VMAT TBI Planning Tool User Manual

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1 Introduction

Welcome to the user manual for VMAT TBI Planning Tool. This document is intended to provide you with all the information needed to utilize the script for VMAT TBI treatment planning. The VMAT TBI planning tool is an Eclipse Scripting API (ESAPI) application.

2 System Requirements

Please make sure your Varian Eclipse Treatment Planning system meets the following requirements before installation:

Version: Varian Eclipse version 15.6 or higher.
License: Varian Eclipse Scripting API license installed. Version 15.6 or higher.
Calculation Algorithm: AAA version 15 or higher available for calculation.
Linear Accelerator Model: Varian TrueBeam with Millennium MLC.

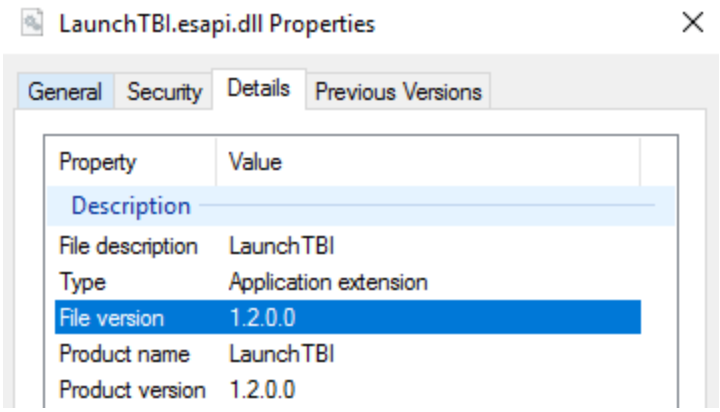
3 Installation Instructions

To install VMAT TBI Planning Tool please follow these steps:

1. Download the file VMAT-TBI_Planning.zip from Varian Medical Affairs repository.

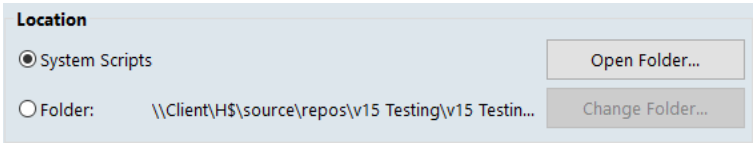
2. Unzip the file. There should be a single file named “LaunchTBI.esapi.dll” and a folder named “VMAT_TBI”.

3. Right click on the LaunchTBI.esapi.dll and select Properties. From the Details tab, note the current version of the software, as in the figure below.



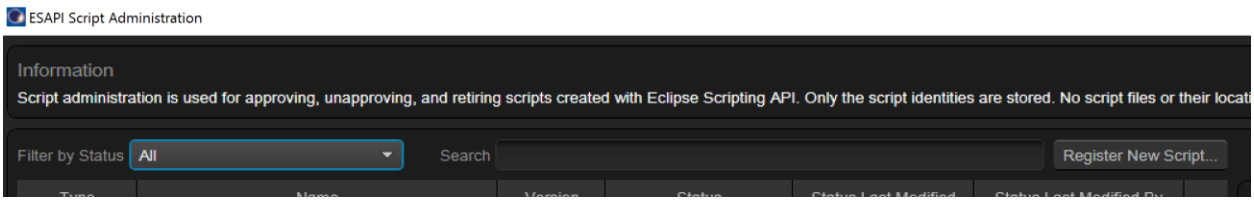
The current version for this release is 1.2.0.0

4. Move both the file and folder into the System Scripts folder set within the institutional organization. This path can be found in Eclipse by opening the Scripts window from the Tools toolbar. Highlight the "System Scripts" radio button and then click the "Open Folder…" button and move the file and folder into this destination.



This application generates structures, fields, plans, and doses within Eclipse, and therefore requires write access that must be applied in the ESAPI Script Administration. Note that this permission is not needed in Eclipse databases set to Research Mode.

5. Go to Tools, Script Approvals and click on "Register New Script". Navigate to the subfolder VMAT_TBI, and select **VMAT_TBI.exe**.



6. Confirm the Version of the software matches the version checked earlier. **The version for this release is 1.2.0.0.**

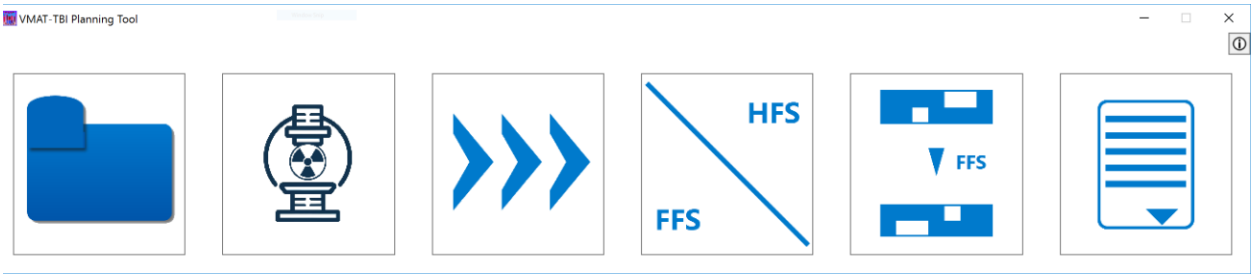
7. Provide the file with either Approve or Approve for Evaluation Testing status.

8. Apply and click OK.

Any future update to the script will be identified by an updated version and will require re-approval of the new script as the existing script is retired.

4 User Interface Overview

The VMAT TBI Planning Tool user interface is designed to be intuitive and easy to use. The user interface provides access to six different modules that flow sequentially from left to right. Here is a brief overview of the different parts of the interface:



4.1 Launching the VMAT TBI Planning Tool

To launch the VMAT TBI Planning tool:

1. Go to Tools -> Scripts

2. Select the radio button ‘Folder’ and click on ‘Change Folder’

3. Browse to the location where the file LaunchTBI.dll resides

4. LaunchTBI.dll will show now in the selection menu.

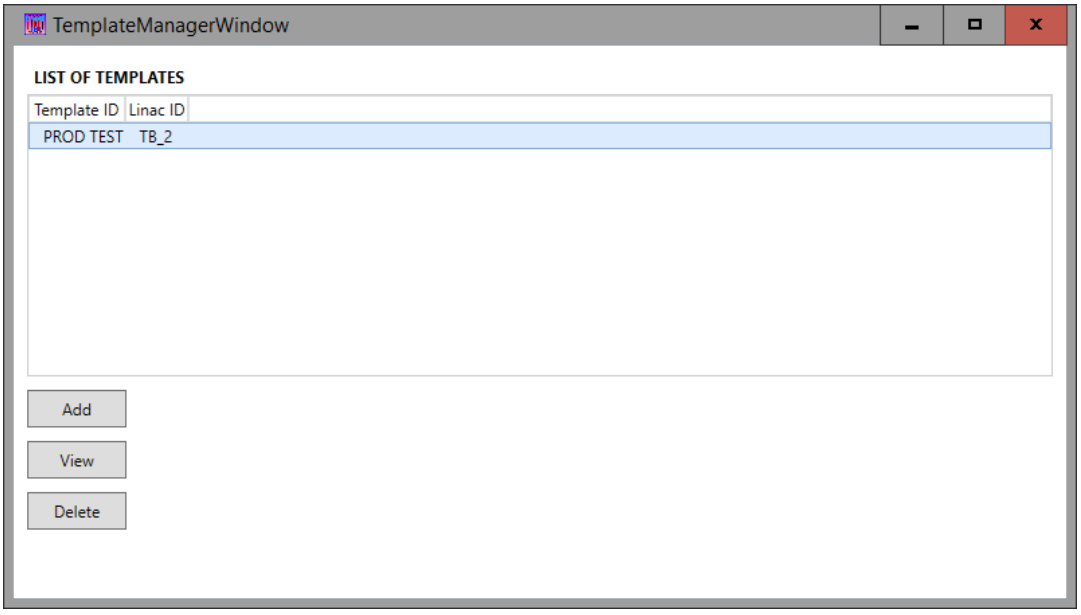
5. Select LaunchTBI.dll and click ‘Run’.

The VMAT TBI tool is comprised by six modules. Below there is a description of the usage of the tool per individual module.

4.2 Template Manager

The Template Manager allows the user to create, view and delete templates for VMAT TBI treatment planning. Templates are responsible for storing treatment machine settings, prescription doses, OAR dose constraints, and PTV rules for user defined treatment regimens for future use.

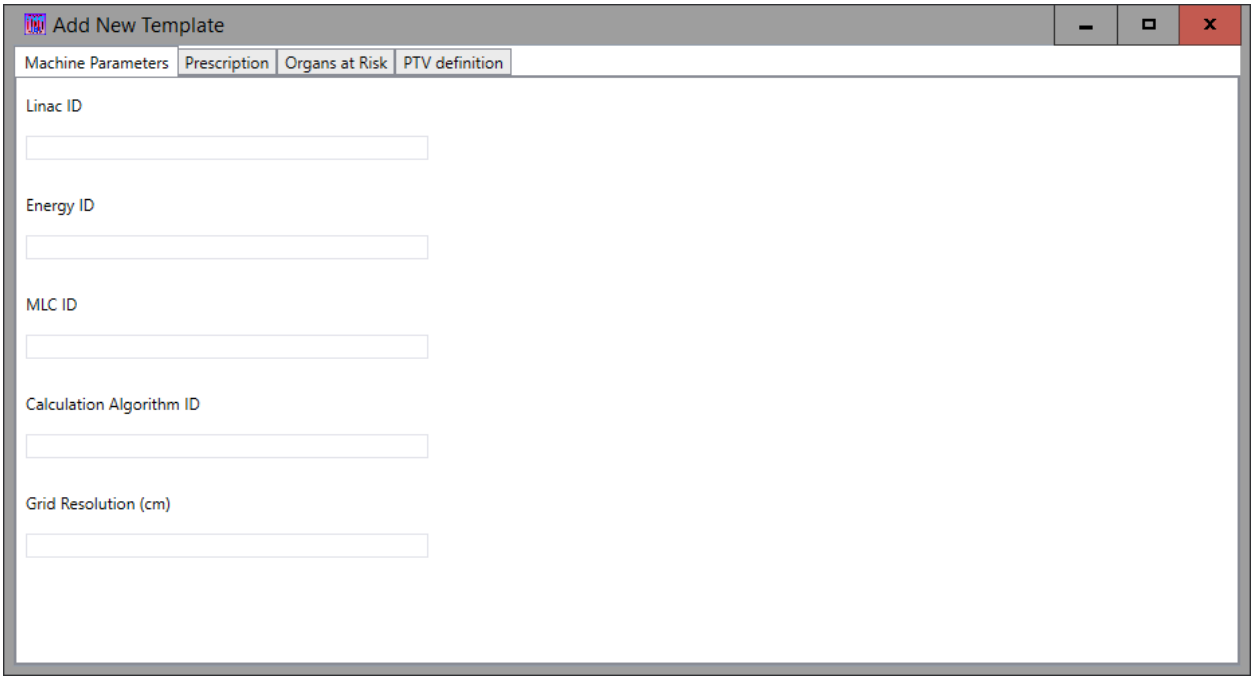
By clicking in the Template Manager button the user will be shown the available templates, and the possible options to either create a new template, view an available template, or delete a template.



