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ArcCHECK™

Verifikation und Dosimetrie bei der Rotationsbestrahlung mit einem 3-D-Messphantom

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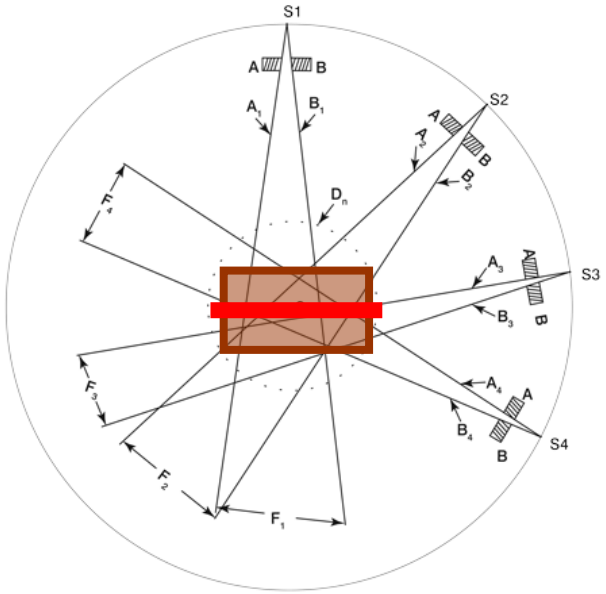
DGMP AK IMRT Bamberg, Freitag, 16.04.2010

Your Most Valuable QA & Dosimetry Tools

QA Challenge for Rotational Beams

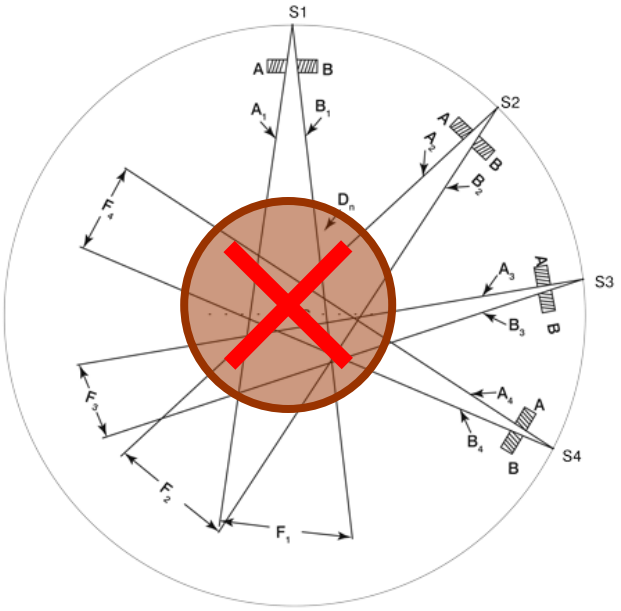
- Modern technologies are becoming rotational
  - (RapidArc®, VMAT, TomoTherapy®, IMAT)
- Rotational beam delivery creates a challenge for patient specific QA
- An ideal QA tool would be a volume detector, such as Bang Gel, but this is not always practical. SNC developed the MapCHECK and MapPHAN combination, as the effective solution. However, SNC developed the ArcCHECK as the ***best*** QA solution

What is 3D?



Is this 3D?

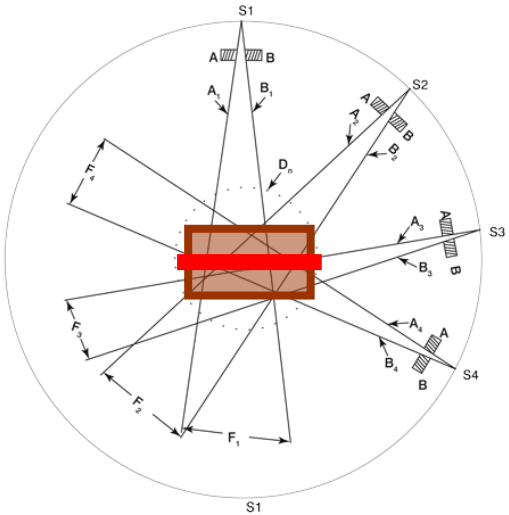
- *No*
- *A 2D detector plane designed for IMRT QA*

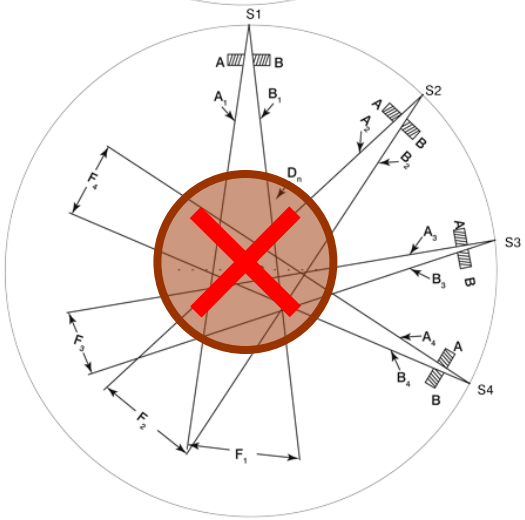


Is this 3D?

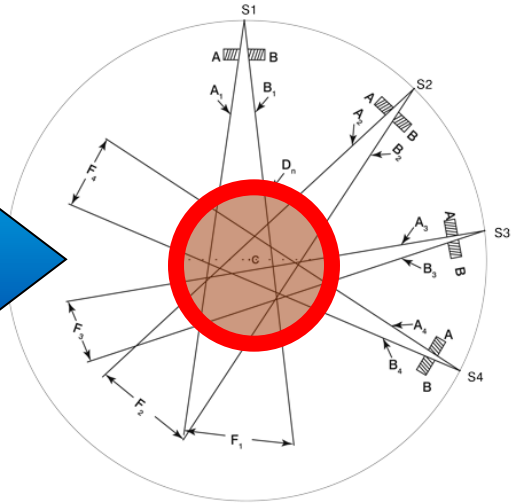
- *No*
- *Two orthogonal 2D detector planes designed for IMRT QA*

The Future in 3D



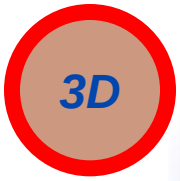


Make the detector plane "coherent" to the beam



Is this 3D?

