DataRay Inc. Application Note

Beam Fit Algorithms

www.dataray.com

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Applies to:

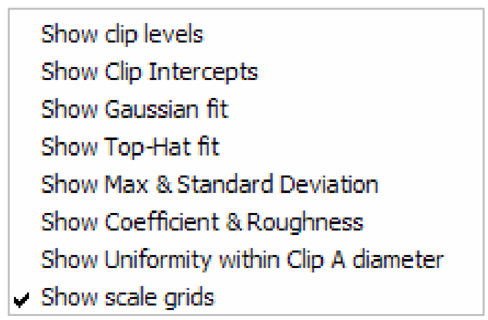
- All products
- Versions 5.00Q4 and higher of the **iDataRayOcx.exe** software

You need to know that:

There are no formal 'Standards' on how fits should be done. Some aspects of our approach are generally accepted industry practice. Some represent specific customer requests that have been incorporated in the software.

The Algorithms described here are for:

- **Gaussian Fit**, including **GFit**, **G 2W Max. Deviation**, **Std. Deviation**, **Coefficient** and **Roughness**.
- **Top Hat Fit**, including **Max. Deviation** and **Std. Deviation**
- **Non-uniformity**
- **Effective Diameter**



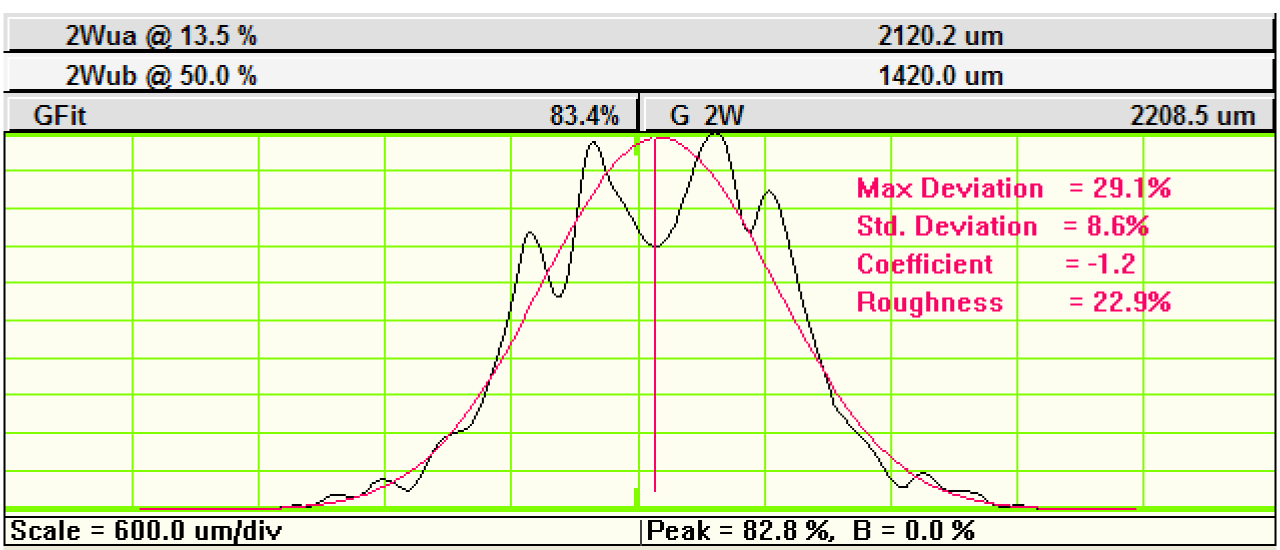
These options are accessed by right-clicking on the graph-like 'profiles' area in the lower part of the screen,

In all modes, the software first determines and subtracts the baseline.

If you need a function that is not included in the current version, please fill out and fax back a Function Request form found as Appendix A of every manual, or email us. Many requested software functions can be added with relative ease, and may be done for free, and possibly added to future releases. However, if the requested embellishment is considered extensive and/or obscure, we reserve the right to quote a fee for the requested change.

TIP: On slower PCs, to speed up the processing, do not show these options.

- **Show Gaussian fit**. A **GFit** results line appears under the **2W** results and a red line Gaussian appears superimposed over the profile. The Gaussian fit is based upon a fit algorithm that, *whilst keeping the power under the curve constant, and the centroid the same as that of the profile*, iteratively adjusts the height and width of the Gaussian until the Least Squares difference between the actual profile and the Gaussian profile is minimized.



Specifically, the steps are:

- Set the centroid position of the fitted Gaussian the same as that of the actual profile.
- Set the area under the fitted Gaussian equal to the area under the actual beam profile. i.e. an equal power requirement.

  If the area under the curve is 'A', and the actual 13.5% diameter is 2W, then for iteration purposes, the initial Gaussian height is set to: $H = A.(2/2W).(2/\pi)^{0.5} = 1.596.A/2W$.
- The least squares fit iteration starts from the actual 13.5% diameter
- **G 2W** is the calculated diameter of the least squares fitted Gaussian.
- 1.596.A/(G 2W) is then the calculated height of the least squares fitted Gaussian.
- **GFit** in **%** is calculated as: 100 x [1 - [(Sum of absolute differences)/(Gaussian profile area)]]

□ **Show Max & Standard Deviation** A vertical red line appears on the graph at the point of maximum deviation, and the **Max Deviation = xx.x%** and **Std. Deviation = xx.x%** are overwritten in red on the graph.

