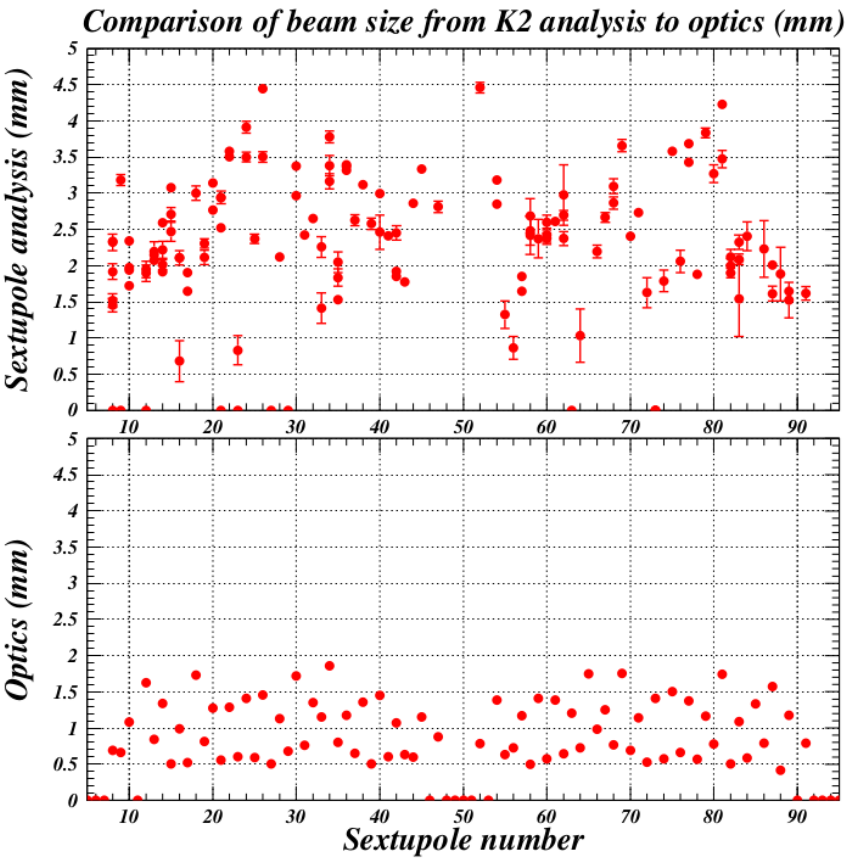
Proposed Resolution of the Beam Size Measurement Puzzle



