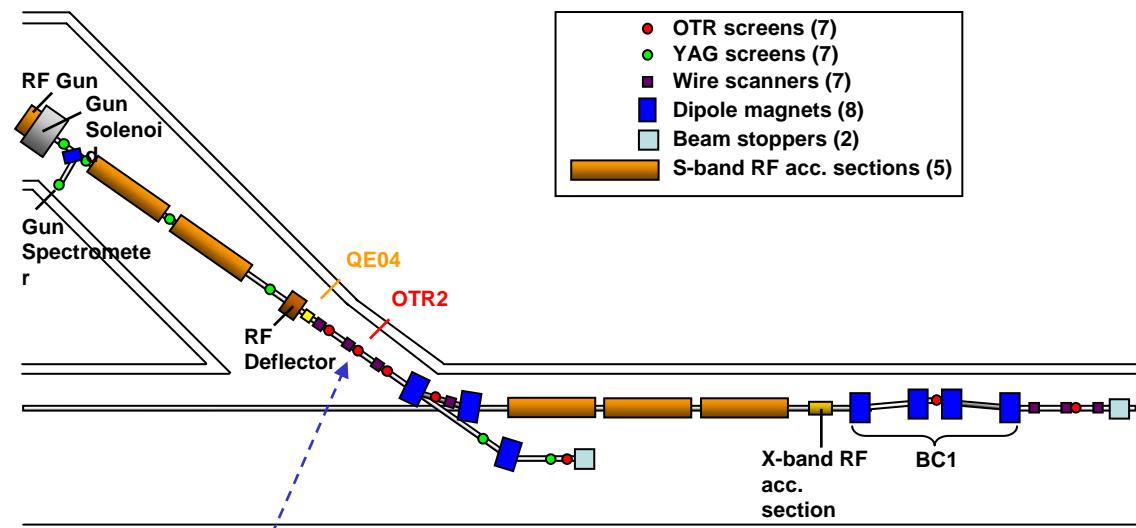


Analysis of LCLS Emittance Measurement Data with FLASH Tools

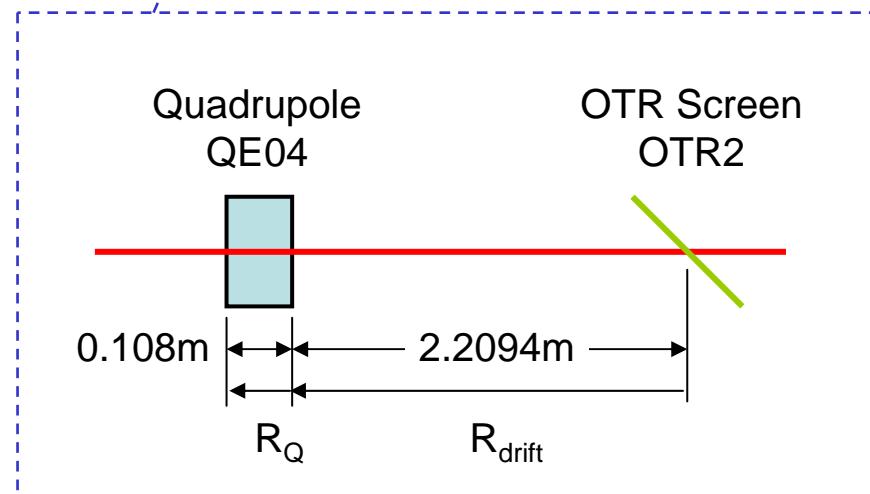
Christopher Gerth and Florian Löhl
DESY Hamburg

LCLS Injector Layout

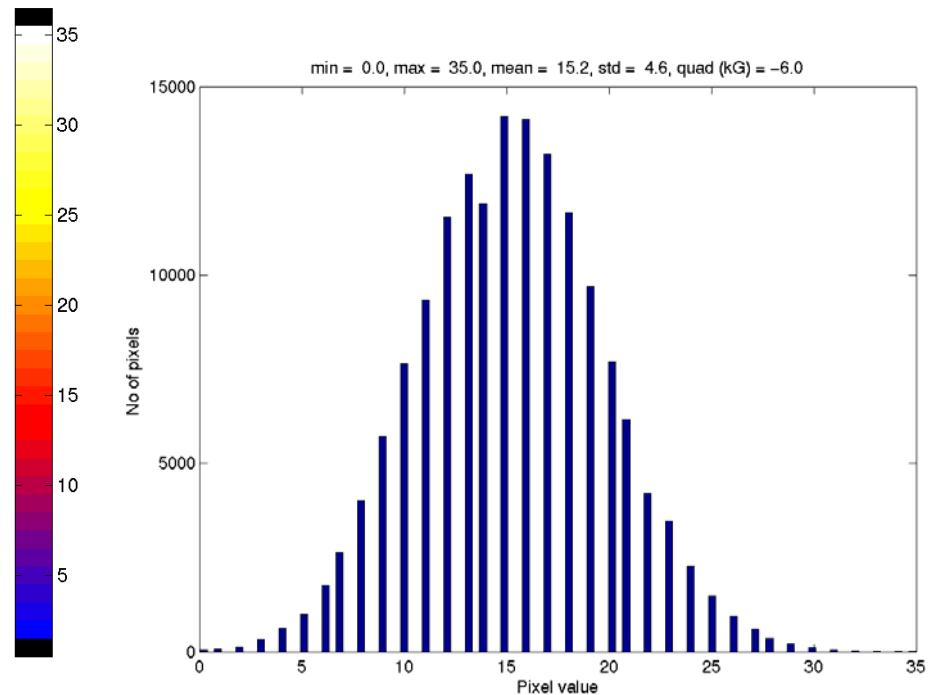
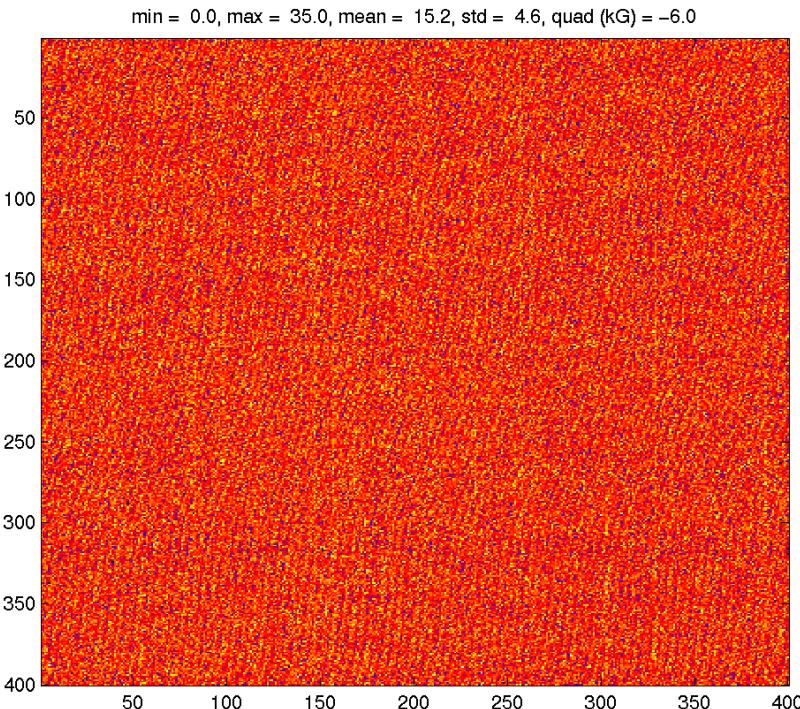


Layout for LCLS Injector Emittance Measurement

Data provided on the web:
 Gun solenoid scan: 8 datasets
 Quad scan: 7 quad set points
 5 images and 1 bg image

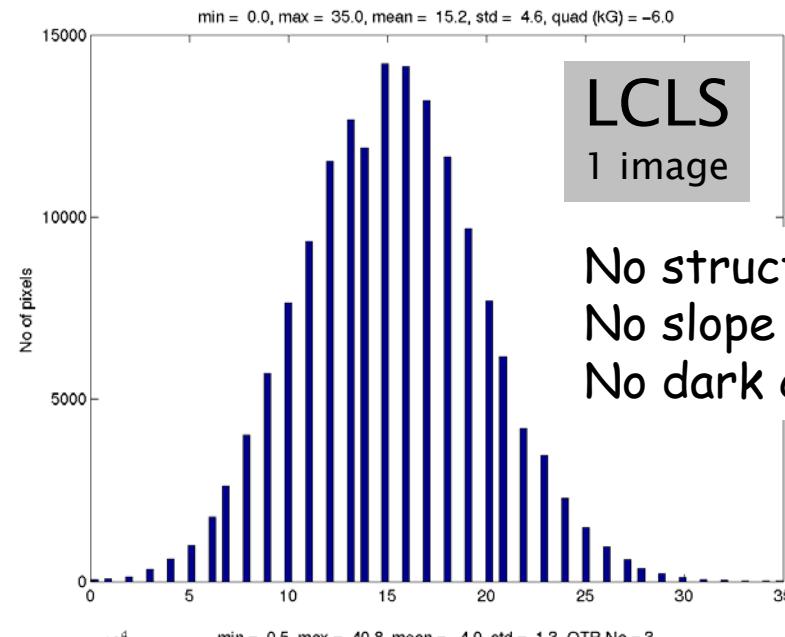
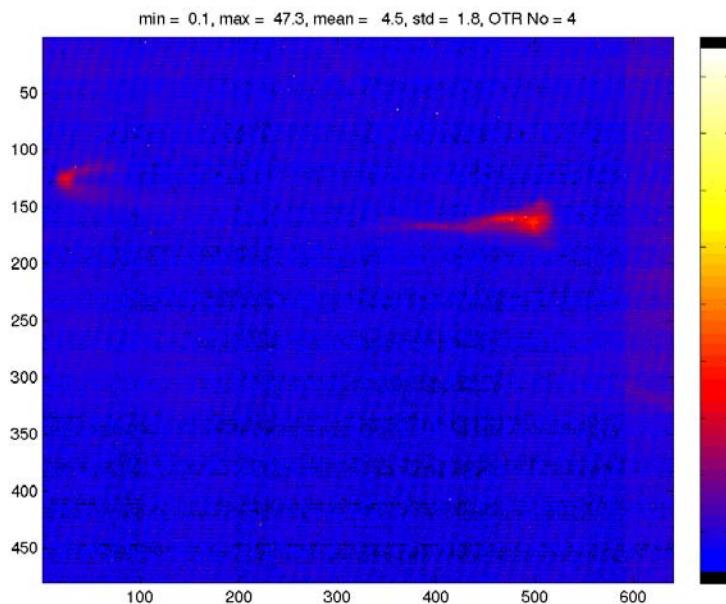
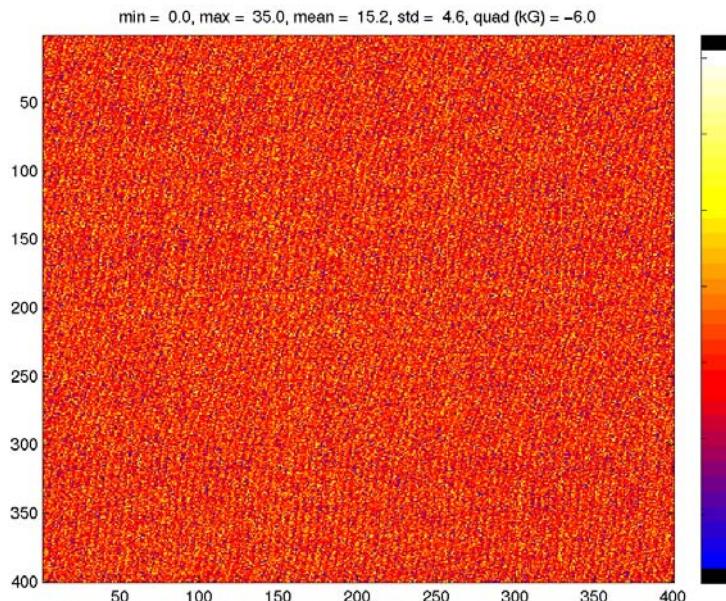


