SlicerRT
radiation therapy extension for 3D Slicer
DICOM aspects

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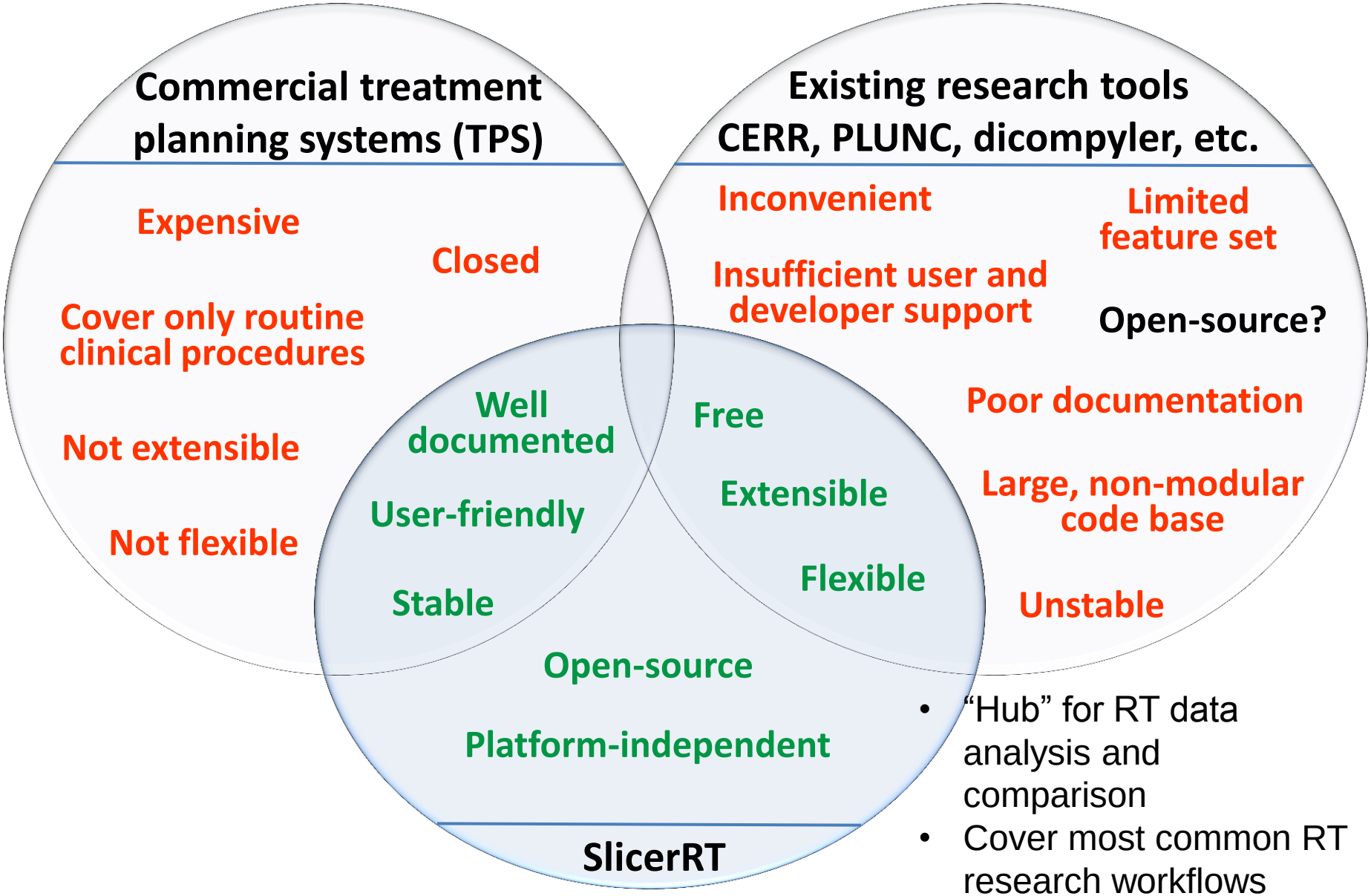
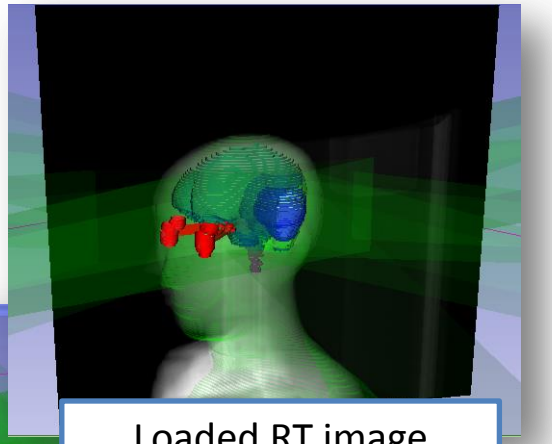


