Phase 1- Upgrade Injector Model for KLF

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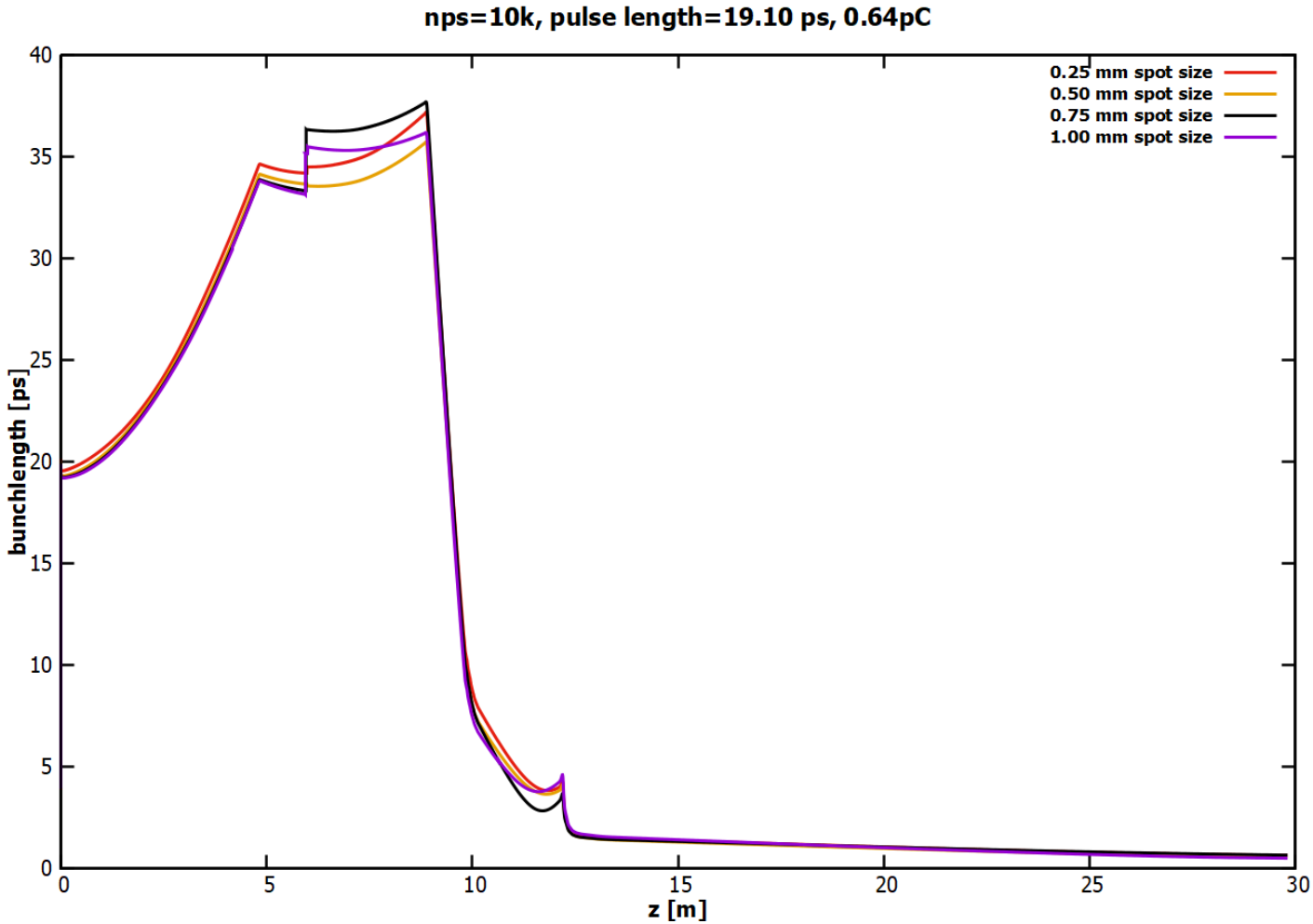
Outline

- Used the optimized parameter Phase 1 Upgrade Injector GPT Model (Courtesy- Alicia Hofler, 06/16/2021)
- Positions for elements from the gun through MFA0I03 are based on beamlinelayoutapril152020-gun-chopper.pdf and is noted as beamlinelayoutapril15.pdf in the GPT files.
- Downstream of MFA0I03, the positions are based on measurements Y. Wang and A. Hofler made in 2011, information from mechanical drawings, and even extracted from the old CEBAF PARMELA deck.
- Reference the quick reference drawing injector-quick-reference-rev6-20210607.pdf
- Initial distributions
- Energy gain
- Beam Characteristics
- End distribution

Initial distribution

- 130 kV D.C. gun
- 1 Prebuncher, 1Buncher, 5 Captures, Old 5-5 1/4 Cryomodule Booster (2 Cornell-style 5-cell cavities)
- 320 μA (0.64 pC, 128 ns) beam current at laser rf frequency=499 MHz (with space charge3Dmesh)
- Equivalent to 5 μA, 7.80 MHz repetition rates
- GaAsMTE = 0.030691;
- Thermal emittance 0.061 mm-mrad, Gaussian Beam
- Laser spot sizes (0.25 mm, 0.50 mm, 0.75 mm, 1.00 mm) and pulse lengths (19.10 ps, 25.48 ps, 31.85 ps, 38.20 ps, 44.58 ps) varied individually and simultaneously as well for 10k macro-particles

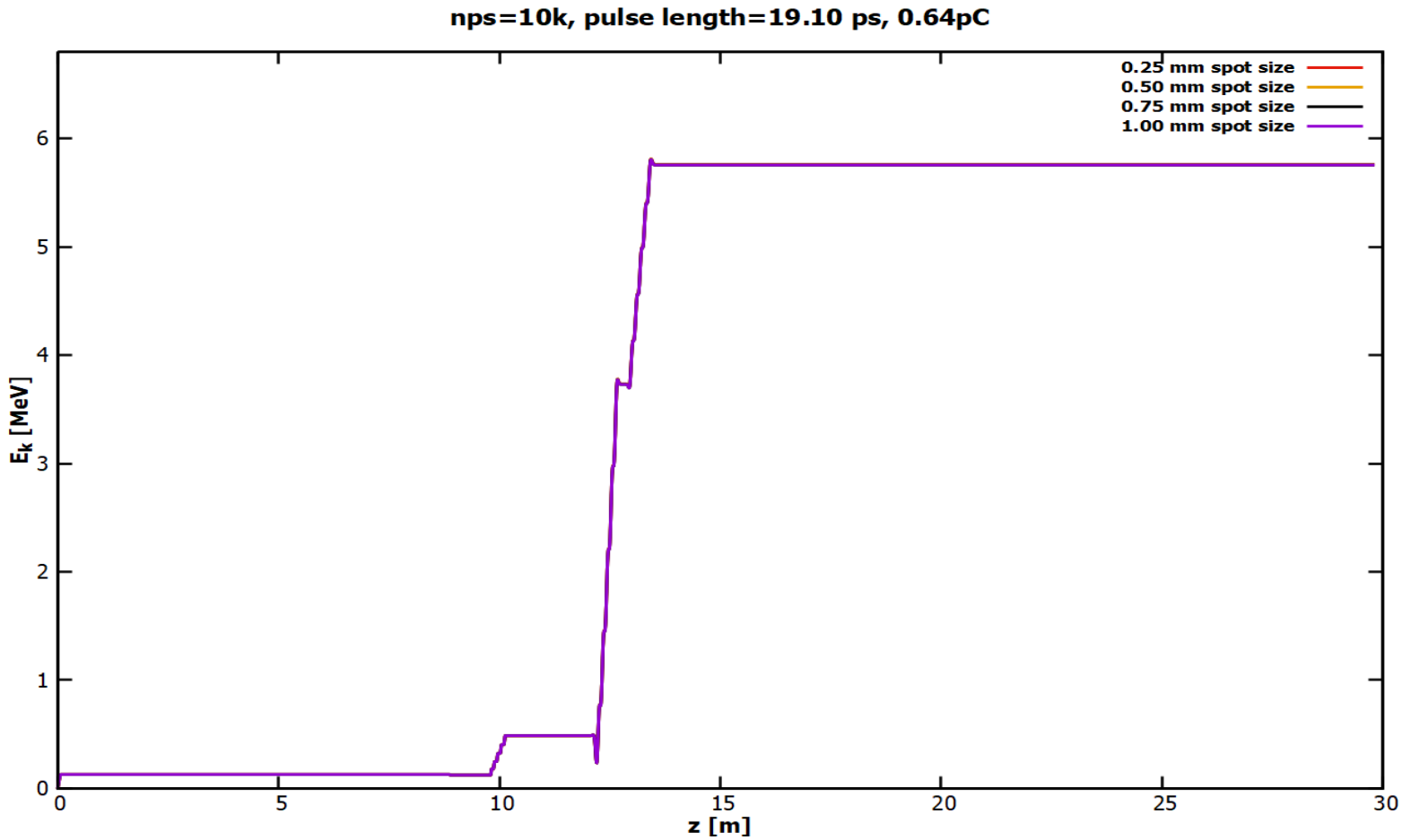
Beam Characteristics- Beam size variation



Bunchlength upstream of the full module are 0.64 ps for 0.25 mm, 0.50 ps for 1.0 mm,

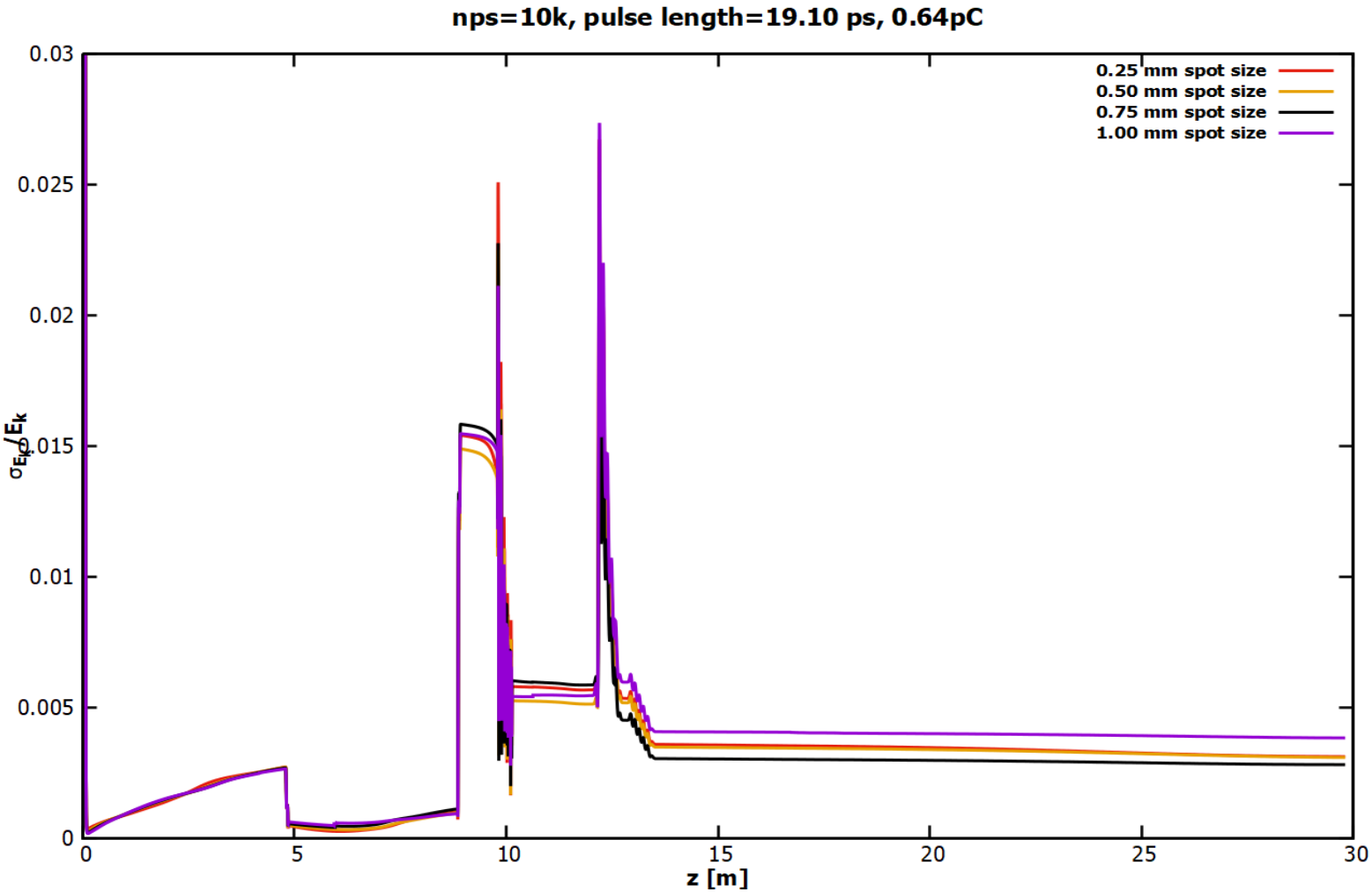
Beam Characteristics- Beam size variation

