

COMPARISON OF TWO DETECTOR ARRAYS FOR RAPIDARC QUALITY ASSURANCE

Evaluation of Plan Analysis Parameters

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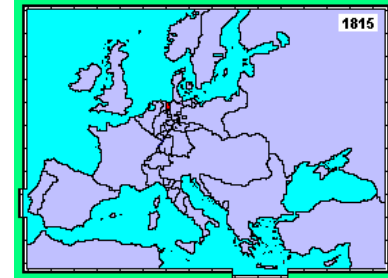
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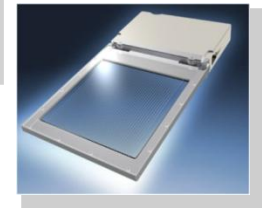
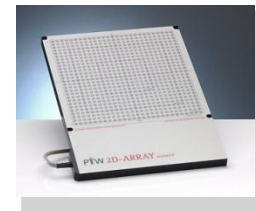
Introduction



Oldenburg



- located about 150 km west of Hamburg
- approx. 150.000 inhabitants > 15.000 students at 3 universities
- Germany's City of Science 2009



Cooperation with Wolfram Laub from OHSU since 2010...
following results are part of the Master thesis of G. Heilemann

Introduction

- Purpose of the project:
 - To simulate and analyze the effect of MLC leaf misalignments in the delivery of Rapidarc treatment plans by introducing modifications into Rapidarc DICOM files before plan delivery.
 - To analyze the Gamma-index criterion and the 90% passing rate of two detector arrays (Delta4 and Octavius) as a verification method for Rapidarc.

- Number of Rapidarc cases investigated:
 - 5 prostate plans
 - 3 head&neck plans with 2 arcs
 - 3 head&neck plans with 3 arcs

Introduction



RapidArc™

One revolution is all it takes.



Introduction

RapidArc™
One revolution is all it takes.



Do we need (at least a small) “change”
in the way we see QA?

Introduction

RapidArc™
One revolution is all it takes.



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Quality assurance

Clinical significance of multi-leaf collimator positional errors for volumetric modulated arc therapy

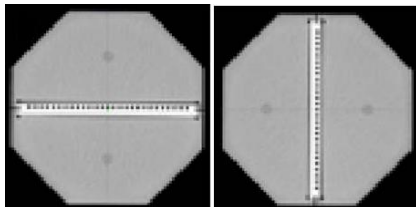
Mike Oliver*, Isabelle Gagne, Karl Bush, Sergei Zavgorodni, Will Ansbacher, Wayne Beckham

Department of Medical Physics, BC Cancer Agency - Vancouver Island Center, Victoria, British Columbia, Canada

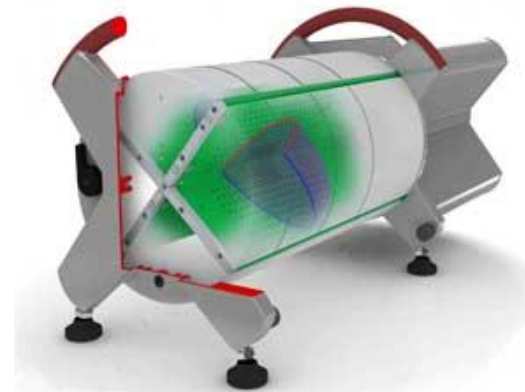
QA devices



- Octavius with 2D-Array
 - Matrix of 27x27 ionization chambers with cross section 5mmx5mm with 10mm pitch

