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Eclipse Scripting in Focus: Applications in Radiation Oncology

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25.05.2024

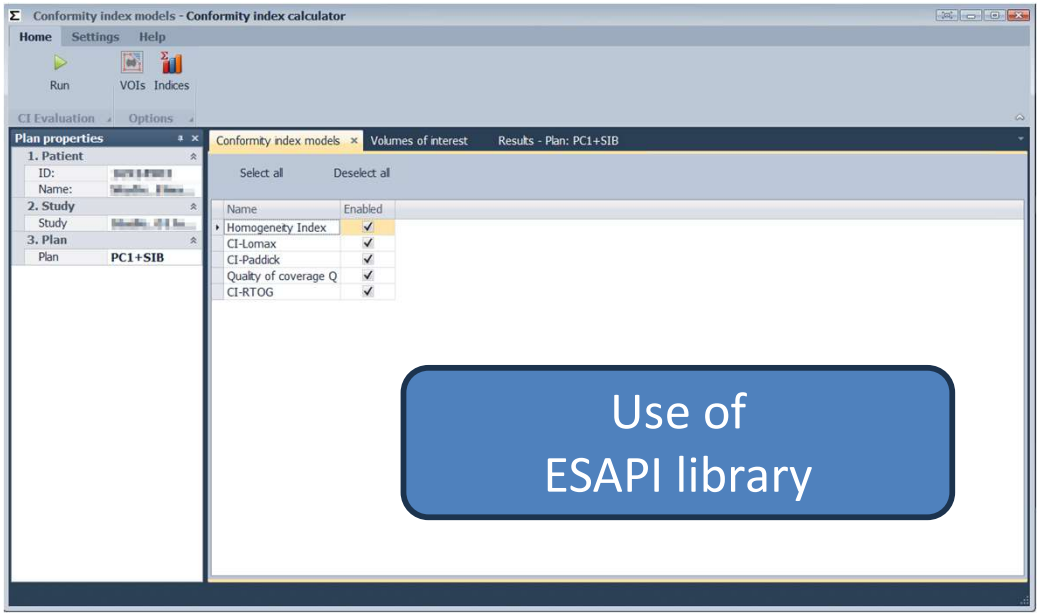
Med. Physik Abteilung, Straheilkunde, Universität Freiburg

Outline

- What is Eclipse Scripting?
- ESAPI Features / Functionalities
- In-house applications for Med. Physics / Radiation Oncology
- Elements on best practises for code development
- Conclusion

What is Eclipse Scripting?

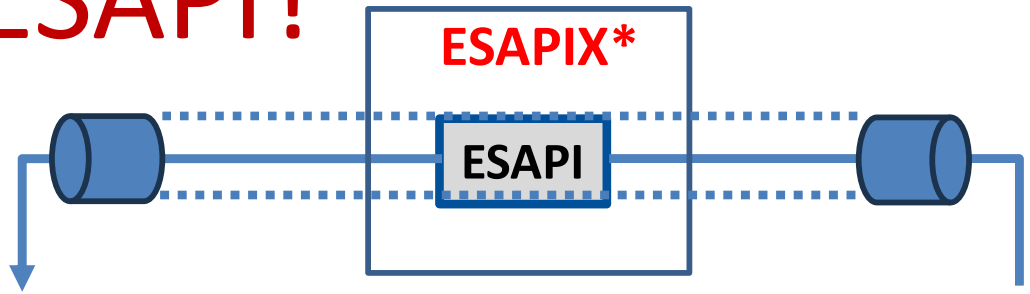
- Software application
- **ESAPI** => **E**clipse **S**cripting **A**pplication **P**rogramming **I**nterface

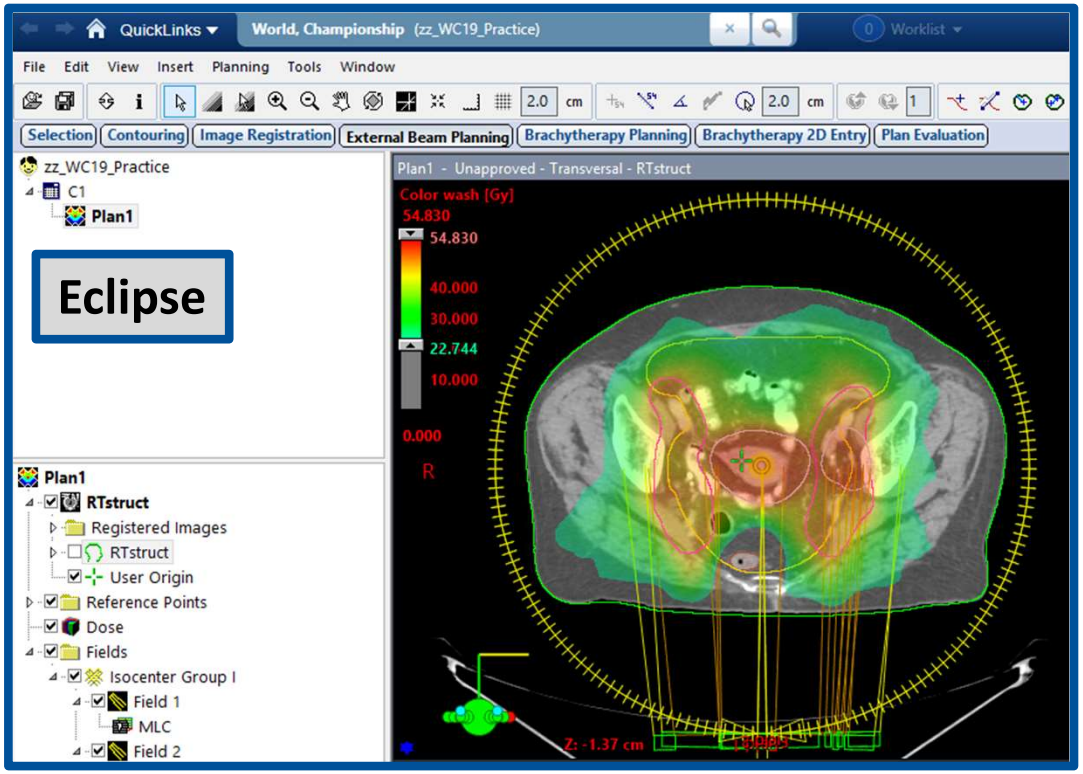


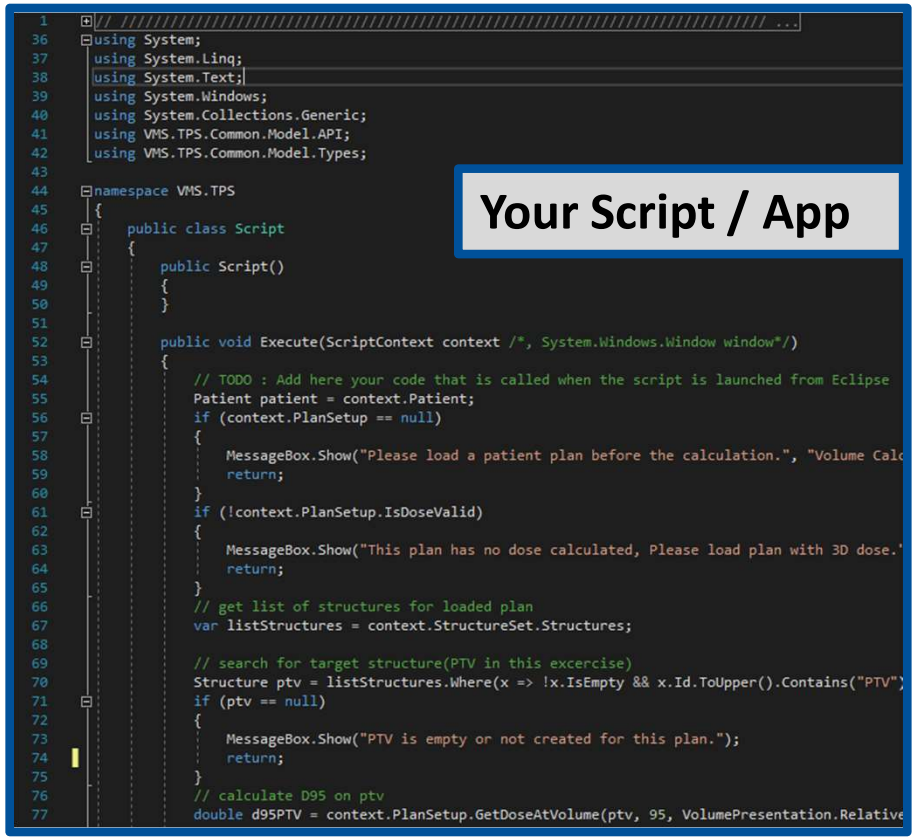
What is ESAPI?

- Collection of .NET (software development framework by Microsoft) libraries
- Enables developers to build .NET scripts, DLLs, or application with .NET enabled languages (**C#**, Visual Basic, C++, F#)
- Operates on patient data loaded into Eclipse and/or all patients available in Eclipse database (ARIA DB)

What is ESAPI?







