

VMAT Total Body Irradiation (TBI) Treatment Planning Techniques

Presenter: Chengzhu Zhang, Ph. D.

Advisor: Xiao Wang, Ph. D.

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The logo for Rutgers University, featuring the word "RUTGERS" in a large, red, serif font. The letter "R" is stylized with a long, sweeping tail that extends downwards and to the left.

Robert Wood Johnson
Medical School

- The role of TBI is to destroy the recipient's bone marrow and tumor cells, and to immunosuppress the patient sufficiently to avoid rejection of the donor bone marrow transplant.
- Following TG-17, the TBI protocol requires dose homogeneity along the body central axis to be within 10%.

Conventional Simulation

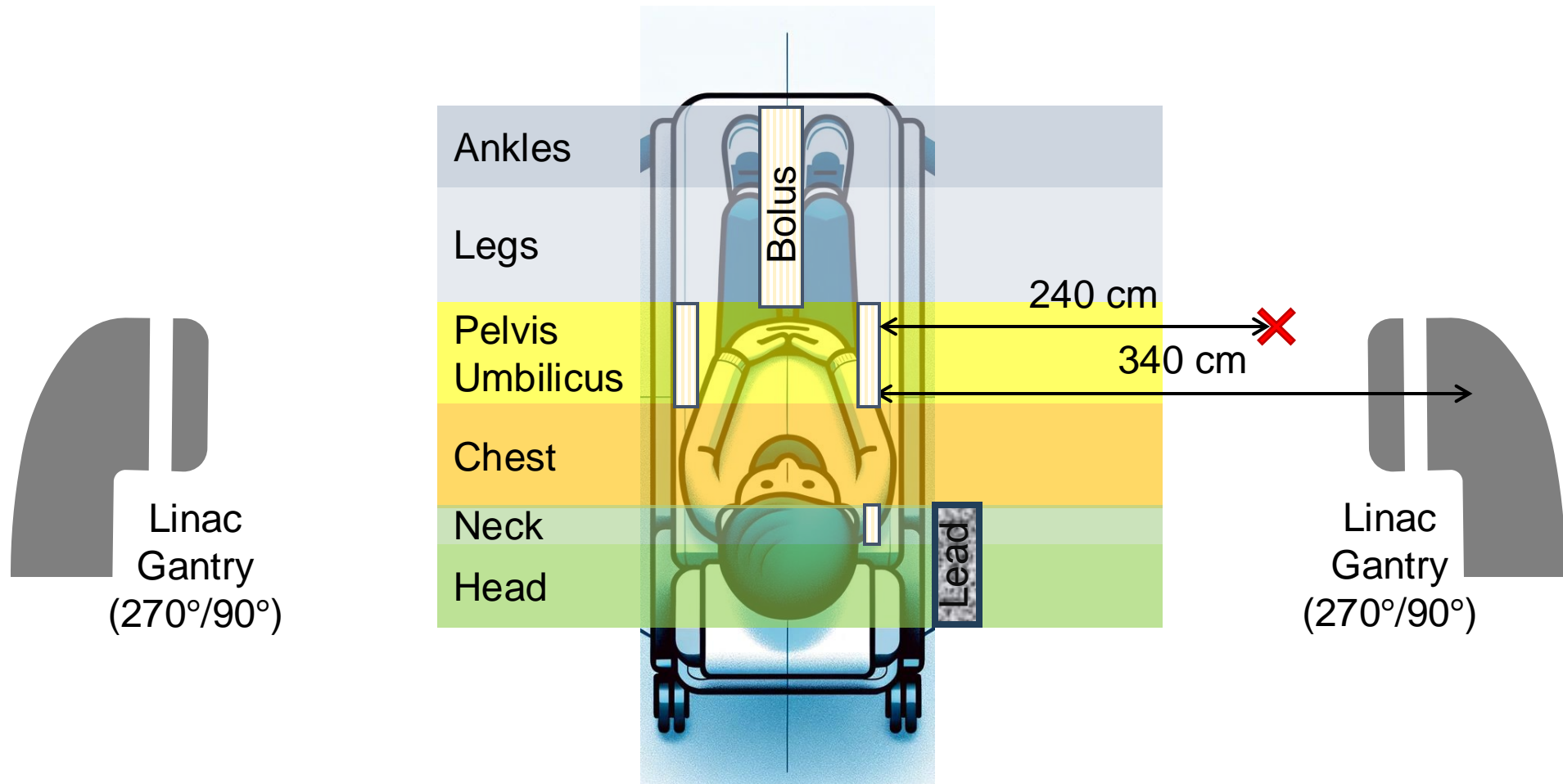


TBI patient in SIM

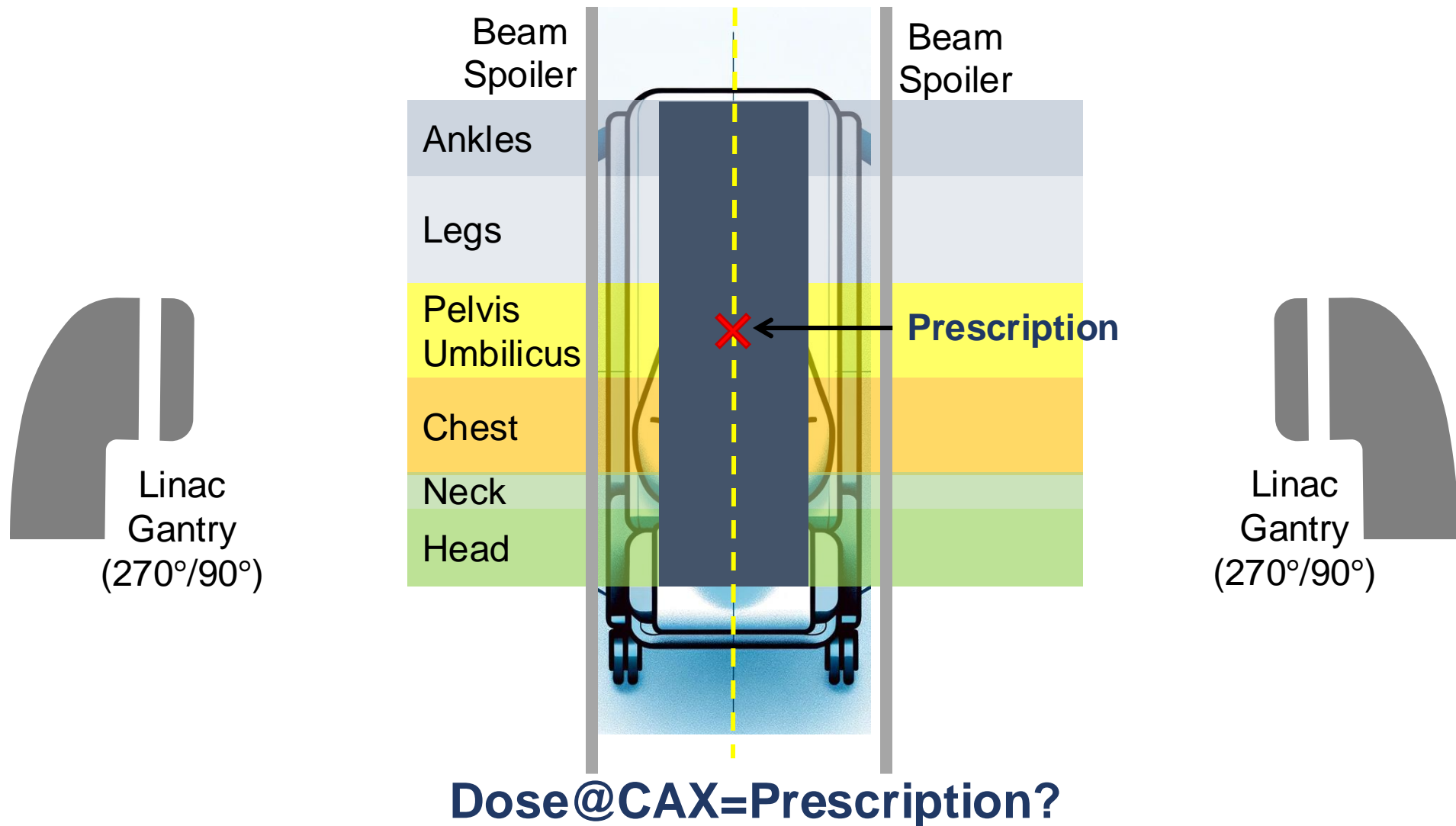


a diligent resident

Conventional Planning



Conventional Planning



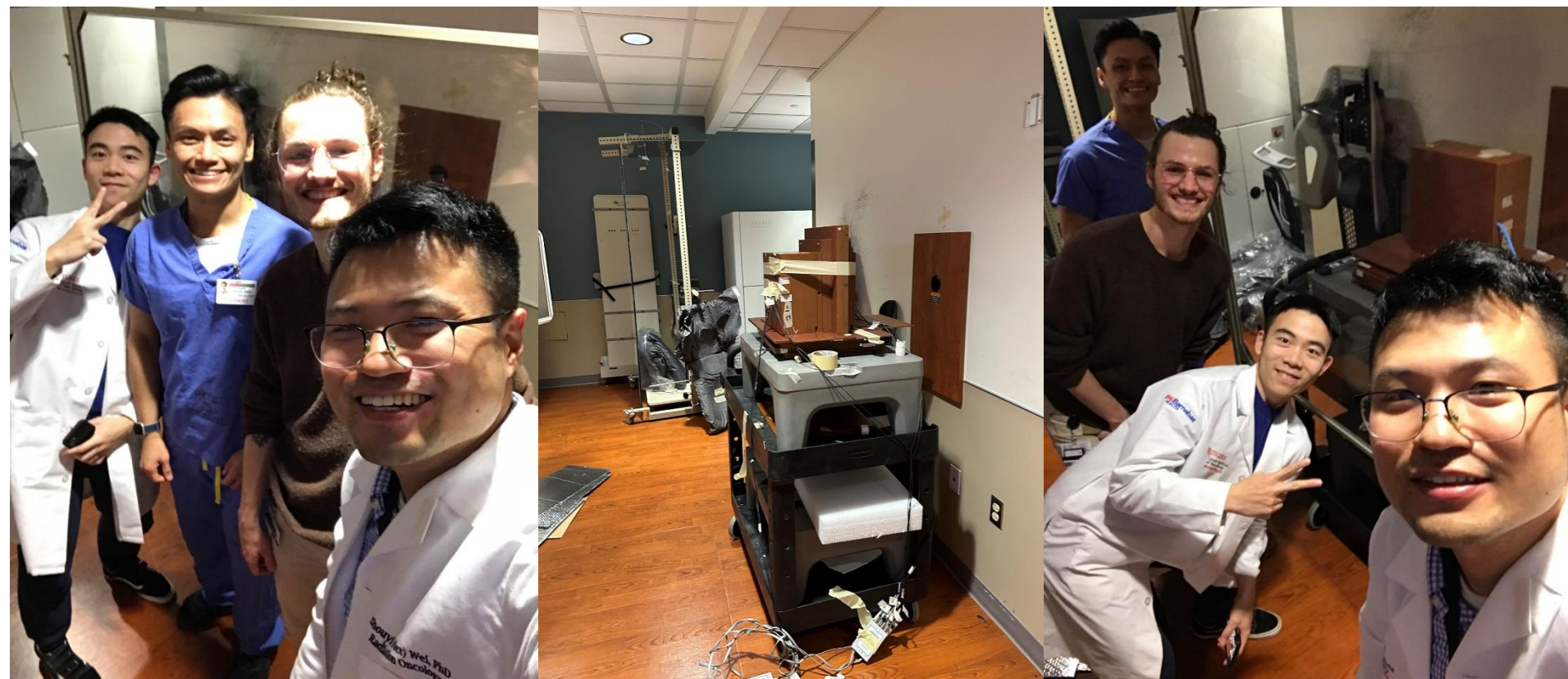
- Significant side effects
 - Interstitial pneumonitis (25% in patients)
 - Chronic kidney dysfunction
 - Cataract (30%-40%)

- Laborious Treatment Planning
 - Tedious parameter input, highly error prone.
 - Large uncertainty in measurement and setup.

