12</sup> The fields below are additional pertinent fields that give information about the image capture which are not, or are not consequently and always correctly embedded by the image capture software.**

**3.1 DPI [ID0301]:** The DPI or dots per inch of the photograph allows for the user to know the output resolution of the image, even if the image is cropped during processing. Only the value is entered, no dpi suffix.

Ex. 1:  
 "IMI\_DPI: 900"

CORE: Yes TYPE: Single DOMAIN: Real Number

**3.2 Image Capture Software [ID0302]:** This specifies the software application used in order to capture the image. For example 'Spectral XV', 'Capture One' or NIKON D610 (the latter when the

<sup>12</sup> As Imaging Information (IMI) the basic capture information should be automatically embedded in the EXIF-Camera Information fields by the imaging capture system that is being used. Unfortunately, not all image capture systems follow the same procedure and/or give them the same label. The KU Leuven NBMSI metadata standard define as crucial: 'Date created/DateTimeOriginal', 'Make', 'Model', 'Lens (specification)', 'Focal Length', 'Exposure Time', 'FNumber', 'ISO Speed', 'Dimensions (in pixels)', 'Resolution (dpi)'.



images are taken without computer steered software, but directly with a camera). When applicable, the version of the software application should also be marked.

Ex. 1:

“IMI\_Image\_Capture\_Software: Capture One, Spectral XV”

CORE: Yes TYPE: Compound DOMAIN: Text

**3.3 Image Processing software [ID0303]:** This specifies the software application which has been used to process the original (raw) captured image into the current file. This can be partly the same as the 3.2 Image Capture Software, whether or not supplemented with other software applications. Try to be as accurate as possible. For ex., in Spectral XV the processing software is in fact COPE: Capture One Processing Engine. When applicable, the version of the software application should also be marked. If more than one software application is used, it should be entered and separated with a comma.

Ex. 1:

“IMI\_Image\_Processing\_Software: COPE, ImageJ v1.52r-Paleo Toolbox v1-20a”

CORE: Yes TYPE: Compound DOMAIN: Text

**4. Data Type Information (DTI): After the original capture and raw conversion this file was created. The fields below give information on the resulting data file. What it is and what additional processing it that it has gone through.**

**4.1 File Type [ID0401]:** The file type of the final processed image (i.e. after capture in raw the image is processed to a standard output; that is the file in which all gathered information for the NBMSI Metadata Standard has been entered in its IPTC Description field). Use capitals to enter this file extension.

Ex. 1 :

“DTI\_File\_Type: TIFF”

CORE: Yes TYPE: Single DOMAIN: Text

**4.2 File Processing Techniques [ID0402]:** Any processing changes should be registered that have been made to the raw image file to create the final processed image (that is the image file described in this NBMSI Metadata Standard). Among many, examples are: ‘Sharpening Amount 661’, ‘Sharpening Radius 0.8’, ‘Sharpening Threshold 0’, ‘Flattened’, ‘ICCprofile’, ... If there are

preset values that one uses within a processing system these should be recorded here. That entry is preceded by the software application in which it was processed, when applicable, the version of that software application should also be marked. The separator between the 'software application' and 'process' is a '\_' (i.e. underscore). If more than one process is applied, it should be given and separated with a comma.

Ex. 1:

"DTI\_File\_Processing\_Techniques: Spectral XV \_Flattened, Spectral XV\_ ICCProfile Phase One Gray G1.0"

CORE: Yes TYPE: Compound DOMAIN: Text

**5. Content Description Information (DCI): This specifies which image of the captured dataset or stack is described in this NBMSI Metadata Standard.**

**5.1 Content Description [ID0501]:** This is a brief description of the content of the dataset, when possible including the number of shots in the stack, putting single images in relation to other images in the larger dataset which were part of one and the same recording effort. Depending on the situation, the entry is as complete and clear as possible.