Deviation is defined at each position on the profile, relative to the fitted Gaussian curve or relative to the fitted Top Hat line, depending on the fit chosen. i.e. at position 'j' on the profile, if the Gaussian level is Gj, and the profile value is Pj, then the deviation at that point is defined as: Deviation in % = 100*((Pj-Gj)/Gj)

E.G. If Pj = Gj, the Deviation is 0%. If Pj = 2*Gj, then the Deviation = 100%. Therefore the Deviation value can be >100%, and as low as -100%.

Max. Deviation is defined as the maximum value (positive or negative) of the Deviation.

Std. Deviation is calculated over the fitted region using the Deviation values as calculated above.

□ **Show Coefficient & Roughness**. Additional information is given by the alternative 'Gaussian Fit Coefficient' and the 'Gaussian Roughness coefficient', defined as follows:

- Find the average difference between the Actual point, Pj, and the fitted Gaussian, Gj.

  A = [Sum (Pj – Gj)] / N (N is the # of points)

- For each point determine the difference, Dj, from the average of the deviation:

  Dj = (Pj – Gj) - A

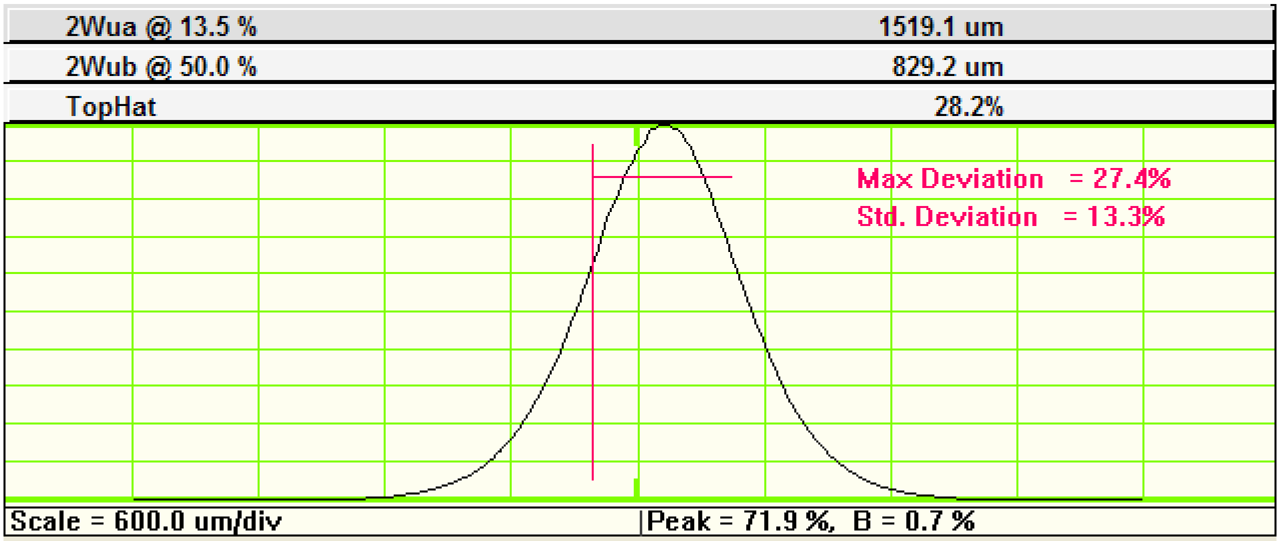
- Determine the sum of Dj^2: S = Sum (Dj^2)

- Determine the Gaussian Fit **Coefficient**, **C**, as follows: **C** = $1 – ((S/N^{0.5})/N)$

- Determine the Gaussian Fit **Roughness**, **R** %, as follows: **R** = 100 x [Max (Pj – Gj)]/[Max (Pj)]

□ **Show Top-Hat fit** The Top Hat fit:

- Determines the '50% of peak' outer edges of the profile. Defines the center (as opposed to centroid) of the beam as the midpoint between these two points.
- Determines the mean level of the central 80% of this region. It plots a straight line at this level, and defines it as 100% for the purpose of subsequent TopHat fit calculations.
- Shows the **Top-Hat** fit in % as: 100[1- (Total area of |deviations|/Area under line)].
- **Show max deviation** A vertical red line appears on the graph at the point of maximum deviation, and the **Max Deviation = xx.x%** and **Std. Deviation = xx.x%** are overwritten in red on the graph.



□ **Show Uniformity within Clip A Diameter**

- Found by right-clicking on the profiles area.
- Determines the Clip A edges of the profile. For the central 90% of this region, it calculates the following function in % terms:

  Non-uniformity = (100-Min)/(100+Min)

  The values displayed on the profile are the values for the profiles shown.

  In the **View** menu you can also choose **Show Non-uniformity (WinCamD only)**, the average non-uniformity value taken in 360 one degree slices about the centroid is displayed in the left hand panel.

□ **Effective Diameter**

- Effective diameter is defined based upon the total area above a certain Clip level.

  Count the N pixels above 13.5%. The area of each pixel is Ap. The total area = N*Ap

  The effective beam diameter Deff is then: **Eff. Diam.** = [4*N*Ap/π]

  In the **Setup** menu choose **Set Effective Diameter Clip Level** to change the clip level from its default value of 13.5%.