Eclipse

Treatment Planning - The Basics

Martin Sabel
Varian Medical Systems
Zug, Switzerland

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Agenda

- Treatment planning
- Workflow: Conventionel planning
- Images
- Contouring
- Beam setup
- Dose calculation
- Workflow: Inverse planning
- Eclipse Helios

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What is Treatment Planning

- Treatment Planning is a process which results in
  - Blueprint for the optimal treatment
  - Optimal treatment:
    - Maximizing target coverage
    - Minimizing normal tissue care

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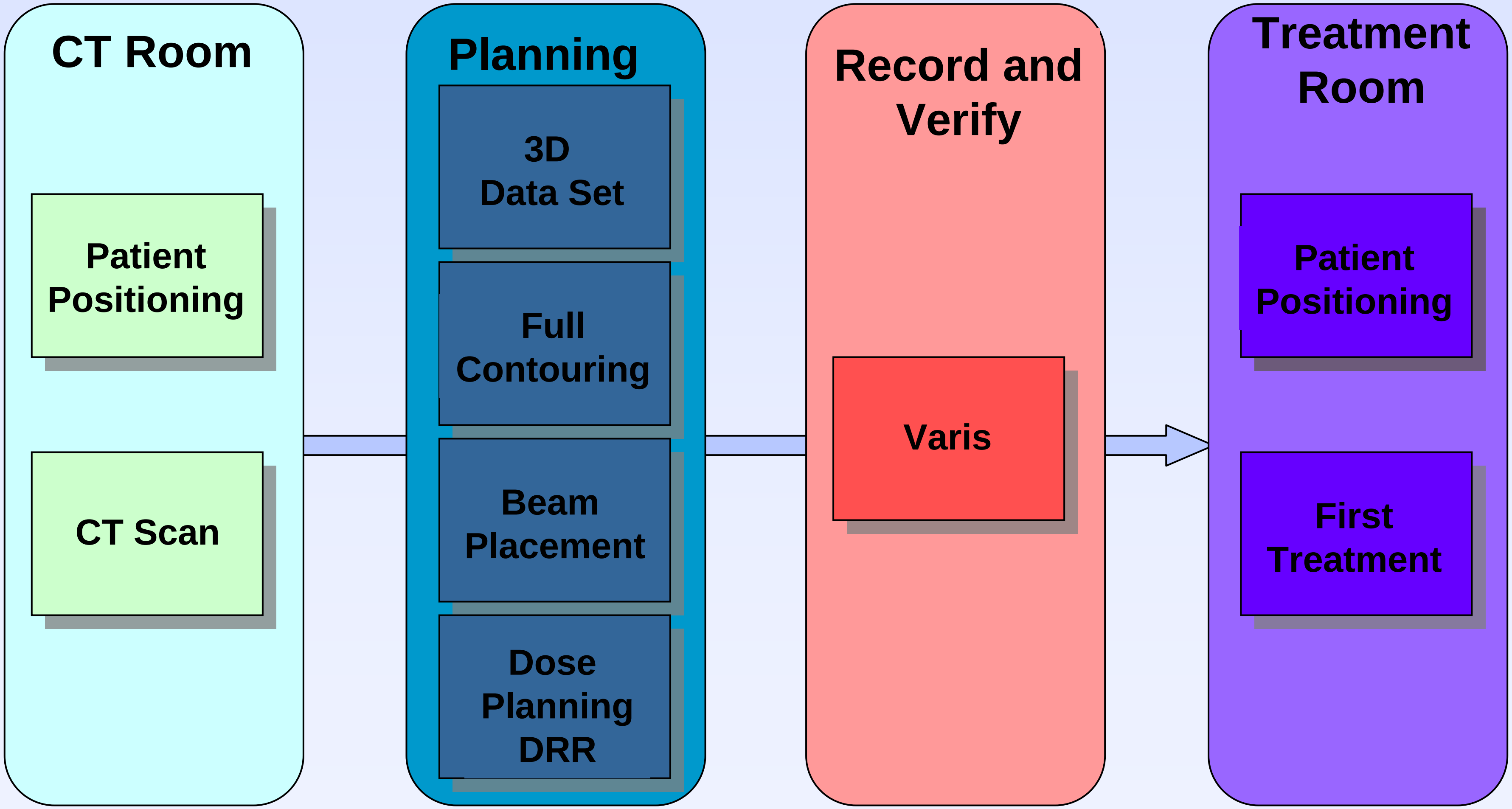
Workflow: 3D conventional radiotherapy



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Workflow in Eclipse

Patient Preparation
- Image Import
- 3D Data Set

Contouring
- Body contour
- Target outlining
- Critical structures

Field Setup
- Beam placement
- Beam modifiers
- DRR generation

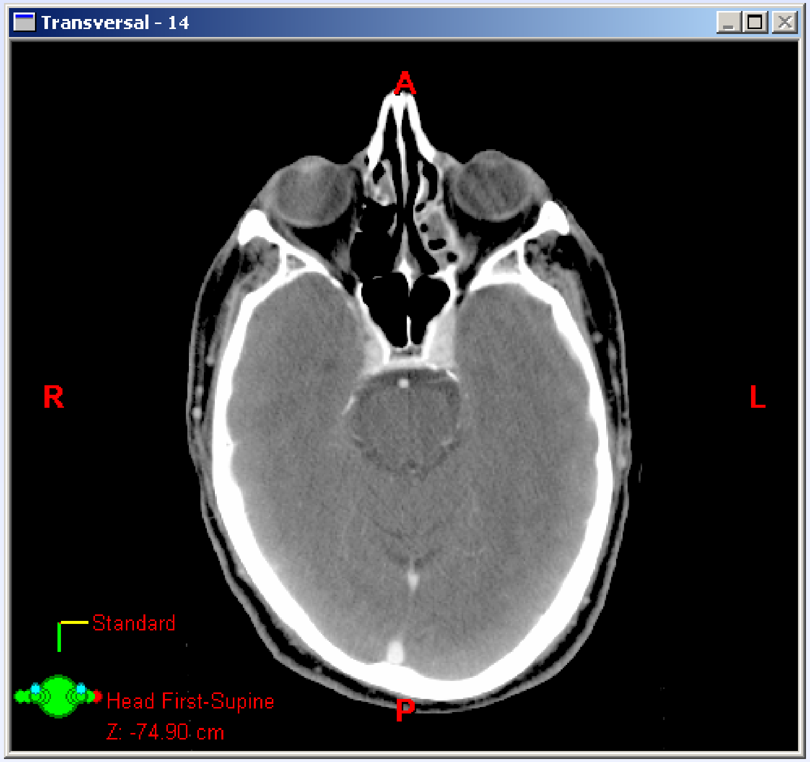
Dose Calculation
- Algorithm selection
- Dose calculation
- Printouts

Patient Preparation

- What does Eclipse require?
  - Images in Dicom 3 format
- What kind of images?
  - CT
  - MRI
  - PET

Images for Treatment Planning

- Primary Imaging Modality
  - CT Images
    - Represents the electron density directly in the image
    - Very robust geometrical accuracy
    - Short scanning time



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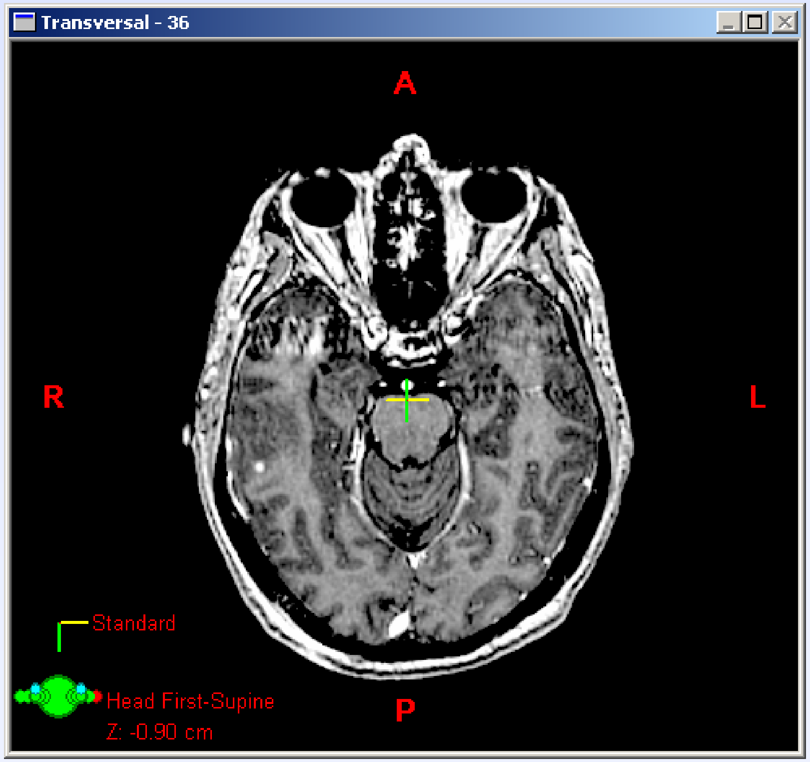
Images for Treatment Planning

- Other Modalities
  - Magnetic Resonance Imaging (MRI)
  - Advantages of MR images
    - CT is unable to visualize tumors that exhibit little change in atomic numbers compared to their surroundings
    - Not constrained to the axial plane
    - No potential artifacts

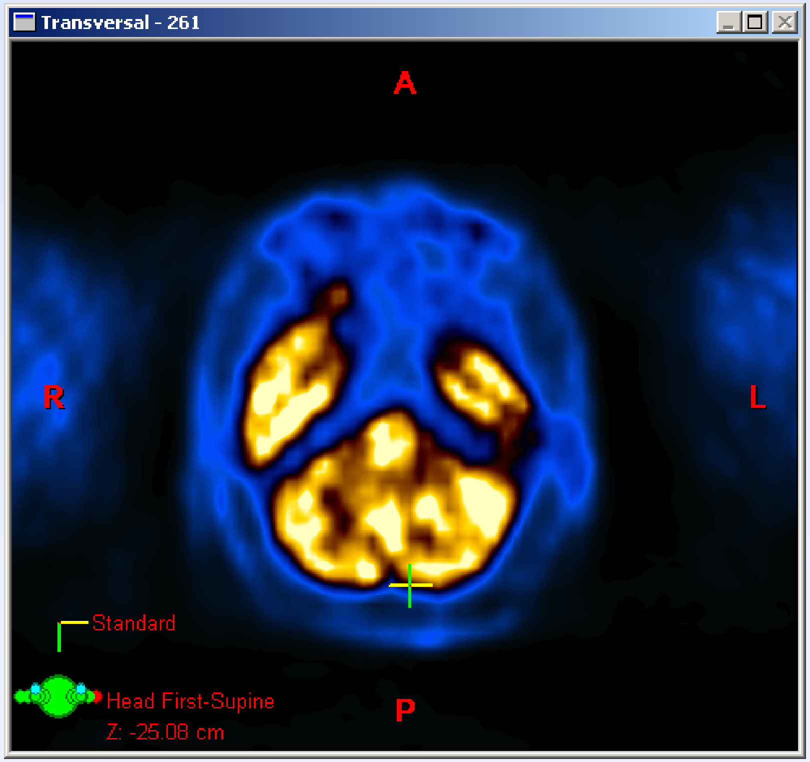


Images for Treatment Planning

- Other Modalities
  - Magnetic Resonance Imaging (MRI)
  - Disadvantages of MR images
    - No electron density information
    - Sometimes geometrical distortions

Images for Treatment Planning

- Other Modalities
  - Positron Emission Tomography (PET)
  - Advantages of PET images
    - Ability to achieve absolute quantification of the radiotracer concentration → allows evaluation of treatment response
    - Show the active tumor and the active lymph nodes



Better technology. Better outcomes.

Images for Treatment Planning

- Other Modalities
  - Positron Emission Tomography (PET)
  - Disadvantages of PET images
    - No electron density information
    - Resolution
    - Scanning time
    - Table without inserts

Images for Treatment Planning

	CT	MRI	PET
Primary Signal	Electron Density	Proton Density	Isotope Concentration
Resolution	~ 0.78mm	1mm	4 mm
Tumor Specificity	Low	Low	Med-High
Tumor Sensitivity	Low	High	High
Scanning Time	short	1-10 min	10-80 min

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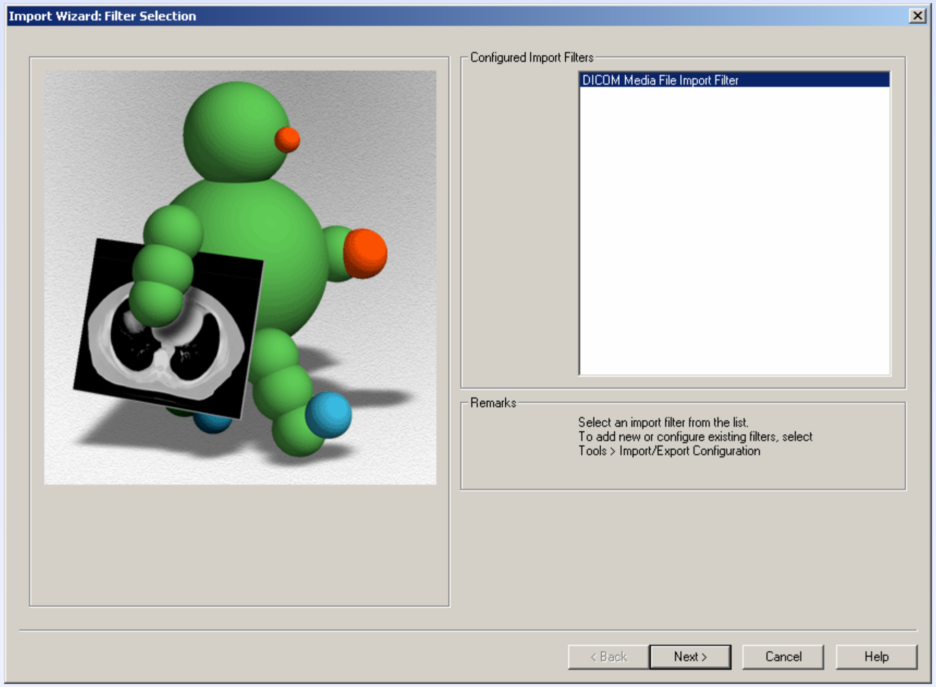
Images for Treatment Planning

- CT images are needed for the dose calculation (information about the electron density) and MRI or PET images for the good localization of tumors and in case of PET images for the treatment response.

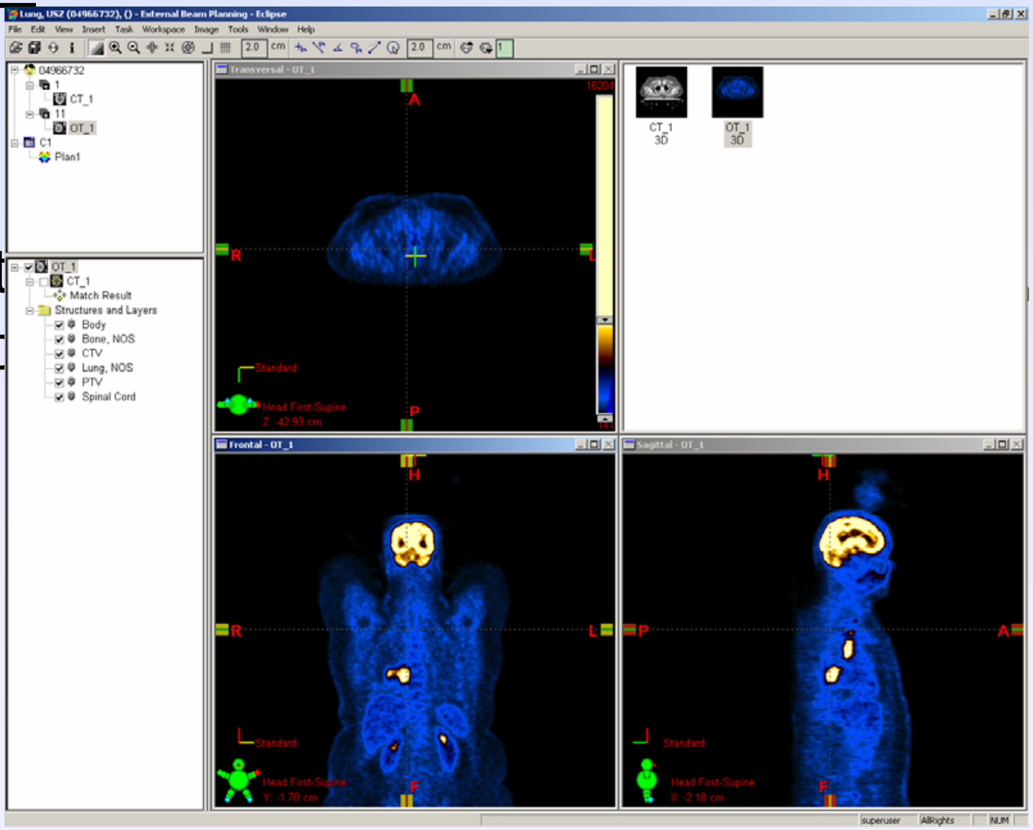
Images Import

- How can you bring in the images from your scanners into the Eclipse system?
  - Import Wizard for Dicom Images



3D Image Set

- Eclipse needs a 3D CT data set for treatment planning
- Additional 3D data set can be created: PET o MRI



Registration

- 3 different possibilities
  - CT – CT
  - CT – MRI
  - CT – PET

Registration CT – MRI or CT- CT

- 4 points in each modality
- Each point pair is at the same anatomical position
- Indicator shows a rough matchresult (better than 10mm)
- Match button

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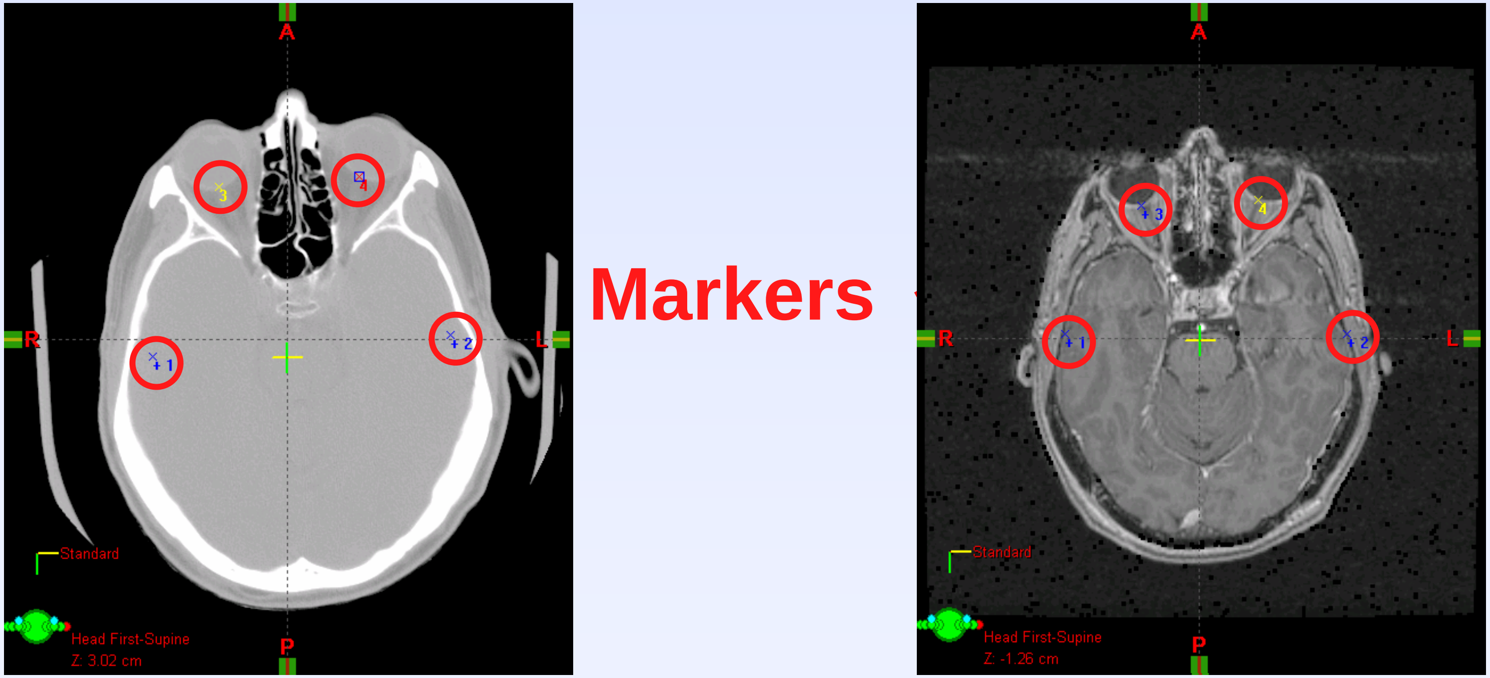
Registration with Markers

- CT-MRI manual match



CT Image

MR Image

Match Indicator

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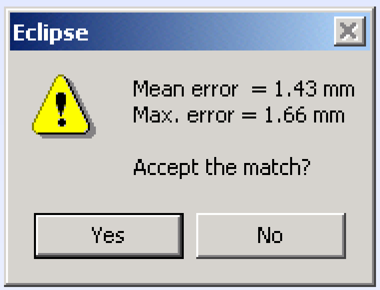
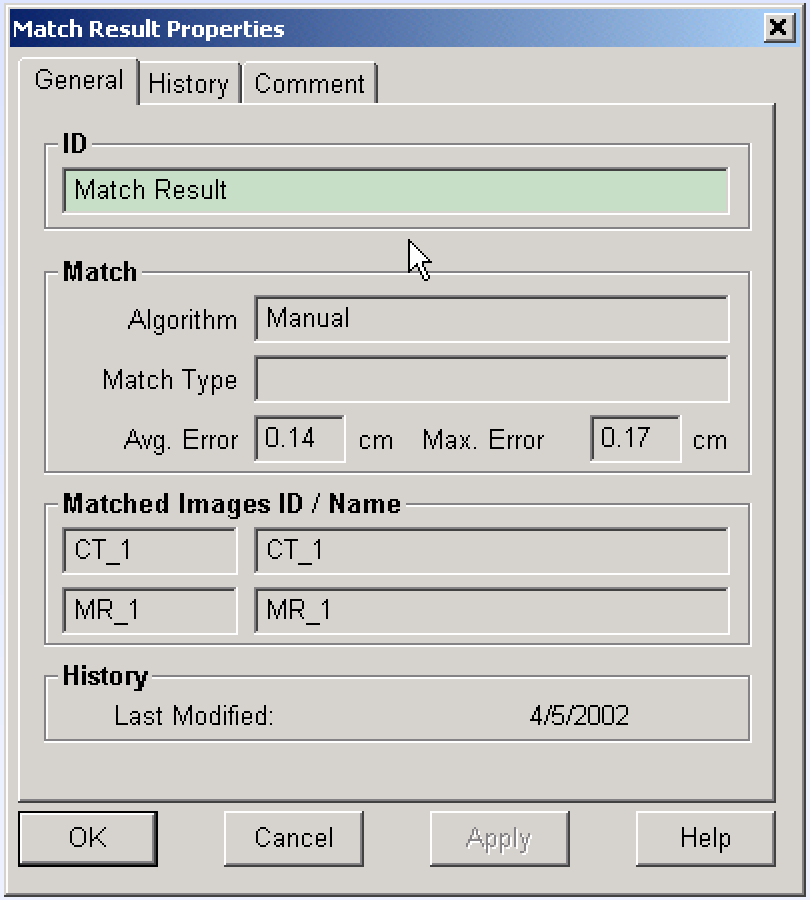
Registration with Markers

