Dosimetry Pioneers since 1922

Mohsen Shahrabi – International Sales Manager

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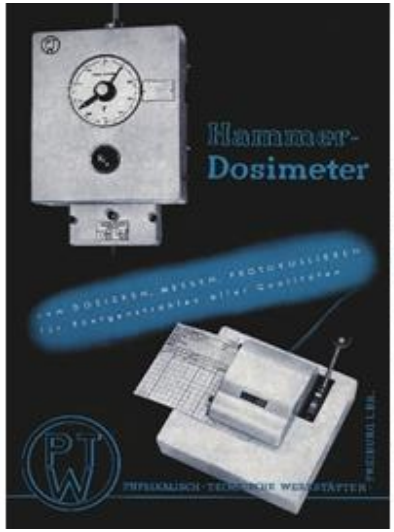
From Humble Beginnings

- **It started with a groundbreaking invention.**



1919: Professor Wilhelm Hammer invents electrostatic relay.

1922: PTW is founded. First Hammer dosemeters produced in backyard of Hammer residence.

1927: Dr. Herbert Pychlau resumes ownership. PTW had six employees. More than 1,000 Hammer dosemeters produced by late 1920s.

1958: PTW moves into current head-quarters building in Lörracher Str. 9, Freiburg.

PTW Today - A Global Leader in Dosimetry

- Full range supplier of radiation dosimetry products – in family hands for almost a century
- Industry-leading product portfolio (> 350 products)
- 328 employees worldwide
- 9 international subsidiaries, 2 manufacturing sites, worldwide sales and service network
- Strong commitment to quality and safety: PTW Calibration Lab / PTW Dosimetry School

PTW Calibration Laboratory

PTW CALIBRATION LAB

Calibrations traceable to national and international standards

- One of the oldest and largest calibration laboratories for ionizing radiation worldwide
- Secondary Standard Dosimetry Laboratory (SSDL)
- Accredited by PTB since 1979
- Member of DAkkS and IAEA / WHO SSDL Network
- 11 calibration benches
- 12,000 chamber calibrations per year

ilac-MRA

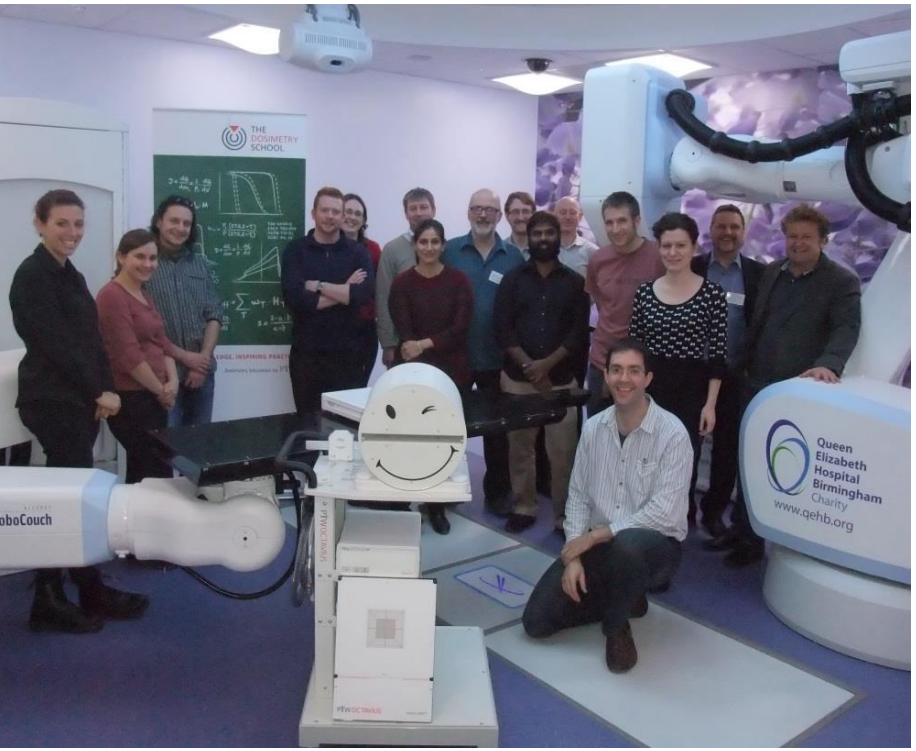
DAkkS Deutsche Akkreditierungsstelle D-K-15059-01-00

IAEA International Atomic Energy Agency

World Health Organization

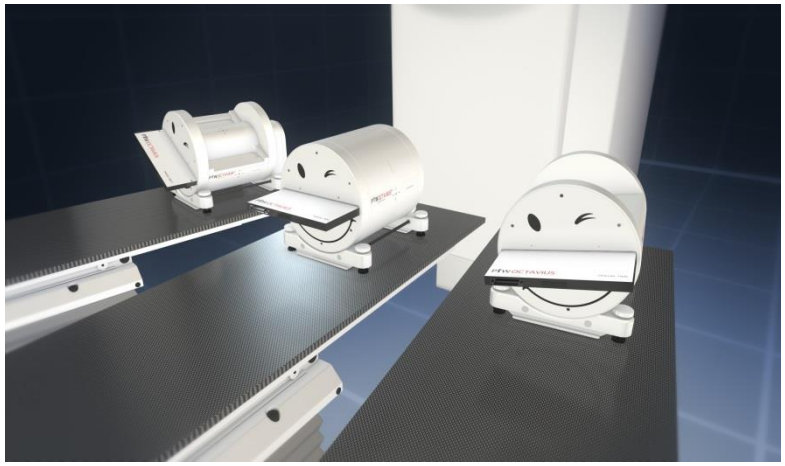
PTW

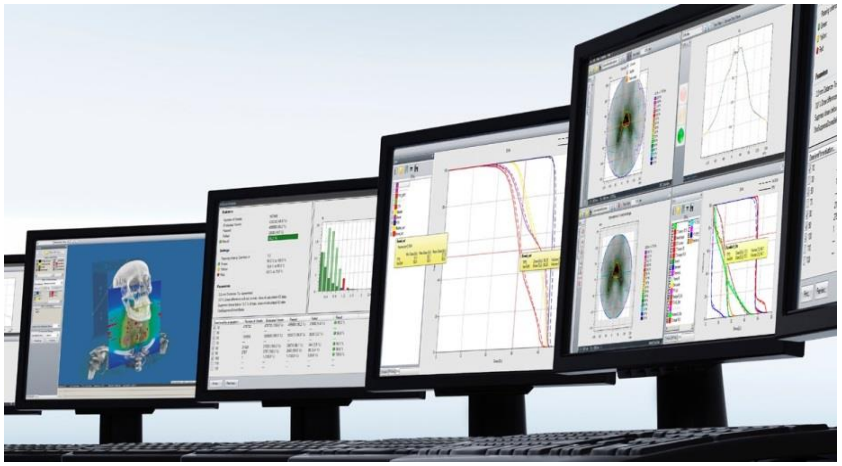
The Dosimetry School



Sharing Knowledge
Inspiring Practice

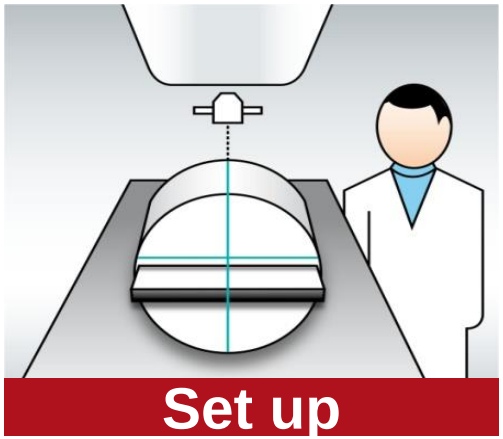
- Founded in 2014
- Nationwide education initiative to enhance understanding and practice of clinical dosimetry
- Great variety of training opportunities - scientific and practical trainings
- Worldwide cooperation network with clinical partners
- Expert platform to meet and share knowledge

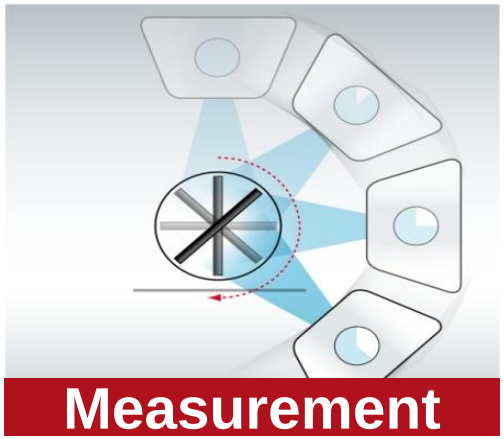




OCTAVIUS® 4D
New Features and Future Outlook

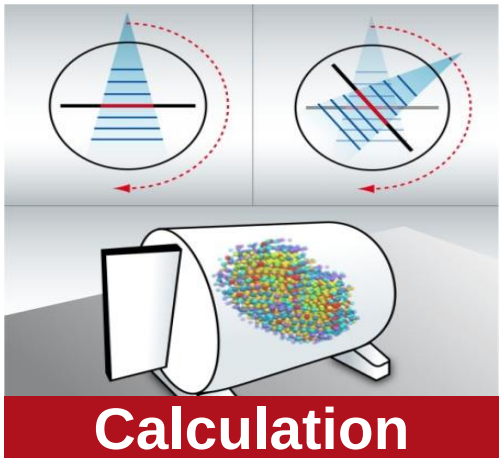
OCTAVIUS® 4D – Principal Workflow


Set up


Measurement

Only Input:

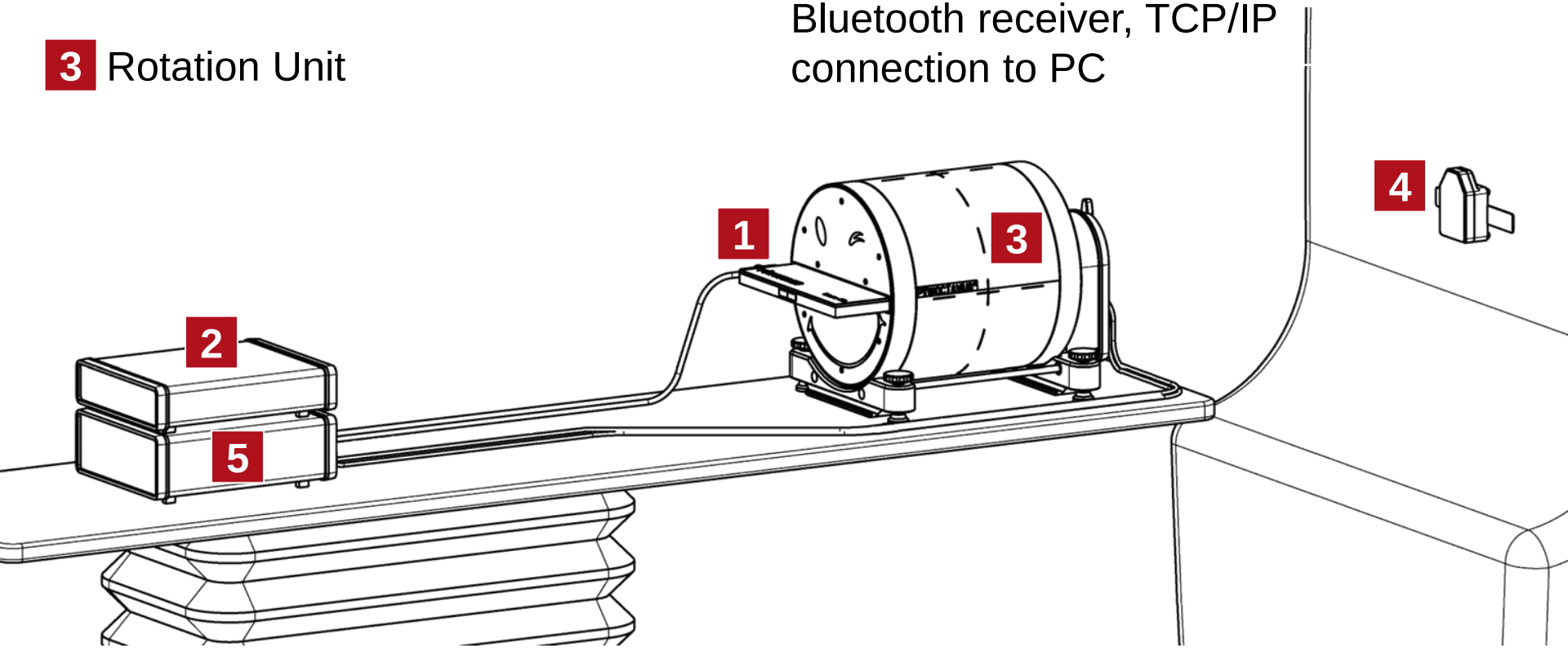
SSD 85 cm PDDs measured in water


Calculation


Evaluation

OCTAVIUS® 4D – System components

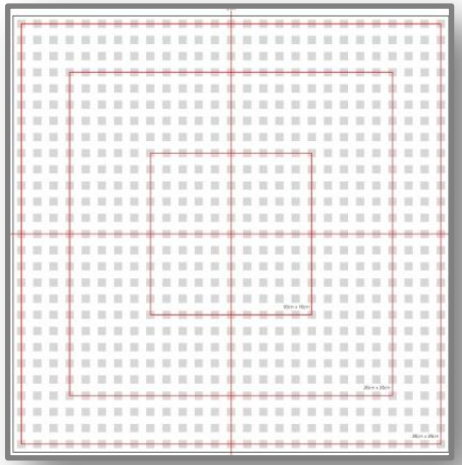
1. OCTAVIUS® Detector Family
2. Detector Interface
3. Rotation Unit
4. Wireless Inclinometer (Bluetooth)
5. Control Unit with integrated Bluetooth receiver, TCP/IP connection to PC



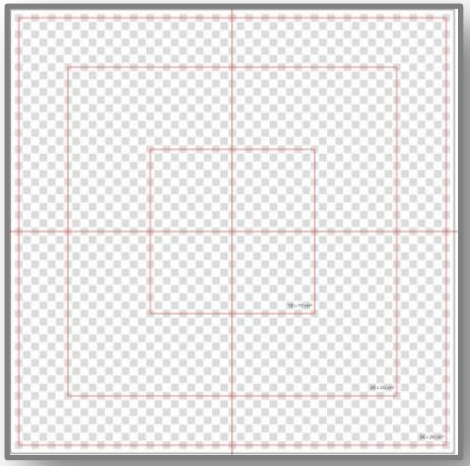
OCTAVIUS® 4D – System components

Application-dependent patient QA…

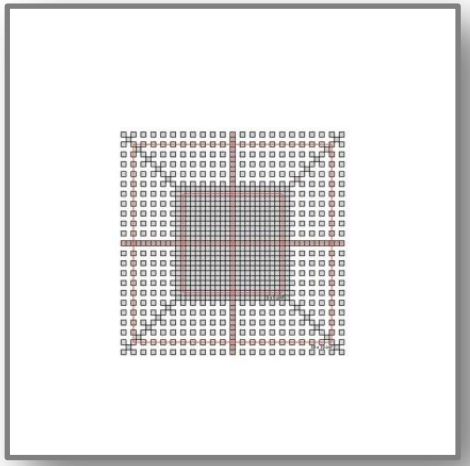
…with suitable OCTAVIUS® detectors.



OCTAVIUS®
Detector
729



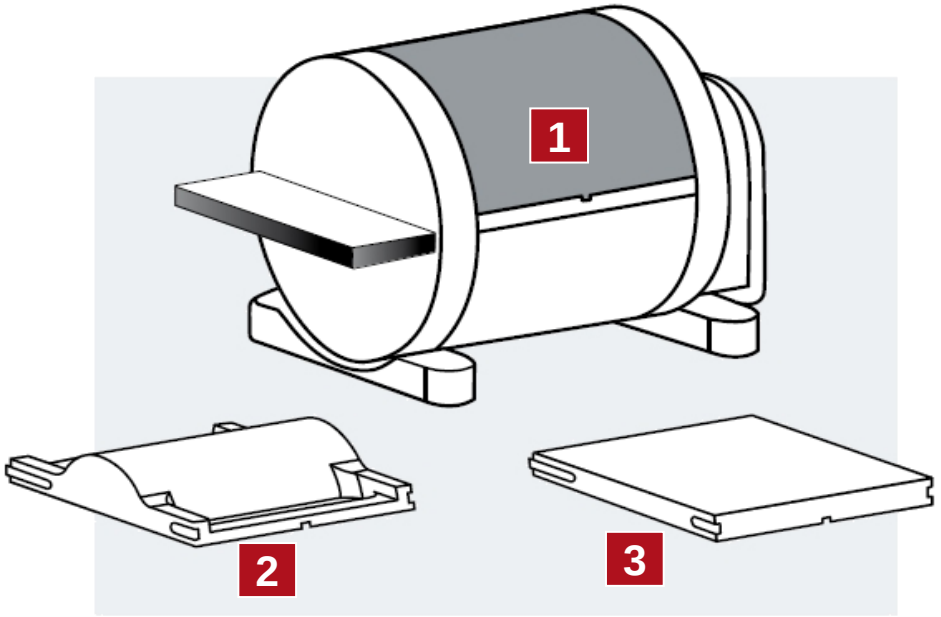
OCTAVIUS®
Detector
1500



OCTAVIUS®
Detector
1000SRS

The modular OCTAVIUS® 4D phantom

- Motorized base unit with **Standard phantom top** (1), Ø 32 cm

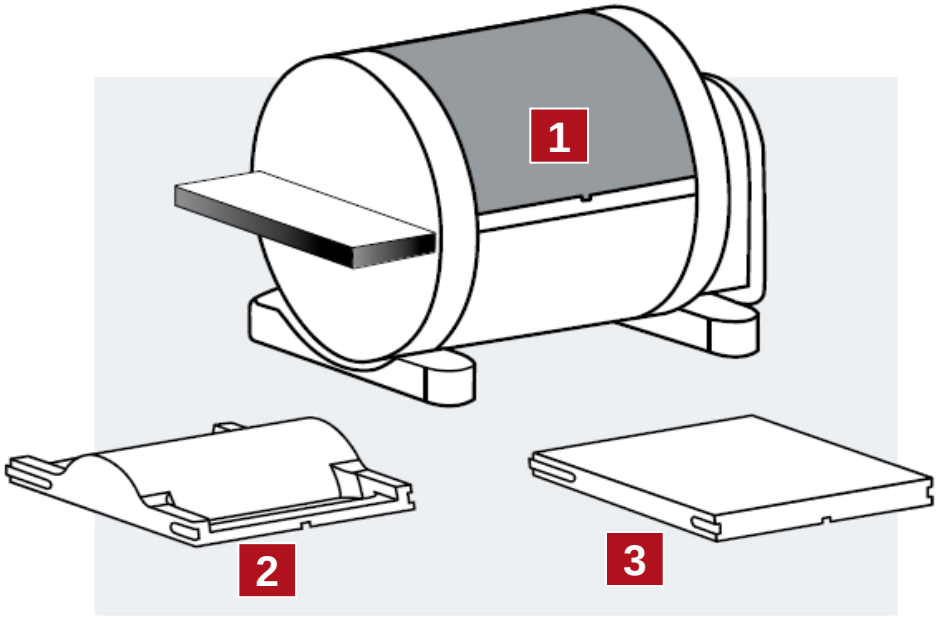


- **SRS QA top** (2): Ø 17 cm, for small field sizes/volumes
  - More accurate:

    TPS-calculation is often less accurate in larger depths
  - Closer to the patient‘s geometry in SRS applications in H&N regions
  - Faster TPS-calculation at typically (very) high calculation resolution
  - Small-sized Export-files

The modular OCTAVIUS® 4D phantom

- **LINAC QA top** (3): flat, 5 cm build-up material
  - Classical LINAC QA from different angles



- Unlock top, pull out top, push in top you want to use, relock – done!

Application-dependent patient QA…

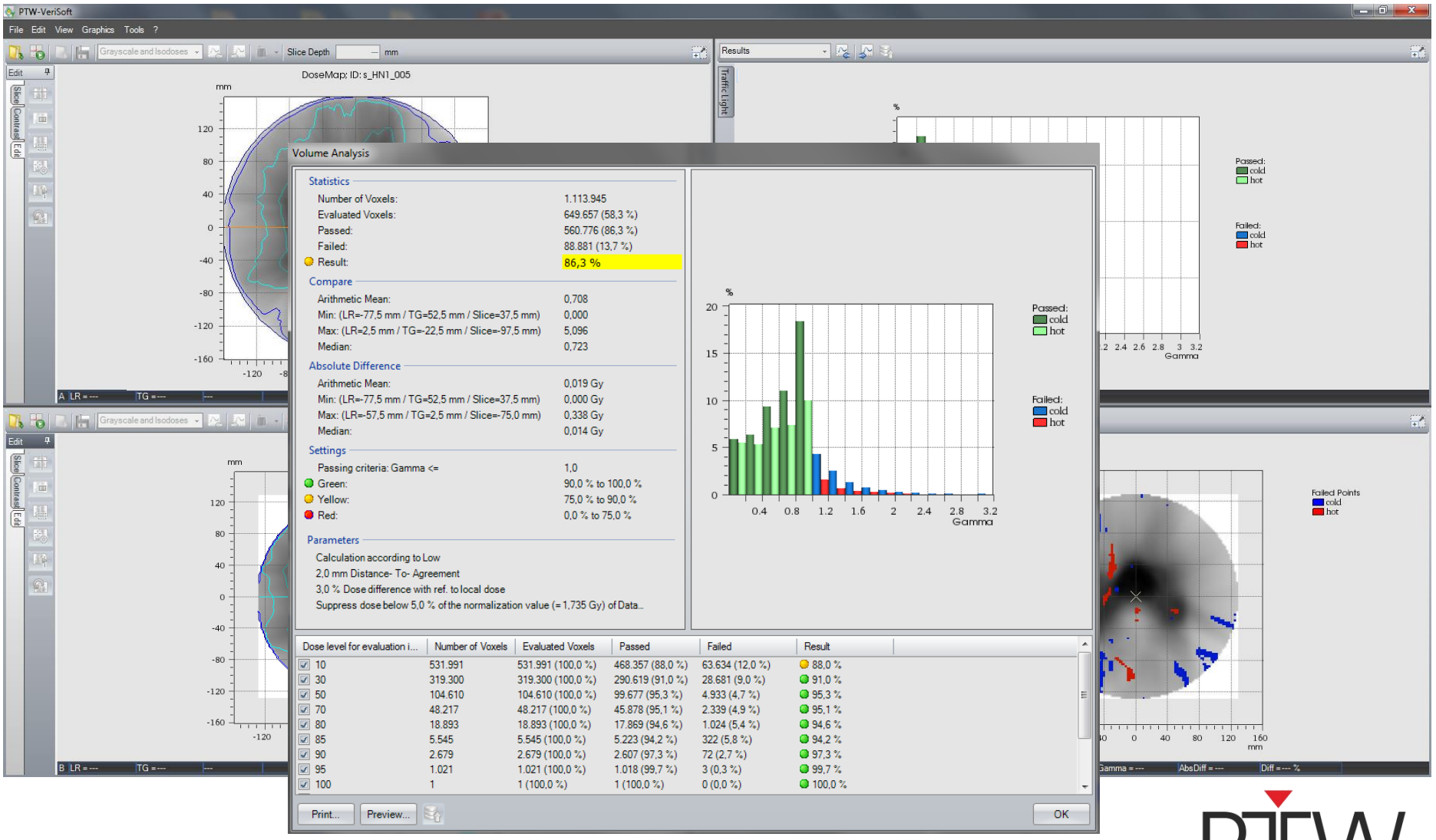
…with appropriate phantom setups.

