

SOFTWARE OFFERINGS SUMMARY

QIPCM provides image viewing and analytical software tools that help researchers and trial sponsors gather quantitative information from medical imaging.

Below is a summary of software packages available on the QIPCM platform and their functionalities for image analysis of various medical imaging modalities (e.g., 2D/3D/4D: CT, MRI, PET, SPECT, RT plans, fluoroscopy, etc.). A brief description of each functionality can be found in the pages that follow.

If you do not see a functionality needed for your research, [please contact us](#). The QIPCM platform is flexible and can accommodate other software options. The QIPCM team will work with you to make software alternatives available, as well as validate them to ensure they will help meet your research objectives.

Functionality	Weasis	RadiAnt	Clear Canvas	MIM	QIPCM OHIF
QIPCM Platform	VM				Web
Length Measurement (axial)	✓	✓	✓	✓	✓
Contour Review (axial)	✓		✓	✓	✓
Contouring 2D (axial)			✓	✓	
Contouring 3D (triplanar)				✓	
Contouring by Thresholding				✓	
Contouring by Atlas				✓	
RECIST Measurement	✓	✓	✓	✓	✓
Export to STL		✓		✓	
Image Fusion (PET/CT)		✓	✓	✓	✓
Image Fusion (MultiModal)		✓		✓	✓
SUV Calculation	✓	✓	✓	✓	✓
PET Total Lesion Glycolysis				✓	
PERCIST Measurement				✓	✓
Rigid Image Registration				✓	
Deformable Image Registration				✓	
Image Resampling				✓	
ROI Propagation (No registrations)			✓	✓	
ROI Propagation (With registration)				✓	
Radiotherapy (RT) Plan Review QA	✓			✓	

DVH Comparison				✓	
RT Plan Beam/DRR Visualization				✓	
4D Voxelwise Data Export			✓	✓	
Tofts Modeling (CT/MRI) ^{1,3,6,7,8,11}			✓	✓	
Partial Volume Correction (PET) ^{4,9}				✓	
Spillover Correction (PET) ⁴				✓	
Hypoxic Fraction/Volume (PET) ^{4,9,10}			✓	✓	
Compartmental Modeling (PET) ^{2,4,5,9}				✓	

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FUNCTIONALITIES INCLUDE

RADIOLOGY and NUCLEAR MEDICINE IMAGING

These common measurement, delineation, and export functionalities can be used directly by a PI, their team, or a QIPCM research associate on the QIPCM platform.

- Longitudinal RECIST (with image co-registration) (Figure 1)
 - *Assess tumor burden from anatomical imaging by performing length measurements on axial images from multiple days*
- Longitudinal PERCIST (with image co-registration) (Figure 1)
 - *Assess tumor burden/metabolic activity from nuclear medicine imaging by performing volume-based measurements on images from multiple days*
- Contouring 2D/3D (brush, freehand, polygon, atlas, threshold) (Figure 2)
- PET total lesion glycolysis for each ROI/patient
- 3D Rendering
- Image export to STL (Figure 3)
 - *Plan surgeries and biopsies using patient-specific anatomical imaging*

Figure 1. Longitudinal RECIST or PERCIST can be performed on images from multiple days with the aid of multi-modal image fusion and co-registration.