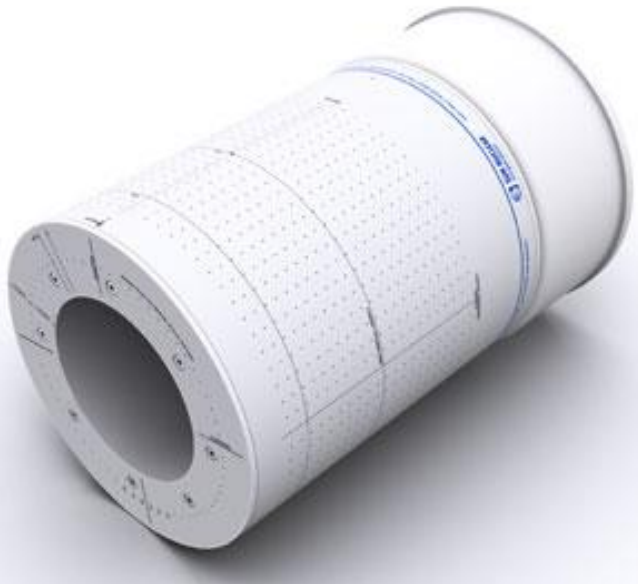
→ ***Yes!***



An isotropic 3D array is defined by the detector geometry, not just by the phantom shape around the detectors!

ArcCHECK Introduction

- Designed for Helical & Arc Delivery
  - **RapidArc®, TomoTherapy®, VMAT**
- **1386** diodes in a helical geometry
  - This detector geometry is patent pending
- 21cm diameter, 21cm length
- 1cm spacing, 2.9cm depth (3.3 cm effective)
- Weight: 16kg
- 4th Dimension = Time
  - **50ms update frequency**



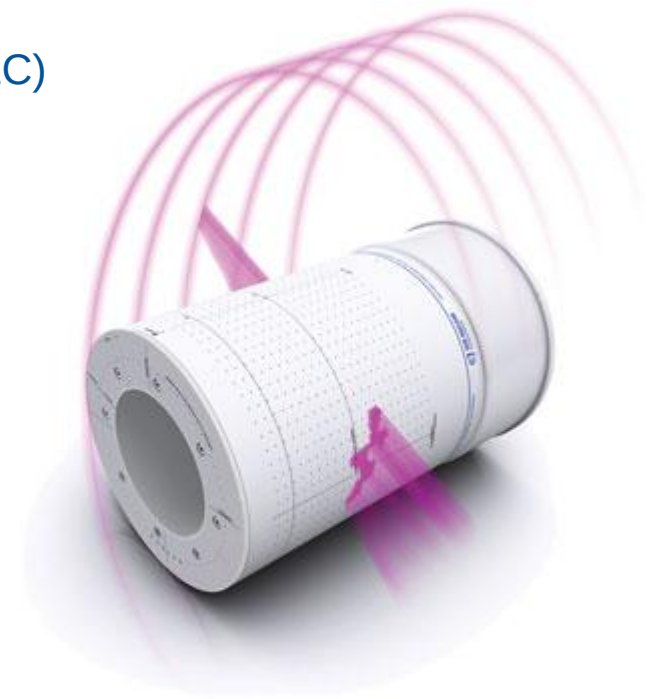
ArcCHECK Easy Setup

As with all Sun Nuclear solutions, efficiency is an essential part of the ArcCHECK design:

- Single power/data cable
  - Manages all power and data in one connection.
- Integrated electronics
  - ArcCHECK is self-contained with no electronics to setup separately
  - A separate phantom is not needed as with 2D arrays
- Lightweight (16kg)
  - ArcCHECK is easily portable for daily use without the need for a separate cart

Applications

- Fast plan QA
  - Composite and *real-time* measurement
  - Finds failure mechanisms (e.g. TPS, Linac, MLC)
- Ability to measure
  - Gantry angle
  - Leaf end position
  - Dose
- Time synchronized analysis
- Routine machine QA, imaging QA, setup QA
- RapidArc®, VMAT, Tomotherapy helical delivery commissioning



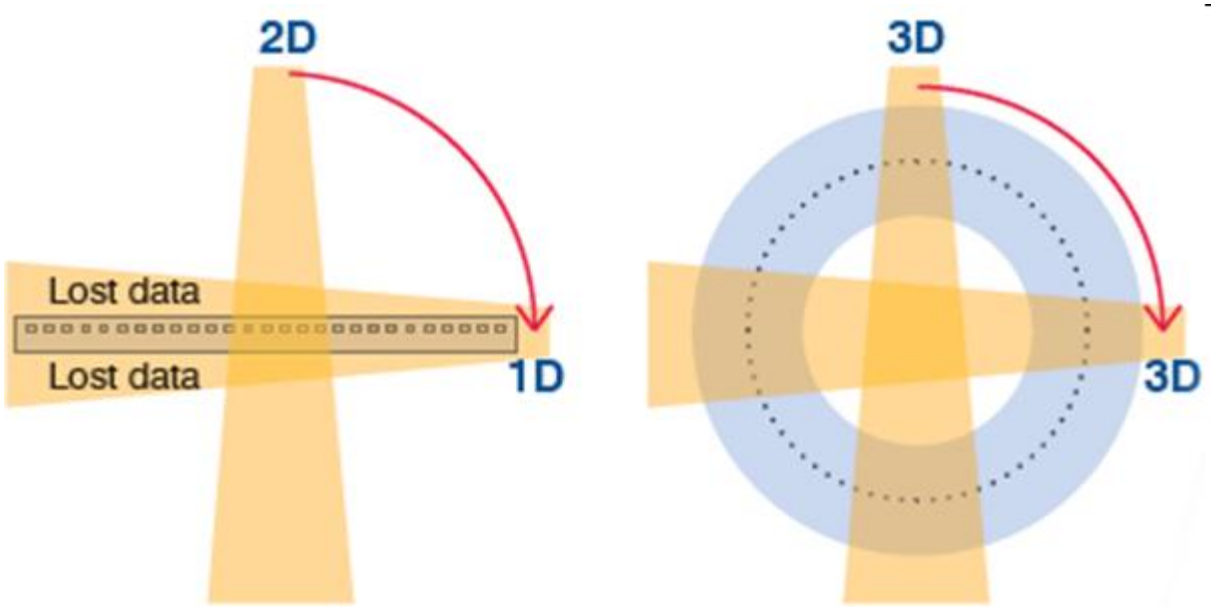
Why Cylindrical?

