Treatment Planning Basics

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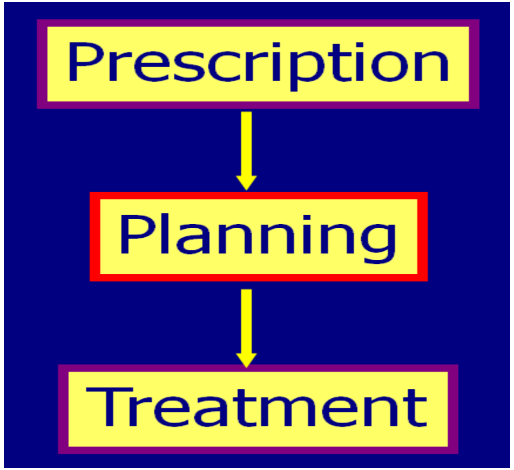
Agenda

- Radiation Treatment Planning
- Planning Process Overview
- Patient data - Volume definitions
- Computed Tomography – CT
- Plan Evaluation-Isodose distribution
- Treatment unit data
- Dose calculation algorithm
- Example of plan step by step

Radiation treatment planning

- **The radiation treatment planning is the process in which a team consisting of radiation oncologist, radiation therapist and medical physicist plan the appropriate external (or internal) radiotherapy.**



- **The treatment planning is the task to make sure a prescription is put into practice in an optimized way.**

Planning process overview

Patient information →
- CT, MRI, PET, SPECT, ultrasound
- Localization of tumour and critical structures

Treatment unit data →
- Field sizes
- PDDs
- Profiles
- Radiation quality

Planning →
- Optimization of source and beam placement
- Dose calculation

Treatment plan →
- Dose calculation
- Preparation of treatment sheet
- Record and verify data

Patient data ->Volume definitions

- **The patient‘s body is neither homogeneous nor flat in surface contour.**
- **The dose distribution in a patient may differ from a standard distribution (usually measured in a water phantom, in standard conditions).**
- **Accurate patient dosimetry is possible when sufficiently accurate patient data are available:**
  - Body contour
  - Density of relevant internal structures
  - Location and extension of target volumes
  - .....

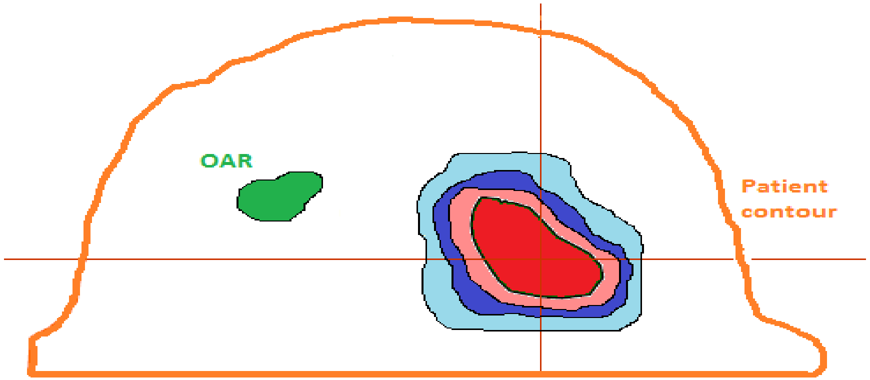
PTV - history

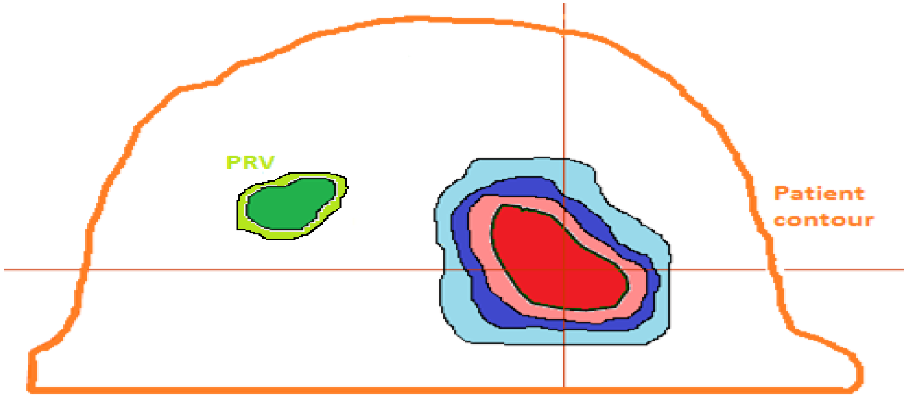
ICRU report	Definitions	Uncertainties
Report 29 (1978) 2D RT	TV Target volume	Biological + Repositioning
Report 50 (1993) early 3D RT	CTV Clinical Target Volume	Biological
	PTV Planning Target Volume	Repositioning
Report 62 (1999) advanced 3D RT	CTV Clinical Target Volume	Biological Subclinical extension
	ITV Internal target Volume	Organ motion
	PTV Planning Target volume	Repositioning

Organ At Risk - OAR

Organs at risk are normal tissues whose radiation sensitivity may significantly influence treatment planning and/or prescribed dose

- **Margins needed to be added to compensate for its movements (internal movements or set-up).**
- **This leads to the concept of the Planning Organ at Risk Volume (PRV).**



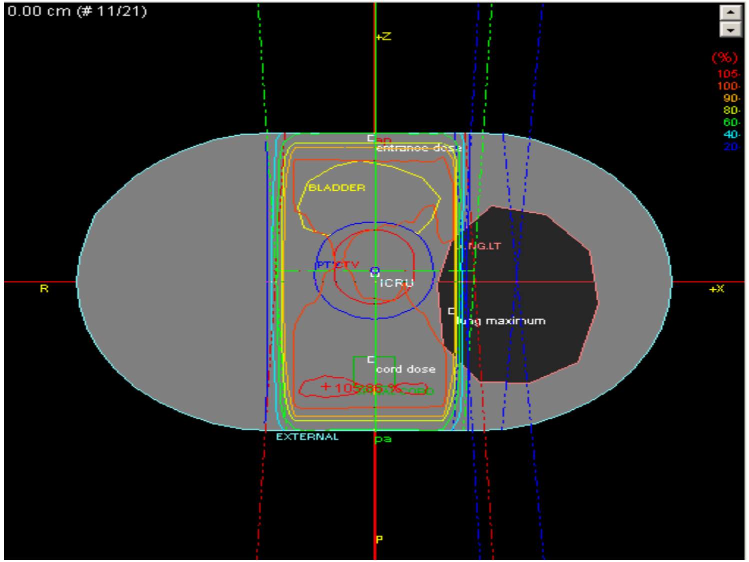


Computed Tomography - CT

- For 3D treatment planning a CT data set is required.
- On each CT slide shall be delineated: external contours (skin or immobilization mask), tumor, target volumes and, if necessary, organs at risk.
- The patient shall be in the same position as in the treatment.