(*) https://github.com/rexcardan/ESAPIX

VARIAN ecosystem - APIs

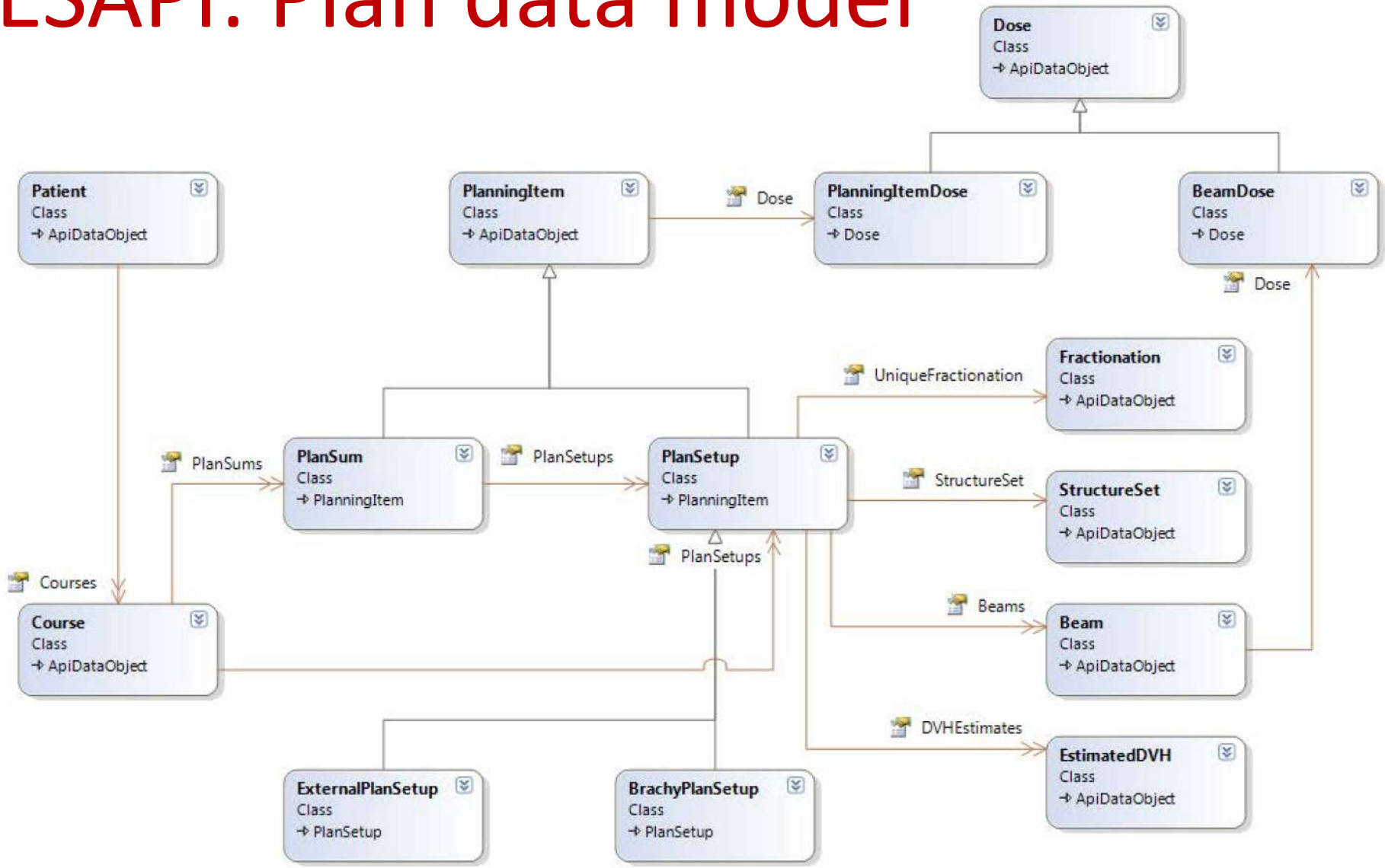
- Image Registration and Segmentation Scripting API
  - structures and structure sets
  - rigid and non-rigid registrations
- ARIA Portal Dosimetry Scripting API
  - portal dose images, predicted dose images and composite images
  - portal Dosimetry Analysis, including tests and gamma analysis
  - portal Dosimetry analysis templates
- Eclipse Scripting API

=> Microsoft .NET Framework library v4.6.2 (ESAPI 15.6)

ESAPI v15.5 (or newer)

- ESAPI Access (read) to External Beam Planning Information: Patient, Course, Plan, Beams, Structures, DVHs, Doses, Images, Imaging Registration
- Access (read) to Eclipse Brachytherapy and Proton Data
- Eclipse Automation for External Beam Planning (read/write): Create Courses, Plans, Beams, Optimization, Dose calculation

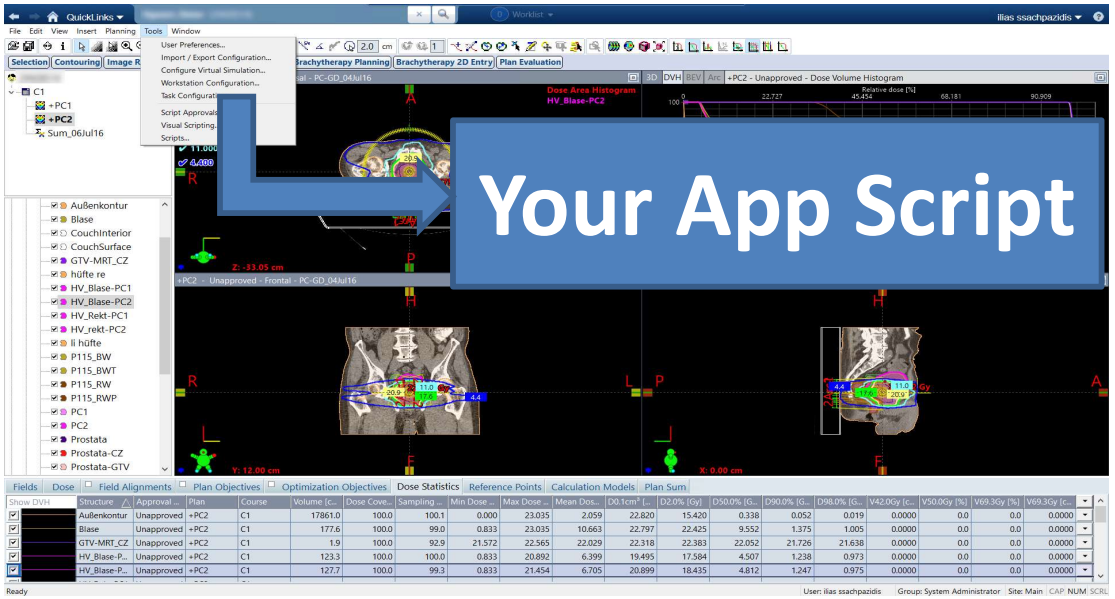
ESAPI: Plan data model



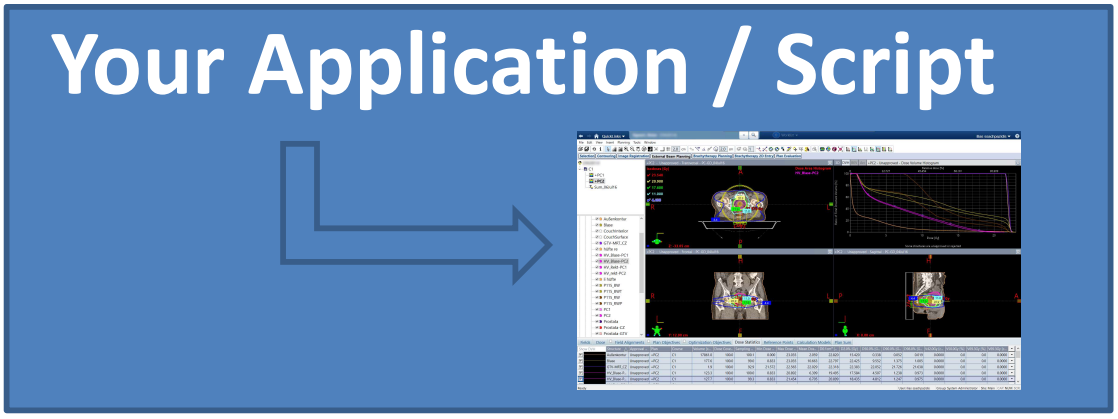
Source: Eclipse Scripting API Reference Guide, VARIAN

Scripting running modes

Plugin Script



Standalone Application



General ESAPI Applications

- Contouring of help structures
  - Boolean operations,
  - a/symmetric margins
- Treatment planning
  - Automatic plan generation and optimization
  - Creation and calculation of verification plans
  - DVH-Analyser Documentation (Standard Treatment Plan Report, Dose Metric Report)
- Data extraction
  - Patient filtering with specific plan parameters
  - Extraction of DVH, structure 3D meshes, plan parameters, etc…

In-house ESAPI applications

R&D:

- Export of 3D meshes of structures => Radiomics
- Exporting Dose-Volume indices (Dxx, Vxx) for single and summation plans => DVHs in EQD2
- Plan Optimization / Prescription free optimization
- Monte carlo simulation => EGS dose => Eclipse import

Clinical:

- Conformity Index Calculator
- Dosimetric Plan Evaluation
- Plan Dose Control (Secondary Independent Dose Verification)

