Developments in AI model: 2D and 3D

14/03/25

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Sommario

Fase 2D

- Risultati finali
    - Modello, addestramento, gamma-analisi
- DEMO InTrEPID-2D system
- Paper per Radiotherapy & Oncology

Fase 3D

- Data exploration
- Coregistrazione CT-RTDOSE
- Qualche idea…

Fase 2D

Dati, preprocessing, rete, training, gamma-analisi

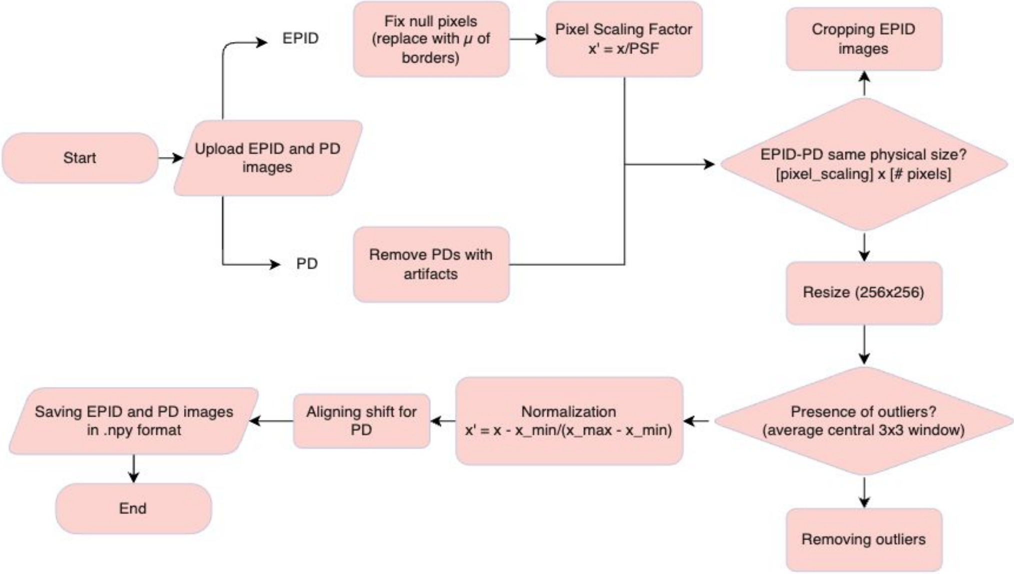
Table 1: Composizione del dataset suddiviso per forma e dimensione dei fantocci. OMG= Omogeneus, MP=Multiplag

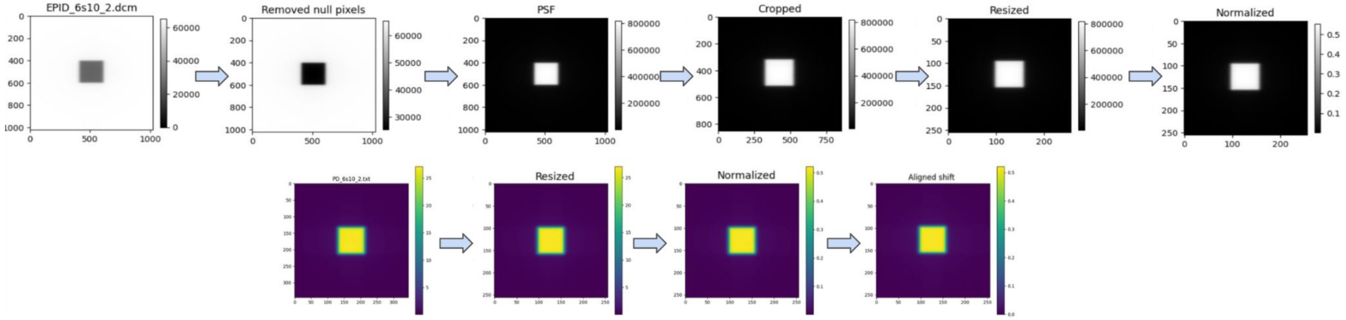
Area [cm^2]	OMG	CIRS	SLAB	MP	Tot
2×2	14	8	7	-	29
5×5	12	9	7	12	40
10×10	16	7	7	8	38
20×20	14	-	7	-	21
2×10	13	8	7	8	36
10×2	13	8	2	-	10
15×1	4	8	-	8	16
1×15	-	8	-	-	8
4×20	-	-	7	-	7
Ellipses	-	-	-	8	8

TEST SET

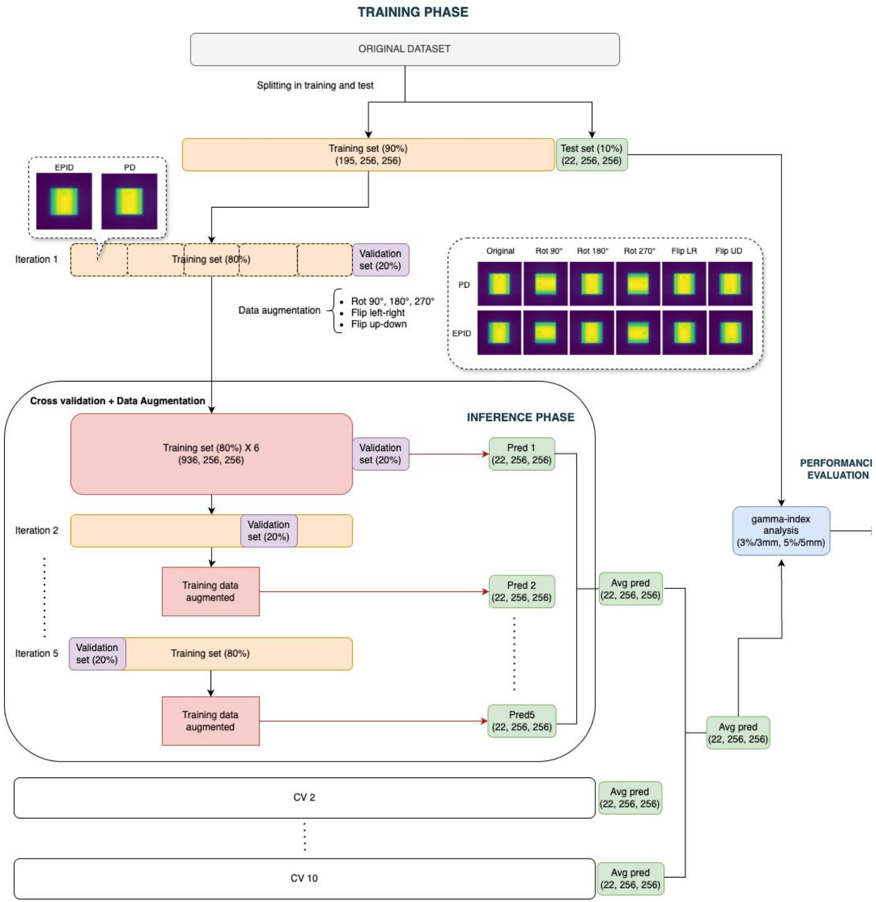
	QUADRATI				RETTANGOLI					CERCHI/ELLISSI
Phantoms	2x2 cm^2	5x5 cm^2	10x10 cm^2	20x20 cm^2	2x10 cm^2	10x2 cm^2	15x1 cm^2	1x15 cm^2	4x20 cm^2	
Omogeneus	6s10b3_1	6s30b1_2	6s10b2_3	6s20_4	6s10b2_6				SLABBone_5	
CIRS	CIRS_0gradi_ISOlesione_1	CIRS_270gradi_ISOlesione_2	CIRS_0gradi_ISOlesione_3		CIRS_270gradi_ISOcentro_6	CIRS_90gradi_ISOlesione_7	CIRS_0gradi_ISOcentro_8	CIRS_0gradi_ISOlesione_9		
SLAB	SLABinhomAir2_1	SLAB_Boneb2_2slab_2	SLABBone_3	SLAB_Bone_2slab_4	SLABinhomAir2_6					
Multi_Plug		Multiplug_90g_5cm_ARIA_2	Multiplug_PMMA_90g_3		Multiplug_PMMA_180g_6		Multiplug_Ti_90g_8			Multiplug_Ti_tondo_1E0g
# images	3	4	4	2	4	1	2	1	1	1

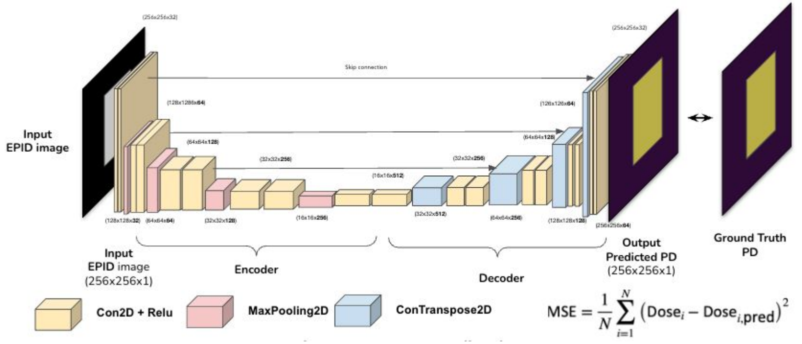
Dati, **preprocessing**, rete, training, gamma-analisi





Dati, preprocessing, rete, training, gamma-analisi





$$\mathrm{MSE} = \frac{1}{N}\sum_{i=1}^{N}\left(\mathrm{Dose}_i - \mathrm{Dose}_{i,\mathrm{pred}}\right)^2$$

Hyperparameter Optimization

A **GS** approach was implemented to find out the best hyperparameter configurations: # filters: [8, 16], learning rate: [0.01, 0.001, 0.0001], batch size: [4, 8, 16, 32] → 24 different configuration!

Cross-Validation Strategy

To improve generalization and reduce overfitting, **10 CV** schemes were applied. Each training: **150 epochs** per model, **5-fold CV** per training

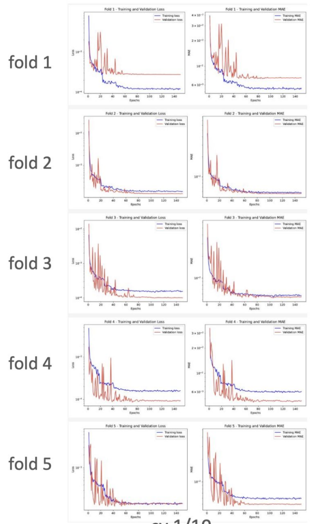
Ensemble Learning

An EL approach was adopted by averaging the predictions of the best models from each training run.

Hardware

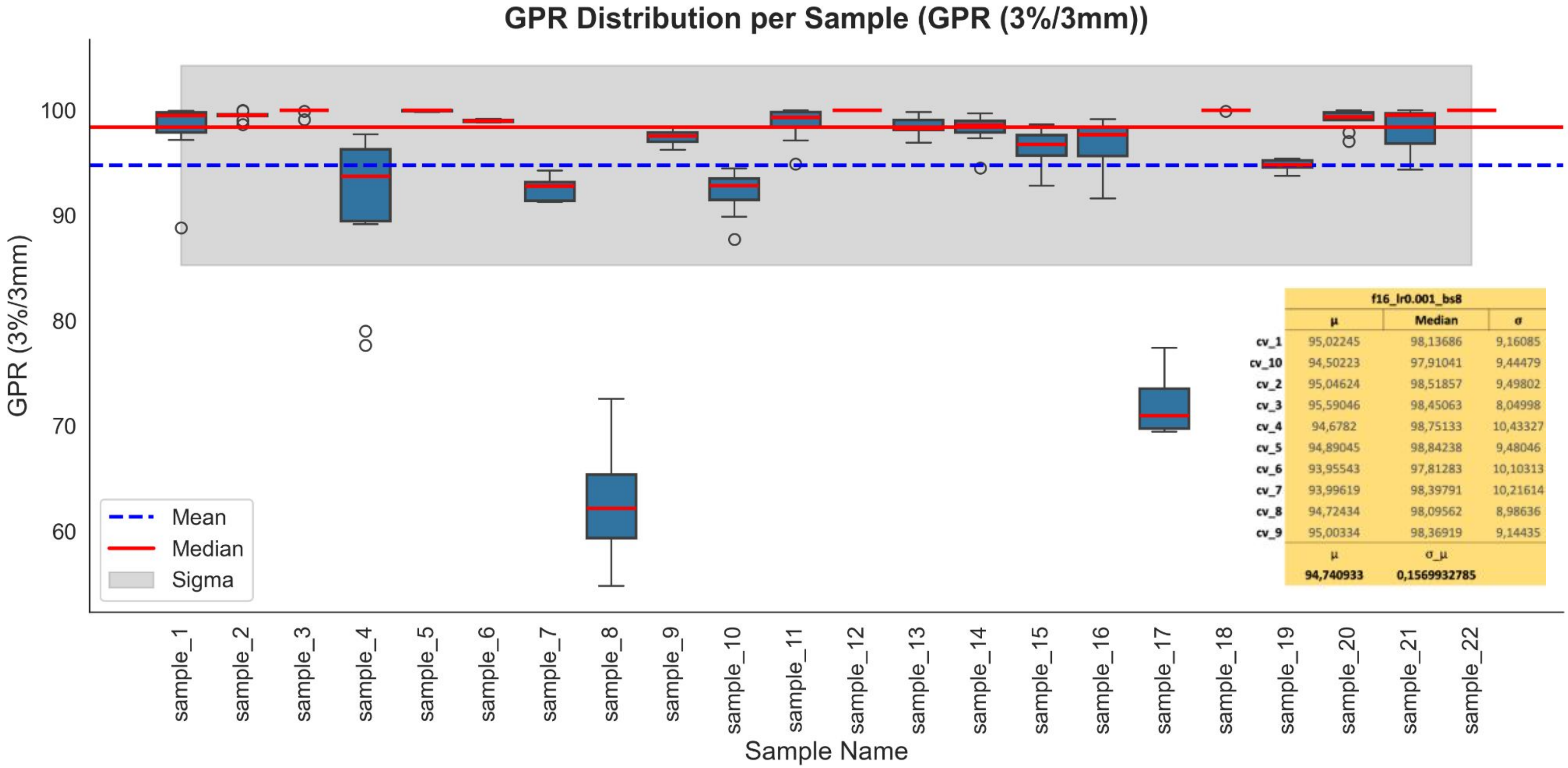
The training process was conducted using the NVIDIA V100 Tensor Core GPU of the **Computing Center of the INFN - Pisa division**.

f16, lr0.001, bs8



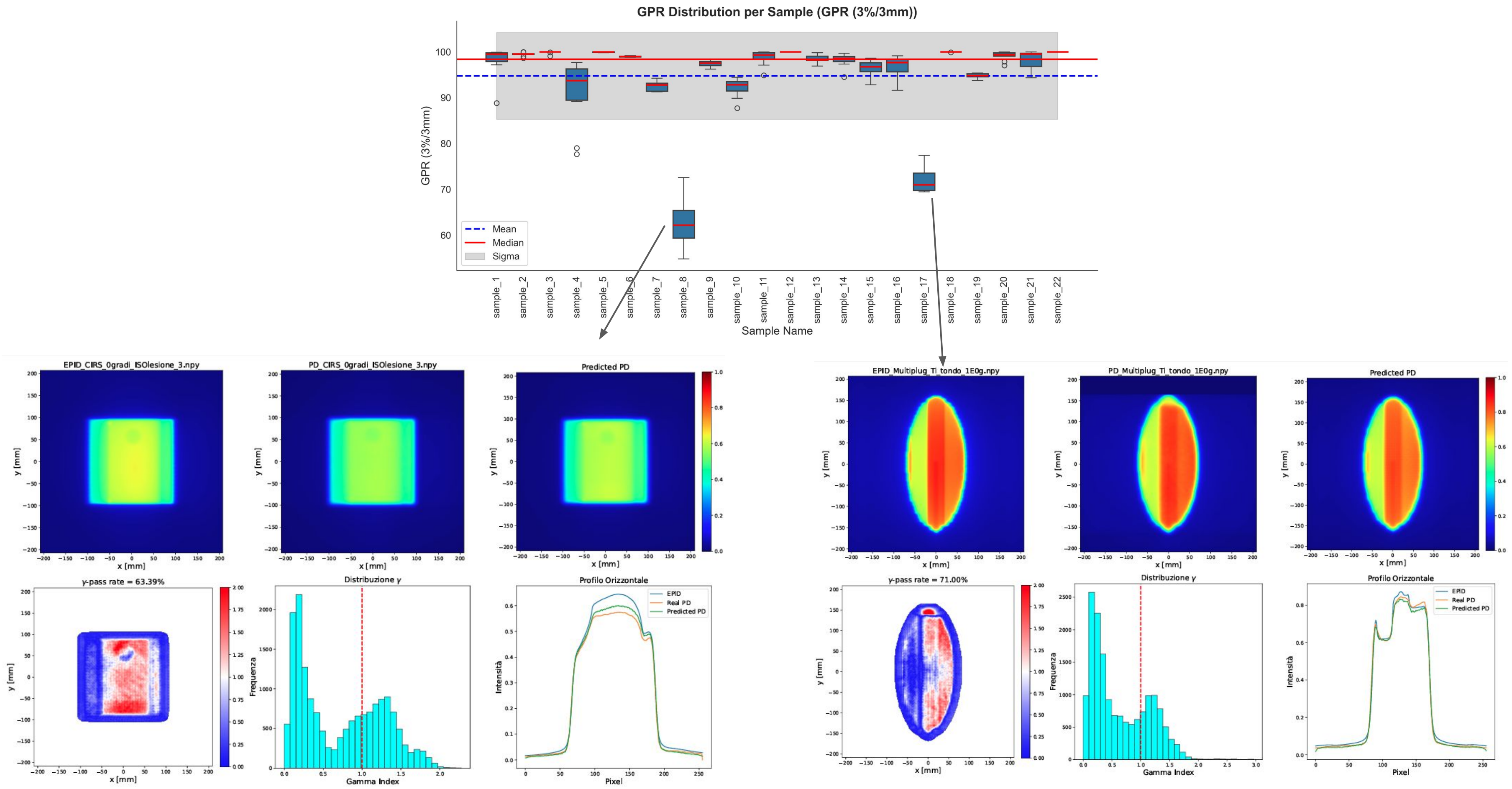
cv 1/10

Dati, preprocessing, rete, training, **gamma-analisi**



	f16_lr0.001_bs8		
	μ	Median	σ
cv_1	95,02245	98,13686	9,16085
cv_10	94,50223	97,91041	9,44479
cv_2	95,04624	98,51857	9,49802
cv_3	95,59046	98,45063	8,04998
cv_4	94,6782	98,75133	10,43327
cv_5	94,89045	98,84238	9,48046
cv_6	93,95543	97,81283	10,10313
cv_7	93,99619	98,39791	10,21614
cv_8	94,72434	98,09562	8,98636
cv_9	95,00334	98,36919	9,14435
	μ	σ_μ	
	94,740933	**0,1569932785**	

Dati, preprocessing, rete, training, gamma-analisi



Conclusions

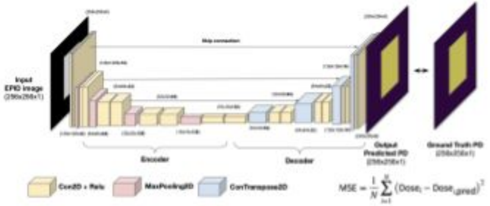
189 pairs of EPID and PD images were allocated to the training set, 22 pairs to the test set.

TRAINING SET

	QUADRATI				RETTANGOLI					CERCHI/ELLISSI
Phantoms	2x2 cm^2	5x5 cm^2	10x10 cm^2	20x20 cm^2	2x10 cm^2	10x2 cm^2	15x1 cm^2	1x15 cm^2	4x20 cm^2	
Omogeneus	14	12	16	14	13				13	4
CIRS	8	9	7		8	8	8	8		
SLAB	7	7	7	7	7	2			7	
Multi_Plag		12	8		8		8			8
Somma	29	40	38	21	36	10	16	8	20	12
Percentuale	13.00%	17.00%	17.00%	9.00%	16.00%	4.00%	7.00%	3.00%	9.00%	5.00%

TEST SET

	QUADRATI				RETTANGOLI					CERCHI/ELLISSI
Phantoms	2x2 cm^2	5x5 cm^2	10x10 cm^2	20x20 cm^2	2x10 cm^2	10x2 cm^2	15x1 cm^2	1x15 cm^2	4x20 cm^2	
Omogeneus	1	1	1	1	1				1	
CIRS	1	1	1		1	1	1	1		
SLAB	1	1	1	1	1				1	
Multi_Plag		1	1		1		1			1
Somma teorica	3	4	4	2	4	1	2	1	2	1

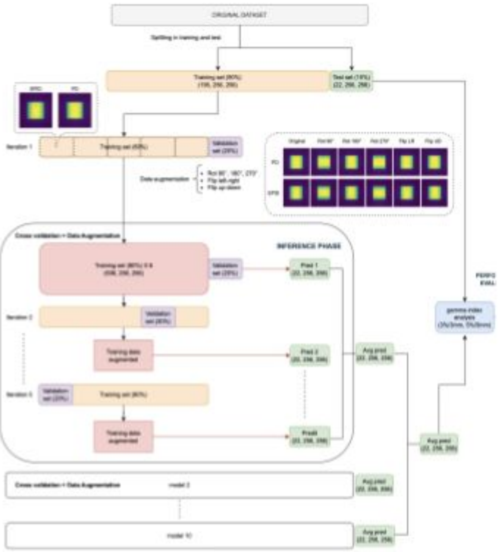


DL Architecture

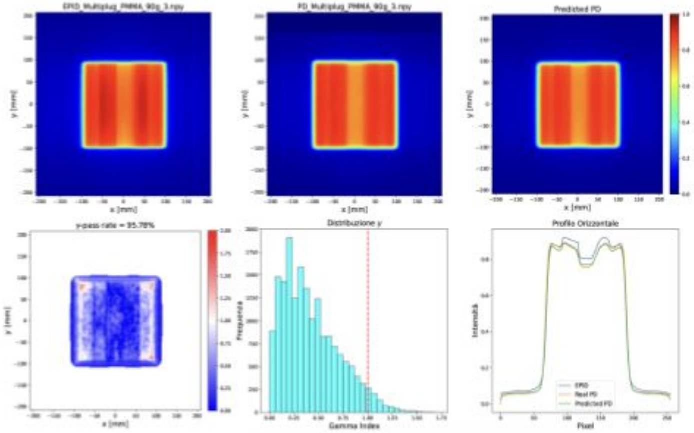
5 depth levels with skip connections between encoder and decoder. Each level applies **2 convolutions (3×3)** with filters doubling up to **128** at the bottleneck, using **MaxPooling** for downsampling and **Transposed Convolutions** for upsampling, with **Batch Normalization** in deeper layers and **ReLU** as activation.

Training

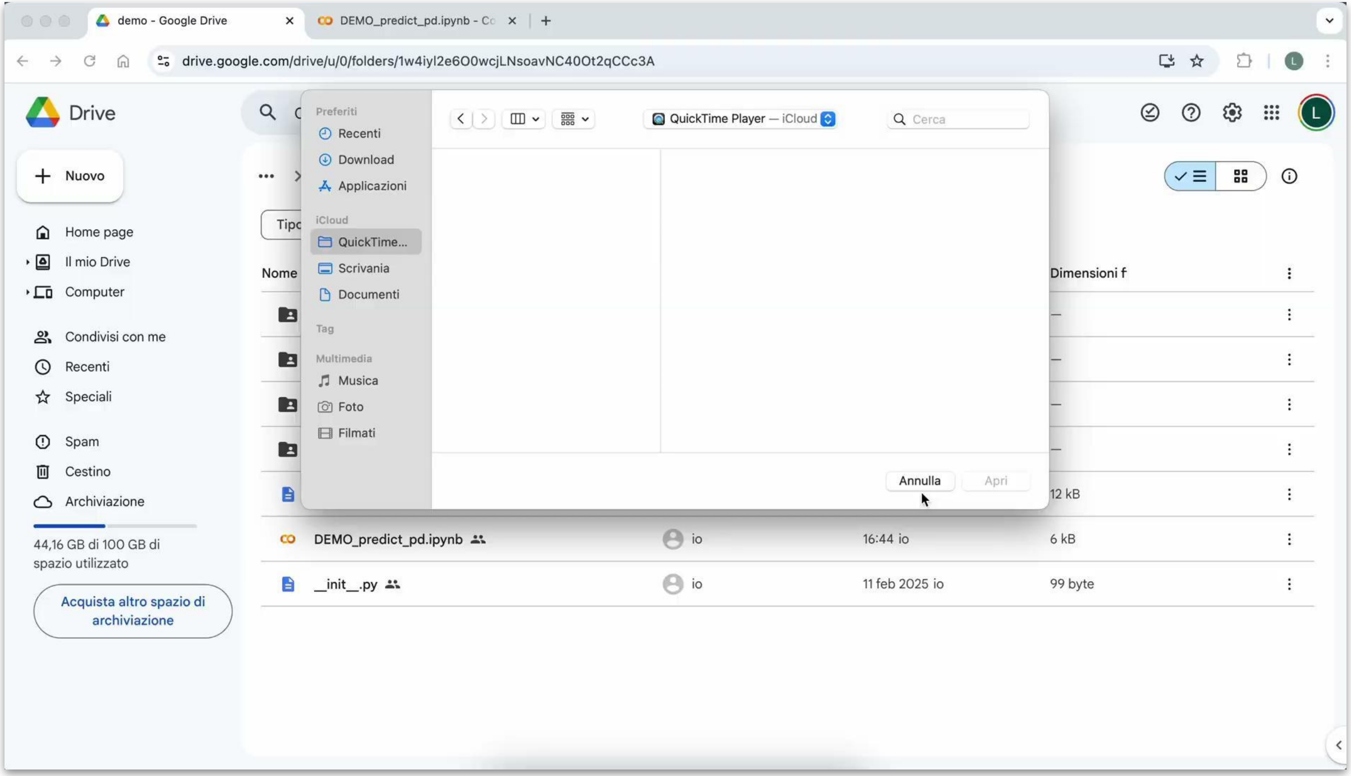
Grid search: # initial filters (8, 16), learning rate (0.01, 0.001, 0.0001), batch size (4, 8, 16, 32)
Training phase: 10 cv with k=5, epochs 150, data augmentation



		μ	σ_μ	Med
a)	3%/3mm	94,53%	2,08%	98,00%
	5%/5mm	99,55%	0,25%	100,00%
		μ	σ_μ	Med
b)	3%/3mm	92,45%	2,42%	98,00%
	5%/5mm	99,27%	0,48%	100,00%
		μ	σ_μ	Med
c)	3%/3mm	92,21%	2,59%	98,00%
	5%/5mm	98,44%	1,33%	100,00%



DEMO 2D-InTrEPID system



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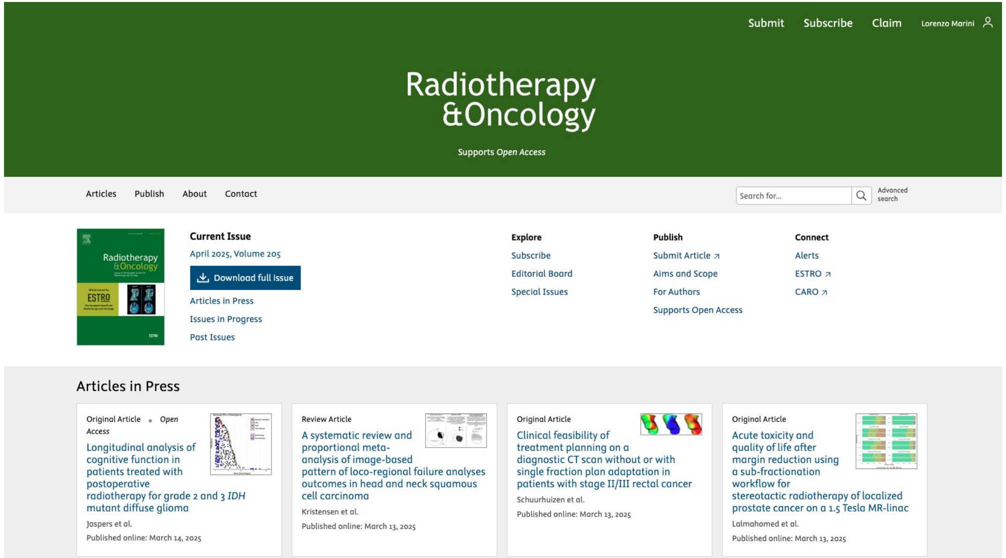
Paper



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Per essere aggiunti, chiedere ad @Alessandra

6 pagine, 6 figure. *Manca qualche autore??*

Deep learning methods for transit dosimetry with EPID images

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Abstract

Background and Purpose: The complexity of external beam photon radiotherapy has significantly increased, leading to a higher risk of errors that require advanced systems for dose verification. Electronic Portal Imaging Devices (EPIDs), originally designed for patient positioning, have become essential tools for in-vivo dosimetry (IVD) and pre-treatment dose verification. Traditional dose reconstruction methods, such as physical models and Monte Carlo simulations, face limitations in complexity, computational power, and time-efficiency, hindering routine clinical use. **Materials and methods**: This study introduces a deep learning (DL) framework for 2D dose reconstruction using real EPID images acquired during treatment. A 2D U-Net model maps EPID images to water-equivalent portal dose images (PDIs), leveraging a database of 211 EPID-PD pairs obtained from phantoms with diverse material densities. The performance was evaluated through mean absolute error (MAE) metrics and 2D -analysis with a 3mm/3% and 5mm/5% criterion. **Results**: 2D framework achieved a predictive mean -passing rate of (94.53 ± 2.08)% and (99.55 ± 0.25)% for the 3mm/3% and 5mm/5% criteria, respectively. The median -passing rates across all test cases were 98.03% and 100.00%. demonstrating the model's robustness across different scenarios. The dose predictions completed within 1 second, significantly faster than TPS calculations (≈20–30 minutes). **Conclusions**: Deep learning enables real-time, accurate dose reconstruction from EPID images, demonstrating its potential for in-vivo treatment verification. This work highlights the performance of the 2D model, emphasizing their clinical potentiality in radiotherapy.

