Beyond the Physics: Defining, Measuring, and Achieving Proton Plan Quality for Head & Neck Cancer

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Presented by - Zachary Fellows

Disclosures

– Chief Marketing Officer APEX Dosimetry

Why this matters

IMPT offers unmatched precision and OAR sparing, but outcomes depend on planning quality.

- Plan quality determines clinical outcomes
- Significant variability exists between centers
- Physics alone is insufficient
- Standardization is urgently needed

Learner Objectives

1. Key elements that define proton plan quality for head and neck cancer beyond standard dosimetric metrics
2. Recognize sources of variability in proton plan quality across centers
3. Identify strategies to improve and standardize IMPT planning

Traditional Measures of Plan Quality

What We Measure	What We Often Miss
Coverage	Planning Philosophy
Conformity	Tradeoff Decisions
Homogeneity	Clinical Priorities
OAR Sparing	Robustness Strategy
Robustness	Reproducibility

Traditional Measures of Plan Quality

DVH | Clinical goals | Dose statistics | 2D | Image

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Priority	ROI/POI	Clinical goal	Value	Result
1	GTVn1	At least 100.00 % volume at 7000 cGy (RBE) dose	100.00 %	✓
2	CTV_High	At least 99.00 % volume at 7000 cGy (RBE) dose	99.00 %	✓
3	CTV_Mid	At least 99.00 % volume at 6300 cGy (RBE) dose	99.16 %	✓
4	CTV_Low	At least 99.00 % volume at 5600 cGy (RBE) dose	99.31 %	✓
10	Brainstem	At most 5000 cGy (RBE) dose at 0.03 cm³ volume	1806 cGy (RBE)	✓
11	SpinalCord	At most 4500 cGy (RBE) dose at 0.03 cm³ volume	2456 cGy (RBE)	✓
12	Parotid_L	At most 2600 cGy (RBE) average dose	2628 cGy (RBE)	!
12	Parotid_R	At most 2600 cGy (RBE) average dose	4334 cGy (RBE)	!
13	Glnd_Submand_L	At most 3000 cGy (RBE) average dose	5733 cGy (RBE)	!
14	Esophagus	At most 1.00 cm³ volume at 5400 cGy (RBE) dose	0.00 cm³	✓
14	Esophagus	At most 2500 cGy (RBE) average dose	1107 cGy (RBE)	✓
14	Esophagus	At most 5600 cGy (RBE) dose at 0.03 cm³ volume	3822 cGy (RBE)	✓
15	Cavity_Oral	At most 2500 cGy (RBE) average dose	1228 cGy (RBE)	✓
16	Bone_Mandible	At most 7000 cGy (RBE) dose at 0.03 cm³ volume	7059 cGy (RBE)	!
17	BrachialPlex_L	At most 7000 cGy (RBE) dose at 0.03 cm³ volume	6345 cGy (RBE)	✓
17	BrachialPlex_R	At most 7350 cGy (RBE) dose at 0.03 cm³ volume	7093 cGy (RBE)	✓
19	Glnd_Thyroid	At most 4500 cGy (RBE) average dose	4556 cGy (RBE)	!
30	Cochlea_R	At most 3000 cGy (RBE) average dose	2285 cGy (RBE)	✓
31	Cochlea_L	At most 3000 cGy (RBE) average dose	2259 cGy (RBE)	✓
32	Larynx	At most 4500 cGy (RBE) average dose	1208 cGy (RBE)	✓
32	Pharynx^Const	At most 4500 cGy (RBE) average dose	1661 cGy (RBE)	✓
101	CTV_High	At least 90.00 % volume at 7000 cGy (RBE) dose	99.00 %	✓
102	CTV_High	At least 95.00 % volume at 6650 cGy (RBE) dose	100.00 %	✓
103	CTV_Mid	At least 90.00 % volume at 6300 cGy (RBE) dose	99.16 %	✓
104	CTV_Mid	At least 95.00 % volume at 5985 cGy (RBE) dose	99.92 %	✓
105	CTV_Low	At least 90.00 % volume at 5600 cGy (RBE) dose	99.31 %	✓
106	CTV_Low	At least 95.00 % volume at 5320 cGy (RBE) dose	99.88 %	✓
110	_body^proton	At most 7700 cGy (RBE) dose at 0.10 cm³ volume	7419 cGy (RBE)	✓

Beyond Dosimetry: What Great Proton Plans Actually Require

Good Plan

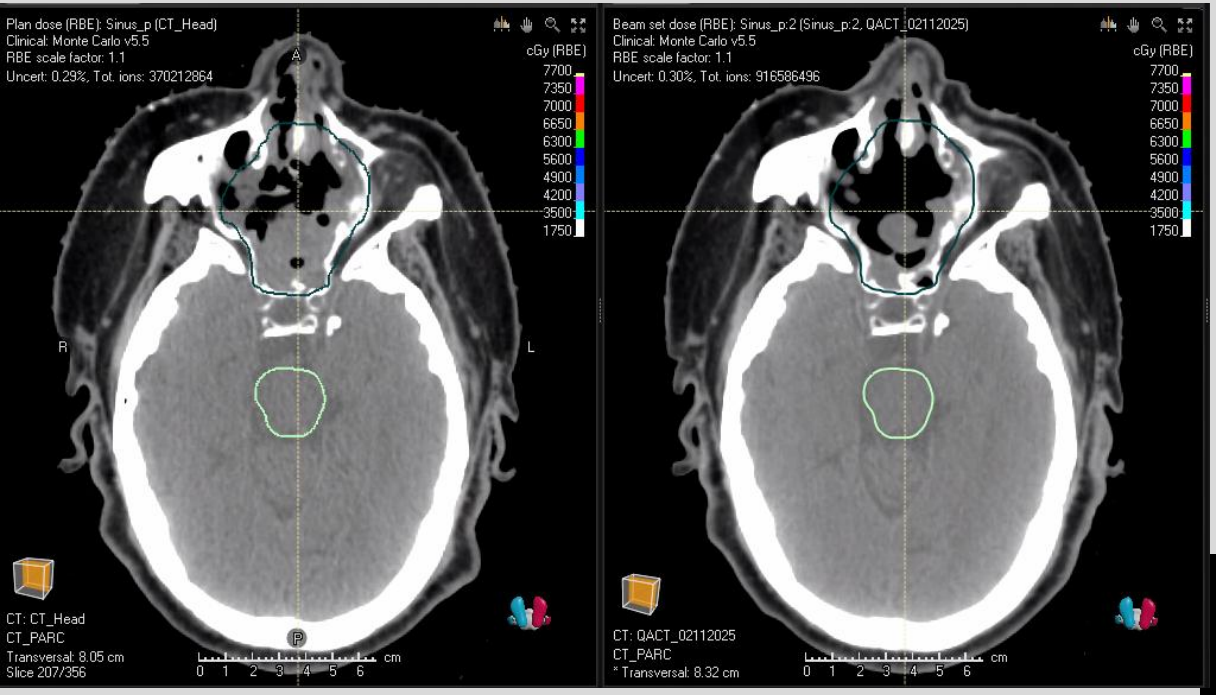
- Meets Coverage
- Meets Constraints
- Passes Robustness
- Acceptable DVH

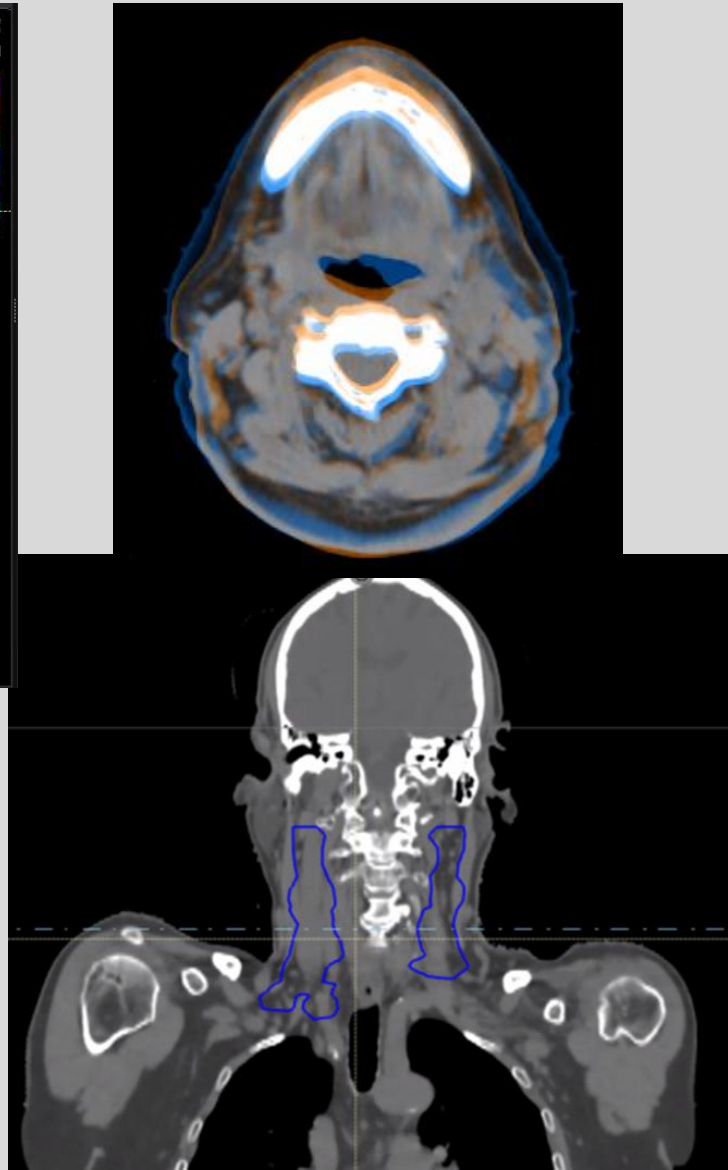
Great Plan

- Real-World Robustness
- Thoughtful Beam Geometry
- Optimized Toxicity Reduction
- Reproducible Across Patients

Excellent proton plans are not merely optimized — they are intentional.

