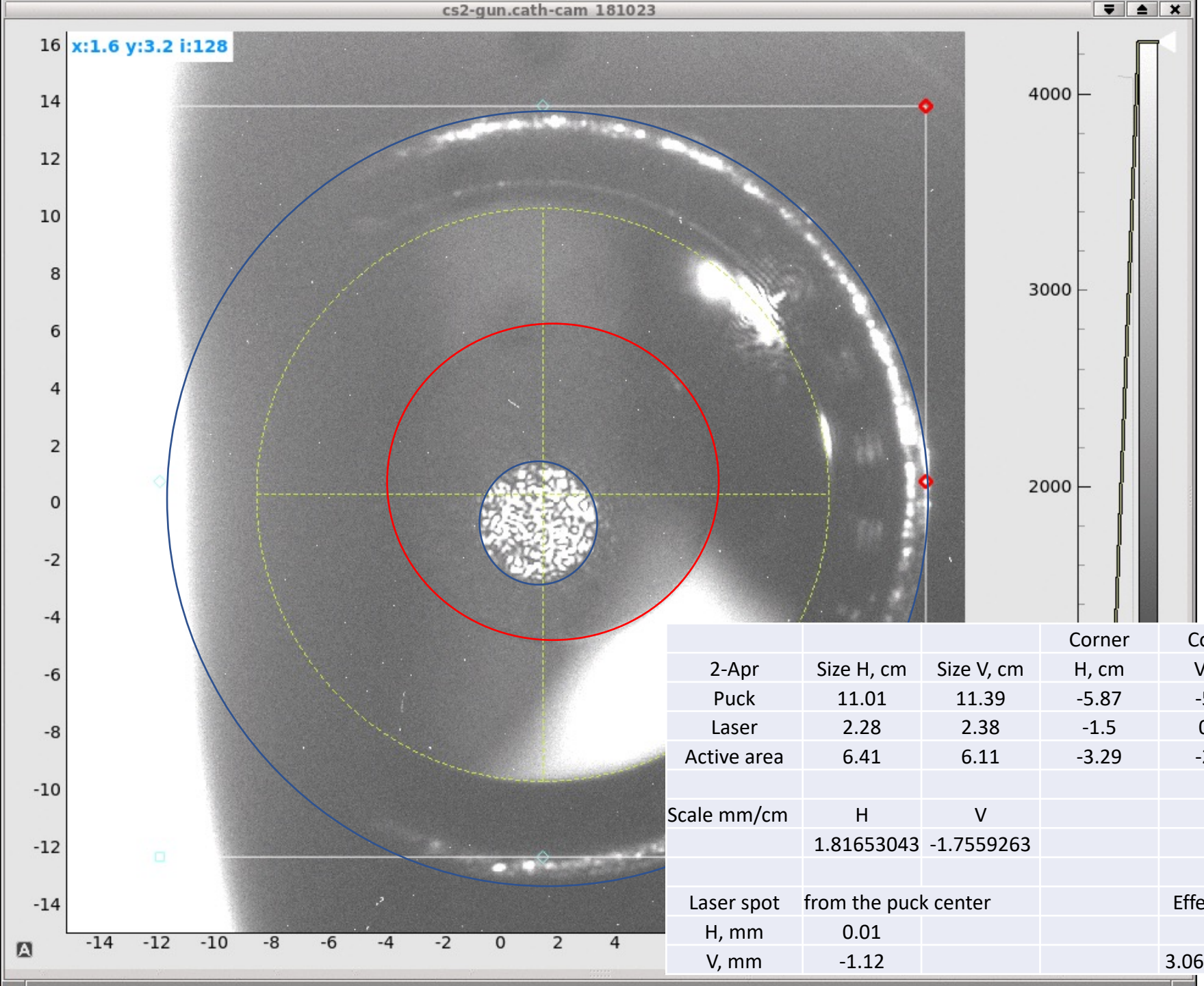
# Cathode and SRF gun axis

VL – analysis of data collected by G. Wang and I. Petrushina

July 5, 2022




April 2
Controls
H=0
V=-1000

Indeed, we had laser spot down by 1.1 mm, which gave us extra 3 mrad vertical kick!

