Introduction

This document will only cover the usage and methodology of the analysis script. For full details of the Logos XRV-124 hardware and related software, see the appropriate manuals and work instructions.

The current version of the script considers (full details later):

- Spot shifts (in x and y of BEV coordinates for various gantry angles and beam energies)
- Spot sizes in terms of a directionless measure of equivalent diameter
- Spot sizes in terms of sigmas from a Gaussian fit, for x and y in both the BEV and spot coordinate systems

Overview of data acquired

Currently the script assumes a very specific acquisition, as per monthly QA. Beams are acquired at 13 gantry angles (-180 degrees to +180 in 30 degree steps) and with 19 beam energies (245, 240 MeV then down to 70 MeV in 10 MeV intervals). Version 0.1.0 of the script will not run if there is missing data.

Using the default General acquisition script, when the Logos software captures a beam, it makes a csv file and a txt file for the entry and exit spots and produces a bmp image of the raw image captured by the CCD camera. The csv and txt files contain various information, like calculated spot diameter, isofocus coordinates, beam width, divergence (plus more) along with an array of pixel values for each spot's image. These are 2D square images, related in some way to the BEV/steering coordinates, that have been "unfolded" from the surface of the cone.

The XRV-124 has the ball bearing in place during acquisition, which should be positioned at the isocentre, hence the exit beams have a shadow in them. The shift from the centre of the image to the centre of this shadow is then how far the beam is missing the isocentre.

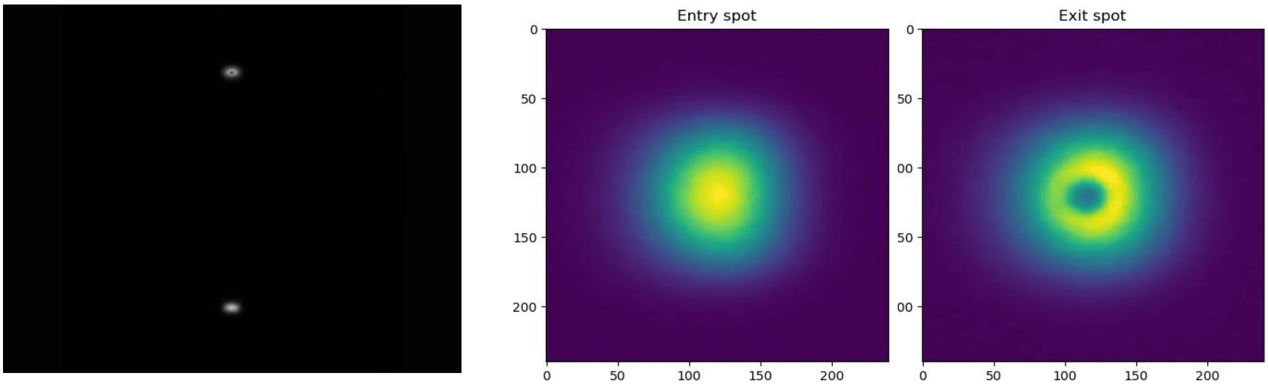

Figure 1: Left: An example of the bmp image produced for a beam at GA of -180. Notice the small shadow in the exit spot (top) due to the beam passing through the ball bearing. Centre: Entry spot read in from the csv file. This image has been unwrapped from the cone surface. Right: Exit spot with ball-bearing shadow.