Real-World Robustness: The Hidden Source of Variability

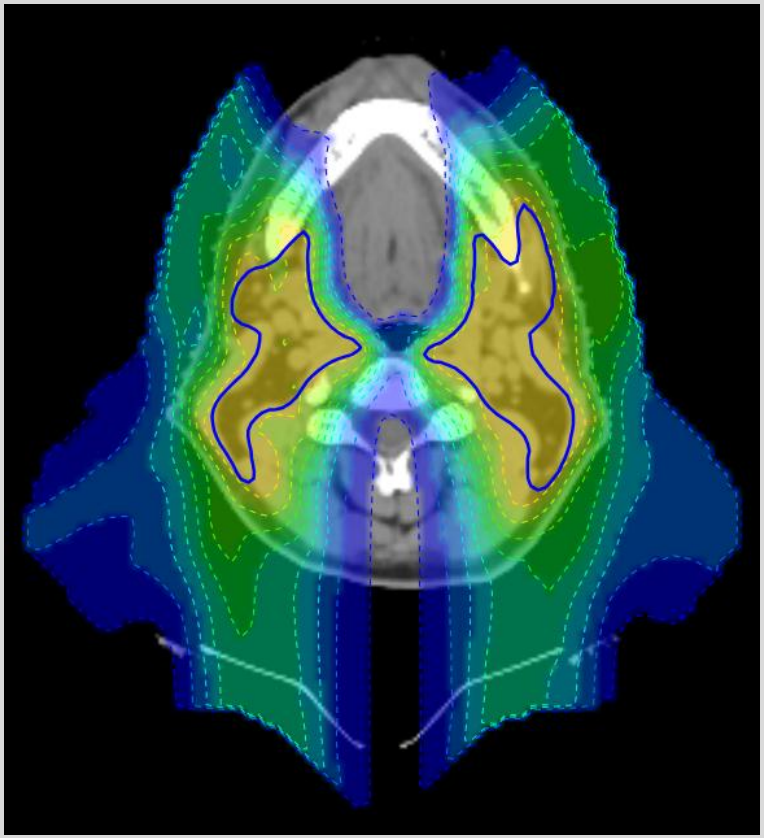




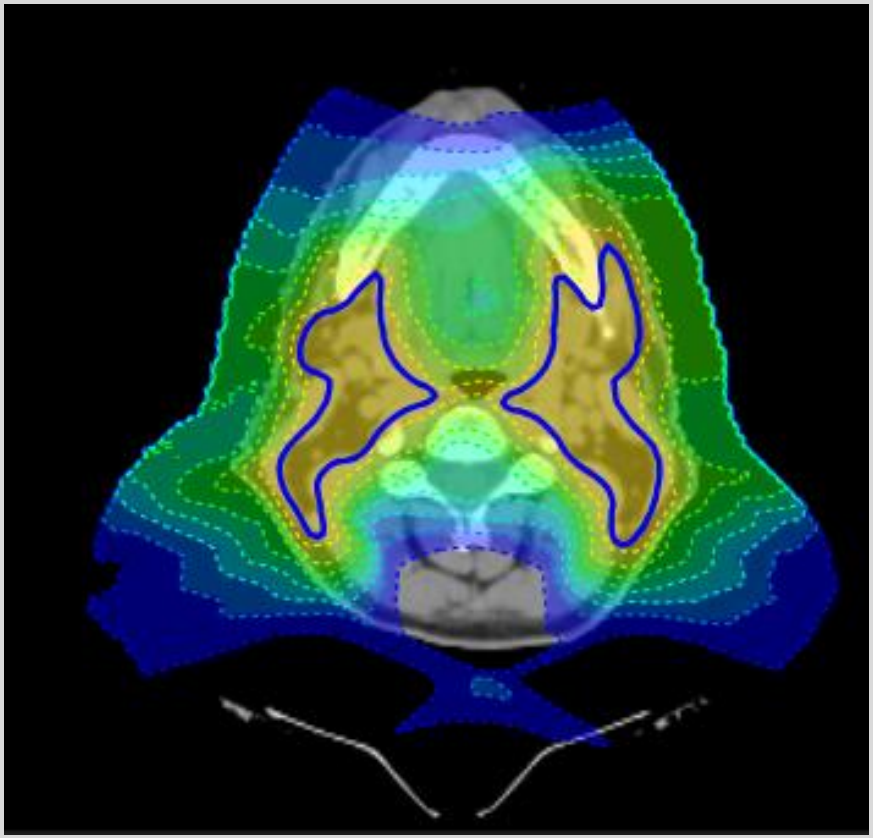
What you see is not always what you get

Beam Arrangement Philosophy

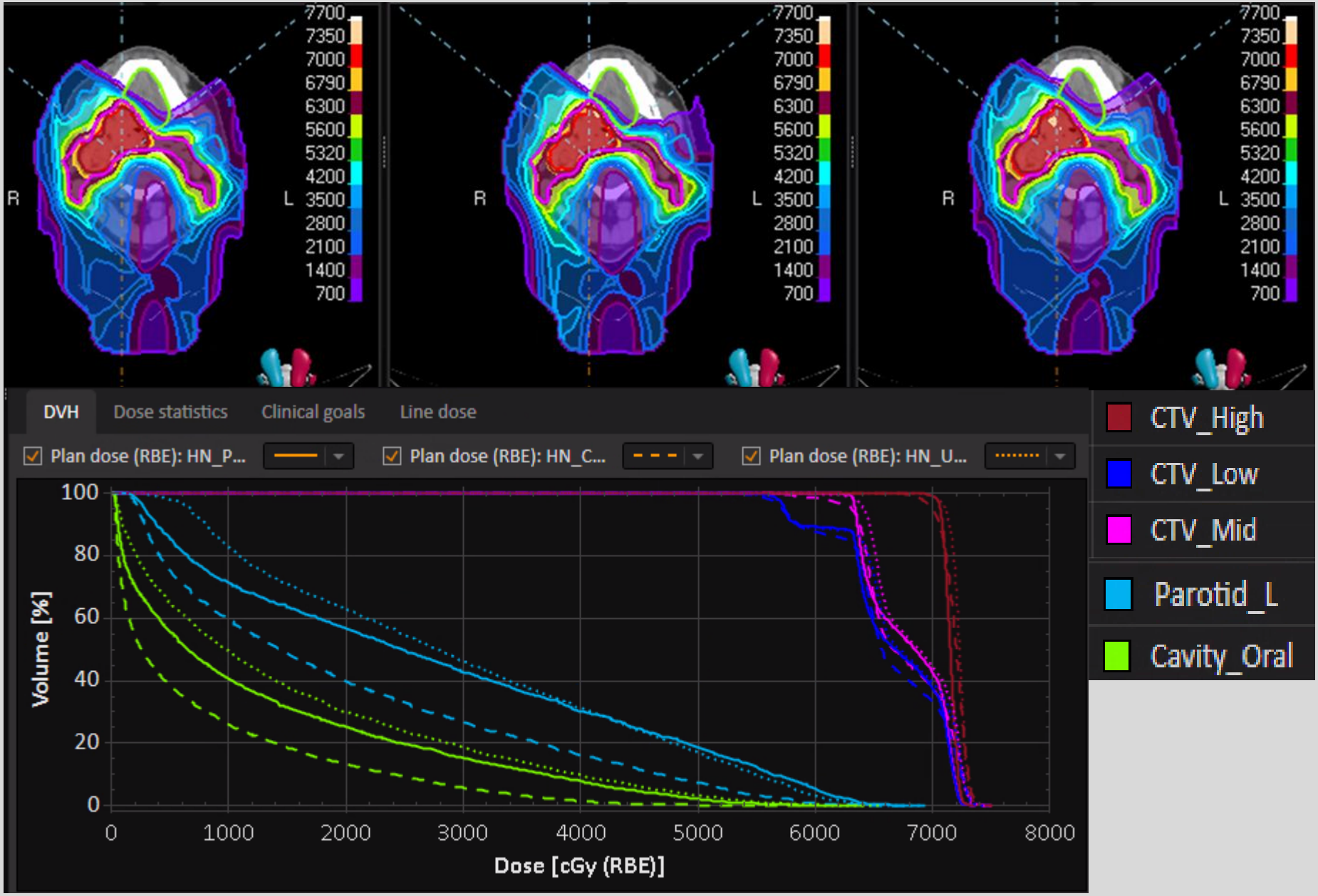
More Fields W/ Minimal WET Arrangement



Posterior Advert Arrangement



Multiple Solutions. Different Tradeoffs.



What Happens When Experts Plan the Same Patient?

The Multicenter Competitive Planning Study

Same Patient

↓

Same Structure Set

↓

Same Planning Goals

↓

12 Expert Institutions

↓

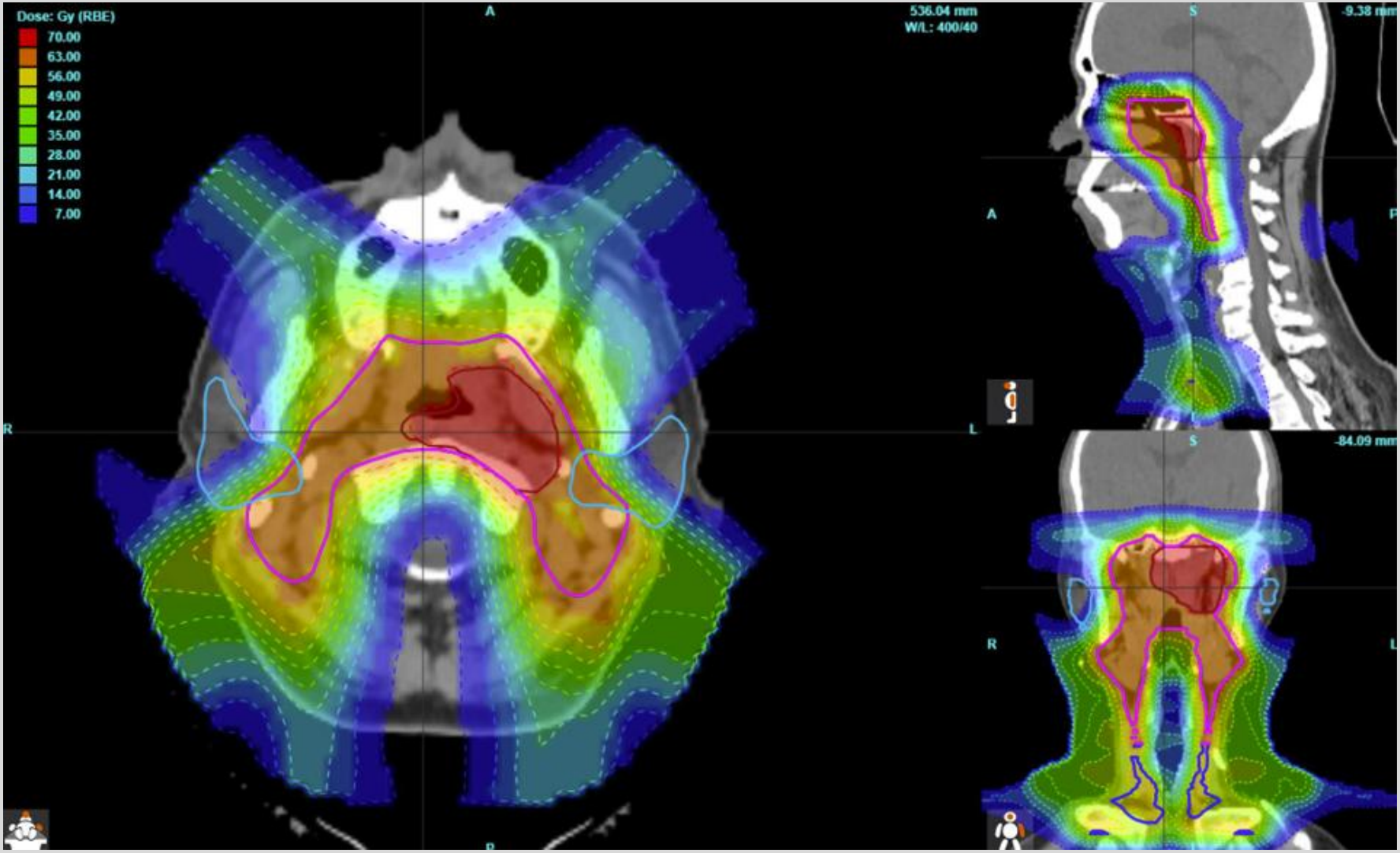
“Do What You Do”