Dose-Volume Indices - Input

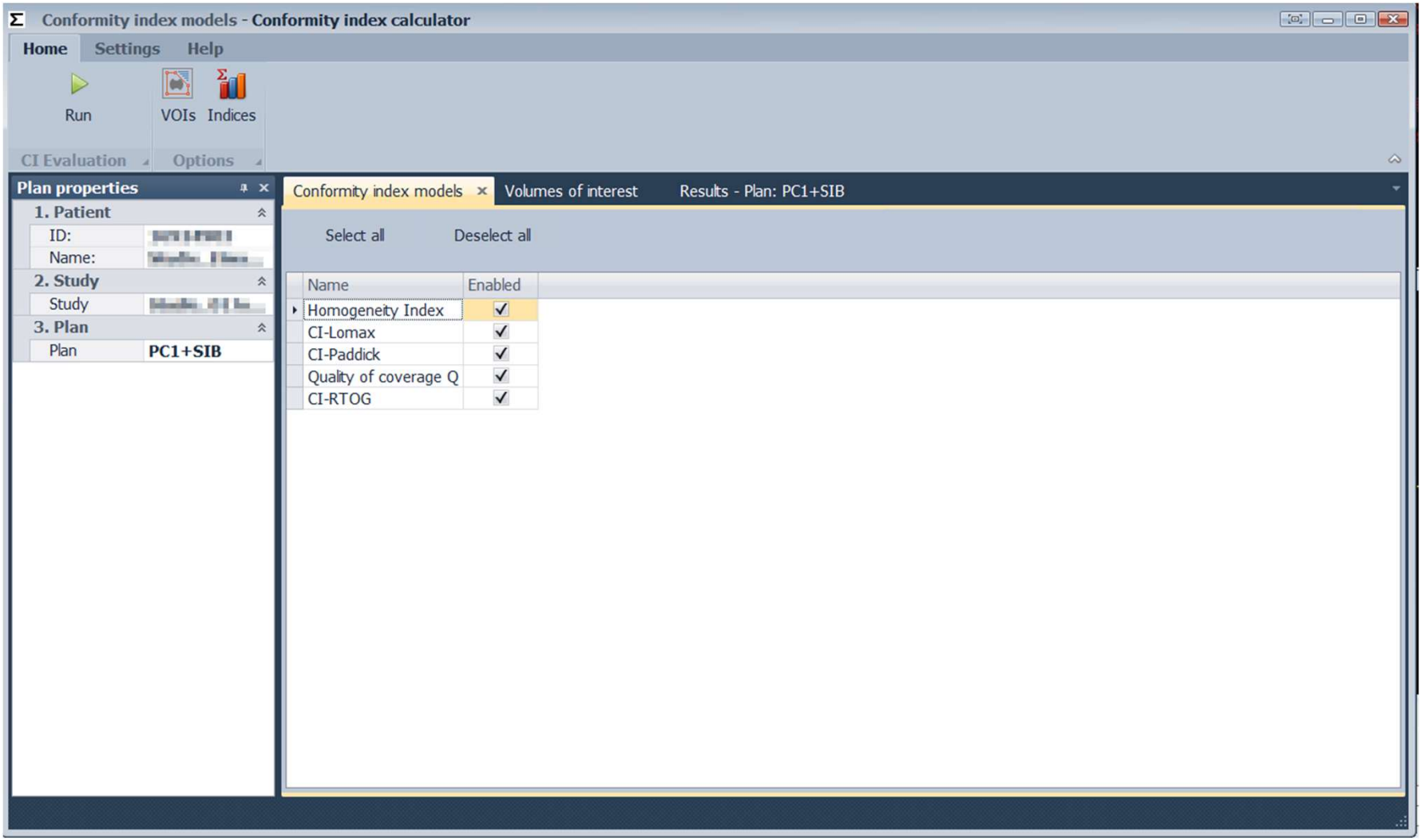
DVH_data_collection.csv

	A	B	C	D	E	F	G
1	**PIZ**	**Course**	**Plan**	**StructureClass**	**Structure**	**DoseMetrics**	**VolumeMetrics**
2	[redacted]	Scha[redacted]17	+rGBM_PET	GTV_PET	GTV_PET	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
3	[redacted]	Scha[redacted]17	+rGBM_PET	GTV_MRT	GTV_MRT	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
4	[redacted]	Scha[redacted]17	+rGBM_PET	PTV_MRT	rGBM_MRT	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	V95%[%], V90%[%], V
5	[redacted]	Scha[redacted]17	+rGBM_PET	PTV_PET	rGBM_PET	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	V95%[%], V90%[%], V
6	[redacted]	Scha[redacted]17	+rGBM_PET	Optic Chiasm	Chiasm	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
7	[redacted]	Scha[redacted]17	+rGBM_PET	Right optic nerve	Optic Nerve, Rig	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
8	[redacted]	Scha[redacted]17	+rGBM_PET	Left optic nerve	Optic Nerve, Lef	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
9	[redacted]	Scha[redacted]17	+rGBM_PET	Brainstem	Brainstem	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
10	[redacted]	Scha[redacted]17	+rGBM_PET	Left Retina	Left Retina	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
11	[redacted]	Scha[redacted]17	+rGBM_PET	Right Retina	Right Retina	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
12	[redacted]	Scha[redacted]r18	+rGBM-PET	GTV_PET	GTV-PET	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
13	[redacted]	Scha[redacted]r18	+rGBM-PET	GTV_MRT	GTV-MRT	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]
14	[redacted]	Scha[redacted]r18	+rGBM-PET	PTV_MRT	rGBM-MRT	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	V95%[%], V90%[%], V
15	[redacted]	Scha[redacted]r18	+rGBM-PET	PTV_PET	rGBM-PET	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	V95%[%], V90%[%], V
16	[redacted]	Scha[redacted]r18	+rGBM-PET	Optic Chiasm	Chiasm	Min[Gy], Max[Gy], Mean[Gy], D50%[Gy], D50%[EQD2Gy(8.0)]	Volume[cc]

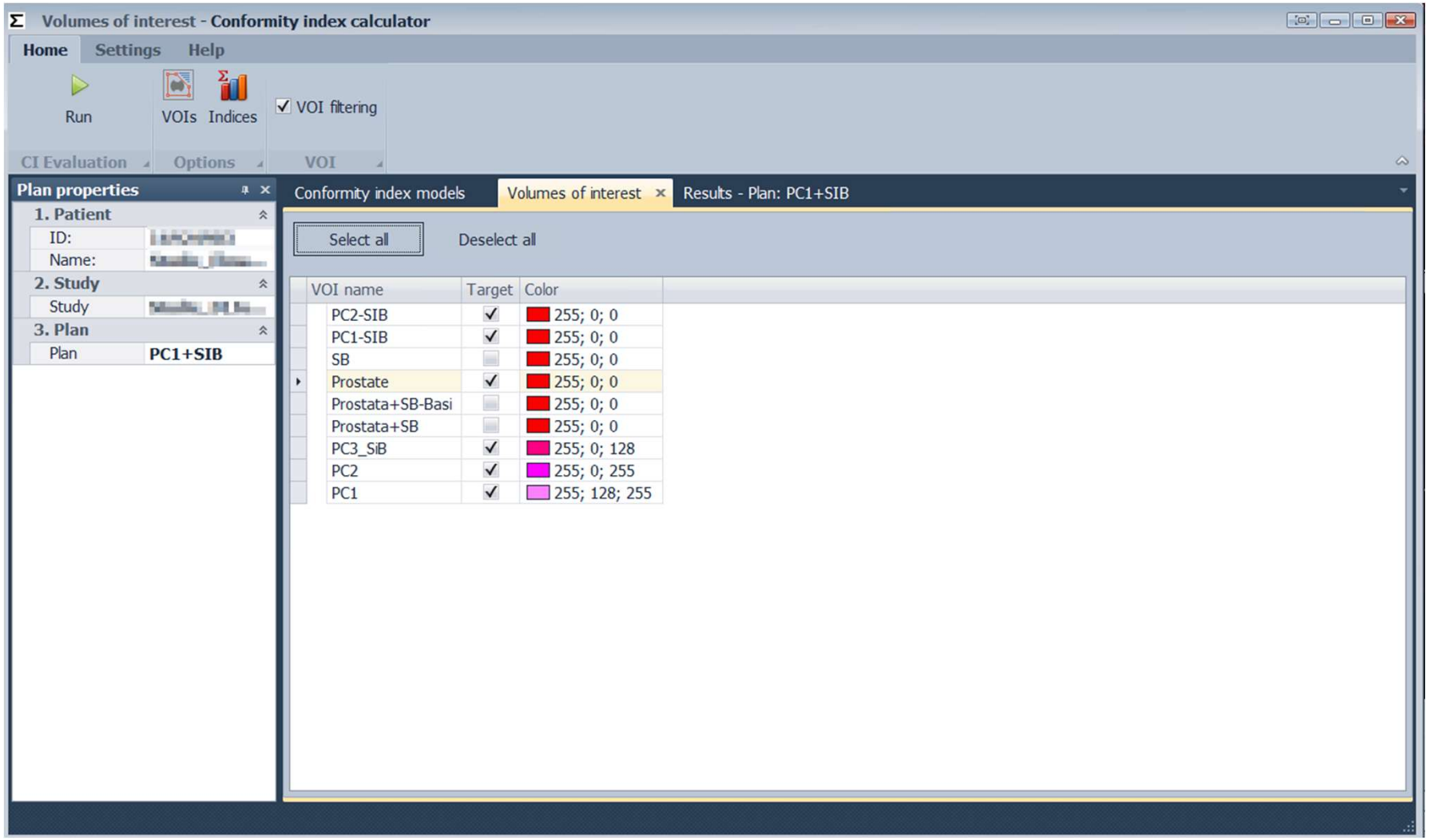
Dose-Volume Indices - Output

A	B	C	D	E	F	G	H
Piz	Course	Plan	GTV_PET_Min[Gy]	GTV_PET_Max[Gy]	GTV_PET_Mean[Gy]	GTV_PET_Volume[cc]	GTV_MRT_M
		+rGBM_PET	36.924	40.083	38.989	2.7938	
		+rGBM-PET	37.272	41.216	38.742	17.2615	
		Sum_14Aug19	21.882	40.808	39.132	36.016	
		+rGBM-PET	27.894	41.672	39.738	44.7287	
		+rGBM_PET	36.796	41.226	38.764	16.0789	
		+rGBM-MRT	34.546	41.974	39.272	12.5642	
		+rGBM-PET	37	40.918	39.509	23.7267	
		+rGBM-PET	38.108	40.899	39.915	5.4064	
		+rGBM-PET	38.788	40.795	40.181	1.342	
		+rGBM-MRT	24.253	40.953	38.893	28.8776	
		+rGBM-PET	38.237	40.589	39.695	0.5748	
		+rGBM-MRT	14.173	41.6	39.08	21.0325	
		+rGBM-MRT	26.424	41.343	39.581	16.2244	
		+rGBM-PET	38.395	41.184	39.897	6.6692	
		+rGBM-MRT	17.274	41.24	39.499	17.0338	
		+rGBM_MRT mod	39.582	40.409	40.088	0.2687	
		Sum_29Jun20 v1	39.063	40.906	39.895	4.5564	
		+rGBM-MRT	9.621	40.78	34.548	9.7951	
		+rGBM-PETmod2	18.581	42.026	39.082	2.3765	

