Update on seeded FEL simulations with Genesis 4

Simulation parameters tests

Flattop and long gaussian pre-bunched beams

Georgi Georgiev
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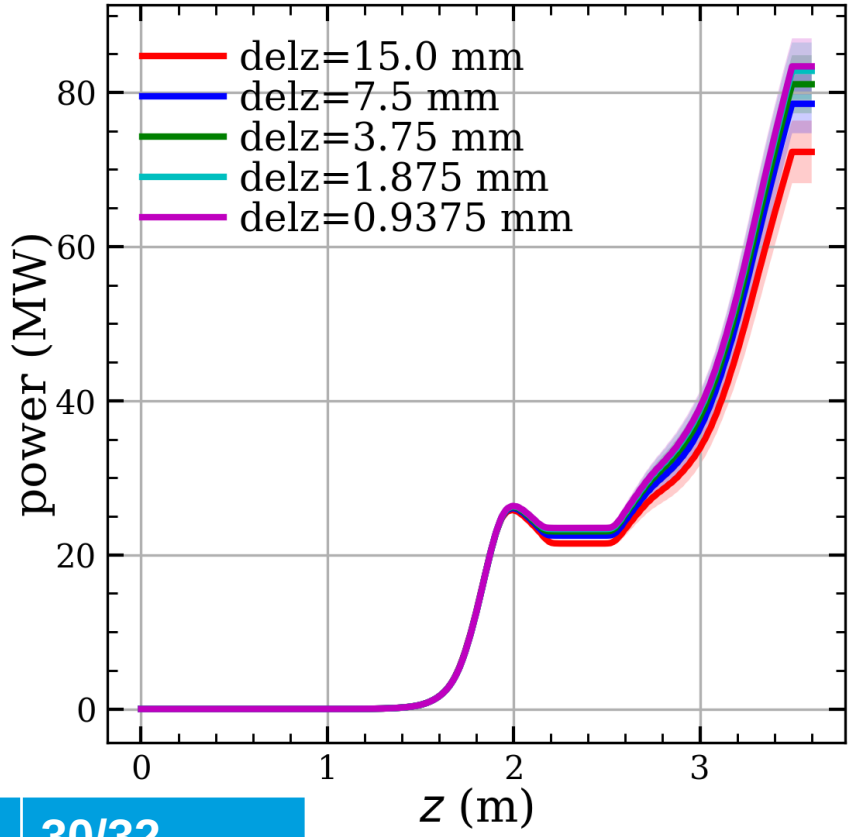
Simulation parameters tests

Simulation step

bunch=1e-3

- Noticeable effect, smaller step:
  - Higher FEL output
  - Longer simulation time
- Chosen best: delz = 3 mm



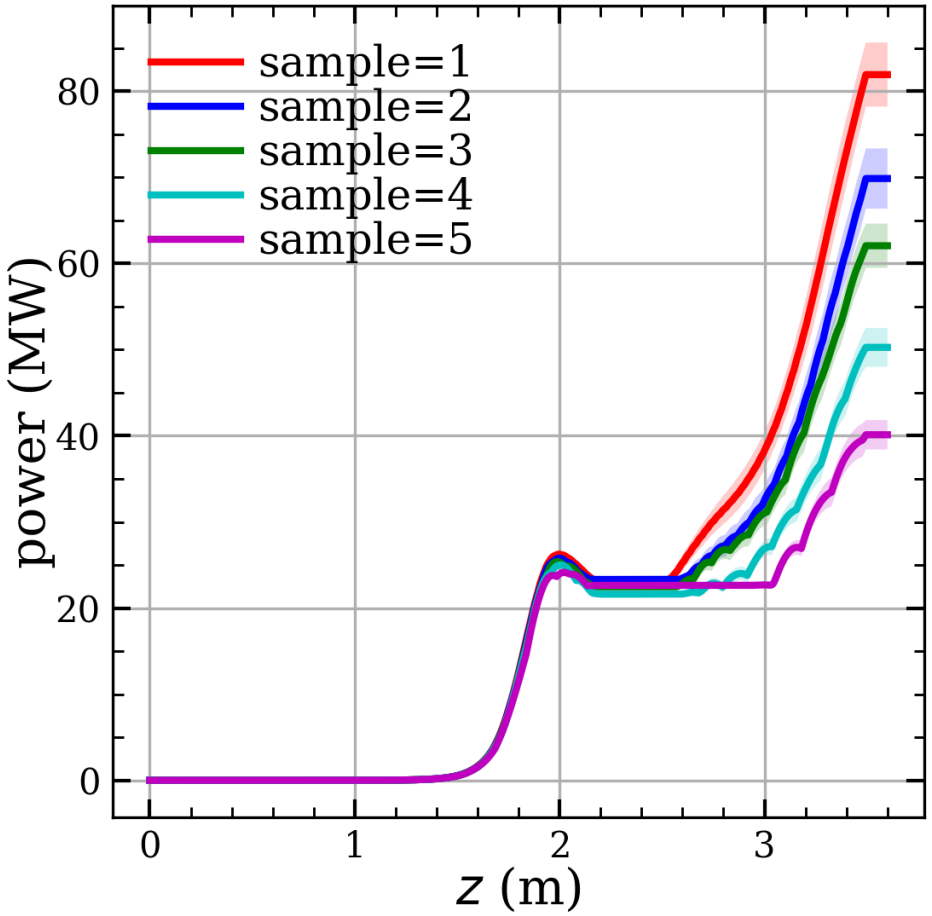
delz, mm	30/2	30/4	30/8	30/16	30/32
Energy, µJ	573	620	645	663	669±15
Power, MW	72	79	81	83	83±3.6

