

IMRT mit dem Mikromultileafkollimator m3 – Vorteile, Probleme und praktische Beispiele

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Einführung der IMRT in Jena



Januar 2001: vorwärtsgeplante IMRT
mit step & shoot

Juli 2001: invers geplante IMRT
mit Kompensatoren

Juni 2003: invers geplante IMRT
mit step & shoot 1cm Lamellen

November 2007: invers geplante IMRT
mit step & shoot + Mikromultileafkollimator

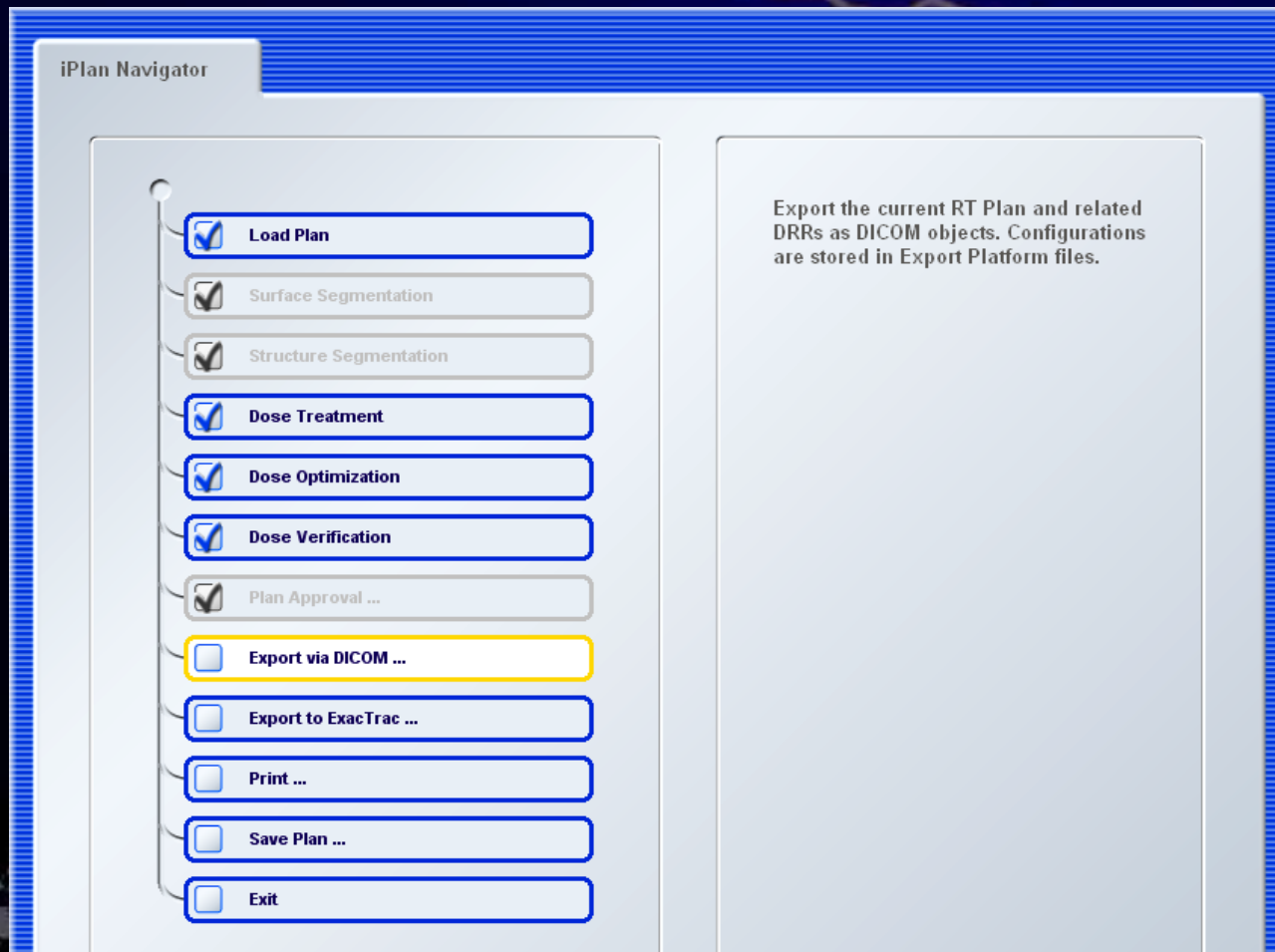
Hardware:

- Siemens Oncor 6MV und 15MV
- Mikromultileafkollimator m3 (Brainlab)
- Siemens-Integration-Kit (Brainlab)
- Stereotaxiesystem (Brainlab)



Software:

- IPlan RT Dose V 3.0.2 (Brainlab) mit „Navigator“
- m3 User Interface (BrainLAB)
- V & R – System Lantis V 6.1 H4 (Siemens)



Vorteile:

- kleine Lamellen 3mm, 4.5mm, 5.5mm
- geringe Transmission 2%
- wenn closed jaws: Transmission $<0,5\%$
- stereotaktische Einstellung + Tiltkorrektur möglich
- **hohe Lagerungsreproduzierbarkeit in stereotakt. Maske**
- **Überlagerung des Isodosenplanes im MR-Datensatz**

Vorteile:

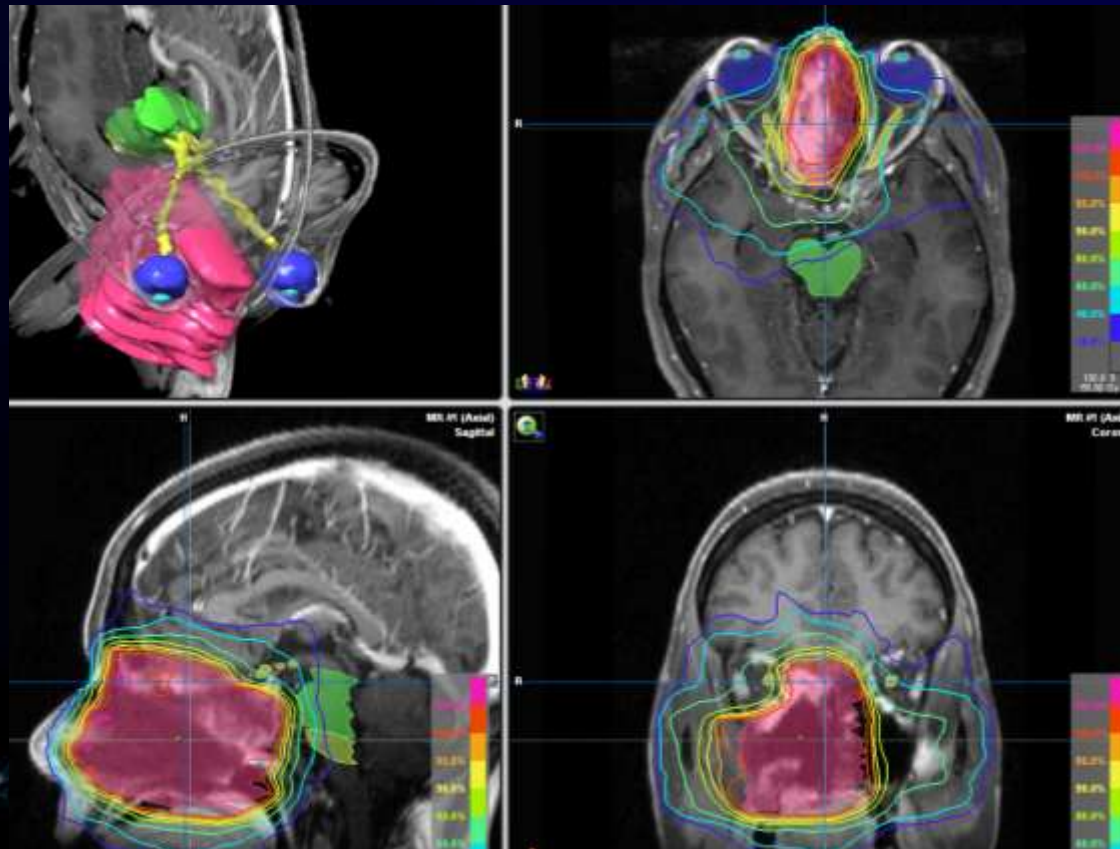
- **kleine Lamellen 3mm, 4.5mm, 5.5mm**
- **geringe Transmission 2%**
- **stereotaktische Einstellung + Tiltkorrektur möglich**
- **hohe Lagerungsreproduzierbarkeit in stereotakt. Maske,
→ Standardabweichung <1mm**
- **Überlagerung des Isodosenplanes im MR-Datensatz**

...standard deviations of patients with and patients without bite block (bb) were compared and significance tested with Mann-Whitney-U-Test.
The use of the bite block shows a **clear and significant advantage with a better immobilization....**

	with bb	without bb	p-value
lateral	0,36 mm	0,75 mm	0,025
longitudinal	0,47 mm	1,43 mm	0,0001
vertical	0,5 mm	0,65 mm	0,029

Vorteile:

