Harp Scan and Beam Position

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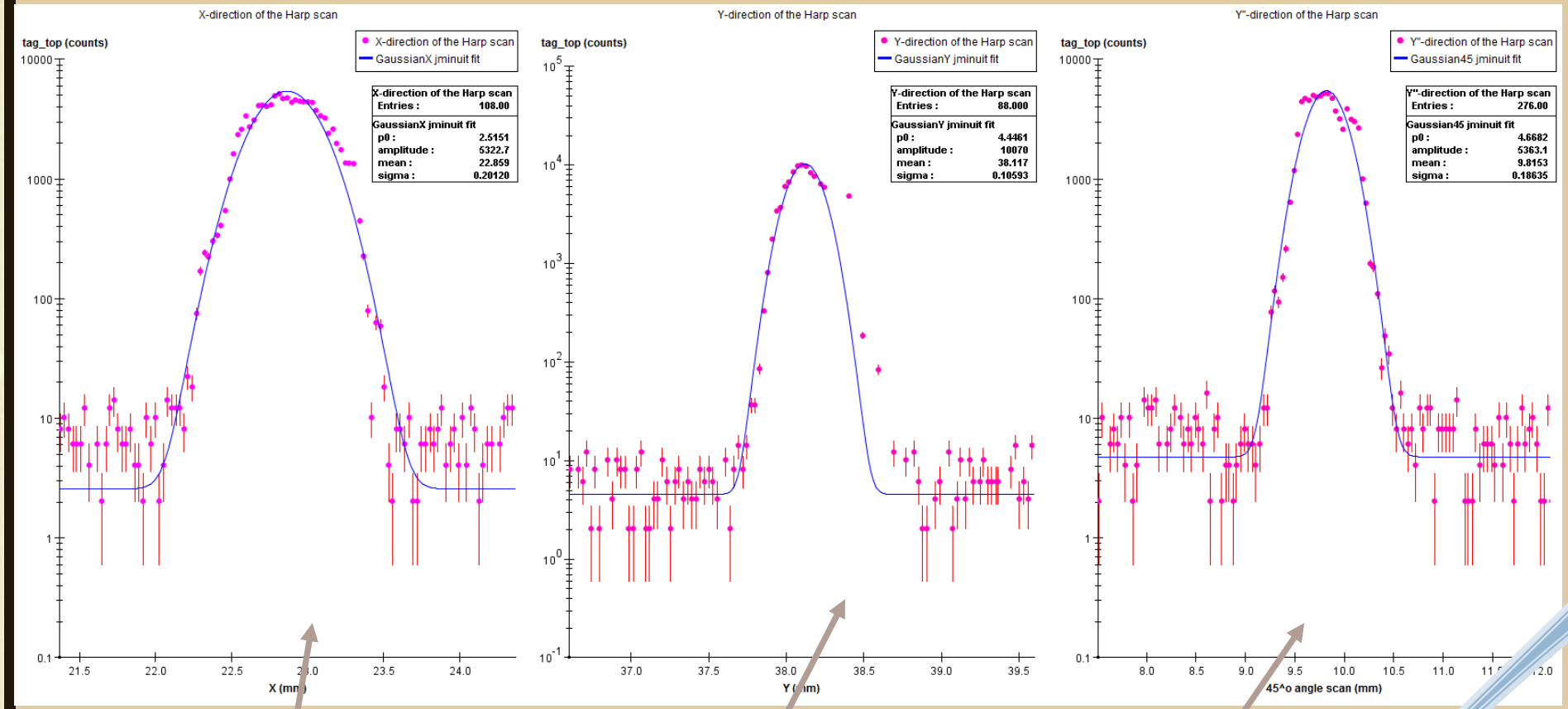
Introduction

- Hall B harp scan
- Wire scanner system and the inclination angle problem.
- The solution of this problem.
- Simulated data
- Results
- Conclusion

