

Klinik für Strahlenheilkunde

A radiobiological modelling and evaluation system for radiation oncology treatment planning

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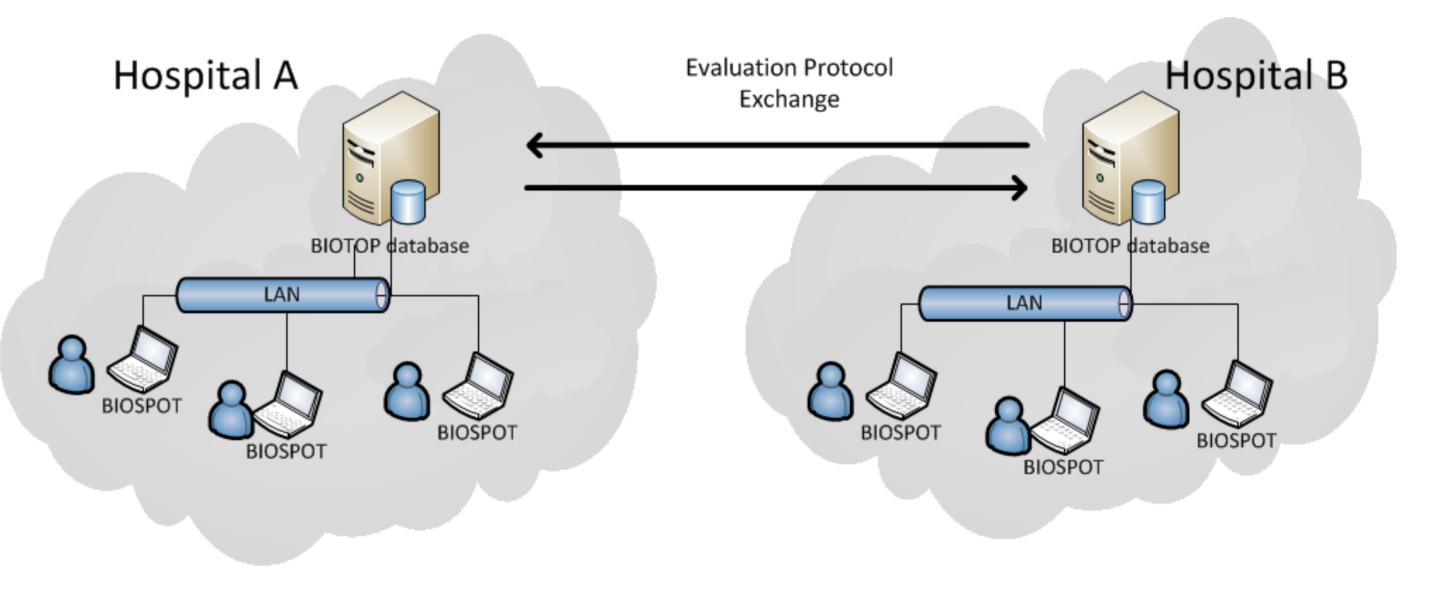
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BIOTOP is an expert, network based database system where the users can define models' parameter set along with anatomical information.

The users are able to build their evaluation protocols by selecting appropriate models and specifying related model parameters for well-defined endpoints. In addition, a literature database is available and all user-defined and predefined model parameters are linked to specific literature. In this way, the user has immediately access to the referenced literature for further consultation. Furthermore, an evaluation protocol is linked to one or more treatment protocols.

