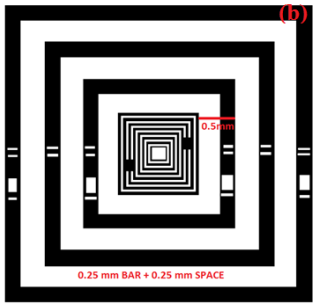
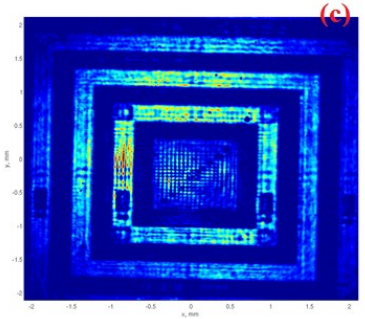
Electron beam imaging studies (Q. Zhao)

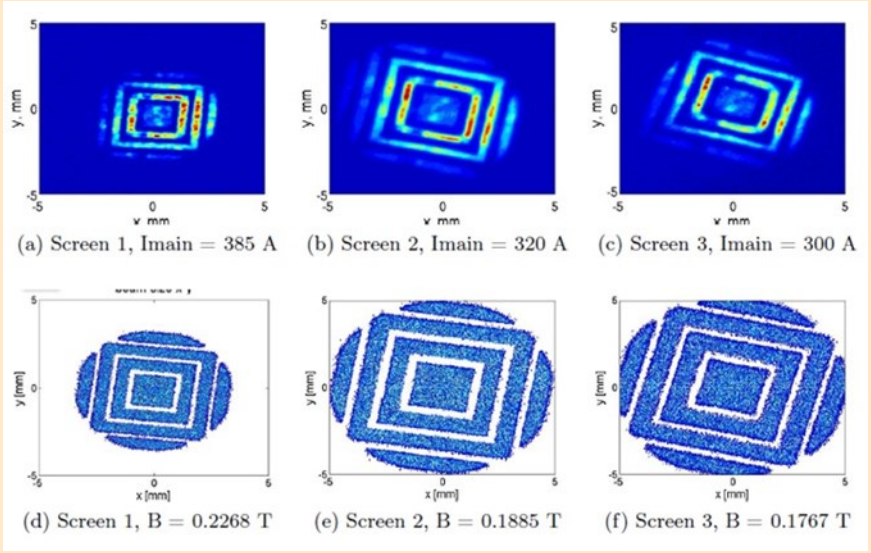
Main idea: beam dynamics w/o space charge to confirm RF gun + solenoid electron optics, e.g. the main solenoid calibration: $B_{z,main}[T]=5.889\times10^{-4}*I_{main}[A]+7.102\times10^{-5}$

Tools: grid at the BSA location → to be imaged onto the cathode, then electron image at LOW.Scr1,2,3 for various RF peak power level (E_{cath}) by I_{main} tuning.

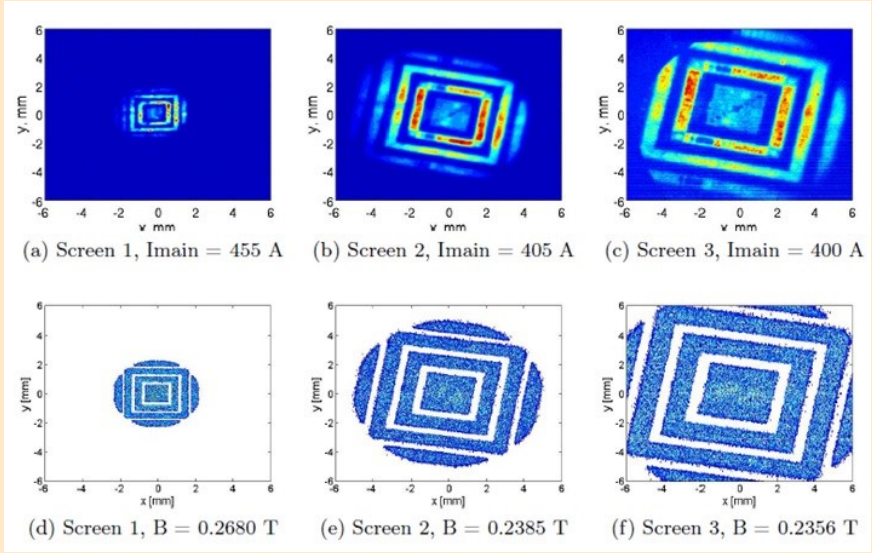




P_{gun}=3MW (42.5MV/m → 4.84MeV/c)