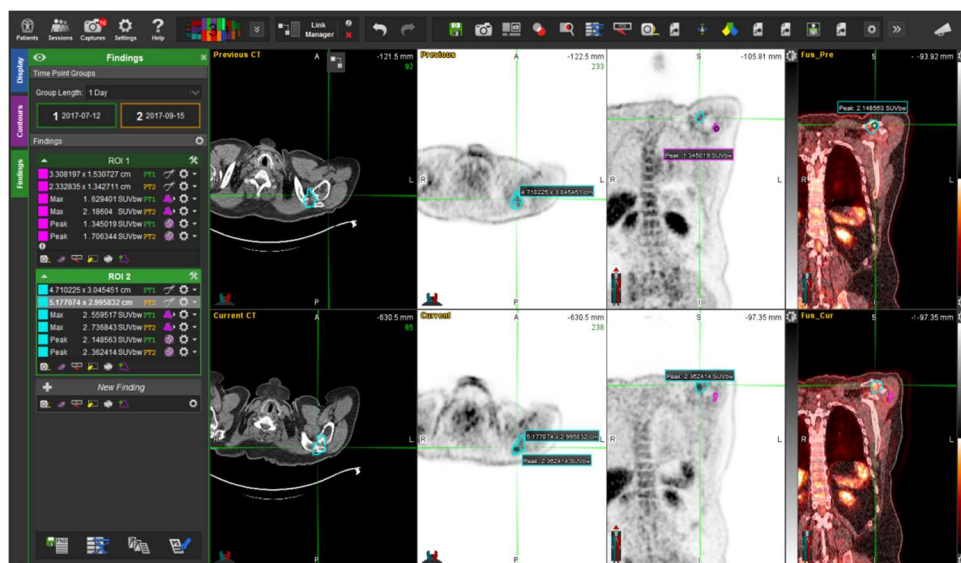
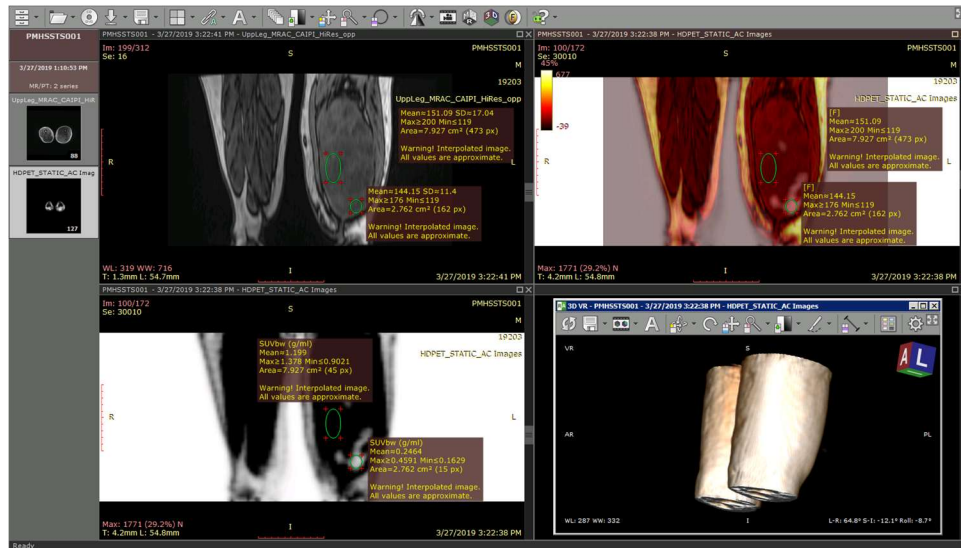


Figure 2. QIPCM OHIF viewer's toolbar are shown. Available tools includes contrast windowing within a drawn ROI, length and angle measurement, 3D probing of image intensity, and displaying RT (Radiation Therapy) Structure.



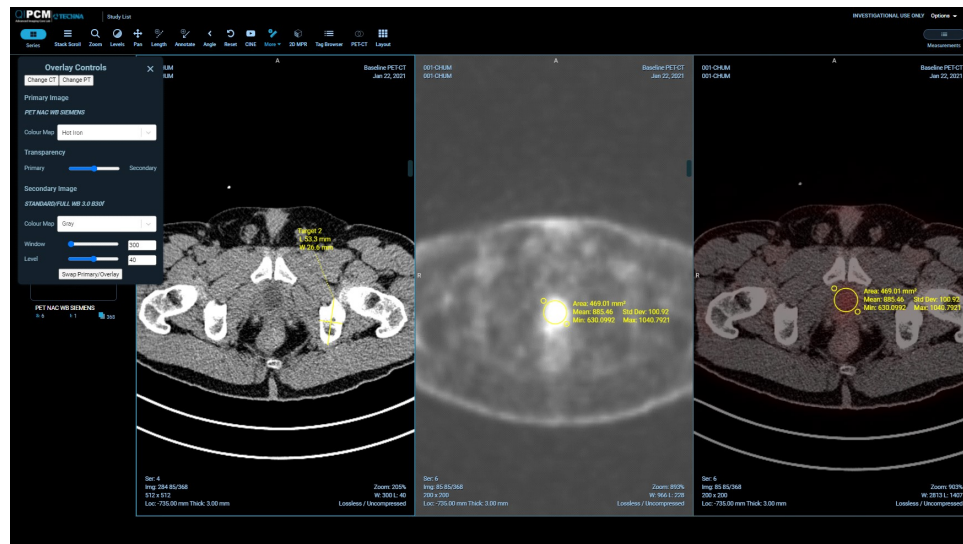
Figure 3. Review images in fusion mode or export images as an STL file for CAD processing or biopsy planning in RadiAnt.



