QUADRUPOLE SCAN MEASUREMENTS IN EMMA INJECTION BEAMLINE

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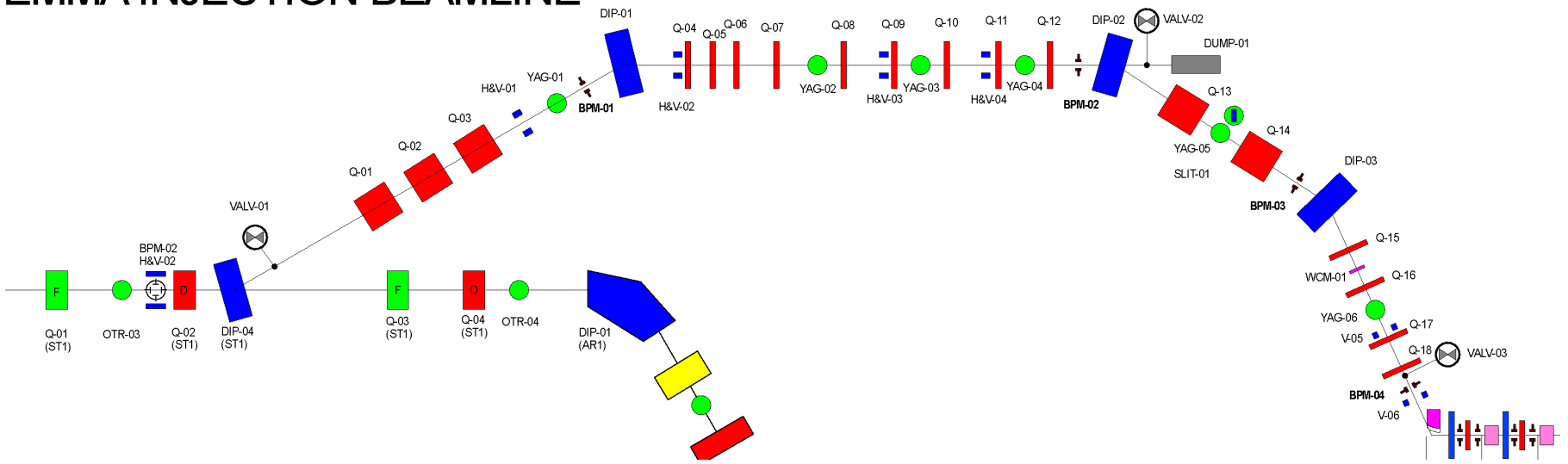
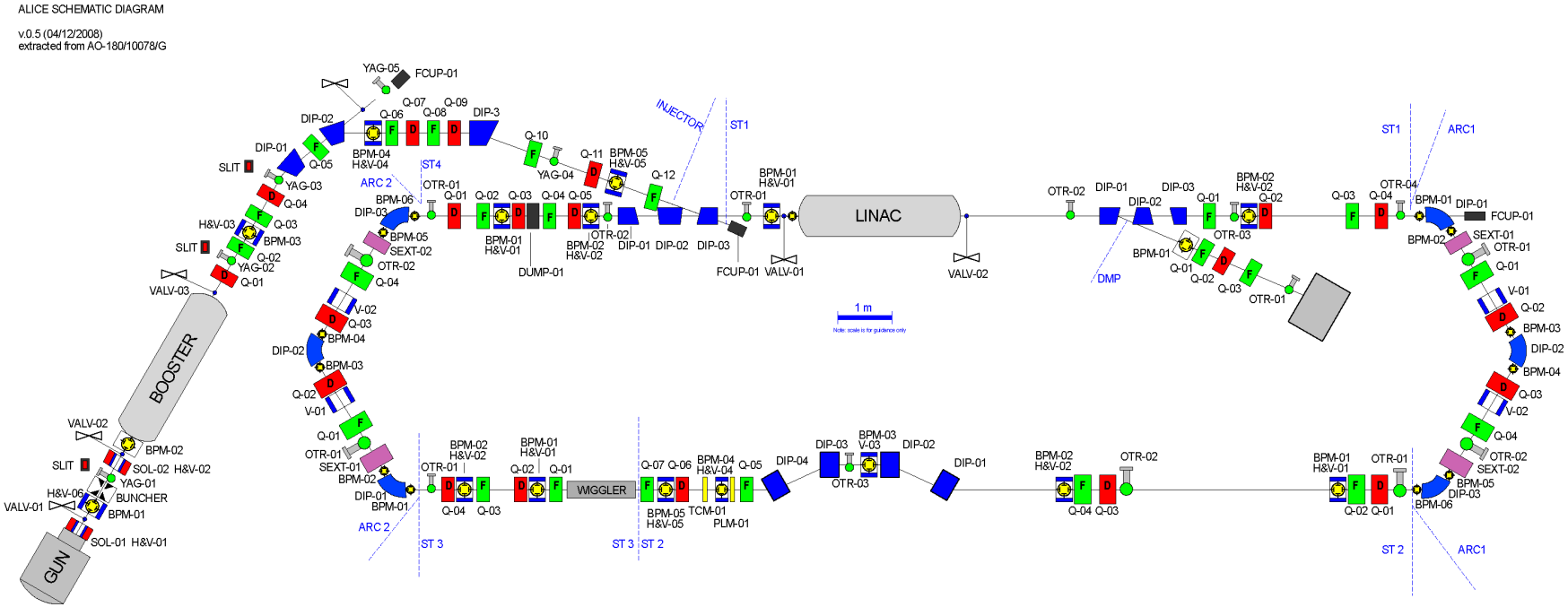
LAYOUT OF EMMA INJECTION BEAM LINE

EMMA INJECTION BEAMLINE





QUADRUPOLE SCAN TECHNIQUE

Linear transformation

$$\begin{pmatrix} x \\ x' \end{pmatrix}_f = \begin{pmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{pmatrix}_{fi} \begin{pmatrix} x \\ x' \end{pmatrix}_i$$

Quadrupole of gradient

$$K = (\partial B/\partial x)/(B\rho)$$

$$\phi = l_q\sqrt{|K|}$$

Matrix for a focusing quadrupole

$$\mathbf{R}_{quad} = \begin{pmatrix} \cos\phi & \sin\phi/\sqrt{|K|} \\ -\sqrt{|K|}\sin\phi & \cos\phi \end{pmatrix}$$

integrated gradient $\quad k = |K|l_q$

$$\mathbf{R}_{thin-lens} = \begin{pmatrix} 1 & 0 \\ -k & 1 \end{pmatrix}$$

Drift space of length L

$$\mathbf{R}_{drift} = \begin{pmatrix} 1 & L \\ 0 & 1 \end{pmatrix}$$

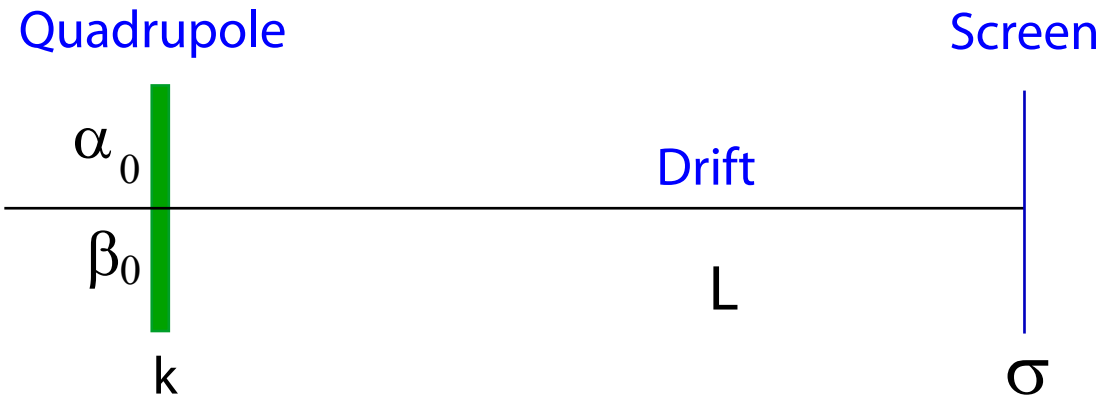
$$\mathbf{R}_{drift} \ \mathbf{R}_{thin-lens}$$