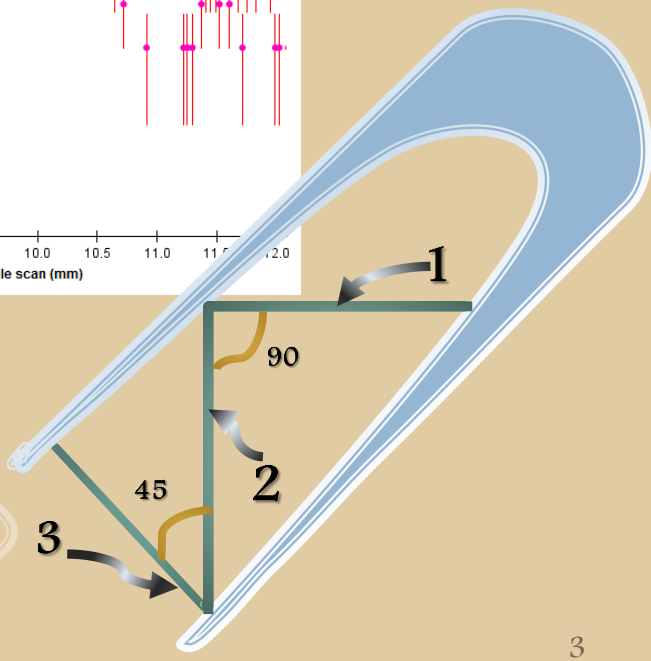
Harp Scan with Gaussian fit



2nd wire scan

1st wire scan

3rd wire scan

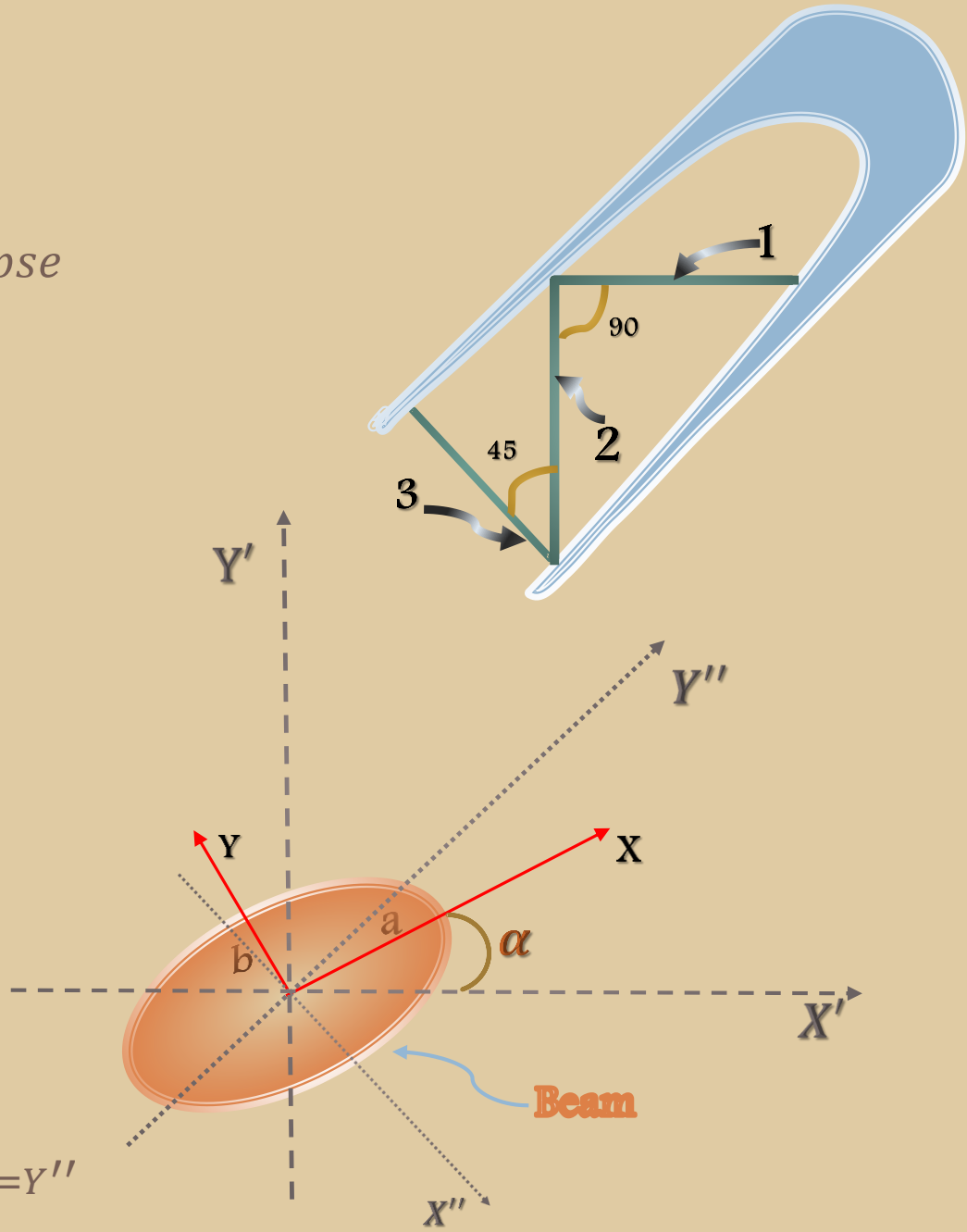


Wire Scanner System

- $X' and\ Y'\ are\ along\ major\ axises\ of\ an\ ellipse$
- $\sigma_{X'} \equiv a \rightarrow semi-major\ axis$
- $\sigma_{Y'} \equiv b \rightarrow semi-minor\ axis$
- σ_X, σ_Y and $\sigma_{\omega_{45}}$ – scan along X, Y and ω_{45}

- 1 wire scan – gives σ_Y
- 2 wire scan – gives σ_X
- 3 wire scan – gives $\sigma_{\omega_{45}}$

- $\sigma_X^2\, cos^2\,\alpha + \sigma_Y^2\, sin^2\,\alpha = \sigma_{X'}^2$
