CBPM single-turn precision as a function of timing performance

Antoine

June 13th, 2024

Monte Carlo simulation

Procedure:

- ✗ independently draw random x and y positions within ±5 mm
- ✗ extract button amplitude from Poisson map given x/y positions
- ✗ scale amplitudes with reference:
  - ➢ amplitude at (x, y) = (0, 0) uniformly random in [15000, 20000] ADC counts
- ✗ draw random timing offset from the peak uniformly in [0, 10] ps
- ✗ keep beam position fixed and simulate many turns (1,000+). For each turn:
  - ➢ randomly draw sampling clock jitter from Gaussian with 10 ps width
  - ➢ scale button amplitudes with timing jitter and offset
  - ➢ randomly draw electronics noise from Gaussian with 9 ADC counts width
  - ➢ scale button amplitude with electronics noise
- ✗ reconstruct beam positions → extract precision

Repeat procedure 100 times and quote precision as the distribution mean

Precision estimates

For the current setup:

- ✗ noise RMS ~9 ADC count
- ✗ time step size of 10 ps
- ✗ sampling clock jitter ~10 ps

	North Arc	South Arc
σ_x [μm]	13.8	5.3
σ_y [μm]	10.4	5.4

Precision estimates

Change **noise RMS**:

- ✗ noise RMS **9** → **3** ADC count
- ✗ time step size of 10 ps
- ✗ sampling clock jitter 10 ps

		North Arc	South Arc
nominal	σ_x [μm]	13.8	5.3
	σ_y [μm]	10.4	5.4
	σ_x [μm]	12.1	4.8
	σ_y [μm]	9.1	4.8

Precision estimates

Change **noise RMS** + **time step size**:

- ✗ noise RMS **9** → **3** ADC count
- ✗ time step size of **10** → **5** ps
- ✗ sampling clock jitter 10 ps

		North Arc	South Arc
nominal	σ_x [μm]	13.8	5.3
	σ_y [μm]	10.4	5.4
	σ_x [μm]	10.2	4.0
	σ_y [μm]	7.6	4.0

Precision estimates

Change **noise RMS** + **time step size + jitter**:

- ✗ noise RMS **9** → **3** ADC count
- ✗ time step size of **10** → **5** ps
- ✗ sampling clock jitter **10** → **5** ps

	North Arc	South Arc
nominal: σ_x [μm]	13.8	5.3
nominal: σ_y [μm]	10.4	5.4
σ_x [μm]	**3.8**	**1.5**
σ_y [μm]	**2.8**	**1.5**

Precision estimates

Change **noise RMS** + **time step size + jitter**:

- ✗ noise RMS **9** → **3** ADC count
- ✗ time step size of **10** → **2** ps
- ✗ sampling clock jitter **10** → **2** ps

		North Arc	South Arc
nominal	σ_x [μm]	13.8	5.3
	σ_y [μm]	10.4	5.4
	σ_x [μm]	**2.3**	**0.9**
	σ_y [μm]	**1.8**	**0.9**

Extras

Discussed in meeting

Discussion

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