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DICOM
Digital Imaging and Communications in Medicine

Interoperability Issues in Image Registration and ROI Generation

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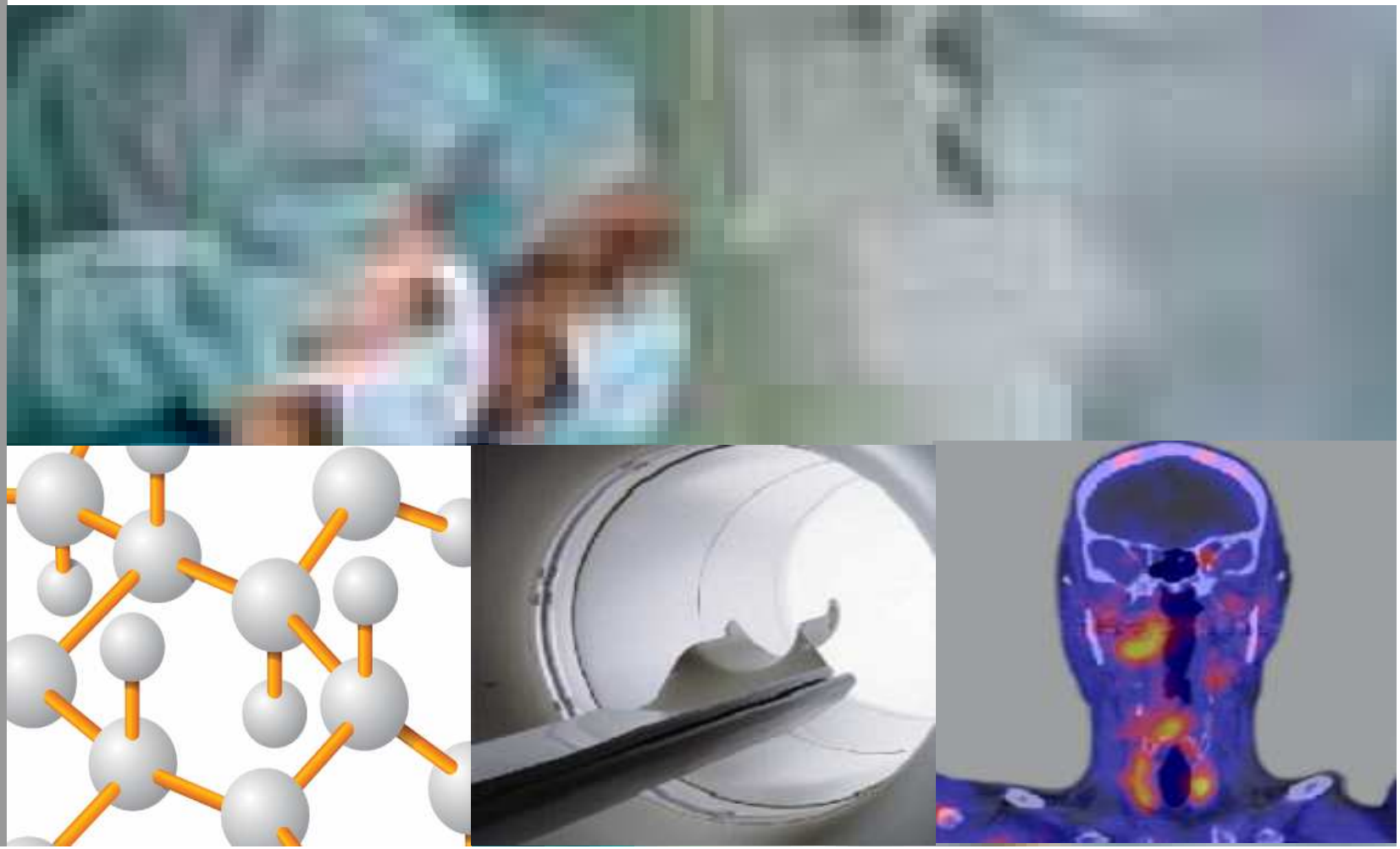


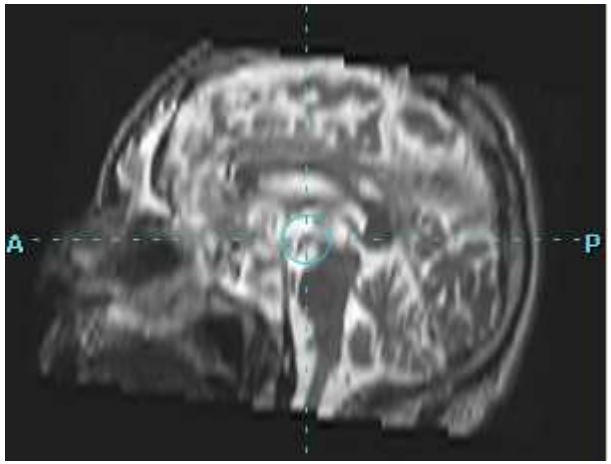
Siemens **Medical Solutions** that help

Scope

- **The following DICOM Storage SOP Classes are subject to this study:**
  - CT Image (single frame)
  - MR Image (single frame)
  - NM Image (SPECT)
  - PET Image
  - RT Structure Set
  - Secondary Capture Image (special case)
- **Most considerations also applicable to other DICOM images with exact spatial geometry (CT and MR multi-frame etc.)**

