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# IMRT patient-specific QA using the Delta<sup>4</sup> dosimetry system and different evaluation methods

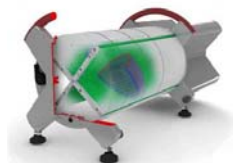
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## Objective

To study the result of patient-specific IMRT QA  
with the combination of:

The Delta4 dosimetry system



The Delta<sup>4</sup> phantom

Different evaluation methods

- The ICRU report 83
- Modifications of ICRU 83
- Often used gamma evaluation



Our goal:

To detect dose differences in dose volume metrics of interest  
between planned and delivered dose.

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# The Delta<sup>4</sup> dosimetry system

## Phantom

- PMMA cylinder Ø 22 cm
- Two orthogonal planes, total of 1069 diodes (p-type Si)
- Diode spacing
  - 5 mm (central area, 6 cm x 6 cm)
  - 10 mm (outer area)

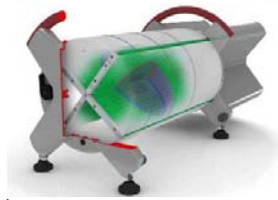


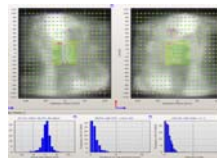
Image from: <http://acreo.se/en/Technology-Areas/Nano-electronics/Success-Cases/MEMS-Technology/>

## Software

- Compare measured and planned dose

### For evaluation:

- User defined pass/fail criteria
  - Gamma
  - Relative dose difference
  - Distance to agreement
- Include user defined detectors
  - Based on dose [%]
  - Based on gradient [%/cm]



## Different evaluation methods:

<b>1.</b>	<b>ICRU report 83 recommendations</b>			
	High gradient region (>20 %/cm):	DTA 5 mm	pass rate 85 %	
	Low gradient region (<20 %/cm):	Dose diff. 5 %	pass rate 85 %	
	Gamma evaluation	5 %, 5 mm	pass rate 85 %	(no dose cut off)
<b>2.</b>	<b>Modified version of ICRU report 83 recommendations</b>			
	High gradient region (>20 %/cm):	DTA 3 mm	pass rate 85 %	
	Low gradient region (<20 %/cm):	Dose diff. 3 %	pass rate 85 %	
	Gamma evaluation	3 %, 3 mm	pass rate 85 %	(no dose cut off)
<b>3.</b>	<b>Often used gamma evaluation</b>			
	Global and local Gamma evaluation	(3 %, 3 mm)	pass rate 95 %	(20% dose cut off)

## Method

1. Four original H&N IMRT treatment plans with sliding window
  - Four different patients
2. Measured with the Delta<sup>4</sup> dosimetry system

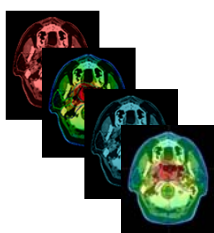


Image from:  
<http://www.scandidos.com/Delta4/RealMeasurements.aspx>

## Method

3. Original treatment plans modified within the TPS to create known dosimetric deviations

	PTV-T	PTV-N	Spinal cord	Brainstem	Parotid glands
5 %	<ul style="list-style-type: none"> <li>• Near maximum <math>D_{2\%}</math></li> <li>• Near minimum <math>D_{98\%}</math></li> </ul>	<ul style="list-style-type: none"> <li>• Near maximum <math>D_{2\%}</math></li> <li>• Near minimum <math>D_{98\%}</math></li> </ul>	<ul style="list-style-type: none"> <li>• Near maximum <math>D_{2\%}</math></li> </ul>	<ul style="list-style-type: none"> <li>• Near maximum <math>D_{2\%}</math></li> </ul>	<ul style="list-style-type: none"> <li>• Mean dose</li> </ul>
2 %	<ul style="list-style-type: none"> <li>• Mean dose</li> </ul>	<ul style="list-style-type: none"> <li>• Mean dose</li> </ul>			

**Our goal:**  
 Dose differences > 5% or 2%  
 (in at least two of the above structures)  
 are considered as relevant for the treatment of the patient  
 and should be detected by the QA.