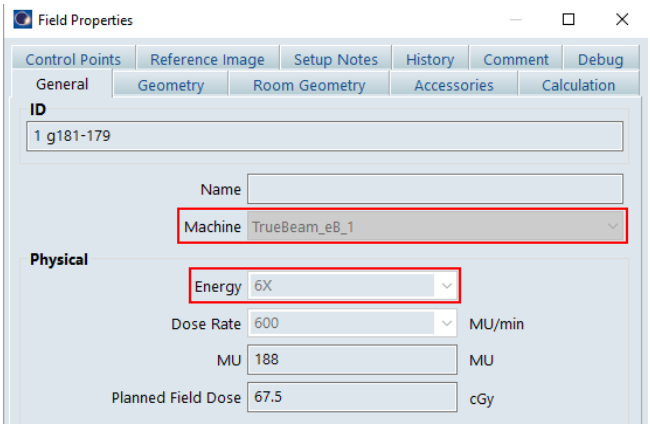
The figure above displays the Template Manager. An example template with ID ‘PROD TEST’ for Linac ‘TB_2’ is available by default.

- Adding a New Template

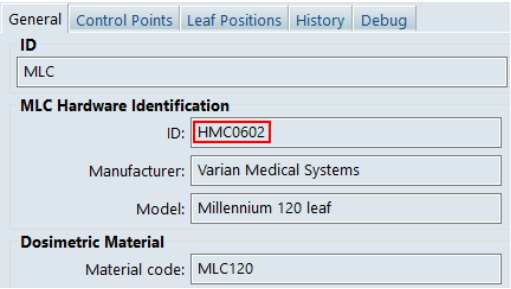
By clicking in ‘Add’, the user will be presented with the Template Editor as shown below.



Note that the template editor contains four tabs based on the information category needed for the template. All tabs need to be completed before saving a new template. Values for each of these can be found in Eclipse from a loaded plan with the desired machine, energy, and MLC model. Linac ID and Energy ID can be found by right clicking on a treatment field in a loaded plan and looking in the General tab:



The MLC ID can be found by right clicking on an MLC within an MLC-blocked field and reviewing the Properties and General tab:

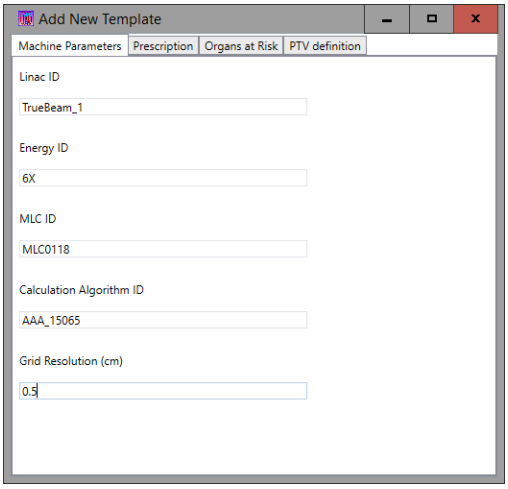


The Calculation Algorithm ID can be found in the Info Window under the Calculation Models:

Particle Type	Calculation Type	Calculation Model	Use GPU	
Photon	Volume Dose	AAA_15605		OK
	DVH Estimation	DVH Estimation Algorithm [15.6.05]		OK
	Portal Dose	PDIP_15605		OK
	Beam Angle Optimization	PGO_13714		Not supported
	IMRT Optimization	PO_15605	☐	OK

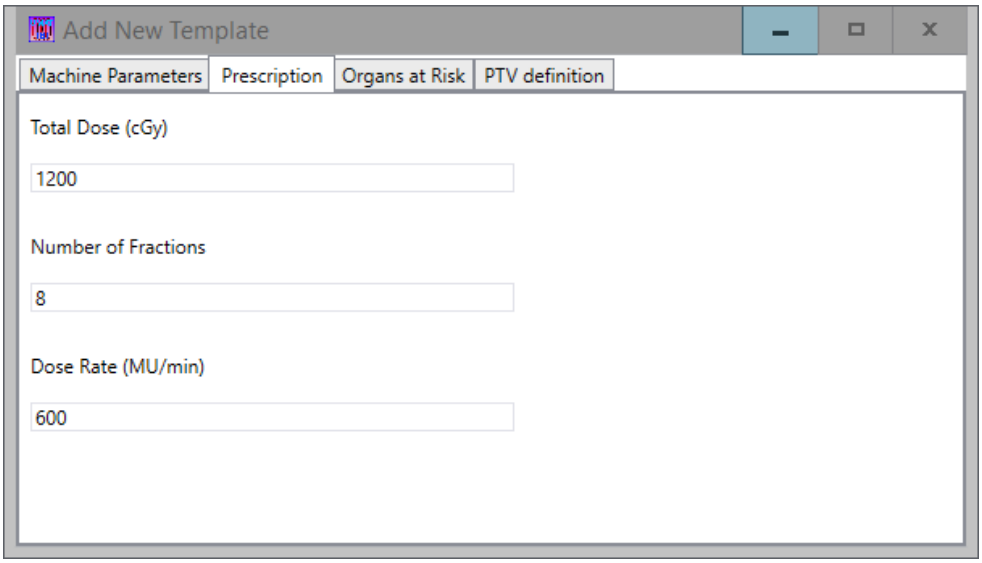
- Machine Parameters Tab

In this tab, presented in the image above, the user needs to enter five parameters: Linac ID, Energy ID, MLC ID, Calculation Algorithm ID and desired Grid Resolution in cm. Below there is an example, however, values will be institution dependent. The Grid Resolution will be dependent on the algorithm and will affect the optimization and dose calculation depending on the memory and processors available in the calculation environment. This application was developed using 0.5 cm exclusively for VMAT TBI.



- Prescription Tab

In the prescription tab, the user must enter the total dose (cGy), number of fractions and dose rate (MU/min). See below an example. Note that while the script can work with both systems configured in Gy or cGy, the templates **must be set in cGy.**



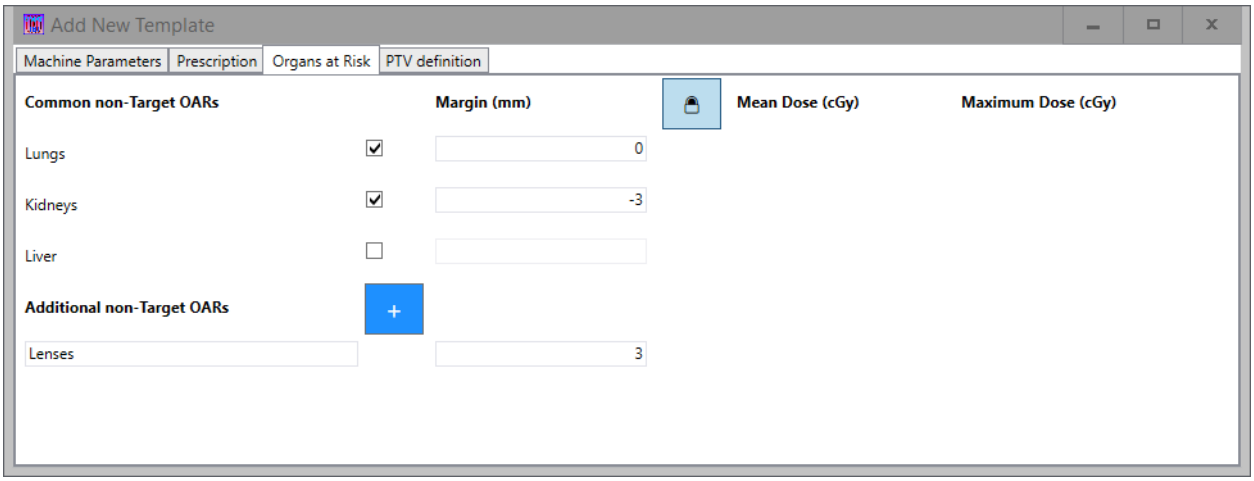
- Organs at Risk Tab

In this tab, the user will enter the desired Organs at risk (OARs) to be spared. The tab is divided into common OARs and additional OARs.

Common OARs: To select sparing for lungs, kidneys or liver, the user only needs to select the appropriate checkbox and enter a desired OAR margin. During PTV creation, the selected OARs will be subtracted from the PTV. If a positive margin is selected, the PTV will have an additional margin from the OAR. If a negative margin is selected the PTV will be extended into the OAR by that margin amount.

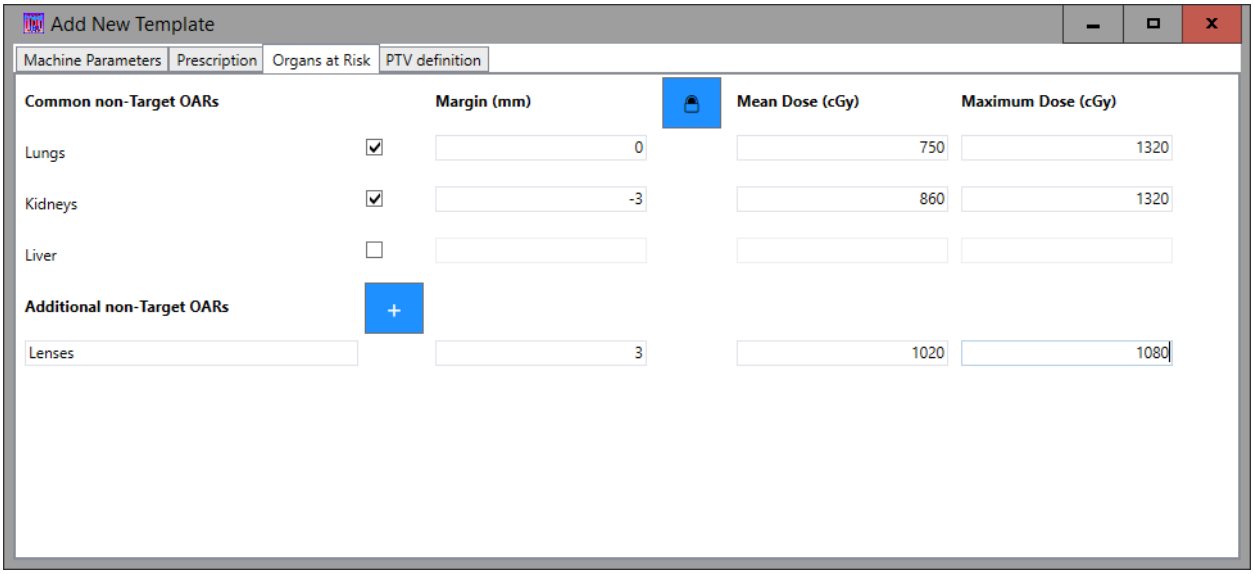
Additional OARs: Users can enter a maximum of five additional OARs by pressing the plus sign, entering an OAR ID and a margin.