- kleine Lamellen 3mm, 4.5mm, 5.5mm
- geringe Transmission 2%
- stereotaktische Einstellung + Tiltkorrektur möglich
- hohe Lagerungsreproduzierbarkeit in stereotakt. Maske
- Überlagerung des Isodosenplanes im MR-Datensatz



Workflow (vor inverser Planung):

- **Konturierung PTV und OARs**
- **Vorgabe der Constraints numerisch oder per DVH**
- **Vorgabe der Parameter für den Segmentierer**

Objects

- PTV
- linse links**
- linse rechts
- Optic Nerve, Left
- Optic Nerve, Right
- retina, Left
- retina, Right
- Brainstem
- Chiasm
- Medulla Oblongata
- Normal Tissue
- All Objects

Isocenter Relation

Absolute Dose Unit

☐ cGy

☒ Gy

Dose Display option

☒ Relative

☐ Absolute

☐ PTV

☐ Boost

☒ OAR Type 1

☐ OAR Type 2

☐ OAR Type 3

☐ Regular

Fractionation

Number of Fractions

31

Dose for

☒ All Fractions

55.80 Gy

☐ Single Fraction

1.80 Gy

Display Dose Relation

100.0 % Dose related to

55.80 Gy

linse links

Volume (%)	Dose [%]	0.0	17.9	18.3	18.3	18.3
Volume [%]	100.0	100.0	50.0	25.0	0.0	

guardian: 100%

Dose (%) 100% = 55.80 Gy

Numeric

Constraint Templates

<Custom>

Save As ...

Delete

Workflow (vor inverser Planung):

- Konturierung PTV und OARs
- Vorgabe der Constraints numerisch oder per DVH
- Vorgabe der Parameter für den Segmentierer

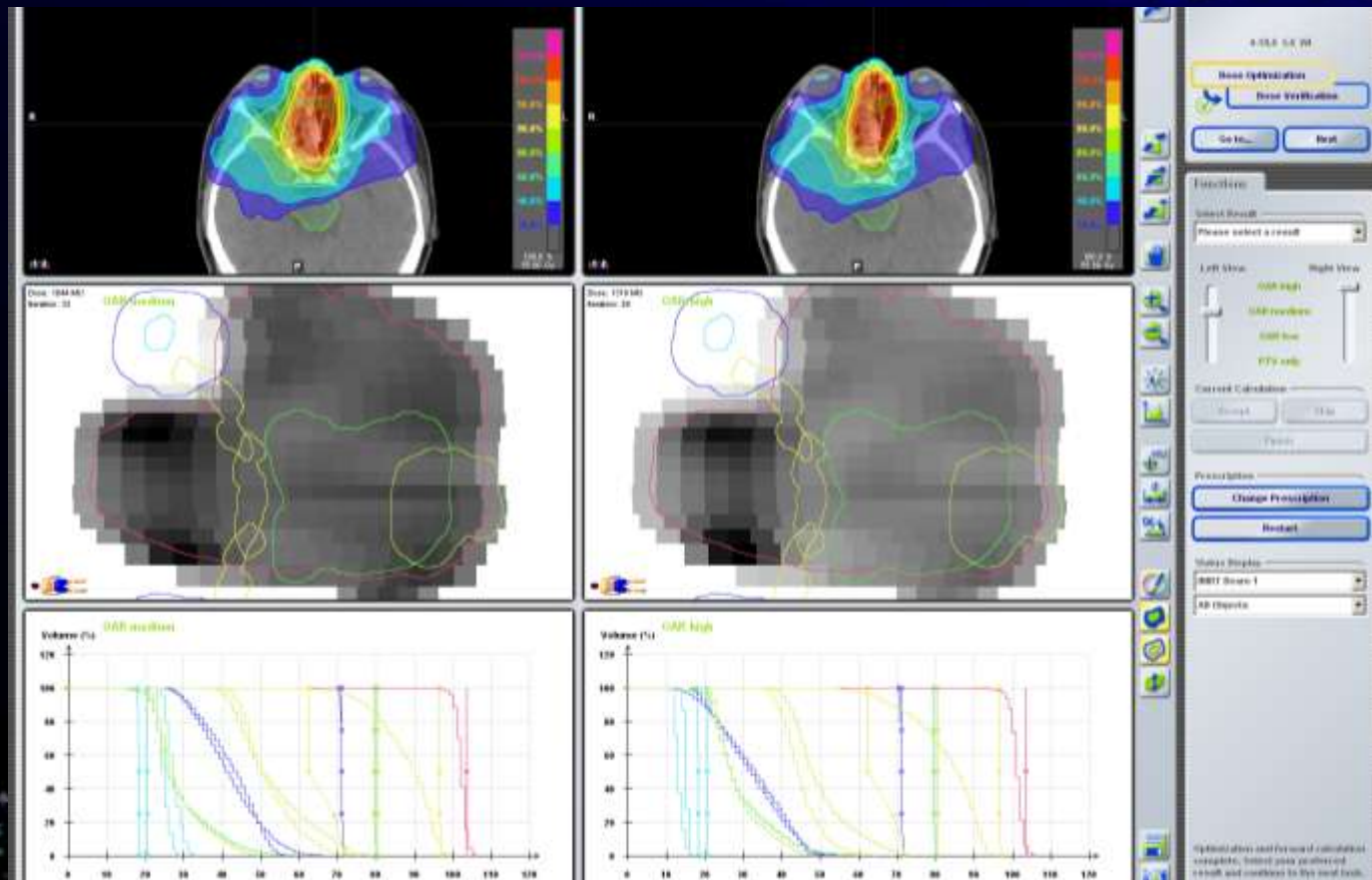
The screenshot displays a software interface for radiotherapy planning, divided into several panels:

- Calculation Grid:**
 - PTV Dose Grid size: 3.0 mm
 - OAR Dose Grid size: 4.0 mm
 - ☒ Use Adaptive Resolution
 - Table of objects and grid sizes:

Object	Grid size	Calc. Points
PTV		
retina, Left		
retina, Right		
linse links		
linse rechts		
Optic Nerve, Left		
- Sharp Edge Smoothing:**
 - Filter Parameter: 3%
 - Slider from Low to High
- Hot Beamlet Restriction:**
 - IMRT MU Result above Conformal Beam MU w/o IMRT
 - max. 100.0 %
- Normal Tissue Restriction:**
 - ☒ Use Normal Tissue Restriction
 - Normal Tissue Dose Grid size: 8.0 mm
 - Margin around PTV w/o restriction: 10.0 mm
 - ☐ Use Outer Contour
 - Margin around PTV with restriction: 24.0 mm
- LIIAC Specific Settings:**
 - Selected profile: Oncor_m3_6MV
 - Beamlet size max.: 5.0 mm
 - ☐ Align Beamlets
 - Leaf Sequencing: ☐ Dynamic, ☒ Step-and-Shoot
 - 10 segments
 - ☒ Use Tongue-and-Groove Optimization
- Est. Memory Usage:**
 - Calculating ...

Workflow (nach inverser Planung):

- inv. Planung basiert auf „dynamically penalized likelihood“-Algorithmus nach Llacer et.al.
- IMRT-Wizzard bietet 4 Lösungen an
- PTV only, OAR low, OAR medium, OAR high
- keine interaktive Planung wie z.B. bei Konrad



Workflow (nach inverser Planung):

- nach Auswahl eines Planvorschlages Möglichkeit der Normierung und Approval
- Export des IMRT-Plans zu Lantis + m3 Workstation



The image shows a 'DICOM Export' dialog box with a blue border. It contains two main sections: 'Export Platform Selection' and 'Description'. In the 'Export Platform Selection' section, there is a dropdown menu for 'Export Platform' set to 'Lantis mit m3', an 'SCP' field with the value 'LAHTIS_DICOM@r-lantis:104', and a 'Test connection' button. Below the button, it says 'Connection not tested'. The 'Description' section contains the text 'Export Platform for the Siemens Lantis RV system.' At the bottom are 'OK' and 'Cancel' buttons.

DICOM Export

Export Platform Selection

Export Platform: Lantis mit m3

SCP LAHTIS_DICOM@r-lantis:104

Test connection Connection not tested

Description

Export Platform for the Siemens Lantis RV system.

