# In-vivo verification of Tomotherapy treatment plan using the Dosimetry Check software. The Reggio Emilia experience

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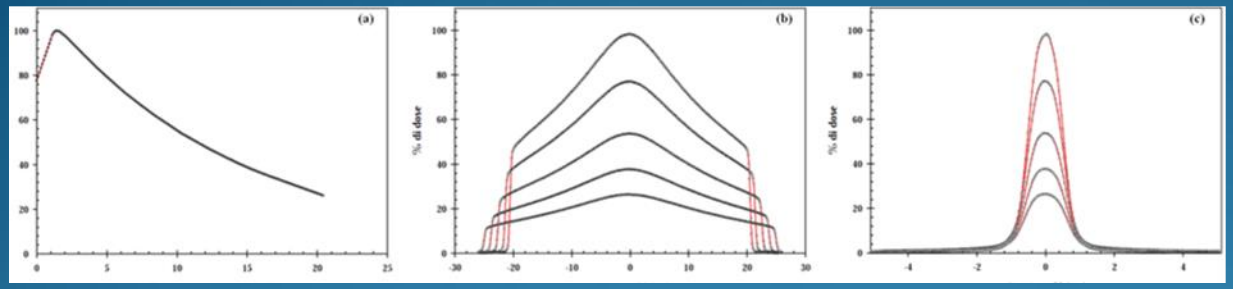
# DOSIMETRY CHECK™ : configuration

**Clinical beam profile measurements from acceptance test measurements (ATP)**
**(example case for field width 1cm)**




**Gaussian monoenergatic dose kernel**

**Modelling**

**NO**

**New photonic spectra (ϕ)**

$$\phi(E_i) = A \cdot exp\left(-\frac{(E_i - E_0)^2}{\sigma^2}\right)$$

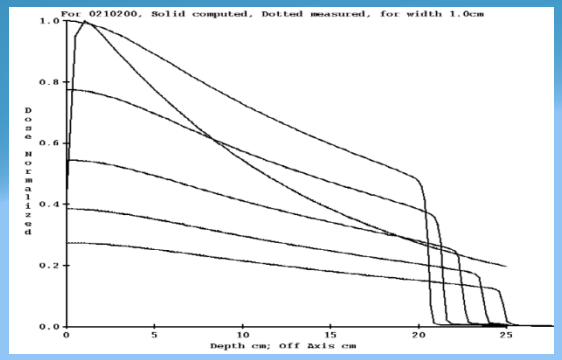
**Minimizing the cost function σ(ϕ) between measured and computed Percent Depth Dose (PDD)**

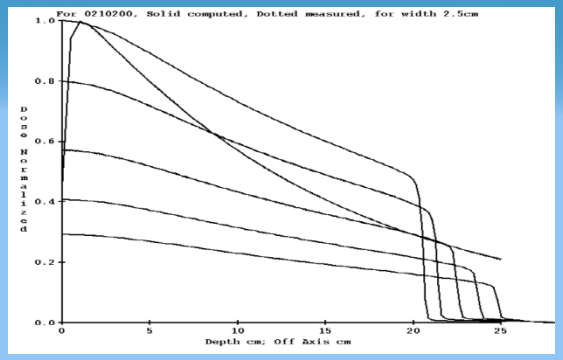
**YES**

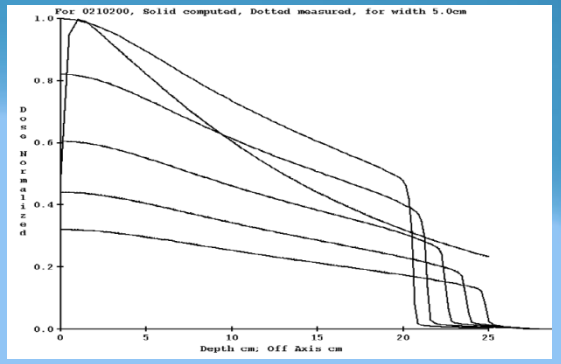
**Polyenergetic dose kernel (not gaussian)**

$$\sigma(\phi(E_i)) = \frac{\sqrt{\sum_{j=1}^{m}\left[D(z_j) - \sum_{E_i=0.1MV}^{8.MV}\phi(E_i)\cdot D(E_i, z_j)\right]^2}}{m}$$

**Fit Tomotherapy dose kernel final results for all field width**

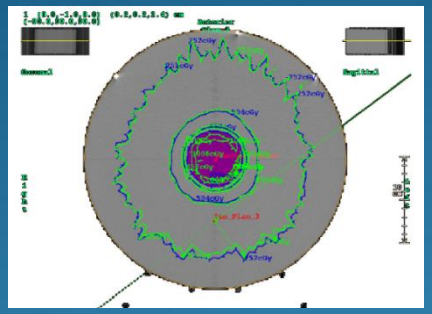


# Phantom test: voxel dimension and comparison with conventional detector

TPS (blue) DC (green) dose distribution comparison, considering a Tomotherapy IMRT verification test



2D dose comparison perfomed by means of Verisoft v 4.2 between DC, TPS and 2Darray dose for in-vivo simulationsituation

***2Darray vs DC***

*DC voxel: 5mm*

| | FW (cm) | $\gamma_{mean}$ | $(\gamma \leq 1)_{local}$ | point diff% |
|---|---|---|---|---|
| **PLAN 5** | 1,0 | 0,404 | 96,3% | -2,0% |
| **PLAN 3** | 2,5 | 0,581 | 82,4% | -3,3% |
| **PLAN 1** | 5,0 | 0,475 | 80,8% | -4,2% |

*DC voxel: 2mm*

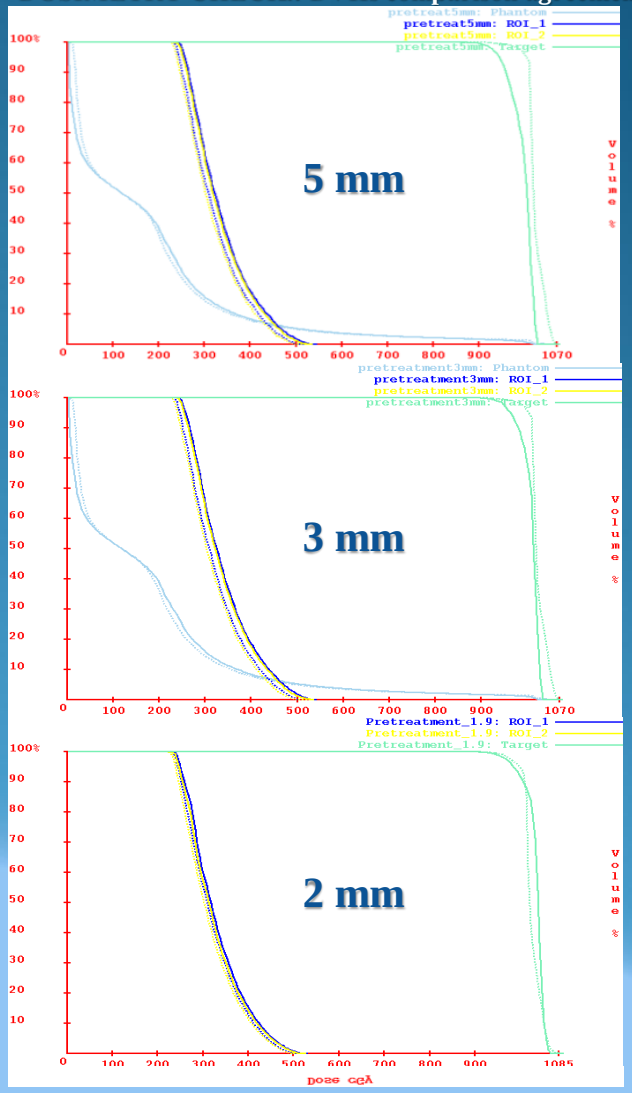
| | FW (cm) | $\gamma_{mean}$ | $(\gamma \leq 1)_{local}$ | point diff% |
|---|---|---|---|---|
| **PLAN 5** | 1,0 | 0,357 | 98,4% | -1,7% |
| **PLAN 3** | 2,5 | 0,402 | 96,3% | -0,8% |
| **PLAN 1** | 5,0 | 0,421 | 95,7% | -1,5% |

