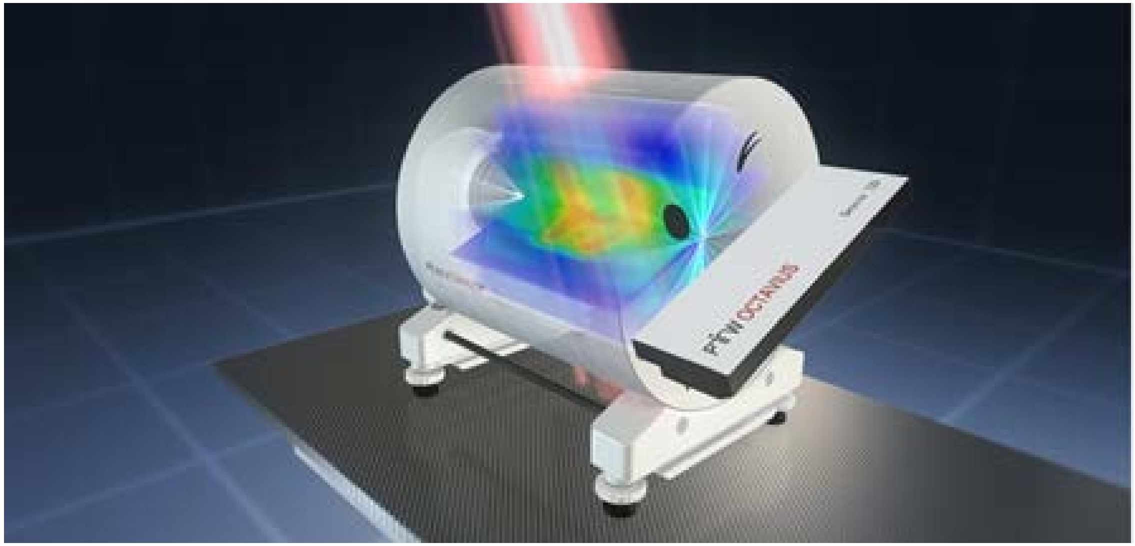

Introduction to OCTAVIUS 4D

Dr. Jan U. Wuerfel
Project Manager, PTW-Freiburg

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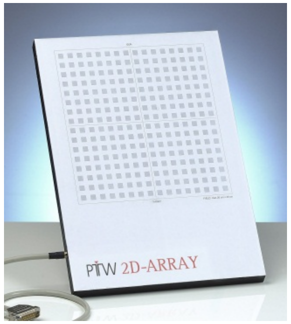
Knowing what responsibility means

Bild: Luc Viatour, CC-BY-SA 3.0

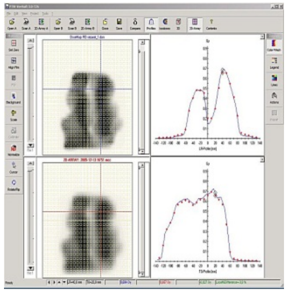
Overview

1 Introduction
2 Nice features
3 The algorithm
4 Conclusion

The OCTAVIUS Family



1999



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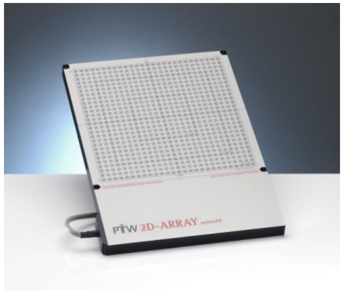

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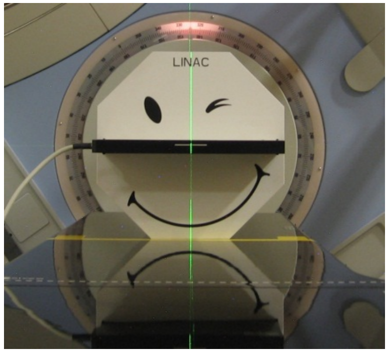
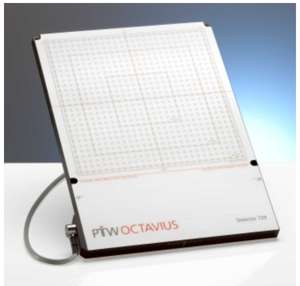
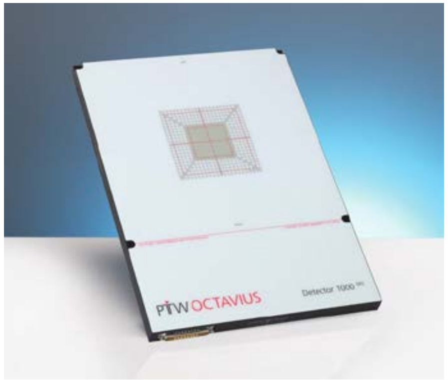