Keywords: EPID, Transit dosimetry, Radiotherapy, Deep Learning, U-Net

1. Introduction

In the last decades, the complexity of external beam photon radiotherapy treatments has increased significantly [1]. However, due to the advancement in technical complexity, the risk of errors has grown too requiring sophisticated systems to ensure correct dose administration and verification [2]. Errors caused by equipment malfunctioning, patient positioning or anatomical changes must be promptly detected to prevent accidents and comply with the stringent EU dose verification guidelines [3].

Electronic Portal Imaging Devices (EPIDs), initially designed for real-time monitoring patient positioning, have become the preferred tools for both in-vivo dosimetry (IVD) and for pre-treatment dose verification [4, 5, 6]. EPIDs measure X-ray fluence on an amorphous silicon flat-panel detector, producing 2D digital images containing dose information (the so-called Portal Dose, PD). Therefore, a dose reconstruction is then possible, and it is generally achieved by means of physical models and Monte Carlo simulations. Nonetheless, these methods have several limitations, due the complexity of the dose reconstruction algorithms, the computing power and the significant time-consuming, limiting their routine clinical use.

In this scenario, Artificial Intelligence, in particular Deep Learning (DL), offers a promising alternative for IVD in radiotherapy [7, 8, 9]. By bypassing the traditional physical models, DL can achieve Monte Carlo-level accuracy while maintaining the speed of a trained model. Most existing studies are mainly based on simu-

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   b. *Preprocessing*
   c. *Deep learning model and training phase*
   d. *Grid search, repeated k-fold cross-validation and ensemble learning*
   e. *Evaluation of the performance*
3. **Results**
   a. *Dataset quality*
   b. *Model performance*
4. **Discussion**
5. **Credit authorship contribution statement**
6. **Declaration of competing interest**
7. **Acknowledgements**
8. **References**


ing phantoms with higher density gradients, where the γ-passing rate dropped below ???%. This suggests that the model may struggle with more complex dose distributions, where important scatter effects or significant heterogeneities are present.

5. Credit authorship contribution statement

Lorenzo Marini:, Carlotta Mozzi:, Aafke C. Kraan: , Michele. Avanzo: , Francesca Lizzi: , Alessandra Retico: , Icro Meattini: , Livia Marrazzo: , Cinzia Talamonti:

6. Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. Acknowledgements

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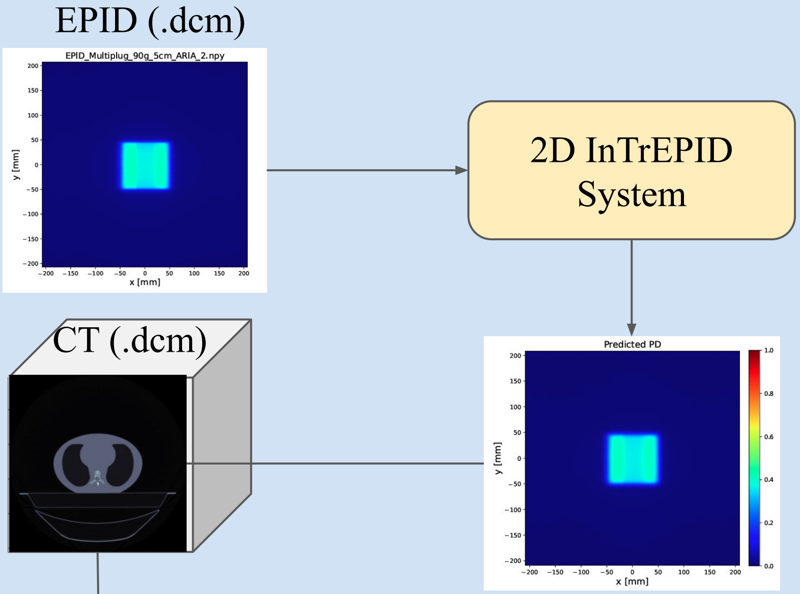
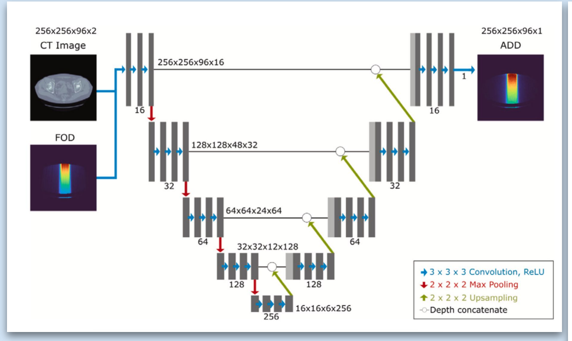
References

[1] Koka, K., Verma, A., Dwarakanath, B. S., Papineni, R. V. L. Technological Advancements in External Beam Radiation Therapy (EBRT): An Indispensable Tool for Cancer Treatment. *Cancer Management and Research*, 2022.
[2] Shafiq, J., Barton, M., Noble, D., Lemer, C., Donaldson, L. J. An international review of patient safety measures in radiotherapy practice. *Radiotherapy and Oncology*, 92(1), 15-21, 2009.
[3] European Union. Article 63 of the EU directive 2013/59/EURATOM, 2013.
[4] Antonuk, L. E., et al. Initial performance evaluation of an indirect-detection, active matrix flat-panel imager (AMFPI) prototype for megavoltage imaging. *International Journal of Radiation Oncology, Biology, Physics*, 42(2), 437-454, 1998.
[5] van Elmpt, W., et al. A literature review of electronic portal imaging for radiotherapy dosimetry. *Radiotherapy and Oncology*, 88(3), 289-309, 2008.
[6] Olaciregui-Ruiz, I., et al. In vivo dosimetry in external beam photon radiotherapy: Requirements and future directions for research, development, and clinical practice. *Physics and Imaging in Radiation Oncology*, 15, 108-116, 2018.
[7] Zhang, J., Cheng, Z., Fan, Z., et al. A feasibility study for in vivo treatment verification of IMRT using Monte Carlo dose calculation and deep learning-based modeling of EPID detector response. *Radiation Oncology*, 17, 31, 2022.
[8] Chan, M. F., Witztum, A., Valdes, G. Integration of AI and Machine Learning in Radiotherapy QA. *Frontiers in Artificial Intelligence*, 3, 2020.
[9] Li, Y., Xiao, F., Liu, B., Qi, M., Lu, X., Cai, J., Zhou, L., Song, T. Deep learning-based 3D in-vivo dose reconstruction with an electronic portal imaging device for magnetic resonance-linear accelerators: a proof of concept study. *Physics in Medicine and Biology*, 66(23), 2021.
[10] Ronneberger, O., Fischer, P., Brox, T. U-Net: Convolutional Networks for Biomedical Image Segmentation. *Lecture Notes in Computer Science*, vol. 9351, Springer, 2015.
[11] Ioffe, S., Szegedy, C. Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift. *arXiv preprint*, arXiv:1502.03167, 2015.
[12] Low, D. A., Harms, W. B., Mutic, S., Purdy, J. A. A technique for the quantitative evaluation of dose distributions. *Medical Physics*, 25(5), 656-661, 1998.
[13] Li, H., Dong, L., Zhang, L., Yang, J. N., Gillin, M. T., Zhu, X. R. Toward a better understanding of the gamma index: Investigation of parameters with a surface-based distance method. *Medical Physics*, 38, 6730-6741, 2011.
[14] Khan, F. M., Gibbons, J. P. *Khan's The Physics of Radiation Therapy*. Lippincott Williams Wilkins, 2014.
[15] Santos, T., Ventura, T., do Carmo Lopes, M. A review on radiochromic film dosimetry for dose verification in high energy photon beams. *Radiation Physics and Chemistry*, 179, 109217, 2021.
[16] Marrazzo, L., Zani, M., Pallotta, S., Arilli, C., Casati, M., Compagnucci, A., Talamonti, C., Bucciolini, M. GafChromic® EBT3 films for patient specific IMRT QA using a multichannel approach. *Physica Medica*, 31(8), 1035-1042, 2015.
[17] Cilla, S., Fidanzio, A., Greco, F., Sabatino, D., Russo, A., Gargiulo, L., Azario, L., Piermattei, A. Correlation functions for Elekta aSi EPIDs used as transit dosimeter for open fields. *Journal of Applied Clinical Medical Physics*, 12(1), 218-233, 2011.

Fase 3D





2.3. First order dose approximation

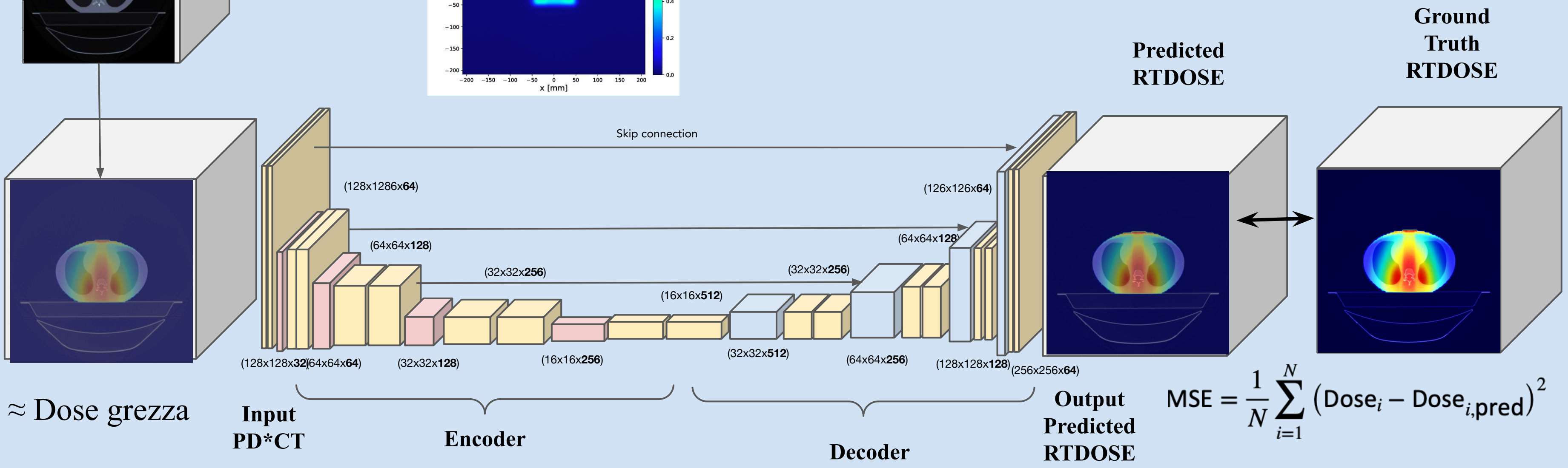
With every patient 3D dose simulation, the corresponding EPID transmitted signal was simultaneously scored as a 2D dose-to-water distribution, as explained in 2.2. This 2D EPID signal was used to produce a 3D FOD approximation inside the patient geometry. The FOD is corrected for geometric magnification, inverse square effects and attenuation inside the patient geometry.

The corrections were performed separately: first, the 2D dose-to-water distribution was backprojected into several parallel planes d towards the radiation source, creating a 3D matrix of dose-to-water distribution ($D_{w,d}$ in Eq. (3)). This step was performed using a modified 3D ray tracing algorithm [55] based on the Siddon method [56], which accounted for geometric magnification. Next, the intensity of the signal was corrected for the inverse square law effect (second term on Eq. (3)), where r_d and r_{EPID} are the distances from the radiation source to the projection plane d and the EPID plane, respectively.

$$\mathrm{FOD}_d = D_{w,d} \cdot \left(\frac{r_d}{r_{\mathrm{EPID}}}\right)^{-2} \cdot e^{(\mu_{w,E} \cdot L)} \tag{3}$$

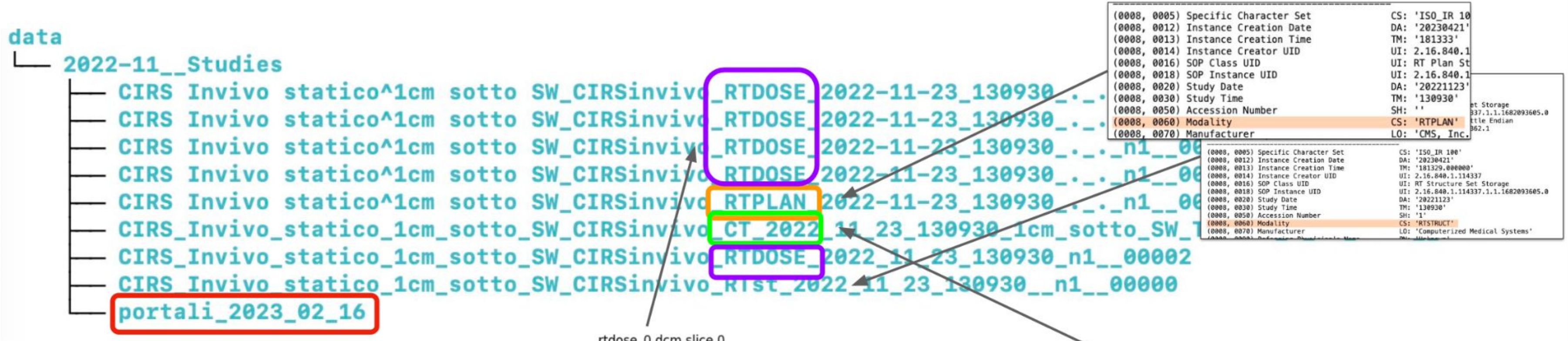
Predicted PD (.npy)

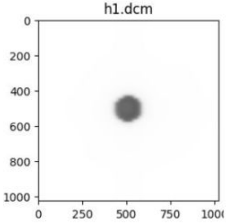
Martins et al. Physica Medica, 2023



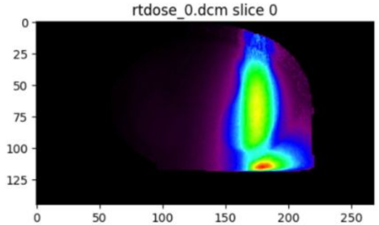
$$\mathrm{MSE} = \frac{1}{N}\sum_{i=1}^{N}\left(\mathrm{Dose}_i - \mathrm{Dose}_{i,\mathrm{pred}}\right)^2$$

Data exploration 3D



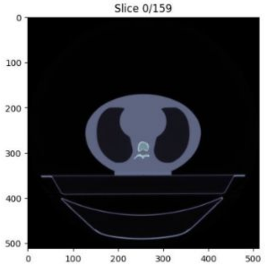


EPID
4 images in dicom format (1024x1024) 16 bit



RTDOSE
5 images, **79** frames for image in dicom format (145x268), 16 bit

CT
159 images in dicom format (512x512), 16 bit



DATASET:
https://drive.google.com/drive/folders/1sfwZSsa1BGuNRctZgY_K5z6ylrdQZAug?usp=drive_link

Coregistrazione

How does 3D Slicer overlay the RTDOSE and Image data in the correct position?

Support | python | dicom | extensions-manager | registration | slicerrt

Iman_Shokatian — 1 — Oct 2019

Hello,

I'm currently an MS student in Medical Physics and I have a great need to be able to overlay an isodose distribution from an RTDOSE file onto a CT image from a .dcm file set.

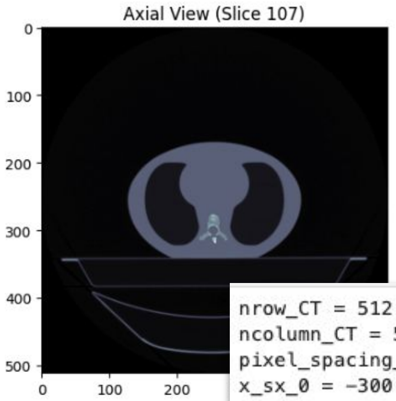
I've managed to extract the image and the dose pixel arrays myself using pydicom and dicom_numpy, but the two arrays are not the same size! So, if I overlay the two together, the dose will not be in the correct position based on what the Elekta Gamma Plan software exported it as.

I've played around with slicerrt and it obviously is able to do this even though the arrays are not the same size. However, I think I cannot export the numerical data when using slicerrt…I can only scroll through and view it as an image. What section of the code has the algorithm for overlaying the RTDOSE to an image?

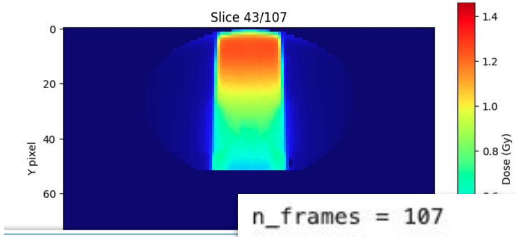
Oct 2019

1 / 23
Oct 2019

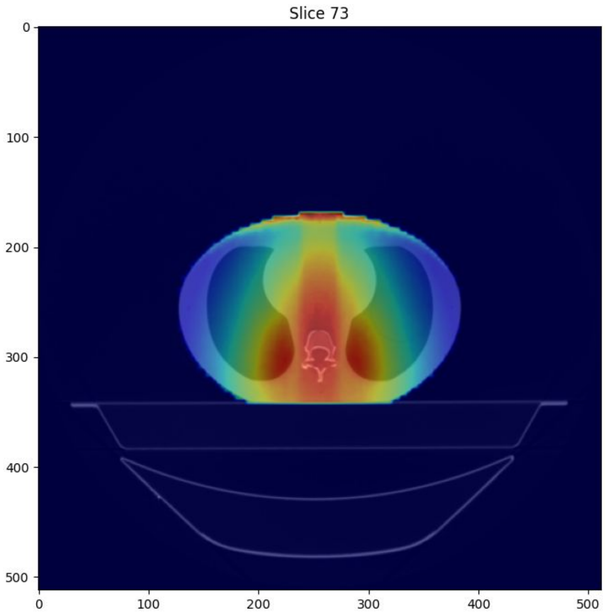
Sep 2023



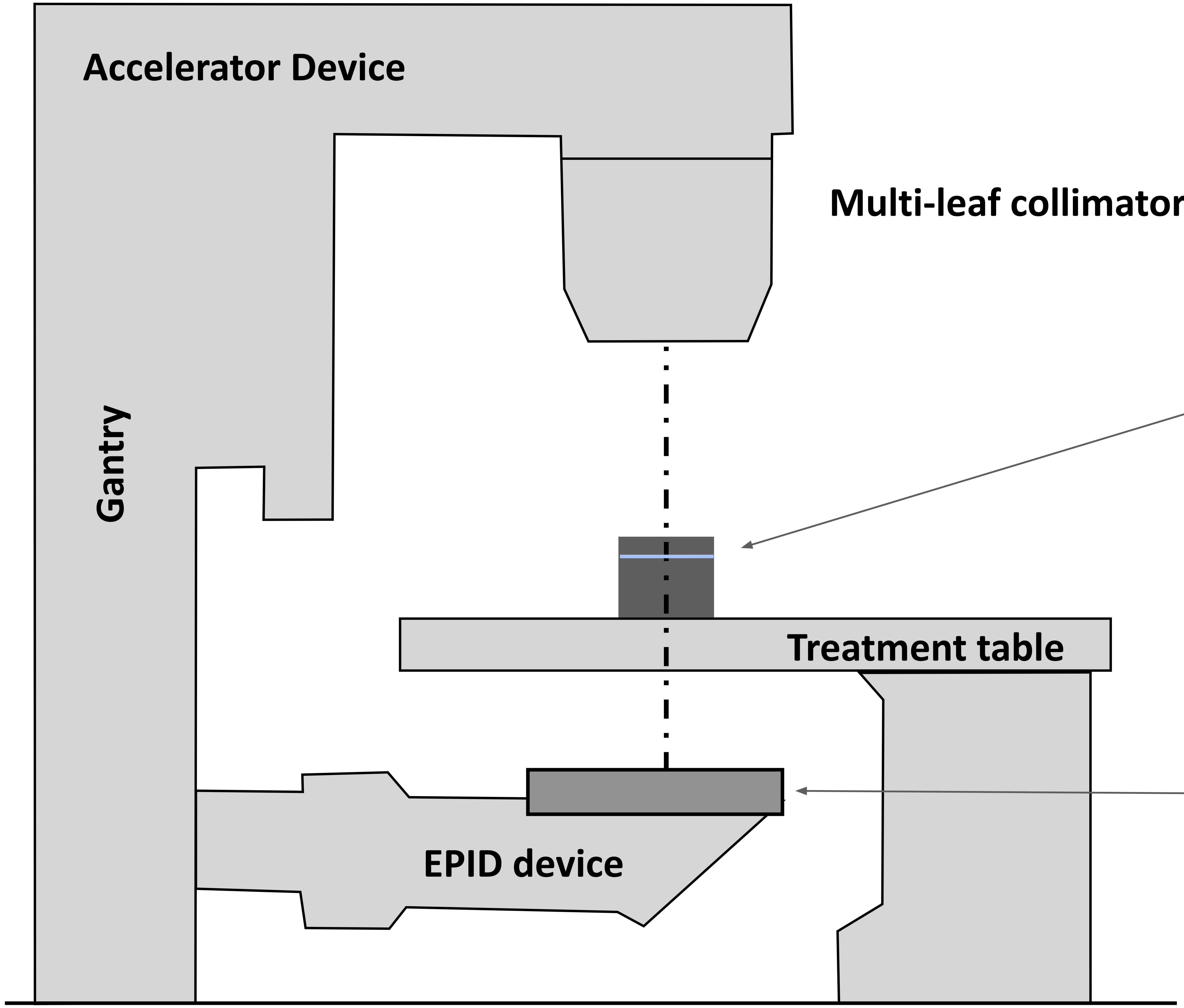

```
nrow_CT = 512
ncolumn_CT = 512
pixel_spacing_CT = [1.171875, 1.171875] mm
x_sx_0 = -300 mm
y_sx_0 = -207 mm
z_0 = -220 mm
```



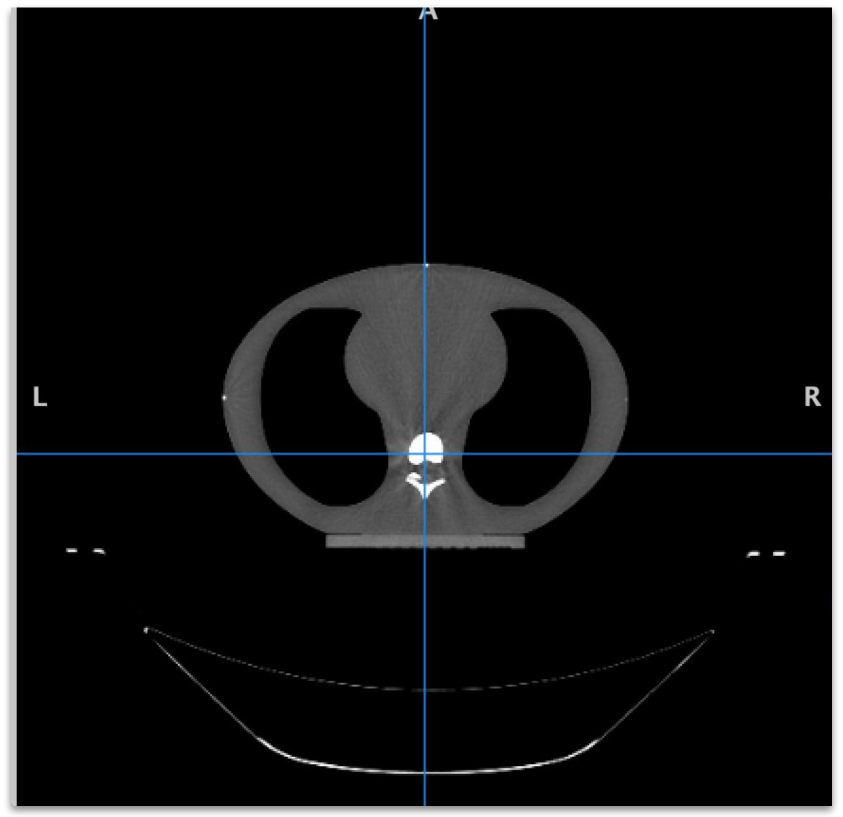

```
n_frames = 107
rows = 95
columns = 135
pixel_spacing = [4, 4] mm
x_sx_0 = -268.6 mm
y_sx_0 = -11.6 mm
z_sx_0 = -219 mm
```



