

IMRT-QA mit dem
PTW-*Octavius* Phantom + 2D Array *seven29*

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Das Equipment



Octavius-Phantom

- Maße: $\varnothing = 32 \text{ cm}$
 $L = 32 \text{ cm}$
- Gewicht: $\sim 24 \text{ kg}$
- Dichte: $1,04 \text{ g/cm}^3$
- Material: Polystyrol
- Separates LINAC- und CT-Unterteil

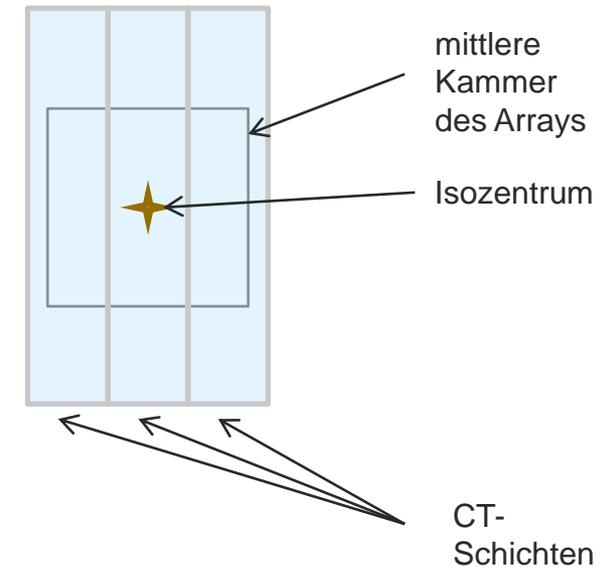
2D-Array

- Detektoren: 729
- Detektor Größe: $0,125 \text{ cm}^3$ ($0,5 \times 0,5 \times 0,5 \text{ cm}^3$)
- Detektor Abstand: 10 mm (center-to-center)
- Max. Feldgröße: $27 \times 27 \text{ cm}^2$
- Array Maße: $30 \text{ cm} \times 42 \text{ cm} \times 2,2 \text{ cm}$ (WxDxH)
- Gewicht: $\sim 5,7 \text{ kg}$

- CT-Scan des Phantoms inkl. Array
- Planung mit Pinnacle
- Bestrahlung des Phantoms mit QA-Plan
- Auswertung mit VeriSoft
- Patientenbeispiele
- Zusammenfassung

CT-Scan

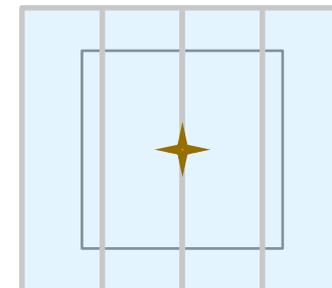
- Siemens Somatom Emotion
- Schichtdicke 2 mm
- 177 Schichten
- 512 x 512 Pixel



Offene Fragen:

- **Optimale Schichtdicke?**
- **Optimale Schichtanordnung?**

Alternative
Schichtanordnung



Planung mit Pinnacle – Ablauf

- Übertragung des Patientenplans auf das Phantom
- Neuordnung der Strahlrichtungen auf 0°
(senkrechte Bestrahlung des Arrays)
- Rechenraster $2 \times 2 \text{ mm}^2$
- Export
 - QA-Plan zur Bestrahlung an Mosaiq
 - 2D-Dosisverteilungen für Einzelfelder und Summenfeld
(.img + .header Files)
 - Dosiswürfel im DICOM-Format möglich

Offene Fragen:

- **Optimales Rechenraster?**

Planung mit Pinnacle – IMRT-Parameter

Pinnacle:

- Mindest-MUs / Segment: 5
- Mindestsegmentfläche: 2 cm²
- Max. Iterationen: 25

Bestrahlung:

- Gesamtdosis: 45-80 Gy
- Dosis/Fraktion: 1,6-2,2 Gy
- Anzahl Fraktionen: 10-38
- Anzahl Strahlrichtungen: 3-8
- Segmente / Richtung: 8-22
- Gesamtsegmente: 40-100

Offene Fragen:

