



astroid Planning App User Guide

for app version 1.0.0-a11

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Planning Overview

App Version: 1.0.0-a11

Note: This user guide is intended only for the latest version of the astroid Planning App listed above. Please refer to the [planning version history](#) for the complete listing of user guides.

The .decimal astroid Planning App is a cloud based software used for treatment planning of proton radiation therapy treatments. The astroid Planning App is an interactive end user application that leverages the existing .decimal Dosimetry App functions for device creation, dose calculation, and optimization to facilitate efficient development of proton radiation treatment plans.

Access, permissions, and calculations for the astroid Planning App are managed by the thinknode™ cloud platform service. By using this advanced cloud based technology, the astroid Planning App is able to perform well on any lightweight Windows computer, reducing the hardware and up-front setup costs that are typically associated with owning a radiation treatment planning system.

Note: This product is in the development pre-FDA 510(k) stage.

User Guide

The Planning App [User Guide](#) provides help material as well as walkthrough guides and a glossary of terms associated with the application.

Getting Started Basic setup and overview of the **Known Limitations** Known application astroid Planning App. limitations, defects, or inconsistencies.

Tutorials Examples and guides for performing common tasks in the astroid Planning App.

Instructions For Use

The Planning App [Instructions For Use](#) outlines the intended use and user requirements of using the Planning App.

Overview Intended use and indications for use of **User Profile** Recommended user education and the application. experience level.

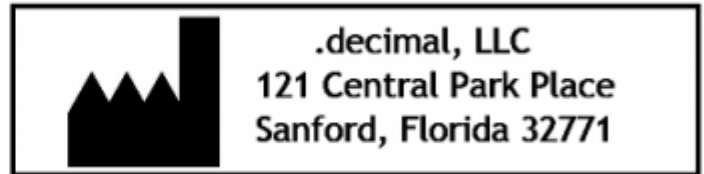
Warning Warning of potential misuse.

Testing Responsibilities Testing responsibilities for ensuring correct setup and configuration of the astroid Planning App.

Product Features High level features of the astroid Planning App.

About

This product is pre-510k and is not currently approved for sale or marketing.



Support

For questions, comments, or to schedule a training session, please contact our customer support team at: appsupport@dotdecimal.com

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Last update: **2016/09/20 19:02**

Planning App User Guide

Overview

The .decimal astroid Planning App is used for treatment planning of proton radiation therapy treatments. The astroid Planning App is an interactive end user application that leverages the existing .decimal Dosimetry App functions for device creation, dose calculation, and optimization to facilitate efficient development of proton radiation treatment plans.

Purpose

The purpose of this document is to provide guidance on the setup, access, and usage of the astroid Planning App.

Getting Started

Instructions for Use

The [Instructions for Use](#) outlines the intended use of the astroid Planning App. Refer to each section below for more detail:

- [Overview](#)
- [Warning](#)
- [User Profile](#)
- [Product Features](#)
 1. [Function Access and Data Storage](#)
 2. [Proton Dose Calculations](#)
 3. [Proton Aperture Designs](#)
 4. [Proton Range Compensator Designs](#)
 5. [Patient Specific Data Model](#)
 6. [Proton Treatment Delivery Machine Model](#)
- [Data Model](#)

Precautions

It is the responsibility of those utilizing this application to ensure all that all usages of this product relating to patient treatments are performed by trained and qualified personnel only and that such personnel is aware that the quality of any generated treatment plans is highly dependent on the quality and correctness of the input data; therefore if any questions or uncertainties exist regarding the quality,

units, or identification of input data arise, they must be investigated and resolved before the data are used.

Tutorials

Task Descriptions

The following task descriptions are thorough guides providing complete information about each task within the Astroid Planning Application.

- [Uploading a DICOM Patient](#)
- [Importing Patient Data](#)
- [Snapshots](#)
- [Creating a Plan](#)
 - [Structure Geometry](#)
 - [Dose Grid](#)
 - [PBS Beams](#)
 - [Defining an Aperture](#)
 - [Fraction Groups](#)
 - [Defining Constraints](#)
 - [Setting Objectives](#)
 - [Astroid Optimization](#)
 - [Feasibility & Constraints](#)
 - [Running the Optimizer](#)
 - [Dose Normalization](#)
 - [Navigating the Solutions](#)
 - [Using the Plan History](#)
 - [Publishing a Plan](#)
 - [Exporting a Plan](#)
 - [Generating Plan Reports](#)

End-to-End (Plan) Walkthroughs

The following walkthroughs will take you through the process of creating complete treatment plans in the Astroid Planning App. They provide detailed steps so that any user can begin using the software. Each guide covers a specific type of treatment plan, and although some walkthroughs share certain steps, each has been written as a self-contained unit so that you may begin with whatever guide is the most useful.

- [Prostate Plan Walkthrough](#)
- [Head and Neck Plan Walkthrough](#)

System Usage

Details...

Improper System Usage

When using the astroid Planning App, as with any complex program, there is the potential for misuse. The various astroid Apps comprise a suite of radiotherapy treatment planning tools that are intended to be used by experienced and knowledgeable professionals working in the field of radiation therapy.

Known Application Limitations

Below are listed the known application limitations, defects, or inconsistencies.

1. The astroid Planning App is pre-510(k) at this time and has not been validated for use in actual patient treatments
2. Structures that are expanded in the axis of the CT image slices will have the expansion distance limited by the CT image spacing. So the expansion distance may appear to be an incorrect distance.

See [Thinknode Errors](#) for common problems that occur during usage of the Planning app.

Should you discover or suspect any additional errors or limitations not noted above, please contact the .decimal astroid Planning App development lead, Kevin, Erhart, at kerhart@dotdecimal.com with details of your concerns. All concerns will be addressed as quickly as possible and follow up with the submitter will occur throughout the inquire and correction process.

USR-005

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Last update: **2016/09/20 17:07**

Instructions for Use

Astroid Patient Data Model

The following page describes the hierarchy of data used to manage patient data records within the Astroid planning environment.

Hierarchy

- Patient
 - Course [0,1,...,N]
 - Course data stuff here 
 - Intent [0,1,...,N]
 - Intent data stuff here 
 - Directive [0,1,...,N]
 - Clinical Goals
 - Clinical Goals data stuff here 
 - Phase
 - Prescription
 - Prescription data stuff here 
 - Conceptual Structure List [0,1,...,N]
 - Conceptual Point List [0,1,...,N]
 - Snapshot [0,1,...,N]
 - Imaging Data
 - Structure Data [0,1,...,N]
 - Active Variant
 - A specific model of a target, OAR, or other structure. A physician may provide an initial target contour and a treatment plan generated using this information. The physician may later (using the same CT image set) provide a revised target contour. Rather than import this revision as a new structure or override the original, you may specify this new contour as a variant of the original. Each contour may have only a single “active” variant and the plan will automatically update based on the selection of the active variant. However, in some cases it is not desirable to update the plan, so the user may also choose to lock the plan and simply recompute DVH and other volume based statistics based on the new active variant geometry. In either case, variants can be used to streamline workflows and prevent accidental misuse of out-dated contours.
 - Variant List [0,1,...,N]

- Plans [0,1,...,N]
 - Image Calibration
 - Points [0,1,...,N]
 - Structures [0,1,...,N]
 - Calculation Grid
 - Treatment Room
 - Beams [1,...,N]
 - Snout
 - Devices & Spot Options
 - DRRs
 - Fraction Groups [1,...,N]
 - Target
 - Constraint [0,1,...,N]
 - Target Dose Constraints [1,...,N]
 - Target
 - Constraint [0,1,...,N]
 - Beamset [1,...,N]
 - Constraint [0,1,...,N]
 - Beam [1,...,N]
 - Constraints [0,1,...,N]
 - Objectives [0,1,...,N]
 - Dose Results

Descriptions

- **Patient:**
 - A person receiving medical treatment. A Patient record contains basic personal information and demographics, as well as any number of treatment Courses.
 - This is where the patient name (prefix, given name, middle name, family name, suffix), medical record number (MRN#), sex (male, female, other, any) and date of birth (month, day, year) are stored.
- **Course:**
 - A prescribed regimen to be followed to treat a specific disease occurrence for a specific period of time. A Course will contain the physician's Intent.
 - The user will label the Course of treatment and specify the physician of record. The user has the option of adding a description of the course of treatment.
- **Intent:**
 - The physician's purpose for this Course of radiation treatment. An Intent contains information about any protocols this patient is under, as well information regarding the disease site, body system, and body part (for both templating and billing purposes). An Intent can contain any number of Directives (although it's uncommon to have more than one). The user will define the type of treatment (curative, palliative, or prophylactic), as well as the treatment site at this level. A narrative of what the physician desires to achieve as a result of the course is also saved here.
- **Directive:**
 - The physician's orders for treating this Course. A Directive contains information about the

prescription, phases, and other clinical goals for the Course. A Directive also contains any number of Snapshots.

- **Snapshot:**

- A description of the patient's anatomy. Contains a single CT image set and all contour variants (targets and organs at risk) associated with these images. A Snapshot can contain any number of associated Requests.
- **Variant:**
 - A specific model of a target, OAR, or other structure. A physician may provide an initial target contour and a treatment plan generated using this information. The physician may later (using the same CT image set) provide a revised target contour. Rather than import this revision as a new structure or override the original, you may specify this new contour as a variant of the original. Each contour may have only a single "active" variant and the plan will automatically update based on the selection of the active variant. However, in some cases it is not desirable to update the plan, so the user may also choose to lock the plan and simply recompute DVH and other volume based statistics based on the new active variant geometry. In either case, variants can be used to streamline workflows and prevent accidental misuse of out-dated contours.

- **Request:**

- A message giving an alert that a Plan needs to be created. As DICOM Gen2 is finalized and implemented, a request can be implemented from many locations, including the TPS itself, a contouring program, or other workflow management software tools. The request will include the date of implementation and the number of fractions to be treated (can be all fractions or a specific number of fractions). Until DICOM Gen2 is widely supported, the Request will simply be a "click-through" in Astroid as it will be the treatment planner directly creating it.
- A Request may contain many trial plans that each attempt to meet the requirements of the physician, but only one may be marked as "approved".

- **Plan:**

- A detailed model of a proton therapy treatment. Most aspects of the patient planning information are stored here (e.g. Beams, Fraction Groups, Optimization Information, and Dose Results). A Plan should satisfy the Request and meet the prescription and goals laid out within the Directive in so much as is possible. Physicians will approve a Plan to indicate it is ready to proceed to QA and (if successful) on to actual patient treatment. There should be only one "approved" Plan per Request.

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Last update: **2016/09/20 17:06**

Tutorials

Uploading a DICOM Patient

Importing a new patient into the Planning App requires taking a local DICOM directory and posting each of the files through the [Dicom App](#) utilizing thinknode. Each DICOM patient is posted to the thinknode ISS and an entry added to the thinknode RKS that allows Planning to see a new patient has been added.

Importing the DICOM directory to thinknode is accomplished using a python script as described below.

Importing using Python

Note: This guide requires the user to be familiar with python and the existing [.decimal python libraries](#).

1. From the [.decimal GitHub repository](#) open and edit the `post_dicom_patient_rks.py` python file.
2. Ensure the `thinknode.cfg` file is set appropriately for your user, account, and realm.
3. Edit the following line to point to the directory in which the DICOM patient files are located (note: all DICOM files in this directory will be uploaded):

```
# Post patient data into ISS
obj_list_id = dicom.make_dicom_object_from_dir(iam, 'F:/Datasets/demo-
patient/prostate')
```

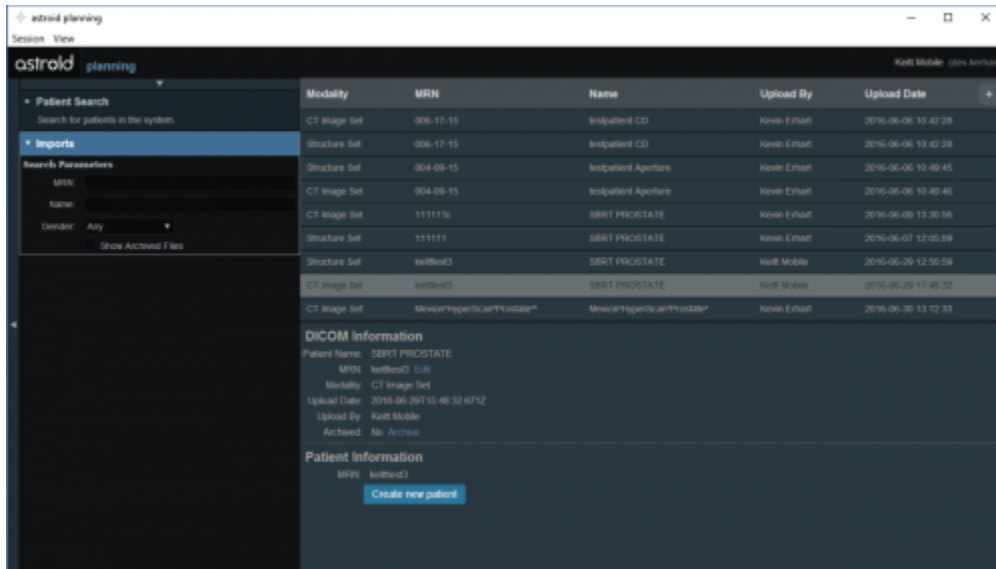
4. Run the script and allow the patient to upload to thinknode ISS. After the DICOM patient is uploaded to ISS, an RKS entry will be created for the patient for the Planning App to recognize it as a newly imported patient.

2016/08/17 12:55

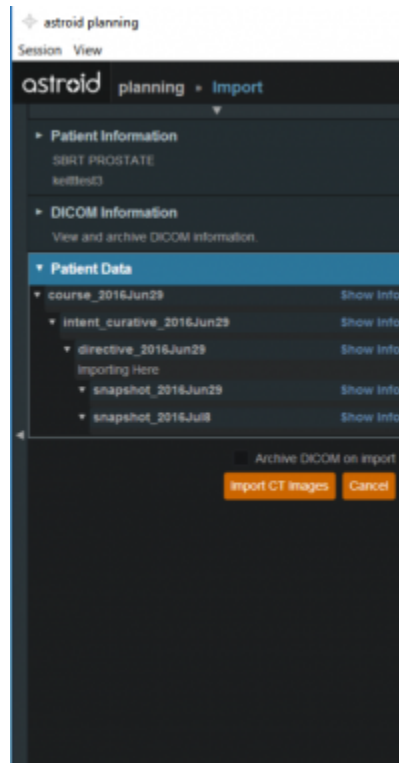
Importing Patient Data

Now that a patient has been uploaded from DICOM to thinknode ISS and an RKS entry created, the Planning App should recognize that a new patient is available to import into a Planning patient.

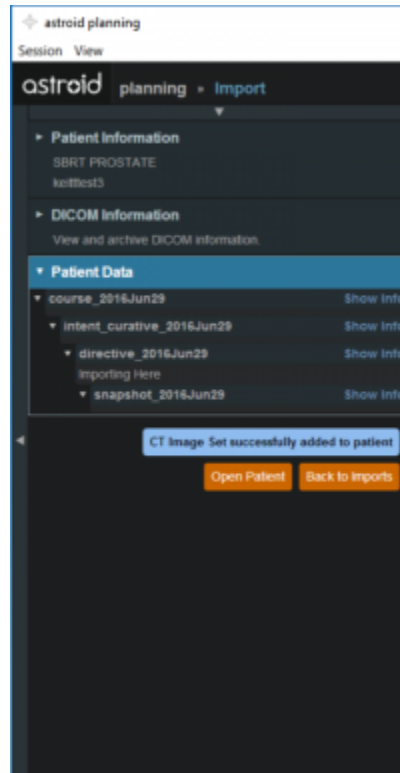
1. Go to the Imports page. Here you have the ability to search for patients to import by MRN, Name or Gender.
2. Select the CT data set you would like to import by selecting the row for the CT Image Set of the desired patient.
3. Once you have highlighted the patient name you may edit the MRN if needed in the DICOM Information window by selecting the edit button by the MRN number. Once edited hit save to save your changes.
4. When ready to import the patient into the Astroid TPS select the blue "Create New Patient" button in the patient information window



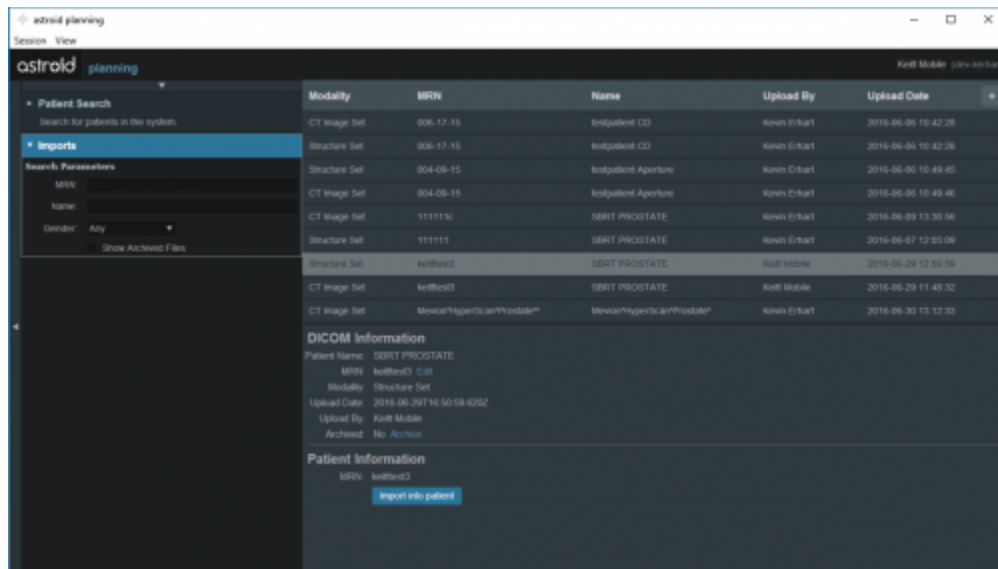
5. You will then need to click on the orange Import CT Images button



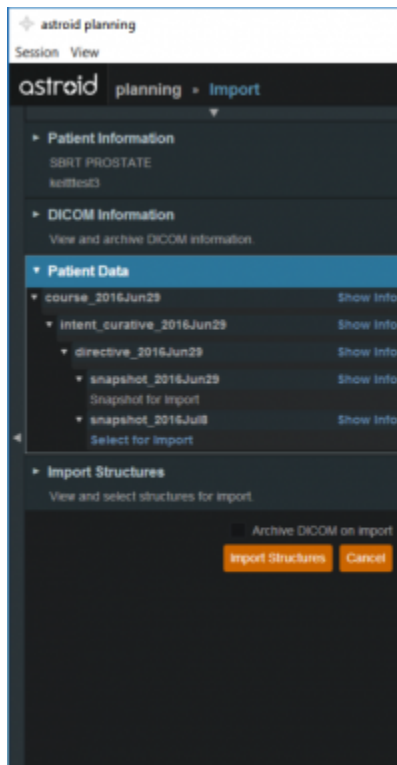
6. A message will pop up acknowledging the CT Images have been imported



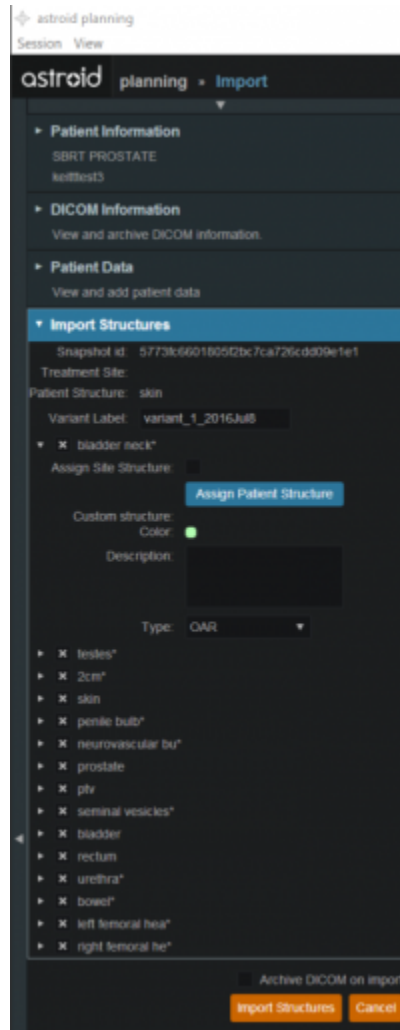
- 7. Select the orange back to “Back to Imports” button in order to import any structures associated with the chosen CT Data set
- 8. Select the structure set associated with the imported CT Images. Again at this time you make any edits to the MRN that are needed. As in the CT Image import select the blue “Import into patient” button in the patient information window



- 9. On the left hand side open the Import Structure block.