Sample – harmonic slicing

bunch=1e-3

- Noticeable effect
  - Similar final energy (655±14 for 1, 586±3 for 5)
  - Different peak power, time profile
  - Odd trends with higher sample
- Chosen best: sample=1

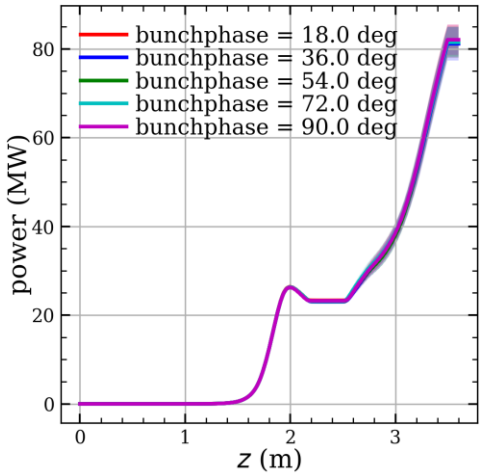
Sample	1	2	3	4	5
Power, MW	82	70	62	50	40
Power x sample	82	140	186	200	200

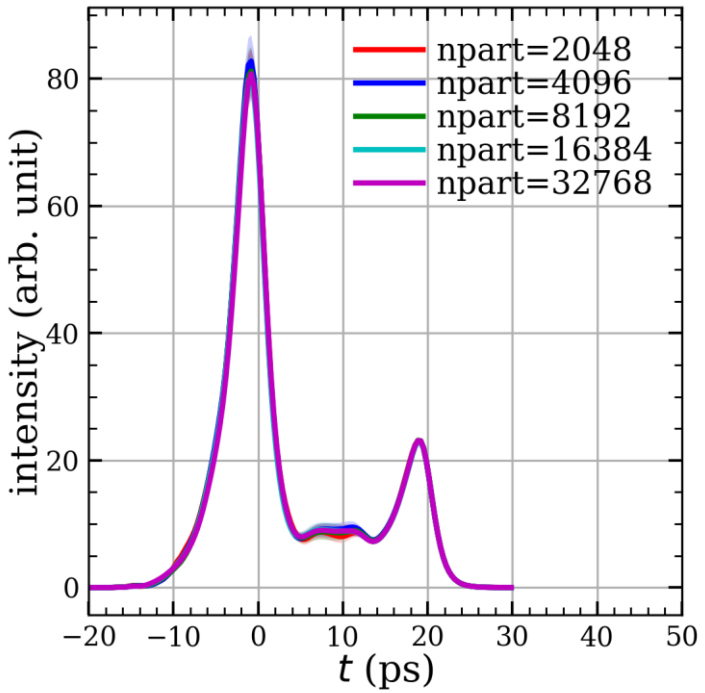


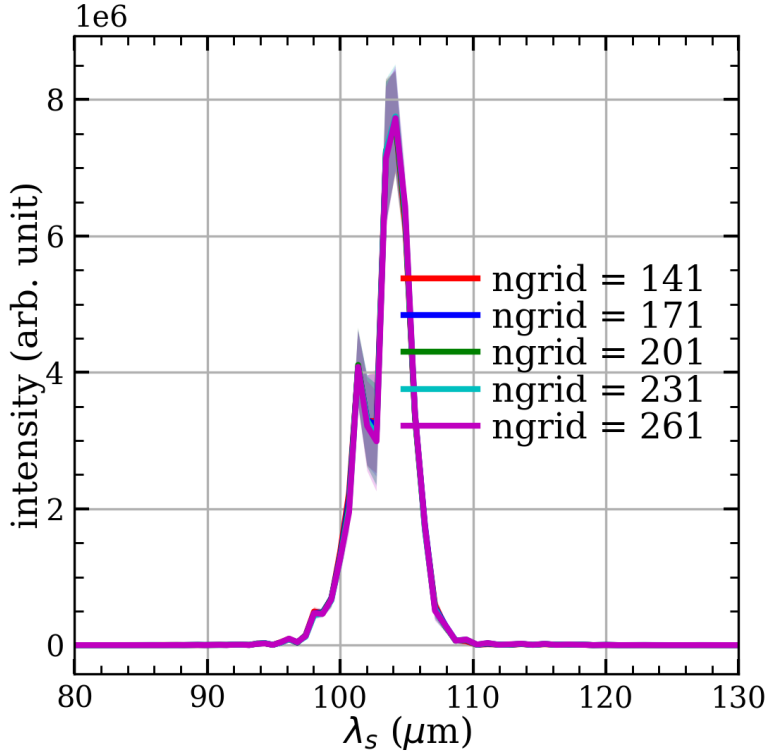
Macro particles, radiation grid and bunching phase

bunch=1e-3

- Negligible effect
- Problem with **even number points**
  - Missing central point?
- Chosen best:
  - npart=8192
  - ngrid=201
  - bunchphase=0