**Best agreement between DC computed and 2Darray measured dose!**

***TPS vs 2Darray/OCTAVIUS***

| | FW (cm) | $\gamma_{mean}$ | $(\gamma \leq 1)_{local}$ | point diff% |
|---|---|---|---|---|
| **PLAN 5** | 1,0 | 0,365 | 100,0% | 2,7% |
| **PLAN 3** | 2,5 | 0,227 | 100,0% | 0,6% |
| **PLAN 1** | 5,0 | 0,182 | 100,0% | 0,7% |

**Choice of the voxel dimension for dose computation performed by DOSIMETRY CHECK.: DVHs comparison agreement**



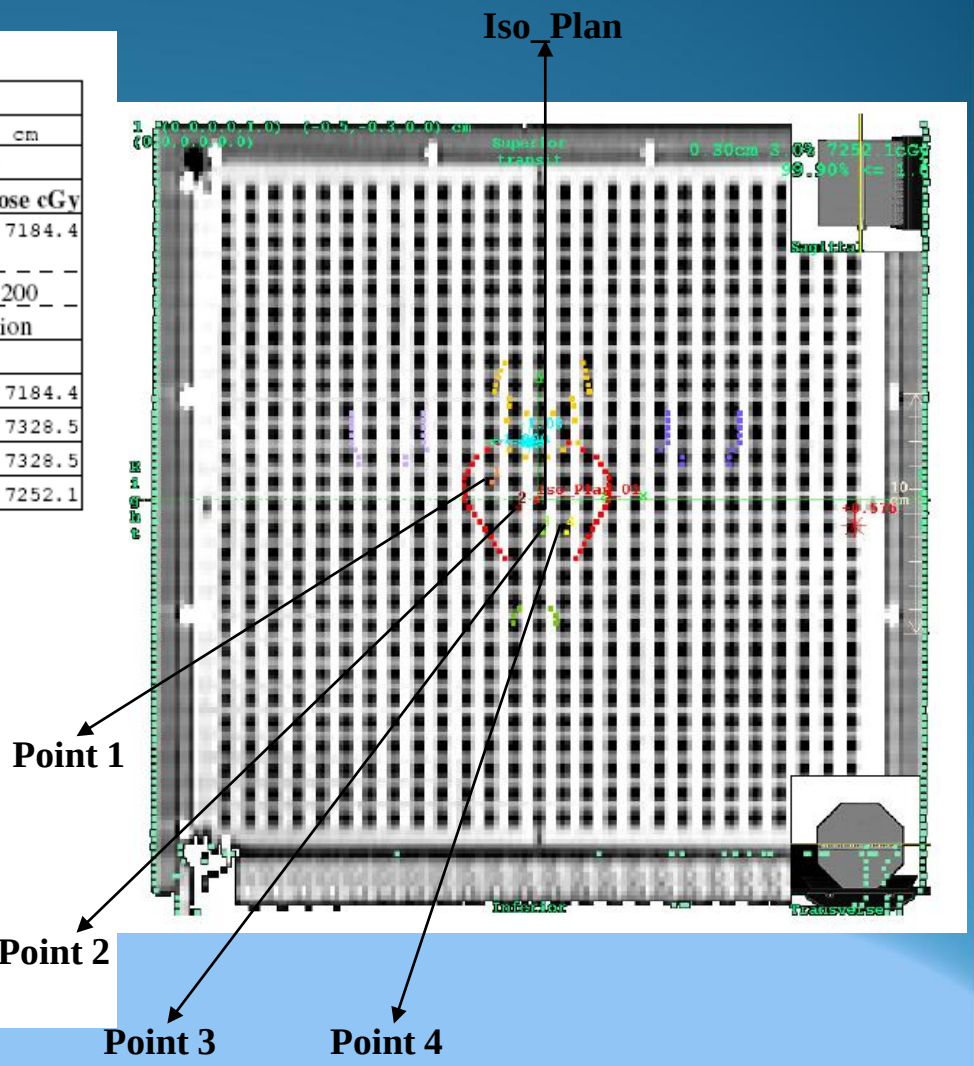
# In-vivo simulation of a prostate treatment performed on 2Darray/OCTAVIUS

Specific Points transit, ID=19

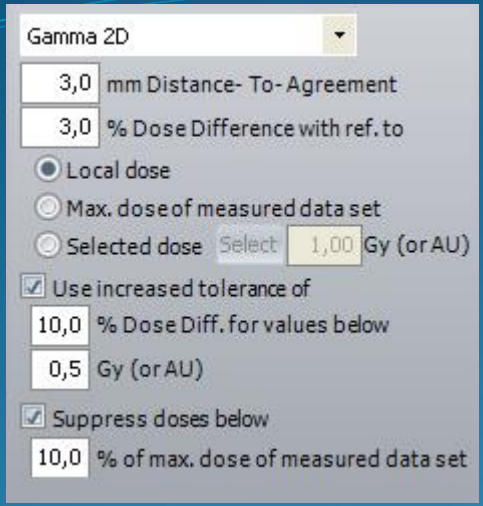
| Point Name: | 1 | 2 | 3 |
|---|---|---|---|
| | x, y, z cm | x, y, z cm | x, y, z cm |
| Coordinates | -2.0, 1.0, 0.0 | -0.9, -0.0, 0.0 | 0.0, -1.0, 0.0 |
| | Dose cGy | Dose cGy | Dose cGy |
| Helical_TomoTherapy_Beam | 7271.2 | 7267.5 | 7184.4 |
| Machine Name | Tomotherapy200 | Tomotherapy200 | Tomotherapy200 |
| Check Type | Exit-Integration | Exit-Integration | Exit-Integration |
| BEV Coordinates | -1.6, 0.7, -1.0 | -0.6, -0.3, -0.4 | 0.2, -1.3, 0.1 |
| Total Dose cGy | 7271.2 | 7267.5 | 7184.4 |
| Plan Dose cGy | 7317.8 | 7263.8 | 7328.5 |
| Difference % | -0.64% of 7317.8 | 0.05% of 7263.8 | -1.97% of 7328.5 |
| Difference % | -0.64% of 7252.1 | 0.05% of 7252.1 | -1.99% of 7252.1 |