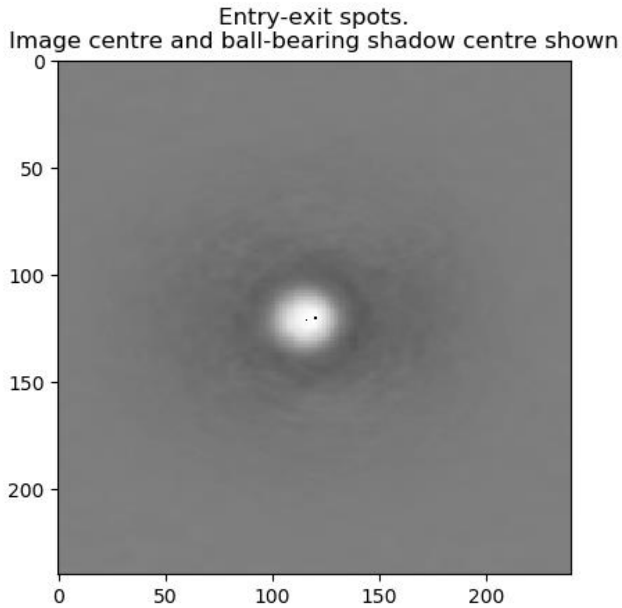

Figure 2: This is (entry-exit) spots, so the bright region is the ball bearing shadow. Zooming in a mark can be seen at the image centre (coord 120,120) and a second located at the centre of the ball-bearing shadow (coord 116,121). The difference imagecentre-shadowcentre is what I'm calling the "shift" for now. So in pixels that's shifts of (x,y)=(4,-1). The pixel width (pitch) can be read from the csv/txt files and is 0.1mm, so the actual shifts are (0.4,-0.1)mm. Note these are given in the IMAGE COORDINATE SYSTEM, where (0,0) is the top left pixel with x increasing going to the right and y increasing going down the image.

Coordinate systems

There are several distinct coordinate systems we need to be aware of when analysing data from the XRV-124: (1) that employed by the XRV-124; (2) the IEC 61217 system employed in radiotherapy; (3) the beam's eye view (BEV) coordinates of the machine head, related to the steering magnets; (4) some image coordinate system which relates to the 2D images of the spots unwrapped from the cone surface by the Logos software and (5) the spot coordinates, defined within the beam line. These are shown in Figure 3. For the current version of the script we will only be using (3)-(5).

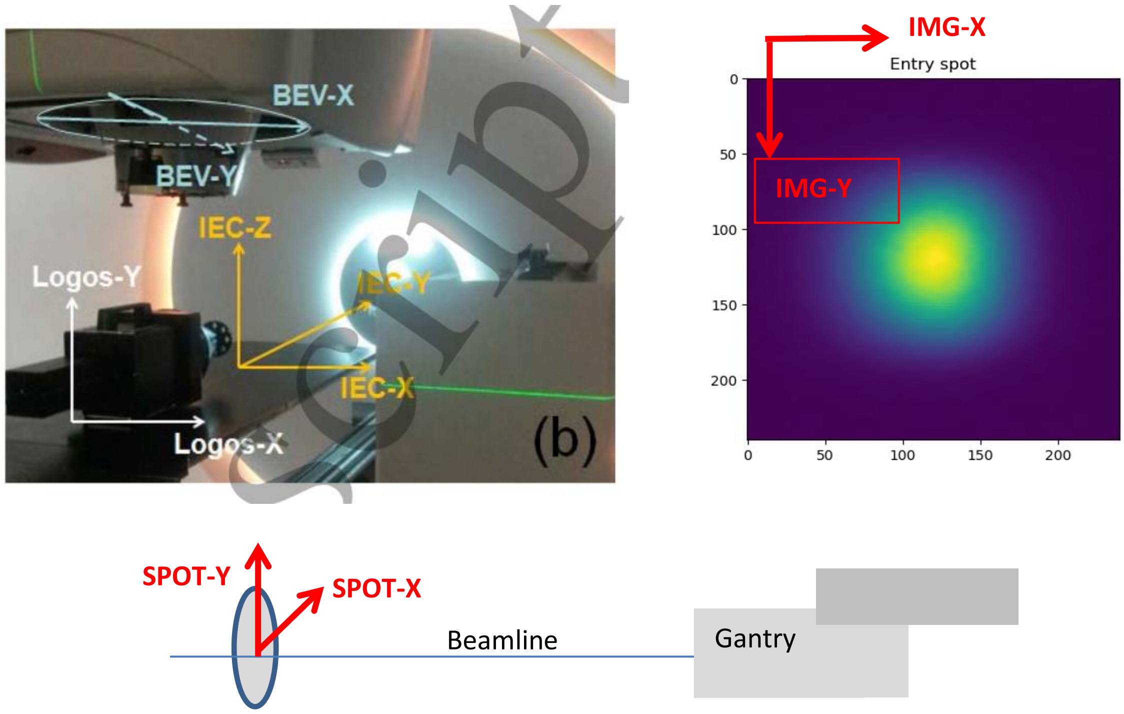

Figure 3: Relevant coordinate systems. Left: the beams eye view (BEV), IEC and Logos XRV-124 coordinates. Right: the image coordinates. Bottom: spot coordinates defined such that along the beam line, just before entering the gantry, the y-axis aligns vertically with gravity.