- **Optimale Auswahl der Parameter?**
- **Was bedeutet optimal? Für Patient? Für QA?**

Planung mit Pinnacle – Beispiele

Entität	Dosis / Gy	Felder	Segmente	Seg./Feld (im Mittel)
Hirntumore	0-50/56	4	46	11
KHT + LAW li v re + LAW li/re	0-60/60/54	7	86-90	12-13
BC	0-50	3	60-65	20-22
Mamma + SIA	0-50/54	4	85	21
Magen	0-45	6	55	9
Prostata -Loge/+SB/+int. Boost	0-66 / 0-76 / 0-76/80	5	69/48/66	14/10/13
Becken / +Leisten	0-45 / 0-50/42	5/8	43/100	8/12
Anal-Ca	0-56	7	88	13

Bestrahlung

- Referenzfeld $10 \times 10 \text{ cm}^2$
 - geplant: 2 Gy in der Zentrumschamber, jeweils für 6, 10 und 15 MV
- Verifikation mit $0,3 \text{ cm}^3$ -Stielkammer
 - Korrigiert mit Prüfnorm und nach DIN 6800-2 (2008-03)
 - Ergebnis im Bereich $\pm 1\%$
- Bestrahlung des 2D-Arrays mit Referenzfeld
 - 3x pro Energie ohne Korrekturwert
 - => Mittelwert (Messwerte stabil!)
 - Bestimmung eines Korrekturfaktors pro Energie
 - Korrekturfaktor = Messwert Zentrumschamber / 2Gy
- Abstrahlen der Patientenpläne
 - Speicherung der Einzelfelder
- Am Ende Wiederholung der Messungen des Referenzfeldes mit 2D-Array und Bestimmung der Korrekturfaktoren

Auswertung mit VeriSoft

- Öffnen der 2D-Dosisverteilung des Summenfeldes aus Pinnacle
 - Pinnacle exportiert das Summenfeld in cGy => Umwandlung in Gy
- Öffnen der gemessenen Felder
 - Aufaddieren der einzelnen Felder beim Laden
 - Anwendung des zuvor bestimmten Korrekturfaktors
- Auswertungsparameter 2D
 - $\pm 3,0$ mm Abstandstoleranz
 - $\pm 3,0$ % Dosisstoleranz bezogen auf Maximumsdosis der Messdaten
 - Erhöhte Toleranz von $\pm 6,0$ % bei Dosiswerten $<0,1$ Gy
 - Unterdrückung von Dosiswerten $<5,0$ % des Messdatenmaximums
- Ergebnisampel:
 - $\geq 90\%$ der Punkte **Grün**
 - $\geq 75\%$ und $< 90\%$ der Punkte **Gelb**
 - $< 75\%$ der Punkte **Rot**

Beispiele – Prostata-Ca 15MV (2D-Array)

PTW-VeriSoft

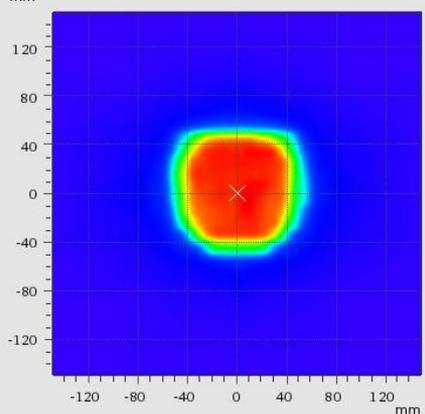
File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

Edit

Contrast Edit

mm DoseMap: ID:



100 % = 2.108 Gy

100 %
80 %
60 %
40 %
20 %
0 %

mm

A LR = -143,1 mm TG = -6,1 mm 0,024 Gy Mean = --- ...DosePlan...

Results

Traffic...

