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RF Pulse Step Tuning Range and Energy Gain Loss

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On behalf of the RF team

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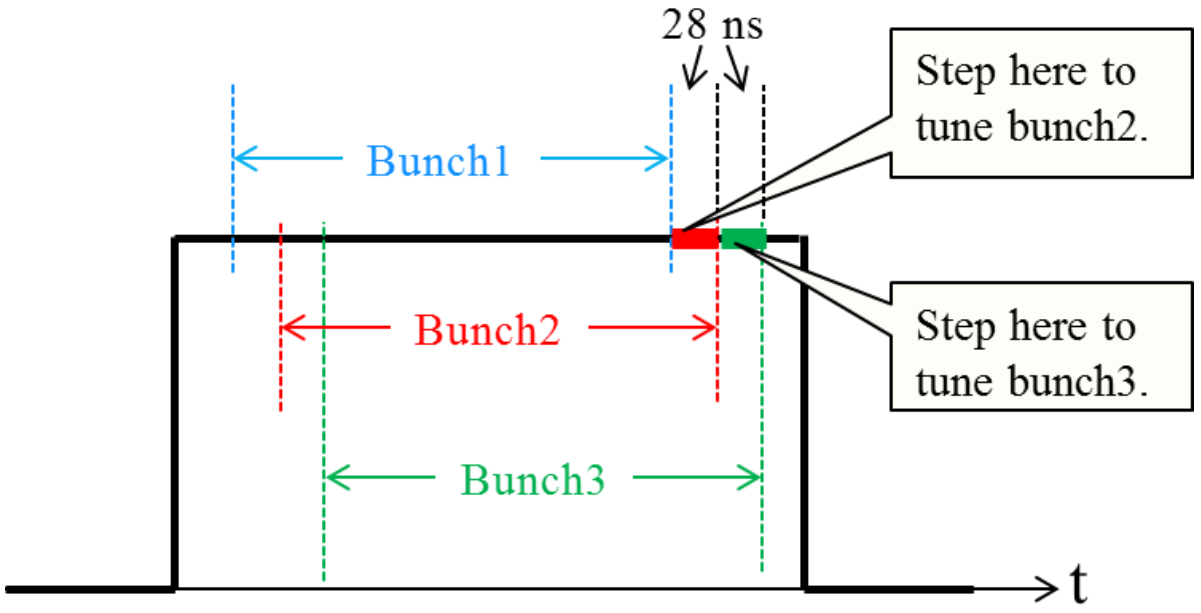
Recall the Tuning Method – RF Pulse Step

- Use two steps in the RF pulse to tune Bunch2 and Bunch3.



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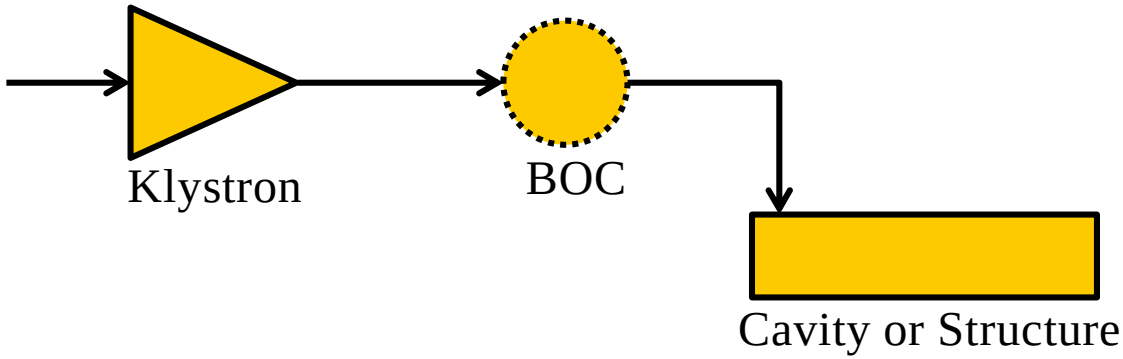
Tuning Range with different Bunch Spacing

Tuning Range with different Bunch Spacing

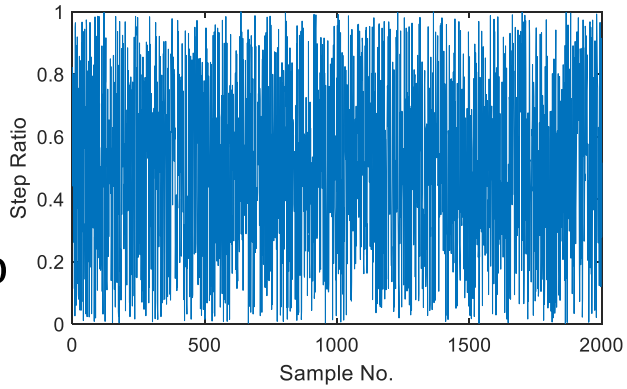
	28 ns spacing		21 ns spacing		14 ns spacing	
Gun	-1.8 % ~ 0.9 %	±1.3°	-0.9 % ~ 0.7 %	±0.8°	-0.3 % ~ 0.4 %	±0.3°
S-band	-1.7 % ~ 0.0 %	±0.8°	-1.0 % ~ 0.0 %	±0.5°	-0.5 % ~ 0.0 %	±0.2°
C-band	-4.8 % ~ -2.9 %	±0.9°	-2.9 % ~ -1.4 %	±0.7°	-1.4 % ~ -0.6 %	±0.4°
X-band	-21.6 % ~ 0.0 %	±11.5°	-14.0 % ~ 0.0 %	±7.2°	-6.9 % ~ 0.0 %	±3.4°

