Fraction Groups

Defining *Fraction Groups* is the first step in the PBS Optimization process within Astroid. Most commonly, a fraction group is simply an arrangement of beams that will be used in a typical daily treatment fraction. The Fraction Group contains some basic group information, as well as Fraction Group level constraints and collections of *Beam Sets* and *Constraints* for each target of the fraction group. The *Beam Set* and various *Constraint* levels are key concepts within Astroid that allow for high levels of control over the Astroid PBS Optimization engine. Further details of these critical items are provided below and additionally, examples of some common cases and how fraction groups, targets, and beam sets can be constructed to meet the clinical needs of various clinical cases can be found in the Prostate Plan Walkthrough.

General Fraction Group Data

- Color: Display color of the Fraction Group
- Description: Optional, user specified text describing the Fraction Group
- **Phase**: Phase prescription that the *Fraction Group* implements; note that only targets containing prescription doses from this Phase will be available in for adding Targets to the Fraction Group
- **Fraction Count**: The total number of fractions to be delivered for this *Fraction Group*; this is very important as it will determine the appropriate Monitor Units for the individual beams
- **Group Constraints**: These *Constraints* apply to the total dose across all beams in the *Fraction Group* (For *Constraint* details click here)

Fraction Group Targets

Simply speaking, a Fraction Group Target is just a collection of *Beam Sets* and *Constraints* that together will provide a specified dose to a particular target. In clinical practice, most standard single lesion treatments will use only one Fraction Group Target. More complex prescriptions, such as Simultaneous Integrated Boosts (SIB), generally contain two Fraction Group Targets, one for the primary target and a second for the boost target. Within the Fraction Group Target, a target structure is specified along with one or more *Beam Sets* and any beam set level constraints necessary to meet the clinical goals for this target.

- **Target**: The target structure for the beam sets that will be defined below. The available selections will only contain targets with prescriptions specified for the phase selected in the main *Fraction Group* and that also exist in the treatment plan (note this excludes Directive level structures with prescription information, but no physical contour data).
- **Beam Sets**: A list of Beam Sets that will be used to achieve the specified constraint doses (see below for a more detailed definition of a *Beam Set*).
- **Constraints**: These Beam Set Level *Constraints* are split evenly and applied individually to each *Beam Set*
 - $\circ\,$ In other words, the Constraint dose is divided by the number of Beam Sets for the Target, so that both SFUD and IMPT can be achieved

Beam Sets

The *Beam Set* is the lowest level unit for the Astroid PBS Optimizer and proper arrangement of the beams within a beam set allows for both Single Field Uniform Dose (SFUD) and Intensity Modulated Proton Therapy (IMPT) fields to be included within the same fraction. A careful review of the Beam Set Level (BSL) Constraints described above, should reveal how to properly arrange beams within Beam Sets to achieve a desired type of treatment. Since BSL Constraints are equally split and are then applied individually to each Beam Set, SFUD beams can easily be achieved by placing each beam in its own Beam Set. Conversely, IMPT beams are created when multiple beams are included within a single Beam Set. Further details of these two cases are presented below.

SFUD Beams

Single Field Optimized treatment beams are produced by including each beam in a separate Beam Set. This is best understood by example. Suppose a target is intended to receive 20 Gy (2 Gy per day for 10 fractions) from a two beam Fraction Group using a SFUD approach. This is achieved by specifying a min dose of 18 Gy and a max dose of 22 Gy using Beam Set Level Constraints. Now two beam sets are created, each containing a single beam, as shown below. Since the BSL constraints are split between the beam sets, this actually tells the optimizer that each beam must provide a min dose of 9 Gy and a max dose of 11 Gy (1/2 of the BSG constraint doses). Therefore, each individual beam will be providing coverage to the entire target as is expected for a SFUD approach.



