

Gamma Commissioning report for AutoEPID V5

1. Introduction

Recently issues associated with the Gamma report in AutoEPID V3 were identified, debugged and fixed. The Gamma function used in AutoEPID was benchmarked against the ones used in TomoExit and OminIMRTPro. The purpose of the report is to summarize the procedure and benchmark results.

2. Materials and methods

Comparison without registration.

If the user chooses the option of no-registration in AutoEPID, there is a different meaning for VMAT and IMRT. For IMRT beams, it means that there is no translation between TPS dose image and EPID dose images, but the rotation is applied to the EPID image if the collimator is zero. For VMAT beams, no rotation and translation between EPID image and TPS dose image if no-registration is selected.

To remove the effect of registration on Gamma map and reporting, all the comparison between different gamma functions used in different software were performed without registration.

Generation of Gamma report using AutoEPID without registration

As shown in figure Figure 1, to generate gamma map without registration, simply just choose the option ‘no registration’ for VMAT beam and make sure the collimator is zero for IMRT beam.

Comparison between Gamma used in AutoEPID and TomoExit

For the comparison purpose, the gamma function used in TomoExit was also integrated into AutoEPID. The gamma function used in TomoExit and AutoEPID was implemented independently by different persons.

Figure 1 Use no-registration to generate Gamma report for comparison.

Generation of the gamma report in OminiIMRTPro without registration.

Load TPS and EPID as described in the AutoEPID user guide or OminiIMRTPro, then directly calculate, as shown in Figure 2.

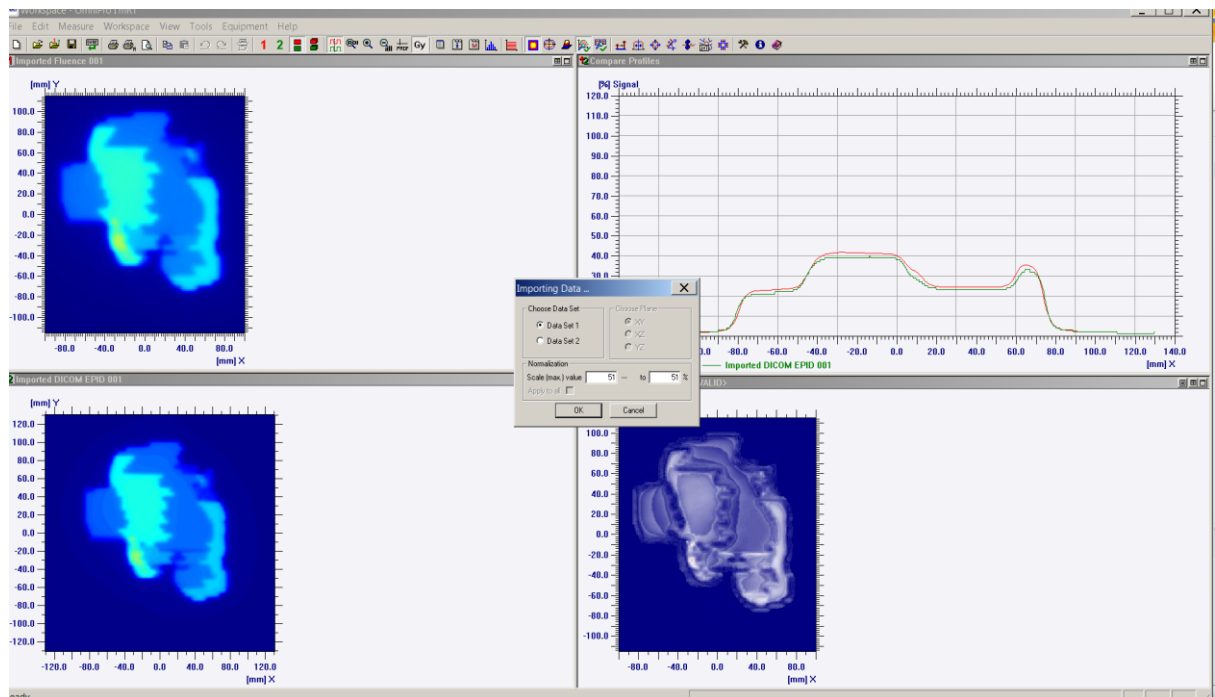


Figure 2 Load TPS and EPID dose image and then calculate gamma without any other process.