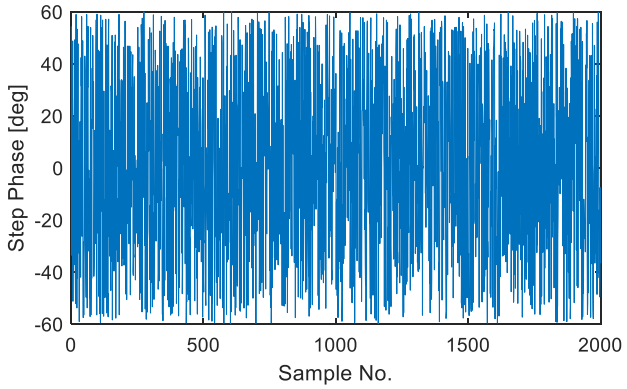


- Simulation includes the dynamics of klystron, BOC and the cavity or structure.
  - Klystron half-bandwidth: S-band 8 MHz, C-band 10 MHz, X-band 15 MHz
  - BOC: $\beta = 9$, $Q_L = 22000$
  - Gun cavity: $\beta = 2$, $Q_L = 4280$
- Range of step ratio: 0 to 1 (better not over 1 due to klystron saturation or breakdown)
- Range of step phase: -60° to 60° (large phase change may trigger reflection interlock)

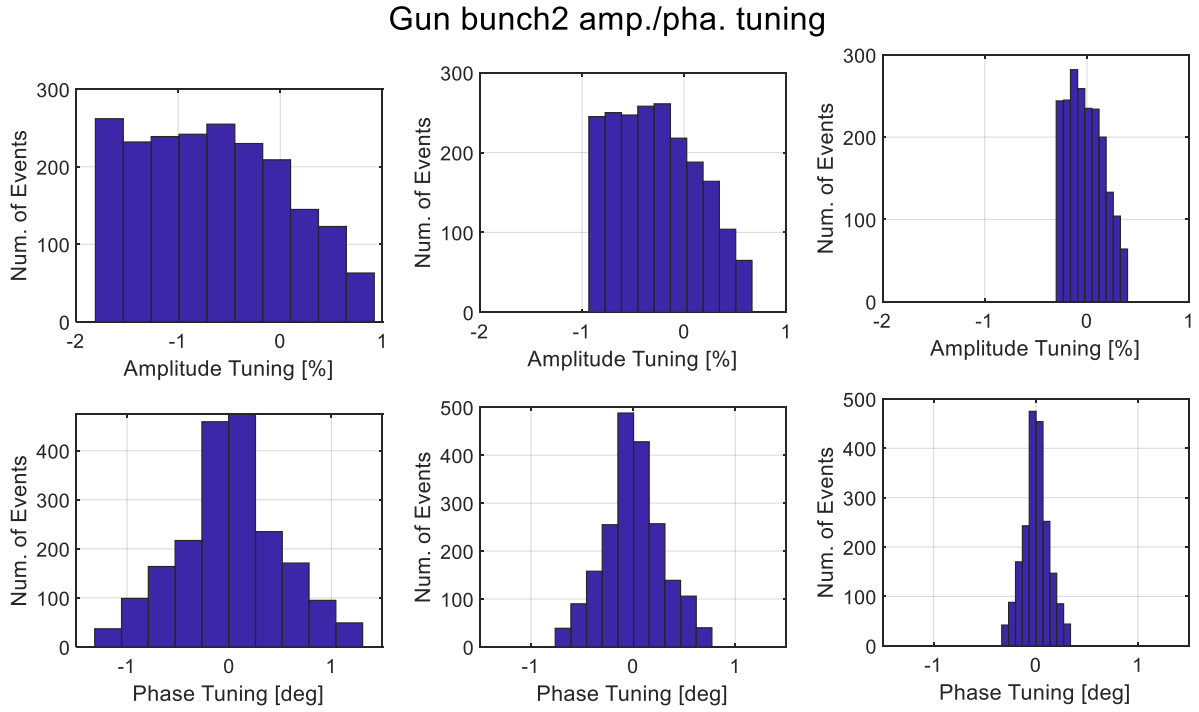
Data of Simulation

2000 pairs of randomly assigned step ratios and step phases.





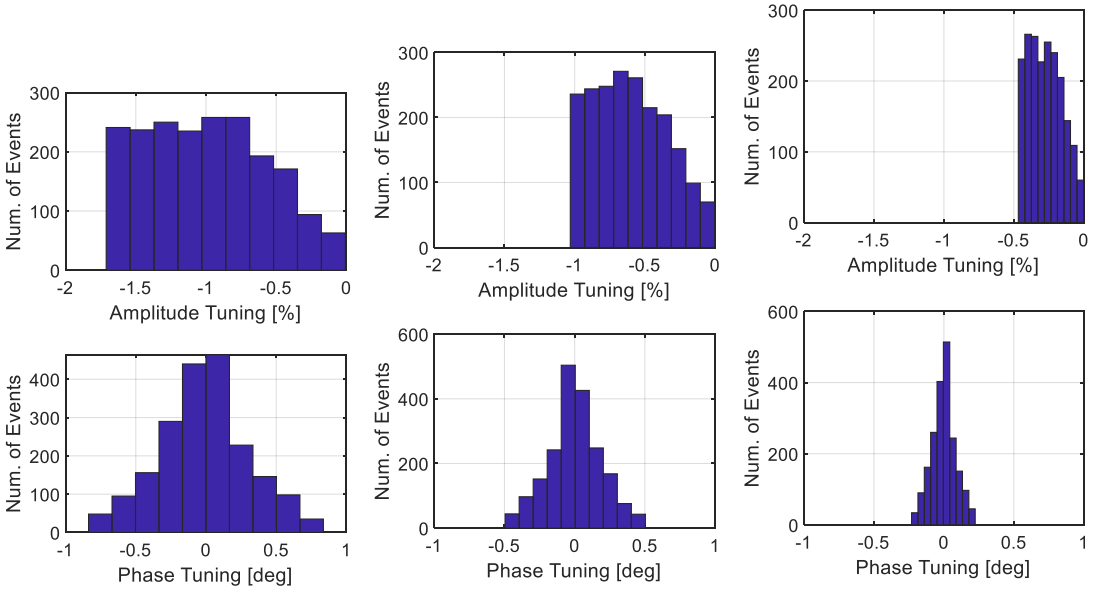
Distribution of the amplitude and phase tuning for the bunch affected by the step.