Ex. 1:

"CDI\_Content\_Description: Image 07 of 27 NBMSI captures in a stack"

Ex. 2:

"CDI\_Content\_Description: 3"

CORE: Yes TYPE: Single DOMAIN: Text

**6. Metadata Reference Information (MRI): These fields give information about the validity of the metadata; the NBMSI Metadata Standard being implemented and the scheduled review information.**

**6.1 Metadata Status [ID0601]:** A flag for the presence and validity of all core metadata. The value is only 'Valid' if all fields have been determined. A '/' (slash) counts as a determination, when this is a correct representation, not if that '/' is used to indicate an unknown feature.

Ex. 1:

"MRI\_Metadata\_Status: Valid"

CORE: Yes TYPE: Single DOMAIN: "Valid" or "Incomplete"

**6.2 Metadata Date [ID0602]:** The date the metadata was created or last updated.

Ex. 1

"MRI\_Metadata\_Date: 2020-03-31"

CORE: Yes TYPE: Single DOMAIN: Text

**6.3 Metadata Review Date [ID0603]:** The date the metadata was last reviewed. When not yet reviewed enter '/' (slash).

Ex. 1

"MRI\_Metadata\_Review\_Date: 2020-04-02"

CORE: No TYPE: Single DOMAIN: Text

**6.4 Metadata Future Review Date [ID0604]:** The date the metadata is to be reviewed in the future. This can be set as part of a digitization workflow. If that is not part of the digitization workflow enter '/' (slash).

Ex. 1

"MRI\_Metadata\_Future\_Review\_Date: /"

CORE: No TYPE: Single DOMAIN: Text

**6.5 Metadata Creator [ID0605]:** The person or persons responsible for the creation of the metadata. One individual per entry; this entry can be multiplied.

Ex. 1:

"MRI\_Metadata\_Creator: Madeleine Anne Bognar"

CORE: Yes TYPE: Compound DOMAIN: Text

**6.6 Metadata Contact [ID0606]:** The person or persons to be contacted as they are identified to be responsible for the metadata management. One individual per entry; this entry can be multiplied.

Ex. 1:

"MRI\_Metadata\_Creator: Bruno Vandermeulen"

CORE: Yes TYPE: Compound DOMAIN: Text

**6.7 Metadata Standard Name [ID0607]:** The name of the metadata standard used.

Ex. 1:

"MRI\_Metadata\_Standard\_Name: KU Leuven NBMSI Metadata Standard"

CORE: Yes TYPE: Single DOMAIN: Text

**6.8 Metadata Standard Version [ID0608]:** The version of the metadata standard used.

Ex. 1:

"MRI\_Metadata\_Standard\_Version: 1.0"

CORE: Yes TYPE: Single DOMAIN: Text

**6.9 Metadata Extensions [ID0609]:** A reference to extended elements to the standard which may be defined by a metadata producer or the academic community. Extended elements are subjective elements outside the Standard, but needed by the metadata producer or user, sometimes referred to as dynamic metadata. If extended elements are created, they must follow the geospatial and/or Dublin Core guidelines for Creating Extended Elements and this document format.

Ex. 1:

"MRI\_Metadata\_Extensions: produced in dark"

CORE: No TYPE: Compound DOMAIN: Text

## IMPLEMENTATION EXAMPLE 1:

Metadata field drafted according to the specifications in the KU Leuven MSI Metadata Standard (Version 1.0; <https://doi.org/10.5281/zenodo.3607364>).

This image was made together in a sequence with others, all of these shots in the stack are numbered and differ across a number of settings which are registered in the EXIF metadata and in the attributed file name. The stack was made according to the KU Leuven Basic MS Sequence: <https://doi.org/10.5281/zenodo.3675269>, version 1.0. The capture hardware used for this stack is described in <https://doi.org/10.5281/zenodo.3607302>, version 1.0.