Statistics

Number of Dose Points:	729
Evaluated Dose Points:	171 (23,5 %)
Passed:	171 (100,0 %)
Failed:	0 (0,0 %)
Result:	100,0 %

Gamma 2D

Arithmetic Mean:	0,277
Min: (LR=-40,0 mm / TG=-50,0 mm)	0,004
Max: (LR=-20,0 mm / TG=0,0 mm)	0,863
Median:	0,218

Absolute Difference

Arithmetic Mean:	0,034 Gy
Min: (LR=-40,0 mm / TG=-50,0 mm)	0,000 Gy
Max: (LR=-10,0 mm / TG=-50,0 mm)	0,153 Gy
Median:	0,022 Gy

Settings

Passing criteria: Gamma <= 1,0

- Green: 90,0 % to 100,0 %
- Yellow: 75,0 % to 90,0 %
- Red: 0,0 % to 75,0 %

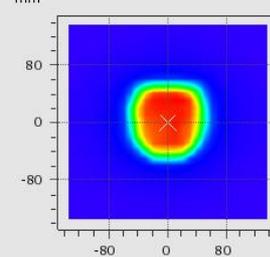
Failed Points Isodose Area B

Compare

Gamma 2D

- 3,0 mm Distance- To- Agreement
- 3,0 % Dose Difference with ref. to
- Local dose
- Max. dose of measured data set
- Selected dose Select: 3,00 Gy (or AU)
- Use increased tolerance of
- 6,0 % Dose Diff. for values below
- 0,1 Gy (or AU)
- Suppress doses below
- 5,0 % of max. dose of measured data set

mm



Failed Points

- cold
- hot

Apply

Gamma... LR = --- TG = ---

B LR = -143,1 mm TG = -6,1 mm --- Meas = --- k = 1,035 Added Data

Beispiele – Anal-Ca 15MV (2D-Array)

PTW-VeriSoft

File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

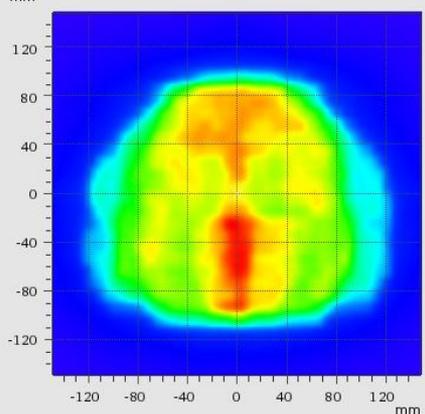
Edit

Contrast Edit

Cal

Nor

DoseMap: ID:



100 % = 1.950 Gy

100 %

80 %

60 %

40 %

20 %

0 %

A LR = -99,2 mm TG = -98,6 mm 0,189 Gy Mean = 0,168 Gy

Results

Traffic...

Statistics

Number of Dose Points:	729
Evaluated Dose Points:	590 (80,9 %)
Passed:	571 (96,8 %)
Failed:	19 (3,2 %)
Result:	96,8 %

Gamma 2D

Arithmetic Mean:	0,388
Min: (LR=10,0 mm / TG=120,0 mm)	0,002
Max: (LR=0,0 mm / TG=0,0 mm)	1,816
Median:	0,317

Absolute Difference

Arithmetic Mean:	0,033 Gy
Min: (LR=10,0 mm / TG=120,0 mm)	0,000 Gy
Max: (LR=0,0 mm / TG=-110,0 mm)	0,218 Gy
Median:	0,026 Gy

Settings

Passing criteria: Gamma <= 1,0

- Green: 90,0 % to 100,0 %
- Yellow: 75,0 % to 90,0 %
- Red: 0,0 % to 75,0 %

Failed Points

Isodose Area B

Compare

Gamma 2D

3,0 mm Distance- To- Agreement

3,0 % Dose Difference with ref. to

Local dose

Max. dose of measured data set

Selected dose Select 3,00 Gy (or AU)

Use increased tolerance of

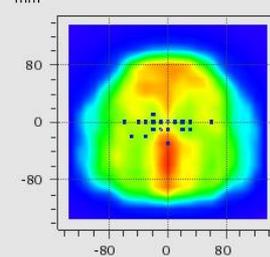
6,0 % Dose Diff. for values below

0,1 Gy (or AU)

