

Expansion of SGRT: The dosimetric benefits of non-coplanar treatments

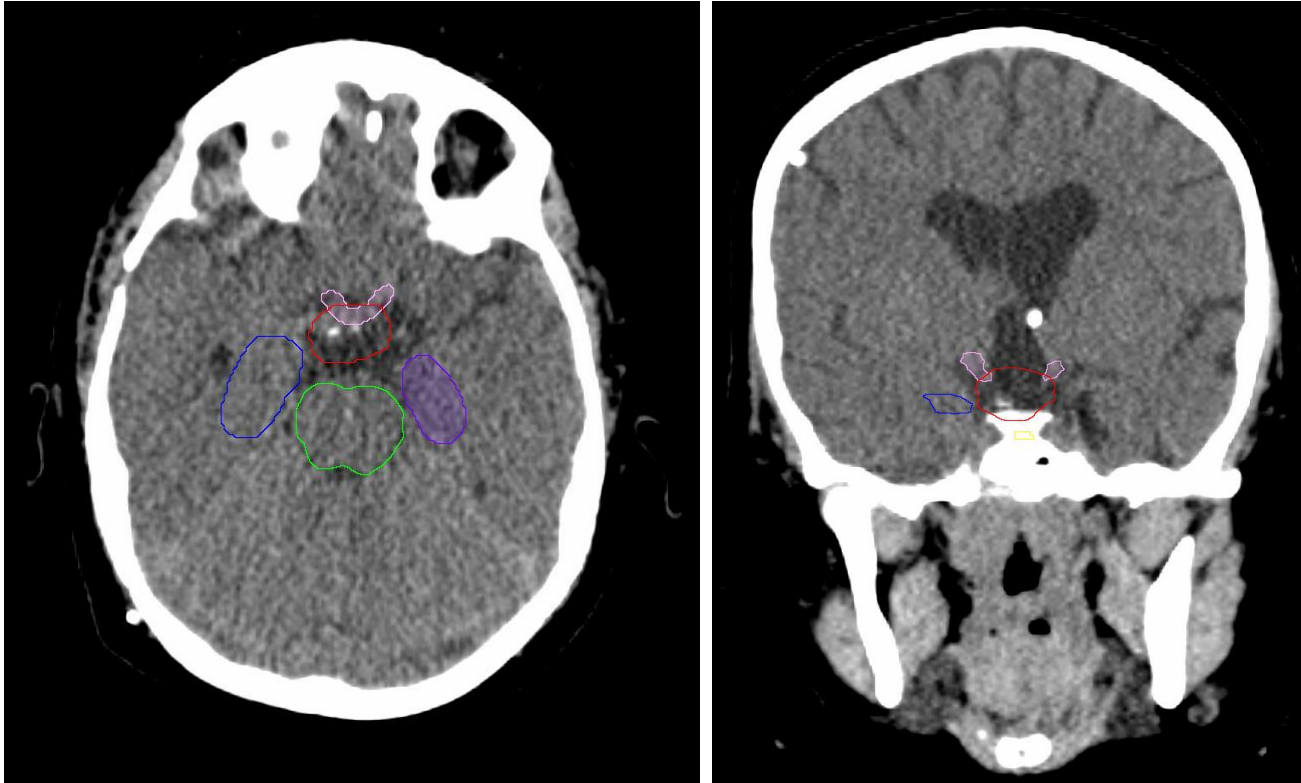
David Parsons

May 6, 2026

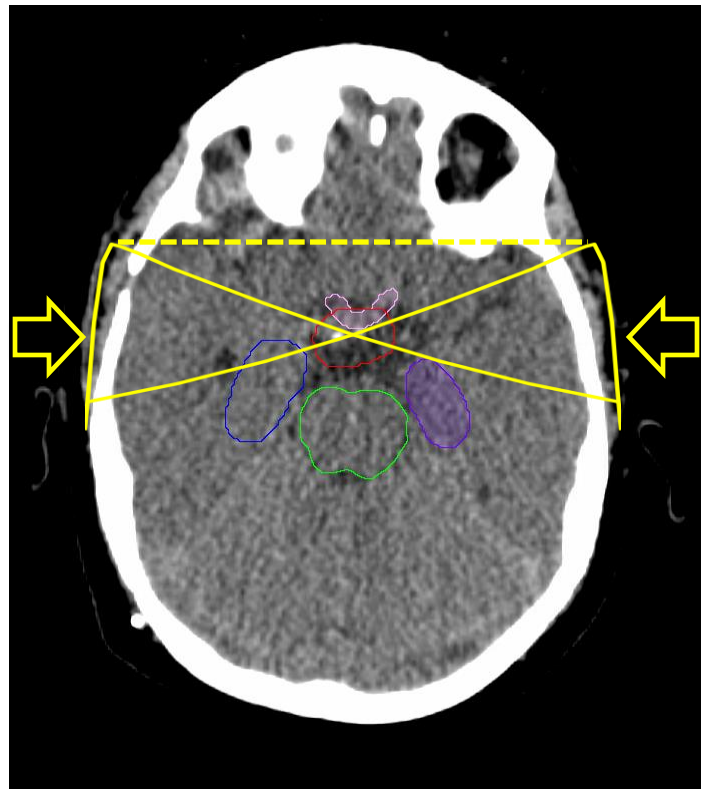
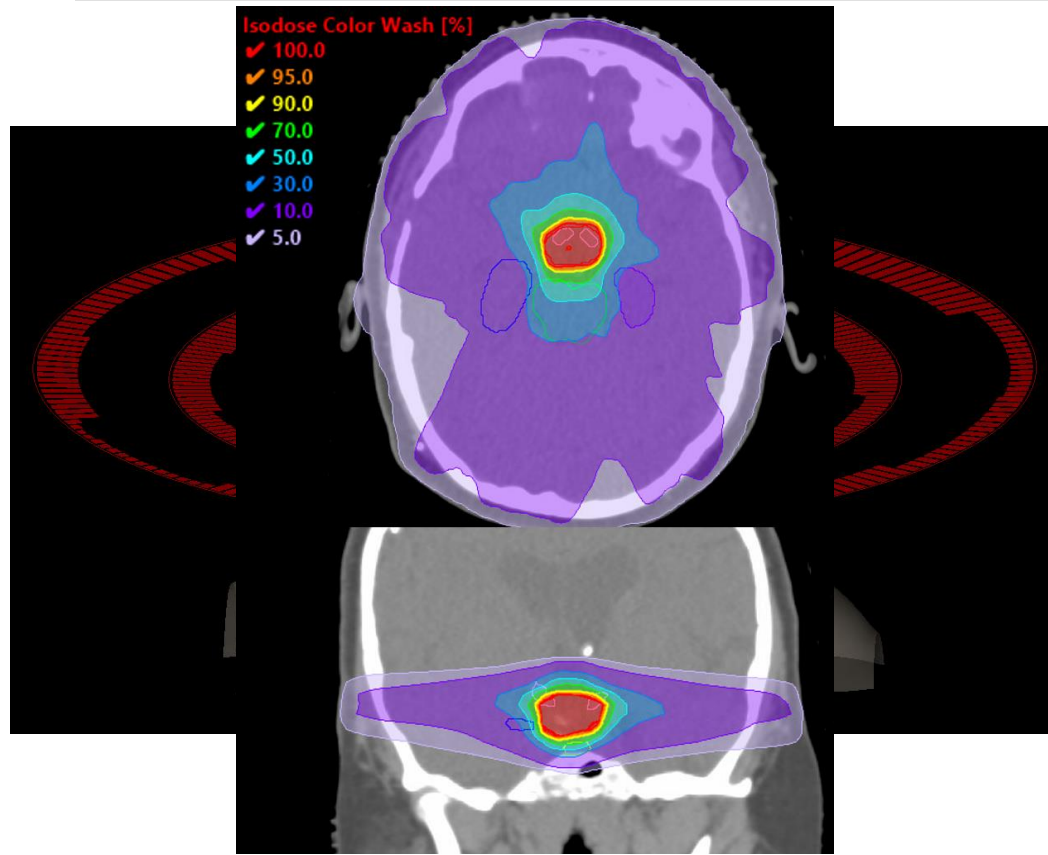
Outline