2007



2010

2012



2012

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OCTAVIUS II vs. OCTAVIUS 4D

OCTAVIUS II	OCTAVIUS 4D
+ Fast setup	+ 4D information
− 2D information	+ No angular dependence
− 1 measurement plane only	− Setup needs longer

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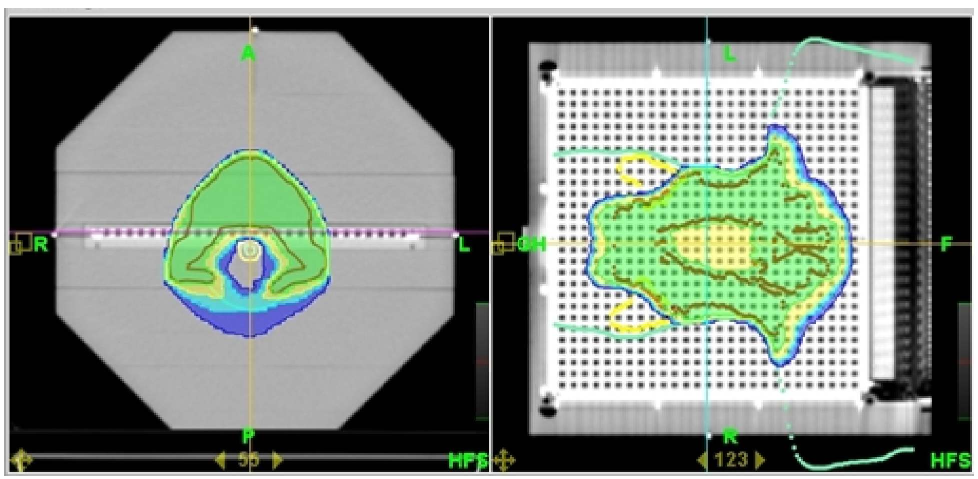
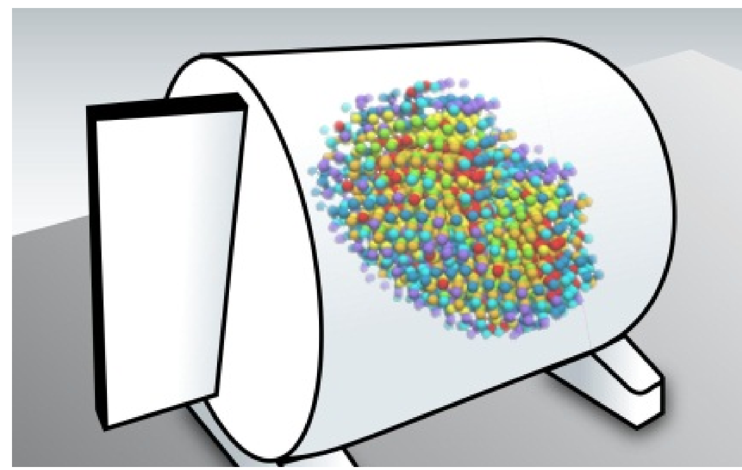
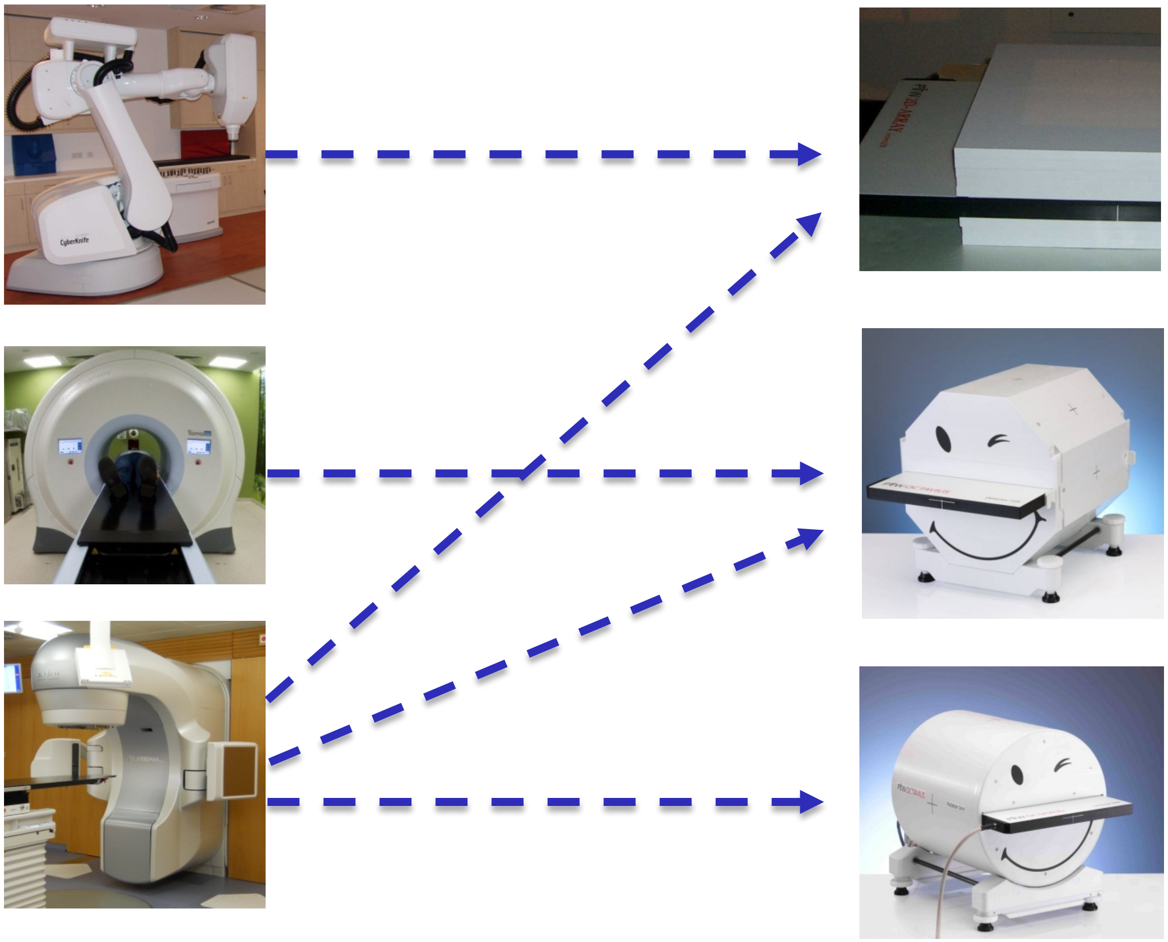
OCTAVIUS II vs. OCTAVIUS 4D





