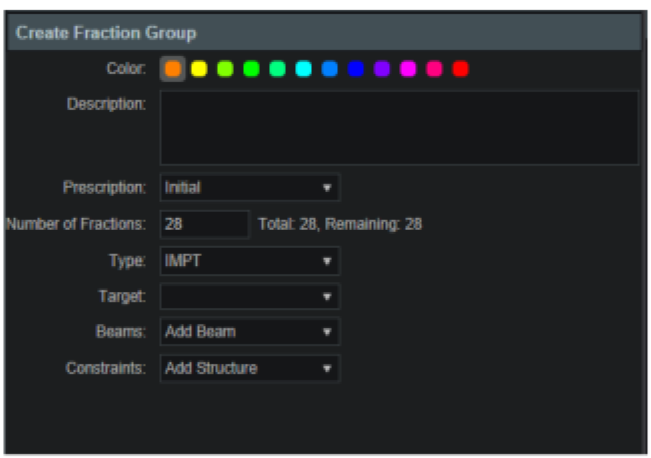
Fraction Groups

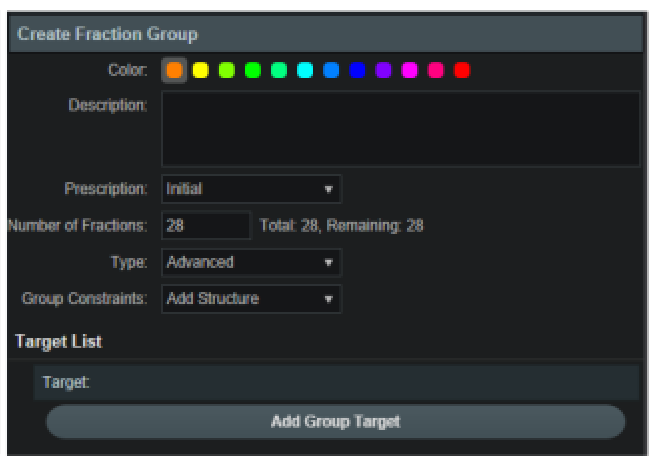
Defining *Fraction Groups* is the first step in the PBS Optimization process within Astroid. Most commonly, a fraction group is simply an arrangement of beams that will be used in a typical daily treatment fraction. The Fraction Group contains some basic group information, as well as Fraction Group level 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*
- **Prescription**: Prescription that the *Fraction Group* implements; note that only targets containing dose statements from this Prescription will be available when selecting the Target for the Fraction Group
- **Number of Fractions**: 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
- **Type**: The delivery approach that will be used for the beams in the Fraction Group. Options for this include SFO, IMPT, and Advanced. If either SFO or IMPT are selected the Fraction Group user interface will remain in "Simple Mode", whereas selecting Advanced as the type will switch the interface to the "Advanced Mode"



Simple Fraction Group User Interface
(for SFO and IMPT options)



Advanced Fraction Group User Interface

Simple Type Fraction Groups

SFO

Single Field Optimized treatments are created using this type option. Simply select *SFO* from the *Type* drop down and then add any number of beams and constraints. Each constraint will be equally divided among each beam during optimization. For example, if three beams are included in the Fraction Group and a PTV min constraint of 60 Gy(RBE) is added, then each beam will be individually set to have a constraint of 20 Gy(RBE) (60/3) when running the optimization.

IMPT

Intensity Modulated Proton Therapy treatments are created using this type option. Simply select *IMPT* from the *Type* drop down and then add any number of beams and constraints. These constraints will be applied to the collective (total) dose from all beams in the Fraction Group. Using the same example as the SFO section, if three beams are included and a PTV min constraint of 60 Gy(RBE) is added, then the total dose from the three beams must be above 60 at all points within the PTV, however, no restrictions are placed per beam, so that each beam is free to give any portion of the 60 Gy(RBE) dose. This allows for maximum flexibility in sculpting dose to the target, but generally at the expense of increased sensitivity to motion and patient positioning uncertainty.

Advanced Type Fraction Groups

Advanced type fraction groups are needed only in rare occasions when beams must be mixed such that a standard IMPT or SFO approach simply doesn't provide the necessary control over the constraints. Since the advanced more UI is significantly more complex, the following section is dedicated to providing a more detailed understanding of the available options. It should be noted that Advanced mode allows for multiple targets and for constraints to be specified at the Fraction Group level and the Beam Set level and it is important to learn these differences in order to make proper use of the advanced options.

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.

