DIGESTIVE TRACT

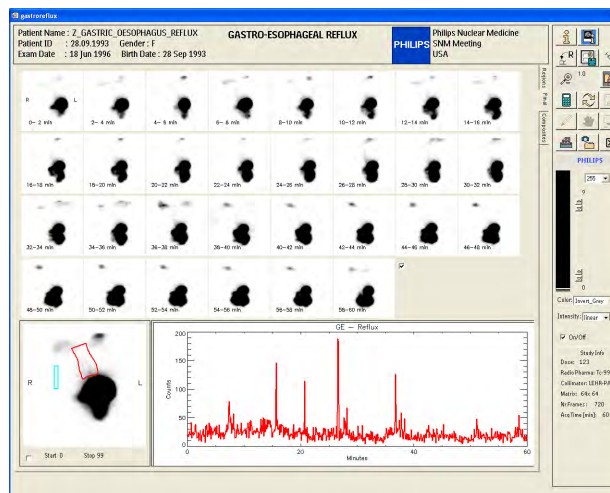# 26 Gastric: Gastro-Esophageal Reflux

26.1 General

Figure 242   Gastro-Esophageal Reflux application

This application displays gastro-esophageal reflux by means of a dynamic image and a time activity curve of the esophagus region.

26.2 Acquisition

Dynamic image, matrix 64 x 64 typical, 720 frames at 5 seconds/frame.
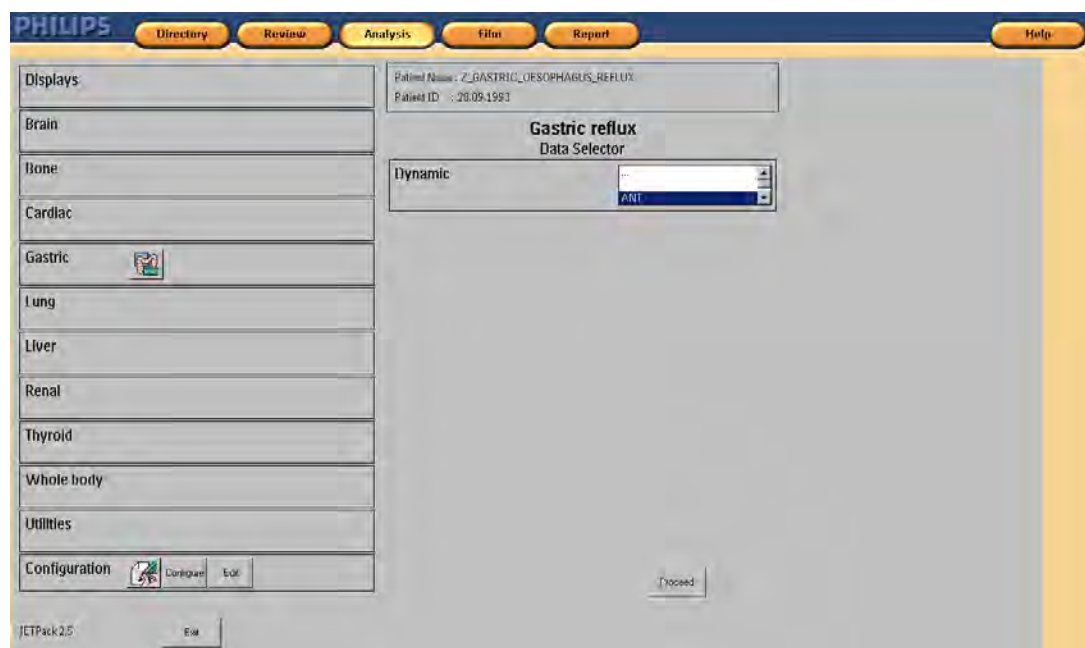
26.3   Processing

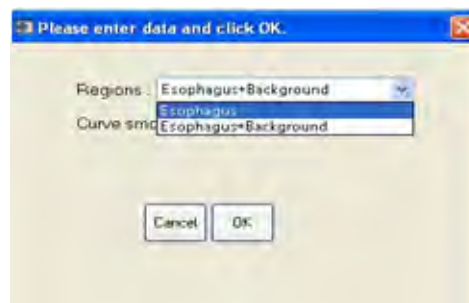**Figure 243**   ISP JETPack panel, Gastric Reflux application selected

If required adjust the selected file in the data bucket and click **Proceed**.

26.4   Button Panel, Image Control, and Annotations

See Chapter 1, "Getting Started."

Set Defaults: Click this button to bring up the default selection panel for the esophageal region.

You can choose to generate the gastric-esophageal curve with or without background correction and with or without smoothing. The **Region Control** menus are modified accordingly.

Important   You must exit the application and then restart to activate the new default settings.
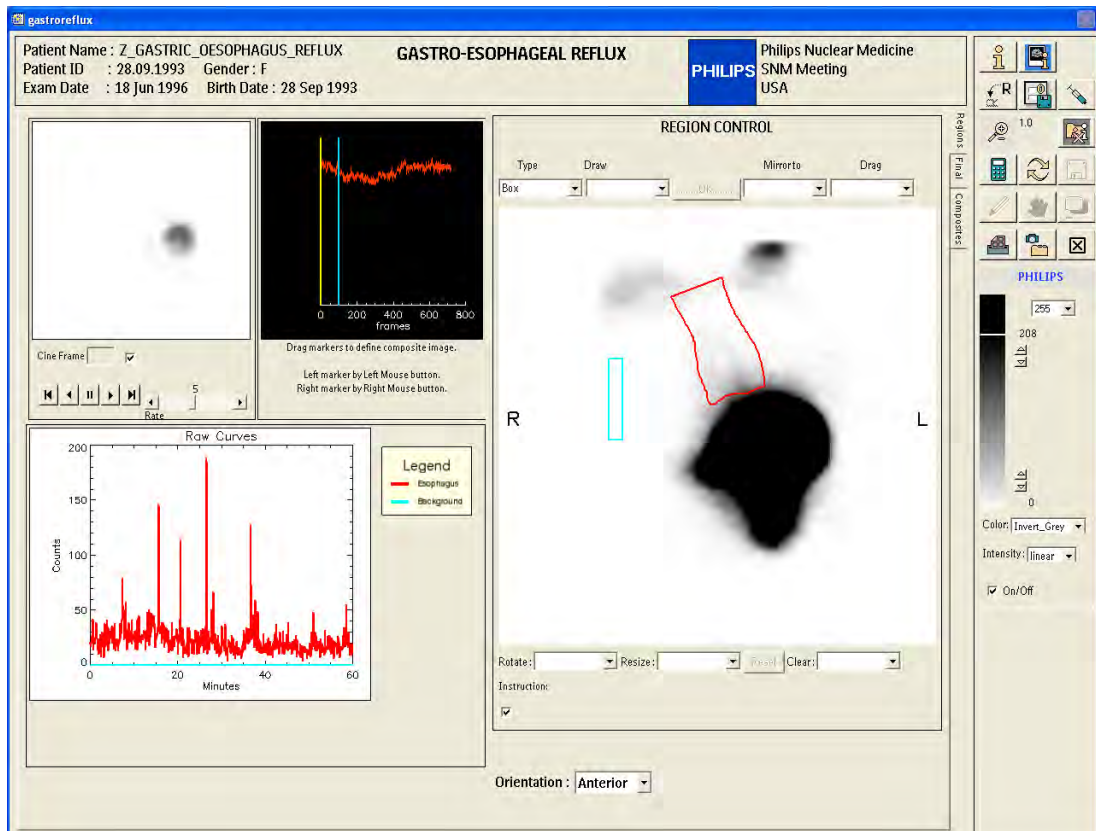
26.5 Regions Page

Figure 244 Regions page, Cine, Composite selection, Regions control, raw Curves

The dynamic image appears in the Cine panel and a composite image is generated and displayed in the Region control viewport. You can enable the individual images by means of the image checkboxes for adjustment of window setting, color map, and Intensity (log, exp) etc.

Use the cine controls to display the dynamic image in motion or step through individual frames. Drag the yellow and blue markers on the composite selection curve to build a different **composite image** if so desired.

Select the processing method **Esophagus Only** or **Esophagus** and **Background** from the Set Defaults panel.

Regions: Draw the esophagus and background regions by Polygon, Freehand, or Box mode. Once you have drawn the required regions, the Calculate & Display button becomes available. Click that button to generate the curves. The Raw Curve set appears at the bottom left curve display. Click the **Final** tab to view the area-normalized background-subtracted esophagus curve.
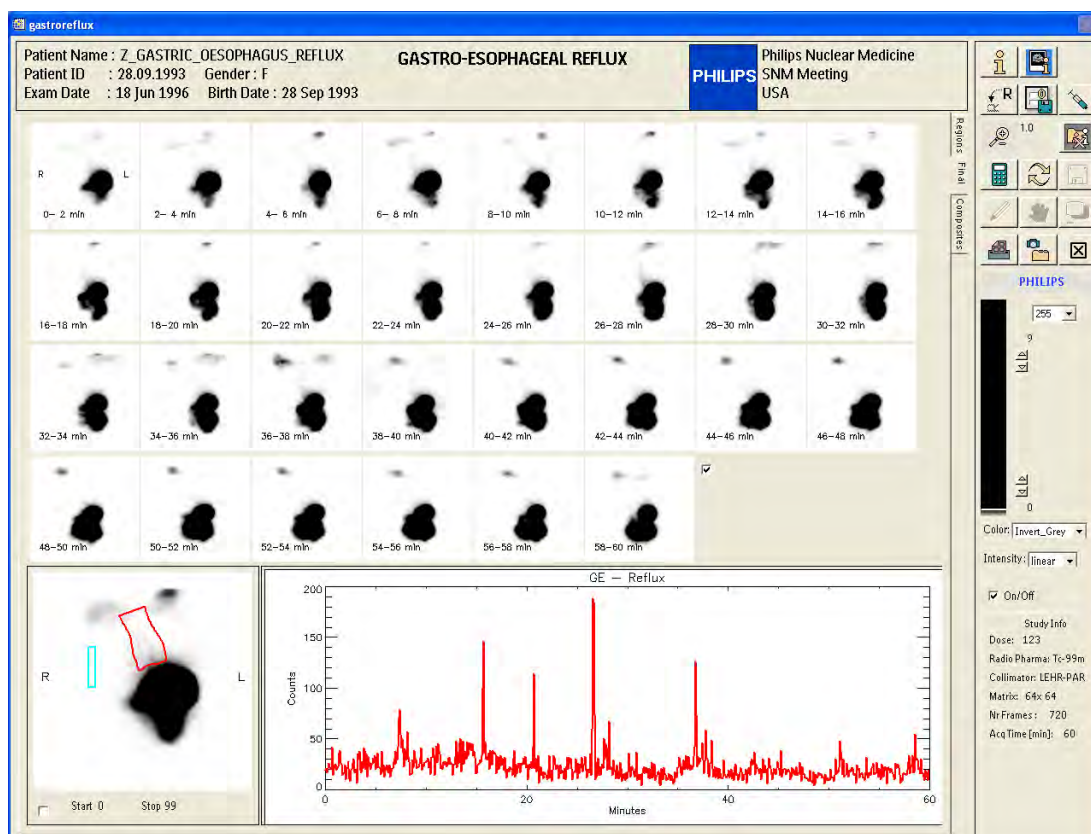
26.6　　　Final Page

Figure 245　Final page with Study Info panel

The Final page shows the following:

Thirty composite images appear with time ranges derived from the input image by dividing the total time in 30 segments. You can use zoom and image controls to adjust the images as a series.