- **What is a non-coplanar treatment?**
- **Why non-coplanar treatments matter?**
- **Clinical use cases:**
 - **Brain**
 - **Head and neck**
 - **Thorax**
 - **Breast**
 - **Abdomen Pelvis**
- **Practical barriers to implementation**

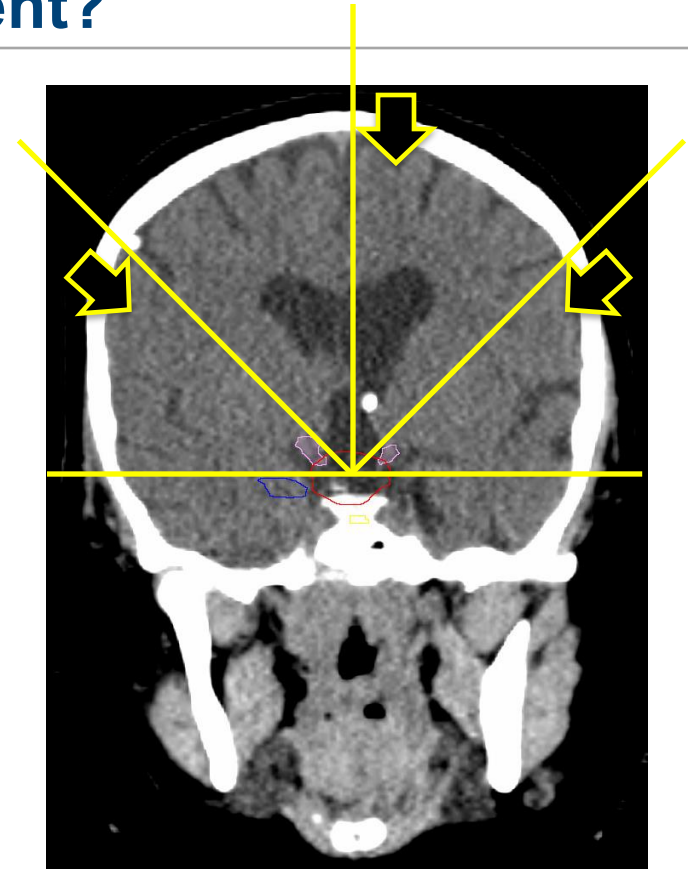
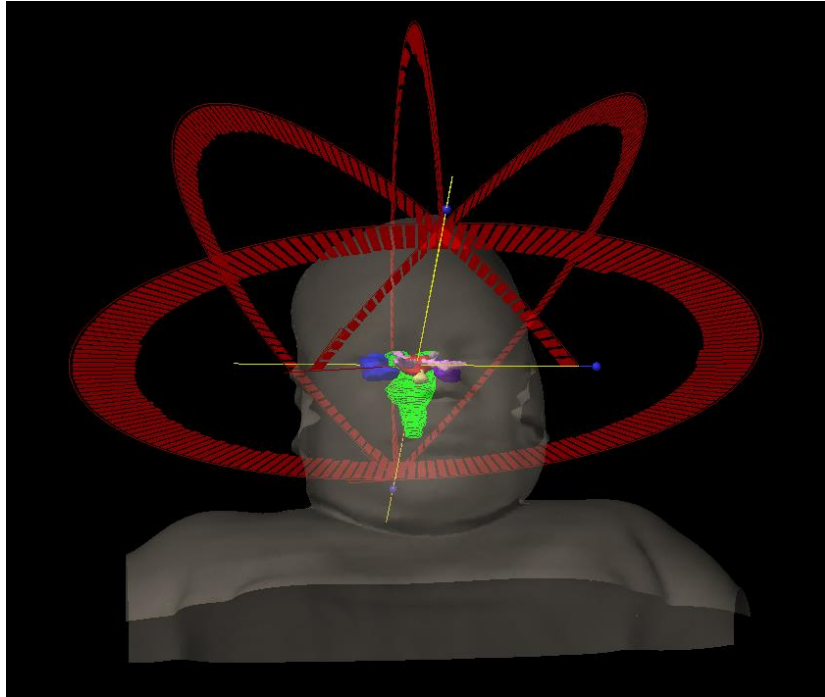
What is a non-coplanar treatment?



