

An overview of international audit

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The importance of clinical dosimetry audits for advanced techniques

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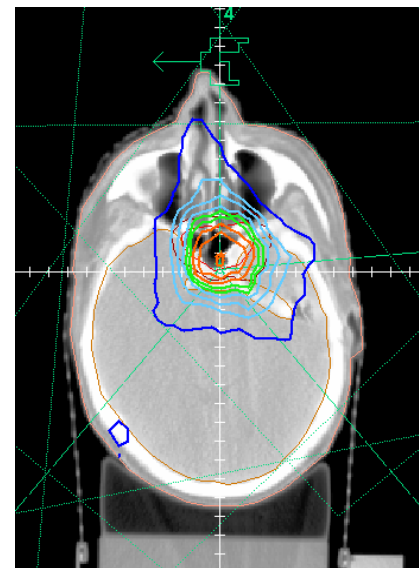
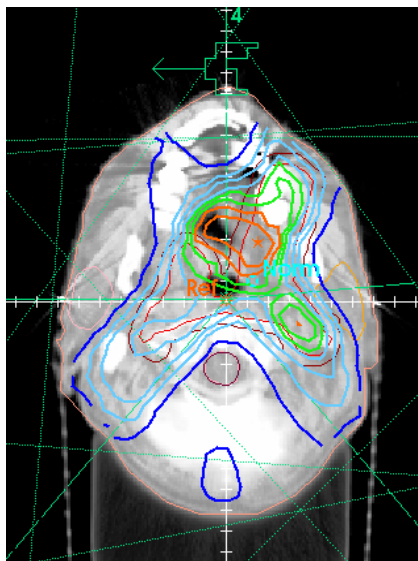
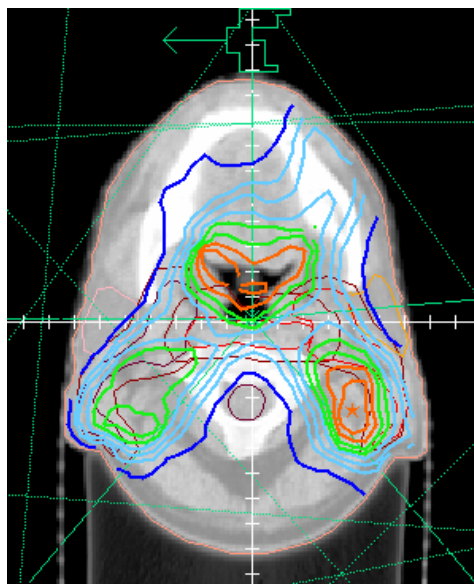
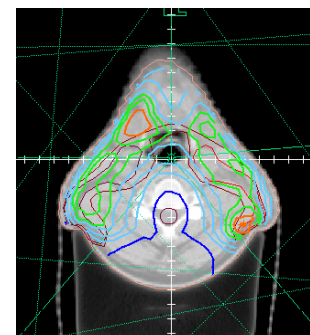
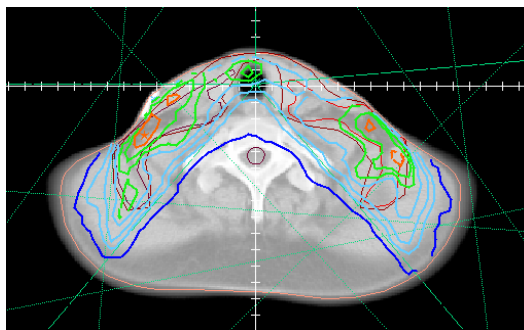
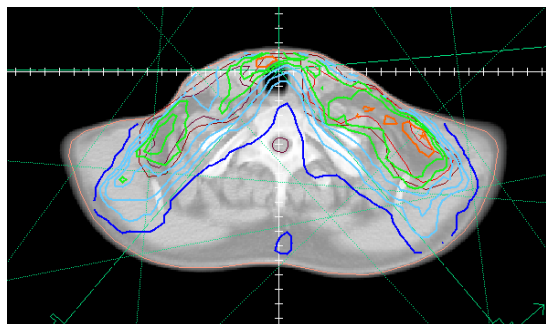
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Disclosure/conflict of interest

- 2010-today: Chairman of EORTC ROG QA RT Department
- 2006-2008: Scientific Director of ESTRO & EQUAL ESTRO laboratories (Paris/Hamburg) (Quality assurance and Dosimetry audits w/wo clinical trials)
- No conflict of interest



Is (external) Quality Assurance in 3D-CRT / IMRT important ?



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*Some problems/errors are
visible . . .*



Courtesy of J. Cunningham, ROSIS



Others not at all !

What-where-how?

Courtesy of J. Cunningham, ROSIS

Complex technique : Planning and Delivery - QA required at each step

Black Box



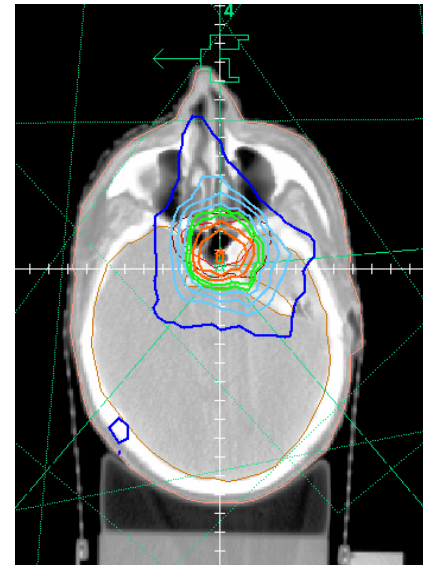
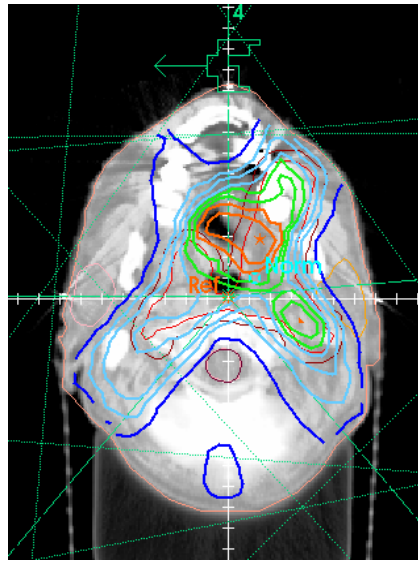
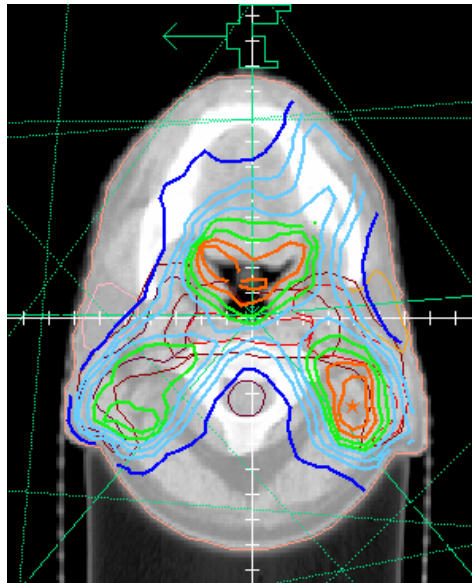
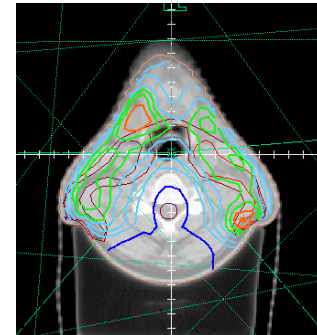
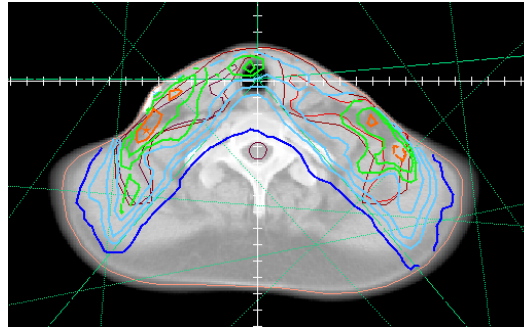
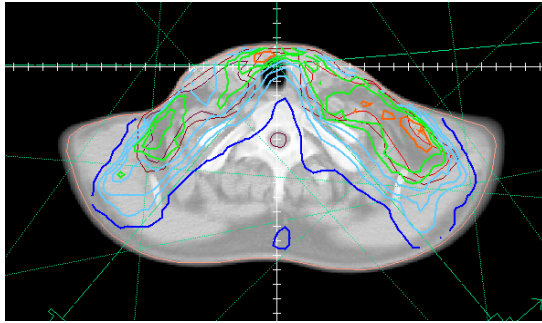
Aim