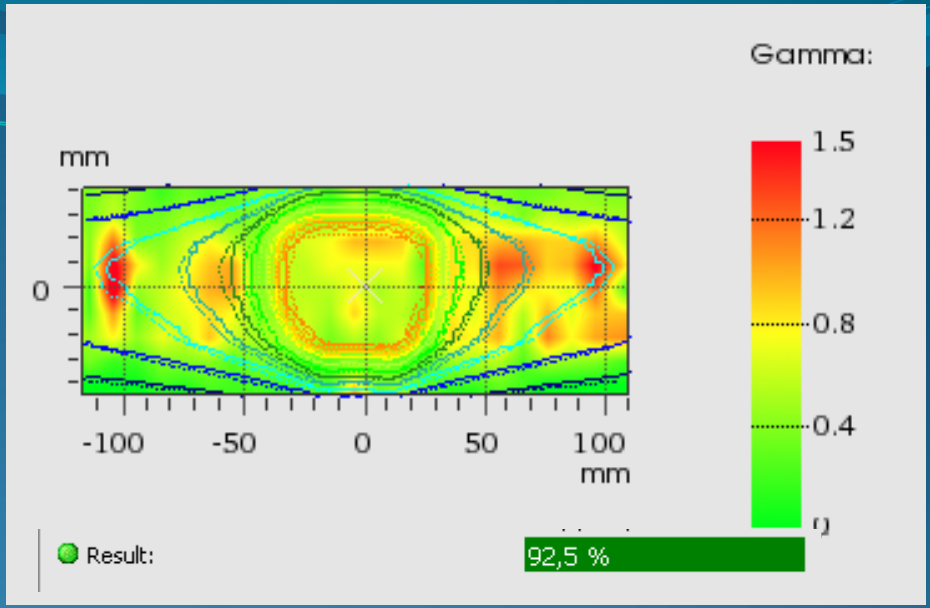
Specific Points transit, ID=19

| Point Name: | 4 | Iso_Plan_01 |
|---|---|---|
| | x, y, z cm | x, y, z cm |
| Coordinates | 1.0, -1.0, 0.0 | -0.2, 0.3, -0.0 |
| | Dose cGy | Dose cGy |
| Helical_TomoTherapy_Beam | 7198.4 | 7263.3 |
| Machine Name | Tomotherapy200 | Tomotherapy200 |
| Check Type | Exit-Integration | Exit-Integration |
| BEV Coordinates | 1.0, -1.3, 0.6 | -0.0, 0.0, -0.0 |
| Total Dose cGy | 7198.4 | 7263.3 |
| Plan Dose cGy | 7252.5 | 7252.1 |
| Difference % | -0.75% of 7252.5 | 0.15% of 7252.1 |
| Difference % | -0.75% of 7252.1 | 0.15% of 7252.1 |

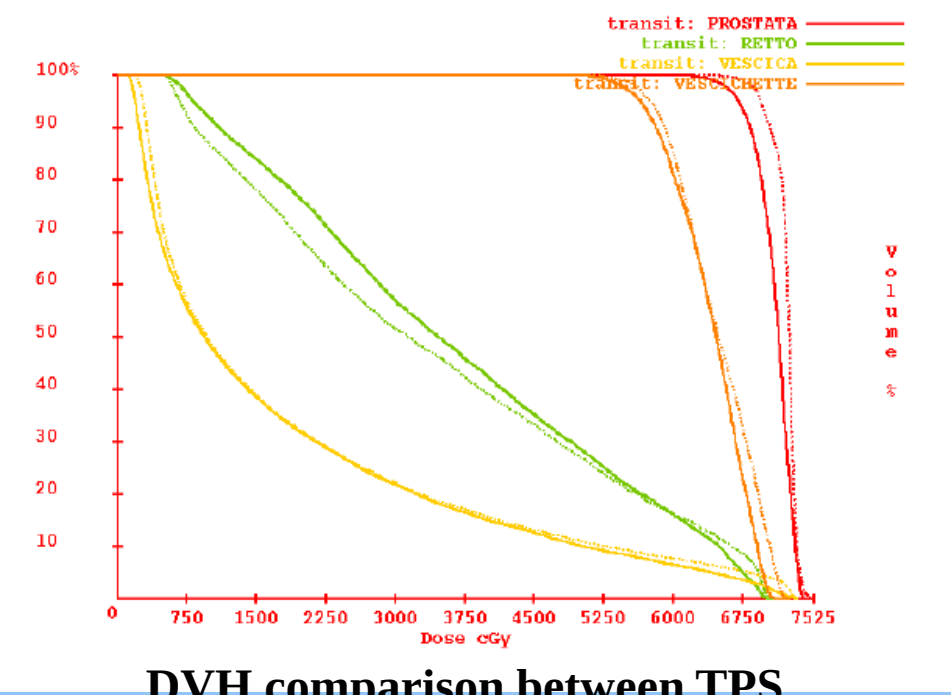


# Gamma analisys: metric used in Verisoft

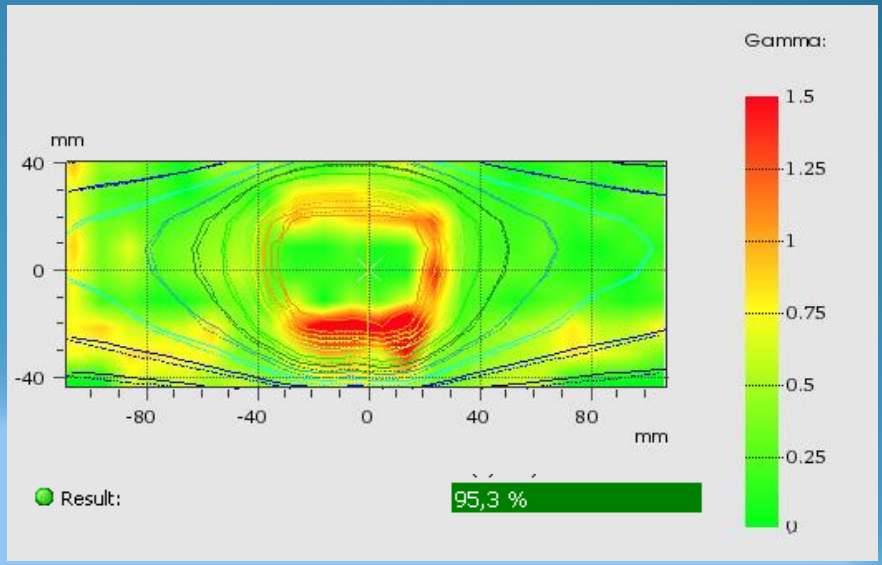



TPS dose vs 2Darray measurement




DVH comparison between TPS (dotted) and DC (continuous)