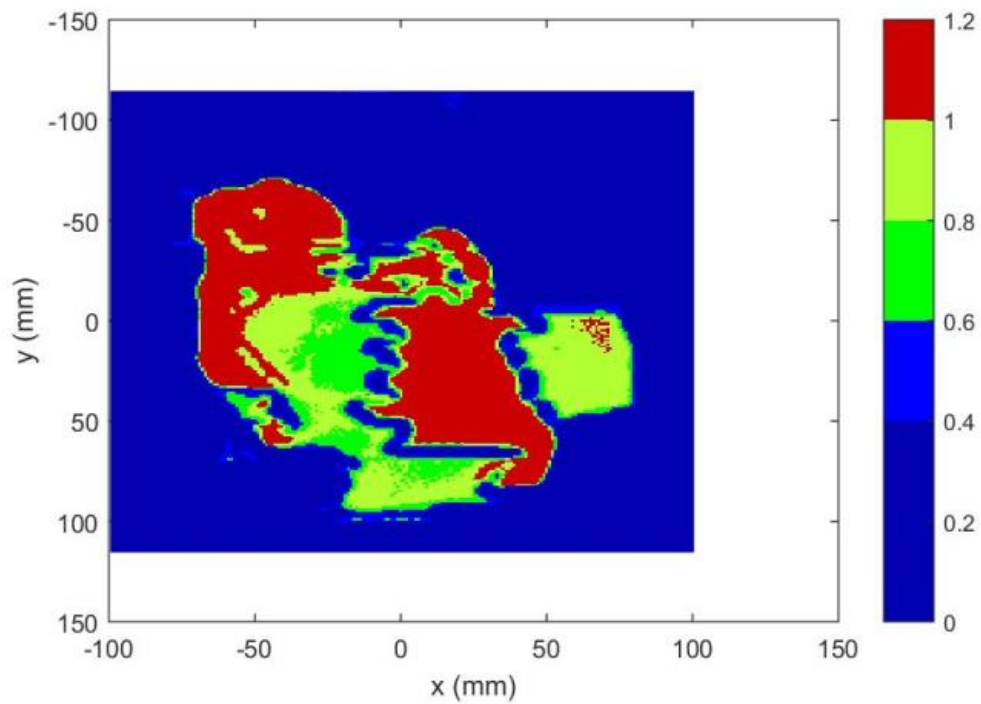
Selection of patients for comparison

A series of patients were selected from the list of clinical patients and a list of patients identified by Alison. The comparison also performed for a different combination of VMAT/IMRT and registration/no-registration.

3. Results and discussion

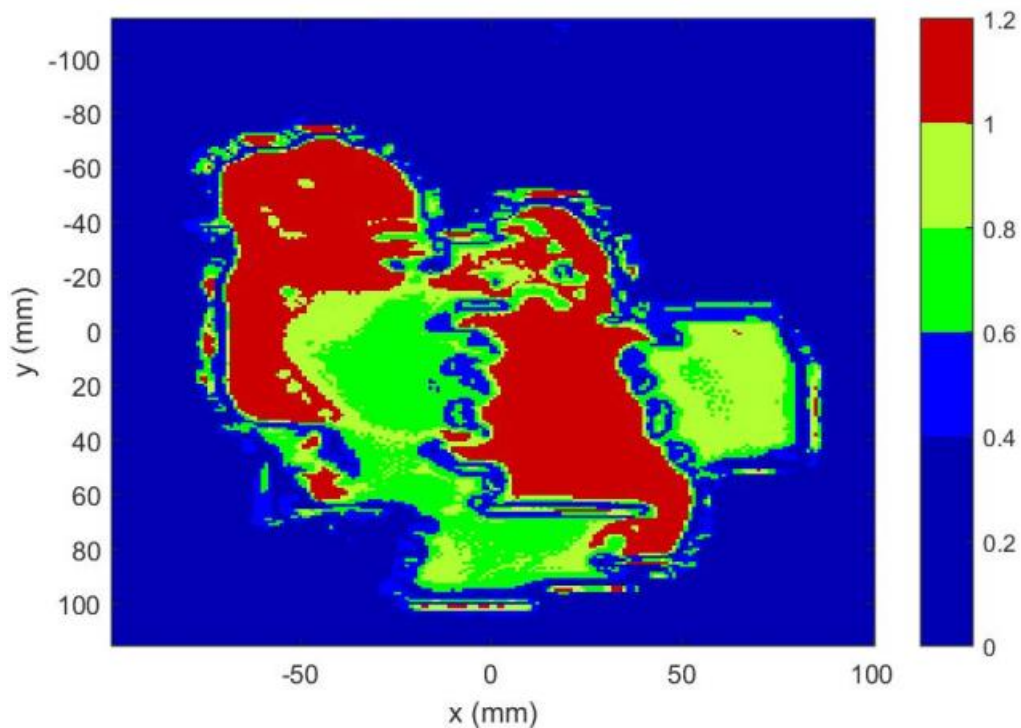
Gamma calculated with TomoExit Gamma and AutoEPID

The gamma map calculated using TomoExit Gamma and are considered to be the same despite the slight difference at the edge of the gamma map due to the different application. The Gamma pass rates agree with each other with 1%. As an example, showed a gamma map calculated using both gamma functions without registration.



