DICOM

Supplement 188
Multi-Energy CT Imaging

DICOM Working Group 21

Computed Tomography

Rationale

Short introduction of Multi Energy (ME) Images

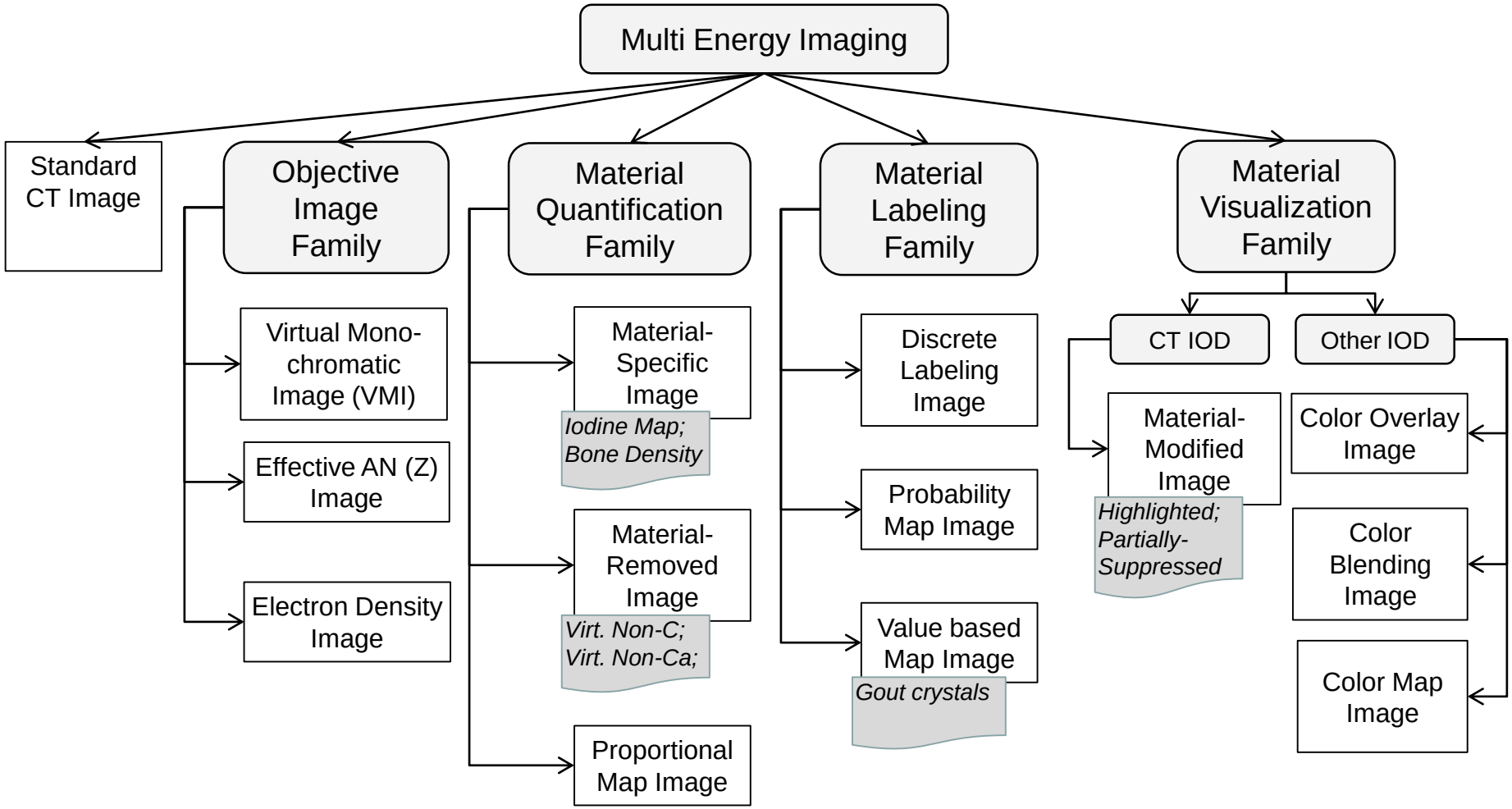
Overview:

- Imaging techniques, including scanning, reconstruction, processing, when the scanner utilizes multiple energies from the X-Ray beam spectrum, as opposed to the conventional CT imaging, when a single (accumulated) X-Ray spectrum is used.
- The existing CT and Enhanced CT (eCT) IODs do not adequately describe the new CT multi-energy imaging. Although different vendors apply different scanning and detection techniques to achieve multi-energy images, there is large commonality in the generated diagnostic images.