10. You will see a list of structures that have been contoured on the image set. Here you may choose to delete (not importing it) the structure hitting the x beside the structure name.
11. Simply expand the collapsed structure to edit and you will be given choices such as assigning that structure as the patient structure by clicking the blue “Assign Patient Structure”.
12. You also have the ability to edit any custom structure that does not match the directive level structures defined in the site configuration. These custom structures are designated with an asterisk(*) at the end of the structure name in the structure list.
 1. You may chose to optionally assign a custom structure to a defined site structure. Doing so will result in the imported structure inheriting all the predefined structure properties (e.g. type, color).
 2. For a custom structure the type is by default set to “Other”, but may be changed here at the import.
13. Once you have all your structures customized as you would like click the orange “Import Structures” button



14. After your structures are imported you may either choose to proceed to clicking “Open Patient” or you may import more patients by clicking “Back to Imports”



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Snapshots

Once the Directive has been completed the next block will be Snapshot. The Snapshot contains a single CT image set and all contour variants (targets and organs at risk) associated with these images.

About Snapshots

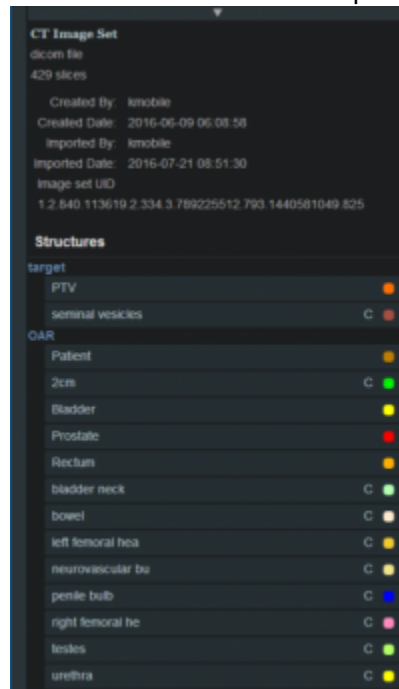
- **Snapshot:** captures the state (anatomy) of a patient at a certain point in time. Each snapshot contains a single Image Set (typically CT) and all contour (structure) variants associated with these images. Each unique Image Set imported into the patient should produce a new Snapshot. Each unique structure set imported into the snapshot should produce new contour variants for each unique contour. Each contour may have only a single “active” variant and the plan will automatically update based on the selection of the active variant.
- **Variant:** A specific model of a target, OAR, or other structure. A physician may provide an initial target contour and a treatment plan generated using this information. The physician may later (using the same CT image set) provide a revised target contour. Rather than import this revision as

a new structure or override the original, you may specify this new contour as a variant of the original. Each contour may have only a single “active” variant and the plan will automatically update based on the selection of the active variant.

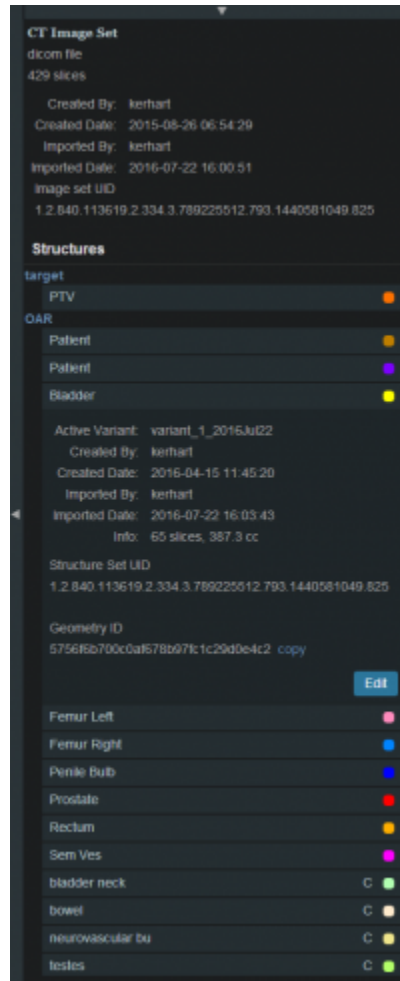
Working with Snapshots

Within Astroid the planner has the ability to view the snapshot details and edit certain structures in a limited capacity.

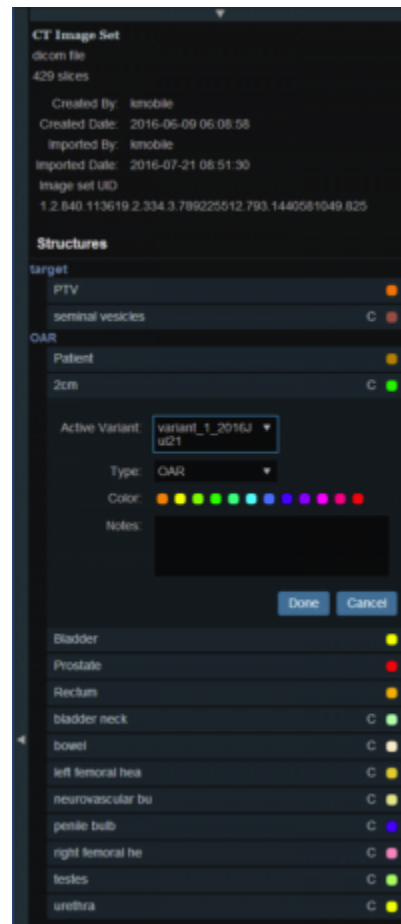
1. A snapshot contains data relating to the image set such as the number of slices, who imported the image set, the import date and the UID.
2. A snapshot also contains a list of the structures that were imported.



3. The user may choose to set the active variant for any structure present in the snapshot.



- 4. Structures not defined in the site config (a custom structure) are denoted with a “c” beside it. These structures have the ability to be edited in a limited capacity. The planner may choose to change the structure variant, color, and structure type. The planner may also choose to enter any notes that may be helpful at this point.

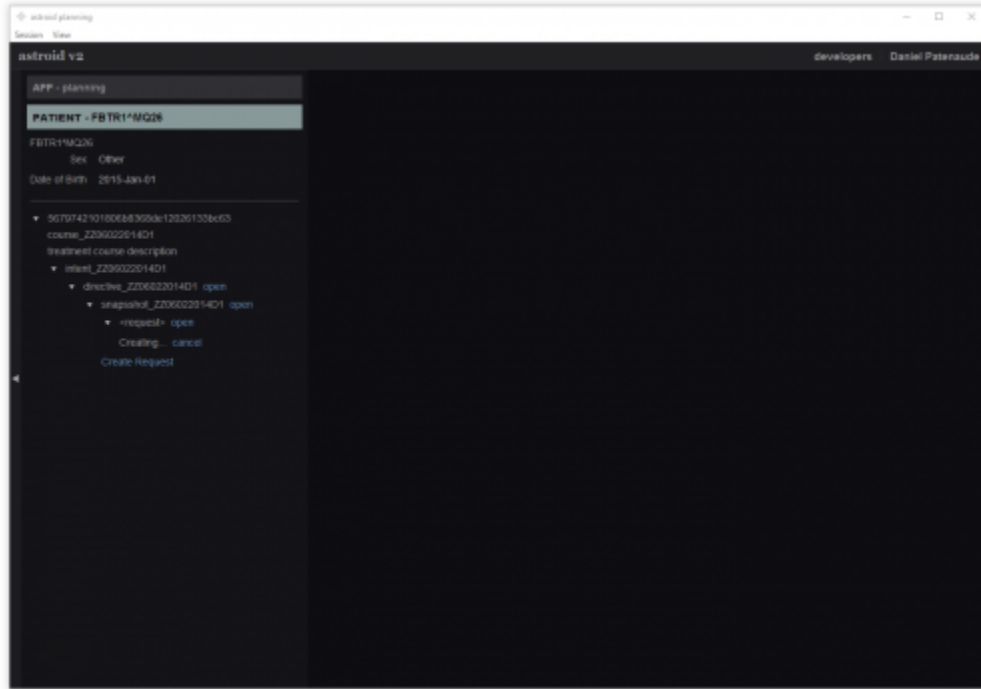


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Creating a Plan

Once a Planning patient has been added, a new request and plan can be created.

1. From the *Patient list*, select the patient to open.
2. Open the patient by double clicking the patient row or selecting the *Open* button in the *preview UI*.
3. From the *patient overview* select the *Create Request* button.
 1. The *treatment request* and *schedule* can be set from within the *request*.
4. Now that a *request* has been created, select the *Create Plan* button.
 1. Name the plan and add any relevant description.
5. Once the plan is created, select the *open* button next to the plan name.



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Structure Geometry

The Astroid Planning App allows for new structure creation using modifications of existing structures. These modifications include boolean combinations, expansions/contractions, rinds, and clipping (i.e. splitting by a plane).

General Structure Options

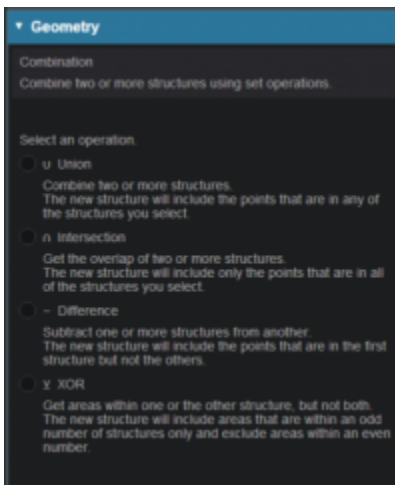
- **Type:** Set the type of the new structure (Target, OAR, Avoidance, etc)
 - Type may be left blank to allow it to be “inherited” from the type of the base structure
- **Color:** Display color for the new structure
- **Description:** Optional, user specified text describing the new structure

Structure Geometry

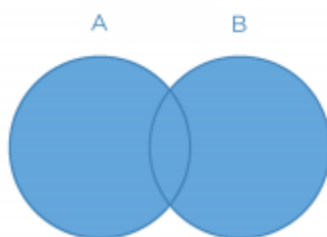
The following is a detailed explanation of each of the structure geometry functions that may be used to create or edit structures within Astroid.

Combination

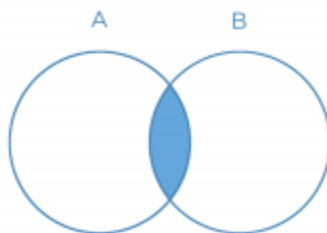
Allows for the combination of two or more structures using set (boolean) operations. The planner must choose which type of set operation they desire to create the new structure.



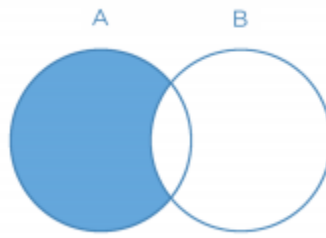
- **Union** - Combine two or more structures. The resulting new structure will contain the points that are in **ANY** of the selected structures. Structures are selected from a series of simple drop down menus. Refer to [this example](#) for a sample of a union structure being created.



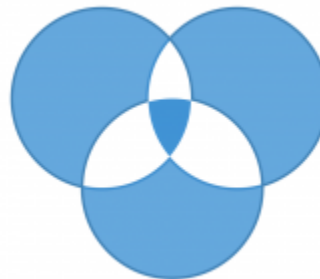
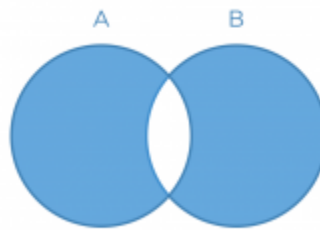
- **Intersection** - Use only the overlap of two or more structures. The resulting new structure will include only the points that are in **ALL** of the selected structures. Structures are selected from a series of simple drop down menus. Refer to [this example](#) for a sample of a intersection structure being created.



- **Difference** - Subtract one or more structures from a base structure. The resulting new structure will include the points that are in the first structure but not the others. The base structure is selected from the first drop down. The structures to subtract are then selected from the next series of simple drop down menus. Refer to [this example](#) for a sample of a difference structure being created.

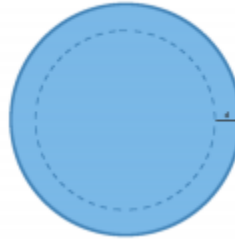


- **XOR** (Exclusive OR) - Combine two or more structures with exclusivity. The resulting new structure will include areas that are within an odd number of structures only and will exclude areas that are within an even number of structures. Two or more structures need to be chosen from the drop down to create the new structure. The shaded areas in the examples below show the new structure and demonstrate the XOR functionality. The non-shaded areas would be excluded from the new structure.



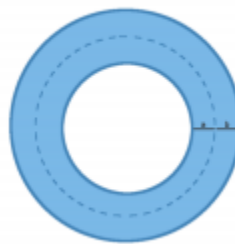
Expansion

Allows for creation of a new structure as an expansion or contraction of an existing structure. The base structure is selected from a simple drop down menu. An expansion is performed by entering a positive number for the expansion amount. Conversely, a contraction is performed by entering a negative number for the expansion amount. Structures may be expanded in two dimensions (structure will only expand/contract within its original slice planes) or three dimensions (structure will expand onto other slices as a true 3D expansion). Refer to [this example](#) for a sample of an expansion structure being created.



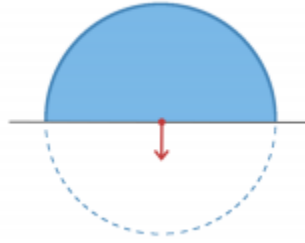
Rind

Allows for creation of a new structure as a thin ring around the outside surface of an existing structure. The base structure is selected from a simple drop down menu and then both an inner margin and outer margin are specified. Inner margin is the thickness of the ring within the existing base structure. Outer margin is the thickness of the ring outside the existing base structure. Negative margins are not permitted. Refer to [this example](#) for a sample of a rind structure being created.



Clipped

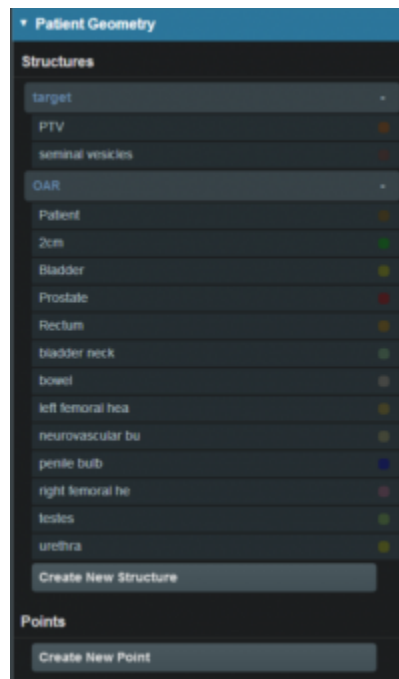
Creates a new structure by splitting an existing structure by a user defined plane (and discarding the portion on the positive side of the plane). Any existing structure may be selected for splitting from a simple drop down menu. The split plane is defined by a single point and a normal vector pointing away from the portion of the structure that will be kept. The normal vector is defined by its three direction components XYZ and the point may be selected (or created) from the available point list menu. The XYZ normal vector directions refer to patient coordinates so that X is left-right, Y is ant-post, and Z is inf-sup (note: if the “wrong” side of the structure is removed, simply reverse the direction of the normal vector by changing the sign of each XYZ value). Refer to [this example](#) of a clipped structure being created.



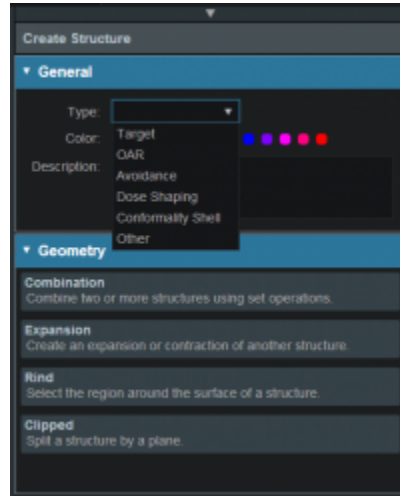
Working with Structures

Within Astroid the planner has the ability to create additional structures that may be needed when building the treatment plan.

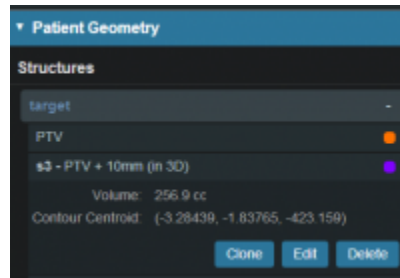
1. Open the *Patient Geometry* block
 1. This will open the patient *Structures* list.
2. Click the *Create New Structure* button at the bottom of the list



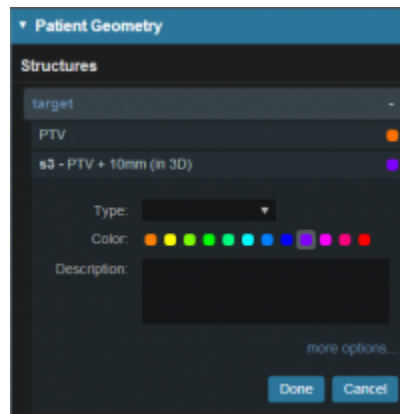
3. Next, choose the *Type* of structure that should be created from the drop down menu at the top (or leave this blank to "inherent" the type from the base structure)
4. Change the *Color* and enter a *Description* if desired
5. Then, select the method of creation desired for the new structure: *Combination*, *Expansion*, *Rind*, or *Clipped* (see above for details about each method).