# Method

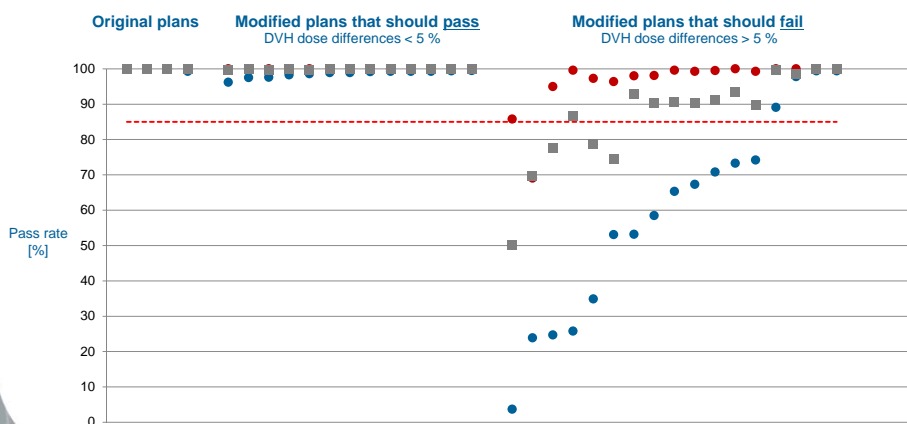
4. 34 H&N IMRT treatment plans with sliding window
  - 4 original plans
  - 13 modified plans with dose differences < 5 % (< 2 % target mean dose)
  - 17 modified plans with larger dose differences > 5 % (> 2 % target mean dose)
5. Evaluation of comparisons with the four measured original dose distributions

- **ICRU report 83 recommendations**
  - Low & High (5 % and 5 mm)
  - Gamma (5 %, 5 mm)
- **Modified version of ICRU report 83 recommendations**
  - Low & High (3 % and 3 mm)
  - Gamma (3 %, 3 mm)
- **Often used gamma evaluation**
  - Gamma (3 %, 3 mm)

# Result

## ICRU report 83 recommendations (5% and 5 mm)

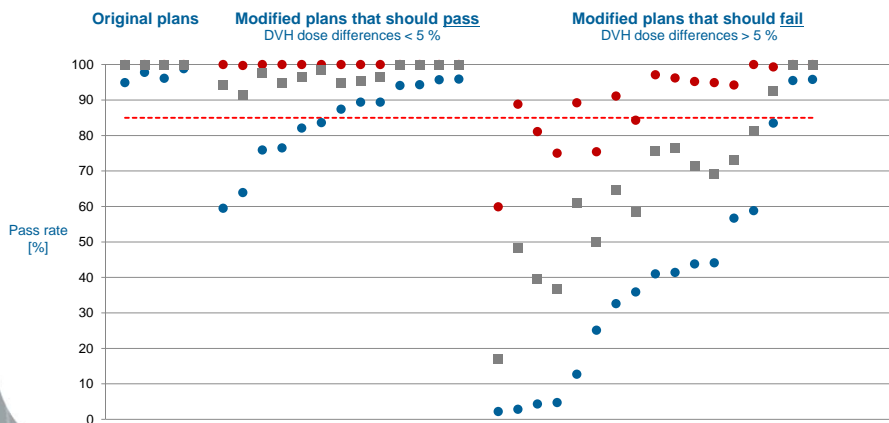
- Low gradient region (5 % dose diff)
- High gradient region (5 mm DTA)
- Gamma evaluation (5 %, 5 mm)
- Pass rate (85%) (no dose cut off)