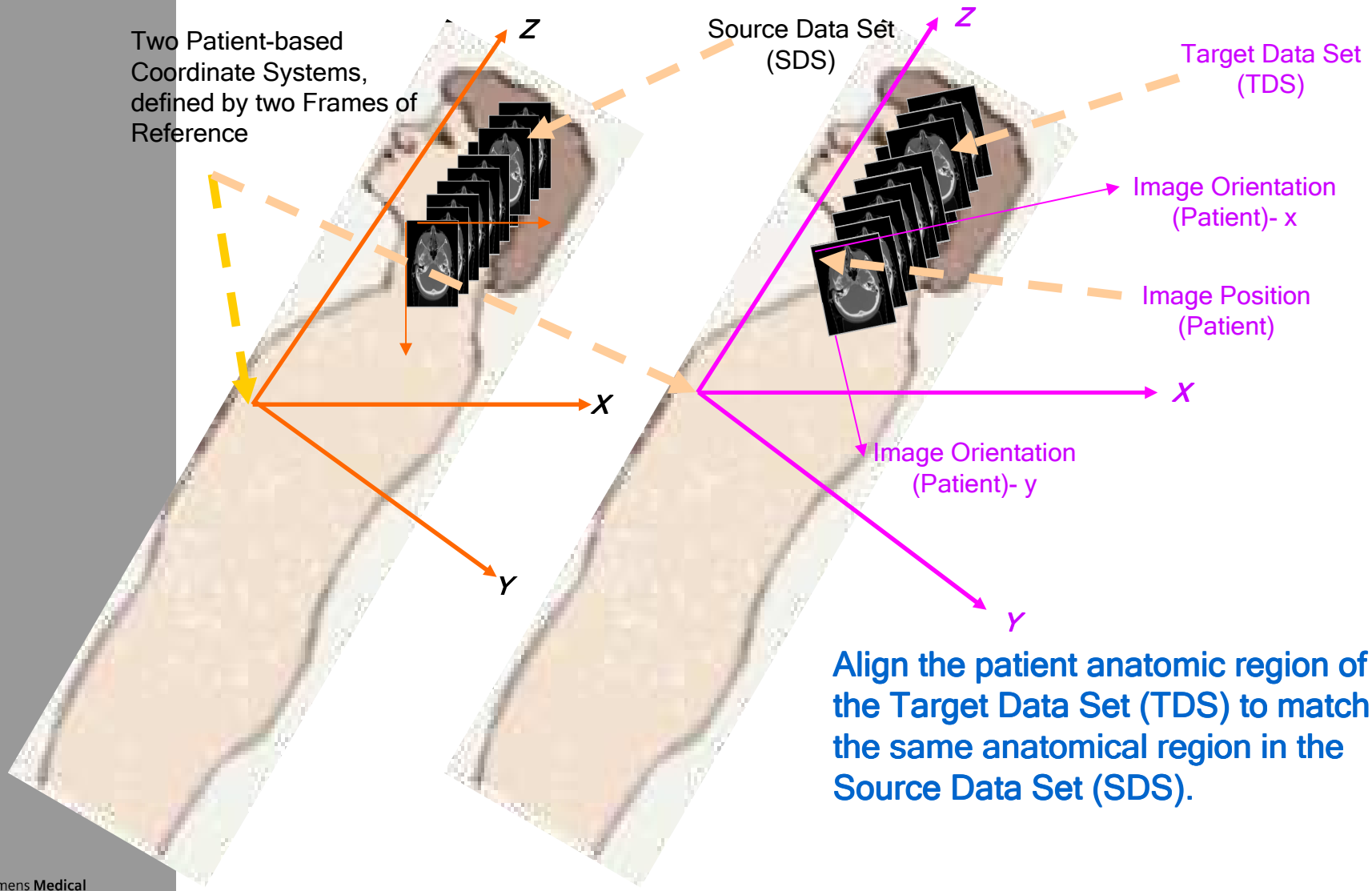
What is it about?

Brain CT



Brain MR

DICOM Image Plane and 3-D Spatial Registration



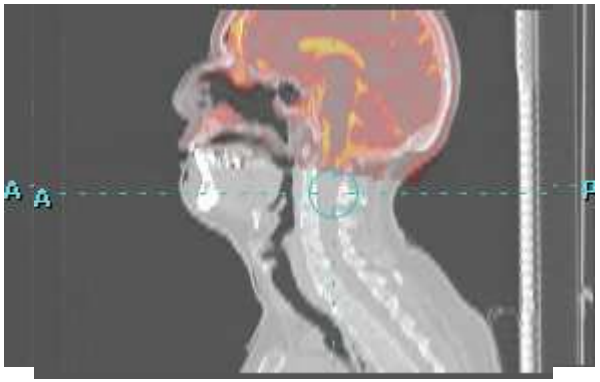
Align the patient anatomic region of the Target Data Set (TDS) to match the same anatomical region in the Source Data Set (SDS).

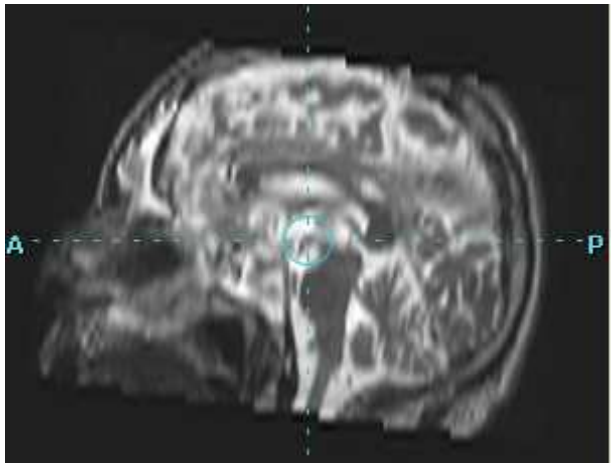
Registration=>Fusion (CT-MR)