- 6. Choose the required structures and enter any other required information for this method and then click *Create* to complete the new structure
- 7. Once a structure has been created, it can be edited, cloned, or deleted by clicking on the structure and then clicking on the appropriate button.



- 8. If further editing of the structure is needed, simply click on the *Edit* button then click *more options*. This will open the structure editing task and allow for full editing of all structure options.



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Dose Grid

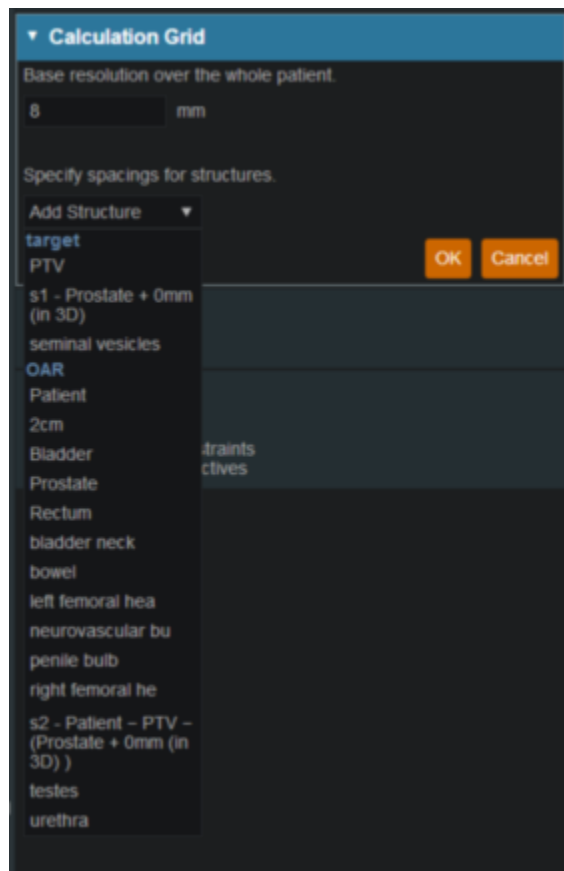
The calculation grid resolution/size used affects the accuracy of the dose distribution. In Astroid you have the ability to vary the grid size dependent on the structure. The calculation grid base resolution is set to

the patient. By using a larger grid in areas that are not critical to the calculation you have the ability to speed up the calculation.

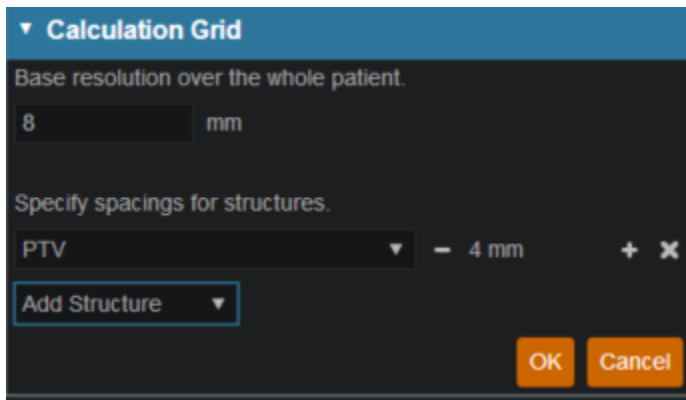
1. Open the Calculation Grid block



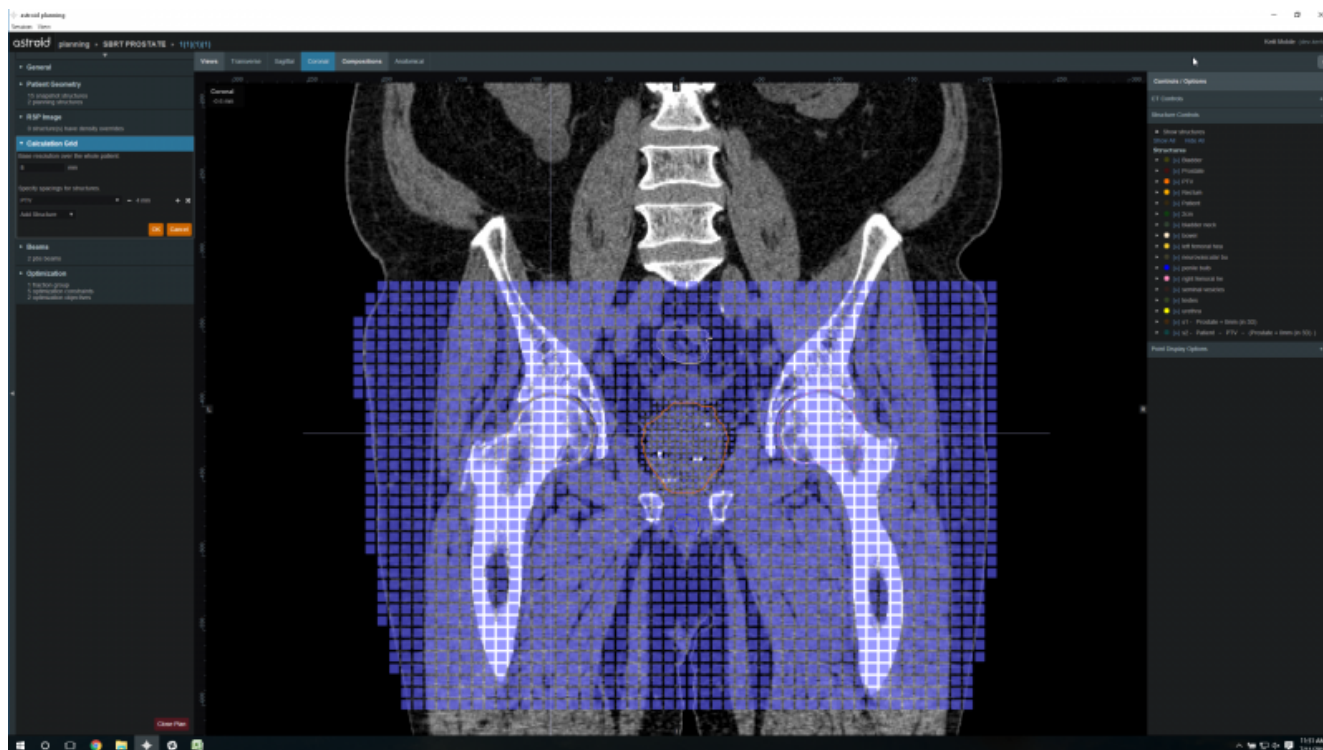
2. The default grid size is set in the site specific configuration settings and is set to the patient. You may make it larger or smaller if needed by typing in the desired number.
3. If you want to use a smaller grid in a target or OAR choose that structure from the dropdown.



4. Whatever grid size you set to the patient you may scale down by in powers of 2 in the areas of critical structures and regions of interest by using the +/- on either side of the region spacing setting



5. Notice the different size grid in the PTV and the patient



6. You may have more than one structure with a different calculation grid spacing set.

7. After you have your calculation grid set hit the OK button

8. You may always come back and adjust your grid if needed

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Creating a PBS Beam

After a calculation grid is defined, a pbs beam can be added to the plan. From within the *beam creation* task, the geometry, target, beam devices, and spot optimization can be defined.

1. From within the *plan overview* select the *Beams* block
2. Select the new *Dosimetric Beam* button
3. Set the beam geometry parameters:
 1. Select the Isocenter

2. Set the gantry angle
3. Set the couch angle
4. Select the intended target
5. If desired, add an aperture
 1. Refer to [Creating a New Aperture](#) for detailed instruction
6. Select the snout size
7. If desired, select the range shifter to use based on the ones available for the selected snout
8. Set the air gap distance
9. Set the spot placement parameters



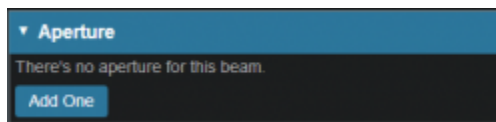
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Creating an Aperture

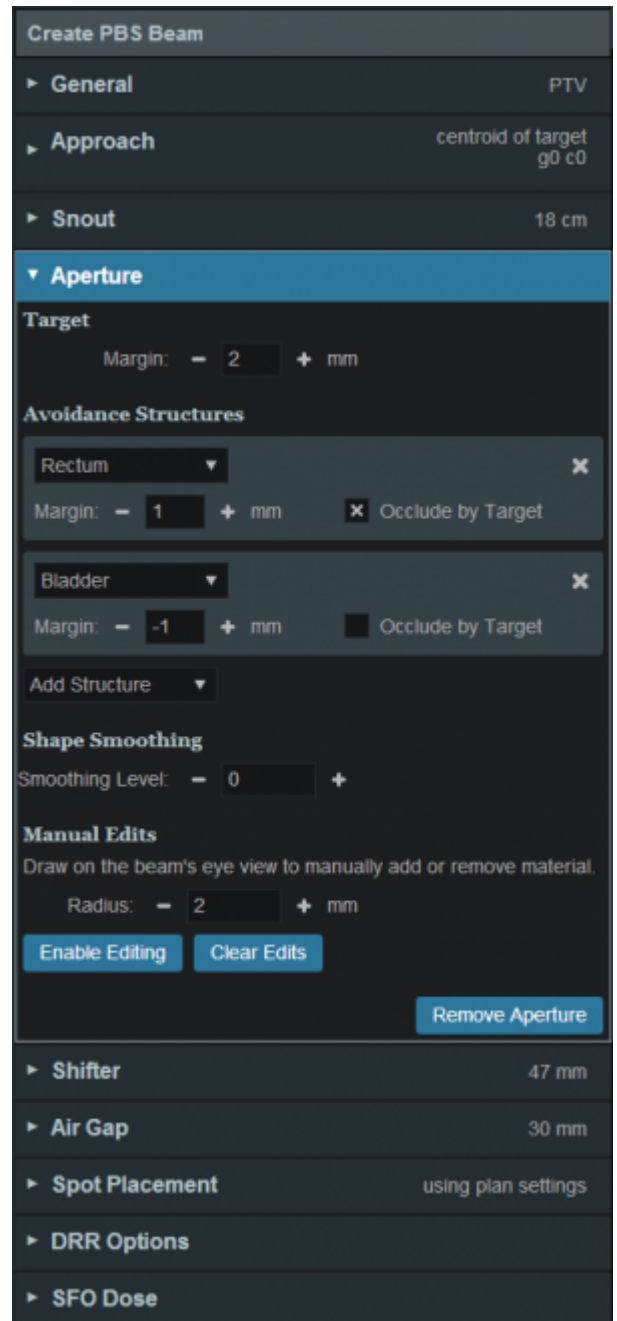
An aperture can be added for any snout that has slabs defined for use in the site specific machine model.

Adding an Aperture

- From within the PBS Beam Task you may add an aperture to a beam by selecting the Aperture Task Block clicking the "Add One" button.



Target





- Your target structure is automatically selected from your beam information so you need to only specify the number of millimeters you want to expand your aperture around the target structure using the “Margin” option to generate your initial aperture shape.
 - Your aperture should now appear in the BEV display window.


Avoidance Structures

- In many cases you may have nearby critical structures that must be avoided. You can add an “Avoidance Structure” to your aperture design by clicking on the “Add Structure” dropdown and



selecting a structure.

- Once added you can now specify a margin (mm) around this structure if desired (note negative margins will reduce the size of the blocked area of the structure).
 - You may also choose to occlude the structure by the target or not using the “Occlude by Target” option.
 - By checking the “Occlude by Target” box you are choosing to give the target priority over the structure in the view you are looking at in the DRR. In other words the visible target (target in front of this structure) will not be blocked by the aperture. <add screen shot> 
 - If you leave the “Occlude by Target” unchecked, you are choosing to give the structure priority over the target. This means you will block the entire structure regardless of its position relative to the target. <add screen shot> 
- You may add as many Avoidance Structures as needed to design your aperture shape.

Shape Smoothing

- The “Shape Smoothing” section allows you to smooth the aperture if needed.
- The smoothing level value can be set from 0-20, with zero applying no smoothing and higher numbers increasing the smoothness of the aperture. More details regarding the smoothing algorithm and process can be found here <link> .

Manual Edits

- Manual edits allow you to draw on the BEV in order to manually edit the aperture shape.
- First, set the radius of the editing tool to the desired size (you can directly type a size or use the -/+ on either side to increment the size)
- Next, click the “Enable Editing” button to allow manual edits. You are now free to draw manual override regions directly on the BEV. You draw by simply clicking and dragging the mouse at the desired positions.
 - The editing tool automatically switches between adding or subtracting material based on the position of the tool when the mouse is first clicked (i.e. when starting each new draw operation).
 - When outside the aperture, you edit the aperture by pushing in/subtracting and your edit regions are drawn in a blue color. <screen capture> 
 - When inside the aperture, you edit the aperture by pushing out/adding and your edit regions are drawn as the color of your target. <screen capture> 
 - Once done with manually editing, click the “Disable Editing” button to end the process.
 - Note that your edits and the resulting aperture shape will still show on the DRR (BEV) and your edits will remain active even when changing other options.
 - If you need to remove the manual edits for any reason, you may do so by pressing the “Clear Edits” button. Pressing this button will remove ALL manual edits for this aperture.


Removing an Aperture

- If you wish to remove the aperture from this beam, simply press the “Remove Aperture” button at

the bottom of the Aperture Task Block

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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*, referred to as *Beam Set Groups*. The *Beam Set* and *Beam Set Group* 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, beam set groups, and beam sets can be constructed to meet the clinical needs of various clinical cases can be found  here.

General Fraction Group Data

- **Color:** Display color of the *Fraction Group*
- **Description:** Optional, user specified text describing 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](#))

Beam Set Groups

Simply speaking, a *Beam Set Group* is just a collection of *Beam Sets* that together will provide a specified dose to a particular target, so in clinical practice each *Beam Set Group* is most commonly associated with a single target structure (i.e. there will be one *Beam Set Group* per target). Most standard single lesion treatments will therefore use only one *Beam Set Group*. More complex prescriptions, such as Simultaneous Integrated Boosts (SIB), are typically split into two groups, one for the primary target and a second for the boost target. Within the *Beam Set Group*, a target 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 this beam set group
- **Beam Sets:** A list of Beam Sets that will be used for this beam set group (see below for a detailed description of a *Beam Set*)
- **Constraints:** These *Constraints* are split evenly and applied individually to each *Beam Set*
 - In other words, the Constraint dose is divided by the Beam Sets in the Beam Set Group, so that both SFO and IMPT can be achieved

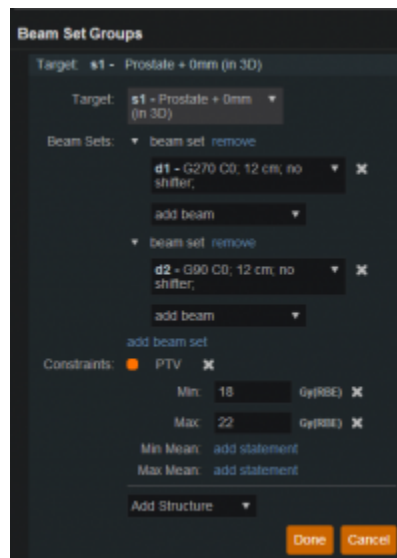
Beam Sets

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 Group (BSG) Constraints described above, should reveal how to properly arrange beams within Beam Sets to achieve a desired type of treatment. Since BSG Constraints are equally split and are then applied individually to each Beam Set, SFO 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.

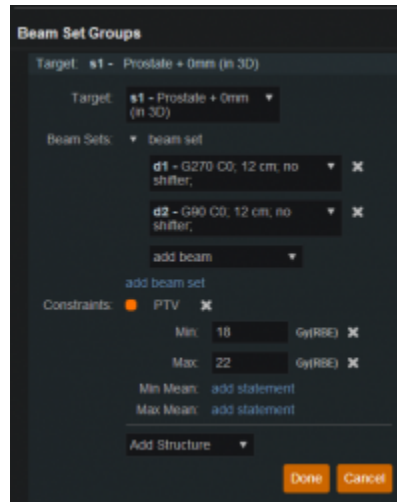
SFO Beams

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 Group Constraints. Now two beam sets are created, each containing a single beam, as shown below. Since the BSG 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

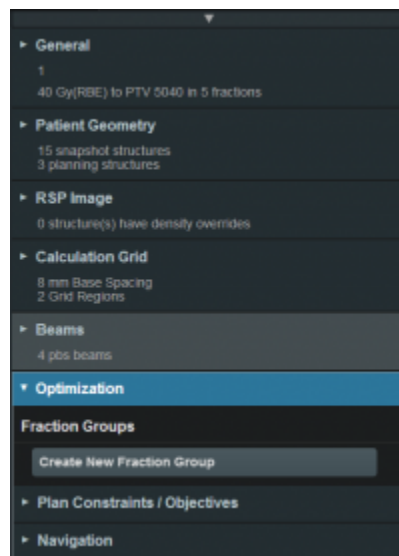
Intensity Modulated Proton Therapy treatment beams are produced by including all desired beams in a single Beam Set. This is again best understood by example. Suppose a target is intended to receive 20 Gy (2 Gy per day for 10 fractions) from a two beam Fraction Group using an IMPT approach. This is achieved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



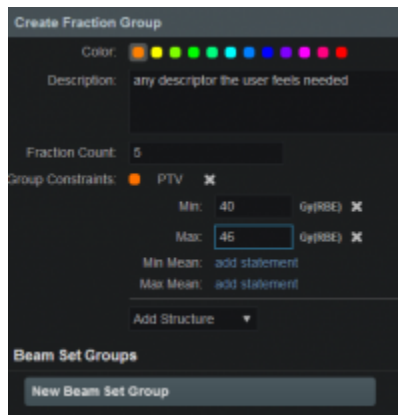
By understanding the notion that Beam Set Group Constraints are equally split among the beam sets, it can also be seen how SFO and IMPT may be mixed within a Beam Set Group and even the most complex of treatment scenarios can be handled directly in Astroid.