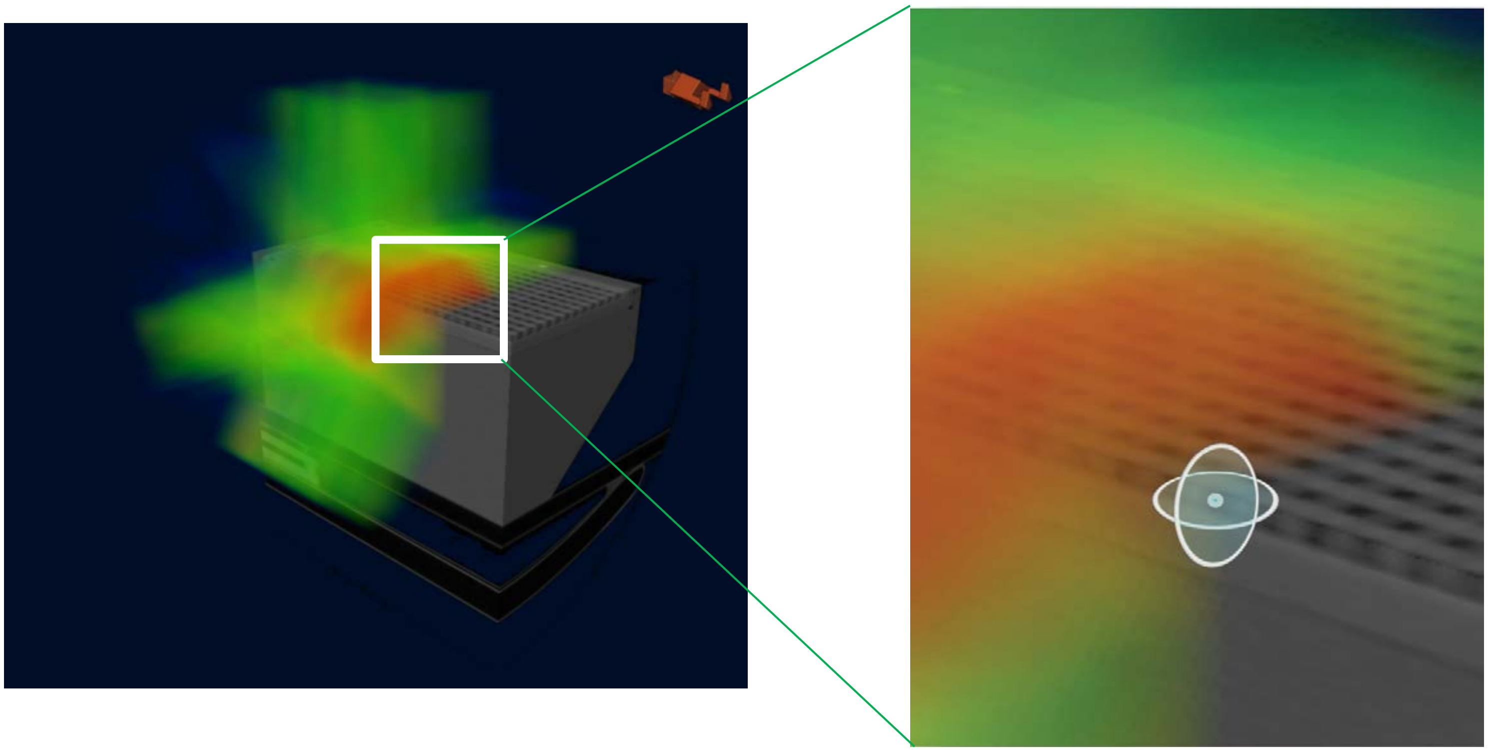
OCTAVIUS II vs. OCTAVIUS 4D

Which OCTAVIUS for IMRT, VMAT, RapidArc, TomoTherapy, Cyberknife, …



3D γ Analysis

OCTAVIUS II and OCTAVIUS 4D



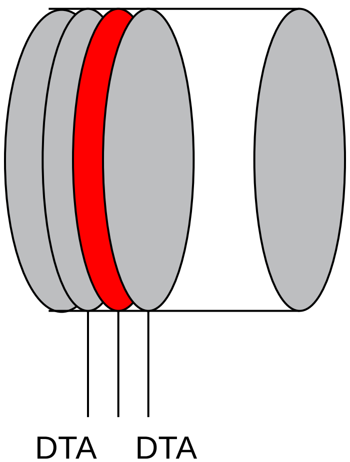
3D γ Analysis