P_{gun}=5MW (54.4MV/m → 6.07MeV/c)



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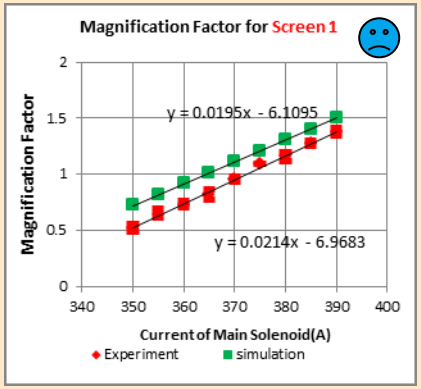
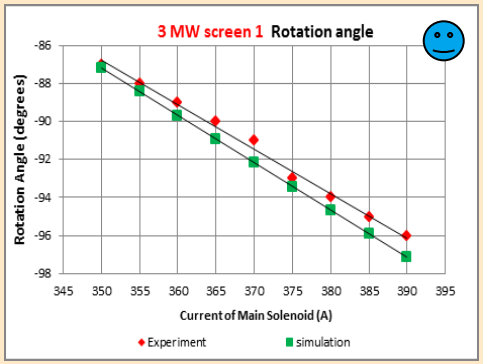
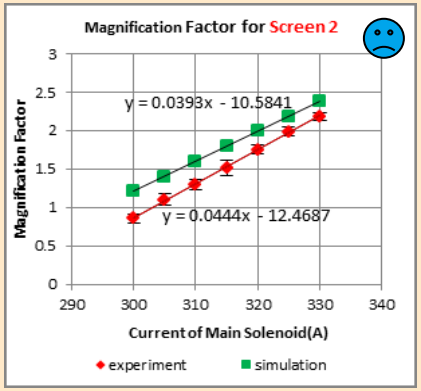
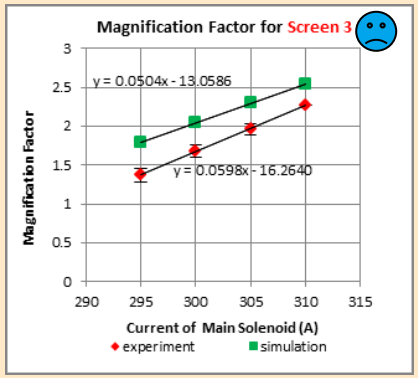
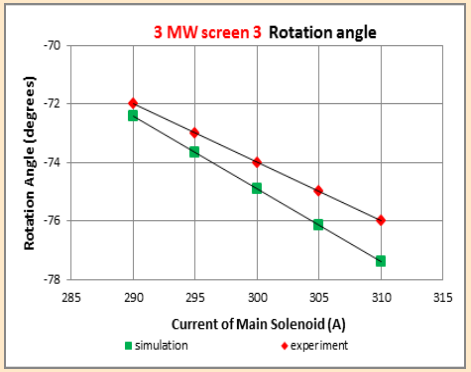






- Measurement-simulation discrepancy in magnification factor for **ALL** screens (resolution?)