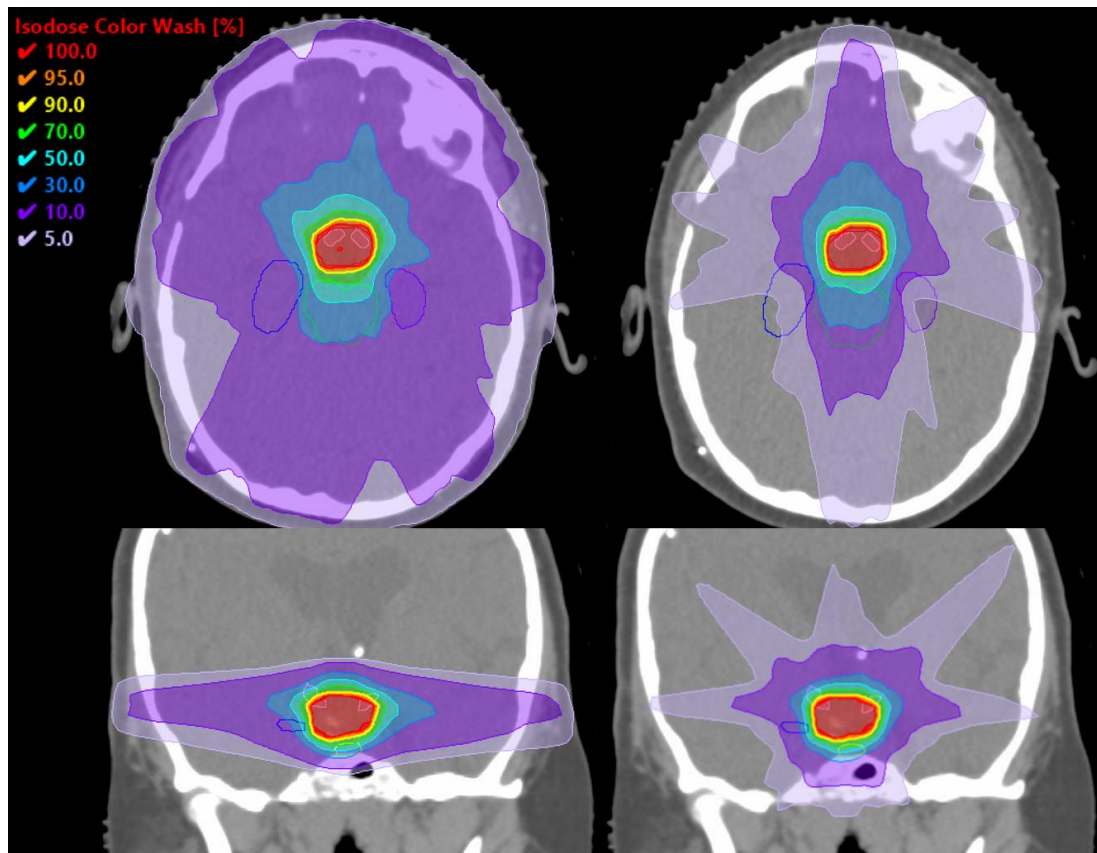
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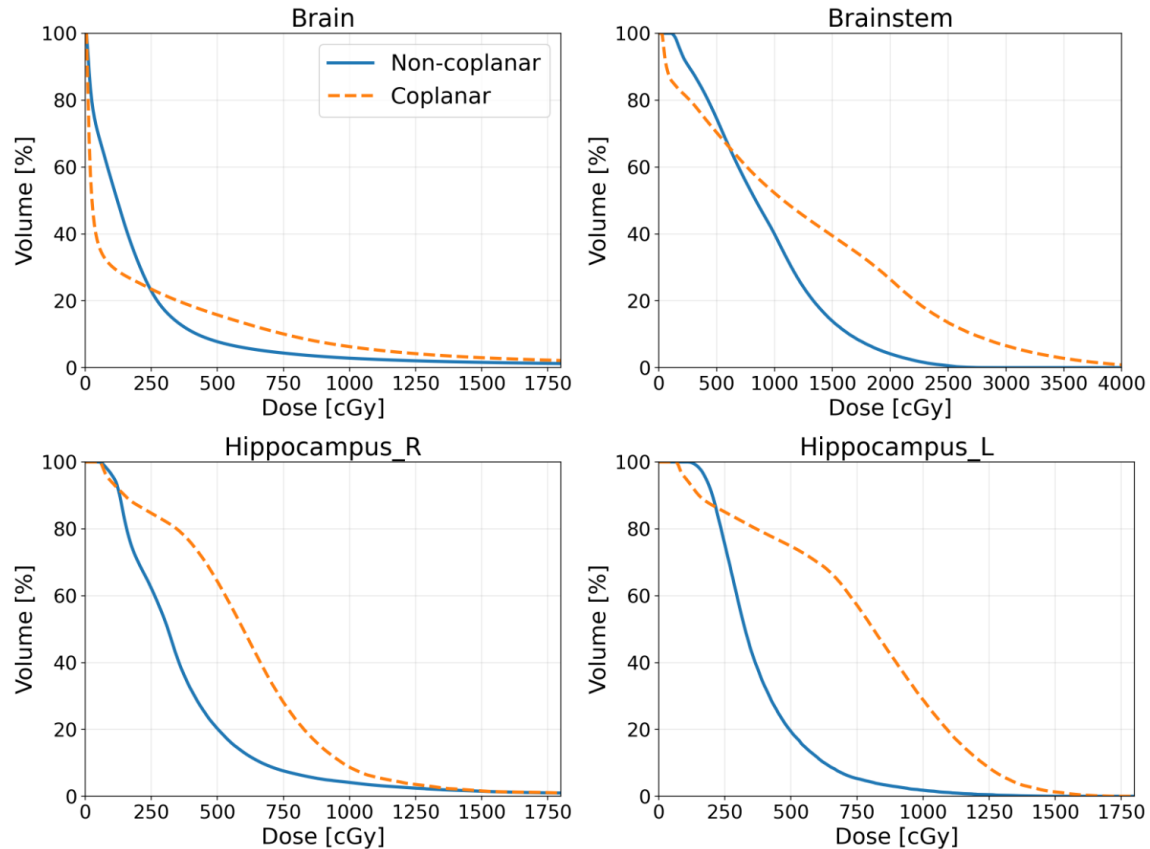
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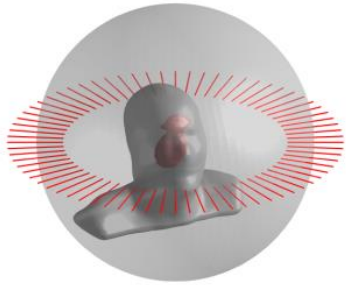
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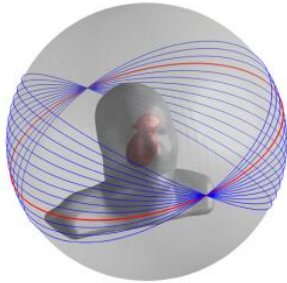
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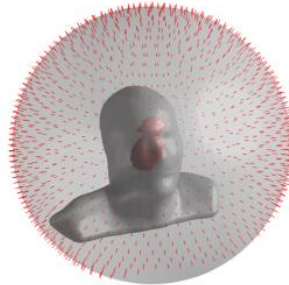
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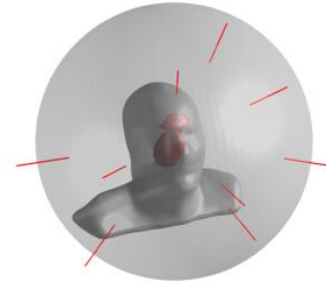
**Coplanar VMAT
(aka 2π)**



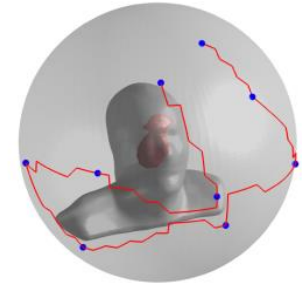
**Non-coplanar
VMAT**



4π



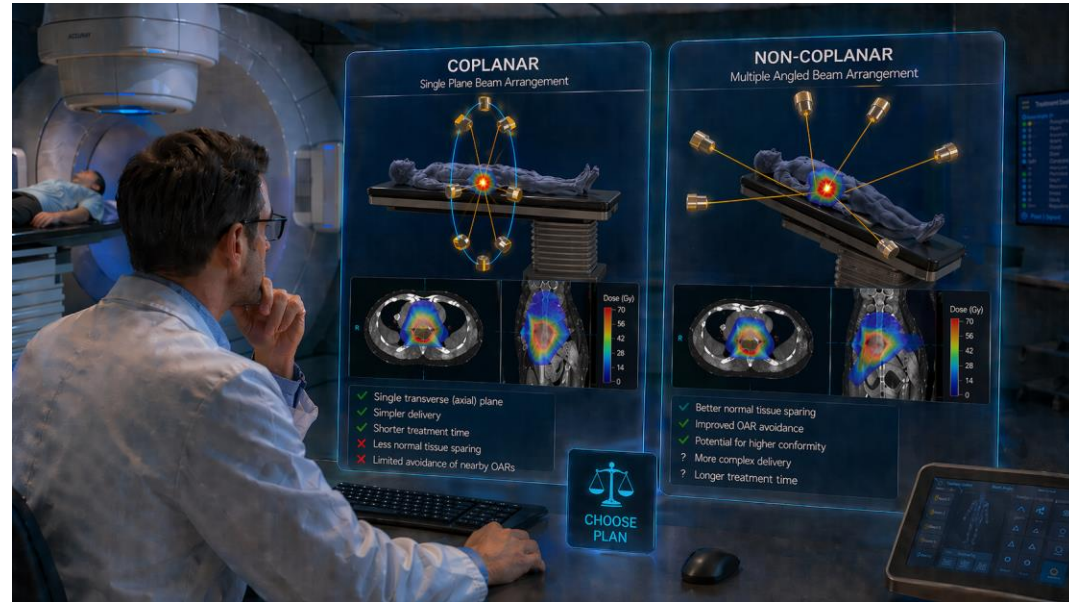
**Non-coplanar
Beam angle optimization
(BAO)**



- Adds beam directions beyond a single geometric plane
- Can reduce beam overlap through normal tissues
- Most relevant when nearby OARs limit plan quality
- Clinical adoption remains limited by workflow and deliverability challenges

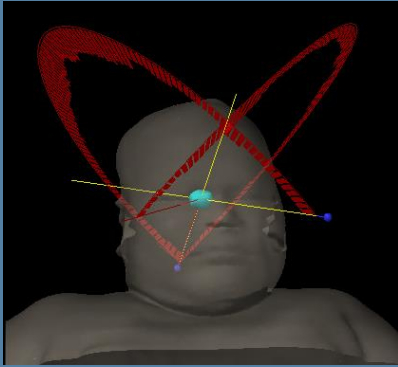
When should you use non-coplanar?