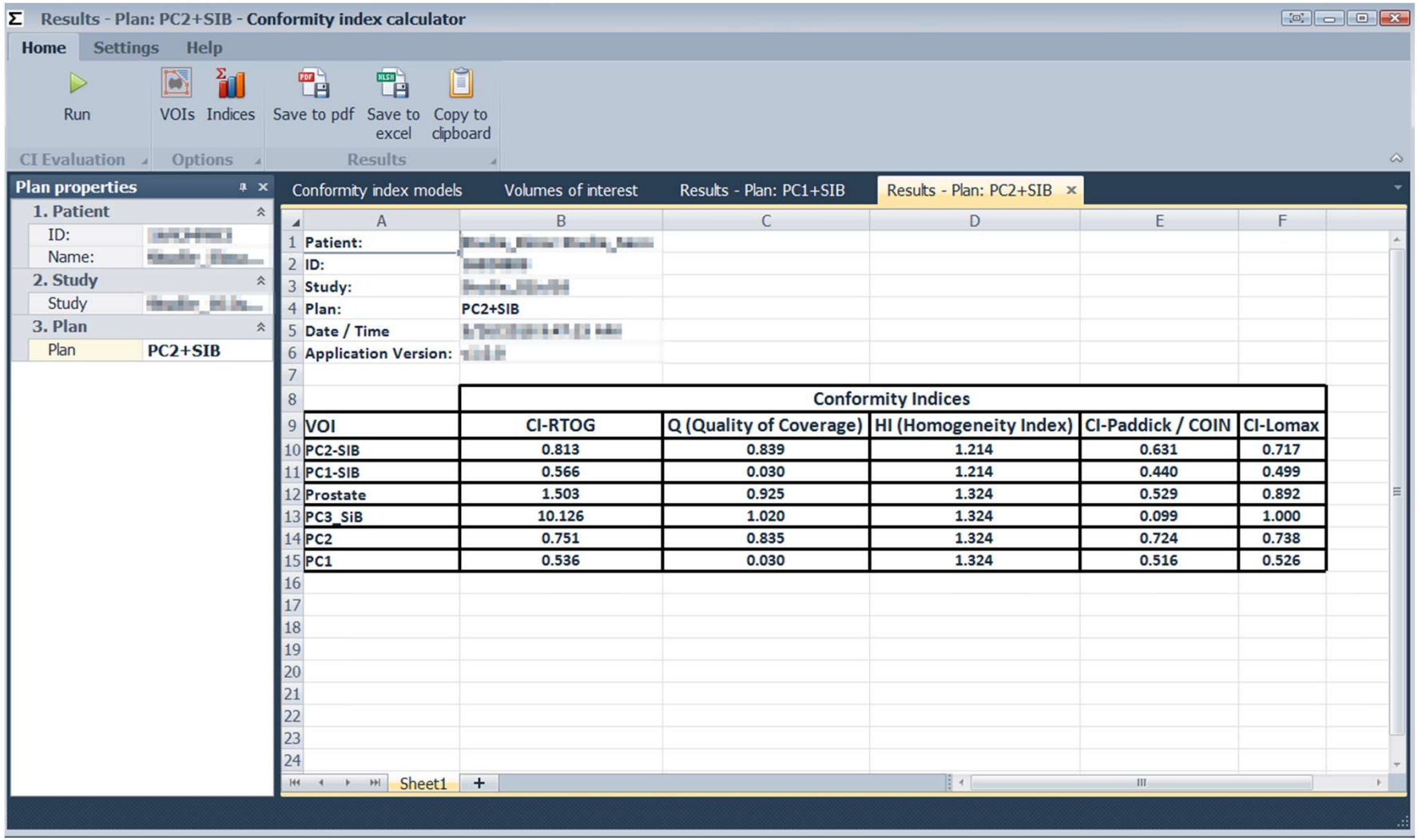
Conformity Index Calculator



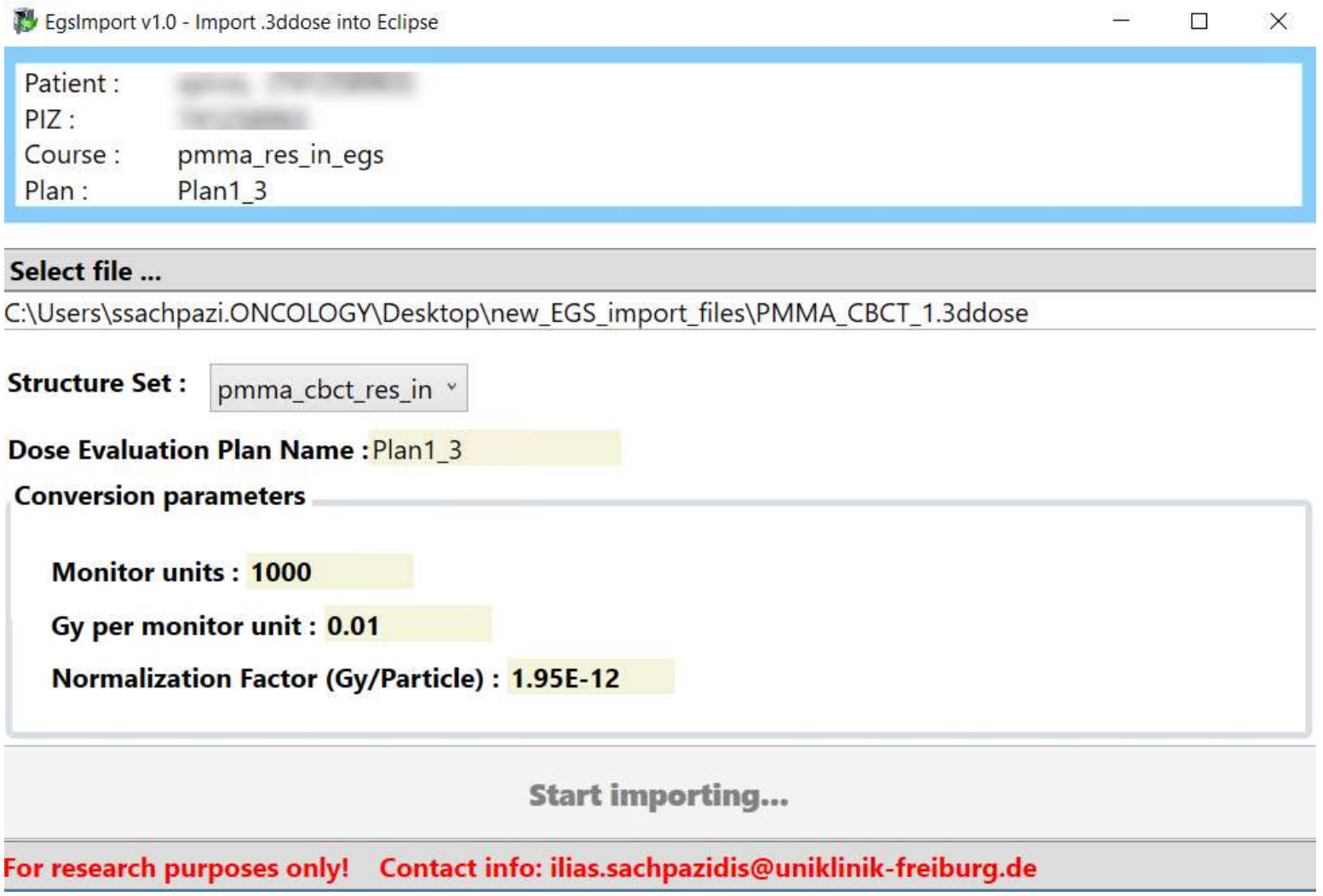
Conformity Index Calculator



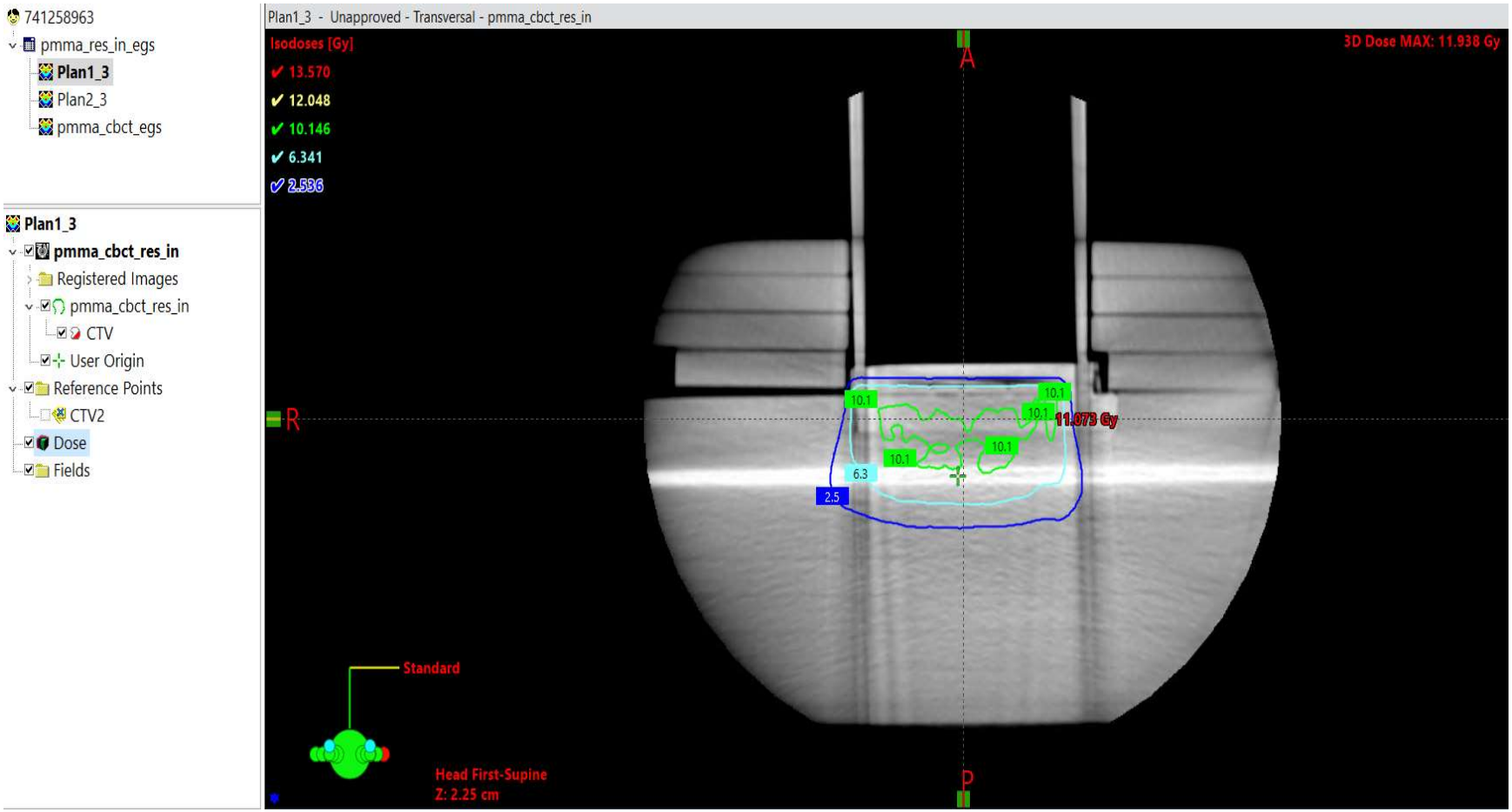
Conformity Index Calculator



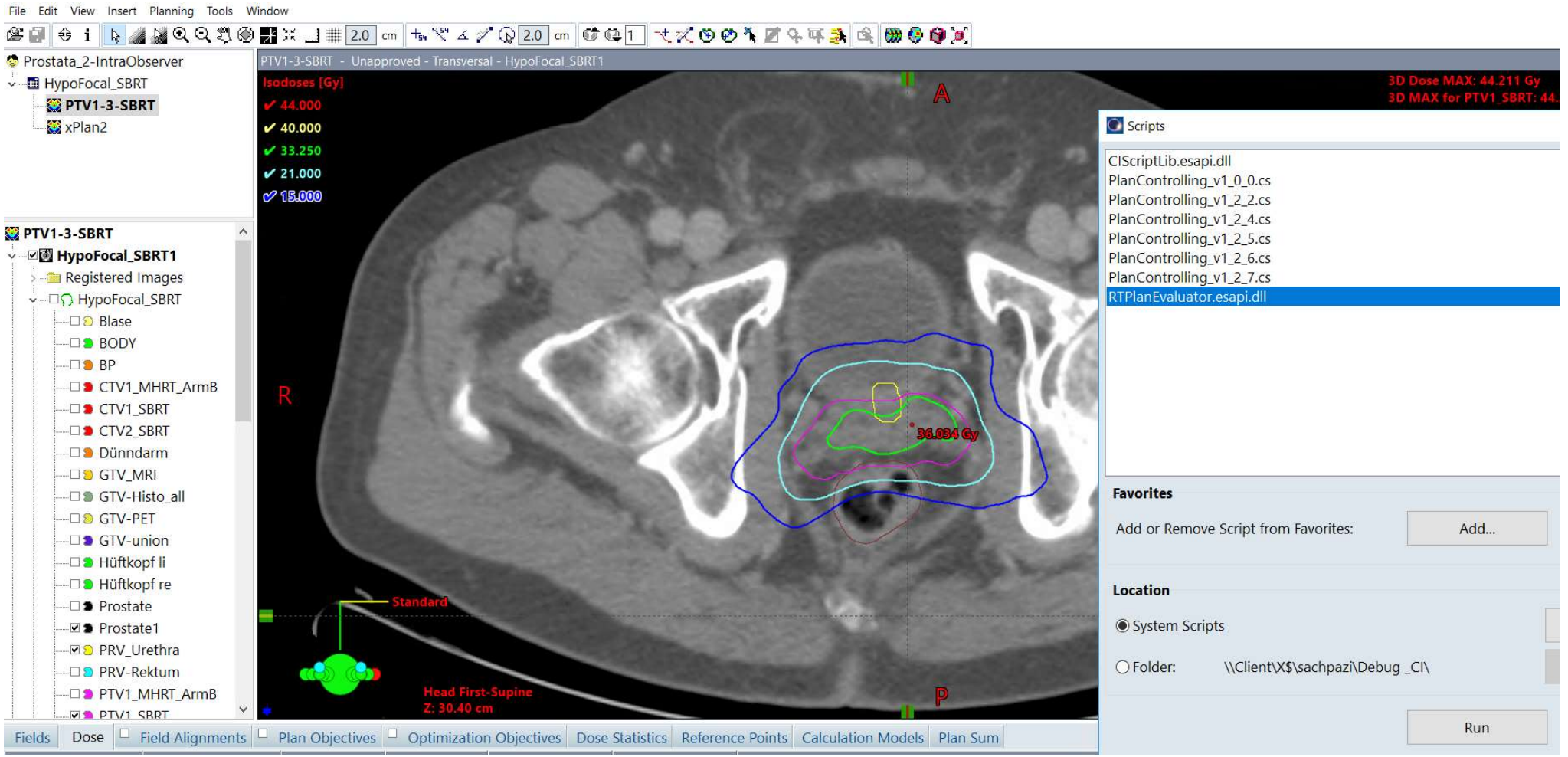
EGS Dose Import



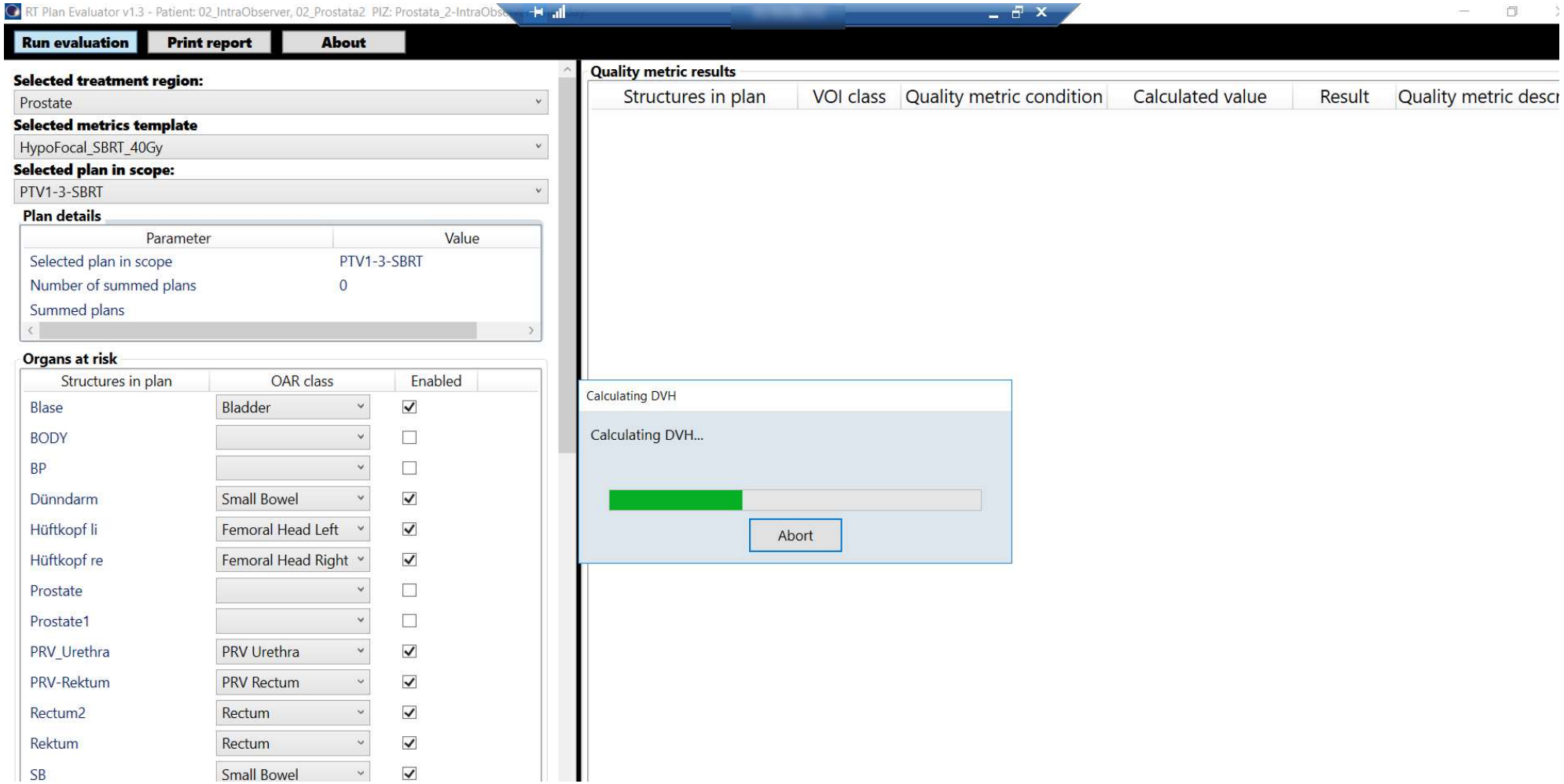
EGS Dose Import



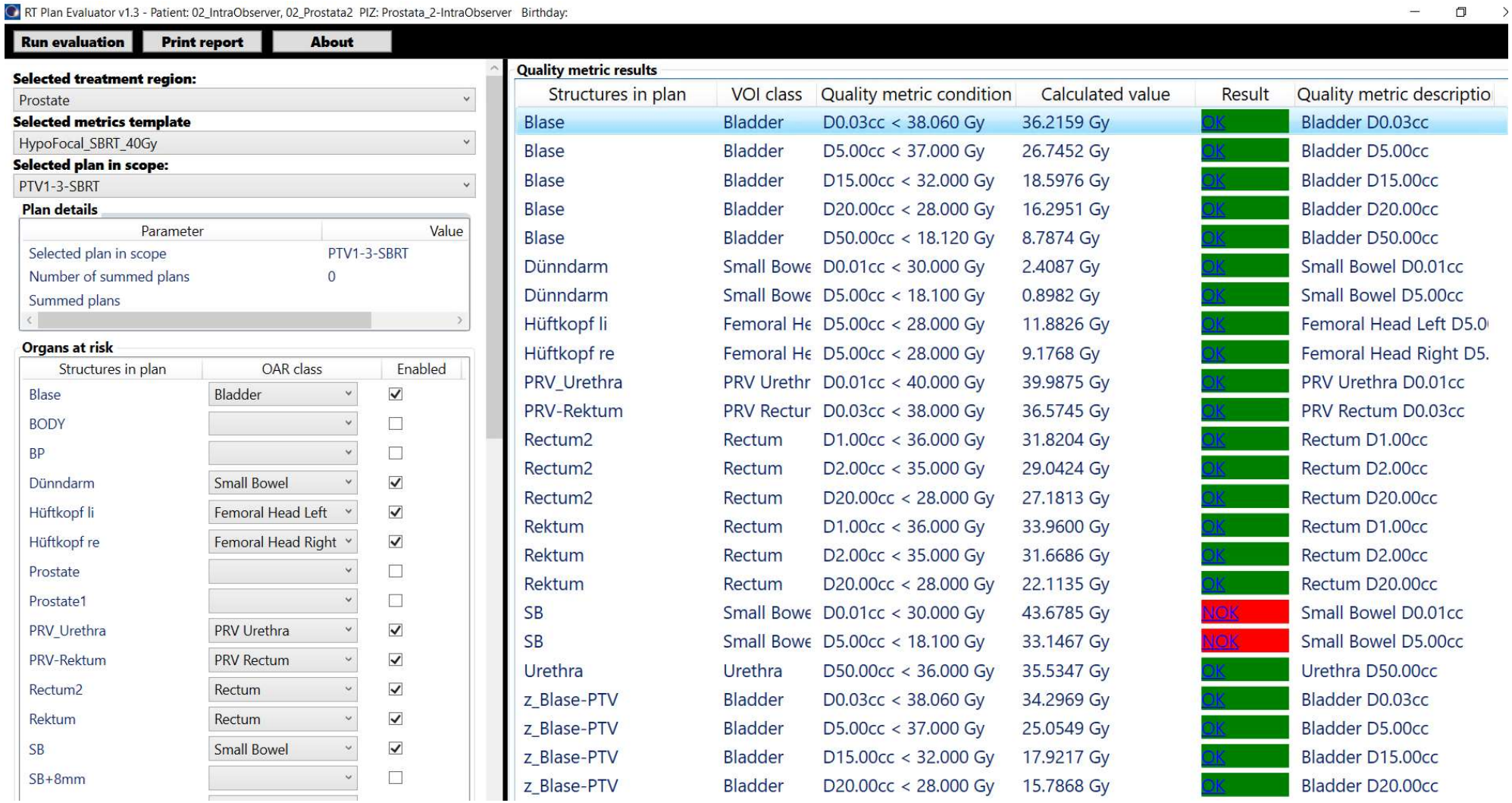
Dosimetric Plan Evaluation



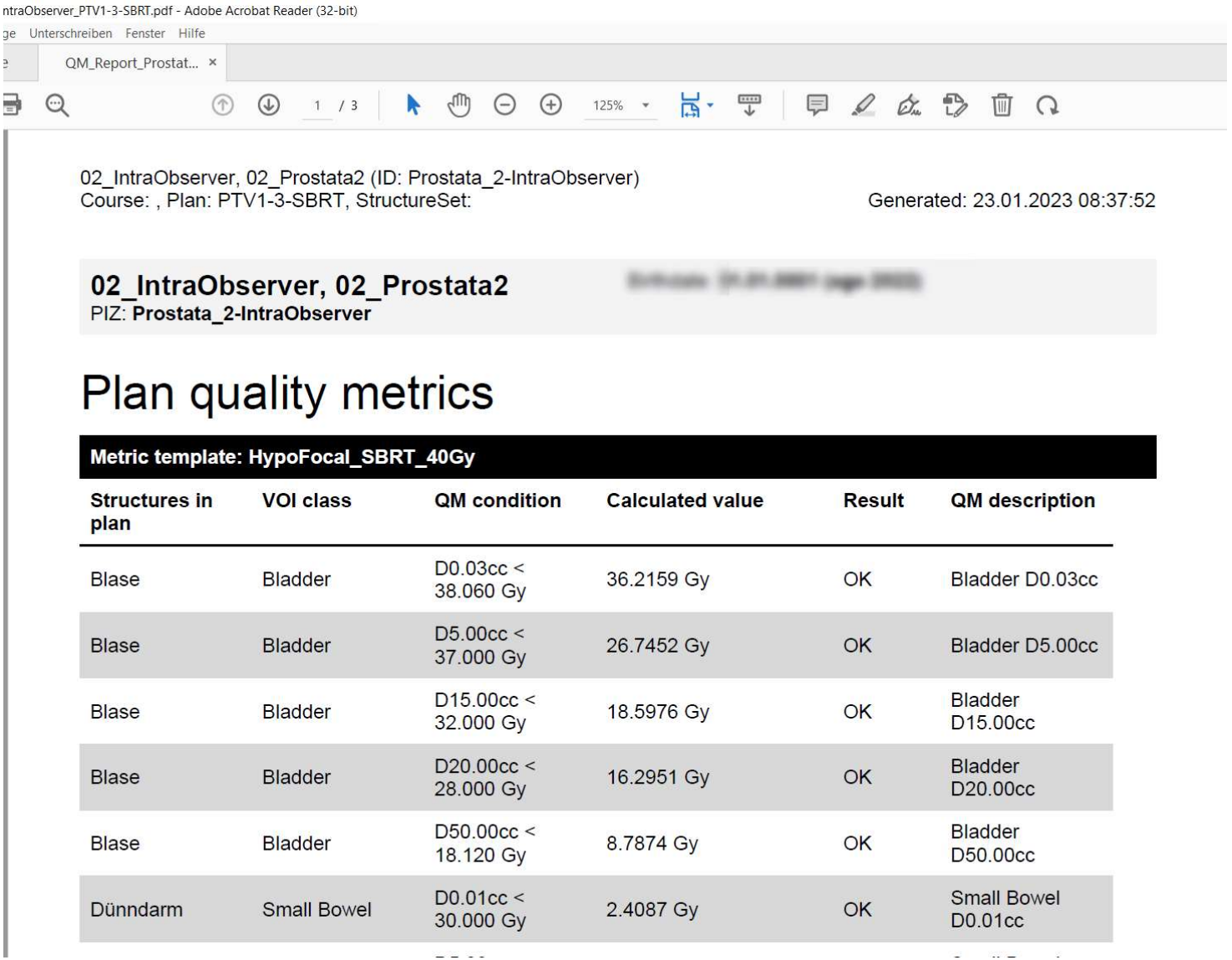
Dosimetric Plan Evaluation



Dosimetric Plan Evaluation



Dosimetric Plan Evaluation


ntraObserver_PTV1-3-SBRT.pdf - Adobe Acrobat Reader (32-bit)

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QM_Report_Prostat... ×

1 / 3 125%

02_IntraObserver, 02_Prostata2 (ID: Prostata_2-IntraObserver)
Course: , Plan: PTV1-3-SBRT, StructureSet:

Generated: 23.01.2023 08:37:52

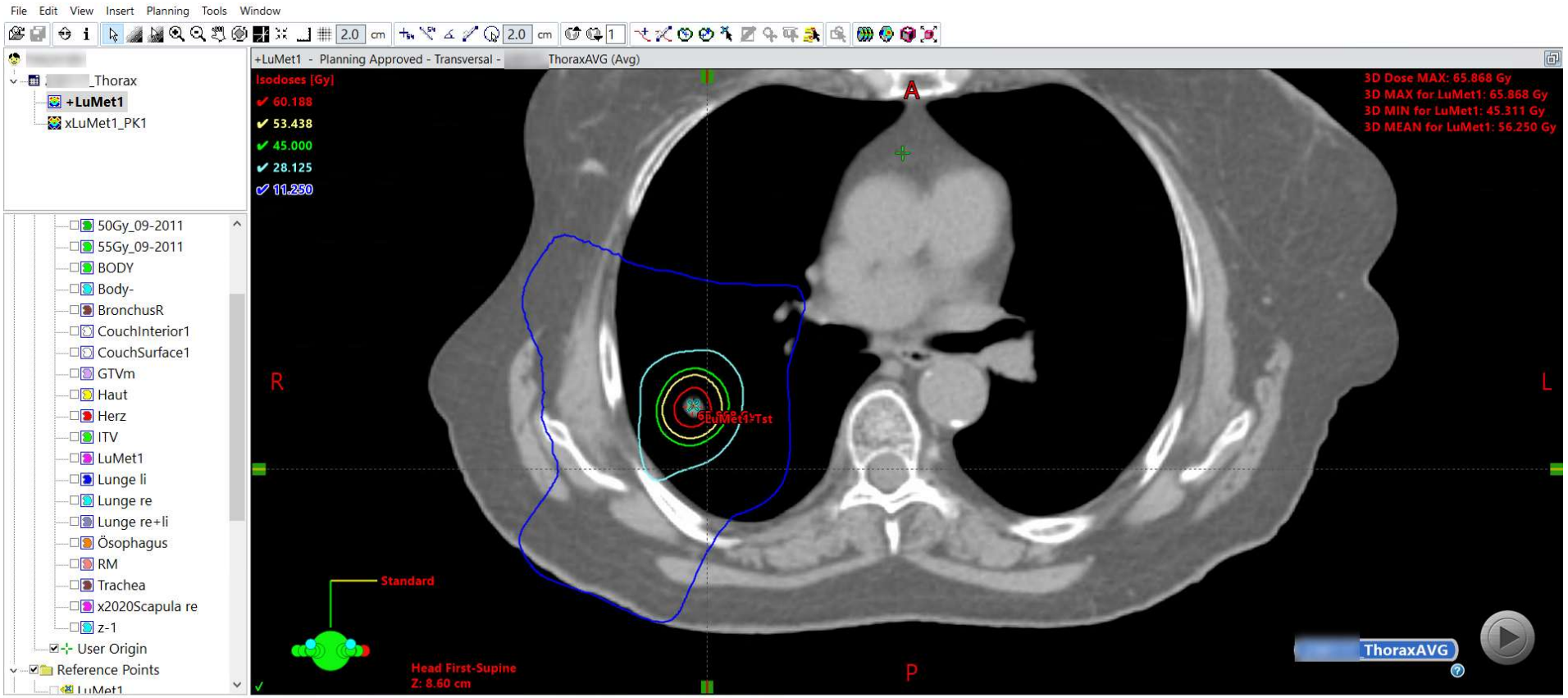
02_IntraObserver, 02_Prostata2
PIZ: **Prostata_2-IntraObserver**

Plan quality metrics

Metric template: HypoFocal_SBRT_40Gy

Structures in plan	VOI class	QM condition	Calculated value	Result	QM description