- Phantoms are ideally shaped like a patient
  - ArcCHECK emulates patient geometry
  - Solid inserts are available to provide homogeneous density

Detector Geometry - Coherent

- A 2D array irradiated from the side effectively becomes one dimensional
  - Shadowing effect normally present
  - Even if no shadowing, significant information is lost

- ArcCHECK detectors stay coherent to the beam regardless of gantry angle

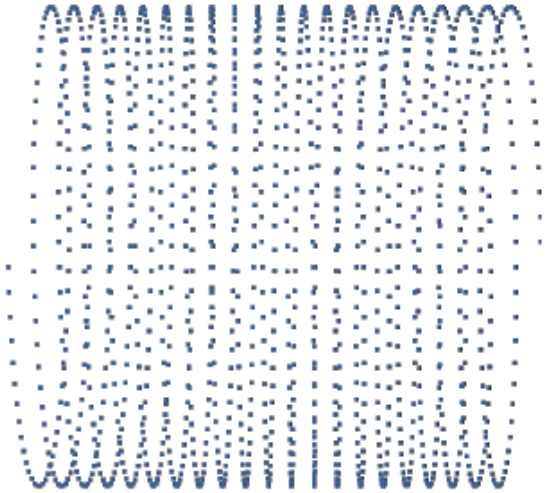


Detector Geometry

- ArcCHECK's 3D shape is unique among detector arrays and offers three key benefits:
  - Maximize detector density for each beam angle
  - Minimize detector shadowing for each beam angle
  - Minimize angular dependence for each beam angle

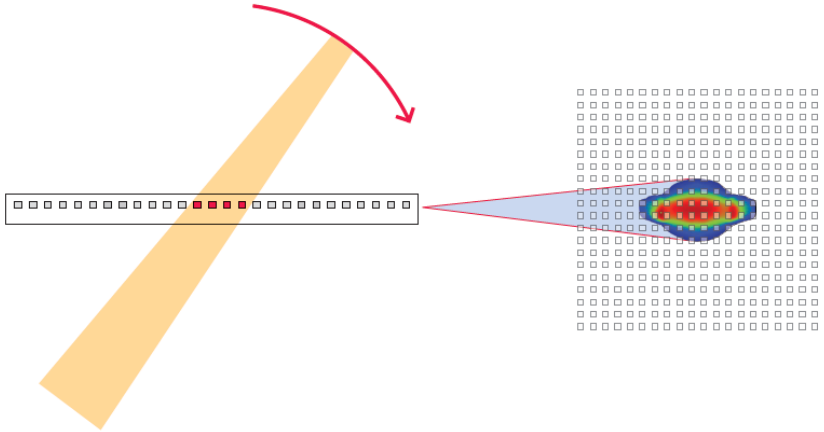
Detector Geometry

- Entrance and exit dose are measured
  - Effectively doubling the detector density in the measurement field.
- Central 10x10 contains approximately 221 detectors - same as MapCHECK 2 10x10
- Detectors are arranged on a HeliGrid™
  - Increase the sampling rate and reduce detector overlap from the Beams Eye View (BEV)
- Entrance and exit dose can be correlated to determine gantry angle

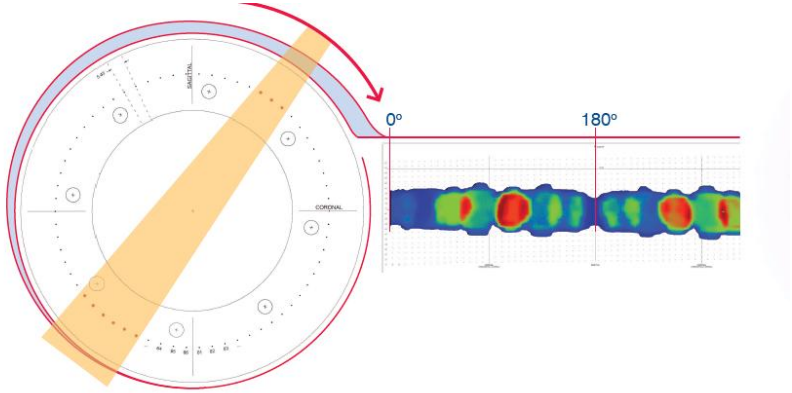


2D versus ArcCHECK

- What you see with a 2D array

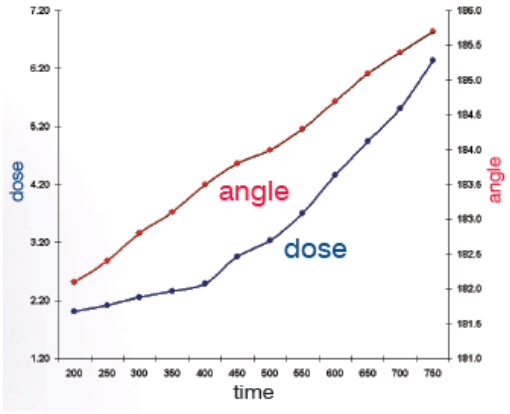


- What you see with ArcCHECK



4D Dosimetry

- ArcCHECK measures in 50ms intervals
  - Saves all measurement data as a function of time
  - Correlation of time with ArcCHECK's 3D measurement data equates to a 4D dosimetry system

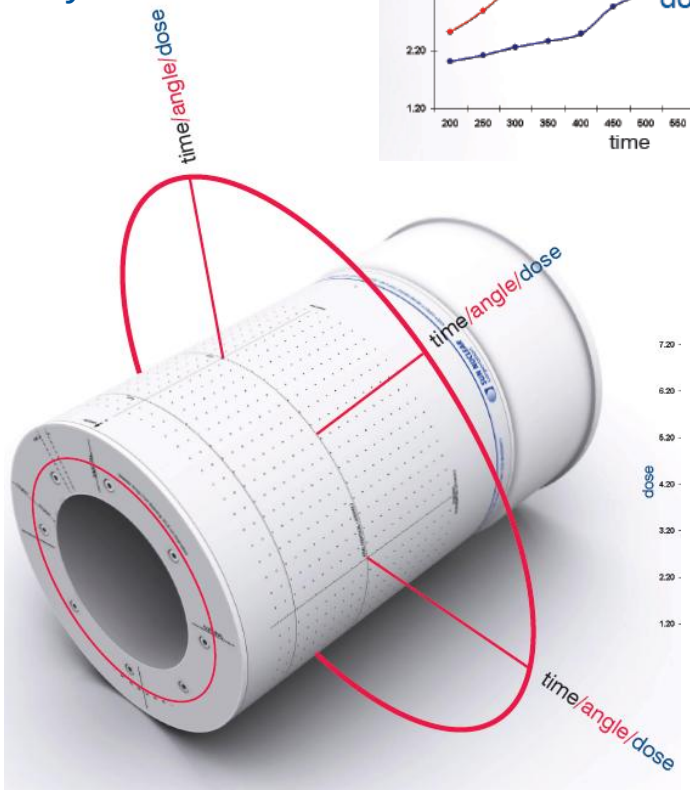


Three key benefits of the 4D system:

1 Detect delivery errors as a function of beam, gantry angle, and control point in real time

2 Optimize treatment plans or number of control points

3 Verify gantry angle with entrance and exit dose ray tracing

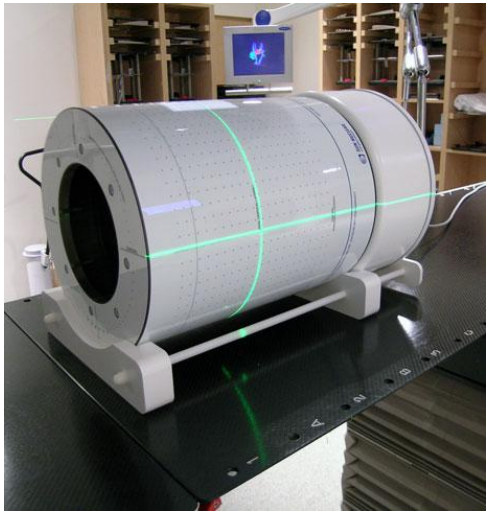


Array Calibration

- Sun Nuclear SunPoint™ diodes are very stable
  - Users calibrate infrequently, typically every one to three years
- ArcCHECK utilizes a patented Wide Field Calibration (WFC) method
  - Similar to other Sun Nuclear devices
  - Quick and Efficient
- In clinical use since 1996, Sun Nuclear's calibration method offers several key benefits:
  - Instrument does not need to be returned to the factory for re-calibration
  - User may independently verify the accuracy of the calibration
  - Calibration does not require a flat beam
  - Calibration files are not Linac specific
  - Instrument does not need to be disassembled

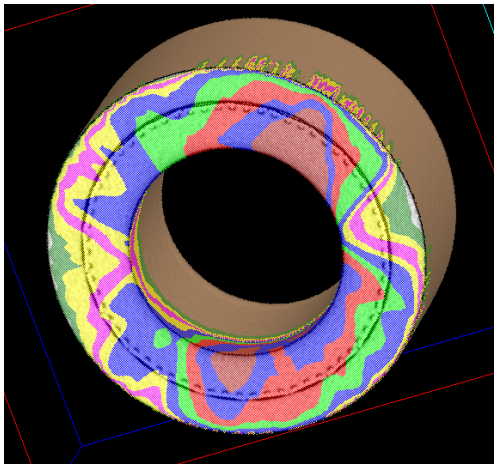
Dose Calibration

- ArcCHECK absolute dose calibration is similar to the proven MapCHECK method
  - ArcCHECK is positioned with it's axis coincident to SAD, utilizing the coronal and sagittal lasers
  - A 200 MU beam with a 10x10cm field is delivered to the device
  - Known dose at the detector location (90 cm SDD) is entered to arrive at an absolute dose correction, applicable to all ArcCHECK diode detectors
  - Process takes approximately one minute prior to arc delivery QA



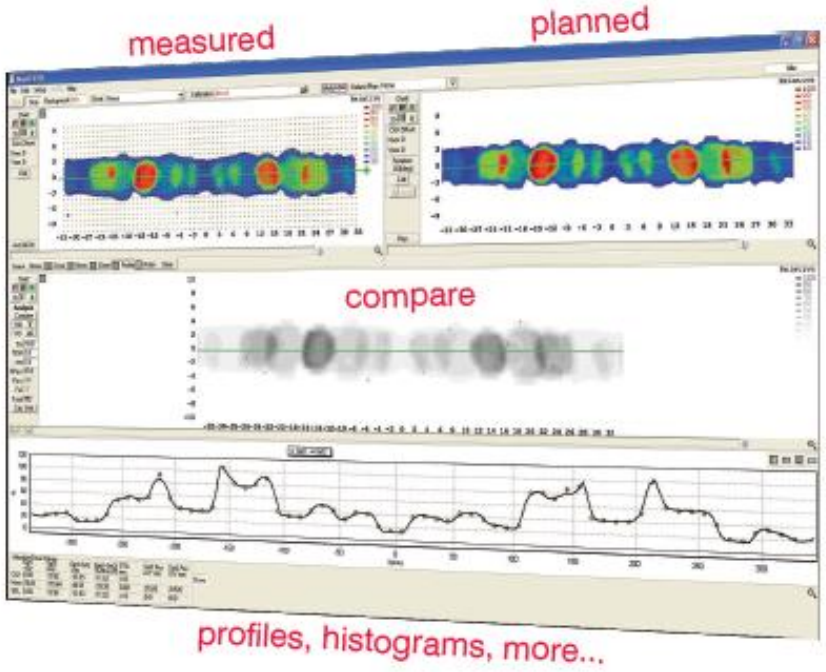
ArcCHECK Workflow

- Treatment plan created and approved in Treatment Plannig Software
- Plan transferred to phantom and recalculated
- RT Plan and RT Dose are exported to ArcCHECK software via DICOM RT file transfer
- Dose is compared in ArcCHECK software



ArcCHECK Software

- The ArcCHECK interface is a new version of MapCHECK software
  - ArcCHECK QA plans are in three dimensions
    - DICOM RT Dose is imported and ArcCHECK software then extracts 3D dose corresponding to detector locations, and performs a comparison
  - Same analysis and workflow options from MapCHECK are available in ArcCHECK
  - All data files from ArcCHECK are an open format for easy export, including raw data



Clinical Reference Sites

- **RapidArc**
  Credit Valley Hospital
  Toronto, Canada
- **TomoTherapy**
  MD Anderson Cancer Center
  Orlando, USA
- **VMAT**
  Princess Margret Hospital
  Toronto, Canada

"ArcCHECK offers a very comprehensive QA solution for TomoTherapy deliveries with each beam passing through the cylindrical diode array. The diode arrangement minimizes any directional dependence. Our initial clinical results for TomoTherapy DQA demonstrated a very good agreement between the plan and the measurement and indicate that ArcCHECK is a very useful QA tool."