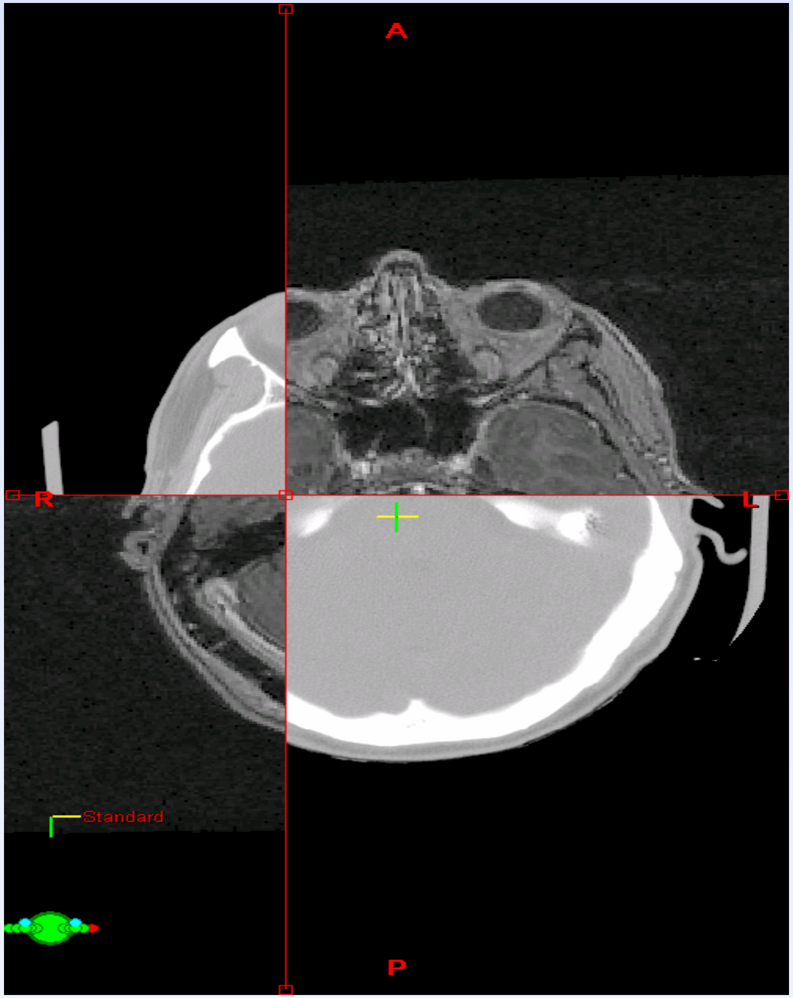
- CT-MRI manual match



Match result



Registration with Markers



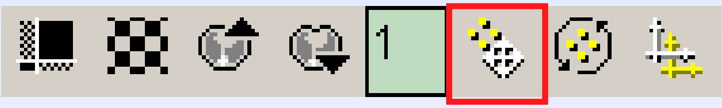
Registration CT-PET

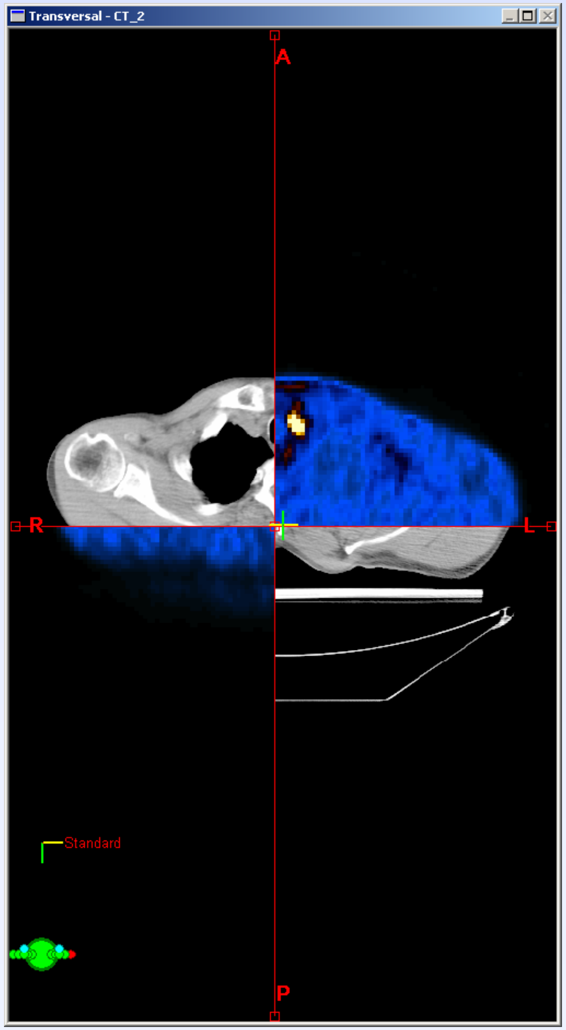
- In case the RT department has access to a PET-CT scanner, the match process is faster

- PET-CT scanner advantage
  - PET and CT data set are taken at the same time
  - Patient position is the same
  - Coordinate system is the same
  - Table is the same

Registration CT-PET

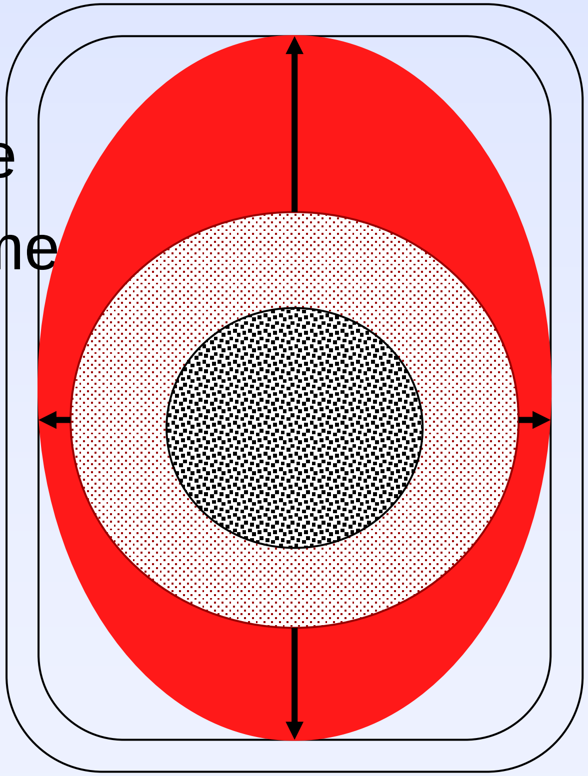
- One click on the translation icon registers the CT and the PET data set





Contouring

- GTV – CTV – PTV:
  - Gross Tumor Volume
  - Clinical Target Volume
  - Planning Target Volume
  - Treated Volume
  - Irradiated Volume



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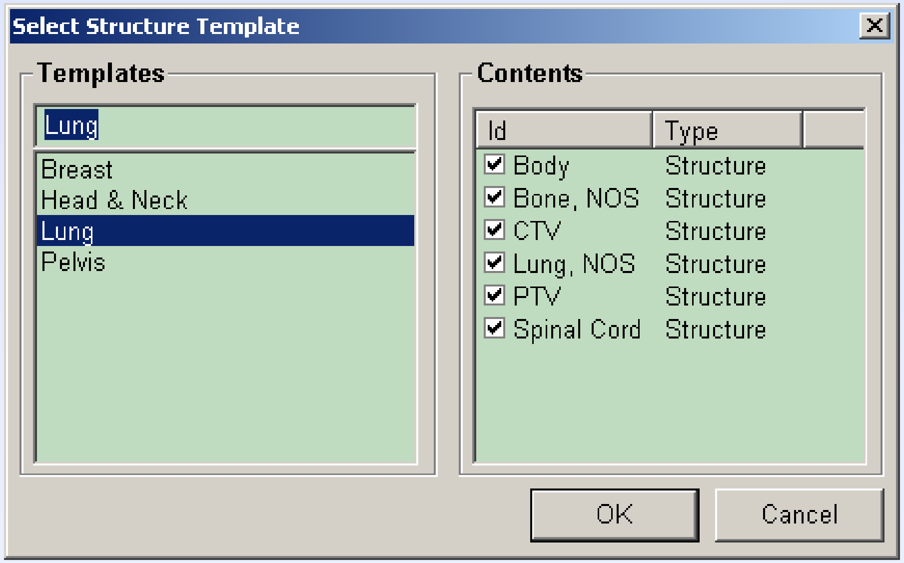
Contouring

- GTV
  - Gross palpable or visible extend and location of malignant growth
- CTV
  - GTV and/or sub-clinical microscopic malignant disease which have to be elimanted
  - That‘s what we hope to sterilize or eradicate with the help of radiotherapy

Contouring CTV

- Structure Templates
  - Userdefinable templates
  - Structure name
  - Structure type
  - Structure color
  - Structure search values

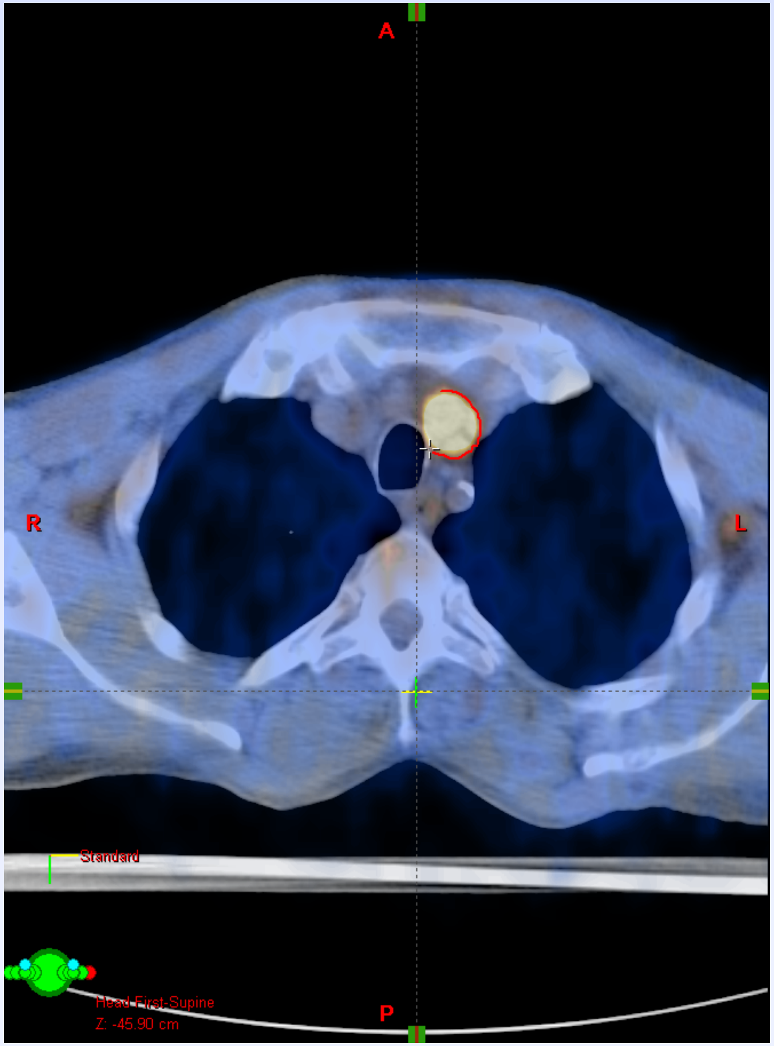


Contouring CTV

- Where is the CTV in the CT image?

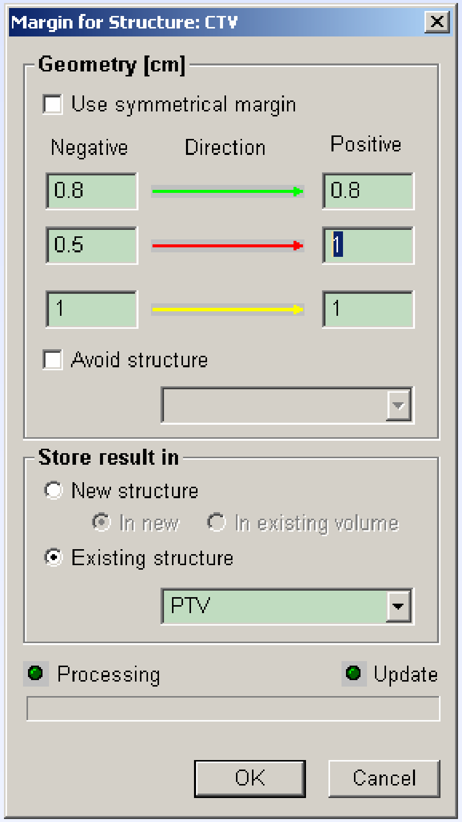
Contouring CTV

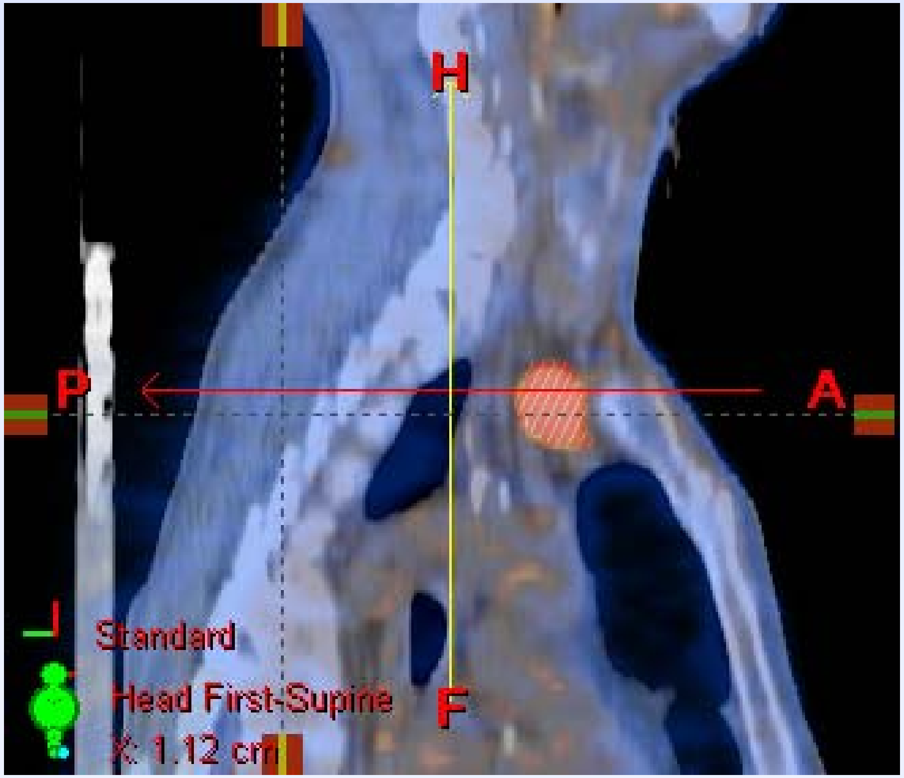
- Manual contouring tool
- Example with PET overlay



Contouring PTV

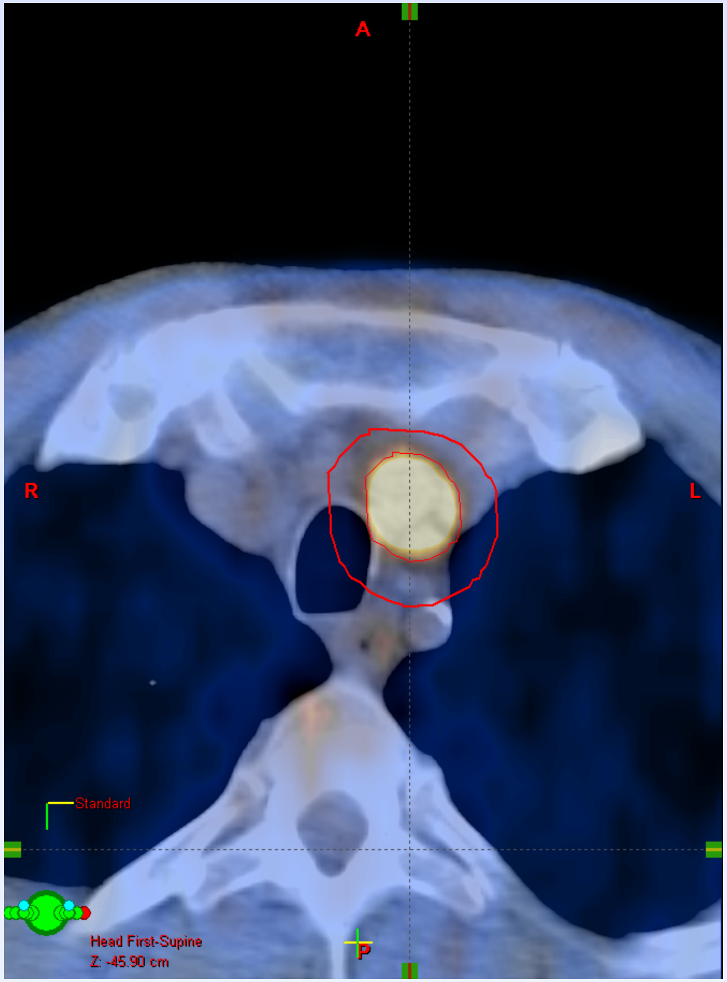
- Add margin tool





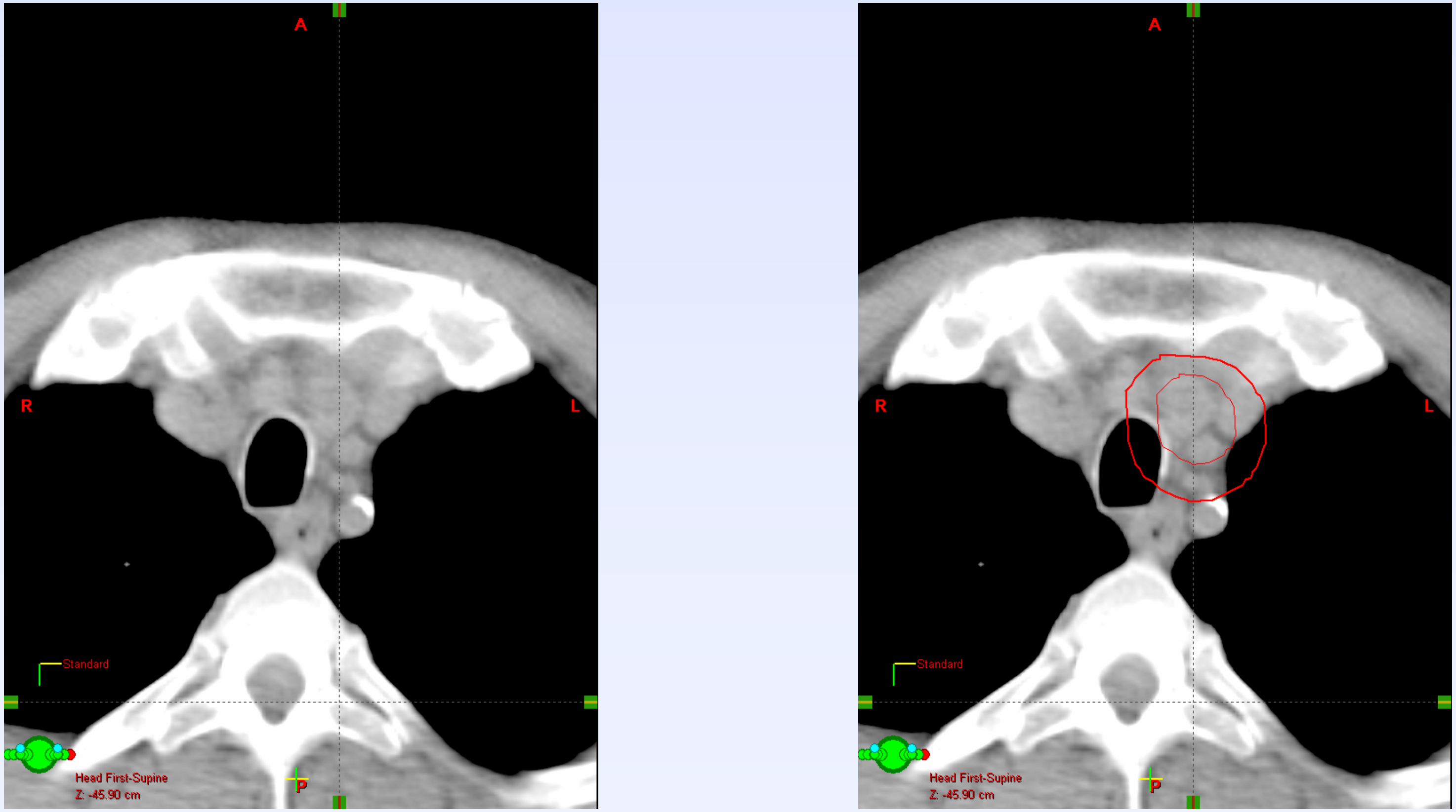
Contouring PTV

- PTV with asymmetrical margin around CTV



Contouring CTV, PTV

- Where is the CTV?