Rotation unit top
Standard

Rotation unit top
SRS

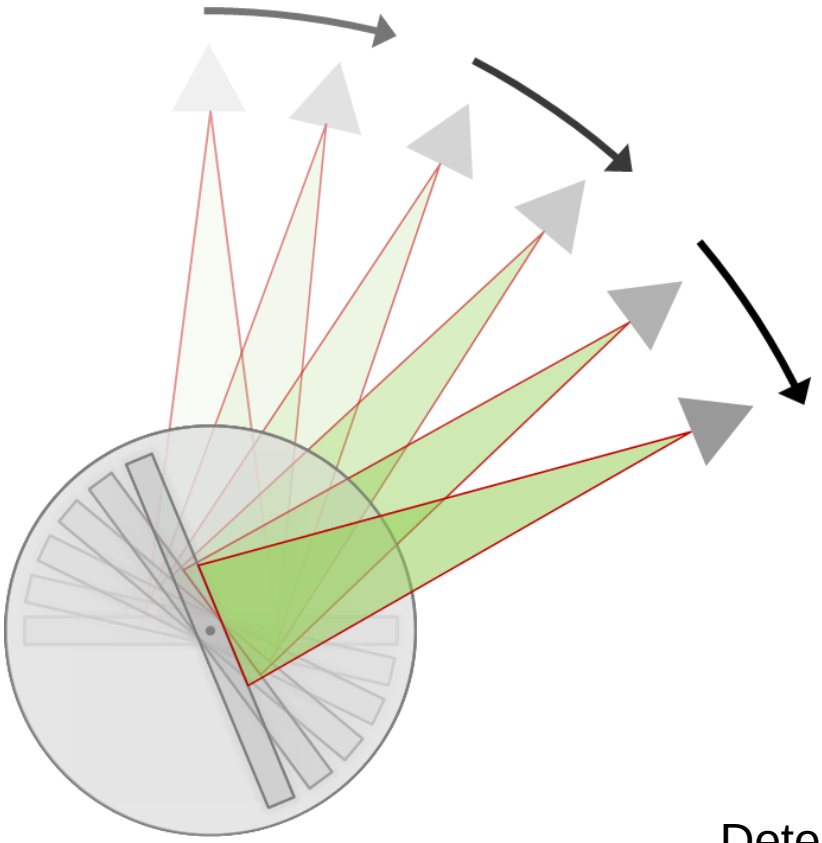
Rotation unit top
Linac QA

VeriSoft® – A flexible verification platform



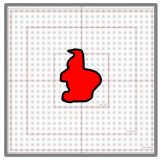
Verisoft – Dose Reconstruction principle

Measurement (time & angle dependent)

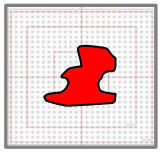


Data Processing (Example)

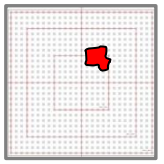
Interval 1:
Time 0 – 200 ms // angle 0.0°



Interval 2:
Time 200 – 400 ms // angle 0.5°

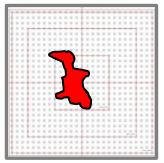


Interval 3:
Time 400 – 600 ms // angle 1.2°



⋮

Interval n:
Time xxx-xxx ms // angle xx.x°

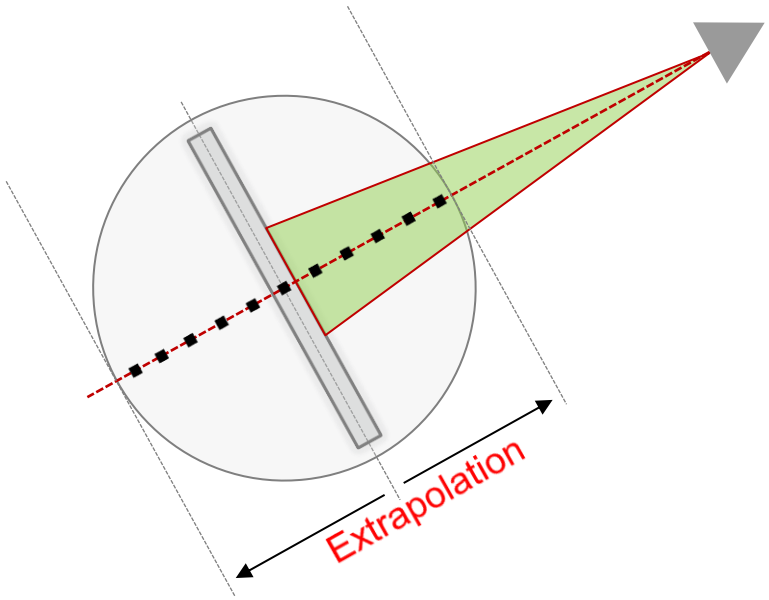


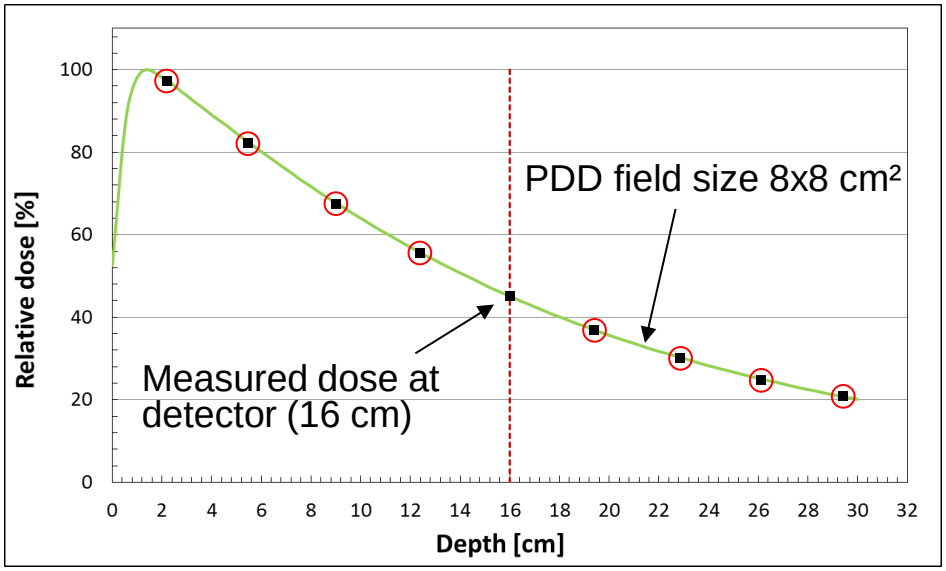
Determination of an **equivalent field size** for each interval

Verisoft – Dose Reconstruction principle

- Dose reconstruction based on measured PDDs (0x0 cm² to 26x26 cm²) in water phantom

Example: Reconstruction of an interval with equivalent field size 8x8 cm²



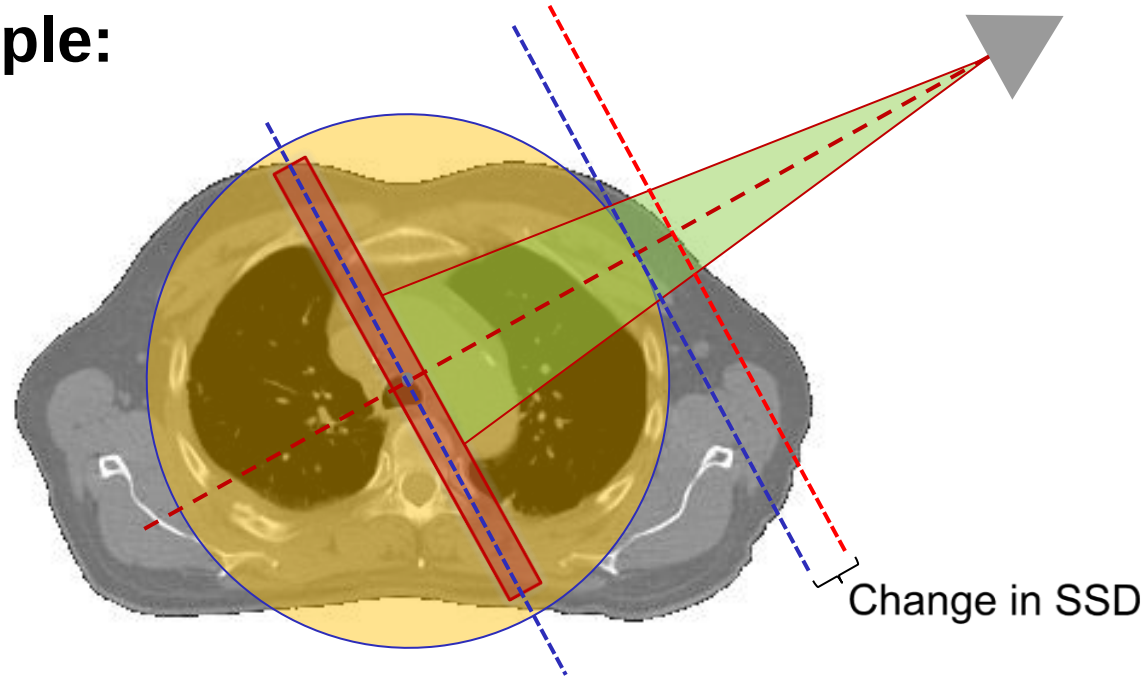


- Summation of all dose points, measured and extrapolated at a given interval, over all intervals leads to the **3D phantom dose distribution**

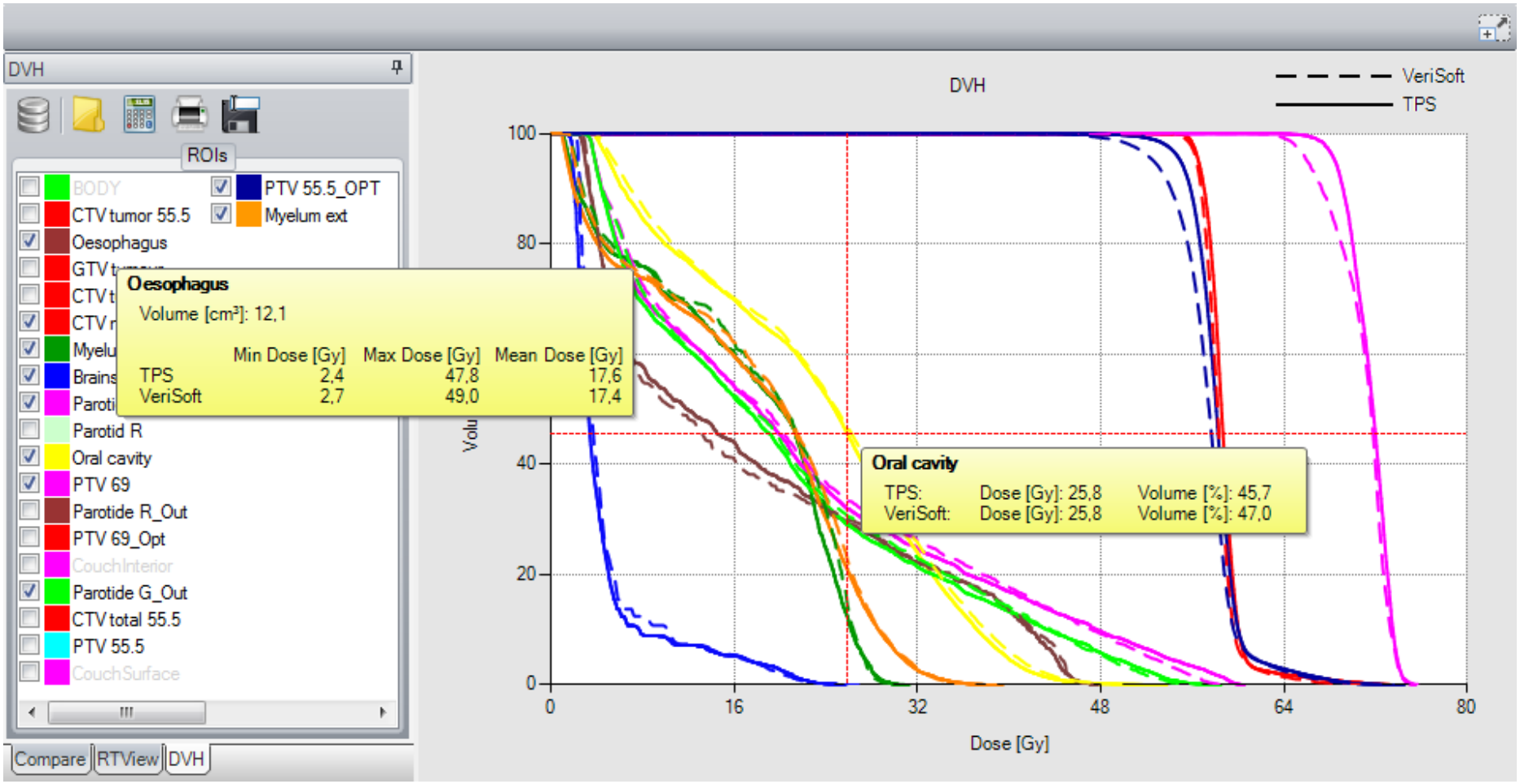
OCTAVIUS® 4D– DVH Analysis

- Patient dose calculation based on measurement & patient‘s CT DICOM
- Algorithm takes changes in SSD and different densities into account
- TPS DVHs are recalculated (not every TPS stores DVHs in DICOM-RT)
- Comparison of measured and planned DVHs of structures in RT_Struct

