Enhancing a Physicist's Role in the Assessment of Treatment Plan Quality

Disclosures

Learning Objectives

- To define quality in radiotherapy treatment planning
- To understand the role of a physicist in determining quality
- To learn how to evaluate technical features than affect plan quality
- To learn how to evaluate clinical features than affect plan quality
- To understand how automation and data-drive plan quality control tools can be used clinically to support quality

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Definition of quality

Quality (Merriam Webster):

“How good or bad something is.”

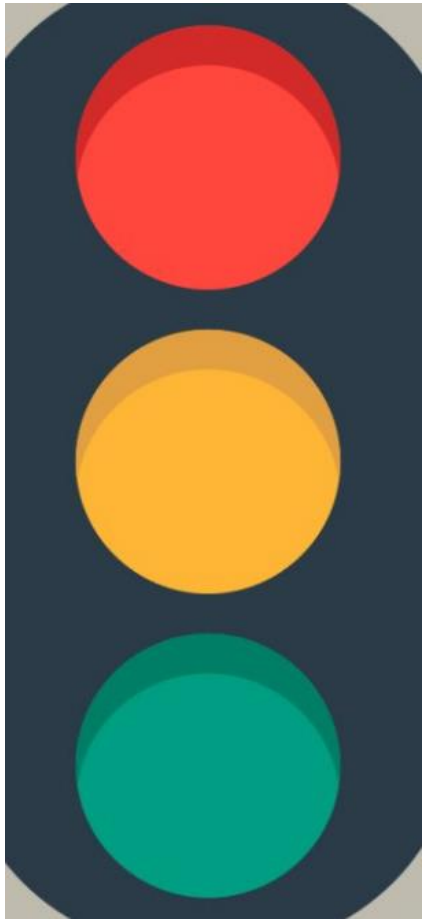
Plan quality (TG-308):

“Given a desired therapeutic dose of radiation to a patient, treatment plan quality is the degree to which a dose distribution maximizes tumor control and minimizes normal tissue injury for a given technique.”

Features impacting plan quality

Clinical aspects:	**Technical aspects:**
• Patient specific target/OAR relationship • Contour accuracy • Balance of target coverage and normal tissue sparing • Patient's physical limitations	• Patient setup and immobilization • Motion management • Treatment planning scan quality • Treatment technique • Optimization

Stoplight approach to plan quality



Unacceptable: Plan is unsafe for treatment

Acceptable: Plan will not harm patient, but could be improved

High Quality: Plan strikes a balance between target coverage, normal tissue sparing, robustness, and clinical practicality

Spectrum of Plan Quality

SAM Question #1

- Plan quality:

a) Maximizes tumor control
b) Minimizes normal tissue injury
c) Depends on treatment technique
d) All of the above

Reference: TG-308 – not sure if we can use this yet?