Kinetic Energy (E_k)



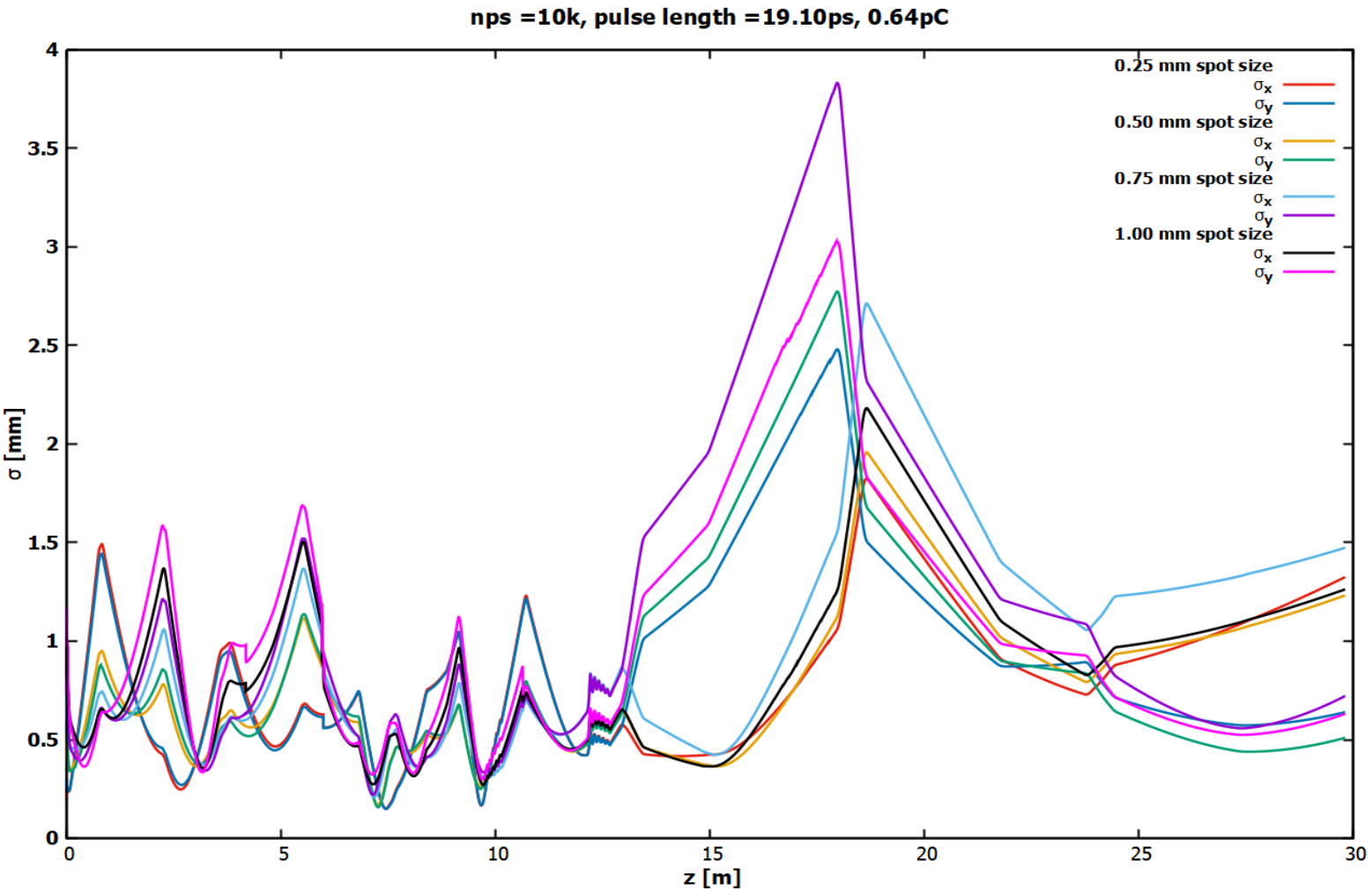
The average KE is 5.76 MeV

Beam Characteristics- Beam size variation



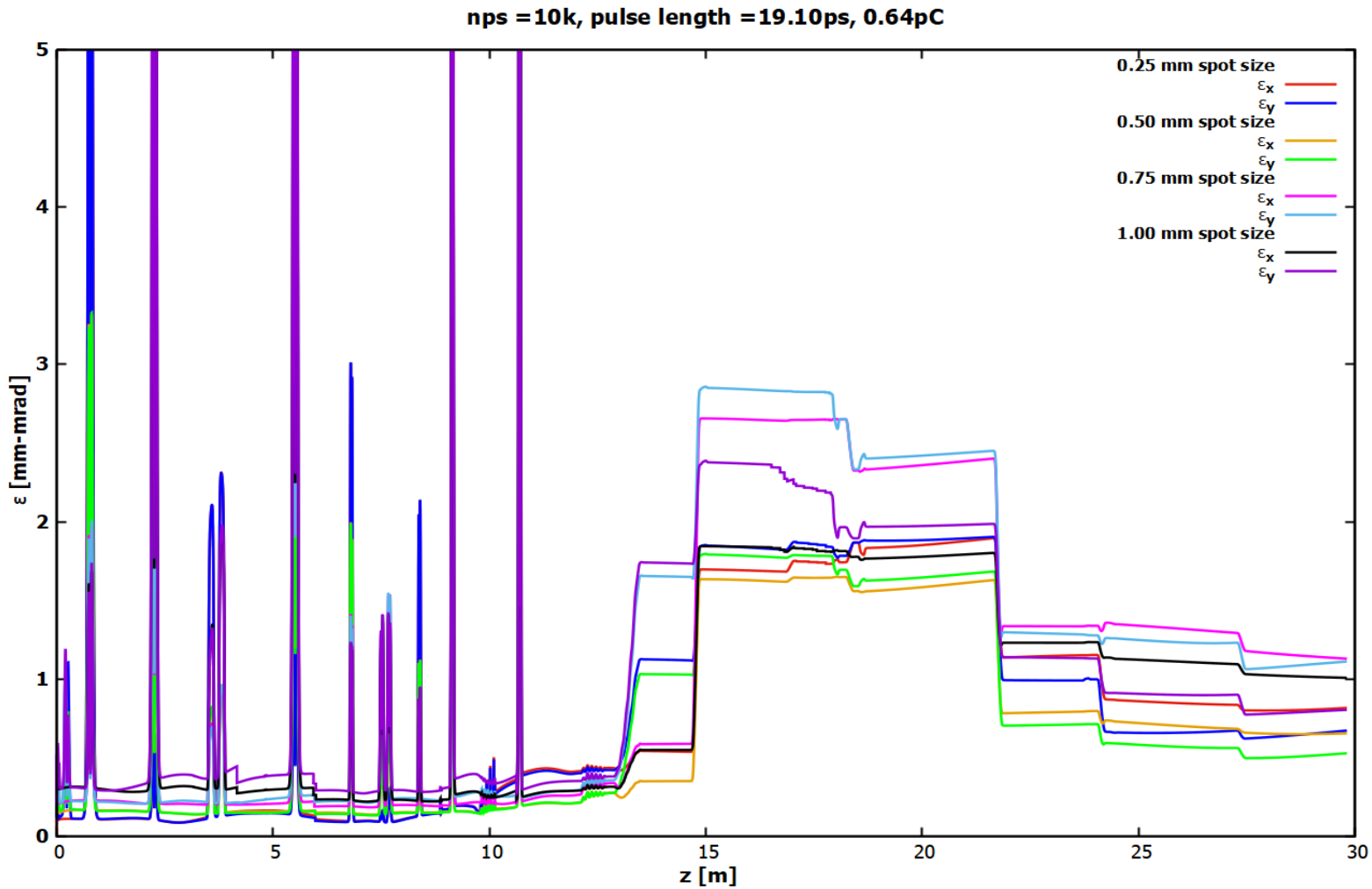
Fractional energy spread < 0.004 with space charge