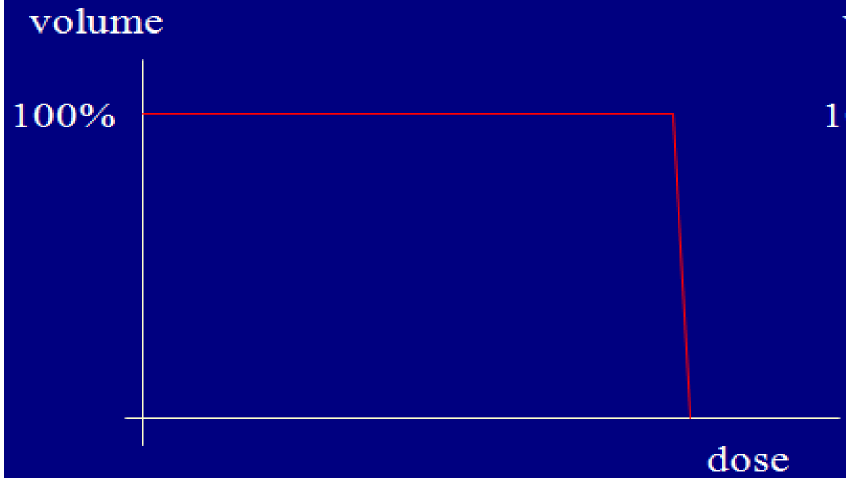
Plan Evaluation-Isodose distribution

- **The isodose distribution is verified to ensure that the target coverage is adequate and the critical structures are spared as necessary.**

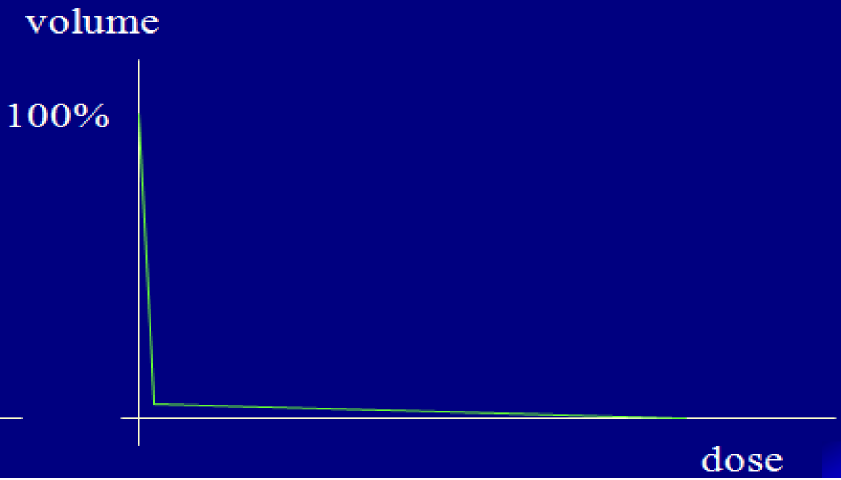


Plan Evaluation-Ideal DVH

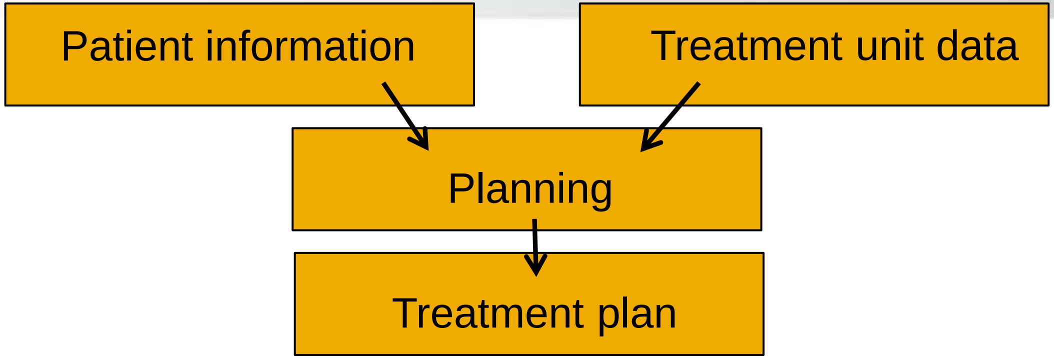
- Tumour:
  - High dose to all
  - Homogenous dose



- Critical organ
  - Low dose to most of the structure



Treatment unit data



- Field sizes
- Output factors
- Profiles
- PDD for SSD setup
- TAR for SAD setup
- Beam quality

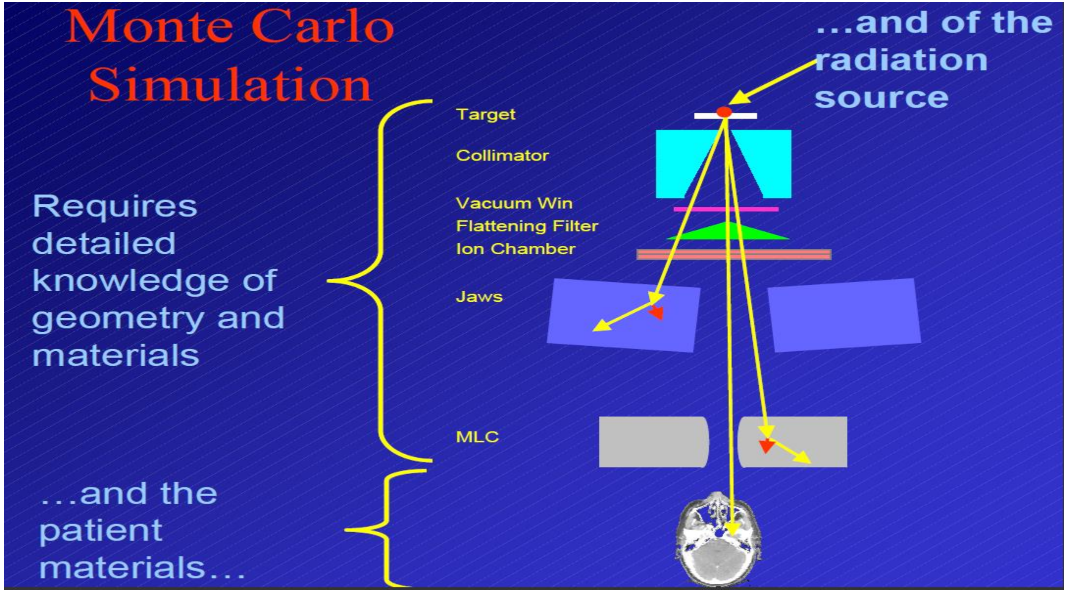
- Calibration
- Mechanical components
- Jaws and MLC
- Static and virtual wedges

Dose calculation algorithm

- The intent of a dose calculation algorithm is to predict the dose to any point in the patient as much accurate as possible.
- These algorithms have inherent limitations due to approximations used in the physical model.
- Prior the 1970s the algorithms were intended for manual calculation: simple and straightforward, but really time consuming.
- From 1970s the development of CT and powerful computers lead to CT-based computerized TPS: dose distribution could be viewed directly superimposed upon patient´s axial anatomy.

