PhD 34 - Resolution analysis

Laura Karina Pedraza,
A. Aryshev, B. Gimeno-Martínez, C. Blanch-Gutierrez, D. Esperante-Pereira, D. Gonzáles-Iglesias,
J.C. Fernández-Ortega, M. Boronat, M. Moreno-Llácer, N. Fuster-Martínez, N. Terunuma, T. Okugi

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laura.pedraza@ific.uv.es

PhD34 - Resolution Analysis

PhD Journal #34, 15/09/2026

INSTITUT DE FÍSICA CORPUSCULAR

Introduction

I. Resolution estimation results
   A) Resolution calculation with Pseudo-inverse
   B) Selecting a specific set of data

II. Pseudo-inverse method limitations
   A) Pseudo-experiments
   B) Resolution as a function of beam position
   C) Resolution as a function of bunch charge

III. Calibration corrections
   A) Compensating for stripline electronics amplitude difference
   B) Inclusion of the profile monitors
   C) ...

Conclusion

I. Resolution estimation results

A) Resolution calculation with Pseudo-inverse

Taking a long set of data in a single beam position:

$P = 1000$ is the number of pulses

$M = 20$ is the number of BPMs used

Model Independent Analysis: [8]

$$\mathbf{d} = \mathbf{D} \cdot \mathbf{v}$$

cBPM measured values ⟶

$$\begin{pmatrix} d_{k0} \\ d_{k1} \\ \vdots \\ d_{kP} \end{pmatrix} = \begin{pmatrix} d_{00} & d_{10} & \dots & d_{i\neq k,0} & \dots & d_{M0} \\ d_{01} & d_{11} & \dots & d_{i\neq k,1} & \dots & d_{M1} \\ \vdots & \vdots & & \vdots & & \vdots \\ d_{0P} & d_{1P} & \dots & d_{i\neq k,P} & \dots & d_{MP} \end{pmatrix} \cdot \begin{pmatrix} v_0 \\ v_1 \\ \vdots \\ v_M \end{pmatrix}$$

⟵ correlation coefficients

↑ stripline BPM measured values

To find the correlation coefficients: $\mathbf{v} = \mathbf{D}^{-1} \cdot \mathbf{d}$ where the inverse of $\mathbf{D}$ is calculated using the SVD method: $SVD(\mathbf{D}) = \mathbf{USV^T}$

↓

$$\mathbf{D}^{-1} = \mathbf{V^{TT}S^{-1}U^T} = \mathbf{V} \begin{pmatrix} 1/\sigma_1 & & \\ & \ddots & \\ & & 1/\sigma_M \end{pmatrix} \mathbf{U^T}$$

The residuals between measured position and estimated position are calculated as $\mathbf{R} = \mathbf{d} - \mathbf{D} \cdot \mathbf{v}$

And the resolution is estimated with the rms of the residuals:

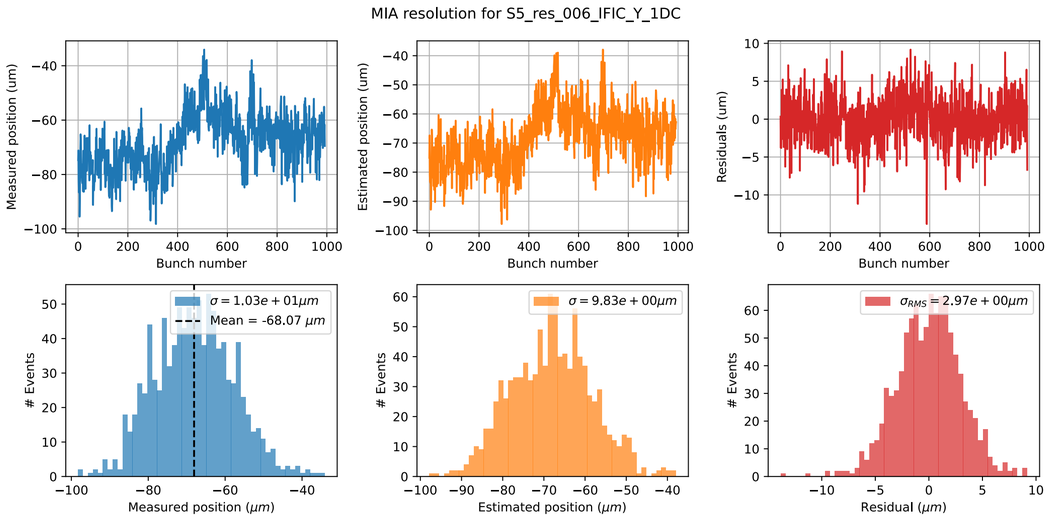
$$\sigma = \sqrt{\frac{\Sigma_i^P \ R_i^2}{P}}$$

BPMs taken: up-stream: ML1L .... ML15L, ML1P, ML2P, ML3P ; down-stream: ML4P

I. Resolution estimation results

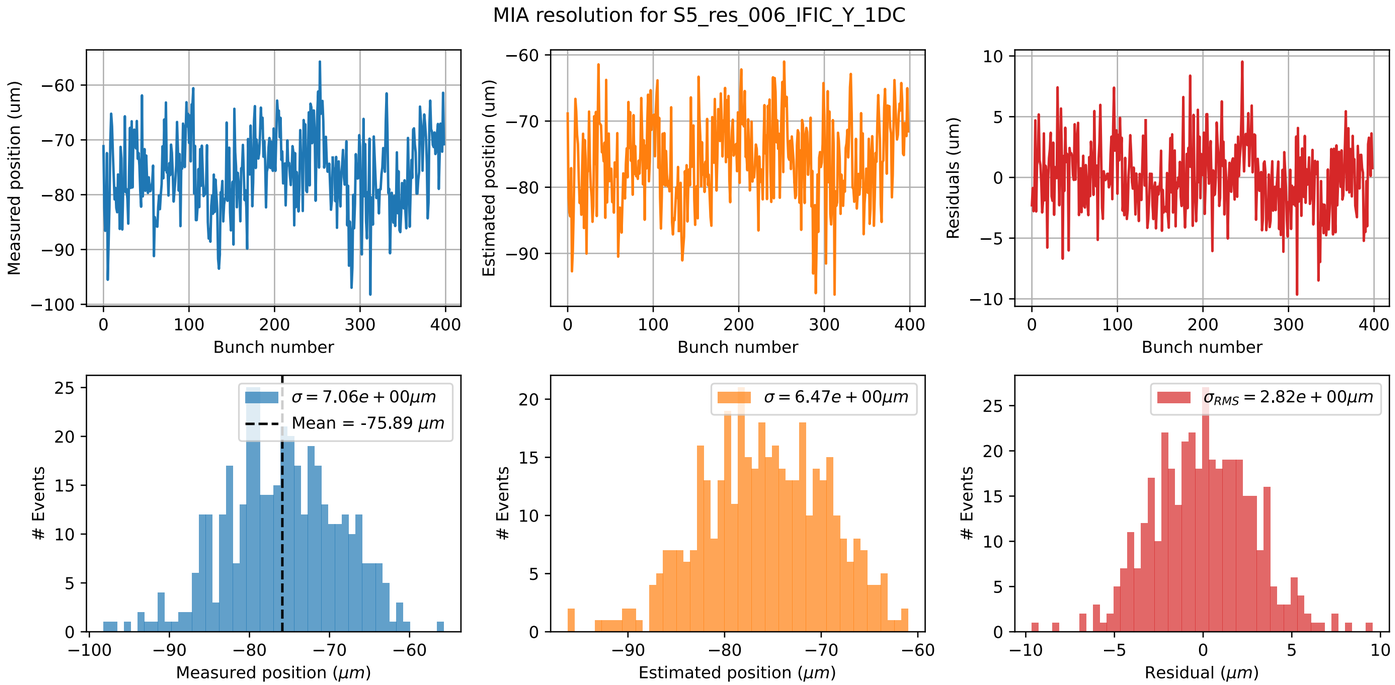
B) Selecting a specific part of the data

Full measurement



RESOLUTION with other cBPM			
resolution	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
2.97	2.34	0.59	2.46

First 400 bunches

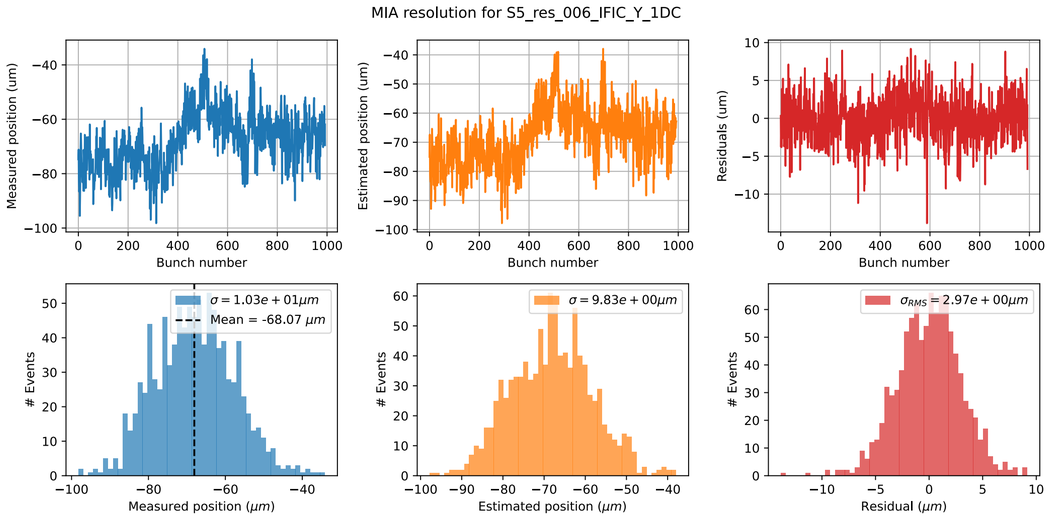


RESOLUTION with other cBPM			
resolution	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
2.82	2.20	0.82	2.46

I. Resolution estimation results

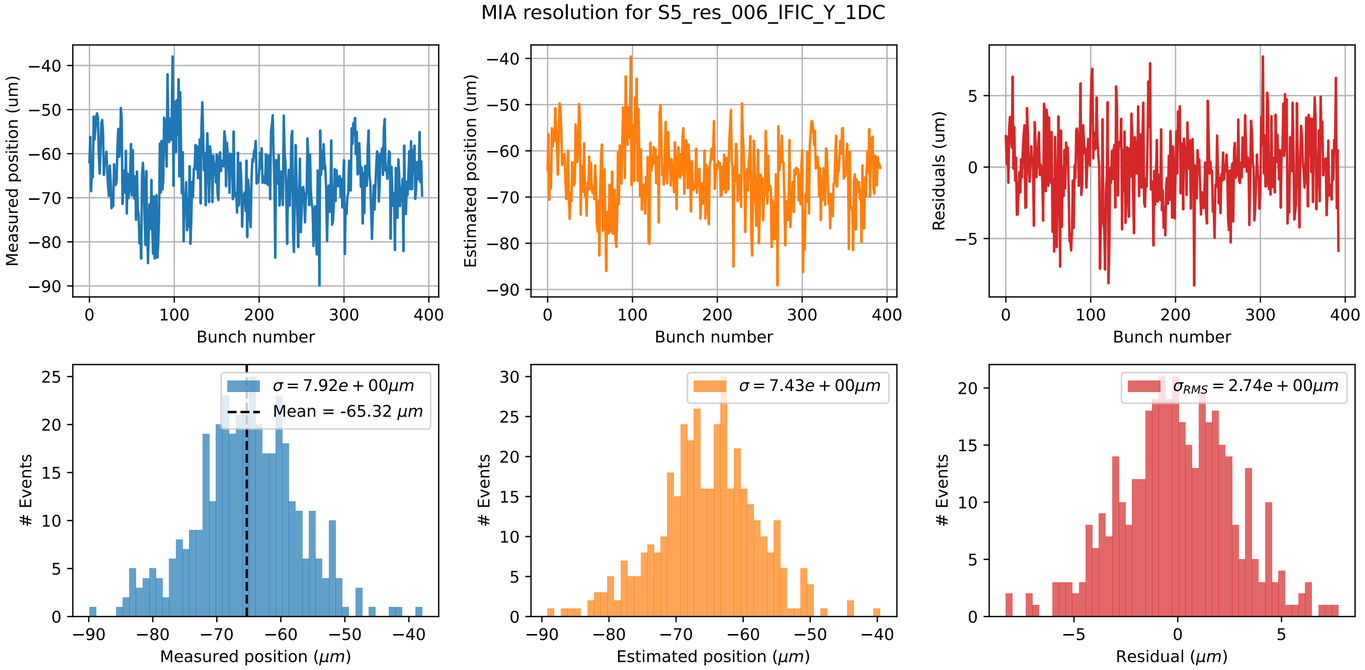
B) Selecting a specific part of the data

Full measurement



RESOLUTION with other cBPM			
resolution	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
2.97	2.34	0.59	2.46

Last 600 bunches



RESOLUTION with other cBPM			
resolution	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
2.74	2.39	0.91	2.64

I. Resolution estimation results

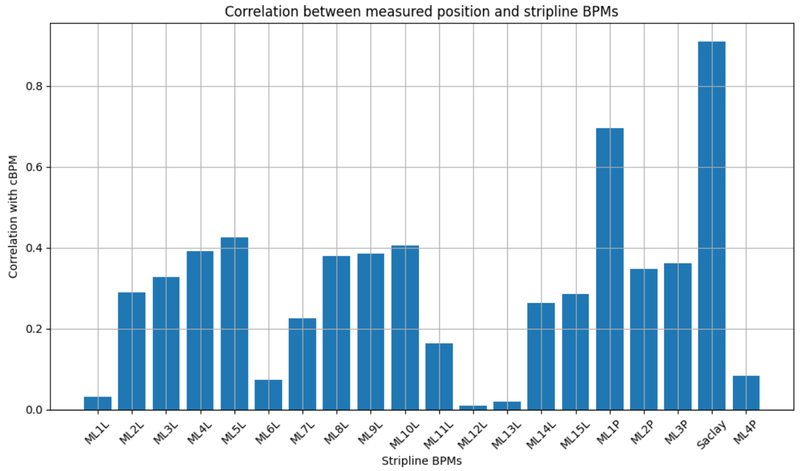
C) Removing BPMs from the study

Based on correlation coefficients

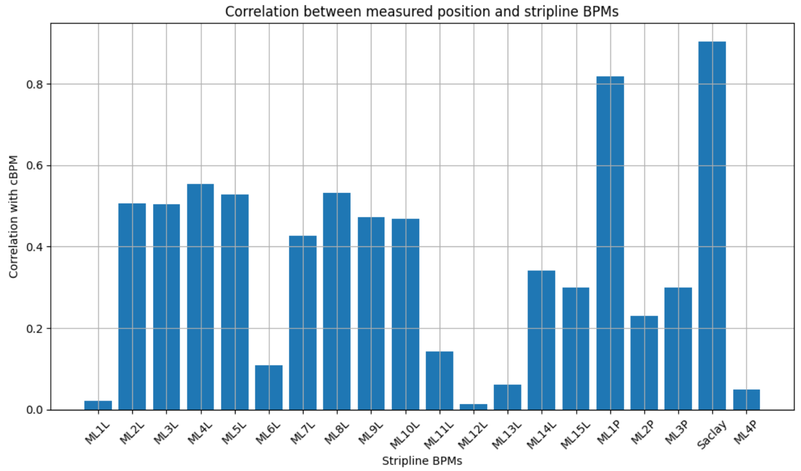
Calculated with `np.corrcoef(matrix)` from the Covariance matrix

