Proton Delivery System Conventions

Coordinate system representations are an integral part of any treatment planning system. Understanding the various coordinate systems and how they relate to one another is a key component for anyone wishing to properly utilize this application. In order to ensure a consistent and natural convention for the various coordinate systems, this application follows the standard convention outlined for radiotherapy coordinates in IEC 61217. The three most commonly used coordinate systems will be the patient system, the couch (fixed) system, and the beam (or gantry) system.

Coordinate Systems

The patient coordinate system is oriented as shown in the figure below and the isocenter, which is to be used as the origin of both the fixed and gantry coordinate systems, should be specified in patient coordinate space. So the patient orientation (HFS, FFP, etc) along with the isocenter position is enough to provide all the data needed to perform conversion from patient space to fixed space (axis orientations are given in the figure below for each patient orientation). The beam coordinate system uses the isocenter as its origin and the x axis is such that it is parallel to the fixed system x axis at zero gantry angle (i.e. vertical) and the z axis has a positive direction going toward the radiation source.

Other common system positioning movements, such as gantry rotations and couch rotations are most easily referenced to the fixed coordinate system. Gantry rotations imply isocentric rotation about the positive y axis of the fixed system, while couch rotations imply isocentric rotation about the positive z axis of the fixed system.

When performing dose calculation functions within this application, the *stopping_power_image* and *dose_points* are specified in patient coordinates. The *geometry* specifies the beam location using a coordinate transformation, and the *bixel_grid*, *oar_image*, *downstream_degraders*, and *aperture* are all provided directly in beam space. While this may at first glance sound like an unwanted mixing of coordinate systems, upon using the system one will quickly realize that this is the most natural and user friendly option for working with each object.

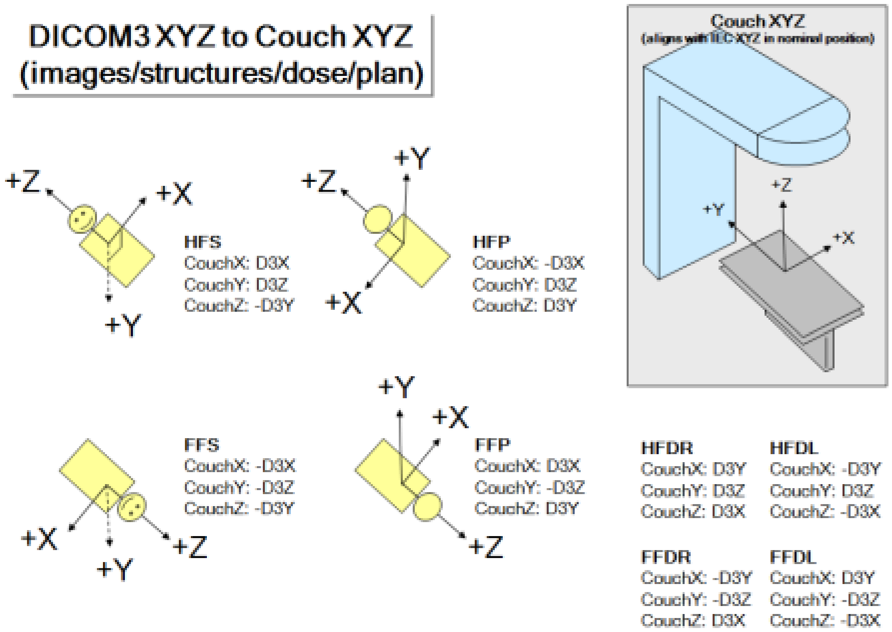

Fig. 1: IEC Coordinate Systems

Beam Representation

The *beam_geometry* data type provides the proton beam's orientation in space. The available beamline device (apertures and range compensators) positions are specified by their location along the beam's CAX. As shown in the figures below, both device types are specified by the position of their patient-side (downstream) surface. This is critical for range compensators, as most treatment systems utilize variable overall thicknesses for range compensators, therefore using the downstream surface allows for use of a fixed air-gap to be specified during range compensator design. It should be noted however, that if the physical treatment machine requires the aperture and range compensator to be abutting, the aperture position will need to be adjusted based on the overall thickness of the range compensator (however, such small adjustments to the aperture position will have insignificant impact on the dose calculation and are therefore favored over the case of allowing the air-gap to change.