OK Cancel

Verifikation (klassisch)

Phantom fixed to
coordinates
(stereotactical)

CT scanning

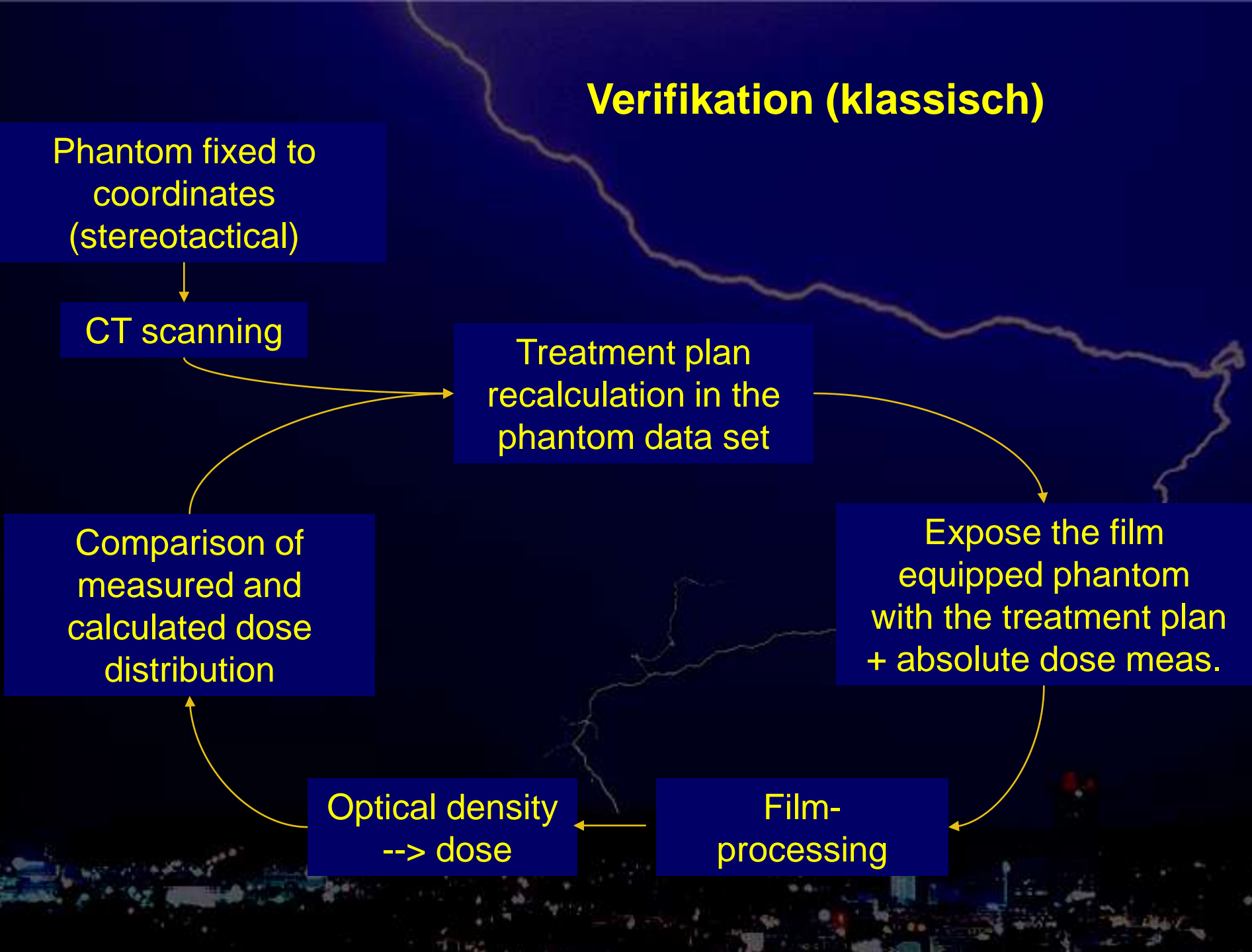
Treatment plan
recalculation in the
phantom data set

Expose the film
equipped phantom
with the treatment plan
+ absolute dose meas.

Comparison of
measured and
calculated dose
distribution

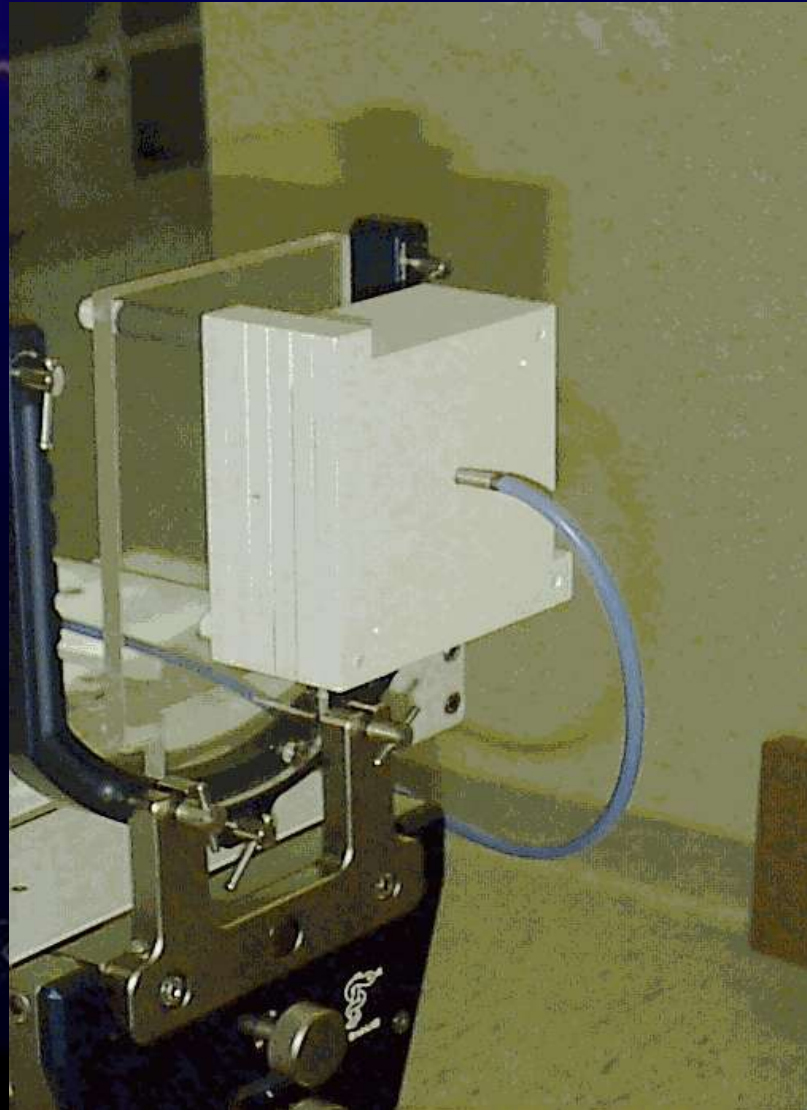
Optical density
--> dose

Film-
processing



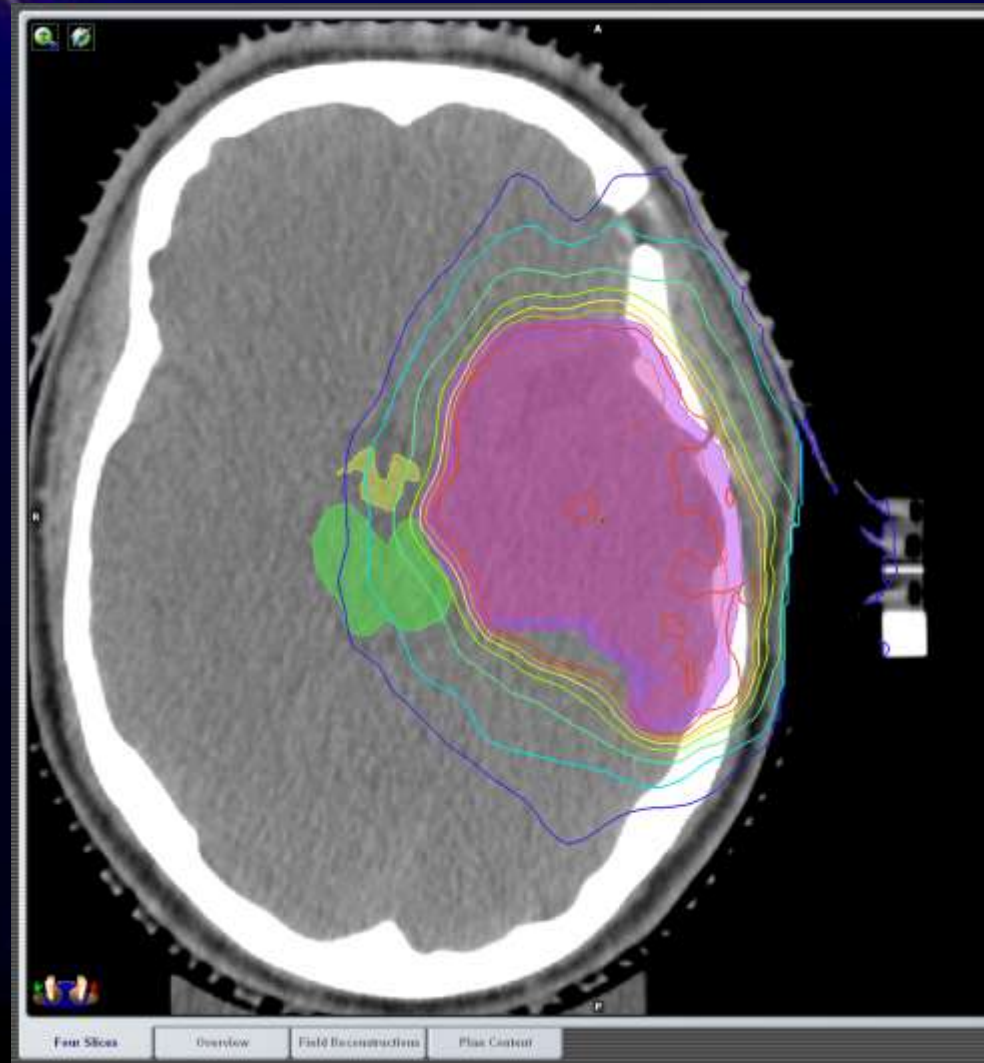
2^{1/2}D-Phantom

- in stereotakt. Koordn.
- EBT Gafchromic
- Ionisationskammer mit kleinem Volumen