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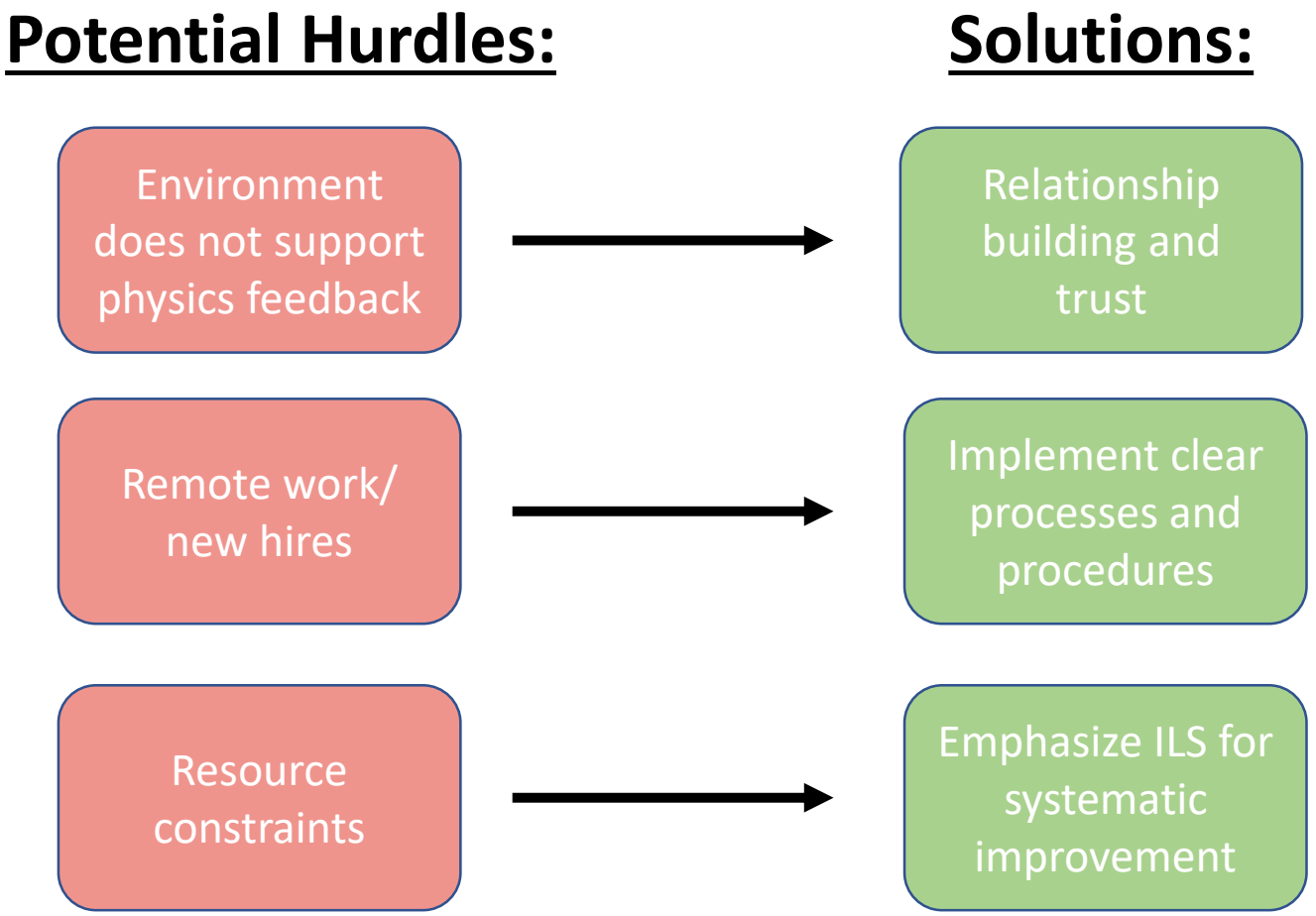
Role of a Physicist in Radiation Oncology

"The first responsibility of the radiation oncology physicist is to the ***patient***--to assure the ***best possible*** treatment given the state of technology and the skills of the other members of the radiation oncology department." – Task Group 38

Create a culture that promotes quality

1. Multi-disciplinary, collaborative approach to achieve the best plan possible for a given patient
    - Discuss quality early in the planning process to receive feedback from all team members
2. Review plans as a physicist with a critical eye
    - Is the dose distribution optimal for this patient?
    - Could technical aspects/robustness of the plan be improved?
    - Is the plan clinically practical?
3. Implement automation and data-driven methods to support quality

Potential hurdles to a culture that promotes quality



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Overview

- Slide on goals for this section
  - Provide a high level review of many parameters physicists should consider
  - Relavent examples provided
  - Not comprehensive
  - Discuss that a plan quality check is often most beneficial prior to physician review and plan write up.