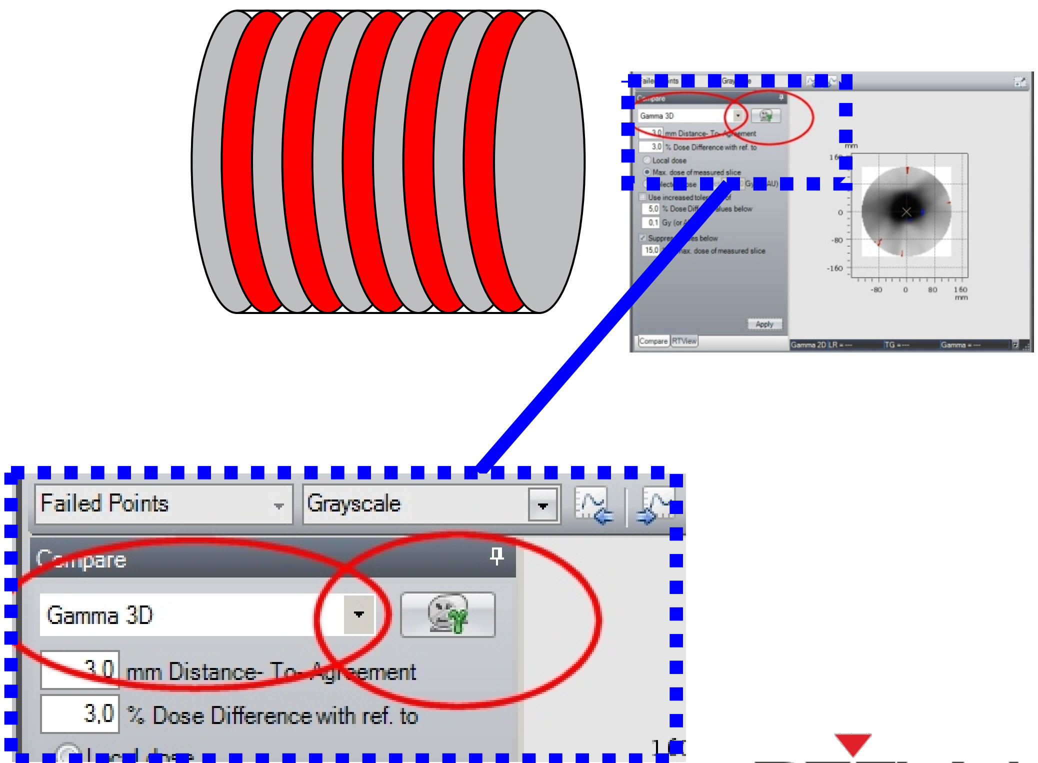
2D or 3D γ in a plane

OCTAVIUS II and OCTAVIUS 4D

Full Volume Analysis

OCTAVIUS 4D





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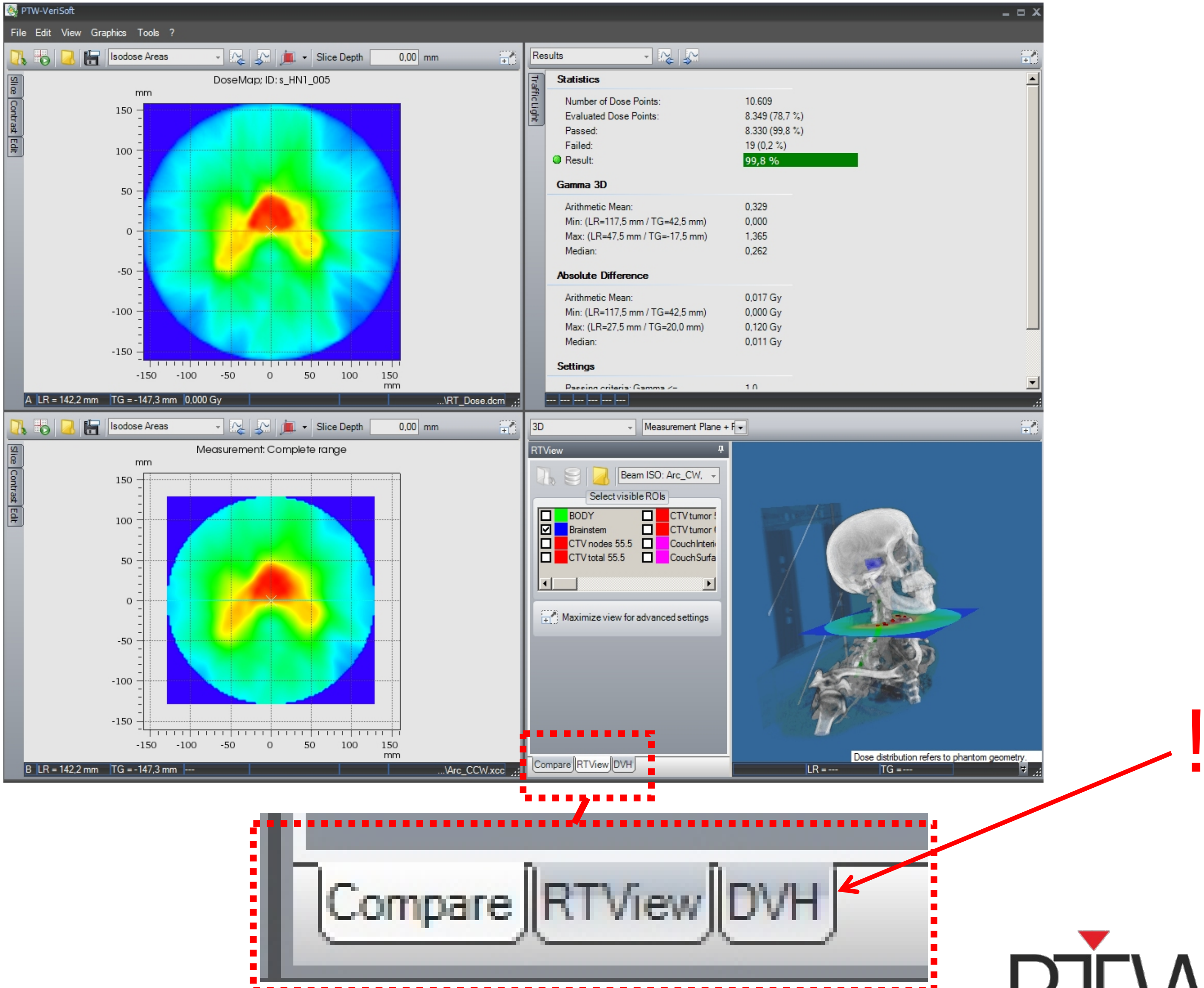
DVH 4D



