

Dose Volume Parameters Organs at Risk in Clinical Practice

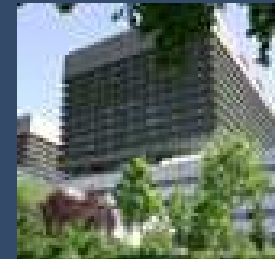
Rectum:
Brachytherapy +/- External Beam Therapy

**Dose-Volume Parameters
or
Volume-Dose Parameters ?**

Gregor Goldner, Christian Kirisits



Department of Radiotherapy and Radiobiology
Medical University of Vienna



Definition of Volume and Definition of Reporting

- **Absolute or relative Dose-Volume Parameters?**
- **Rectum or Rectal Wall ?**

Side Effects

- **Macroscopic Mucosal Changes**

Overview about current Literature

Medline - Search 10/2006 : 92 Papers

„Radiotherapy“ and „Rectum“ and „DVH“

74 (80 %) Teletherapy

18 (20 %) Brachytherapy

87 (95 %) Prostate-Cancer

STATUS of rectum -DVH parameters in use for REPORTING

Example of 10 studies about prostate cancer RT
(seeds-application or HDR brachytherapy)

relative DVH parameters

5 studies

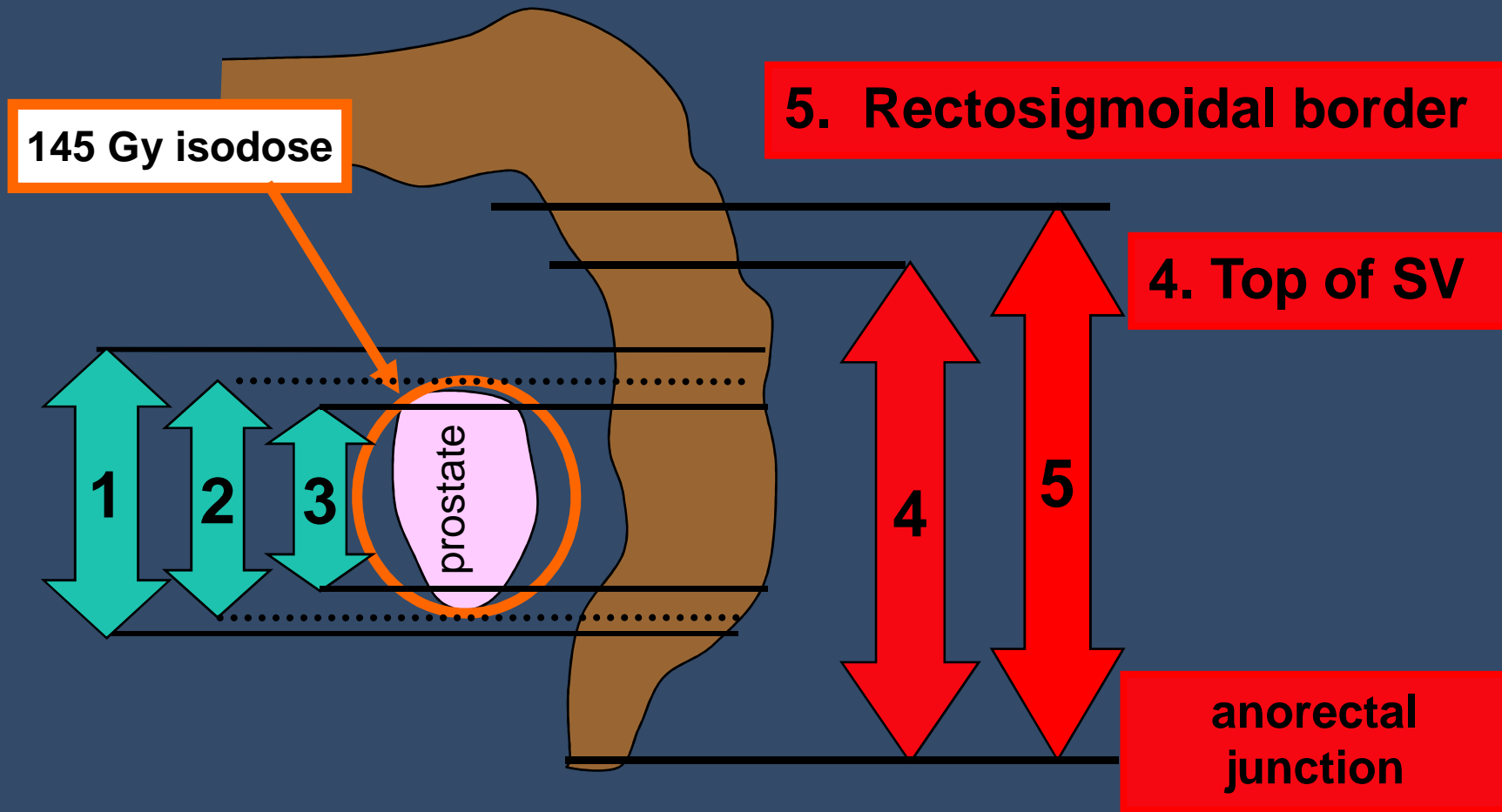
D_{30} , D_{10} , D_5
 V_1 , V_5 , V_{10} , V_{15} , V_{20} , V_{25} , V_{30} ,
 V_{50} , V_{75} , V_{80} , V_{90} , V_{100} , V_{125} ,
 V_{150} , V_{200} , V_{250} , V_{300}

absolute DVH parameters

5 studies

D_{2cc} , D_{1cc} , $D_{0,1cc}$
 V_{50} , V_{100} , V_{150} , V_{200} , V_{300} in ccm