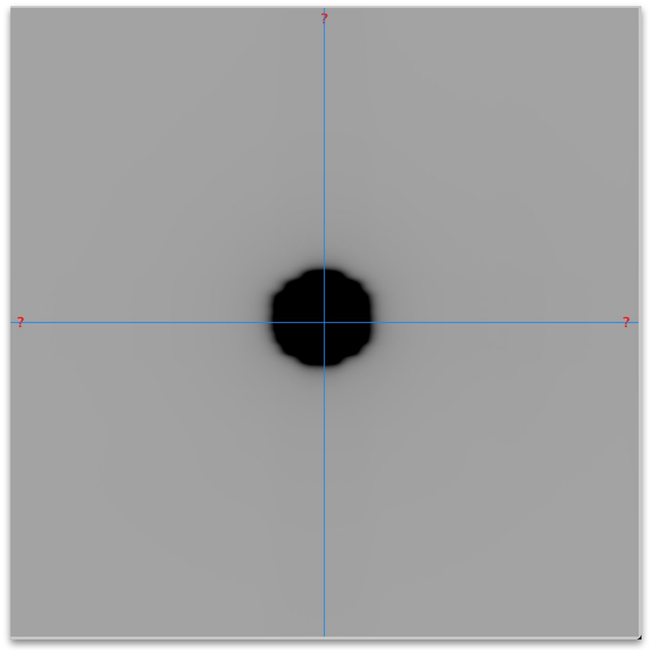
Experimental setup



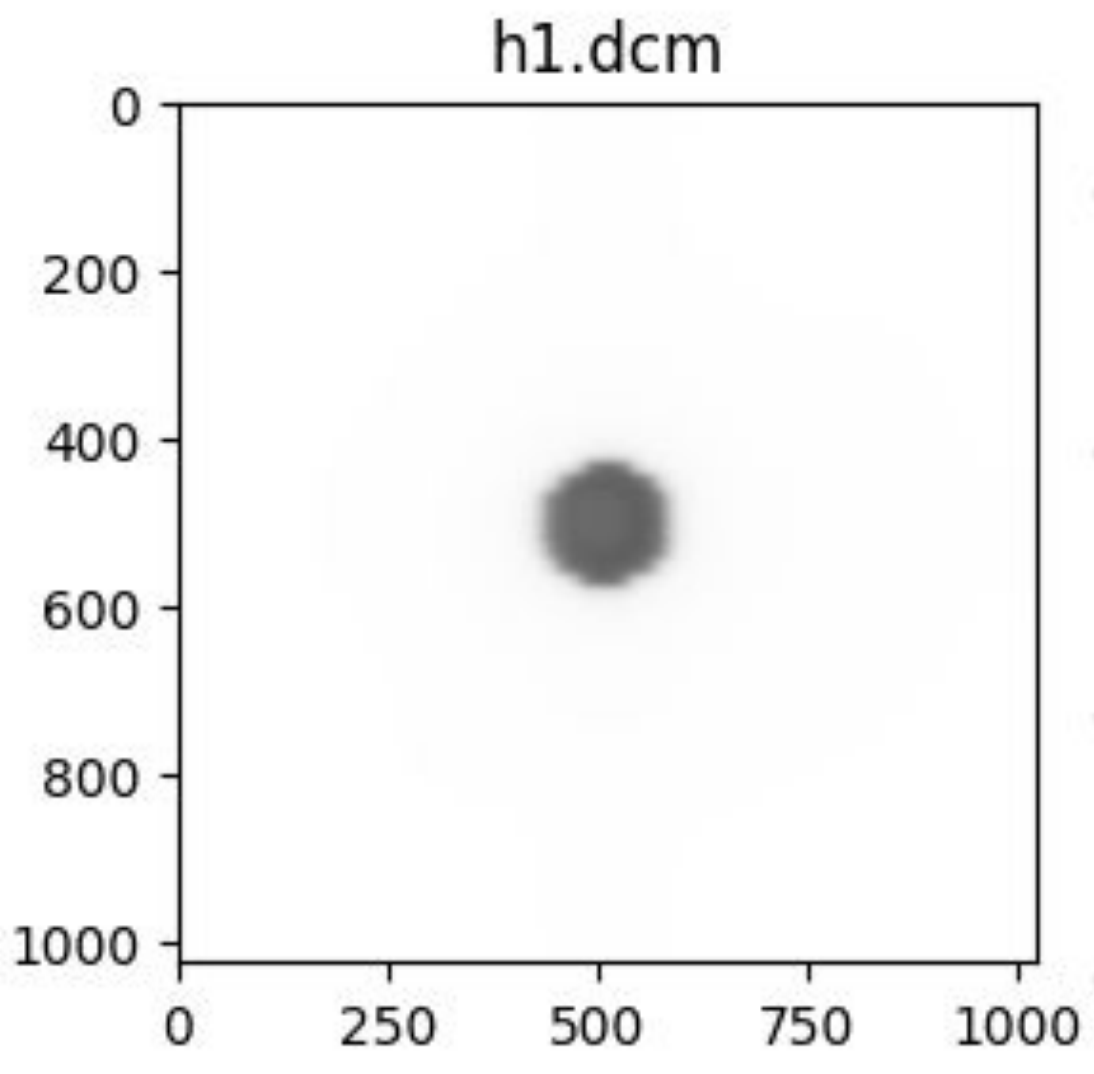
Phantom CT

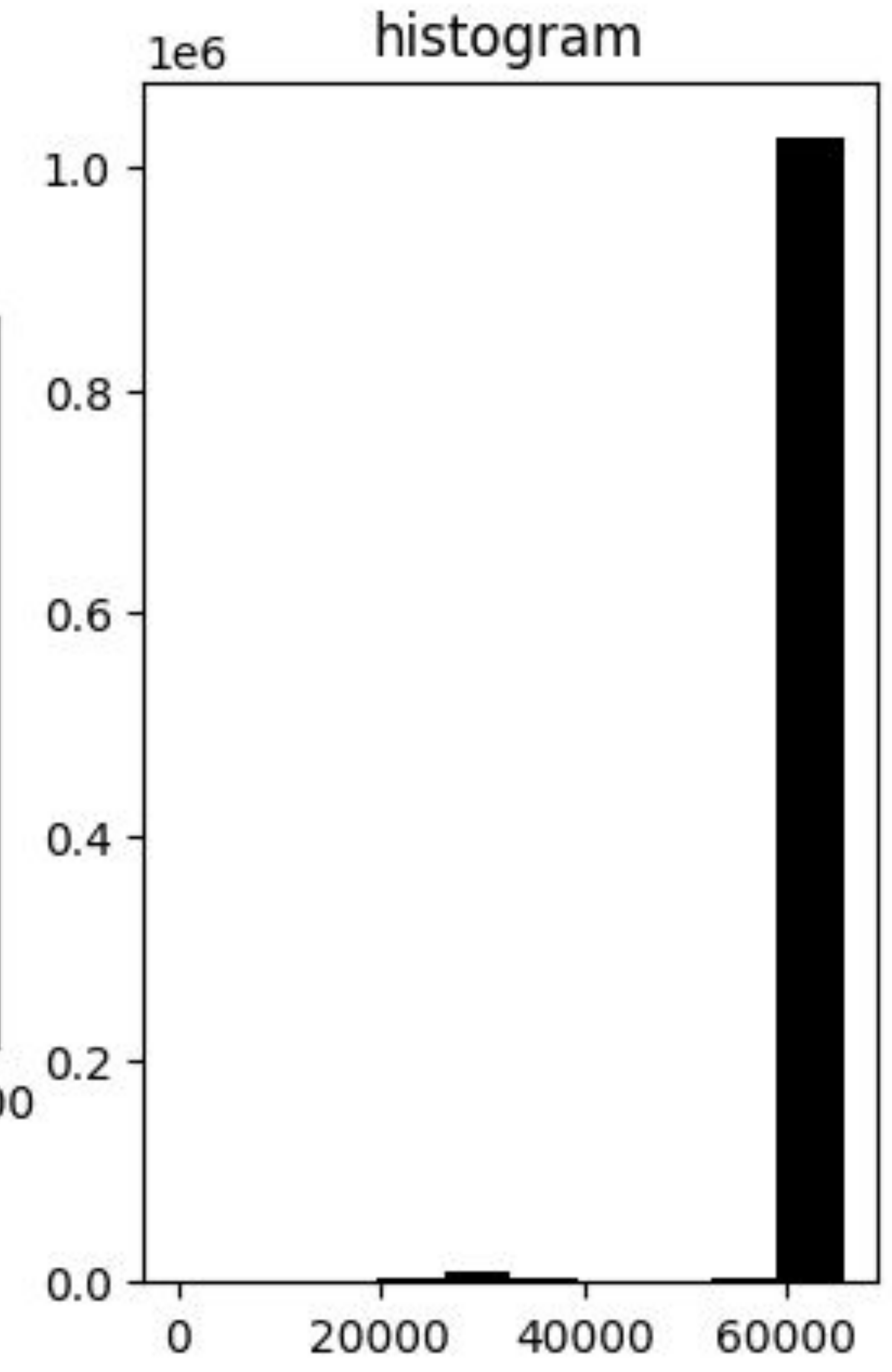


EPID image



```
(0020, 0011) Series Number                      IS: '10517'
(0020, 0013) Instance Number                    IS: '10521'
(0020, 0020) Patient Orientation                CS: ''
(0020, 1002) Images in Acquisition              IS: '1'
(0021, 0010) Private Creator                    LO: 'Elekta: Portal image'
(0021, 1002) Private tag data                   DS: '0.0937319'
(0028, 0002) Samples per Pixel                  US: 1
(0028, 0004) Photometric Interpretation         CS: 'MONOCHROME2'
(0028, 0010) Rows                               US: 1024
(0028, 0011) Columns                            US: 1024
(0028, 0100) Bits Allocated                     US: 16
(0028, 0101) Bits Stored                        US: 16
(0028, 0102) High Bit                           US: 15
(0028, 0103) Pixel Representation               US: 0
(0028, 1050) Window Center                      DS: '62234.3'
(0028, 1051) Window Width                       DS: '22555.1'
(3002, 0002) RT Image Label                     SH: 'iViewPortalImage'
(3002, 000a) Reported Values Origin             CS: 'OPERATOR'
(3002, 000c) RT Image Plane                     CS: 'NORMAL'
(3002, 000e) X-Ray Image Receptor Angle         DS: '0.0'
(3002, 0011) Image Plane Pixel Spacing          DS: [0.405, 0.405]
(3002, 0012) RT Image Position                  DS: None
(3002, 0020) Radiation Machine Name             SH: ''
(3002, 0022) Radiation Machine SAD              DS: '1000.0'
(3002, 0024) Radiation Machine SSD              DS: '0.0'
(3002, 0026) RT Image SID                       DS: '1600.0'
(300a, 00b3) Primary Dosimeter Unit             CS: ''
(300a, 011e) Gantry Angle                       DS: '-0.1'
(7fe0, 0010) Pixel Data                         OW: Array of 2097152 elements
```

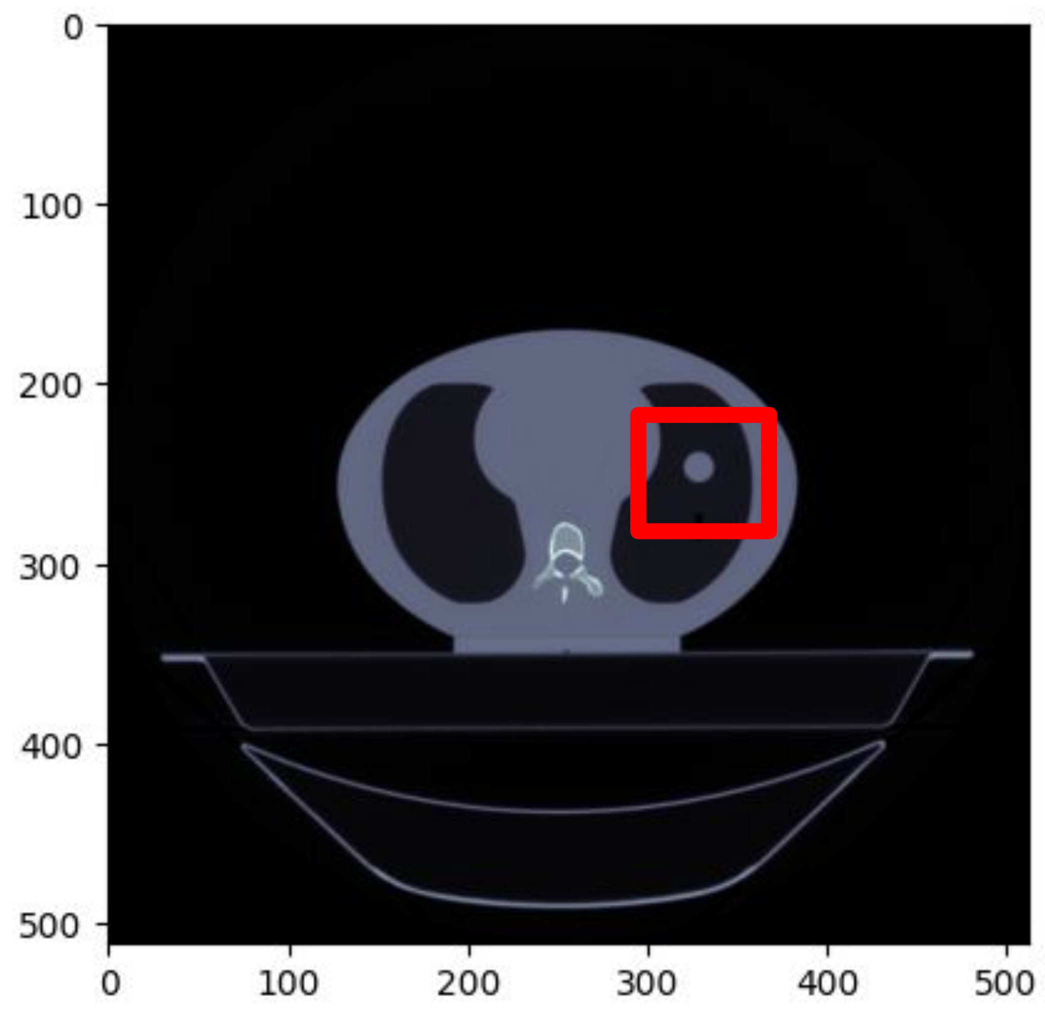


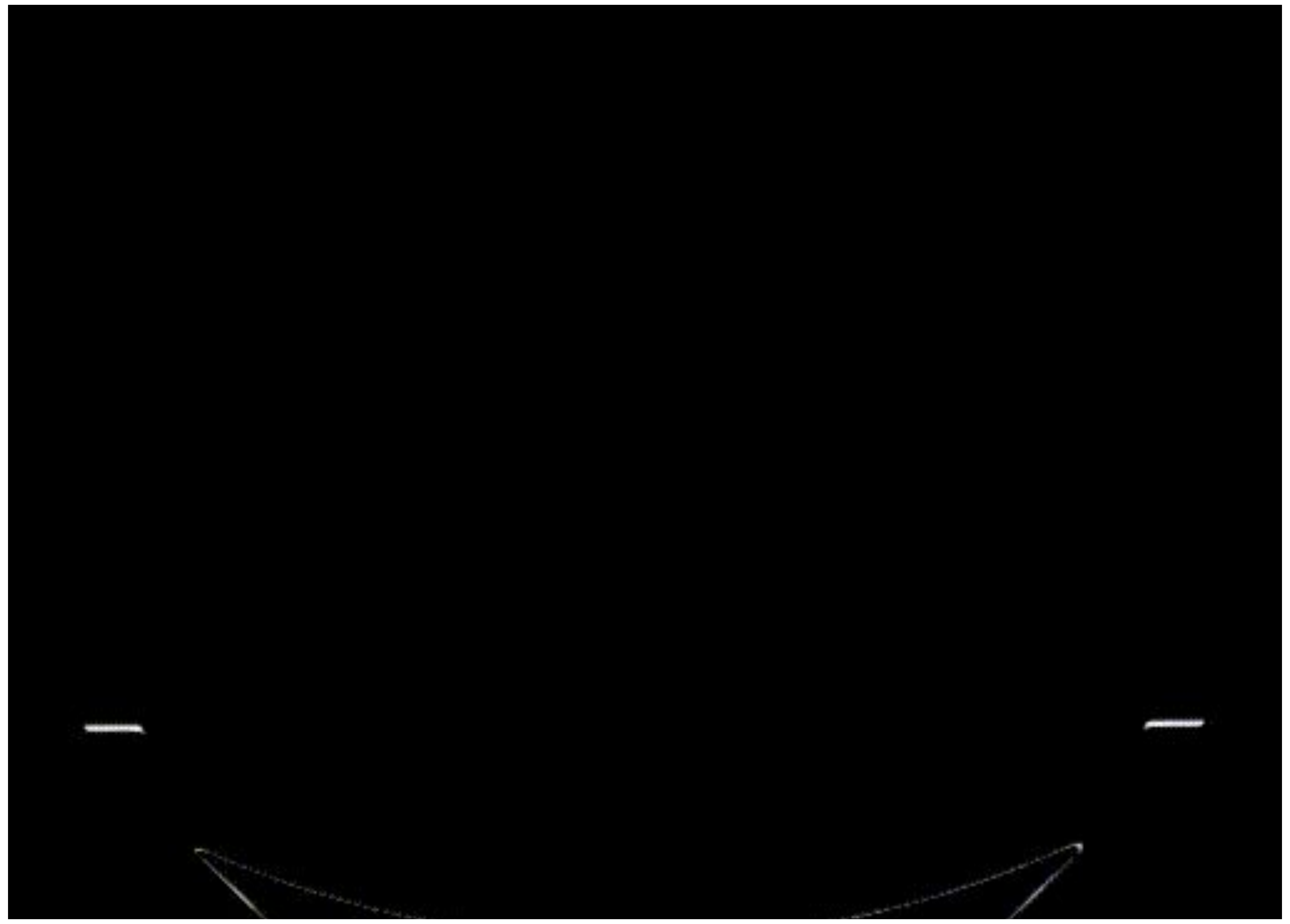


See: [DICOM Standard Browser]

CT images

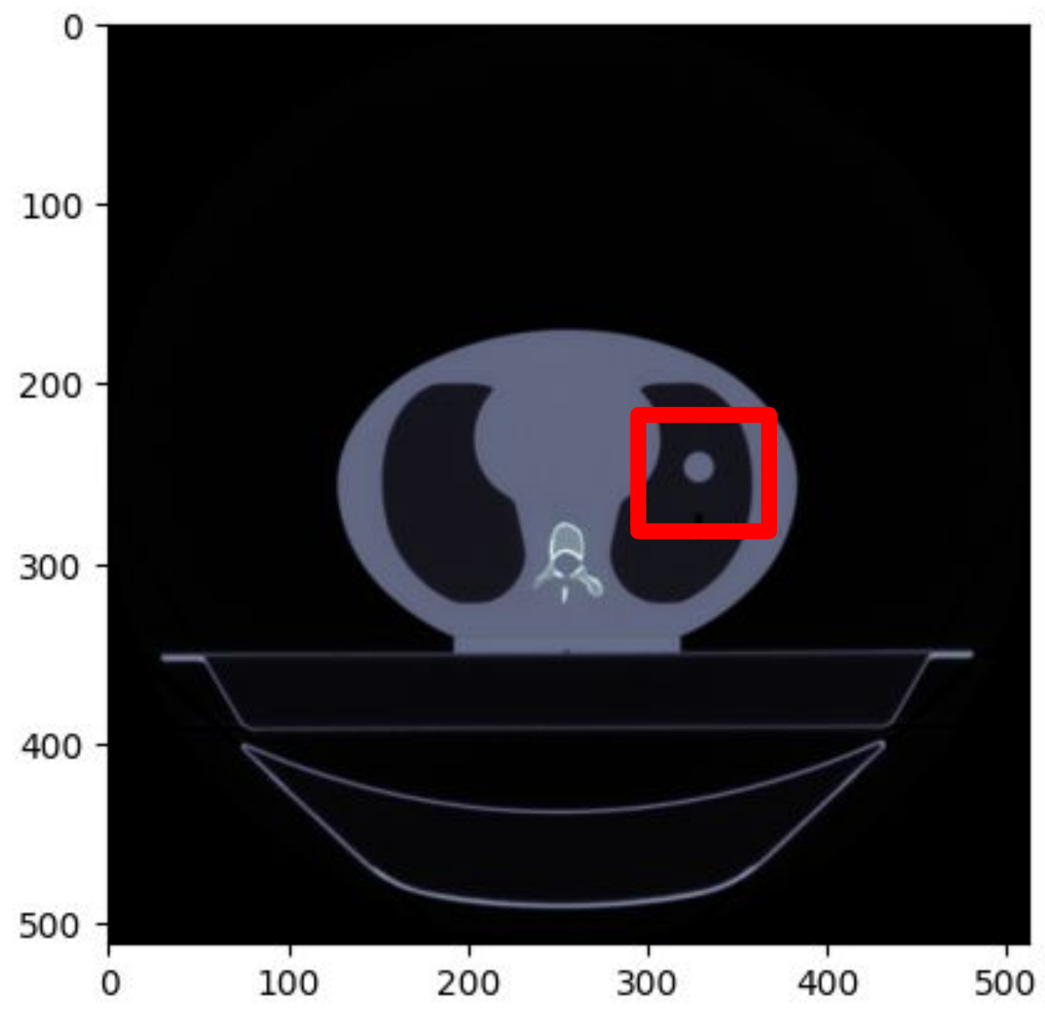
```
Dataset.file_meta -------------------------------
(0002, 0000) File Meta Information Group Length  UL: 174
(0002, 0001) File Meta Information Version       OB: b'\x00\x01'
(0002, 0002) Media Storage SOP Class UID         UI: CT Image Storage
(0002, 0003) Media Storage SOP Instance UID      UI: 1.2.840.113704.1.111.2344.1669205565.21376
(0002, 0010) Transfer Syntax UID                 UI: Explicit VR Little Endian
(0002, 0012) Implementation Class UID            UI: 2.16.840.1.114362.1
(0002, 0013) Implementation Version Name         SH: 'MIM723M31402'
-------------------------------------------------
(0008, 0005) Specific Character Set              CS: 'ISO_IR 100'
(0008, 0008) Image Type                          CS: ['ORIGINAL', 'PRIMARY', 'AXIAL', 'HELIX']
(0008, 0012) Instance Creation Date              DA: '20221123'
(0008, 0013) Instance Creation Time              TM: '131245'
(0008, 0016) SOP Class UID                       UI: CT Image Storage
(0008, 0018) SOP Instance UID                    UI: 1.2.840.113704.1.111.2344.1669205565.21376
(0008, 0020) Study Date                          DA: '20221123'
(0008, 0022) Acquisition Date                    DA: '20221123'
(0008, 0023) Content Date                        DA: '20221123'
(0008, 002a) Acquisition DateTime                DT: '20221123131232+0100'
(0008, 0030) Study Time                          TM: '130930'
(0008, 0032) Acquisition Time                    TM: '131232'
(0008, 0033) Content Time                        TM: '131233.985001'
(0008, 0050) Accession Number                    SH: ''
(0008, 0060) Modality                            CS: 'CT'
(0008, 0070) Manufacturer                        LO: 'Philips'
(0008, 0080) Institution Name                    LO: 'A.O.U. CAREGGI    FI'
(0008, 0081) Institution Address                 ST: 'FIRENZE'
(0008, 0090) Referring Physician's Name          PN: ''
(0008, 1010) Station Name                        SH: 'HOST-7424'
(0008, 1030) Study Description                   LO: '1cm sotto SW'
(0008, 103e) Series Description                  LO: 'TORACE 5 MM'
(0008, 1040) Institutional Department Name       LO: 'Radioterapia DEAS_1'
(0008, 1070) Operators' Name                     PN: ''
(0008, 1090) Manufacturer's Model Name           LO: 'Brilliance Big Bore'
(0008, 1140)  Referenced Image Sequence  1 item(s) ----
```

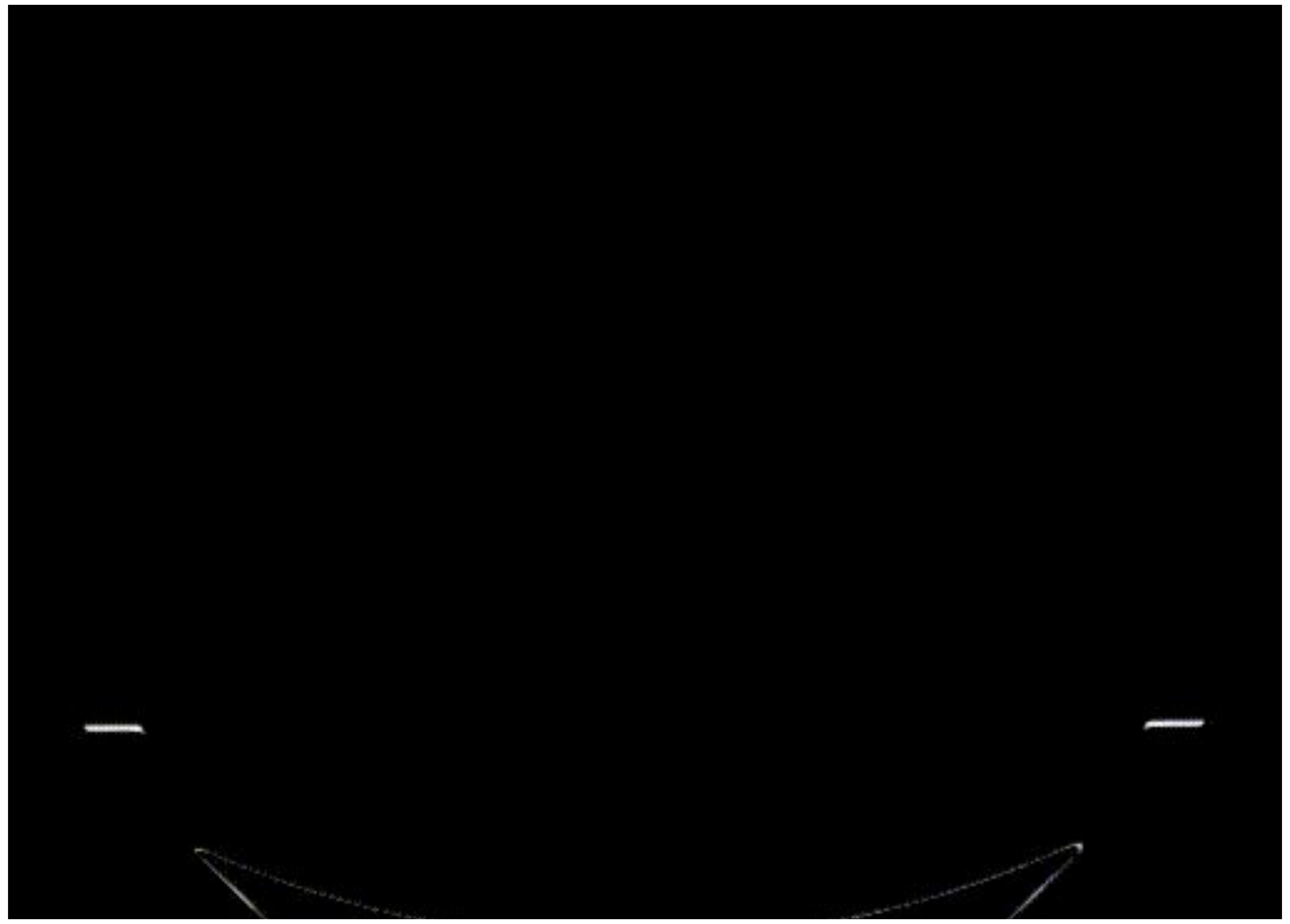




CT images

```
   (0008, 1150) Referenced SOP Class UID          UI: CT Image Storage
   (0008, 1155) Referenced SOP Instance UID       UI: 1.2.840.113704.1.111.2344.1669205515.21357
   ---------
(0008, 2111) Derivation Description            ST: '[EMGDCM] Lossless Compression (JPEG p14), Selection Value =
1, Point Transform = 0, compression ratio = 3.867400'
(0010, 0010) Patient's Name                    PN: 'CIRS Invivo statico^1cm sotto SW'
(0010, 0020) Patient ID                        LO: 'CIRSinvivo'
(0010, 0030) Patient's Birth Date              DA: '20021122'
(0010, 0040) Patient's Sex                     CS: 'O'
(0010, 1010) Patient's Age                     AS: '020Y'
(0010, 2000) Medical Alerts                    LO: ''
(0018, 0022) Scan Options                      CS: 'HELIX'
(0018, 0050) Slice Thickness                   DS: '2.0'
(0018, 0060) KVP                               DS: '120.0'
(0018, 0088) Spacing Between Slices            DS: '1.0'
(0018, 0090) Data Collection Diameter          DS: '600.0'
(0018, 1020) Software Versions                 LO: '2.3.5'
(0018, 1030) Protocol Name                     LO: 'TORACE 5mm/OncoBody'
(0018, 1100) Reconstruction Diameter           DS: '600.0'
(0018, 1120) Gantry/Detector Tilt              DS: '0.0'
(0018, 1130) Table Height                      DS: '173.0'
(0018, 1140) Rotation Direction                CS: 'CW'
(0018, 1150) Exposure Time                     IS: '1230'
(0018, 1151) X-Ray Tube Current                IS: '317'
(0018, 1152) Exposure                          IS: '390'
(0018, 1160) Filter Type                       SH: 'C'
(0018, 1210) Convolution Kernel                SH: 'C'
(0018, 5100) Patient Position                  CS: 'HFS'
(0018, 9321)  CT Exposure Sequence  1 item(s) ----
   (0018, 9323) Exposure Modulation Type          CS: 'ZDOM'
   (0018, 9324) Estimated Dose Saving             FD: 0.0
   (0018, 9328) Exposure Time in ms               FD: 1.2302839116719242
   (0018, 9330) X-Ray Tube Current in mA          FD: 317.0
   (0018, 9332) Exposure in mAs                   FD: 390.0
   (0018, 9345) CTDIvol                           FD: 20.6
```