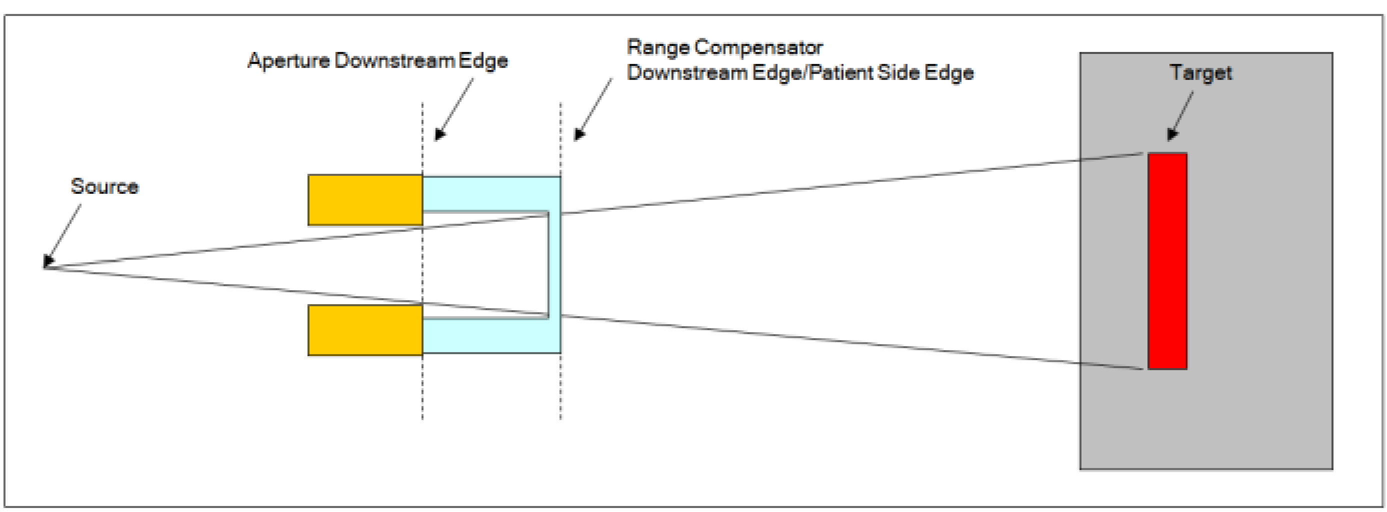

Fig. 2: Proton Beamline Positioning

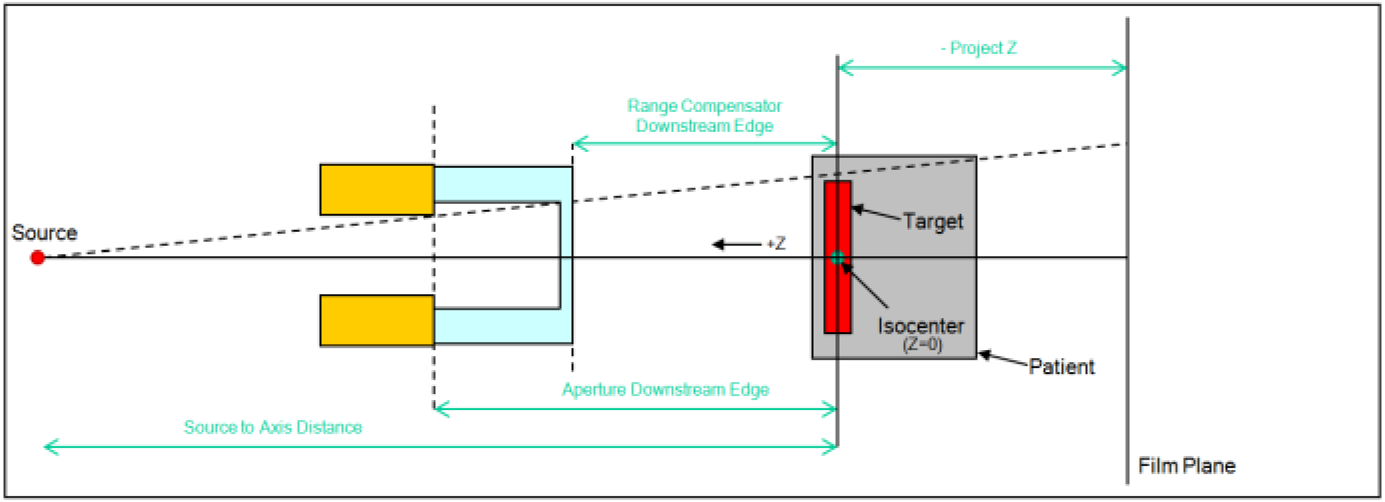

Fig. 3: Proton Beamline Positioning

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