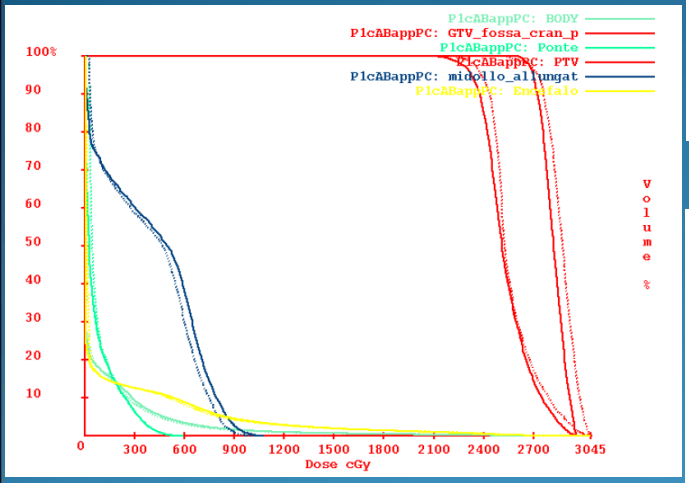

DC computed dose vs 2Darray measurement

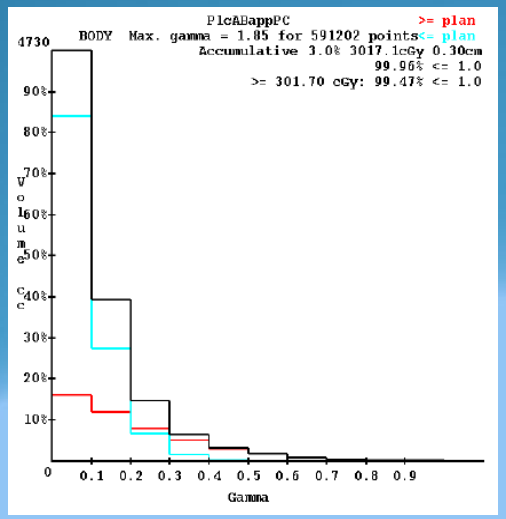
In-vivo dosimetry of patient-specific Tomotherapy treatment plans:

- Brain
- Prostate
- Head & neck
- Thorax

considered during the first session of their treatment session.

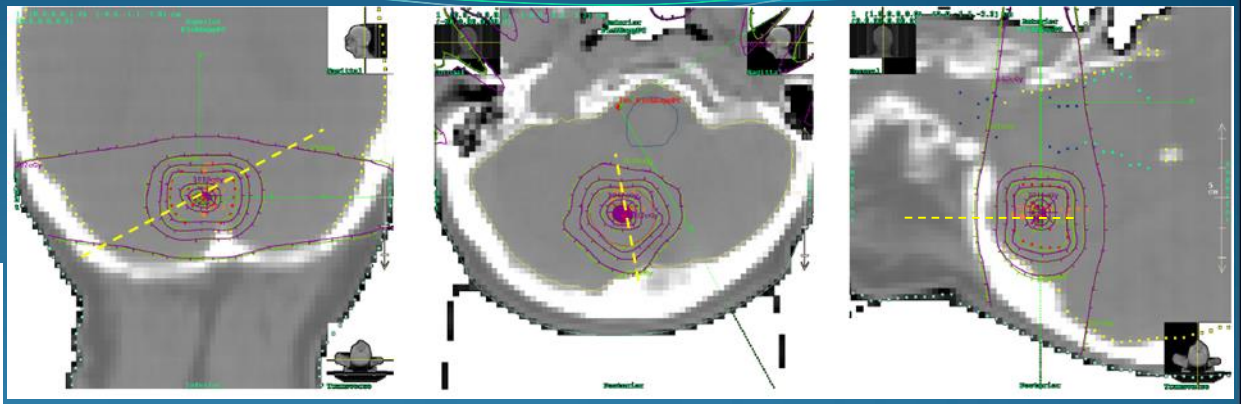
# Brain



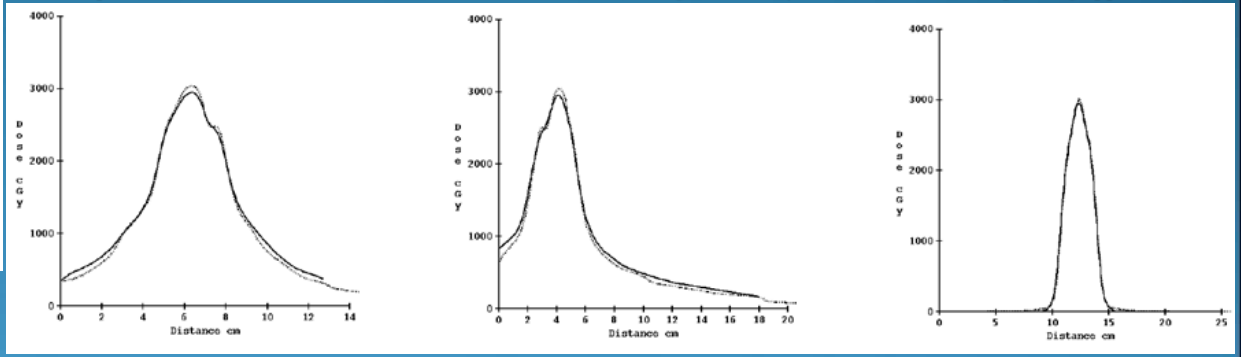




3D Isodose line comparison (magenta TPS, green DOSIMETRY CHECK).

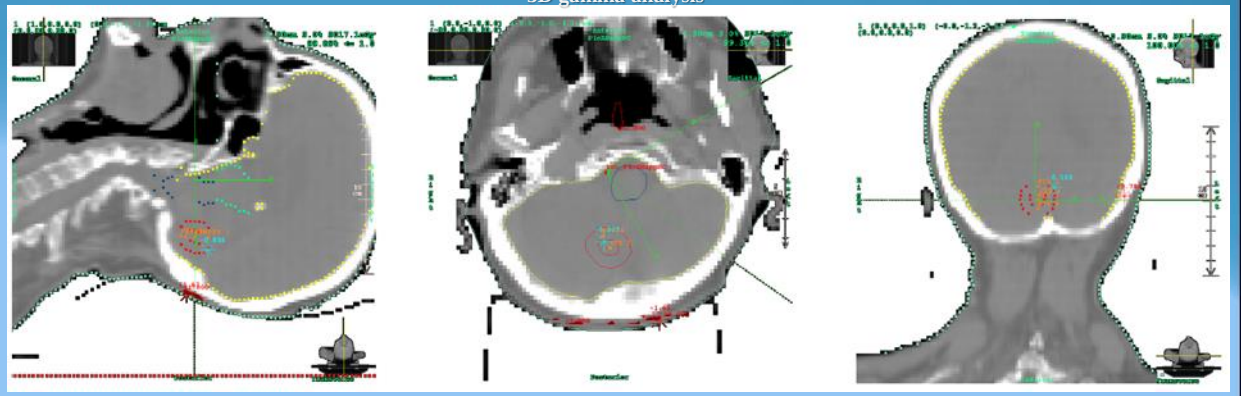
Transverse view | Sagittal view | Coronal view