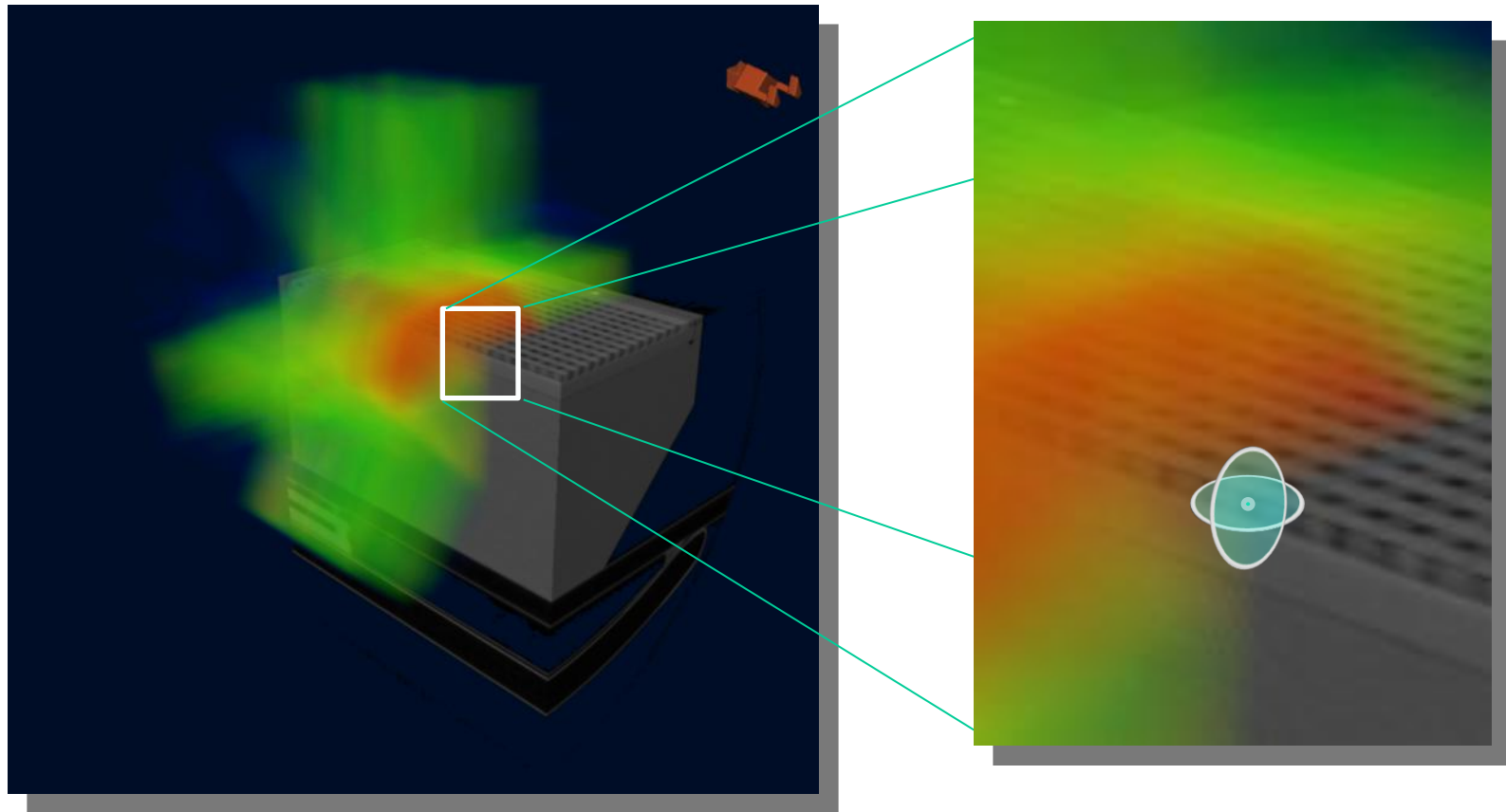


- Measurements in coronal and sagittal orientation



- Delta4
 - Two intersecting matrices with 1069 detector diodes
 - Central area 6cmx6cm with pitch of 5mm
 - Outer area 20cmx20cm with pitch of 10mm