Different ways of contouring the rectum / rectal wall



1. Prostate +/- 0,5 cm or (+/- 1 cm) or (+/- 1 slice)

2. Prescription dose

3. Radioactive seeds visible

Absolute or Relative

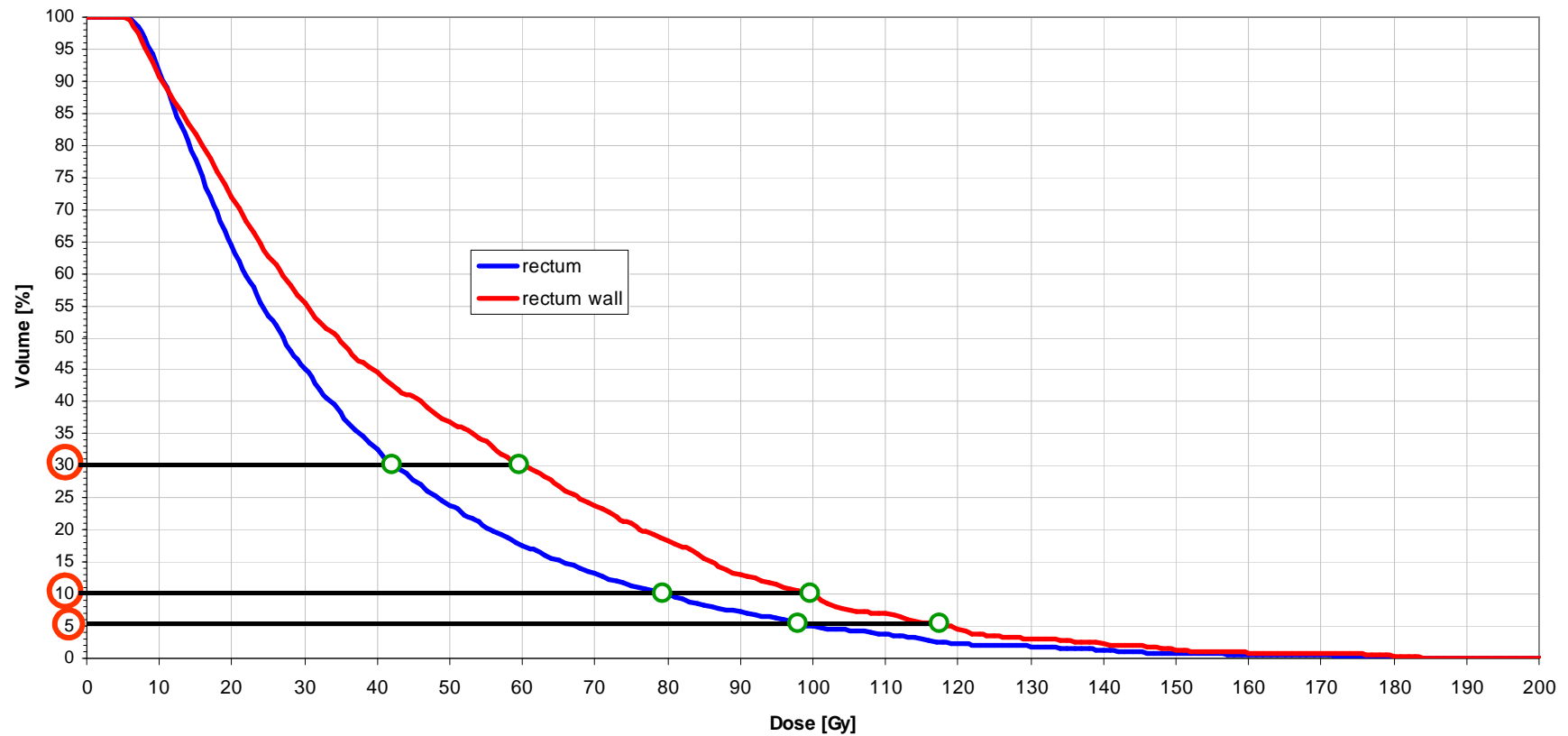
Dose Volume Parameters

Rectum or Rectal Wall



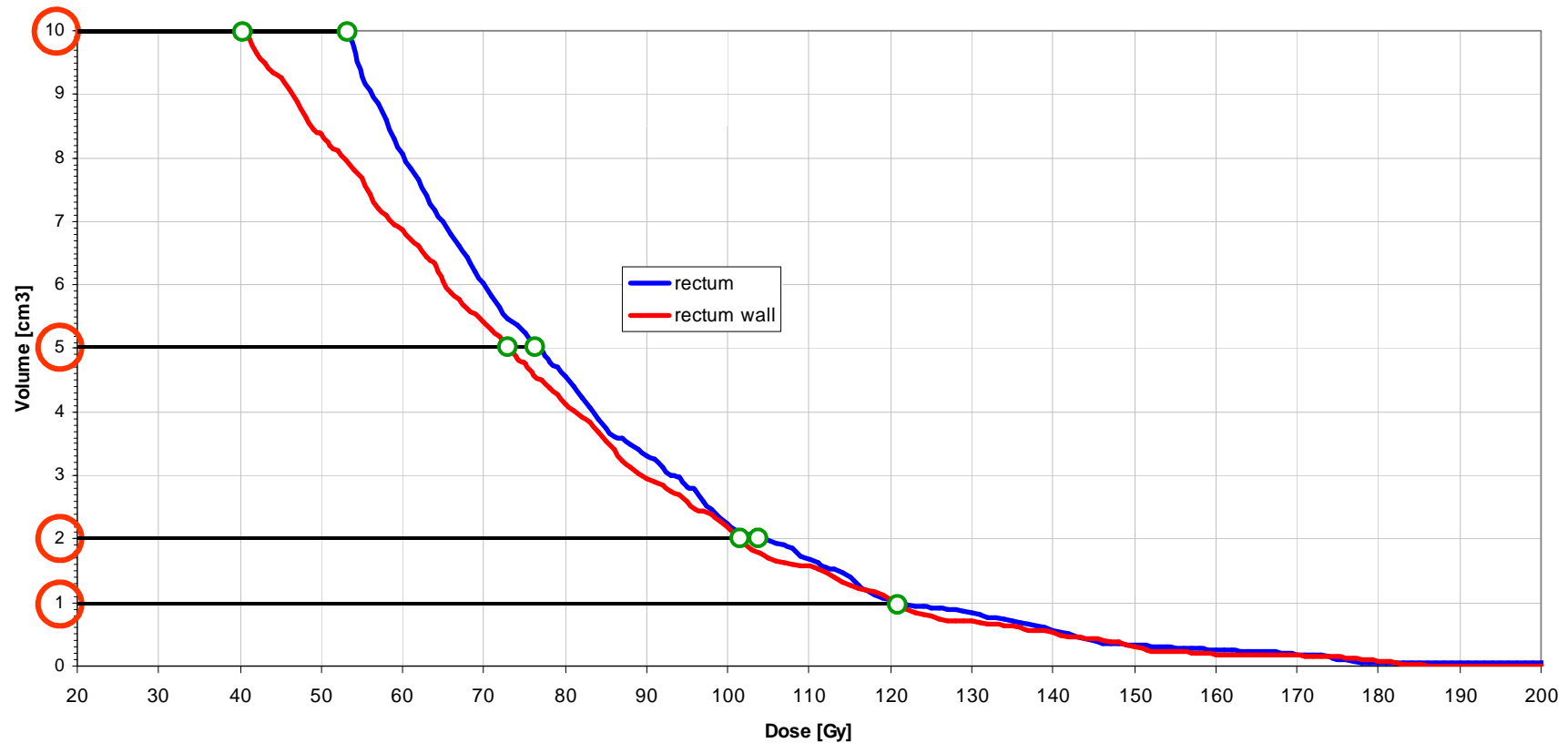
DVH relative Volume

	Wall	Total	deviation
Volume	22 cm ³	45 cm ³	
D ₃₀	60 Gy	42 Gy	-42 %
D ₁₀	99 Gy	79 Gy	-25 %
D ₅	118 Gy	99 Gy	-19 %
D ₁	155 Gy	143 Gy	-9 %