- Patient discomfort in sitting positions

Not QA friendly

RUTGERS

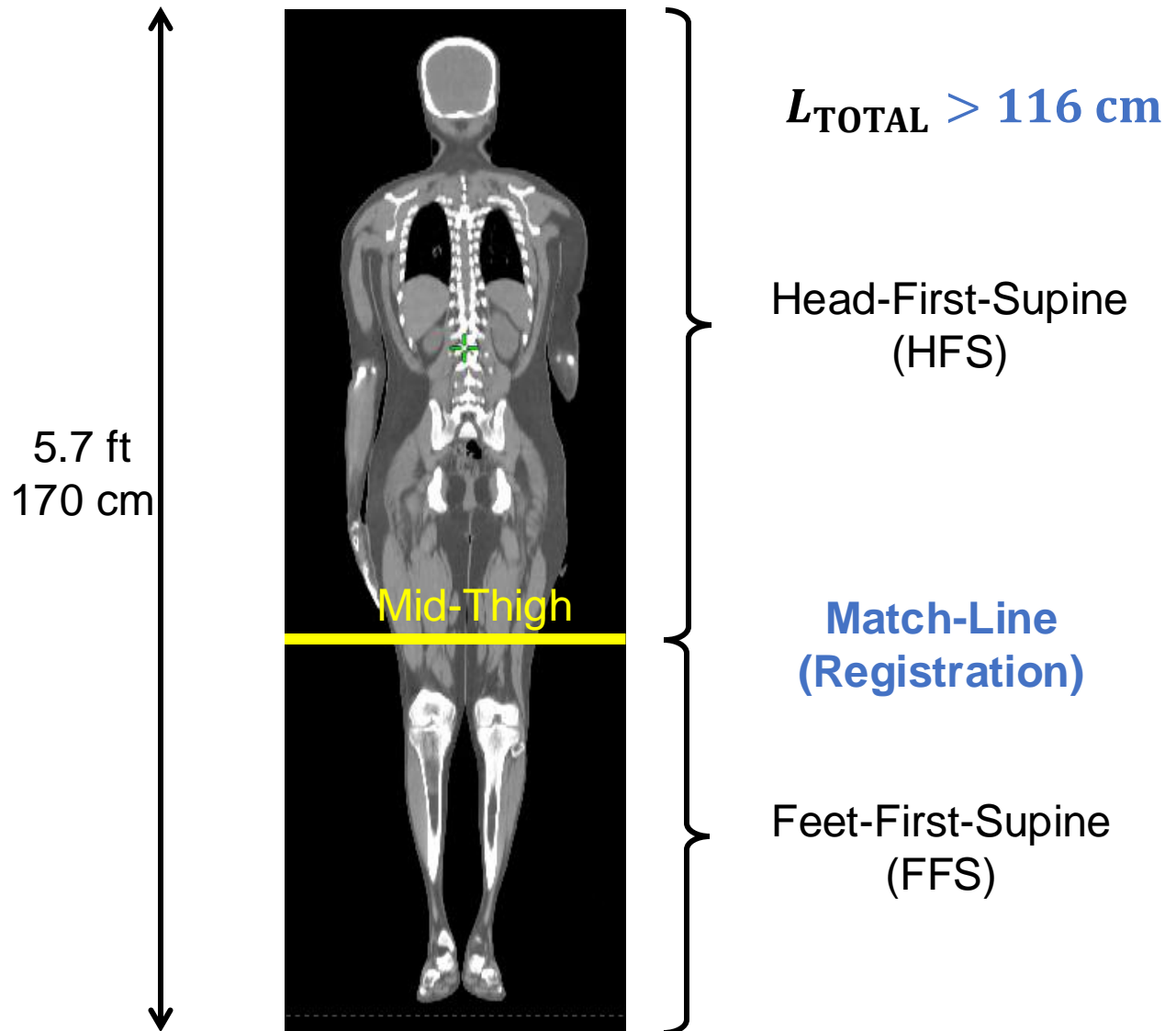


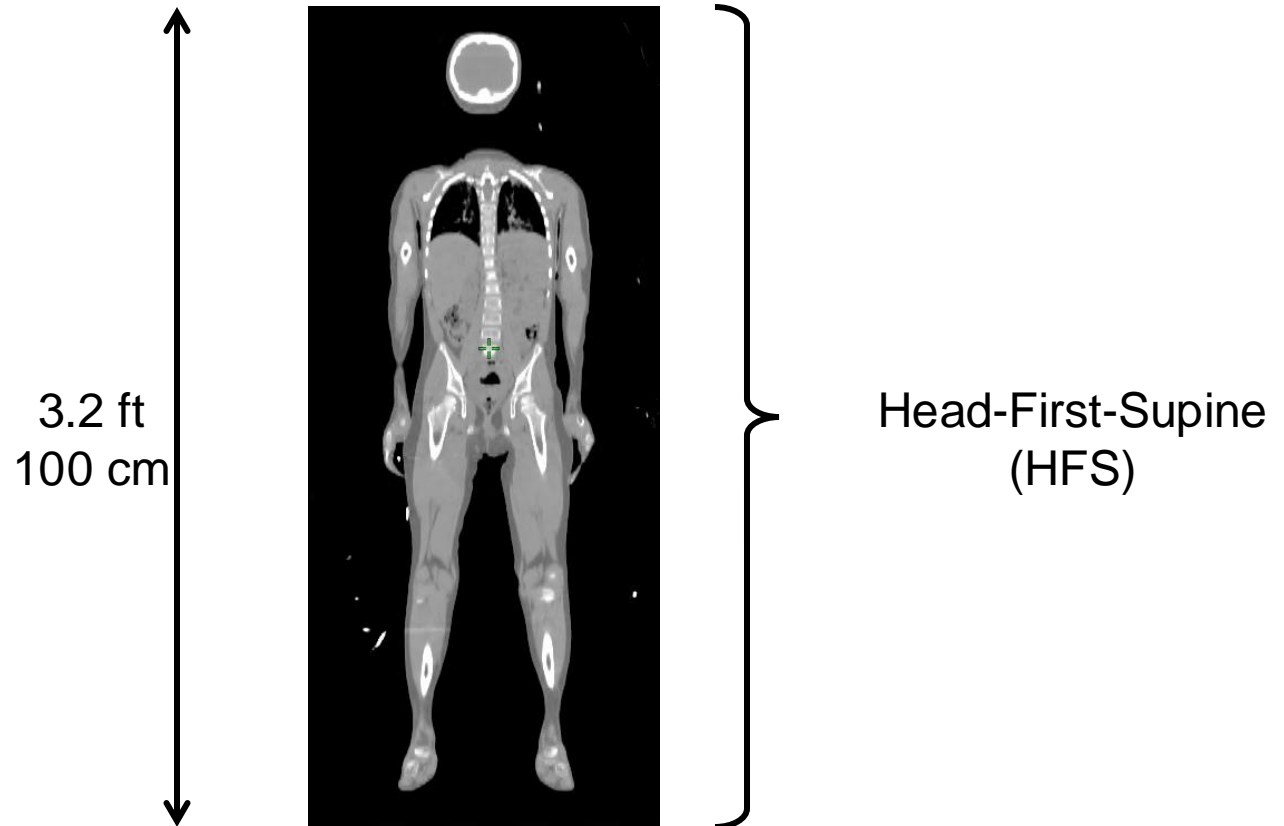
- Institutional implementation (covered by Xiao)
- Proposed Simulation (covered by Xiao)
- Treatment Planning Technique (this presentation)

Techniques deciphered from Stanford convention

Based on <https://github.com/esimiele/VMAT-TBI-CSI>

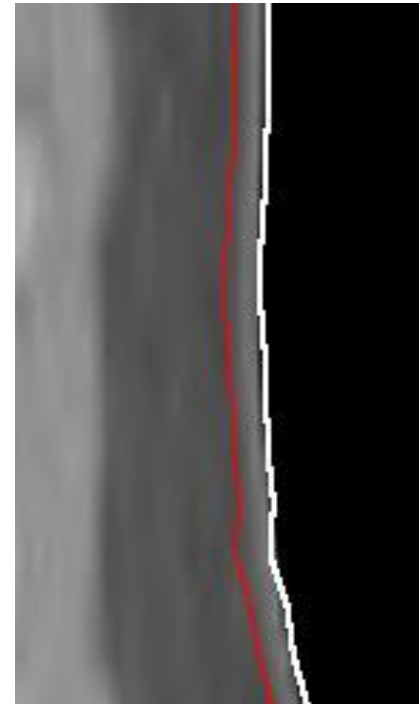
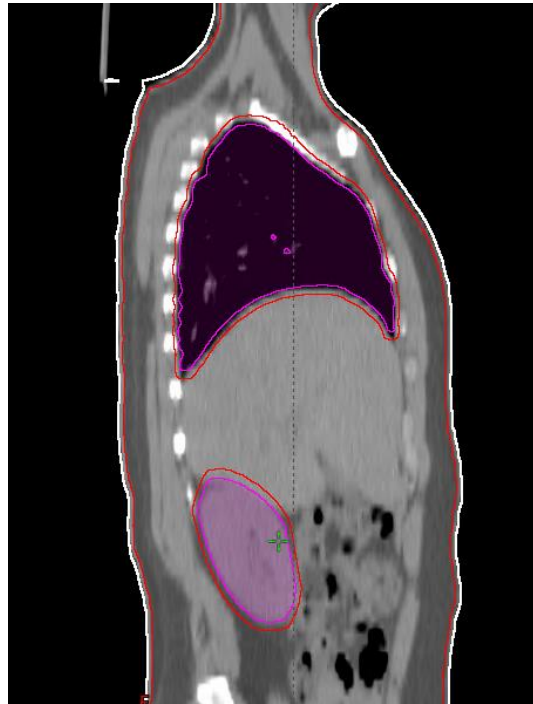
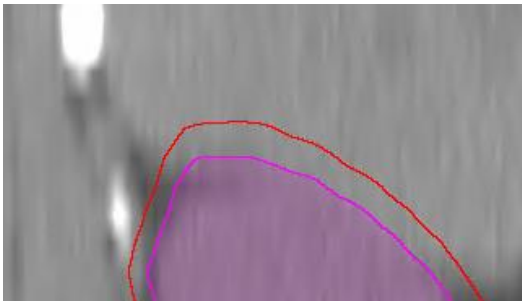
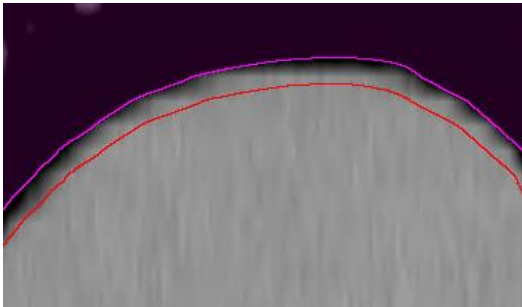
Acquisition of Whole-body CT





Lung + 3 mm

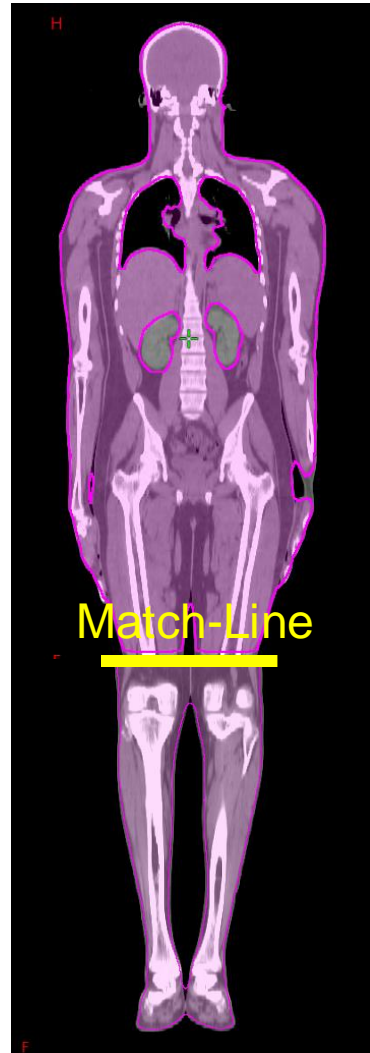
PTV = Body – 3 mm



Kidney + 3 mm

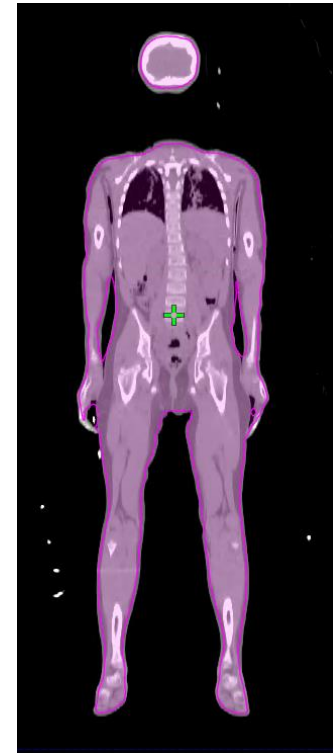
PTV_VMAT

PTV_LEG



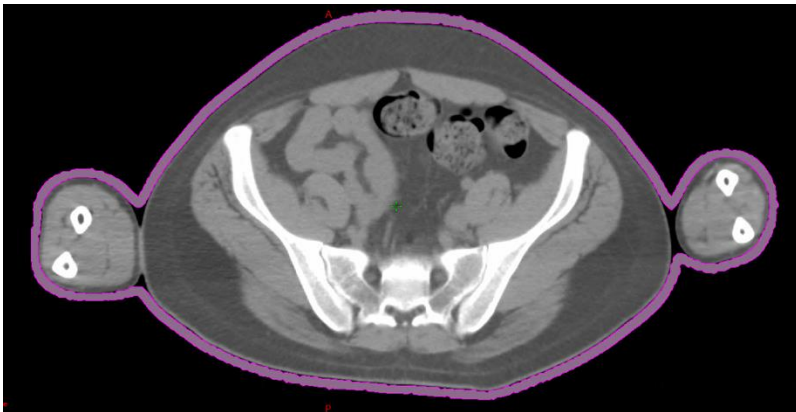
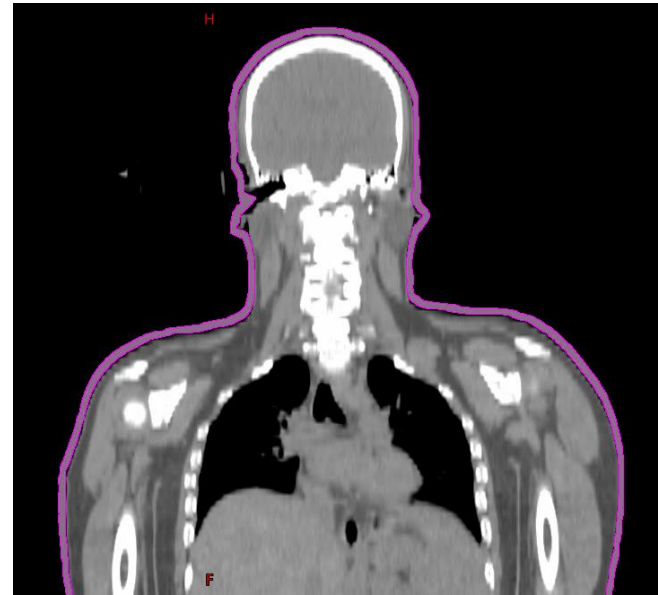
Adult