Beam Characteristics- Beam size variation



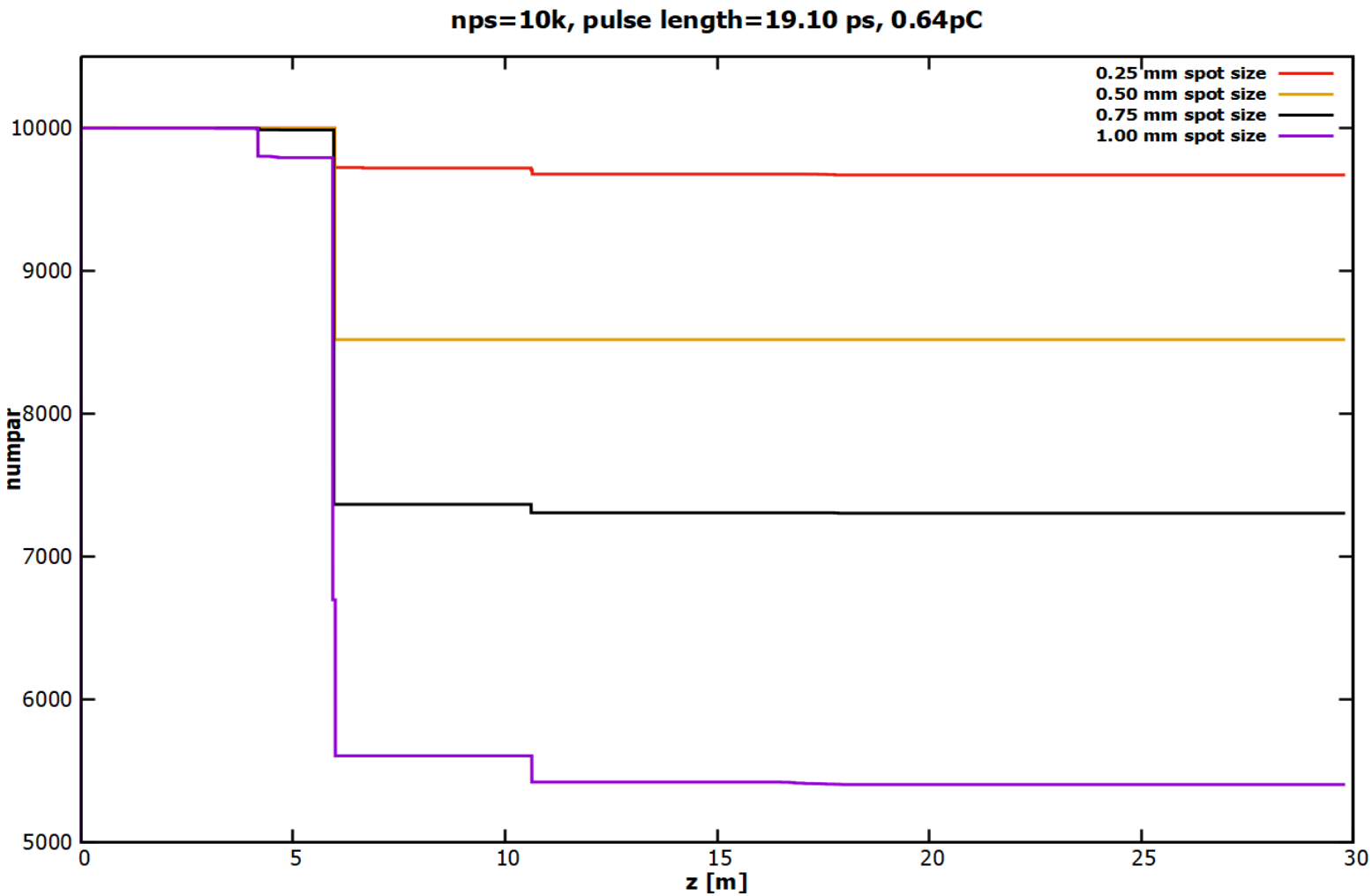
Beam Sizes σ_x, σ_y

Beam Characteristics- Beam size variation



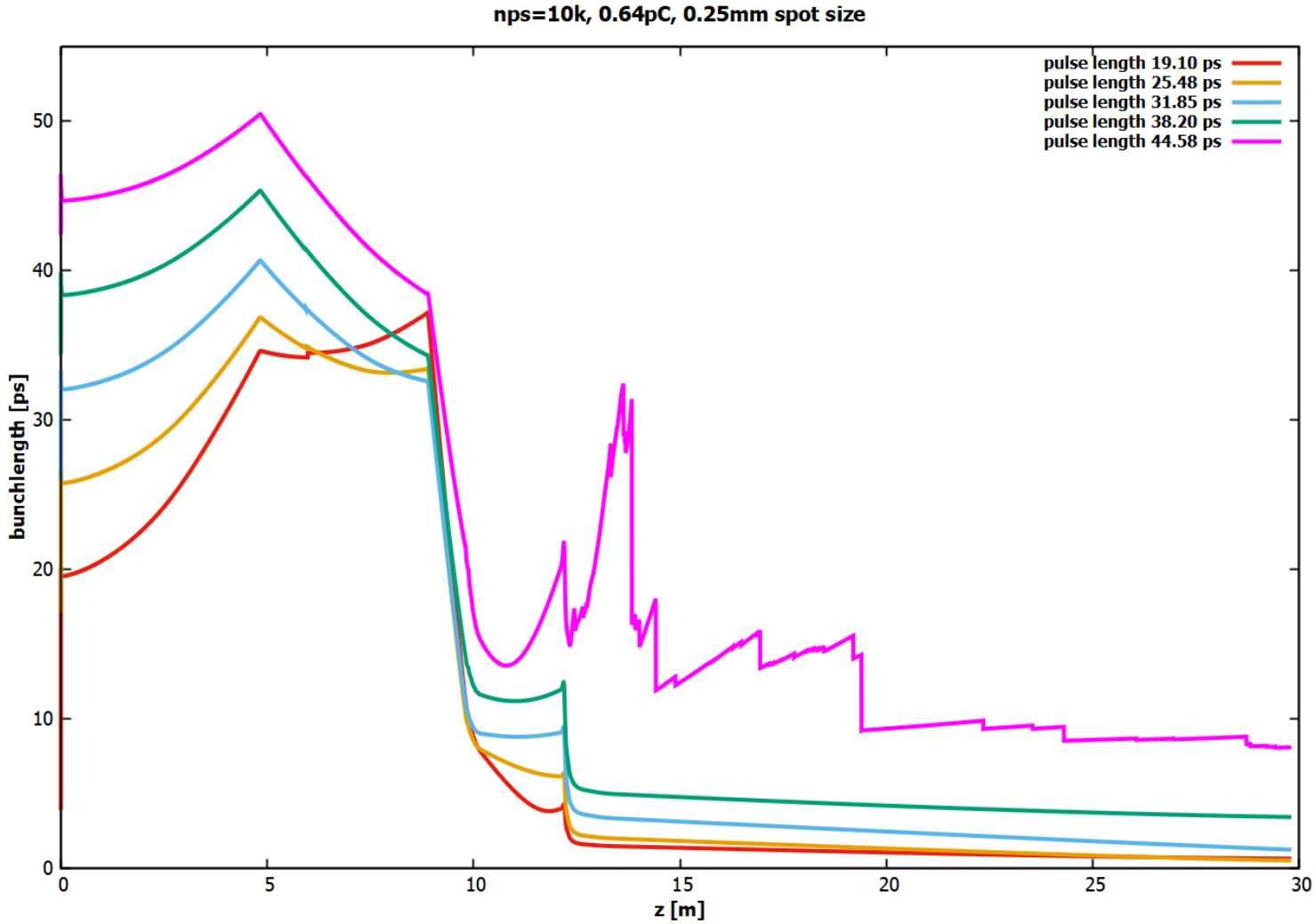
Normalized Emittances ϵ_{n_x}, ϵ_{n_y}

Beam Transmission- Beam size variation



Beam transmission decreases with increase in spot size

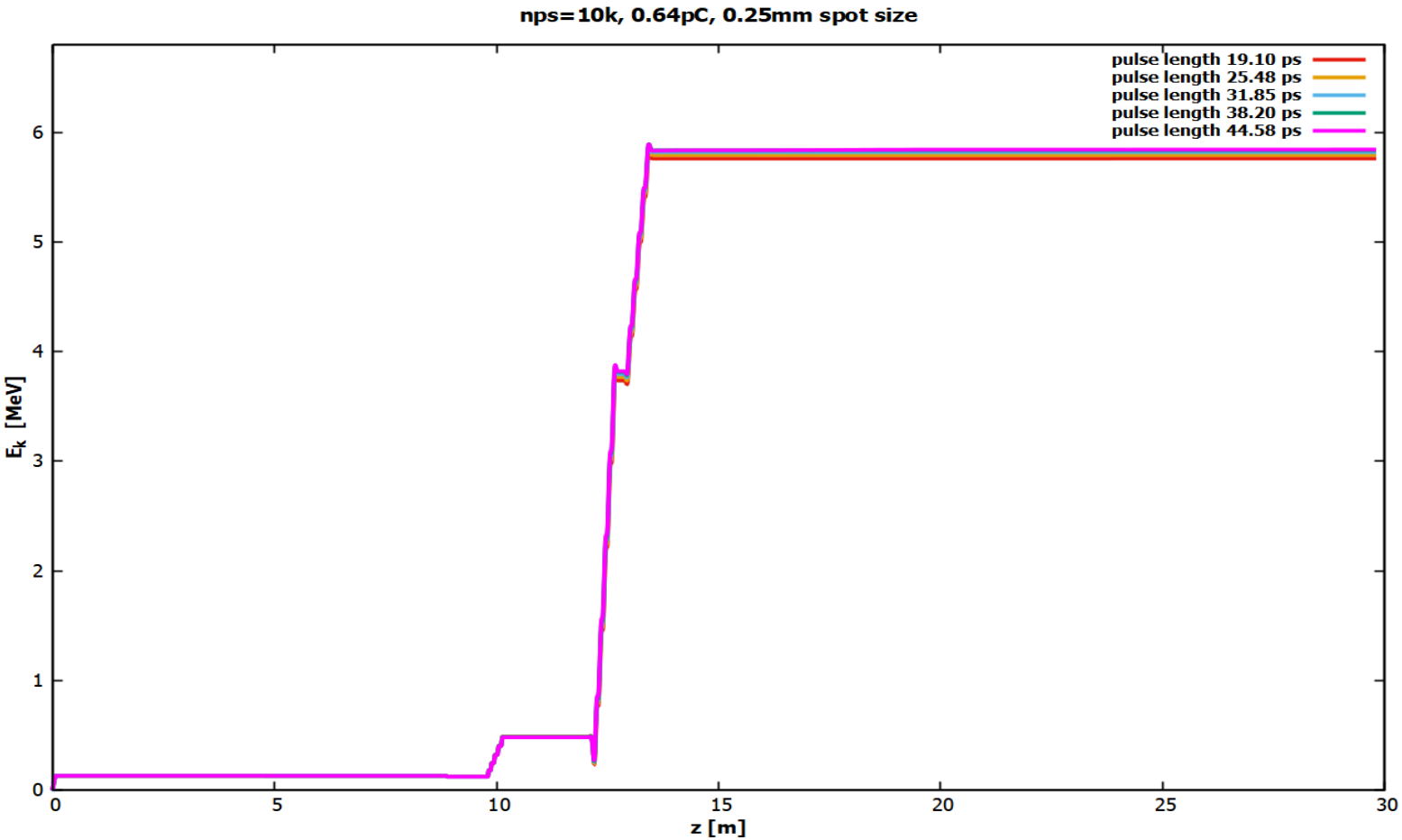
Beam Characteristics- pulse length variation



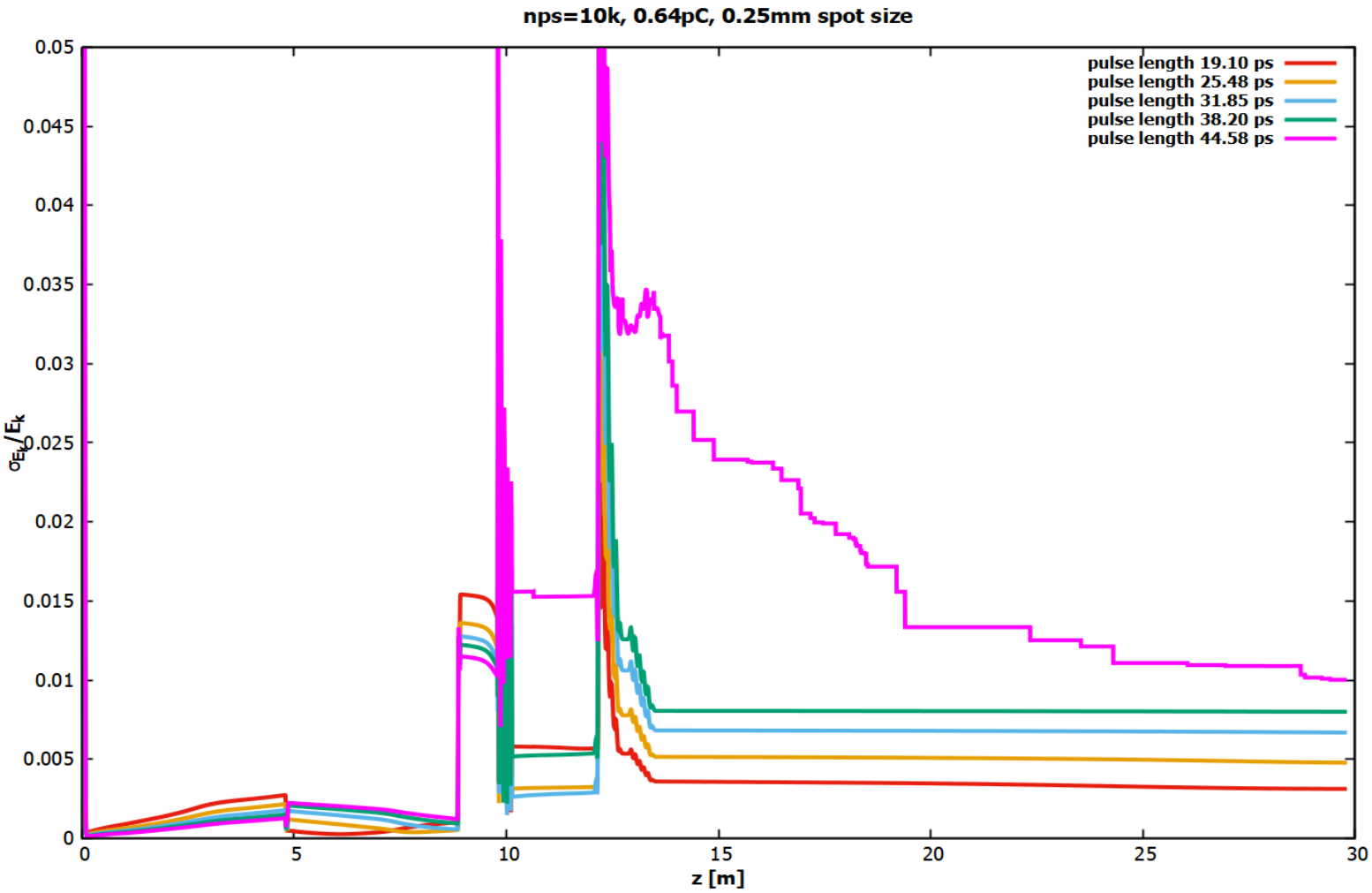
Bunchlength upstream of the full module is 1.24 ps for 31.85 ps,

Beam Characteristics- pulse length variation

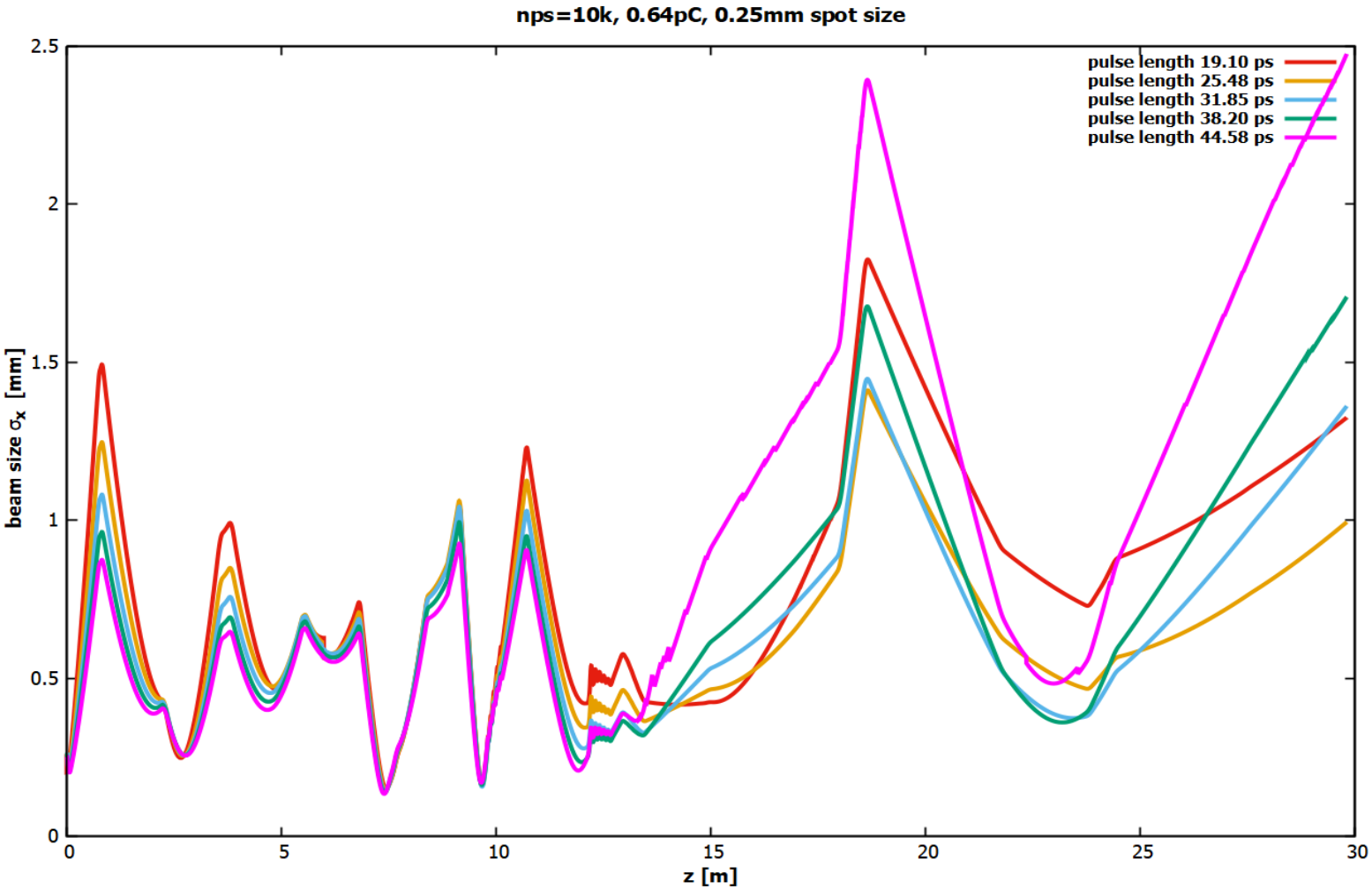
Kinetic Energy (E_k)