IMPT Beams

Intensity Modulated Proton Therapy treatment beams are produced by including all desired beams in a single Beam Set. This is again best understood by example. Suppose a target is intended to receive 20 Gy (2 Gy per day for 10 fractions) from a two beam Fraction Group using an IMPT approach. This is achieved by specifying a min dose of 18 Gy and a max dose of 22 Gy using Beam Set Level Constraints. Now one Beam Set is created, containing both beams, as shown below. Since there is only Beam Set, the

BSL constraints will be applied to the combined dose from the two beams. Therefore, there are no guarantees regarding the uniformity of dose from either beam and instead there is simply the guarantee that the combined dose from the two beams meets the given constraints, thereby producing an IMPT treatment approach.

Target List				
Target: \$1 -				
Target	s1 - Prostate (in 3D)	+ Omm 🔻		
Beam Sets:				
	d1 - G270 shifter;	0 CO; 12 cm; r	10 •	×
	d2 - G90 shifter;	C0; 12 cm; no		×
	add beam		•	
Constraints:	😑 PTV 🕻			
			Gy(RBE)	×
		22	Gy(RBE)	×
	Max Mean:			
	Add Structure			
			Done	Cancel

By understanding the notion that Beam Set Level Constraints are equally split among the Beam Sets, it can also be seen how SFUD and IMPT may be mixed within a Target and even the most complex of treatment scenarios can be handled seamlessly in Astroid.

Working with Fraction Groups

1. Select the Create New Fraction Group button



- 2. In the newly opened block the planner will:
 - $\circ\,$ Choose the color the fraction will be denoted in
 - Type in any descriptor that may be needed
 - Select the phase that the fraction group is implementing
 - Enter the total number of fractions to be treated
 - Enter the group constraints if desired
 - Group constraints apply to the total dose from the whole fraction group
 - Constraints for multiple structures may be entered at this stage

Edit Fraction Grou	up	
Color:		• • • • • • • •
Description:		
Phase:	orig walkthro	ough 🔻
# of Fractions:	44	Total: 44, Remaining: 44
Group Constraints:	PTV_79	20 🗙
	Min:	add statement
	Max:	73 Gy(RBE) 🗙
	Min Mean:	add statement
	Max Mean:	add statement
	Add Structur	e 🔻
Target List		
	Add 1	Target

3. Click Add Target

Create Fraction G	roup			
Color:		• • • • •	• • •	
Description:				
Phase:	orig walkthro	ugh 🔻		
# of Fractions:	4	Total: 44, Rer	maining: 44	\$
Group Constraints:	PTV_792	20		×
	Min:	75	сујявеј 🗙	
	Max:	83	су(яве) 🗙	
	Min Mean:	add statemen		
	Max Mean:	add statemen		
	Add Structur	e 🔻		
Target List				
	Add T	arget		

- Select the target structure
- $\circ\,$ Create any Beam Sets that are desired

Tar	get List	
		Add Target
	Target:	PTV_7920 V
	Beam Sets:	 ✓ beam set b1 - G90 C0; 12 cm; no shifter; X b2 - G270 C0; 12 cm; no shifter; X
		add beam 🔻
		add beam set
	Constraints:	Add Structure 🔻
		Done Cancel

- There may be multiple Beam Sets associated to a target to construct SFUD or IMPT beam groupings (see above for further details)
- Enter any desired Beam Set Level constraints
 - The constraints chosen at this point will be evenly divided and applied separately to each Beam Set (see above for further details)

Add Target Target: PTV_7920 Beam Sets: beam set remove b1 - G90 C0; 12 cm; add beam	no shifter; X
Target: PTV_7920 Beam Sets: beam set remove b1 - G90 C0; 12 cm;	no shifter; 🗙
Beam Sets: beam set remove b1 - G90 C0; 12 cm; add beam	no shifter; 🗙
add beam	•
agg beam	
 beam set remove b2 - G270 C0; 12 cm 	; no shifter; 🗙
add beam	•
add beam set	
PTV_7920	×
Min: 70	су(пак) 🗙
Max: add stater	
Min Mean: add stater	ment
max mean. add stater	
Add Structure 🔻	
	one Cancel

• The user may also have multiple Targets, with each associated to a distinct target within the selected *Fraction Group* Phase

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