Gamma Criteria: 3mm/3% of maximum TPS dose and 10% threshold
Gamma Map Statistics
Total gamma pixel number: 46000
Passed gamma pixel number(gamma<1): 39006
Minimum Value: 5.2876e-06
Maximum Value: 2
Mean Value: 0.43609
Gamma range (0-1): 84.7957%
Gamma range (>1): 15.2043%

(a)



Gamma Criteria: 3mm/3% of maximum TPS dose and 10% threshold
Gamma Map Statistics
Total gamma pixel number: 46000
Passed gamma pixel number (gamma < 1): 38826
Minimum Value: 4.9629e-06
Maximum Value: 2.8645
Mean Value: 0.45591
Gamma range (0-1): 84.4043%
Gamma range (>1): 15.5957%

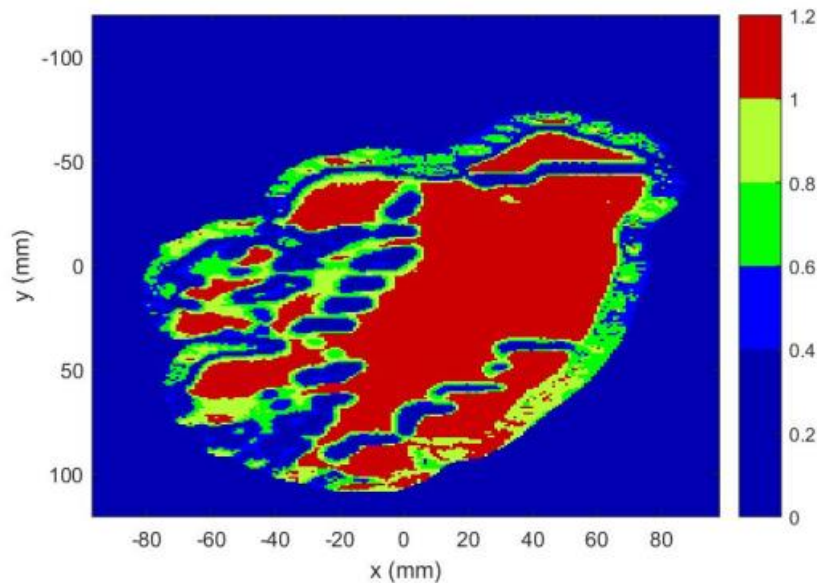
(b)

Figure 3 The gamma map and gamma statistics calculated using gamma function for one IMRT beam used in TomoExit (a) and AutoEPID (b).

Gamma calculated AutoEPID and OminIMRTPro

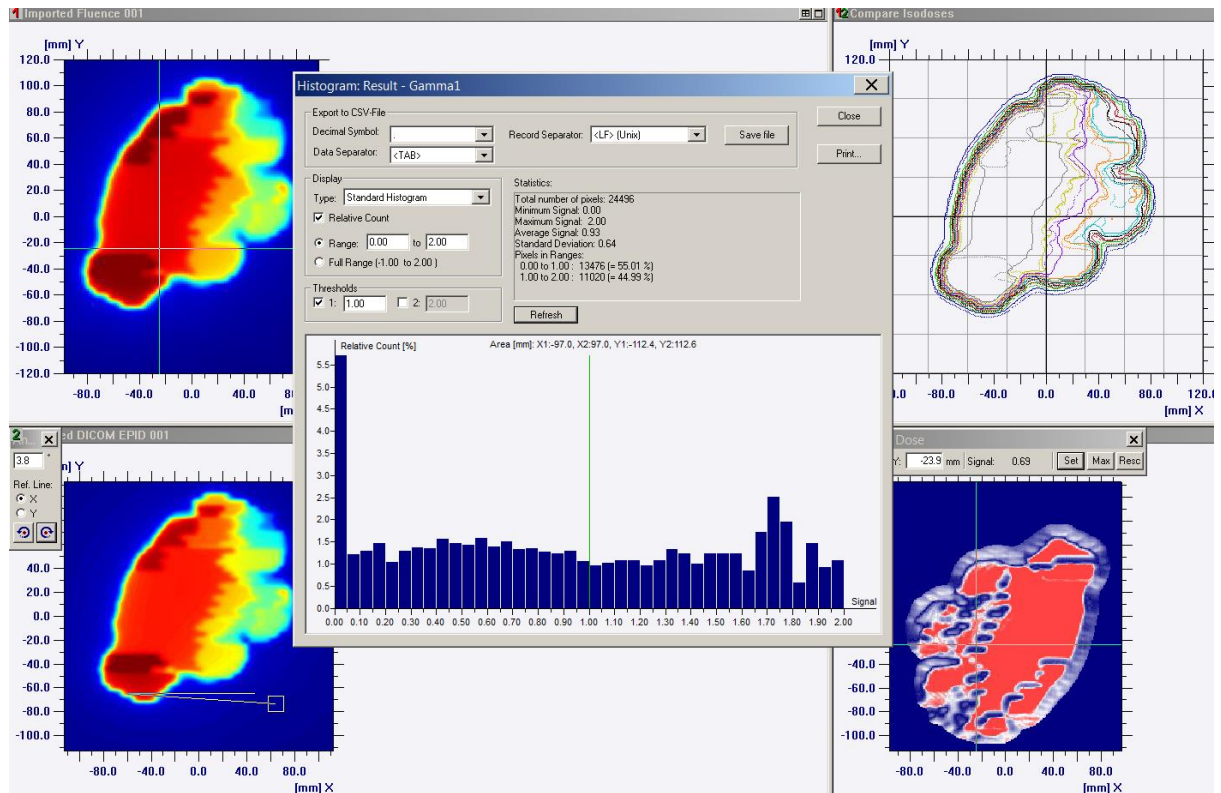
The gamma maps calculated within OminIMRTPro and ones calculated with AutoEPID are equivalent in term of (1) the pass and failing areas are the same ; (2)

the gamma pass rate is approximately equivalent and differ by a few percentages. This is due to the different implementation of the Gamma function in OminiIMRTPro and AutoEPID. As an example, the **Figure 4**, **Figure 6** and **Figure 6** showed gamma map calculated by two software tools for some IMRT and VMAT beams.