Technical Review – Beam Configuration

- Number of arcs
  - Too few:
    - Reduced degrees of freedom necessary for maximum OAR sparing/target coverage
  - Too many:
    - Decreased delivery efficiency, slow dose rate (arcs)
  - Often standardized
    - Depends on institution, treatment site, complexity
    - For arc treatments,
- Example (keep as comment) (Eric)
  - Simple vs. complex
  - Patient specific parameters can dictate
  - Institutional/individual practice can guide

Technical Review – Beam Configuration

- Arc/Field Angles (Dustin)
  - Preferential path to target while minimizing in-field OARs
    - Example: CW VMAT
    - Example: Prostate Static Field utilizing lateral fields
  - Clearance of patient
    - Both for field path AND between fields/arc
    - Minimize shifting of patient
    - Example: posterior field from contralateral side

Technical Review – Beam Configuration

- Arc/Field Angles (Minsun)
  - Maximize target coverage from multiple angles
    - Example: Not covering all aspects of target causing dose streaking
  - Minimize entry through critical OARs with low dose objectives
  - Avoid entry through poorly reproducible anatomy
    - Example: Shoulder reproducibility for HN patients impacting dose to target and cord.

Technical Review – Beam Configuration

- Collimator Angles (James)
  - Utilize collimator angles to minimize in-field OARs
    - Example: Breast/CW VMAT plans
  - Varying collimator angles for multiple arcs to increase degrees of freedom
  - No zero collimator angle for VMAT
    - Example: Zebra stripe leakage effect (maybe more impactful for older linacs)
  - Orientation of MLCs relative to targets
    - Example: Concave targets
    - Example: Multi-met targets with single isocenter

Technical Review – Beam Configuration

- Field Size Selection (Joey)
  - For large targets
    - Carriage splits vs. broad field optimization
    - Maximize critical OARs with low dose objectives under the jaws
    - Limited jaw size and MLC travel
  - Examples:

Technical Review – Optimization Strategy

- No one correct way to optimize (James, Dustin)
  - Objective weighting variability,
  - Utilization of point vs global objectives
  - Differences in planning systems
- Review of optimization objectives used still beneficial
  - Achievable objectives
  - Conflicting objectives
  - Omitted OARs/Targets
  - General objective weight strategy

- Example from optimizer of two different optimization strategies for same treatment site?

Technical Review – Optimization Strategy

- Achievable Objectives (James, Dustin)
  - All targets have lower objectives
  - Upper objectives above lower objectives by sufficient amount
  - Lower objectives exist only on target volumes
- Example from optimizer for IMRT and SBRT
  - Describe these are strategies for exploring for issues
  - Tips for troubleshooting
  - Use a Unacceptable plan as an example, then go into opt strat
- OAR/target objectives omitted from optimization

Technical Review – Optimization Strategy

- Conflicting Objectives (Dustin, James)
  - OAR/Target objectives not simultaneously achievable
  - Optimizer may prioritize these conflicting objectives, minimizing sparing of other OARs
  - Maybe visible through general review of objectives or impact of each objective on the optimization
  - Solutions:
    - Physician provided ranking for objectives
    - Creation of optimization structures that exclude overlap region
- Example: Min dose to target lower than max dose to OARs in optimizer
- Example: Weight within optimizer for above example prioritizing these two structures

Technical Review – Optimization Strategy

- Objective weighting review (Mu-Han)
  - General weighting on objectives should follow target/OAR prioritization
  - Should be reasonable relative to build-in parameters
- Example: Show prioritization list and OAR optimization weight
- Example: Show smoothing weighting values in Eclipse

Technical Review – Plan Modulation

- Heavily modulated plans may exceed accuracy of dose calculation models
  - Resulting QA rates may start to decrease
  - Best to evaluate and mitigate prior to plan approval/write-up/QA
- Plan complexity evaluation includes
  - MU/modulation ratios within expected ranges (planning modality and treatment site)
  - MLC aperature size and motion within BEV
  - Complexity factors when available
- Examples: MU Ratio ranges for standard plan vs. complex plan?