Suppress doses below

5,0 % of max. dose of measured data set

Apply



Failed Points

cold

hot

B LR = -99,2 mm TG = -98,6 mm 0,217 Gy Meas = 0,183 Gy k = 1,035 Added Data

Gamma... LR = -100,0 mm TG = -100,0 mm

Beispiele – Kieferhöhlen-Ca 6MV (2D-Array)

PTW-VeriSoft

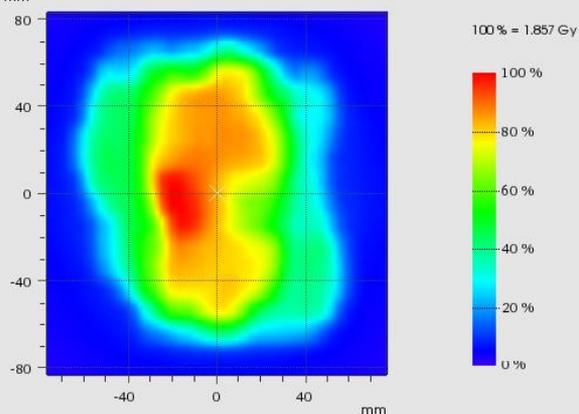
File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

Edit

Contrast Edit Cal Nor

mm DoseMap: ID:



100 % = 1.857 Gy

100 %
80 %
60 %
40 %
20 %
0 %

A LR = 39,3 mm TG = 80,6 mm 0,079 Gy Mean = 0,080 Gy

Results

Traffic...

Statistics

Number of Dose Points:	255
Evaluated Dose Points:	223 (87,5 %)
Passed:	218 (97,8 %)
Failed:	5 (2,2 %)
Result:	97,8 %

Gamma 2D

Arithmetic Mean:	0,390
Min: (LR=-30,0 mm / TG=80,0 mm)	0,006
Max: (LR=-20,0 mm / TG=0,0 mm)	1,164
Median:	0,352

Absolute Difference

Arithmetic Mean:	0,040 Gy
Min: (LR=0,0 mm / TG=80,0 mm)	0,000 Gy
Max: (LR=-30,0 mm / TG=0,0 mm)	0,173 Gy
Median:	0,033 Gy

Settings

Passing criteria: Gamma <= 1,0

- Green: 90,0 % to 100,0 %
- Yellow: 75,0 % to 90,0 %
- Red: 0,0 % to 75,0 %

Failed Points Isodose Area B

Compare Select view of comparison result

Gamma 2D

3,0 mm Distance- To- Agreement

3,0 % Dose Difference with ref. to

Local dose

Max. dose of measured data set

Selected dose Select 3,00 Gy (or AU)

Use increased tolerance of

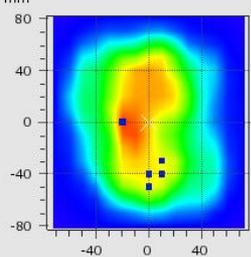
6,0 % Dose Diff. for values below

0,1 Gy (or AU)

Suppress doses below

5,0 % of max. dose of measured data set

mm

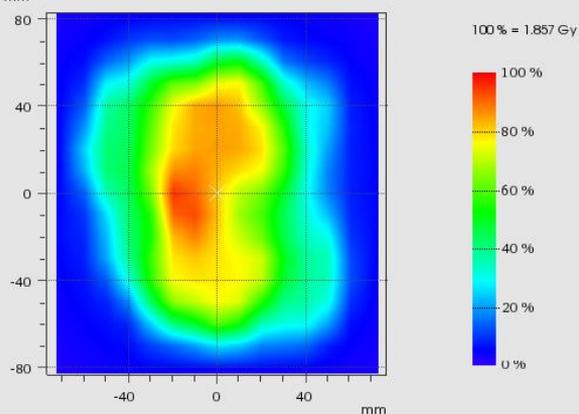


Failed Points
cold
hot

Apply

Gamma... LR = 40,0 mm TG = 80,0 mm

mm DoseMap



100 % = 1.857 Gy

100 %
80 %
60 %
40 %
20 %
0 %

B LR = 39,3 mm TG = 80,6 mm 0,077 Gy Meas = 0,078 Gy k = 1,019 Added Data

Beispiele – Kieferhöhlen-Ca 6MV (Film)