Background image



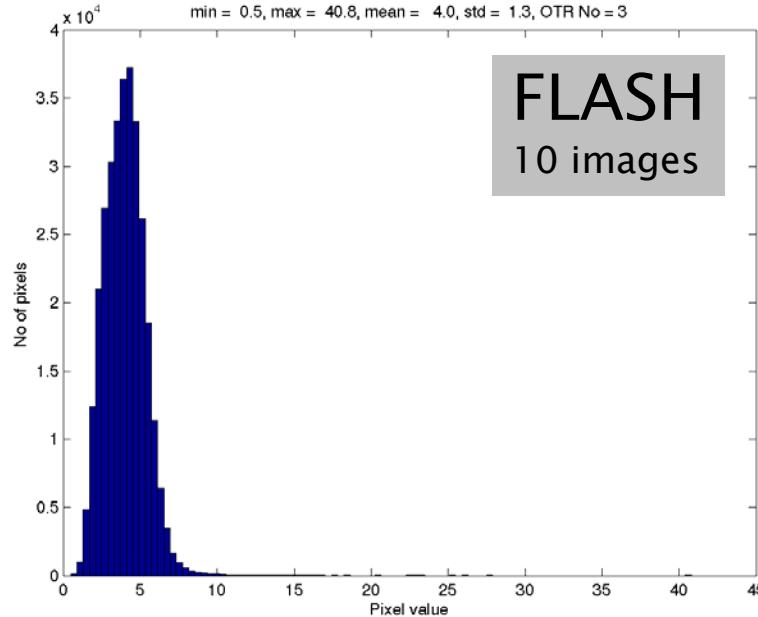
- Only 1 background image per Quad setting
- Gaussian noise
- Only few images with a spike (all outside ROI)
- Using the average of all bg images for a data set does not change the calculated emittance within error bars

Comparison of background images



LCLS
1 image

No structure
No slope
No dark current



FLASH
10 images

Same Emittance Tool used to calculate emittances as for FLASH:

1) Initial ROI:

Circle: – Radius = 10 pixels
– Centre = maximum of profiles

Pixels outside the ROI are used to estimate offset, which is subtracted from the image

Content of ROI is used for rms beam size calculations

2) Following ROIs:

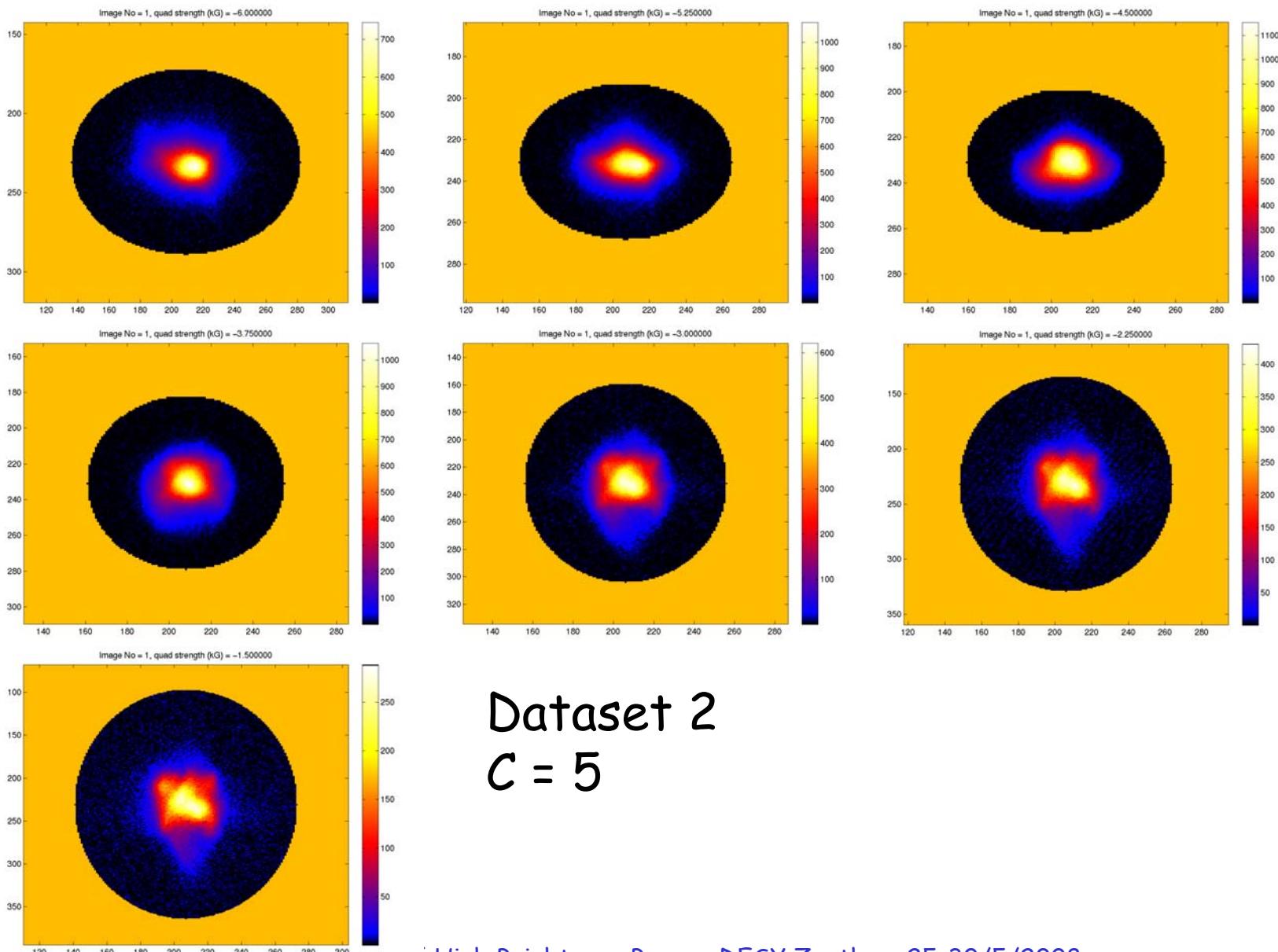
$$a_x^{(i)} = C \cdot x_{rms}^{(i-1)}$$

(Standard: $C = 5$)

$$a_y^{(i)} = C \cdot y_{rms}^{(i-1)}$$

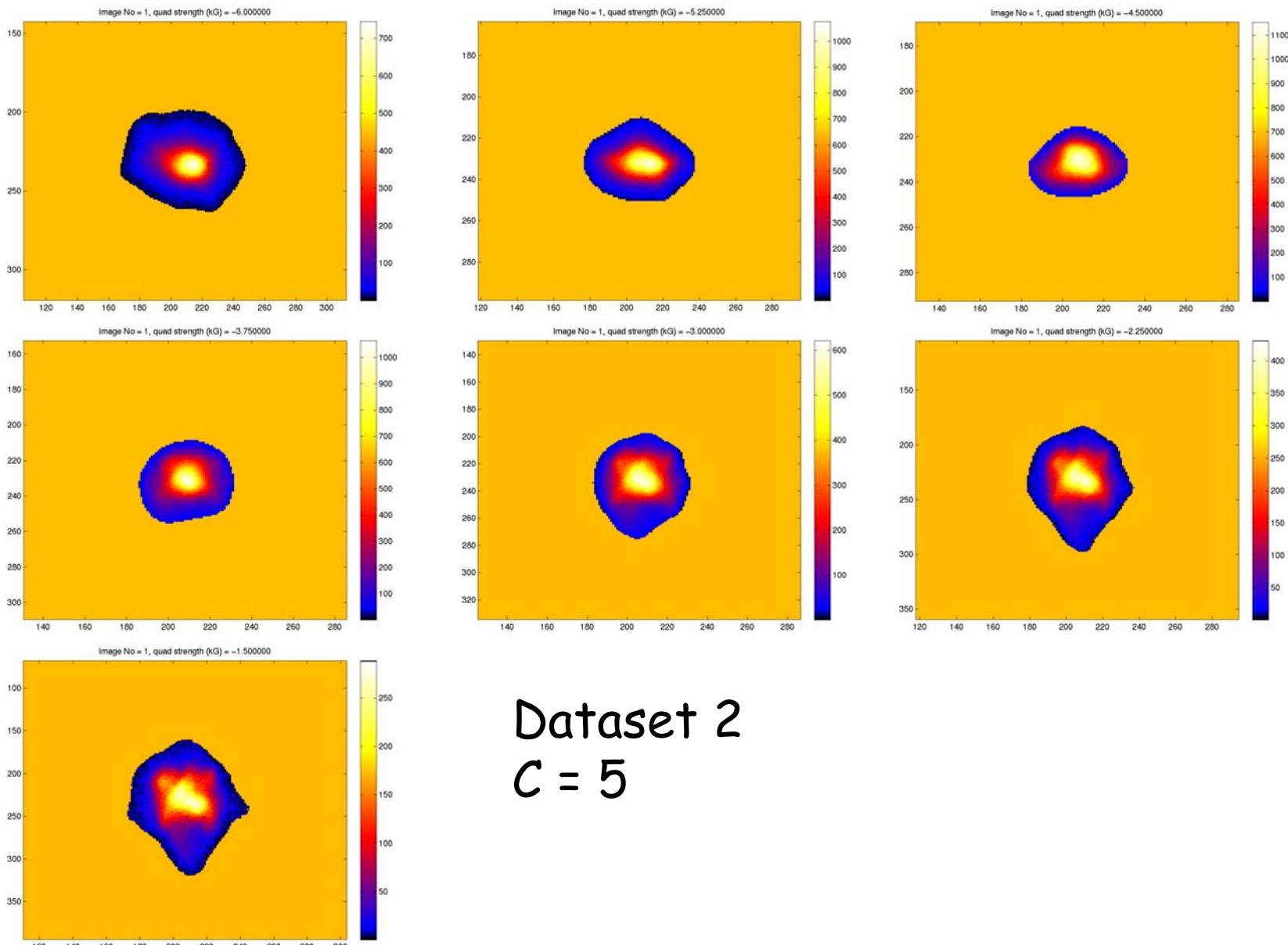
3) Repeat until rms beam sizes converge.