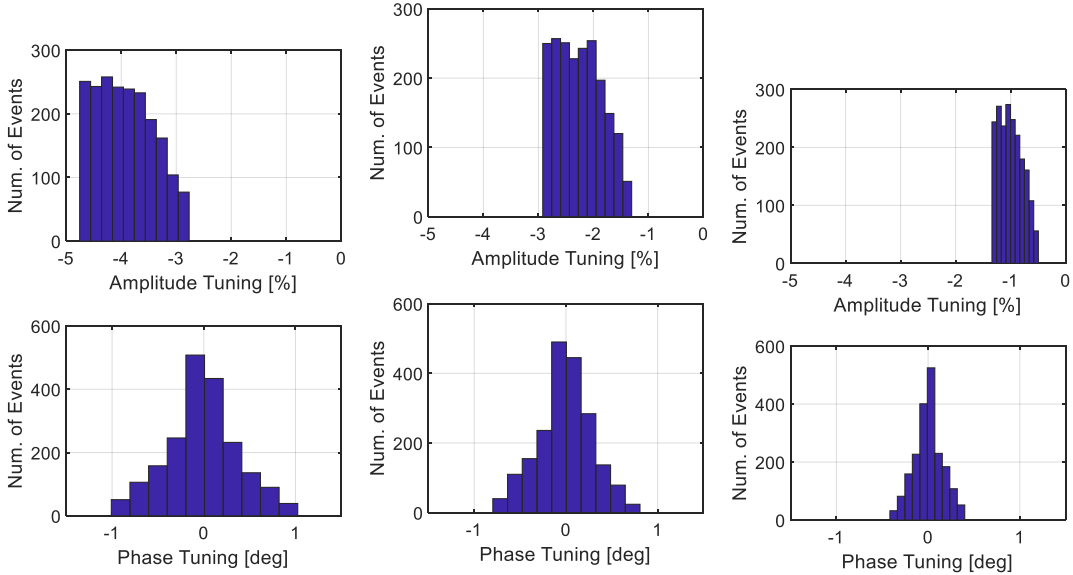
28 ns Spacing 21 ns Spacing 14 ns Spacing

Data of Simulation (cont.)