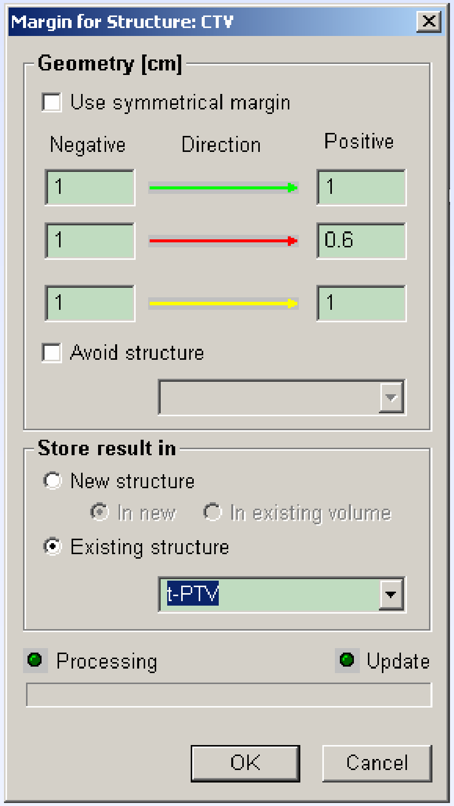


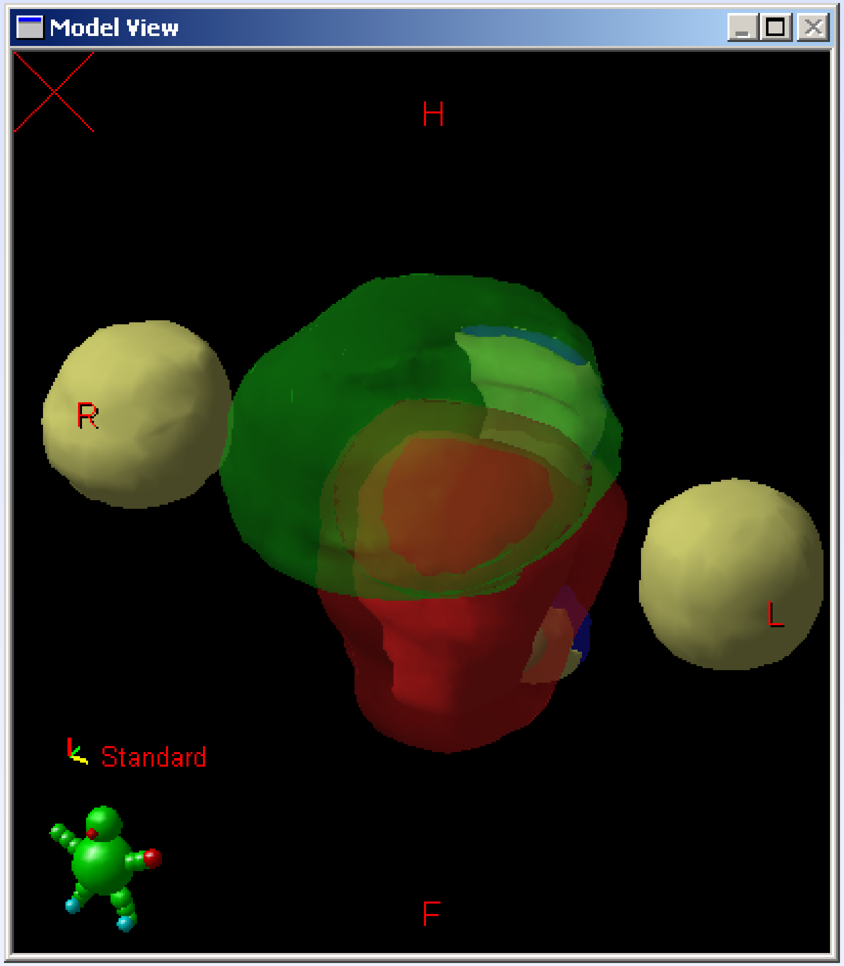
Contouring

- Basic manual contouring tools
  - Drawing tool
  - Correction tool
  - Brush
  - Eraser

Contouring

- Automatic margin tool





Contouring

- Body contour
  - For virtual simulation
  - For dose calculation

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Contouring

- More structures
  - Spinal cord
  - Lung
  - Brain

Contouring

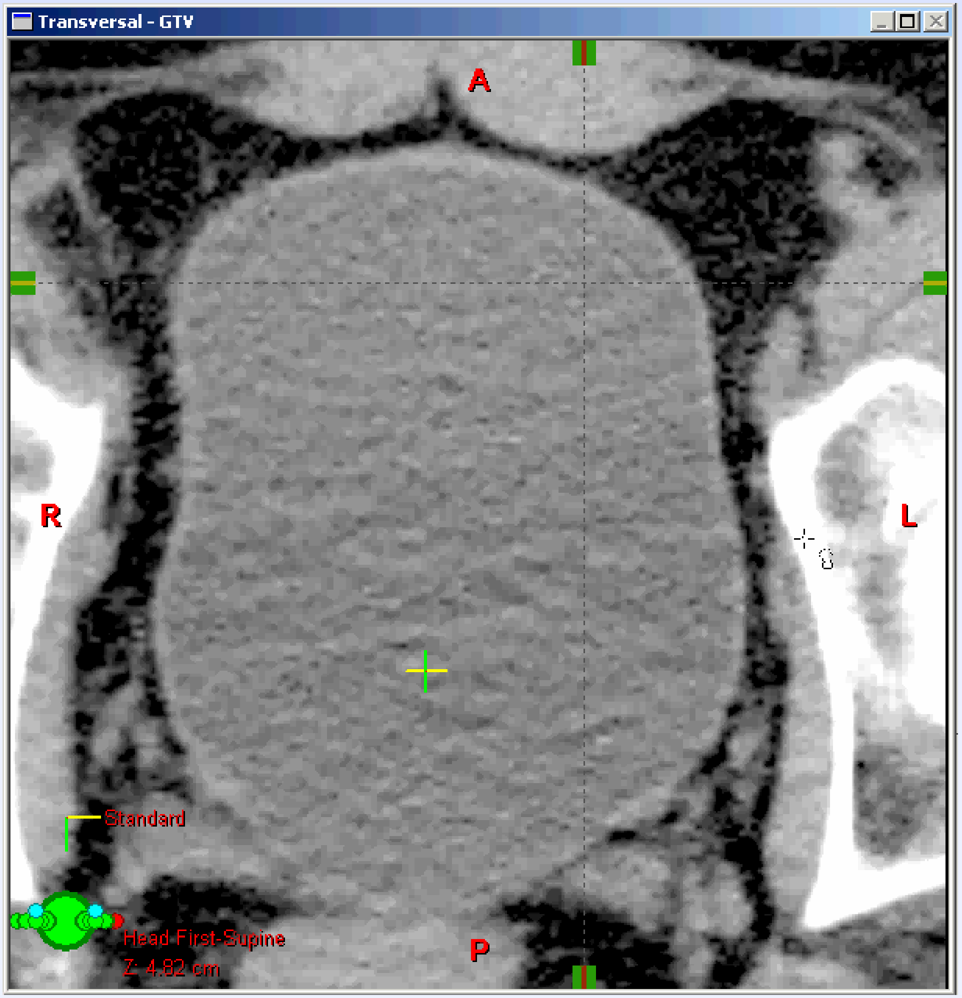
- Advanced contouring tools
  - Segmentation wizard
    - Boolean Operators
    - Intersect with a margin

→ Reduce contouring time

→ More complex contouring for IMRT

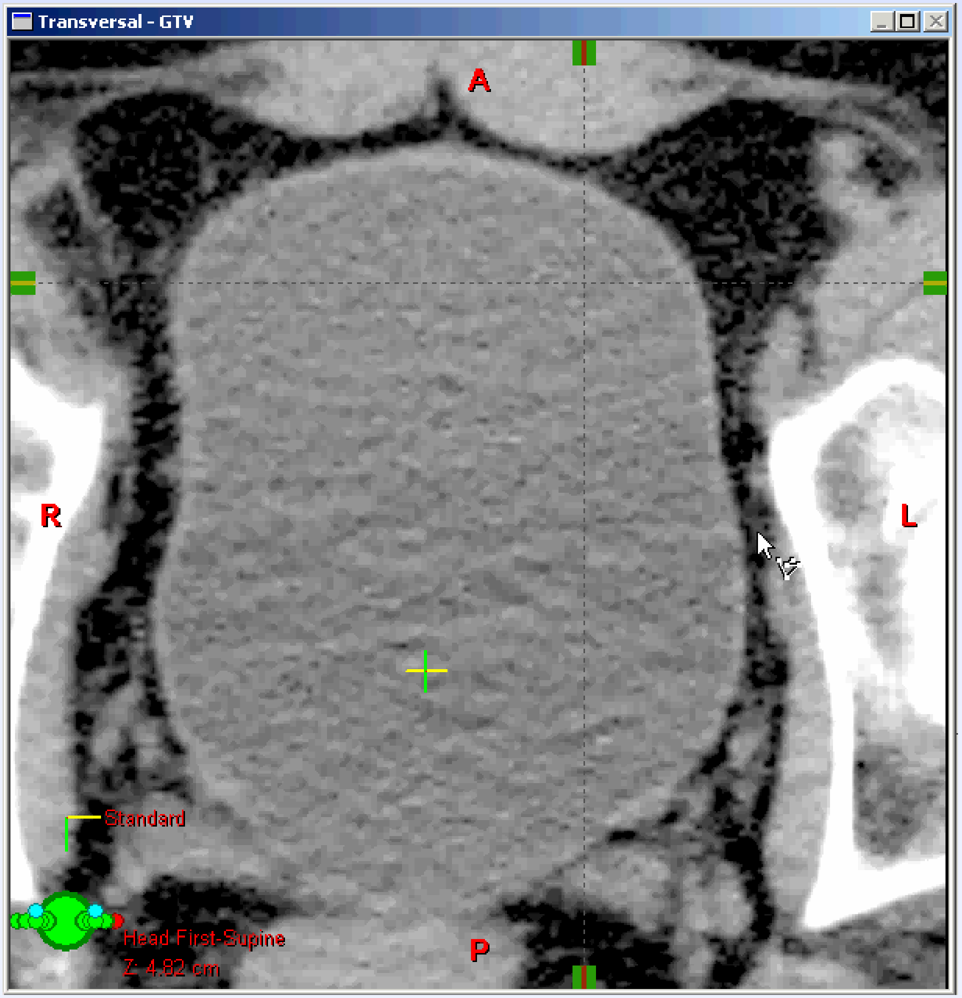
Example: Live Wire

- Automatic detection of structure boundary



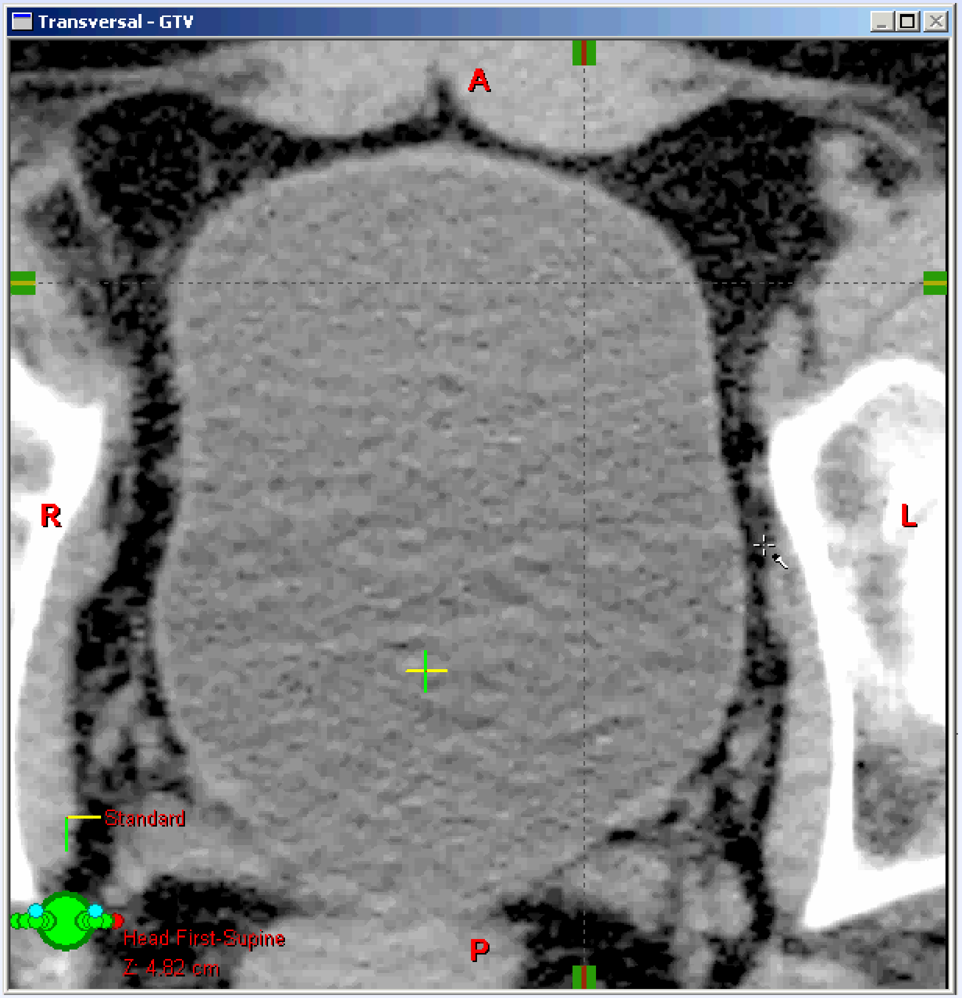
Example: Spline Snake

- Optimization of the spline function



Example: Brush

- Brush with user definable density detection
- 2D mode
- 3D mode



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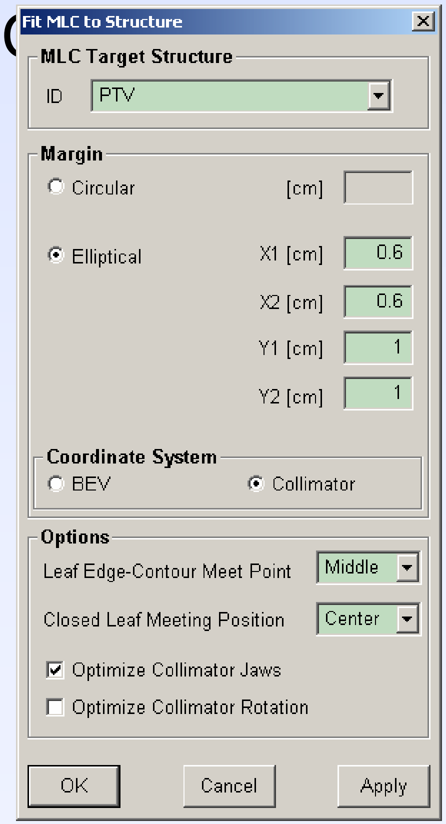
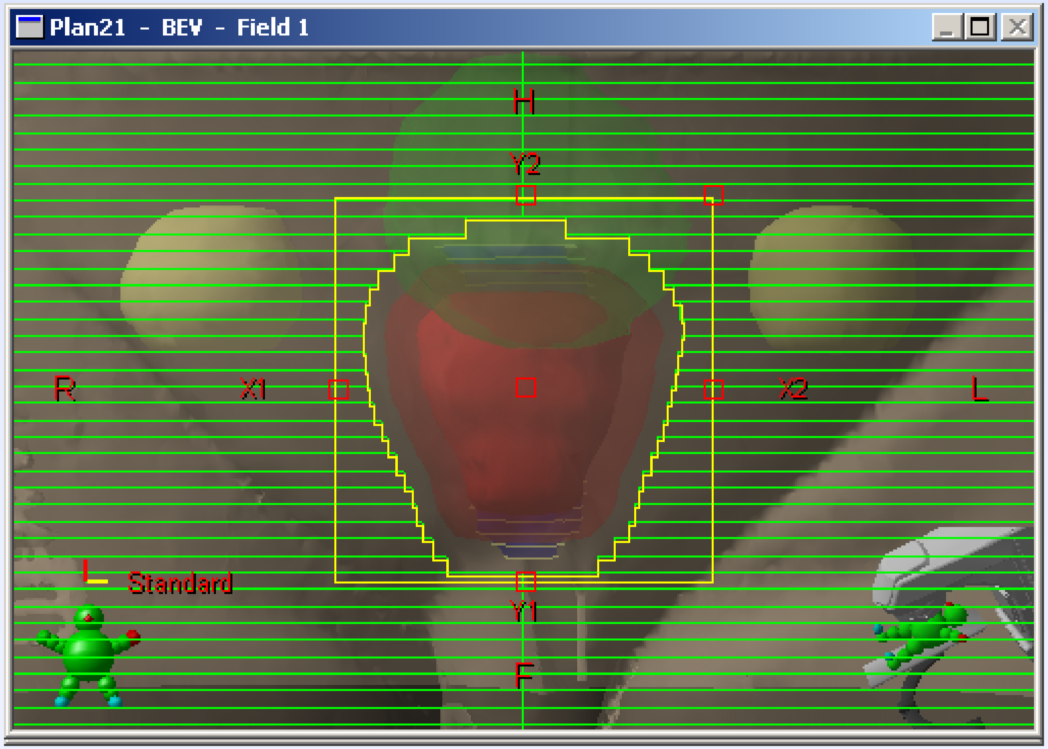
Beam setup

- Basics
  - Based on experience
  - Interactiv beam setup with mouse
  - Plan templates

Planning: Example 4 field MLC box

- BEV Field 1 with MLC





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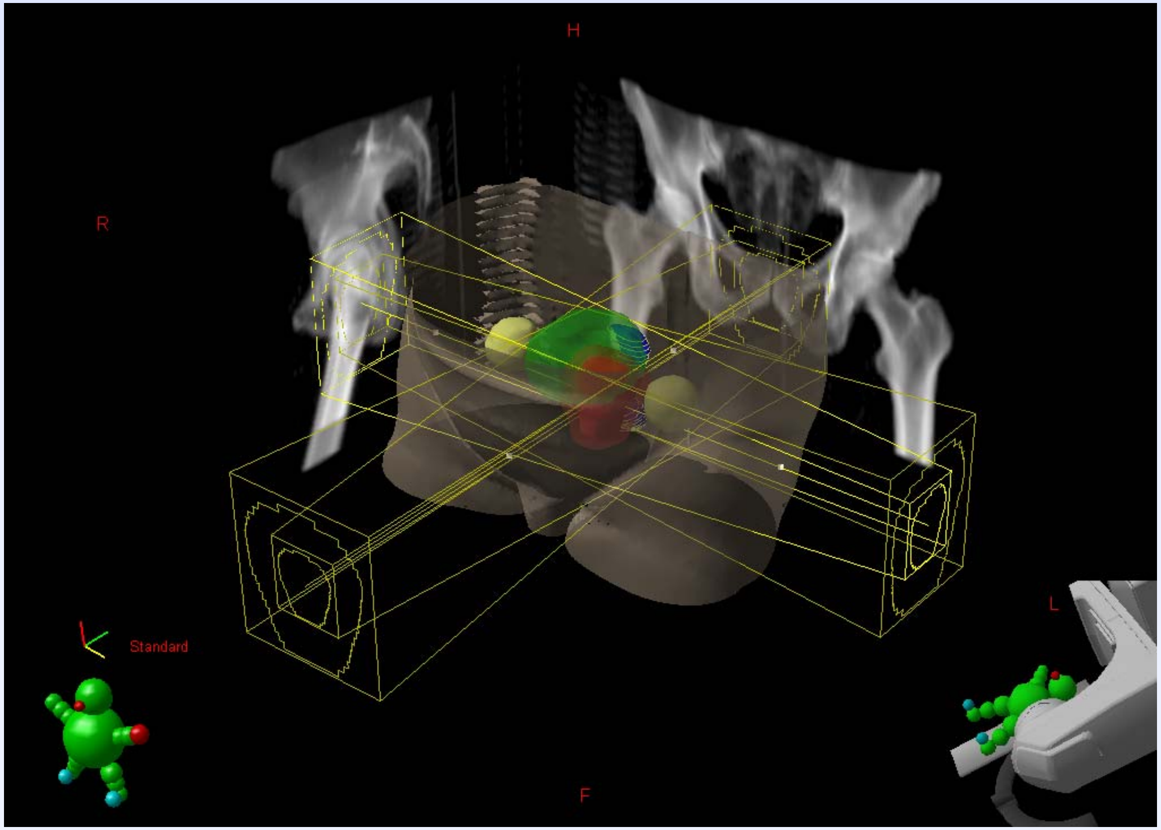
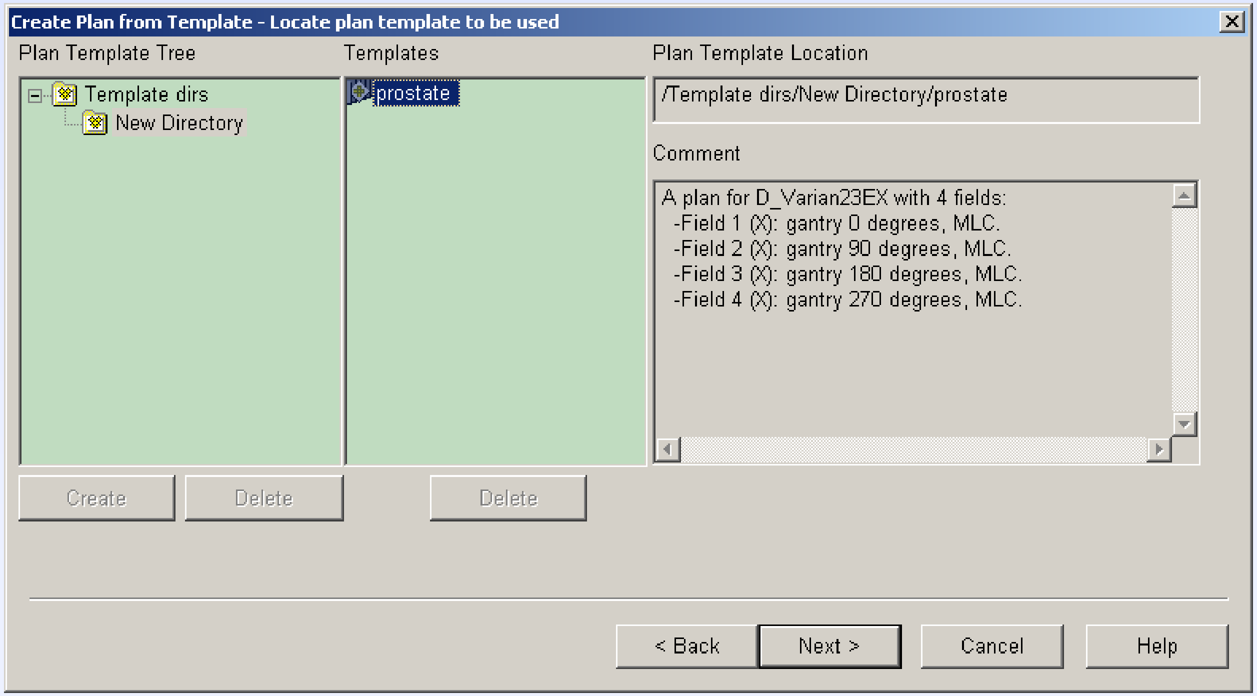
Planning: Example 4 field MLC box