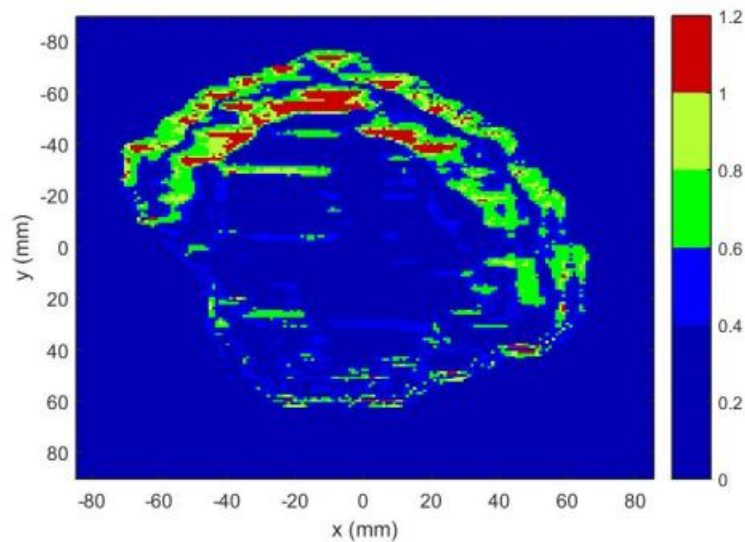
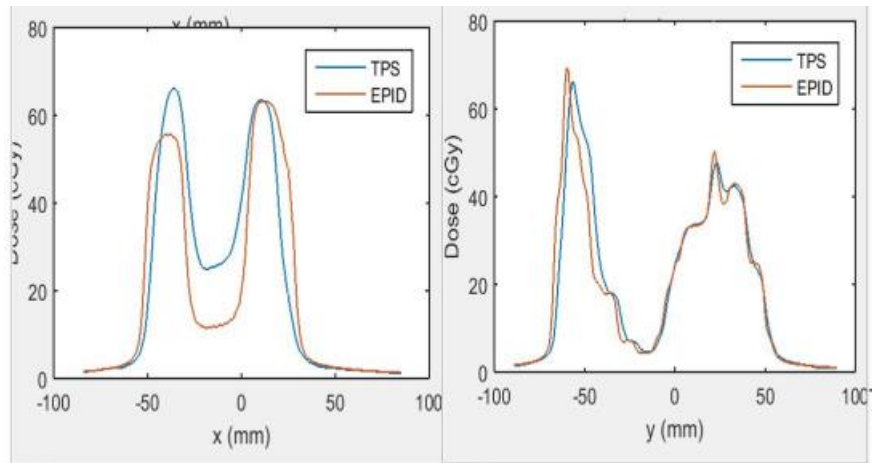
Gamma Criteria: 3mm/3% of maximum TPS dose and 10% threshold
Gamma Map Statistics
Total gamma pixel number: 21208
Passed gamma pixel number(gamma<1): 11288
Minimum Value: 0.00052456
Maximum Value: 2
Mean Value: 0.93563
Gamma range (0-1): 53.2252%
Gamma range (>1): 46.7748%

(a)