$$R_{ij} = \frac{C_{ij}}{\sqrt{C_{ii} C_{jj}}}$$

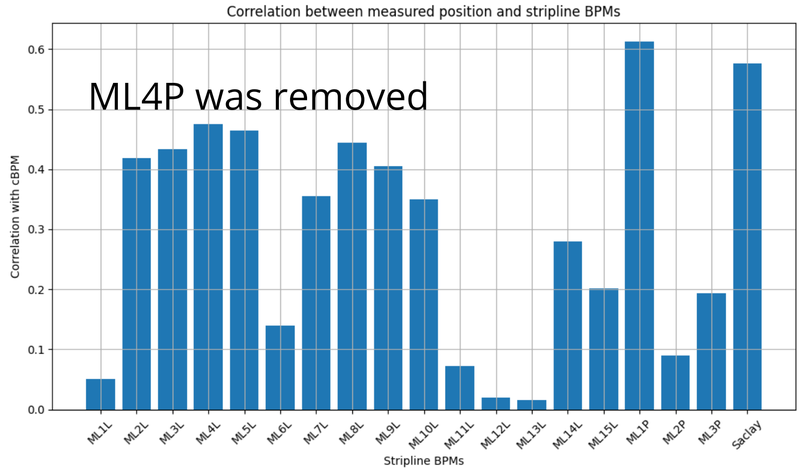
S5_res_001_IFIC_Y_1DC



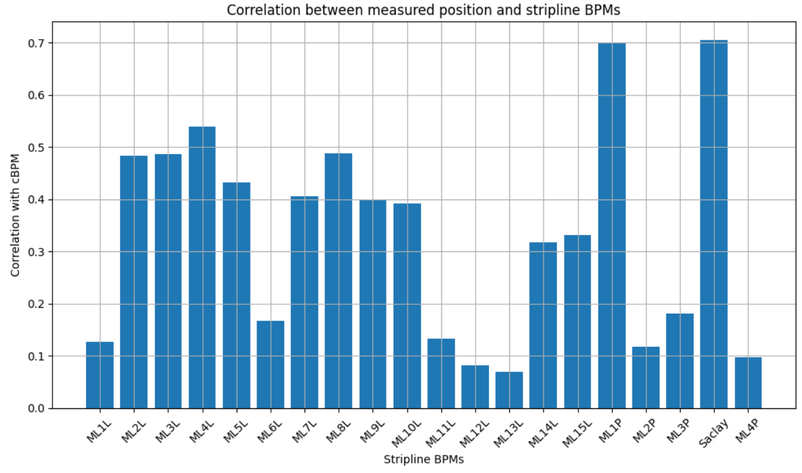
S5_res_002_IFIC_Y_1DC



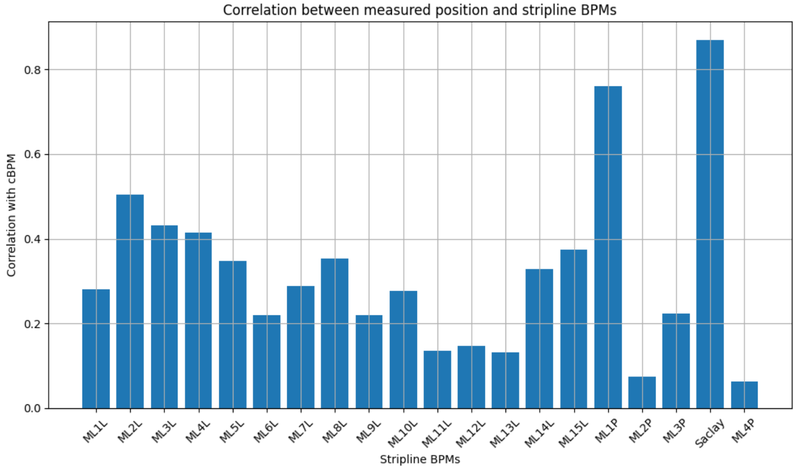
S5_res_003_IFIC_Y_1DC



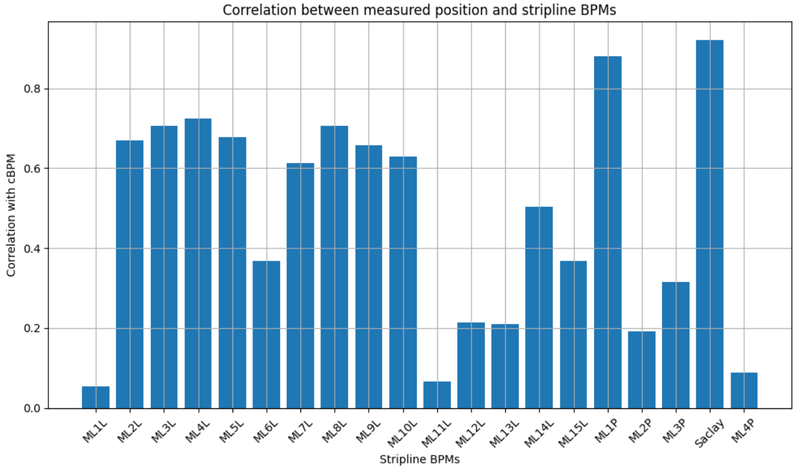
S5_res_004_IFIC_Y_1DC



S5_res_005_IFIC_Y_1DC



S5_res_006_IFIC_Y_1DC

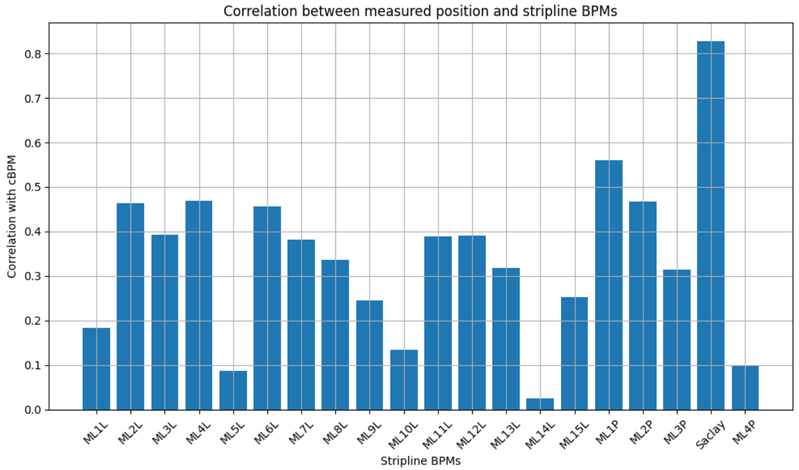


I. Resolution estimation results

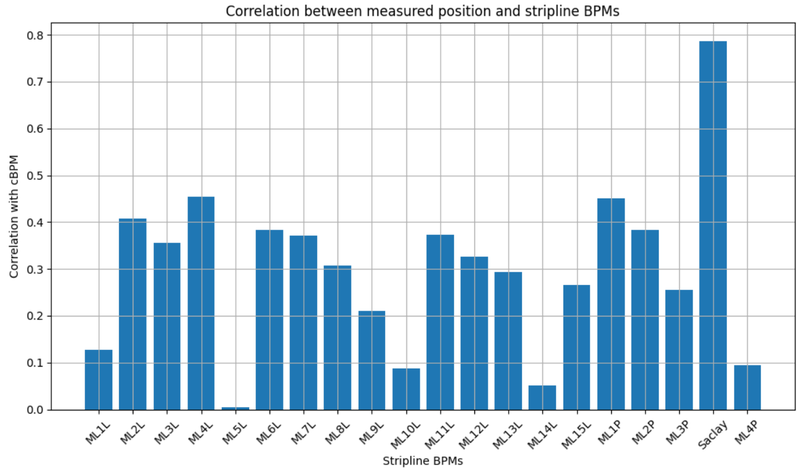
Based on correlation coefficients

C) Removing BPMs from the study

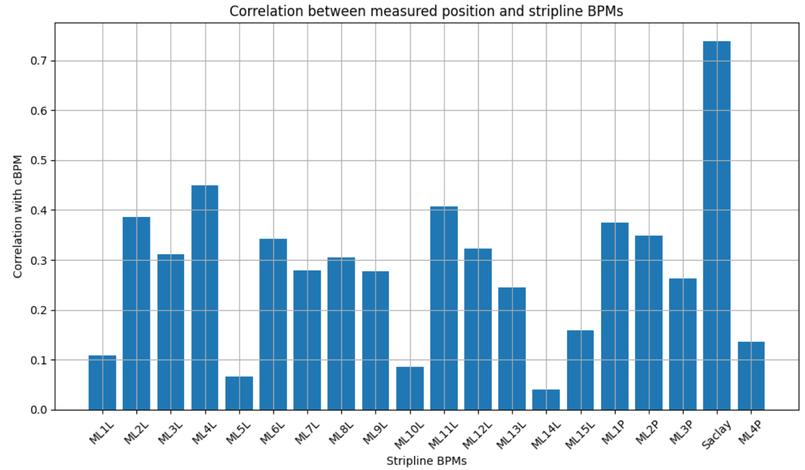
S6_res_004_IFIC_Y_1DC



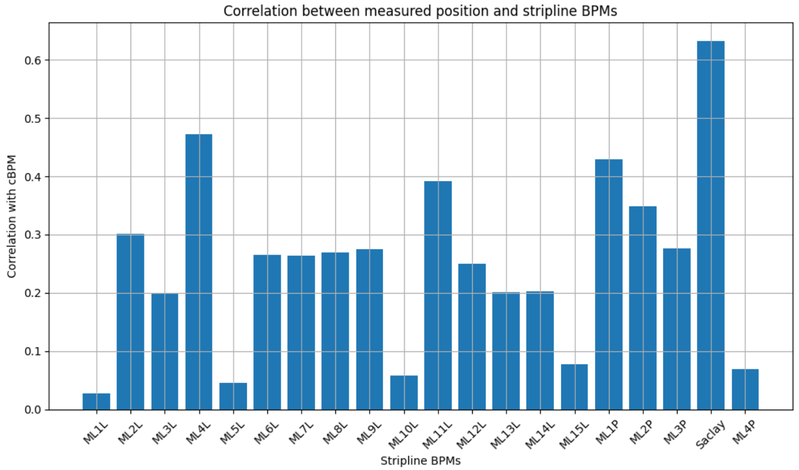
S6_res_005_IFIC_Y_1DC



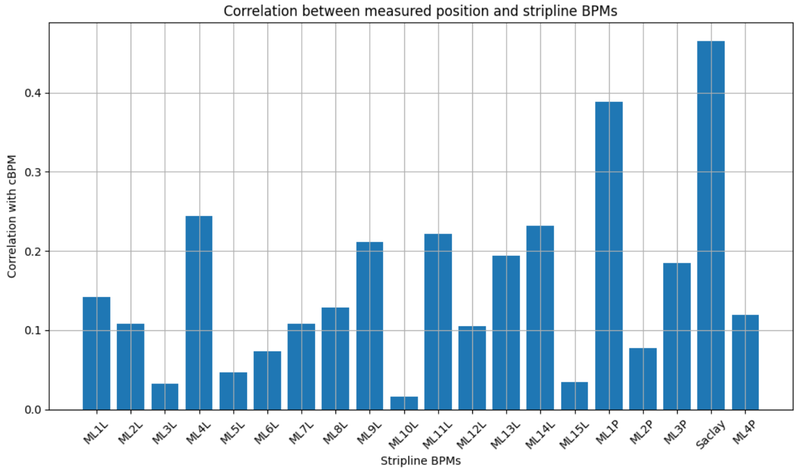
S6_res_006_IFIC_Y_1DC



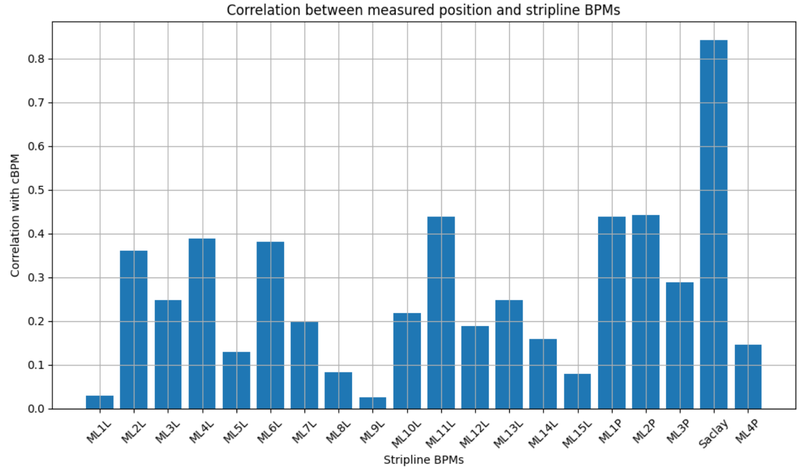
S6_res_007_IFIC_Y_1DC



S6_res_008_IFIC_Y_1DC



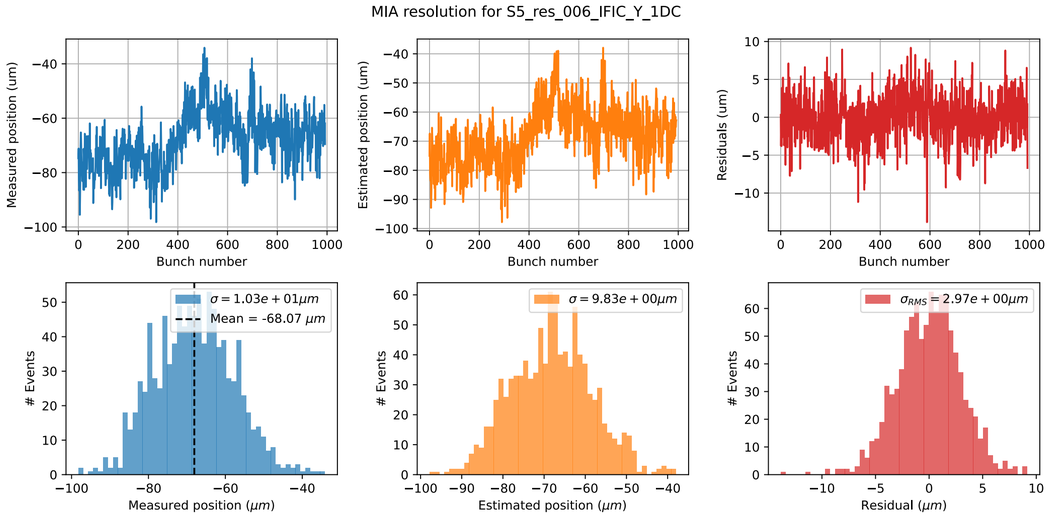
S6_res_006_IFIC_Y_1DC



I. Resolution estimation results

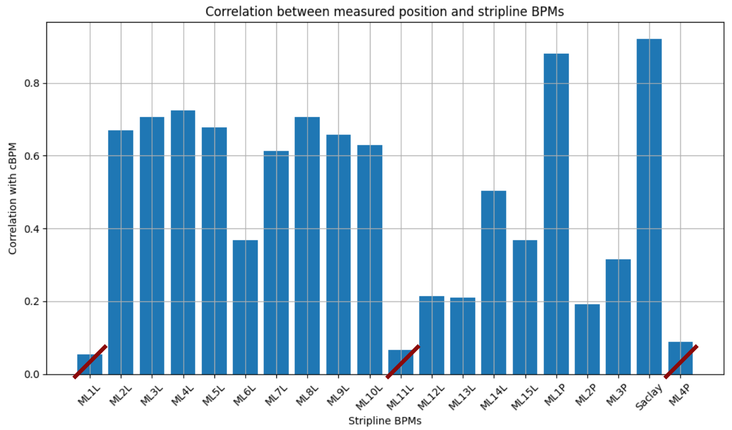
C) Removing BPMs from the study

Based on correlation coefficients

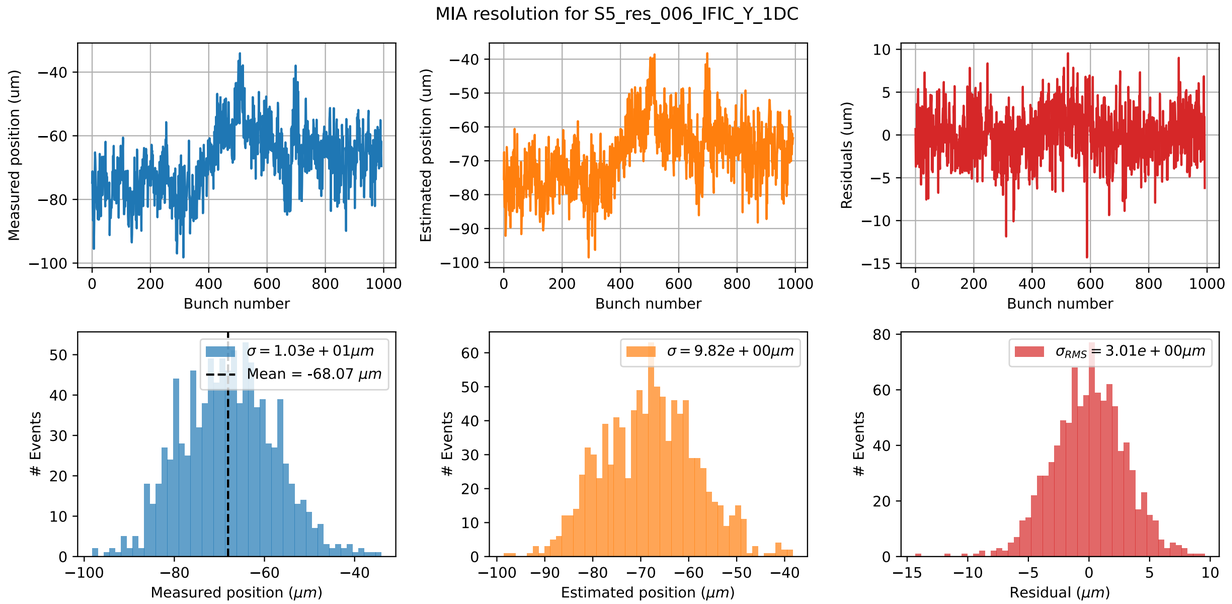


RESOLUTION with other cBPM			
resolution_			
	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
2.97	2.34	0.59	2.46

S5_res_006_IFIC_Y_1DC



After removing BPMs ML1L, ML11L, and ML4P

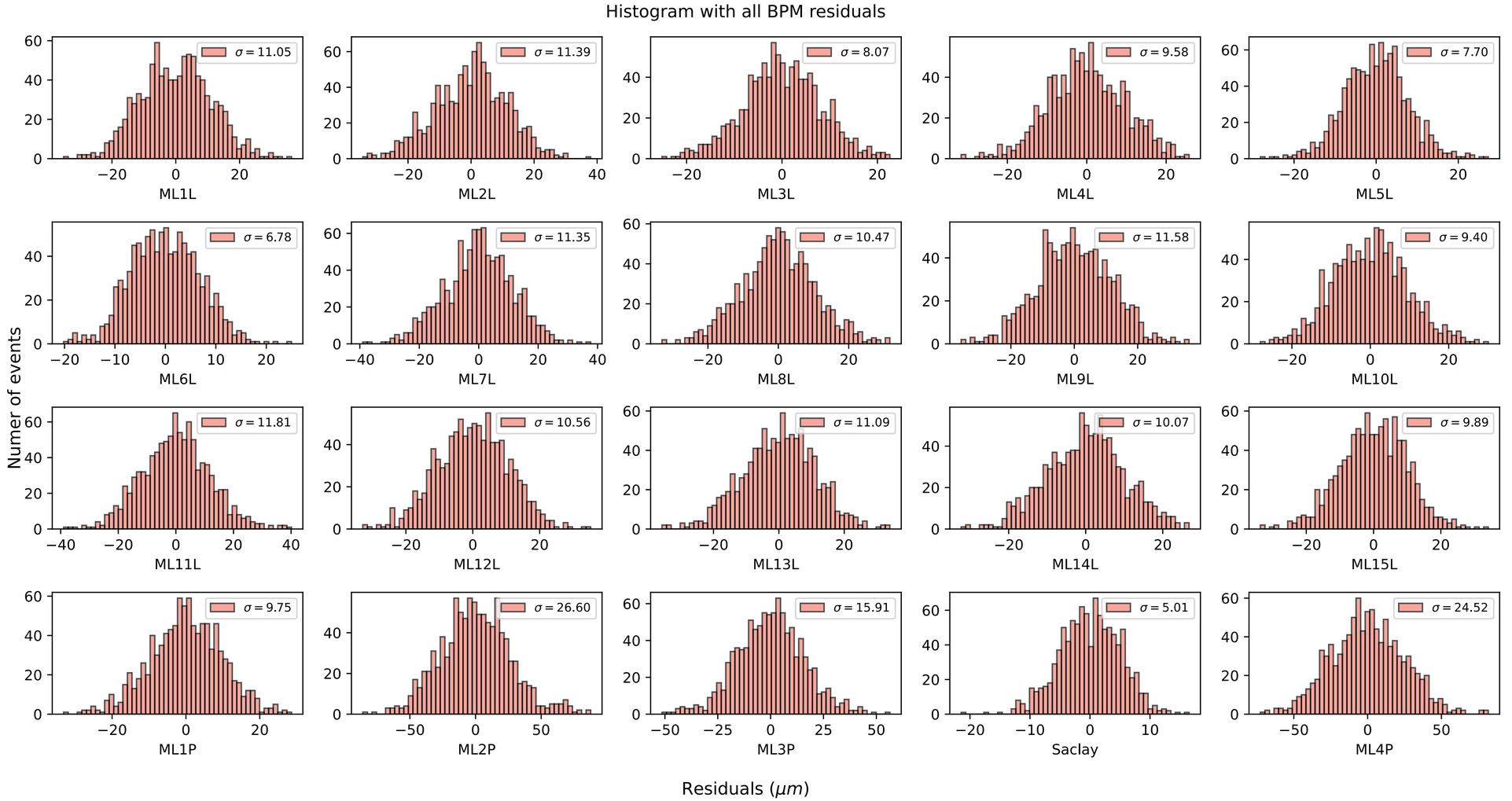


RESOLUTION with other cBPM			
resolution_2			
	res_err_n	res_err_c	res_err_2
(um)	(um)	(um)	(um)
3.01	2.38	0.54	2.49

I. Resolution estimation results

Based on the BPMs resolution

C) Removing BPMs from the study



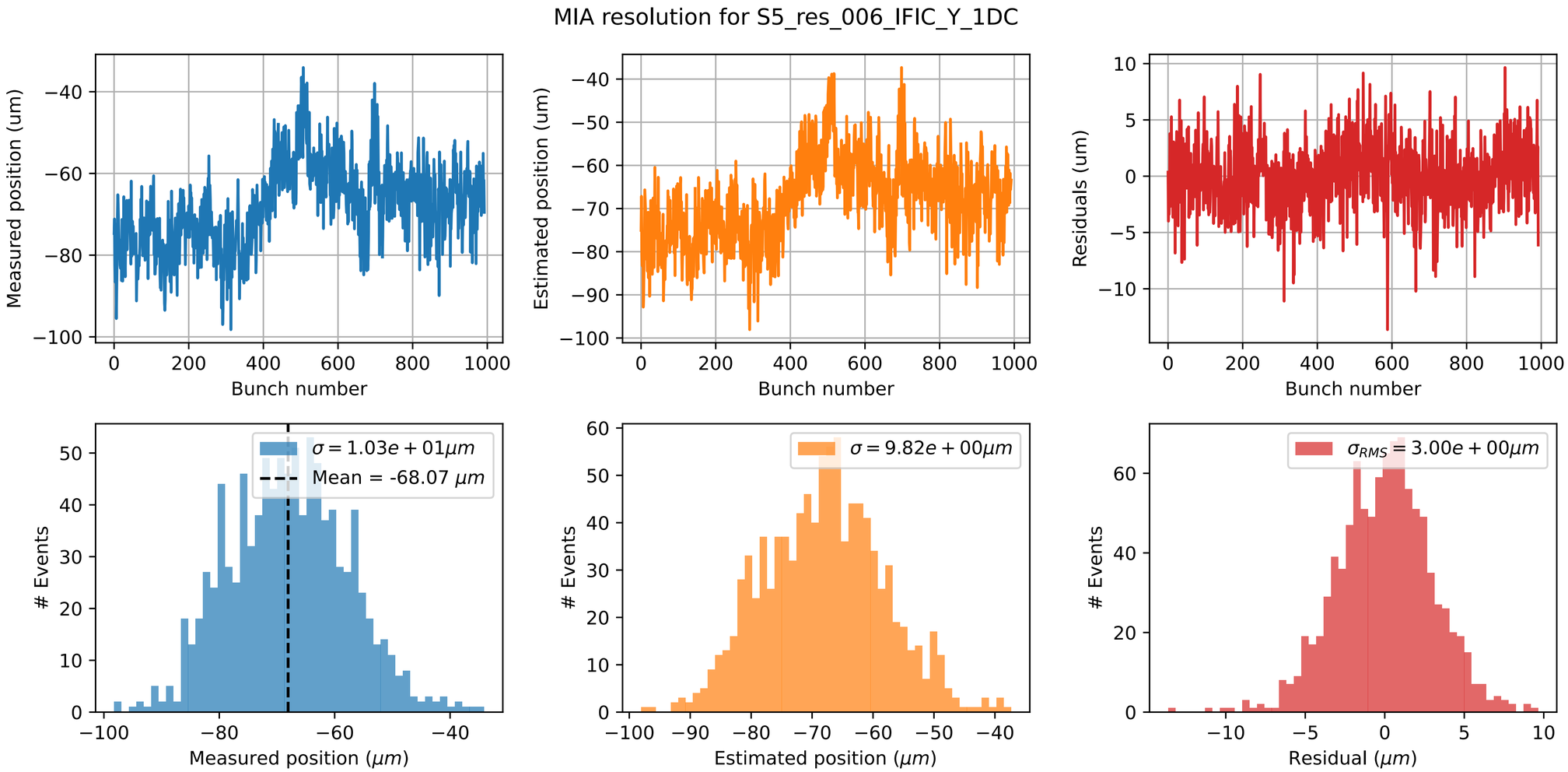
BPMs ML2P and ML4P are the ones consistently presenting a resolution above 25 μm for this shift and others.

I. Resolution estimation results

C) Removing BPMs from the study

Based on the BPMs resolution

After removing BPMs
ML2P and ML4P



with similar errors

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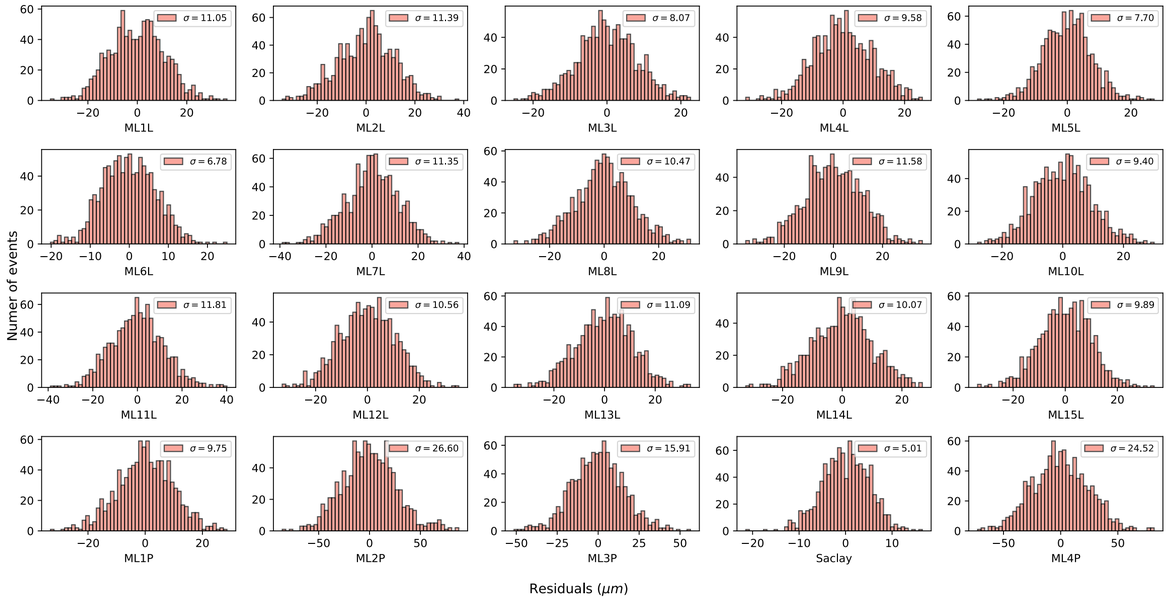
Conclusion

II. Pseudo-inverse method limitations

A) Pseudo-experiments

Contribution of the resolution of other BPMs:

The previous method is employed for all BPMs:



Stripline BPMs showed resolutions between 7 μm and 25 μm, while the CEA-Saclay cBPM has shown to have a resolution of 3 μm under these beam conditions.

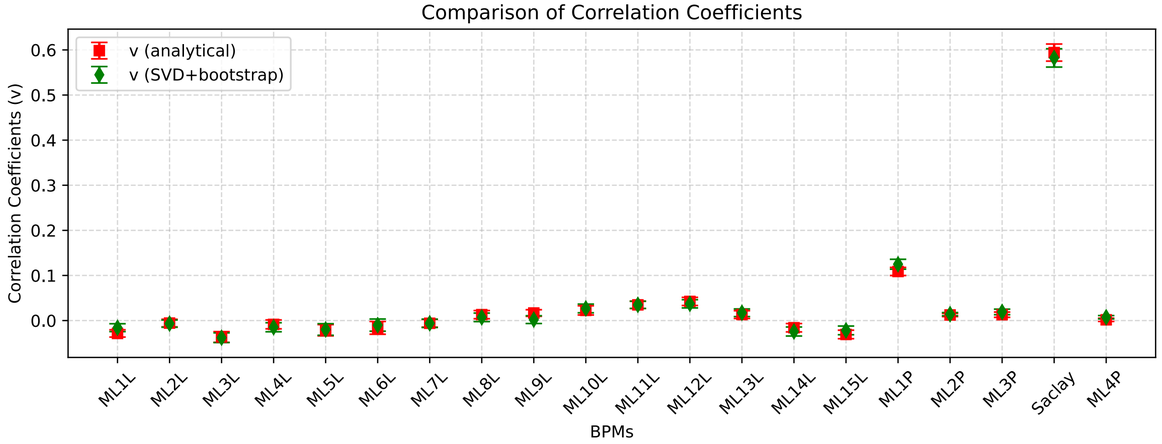
Uncertainties on the correlation coefficients from MIA:

- **Analytically:**
  from the square root of the diagonal elements of the covariance matrix $Cov(\mathbf{v})$, where

$$Cov(\mathbf{v}) = \sigma_{\hat{d}}^2 \left[\mathbf{D}^T\mathbf{D}\right]^{-1} = \frac{\| \mathbf{R} \|^2}{P-1} \left[\mathbf{D}^T\mathbf{D}\right]^{-1}$$

  assuming measurement noise in the cBPM is uncorrelated across pulses.

- **Via Bootstrap method:**
  resampling pulses from $\mathbf{d}$ and $\mathbf{D}$ with replacement and recalculating $\mathbf{v} = \mathbf{D}^{-1} \cdot \mathbf{d}$



II. Pseudo-inverse method limitations

A) Pseudo-experiments

Influence of BPMs resolution and correlation coefficient errors on the resolution estimation:

$$\mathbf{d} = \mathbf{D} \cdot \mathbf{v}$$

$$\begin{pmatrix} d_{k0} \\ d_{k1} \\ \vdots \\ d_{kP} \end{pmatrix} = \begin{pmatrix} d_{00} & d_{10} & \dots & d_{i\neq k,0} & \dots & d_{M0} \\ d_{01} & d_{11} & \dots & d_{i\neq k,1} & \dots & d_{M1} \\ \vdots & \vdots & & \vdots & & \vdots \\ d_{0P} & d_{1P} & \dots & d_{i\neq k,P} & \dots & d_{MP} \end{pmatrix} \cdot \begin{pmatrix} v_0 \\ v_1 \\ \vdots \\ v_M \end{pmatrix}$$

To find the correlation coefficients: $\mathbf{v} = \mathbf{D}^{-1} \cdot \mathbf{d}$ → done **for all events**

Estimated lower limit resolution:

Table 2: Resolution error contributions breakdown from pseudo-experiments method (in μm).

	Meas. res	**Resolution error**		
	σ	$\sigma_{err,BPMs}$	$\sigma_{err,v}$	σ_{err}
Striplines only	**4.17**	3.30	0.78	3.44
with Saclay cBPM	**2.98**	2.34	0.59	2.46

➡ **For a given bunch i and a simulation l:** We simulate the noise with $\sigma_{strip,i}$ and σ_{v_i} in $\mathbf{E}_{l,i}$ which is added to $\mathbf{D}_i$ and $\mathbf{v}_i$:

The simulated estimation position is: $\mathbf{D}_{sim,l,i} \cdot \mathbf{v}_{sim,l,i}$ where $\mathbf{D}_{sim,l,i} = \mathbf{D}_i + \mathbf{E}_{D,l,i}$ and $\mathbf{v}_{sim,l,i} = \mathbf{v}_i + \mathbf{E}_{v,l,i}$

The simulated residuals between measured position and estimated position are calculated as: $\mathbf{R}_{sim,l,i} = \mathbf{d}_i - \mathbf{D}_{sim,l,i} \cdot \mathbf{v}_{sim,l,i}$

We observe the standard deviation of the residuals for a given bunch i across all L simulations:

$\sigma_{residuals,i}(\mathbf{R}_{sim,l,i})$ Performing simulations over several bunches, determines the expected resolution error.

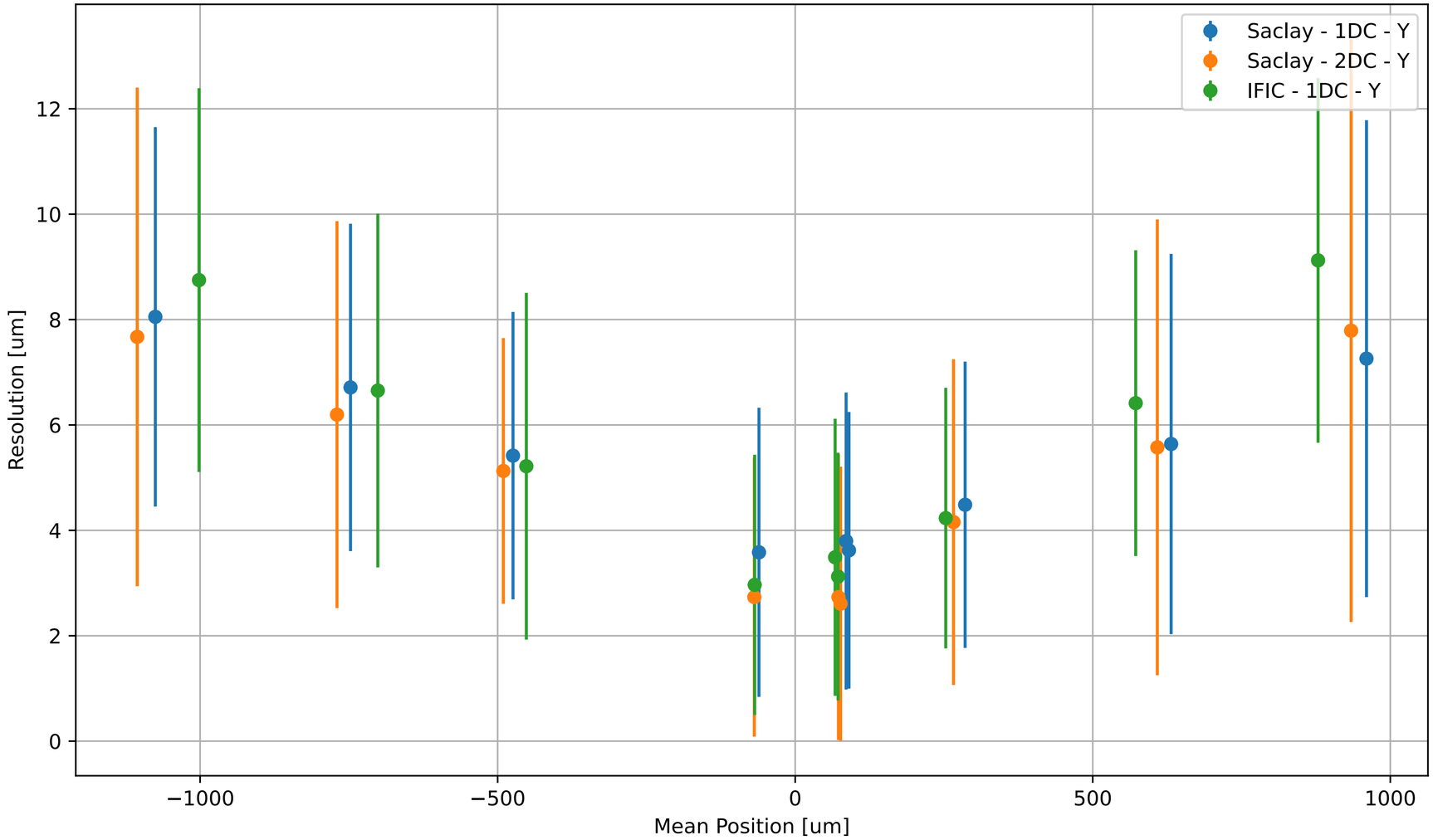
II. Pseudo-inverse method limitations

B) Resolution as a function of beam mean position

Runs no. 1 to 9 on shift 5 consisted on resolution measurements at different beam positions for both BPMs simultaneously.