Blase	Bladder	D0.03cc < 38.060 Gy	36.2159 Gy	OK	Bladder D0.03cc
Blase	Bladder	D5.00cc < 37.000 Gy	26.7452 Gy	OK	Bladder D5.00cc
Blase	Bladder	D15.00cc < 32.000 Gy	18.5976 Gy	OK	Bladder D15.00cc
Blase	Bladder	D20.00cc < 28.000 Gy	16.2951 Gy	OK	Bladder D20.00cc
Blase	Bladder	D50.00cc < 18.120 Gy	8.7874 Gy	OK	Bladder D50.00cc
Dünndarm	Small Bowel	D0.01cc < 30.000 Gy	2.4087 Gy	OK	Small Bowel D0.01cc

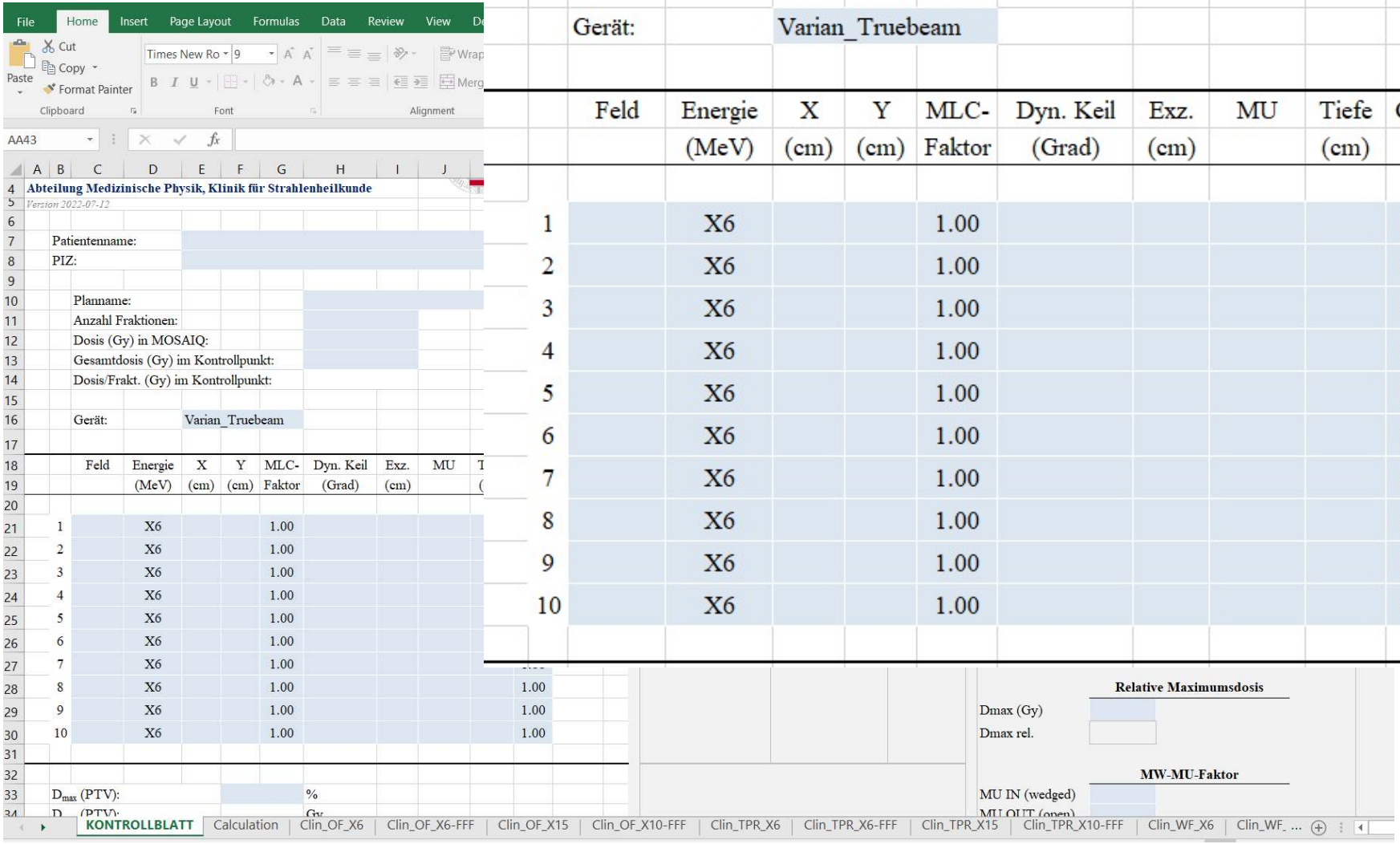
Independent Dose Control: 3D and Dynamic Arcs Plans



Fields | Dose | Field Alignments | Plan Objectives | Optimization Objectives | Dose Statistics | Reference Points | Calculation Models | Plan Sum

Group	Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU	Ref. D [Gy]
I	3DYNA	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	181.0 CW 230.0	0.0	0.0	None	4.4	-2.3	+2.1	4.4	-2.2	+2.2	-8.50	10.00	8.60	82.9	1201.9	
I	3DYNB	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	220.0 CW 300.0	0.0	0.0	None	4.4	-2.4	+2.0	4.4	-2.2	+2.2	-8.50	10.00	8.60	77.7	1201.9	