Curves: Esophagus curve

Composite image: with regions superimposed

Injected Dose: as calculated from input in the Enter Injected Dose input panel.
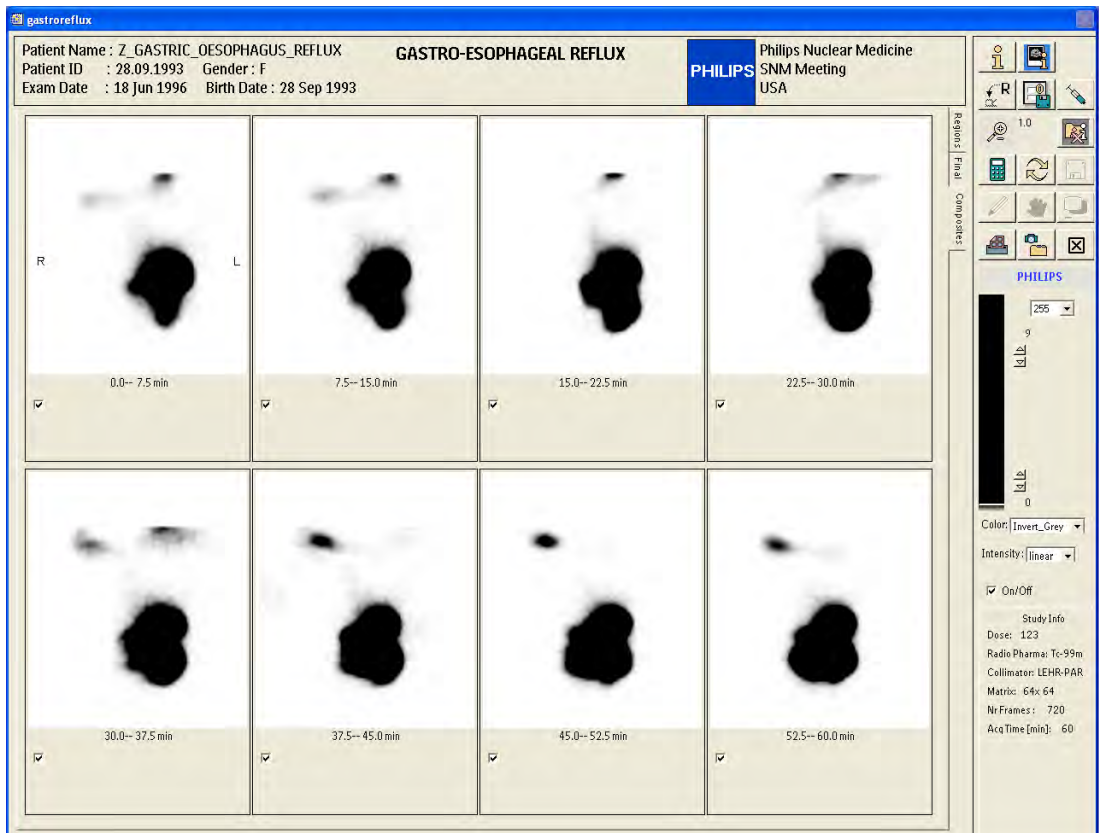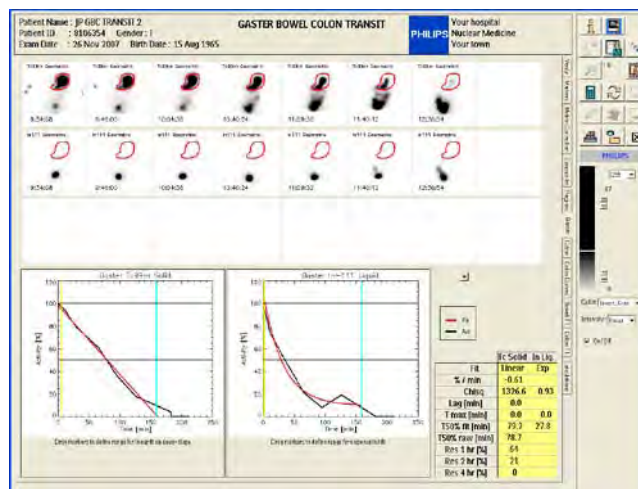
26.7   Composites Page

Figure 246   Composites page

The Composites page displays eight composite images that were made from the input images by splitting the total acquisition time into eight segments. The calculated time range per composite appears below each image. A checkbox near each image allows individual or combined image adjustment. With the On/Off checkbox flagged in the Button Panel, all image checkboxes are set or cleared, thus causing the image and zoom controls on the button panel to work on all composites simultaneously.

27   Gaster Bowel Colon Transit

27.1   General

The Gaster Bowel Colon Transit application can be used to measure Gastric Emptying half times of Tc99m and In111 for Solid or Solid+Liquid emptying studies respectively.

In addition Small Bowel Transit and Colon Transit times can be determined if additional static images of In111 capsule acquisitions are supplied. It is recommended to simultaneously acquire a marker, taped to the patient, to allow for motion correction.

27.2   Acquisition

For Gastric emptying measurements either Dynamic images or sets of Static images can be used, for small bowel and colon measurement you must add the Colon static images. The number of frames in the dynamic image(s) should be selected such that the full range of 12 frames in the application can be used to build the curves. Time per frame must be 1 minute in dynamic mode.

The dynamic images are sampled to extract 12 frames. If you want to calculate the residual activity at 90 minutes the proper number of frames is 8 x 12 = 96 or more, then every 8th frame is extracted. If you only have 90 frames in the study the application will sample every 7th frame, up to 84 then take the 90th frame as the last frame. In general you should try to acquire the number of frames as being multiples of 12.

If you want to measure bowel and colon transit times as well, you must acquire static images during the Gastric emptying phase for 4 hours at the recommended intervals.

27.2.1 Gastric Emptying Solid only measurement: select one situation

1 Minimum: Dynamic image of Tc99m in anterior view. Processing is on the anterior image only. Matrix 128by, 1 min/frame, for at least 98 minutes.

2 Dynamic images of Tc99m in anterior + posterior view, matrix 128by, 1 min/frame, at least 98 minutes. Processing of Anterior and Posterior images separately or via Geometric images, you can set the default accordingly.

3 Static Images:

• Static images: matrix 128x128, acquisition duration typically150 seconds per image.

• Simultaneous anterior + posterior of Tc99m for solid phase only

• Typical acquisition times: 0, 15, 30, 90, 120, 180, 240 min for gastric investigations only.

27.2.2 Gastric Emptying Solid and Liquid measurements, select one situation

1 Dynamic images: Tc99m anterior and In111 anterior, simultaneous acquisition in dual isotope mode. Matrix 128by, 1 min/frame, for at least 98 minutes.

2 Dynamic images: Tc99m anterior + posterior, In111 anterior + posterior , simultaneous acquisition in dual isotope mode. Matrix 128by, 1 min/ frame, for at least 98 minutes. This will generate geometric images of Tc99 and In111 for processing.

3 Static Images:

• Static images: matrix 128x128, acquisition duration typically 150 seconds per image.

• Simultaneous acquisition of anterior + posterior of dual isotope Tc99m+In111 for solid + liquid phase

• Typical acquisition times: 0, 15, 30, 90, 120, 180, 240 min for Gastric investigations only.

27.2.3 Small bowel and Colon transit time measurements

Acquire static images for the gastric phase as indicated above.

Acquire additional images for colon investigations using In111 applied in a   special capsule.

- Static images: matrix 128x128, acquisition duration typically150 seconds per image.

- Simultaneous acquisition of anterior + posterior of dual isotope Tc99m+In111 for solid + liquid phase

- Typical acquisition times at: 5, 6, 7, 8, 10,12, 24, 36 hrs.

27.2.4   Processing steps with Marker activity

Use the following processing sequence if you have marker activity taped to the patient:

1 Verify page

2 Draw Marker(s)

3 Correct images for motion, using the marker ROI.

4 Determine composite image from motion corrected images

5 Draw regions Stomach and background ROIs.

6 Calculate and adjust time ranges for curve fits.

27.2.5   Processing steps without Marker activity

Use the following processing sequence if you do NOT have marker activity taped to the patient:

1 Verify page

2 Regions page

3 Draw stomach and background ROIs

4 Return to the motion correction page, adjust the images such that the stomach activity fits the stomach ROI

5 Calculate and adjust time ranges for curve fits.
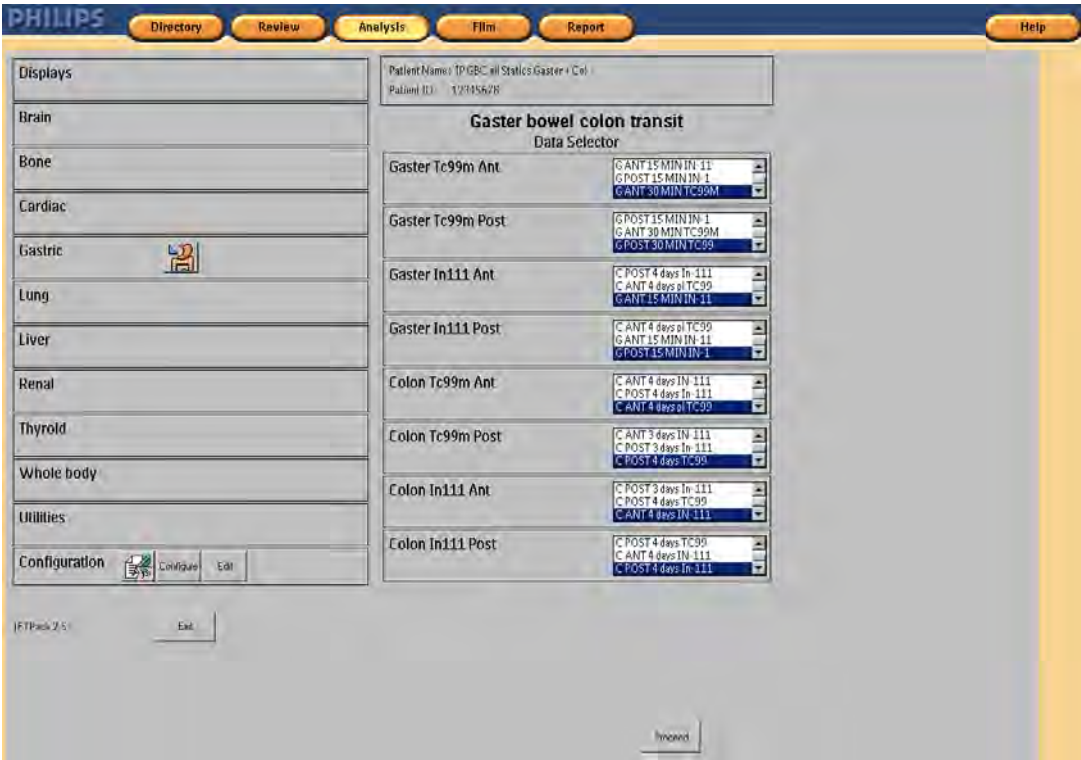
27.3 Processing

Figure 247 ISP JETPack panel, Gaster Bowel Colon application selected

If required adjust the selected file in the data bucket and click **Proceed**.

The patient and image selection for the application shows eight buckets for Gaster Tc99m Anterior+ Posterior, Gaster In111 Anterior + Posterior, Colon Tc99m Anterior+ Posterior and Colon In111 Anterior + Posterior objects. Be aware that the top four buckets accept either a dynamic image or multiple static objects.

Through 'Auto matching strings' in the names of the objects the load process can be simplified considerably. The following image sorting is set up in the so-called apphook file.(gasterbowel.ini). For instance an object name "G ANT 0 MIN IN-111" that contains G , IN-1 and Ant will be loaded into the bucket by the name "Gaster Static In 111 Ant" , see the table below.