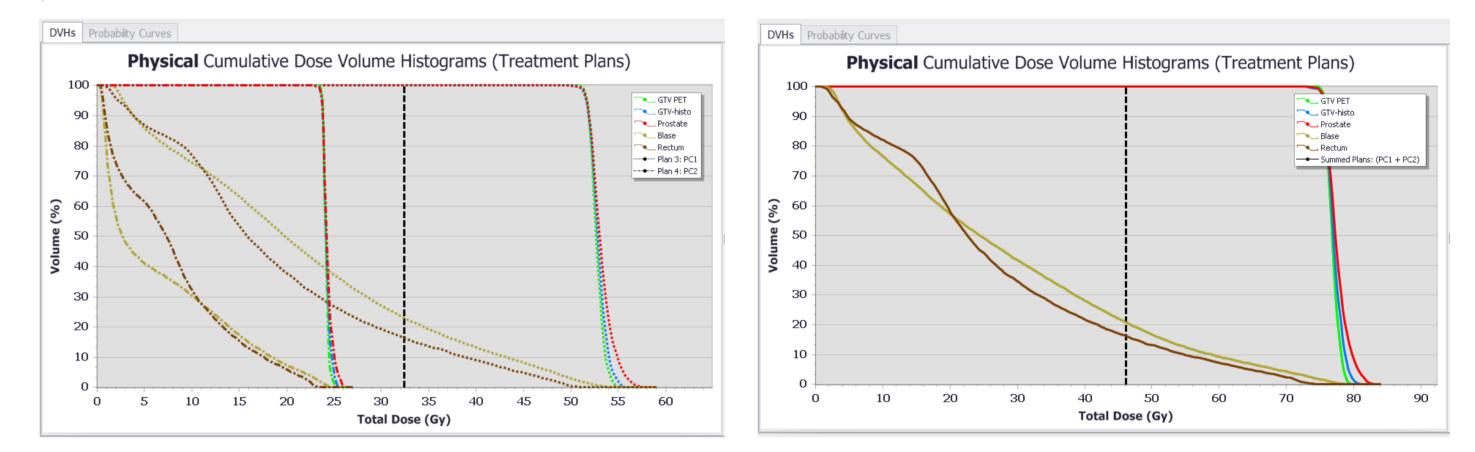
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componer	1											System Adm	inisu du
Protocols ^	Evaluation Pro	otocols											
Evaluation	Name		▲	tadiobiological Model or OARs		Radiobiological Model for Targets	Treatment Protocol		Linked Evaluati	on Protocol		Last Modified	Appro
Protocols	Head and Neck -	10.70.2Gv	HEAD AND NECK L			inear-Quadratic	Head and Ne	ck 70.2Gv	Lvalada	01111000001		17.09.2015 16:41:23	Pana
Treatment		Poisson - Relative Seriality 70.20		•		Fumor Poisson	Head and Ne		Head an	nd Neck - Voxel Re		17.09.2015 16:51:11	
Protocols		Voxel Response 70.2Gy	HEAD AND NECK			/oxel-Response	Head and Ne			nd Neck - LQ 70.20		17.09.2015 16:46:05	-
Dose Volume		ntinos Flame-Trial				/oxel-Response				e-LQ-Model Consta		07.09.2016 09:28:02	
Evaluation Protocols		ntinos Flame-Trial-Density		elative-Seriality with Voxel-Respo			-Response Poison Prostate-Fla	Prostate-Flame-Trial		e-LQ-Model Consta		23.09.2016 14:19:36	
	Prostate Constar	ntinos FTNew		elative Seriality			-Response Poison Prostate-Fla			-LQ-Model Consta		23.09.2016 14:15:20	-
	Prostate-EUD-Mo	odel Intermediate Risk-Combi	PELVIS	UD	EUD			ermediate Risk KOMBI				27.11.2013 13:30:55	Prof.
	Prostate-EUD-Mo	odel Post operative 66.6Gy	PELVIS E	UD	E	EUD	e post operative 66.6Gy				22.11.2013 17:41:11	Prof.	
		odel Prostate + SV 72Gy		UD	E	EUD	Prostate+SV				22.11.2013 17:46:48		
		odel-Monotherapy 2 x 14Gy	PELVIS E	UD	E	EUD	0R Monotherapy 2 x 14Gy				27.11.2013 13:40:39	Prof.	
		odel-Monotherapy 3 x 11.5Gy	PELVIS E	UD	E	EUD	Prostate HDP	R Monotherapy 3 x 11.50	δy			22.11.2013 17:22:44	Syst
		Nodel Intermediate Risk-Combi	PELVIS	EUD	ç	JEUD	ermediate Risk KOMBI	Prostate	-LQ-Model Interm	ediate Risk-Combi	26.10.2015 16:27:54	Prof.	
	Prostate-LQ-Mod	lel 78Gy	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate ERT	78Gy				27.05.2016 09:51:12	Syst
	Prostate-LQ-Mod	lel Constantinos-Trial	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate-Fla	me-Trial				21.09.2016 09:18:49	Syst
	Prostate-LQ-Mod	del Intermediate Risk-Combi	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate Inte	ermediate Risk KOMBI				27.11.2013 13:30:55	Prof.
	Prostate-LQ-Mod	lel Post operative 66.6Gy	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate pos	t operative 66.6Gy				22.11.2013 17:42:41	Prof.
	Prostate-LQ-Mod	lel Prostate + SV 72Gy	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate+SV	Prostate+SV Total 72Gy Prostate HDR Monotherapy 2 x 14Gy				22.11.2013 17:43:57	Prof.
	Prostate-LQ-Mod	lel-Monotherapy 2 x 14Gy	PELVIS I	inear-Quadratic	L	inear-Quadratic	Prostate HDP					27.11.2013 13:40:39	Prof.
	Prostate-LQ-Mod	lel-Monotherapy 3 x 11.5Gy	PELVIS I			inear-Quadratic	Prostate HDP	R Monotherapy 3 x 11.50	Sy			22.11.2013 17:20:50	Prof.
	Prostate-Poisson	-Relative Seriality ERT 78Gy	PELVIS F			Tumor Poisson	Prostate ERT	78Gy	Prostate	e-Voxel-Response-	Model 78Gy	10.05.2016 13:08:54 5	
	Prostate-Radiobi	ological-Protocol-78Gy	PELVIS	elative Seriality	١	/oxel-Response	Prostate ERT	78Gy	Prostate	e-LQ-Model 78Gy		10.05.2016 14:59:01	Syst
		Head and Neck - LQ 70.2Gy the Protocol Related Literature											
	VOI Type	VOI Name	 VOI Class 	Radiobiological Endpoir	nt	Radiobiological M	Parameter	Value	CI Low	CI High	Unit	Lit. Reference	ce
	► - OARs												
	-	Esophagus	Esophagus	Esophageal stricture		Linear-Quadratic	Set: OAR late effect default						
							0		0.6	0.6	Gy ⁻¹	-	
							α/β T1/2-repair	-	3 0.0625	3 0.0625	Gy days	-	
							Tk		1000	1000	days	-	
							Tpot		0	0	days	-	
		Lung both	Lung	Radiation pneumonitis		Linear-Quadratic	Set: OAR late effect default				/-		
							a		0.6	0.6	Gy ⁻¹	-	
							α/β	3	3	3	Gy	-	
							T1/2-repair		0.0625	0.0625	days	-	
							Tk Tpot		1000 0	1000	days days	-	