Below is an example that creates a template to spare Lungs, Kidneys and Lenses. The Lungs in this example are subtracted from the PTV without any margin (0), the PTV includes the first 3 mm of the kidneys (-3 mm margin), and the lenses plus 3 mm are subtracted from the PTV (3 mm margin).



Dose Objectives: If explicit objectives are not entered, the script will balance and ALARA approach with a minimum coverage goal of PTV V100% > 90% and PTV D98% > 85%. In most cases, this should provide mean doses below 65% Rx dose for larger organs such as the lungs, below 75% Rx dose for medium sized organs such as the kidneys, and below 90% Rx dose for very small OARs such as the lenses.

However, the user can set specific sparing goals by unlocking the mean and maximum OAR doses by clicking the lock button. Below is the same example with user-defined criteria for OAR sparing.



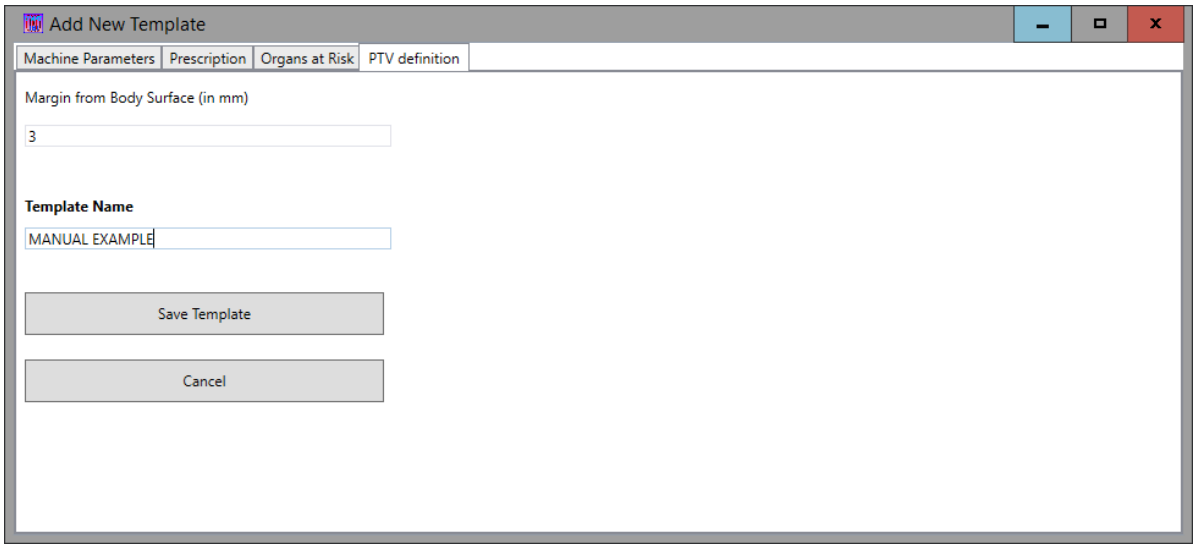
Do not click lock button after setting user-defined goals or the software will default to ALARA criteria instead of entered values.

Be cautious when setting user-defined goals, as the software will not check for the validity of these values and odd results can be obtained if sparing goals are unrealistic for the technique.

- PTV definition Tab

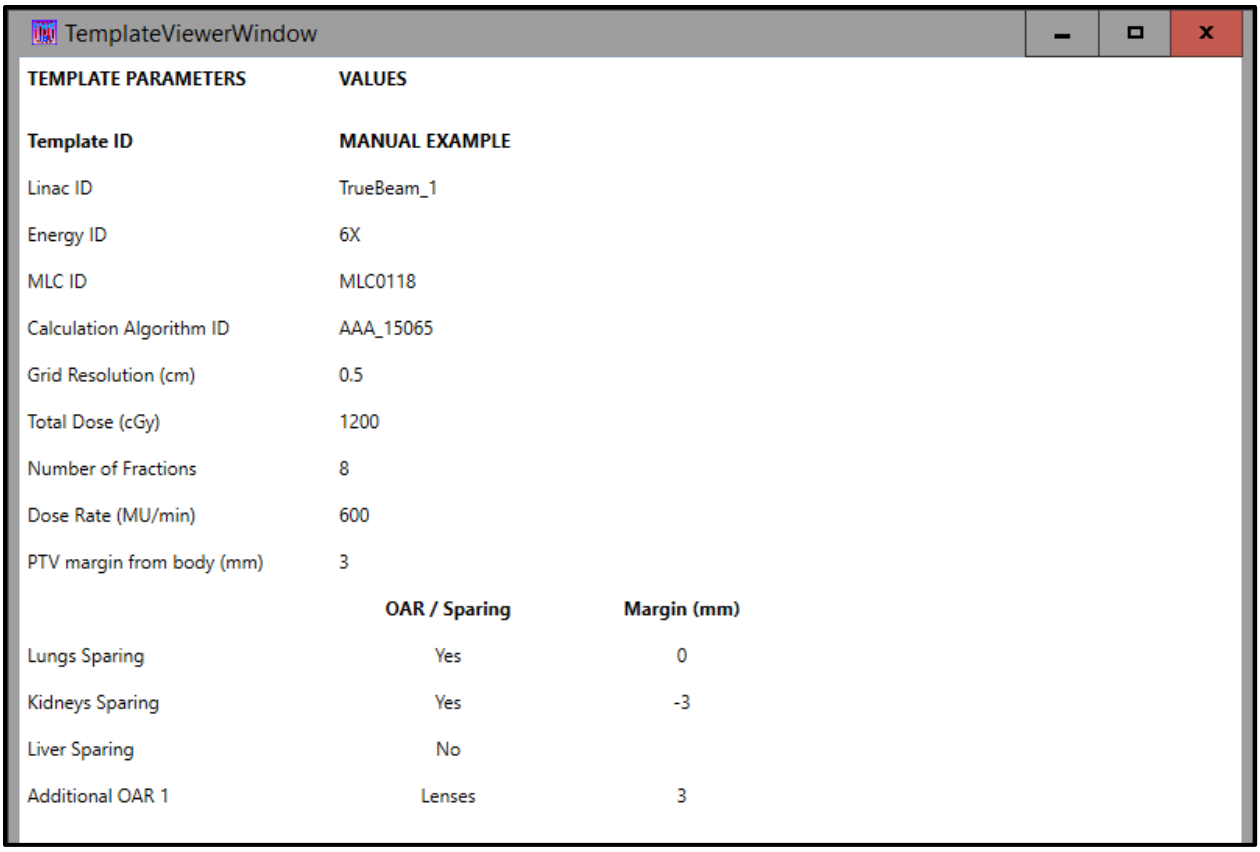
In this tab, the user can select a margin to create the PTV from the Body_Only contour (excluding immobilization or couch structures). The PTV will be cropped by the body surface by the amount entered in this field. Be conscious of the buildup needed when setting up this value. Values above 3 mm are recommended in this field.

Additionally, the user must enter a name for the template in order to save it into the database.



- Viewing an Existing Template

Users can see the parameters of any template by selecting the Template ID and clicking the View button in the Template Manager. See below the result for the template presented in this manual.



- Deleting an Existing Template

Users can delete any template by selecting the Template ID and clicking on Delete while in the Template Manager.

4.3 Treatment Planning Module

The Treatment Planning Module optimizes and calculates a complete VMAT TBI plan based on a selected template. Once the structures are matched, the module automatically goes into planning and will take between 60 and 150 minutes to complete (depending on planning computing power).

Required Inputs:

- One full body CT dataset in the Head-First Supine orientation.
- Complete structure set containing a Body_Only contour (excluding any immobilization or couch structures) and the OARs expected to be spared per the template selected.
- Body_Only and OAR contours set as type ORGAN.

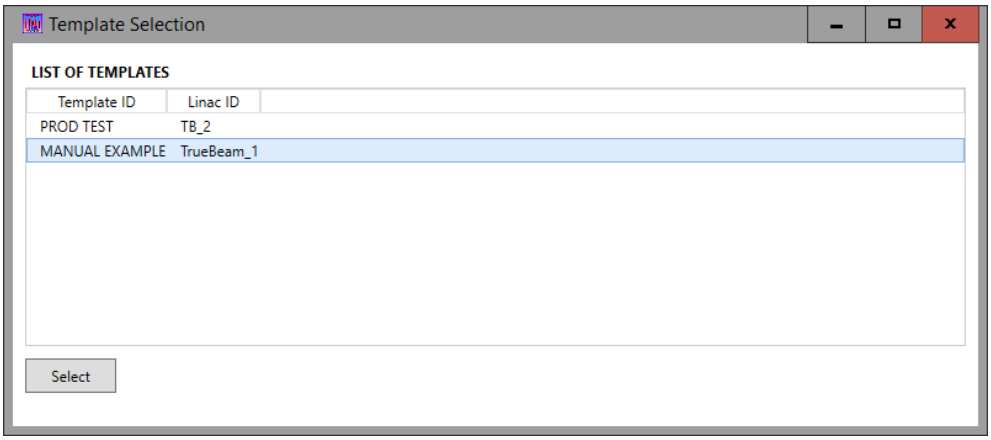
Output: A plan 'TBI VMAT' with calculated dose in course 'FULL VMAT'.

Notes:

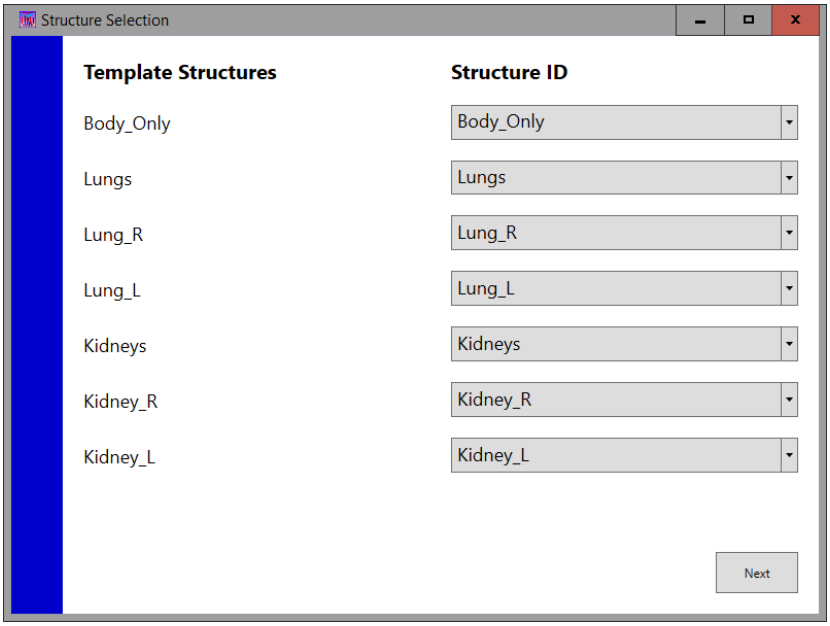
- The PTV structure is automatically generated by the script based on the Body_Only contour and selected template parameters and **must not be entered manually by the user.**
- At this stage, ensure there is no plan with ID 'TBI VMAT' in a course with ID 'FULL VMAT'.
- For some steps, the module progress window updates are not continuous. As long as the timer keeps running and the window is responsive, the execution is active.
- Eclipse may display warnings if certain conditions exist during the calculation progress. **All progress will be paused until the warnings are acknowledged**. The user needs to acknowledge warnings for the script to continue execution.
- **Do not close the module progress after optimization has started**. If closed, the optimization will continue in the background and will eventually save in the patient.