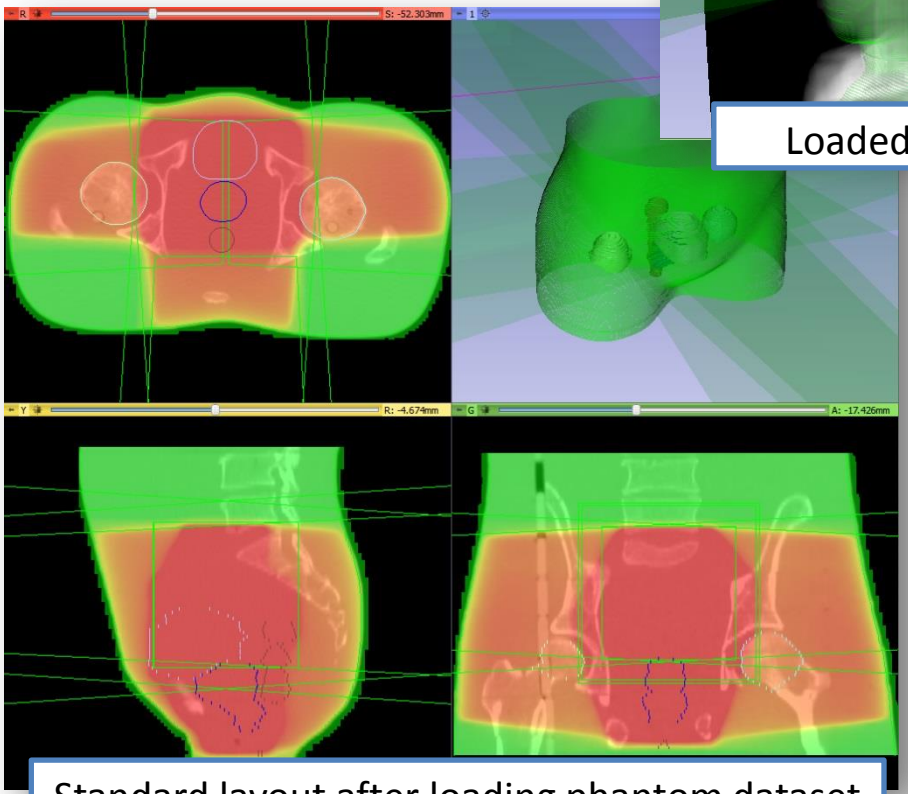
- "Hub" for RT data analysis and comparison
- Cover most common RT <u>research</u> workflows
- Funding secured till 2016

DICOM-RT loading

- Using Slicer core's DICOM import plugin mechanism
- Supported data types:
  - RT structure sets
    → Contour nodes
    → Markup nodes
  - RT dose map
    → Volume node
  - RT image
    → Volume
    + Planar image node
  - RT plan:
    → Plan node
    → Markup points



Loaded RT image



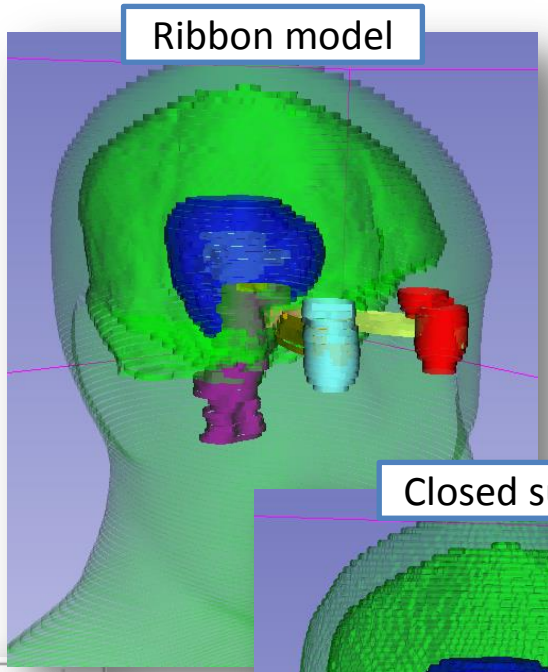
Standard layout after loading phantom dataset