Beam Characteristics- Pulse length variation

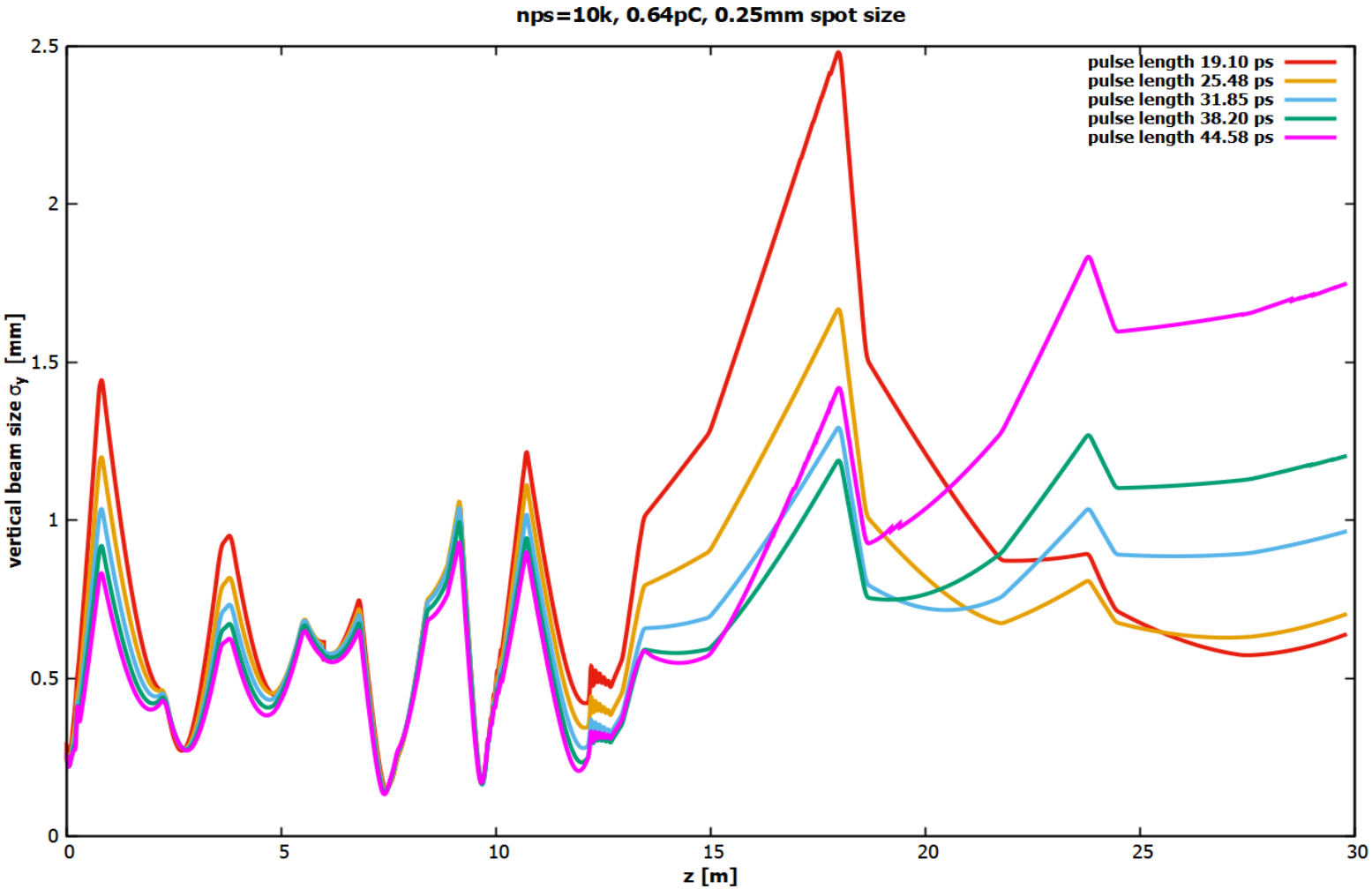


Beam Characteristics- pulse length variation



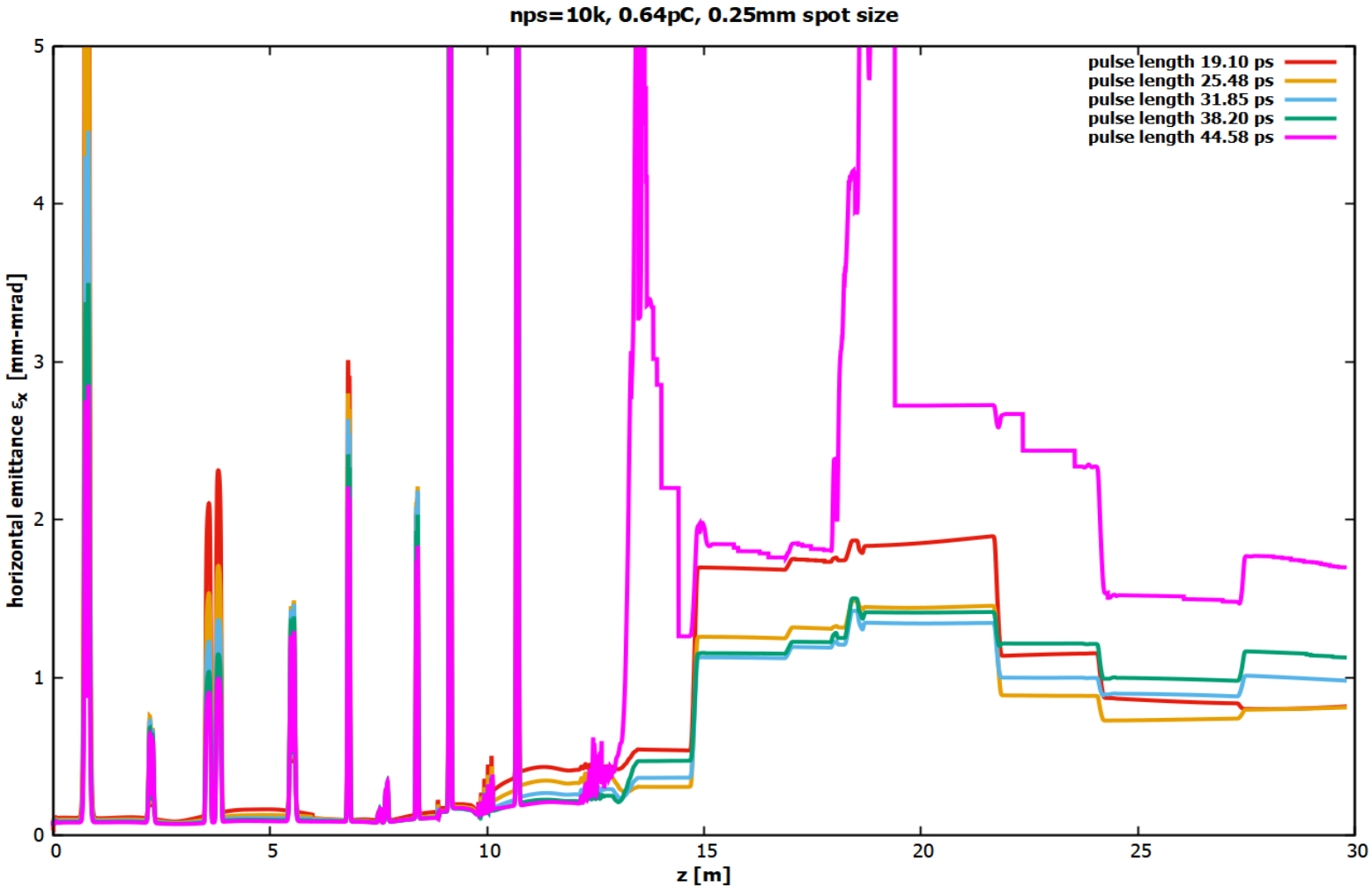
Beam Sizes σ_x

Beam Characteristics- pulse length variation



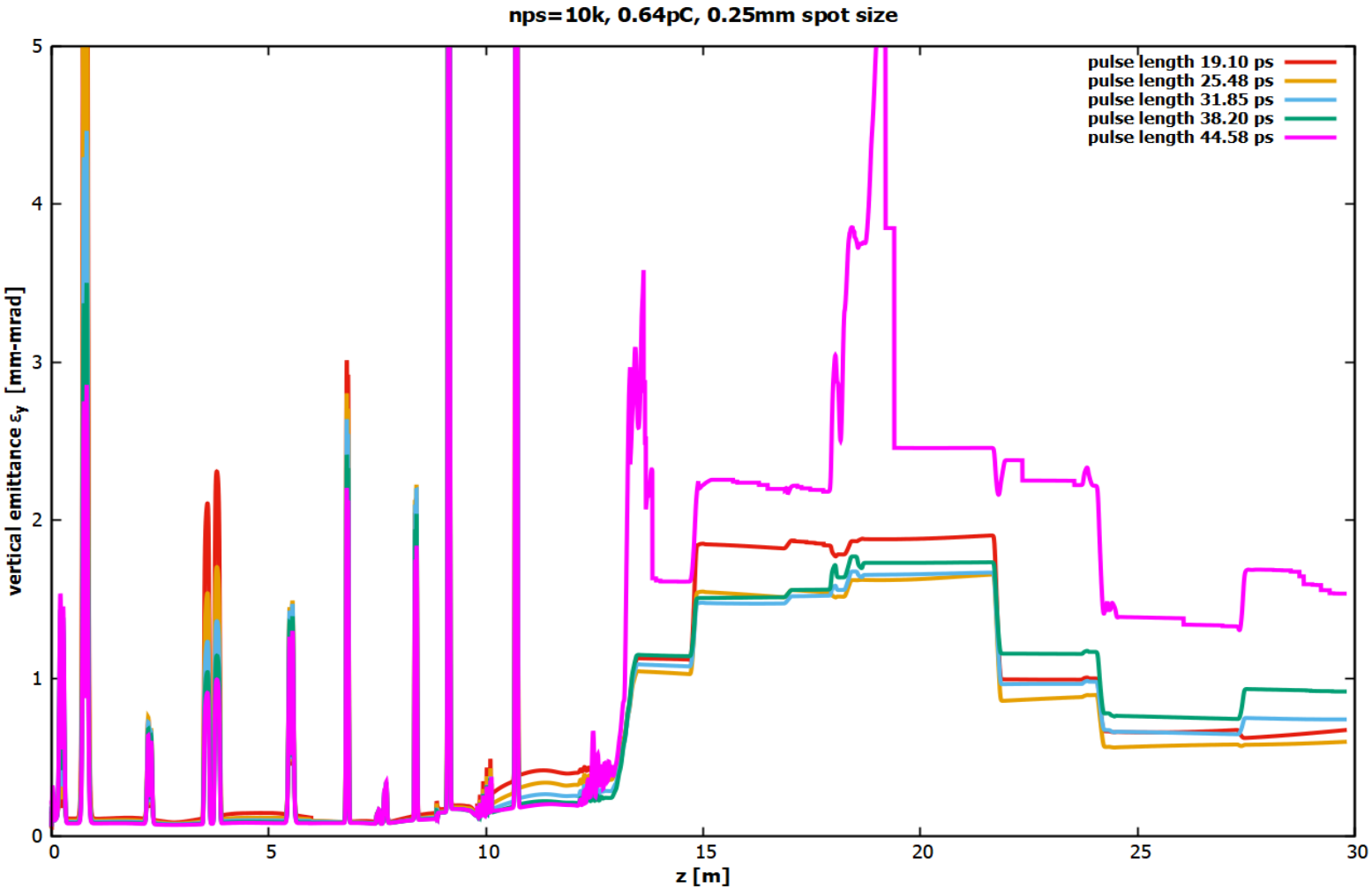
Beam Sizes σ_y

Beam Characteristics- pulse length variation