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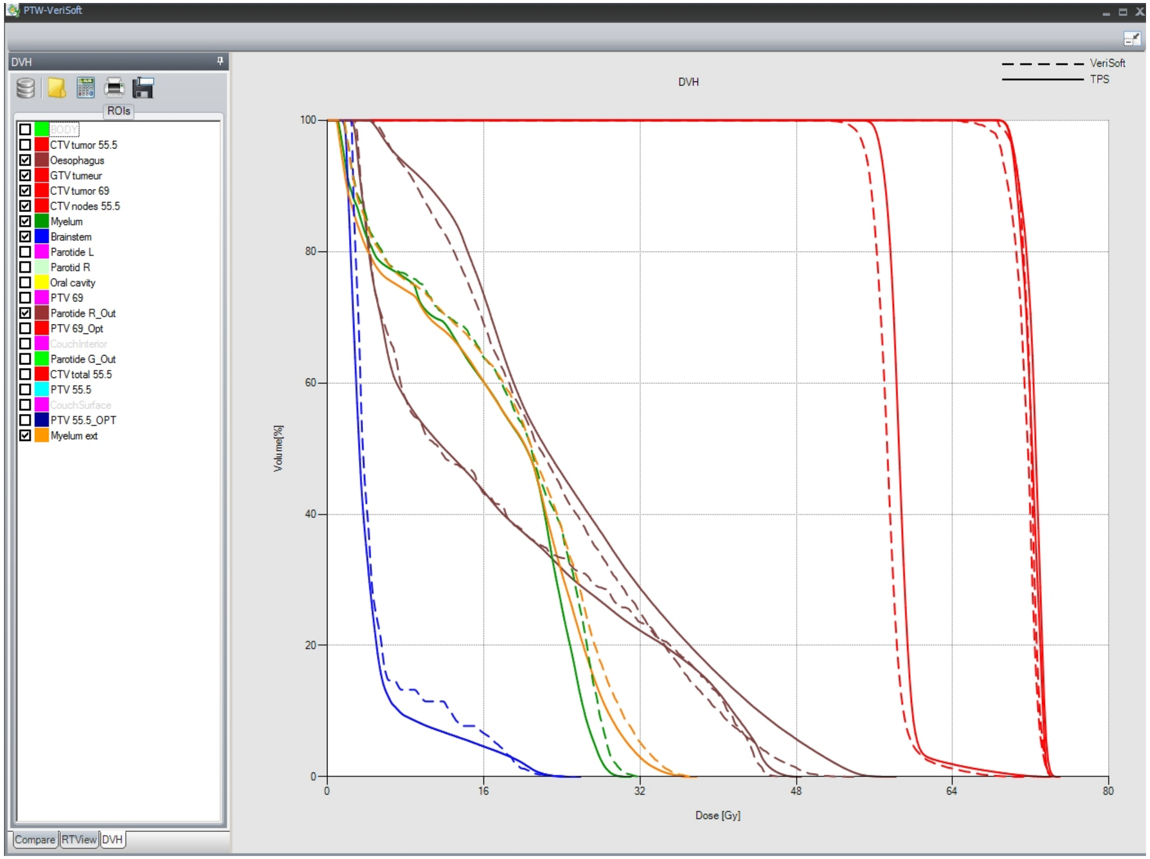
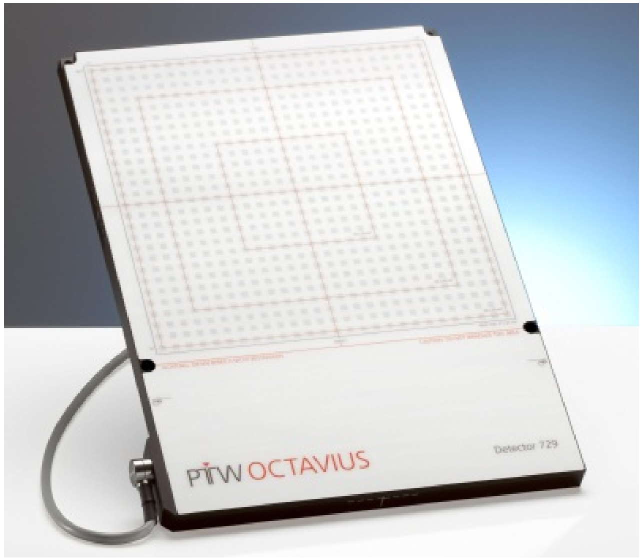
DVH 4D

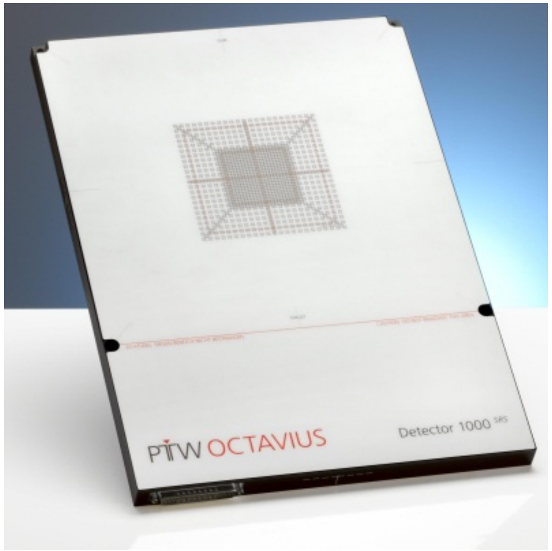


- Calculated independent from TPS
- Calculation in patient anatomy
- Based on ion chamber measurements
- Fast calculation (approx. 2 min for VMAT plan)
- Optional software module
- Requires VeriSoft 6.0 and Rotation Unit

Want to Change the Resolution?

