Protons and ACT Issues

January, 2008

Proton
Physical Dose and Dose Equivalent

- For protons, doses may be prescribed in terms of Cobalt Gray Equivalent (CGE).
- For protons, the physical dose in Gy is equal to the equivalent dose in CGE divided by the RBE of 1.1, i.e.

  Gy (physical dose) = CGE/1.1
- For photons, the RBE is 1.0.

Patient Setup Issues

- Treatment couch motions: The Hitachi couch is a 6 degree of freedom couch, capable of limited pitch and roll rotations.
- Anderson has one photon couch with similar capabilities.
- How should six degrees of freedom couches be managed in the cooperative group setting?

Protons: Imaged Guided Therapy

- At PTC-H, at least one set of orthogonal radiographs are taken every day for each isocenter. (For adult patients, an initial set of images are taken, the couch is shifted, and a second post-shift is taken. For pediatric patients, the second set is not taken.)
- Should these daily setup images be forwarded for central review? Each image is 2 MB.

Target Definitions

- For treatment planning purposes, a different convention may be used in proton planning than is used for photon planning.
- The proton convention addresses the issues of proximal and distal range uncertainties and smearing for the compensator.
- Many proton treatment planners avoid the concept of PTV, as it does not address the field specific concerns of range uncertainties.

0415 Proposal for Protons

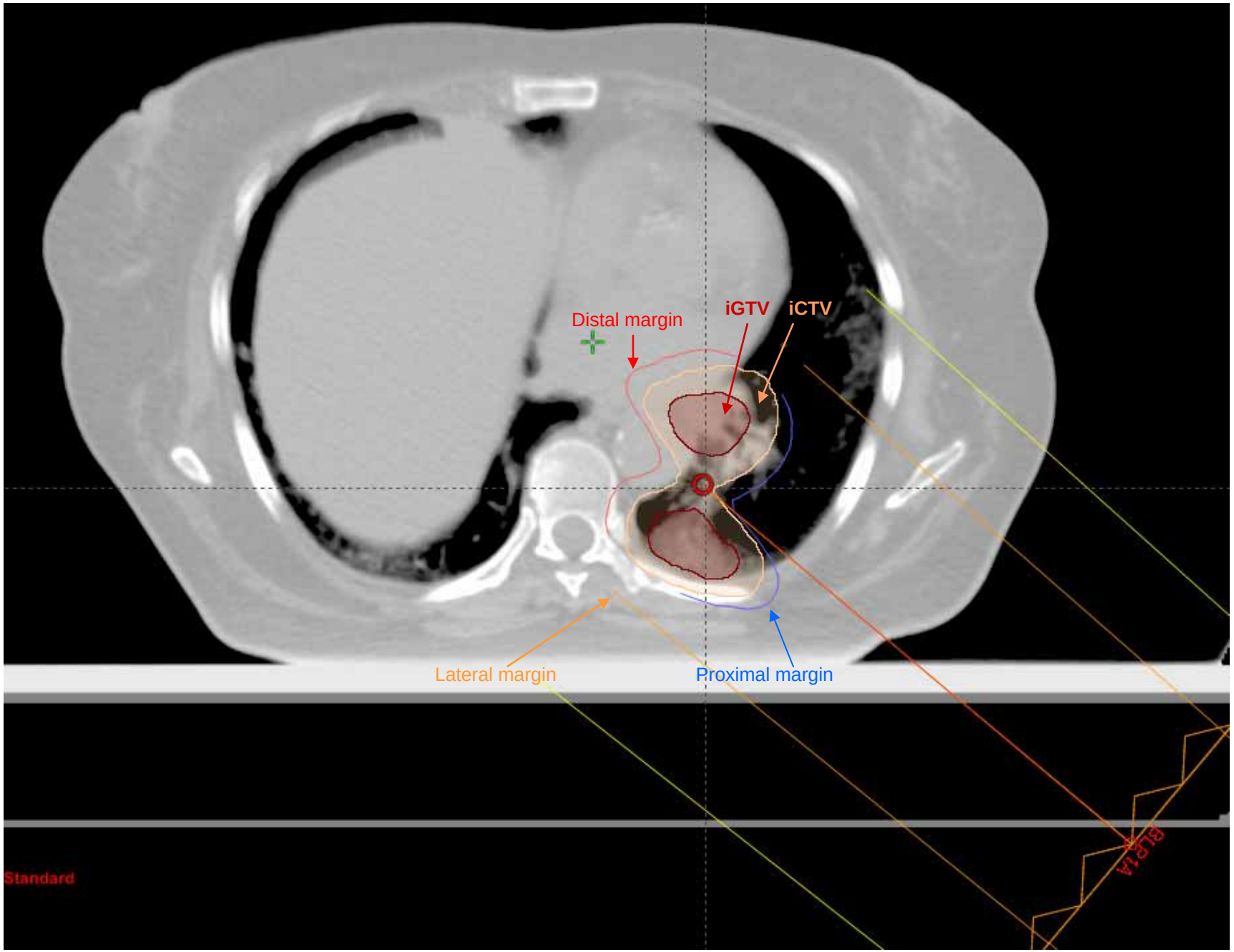
- Specify dose in terms of CGE for photons and protons
- Maintain the PTV, as for photons
- Maintain the same specification of dose coverage for the PTV, as for photons, namely that the prescription dose is the minimum dose to the PTV
- Add the requirement that the range uncertainties are addressed in some fashion.
- (This pragmatic approach troubles the proton purists.)