Data Bucket	Include string
Gaster Static Tc 99m Ant	G*ANT*TC9*
Gaster Static Tc 99m Post	G*POST*TC9*
Gaster Static In 111 Ant	G*ANT *IN-1*
Gaster Static In 111 Post	G*POST*IN-1*

Philips Healthcare

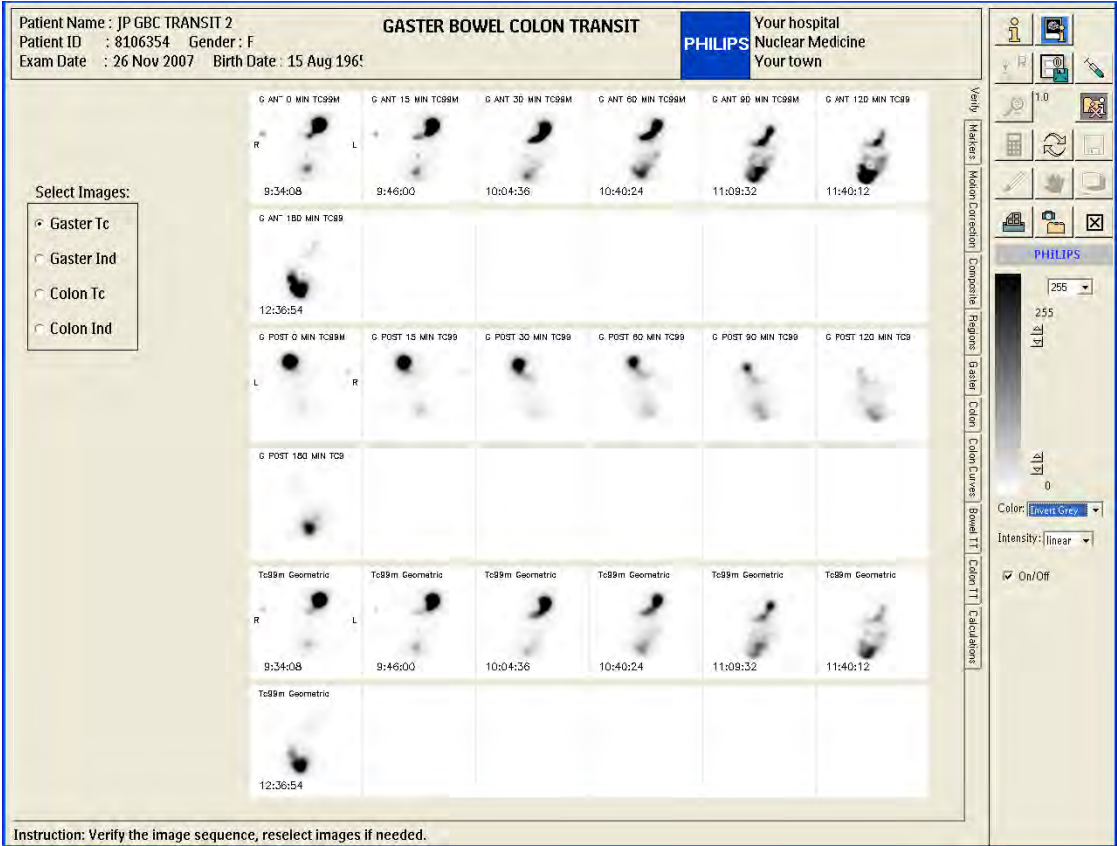| Colon Static Tc 99m Ant	C*ANT*TC9*
Colon Static Tc 99m Post	C*POST*TC9*
Colon Static In 111 Ant	C*ANT*IN-1*
Colon Static In 111 Post	C*POST*IN-1*

27.4   Verify Page

Figure 248   Verify page.

The selected images are automatically sorted by incrementing time of acquisition. anterior and posterior images of the same set, e.g. Tc99mm gaster, are used to build the geometric mean images. For all four sets, gaster Tc99m, gaster In111, colon Tc99m and Ind111, these geometric mean images are generated if the required images were selected.

It is possible to run the application with just gaster images for gastric emptying calculations, using only Tc99m or with Tc99m +In111, for solid or solid + liquid phase.

On this page the left hand "radio style" switch allows display of the up to four different image sets. Notice that the top two rows of images on the screen display the anterior images, the central two rows the posterior and the bottom two rows the calculated geometric mean images.

Figure 249   Defaults entry panel

Use this panel to set up the defaults for the application. In order for the new defaults to have effect you need to exit and restart the application.

In111 crosstalk: presets the In111 crosstalk factor into Tc99. The standard value is preset to 0.44

Gastric Solids Anterior+Posterior: Geometric Images?

In the case of Gastric Solids only you may work with the individual Anterior and Posterior images to define ROIs or work with Geometric images. If you acquire on a single head camera with Static images the non-geometric images mode is recommended as it allows you to correct the images for motion. If you however acquire on a dual head camera anterior and posterior images are already aligned to generate proper Geometric images. That mode will save time as there is no need to draw ROIs for Anterior and Posterior individually and align both sets of images for motion correction.

Bowel/Colon Tests: No, removes the additional pages that are used for Bowel and Colon measurements. Set this to No if you only use this application for Gastric Emptying. If you select yes here the "Calculate results from" will be forced to 'from t=0'. The selection Bowel/Colon

test= Yes will also force the setting of Geometric Image to Yes, even though you selected No previously. Bowel and Colon Tests only work with geometric images.

Colon Weigh Factors: Enter the five weighing factors for the colon regions to calculate the geometric centers of activity in the colon images. Typical values are shown in Figure 249.

Calculate results from: Selection of "t=0" will calculate and display the values for T1/2 and residual percentages at 1, 1.5, 2 and 4 hour in the Gaster page table with respect to the start time of acquisition (t=0). If you select "Tmax" here the same results will be calculated from the time of maximum of the Tc99 and In-111 curves respectively. Lag times are always calculated from Tmax irrespective of the switch settings.

In case of Bowel/Colon tests the results will always be calculated from t=0.

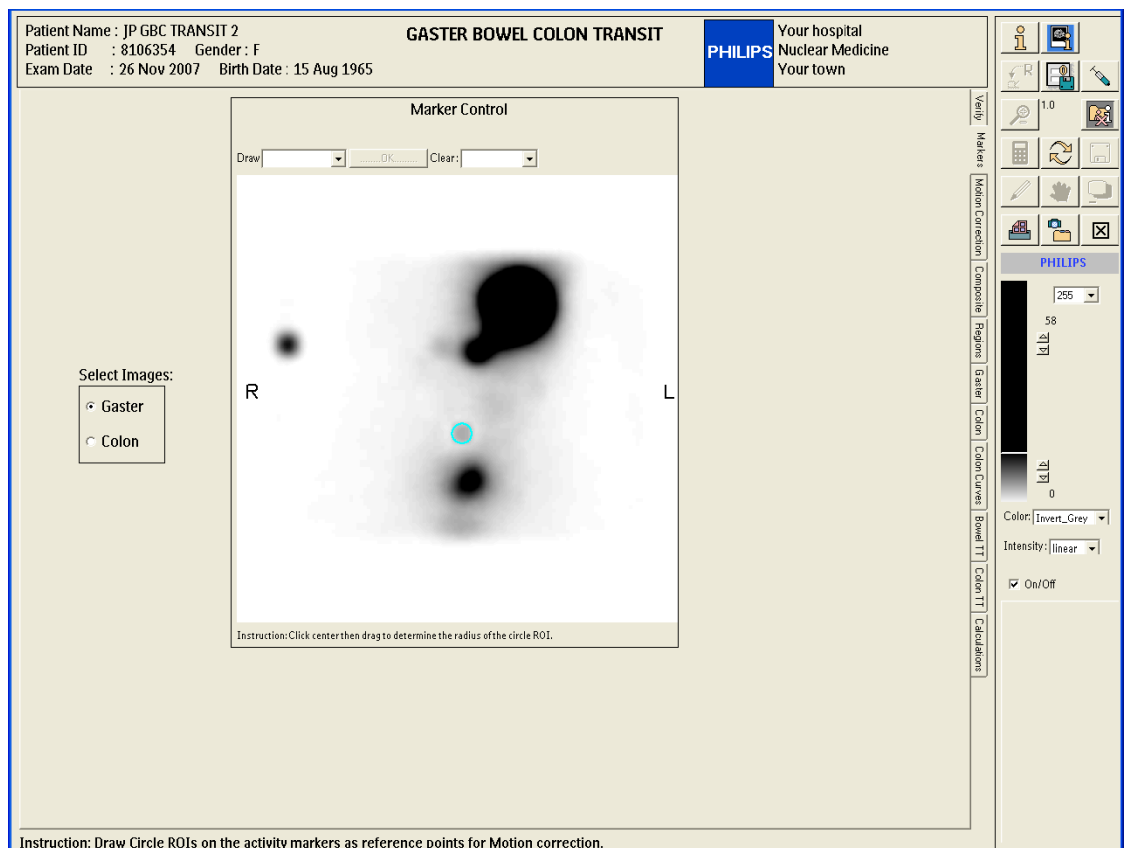## 27.5   Marker Page

Figure 250   Marker page

The first anterior images of Tc-Gaster and Tc-Colon (if acquired) are presented here. Each image must be marked with one or two circle ROIs to indicate the location of the activity of the cobalt marker(s). These ROIs are then used on the next page to align the various images.

Marking the patient with cobalt markers is recommended because of the method of acquisition were the patient is acquired for a short time then is moved away from the camera to be returned may be half an hour later for the next acquisition etc. Notice that the marker activity in this example picture is radiating through a hole in a small lead circular plate, this causes a marker activity that is easily visible for alignment.

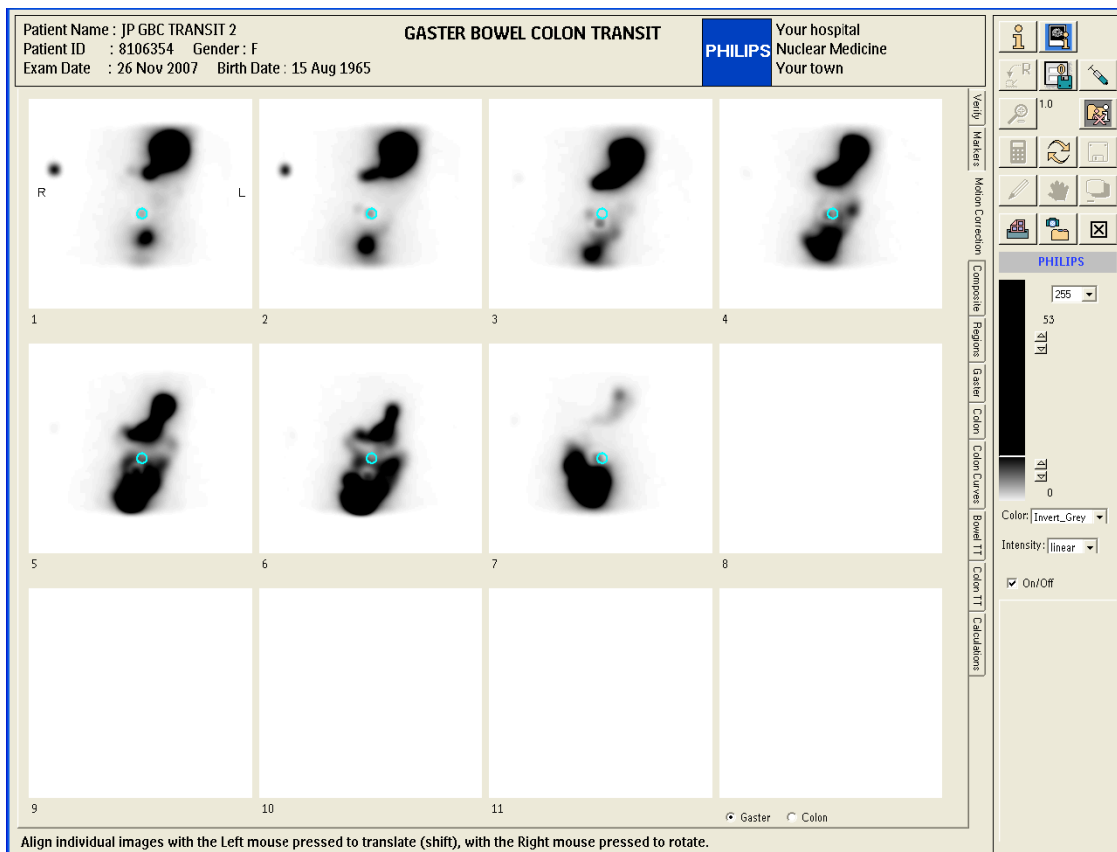## 27.6   Motion correction

Figure 251   Motion correction page

The anterior images of the Gaster Tc99 acquisition are displayed with the gaster marker ROI superimposed. Click on an image then drag the image to align the marker activity with the marker ROI. The accompanying Gaster geometric Tc99 and In111 images will be aligned at the same time. Click on the radio switch near the bottom right of the screen to select the Colon images (if selected). Notice that the marker ROI is at the correct position in the first image here, this is the situation before the images were aligned.