$$\sigma_X^2 = -2\,\frac{\Delta p_X}{\Delta K_2 L} + Y_0^2 - X_0^2$$

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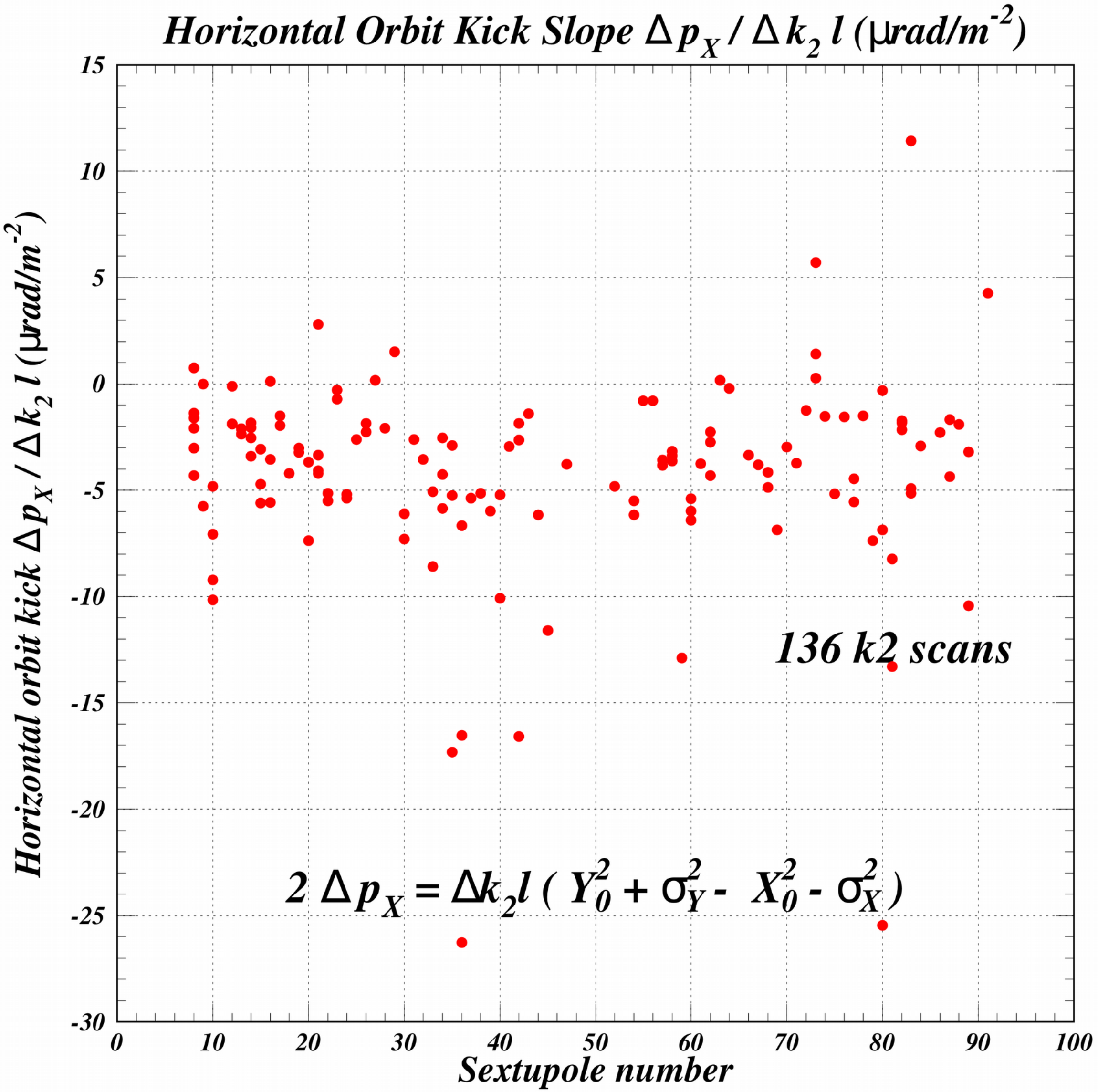
$\Delta p_x / \Delta K_2 L$ for all K_2 scans



$$\sigma_X^2 = -2 \frac{\Delta p_X}{\Delta K_2 L} + Y_0^2 - X_0^2$$

In general, $\Delta p_x / \Delta K_2 L$ is too negative.

Train of thought

1. There exists a non-sextupole contribution to Δp_X as measured:

$$\Delta p_X^{\mathrm{meas}} = \Delta p_X + \Delta p_X^{\mathrm{nonsext}}$$

2. Idea: Δp_Y results from the same field along the trajectory.

Use it as a “canary in the coal mine.”

$$\Delta p_Y^{\mathrm{meas}} = \Delta p_Y + \Delta p_Y^{\mathrm{nonsext}}$$

$$\Delta p_Y^{\mathrm{nonsext}} = \Delta p_Y^{\mathrm{meas}} - K_2 L\, X_0\, Y_0$$

3. Proposal to be discussed on slide 5:

$$\Delta p_X^{\mathrm{nonsext}} = \frac{\Delta p_Y^{\mathrm{nonsext}}}{2}$$

4. For the beam size calculation, calculate Δp_X as:

$$\Delta p_X = \Delta p_X^{\mathrm{meas}} - \frac{(\Delta p_Y^{\mathrm{meas}} - K_2 L\, X_0\, Y_0)}{2}$$

Example: scan 85, sextupole 10AW

$$\frac{\Delta b_1}{\Delta K_2 L} = X_0 = -2.4355 \pm 0.0088 \text{ mm}$$

$$\frac{\Delta a_1}{\Delta K_2 L} = Y_0 = -0.4267 \pm 0.0031 \text{ mm}$$

$$\frac{\Delta p_X}{\Delta K_2 L} = -4.82 \pm 0.10 \ \mu\text{rad/mm}^2$$

$$\frac{\Delta p_Y}{\Delta K_2 L} = -3.69 \pm 0.13 \ \mu\text{rad/mm}^2$$

$$\sigma_x^2 = -2\frac{\Delta p_X}{\Delta K_2 L} + Y_0^2 - X_0^2 = 3.88 \pm 0.21 \text{ mm}^2$$

