



2011 JOINT AAPM/COMP MEETING · JULY 31 - AUGUST 4
· VANCOUVER ·

Nuances of Proton Therapy Planning and Delivery

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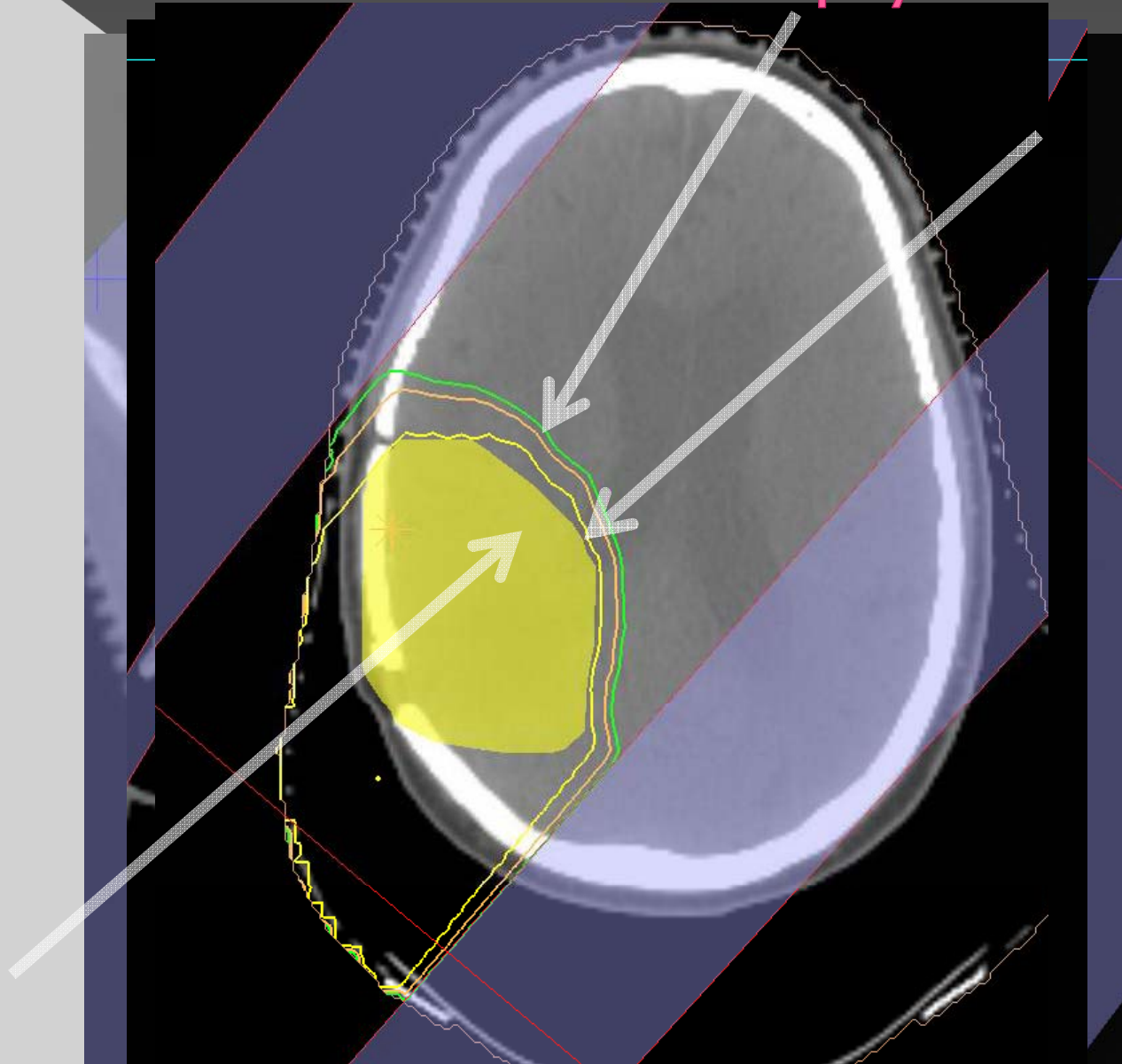
Overview of today discussion

- Proton Therapy Planning Basics
- Target definitions and the variable PTV
- Beam delivery methods and what they can offer

Planning Strategies 101

- ◉ Cover the target with appropriate margins
- ◉ Spare the critical structures
- ◉ Plan with fields that deliver the most “robust” plan

What is "Robust" in Proton therapy ??



Tools to do our job

- ◎ Photons

- > Energy
- > Wedging
- > Weighting
- > IMRT

- ◎ Protons

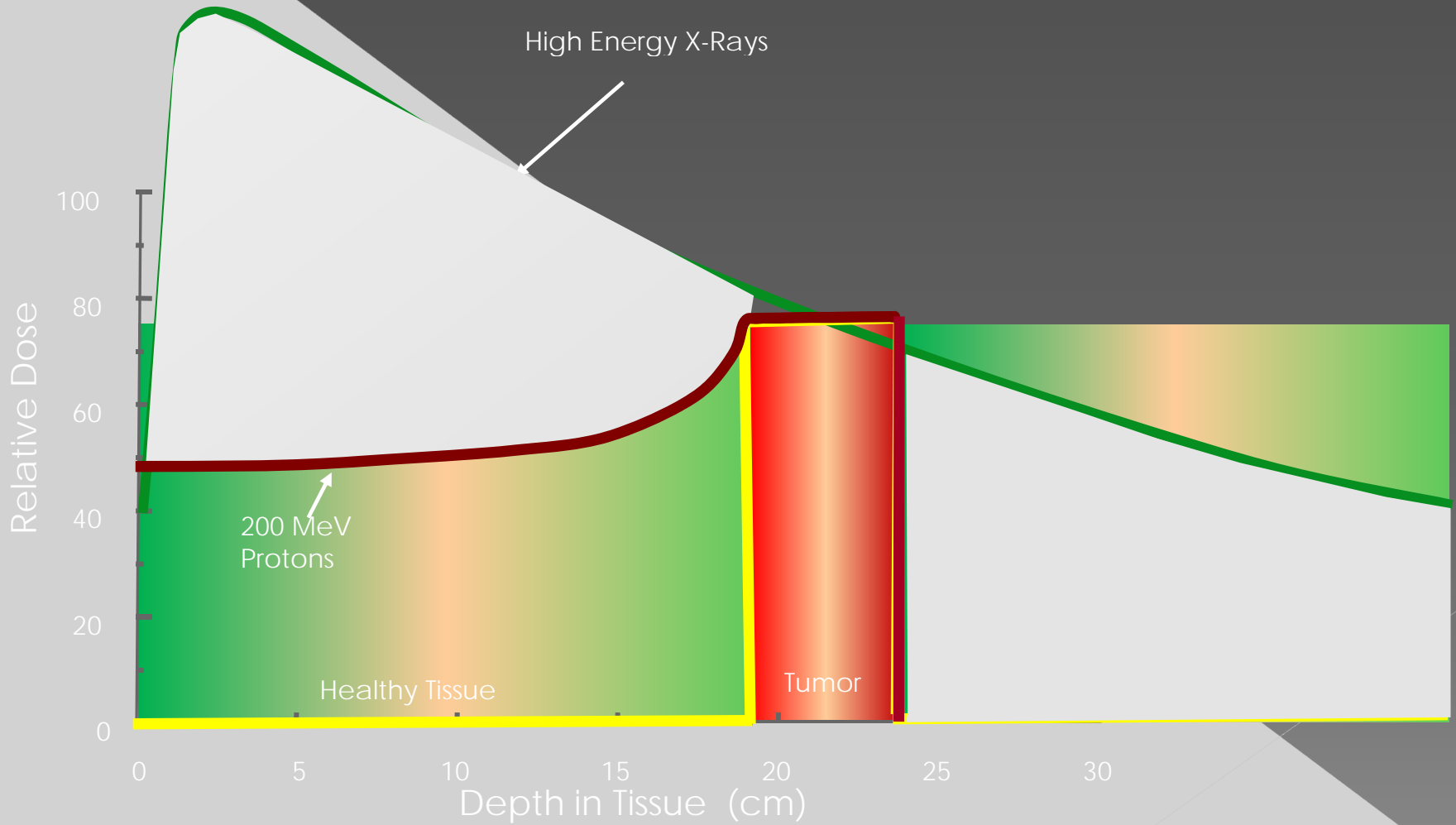
- > Range
- > Modulation
- > Compensators
- > IMPT

Equivalent Path Lengths

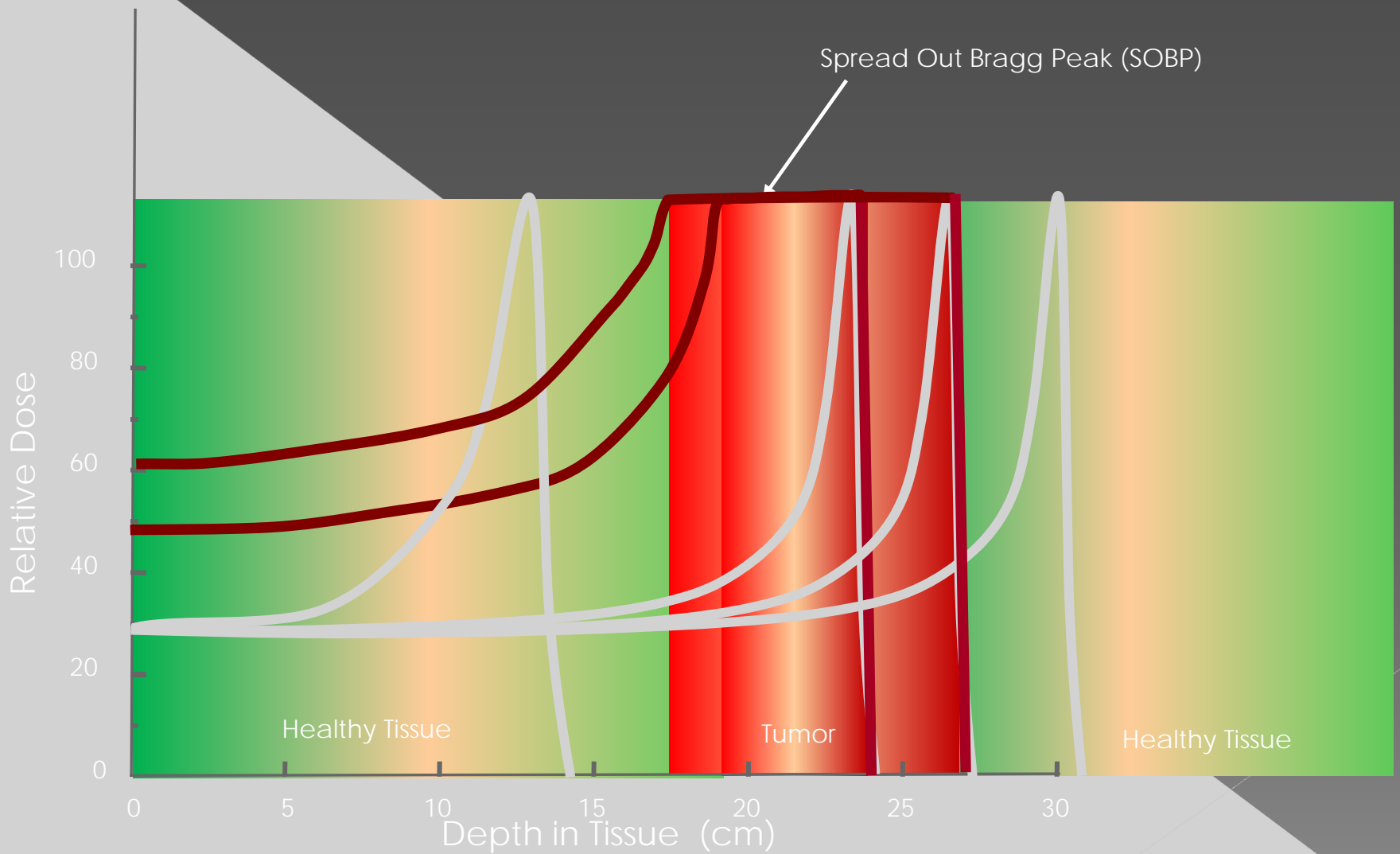
- ◉ In Photons
 - > Convert HU to Relative Electron/Physical Density
- ◉ In Proton
 - > Convert HU to Relative Stopping Power Ratios

The Physics of Protons

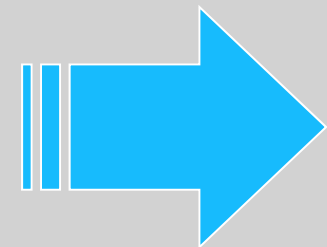
Depth Dose Curves for Different Treatment Types



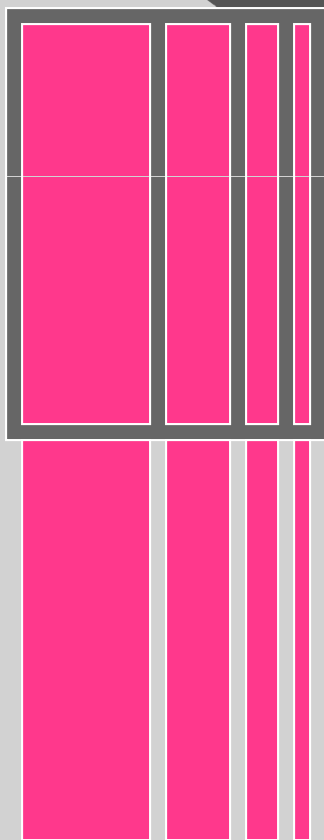
The Physics of Protons



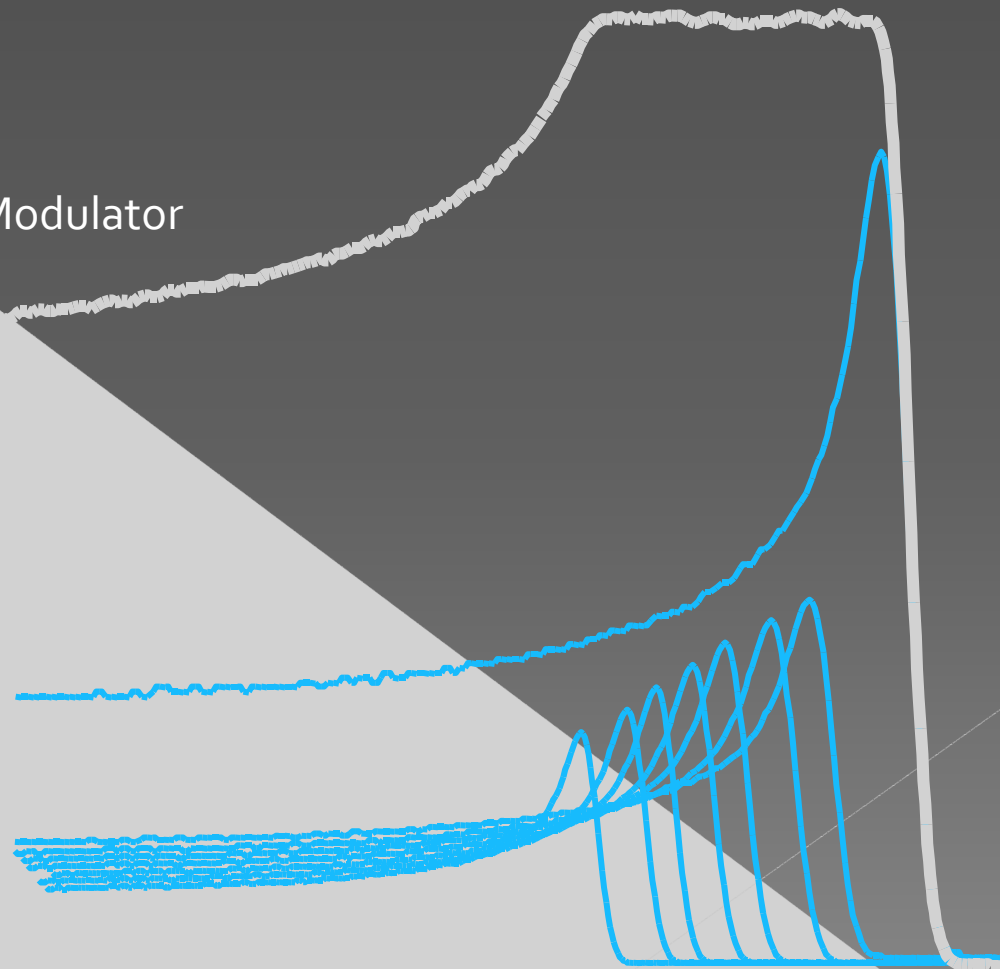
Range Modulator Energy Stacking



Proton Beam



Range Modulator



Range and Modulation

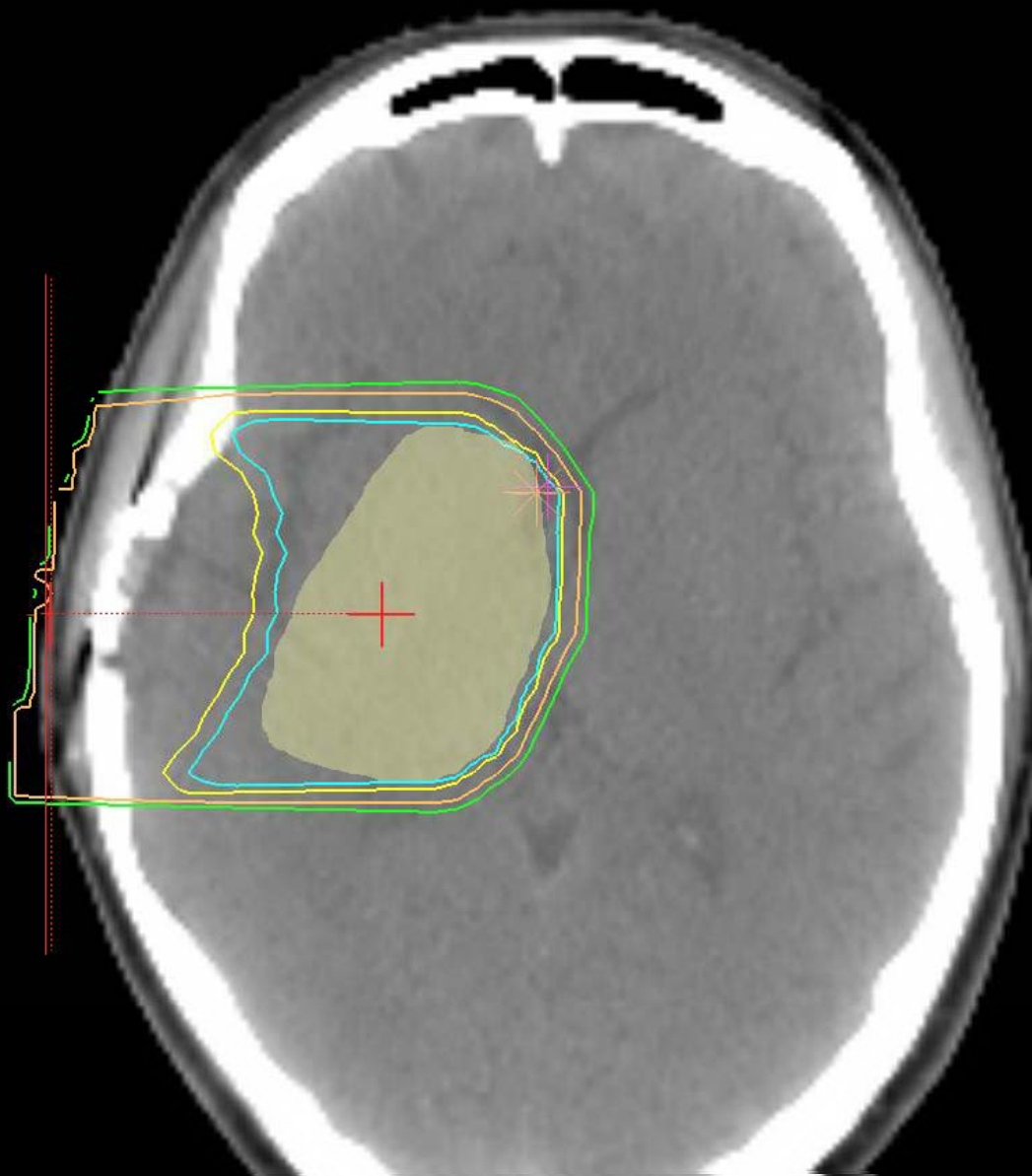
Isovalues (%)