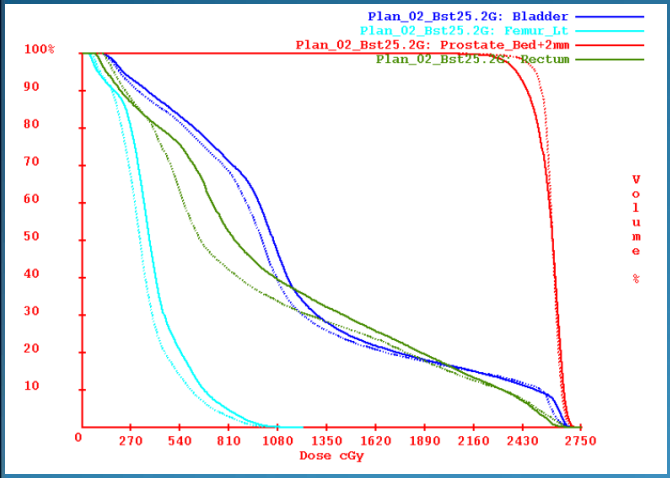
Line profiles (dotted TPS, continuous DOSIMETRY CHECK) along the dotted yellow line in the corresponding upper view.

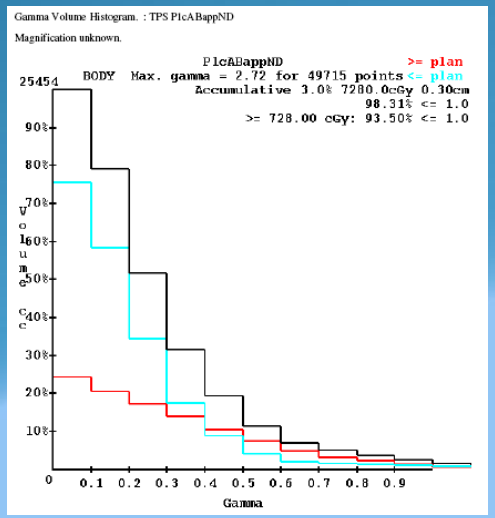



3D gamma analysis



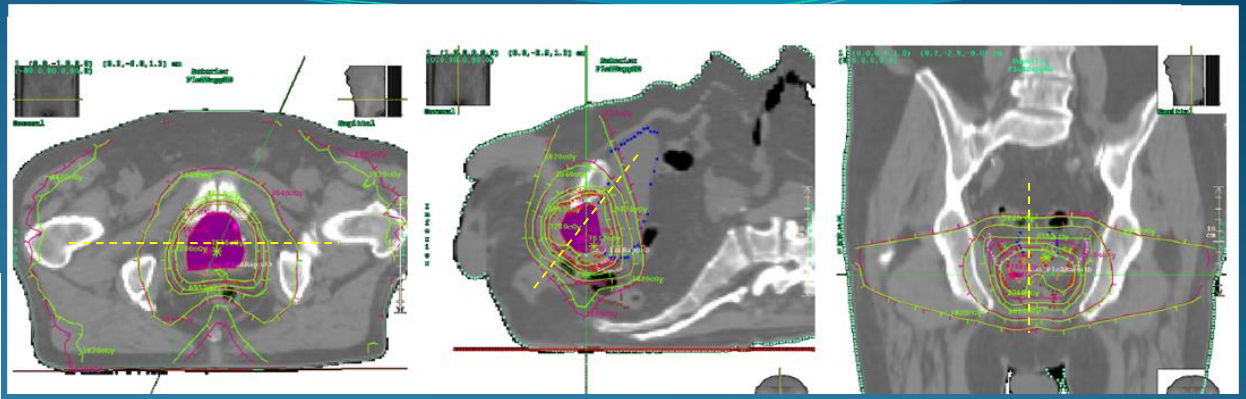
# Prostate



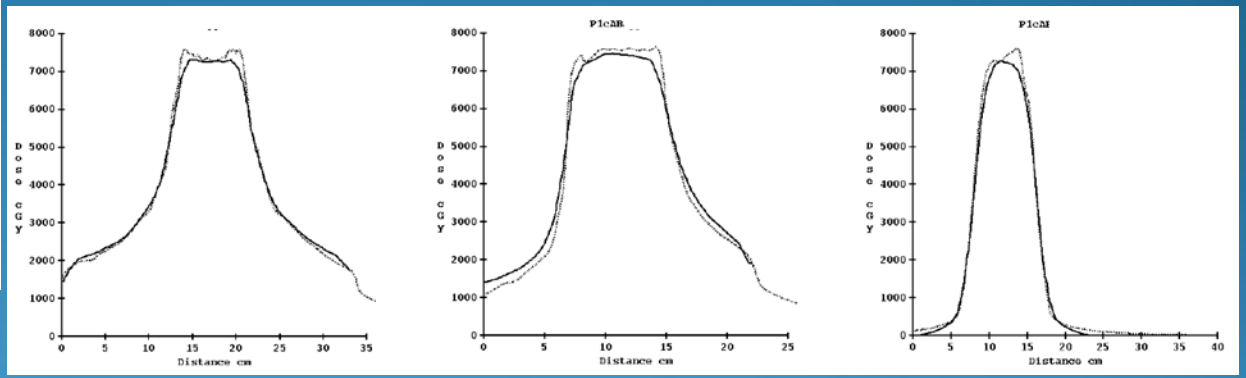




3D Isodose line comparison (magenta TPS, green DOSIMETRY CHECK).

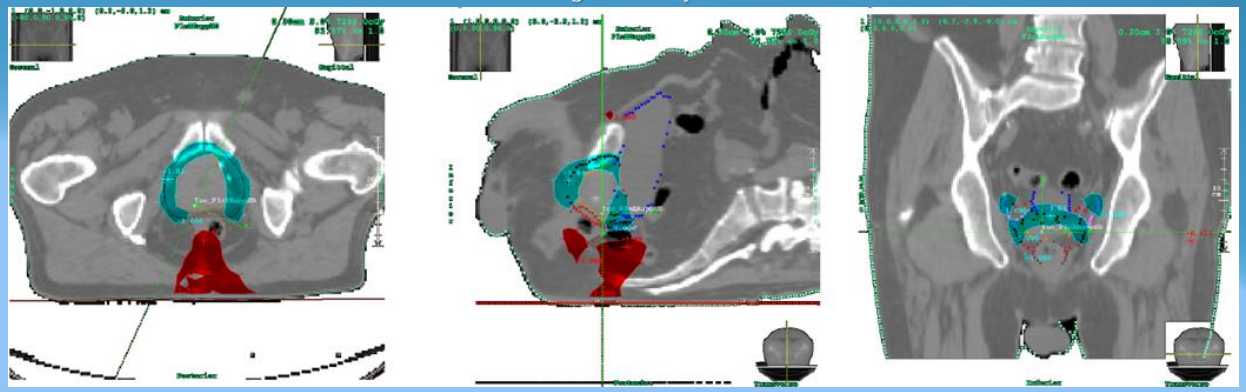
Transverse view | Sagittal view | Coronal view



Line profiles (dotted TPS, continuous DOSIMETRY CHECK) along the dotted yellow line in the corresponding upper view.