- New technologies no longer limited to academic centers, are being rapidly assimilated into diverse clinical sites
- “one is left applying manufacturers procedures” (International codes of practice for dosimetry not accommodated)
- No independent verification and traceability to National and International standards
- It is essential that optimal dose delivery is maintained for all patients (especially where clinical trials are being implemented)
- Example: IMRT, Dynamic Arctherapy (VMAT/RapidArc), Helical Tomotherapy, Cyberknife, etc



What to do ?, how to react ?

GORTEC study



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External dosimetry audit in IMRT – European study



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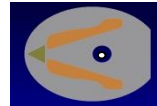
External dosimetry audit in IMRT – European study

- Absolute dosimetry: 7 points (« inhomog. dose gradients dispersed»)

- Point 1: Isocenter



- Point 2: Spinal cord isocenter



- Point 3: Spinal cord cranial



- Point 4: PTV T R



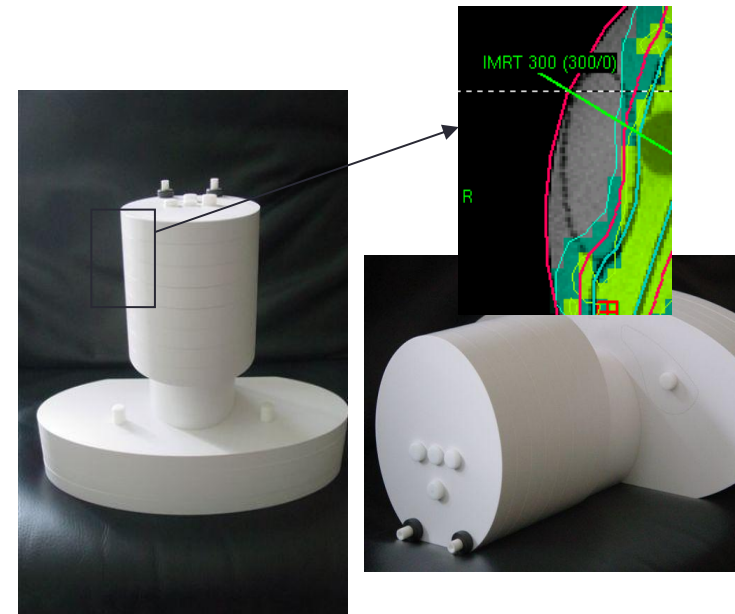
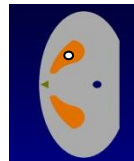
- Point 5: PTV T R cranial