100.0

95.0

70.0

50.0



No Compensator

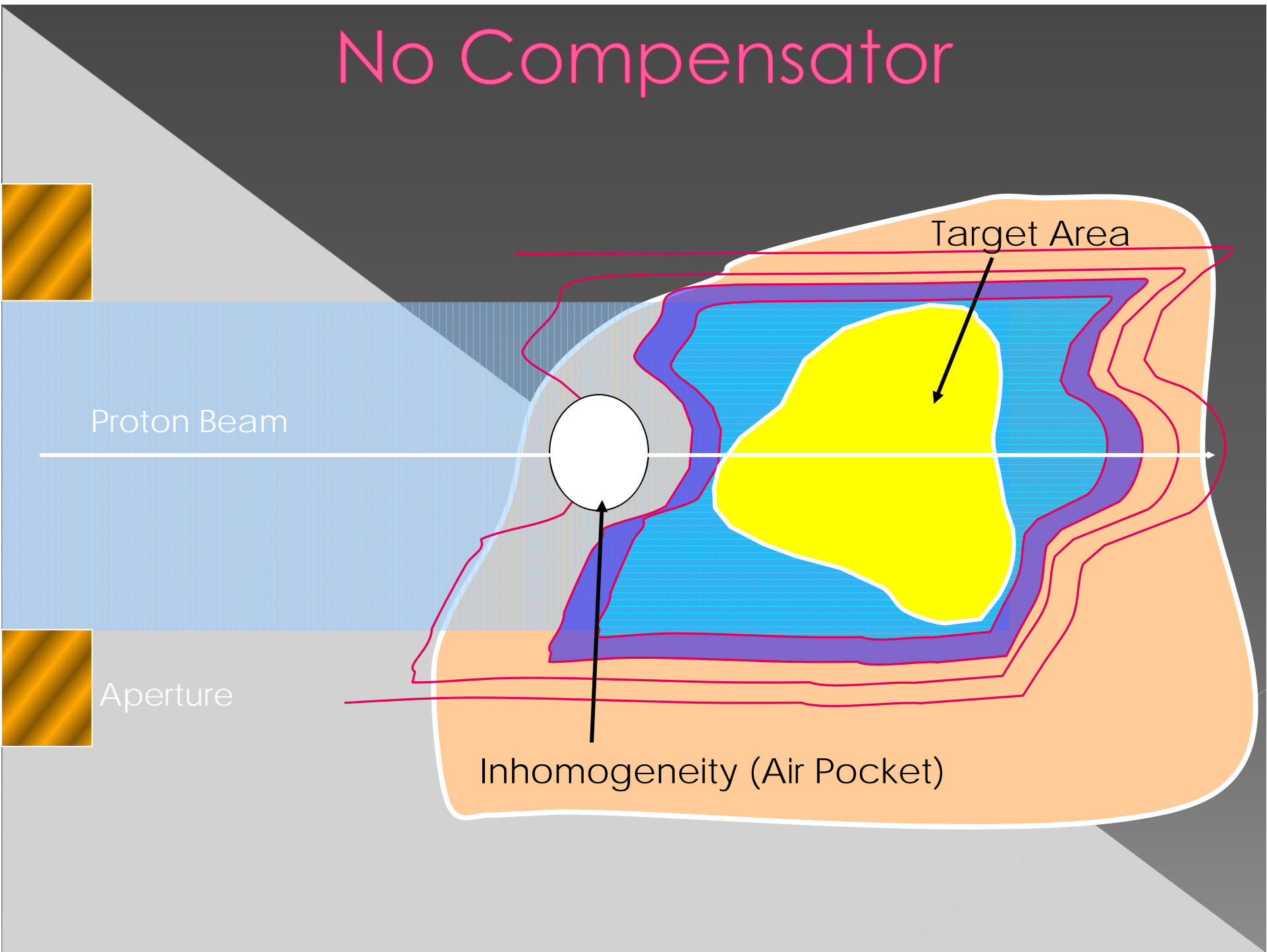


Proton Beam

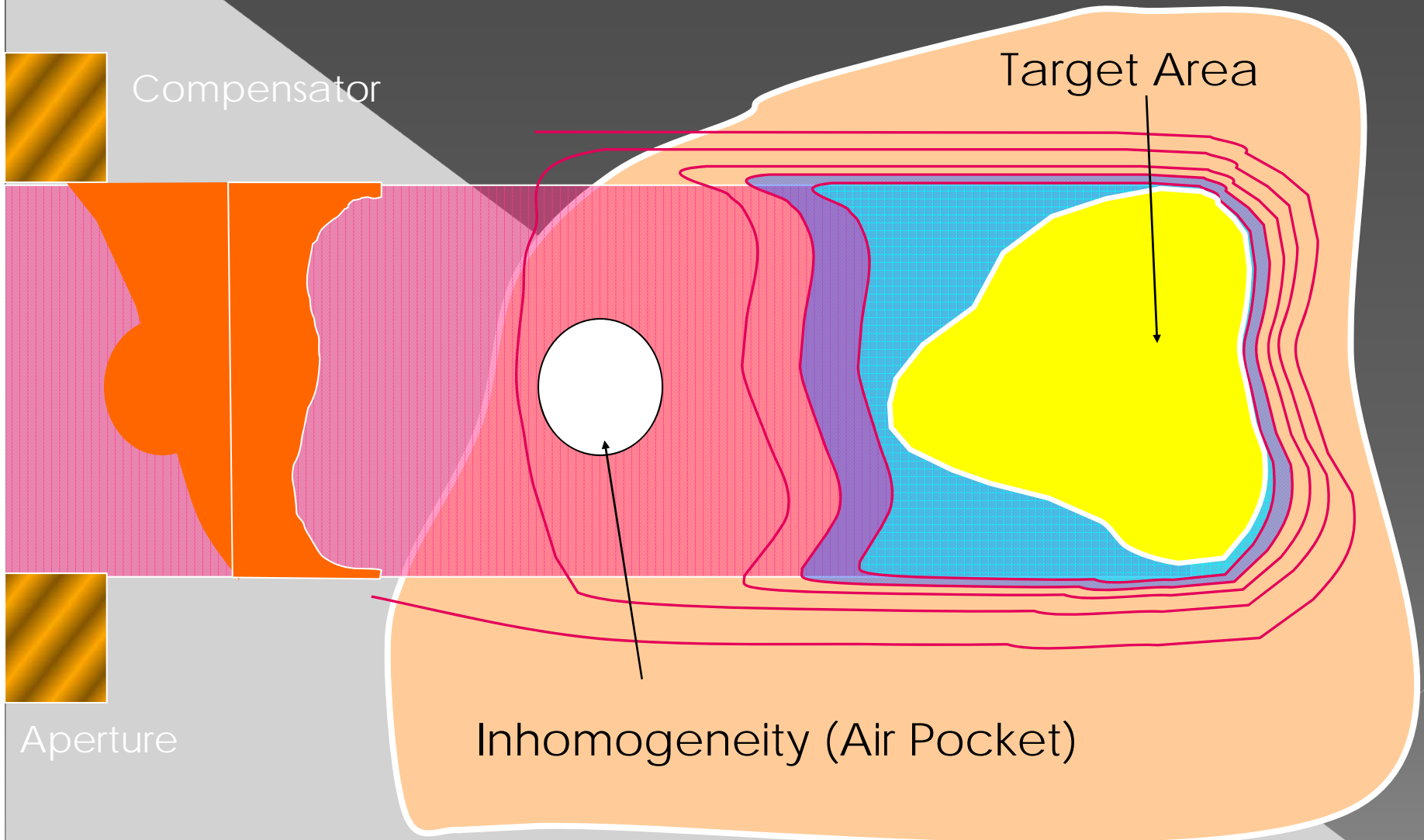
Aperture

Target Area

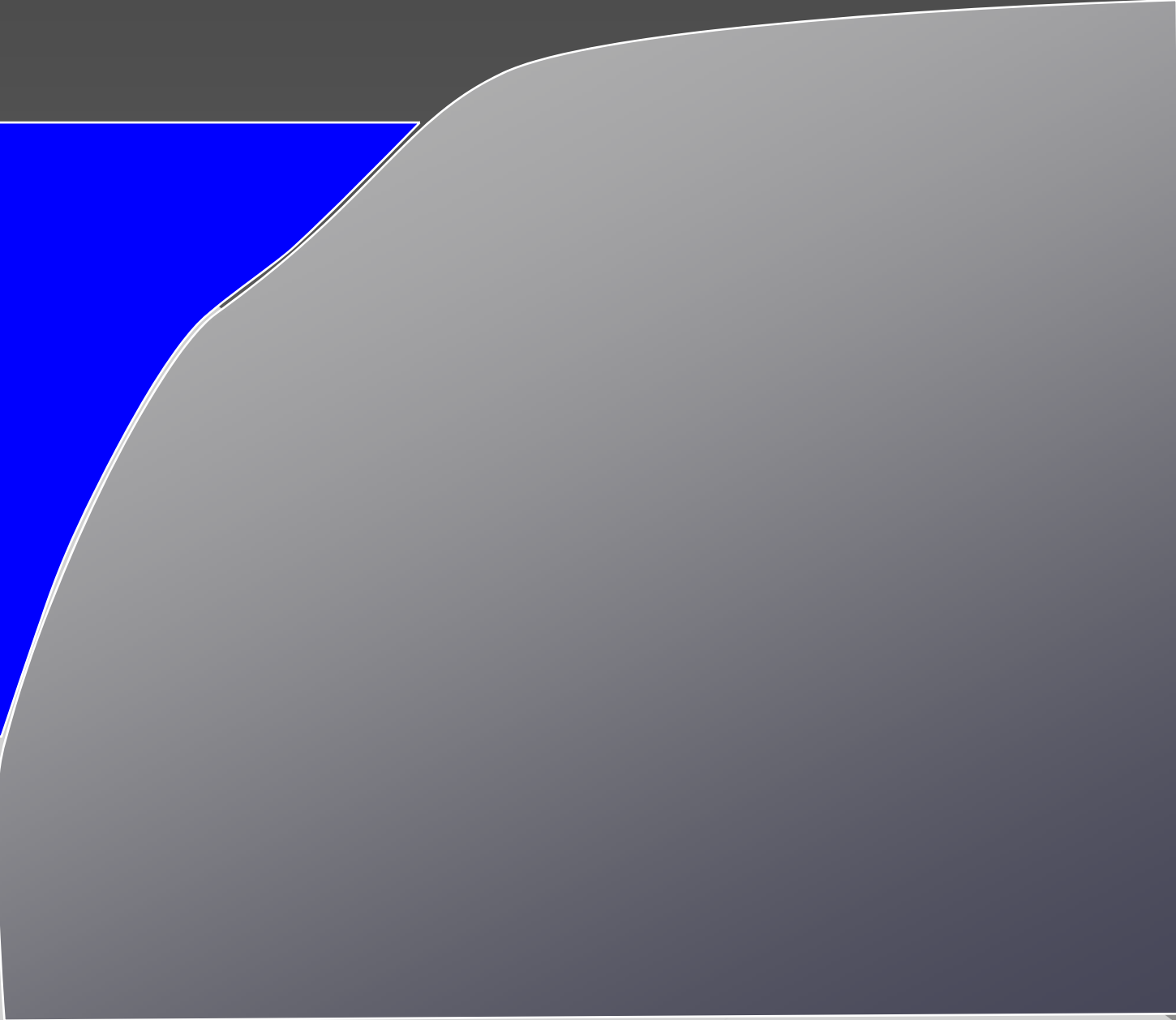
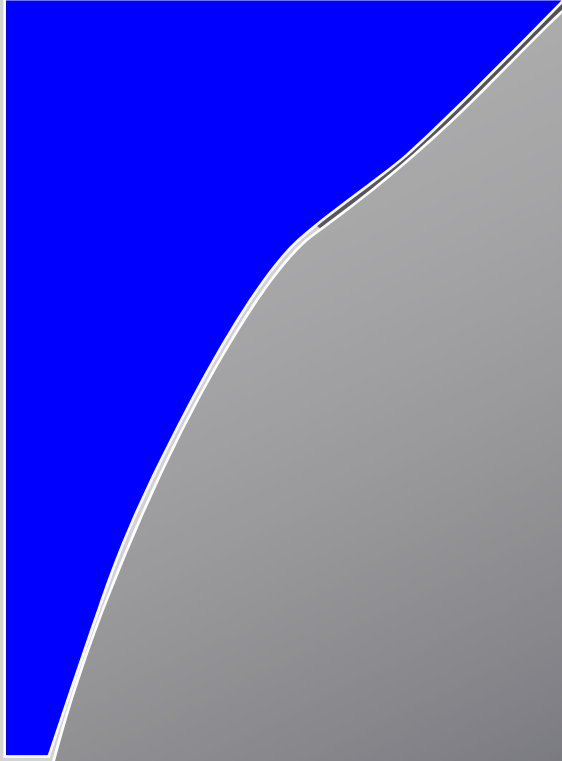
Inhomogeneity (Air Pocket)