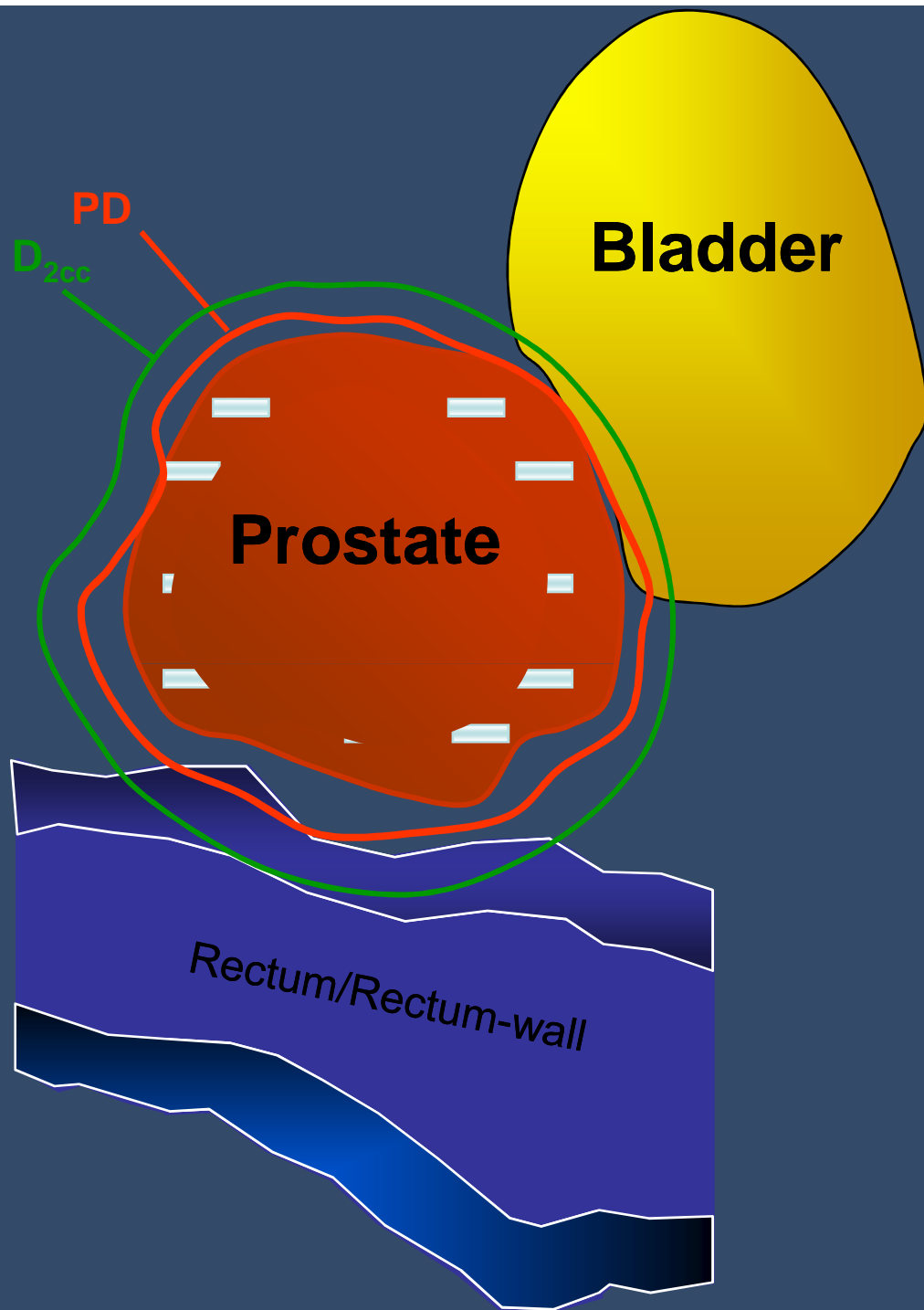
DVH absolute Volume

	Wall	Total	deviation
Volume	22 cm ³	45 cm ³	
D _{10cc}	40 Gy	53 Gy	24 %
D _{5cc}	73 Gy	76 Gy	5 %
D _{2cc}	101 Gy	104 Gy	2 %
D _{1cc}	120 Gy	120 Gy	0 %
D _{0.1cc}	179 Gy	175 Gy	-3 %



Parameter	Rectal whole organ		deviation
Volume	28 cm ³	46 cm ³	
D2cc	131 cm ³	131 cm ³	0%
D0.1cc	234 cm ³	234 cm ³	0%
D10	116 cm ³	95 cm ³	-22%
D5	143 cm ³	122 cm ³	-17%
V100	5%	3%	-62%
V100	1,3 cm ³	1,3 cm ³	0%

	Rectal wall		
Volume	20 cm ³	27 cm ³	
D2cc	128 cm ³	128 cm ³	0%
D0.1cc	241 cm ³	241 cm ³	0%
D10	128 cm ³	117 cm ³	-10%
D5	161 cm ³	146 cm ³	-10%
V100	7%	5%	-37%
V100	1,5 cm ³	1,4 cm ³	-1%



Do we need more than one dose parameter?

Example for comparison:

Background:

HDR boost	e.g Hoskin et al.	2 x 8.5 Gy + 35.7 in 13 fractions EBRT
HDR mono	e.g. Martinez et al.	4 x 9.5 Gy

Based on the last 14 HDR patients from Vienna a possible ratio between prescribed dose to $D_{0.1cc}$ and D_{2cc} could be on average 0.86 and 0.63, respectively.

Dose is normalized to 2 Gy per fraction (EQD2) Dale 1985

Rectum $\alpha/\beta = 3$ Gy

Do we need more than one dose parameter?

	EBRT	HDR boost	HDR mono
EBRT	70 Gy	35.7 Gy 13 fr.	0
BT	0 Gy	2 x 8.5 Gy	4 x 9.5 Gy
EQD2	70 Gy	??80 Gy??	??95 Gy??
D_{2cc}	70 Gy	2 x 5.4 Gy	4 x 6.0 Gy
EQD2	70 Gy	59 Gy	43 Gy
$D_{0.1cc}$	70 Gy	2 x 7.3 Gy	4 x 8.2 Gy
EQD2	70 Gy	71 Gy	73 Gy
	1.0	1.2	1.7

Volume dose relations?

Recommendations by Crook et al. Brachytherapy 2005:

V100 for wall contour in cm³

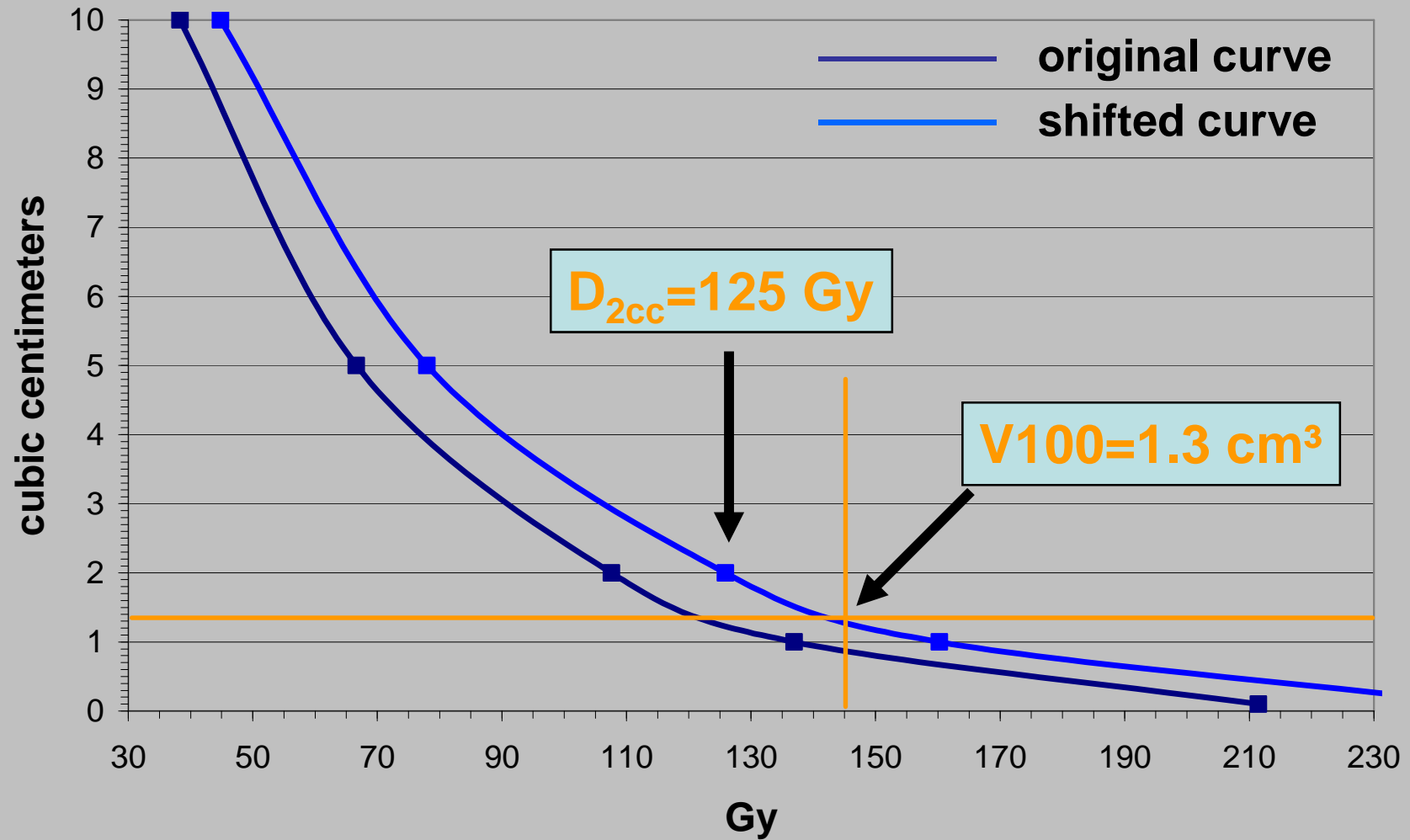
e.g. Snyder et al. IJROBP 2001

Rectal volume threshold for <5% risk of grad 2 proctitis at 5 years

$$V100 < 1.3 \text{ cm}^3$$

Conversion of V100 constraint to D2cc constraint possible?

„Standardized DVH“ based on 24 patients



Can we compare permanent to HDR implants?

Difficult and controversial!

Using LQ Model, e.g. Stock et al. IJROBP 2006, Dutreix J 1997

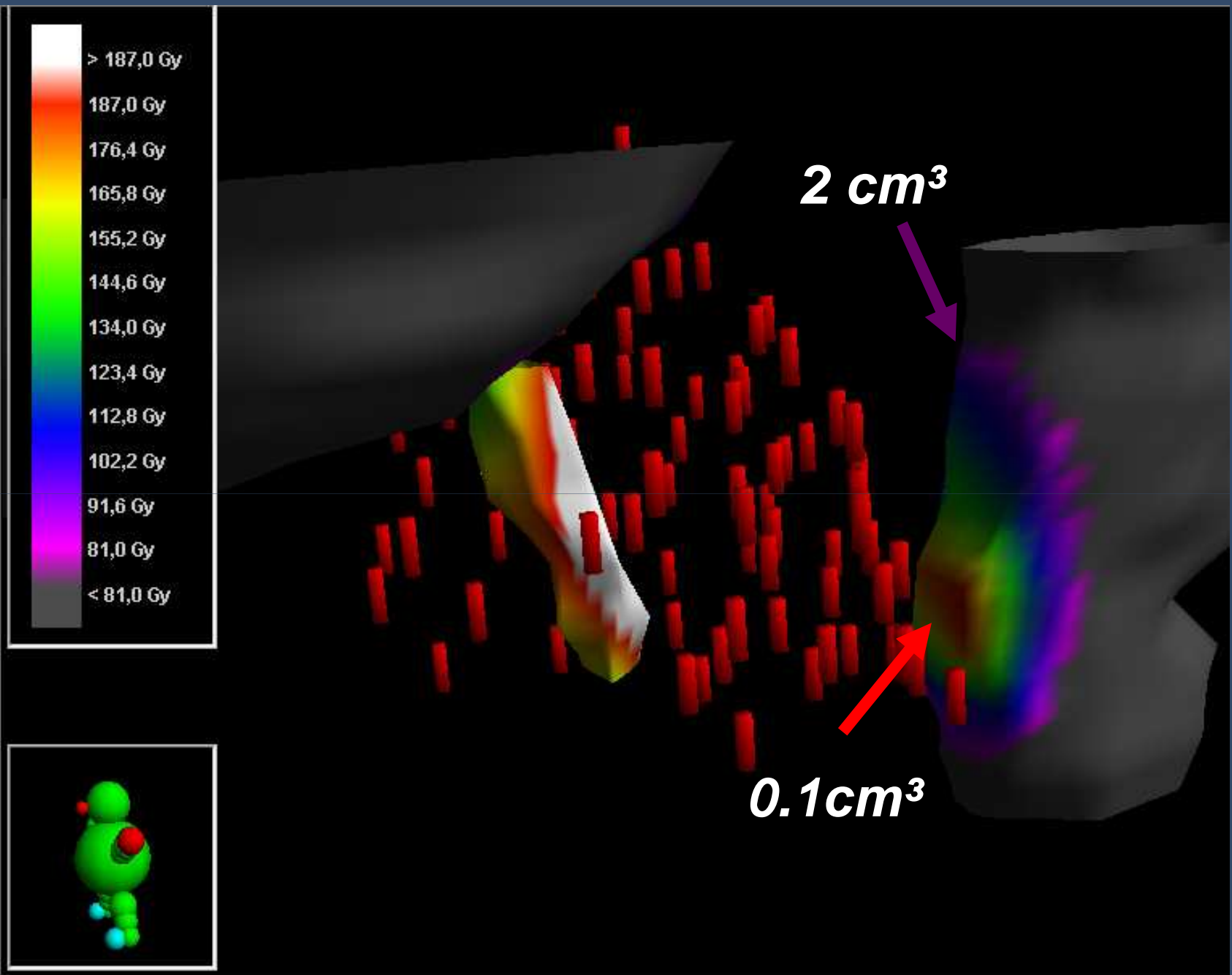
without taking into account different RBE for I-125

