FONT Meeting

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Calibration by iteration

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  - Method for iterative fit of calibration constants

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  - From ColinRun3, nominal position and tilt
  - Calibration, resolution and “scale” i.e. $\langle |k| \rangle$

“Fit calibration” method

- In the “fit scale” method, the position at the BPM of interest is described as a linear combination of the positions at the other two BPMs: $\boldsymbol{y_\kappa} = \alpha_{\kappa\lambda}\boldsymbol{y_\lambda} + \alpha_{\kappa\mu}\boldsymbol{y_\mu}$
  - This is equivalent to fitting the calibration scale factors k_λ and k_μ (for fixed k_κ)
- The fit can be improved by increasing the number of degrees of freedom:

$$\boldsymbol{y_\kappa} = \alpha_{\kappa I_\lambda}\frac{\boldsymbol{I_\lambda}}{\boldsymbol{q}} + \alpha_{\kappa Q_\lambda}\frac{\boldsymbol{Q_\lambda}}{\boldsymbol{q}} + \alpha_{\kappa I_\mu}\frac{\boldsymbol{I_\mu}}{\boldsymbol{q}} + \alpha_{\kappa Q_\mu}\frac{\boldsymbol{Q_\mu}}{\boldsymbol{q}}$$

- The corresponding geometric expression is:

$$\boldsymbol{y_\kappa} = \frac{C_{\kappa\lambda}}{k_\lambda}\left(\cos\theta_\lambda \frac{\boldsymbol{I_\lambda}}{\boldsymbol{q}} + \sin\theta_\lambda \frac{\boldsymbol{Q_\lambda}}{\boldsymbol{q}}\right) + \frac{C_{\kappa\mu}}{k_\mu}\left(\cos\theta_\mu \frac{\boldsymbol{I_\mu}}{\boldsymbol{q}} + \sin\theta_\mu \frac{\boldsymbol{Q_\mu}}{\boldsymbol{q}}\right)$$

- So the calibration constants can be expressed in terms of the fit parameters as follows:

$$k_\lambda{}^2 = \frac{C_{\kappa\lambda}{}^2}{\alpha_{\kappa I_\lambda}{}^2 + \alpha_{\kappa Q_\lambda}{}^2} \qquad \cos\theta_\lambda = \frac{k_\lambda}{C_{\kappa\lambda}}\alpha_{\kappa I_\lambda}$$

- i.e. the fit calibration method fits k_λ, θ_λ, k_μ, θ_μ (for fixed k_κ and θ_κ)

Constraint on calibration

- The calculation is typically performed three times using a different BPM as the one with a fixed calibration each time and three different estimates for the resolution are obtained

$$\frac{1}{k_\kappa}\frac{\boldsymbol{I}'_{\boldsymbol{\kappa}}}{\boldsymbol{q}} = \frac{C_{\kappa\lambda}}{k_\lambda}\frac{\boldsymbol{I}'_{\boldsymbol{\lambda}}}{\boldsymbol{q}} + \frac{C_{\kappa\mu}}{k_\mu}\frac{\boldsymbol{I}'_{\boldsymbol{\mu}}}{\boldsymbol{q}}$$

