

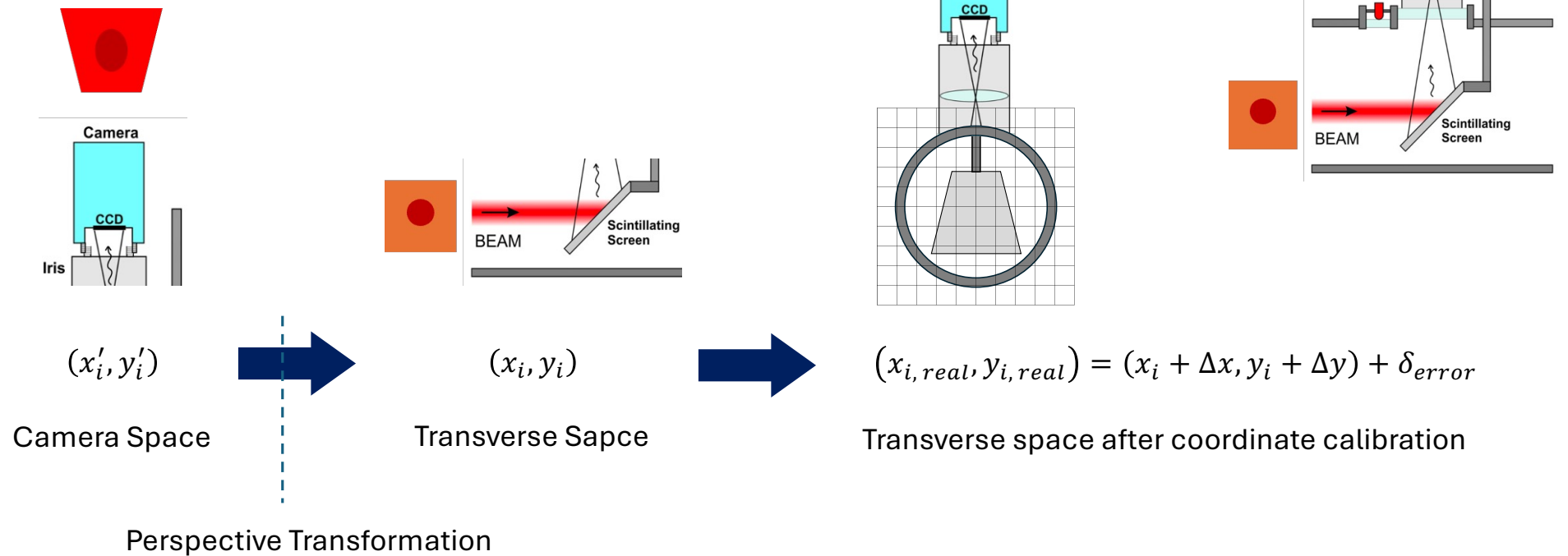
Research Progress

19. september 2025

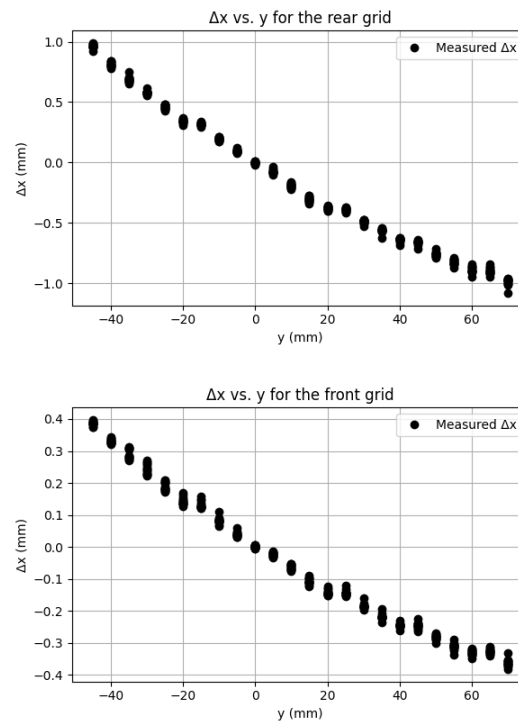
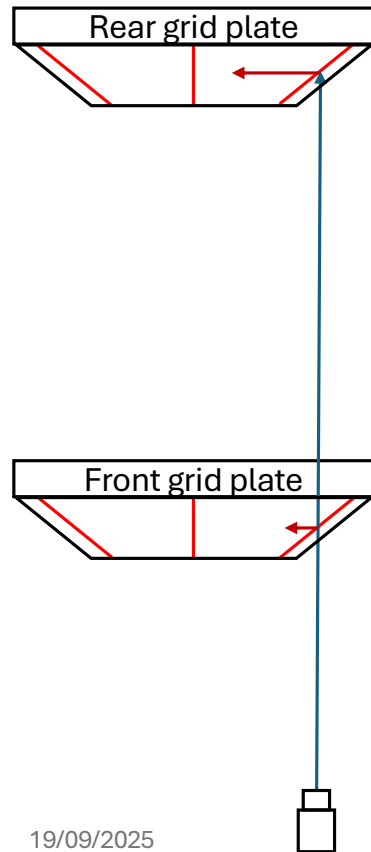
Juhwan Yoon

DANE

Research Overview



x-coordinate mapping on grid plate



