Buyer Beware: QA of Outsourced Beam Modulators and Physics Work

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AAPM Spring Clinical Meeting

March 19, 2017

Outline

- QA for Outside Physics Services
  - Range of outside services which require verifications
  - Peer review recommendations and requirements
- Quality assurance for Beam Modulators
  - QA for photon-based Beam Modulators
  - QA for electron-based Bolus Conformal Therapy
- Conclusions

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Quality assurance for Physics Services: Introduction

Examples of “Outside Physics Services”

- Accept and/or Commission a medical device or procedure
- Provide temporary coverage for clinical physics services
- Outside consultant(s) to aid with equipment selection

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Quality assurance for Physics Services: Introduction

Preliminary Issues to Consider

- Ensure that where warranted, services are provided by a Qualified Medical Physicist
- Know hospital/outpatient facility credentialing guidelines for medical physicists
- Be specific in contract agreement with outside consultant
- Keep administrative personnel abreast of selection, negotiation process

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Quality assurance for Physics Services: Introduction

What Should I Verify from an “Outside Physics Service”?

- Some independent verification warranted in most circumstances
- Verification of all provided service may be unreasonable
- Reasonable verification should be similar to outside peer review of internal medical physics practice

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Quality assurance for Physics Services: AAPM Task Group 103

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 6, NUMBER 4, FALL 2005

AAPM Task Group 103 report on peer review in clinical radiation oncology physics

Per H. Halvorsen,[1] Indra J. Das,[2] Martin Fraser,[3] D. Jay Freedman,[4] Robert E. Rice III,[4] Geoffrey S. Ibbott,[5] E. Ishmael Parsai,[6] T. Tydings Robin Jr.,[7] and Bruce R. Thomadsen[8]

- Established by Professional Information and Clinical Relations Committee (PICR)
- Task Group Charges
  1. Gather information on existing peer review processes (e.g., RPC, ACR/ACRO practice accreditation)
  2. Formulate a framework for peer review between two clinical radiation oncology physicists
  3. Suggested format of written report summarizing the review

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Quality assurance for Physics Services: AAPM Task Group 103 - Introduction

- 29% of clinical physicists are only physicist in their department
- TG-11 of PICR recommends annual peer review by a QMP
- Physician colleagues long-time proponents of peer-review
    - ABMS MOC program which includes “evidence of evaluation of performance”
    - ABR support peer-review as a method of satisfying this MOC component

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Quality assurance for Physics Services: AAPM Task Group 103 - Summary

- Annual Review; or at least every three years
- On site visit and exit interview
- Written Report
- Peer review process is not to be adversarial

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Quality assurance for Physics Services: AAPM Task Group 103 - Components

1. Linac output calibration (within 5%)
2. Chart audit (N>5)
3. Review QA program
4. Physics program documentation
5. Physics program meets state/federal regulations

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Quality assurance for Physics Services: AAPM Task Group 103 - Components

6. Physicist professional development records
7. Arrangements for physics coverage
8. On-site coverage sufficient (although staffing-levels not discussed in TG)
9. Vendor service agreements
10. Review of last peer-review report

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Quality assurance for Physics Services: AAPM Task Group 103 - Checklists

PHYSICS INSTRUMENTATION CHECKLIST

This can be completed by the incumbent physicist prior to the reviewer's on-site visit, and mailed to the reviewer. In this case, the reviewer would only need to verify the information on site.

DATE: *11-15-03*

Facility Name: **Community Cancer Center** **Physicist name:** **Mary Precise**

Category	Description	Cal. Date & Institution
Ionization chamber 1	Manufacturer: Exradin Model: A12	8-1-03 K&S
Ionization chamber 2	Manufacturer: NEL Model: 2571	8-20-03 Indirect
Ionization chamber 3	Manufacturer: Std Imaging Model: HDR1000+	8-2-03 K&S
Electrometer 1	Manufacturer: Inovision Model: 35040	8-1-03 K&S
Electrometer 2	Manufacturer: Keithley Model: 35614	8-20-03 Indirect
Scanning dosimetry system ("water tank")	Manufacturer: Wellhofer Model: WP700 ☐ 2D ☒ 3D ☐ Multi-detector array	
Film dosimetry	Manufacturer: RIT Model: 113 Film scanner model: Vidar VXR-16DP	
Calibration phantom	Material: ☐ Poly ☐ Acrylic ☒ Solid H_2O ☒ Water Protocol: ☐ TG-21 or ☒ TG-51	
In-vivo dosimetry 1	Manufacturer: T&N Model: TN-RD-50	
In-vivo dosimetry 2	Manufacturer: Model:	
Special-purpose phantom (e.g. RPC anthropomorphic, "hybrid IMRT", etc.)	Manufacturer: Med-Tec Model/description: IMRT with heterogeneities	
Other	Describe:	
Thermometer(s) (quantity)	2 Mercury column ___ Thermocouple ___ Alcohol ___ Thermistor	
Barometer(s) (quantity)	1 Mercury column → *Are appropriate temperature and gravity (latitude) corrections applied?* Yes 1 Aneroid ___ Digital	

Privileged and Confidential Peer Review

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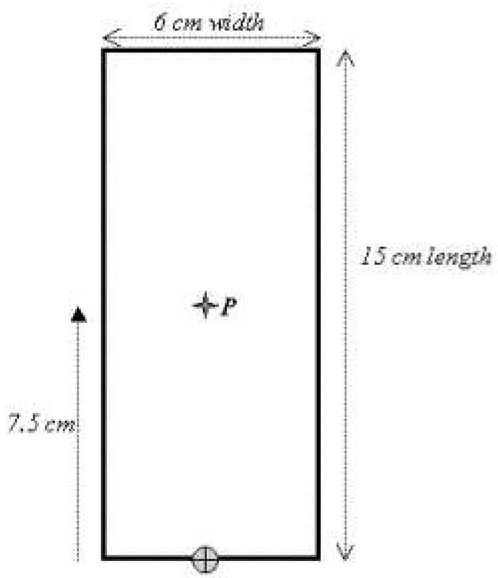
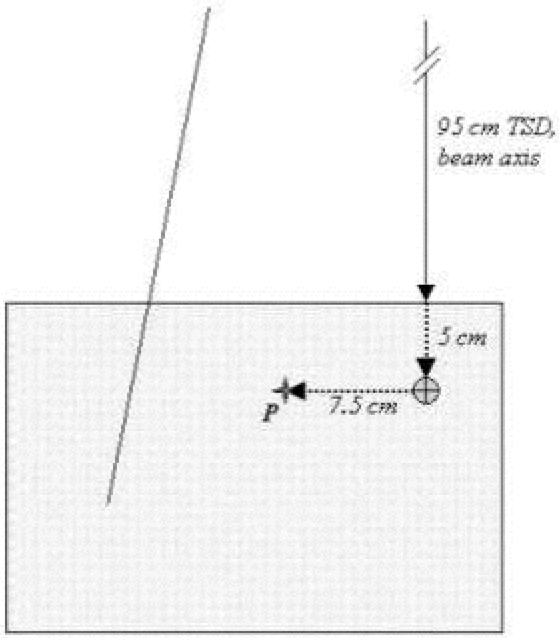
Quality assurance for Physics Services:

AAPM TG-103 – End-to-end Tests



BEV



Setup

Quality assurance for Physics Services: TG-103 Applicability

What TG-103 Recommendations are appropriate for Quality Assurance of “Outside Physics Services”?