Katja Langen, Ph.D.
MD Anderson,
Orlando, Florida

"Novel dosimetric phantom for quality assurance of volumetric modulated arc therapy",
Daniel Létourneau, Julia Publicover, Jakub Kozelka, Douglas J. Moseley and David A. Jaffray, Medical Physics, Vol. 36, No. 5, May 2009

Cavity Plug (Option)

- ArcCHECK features a versatile central cavity for capturing isocenter dose
  - With the cavity empty the ArcCHECK weighs only 16kg making it very easy to move and setup
  - May be used to accommodate different detectors and inserts
  - Empty cavity tests the TPS inhomogeneity planning

FAQ: ArcCHECK Cavity

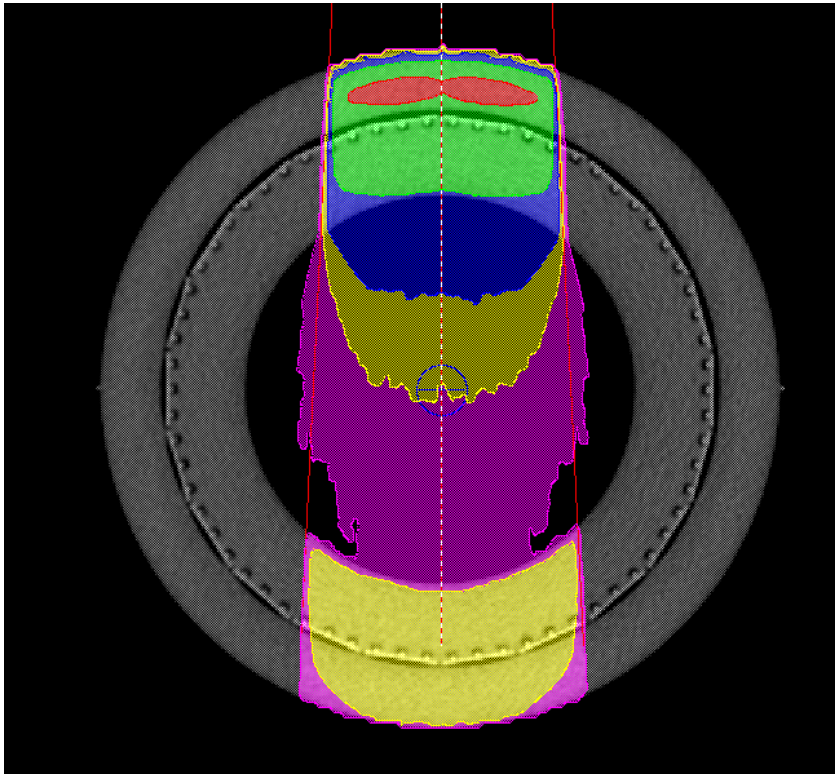
Q: Why does ArcCHECK have a cavity?

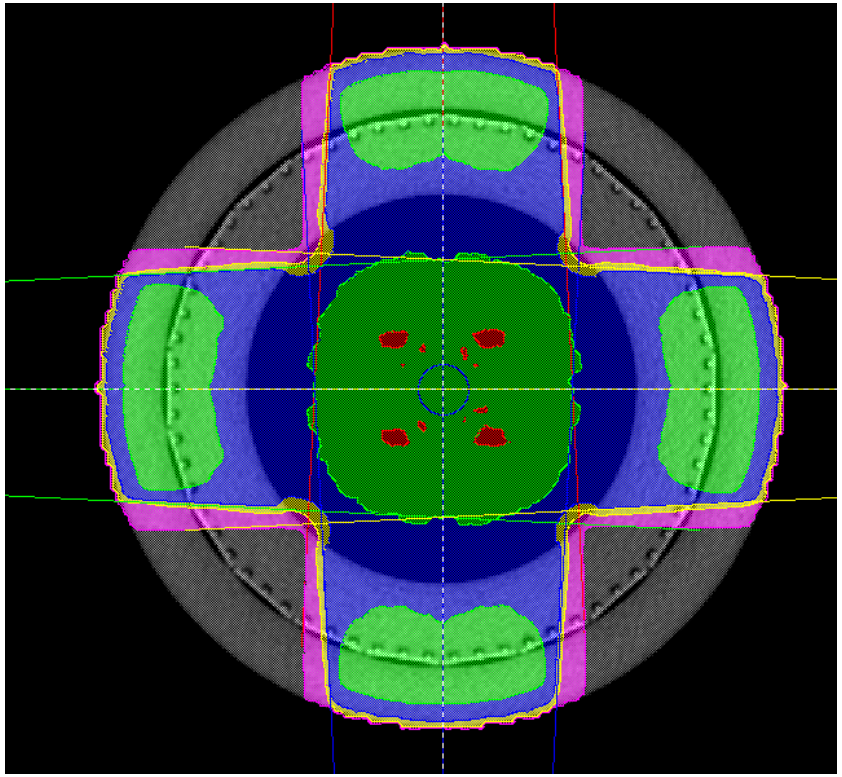
A:

- QA on the TPS/delivery system
  - All treatment planning systems should be capable of creating a plan on ArcCHECK without the cavity plug option inserted – like creating a plan that includes a lung as one of the structures
- Easy to transport/lightweight
- Flexibility of inserts
  - Point dose measurements at different locations
  - Heterogeneous inserts for dose calculation and imaging QA

High Dose vs. Low Dose

- Does ArcCHECK measure dose in the Low Dose region or the high dose region? Both!





FAQ: Isocenter Dose

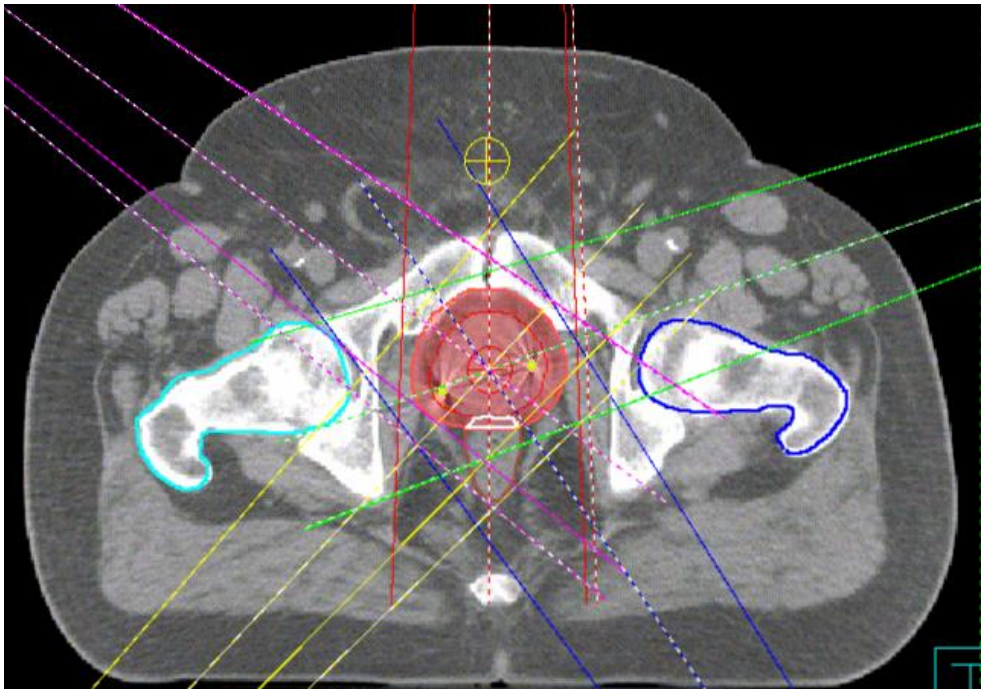
Q: Is it necessary to measure isocenter dose?