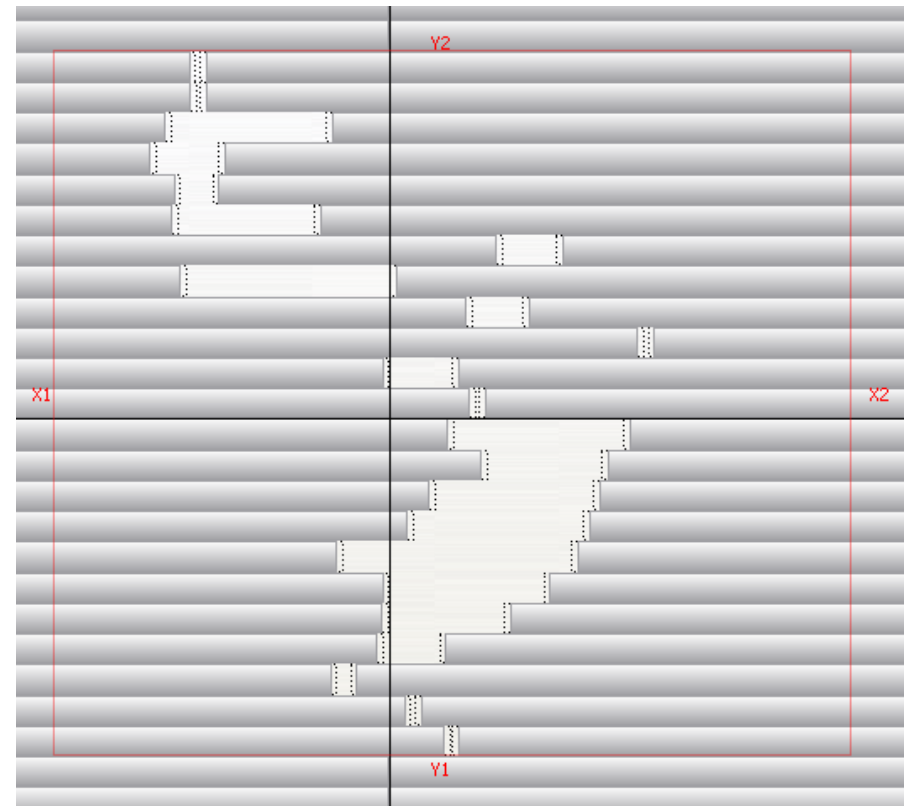
QA Method



Gamma-Index 3mm/3%, d_{\max} as reference value, 90% passing rate

Modifications in detail

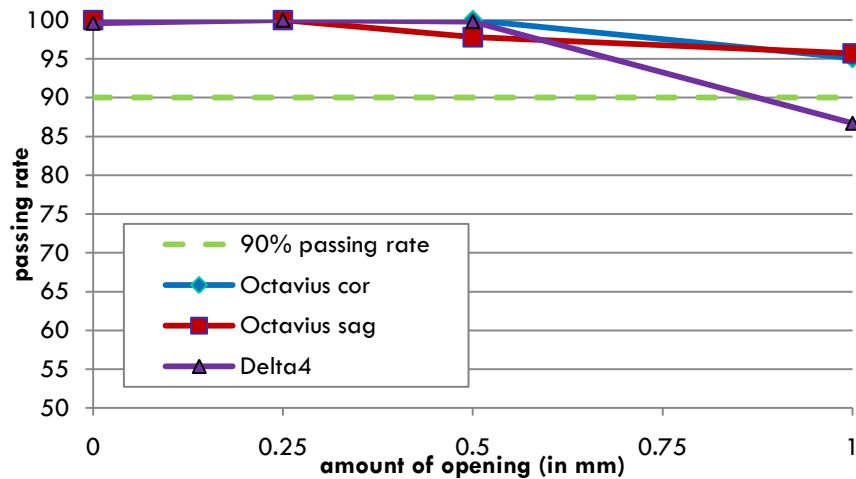
- **Opened leaves – type 1**
 - For all control points both MLC banks are opened an additional 0.25mm, 0.50mm and 1.00mm compared to the original plan.
- **Closed leaves – type 2**
 - both MLC banks are closed by an additional 0.10mm, 0.25mm and 0.50mm.
- **Gravitational shift – type 3**
 - all leaves are shifted by 1mm, 2mm and 3mm in the same direction in relation to the gantry position to simulate gravitational forces.