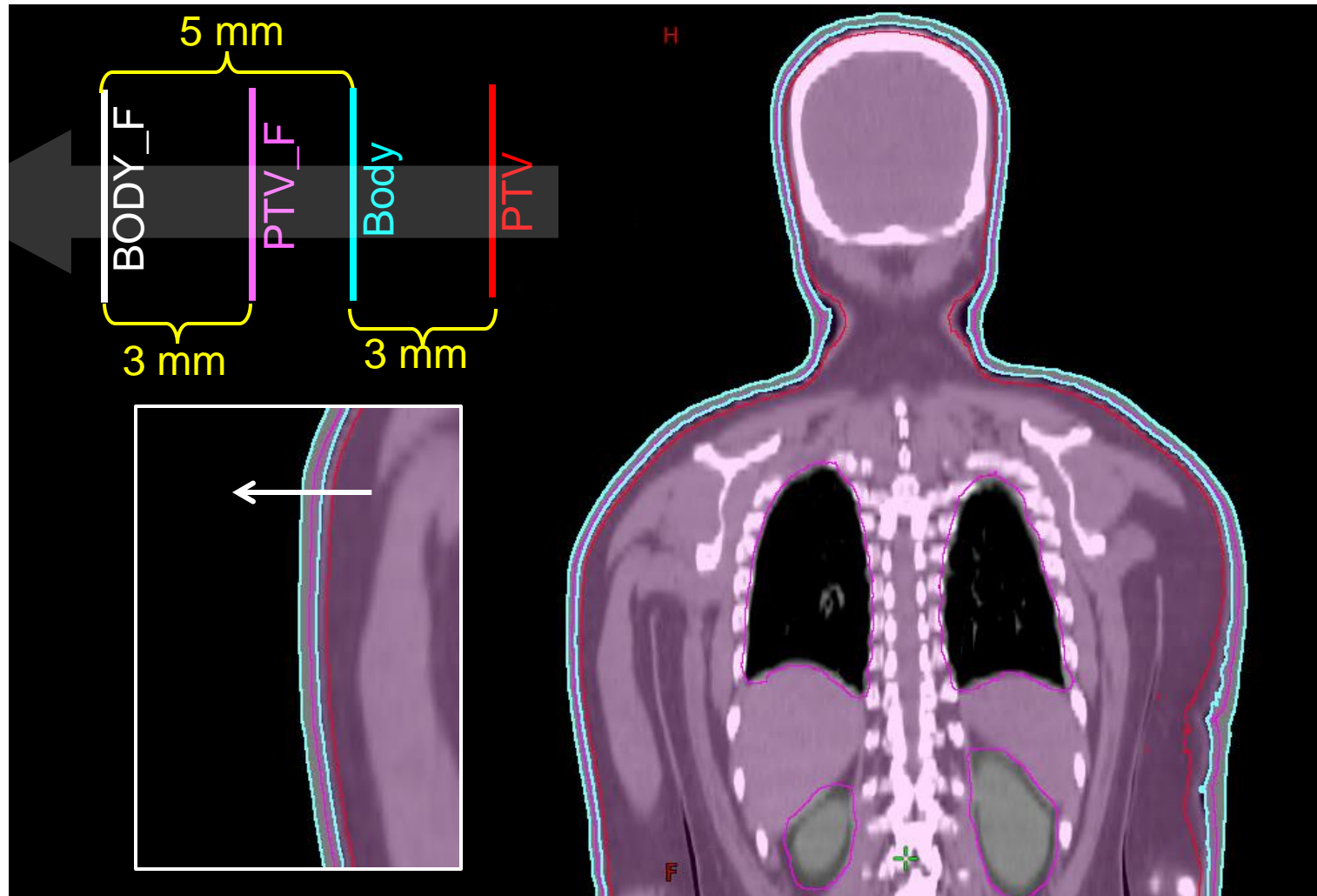
PTV_VMAT



Pediatric

Body Flash





Iso-center determination

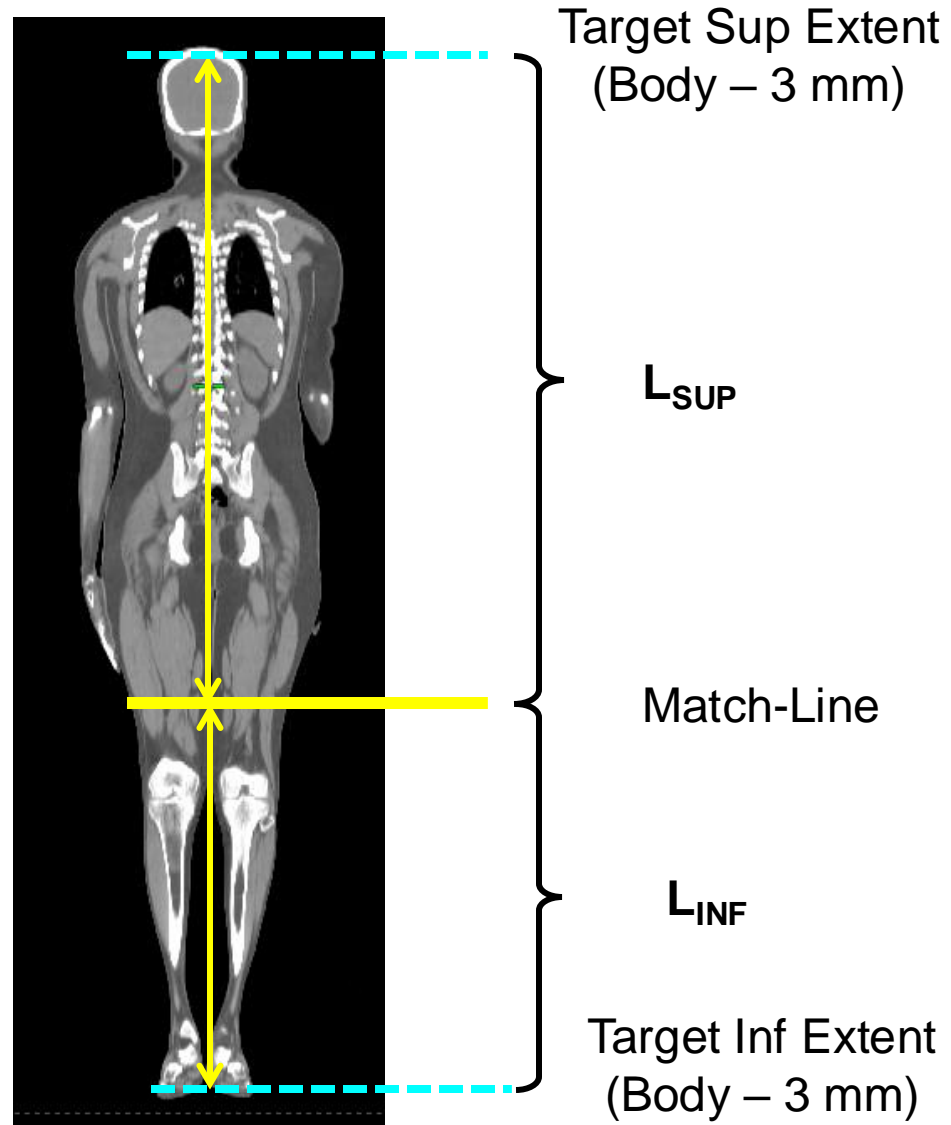
$$\#VMAT = \frac{L_{SUP} + L_{INF}}{\bar{\Delta}}$$

$\bar{\Delta}$ = Max Separation

max Field Size – min Overlap
= 40 cm – 2 cm = 38 cm

$$\#VMAT \leq 4$$

#Leg = 1 if one field covers
i.e. $L_{INF} < 40\text{cm}$
= 2 if two fields cover