Rectum $\alpha/\beta = 3$ Gy and $T1/2 = 1.5$ h

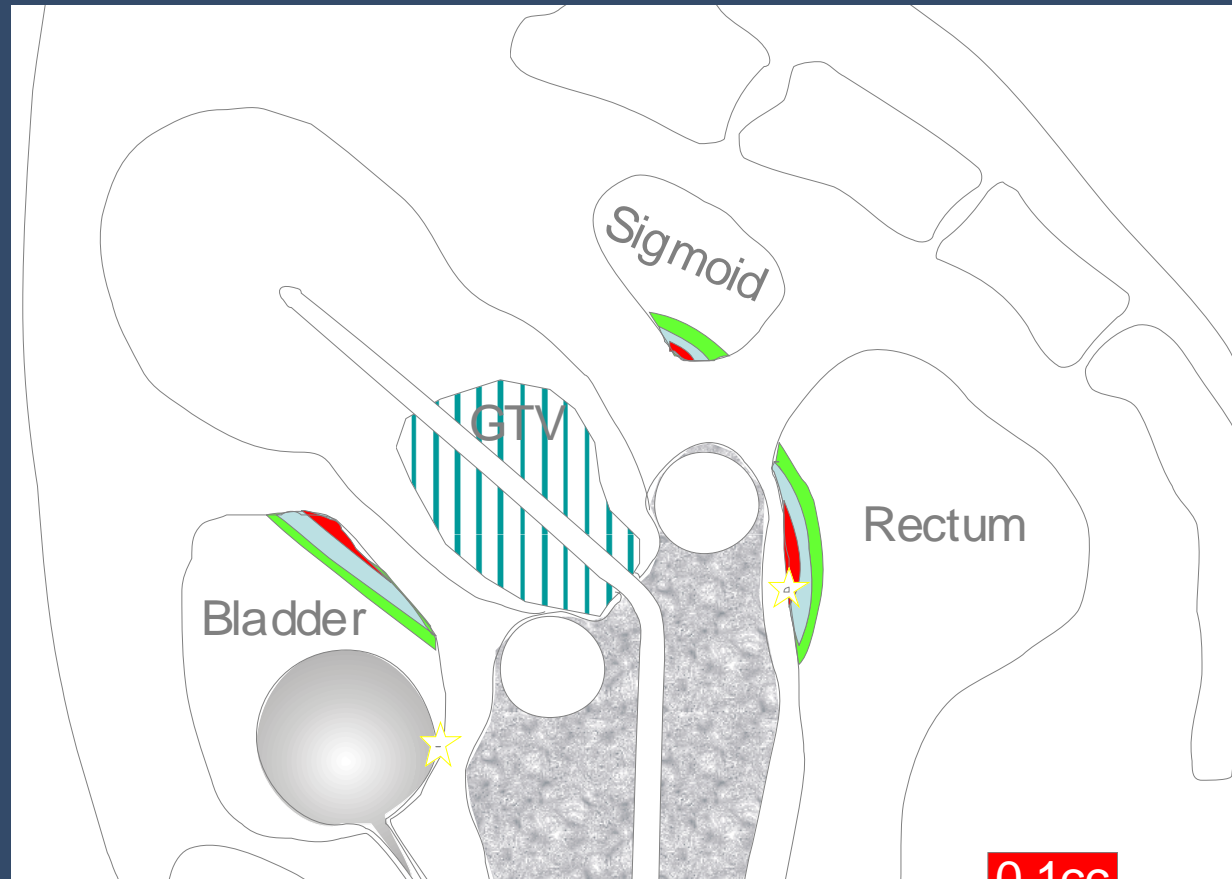
$D_{2cc} = 125$ Gy with I-125 LDR

compares to

$D_{2cc} = 78$ Gy EQD2

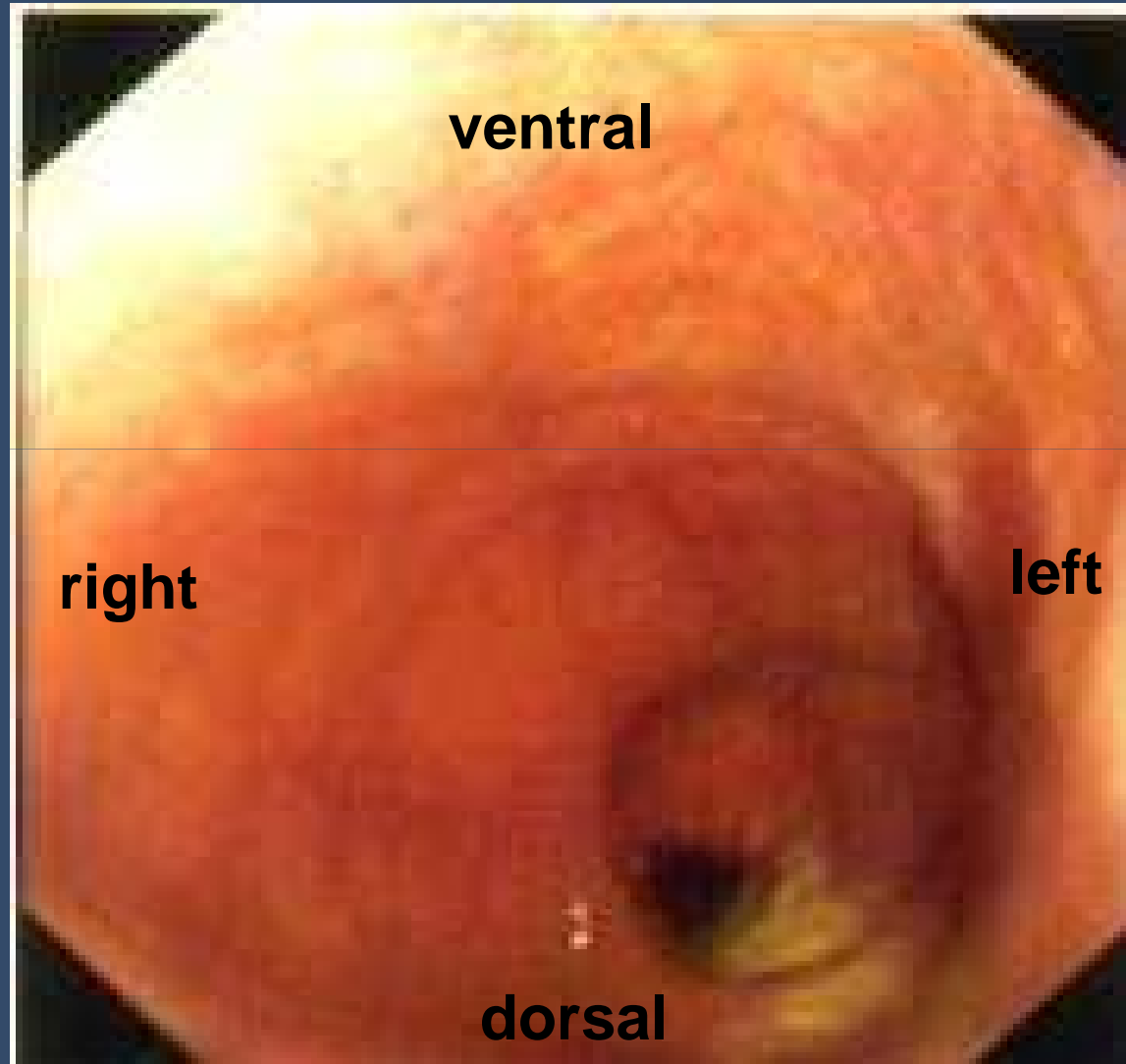


GEC-ESTRO Recommendations

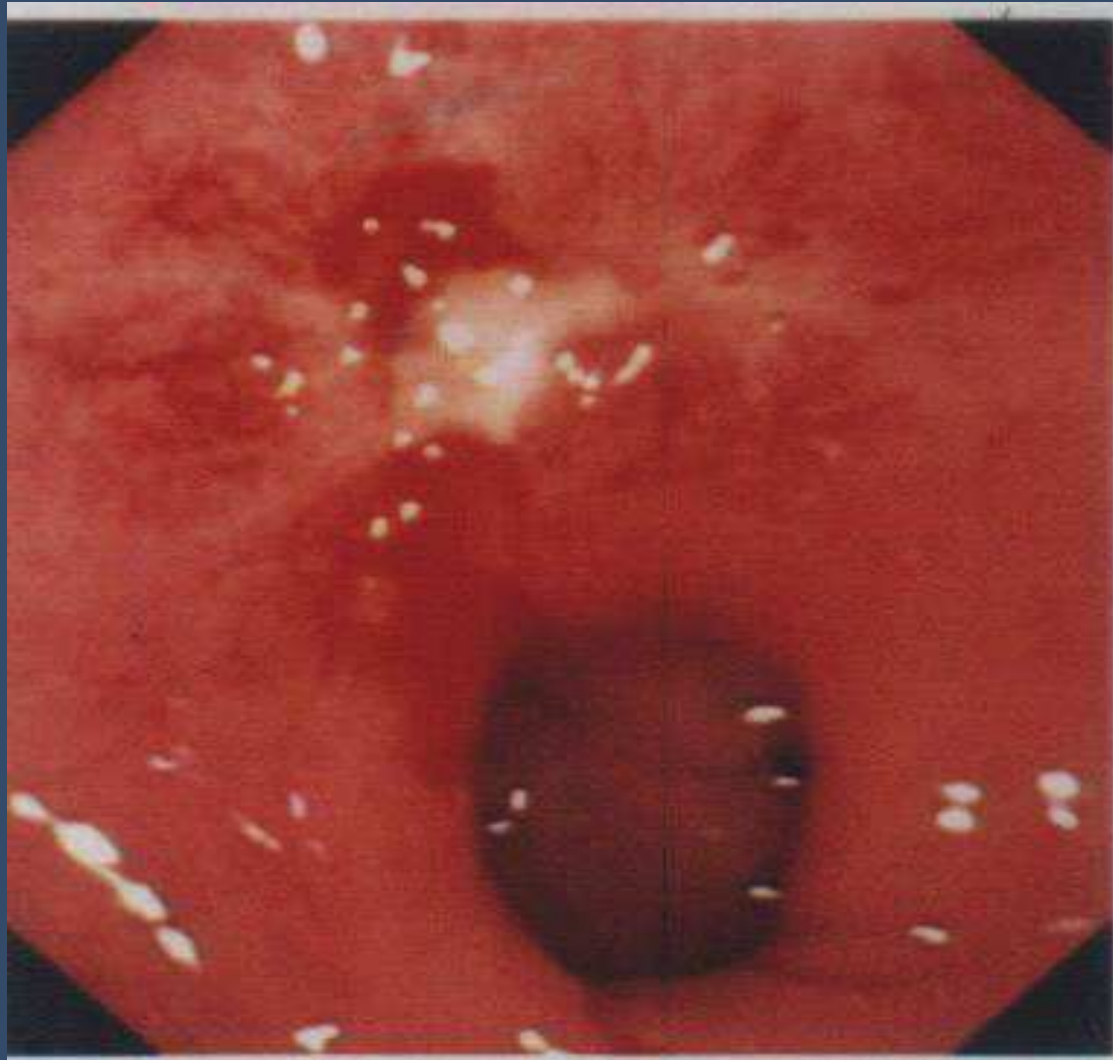


“ It is recommended to analyze the high dose regions, which are for brachytherapy limited to small volumes. DVH allow to report the D_{2cc} , D_{1cc} and $D_{0,1cc}$ defined as the minimum dose to the most exposed $2cm^3$, $1cm^3$ and $0,1cm^3$ of rectum (organs at risk) .”