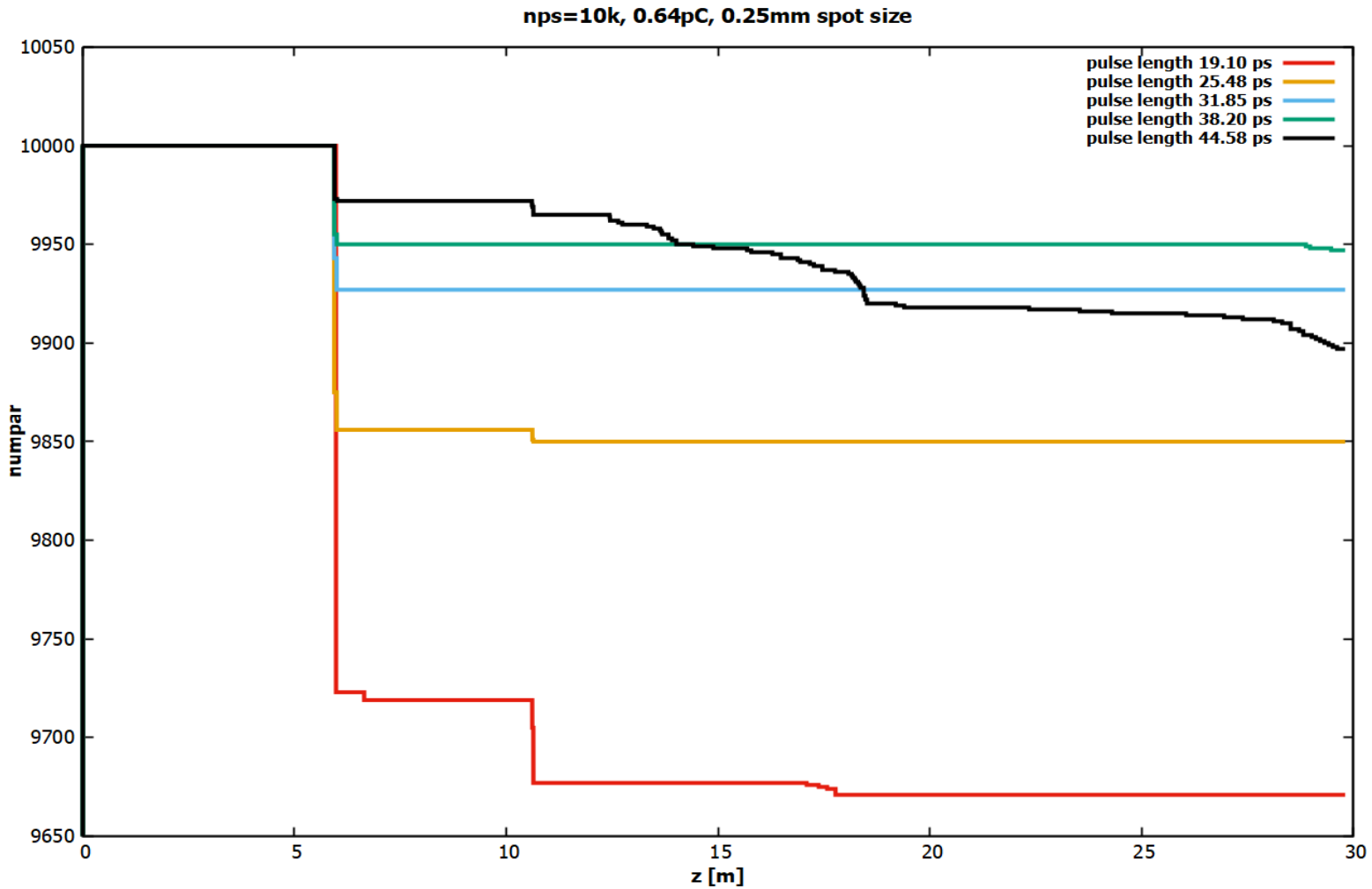
Normalized Emittances ϵ_{n_x}

Beam Characteristics- pulse length variation



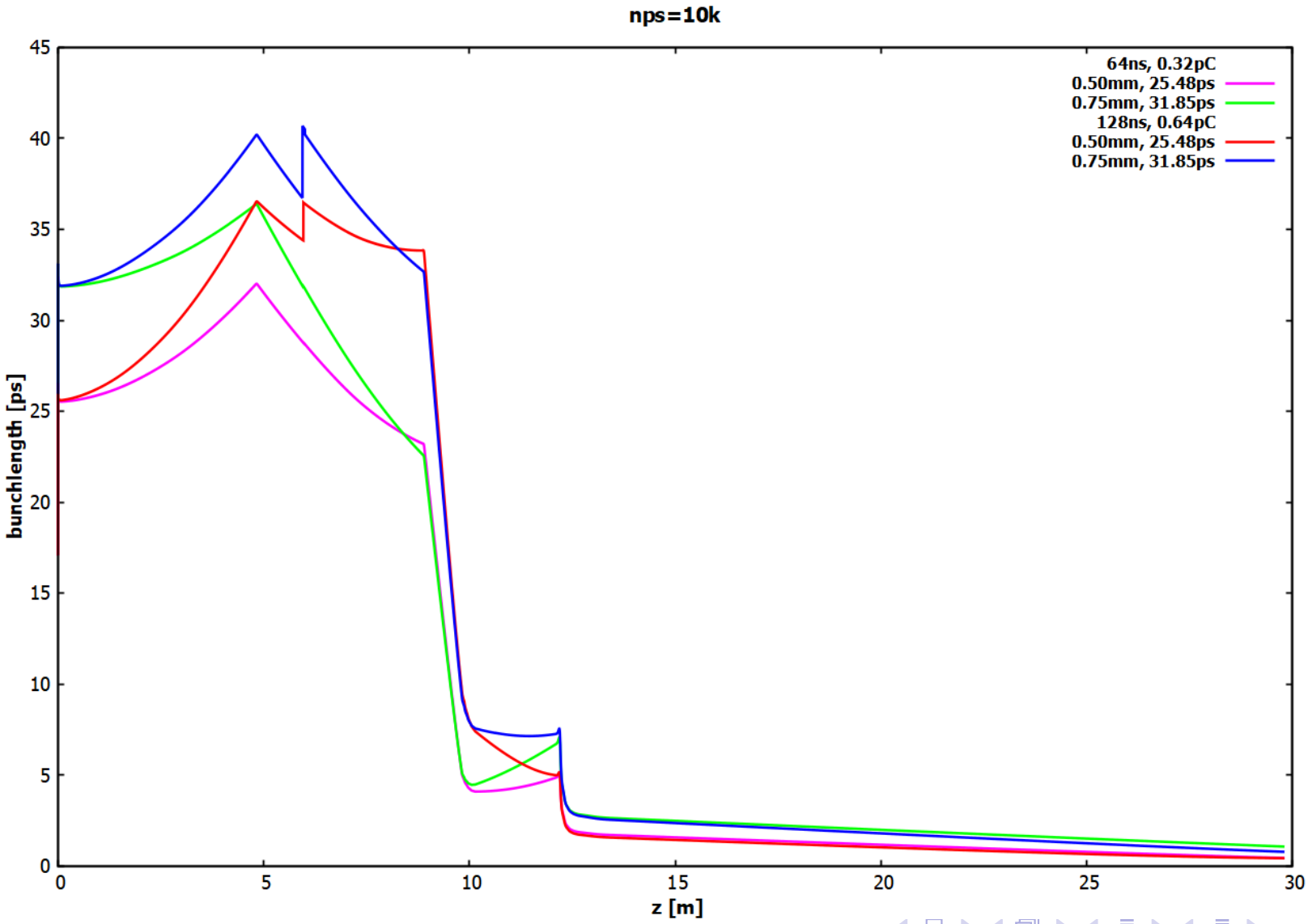
Normalized Emittances ϵ_{n_y}

Beam Transmission- pulse length variation

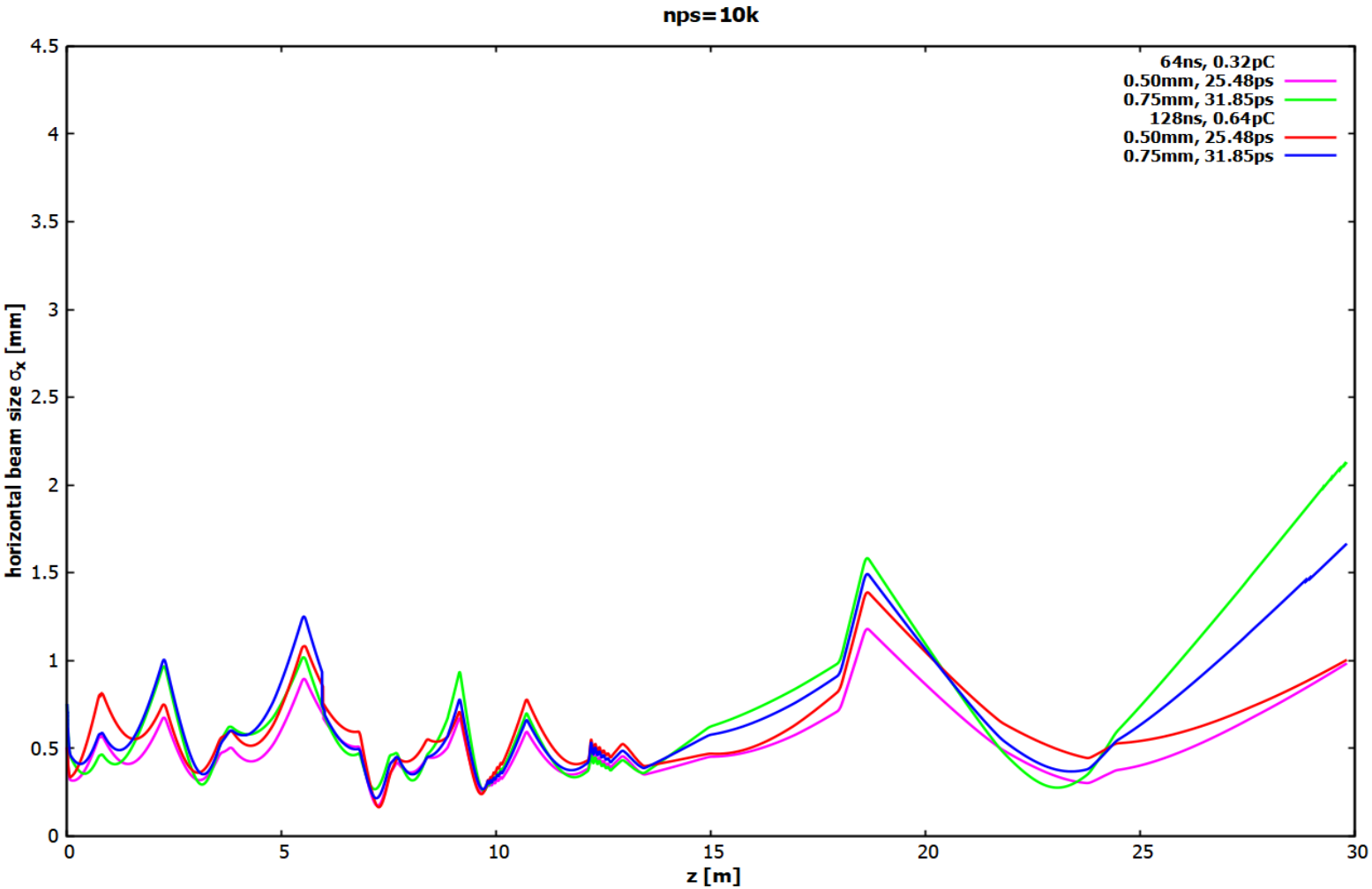


Beam transmission increases with increase in pulse length

