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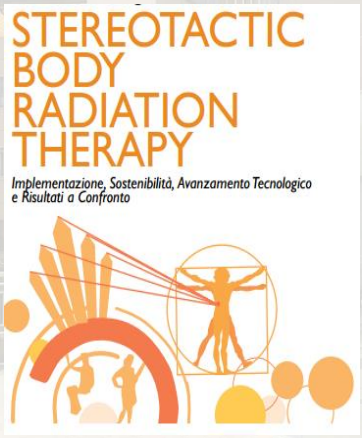

SBRT pre-treatments QA: two different approaches

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SBRT treatment technology

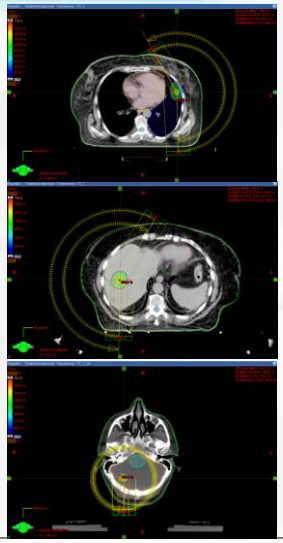
Stereotactic body radiation therapy (SBRT) delivers a very high dose of radiation to the tumor target with high precision using a small number of fractions

SBRT is the result of technological advances in:

1. Patient/tumor immobilization
2. Image guidance
3. Treatment planning and delivery
4. More comprehensive quality assurance program

6 SBRT and 3 SRS treatments with different dose fractionations

- **3 Lung Cases**
  - 2 patients: 15 x 3 Gy
  - 1 patient: 8 x 4 Gy
- **3 Liver Cases**
  - 2 patients: 15 x 3 Gy
  - 1 patient: 10 x 3 Gy
- **3 Brain Cases**
  - 2 patients: 21 x 1 Gy
  - 1 patient: 15 x 1 Gy



Purpose

The aim of this study is to test a 3D dosimetry analysis package (IBA), COMPASS 3.0 with MatriXX^{Evolution} ion chamber array, for SBRT pre treatment verification in terms of 3D dose, gamma analysis, Target and OAR structures DVH.

MatriXX on gantry: aligned for VMAT/RapidArc® QA

In comparison with our routinely used EPID dosimetry system based on the EPIQA™ software

Pre-treatment verification Epiqa™

Amorphous Silicon Electronic Portal Imager Portal Vision As1000 (pixel size of 0.392 mm)

EPID dosimetric image are converted into Dose Map and compared with a reference dose distribution

Conversion is based on the GLAaS algorithm

Integrated images were acquired with EPID positioned in the isocenter

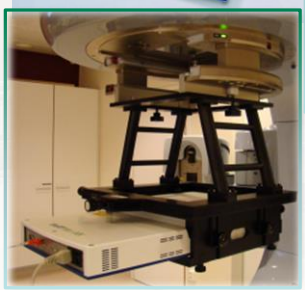
Epiqa version 3.1.0

EPIQA benefits:

- Calibration based on data measured by user
- Resolution comparable to film dosimetry
- Very good long term stability
- Independent of TPS