| | | | Corner | Corner | Center | Center | Center | Center |
|---|---|---|---|---|---|---|---|---|
| 2-Apr | Size H, cm | Size V, cm | H, cm | V, cm | H, cm | V, cm | H, mm | V, cm |
| Puck | 11.01 | 11.39 | -5.87 | -5.12 | -0.365 | 0.575 | -0.66 | -1.01 |
| Laser | 2.28 | 2.38 | -1.5 | 0.02 | -0.36 | 1.21 | -0.65 | -2.12 |
| Active area | 6.41 | 6.11 | -3.29 | -2.64 | -0.085 | 0.415 | -0.15 | -0.73 |
| | | | | | | | | |
| Scale mm/cm | H | V | | | | | | |
| | 1.81653043 | -1.7559263 | | | | | | |
| | | | | | | | | |
| Laser spot | from the puck center | | | Effect of V | | | | |
| H, mm | 0.01 | | | | | | | |
| V, mm | -1.12 | | | 3.06315936 | | | | |

# Gang's measurement, April 17 using gun solenoids

$$\Phi = \frac{1}{2}\sum_i \left(x_i - x_0 - a\cdot H_i - b\cdot V_i\right)^2$$

$$\begin{bmatrix} \sum_i H_i^2 & \sum_i H_i V_i \\ \sum_i H_i V_i & \sum_i V_i^2 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} \sum_i H_i\left(x_i - x_{0i}\right) \\ \sum_i V_i\left(x_i - x_{0i}\right) \end{bmatrix}$$

| Laser | | xo, mm | y0, mm | x'0, mrad | y'0, mrad |
|---|---|---|---|---|---|
| 0 | 0 | -7.523 | 4.310 | -13.017 | 7.420 |
| | sigma | 0.06 | 0.03 | 0.06 | 0.06 |
| H, mm | V, mm | x, mm | y, mm | x', mrad | y', mrad |
| 0 | 0 | -7.55 | 4.34 | -13.05 | 7.48 |
| 0 | 0 | -7.45 | 4.29 | -12.95 | 7.36 |
| 0 | 0 | -7.57 | 4.3 | -13.05 | 7.42 |
| 0 | 2 | -7.34 | 1.94 | -12.86 | 2.17 |
| 2 | 2 | -9.61 | 1.62 | -18.25 | 1.31 |
| 2 | 2 | -9.65 | 1.49 | -18.2 | 1.2 |
| -2 | 2 | -4.51 | 1.97 | -6.91 | 2.61 |
| -4 | 2 | -1.6 | 2.26 | -0.53 | 2.94 |
| -4 | 3 | -1.34 | 0.9 | -0.226 | 0.15 |
| -4.5 | 3 | -0.54 | 0.91 | 1.58 | 0.11 |

| M | 60.25 | -33.5 | | 1 | 0 |
|---|---|---|---|---|---|
| | -33.5 | 34 | | 0 | 1 |
| det | 926.25 | | | | |
| x | 0.03670715 | 0.03616734 | -90.091667 | a | -1.371 |
| | 0.03616734 | 0.06504723 | 53.5266667 | b | 0.223 |
| | | | | | |
| y | 0.03670715 | 0.03616734 | 36.31 | a | -0.094 |
| | 0.03616734 | 0.06504723 | -39.46 | b | -1.254 |
| | | | | | |
| x' | 0.03670715 | 0.03616734 | -189.42433 | a | -3.002 |
| | 0.03616734 | 0.06504723 | 109.245333 | b | 0.255 |
| | | | | | |
| y' | 0.03670715 | 0.03616734 | 77.185 | a | -0.246 |
| | 0.03616734 | 0.06504723 | -85.15 | b | -2.747 |

Note - horizontally +1000 in steps is -1 mm in CeC accelerator coordinates. We looking upstream to the cathode and this changes sign of X

$$\begin{bmatrix} x - x_o \\ y - y_o \end{bmatrix} \cong \begin{bmatrix} -1.4 & -0.1 \\ 0.2 & -1.3 \end{bmatrix} \begin{bmatrix} H \\ V \end{bmatrix}$$

$$\begin{bmatrix} x' - x'_o \\ y' - y'_o \end{bmatrix}_{mrad} \cong \begin{bmatrix} -3 & -0.25 \\ 0.25 & -2.75 \end{bmatrix} \begin{bmatrix} H \\ V \end{bmatrix}_{mm}$$