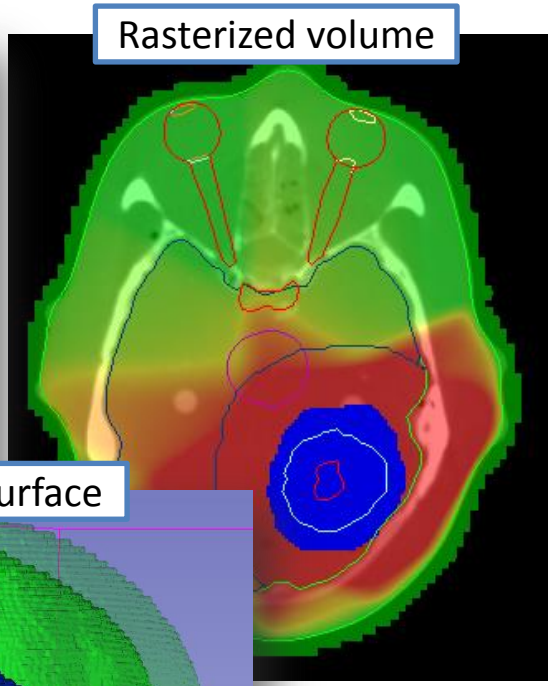
Challenges: DICOM-RT loading

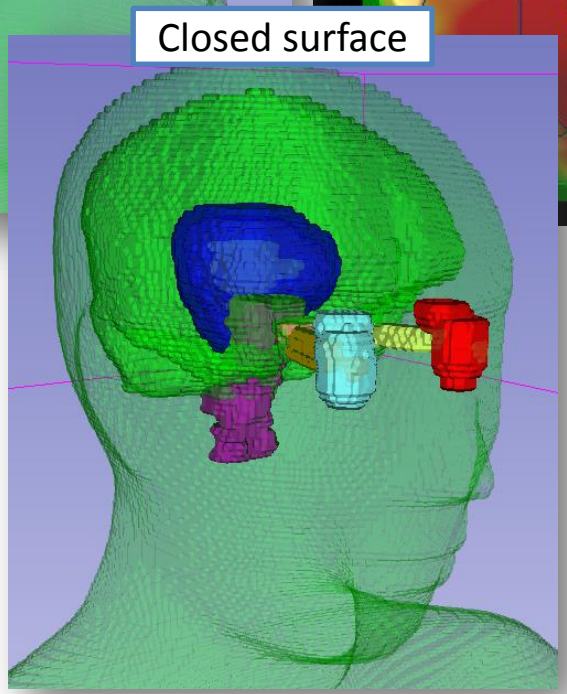
1. References between DICOM objects
   - **Partial/random order loading** of a study and series. How to interpret data that depends on data that is not loaded?
     - Current solution: Store objects with DICOM UID in subject hierarchy. Check after each node adding if any new relationships can be added to the scene. Works so far for the RTIMAGE->RTPLAN, RTSTRUCT->CT, **could be generalized**.
   - Resolving node references requires a lot of work (retrieve UID, find file, parse, search for needed data) – **Could higher-level objects be added to DCMTK?**