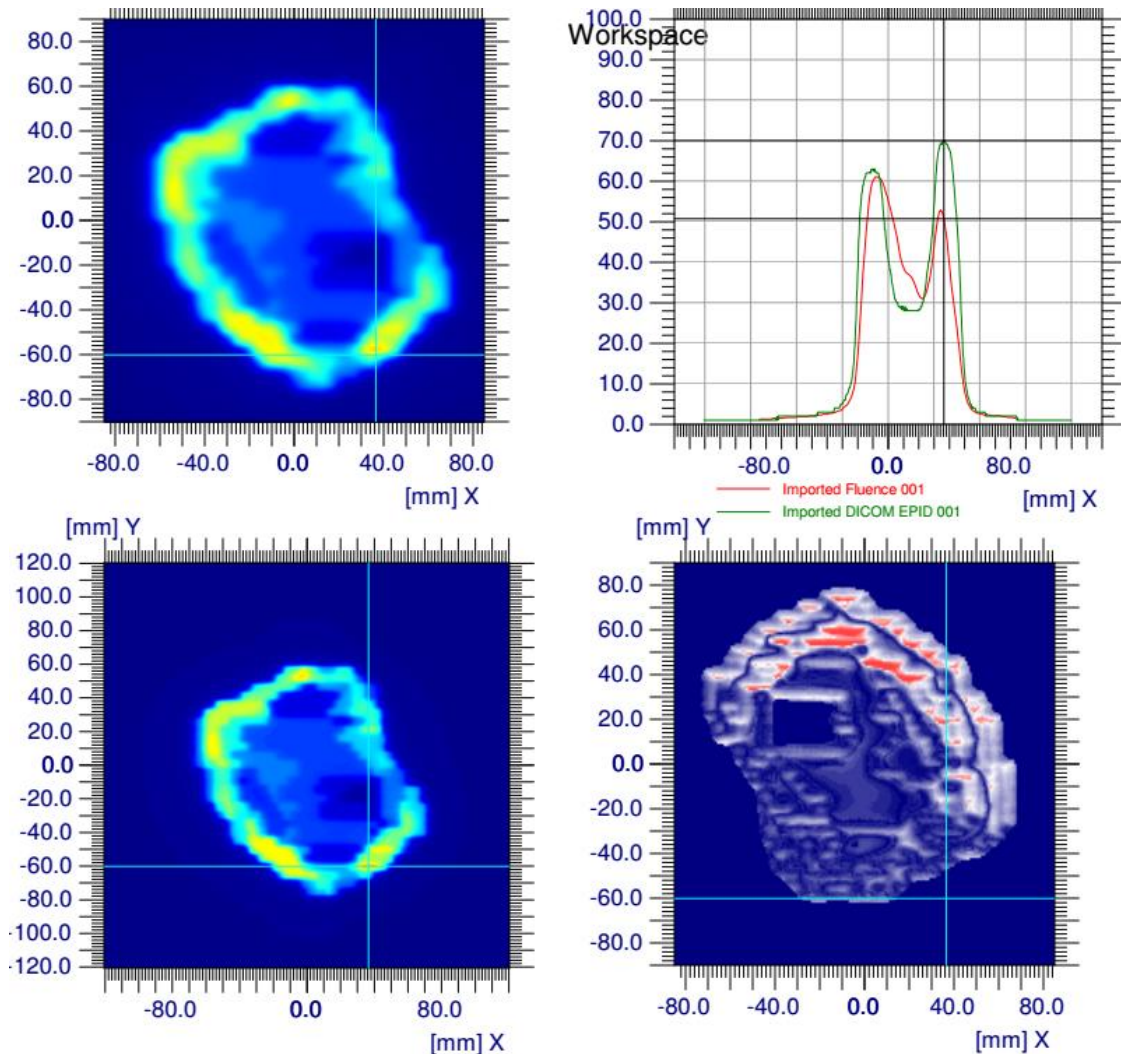
(b)

Figure 4 The Gamma map and gamma statistics calculated with AutoEPID (a) and OminIMRTPro (b) for one IMRT beam selected from the list of patients with problems.



Gamma Criteria: 3mm/3% of maximum TPS dose and 10% threshold
Gamma Map Statistics
Total gamma pixel number: 12837
Passed gamma pixel number (gamma < 1): 12258
Minimum Value: 8.6054e-05
Maximum Value: 1.6933
Mean Value: 0.42279
Gamma range (0-1): 95.4896%
Gamma range (> 1): 4.5104%

(a)



Field (data set 1):
Imported Fluence 001

Field (data set 2):
Imported DICOM EPID 001

Comment:
Total number of pixels: 13457
Minimum Signal: 0.00
Maximum Signal: 1.36
Average Signal: 0.37
Standard Deviation: 0.28
Pixels in Ranges:
0.00 to 1.00 : 13131 (= 97.58 %)
1.00 to 1.36 : 326 (= 2.42 %)

