SUBJECT: Gantry and Collimator Starshot Analysis

The following information is provided as a service to our users and customers:

The star shot is a standard method for measuring the stability of rotation of the linear accelerator (linac) gantry or collimators.

To measure the stability of **gantry** rotation, one of the collimators is closed to form a thin slit (usually 1-2 cm wide). A film is positioned vertically and centered iso-centrically on the couch, and images of the slit collimator are acquired for several gantry positions.

To measure the stability of **collimator** rotation, one set of collimators is closed to form a thin slit and a film is placed horizontally and centered iso-centrically on the couch (An EPID, or electronic portal imaging device, may be used to acquire the images in this case). Images of the slit collimator are acquired for several rotational positions of the collimator.

Conventional analysis of a star shot film involves determining the location of a line through the center of each slit projection with the aid of a densitometer. The intersection of all such lines is then analyzed, often using a magnifying glass, to determine the extent of the instability of gantry or collimator rotation. This can be a time consuming and subjective process which must be performed on a regular basis as part of a routine quality assurance program.

The following describes a PIPSpro User program called *Star.exe* which automates the analysis procedure.

How to use the *Star.exe* program

Copy the file *Star.exe* to the directory PIPSpro\User, and the sample image to PIPSpro\User\Images. Install the *Star.exe* file with the **Edit Usr Menu** in PIPSpro (see Fig. 1)

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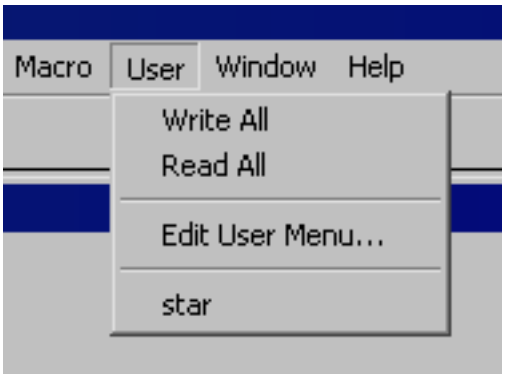

Figure 1. PIPSpro User interface allows users to add their own programs into PIPS.

[1] Acquire a standard star shot on film or a portal imager (if measuring collimator rotation):

For example, a 6 projection 30° gantry star acquired on film is shown in Fig. 2.

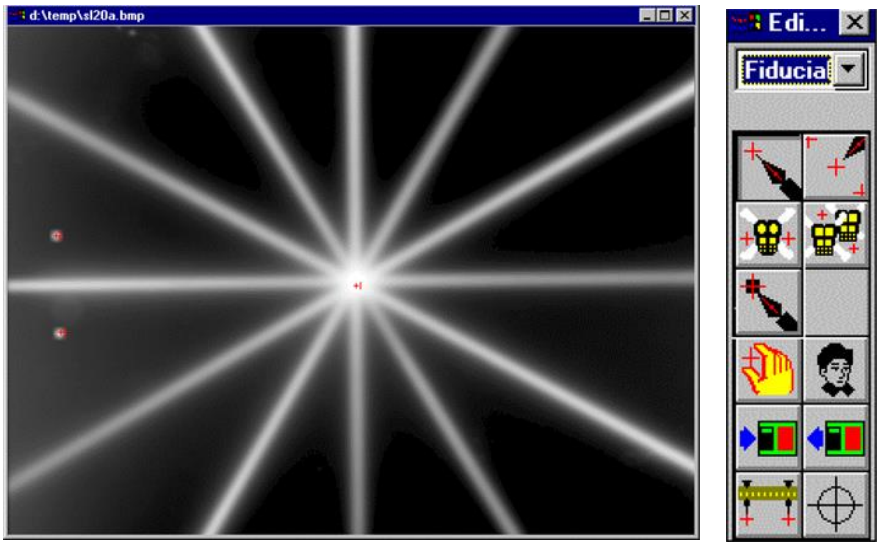

Figure 2. A typical star shot image with 3 fiducial markers placed to mark the approximate center of the star and two calibration points. Also shown is the PIPS EditTool in Fiducial mode.

Note: The minimum number of projections for the *Star.exe* User program is 3. There is no upper limit on the number of projections or on their specific orientation to each other.

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[2]
Before digitizing the film, make two marks on the film at a known distance apart. For example you may want to make the marks 2 cm apart on a background region of the image as shown in Fig. 2. These marks will be used by the *Star.exe* to calibrate the results in mm. Ensure that the marks can be seen in the digitized image (a permanent marker works well).

[3]
After digitization, open the image in PIPSpro. Open the PIPS EditTool and select Fiducial mode. Note: If the images lack contrast, use Windowing or contrast enhancement. *Star.exe* requires 3 fiducial points to be placed on the image in the following order.

The first fiducial point should be placed at the approximate center of the star shot as shown in Fig. 2. It does not have to be at the exact center, the Star.exe program only uses this fiducial point as a starting location for the analysis and will automatically readjust it to the correct center.

Next place 2 fiducial points over the two calibration marks on the film. You will be prompted to specify the actual distance between these two points in order to calibrate the image in mm:

Enter separation between calibration points in mm
Default is 20 mm.