- Point 6: PTV N L



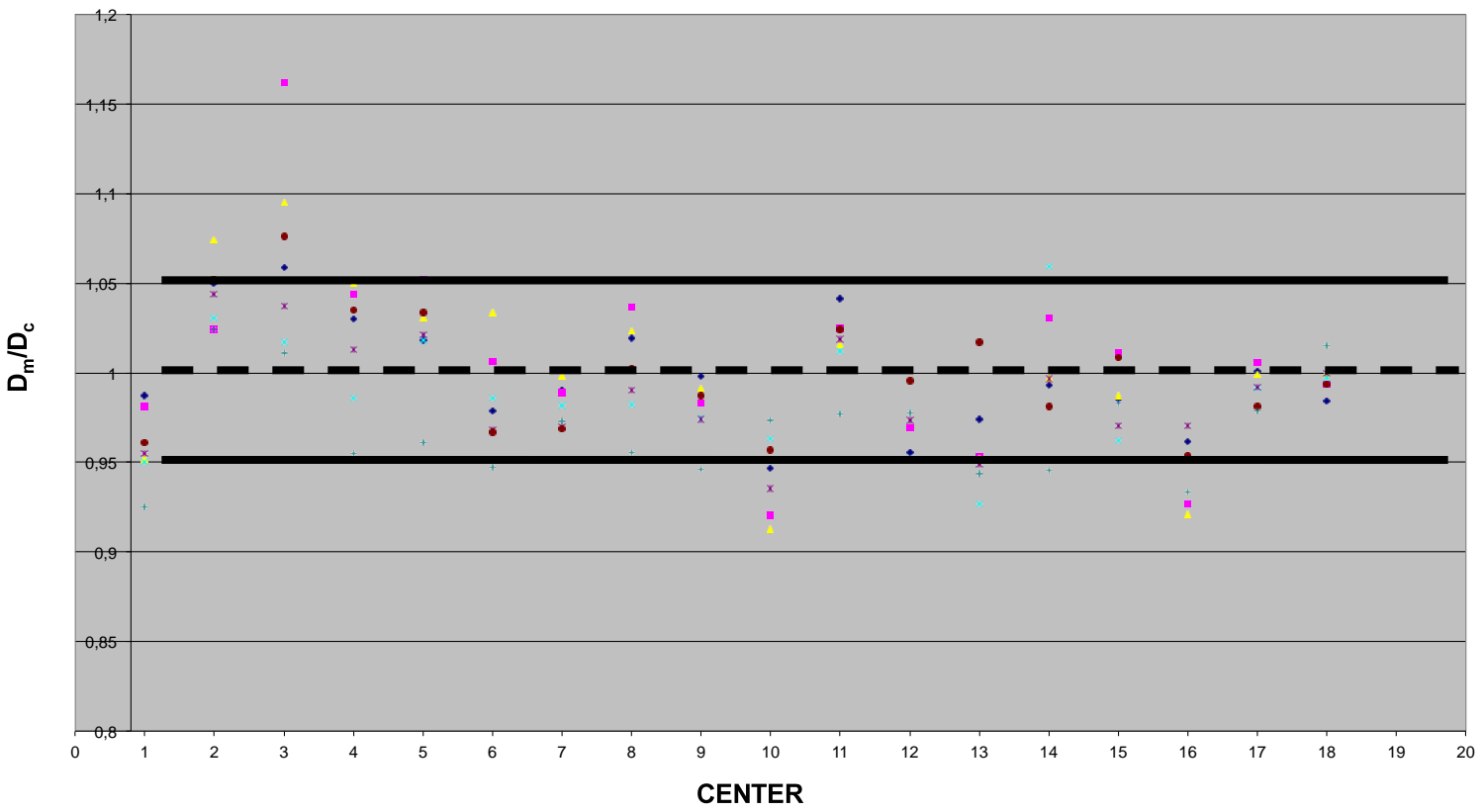
- Point 7: PTV N L caudal



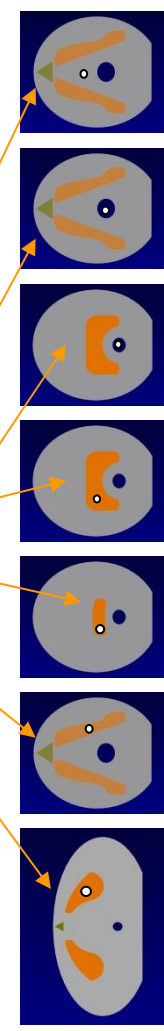
M. Tomsej et al "Validation of IMRT treatments in head and neck cancer through a European multicentric dosimetry study", *Radiotherapy and Oncology* 76 (September 2005).

Results – GORTEC audit

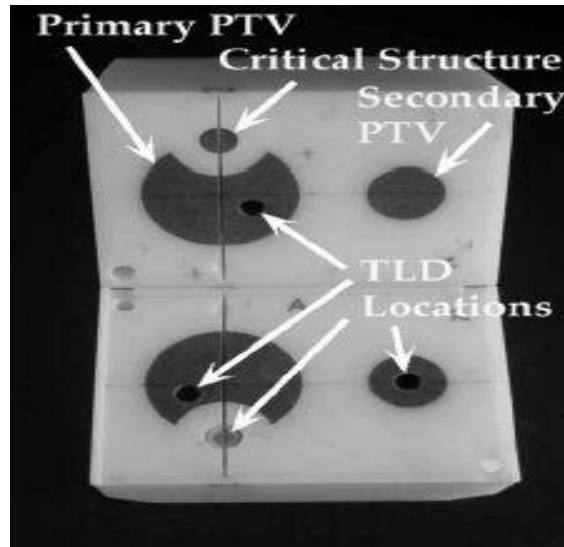
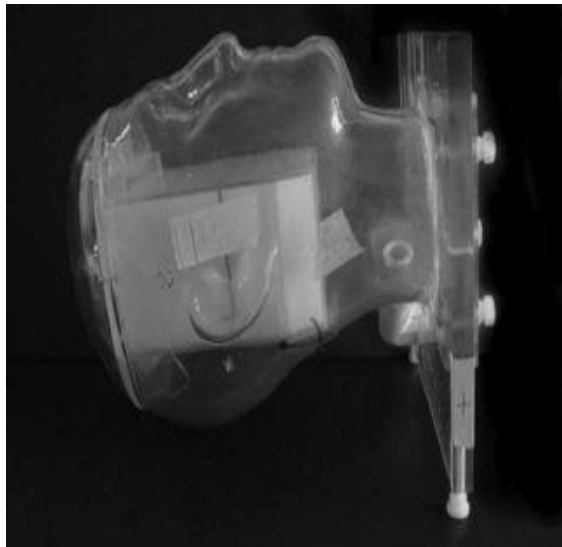
$D_m/D_c = f(\text{CENTER})$ per meas. pt



- ◆ isocenter
- ◆ spinal cord iso
- ◆ spinal cord cranial
- ◆ PTV T D
- × PTV T D cranial
- PTV N G
- + PTV N G caudal



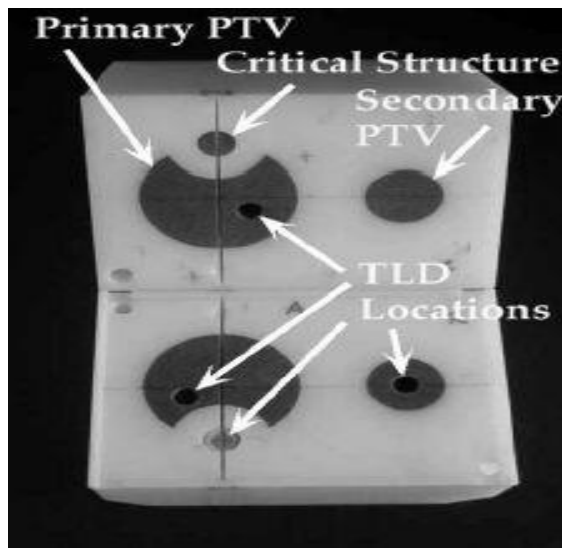
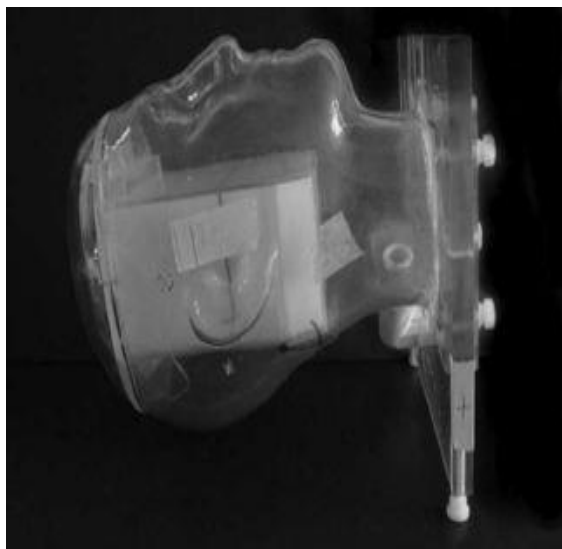
Dosimetry Audit – USA RPC - RTOG



RPC's IMRT
head and neck
phantom

“During a postal audit of IMRT performed by the RPC (Houston, USA), it was found that only 62 % of the participants met the criteria (7% in dose and 4 mm in spatial accuracy)”