Working with Fraction Groups

1. Select the Create New Fraction Group button

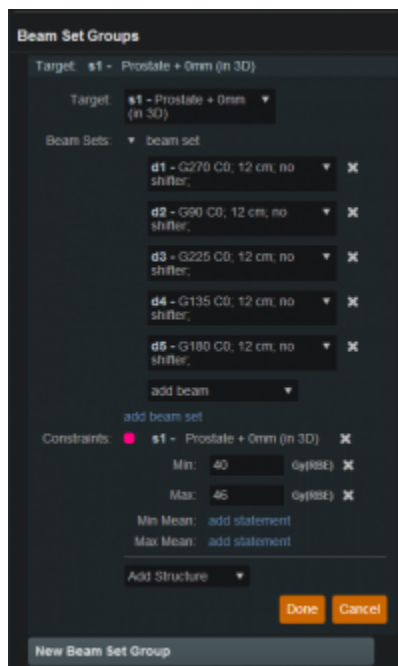


2. In the newly opened block the planner will:
 - o Choose the color the fraction will be denoted in
 - o Type in any descriptor that may be needed
 - o Enter the total number of fractions to be treated
 - o Enter the group constraints
 - Group constraints apply to the total dose from the whole fraction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



3. Click *New Beam Set Group*

- Select the target of this Beam Set Group
- Create any Beam Sets that are desired
 - There may be multiple Beam Sets associated to a target to construct SFO or IMPT beam groupings (see above for further details)
- Enter any desired Beam Set Group 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 Beam Set Groups, typically with each associated to a distinct target within the *Fraction Group*



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Optimization Constraints

About Constraints

Constraints can be set in multiple levels (*Plan, Fraction Group, Beam Set Group*) and they will function differently in each level. Note all constraints are considered “hard limits”- constraints that must be achieved. *Constraints* are what drive the feasibility calculation- whether the plan is achievable. *Constraints* at the *Plan* level are applied to the total dose across all beams. *Constraints* at the *Fraction Group* level apply to the total dose across all beams in the Fraction Group. *Constraints* at the *Beam Set Group* level are split evenly and applied individually to each Beam Set. In other words, the *Constraint* dose is divided by the *Beam Sets* in the *Beam Set Group*, so that both SFO and IMPT can be achieved (see [Fraction Groups](#)). The following will provide a walk through of the different levels and how constraints work at each one.

The following constraint types are available. Note certain constraints are available only for *Target* type structures.

- **Min:** The minimum dose the structure must receive
- **Max:** The maximum dose the structure must receive
- **Min Mean:** The minimum mean dose a structure must receive
 - This will drive the dose up across the structure
- **Max Mean:** The maximum mean dose a structure must receive
 - This will limit the mean dose across the structure

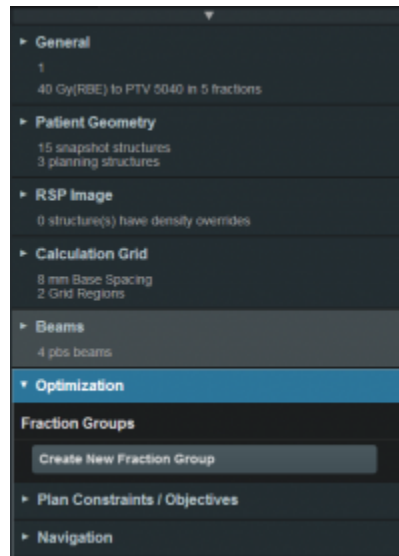
- The user can choose to apply one of these constraints or multiple constraints to the structure

Working with Constraints

Working with Fraction Group Constraints

Constraints at the *Fraction Group* level apply to the total dose across all beams in the *Fraction Group*

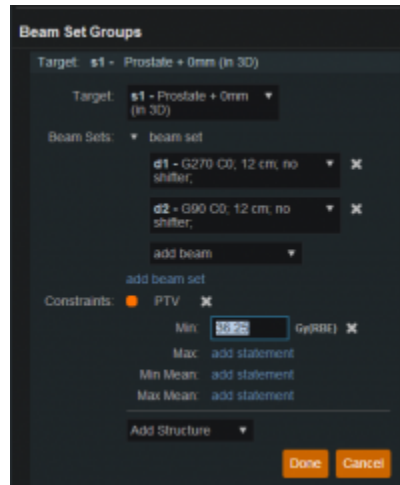
1. Select the *Fraction Group* if it has been created or create a new *Fraction Group*



2. Choose from the drop down the structure or structures to which constraints should be added
3. Define what constraint(s) should be applied to each structure by choosing the constraint and entering the dose



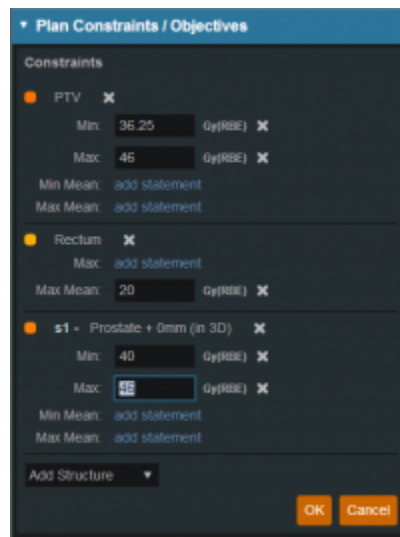
4. Once the constraints are set in the *Fraction Group* the user will create *Beam Set Groups* and assign *Constraints*
5. The assigned constraint doses will be divided evenly among the *Beam Sets* in the *Beam Set Group*



Working with Plan Constraints

Constraints at the *Plan* level are applied to the total dose across all beams.

1. Open the *Constraint* sub block contained in the *Plan Constraints/Objectives* block
2. Choose from the drop down the structure or structures to which constraints should be added
3. Define what constraint(s) should be applied to each structure by choosing the constraint and entering the dose



Once all the Constraints have been set the user can either start the Feasibility or move on to defining the Objectives

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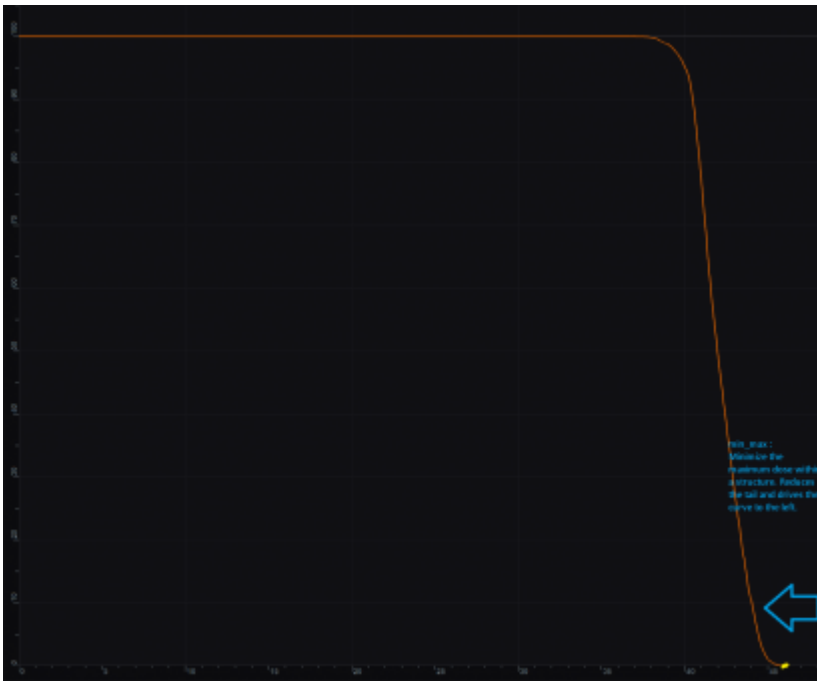
Optimization Objectives

Objectives communicate to the optimizer the goals that are important to strive for in your plan.

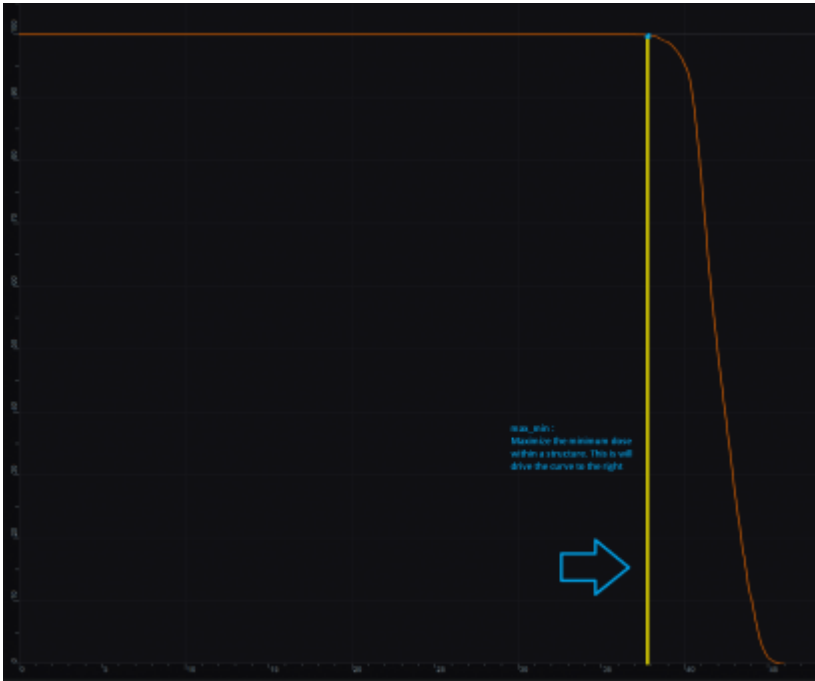
Objectives are set at the *Plan* level under *Plan Constraints/Objectives* and they apply to the total, combined dose from all beams. *Objectives* are not given relative importance at this point and can they can be added in order you desire within impacting the results as the *Objectives* drive the solution of the Multi Criteria Optimization (MCO). It should also be noted that for each *objective* a corresponding *Navigation Slider* will be presented to allow for exploration of trade-offs in the case of competing objectives (for more information about the MCO process and how objective importance/weighting is handled in Astroid refer to [this article](#)).

The following objective selections are available in Astroid:

- **min_max**: Minimize the maximum dose within a structure
- **max_min**: Maximize the minimum dose within a structure

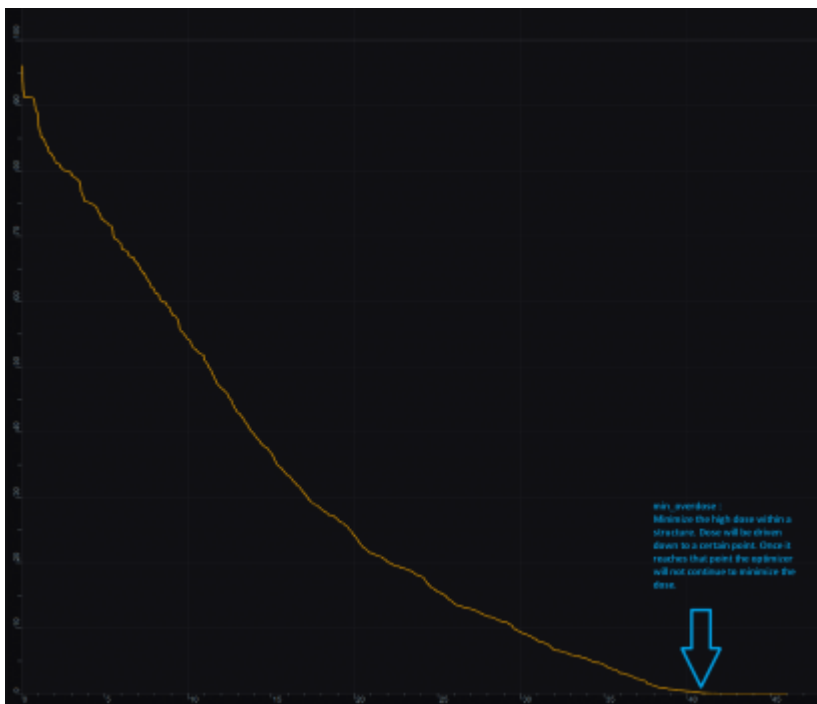


min_max: Minimize the Max Dose

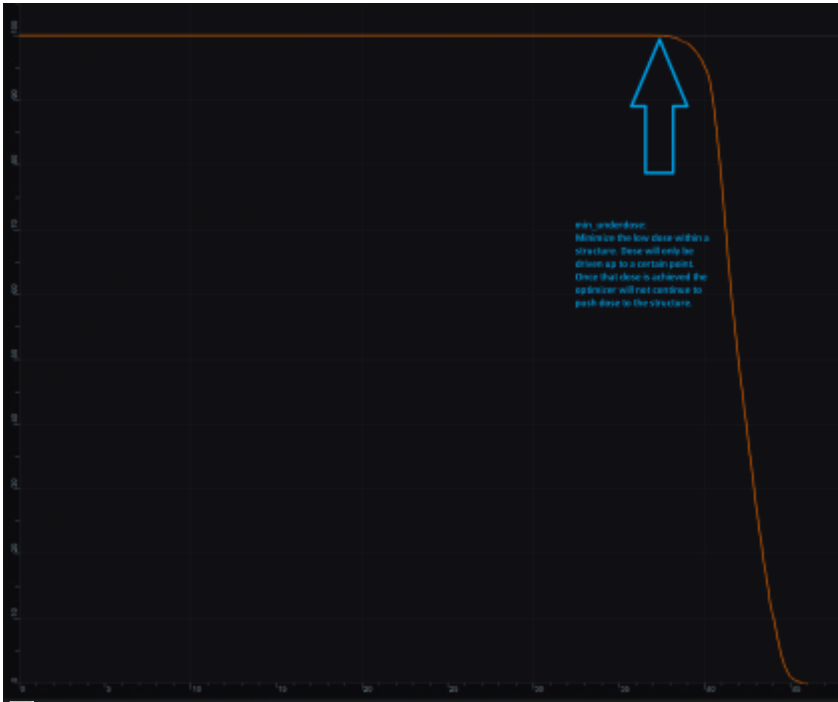


max_min: Maximize the Min Dose

- **min_mean:** Minimize the mean dose within a structure
- **max_mean:** Maximize the mean dose across the structure
- **min_overdose:** Minimize the high dose within a structure
 - Dose will only be driven down to the specified limit (this is often more relevant than min_max, since it may not be beneficial to continue minimizing beyond a certain dose level)
- **min_underdose:** Minimize the low dose within a structure
 - Dose will only be driven up to the specified limit (this is often more relevant than max_min, since it may not be beneficial to continue maximizing beyond a certain dose level)



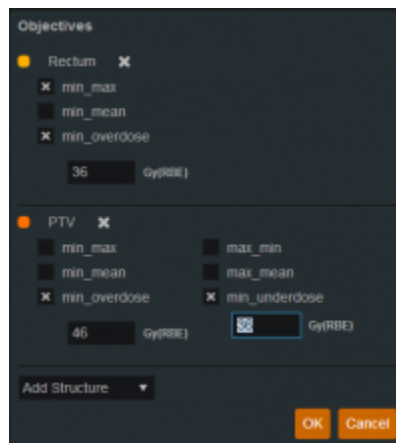
min_overdose: Minimize the high dose



min_underdose: Minimize the low dose

Working with Objectives

1. Open the *Objectives* sub-block contained in the *Plan Constraints/Objectives* block
2. Choose the structures to apply objectives
3. Check the boxes for the objectives to apply to the structure and set the dose level if applicable



Once all the *Objectives* have been set the user can move to *Navigation* block to start the MCO.

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Astroid Optimization

With IMRT plans the variety of possible dose distributions is quite large. Typically if a physician does not like an IMRT plan they will request a plan to be re-run. This requires the planner to input new constraints and objectives and a new plan to be run from the beginning of the optimization process. This is a time consuming process. Astroid eliminates this cycle using a Multi Criteria Optimization (MCO) approach that allows planners and physicians to visualize the trade off of target volume coverage vs reduced dose to the OAR's in real time. MCO treatment planning is based on a set of Pareto optimized plans, where a plan is considered Pareto optimal if it satisfies all the constraints and none of the objectives can be improved without worsening at least one of the other objectives. So instead of creating just one plan, Astroid creates a set of optimal plans that satisfies the treatment plan constraints and puts an interactive exploration of dosimetric objectives at the planners and physicians fingertips via a unique, highly intuitive, Pareto surface navigation slider bar system.

Constraints play an important role in the optimization process, as they bound the solution space and ensure your navigation process is focused only on plans that meet your non-negotiable, highest priority dosimetric needs. It should be noted that if the *constraints* are too tight, there may be no feasible plans. However, if the *constraints* are too loose, too many solutions will exist and the navigation will be too broad to provide adequate resolution over the truly clinically useful plans. Therefore care should be taken to ensure appropriate constraints are set, which is facilitated using the Astroid *feasibility* check feature. So while constraints supply hard limits, *objectives* are the negotiable goals, they do not have a hard level that must be obtained, but “pushing” them harder does result in benefit to the patient. The number and type of *objectives* chosen should be such that all the relevant trade offs can be demonstrated and explored.

Feasibility and Constraints

After the *constraints* have been entered, the user may start the *Feasibility* calculation by clicking *calculate* in the *Feasibility* block. The *Feasibility* calculation is based solely on the *constraints* and it should be used to ensure there is a feasible plan possible. The *Feasibility* calculation may be an iterative processes in order to get appropriate constraints established for a particular plan. In other words, the user may need to enter a *constraint*, check the feasibility, then progressively drop the *constraint* and check the *feasibility* until the plan is no longer feasible. It is recommended practice to start by obtaining a feasible plan utilizing only target *constraints* then add OAR *constraints* as desired. Remember, using a narrow range of *constraints* can improve the optimizer performance and improve the resolution of the Pareto surface navigation.

The user also needs to be aware of the impact of *constraints* being set on *Fraction Group* level versus the *Plan* level. For example, it is possible to have a *constraint* set in the *Plan* level so that the whole dose to an OAR is given on one day and none on the other day. This could happen when there are two *Fraction Groups* and the OAR dose is not split between the two by using *Fraction Group* level constraints.

Running the Optimizer

The *Objectives*, as stated before are the negotiable goals where they may be no hard limit, but there is benefit to improving them. Astroid allows *Objectives* on both Targets and OAR's. *Objectives* can be placed on structures to either increase or decrease dose. The *Objectives* are the sole driving force

guiding the MCO and it is important to recall from the discussion above that Astroid will only navigate to plans that are “optimal” in at least one objective (meaning again that this objective cannot be improved without another objective getting worse. Unlike *Constraints*, *Objectives* should be added all at once and there is no need to place them in any particular order (order is irrelevant). Additional information about *Objectives* can be found [here](#). Since the MCO is finding a large set of optimal solutions the optimization can be a lengthy process. The following factors have the largest impact on the optimization run time:

- The number of points in the calculation grid (linear impact)
- The total number of spots from all beams (linear impact)
- The number of objectives (quadratic impact)

The number of calculation points and number spots will have a direct 1:1 (linear) impact on the calculation times; in other words, doubling one of these items will (roughly) double the MCO calculation time. The number of objectives scales quadratically, meaning that doubling the number of objectives creates a four-fold increase ($2^2 = 4$) in the number of MCO calculations that are required. For objectives, this does not always increase the overall wait time on the calculation however, thanks to the parallelization that be achieved using the Astroid cloud services back end. So for small numbers of objectives 1-3, you may not notice much (if any) increase in wait time by increasing up to 3-5 objectives (but this does depend on the availability and load on the Astroid cloud calculation servers).

