CEBAF Injector Model for K_L beam Conditions (Phase 1)

Sunil Pokharel

March 18, 2022

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

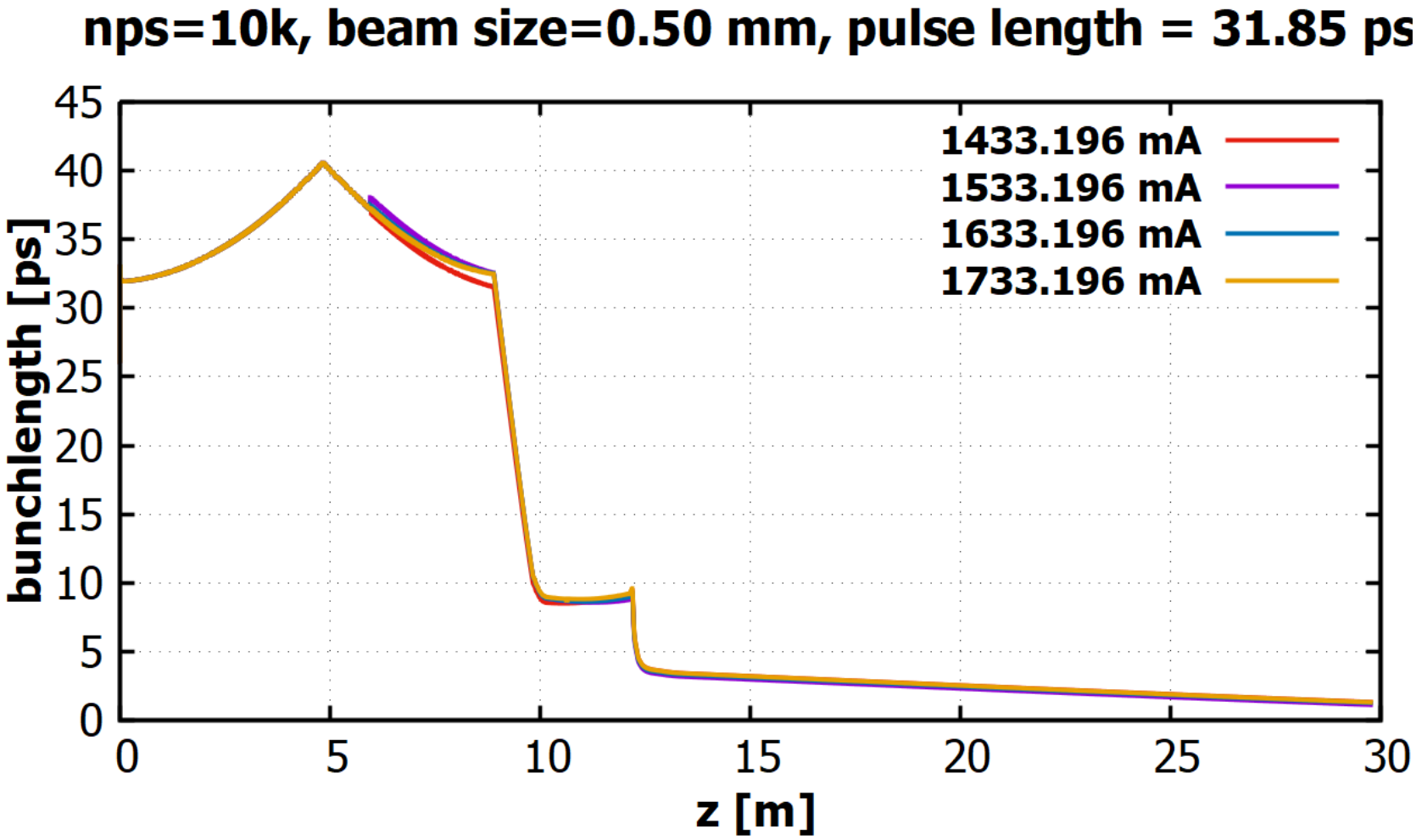
Initial distribution

- 130 kV D.C. gun
- 1 Prebuncher, 1Buncher, 5 Captures, Old 5-5 1/4 Cryomodule Booster (2 Cornell-style 5-cell cavities)
- Thermal emittance 0.061 mm-mrad, Gaussian Beam
- Varied laser spot sizes and pulse length individually/simultaneously for 10k macro-particles