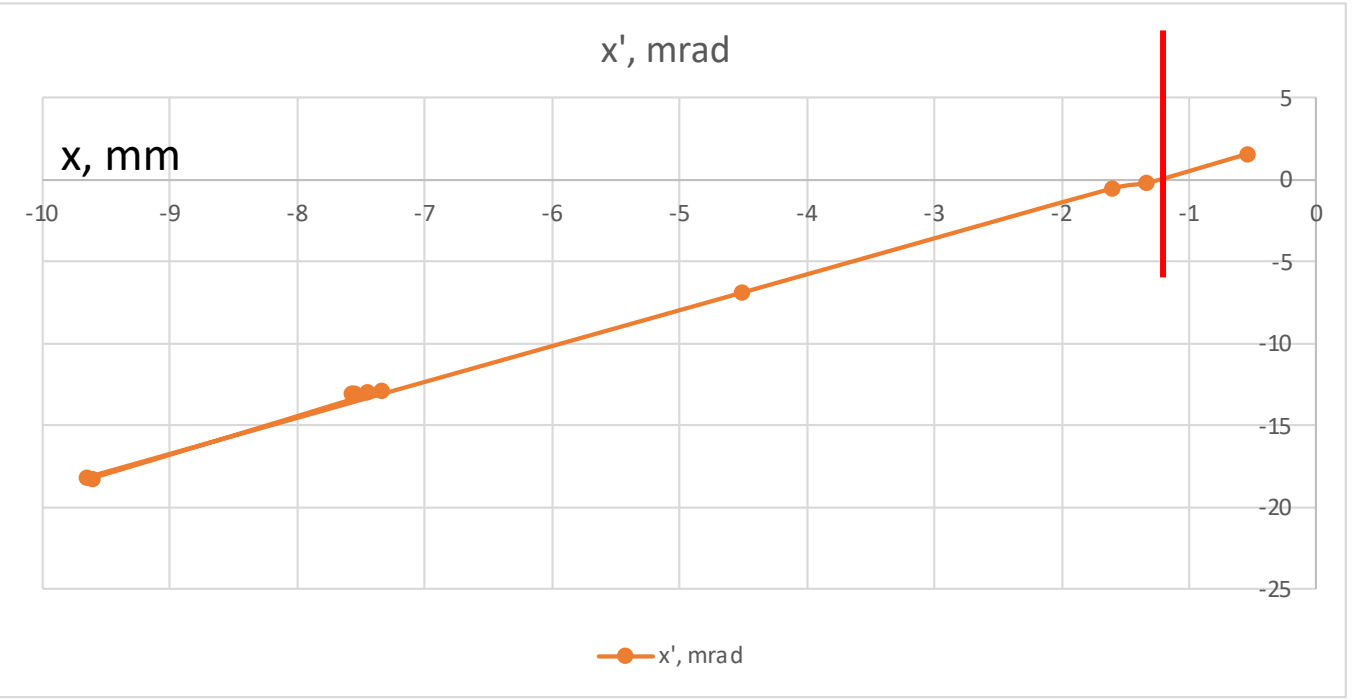
| Position | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -1.371 | -0.094 | det | 1.74 | | | | | |
| 0.223 | -1.254 | | | | | | | |
| Inverse | | | | | | | | |
| -0.7205126 | 0.05421778 | 7.523 | H | -5.65 | | | | |
| -0.1283993 | -0.7880867 | -4.310 | V | 2.43 | | | | |
| Angles | | | | | | | | |
| -3.002 | -0.246 | det | 8.31 | | | | | |
| 0.255 | -2.747 | | | | | | | |
| Inverse | | | | From | actual | | | |
| -0.3305787 | 0.02965099 | 13.017 | H | -4.52 | -4.51 | R | 4.66 | mm |
| -0.0307009 | -0.3612539 | -7.420 | V | 2.28 | 1.17 | Laser | 1.8 | mm |
| | | | | | | Coating, R | 6.46 | mm |

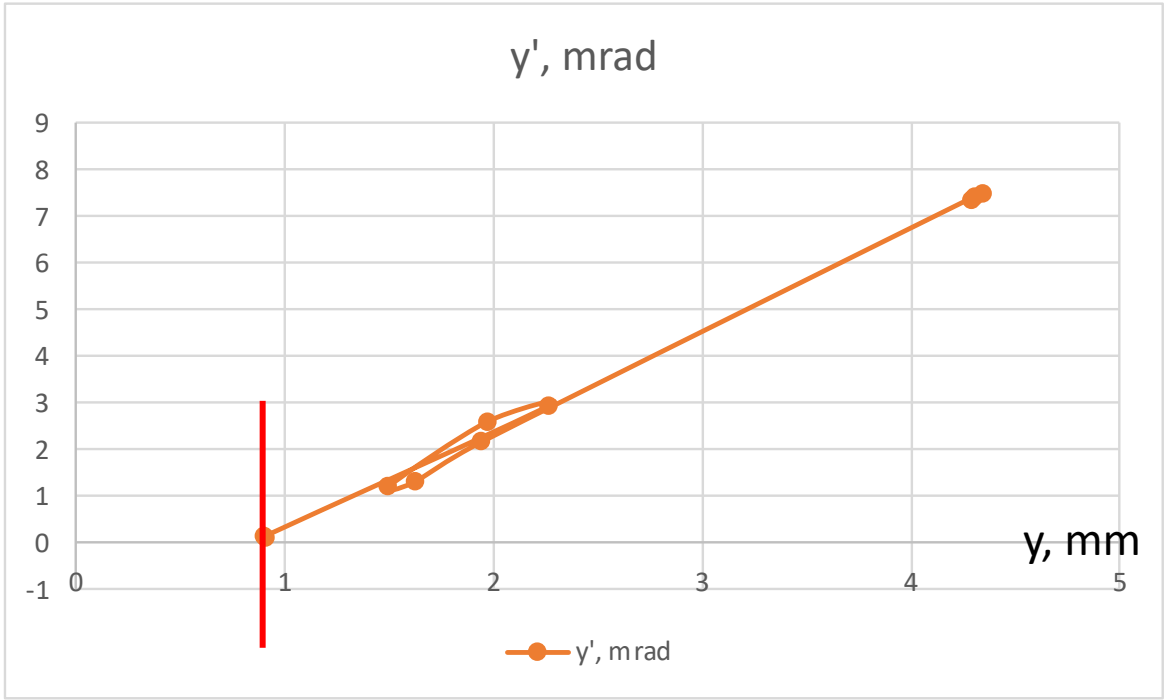
# Irina's measurements on April 15 of the gun axis angles