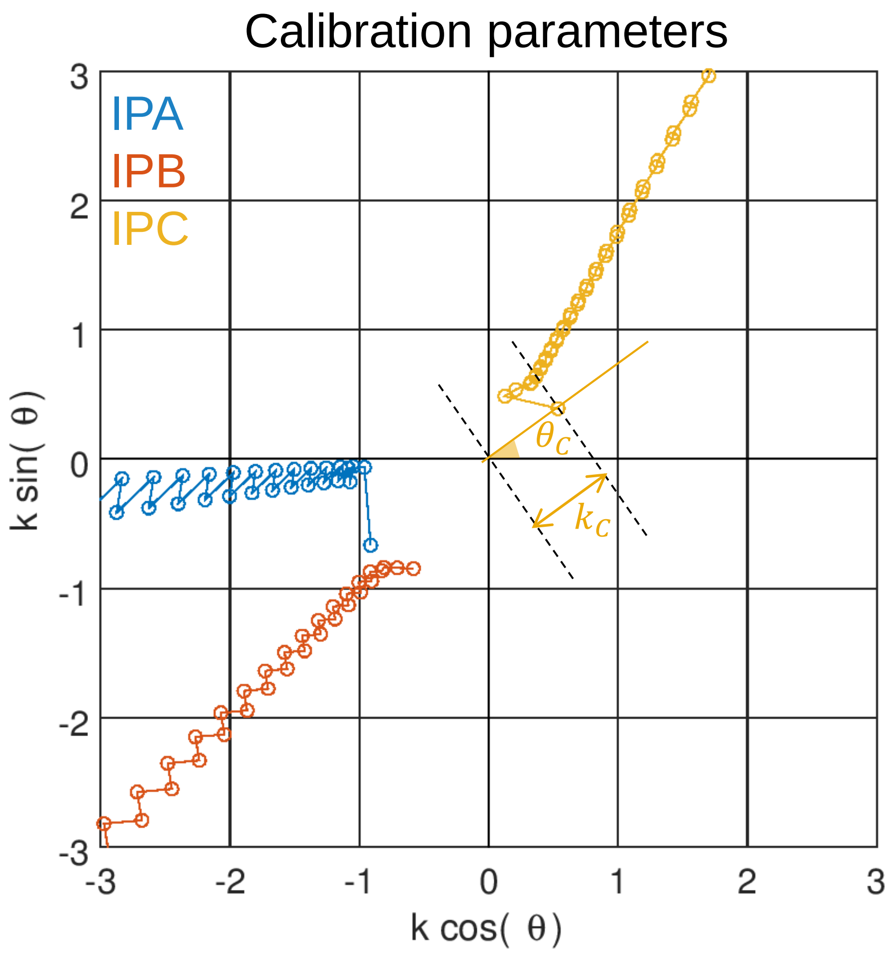
- Not possible to allow three scale factors to vary freely due to trivial solution to above eqn:

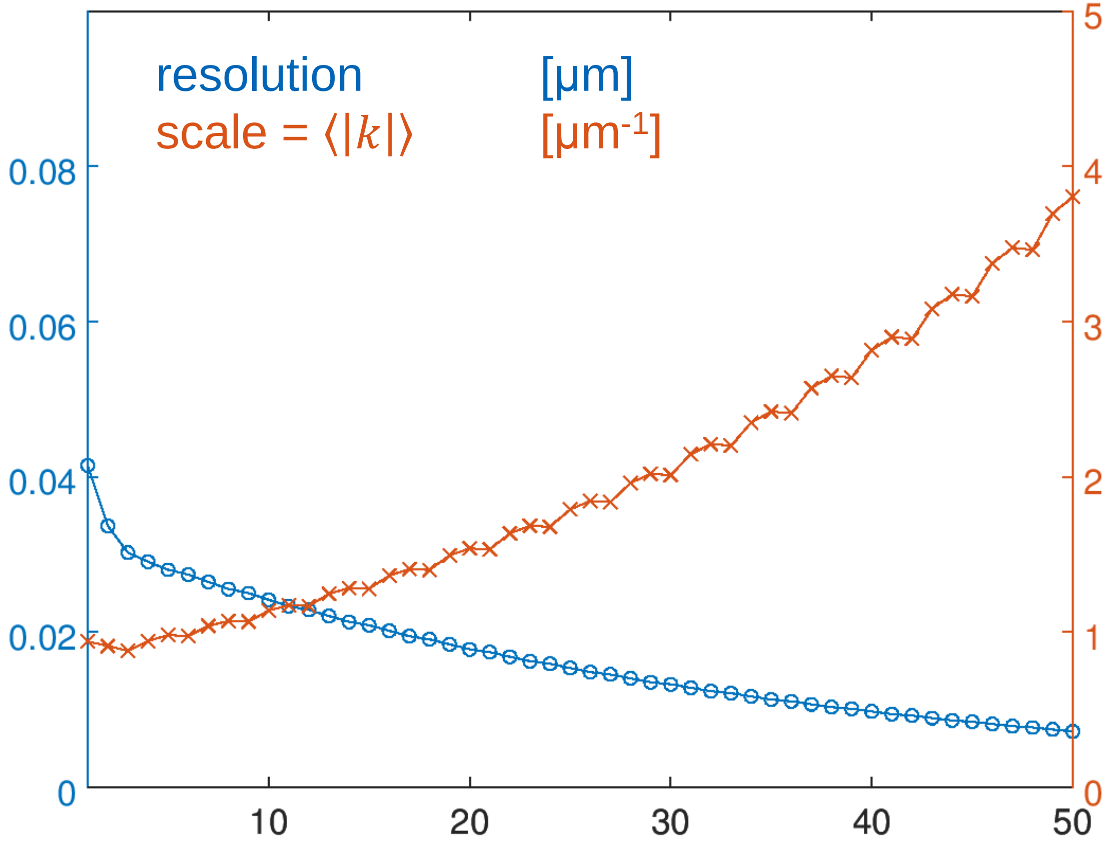
$$k_\kappa = k_\lambda = k_\mu = \infty$$