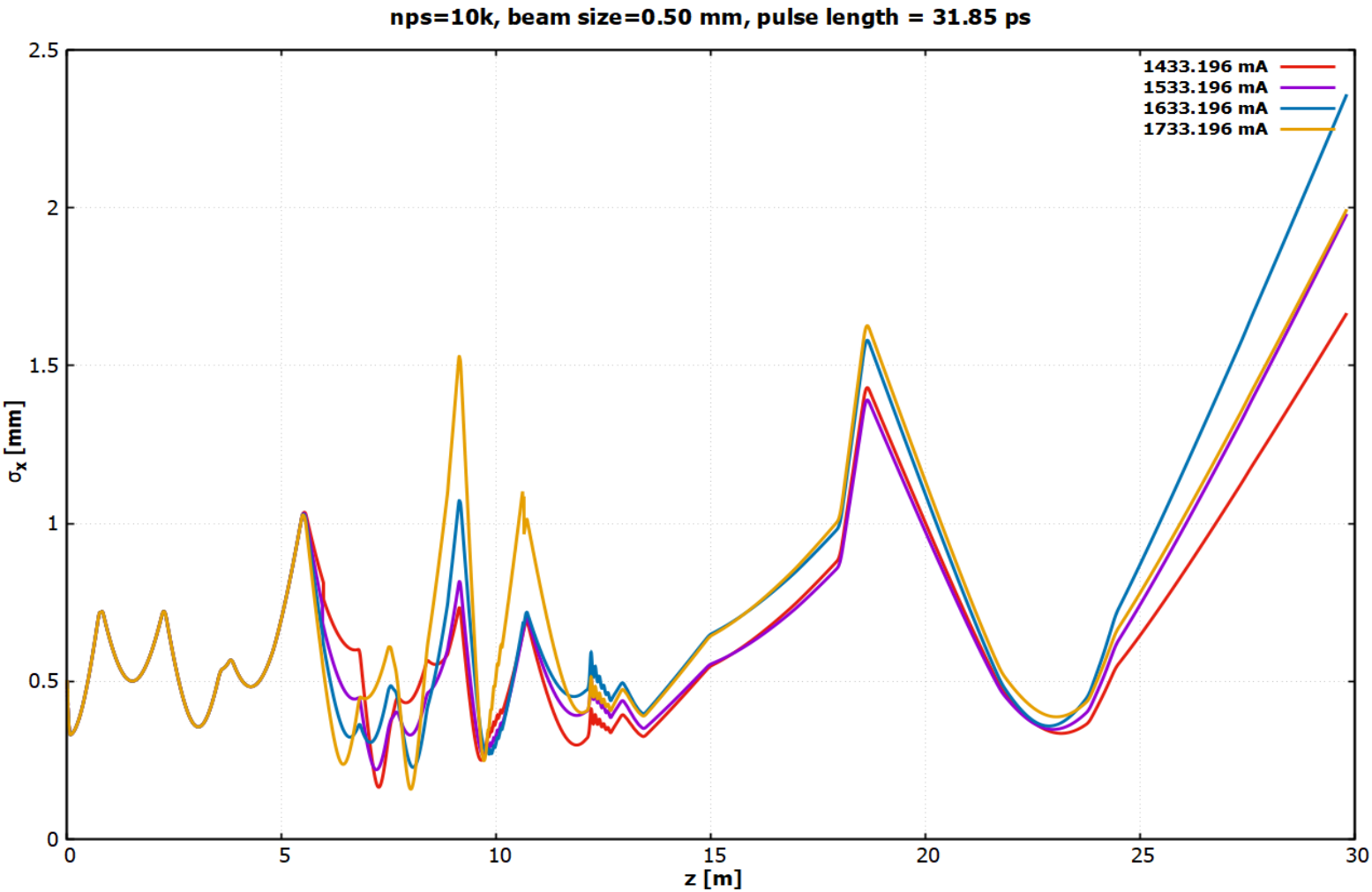
Simulated Beam characteristics

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

Beam Characteristics- solenoid current variation

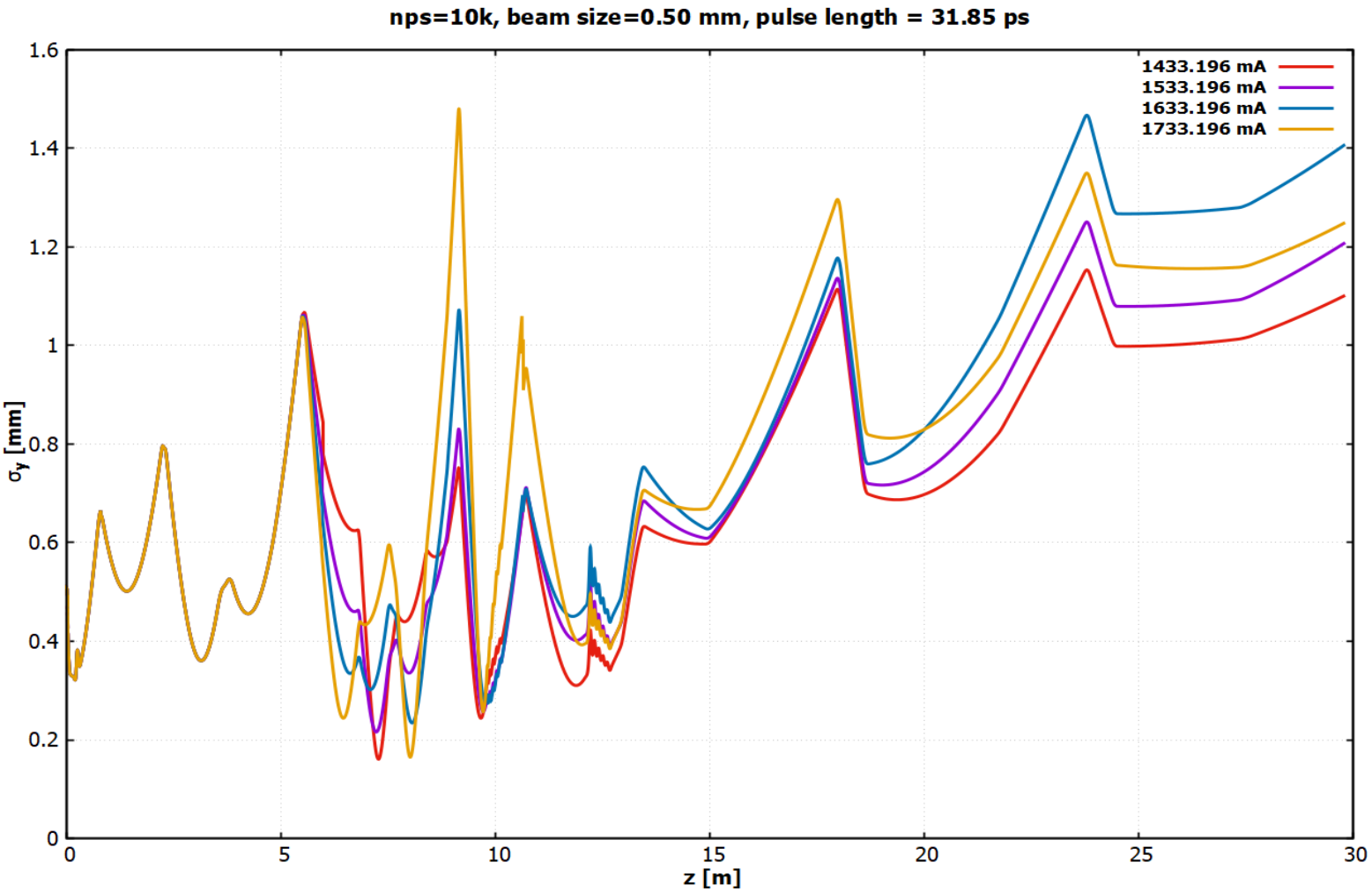


Beam Characteristics- solenoid current change