A:

- ArcCHECK measures entry dose and exit dose, at two effective depths for every angle
- Measuring completely around the volume in a uniform manner for each angle is more stringent measurement than a simple composite dose point measurement
- Errors visible in at the isocenter will also be visible in the surrounding dose measurements, but in more detail
- For those who would like to measure the dose at isocenter or target, Sun Nuclear offers a cavity plug option with detector insert.

Target Dose Discussion

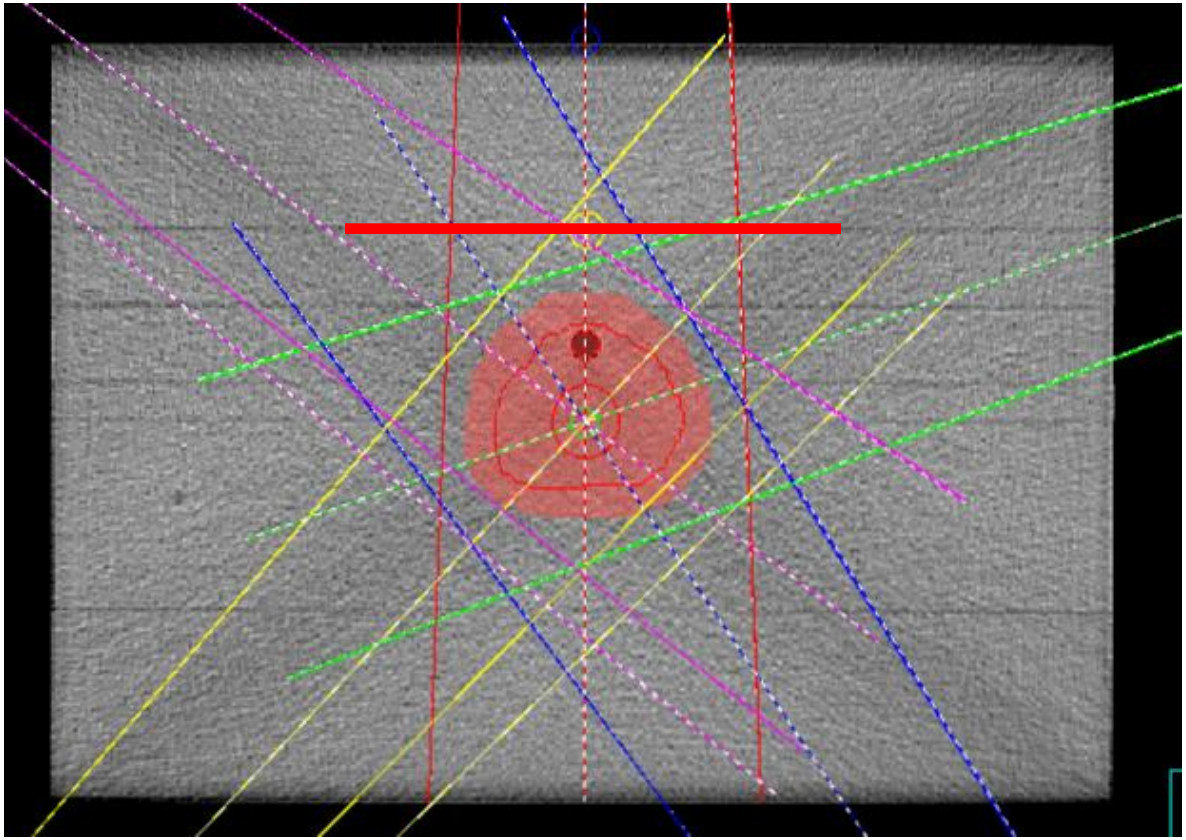
- The target is in the patient and the dose is not measured in the patient.
- Here's what the physicists have been doing until now:



The yellow dot is a point at the depth of 5 cm. The beam from the plan is applied to the phantom and dose to a plane is calculated.