- Exit interview/review of written report with consultant
- Repeat of important measurements (e.g., Linac output)
- End-to-End test(s)
- Internal report of in-house verification

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Quality assurance for Beam Modulators: Photon Compensators – Introduction

- Physical compensators for photons have been used for years; Compensators for IMRT first suggested by Brahme.
- Photon IMRT Compensators have many advantages:
  - Higher resolution in the direction normal to MLC leaf travel
  - No matchline/tongue-and-groove problems
  - No interplay effects: All parts of the field are simultaneously irradiated
  - Wider fields possible
  - More monitor unit and treatment time efficient
  - Dose computation simpler/more accurate

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Quality assurance for Beam Modulators: Photon Compensator – Quality Assurance

- Quality Assurance for compensator-based IMRT delivery
  - Manual check of thickness versus position (Salz et al., 2005)
  - Point dose measurements in phantom
  - In vivo dosimetry (Chang et al., 2004)
  - Standard Copy-to-Phantom technique

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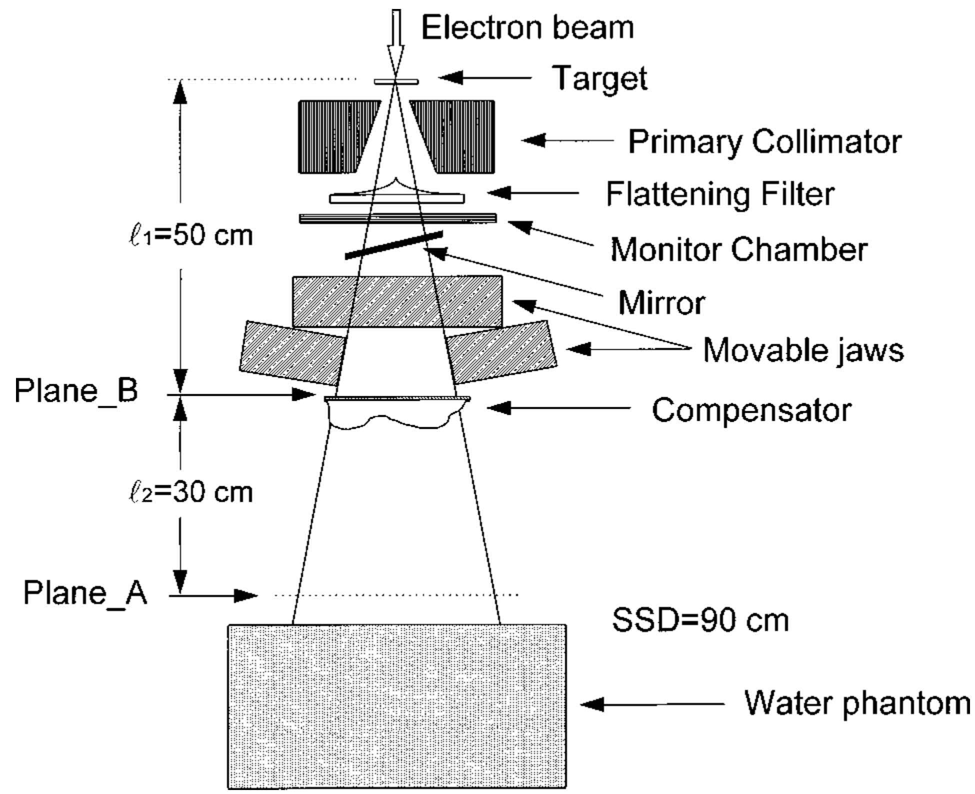
Quality assurance for Beam Modulators: Photon Compensators – Beam Hardening

On compensator design for photon beam intensity-modulated conformal therapy

Steve B. Jiang[a] and Komanduri M. Ayyangar
Department of Radiation Therapy, Medical College of Ohio, 3000 Arlington Avenue, Toledo, Ohio 43614-2598

Med Phys ***25****(5): 668-675 (1998)*

- Developed automated compensator design algorithm
- Calculated beam effects (energy, scatter, surface dose) of compensator using MC (Omega code)
- Reported results for 6MV photons with cerrobend compensators



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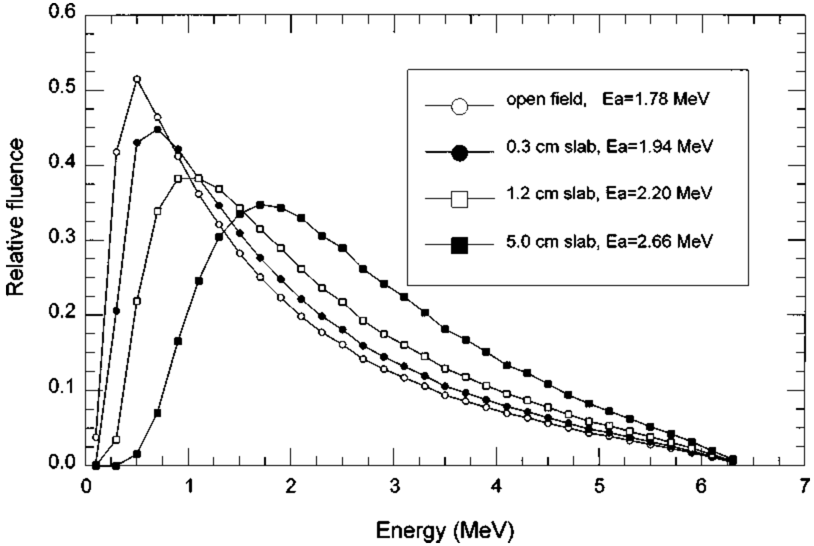
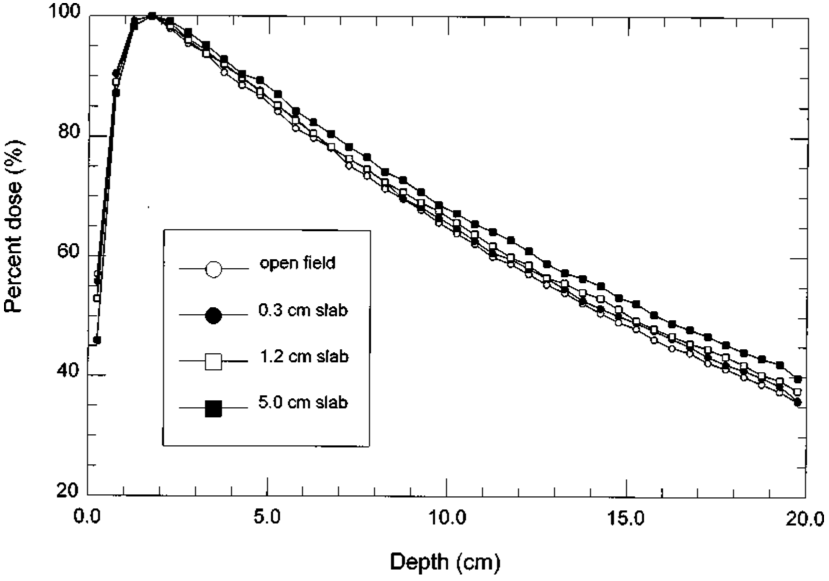
Quality assurance for Beam Modulators: Photon Compensators – Beam Hardening





Jiang and Ayyangar, Med Phys 25: 668 (1998)

Quality assurance for Beam Modulators: Photon Compensators – Film Dosimetry

IMRT with Compensators for Head-and-Neck Cancers

Treatment Technique, Dosimetric Accuracy, and Practical Experiences

Henning Salz, Tilo Wiezorek, Marcel Scheithauer, Michael Schwedas, Jochen Beck, Thomas Georg Wendt[1]

*Stahlentherapie and Onkologie **181**: 6650-672 (2005)*

- MCP96-compensators demonstrate energy-depedendent discrepancies with radiographic film dosimetry (X-omat and EDR2)
- Differences ~5% between thin (3-4mm) and thick (30-35mm) compensator thicknesses
- Recommend other dosimeters (ion chambers, TLDs, etc..), or account for energy dependence in analysis

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Quality assurance for Beam Modulators: Photon Compensators – Film Dosimetry

The value of EDR2 film dosimetry in compensator-based intensity modulated radiation therapy

R P Srivastava and C De Wagter

Department of Radiotherapy, Ghent University Hospital, De Pintelaan 185, B-9000 Gent, Belgium

*Phys Med Biol **52**(19): N449-N457 (2007)*

- MCP-96 Compensators of thicknesses up to 5 cm
- Measured depth doses/profiles from 6MV & 25MV photons (Elekta SL25)
- Compared results between EDR2 and diamond detector
- Concluded film underresponse from hardening (~1-1.5%) within overall uncertainty of film dosimetry (3%).