- Translate
- Rotate
- Scale

} Rigid Registration

- Warp- optional (Deformable Registration)
- Fuse

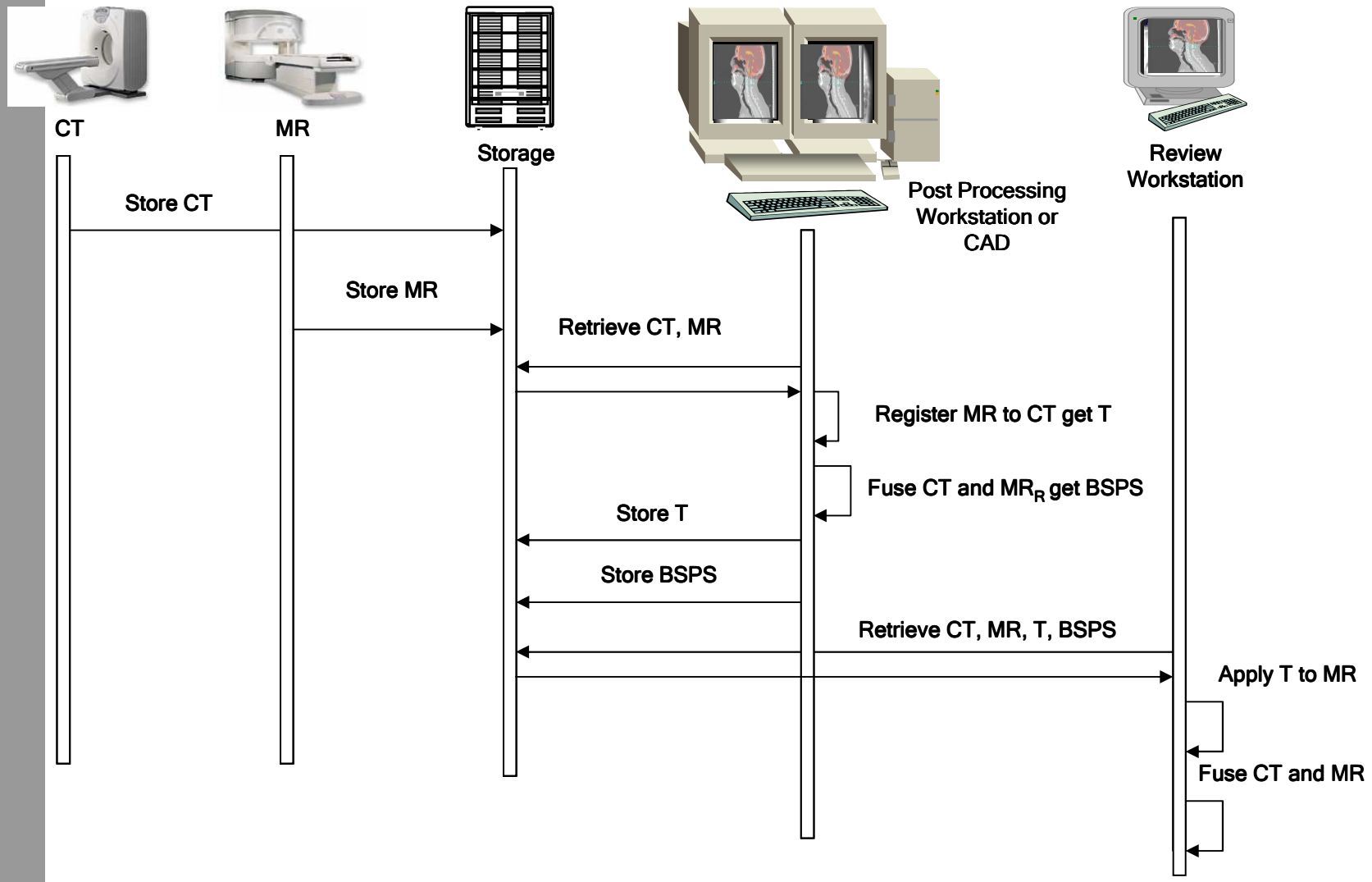




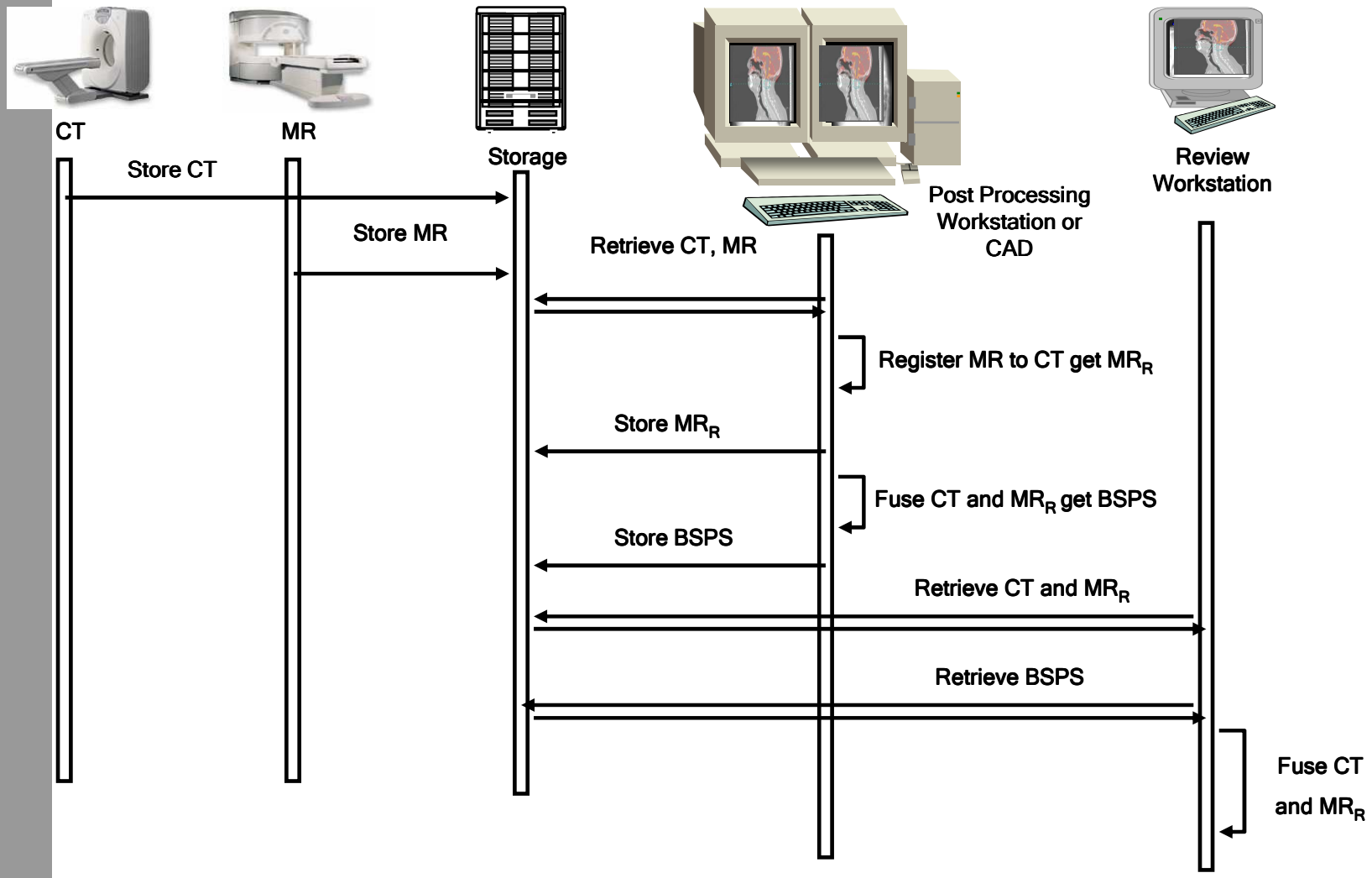
Interoperability for Image Registration

- **We want to display fused data, generated from one workstation on another vendor's system.**
- **Two possible methods:**
  - **Export the alignment solution (transformation matrix) and reproduce the transformation on the receiving workstation. *(Supplement 73, Spatial Registration Storage SOP Classes - in the Standard since 2003)***
  - **Export the transformed/re-sampled (derived) TDS and display it on the receiving workstation.**
