

## Angular Divergence

### Introduction

DataRay software provides the option to correct beam measurements to account for the spherical nature of a beam as it propagates. Due to the flatness of the DataRay sensor, the edges of a beam strike the sensor at an angle, having traveled farther than the rays at the center. This produces readings of slightly diminished intensity, which can be accounted for by correcting the data values to approximate a more accurate measurement - as though all rays had traveled the same distance before striking the sensor. The most common way to achieve this correction is by recalculating measurements as they grow further from the centroid of the beam, dividing them by a factor of  $\cos^2\theta$  or  $\cos^3\theta$  where  $\theta$  is the angle from the center of the beam.

This note discusses the process of calculating the distance from the source of a beam to the measurement plane when this exact distance cannot be otherwise obtained for divergence measurements. In addition, this note discusses how to use the DataRay software to enhance measurements by accounting for the angular divergence of a beam through the discussed correction process.

### Calculating the Source to Measurement Plane Distance

Use the following steps to obtain the distance from the beam source to the measurement plane (the surface of the sensor) when the exact distance is unknown. Note that distance variables referenced in this section can be seen in Fig. 1.

1. Set the instrument at a distance from the source such that the beam diameter is within its measurement capability. The profile should be continuous and have 'tails' which go to zero as seen in Fig. 3.
2. Set **Average** to **Average 20** and measure the FWHM beam diameter  **$2W_{ub}$  @ 50.0 %**. Record this FWHM value as  **$2W_d$**  at unknown distance **D**.

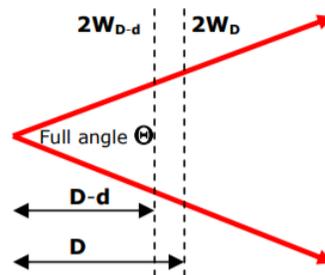


Figure 1: Dimensions of beam source placement for accurate calculation

3. Using an accurate z stage, preferably with a digital micrometer, move the source *toward* the instrument (or vice-versa) by a small defined distance **d**, where **d** is around 10% to 20% of **D**. Record the new FWHM diameter  **$2W_{D-d}$**  at this position.
4. Calculate the unknown distance **D** from the known values in the following equation:

$$D = \frac{2W_D \times d}{2W_D - 2W_{D-d}} \quad (1)$$

5. Calculate the current position of the measurement plane, **D – d**.

## Using Angular Divergence Options

Use the following steps to setup the angular divergence settings for corrected measurements in the DataRay software. Note that all options can be seen in Fig. 2.

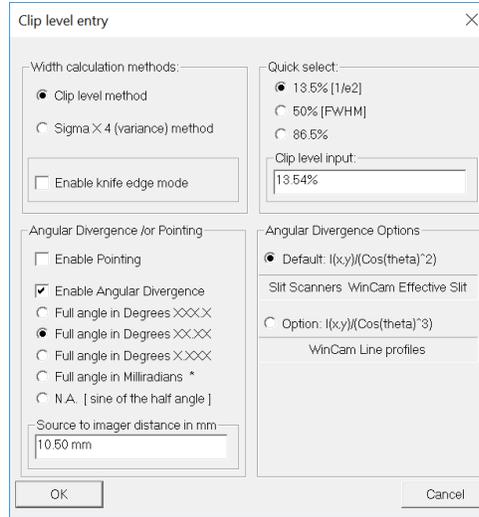


Figure 2: The Clip Level Entry Dialog with angular divergence enabled and  $\cos^2$  correction enabled

1. Left click on the **Clip[a]** box in the top left of the standalone DataRay software to open the **Clip Entry Dialog**.
2. Enter the above calculated **D – d** value into the **Source to slits distance in mm** field.
3. Select **Enable Angular Divergence** and select a **Full angle** unit to be displayed above the profile, as in Fig. 3.
4. Finally, select one of the **Angular Divergence Options** and click **OK**. Note that  $\cos^2$  correction (the default option) is recommended while in **Effective Slits** mode (which processes the image data as if it were a scanning slit instrument). The  $\cos^3$  correction is used for standard WinCam line profiles. For more information on the specifics of these calculations, see Section 1.2.3 of the [SynthLight Handbook](#). This resource explains the specifics of the Cosine Cubed Law, which is applied directly to  $\cos^3$  correction and is slightly modified for use with effective slits in  $\cos^2$  correction.

Upon running the camera or recalling a file, the measured profile is corrected for **cos $\theta$**  effects per the checked **Angular Divergence Options**, before the profile is displayed or the  **$\theta$**  value for the selected clip level is calculated.

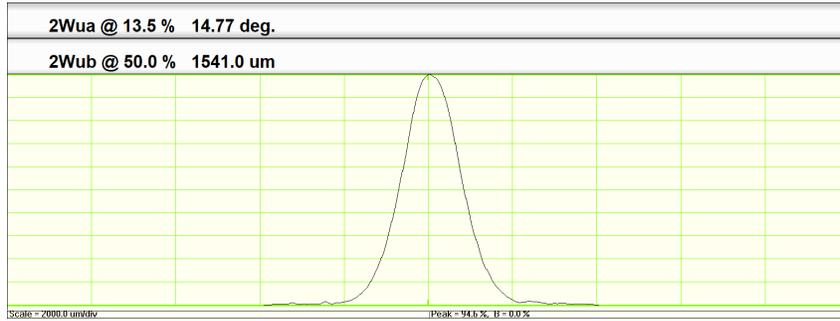


Figure 3: An example profile, showing general shape of profile data and measurement display after enabling angular divergence