Monte Carlo methods

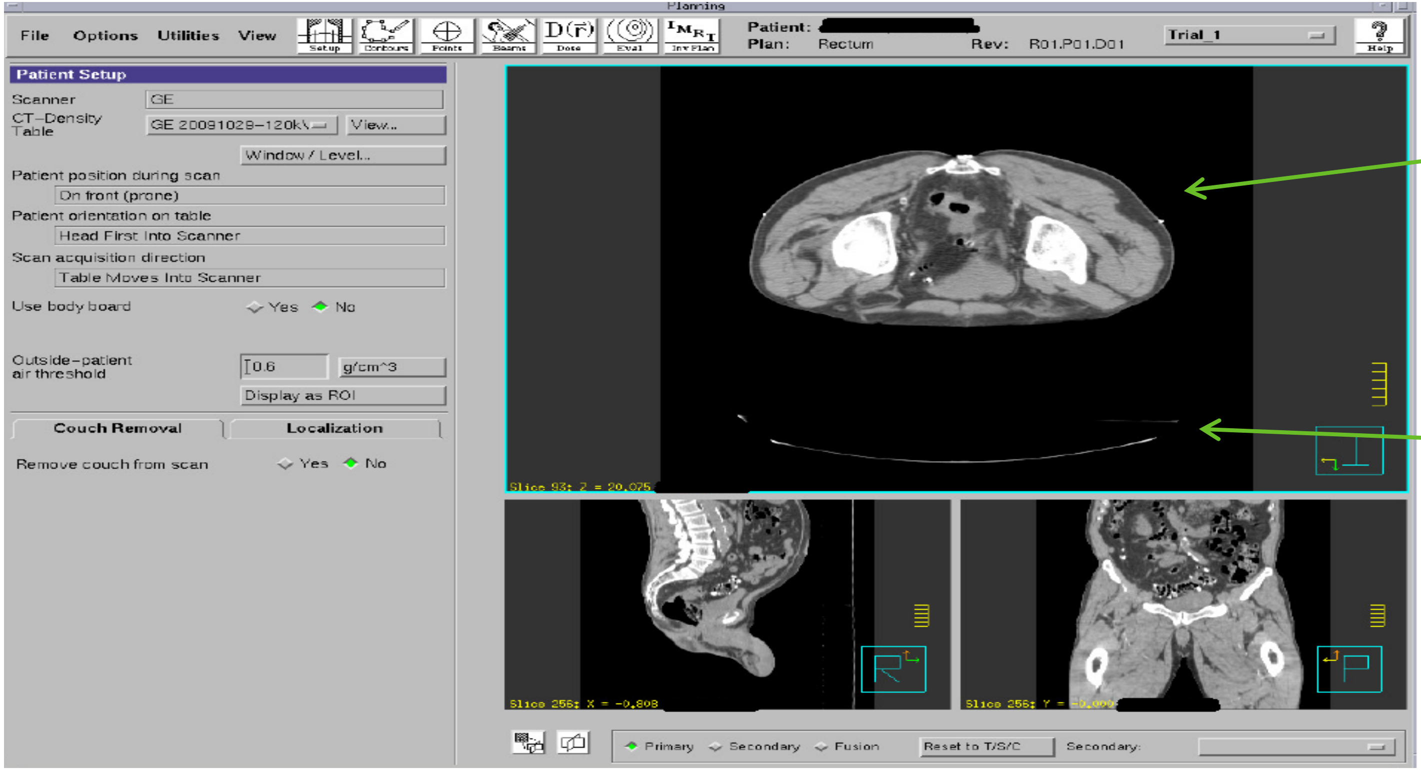
- Monte Carlo techniques are used to generate dose distributions by following the histories (from the source to the patient) of a large number of particles.
- MC needs information regarding linac and patient.



Example of plan step by step

1. CT of the patient.

CT setup parameters



markers

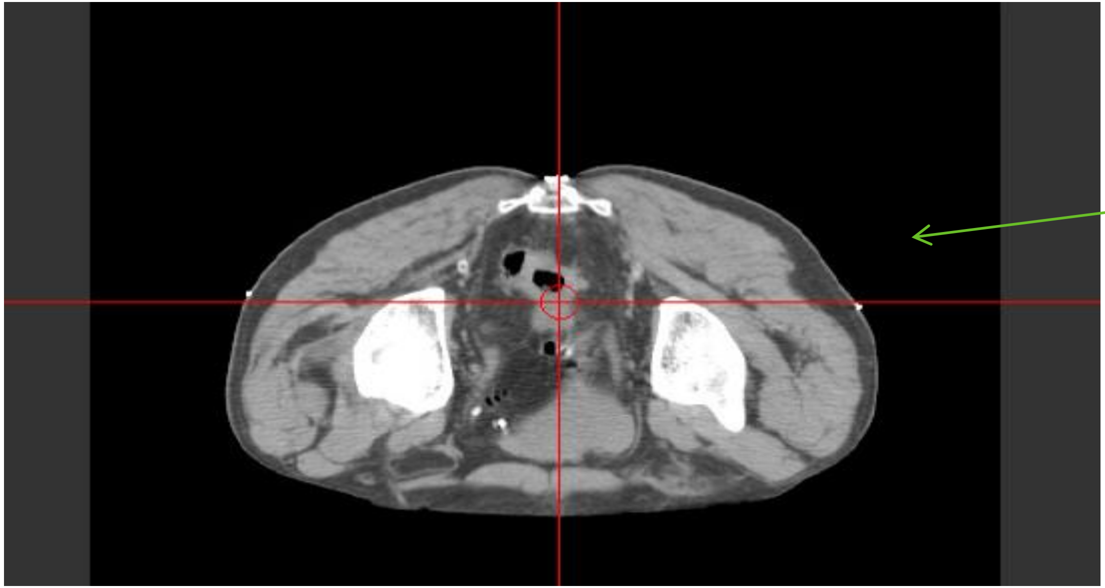
table

Example of plan step by step

2. Creation of the laser point.

It´s the internal point aligned with the markers.