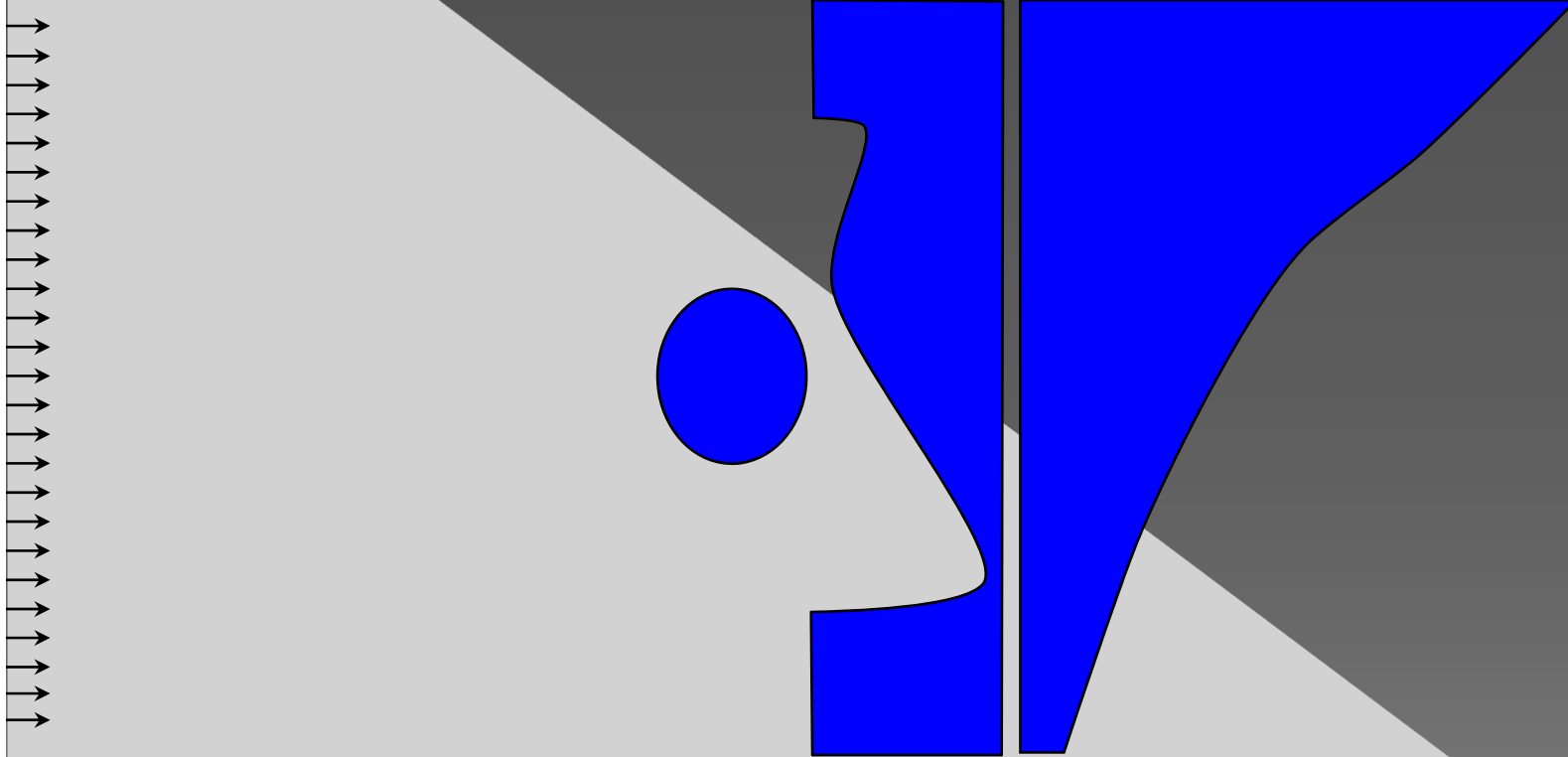
With Compensator



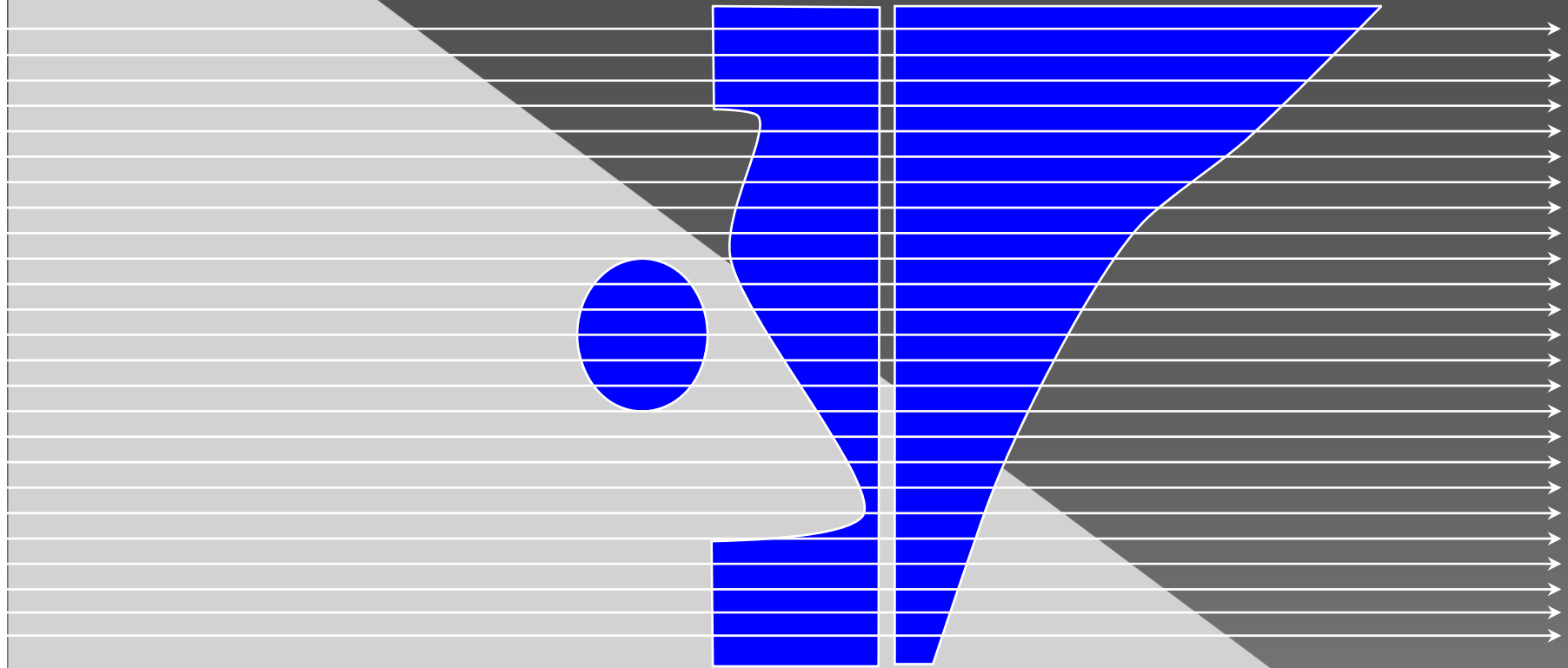
Theoretical to Actual



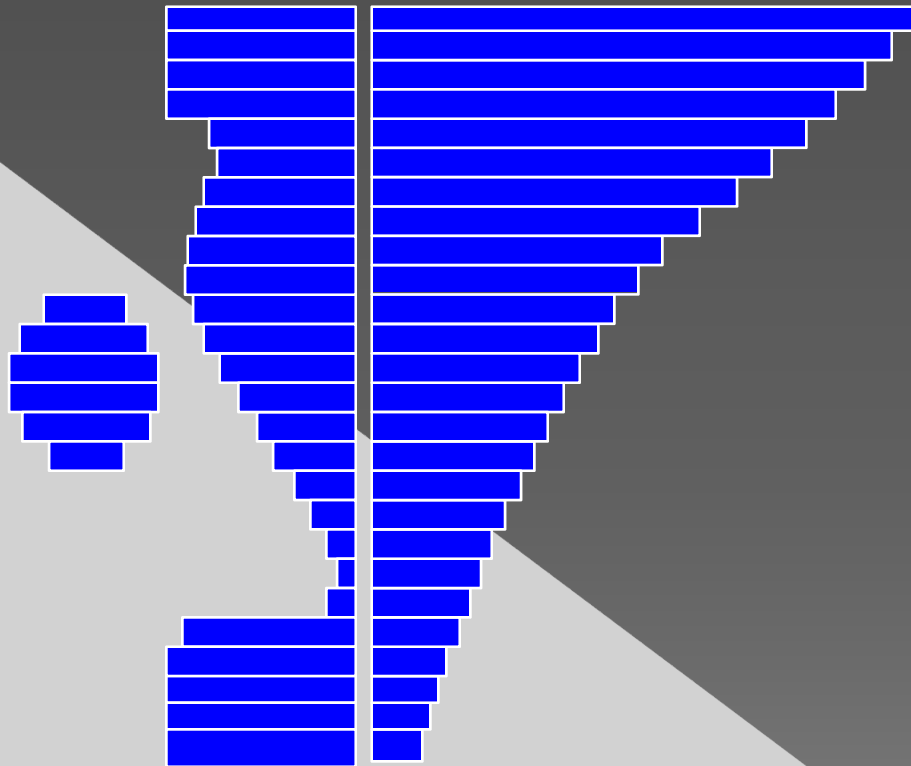
What we need for distal conformity



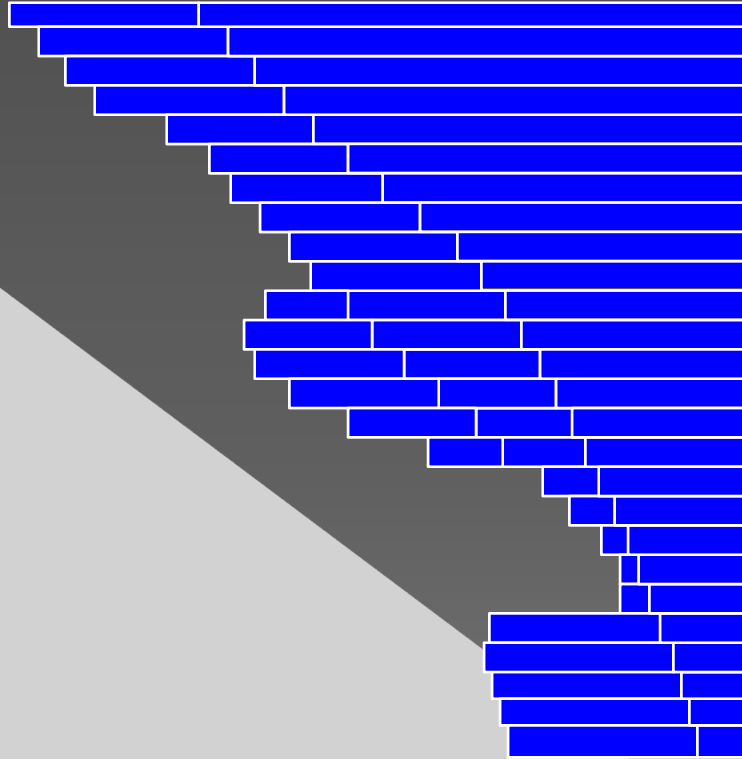
Ray Trace the Proton



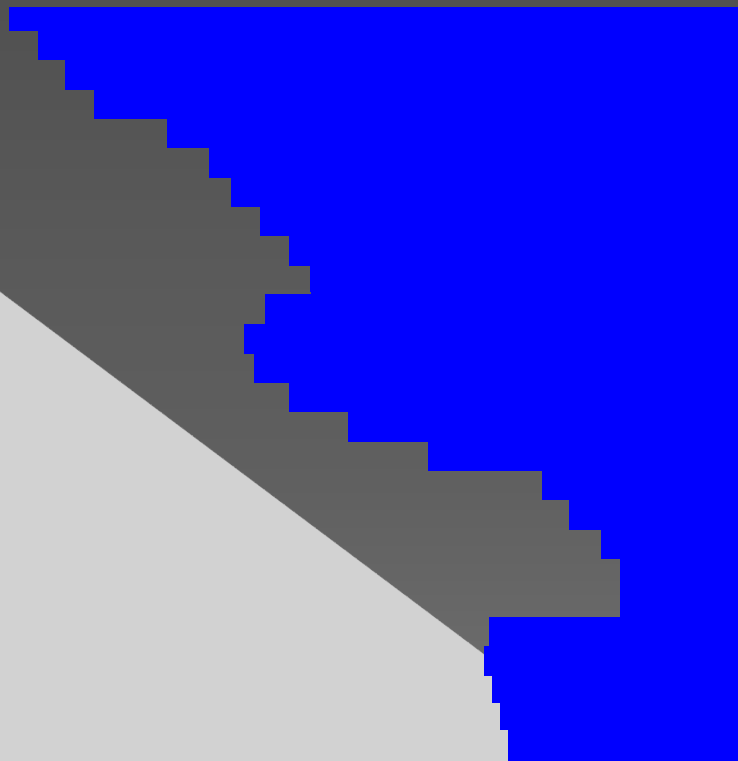
Limiting Resolution of Drill Bit



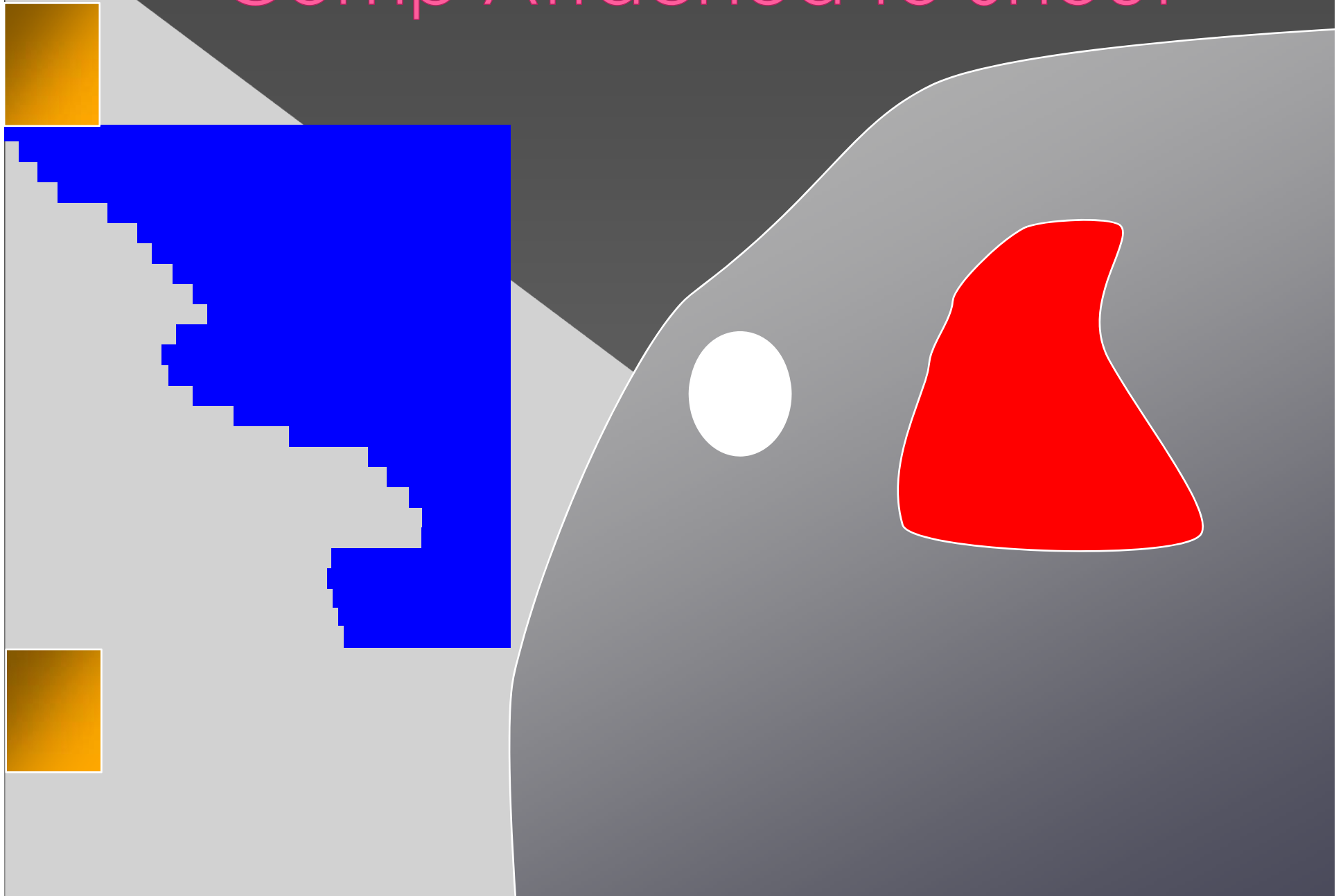
Single Compensator