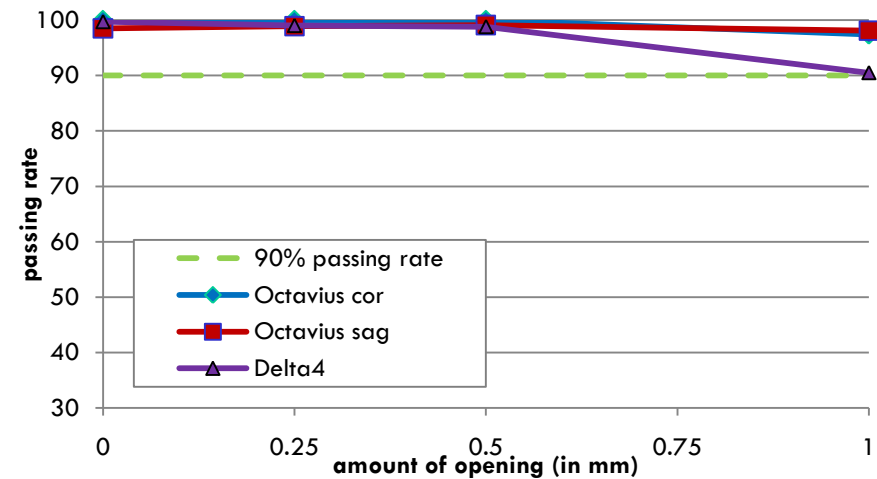
MLC setup (type 1 modification) for one control point with respect to original position (dotted lines). Screenshot taken from in-house developed MLC Editor software.

Results – open leaves (type 1)