- When anatomy creates directional avoidance opportunities
- Beam/trajectory selection is decided with the critical anatomy
- Benefit is site-, patient-, and workflow-dependent
- When the chosen geometry is safe and deliverable



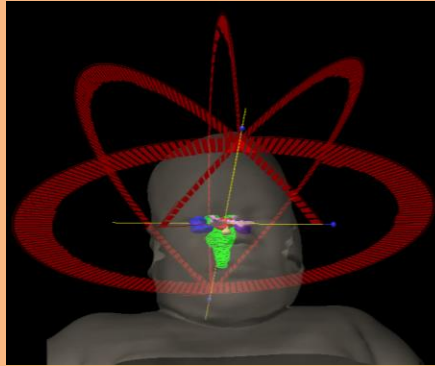
How non-coplanar geometry is chosen matters

Simple Non-Coplanar



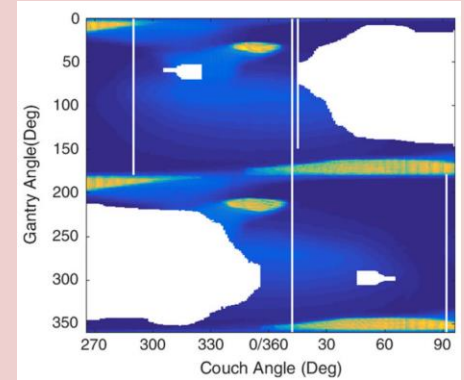
- Manual beam selection
- Few added couch kicks
- Limited search of beam space

Class solution



- Predefined template or class solution
- Standardized for a site/workflow
- Practical compromise between quality and efficiency

Optimized Non-Coplanar



- Beam angle/trajectory optimization
- Patient-specific selection
- Better use of available geometry

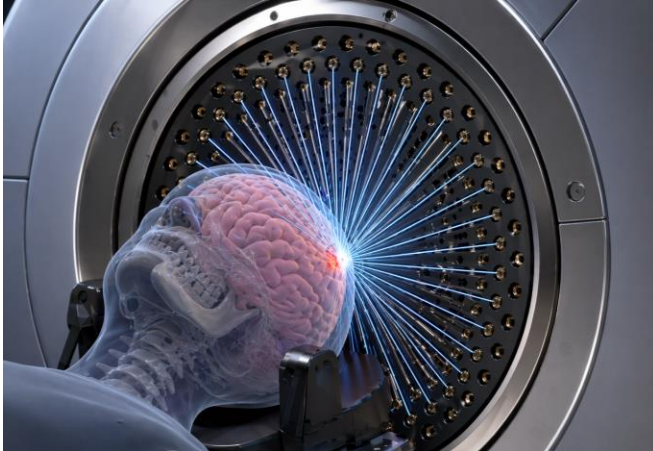
Clark et al, Pract Radiat Oncol, 2(4), 2012

MacDonald et al, Medical Physics, 44(1), 2017

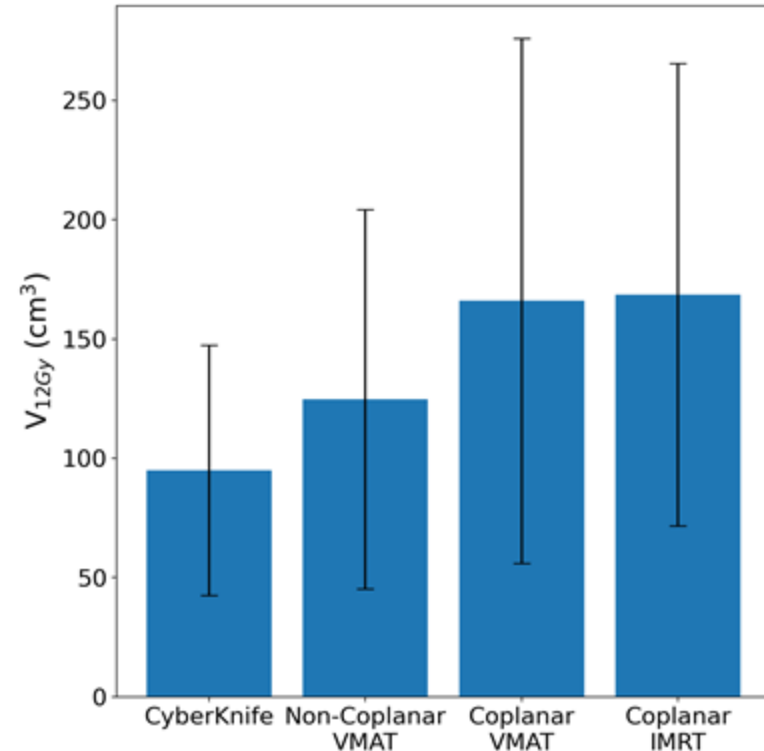


Cranial disease: strongest proof-of-principle

- Improves conformity and dose falloff in SRS/SRT
 - Standard-of-care
- Can reduce dose to normal brain and selected OARs



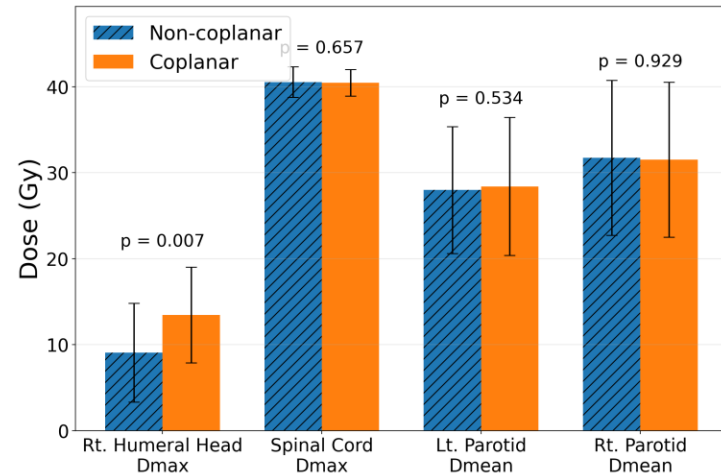
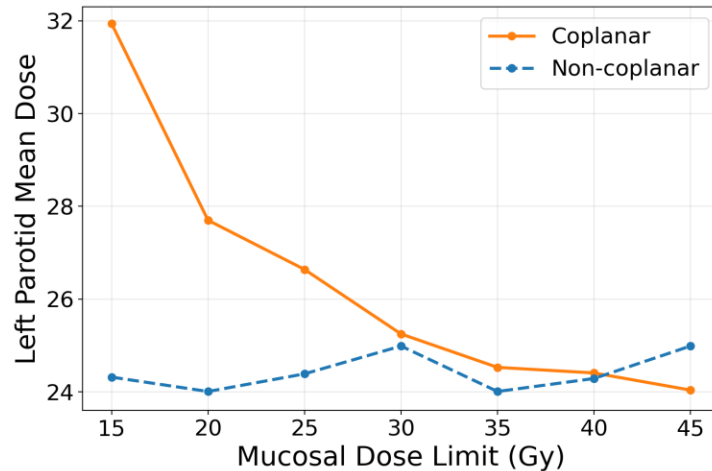
Multi-target plan quality



Zhang et al, Technology in Cancer Research & Treatment, 18, 2019

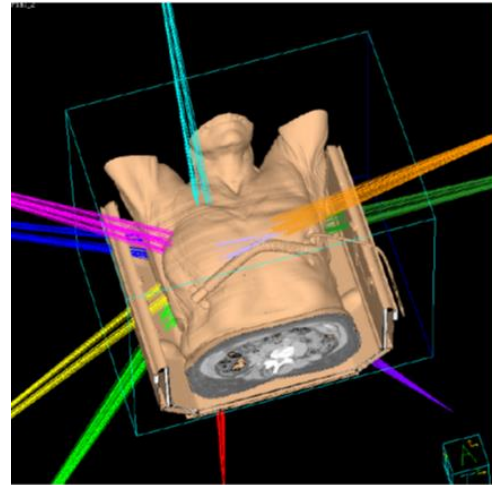
Head and neck: complex anatomy favors directional avoidance