FUNCTIONAL/MULTI-MODAL IMAGING

- PET SUV measurement
 - Calculate SUV by body weight or lean body mass for any ROI
- ROI contouring 2D/3D (brush, freehand, polygon, atlas, threshold)
 - Choose between manual contouring or semi-automatic contouring to reduce contouring/interoperator variability
- Image fusion of PET-CT, PET-MRI, SPECT-CT (Figure 1 & Figure 4)
 - For viewing multi-modal image studies that provide anatomical and functional/metabolic information or overlaying complementary image studies
- ROI propagation
 - Reduce contouring efforts and interoperator variability by transferring contours from planning CTs and applying them to other modalities
- Rigid/Deformable registration
 - Perform registrations for CBCT to CT, MR to CT, CT to CT, and MR to MR, or correct mis-aligned multi-modal imaging such as PET/CT or SPECT/CT
- Image Resampling
 - Resample a secondary image set after registration to obtain 1:1 voxel correspondence with the primary image set.
- Voxel wise export of temporal/dynamic imaging data
 - For additional customized batch processing

Figure 4. Built by QIPCM on top of OHIF platform, this PET/CT fusion tool shows PET on primary, CT on secondary and their overlay on fused viewport. Bidirectional measurement for PERCIST, SUV calculated inside an ellipse, and quick keys for PET specific window level presets are some of the tools demonstrated here.



QIPCM RESEARCH FUNCTIONALITIES

The following imaging functionalities were created by QIPCM as part of ongoing research projects. They were built on existing open-source or commercial software. The required inputs (e.g., ROIs) can often be prepared and initiated by a PI, their team, or a QIPCM research associate. Further use of these functionalities requires application training due to their uniquely flexible customization properties. QIPCM can work with a PI and their team to discuss customization requirements for any given trial.

- Tofts modeling for DCE-MRI/DCE-CT^{1,3,6,7,8,11} (Figure 5 & Figure 6)
 - *Simulate contrast agent uptake by individual tissue/tumor voxels within dynamic contrast-enhanced MRI or CT imaging through Tofts modeling, and obtain kinetic parameters and maps*
- PET partial volume effect correction^{4,9}
 - *Recover radiotracer PET signal lost due to imaging physics limitations*
- PET contour contamination removal⁴ (Figure 7)
 - *Detect and remove irrelevant PET signal spillover in an ROI, caused by nearby structures with extremely high radiotracer uptake/metabolism*
- Hypoxic fraction/volume calculation (via blood or muscle surrogate)^{4,9,10} (Figure 8)
 - *Determine which voxels in an ROI are likely to be hypoxic relative to blood or a muscle surrogate with healthy pO_2 levels*
- Voxelwise compartmental modeling of dynamic PET data and parameter visualization^{2,4,5,9} (Figure 9)
 - *Simulate radiotracer uptake in individual tissue/tumor voxels within dynamic PET imaging through compartmental modeling, and obtain kinetic parameters and maps*

Figure 5. Estimate parameters of the Tofts model or the Modified Tofts model within ClearCanvas for a given ROI and input function using dynamic contrast-enhanced CT or MRI images.^{1,3,6,7,8,11}