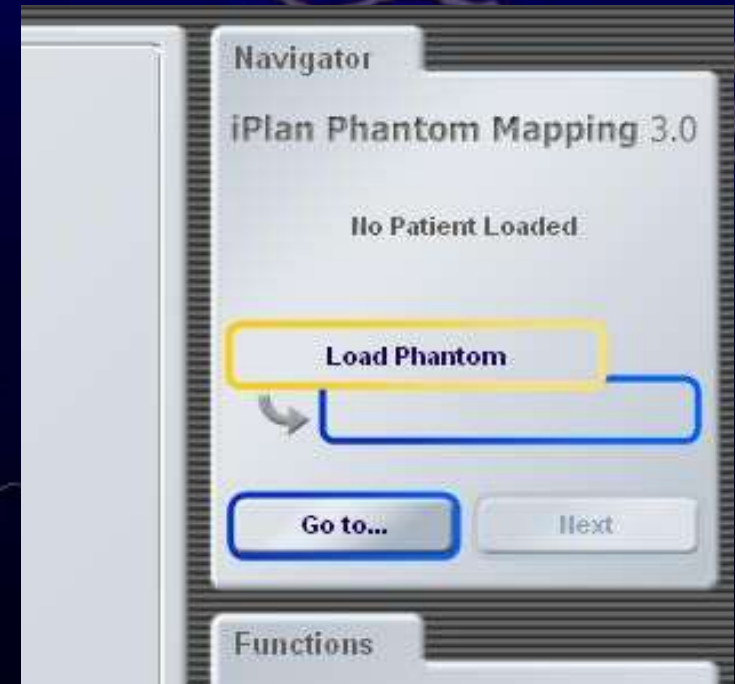
Beispiel Verifikation

- Dosisverteilung im Patientendatensatz



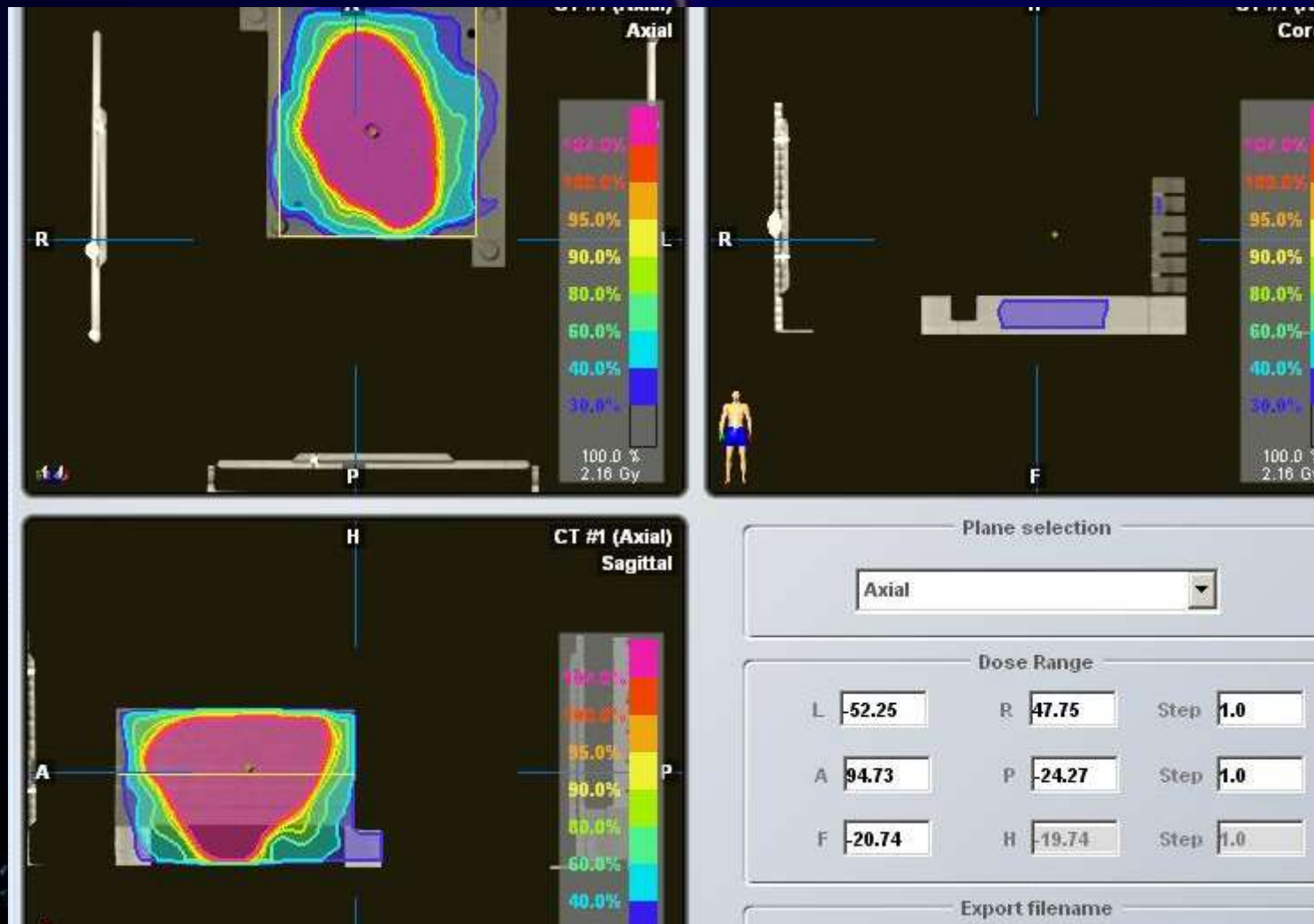
Beispiel Verifikation

- Phantom Mapping ist komfortabel



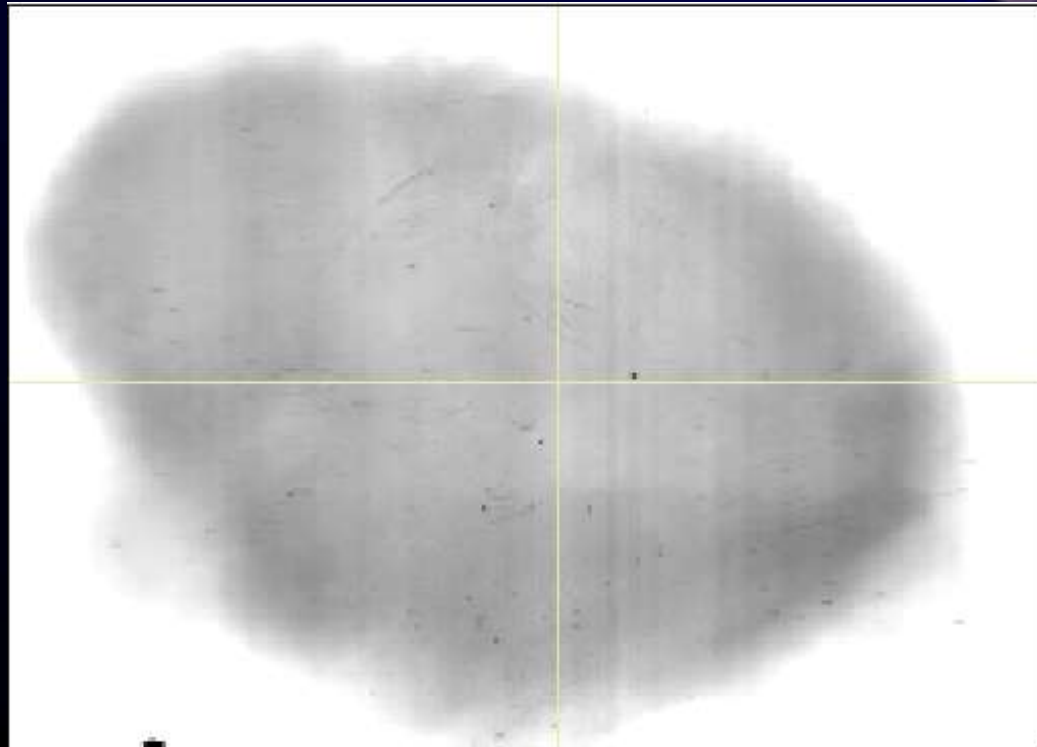
Beispiel Verifikation

- Definieren von Lage und Größe der Matrix