CT images

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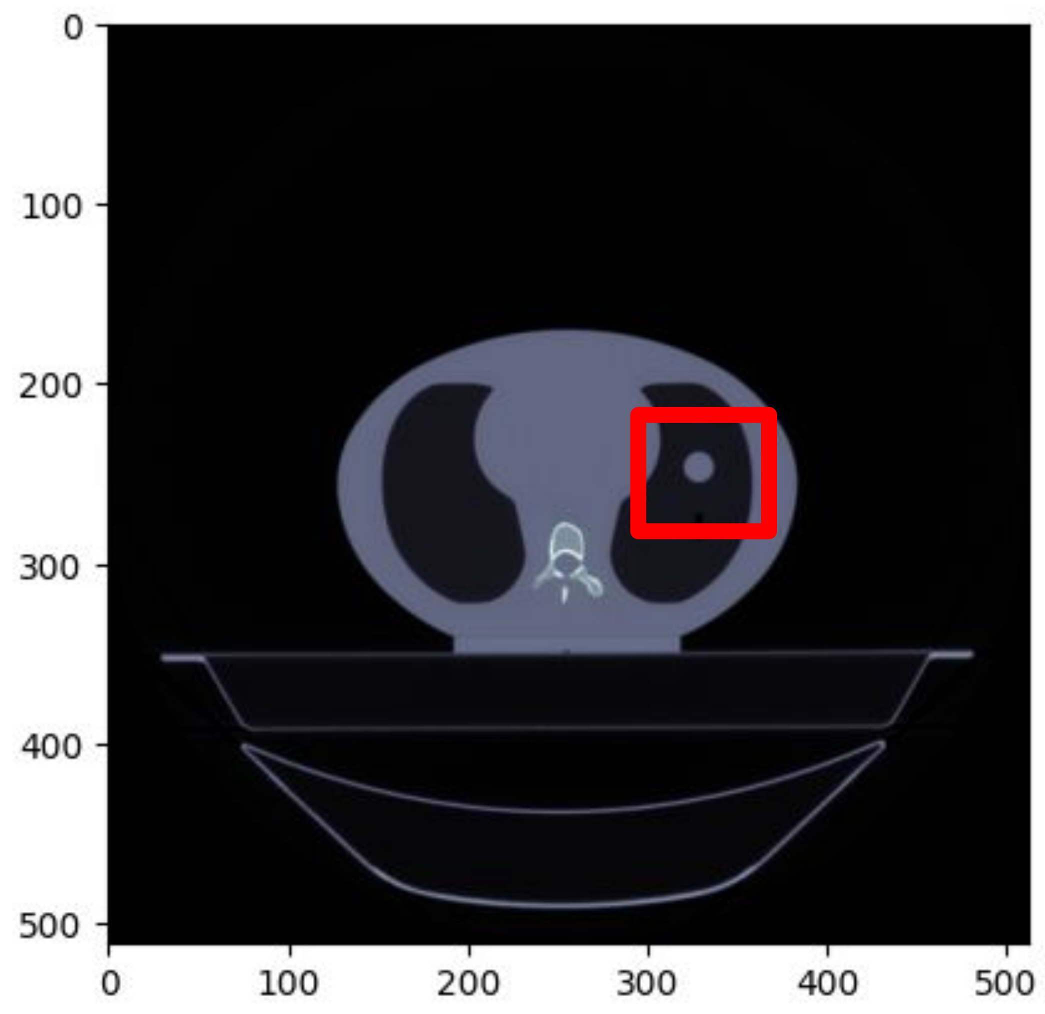
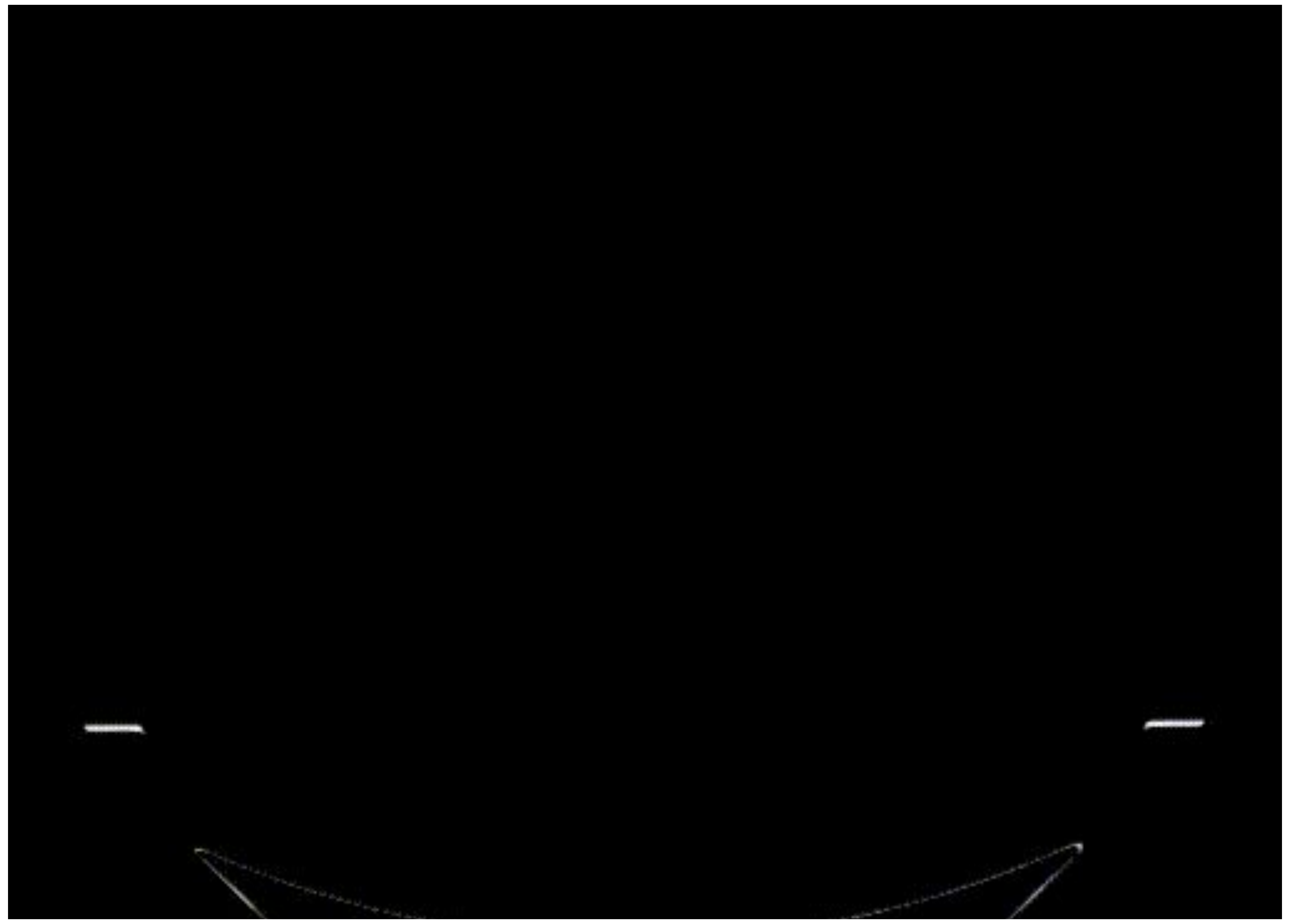
  ---------
(0018, 9323) Exposure Modulation Type            CS: 'ZDOM'
(0018, 9324) Estimated Dose Saving               FD: 0.0
(0018, 9345) CTDIvol                             FD: 20.6
(0020, 000d) Study Instance UID                  UI: 1.2.840.113704.1.111.3464.1669205363.54
(0020, 000e) Series Instance UID                 UI: 1.2.840.113704.1.111.6596.1669205536.6
(0020, 0010) Study ID                            SH: '56000'
(0020, 0011) Series Number                       IS: '2'
(0020, 0012) Acquisition Number                  IS: None
(0020, 0013) Instance Number                     IS: '19'
(0020, 0032) Image Position (Patient)            DS: [-300, -218, -658]
(0020, 0037) Image Orientation (Patient)         DS: [1, 0, 0, 0, 1, 0]
(0020, 0052) Frame of Reference UID              UI: 1.2.840.113704.1.111.6596.1669205471.3
(0020, 0060) Laterality                          CS: ''
(0020, 1040) Position Reference Indicator        LO: ''
(0020, 1041) Slice Location                      DS: '-658.0'
(0020, 4000) Image Comments                      LT: 'TORACE 5 MM'
(0028, 0002) Samples per Pixel                   US: 1
(0028, 0004) Photometric Interpretation          CS: 'MONOCHROME2'
(0028, 0010) Rows                                US: 512
(0028, 0011) Columns                             US: 512
(0028, 0030) Pixel Spacing                       DS: [1.171875, 1.171875]
(0028, 0100) Bits Allocated                      US: 16
(0028, 0101) Bits Stored                         US: 12
(0028, 0102) High Bit                            US: 11
(0028, 0103) Pixel Representation                US: 0
(0028, 1050) Window Center                       DS: [00050, 00050]
(0028, 1051) Window Width                        DS: [00350, 00350]
(0028, 1052) Rescale Intercept                   DS: '-1024.0'
(0028, 1053) Rescale Slope                       DS: '1.0'
(0032, 1070) Requested Contrast Agent            LO: ''
(0040, 0012) Pre-Medication                      LO: ''
(0040, 0253) Performed Procedure Step ID         SH: '5600096'
(00e1, 0010) Private Creator                     LO: 'ELSCINT1'
(00e1, 1001) [Data Dictionary Version]           US: 1
(00e1, 1022) [Presentation Relative Center]      DS: [00000, 00000]
(00e1, 1023) [Presentation Relative Part]        DS: [00001, 00001]
(00e1, 1040) [Image Label]                       SH: 'TORACE 5 MM'
(00e1, 1042) [Unknown]                           LO: '453567-129831'
```





CT images

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(00e1, 1050) [Acquisition Duration]            DS: '10.219'
(00e1, 1061) [Protocol File Name]              LO: 'OncoBody_Multi_1063_usr.proc'
(00e1, 1063) [Patient Language]                SH: 'ITALIAN'
(01e1, 0010) Private Creator                   LO: 'ELSCINT1'
(01e1, 1041) Private tag data                  UN: Array of 128 elements
(01f1, 0010) Private Creator                   LO: 'ELSCINT1'
(01f1, 1001) [Acquisition Type]                CS: 'SPIRAL'
(01f1, 1002) [Unknown]                         CS: 'STANDARD'
(01f1, 1003) [Concurrent Slices Generation]    CS: 'E'
(01f1, 1004) [Angular Sampling Density]        CS: 'NORMAL'
(01f1, 1005) [Reconstruction Arc]              DS: '180.0'
(01f1, 1007) [Table Velocity]                  DS: '19.5'
(01f1, 1008) [Acquisition Length]              DS: '160.0'
(01f1, 100a) [Edge Enhancement Weight]         US: 0
(01f1, 100c) [Scanner Relative Center]         DS: [0, 0]
(01f1, 100d) [Rotation Angle]                  DS: '0.0'
(01f1, 100e) [Unknown]                         FL: 0.0
(01f1, 1026) [Pitch]                           DS: '0.813'
(01f1, 1027) [Rotation Time]                   DS: '1.0'
(01f1, 1032) [Image View Convention]           CS: 'RIGHT_ON_LEFT'
(01f1, 1042) [Unknown]                         SH: 'No'
(01f1, 1044) [Unknown]                         OW: Array of 644 elements
(01f1, 1046) [Unknown]                         FL: 1.5
(01f1, 1047) [Unknown]                         SH: '3D'
(01f1, 1049) [Unknown]                         DS: '390.0'
(01f1, 104a) [Unknown]                         SH: 'DOM'
(01f1, 104b) [Unknown]                         SH: '16x1.5'
(01f1, 104c) [Unknown]                         SH: 'NO'
(01f1, 104d) [Unknown]                         SH: 'YES'
(01f1, 104e) [Unknown]                         LO: 'Body'
(01f7, 0010) Private Creator                   LO: 'ELSCINT1'
(01f7, 1010) [Unknown]                         OB: None
(01f7, 1011) [Unknown]                         OW: Array of 552 elements
(01f7, 1013) [Unknown]                         OW: Array of 136 elements
(01f7, 1014) [Unknown]                         OW: Array of 108 elements
(01f7, 1015) [Unknown]                         OW: Array of 188 elements
(01f7, 1016) [Unknown]                         OW: Array of 40 elements
(01f7, 1017) [Unknown]                         OW: b'\x00\x00\x00\x00\x00\x00\x00\x00'
(01f7, 1018) [Unknown]                         OW: Array of 228 elements
```
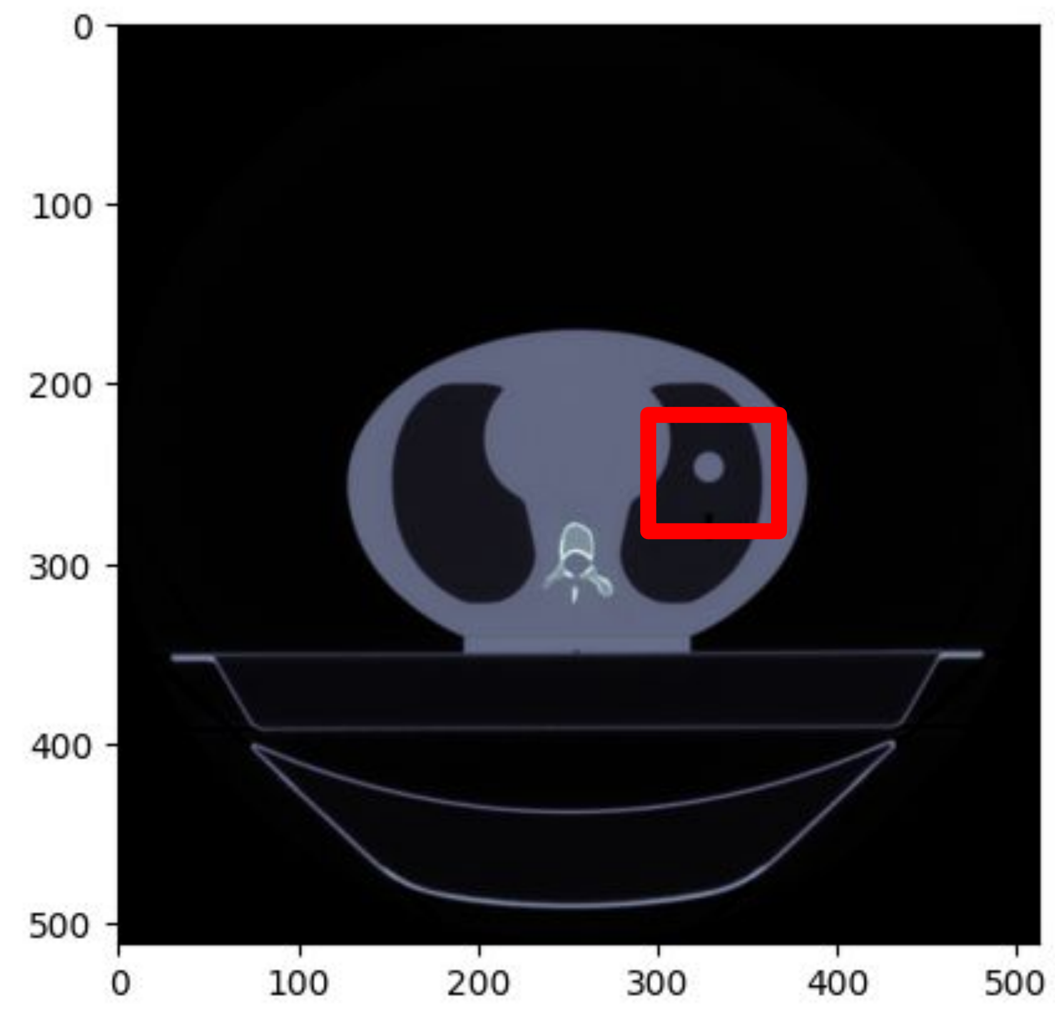
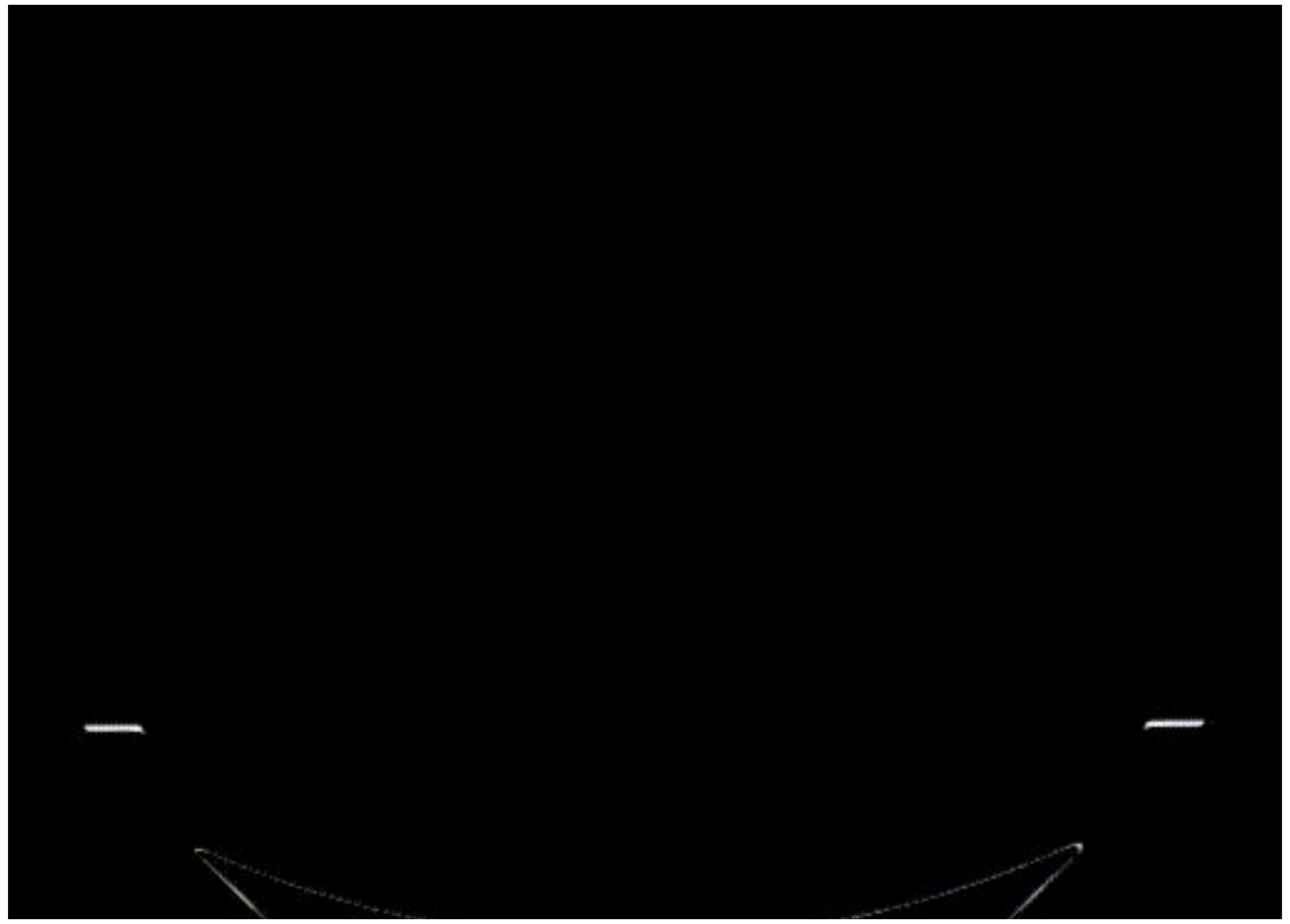
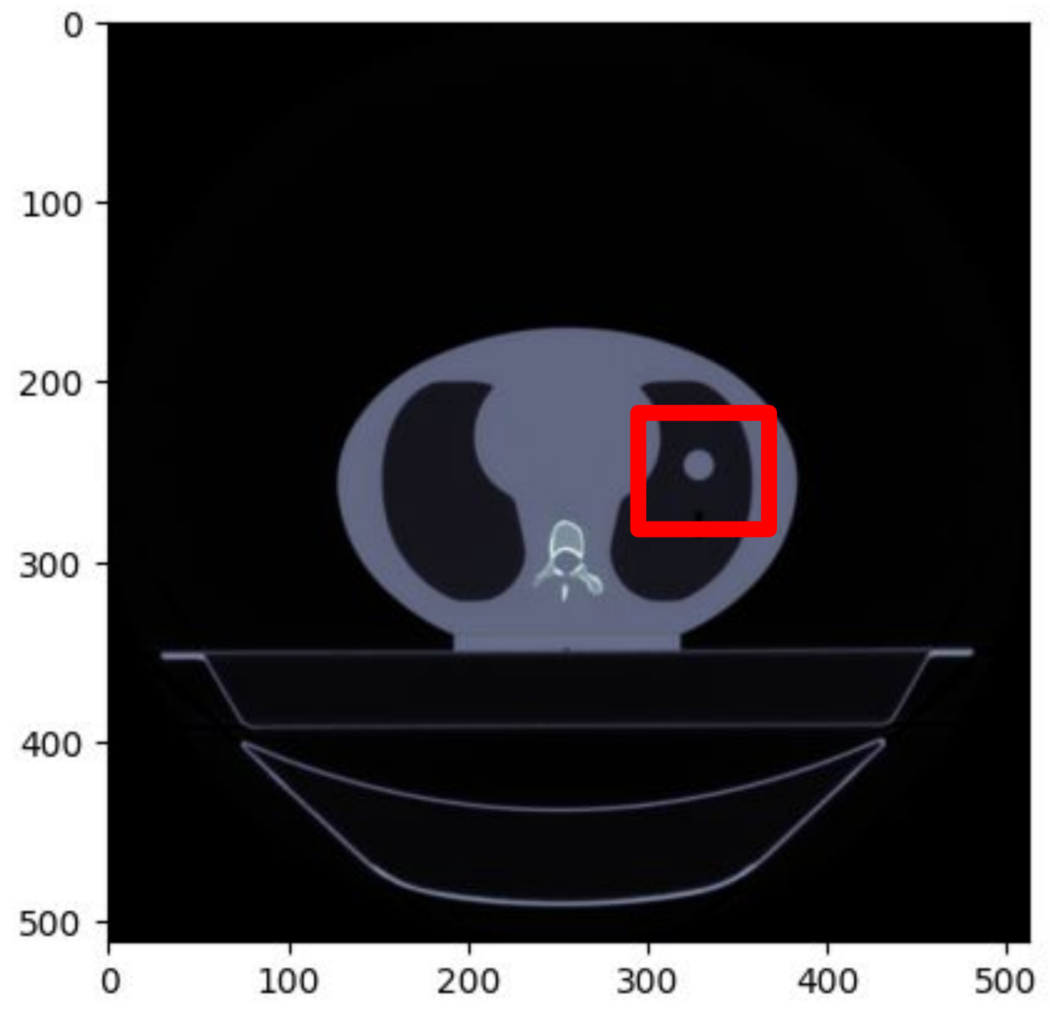
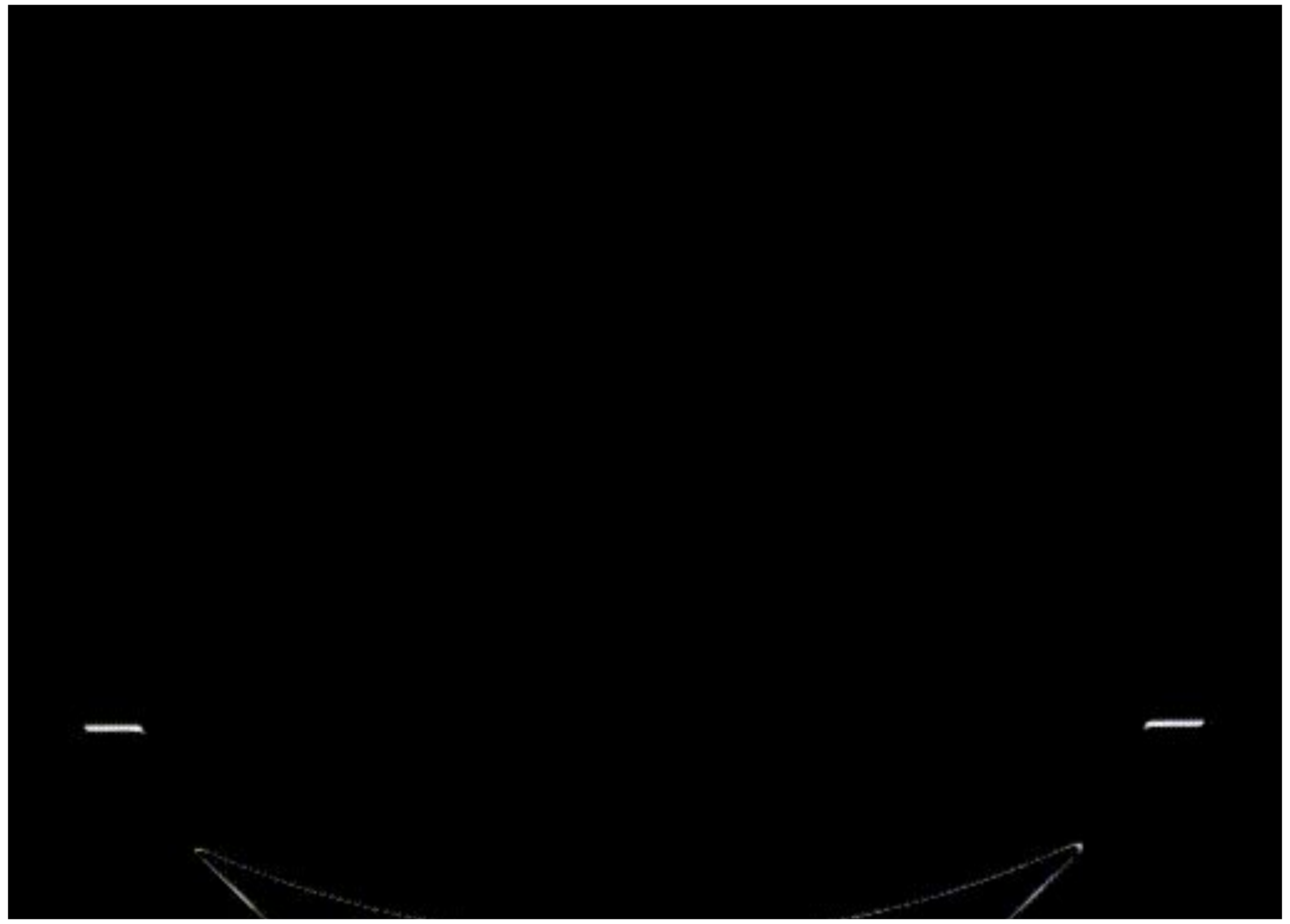





CT images

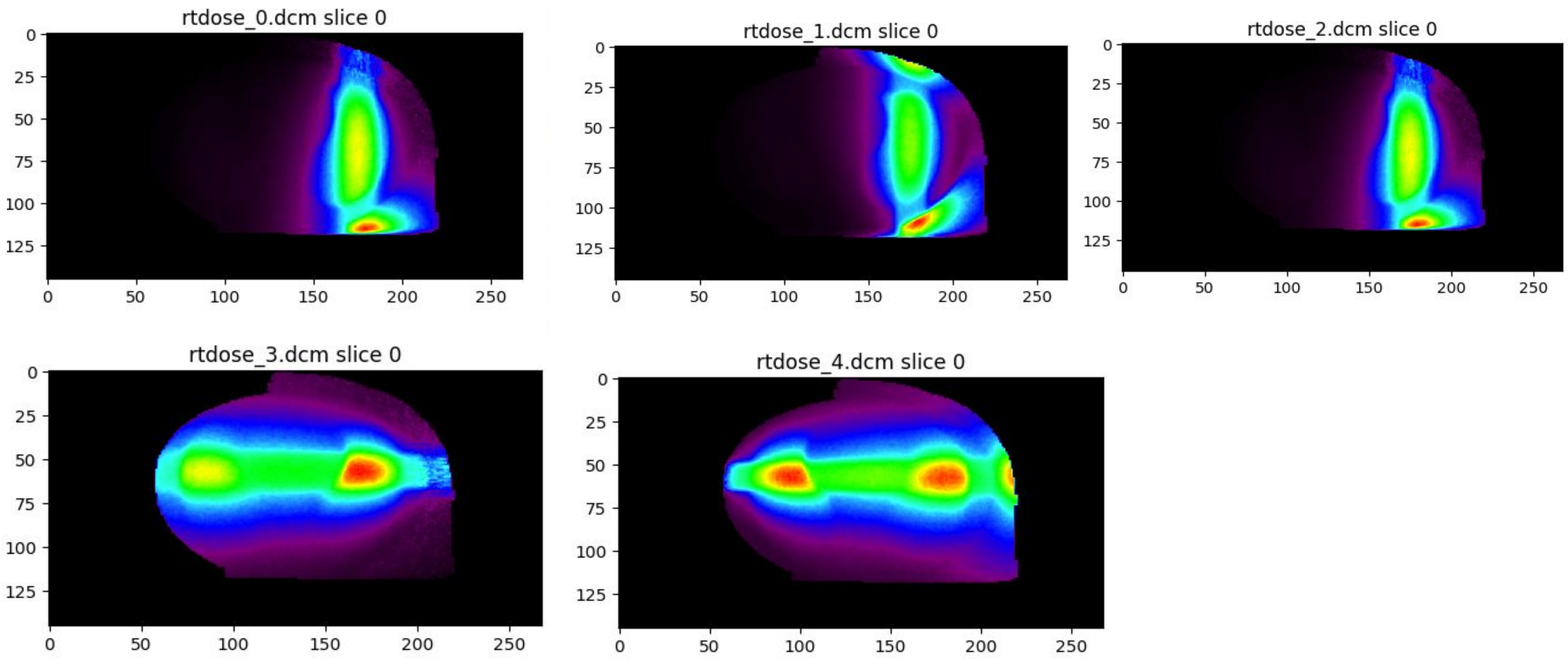
```
(01f7, 1019) [Unknown]                     OW: Array of 2160 elements
(01f7, 101a) [Unknown]                     OW: Array of 28 elements
(01f7, 101b) [Unknown]                     OW: Array of 1744 elements
(01f7, 101c) [Unknown]                     OW: Array of 116 elements
(01f7, 101e) [Unknown]                     OW: Array of 364 elements
(01f7, 101f) [Unknown]                     OW: Array of 148 elements
(01f7, 1022) [Unknown]                     UI: 1.2.840.113704.1.111.6596.1669205536.5.1.11111111111111111
(01f7, 1023) [Unknown]                     OW: b'.\x00\x00\x00'
(01f7, 1025) [Unknown]                     OW: b'\x01\x00\x00\x00\x00\x00\x00\x00p\xf2\x12\x00'
(01f7, 1026) [Unknown]                     OW: Array of 10764 elements
(01f7, 1027) [Unknown]                     OW: Array of 36 elements
(01f7, 1029) [Unknown]                     OW: Array of 440 elements
(01f7, 102b) [Unknown]                     OW: Array of 36 elements
(01f7, 102c) [Unknown]                     OW: Array of 656 elements
(01f7, 102d) [Unknown]                     OW: b'\x00\x00\x00\x00\x00\x00\x00\x00'
(01f7, 1030) [Unknown]                     OW: b'\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00
\x00'
(01f7, 1031) [Unknown]                     OW: Array of 124 elements
(01f7, 1070) [Unknown]                     OW: Array of 1312 elements
(01f7, 1074) [Unknown]                     OW: Array of 288 elements
(01f7, 1075) [Unknown]                     OW: Array of 136 elements
(01f7, 107f) Private tag data              UN: Array of 1312 elements
(07a1, 0010) Private Creator               LO: 'ELSCINT1'
(07a1, 1010) [Tamar Software Version]      LO: '3.5'
(7fdf, 0010) Private Creator               LO: 'ELSCINT1'
(7fdf, 10f0) [Unknown]                     OB: None
(7fdf, 10ff) [Unknown]                     SH: ''
(7fe0, 0010) Pixel Data                    OW: Array of 524288 elements
```





RT dose data

Multi-frame dose images → the dose distribution is encoded as a multi-frame image (79 frames)



RT dose file: tags & attributes

```
Dataset.file_meta -------------------------------
(0002, 0000) File Meta Information Group Length  UL: 168
(0002, 0001) File Meta Information Version       OB: b'\x00\x01'
(0002, 0002) Media Storage SOP Class UID         UI: RT Dose Storage
(0002, 0003) Media Storage SOP Instance UID      UI: 2.16.840.1.114337.1.1.1682093615.0
(0002, 0010) Transfer Syntax UID                 UI: Implicit VR Little Endian
(0002, 0012) Implementation Class UID            UI: 2.16.840.1.114362.1
(0002, 0013) Implementation Version Name         SH: 'MIM723M31402'
-------------------------------------------------
(0008, 0005) Specific Character Set              CS: 'ISO_IR 100'
(0008, 0016) SOP Class UID                       UI: RT Dose Storage
(0008, 0018) SOP Instance UID                    UI: 2.16.840.1.114337.1.1.1682093615.0
(0008, 0020) Study Date                          DA: '20221123'
(0008, 0030) Study Time                          TM: '130930'
(0008, 0050) Accession Number                    SH: ''
(0008, 0060) Modality                            CS: 'RTDOSE'
(0008, 0070) Manufacturer                        LO: 'CMS, Inc.'
(0008, 0090) Referring Physician's Name          PN: ''
(0008, 1090) Manufacturer's Model Name           LO: 'Monaco'
(0010, 0010) Patient's Name                      PN: 'CIRS Invivo statico^1cm sotto SW'
(0010, 0020) Patient ID                          LO: 'CIRSinvivo'
(0010, 0030) Patient's Birth Date                DA: '20021122'
(0010, 0040) Patient's Sex                       CS: 'O'
(0018, 0050) Slice Thickness                     DS: None
(0018, 1020) Software Versions                   LO: '5.51.10'
(0020, 000d) Study Instance UID                  UI: 1.2.840.113704.1.111.3464.1669205363.54
(0020, 000e) Series Instance UID                 UI: 2.16.840.1.114337.1.1.1682093613.0.1.3
(0020, 0010) Study ID                            SH: '56000_6'
(0020, 0011) Series Number                       IS: None
(0020, 0013) Instance Number                     IS: '1'
(0020, 0032) Image Position (Patient)            DS: [-265.3, -41.9, -675]
(0020, 0037) Image Orientation (Patient)         DS: [1, 0, 0, 0, 1, 0]
(0020, 0052) Frame of Reference UID              UI: 1.2.840.113704.1.111.6596.1669205471.3
(0020, 1040) Position Reference Indicator        LO: ''
(0028, 0002) Samples per Pixel                   US: 1
(0028, 0004) Photometric Interpretation          CS: 'MONOCHROME2'
```

```
(0028, 0008) Number of Frames                    IS: '79'
(0028, 0009) Frame Increment Pointer             AT: (3004, 000c)
(0028, 0010) Rows                                US: 145
(0028, 0011) Columns                             US: 268
(0028, 0030) Pixel Spacing                       DS: [2, 2]
(0028, 0100) Bits Allocated                      US: 16
(0028, 0101) Bits Stored                         US: 16
(0028, 0102) High Bit                            US: 15
(0028, 0103) Pixel Representation                US: 0
(0028, 0106) Smallest Image Pixel Value          US: 0
(0028, 0107) Largest Image Pixel Value           US: 65535
(3004, 0002) Dose Units                          CS: 'GY'
(3004, 0004) Dose Type                           CS: 'PHYSICAL'
(3004, 000a) Dose Summation Type                 CS: 'BEAM'
(3004, 000c) Grid Frame Offset Vector            DS: Array of 79 elements
(3004, 000e) Dose Grid Scaling                   DS: '9.53212e-06'
(3004, 0014) Tissue Heterogeneity Correction     CS: 'ROI_OVERRIDE'
(300c, 0002)  Referenced RT Plan Sequence  1 item(s) ----
   (0008, 1150) Referenced SOP Class UID           UI: RT Plan Storage
   (0008, 1155) Referenced SOP Instance UID        UI: 2.16.840.1.114337.1.1.1682093613.0
   (300c, 0020)  Referenced Fraction Group Sequence  1 item(s) ----
      (300c, 0004)  Referenced Beam Sequence  1 item(s) ----
         (300c, 0006) Referenced Beam Number             IS: '2'
         ---------
      (300c, 0022) Referenced Fraction Group Number    IS: '1'
      ---------
   ---------
(300c, 0060)  Referenced Structure Set Sequence  1 item(s) ----
   (0008, 1150) Referenced SOP Class UID           UI: RT Structure Set Storage
   (0008, 1155) Referenced SOP Instance UID        UI: 2.16.840.1.114337.1.1.1682093605.0
   ---------
(7fe0, 0010) Pixel Data                          OW: Array of 6139880 elements
```

RT dose file: tags & attributes

Selection of specific tags

```
PatientName: CIRS Invivo statico^1cm sotto SW
PatientID: CIRSinvivo
StudyDate: 20221123
Modality: RTDOSE
SliceThickness: None
Image Position: [-265.3, -41.9, -675]
Image Orientation: [1, 0, 0, 0, 1, 0]
NumberOfFrame: 79
Rows: 145
Columns: 268
PixelSpacing: [2, 2]
BitsAllocated: 16
BitsStored: 16
Dose Units: GY
Dose Type: PHYSICAL
DoseSummationType: BEAM
GridFrameOffsetVector: [0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46,
48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 1
04, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 1
50, 152, 154, 156]
DoseGridScaling: 9.53212e-006
```

Meaning of the tags

(0008, 0060) Modality: Type of equipment that originally acquired the data used to create the images in this Series.