↓

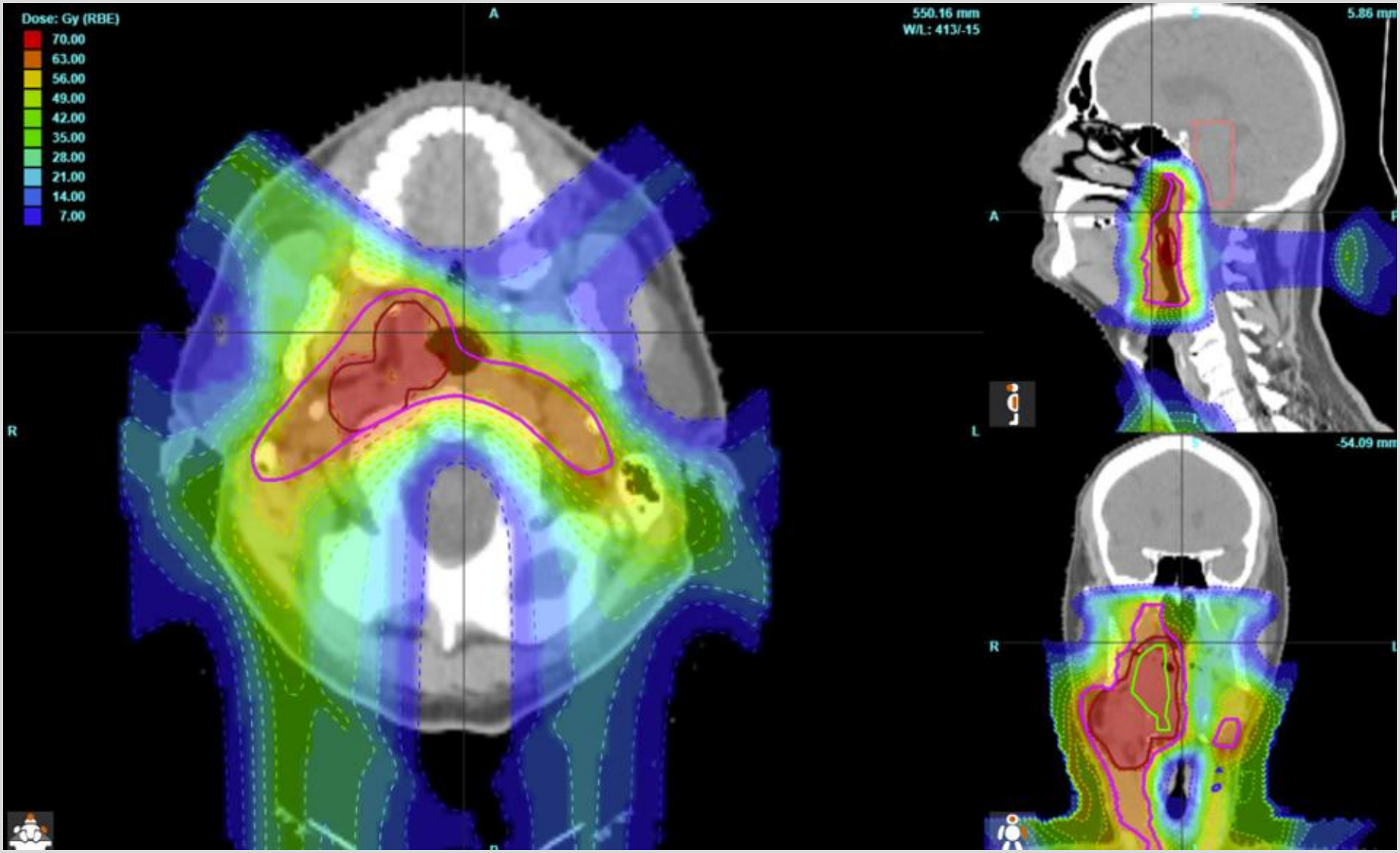
Compare Results

PTCOG HN Subcommittee Planning – ParaNasal Sinus

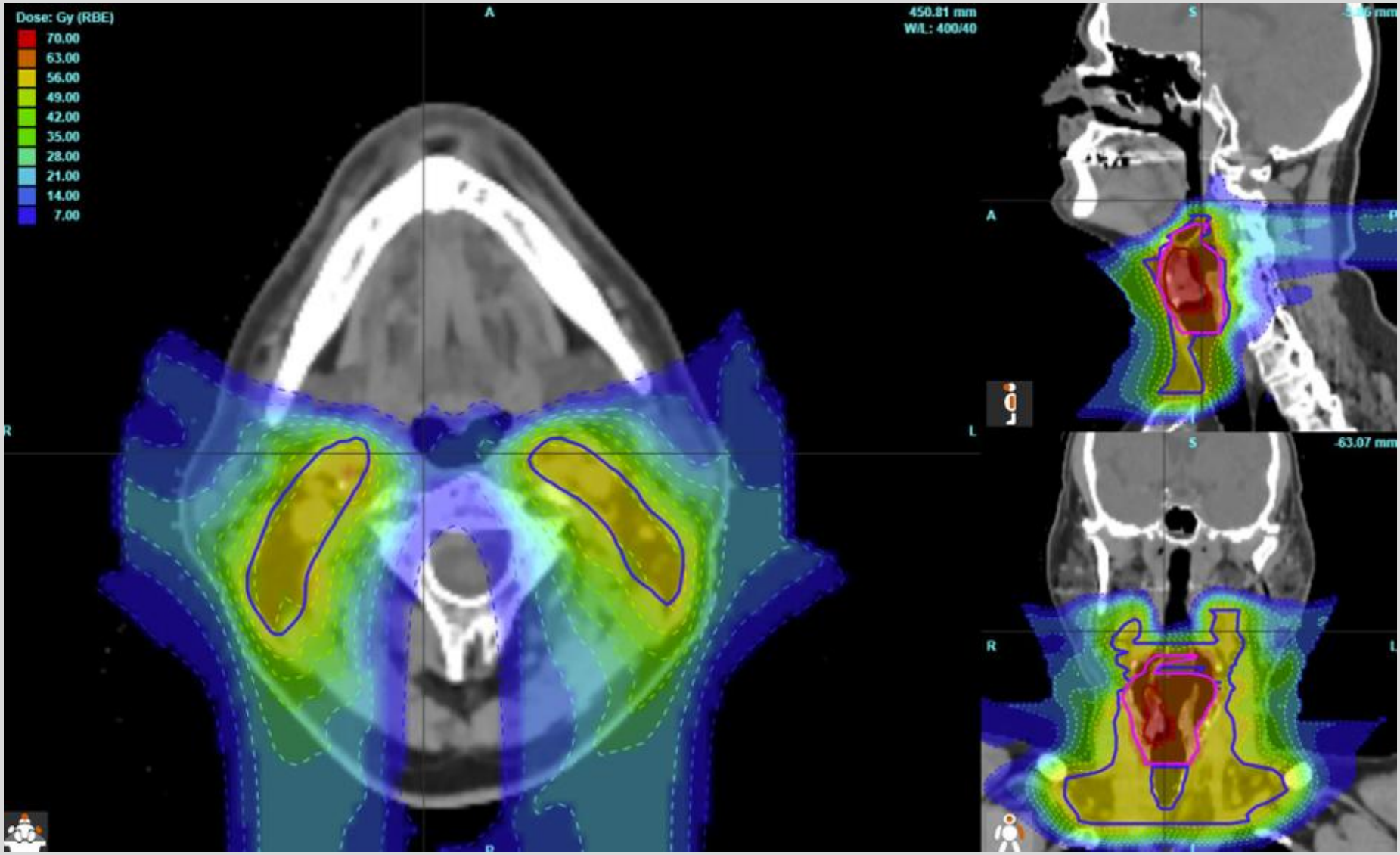
PTCOG HN Subcommittee Planning – Nasopharynx



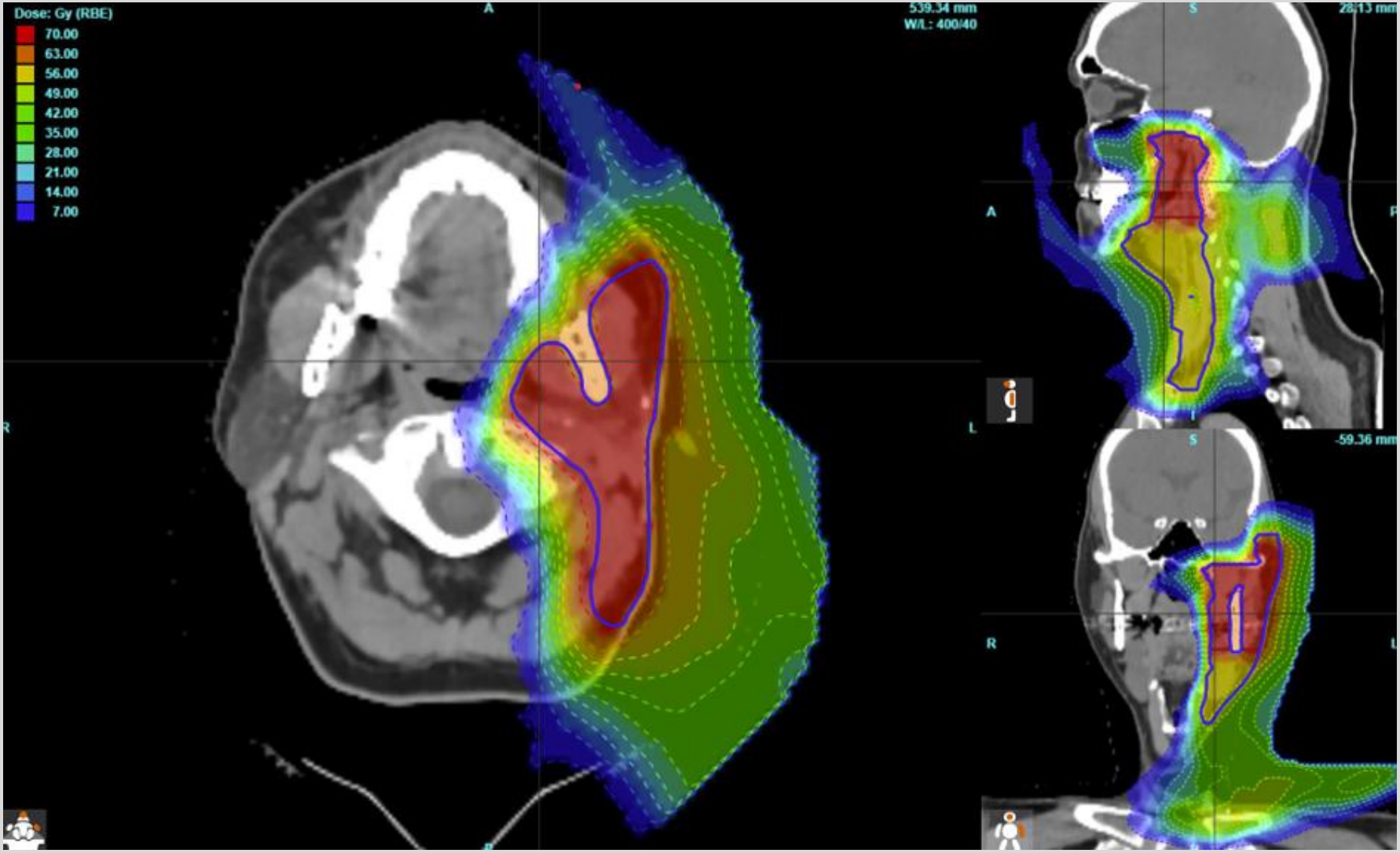
PTCOG HN Subcommittee Planning – Oropharynx



