Delta^4
by ScandiDos

Delta^4 TPV

A unique Monte Carlo based Treatment Planning Verification in 4D

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What is Delta⁴ TPV?

- Secondary dose calculation tool
- With a Monte Carlo dose engine
- Fast *and* accurate

Why Monte Carlo?

- Gold standard
  - *Monte Carlo is the gold standard computation method for accurate dose calculations in radiotherapy*

Why Monte Carlo?

- Speed
  - *Monte Carlo computation time scales very well with the number of cores*

Why Monte Carlo?

- ICRU 83 recommendations
  - *"Therefore, as an alternative to a set of measured absorbed-dose distributions, it is acceptable to use an* ***independent absorbed-dose calculation that is at least as accurate*** *as the absorbed-dose calculation being tested as previously verified against commissioning measurements."*

Cooperation with Radyalis

Radyalis

- Exclusive cooperation with American company Radyalis
- Radyalis are experts on Monte Carlo calculations for radiotherapy applications

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What is Delta⁴ TPV?

Dose QA

and

Plan QA

- Target covered?
- OAR dose acceptable?
  - RTOG protocols

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Where does it fit in the Delta⁴ Family?

Plan Verification	Pre-treatment Verification	At-treatment Verification
• Delta⁴ TPV	• Delta⁴ Phantom+	• Delta⁴ Discover

Good plan… delivered correctly… every day.

What is the Delta⁴ TPV workflow?

Automated Process

- Export DICOM files from TPS
- Delta⁴ TPV automatically
  - Starts the Monte Carlo calculation
  - Evaluates the results
  - Saves the results in the Delta⁴ database

What is the Delta4 TPV workflow?

Evaluation

- Overview

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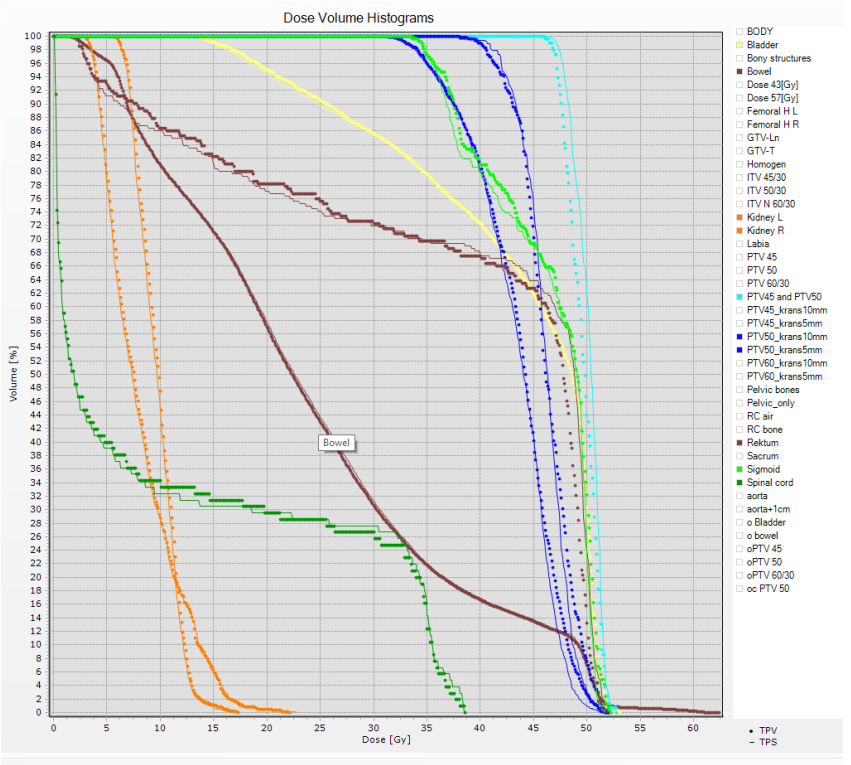
What is the Delta⁴ TPV workflow?