Goals for ME Image implementation:

- provide new essential ME information (acquisition, reconstruction and processing attributes) within the IOD.
- facilitate fast and easy adoption of standard based ME imaging across the imaging community, both modalities and PACS/Displays.
- address (or at least to minimize) the risk of mis-interpretation when the ME images are displayed by a display does not support the new attributes of the ME-image, including incorrect measurements
- adapt existing attributes of the CT / Enhanced CT IOD to fit ME techniques.

Overview

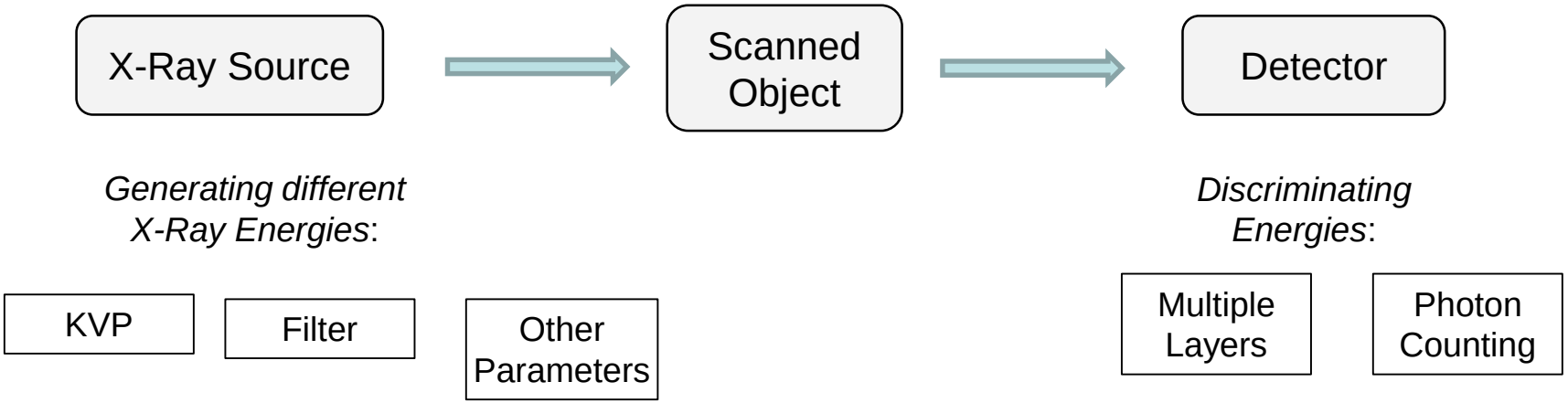

Multi Energy Imaging
Standard CT Image
Objective Image Family
Virtual Mono-chromatic Image (VMI)
Effective AN (Z) Image
Electron Density Image
Material Quantification Family
Material-Specific Image
Iodine Map; Bone Density
Material-Removed Image
Virt. Non-C; Virt. Non-Ca;
Proportional Map Image
Material Labeling Family
Discrete Labeling Image
Probability Map Image
Value based Map Image
Gout crystals
Material Visualization Family
CT IOD
Other IOD
Material-Modified Image
Highlighted; Partially-Suppressed
Color Overlay Image
Color Blending Image
Color Map Image

Organization Structure

Multi-energy CT Macro (*new added to CT IODs*)

- **Multi-energy Flag (Y/N)**
- **Multi-energy CT Acquisition Sequence (1C, 1 item)**
  - Multi-energy CT Acquisition Sequence (1-N)
    - Multi-Energy Source Technique
    - Multi-Energy Detection Technique
    - *Other ME-specific attributes*
    - Common CT Acquisition Macro
- **Multi-energy CT Processing Sequence (1C, 1 item)**
  - Decomposition Method
  - Decomposition Basis Sequence (2-N items, one for each basis)
  - *Other decomposition attributes*
- **Multi-energy CT Characteristics Sequence (1C)**
  - Monochromatic Energy Equivalent (*for Virtual Monochromatic Image*)
  - Multi-energy Quantification CT Image Macro
    - Specific Material Code Sequence
    - Material Modification Sequence
  - Multi-energy Labeling CT Image Sequence (1 item)
    - Material Labeling Type
    - Material Modification Sequence