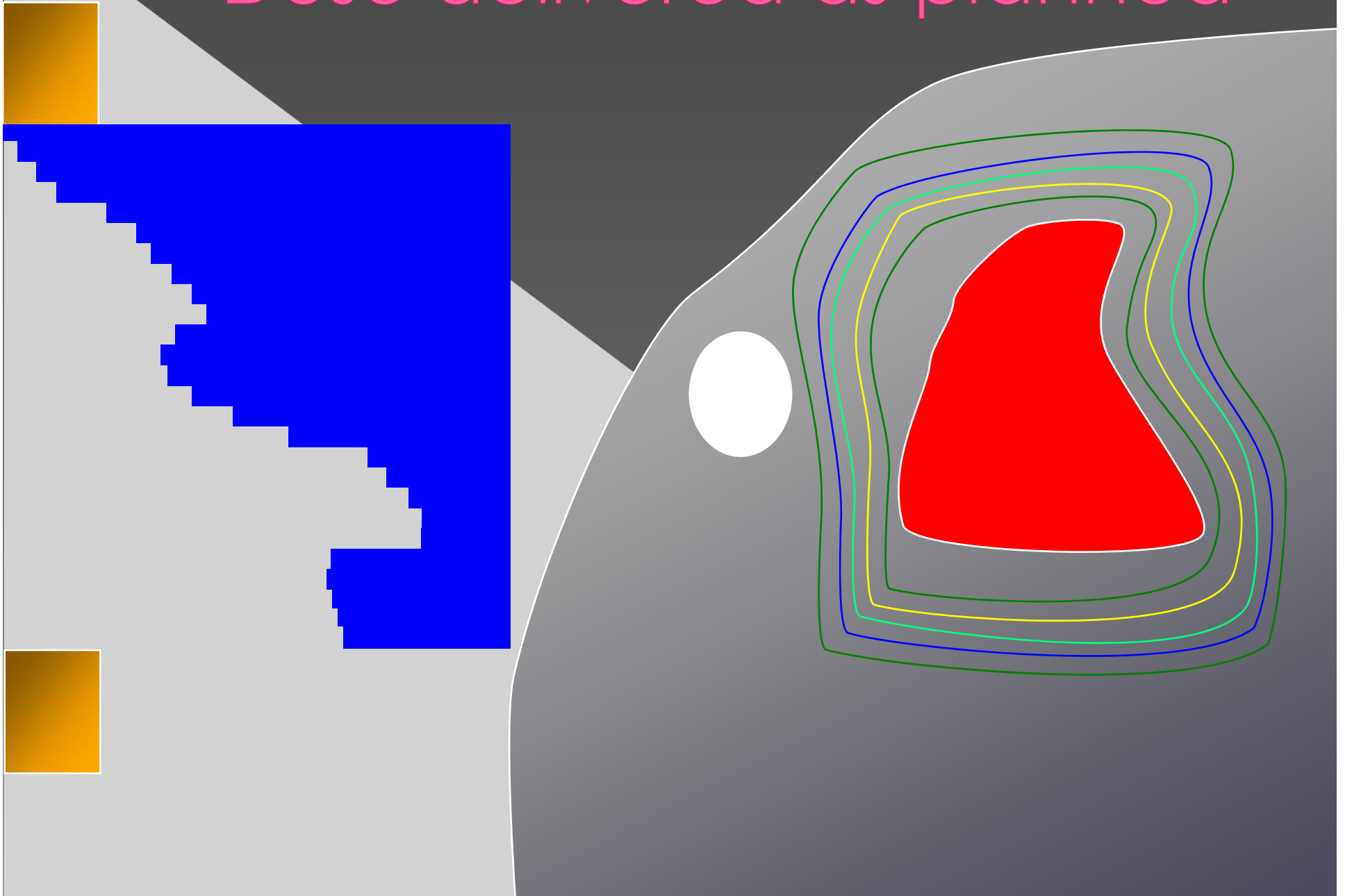
Manufactured Device



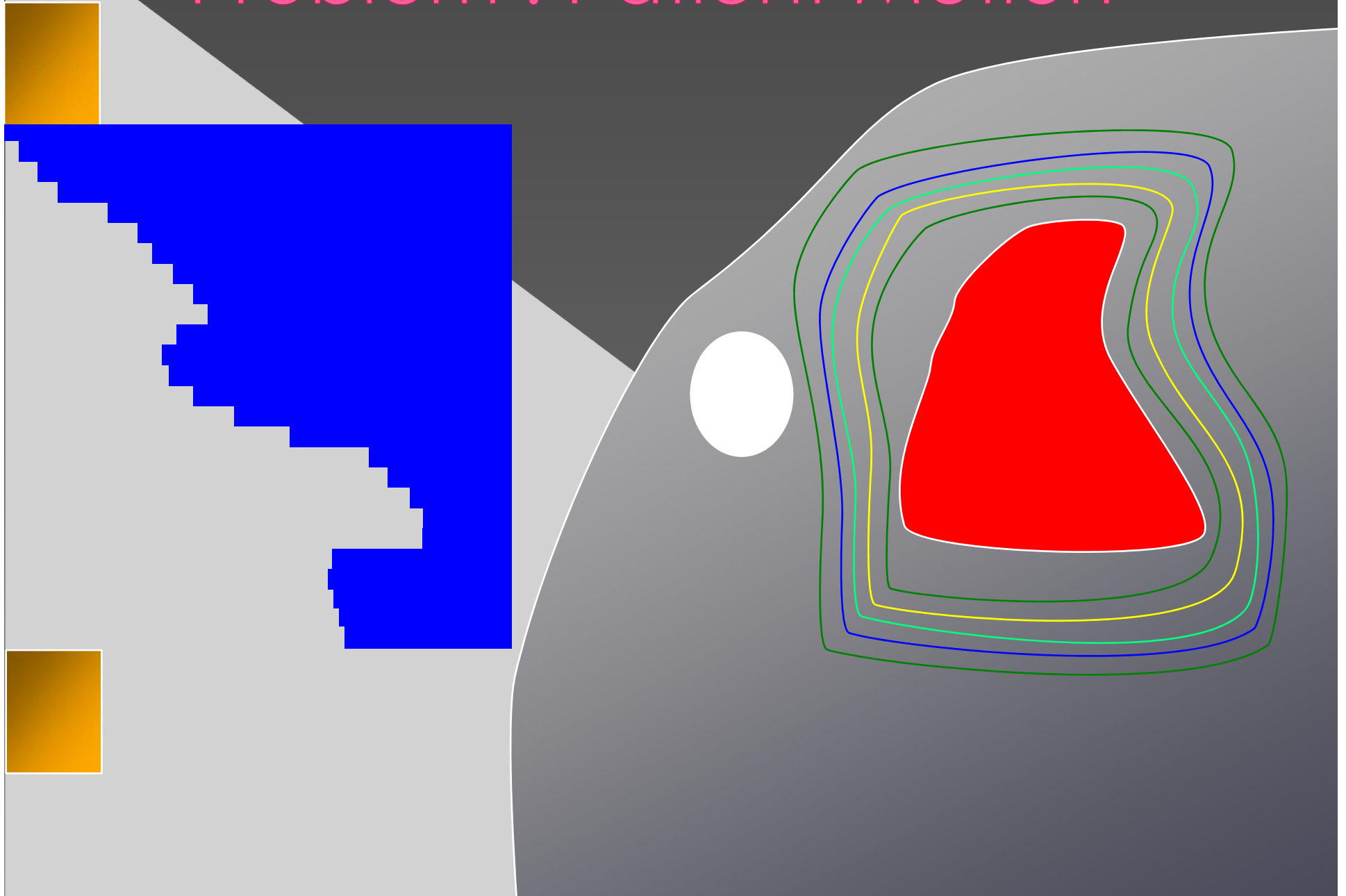
Comp Attached to Snout



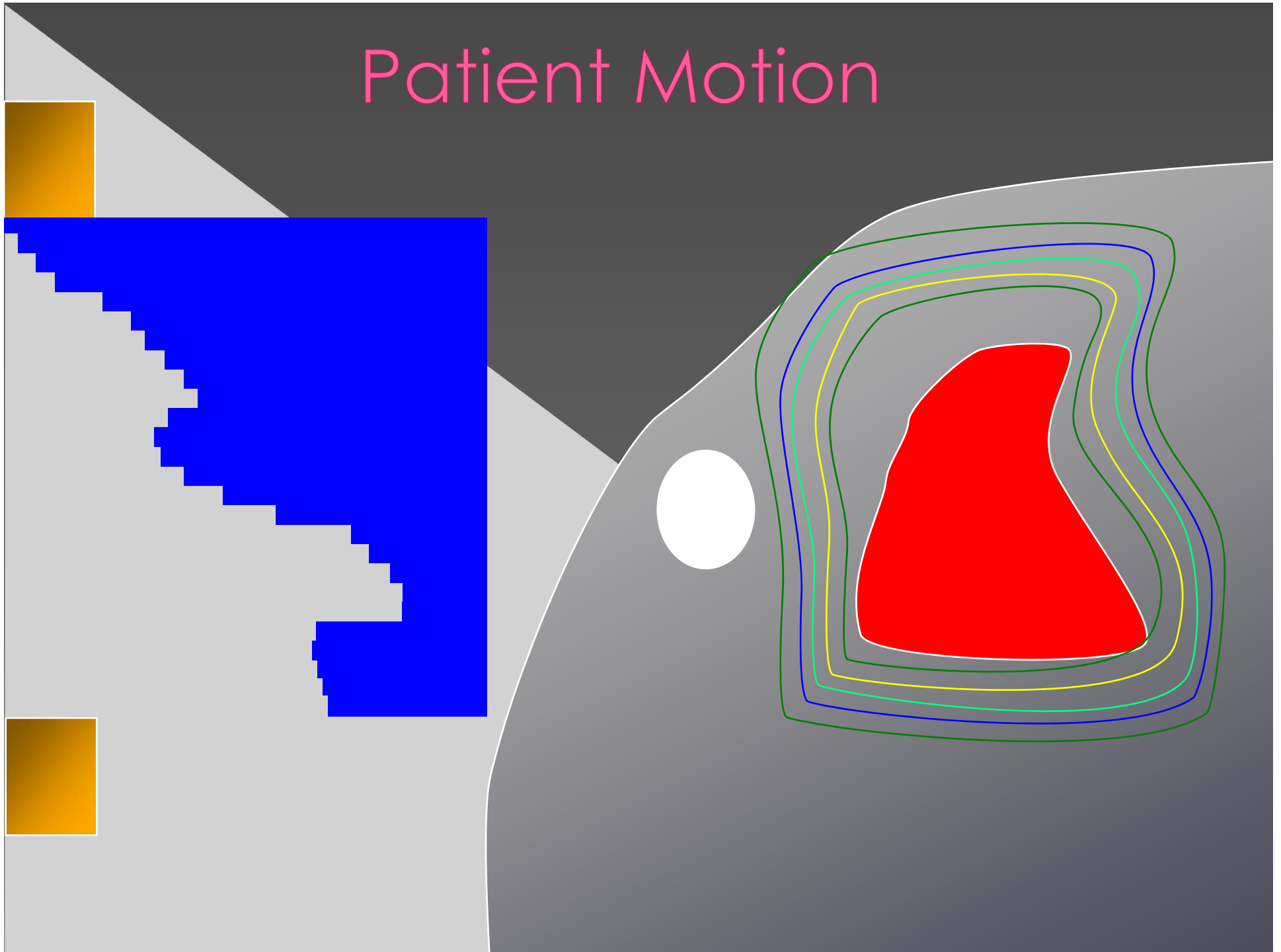
Dose delivered as planned



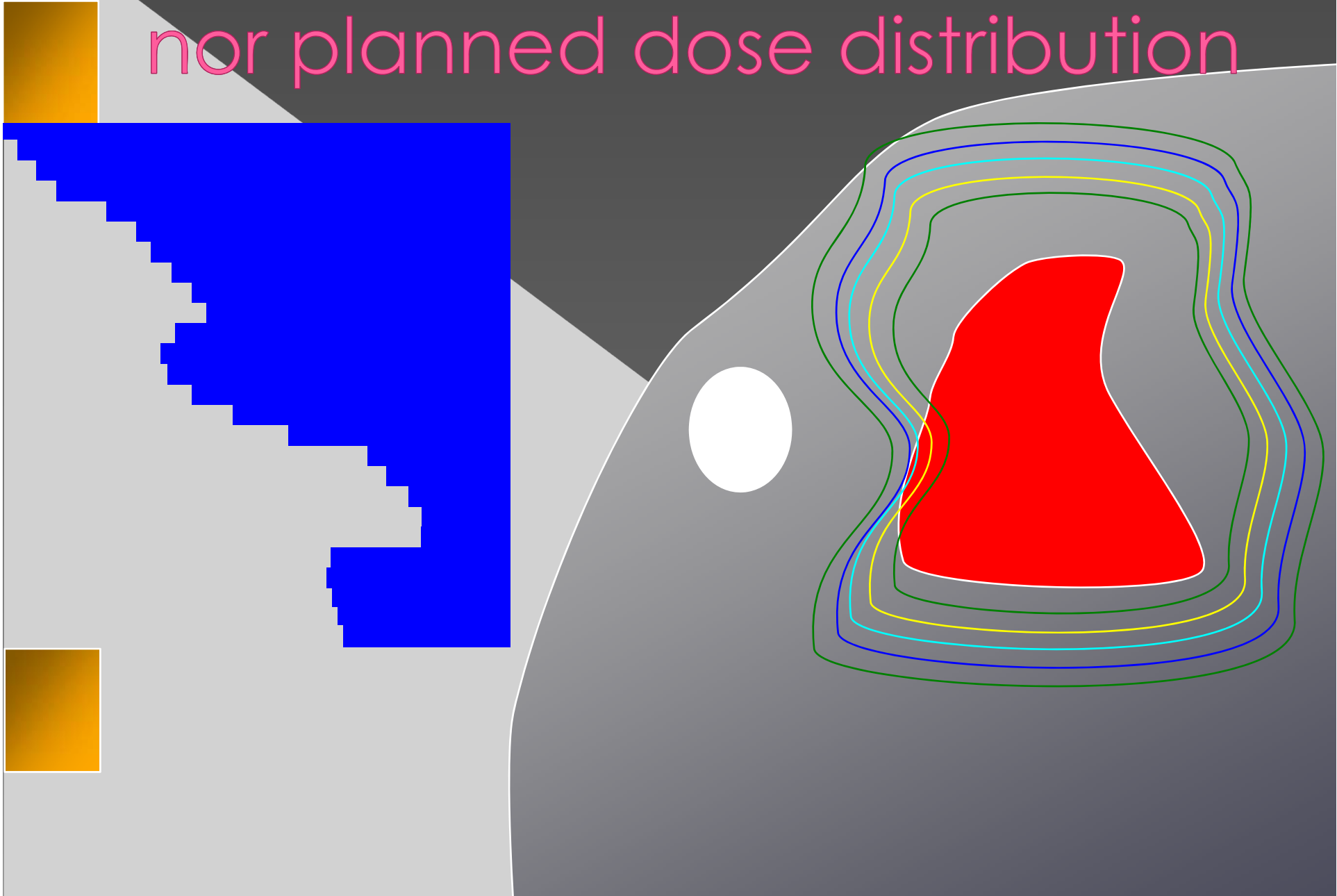
Problem : Patient Motion



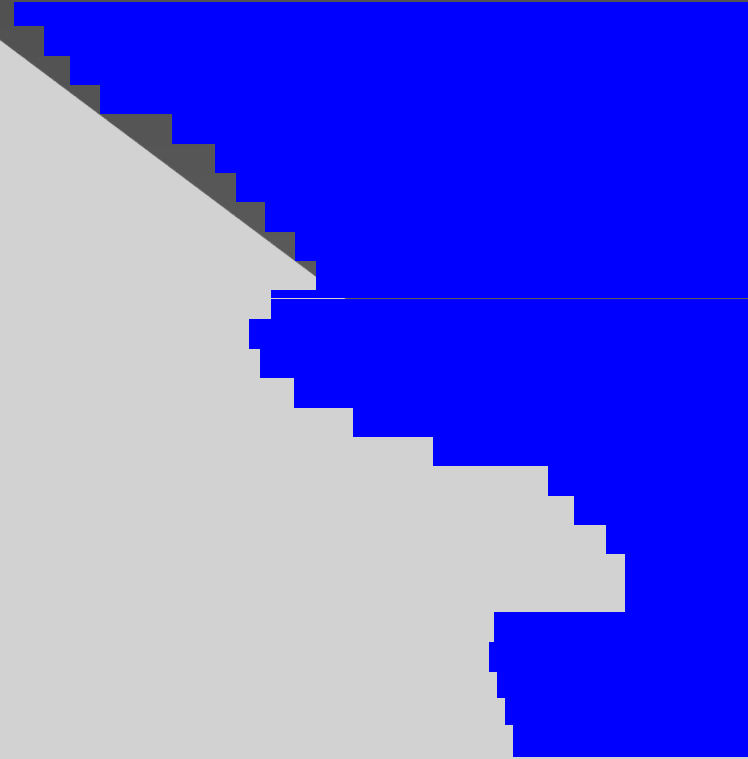
Patient Motion



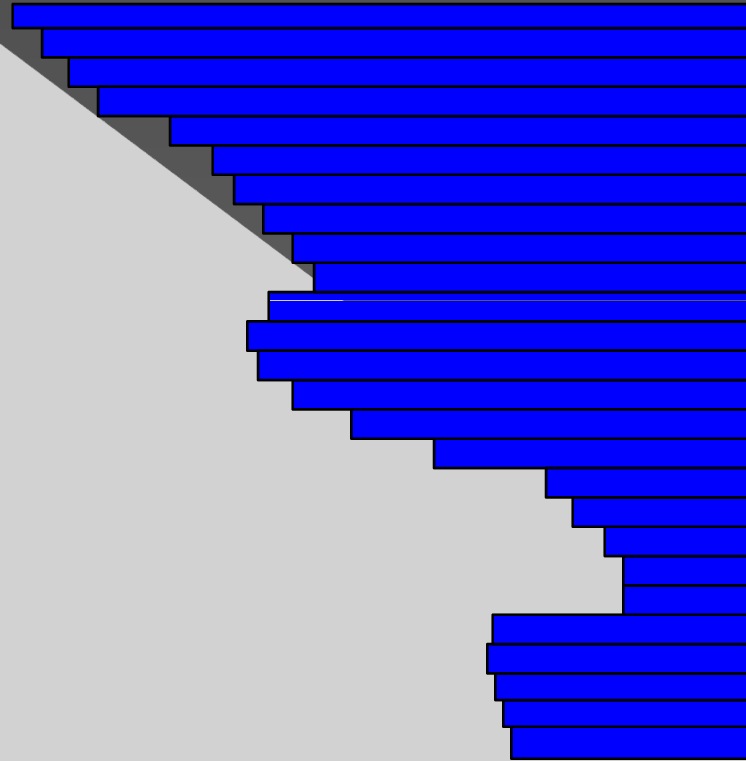
Not the desired compensation
nor planned dose distribution