- Multiple adjacent OARs create opportunities for non-coplanar sparing
- Optimized non-coplanar planning can reduce dose to key structures
- Gains are more convincing when geometry is selected intelligently
- Not every H&N comparison shows a strong advantage

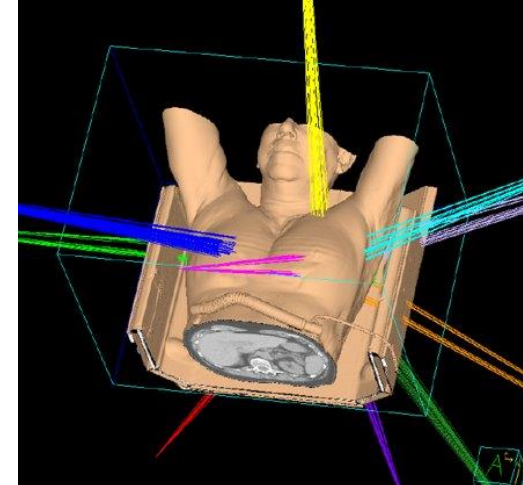


Lung and thorax: Class solution (circa 2007)

Right Sided		Left Sided	
Gantry	Couch	Gantry	Couch
150	0	210	0
90	0	270	0
45	345	315	15
330	90	30	90
30	90	330	90
315	0	50	0
270	15	90	15
270	345	90	345
220	10	160	350
180	0	180	0

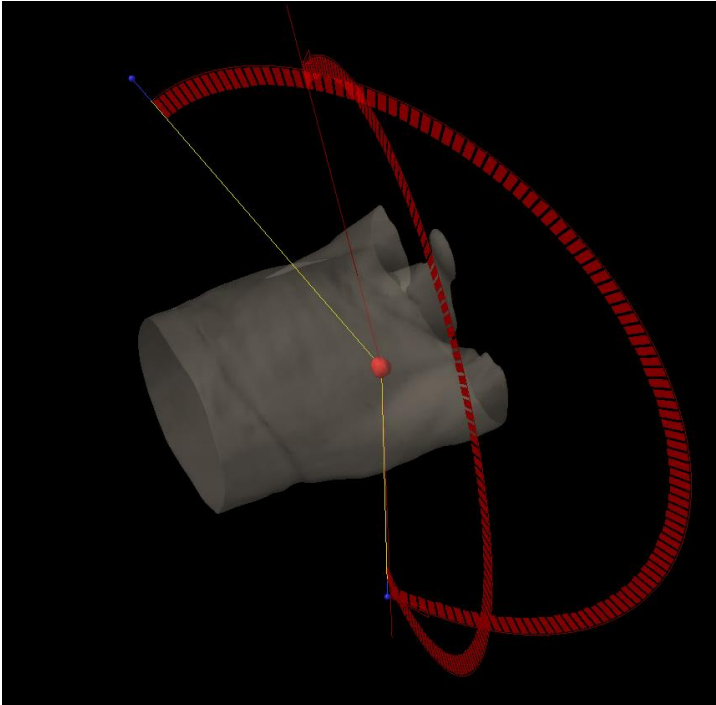
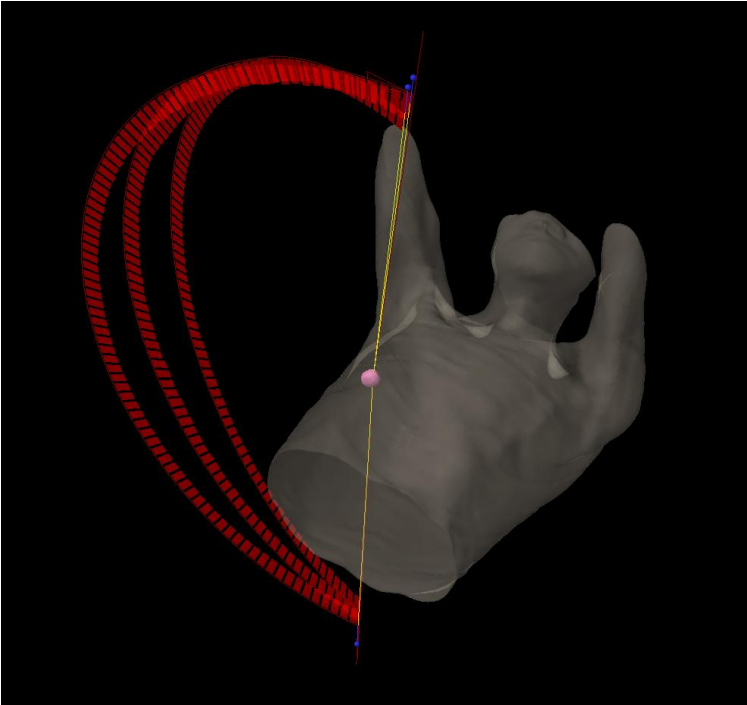


Right Sided Angles



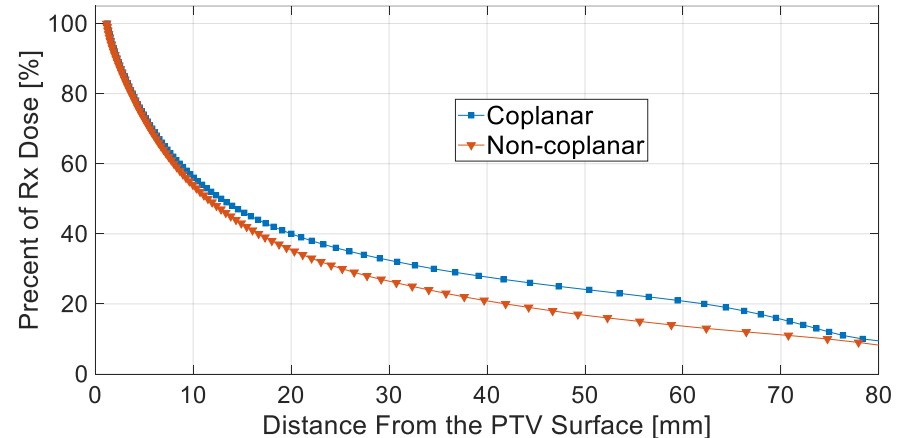
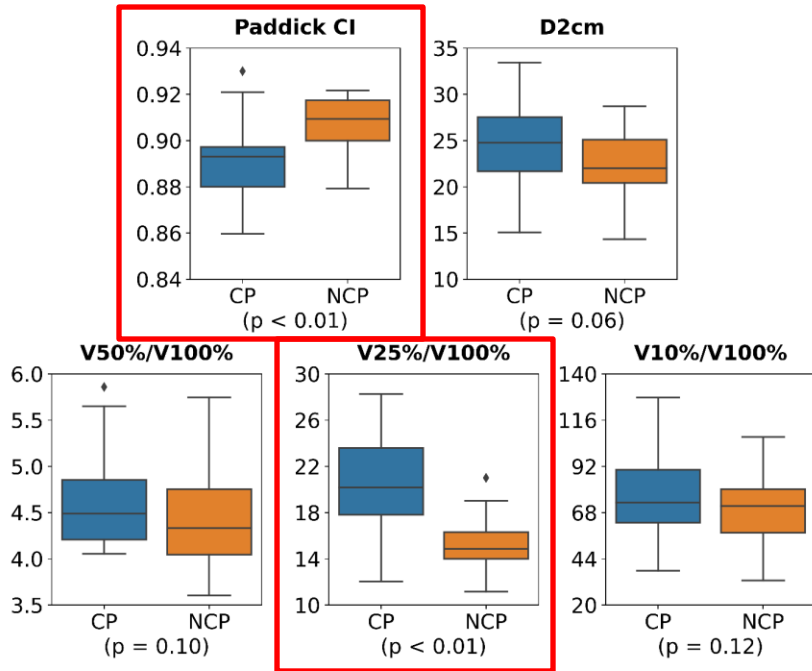
Left Sided Angles