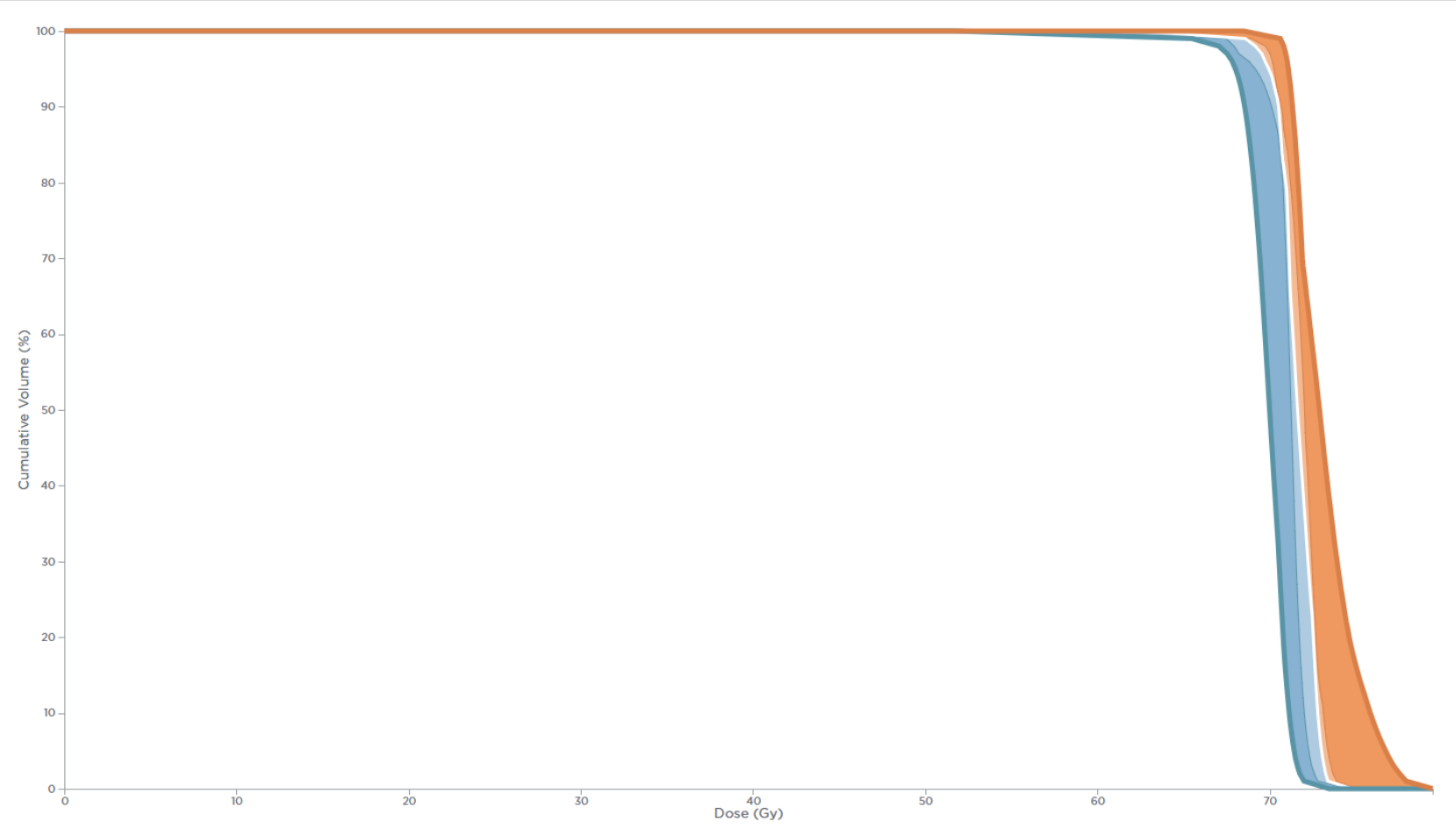
PTCOG HN Subcommittee Planning – Larynx



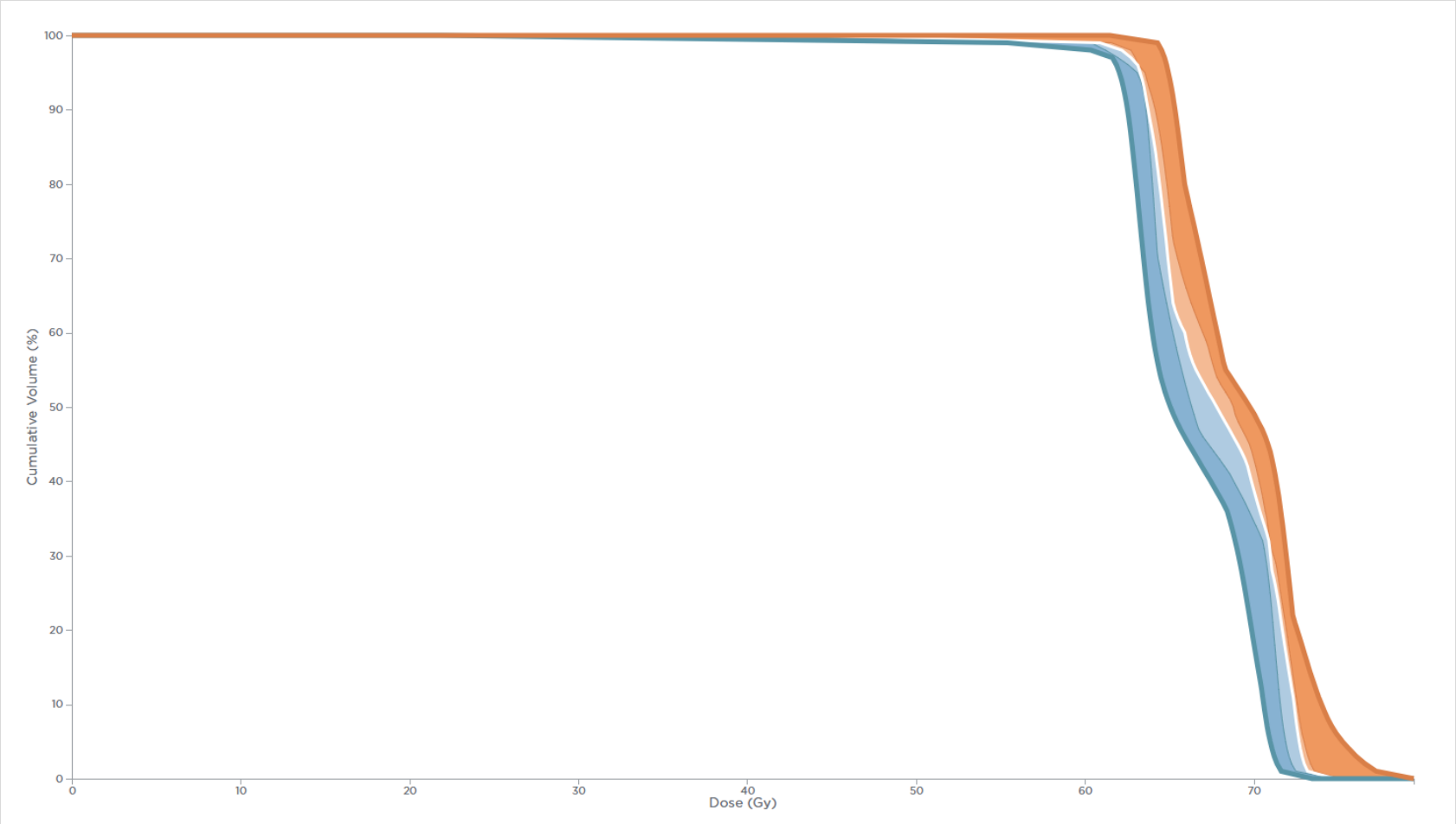
PTCOG HN Subcommittee Planning – Ipsilateral