Dosimetry Audit – USA RPC - RTOG



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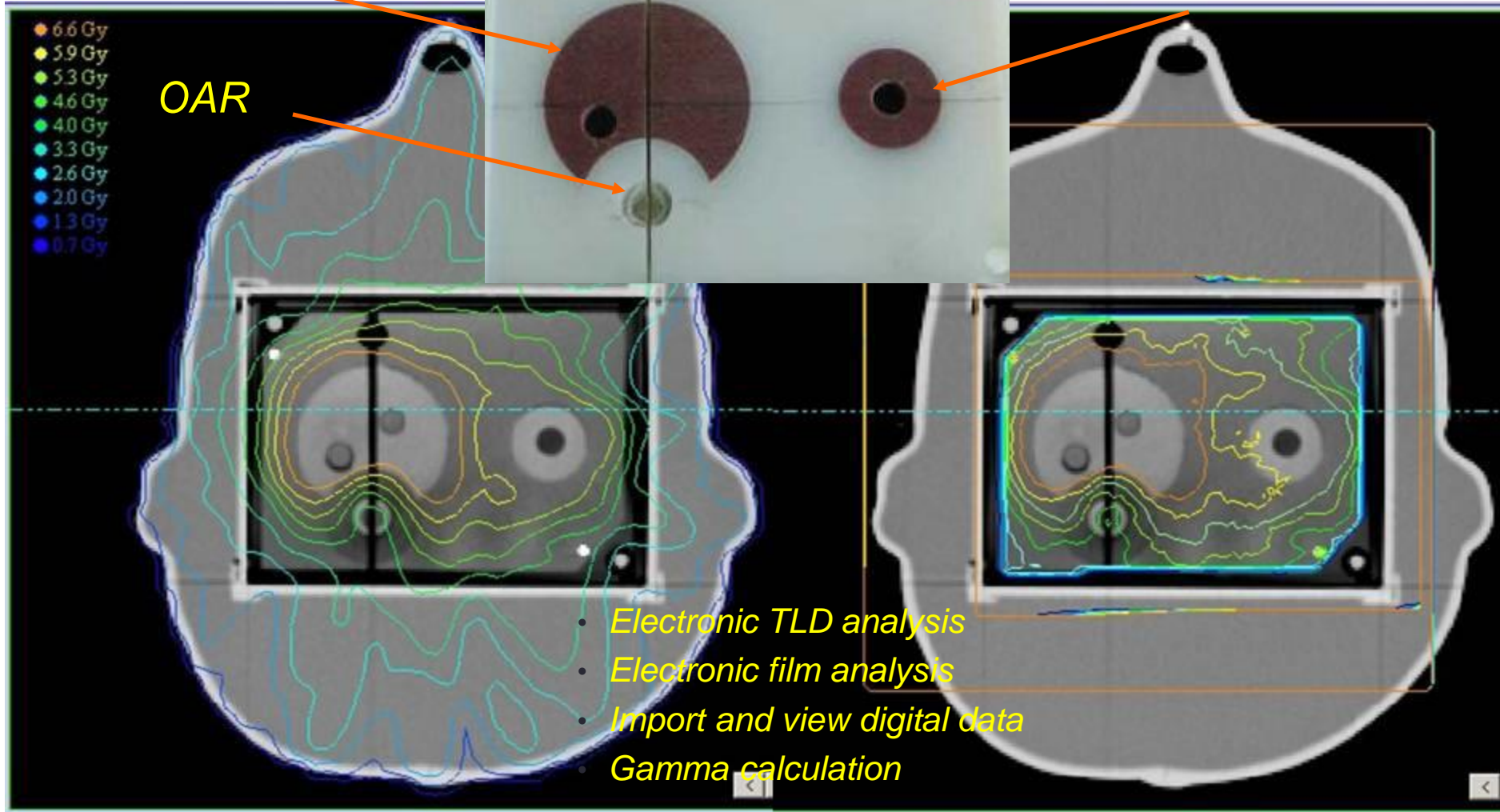
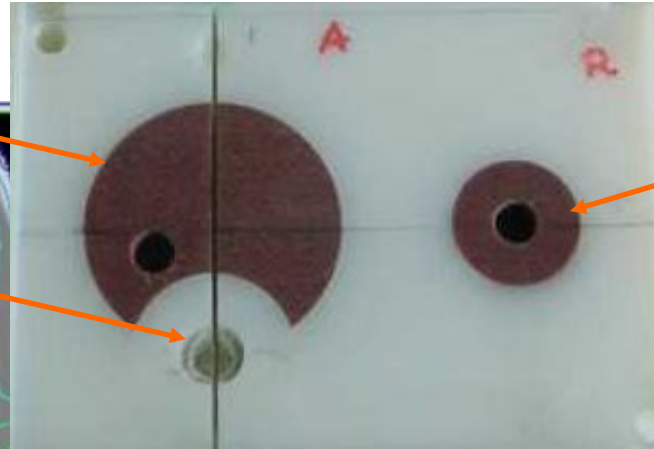
Plan vs. Treatment

Primary PTV

Secondary PTV

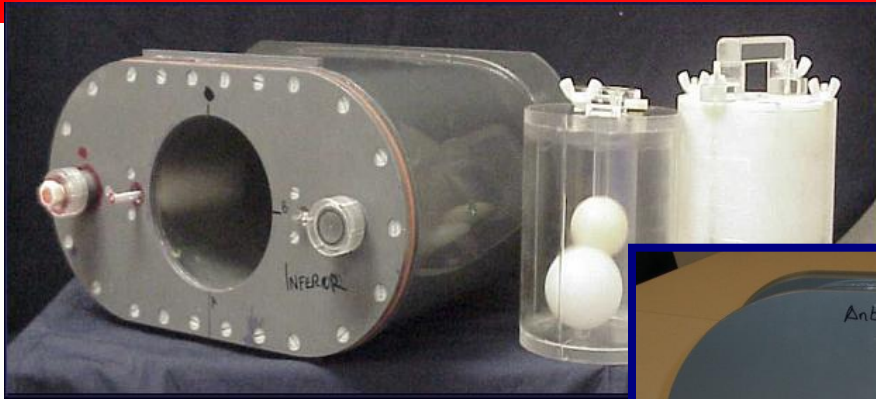
OAR

- 6.6 Gy
- 5.9 Gy
- 5.3 Gy
- 4.6 Gy
- 4.0 Gy
- 3.3 Gy
- 2.6 Gy
- 2.0 Gy
- 1.3 Gy
- 0.7 Gy

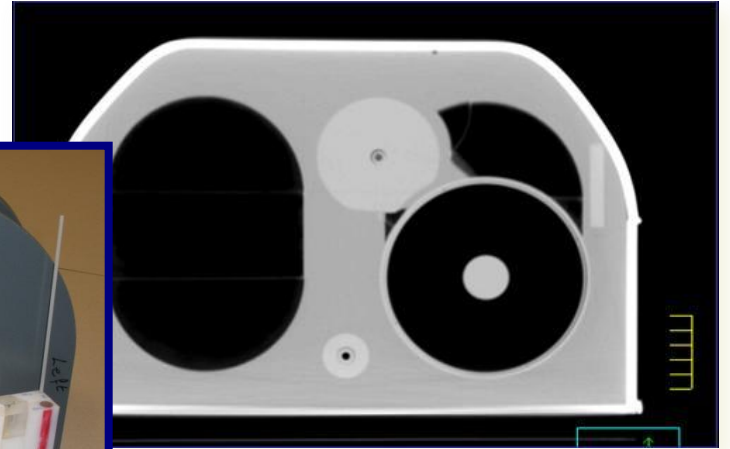


- Electronic TLD analysis
- Electronic film analysis
- Import and view digital data
- Gamma calculation