- **Both methods are complemented by the use of Blending Softcopy Presentation State (BSPS) *(Supplement 100: Color Softcopy Presentation State Storage SOP Classes- in the 2005 Standard)***

Use Case- Brain CT-MR, Store-Retrieve-Apply Transformation



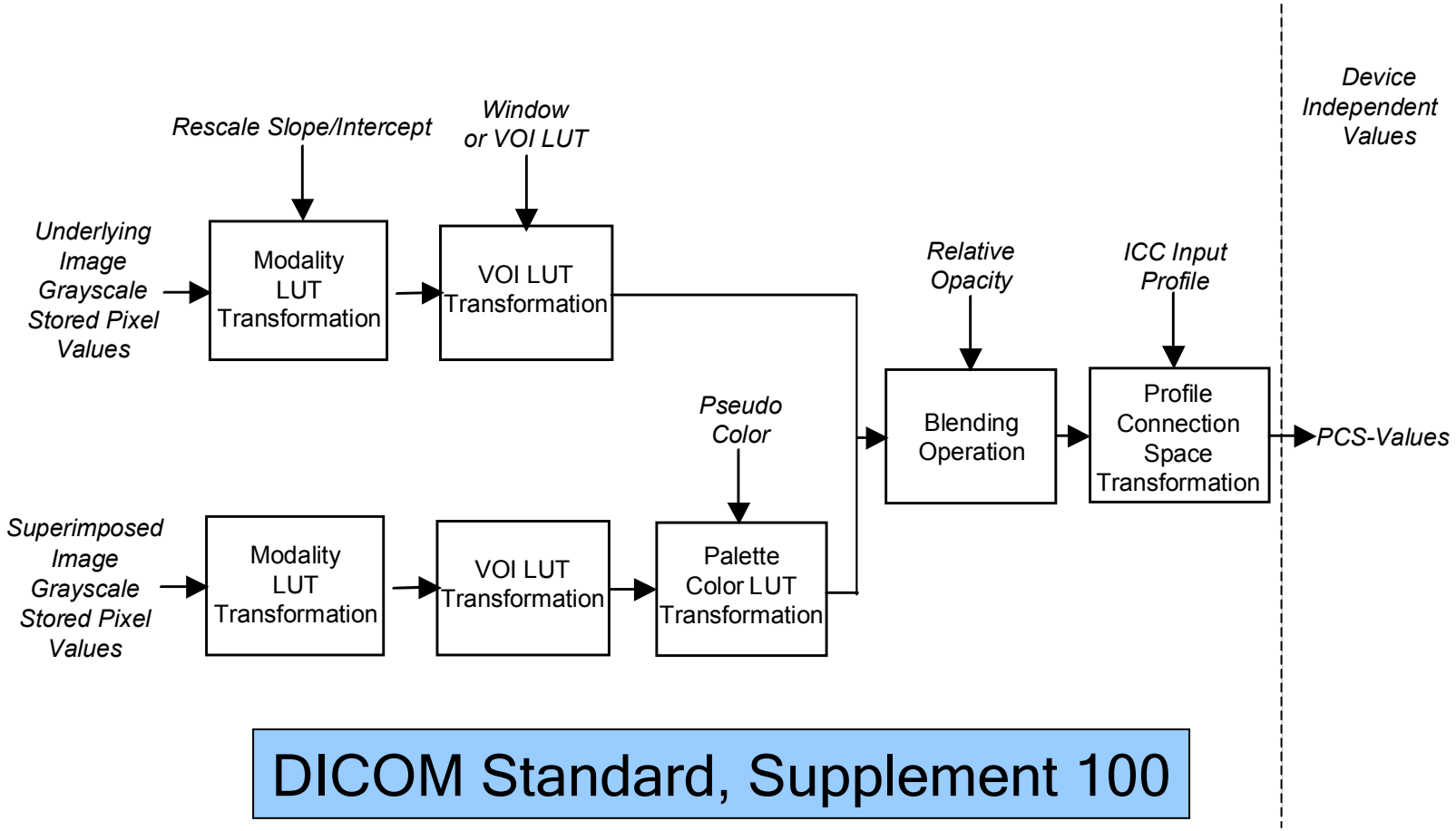
Use Case- Brain CT-MR, Store-Retrieve-Display Transformed TDS



Pros and Cons

- **Export Transformation Matrix:**
  - **Pros:**
    - **Save storage space and bandwidth.**
  - **Cons.**
    - **More expensive**
    - **Slower**
- **Export Derived TDS:**
  - **Pros:**
    - **Less expensive**
    - **Quicker**
  - **Cons:**
    - **Re-sampled data may be too big (ex. PET res. to CT res.)**

Blending Softcopy Presentation State SOP Class

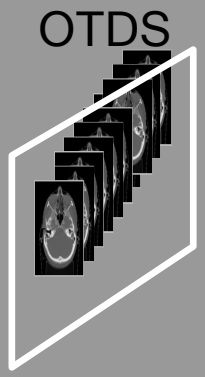


DICOM Standard, Supplement 100

Deriving- what are the implications?