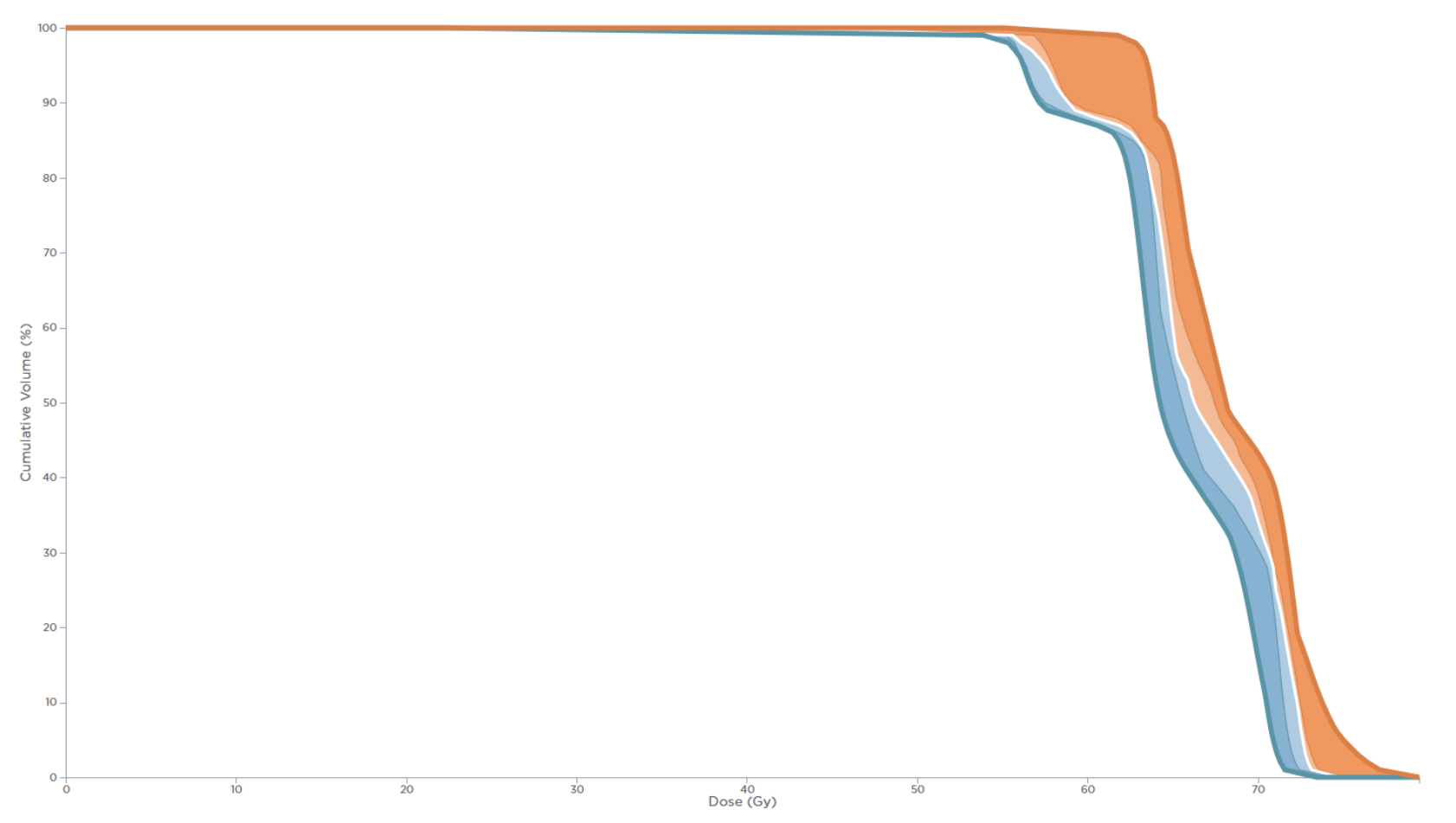
Key Results: Coverage – *CTV_High*



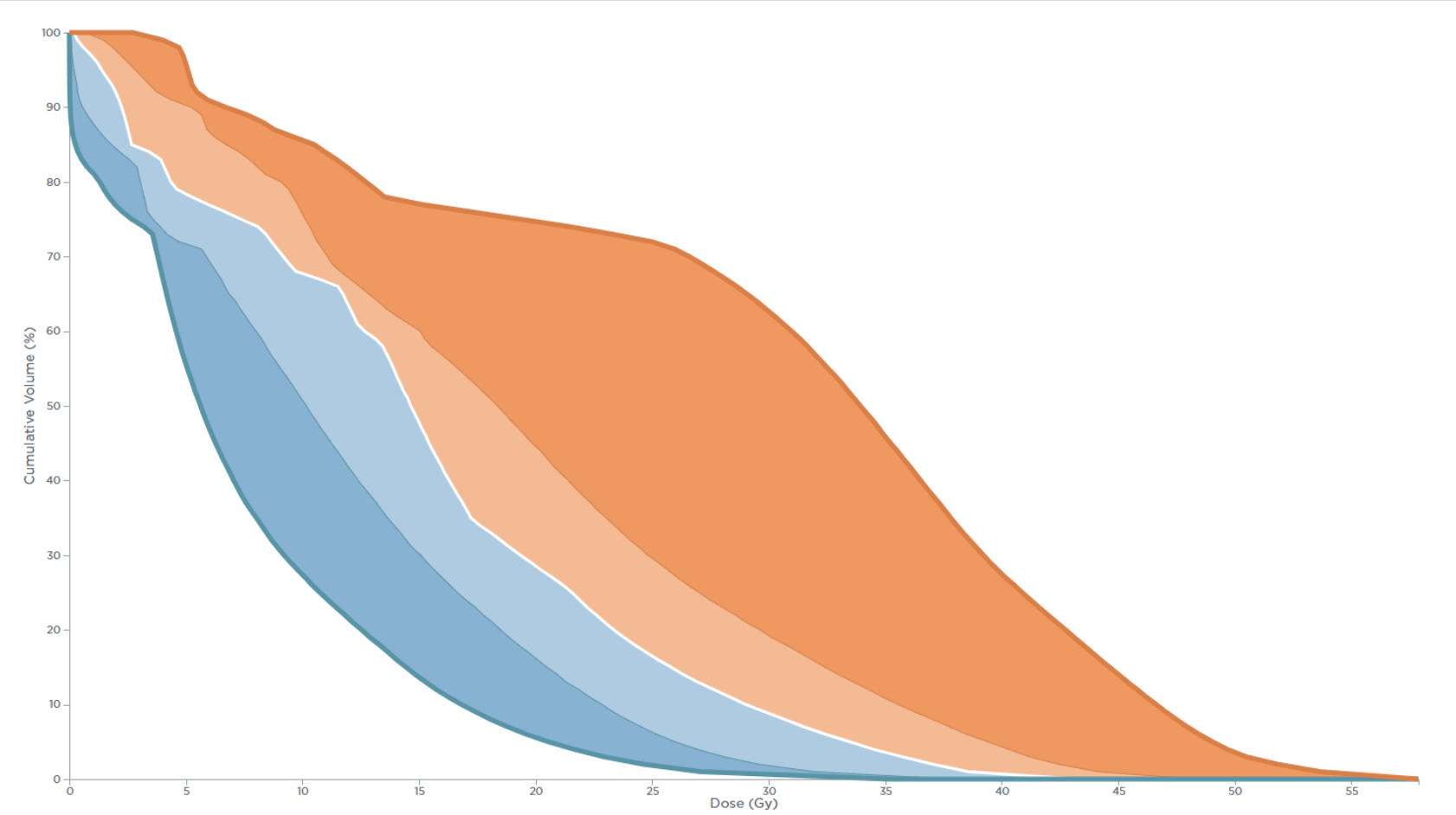
Key Results: Coverage – *CTV_Mid*



Key Results: Coverage – *CTV_Low*

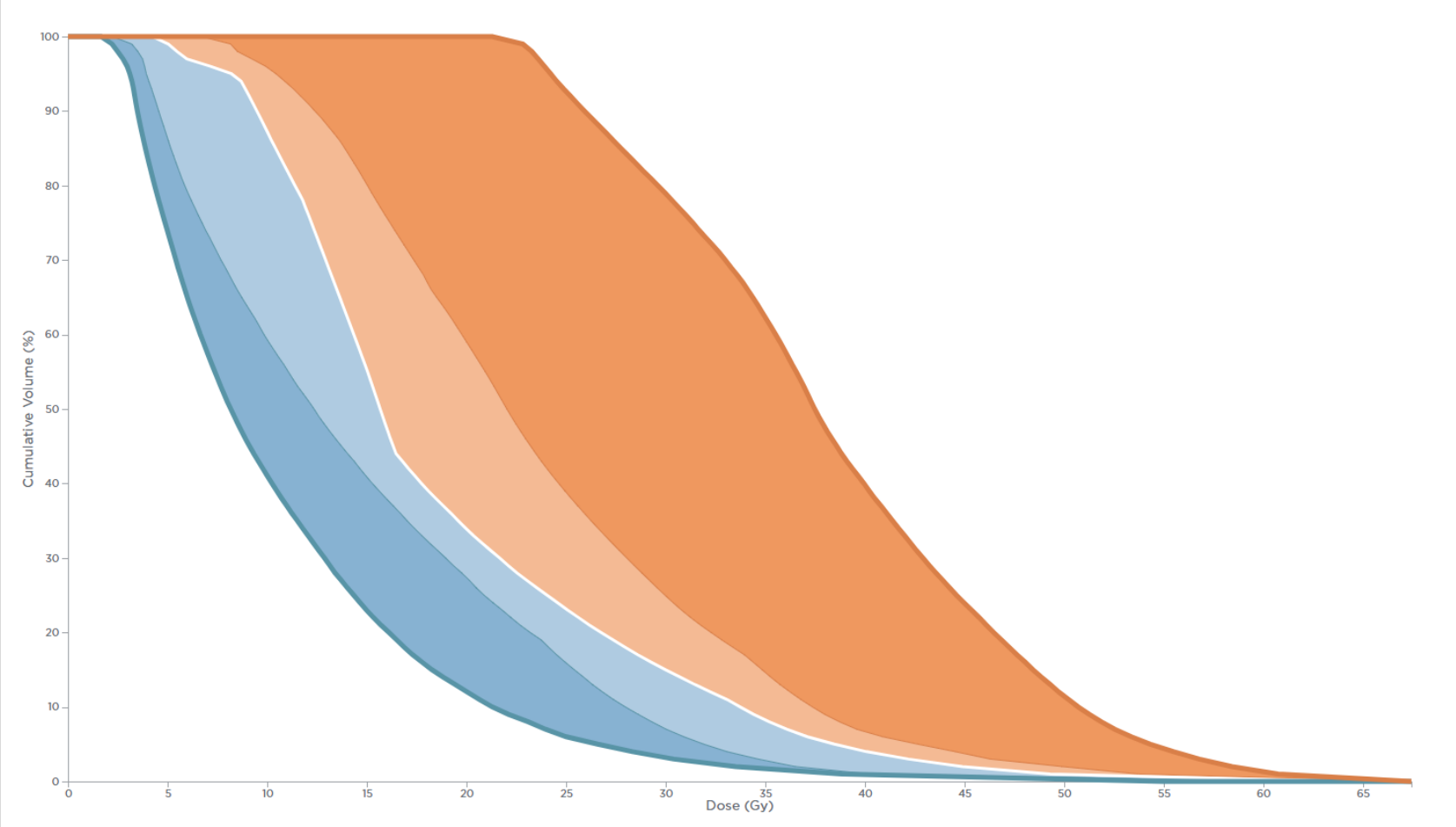


Key Results: OAR Toxicity – *Esophagus*



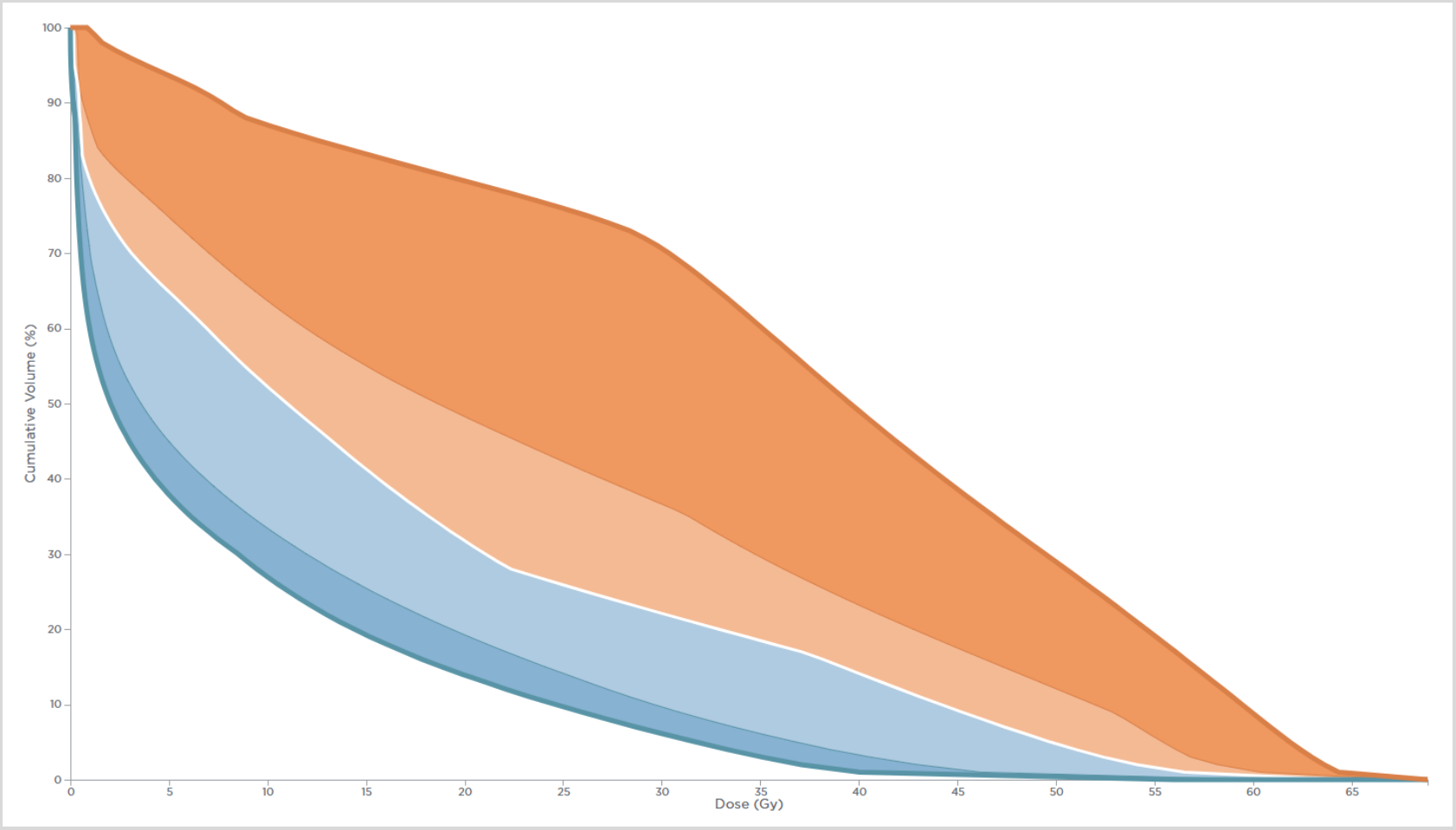
OAR	Mean (Gy)	Median (Gy)	Range (Gy)
Esophagus	16.4	15.8	7.7 – 29.2

Key Results: OAR Toxicity – *Larynx*



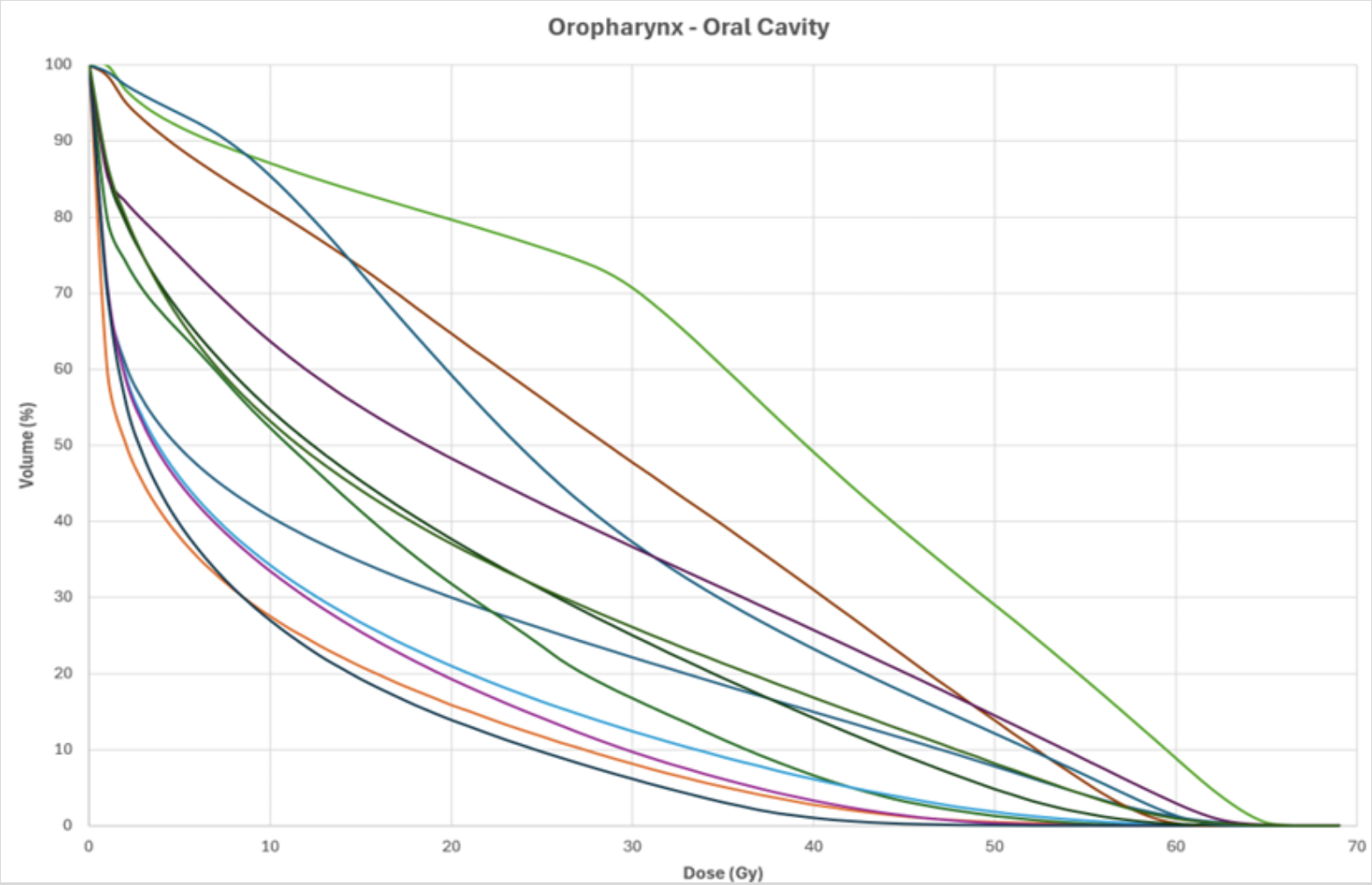
OAR	Mean (Gy)	Median (Gy)	Range (Gy)
Larynx	20.6	19.4	10.7 – 38.2