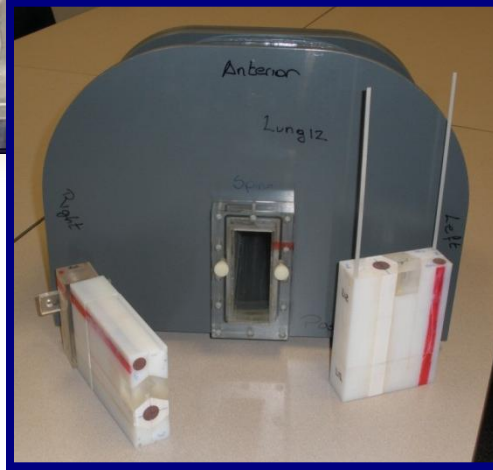
RPC Phantoms



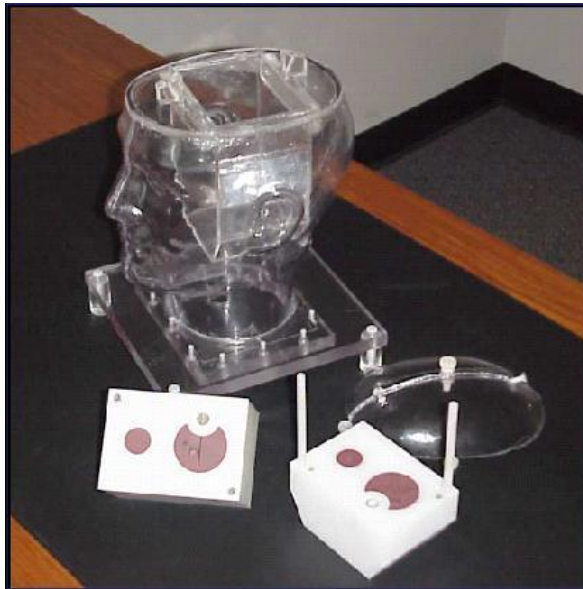
Pelvis (10)



Thorax (10)



Spine (8)

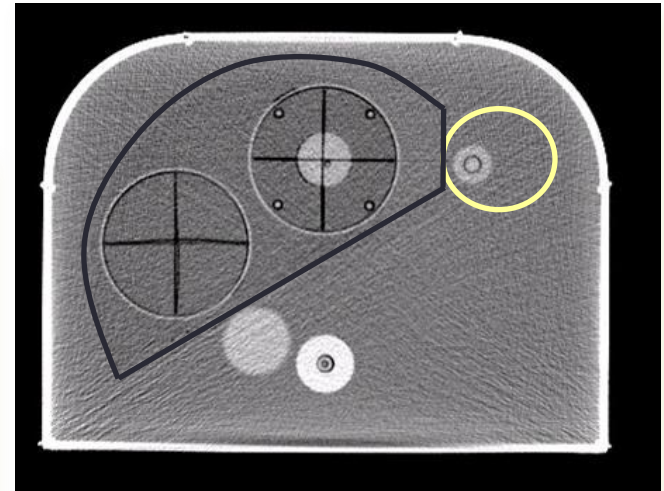


H&N (31)

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SRS Head (8)



Liver (2)



Table 7.3 Results from studies of the accuracy of dose determinations of IMRT treatments. (ESTRO IMRT QA booklet #9)

Reference	Region	Site	No	Mean	SD (%)
Gillis et al., 2005 ESTRO-QUASIMODO	Europe	Pelvis PTV OAR	10	1.014 0.997	1.6 3.6
Tomsej et al., 2005 GORTEC	France and Belgium	Head-and- neck	16	0.992	3.9
Ibbott et al., 2006 RPC-RTOG	USA	Head-and-neck Primary PTV Secondary PTV	450 223	0.99 0.99	8 7
Tomsej et al., 2007 ESTRO-OECI TomoTherapy	Europe	Fictitious volume (after internal QA)	7	0.966 0.978	2.4 1.5





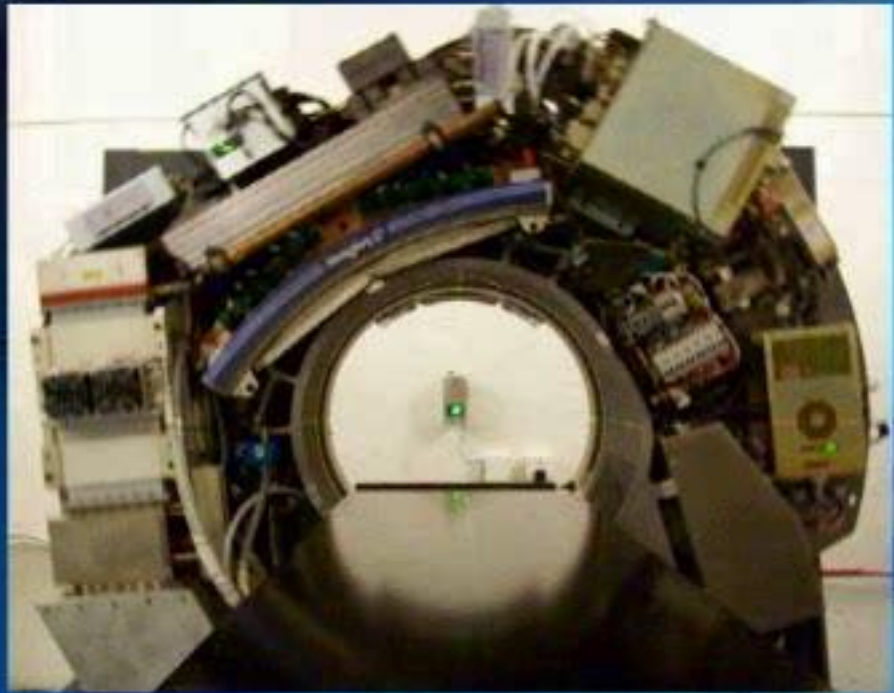
OECE

A new collaborative ESTRO-OECE Task Group on implementation of *external postal dosimetry audit* for new technologies in
Radiotherapy Clinical Trials:
The Helical Tomotherapy Working Group

***M. Tomsej, A. Bartels, S. Broggi, A. Chemin,
P. Francois, A. Lisbona, D. Nicholas, P. Nilsson, A.
Roue, R. Schmidt, K. Schubert, D. Verellen***