In general doesn´t correspond to the isocenter

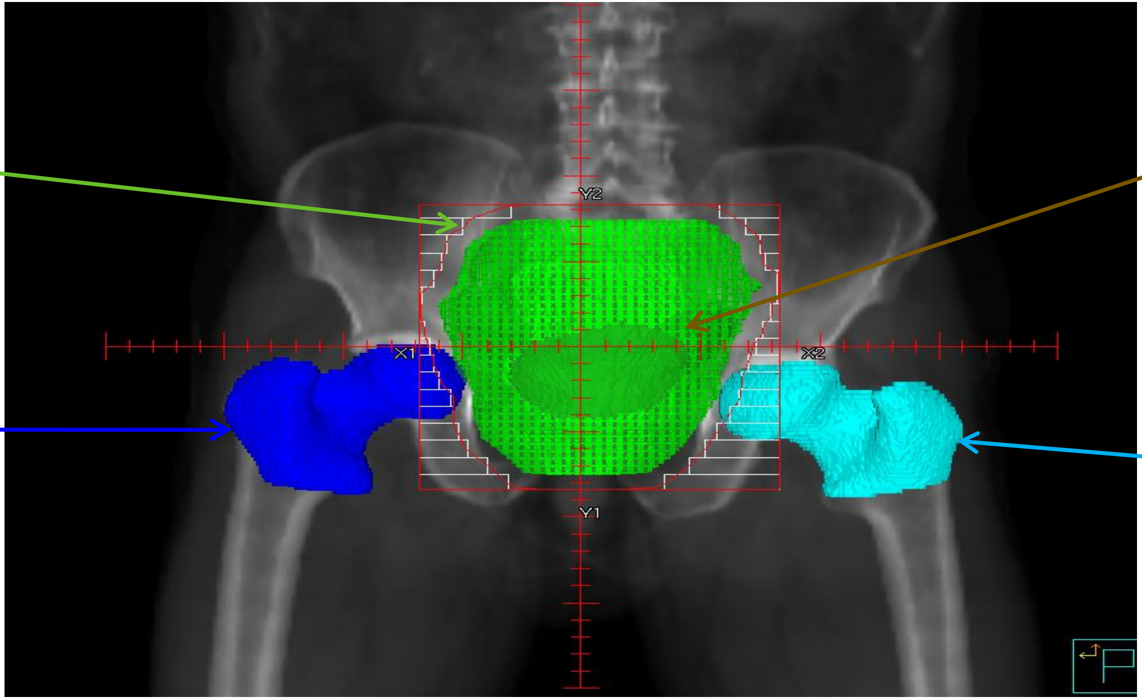


markers

Example of plan step by step

3. PTV and OAR

PTV is given by the oncologist.

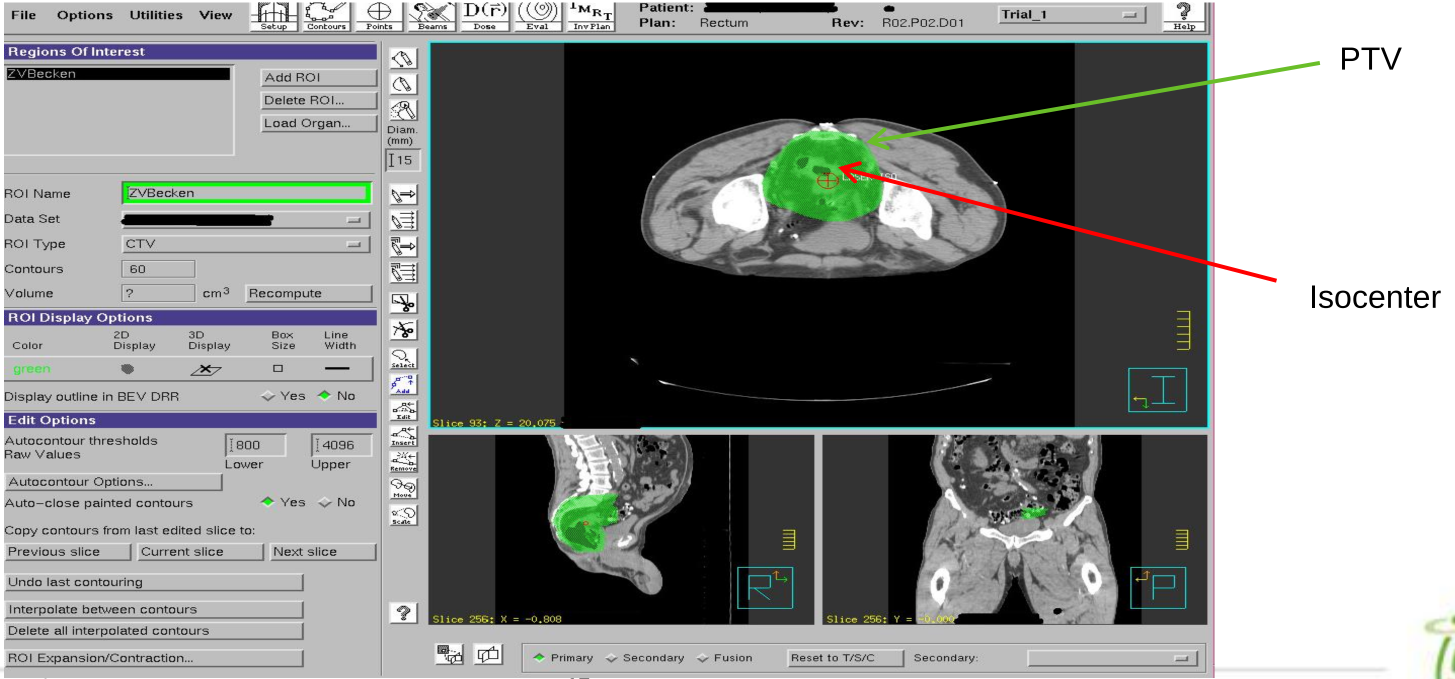


Example of plan step by step

4. Creation of the isocenter.

It´s usually located at the center of the PTV.