Pre-treatment verification Compass 3.0-MatriXX Evolution

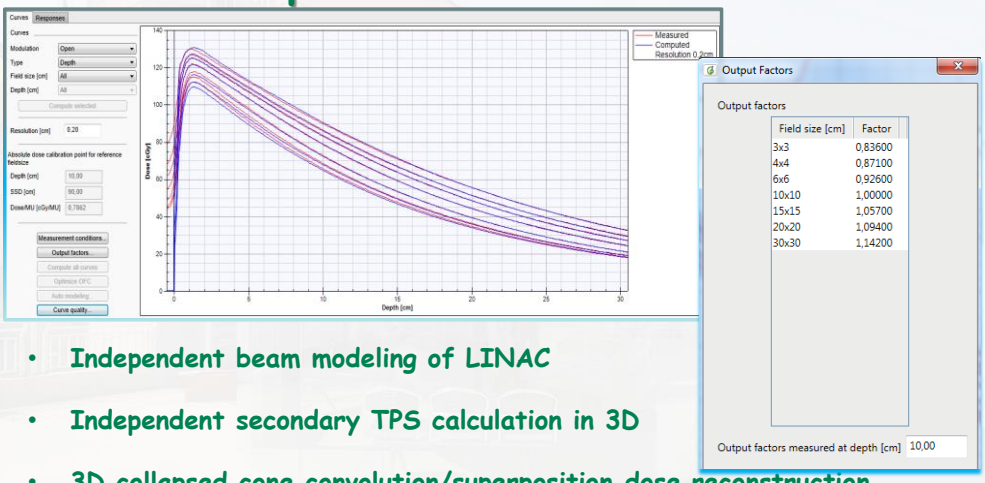
iba Dosimetry



MatriXX Evolution	
Number of chambers:	1020
Active area:	24.4 x 24.4 cm²
Sensor layout:	matrix in a plane arranged in a 32 x 32 grid
Pixel distance:	7.62 mm center-to-center
Chamber type:	vented pixel ionization chambers
Chamber size:	4.5 (Ø) x 5 (h) mm, chamber volume 0.08 cm³
Typical sensitivity:	0.42 Gy/nC
Effective point of measurement:	3 mm from surface
Accuracy of angle sensor:	+/- 0.6°

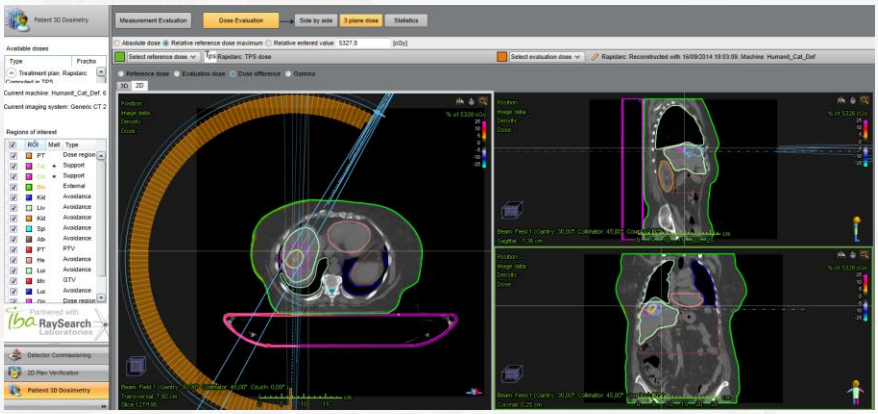
Attached to the Gantry (SSD 76 cm) provides zero angular dependency higher data quality for 360° measurements;
Gantry Angle Sensor;

Pre-treatment verification Compass 3.0-MatriXX Evolution



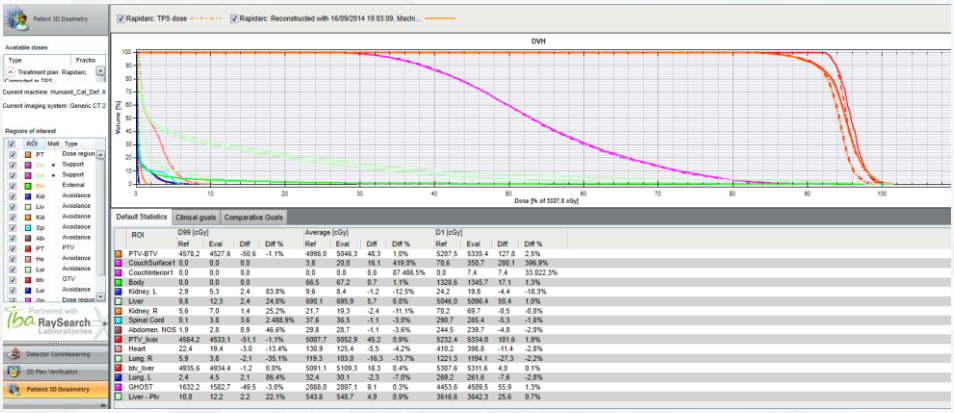
- Independent beam modeling of LINAC
- Independent secondary TPS calculation in 3D
- 3D collapsed cone convolution/superposition dose reconstruction