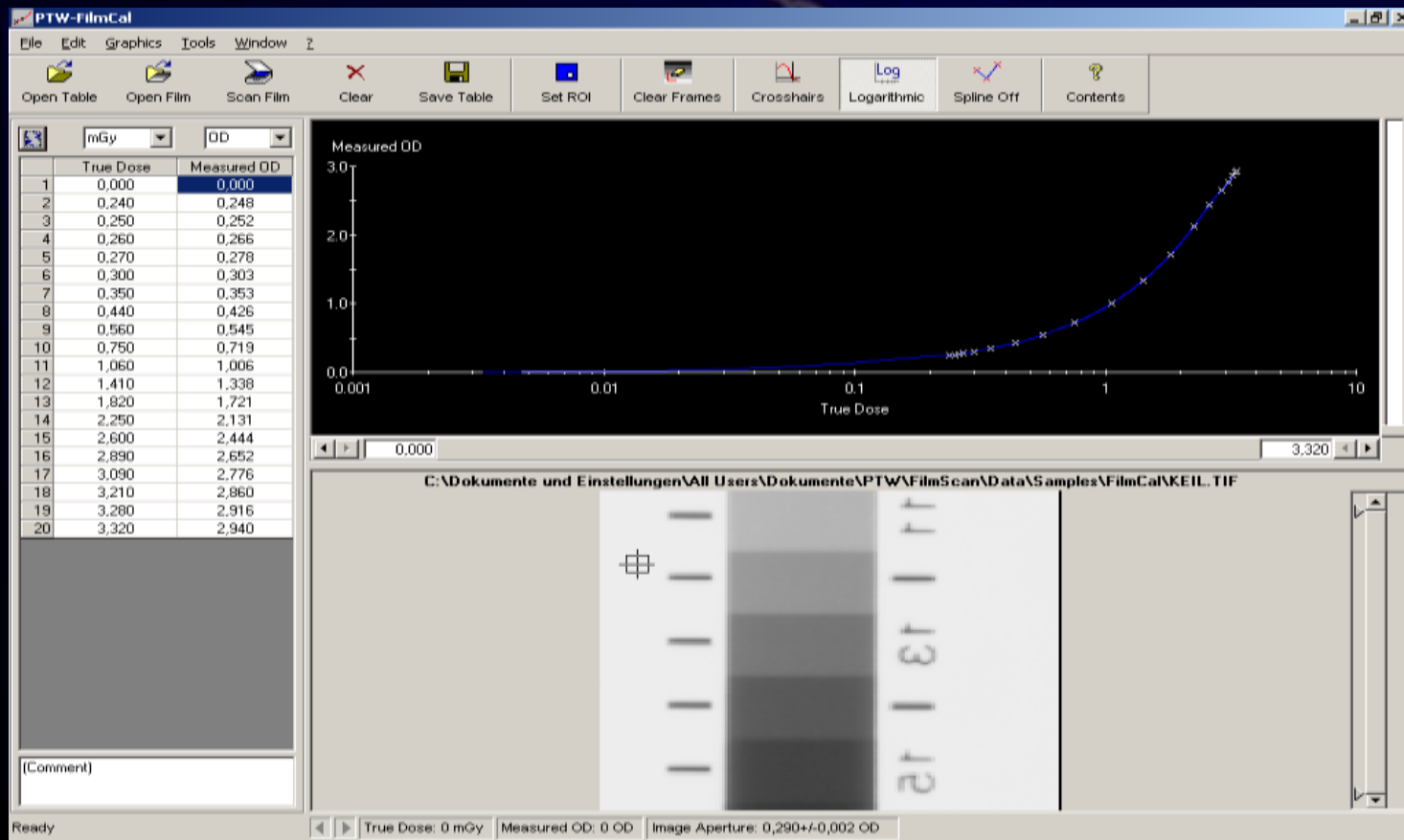
Beispiel Verifikation

- Scannen des EBT (ca. 24h Reifung)
- früher mit VIDAR 12, jetzt Epson V700
- optische Dichteverteilung (->Grauwert / pixel value)

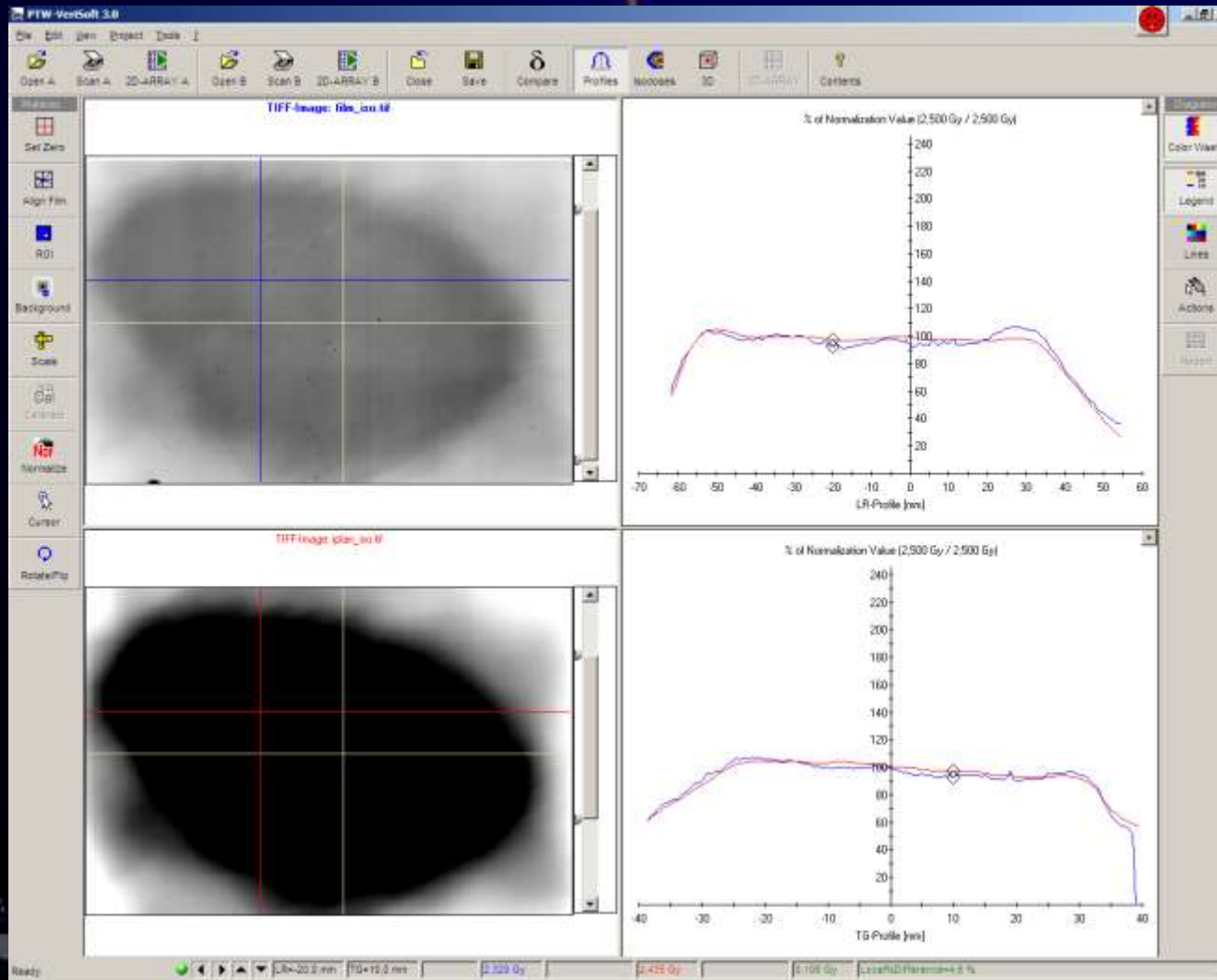


Beispiel Verifikation

- Transformation Grauwertverteilung in Dosis in Verisoft FilmCal (PTW)