Drag an image with the left mouse button clicked for horizontal and/or vertical movement, click the right mouse button and drag to rotate and image.
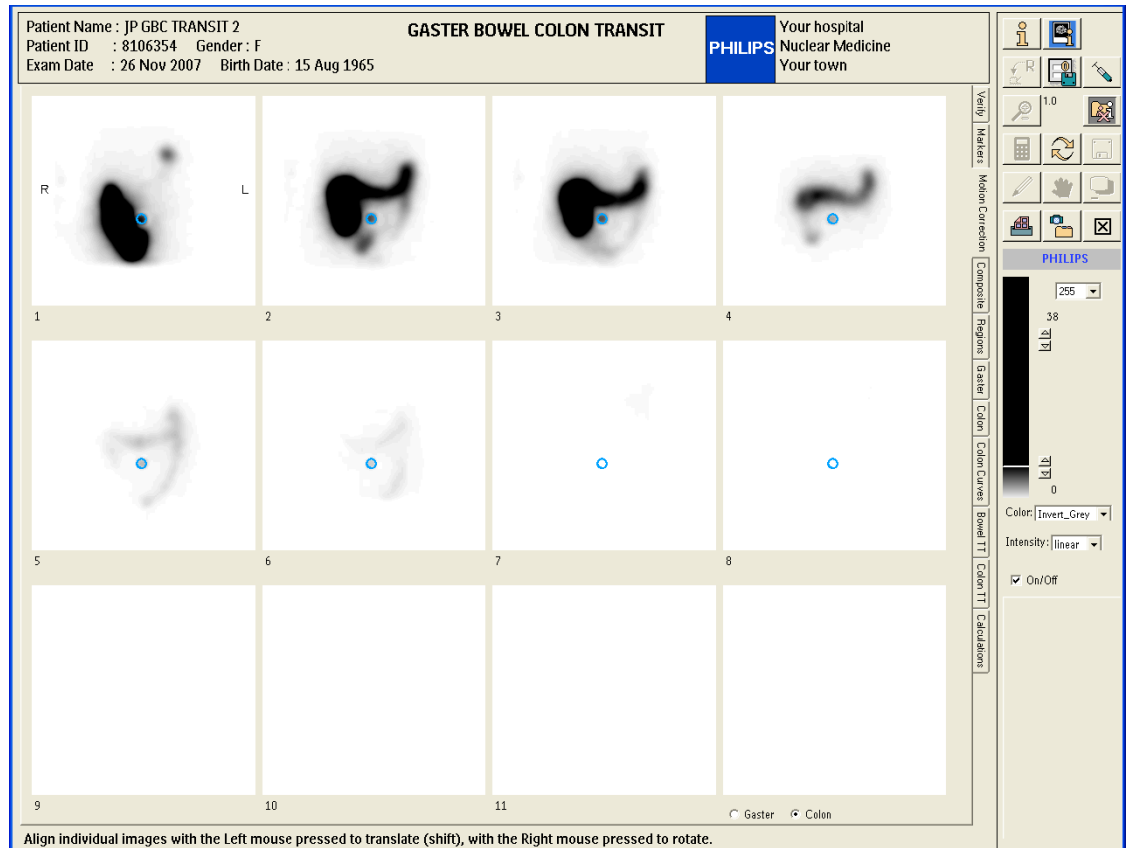

Figure 252   Colon images selected, showing the colon Tc99 images with the colon marker ROI superimposed. Images were aligned to the marker ROI.
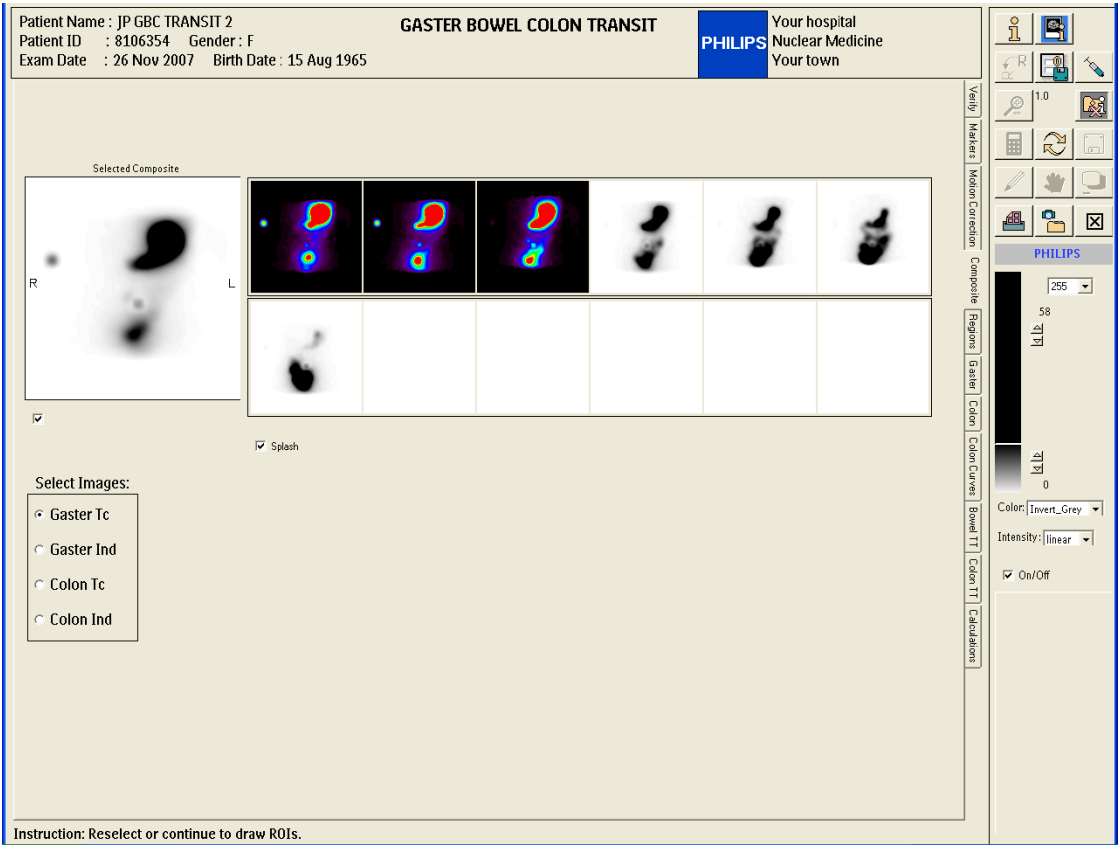
27.7   Composites Page

Figure 253   Composite select page

Click on a start frame and an end frame in the splash section, to build a composite image that you want to use for region drawing. In this example you can select four composite images, one per geometric set; gaster Tc99, gaster In-111, colon Tc99 or colon In-111.
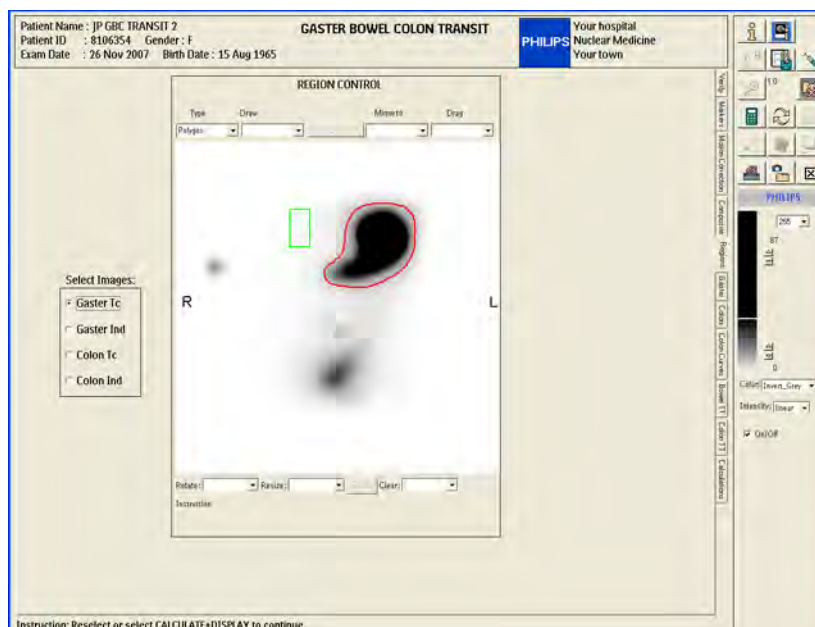
27.8   Regions Page

Figure 254   Regions page: Gaster ROIs

Select gaster Tc or gaster Ind to display the image where you want to draw the gaster ROIs. Gaster regions consist of the gaster and background ROIs.
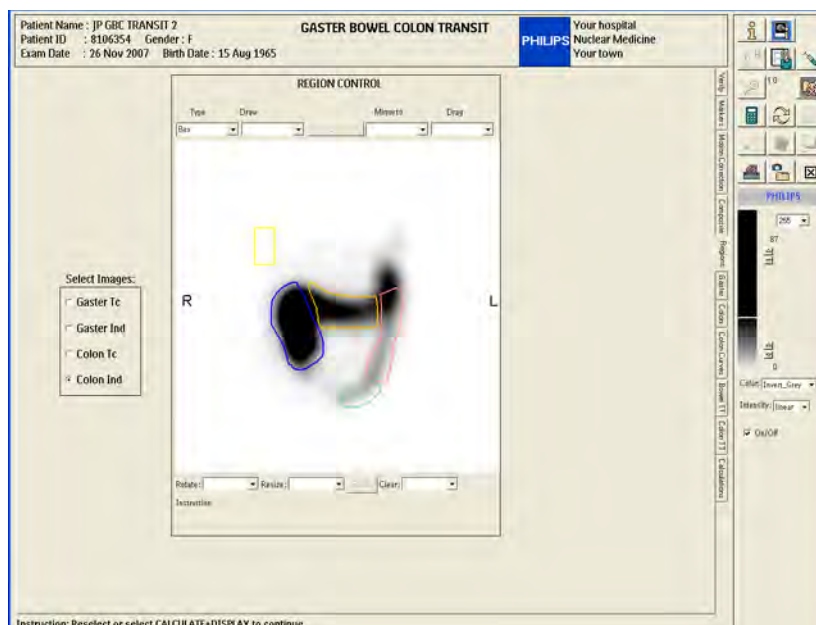