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TomoTherapy
HI-ART



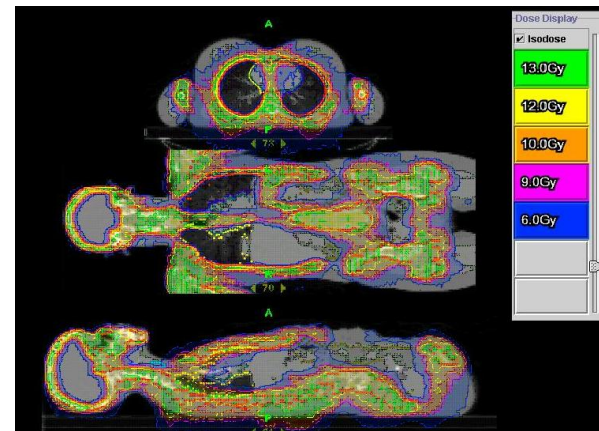
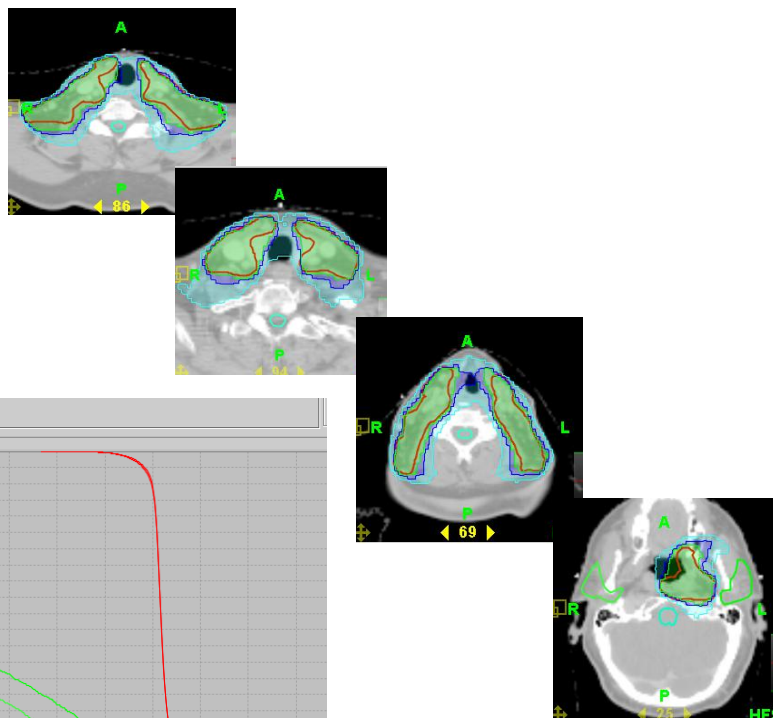
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NPL Management Ltd - Internal

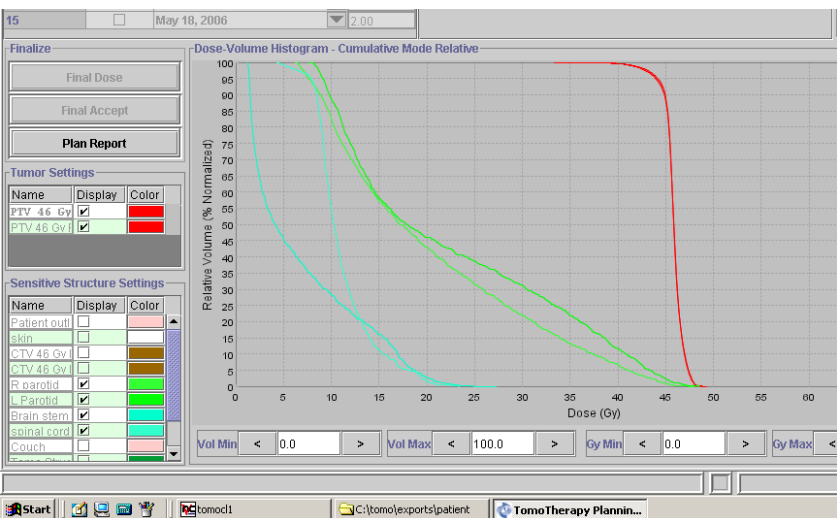


Aim

Head & neck case



TMI case



So ... we can realize nice dose distributions ...
How can the medical physicist check the doses claimed by the TPS ?
But what about traceability ?



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Around 30 000 segments ...

Material

- Phantoms
 - ESTRO Easycube phantom containing pre-loaded radiochromic films
 - Solid water (RW3)
 - Cheese phantom (from Tomotherapy Inc.)
 - Inserts for ion chambers
 - Inserts for TLDs capsules
- Detectors
 - Radiochromic films (EBT)
 - Self-developing
 - Nearly tissue-equivalent
 - Energy and field size independent
 - High spatial resolution
 - No fading
 - TLDs (Paris laboratory)
 - Big experience in lab
 - Appropriate for postal dosimetry audit

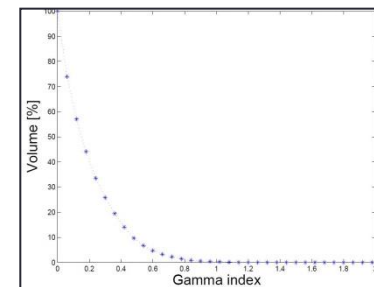
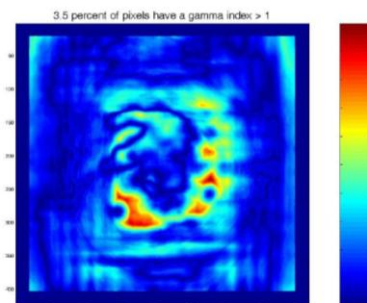
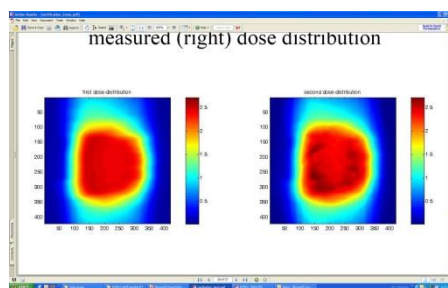
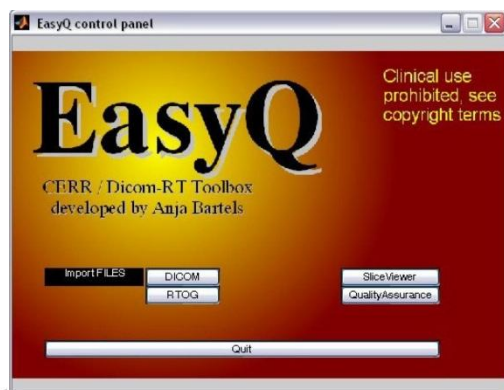


Material

- Software EasyQ (UKE - Hamburg)
 - Based on Matlab subroutines
 - Import calculated plans from TPS
 - Compare computed and measured dose distributions (from films) using different criteria



Appropriate for postal dosimetry audit !!!