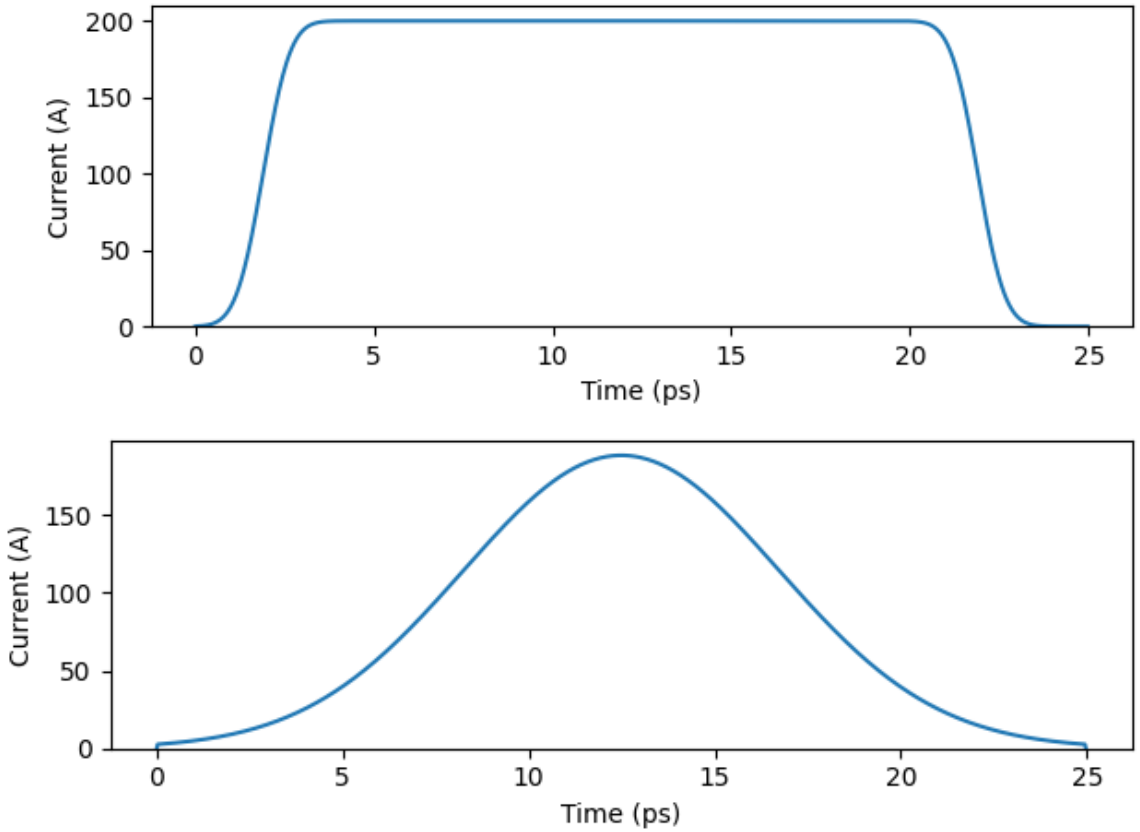




Flattop and long gaussian pre-bunched beams

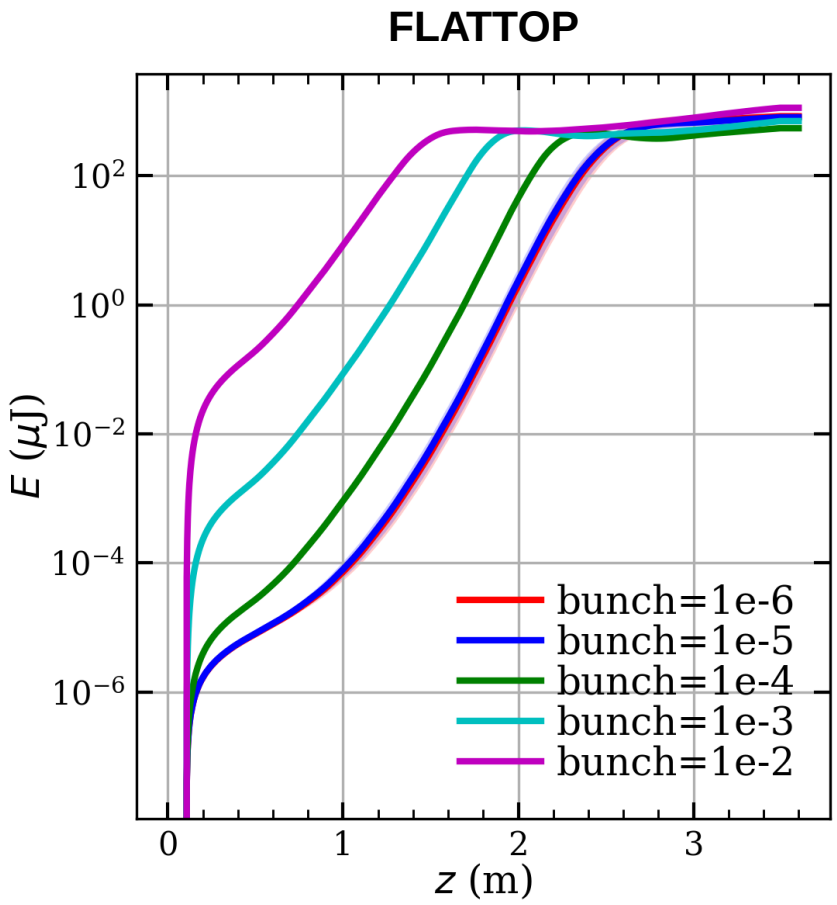
Simulation setup

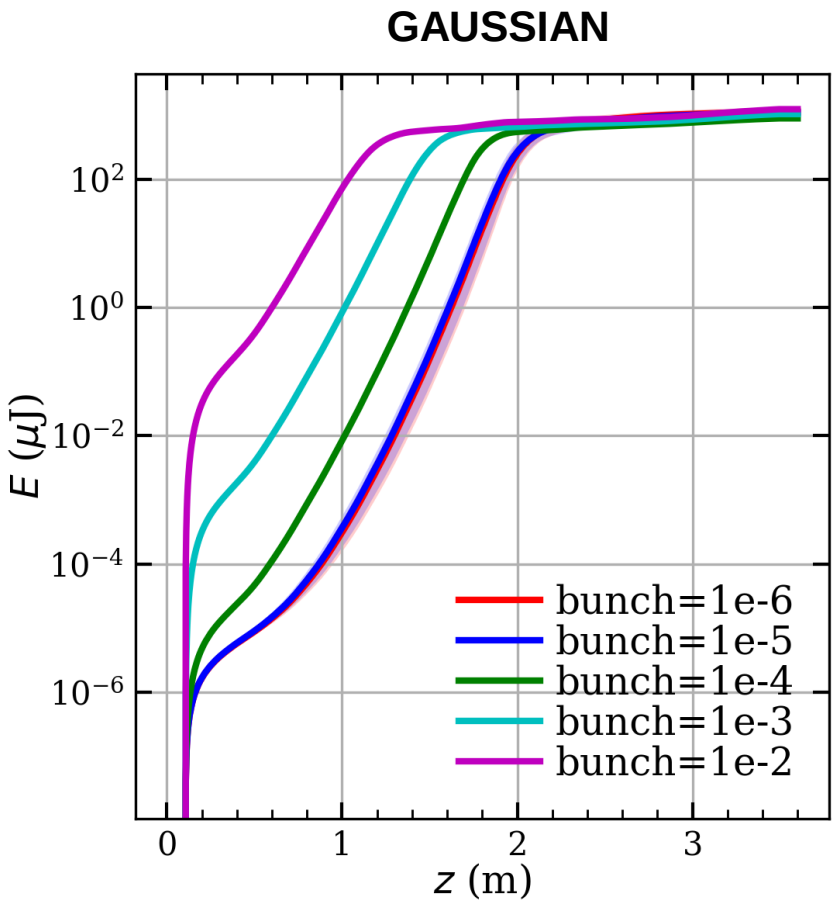
- Two current profiles scaled to 1 nC, 2nC, 4nC
- Fixed parameters: 3 THz, delz=0.003, npart=8192, delgam=0.5%, ex=4e-6, ey=4e-6, emod=0, power=0, ngrid=201
- Statistics for **100 shots**
- Scan over **bunching factor**
- Results after end of the undulator
- NO SPACE CHARGE (Genesis 4 bug)