Scan vertically at $x = -70, 0, 70$ mm each 5 times
Deviated horizontally, occurring Δx



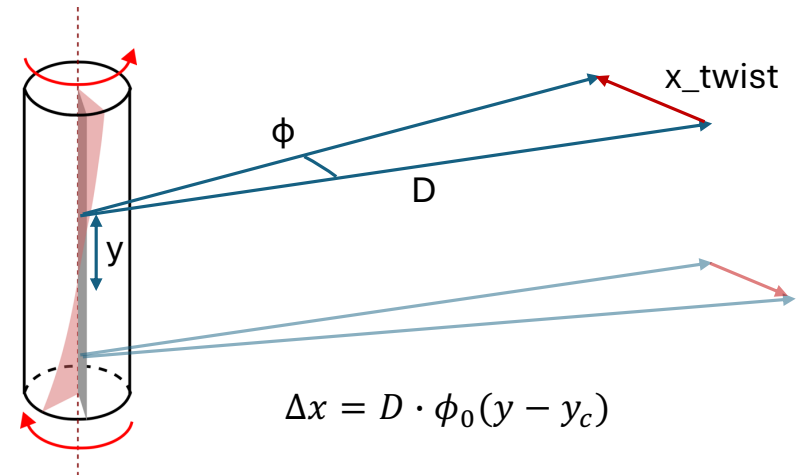
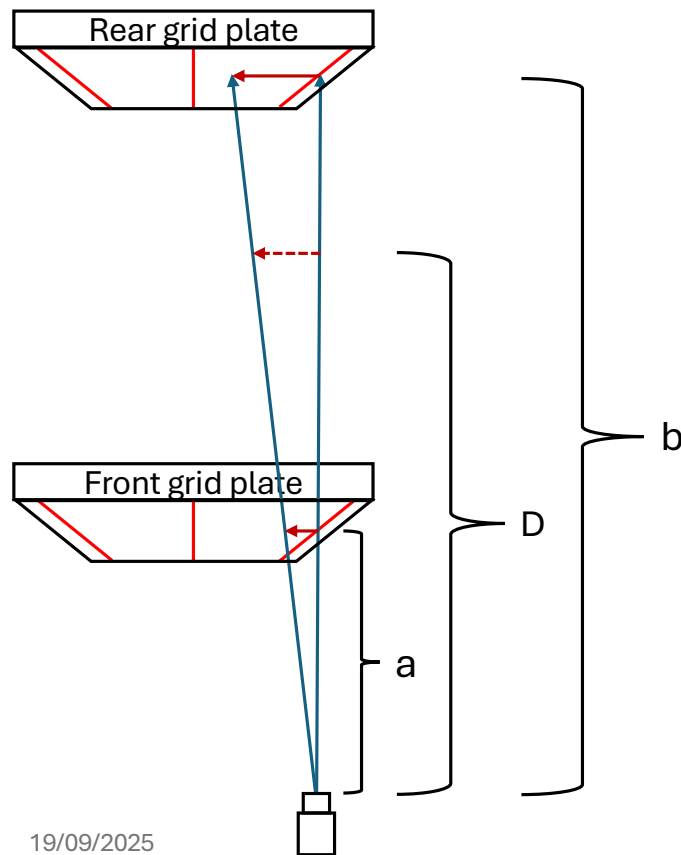
$$\Delta_{rear}x(y) = spline_2(y)$$