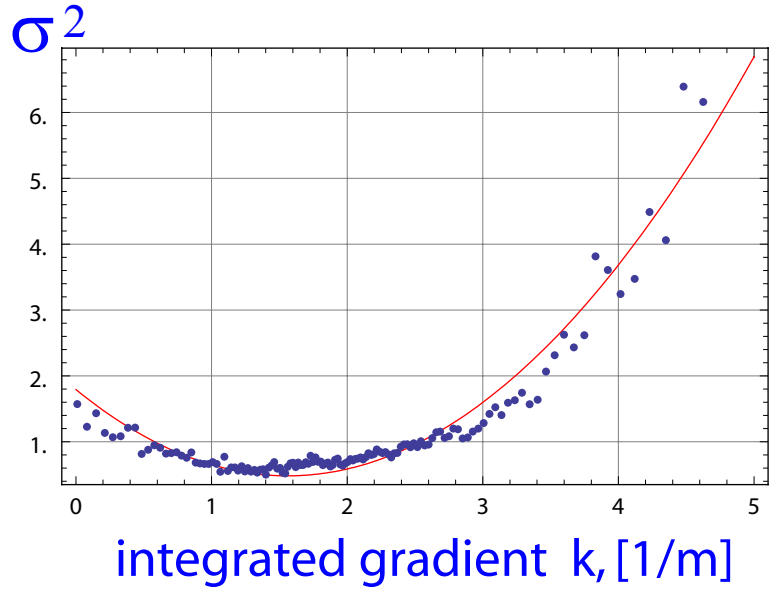
$$\begin{pmatrix} \beta \\ \alpha \\ \gamma \end{pmatrix}_f = \begin{pmatrix} R_{11}^2 & -2R_{11}R_{12} & R_{12}^2 \\ -R_{11}R_{21} & 1+2R_{12}R_{21} & -R_{12}R_{22} \\ R_{21}^2 & -2R_{21}R_{22} & R_{22}^2 \end{pmatrix}_{fi} \begin{pmatrix} \beta \\ \alpha \\ \gamma \end{pmatrix}_i$$

$$\sigma^2 = \varepsilon\beta = \varepsilon[\,(1-kL)^2\beta_0 - 2(1-kL)\,L\,\alpha_0 + L^2\,\gamma_0\,]$$

QUADRUPOLE SCAN TECHNIQUE

$$\sigma^2 = \varepsilon\beta = \varepsilon\left[(1-kL)^2 \beta_0 - 2(1-kL)\, L\, \alpha_0 + L^2 \gamma_0 \right]$$