S-band bunch2 amp./pha. tuning

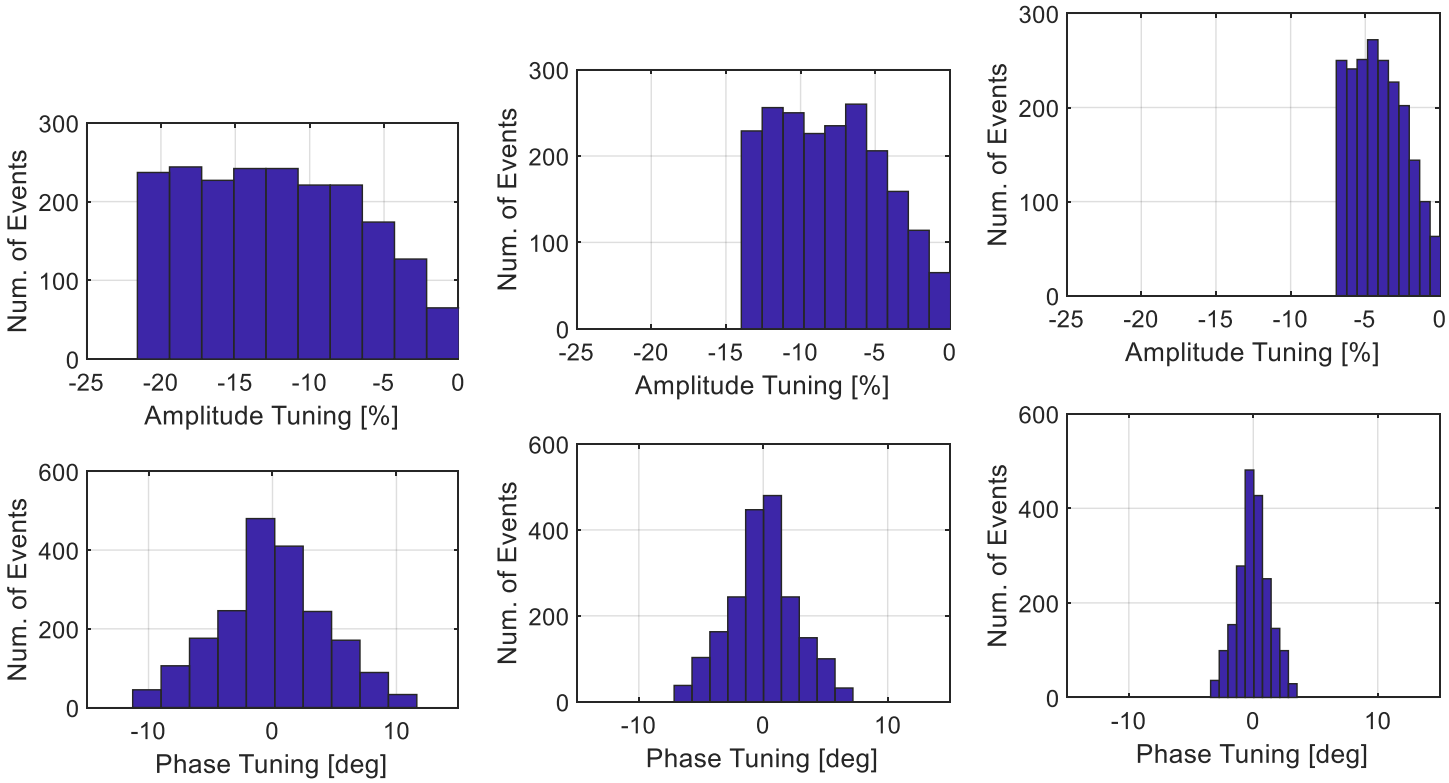


C-band bunch2 amp./pha. tuning



Data of Simulation (cont.)

X-band bunch2 amp./pha. tuning



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Energy Gain Loss with different Bunch Spacing

Estimate of Energy Gain Loss with different Bunch Spacing

- Consider **three bunches** – energy gain loss compared to single-bunch case.
- X-band should lose less if we expand the pulse width.
- S10CB09 pulse shape was not optimized.

	28 ns spacing	21 ns spacing	14 ns spacing
SINSB01	1.4 MeV	0.6	0.3
SINSB02	1.0	0.6	0.4