$$\Delta_{front}x(y) = spline_1(y)$$



$$x_{real} = x + \Delta x(y)$$

x-coordinate mapping between grids

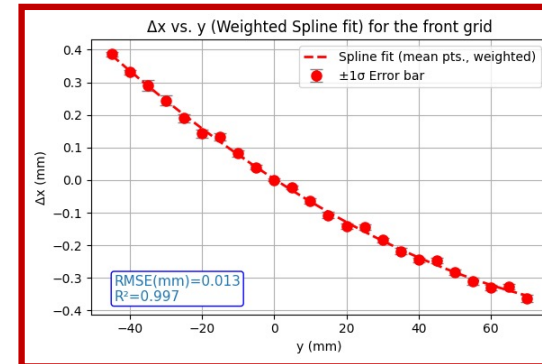
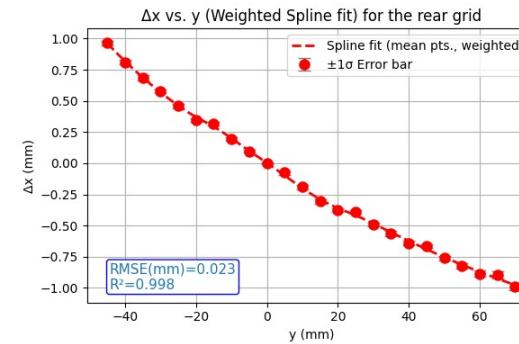
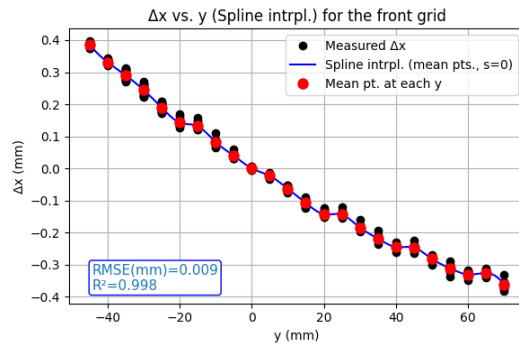
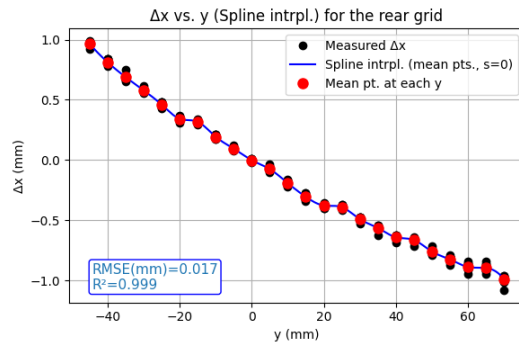


$$\frac{b \text{ (camera - rear)}}{a \text{ (camera - front)}} = \frac{\Delta_{\text{rear}} x}{\Delta_{\text{front}} x} = 2.61 \pm 0.14$$