- Image Geometry
- Study/Series/SOP Instance UID
- Image Type
- Patient Positioning and Orientation ?
- General Image, Pixel and Presentation
- Overlays
- Timing
- Quantification
- Contouring

Image Geometry and Patient Orientations



- **We build a volume and take new transversal projections in OTDS to produce the registered DTDS (re-sampled and interpolated**
- ***Pixel Spacing* - changes**
- ***Image Position, Image Orientation and Frame of Reference UID-* change**
- ***Patient Position* (in respect to gantry or gravity)- no change**
- ***Patient Orientation* (patient positioning in respect to image plane)- changes**

Study/Series/SOP Instance UID etc.

- Study Instance UID- same, two options
- Series Instance UID- new
- SOP Instance UID- new
- Image Type Value 1- DERIVED
- Linking and Identification:
  - Source Image Sequence
  - Series Description
  - Derivation Description
  - Related Series Sequence

General Image, Pixel and Presentation

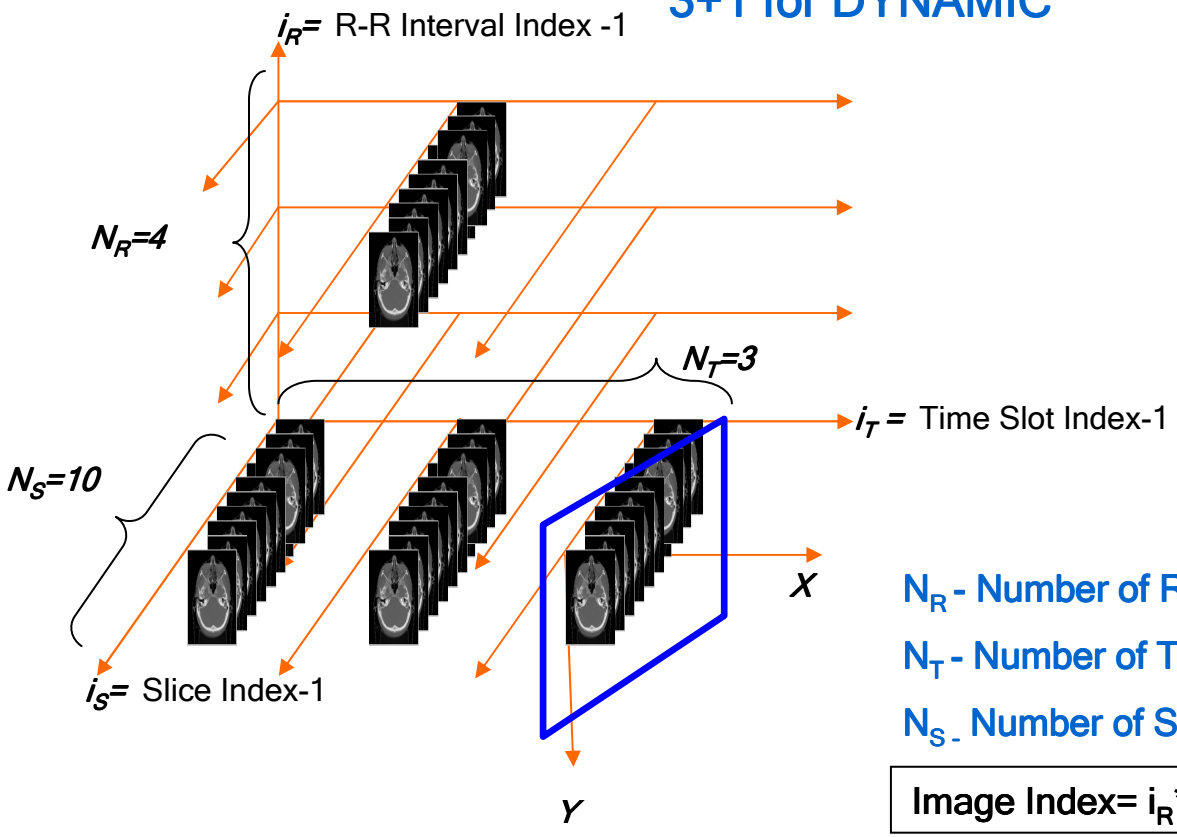
- All General Image and Image Pixel attributes- consistent with the produced new pixel data, resulting after re-sampling and interpolating of TDS
- Modality LUT (Rescale Slope/Intercept)- changes
- Overlays- deleted

Secondary Capture

- We export color images of the fused (blended) volume for review. These are basically *key images in different orthogonal projections* (axial, coronal, sagittal)
- Secondary Capture does not contain the image geometry and *cannot be used for further processing*
- The secondary capture is a new series in the primary study (SDS is normally considered as primary)

PET Specifics

The DICOM PET data set is multi-dimensional- 3+2 dimensions for GATED, 3+1 for DYNAMIC



N_R - Number of R-R Intervals (0054,0061)