| mrad | | | actual |
|---|---|---|---|
| -13 | H | -4.49 | -4.48 |
| 6.6 | V | 1.99 | 0.87 |

# Correlation between position and angle in gun solenoid

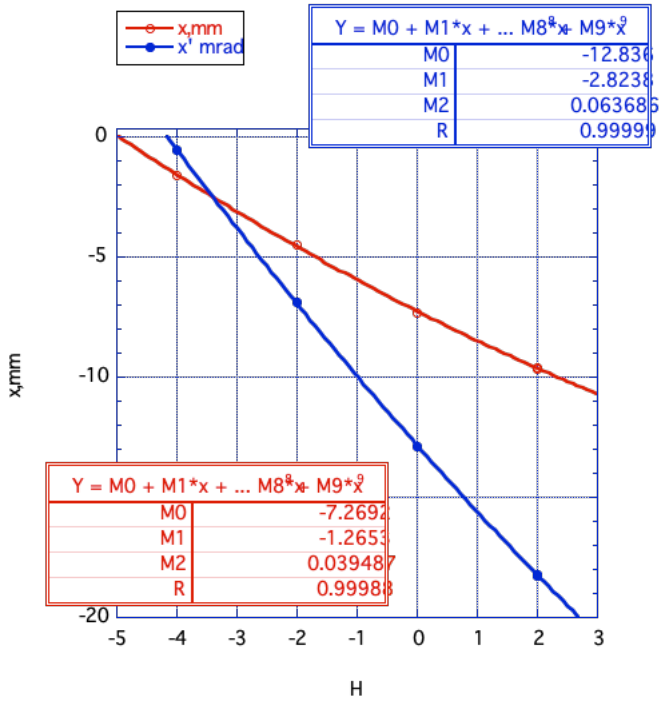
## Compensating the angles will put beam close to solenoids axis



# Concerns

- Astigmatism – horizontal and vertical focusing is already different by 10% (if we believe data)
- There is measurable nonlinearity of the focusing (see graph) – at H=4 mm constitution of the second term contributes~ 2.3% horizontal angle and ~ 3% in horizontal position. Focusing effect is twice this values
- There is also measurable effect on vertical: H= 4 mm reduces dy/dV by 14%, when compared with that at H=0. Unfortunately,  there are very few points with fixed H and varying V
- We should try and see if effect is tollerable




Measured dependence of horizontal position and angle as function of H (laser spot) at V=2 mm

# Conclusion

- Measurements of the gun axis angle using two technique gave similar results: -13 mrad horizontally, +7 mrad vertically
- Gang's measurements also showed that there is displacement correlated with the angle
- Measurements show that moving laser spots generates angles of -3 mrad/mm horizontally and -2.75 mrad/mm vertically – i.e. focusing length of the SRF gun is ~ 33 to 36 cm.
- Coupling y to H and x to V are ~ 10%
- Beam position at the entrance of the gun solenoid correlates well with the angles. It is likely that we compensation of the gun's angle by displacing the laser spot will reduce beam displacement in the gun solenoid to 1 mm or less. It probably can be compensated by moving the gun solenoid.
- We operated laser with spot located 1.1 mm below the puck's center, which resulted in additional 3 mrad vertical angle
- To remove SRF gun's angles we will need 4.5 mm horizontal displacement and 1 mm vertical displacement.
- We need 7 mm radius of the active area, or 10 mm active area shifted by 5 mm