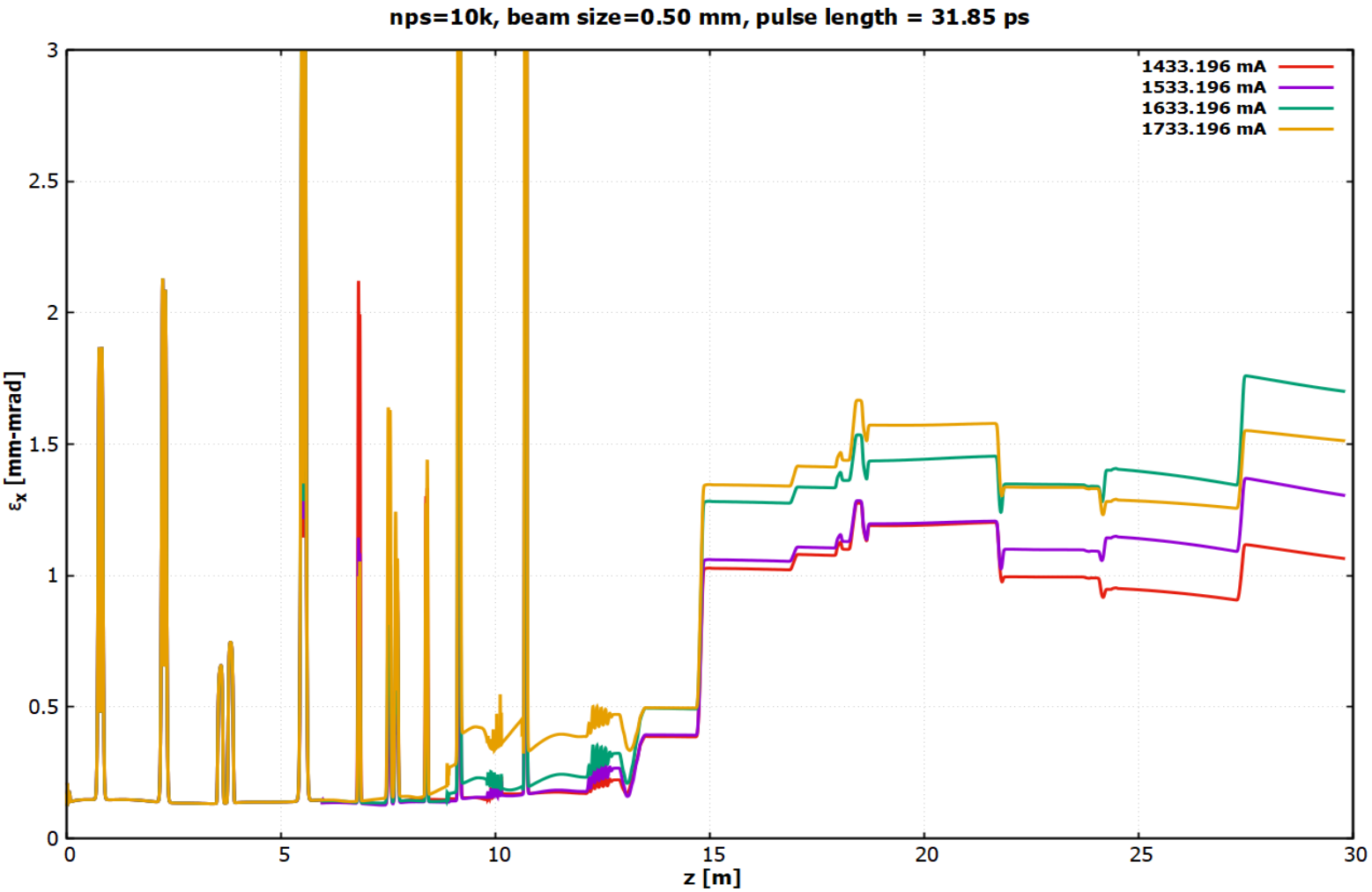
Beam Sizes σ_x

Beam Characteristics- solenoid current change



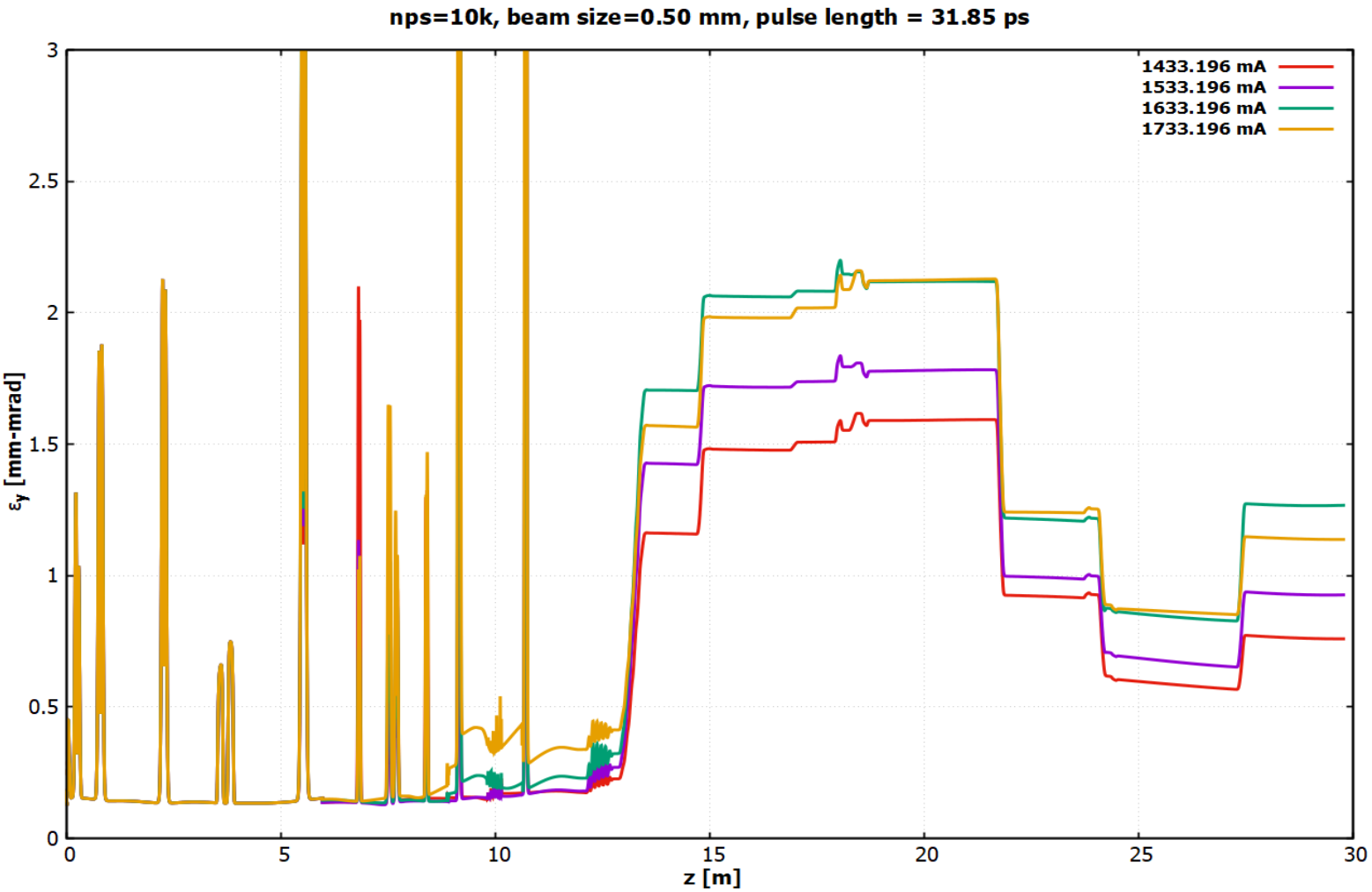
Beam Sizes σ_y

Beam Characteristics- solenoid current change



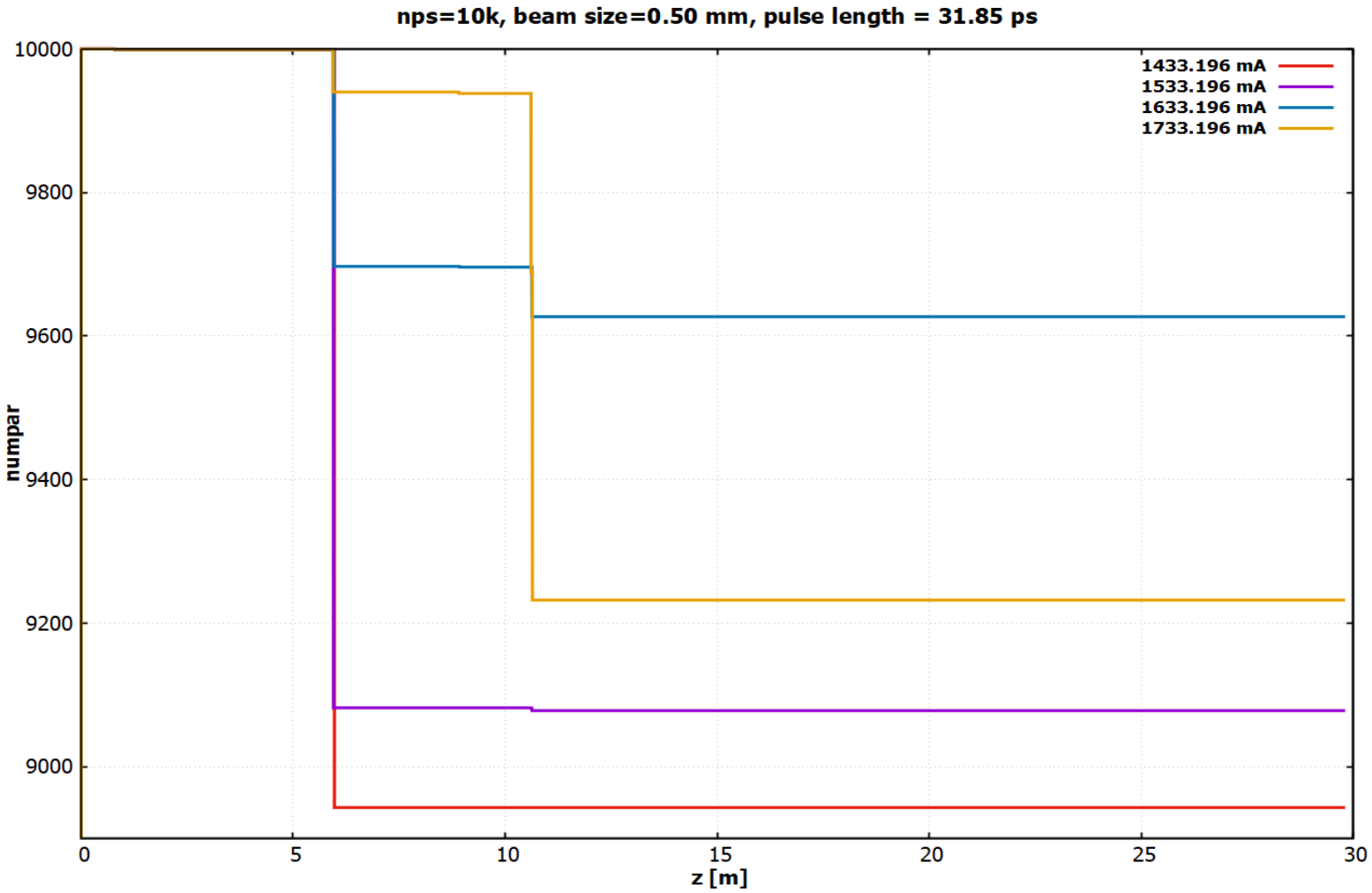