Result: Gamma, 3.0 %, 3.0 mm

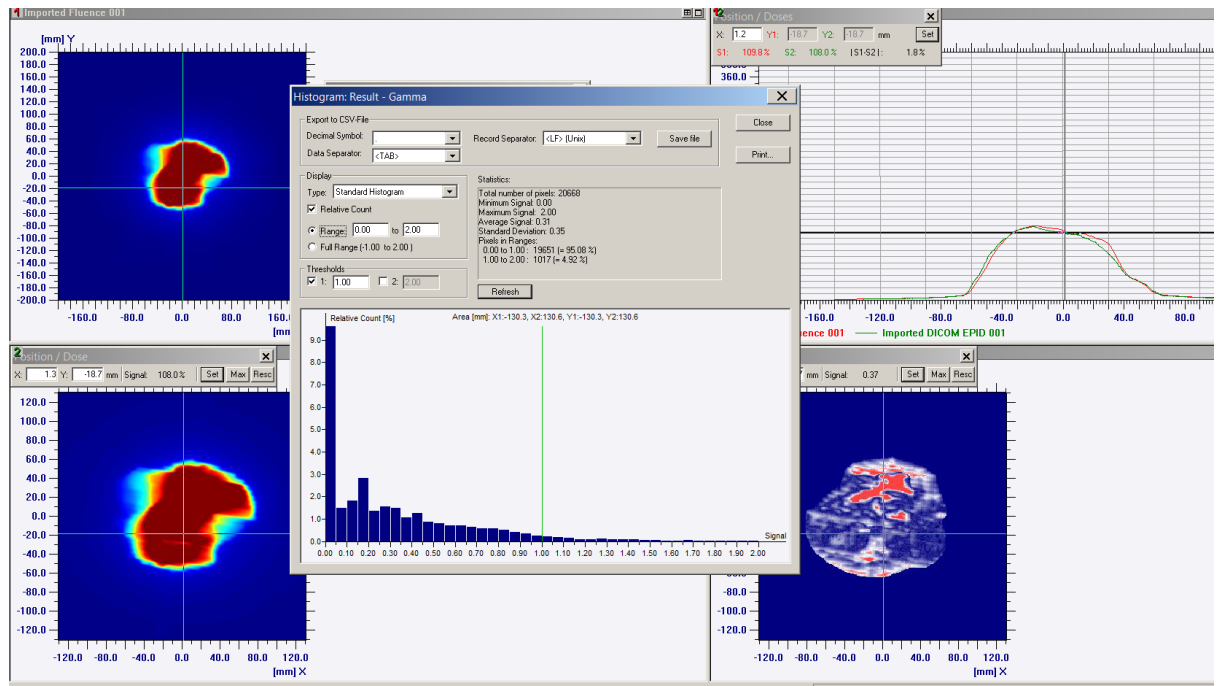
Administrative:
Date:

Signature:

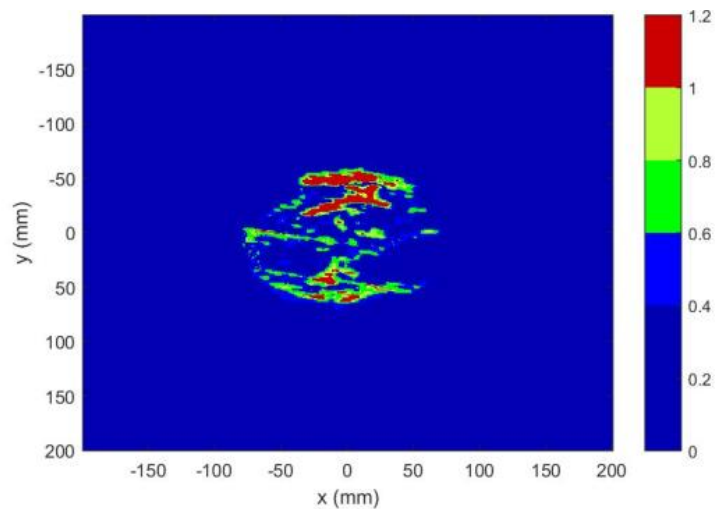
Name: AX

(b)

Figure 5 The Gamma map and gamma statistics calculated with AutoEPID (a) and OminIMRTPro (b) for another IMRT beam selected from one clinical patient.



(a)



Gamma Criteria: 3mm/3% of maximum TPS dose and 10% threshold
Gamma Map Statistics
Total gamma pixel number: 27802
Passed gamma pixel number (gamma < 1): 26528
Minimum Value: 5.2524e-06
Maximum Value: 1.8362
Mean Value: 0.32052
Gamma range (0-1): 95.4176%
Gamma range (>1): 4.5824%