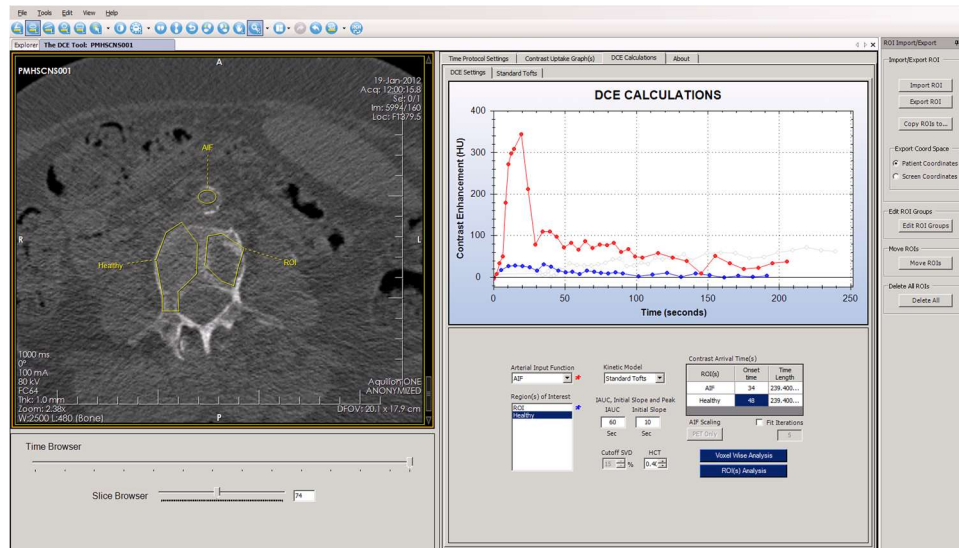


Figure 6. MIM DCE Analysis Extension. This Matlab based extension for MIM uses QIPCMs GPU enabled Virtual Machines to rapidly perform 3D volumetric kinetic modelling of DCE-CT and DCE-

MR images. This figure depicts the results of running this tool on a single Brain DCE-MR with the (clockwise from the top) original DCE-MR, ADC, T₁ Map, V_e, V_b and K_{Trans} images.

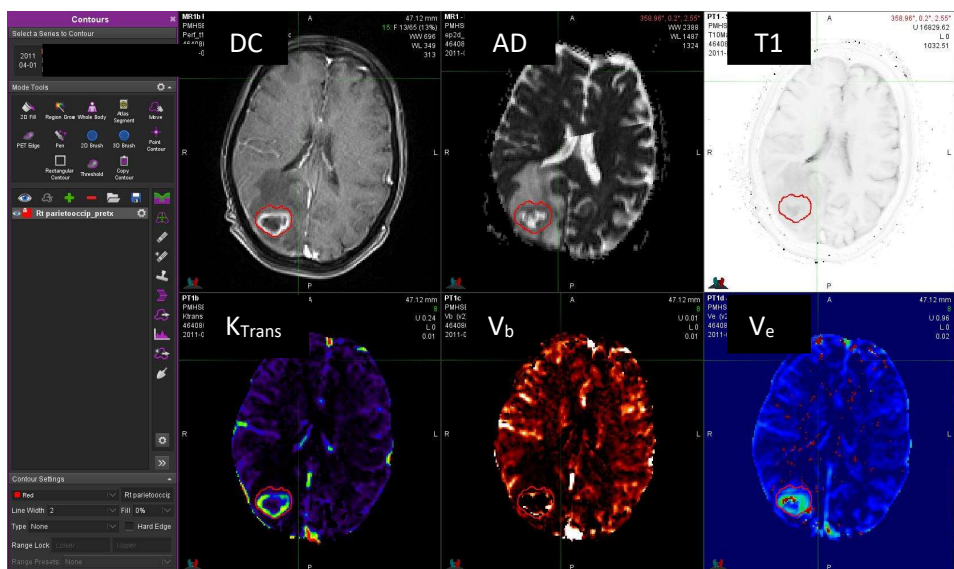


Figure 7. Spillover correction in PET can be applied using an extension created by QIPCM for MIM to remove regions from an ROI (yellow) where PET signal was contaminated by another structure (bladder in purple). The corrected ROI is delineated in green.⁴ The calculation of hypoxic fractions and volumes can be done using another QIPCM extension. Required inputs are the ROI and a reference region (muscle or blood).^{4,9,10}