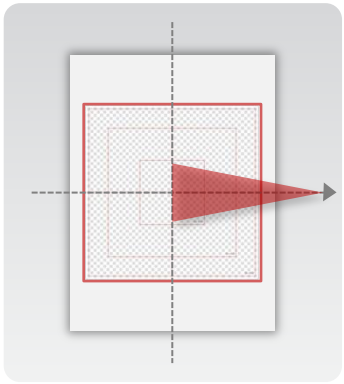
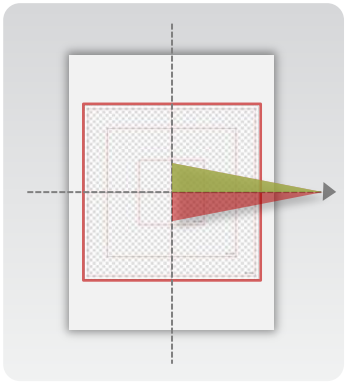
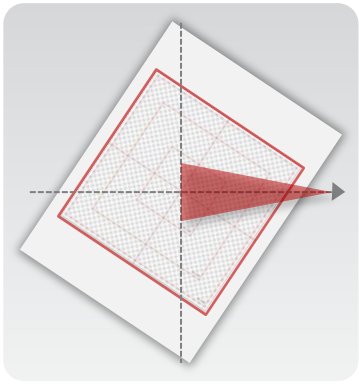
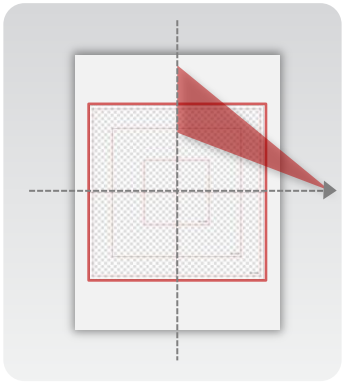
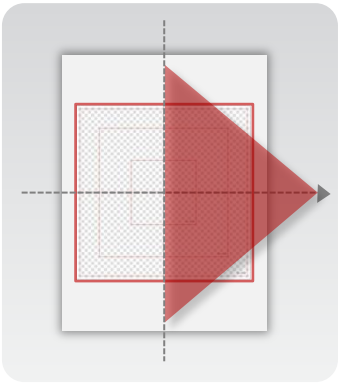
Example:



OCTAVIUS® 4D – DVH Analysis



VeriSoft 7 – New special dosimetry apps

Standard	Diff. Energies	Non-coplanar	Off-axis	Large fields
				
Classical IMRT / VMAT application	IMRT / VMAT application + Beams with multiple energies	IMRT / VMAT application + Non-coplanar beams	IMRT / VMAT application + Off-axis PTVs (outside FOV)	IMRT / VMAT application + Large PTVs (larger than FOV)

Standard algorithm

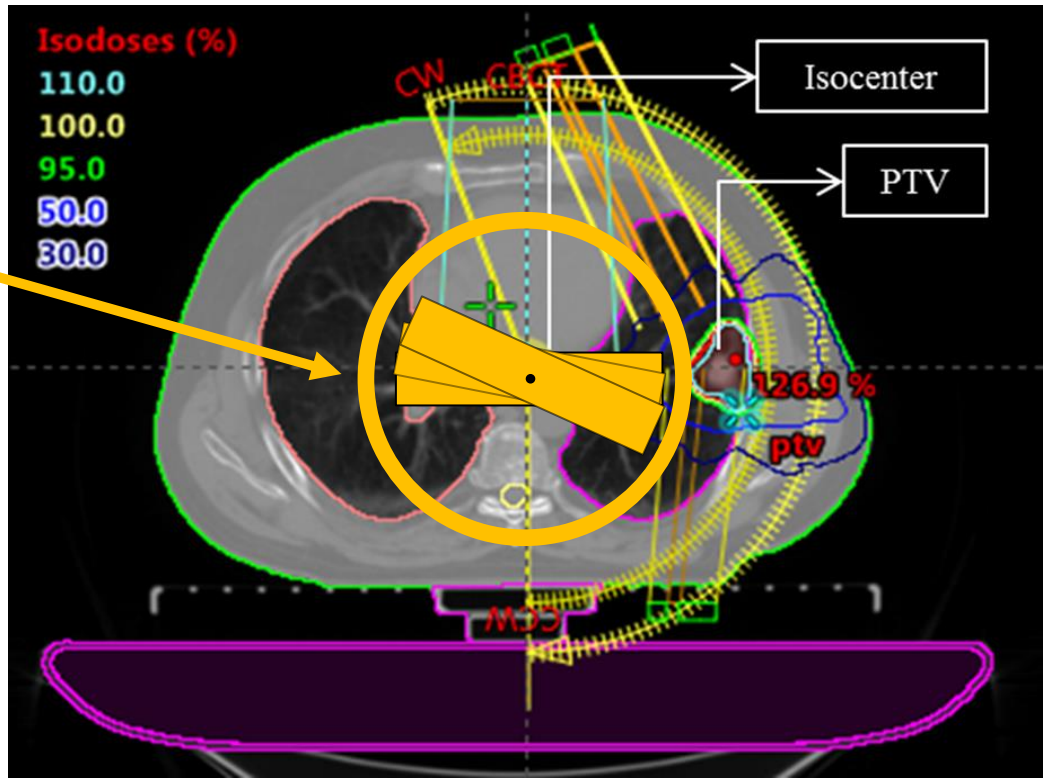
New algorithms!

Verification of off-axis target volumes

- In a few treatment scenarios the isocenter is far away from the PTV (i.e. **Lung SABR patients**)
- => **PTV not/ not completely covered** by OCTAVIUS® detector

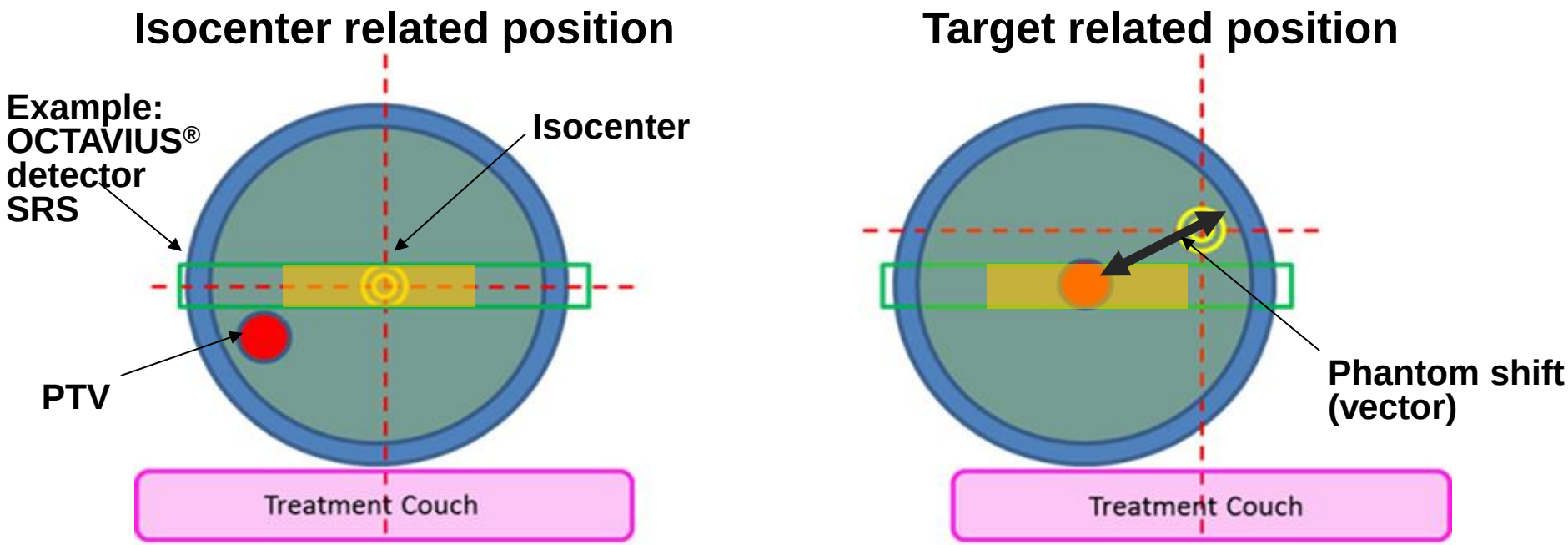
Example:

OCTAVIUS® detector SRS with Rotation Unit SRS



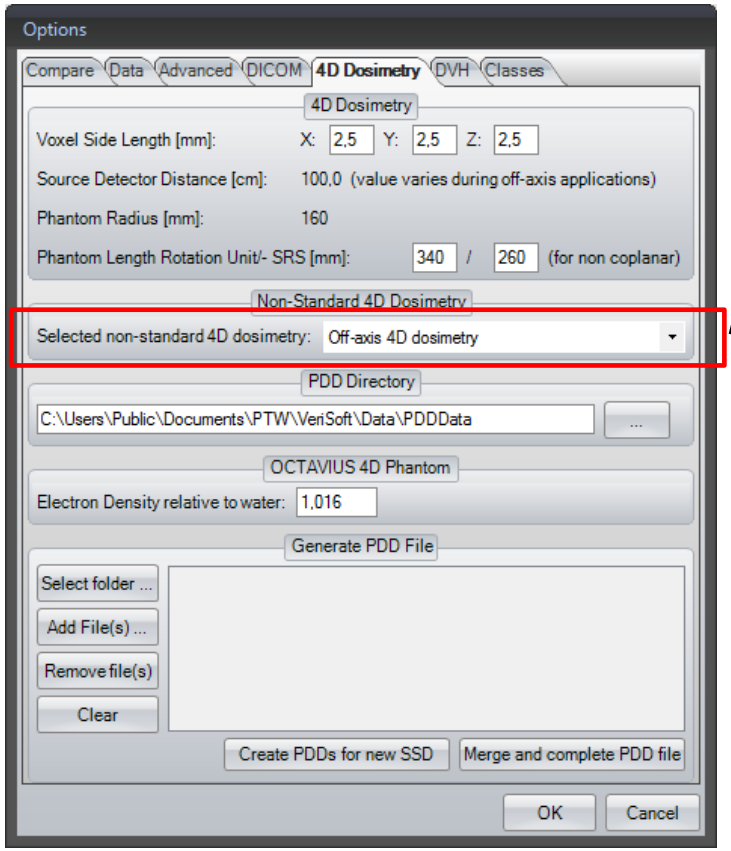
Verification of off-axis target volumes

- A new algorithm allows dose reconstruction of measurement data aquired at **arbitrary poitions** of the OCTAVIUS® 4D phantom
- Simply type in the x,y,z coordinates of the new phantom center position