- Final Plan incl. DRR



Plan Template

- Plan Template: fast beam setup for standard plans



Plan Template

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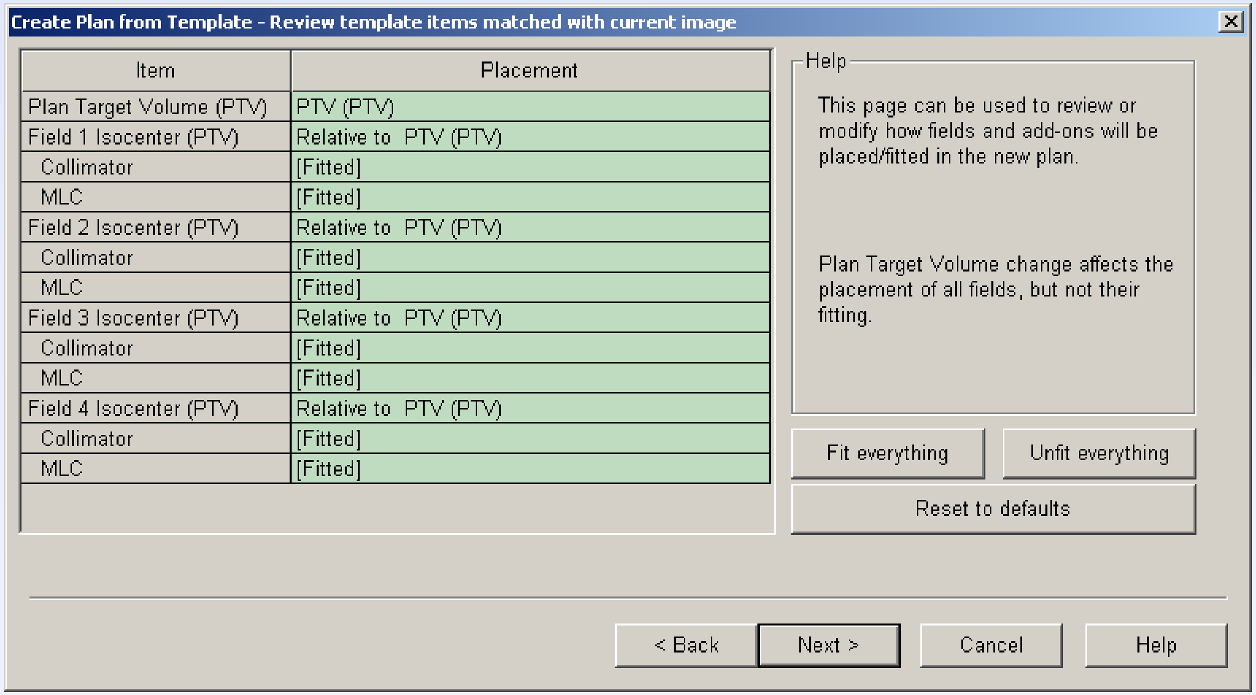

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DRR

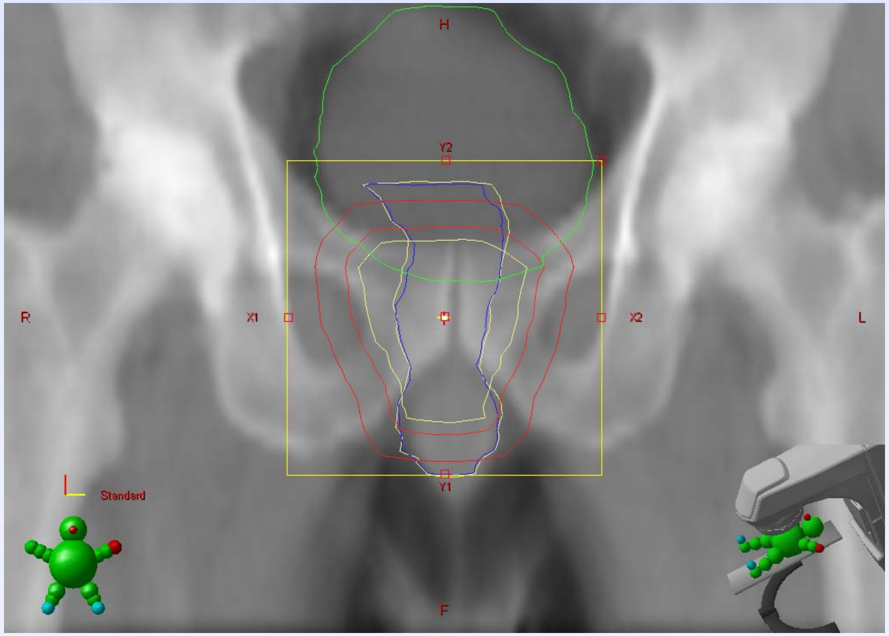
- DRR (Digital Reconstructed Radiograph) is used for patient position checks

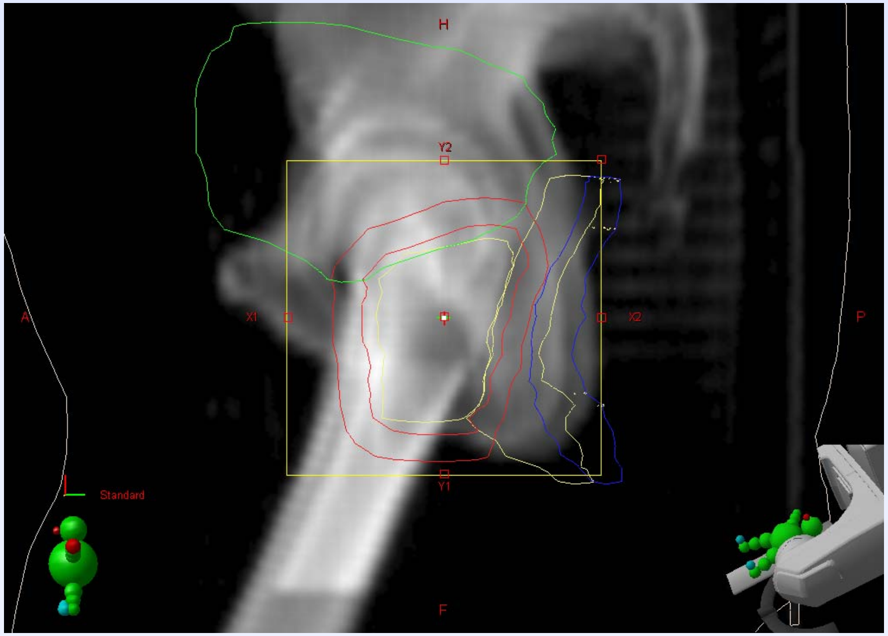
  → comparison with a Portal Image

- Different DRR settings available
  - Bones
  - Lung
  - Soft Tissue

DRR

- DRRs of a prostate patient





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DRR

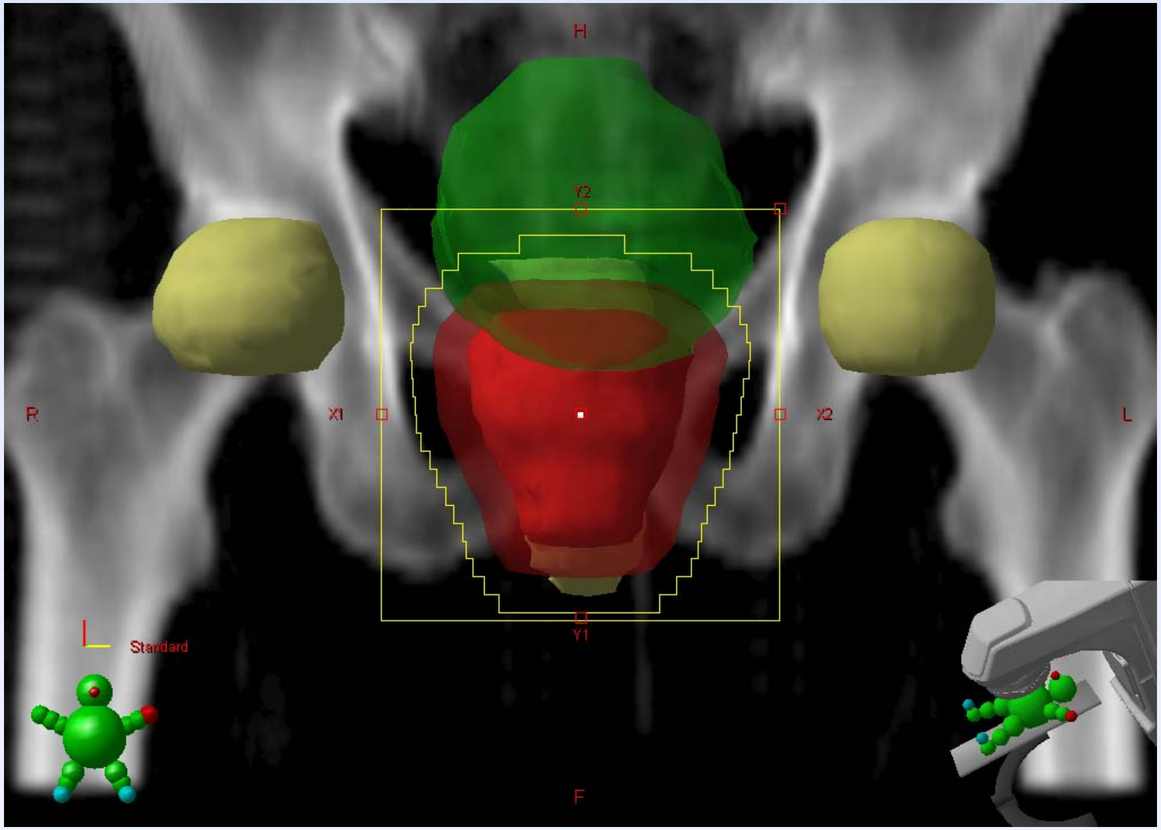
- DRR of a lung patient

DRR

- DRR of a head and neck patient

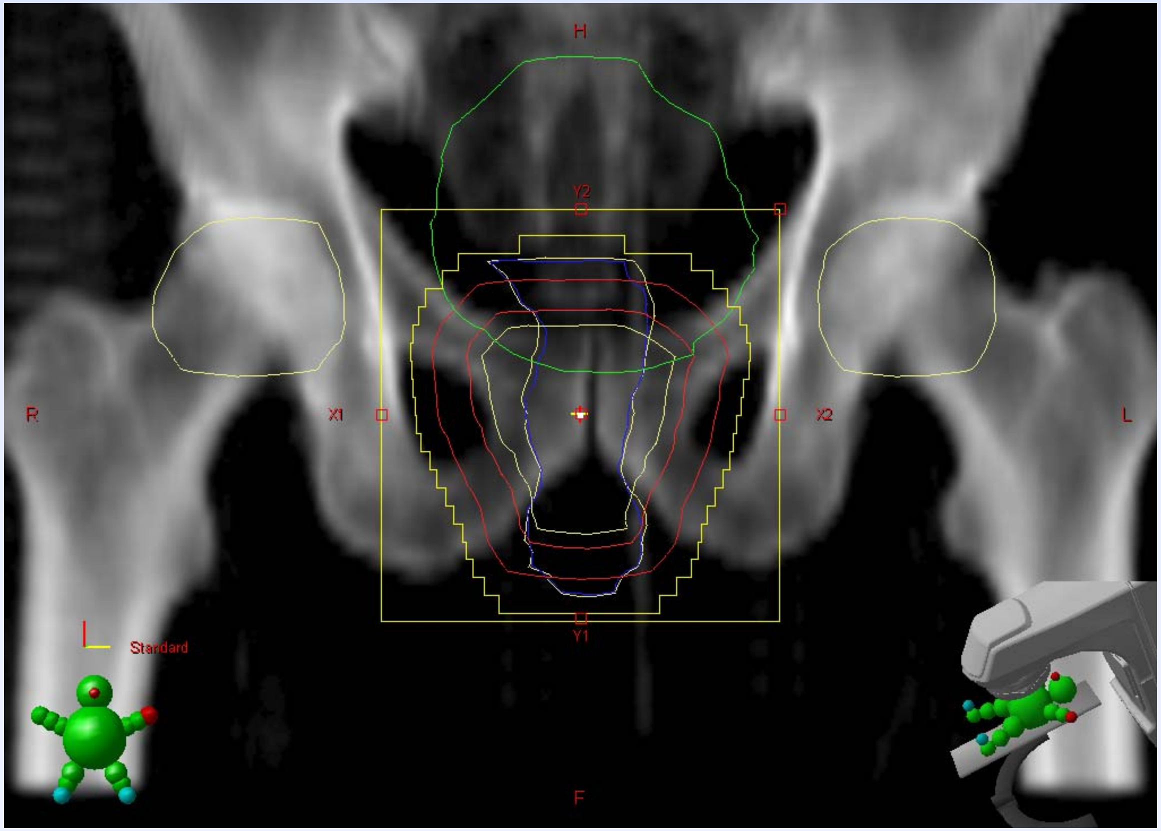
DRR additional options

- Standard view



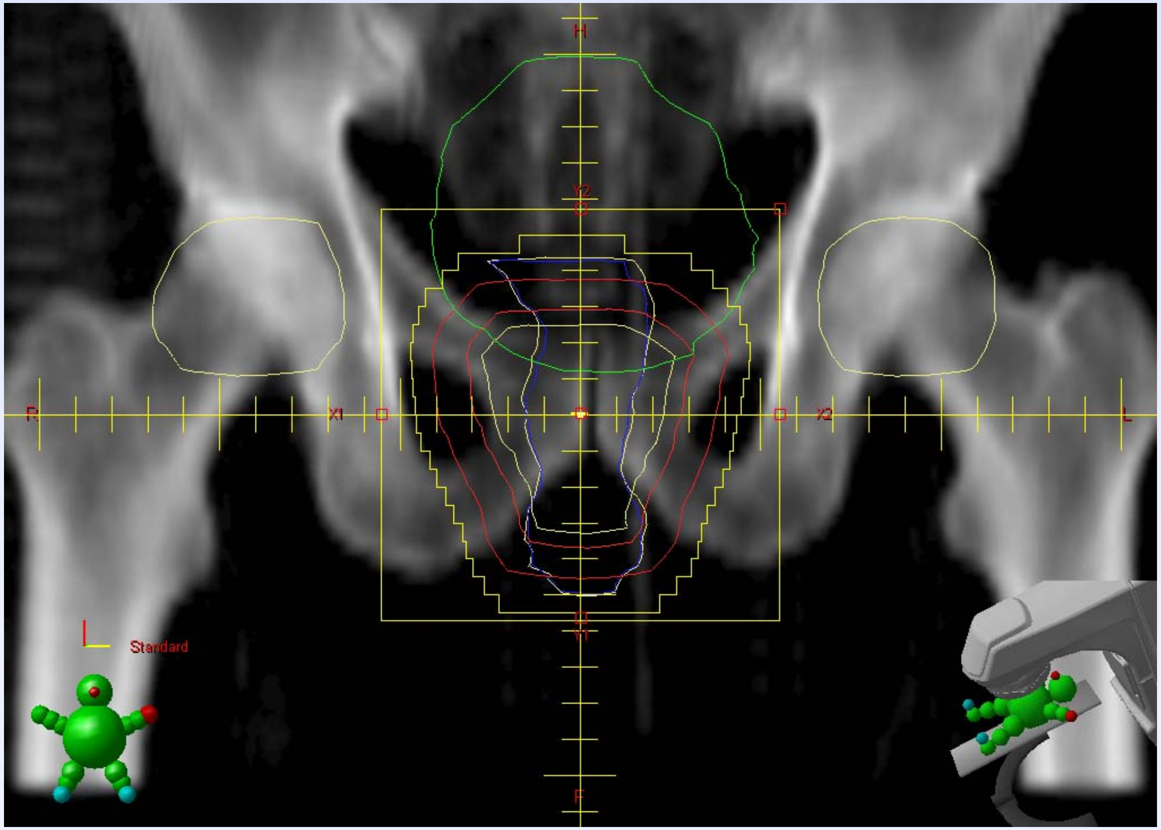
DRR additional options

- Structures: outline



DRR additional options

- Graticule



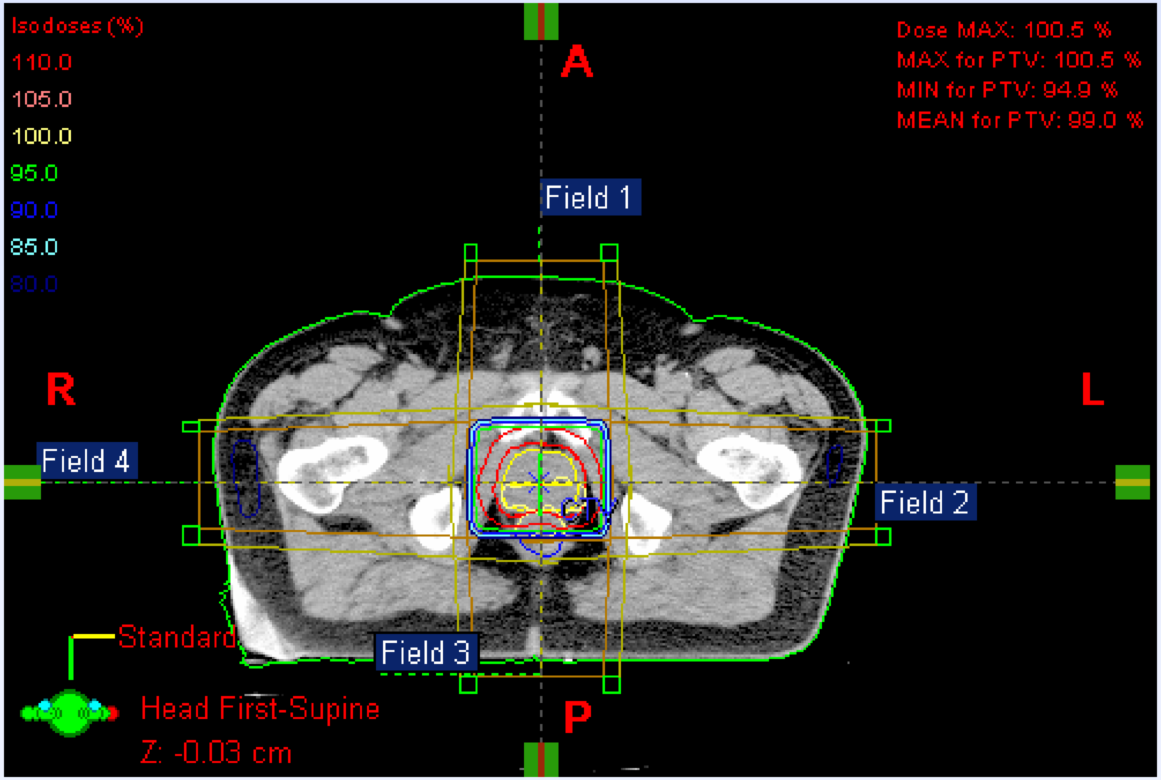
Dose Calculation

- Select Algorithm
  - Photons: Single Pencil Beam with different inhomogeneity corrections, (AAA)
  - Electrons: Gaussian Pencil Beam, (EMC)