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Methods - Process

- External postal dosimetry audit based on fixed clear protocol : criteria of inclusion
 - Select same clinical case for all centers:
 - Patient: head and neck
 - Technique: IMRT SIB (helical delivery)
 - Dose prescription:
 - PTV th. : 69 Gy (30*2.3 Gy)
 - PTV proph. : 55.5 Gy (30*1.85 Gy)
 - Machine parameters:
 - Pitch: 0.3
 - Field size: 2.5 cm
 - Modulation factor fixed to 2.0



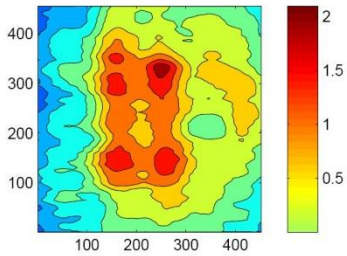
Results

- 1. Relative and absolute dosimetry

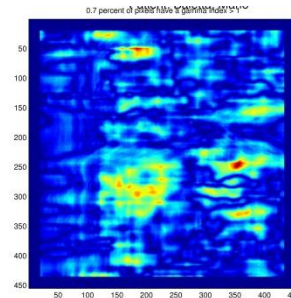
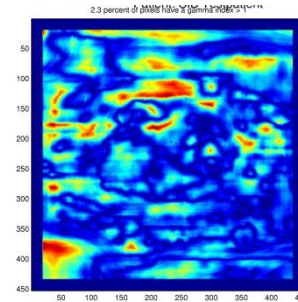
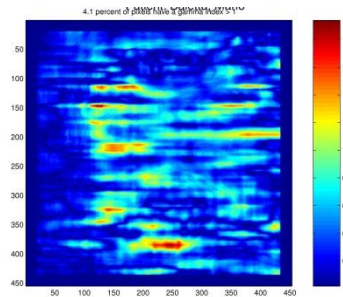
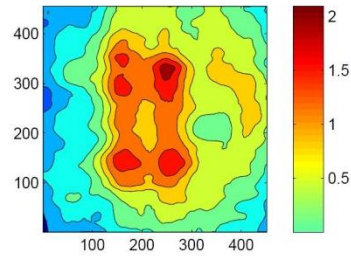
(radiochromic films set @ different planes -5cm, 0, +5cm)

- Dose distributions matching, gamma index distribution and histogram

contour plot of the first imported dose distribution



contour plot of the second imported dose distribution



Results

- 2. Crosscheck absolute dosimetry (TLDs)
 - “Output” Static beam (5cm*40cm, SSD= 85.0cm, z= 1.5cm, solid water rect. slab phantom, all leaves retracted, 1 min)

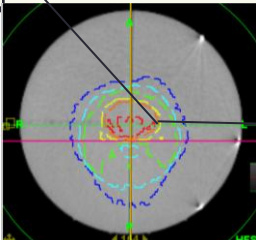
Site 1 (TLD/IC, %)	Site 2 (TLD/IC, %)	Site 3 (TLD/IC, %)	Site 4 (TLD/IC, %)	Site 5 (TLD/IC, %)	Site 6 (TLD/IC, %)	Site 7 (TLD/IC, %)
+1.4	-0.3	-0.7	+3.1/0.0 (intern QA)	1.3	-0.1	+0.9

- Modulated helical beam (clinical treatment conditions, located in “low-dose gradients”)

Site 1 (TLD/TPS, %)	Site 2 (TLD/TPS, %)	Site 3 (TLD/TPS, %)	Site 4 (TLD/TPS, %)	Site 5 (TLD/TPS, %)	Site 6 (TLD/TPS, %)	Site 7 (TLD/TPS, %)
-2.8	-4.2	-4.7 / -3.3 (intern QA)	-8.0 / +0.1 (intern QA)	-1.2	-0.1	-3.6
+6.2 / +7.6 (intern QA)	-1.9	-5.0 / -3.3 (intern QA)	-7.3 / -1.1 (intern QA)	-3.4	+3.6 / +4.7 (intern QA)	-3.7
-3.8	-4.9	-5.1 / -3.5 (intern QA)	-5.9 / -1.1 (intern QA)	-4.3	+2.2	-4.0



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The U.K. - PARSPORT trial

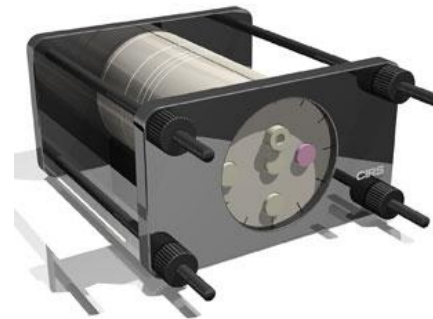
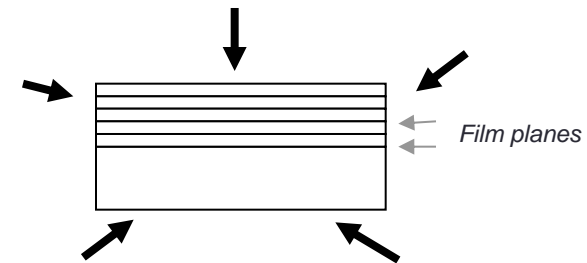
(C. Clark et al., 2009)

- Multi-centre randomised trial comparing IMRT and CRT for head and neck localisations
- Dosimetry audit: to verify plan delivery in participating centres, and develop IMRT credentialing program
- Rigorous pre-trial quality assurance program
 - *Volume delineation*, planning, process documentation, questionnaire and data transfer verification



Background to PARSPORT

- 1. Geometric (simple) TPS tests
- 2. Individual field verification films (gantry 0°)
- 3. Combined field film (gantry angles from the clinical plan)
- 4. Dose point measurements



Individual field results

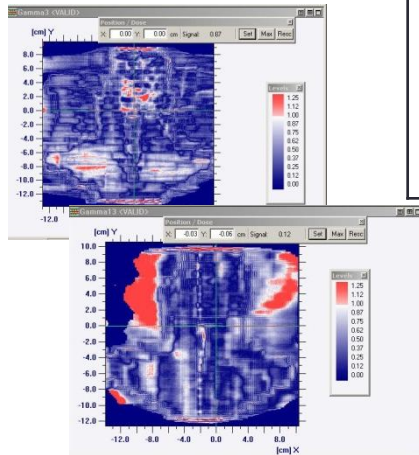
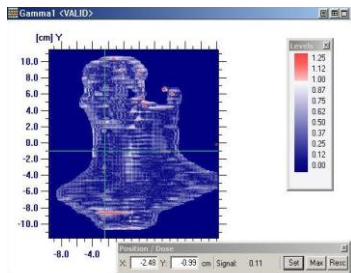
Combined fields results

Point doses results

Gamma parameters	% of films passing (/31)	Mean
4%/4mm	100% (31)	99.4
4%/3mm	100% (31)	98.7
3%/3mm	94% (29)	97.7
3%/2mm	84% (26)	95.0
2%/2mm	48% (15)	90.9