I	3DYNC	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	300.0 CW 0.0	0.0	0.0	None	4.6	-2.4	+2.2	4.4	-2.2	+2.2	-8.50	10.00	8.60	90.8	1201.9	
I	3KVA	STATIC-I	Clinac4 - 6X-FFF		0.000	IEC61217	0.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	-8.50	10.00	8.60	82.9		
I	3KVR	STATIC-I	Clinac4 - 6X-FFF		0.000	IEC61217	270.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	-8.50	10.00	8.60	89.2		

Independent Dose Control: 3D and Dynamic Arcs Plans



Abteilung Medizinische Physik, Klinik für Strahlenheilkunde

Version 2022-07-12

Patientenname:
PIZ:
Planname:
Anzahl Fraktionen:
Dosis (Gy) in MOSAIQ:
Gesamtdosis (Gy) im Kontrollpunkt:
Dosis/Frakt. (Gy) im Kontrollpunkt:
Gerät: Varian_Truebeam

	Feld	Energie (MeV)	X (cm)	Y (cm)	MLC-Faktor	Dyn. Keil (Grad)	Exz. (cm)	MU	Tiefe (cm)	Gew.	D/Frakt. (Gy)
1		X6			1.00					1.00	
2		X6			1.00					1.00	
3		X6			1.00					1.00	
4		X6			1.00					1.00	
5		X6			1.00					1.00	
6		X6			1.00					1.00	
7		X6			1.00					1.00	
8		X6			1.00					1.00	
9		X6			1.00					1.00	
10		X6			1.00					1.00	

D_{max} (PTV): %

Relative Maximumsdosis
Dmax (Gy)
Dmax rel.