Users can export/import evaluations treatment protocols and share them with other users located to remote locations.



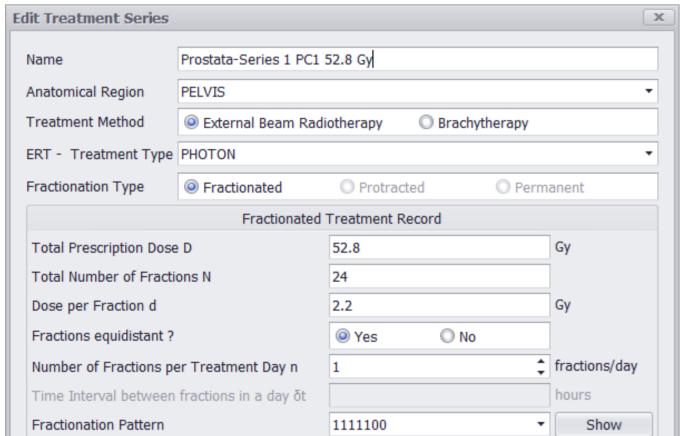
BIOSPOT is a treatment plan evaluation system of radiation plans based on both predefined and user-defined evaluation protocols. The evaluation parameters are stored in BIOTOP rational database.

DICOM RT data are imported and linked to a selected evaluation protocol. BIOSPOT computes the dose volume histogram for each structure and each plan. Summation of the plans can also be performed.