Radiation energy

4 nC beams

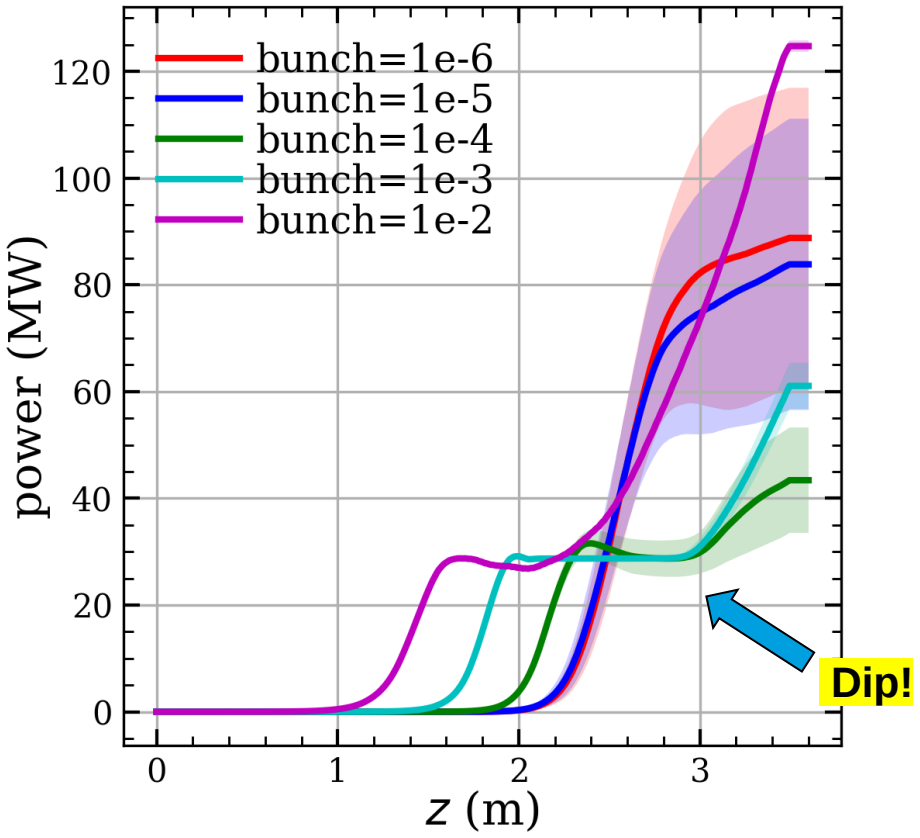




Peak (slice) power

4 nC beams

FLATTOP



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