The estimated resolution + the uncertainty on the resolution is plotted here.

To be studied: why Saclay 1DC and Saclay 2DC yield different positions for a similar run?



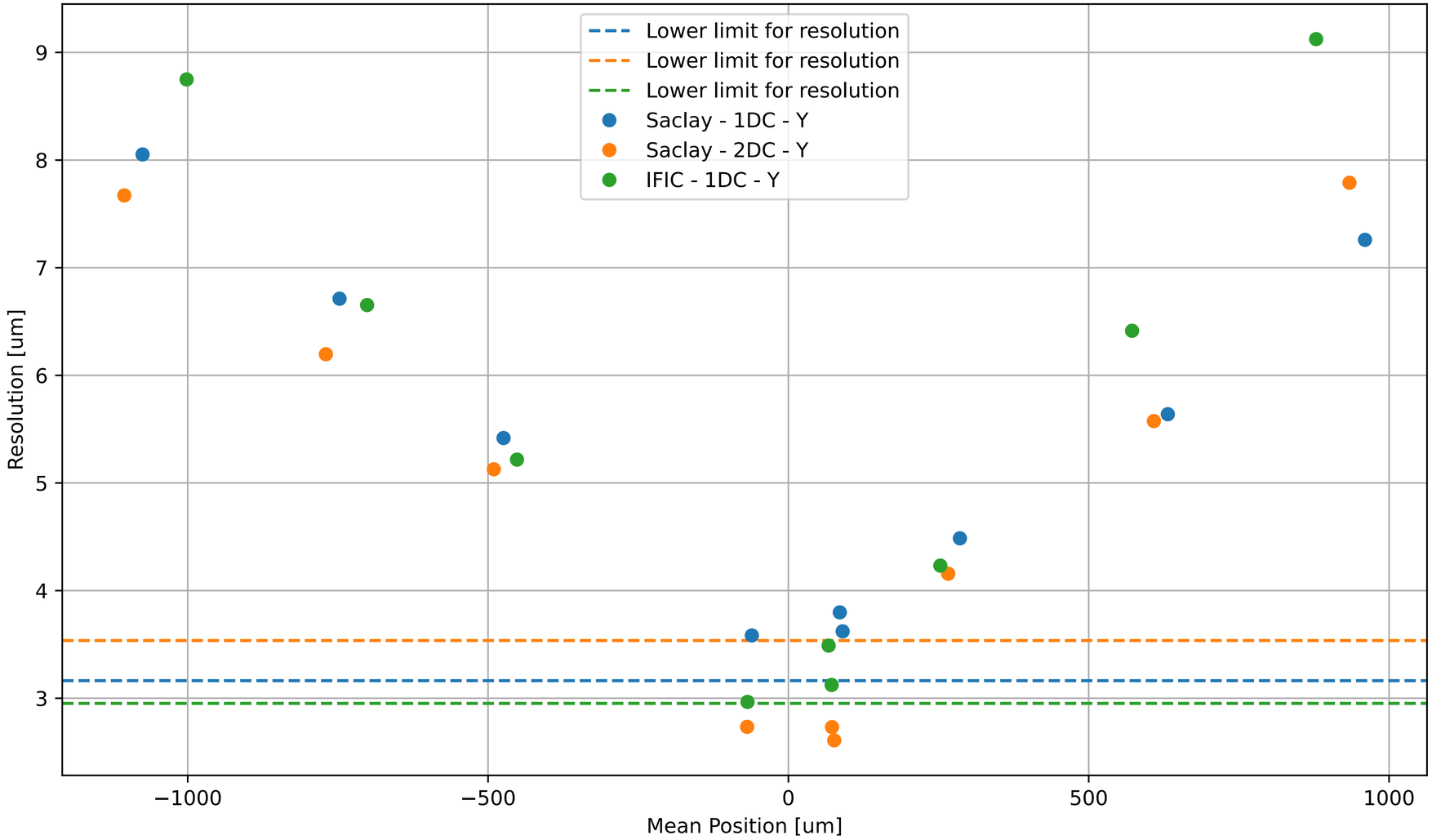
II. Pseudo-inverse method limitations

B) Resolution as a function of beam mean position

Runs no. 1 to 9 on shift 5 consisted on resolution measurements at different beam positions for both BPMs simultaneously.

The estimated resolution + the lower limit on the resolution estimation is plotted here.

We are also investigating the effect of the beam angle of attack on the resolution measurements.

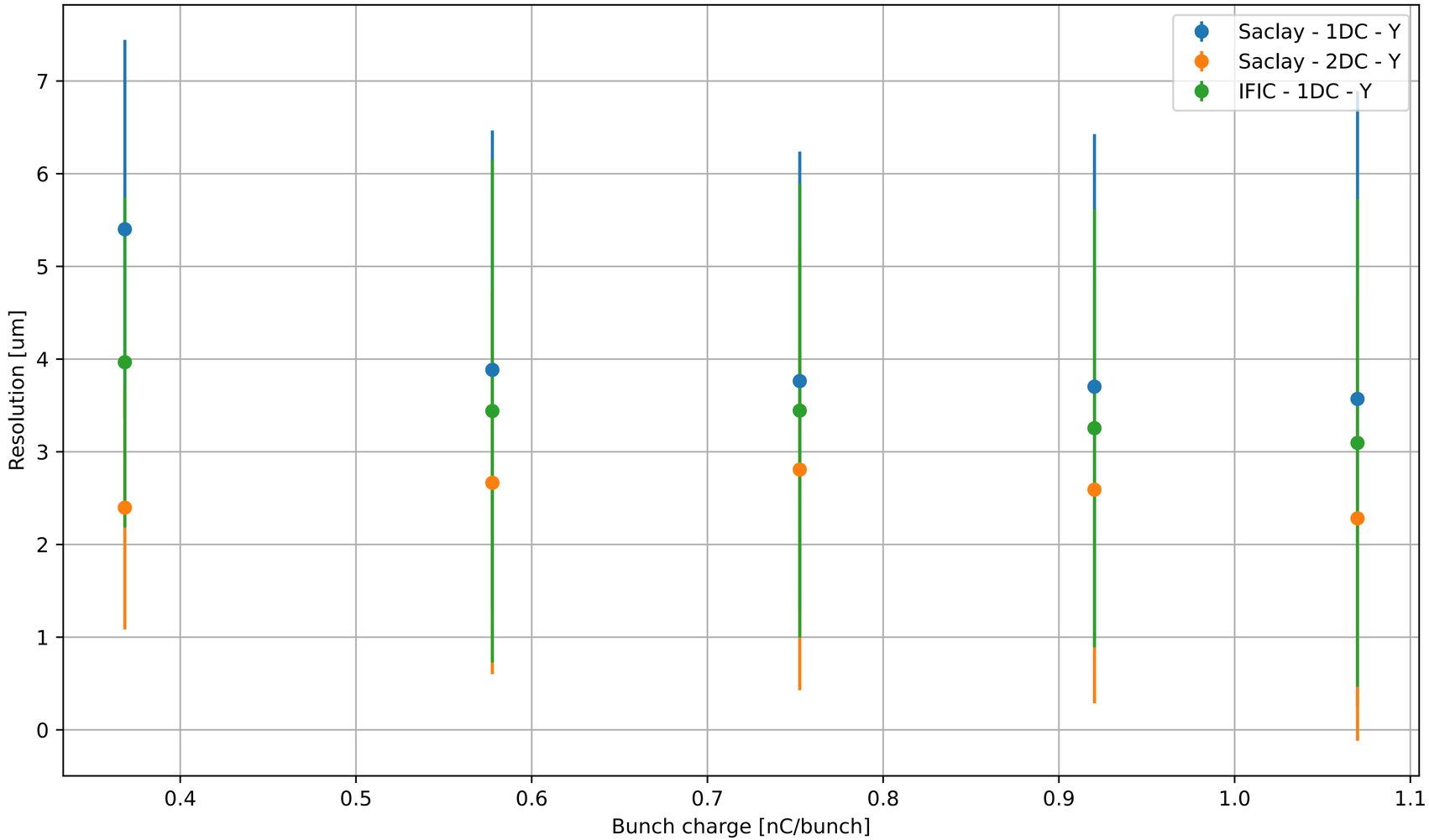


II. Pseudo-inverse method limitations

C) Resolution as a function of bunch charge

Runs no. 10 to 14 on shift 5 consisted on resolution measurements at different bunch charges for both BPMs simultaneously.

The estimated resolution + the uncertainty on the resolution is plotted here.



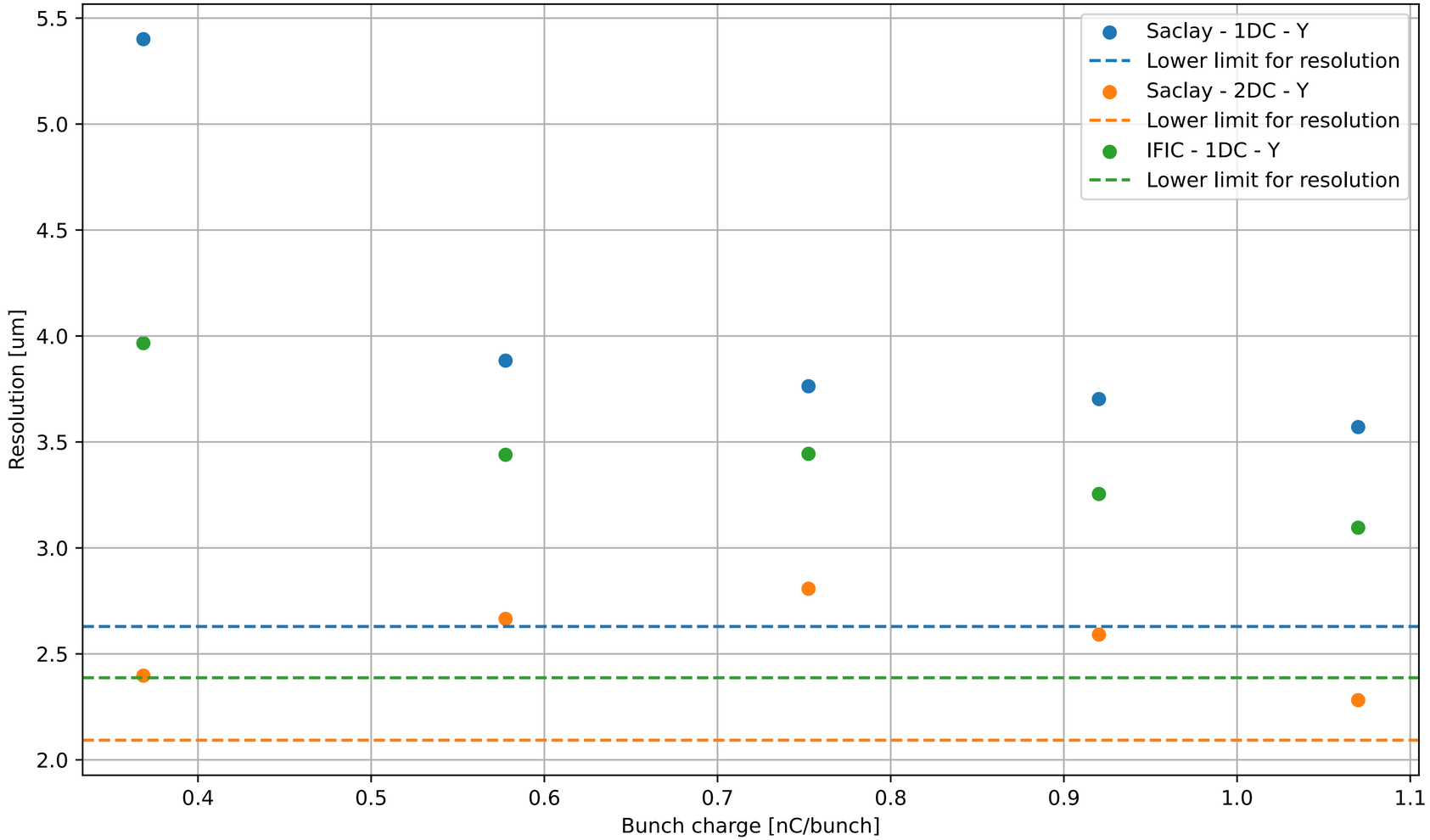
II. Pseudo-inverse method limitations

C) Resolution as a function of bunch charge

Runs no. 10 to 14 on shift 5 consisted on resolution measurements at different bunch charges for both BPMs simultaneously.

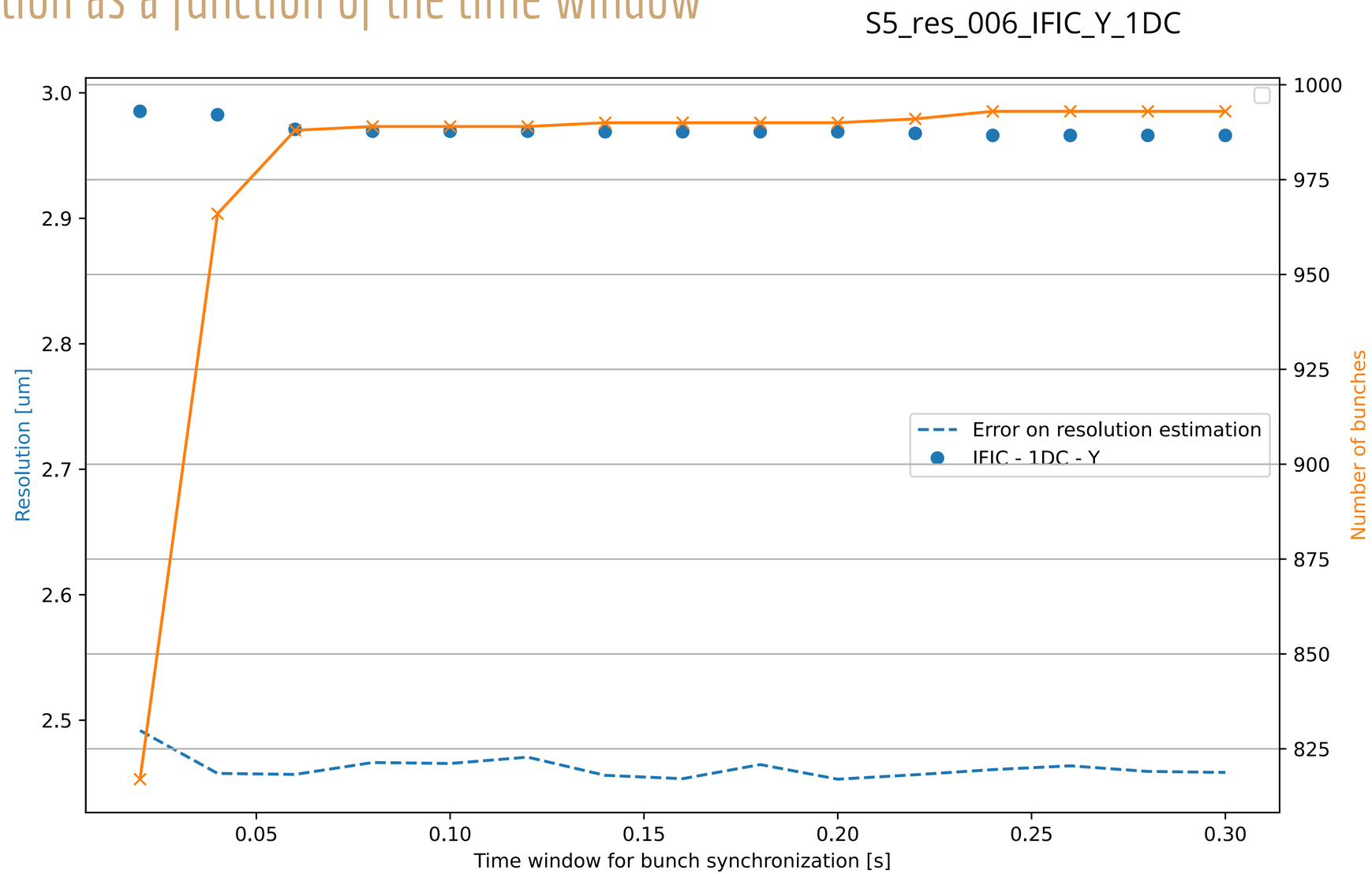
The estimated resolution + the lower limit on the resolution estimation is plotted here.

Differences between 1DC and 2DC are still under investigation via simulations.



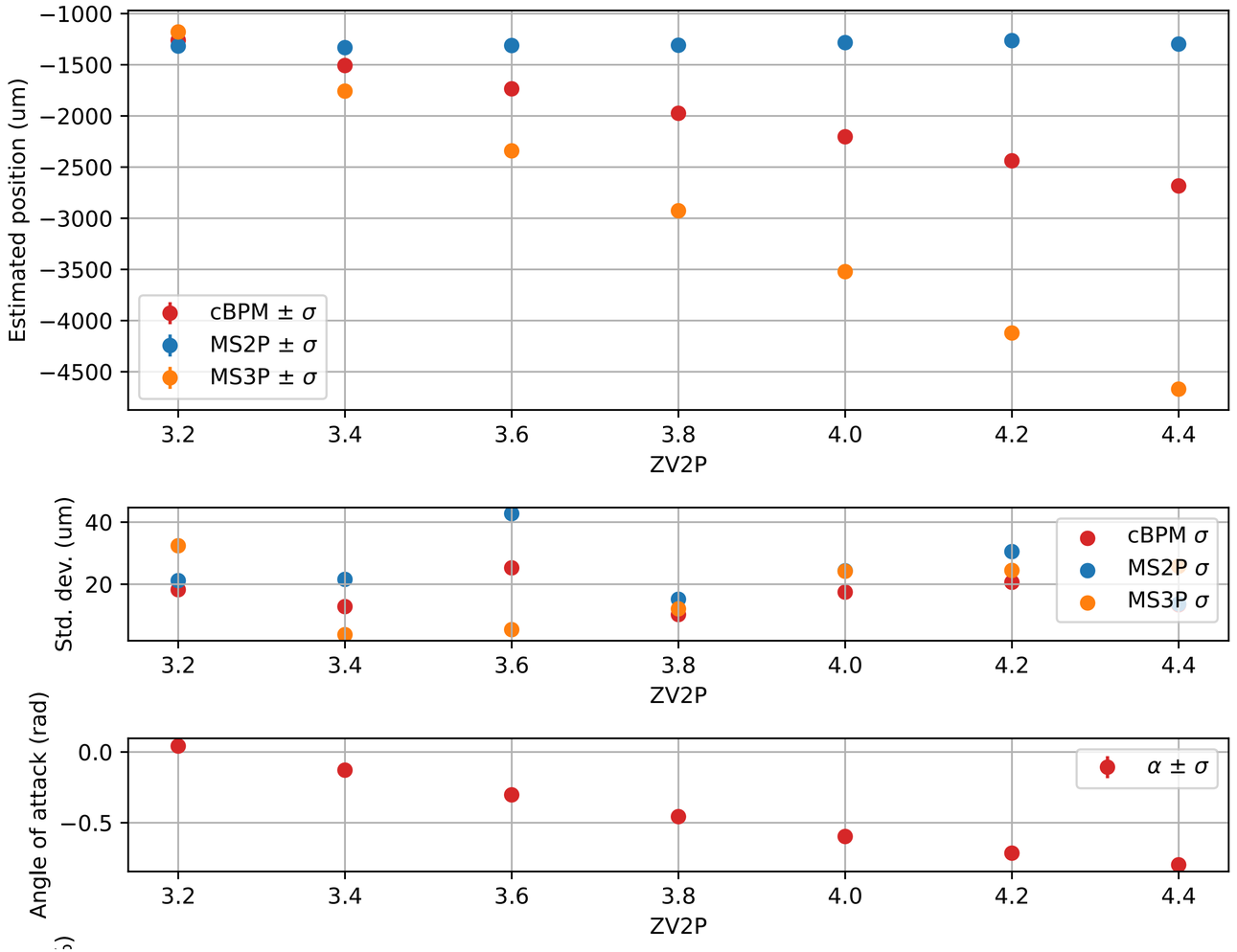
II. Pseudo-inverse method limitations

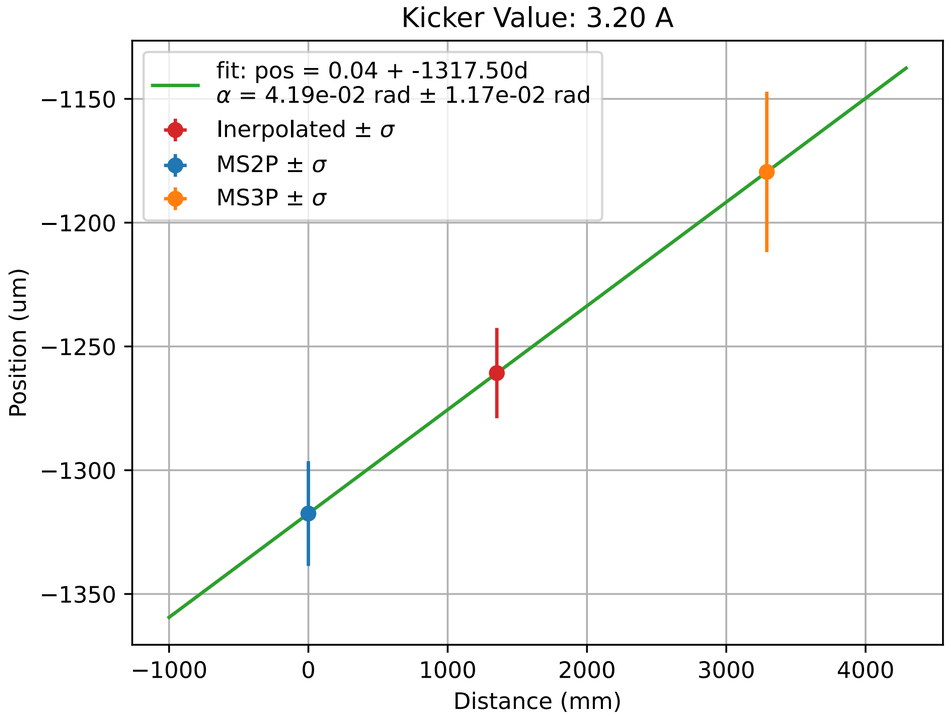
D) Resolution as a function of the time window



II. Pseudo-inverse method limitations

E) Resolution as a function of the angle of attack



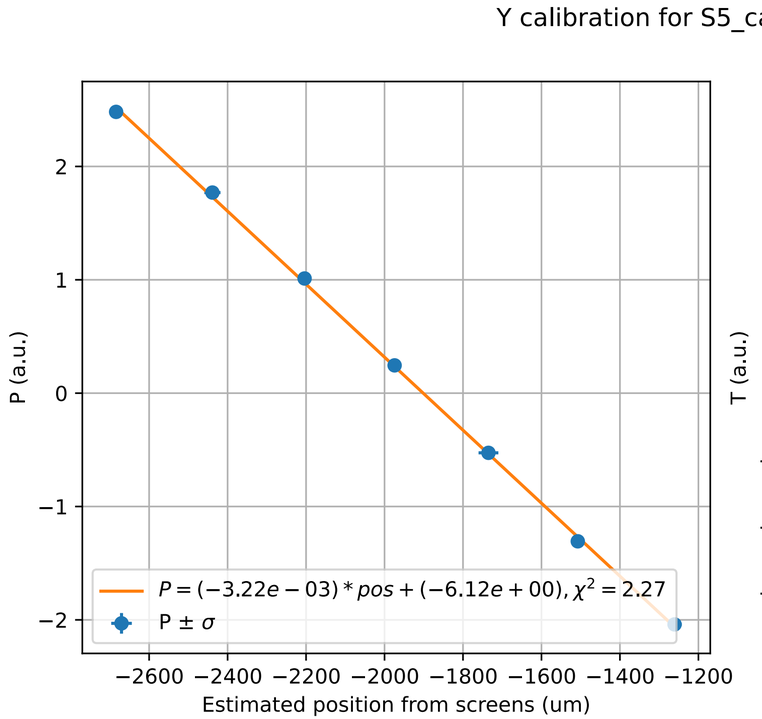


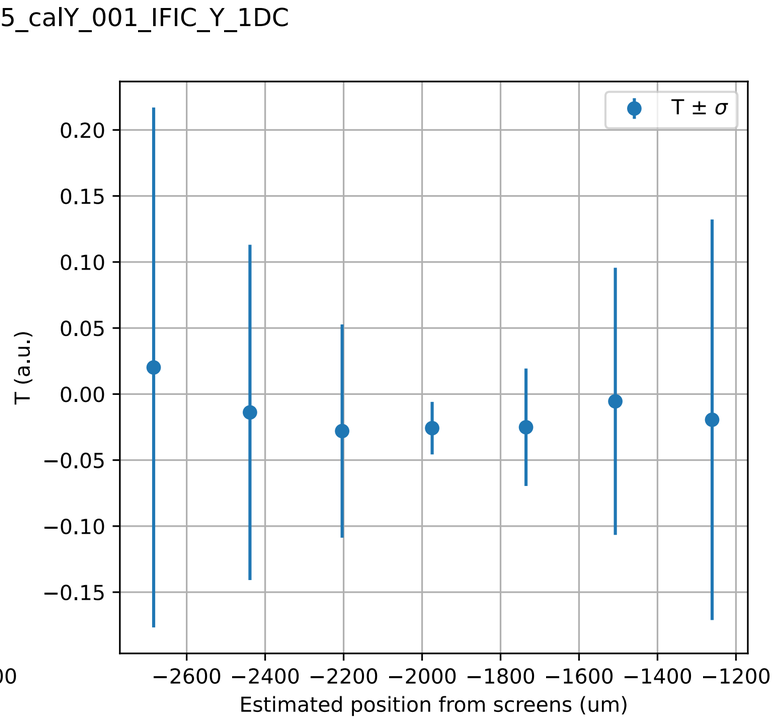
The angle is calculated for each of the steering magnet values to include the angle of attack on the calibration