Off-Axis – Evaluation workflow

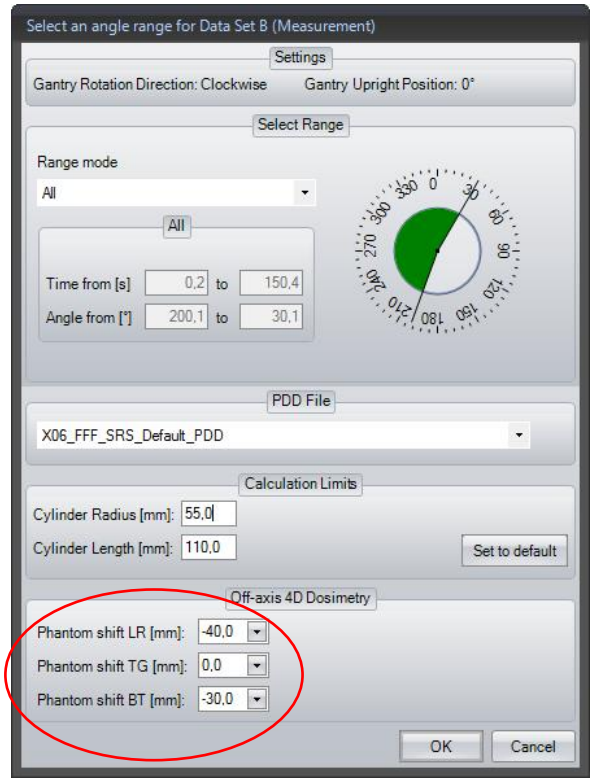
For off-axis dose reconstruction in VeriSoft “Off-axis 4D dosimetry” has to be activated in the options menu…

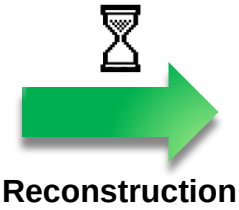


Off-Axis dosimetry must be activated !!

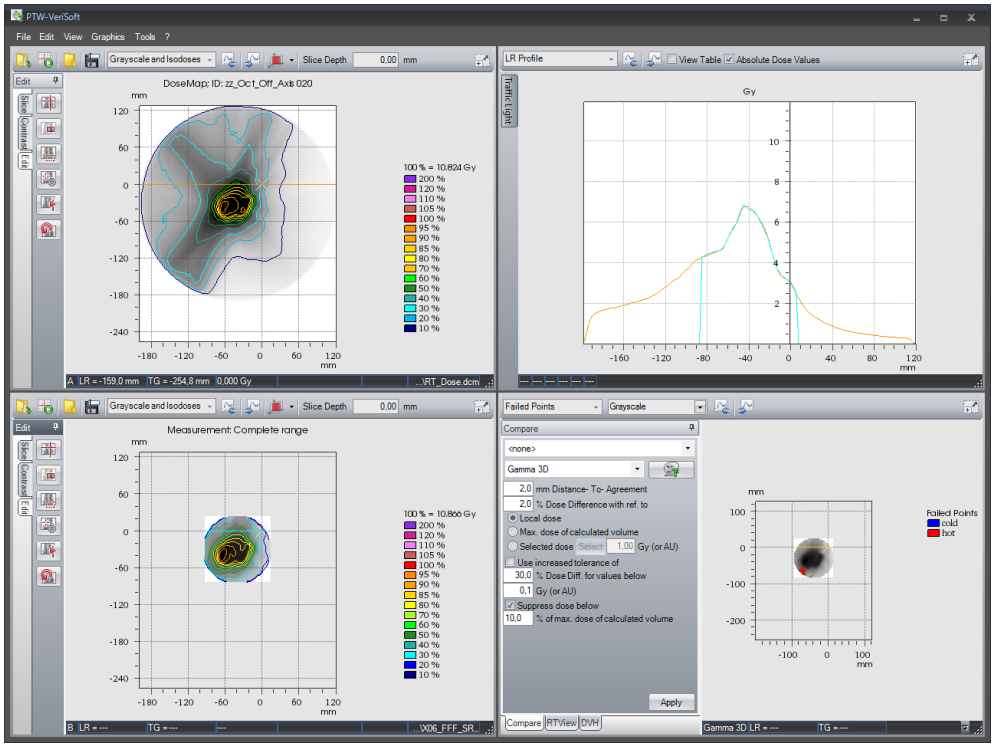
Off-Axis – Evaluation workflow

- Simply load the measurement file(s) & assign the phantom shift before dose reconstruction…



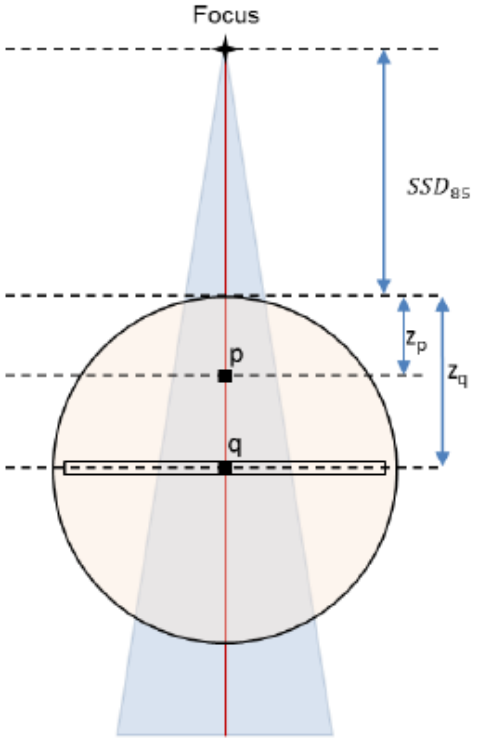


Reconstruction

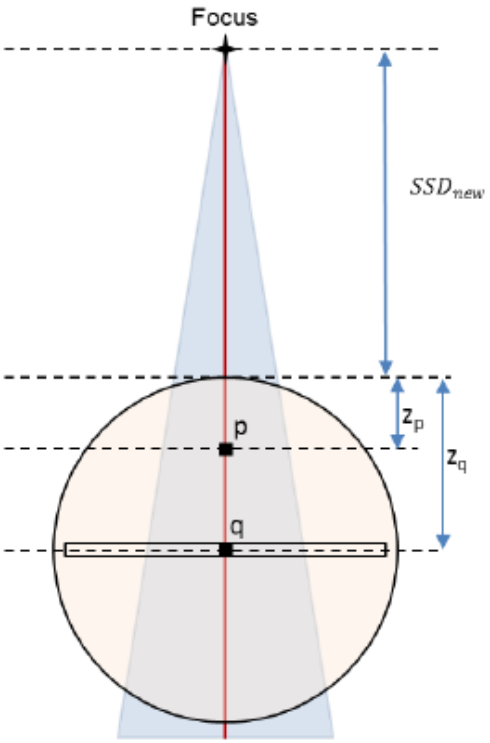


Verification of off-axis target volumes

- Dose reconstruction principle comparable to non-coplanar dosimetry
- Additionaly, the new phantom center position is taken into account



Classical setup
Phantom center = isocenter



Off-axis setup
Phantom center ≠ isocenter

Dose measured by the OCTAVIUS detector

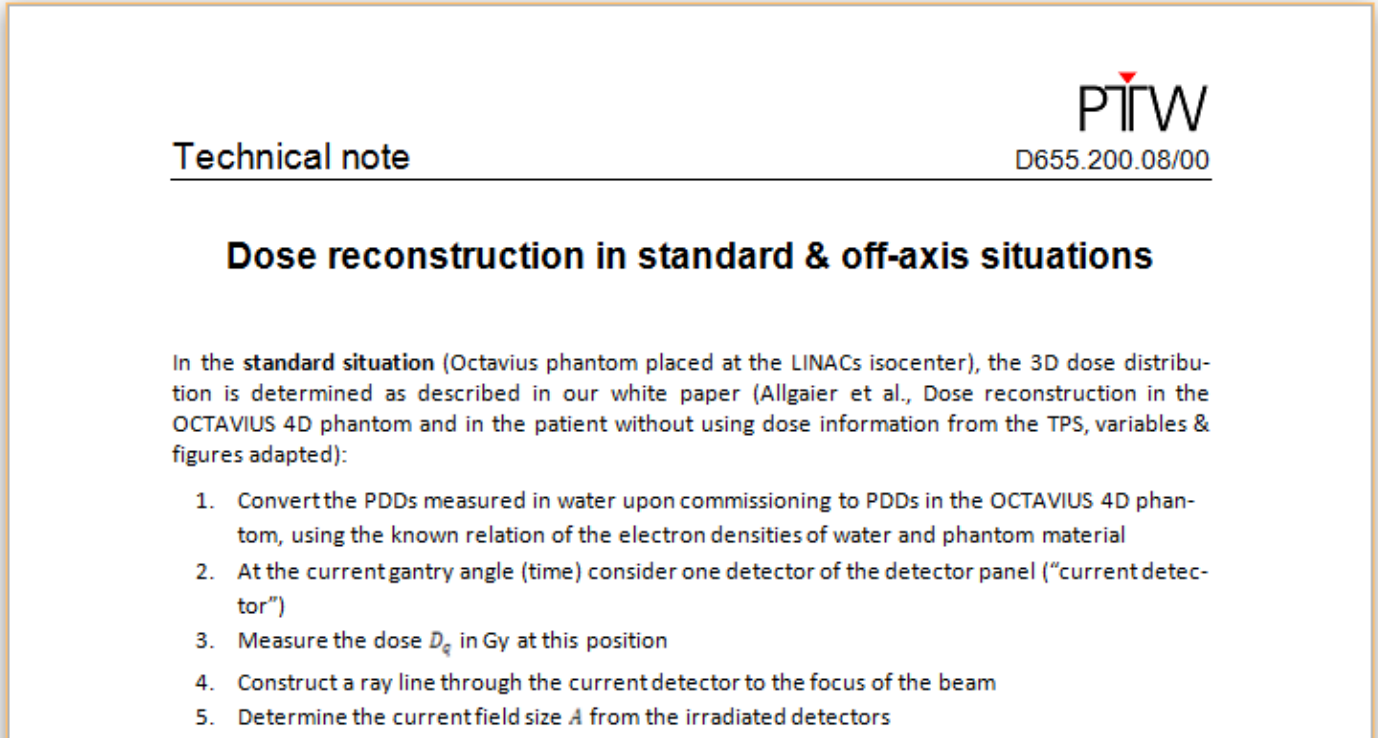
$$D_P = D_q \cdot \frac{PDD(z_p, A, SSD_{85}, hv) \cdot \left(\frac{SSD_{85} + z_p}{SSD_{new} + z_p}\right)^2}{PDD(z_q, A, SSD_{85}, hv) \cdot \left(\frac{SSD_{85} + z_q}{SSD_{new} + z_q}\right)^2}$$

Relative dose at depth z_p (normalized), PDD curve for detected fieldsize A

SSD correction

Verification of off-axis target volumes

- Further information concerning details on the dose reconstruction principle in off-axis setups can be taken from the following document …
(see homepage)



PTW

Technical note D655.200.08/00

Dose reconstruction in standard & off-axis situations

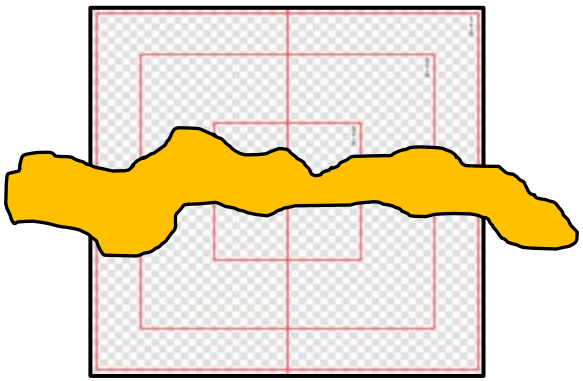
In the **standard situation** (Octavius phantom placed at the LINACs isocenter), the 3D dose distribution is determined as described in our white paper (Allgaier et al., Dose reconstruction in the OCTAVIUS 4D phantom and in the patient without using dose information from the TPS, variables & figures adapted):

1. Convert the PDDs measured in water upon commissioning to PDDs in the OCTAVIUS 4D phantom, using the known relation of the electron densities of water and phantom material
2. At the current gantry angle (time) consider one detector of the detector panel ("current detector")
3. Measure the dose D_q in Gy at this position
4. Construct a ray line through the current detector to the focus of the beam
5. Determine the current field size A from the irradiated detectors

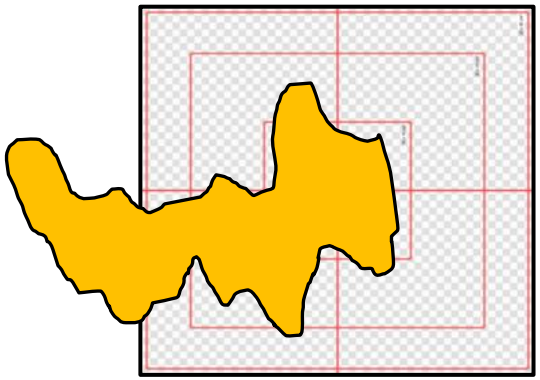
Compose – When do I need it?