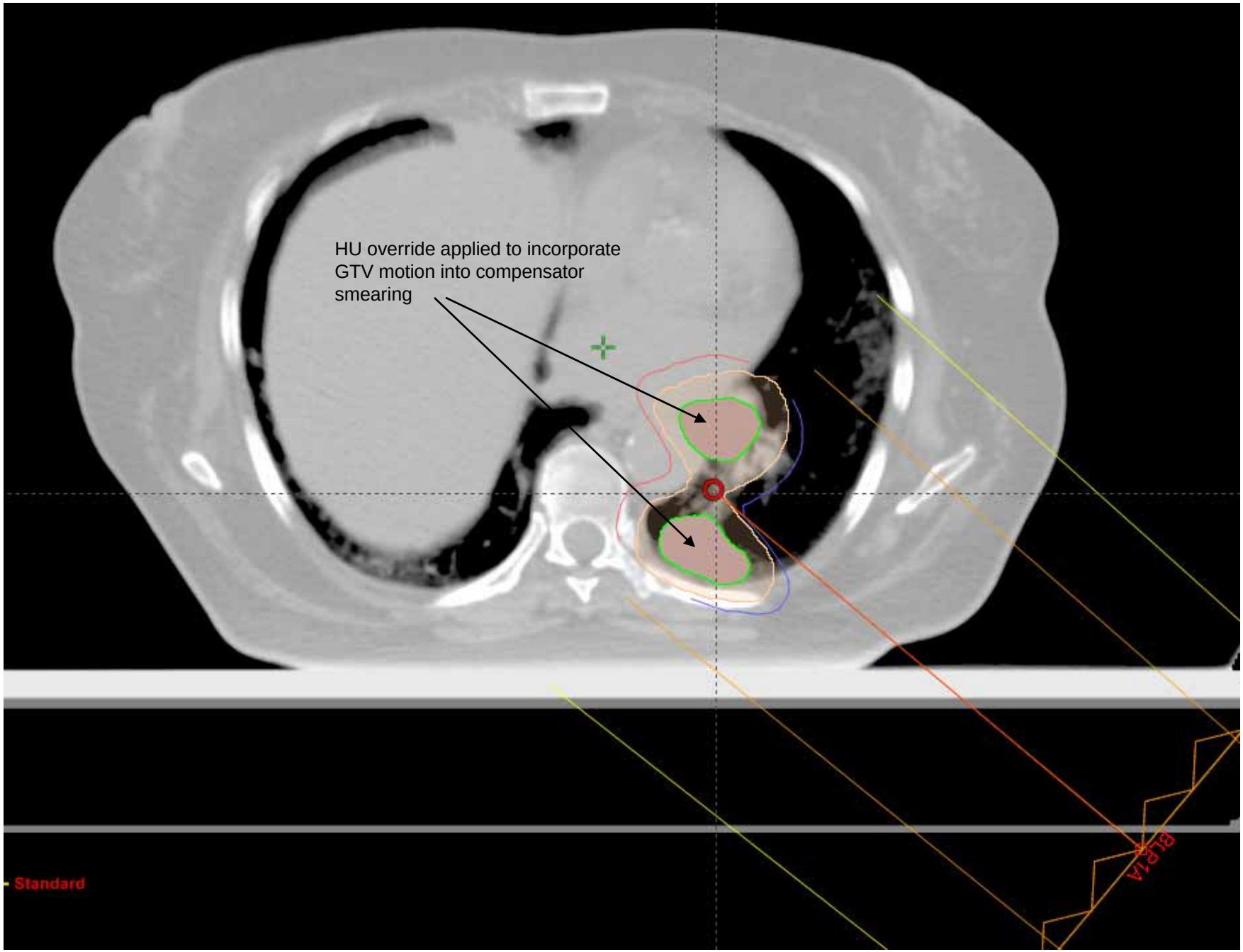
Target Definitions

- For protocols which involve photons and protons and for protocols which involve protons only, what modifications need to be made to PTV to build upon our experience with this concept in previous protocols?
- For example, 0617 “The minimum PTV dose must not fall below 95% of the prescription dose.” If PTV is not used for protons, what should be used?