- Import der Rechen- und Meßmatrix in VeriSoft (PTW)
- Auswertung per overlay



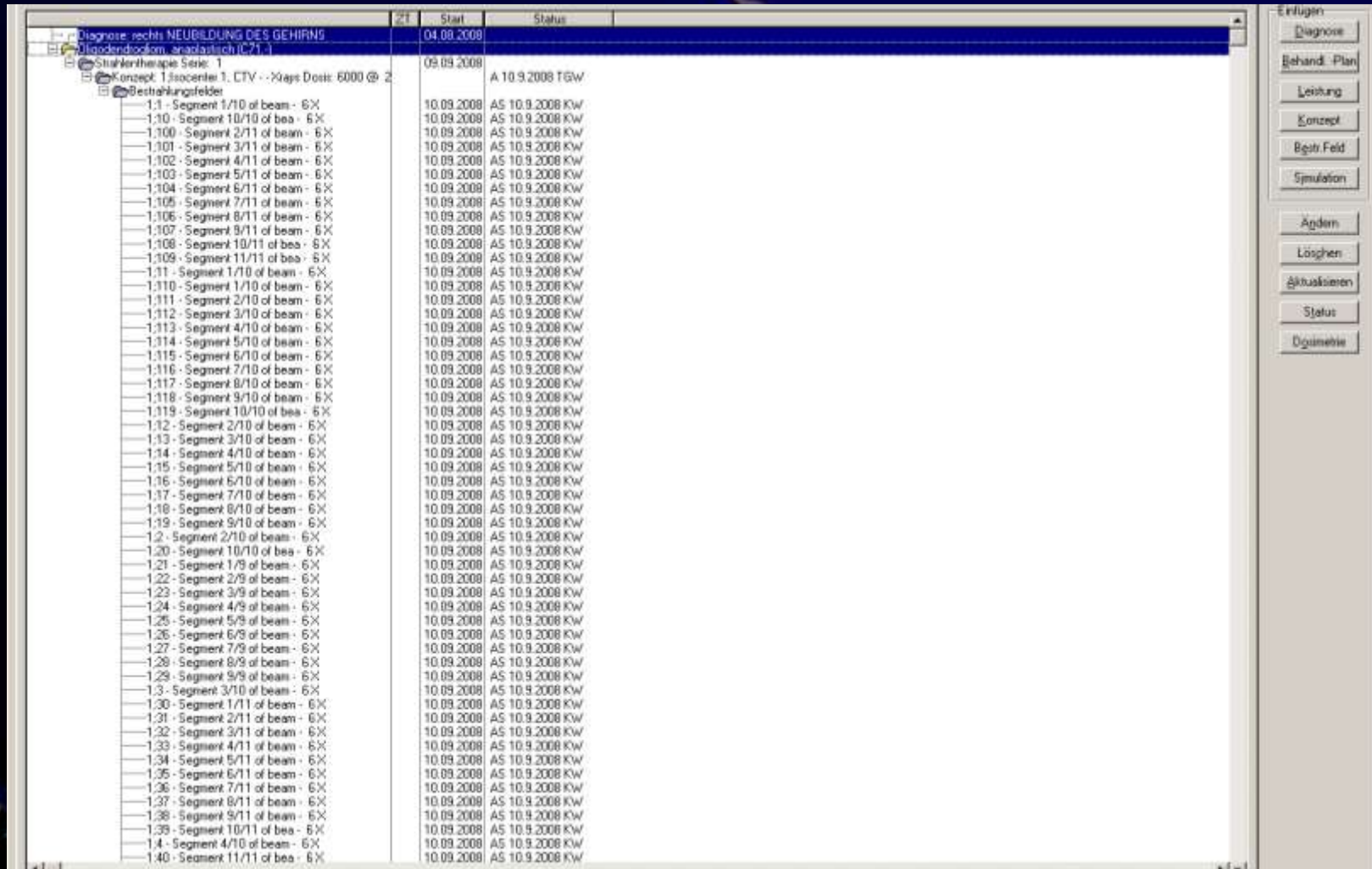
Beispiel Verifikation

- Erneuerung des IMRT-Phantoms
- m3-Felder $10 \times 10 \text{ cm}^2$ werden besser abgedeckt, weniger Kanten
- identisches Phantom für Relativ- und Absolutmessung
- Ausfräsung für EBT-Filme



Probleme / Nachteile

- Datenhandling in Lantis
- Feldsegmente werden wie Einzelfelder behandelt
→ umständlich für Freigabe durch Zweitphysiker !!

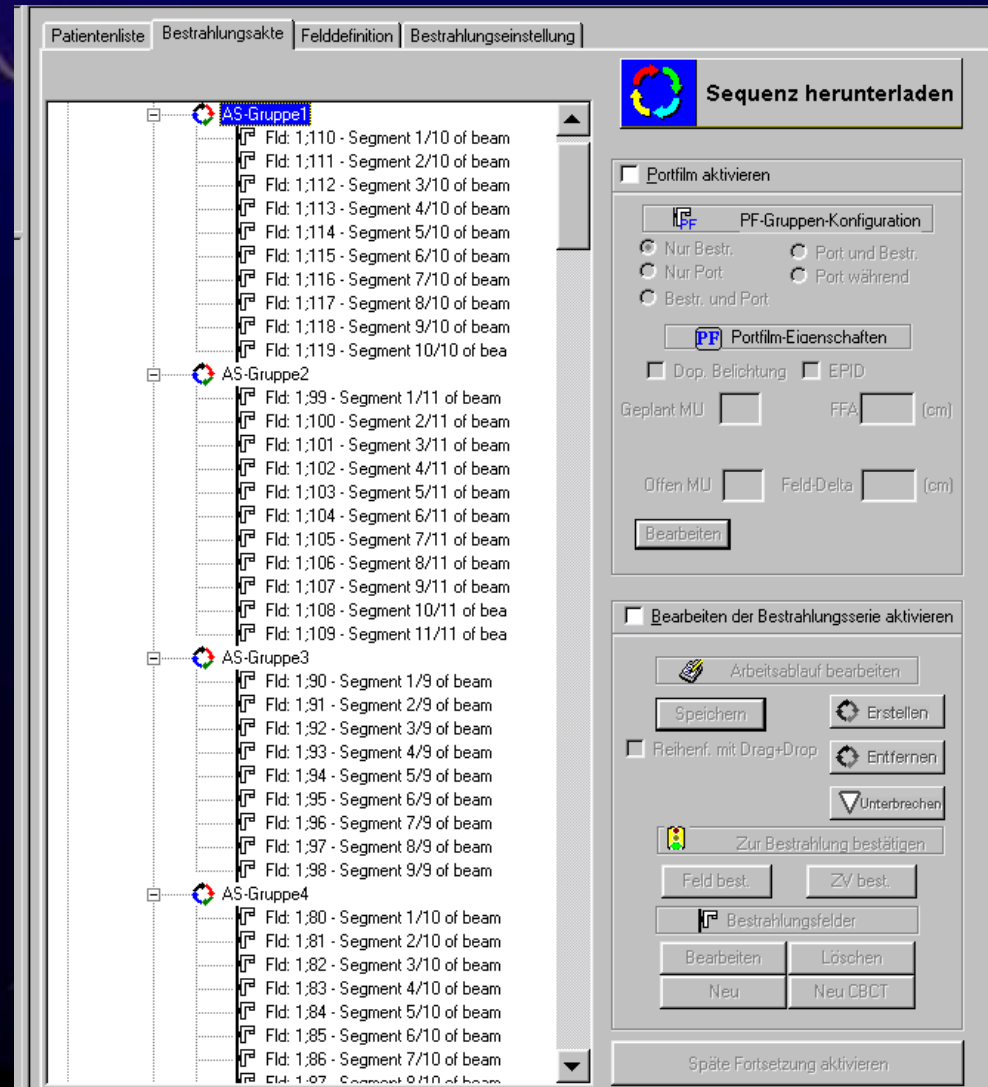


The screenshot shows the Lantis software interface. The main window displays a table with columns for 'Start' and 'Status'. The table lists various beam segments and their corresponding dates and statuses. The sidebar on the right contains buttons for 'Diagnose', 'Behand.-Plan', 'Leistung', 'Konzept', 'Bestr.-Feld', 'Simulation', 'Ändern', 'Löschen', 'Aktualisieren', 'Status', and 'Dokumentation'.

	Start	Status
Diagnose: rechts NEUBILDUNG DES GEHIRNS	04.09.2008	
Urogendendosk. anastastisch (C71.)		
Strahlentherapie Serie: 1	09.09.2008	A 10.9.2008 T6W
Konzept: 1 isocenter 1. CTV - Xrays Dosis: 5000 @ 2		
Bestrahlungsfelder:		
1:1 - Segment 1/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:10 - Segment 10/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:100 - Segment 2/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:101 - Segment 3/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:102 - Segment 4/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:103 - Segment 5/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:104 - Segment 6/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:105 - Segment 7/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:106 - Segment 8/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:107 - Segment 9/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:108 - Segment 10/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:109 - Segment 11/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:11 - Segment 1/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:110 - Segment 2/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:111 - Segment 3/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:112 - Segment 4/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:113 - Segment 5/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:114 - Segment 6/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:115 - Segment 7/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:116 - Segment 8/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:117 - Segment 9/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:118 - Segment 10/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:119 - Segment 11/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:12 - Segment 2/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:13 - Segment 3/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:14 - Segment 4/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:15 - Segment 5/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:16 - Segment 6/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:17 - Segment 7/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:18 - Segment 8/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:19 - Segment 9/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:2 - Segment 2/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:20 - Segment 10/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:21 - Segment 1/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:22 - Segment 2/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:23 - Segment 3/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:24 - Segment 4/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:25 - Segment 5/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:26 - Segment 6/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:27 - Segment 7/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:28 - Segment 8/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:29 - Segment 9/9 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:3 - Segment 3/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:30 - Segment 1/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:31 - Segment 2/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:32 - Segment 3/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:33 - Segment 4/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:34 - Segment 5/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:35 - Segment 6/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:36 - Segment 7/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:37 - Segment 8/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:38 - Segment 9/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:39 - Segment 10/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:4 - Segment 4/10 of beam - 6X	10.09.2008	AS 10.9.2008 KW
1:40 - Segment 11/11 of beam - 6X	10.09.2008	AS 10.9.2008 KW