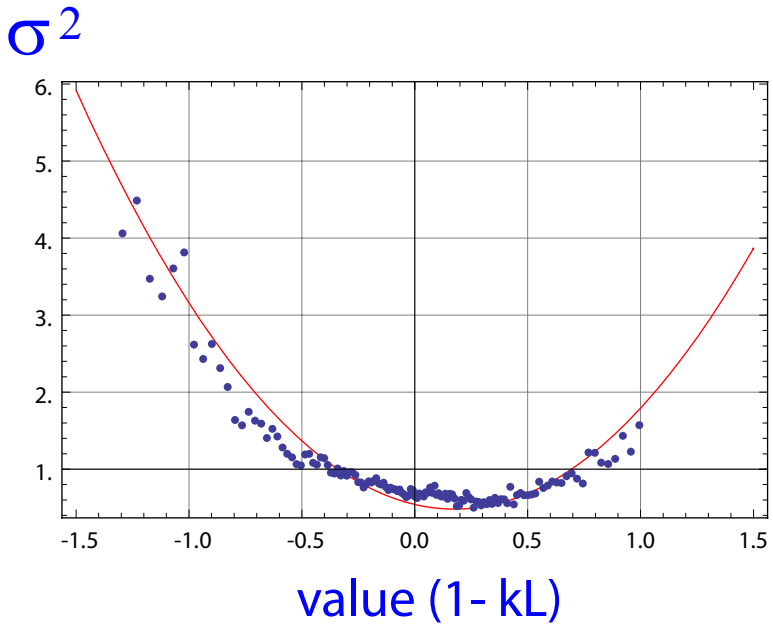


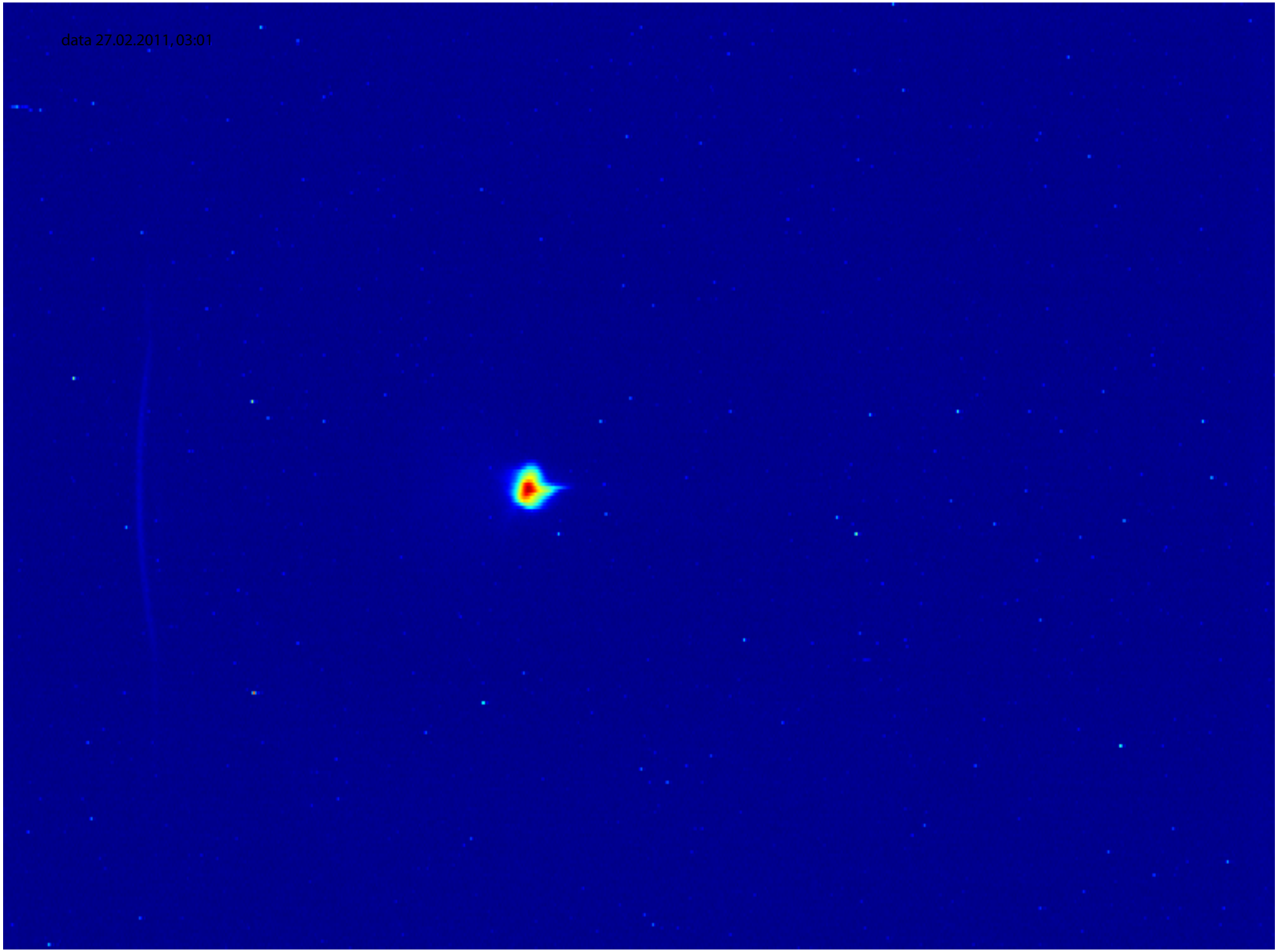


$$\sigma^2 = A(1-kL)^2 + B(1-kL) + C$$

$$A = \varepsilon\beta_0$$
$$B = -2\varepsilon L\alpha_0$$
$$C = \varepsilon L^2 \gamma_0$$