Once all the desired *Objectives* are entered the MCO calculation is started just by clicking the *calculate* option in the *Navigation* block. It should be noted that the *Feasibility* will be re-checked if any of the *Constraints* have changed since the feasibility was last run. The MCO calculations will run in the cloud and the user can simply leave the Astroid application running and move on to other things while the calculations process. Please note that at this time the Astroid App should be left open in this state to ensure the calculations run to completion, however, users may open additional instances of Astroid and work on other plans while these calculations proceed (no performance issues should be encountered when using multiple instances since the “heavy” calculations are off-loaded to the cloud calculation servers).

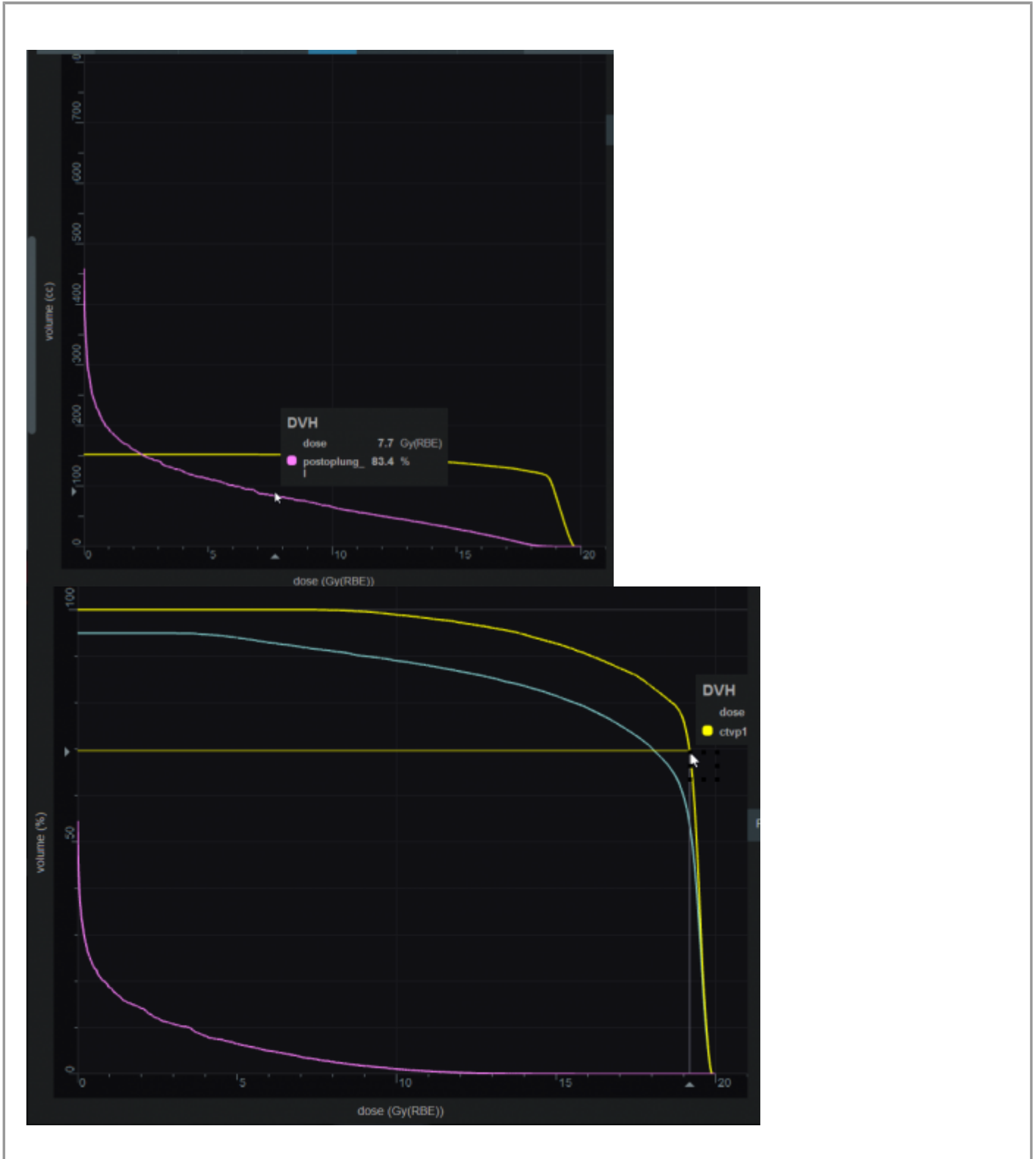
 Discuss how to check progress (put in later when progress widget done)

Dose Normalization and Display

The user has many options for how the dose is displayed. The options for controlling the display of the dose are on the right hand side of the display under *Dose Options*. The *Dose Options* provide controls over the DVH type (relative or absolute volume), the colors and scaling of the display dose, and the type of dose display shown (colorwash, isolines, or isobands).

Dose Volume Histogram (DVH)

The planner has the option of viewing the dose for the DVH in relative volume (dose per percentage of the volume) or in absolute volume (dose per cc of the structure) using the *Absolute DVH* option. The user may also hover over any area of the DVH curve to obtain the dose and percentage of a given structure or click on a line to obtain start tracking the cursor value for one or more lines.

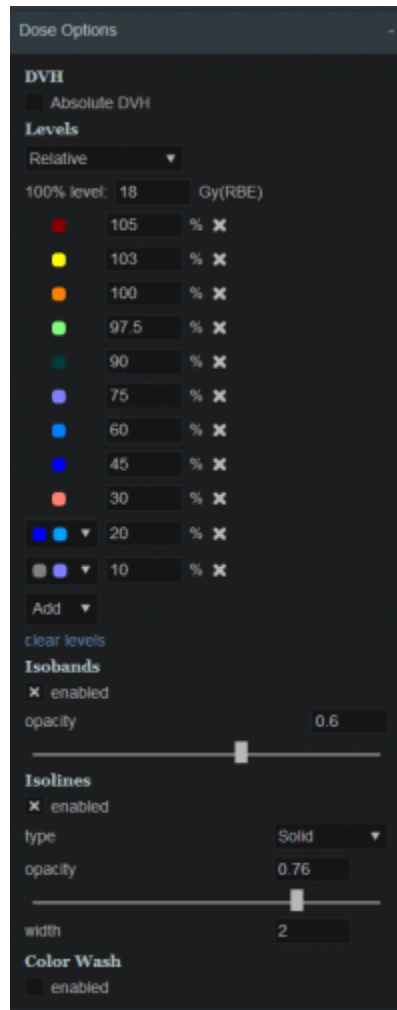


Dose Display Normalization

As in the DVH the user has multiple options for displaying the dose. The dose can be displayed in either relative (percentage) or absolute. This can be chosen by using the drop down menu under *Levels*. If the

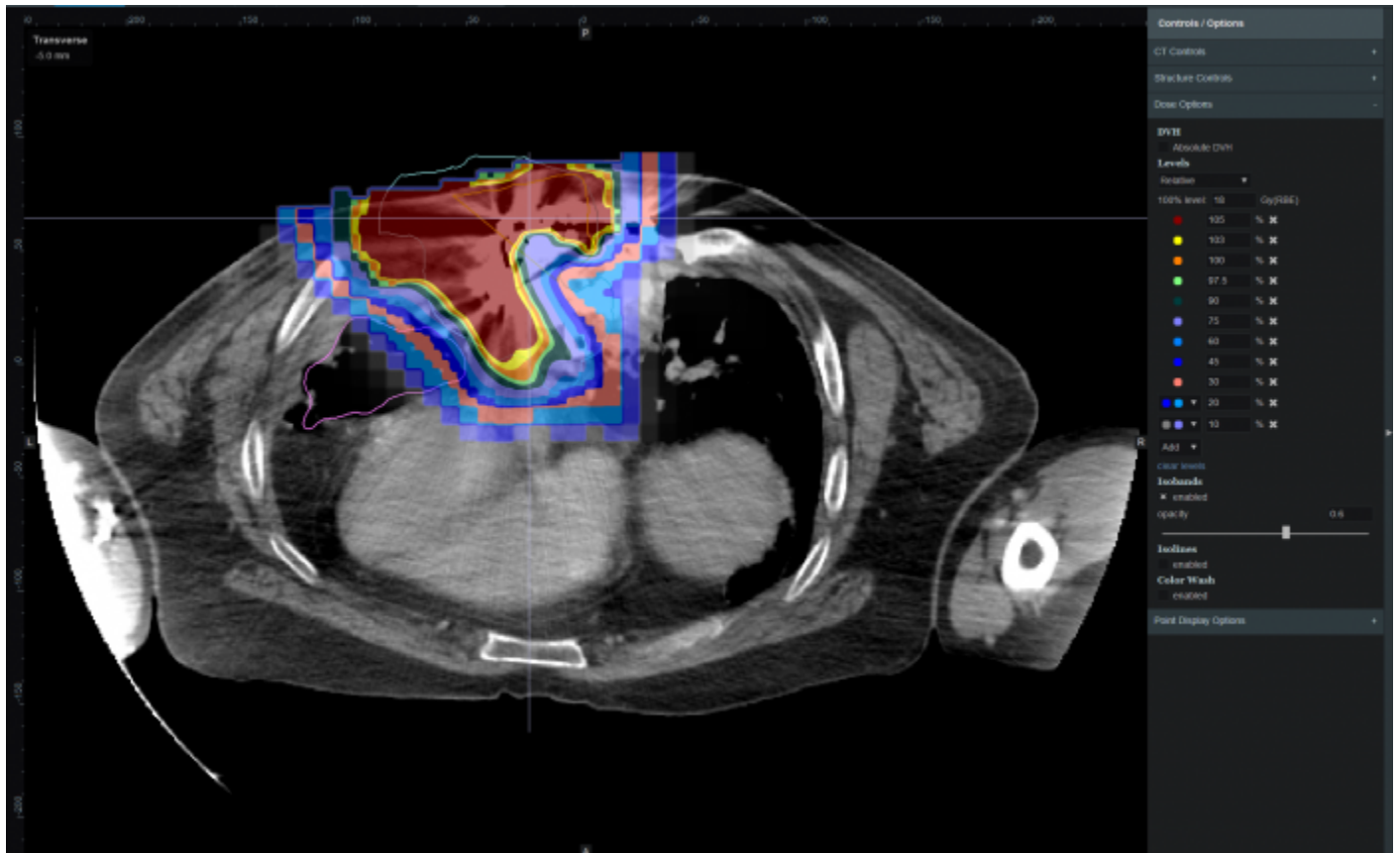
user chooses to view dose in relative mode they must then enter the 100% line dose- usually the prescription dose. The percentage isodose lines that the user wants to see must then be entered. If the user chooses to view absolute dose they need to choose absolute from the drop down and then enter the dose lines that they want to see.

The user also can choose to view the isodose as either isobands, isolines, color wash or combinations of these. The user may use the sliders to set the opacity for each of these as well. They may also choose the line width and whether it is solid, dashed or dotted for isolines.



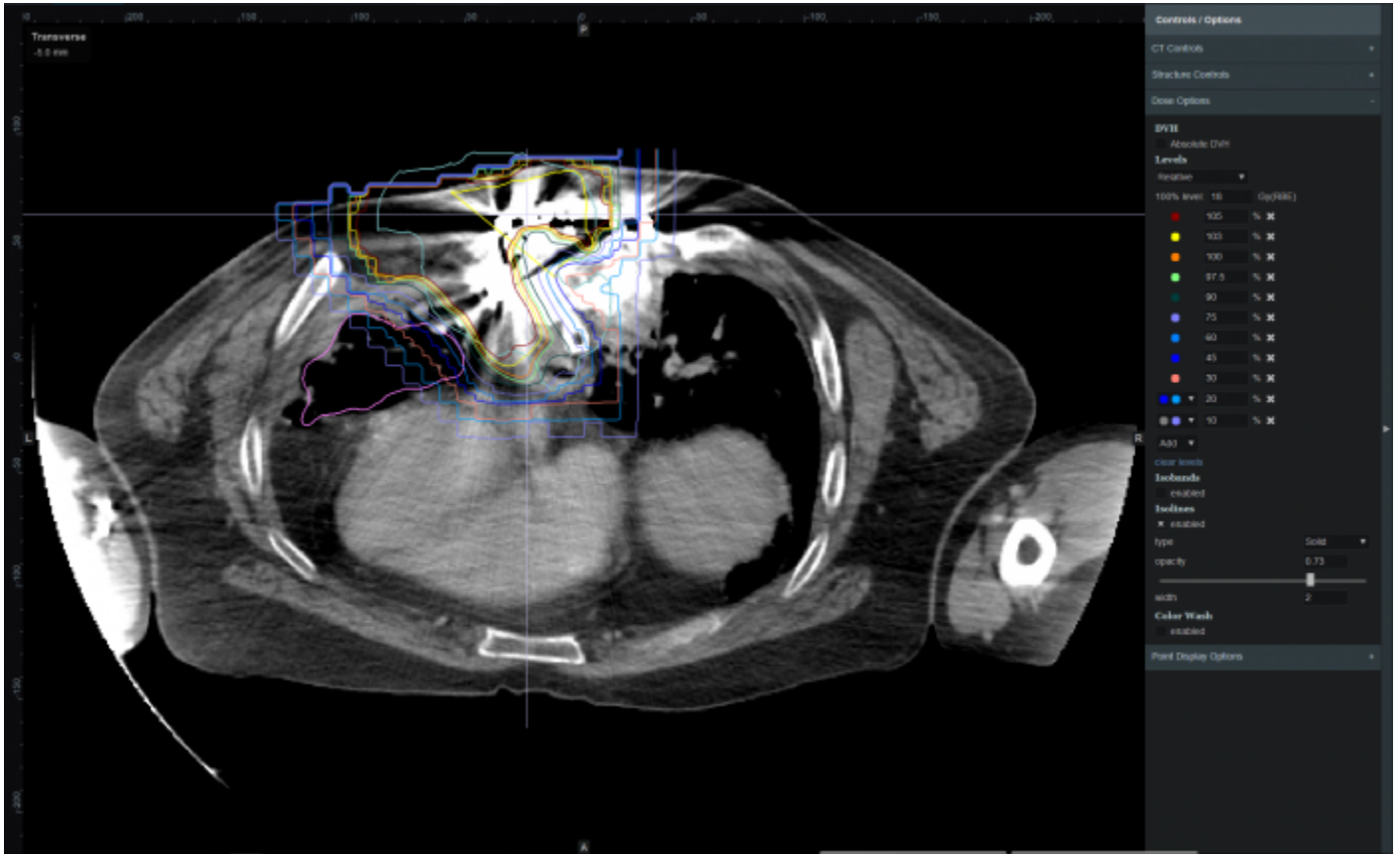
Isobands

Isobands are an interpolation of dose from isodose line to isodose line. Isobands take a range of interpolated dose and fills it in with color.



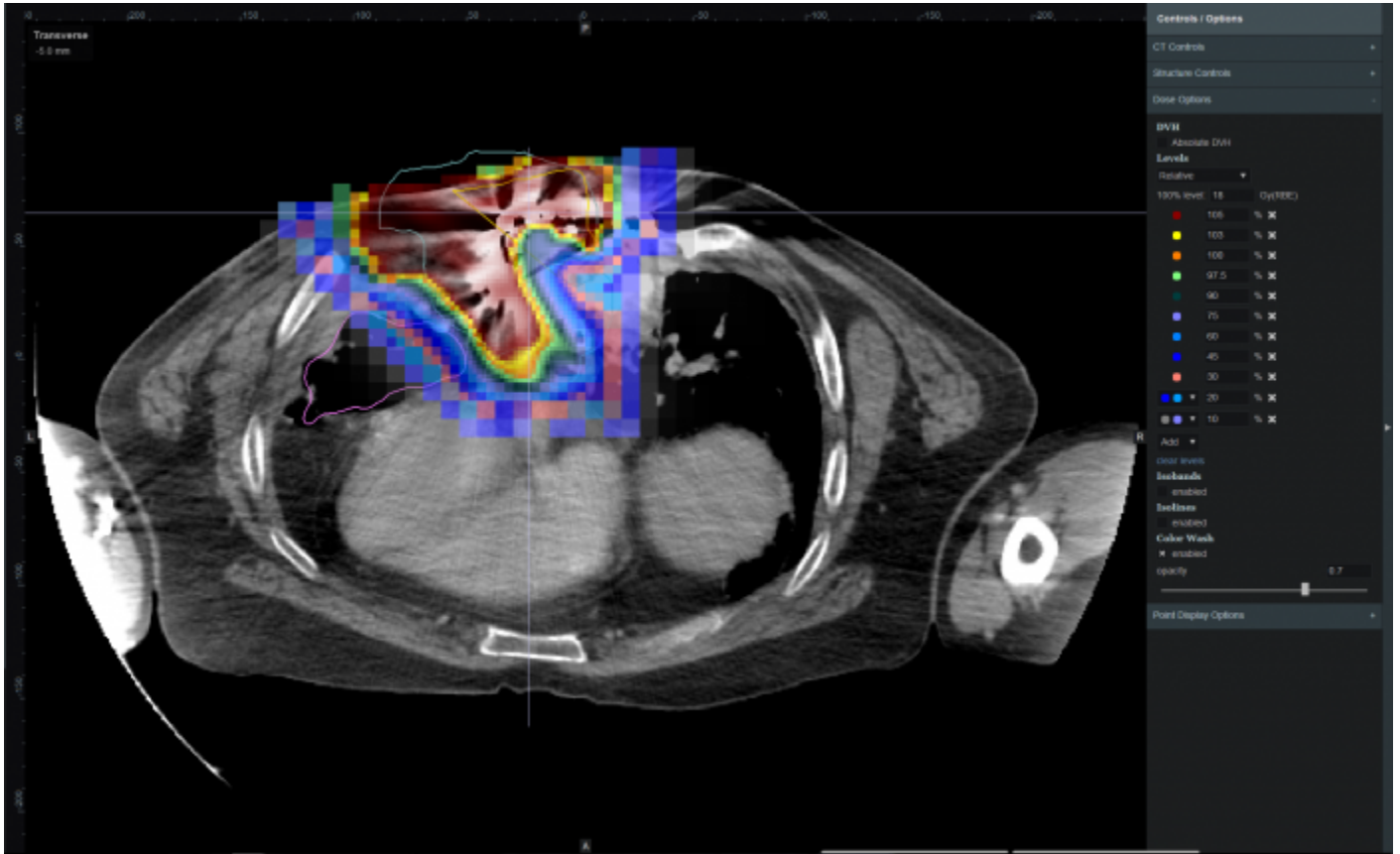
Isoline

Isoline display either the absolute or relative isodose line in the form of a single line. These are lines that pass through the points of equal dose.