Normalized Emittances ϵ_{n_x}

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

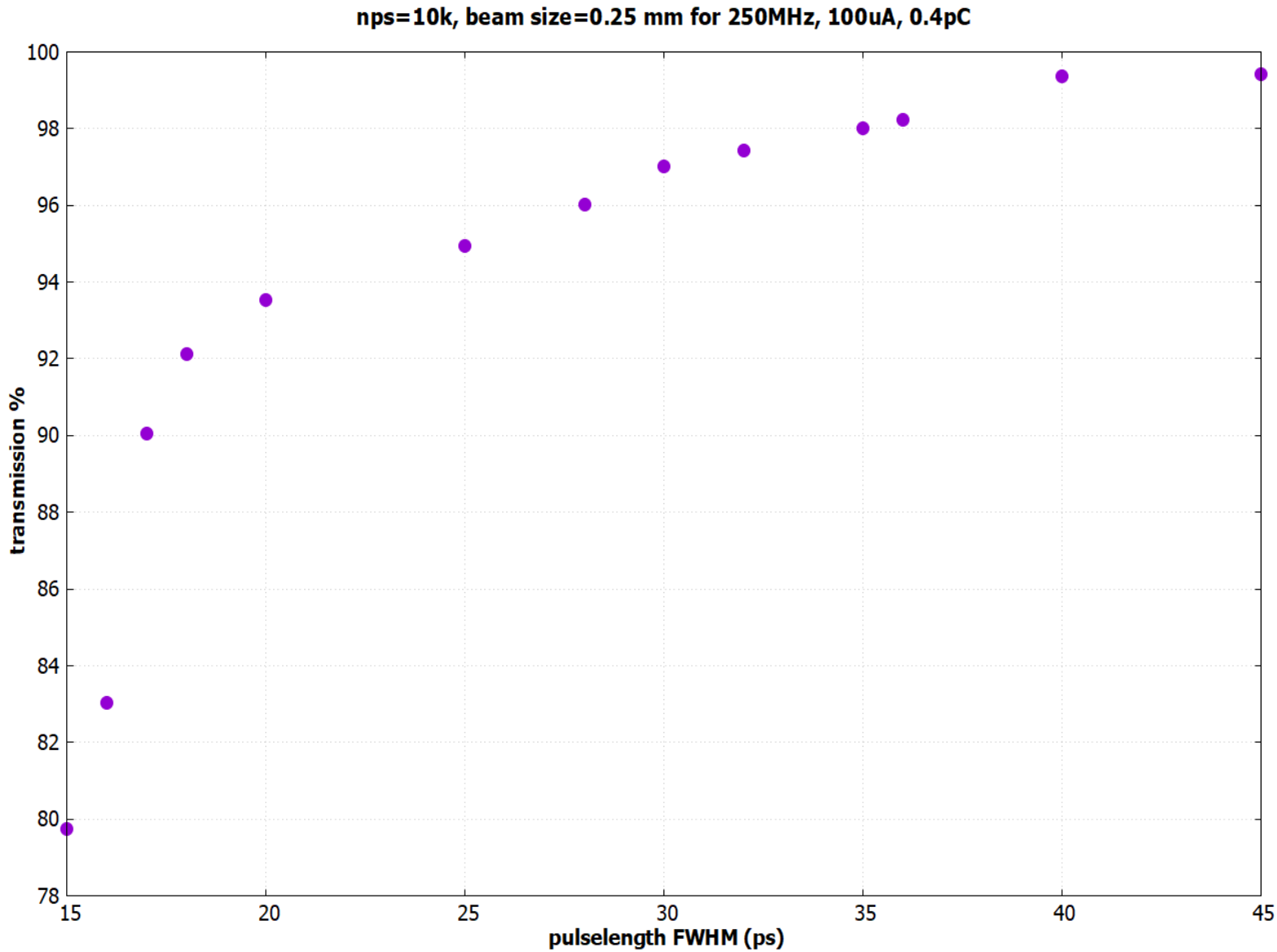
solenoid current (mA)	Bunchlength (ps)	beam size (mm)	emittances (mm-mrad)	beam transmission %
1433.196	1.32	$\sigma_x = 1.66$, $\sigma_y = 1.10$	$\epsilon_{n_x} = 1.06$, $\epsilon_{n_y} = 0.76$	89.43
1533.196	1.12	$\sigma_x = 1.98$, $\sigma_y = 1.20$	$\epsilon_{n_x} = 1.30$, $\epsilon_{n_y} = 0.92$	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