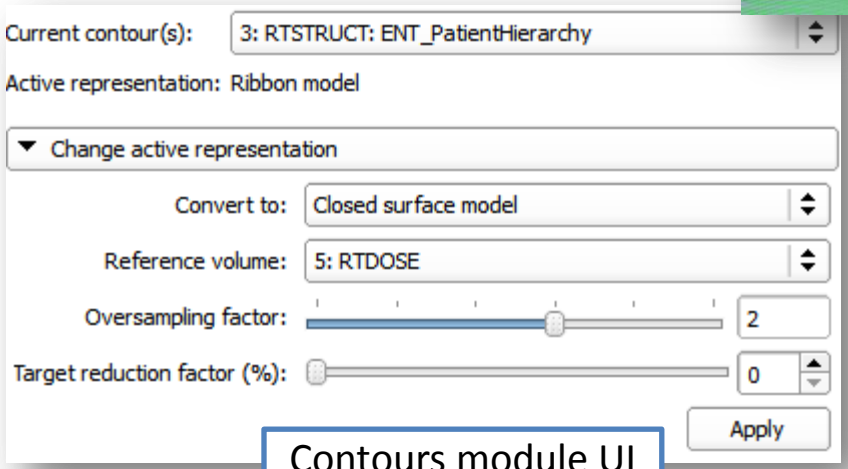
Contour node

- Multiple representations
  - Ribbon model
  - Rasterized volume
  - Closed surface model
- Any representation is available: automatic conversion, caching
- Node selector widget