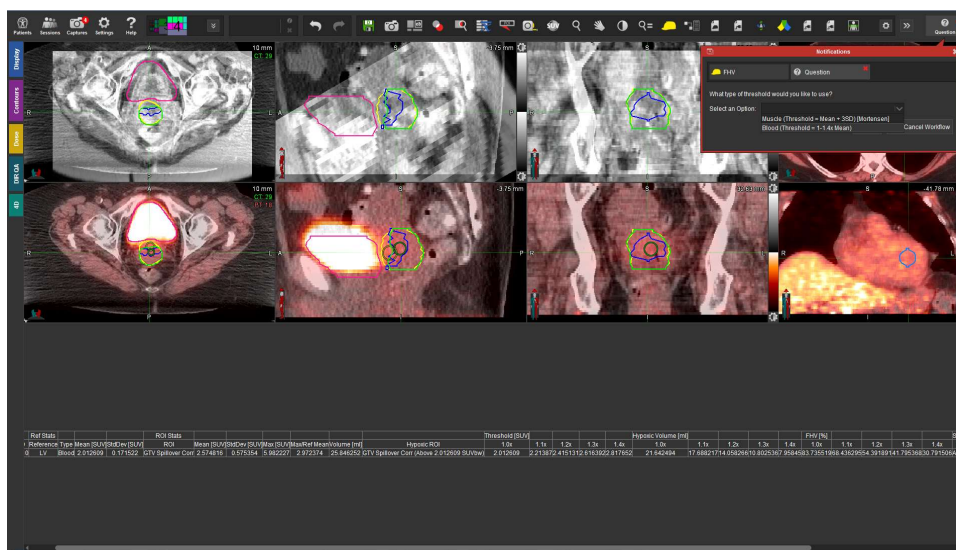


Figure 8. The visualization of contours and hypoxic regions, and the manipulation and measurement of ROIs can all be done using ClearCanvas. Hypoxia-related calculations and visualizations require two ROIs: one target and one reference.

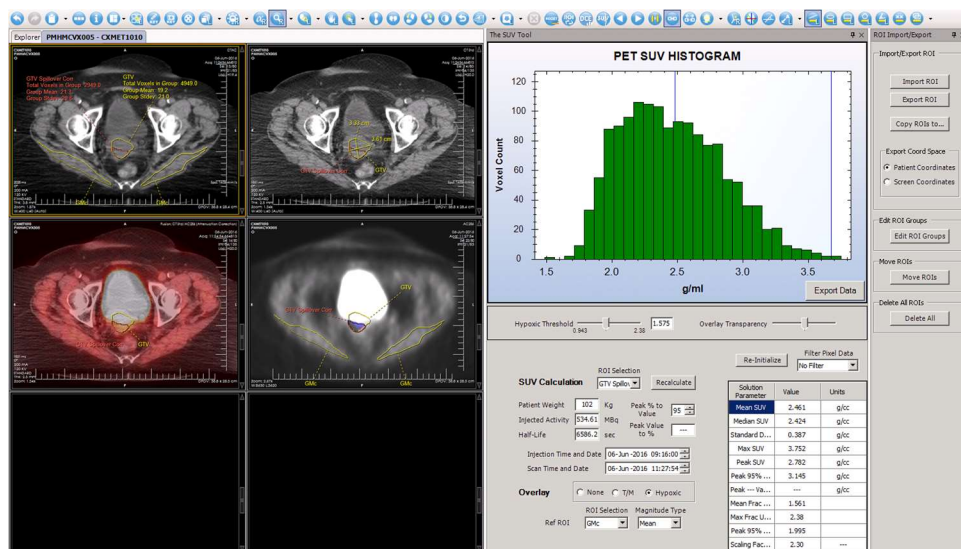


Figure 9. Obtain parametric maps (bottom row) from compartmental modeling of dynamic PET images using an extension built by QIPCM for MIM. Required inputs are an ROI and an input function. Deformable registration in MIM enables multi-modal imaging analysis. The top left image shows a PET-MRI constructed from a SUM PET of the modeled dynamic series. The central and right images of the top row show a deformed PET-MRI from a later time and a T1-Gadolinium MRI from an earlier day, respectively.



RADIATION PLANNING IMAGING

The following RT Plan functionalities enable users to review the quality of radiation therapy treatment plans (e.g., IMRT, VMAT, palliative) on the QIPCM platform as part of a local/centralized retro/prospective clinical trial. Usage requires some application training by a PI, their team, or a medical physicist. QIPCM can also act as a delegate, in addition, to help automate the QA of specific ROI labeling/dosimetric requirements on a per trial basis.