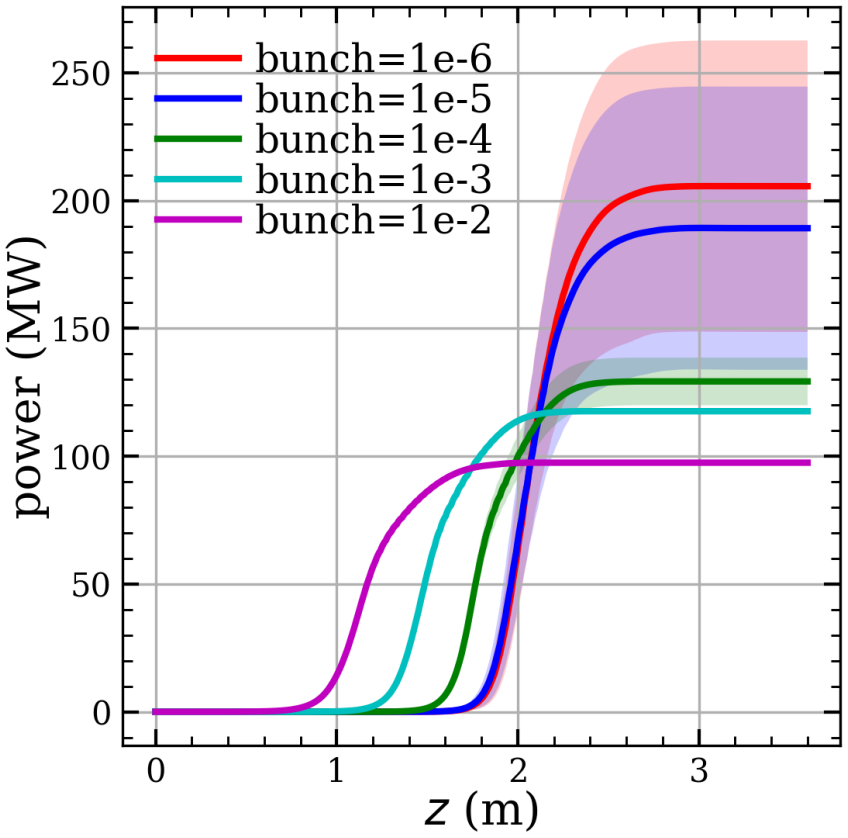
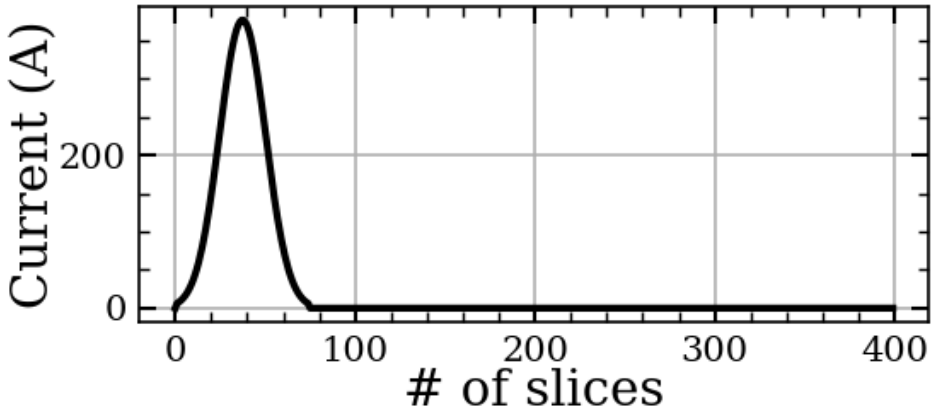
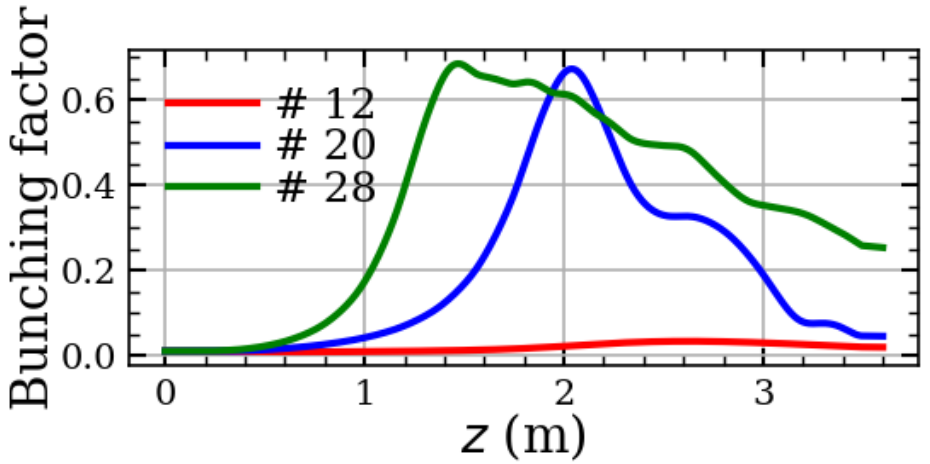