Treatment protocols may be composed of several treatment series utilizing different treatment techniques and fractionation schemes:

ries Groups							Total				Number	Time Interval		Total
Name	Anatomical Region	Treatment Method	ERT / BRT Treatment Type	Source Isotope	Decay Half Life (days)	Fractionation Type	Total Prescription Dose (Gy)	Total Number Of Fractions	Dose per Fraction (Gy)	Fractions Equidistant	Number of Fractions per		Fractionation Pattern	Total Treatment Time (days)
ERT Breast 25x2Gy	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	50	25	2	YES	1		1111100	32
ERT Breast Boost 7x2Gy	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	14	7	2	YES	1		1111100	8
Prostate LDR 144Gy	PELVIS	BRACHYTHERAPY (BRT)	LDR	I-125	59.49	BRT PERMANENT	144							
Accelerated Partial Breast Irradiation (APBI) 8x4Gy	THORAX	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	32	8	4	YES	2	8	11111111110000	3
Head and Neck 70.2Gy	HEAD AND NECK	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	70.2	39	1.8	YES	1		1111100	52
Prostate ERT 70.2Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	70.2	39	1.8	YES	1		1111100	52
Prostate ERT 78Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	78	39	2	YES	1		1111100	52
Prostate ERT 79.2Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	79.2	44	1.8	YES	1		1111100	59
ERT-Part with 45Gy of the Prostate Combi-Treatment	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	45	25	1.8	YES	1		1111100	32
IMRT Prostate 1cm Margin 5x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	9	5	1.8	YES	1		1111100	4
IMRT Prostate asymmetric Margins 7x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	12.6	7	1.8	YES	1		1111100	8
IMRT Prostate+SV 1cm Margin 28x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	50.4	28	1.8	YES	1		1111100	37
Prostate post op 30 x 1.8Gy incl 1cm margin	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	54	30	1.8	YES	1		1111100	39
Prostate post op 7 x 1.8Gy incl asymmetric margin	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	12.6	7	1.8	YES	1		1111100	8
SBRT Lung 1 x 26Gy T1a peripheral localisation	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	26	1	26	YES	1		1111100	0
SBRT Lung 3 x 18Gy T1b peripheral localisation	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	54	3	18	YES	1		1111100	2
SBRT Lung 5 x 11Gy T1 thoracic wall, T2 peripheral	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	55	5	11	YES	1		1111100	4
SBRT Lung 8 x 7.5Gy central localisation	THORAX	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	60	8	7.5	YES	1		1111100	9
SRS 1 x 15Gy for GTV > 3.0cm	HEAD	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	15	1	15	YES	1		1111100	0
SRS 1 x 18Gy for GTV 2-3cm	HEAD	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	18	1	18	YES	1		1111100	0
HDR - Monotherapy single fraction 11.5Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	11.5	1	11.5	YES	1		1000000	0
HDR - Monotherapy single fraction 14Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	14	1	14	YES	1		1000000	0
HDR - single fraction 10.5Gy of the Prostate Combi-Treatment	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	10.5	1	10.5	YES	1		1000000	0
Prostata-Flame-Series 1 PC1 and PC3	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	52.8	24	2.2	YES	1		1111100	31
Prostata-Flame-Series 2 PC2 and PC3	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	24.2	11	2.2	YES	1		1111100	14
Prostata-Series 1 PC1 52.8 Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	52.8	24	2.2	YES	1		1111100	31
Prostata-Series 2 PC2 24.2 Gy	PELVIS	EXTERNAL BEAM RADIOTH	PHOTON			FRACTIONATED	24.2	11	2.2	YES	1		1111100	14