- Radiation therapy plan quality review (IMRT, VMAT)
- *Improve treatment planning and target dose allocation*
- Planning dose/contour/point/beam/DRR visualization (Figure 10)
- *Review treatment delivery through gantry rotation playback, patient setup, and beam energies*
- Dose volume histogram (DVH) generation (Figure 11 & Figure 12)
- DVH comparison (Figure 13)
- *Improve dose localization of targets and organs at risk*

Figure 10. RT Plan Review in MIM enables contour review, contouring, beam and MLC visualization and playback, as well as in-depth beam specs.

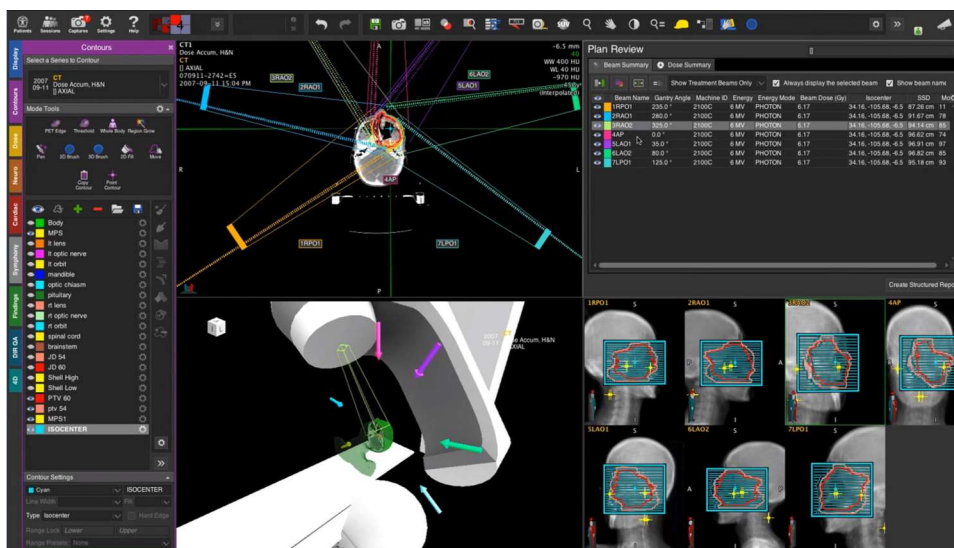


Figure 11. RT Plan QA in MIM enables automated QA of trial-specific dosimetric and labelling constraints, and the generation of DVHs.

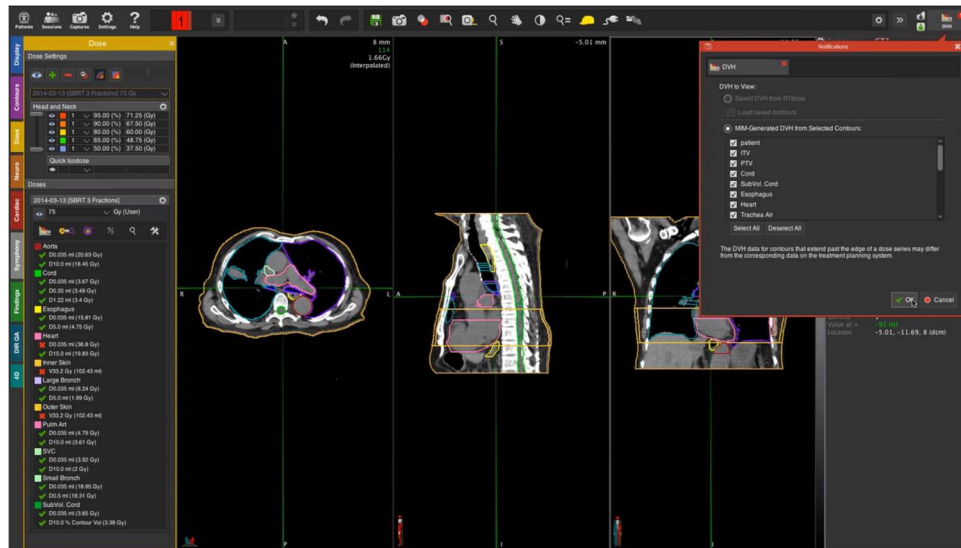


Figure 12. Review contours and DVHs of RT plans using Weasis.