(0018, 0050) Slice Thickness: Nominal slice thickness, in mm.

(0020, 0032) Image Position (Patient): The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the image, in mm.

(0020, 0037) Image Orientation (Patient): The direction cosines of the first row and the first column with respect to the patient. See https://dicom.innolitics.com/ciods/rt-dose/image-plane/00200037

(0020, 0052) Frame of Reference UID: Uniquely identifies the Frame of Reference for a Series. See https://dicom.innolitics.com/ciods/rt-plan/frame-of-reference/00200052

(0028, 0008) Number of Frames: Number of frames in a Multi-frame Image. A Multi-frame Image is defined as a Image whose pixel data consists of a sequential set of individual Image Pixel frames. A Multi-frame Image is transmitted as a single contiguous stream of pixels. Frame headers do not exist within the data stream.

(0028, 0010) Rows: Number of rows in the image.

(0028, 0011) Columns: Number of columns in the image.

(0028, 0030) Pixel Spacing: Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm.

(0028, 0100) Bits Allocated: Number of bits allocated for each pixel sample.

(0028, 0101) Bits Stored: Number of bits stored for each pixel sample.

(3004, 0002) Dose Units: Dose axis units.

(3004, 0004) Dose Type: Type of dose. Defined Terms:

- **PHYSICAL**: physical dose
- **EFFECTIVE**: physical dose after correction for biological effect using user-defined modeling technique
- **ERROR**: difference between desired and planned dose

(3004, 000a) Dose Summation Type: Type of dose summation. Defined Terms:

- **PLAN**: dose calculated for entire delivery of all fraction groups of RT Plan
- **MULTI_PLAN**: dose calculated for entire delivery of 2 or more RT Plans
- **FRACTION**: dose calculated for entire delivery of a single Fraction Group within RT Plan
- **BEAM**: dose calculated for entire delivery of one or more Beams within RT Plan
- **BRACHY**: dose calculated for entire delivery of one or more Brachy Application Setups within RT Plan
- **FRACTION_SESSION**: dose calculated for a single session ("fraction") of a single Fraction Group within RT Plan
- **BEAM_SESSION**: dose calculated for a single session ("fraction") of one or more Beams within RT Plan
- **BRACHY_SESSION**: dose calculated for a single session ("fraction") of one or more Brachy Application Setups within RT Plan
- **CONTROL_POINT**: dose calculated for one or more Control Points within a Beam for a single fraction
- **RECORD**: dose calculated for RT Beams Treatment Record

(3004, 000c) Grid Frame Offset Vector: An array that contains the dose image plane offsets (in mm) of the dose image frames in a multi-frame dose. Required if multi-frame pixel data are present and Frame Increment Pointer (0028,0009) points to Grid Frame Offset Vector (3004,000C).

(3004, 000e) Dose Grid Scaling: Scaling factor that when multiplied by the dose grid data found in Pixel Data (7FE0,0010) Attribute of the Image Pixel Module, yields grid doses in the dose units as specified by Dose Units (3004,0002).

Grid Frame Offset Vector

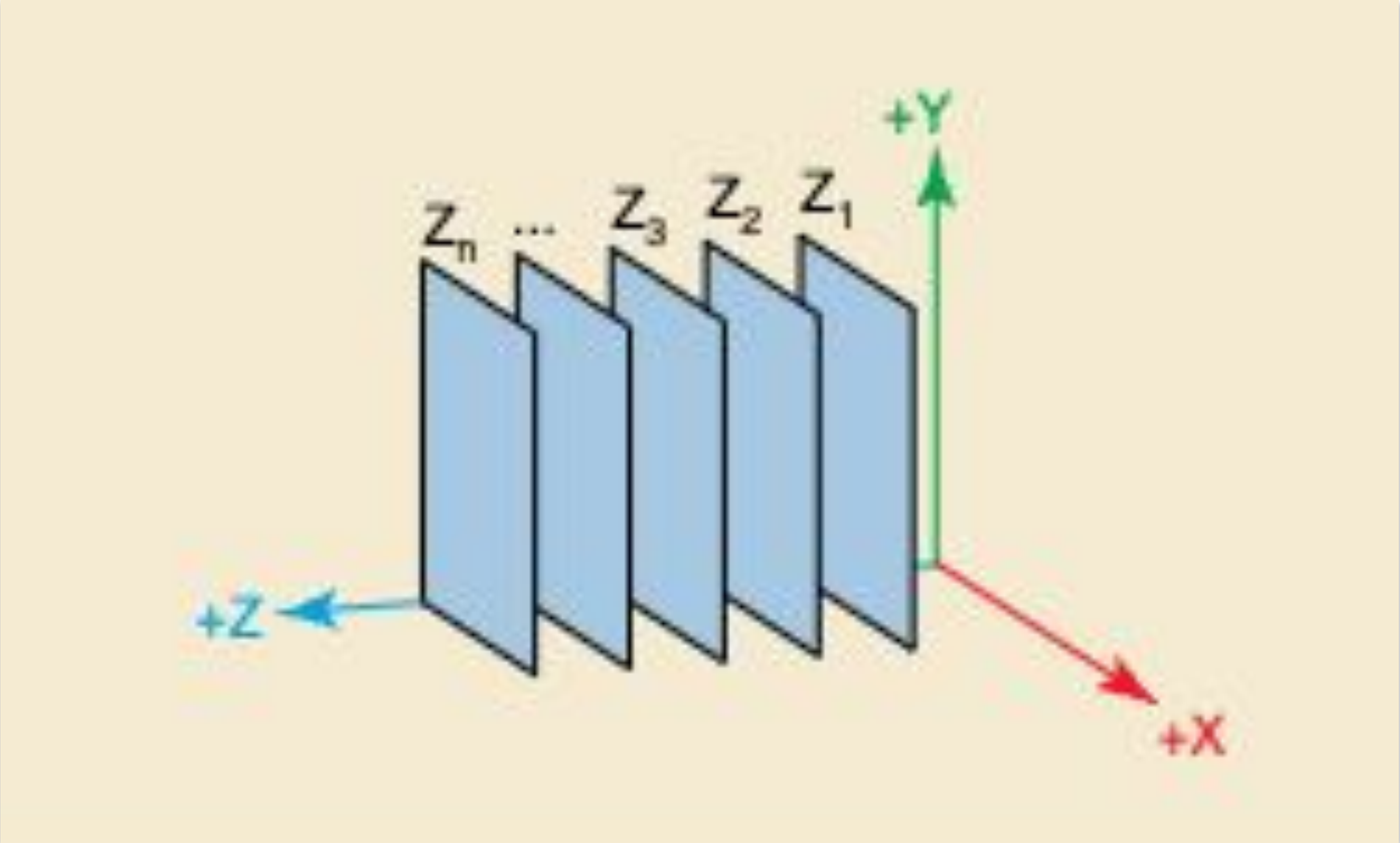
Grid Frame Offset Vector Attribute

Tag	(3004,000C)
Type	Conditionally Required (1C)
Keyword	GridFrameOffsetVector
Value Multiplicity	2-n
Value Representation	Decimal String (DS)

An array that contains the dose image plane offsets (in mm) of the dose image frames in a multi-frame dose. Required if multi-frame pixel data are present and Frame Increment Pointer (0028,0009) points to Grid Frame Offset Vector (3004,000C). See Section C.8.8.3.2.

https://dicom.innolitics.com/ciods/rt-dose/rt-dose/3004000c

Dose Grid Frame example




```
Dose Units: GY
Dose Type: PHYSICAL
DoseSummationType: BEAM
GridFrameOffsetVector: [0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46,
48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 1
04, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 1
50, 152, 154, 156]
DoseGridScaling: 9.53212e-006
```

Grid Frame Offset Vector

Section C.8.8.3.2

C.8.8.3.2 Grid Frame Offset Vector

Grid Frame Offset Vector (3004,000C) shall be provided if a dose distribution is encoded as a multi-frame image. Values of the Grid Frame Offset Vector (3004,000C) shall vary monotonically and are to be interpreted as follows:

a. If Grid Frame Offset Vector (3004,000C) is present and its first element is zero, this Attribute contains an array of n elements indicating the plane location of the data in the right-handed image coordinate system, relative to the position of the first dose plane transmitted, i.e., the point at which Image Position (patient) (0020,0032) is defined, with positive offsets in the direction of the cross product of the row and column directions.

b. If Grid Frame Offset Vector (3004,000C) is present, its first element is equal to the third element of Image Position (patient) (0020,0032), and Image Orientation (patient) (0020,0037) has the value (1,0,0,0,1,0), then Grid Frame Offset Vector contains an array of n elements indicating the plane location (patient z coordinate) of the data in the Patient-Based Coordinate System.

In future implementations, use of option a) is strongly recommended.

This Attribute is conditional since the RT Dose Module may be included even if pixel doses are not being transmitted, or the image may be a single-frame image. If the Multi-frame Module is present, Frame Increment Pointer (0028,0009) shall have the Enumerated Value of 3004000C (Grid Frame Offset Vector).

Note

Option (a) can represent a rectangular-parallelepiped dose grid with any orientation with respect to the patient, while option (b) can only represent a rectangular-parallelepiped dose grid whose planes are in the transverse patient dimension and whose x- and y-axes are parallel to the patient x- and y-axes.

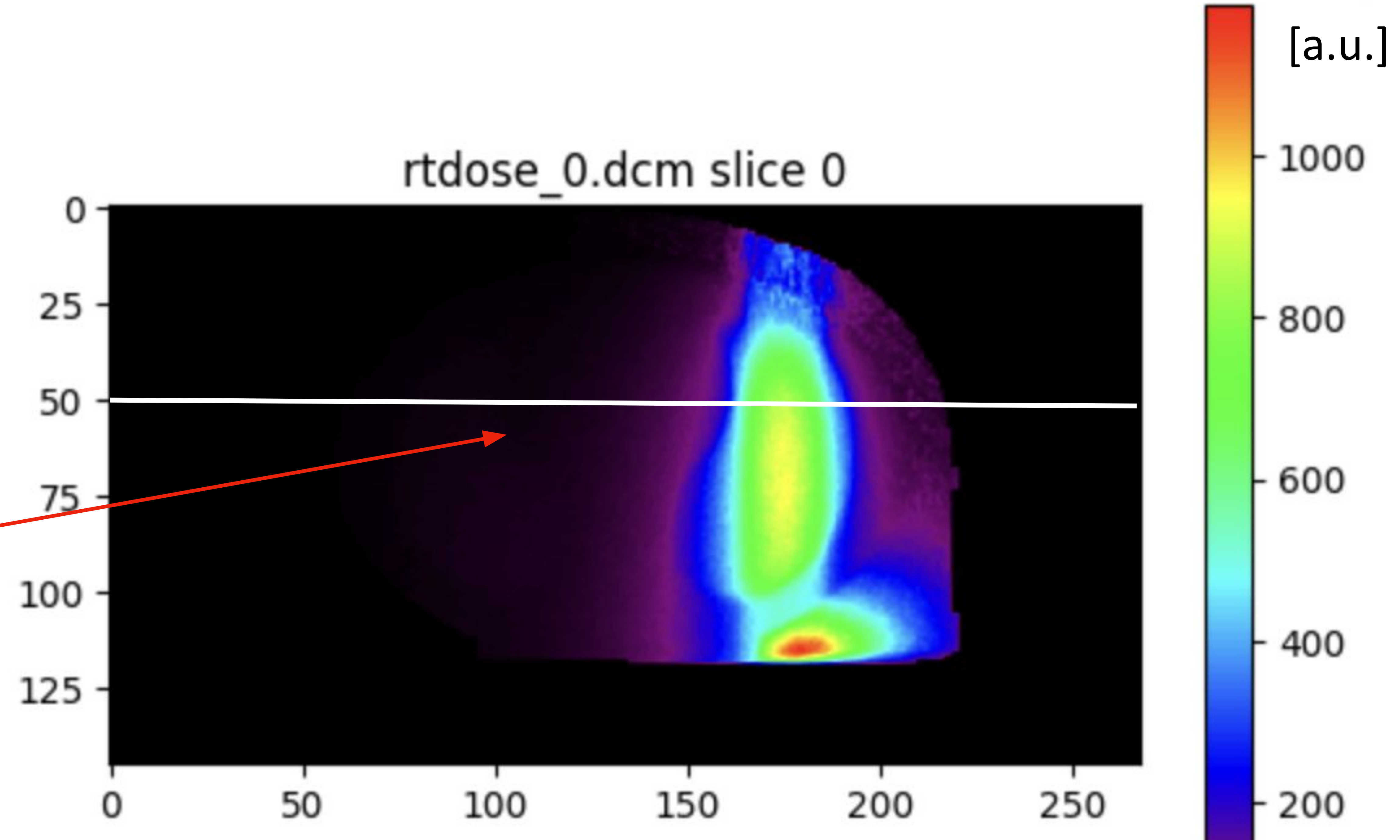
https://dicom.innolitics.com/ciods/rt-dose/rt-dose/3004000c

GridFrameOffsetVector: [0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156]

RT dose

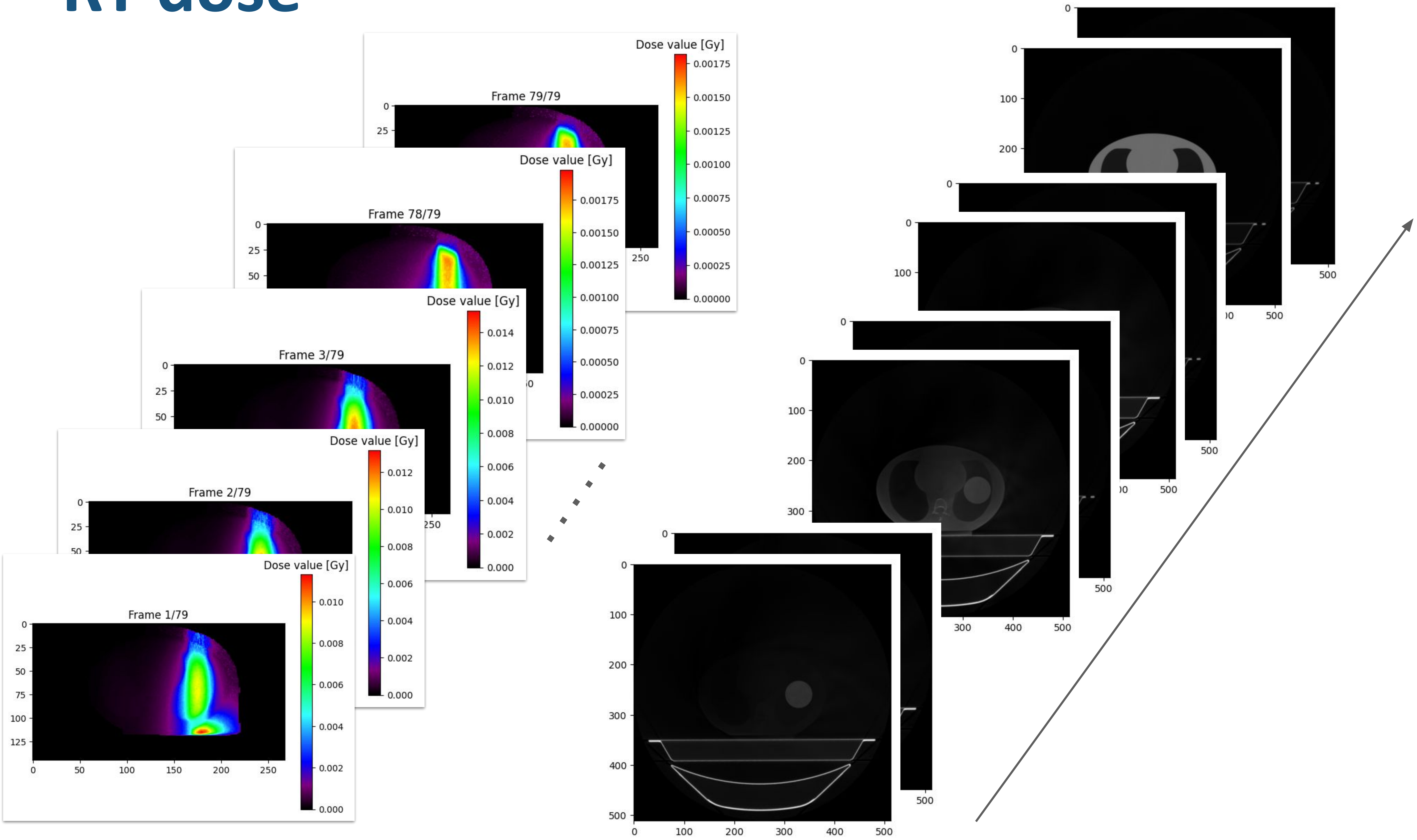
rt_dose[**0**][**50**][:]

```
[  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   3   4   4   4   6   6   6   6   6   6   6   7   7
   7   9   9  10  10  13  13  13  13  15  15  15  15  15  17  17  17  17
  17  17  18  18  18  18  18  19  19  20  18  18  18  17  15  15  18  17
  15  17  19  18  19  19  20  20  21  21  21  23  24  24  25  26  26  30
  32  30  35  35  34  36  38  40  40  44  49  49  53  54  57  60  66  66
  72  74  81  85  93  95  99 108 108 112 122 129 143 160 177 189 219 258
 336 439 507 581 653 691 728 757 771 821 834 830 830 844 850 845 797 805
 774 744 720 663 627 553 487 467 402 346 320 267 217 173 151 137 126 108
 104  98  88  85  89  75  63  57  55  69  78  53 100  60  49  57  49  61
  57   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
```



rt_dose[**frame**][**row**][**column**]

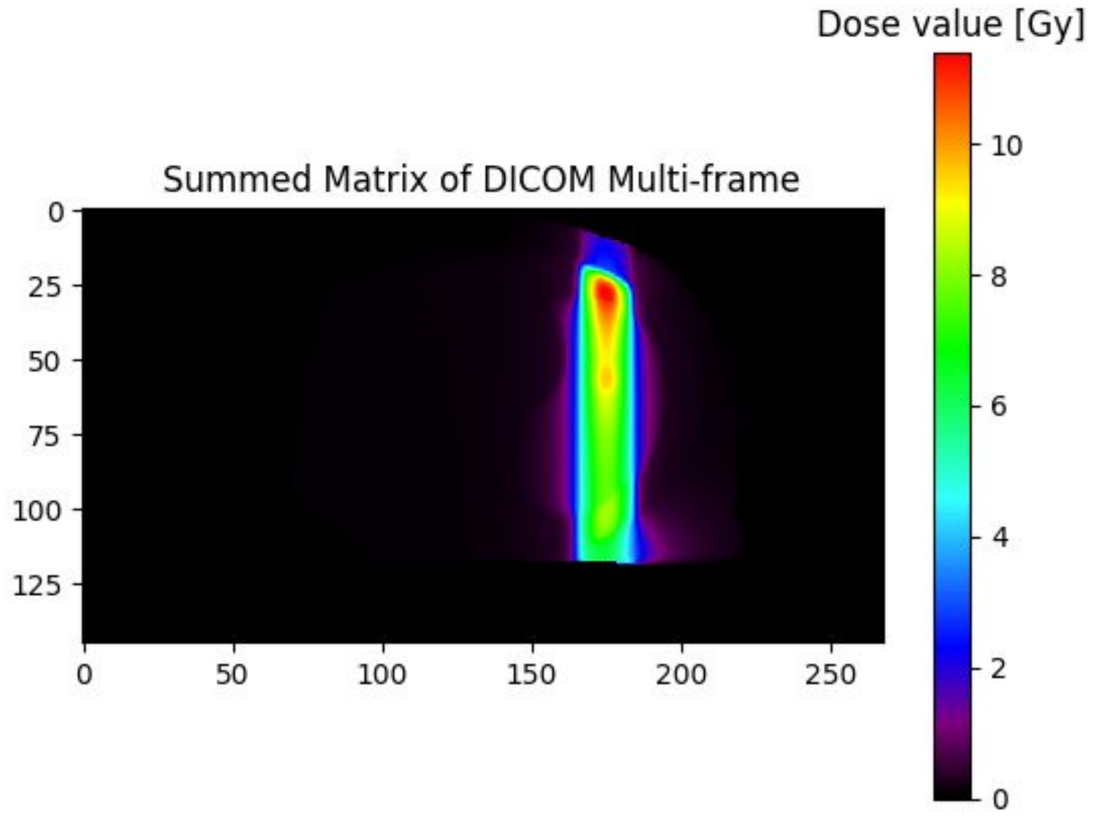
RT dose



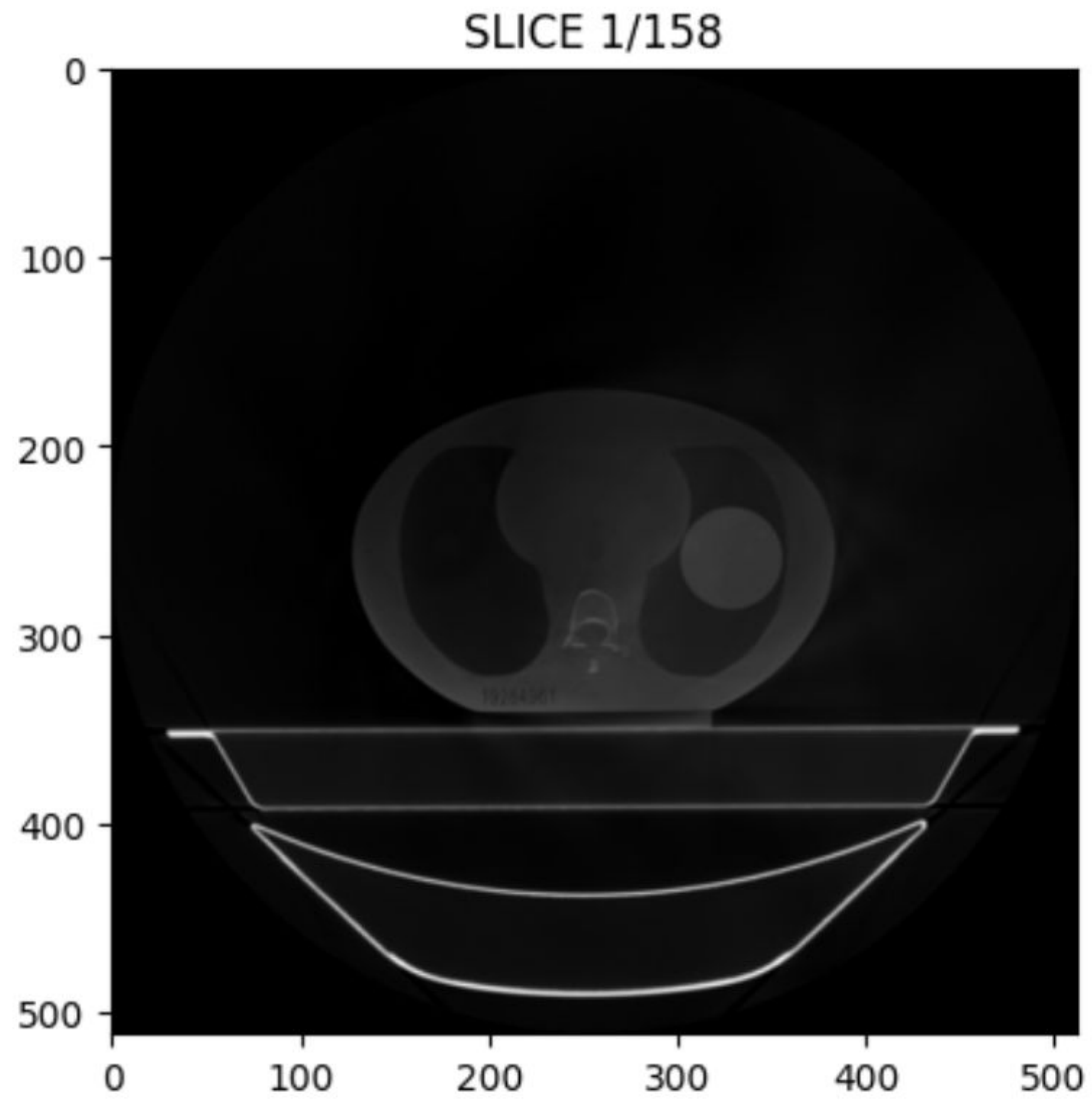
ogni due slice CT ho una distribuzione di dose

RT dose & CT

```
PatientName: CIRS Invivo statico^1cm sotto SW
PatientID: CIRSinvivo
StudyDate: 20221123
Modality: RTDOSE
SliceThickness: None
Image Position: [-265.3, -41.9, -675]
Image Orientation: [1, 0, 0, 0, 1, 0]
NumberOfFrame: 79
Rows: 145
Columns: 268
PixelSpacing: [2, 2]
BitsAllocated: 16
BitsStored: 16
Dose Units: GY
Dose Type: PHYSICAL
DoseSummationType: BEAM
GridFrameOffsetVector: [0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22,
48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80
04, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 13
50, 152, 154, 156]
DoseGridScaling: 9.53212e-006
```




```
----------------------------------------------------------
SLICE 1/158
Image Type: ['ORIGINAL', 'PRIMARY', 'AXIAL', 'HELIX']
Acquisition Time: 131232
Modality: CT
Slice Thicknessws: 2.00
Spacing Between Slices: 1.0
Table Height: 173.000000
Image Position (Patient): [-300, -218, -675]
Image Orientation (Patient): [1, 0, 0, 0, 1, 0]
Slice Location: -675.00
Rows: 512
Columns: 512
Pixel Spacing: [1.171875, 1.171875]
Bits Allocated: 16
Window Center: [00050, 00050]
Window Width: [00350, 00350]
```



Hanno stessa z ⟶ Provare a sovrapporre
le due immagini

How to overlay the RTDOSE and Image data in the correct position?