Execution:

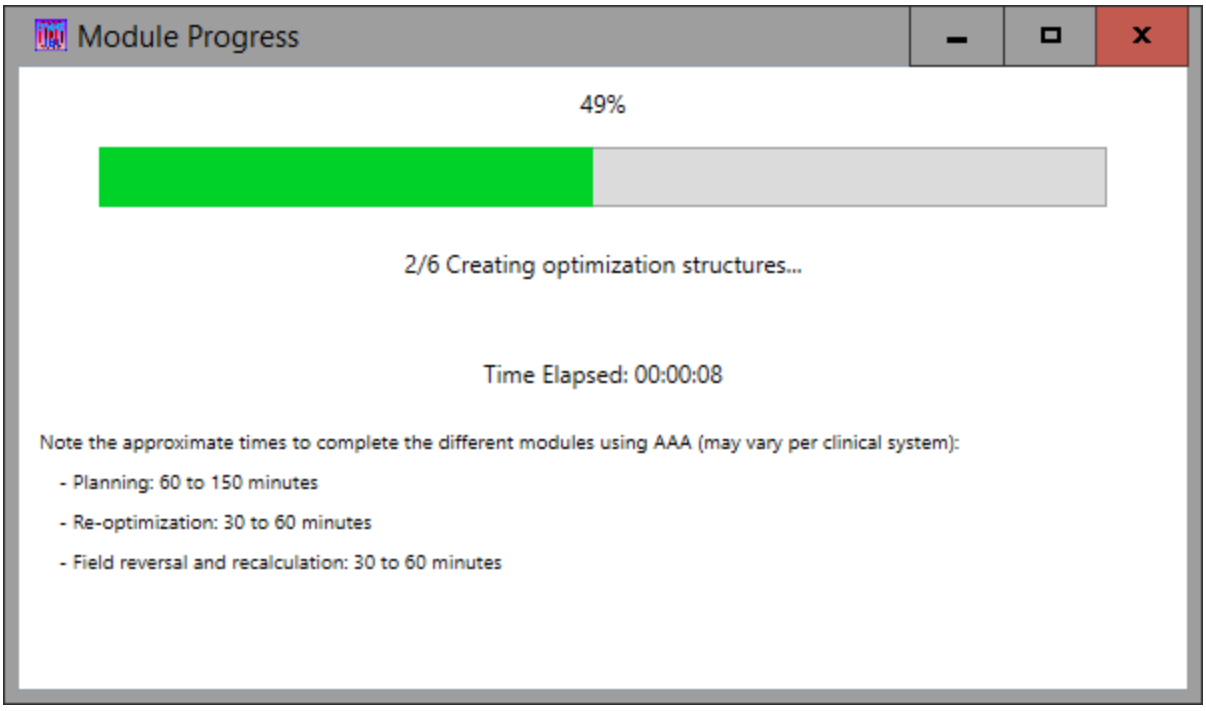
1. Ensure the structure set with required structures is opened in the context window.
2. Click on Treatment Planning Module button.
3. Select from available templates.

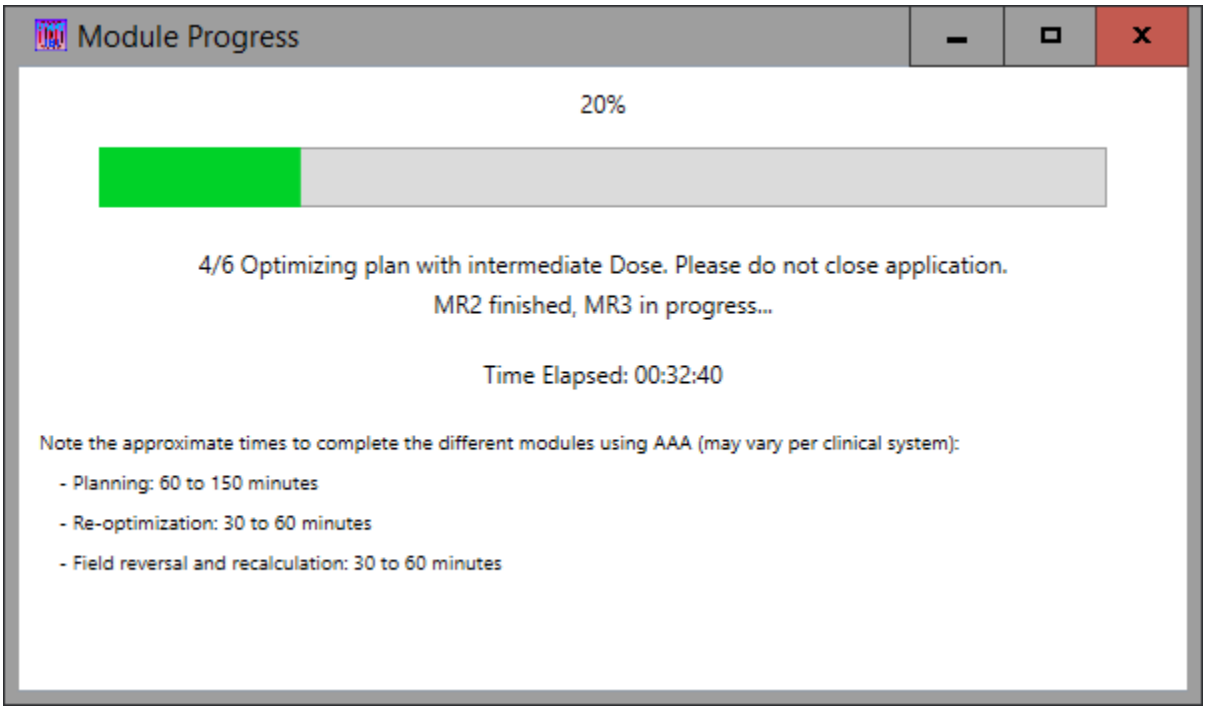


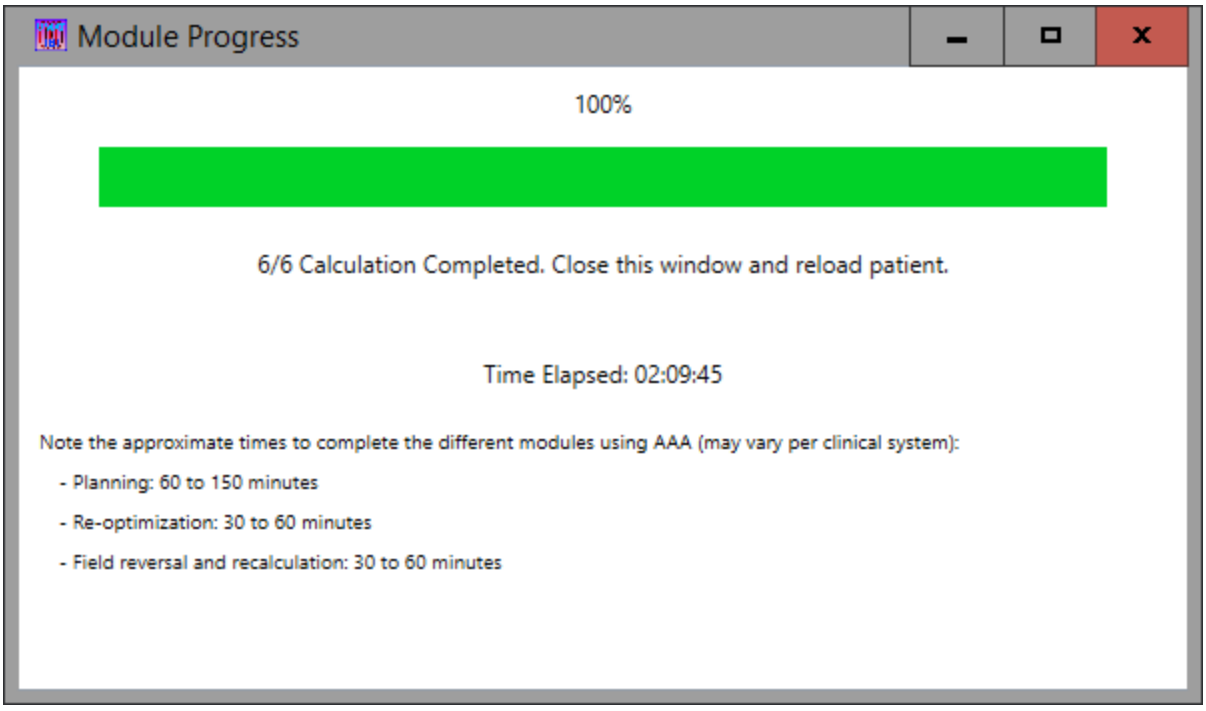
4. Match required structures using the dropdowns.



5. Wait for the progress window to complete all steps. See below examples of the progress window status during planning. Do not close the window until 100% in stage 6 has been reached.