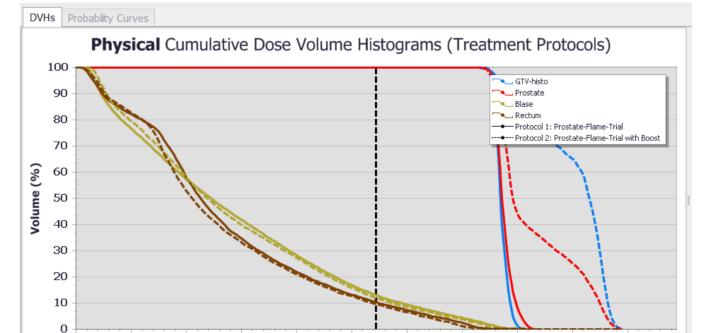


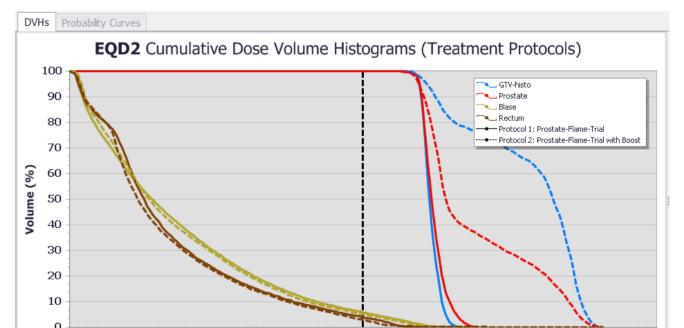
dit Treatment Series				
Name	Prostata-Series 2 PC	2 24.2 Gy		
Anatomical Region	PELVIS			
Treatment Method	External Beam Ra	diotherapy 🛛 🔾	Brachytherapy	
ERT - Treatment Type	PHOTON			
Fractionation Type	Fractionated	O Protracted	O Perm	anent
	Fractionate	d Treatment Record	l	
Total Prescription Dos	se D	24.2		Gy
Total Number of Frac	tions N	11]
Dose per Fraction d		2.2		Gy
Fractions equidistant	?	Yes	🔘 No]
Number of Fractions	per Treatment Day n	1	÷	fractions/day
Time Interval betwee	n fractions in a day δt			hours
Fractionation Pattern		1111100	•	Show

Treatment protocols defined in the evaluation protocol can be assigned to patient plans. Additionally, treatment protocols can be copied and the user is able to assign different plans or even to change the number of fraction or the dose per fraction.

Data Type	Nu of	Dose per (Gy)	Total Prescripti (Gy)	Total Treatme (days)	•				
Protocol #1: Prostate-Flame-Trial				48.04					
Series #1 - Prostata-Flame-Series 1 PC1 and PC3	24	2.20	52.80	33.04					
Plan #3: PC1	24	2.20	52.80	-					
Series #2 - Prostata-Flame-Series 2 PC2 and PC3	11	2.20	24.20	14.04					
Plan #4: PC2	- 🥈 Treatmen	t Protocols							
Protocol #2: Prostate-Flame-Trial with Boost	- Protoco	#1: Prostate	e-Flame-Trial						0.00
Series #1 - Prostata-Flame-Series 1 PC1 and PC3	- 💋 Serie	s #1 - Prosta	ta-Flame-Series 1	PC1 and PC3		24	2.20	52.80	0.00
Plan #1: PC1+SIB	🔏 Pl	an: ??? UNDE				-	-	-	-
Series #2 - Prostata-Flame-Series 2 PC2 and PC3	- 💋 Serie	s #2 - Prosta		DC2 and DC2		11	2.20	24.20	0.00
Plan #2: PC2+SIB	💰 Pl	an: ??? UNDE	FIN Link Plan 🔸	Plan #1: PC1+SIB		-	-	-	-
Reports	Reports			Plan #2: PC2+SIB					
•				Plan #3: PC1					·
	Please press Line			Plan #4: PC2					

As soon as a radiobiological evaluation protocol is selected BIOSPOT calculates voxel based equieffective doses (BED/EQD0 or EQD2) as 3D dose distribution and extracts the corresponding DVHs.



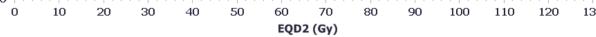


Total	Treatment Time T	31	days	Total Treatment Time T	14		days
Avera	age Time Interval between Fractions δt-a	1.3	days	Average Time Interval between Fractions $\delta t\text{-a}$	1.4		days
		Save	Cancel		Sa	ive	Cancel

An evaluation protocol might also be composed of a group of treatment protocols. For instance, we might have a combination of treatments of external and brachytherapy.