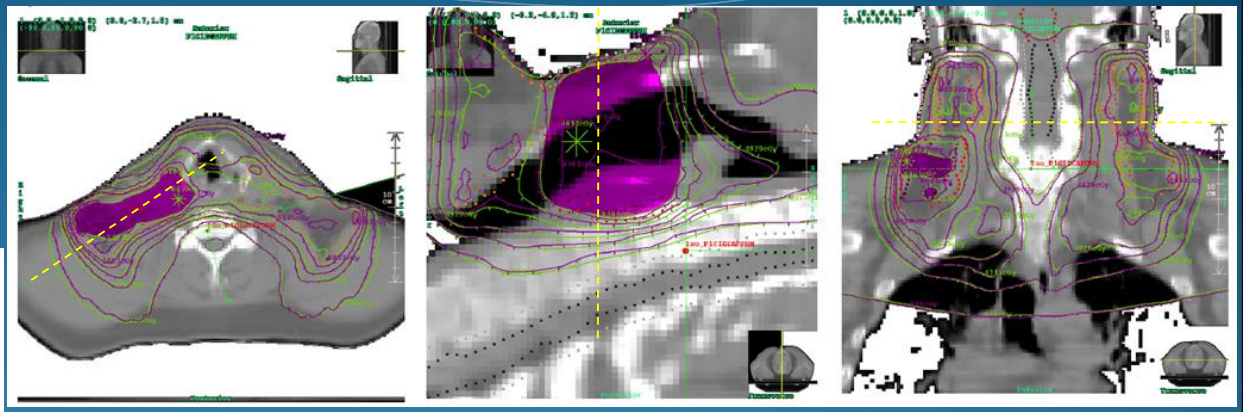

3D gamma analysis

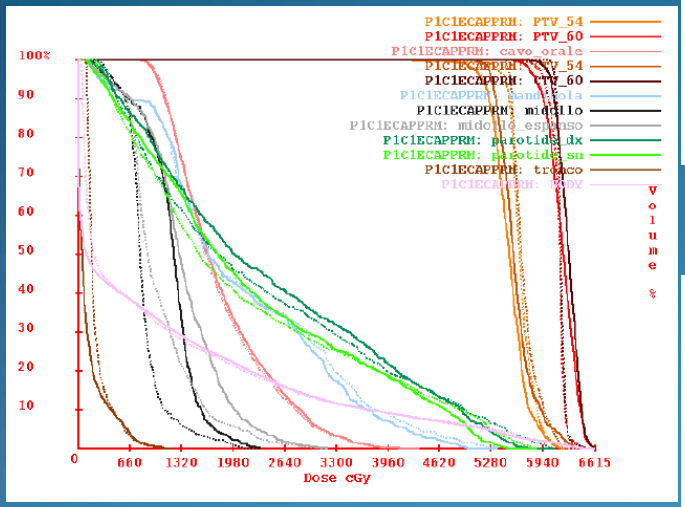


# Head & neck

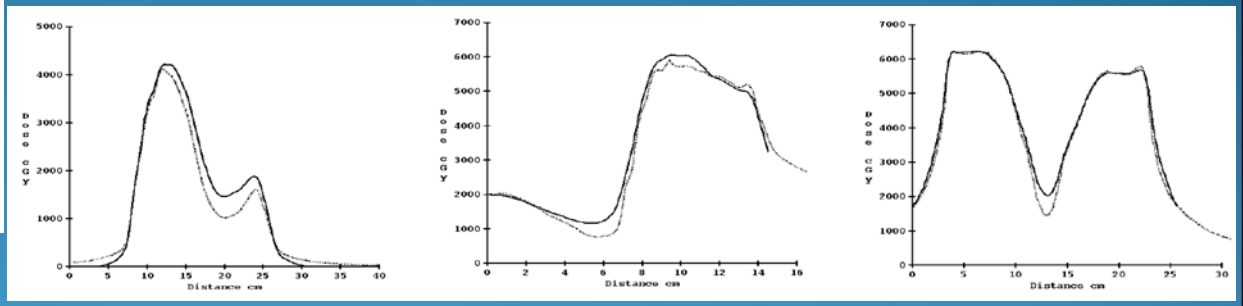
3D Isodose line comparison (magenta TPS, green DOSIMETRY CHECK).

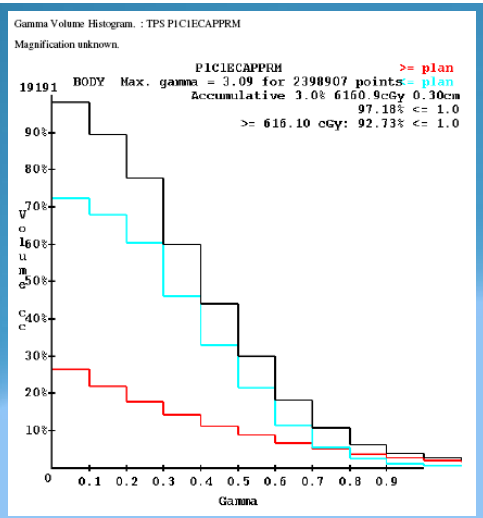
Transverse view | Sagittal view | Coronal view



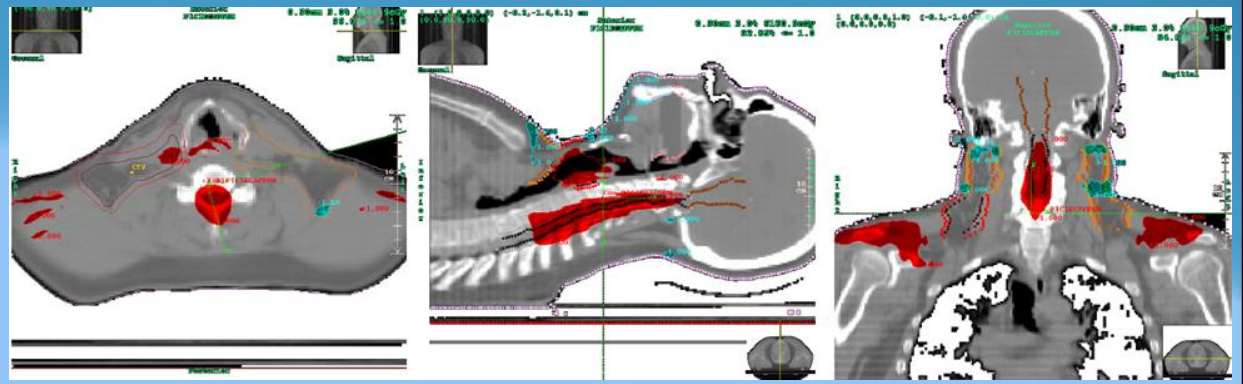



Line profiles (dotted TPS, continuous DOSIMETRY CHECK) along the dotted yellow line in the corresponding upper view.