VMAT Isocenters and Coverage

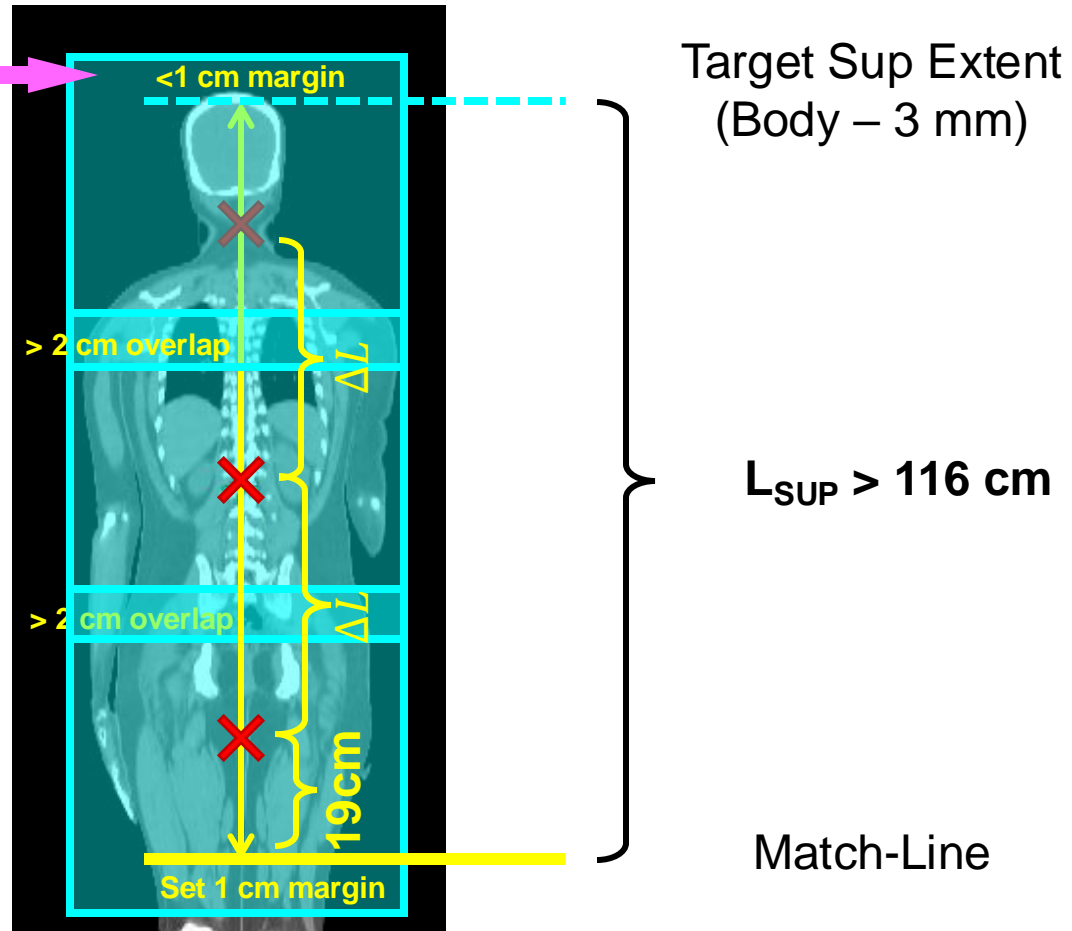
5 mm limit

$\bar{\Delta}$ = Max Separation
= 38 cm

Separation ΔL

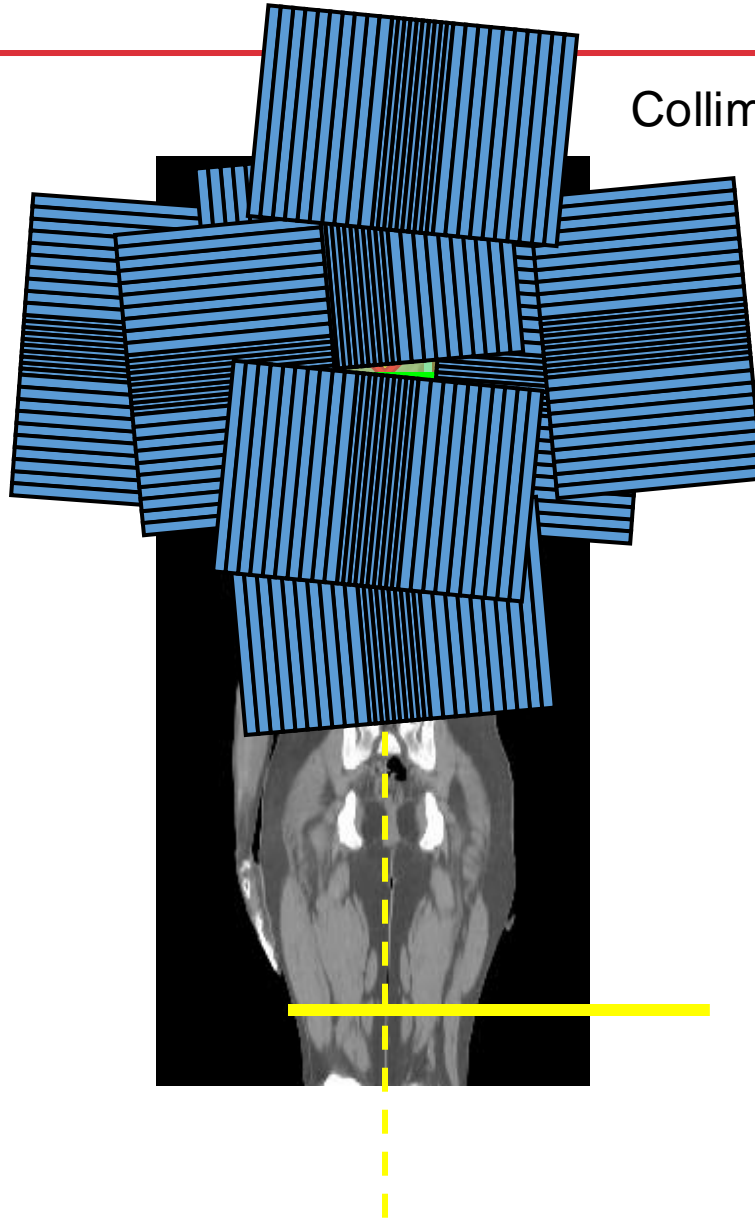
$$= \frac{L_{\text{SUP}} - \bar{\Delta}}{\# \text{Iso} - 1}$$

$\leq 38 \text{ cm}$

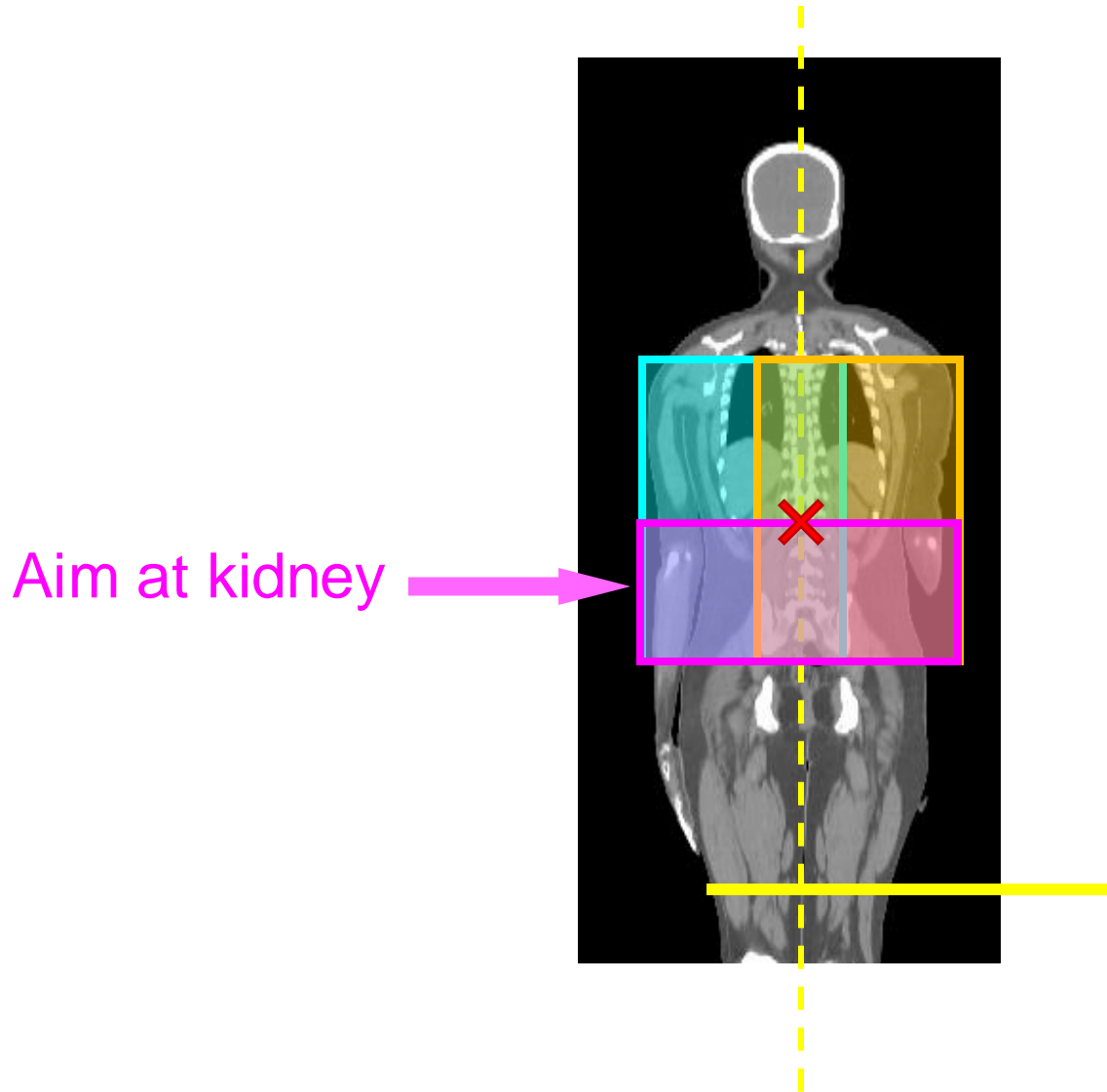


Field Setups: Head

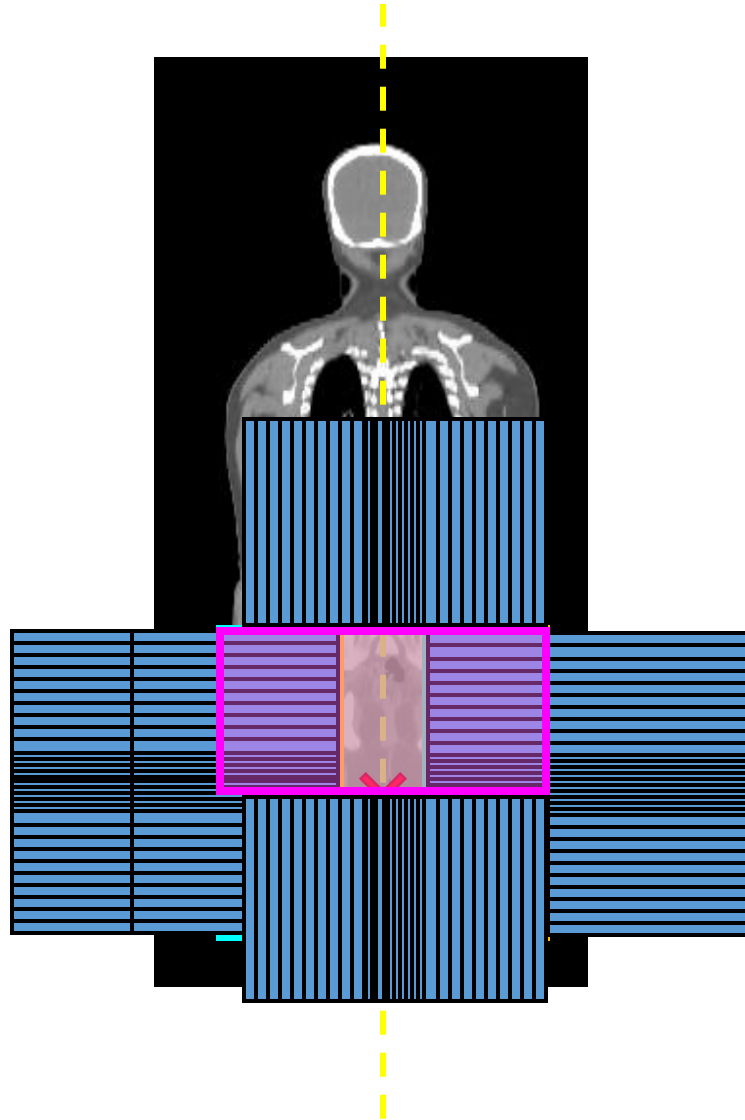
Collimators $\pm 3^\circ$ Jaws: -20cm, 2 cm