Relating image coordinates to BEV coordinates

To check how the images relate to the BEV we acquired F-shaped fields at all cardinal gantry angles. Both the entry and exit images read in from the csv and txt files are always unwrapped into the same orientation, irrespective of gantry angle, hence there is a direct correspondence between the image (IMG) and the beam's eye view (BEV) coordinates as shown in Figure 4. (The F-shaped field was aligned such that it was the correct way round if standing and reading from the foot of the couch, the end farthest from the gantry).

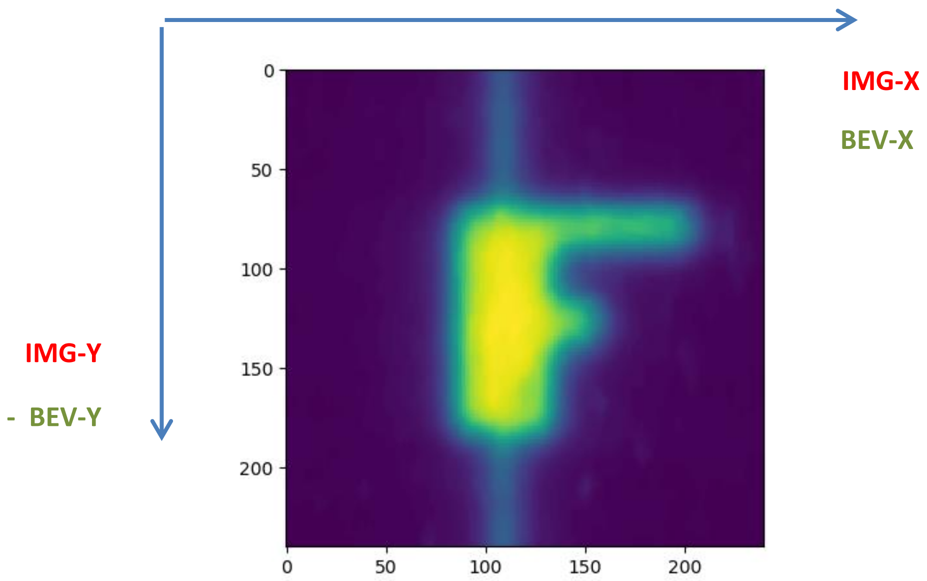

Figure 4: The F-shaped field image always unwraps into the same orientation irrespective of the gantry angle, thus giving a direct relation between image (IMG) and beam's eye view (BEV) coordinate systems.

Relating image/BEV coordinates to spot coordinates

Since the spot coordinates are fixed in the beamline, and since the orientation of the spot does not physically rotate with the gantry, there will not be a constant correspondence between BEV and spot coordinate axes. Figure 5 shows that the x and y axes of these 2 coordinate systems align at gantry angle 0, but switch at gantry angle 90. What this means is that when rotating the gantry, if we want to measure the beam width in terms of the spot coordinate system then we must rotate the angle through which we are reading the profiles to which we fit a Gaussian to. This is illustrated in Figure 6.