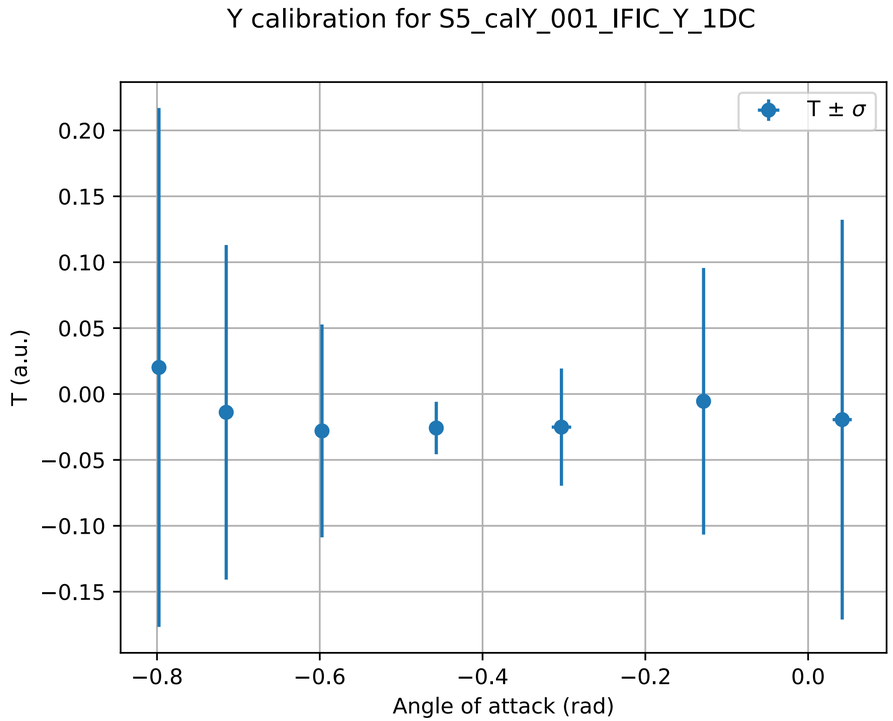
II. Pseudo-inverse method limitations

E) Resolution as a function of the angle of attack

The component T is plotted against the position, and angle of attack:





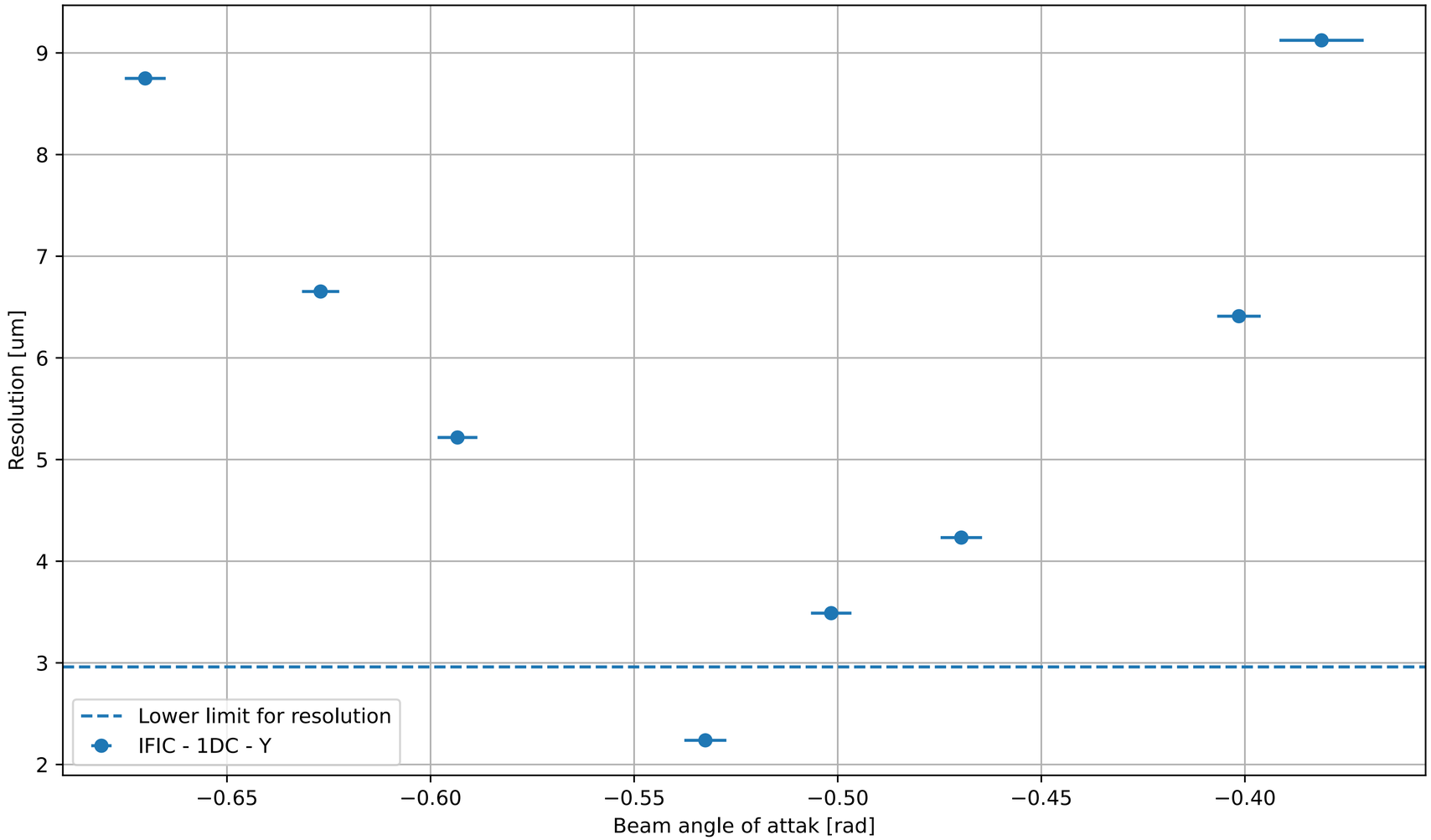


II. Pseudo-inverse method limitations

E) Resolution as a function of the angle of attack

Runs no. 1 to 9 on shift 5 consisted on resolution measurements at different beam positions for both BPMs simultaneously. These can be used for evaluating the angle of attack dependency as well.

The estimated resolution + the lower limit on the resolution estimation is plotted here.



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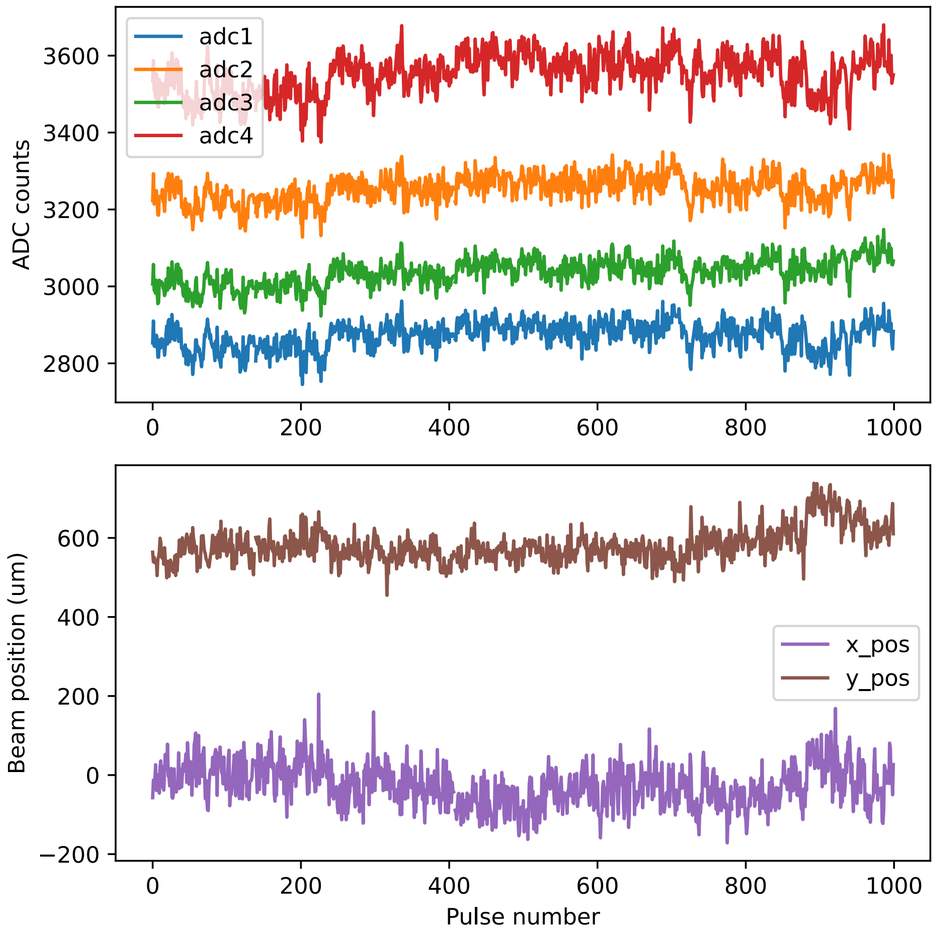
II. Pseudo-inverse method limitations
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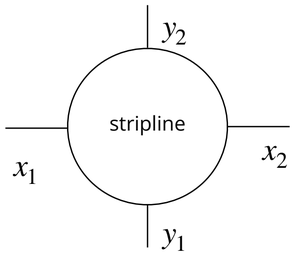
III. Calibration corrections
   A) Compensating for stripline electronics amplitude difference
   B) Inclusion of the profile monitors
   C) ...

Conclusion

III. Calibration corrections

A) Compensating for stripline electronics amplitude difference





The beam position is reconstructed as follows:

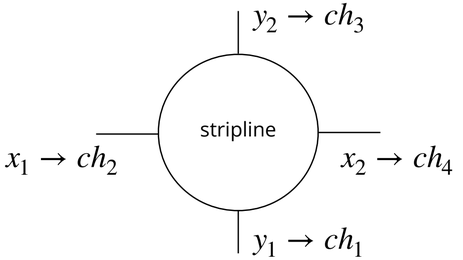
$$x = S_x \frac{x_1 - x_2}{x_1 + x_2 + y_1 + y_2} \qquad y = S_y \frac{y_1 - y_2}{x_1 + x_2 + y_1 + y_2}$$

Having the ADC raw data (and pedestals) and the measured position, the Scaling factor can be determined.

$$S_x = x \frac{x_1 + x_2 + y_1 + y_2}{x_1 - x_2} \qquad S_y = y \frac{x_1 + x_2 + y_1 + y_2}{y_1 - y_2}$$

III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



Procedure to compute the scaling factor for a given BPM:

- The measured position from the BPMs is extracted: $x \rightarrow$ is the "x_pos" registered in EPICS
  $y \rightarrow$ is the "y_pos" registered in EPICS

- The ADC values are cleaned with the pedestals (the pedestals are constants per ADC channel):

$$x_1 = ch_2 - ped_2 \qquad x_2 = ch_4 - ped_4 \qquad y_1 = ch_1 - ped_1 \qquad y_2 = ch_3 - ped_3$$

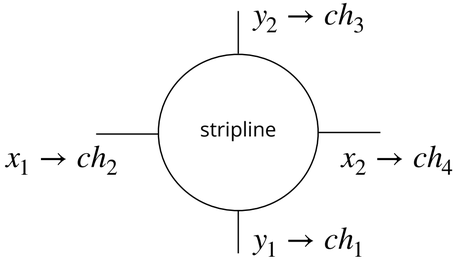
- An array containing the Scaling Factor per pulse is computed as: $S_x = x\dfrac{x_1 + x_2 + y_1 + y_2}{x_1 - x_2}$ $S_y = y\dfrac{x_1 + x_2 + y_1 + y_2}{y_1 - y_2}$

- The mean value $\nu(S_{x,y})$ and standard deviation $\sigma(S_{x,y})$ of the Scaling Factors are computed.

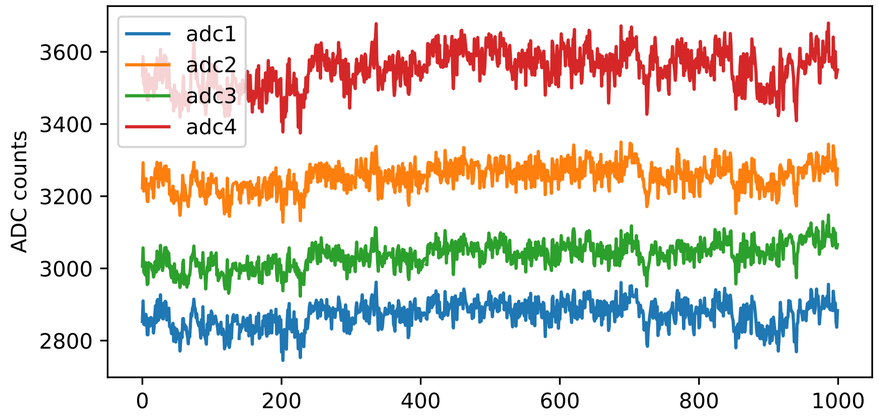
  - The standard deviation $\nu(S_{x,y})$ shouldn't be zero? Why the relationship between the ADC counts and the measured positions varies along the pulses?
  - The following slides show how the Scaling Factor changes as a function of the pulse number. This is particularly noticeable for S_x of ML2P.

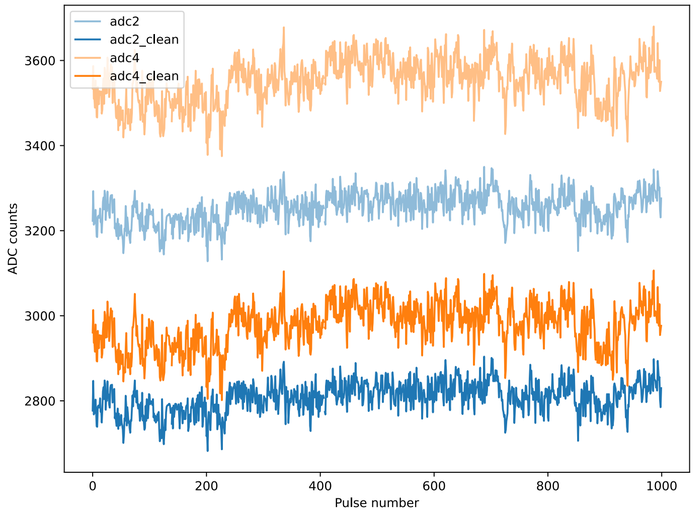
III. Calibration corrections

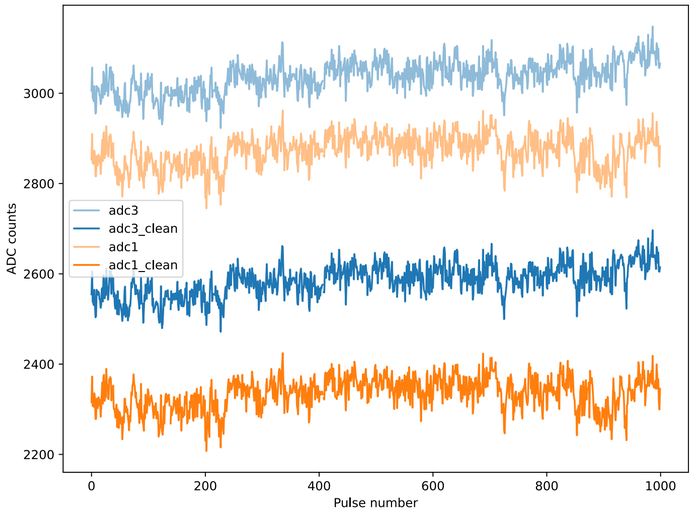
A) Compensating for stripline electronics amplitude difference

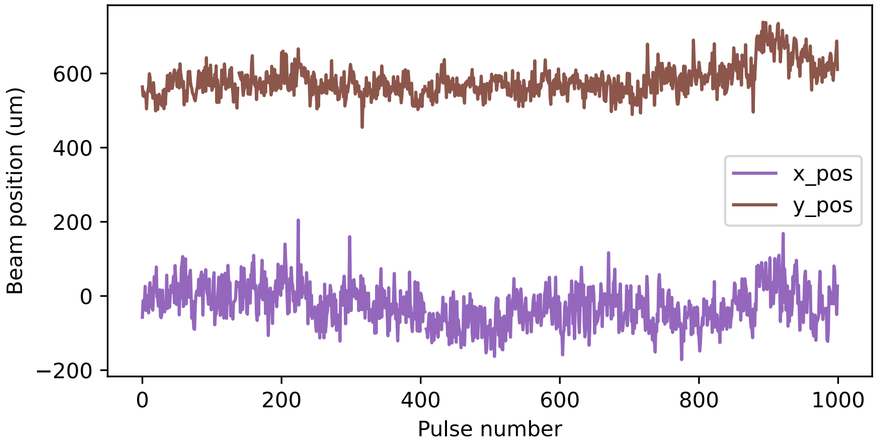


How is the Scaling factor? ML2P



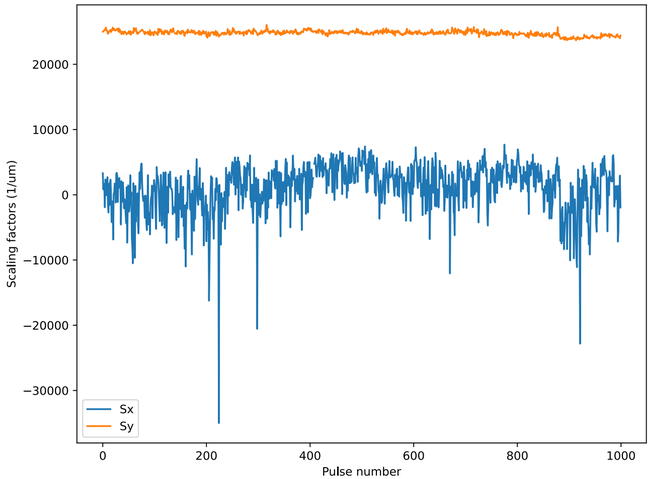






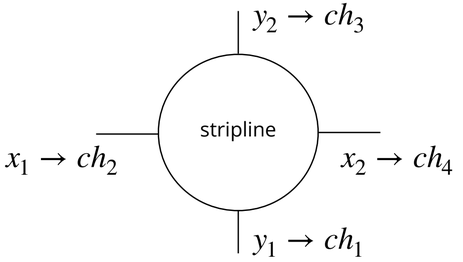
$$S_x = x\frac{x_1 + x_2 + y_1 + y_2}{x_1 - x_2}$$

$$S_y = y\frac{x_1 + x_2 + y_1 + y_2}{y_1 - y_2}$$

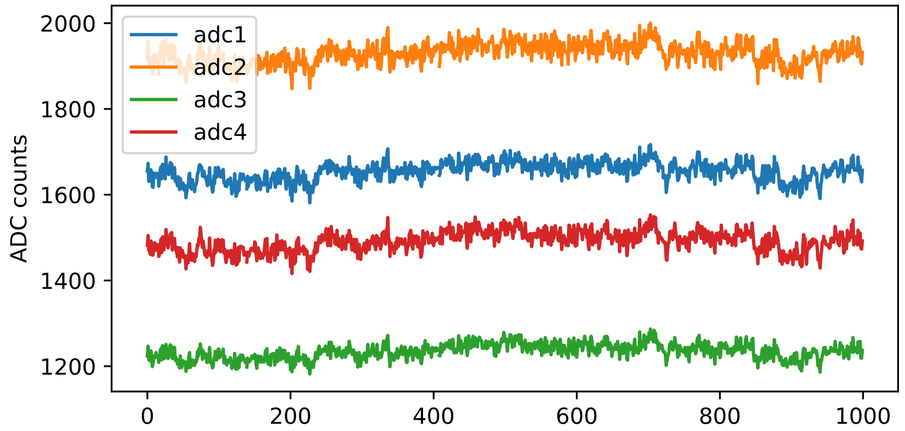


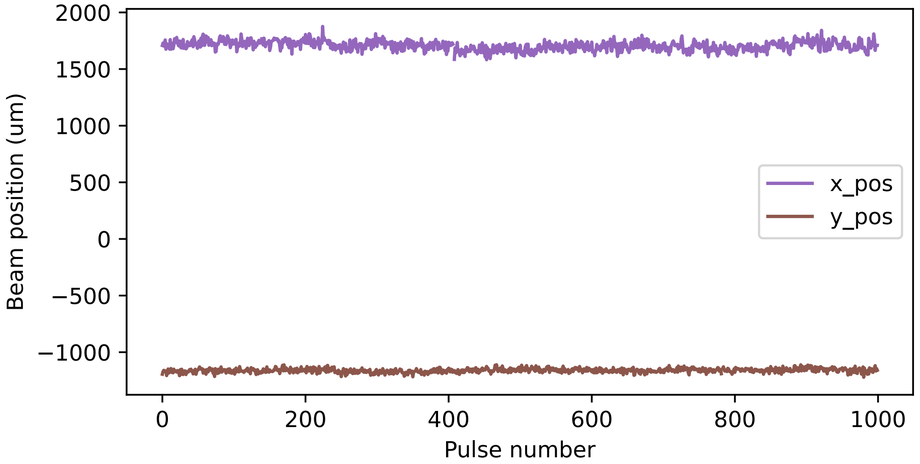
III. Calibration corrections

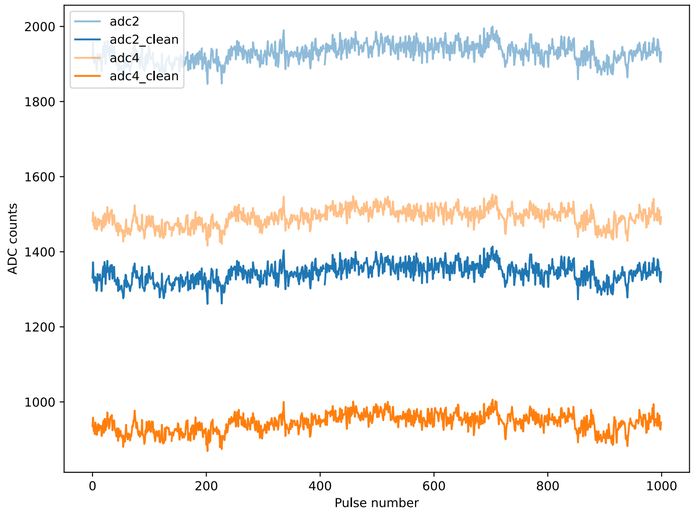
A) Compensating for stripline electronics amplitude difference

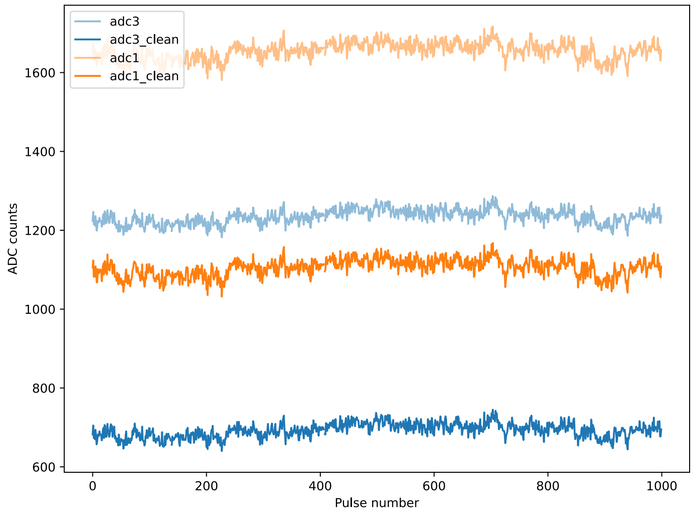


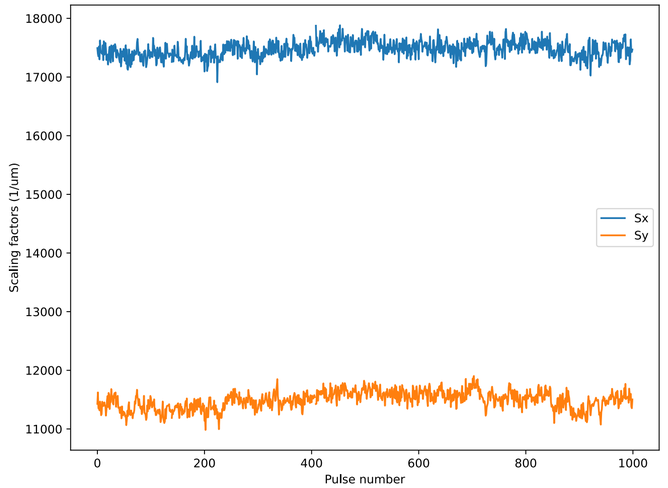
How is the Scaling factor? ML3P





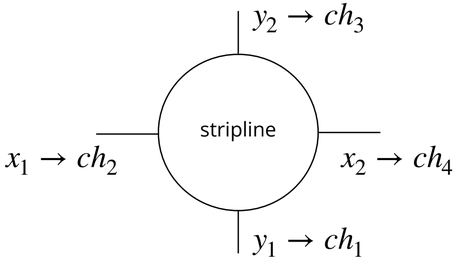




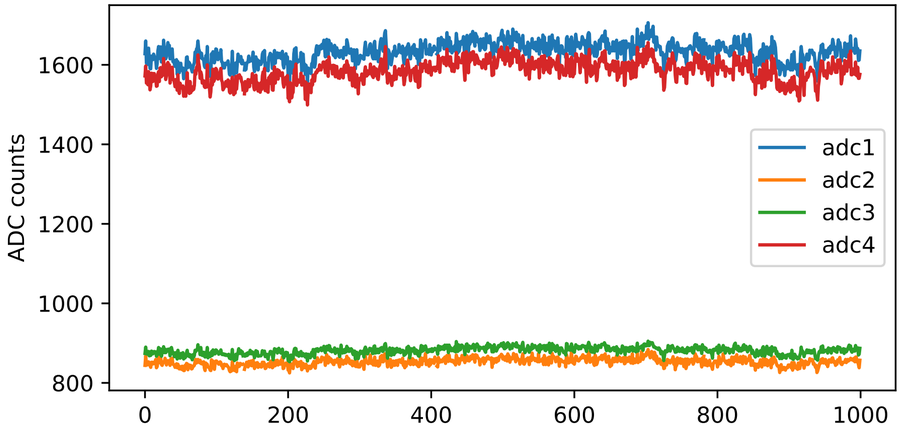


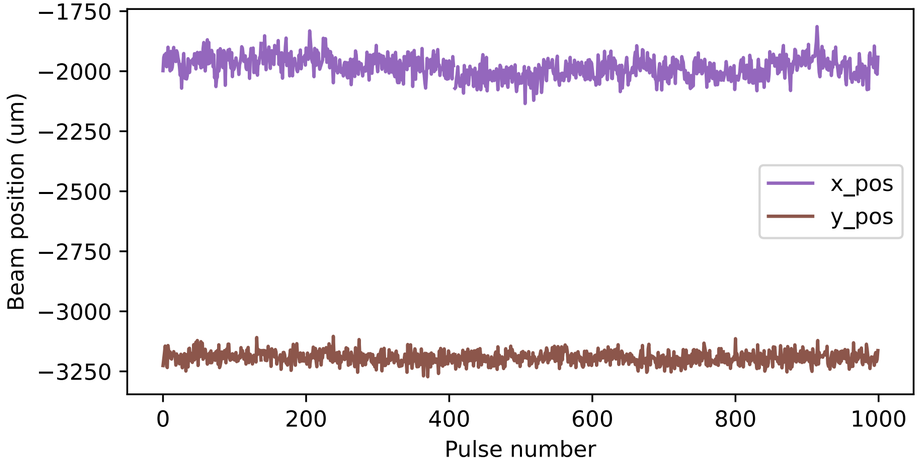
III. Calibration corrections

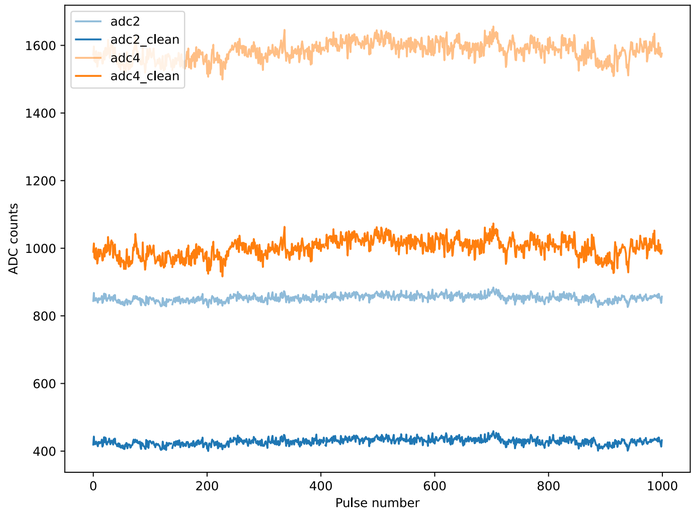
A) Compensating for stripline electronics amplitude difference