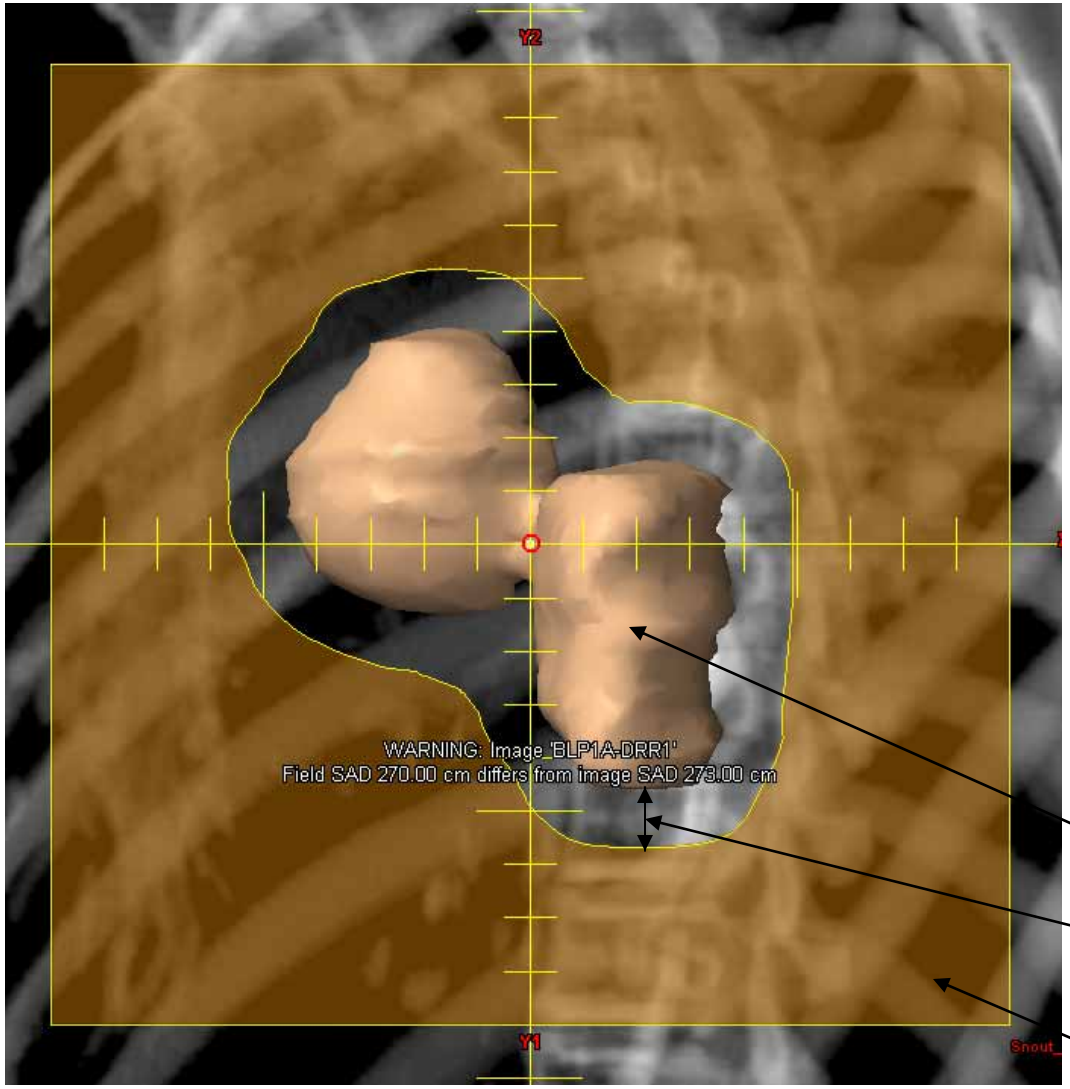
Target Definition

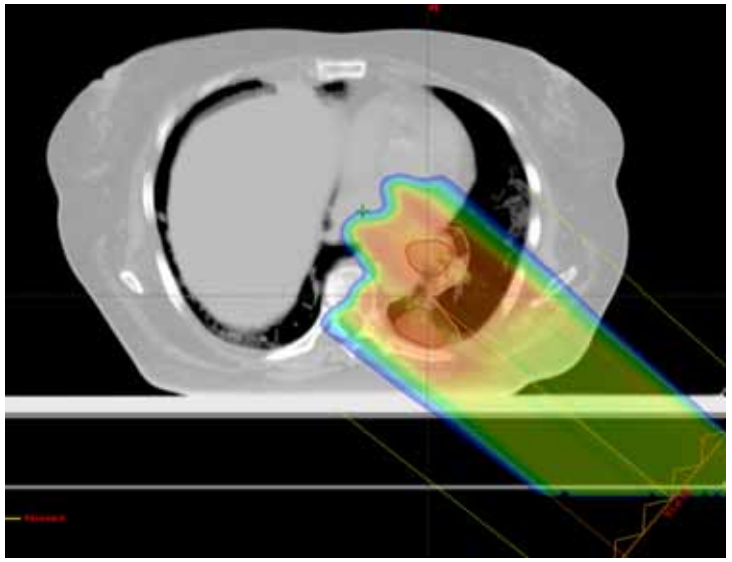
- For proton planning, each beam has an individual and unique PTV expansion from the ITV. In the plane perpendicular to the proton beam axis, the PTV expansion from the ITV is consistent with the method used for photons. However, along the direction parallel with the proton beam axis, the PTV expansion from the ITV is based, primarily, on the range uncertainty of the beam, hence our so-called distal margin and proximal margins.


Distal margin
iGTV
iCTV
Lateral margin
Proximal margin
Standard


HU override applied to incorporate GTV motion into compensator smearing
Standard
BLF1A

Beam’s Eye View





Dose distribution from single field

iCTV

Lateral margin

(set-up uncert + penumbra)

Brass aperture

Target Definition

- The equation for distal margin is shown below:
- **Distal margin = (0.035 x distal CTV radiological depth) + 3 mm**
- where 0.035 is the currently accepted 3.5% uncertainty in CT numbers and their conversion to stopping power. Thus this value depends on the radiological depth to the distal side of the CTV (or ITV). The 3 mm is an added margin to accommodate uncertainty in proton penetration due to beam energy, beamline components, compensator manufacture, and density.
- The same principle applies to the proximal margin:
- **Proximal margin = (0.035 x proximal CTV radiological depth) + 3 mm**

Target Definition
Smearing the compensator

- Smearing the compensator is done to ensure distal coverage as the target moves relative to other structures such that the radiological path lengths along each ray line of the beam change.
- **Smearing radius = sqrt {(0.03 x distal CTV radiological depth)^2 + (setup uncertainty)^2)}**