  - Calculation grid

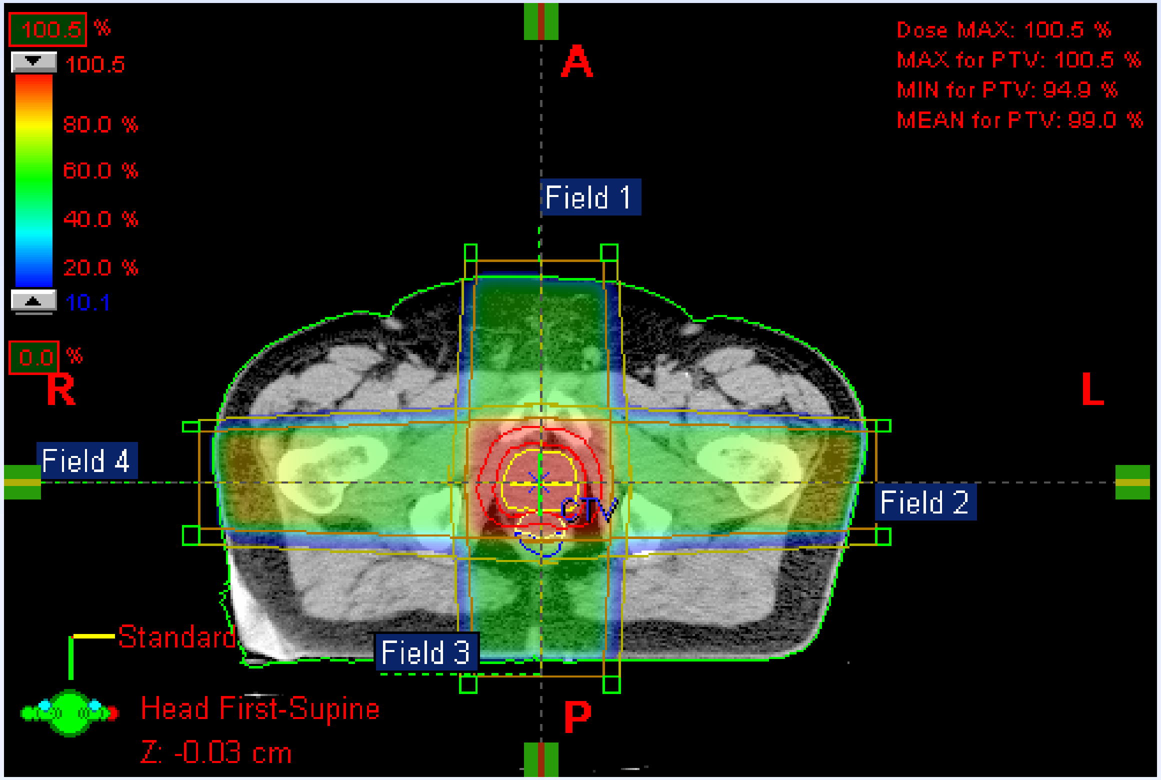
Dose Distibrution

- 2D dose distribution: Isodose lines



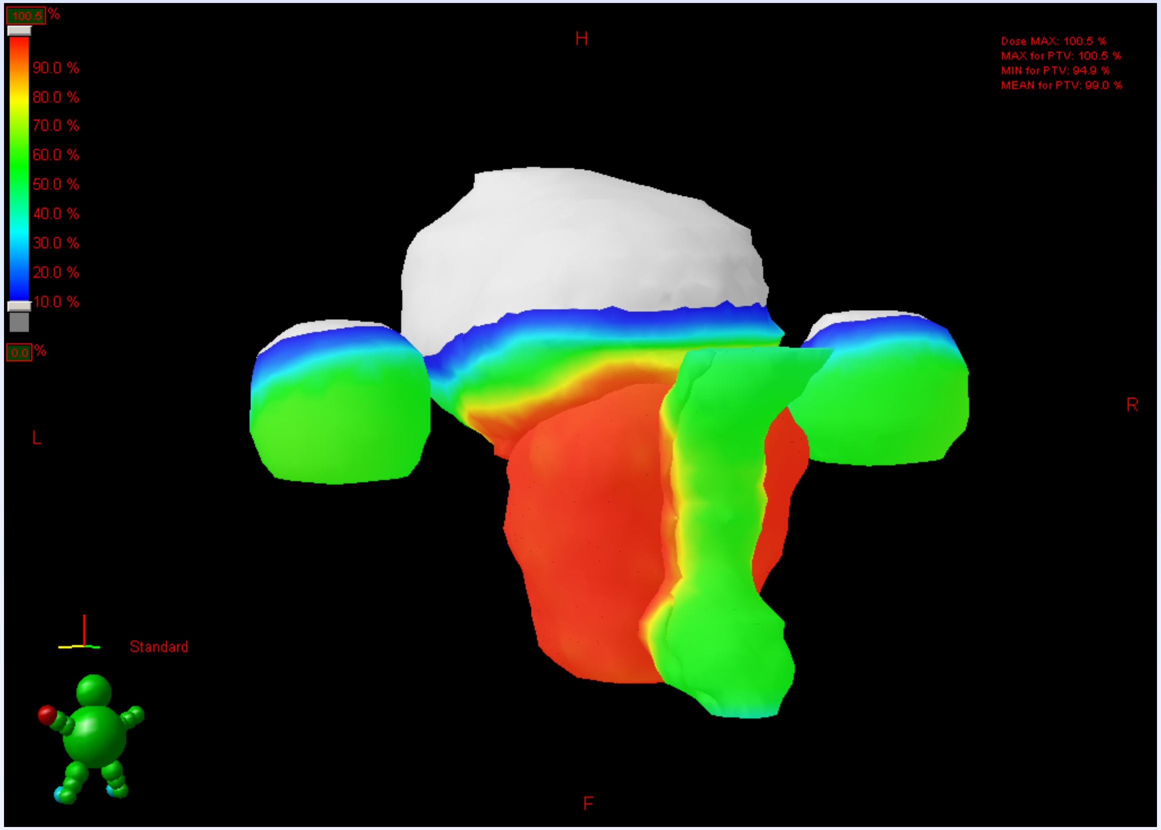
Dose Distibrution

- 2D dose distribution: Isodose lines



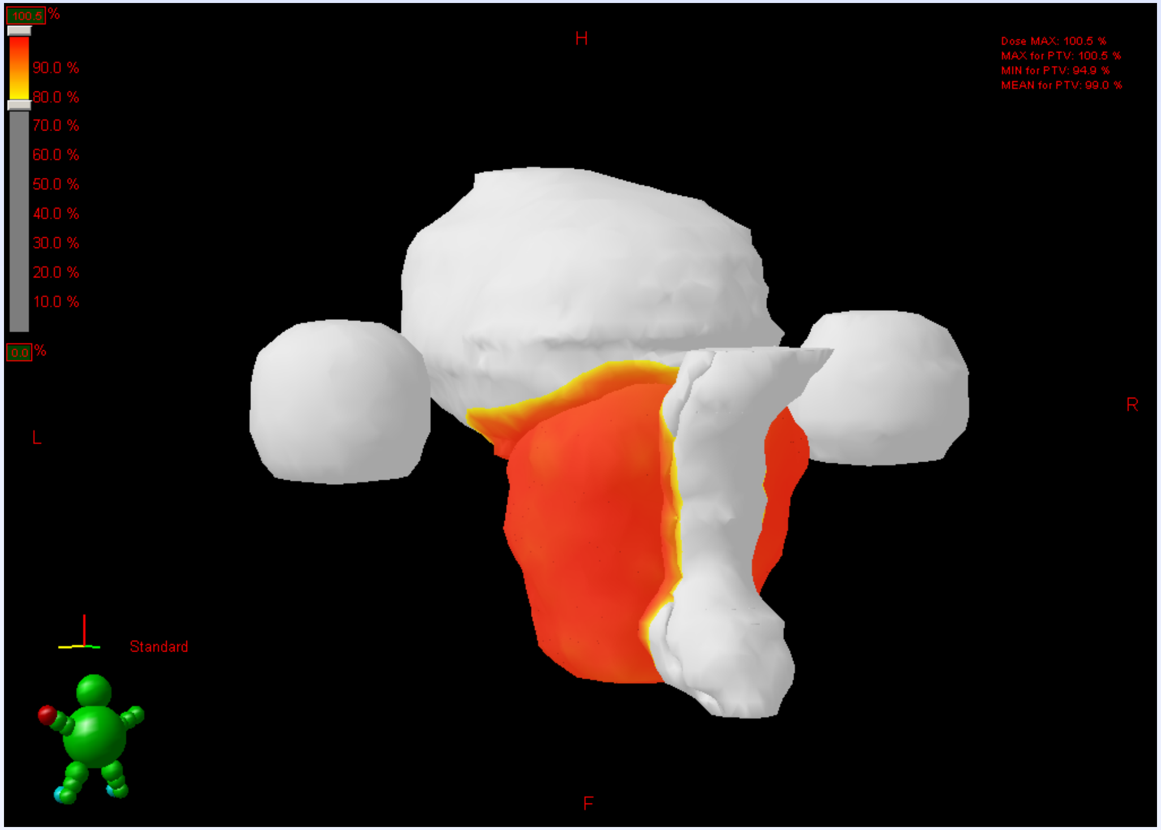
Dose Distibrution

- 3D dose distribution: Surface dose



Dose Distibrution

- 3D dose distribution: Surface dose



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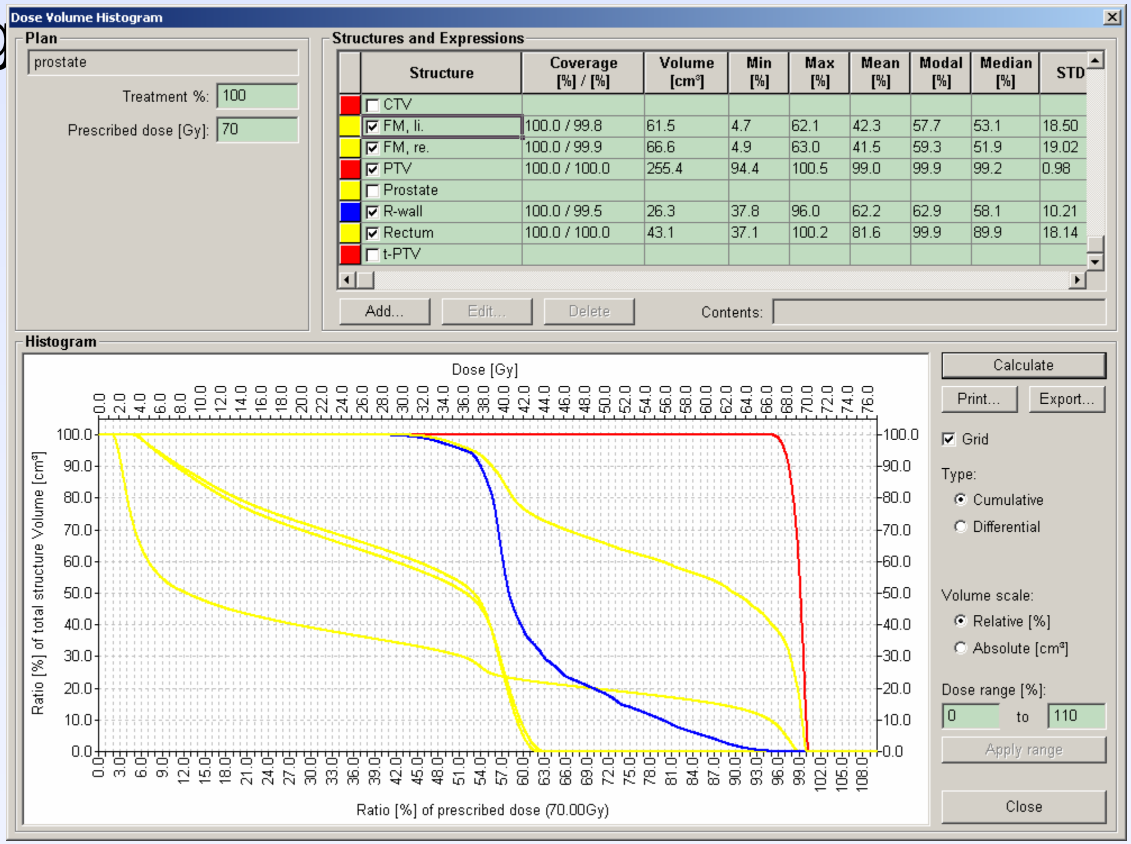
Plan Evaluation

- Dose Volume Histog



Structure	Coverage [%] / [%]	Volume [cm³]	Min [%]	Max [%]	Mean [%]	Modal [%]	Median [%]	STD
CTV								
FM, li.	100.0 / 99.8	61.5	4.7	62.1	42.3	57.7	53.1	18.50
FM, re.	100.0 / 99.9	66.6	4.9	63.0	41.5	59.3	51.9	19.02
PTV	100.0 / 100.0	255.4	94.4	100.5	99.0	99.9	99.2	0.98
Prostate								
R-wall	100.0 / 99.5	26.3	37.8	96.0	62.2	62.9	58.1	10.21
Rectum	100.0 / 100.0	43.1	37.1	100.2	81.6	99.9	89.9	18.14
t-PTV								

Inverse Planning

- The inverse planning tool in Eclipse: Helios
  - How does inverse planning with IMRT change the RT process?
  - What parts inside the planning system are important to do inverse planning with IMRT?

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Workflow in Eclipse doing IMRT

Patient Preparation
- Image Import
- 3D Data Set

Contouring
- Body contour
- Target outlining
- Critical structures

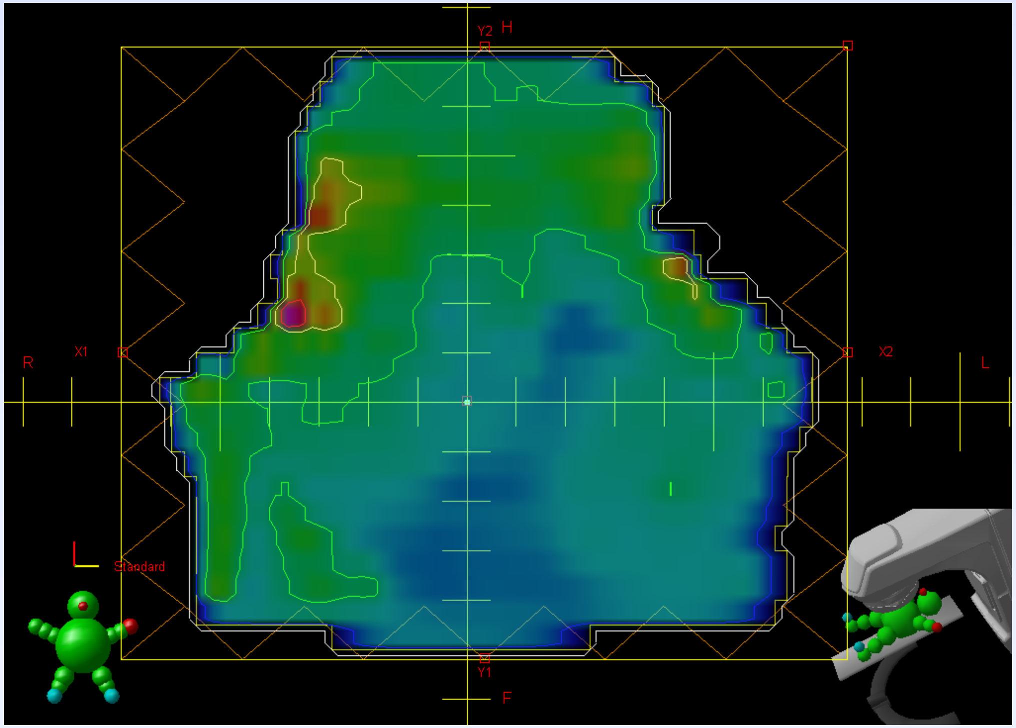
Field Setup
- Beam placement
- DRR generation

Helios
- Constraints Definition
- Interactive Optimization
- LMC Calculation

Dose Calculation
- Algorithm selection
- Dose calculation
- Printouts

What is IMRT?

- Intensity modulated radiotherapy
  - Standard flat fields are modulated
  - This modulation can be created with inverse planning systems



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What is inverse planning?

- Target doses and doses for organs at risk are used as constraints
- An optimization algorithm starts to modulate the fields (IMRT) to fulfill the constraints
- Final optimal dose is calculated with the modulated fields

What is important to do IMRT with a TPS?

- You need a good optimization algorithm
- You don't need a black box → interactive optimization
- You need a accurate leaf sequencing program

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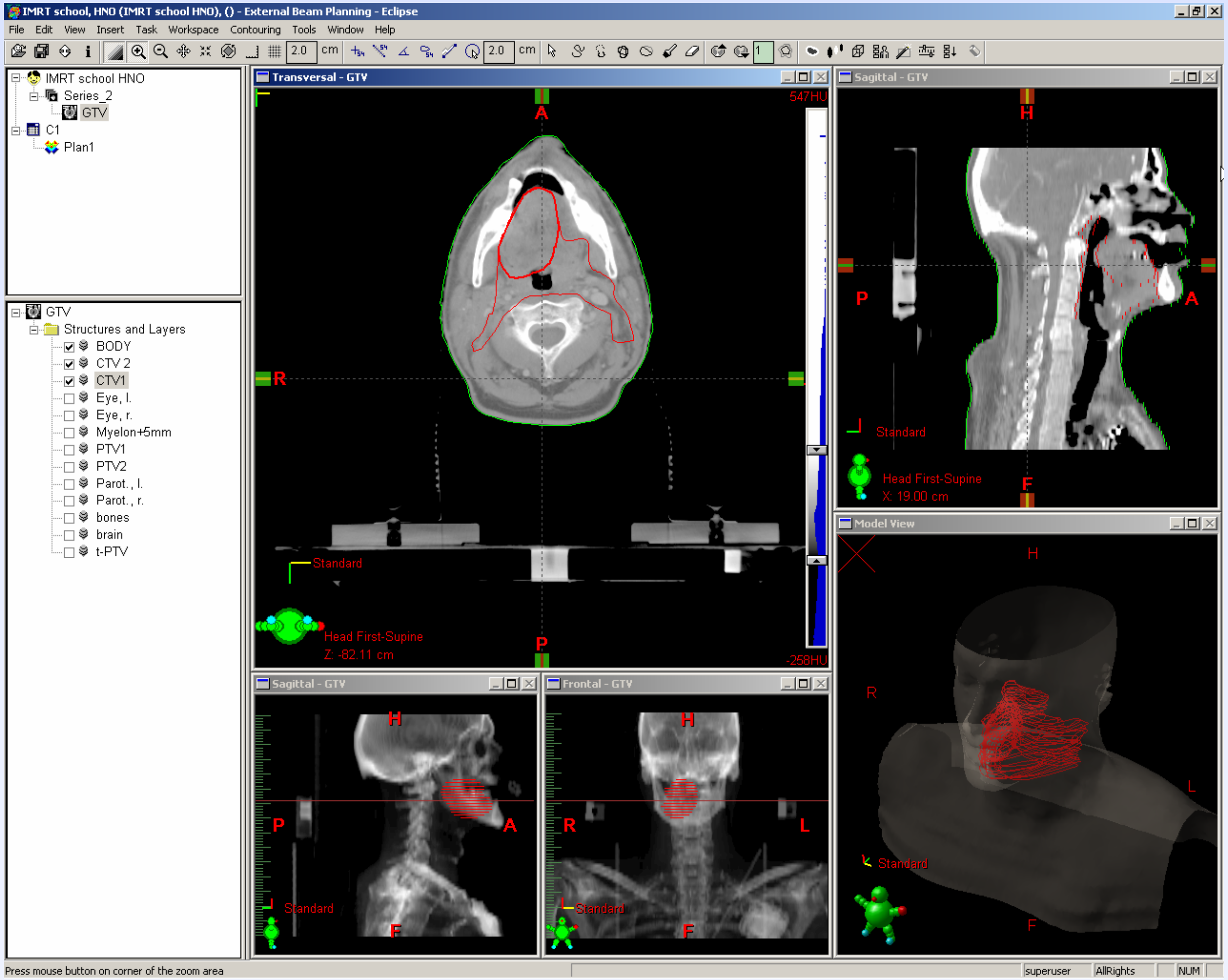
Contouring

- CTV
- PTV



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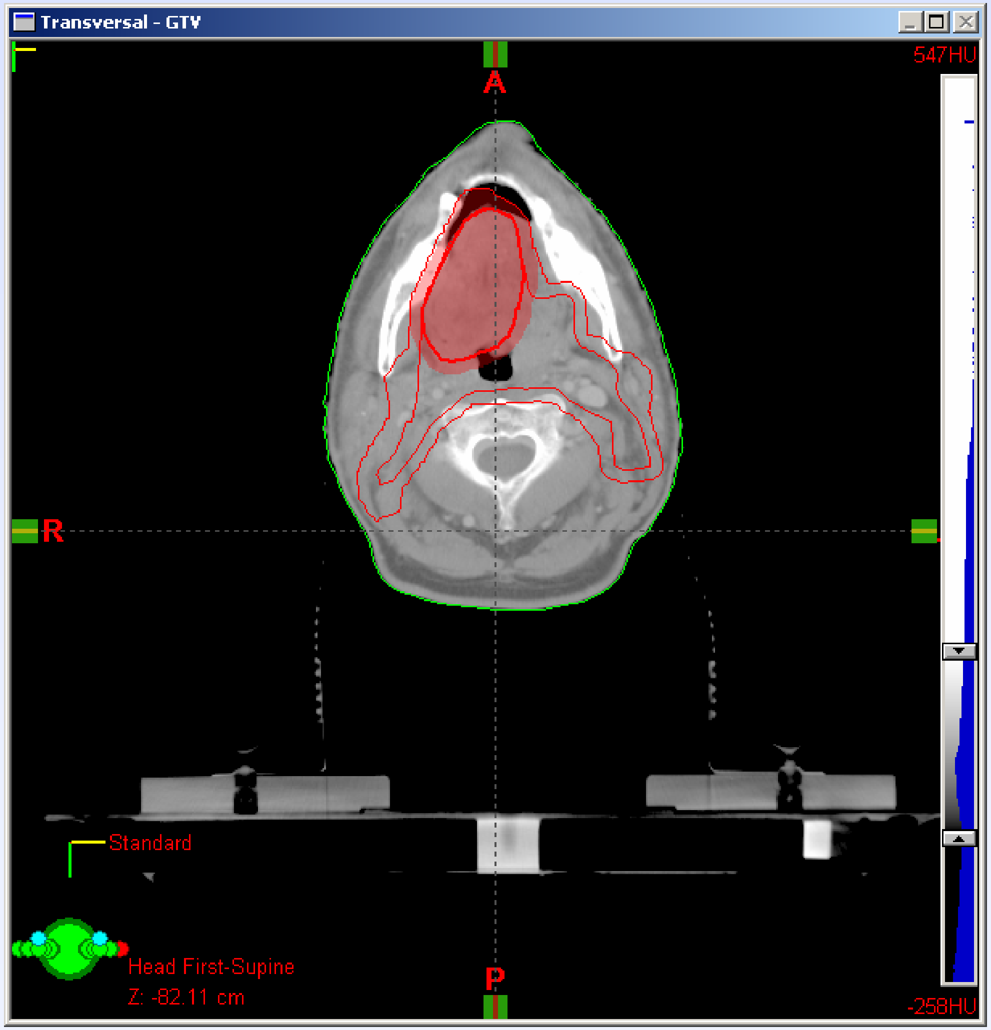
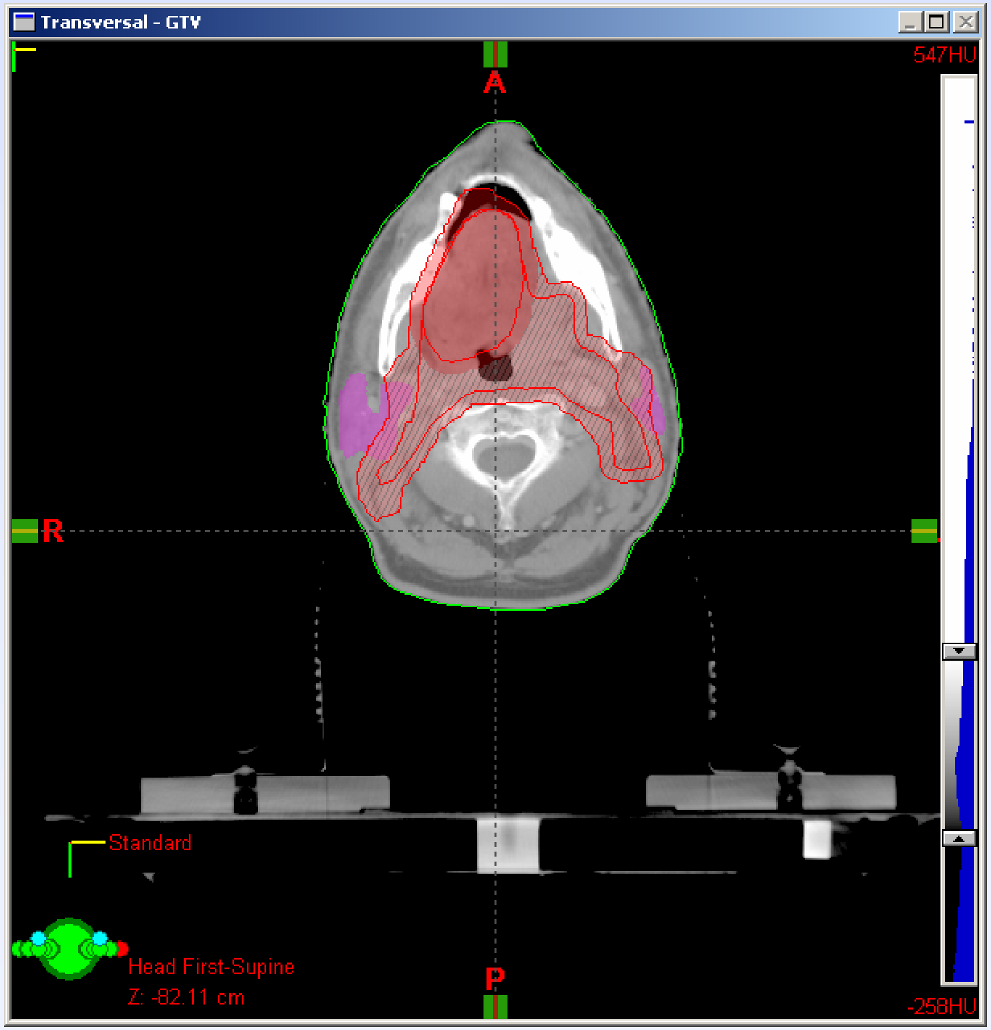
Contouring