- $\sigma_X^2\, sin^2\,\alpha + \sigma_Y^2\, cos^2\,\alpha = \sigma_{Y'}^2$
- $\sigma_{Y'}^2\, cos^2(\frac{\pi}{4} - \alpha) + \sigma_{X'}^2\, sin^2(\frac{\pi}{4} - \alpha) = \sigma_{\omega_{45}=Y''}^2$



Get α, σ_X and σ_Y parameters of the beam.

- $\sigma_X^2 \cos^2\alpha + \sigma_Y^2 \sin^2\alpha = \sigma_{X'}^2$
- $\sigma_X^2 \sin^2\alpha + \sigma_Y^2 \cos^2\alpha = \sigma_{Y'}^2$
- $\sigma_{Y'}^2 \cos^2(\frac{\pi}{4} - \alpha) + \sigma_{X'}^2 \sin^2(\frac{\pi}{4} - \alpha) = \sigma_{Y''}^2$

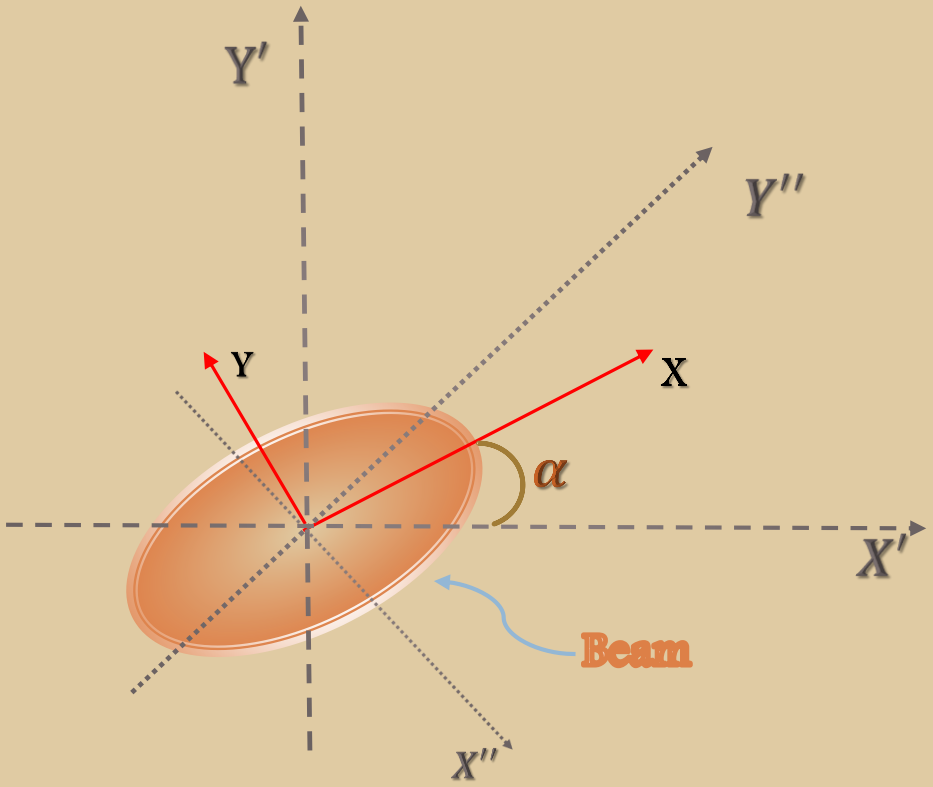
$$\cos 2\alpha \geq \frac{\sigma_{X'}^2 - \sigma_{Y'}^2}{\sigma_{X'}^2 + \sigma_{Y'}^2}$$