Pre-treatment verification: Compass 3.0-MatriXX Evolution



- Patient anatomy based verification with RTPS accuracy
- Pre-treatment verification in terms of 3D dose, gamma analysis,and DVH

Pre-treatment verification: Compass 3.0-MatriXX^{Evolution}



- Patient anatomy based verification with RTPS accuracy
- Pre-treatment verification in terms of 3D dose, gamma analysis,and DVH

Parameters Evaluation

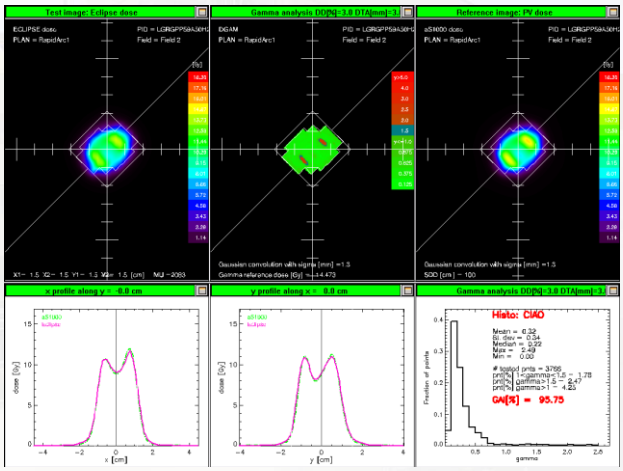
Eclipse TPS (*AAA* 10.0.28) vs Compass TPS → Evaluation in terms of $D_{99\%}$, $D_{1\%}$, D_{Mean}

Compass 3.0 MatriXX^{Evolution} → Local gamma analysis: 3%-3 mm and 2%-2 mm on Targets and OAR;local calculation threshold of 10 % of D_{Max}
DVH analysis in terms of $D_{99\%}$ $D_{1\%}$ D_{Mean}

Epiqa^{TM} → Global gamma analysis: 3%-3 mm and 2%-2 mm; Gaussian Convolution with a Sigma of 1.25 mm

EPID dosimetry with EPIQA™

Results



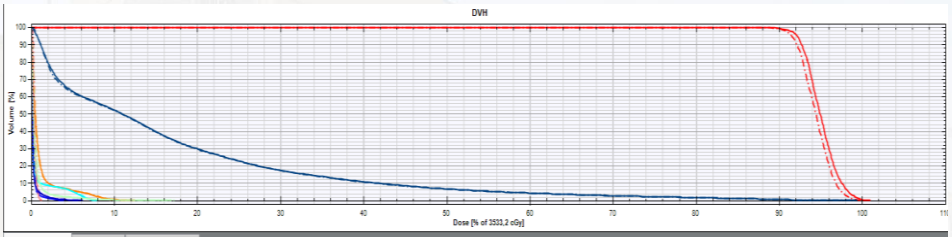
CIAO: the fraction of open field within the shape defined by the MLC (the Completely Irradiated Area Outline)

EPID dosimetry with EPIQA™

Results

EPIQA Gaussian Convolution Sigma 1.25 mm GLOBAL GAMMA		
	3 % ; 3mm	2% ; 2 mm
BRAIN	97.87 %	95.66 %
	99.20 %	97.19 %
	97.16 %	94.92 %
LIVER	98.96 %	94.11 %
	99.92 %	99.13 %
	98.99 %	96.35 %
LUNG	98.79 %	94.39 %
	98.41 %	96.56 %
	97.56 %	94.85 %

Compass 3.0-MatriXX *Evolution*
Eclipse TPS vs Compass TPS - Results



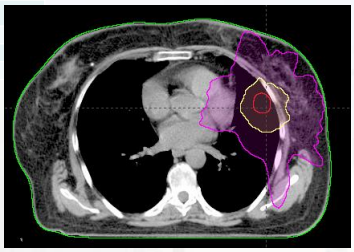
Default Statistics | Clinical goals | Comparative Goals