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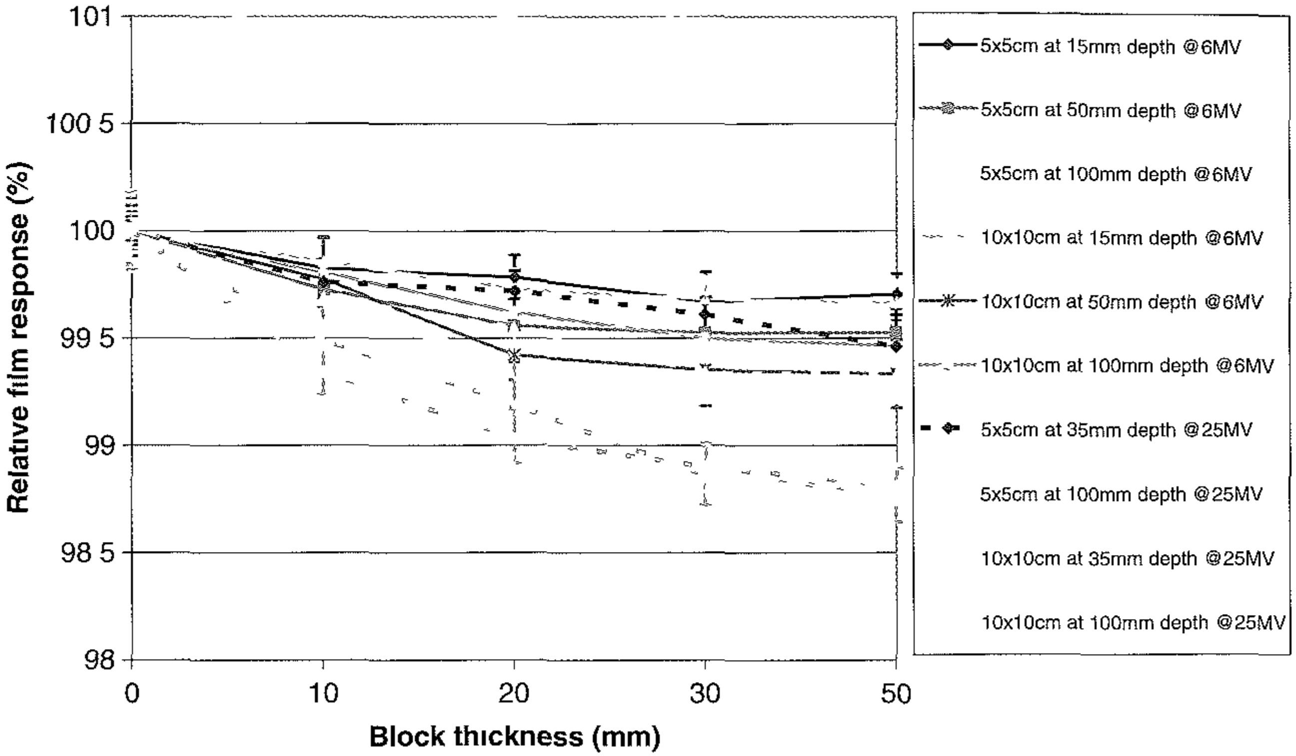
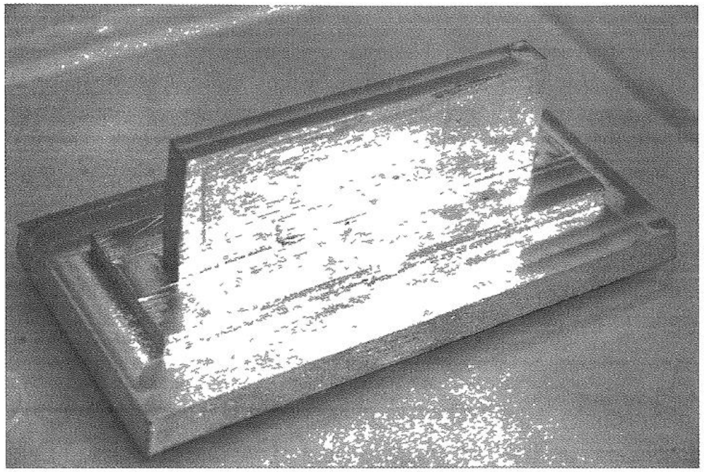
Quality assurance for Beam Modulators: Compensators – Film Underresponse

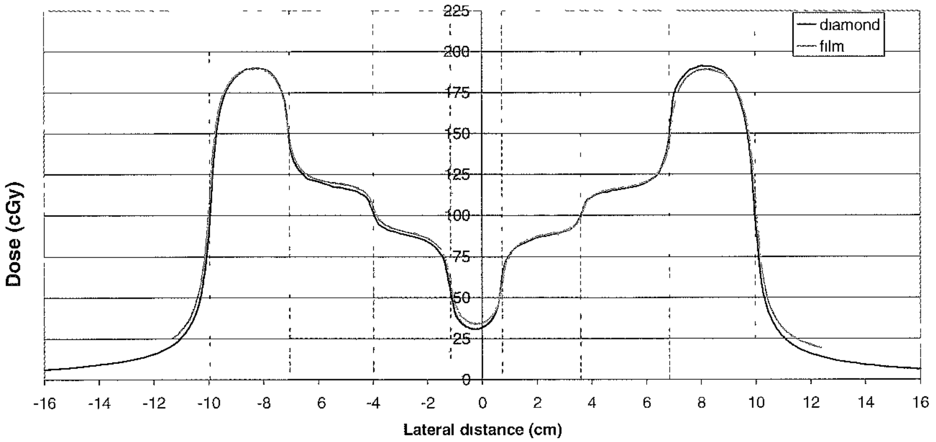


Srivastava and Wagter, Phys Med Biol 52: N449 (2007)

Quality assurance for Beam Modulators:

Compensators – Film v Diamond Detector





(b)

Srivastava and Wagter, Phys Med Biol 52: N449 (2007)

Quality assurance for Beam Modulators: Bolus - Electron Conformal Therapy

- Bolus ECT technology is provided by .decimal, LLC:
  - Free bolus design software *planning.decimal* (p.d) compatible with most treatment planning systems
  - Bolus is fabricated and mailed to clinic for reasonable cost

- Accuracy of electron dose algorithms well documented for bolus ECT:
  - p.d PBRA
  - Varian eMC
  - Pinnacle PBA