Key Results: OAR Toxicity – *Oral Cavity*



OAR	Mean (Gy)	Median (Gy)	Range (Gy)
Oral Cavity	18.15	16.2	7.8 – 37.2

Key Results: OAR Toxicity – *Oral Cavity*



Key Results: OAR Toxicity – *Oral Cavity*

Case	Mean (Gy)	Median (Gy)	Range (Gy)	St.Dev
PNS	17.3	15.6	4.9 - 32.9	8.3
NPX	19.4	17.2	10.2 - 36.5	7.6
OPX	18.2	16.3	7.8 – 37.2	8.8
LRX	7.1	6.9	1.7 – 11.5	3.1
Ipsi	8.2	9.2	1.4 – 12.5	3.5

Major Findings:
Significant Variability Between Expert Centers

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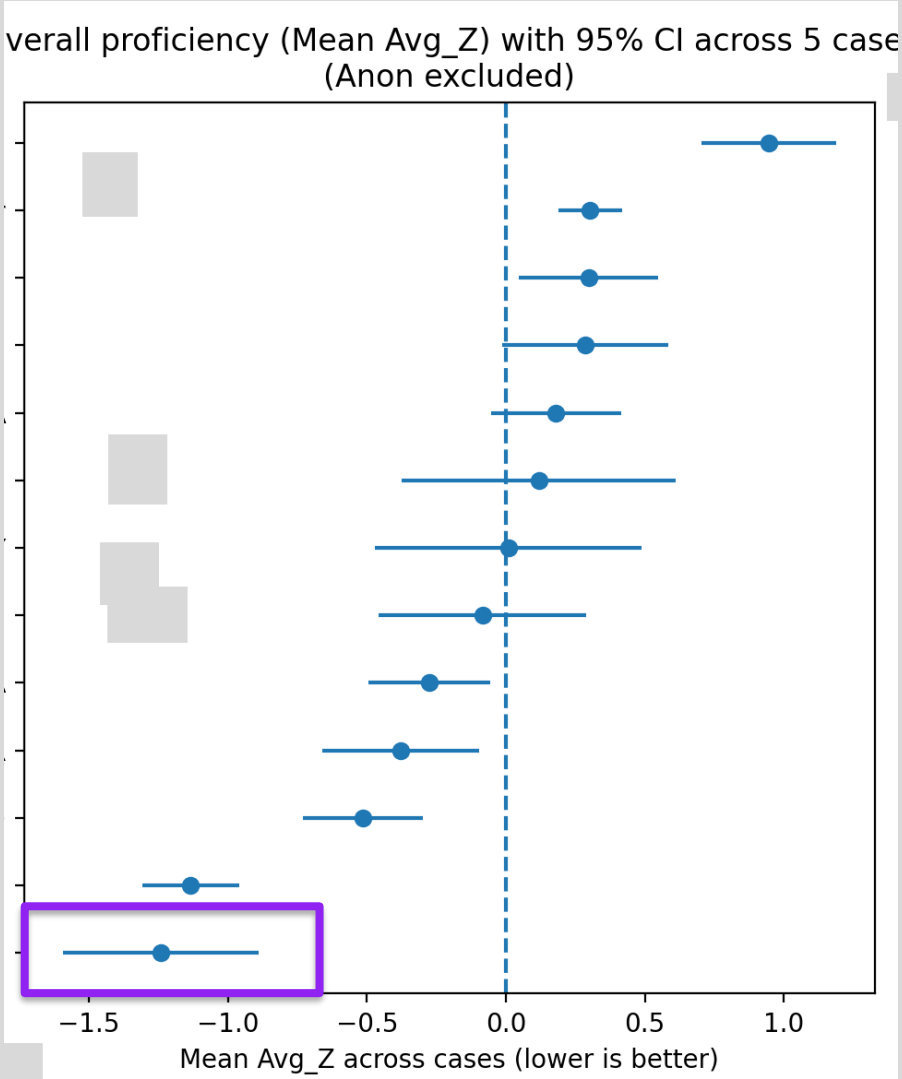