- Large fields that extend the FOV (= field of view) of the OCTAVIUS Detector **on both sides (case 1)**
- Large fields that extend the FOV (= field of view) of the OCTAVIUS Detector **on a single side (case 2)**
- Typical clinical examples:
  - Craniospinal treatments
  - More-field breast irradiations with isocenter positioned far away from field center

Case 1:

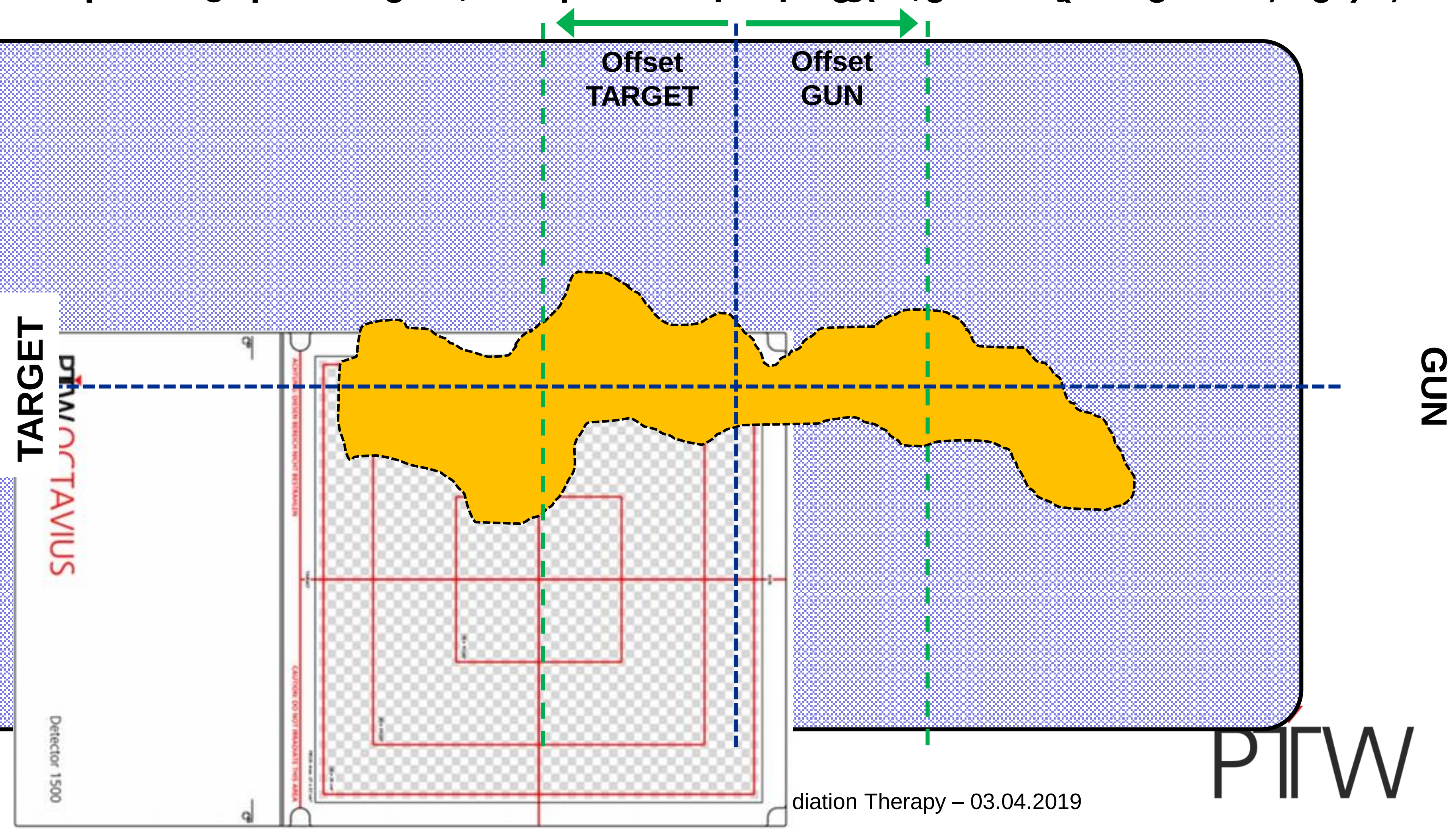


Case 2:



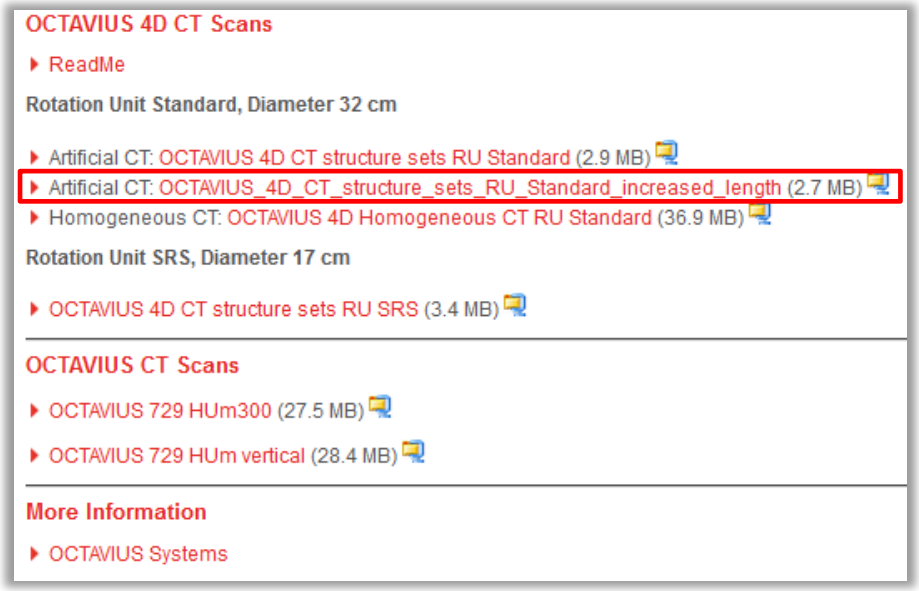
Compose – Measurement Workflow

Step [illegible]



Compose – Workflow at the TPS

- Plan on the extended artificial CT dataset of OCTAVIUS provided by PTW: http://www.ptw.de/index.php?id=2469



Artificial CT:
OCTAVIUS_4D_CT_structure_sets_RU_Standard_increased_length

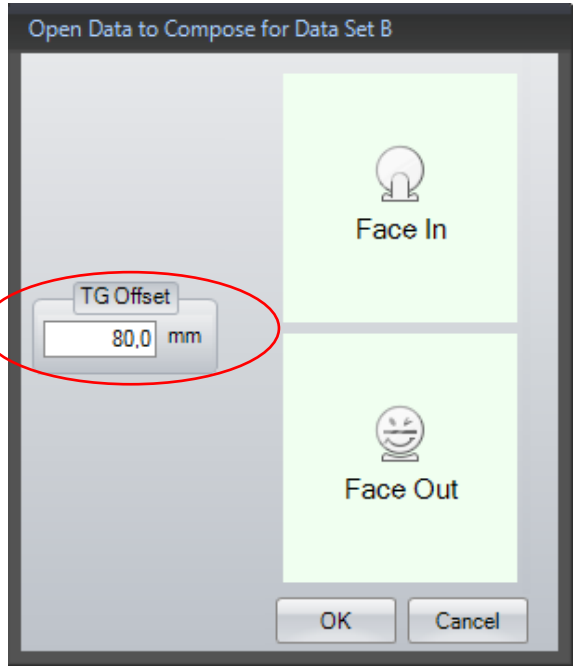
Phantom Length: 500 mm

- Treatment plan should include the total dose
- Export of RT Dose + RT Plan (total dose is recommended)

Compose – Evaluation with VeriSoft

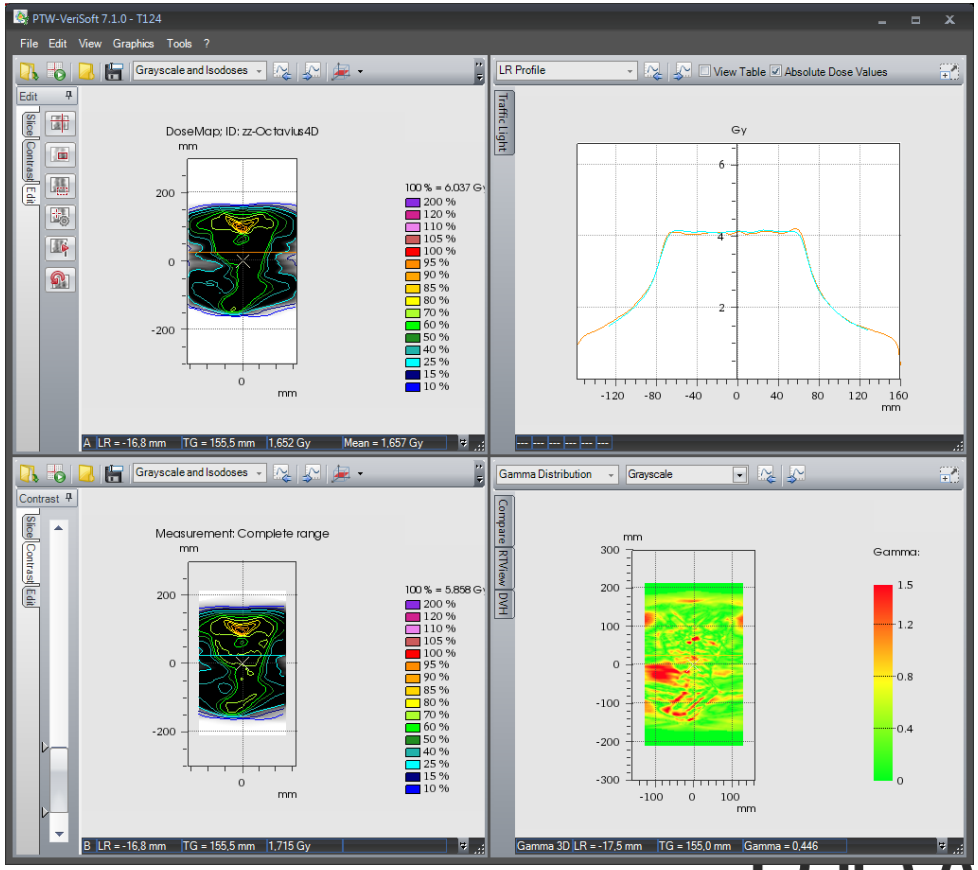
- Simply load in the measurement files & type in the TG shift of the OCTAVIUS 4D phantom