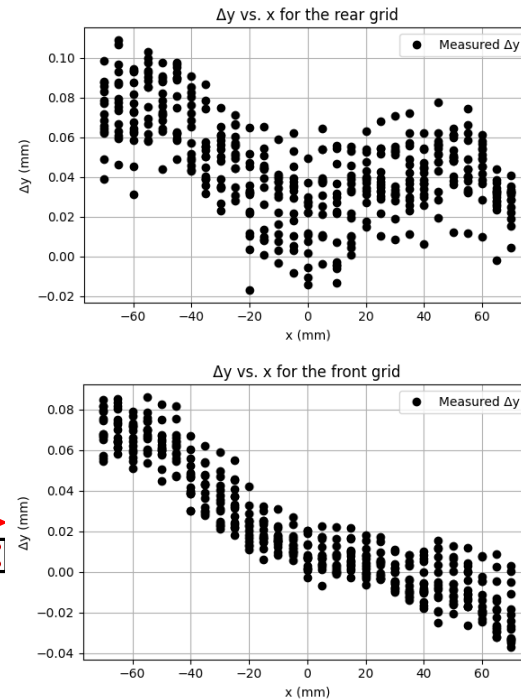
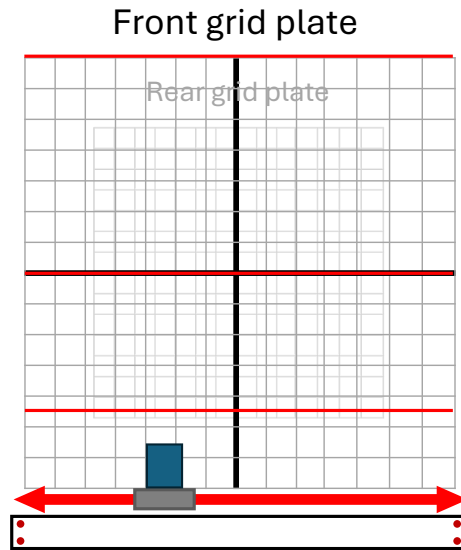


$$\Delta x(y, D) = \Delta x_{\text{front}} + \frac{D - D_{\text{front}}}{D_{\text{rear}} - D_{\text{front}}} (\Delta x_{\text{rear}} - \Delta x_{\text{front}})$$
 Linear interpolation

x-coordinate mapping



y-coordinate mapping on grid plate



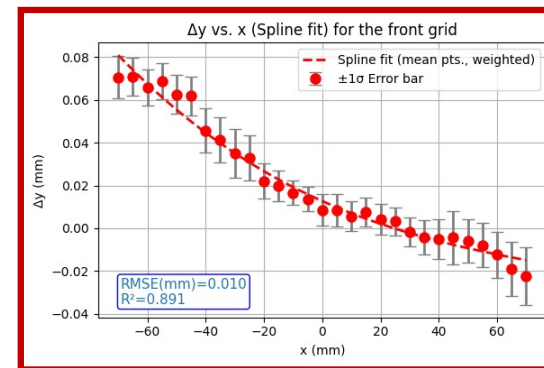
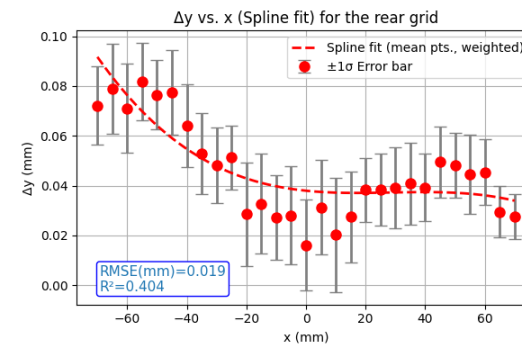
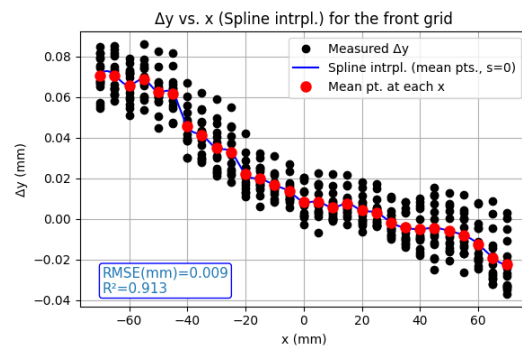
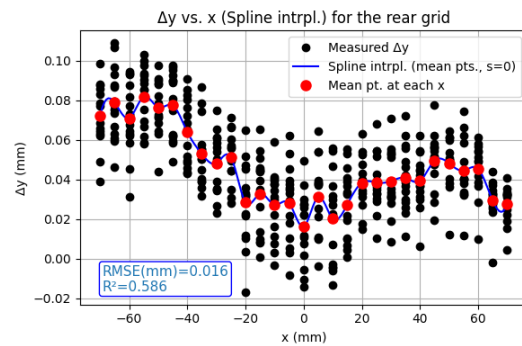
Scan horizontally at $y = -45, 0, 70$ mm each 5 times
Deviated vertically, occurring Δy