SINSB03	0.5	0.4	0.2
SINSB04	1.1	0.8	0.6
SINXB01	*-3.7*	*-2.0*	*-0.8*
S10CB01	6.7	4.3	1.4
S10CB02	7.7	3.8	2.3
S10CB03	8.5	4.8	2.3
S10CB04	9.0	6.8	4.4
S10CB05	7.4	4.1	2.8
S10CB06	8.0	5.0	3.0
S10CB07	6.4	4.7	3.2
S10CB08	8.0	6.1	3.1
S10CB09	*2.0*	*1.7*	*0*

Linac1 Loss: 69 MeV 45 MeV 25 MeV

C-band Loss: 200 MeV 129 MeV 73 MeV

Estimate of Energy Gain Loss with different Bunch Spacing

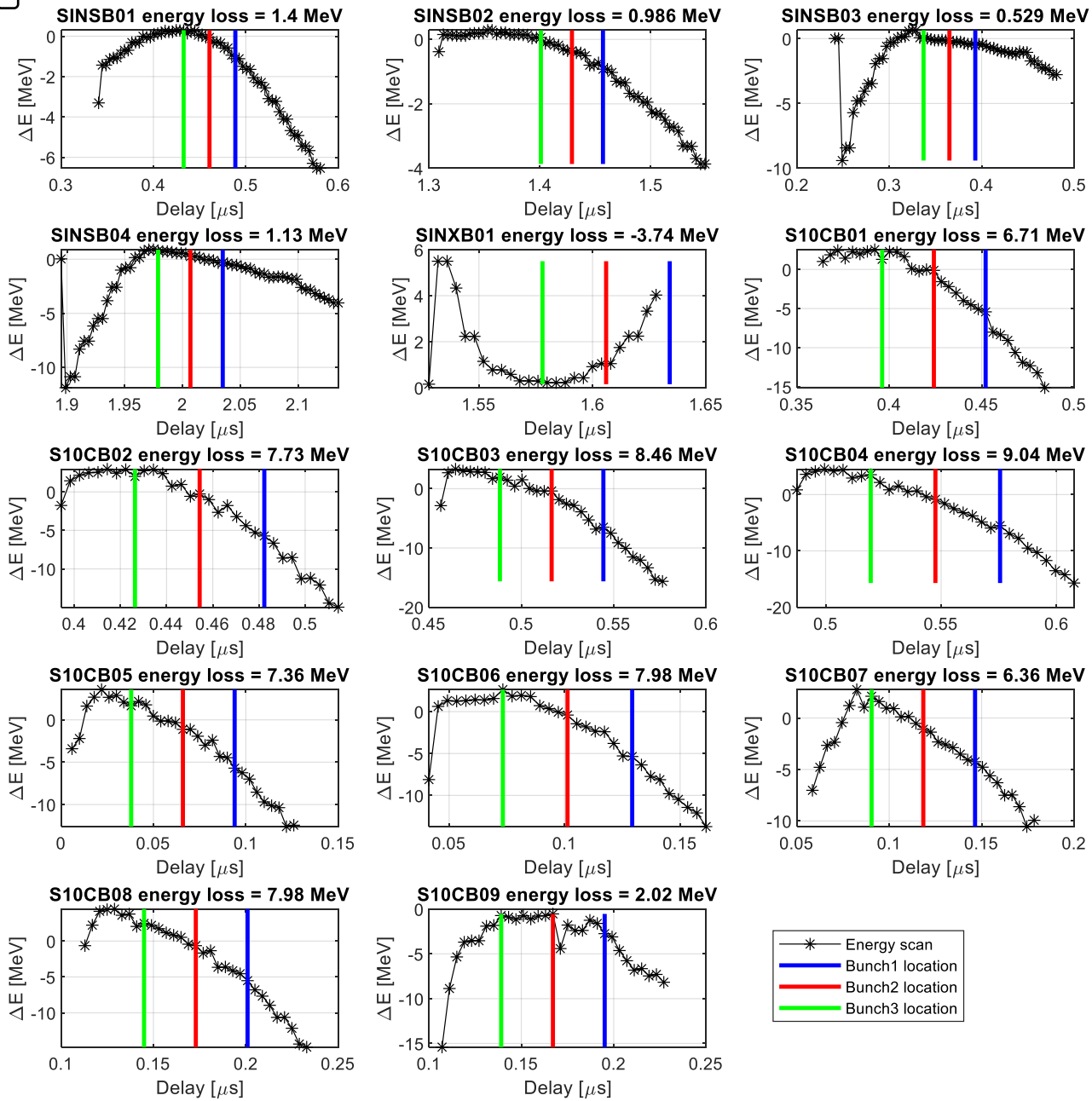
- Consider **four bunches** – energy gain loss compared to single-bunch case.
- X-band should lose less if we expand the pulse width.
- S10CB09 pulse shape was not optimized.