# Result

## Modified version of ICRU 83 recommendations (3% and 3 mm)

- Low gradient region (3 % dose diff)
- High gradient region (3 mm DTA)
- Gamma evaluation (3 %, 3 mm)
- Pass rate (85%) (no dose cut off)



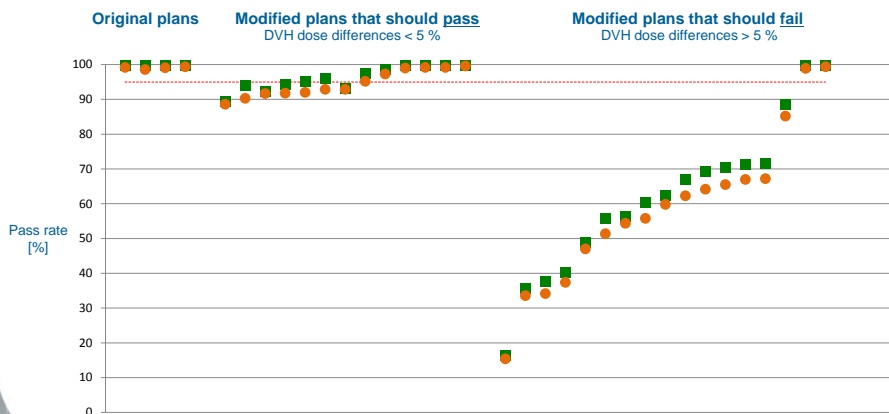
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# Result

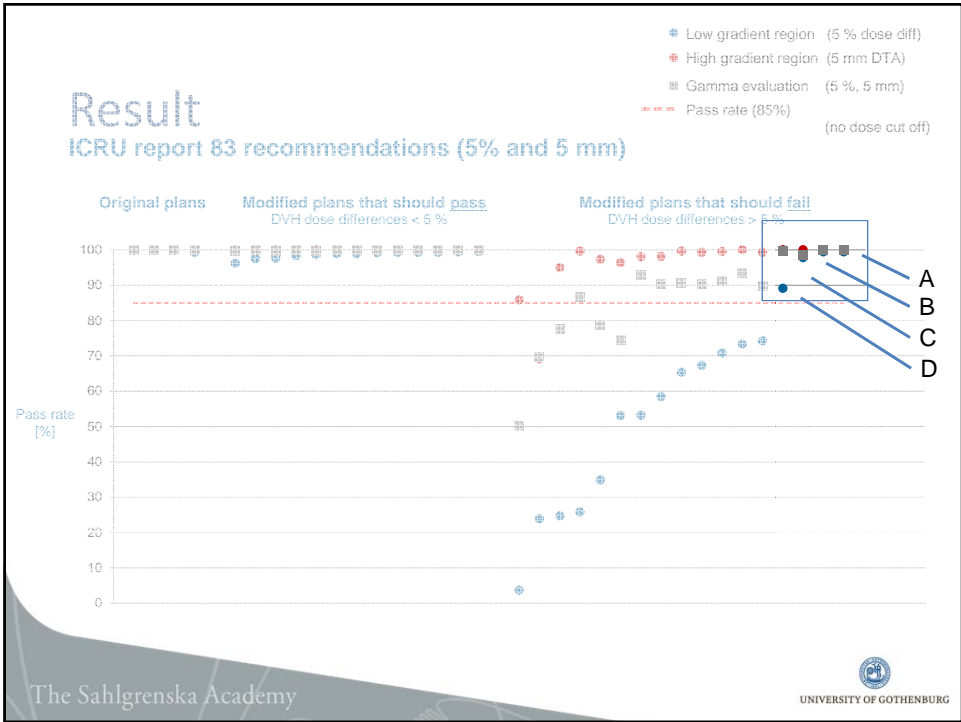
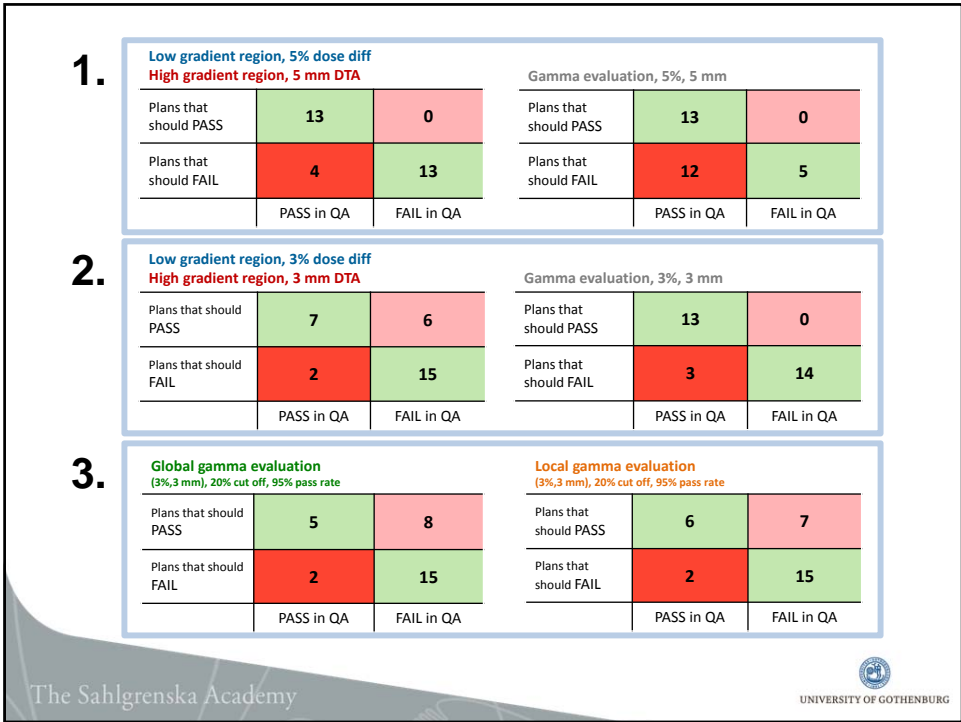
## Global and local gamma evaluation 3 %, 3 mm and 20% dose cut off