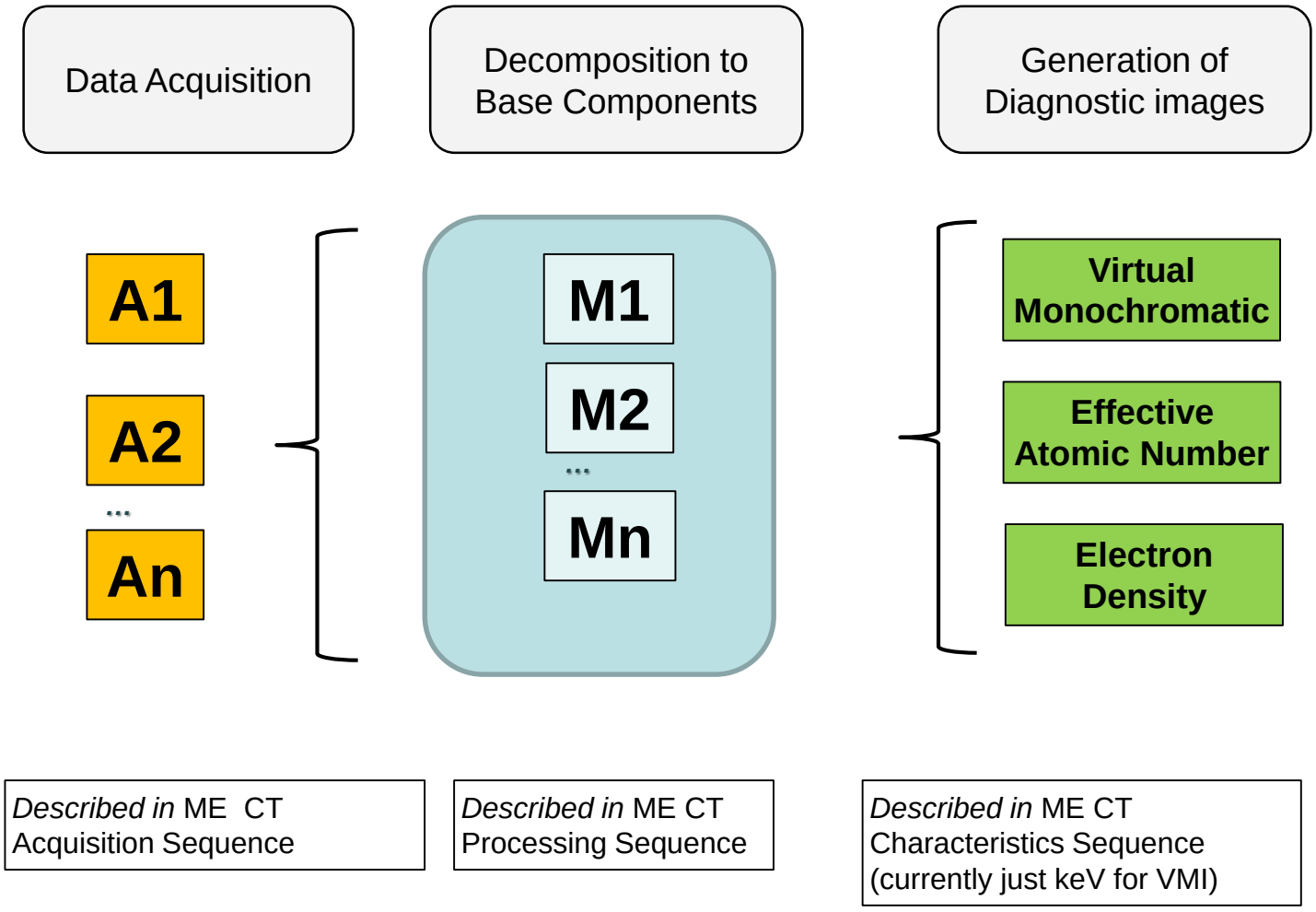
Multi-Energy CT Acquisition Techniques



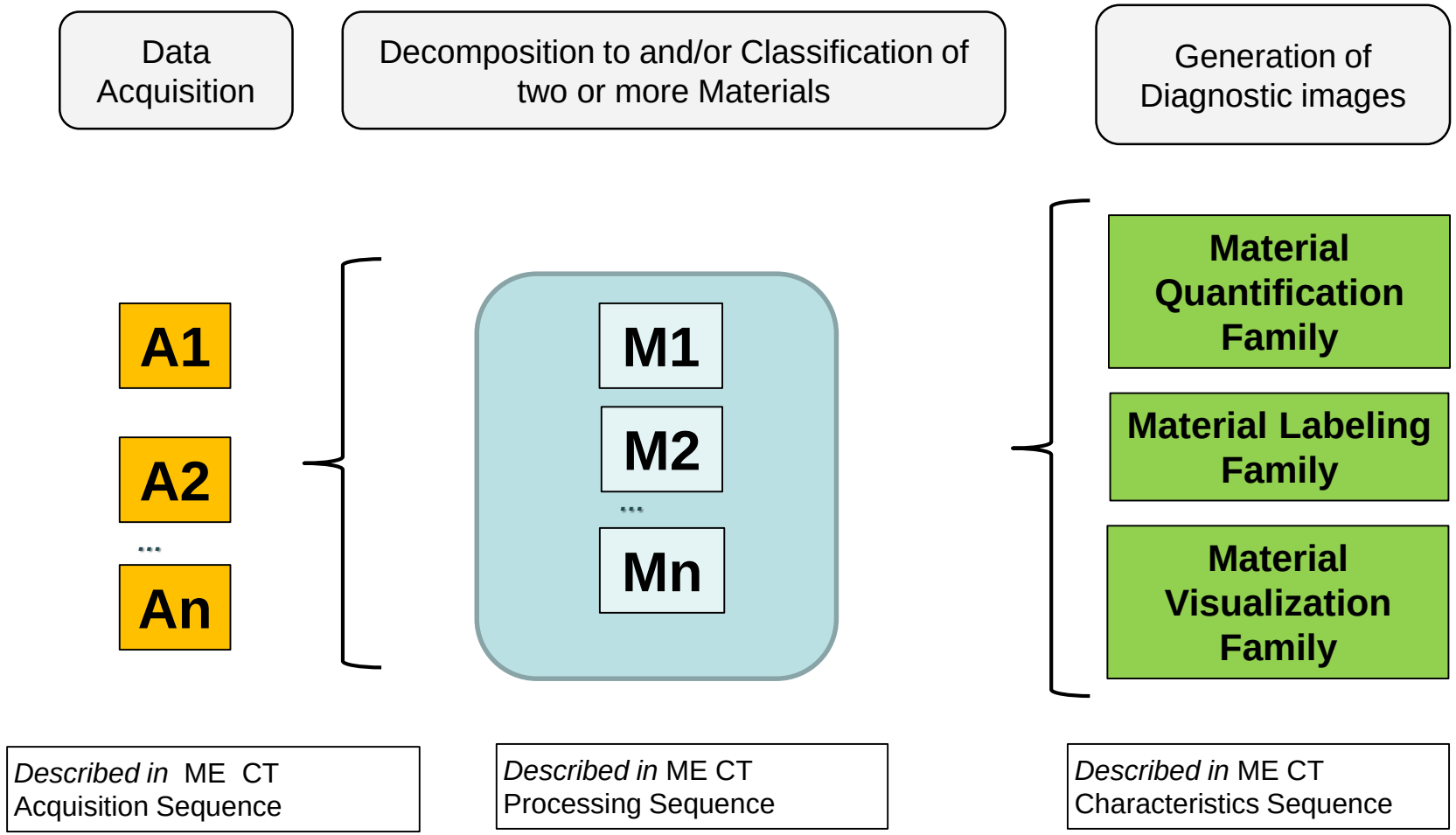
Methods to separate at least two energies include

- **Multiple Scans of the same area with diff parameters**
- **Multiple X-Ray Sources and/or Detectors**
- **Switch KVP during the rotation**
- **One source with Multi-Layer Detector**
- **One source with Photon Counting Detector**