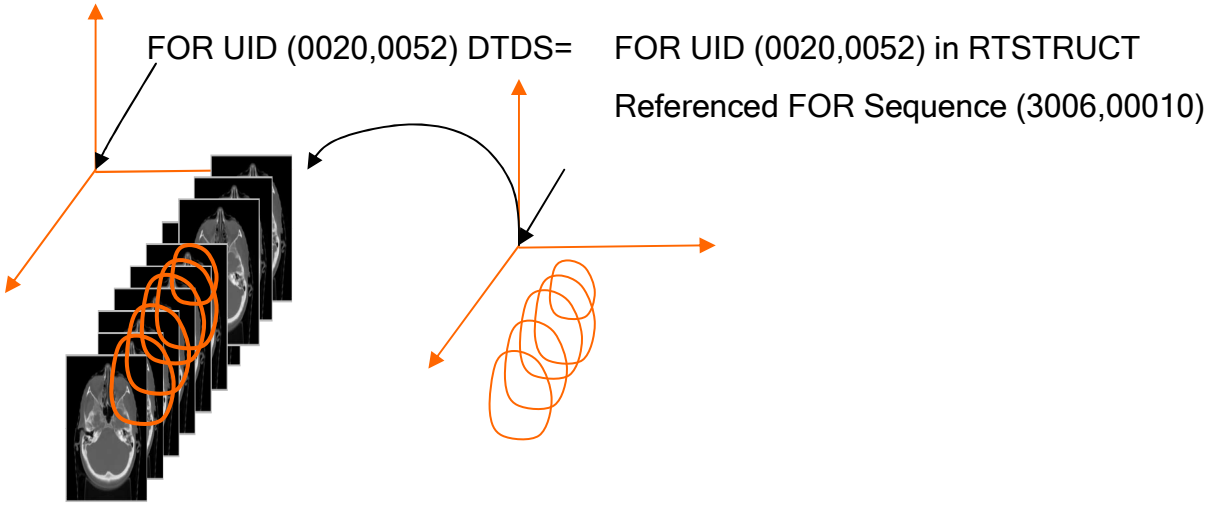
N_T - Number of Time Slots (0054,0071)

N_S - Number of Slices (0054,0081)

Image Index= $i_R*N_T*N_S + i_T*N_S+(i_S-1)$

- **Re-sampling requires Image Index to be re-calculated for each slice (resolution in Z may change)**
- **Transversal projections in the new orientation generate new re-sampled slices, which interpolate pixel data from multiple original slices**
- **Quantification requires OTDS to be Decay Corrected to the same time**

ROI Generation

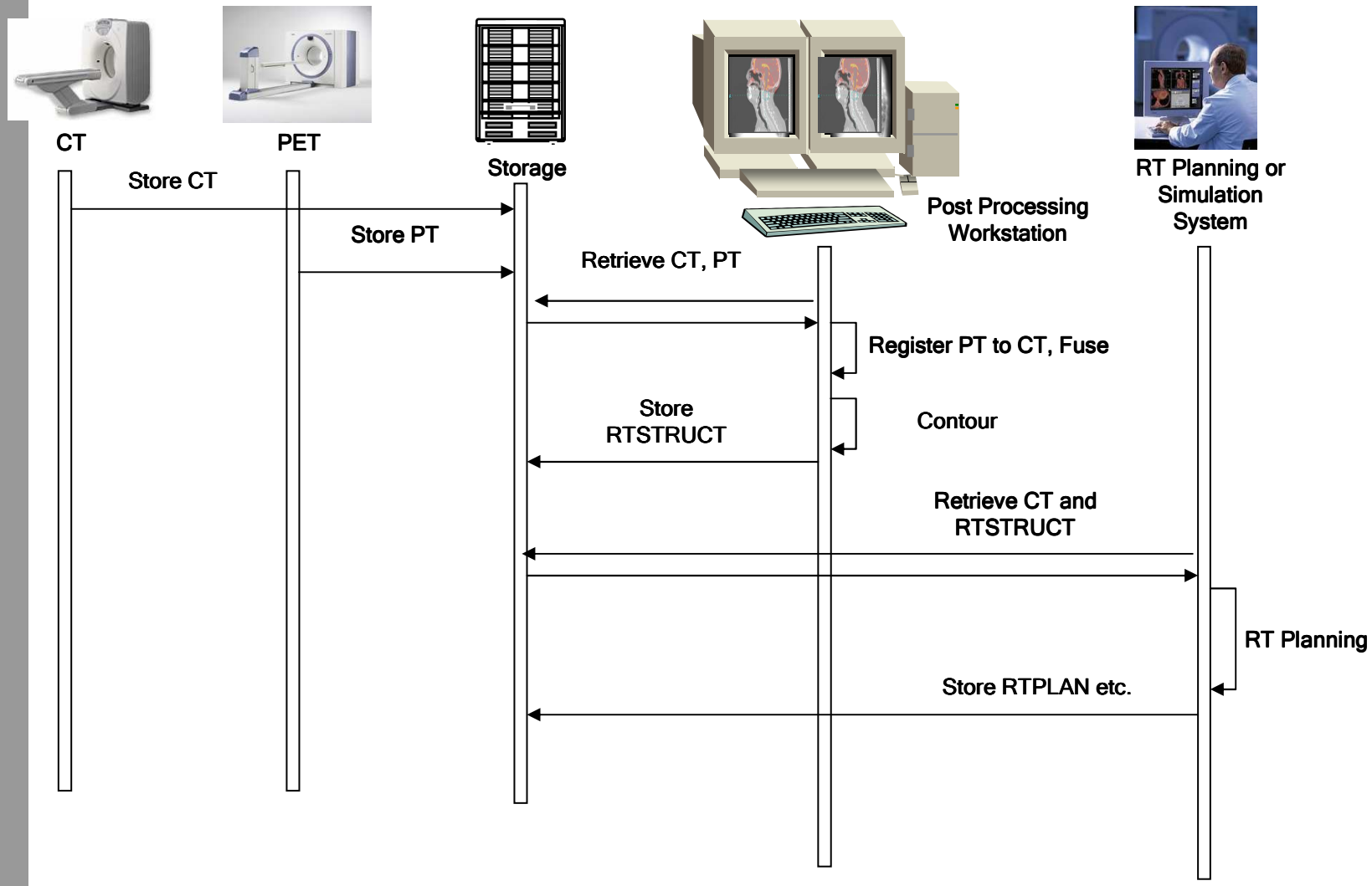


- **Contours drawn in TDS need to reference the new (transformed) data (DTDS)**
- **Two options:**
  - **Contouring after fusion**
  - **Register the contour with the same T matrix used for images as well!**

Workflow

- **Can be very complex**
- **We need efficient workflow management. Two aspects:**
  - Efficient Services. Options are:
    - Direct push between workstations (C-STORE)
    - Store and Query-Retrieve (C-STORE, C-FIND, C-MOVE)
    - Modality Work List and Modality Performed Procedure Step
    - **Post Processing Work List and Performed Procedure Step**
  - Advanced Data Objects- most existing objects have been designed earlier without the new modern acquisitions and post-processing in mind.