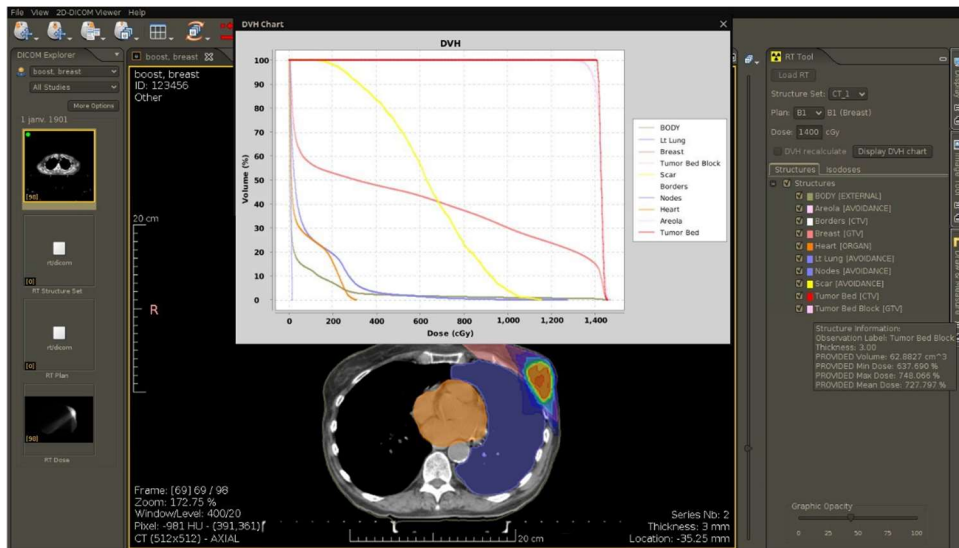
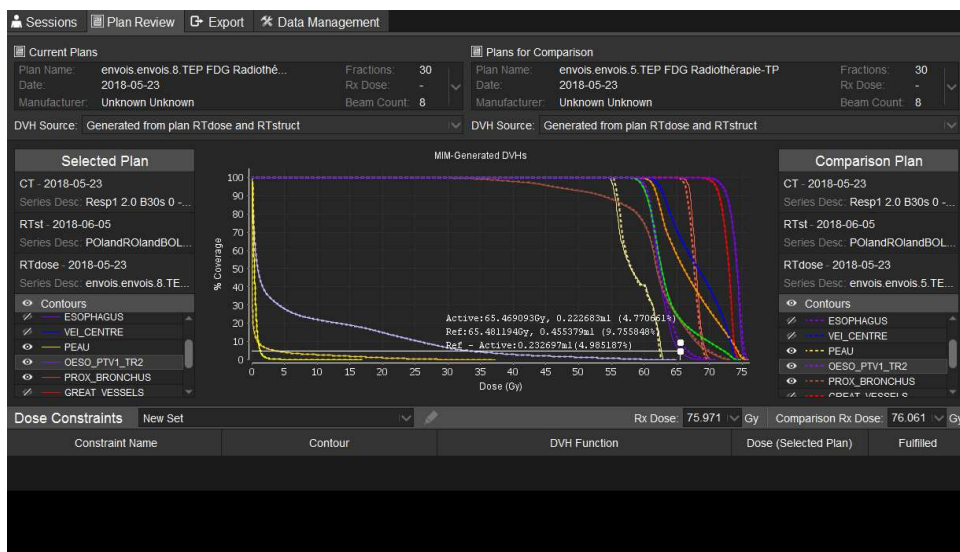


Figure 13. Visually compare two DVHs in MIM. Move the cursor along each DVH line to get precise dose values.



PERSONALIZED RADIOTHERANOSTIC DOSIMETRY

QIPCM has developed a personalized radiotheranostic dosimetry platform for Lu177-DOTATATE using a MATLAB extension for MIM. This workflow allows radiation therapists to contour SPECT-CT images (Figure 14) have them reviewed by a radiation oncologist and have PDF based dosimetry reports generated which can be reviewed and signed off by Medical Physicists (Figure 15).