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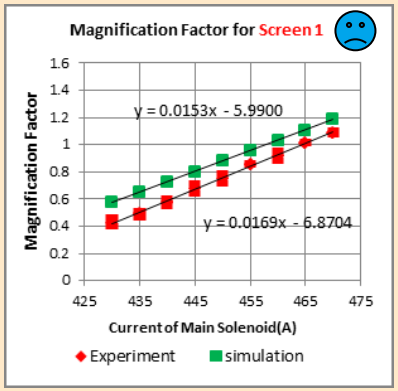
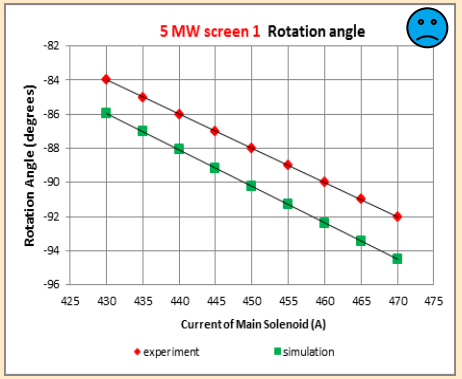
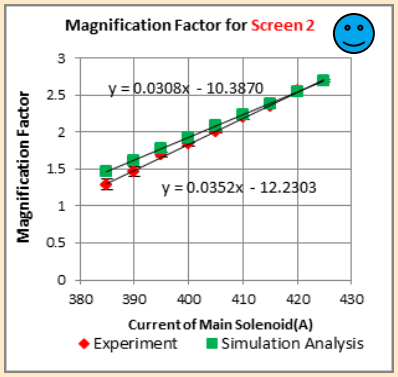
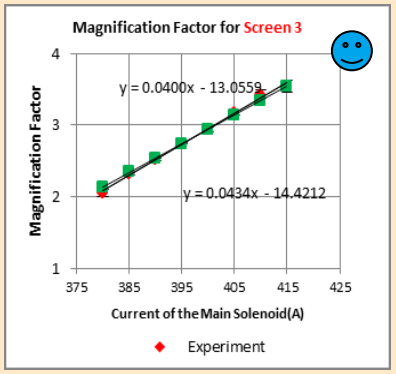
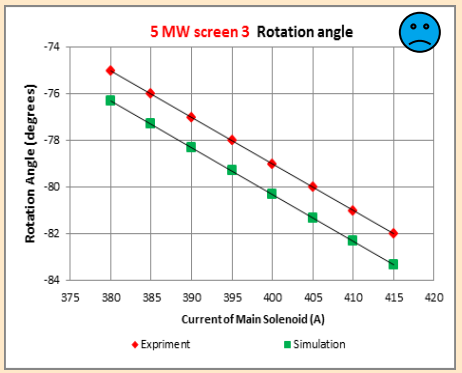






- Measurement-simulation discrepancy in magnification factor for **LOW.Scr1 only**

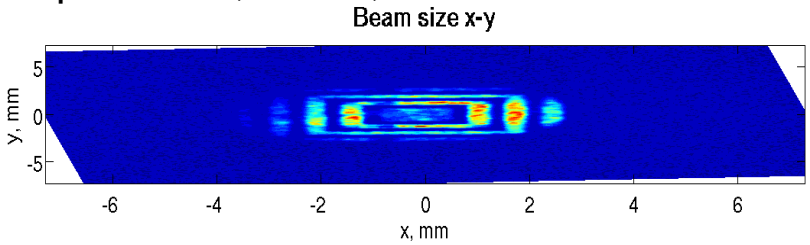


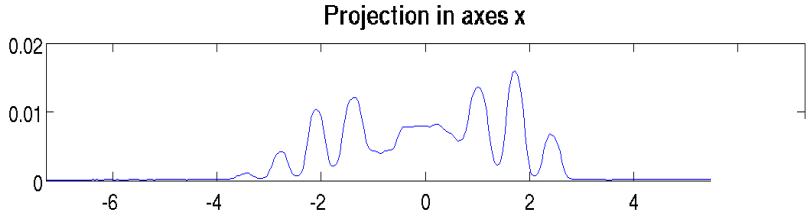


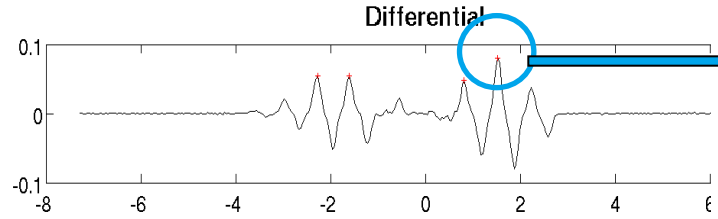
The discrepancy is still to be understood