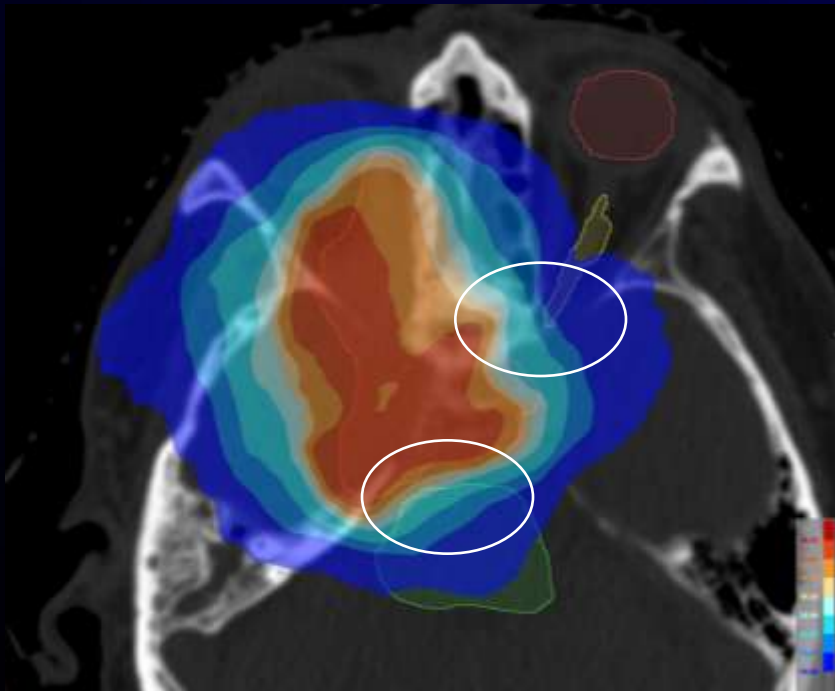
Probleme / Nachteile

- Datenhandling in PrimeView
- Zusammenfassung der Feldsegmente zu Gruppen jeweils pro Einstrahlrichtung durch MTRA

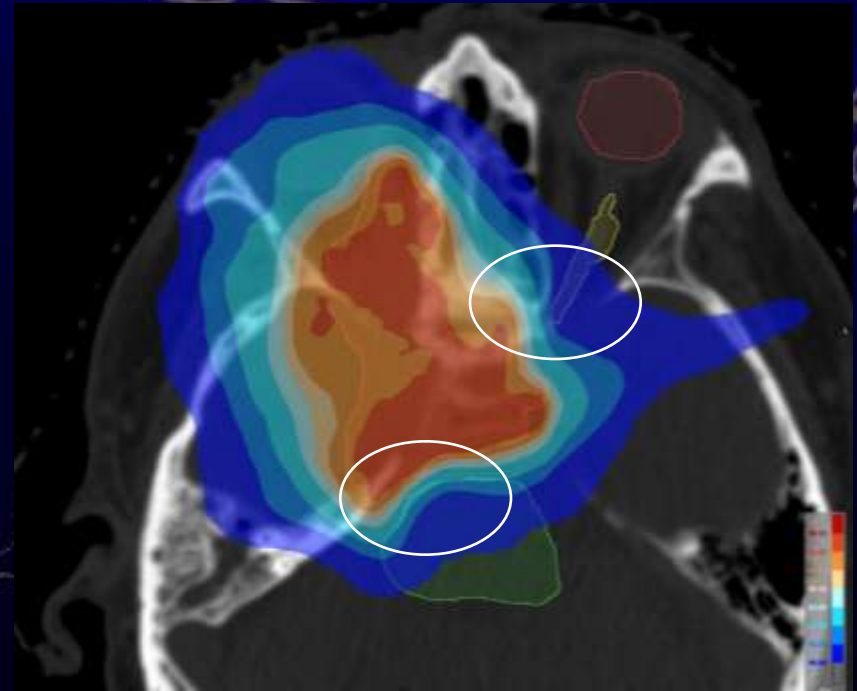


Beispiel 1

- **Schonung Hirnstamm, Sehnerv, Chiasma**
- Vergleich zu einem nonkoplanar konformale Plan
- identische Einstrahlrichtungen



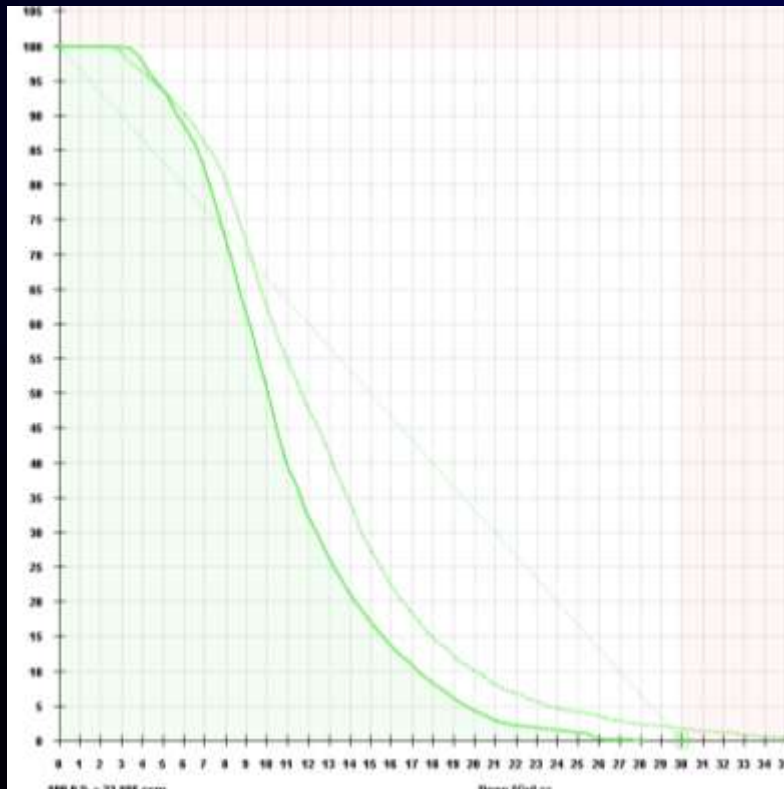
ohne IMRT



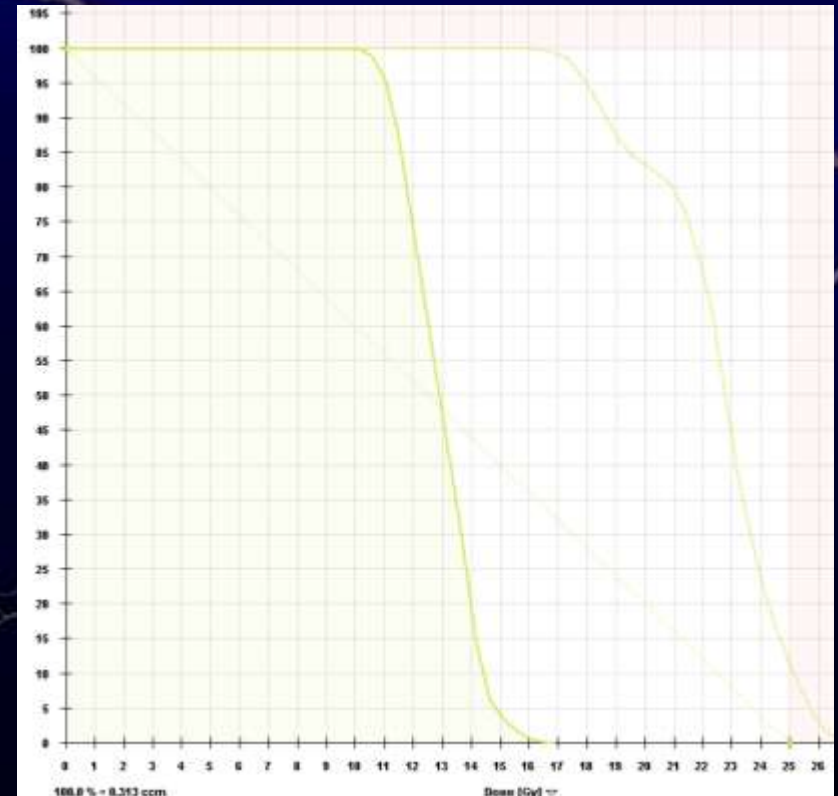
mit IMRT

Beispiel 1

- **Schonung** Hirnstamm, **Sehnerv**, Chiasma
- Vergleich zu einem nonkoplanar konformale Plan
- identische Einstrahlrichtungen