- Global gamma (3 %, 3 mm)
- Local gamma (3 %, 3 mm)
- Pass rate (95%)



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## Examples

Relative dose difference [%]  
between original and modified calculated treatment plans

Plan	PTV						OAR			
	PTV-T			PTV-N			Spinal cord	Right parotid	Left parotid	Brainstem
	D <sub>98%</sub>	mean	D <sub>2%</sub>	D <sub>98%</sub>	mean	D <sub>2%</sub>	D <sub>2%</sub>	mean	mean	D <sub>2%</sub>
A	-5,5	-0,7	-0,1	-4,4	-0,7	-0,1	4,3	-4,5	-5,1	4,3
B	-5,6	-0,7	0	-6,0	-0,9	-0,3	2,5	-12,7	5,7	3,0
C	-3,3	-2,2	-1,7	-5,5	-2,7	-1,8	-3,0	-8,9	5,8	
D	5,2	5,3	5,4	5,3	5,3	5,2	5,3	5,4	5,4	

- Red indicates a DVH dose difference > 5 % or 2 % (mean dose to PTV) between original and modified plans
- Green indicates a DVH dose difference < 5 % or 2 % (mean dose to PTV) between original and modified plans

## Conclusion

Patient-specific QA evaluation with the Delta<sup>4</sup> dosimetry system and the recommendations in the ICRU report 83 for evaluation can not be used with a goal to detect differences of 5 % in dose volume metrics of interest between planned and delivered dose. Gamma evaluation with 3%/3mm and pass rate 95% detected more erroneous plans but still did not detect 2 plans with dose deviations > ±5 %.

## Reflections

It is important to define the goal of a QA procedure  
and to validate that the procedure is able to fulfill that goal.

# Thank you!

Special thanks to



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