FCC-ee Injectors Studies

(Updated with new kly. power per struc.)

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46th FCCee injector collaboration WP1 meeting

12 December 2024

Acc. Structure parameters

Structure parameters are calculated for the single bunch case.

	HE-linac	E-linac	P-linac
Frequency [GHz]	2.8	2.8	2
Avg. Aperture	0.12λ	0.15λ	0.2λ
Entr., exit aperture	14.85 mm, 10.85 mm	17.13 mm, 14.99 mm	30 mm, 30 mm
Iris thickness	2.84 mm → 4.04 mm	10.4 mm → 13.7 mm	14.3 mm → 20 mm
Vg (% c)	3.92 → 1.25	3.14→ 1.38	2.58 → 1.92
r/Q (kOhm/m)	3.63 → 4.38	3.28 → 3.67	1.49 → 1.52
Q	16571 → 16039	14599 → 13668	20977 → 19102
Structure Length [m]	3	3	3
Filling time	460 ns	486 ns	447 ns
SLED coupling	15	15	17
Eff. shunt impedance	102 .25 MΩ/m	87.17 MΩ/m	38.73 MΩ/m
Repetition rate [Hz]	100	100	100
Klystron power per structure	14.2MW	14.2 MW	15.4 MW
Average Structure Input Power	3.72 kW	3.76 kW	3.68 kW
G_{avg}	22 MV/m	20.3 MV/m	14.1 MV/m
E_{max} (instant.)	73 MV/m	77 MV/m	55 MV/m
$S_{c,max}$ (instant.)	501 mW/μm^2	453 mW/μm^2	298 mW/μm^2

Acc. Structure parameters

Structure parameters are calculated for the four bunches case.

	HE-linac	E-linac	P-linac		
Eff. shunt impedance (Four bunches)	95.65 MΩ/m	81.69 MΩ/m	36 MΩ/m		
Unloaded G_{avg}	21.28 MV/m	19.66 MV/m	13.59 MV/m		
Bunch Charge	5 nC	5 nC	5 nC	10 nC	15 nC
Loaded G_{avg}	21.06 MV/m	19.49 MV/m	13.5 MV/m	13.42 MV/m	13.31 MV/m

HE-Linac Studies

Compansated

- **HE Linac:**

4 Bunches case:

P_klys = 14.2 MW

3m structure

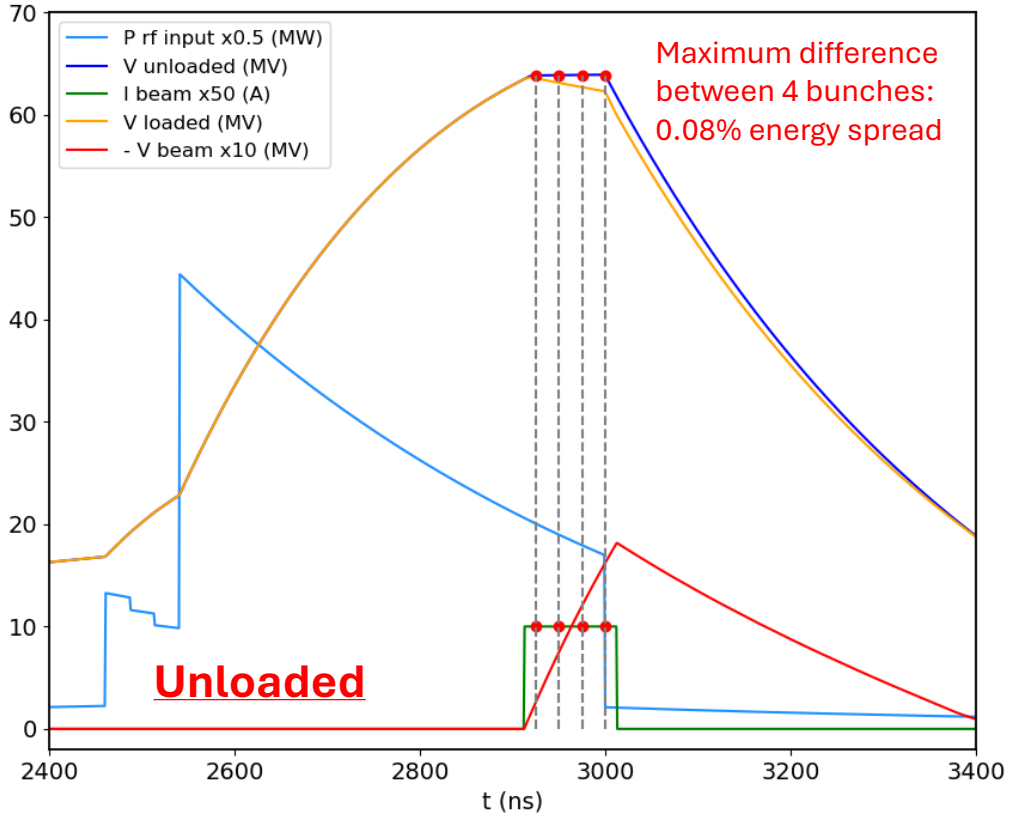
G = V/L

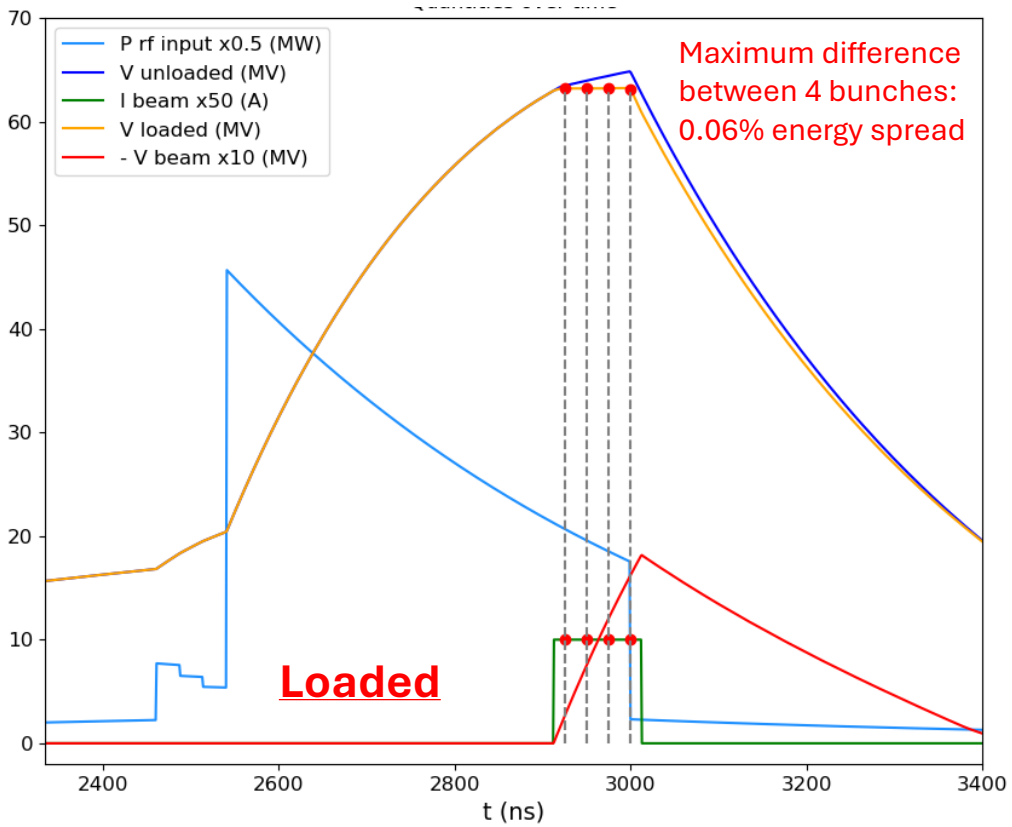
For bunch charge: 5 nC

25 ns of bunch spacing

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	Rsh
Single Bunch	66 MV				102.25 MΩ/m
4 Bunches	63.81 MV	63.84 MV	63.86 MV	63.82 MV	95.65 MΩ/m

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	65.75 MV			
4 Bunches	63.19 MV	63.19 MV	63.20 MV	63.16 MV