$$\varepsilon = \frac{\sqrt{4AC - B^2}}{2L}$$

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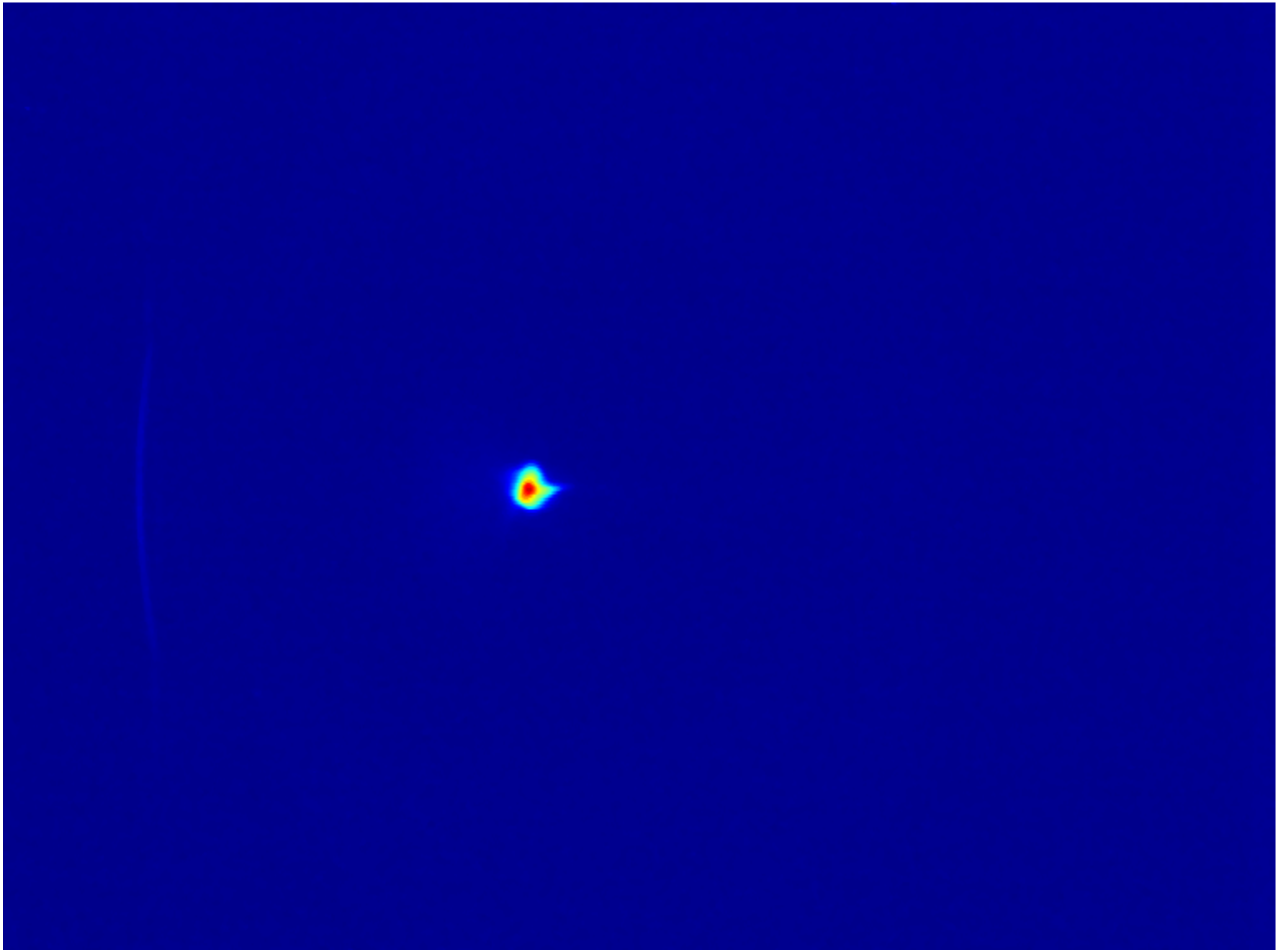
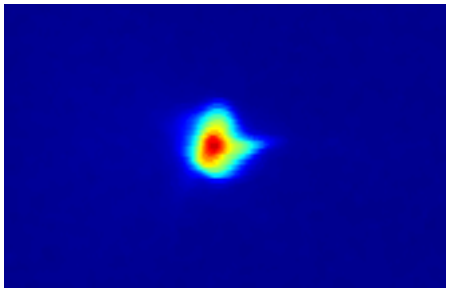