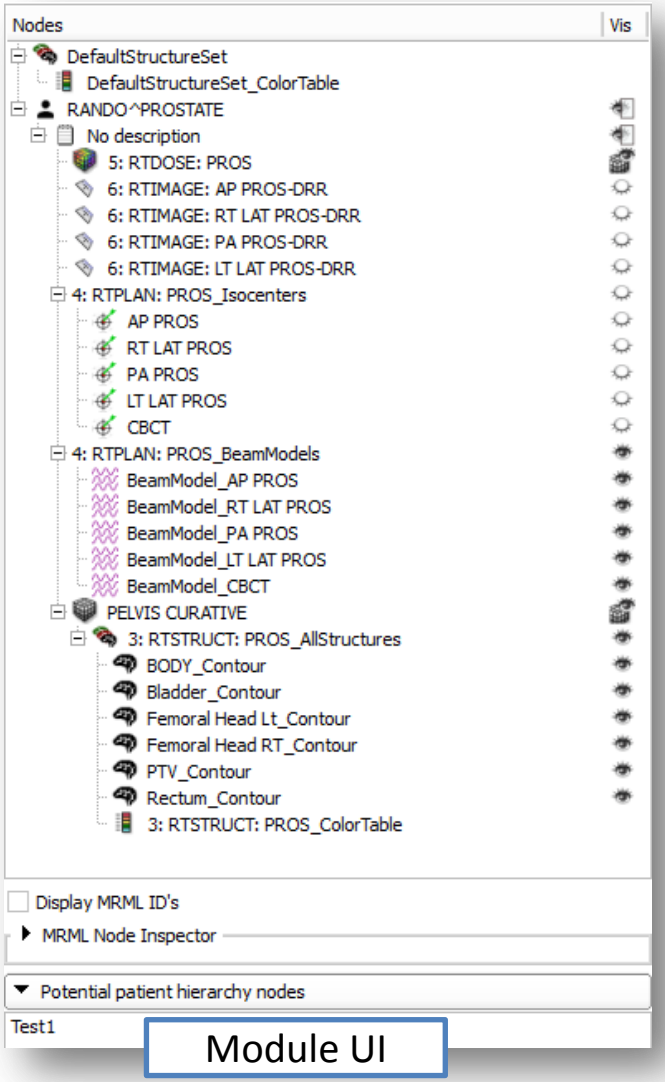
Contours module UI

Challenges: contours

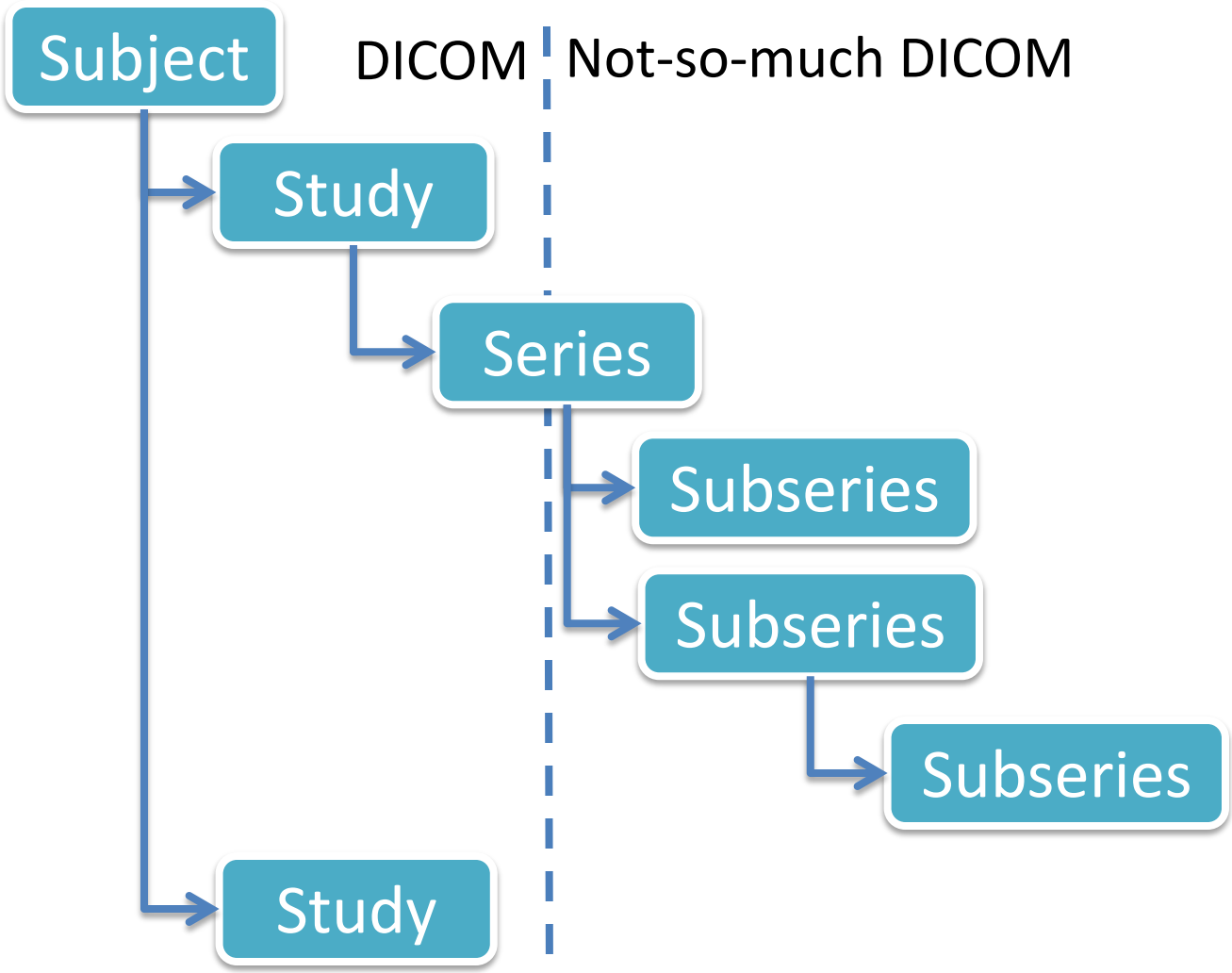
1. Conversion from DCMTK to ITK/VTK objects
   - Should we have some common implementation? In ITK, VTK, CTK?
2. Loss-less ribbon (planar contours) to closed surface conversion
   - Algorithm development needed. Should we have some common implementation? In DCMTK, CTK, ITK, …?
3. Co-existence with current segmentation management (that only uses labelmap volumes but allows multiple non-overlapping labels in a volume)
   - Contours should be integrated to the Slicer core. Editor, viewer, and CLI framework may require a lot of work.

Subject Hierarchy

- Group data for easier browsing
  - Show/hide branch; [future] show layout for whole study (e.g., PET/CT) and/or for a specific task (registration, dose accumulation, …)
- Group data for easier processing
  - [future] Transformation of a whole study
- Define relationships
  - Bind MRML nodes to each other (e.g., isodose sets, color tables and dose volumes)
  - Bind MRML nodes to DICOM objects (e.g., allows accessing to all DICOM tags)
- Store metadata
  - In parent or associated hierarchy nodes
  - Data is modifiable (patient name etc. can be changed, useful for DICOM export)



Subject hierarchy tree structure



Subject hierarchy plugin mechanism

Outsources operations for specific node types. Virtual functions to override:

- Add node to the subject hierarchy
- Move node inside the subject hierarchy (reparent)
- [future] Create children node (get possible types, add a new child node)
- [future] Icon, tooltip

Example: contours have to deal with color tables and labelmap volume labels.