Beam Transmission

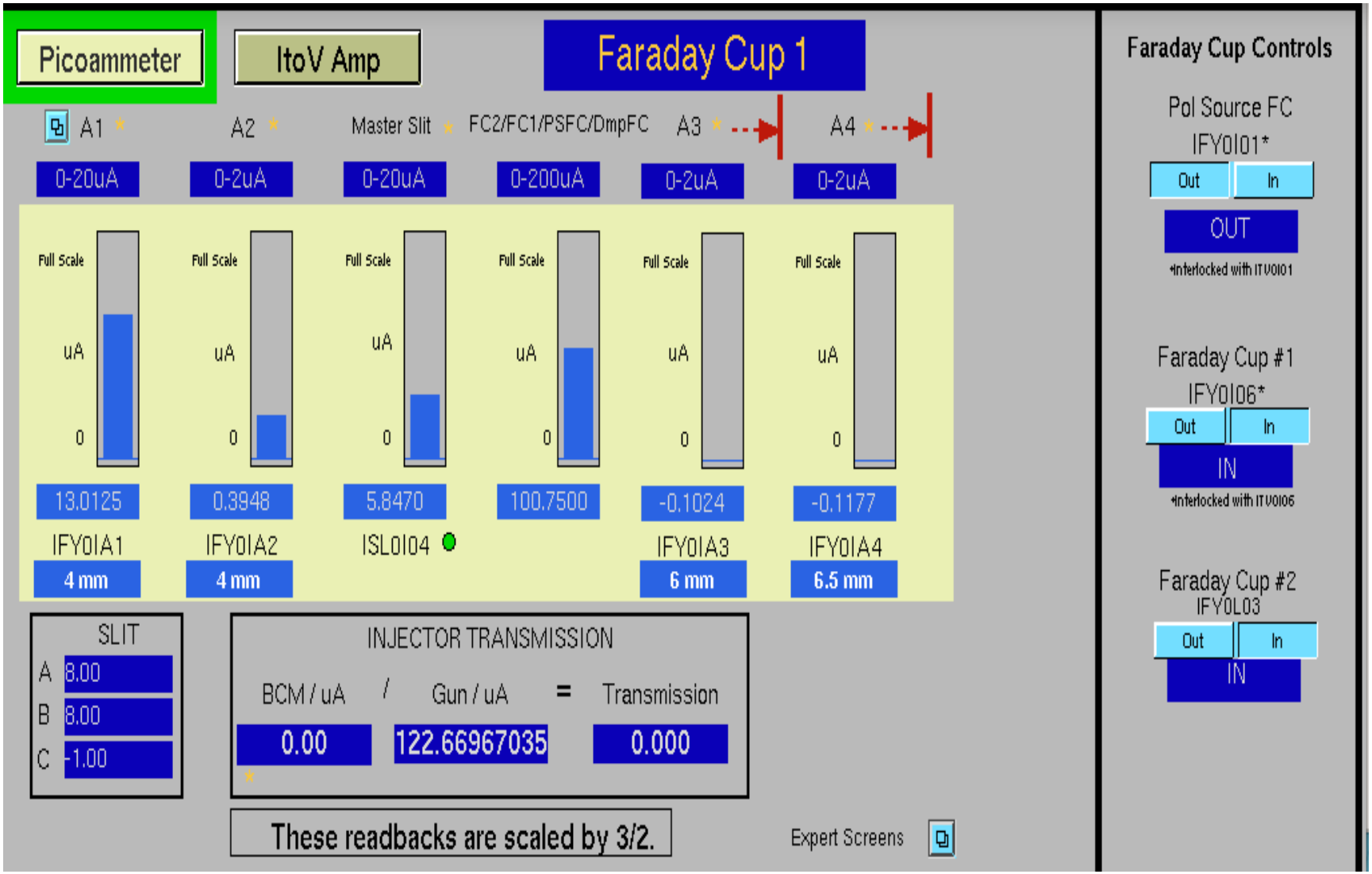
Beam Transmission through A1 with variation of laser pulselength (FWHM) for 0.4 pC bunch charge

#PULSELENGTH(ps)	TRANSMISSION (%)
# FOR 0.25mm SPOT SIZE FOR 100uA, 0.4pC, 250 MHz	
45	99.41
40	99.35
36	98.22
35	98.01
32	97.44
30	97.02
28	96.02
25	94.93
20	93.54
18	92.13
17	90.06
16	83.03
15	79.73