- Possible to impose a constraint on the scale factors such as $k_\kappa + k_\lambda + k_\mu =$ constant
- For this study, the procedure was as follows:
  - Start with the calibration parameters from an actual calibration: k_A , θ_A, k_B, θ_B, k_C and θ_C
  - Obtain new estimates for k_B, θ_B, k_C and θ_C by fitting to $\boldsymbol{y_A}$ calculated using k_A and θ_A
  - Recalculate $\boldsymbol{y_B}$ and obtain new estimates for k_A, θ_A, k_C and θ_C by fitting to it
  - Recalculate $\boldsymbol{y_C}$ and obtain new estimates for k_A, θ_A, k_B and θ_B by fitting to it
  - Repeat
- Ultimately expect to converge on trivial solution

Colin3_posNomTiltNom1

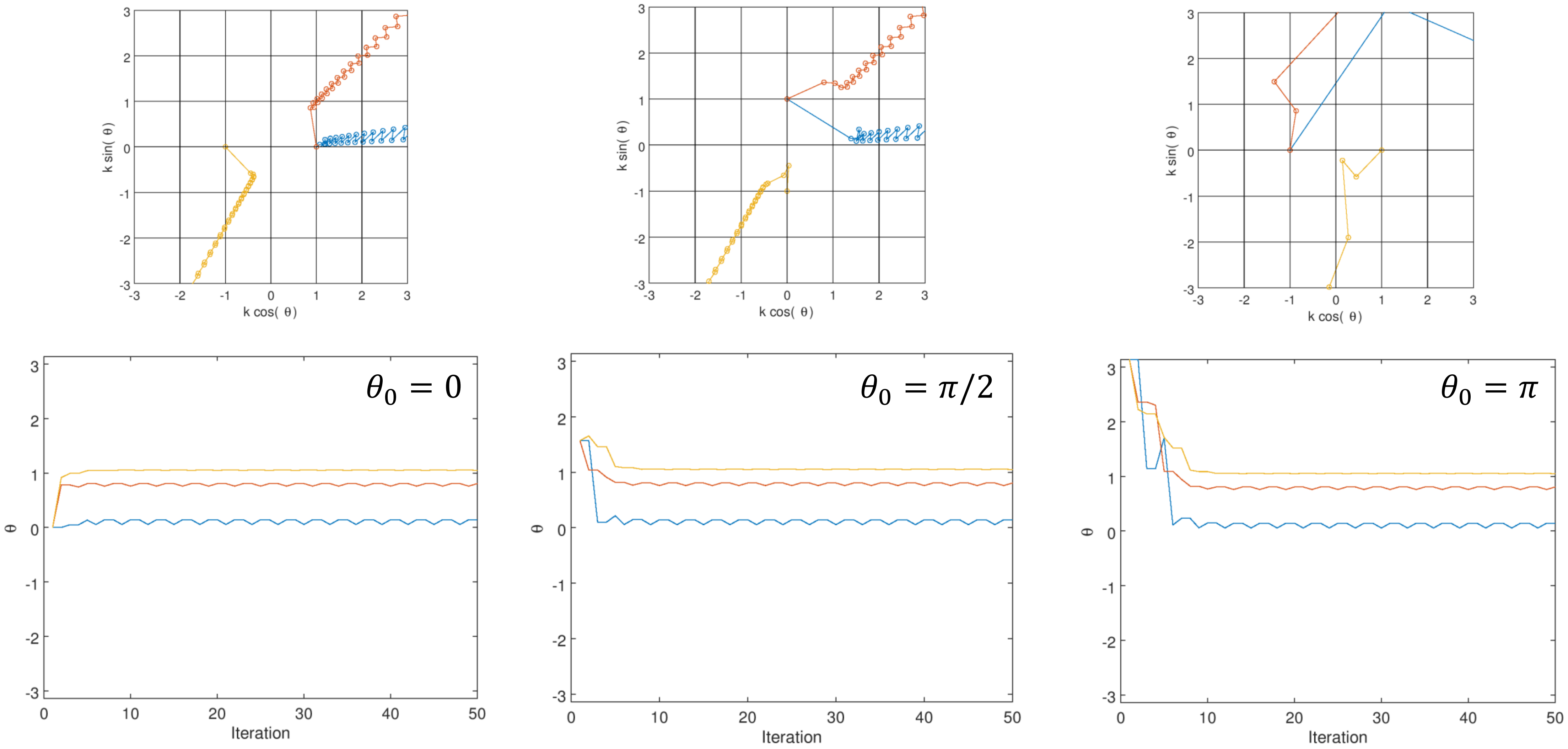
	$\boldsymbol{k_0}$	$\boldsymbol{\theta_0}$
IPA	-1.13	0.63
IPB	-1.03	0.97
IPC	0.66	0.66