Relationship between nodes

1. Subject hierarchy
   A. Parent/child/sibling relationship
      - Good: **user can easily see & rearrange it**
      - Bad: both related nodes have to be in the scene, only tree structure

   B. DICOM UID in associated hierarchy node
      - Good: allows **accessing original DICOM data set** (with all DICOM tags), relationship can be defined for **nodes that are not in the scene yet**
      - Bad: only available for DICOM data, and relationships defined in DICOM

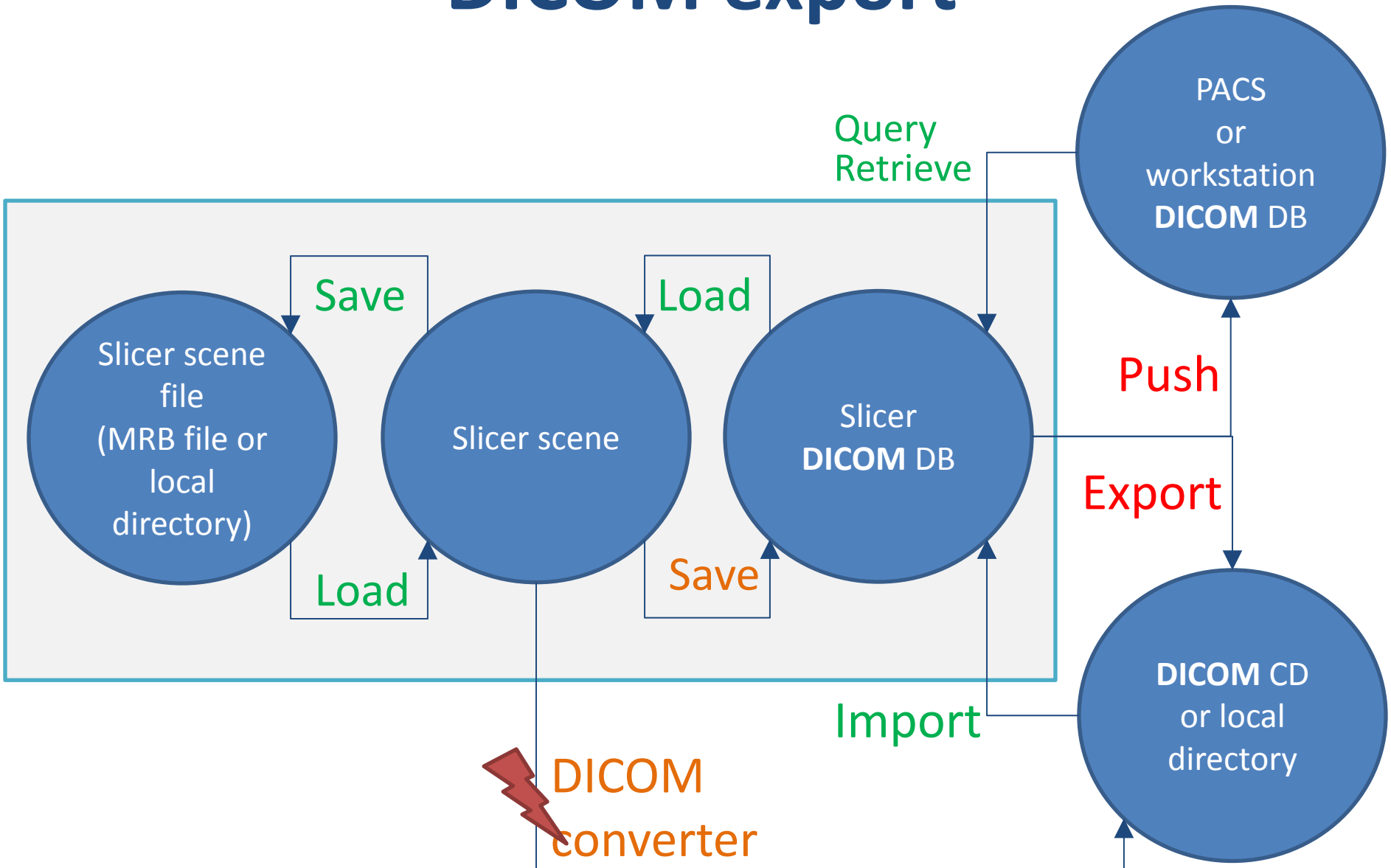
   Note: DICOM UID in node attribute is similar as in subject hierarchy, but less flexible – probably subject hierarchy will make it obsolete