Beam Transmission through A1



Beam Transmission- 100uA, 250MHz measurement

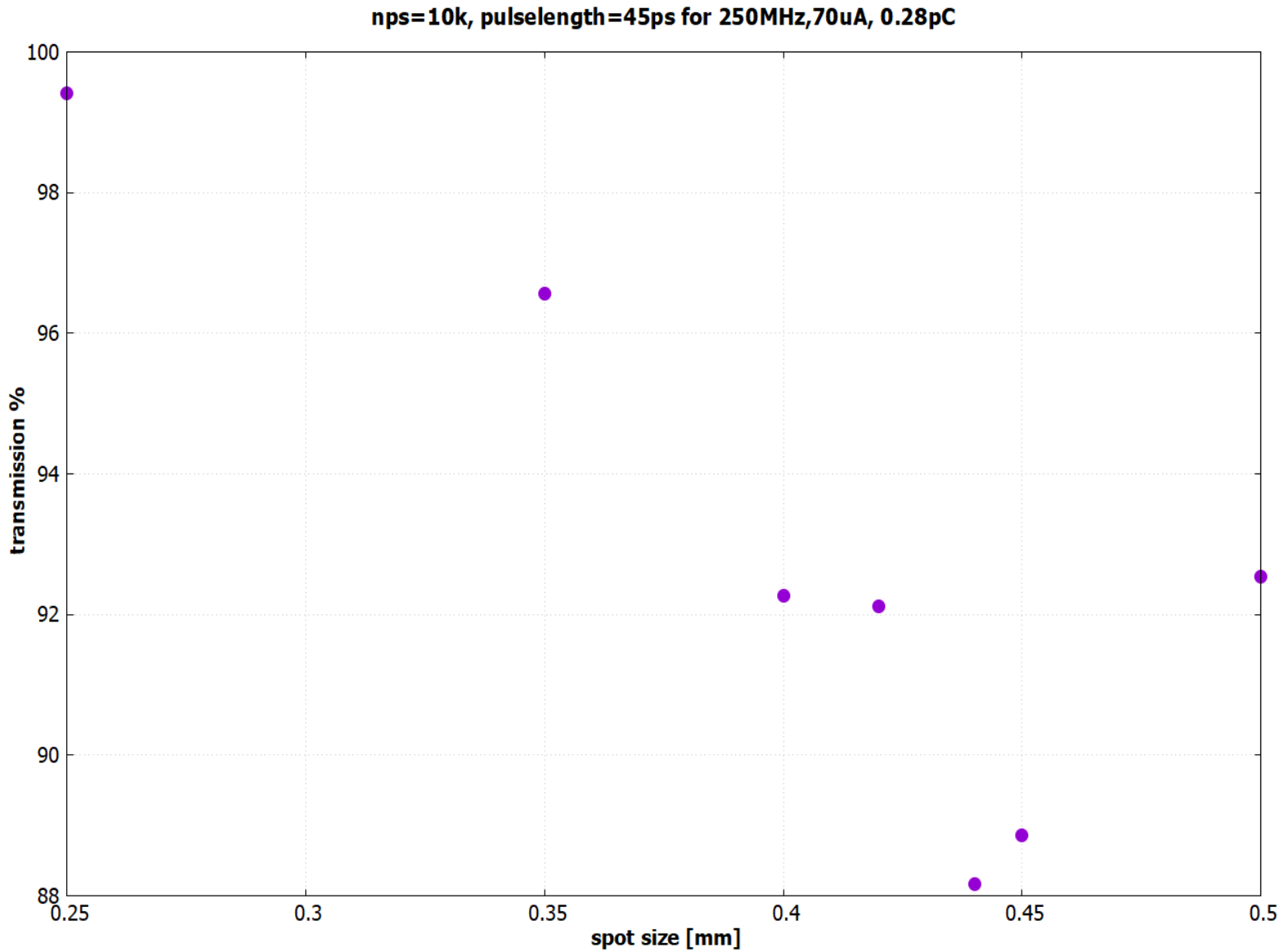


Beam Transmission-simulation

Beam Transmission through A1 with variation of laser spot-size for 0.4 pC bunch charge

#SPOT SIZE(mm)	TRANSMISSION (%)
# FOR 45ps PULSELENGTH 100uA, 0.4pC, 250MHz	
0.25	99.41
0.35	96.56
0.40	92.26
0.42	92.11
0.44	88.17
0.45	88.86
0.50	92.54