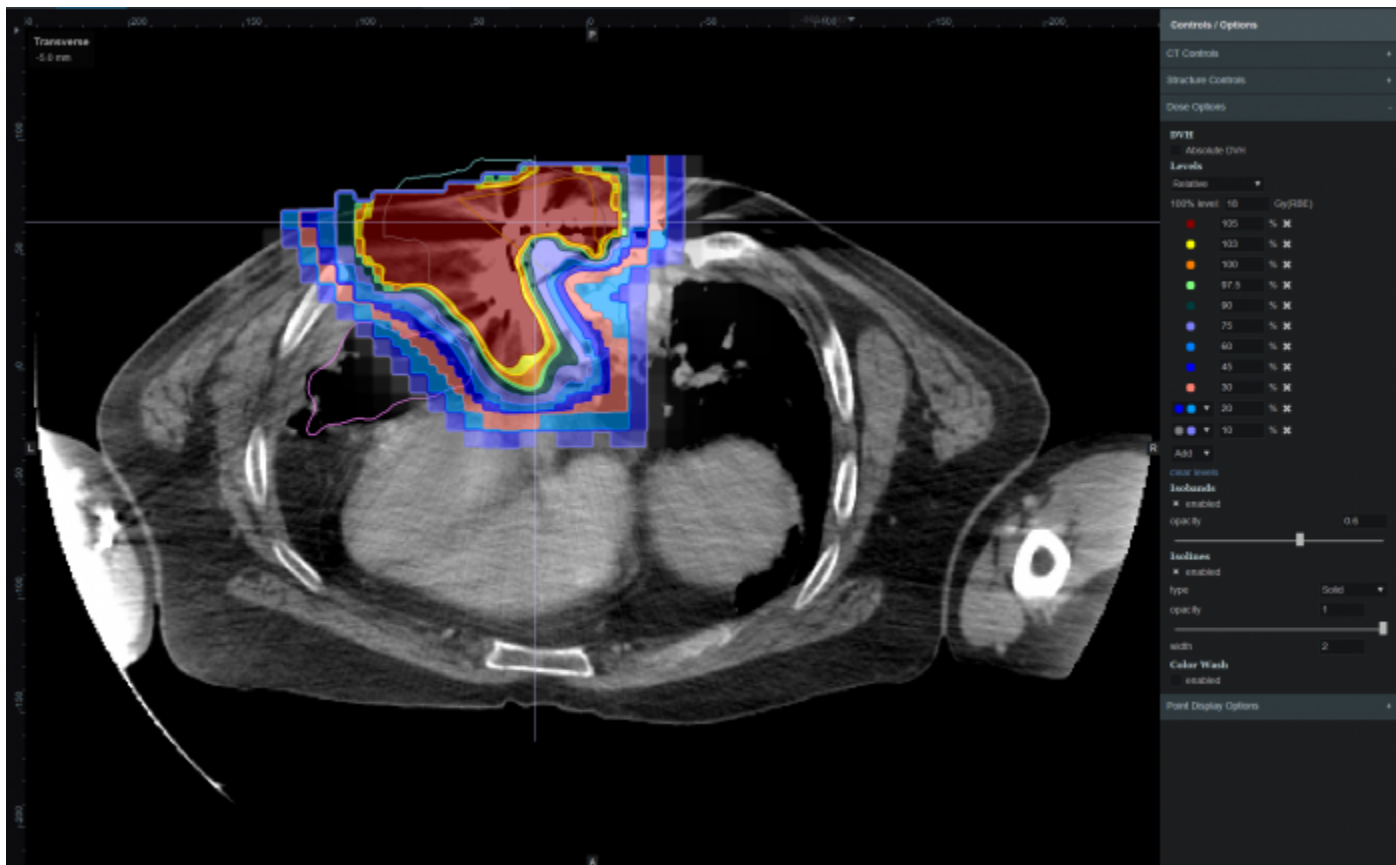
Color Wash

Color Wash demonstrates the raw dose across a range. It shows the raw dose across an area.



Combination

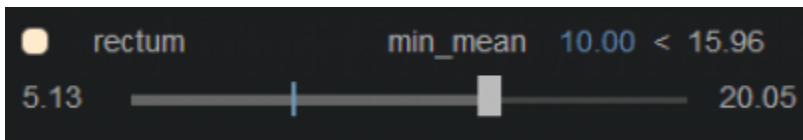
The user does have the ability to combine multiple representations. Below shows a combination of Isobands and Isolines



Navigating the Solutions

Once the plan has been calculated the *Navigation* block will become active. This block contains entries for all the active objectives and under each objective is a slider bar. This slider bar allows the user to adjust the importance of an objective and to see, in real time, how the change will affect the dose to the patient.

The Navigation Sliders should provide an intuitive process for finding the optimal plan, but by gaining a complete understanding of the Navigation Sliders users will be better equipped to quickly reach their plan goals. On each slider there are two vertical bars. The thick white bar is the user controlled slider handle and it represents the worst value of an objective that the user wants to allow (note sliders for minimize objectives will slide to the left and sliders for maximize objectives will slide to the right). Simply stated, the objective will not go past this limit. The thin blue bar denotes the actual current value of the objective. Astroid calculates this value by balancing the solution over the available ranges of each objective. It should now be clear that moving a slider does **not** directly set an objective, but rather it places limits on the allowable range of an objective. It is this feature that makes navigating the solution space very clear and effective.



The blue and white numbers to the upper right of each slider correlate to the objective value for the

current plan and the objective limit based on the slider position, respectively. blue and white and white vertical bars are at. The numbers at the end of each slider bar denote the overall range for the objective value (i.e worst and best possible values). The main slider horizontal bar is also separated into two sections. The thicker, lighter grey horizontal bar is the range or window that the objective is currently limited to stay within (it is limited due to the positioning of the other sliders by the user). The user will notice as they drag the slider handle (white bar) on one objective, this light grey area will change on some of the other sliders. This allows the user to know the limits they have to work in and the impacts (trade-offs) that one objective is having on the others.

Fix Me! Add some details of how to adjust and why (need to discuss with MGH??)

All of these adjustments are able to be done without running a new plan as would needed to be done in traditional treatment planning systems. This allows the user to look at many different solutions in a short amount of time.

If the user does not like the adjustments they have made to the structure objective slider they may hit the *Reset* button in the bottom left corner to reset all the objectives to their last saved state. If the user does like the adjustment that was made they may choose the *Save* button in the bottom right hand corner. This will save the objectives at their current position. The *Cancel* button will close the *Navigation* block in its current state.



2016/08/17 13:00

Plan History



2016/09/20 16:57

Plan Publishing



2016/09/20 16:57

Plan Export



2016/09/20 16:57

Plan Reports



2016/09/20 16:58

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<http://apps.dotdecimal.com/> - **astroid App Documentation**

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Last update: **2016/09/20 15:42**

Walkthroughs

Overview and Purpose

This walkthrough is intended to be an easy to follow step-by-step guide for creating a plan for a simple prostate patient. In many cases specific prescription, constraint, and other dosimetric values are given to use as input. It should be noted that these values are not intended to provide clinical guidelines and should in no way be considered a recommendation for values that are appropriate for clinical use. The intent is that after completing this walkthrough, you will have gained an understanding of many of the details and much of the information that will be required to generate a complete Astroid treatment plan. Armed with this information and knowledge, you will then be able to complete the process using the clinical protocols and requirements from your facility to generate clinically appropriate patient treatment plans using Astroid.

Prostate Plan Walkthrough

1. Select the CT image set from the list of available files for import
2. Ensure that the MR is correct
 1. If MR needs to be changed you may edit it by choosing the *Edit* button to the left
3. Click the *Create New Patient* button to start the import process
4. Fill in the Patient Intent information and select the appropriate HU to RSP curve (as shown below)

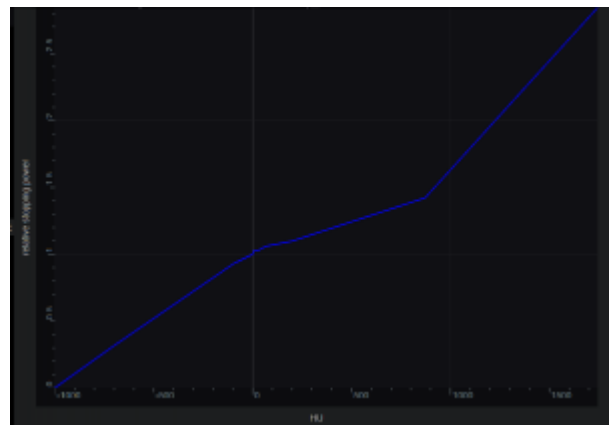
The screenshot shows the 'Patient Data' form with the following fields and values:

- Intent Data**
 - Type: Curative
 - Label: intent_curative_2016Sep13
 - Treatment Site *: Prostate_fossa_standard
 - Narrative: (empty text area)
 - Protocol: 123456 (with 'New Protocol' link)
 - Body System *: Male Reproductive System
 - Body Part *: Prostate
 - ICD-10 Code: DV004ZZ
- RSP Data**
 - HU to RSP Curve*: Scanner1; 120 kVp; FOV [0, 1000]
 - Archive DICOM on import: (checkbox)

Buttons at the bottom: 'Create Patient' and 'Cancel'.

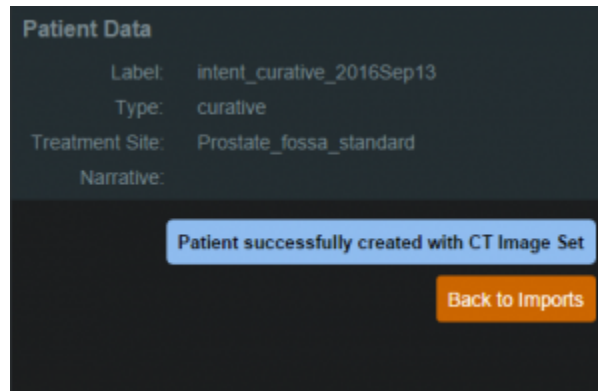
The screenshot shows the 'RSP Image' configuration panel with the following details:



- HU to RSP Curve**: Scanner1, 120 kVp, FOV [0, 1000]
- Overrides**: none
- Edit** button

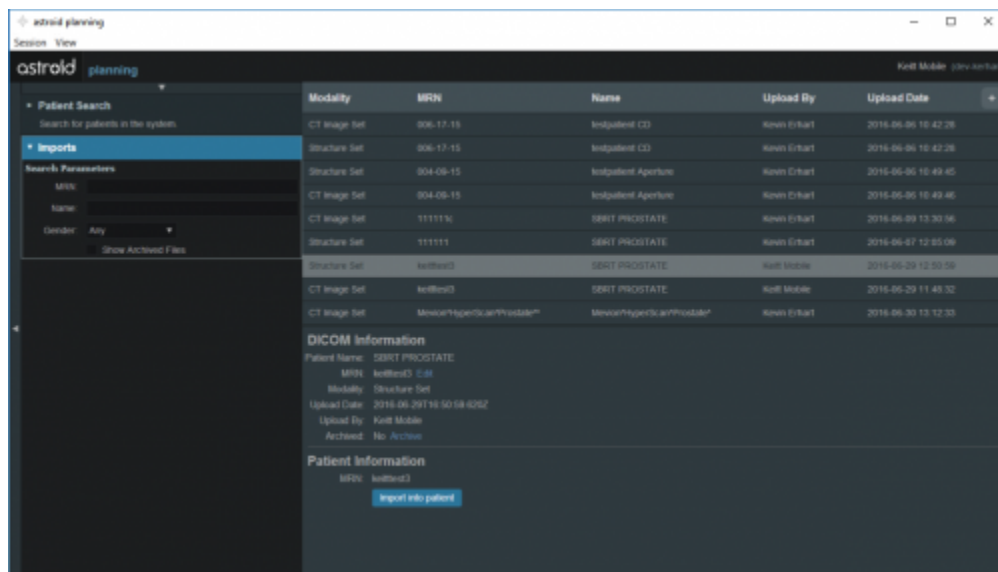


5. Click the *Create Patient* button and wait for the import to complete

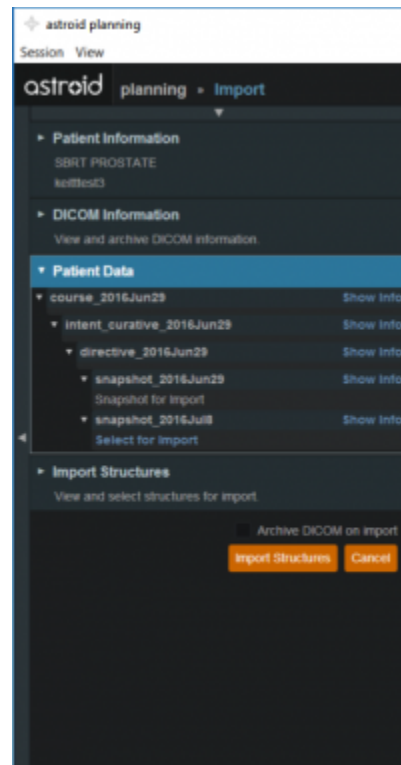
6. Click the *Back to Imports* button





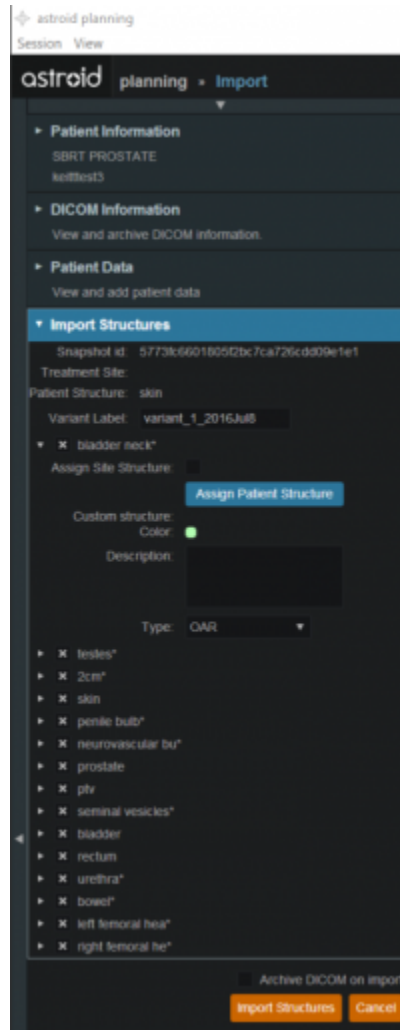
7. Select the Structure Set file that is associated with this patient
 1. Make sure Structure Set MR matches CT image set MR (make any edits to the MRN that are needed)
8. Click the *Import into Patient* button in the patient information window  Remove Mevion from this image 



9. In the control pane on the left hand side, the image snapshot will be automatically selected based on the structure set DICOM UID information, and then the *Import Structure* block will automatically expand.





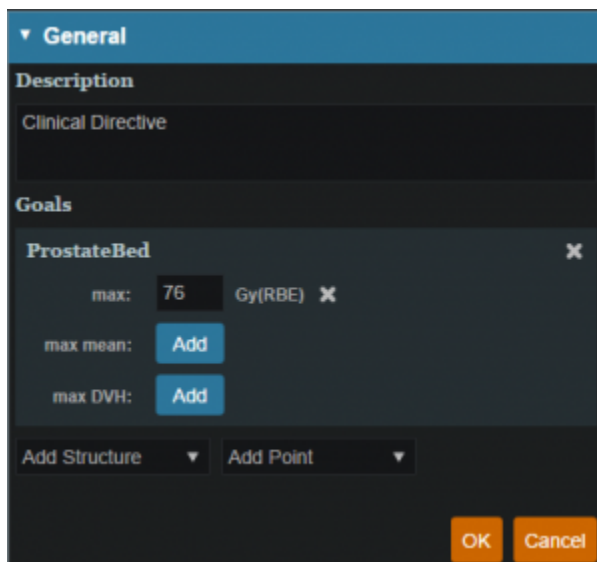
10. You will see a list of the imported structures. Here you may choose whether or not to import each structure by checking or unchecking the box beside each structure name.
 1. For this case, we will import all available structures
11. You also have the ability to assign or edit any structures that are shown as *custom*, which indicates the name did not exactly match a directive structure from the treatment site template list you specified during patient creation.
 1. Matched, Assigned, and Custom structures are designated with corresponding tags at the end of the structure name in the structure list.
 2. Assigning a custom structure to a defined directive structure will result in the imported structure inheriting all the predefined structure properties (e.g. name, type, color)
 3. For all custom structures the type is by default set to "Other" unless it contains the letters "TV" (as in PTV or CTV), in which case it is assigned the type of "Target"; this may be changed here at the import
12.  Update this to tell what to do, not open ended  Once you have all your structures customized as you would like, click the orange "Import Structures" button




13. After your structures are imported you may either choose to proceed to clicking “Open Patient” or you may import more patients by clicking “Back to Imports”

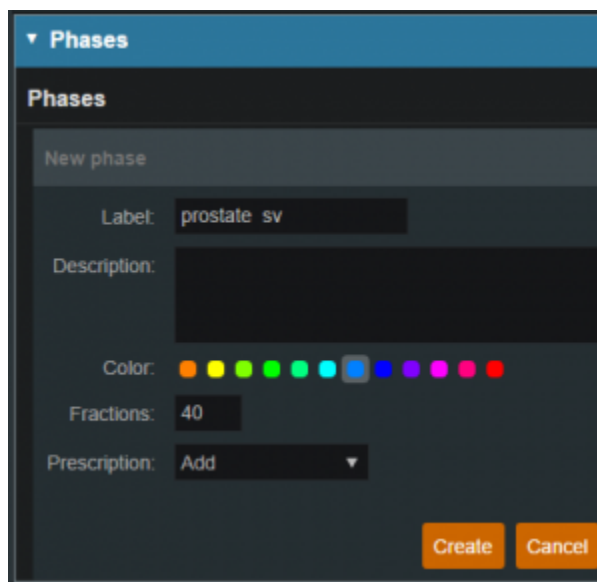


- 14. Click on the *Back to Import* button
- 15. Click the *Planning* task
- 16. Click the new patient entry from the table
- 17. First the patient prescription information will be filled
- 18. Open *Directive* block
- 19. Under *General* fill in *Goals*  Give specific *Goals* here 



20. Under *Phases* fill in *label*, *fraction* and *prescription*

1. This will be the prescription for this phase  Give specific prescription info here 





21. Click the *Add Request*

1. If this plan will only fulfill a portion of the prescription, then the *Request* should be edited to reflect this, otherwise just proceed to adding a plan
 1. In this case, we will be fulfilling the entire prescription with a single plan, so no editing is needed