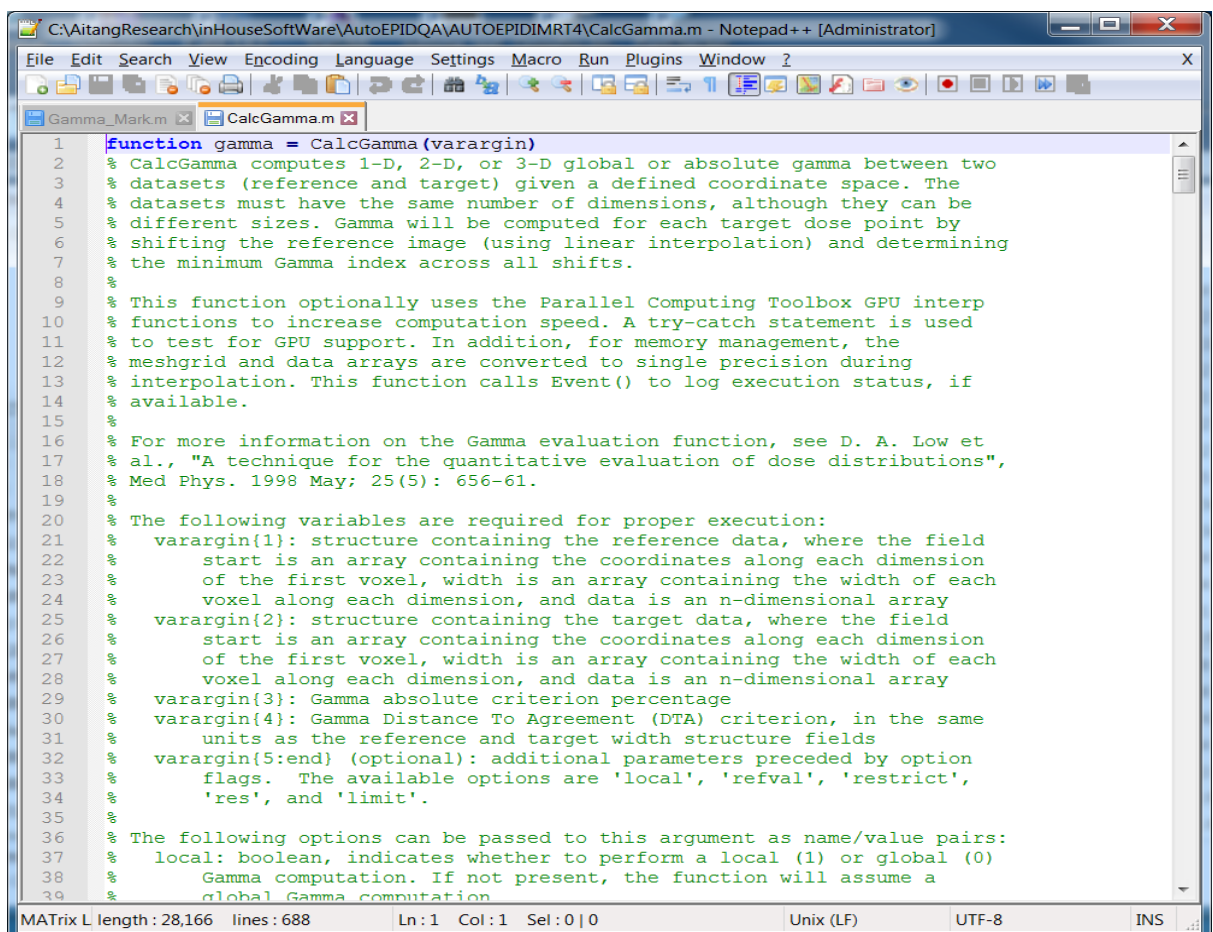
Figure 6 The Gamma map and gamma statistics calculated with AutoEPID (a) and OminIMRTPro (b) for one VMAT beam.

4. Conclusions

The gamma function used in AutoEPID was compared with one used in TomoExit and OminIMRTPro after debugging and issues fixed. The Gamma map and Gamma report from AutoEPID are same or equivalent with OminiIMRTPro and TomoExit considering the difference caused by different gamma function implementation in three software tools.