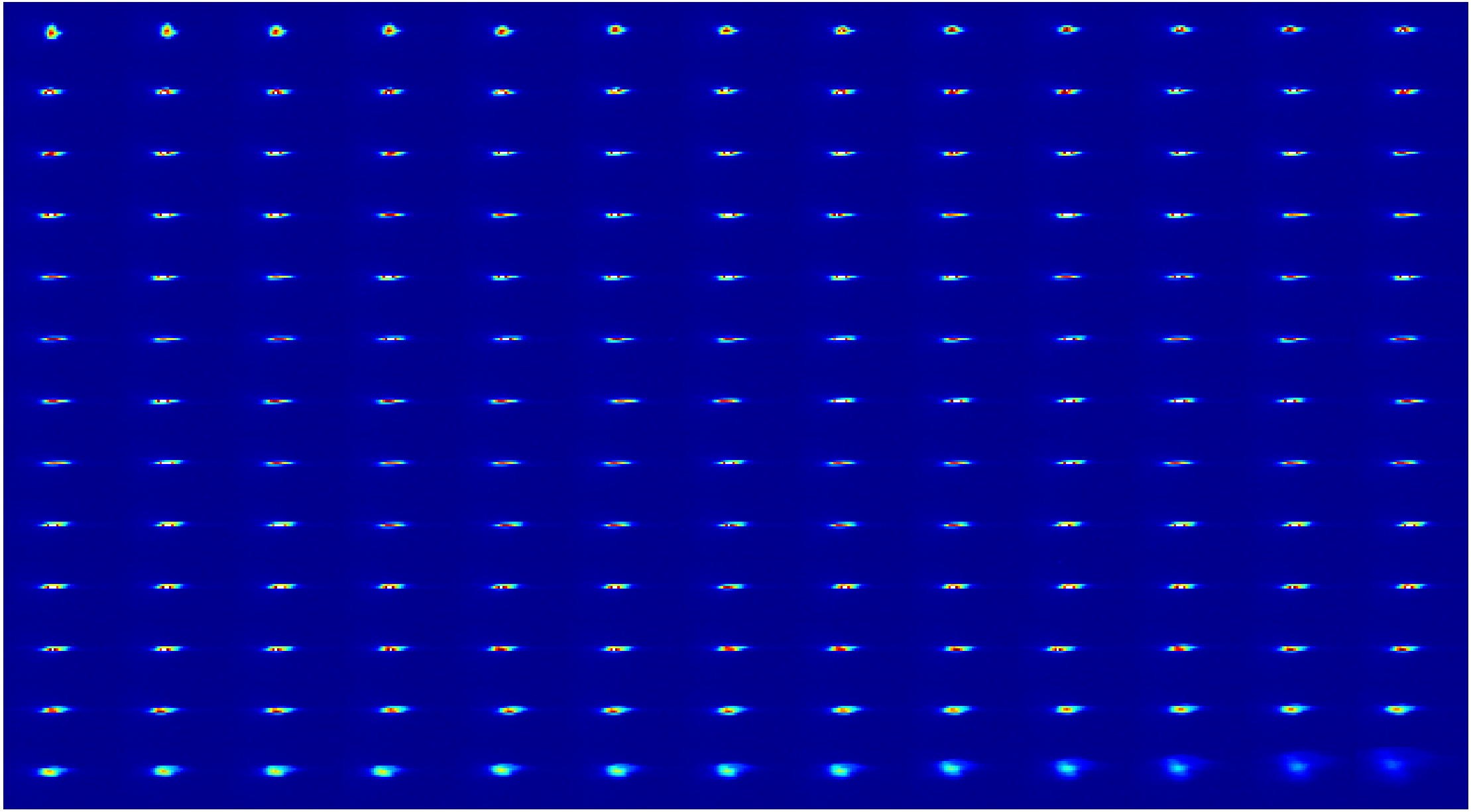
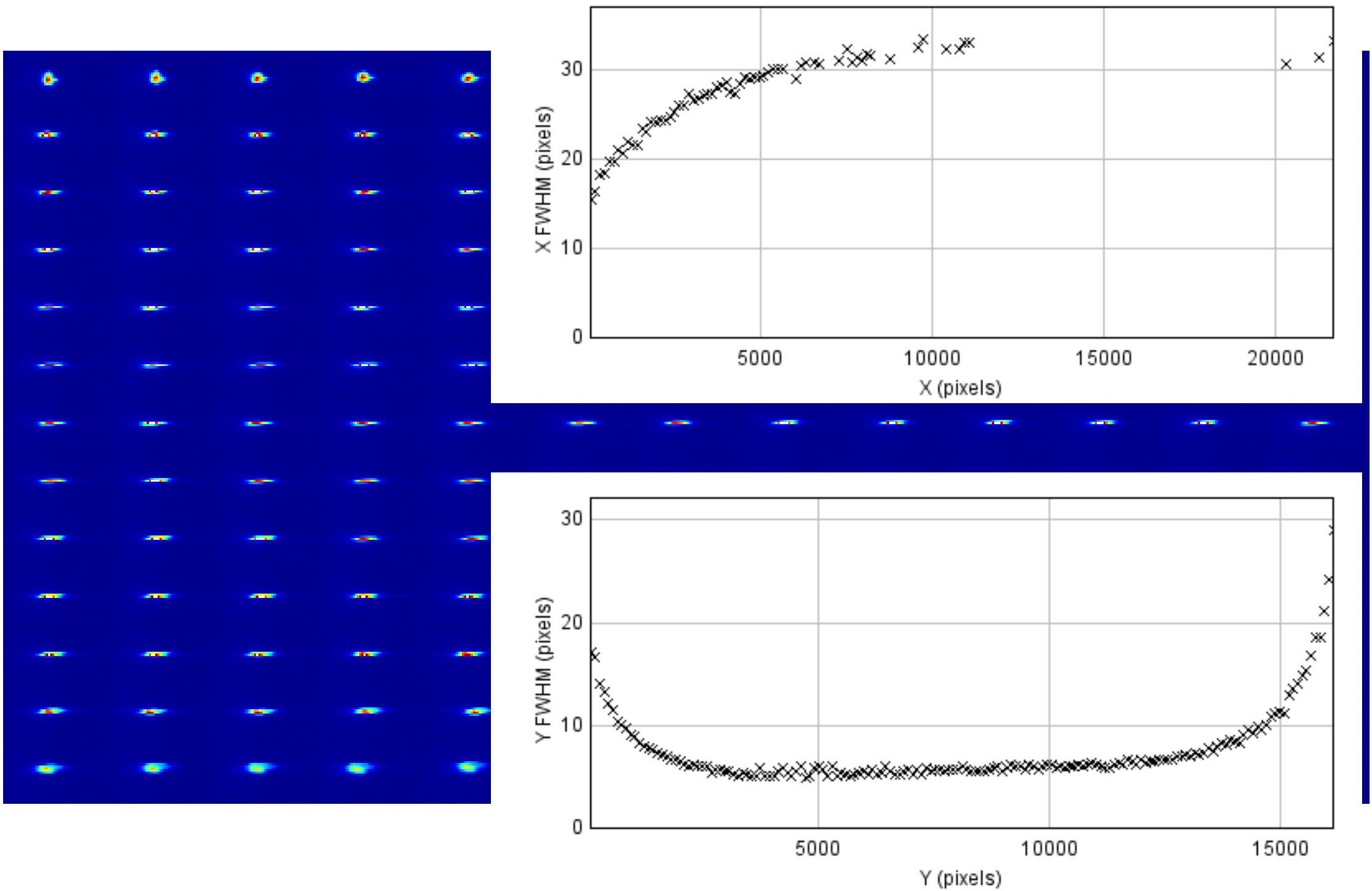
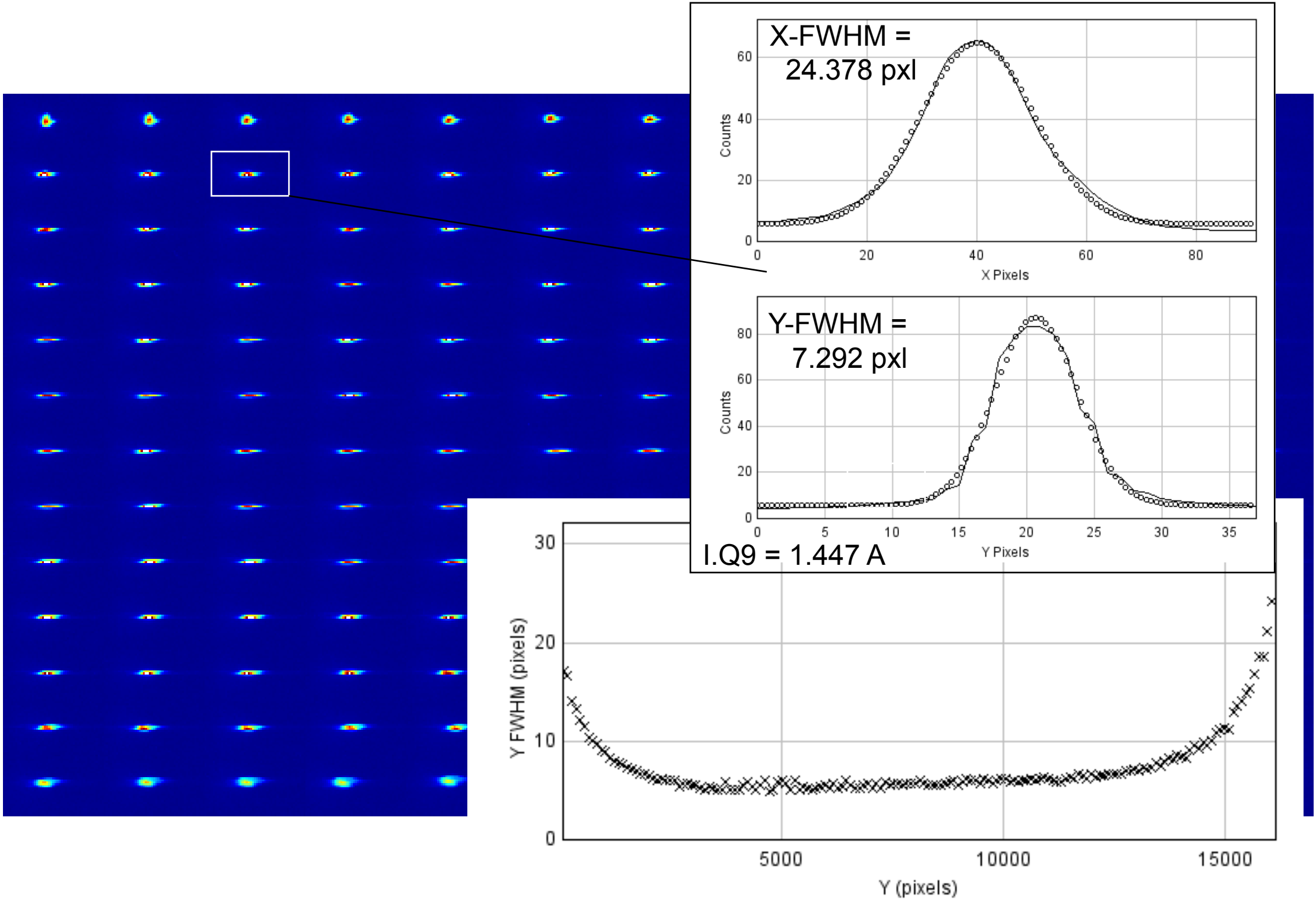
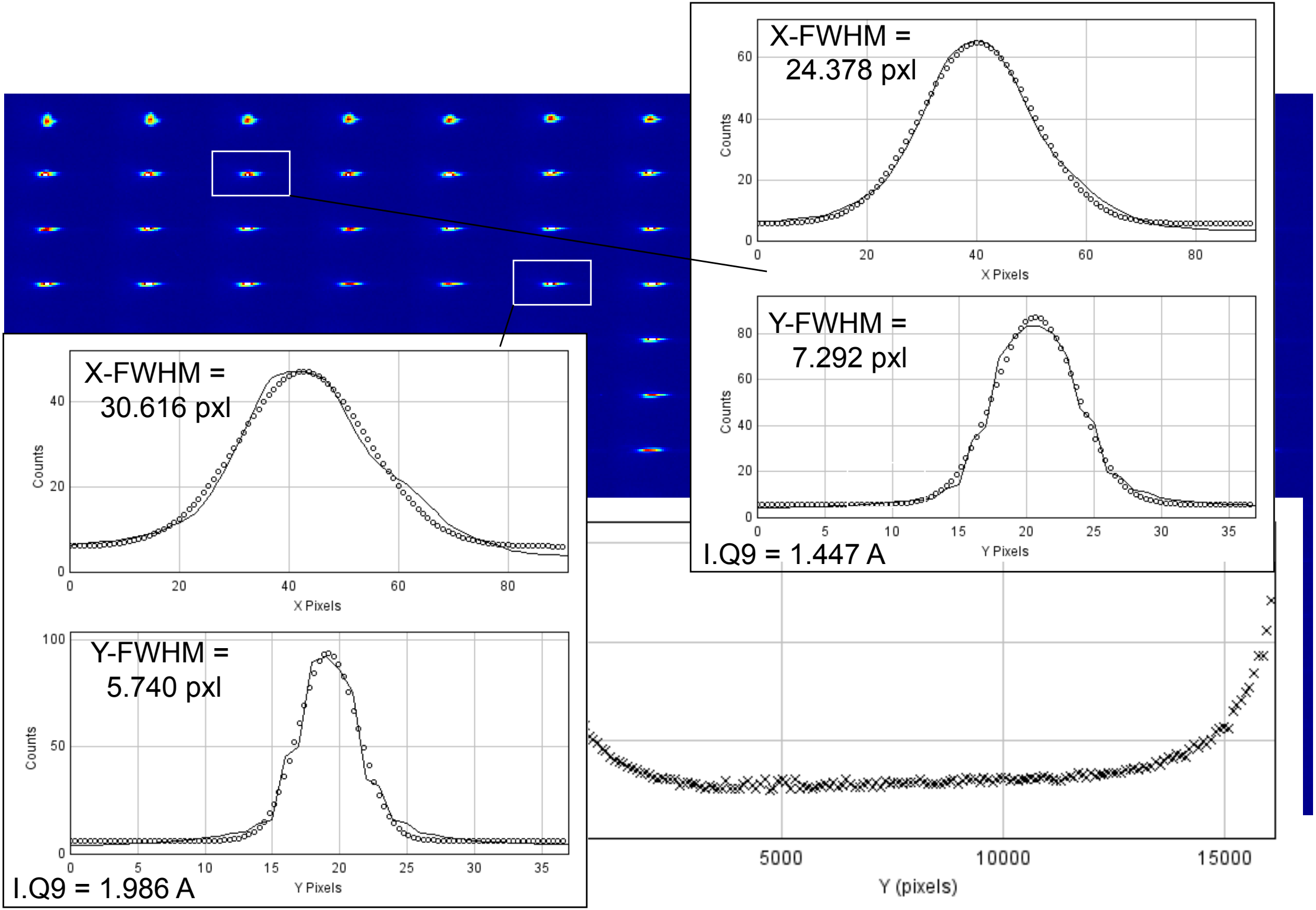