Technical Review – Density Overrides

- Treatment Couch (Carlos, Jose)
  - Correct couch, position, type and density
  - Dosimetric Impact of couch – Need paper, likely good SAM questions
- Examples: Visual impact of couch added vs. not added

Technical Review – Density Overrides

- Artifact/Contrast overrides (Carlos, Mu-Han)
  - Not physically present during treatment
  - Location, volume, proximity to target all dictate when it is important
  - No universal standards
- Examples: High density artifacts in/near target
- Examples: Contrast override in/near target.

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Clinical Review - Images

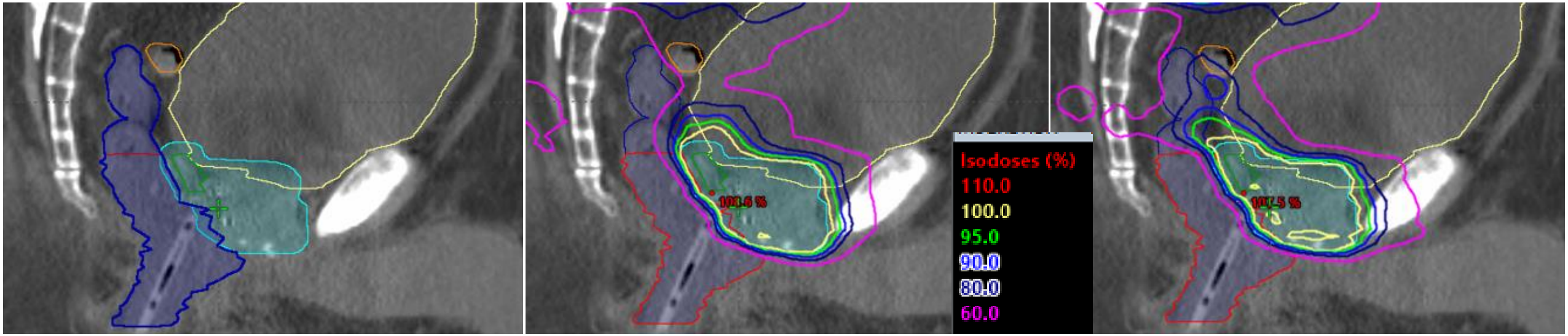
- Appropriate primary dataset
  - AIP for lung,
  - Sub-average/MIP for gated
  - Originates from scanner with characterized electron density tables
  - Example: Full average used for gated lung?

Clinical Review - Registrations

- Evaluate primary to secondary dataset registrations (Carlos)
  - Rigid and deformable registrations reviewed.
  - Positioning of patient in secondary dataset may be different
  - Accuracy of registration may be limited to small region, impacting target/OAR delineation
  - Communicate any unusual variations to physician.
  - Examples: MRI image distortion
  - Example: Motion of tumor in 4DCT relative to delineated target volume

Clinical Review – Contours

- Accuracy of contours impacts plan trade-offs and quality evaluation
  - Missing contours
  - Incomplete contours (impact volumetric DVH planning)
  - Incorrect labeling of contours