2. MRML node reference
   – Good: **can be used for observation** of node events (modifications, etc.)
   – Bad: both related nodes have to be in the scene

Challenges: subject hierarchy

1. CLI compatibility
   - Processing results should be placed into the subject hierarchy automatically
   - Also save some node attributes?
2. Data is attached to a patient in the subject hierarchy. Should it appear in the DICOM browser?
3. Subject hierarchy plugins should be added
   - for structured reports, registration objects, etc.
4. Should be part of the Slicer core
5. How to identify patients? (how UIDs are usually composed?)

DICOM export



Challenges: DICOM export

1. Too many data repositories – can be simplified?
   - Can we unify the DICOM loading/saving and other file loading/saving in the same browser? Store both DICOM and non-DICOM data in the Slicer database?
   - Workflow? Where to put in the GUI?
2. No plugin architecture exists yet for DICOM exporters

Multidimensional data

- Store/retrieve/analyze data along multiple dimensions
  - Dimensions: Time, modality, imaging parameters…
- Multidimensional array is decomposed and stored in a tree structure
- Design options:
  - Store all the data in the scene: save/load, references, access to nodes are solved; problems: potential performance issues, hidden nodes are not well supported
  - Store data in sub-scenes (similar to scene views): better performance (scene doesn't get too big), nodes are not all available in the scene

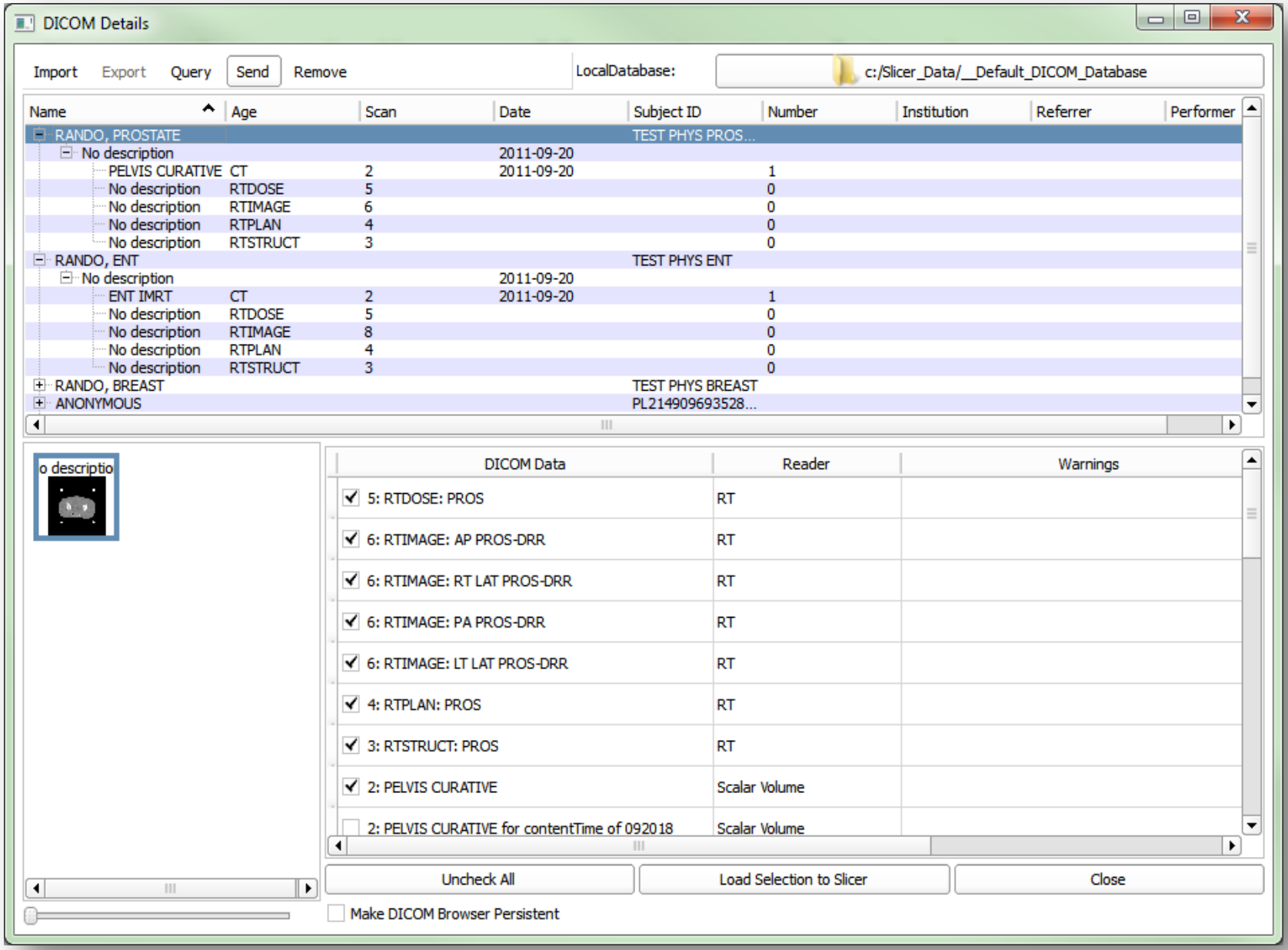
Thank you!