Gamma parameters	% of films passing (/12)	Mean
5%/5mm	100% (12)	99.4
5%/4mm	92% (11)	99.1
5%/3mm	92% (11)	98.7
4%/4mm	83% (10)	98.2
4%/3mm	75% (9)	97.4
3%/3mm	67% (8)	94.9

CONV IMRT	Dose average (Gy)	Dose range (Gy)	Centre no.						Mean	SD
			1	2	3	4	5	6		
PTV1	1.95	1.83-2.11	1.1	2.0	1.2	-0.9	0.0	0.9	0.7	1.0
	2.24	2.17-2.32	0.1	-0.4	-2.0	1.8	-2.4	-0.5	-0.6	1.5
PTV2	1.89	1.69-2.06	0.9	1.7	0.3	-0.3	-0.7	-2.6	-0.1	1.5
	1.82	1.68-2.02	0.5	2.2	-1.9	-2.7	-2.4	-0.7	-0.8	1.9
Cord	0.46	0.24-1.06	-1.7	0.0	-1.5	-35.8	2.9	-11.5	17.8	
	1.12	0.55-1.43	-0.5	2.4	-6.4	4.2	-4.9	-2.6	-1.3	4.1



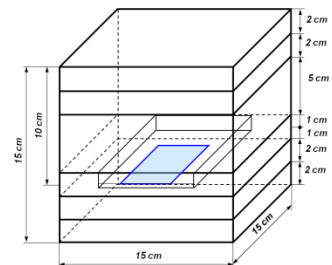
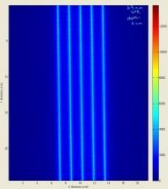
For future multi-centre head and neck IMRT trials suggest tolerances of:

- 3% for target point doses.
- 3%/3mm on individual films
- 5%/3mm for combined films



IAEA « Advanced Technology in Radiotherapy Dose Delivery »

- Description of new Research Project of IAEA
 - D. Followill (USA), D. Georg (Austria), J. Izewska (IAEA), M. Tenhunen (Finland), D. Thwaites (Australia), M. Tomsej (Belgium)
- Methodology
 - 1. IMRT Preliminary tests
 - Small field size dose rate dependence
 - MLC performance (picket fence test) for IMRT dose delivery (radiochromic film)
 - 2. Photon beam single IMRT field (TLD and film)
 - 3. « end-to-end » IMRT treatment delivery (including imaging, TP, setup, delivery) (TLD and film)



EORTC - Virtual Phantom Project

How ? Methodology ?

- Download a “dummy patient” (Dummy Run) and specific planning instructions and plan him
- Without modification in MUs, transfer the plan onto the site’s own homogeneous phantom
- Irradiate the phantom (as a real patient QA)
- Send the dosimetric results
 - Measurement of 2D dose planes by a capable device

Results:

- Work in progress



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Conclusions - take home messages

- New technologies no longer limited to academic centers, are being rapidly assimilated into diverse clinical sites
- Pre-clinical trials dosimetry
- “one is left applying manufacturers procedures” (International codes of practice for dosimetry not accommodated) : importance of external independent audit !
- It is essential that optimal dose delivery is maintained for all patients (especially where clinical trials are being implemented)



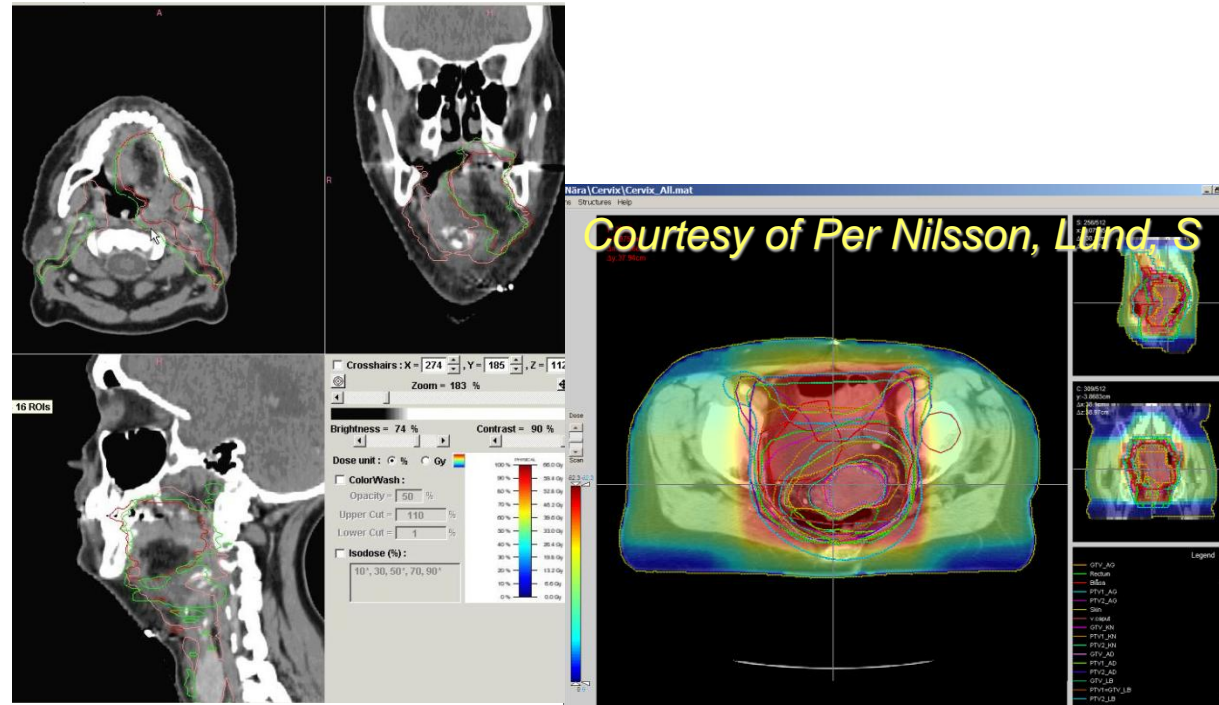
Conclusions - Proposal

- At present, for complex techniques (IMRT, rotational/helical techniques)
 - Beldart (B)
 - EORTC (Europe)
 - IAEA
 - NCS/VSL ? (NL)
 - NPL, PARSPORT (UK)
 - RPC – MD Anderson Laboratory (USA)
 - TROG (Asia-Australia)
- Interest of comprehensive dosimetry audit, eg end-to-end test
- Interest of site visits ? (when exceeding tolerance of ... ?)



Conclusions - Proposal

- Interest of auditing FFF beams ?
- Imaging systems ?
- !!! High importance of clinical (other than dosimetry) audits:
 - Selection of VOIs
 - Delineation of VOIs
 - ...



Acknowledgements

- EORTC ROG QA

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- IAEA (Joanna Izewska et al)

- RPC (David Followill et al)



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