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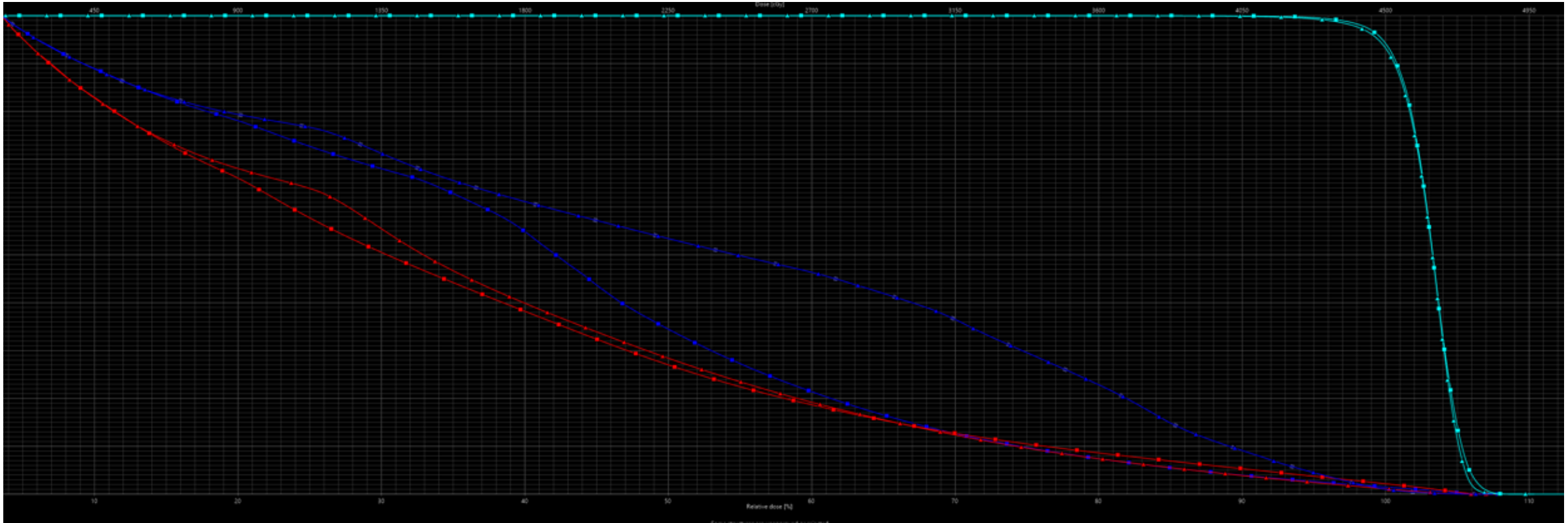
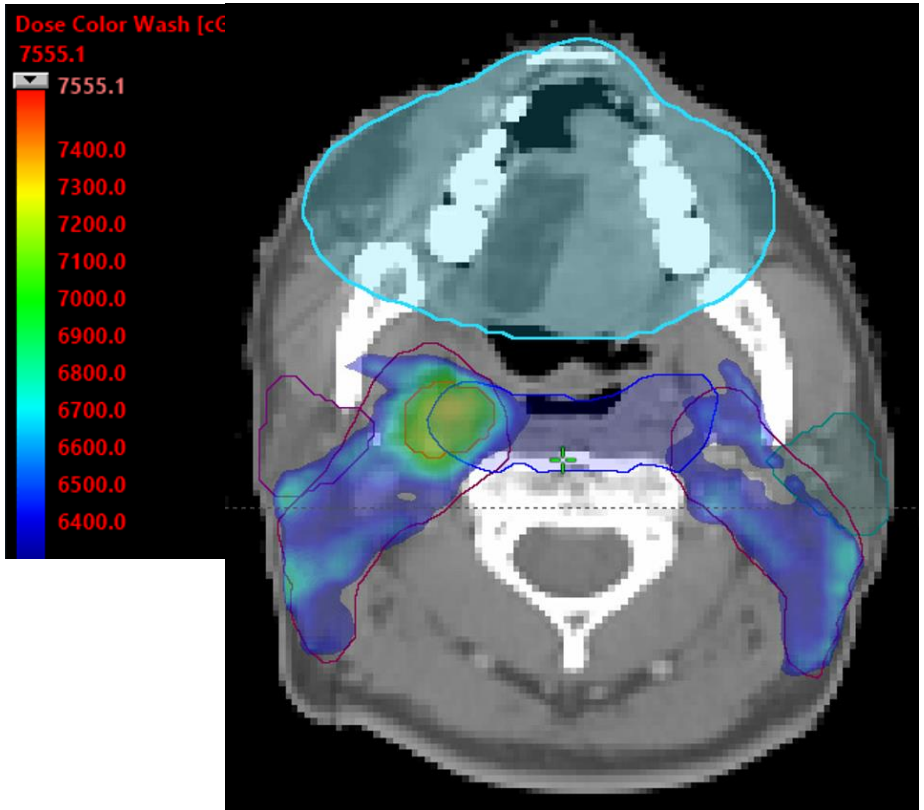