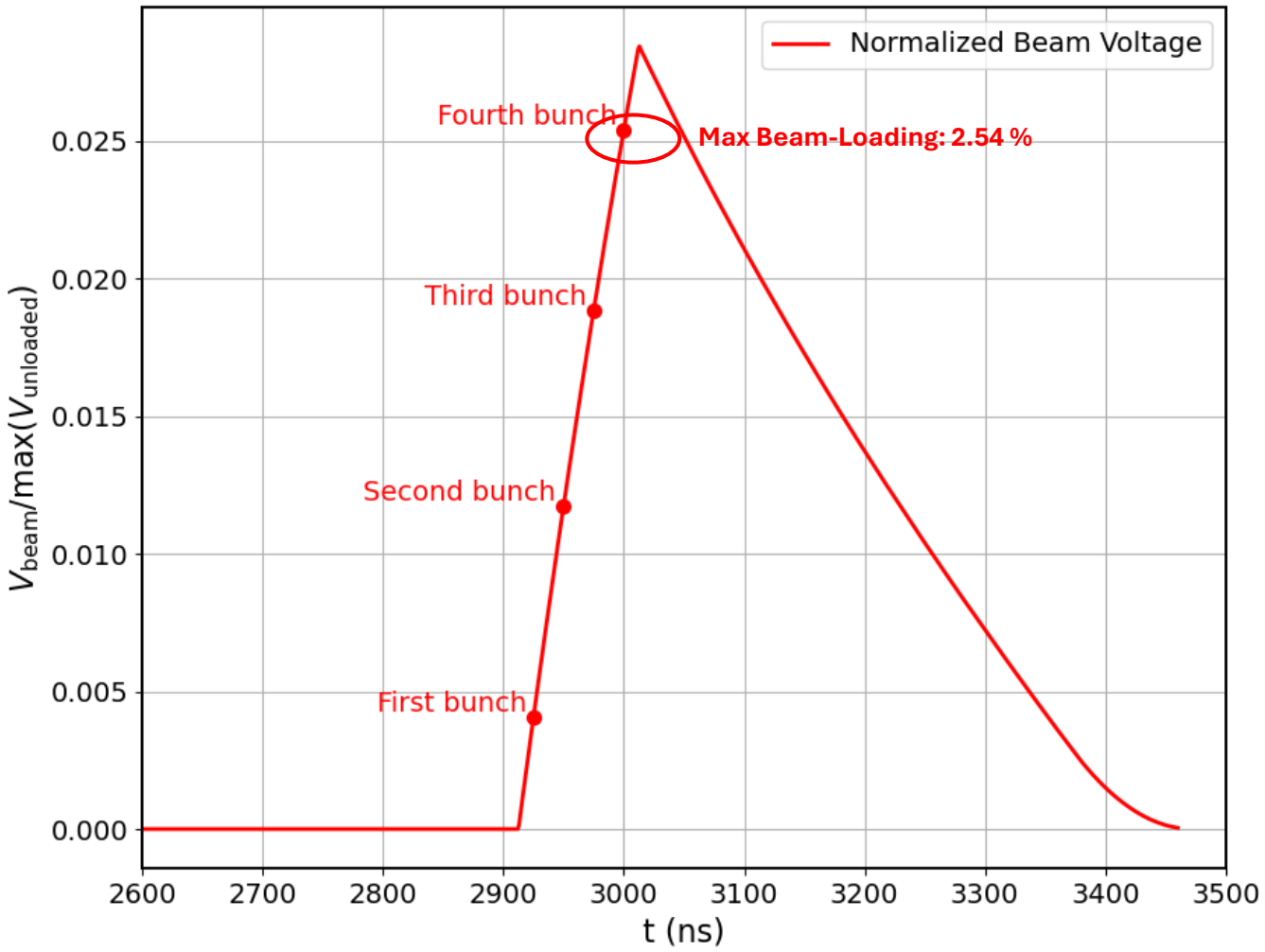


- **HE Linac:**

4 Bunches case:

Beam loading effect

For bunch charge: 5 nC
25 ns of bunch spacing



Golden pulse applied

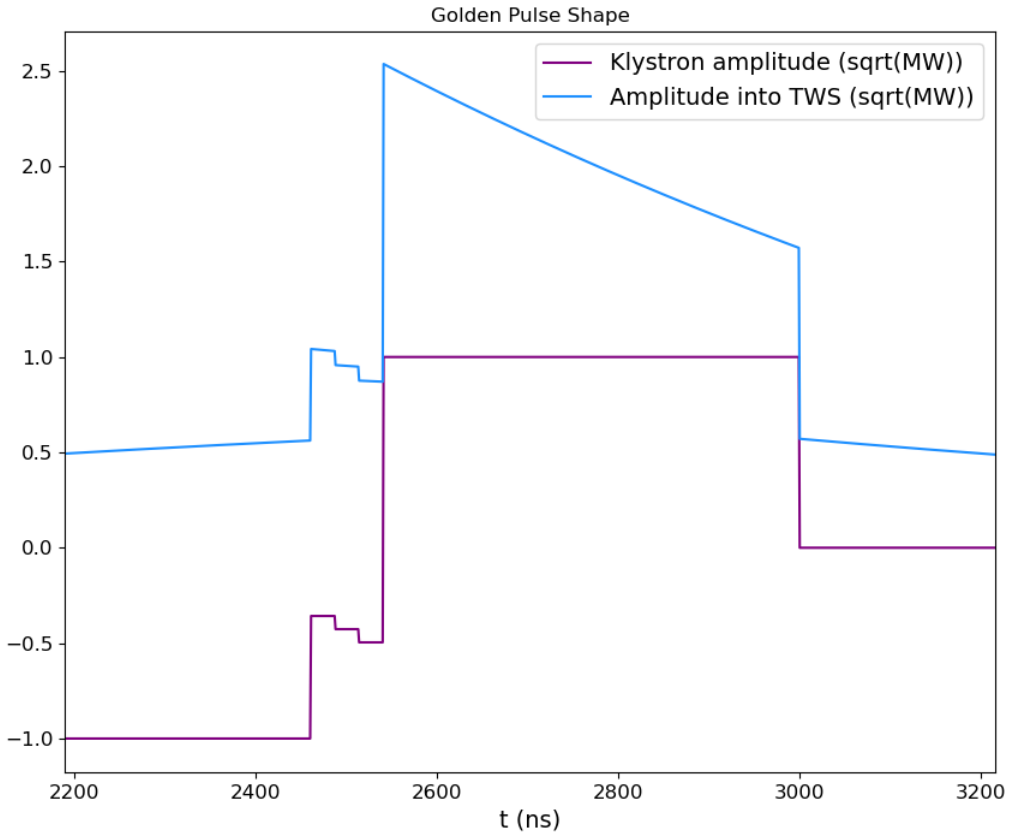
- **HE Linac:**

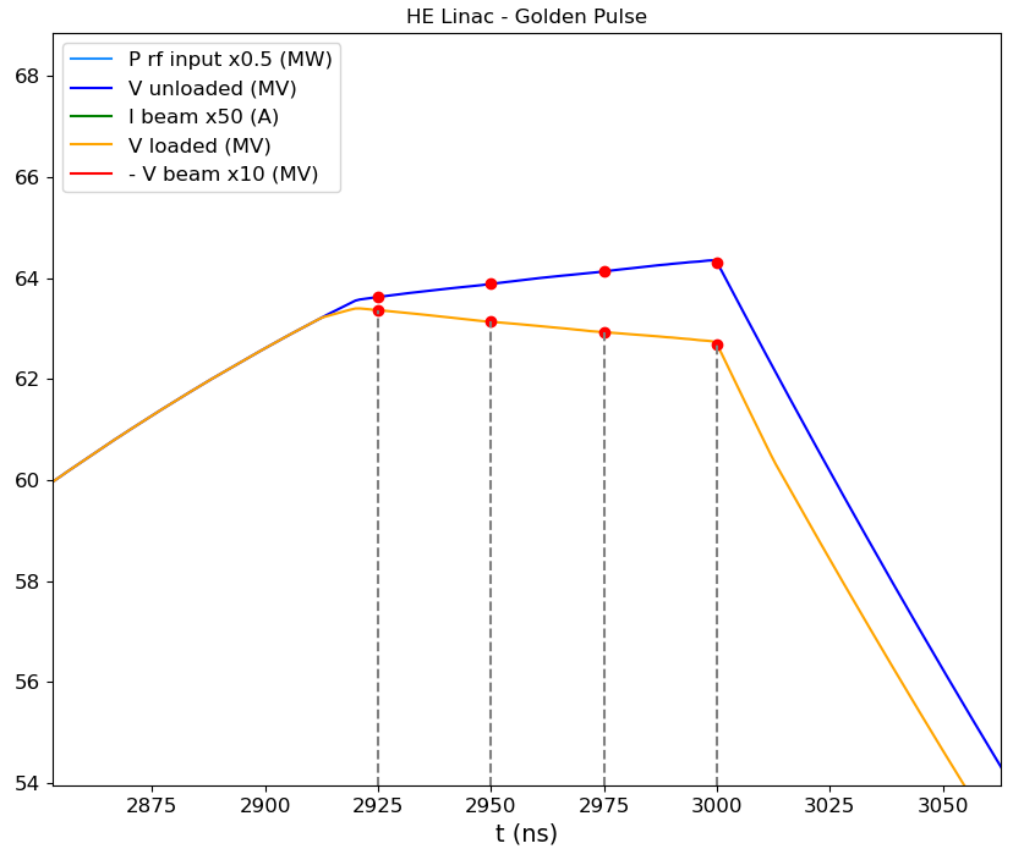
4 Bunches case:

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	66 MV				
4 Bunches	63.63 MV	63.89 MV	64.13 MV	64.30 MV	+1.1% energy spread

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	65.75 MV				
4 Bunches	63.37 MV	63.14 MV	62.93 MV	62.68 MV	-1.1 % energy spread