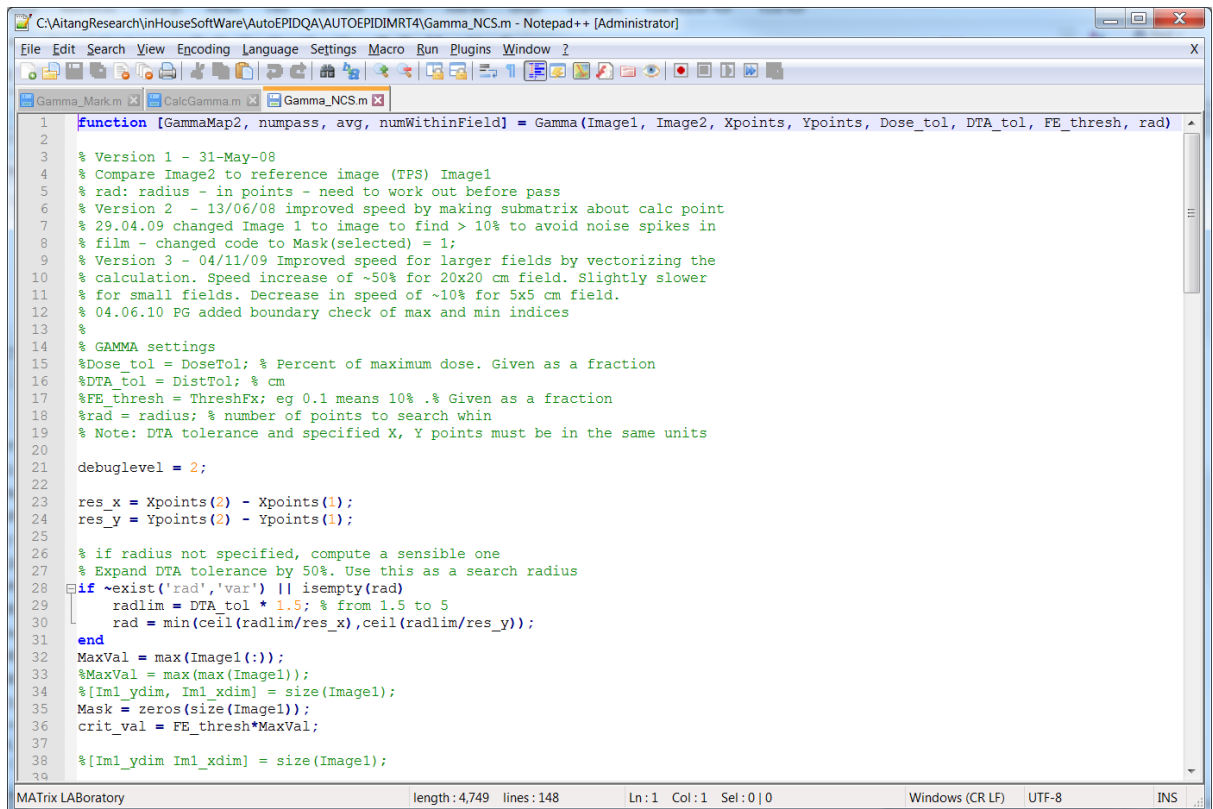
5. Appendix

Figure 7 The Gamma function used in TomExit.



```
1 function gamma = CalcGamma(varargin)
2 % CalcGamma computes 1-D, 2-D, or 3-D global or absolute gamma between two
3 % datasets (reference and target) given a defined coordinate space. The
4 % datasets must have the same number of dimensions, although they can be
5 % different sizes. Gamma will be computed for each target dose point by
6 % shifting the reference image (using linear interpolation) and determining
7 % the minimum Gamma index across all shifts.
8 %
9 % This function optionally uses the Parallel Computing Toolbox GPU interp
10 % functions to increase computation speed. A try-catch statement is used
11 % to test for GPU support. In addition, for memory management, the
12 % meshgrid and data arrays are converted to single precision during
13 % interpolation. This function calls Event() to log execution status, if
14 % available.
15 %
16 % For more information on the Gamma evaluation function, see D. A. Low et
17 % al., "A technique for the quantitative evaluation of dose distributions",
18 % Med Phys. 1998 May; 25(5): 656-61.
19 %
20 % The following variables are required for proper execution:
21 %   varargin{1}: structure containing the reference data, where the field
22 %               start is an array containing the coordinates along each dimension
23 %               of the first voxel, width is an array containing the width of each
24 %               voxel along each dimension, and data is an n-dimensional array
25 %   varargin{2}: structure containing the target data, where the field
26 %               start is an array containing the coordinates along each dimension
27 %               of the first voxel, width is an array containing the width of each
28 %               voxel along each dimension, and data is an n-dimensional array
29 %   varargin{3}: Gamma absolute criterion percentage
30 %   varargin{4}: Gamma Distance To Agreement (DTA) criterion, in the same
31 %               units as the reference and target width structure fields
32 %   varargin{5:end} (optional): additional parameters preceded by option
33 %               flags. The available options are 'local', 'refval', 'restrict',
34 %               'res', and 'limit'.
35 %
36 % The following options can be passed to this argument as name/value pairs:
37 %   local: boolean, indicates whether to perform a local (1) or global (0)
38 %           Gamma computation. If not present, the function will assume a
39 %           global Gamma computation.
```

Figure 8 The Gamma function used in AutoEPID.



```
1 function [GammaMap2, numpass, avg, numWithinField] = Gamma(Image1, Image2, Xpoints, Ypoints, Dose_tol, DTA_tol, FE_thresh, rad)
2
3 % Version 1 - 31-May-08
4 % Compare Image2 to reference image (TPS) Image1
5 % rad: radius - in points - need to work out before pass
6 % Version 2 - 13/06/08 improved speed by making submatrix about calc point
7 % 29.04.09 changed Image 1 to image to find > 10% to avoid noise spikes in
8 % film - changed code to Mask(selected) = 1;
9 % Version 3 - 04/11/09 Improved speed for larger fields by vectorizing the
10 % calculation. Speed increase of ~50% for 20x20 cm field. Slightly slower
11 % for small fields. Decrease in speed of ~10% for 5x5 cm field.
12 % 04.06.10 PG added boundary check of max and min indices
13 %
14 % GAMMA settings
15 %Dose_tol = DoseTol; % Percent of maximum dose. Given as a fraction
16 %DTA_Tol = DistTol; % cm
17 %FE_Thresh = ThreshEx; eg 0.1 means 10% .% Given as a fraction
18 %rad = radius; % number of points to search whin
19 % Note: DTA tolerance and specified X, Y points must be in the same units
20
21 debuglevel = 2;
22
23 res_x = Xpoints(2) - Xpoints(1);
24 res_y = Ypoints(2) - Ypoints(1);
25
26 % if radius not specified, compute a sensible one
27 % Expand DTA tolerance by 50%. Use this as a search radius
28 if ~exist('rad','var') || isempty(rad)
29     radlim = DTA_tol * 1.5; % from 1.5 to 5
30     rad = min(ceil(radlim/res_x),ceil(radlim/res_y));
31 end
32 MaxVal = max(Image1(:));
33 %MaxVal = max(max(Image1));
34 % [Iml_ydim, Iml_xdim] = size(Image1);
35 Mask = zeros(size(Image1));
36 crit_val = FE_thresh*MaxVal;
37
38 % [Iml_ydim Iml_xdim] = size(Image1);
39
```