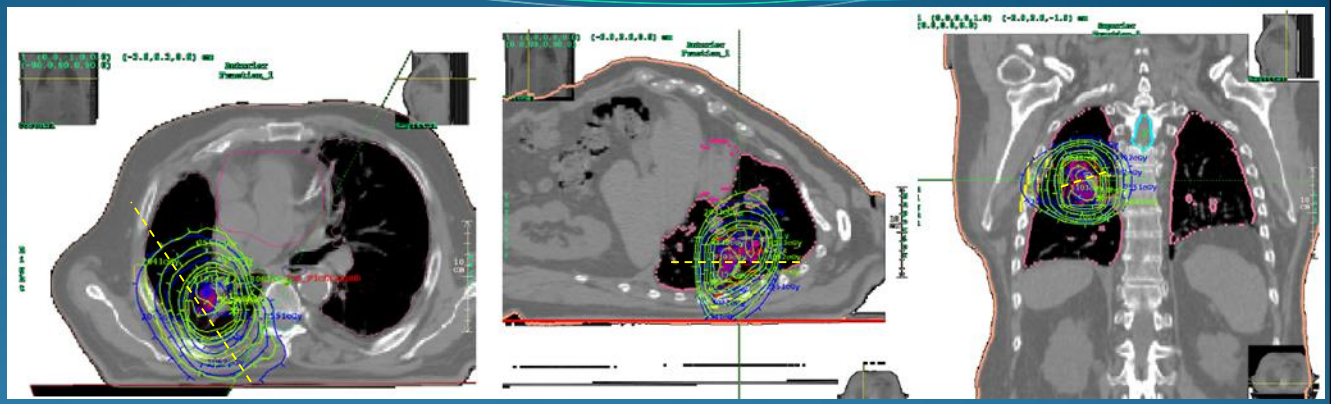

3D gamma analysis

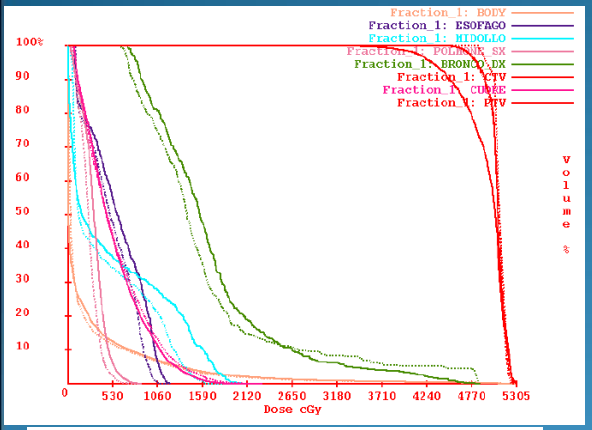


# Thorax

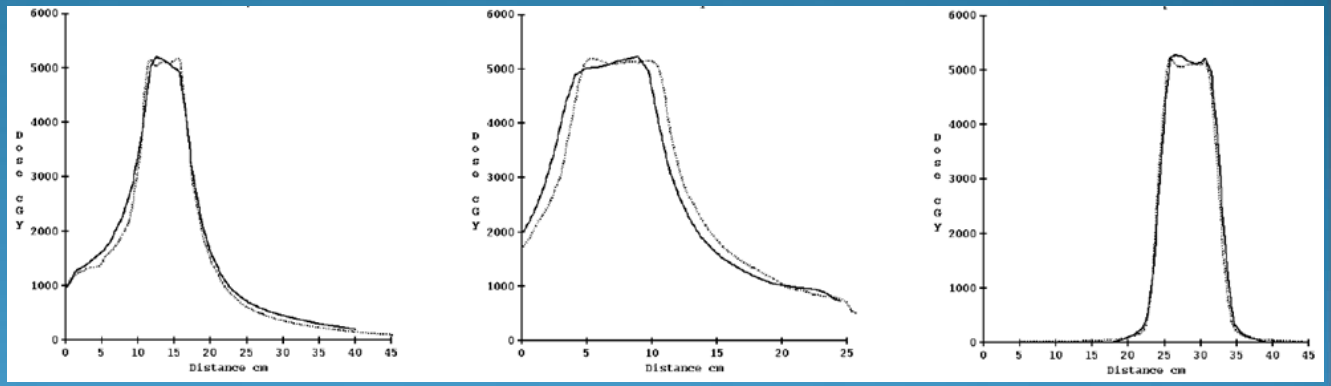
3D Isodose line comparison (blue TPS, green DOSIMETRY CHECK).

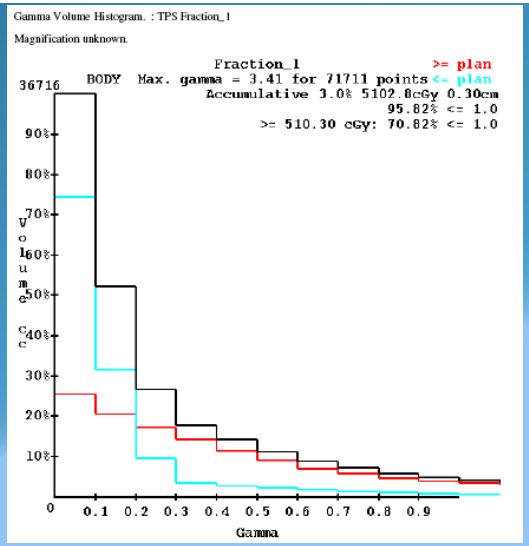
Transverse view | Sagittal view | Coronal view



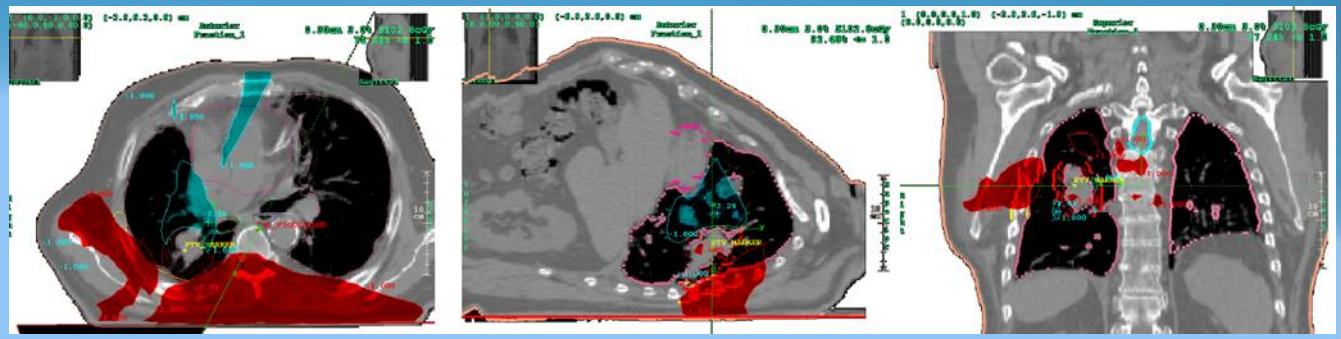



Line profiles (dotted TPS, continuous DOSIMETRY CHECK) along the dotted yellow line in the corresponding upper view.