Resolution analysis

Example: 3MW, 390A, scr1



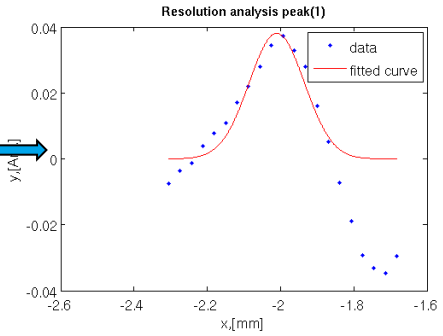


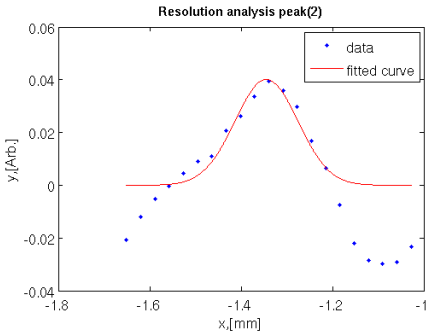


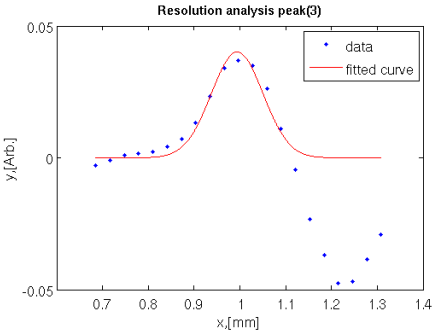
$$f(x) = a\exp\left(-\frac{(x-b)^2}{2c^2}\right)$$