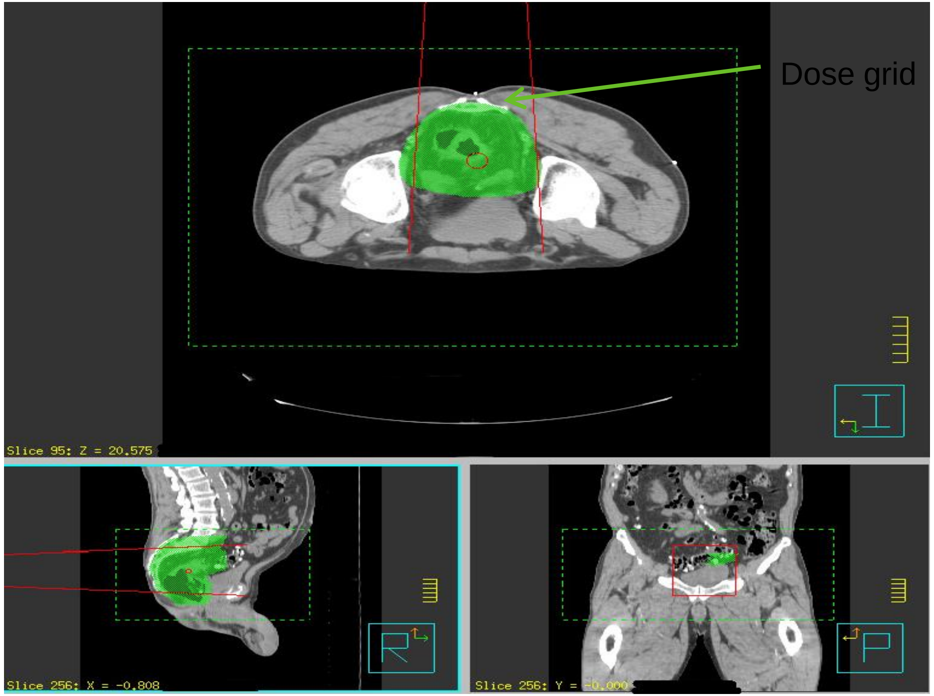
In this case the laser point is inside the PTV and corresponds to the isocenter.



Example of plan step by step

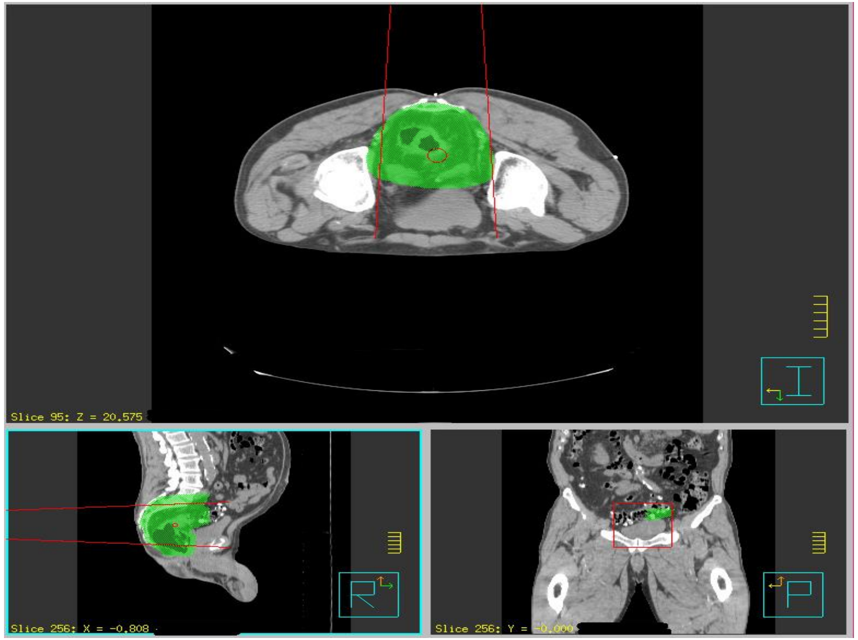
5. Dose grid definition.

Definition of the area where the dose calculation takes place. The dose grid has to be defined in the three directions.