Simulated Beam Characteristics

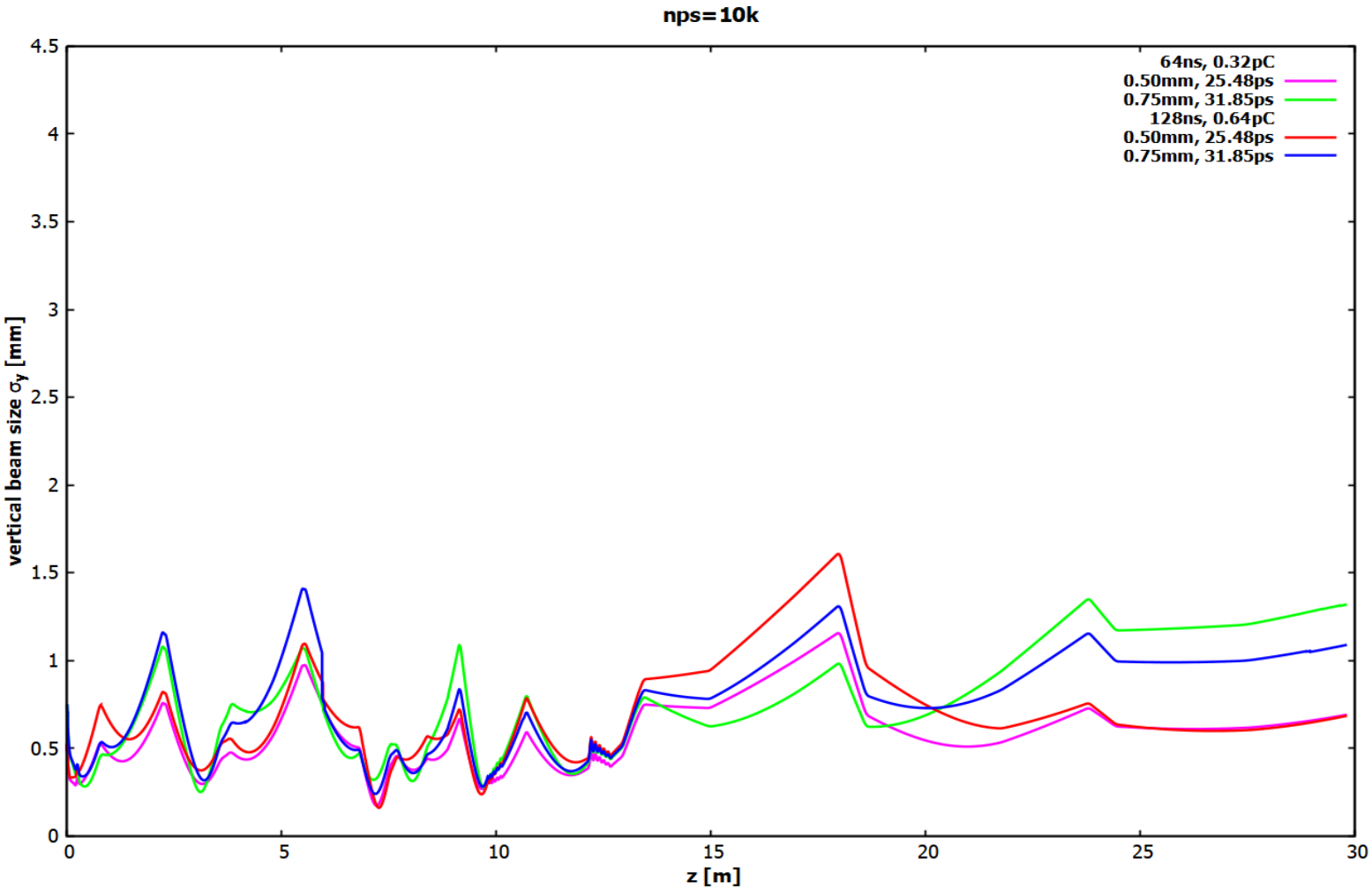


Simulated Beam Characteristics



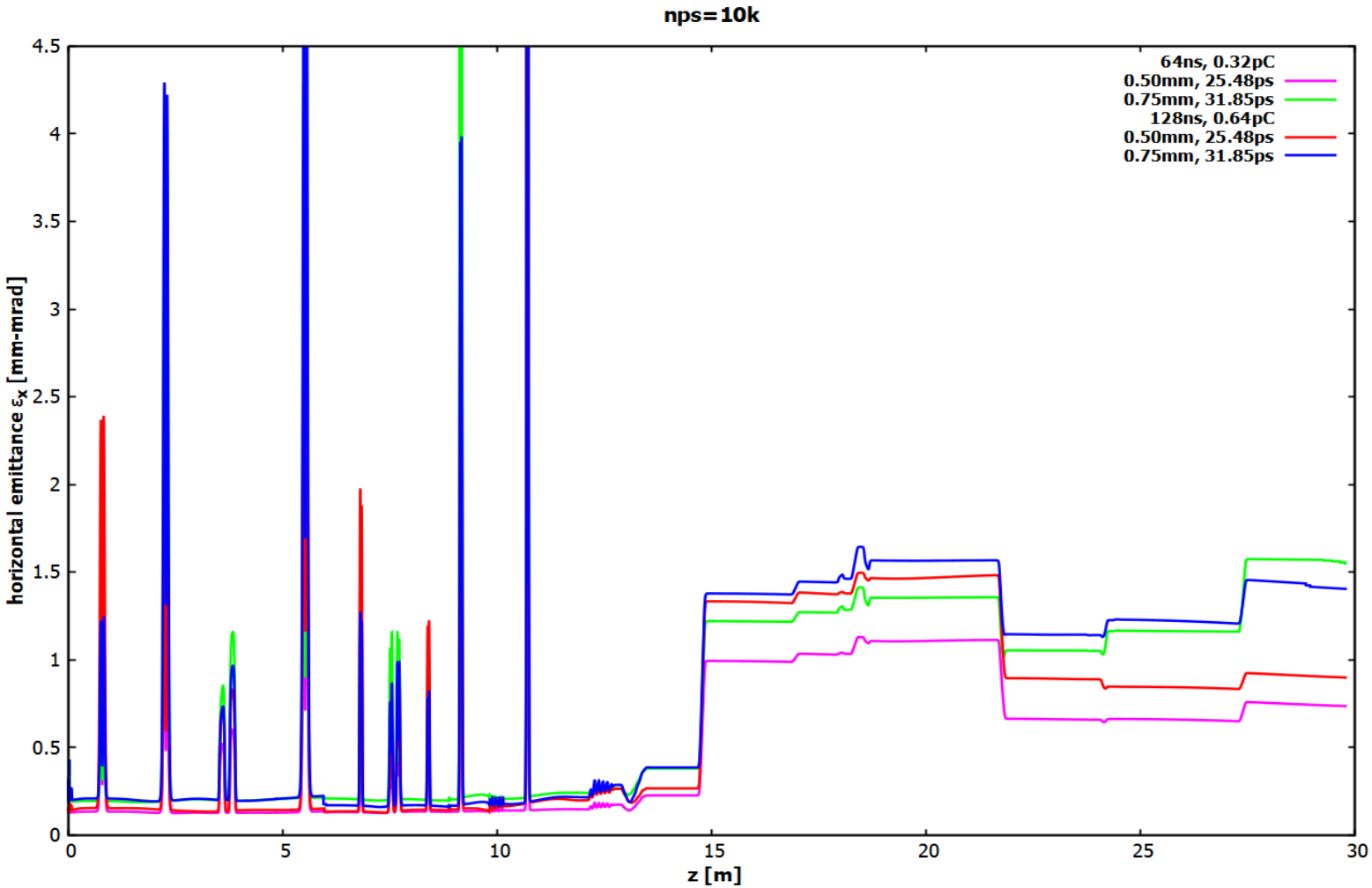
Beam Sizes σ_x

Simulated Beam Characteristics



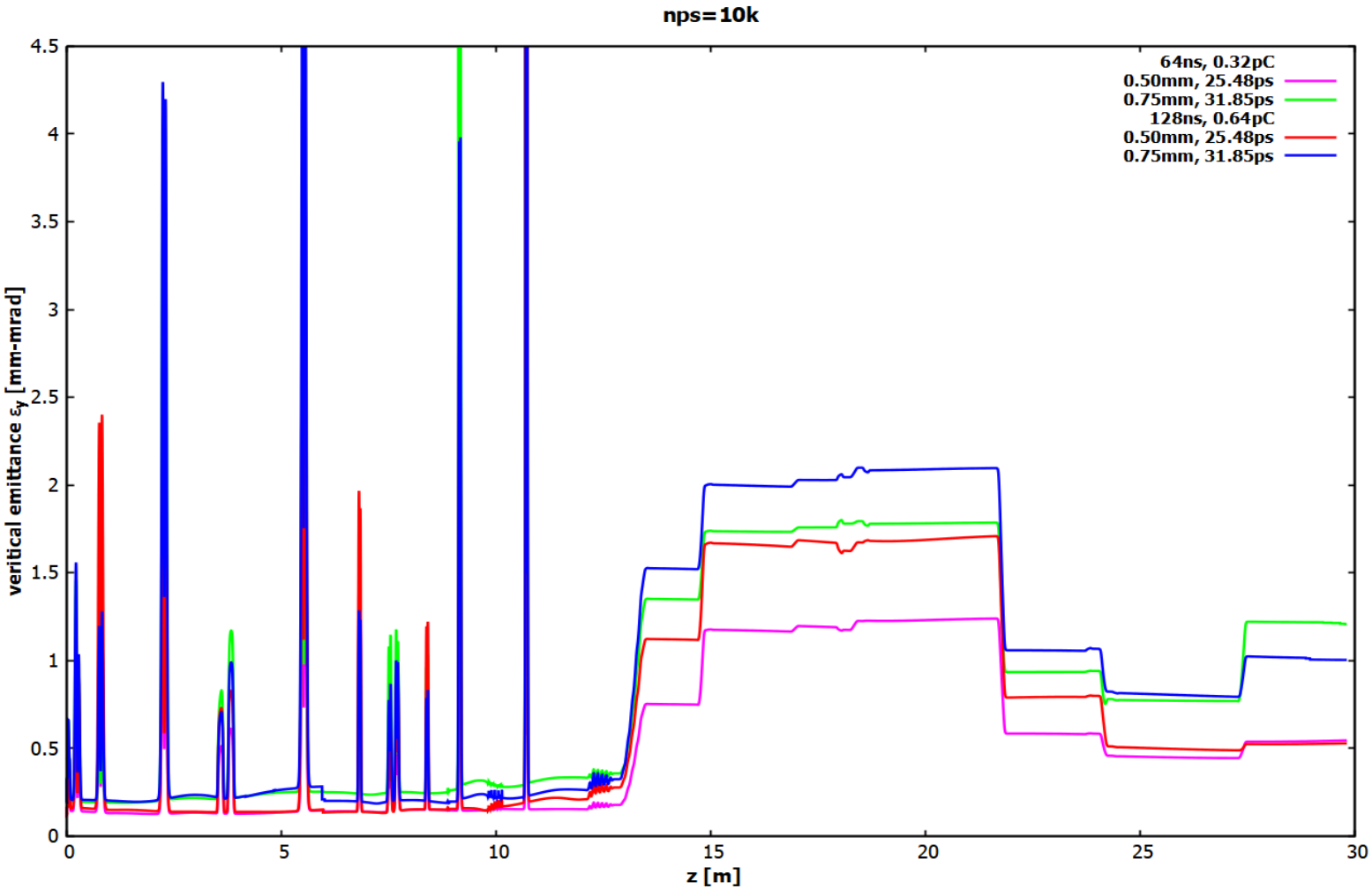
Beam Sizes σ_y

Simulated Beam Characteristics



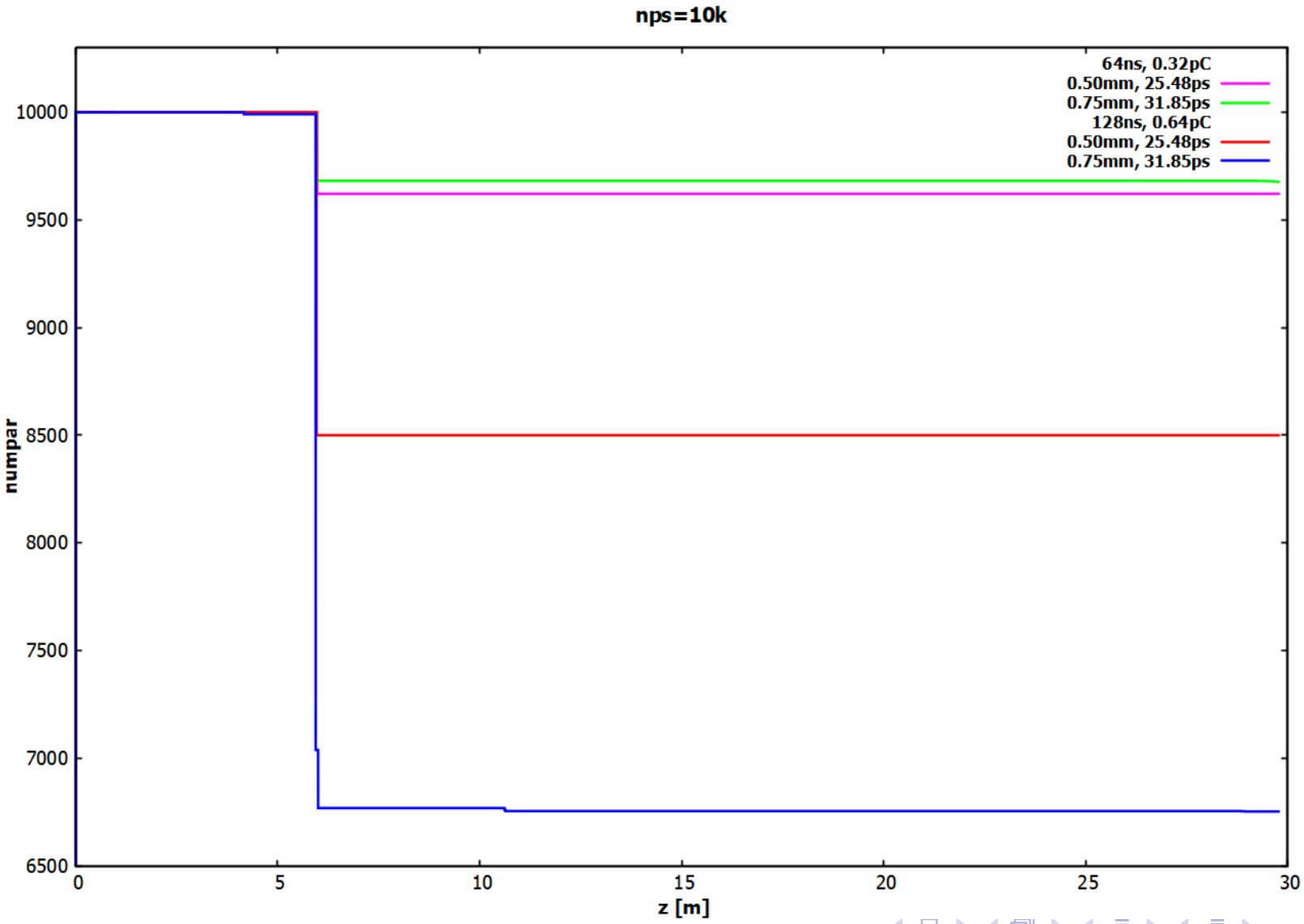
Normalized Emittances ϵ_{n_x}