3mm/3%



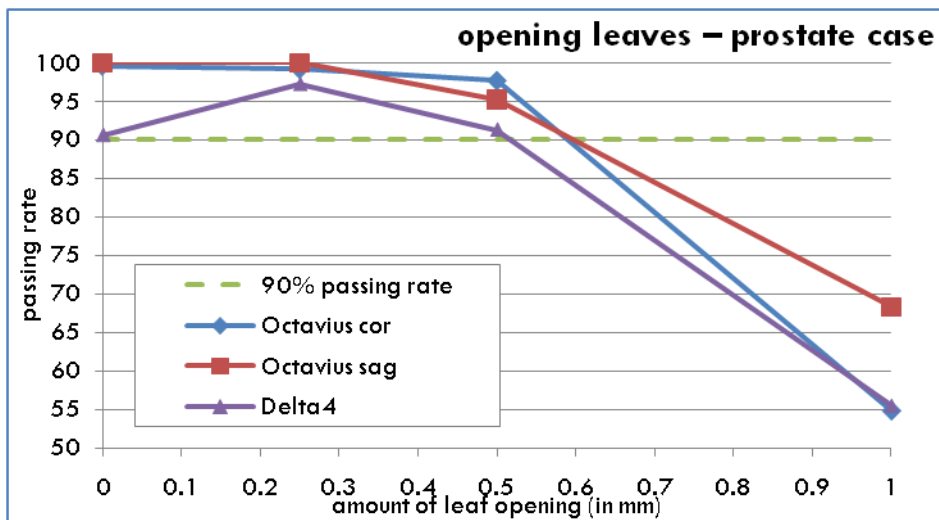
Typical Prostate Plan



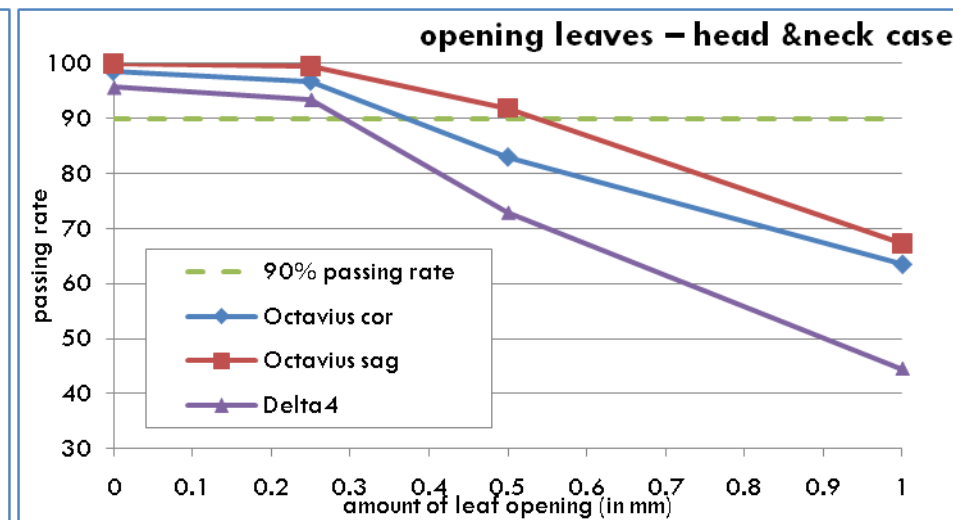
Typical H&N-Plan

Results – open leaves (type 1)

2mm/2%

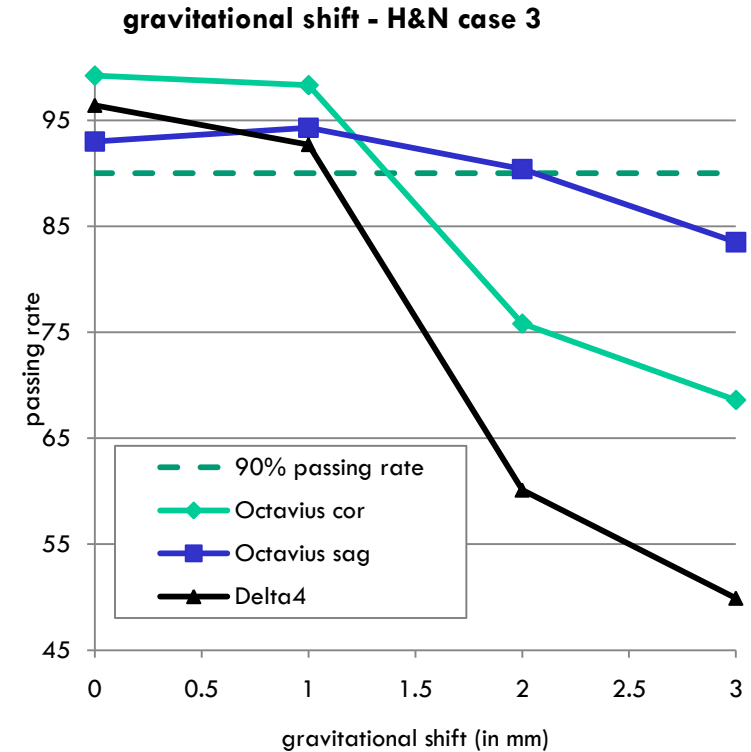
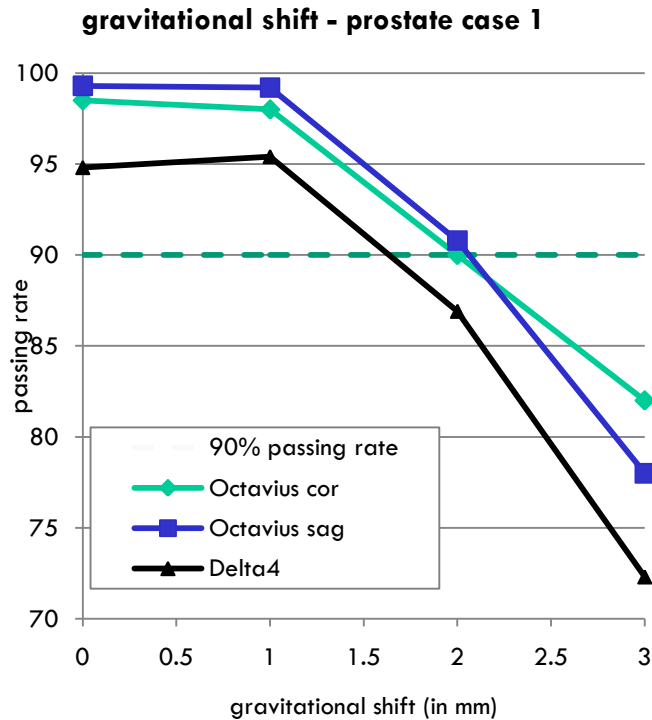