Figure 255   Regions Page: Colon ROIs

Draw colon regions on either the Tc99m or In111 composite image. The regions to draw here are; Ascending, Transverse, Descending, Rectum and Background. With all regions drawn click on the "Calculator" button to generate the curves.
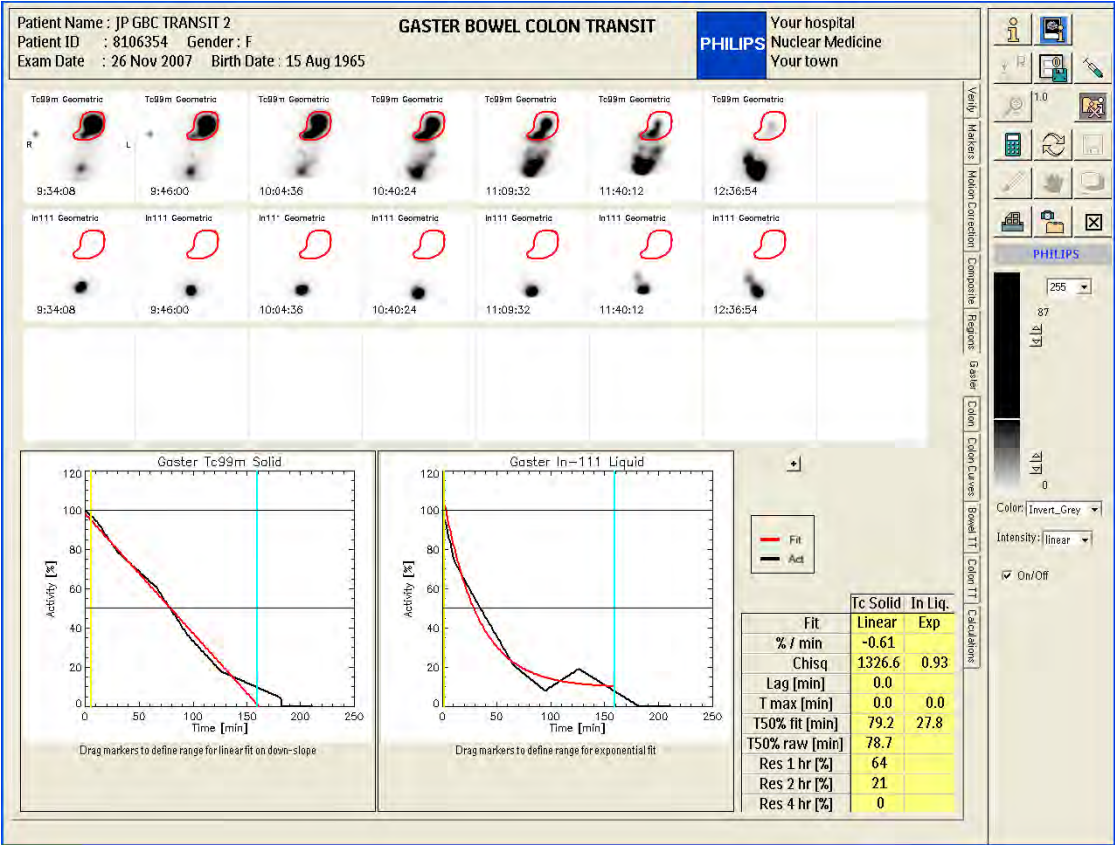
27.9   Gaster Page

Figure 256   Gaster result page

This result page shows Tc99m geometric images with the gaster region and In111 geometric images with the gaster region in the top half of the screen. In the lower left the graph of the Gaster Tc99m Solid curve. Drag the yellow cursor by means of the left mouse button pressed or the right blue cursor with the right mouse button pressed to define the range of original data points of the Gastric curve that will be used for a linear curve fit. The result of the linear curve fit is shown in the left column of the table labeled "Tc Solid". For Tc99m solid emptying, the values of %/min point, the error of fit (Chisq), the Lag time (point where the fit curve crosses 100% line), the calculated Tmax , T50% of the fit curve , T50% of the "Raw" curve and the percentages of residual activity at 1, 1.5, 2 and 4 hours can be found in the left column.

To define the range of original data points of the Gaster In111 curve that will be used for an exponential curve fit, drag the yellow and/or blue cursors in the graph with the title Gaster In111 Liquid. The error (chisq), calculated Tmax and T1/2 of the resulting exponential fit curve are shown in the right column of the table.

Notice the small pushbutton marked '+' above the curve legend. If you click this button the Colon ROIs will be added to display of the Gaster ROI on all the images. See the next figure.
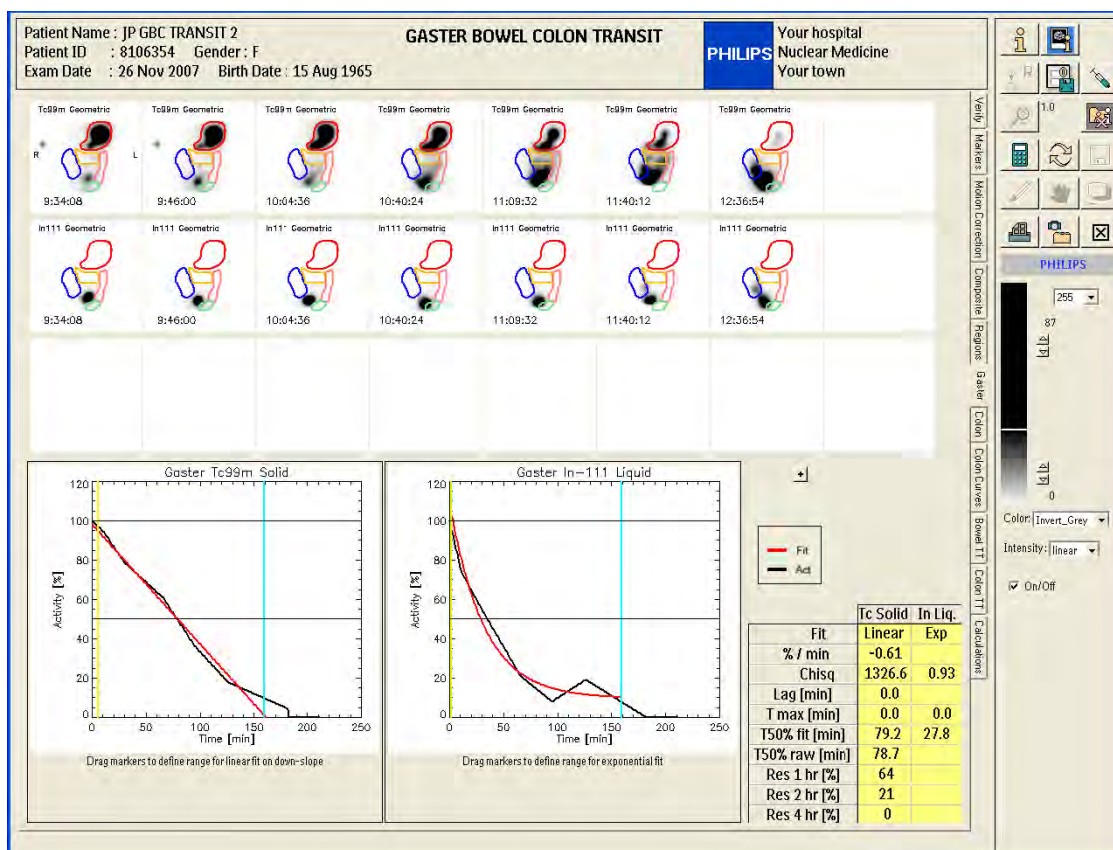
Figure 257   Gaster page with "+" button clicked to show both the Gaster and the colon ROIs on the Gaster images.

27.10 Gaster page, Calculations from T=0 or from Tmax
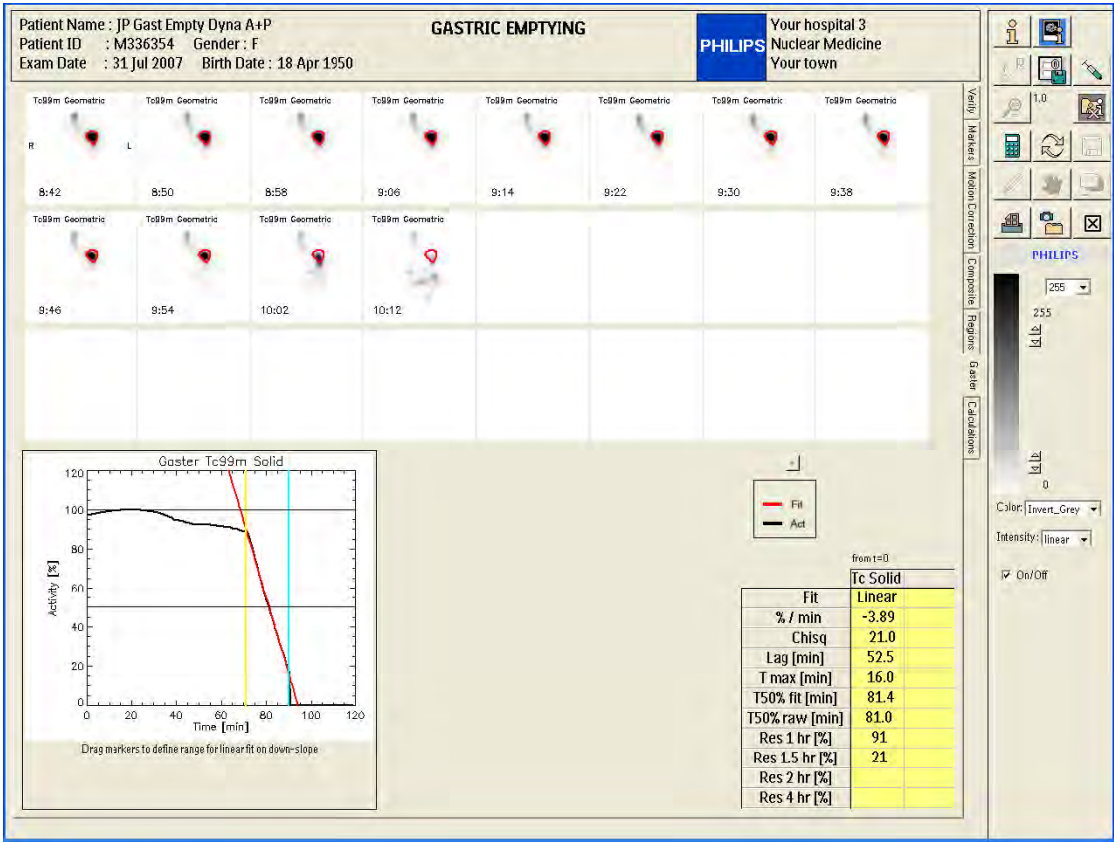

Figure 258   Example study, no colon images, where Calculations from t=0 was selected in the defaults.

The values for T50% of fit and raw curve(s) and the residual percentages at 1, 1.5, 2 and 4 hours, if available, are calculated from the start time ,t=0, of the raw curve

from Tmax	
	Tc Solid
Fit	Linear
% / min	-3.89
Chisq	21.0
Lag [min]	52.5
T max [min]	16.0
T50% fit [min]	65.4
T50% raw [min]	65.0
Res 1 hr [%]	75
Res 1.5 hr [%]	0
Res 2 hr [%]	
Res 4 hr [%]	

Figure 259   Calculations from Tmax

The values for T50% of fit and raw curve(s) and the residual percentages at 1, 1.5, 2 and 4 hours, if available, are calculated from the time of the maximum value of the raw curve.

Notice that in the Lag time, defined as the time from Tmax to where the fit curve intersects with the 100 % horizontal line is always calculated from Tmax. Lag time is 0 or a positive number.