Contouring for RT Planning (Q/R based)

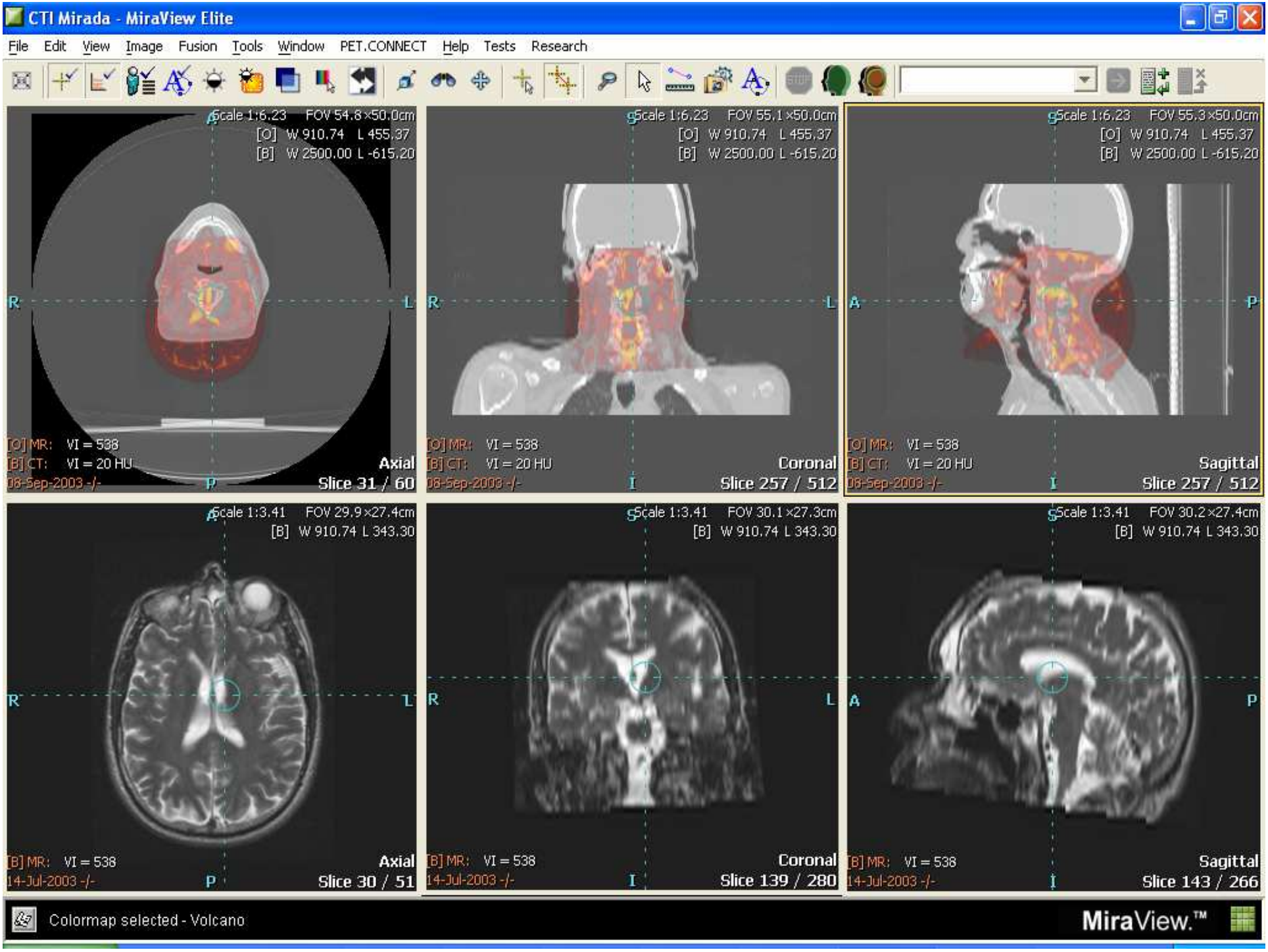


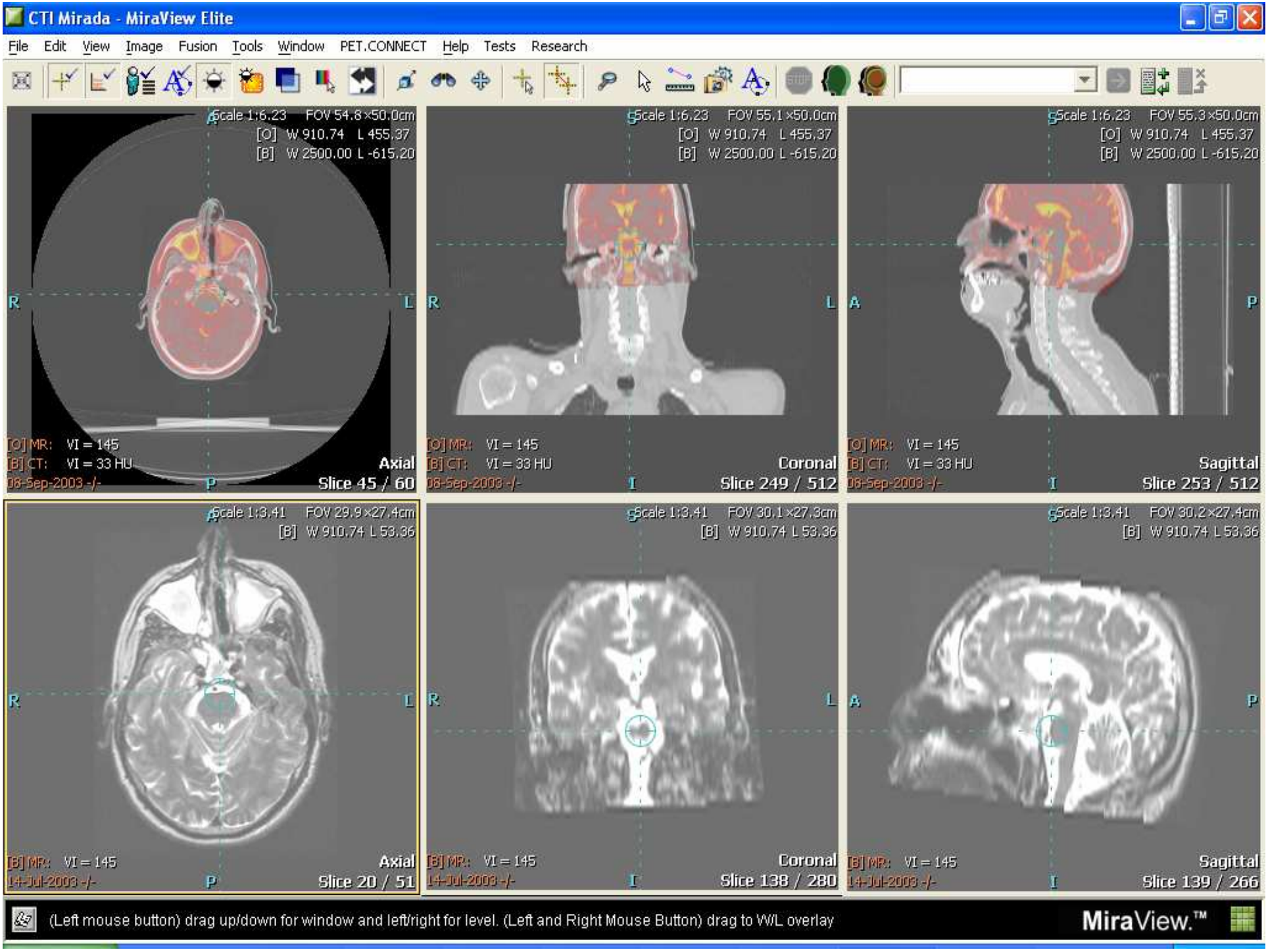
Enhanced CT, MR- what do they do to help better image post-processing?