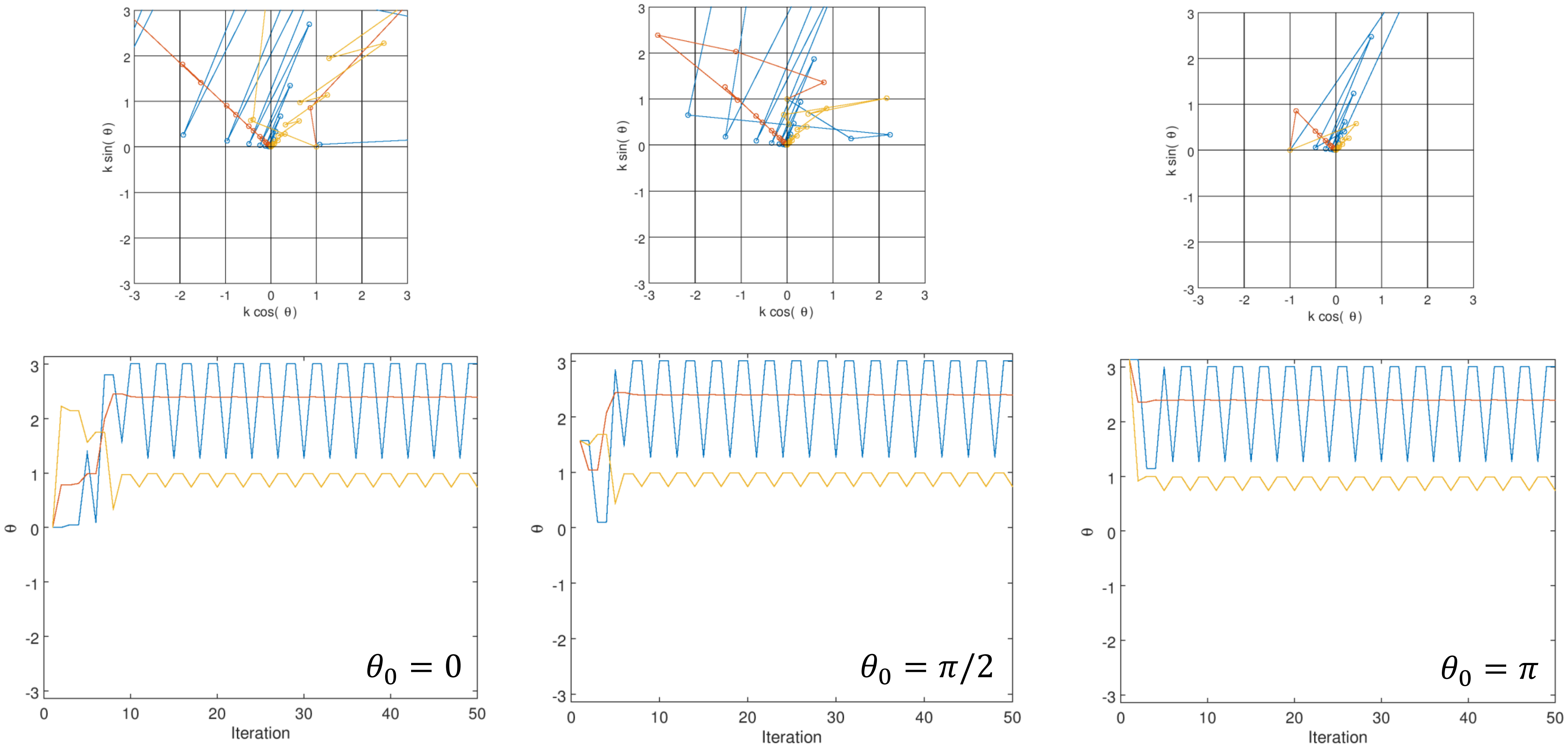
$k_A = k_B = 1, k_C = -1$

Consistency of θ

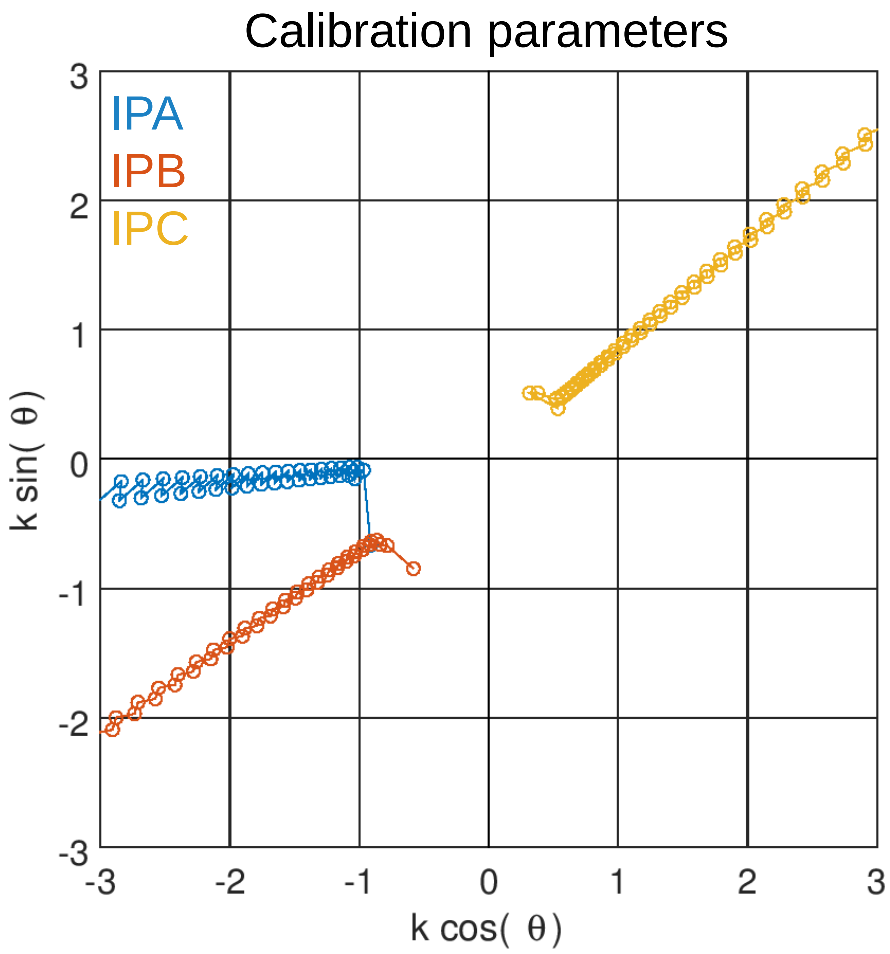