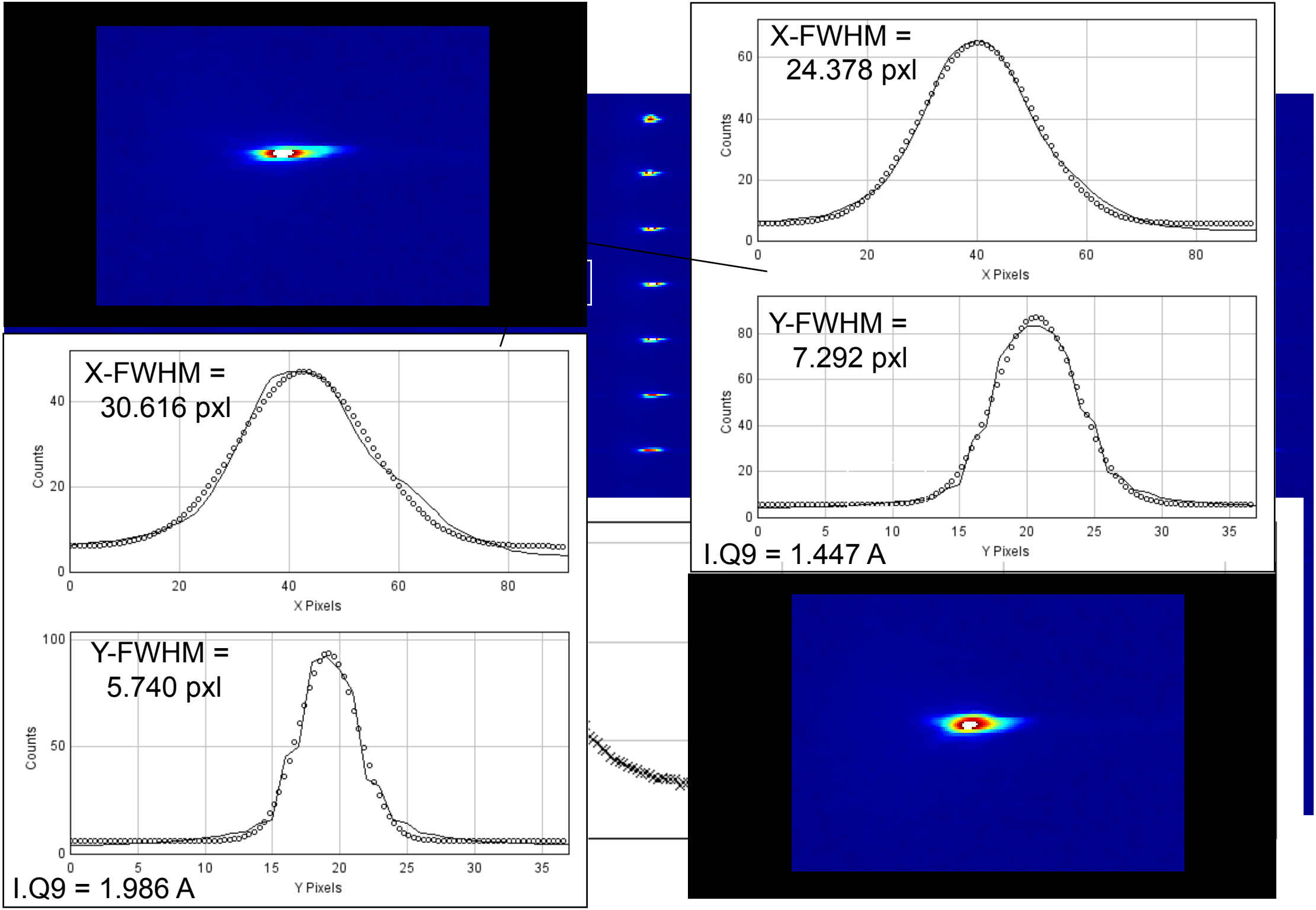




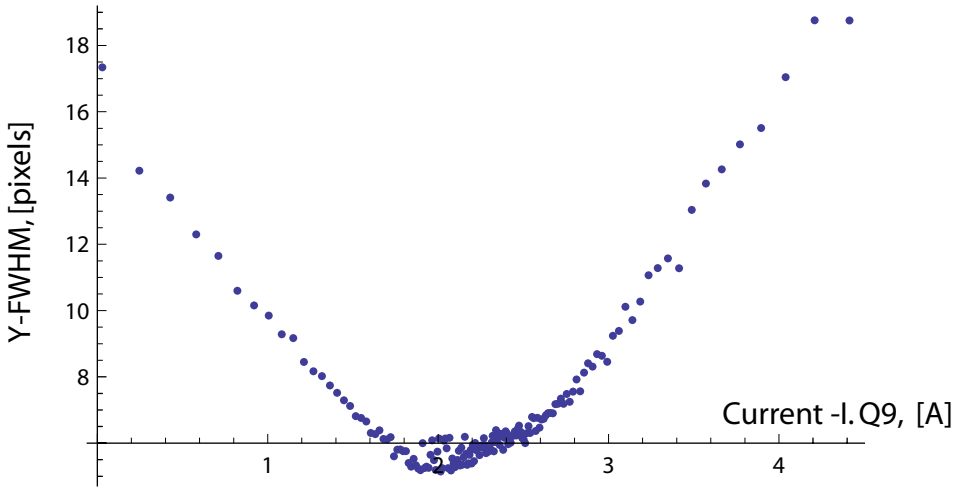

X FWHM (pixels)
0
10
20
30
5000
10000
15000
20000
X (pixels)
Y FWHM (pixels)
0
10
20
30
5000
10000
15000
Y (pixels)


X-FWHM =
24.378 pxl
Counts
X Pixels
Y-FWHM =
7.292 pxl
Counts
Y Pixels
I.Q9 = 1.447 A
Y FWHM (pixels)
Y (pixels)


X-FWHM =
24.378 pxl
Counts
X Pixels
Y-FWHM =
7.292 pxl
Counts
Y Pixels
I.Q9 = 1.447 A
X-FWHM =
30.616 pxl
Counts
X Pixels
Y-FWHM =
5.740 pxl
Counts
Y Pixels
I.Q9 = 1.986 A
5000
10000
15000
Y (pixels)


X-FWHM =
24.378 pxl
Counts
X Pixels
Y-FWHM =
7.292 pxl
Counts
Y Pixels
I.Q9 = 1.447 A
X-FWHM =
30.616 pxl
Counts
X Pixels
Y-FWHM =
5.740 pxl
Counts
Y Pixels
I.Q9 = 1.986 A

Q9 QUADRUPOLE SCAN



Q9 scanned, Q8 off, YAG-03 used

Calibration factor for YAG-03;

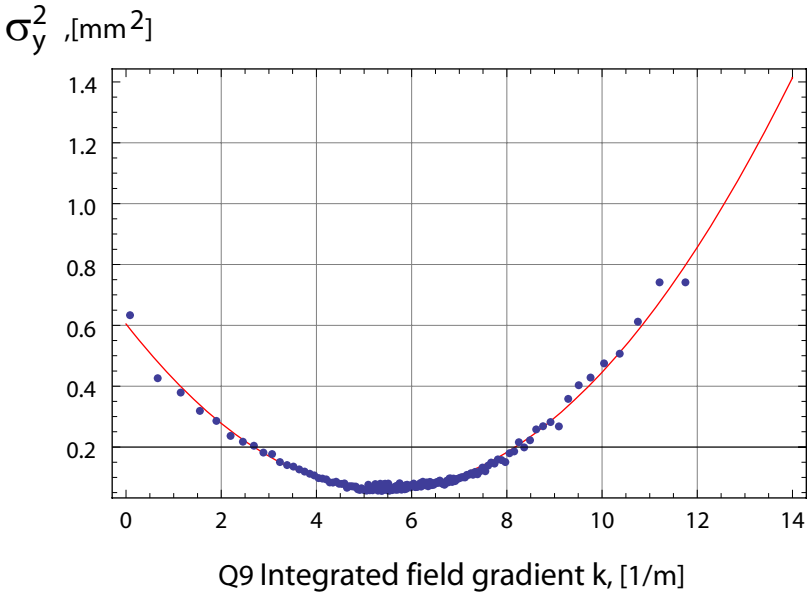
Horizontal: 0.0764 mm/pxl
Vertical: 0.1081 mm/pxl