Example of plan step by step

6. Beams definition.

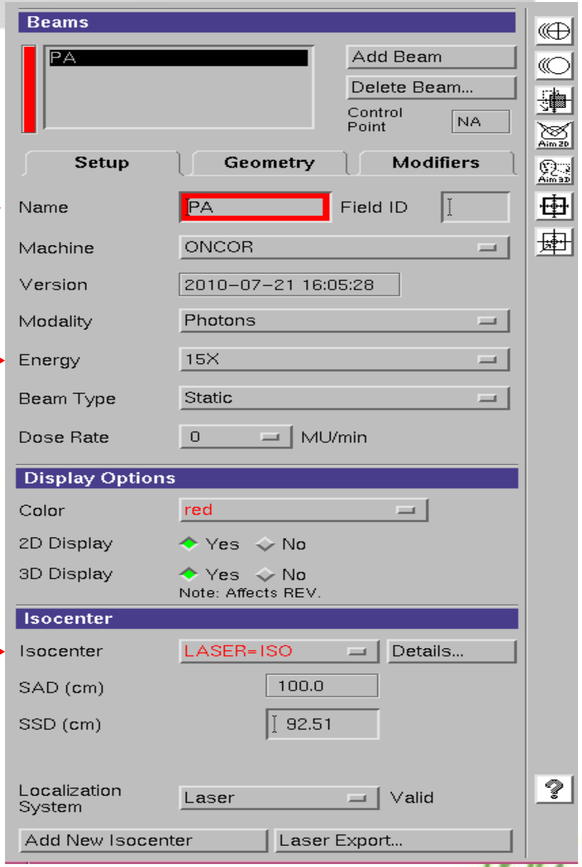


Direction

Energy

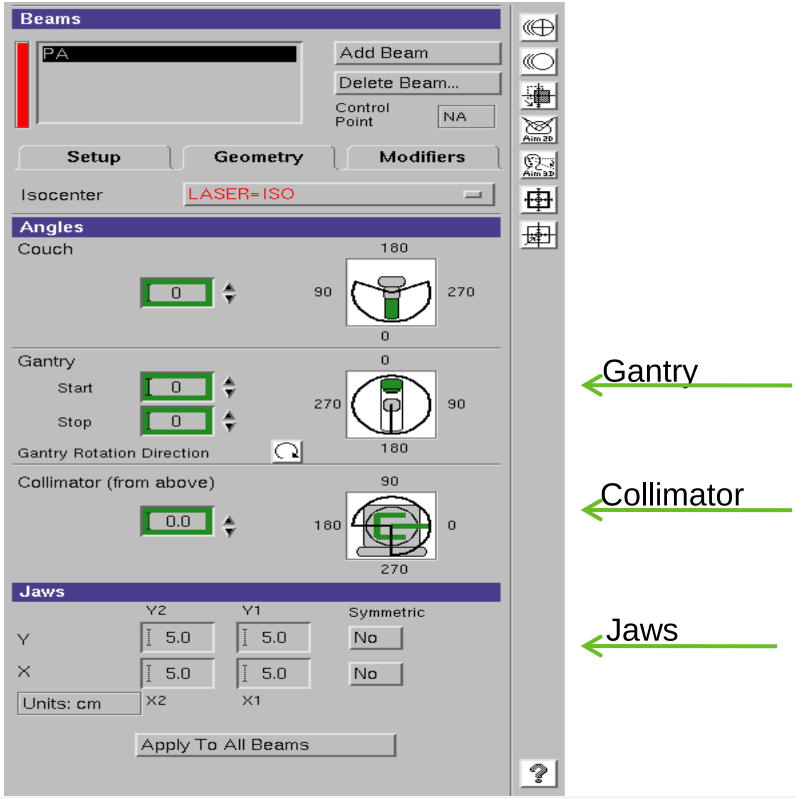
Display

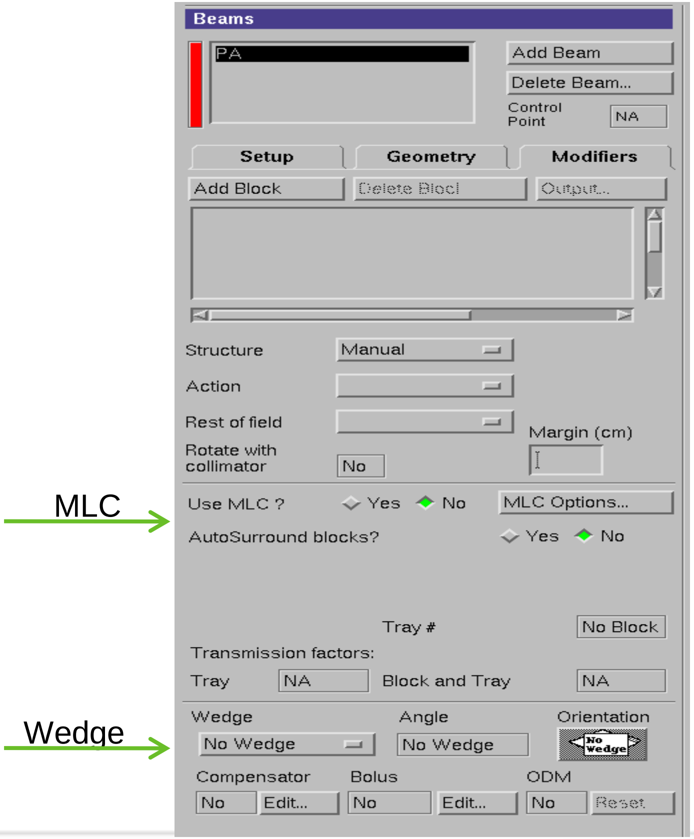
Isocenter



Example of plan step by step

6. Beams definition.



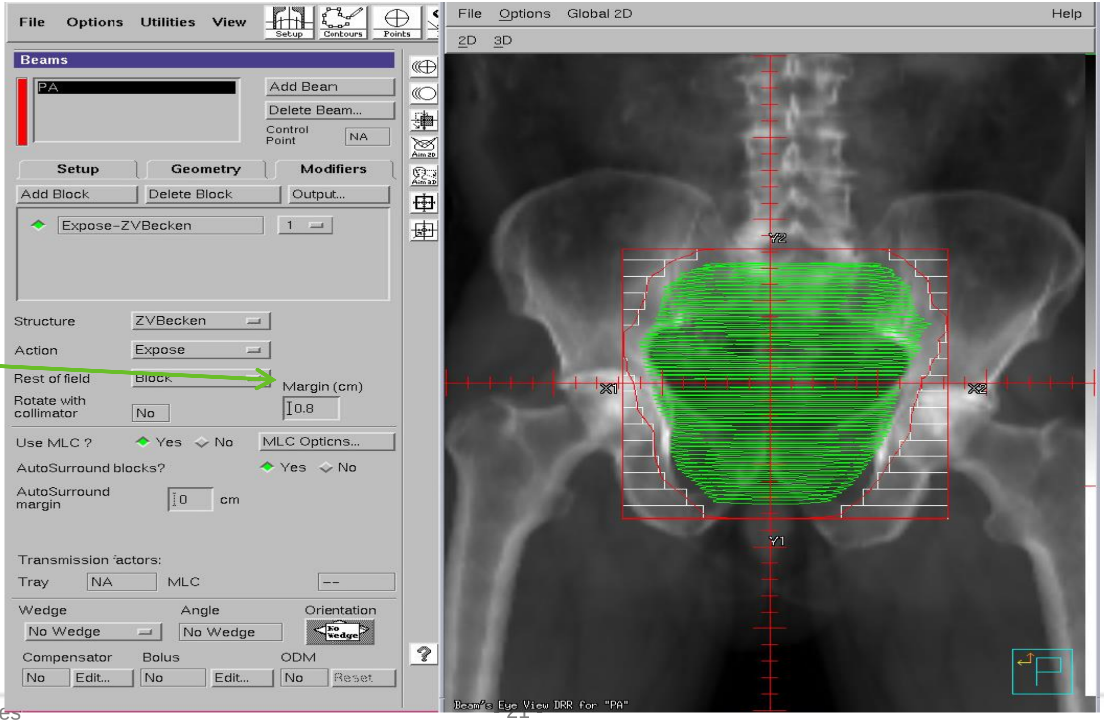


Example of plan step by step

7. MLC definition.

Automatically adjusted around the PTV. The penumbra margin is now taken into account.