IDI\_Resource\_Identifier [ID0101]: KU Leuven Archives\_ScopeID849162

IDI\_File\_Name [ID010101] (number refers to the recorded stack number, only one of them applies to this particular image, see 'CDI\_Content\_Description' to identify which file name applies to this particular image):

[001]LCP\_LCP0118-recto01-365N\_001\_F  
 [002]LCP\_LCP0118-recto01-385N\_002\_F  
 [003]LCP\_LCP0118-recto01-410N\_003\_F  
 [004]LCP\_LCP0118-recto01-420N\_004\_F  
 [005]LCP\_LCP0118-recto01-450N\_005\_F  
 [006]LCP\_LCP0118-recto01-480N\_006\_F  
 [007]LCP\_LCP0118-recto01-510N\_007\_F  
 [008]LCP\_LCP0118-recto01-530N\_008\_F  
 [009]LCP\_LCP0118-recto01-550N\_009\_F  
 [010]LCP\_LCP0118-recto01-600N\_010\_F  
 [011]LCP\_LCP0118-recto01-630N\_011\_F  
 [012]LCP\_LCP0118-recto01-640N\_012\_F  
 [013]LCP\_LCP0118-recto01-660N\_013\_F  
 [014]LCP\_LCP0118-recto01-740N\_014\_F  
 [015]LCP\_LCP0118-recto01-850N\_015\_F  
 [016]LCP\_LCP0118-recto01-940N\_016\_F  
 [017]LCP\_LCP0118-recto01-365U\_017\_F  
 [018]LCP\_LCP0118-recto01-365G\_018\_F  
 [019]LCP\_LCP0118-recto01-410G\_019\_F  
 [020]LCP\_LCP0118-recto01-420G\_020\_F  
 [021]LCP\_LCP0118-recto01-450G\_021\_F  
 [022]LCP\_LCP0118-recto01-365R\_022\_F  
 [023]LCP\_LCP0118-recto01-410R\_023\_F  
 [024]LCP\_LCP0118-recto01-420R\_024\_F  
 [025]LCP\_LCP0118-recto01-450R\_025\_F  
 [026]LCP\_LCP0118-recto01-385V\_026\_F  
 [027]LCP\_LCP0118-recto01-000N\_027\_F  
 IDI\_Author\_Creator [ID0102]: Hendrik Hameeuw  
 IDI\_Contributor [ID0103]: /  
 EII\_Camera\_Angle [ID0201]: Vertical down\_180  
 EII\_Dist\_to\_Center\_Object [ID0202]: 110  
 EII\_Dist\_Sensor\_to\_Floor [ID0203]: 182.5  
 EII\_Height\_of\_Table [ID0204]: 82.1  
 EII\_Height\_Light\_Source [ID0205]: Lightsource1\_153, Lightsource2\_153  
 EII\_Light\_Source\_IDs [ID0206]: LightSource1\_0205-20181207-eqpi\_Left-0205-Light1,  
 Lightsource2\_0206-20181208-eqpi\_Right-0206-Light2  
 EII\_Angle\_Light\_Sources [ID0207]: Lightsource1\_35, Lightsource2\_31  
 EII\_Position\_Light\_Source [ID0208]: Parallel, dist\_Lightsource1\_100, dist\_Lightsource2\_100,  
 pos\_Lightsource1\_0, pos\_Lightsource2\_0

EII\_Applied\_Light [ID0209] (number refers to the recorded stack number, only one of them applies to this particular image, see 'CDI\_Content\_Description' to identify which light applies to this particular image):

- [001]Reflecting, LED, 365
- [002]Reflecting, LED, 385
- [003]Reflecting, LED, 410
- [004]Reflecting, LED, 420
- [005]Reflecting, LED, 450
- [006]Reflecting, LED 480
- [007]Reflecting, LED, 510
- [008]Reflecting, LED, 530
- [009]Reflecting, LED, 550
- [010]Reflecting, LED, 600
- [011]Reflecting, LED, 630
- [012]Reflecting, LED, 640
- [013]Reflecting, LED, 660
- [014]Reflecting, LED, 740
- [015]Reflecting, LED, 850
- [016]Reflecting, LED, 940
- [017]Reflecting, LED, 365
- [018]Fluorescent, LED, 365
- [019]Fluorescent, LED, 410
- [020]Fluorescent, LED, 420
- [021]Fluorescent, LED, 450
- [022]Fluorescent, LED, 365
- [023]Fluorescent, LED, 410
- [024]Fluorescent, LED, 420
- [025]Fluorescent, LED, 450
- [026]Fluorescent, LED, 385
- [027]None, LED, 000