PTW-VeriSoft

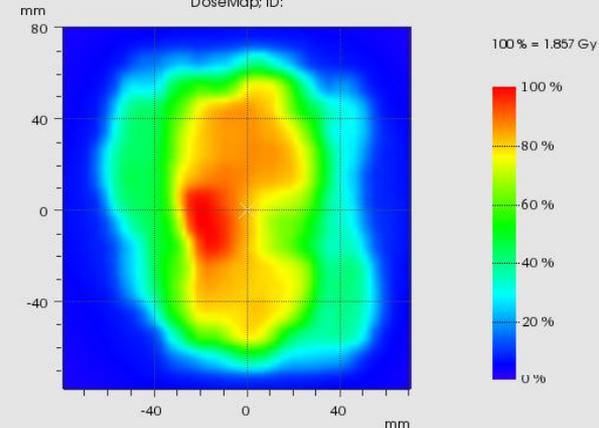
File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

Edit

Contrast Edit

mm DoseMap: ID:



100 % = 1.857 Gy

100 %

80 %

60 %

40 %

20 %

0 %

mm

A LR = 64,8 mm TG = 32,7 mm 0,123 Gy ...DosePlan...

Results

Traffic...

Statistics

Number of Dose Points:	94500
Evaluated Dose Points:	91349 (96,7 %)
Passed:	91010 (99,6 %)
Failed:	339 (0,4 %)
Result:	99,6 %

Gamma 2D

Arithmetic Mean:	0,320
Min: (LR=49,0 mm / TG=-67,0 mm)	0,000
Max: (LR=-23,5 mm / TG=5,5 mm)	2,045
Median:	0,299

Absolute Difference

Arithmetic Mean:	0,030 Gy
Min: (LR=49,0 mm / TG=-67,0 mm)	0,000 Gy
Max: (LR=12,0 mm / TG=60,0 mm)	0,231 Gy
Median:	0,024 Gy

Settings

Passing criteria: Gamma <= 1,0

- Green: 90,0 % to 100,0 %
- Yellow: 75,0 % to 90,0 %
- Red: 0,0 % to 75,0 %

Failed Points Isodose Area B

Compare

Gamma 2D

3,0 mm Distance- To- Agreement

3,0 % Dose Difference with ref. to

Local dose

Max. dose of measured data set

Selected dose Select 3,00 Gy (or AU)

Use increased tolerance of

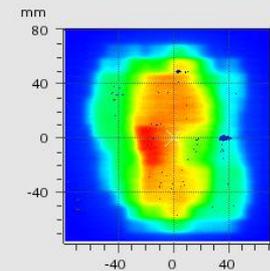
6,0 % Dose Diff. for values below

0,1 Gy (or AU)

Suppress doses below

5,0 % of max. dose of measured data set

mm



Failed Points

cold

hot

mm

B LR = 64,8 mm TG = 32,7 mm 0,131 Gy ...Wachtme...

Apply

Gamma... LR = 64,8 mm TG = 32,7 mm

Beispiele – LWK 4 mit 6MV (2D-Array)

PTW-VeriSoft

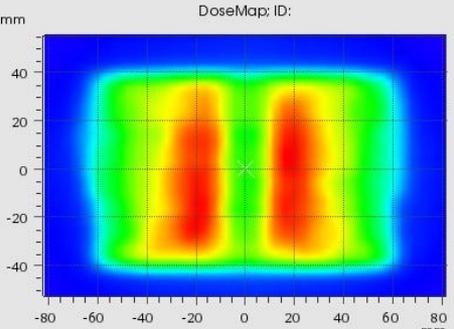
File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

Edit

Contrast Edit

DoseMap; ID: 100% = 1.711 Gy



mm

40

20

0

-20

-40

-80 -60 -40 -20 0 20 40 60 80 mm

100 %

80 %

60 %

40 %

20 %

0 %

A LR = 69,1 mm TG = -19,3 mm 0,141 Gy Mean = 0,137 Gy ...DosePlan...