- CTV
- PTV



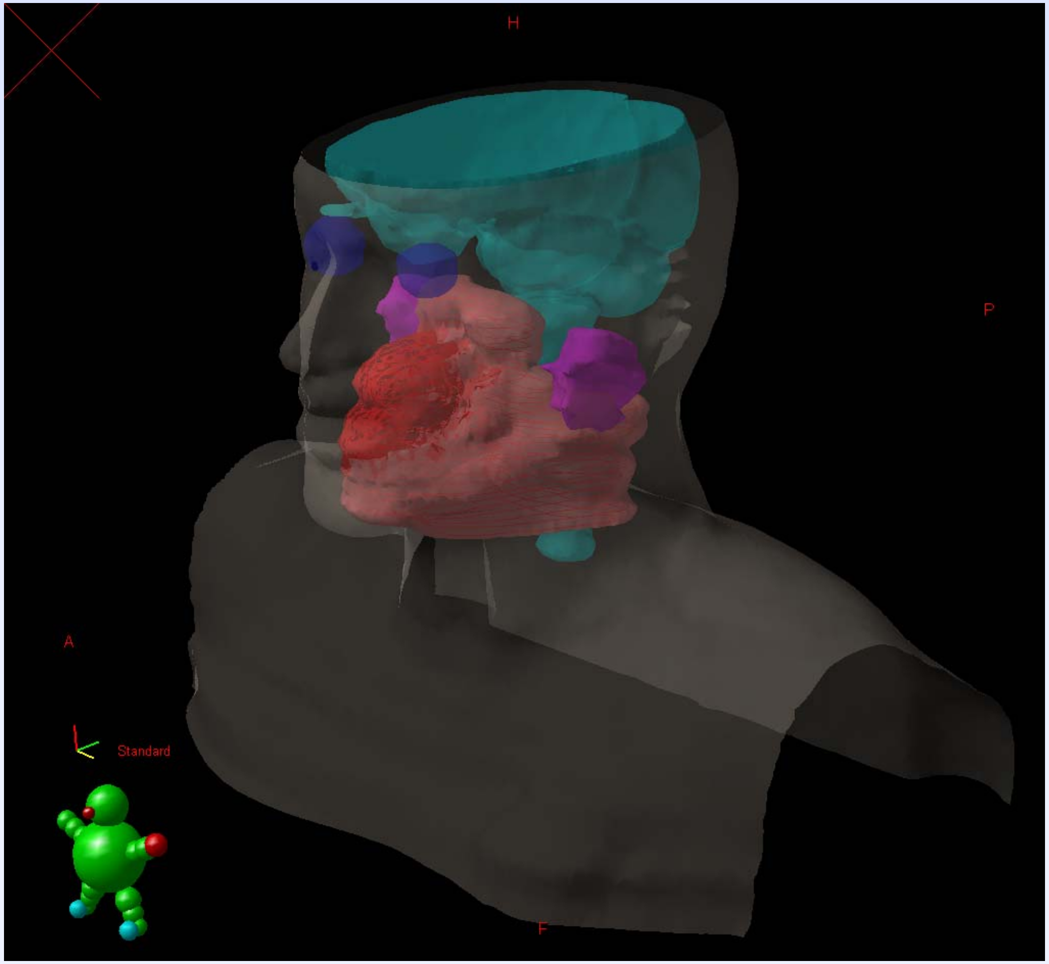
Contouring

- CTV
- PTV
- Partial PTV
- Parotis left
- Parotis right



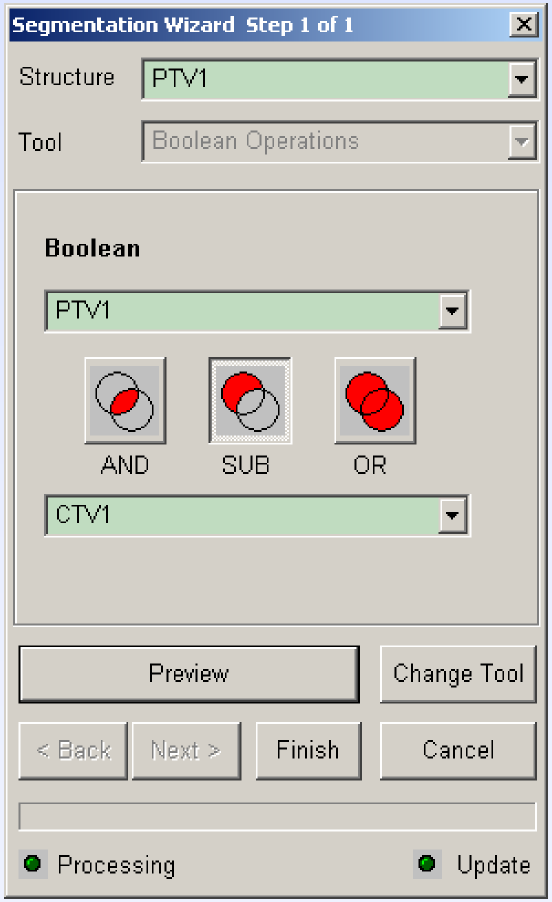
Contouring

- Spinal cord
- Eyes
- Brain



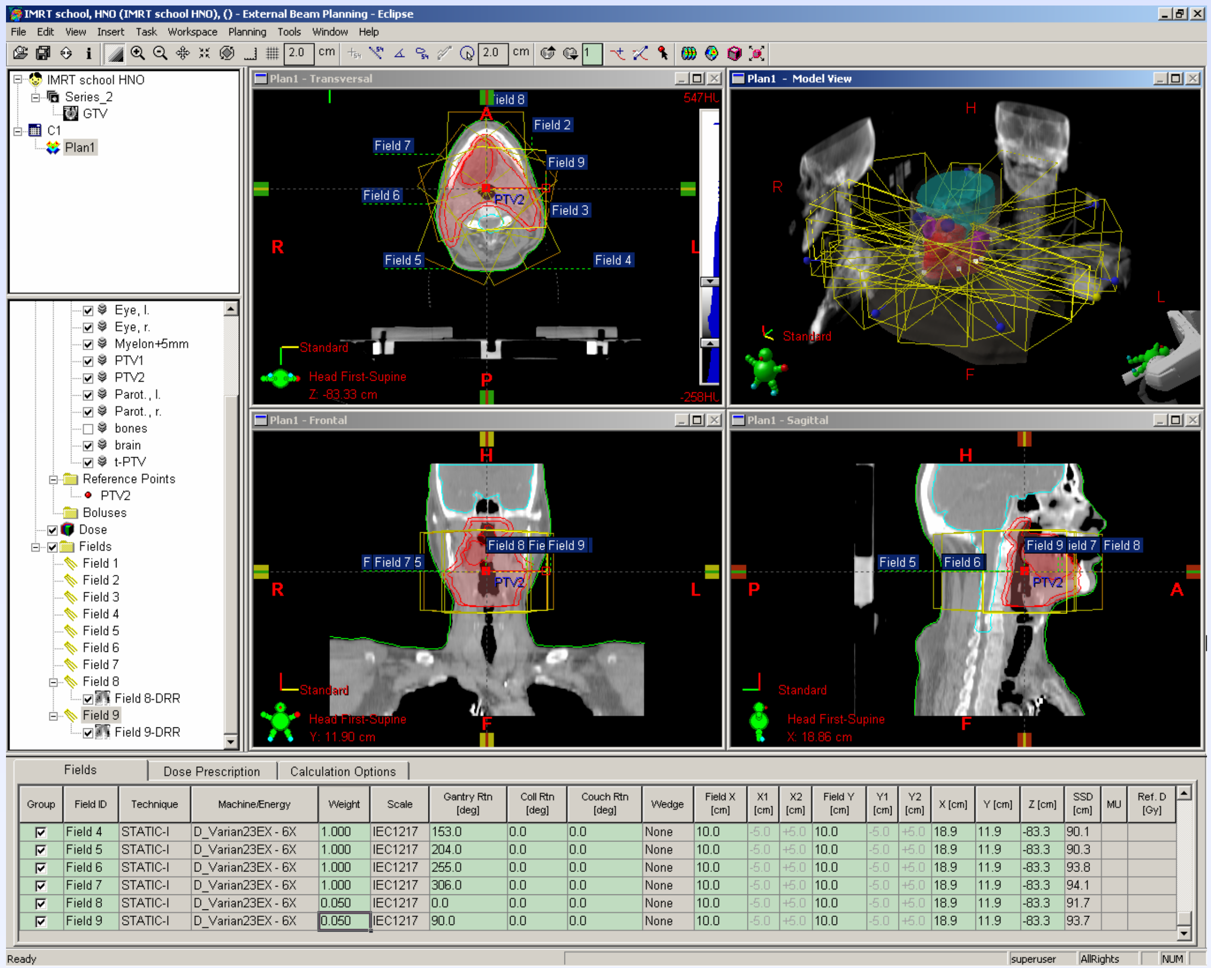
Contouring

- Special contouring tools
- Why?
  - Constraints for different structures may compete each other
  - Dose escalation
- What kind of tools?
  - Boolean operators
  - Extract wall tool
  - Intersect with a margin



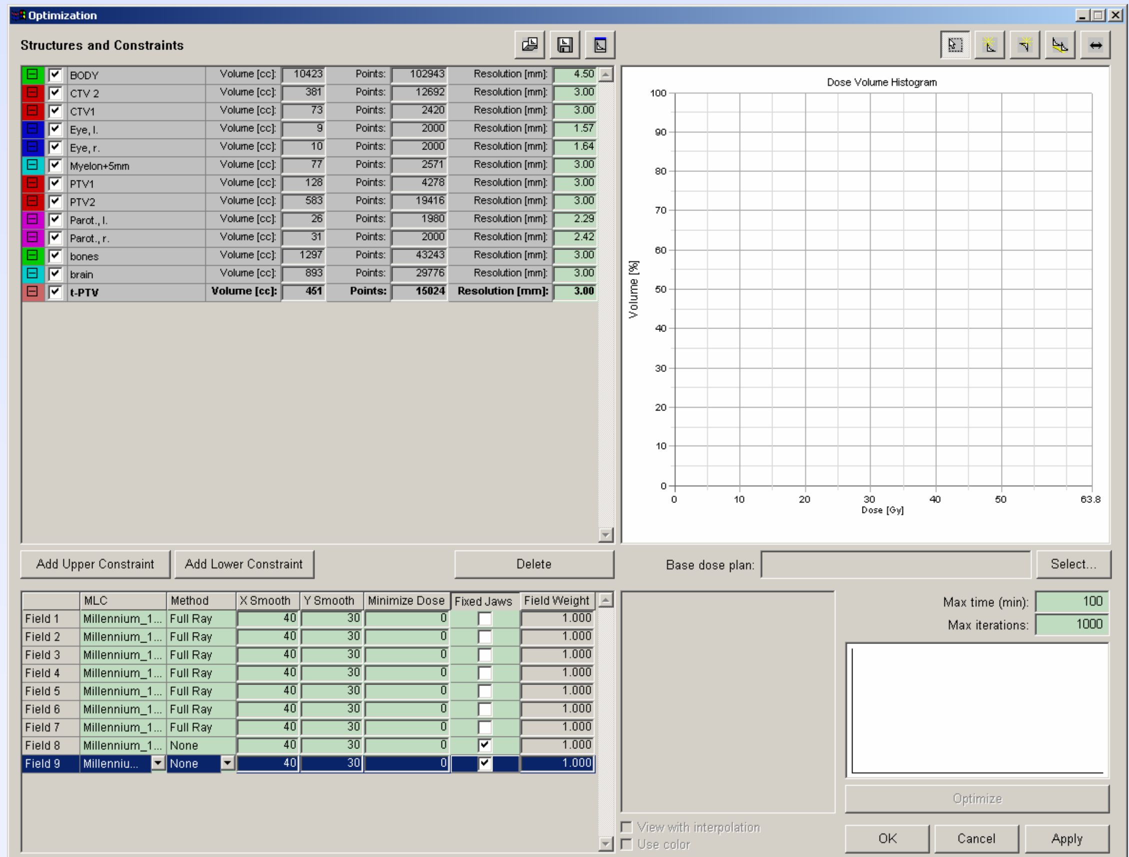
Beam setup

- 7 IMRT fields:
  - 0
  - 51
  - 102
  - 153
  - 204
  - 255
  - 306
- 2 verification fields:
  - 0
  - 90



Optimization

- First step
  - Switch of optimization for verification fields
- Option
  - Load constraints from library



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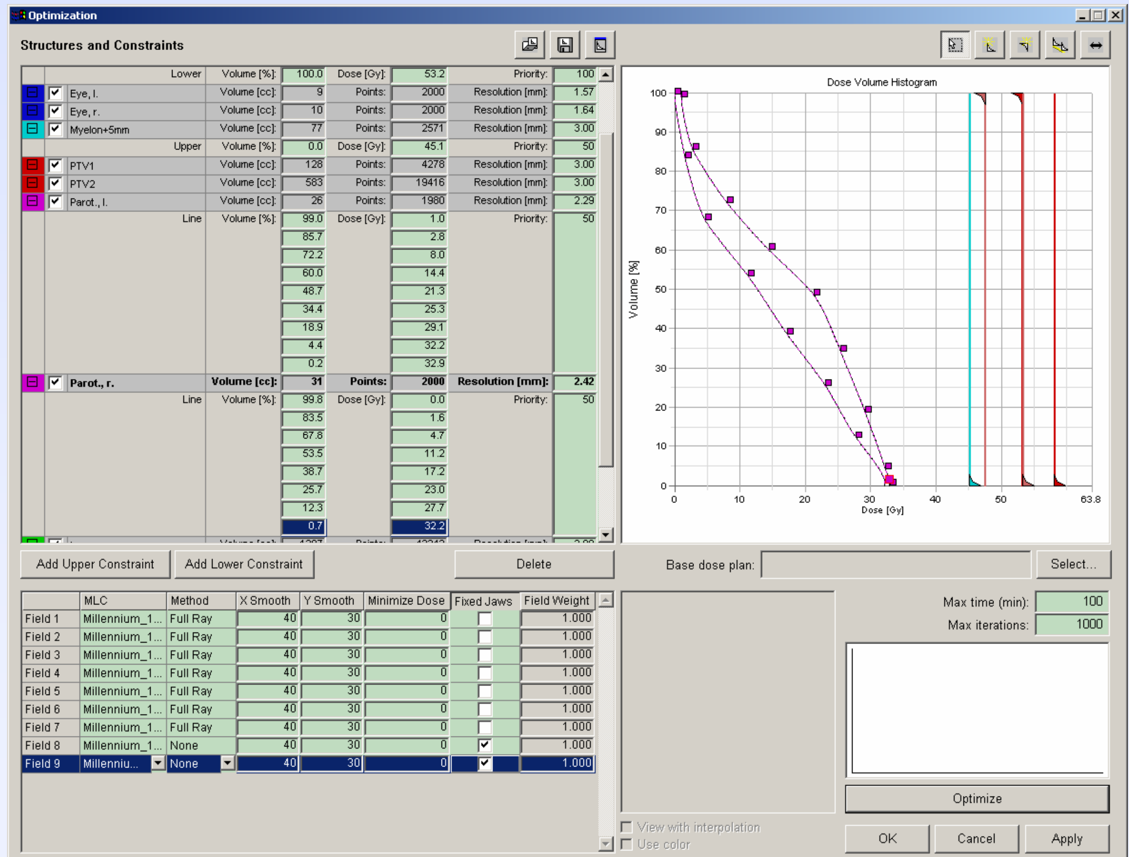
Optimization

- Put in constraints
- Example: Head and neck
- CTV 53.2<D<58
- T-PTV 47.5<D<53.2
- Spinal cord D<45
- Parotis Dmean<26



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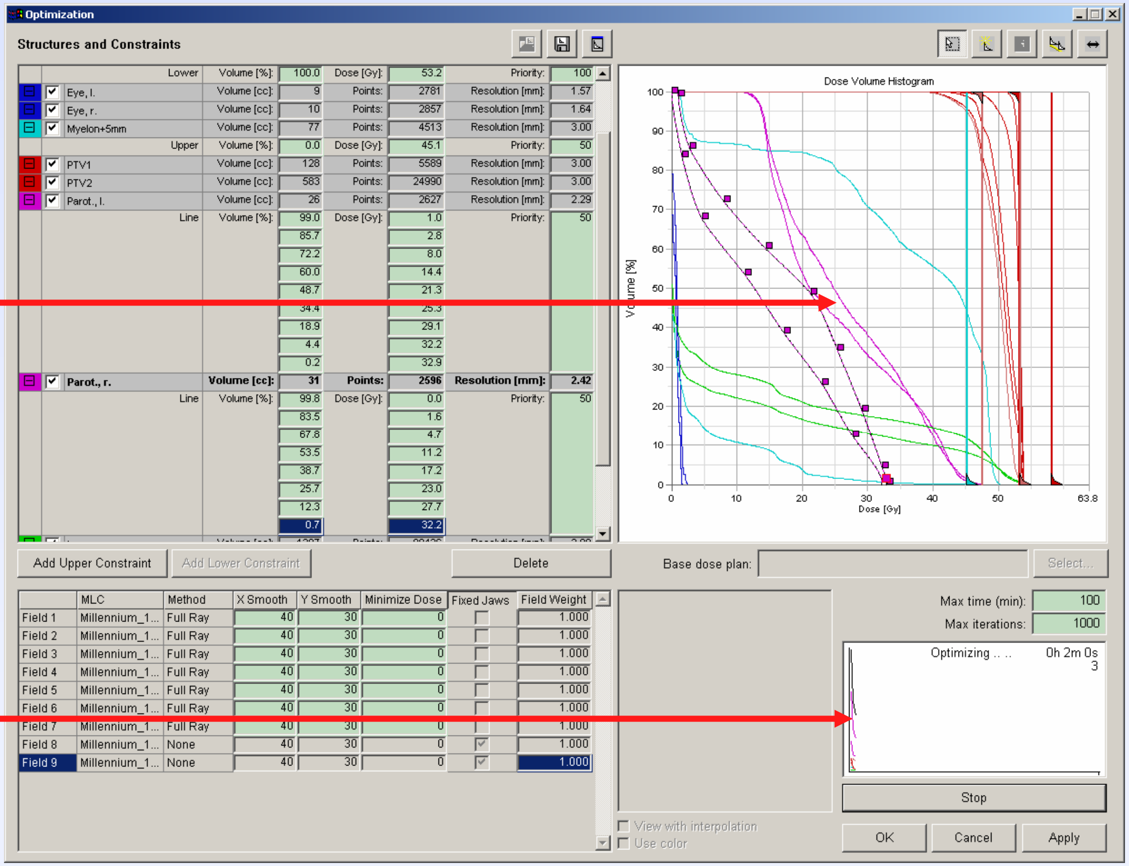
Optimization

- After a few iterations
  - Actual DVH
  - Optimization function



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Optimization

- Optimization process shouldn‘t be a black box
- Why?
  - Result is only as good as the constraints are
  - It is possible to have too restrictive constraints, probably a restart is needed
- In Eclipse Helios
  - User can interactively change all constraints, penalty factors
  - It is always possible to interrupt an optimization, calculate the dose and continue with the optimization in case the dose distribution is not satisfying yet

→ saves a lot of time

→ results in better dose distributions

→ steep learning curve

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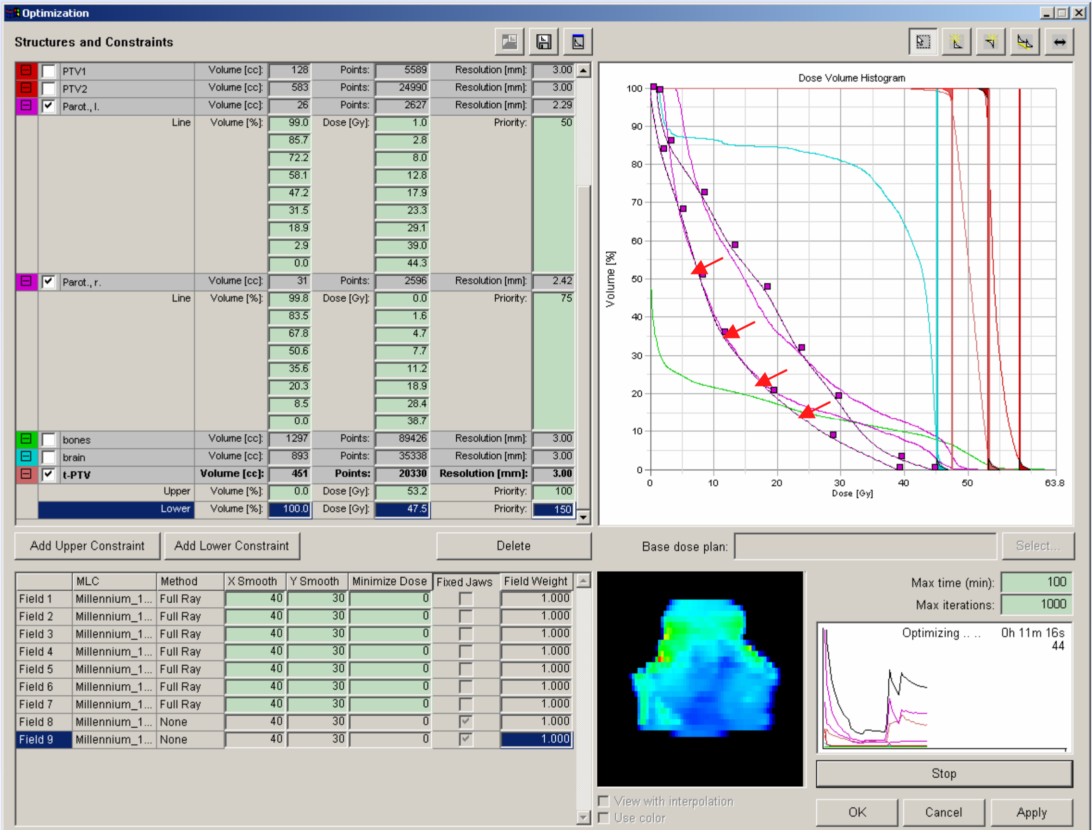
Optimization

- Reduce the dose for the right parotis



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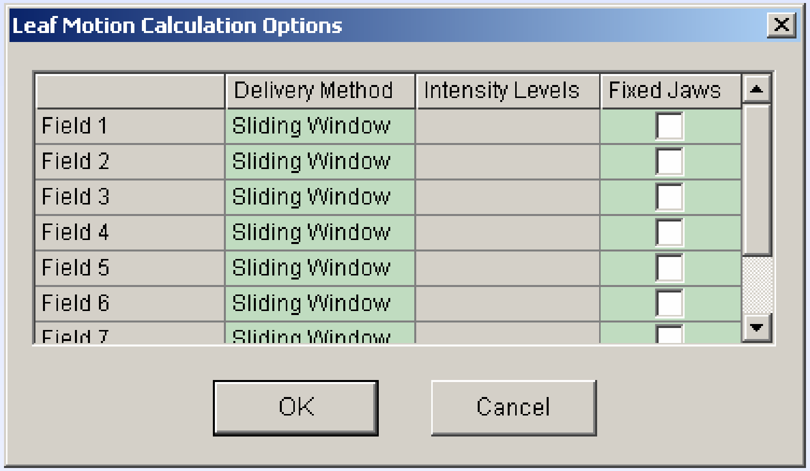
Leaf Motion Calculator

- Converts optimal fluence into actual fluence
- Creates optimal leaf motion
  - Leaf transmission
  - Max leaf speed
  - Rounded leaf ends