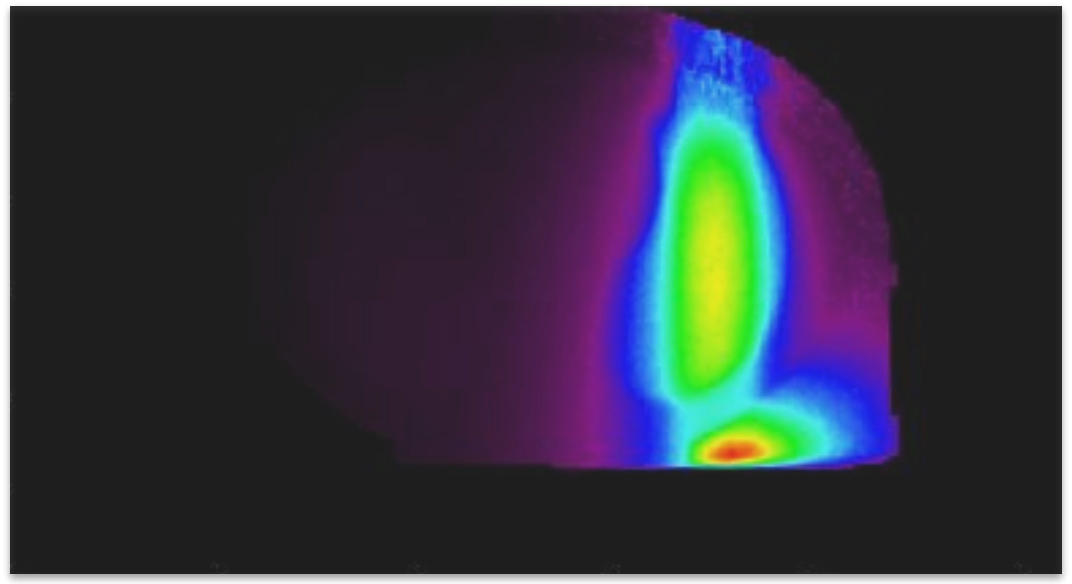
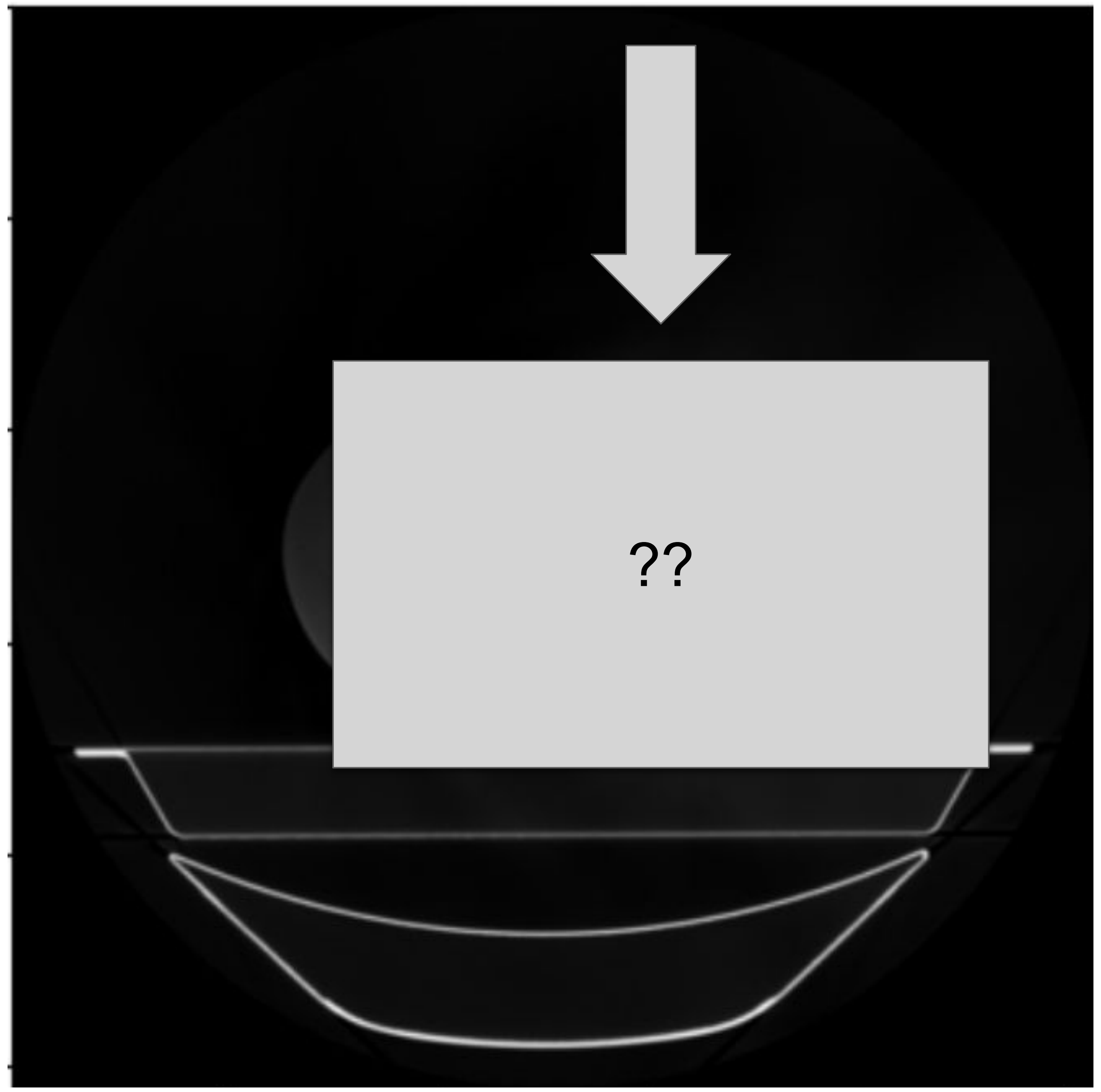
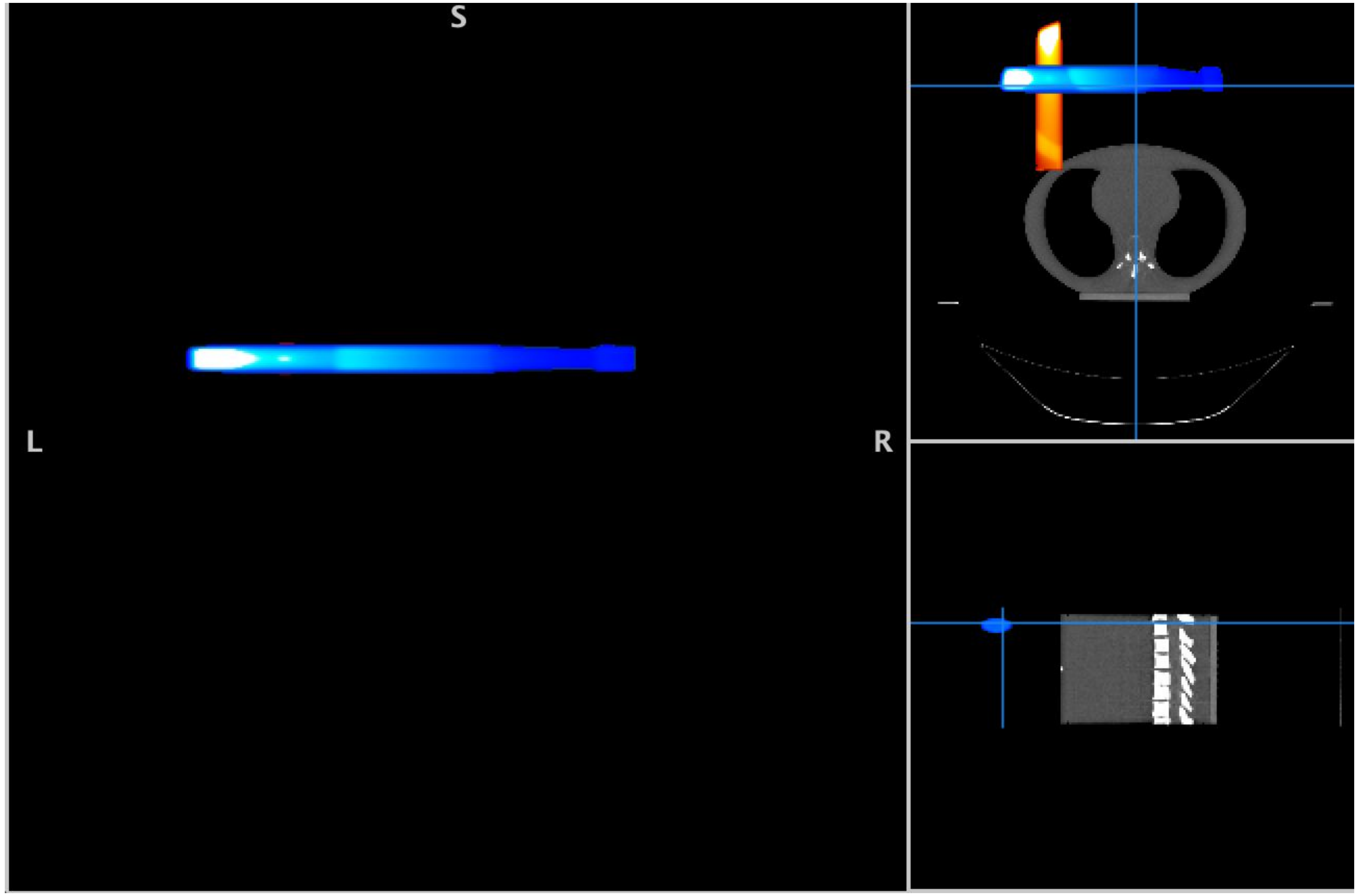
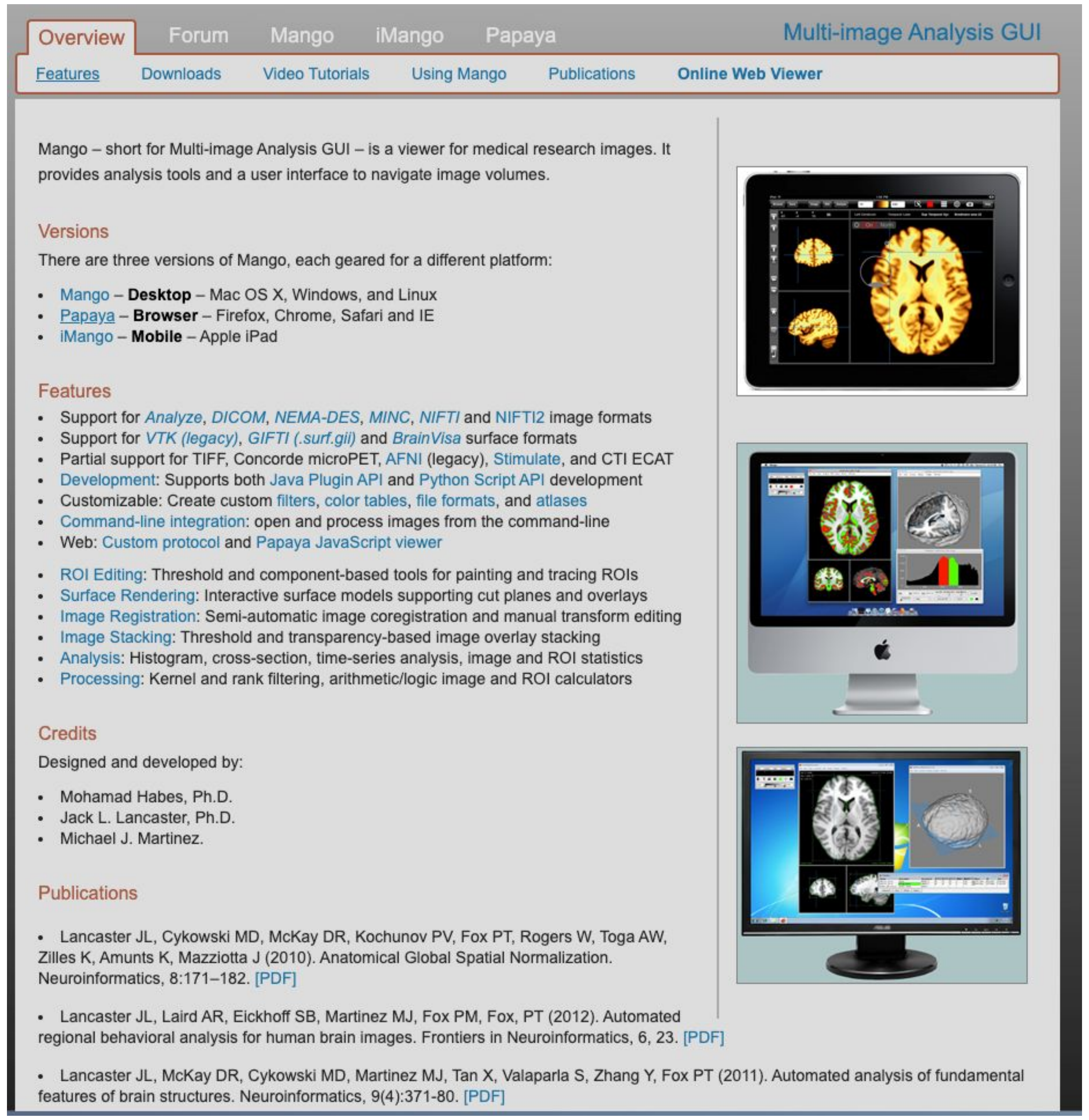


	Image Position (Patient) [mm]	Pixel Spacing [mm]
CT	[-300, -218, -675]	[1.171875, 1.171875]
RTDOSE	[-265.3, -41.9, -675]	[2, 2]






Overview Forum Mango iMango Papaya Multi-image Analysis GUI

Features Downloads Video Tutorials Using Mango Publications Online Web Viewer

Mango – short for Multi-image Analysis GUI – is a viewer for medical research images. It provides analysis tools and a user interface to navigate image volumes.

Versions

There are three versions of Mango, each geared for a different platform:

- Mango – **Desktop** – Mac OS X, Windows, and Linux
- Papaya – **Browser** – Firefox, Chrome, Safari and IE
- iMango – **Mobile** – Apple iPad

Features

- Support for *Analyze*, *DICOM*, *NEMA-DES*, *MINC*, *NIFTI* and NIFTI2 image formats
- Support for *VTK (legacy)*, *GIFTI (.surf.gii)* and *BrainVisa* surface formats
- Partial support for TIFF, Concorde microPET, AFNI (legacy), Stimulate, and CTI ECAT
- Development: Supports both Java Plugin API and Python Script API development
- Customizable: Create custom filters, color tables, file formats, and atlases
- Command-line integration: open and process images from the command-line
- Web: Custom protocol and Papaya JavaScript viewer

- ROI Editing: Threshold and component-based tools for painting and tracing ROIs
- Surface Rendering: Interactive surface models supporting cut planes and overlays
- Image Registration: Semi-automatic image coregistration and manual transform editing
- Image Stacking: Threshold and transparency-based image overlay stacking
- Analysis: Histogram, cross-section, time-series analysis, image and ROI statistics
- Processing: Kernel and rank filtering, arithmetic/logic image and ROI calculators

Credits

Designed and developed by:

- Mohamad Habes, Ph.D.
- Jack L. Lancaster, Ph.D.
- Michael J. Martinez.

Publications

- Lancaster JL, Cykowski MD, McKay DR, Kochunov PV, Fox PT, Rogers W, Toga AW, Zilles K, Amunts K, Mazziotta J (2010). Anatomical Global Spatial Normalization. Neuroinformatics, 8:171–182. [PDF]
- Lancaster JL, Laird AR, Eickhoff SB, Martinez MJ, Fox PM, Fox, PT (2012). Automated regional behavioral analysis for human brain images. Frontiers in Neuroinformatics, 6, 23. [PDF]
- Lancaster JL, McKay DR, Cykowski MD, Martinez MJ, Tan X, Valaparla S, Zhang Y, Fox PT (2011). Automated analysis of fundamental features of brain structures. Neuroinformatics, 9(4):371-80. [PDF]

https://mangoviewer.com/

3D Slicer image computing platform

Download | Documentation | Developers

Training | Forum | Twitter

3D Slicer is a **free**, **open source** software for visualization, processing, segmentation, registration, and analysis of medical, biomedical, and other 3D images and meshes; and planning and navigating image-guided procedures.

What is **3D Slicer** ?

Desktop software to solve advanced image computing challenges with a focus on clinical and biomedical applications.

Development platform to quickly build and deploy custom solutions for research and commercial products, using free, open source software.

Community of knowledgeable users and developers working together to improve medical computing.

https://www.slicer.org/

https://slicer.readthedocs.io/en/latest/
https://pypi.org/project/pynrrd/

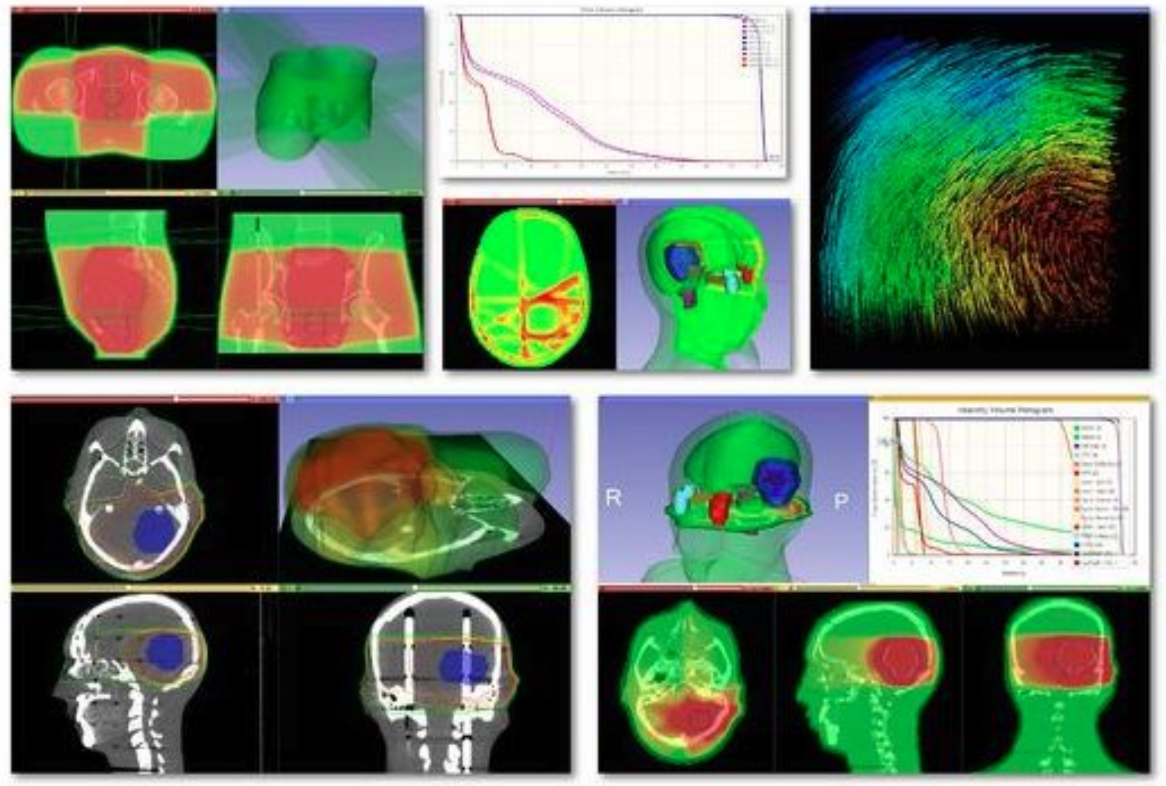
https://www.slicer.org/w/index.php/Documentation/Nightly/Extensions/SlicerRT#Tutorials

https://discourse.slicer.org/t/how-does-3d-slicer-overlay-the-rtdose-and-image-data-in-the-correct-position/8924

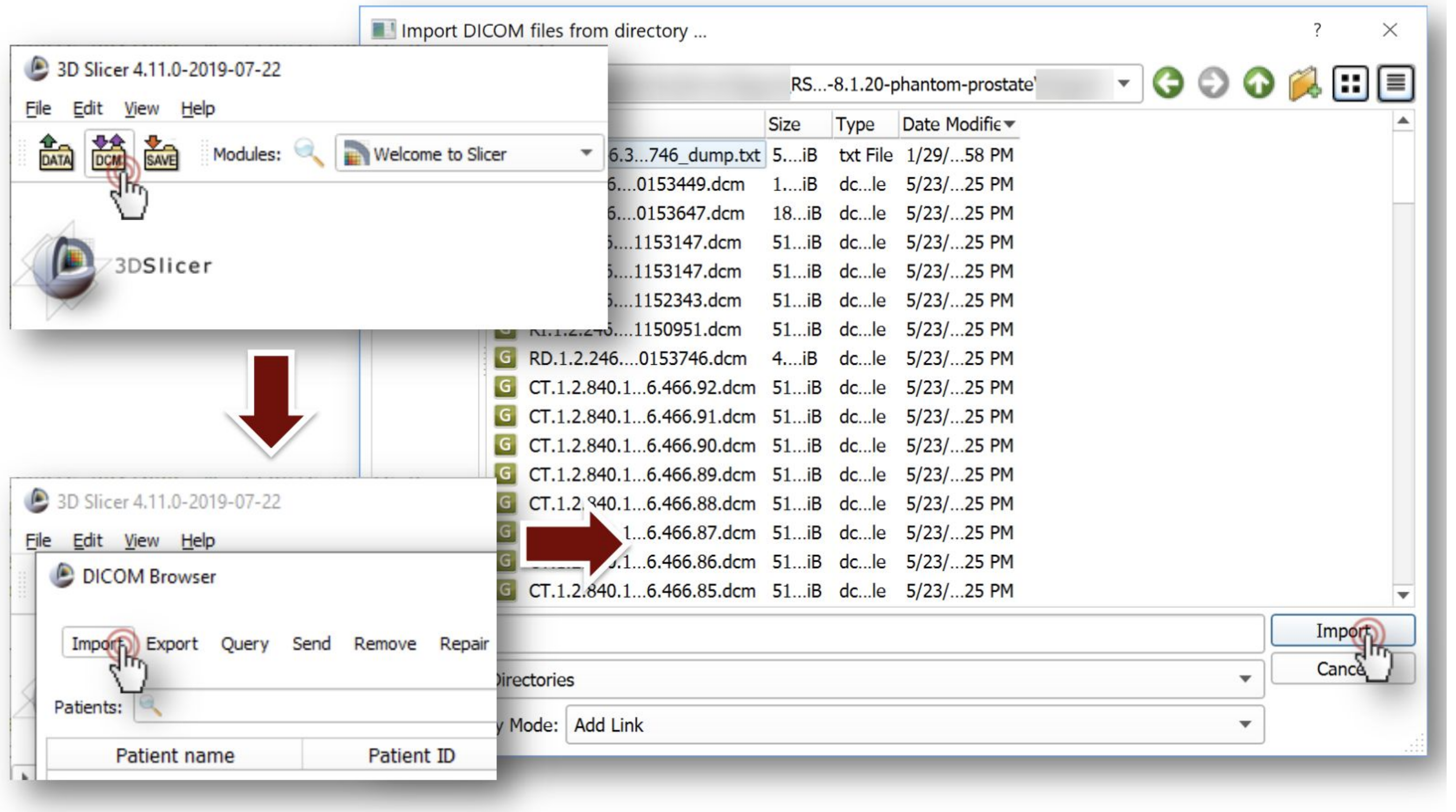
- SlicerRT is a radiation therapy toolkit for 3D Slicer, containing generic RT features for import/export, analysis, visualization, aiming to make 3D Slicer a powerful radiotherapy research platform. SlicerRT development is currently funded by CANARIE.
  SlicerRT was originally created via funding by Cancer Care Ontario and the Ontario Consortium for Adaptive Interventions in Radiation Oncology (OCAIRO) to provide free, open-source toolset for radiotherapy and related image-guided interventions.
- The SlicerRT extension incorporates Plastimatch modules and algorithms.
- Additional information for users can be found on the User's Guide page

Modules

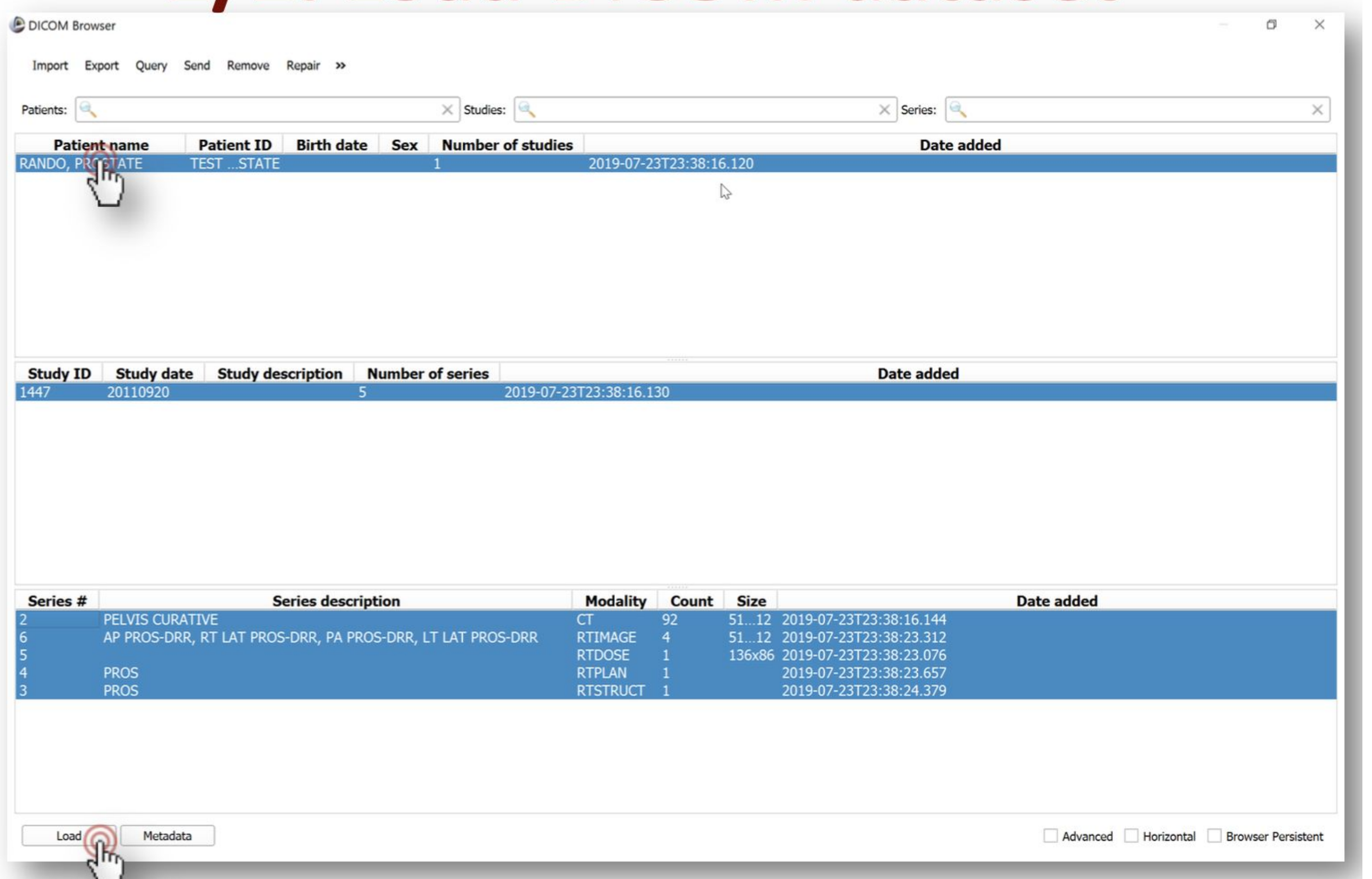
- External Beam Planning (Treatment planning)
- Dose analysis
  - Dose volume histogram
  - Dose accumulation
  - Dose comparison (Gamma dose similarity index)
  - Isodose line and surface display
- Contour analysis
  - Segment comparison (Dice Similarity Coefficient, Hausdorff distances)
  - Segment morphology (Add/remove margin, Unify, Intersect, etc.)
- I/O
  - DICOM-RT import, export (handles datasets of types RT Structure Set, RT Dose, RT Plan, RT Image)
  - DICOM-SRO import/export (handles DICOM Spatial Registration object, both rigid and deformable)
- Batch processing scripts (currently only one is available for command-line conversion of RTSS to volume nodes)
- Modules from Plastimatch
  - Plastimatch Automatic deformable image registration
  - Plastimatch LANDWARP Landmark