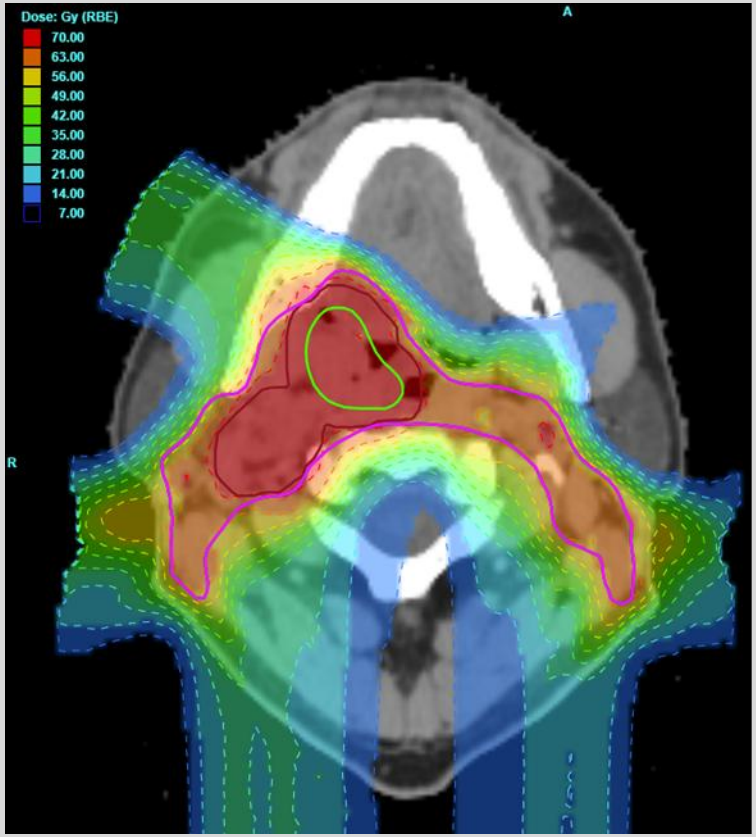
Major Findings:
Significant Variability Between Expert Centers

Beam Arrangements

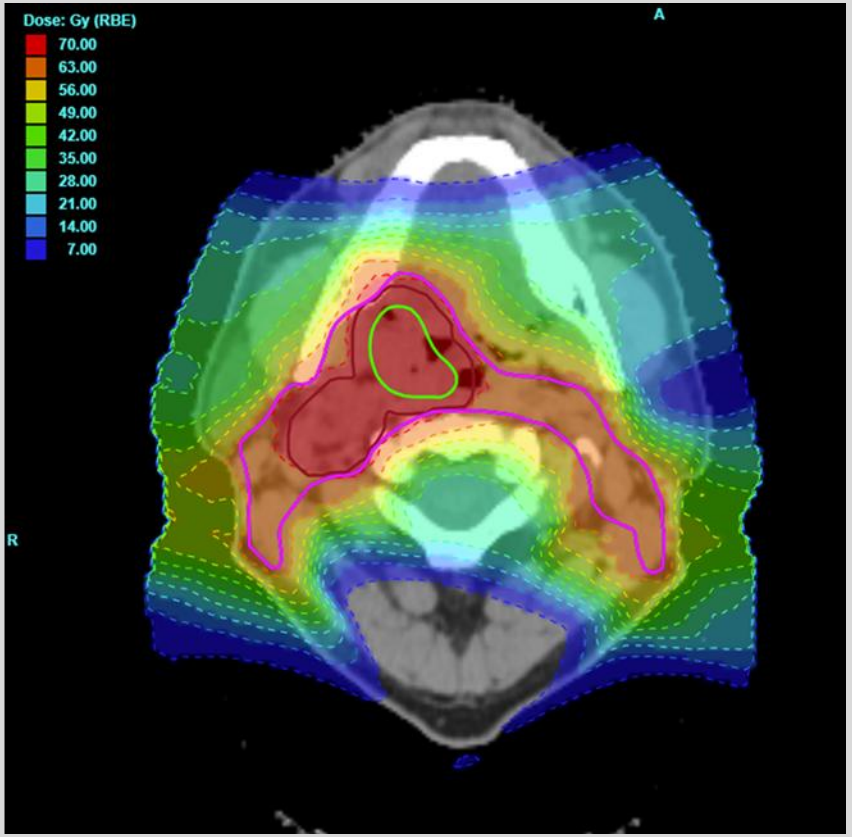
	Fields (Mean)	Fields (Median)	Fields (Range)	St. Deviation
ParaNasal Sinus	5.3	5.5	3-7	1.0
Nasopharynx	4.9	5.0	3-7	1.2
Oropharynx	4.4	4.5	3-7	0.9
Larynx	4.2	4.0	3-6	1.2
Ipsi Lateral	3.1	3.0	2-4	.6

Major Findings:
Significant Variability Between Expert Centers

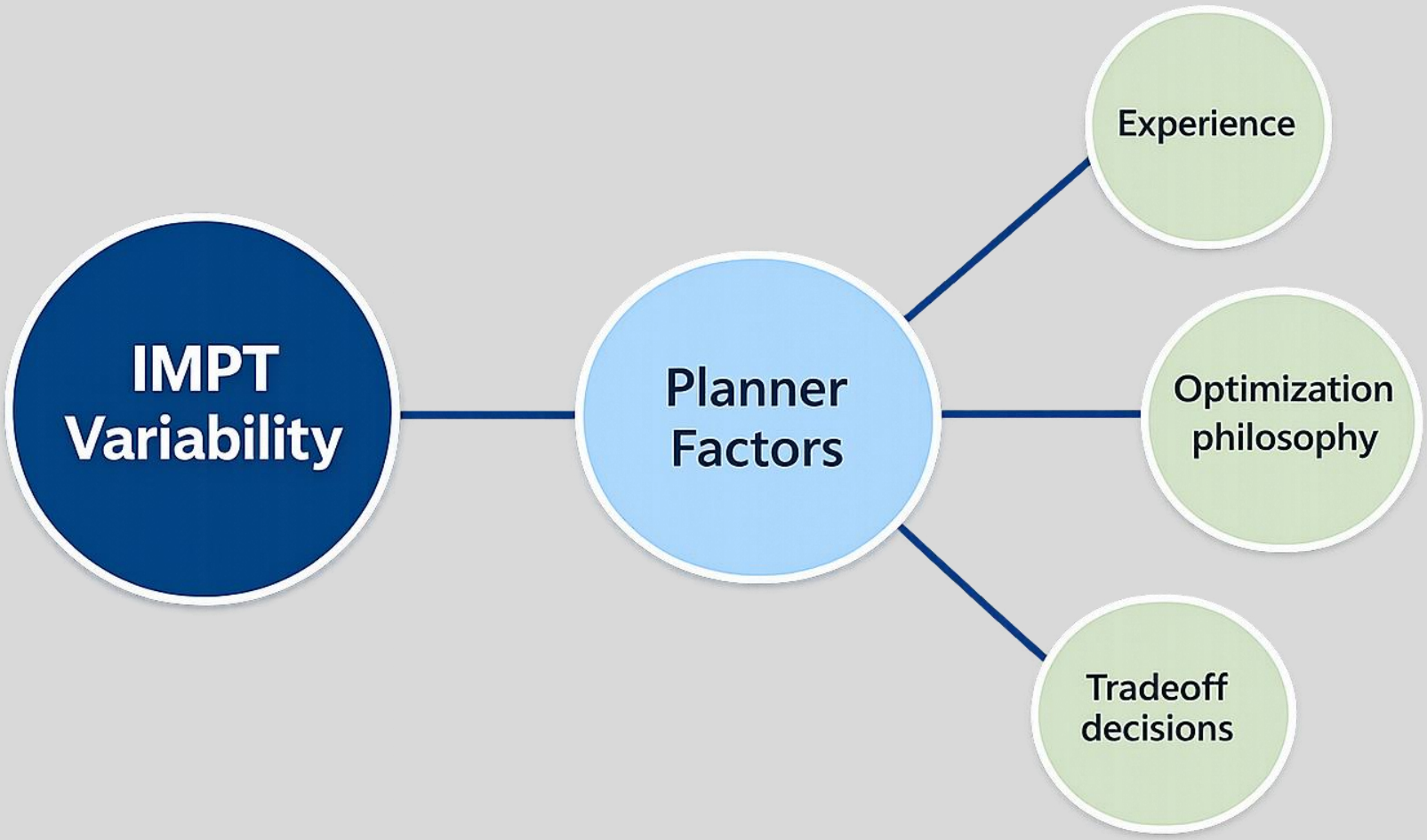
Plan A



Plan B



Why Does Variability Exist?



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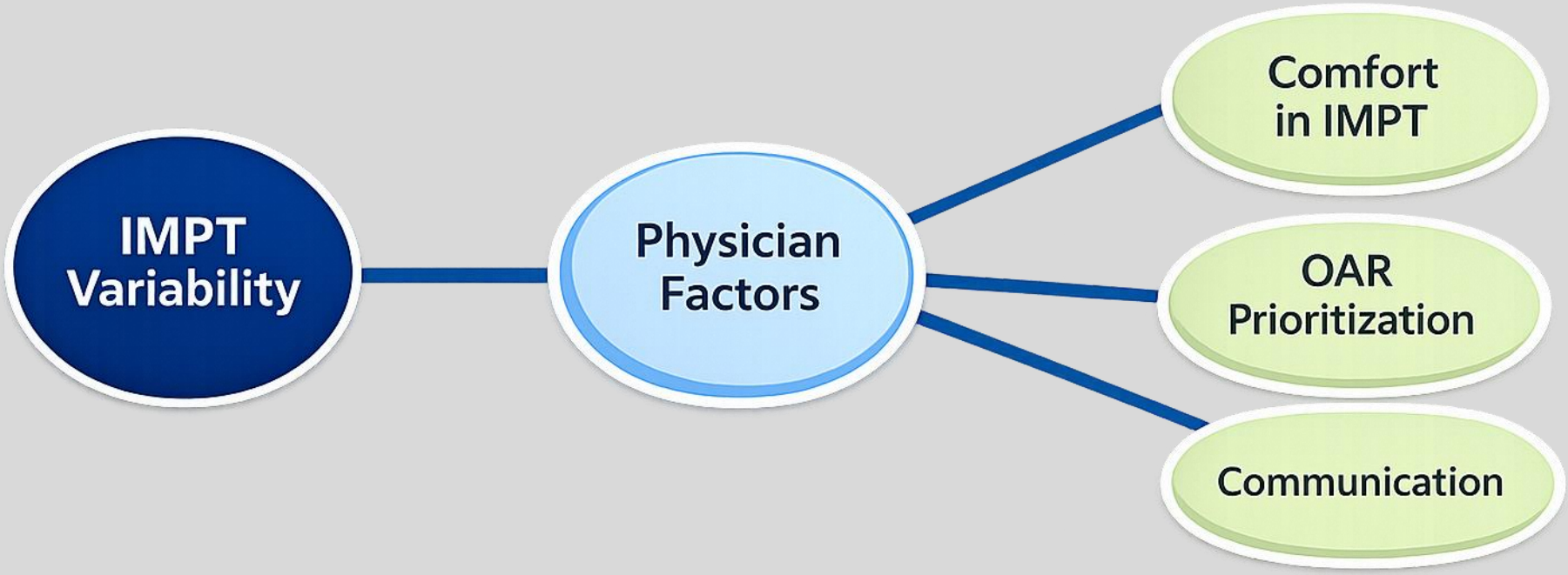