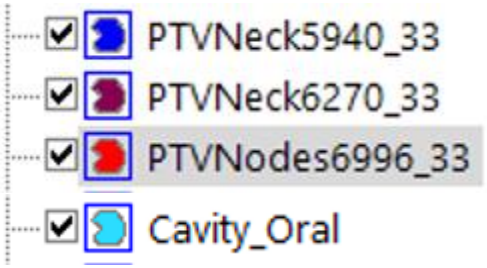
Clinical Review – Isodose

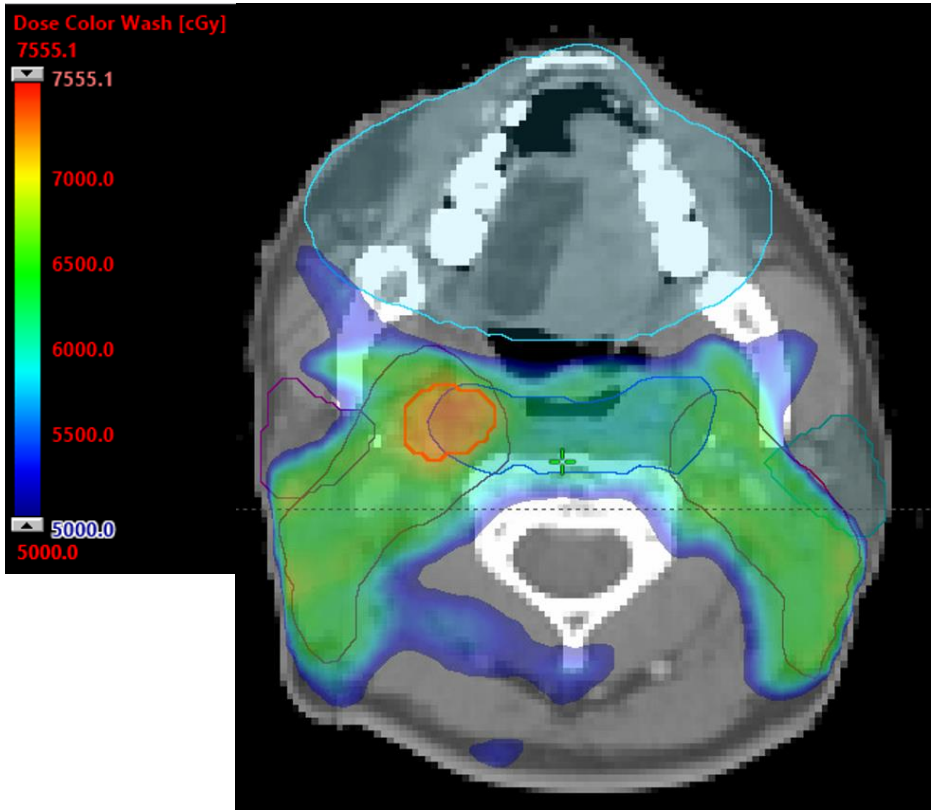
- Review plans for poor quality (needs revision) vs. sub-optimial differences.
- Prescription conformity to target (Poor Quality Examples)
  - Example: Ditzels or optimization structures driving dose to unintended volumes
  - Example: Appropriate prescription dose to each target

Clinical Review – Isodose

- Reviewing isodoses for unusual/unexpected dose distribution
- Medium-to-High dose streaking (Sub-optimal)
  - Example: OARs dominating optimization