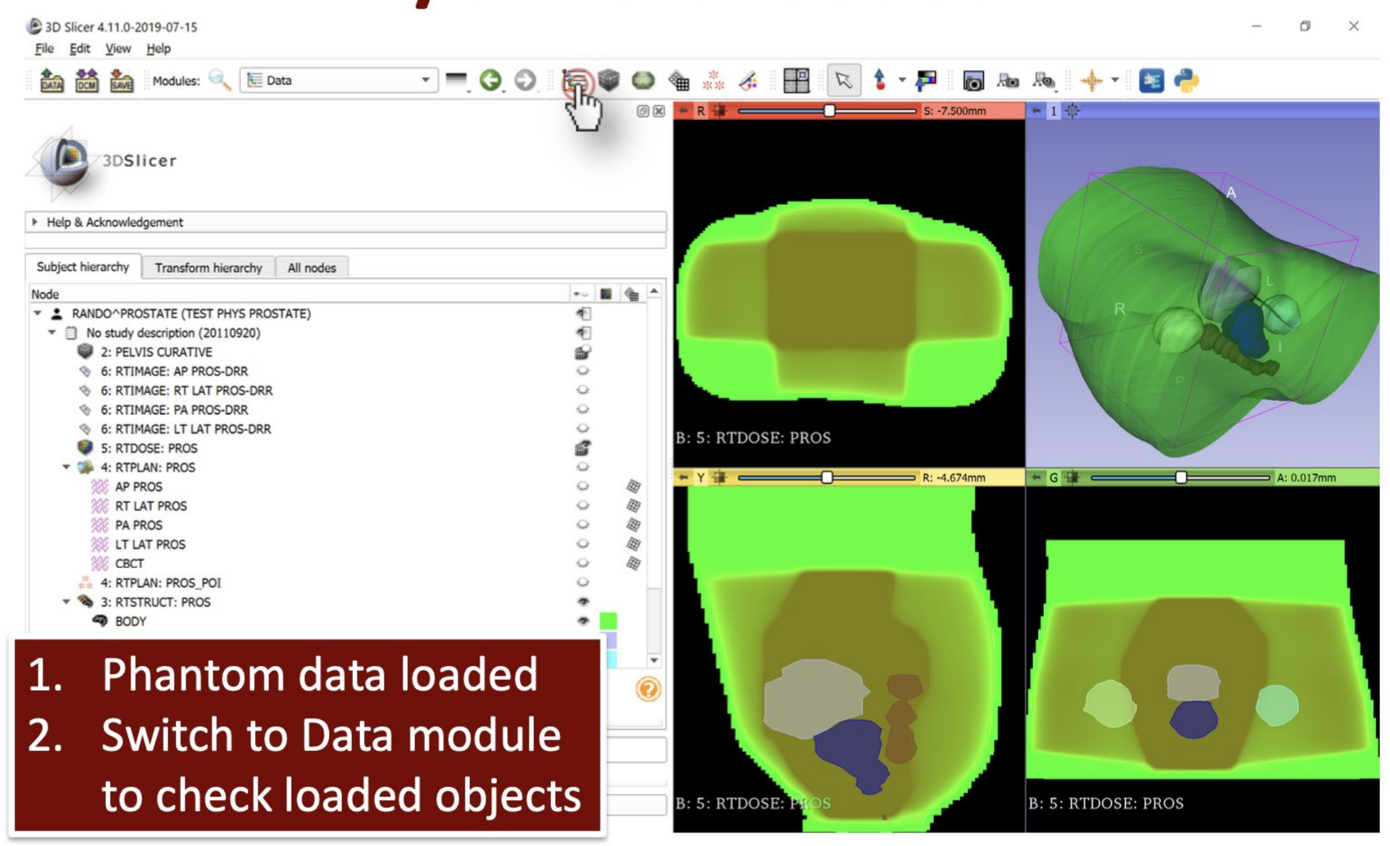
2/1. Import DICOM dataset



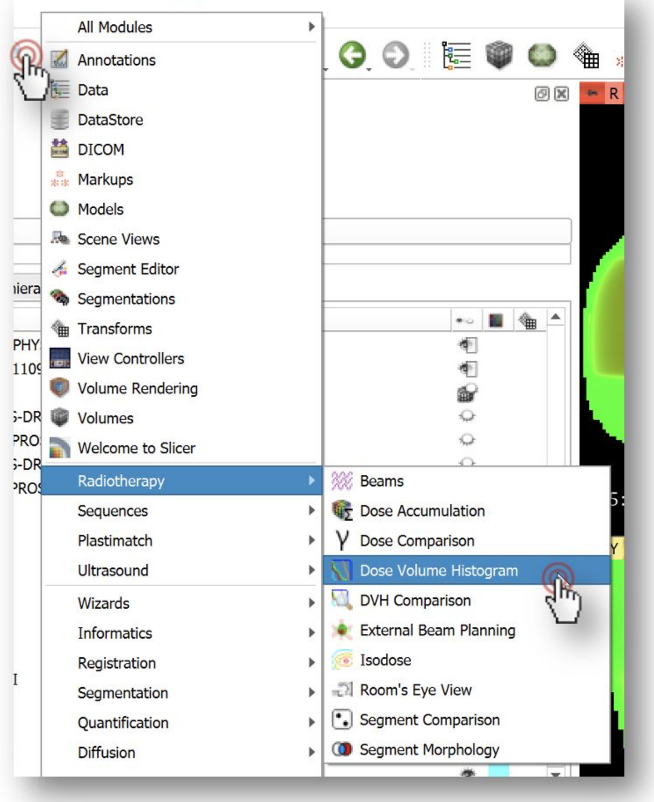
2/2. Load DICOM dataset



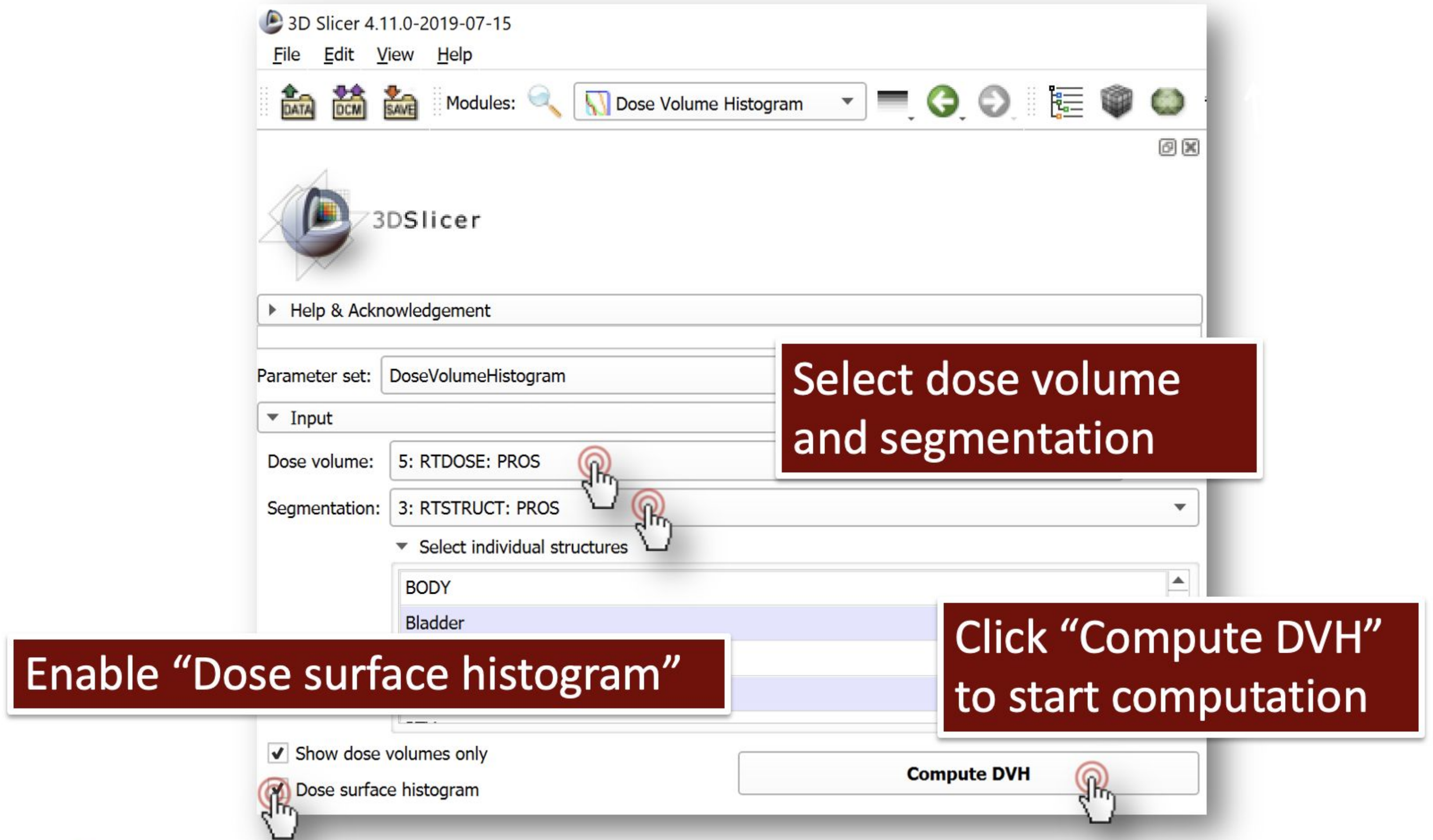
2/3. Data loaded



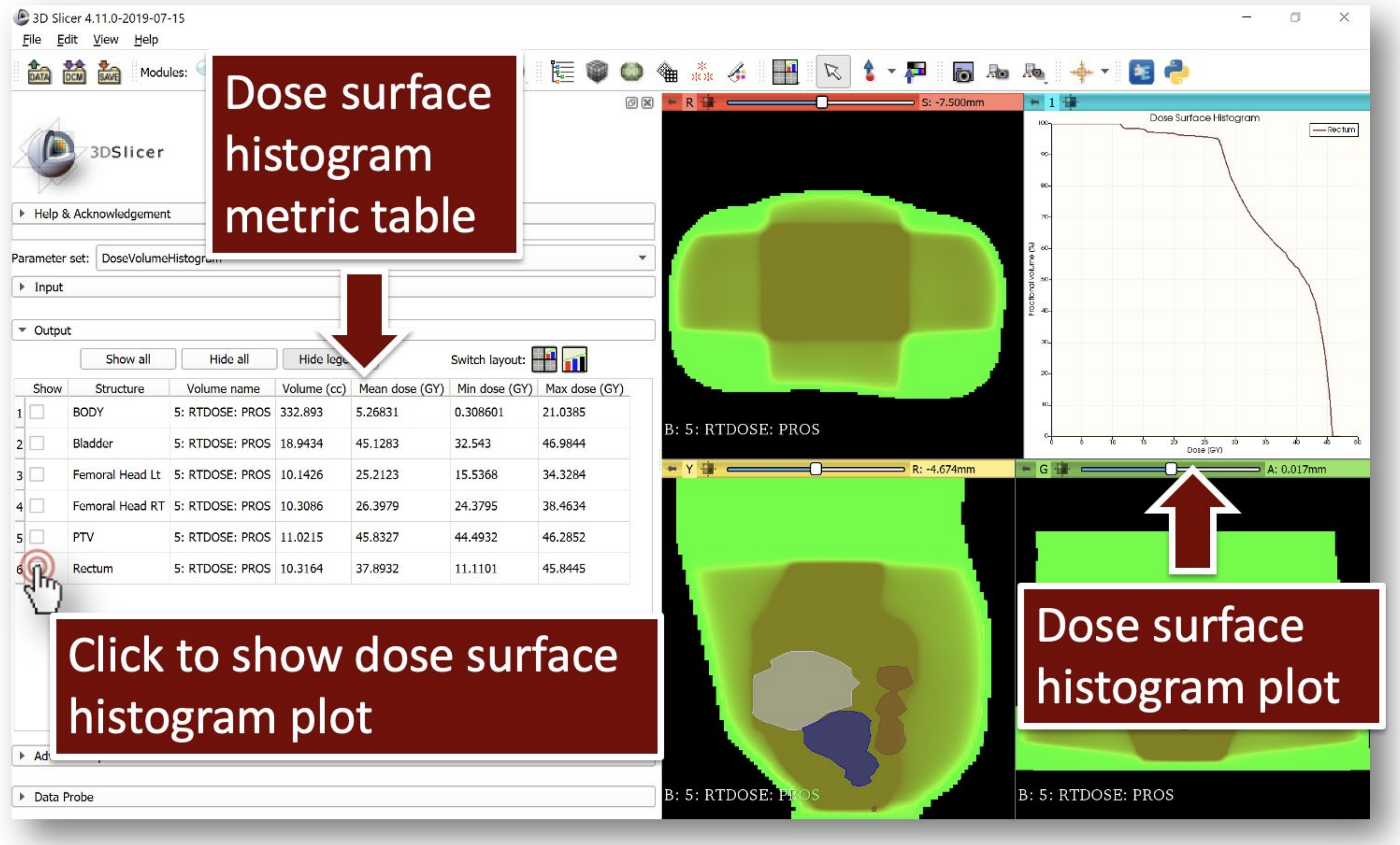
3/1. Switch to Dose Volume Histogram module



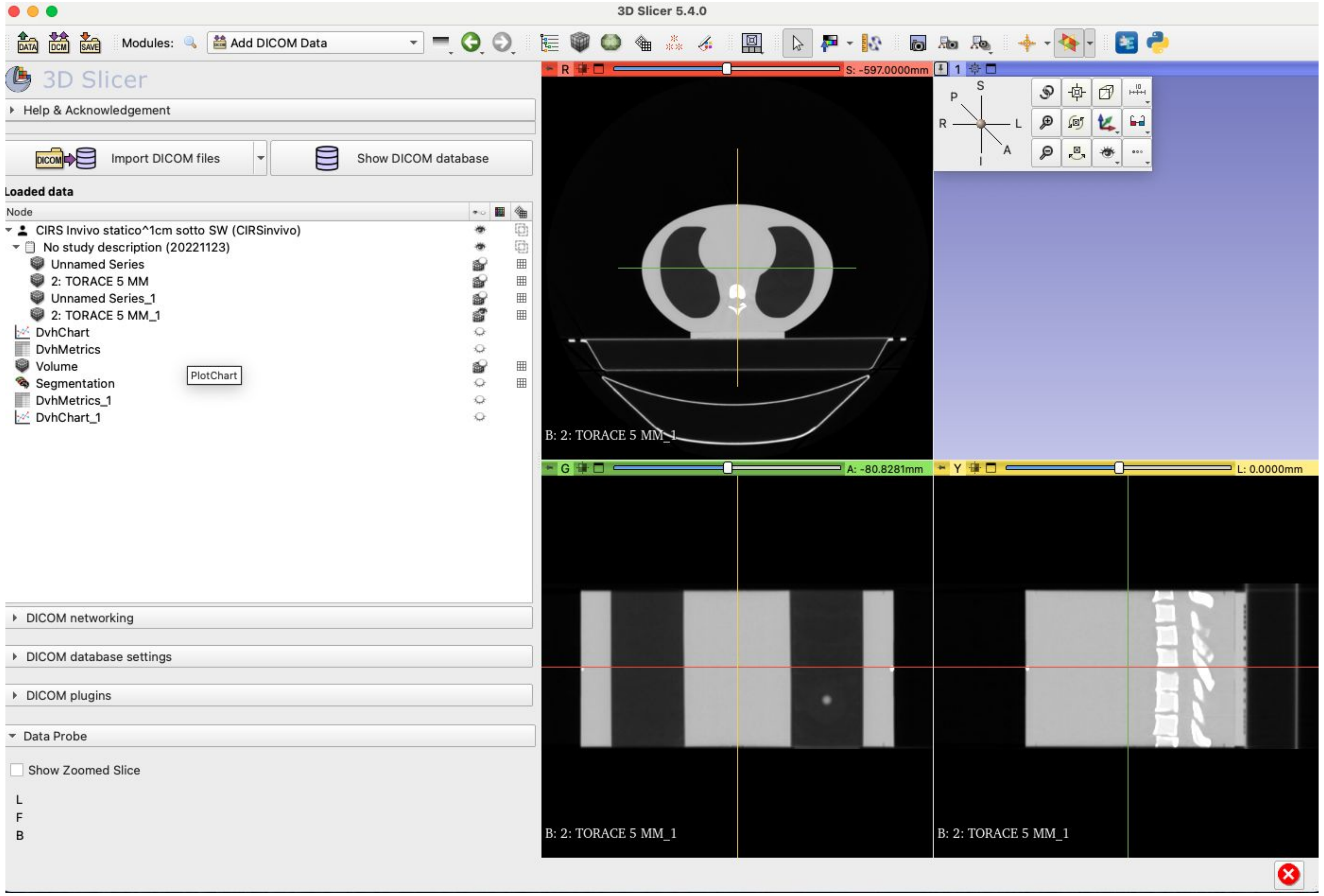
3/2. Set inputs and compute

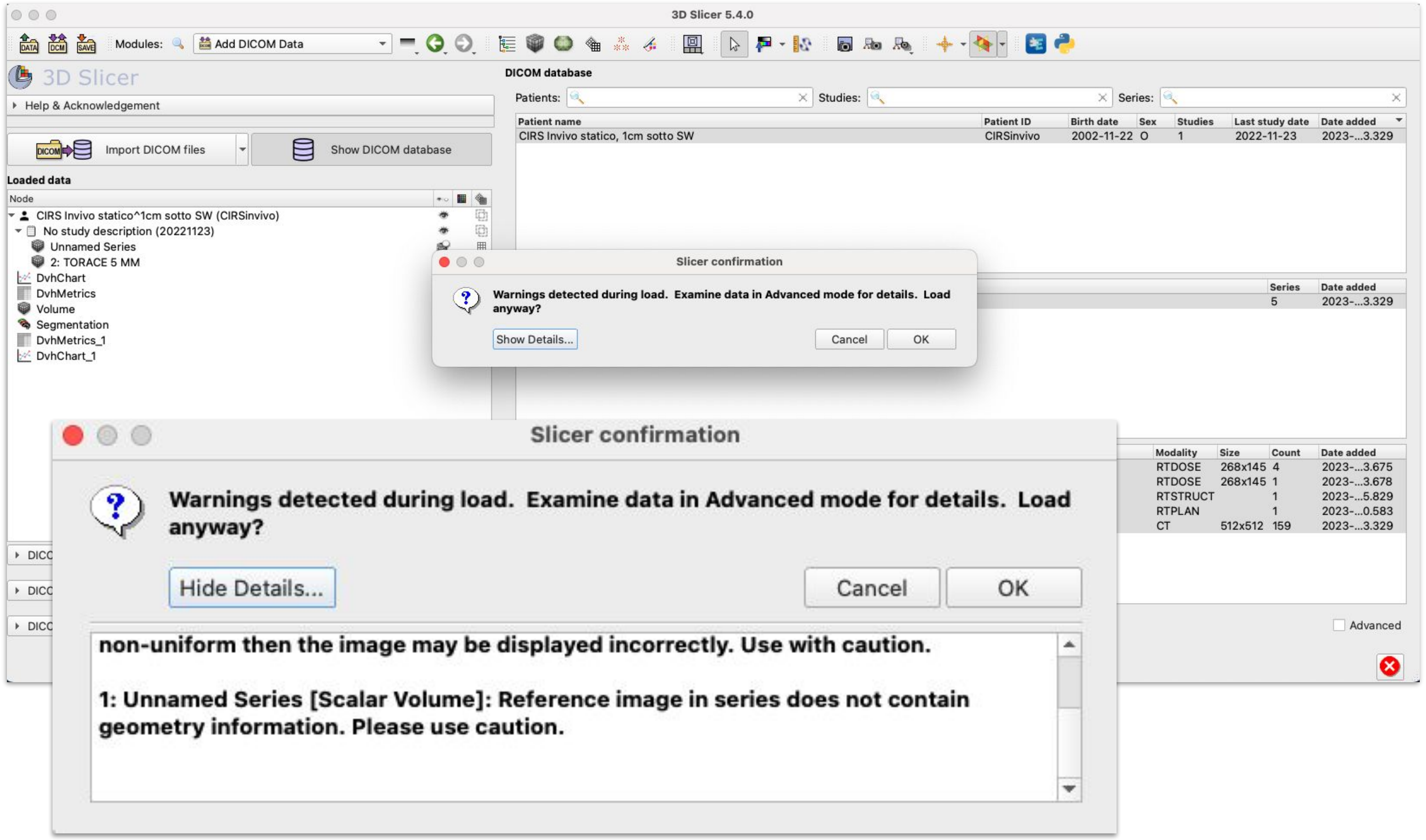


3/3. Output dose is visualized



How to overlay the RTDOSE and Image data in the correct position?





How to overlay the RTDOSE and Image data in the correct position?

When I click on "Load selection to Slicer" I get an error message "Could not load … as a scalar volume"

A common cause of loading failure is corruption of the DICOM files by incorrect anonymization. Patient name, patient ID, and series instance UID fields should not be empty or missing (the anonymizer should replace them by other valid strings). Try to load the original, non-anonymized sequence and/or change your anonymization procedure.

If none of the above helps then check the Slicer error logs and report the error on the Slicer forum. If you share the data (e.g., upload it to Dropbox and add the link to the error report) then Slicer developers can reproduce and fix the problem faster.

https://slicer.readthedocs.io/en/latest/user_guide/modules/dicom.html#when-i-click-on-load-selection-to-slicer-i-get-an-error-message-could-not-load-as-a-scalar-volume

Series #	Series description	Modality	Size	Count	Date added
0		RTDOSE	268x145	4	2023-...3.675
0		RTDOSE	268x145	1	2023-...3.678
1	STRCTRNAME	RTSTRUCT		1	2023-...5.829
1	4beams	RTPLAN		1	2023-...0.583
2	TORACE 5 MM	CT	512x512	159	2023-...3.329

RT plan

- CT
- EPID
- RT
- RTDOSE
- RTPLAN

RT Plan

The focus for this Radiotherapy Plan IOD (RT Plan IOD) is to address the **requirements for transfer of treatment plans generated by** manual entry, a virtual simulation system, or a **treatment planning system** before or during a course of treatment. Such plans may **contain fractionation information**, and **define external beams** and/or brachytherapy application setups.

```
Out[63]: Dataset.file_meta -------------------------------
(0002, 0000) File Meta Information Group Length  UL: 168
(0002, 0001) File Meta Information Version       OB: b'\x00\x01'
(0002, 0002) Media Storage SOP Class UID         UI: RT Plan Storage
(0002, 0003) Media Storage SOP Instance UID      UI: 2.16.840.1.114337.1.1.1682093613.0
(0002, 0010) Transfer Syntax UID                 UI: Implicit VR Little Endian
(0002, 0012) Implementation Class UID            UI: 2.16.840.1.114362.1
(0002, 0013) Implementation Version Name         SH: 'MIM723M31402'
-------------------------------------------------
(0008, 0005) Specific Character Set              CS: 'ISO_IR 100'
(0008, 0012) Instance Creation Date              DA: '20230421'
(0008, 0013) Instance Creation Time              TM: '181333'
(0008, 0014) Instance Creator UID                UI: 2.16.840.1.114337
(0008, 0016) SOP Class UID                       UI: RT Plan Storage
(0008, 0018) SOP Instance UID                    UI: 2.16.840.1.114337.1.1.1682093613.0
(0008, 0020) Study Date                          DA: '20221123'
(0008, 0030) Study Time                          TM: '130930'
(0008, 0050) Accession Number                    SH: ''
(0008, 0060) Modality                            CS: 'RTPLAN'
(0008, 0070) Manufacturer                        LO: 'CMS, Inc.'
(0008, 0090) Referring Physician's Name          PN: ''
(0008, 1070) Operators' Name                     PN: ''
(0008, 1090) Manufacturer's Model Name           LO: 'Monaco'
(0010, 0010) Patient's Name                      PN: 'CIRS Invivo statico^1cm sotto SW'
(0010, 0020) Patient ID                          LO: 'CIRSinvivo'
```