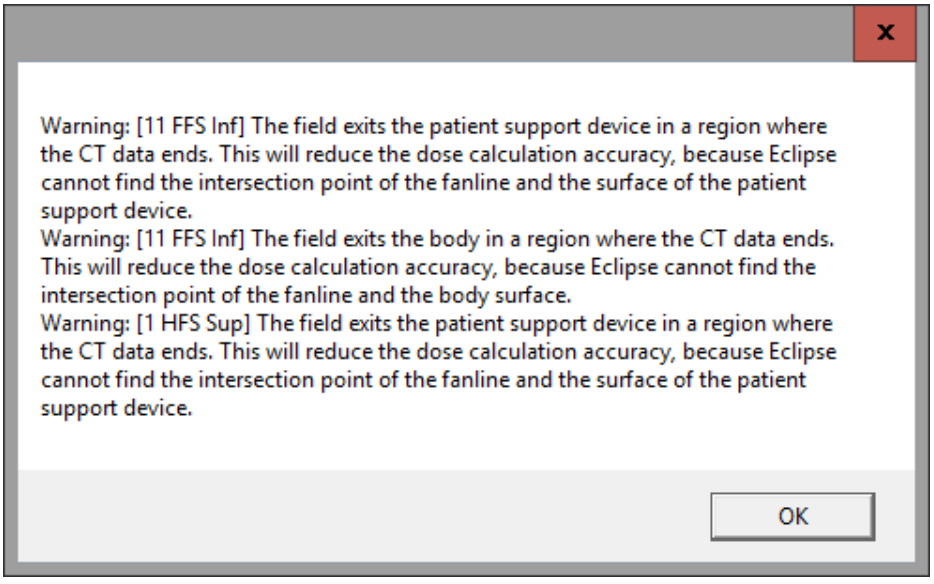

Module Progress
49%
2/6 Creating optimization structures...
Time Elapsed: 00:00:08
Note the approximate times to complete the different modules using AAA (may vary per clinical system):
- Planning: 60 to 150 minutes
- Re-optimization: 30 to 60 minutes
- Field reversal and recalculation: 30 to 60 minutes


Module Progress
20%
4/6 Optimizing plan with intermediate Dose. Please do not close application.
MR2 finished, MR3 in progress...
Time Elapsed: 00:32:40
Note the approximate times to complete the different modules using AAA (may vary per clinical system):
- Planning: 60 to 150 minutes
- Re-optimization: 30 to 60 minutes
- Field reversal and recalculation: 30 to 60 minutes

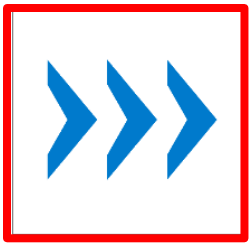


6. Once the last step (above) is achieved, close this window, reload the patient and evaluate results for plan 'TBI VMAT' in 'FULL VMAT' course.

Example warning that needs to be acknowledged by user in clinical environment:



4.4 Re-optimization Module



The Re-optimization Module automatically re-optimizes an existing VMAT TBI plan with a focus on improving PTV coverage.

Required Input: Complete plan with ID 'TBI VMAT' in course 'FULL VMAT' previously created using the Treatment Planning Module.

Output: Re-optimized plan 'TBI VMAT' in course 'FULL VMAT'. Additionally, the initial plan is saved as a copy with ID 'TBI VMATX' where X denotes the number of iterations.

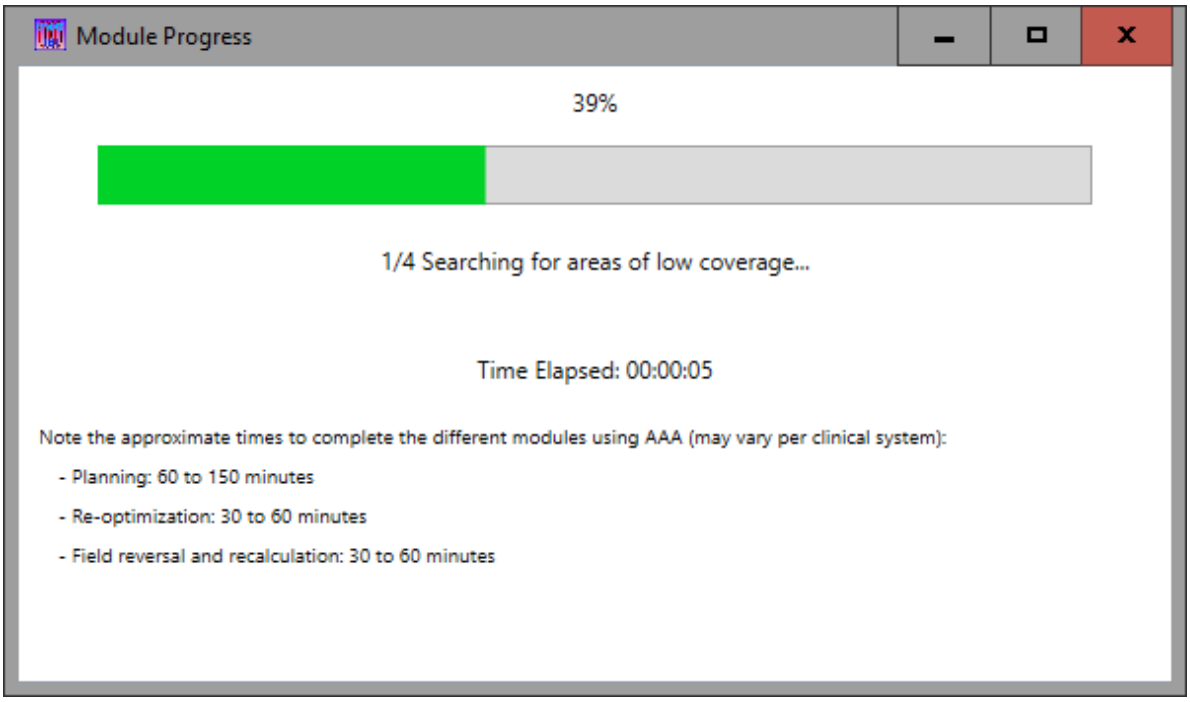
Notes:

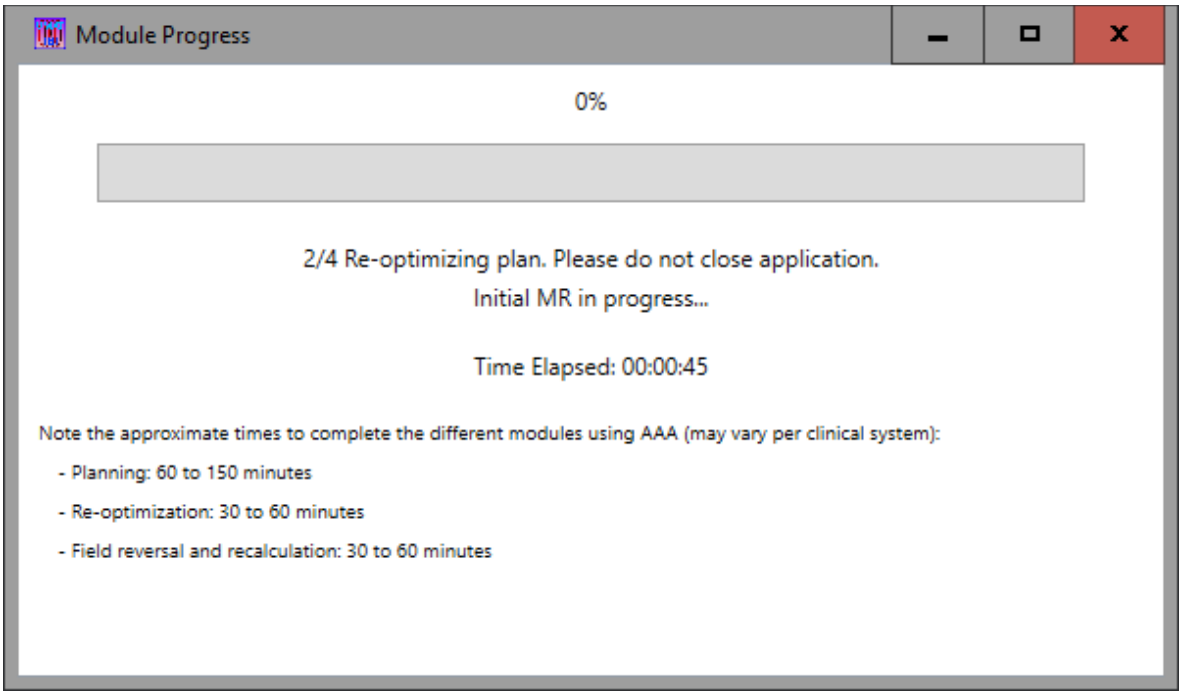
- For some steps, the module progress window updates are not continuous. As long as the timer keeps running and the window is responsive, the execution is active.
- Eclipse might show warnings in some cases as part of the calculation progress. In this case, the user need to acknowledge them for the script to continue execution.
- Do not close the module progress after optimization has started. If closed, the optimization will continue in the background and will eventually save in the patient.

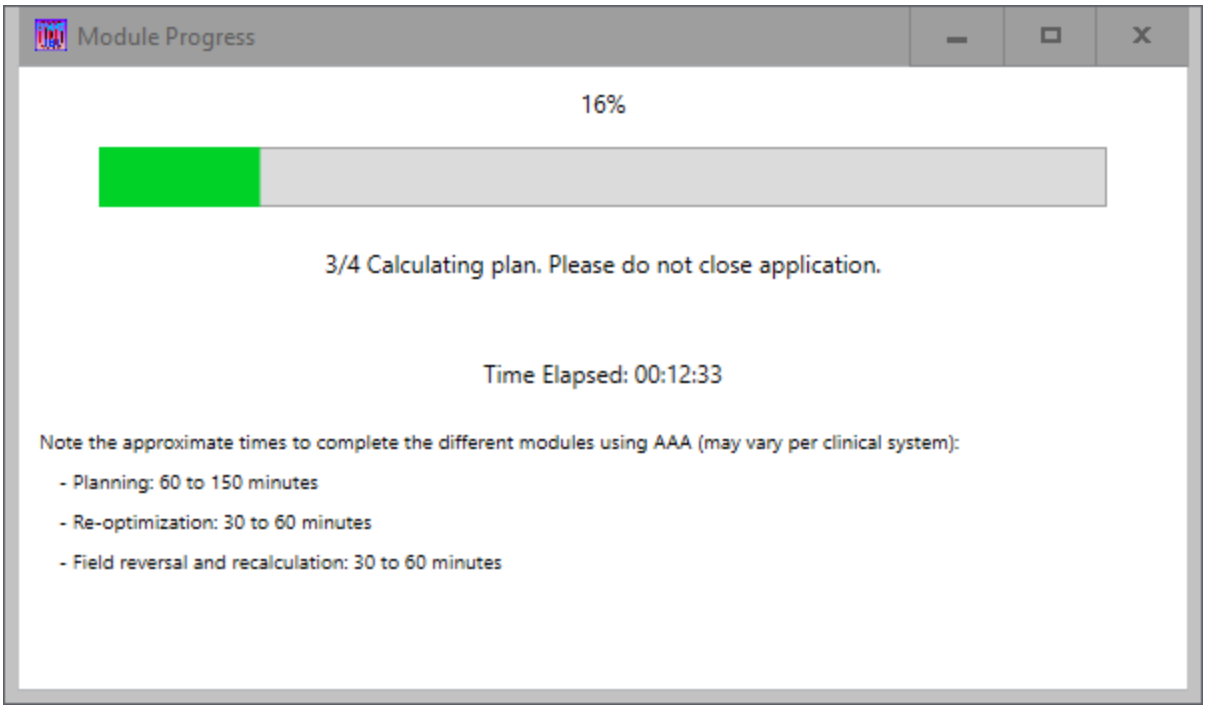
Execution:

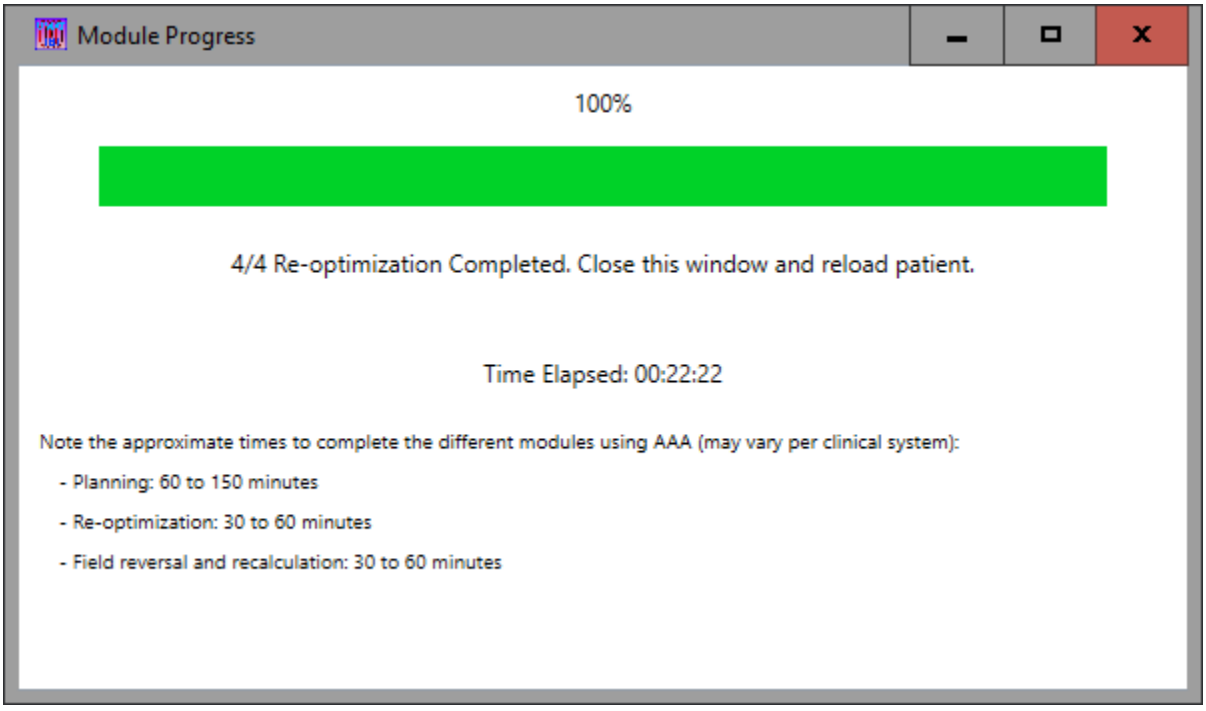
1. Ensure the plan with ID 'TBI MAT' in course 'FULL VMAT' exists and it is calculated.
2. Click on Re-optimize Module.
3. Select template (should be same template used for original plan).

4. Wait for the progress window to complete all steps. See below examples of the progress window status during planning. Do not close the window until 100% in stage 4 has been reached. Some steps of the progress window are shown below for this module.

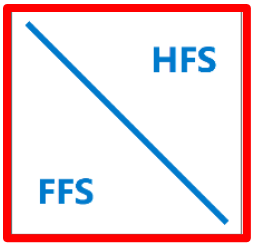





Module Progress
16%
3/4 Calculating plan. Please do not close application.
Time Elapsed: 00:12:33
Note the approximate times to complete the different modules using AAA (may vary per clinical system):
- Planning: 60 to 150 minutes
- Re-optimization: 30 to 60 minutes
- Field reversal and recalculation: 30 to 60 minutes


Module Progress
100%
4/4 Re-optimization Completed. Close this window and reload patient.
Time Elapsed: 00:22:22
Note the approximate times to complete the different modules using AAA (may vary per clinical system):
- Planning: 60 to 150 minutes
- Re-optimization: 30 to 60 minutes
- Field reversal and recalculation: 30 to 60 minutes

4.5 Plan Split Module



The Plan Split Module splits the calculated VMAT TBI for delivery into a plan with the fields to be delivered Head-First Supine (HFS) and a plan with the fields to be delivered Feet-First Supine (FFS).

Required Input: Complete plan with ID 'TBI VMAT' in course 'FULL VMAT' previously created using the script (with or without the use of the Re-Optimization Module).

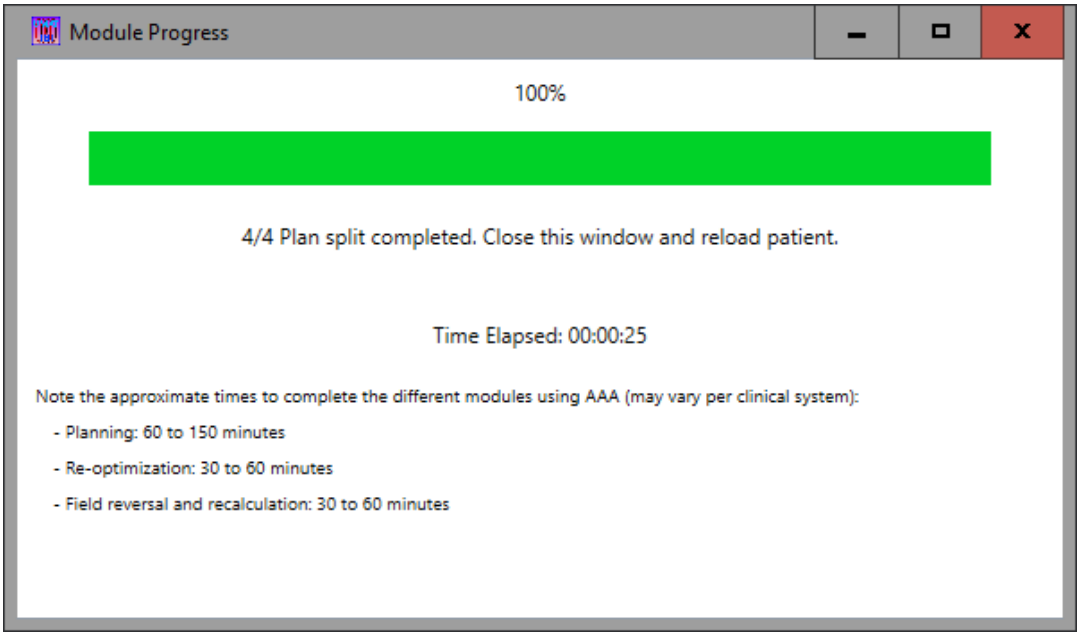
Output: Two additional plans with IDs 'TBI HFS ' and 'TBI FFS' in course 'FULL VMAT'. As a result of the execution of this module, all plans will be uncalculated to allow for plan orientation reversal. Plans will be re-calculated as part of the last module (FFS Reversal Module).

Notes:

- After the execution of this module, and prior to the execution of the last module (FFS reversal), one manual step is needed. This step is detailed in section 4.5.1.

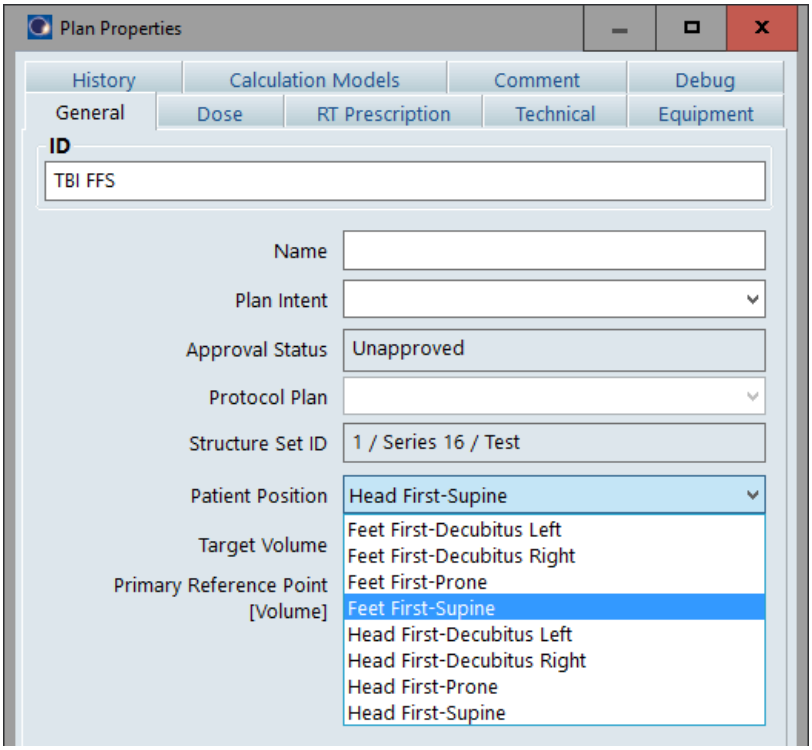
Execution:

1. Ensure the plan with ID 'TBI MAT' in course 'FULL VMAT' exist and it is calculated
2. Click on Plan Split module
3. Wait for the progress window to complete all steps. Do not close the window until 100% in stage 4 has been reached. This module execution time is only a few seconds. Close window and reload patient to see results.

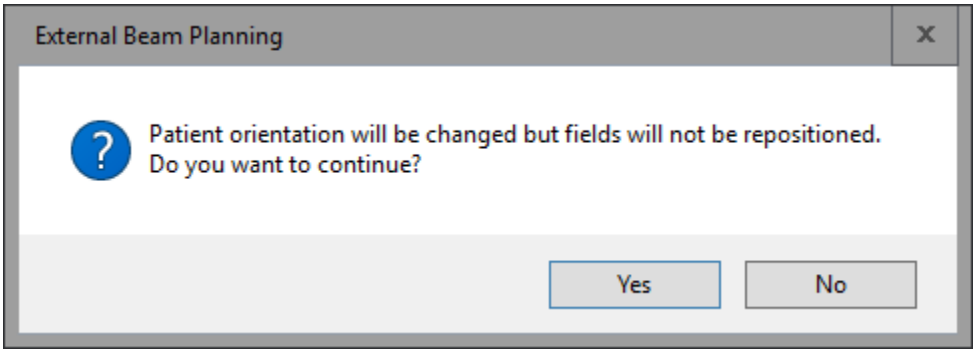


4.5.1 Updating the Orientation of the FFS plan (Manual Step)

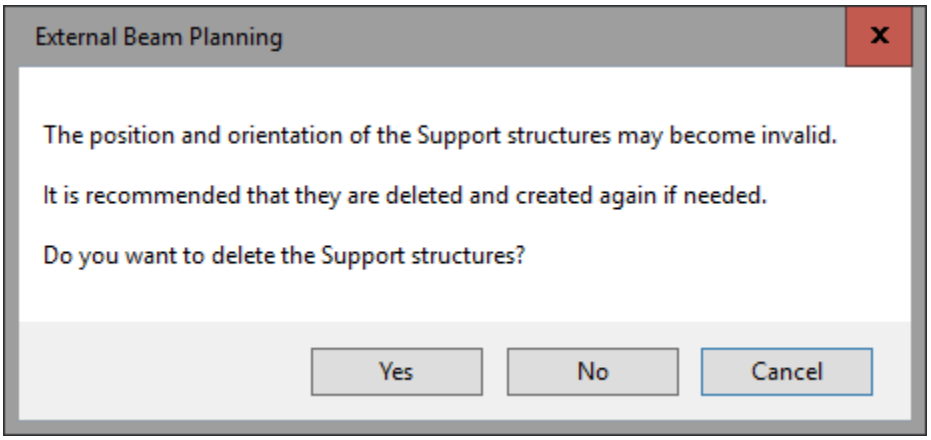
1. Right click on the new plan with ID 'TBI FFS' and select Plan Properties.
2. Change orientation to Feet-First Supine using the Patient Position dropdown.