Images after bg subtraction & ROI



Dataset 2
 $C = 5$

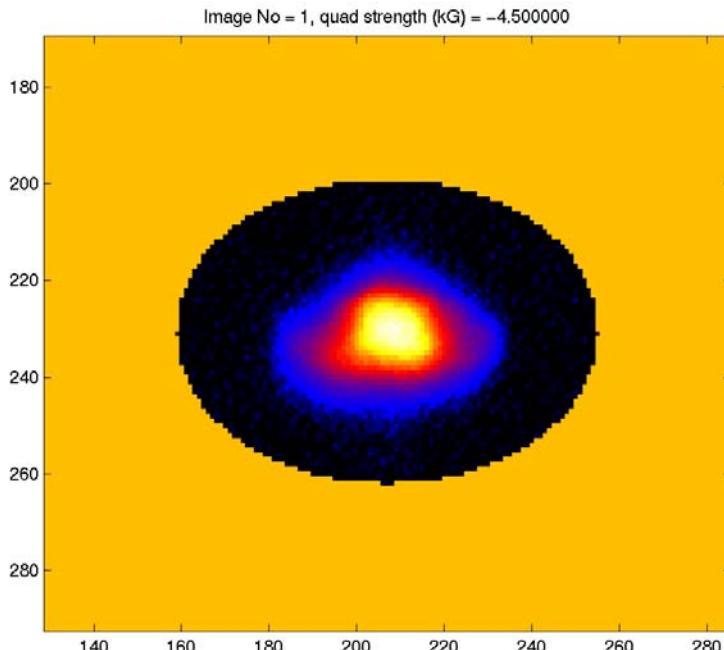
Images of beam „core“ (95%)



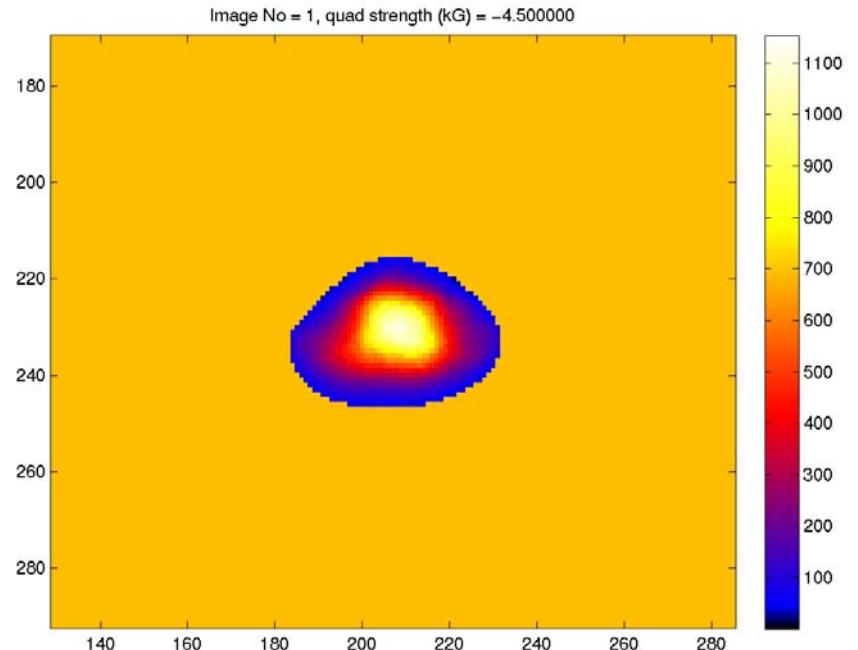
Dataset 2
 $C = 5$

Comparison 'full' beam and 'core'

100%

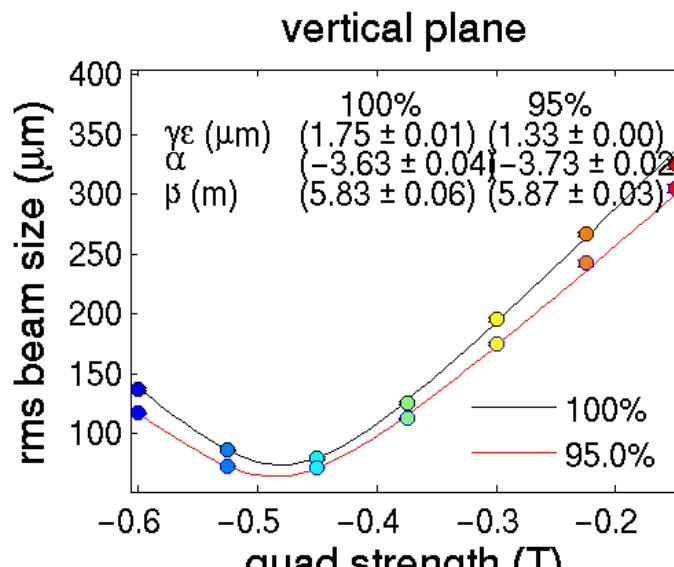
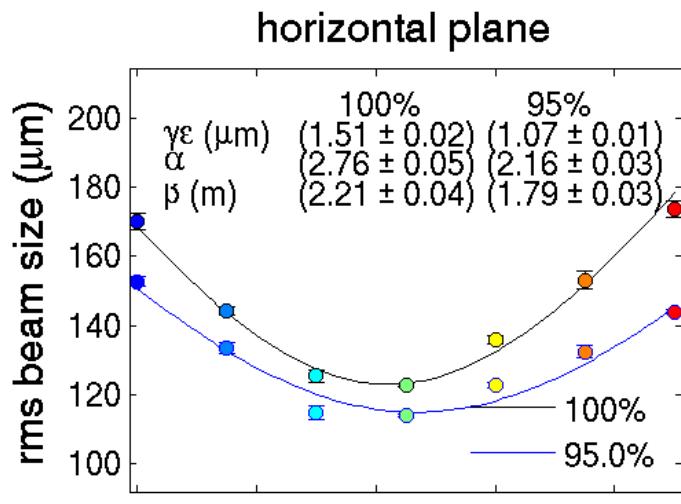


95%

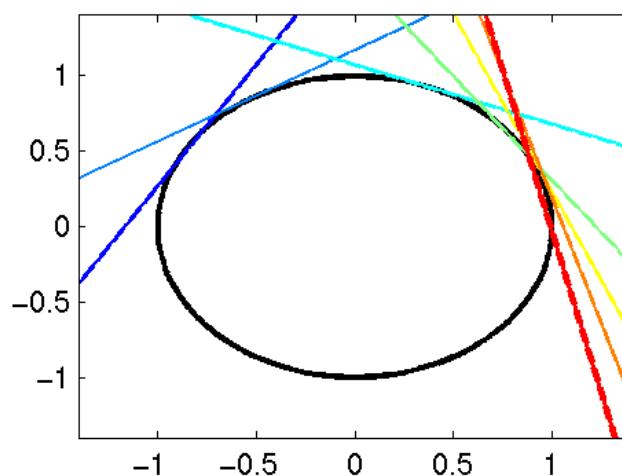
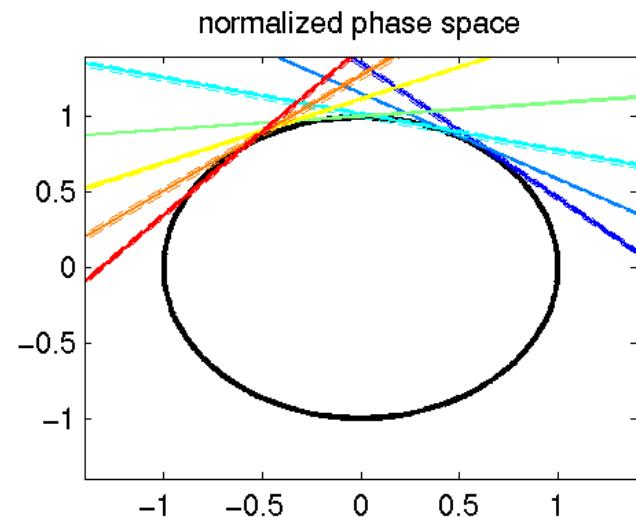


Dataset 2
 $C = 5$

Quad Scan Data

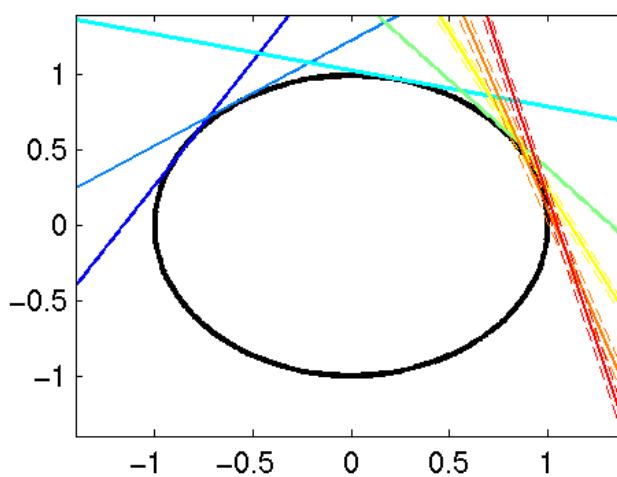
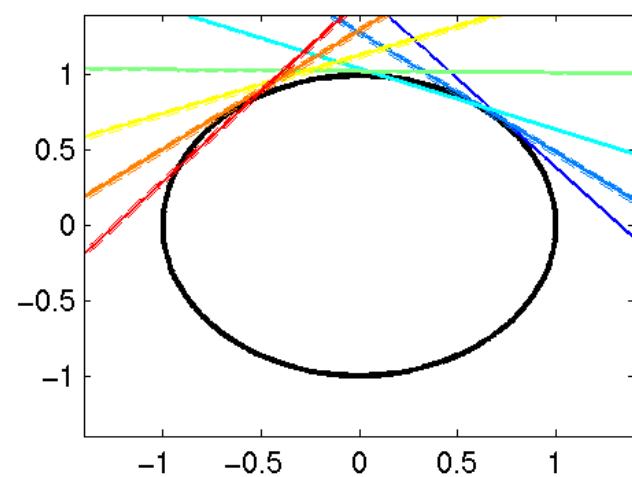
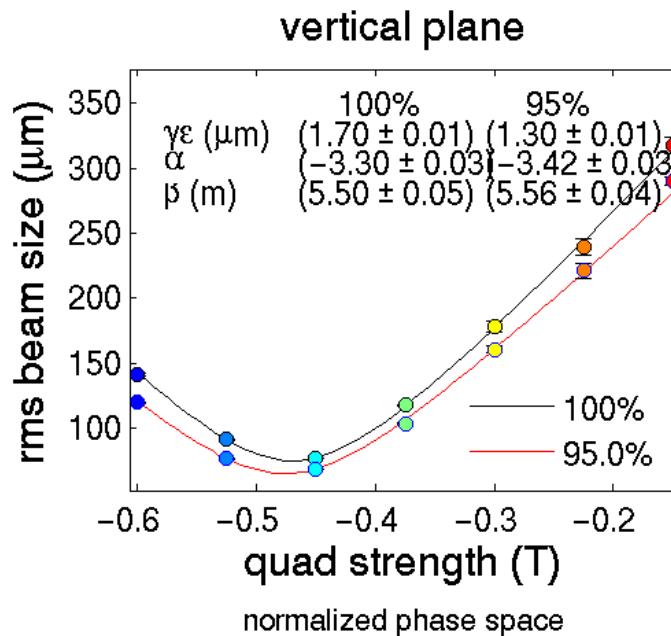
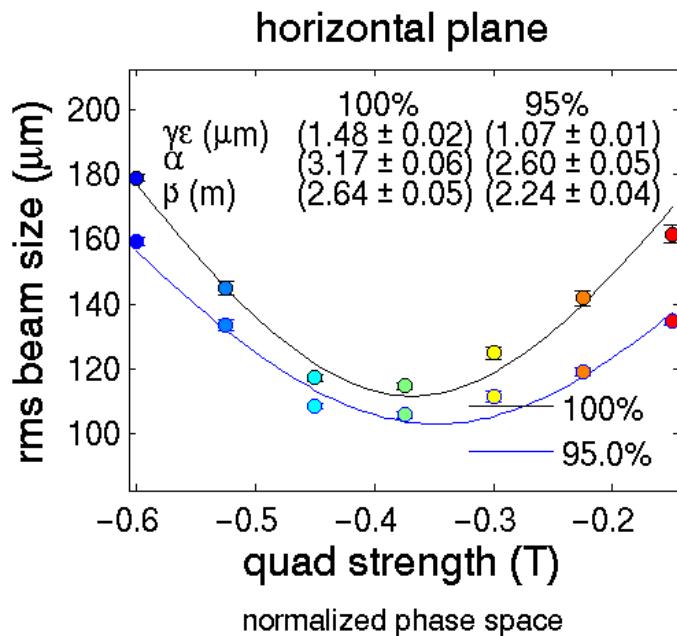