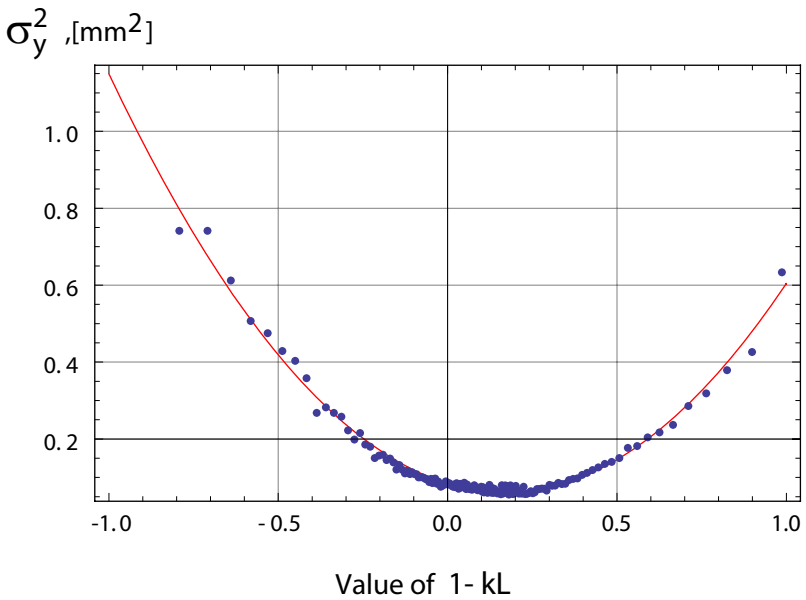
σ = FWHM /2.355

k = (1.5862*I.Q9 + 0.0045)*0.07 / (0.012511/0.29979)

Beam charge: 20pC

Data fit: 0.0842 - 0.2725 (1-kL) + 0.7926 (1-kL)^2





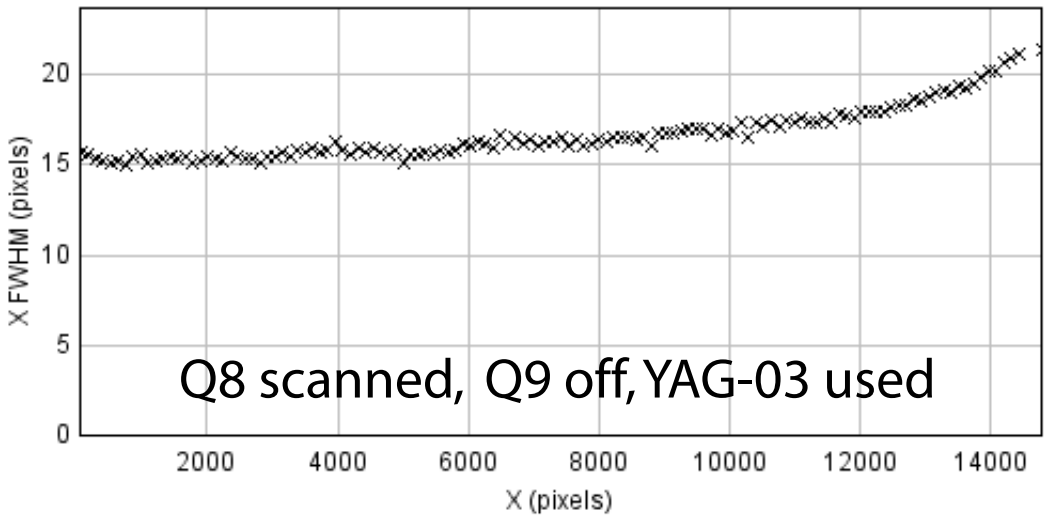
$\varepsilon_y =$ 1.439 mm.mrad

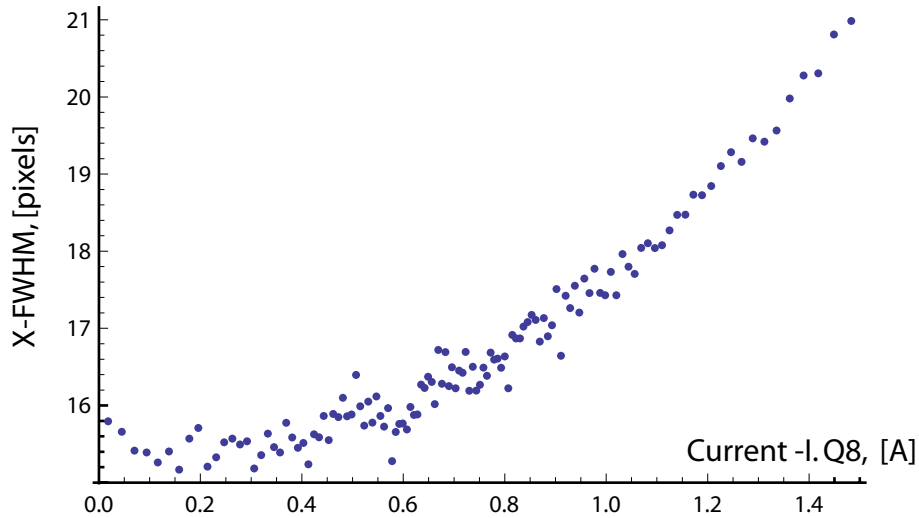
at Q9

$\beta_y = 0.55$ m

$\alpha_y = 0.62$

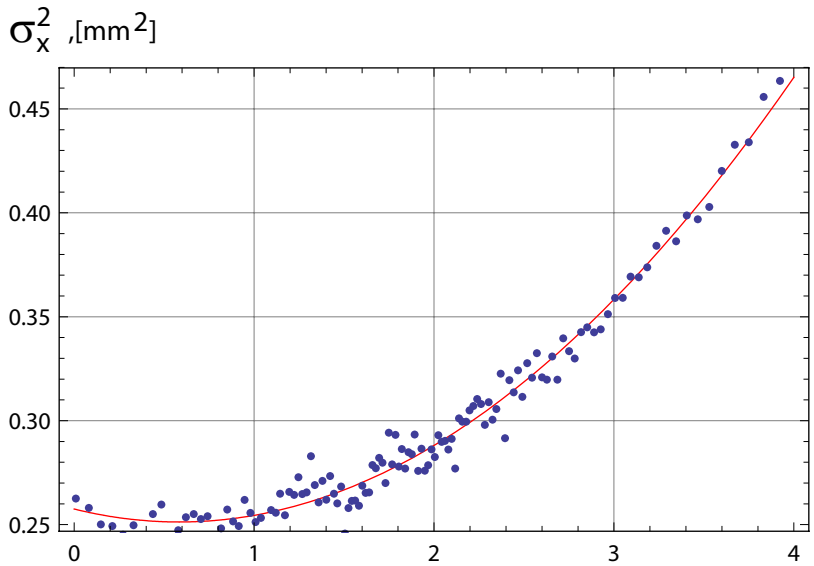
Q8 QUADRUPOLE SCAN



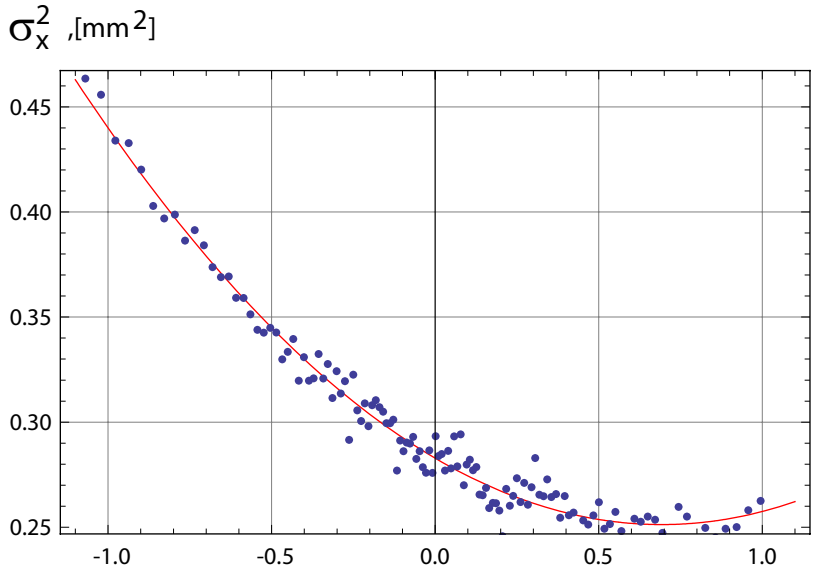


Beam charge: 20pC

Data fit: 0.2828 - 0.0912 (1-kL) + 0.0658 (1-kL)^2



Q8 Integrated field gradient k, [1/m]