Compensator needs to include
uncertainties for Set-up / Motion

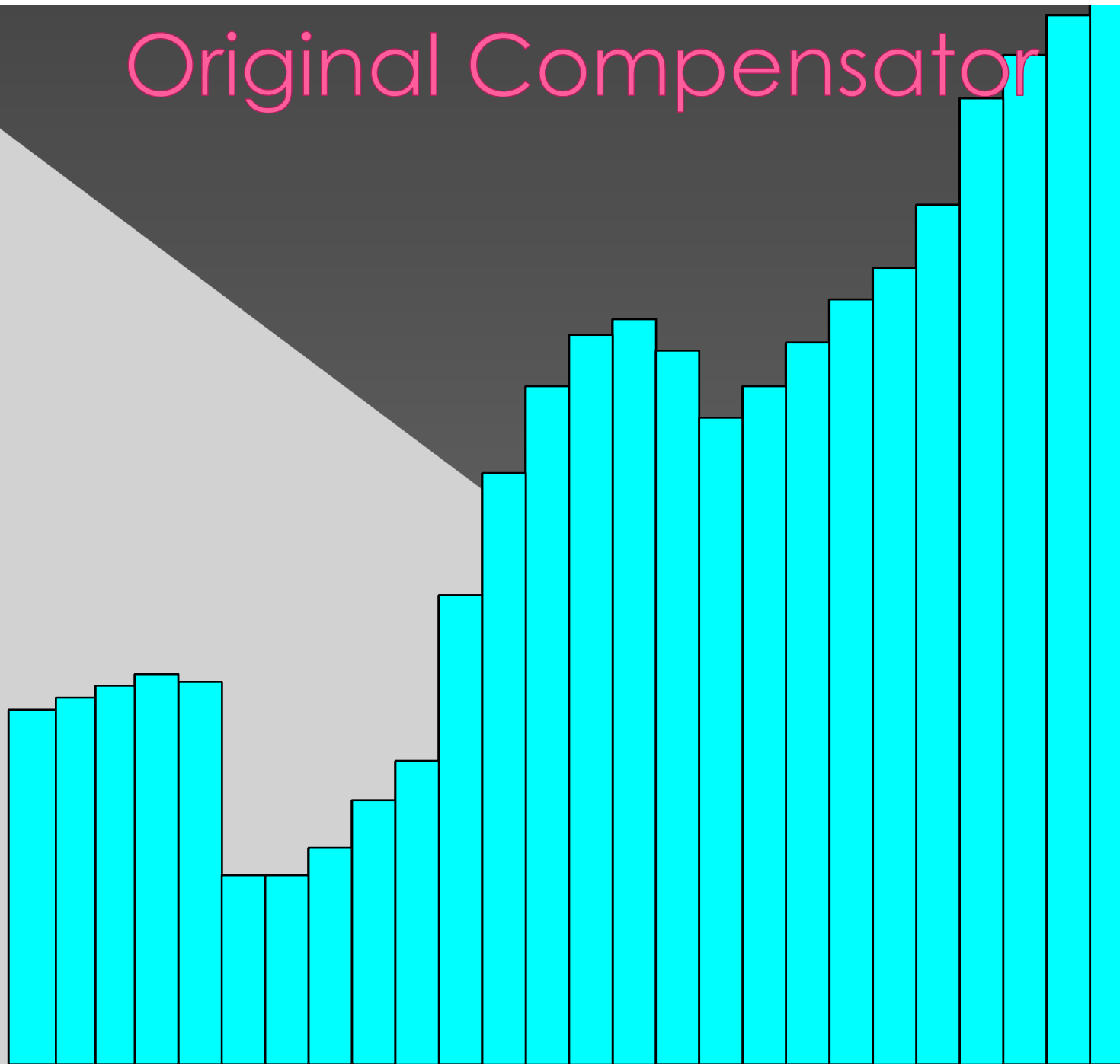


Smearing

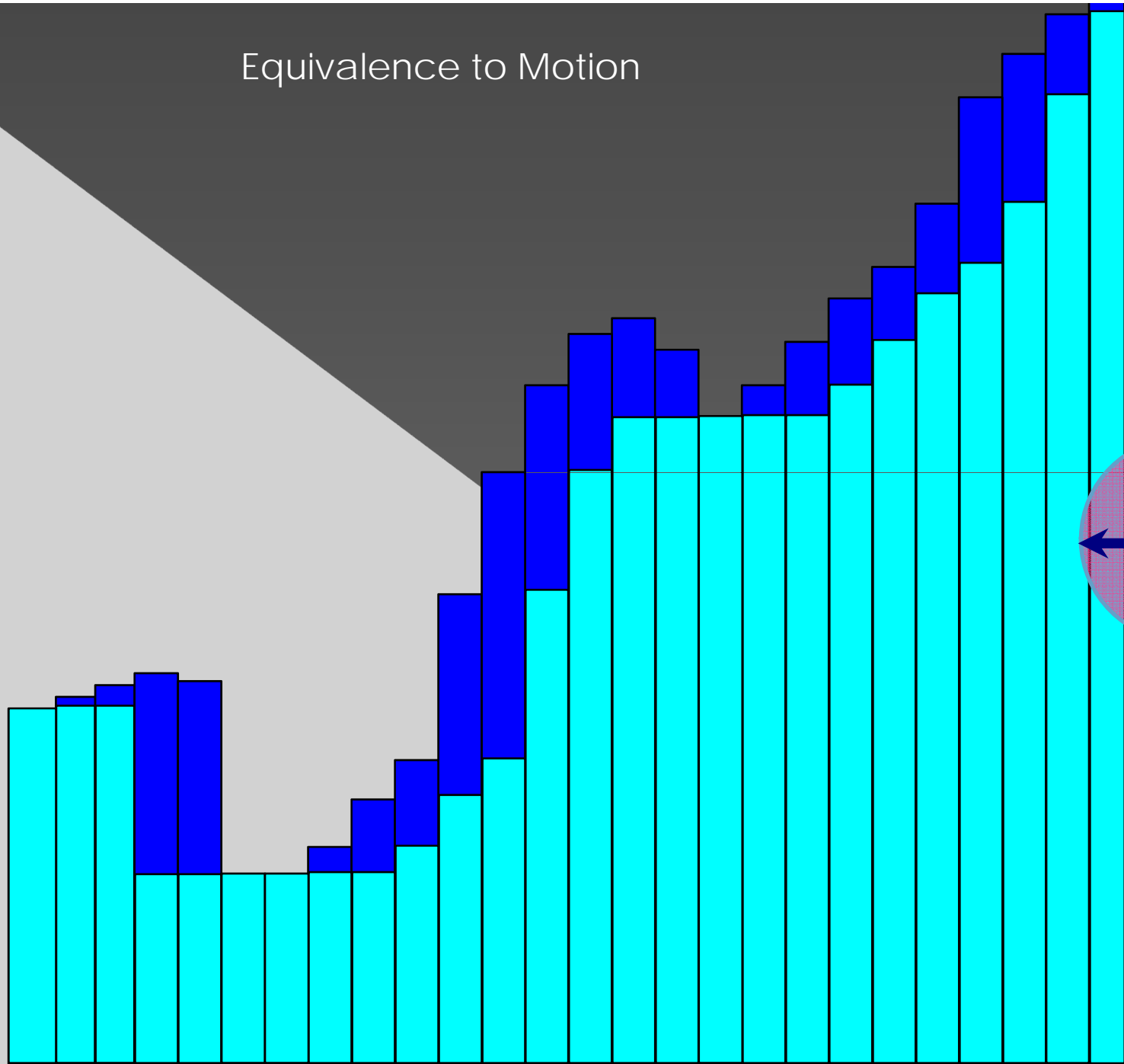


Ensure that required range is present at a particular point AND all points within it's smearing radius

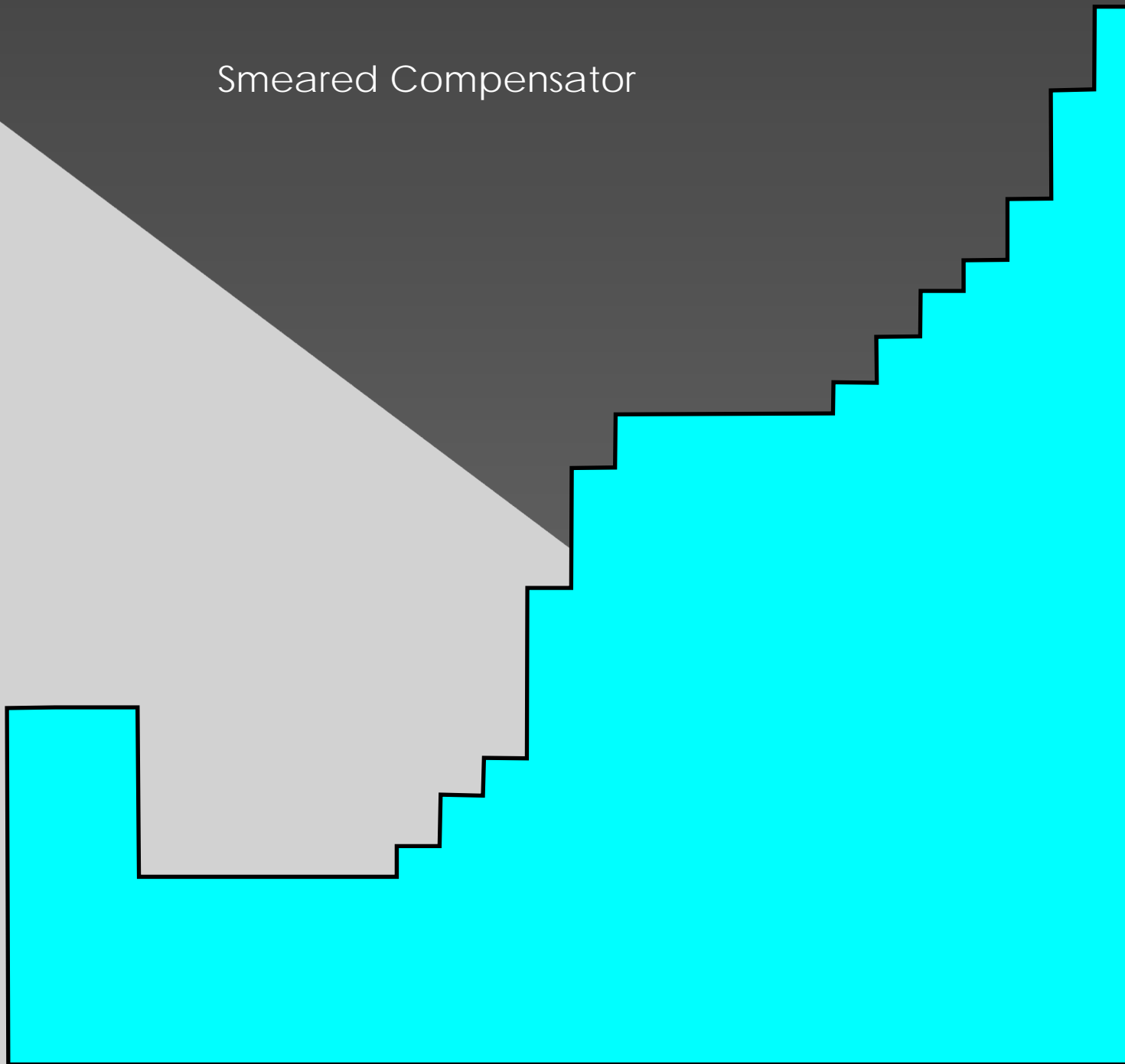
Original Compensator



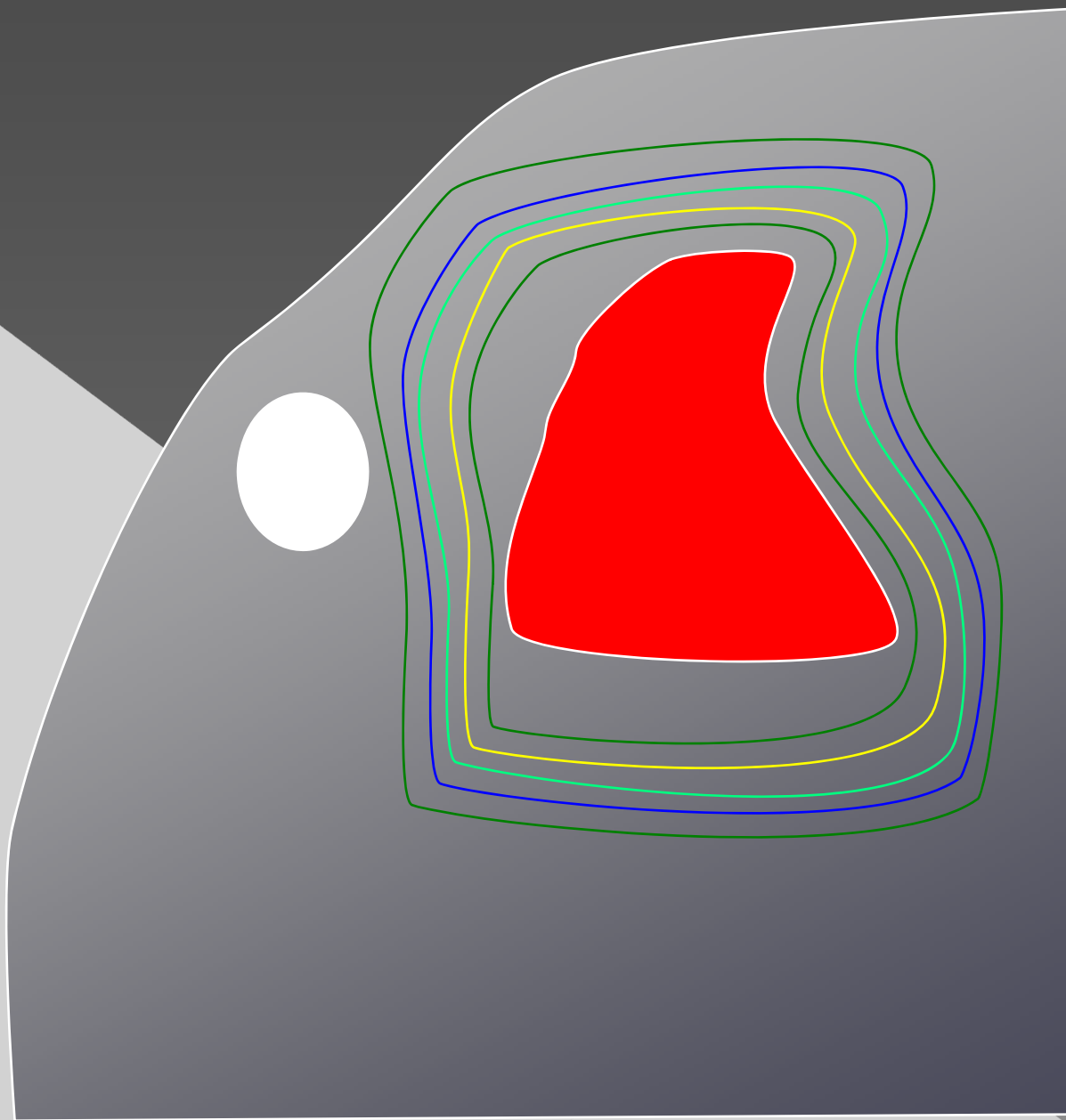
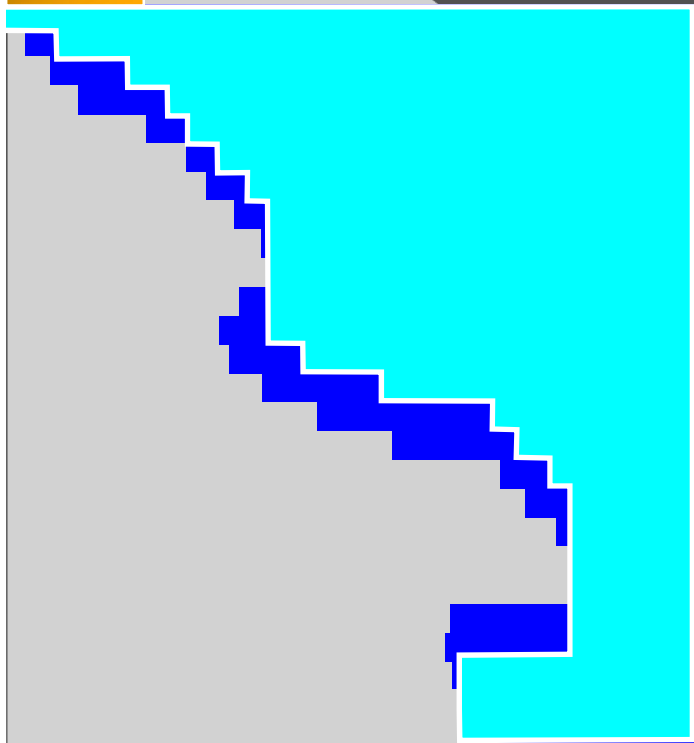
Equivalence to Motion