Compose dialogue



Reconstruction

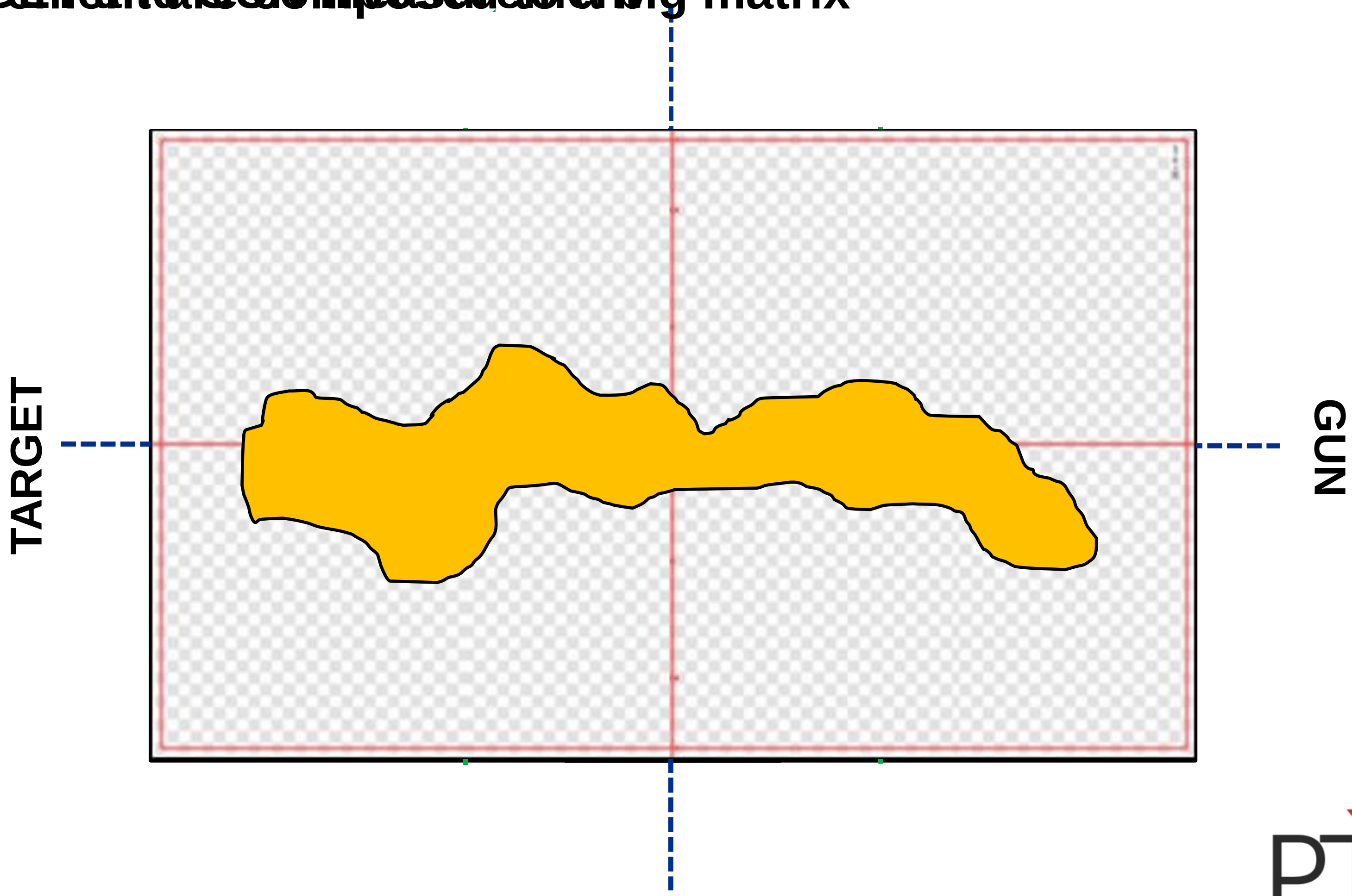
Classical treatment plan verification…



Compose – Dose Reconstruction

The TARGET and GUN measurement … identical

in TARGET and GUN measurement … big matrix



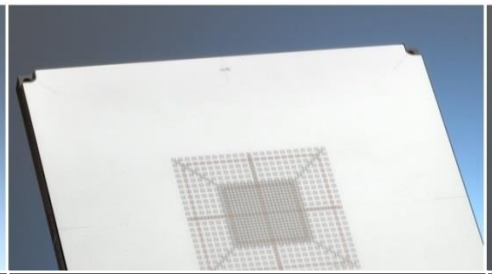
Compose – Hardware Combinations

- OCTAVIUS 4D Phantom types:

- OCTAVIUS Detectors:

- Each Phantom type is compatible with all OCTAVIUS Detectors

Compose – Specifications

Compose relevant specs	 OCTAVIUS® 1500	 OCTAVIUS® 1000 RS	 OCTAVIUS® 729
Detector size	4.4 x 4.4 x 3 mm^3	2.3 x 2.3 x 0.5 mm^3	5 x 5 x 5 mm^3
Detector spacing	10 mm center-to-center in TG direction	2.5 mm center-to-center* in TG direction	10 mm center-to-center in TG direction
Shift increments	10 mm	5 mm	10 mm
Maximum shift in TG	110 mm	45 mm	110 mm
Maximum Field enlargement	(27 x 27) cm^2 ↓ **(48 x 27) cm^2**	(11 x 11) cm^2 ↓ **(22 x 11) cm^2**	(27 x 27) cm^2 ↓ **(48 x 27) cm^2**
Minimum Overlap region	3 Detector Rows (= 3cm)	4 Detector Rows (=2 cm)	3 Detector Rows (=3cm)
Compatibility	• Rot. Unit Top Standard • Rotation Unit Top SRS	• Rot. Unit Top Standard • Rotation Unit Top SRS	• Rot. Unit Top Standard • Rotation Unit Top SRS

Compose – Further information…

- New Product information sheet available on our homepage…

PRODUCT INFORMATION

PTW

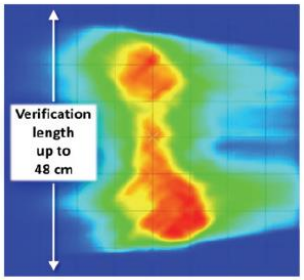
OCTAVIUS 4D

Verification of Long Radiation Fields

1 General Information

Until recently, very long radiation fields, such as typically encountered in craniospinal treatments, could not be verified with OCTAVIUS® 4D as the dimension of the dose volume was not completely covered by the field of view of the OCTAVIUS® detector.

Thanks to a redesign of the OCTAVIUS® 4D Control Unit / Phantom and a new dose reconstruction algorithm implemented in VeriSoft® 7.1, it is now possible to verify large radiation fields. The new **VeriSoft® Compose** feature allows you to compose



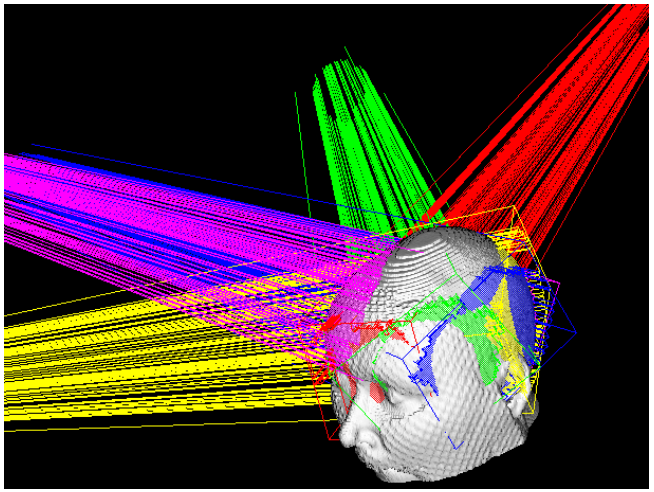
PTW

Non-Coplanar – Where do I need it?

- In general non-coplanar fields are applied to increase the conformity of the treatment plan (=> more dose to PTV & less dose to OARs)
- Mostly, treatment plans contain only coplanar fields. In special situations non-coplanar fields are beneficial (see below).

Clinical Examples:

- Breast treatments, where conventional techniques failed to achieve high conformal avoidance => Minimization of the lung dose
- Lung treatments, e.g. certain lung tumors lying close to the heart in order to minimize
- Stereotactic head treatments, e.g. at brain treatments in order to minimize the dose to the surrounding brain parenchyma



Non-Coplanar – Data Acquisition

Workflow during the measurement with OCTAVIUS 4D:

- Setup the OCTAVIUS 4D system as usual
- Stepwise measurement of the treatment plan:
  - Deliver all fields that belong to a certain couch angle
  - **Always collapse the couch angle to 0° at non-coplanar fields (=> Phantom may not be deflected!)**
  - Start/Stop/Save each measurement

Non-Coplanar – Measurement workflow

Exemplary measurement workflow for a 6-Field Prostate IMRT plan:

6-Field Prostate IMRT

Field No.	Gantry Angle	Couch Angle
Field 1	0°	0°
Field 2	60°	340°
Field 3	120°	0°
Field 4	180°	0°
Field 5	240°	20°
Field 6	300°	20°

Simultaneous Measurement of **Field 1** **Field 3** **Field 4** → Save XCC file for **couch angle 0°**

Simultaneous Measurement of **Field 2** → Save XCC file for **couch angle 340°**

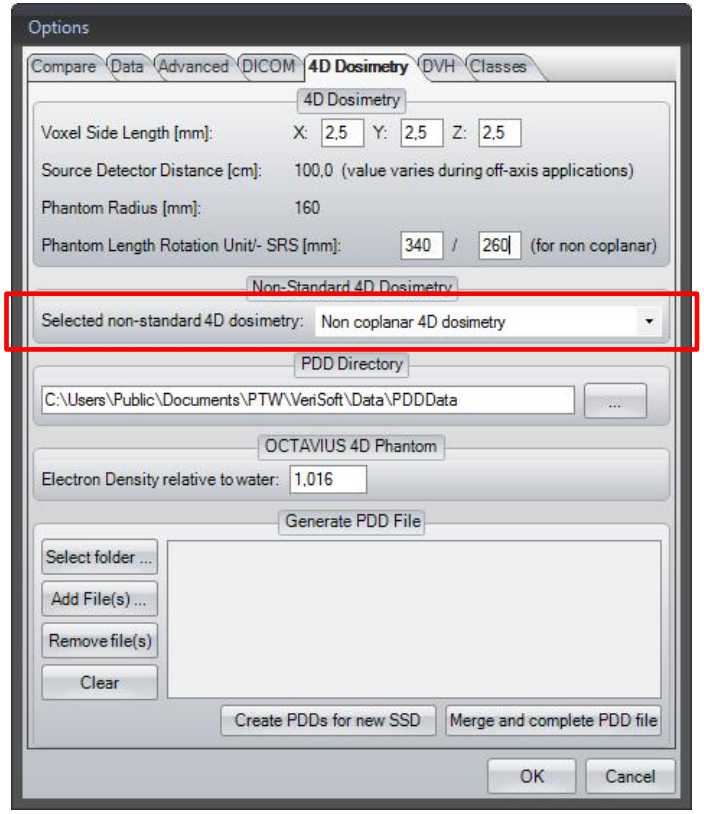
Measure with couch angle 0°!!

Simultaneous Measurement of **Field 5** **Field 6** → Save XCC file for **couch angle 20°**

Measure with couch angle 0° !!