$\sigma_{X'}^2 \neq 0$

$\sigma_{Y'}^2 \neq 0$

$\sigma_{Y''}^2 \neq 0$

- $\alpha = 0.5 arctg(\frac{2\sigma_{Y''}^2 - \sigma_{X'}^2 - \sigma_{Y'}^2}{\sigma_{Y'}^2 - \sigma_{X'}^2})$
- $\sigma_X = \sqrt{0.5(\sigma_{X'}^2 + \sigma_{Y'}^2 + \frac{\sigma_{X'}^2 - \sigma_{Y'}^2}{\cos(2\alpha)})}$
- $\sigma_Y = \sqrt{0.5(\sigma_{X'}^2 + \sigma_{Y'}^2 - \frac{\sigma_{X'}^2 - \sigma_{Y'}^2}{\cos(2\alpha)})}$



The Model for Simulated Data

- Beam profile along Y' axis.

$$I = I_0 \int_{-\infty}^{+\infty} e^{-\left(\frac{X^2}{2\sigma_X^2}+\frac{Y^2}{2\sigma_Y^2}\right)} dx' = I_0 \int_{-\infty}^{+\infty} e^{-Ax'^2+Bx'+C}\, dx' = \sqrt{\frac{\pi}{A}}\, e^{\frac{B^2}{4A}+C} \quad (1)$$

$$A = \frac{\sigma_Y^2 \cos^2\alpha+\sigma_X^2 \sin^2\alpha}{2\,\sigma_X^2\sigma_Y^2},\ \mathrm{B} = -\frac{y \sin 2\alpha(\sigma_Y^2-\sigma_X^2)}{2\,\sigma_X^2\sigma_Y^2},\ \mathrm{C} = -\frac{y^2(\sigma_X^2 \cos^2\alpha+\sigma_Y^2 \sin^2\alpha)}{2\,\sigma_X^2\sigma_Y^2}$$

- Beam profile along X' axis.

$$I = I_0 \int_{-\infty}^{+\infty} e^{-\left(\frac{X^2}{2\sigma_X^2}+\frac{Y^2}{2\sigma_Y^2}\right)} dy' = I_0 \int_{-\infty}^{+\infty} e^{-Ay'^2+By'+C}\, dy' = \sqrt{\frac{\pi}{A}}\, e^{\frac{B^2}{4A}+C} \quad (2)$$