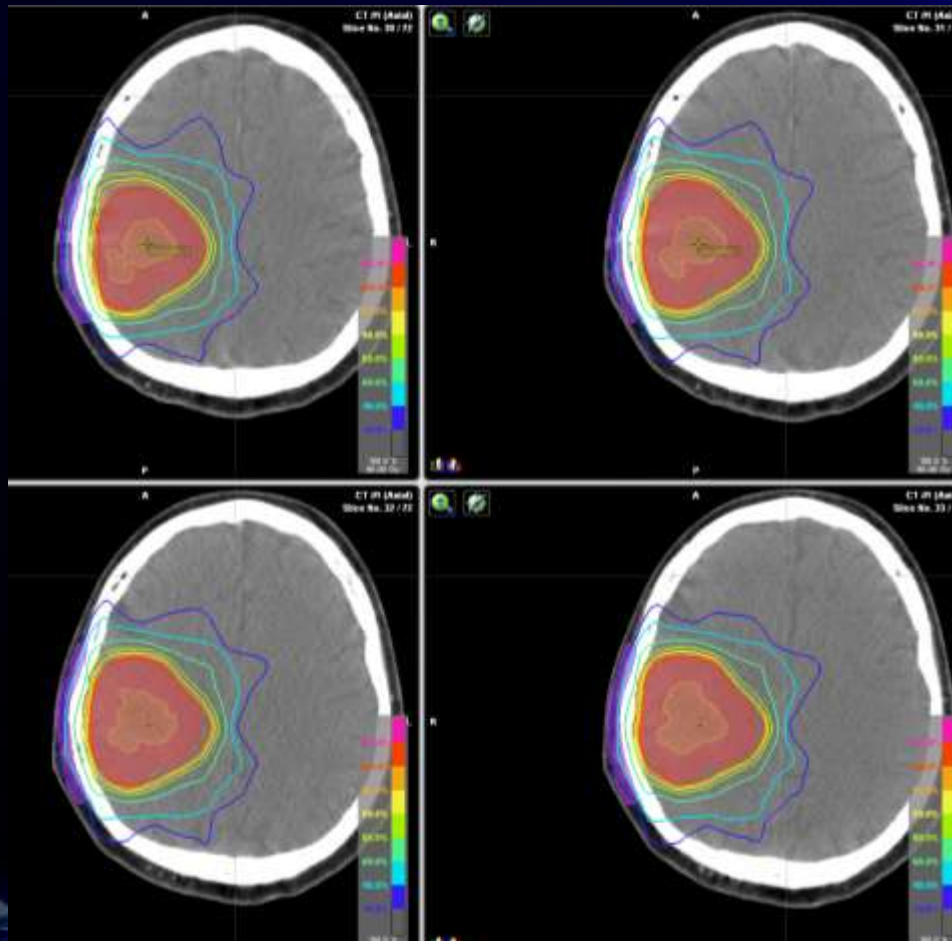
Hirnstamm



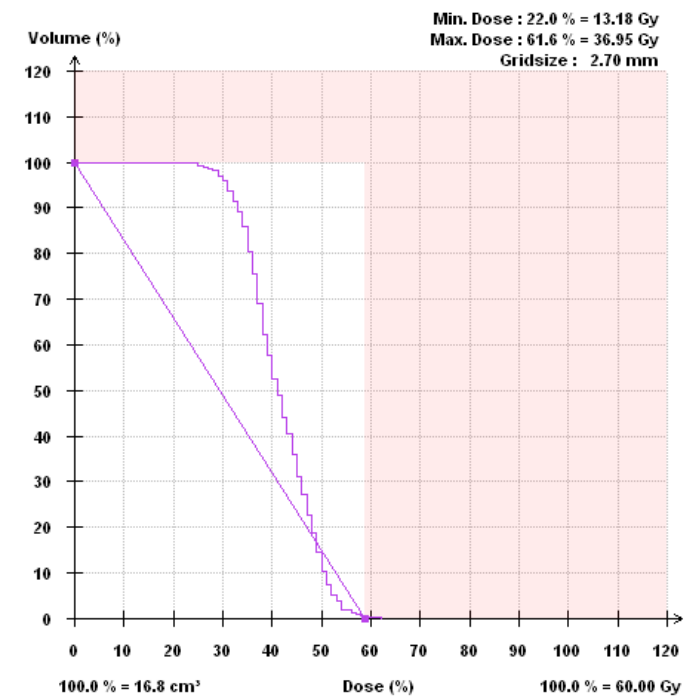
Chiasma

Beispiel 2

- Haarwurzelschonung an 2-fach gekrümmter Fläche bei kurativen Ansätzen z.B. niedrigmaligne Tumore

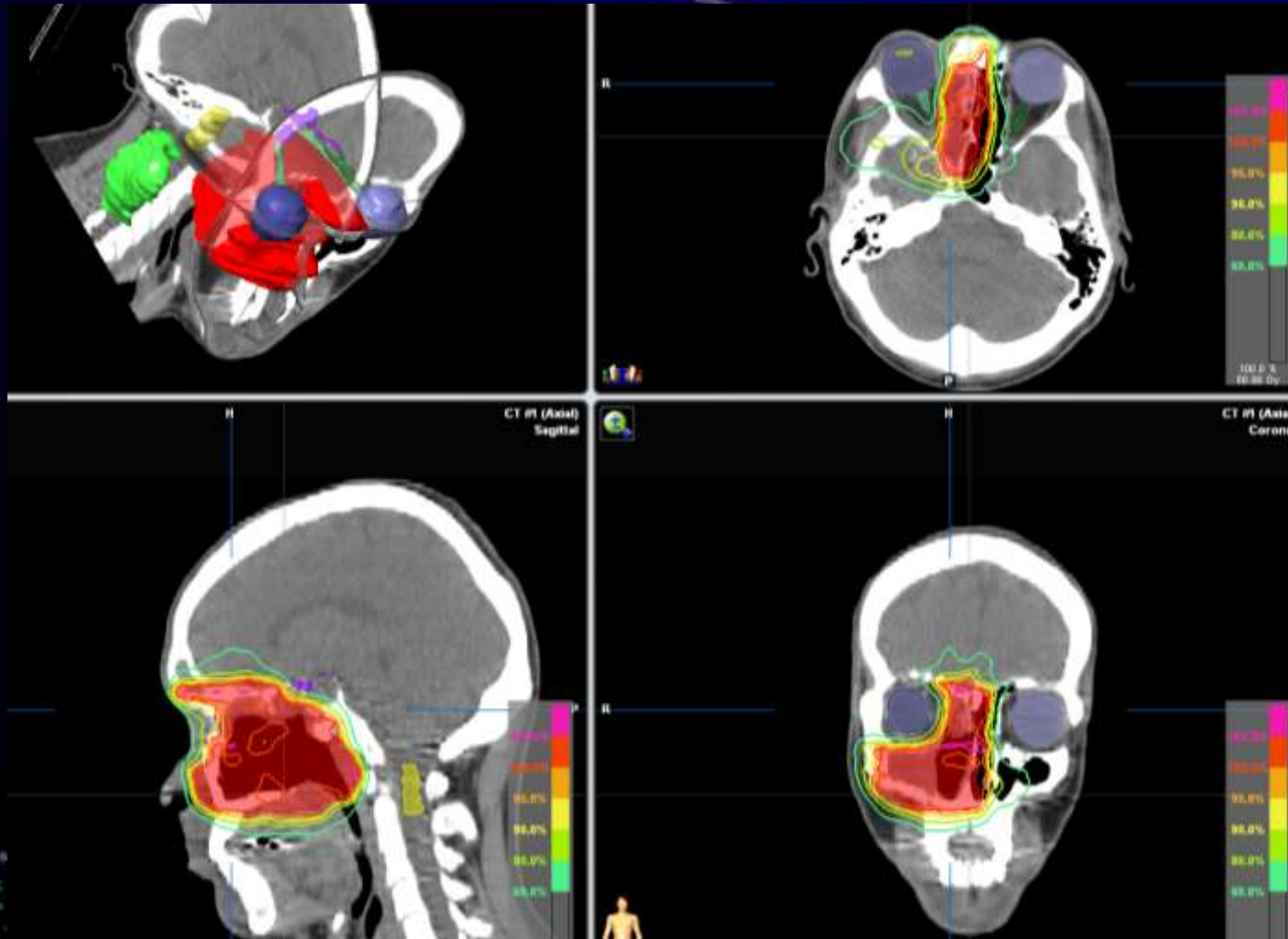


Graph



Beispiel 3

- Schonung von Augenlinse, Bulbus, Sehnerv , Hirnstamm und Chiasma



Literatur

Lopatta E, Liesenfeld SM, Bank P, Wurm R, Günther R, Wiezorek T, Wendt TG. Improved patient repositioning accuracy by integrating an additional jaw fixation into a high precision face mask system in stereotactic radiotherapy of the head. Strahlenther Onkol. 2003 Aug;179(8):571-5.

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Llacer J. Inverse radiation treatment planning using the Dynamically Penalized Likelihood method. Med Phys. 1997 Nov;24(11):1751-64.

Llacer J, Agazaryan N, Solberg TD, Promberger C. Degeneracy, frequency response and filtering in IMRT optimization. Phys Med Biol. 2004 Jul 7;49(13):2853-80.

Llacer J, Deasy JO, Portfeld TR, Solberg TD, Promberger C. Absence of multiple local minima effects in intensity modulated optimization with dose-volume constraints Phys Med Biol. 2003 Jan 21;48(2):183-210.

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