Results

Statistics

Number of Dose Points:	187
Evaluated Dose Points:	172 (92,0 %)
Passed:	163 (94,8 %)
Failed:	9 (5,2 %)
Result:	94,8 %

Gamma 2D

Arithmetic Mean:	0,383
Min: (LR=50,0 mm / TG=50,0 mm)	0,003
Max: (LR=20,0 mm / TG=0,0 mm)	1,487
Median:	0,334

Absolute Difference

Arithmetic Mean:	0,038 Gy
Min: (LR=50,0 mm / TG=50,0 mm)	0,000 Gy
Max: (LR=30,0 mm / TG=0,0 mm)	0,114 Gy
Median:	0,035 Gy

Settings

Passing criteria: Gamma <=	1,0
Green:	90,0 % to 100,0 %
Yellow:	75,0 % to 90,0 %
Red:	0,0 % to 75,0 %

Failed Points Isodose Area B

Compare

Gamma 2D

3,0 mm Distance- To- Agreement

3,0 % Dose Difference with ref. to

Local dose

Max. dose of measured data set

Selected dose Select 3,00 Gy (or AU)

Use increased tolerance of

6,0 % Dose Diff. for values below

0,1 Gy (or AU)

Suppress doses below

5,0 % of max. dose of measured data set

Apply

mm

40

0

-40

-80 -60 -40 -20 0 20 40 80 mm

100 %

80 %

60 %

40 %

20 %

0 %

B LR = 69,1 mm TG = -19,3 mm 0,151 Gy Meas = 0,131 Gy k = 1,019 Added Data

Failed Points

cold

hot

Gamma... LR = 70,0 mm TG = -20,0 mm

Beispiele – LWK 4 mit 6MV (Film)

PTW-VeriSoft

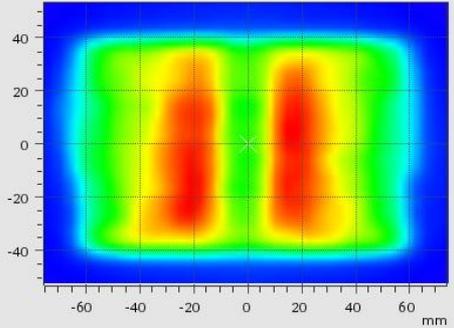
File Edit View Graphics Tools ?

Isodose Areas Slice Depth 0,00 mm

Edit

Contrast Edit

mm DoseMap; ID: 100% = 1.711 Gy



mm

A LR = 69,7 mm TG = 18,0 mm 0,140 Gy

Results

Traffic...

Statistics

Number of Dose Points:	63600
Evaluated Dose Points:	63583 (100,0 %)
Passed:	63025 (99,1 %)
Failed:	558 (0,9 %)
Result:	99,1 %

Gamma 2D

Arithmetic Mean:	0,377
Min: (LR=-13,5 mm / TG=-22,5 mm)	0,000
Max: (LR=17,5 mm / TG=-0,5 mm)	2,019
Median:	0,353

Absolute Difference

Arithmetic Mean:	0,042 Gy
Min: (LR=-13,5 mm / TG=-22,5 mm)	0,000 Gy
Max: (LR=-30,5 mm / TG=-39,0 mm)	0,287 Gy
Median:	0,031 Gy

Settings

Passing criteria: Gamma <= 1,0

- Green: 90,0 % to 100,0 %
- Yellow: 75,0 % to 90,0 %
- Red: 0,0 % to 75,0 %

Failed Points Isodose Area B

Compare

Gamma 2D

3,0 mm Distance- To- Agreement

3,0 % Dose Difference with ref. to

Local dose

Max. dose of measured data set

Selected dose Select 3,00 Gy (or AU)

Use increased tolerance of

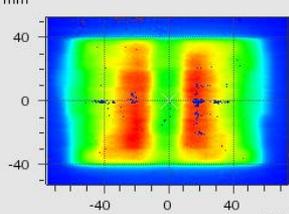
6,0 % Dose Diff. for values below

0,1 Gy (or AU)