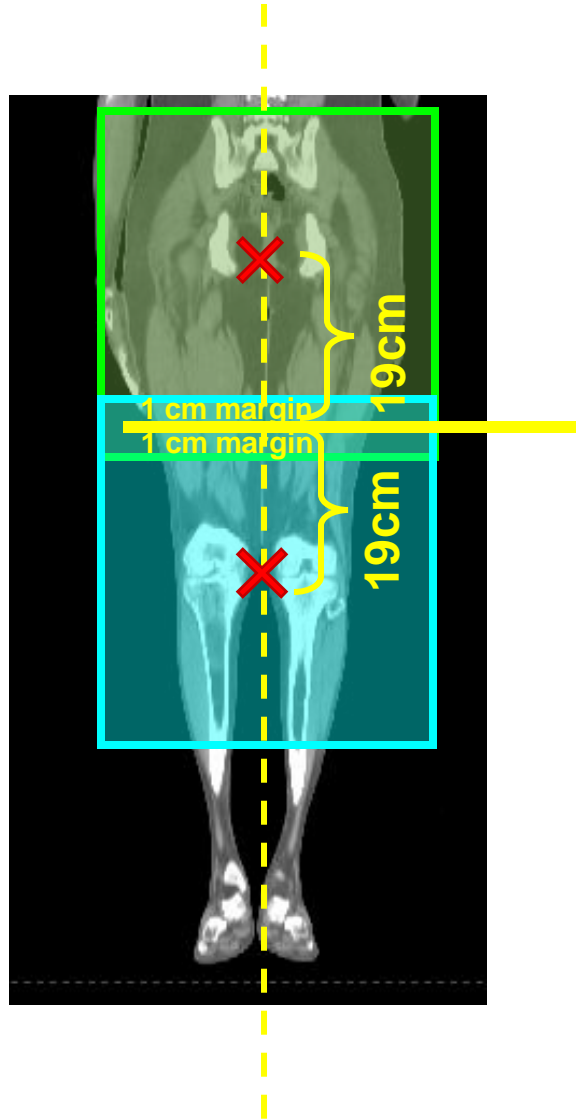


Field Setups: Chest



Field Setups: Pelvis

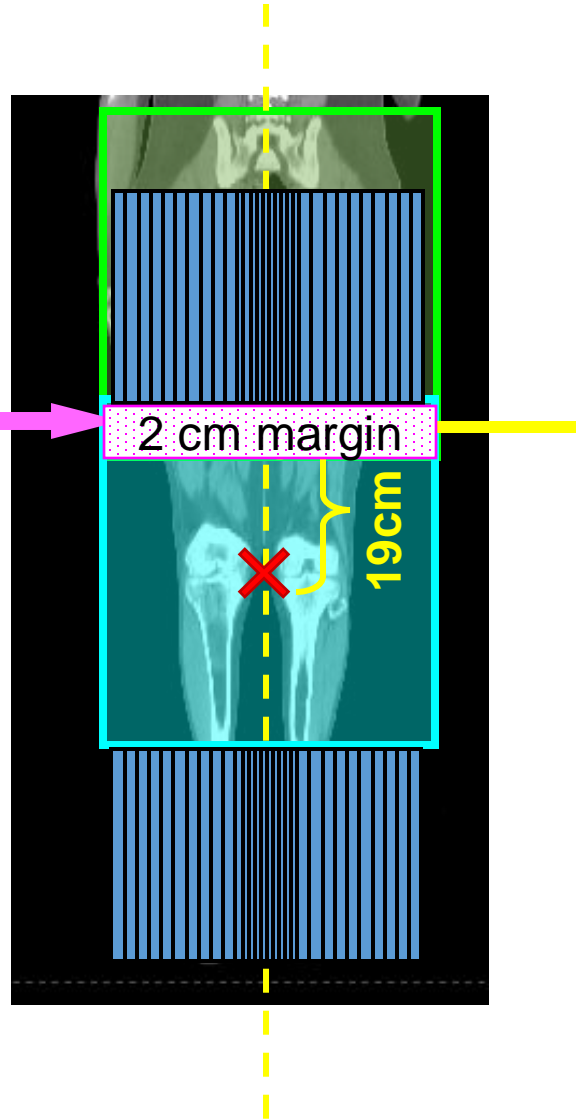




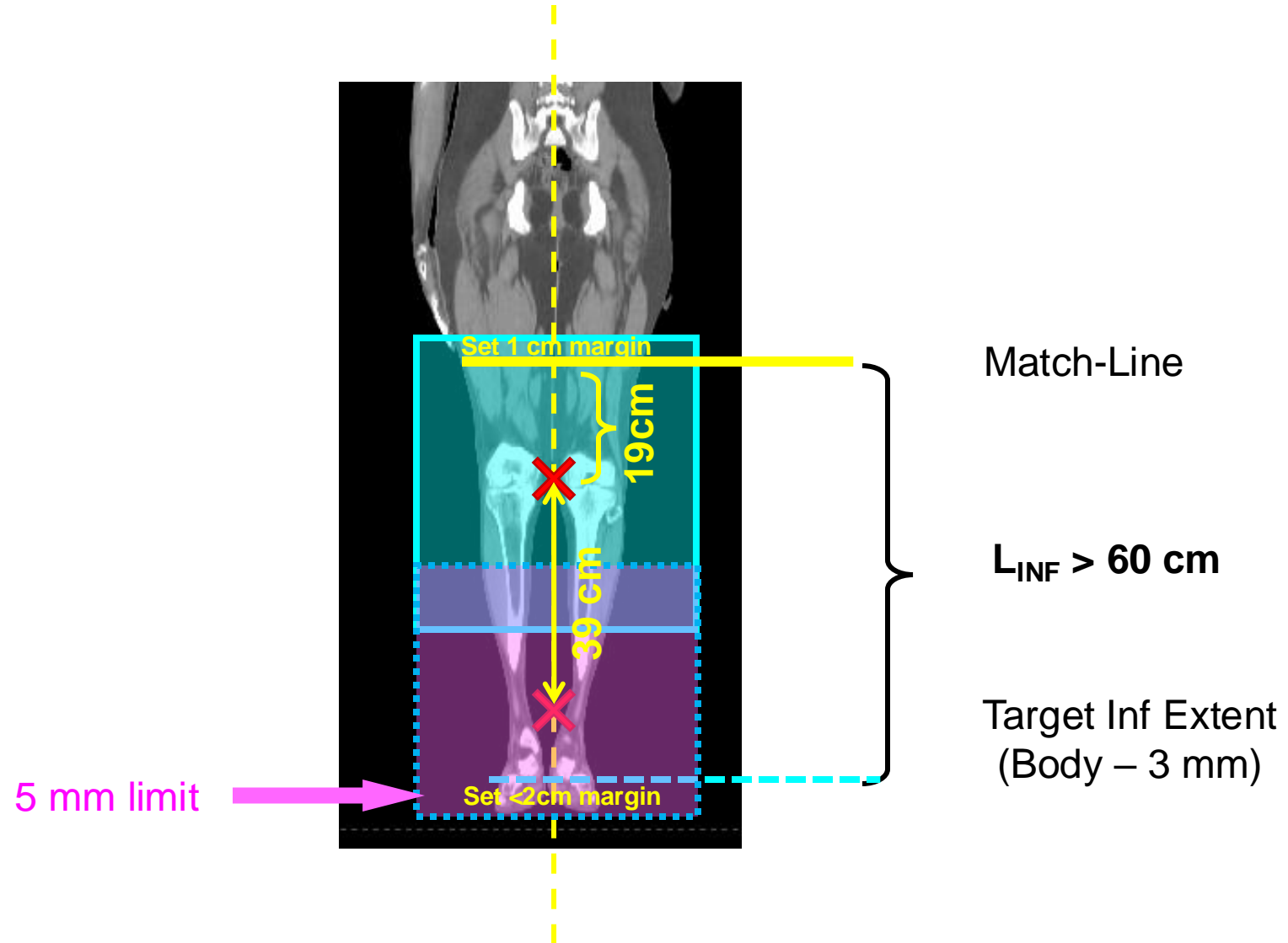
Match-Line

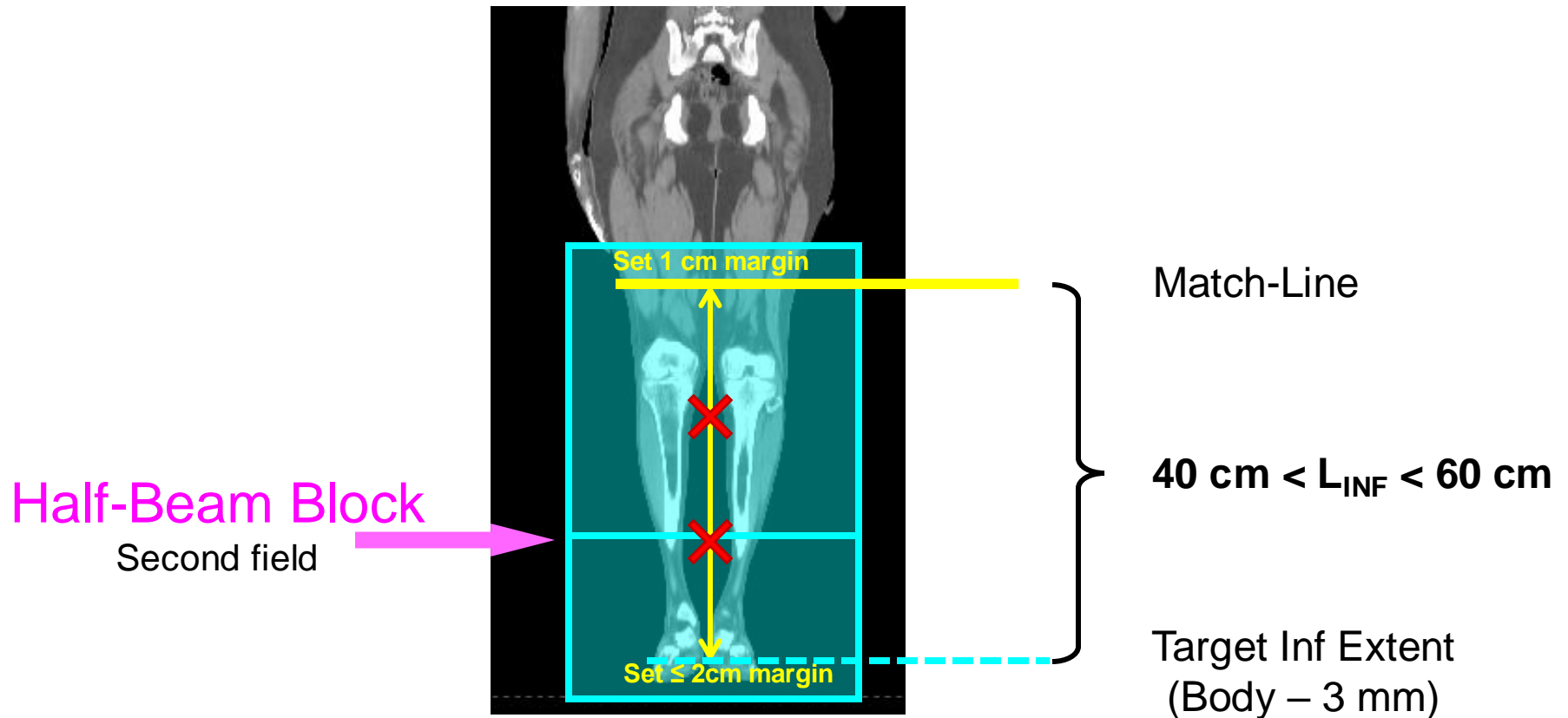
Field-in-Field

Reduce hot spot
in overlapping region



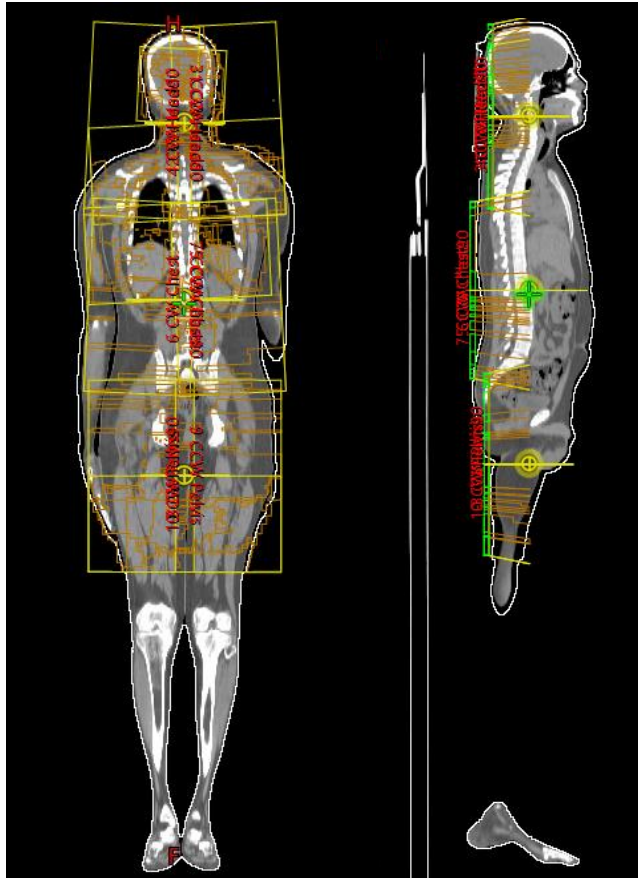
Match-Line



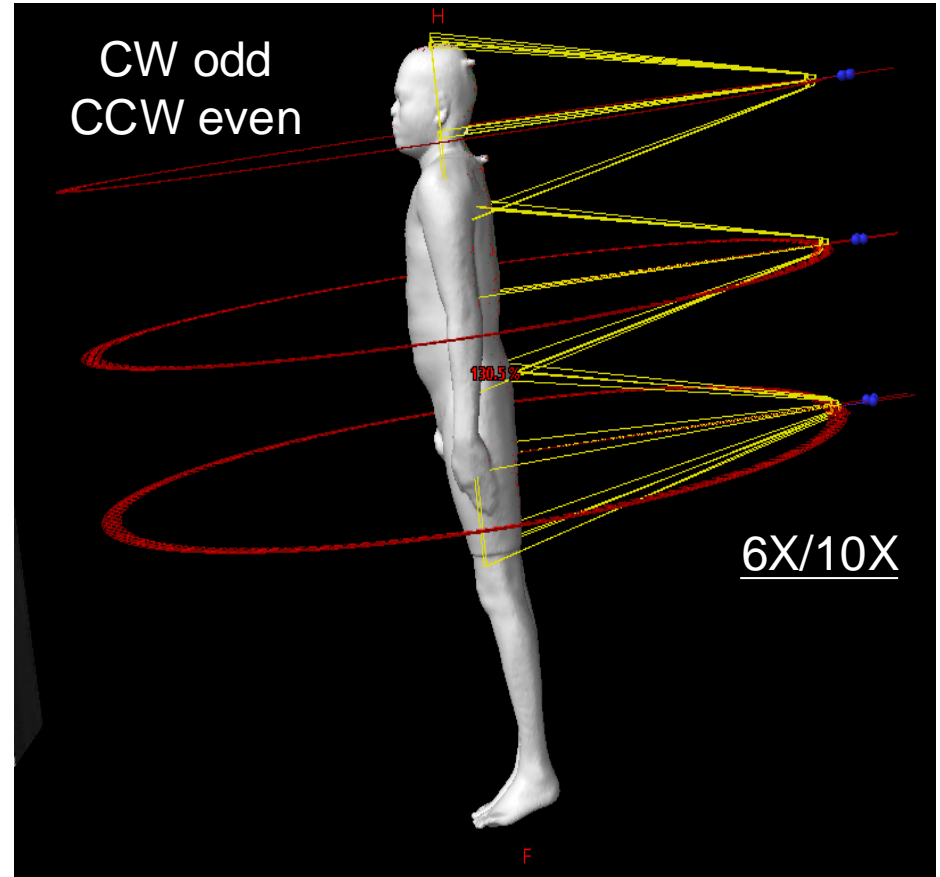


VMAT Beams Set!