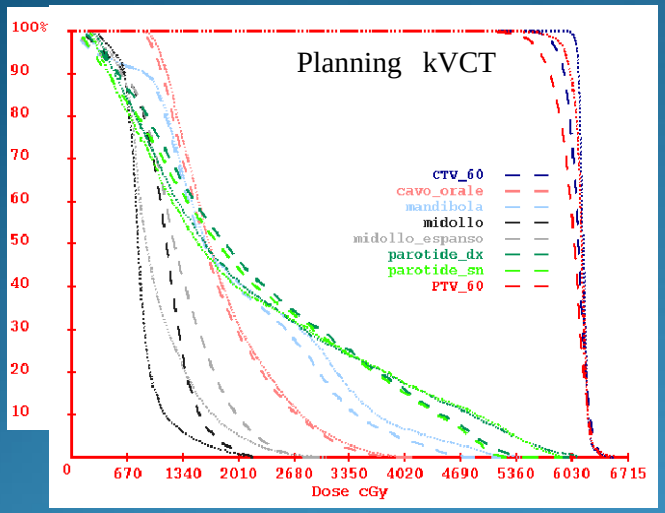




3D gamma analysis



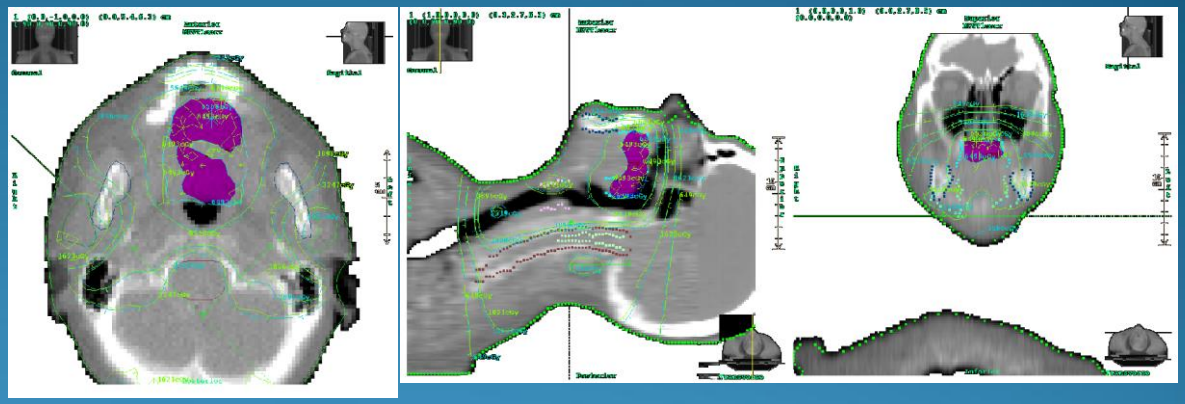
# In-vivo dosimetry of a head & neck patient-specific Tomotherapy treatment plan: MVCT merged on planning kVCT

**DVH comparison between TPS (dotted) and DC (dashed) using the planning kVCT**

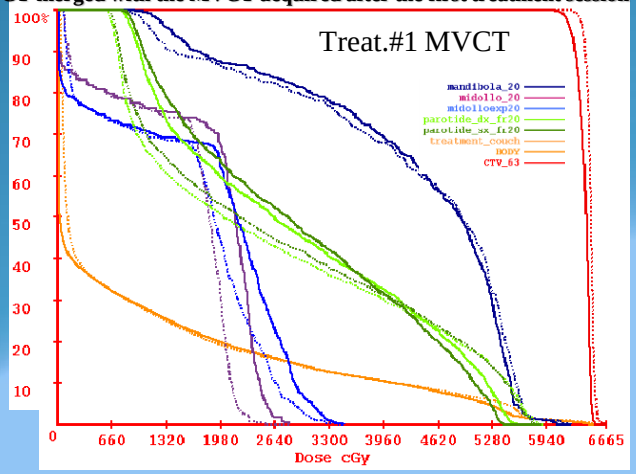



**3D Isodose line comparison (blue TPS, green DOSIMETRY CHECK).**

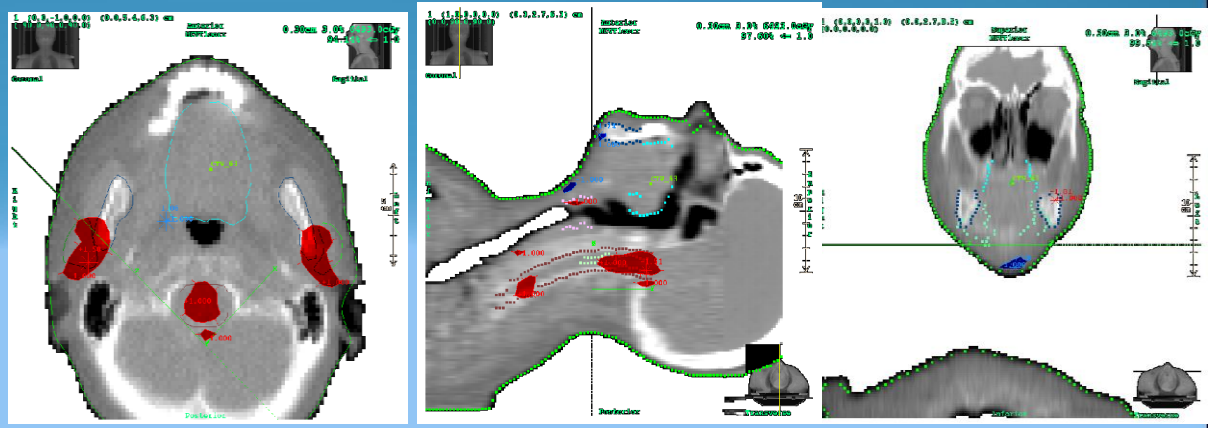
**Transverse view** **Sagittal view** **Coronal view**



**DVH comparison between TPS (dotted) and DC (continuous) using the planning kVCT merged with the MVCT acquired after the first treatment session**




**3D gamma analysis**



**The results here shown represent a summary of those shown at:**

**13th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD13) 7 - 10 October 2013 Siena, Italy**


TORINO
16-19 Novembre 2013

**Forthcoming pubblication:**

E.Mezzenga et al., JINST, April 2014:
"Pre-treatment and in-vivo dosimetry of Helical Tomotherapy treatment plans using the Dosimetry Check system"

# Acknowledgments

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