ENDOSCOPIC EXAMINATION

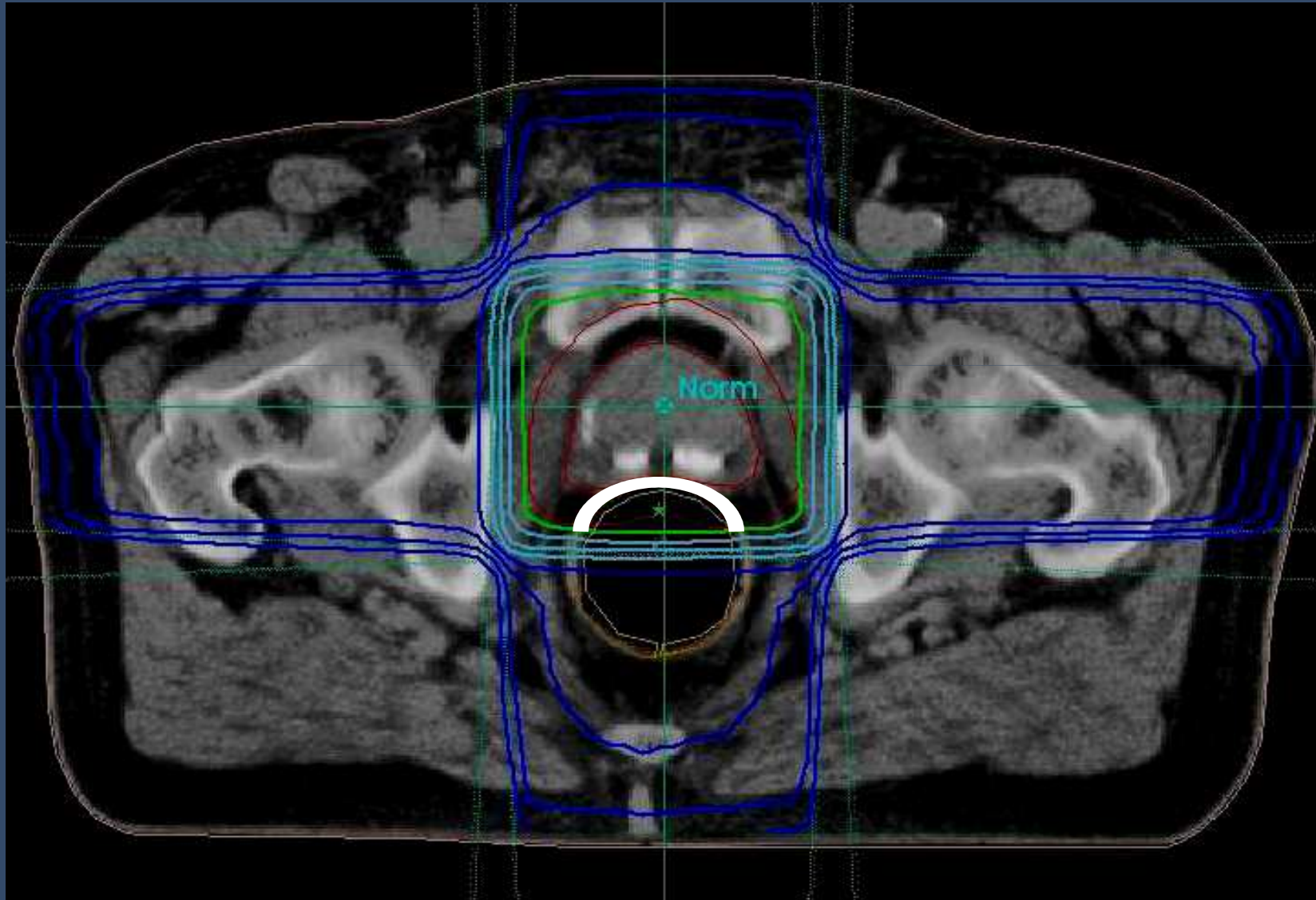


RECTOSCOPY after RADIOTHERAPY



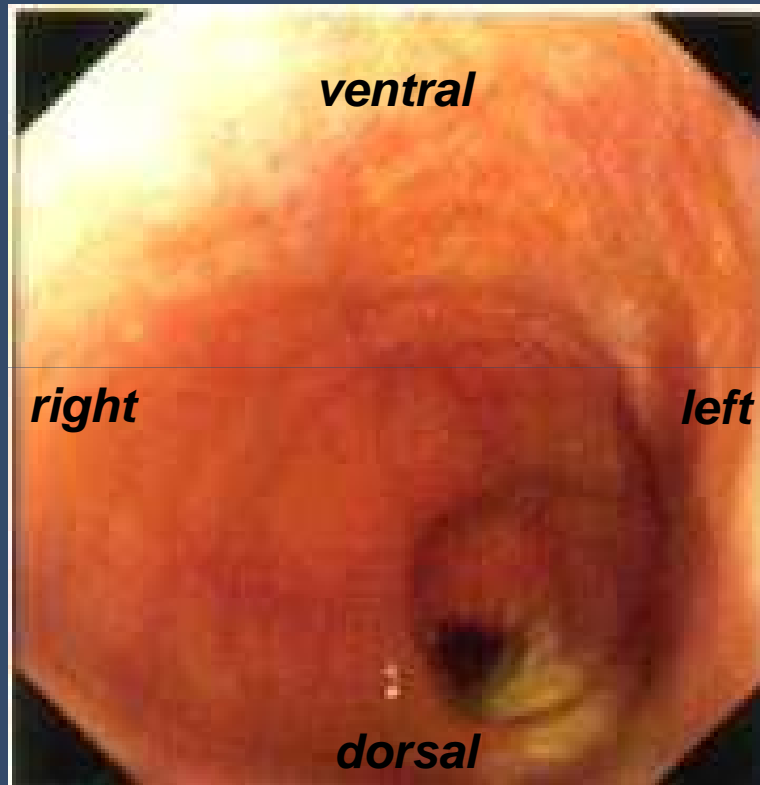
EBRT

homogenous dose distribution at the anterior rectal wall



RECTOSCOPIC FINDINGS after EBRT 66 Gy (44pts.) vs. 74 Gy (50pts.)