Dataset 1
 $C = 5$

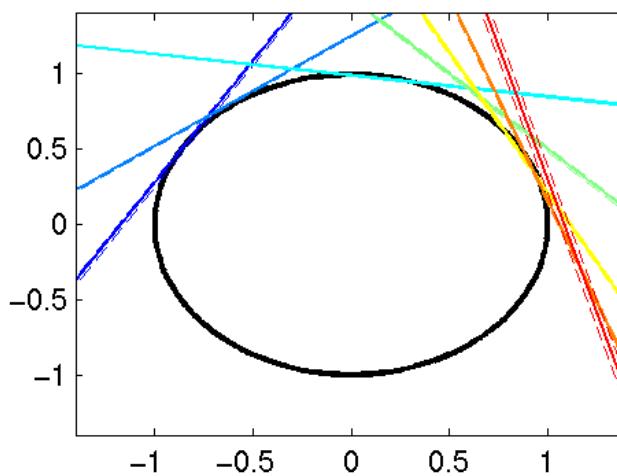
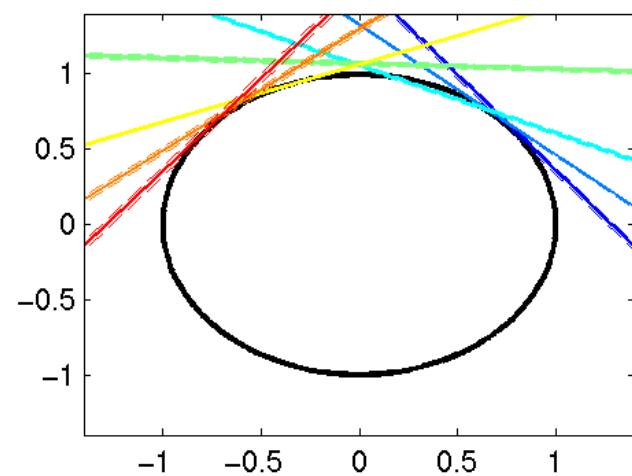
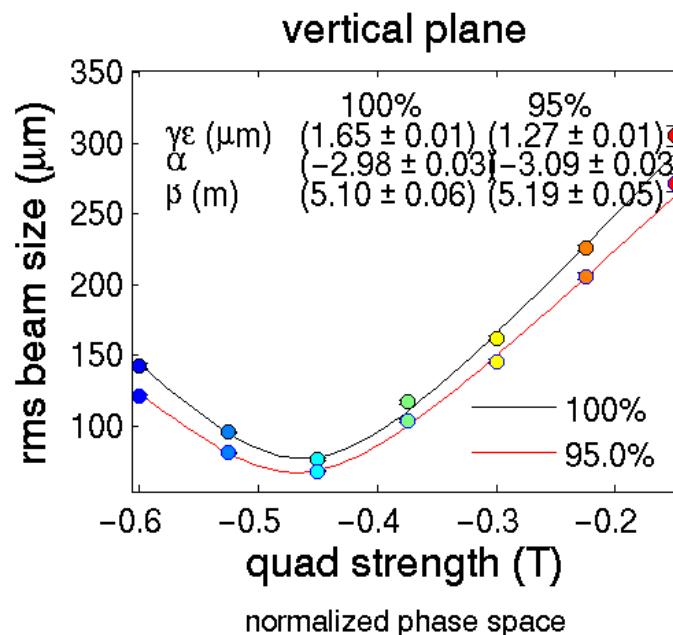
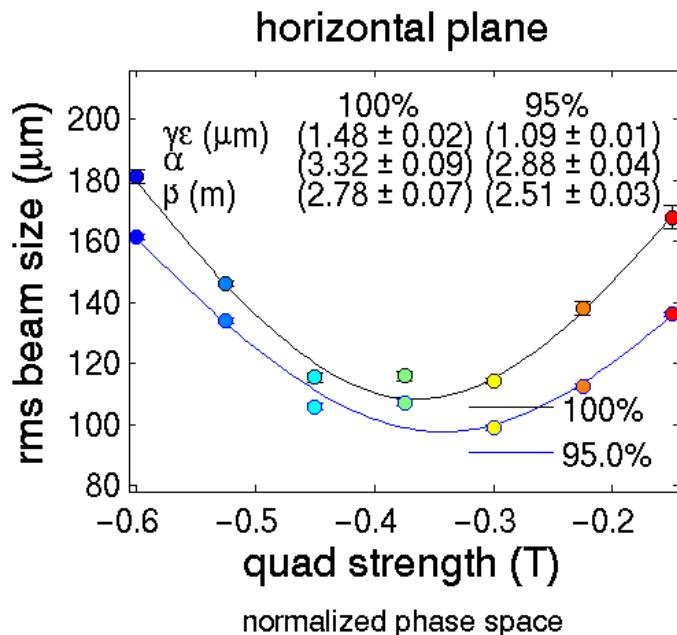