One system, *choice* of arrays





OCTAVIUS Detector 729

- 729 5 mm x 5 mm detectors
- 10 mm detector pitch
- 25 % field coverage
- Up to 27 cm x 27 cm field size

OCTAVIUS Detector 1000 *SRS*

- 977 2 mm x 2 mm detectors
- 2.5 mm detector pitch
- Almost up to 100 % field coverage
- Up to 11 cm x 11 cm field size

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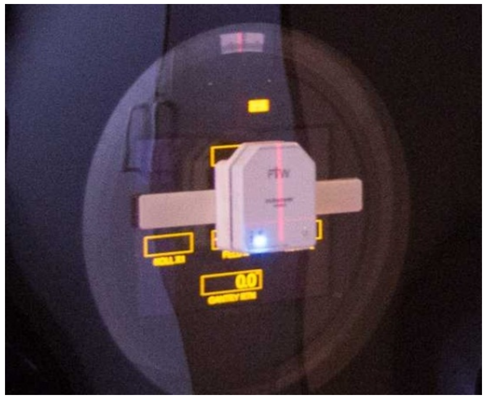
Wireless Inclinometer



- Bluetooth® 2.1
- Operating distance max. 10 m
- Operating time min. 16 h
- Charging time 7.5 h
- 3 rechargeable batteries (AA)
- Available: May 2014
- Upgrade kit (L981443)

General Advantages

- Purely from measured data. No TPS input required
- The plan to be verified is not required for the verification
- No angular dependency because beam is always perpendicular
- Ionization chamber technology
  - No calibration at user site required
  - Long term stable
  - Reliable

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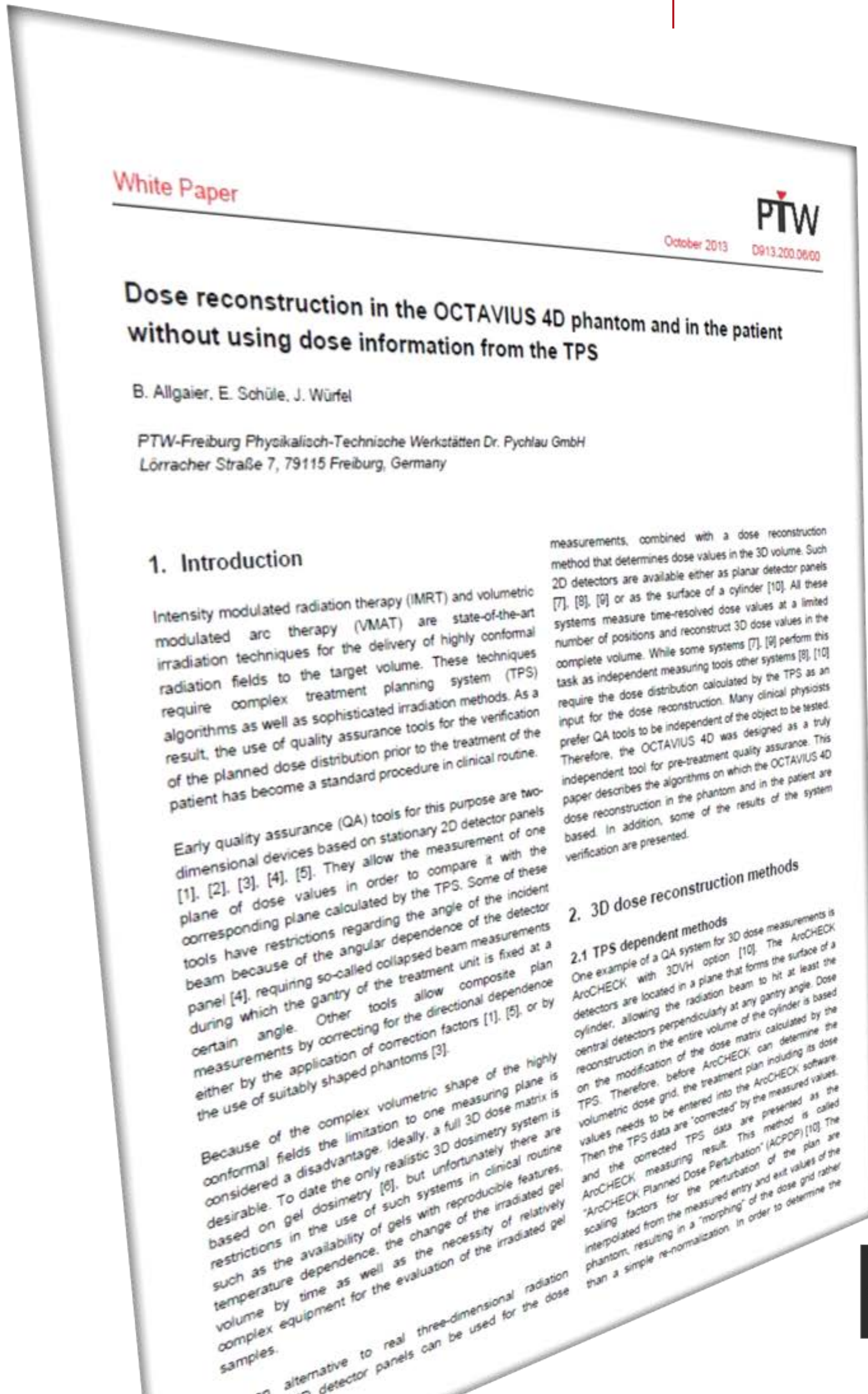
The Algorithm (Abbreviated)