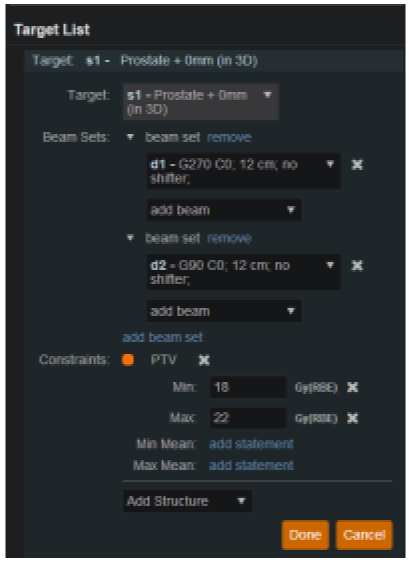
- **Target**: The target structure for the beam sets that will be defined below. The available selections will only contain targets with prescriptions specified for the phase selected in the main *Fraction Group* and that also exist in the treatment plan (note this excludes Directive level structures 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*
    - In other words, the Constraint dose is divided by the number of Beam Sets for the Target, so that both SFO 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 Optimized (SFO) 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, as this will provide the information necessary to allow users to construct complex constraint relationships, which is the purpose of the Advance type UI.

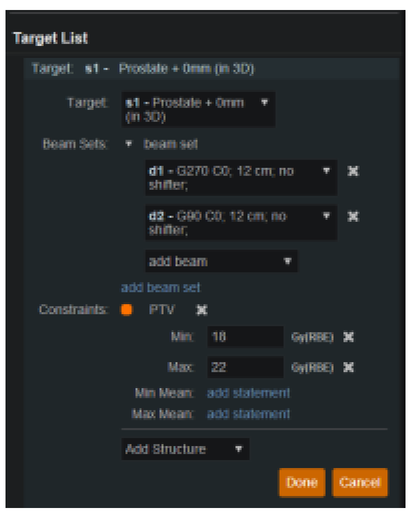
SFO Beams

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 SFO 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 SFO approach.



IMPT Beams

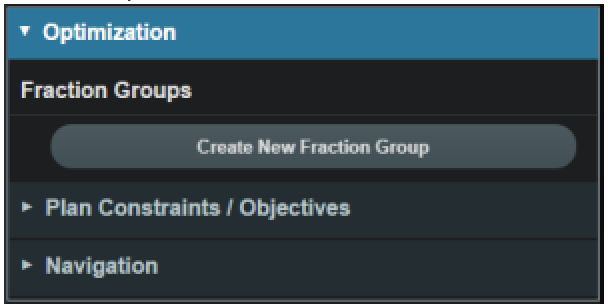
Intensity Modulated Proton Therapy treatment beams are produced by including all desired beams in a single Beam Set. This is again best understood by example. Suppose a target is intended to receive 20 Gy (2 Gy per day for 10 fractions) from a two beam Fraction Group using an IMPT approach. This is achieved 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.



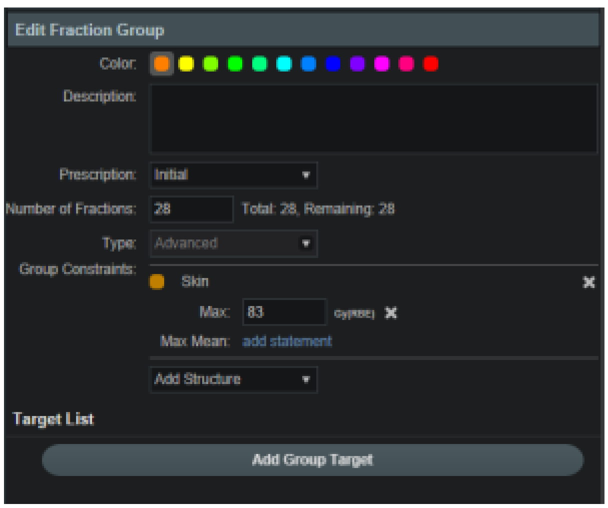
By understanding the notion that Beam Set Level Constraints are equally split among the Beam Sets, it can also be seen how SFUD and IMPT may be mixed within a Target and even the most complex of treatment scenarios can be handled seamlessly in Astroid.

Working with Fraction Groups

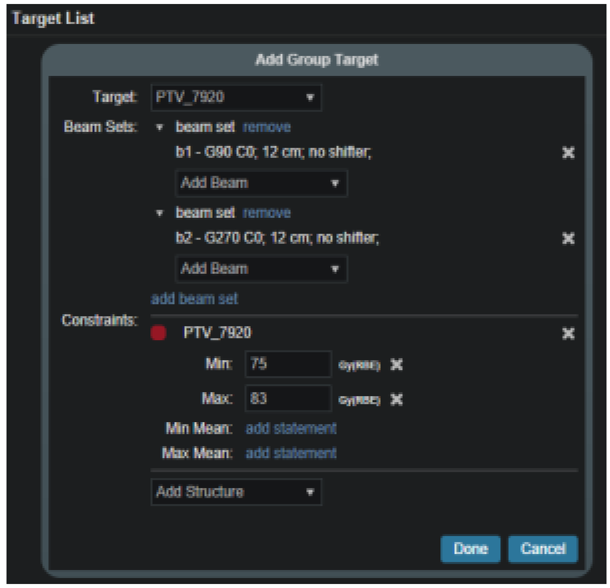
1. Select the Create New Fraction Group button



2. In the newly opened block the planner will:
    - 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
3. Click *Add Target*



    - Select the target structure
    - Create any Beam Sets that are desired
        - 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)



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

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