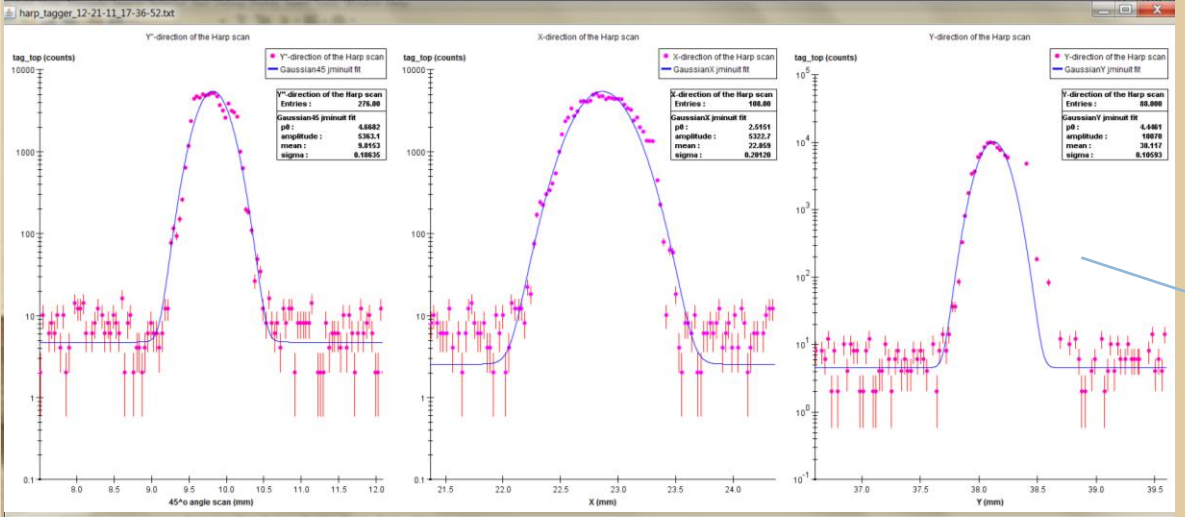
$$A = \frac{\sigma_Y^2 \sin^2\alpha+\sigma_X^2 \cos^2\alpha}{2\,\sigma_X^2\sigma_Y^2},\ \mathrm{B} = -\frac{x' \sin 2\alpha(\sigma_Y^2-\sigma_X^2)}{2\,\sigma_X^2\sigma_Y^2},\ \mathrm{C} = -\frac{x'^2(\sigma_X^2 \sin^2\alpha+\sigma_Y^2 \cos^2\alpha)}{2\,\sigma_X^2\sigma_Y^2}$$

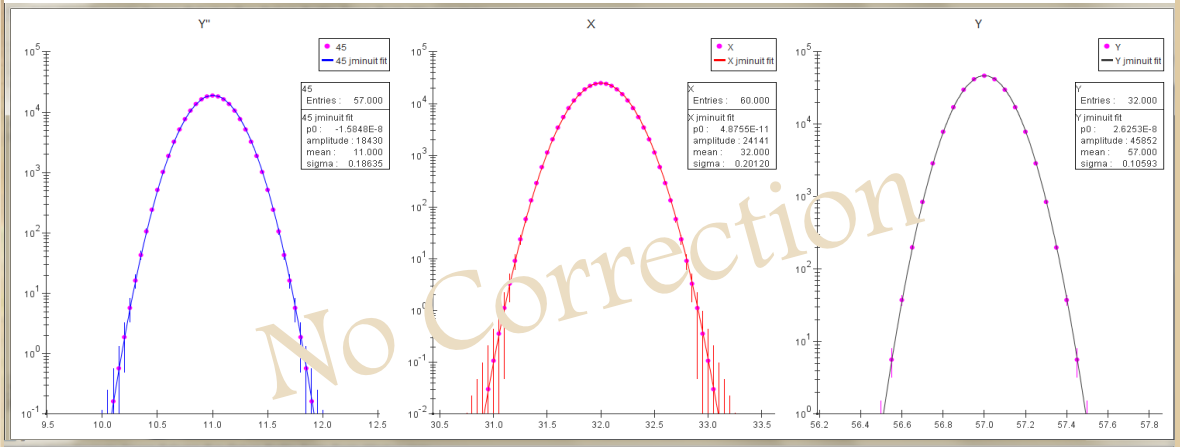
- Beam profile along Y'' axis. $y'' = x' + c$