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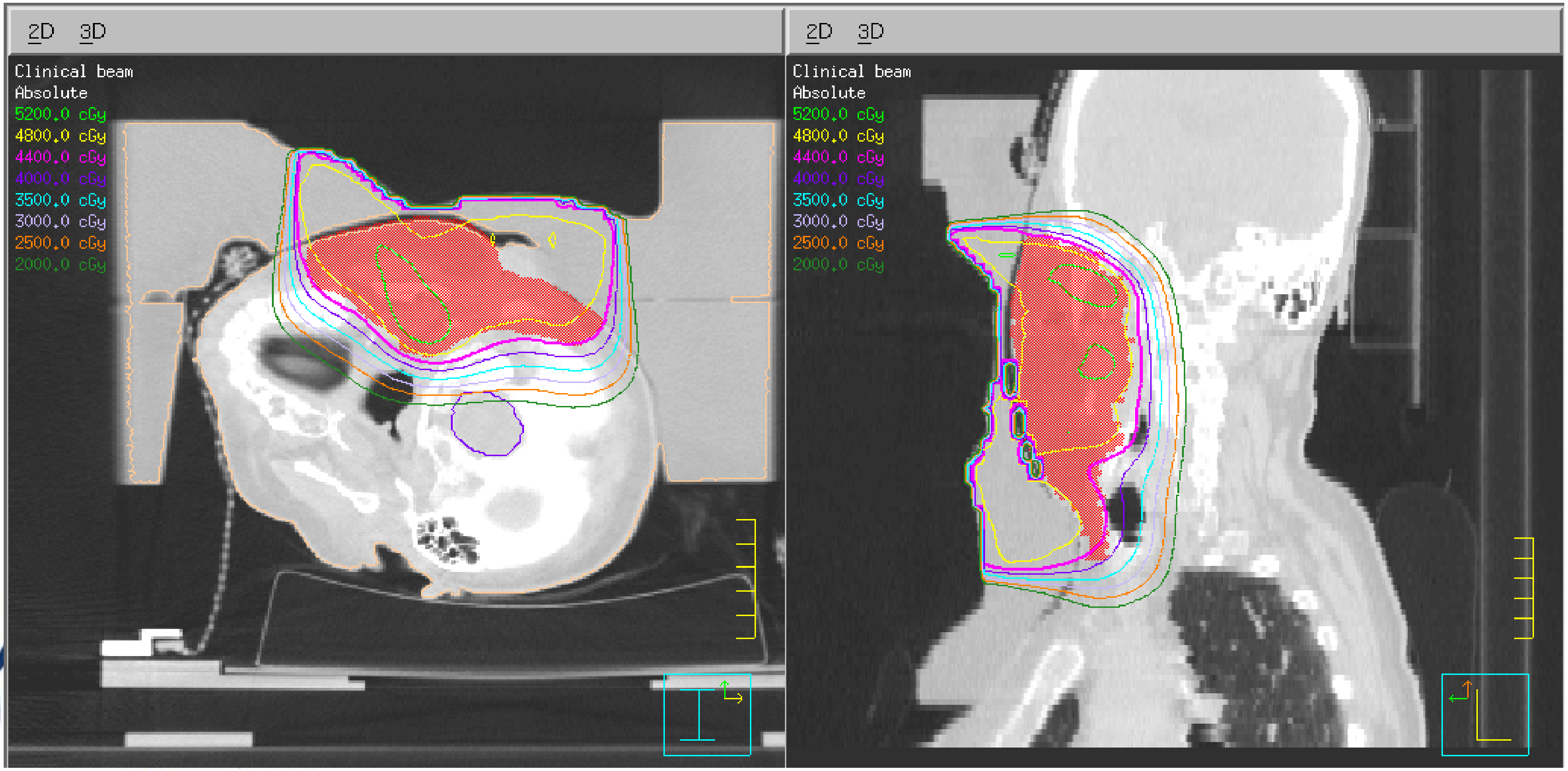
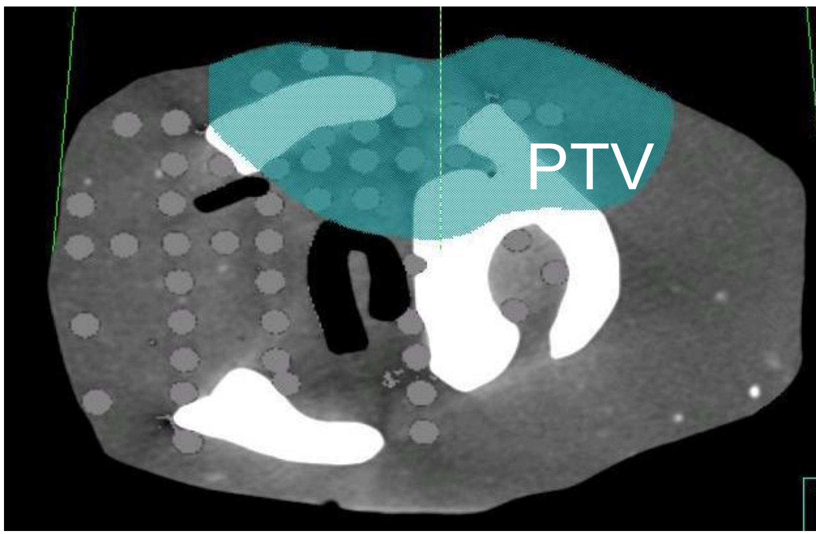
Quality assurance for Beam Modulators: Bolus - Electron Conformal Therapy

- Conforms 90% isodose to PTV
- Decreases dose to normal tissues
- Reduces dose heterogeneity with irregular patient surfaces