Typical Prostate Plan



Typical H&N Plan

Results – Gravitational Shifts



2mm/2%

- A 90% passing rate with 3mm/3% allows in many cases up to several mm leaf shifts!
- Leaf deviations of less than 1mm are usually not detected!
- Is this clinically relevant?
- In our opinion: yes absolutely!

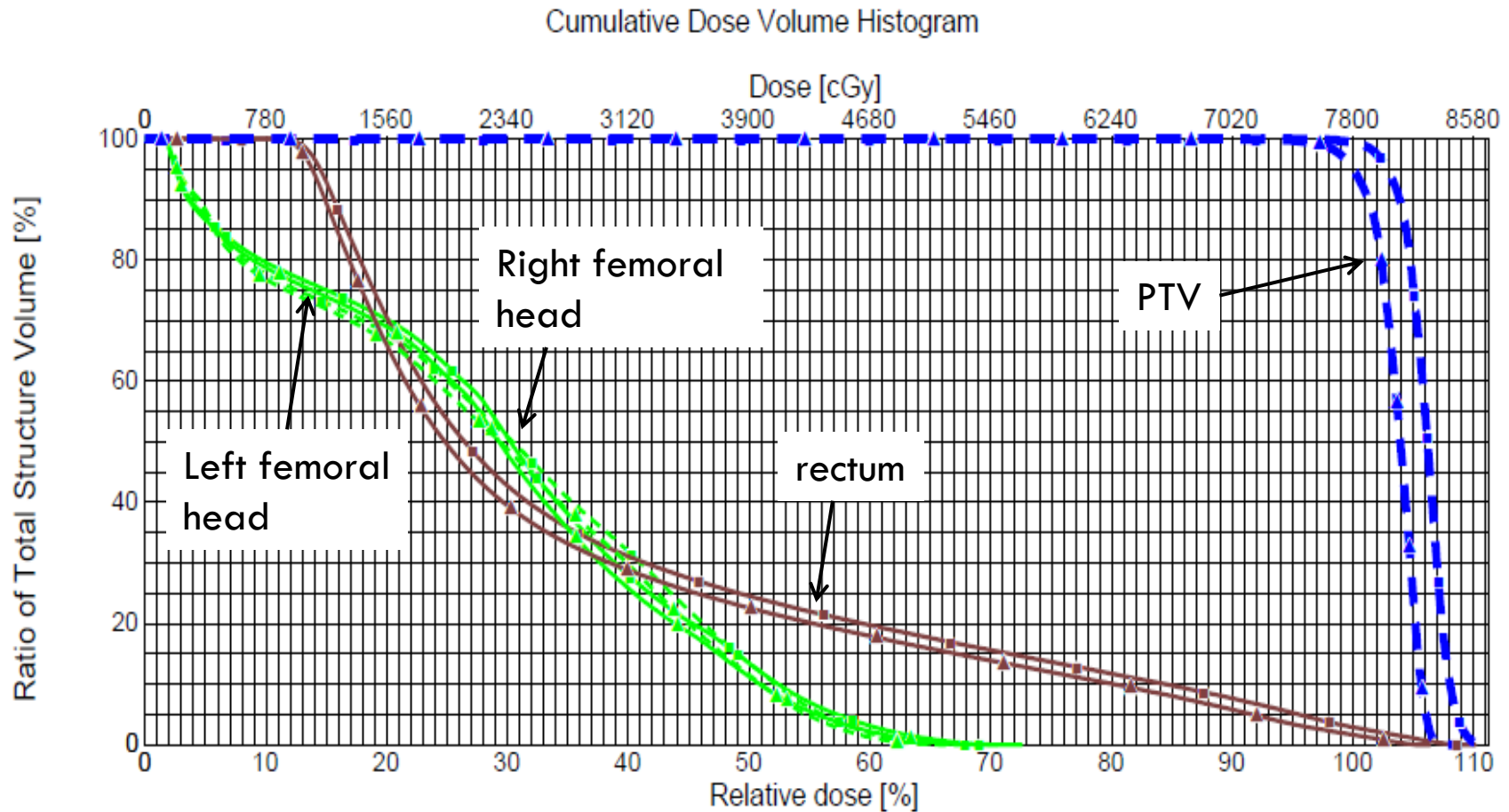
Results – DVH comparison

How to determine clinical relevance...

„Rough“ but practicable way...

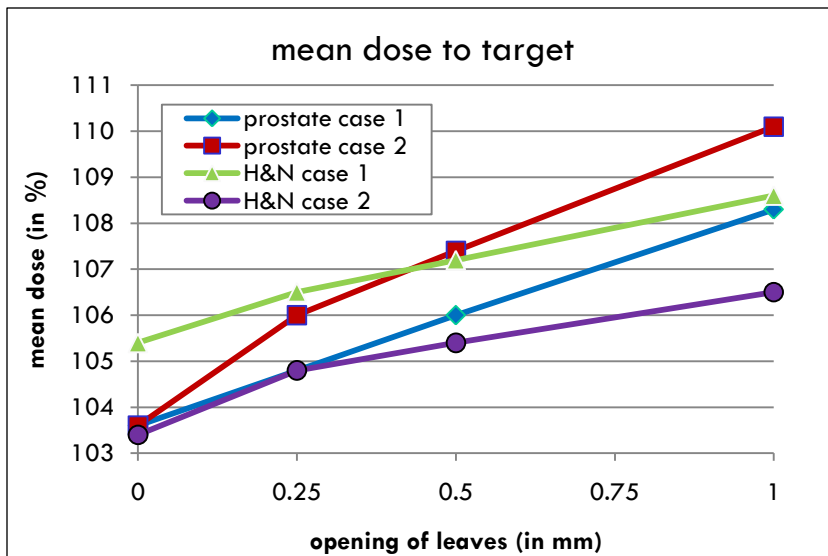
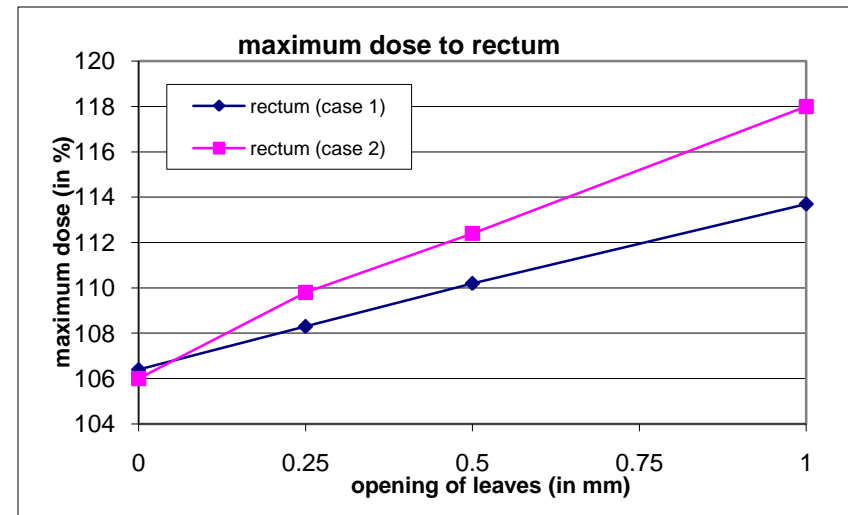
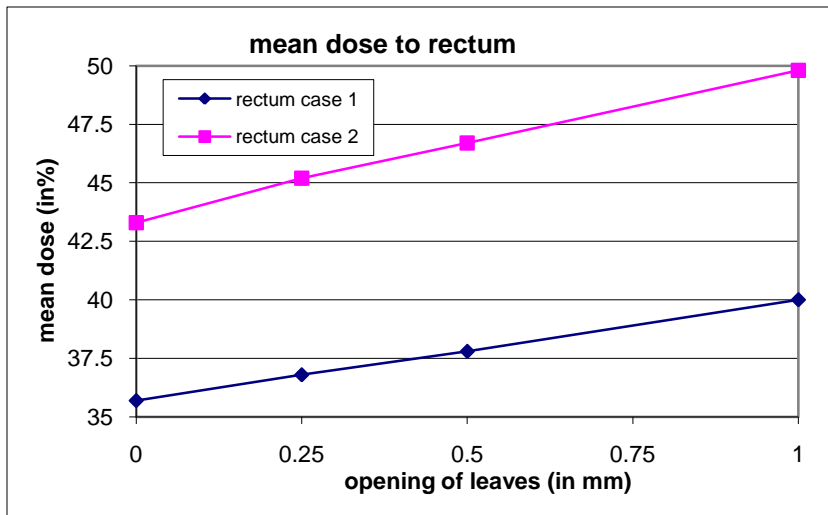
...introduce MLC „errors“ in TPS and compare with „correct“ plans!