Lung and thorax: modern usage

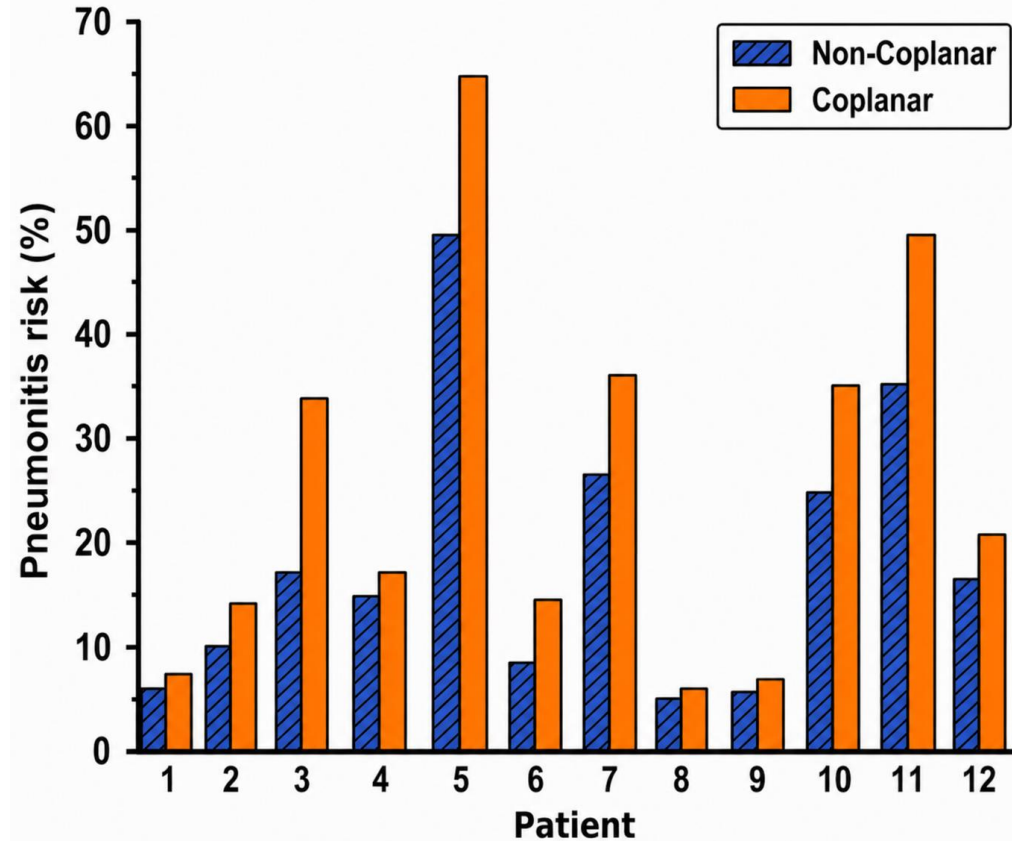


Lung and thorax: Compressed fall-off

- NCP lung plans are **more conformal**
- **Significantly lower $V_{25\%}$**
- **Less low-dose spillage over a large distance from the PTV range**



Lung and thorax: meaningful but selective benefits



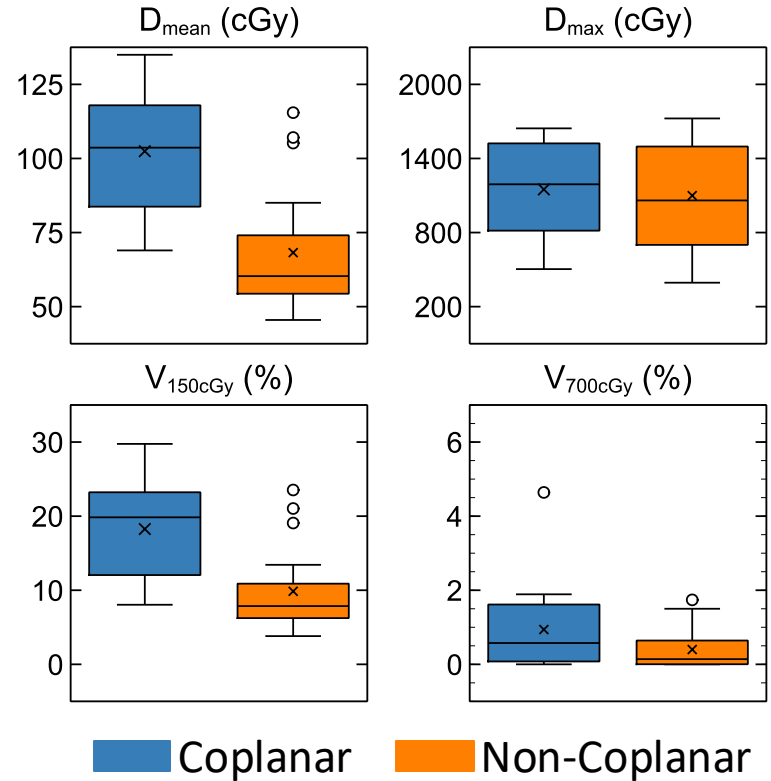
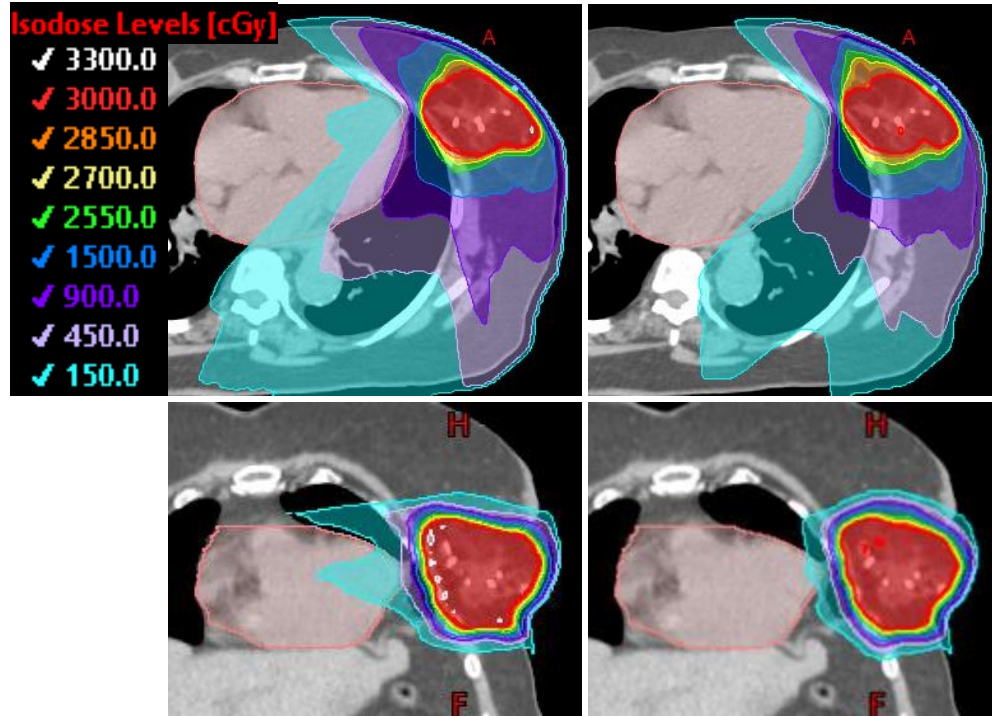
- Can reduce dose to the chest wall, heart, spinal cord, and functional lung
- Benefit remains case-dependent rather than universal