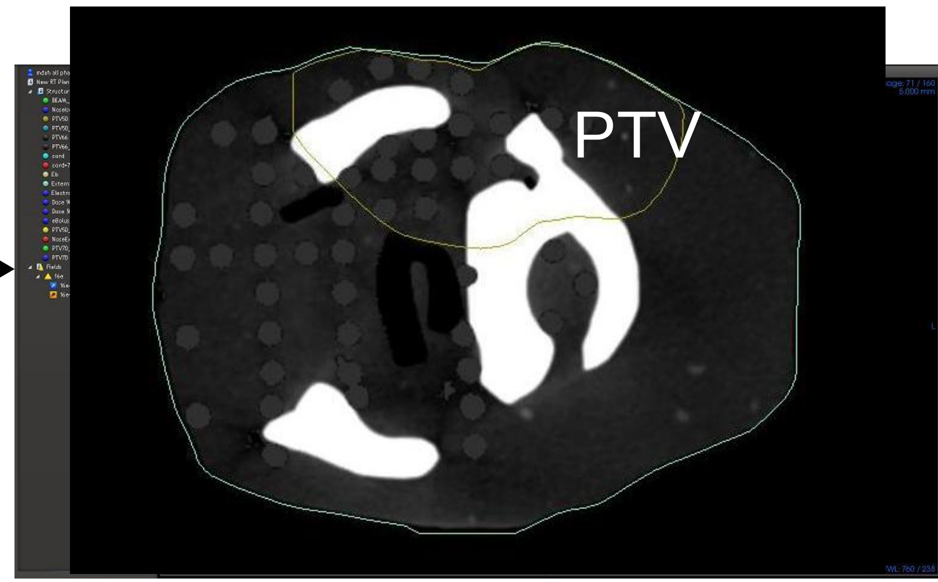


Quality assurance for Beam Modulators:
Bolus ECT – Planning Process

Pinnacle Treatment Planning System



p.d Bolus Creation Software



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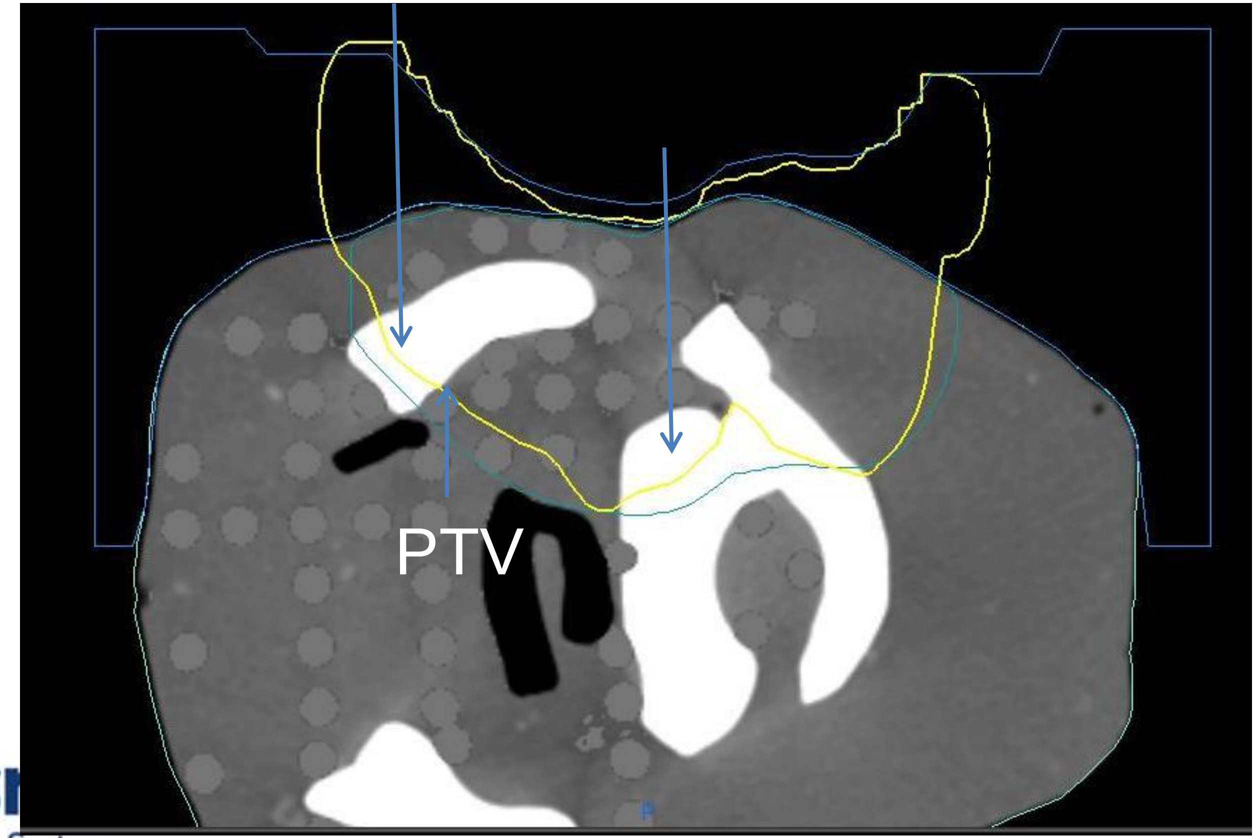
Quality assurance for Beam Modulators: Bolus ECT – Planning Process

Initial Bolus design assigns a constant distance (R_{90}) from the bolus surface to the distal surface of the PTV, as indicated by the arrows



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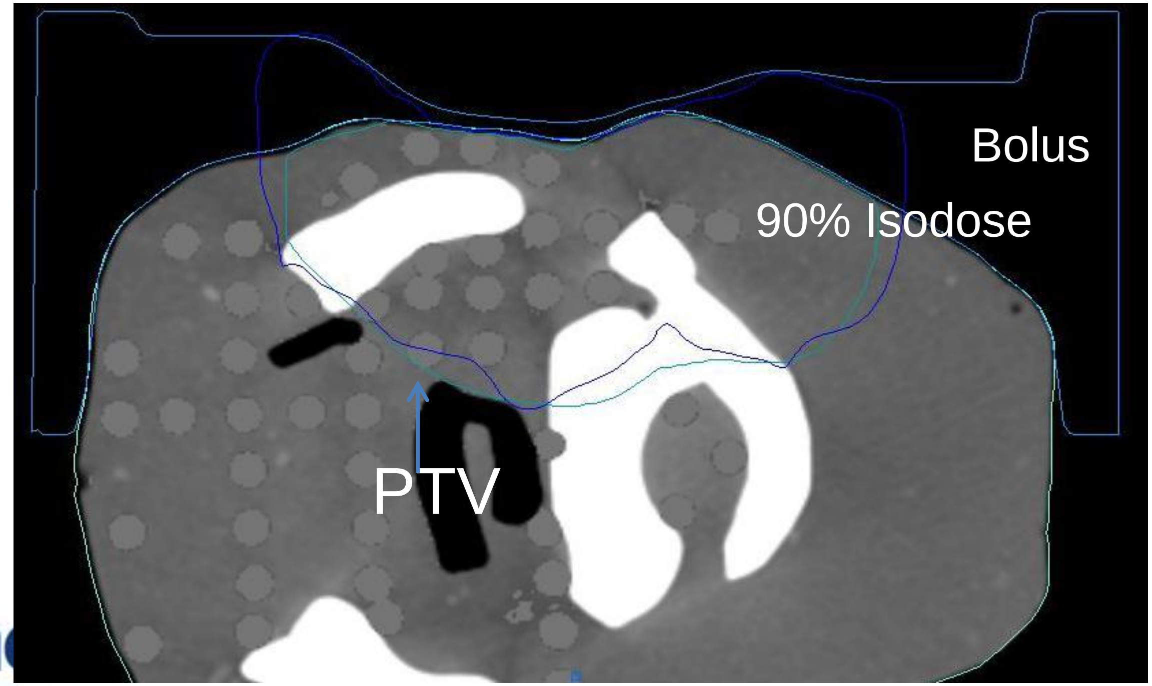
Quality assurance for Beam Modulators: <u>Bolus ECT – Planning Process</u>

The user optimizes the bolus shape until a satisfactory dose distribution is achieved using :

- Previously published operator sequences (Low et al. 1992)
- User defined Low operator sequences
- .decimal’s marching algorithm