EII\_Intensity\_of\_Light\_Source [ID020901]: Lightsouce1\_percent\_100,  
Lightsource2\_percent\_100

EII\_Filters\_Lens [ID0210] (number refers to the recorded stack number, only one of them applies to this particular image, see 'CDI\_Content\_Description' to identify which filter applies to this particular image) “

- [001]No filter
- [002]No filter
- [003]No filter
- [004]No filter
- [005]No filter
- [006]No filter

[007]No filter  
 [008]No filter  
 [009]No filter  
 [010]No filter  
 [011]No filter  
 [012]No filter  
 [013]No filter  
 [014]No filter  
 [015]No filter  
 [016]No filter  
 [017]Band pass, 370  
 [018]Long pass, 515  
 [019]Long pass, 515  
 [020]Long pass, 515  
 [021]Long pass, 515  
 [022]Long pass, 590  
 [023]Long pass, 590  
 [024]Long pass, 590  
 [025]Long pass, 590  
 [026]Long pass, 435  
 [027]No Filter  
 EII\_Filters\_LightSource [ID0211]: **No filter**  
 IMI\_DPI [ID0301]: **900**  
 IMI\_Image\_Capture\_Software [ID0302]: **Spectral XV**  
 IMI\_Image\_Processing\_Software [ID0303]: **COPE, ImageJ v1.52r-Paleo Toolbox v1-20a**  
 DTI\_File\_Type [ID0401]: **TIFF**  
 DTI\_File\_Processing\_Techniques [ID0402]: **Spectral XV\_Flattened, Spectral XV\_Color Profile  
 Phase One Gray G1.0, COPE\_Orientation 180°**  
 CDI\_Content\_Description [ID0501]: **Image XX of 27 NBMSI captures in a stack**  
 MRI\_Metadata\_Status [ID0601]: **Valid**  
 MRI\_Metadata\_Date [ID0602]: **2020-01-14**  
*MRI\_Metadata\_Review\_Date [ID0603]: 2020-04-07*  
*MRI\_Metadata\_Future\_Review\_Date [ID0604]: /*  
 MRI\_Metadata\_Creator [ID0605]: **Hendrik Hameeuw**  
 MRI\_Metadata\_Contact [ID0606]: **Bruno Vandermeulen**  
 MRI\_Metadata\_Standard\_Name [ID0607]: **KU Leuven NBMSI Metadata Standard**  
 MRI\_Metadata\_Standard\_Version [ID0608]: **1.0**  
*MRI\_Metadata\_Extensions [ID0609]: /*

## IMPLEMENTATION EXAMPLE 2:

**Note 1:** ID entries which have no value are indicated with a '/'. IDs which have a value, but are to be found elsewhere in the provided metadata are indicated with '000'; between round brackets it is/should be explained where the correct value for that ID is to be found or can be generated.

**Note 2:** the example below is an extraction, i.e. the section which is based on the NBMSI Metadata Standard, form all the metadata generated by the Spectral XV software package version 2.1.1.4 by (R. B. Toth Associates LLC/Equipoise Imaging LLC). Therefore, when metadata has been automatically generated by this software, i.e. metadata defined to be of importance in the NBMSI Metadata Standard, for these values reference is made between round brackets in front of the related IDs.

**Note 3:** the combination ID and the value of the entry always have the same structure: ... [IDXXXX]:ENTRY; ... [IDXXXX]:ENTRY; ... .

**Note 4:** the discussed matter in the above notes are a first attempt to facilitate and streamline machine readability (in this case with an output generated by the Spectral XV software package), but is not yet optimal, and should be refined in future versions of implementation examples.

Metadata field drafted according to the specifications in the KU Leuven MSI Metadata Standard (Version 1.1; <https://doi.org/10.5281/zenodo.5255194>; the DOI for all versions of this document is <https://doi.org/10.5281/zenodo.3607363>). This image was made together in a sequence with others, all of these shots in the stack are numbered and differ across a number of settings which are registered in the EXIF metadata and in the attributed file name. The stack was made according to, or based on, the KU Leuven Basic MS Sequence:

<https://doi.org/10.5281/zenodo.4545384>, version 1.1 (always check minor variations in the further EXIF data, a shortened stack occurs frequently). The capture hardware used for this stack is described in <https://doi.org/10.5281/zenodo.3607302>, version 1.1 (the DOI for all versions of this document (.zip) is <https://doi.org/10.5281/zenodo.3607301>).