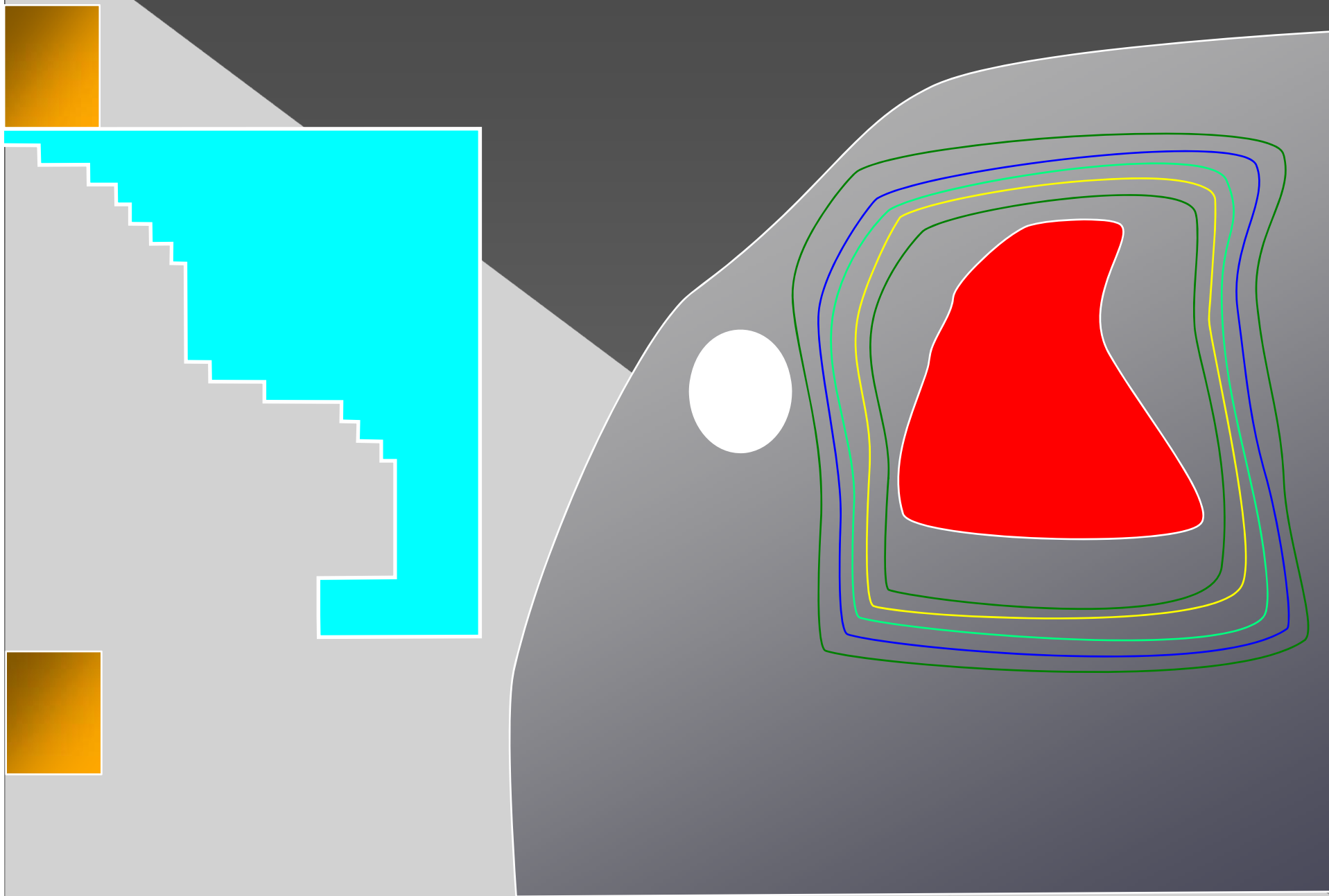
Smeared Compensator



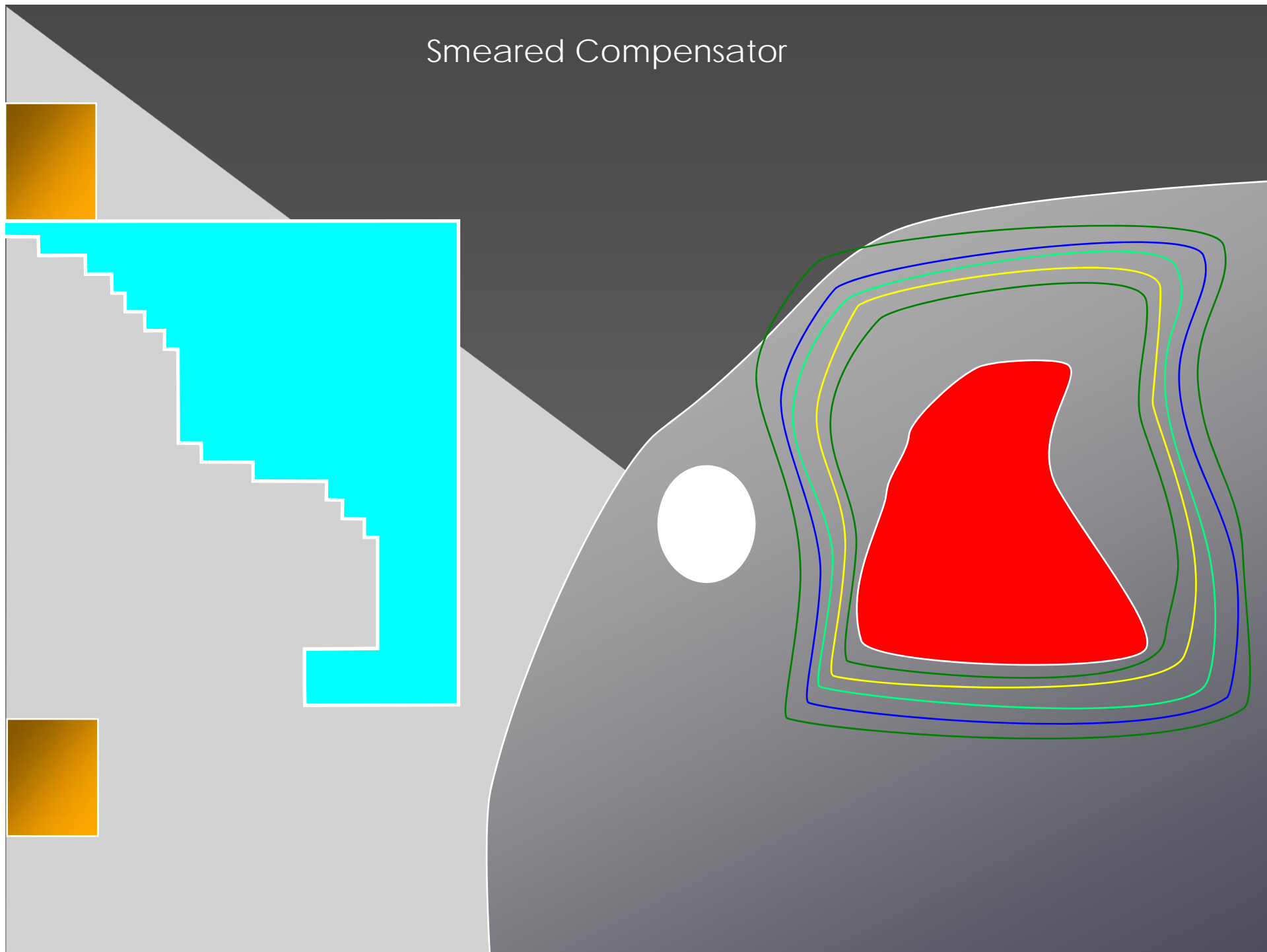
Original vs Smearred Compensator



Original vs Smeared Compensator



Smeared Compensator



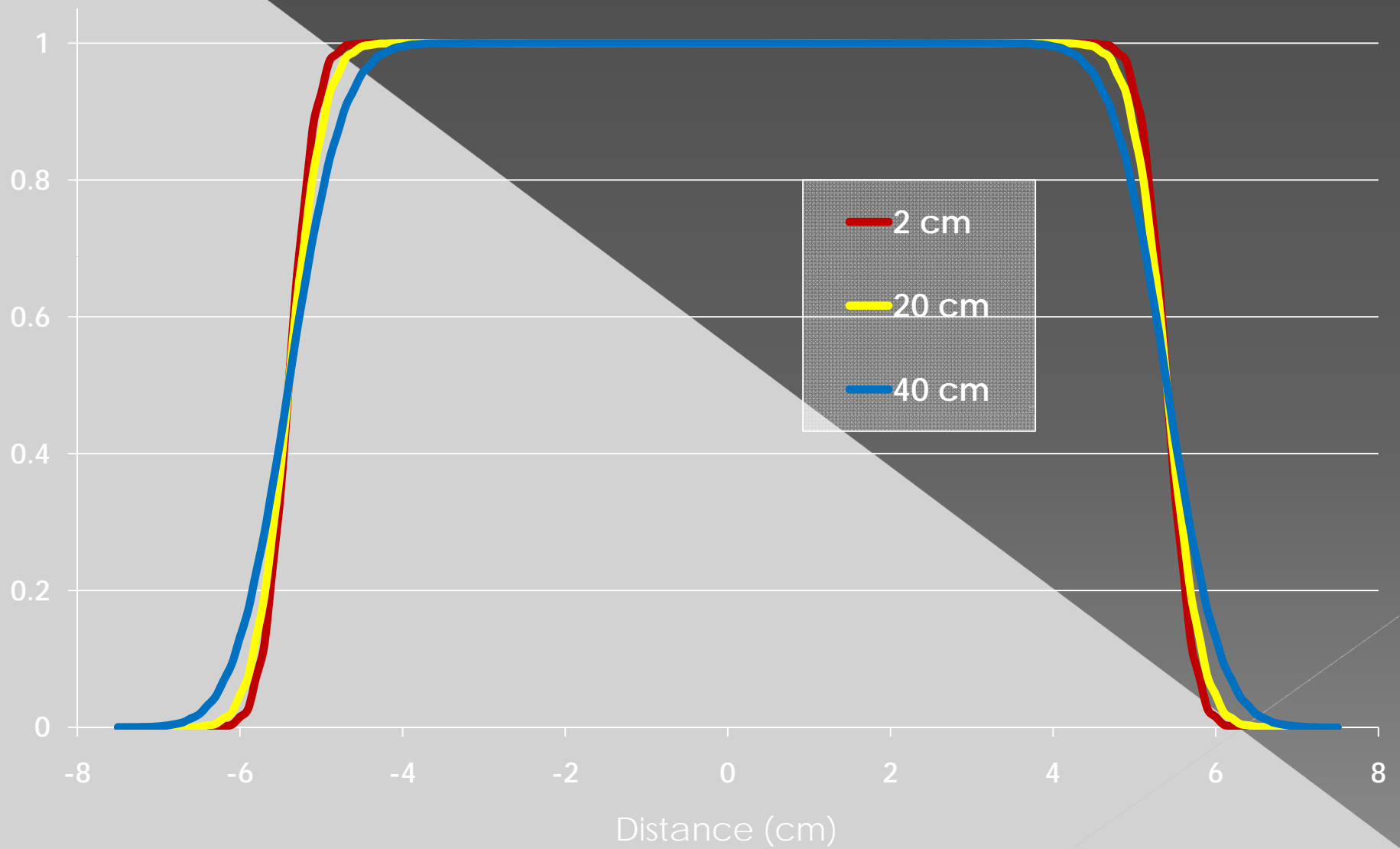
Compensators



Patient Specific Apertures



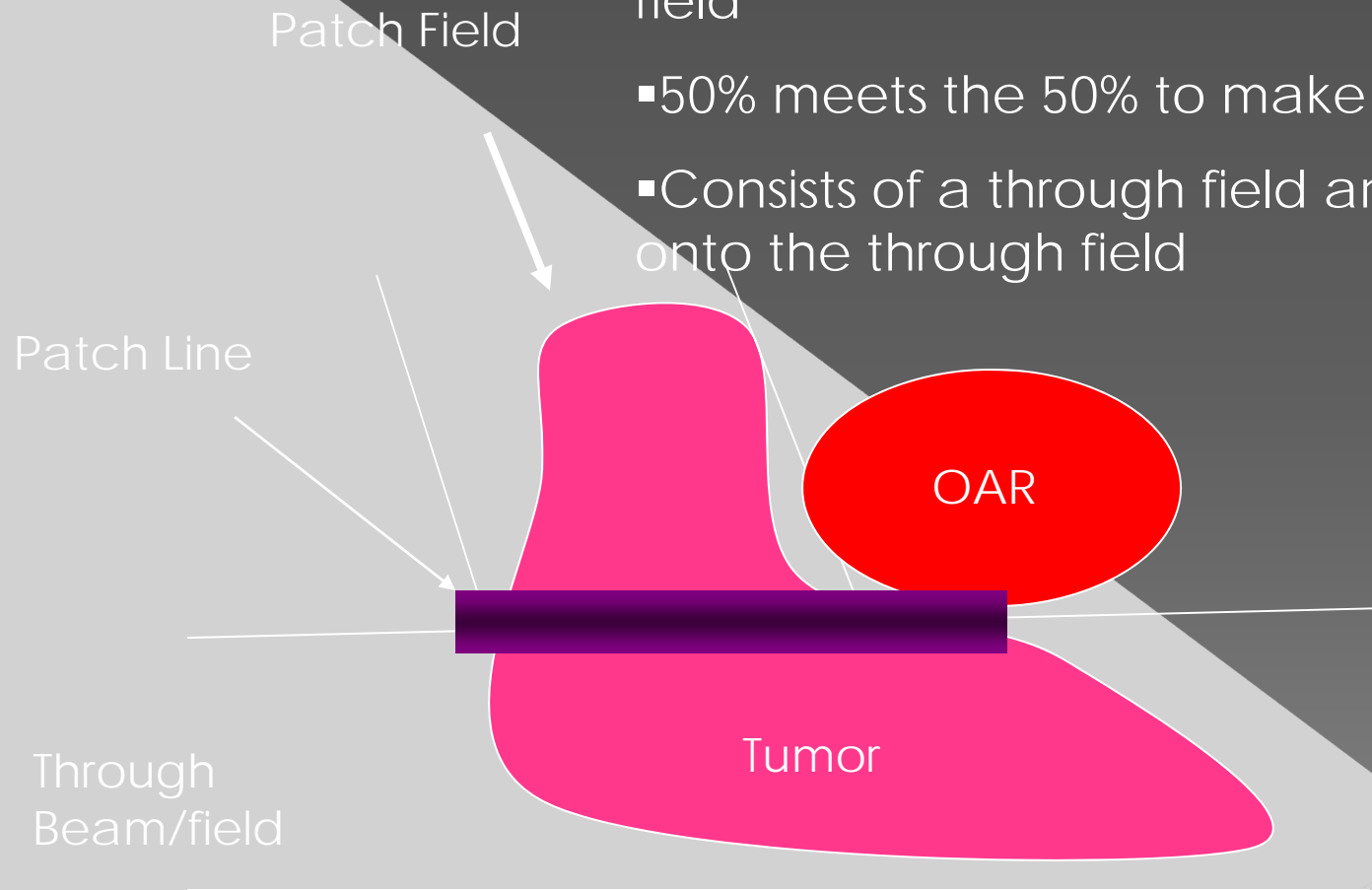
Penumbra at Various Air Gaps



Other Techniques : Patch Fields

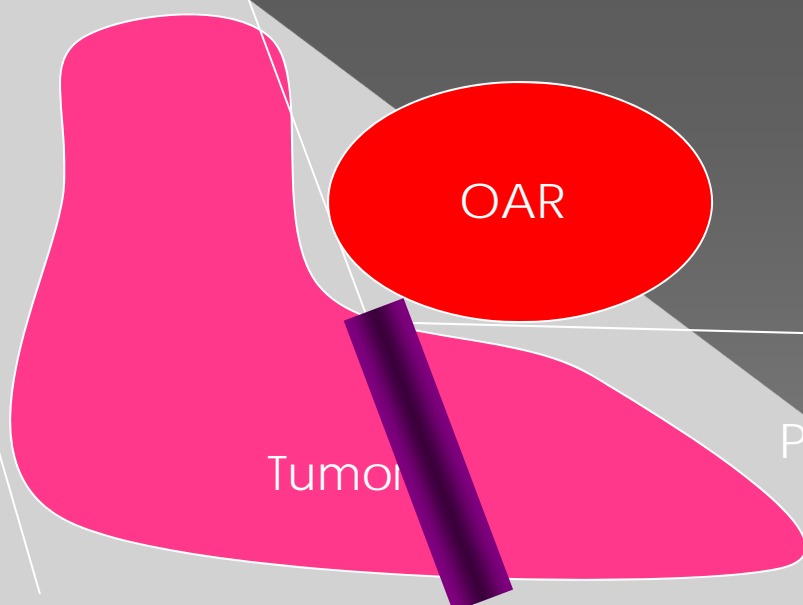
Definition – distal edge of one field meets the lateral border of the other field

- 50% meets the 50% to make up a 100%
- Consists of a through field and a patch onto the through field



Patch Field Technique – *Shifting Patch line*

Through
Beam/field

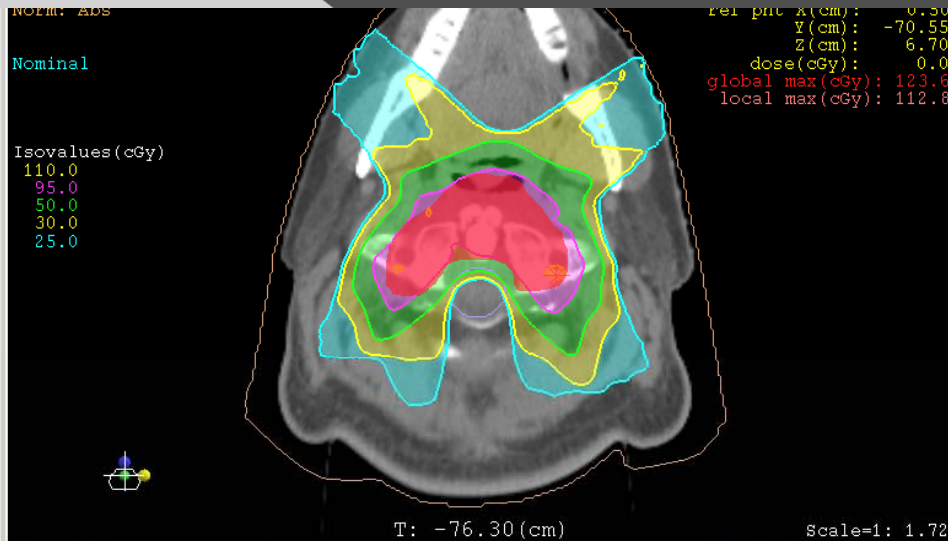


OAR

Tumor

Patch Field

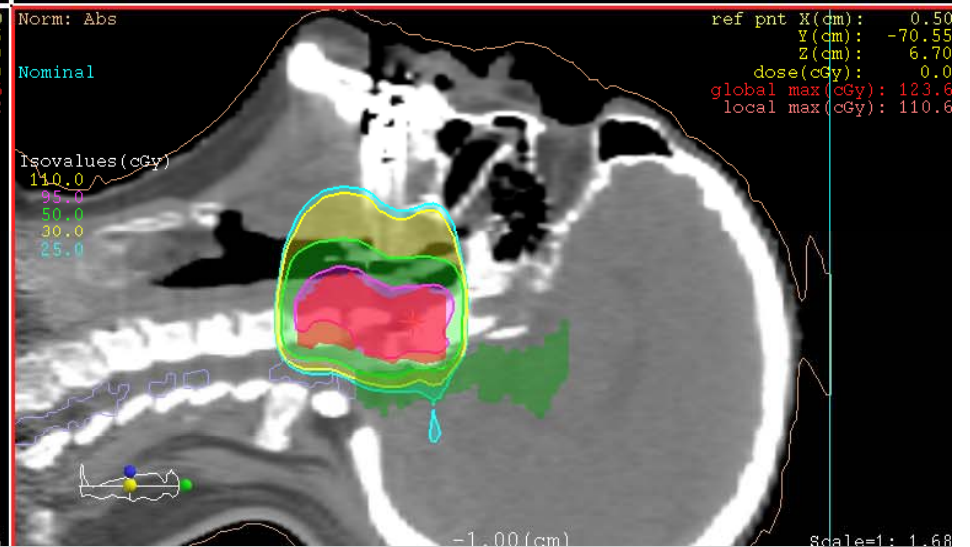
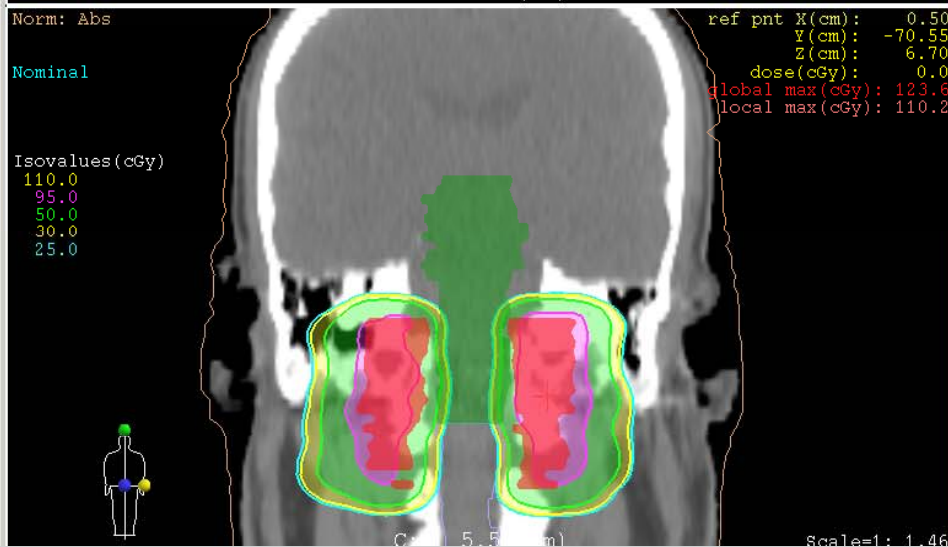
Illustration: Total isodose distribution using 3 patch pairs