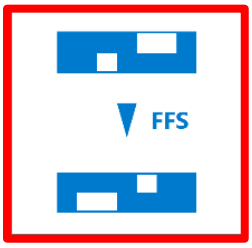
3. Click ‘Yes’ on the repositioning warning shown below.



4. Click ‘No’ in the support structures warning below (Ensure your support structure, if any, is not affected by orientation reversal).



4.6 FFS Reversal Module



The FFS Reversal Module repositions the apertures of the plan with ID ‘TBI FFS’ after manual patient orientation reversal. Additionally, the dose for ‘TBI FFS’, ‘TBI HFS’ and ‘TBI VMAT’ is recalculated.

Required Input: The output of the Plan Split Module is required: Plans with IDs for 'TBI FFS', 'TBI HFS' and 'TBI VMAT' in course with ID 'FULL VMAT'. Additionally, the plan 'TBI FFS' had to be set to patient orientation Feet-First Supine as shown in the Note on the prior section.

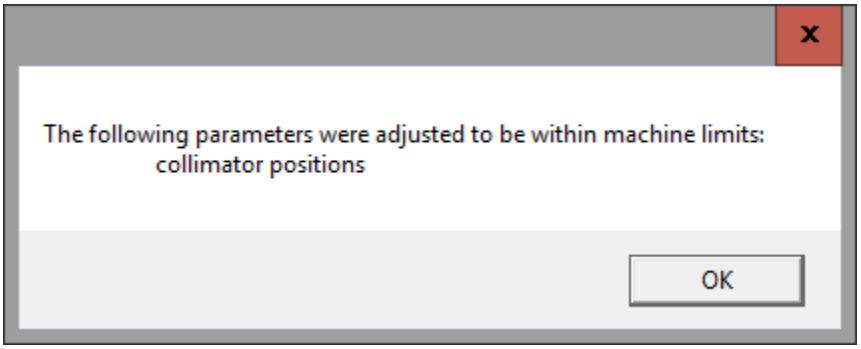
Output: Calculated plans for delivery 'TBI HFS' and 'TBI FFS', where fields have been repositioned for 'TBI FFS' plan. Calculated plan 'TBI VMAT' (only for comparison, not for delivery).

Notes:

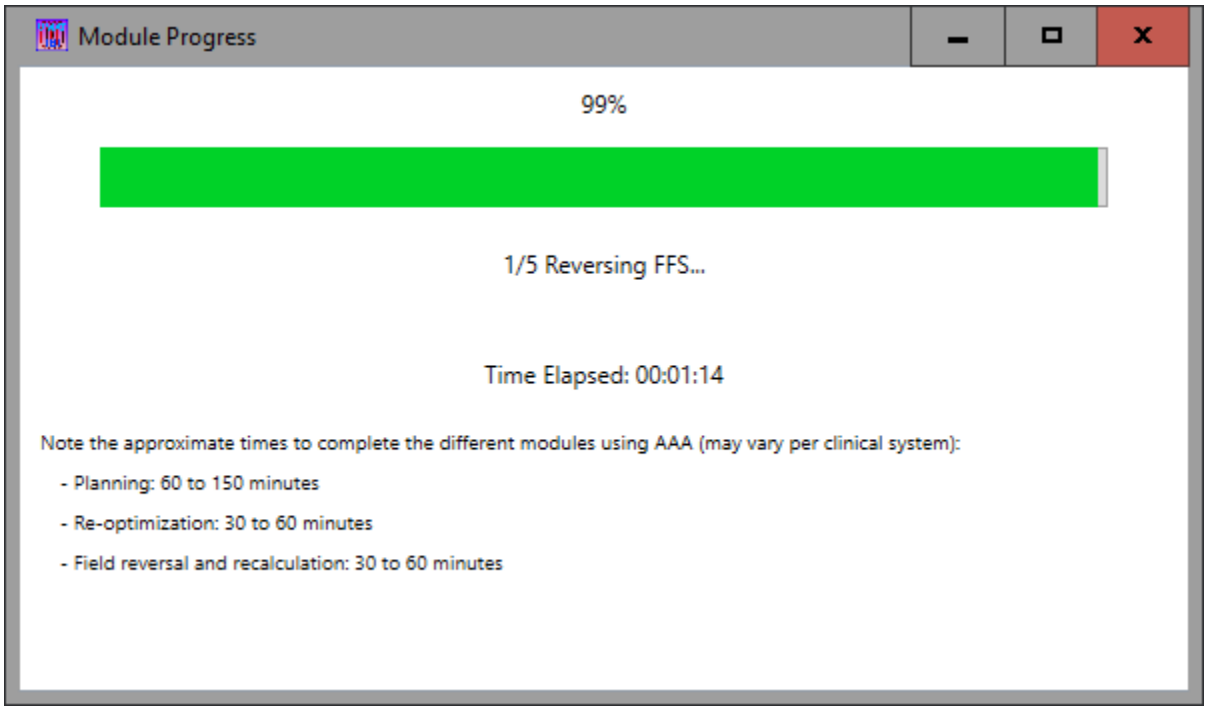
- Ensure the patient orientation of plan 'TBI FFS' is set to Feet-First Supine.
- Any plan using the same structure set as 'TBI FFS' cannot have dose calculated at this point. The prior module takes care of this for all plans in 'FULL VMAT' course. If the user has copied plans to different courses that use the same structure set, the dose must be uncalculated before proceeding.

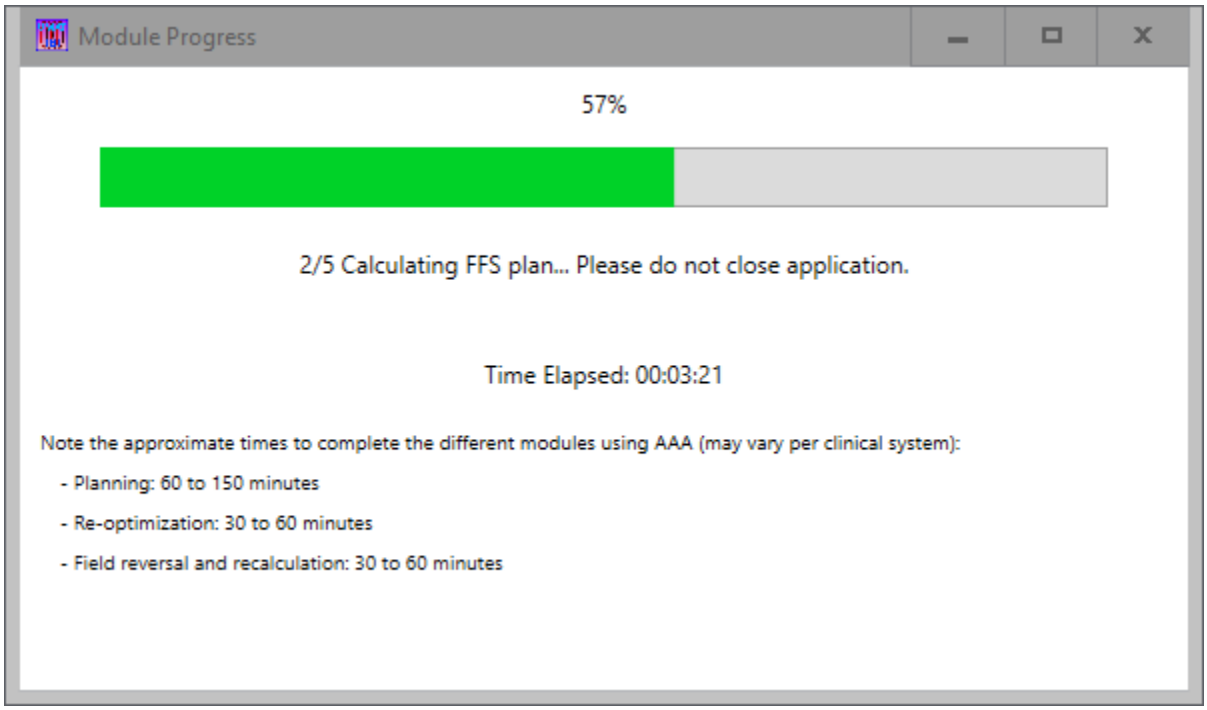
Execution:

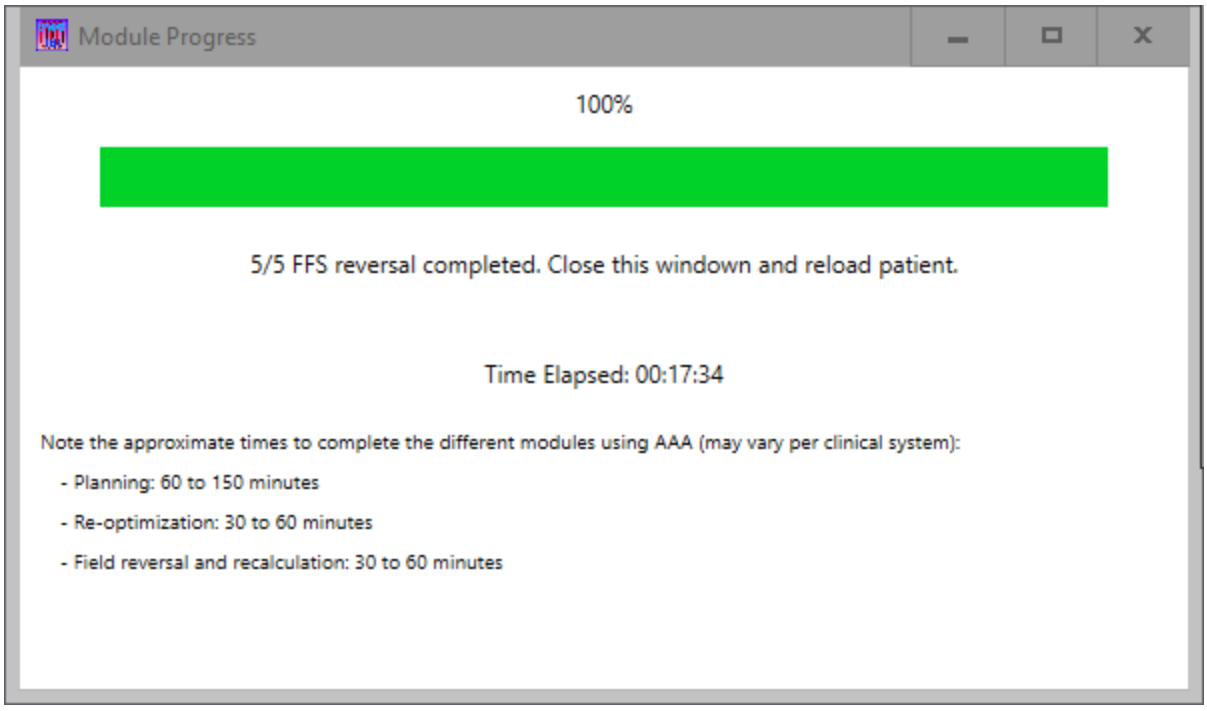
1. Ensure plans with IDs 'TBI FFS', 'TBI HFS' and 'TBI VMAT' in course with ID 'FULL VMAT' exist and patient orientation for plan 'TBI FFS' is Feet-First Supine.
2. Click on FFS Reversal module.
3. Right after execution, this warning may appear. Click OK.