IDI\_Resource\_Identifier [ID0101]: KU Leuven Archives\_ScopeID849162; IDI\_File\_Name (this file is part of a larger stack for which only one recording applies to this particular image, see 'CDI\_Content\_Description [ID0501]' to identify which file name applies to this particular image)

[ID010101]:000; IDI\_Author\_Creator [ID0102]:Hendrik Hameeuw; IDI\_Contributor [ID0103]:/; EII\_Camera\_Angle [ID0201]:Vertical down\_180; EII\_Dist\_to\_Center\_Object [ID0202]:86; EII\_Dist\_Sensor\_to\_Floor [ID0203]:194; EII\_Height\_of\_Table [ID0204]:

104.5; EII\_Height\_Light\_Source [ID0205]:Lightsource1\_131.5,

Lightsource2\_131.5; EII\_Light\_Source\_IDs [ID0206]:LightSource1\_0205-20181207-eqpi\_Left-0205-Light1, Lightsource2\_0206-20181208-eqpi\_Right-0206-Light2,

Lightsource3\_0302\_TX20190516\_eqpi\_TX-0302-Light3; EII\_Angle\_Light\_Sources

[ID0207]:Lightsource1\_35, Lightsource2\_31,

Lightsource3\_Transmitting; EII\_Position\_Light\_Source

[ID0208]:Lightsource1\_parallel\_left\_dist\_100\_pos\_0,

Lightsource2\_parallel\_right\_dist\_100\_pos\_0,

Lightsource3\_transmitting\_behind\_dist\_0; EII\_Applied\_Light (in this metadata field the value can be found following "LightMode:") [ID0209]:000; EII\_Intensity\_of\_Light\_Source

[ID020901]:Lightsource1\_percent\_100, Lightsource2\_percent\_100,



Lightsource3\_percent\_100;EII\_Filters\_Lens (see <https://doi.org/10.5281/zenodo.3607301>, N=no filter, U=UV bandpass, V=violet longpass, G=Green longpass, R=Red longpass, I=IR longpass, in this metadata field the value can be found as the final letter following “ShotUID:”)  
 [ID02010]:000;EII\_Filters\_LightSource [ID0211]:No filters;IMI\_DPI [ID0301]:900;  
 IMI\_Image\_Capture\_Software [ID0302]:Spectral XV;IMI\_Image\_Processing\_Software  
 [ID0303]:COPE, ImageJ v1.52r-Paleo Toolbox v1-20a;DTI\_File\_Type  
 [ID0401]:TIFF;DTI\_File\_Processing\_Techniques [ID0402]:Spectral XV\_Flattened, Spectral  
 XV\_Color Profile Phase One Gray G2.2;CDI\_Content\_Description (to extract which shot in the  
 recorded stack this description applies to, see in this metadata field the value following on  
 “ShotIndex:”; that value refers to the specific index number given to each of the images in the  
 stack as listed under “SiblingFileNames=”, that is, again in this metadata field, between the curly  
 brackets, the index number is given in three digits just before the ”\_F”)  
 [ID0501]:000;MRI\_Metadata\_Status [ID0601]:Valid;MRI\_Metadata\_Date [ID0602]:2021-07-  
 29;MRI\_Metadata\_Review\_Date [ID0603]:2021-07-29;MRI\_Metadata\_Future\_Review\_Date  
 [ID0604]:/;MRI\_Metadata\_Creator [ID0605]:Hendrik Hameeuw;MRI\_Metadata\_Contact  
 [ID0606]:Bruno Vandermeulen;MRI\_Metadata\_Standard\_Name [ID0607]:KU Leuven NBMSI  
 Metadata Standard;MRI\_Metadata\_Standard\_Version [ID0608]:1.1;MRI\_Metadata\_Extensions  
 [ID0609]:produced in a 100% dark lab environment;