Quad Scan Data

Dataset 2
 $C = 5$

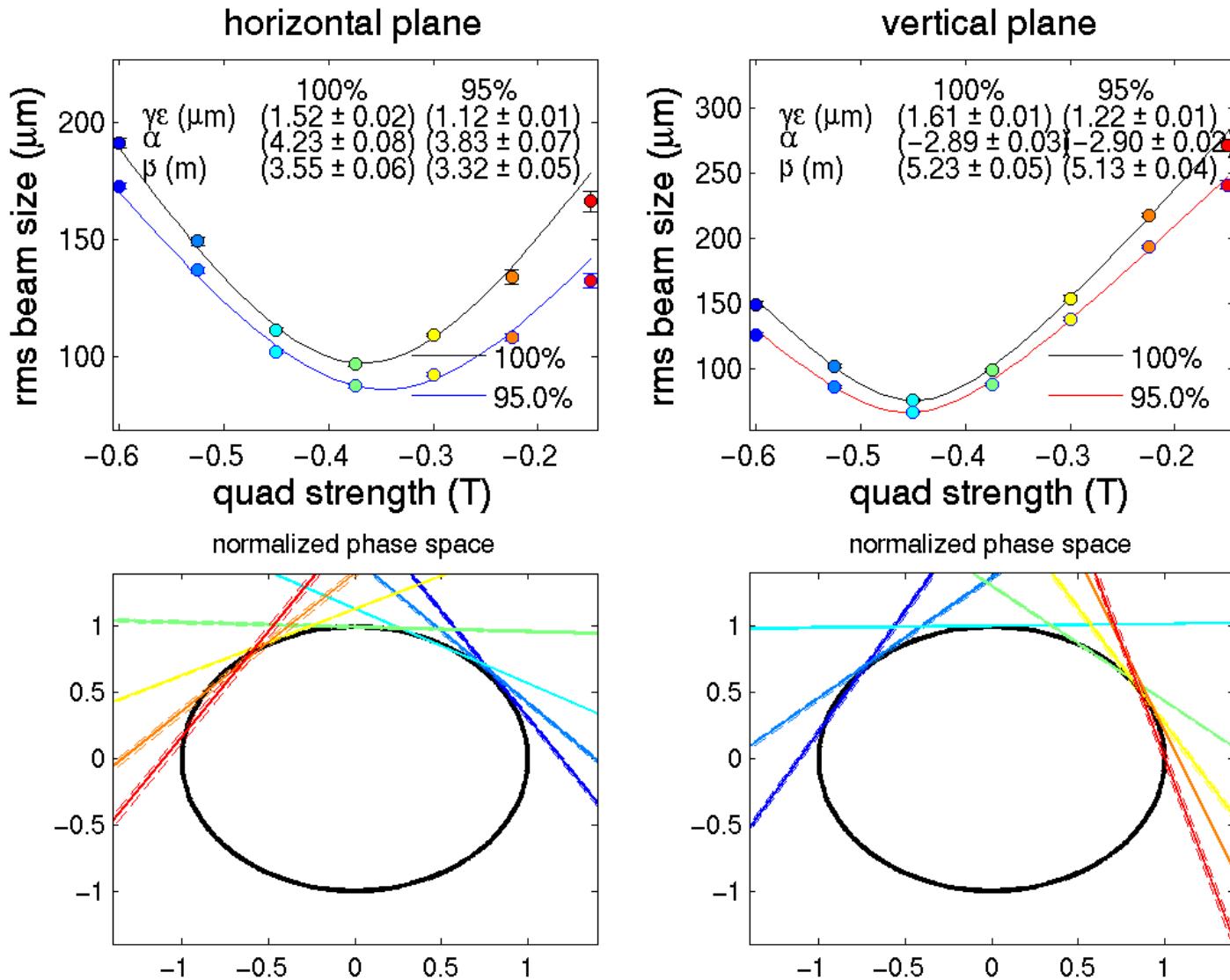


Quad Scan Data

Dataset 3
 $C = 5$ 

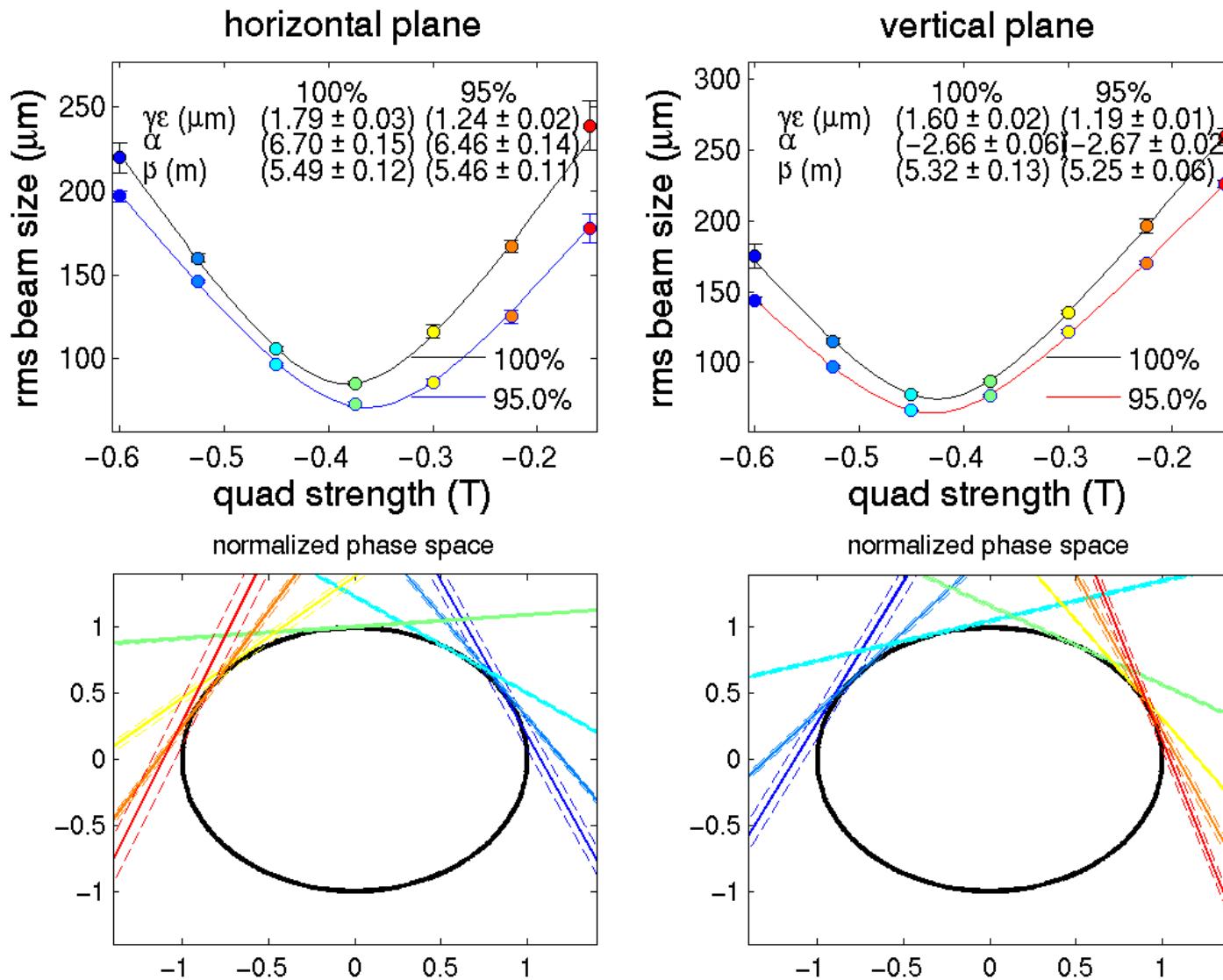
Quad Scan Data

Dataset 4
 $C = 5$



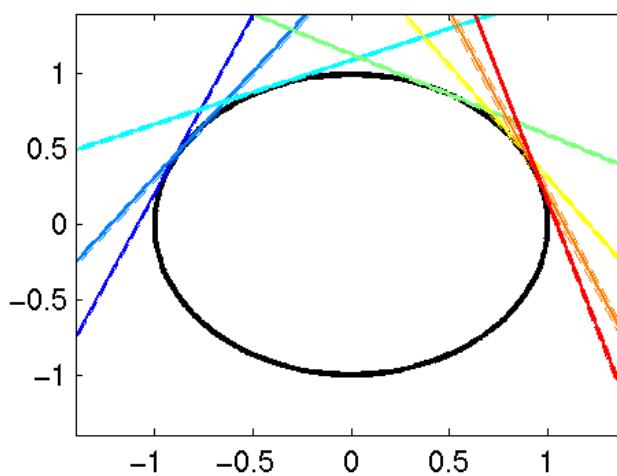
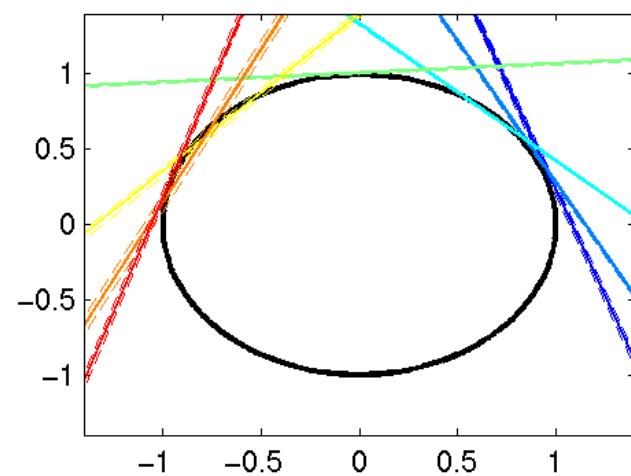
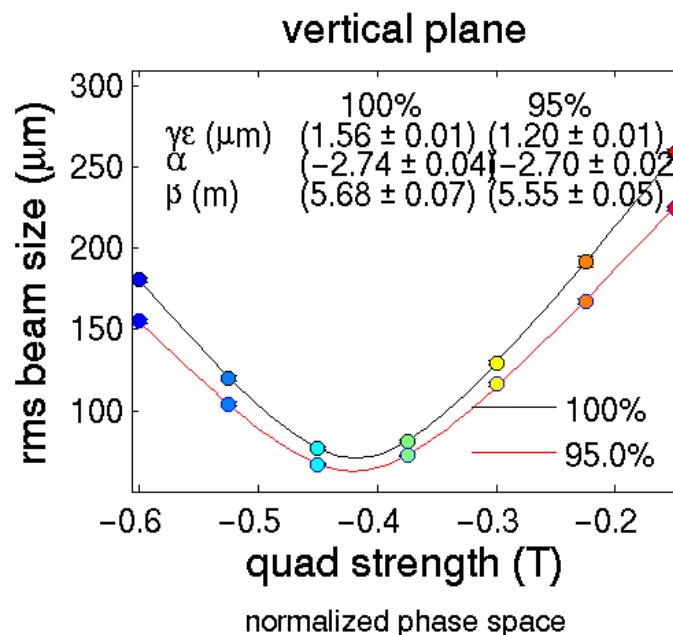
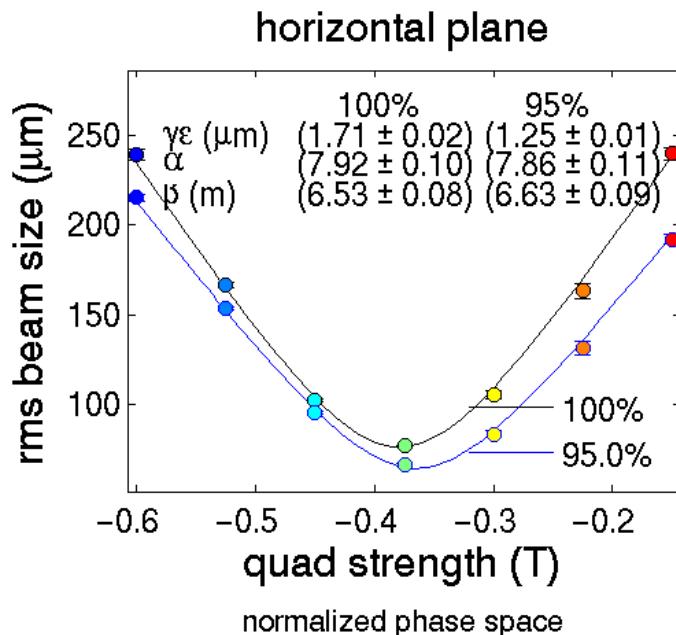
Quad Scan Data

Dataset 5
 $C = 5$

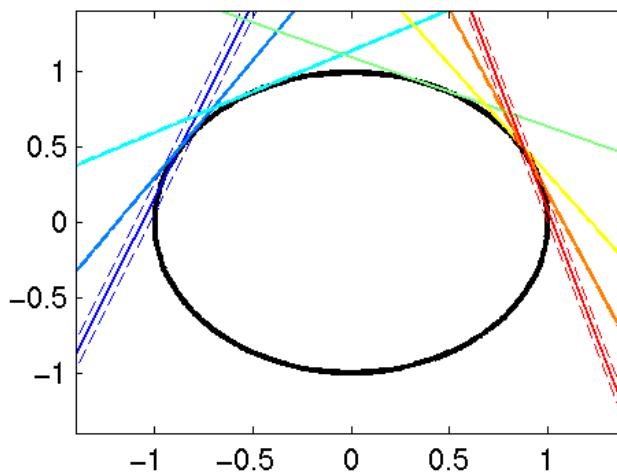
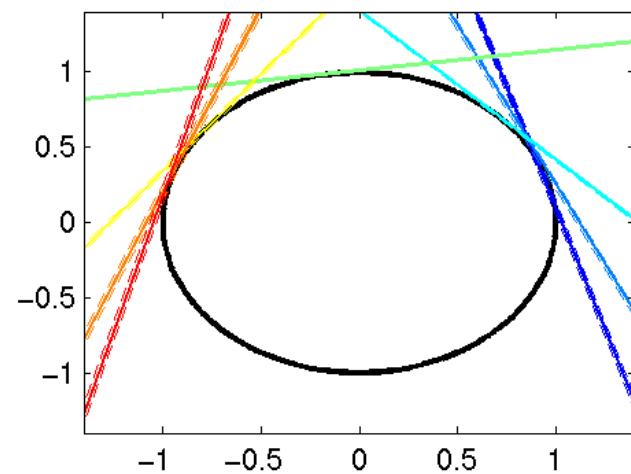
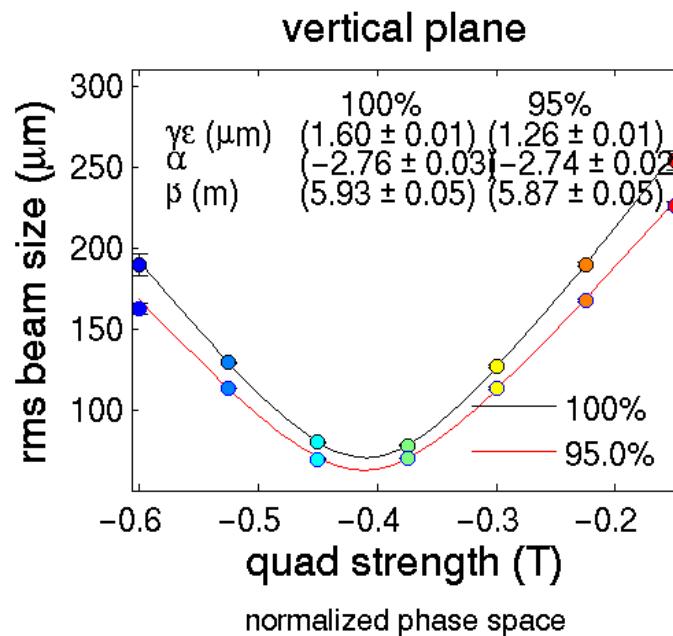
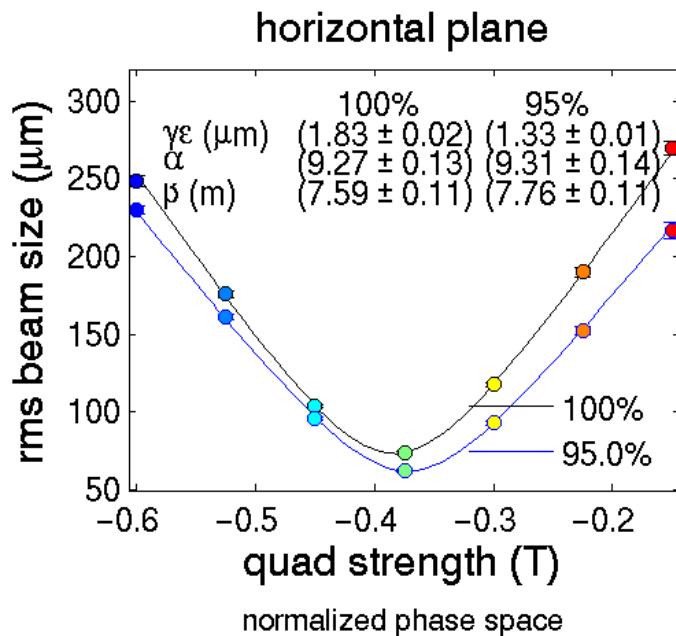