$$\sigma_x = 1.971 \pm 0.052 \text{ mm}$$

$$\sigma^2_{\text{nonsext}} = \frac{\Delta p_Y}{\Delta K_2 L} - X_0 \, Y_0 = -2.367 \pm 0.065 \text{ mm}^2$$

$$\sigma_x^2 = -2\frac{\Delta p_X}{\Delta K_2 L} + Y_0^2 - X_0^2 + \frac{\Delta p_Y}{\Delta K_2 L} - X_0 \, Y_0 = 1.52 \pm 0.22 \text{ mm}^2$$

$$\sigma_x = 1.232 \pm 0.088 \text{ mm}$$

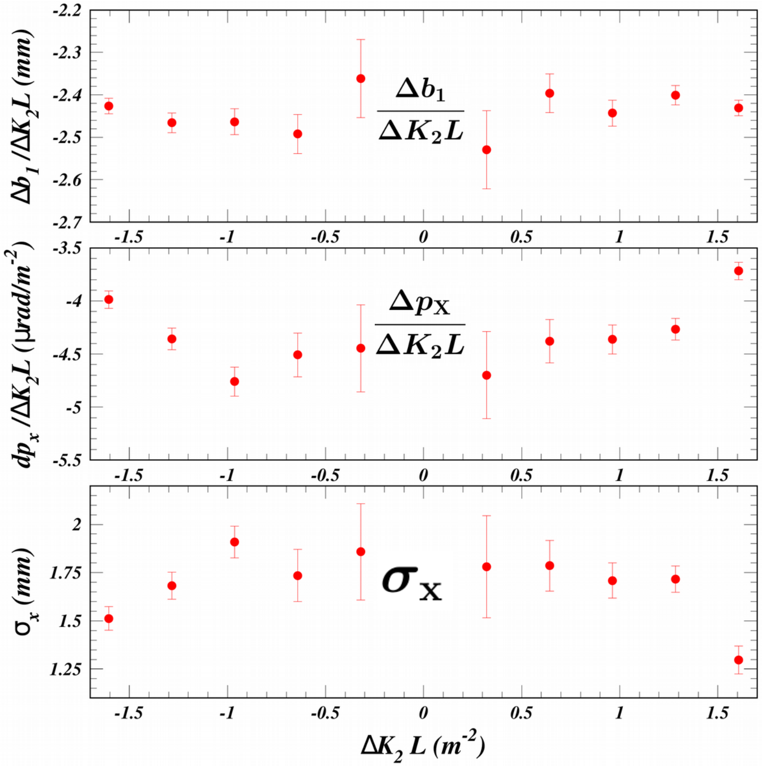
X_0 and Y_0 are measured to better than 1%.

$\Delta p_x/\Delta K_2L$ and $\Delta p_Y/\Delta K_2L$ dominate the uncertainty at 2-3%.

Prior to the "non-sextupole" correction, the beam size calculation is about 20 σ too high.

Afterward it is 1.7 σ greater than the value expected from the optics.

Proposed source: fringe field ?



Relevant parameters

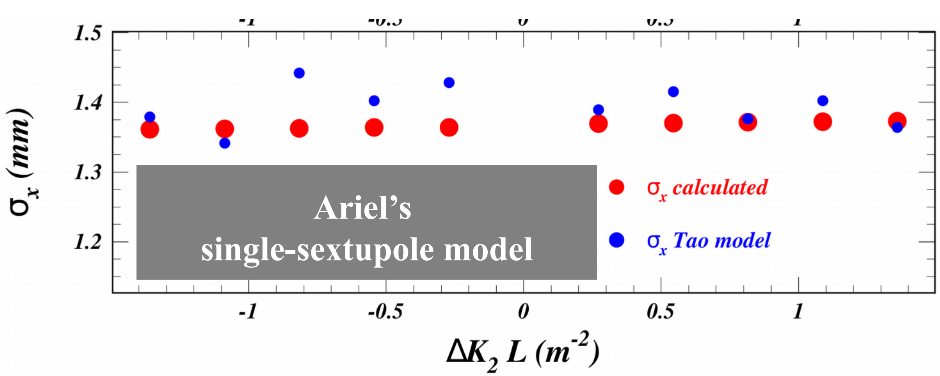
Maximum field change at x = 1 mm is less than 10 Gauss.