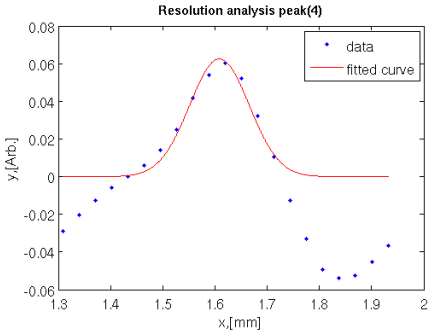
a = 0.08385
b = 1.532
c = 0.09215

c/MF ---- object plane resolution

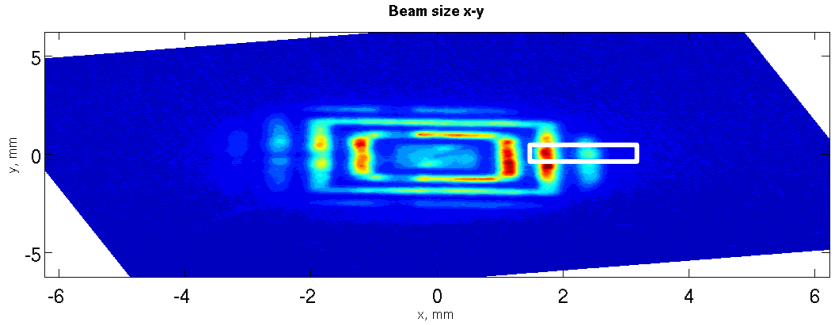


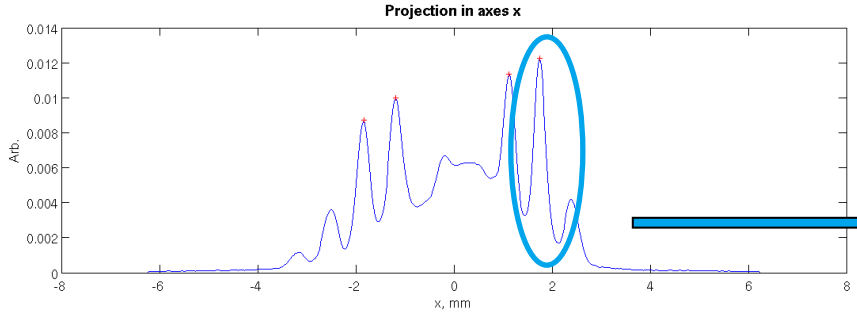


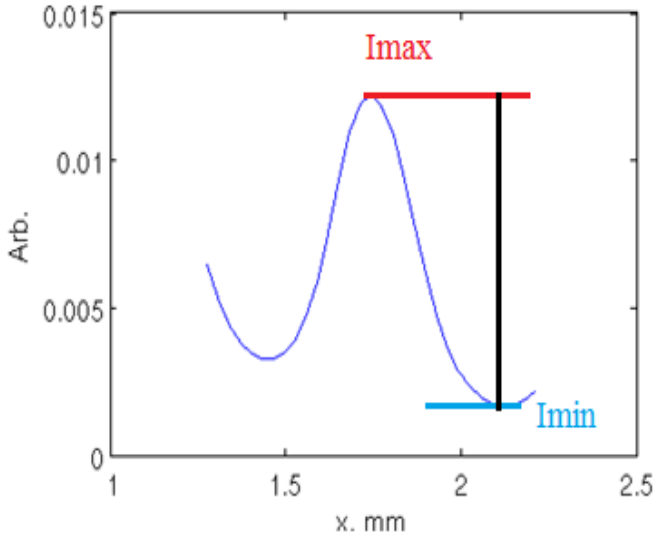




Contrast