Above the table you can find the text "from t=0" or "from Tmax" that indicates which method was applied.
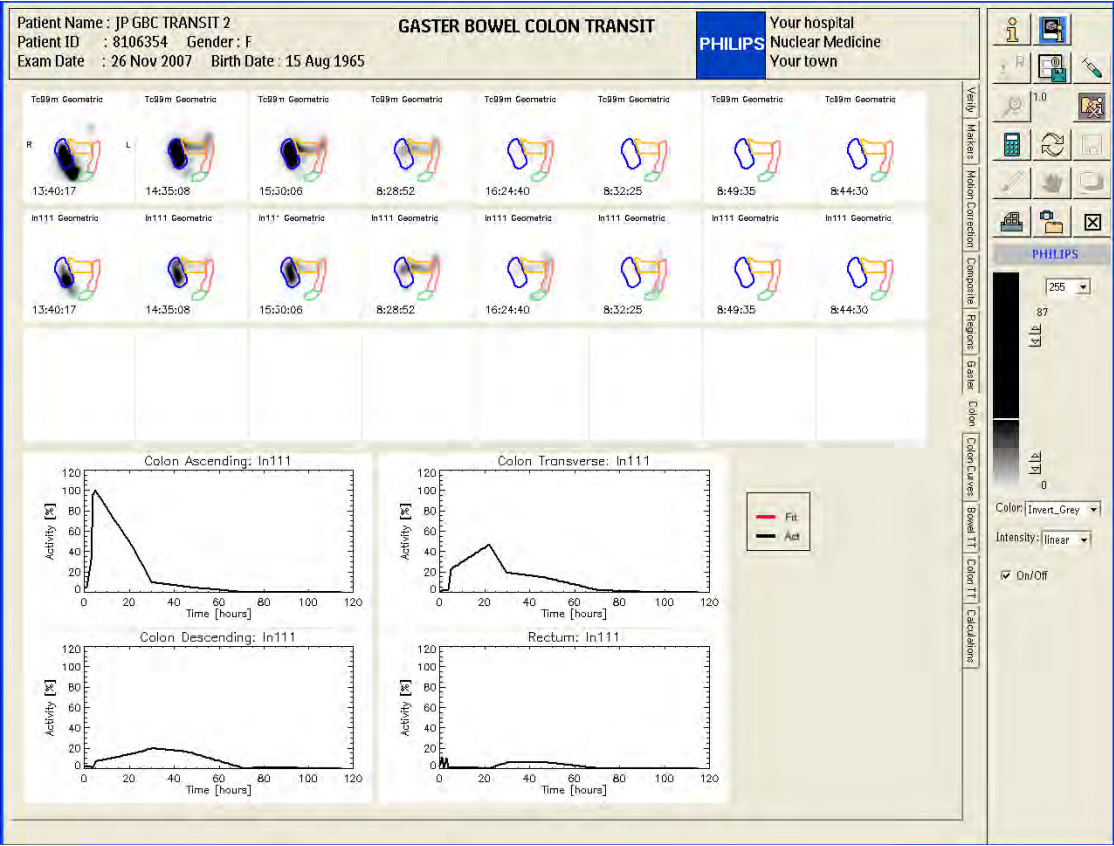
27.11 Colon Page

Figure 260 Colon page;

The Tc99m and In111 geometric image sets of the Colon phase are displayed with the Colon region set overlayed on each image. The curves of Ascending, Transverse, Descending Colon and Rectum as generated by interpolation of the measured region counts of the various images are displayed at the lower half. There is no user interaction on this page. The ROIs are applied to all images, including Gaster and Colon phases. The t = 0 of the curves indicates the time of the acquisition of the first Gaster images.

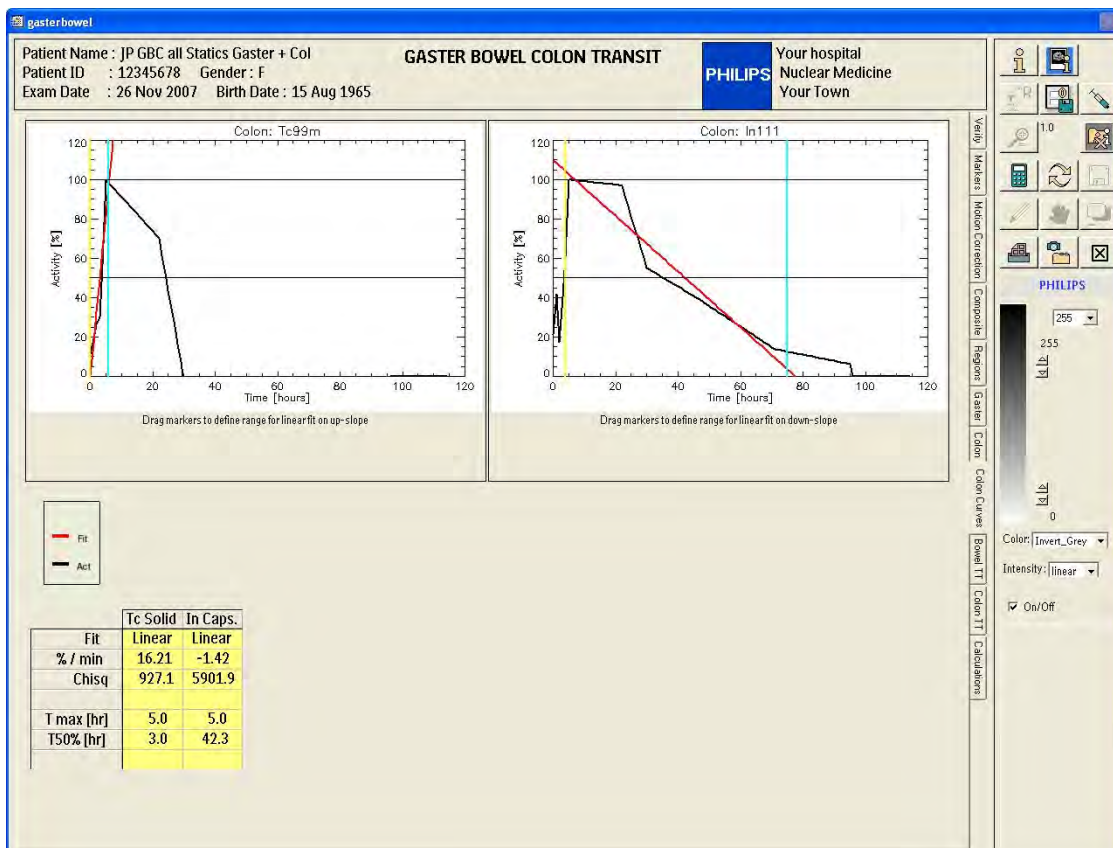## 27.12 Colon curves page

Figure 261   Colon curves page;

In the graph of the Colon Tc99m curve at the top left of the screen adjust the yellow and blue markers to define the range of data used for the linear fit of the UPSLOPE of the Tc99m activity into the Colon.   In the graph of the Colon In-111 curve at the right side of the screen adjust the cursors to define the range of data for calculation of the linear fit curve of the DOWNSLOPE of activity from the colon. The results of both fits are displayed in the table.
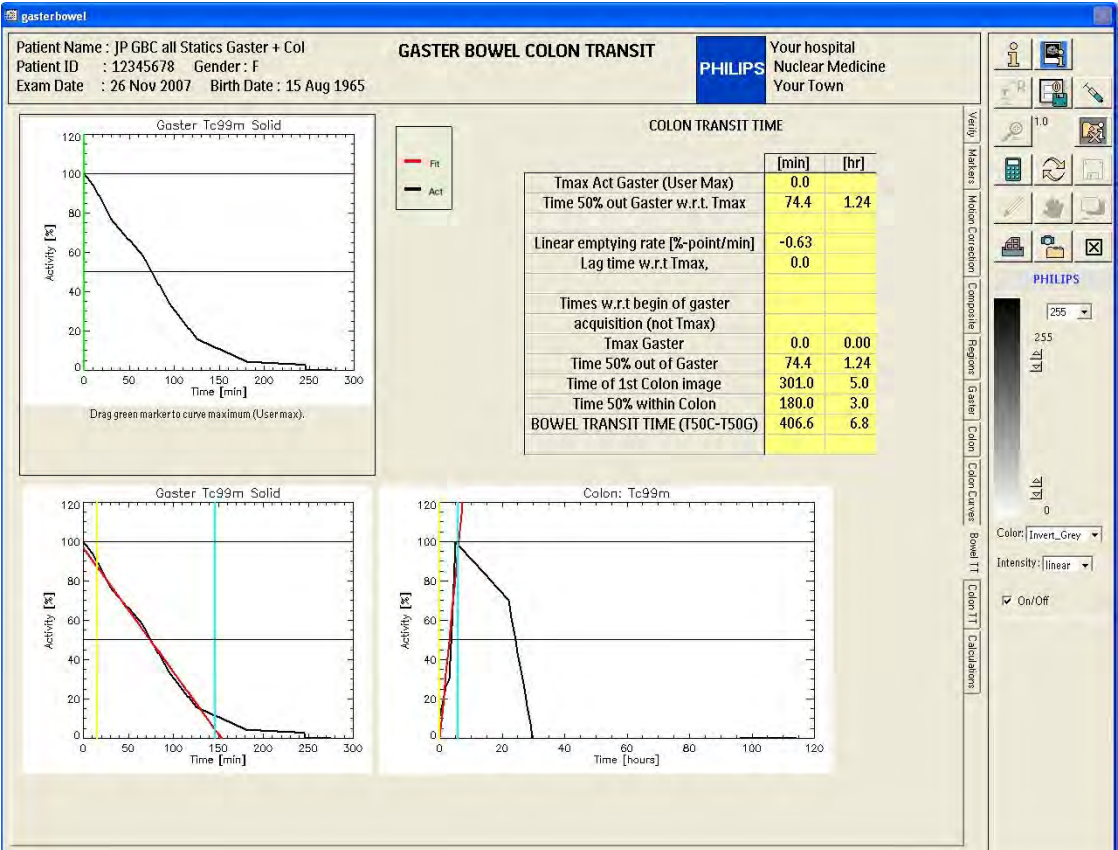
27.13 Bowel Transit Time page

Figure 262 Bowel Transit Time page;

The table shows the values in minutes and hours of the calculated Time of Maximum activity in the Gaster, T ½ (50% out) of Gaster, Time of the first Colon image, time of 50% of activity into the Colon and the resulting Bowel transit time.

The bowel transit time is defined as follows;

BTT =   T50in – T50out where

image.

T50in   = Time of 50% activity into the colon. This is the sum of the time of the first colon image and the time of 50% into the colon. In the above example 5.0 + 3.0 = 8.0 hr.

T50out = Time of 50% of activity out of the Gaster, in the example 1.3 hr.