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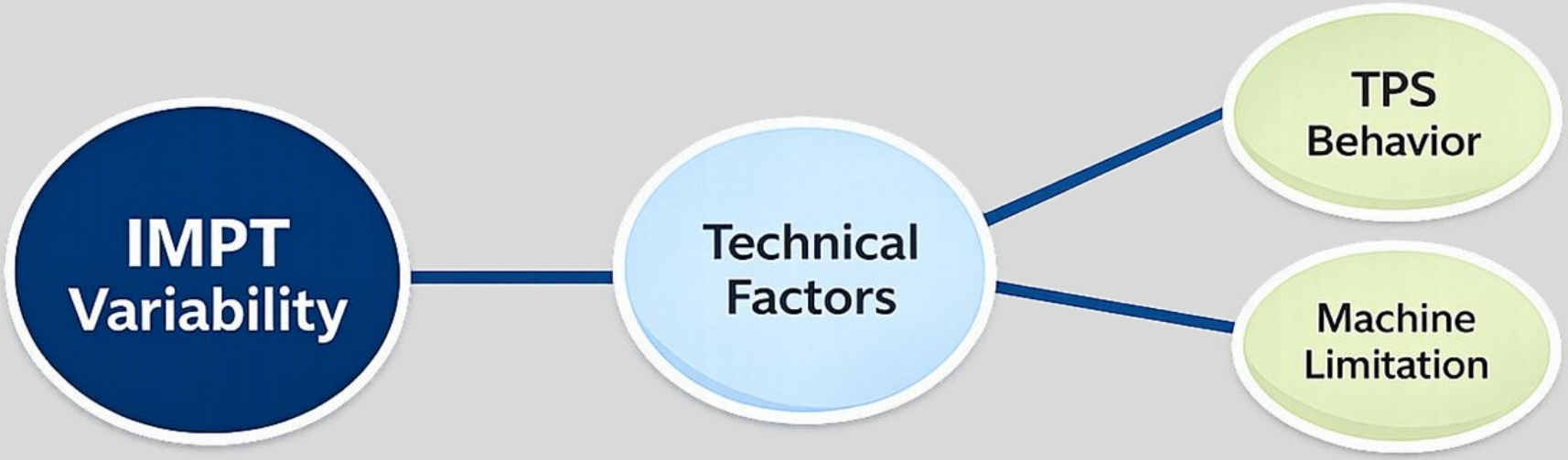

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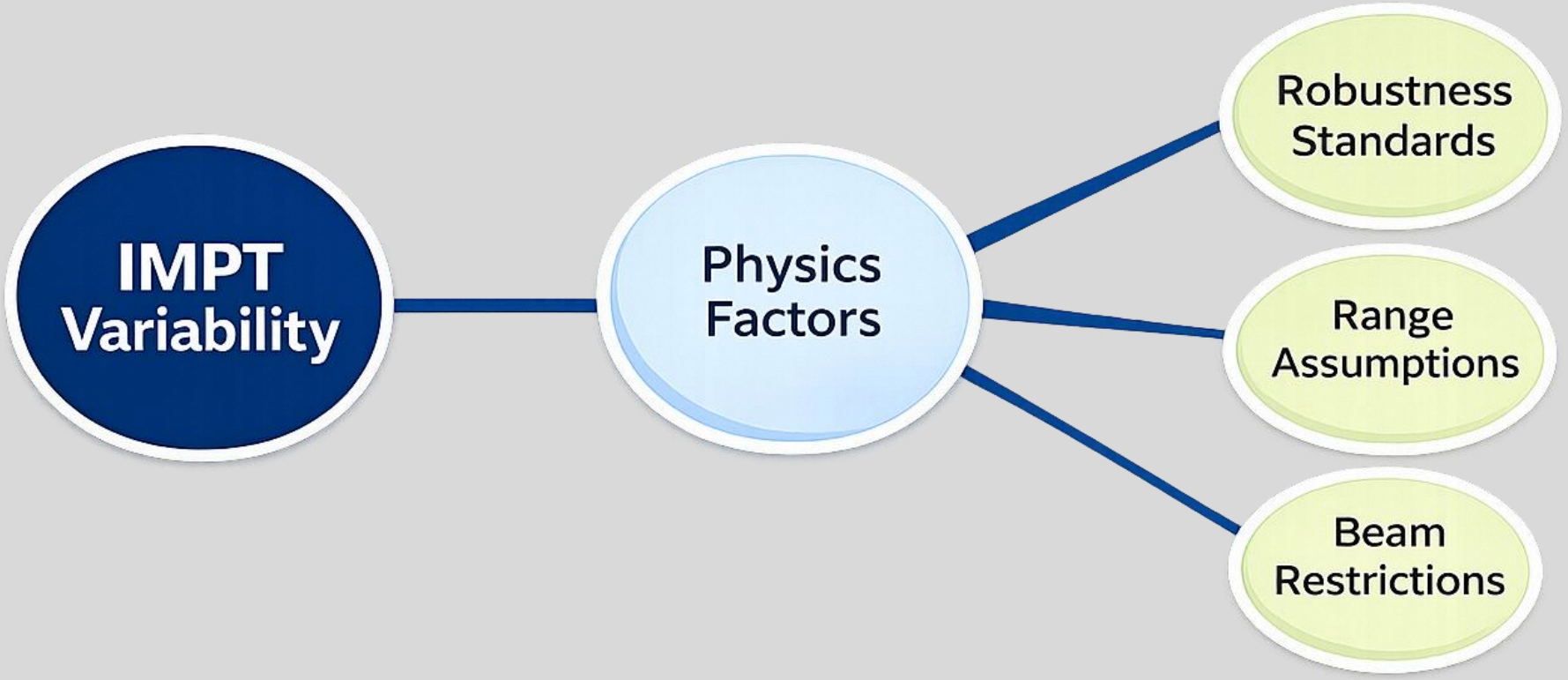


Why Does Variability Exist?

Does Plan Quality Matter Clinically?

Two Phase III Trials. Two Different Answers

TORPEdO	MD Anderson
Endpoint: Patient-Reported Outcomes	Endpoint: Toxicity Reduction
IMPT ≈ IMRT	IMPT > IMRT
No significant QoL advantage	Less feeding tube use
No swallowing advantage	Less weight loss
Excellent outcomes in both arms	Equivalent disease control

What Should Dosimetrists Learn From This?

✓ Better DVHs do not automatically create better outcomes

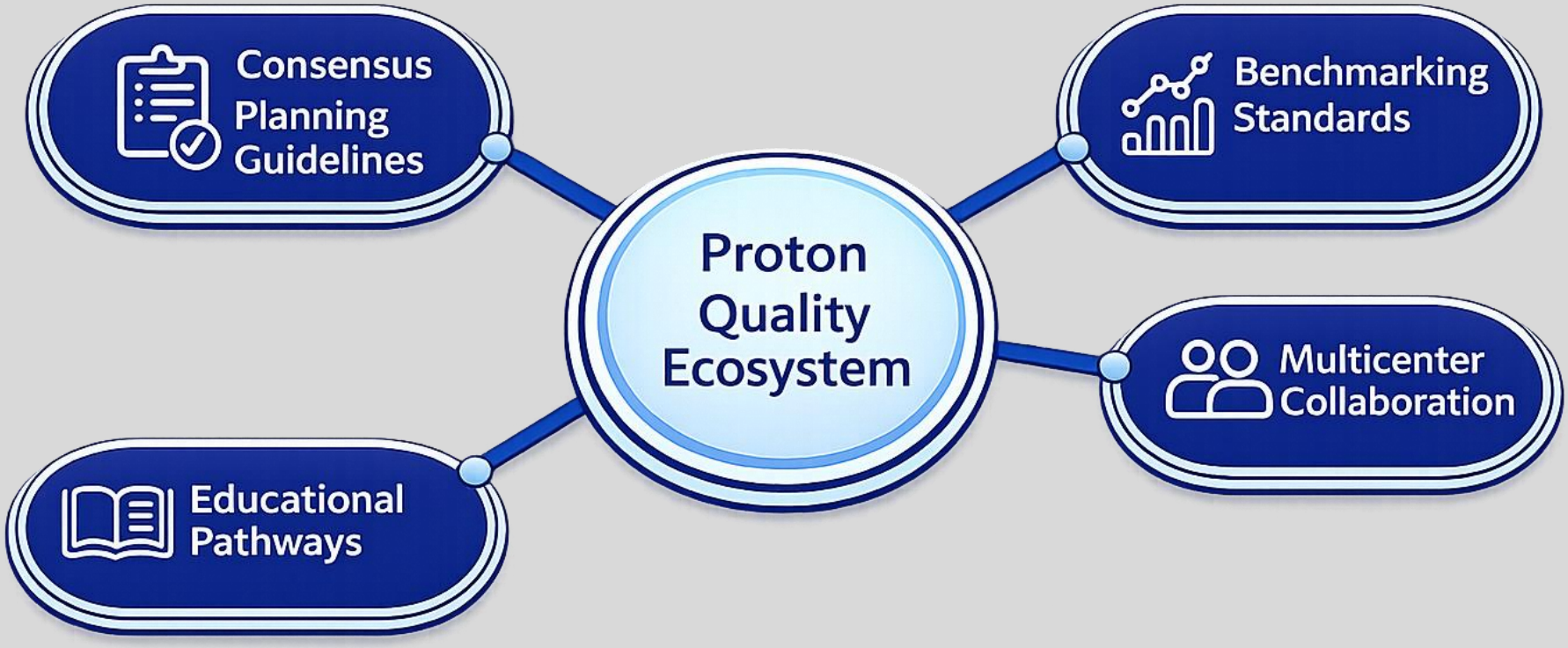
✓ Some dosimetric improvements clearly matter

✓ Modern IMRT is exceptionally good

✓ Treatment quality matters

Where to next?

What the Proton Community Needs Next



From Vision to Action

- Structured Peer Review
- Competitive Replanning
- Benchmark Case Libraries
- Education & Mentorship
- Outcome Feedback Loops

Conclusion

1. Proton therapy is not inherently superior.
2. Plan quality determines clinical value.
3. Significant variability exists — even among expert centers.
4. Clinical outcomes depend on execution, not physics alone.
5. The future of IMPT requires standardization and reproducibility.

Acknowledgments

PTCOG HN Subcommittee

Participating Institutions

Collaborators/Research Coordinators

ProKnow

Dr. J.W. Snider

APEX Dosimetry Team

Q&A

Thank you for your attention!!

smarter plans. smoother process. stronger patient outcomes.