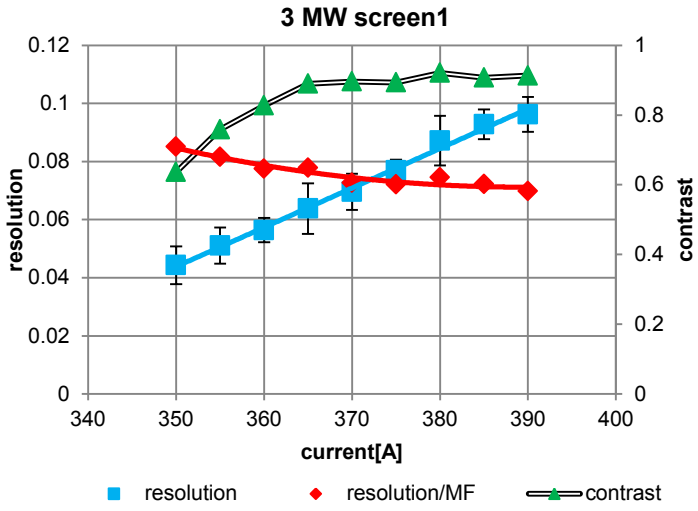


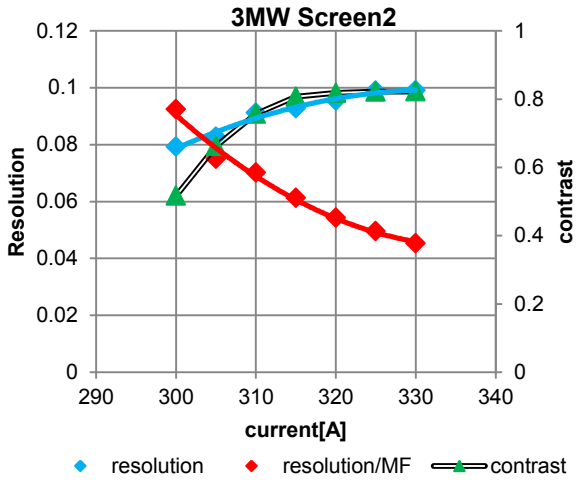


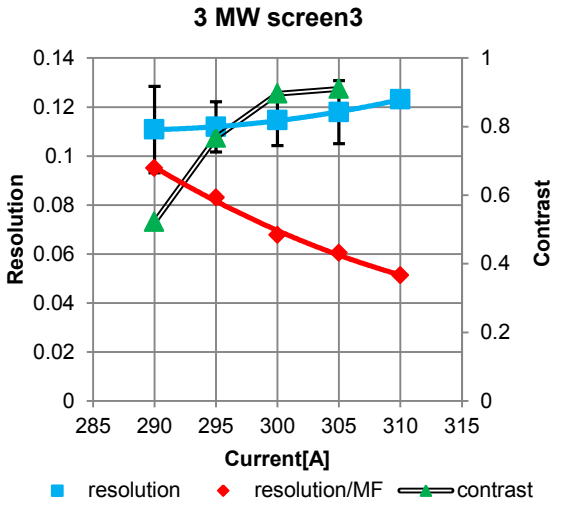


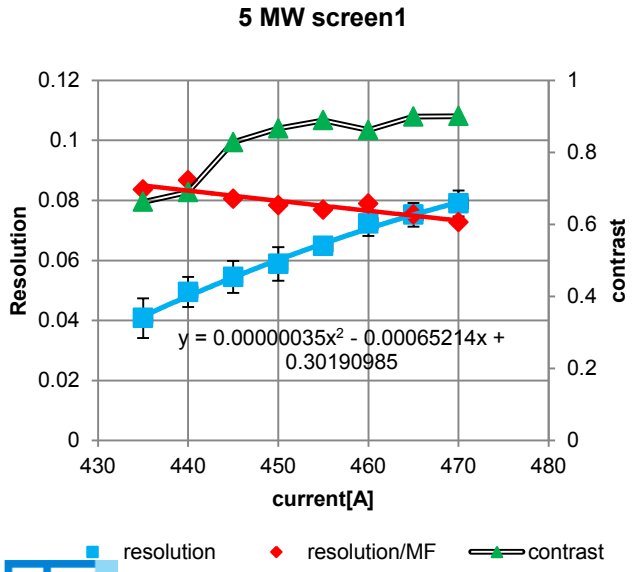
Contrast= (Imax-Imin) / (Imax+Imin)

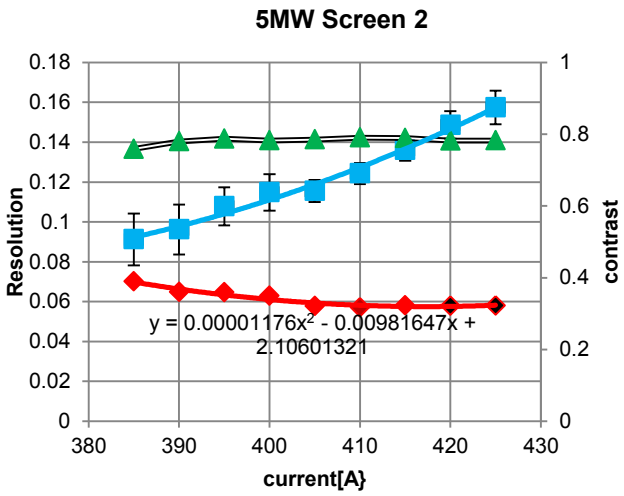
Resolution and Contrast analysis results