	28 ns spacing	21 ns spacing	14 ns spacing
SINSB01	2.2	1.6	0.6
SINSB02	1.4	0.7	0.3
SINSB03	0.8	0.3	0.2
SINSB04	1.4	1.1	0.6
SINXB01	*-3.0*	*-3.1*	*-1.8*
S10CB01	13.1	8.1	4.7
S10CB02	14.2	9.6	4.1
S10CB03	15.0	8.7	4.3
S10CB04	13.4	8.4	4.7
S10CB05	11.5	6.9	3.5
S10CB06	11.7	8.1	4.1
S10CB07	9.46	5.8	3.5
S10CB08	13.7	8.2	4.4
S10CB09	*6.75*	*3.9*	*1.3*

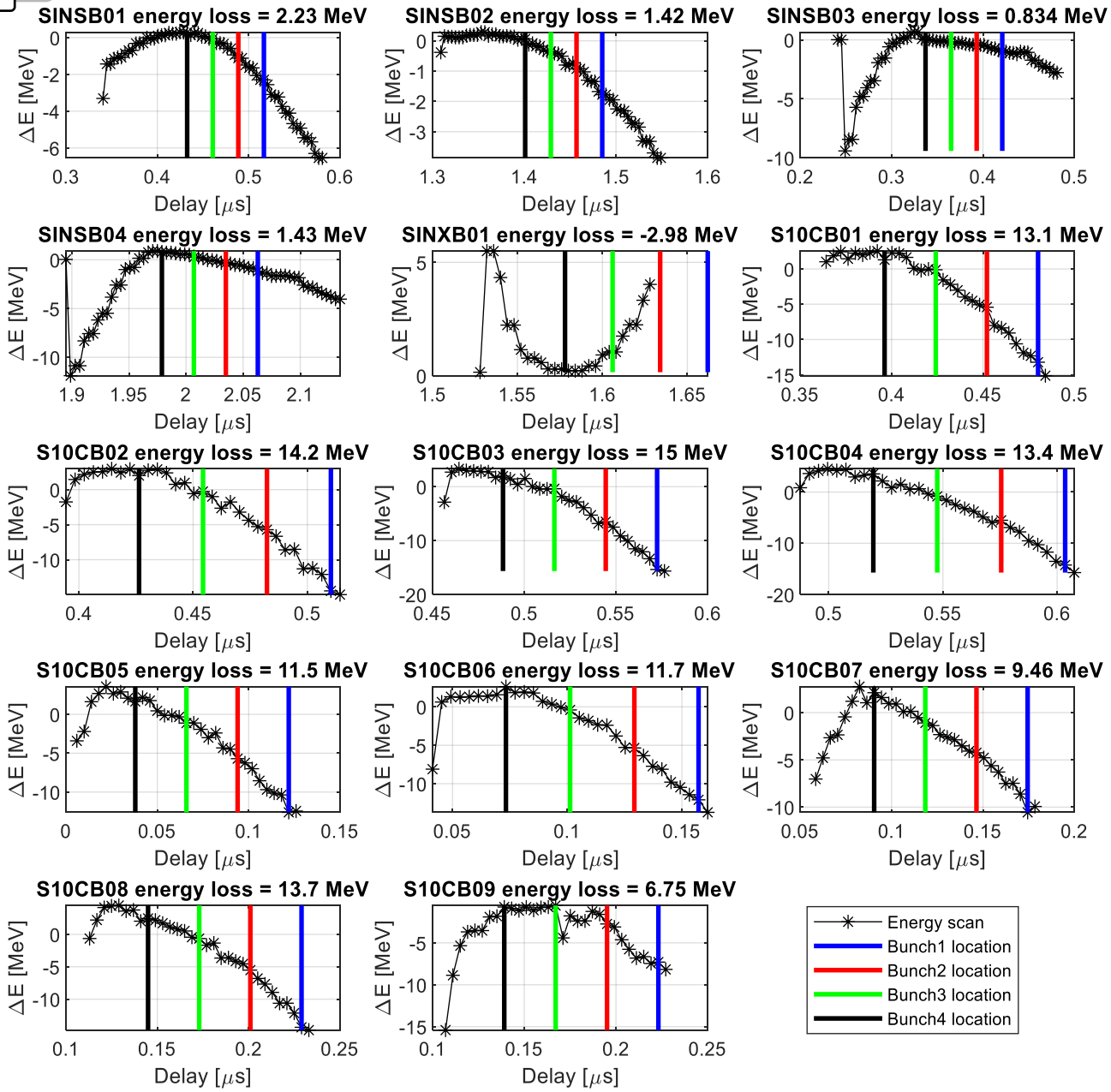
Linac1 Loss: 115 MeV 72 MeV 37 MeV

C-band Loss: 332 MeV 207 MeV 108 MeV

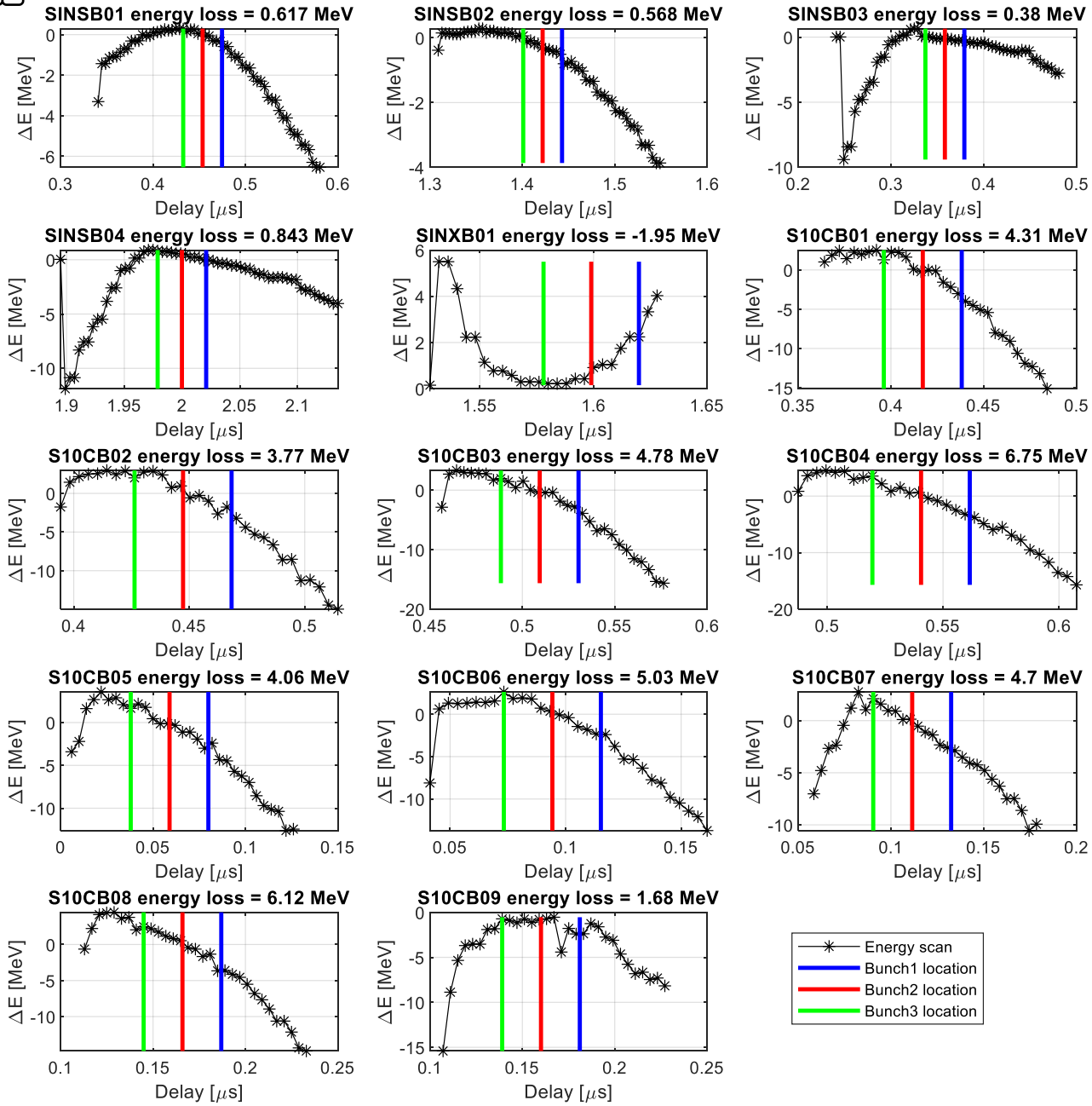
Energy Loss of Bunch Spacing = 28 ns (3 bunches)