Bedford and Ahmed, Phys. Imaging Radiat. Oncol., 28, 2023

Breast: non-coplanar planning for cardiac sparing

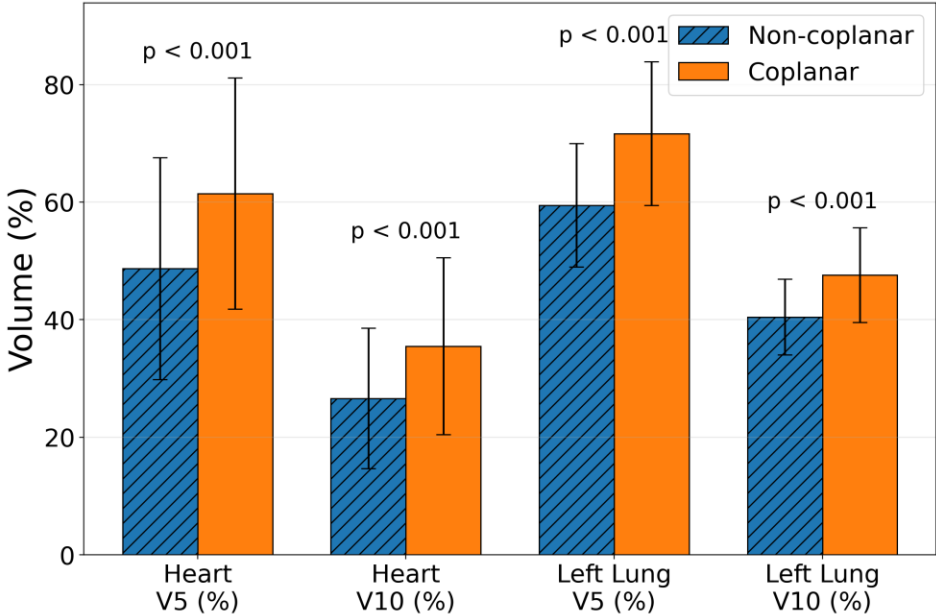
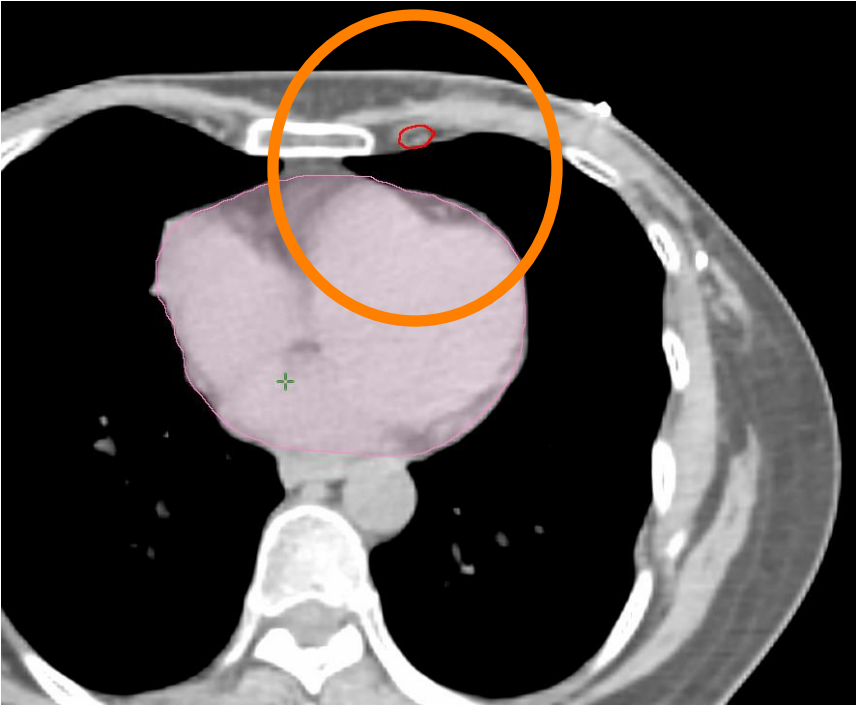


Breast: non-coplanar planning for cardiac sparing



Wang et al, J. Appl. Clin. Med. Phys., 27(5), 2026

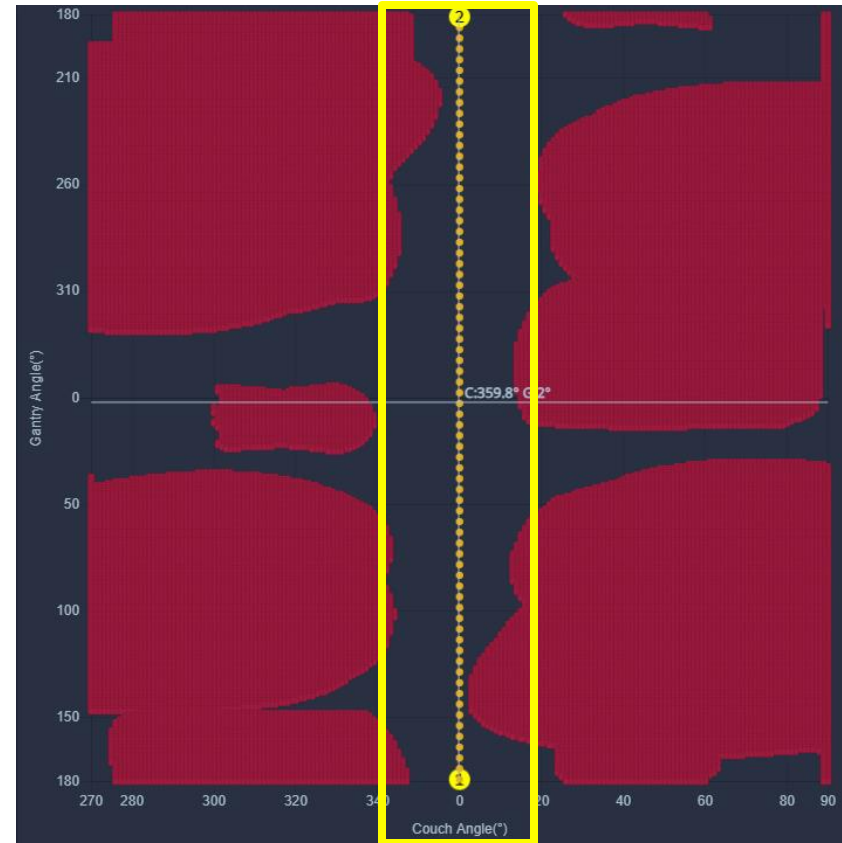
Breast: non-coplanar planning for internal mammary nodes



Xu et al, Radiology and Oncology, 55(4), 2021

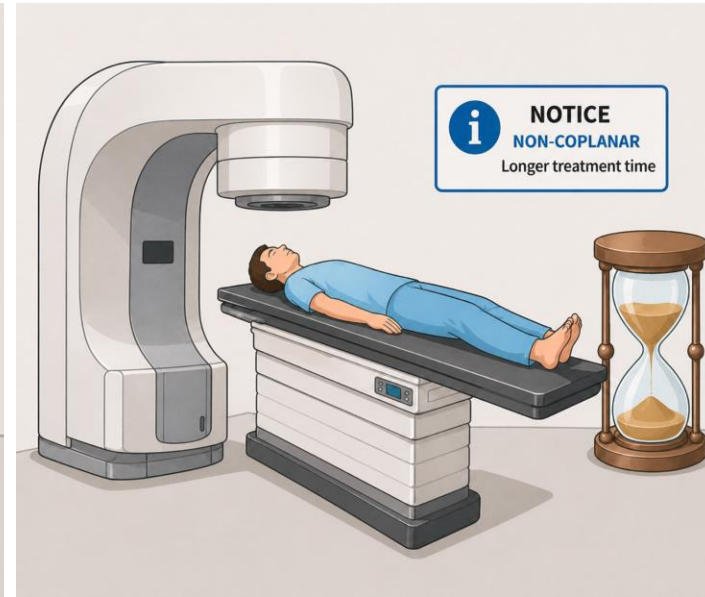
Abdomen Pelvis: available collision space decreases

- As the isocenter moves inferiorly, the collision space decreases
- 4π /BAO has shown promise in increasing the dosimetric gain
- Limited clinical data for non-coplanar VMAT