Name	Anatomical Region	Treatment Method	ERT / BRT Treatment Type	Source Isotope	Decay Half Life (days)	Fractionation Type	Total Prescription Dose (Gy)	Total Number Of Fractions	Dose per Fraction (Gy)	Fractions Equidistant	Number of Fractions per Treatment D
Breast ERT 64Gy	THORAX										
Series 1: ERT Breast 25x2Gy	THORAX	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	50	25	2	YES	1
Series 2: ERT Breast Boost 7x2Gy	THORAX	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	14	7	2	YES	1
Prostate HDR Monotherapy 2 x 14Gy	PELVIS										
Series 1: HDR - Monotherapy single fraction 14Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	14	1	14	YES	1
Series 2: HDR - Monotherapy single fraction 14Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	14	1	14	YES	1
 Prostate HDR Monotherapy 3 x 11.5Gy 	PELVIS										
Series 1: HDR - Monotherapy single fraction 11.5Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	11.5	1	11.5	YES	1
Series 2: HDR - Monotherapy single fraction 11.5Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	11.5	1	11.5	YES	1
Series 3: HDR - Monotherapy single fraction 11.5Gy	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	11.5	1	11.5	YES	1
Prostate Intermediate Risk KOMBI	PELVIS										
Series 1: HDR - single fraction 10.5Gy of the Prostate Combi-Treatment	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	10.5	1	10.5	YES	1
Series 2: HDR - single fraction 10.5Gy of the Prostate Combi-Treatment	PELVIS	BRACHYTHERAPY (BRT)	HDR	Ir-192	73.81	FRACTIONATED	10.5	1	10.5	YES	1
Series 3: ERT-Part with 45Gy of the Prostate Combi-Treatment	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	45	25	1.8	YES	1
 Prostate post operative 66.6Gy 	PELVIS										
Series 1: Prostate post op 30 x 1.8Gy incl 1cm margin	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	54	30	1.8	YES	1
Series 2: Prostate post op 7 x 1.8Gy incl asymmetric margin	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	12.6	7	1.8	YES	1
Prostate+SV Total 72Gy	PELVIS										
Series 1: IMRT Prostate+SV 1cm Margin 28x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	50.4	28	1.8	YES	1
Series 2: IMRT Prostate 1cm Margin 5x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	9	5	1.8	YES	1
Series 3: IMRT Prostate asymmetric Margins 7x1.8Gy	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	12.6	7	1.8	YES	1
Prostate-77Gy	PELVIS										
Series 1: Prostata-Series 1 PC1 52.8 Gy	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	52.8	24	2.2	YES	1
Series 2: Prostata-Series 2 PC2 24.2 Gy	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	24.2	11	2.2	YES	1
Prostate-Flame-Trial	PELVIS										
Series 1: Prostata-Flame-Series 1 PC1 and PC3	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	52.8	24	2.2	YES	1
Series 2: Prostata-Flame-Series 2 PC2 and PC3	PELVIS	EXTERNAL BEAM RADIOTHERAPY (ERT)	PHOTON			FRACTIONATED	24.2	11	2.2	YES	1

	30				100
		Total Do	se (Gy)		



In addition, BIOTOP and BIOSPOT support EUD and gEUD, TCP and NTCP, and the overall uncomplicated tumour control probabilities P+ calculations. Several models for effect probability such as Voxel-Poison response model, Relative seriality model, Lyman-Kutcher-Burman model and Parallel architecture model are supported.

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1.9 1.8											_	-		~					
).7 -).6									, 			Disp	olay Infor	matio	on / Settin	igs			
.6								_/				٧	<i>'</i> isualizatio	n C	osimetry	Statistics	Dose Volum	e Values	Evaluation Results
.4													VOI Nan	ne Pa	arameter	Unit	Protocol #1	Protocol #	2
.2								/				•	Blase	N	тср	%	0.75	0.54	
1								/		P+ MA			GTV-hist	to T	СР	%	32.50	82.02	
0 -	.0	15	20	25	30	35	40	45 50	55	60 65	7		Rectum	N	ТСР	%	0.20	0.12	
							То	tal Prescrip	tion Dos	e (Gy)			TARGET	S B	enefit	%	32.50	82.02	
													ORGANS	5 Ir	njury	%	0.95	0.66	
													ALL	P.	1	%	32.19	81.48	