Magnet gap is 9 cm, length is 27 cm

$\Delta p_x / \Delta K_2 L$ and calculated σ_x depend on $\Delta K_2 L$.

Such nonlinearity suggests hysteretic effect.

But wouldn't hysteresis give a sextupole?



Tao model shows no dependence on $\Delta K_2 L$.

There is no fringe field or hysteresis inTao.

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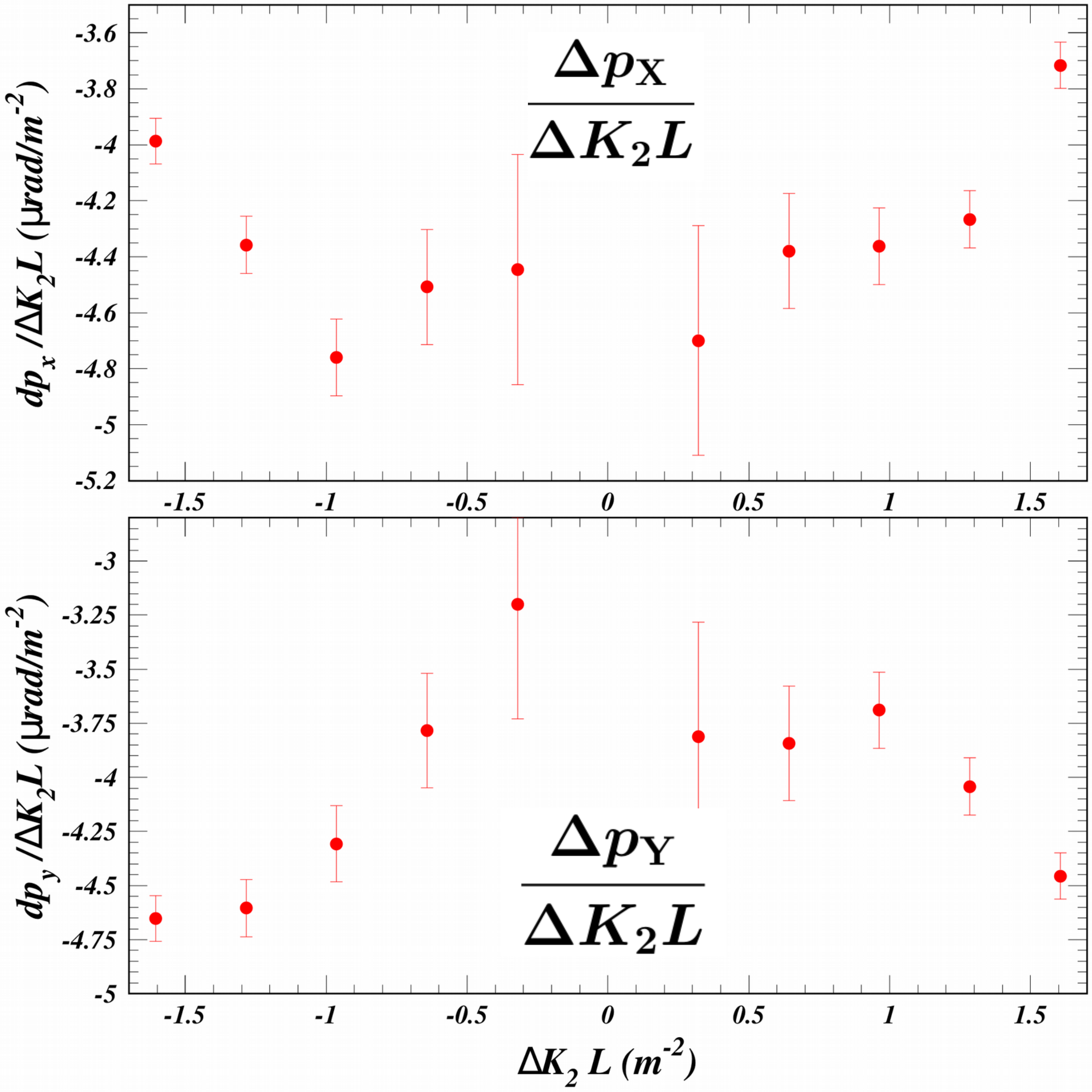
Horizontal and vertical angle ΔK_2 dependence both show the nonlinear behavior



The beam size calculation becomes independent of ΔK_2 .

The canary-in-the-coal-mine approach seems to work.

But what is the source of this non-sextupole field?