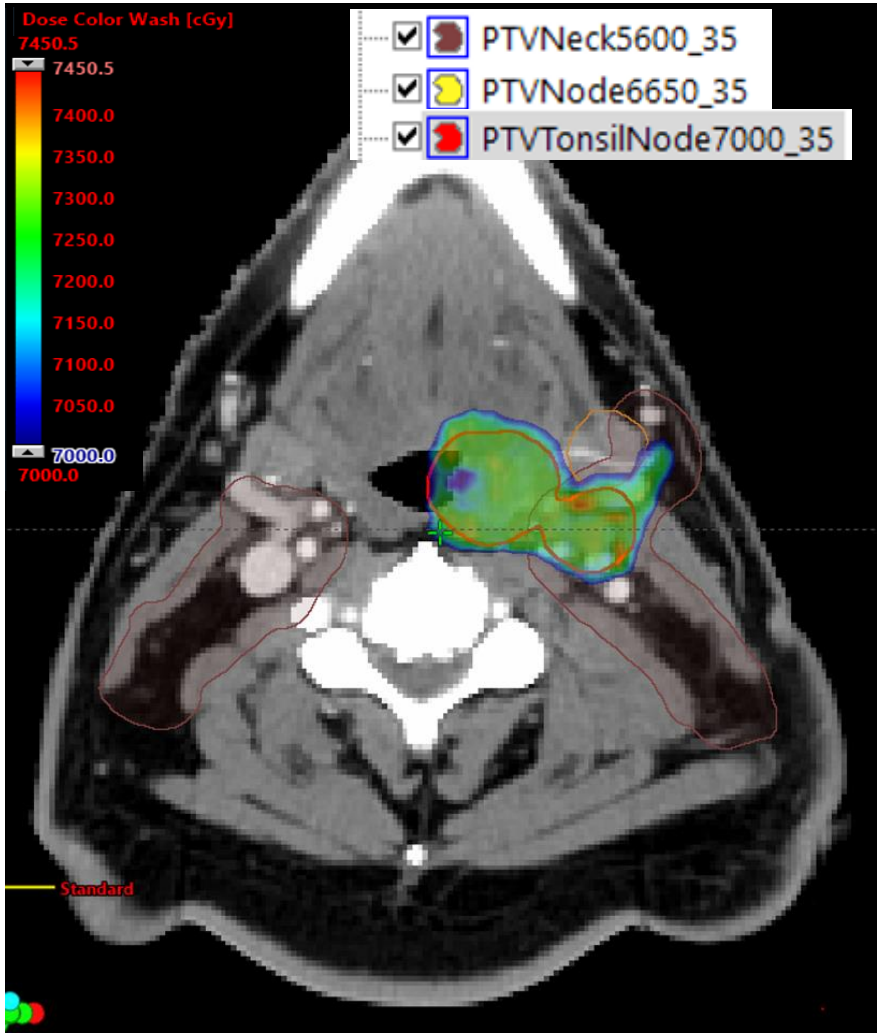






Clinical Review – Isodose

- Maximum plan dose (Hot-Spot)
  - Location within high dose target
  - Minimize overlap with abutting OARs
  - Understand magnitude and location of hot spots
  - ~~Examples: Head and Neck dose spilling~~
  - Examples: adjacent to heart for breast plans



Clinical Review – Isodose

- Dose Gradients vs. Hot Spot trade-off:
  - SRS example from Group 3

Clinical Review - DVH

- Understand national and institutional normal tissues goals
  - Ideally prioritized from MD written directive on a per-patient basis
  - Example: Written directive image with objectives ranked
- Appropriate prioritization of planning goals
  - OAR constraints > target coverage > OAR goals
    - TG-101/HyTex for SBRT
    - Quantec/Clniical trials for specific treatment sites
- During review, dose to higher ranked OARs/targets drives trade-offs
  - Example

Clinical Review - DVH

- Discuss sub-optimal plan that doesn’t maximize OAR objective sparing
  - When constraints and target coverage achieved, continue to minimize dose to lower ranked OARs.
  - Group 3 Parotid sparing example

Clinical Review – Plan Sum Evaluation

- EQD2 when comparing different fractionation scheme treated to a patient