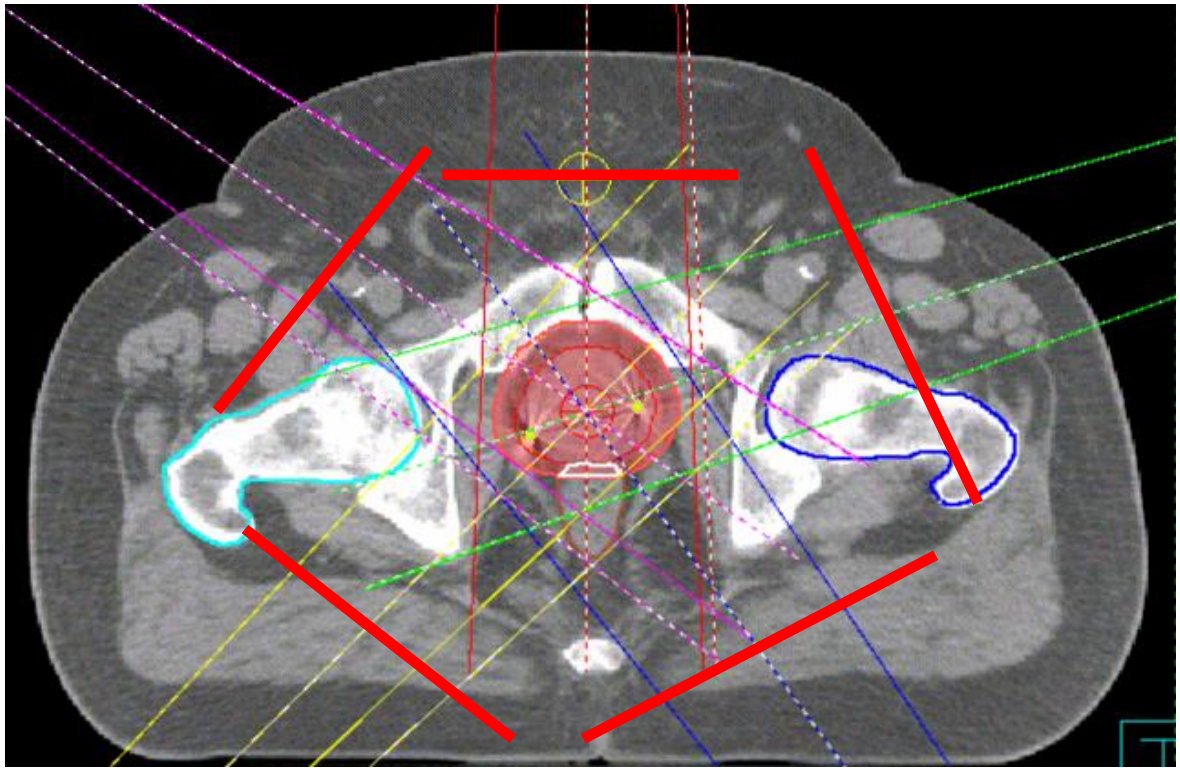
Target Dose Discussion

The dose to a plane drawn through the yellow dot is said to be representative of the “target dose”



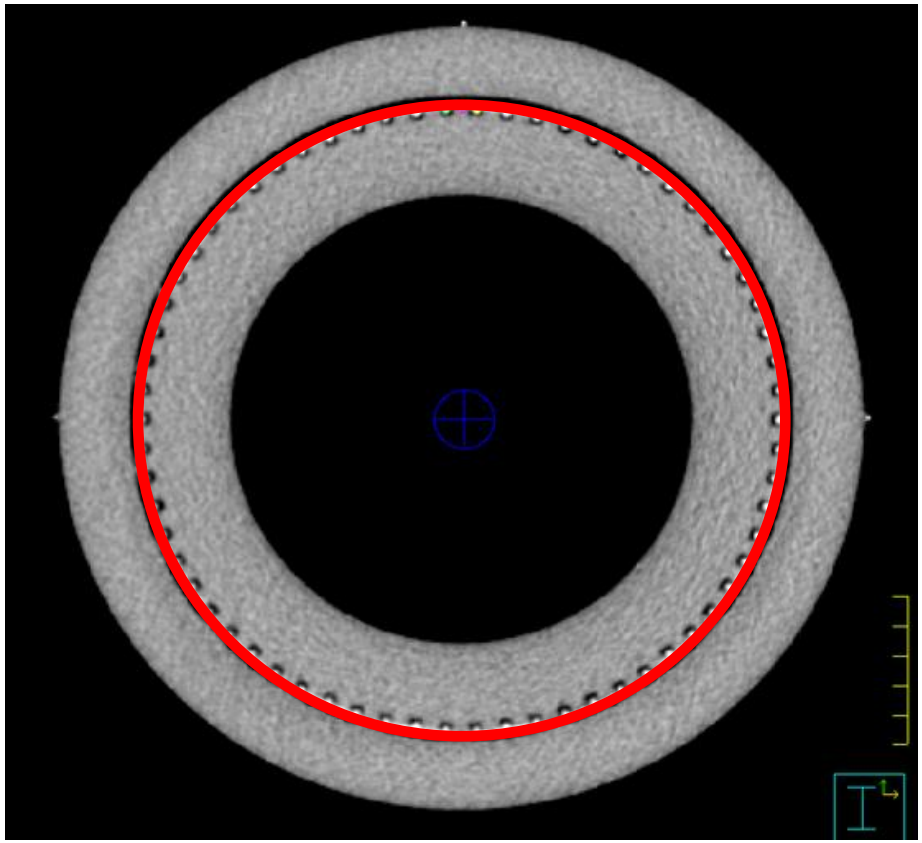
Target Dose Discussion

If we draw a plane at the depth of 5 cm for every beam, red lines are where the dose is measured once the beams are on the phantom (dose this remind us of anything?)



Target Dose Discussion

Therefore, this geometry must be representative of the “target dose” in addition to its other benefits.

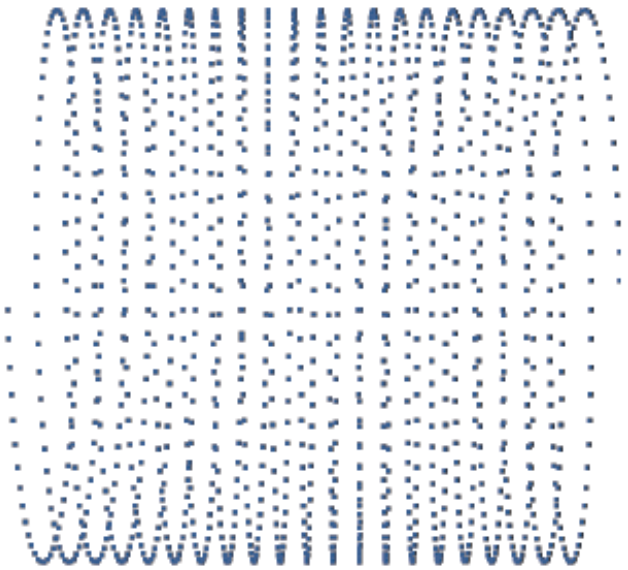


FAQ: Shadowing Effect

Q: Is there a shadowing effect with the detectors in the ArcCHECK?

A:

- The detectors are arranged on a HeliGrid™ to reduce detector overlap from a BEV effectively eliminating shadowing effects.



FAQ: Detector Density

Q: Is the detector density of ArcCHECK sufficient for rotational dosimetry?