- ^{177}Lu -Dotatate SPECT camera sensitivity calibration is carried out.
- SPECT-CT images are collected by QIPCM at every cycle of ^{177}Lu -Dota therapy using the QIPCM-issued image de-identification and transfer pipeline
- Each SPECT-CT is QC'd to ensure quality and calibration values are maintained
- Functionalities above can be adapted to other imaging agents (e.g., PSMA) and isotopes (e.g., ^{225}Ac) upon request

Figure 14. The Individualized dosimetry extension for MIM guides the physician through the process of creating the regions of interest on each of the SPECT-CT time points using co-registered images and auto-propagated contours.

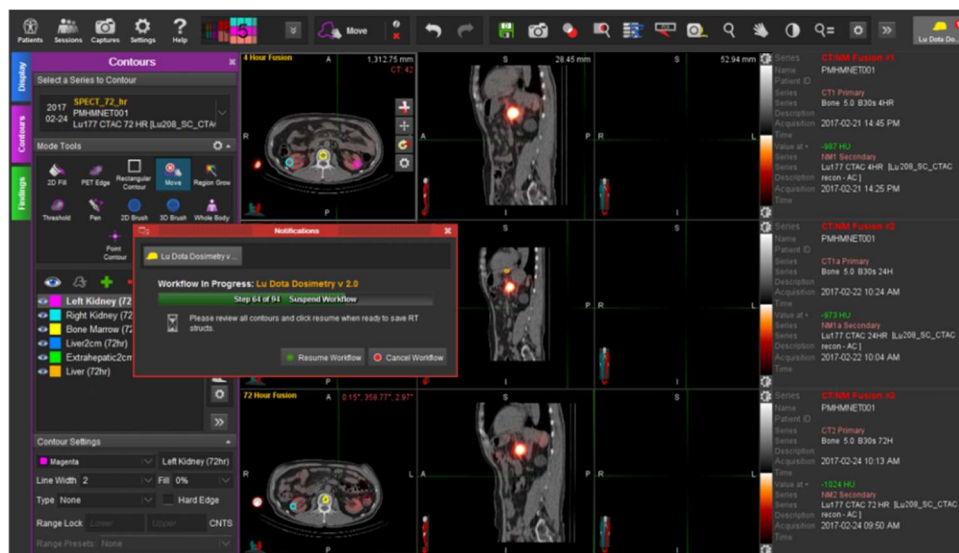
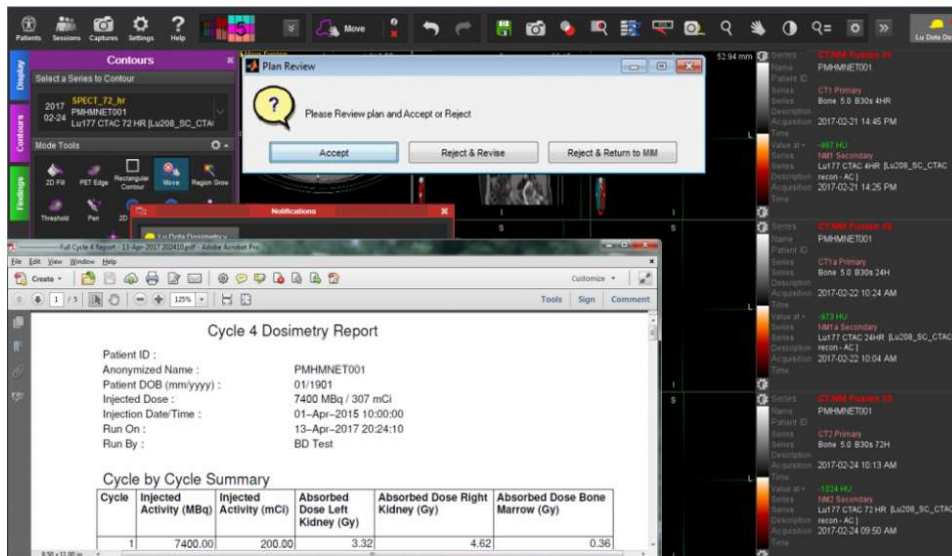


Figure 15. Once complete, the workflow will launch a validated Matlab™ based extension, which will calculate the dose accumulated to the organs at risk and prescribe the dose for the subsequent cycles based on MIRD based dosimetry. A PDF report is generated and automatically sent to the treating physician and a medical physicist for sign-off.



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