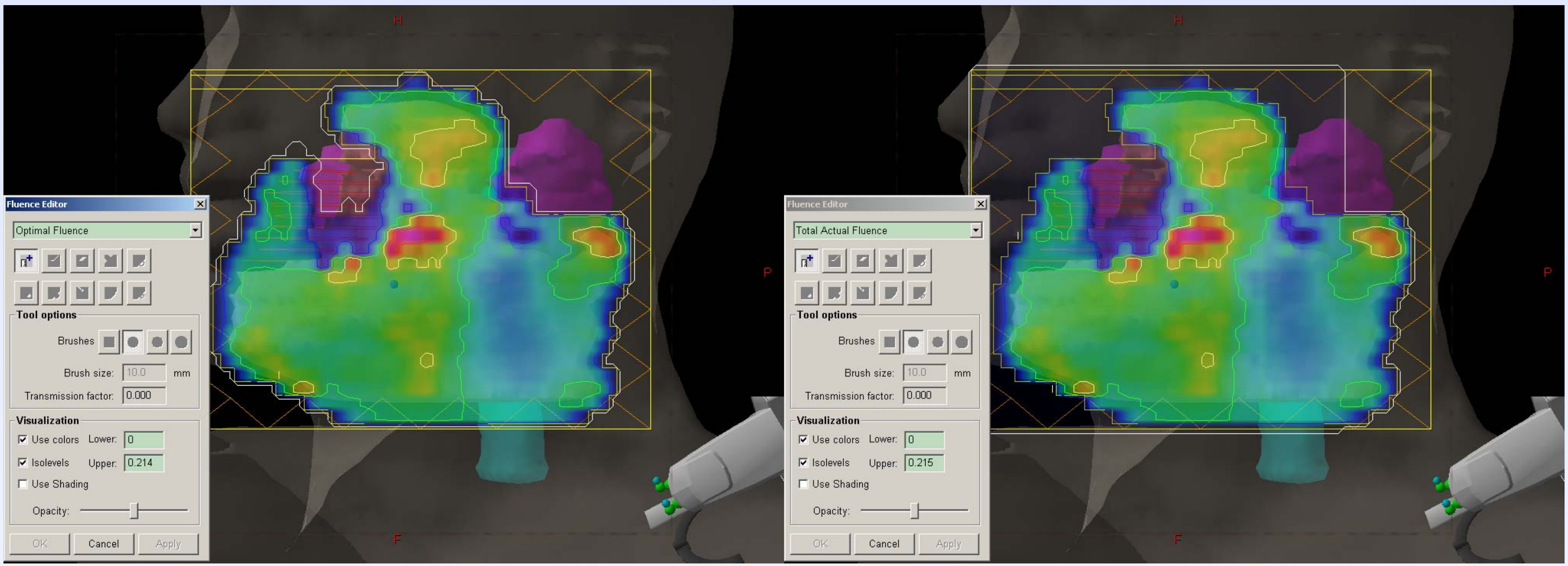


- Sliding window
- Multiple static segments

Optimal fluence vs actual fluence

Optimal Fluence

Actual Fluence (Sliding Window)

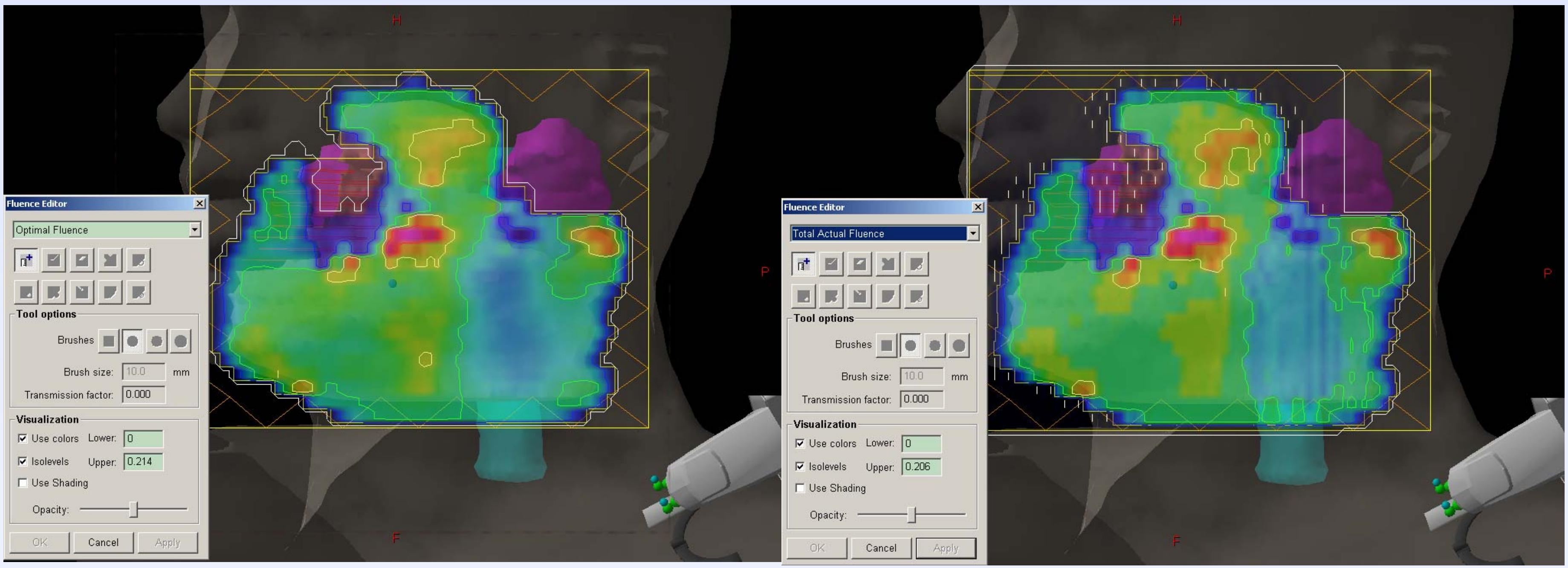


100 Intensity levels, 640 Segments

Optimal fluence vs actual fluence

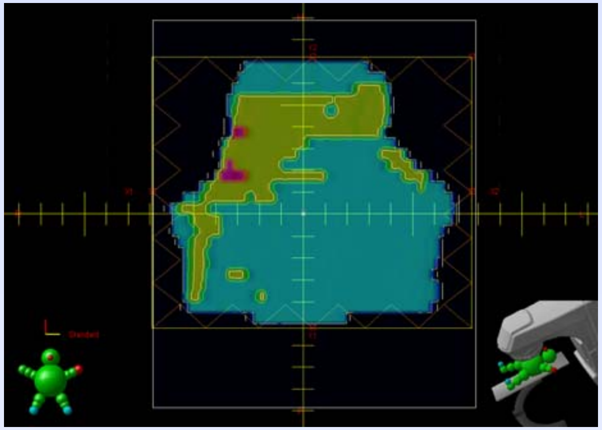
Optimal Fluence (MSS)

Actual Fluence

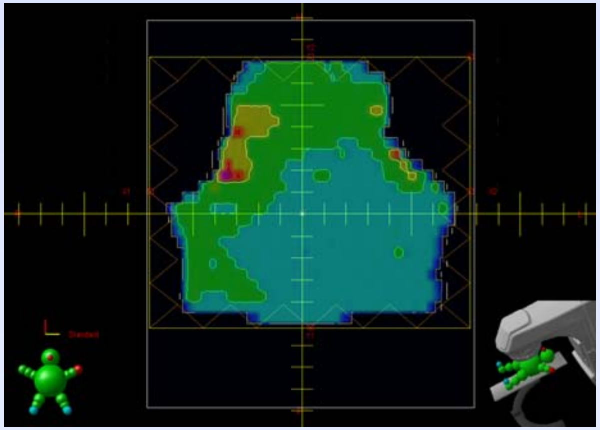


8 Intensity levels, 18 Segments

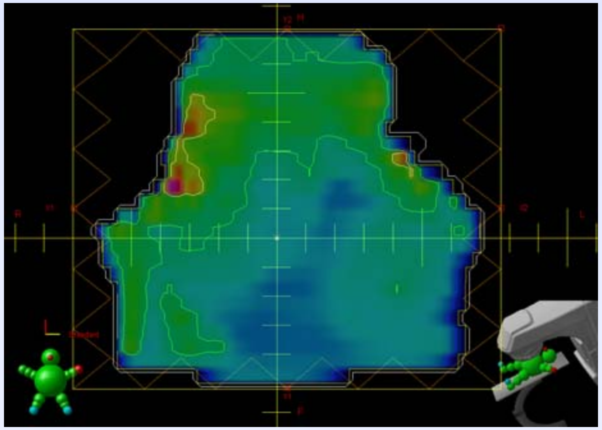
Actual Fluence Maps



4 int levels – 5 segments

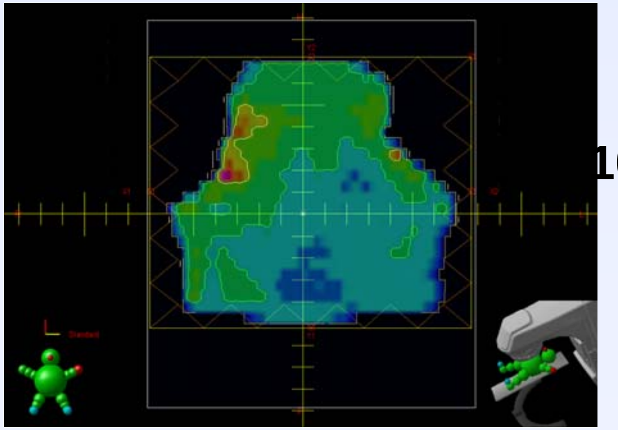


7 int levels – 9 segments

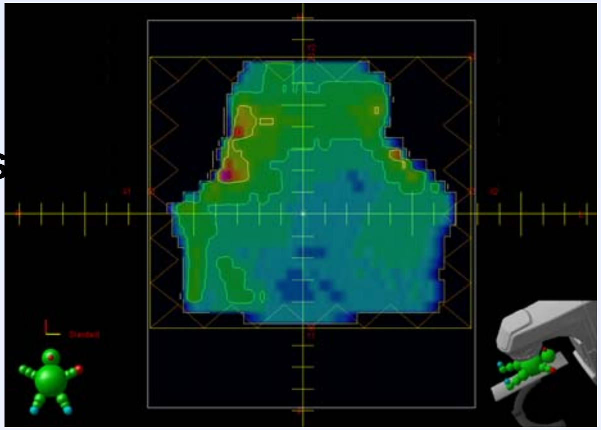


100 int levels – 320 segments

10 int levels – 13 segments



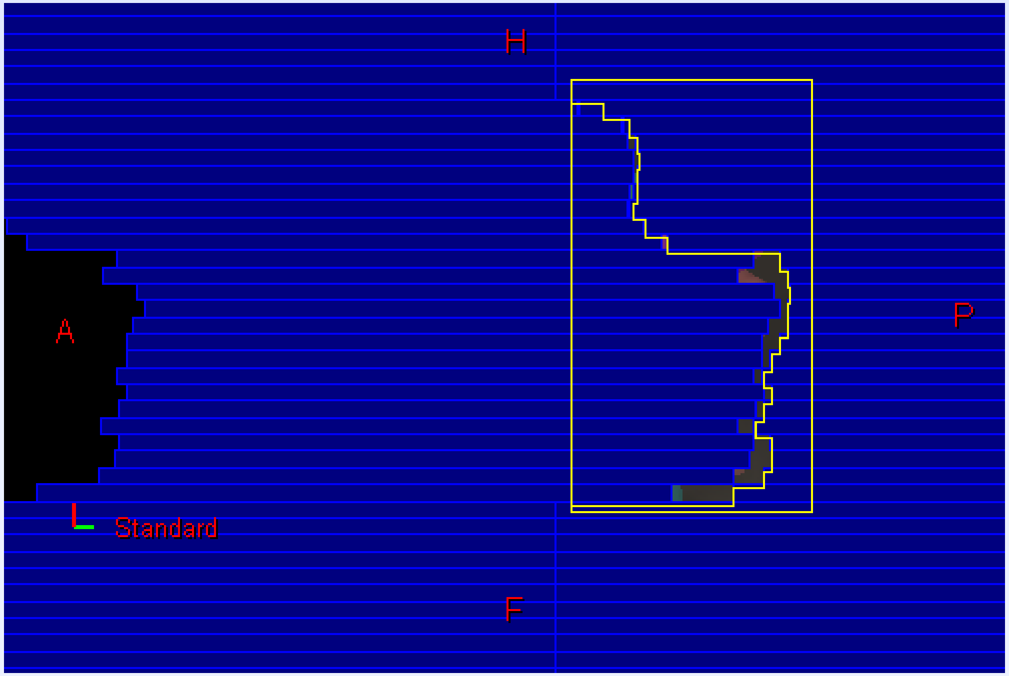
15 int levels – 19 segments



Better technology. Better outcomes.