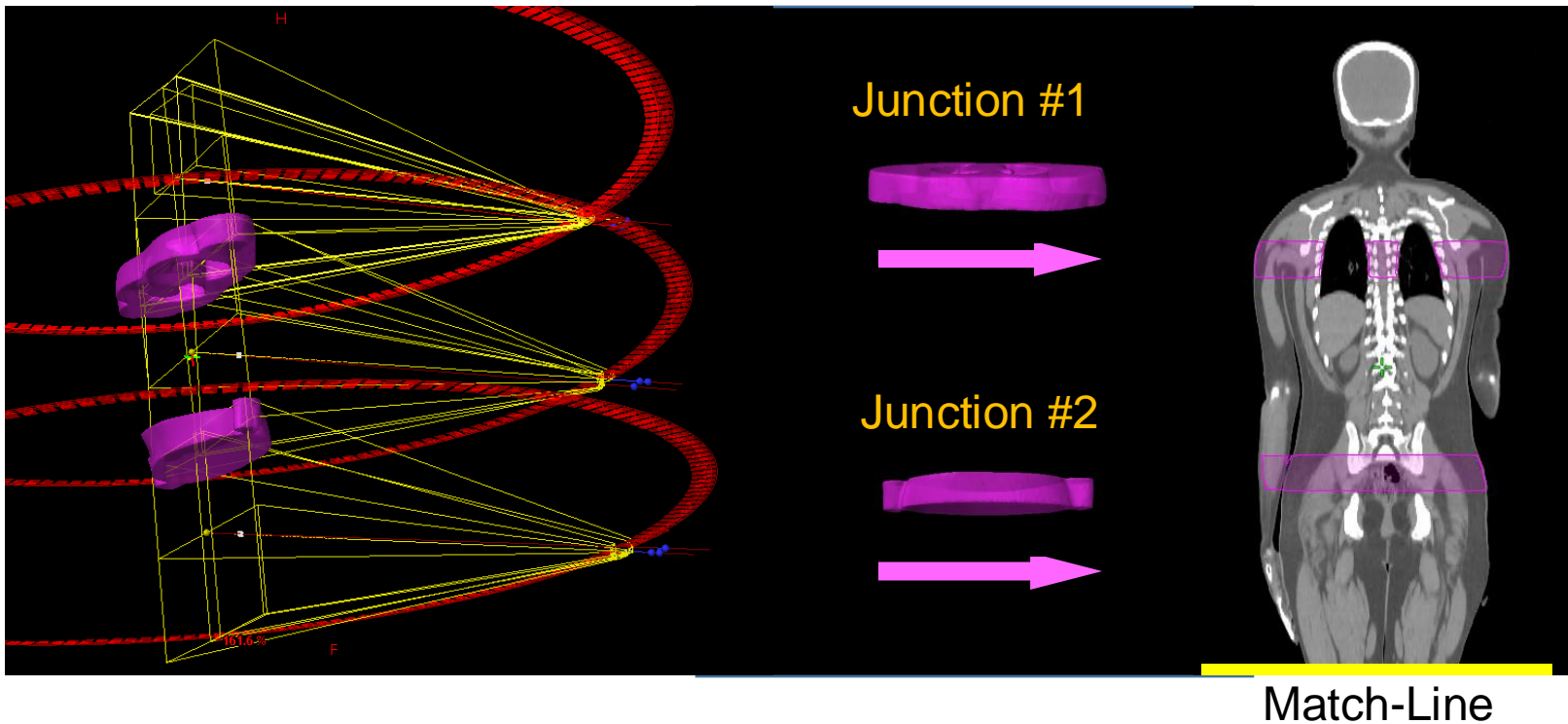
Eclipse Planar View



Eclipse 3D View



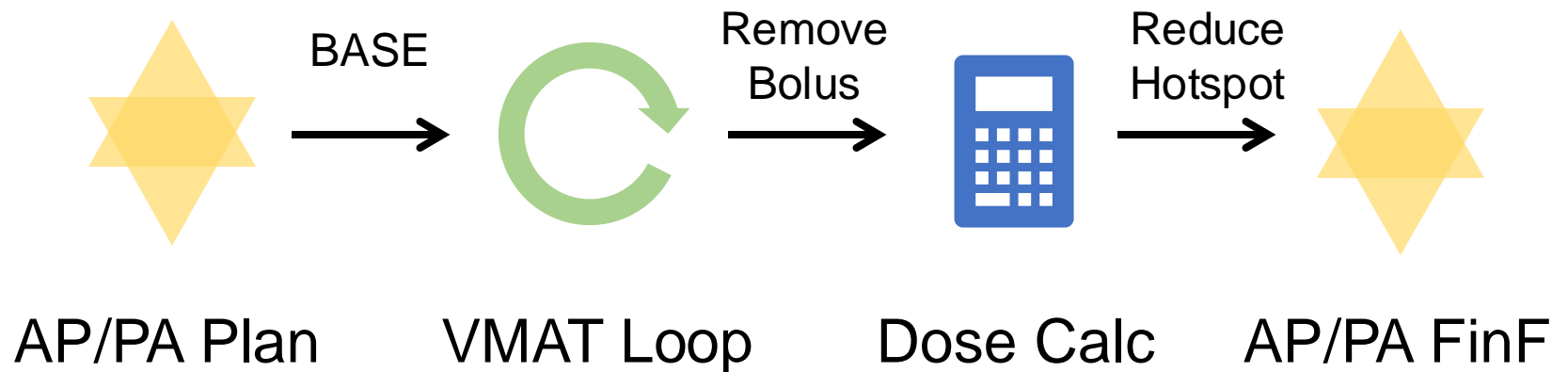
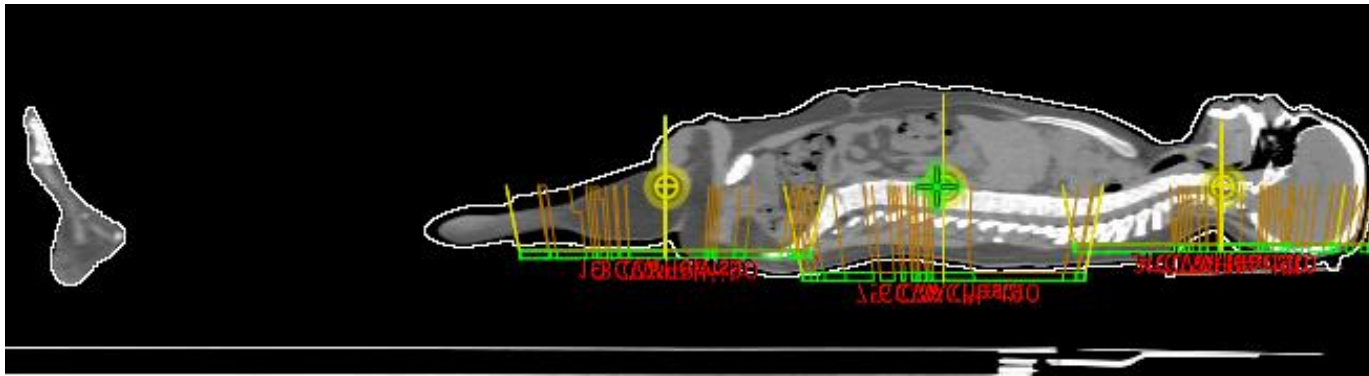
Junction = Field Overlap Slices \cap PTV

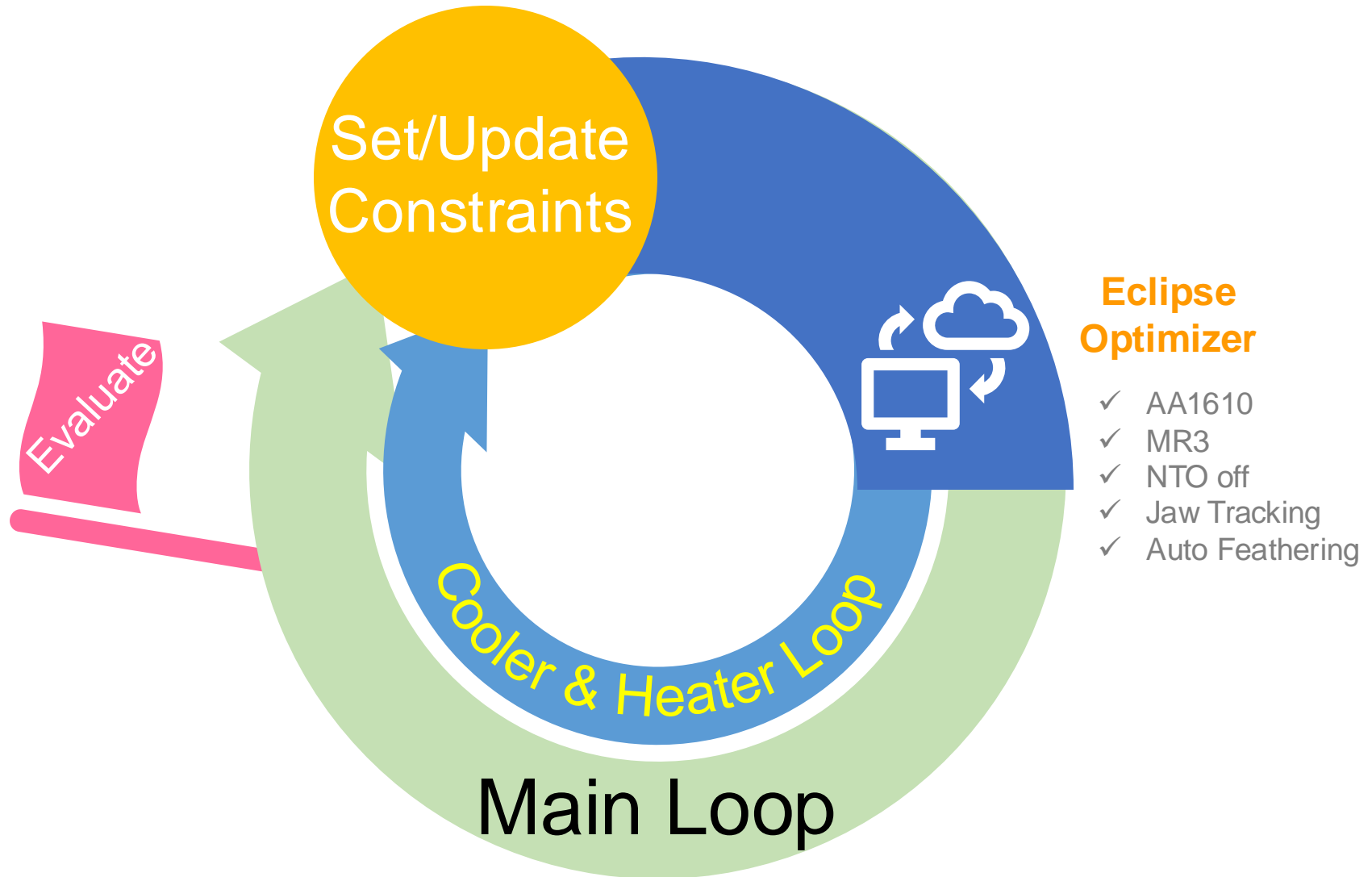


Prescription: $200 \text{ cGy} \times 6 \text{ fx} = 1200 \text{ cGy}$

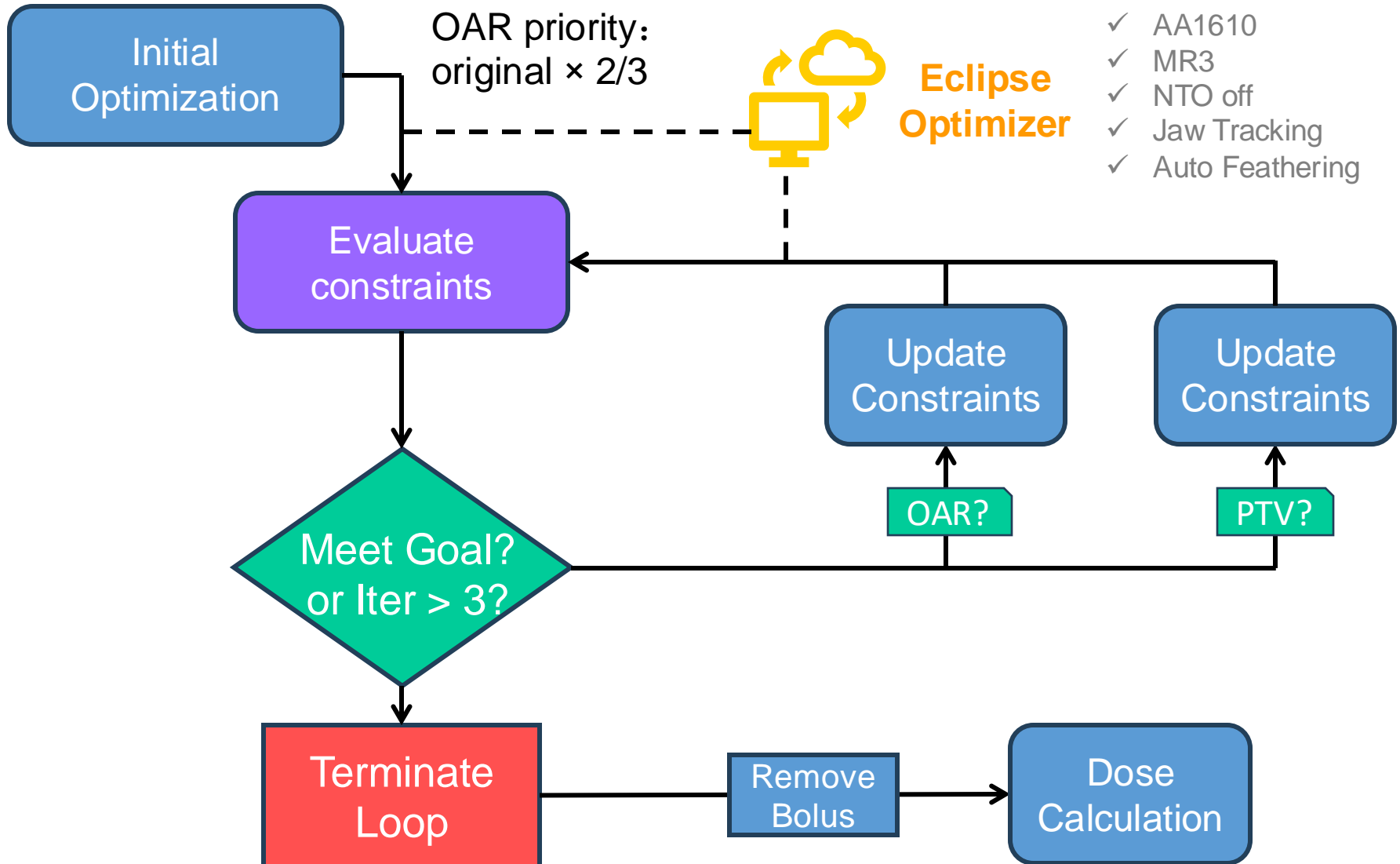
structure Id	constraint type	Dose (%)	volume (%)	dose type
TS_PTV	Lower	100.0	90.0	Relative
TS_PTV	Upper	120.0	0.0	Relative
TS_PTV	Upper	110.0	5.0	Relative
lungs	Mean	60.0	0.0	Relative
lungs-1.0cm	Mean	45.0	0.0	Relative
kidneys	Upper	105.0	0.0	Relative
kidneys	Mean	60.0	0.0	Relative