Deeper evaluation

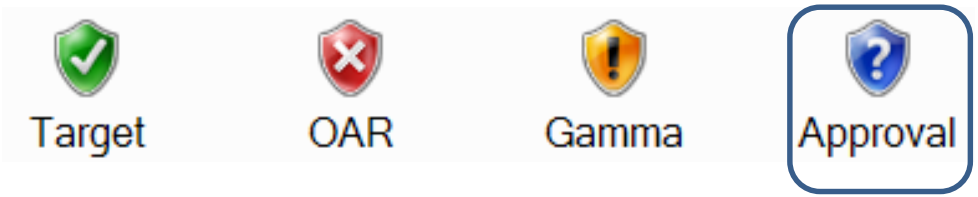
- Gamma
- DVH
- Plan objectives

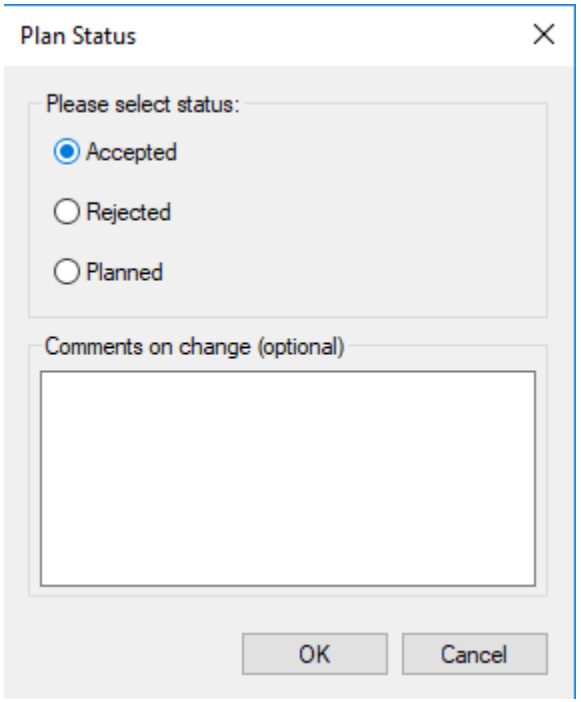
Structure	Objective	TPS	TPV
PTV45 and PTV50	HI = $(D_{2\%}-D_{98\%})/D_{50\%}$ >= 0.10	0.09	0.10
PTV50_krans10mm	HI = $(D_{2\%}-D_{98\%})/D_{50\%}$ >= 0.10	0.35	0.36
PTV50_krans5mm	HI = $(D_{2\%}-D_{98\%})/D_{50\%}$ >= 0.10	0.20	0.23
Bladder	$D_{70\%}$ <= 40.0 Gy	41.2 Gy	41.2 Gy
	$D_{55\%}$ <= 50.0 Gy	47.4 Gy	47.4 Gy
	$D_{30\%}$ <= 70.0 Gy	50.0 Gy	50.0 Gy
	$D_{15\%}$ <= 80.0 Gy	50.5 Gy	50.7 Gy
Kidney L	$D_{100\%}$ <= 23.0 Gy	2.9 Gy	2.9 Gy
	$D_{67\%}$ <= 30.0 Gy	5.7 Gy	5.9 Gy
	$D_{33\%}$ <= 50.0 Gy	9.2 Gy	9.3 Gy



What is the Delta^4 TPV workflow?