ROI	D99 [cGy]				Average [cGy]				D1 [cGy]			
	Ref	Eval	Diff	Diff %	Ref	Eval	Diff	Diff %	Ref	Eval	Diff	Diff %
Dose 20[%]	400,1	402,1	2,0	0,5%	1348,2	1352,2	3,9	0,3%	3396,8	3418,6	21,9	0,6%
Dose 50[%]	991,9	996,4	4,5	0,5%	2433,1	2433,0	-0,1	0,0%	3449,4	3476,6	27,2	0,8%
Dose 70[%]	1985,8	1986,9	1,2	0,1%	2992,3	2993,4	1,1	0,0%	3466,2	3494,4	28,2	0,8%
Dose 90[%]	2670,6	2660,5	-10,1	-0,4%	3260,2	3270,2	10,0	0,3%	3475,6	3510,1	34,5	1,0%
GHOST_Fegato	1400,3	1388,0	-12,3	-0,9%	2379,5	2369,3	-10,2	-0,4%	3240,7	3237,2	-3,5	-0,1%
PTV-CTV_Fegato	3069,1	3063,6	-5,5	-0,2%	3315,7	3332,0	16,2	0,5%	3483,2	3519,7	36,6	1,1%
BODY	0,0	0,0	0,0		54,5	52,7	-1,8	-3,3%	1033,8	1042,8	9,0	0,9%
CouchSurface		0,0				11,3				210,7		
CTV_Fegato	3218,6	3259,8	41,3	1,3%	3348,3	3359,4	11,1	0,3%	3485,7	3495,3	9,7	0,3%
Kidney, L	2,6	0,0	-2,5	-98,5%	11,7	8,2	-3,6	-30,5%	83,5	80,6	-3,0	-3,6%
Liver	13,8	10,9	-2,9	-21,2%	580,4	584,0	3,7	0,6%	3036,1	3014,7	-21,4	-0,7%
PTV_Fegato	3189,3	3196,6	7,3	0,2%	3337,0	3357,7	20,7	0,6%	3486,8	3519,3	32,5	0,9%
Kidney, R	5,7	0,1	-5,5	-97,7%	39,3	36,8	-2,5	-6,4%	323,9	320,6	-3,3	-1,0%
Spinal Cord	0,0	0,0	0,0		22,3	19,4	-2,8	-12,7%	239,9	237,9	-2,0	-0,8%
Lung, R	2,4	0,0	-2,4	-100,0%	25,0	19,2	-5,8	-23,2%	234,3	236,6	2,3	1,0%
Lung, L	1,4	0,0	-1,4	-100,0%	12,1	8,2	-3,8	-31,6%	99,5	96,9	-2,5	-2,5%
Heart	8,2	1,7	-6,4	-78,7%	17,8	13,6	-4,1	-23,3%	38,3	35,6	-2,7	-7,0%

Compass 3.0-MatriXX *Evolution*

Gamma index results
% of points with $\gamma > 1$

	LUNG local gamma 3% 3mm				
	PTV	Dose 50%	Dose 20%	Esophagus	Spinal Cord
Case 1	27.98	7.60	8.20	3.01	0.15
Case 2	3.26	1.55	2	0.17	0.85
Case 3	2.93	0.83	0.54	_	0.44
	LUNG local gamma 2 % 2mm				
Case 1	43.24	15.85	17.95	7.54	1.71
Case 2	13.62	5.86	8.59	1.82	5.61
Case 3	9.04	3.20	2.79	_	3.03



	LIVER local gamma 3% 3mm				
	PTV	Dose 50%	Dose 20%	Liver	Kidney, R
Case 1	2.71	0,92	0,71	1.55	0.46
Case 2	1.38	0.68	1.52	0.72	0.03
Case 3	0.1	0.17	0.56	0.77	0.01
	LIVER local gamma 2 % 2mm				
Case 1	20.24	5,47	4.05	4.77	1.51
Case 2	9.09	4.07	6.08	4.03	2.24
Case 3	0.68	0.73	3.36	3.74	0.1