For bunch charge: 5 nC
25 ns of bunch spacing





E-Linac Studies

- **E Linac:**

4 Bunches case:

P_klys = 14.2 MW

3m structure

G = V/L

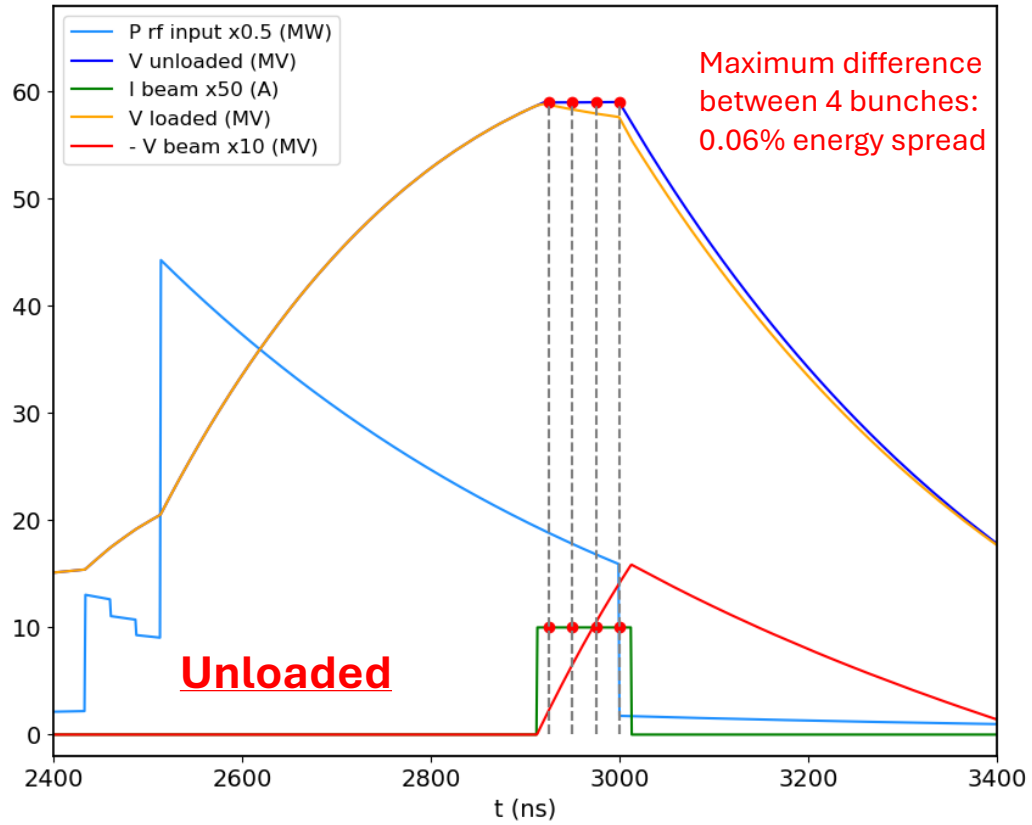
For bunch charge: 5 nC

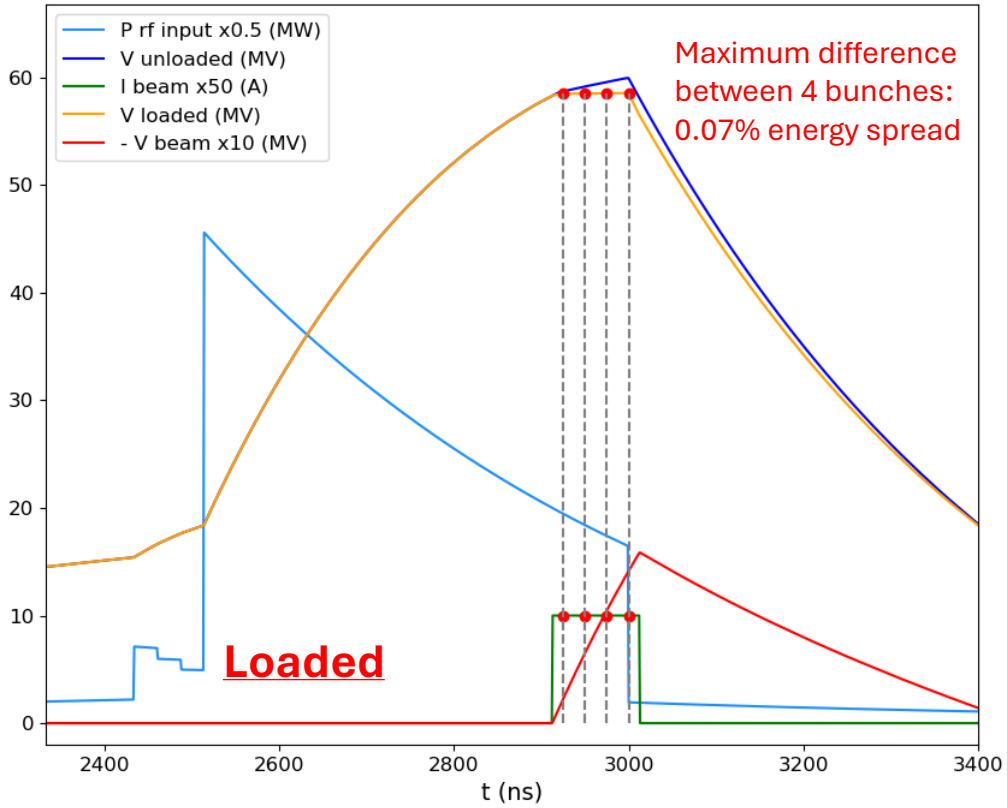
25 ns of bunch spacing

Compansated

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	Rsh
Single Bunch	60.94 MV				87.17 MΩ/m
4 Bunches	59.00 MV	59.00 MV	59.00 MV	58.97 MV	81.69 MΩ/m

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	60.72 MV			
4 Bunches	58.47 MV	58.49 MV	58.51 MV	58.48 MV



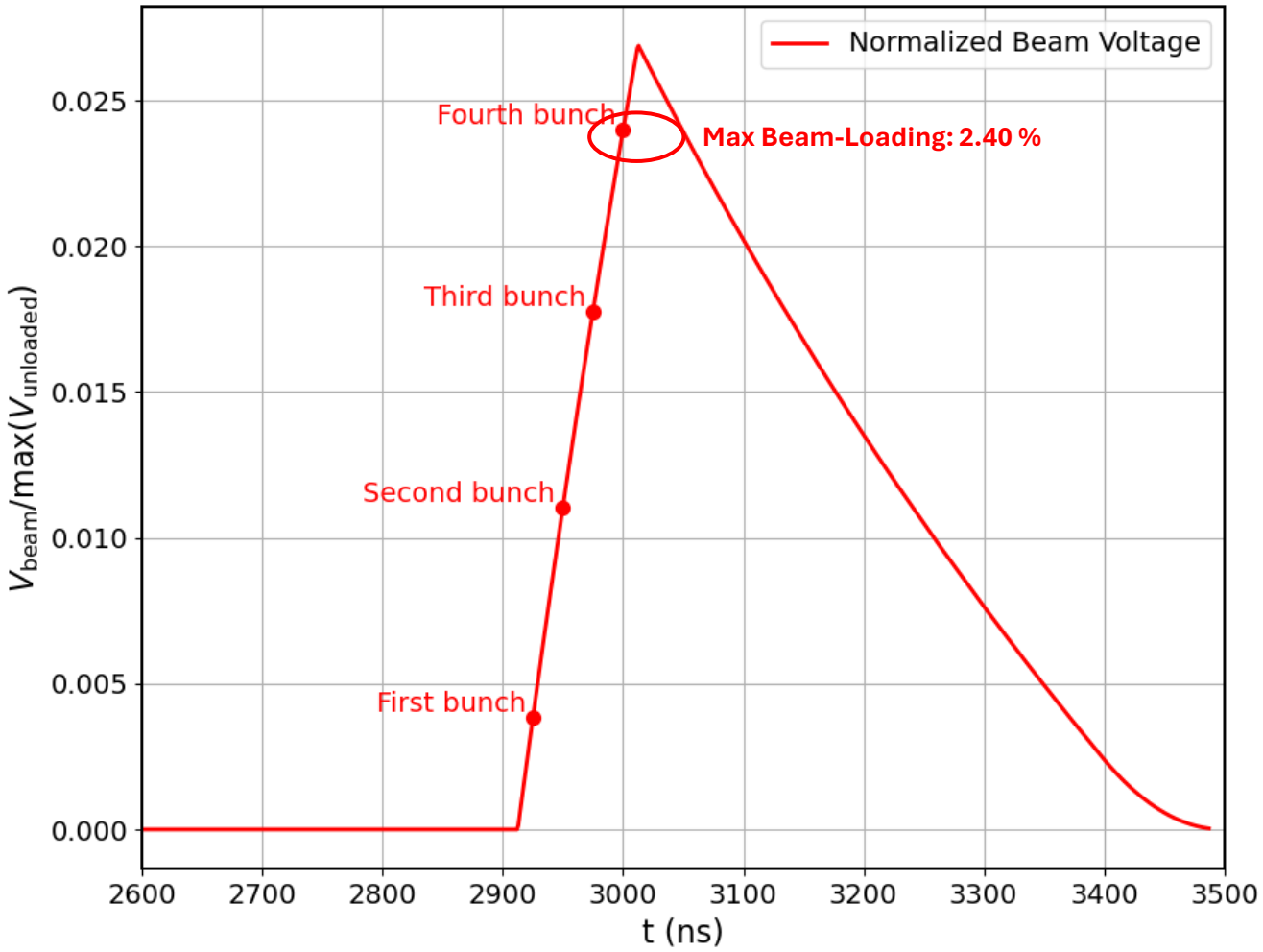


- **E Linac:**

4 Bunches case:

Beam loading effect

For bunch charge: 5 nC
25 ns of bunch spacing



- **E Linac:**

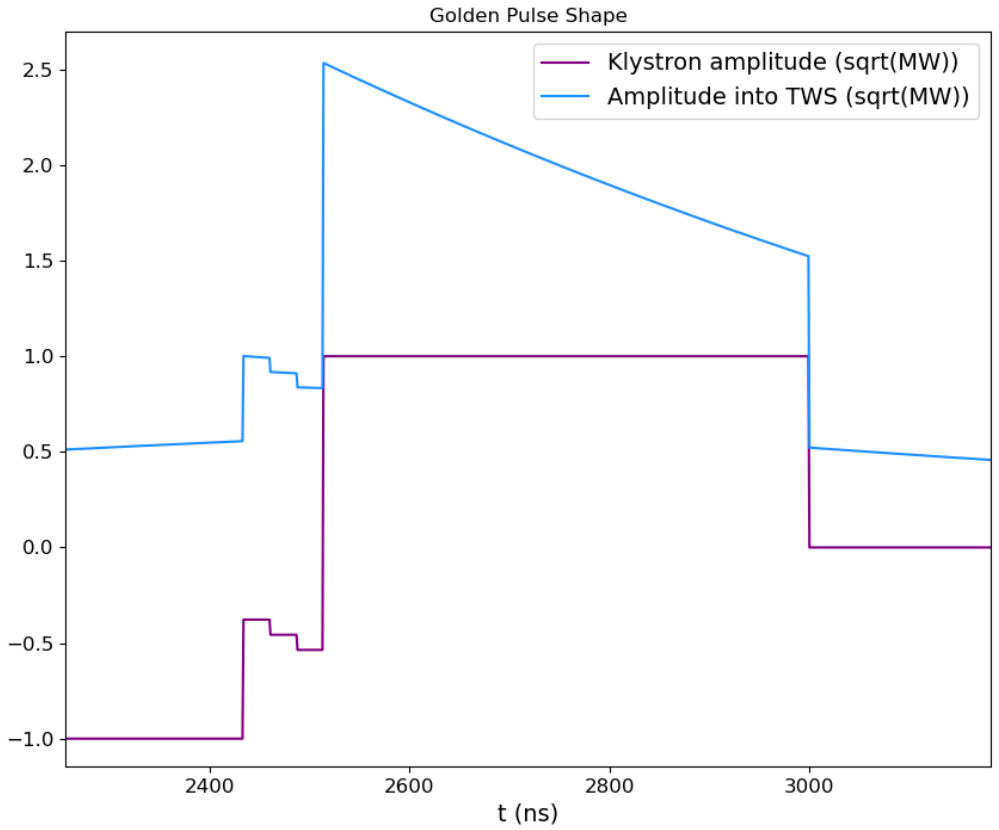
4 Bunches case:

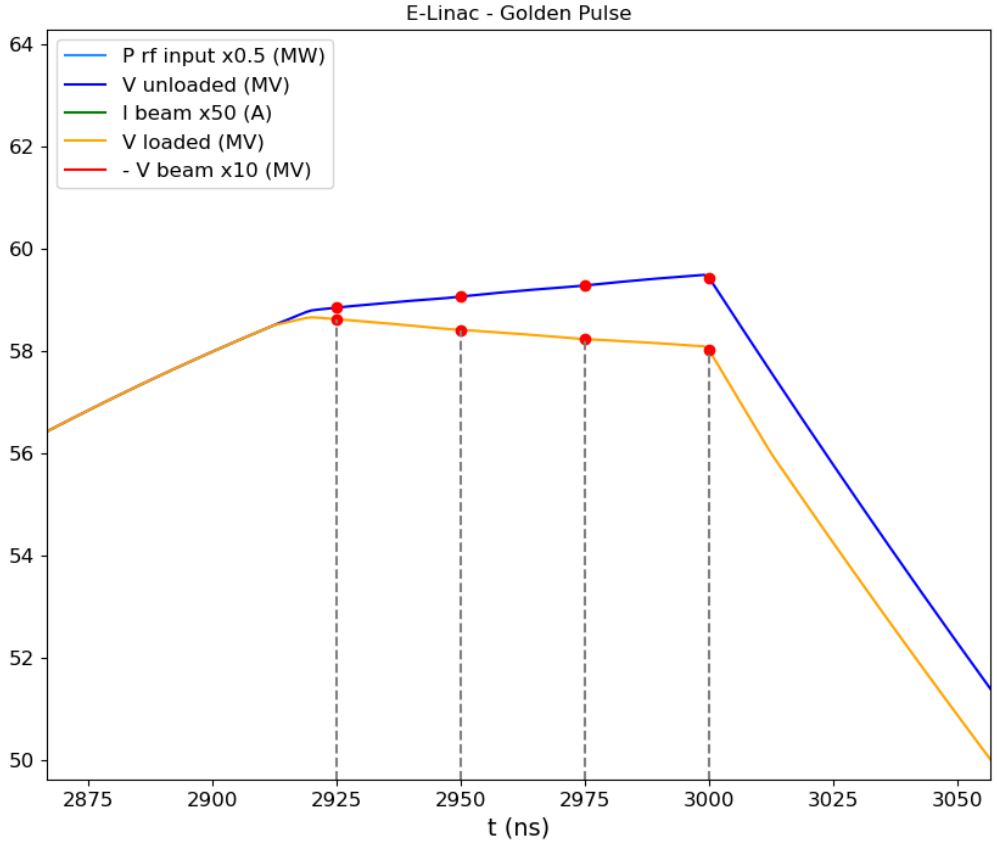
For bunch charge: 5 nC
25 ns of bunch spacing

Golden pulse applied

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	60.94 MV				
4 Bunches	58.85 MV	59.07 MV	59.28 MV	59.43 MV	+1% energy spread

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	60.72 MV				
4 Bunches	58.62 MV	58.41 MV	58.23 MV	58.02 MV	-1 % energy spread





p-Linac Studies
(5 nC bunch charge)

Compansated

- **p-linac:**

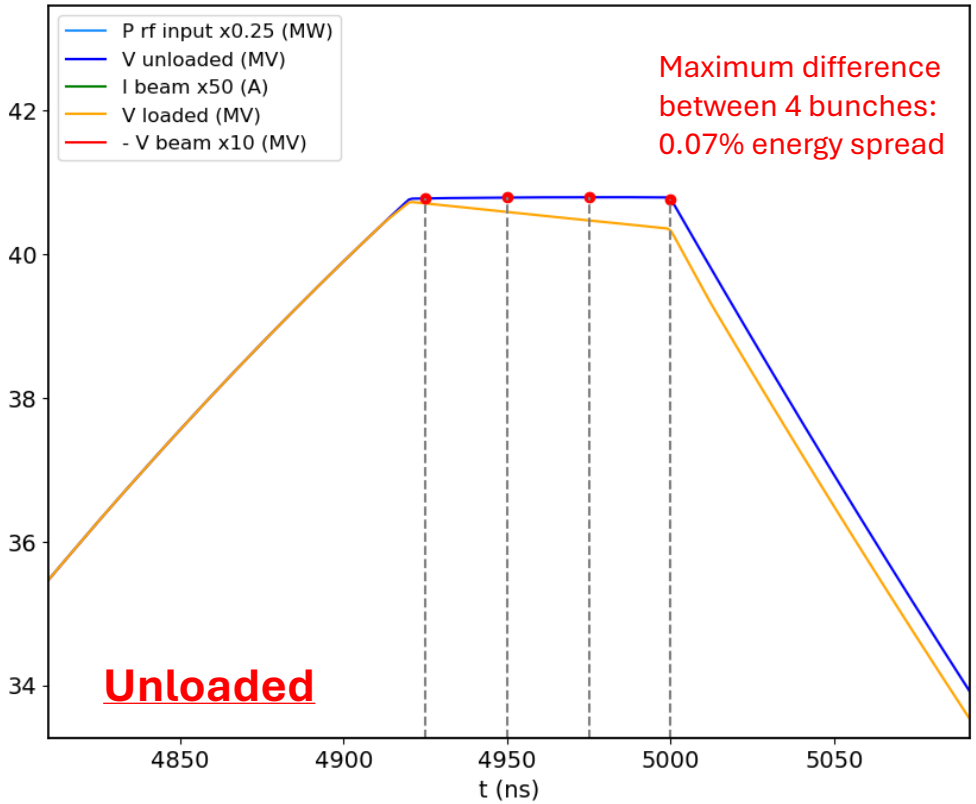
4 Bunches case:

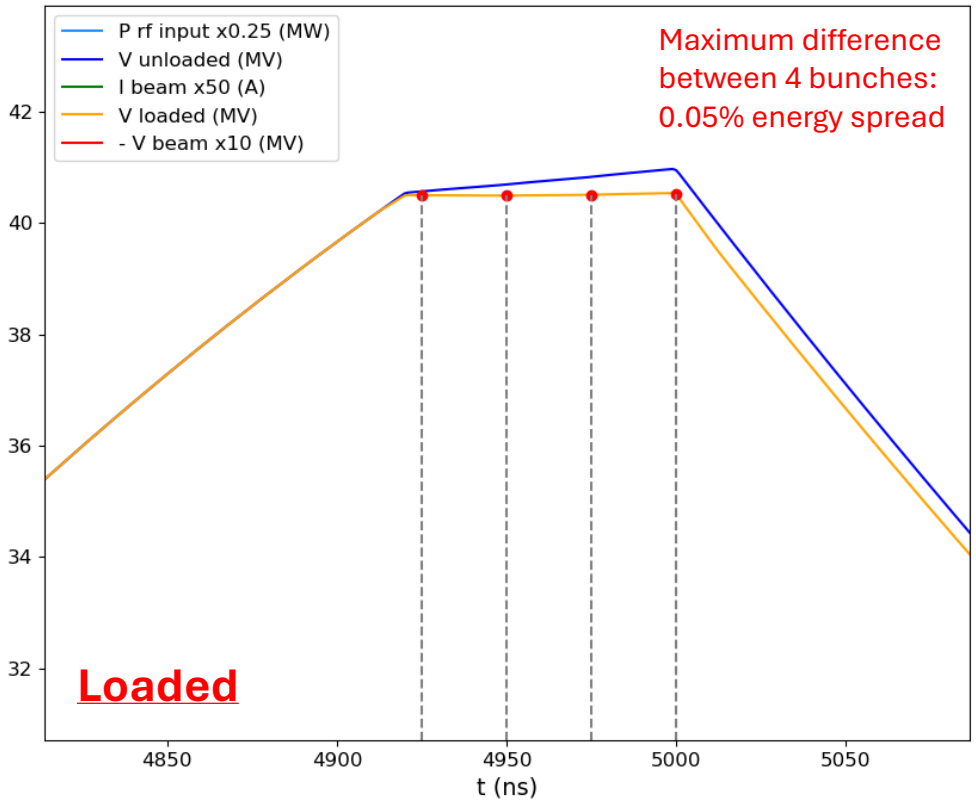
P_klys = 15.4 MW
3m structure
G = V/L

For bunch charge: 5 nC
25 ns of bunch spacing

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	Rsh
Single Bunch	42.30 MV				38.73 MΩ/m
4 Bunches	40.78 MV	40.79 MV	40.79 MV	40.77 MV	36.00 MΩ/m

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	42.23 MV			
4 Bunches	40.50 MV	40.50 MV	40.51 MV	40.52 MV