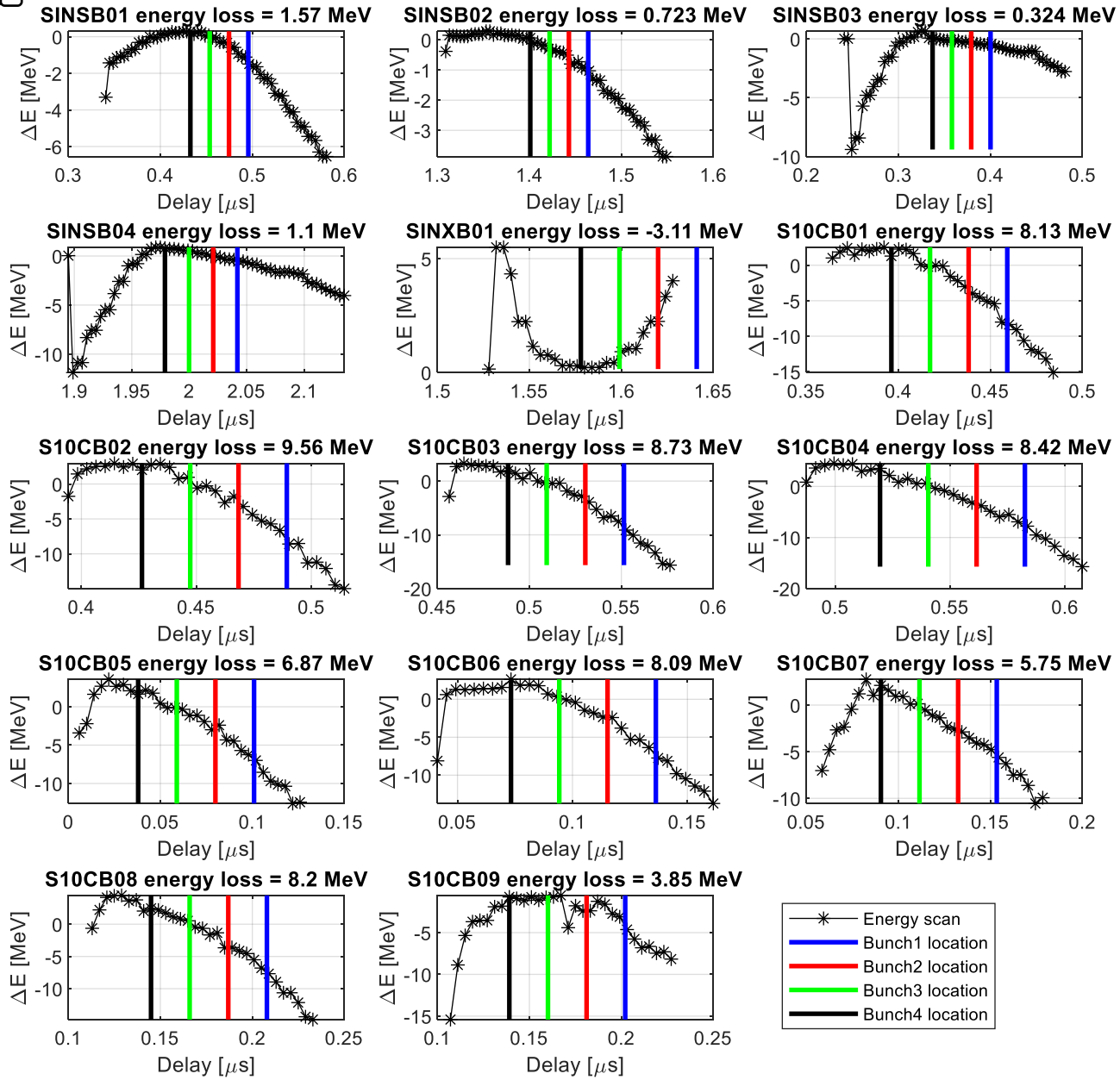
Energy Loss of Bunch Spacing = 28 ns (4 bunches)



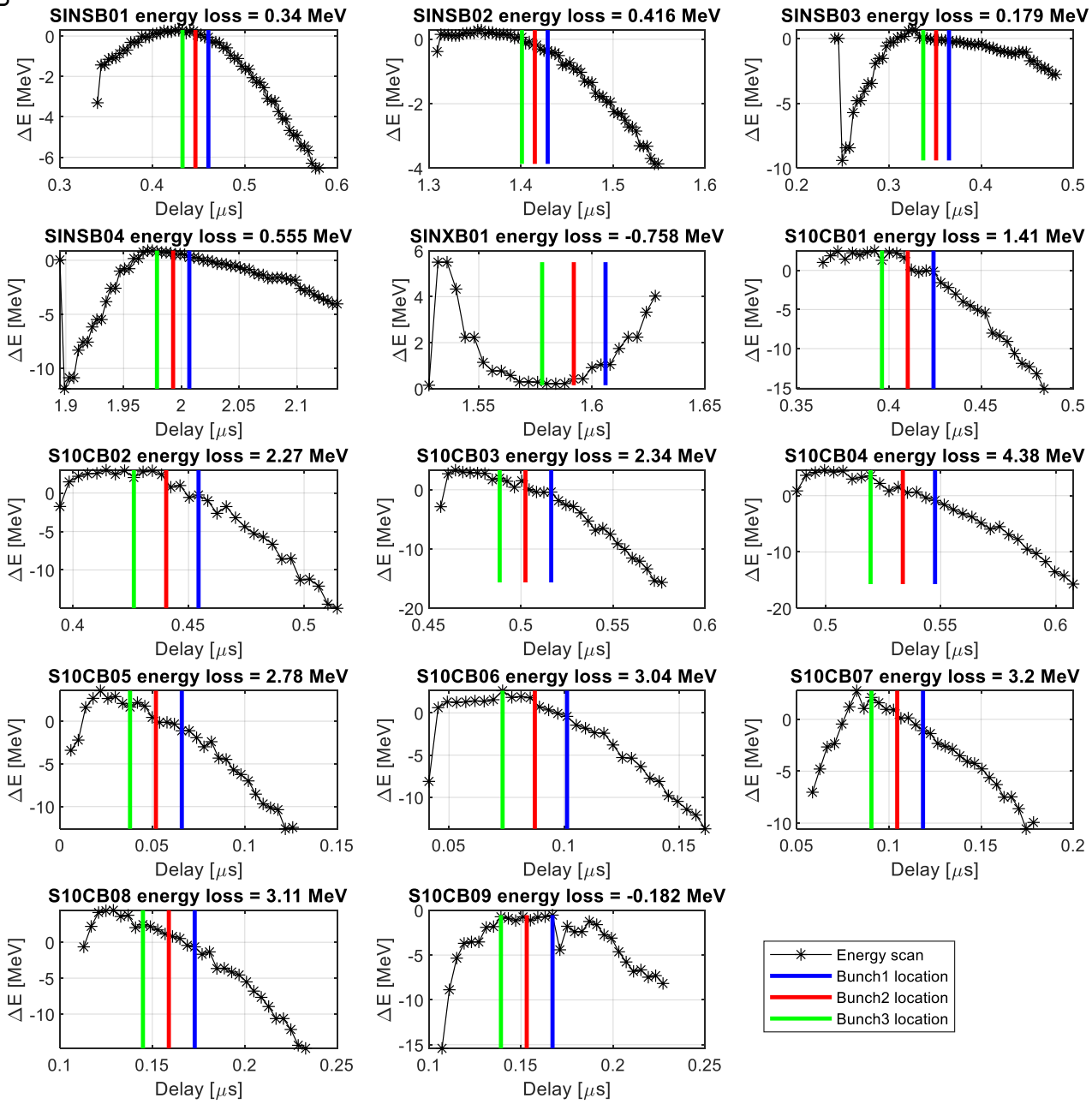
Energy Loss of Bunch Spacing = 21 ns (3 bunches)