Value of 1- kL

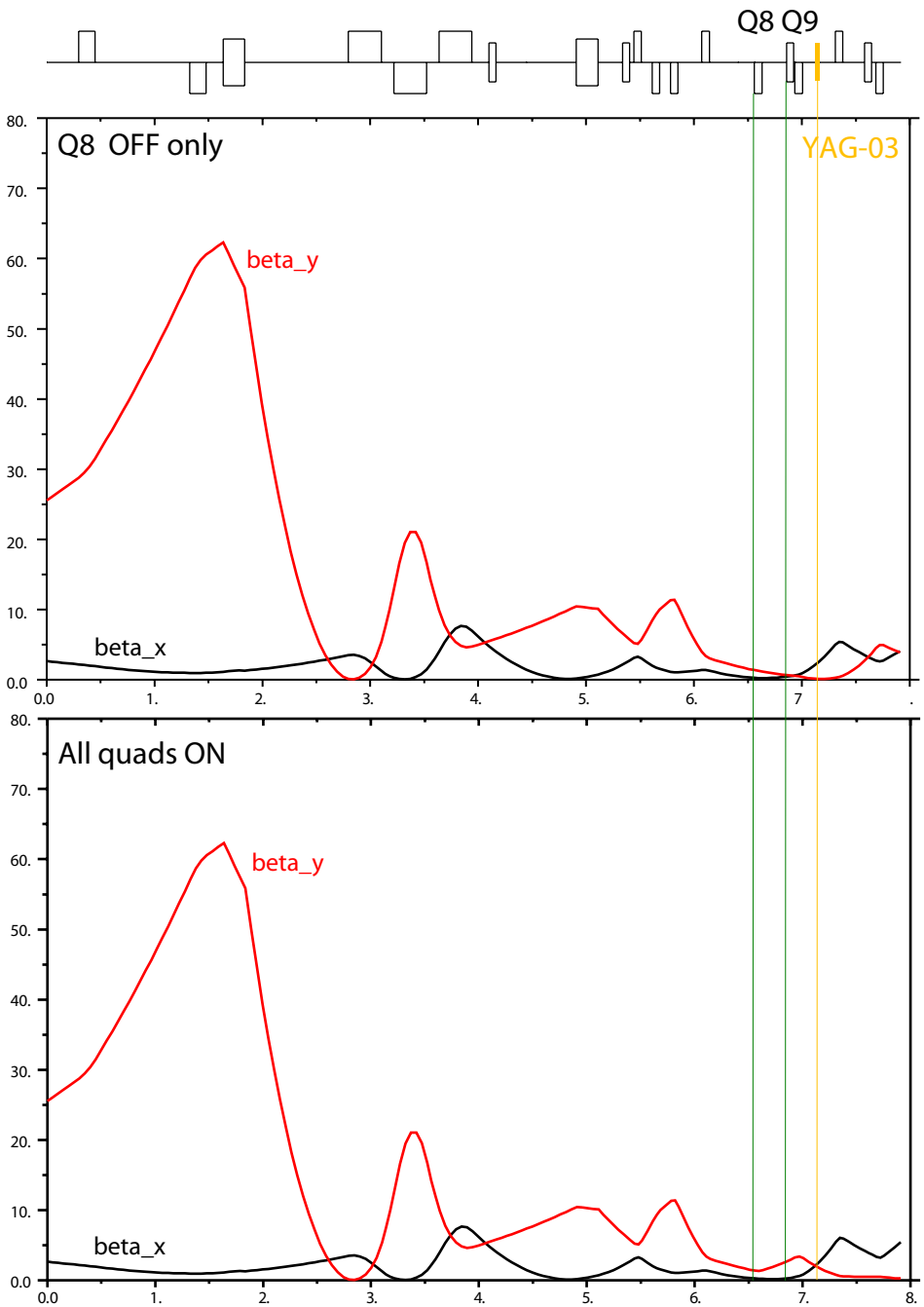
$\varepsilon_x =$ 0.244 mm.mrad

at Q8

$\beta_x = 0.27$ m

$\alpha_x = 0.3545$

LATTICE OF THE INJECTION BEAM LINE



EMMA Injection Line Status .snap file

27/02/11 00:47:29

ST1-Q-01 **0.110**		Q-02 **0.100**	VHCOR-02 **-0.200/-4.000**			ST1-DIP-01 **12.300**			ST1-DIP-02 **12.200**			ST1-DIP-03 **12.200**			ST1-DIP-04 **3.800**		
Q-01 **22.200**	Q-02 **26.000**	Q-03 **22.200**	Q-04 **1.300**	Q-05 **0.400**	Q-06 **0.880**	Q-07 **0.860**	Q-08 **1.050**	Q-09 **1.050**	Q-10 **1.050**	Q-11 **1.050**	Q-12 **0.660**	Q-13 **13.400**	Q-14 **7.300**	Q-15 **1.270**	Q-16 **3.040**	Q-17 **2.020**	Q-18 **1.830**
DIP-01 **3.080**		DIP-02 **3.340**		DIP-03 **3.330**		VHCOR-01 **0.600/3.900**			VHCOR-02 **0.500/-1.600**			VHCOR-03 **-0.100/1.300**		VHCOR-04 **-3.000/0.000**		VC-05 **0.200**	VC-06 **2.200**

Current of dipoles and quads from LogFile

Convert the current to magnetic field

at Q8

$\beta_x = 0.27$

$\alpha_x = 0.3545$

at Q9

$\beta_y = 0.55$

$\alpha_y = 0.62$

Twiss parameters at the beginning of Q8 and Q9 calculated from the quad scan

MAD8

Fitting of Twiss parameters at the beginning of the injection beam line to obtain

beta_x = 2.6636, beta_y = 25.5374,

alfa_x = 0.9005, alfa_y = -5.3158

CONCLUSION AND FUTURE PLANS

The results of quad scan are based on the image collection obtain in ALICE shift 27.02.2011.

Fast image data processing and effective nose reduction can be implemented for a big number of images.

Twiss parameters, vertical and horizontal emittance have been calculated at the beginning of quadrupoles Q8 and Q9 by using quadrupole scan technique.

Initial Twiss parameters and lattice functions through the injection beam line have been reconstructed from the results of the quad scan.

- Process image collections obtained in ALICE shifts 17.02.2011, 9.03.2011.
- Compare results calculated by quad scan technique and tomography method.
- Try to use "single slit" for emittance measurement in future shifts.