- where 0.03 is 3% of proton penetration depth. This distance is comparable to the root-mean-sq multiple scattering distance for protons. In other words, this part of the equation is to account for the lateral scattering of the protons as a function of penetration depth. Setup uncertainty is included. No target position uncertainty is included because we use and IGTV to account for all positions of the GTV, and we also apply a CT numbers overwrite to consider the maximum density within the IGTV at all times.

Target Definition
The Anderson non-solution

- The current Anderson approach is to define a PTV for photon treatments and to expand the ITV protons.
- Thus, there is a different planning target volume for photons and for protons with different dose specifications.
- Photons: PTV = ITV + 5 mm
- Protons: non-PTV = ITV + Distal and proximal margins

Protons – Scanning Beams

- Are there any special parameters associated with scanning beams that should be collected and available for remote review?
- Is there reasonable agreement between the various scanning beam treatment planning systems?

Lung Heterogeneity Corrections Algorithms

- The RTOG position for protocols which are asking a dose question, e.g. 0617,
  - Superpostion/convolution algorithms are accepted. Institutions will still need to complete a questionnaire and submit a digital dry run
  - Alternative algorithms (e.g. Clarkson and Pencil Beam) will need to credential their TPS by irradiating the RPC phantom.

RTOG Criteria

- The criteria for acceptable agreement between measured doses in the RPC lung phantom and calculated doses using older algorithms is:
- Across the PTV, the agreement between measured and calculated dose shall be within 5% or 5 mm.
- This criteria may be modified in the future as additional data becomes available.

Institutions Ready for 0617 January 11, 2008

- 10 Institutions have met the credentialing requirements.
- 4 of these institutions have both met the credentialing requirements and have IRB approval.
- The TPS used by these institutions include Pinnacle (Adaptive Convolve) 4 each, XiO Fast Superposition 2 each, and Eclipse AAA 3 each.