In this example: Bowel Transit Time = 8.0 - 1.24 = 6.8 hr

The graph at the top left with the green marker allows you to select the "User Maximum" value as displayed in the first item of the table. Drag the green cursor to the maximum value of the Gaster curve, the Tmax and "T50% with respect to Tmax" will be updated accordingly.
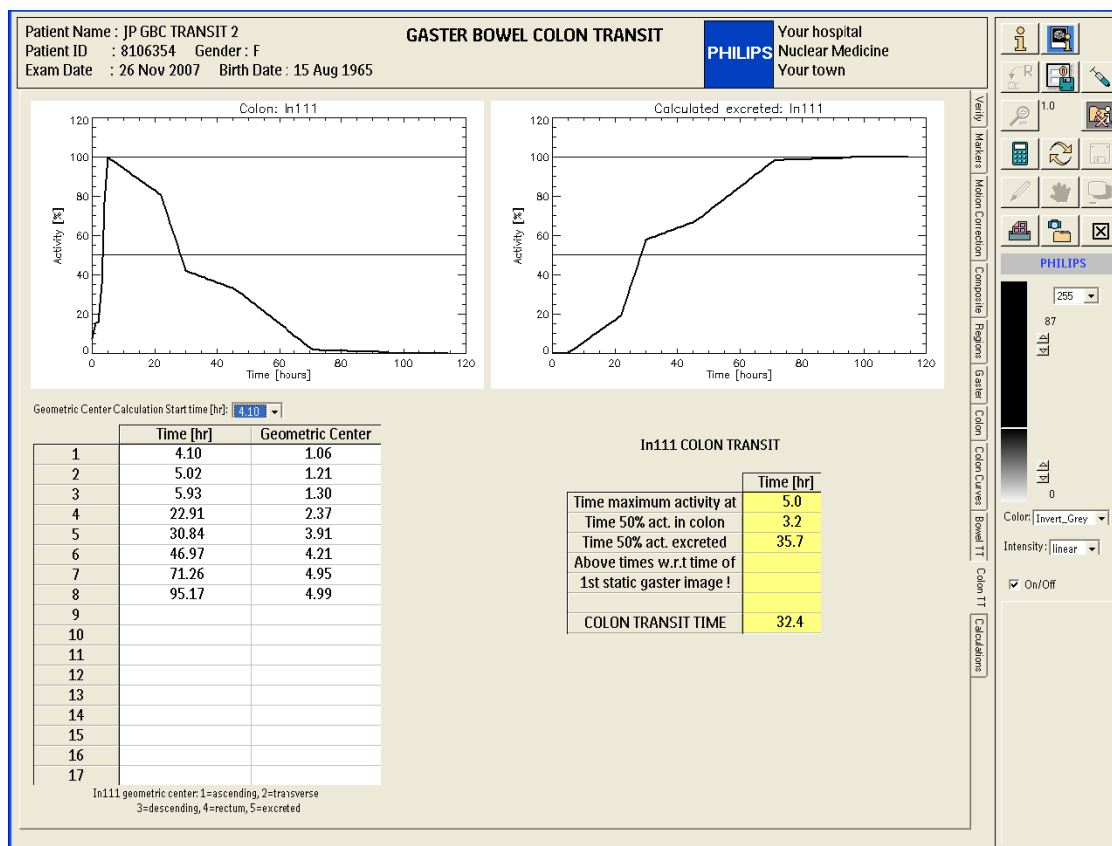
Colon transit time page

Figure 263 Colon Transit Time page

The colon In111 curve is the sum of the Ascending, Transverse, Descending and Rectum curves. The Calculated Excreted curve is the reverse of this curve, 100% - Colon curve.

The table at the right side shows the Time of maximum activity of the Colon, Time of 50% activity into the colon, 50% of activity out of the colon and the resulting Colon Transit time. The Colon Transit time is the Time of 50% excreted minus the Time of 50% into the Colon. The left hand table displays the time of acquisition of each colon image and the geometric center of activity of the ascending, transverse, descending and rectum regions.A pop-down menu labeled "Geometric center calculation start time", allows you to select the time (here 4.10 hr) from where onwards the calculations are displayed. The menu selections are based on the actual time lapses of the various images with respect to the acquisition time of the first Gaster images.

27.15   Reference

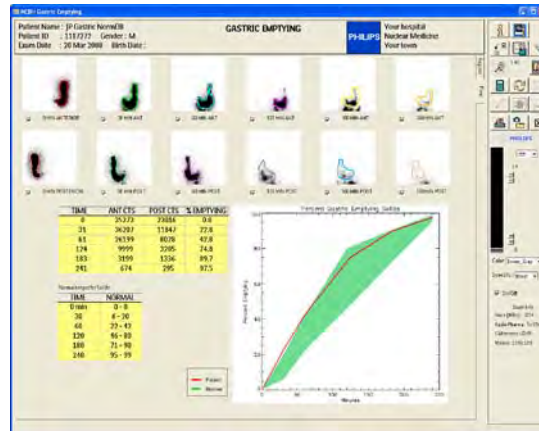1) Measurement of Small bowel and Colonic Transit: Indications and methods

Manfred R. von der Ohe, M.D., Michael Camilleri, M.D., Gastroentrology Research Unit. Mayo Clinic Rochester. Mayo Clinic Proc 67:1169-1192, 1992

2) Human gastric emptying and colonic filling of solids characterized by a new method

Michael Camilleri, e.a Mayo Clinic. Am. J. Physiology 1989 ,G284-G290

28 Gastric Emptying with Normal Database

28.1 General

The Gastric emptying with Normal database application allows generation of a percent gastric emptying or residual curve for either solids or liquids studies and plotting of this curve together with the user defined upper and lower normal values curves. ROIs are drawn on each anterior and posterior image. The geometric mean of the counts in anterior and posterior regions are decay corrected for Tc99 (Solid) or In111 (Liquids).

The normal values tables for solids and liquids can be entered and saved as default by the user.

28.2 Acquisition

Up to six static image pairs of Anterior and Posterior view in 128x128matrix
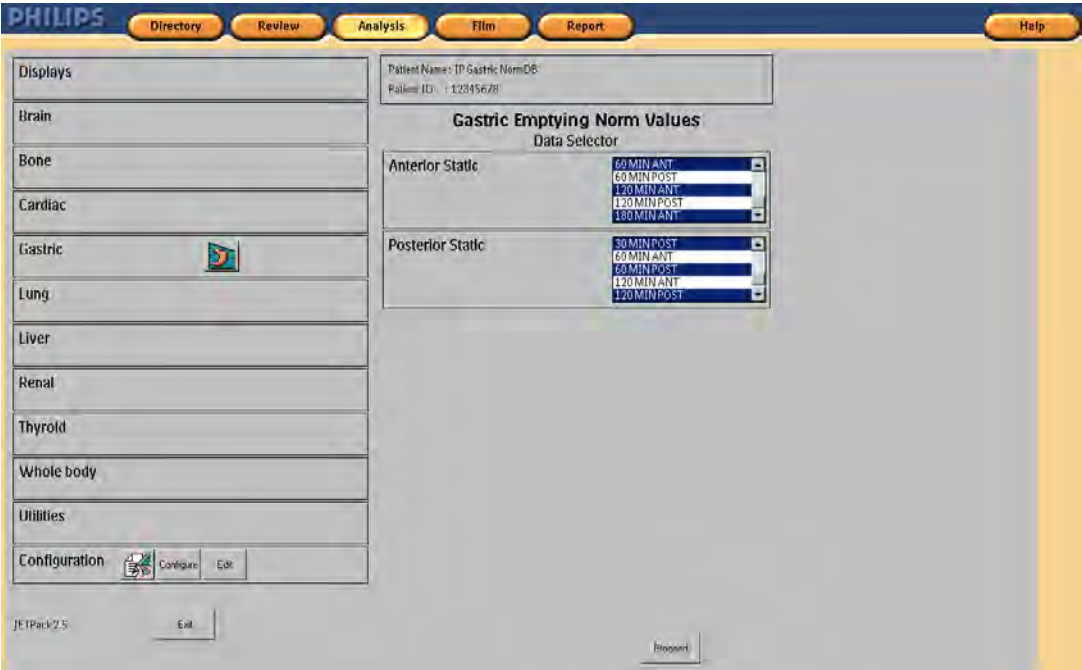
28.3 Processing

Figure 264 ISP JETPack panel, Pick 4x3 application selected

If required adjust the selected file in the data bucket and click **Proceed**.

Select all static images for anterior and posterior then click on the Load button. The anterior and posterior images will automatically be sorted in the two data-buckets.
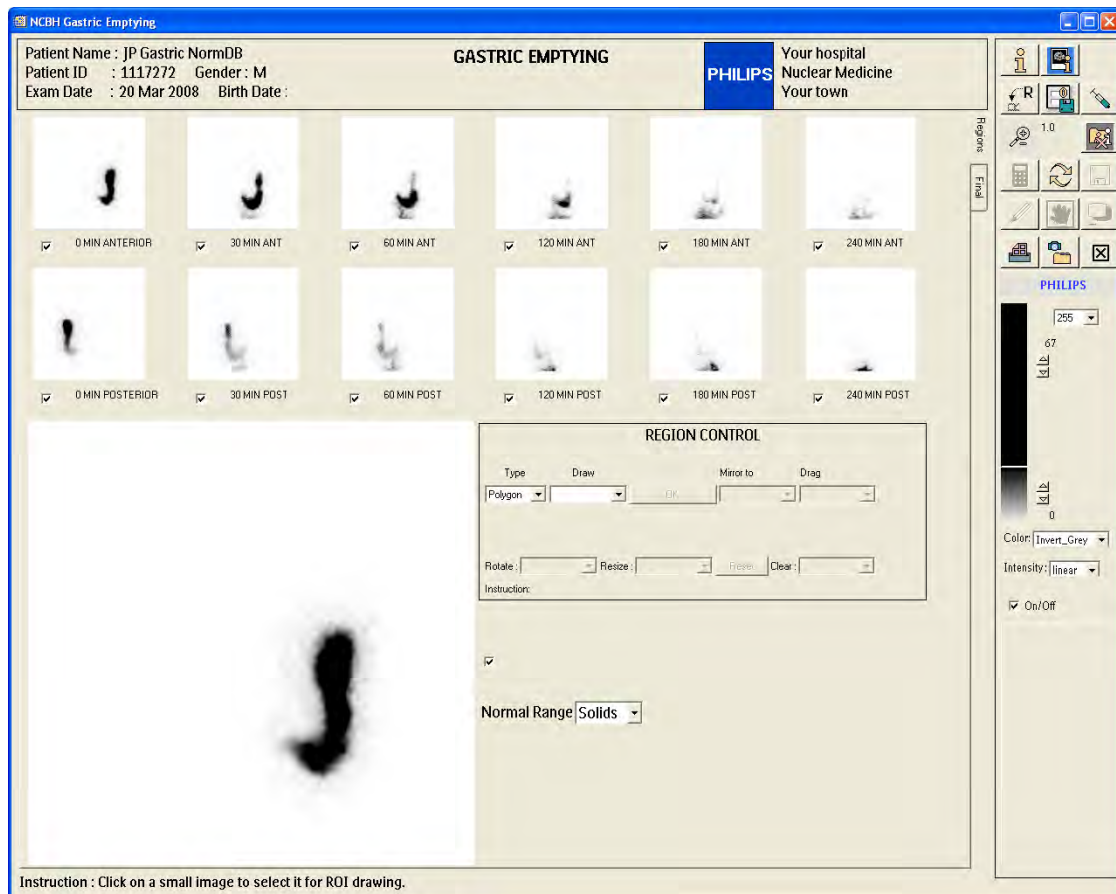
Figure 265 Regions page