structure Id	constraint type	dose (cGy)	volume (%)	priority
TS_PTV	Lower	1200.0	100.0	100
TS_PTV	Upper	1212.0	0.0	100
TS_PTV	Lower	1202.0	98.0	100
TS_jnx1	Lower	1200.0	100.0	100
TS_jnx1	Upper	1212.0	0.0	100
TS_jnx2	Lower	1200.0	100.0	100
TS_jnx2	Upper	1212.0	0.0	100
kidneys	Mean	750.0	0.0	36
kidneys-1.0cm	Mean	400.0	0.0	23
lenses_lowRes	Mean	1140.0	0.0	23
lungs	Mean	600.0	0.0	40
lungs-1.0cm	Mean	300.0	0.0	36
lungs-2.0cm	Mean	200.0	0.0	32



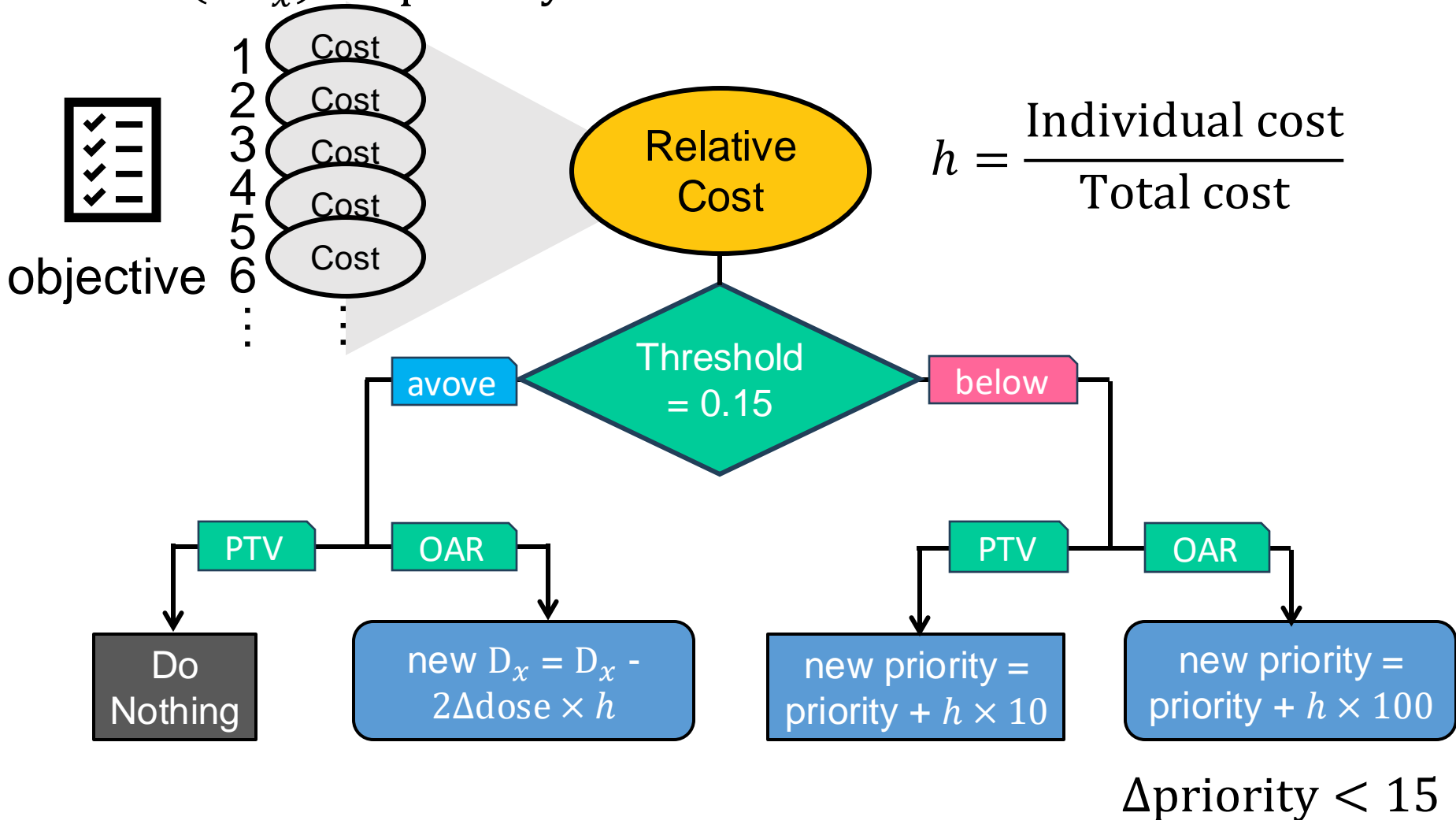


Main Loop



Decision Making

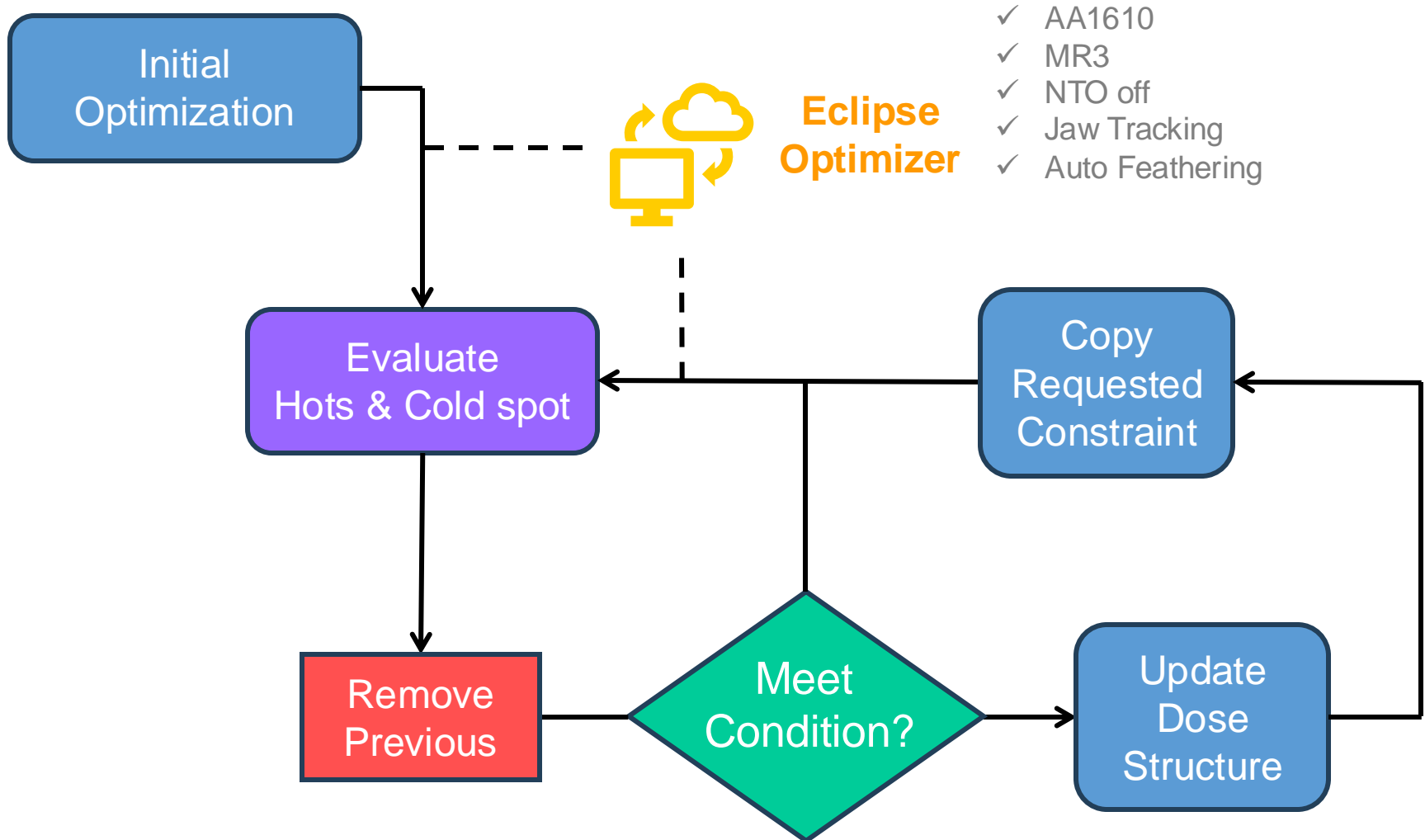
$$\text{Cost} = (\Delta D_x)^2 \times \text{priority}$$



Heater and coolers

structure Id	low D (%)	high D (%)	V (%)	priority	Condition
TS_cooler120	110.0	108.0	0.0	80	Dmax>130%
TS_cooler110	110.0	108.0	0.0	70	Dmax>120%
TS_cooler105	105.0	105.0	2.0	60	Final Iteration Dmax>110%
TS_cooler102	105.0	102.0	1.0	60	Final Iteration
TS_heater90	90.0	100.0	100.0	60	None
TS_heater80	80.0	90.0	100.0	70	Dmax>120%
TS_heater70	70.0	80.0	100.0	80	Dmax>130%, V110%>20%