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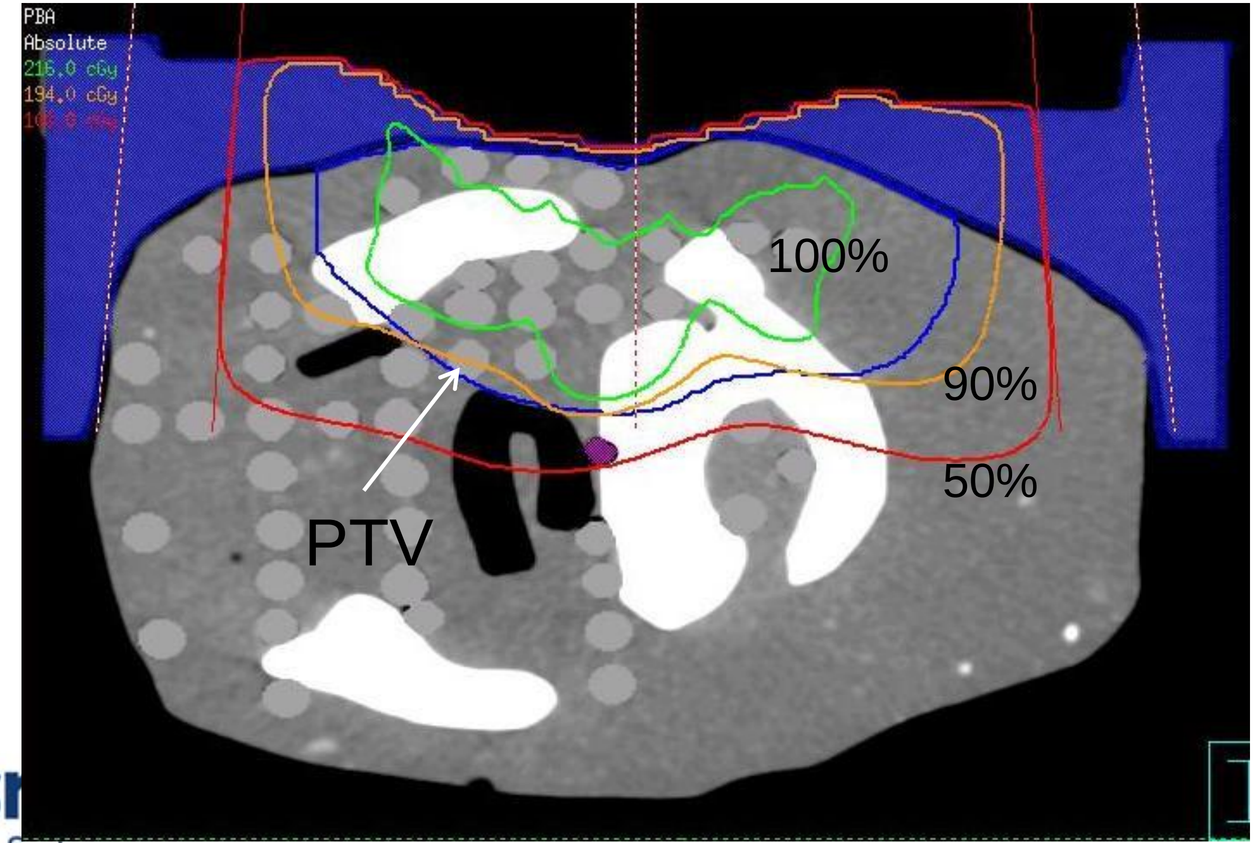
Quality assurance for Beam Modulators: Bolus ECT – Planning Process

Final bolus structure is:

- Exported back to TPS (e.g. Pinnacle[3]) for dose calculation
- Electronically transferred .decimal for fabrication



Quality assurance for Electron Bolus

Bolus ECT - Clinical Examples

http://dotdecimal.com/products/electrons/bolusect/

Posterior Chest Wall
- Sarcoma (Low et al. 1995)
- Chondrosarcoma (Kudchadker et al. 2002)

Post Mastectomy Chest Wall