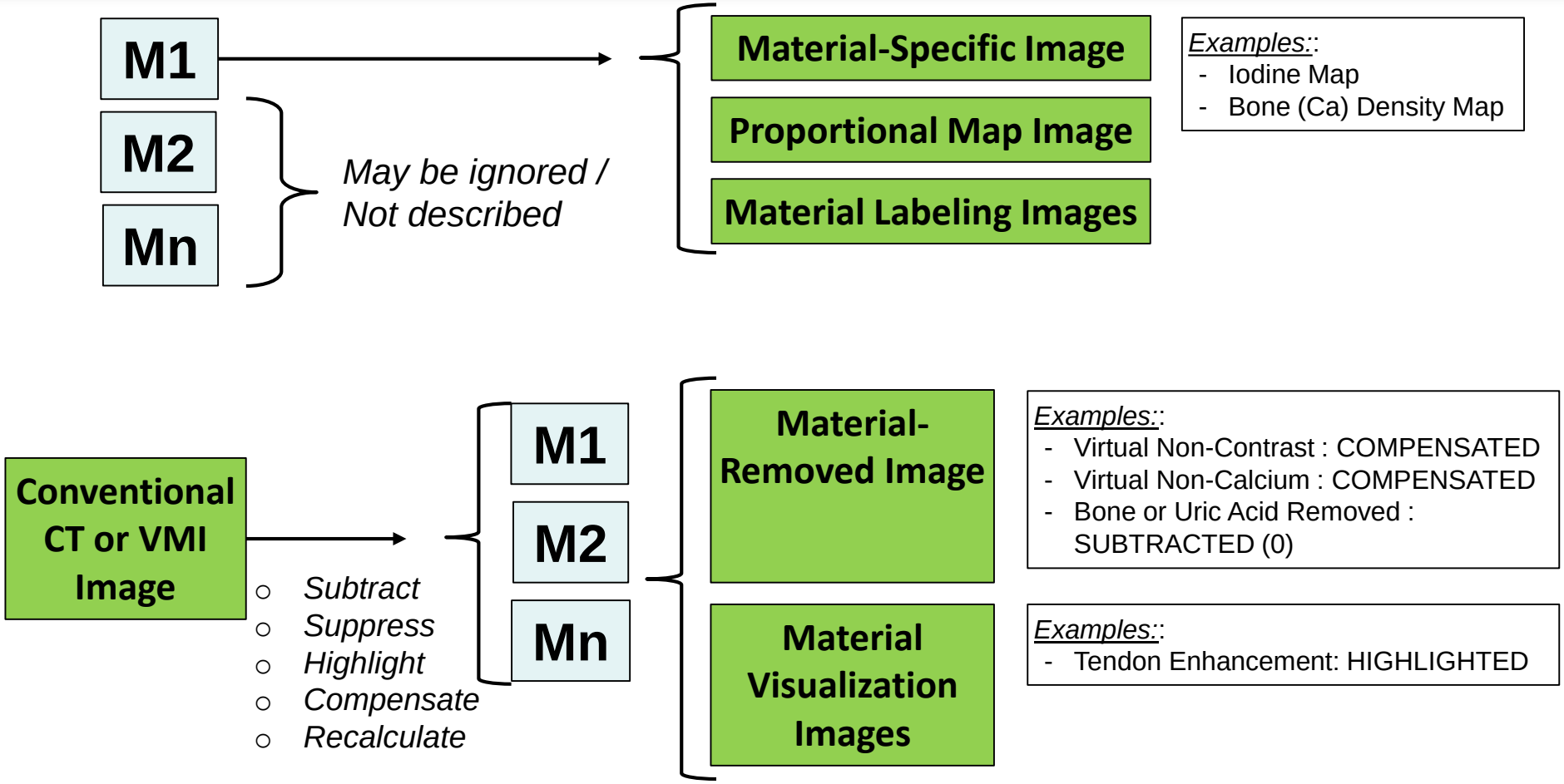
“Objective” Images



“Material” Images

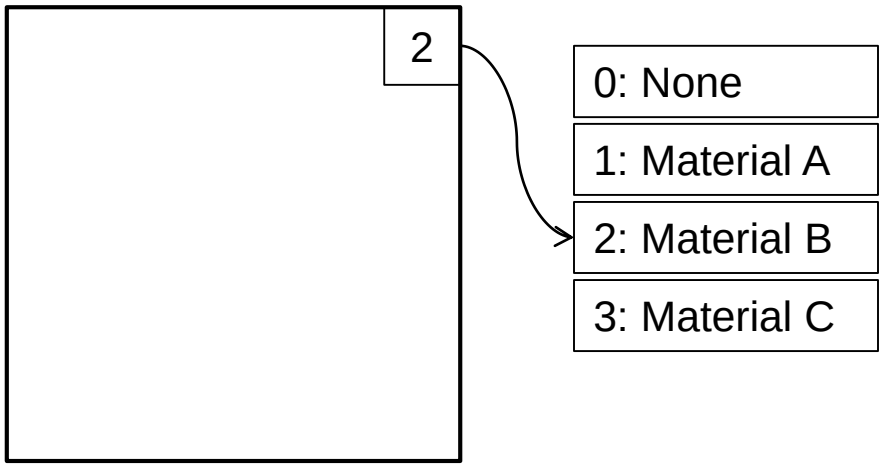


Material Images Generation

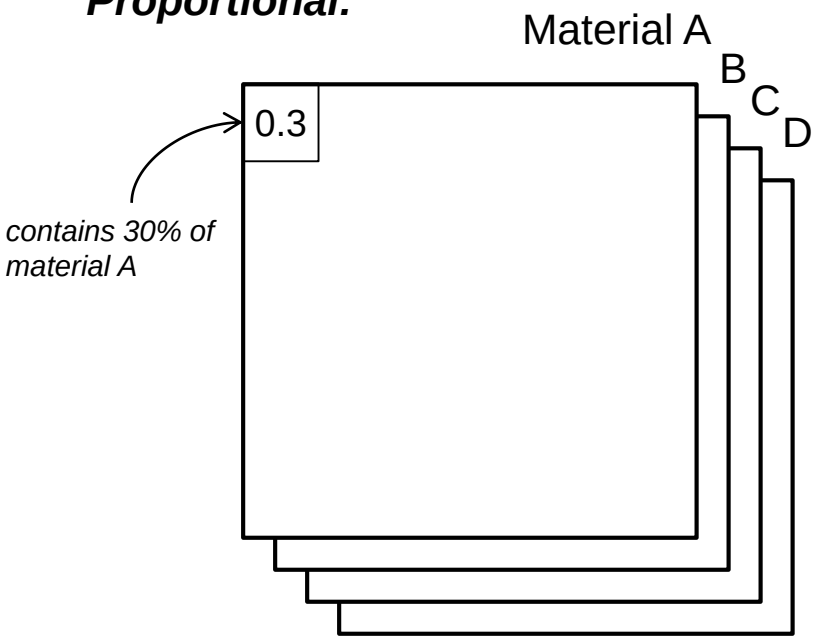