Approval





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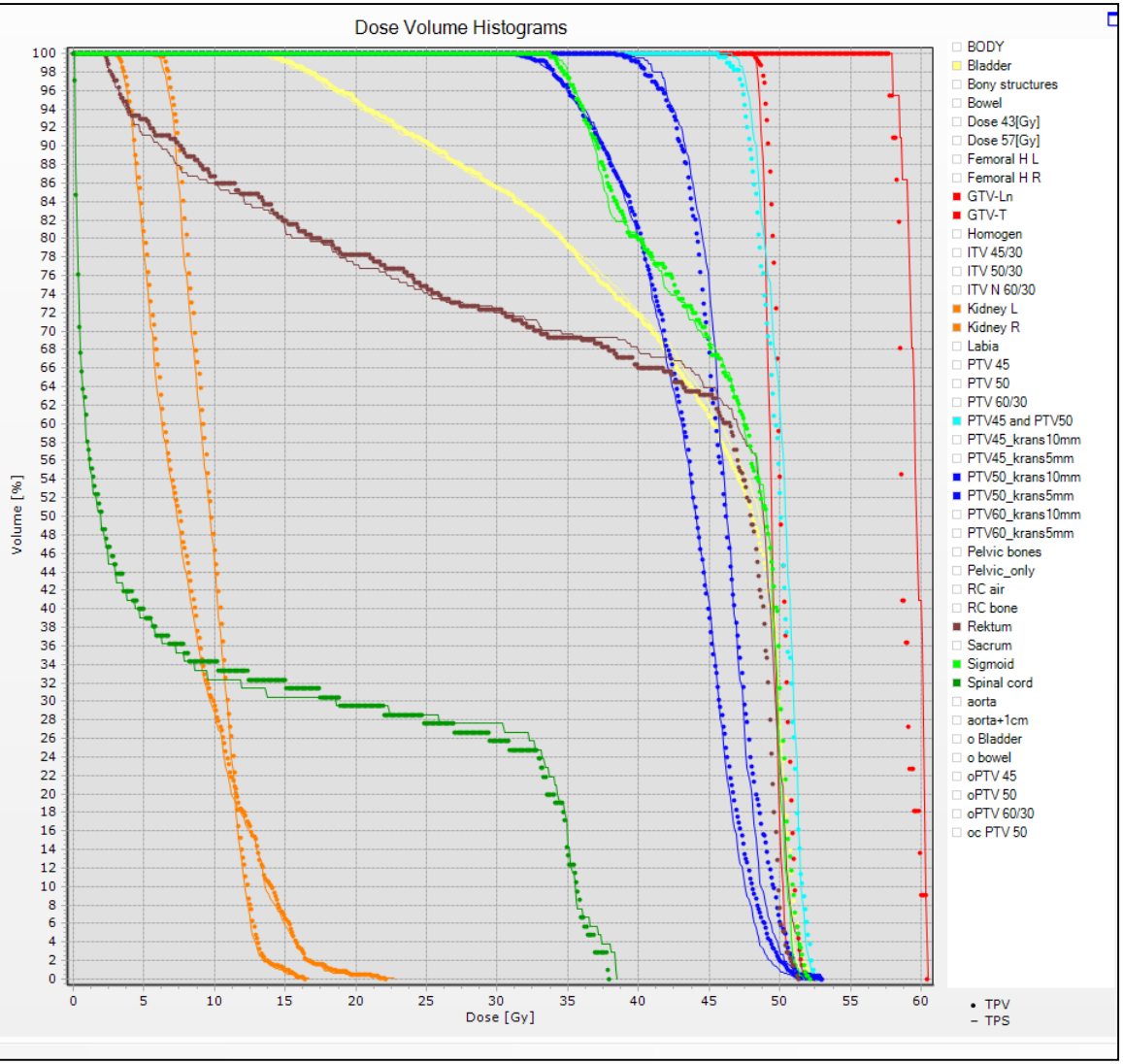
What is the Delta⁴ TPV workflow?