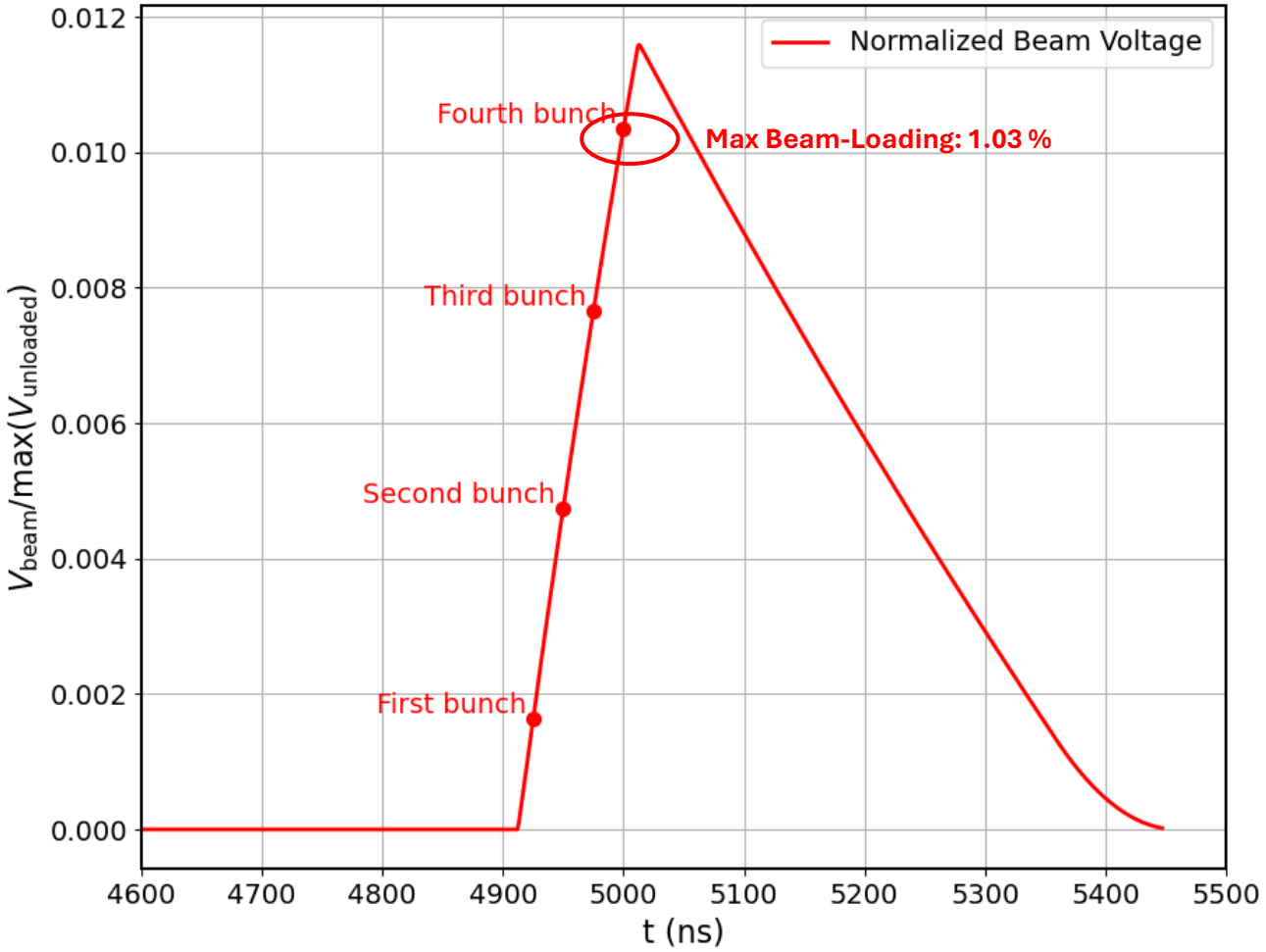


- **p Linac:**

4 Bunches case:

For bunch charge: 5 nC
25 ns of bunch spacing

Beam loading effect



Golden pulse applied

- **p-linac:**

Bunches case:

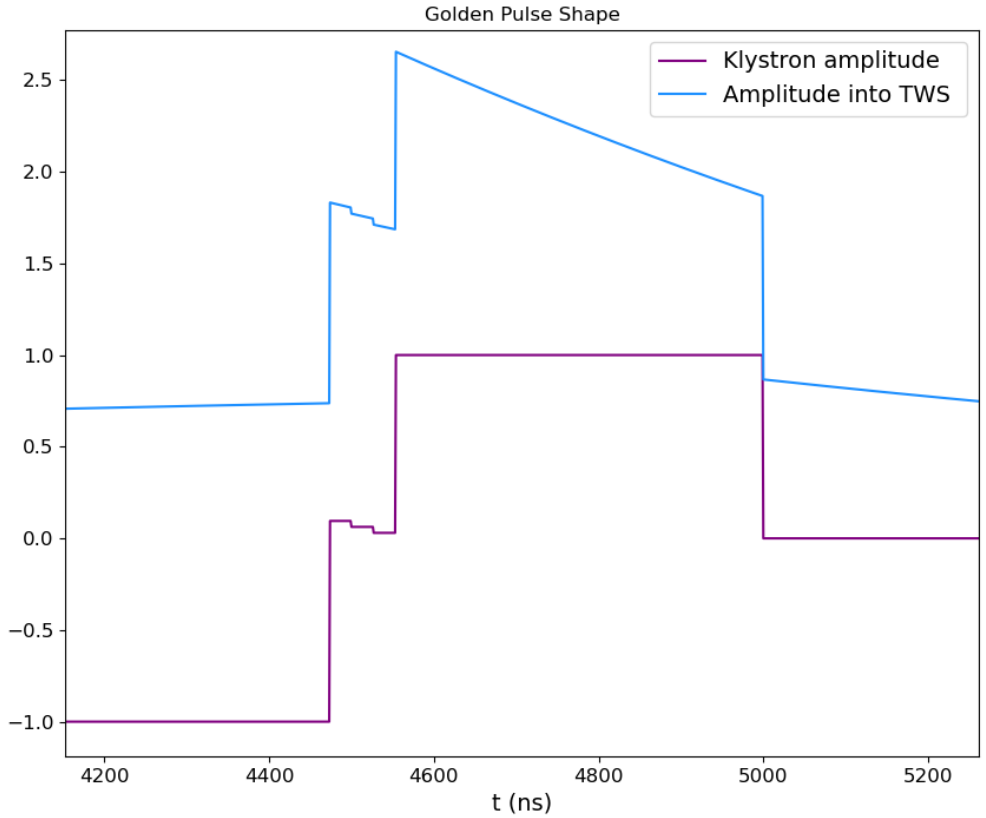
Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	42.30 MV			
4 Bunches	40.67 MV	40.74 MV	40.81 MV	40.86 MV

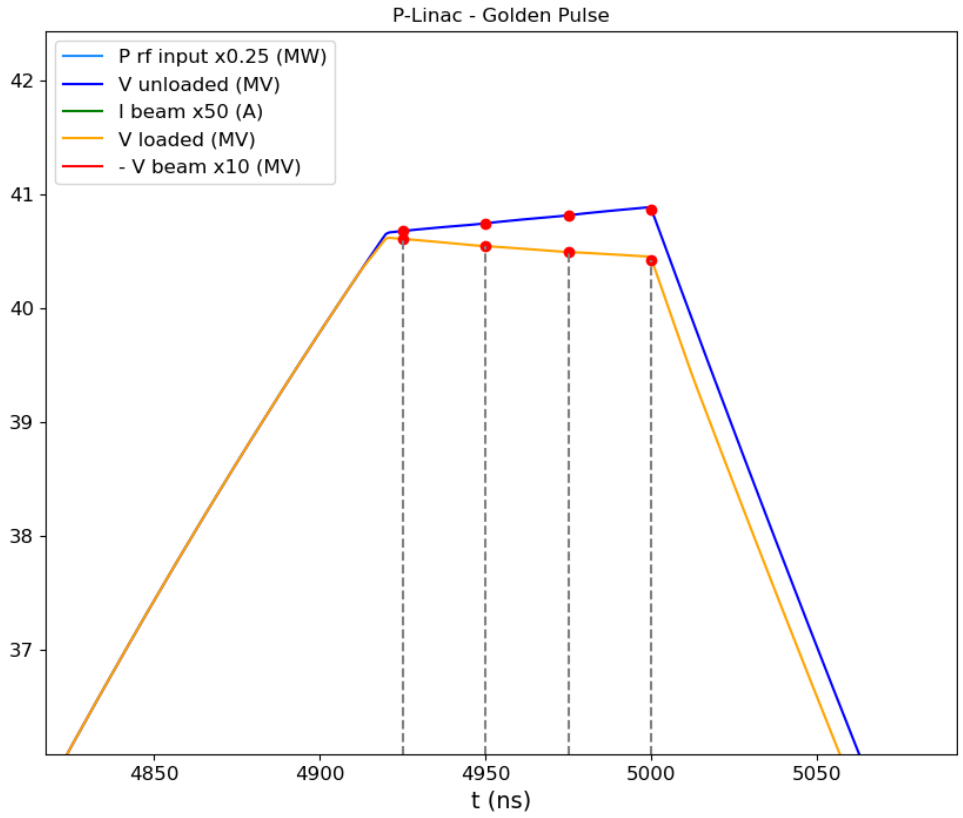
+0.45 % energy spread

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	42.23 MV			
4 Bunches	40.61 MV	40.54 MV	40.49 MV	40.42 MV

-0.45 % energy spread

For bunch charge: 5 nC
25 ns of bunch spacing





p-linac Studies
(10 nC bunch charge)