4. Wait for the progress window to complete all steps. Do not close the window until 100% in stage 4 has been reached. Once stage 5/5 is completed, close window and reload patient to see results.







5. At this point, it is highly recommended to create a Plan Sum (TBI FFS + TBI HFS) and compare it to 'TBI VMAT' to ensure plan equivalency.

Notes:

- For some steps, the module progress window updates are not continuous. As long as the timer keeps running and the window is responsive, the execution is undergoing.

- Eclipse might show warnings in some cases as part of the calculation progress. In this case, the user need to acknowledge them for the script to continue execution.

- Do not close the module progress after optimization has started. If closed, the optimization will continue in the background and will eventually save in the patient.

4.7 Print Report Module

Prints a dosimetric summary report for a selected plan. Prints the following metrics:

- For structures of type Target: V100%, D98%, D95%, and D2%.
- For structures of type Organ: D0.03cc (%), D1cc (%), and Mean Dose (cGy).

Required Input: Calculated plan or plan sum

Output: Dosimetric summary report in pdf format.

Important notes before execution: For plan sum, ensure there is only one plan sum in the current course.

Execution:

1. Move plan or plan sum to view.
2. Click on Print Report button.
3. Select location to store report.

Example (portion of report screenshot):

Targets

PTV - V100% (%)	92.6
PTV - D98% (%)	94.5
PTV - D95% (%)	98.5
PTV - D2% (%)	116.4

Organs at Risk (OARs)

Body_Only - D0.03cc (%)	125.0
Body_Only - D1cc (%)	123.7
Body_Only - Mean Dose (cGy)	1235.9
Bowel - D0.03cc (%)	119.7
Bowel - D1cc (%)	117.7
Bowel - Mean Dose (cGy)	1261.4
Brain - D0.03cc (%)	115.8
Brain - D1cc (%)	115.4
Brain - Mean Dose (cGy)	1307.5
Kidney_L - D0.03cc (%)	106.3
Kidney_L - D1cc (%)	101.8
Kidney_L - Mean Dose (cGy)	889.0

5. Treatment Planning Logic

- The VMAT TBI treatment planning tool creates a complete plan in one iteration that is then split into HFS and FFS delivery.
- The HFS plan consists of 4 equally spaced isocenters that cover an approximate length of 104 cm, typically to waist level. Each HFS isocenter has two collimator 90 treatment arcs, treating the superior half and then the inferior half of the isocenter. The FFS plan consists of a variable

number of isocenters (1 to 5) depending on the patient length. The FFS plan can cover up to a maximum of approximately 115 cm. Each FFS plan isocenter only delivers one treatment field.

- For cases where the patient length is approximately 104 cm or less, the script will create a plan with either 3 or 4 isocenters (two treatment fields per isocenter) that does not require to be split or reverse.

6. Treatment Simulation Considerations

- The use of rice and other tissue compensation devices are unnecessary in VMAT TBI.
- Patients should be well immobilized and comfortable. Thermoplastic immobilization allows modular isolation of each body section.
- Each section of the body should be immobilized to reduce translations and rotations (ex. Head tilt, knee bend, and elbow movement).
- Lateral patient spread and immobilization should be minimized to avoid issues with clearance and coverage at the lateral extent of the patient.
- Patients should be indexed near the end of the treatment table, towards the gantry, in order to treat a fourth isocenter around the waist/pelvis.
- Patient separation should be minimized when possible during simulation. For instance, placing the arms next to the body with the hands and forearms resting on thighs/pelvis.

7. Treatment Delivery Considerations

- After complete execution, the treatment plans for delivery are 'TBI HFS' (Head-First Supine), and 'TBI FFS' (Feet-First Supine).
- For most cases, both plans are needed. However, if the patient height can be accommodated for a HFS delivery only, a FFS plan is not required. If after the execution of the planning tool (or planning + re-opt) the plan contains eight or less fields, the execution is completed.
- It is the responsibility of the institution to ensure deliverability of the plan, this includes but it is not limited to:
    - Commissioning the planning tool internally.

- Perform physics checks on the plan.
- Perform patient-specific QA.
- Ensure the plans are deliverable in the orientations specified and within the treatment couch positioning limits.
- Perform dry runs for isocenter shifts. Ensure the couch can travel longitudinally from the superior to the inferior isocenter.

8. FAQ

Q. The tool looks responsive, but the timer is exceeding the suggested limits posted in the progress screen.

R. If the progress window timer has not stopped and any of the steps is taking longer than usual, please ensure there is no Eclipse warning window waiting to be acknowledged. In some instances, the pop-up windows might be hidden in the background and require Alt+Tab to locate.

Q. What happens if I need to interrupt the execution?

R. If you really need to interrupt the execution, the optimization/calculation may continue in the background. Ensure you kill the hanging progress using Task Manager or in RT Administration. Otherwise, the execution will continue and save in the patient even if you have closed the progress window.

Q. Can I re-optimize the plans generated by the script manually and add new optimization structures?

R. Yes, the user can work directly on the 'TBI VMAT' plan at any point or add any control structures. Remember that the user will need to split their plan as well and reverse the FFS plan with the script tools. However, **split plans 'TBI HFS' and 'TBI FFS' must never be modified manually**.

Q. Can I manually re-normalize the plan using the plan normalization option?

R. Yes, the plan can be re-normalized after calculation. This must be done prior to splitting the plan. Do not re-normalize on the individual HFS and FFS plans.

Q. Do I always need to use the re-optimize module?

R. Not necessarily. If the initial plan result is satisfactory, there is no need to run this module. However, we found it useful almost every time to increase coverage areas receiving low dose (less than 85%) with slight change to sparing. In the event that you are using a template with negative OAR margins (PTV extend inside OARs), the re-optimization module is needed for all cases to boost coverage.

Q. Can I add an additional arc at an isocenter or rotate the collimator?

R. For this release, this is highly discouraged. There is no guarantee that the optimization goals/structures created by the script will work with different field arrangements. In addition, the field reversal tool might not work as intended with user-defined fields. If you are working on research mode and decide to test the addition of fields, make sure that field IDs include either 'HFS' or 'FFS' for the plan split tool to function correctly.

Q. After splitting the plans and reversing the FFS, is the plan sum supposed to be identical to the original 'TBI VMAT' plan?

R. Technically yes. However, there is a small <1 degree uncertainty when reversing the control points for the FFS plan. We have observed the effect on the dose to be less than 0.1%, and therefore dosimetrically negligible. Always remember to compare the plan sum (TBI HFS + TBI FFS) to TBI VMAT to ensure this is the case.

Q. Are there any constraints on maximum dose and mean dose to the Body?

R. Yes, the script aims to keep the maximum dose to the body contour, D2cc (dose to 2cc), below 130% of Rx, and body mean dose below 106 % of Rx. Note that coverage and organ sparing might take preference over these goals. However, deviation from these should be very small for most cases.

Q. At our center, additional OARs are contoured besides the ones entered in the template. These OARs are part of the PTV. Are these taken into account by the script?

R. Yes. Any existing structure of type 'ORGAN' in the structure set will be taken into account by the script. For any contoured OARs that are part of the PTV, the planning script will attempt to avoid hotspots of over 120% of Rx. In addition, it will try to keep the mean dose at or below 106%.

Q. Does the script support the use of bolus or virtual bolus?

R. While the script does not provide that functionality directly, plans can be created with bolus. For this purpose, you might want to use a negative margin for the PTV creation in your template to extend the PTV outside of the body. The user will need to create the bolus manually before running the script, and delete it after execution in case of virtual bolus.

Q. Do I need a Body_Only contour if my BODY contour only contains the patient anatomy (no immobilization or support)?

R. Yes, you still need a Body_Only contour that contains only the patient anatomy and it is of type ORGAN instead of Body.

Q. I have two CT datasets, one of the upper body and one of the lower body. How do I use the script for planning in this case?

R. The script requires one full body CT dataset in the HFS orientation. Prior to running the script, register and stitch both datasets. Several RT and image processing tools, such as Velocity can be used for this purpose.

Q. Can AcurosXB be used?

R. AcurosXB can be used as long as it is defined as the calculation algorithm in the template. However, the calculation has been observed to run out of memory for all but the smaller pediatric patients.

Q. Can I select different dose rates for different fields?

R. The planning template requires a single dose rate to be entered. This maximum nominal dose rate will be employed to generate the plans. Once the plan is created, the maximum dose rate for individual fields can be adjusted in treatment preparation at the user discretion.

Q. Can I use a different linear accelerator than TrueBeam or a different MLC model?

R. No. This application only supports plan for TrueBeam in this version. Furthermore, using a different MLC model will produce unexpected results or error for the field reversal module.

Q. Do I need to provide LaunchTBI.dll with script approval as well?

R. No. The only file that requires script approval is VMAT_TBI.exe. This is the only one that performs write operations. Script approval is only required for clinical use and not needed for research mode.

Q. Is there any approach to troubleshoot issues within the tool?

R. Yes, there is a 'Logs' folder located in the 'VMAT_TBI' folder that contains logs for each execution. These logs can be helpful to troubleshoot any crashes or issues with the execution. Additionally, we welcome feedback for future releases. See support section below.

Q. I have a question that is not in the FAQ section.

R. Send us an email (see support). We will do our best to respond and if deemed relevant we will add it to future user manual releases.

9. Support

The VMAT TBI planning tool has been developed as a collaboration between NYU Langone Health and Varian Medical Systems. The script is provided by Varian without any guarantees. However, any comments/questions are welcome and can be directed to Varian Medical Affairs or to the developers: Jose Teruel (Jose.Teruel@nyulangone.org) and David Barbee (David.Barbee@nyulangone.org).

10. Disclaimer

Treating TBI with VMAT is a new paradigm. The VMAT TBI planning tool is made available through Varian Medical Affairs Division without any guarantees. The use of the script tools and any plan generated by the tool is at the sole discretion and responsibility of the user. Re-distribution is not allowed without written consent.

Nothing in this guide or the software itself represents clinical advice.