Target OAR Gamma Approval

Structure	Objective	TPS	TPV
GTV-Ln	HI = ($D_{2\%}$-$D_{98\%}$)/$D_{50\%}$ >= 0,01	0,04	0,04
GTV-T	HI = ($D_{2\%}$-$D_{98\%}$)/$D_{50\%}$ >= 0,01	0,05	0,05
PTV45 and PTV50	HI = ($D_{2\%}$-$D_{98\%}$)/$D_{50\%}$ >= 0,01	0,09	0,10
PTV50_krans10mm	HI = ($D_{2\%}$-$D_{98\%}$)/$D_{50\%}$ >= 0,01	0,35	0,37
PTV50_krans5mm	HI = ($D_{2\%}$-$D_{98\%}$)/$D_{50\%}$ >= 0,01	0,20	0,23
Bladder	$D_{70\%}$ <= 40,0 Gy	41,2 Gy	41,0 Gy
	$D_{55\%}$ <= 50,0 Gy	47,4 Gy	46,9 Gy
	$D_{30\%}$ <= 70,0 Gy	50,0 Gy	49,9 Gy
	$D_{15\%}$ <= 80,0 Gy	50,5 Gy	50,6 Gy
Kidney L	$D_{100\%}$ <= 23,0 Gy	2,9 Gy	2,9 Gy
	$D_{67\%}$ <= 30,0 Gy	5,7 Gy	5,9 Gy
	$D_{33\%}$ <= 50,0 Gy	9,2 Gy	9,3 Gy
Kidney R	$D_{100\%}$ <= 23,0 Gy	5,9 Gy	5,6 Gy
	$D_{67\%}$ <= 30,0 Gy	8,5 Gy	8,8 Gy
	$D_{33\%}$ <= 50,0 Gy	10,7 Gy	10,8 Gy
Rektum	$D_{200\ cc}$ <= 30,0 Gy		
	$D_{150\ cc}$ <= 35,0 Gy		
	$D_{100\ cc}$ <= 40,0 Gy		
	$D_{20\ cc}$ <= 45,0 Gy	48,8 Gy	47,9 Gy
	D_{Max} <= 52,0 Gy	51,9 Gy	51,3 Gy
Sigmoid	D_{Max} <= 5,0 Gy	51,6 Gy	52,0 Gy
Spinal cord	D_{Max} <= 45,0 Gy	38,4 Gy	37,8 Gy



What hardware do I need?

TPV *Calculation server*

- Powerful PC

Delta4 *Viewing station*

- Evaluation and Approval
- Regular PC

What hardware do I need?

TPV Calculation server

- Runs on any PC with Windows 10
- For speed use at least
  - Processor: Intel® Xeon® W with 18 cores/36 threads/2.3GHz
  - RAM: 64 GB

How fast is Delta⁴ Monte Carlo?

100 - 1000 times faster than general Monte Carlo codes

How fast is Delta⁴ Monte Carlo?

Plan Type	Body Site	Energy Machine Type	Time (seconds)
VMAT	H&N	6 MV Elekta Agility	371
VMAT	Thorax	6 MV Elekta Agility	592
VMAT	Cervix	6 MV Varian TrueBeam Millennium	715
3D conformal	Spine	10 MV Varian TrueBeam Millennium	102
VMAT	Prostate	6 MV FFF Varian TrueBeam Millennium	318

How accurate is Delta⁴ Monte Carlo?

Clinical test cases

- Measurements
- Gamma 2%/2mm: Pass-rate 96%

  For voxels with more than 10% of dose max

Physics test cases

- EGSnrc
- Geant4
- Gamma 1%/1mm: Pass-rate 96%

  For voxels with more than 10% of dose max

Why is Delta⁴ Monte Carlo fast *and* accurate?

- Optimized for radiotherapy applications
- Efficient algorithms, modeling, and data representation
- Utilizes all available computing resources

Why is Delta⁴ Monte Carlo fast *and* accurate?

- Simulates all relevant particles and materials
- Includes all relevant physics, models arbitrary geometries
- Proprietary methods for convergence, statistical noise controls and dose uncertainty bounds

How is commissioning done?

- Same measurements as for TPS commissioning
- Commissioning done by ScandiDos
- Graphical tools for evaluation of the result

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Secondary dose calculation tool
- within the Delta^4 family or Standalone

Time efficient with Automated Process
Highest Accuracy with Monte Carlo
Effective and Objective Evaluation (RTOG)

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