- Disease at CW-IMC Junction (Perkins et al. 2001)
- With Surgical Defect (Kudchadker et al. 2002)
- Post Treatment Recurrence (Kim et al. 2012)
- Altered Chest Geometry (Perkins et al. 2001)

Head and Neck
- Parotid (Kudchadker et al. 2003; Boyd et al. 2003)
- Buccal Mucosa (Kudchadker et al. 2002)
- Ear (Kudchadker et al. 2003)
- Nose (Zeiden et al. 2011)

Extremities
- Foot (Su et al. 2014)

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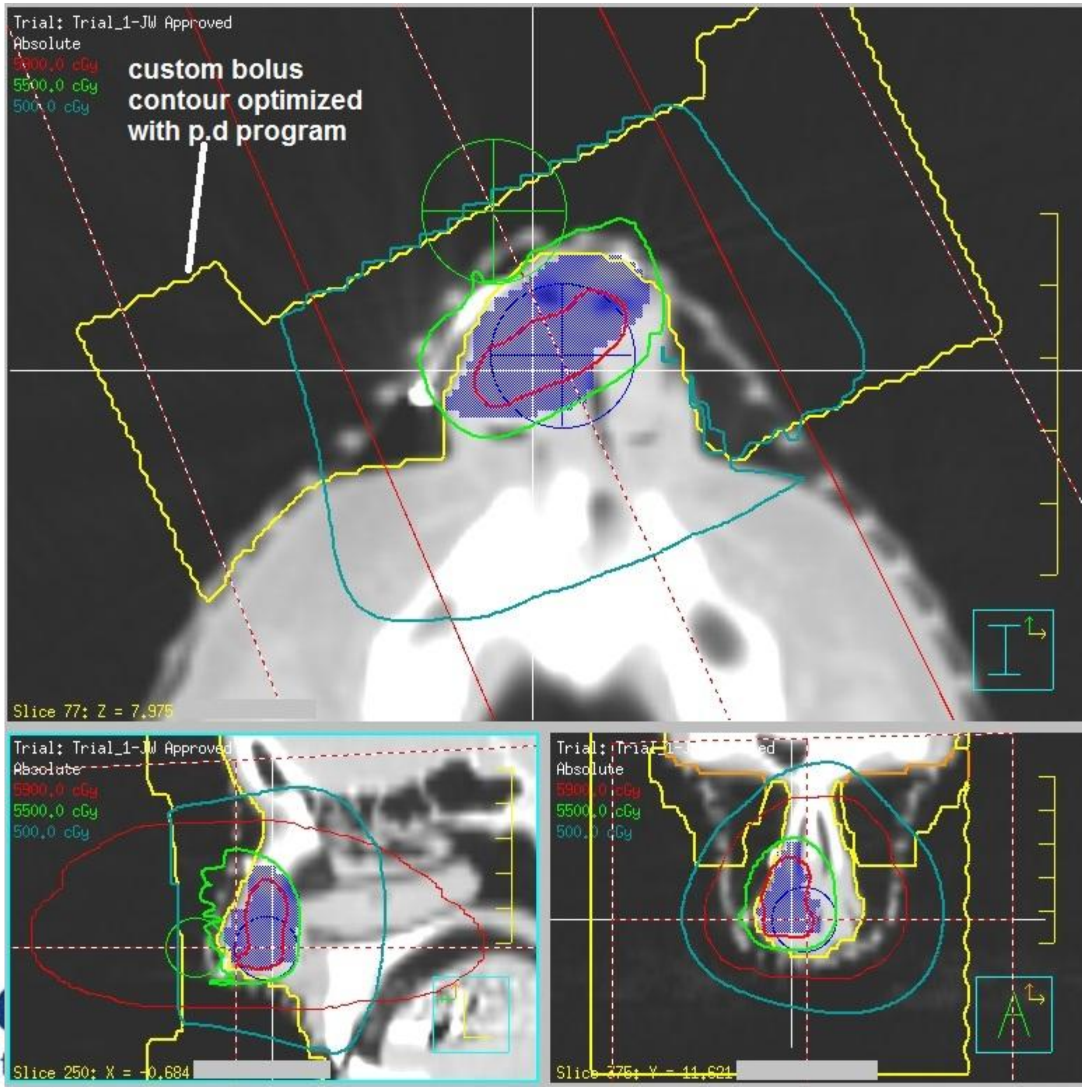
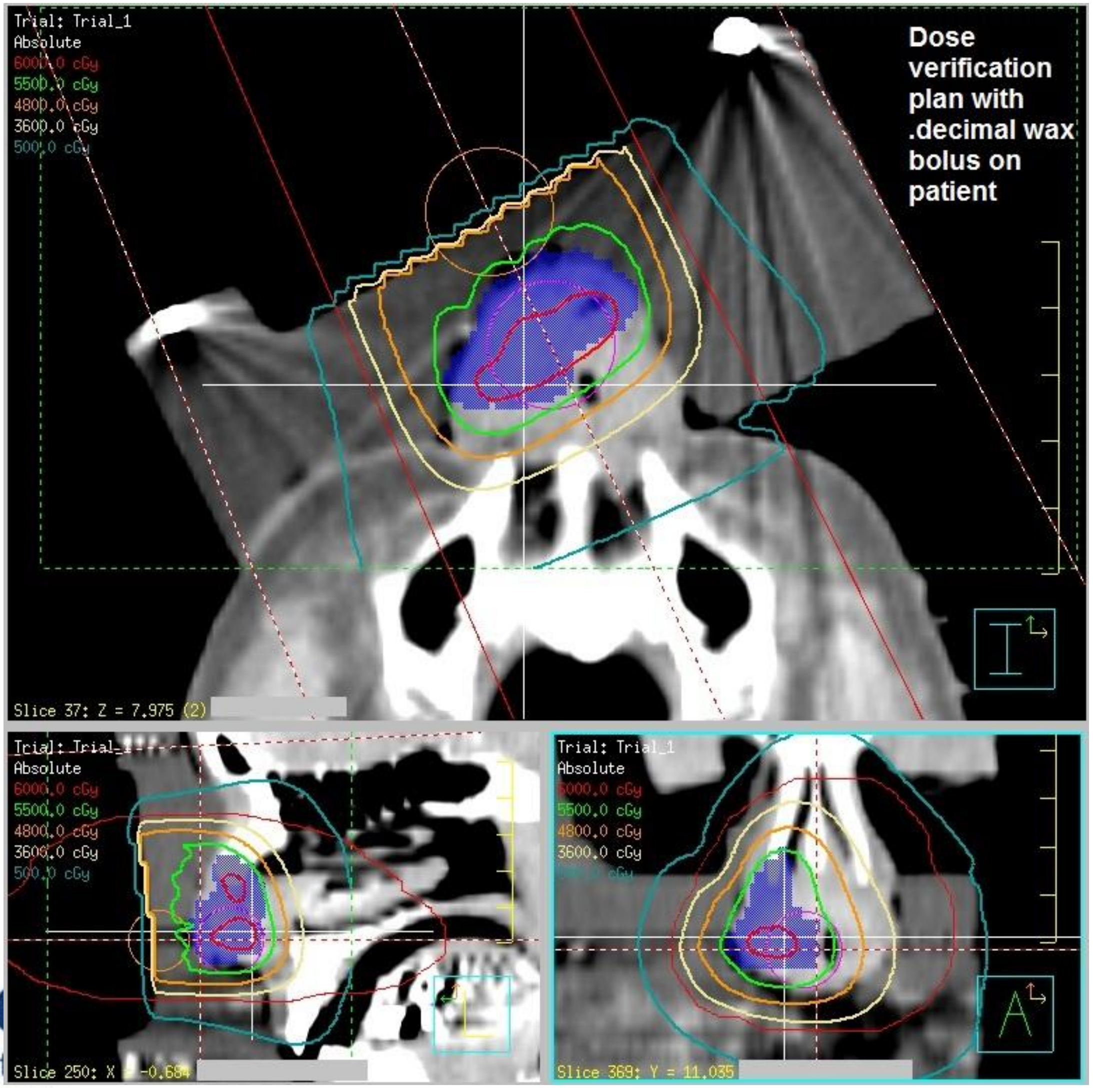
Quality assurance for Beam Modulators:

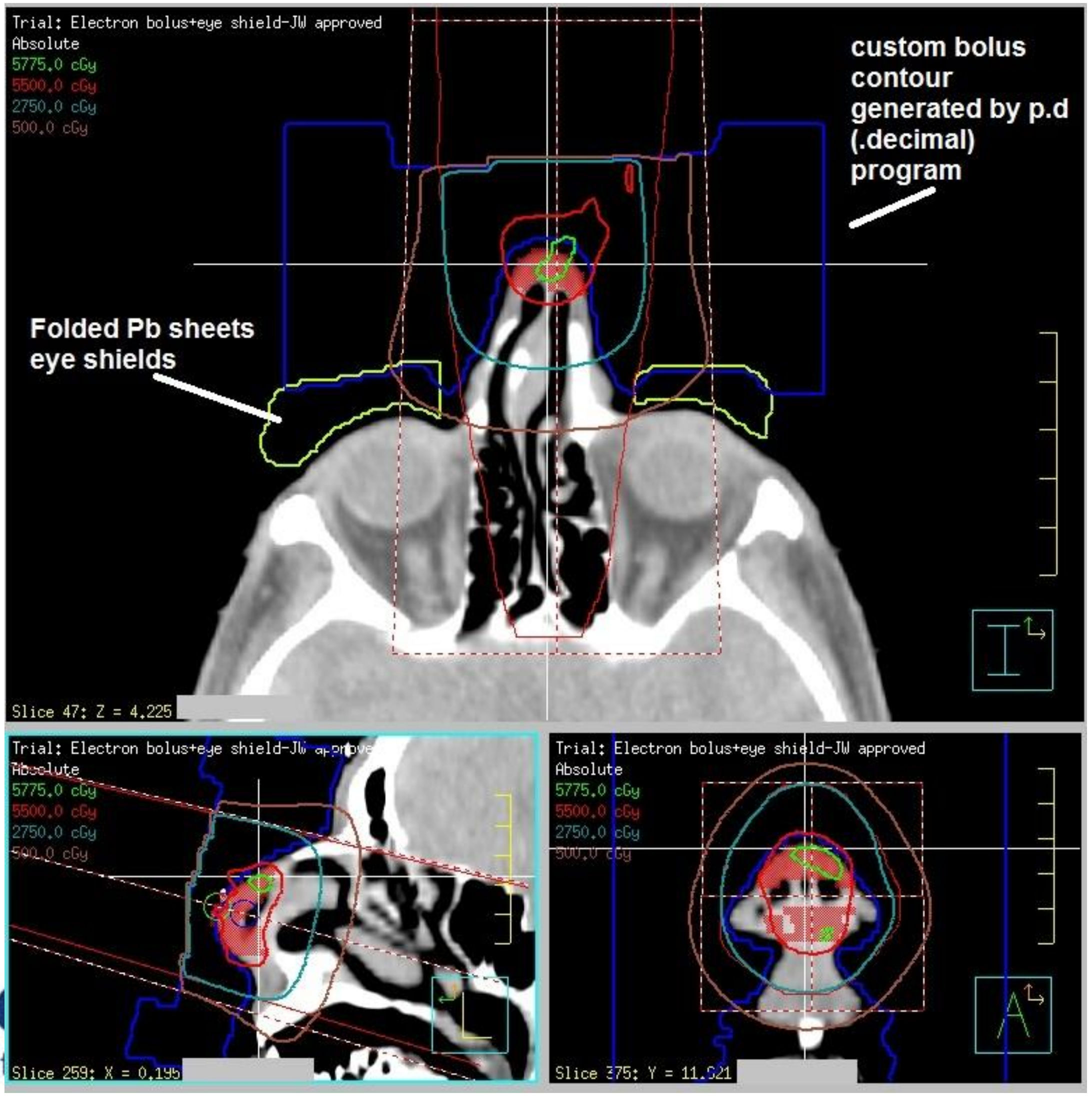
Bolus ECT – Verification Case 1



Quality assurance for Beam Modulators: Bolus ECT – Verification Case 1



Quality assurance for Beam Modulators: Bolus ECT – Verification Case 2



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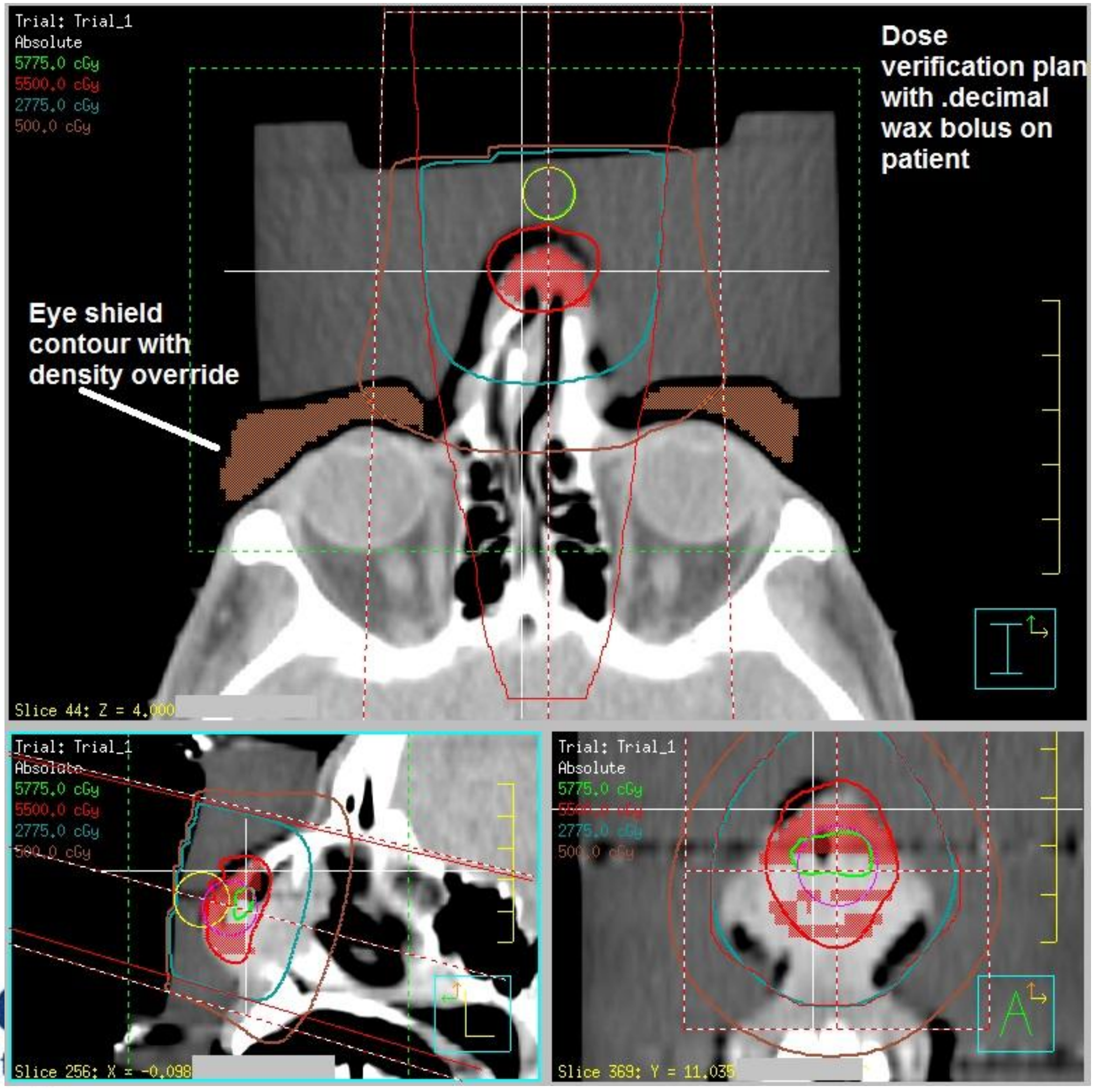
Quality assurance for Beam Modulators: Bolus ECT – Verification Case 2



Quality assurance for Beam Modulators: Bolus ECT – Verification Criteria

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 4, NUMBER 4, FALL 2003

Utilization of custom electron bolus in head and neck radiotherapy

R. J. Kudchadker,* J. A. Antolak, W. H. Morrison, P. F. Wong, and K. R. Hogstrom
Department of Radiation Physics and Department of Radiation Oncology, The University of Texas, M. D. Anderson Cancer Center, 1515 Holcombe Boulevard, Houston, Texas 77030

- Two patients (ear and parotid gland) treated using Bolus ECT
- Bolus designed using in-house TPS; patient rescanned and verified with Pinnacle[3].
- Criteria: 90% Isodose with 2mm; Dose within 90% within 3%

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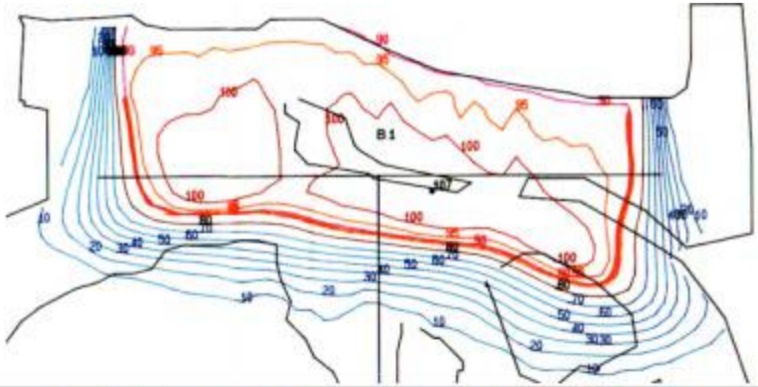
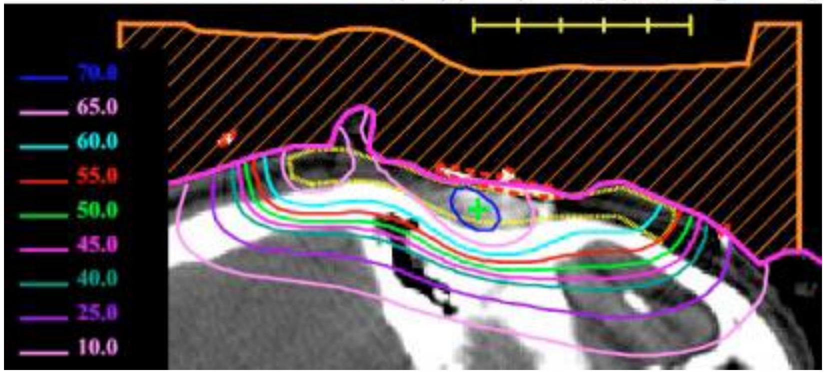
Quality assurance for Beam Modulators:

Bolus ECT – Quality Assurance





Kudchadker et al, JACMP 4(4): 321 (2003)

Quality assurance for Outsourced Work: Conclusions

- Outsourced clinical physics services should be reviewed
  - Local credentialing and/or license requirements should be met
  - Tasks should be specified in as much detail as possible
  - Peer review guidelines of TG-103 may serve as a guide

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Quality assurance for Outsourced Work: Conclusions

- Photon compensators
  - Offer many advantages over conventional MLC-based IMRT.
  - May be verified by physical inspection along with the same methods as those for MLC-based IMRT.
  - Energy-independent detectors are preferred, although the magnitude of these effects are controversial.

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Quality assurance for Outsourced Work: Conclusions

- Bolus Electron Conformal Therapy (Bolus ECT)
  - is a new technique that uses custom milled wax bolus to shape the D_{90} isodose to cover the PTV.
  - has been shown to treat a number of superficial sites
  - is verified by rescanning and recalculating the patient with the optimized bolus in place.

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Acknowledgements:

- Robert Carver, Ph.D. Mary Bird Perkins
- Connel Chu, M.S. Mary Bird Perkins