22. Click *Add Plan*

1. Name the plan and click *Save*

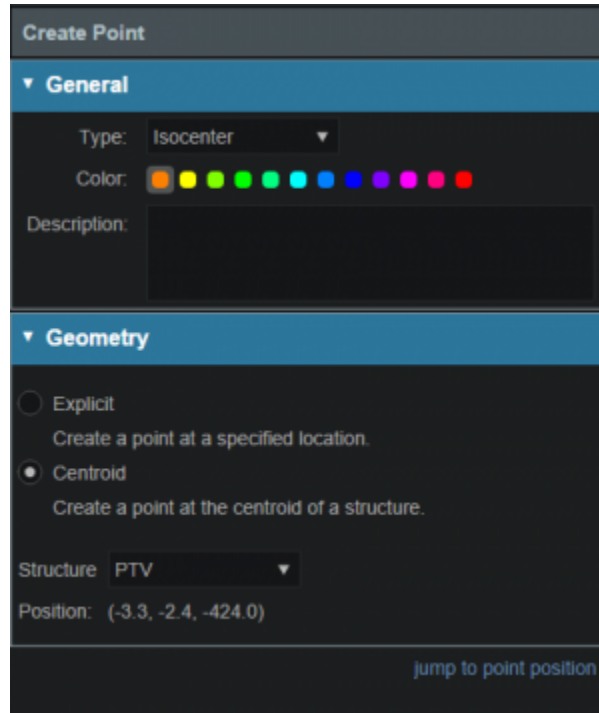
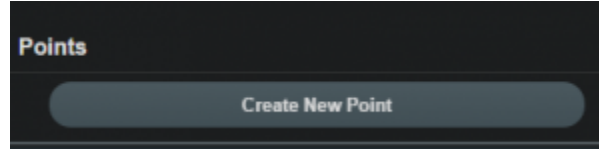
23. Open the *Plan* by selecting the *Open* button in the block

24. In the *Patient Geometry* block, create the following structures and points  No structures are listed 

1. At this point the user may create any planning structures that may be needed (if not created in contouring software), such as PTV (see [Structure Geometry](#) for details on how to Create structures)
2. We will create a point to use for the isocenter (note this step is done for illustration purposes)

is not necessary for most plans)

1. Select a type of isocenter and create the point at the centroid of the prostate

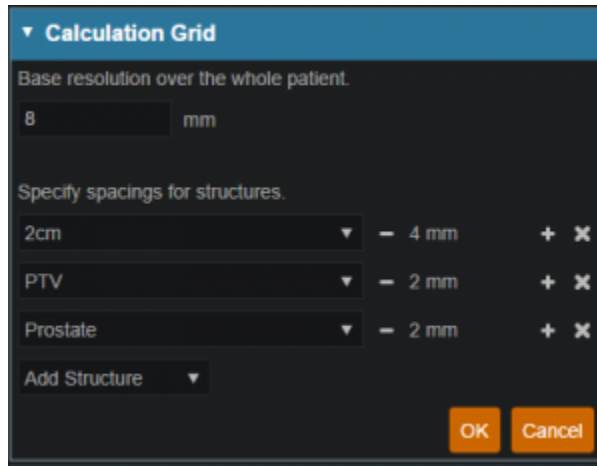


25. Open the *RSP Image* block

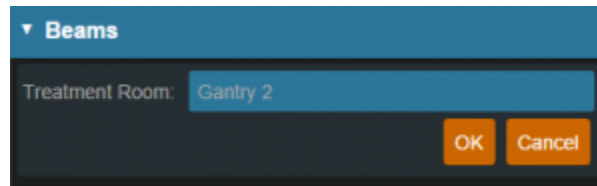
1. If any density overrides are needed they are entered here in the *RSP Image* block
2. If the HU to RSP curve was not chosen upon patient import the user may do so at this point
3. We do have any density overrides to apply for this case and the proper HU curve has already been selected, so we can move past this block

26. Open *Calculation Grid* block and define the dose calculation grid (see [Defining the Dose Grid](#) for a detailed explanation)

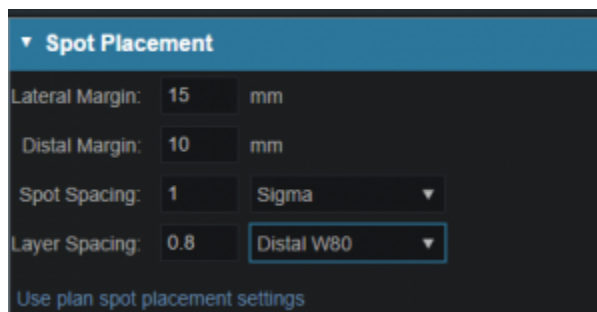
1. Use the following grid settings:
 1. Set the base grid to 8 mm
 2. Set the 2cm structure to 4 mm
 3. Set the PTV and the Prostate to 2 mm





27. Open the *Beams* block (see [Creating a New Beam](#) for detailed explanation)
 1. Choose "Gantry 2" from the *Treatment Room* dropdown

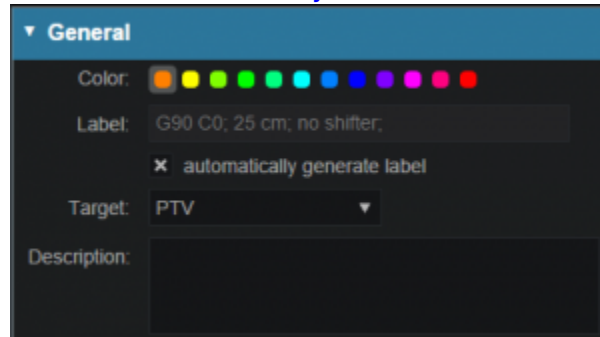


2. Expand the *spot placements* sub-block and set the following values (note this is the plan level spot placement, so it will apply to all our beams)
 1. Lateral margin- 15 mm
 2. Distal margin- 10 mm
 3. Spot spacing- 1 sigma
 4. Layer spacing- .8 Distal 80



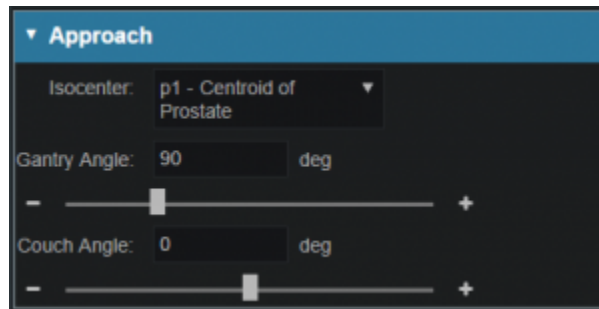
3. Now we will make our beams
4. Start by clicking *Create New Beam*
5.  give specific beams and parameters to use so that a good plan will be achieved
 
 1. Enter the following for each beam
 1. General (target)
 1. The user may choose to automatically generate the beam label or manually enter a label
 1. if the user chooses to automatically generate the label the label will contain the gantry angle, the couch angle, the snout and the shifter
 2. the user may choose the color that the beam will be denoted in
 3. the user will need to choose a target from the dropdown or create a

new target (see [Structure Geometry](#))



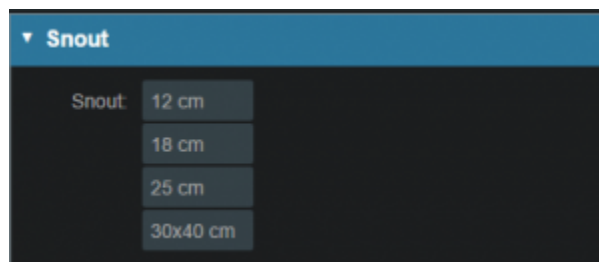
2. Approach

1. At this point the user will choose the isocenter as well as enter the gantry angle and the couch angle
2. Beam orientation should be chosen so as to have the shortest and most homogeneous distance to the target
3. Gantry angles in the range of 90 and 270 (+/- 5 degrees) are typical for prostate plans
4. If the patient has hip prosthesis the angles may need to be increased in order to get adequate coverage



3. Snout

1. The user will choose a snout next
2. Depending on the size of the prostate a 12cm snout should be adequate.
3. If the pelvic nodes need to be included the user may need to increase the snout size to the 18 or 25cm snout

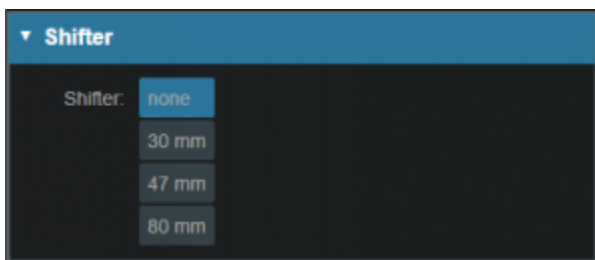


4. Aperture (if desired)

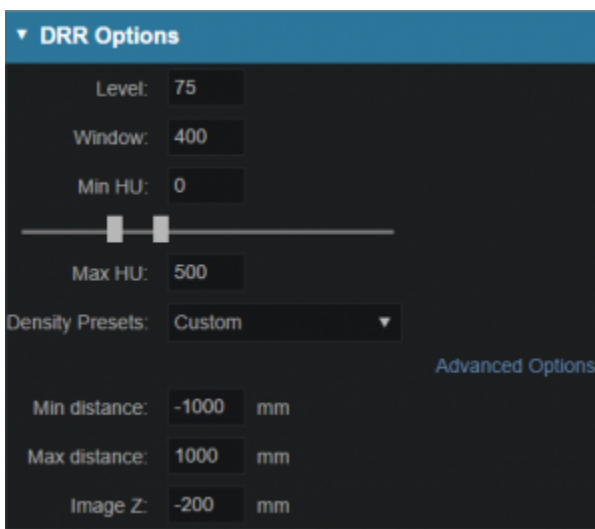
1. If there is the need to use an Aperture for sharper penumbra the user can do so at this juncture (see [Creating an Aperture](#))
2. ASTROID has the ability to utilize an Aperture with pencil beam scanning (IMPT)

5. Shifter

1. For prostate plans there typically is no need to add a shifter
2. If there is a need to add one the user may choose one from the list








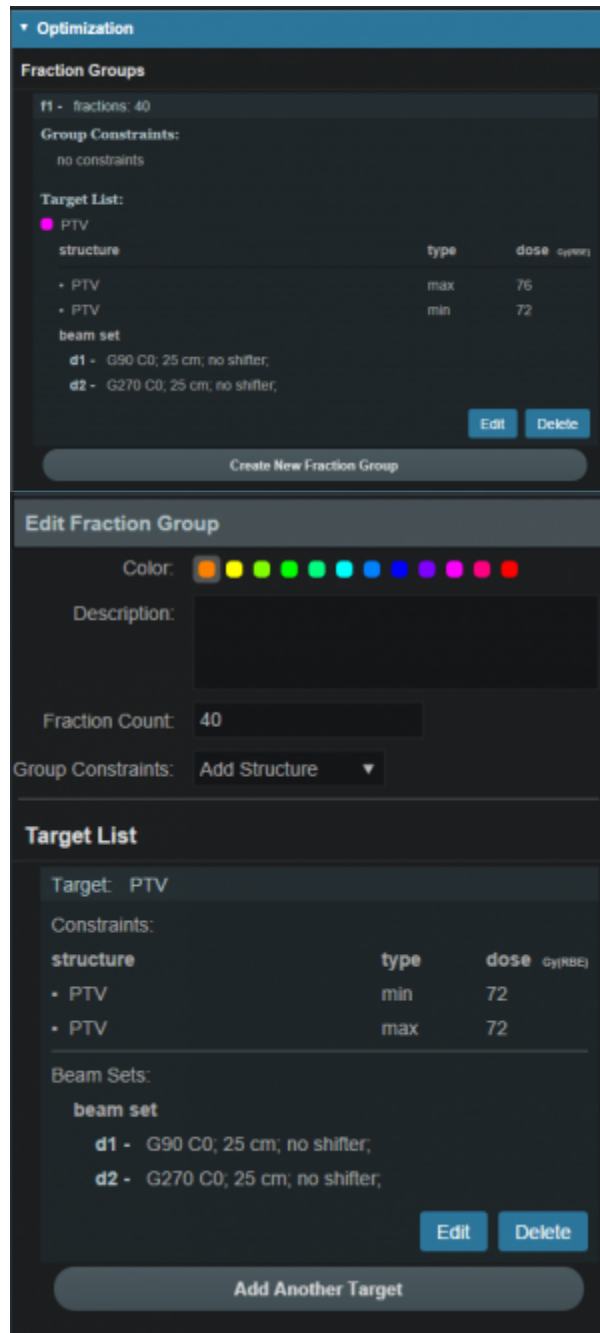
6. Air gap
 1. Depending on patient size, gantry angle etc the user may choose to enter an air gap
 2. The default air gap is 30mm
 3. By clicking on the + or - at the sides the user can increase/decrease the airgap
7. Spot placement
 1. may choose individual spot placements for each beam or leave with original chosen placements
8. DRR options
 1. The user may choose one of the preset *Density Presets* from the drop down or manually set the *level, window, min HU* and *max HU*
 2. The user may also choose to go into *Advanced Options* for more control of the DRR's



2. After one beam is created the user may clone it and change beam angles etc as necessary or they may choose to create a whole new beam



28. With the beams complete, we can now move on organizing our treatment fraction groups and specifying the constraints and objectives
29. Open the *Optimization* block (see [Astroid Optimization](#) for a detailed explanation of *Optimization, Feasibility* and *Constraints*, as well as *Running the Optimizer*)
 1. Create a New Fraction Group under the Fraction Group block
 1. Enter a Fraction Count of **Fix Me!**

2. Create Group Constraints as ... 
3. Add a new Target to the *Target List*
 1. Set the Target to the 
 2. Create the following *Beam Set*  Give the details of the beam set 
 1. Select the beams that will be associated with this fraction group
 3. Constraints for the associate target
 1. Typically the user will put in the prescription dose for the target as a min or mean constraint and the max dose they are willing to allow as a max constraint
 2. Here we will create ... 





4. Click *Create* to complete the Target entry and then *Create* again to complete the

Fraction Group

2. Open the *Plan Constraints/Objectives* block
 1. Enter the *Constraints* for the planning volumes first
 1. These are the “hard stops/non negotiables” for the plan
 2. These doses will be decided per the users' department protocols
 3. For this case we will use the following:
 1.  List plan level target constraints here
 2.  Add note about starting out with target constraints first and why feasibility is broken into two steps
 3. Run the *Feasibility* by choosing the calculate option



4. Enter the *Constraints* for the OAR's
 1. Constraints for OAR's are like the constraints for the planning volumes- non negotiable
 2. Again these will be set per department protocol
 3. For this example we will use the following ... 
5. Run *Feasibility*
6. Enter the *Objectives*
 1. *Objectives* are the goals the user would like to achieve and these will be the driving forces for the optimizer
 2. For this example use the following objectives 

Plan Constraints / Objectives			
Constraints			
structure	type	dose	system
• PTV	max	76	
• PTV	min	72	
• Rectum	max_mean	55	
• Bladder	max_mean	50	
• Skin	max	76	
• Skin	max_mean	45	
Edit			
Objectives			
structure	type	dose	system
• Rectum	max_mean	—	
• Prostate	max_min	—	
• Prostate	min_underdose	72	
• Testes	min_max	—	
• Testes	min_mean	—	
• s1 - Left Femoral Hea u Right Femoral He	min_overdose	45	
• PTV	min_max	—	
• PTV	max_min	—	
Edit			

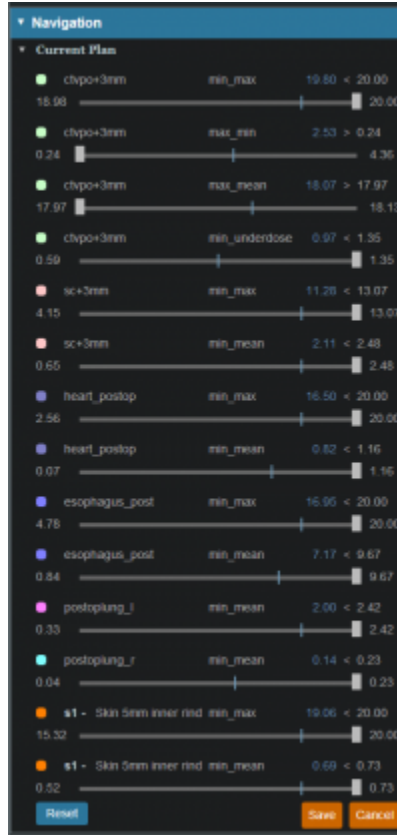
7. Run the MCO


30. Once the MCO has been completed, you can adjust the objectives using the slider bars in the *Navigation* block (see [Astroid Optimization Navigating the Solutions](#) for a detailed explanation of using the slider bars)

1. Adjust the slider bars in the *Navigation* block to find what you feel is the optimal plan for this

case

1. Note: All of these adjustments are made without the user having to run a new plan
2. If you find a plan that you like, but wish to continue exploring further, you can click the *Save* button to save the current slider state
3. You may then return to the last saved state at any time by clicking the *Reset* button
4. The *Cancel* button will close the navigation block without saving the current state

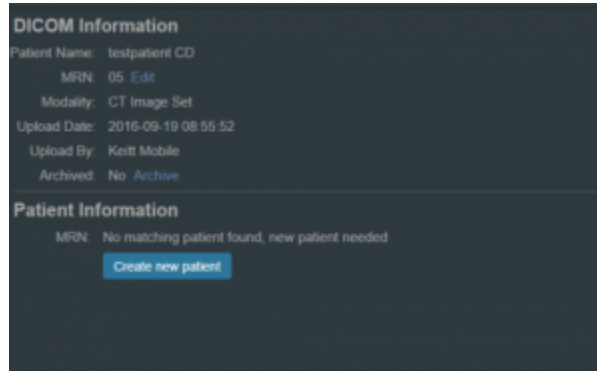


31.  Add some sort of ending here ...

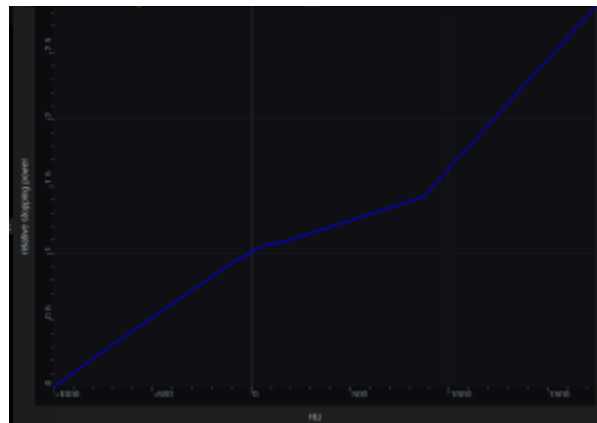
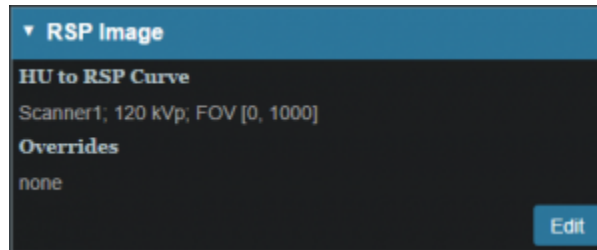
2016/08/29 16:28

Complex Plan Walkthrough

1. Select the CT image set from the list of available files for import
2. Ensure that the MR is correct
 1. If MR needs to be changed you may edit it by choosing the *Edit* button to the left
3. Click the *Create New Patient* button to start the import process



4. Fill in the Patient Intent information and select the appropriate HU to RSP curve (as shown below)



5. Click the *Create Patient* button

The screenshot shows a form titled "Patient Data" with a dropdown arrow. It is divided into two main sections: "Intent Data" and "RSP Data".