$$\Delta_{rear}y(x) = spline_2(x)$$

$$\Delta_{front}y(x) = spline_1(x)$$

$$y_{real} = y + \Delta y(x)$$

y-coordinate mapping



Systematic uncertainties

x-coordinates

$$x = x + \Delta x(y, D) + \delta_{error,x}$$

Error Type	Amount (mm)
Image Processing	±0.00313
Measurement repeatability	±0.01948
Twist ratio	±0.02752
Spline fit RMSE	±0.01277



Total Error: ± 0.0361 mm

y-coordinates

$$y = y + \Delta y(x) + \delta_{error,y}$$

Error Type	Amount (mm)
Image Processing	±0.00414
Measurement repeatability	±0.013034
Grid plate difference	±0.026390
Spline fit RMSE	±0.009934

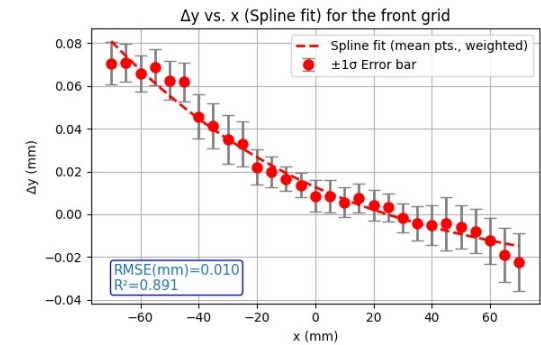
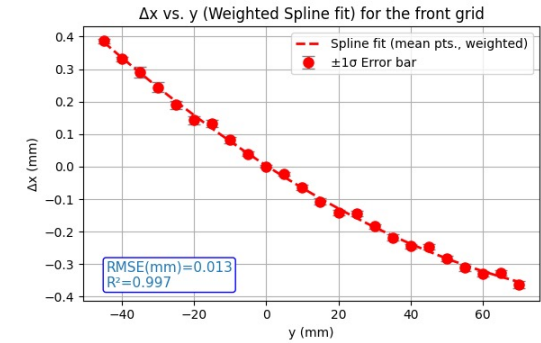


Total Error: ± 0.0313 mm

Coordinate Calibration Equation

$$\begin{aligned}
 x_{real} &= x + \Delta x(y, D) + \delta_{error,x} \\
 &= x + \Delta x_{front} + \frac{D - D_{front}}{D_{rear} - D_{front}} (\Delta x_{rear} - \Delta x_{front}) + \delta_{error,x} \\
 &= x + s(y) + \frac{D - D_{front}}{D_{rear} - D_{front}} (twist_ratio \cdot s(y) - s(y)) + \delta_{error,x}
 \end{aligned}$$

$$y_{real} = y + \Delta y(x) = y + s(x) + \delta_{error,y}$$



THANK YOU