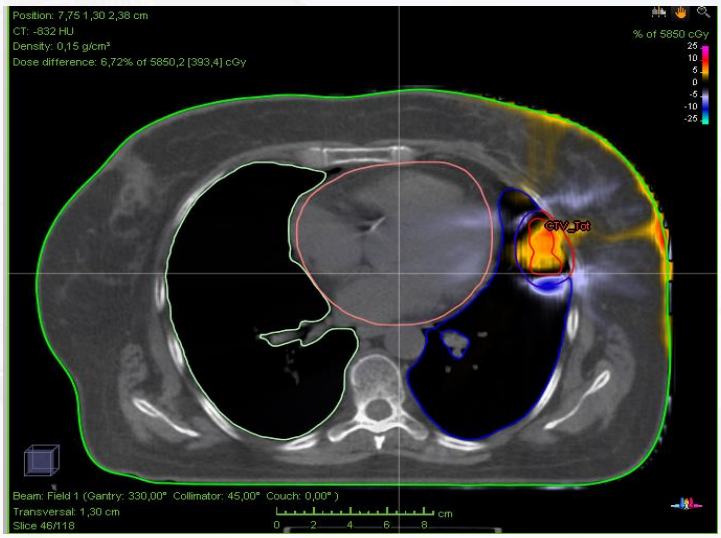
	BRAIN local gamma 3% 3mm			
	PTV	Dose 50%	Dose 20%	Brain Stem
Case 1	3.55	0.77	0.36	1.79
Case 2	1.05	0.34	0.73	0.06
Case 3	2.80	0.59	0.40	0.0
	BRAIN local gamma 2% 2mm			
Case 1	15.26	3.62	2.78	4.28
Case 2	11.41	5.61	6.69	0.2
Case 3	14.61	4.96	4.60	0.4

Issues

Does it exist a correlation between gamma passing rate and clinical evaluation in terms of selected metrics?

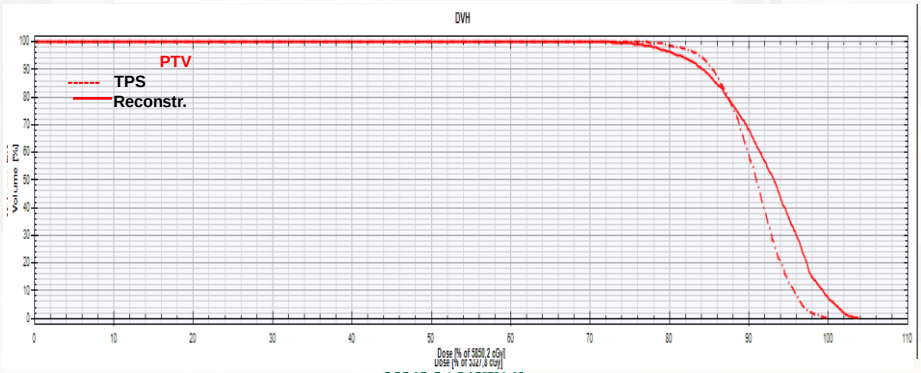
Does it exist a threshold in terms of metrics that can prevent false positives or false negatives in a gamma analysis?

Compass 3.0-MatriXX*Evolution*
Results (Worst Scenario)



Compass 3.0-MatriXX *Evolution* Results

BRAIN Average Dose PTV	Dose Prescr.(Gy)	TPS (Gy)	COMPASS RECONSTRUCTED (Gy)	Absolute diff. (Gy)	Diff. %
Case 1	21	23.42	23.68	0.26	1.1
Case 2	21	22.16	22.38	0.21	1.0
Case 3	15	16.70	16.76	0.06	0.4



Conclusions

- ✓ Different system devices → different kind of measurements.
- ✓ If we apply a «unique» threshold metric we risk to generate false positives or false negatives

Open Questions

- ✓ Need to develop new Monte Carlo based software for QA results in terms of DVH
- ✓ Further studies are required to analyze new methods that will be both effective and practical in the clinical settings
- ✓ Has gamma index a clinical meaning in systems that do not permit to localize «failed points» into the patient's anatomical inhomogeneity?

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