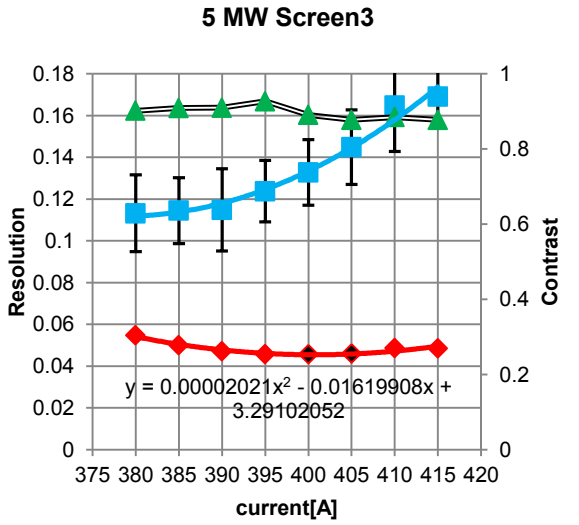




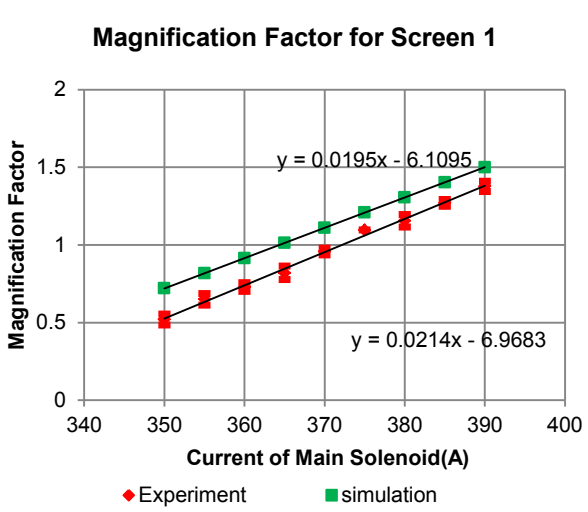


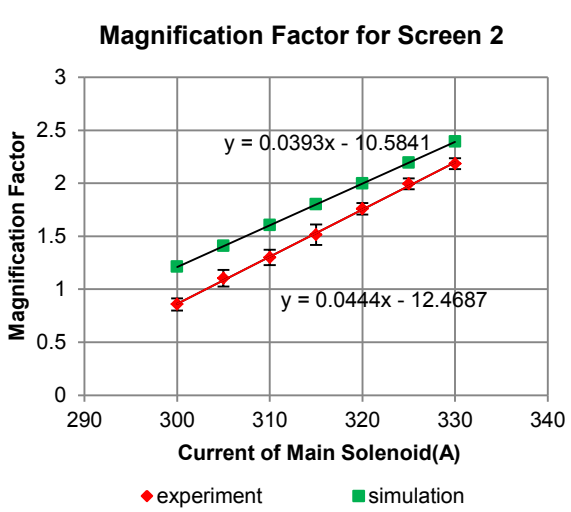


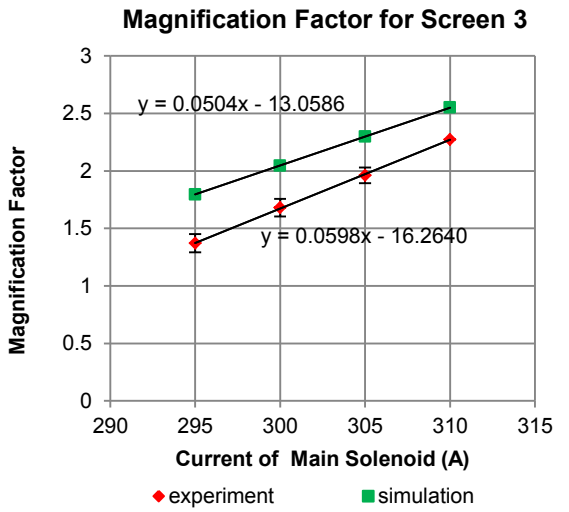


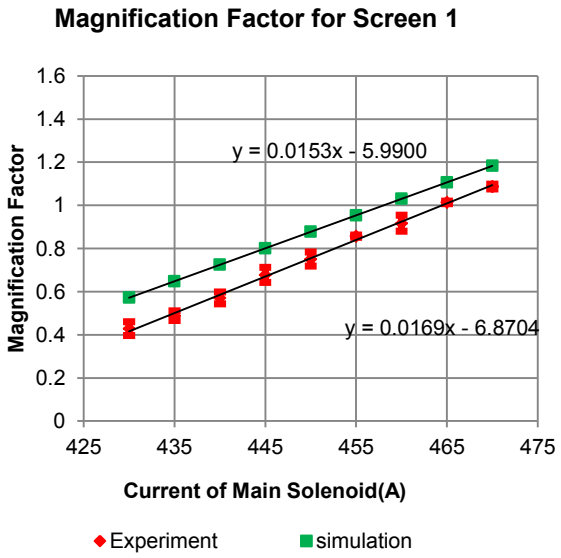


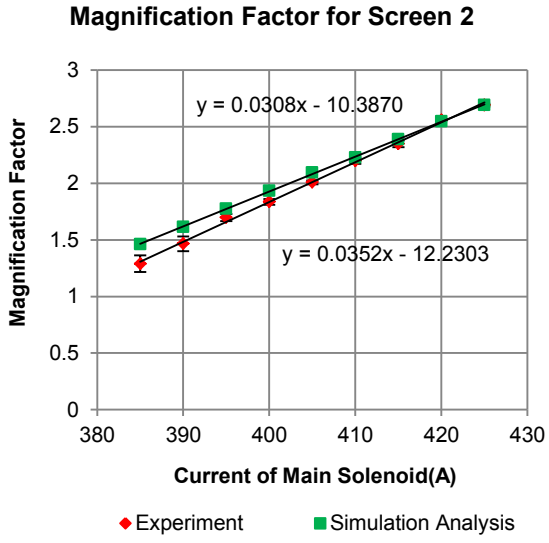
Magnification factor

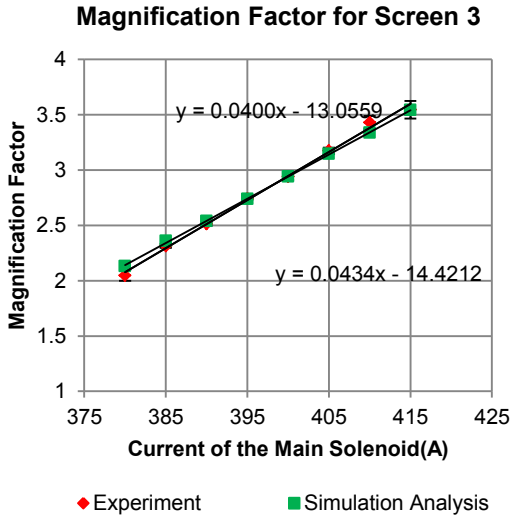




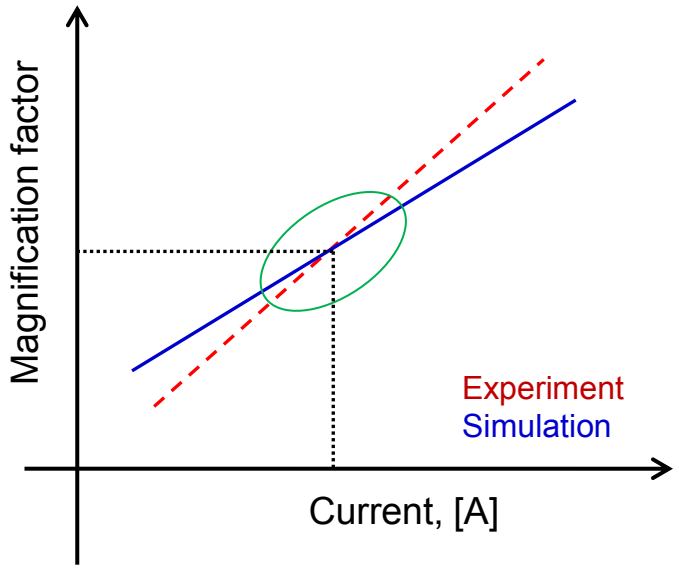








Conditions for best image on different cases



Point to point image, from first order beam optics:

$$X_{image} = R_{11}X_{object} + R_{12}X'_{object}$$

$$Y_{image} = R_{33}Y_{object} + R_{34}X'_{object}$$

$$R_{12} = R_{34} = 0$$

If the image is achieved with best conditions, The magnification from experiment would be Same with simulation (from rms beam size).

R_{12}=0

$$\frac{X_{rms\_image}}{X_{rms\_object}} = R_{11} = M = \frac{X_{image}}{X_{object}}$$

5 MW in the gun		
screen	MF	Solenoid current
1	2.43	550.3 A
2	2.52	418.9A
3	2.96	400.4 A

The calibration of solenoid seems correct.

3 MW in the gun		
screen	MF	Solenoid current
1	2.7	452.0 A
2	3.93	369.5 A
3	4.13	341 A

Another experiment should be taken for 3 MW in the gun to prove.