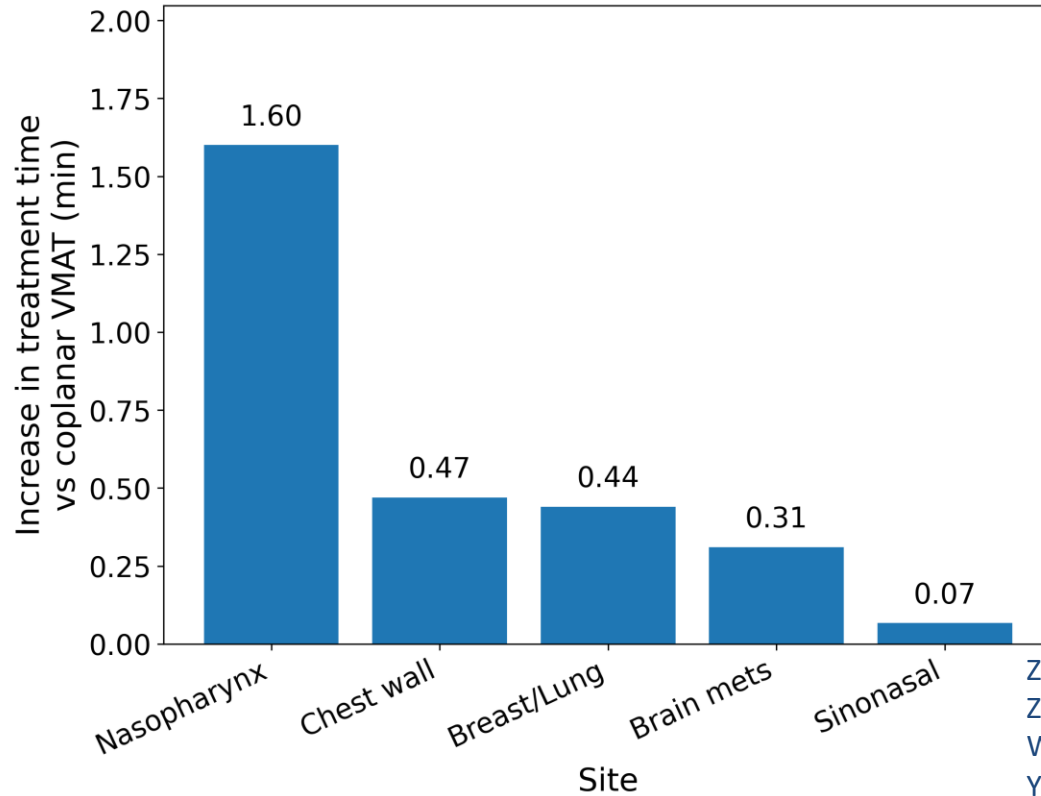


Why is non-coplanar planning underused?

- Theoretical dosimetric benefit is often limited by uncertainty in available beam space
- Added treatment time



Added Treatment Time



Values reflect study-reported increases relative to coplanar VMAT.
Definitions of treatment time may differ across studies.

Zhang et al, Technol. Cancer Res. Treat, 18, 2019
Zhong-Hua et al, Strahlenther Onkol, 191(1), 2015
Wang et al, J. Appl. Clin. Med. Phys., 27(5), 2026
Yu et al, Pract. Radiat. Oncol., 8(4), 2018
Wild et al, Medical Physics, 42(5), 2015

Solutions

Manual dry runs



- Resource-intensive
- Imperfect without the patient

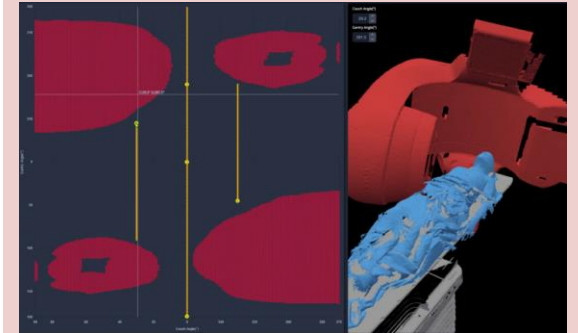
CT-based



🎯 Incomplete CT external contour can miss non-coplanar collision risk.

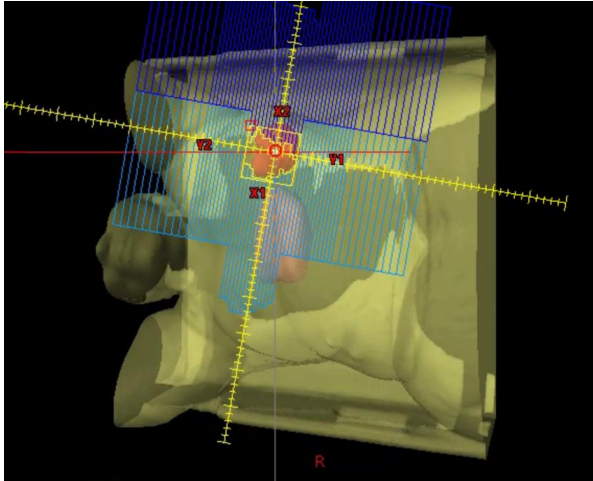
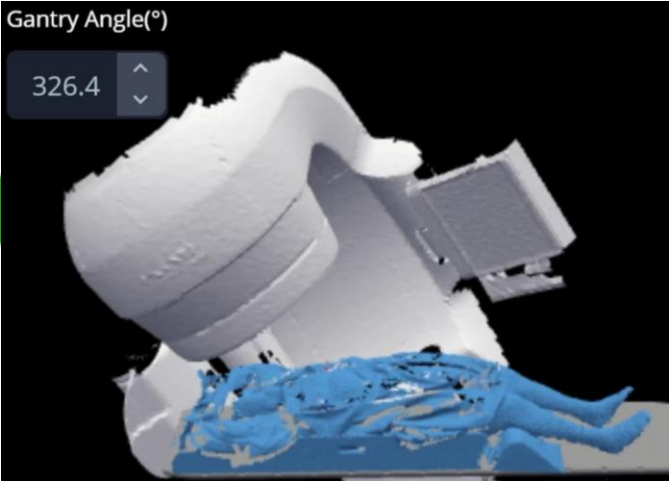
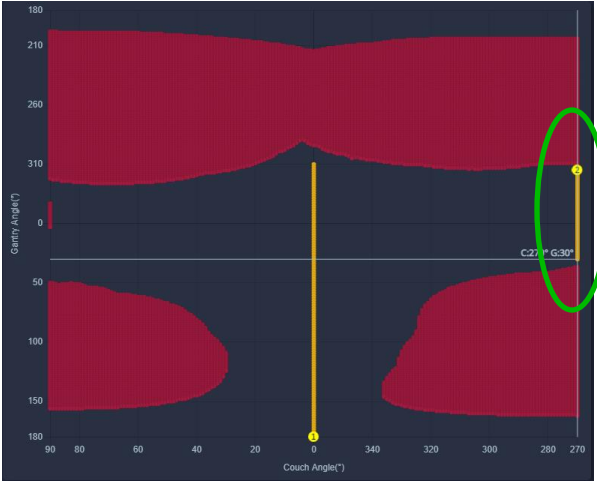
- May miss anatomy outside the scan range

Patient-specific surface-guided



- Accurate copy of the patient's setup
- Machine models to simulate the treatment

Patient-specific clearance mapping enables practical non-coplanar planning



What consistently helps — and what still limits adoption

Consistent advantages

- Better OAR sparing
- Improved conformity and dose compactness
- Selective directional avoidance

Summary

- **Non-coplanar planning is most useful in anatomically favorable, OAR-limited cases**
- **Optimization quality matters more than simply adding couch kicks**
- **The main benefit is usually OAR sparing, not dramatic target coverage gains**
- **Safe, efficient implementation is essential for broader adoption**
- **Patient-specific clearance mapping may help bridge that gap**