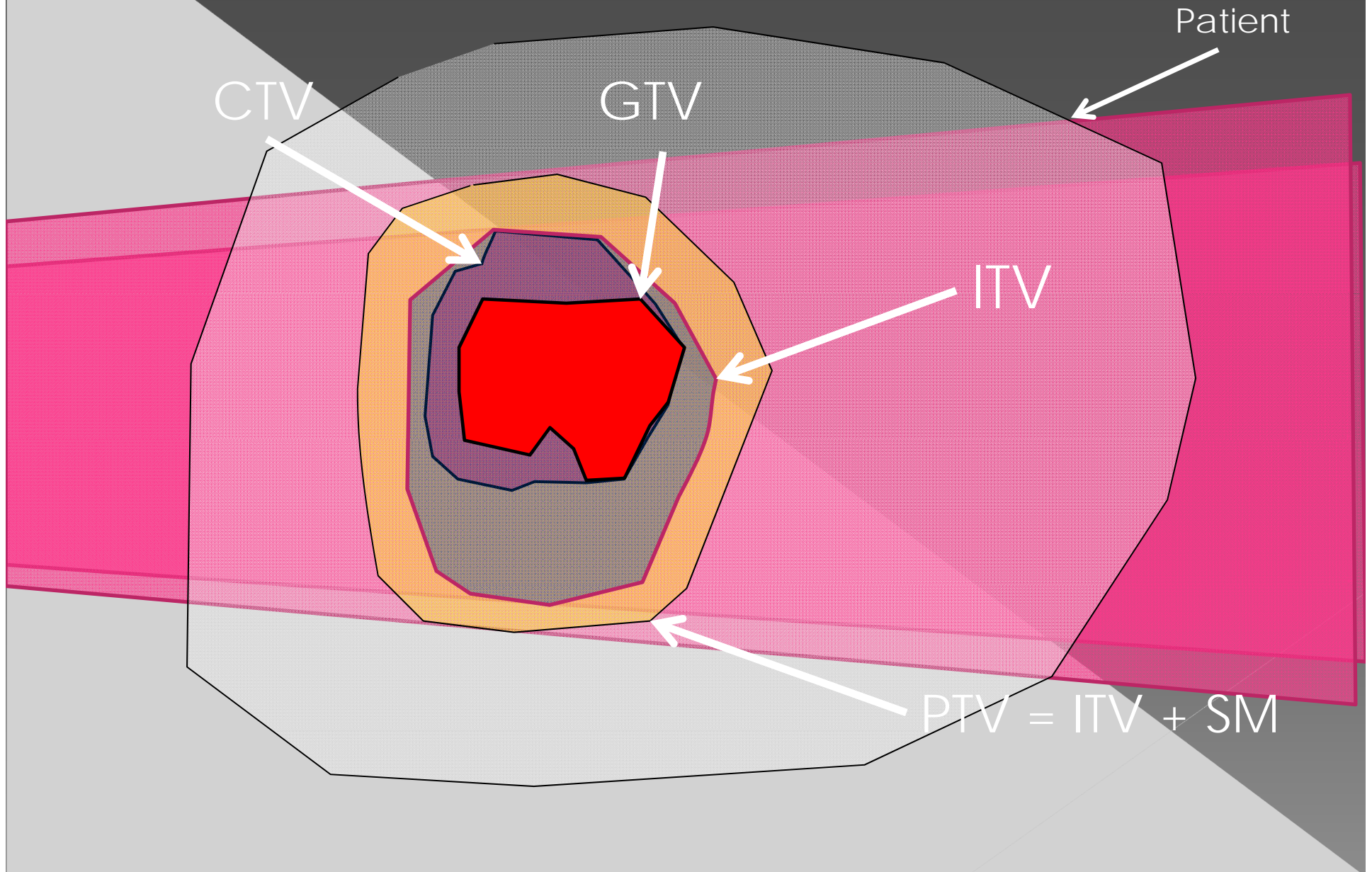
Patch 1- LAO THRU + LPO PATCH

Patch 2- RAO THRU + RPO PATCH

Patch 3-POP THRU LATS + LT and RT POST PATCHES



ICRU Definitions

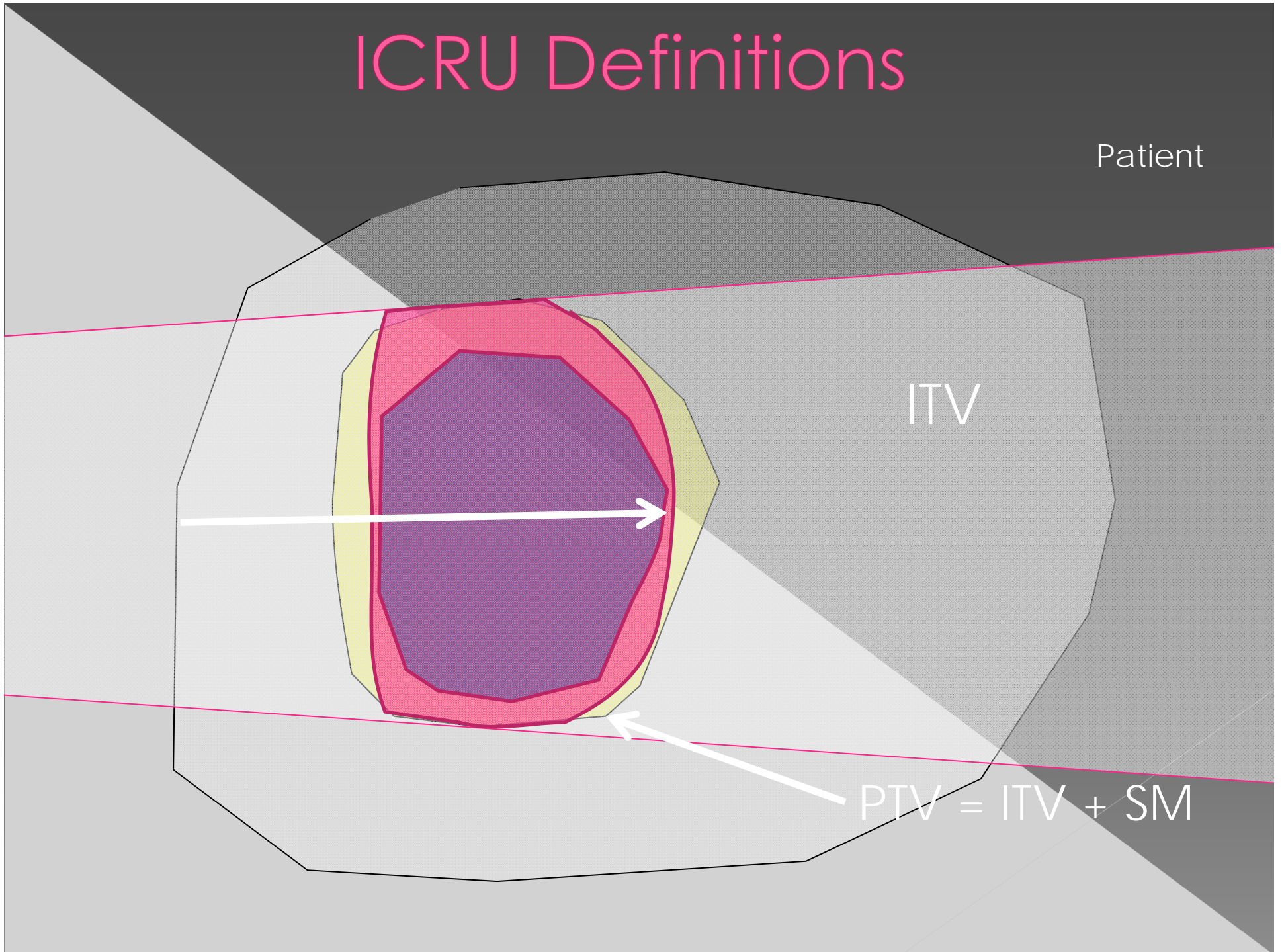


ICRU Definitions

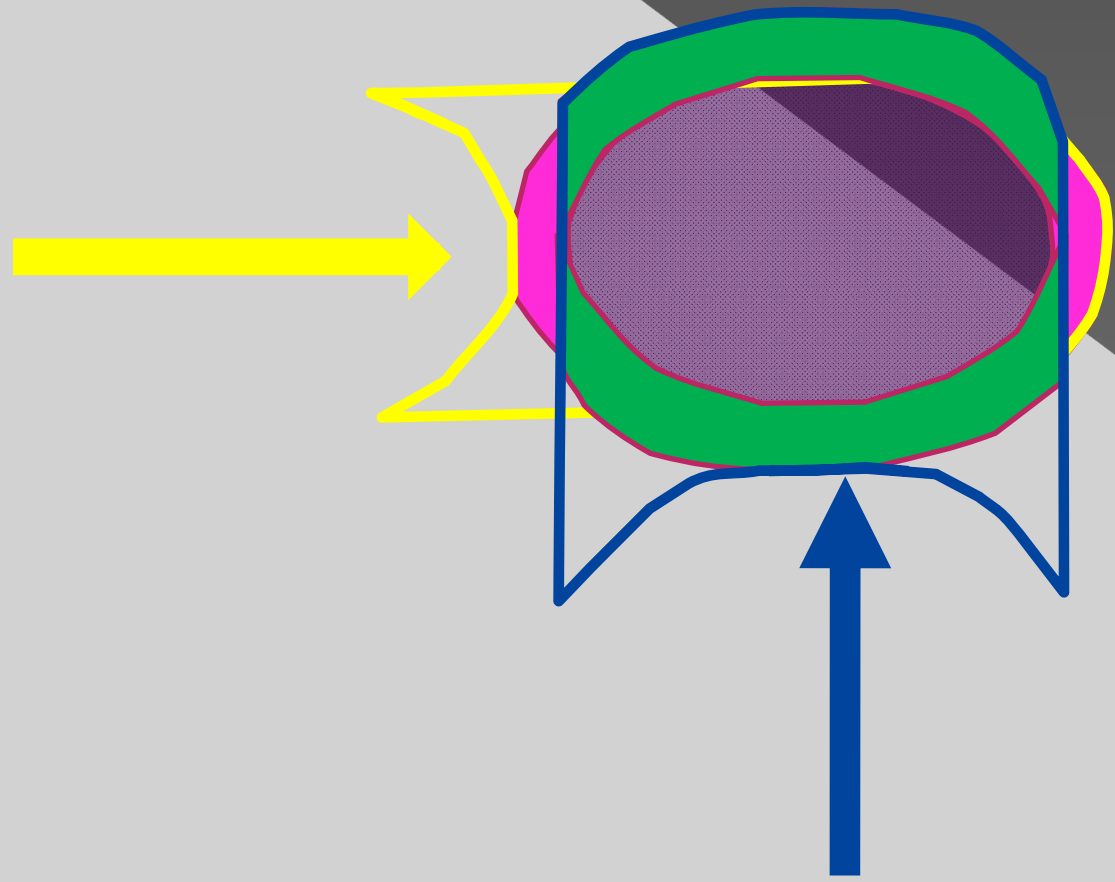
Patient

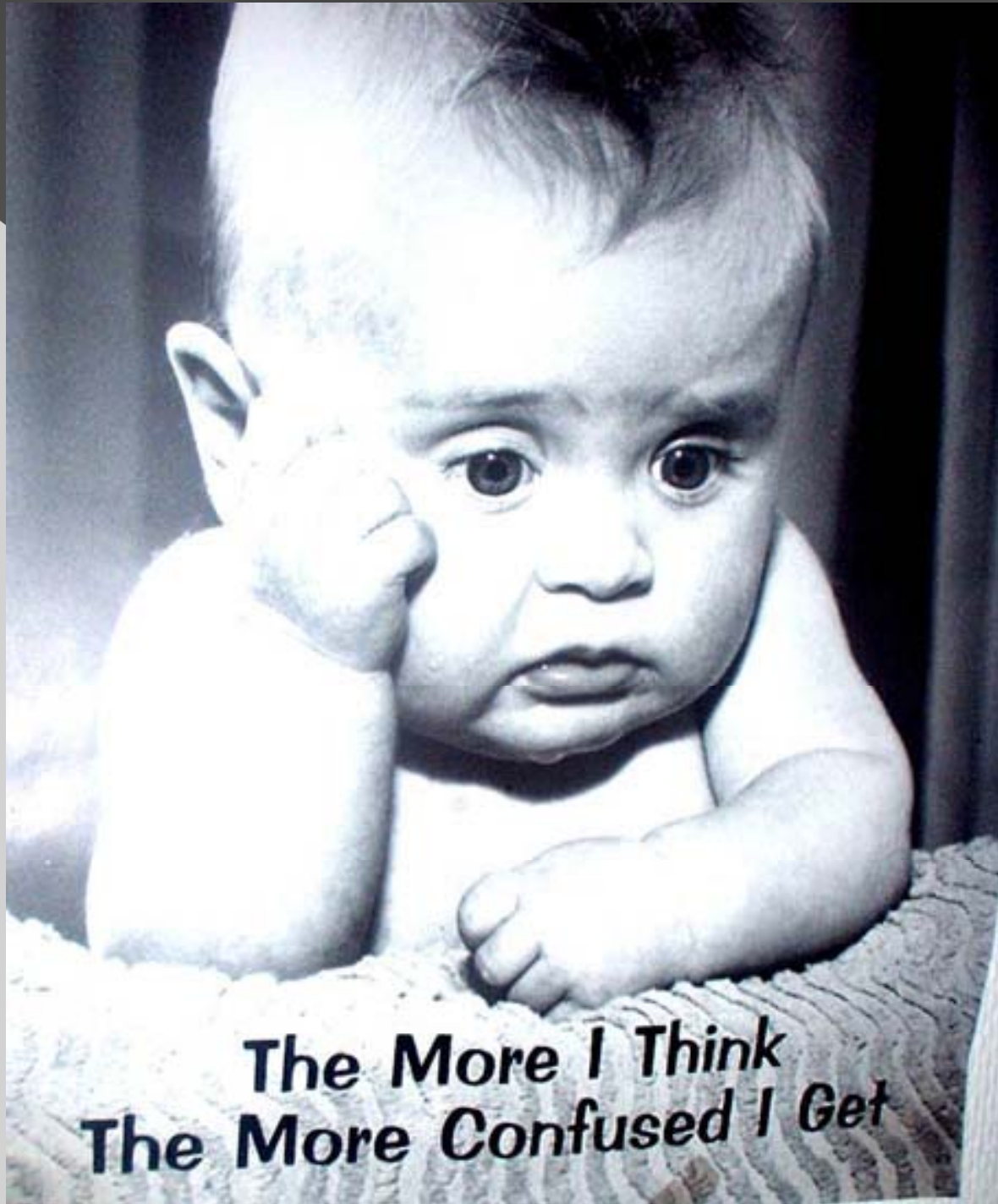
ITV

$PTV = ITV + SM$



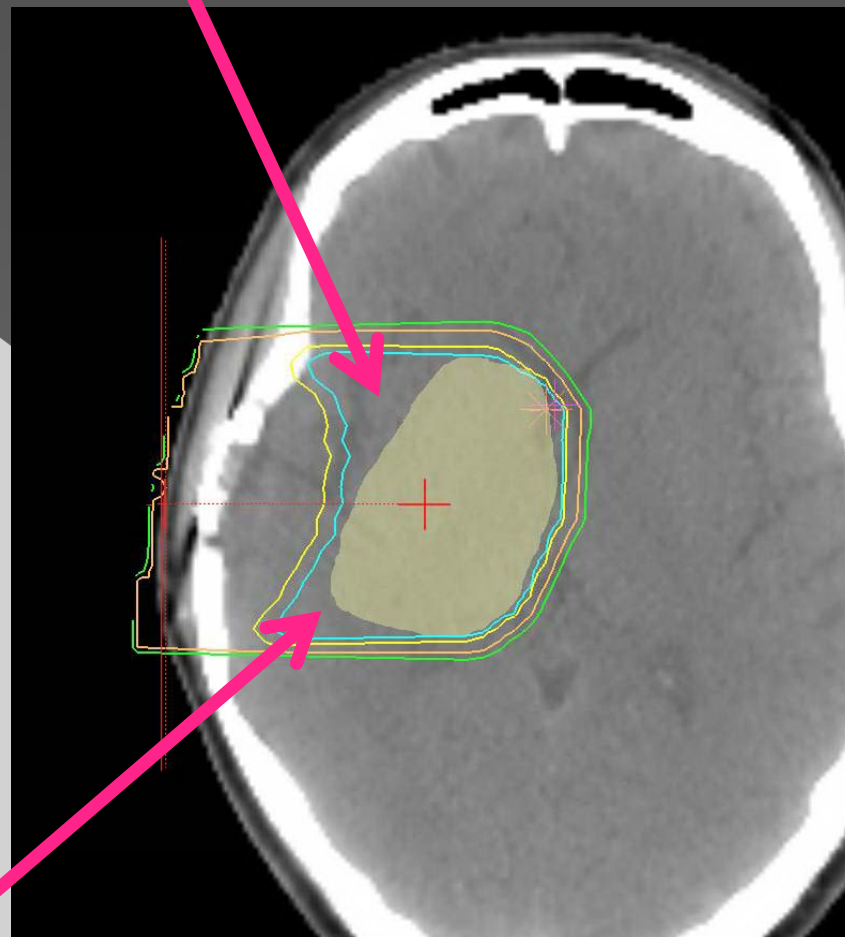
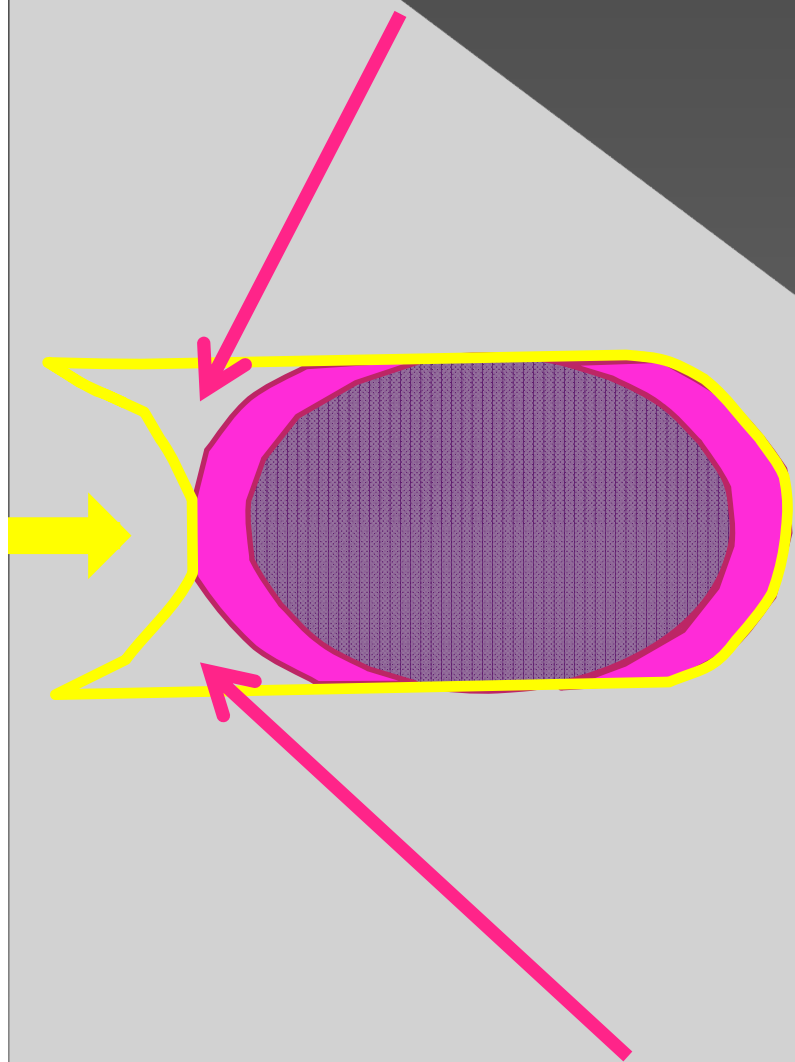