Simulated Beam Characteristics



Normalized Emittances ϵ_{n_y}

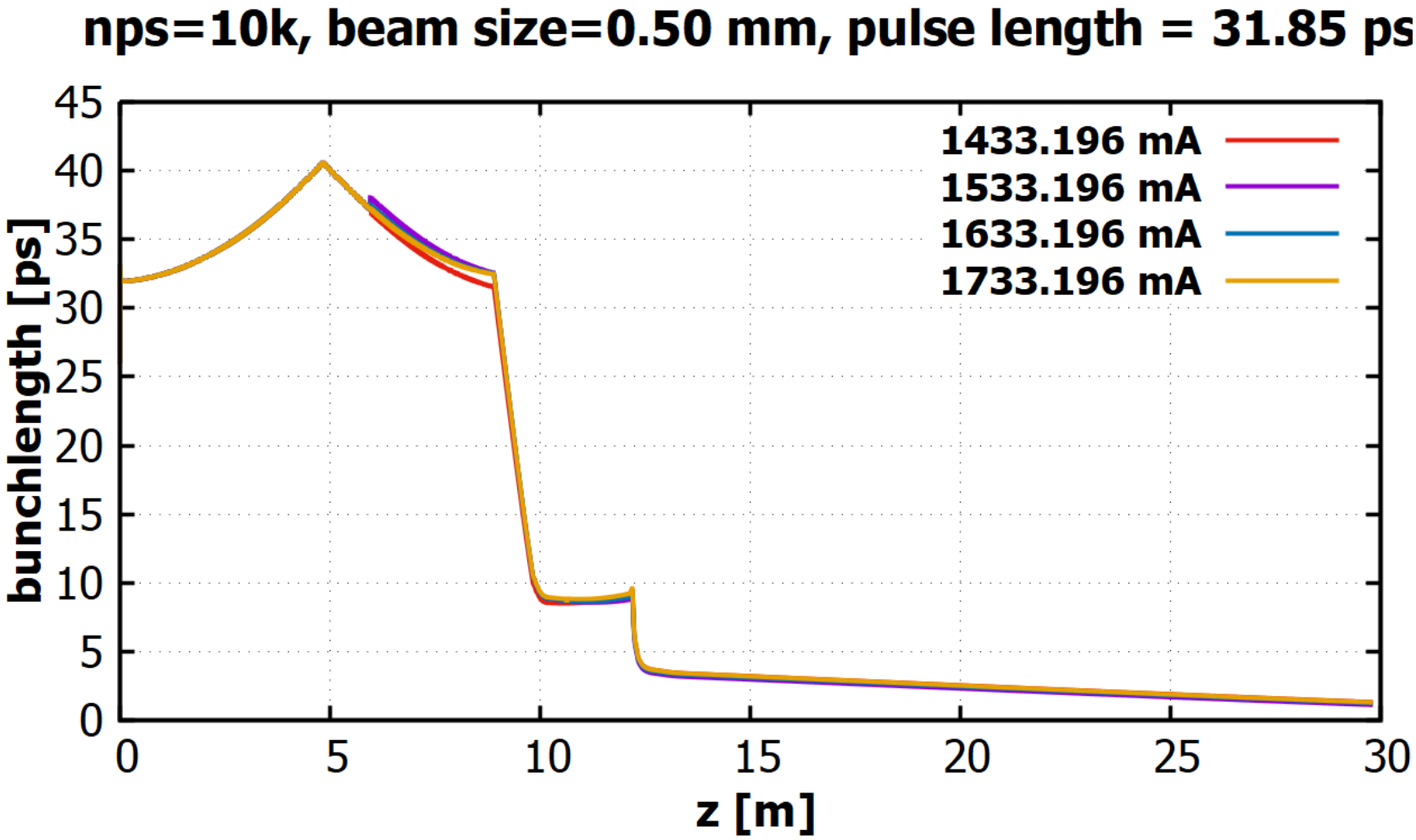
Simulated Beam Characteristics



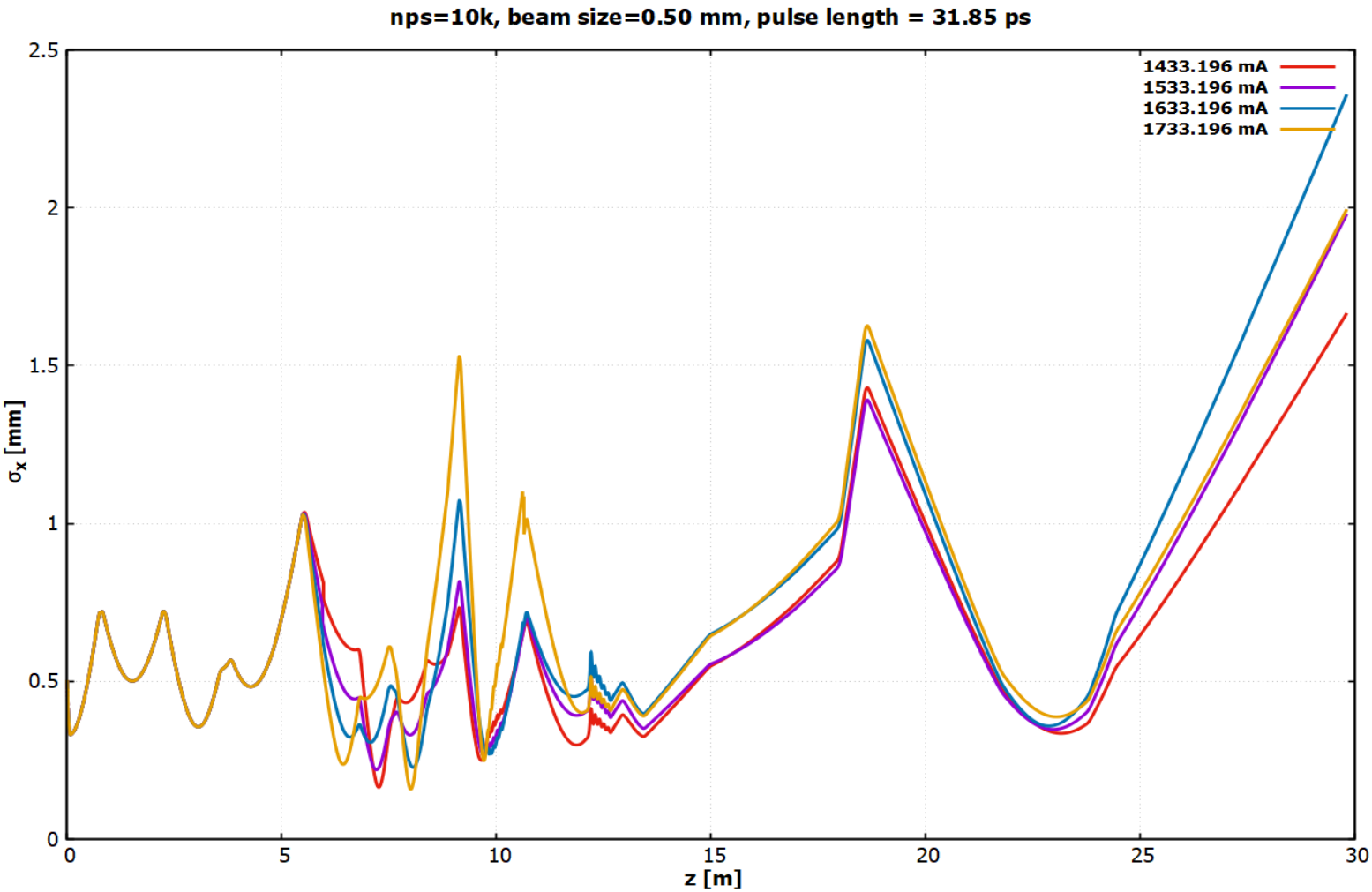
Simulated Beam characteristics

- FWHM=75 ps; 31.85 ps bunch length, 0.50 mm beam size
- Gaussian Beam of 10k macro-particles
- changing solenoid current just beore A_1