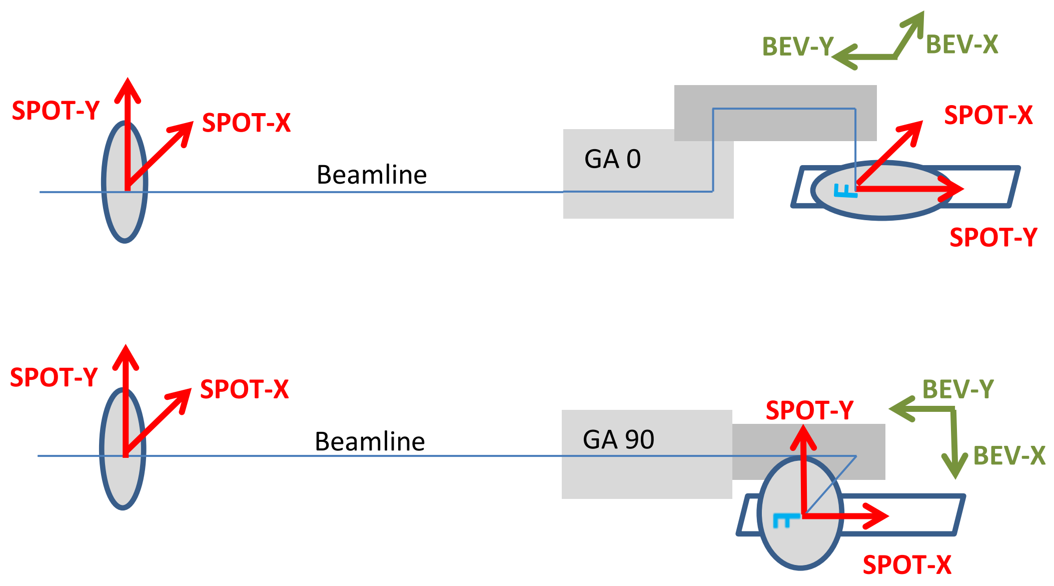

Figure 5: Illustration of how the spot and BEV coordinate systems relate when rotating the gantry angle. We can see that at GA 0 the axes align, however at GA 90 they have switched. Note the small blue F-fields (see Figure 6).

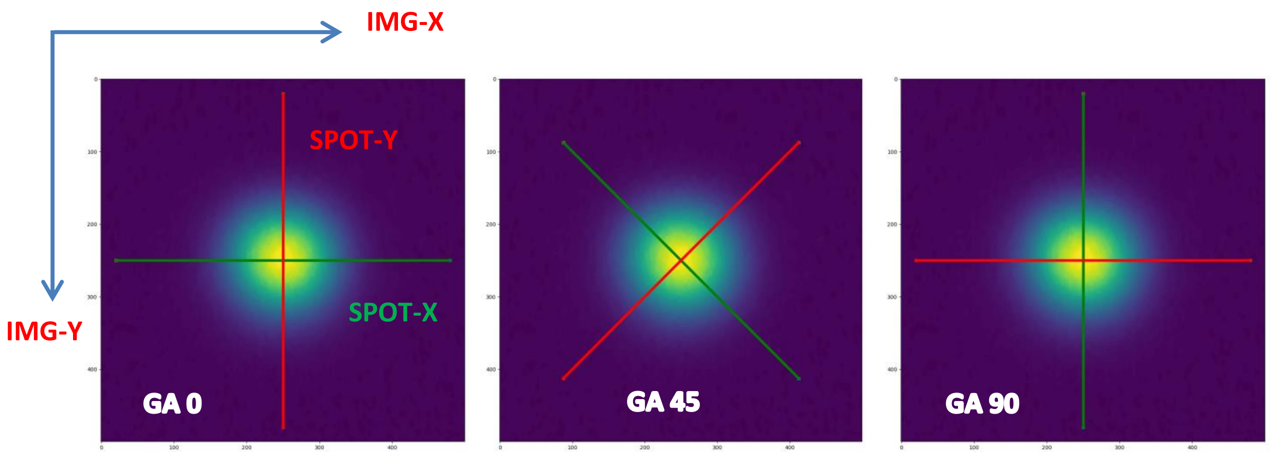

Figure 6: To convert between IMG and SPOT widths (sigmas) at different gantry angles we must fit Gaussians to profiles taken at an angle in the spot image that depends on the gantry angle. Red line corresponds to the SPOT-Y and green to the SPOT-X axes. The 2 systems agree at GA 0 and 180 and are switched at GA 90 and 270. Looking at the small blue "F"s in Figure 5 you can convince yourself that we should be rotating clockwise in the image.