- At the current gantry angle: consider a detector of the array and the dose it has measured
- Construct a ray line through the current detector to the focus of the beam
- Determine the current field size from all irradiated detectors of the array and choose PDD accordingly
- Using the PDD and the dose of the chosen detector: reconstruct the dose along the ray line to the focus
- Do this for all detectors of the detector array
- Do this for all gantry angles
- Sum up all these dose values and sort them into 3D dose voxels

The Algorithm (Full Version)



White Paper

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October 2013 D913.200.06/00

Dose reconstruction in the OCTAVIUS 4D phantom and in the patient without using dose information from the TPS

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Lörracher Straße 7, 79115 Freiburg, Germany

1. Introduction

Intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT) are state-of-the-art irradiation techniques for the delivery of highly conformal radiation fields to the target volume. These techniques require complex treatment planning system (TPS) algorithms as well as sophisticated irradiation methods. As a result, the use of quality assurance tools for the verification of the planned dose distribution prior to the treatment of the patient has become a standard procedure in clinical routine.

Early quality assurance (QA) tools for this purpose are two-dimensional devices based on stationary 2D detector panels [1], [2], [3], [4], [5]. They allow the measurement of one plane of dose values in order to compare it with the corresponding plane calculated by the TPS. Some of these tools have restrictions regarding the angle of the incident beam because of the angular dependence of the detector panel [4], requiring so-called collapsed beam measurements during which the gantry of the treatment unit is fixed at a certain angle. Other tools allow composite plan measurements by correcting for the directional dependence either by the application of correction factors [1], [5], or by the use of suitably shaped phantoms [3].

Because of the complex volumetric shape of the highly conformal fields the limitation to one measuring plane is considered a disadvantage. Ideally, a full 3D dose matrix is desirable. To date the only realistic 3D dosimetry system is based on gel dosimetry [6], but unfortunately there are restrictions in the use of such systems in clinical routine such as the availability of gels with reproducible features, temperature dependence, the change of the irradiated gel volume by time as well as the necessity of relatively complex equipment for the evaluation of the irradiated gel samples.

... alternative to real three-dimensional radiation ... detector panels can be used for the dose measurements, combined with a dose reconstruction method that determines dose values in the 3D volume. Such 2D detectors are available either as planar detector panels [7], [8], [9] or as the surface of a cylinder [10]. All these systems measure time-resolved dose values at a limited number of positions and reconstruct 3D dose values in the complete volume. While some systems [7], [9] perform this task as independent measuring tools other systems [8], [10] require the dose distribution calculated by the TPS as an input for the dose reconstruction. Many clinical physicists prefer QA tools to be independent of the object to be tested. Therefore, the OCTAVIUS 4D was designed as a truly independent tool for pre-treatment quality assurance. This paper describes the algorithms on which the OCTAVIUS 4D dose reconstruction in the phantom and in the patient are based. In addition, some of the results of the system verification are presented.

2. 3D dose reconstruction methods

2.1 TPS dependent methods

One example of a QA system for 3D dose measurements is ArcCHECK with 3DVH option [10]. The ArcCHECK detectors are located in a plane that forms the surface of a cylinder, allowing the radiation beam to hit at least the central detectors perpendicularly at any gantry angle. Dose reconstruction in the entire volume of the cylinder is based on the modification of the dose matrix calculated by the TPS. Therefore, before ArcCHECK can determine the volumetric dose grid, the treatment plan including its dose values needs to be entered into the ArcCHECK software. Then the TPS data are "corrected" by the measured values and the corrected TPS data are presented as the ArcCHECK measuring result. This method is called "ArcCHECK Planned Dose Perturbation" (ACPDP) [10]. The scaling factors for the perturbation of the plan are interpolated from the measured entry and exit values of the phantom, resulting in a "morphing" of the dose grid rather than a simple re-normalization in order to determine the

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Take Home Message OCTAVIUS 4D

- Purely measured data, no TPS dose input required
- DVH 4D: also purely measured data, no TPS dose input required
- The plan to be verified is not required for the verification
- Understandable algorithm, no black-box technology
- Choice of arrays available
- Reliable technology:
  - No angular dependence
  - No user-calibration necessary
  - Long term stable

Thank you for your attention