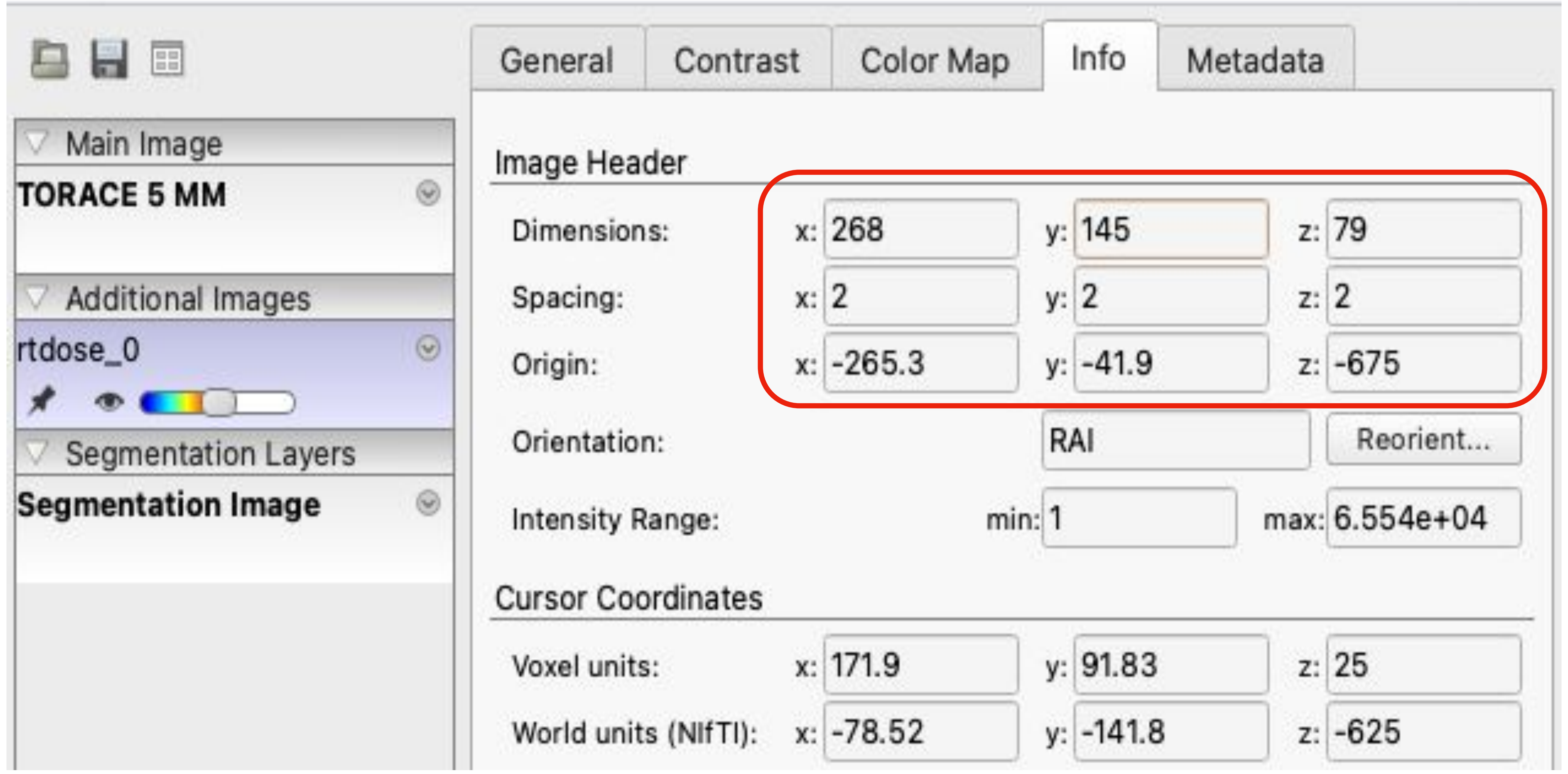
RT

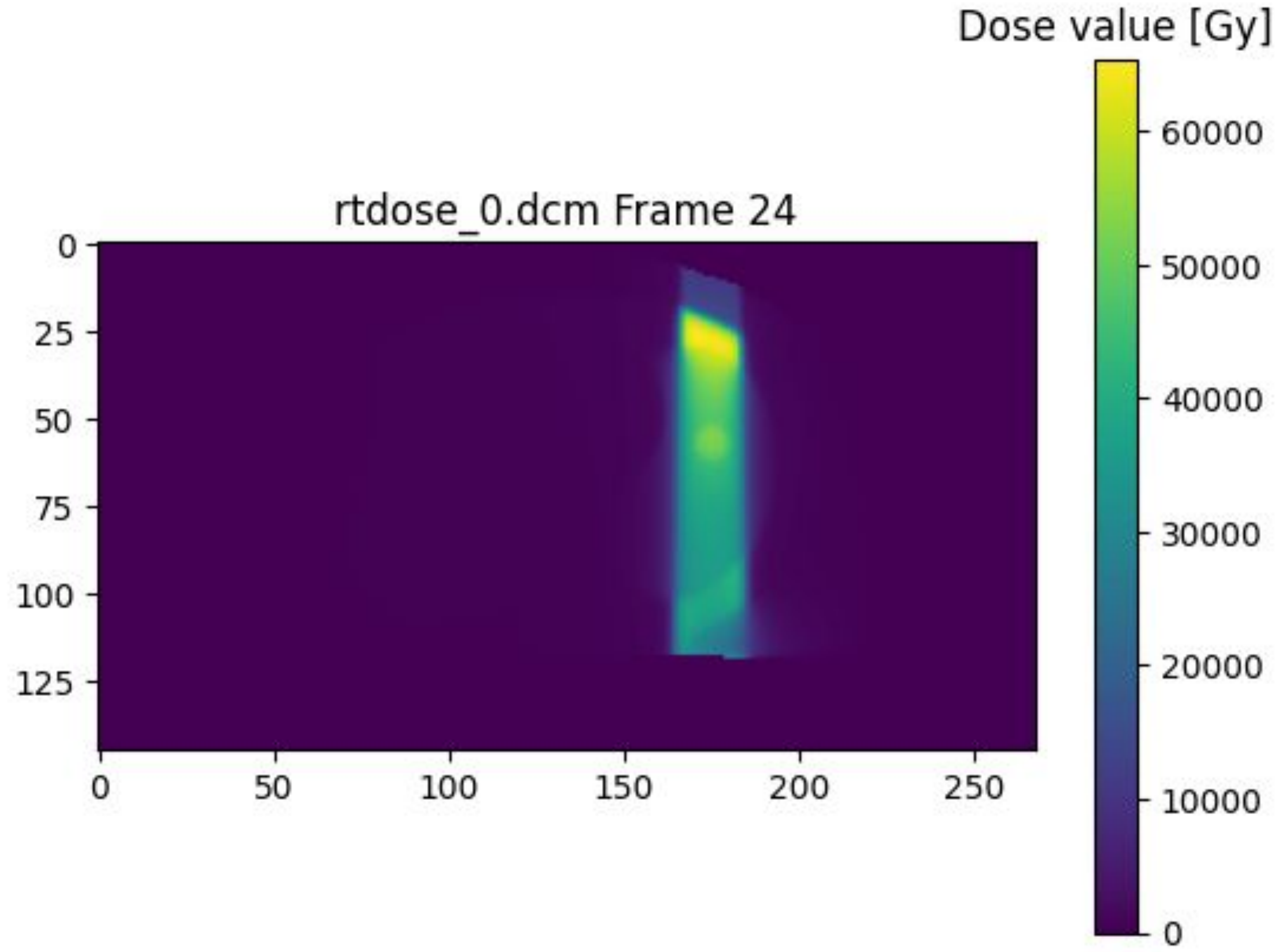
- CT
- EPID
- RT
- RTDOSE
- RTPLAN

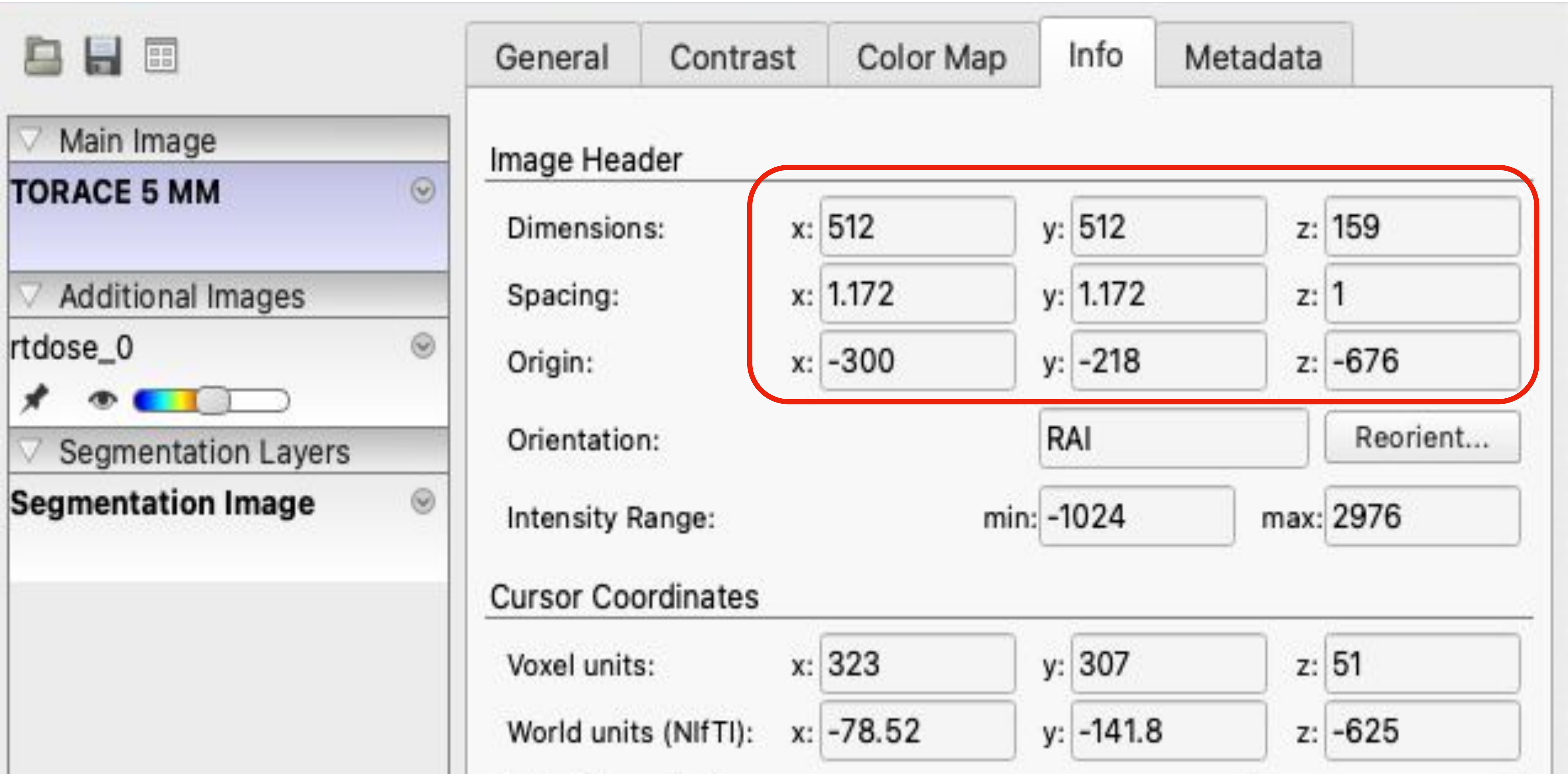
```
Dataset.file_meta -------------------------------
(0002, 0000) File Meta Information Group Length  UL: 168
(0002, 0001) File Meta Information Version       OB: b'\x00\x01'
(0002, 0002) Media Storage SOP Class UID         UI: RT Structure Set Storage
(0002, 0003) Media Storage SOP Instance UID      UI: 2.16.840.1.114337.1.1.1682093605.0
(0002, 0010) Transfer Syntax UID                 UI: Implicit VR Little Endian
(0002, 0012) Implementation Class UID            UI: 2.16.840.1.114362.1
(0002, 0013) Implementation Version Name         SH: 'MIM723M31402'
-------------------------------------------------
(0008, 0005) Specific Character Set              CS: 'ISO_IR 100'
(0008, 0012) Instance Creation Date              DA: '20230421'
(0008, 0013) Instance Creation Time              TM: '181329.000000'
(0008, 0014) Instance Creator UID                UI: 2.16.840.1.114337
(0008, 0016) SOP Class UID                       UI: RT Structure Set Storage
(0008, 0018) SOP Instance UID                    UI: 2.16.840.1.114337.1.1.1682093605.0
(0008, 0020) Study Date                          DA: '20221123'
(0008, 0030) Study Time                          TM: '130930'
(0008, 0050) Accession Number                    SH: '1'
(0008, 0060) Modality                            CS: 'RTSTRUCT'
(0008, 0070) Manufacturer                        LO: 'Computerized Medical Systems'
(0008, 0090) Referring Physician's Name          PN: 'Unknown'
(0008, 1040) Institutional Department Name       LO: 'EpiGray'
(0008, 1090) Manufacturer's Model Name           LO: 'Monaco'
(0010, 0010) Patient's Name                      PN: 'CIRS Invivo statico^1cm sotto SW'
(0010, 0020) Patient ID                          LO: 'CIRSinvivo'
(0010, 0030) Patient's Birth Date                DA: '20021122'
```

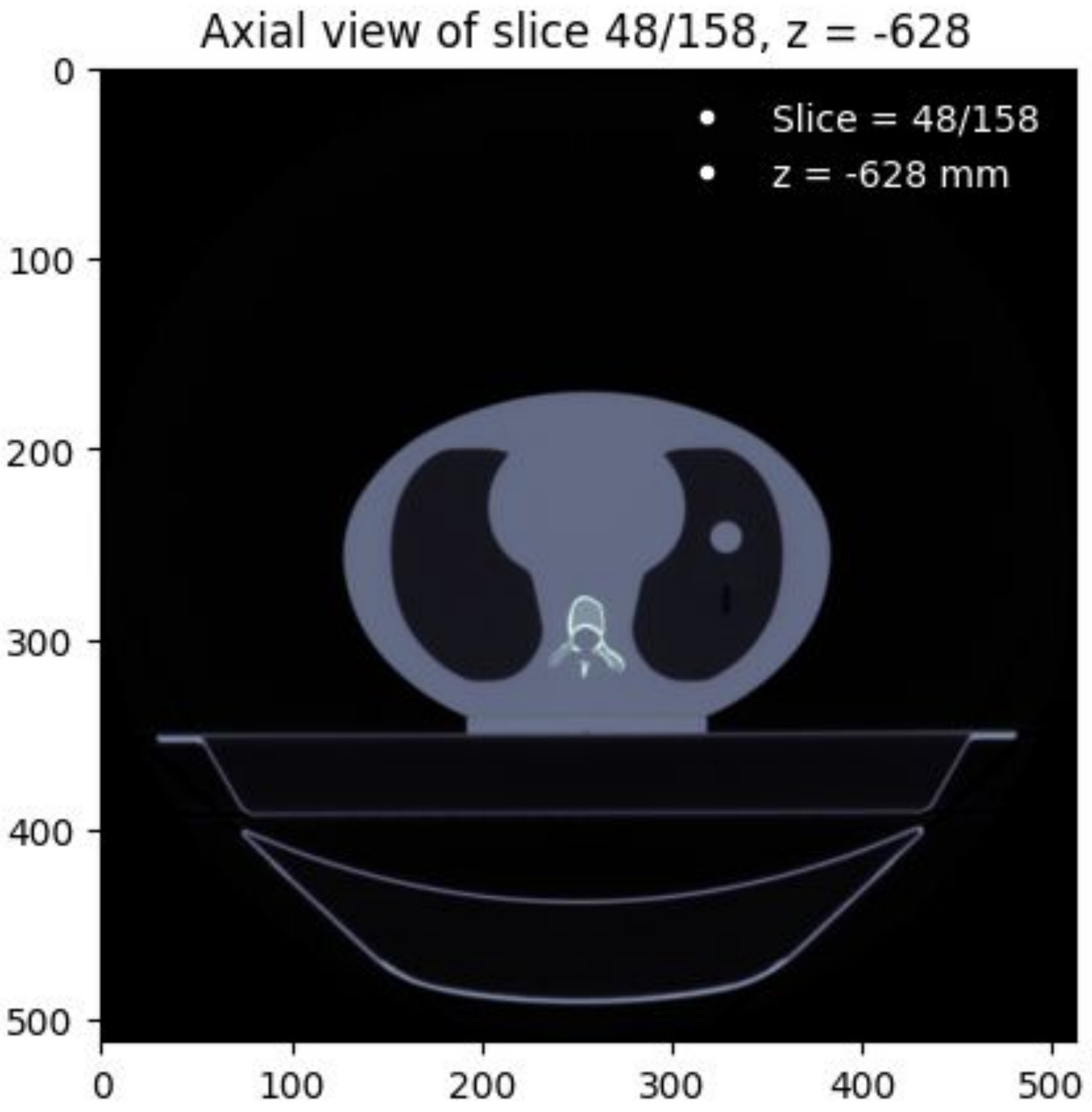
RT Structure Set CIOD

The focus for this Radiotherapy Structure Set IOD (RT Structure Set IOD) is to address the **requirements for transfer of Patient structures and related data defined on CT scanners**, virtual simulation workstations, treatment planning systems and similar devices.

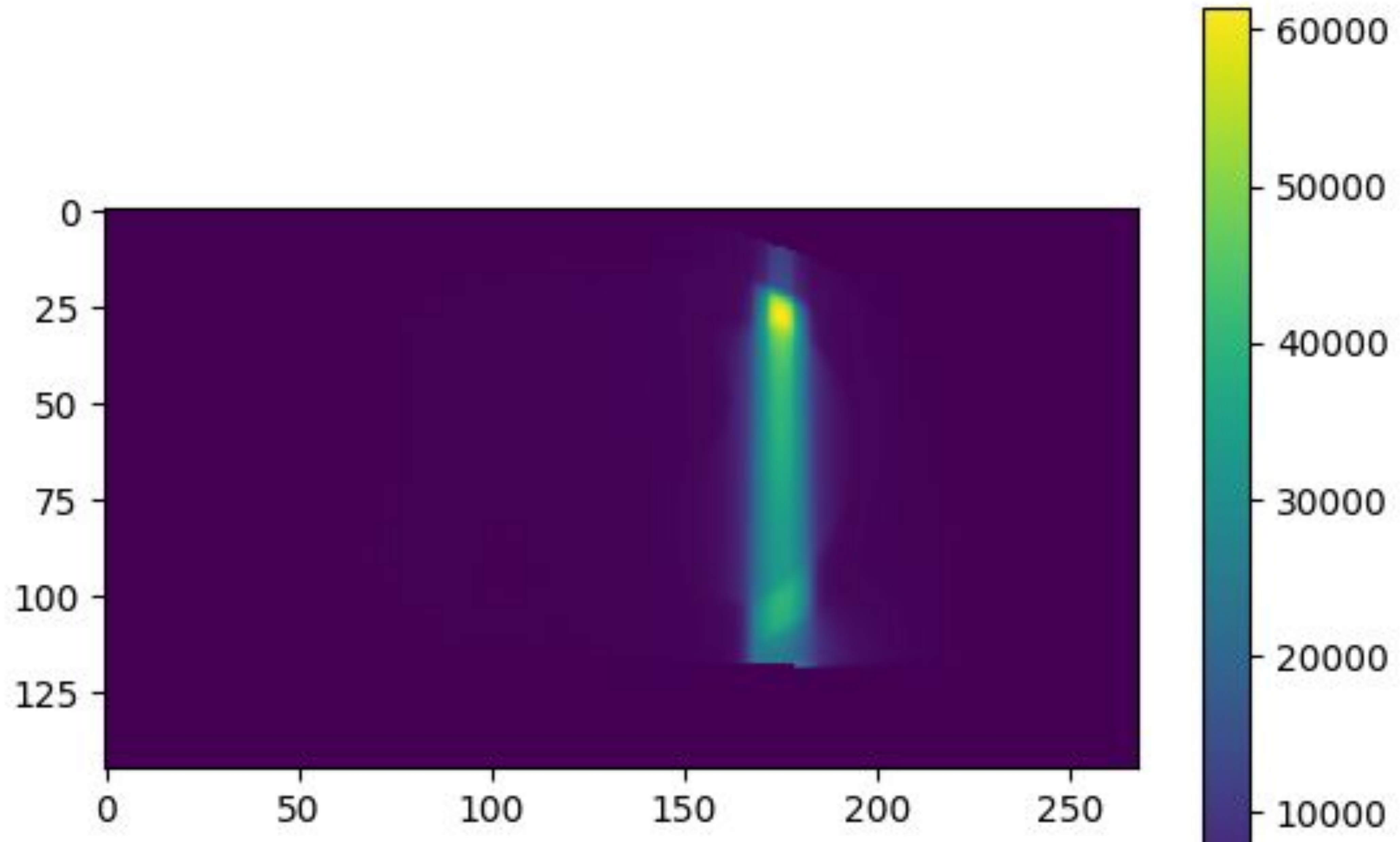

General
Contrast
Color Map
Info
Metadata
Main Image
TORACE 5 MM
Additional Images
rtdose_0
Segmentation Layers
Segmentation Image
Image Header
Dimensions: x: 268 y: 145 z: 79
Spacing: x: 2 y: 2 z: 2
Origin: x: -265.3 y: -41.9 z: -675
Orientation: RAI
Reorient...
Intensity Range: min: 1 max: 6.554e+04
Cursor Coordinates
Voxel units: x: 171.9 y: 91.83 z: 25
World units (NIfTI): x: -78.52 y: -141.8 z: -625


Dose value [Gy]
rtdose_0.dcm Frame 24
0
25
50
75
100
125
0
50
100
150
200
250
60000
50000
40000
30000
20000
10000
0

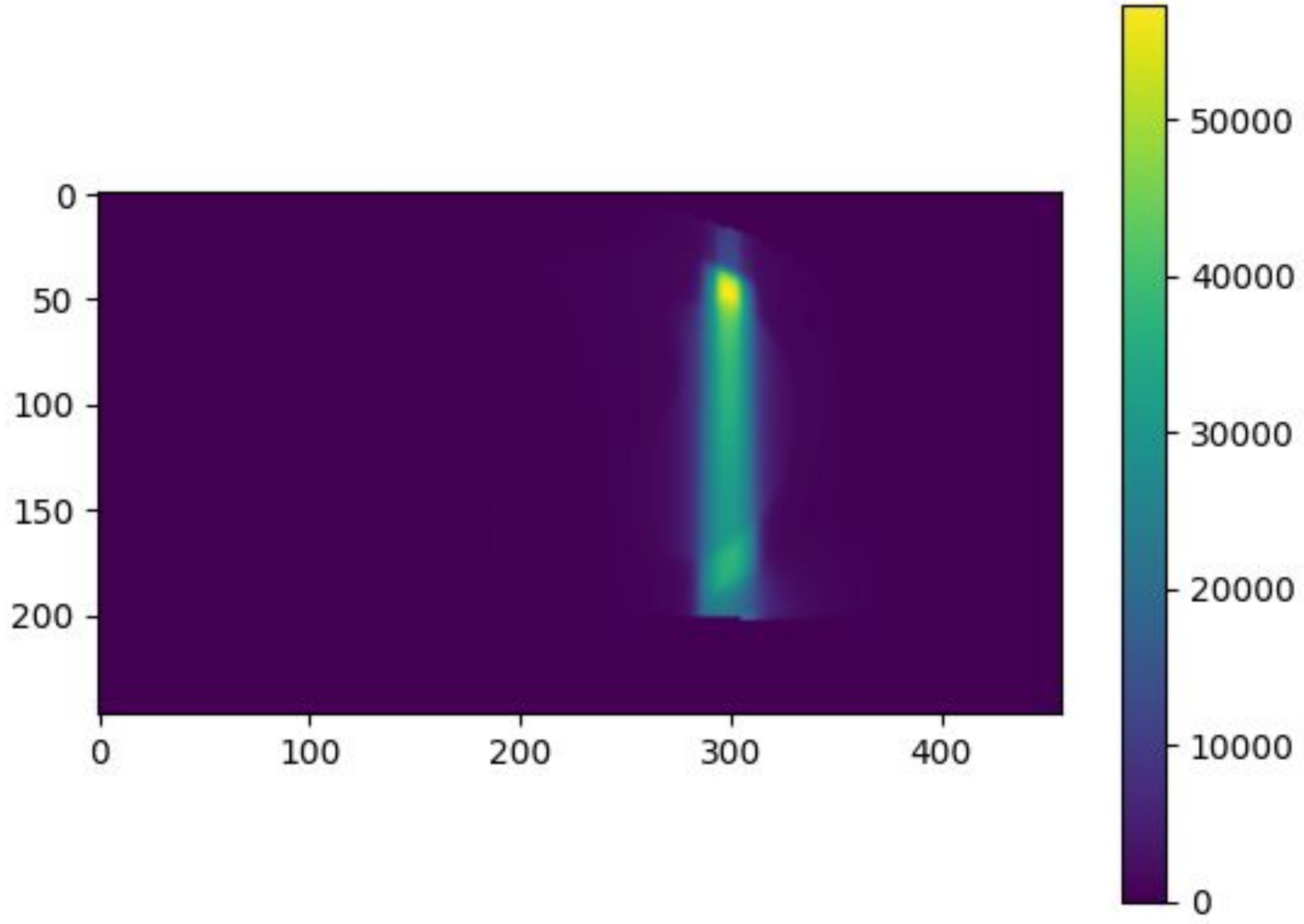

General
Contrast
Color Map
Info
Metadata
Main Image
TORACE 5 MM
Additional Images
rtdose_0
Segmentation Layers
Segmentation Image
Image Header
Dimensions: x: 512 y: 512 z: 159
Spacing: x: 1.172 y: 1.172 z: 1
Origin: x: -300 y: -218 z: -676
Orientation: RAI
Reorient...
Intensity Range: min: -1024 max: 2976
Cursor Coordinates
Voxel units: x: 323 y: 307 z: 51
World units (NIfTI): x: -78.52 y: -141.8 z: -625


Axial view of slice 48/158, z = -628
Slice = 48/158
z = -628 mm
0
100
200
300
400
500
0
100
200
300
400
500

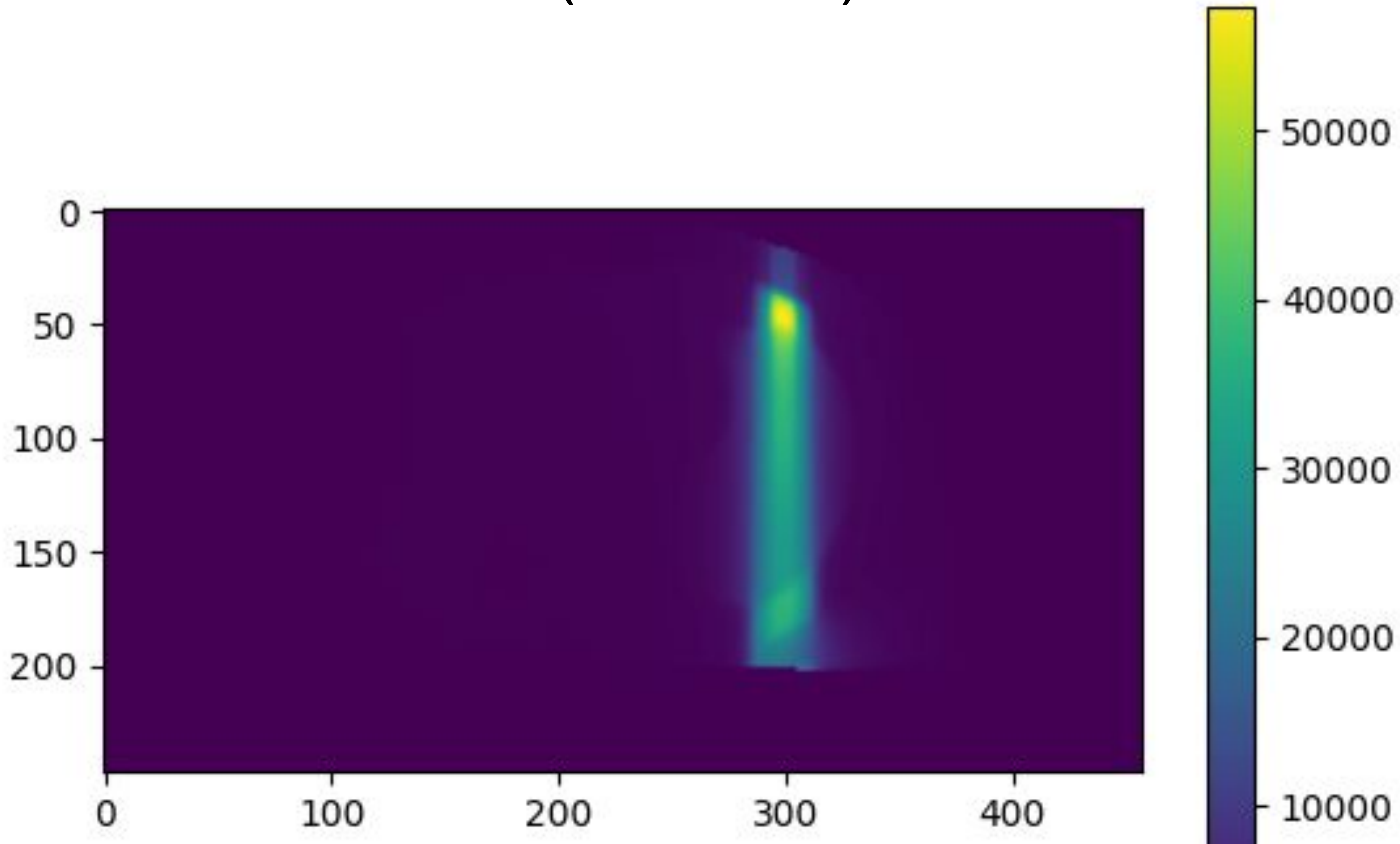
Original image (128x268)



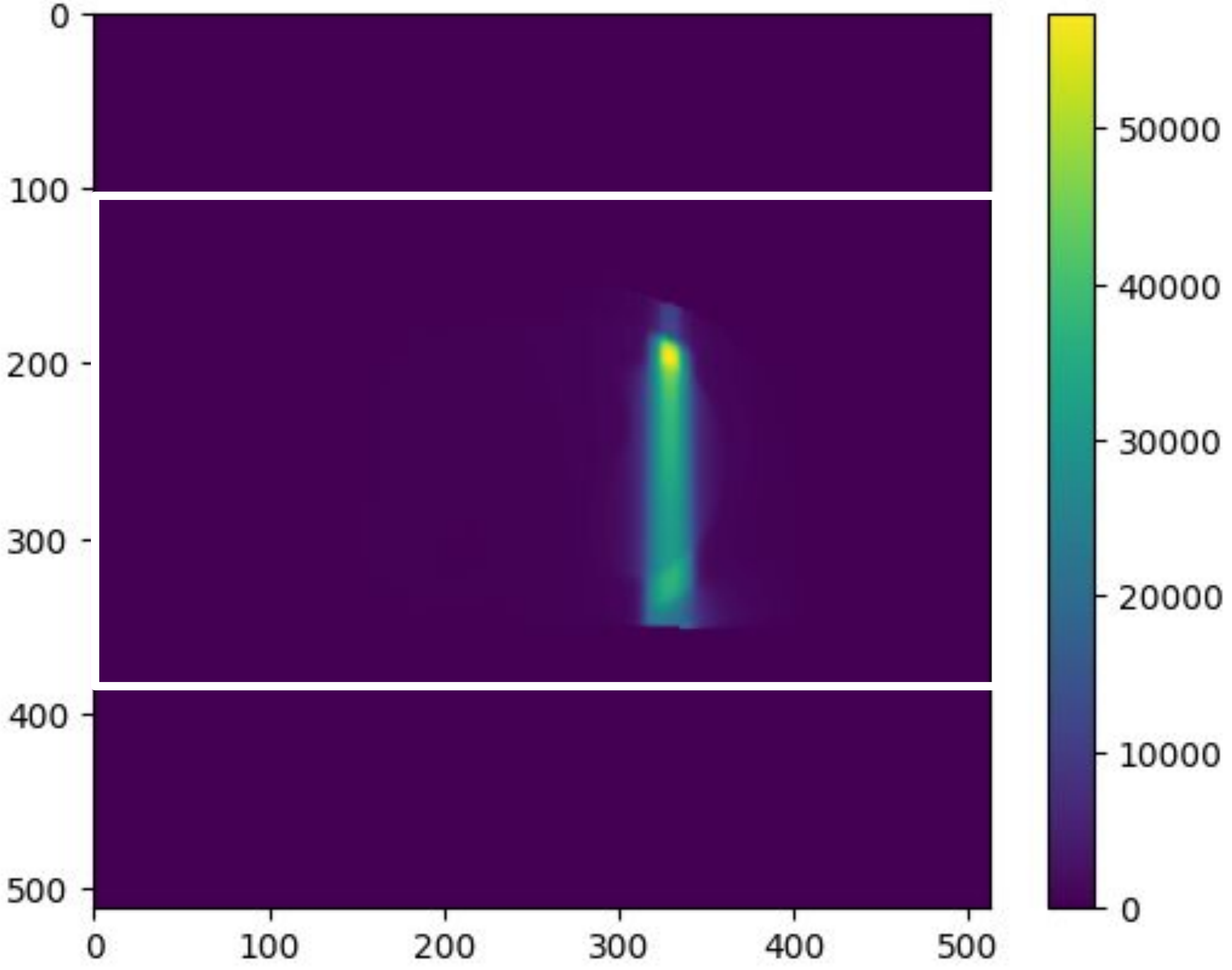
Resized (247x457)



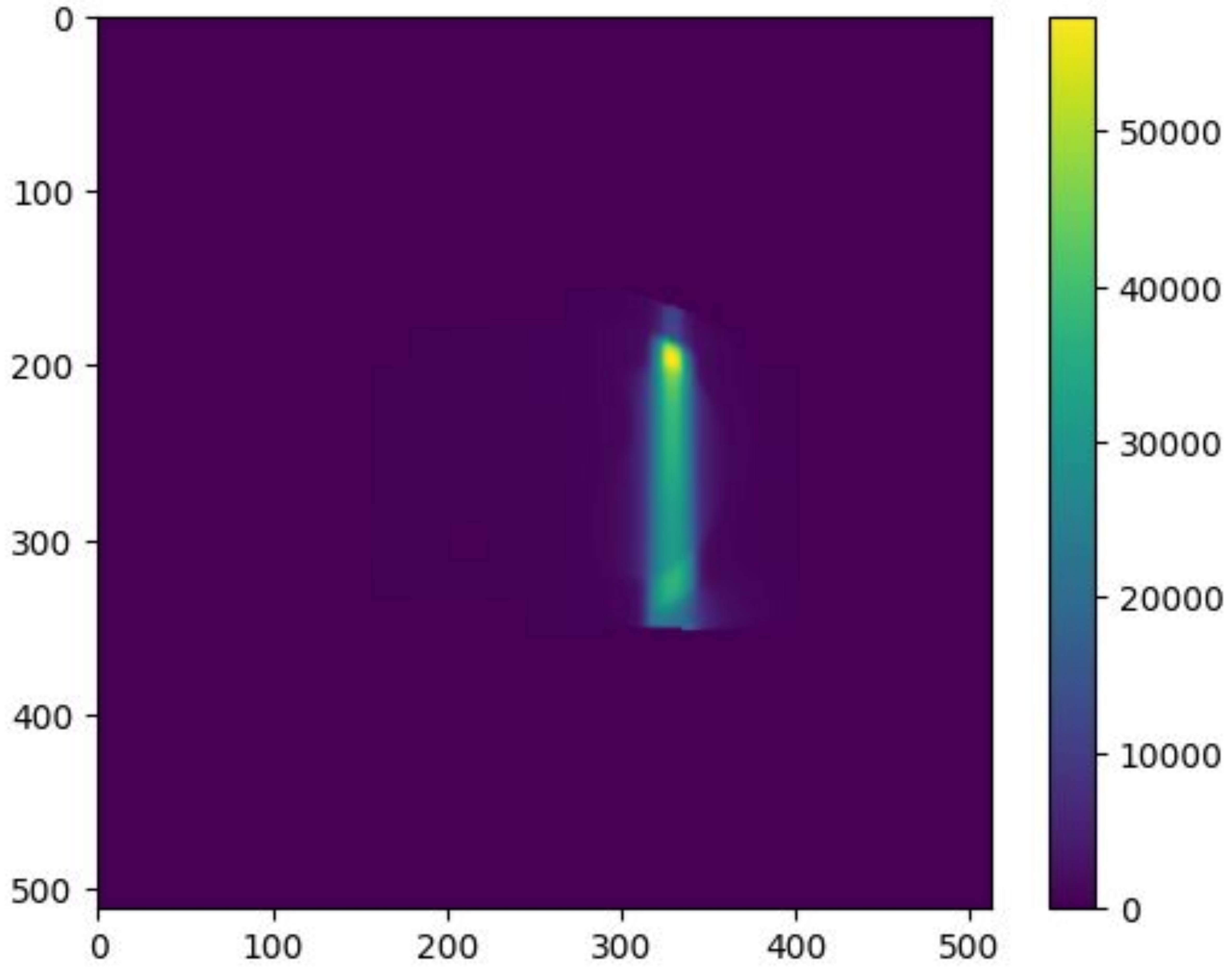
Resized (247x457)



Overlay on a zeros matrix (512x512)



Overlay on a zeros matrix (512x512)



Overlay on a CT slice (512x512)