Suppress doses below

5,0 % of max. dose of measured data set

mm



Failed Points

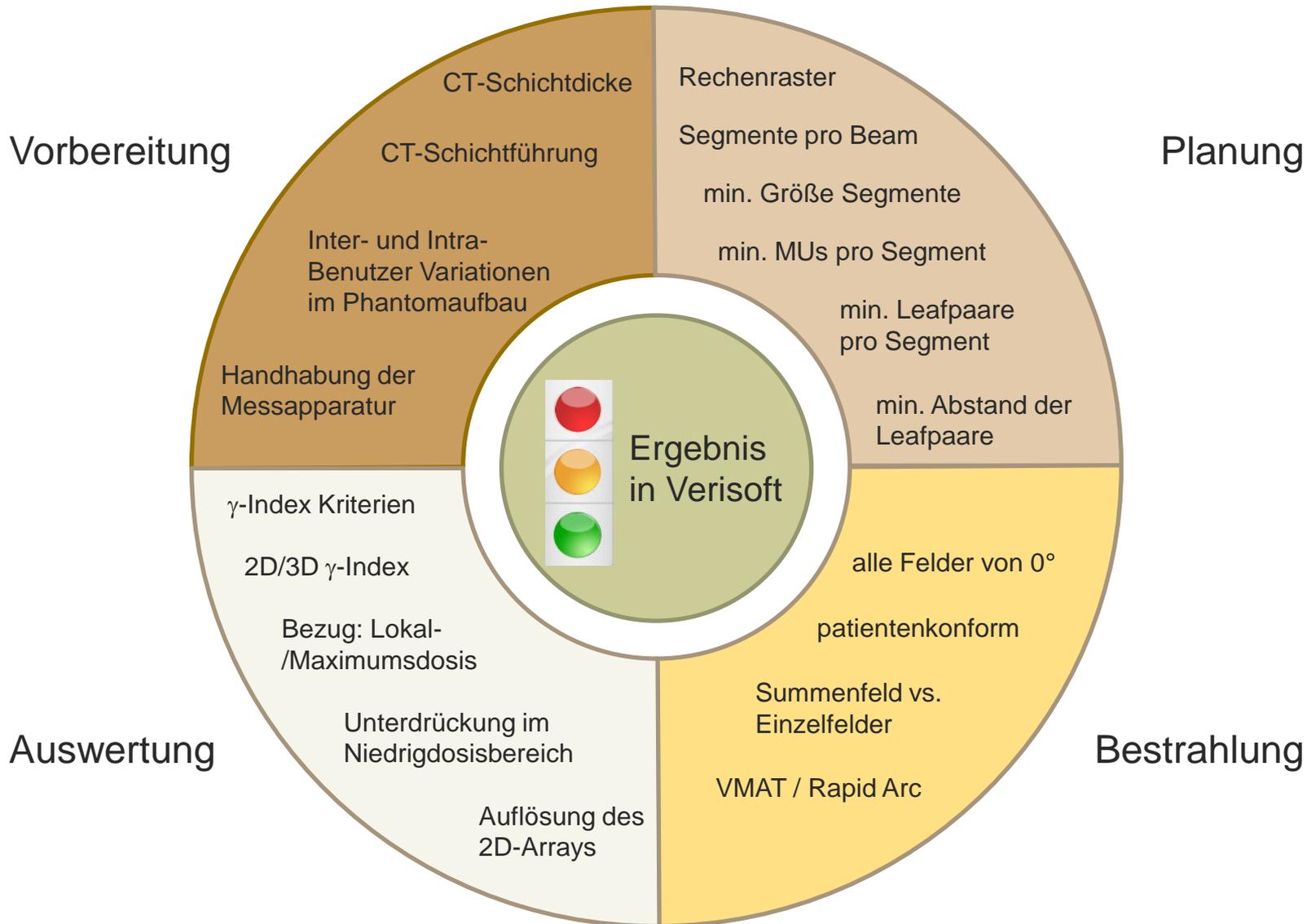
- cold
- hot

Apply

Gamma... LR = 69,7 mm TG = 18,0 mm

B LR = 69,7 mm TG = 18,0 mm 0,155 Gy

Zusammenfassung



Vielen Dank ...

... für Ihre Aufmerksamkeit!