Adding the Uncertainty Process



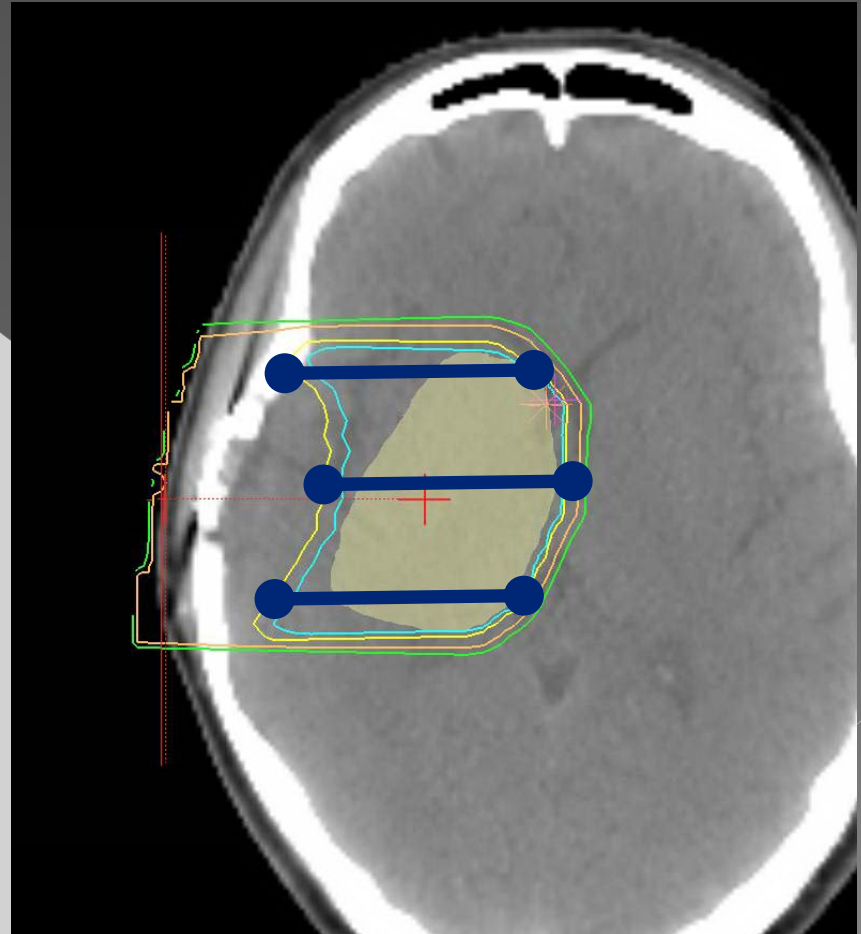
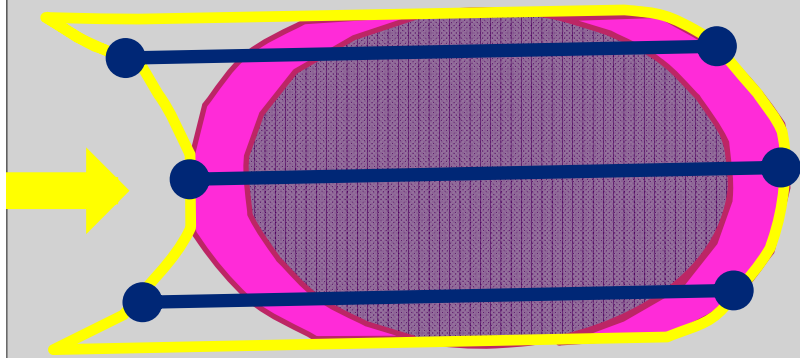


**The More I Think
The More Confused I Get**

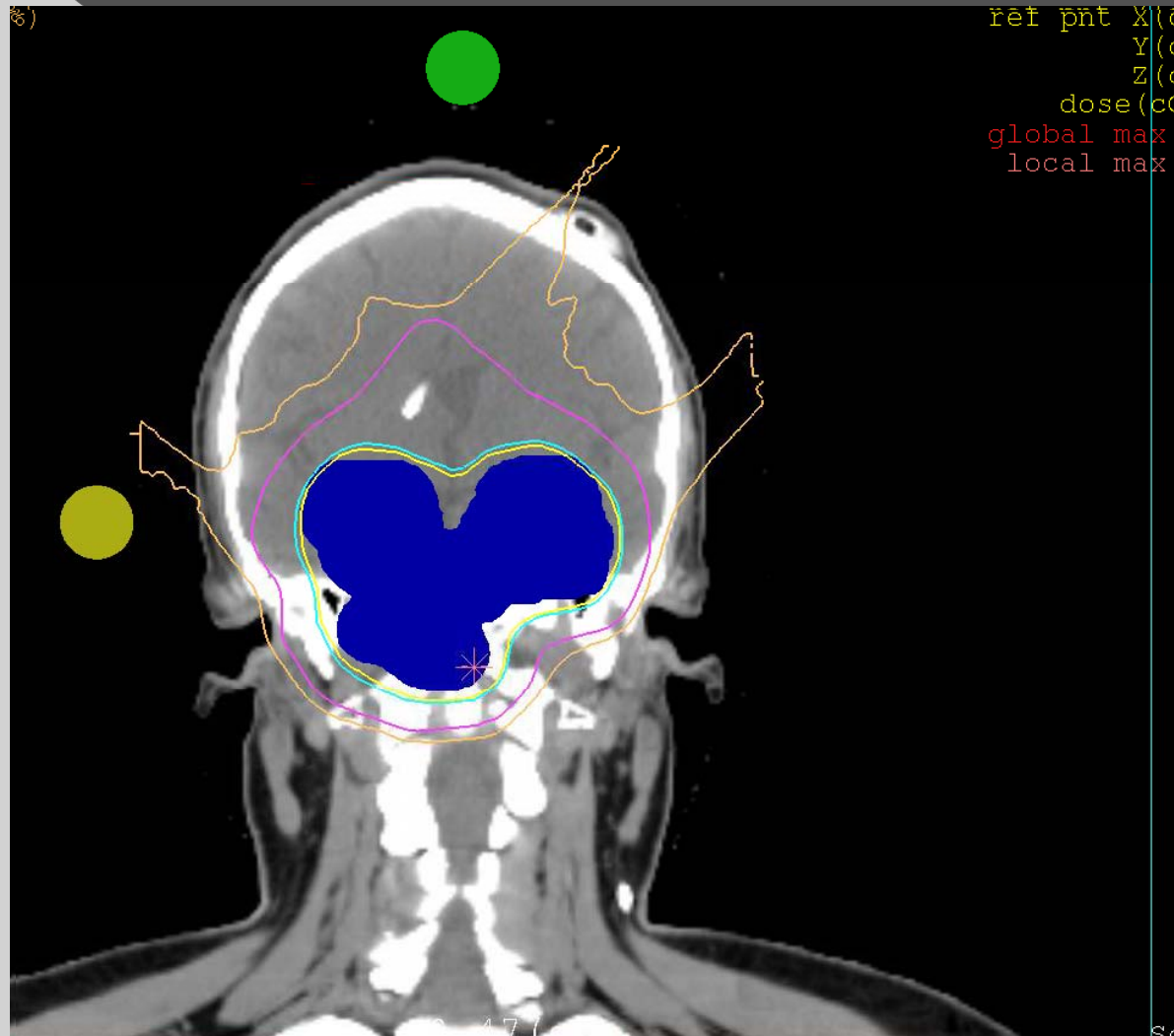
What about those tails ??



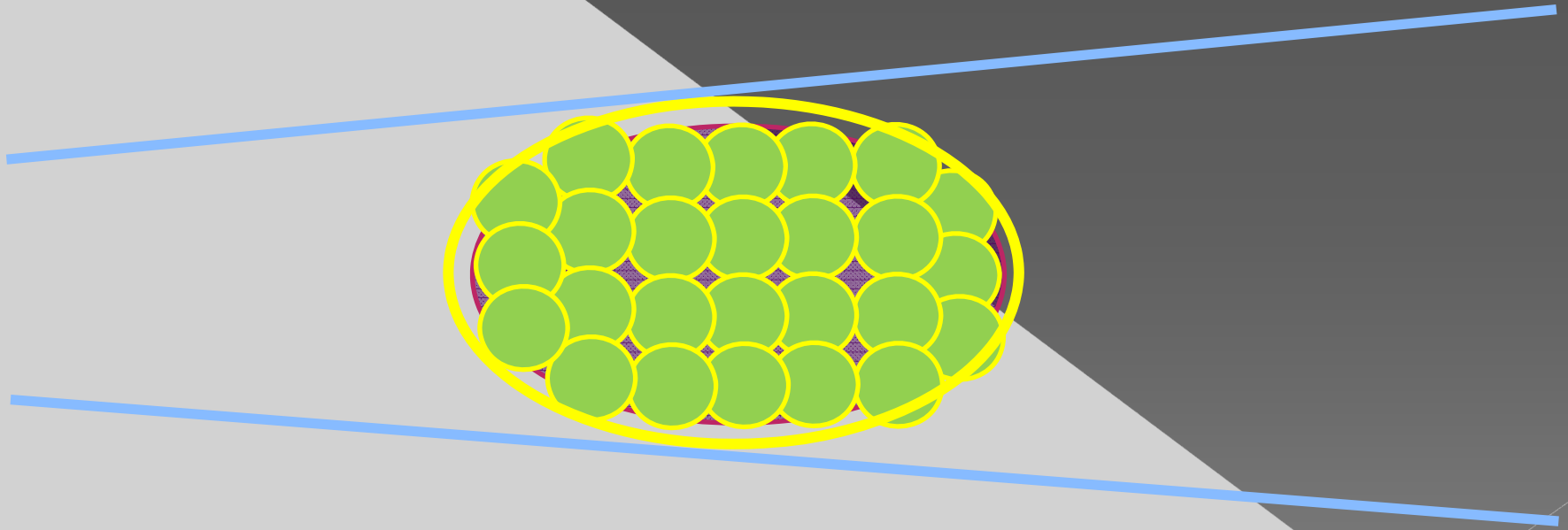
Uniform Modulation



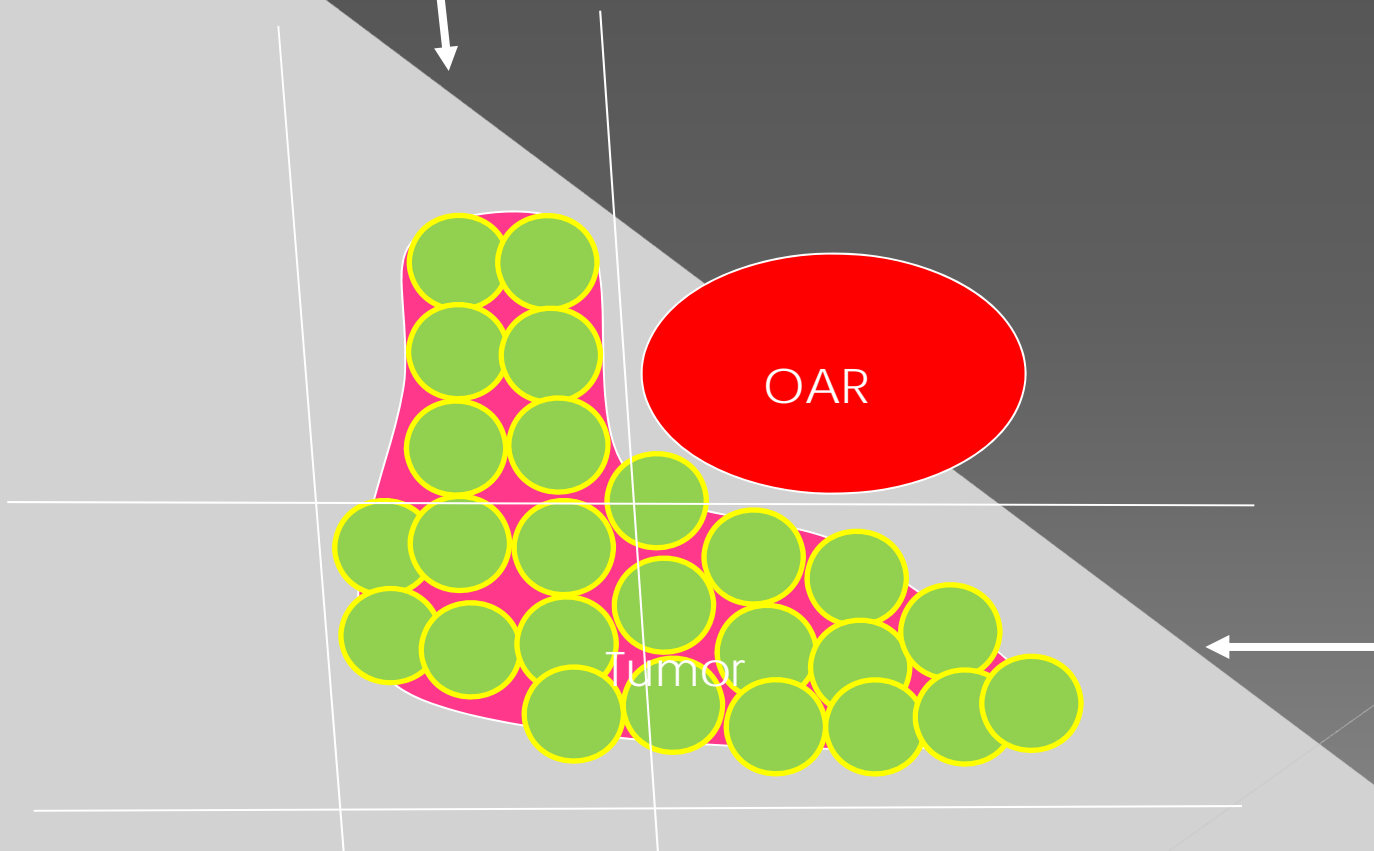
Use of multiple fields daily



Spot Scanning



Spot Scanning -> IMPT





Thank You for your
attention!!