Compansated

- **p Linac:**

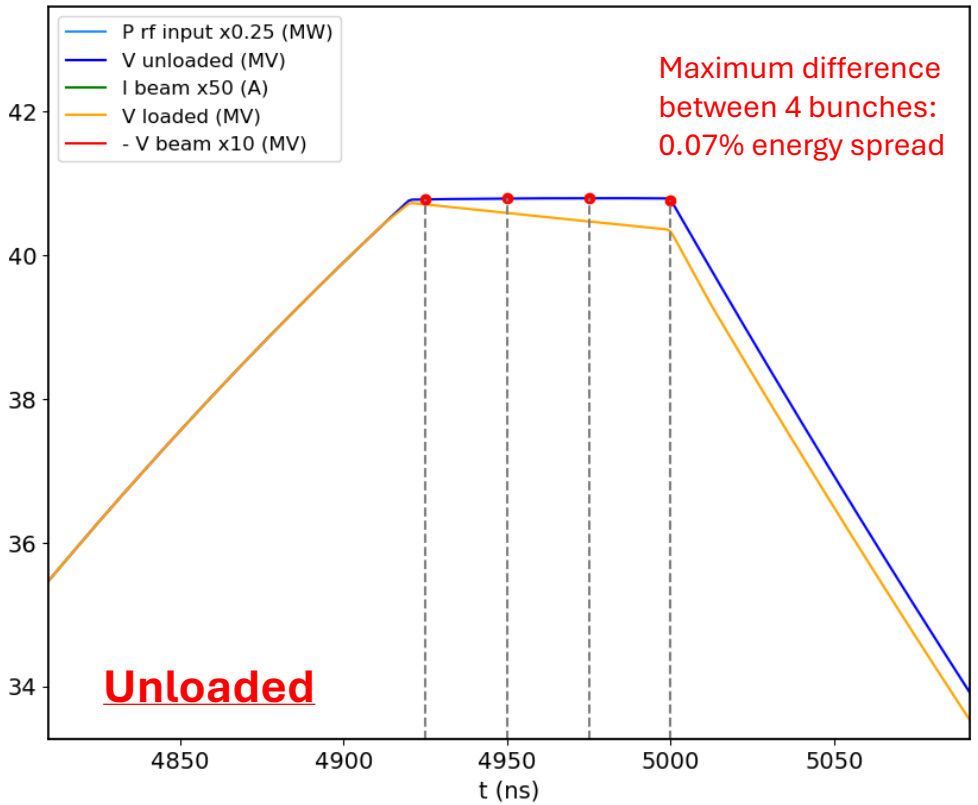
4 Bunches case:

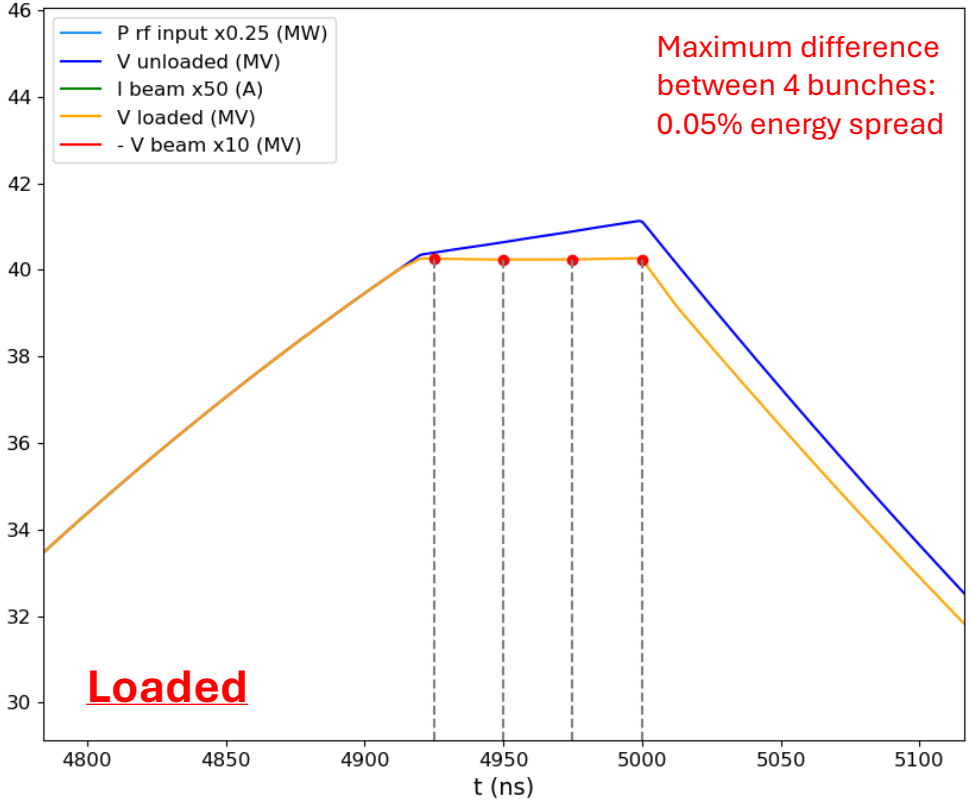
P_klys = 15.4 MW
3m structure
G = V/L

For bunch charge: 10 nC
25 ns of bunch spacing

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	Rsh
Single Bunch	42.30 MV				38.73 MΩ/m
4 Bunches	40.78 MV	40.79 MV	40.79 MV	40.77 MV	36.00 MΩ/m

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	42.16 MV			
4 Bunches	40.26 MV	40.24 MV	40.24 MV	40.24 MV