- Pixel data is encoded in multiple frames- compact.
- Shared and per-frame functional group macros- compact and make explicit what is common
  - Derivation Image Macro- more structured
  - Frame Content Macro
    - Acquisition parameters not required if image is DERIVED
    - Dimension Index Values provide easy access to indices
    - No restriction to the number and type of dimensions
  - Real World Value Mapping Macro- a way to bypass the display pipeline and map stored values to any possible unit.
- Better keying for hanging protocols
- Accurate and well-defined timing and synchronization

Implementations and Validations

- Most of the features discussed here are implemented or in development in our products Fusion7D, MiraView, Novisis, Scenium.
- Interoperability of contouring exported as RT Structure Set and associated images is validated with RT Planning Systems from Siemens, Varian, Elekta, CMS, Prowess, Philips (Pinnacle), Nucletron, BrainLab and the ATC Connectathon 2004.
- DICOM Connectivity validated on IHE EU 2005 Connectathon, NL
- OEM application-hosted integrations for Siemens e.soft; Hitachi Avia; Vital Images Vitrea; McKesson;
- Over 400 installations worldwide (US, UK, EU, Asia)


CTI Mirada - MiraView Elite
File Edit View Image Fusion Tools Window PET.CONNECT Help Tests Research
Scale 1:6.23 FOV 54.8×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 538
[B] CT: VI = 20 HU
08-Sep-2003 -/-
Axial
Slice 31 / 60
Scale 1:6.23 FOV 55.1×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 538
[B] CT: VI = 20 HU
08-Sep-2003 -/-
Coronal
Slice 257 / 512
Scale 1:6.23 FOV 55.3×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 538
[B] CT: VI = 20 HU
08-Sep-2003 -/-
Sagittal
Slice 257 / 512
Scale 1:3.41 FOV 29.9×27.4cm
[B] W 910.74 L 343.30
[B] MR: VI = 538
14-Jul-2003 -/-
Axial
Slice 30 / 51
Scale 1:3.41 FOV 30.1×27.3cm
[B] W 910.74 L 343.30
[B] MR: VI = 538
14-Jul-2003 -/-
Coronal
Slice 139 / 280
Scale 1:3.41 FOV 30.2×27.4cm
[B] W 910.74 L 343.30
[B] MR: VI = 538
14-Jul-2003 -/-
Sagittal
Slice 143 / 266
Colormap selected - Volcano
MiraView.™


CTI Mirada - MiraView Elite
File Edit View Image Fusion Tools Window PET.CONNECT Help Tests Research
Scale 1:6.23 FOV 54.8×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 145
[B] CT: VI = 33 HU
08-Sep-2003 -/-
Axial
Slice 45 / 60
Scale 1:6.23 FOV 55.1×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 145
[B] CT: VI = 33 HU
08-Sep-2003 -/-
Coronal
Slice 249 / 512
Scale 1:6.23 FOV 55.3×50.0cm
[O] W 910.74 L 455.37
[B] W 2500.00 L -615.20
[O] MR: VI = 145
[B] CT: VI = 33 HU
08-Sep-2003 -/-
Sagittal
Slice 253 / 512
Scale 1:3.41 FOV 29.9×27.4cm
[B] W 910.74 L 53.36
[B] MR: VI = 145
14-Jul-2003 -/-
Axial
Slice 20 / 51
Scale 1:3.41 FOV 30.1×27.3cm
[B] W 910.74 L 53.36
[B] MR: VI = 145
14-Jul-2003 -/-
Coronal
Slice 138 / 280
Scale 1:3.41 FOV 30.2×27.4cm
[B] W 910.74 L 53.36
[B] MR: VI = 145
14-Jul-2003 -/-
Sagittal
Slice 139 / 266
(Left mouse button) drag up/down for window and left/right for level. (Left and Right Mouse Button) drag to W/L overlay
MiraView.™

Looking for more…?

- **This work and the related studies have been carried out by the Engineering and Science teams at Siemens Molecular Imaging Software, Oxford UK (formerly Mirada-Solutions)**
- **For more information:**
  - Engineering: Martin Smyth, *martin.smyth@mirada-solutions.com*
  - Visit our Web Sites:
    - http://www.mirada-solutions.com
    - http://www.medical.siemens.com

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Solutions that Help