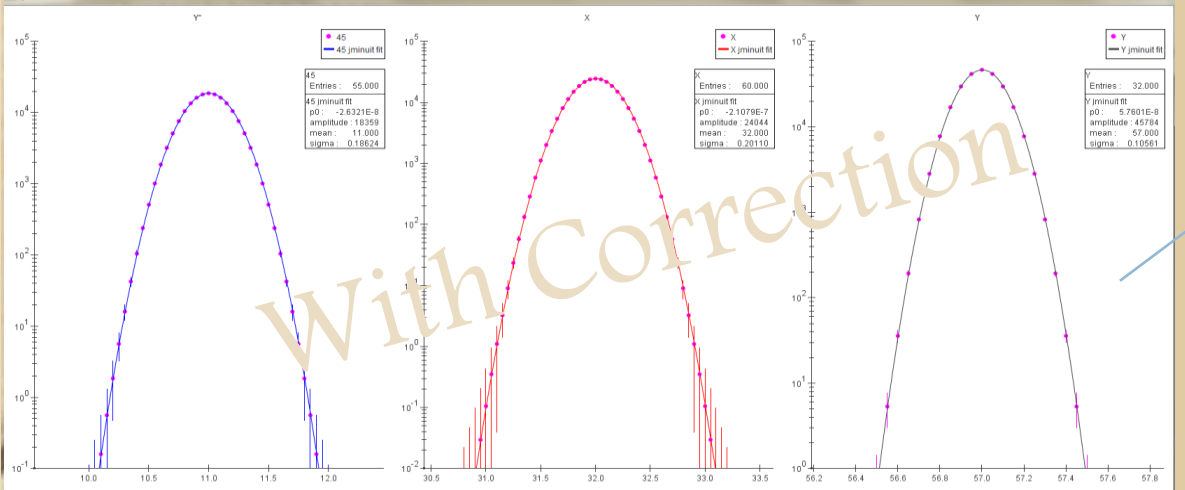
$$I = I_0 \oint_{-\infty}^{+\infty} e^{-\left(\frac{X^2}{2\sigma_X^2}+\frac{Y^2}{2\sigma_Y^2}\right)} dy'' = I_0 \int_{-\infty}^{+\infty} e^{-Ay'^2+By'+C}\, dx' = \sqrt{\frac{\pi}{A}}\, e^{\frac{B^2}{4A}+C} \quad (3)$$

$$A = \frac{\sigma_X^2(1+\sin 2\alpha)+\sigma_Y^2(1-\sin 2\alpha)}{2\,\sigma_X^2\sigma_Y^2},\ \mathrm{B} = \frac{2(\sigma_Y^2 \sin^2\alpha+\sigma_X^2 \cos^2\alpha)+\sin 2\alpha(\sigma_Y^2-\sigma_X^2)}{2\,\sigma_X^2\sigma_Y^2}c,\ \mathrm{C} = -\frac{c^2(\sigma_Y^2 \sin^2\alpha+\sigma_X^2 \cos^2\alpha)}{2\,\sigma_X^2\sigma_Y^2}$$

Results







No Correction

With Correction

- *Without correction*

$\sigma_{Y"} = 0.18635$

$\sigma_{X'} = 0.20120$

$\sigma_{Y'} = 0.10593$

- *Calculated parameters*

$\alpha(\text{real data}) = -15.621042$

$\sigma_X(real\ data) = 0.20727495$

$\sigma_Y(\text{real data}) = 0.093486$

- *Wire thickness =0.05mm*

Arne correction:

$$\sigma_{true} = \frac{\sigma_{mes}}{1 + \frac{0.025}{\sigma_{mes}^{2.826}}}$$

- *With Arne correction*

$\sigma_{Y"} = 0.18623693$

$\sigma_{X'} = 0.20110169$

$\sigma_{Y'} = 0.105613593$

- *Calculated parameters*

$\alpha(\text{real data}) = -15.62569$

$\sigma_X(real\ data) = 0.2071886$

$\sigma_Y(\text{real data}) = 0.0931074$

Conclusions

- The third wire scan analysis are added and the beam profile in 45 deg direction is fitted.
- The inclination angle is calculated.
- The beam parameters in it's own system are obtained.
- The program is tested on simulated and real data.

Thank you for your attention !!!