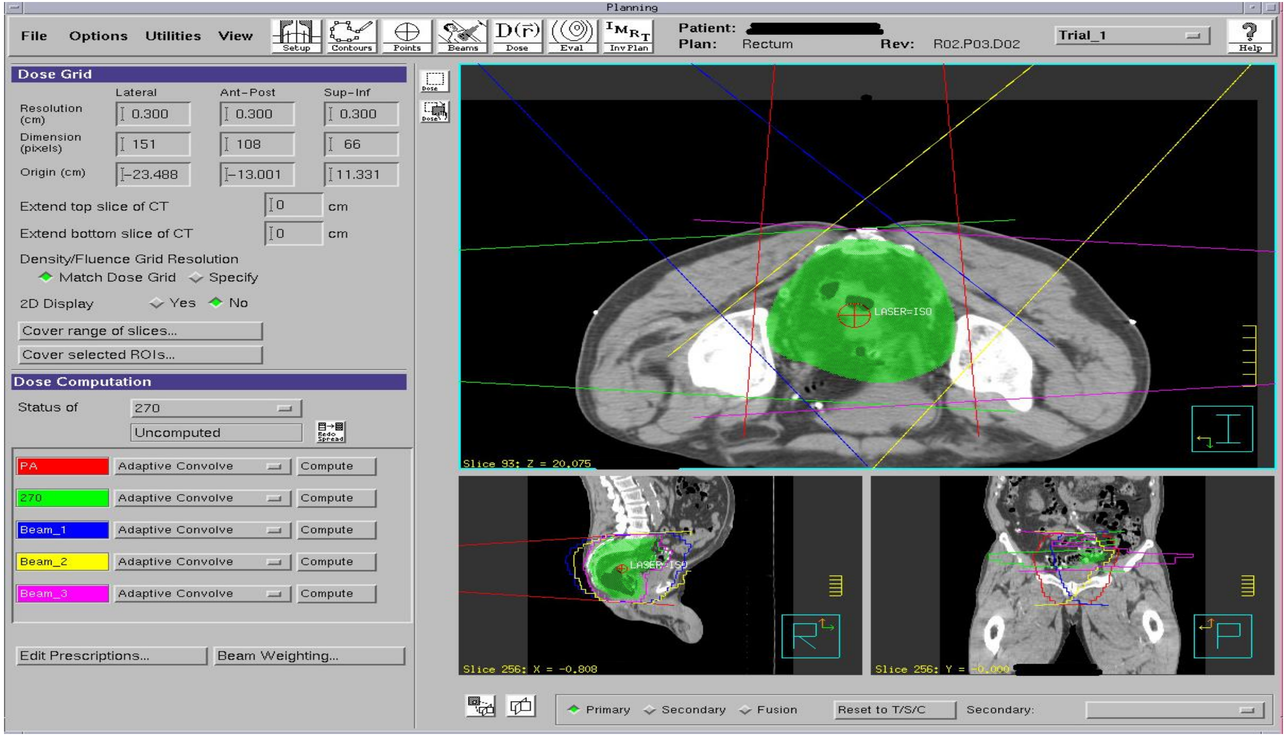
Penumbra margin



Beam Eyes View (BEV)

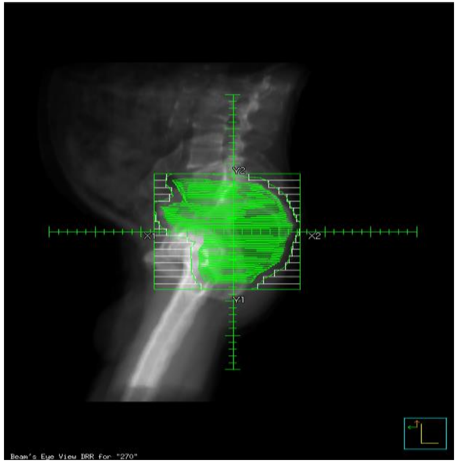
Example of plan step by step

8. Complete beams definition.



5 beams are defined:

- PA
- 270 (BEV under)
- 90
- 320
- 40



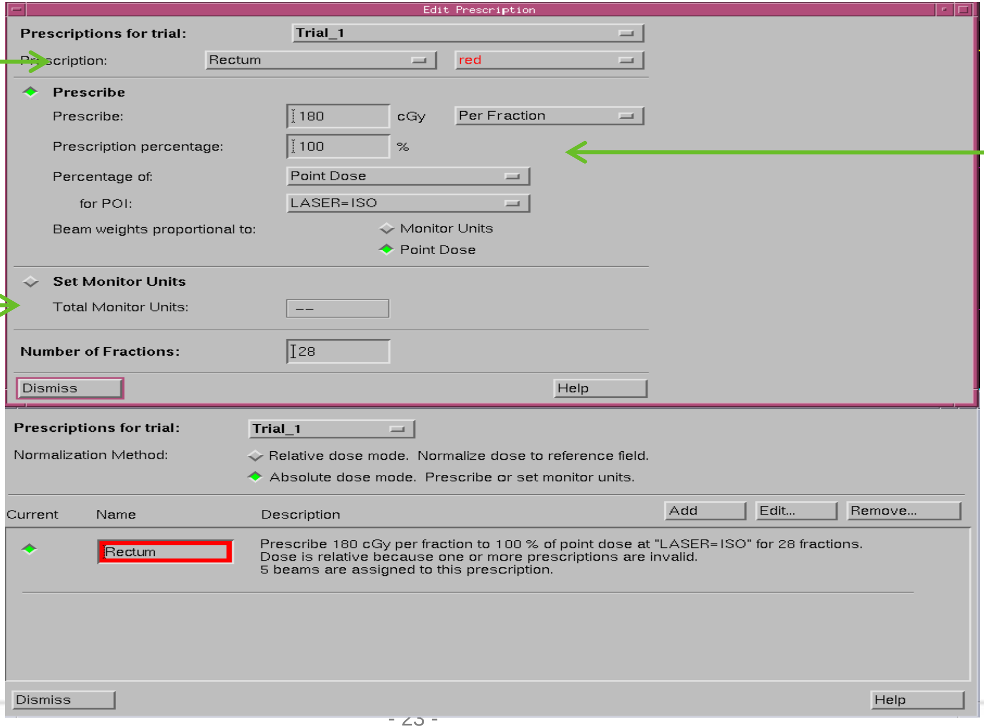
Example of plan step by step

9. Prescription definition.

Dose per fraction and number of fractions are given by the oncologist.