A:

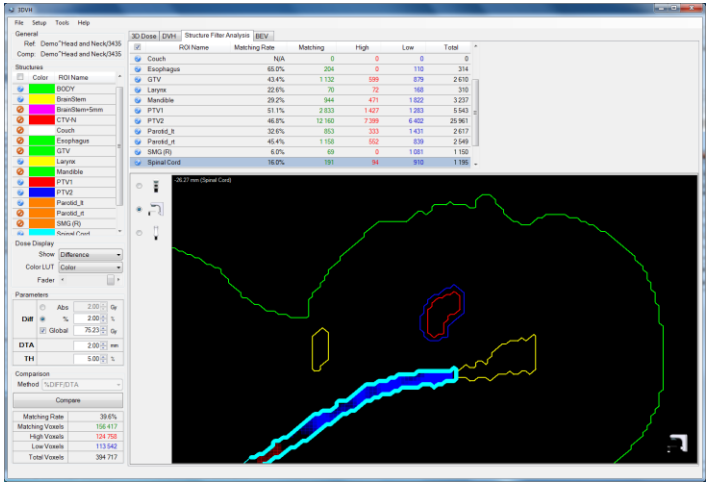
- Detector spacing is 10mm at the detector physical location
- However, the actual detector density can be as small as sub-mm at the entrance and exit locations, due to the HeliGrid detector pattern.
- At least one published paper proved that the MapCHECK, with 7mm and 14mm detector spacing, is as effective as film in detecting MLC offset errors for IMRT QA

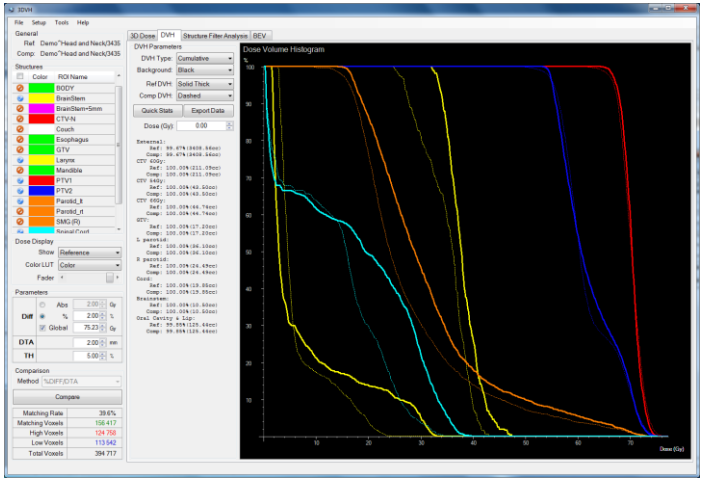
"An Intercomparrison Between Film Dosimetry and Diode Matrix for IMRT Quality Assurance",
F. Banci Buonamici, eta Med. Phys.Volume 34, Issue 4, pp. 1372-1379, April 2007

3DVH™ Option

- Expected release is November, 2010

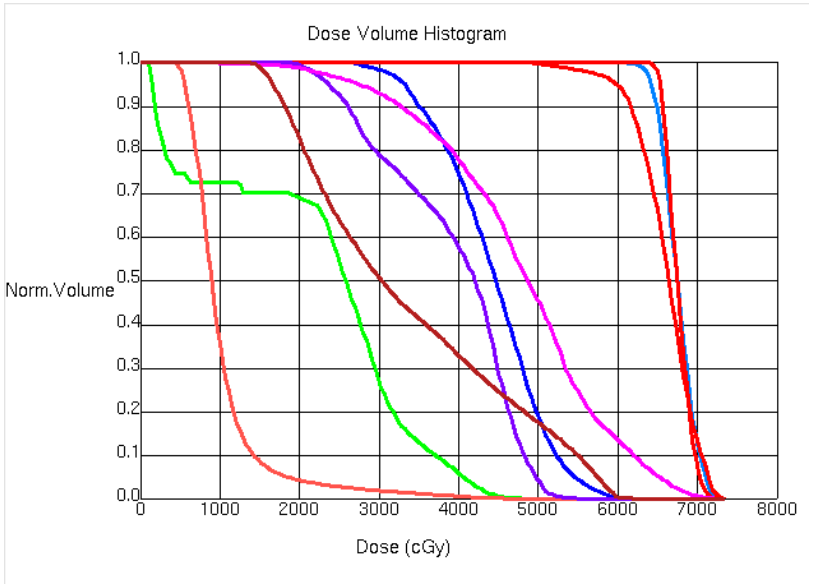
- The most advanced 3D patient dose and DVH tools available
  - Uses existing measurements
  - No secondary dose calculation
  - 3D dose and DVH analysis on patient geometry (not phantom geometry)

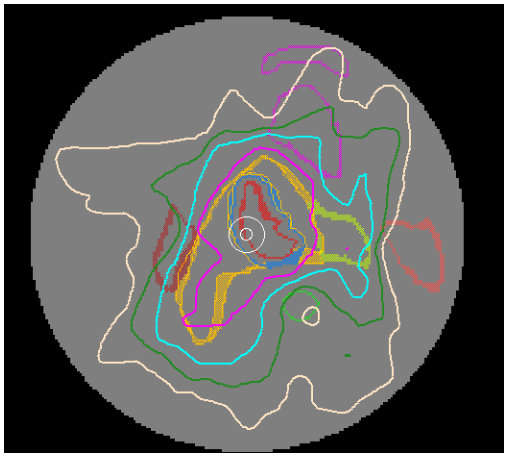




Patient DVH vs. Phantom DVH

Can we compare Patient DVH and Phantom DVH?





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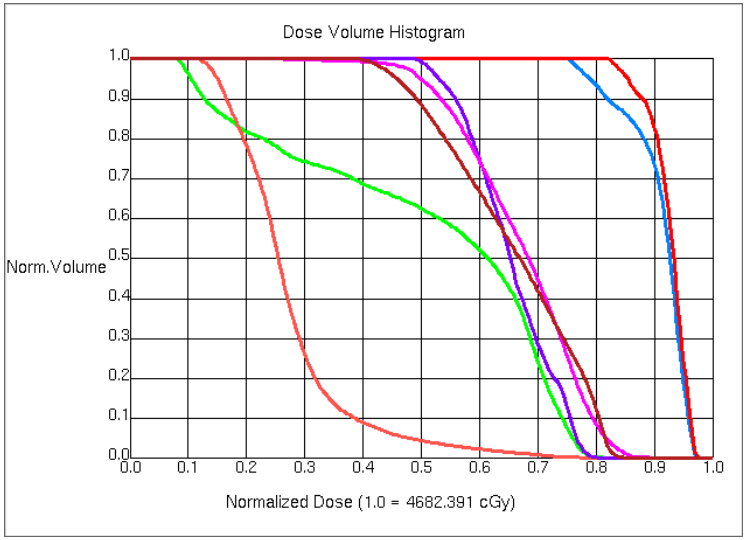

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Thank you,

Questions?

Your Most Valuable QA & Dosimetry Tools