MW-MU-Faktor
MU IN (wedged)

KONTROLLBLATT | Calculation | Clin_OF_X6 | Clin_OF_X6-FFF | Clin_OF_X15 | Clin_OF_X10-FFF | Clin_TPR_X6 | Clin_TPR_X6-FFF | Clin_TPR_X15 | Clin_TPR_X10-FFF | Clin_WF_X6 | Clin_WF_ ...

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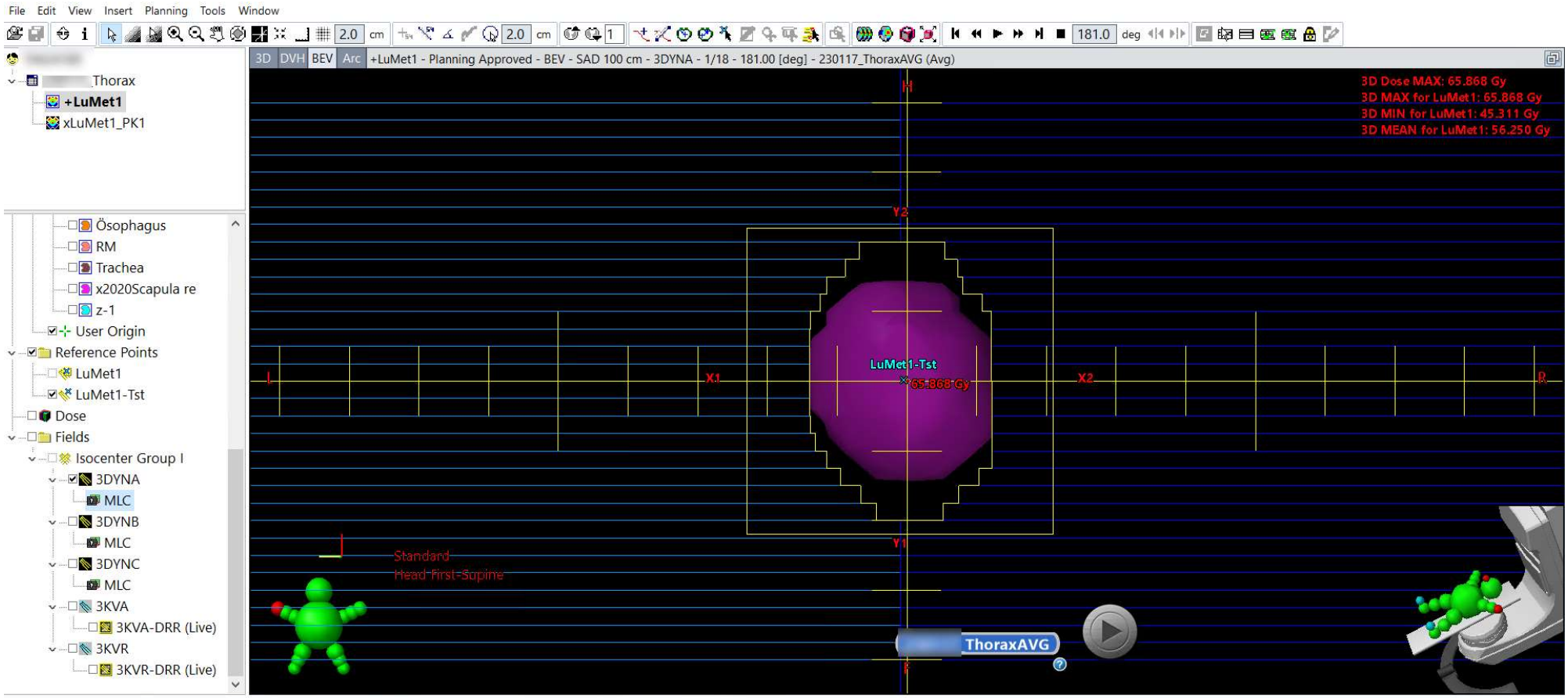
German Cancer Consortium
Partner site Freiburg

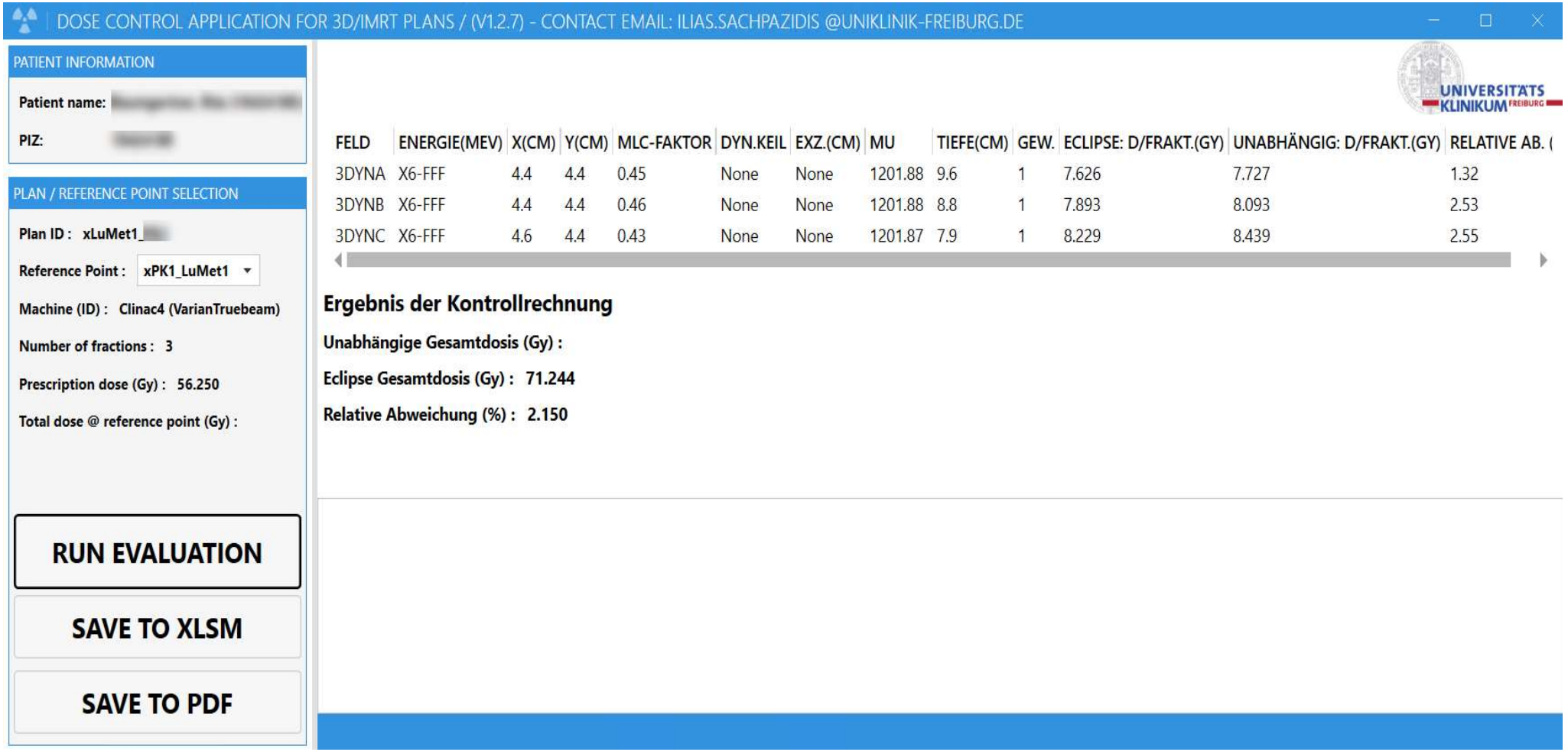
Independent Dose Control: 3D and Dynamic Arcs Plans



Fields | Dose | Field Alignments | Plan Objectives | Optimization Objectives | Dose Statistics | Reference Points | Calculation Models | Plan Sum

Group	Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU	Ref. D [Gy]
I	3DYNA	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	181.0 CW 230.0	0.0	0.0	None	4.4	-2.3	+2.1	4.4	-2.2	+2.2	-8.50	10.00	8.60	82.9	1201.9	
I	3DYNB	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	220.0 CW 300.0	0.0	0.0	None	4.4	-2.4	+2.0	4.4	-2.2	+2.2	-8.50	10.00	8.60	77.7	1201.9	
I	3DYNC	SRS ARC-I	Clinac4 - 6X-FFF	Arc Dynamic	1.000	IEC61217	300.0 CW 0.0	0.0	0.0	None	4.6	-2.4	+2.2	4.4	-2.2	+2.2	-8.50	10.00	8.60	90.8	1201.9	
I	3KVA	STATIC-I	Clinac4 - 6X-FFF		0.000	IEC61217	0.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	-8.50	10.00	8.60	82.9		
I	3KVR	STATIC-I	Clinac4 - 6X-FFF		0.000	IEC61217	270.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	-8.50	10.00	8.60	89.2		

Independent Dose Control: 3D and Dynamic Arcs Plans



Independent Dose Control: 3D and Dynamic Arcs Plans

	Gerät:		Varian_Truebeam								
	Feld	Energie (MeV)	X (cm)	Y (cm)	MLC-Faktor	Dyn. Keil (Grad)	Exz. (cm)	MU	Tiefe (cm)	Gew.	D/Frakt. (Gy)
1	3DYNA	X6-FFF	4.4	4.4	0.45			1201.9	9.6	1.00	7.727
2	3DYNB	X6-FFF	4.4	4.4	0.46			1201.9	8.8	1.00	8.093
3	3DYNC	X6-FFF	4.6	4.4	0.43			1201.9	7.9	1.00	8.440
4		X6			1.00					1.00	
5		X6			1.00					1.00	
6		X6			1.00					1.00	
7		X6			1.00					1.00	
8		X6			1.00					1.00	
9		X6			1.00					1.00	
10		X6			1.00					1.00	