- SlicerRT project homepage: http://www.SlicerRT.org/
- SlicerRT overview paper: Csaba Pinter, Andras Lasso, An Wang, David Jaffray, and Gabor Fichtinger, “SlicerRT: Radiation therapy research toolkit for 3D Slicer”, Med. Phys. 39 (10), October 2012
- Contact: Csaba Pinter (csaba.pinter@queensu.ca), Andras Lasso (lasso@queensu.ca)

Ontario
Cancer Care Ontario
Action Cancer Ontario

SparKit

OCAIRO
Ontario Consortium for Adaptive Interventions in Radiation Oncology


DICOM Details
Import
Export
Query
Send
Remove
LocalDatabase:
c:/Slicer_Data/__Default_DICOM_Database
Name
Age
Scan
Date
Subject ID
Number
Institution
Referrer
Performer
RANDO, PROSTATE
TEST PHYS PROS...
No description
2011-09-20
PELVIS CURATIVE CT 2 2011-09-20 1
No description RTDOSE 5 0
No description RTIMAGE 6 0
No description RTPLAN 4 0
No description RTSTRUCT 3 0
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ENT IMRT CT 2 2011-09-20 1
No description RTDOSE 5 0
No description RTIMAGE 8 0
No description RTPLAN 4 0
No description RTSTRUCT 3 0
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DICOM Data
Reader
Warnings
5: RTDOSE: PROS
RT
6: RTIMAGE: AP PROS-DRR
RT
6: RTIMAGE: RT LAT PROS-DRR
RT
6: RTIMAGE: PA PROS-DRR
RT
6: RTIMAGE: LT LAT PROS-DRR
RT
4: RTPLAN: PROS
RT
3: RTSTRUCT: PROS
RT
2: PELVIS CURATIVE
Scalar Volume
2: PELVIS CURATIVE for contentTime of 092018
Scalar Volume
Uncheck All
Load Selection to Slicer
Close
Make DICOM Browser Persistent

Subject Hierarchy
Series types

- Volume
  Associated to vtkMRMLScalarVolumeNode types
  - Generic (CT, MR, …): modality CT, MR
  - Dose: modality RTDOSE
  - RT image: modality RTIMAGE
- Structure set (contour hierarchy): modality RTSTRUCT
  vtkMRMLDisplayableHierarchyNode type, associated to nothing. Its children subseries are contours (vtkMRMLContourNode) and a color table
  - *DicomRtImport.ContourHierarchy* attribute
- Plan: modality RTPLAN
  vtkMRMLAnnotationHierarchyNode type, associated to nothing. Its children subseries are beams and source, isocenter fiducials