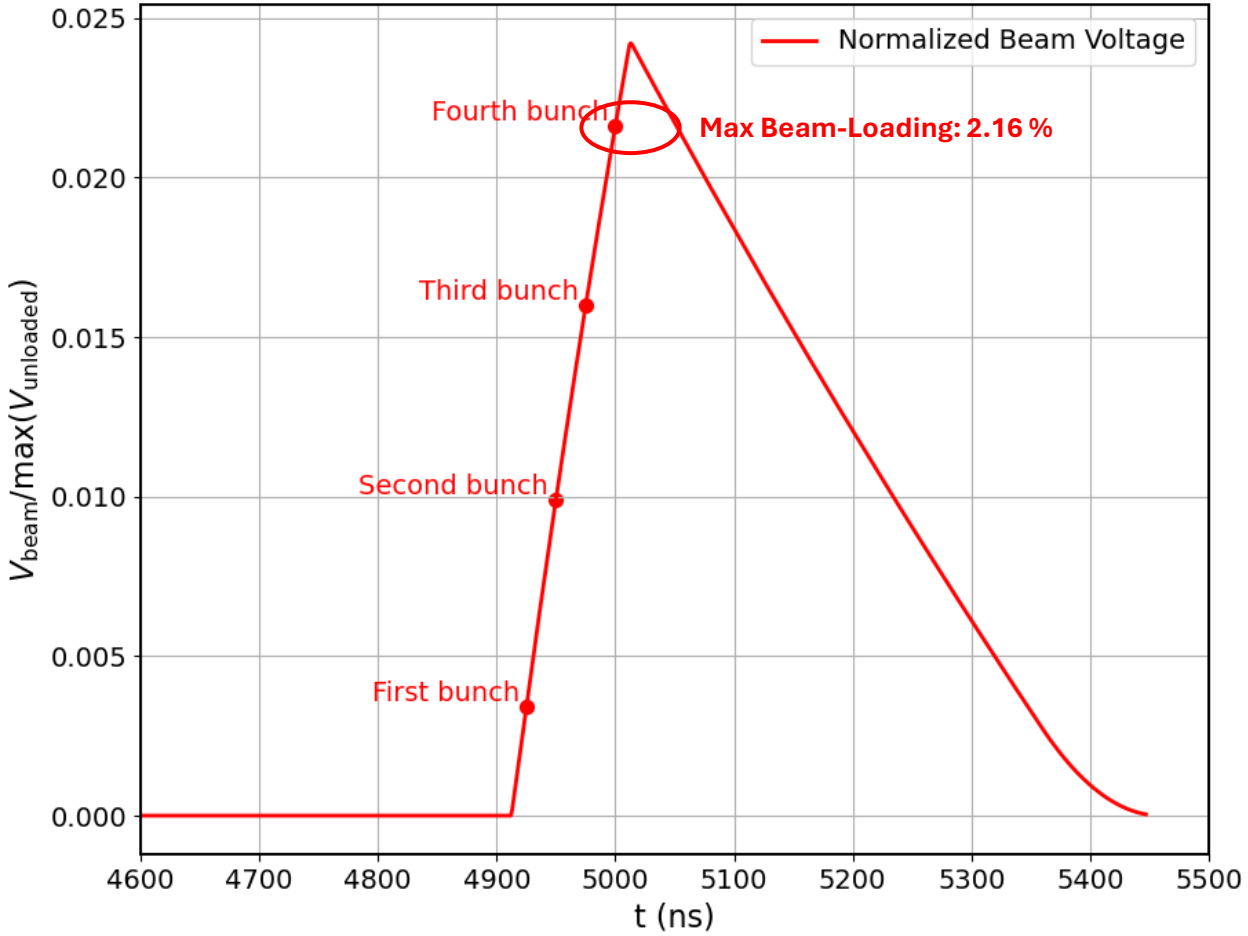


- **p Linac:**

4 Bunches case:

For bunch charge: 10 nC
25 ns of bunch spacing

Beam loading effect



- **p-linac:**

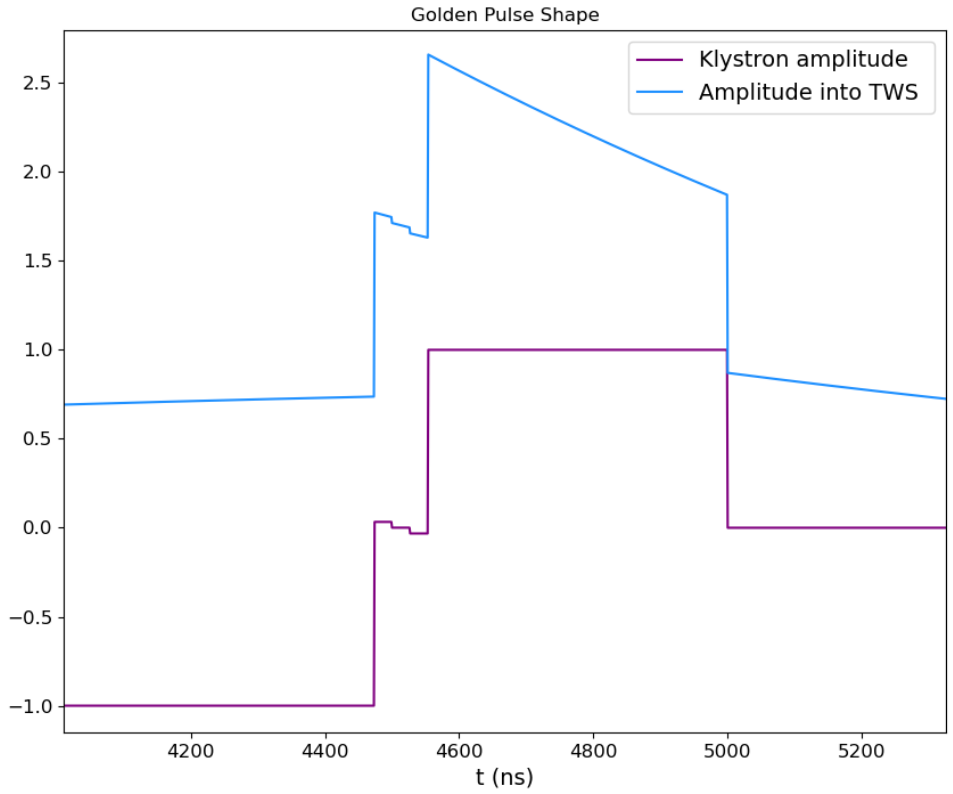
Bunches case:

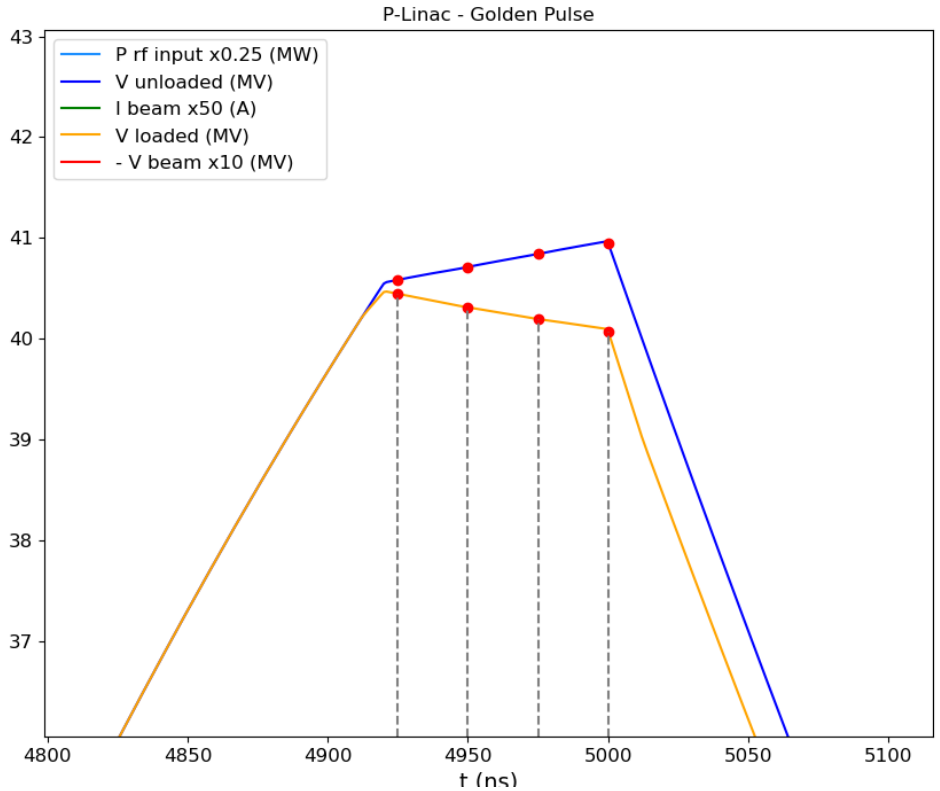
For bunch charge: 10 nC
25 ns of bunch spacing

Golden pulse applied

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	42.30 MV				
4 Bunches	40.58 MV	40.71 MV	40.84 MV	40.94 MV	+0.9 % energy spread

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	42.16 MV				
4 Bunches	40.45 MV	40.31 MV	40.19 MV	40.07 MV	-0.9 % energy spread





p-Linac Studies
(15 nC bunch charge)

Compansated

- **p-linac:**

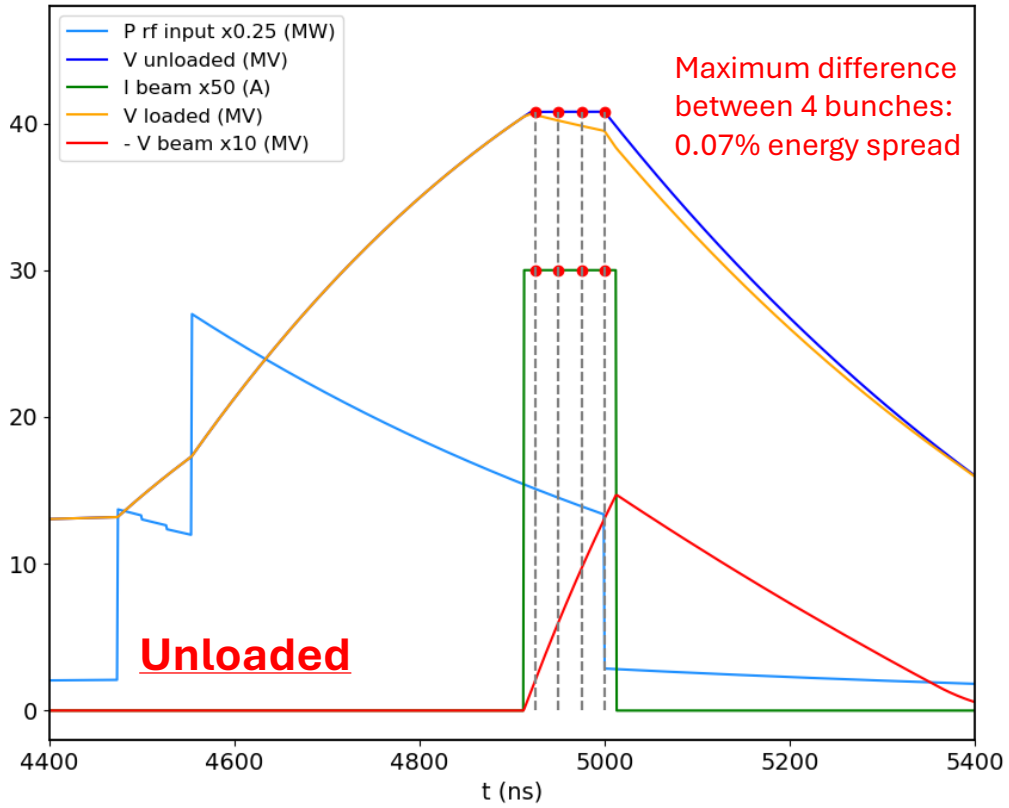
4 Bunches case:

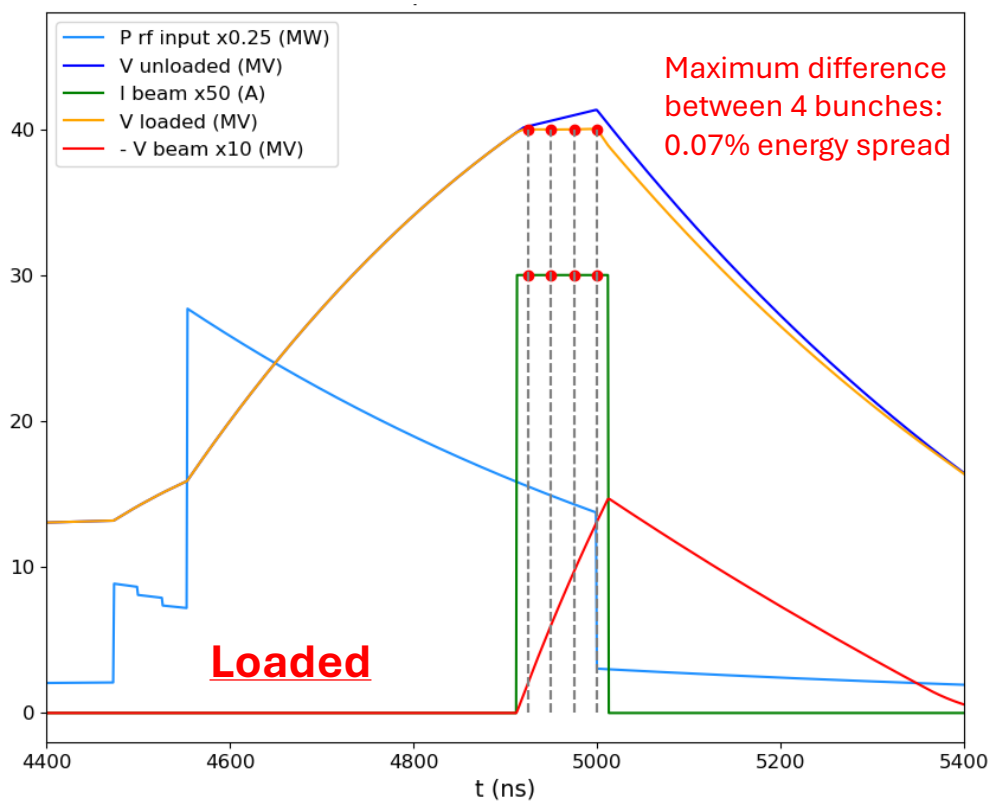
P_klys = 15.4 MW
3m structure
G = V/L

For bunch charge: 15 nC
25 ns of bunch spacing

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	Rsh
Single Bunch	42.30 MV				38.73 MΩ/m
4 Bunches	40.78 MV	40.79 MV	40.79 MV	40.77 MV	36.00 MΩ/m