Beam Characteristics- solenoid current variation

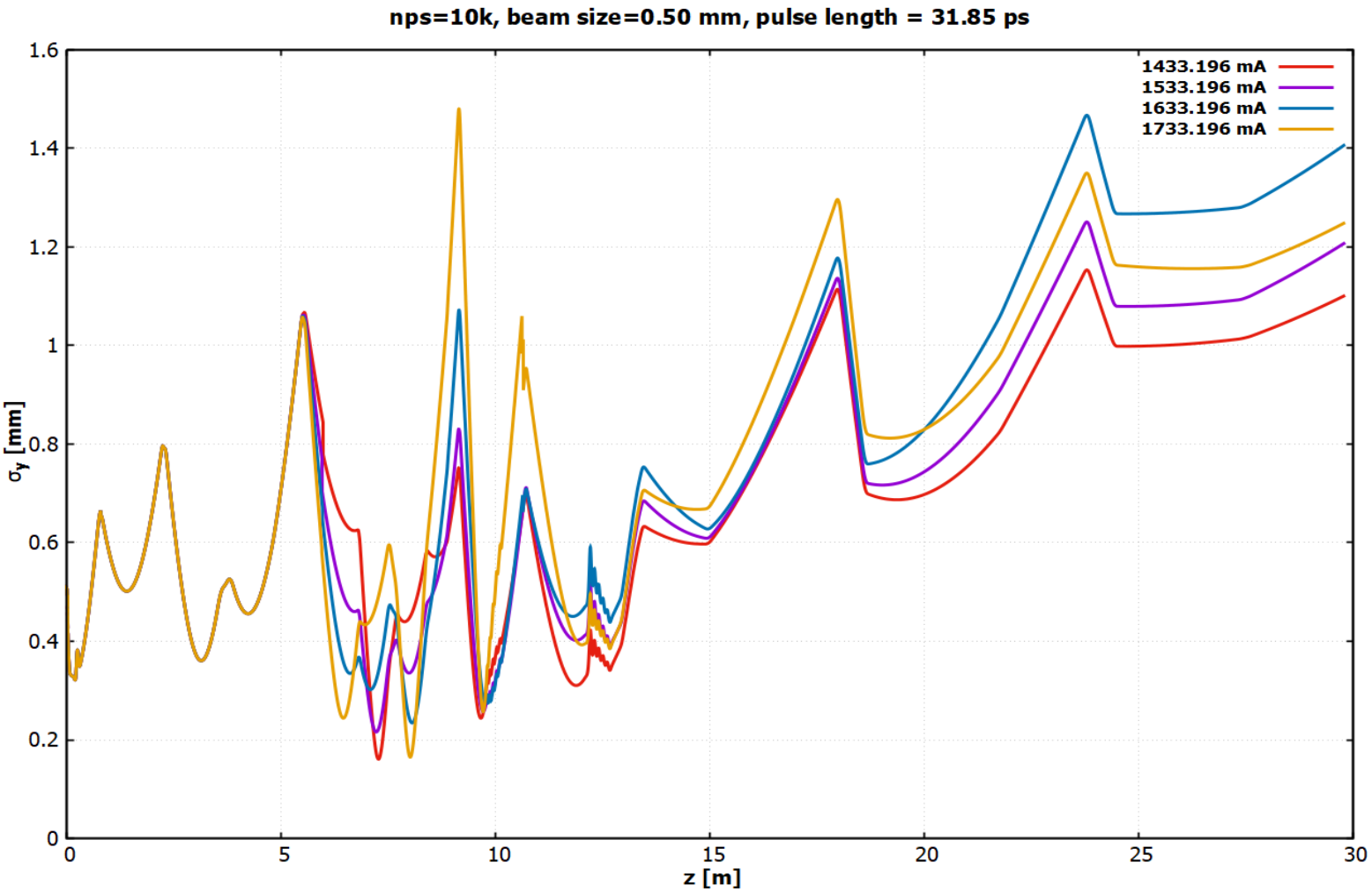


Beam Characteristics- solenoid current change



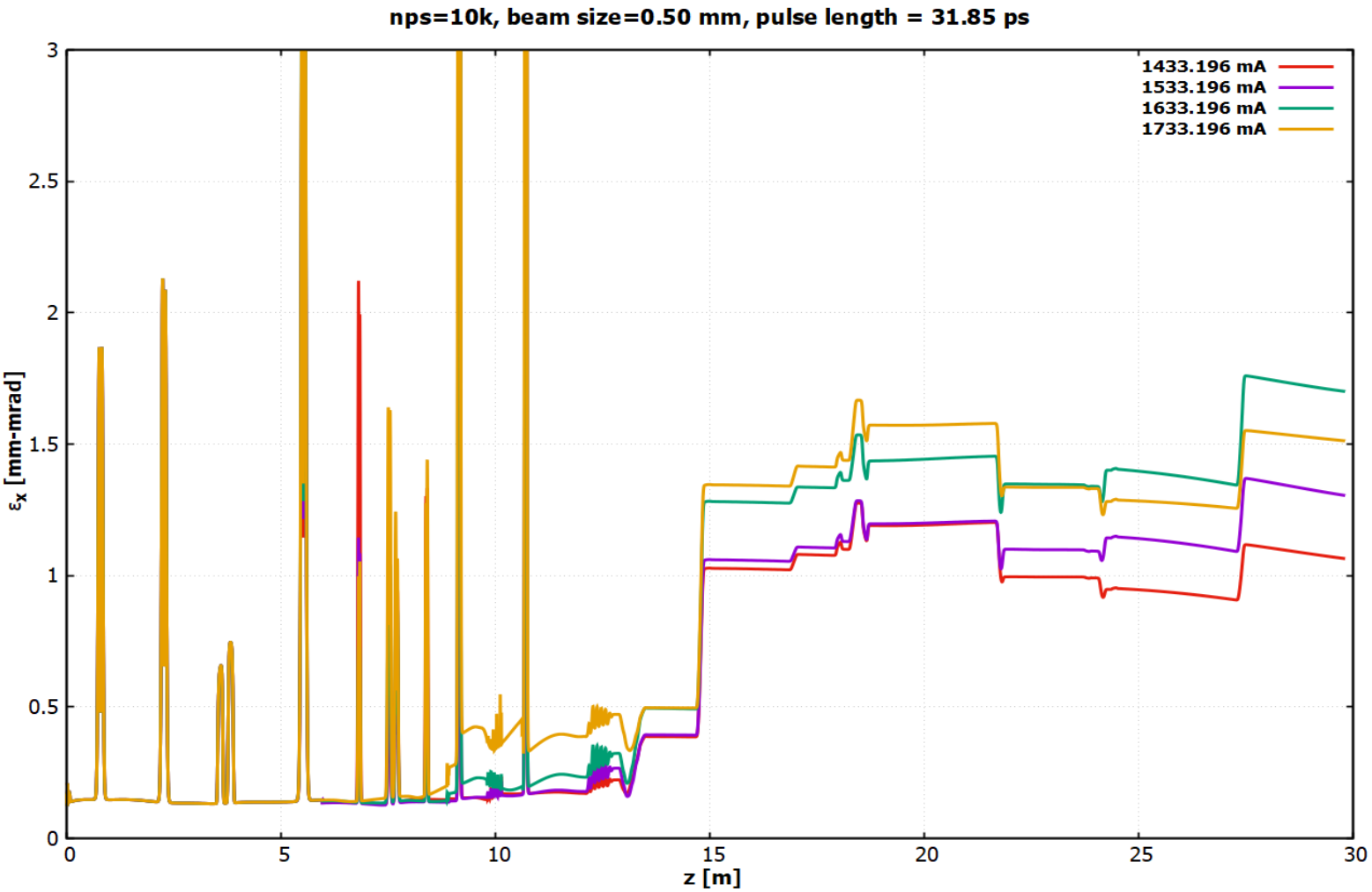
Beam Sizes σ_x

Beam Characteristics- solenoid current change



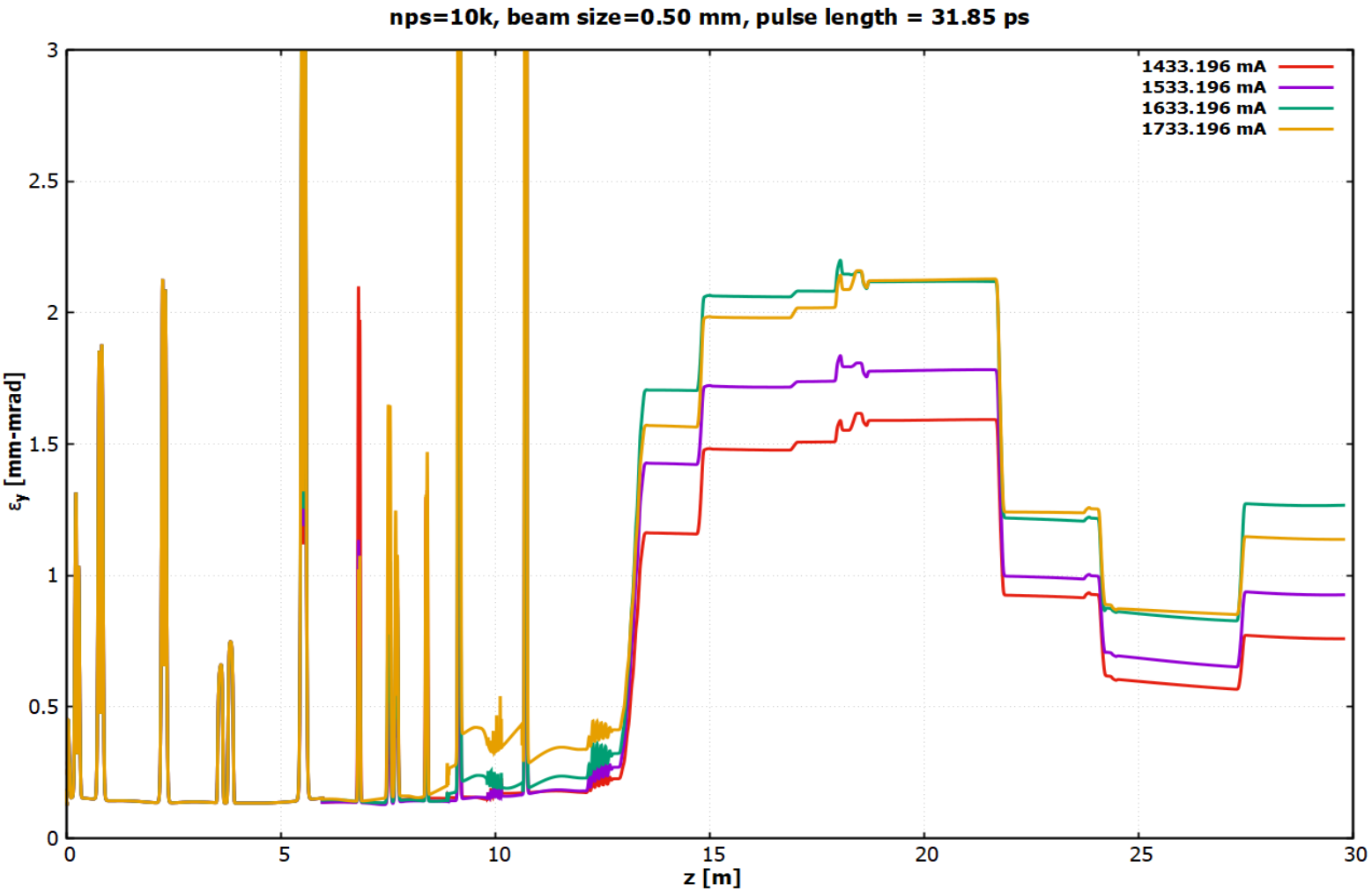
Beam Sizes σ_y

Beam Characteristics- solenoid current change



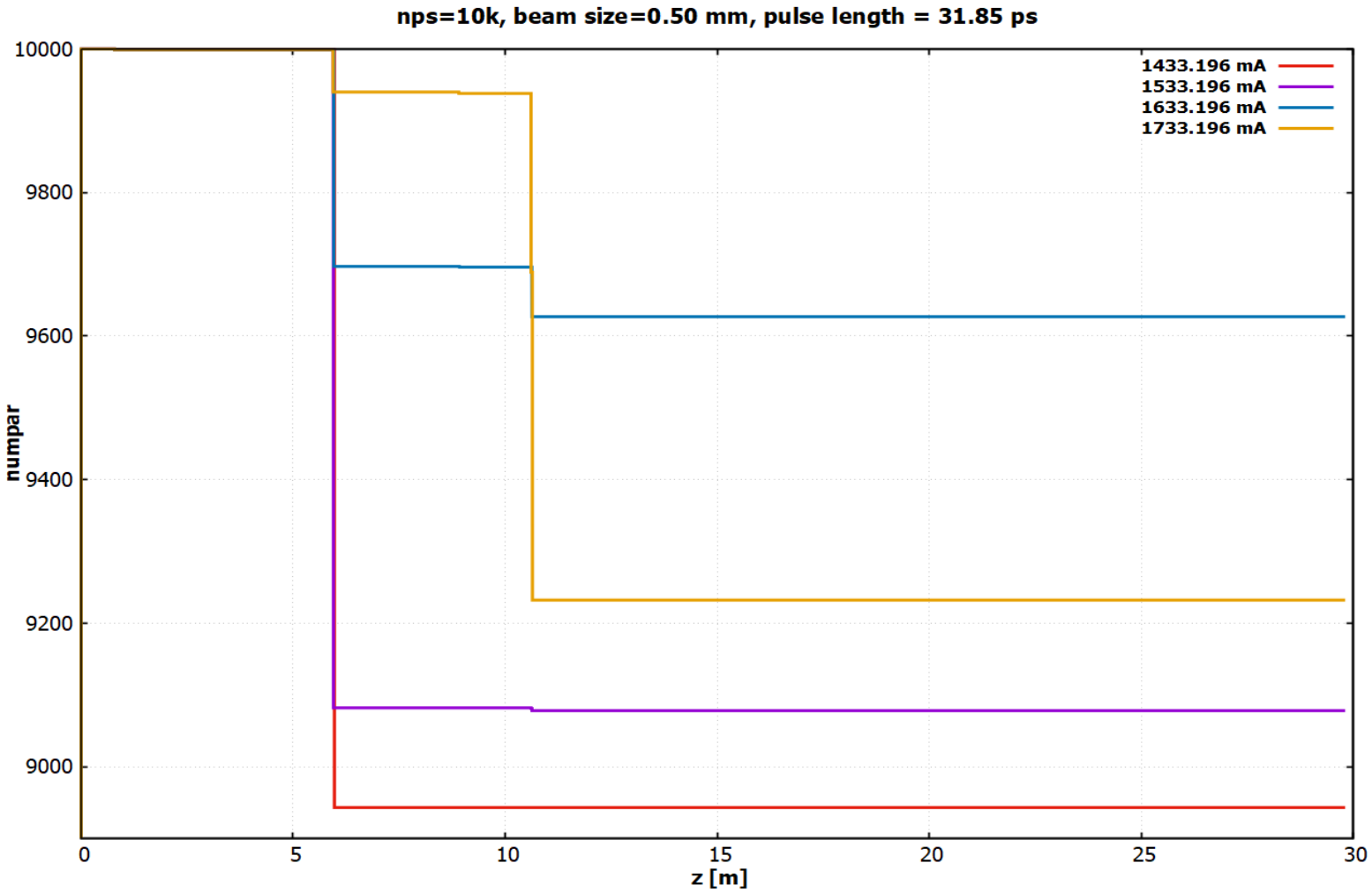
Normalized Emittances ϵ_{n_x}

Beam Characteristics- solenoid current change



Normalized Emittances ϵ_{n_y}

Beam Transmission-solenoid current change



Summary

-Laser spot size =0.50 mm
-Laser pulse length = 31.85 ps
- 128 ns bunch spacing with 0.64 pC bunch charge and current 320 μA

Table: GPT Simulation Results for nps=10k

solenoid current (mA)	Bunchlength (ps)	beam size (mm)	emittances (mm-mrad)	beam transmission %
1433.196	1.32	$\sigma_x = 1.66$, $\sigma_y = 1.10$	$\epsilon_{n_x} = 1.06$, $\epsilon_{n_y} = 0.76$	89.43
1533.196	1.12	$\sigma_x = 1.98$, $\sigma_y = 1.20$	$\epsilon_{n_x} = 1.30$, $\epsilon_{n_y} = 0.92$	90.78
1633.196	1.25	$\sigma_x = 2.35$, $\sigma_y = 1.40$	$\epsilon_{n_x} = 1.70$, $\epsilon_{n_y} = 1.26$	96.27
1733.196	4.33	$\sigma_x = 1.99$, $\sigma_y = 1.24$	$\epsilon n_x = 1.51$, $\epsilon_{n_y} = 1.13$	92.32

Summary

1. Phase 1- Upgrade Injector Model for KLF, 128 ns beam is simulated using GPT
2. For 130 keV beam, the laser pulse lengths and laser spot sizes are varied individually and simultaneously.
3. For 128 ns, maximum beam transmission obtained is 96.27% for 0.50 mm laser spot size and 31.85 ps laser pulse length.

Thank You !