On this page check for the proper sequence of the Anterior images in the top row and posterior images in the bottom row. Use the Rotate button if you need to rotate all input images by steps of 90 degrees. **You must select the Normal range parameter to be Solids or Liquids to have the data processed correctly**.
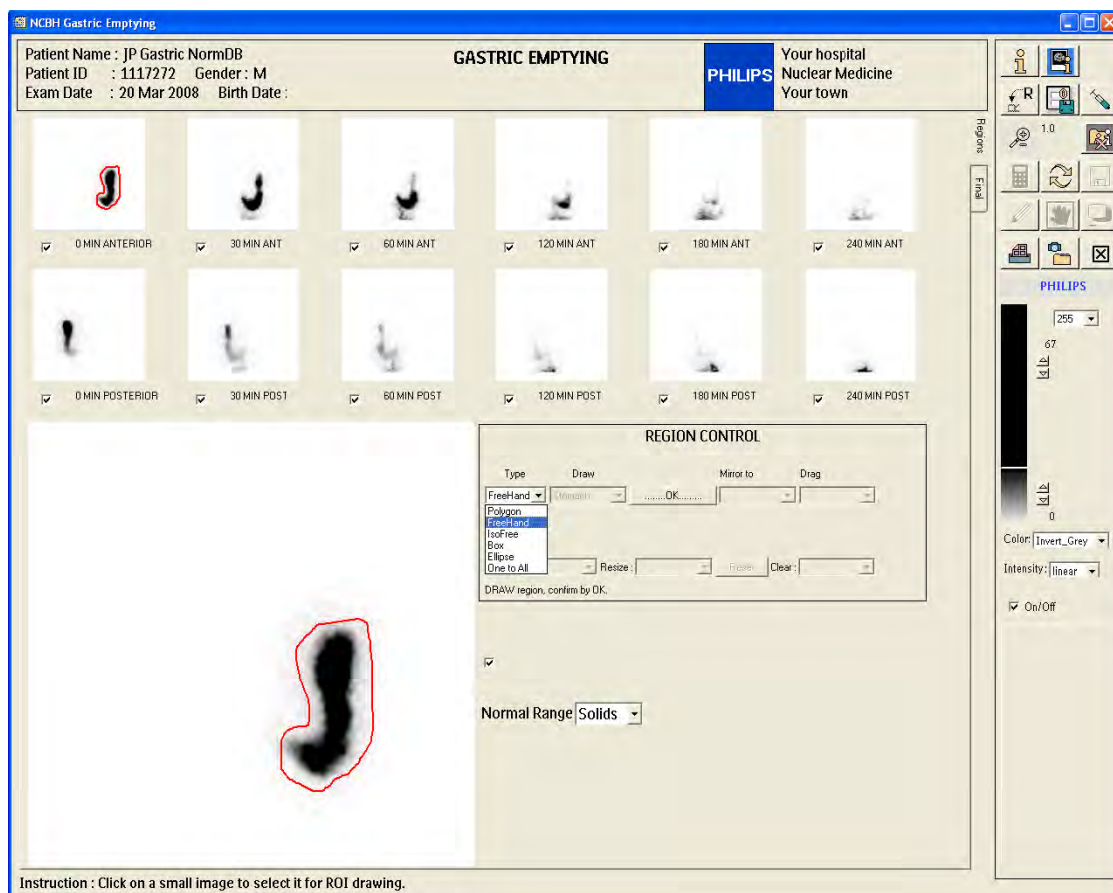
Figure 266 Regions page, first anterior ROI drawn.

The first anterior image is automatically placed in the large view-port during the initialization of the application. ROIs selection is the same as found in other applications with the exception of the "OneToAll" region type selection. When you click this selection after drawing of the ROI on the first anterior image, the ROI is copied to all remaining anterior images and copied, while flipped about the y-axis, to the posterior images. Click on a small image to bring it into the large view-port for ROI drawing or adjustment.
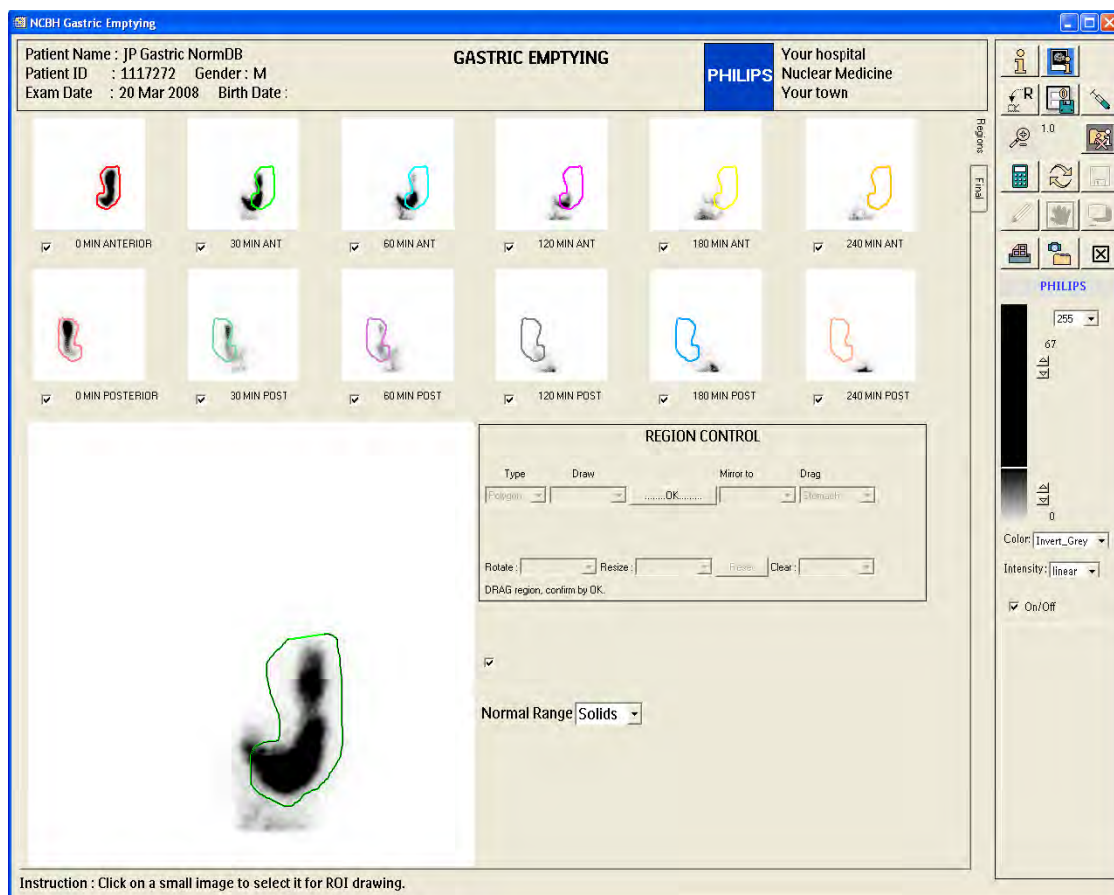
Figure 267 Regions page, second anterior image in the large viewport.

In this example OneToAll type was selected. Notice that each small image now has an ROI as described earlier. The second anterior image was loaded in the ROI viewport then Drag was used to move the large ROI to a better position. The OK button still needs to be clicked to fix the ROI in place and update the small ROI on the second top left image.

You must click each small image then adjust the position of the ROI to fit with the activity.

Once you have adjusted all ROIs click the green "Calculate&Display" button to continue to the final page.

Another option to help draw the ROIs is the "AP or PA" selection. After drawing the ROI on the anterior image select the "AP or PA" to mirror the ROI to the posterior image, or use it vice versa, draw on the posterior image then mirror the posterior ROI to the anterior image.

Because the anterior and posterior images are usually acquired simultaneously the resulting ROI will be correct, however you can adjust the new ROI as you like.

Be aware that the "AP or PA" option works on an active ROI, meaning that right after you have finished drawing an ROI you can use the option to mirror the ROI.

In stead of using the OneToAll type selection you can use the polygon, freehand, box or isofree types to draw the various ROIs. In the example on the next page, ROIs were drawn per image using either the freehand or isofree type..
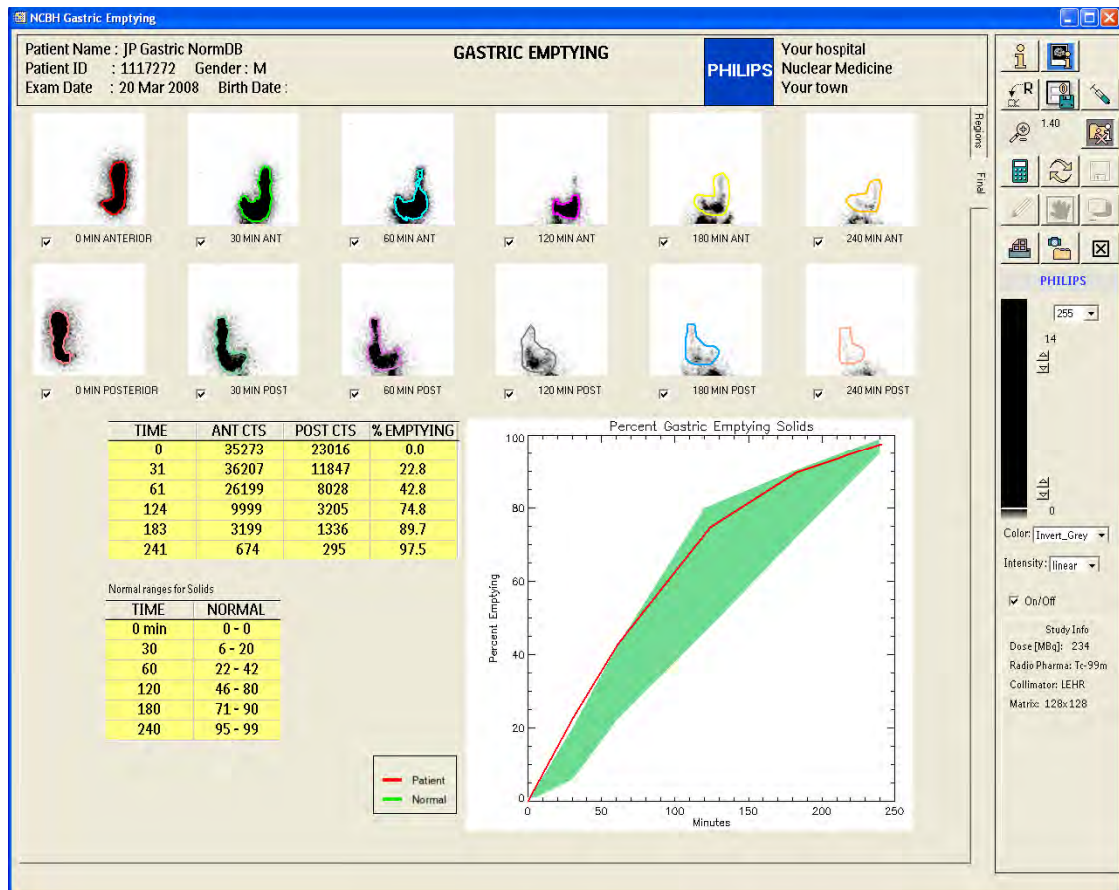

Figure 268   Final page.

The page shows zoomed input images and ROIs in the top two rows. A table with the actual times of acquisition of the anterior+posterior image pairs with counts per ROI and calculated percent emptying of the geometric means per time of acquisition. The percent emptying column is plotted as the red 'Patient' curve.

The "Normal values for Solids" table as found at the bottom left of the screen displays the user defined standard low –high percentages at fixed acquisition times of (in this example) 0,30,20,120,180 and 240 minutes. The upper and lower values are used to plot the upper and lower curves, however not the curves themselves but the area between the two curves is plotted in green to show the normal range area.

The injected dose was entered manually via the button with the syringe picture. The dose is displayed at the lower right corner when you click on the 'More' button at the top right.

This application does not have a "Calculations" page as the % emptying values can be manually determined from the large table for verification.

28.4   Defaults Normal Values

Click this button to bring up the Default entry panel shown below.

Figure 269   Defaults panel for SOLIDS and LIQUIDS normal values.

Process mode: Emptying /Residual: In case of emptying the curve will be display from 0% with an upward slope towards 1005, for residual mode the curve is displayed from 100% with a downward slope towards 0%

Enter your site specific normal values for Solids and Liquids studies. If you don't process Liquids studies you can leave the table blank. make sure the normal values agree with your selection of Emptying or Residual process mode. The Reset button restores the numbers in the solids table to the values as proposed in the reference article by Maurer e.a. see below.

Normal values at the key time points : 1 h (37-90%), 2 h (30 -60%) and 4 h (0 - 10%). After saving new values you must exit and restart the application.

28.5　References

Tougas e.a.: Assessment of Gastric Emptying using a low fat meal: Establishment of International Control values: American Journal of Gastroenterology, Vol 95, No 6, 2000 pages 1456-1462.

Maurer: Consensus report on Gastric Emptying: What's needed to prevent tarnishing a gold standard. JNM vol 49, 2008, page 339