Quad Scan Data

Dataset 6
 $C = 5$

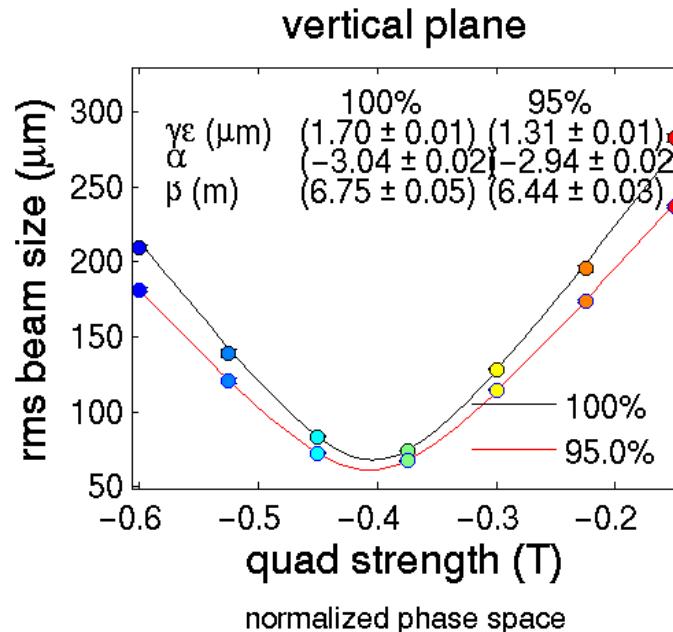
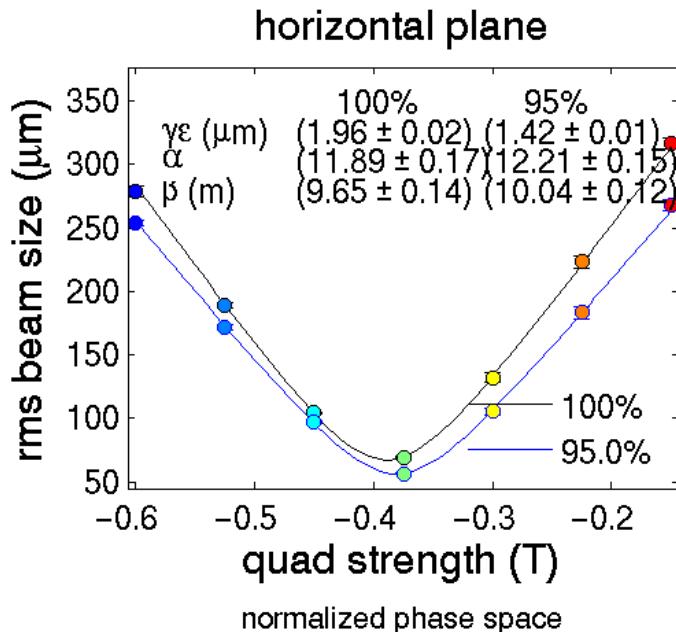


Quad Scan Data

Dataset 7
 $C = 5$ 

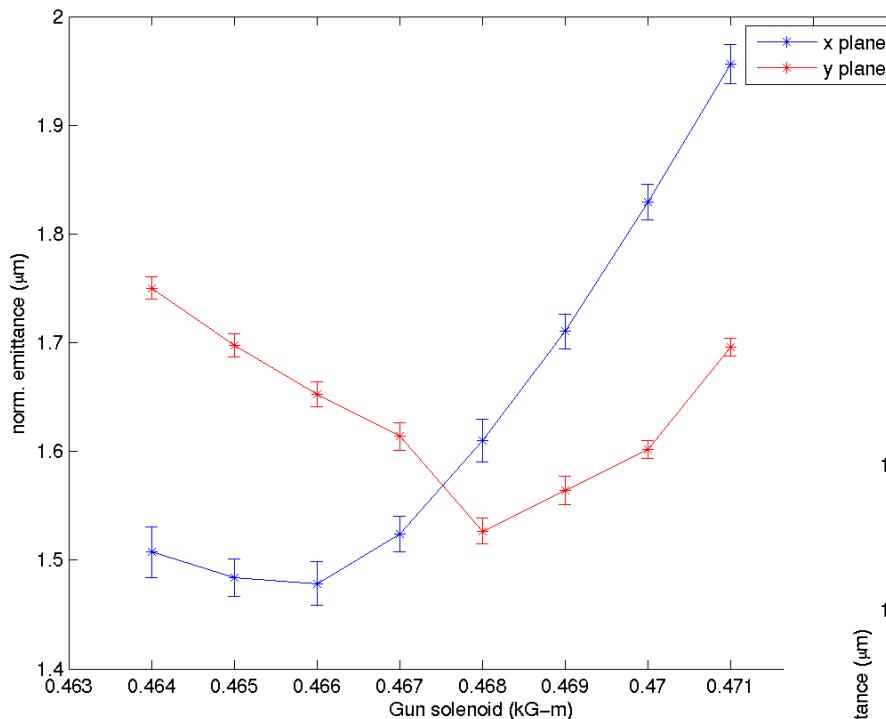
Quad Scan Data

Dataset 8
 $C = 5$

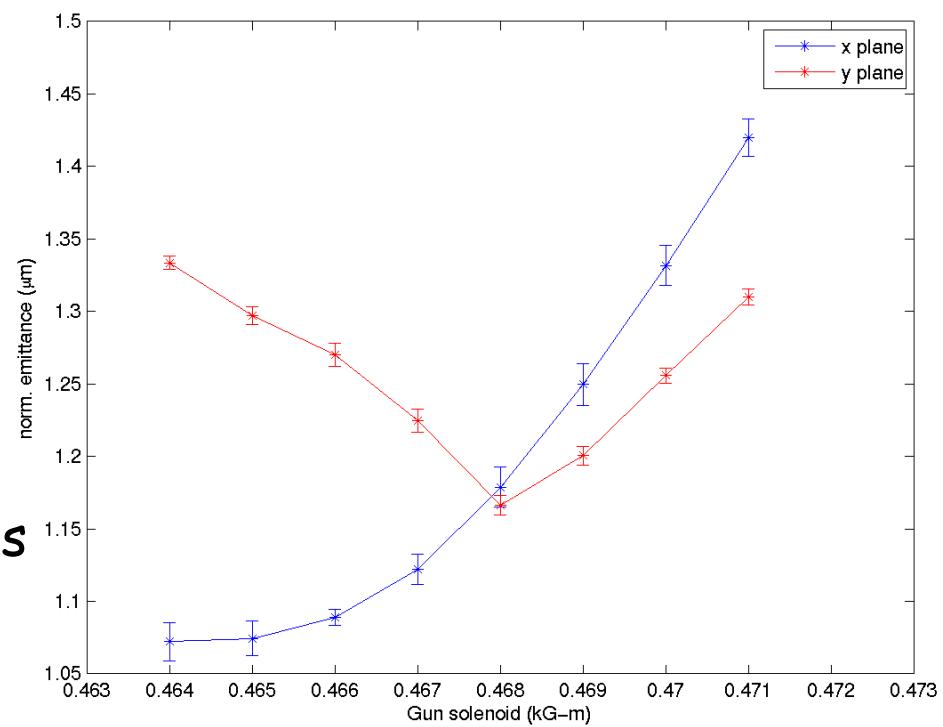


Final result: Gun solenoid scan

100%



95%



Shape of emittance in x plane
different compared to LCLS analysis

Algorithm used in Emittance Tool:

1) Initial ROI:

Circle:

- Radius = 10 pixels
- Centre = maximum of profiles

Pixels outside the ROI are used to estimate offset, which is subtracted from the image