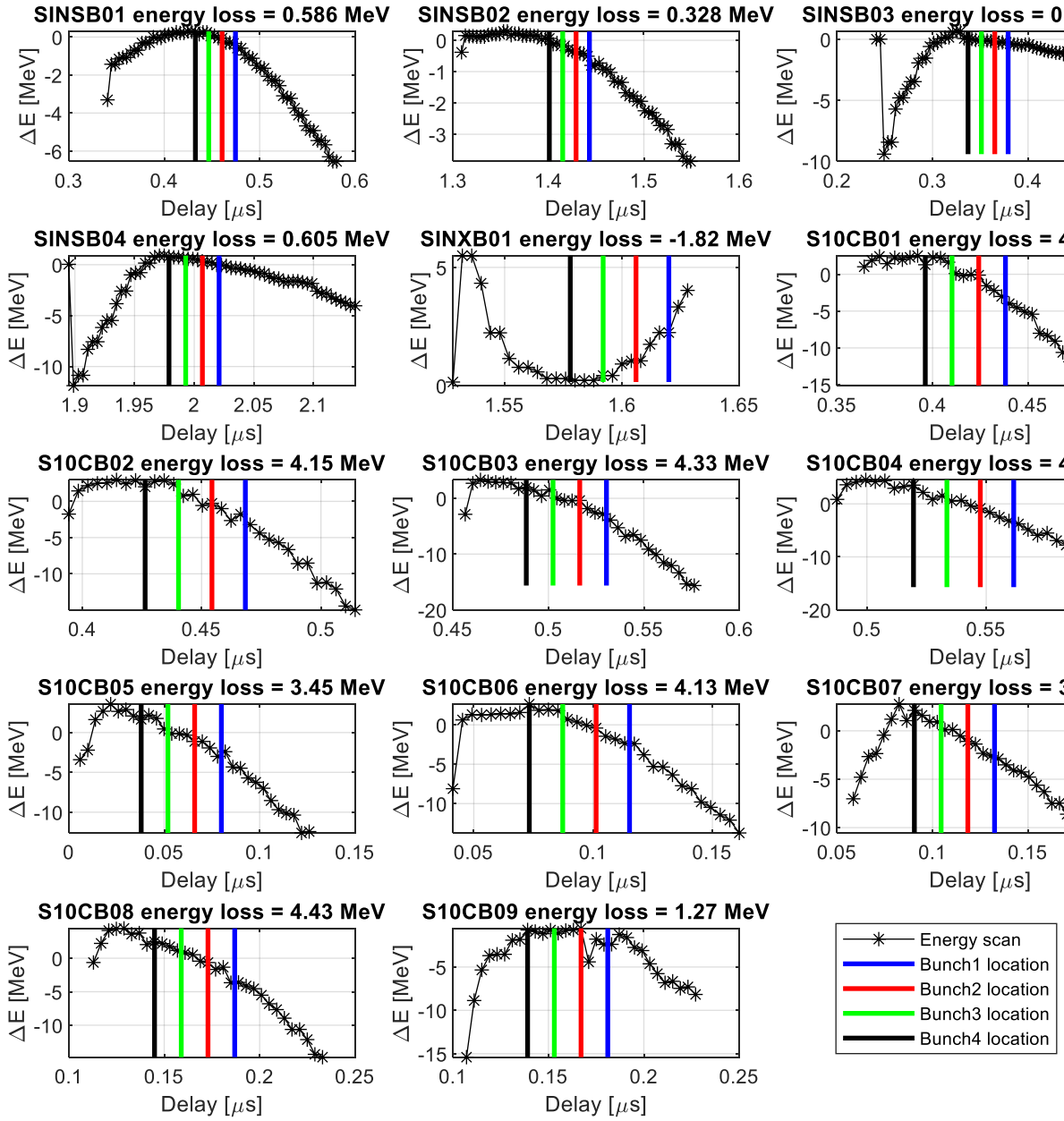
Energy Loss of Bunch Spacing = 21 ns (4 bunches)



Energy Loss of Bunch Spacing = 14 ns (3 bunches)



Energy Loss of Bunch Spacing = 14 ns (4 bunches)



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Discussions