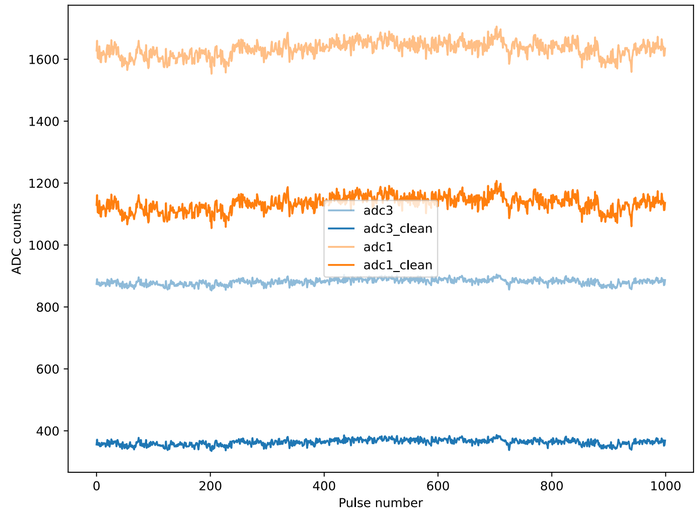


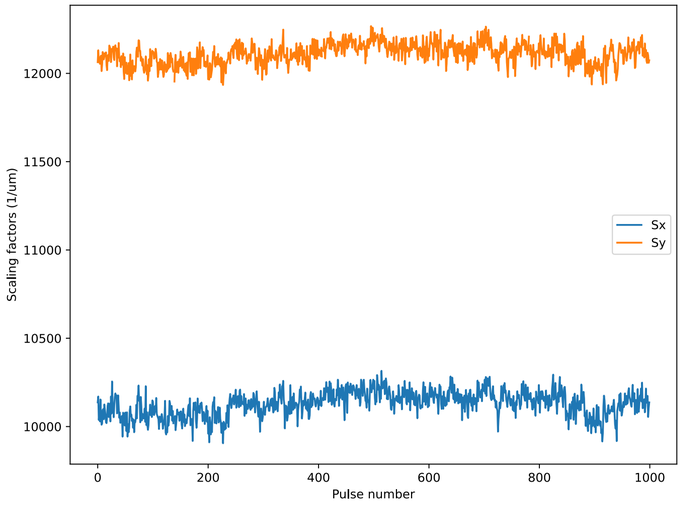
How is the Scaling factor? ML4P





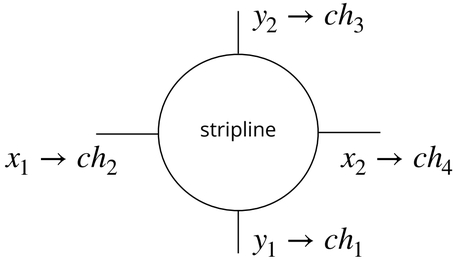






III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



How are the BPMs connected?

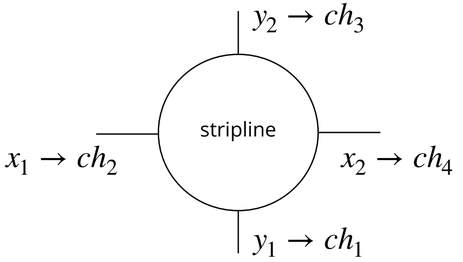
Different connection configurations are evaluated to see how the channels are connected to the BPM.

The relative error (in %) of the scaling factor can be evaluated ($\sigma(S_{x,y})/\nu(S_{x,y}) * 100$) for the different connection configurations

ADC configuration	X: ch1 and ch2 Y: ch3 and ch4	X: ch1 and ch3 Y: ch2 and ch4	X: ch1 and ch4 Y: ch2 and ch3	X: ch2 and ch3 Y: ch1 and ch4	X: ch2 and ch4 Y: ch1 and ch3	X: ch3 and ch4 Y: ch1 and ch2
BPM ML2P σ(Sx) in %	204.4	202.7	220.9	209.7	351.9	241.6
BPM ML2P σ(Sy) in %	14.1	21.4	14.7	7.1	1.3	5.4
BPM ML3P σ(Sx) in %	2.4	2.5	3.7	1.7	0.7	4.3
BPM ML3P σ(Sy) in %	2.2	3.5	1.7	5.3	1.4	4.1
BPM ML4P σ(Sx) in %	1.7	2.5	9.3	10.8	0.8	2.0
BPM ML4P σ(Sy) in %	0.7	1.8	8.8	7.4	0.3	1.1

III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



Correcting the electronics gain:

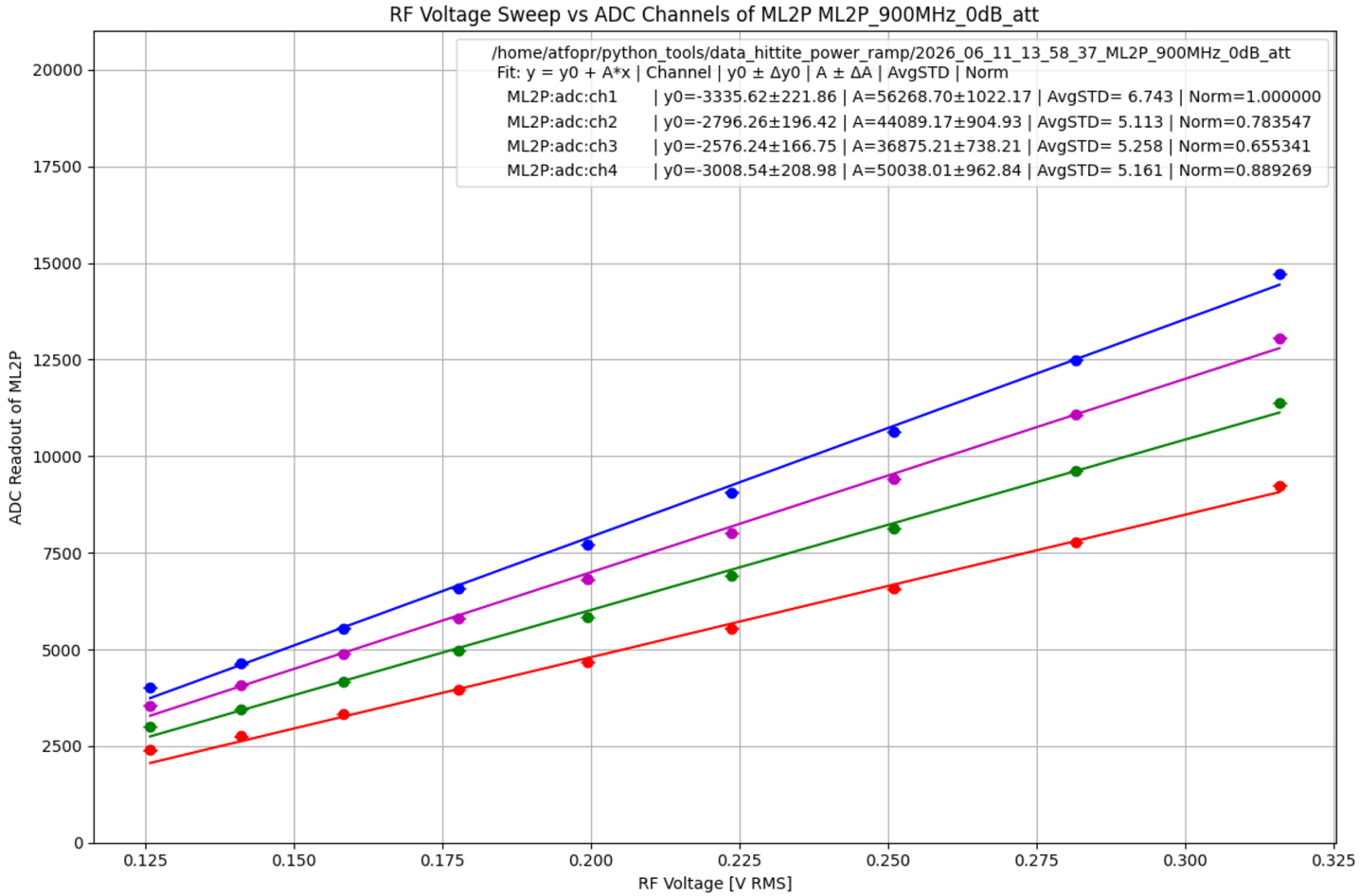
The stripline electronics have slightly different gains for the 4 channels.

So for same RF input voltage, the ADC readout gives different magnitudes.

This can be compensated on post processing by applying the correction factors CF to each ADC channel, compared to the channel that gives the highest gain.

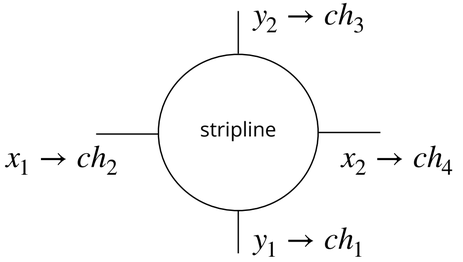
From the example of ML2P:

$$ch_{1,corr} = ch_1$$
$$ch_{2,corr} = ch_2/0.783547$$
$$ch_{3,corr} = ch_3/0.655341$$
$$ch_{4,corr} = ch_4/0.889269$$



III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



Correcting the electronics gain:

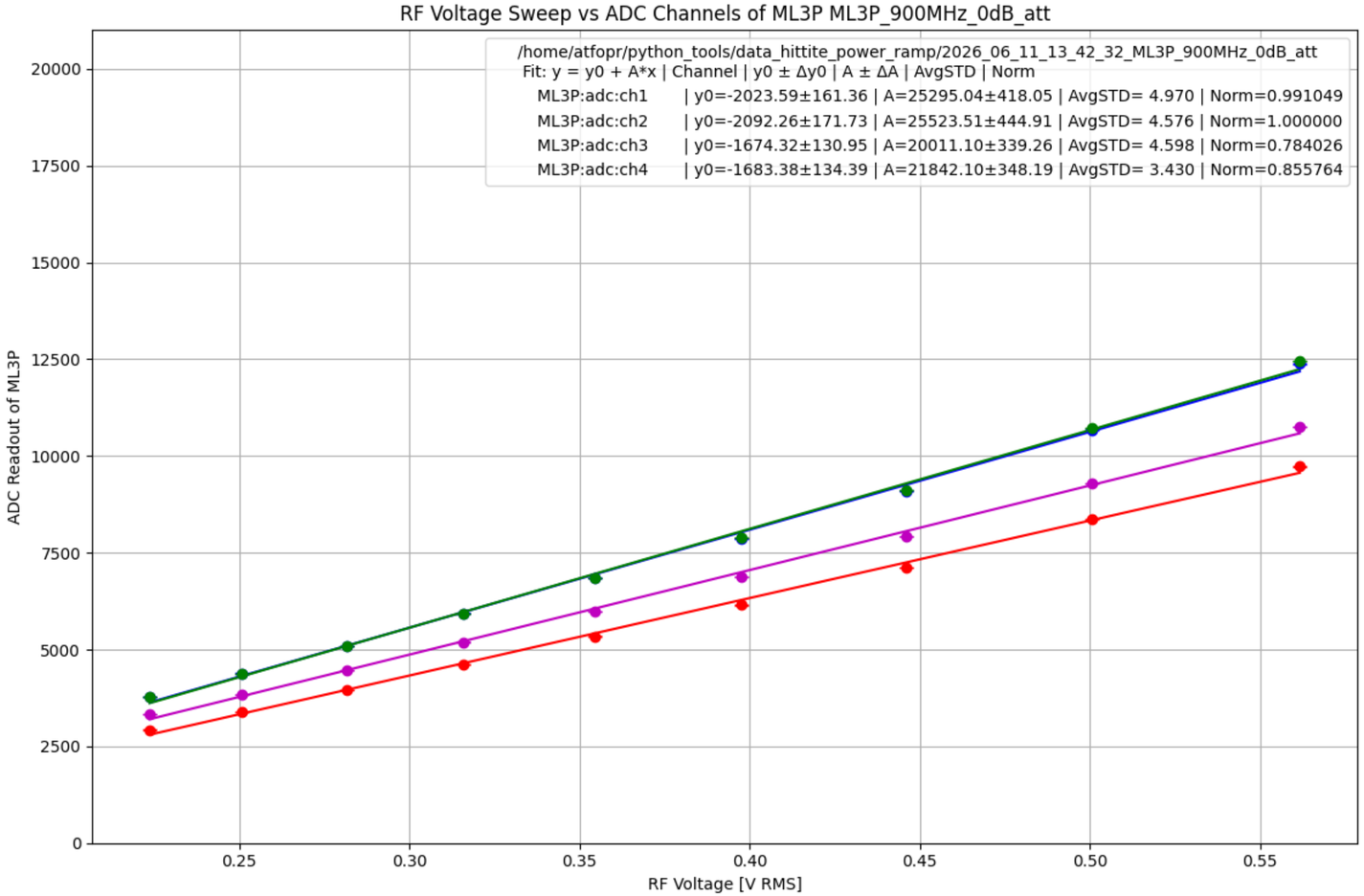
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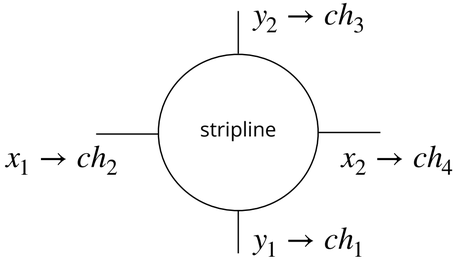
From the example of ML3P:

$$ch_{1,corr} = ch_1/0.991049$$
$$ch_{2,corr} = ch_2$$
$$ch_{3,corr} = ch_3/0.784026$$
$$ch_{4,corr} = ch_4/0.855764$$



III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



Correcting the electronics gain:

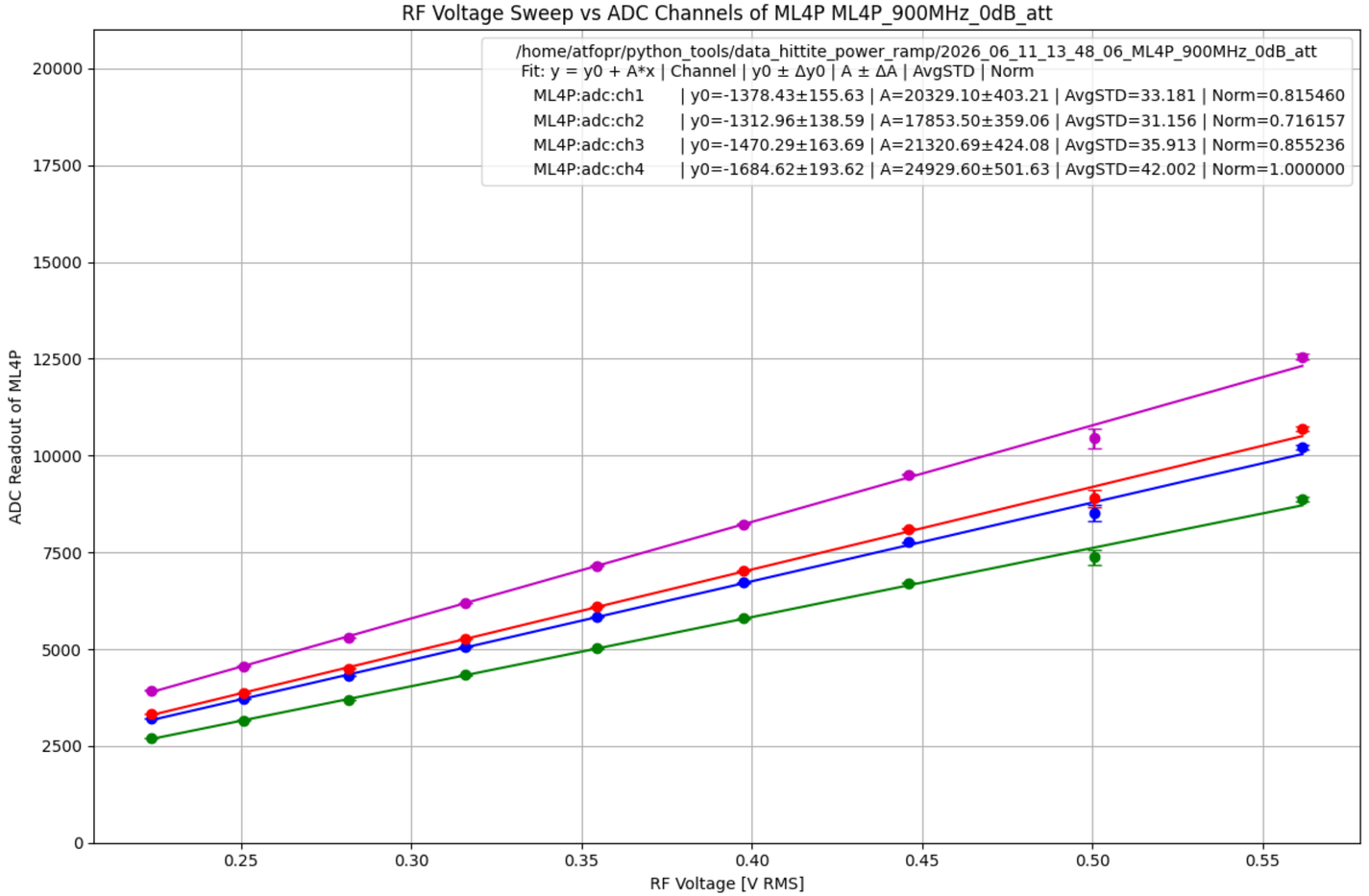
The stripline electronics have slightly different gains for the 4 channels.

So for same RF input voltage, the ADC readout gives different magnitudes.

This can be compensated on post processing by applying the correction factors CF to each ADC channel, compared to the channel that gives the highest gain.

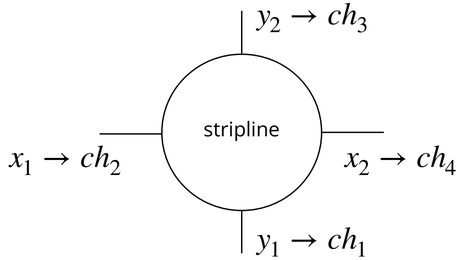
From the example of ML2P:

$$ch_{1,corr} = ch_1/0.815460$$
$$ch_{2,corr} = ch_2/0.716157$$
$$ch_{3,corr} = ch_3/0.855236$$
$$ch_{4,corr} = ch_4$$



III. Calibration corrections

A) Compensating for stripline electronics amplitude difference



Corrected beam positions:

Procedure:

- The pedestals are removed from each channel:

$$x_i = ch_i - ped_i \qquad y_i = ch_i - ped_i$$

- The scaling factor is calculated with the “clean” ADC channels:

$$S_x = x\frac{x_1 + x_2 + y_1 + y_2}{x_1 - x_2} \qquad S_y = y\frac{x_1 + x_2 + y_1 + y_2}{y_1 - y_2}$$

- The correction factors are applied to each channel:

$$x_{i,corr} = x_i/CF_i \qquad y_{i,corr} = y_i/CF_i$$

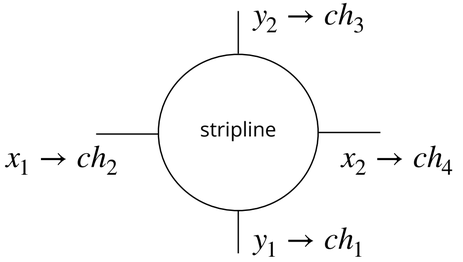
- The corrected position is calculated from the “corrected” ADC channels and **using the <u>mean value of the Scaling Factors:</u>**

$$x_{corr} = \nu(S_x)\frac{x_{1,corr} - x_{2,corr}}{x_{1,corr} + x_{2,corr} + y_{1,corr} + y_{2,corr}} \qquad y_{corr} = \nu(S_y)\frac{y_{1,corr} - y_{2,corr}}{x_{1,corr} + x_{2,corr} + y_{1,corr} + y_{2,corr}}$$

III. Calibration corrections

A) Compensating for stripline electronics amplitude difference

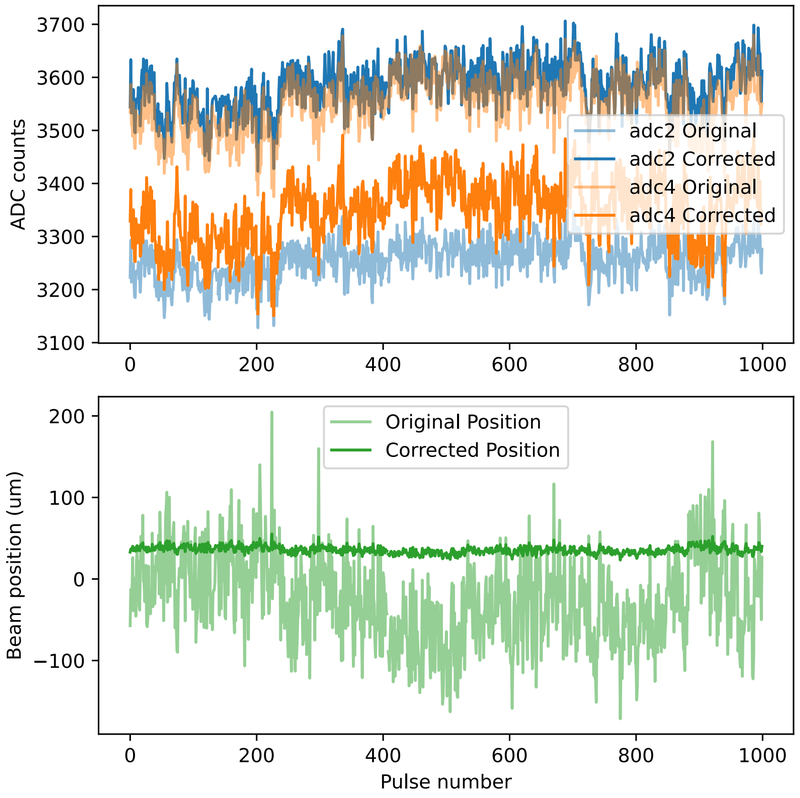
X axis



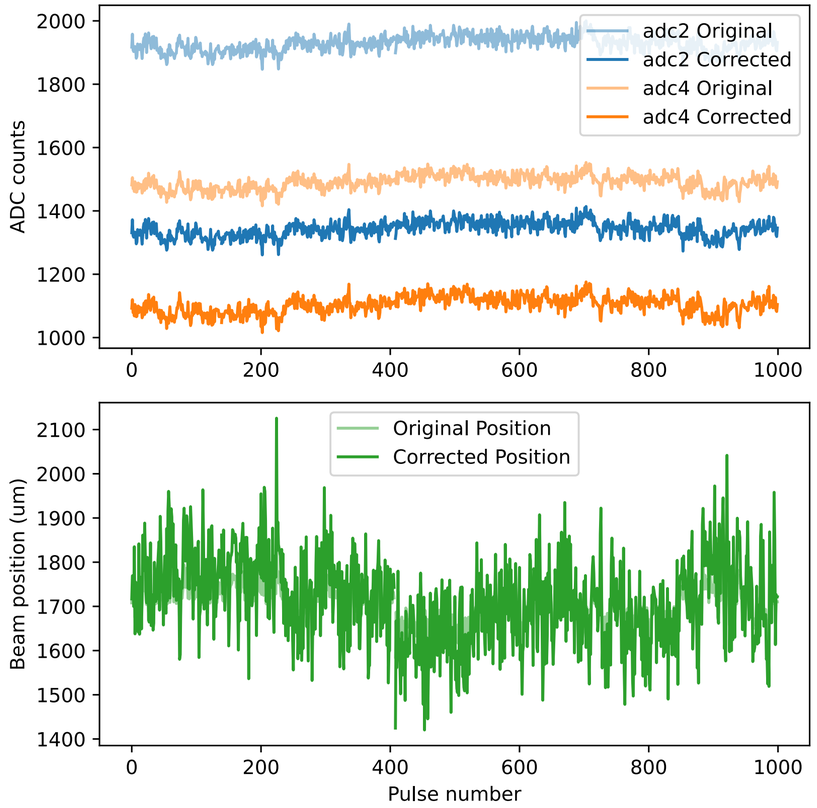
Corrected beam positions:

Procedure: $x_i = ch_i - ped_i \quad \Rightarrow \quad S_x = x\dfrac{x_1 + x_2 + y_1 + y_2}{x_1 - x_2} \quad \Rightarrow \quad x_{i,corr} = x_i / CF_i \quad \Rightarrow \quad x_{corr} = \nu(S_x)\dfrac{x_{1,corr} - x_{2,corr}}{x_{1,corr} + x_{2,corr} + y_{1,corr} + y_{2,corr}}$

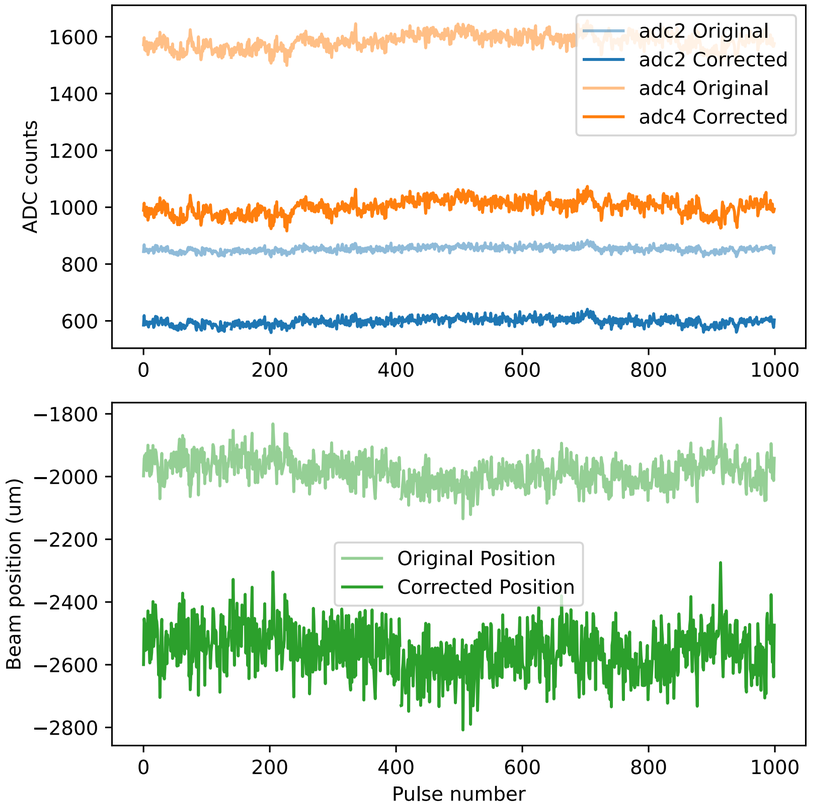
ML2P



ML3P



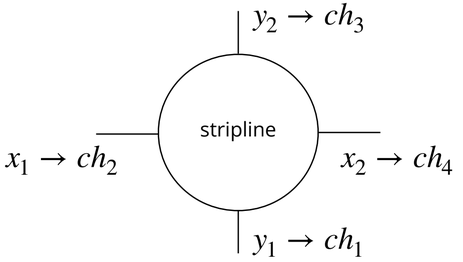
ML4P



III. Calibration corrections

A) Compensating for stripline electronics amplitude difference

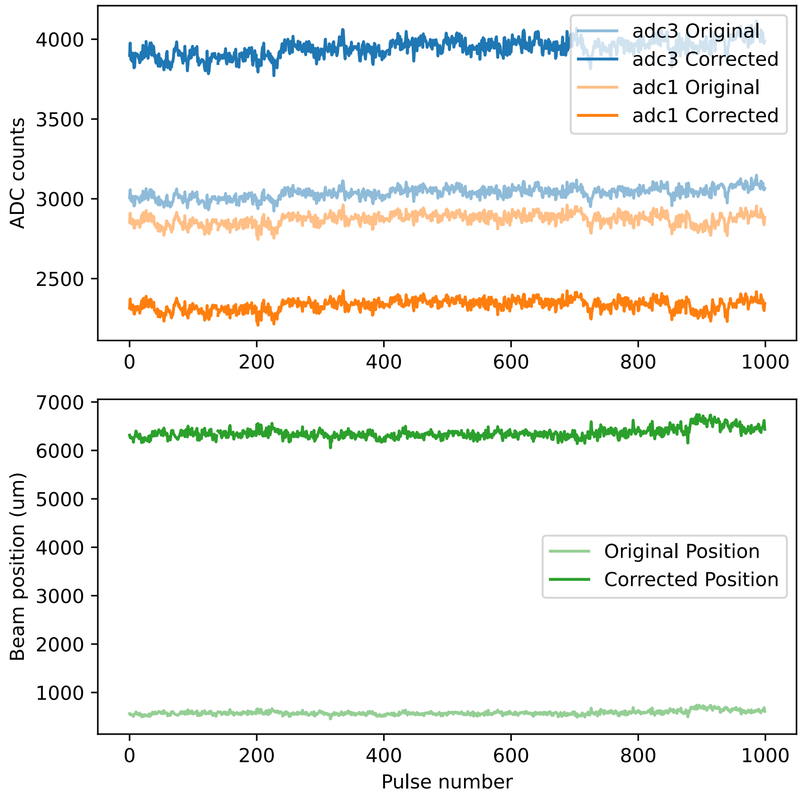
Y axis



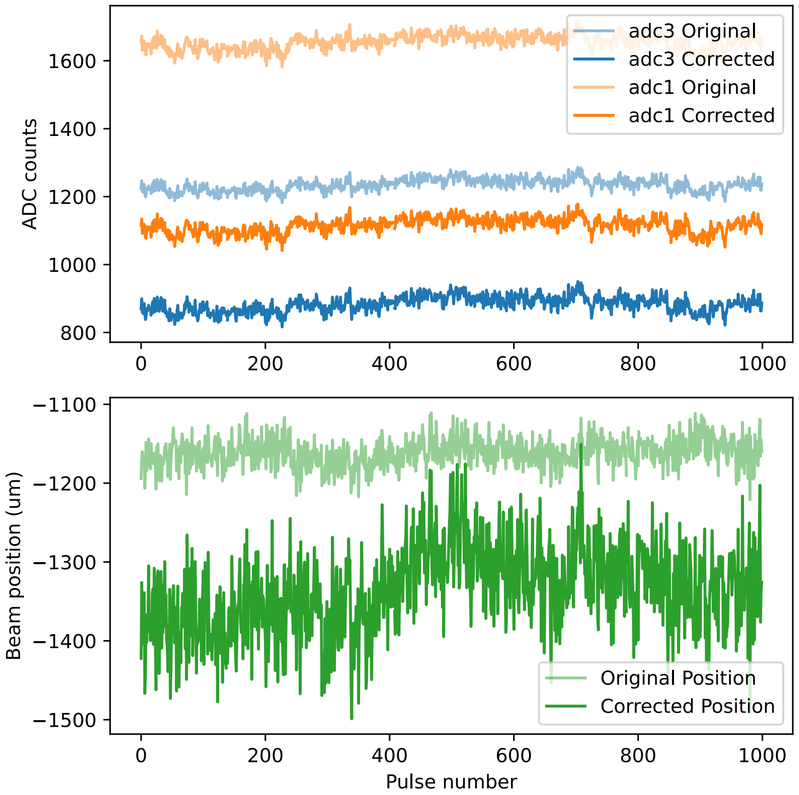
Corrected beam positions:

Procedure: $y_i = ch_i - ped_i \quad \Rightarrow \quad S_y = y\frac{x_1 + x_2 + y_1 + y_2}{y_1 - y_2} \quad \Rightarrow \quad y_{i,corr} = y_i / CF_i \quad \Rightarrow \quad y_{corr} = \nu(S_y)\frac{y_{1,corr} - y_{2,corr}}{x_{1,corr} + x_{2,corr} + y_{1,corr} + y_{2,corr}}$

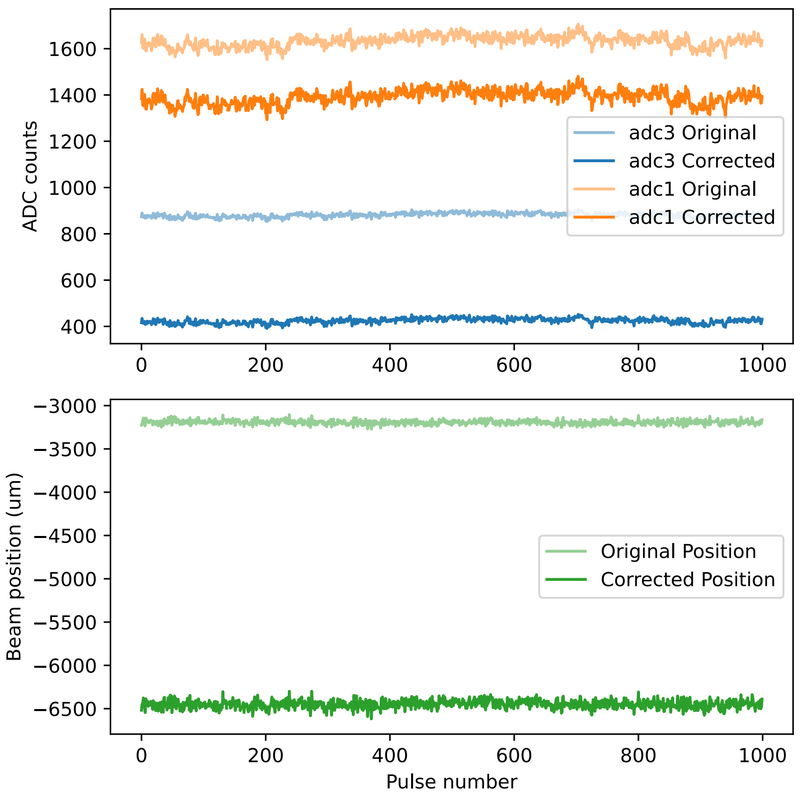
ML2P



ML3P



ML4P



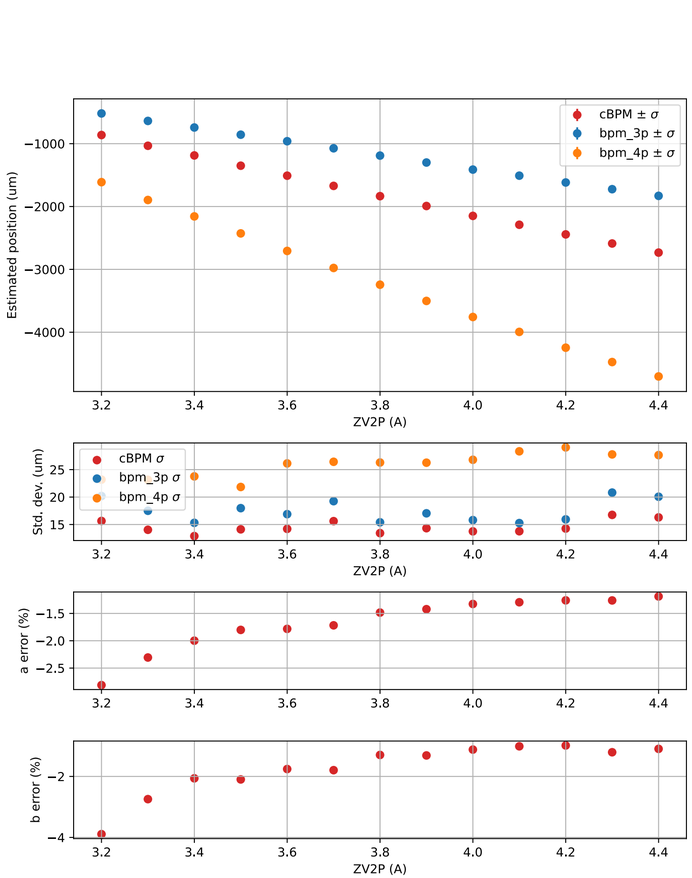
III. Calibration corrections

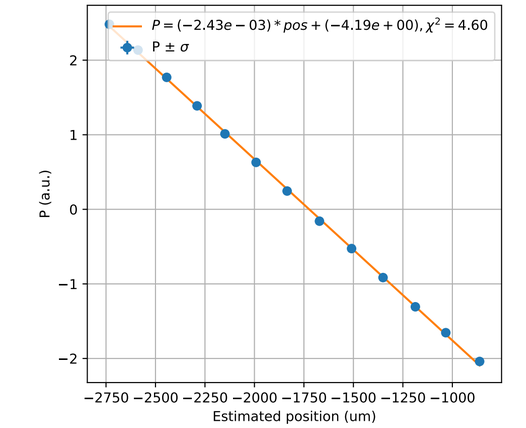
A) Compensating for stripline electronics amplitude difference

Y axis

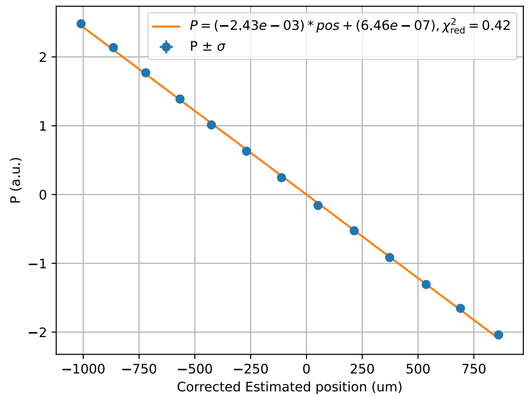
Only applying CF to ML3P and ML4P

Calibration results **without** correction:

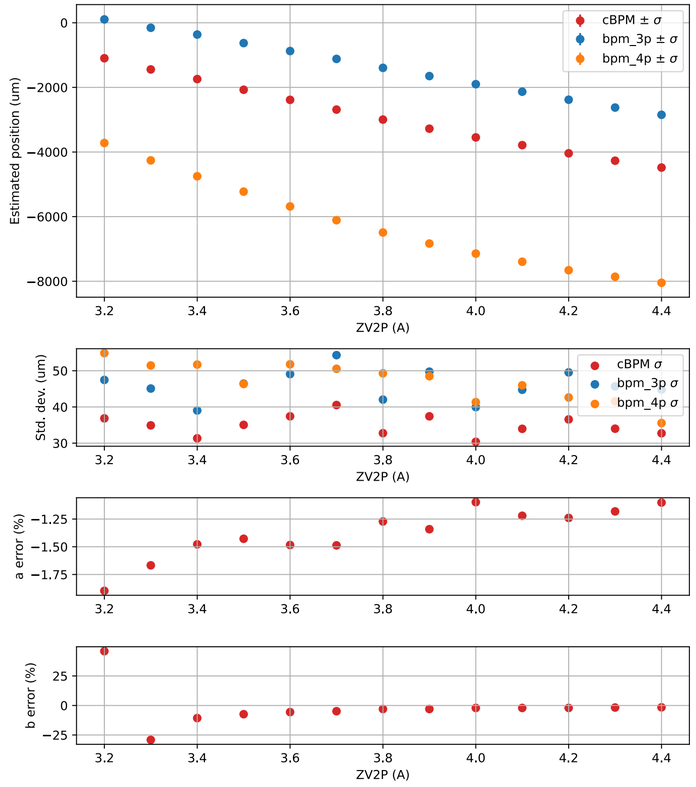


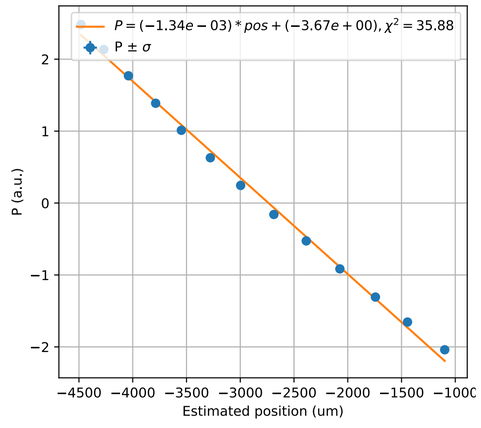


Y calibration for S5_calY_001_IFIC_Y_1DC

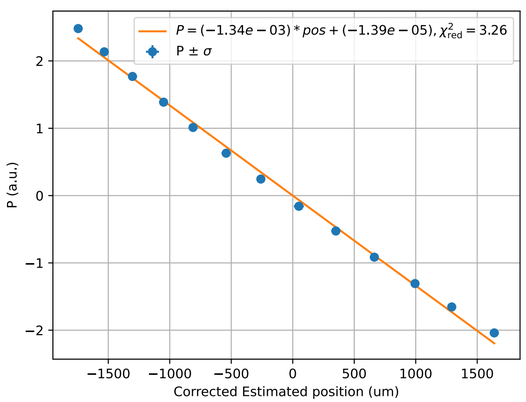


Calibration results **with** correction:





Y calibration for S5_calY_001_IFIC_Y_1DC



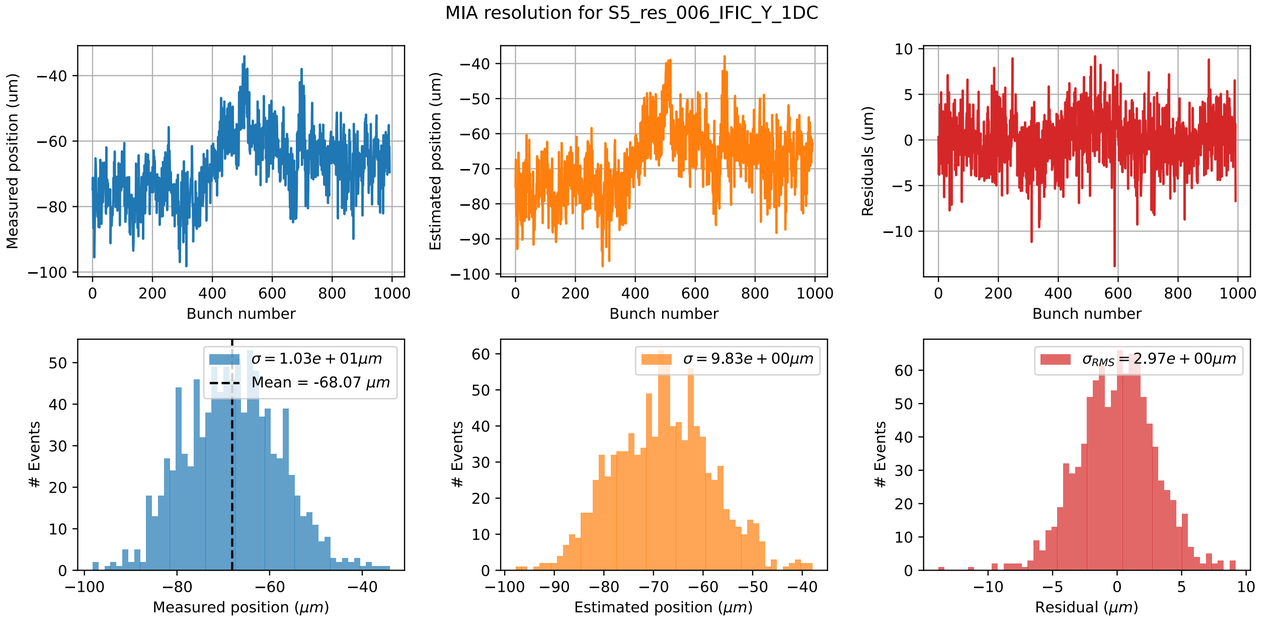
III. Calibration corrections

Y axis

A) Compensating for stripline electronics amplitude difference

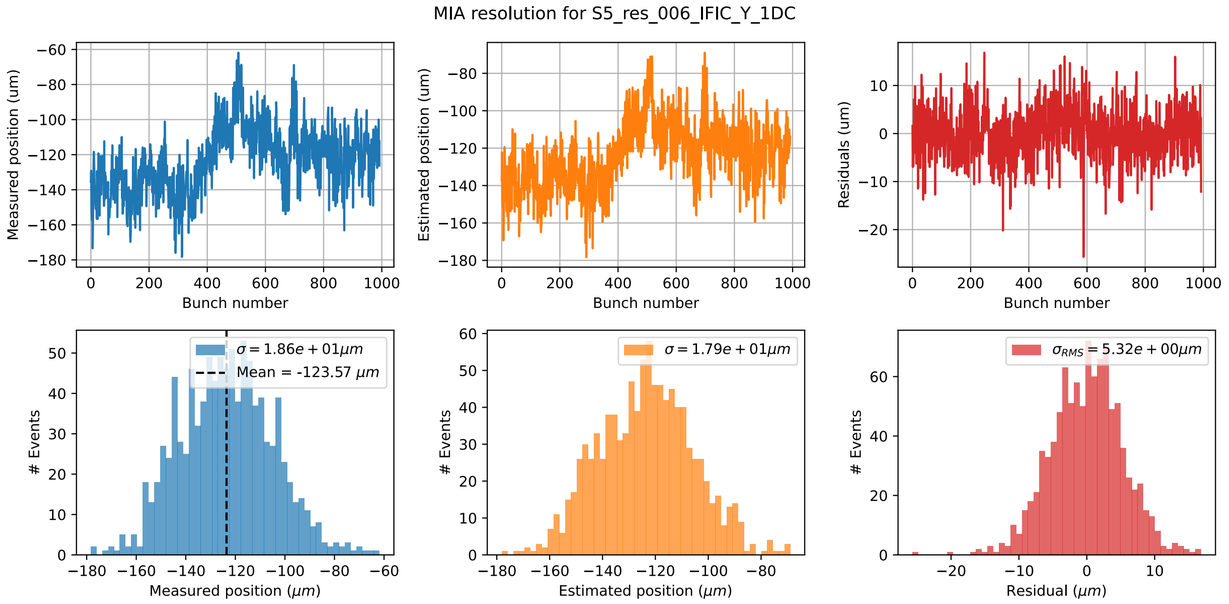
Only applying CF to ML2P, ML3P and ML4P

Resolution results **without** correction:



2.97 µm

Resolution results **with** correction:



5.97 µm

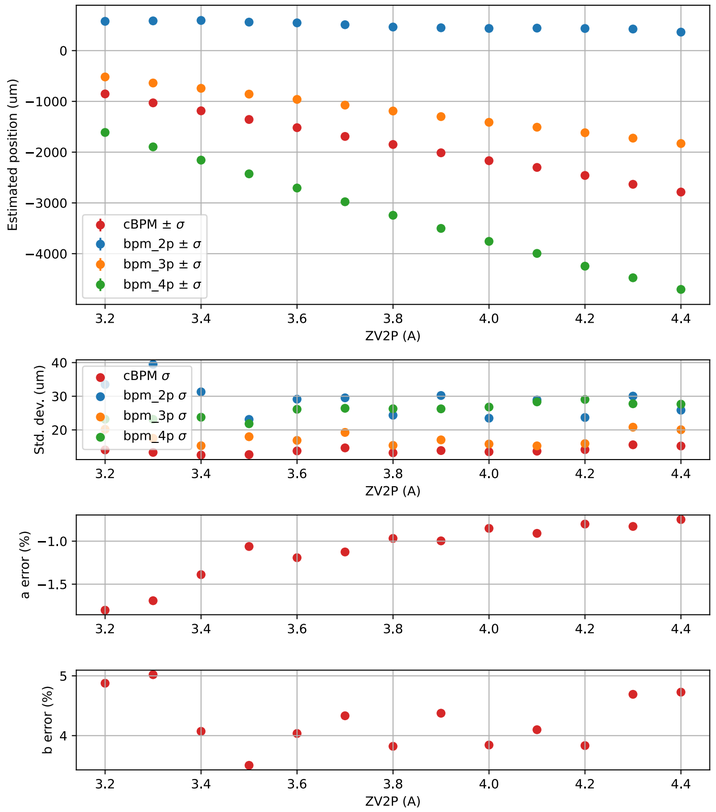
III. Calibration corrections

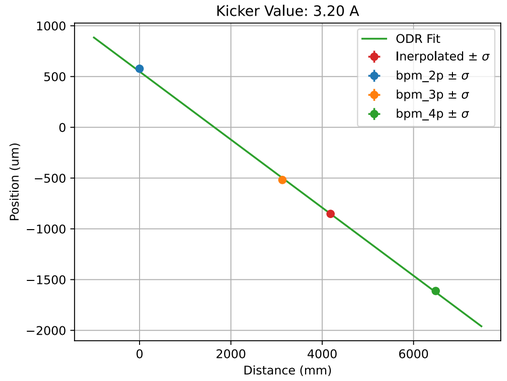
A) Compensating for stripline electronics amplitude difference

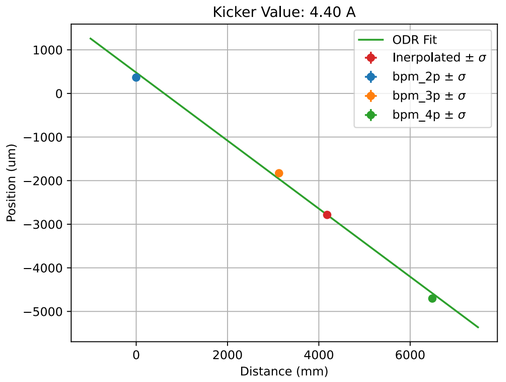
Y axis

Only applying CF to ML2P, ML3P and ML4P

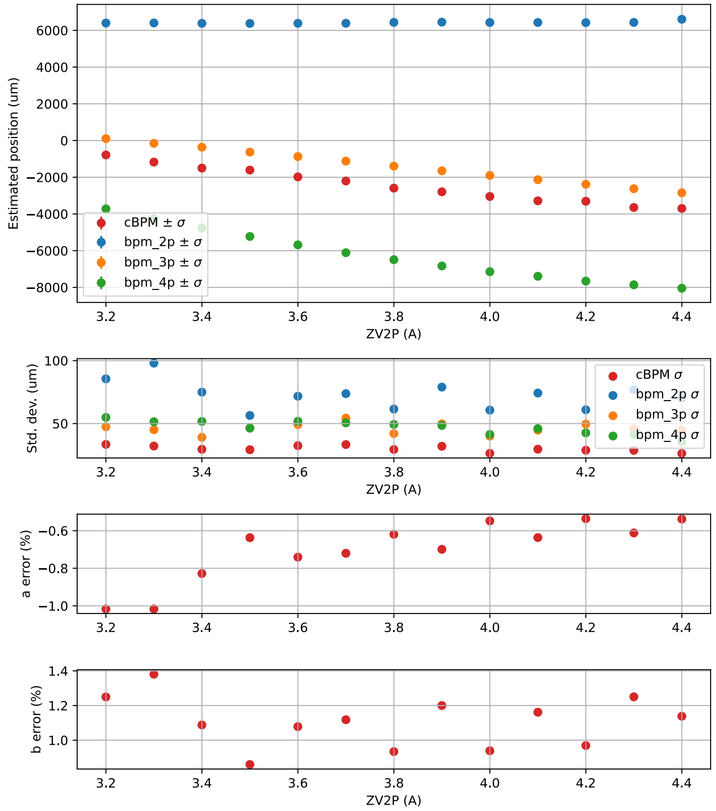
Calibration results **without** correction:

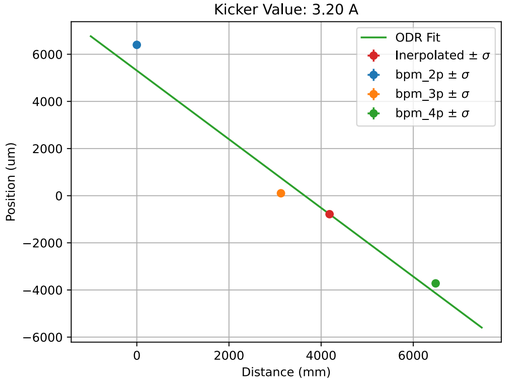


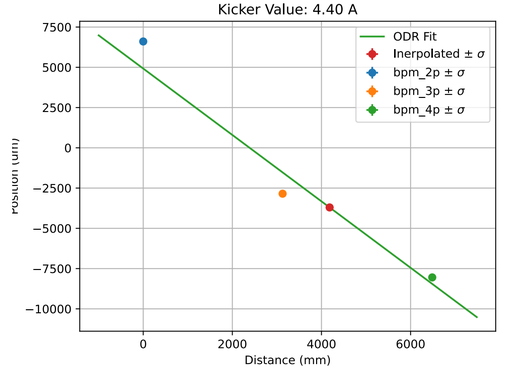




Calibration results **with** correction:







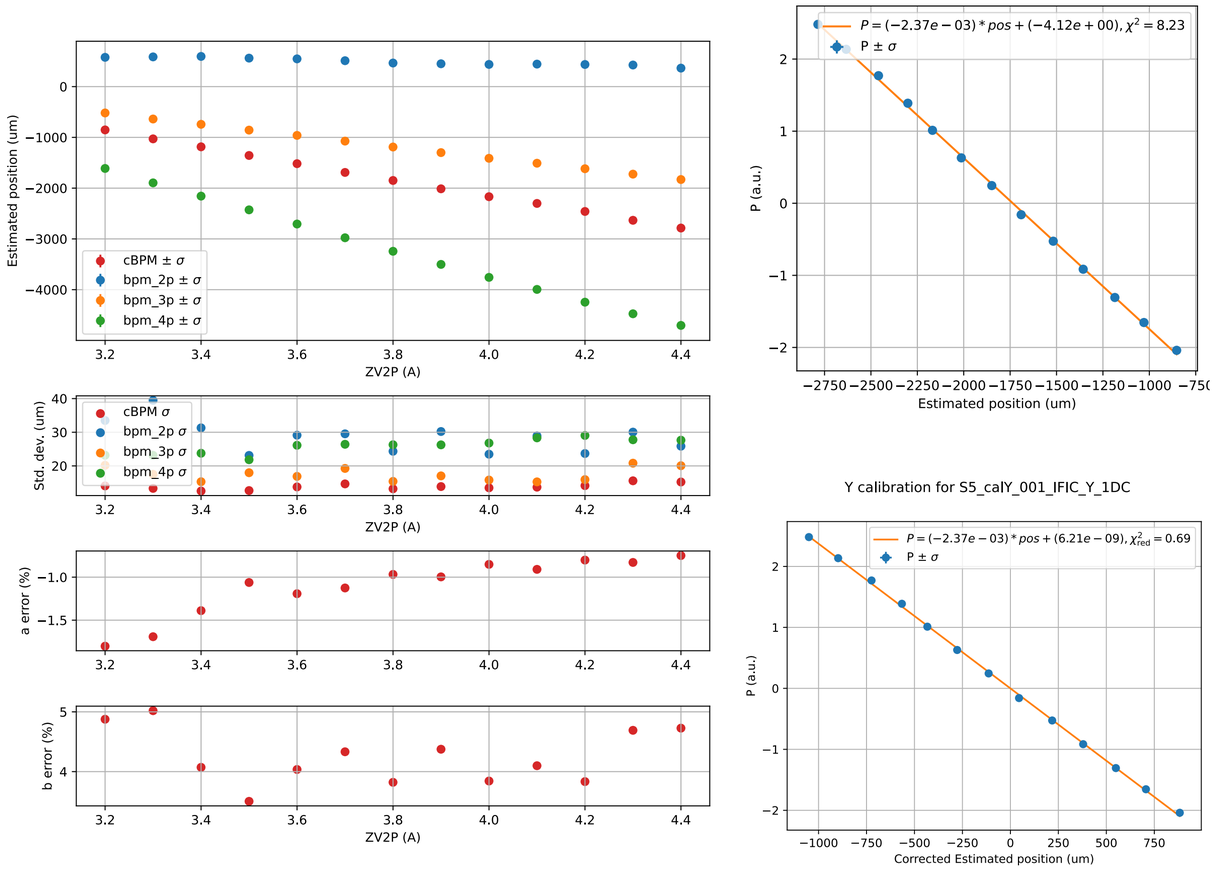
III. Calibration corrections

A) Compensating for stripline electronics amplitude difference

Y axis

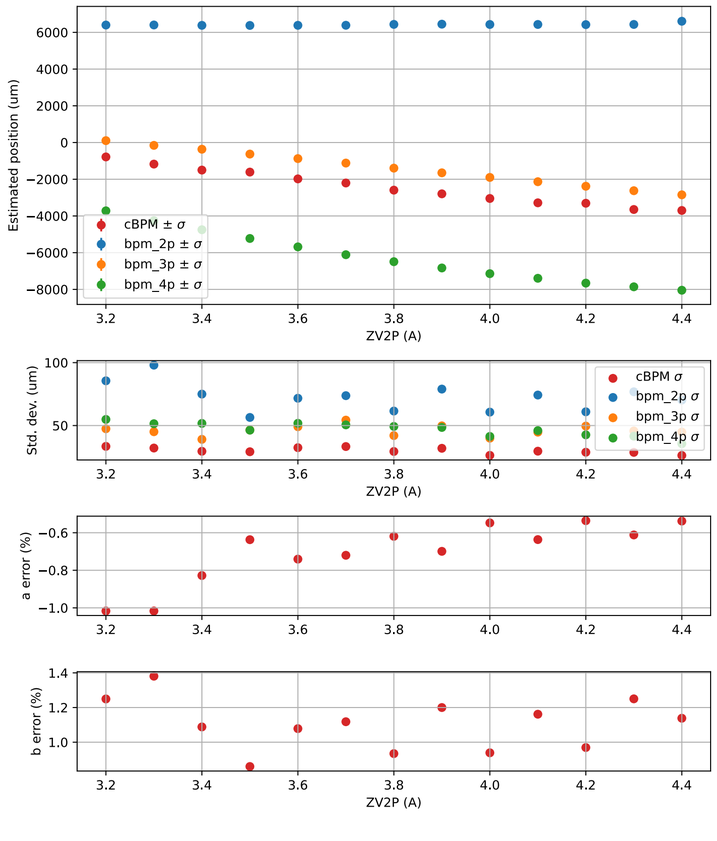
Only applying CF to ML2P, ML3P and ML4P

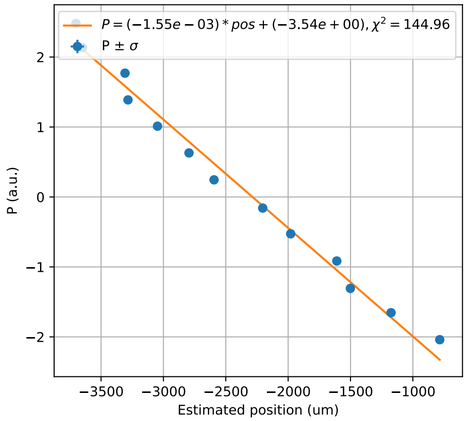
Calibration results **without** correction:



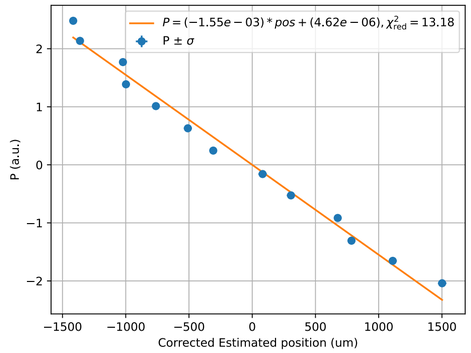
Y calibration for S5_calY_001_IFIC_Y_1DC

Calibration results **with** correction:





Y calibration for S5_calY_001_IFIC_Y_1DC



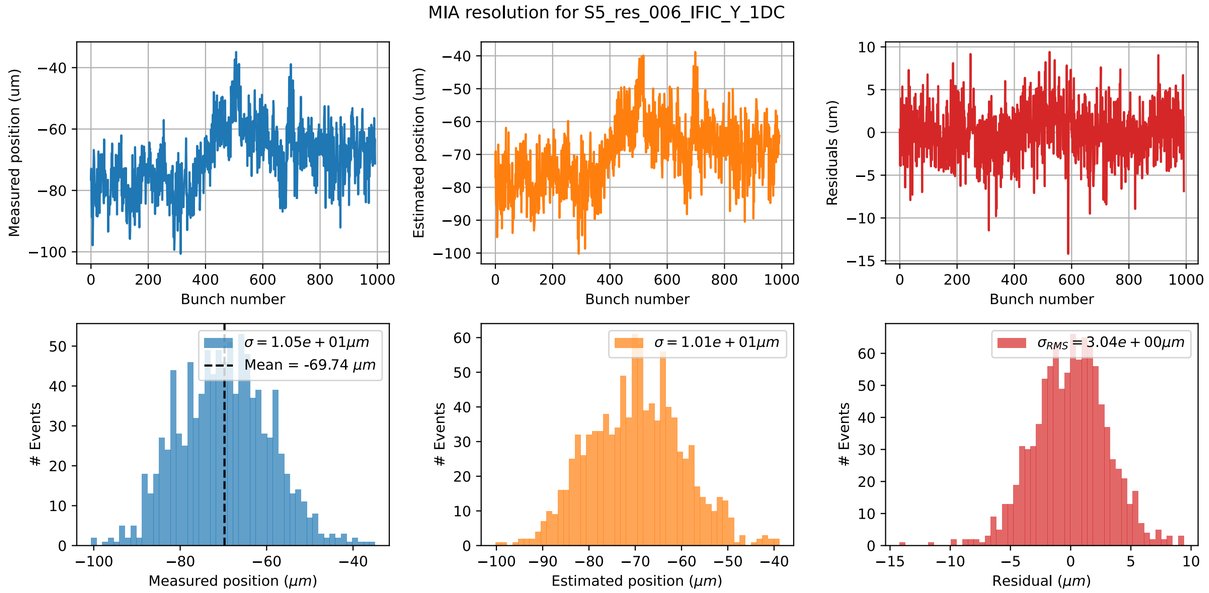
III. Calibration corrections

Y axis

A) Compensating for stripline electronics amplitude difference

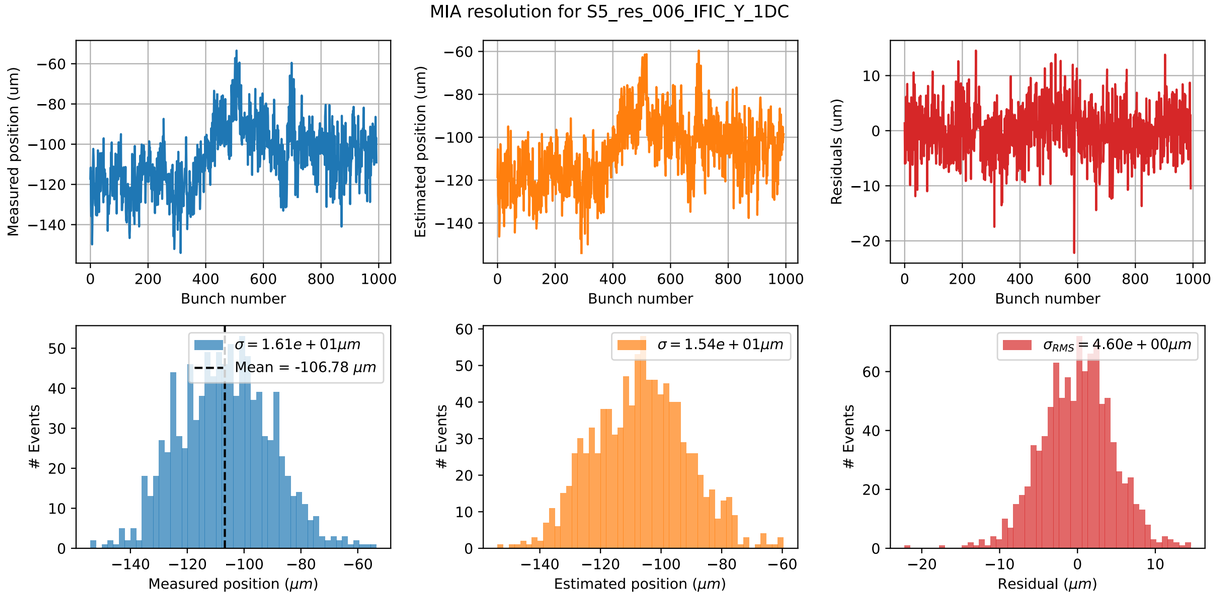
Only applying CF to ML2P, ML3P and ML4P

Resolution results **without** correction:



3.04 μm

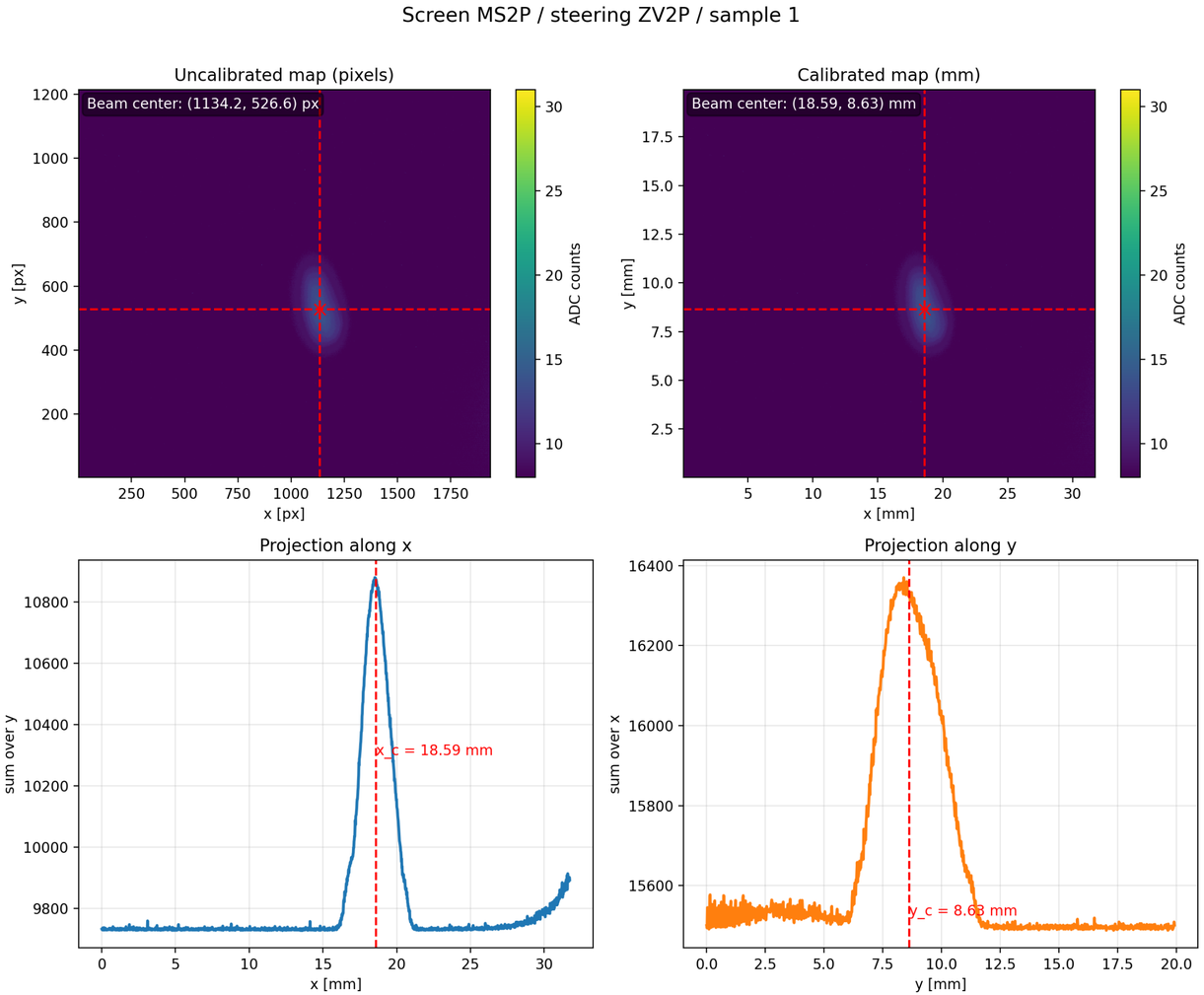
Resolution results **with** correction:

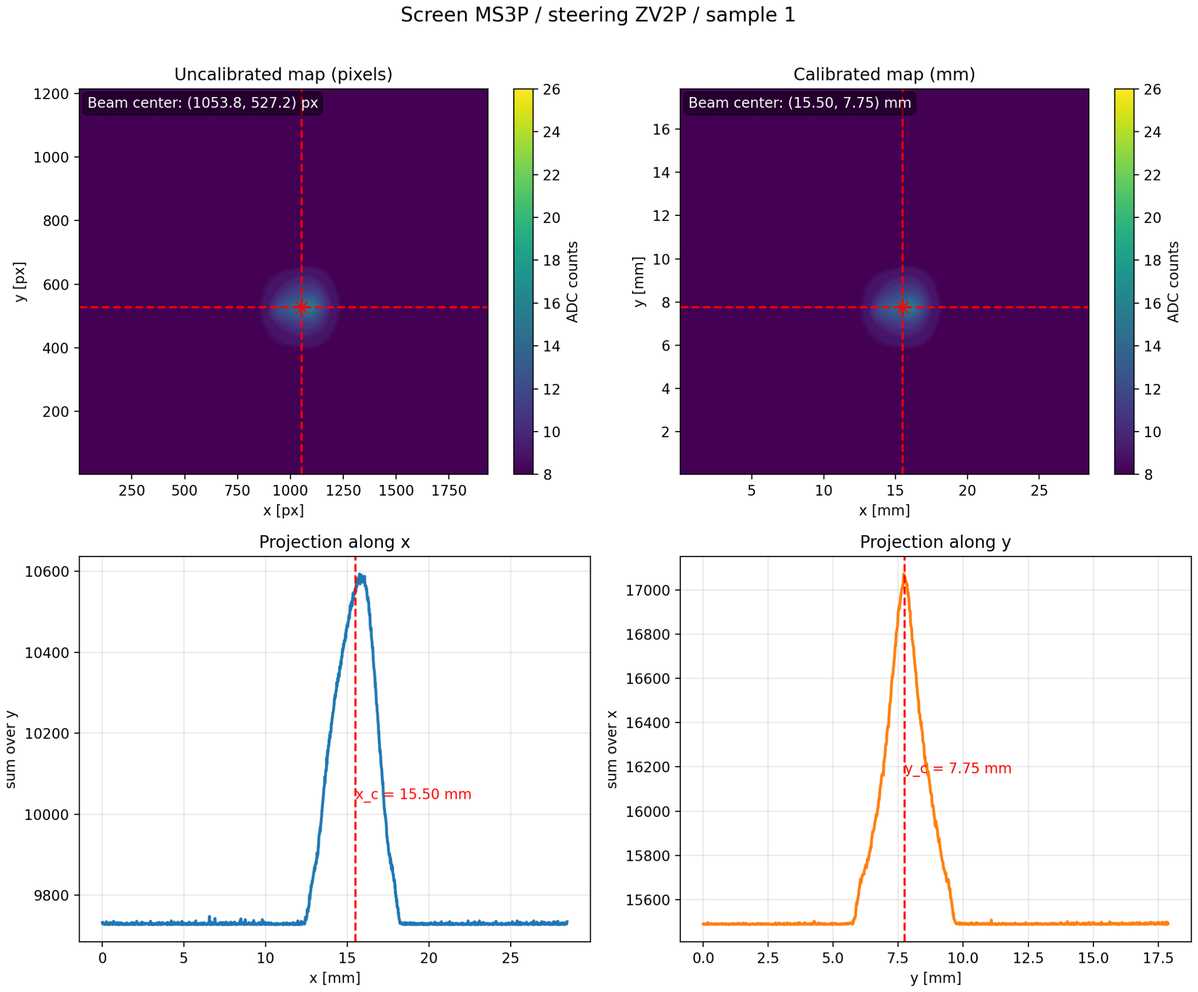


4.60 μm

III. Calibration corrections

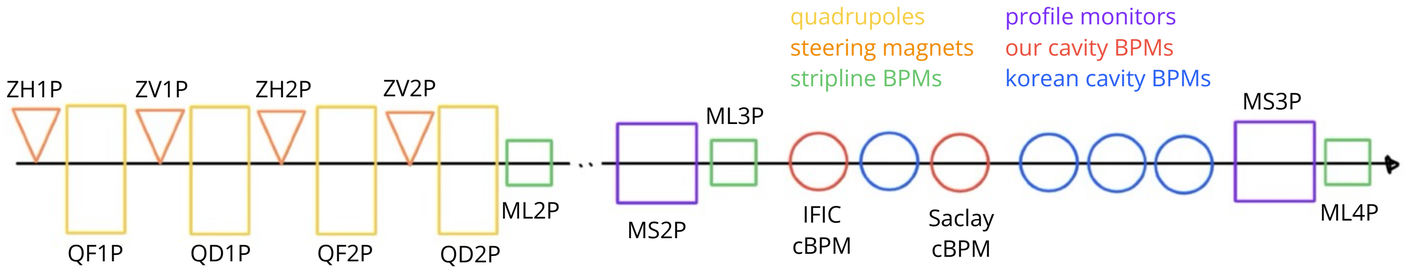
B) Including the profile monitors



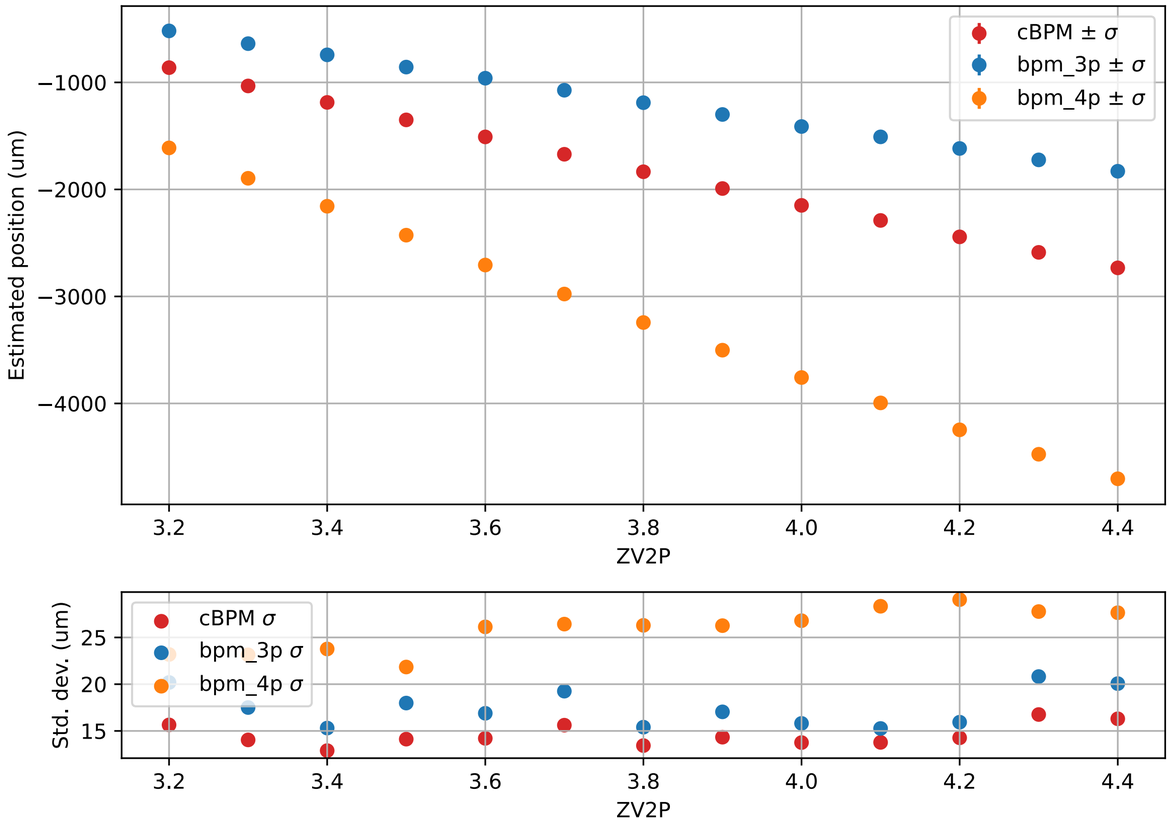


III. Calibration corrections

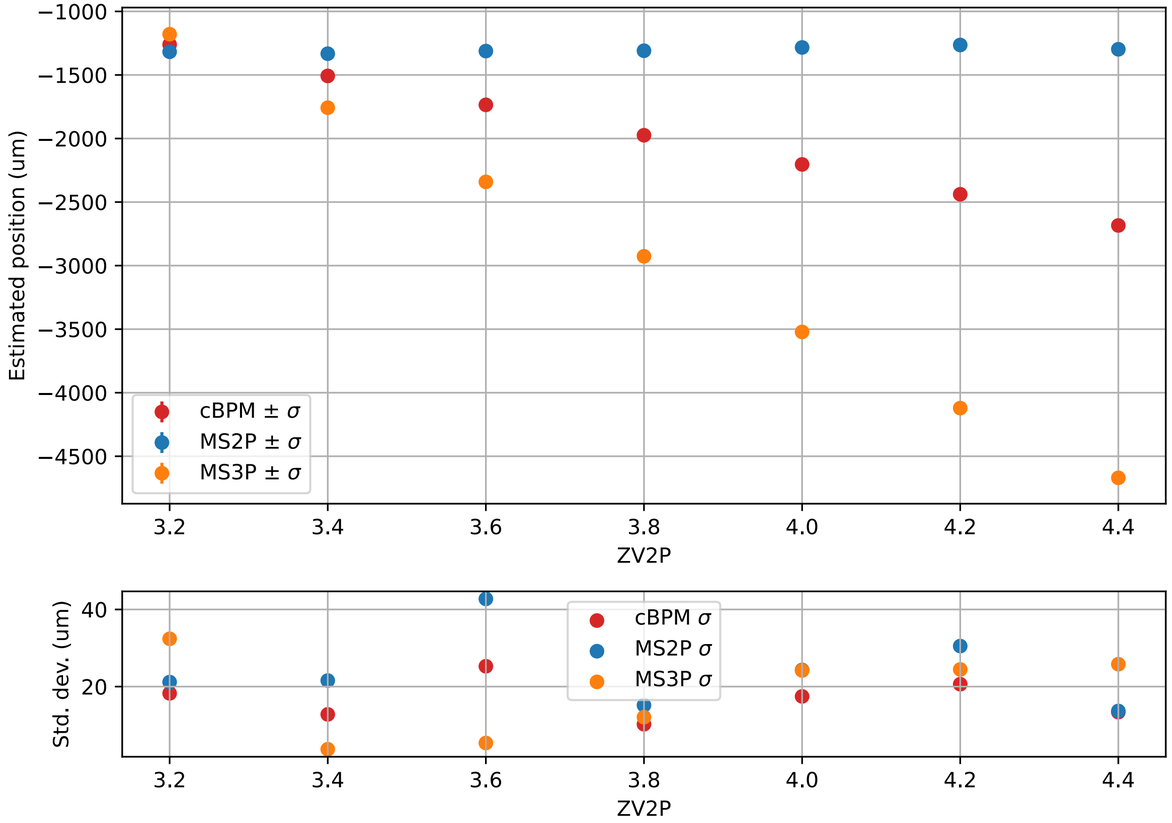
B) Including the profile monitors



Position estimation with **stripline BPMs**

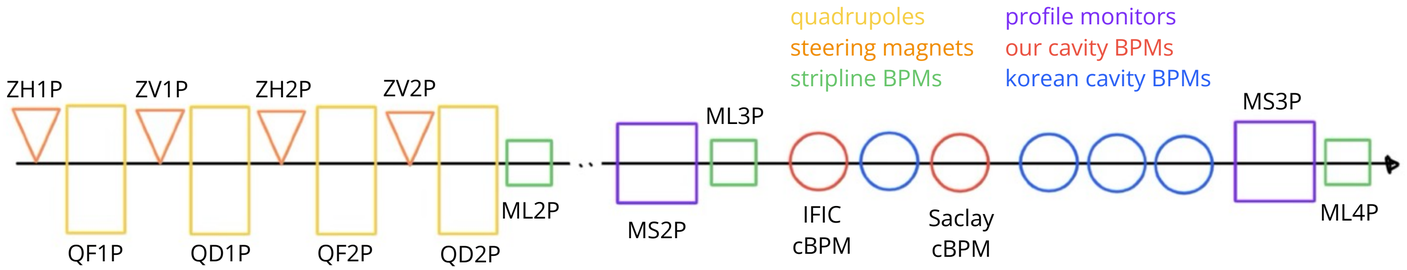


Position estimation with **profile monitors**

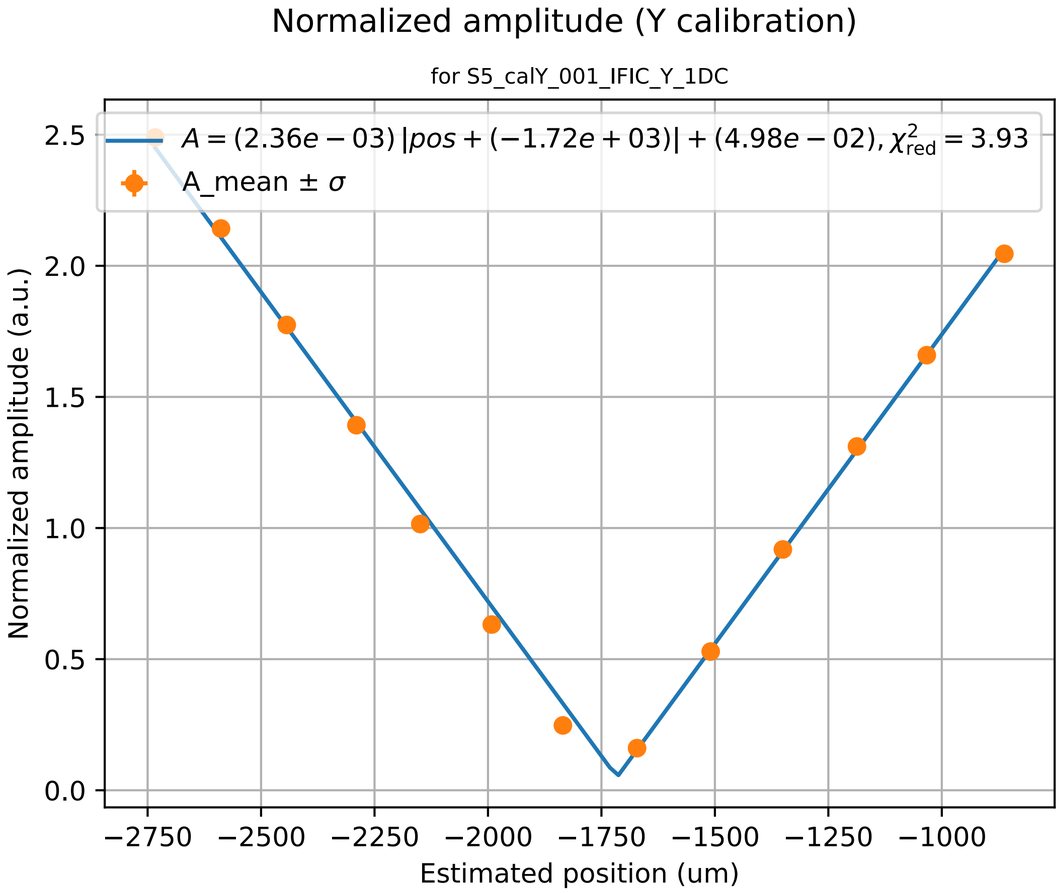


III. Calibration corrections

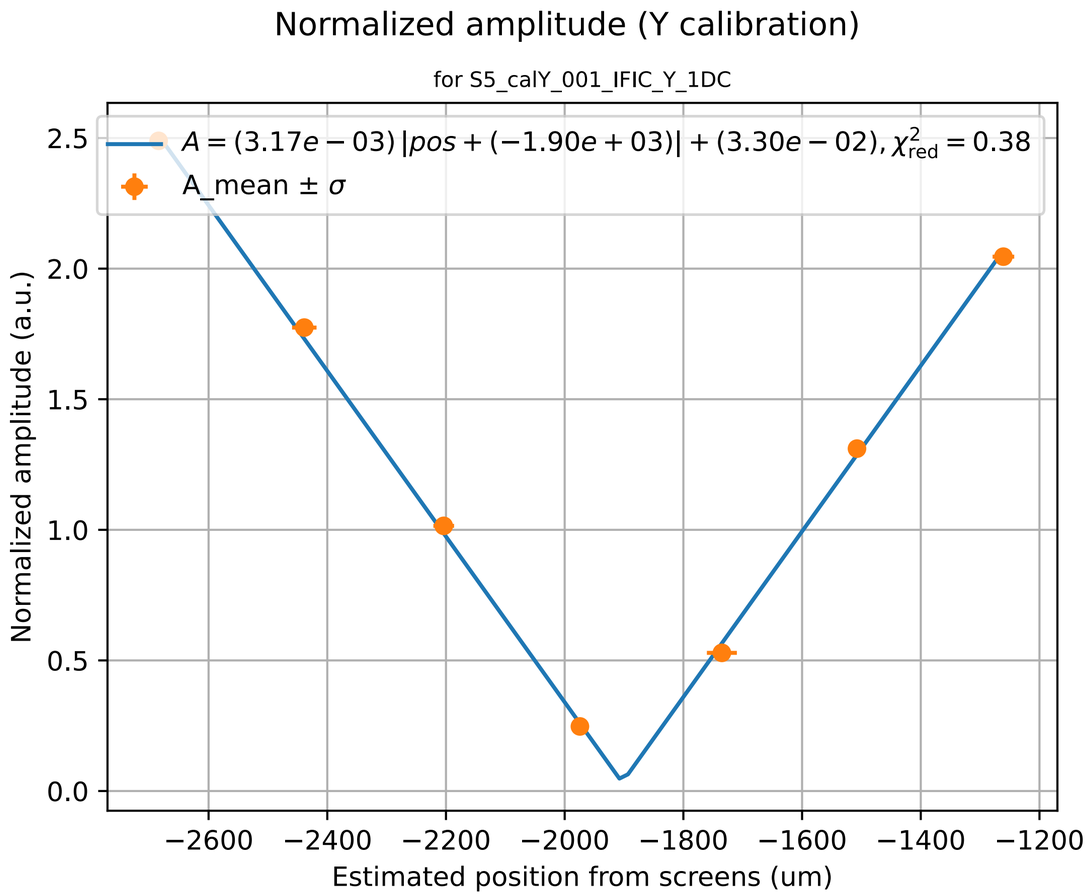
B) Including the profile monitors



Position estimation with **stripline BPMs**

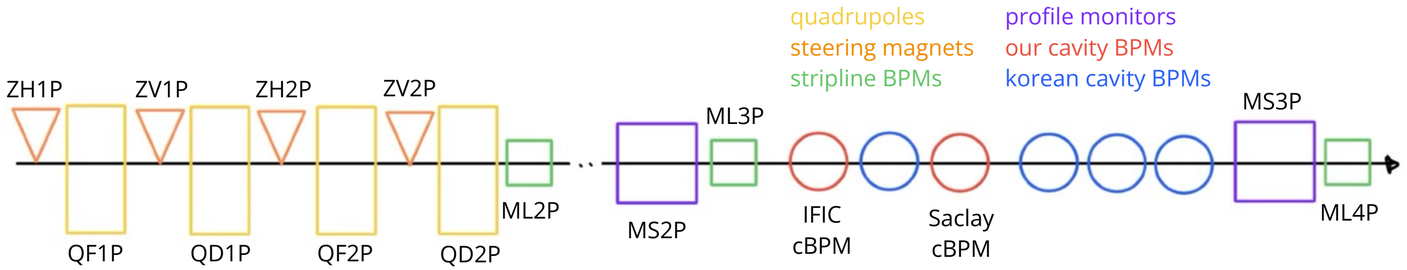


Position estimation with **profile monitors**



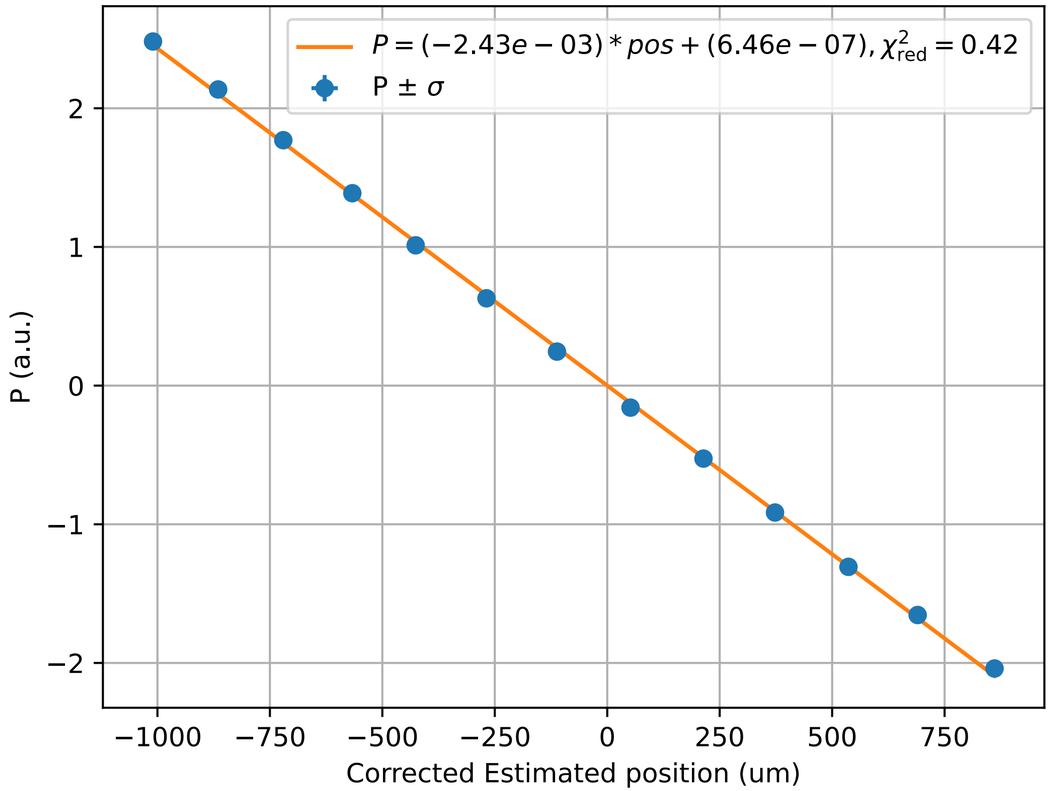
III. Calibration corrections

B) Including the profile monitors



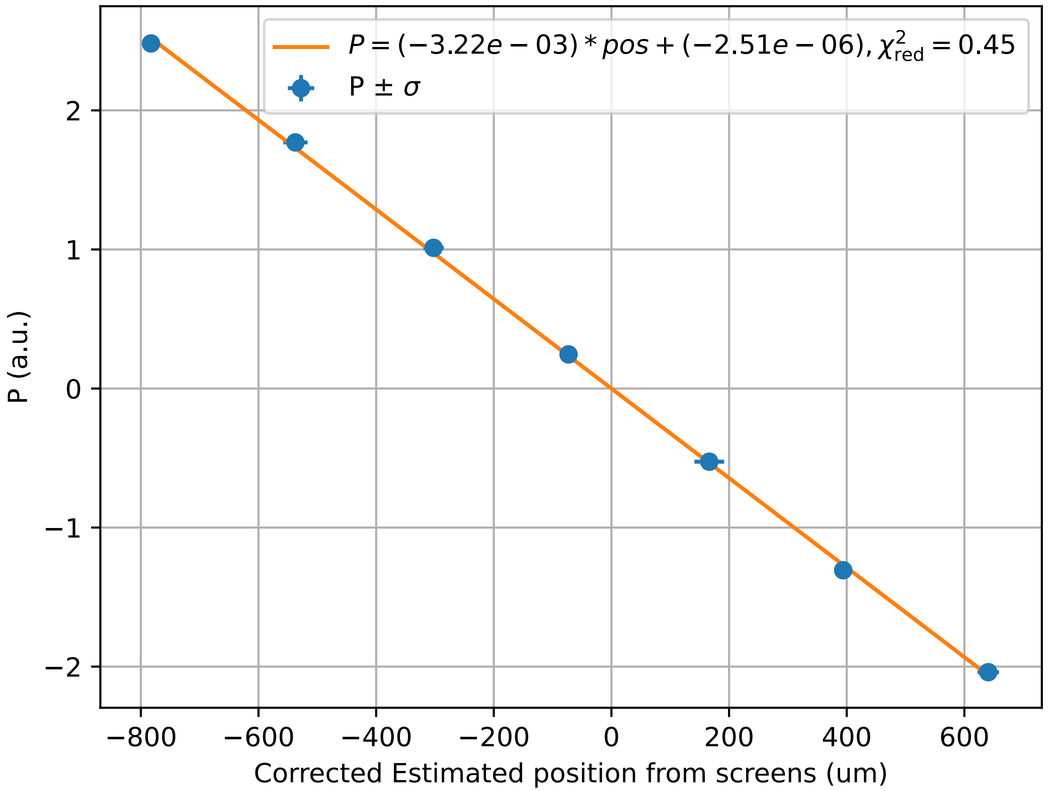
Position estimation with **stripline BPMs**

Y calibration for S5_calY_001_IFIC_Y_1DC



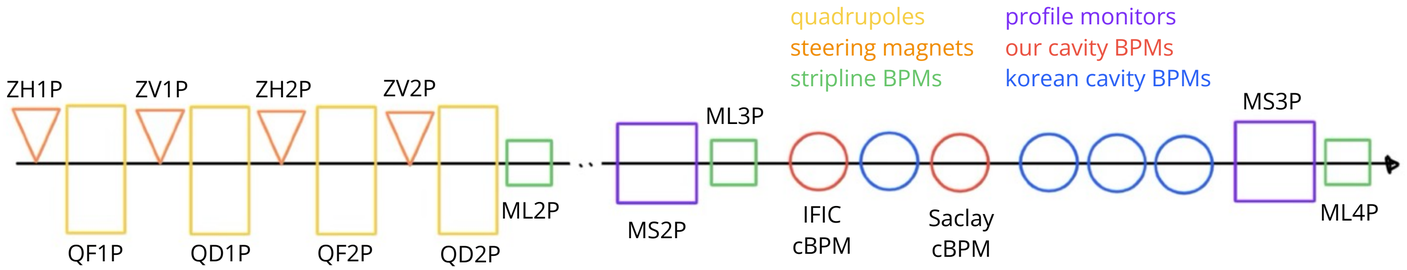
Position estimation with **profile monitors**

Y calibration for S5_calY_001_IFIC_Y_1DC

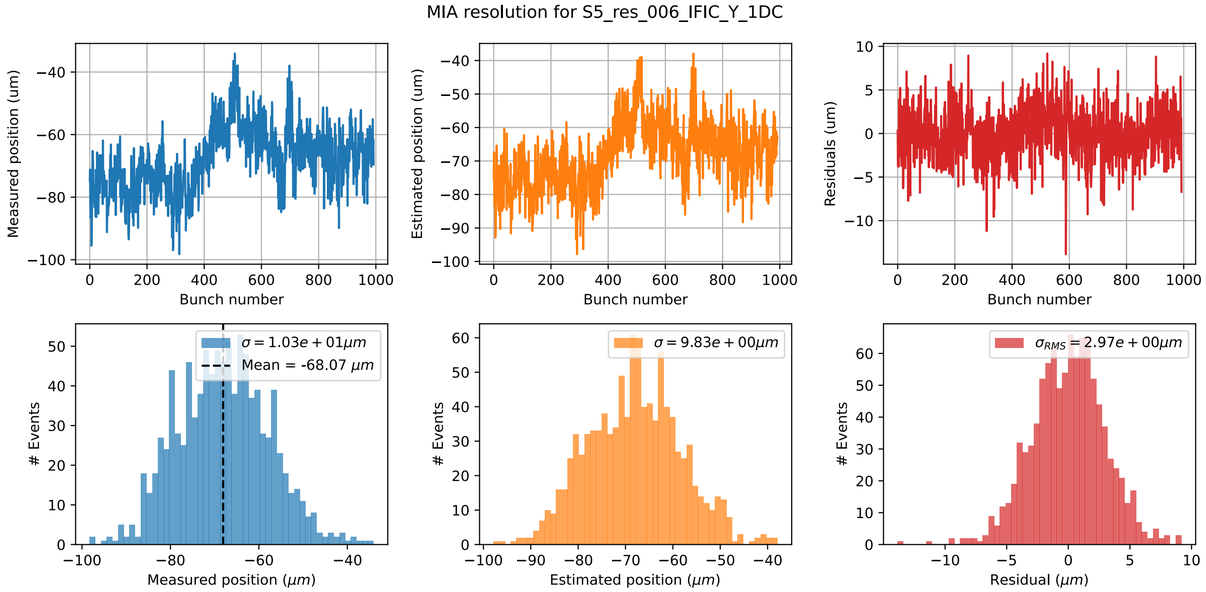


III. Calibration corrections

B) Including the profile monitors

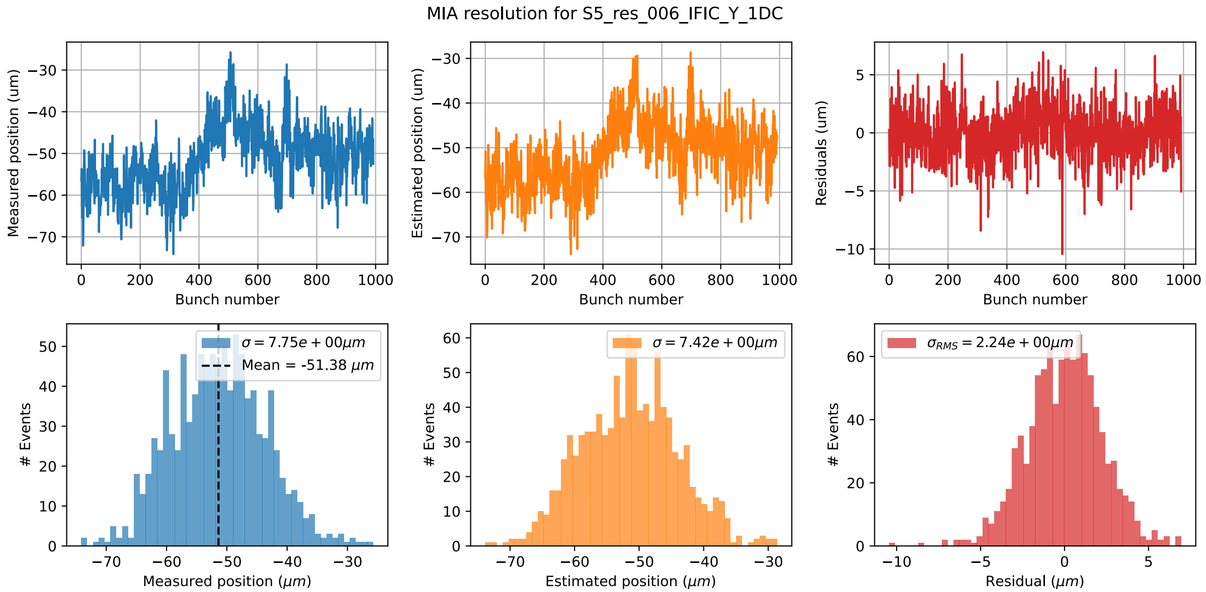


Position estimation with **stripline BPMs**



2.97 µm

Position estimation with **profile monitors**



2.24 µm

IV. Lista de pendientes

❖ **Calibración:**
- Mejorar calibración con información de los ADC (striplines)

✓ Hacer calibración con desplazamiento en pantallas
✓ Hacer calibración quitando puntos de los extremos (res. pasa de 2.97 a 2.96)
✓ Sacar la información de T = f(α)
- Comprobar valores de f_DDC (comparar con resultados de código de JC)

❖ **Verificar medidas 2DC:**
- Verificar: calibración (rango dinámico y errores), medidas a baja carga, comparar medidas 1DC y 2DC

❖ **Pseudo-inverse resolution:**
✓ Evaluar coeficientes de correlación y eliminar BPMs con coeficientes bajos.
✓ Comprobar la estabilidad de la resolución de los striplines para varios runs.
✓ Hacer plots de resolución en función de: posición, carga, angle of attack, time window
- Seleccionar distintas time windows (desplazadas) y ver efecto

❖ **SVD mode análisis:**
- Incluir información de la carga como una nueva columna
- Observar el lag puntual de cada BPM y corregirlo para ver si el análisis mejora (casi todos los lags son = 0)

❖ **Medir la carga con el BPM:**
- Usar medidas de q_bunch (EPICS) y comparar con señal del monopolo

IV. Lista de pendientes

Simulaciones con datos “artificiales”

❖ **Que resolución se puede medir con 3 o 4 cBPMs de 1 um de resolución?**
- RF track
- Datos sintéticos

❖ **Datos sintéticos: SVD mode análisis**
- Crear matriz artificial con medidas de BPM (con resoluciones de cada monitor) → reconstruir resoluciones con SVD
- Insertar un drift o jitter → reconstruir resoluciones con SVD
- Simulaciones con 2 o 3 BPMs muy ruidosos → reconstruir resoluciones con SVD
- Simulaciones con 1 BPM muy bueno → reconstruir resoluciones con SVD
- Comparar resultados con pseudo-inversa

❖ **RF Track:**
- Coger el código de RF track del Linac de ATF
- Hacer análisis de Pseudo-inversa con y sin jitter del 10%
- Hacer análisis de SVD modes con y sin jitter del 10%
- Ver efecto de datos de datos desicronizados
- Hacer plot de correlacion = f (lag) entre dos BPMs con efecto del jitter y comparar con medidas ATF

Thank you for your attention

This work has received financial support from the SO project CEX2023-001292-S funded byMICIU/AEI, the Plan Nacional PID2024-158190NB-C21, CDEIGENT 2021/012 and the ASFAE/2022/013, funded by the Generalitat Valenciana and the European Union's NextGenerationEU program. Additional support was provided by the European Union's Horizon Europe Marie Sklodowska-Curie Staff Exchanges program under grant agreement no. 101086276, and the MEXT (Development of key element technologies to improve the performance of future accelerators Program) Japan Grant Number JP-MXP1423812204.

laura.pedraza@ific.uv.es

Backup-slides

I. Resolution estimation results

A) Resolution calculation with Pseudo-inverse