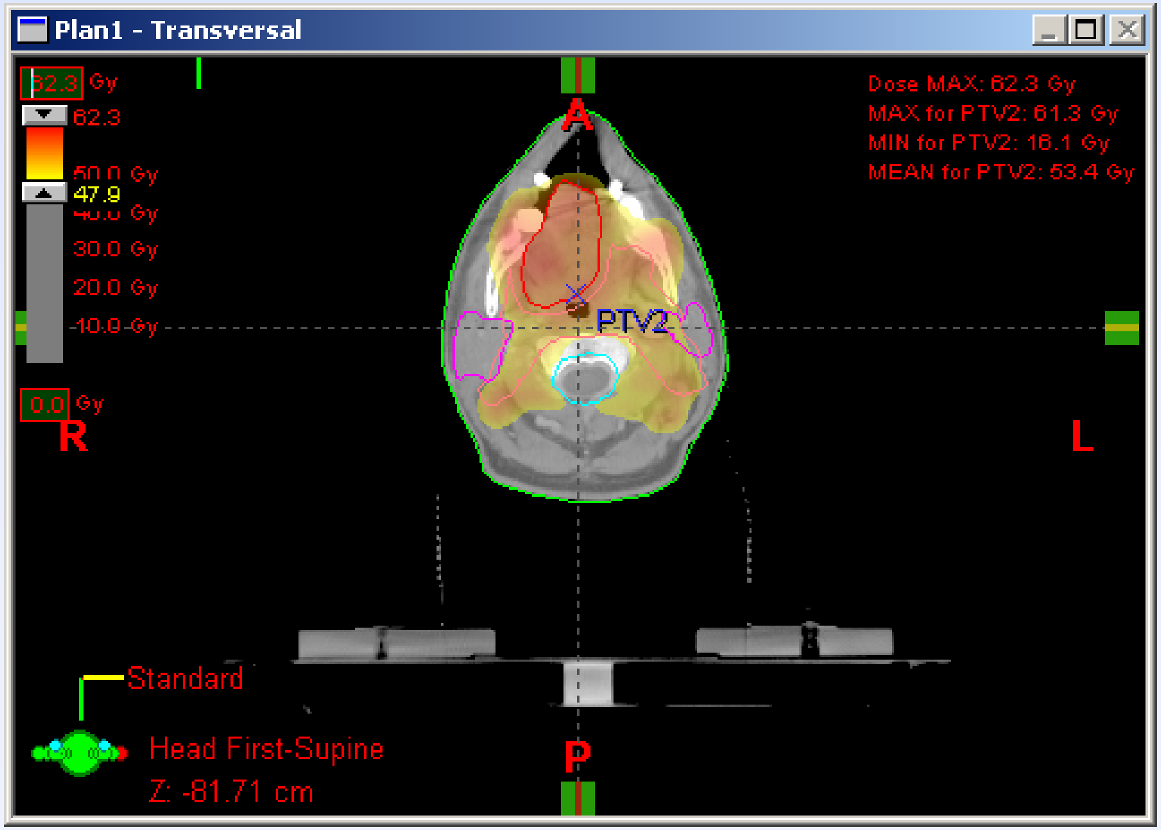
Sliding Window 640 Segments

Multiple static segments 18 Segments



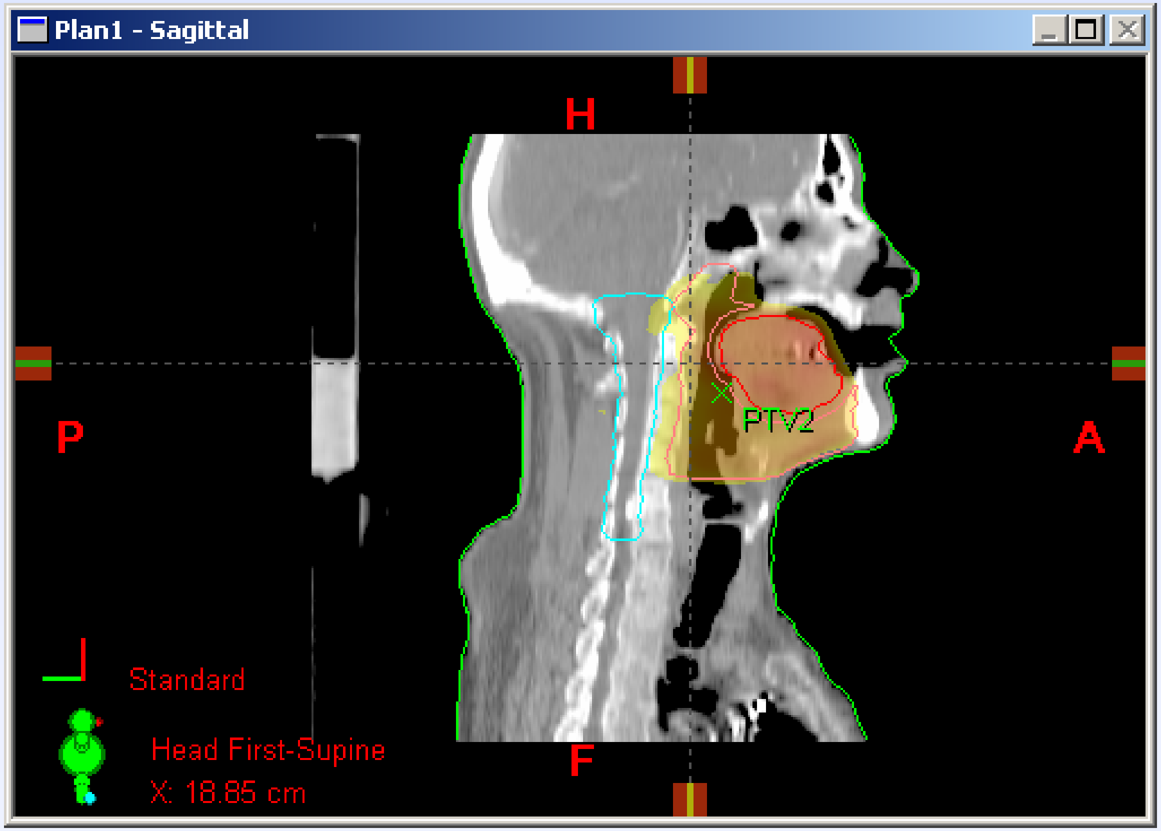
Dose Distribution

- Transversal 2D dose distribution



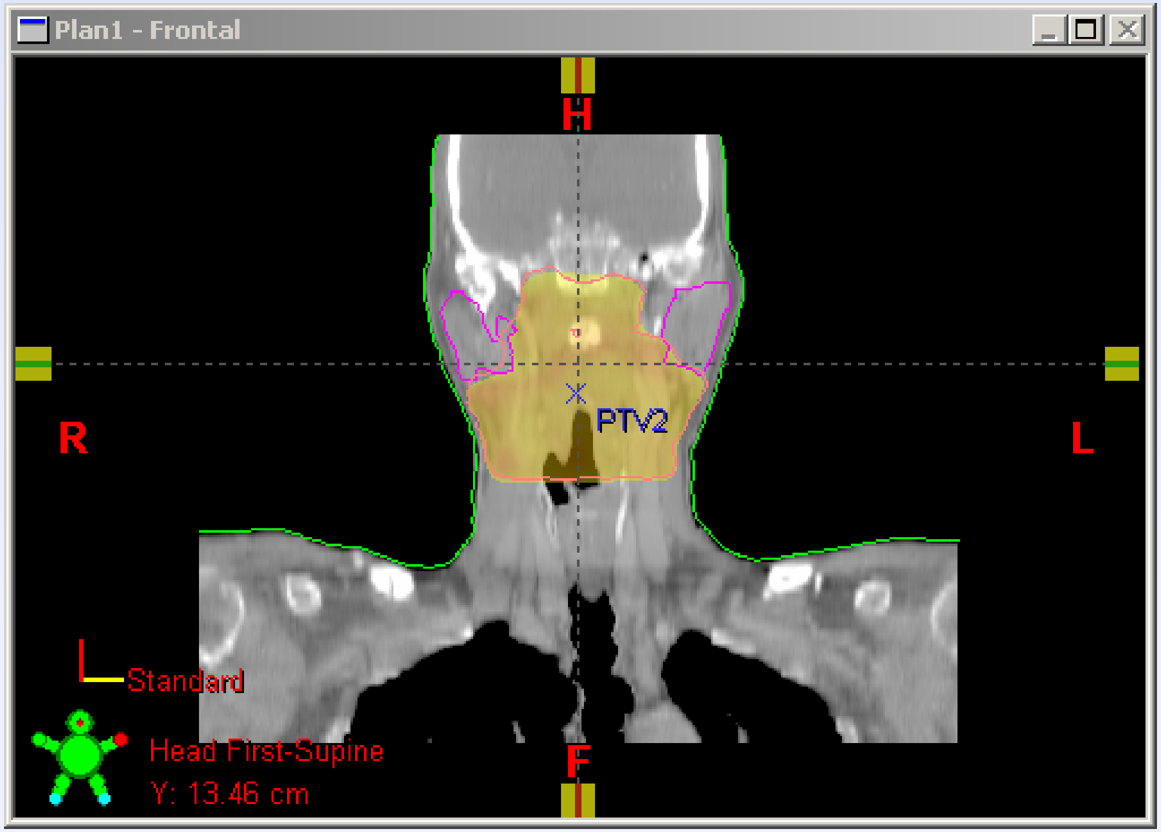
Dose Distribution

- Sagittal 2D dose distribution



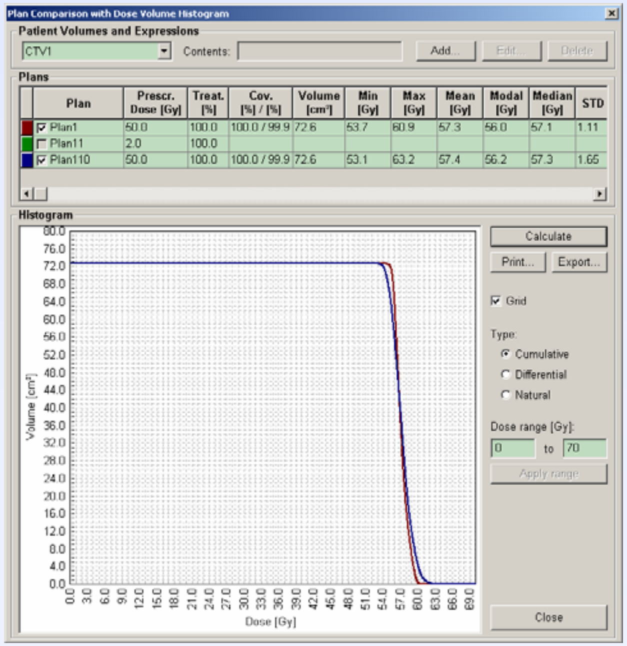
Dose Distribution

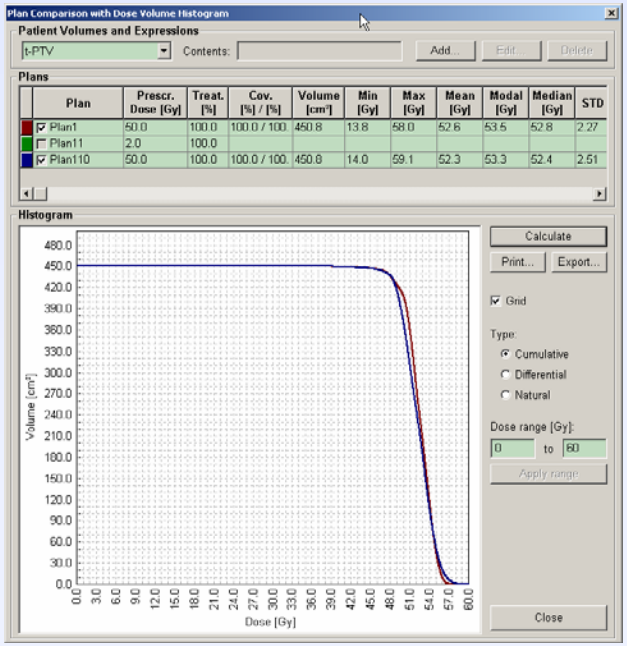
- Frontal 2D dose distribution



Sliding Window vs MSS

- DVH CTV and PTV
  - Sliding window: conformer dose





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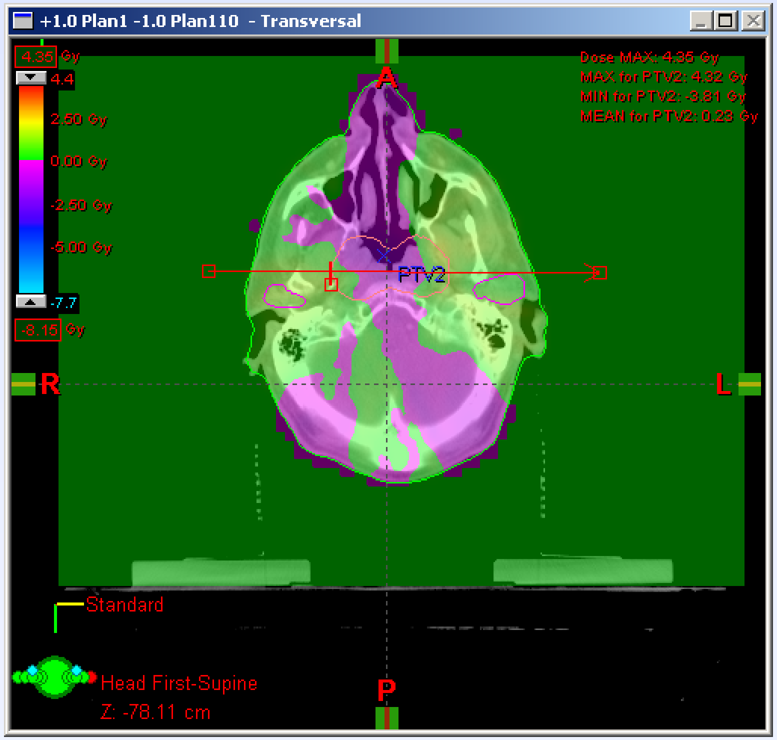
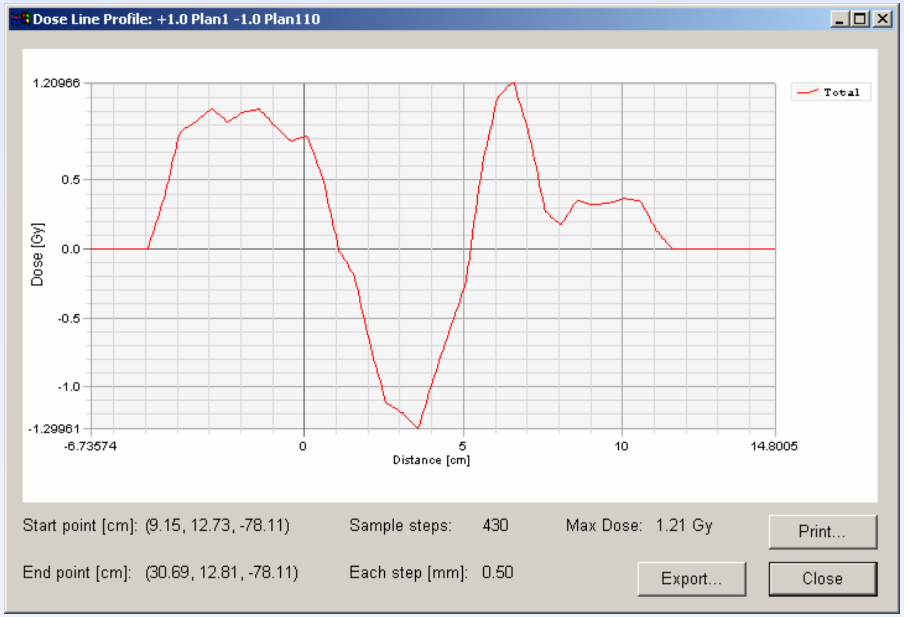
Sliding Window vs MSS

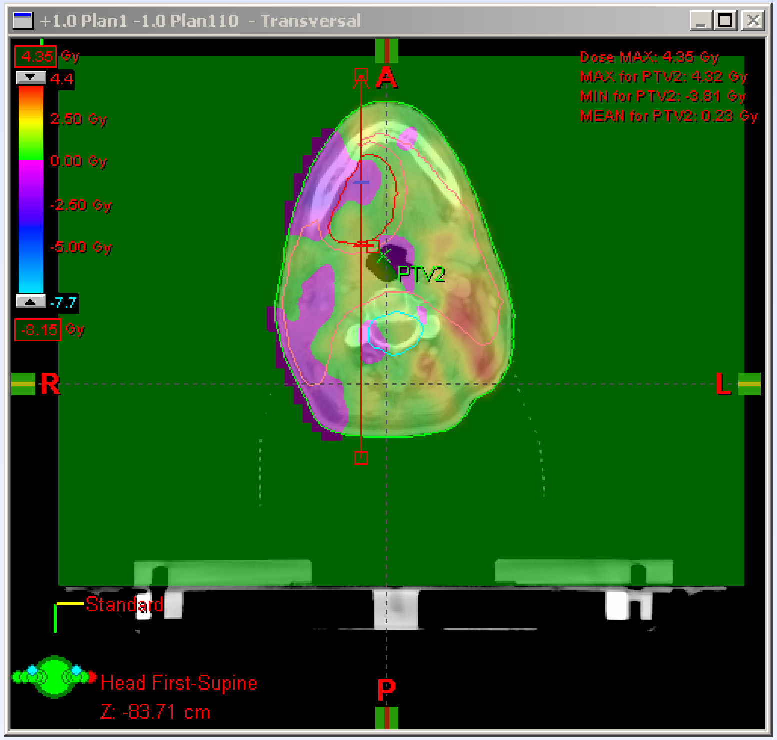
- Plan subtraction Sliding window - MSS

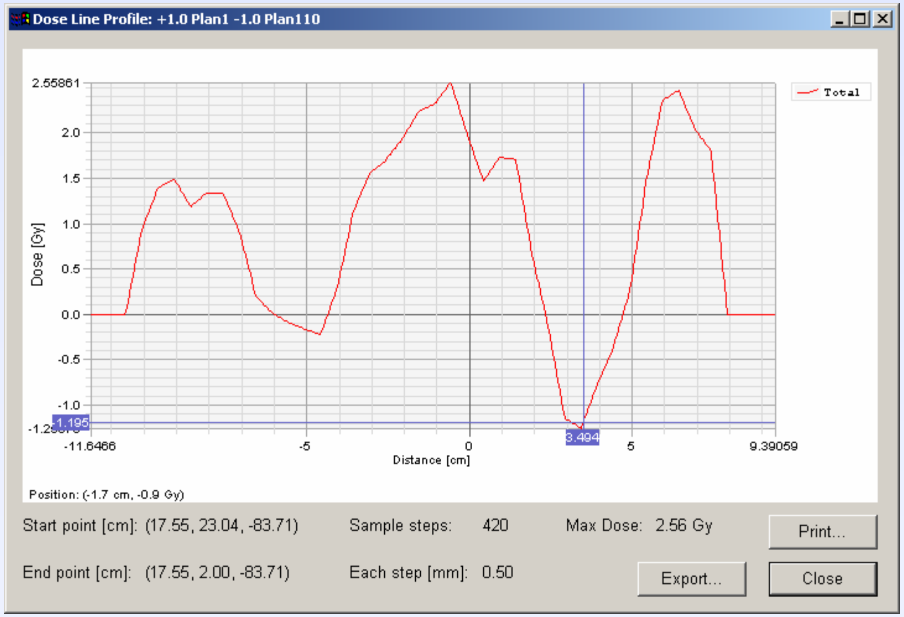




Sliding Window vs MSS

- Plan subtraction Sliding window - MSS





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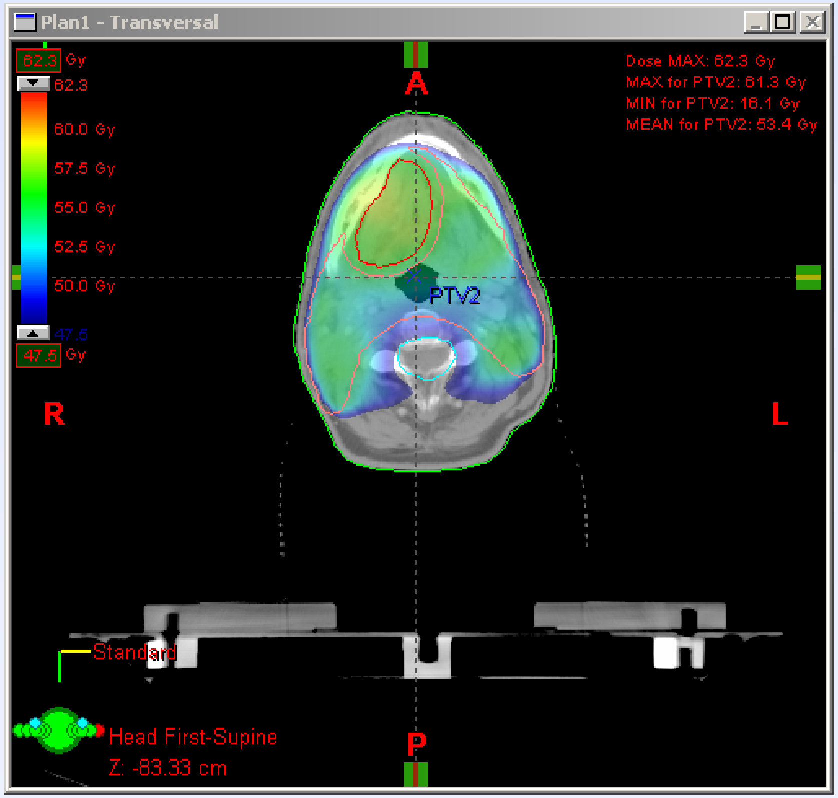
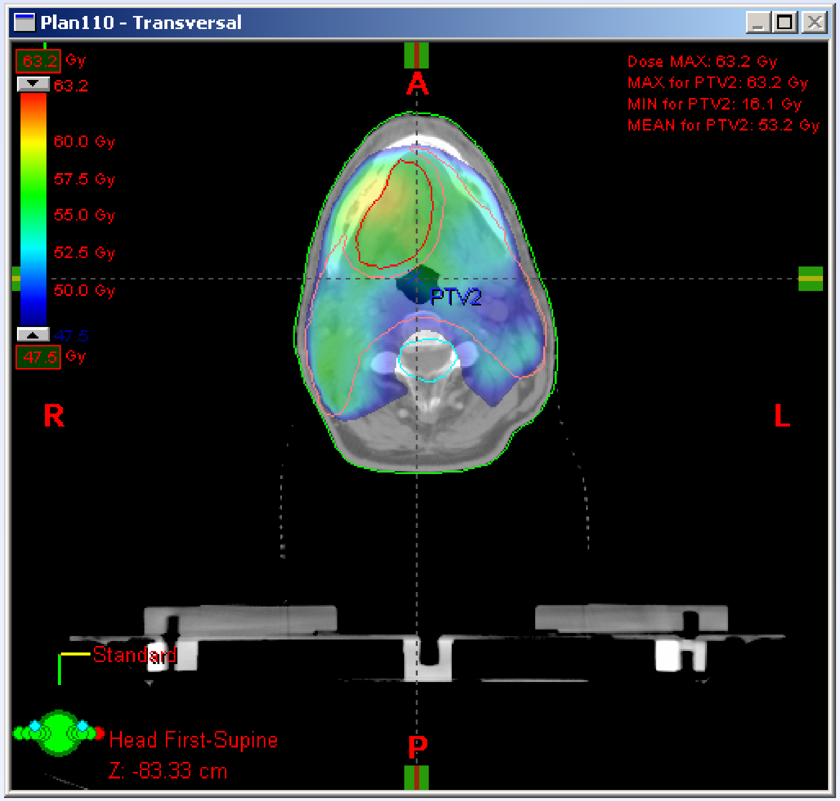
Sliding Window vs MSS

Sliding window



MSS



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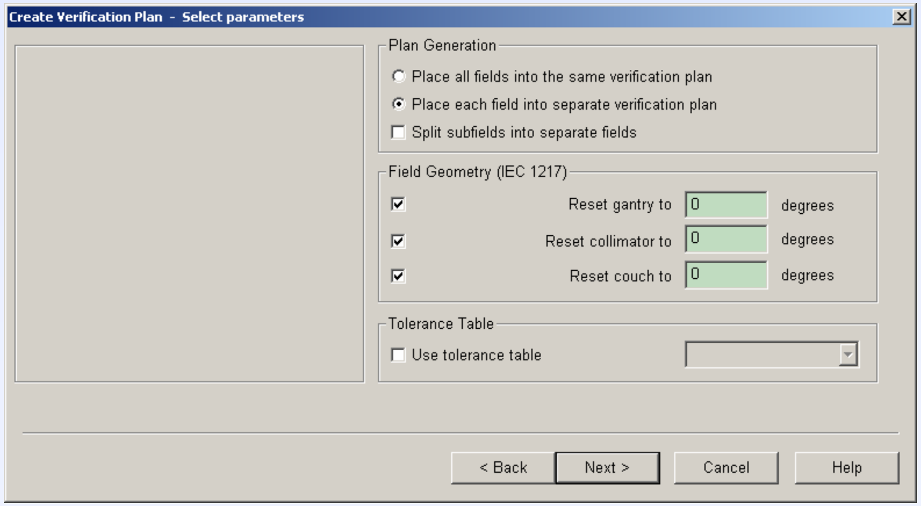
Quality Assurance

- Possible patient QA
  - Verify every single IMRT field (all segments together)

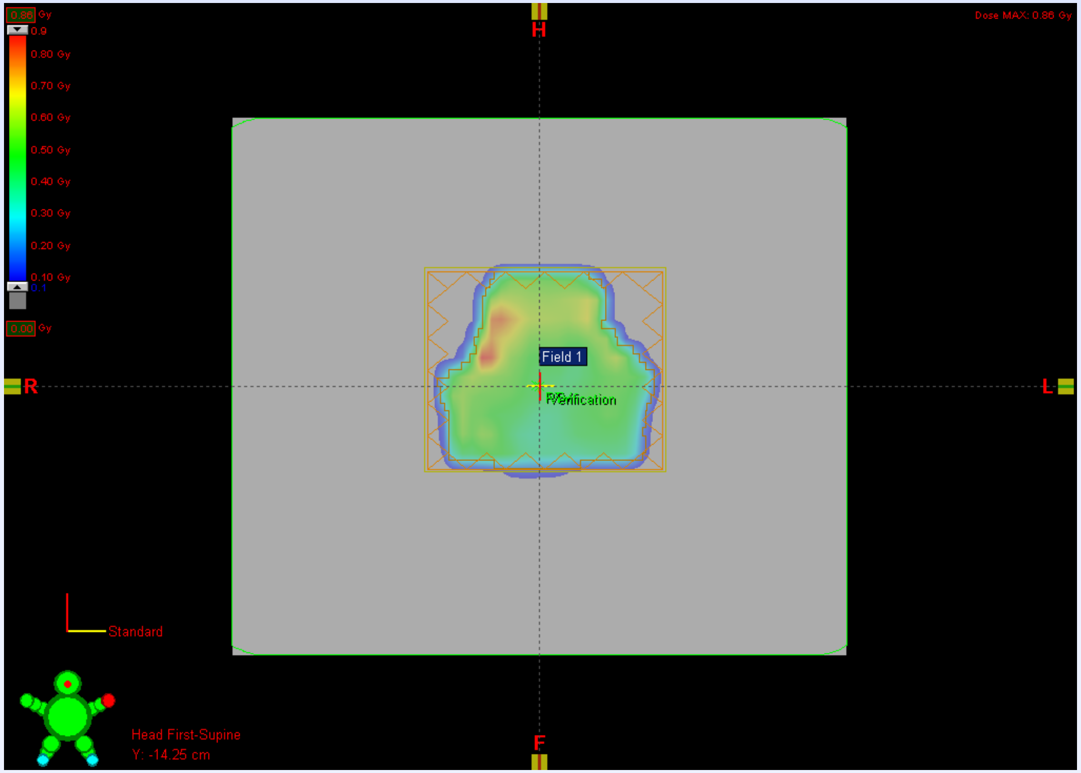
or

  - verify the total plan



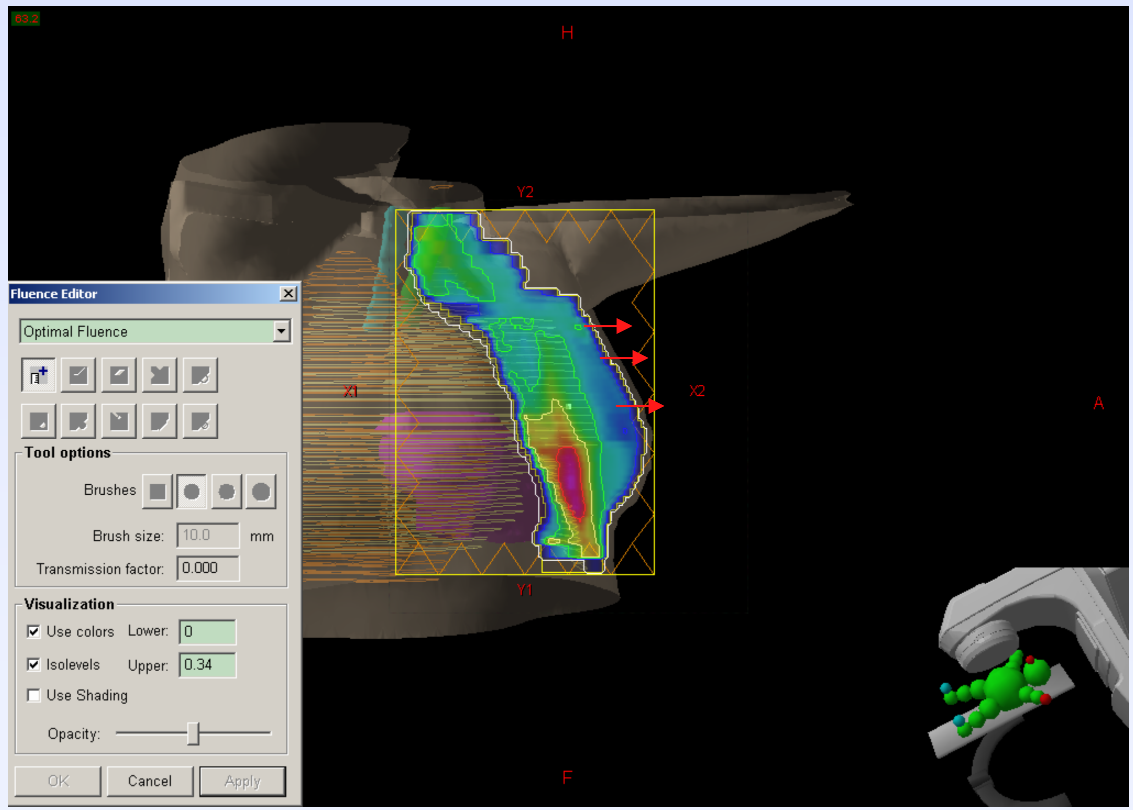
Quality Assurance

- Field by field verification



Special Tool

- Skin flash tool
  - Breast patient
  - Patient movement
    → parts outside the fluence

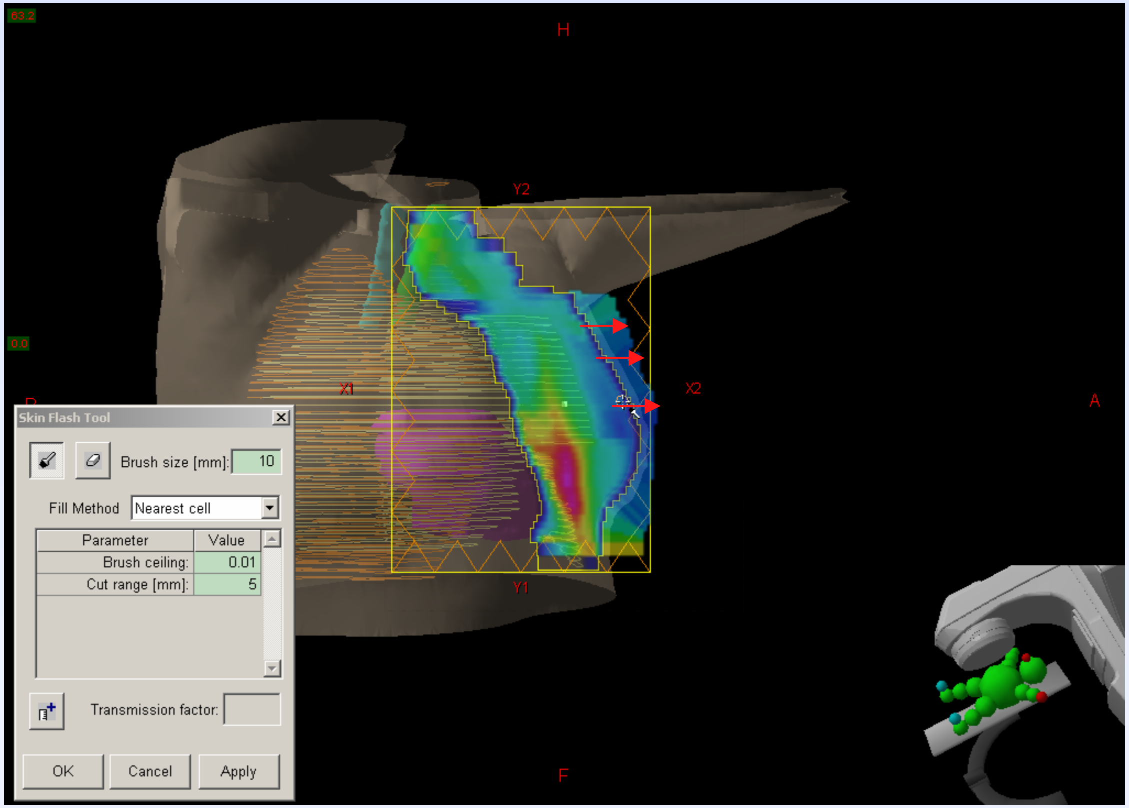


Special Tool

- Skin flash tool
  - Breast patient
  - Patient movement

    → parts outside the fluence

→ Add fluence at the border of the original fluence



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Summary

- Eclipse Helios includes
  - Fast and Interactive Optimization
  - Sliding Window (and MSS)
  - QA tools
  - Skin Flash tool

Summary

- Participant of IMRT School Berlin at the end of the Course:

  "I have learned again to enjoy Radiotherapy"

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Summary

- Eclipse Helios
  - All tools needed for 3D RT planning
  - All tools needed for excellent IMRT planning

→ so, lets continue to work together that our customers can learn to enjoy RT again