Content of ROI is used for rms beam size calculations

2) Following ROIs:

$$a_x^{(i)} = C \cdot x_{rms}^{(i-1)}$$

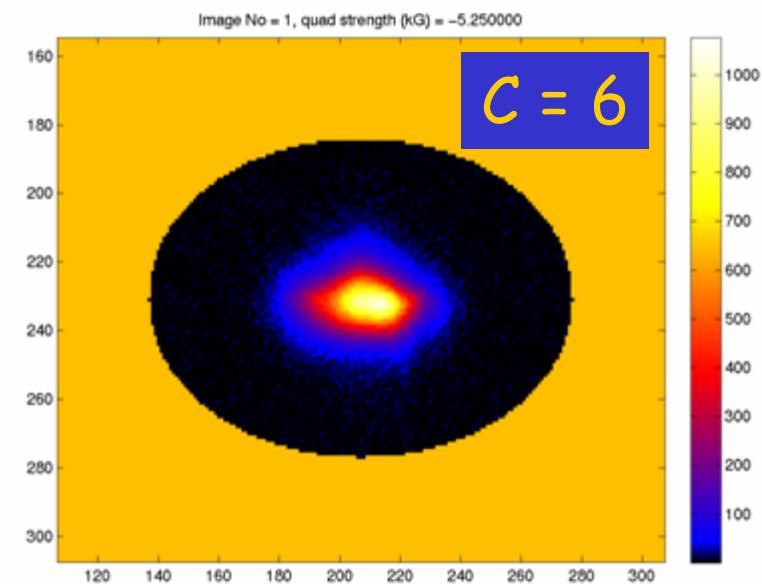
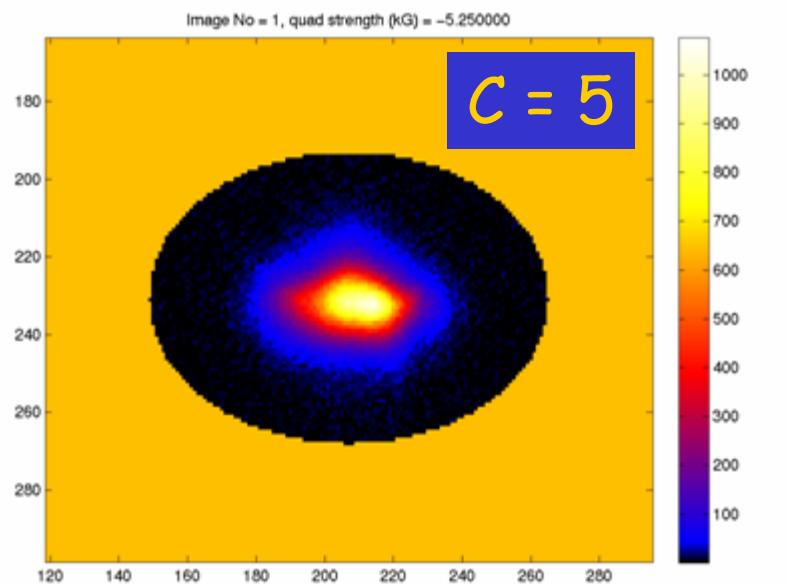
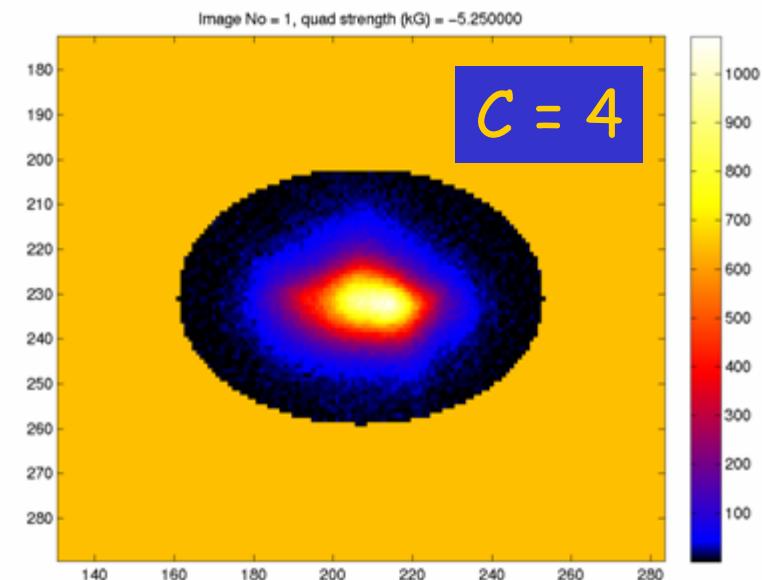
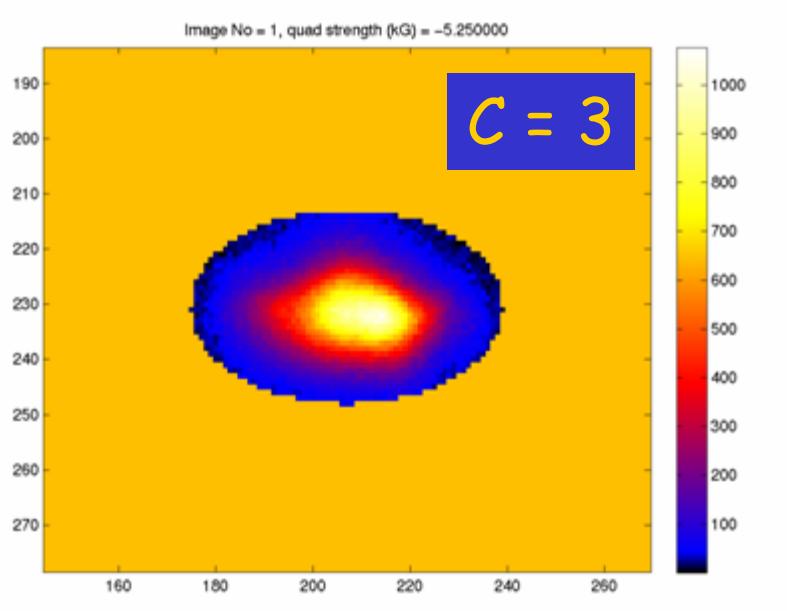
(Standard: $C = 5$)

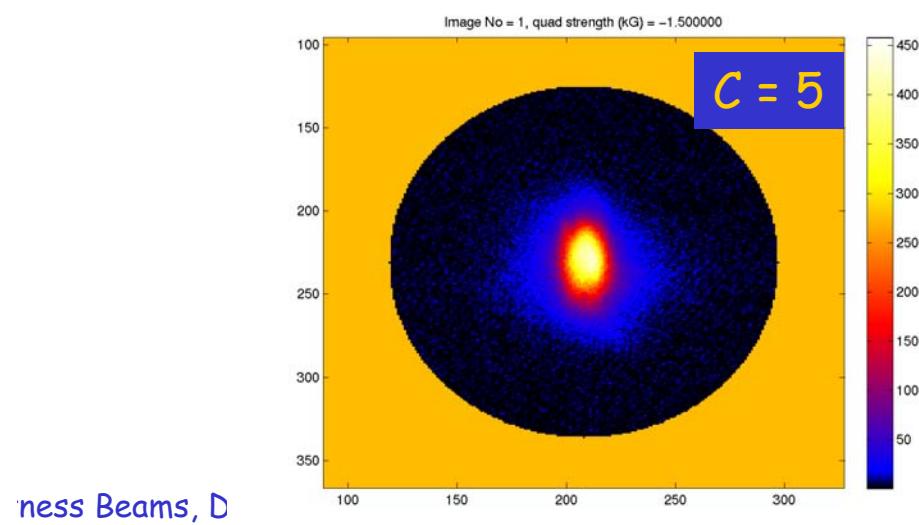
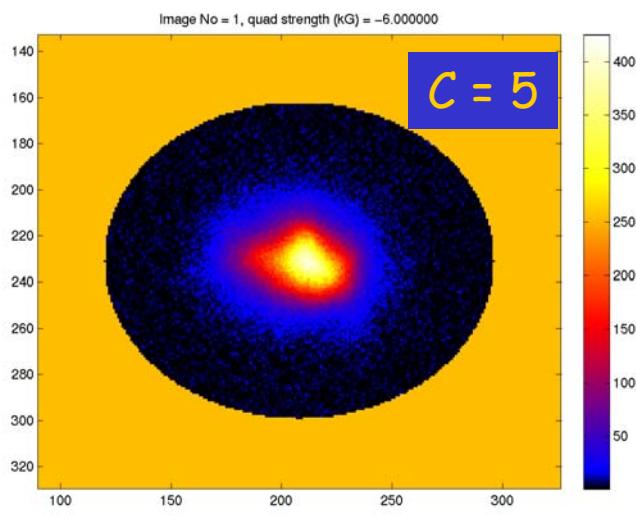
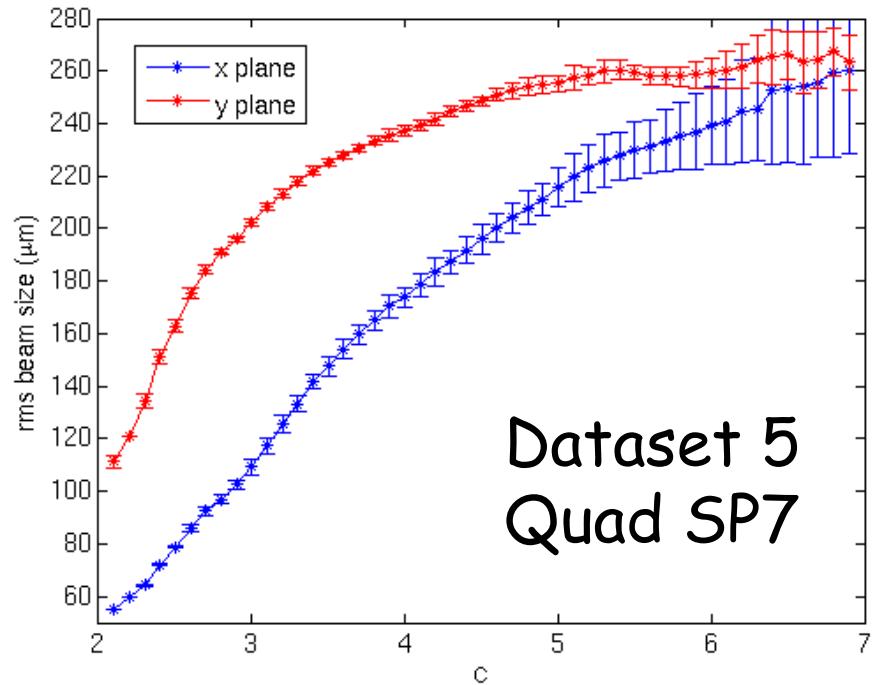
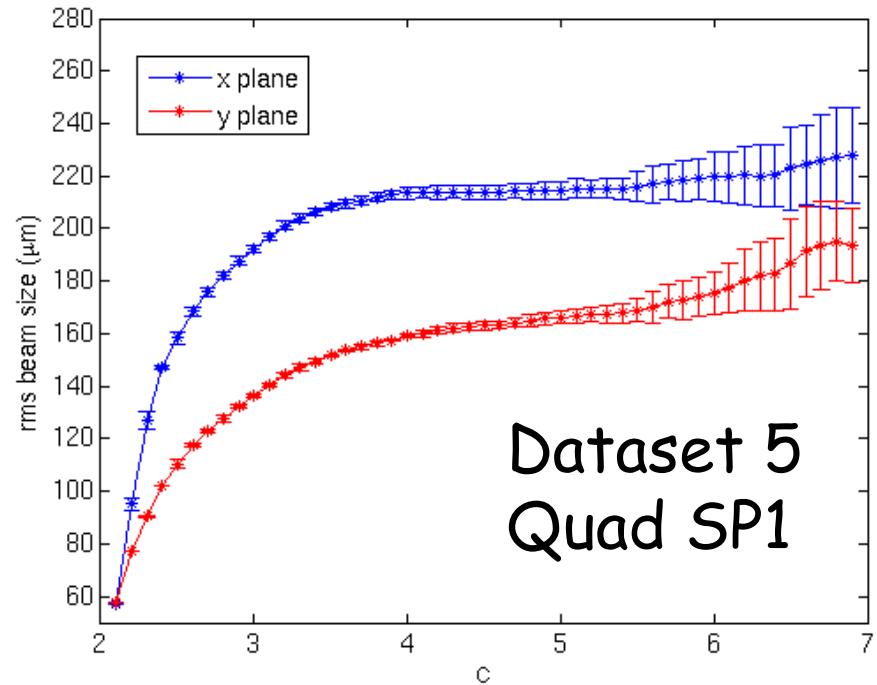
$$a_y^{(i)} = C \cdot y_{rms}^{(i-1)}$$