Results – DVH comparison



- Open leaf: >2% increased mean dose for 0.50mm opening,
- Original plan (Δ) and the modified plan with a 0.50mm MLC leaf bank opening (□)

Results – DVH comparison



- DVH comparison reveals significant dose differences even for small MLC modifications
- significant in/decrease of dose to OAR and target of up to 10% and more of the prescribed dose for a 1mm leaf positioning error.

Conclusion and discussion

- Modified treatment plans (e.g. leaf positioning error of 0.5mm) would easily fulfill the passing rate when compared to the calculated dose with 3mm/3%.
- DVH comparison showed that the introduced modifications have clinically significant impact on the dose distribution.
- even small modifications (e.g. 0.50mm leaf bank opening) change the mean dose to the PTV or OARs by significant amounts but remain unnoticed by the analysis method.

(minimum) Suggestions

At least, a $>90\%$ passing rate with a gamma-index criterion of 2mm/2% should be used.

The 90% criterion itself is related to a possibility of not detecting hotspots in OARs

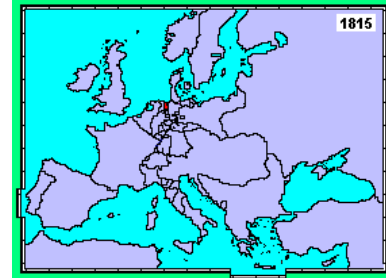
The gamma-index itself cannot be the only pass/fail criteria as it has flaws in detecting small errors that can change the dose significantly.

A more thorough analysis of discrepancies shall be part of the verification process (chamber by chamber analysis and mapping of measured dose on OAR)

The suggestions are independent of the used detector!



Thank you for your attention....





Thank you for your attention....

...and feel free to visit Oldenburg!