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch
Single Bunch	42.10 MV			
4 Bunches	39.98 MV	39.96 MV	39.97 MV	39.99 MV



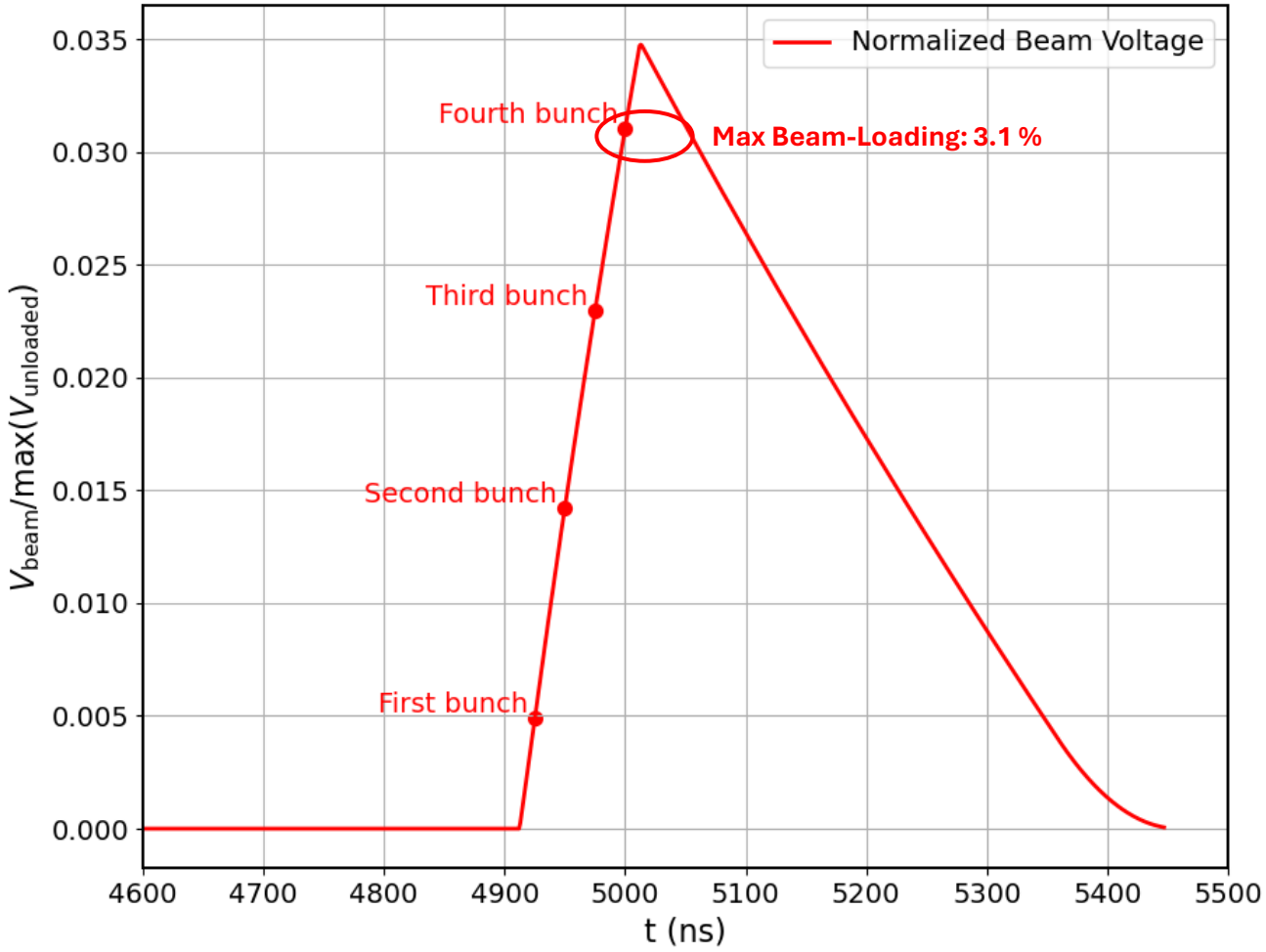


- **p Linac:**

4 Bunches case:

Beam loading effect

For bunch charge: 15 nC
25 ns of bunch spacing



- **p-linac:**

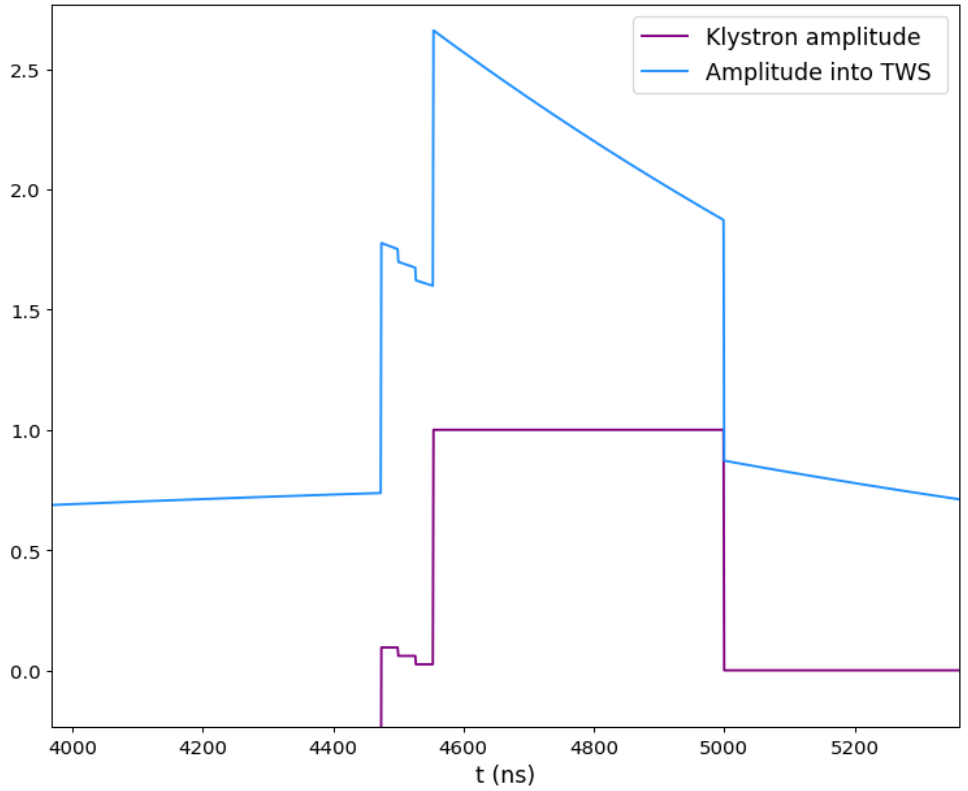
Bunches case:

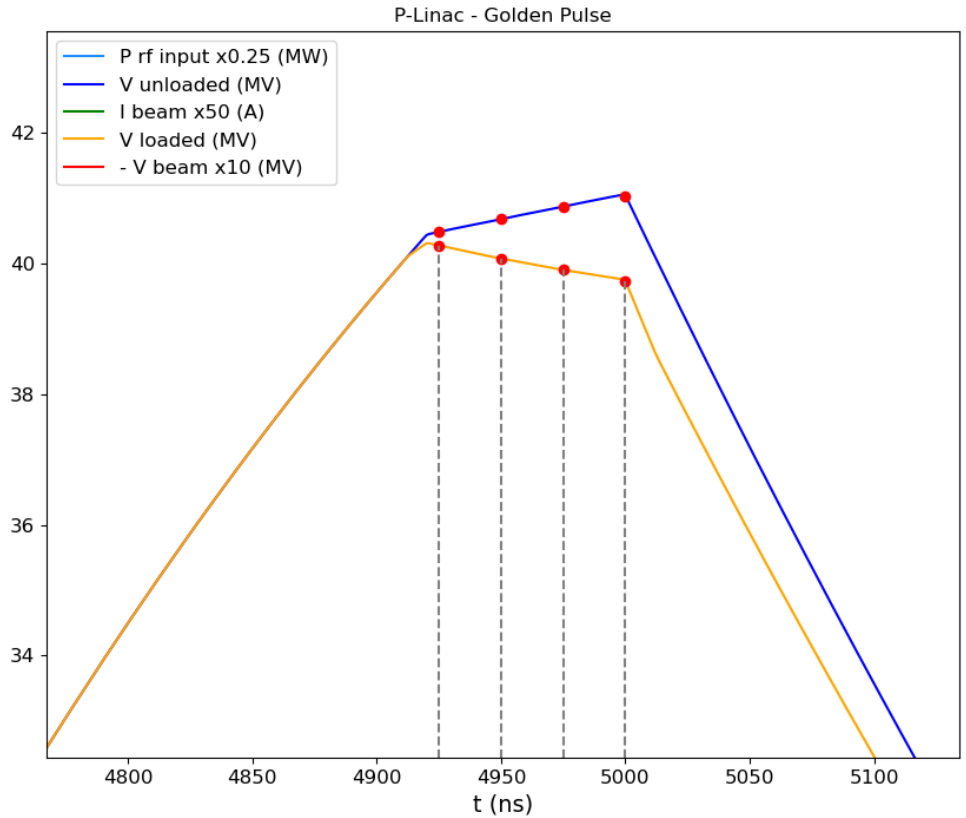
For bunch charge: 15 nC
25 ns of bunch spacing

Golden pulse applied

Unloaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	42.30 MV				
4 Bunches	40.48 MV	40.68 MV	40.87 MV	41.03 MV	+1.4 % energy spread

Loaded Voltages	1st Bunch	2nd Bunch	3rd Bunch	4th Bunch	
Single Bunch	42.10 MV				
4 Bunches	40.28 MV	40.07 MV	39.90 MV	39.72 MV	-1.4 % energy spread





Spare Slides