Heater & Cooler Loop



Preliminary Results

Prescription: $200 \text{ cGy} \times 6 \text{ fx} = 1200 \text{ cGy}$

HOT SOPT 130%

90%

80%

70%

50%

40%

V120 = 0.1%

V110 = 15%

D90 = 99%

D95 = 97%

V90 = 100%

V95 = 97.2%

V100 = 90%

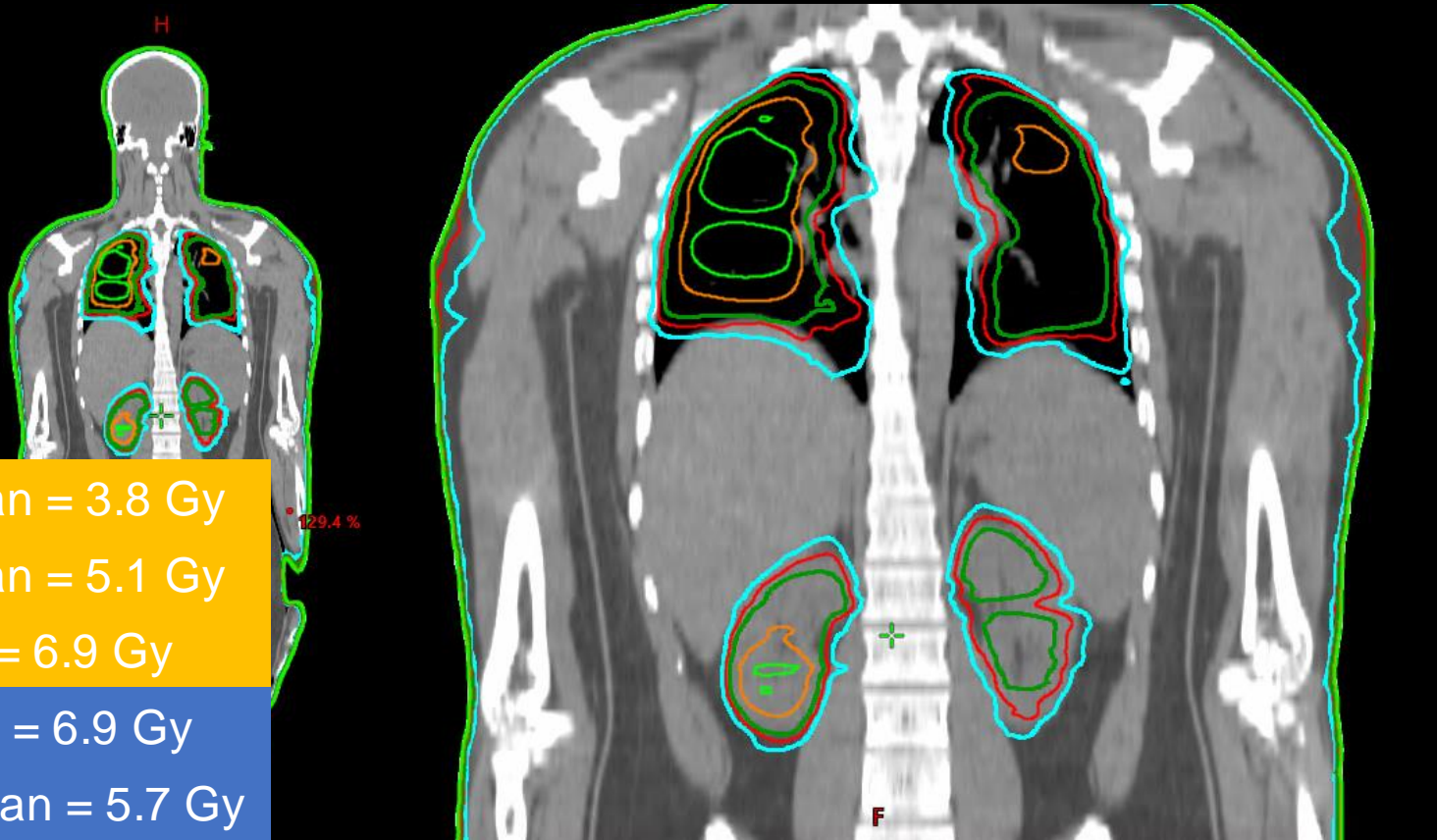
Lung-2cm mean = 3.8 Gy

Lung-1cm mean = 5.1 Gy

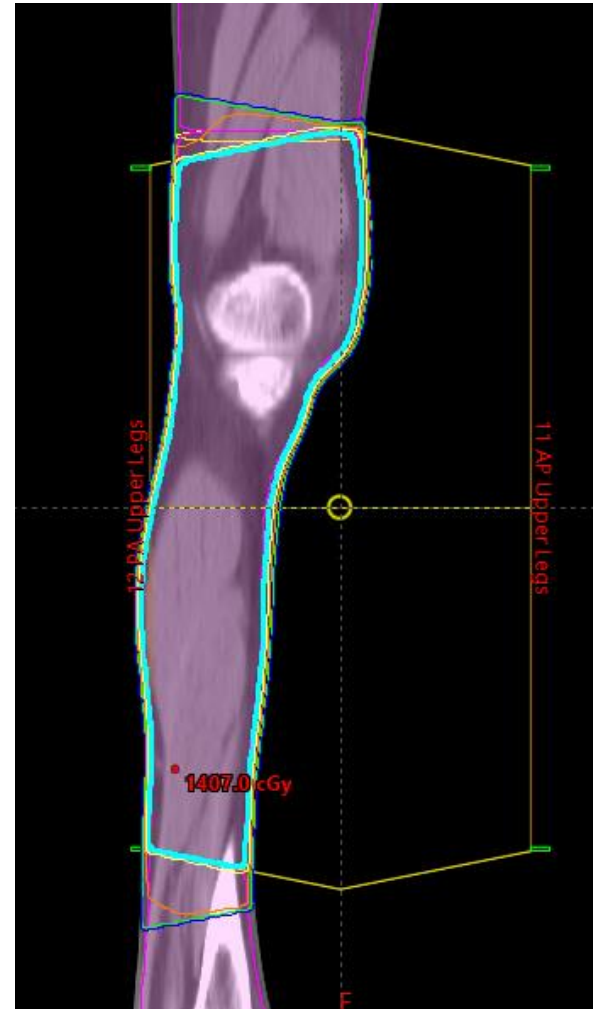
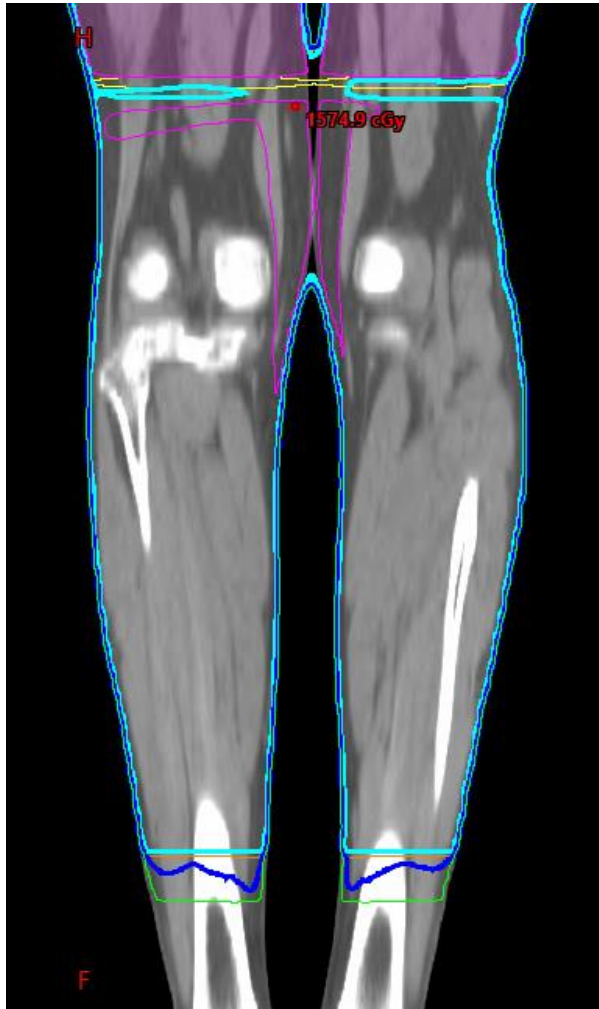
Lung mean = 6.9 Gy

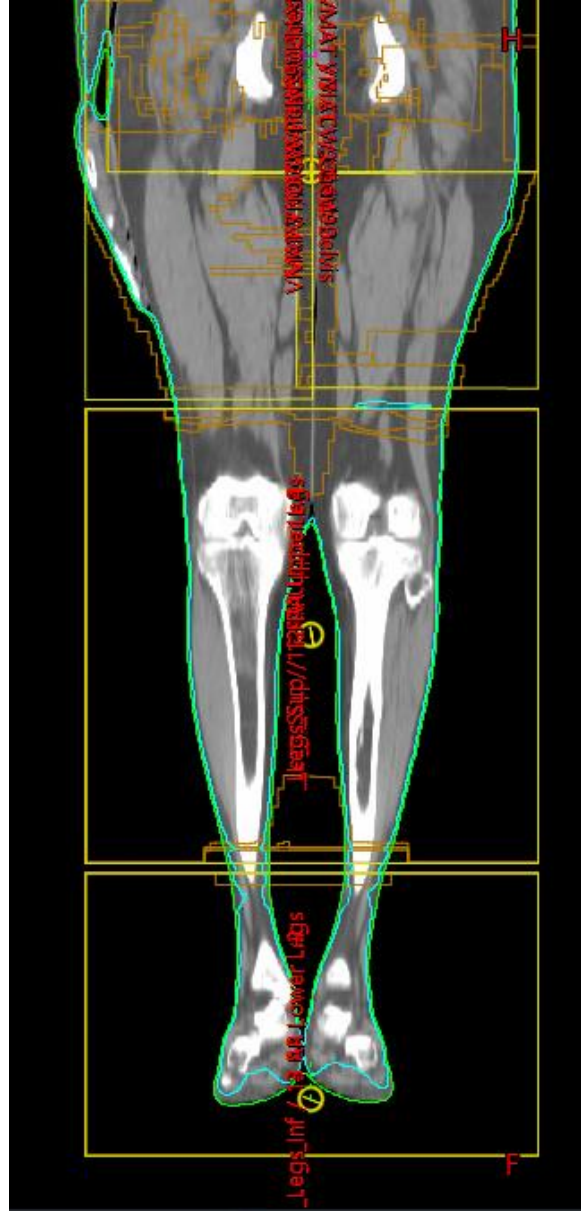
Kidney mean = 6.9 Gy

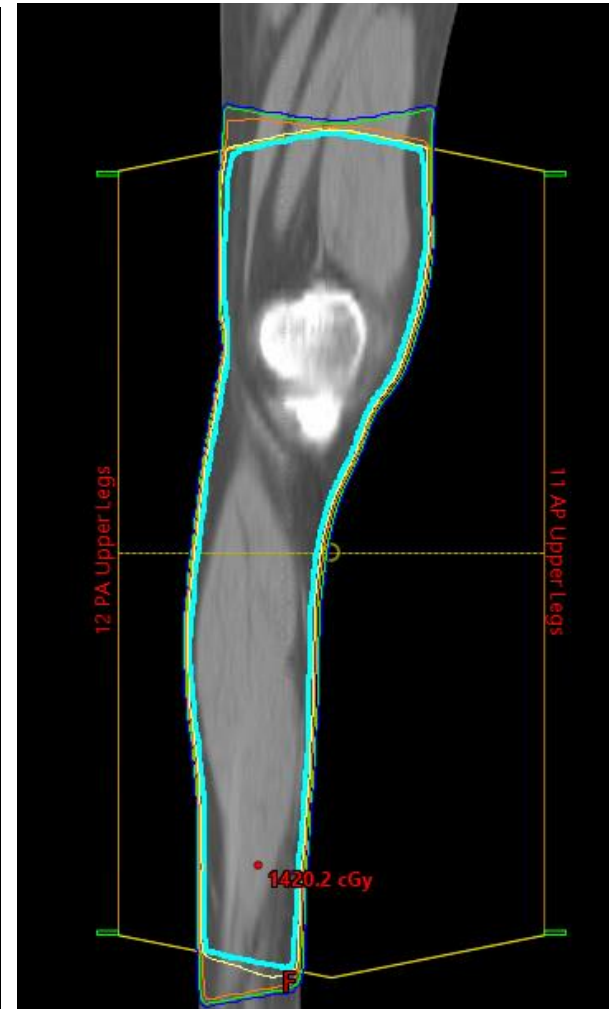
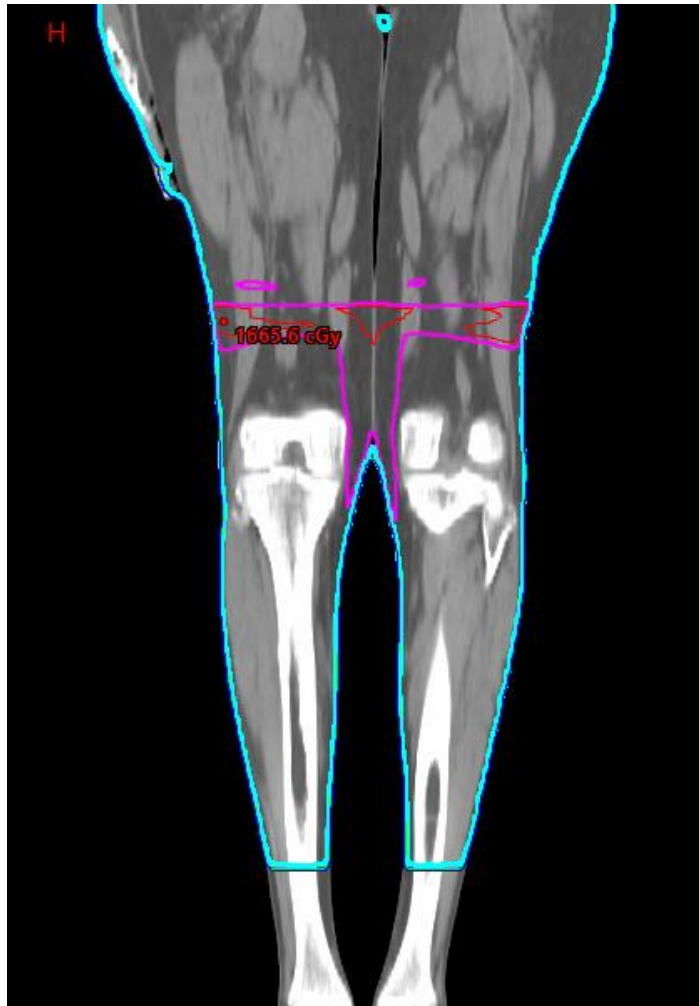
Kidney-1cm mean = 5.7 Gy



VMAT-APPA matchline







- Couch Structure
 - Couch contour: for dose calculation
 - Avoid collision: need vertical offset?
- Shift-Note: to guide the setup
- Use Origin



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Contact: cz453@cinj.Rutgers.edu