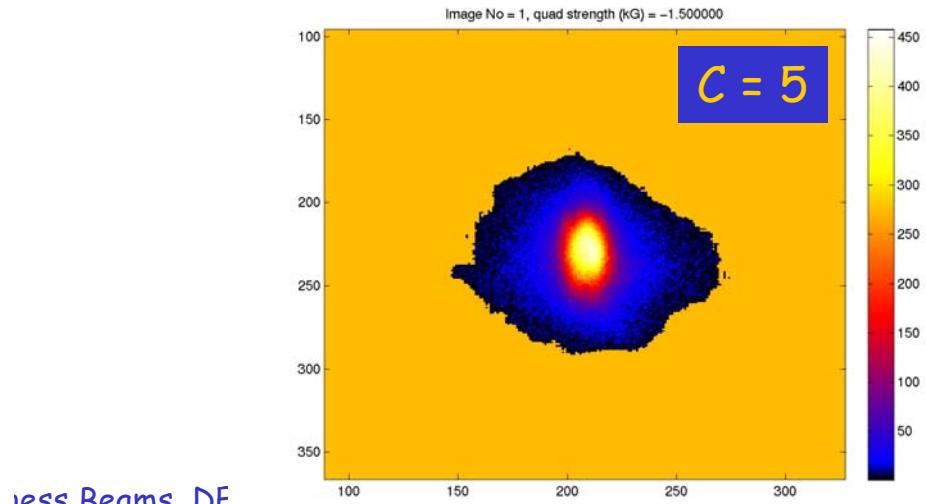
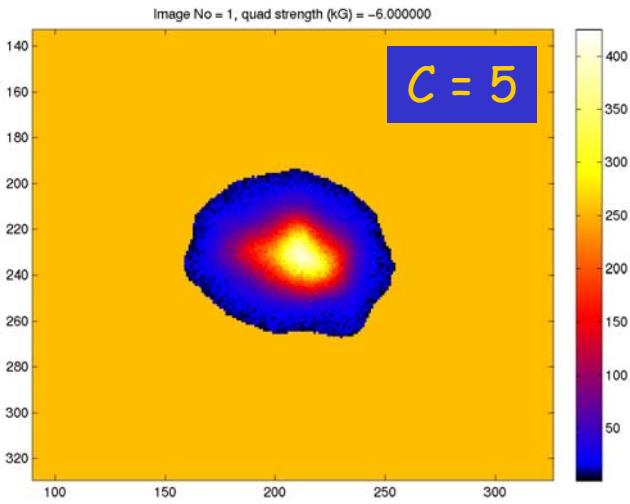
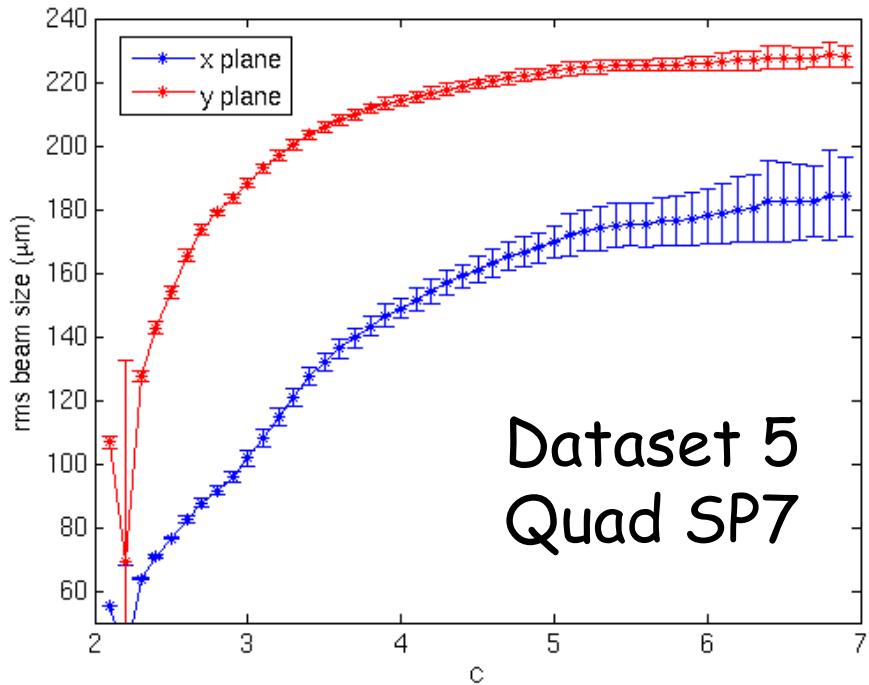
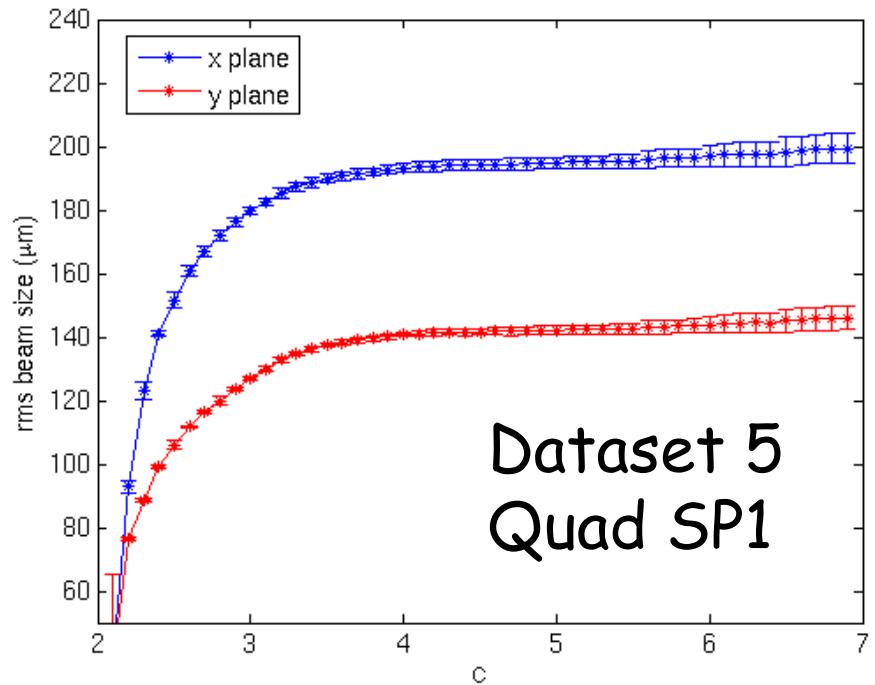
3) Repeat until rms beam sizes converge.

Let's try different Cs

Examples for different ROIs

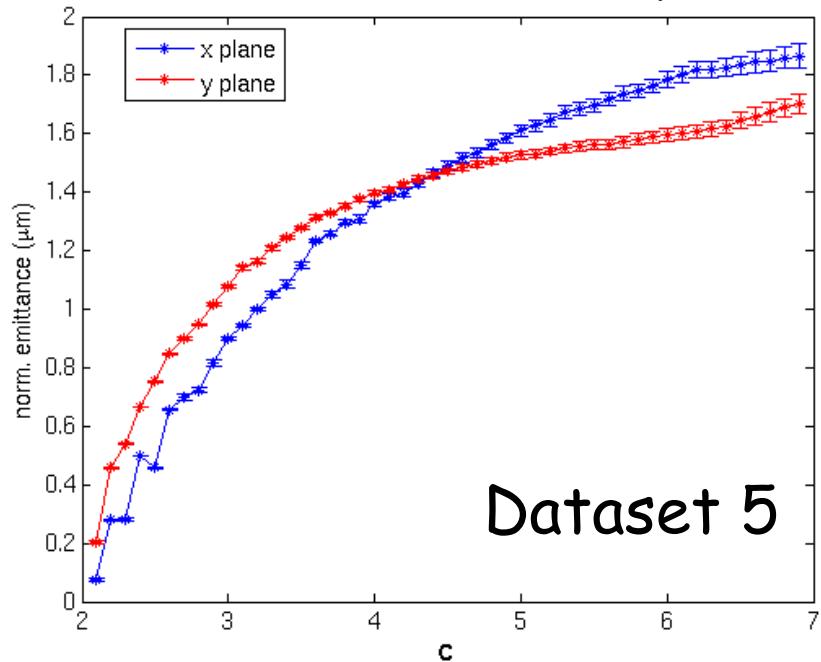






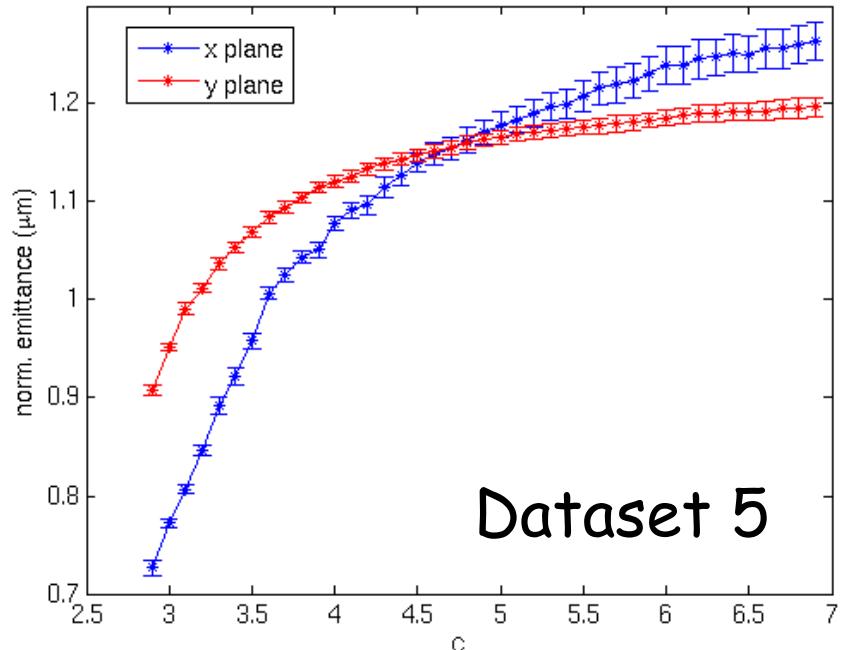
less Beams, DE

100% Intensity



Dataset 5

95% Intensity



Dataset 5

Estimated emittance depends on parameter C

- LCLS Quad scan data were analyzed with the FLASH Emittance Tool
- Estimated emittance for the gun solenoid scan shows a different slope in the x plane as LCLS analysis
- Estimated emittance depends on input parameter C of FLASH emittance tool