Dose for fraction

Fractions

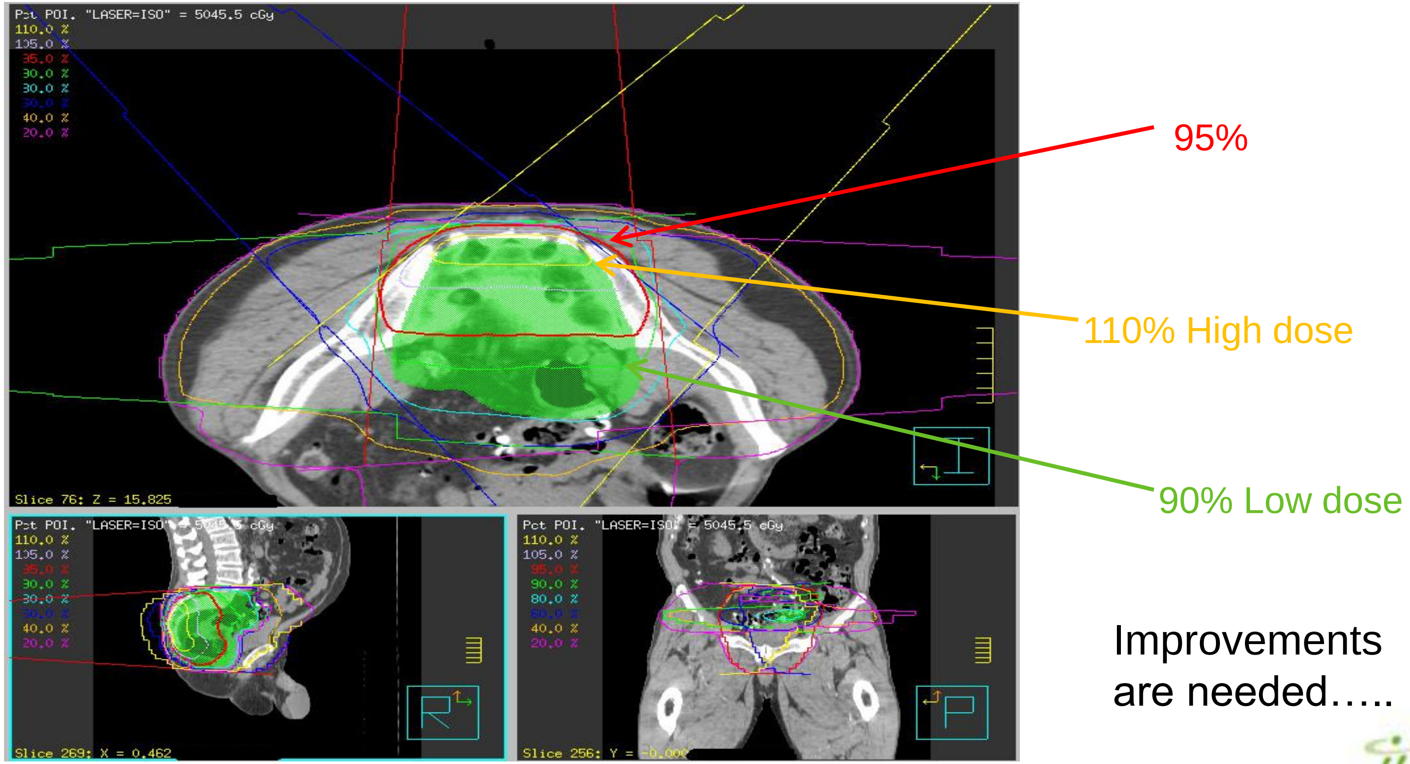


It's important to define the point respect to the dose calculation is computed.

Example of plan step by step

10. First dose calculation

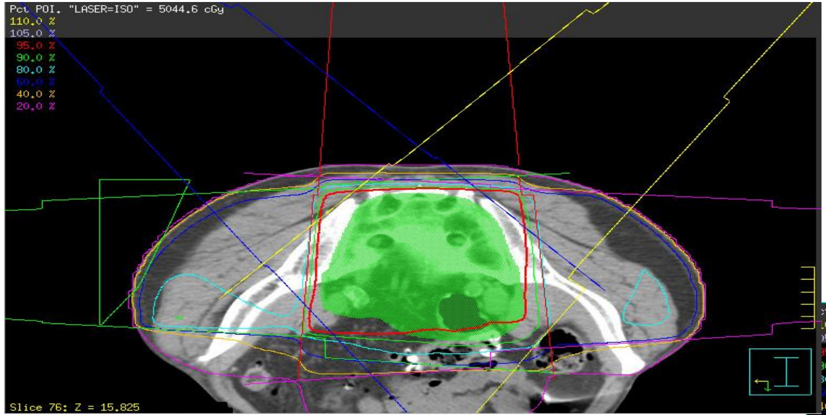
The PTV should be covered by the 95% isodose.
In the PTV no isodose over the 105%.



Improvements are needed…..

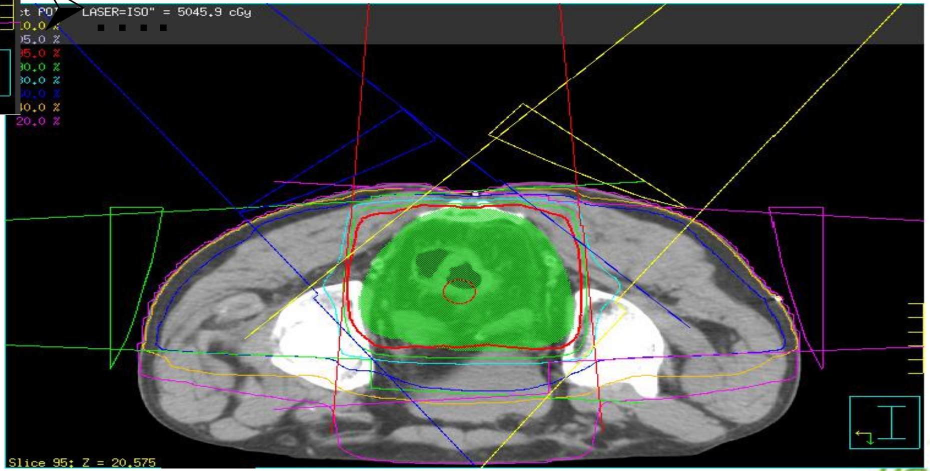
Example of plan step by step

11. Optimization



You can play with:

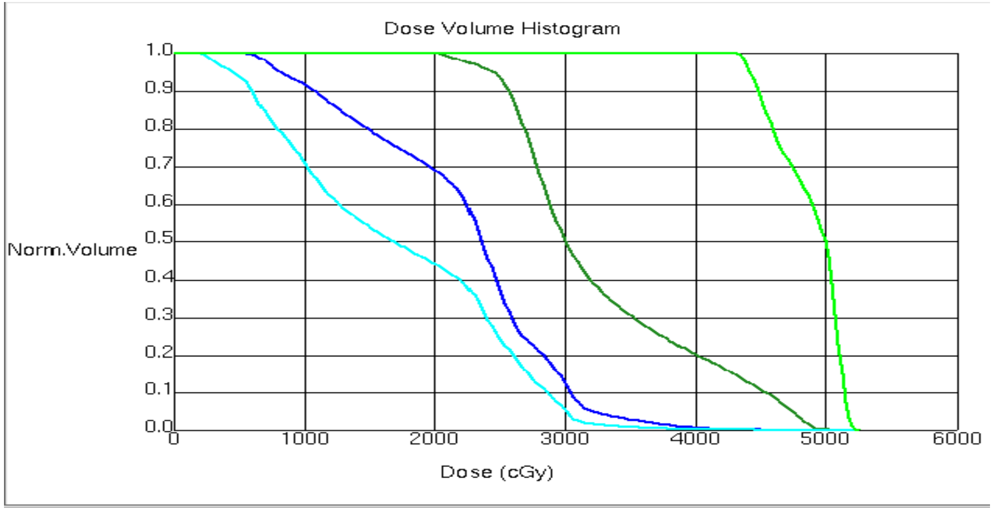
- Wedges
- Beam weight
- Beam angles
- MLC opening
- ....



You have to accept some compromises.

Example of plan step by step

12. DVH and dose values.



ROI Statistics

Line Type	ROI	Trial	Min.	Max.	Mean	Std. Dev.
	Bladder1	SUMENPLAN	1945.6	5027.1	3266.5	730.3
	Femur_L	SUMENPLAN	376.4	4495.8	2211.7	738.0
	Femur_R	SUMENPLAN	211.8	4445.9	1711.6	880.2
	ZVBecken	SUMENPLAN	4172.9	5254.1	4880.5	256.3

Thank you!