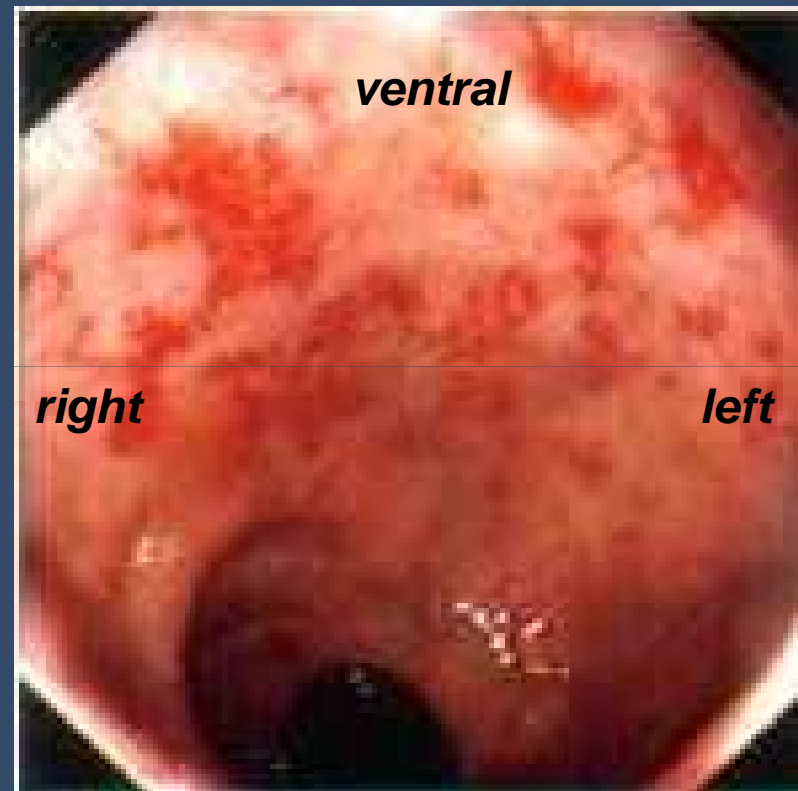
no teleangiectasia



66 Gy : 59 %

74 Gy : 30 %

teleangiectasia



66 Gy : 41 %

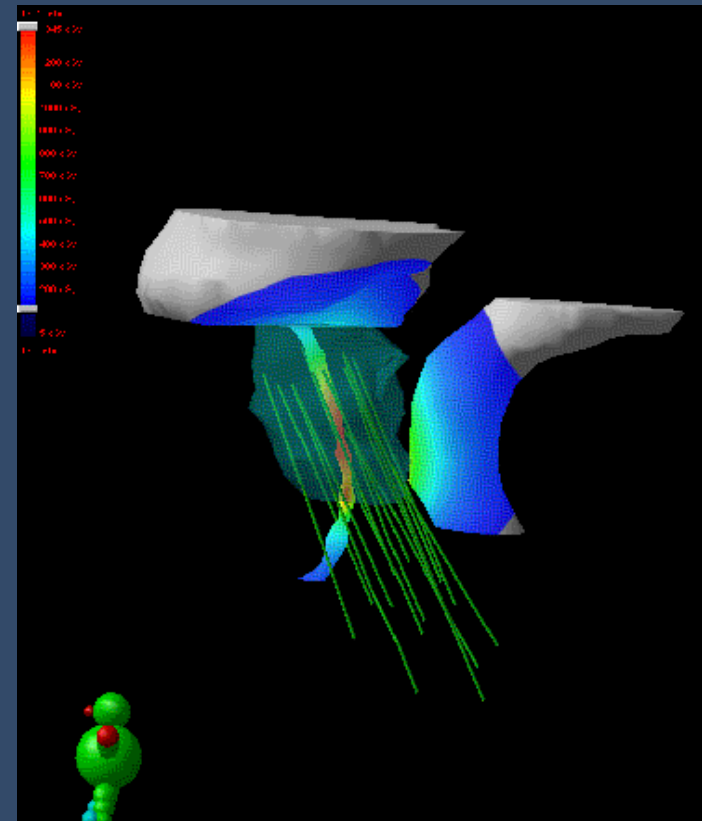
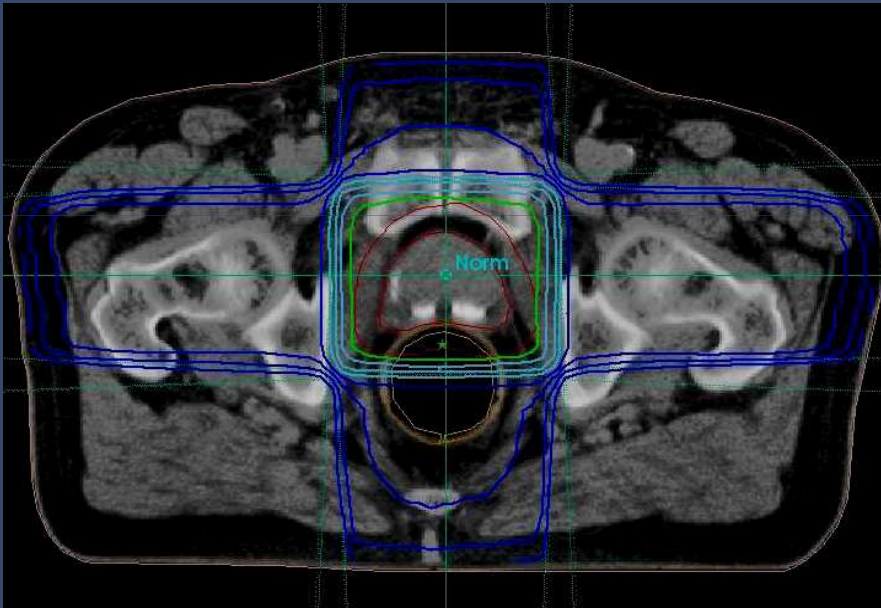
74 Gy : 70 %