If the two points marked on the film are 2 cm apart, just press “Return” as the default is 20 mm. If the two calibration points have some other separation, enter the correct value and press “Return”.

If you do not place these two calibration fiducial points, the program will default to a calibration of 1 pixel/mm.

[4]
You may also use the sample image provided. Open *SL20A.bmp*, place the required fiducial points and run the *Star.exe* program. The calibration marks on the sample image are 2 cm apart.

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Upon completion of the *Star.exe* program, the following output will be displayed to the user (the actual results will depend on the star shot being analyzed and the accuracy in placing the calibration points):

6 projections found.
Maximum circle radius in pixels = 4.74
Maximum circle radius in mm = 1.04
Select File and Exit to Quit

The number of projections will vary depending on how the star shot is acquired. For example a 30° star shot will have 6 projections and a 45° star shot will have 4 projections. Note: The user is not limited to 30° or 45° star shots. Any number of projections in any orientation are allowed provided there are at least three.

The Maximum circle radius is defined as the radius R of a circle that will enclose all points of intersection of all projections as shown in Fig. 3.

Select “File” and “Exit” and a visual representation of the analysis will be displayed as shown in Fig. 3.

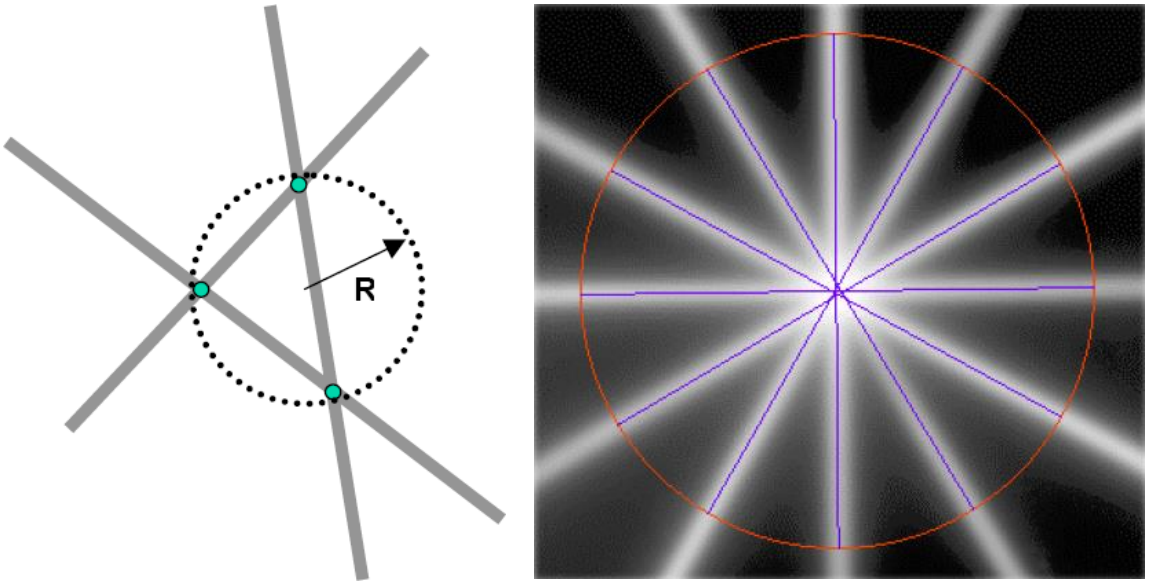

Figure 3. A schematic diagram defining the minimum circle radius and a visual representation of the analysis that is displayed to the operator.

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A file *Star.txt* will be created, showing the calibration factor, the line and intersection coordinates, the star center, and the maximum radius in pixels. This file will be overwritten the next time the program is run.

Notes on the Calibration

(1). Normally calibration is done by making two marks on the film at a known distance apart as explained in [3] above. Designating these marks by fiducial points 2 and 3 permits the program to convert distances in pixels to distances in mm. If the calibration points are not provided, the program uses a default calibration of 1 pixel/mm.

(2). If the star shots are acquired for collimator rotation with an EPID, you can still place two calibration points on the image by inserting two arbitrary fiducial points with the EditTool. Then use InfoDesk to measure the distance in pixels between these two fiducial points (middle mouse button for distance measurements). The calibration should be known for EPID images (or can be determined by acquiring an image of a known object), so the distance in mm between these points can be entered when the program asks for this number.

(3). Alternatively, instead of the procedure in (2), do not insert any calibration points and let the program default to 1 pixel/mm. Then convert the final result from pixels to mm using the known EPID calibration factor.

Independent testing

Interpreting the results of image analysis can be a complex and often confusing task. Many problems occur which can lead to error or misinterpretation, such as improper calibration. Other problems may be associated with the terminology or specific practices in use at different centers. The user should be aware that, as with all software, there may be errors, problems of interpretation, or problems of application in the PIPSpro which were unknown at the time the program was released. It is essential that the user of PIPSpro makes comprehensive independent tests of the results, and ensures that their interpretation and application are error-free. Neither the author of this note, nor Standard Imaging Corporation or any of its officers, employees, programmers, consultants, contractors, distributors or associates accept responsibility of any kind for the interpretation and/or application of any results obtained with PIPSpro. The "Warranty" included in the User's Guide applies to both PIPSpro and to the Starshot analysis program.

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