Non-Coplanar – Evaluation workflow

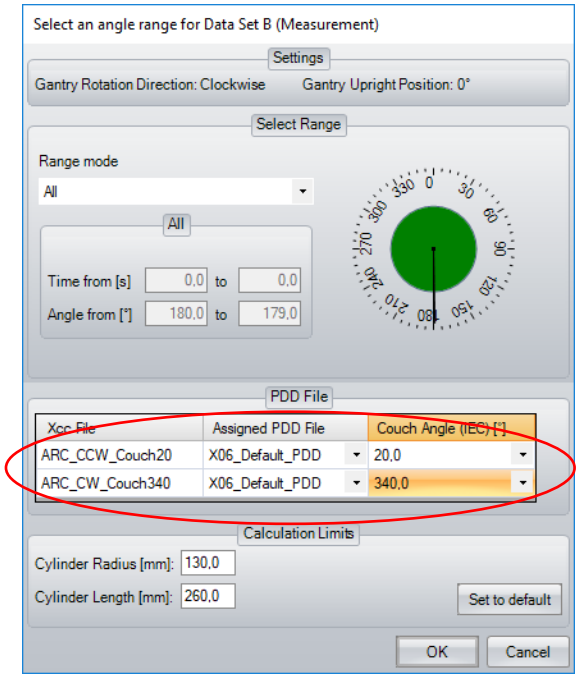
For non-coplanar dose reconstruction in veriSoft “Non-coplanar Dosimetry” has to be activated in the options menu…



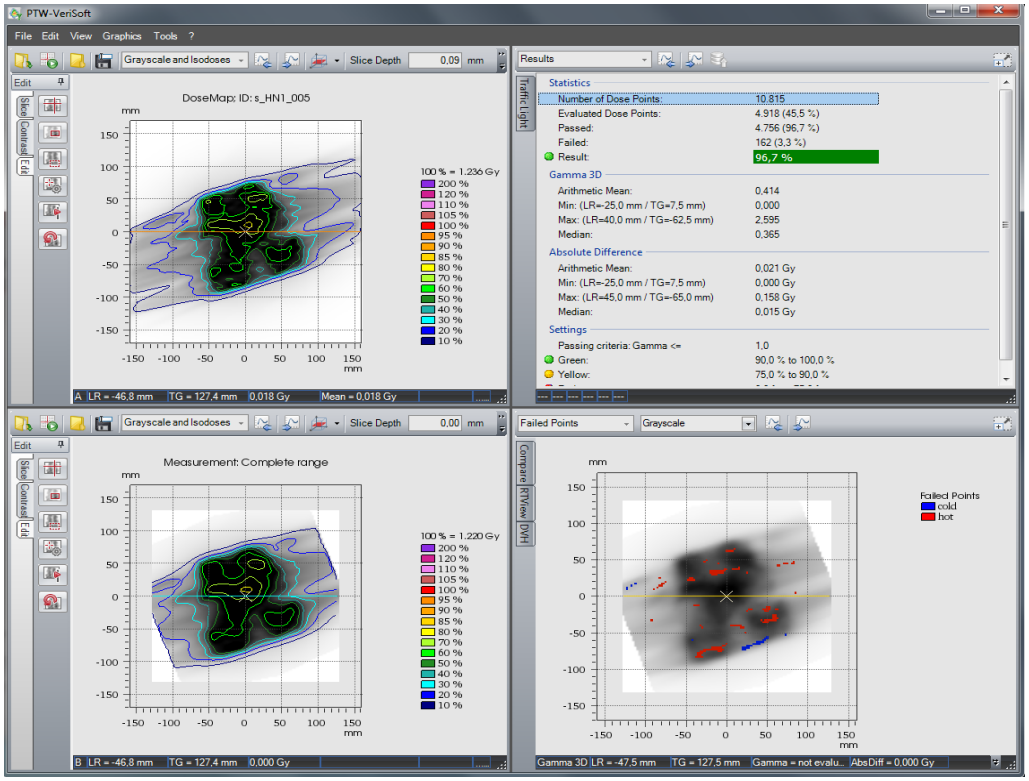
Non-coplanar 4D dosimetry must be activated !!

Non-Coplanar – Evaluation workflow

- Simply load the measurement file(s) & assign PDD file and couch angle to each measurement file…

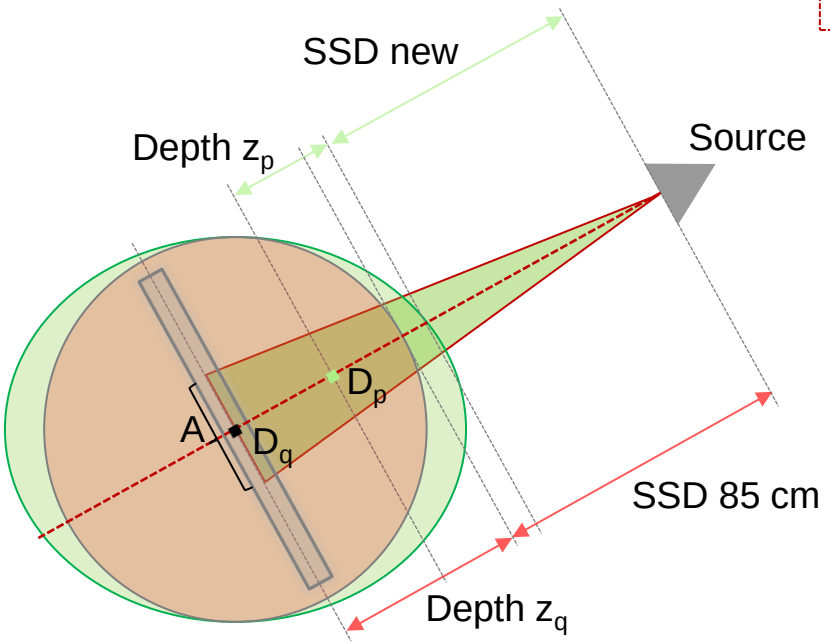


Reconstruction



Non-Coplanar – Dose reconstruction

- Dose reconstruction principle:



Dose measured by the OCTAVIUS detector

$$D_P = D_q \cdot \frac{PDD(z_p, A, SSD_{85}, hv) \cdot \left(\frac{SSD_{85} + z_p}{SSD_{new} + z_p}\right)^2}{PDD(z_q, A, SSD_{85}, hv) \cdot \left(\frac{SSD_{85} + z_q}{SSD_{new} + z_q}\right)^2}$$

Percentage depth dose at depth z_p (normalized) for fieldsize A parameterized at the surface

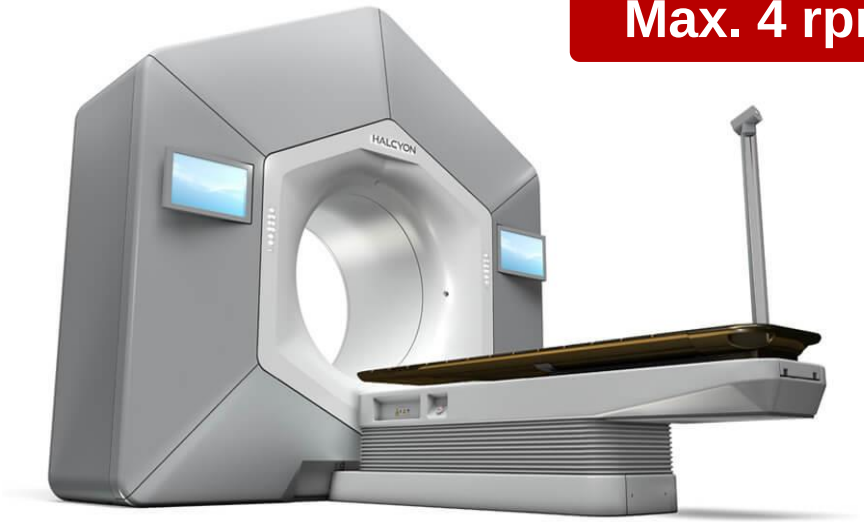
SSD correction

Brown Phantom: OCTAVIUS 4D phantom as used for dose reconstruction of measurements at couch angle 0°

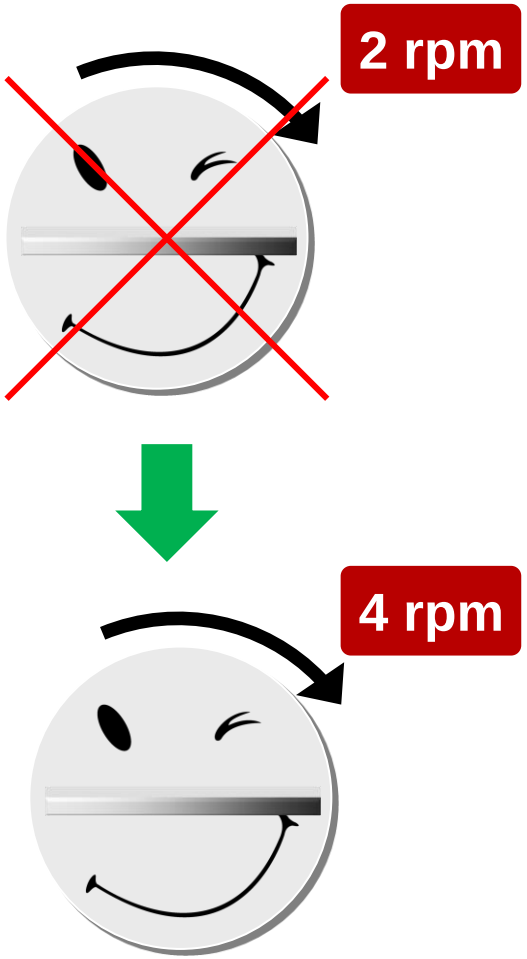
Green Phantom: Virtual, rotated OCTAVIUS 4D phantom, used for dose reconstruction of an arbitrary couch angle x°

OCTAVIUS® 4D – Now available for Halcyon™

Max. 4 rpm



taken from www.varian.com



Key Challenge: Rotation speed

Adaption of OCTAVIUS 4D rotation speed necessary to ensure fast and smooth rotation at 4rpm.

OCTAVIUS® 4D – Integration into VERIQA

VERIQA

Client-based	Server-based	
DICOM and DICOM RT	Pre-treatment QA	Treatment delivery QA
Viewing	Monte Carlo dose calculation	Log file analysis
Evaluation	OCTAVIUS® measurement	Evaluation for adaptive RT

Track-it

OCTAVIUS® 4D – Integration into VERIQA

Treatment Planning System

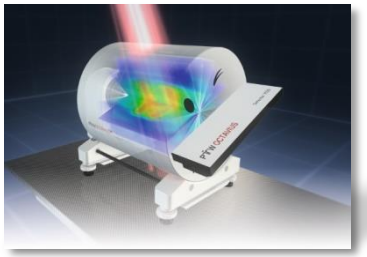
DICOM

Web-Server

RT OCTAVIUS®

Patient worklist generation
Automated dose calculation
Automated dose comparison

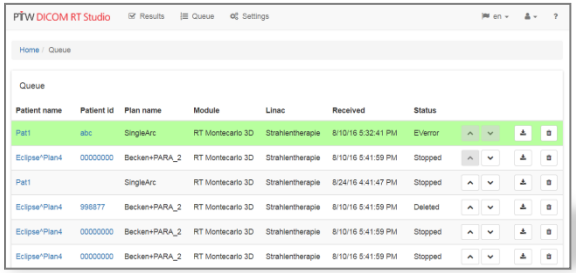
OCTAVIUS® client



Patient worklist processing (OCTAVIUS measurement)

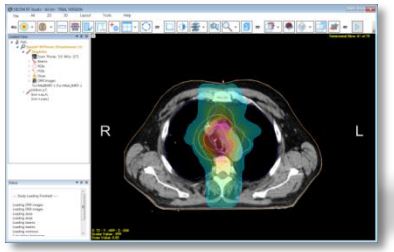
VERIQA web client

@ Email



Evaluation/Configuration

VERIQA Windows client



Detailed evaluation

Track-it

XML + PDF

Auto reporting

PTW


Thank you for
your attention!