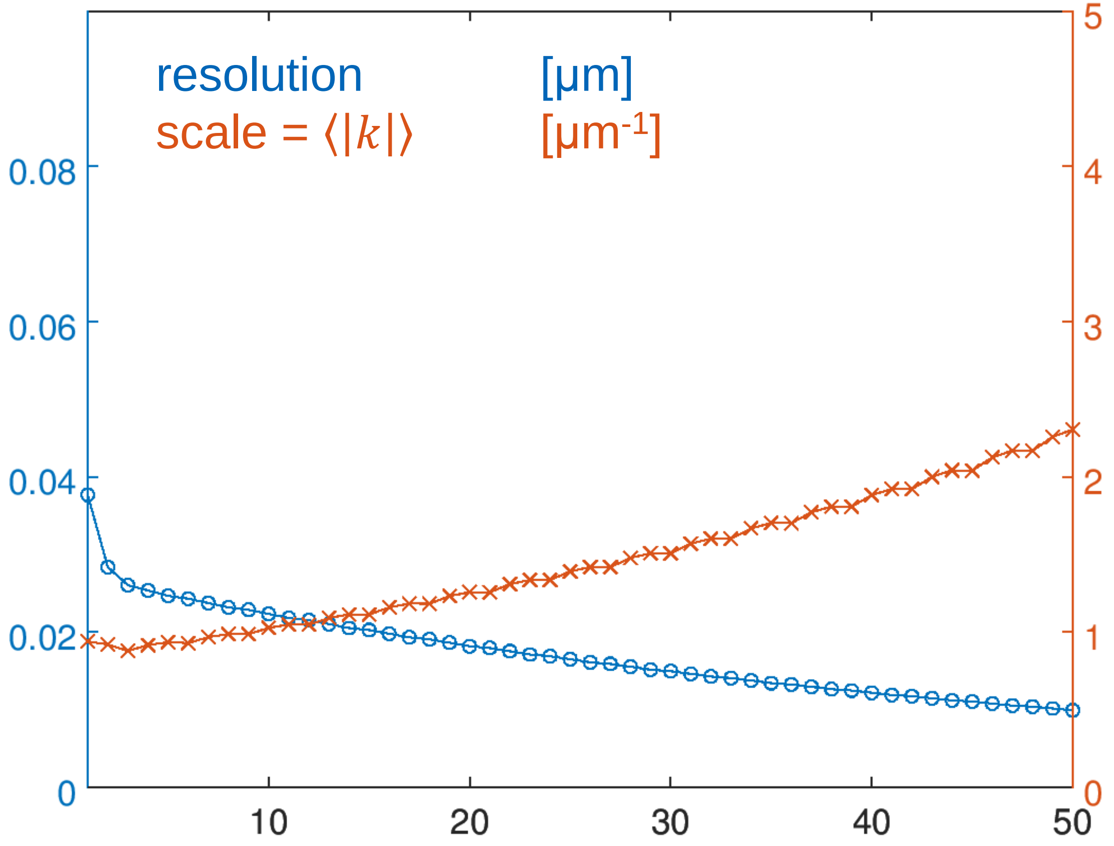
$k_A = k_B = k_C = 1$ not consistent with geometry