EBRT + HDR BT

homogenous dose
distribution

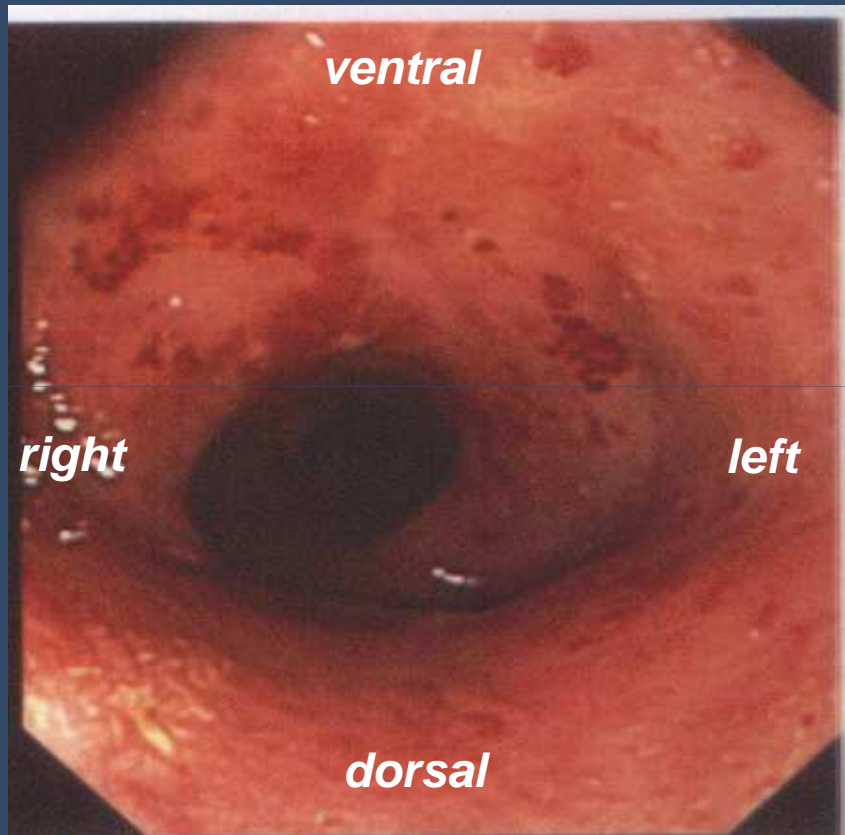


inhomogenous dose
distribution
small areas of high doses



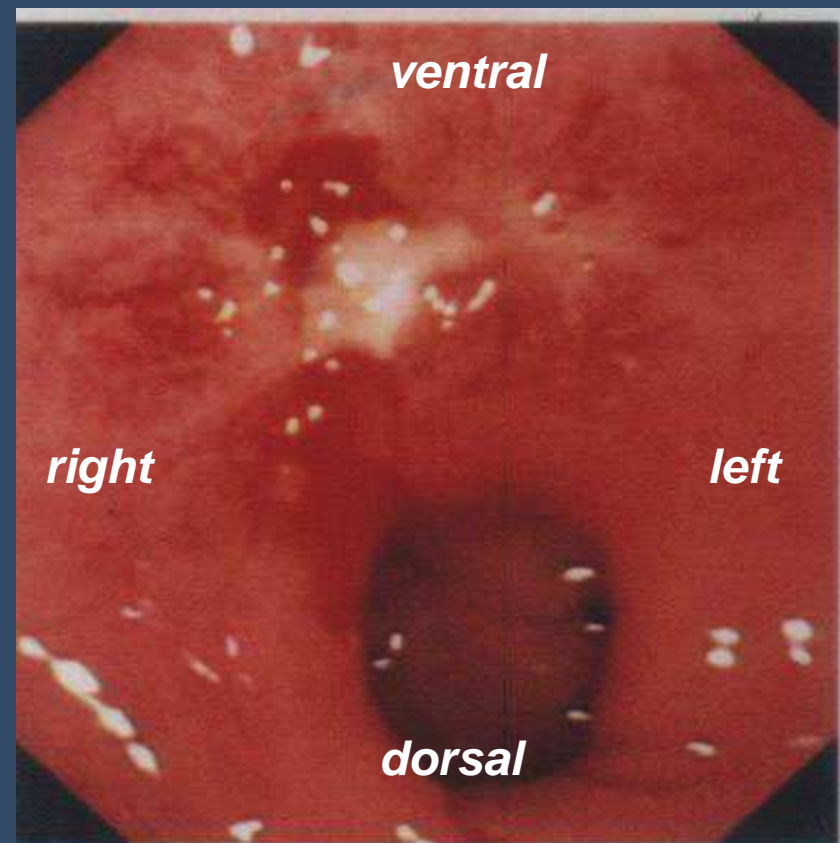
RECTOSCOPIC FINDINGS after EBRT+HDR

teleangiectasia



D2cc = 78 Gy EQD2
D0.1cc = 92 Gy EQD2

teleangiectasia + ulceration



D2cc = 81 Gy EQD2
D0.1cc = 108 Gy EQD2

Rectal Dose Volume Parameters after EBRT + BT according to Clinical Symptoms and Endoscopic Changes

Group 1: asymptomatic patients without mucosal changes

Group 2: symptomatic patients with mucosal changes

	Group 1 (8 pts.)	Group 2 (13 pts.)	p-value
D_{0.1 cc}	74 Gy (+/- 13 Gy)	88 Gy (+/- 10 Gy)	0.03
D_{2 cc}	61 Gy (+/- 8 Gy)	71 Gy (+/- 6 Gy)	0.01

CONCLUSION

- **Large variation of dose parameters**
- **Variation in relative DVH parameters due to contouring protocol**
- **Absolut parameters could provide a reproducible and stable method**
- **More than one parameter to describe the dose distribution within the rectal wall**
- **Macroscopic findings correlate to volume-dose parameters**