Material Labeling Images

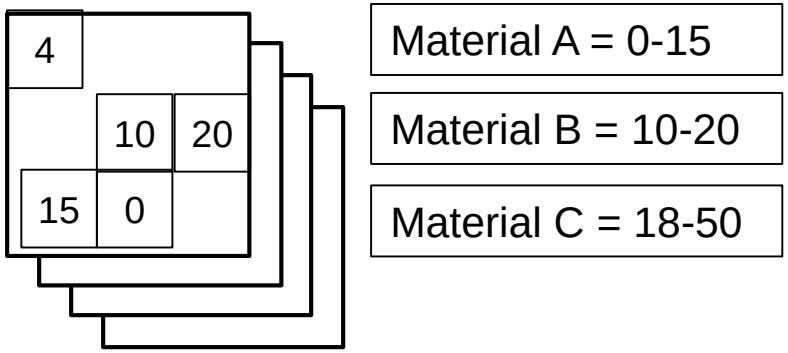
Discrete Labeling *(most-probable material):*



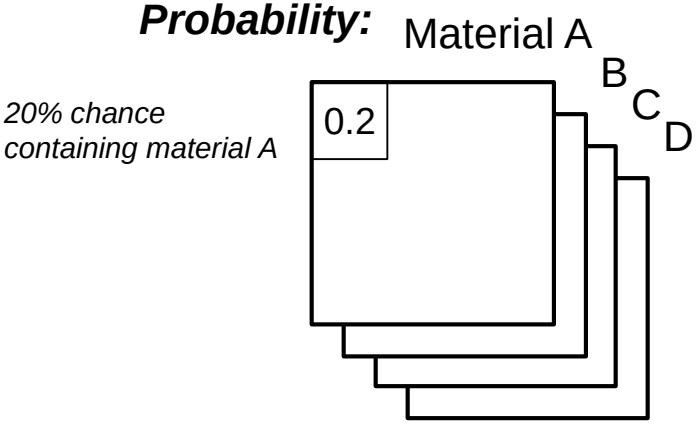
Proportional:



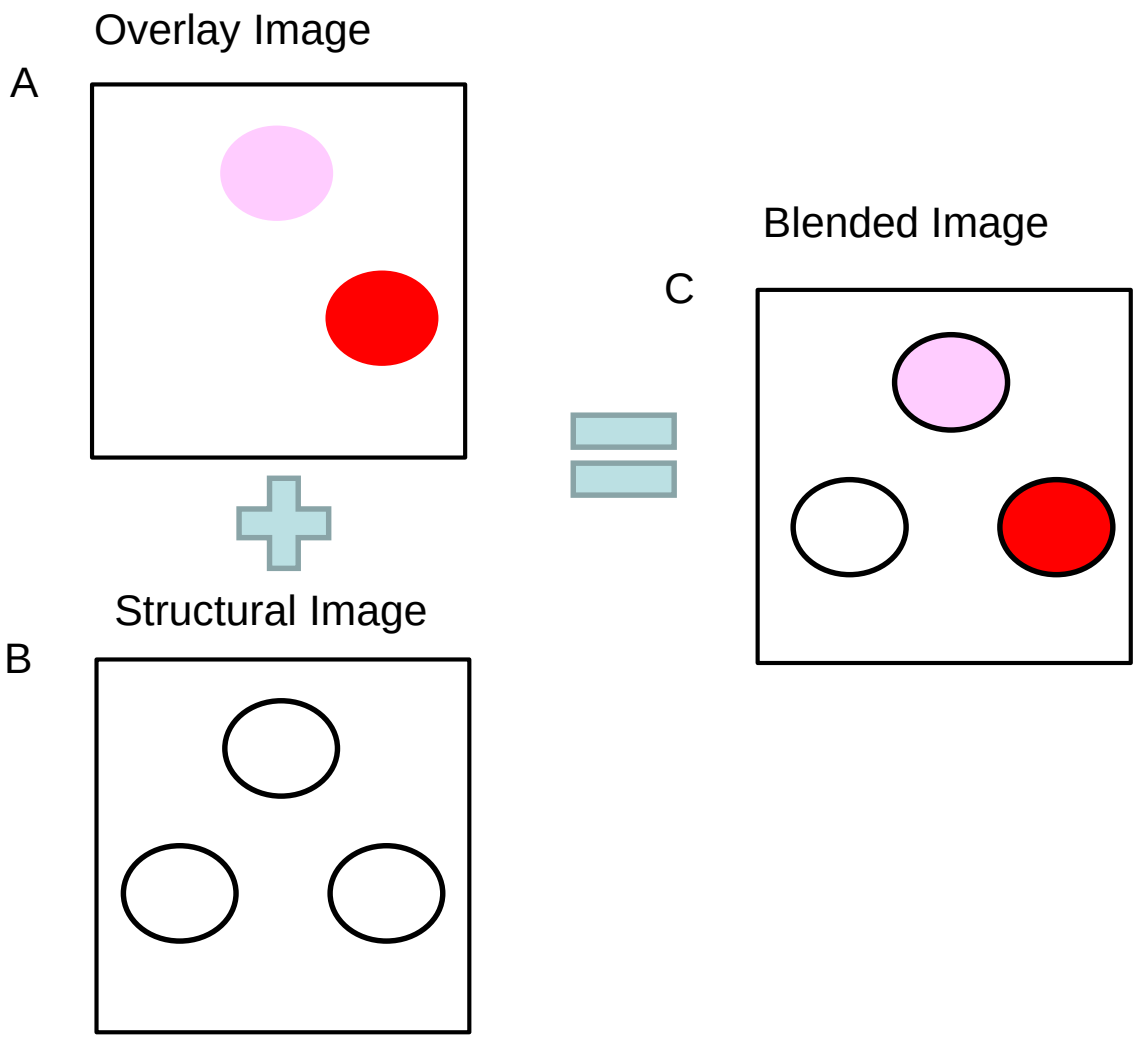
Value based:



Probability:



“Visualization” Images
Color Overlay



A) A CT image that is windowed to highlight a particular material with a color map applied. It also may have a translucency applied to be able to see the image underneath. (E.g. Iodine image, Effective Z image)

B) A structural image showing the anatomical structure.
(E.g. Monochromatic image)

C) The result image (combined information e.g. Secondary Capture, Blending, …)