Consistency of θ

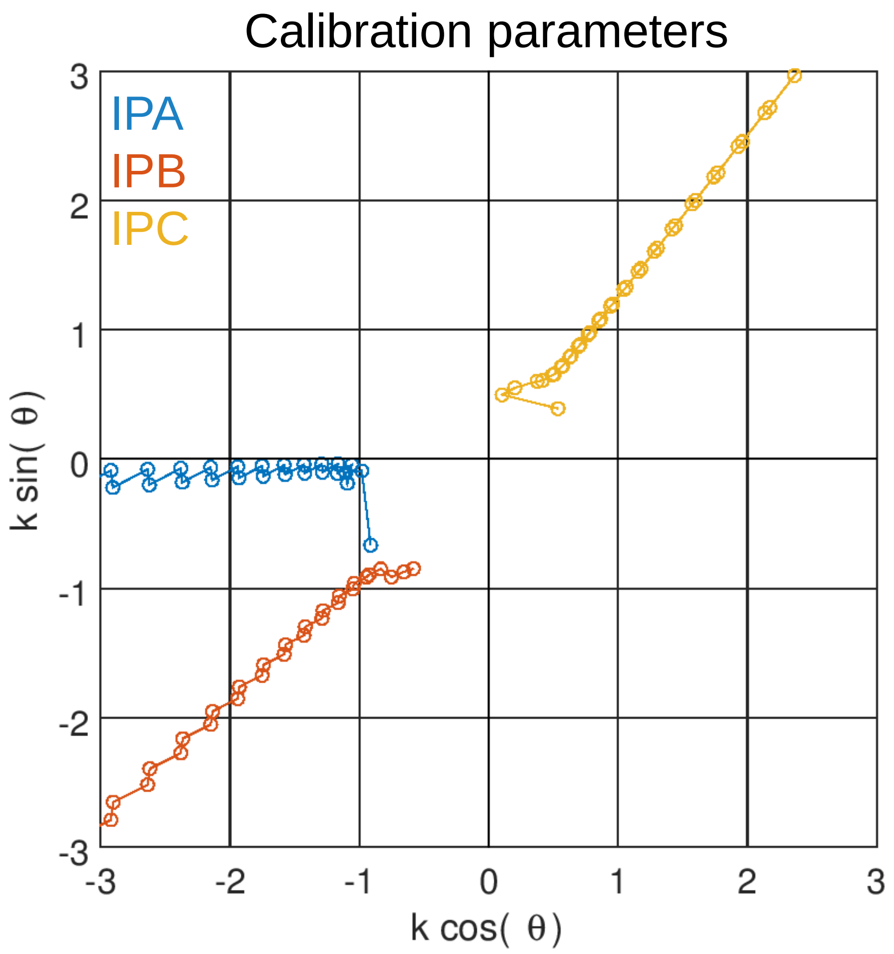


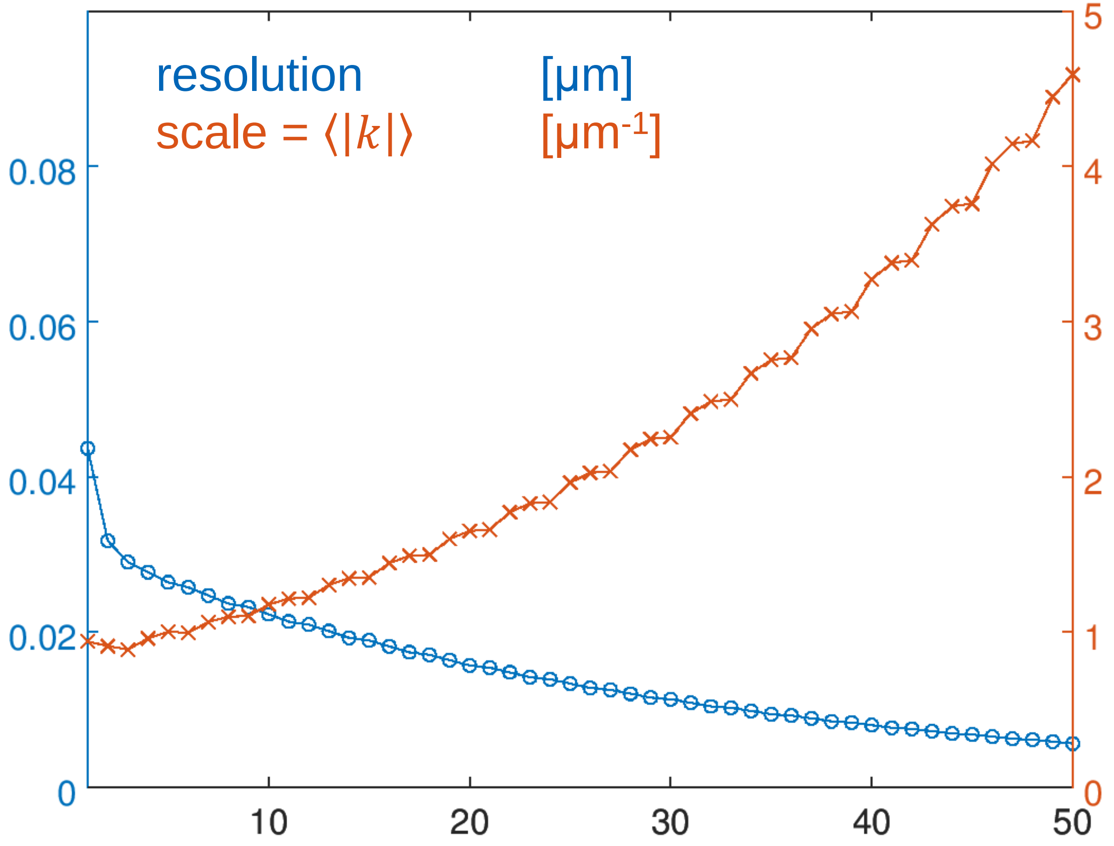
Colin3_posNomTiltNom2



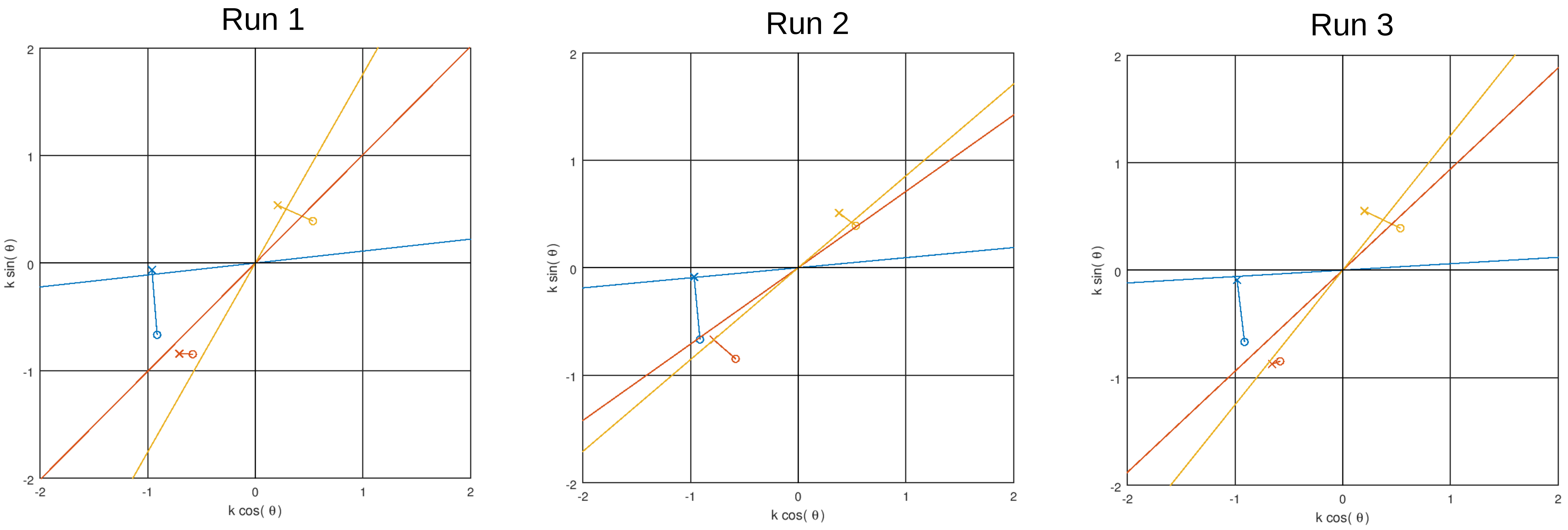


Colin3_posNomTiltNom3





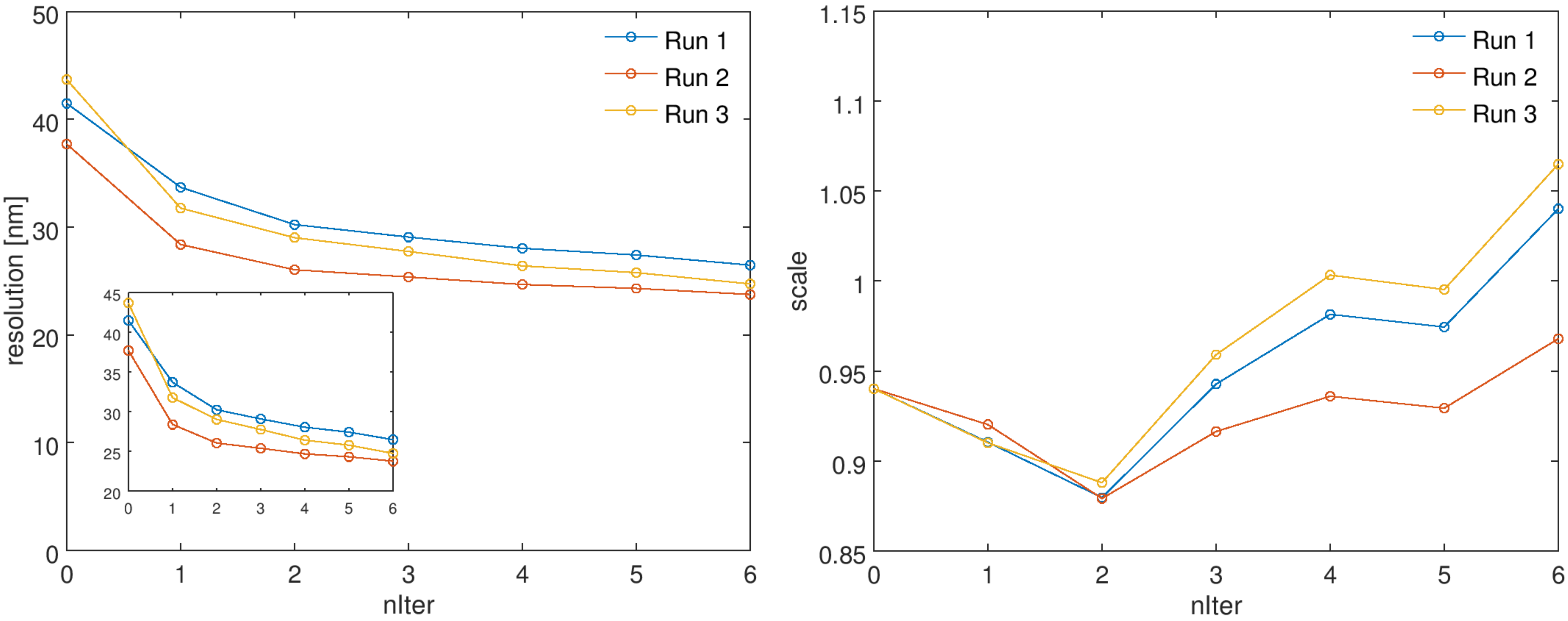
Calibration results



○ initial calibration
× after two iterations
– converged value of θ

IPA
IPB
IPC

Resolution results



Conclusion

- Iterative fit method rapidly "converges" in θ (for sensible initial scale factors)
  - θ switches between two possible values with each iteration
  - variability of θ from run to run (i.e. range) varies from $3°$ for IPA to $20°$ for IPC

- Scale parameter minimized after two iterations
  - Grows exponentially after this, doubling every ~20 iterations

- After two iterations resolution ~30% smaller than initial
  - Second iteration improves resolution by ~9% compared to first iteration