Beam Transmission through A1-simulation

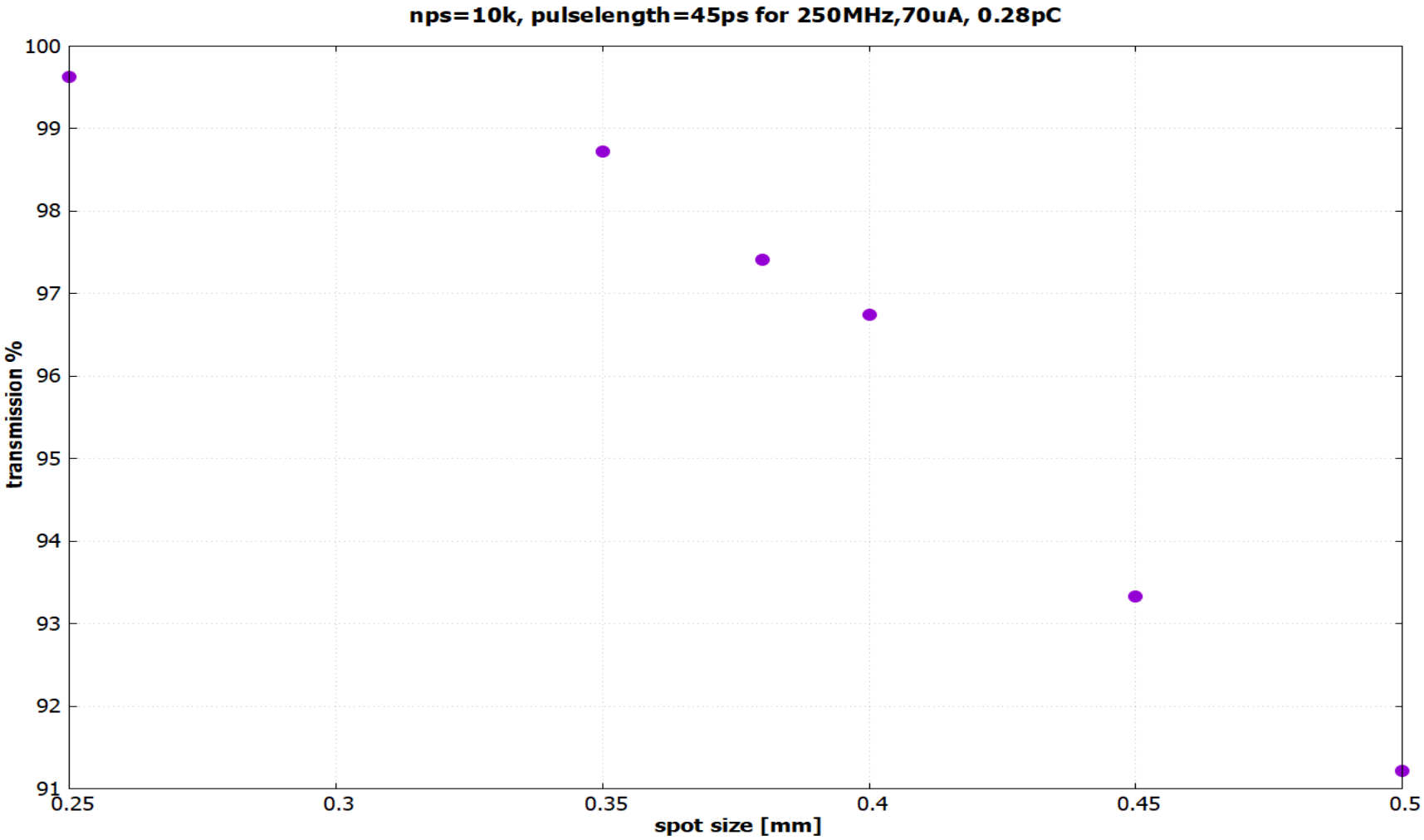


Beam Transmission-70uA, 250MHz-simulation

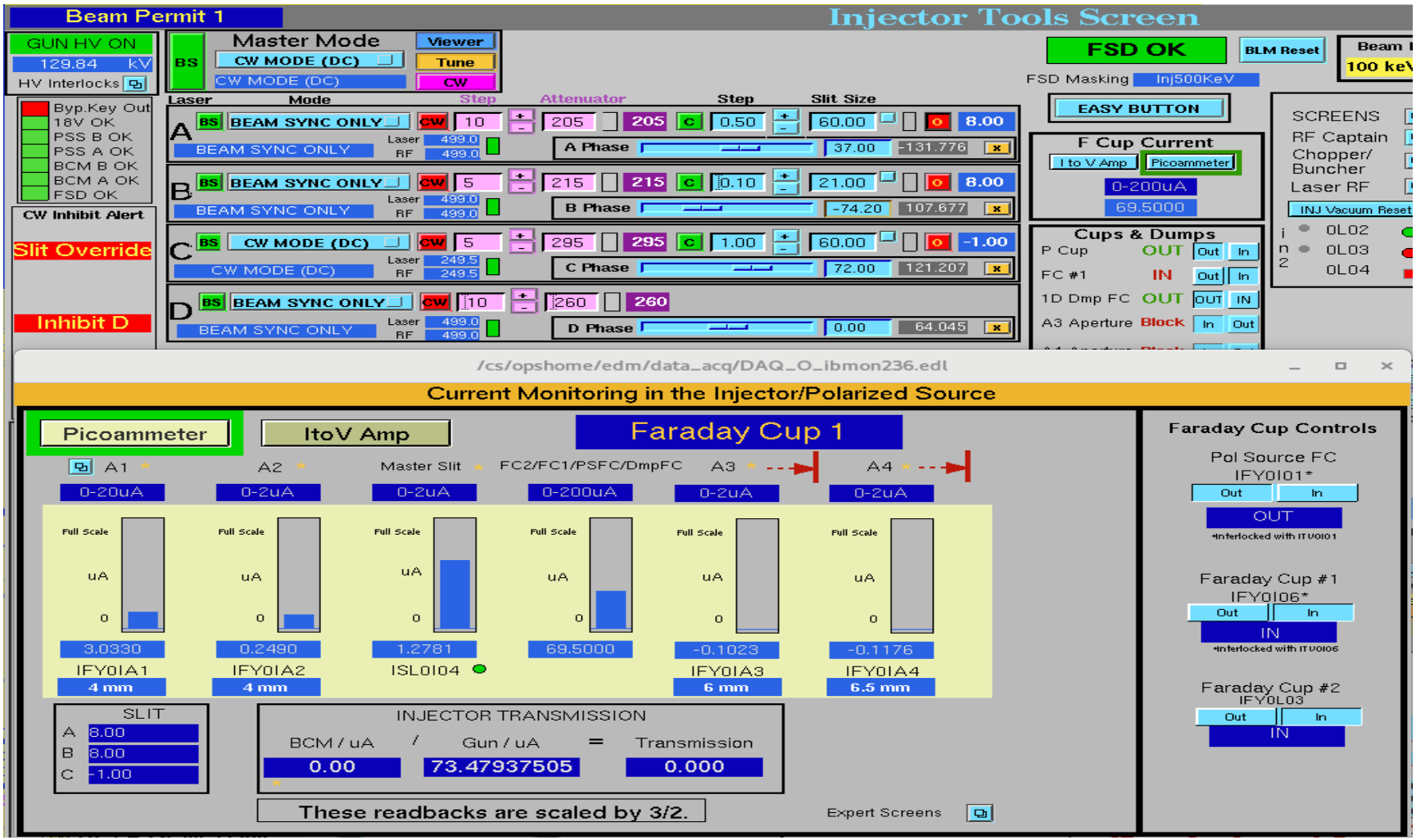
Beam Transmission through A1 with variation of laser spot-size for 0.28 pC bunch charge

```
#SPOT SIZE(mm)  TRANSMISSION (%)
#FOR 45ps PULSELENGTH 70uA, 0.28pC, 250MHz
0.25    99.63
0.35    98.72
0.38    97.41
0.40    96.74
0.45    93.33
0.50    91.21
```

Beam Transmission through A1-simulation



Beam Transmission through A1- 0.28 pC, 250 MHz measurement



Beam Transmission through A1- 0.4pC, 250 MHz simulation

#FOR 100uA, 0.4pC, 250MHz

PULSE LENGTH (ps)	SPOT-SIZE(mm)	TRANSMISSION (%)
45	0.25	99.41
45	0.35	96.56
45	0.40	92.26
45	0.42	92.11
45	0.44	88.17
45	0.45	88.86
45	0.50	92.54
42	0.42	90.08
40	0.30	99.54
40	0.35	87.78
40	0.40	92.44
40	0.44	87.78
38	0.40	92.06

Summary

1. Phase 1 Upgrade Injector Model for KLF, high and low bunch charge 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 0.4 pC bunch charge, 250 MHz, maximum beam transmission from measurement obtained is $\simeq 90\%$ that is for 0.25 mm (??) laser spot-size and 45ps (??) laser pulselength from the baseline for simulation.
4. For 0.4 pC bunch charge, 250 MHz, beam transmission varies with laser pulse length and laser spot sizes. From the simulation $\simeq 90\%$ beam transmission corresponds to 0.25 mm laser spot-size and 17 ps (??) laser pulselength.
5. For 0.4 pC and 0.28 pC bunch charges, 250 MHz, beam transmission for 0.45 mm (??) laser spot size and 45 ps laser pulselength corresponds to the measurements done.

Thank You !