Intent Data:

- Type: Curative (dropdown)
- Label: intent_curative_2016Sep19
- Treatment Site *: Medullo (dropdown)
- Narrative: (text area)
- Protocol: 123456 (dropdown) with a "New Protocol" link
- Body System *: Central and Peripheral Nervous System (dropdown)
- Body Part *: Brain (dropdown)
- ICD-10 Code: D0004ZZ

RSP Data:

- HU to RSP Curve*: Scanner2; 140 kVp; FOV [0, 1000] (dropdown)

At the bottom, there is a checkbox for "Archive DICOM on import" and two orange buttons: "Create Patient" and "Cancel".

6. Once the CT dataset has finished importing select the *Back to Imports* button

The screenshot shows a "Patient Information" window with the following details:

Patient Information:

- Name: testpatient CD
- MRN: 05
- Sex: Female
- Date of Birth: 1969-12-31

DICOM Information:

- Modality: ct
- Upload Date: 2016-09-19
- Updated By: Keitt Mobile

Patient Data:

- Label: intent_curative_2016Sep19
- Type: curative
- Treatment Site: Medullo
- Narrative: (empty text area)

At the bottom, there is a blue success message: "Patient successfully created with CT Image Set" and an orange button: "Back to Imports".

7. Select the Structure Set file that is associated with this patient
 1. Make sure Structure Set MR matches CT image set MR
8. Click the *Import into Patient* button
9. Select the structure set associated with the imported CT Images. Again at this time you make any edits to the MRN that are needed. As in the CT Image import select the blue "Import into patient" button in the patient information window

10. On the left hand side open the Import Structure block.



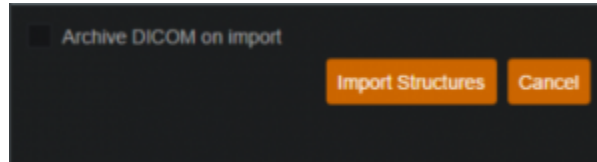
11. You will see a list of structures that have been contoured on the image set. Here you may choose to delete (not importing it) the structure hitting the x beside the structure name.

12. You also have the ability to edit any custom structure that does not match the directive level structures defined in the site configuration. These custom structures are designated with an asterisk(*) at the end of the structure name in the structure list.

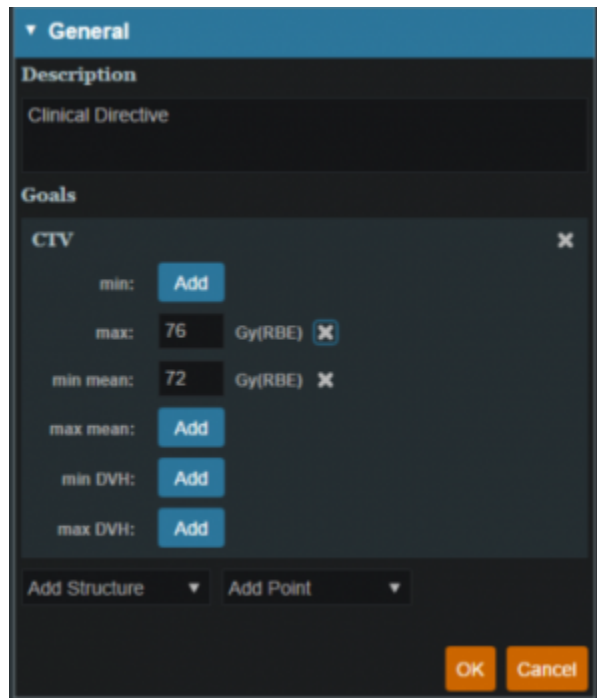
1. You may chose to optionally assign a custom structure to a defined site structure. Doing so will result in the imported structure inheriting all the predefined structure properties (e.g. type, color).

2. For a custom structure the type is by default set to "Other", but may be changed here at the import.

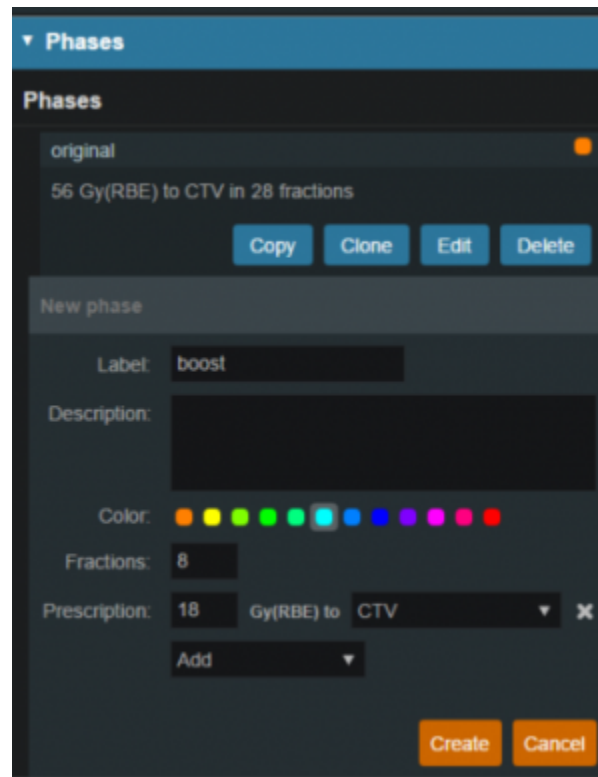
13. Once you have all your structures customized as you would like click the orange "Import Structures" button



- 14. After your structures are imported you may either choose to proceed to clicking "Open Patient" or you may import more patients by clicking "Back to Imports"
- 15. Click on the *Back to Import* button
- 16. Click the *Planning* task
- 17. Click the new patient entry from the table
- 18. First the patient prescription information will be filled
- 19. Open *Directive* block
- 20. Under *General* fill in *Goals*



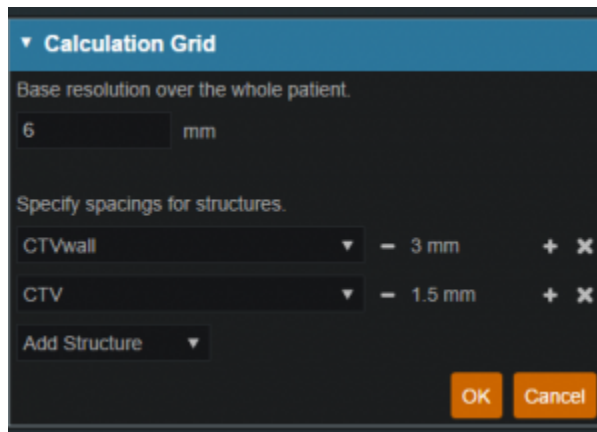
- 21. Under *Phases* fill in *label*, *fraction* and *prescription*



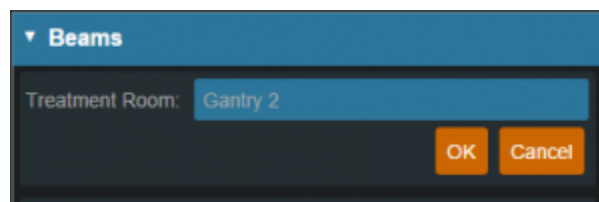
1. This will be the prescription for this phase
2. You may enter multiple phases at this point if you would like
 1. The doses entered here will be for each phase
22. Click the *Add Request*
 1. If desired edit the *Request* as needed
23. Click the *Add Plan*
 1. Name the plan
24. Open the *Plan* by selecting the *open* button in the block
25. In the *Patient Geometry* block create structures and points that may be needed for planning
 1. At this point the user may enter any planning structures that may be needed such as PTV (if not created in contouring software) (see [Structure Geometry](#) for details on how to Create structures)
 2. Combination structures
26. Choose isocenter location
 1. The isocenter is typically either the center of the tumor volume or the center of the PTV



- 27. If any density overrides are needed enter them in the *RSP Image* block
 - 1. If the HU to RSP curve was not chosen upon patient import the user may do so at this point
- 28. Open *Calculation Grid* block and insert how you would like the grid (see [Defining the Dose Grid](#) for a detailed explanation)
 - 1. Typical grid settings are as follows
 - 1. Set the base grid to 6
 - 2. Set an expansion to 3
 - 3. Set the tumor volume to 1.5

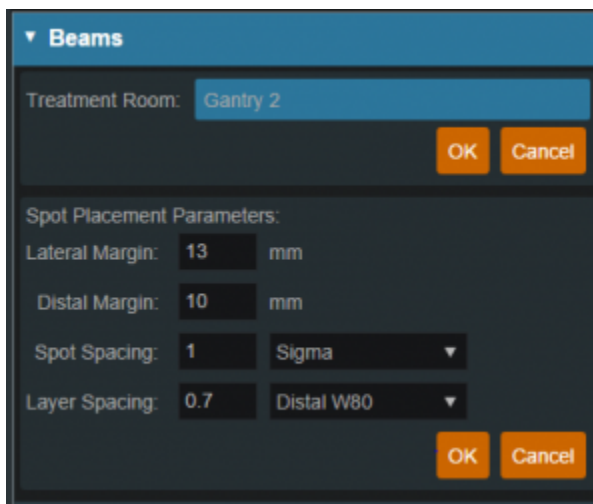


- 29. Open the *Beams* block (see [Creating a New Beam](#) for detailed explanation)
 - 1. Choose *machine* from dropdown



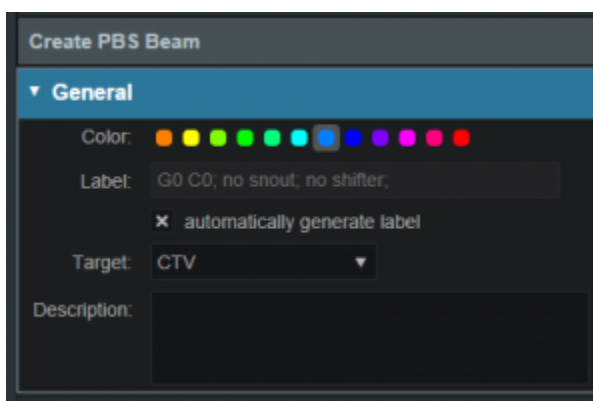
- 1. Choose *spot placements*
 - 1. The user may use the default spot placements or choose to enter custom placements

1. Spot placements are machine dependent
2. Typical spot placements for head and neck plans are as follows
 1. Lateral margin- 13mm
 2. Distal margin- 10mm
 3. Spot spacing- 1 sigma
 4. Layer spacing- .7 Distal 80



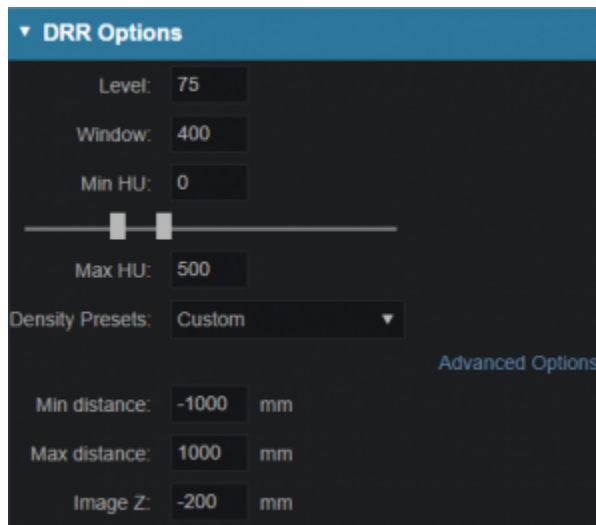
2. Create beams

1. Enter the following for each beam
 1. General (target)
 2. The user may choose to automatically generate the beam label or manually enter a label
 1. if the user chooses to automatically generate the label the label will contain the gantry angle, the couch angle, the snout and the shifter
 2. the user may choose the color that the beam will be denoted in
 3. the user will need to choose a target from the dropdown or create a new target (see [Structure Geometry](#))



1. Approach
2. At this point the use will choose the isocenter as well as enter the gantry angle and the couch angle
 1. Beam orientation should be chosen so as to have the shortest and most homogeneous distance to the target

2. Gantry angles
 1. The gantry angles that are chosen need to be so that the beams will travel the shortest distance and produce the most homogenous beam
 2. If there is any metal (such as fillings or implants) in the field the angles need to be adjusted accordingly to avoid these areas
3. Snout
 1. The user should choose the smallest snout that will provide appropriate coverage
4. Aperture (if desired)
 1. If there is the need to use an Aperture for sharper penumbra the user can do so at this juncture (see [Creating an Aperture](#))
 2. ASTROID has the ability to utilize an Aperture with pencil beam scanning (IMPT)
5. Shifter
 1. If the plan is IMPT there is typically no need for a shifter
6. Air gap
 1. Depending on patient size, gantry angle etc the user may choose to enter an air gap
 2. The default air gap is 30mm
 3. By clicking on the + or - at the sides the user can increase/decrease the airgap
7. Spot placement
 1. may choose individual spot placements for each beam or leave with original chosen placements
8. DRR options
 1. The user may choose one of the preset *Density Presets* from the drop down or manually set the *level, window, min HU* and *max HU*
 2. - The user may also choose to go into *Advanced Options* for more control of the DRR's



- 9. Calculate SFO dose if desired
 - 1. If the user would like to evaluate the contribution from a single beam they may do so at this point by choosing the calculate option in the SFO dose block



- After one beam is created the user may clone it and change beam angles etc as necessary or they may choose to create a whole new beam
 - 1. If the plan is going to utilize multiple phases or fractions it is advisable for all the beams that will be used to be entered at this juncture
- Open the *Optimization* block (see [Astroid Optimization](#) for a detailed explanation of *Optimization*, *Feasibility* and *Constraints*, as well as *Running the Optimizer*)
 - 1. *Create a New Fraction Group* under the *Fraction Group* block

Fraction Groups

View Mode: Collapsed Compact Detailed

Done

f1 - fractions: 14

Group Constraints:
no constraints

Target List:

STV

structure	type	dose	cy(week)
• CTV+3mm	min_mean	28	
• Skin	max	29.4	

beam set

d1 - G290 C0, 25 cm, 47mm;
d3 - G165 C-90, 25 cm, 47mm;

f2 - fractions: 14

Group Constraints:
no constraints

Target List:

STV

structure	type	dose	cy(week)
• CTV+3mm	min_mean	28	
• Skin	max	29.4	

beam set

d2 - G70 C0, 25 cm, 47mm;
d4 - G290 C80, 25 cm, 47mm;

f3 - fractions: 4

Group Constraints:
no constraints

Target List:

STV

structure	type	dose	cy(week)
• CTV	min_mean	7	
• Skin	max	8.4	

beam set

d5 - G260 C0, 25 cm, 47mm;
d8 - G135 C0, 25 cm, 47mm;

f4 - fractions: 4

Group Constraints:
no constraints

Target List:

STV

structure	type	dose	cy(week)
• Skin	max	8.4	
• CTV	min_mean	7	

beam set

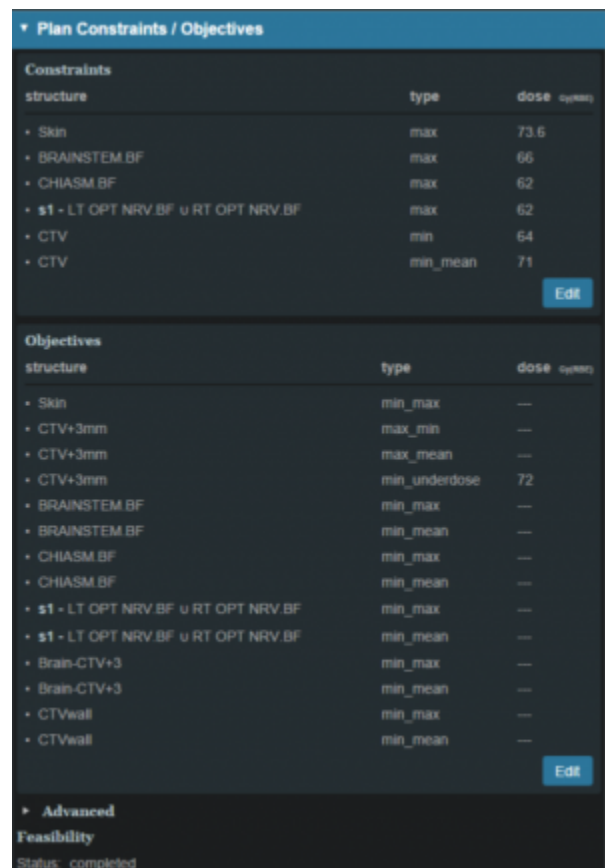
d6 - G85 C0, 25 cm, 47mm;
d7 - G220 C0, 25 cm, 47mm;

Create New Fraction Group

1. Enter Fraction Count
2. Enter Group Constraints
3. Enter Target List
 1. Target
 2. Beam Set
 1. Associated beams
 3. Constraints for the associated target
 4. In the example given above the user has shown how a base plan and a boost may be entered
 1. The user should enter the constraints for each fraction group

- Open the *Plan Constraints/Objectives* block

1. Enter the *Constraints* for the planning volumes first
 1. In the case of a base plan and a boost plan the constraints should be for the total plan dose here
2. Run the *Feasibility*
3. Enter the *Constraints* for the OAR's
4. Run Feasibility
5. Enter the *Objectives*
 1. In the case of a base plan and a boost plan the objectives should be for the total plan dose here



6. Run the MCO

- Once the MCO has been completed the user will be able to adjust the objectives using the slider bars in the *Navigation* block (see [Astroid Optimization Navigating the Solutions](#) for a detailed explanation of using the slider bars)

1. By adjusting the slider bars in the *Navigation* the user can come up with the optimal plan
2. All of these adjustments may be made without the user having to run a new plan
3. If at any point the user does not like the adjustments made they may return to the original settings by choosing the *Reset* button
 1. This will take the user back to the last saved state
4. The *Save* button will save the plan in its current state
5. The *Cancel* button will close the plan in its current state block



2016/09/02 15:30

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Last update: **2016/09/20 17:45**