D_{max} (PTV):	127.1	%	
D_{max} (PTV):	71.51	Gy	
D_{max}/Fraktion (PTV):	23.84	Gy	

Ergebnis der Kontrollrechnung:				
Dosis pro Fraktion:	24.26	Gy	Datum:	23.01.2023
Relative Abweichung:	2.2	%	Med. Physik:	

Kommentar/Notiz:
Kontrollpunkt: xPK1_LuMet1 , Software Version: 1.2.7

Dosiskontrolle für 3D-Pläne

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Abteilung Medizinische Physik, Klinik für Strahlenheilkunde

Version 2023-07-12

Patientenname: [redacted]

PIZ: [redacted]

Planname:	xLuMet1_PK1
Anzahl Fraktionen:	3
Dosis (Gy) in MOSAIQ:	56.250
Gesamtdosis (Gy) im Kontrollpunkt:	71.244
Dosis/Frakt. (Gy) im Kontrollpunkt:	23.748

Gerät: Varian_Truebeam

	Feld	Energie (MeV)	X (cm)	Y (cm)	MLC-Faktor	Dyn. Keil (Grad)	Exz. (cm)	MU	Tiefe (cm)	Gew.	D/Frakt. (Gy)
1	3DYNA	X6-FFF	4.4	4.4	0.45			1201.9	9.6	1.00	7.727
2	3DYNB	X6-FFF	4.4	4.4	0.46			1201.9	8.8	1.00	8.093
3	3DYNC	X6-FFF	4.6	4.4	0.43			1201.9	7.9	1.00	8.440
4		X6			1.00					1.00	
5		X6			1.00					1.00	
6		X6			1.00					1.00	
7		X6			1.00					1.00	
8		X6			1.00					1.00	
9		X6			1.00					1.00	
10		X6			1.00					1.00	

D_{max} (PTV):	127.1	%
D_{max} (PTV):	71.51	Gy
D_{max}/Fraktion (PTV):	23.84	Gy

Ergebnis der Kontrollrechnung:

Dosis pro Fraktion:	24.26	Gy	Datum:	23.01.2023
Relative Abweichung:	2.2	%	Med. Physik:	

Kommentar/Notiz:

Kontrollpunkt: xPK1_LuMet1 , Software Version: 1.2.7

Independent Dose Control: 3D and Dynamic Arcs Plans

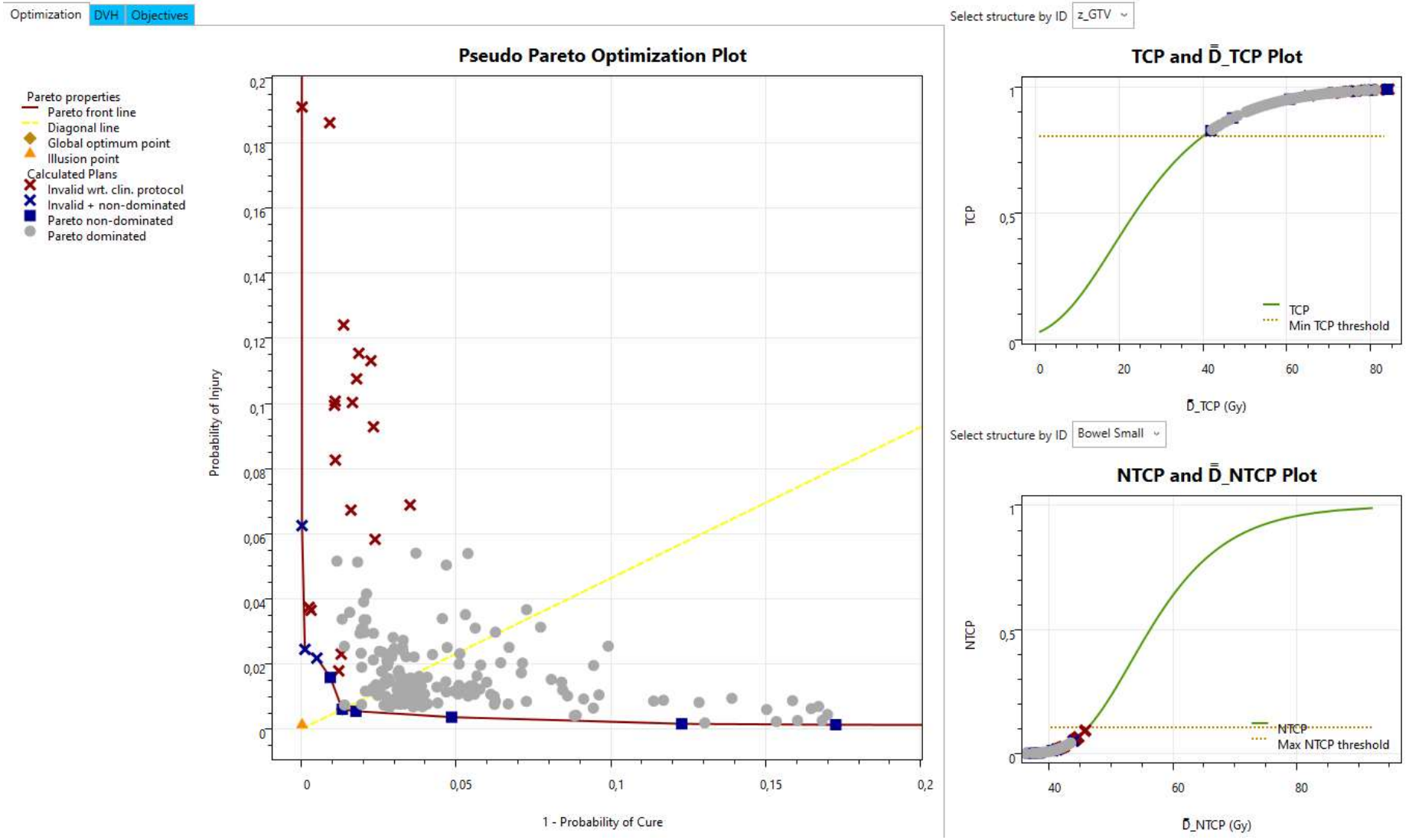
- Ca. 5-10 Plans / Day
- Before (manual):

  (5 to 10) * 10 min = 50 to 100 min

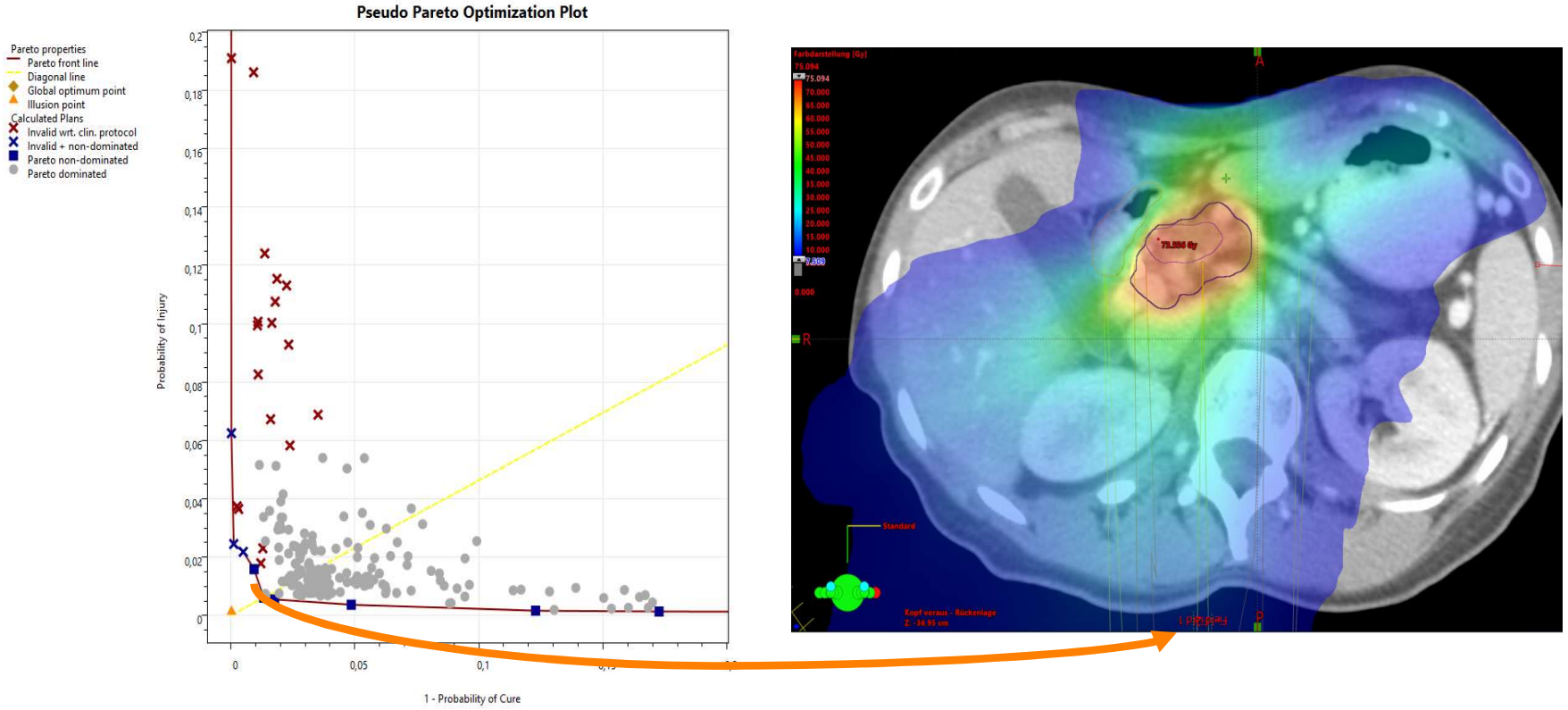
  (average. 1 h)
- After (in automated way):

  10 * 1 min = 10 min

Prescription free plan optimization



Prescription free plan optimization



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Best practises for code development

- Clean and Concise Code:
  - Principles: DRY, KISS, SOLID
  - Object oriented programming (OOP), functional programming
- Meaningful Variable and Function Names
- Consistent Coding Style
- Version Control (e.g. Gitlab)
- **Testing and Test-Driven Development (TDD)**
- NOT comment your code, just produce clean code

Conclusion

- ESAPI empowers us with access to planning information, including patient data, treatment courses, plan parameters, and imaging modalities.
- Automations minimize errors, increase efficiency, and improve quality.
- The learning curve is steep
- Improving your programming skills requires patience and dedicated effort to achieve a high level of proficiency.

Thank you for your attention

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