Bunching evolution

4 nC, 0.01 bunching factor

- SASE 4nC: saturation near undulator exit
- Pre-bunching: rapid bunching evolution
- Early saturation and overbunching
- Electrons **absorb** radiation
  - Analysis pending
- Odd effect: increased initial bunching
  - May result in lower efficiency
  - May impact spectrum negatively
  - But overall better stability (next slides)

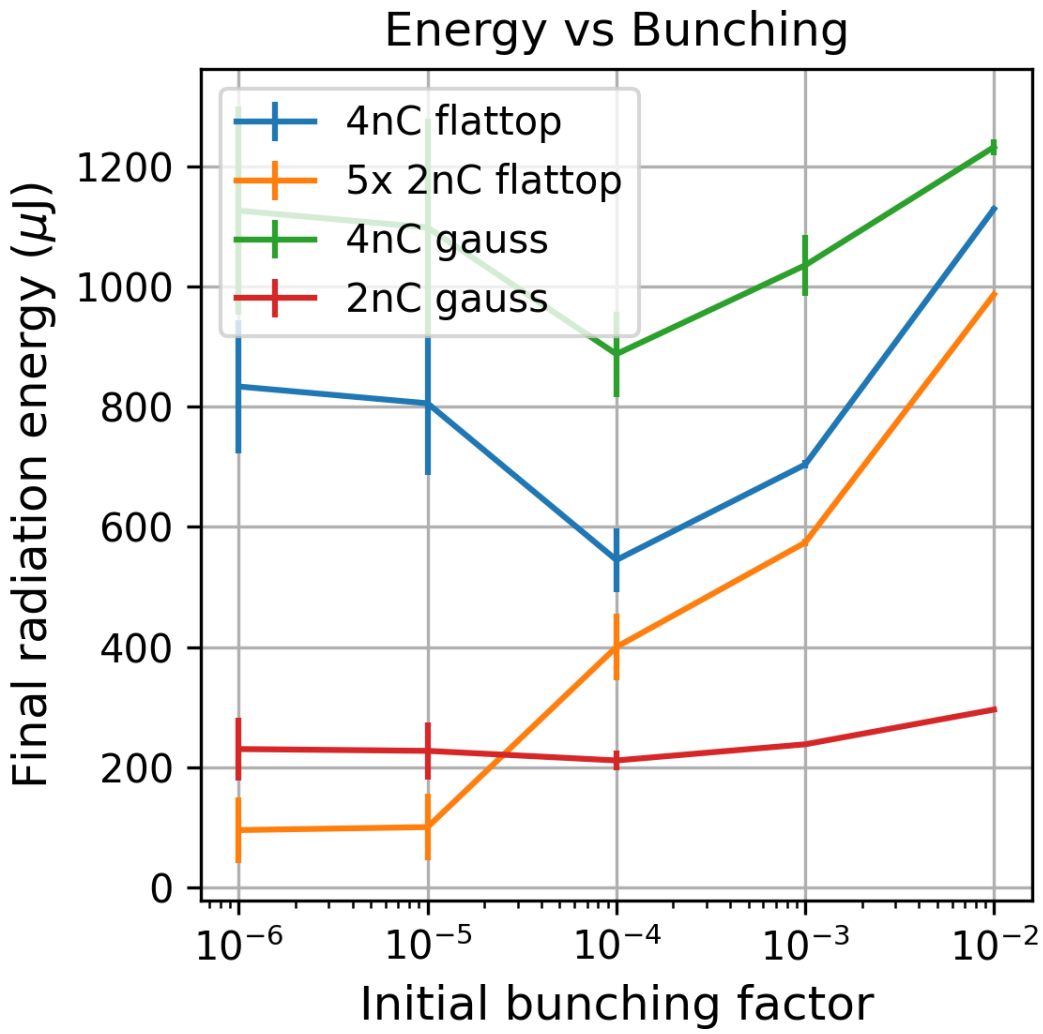




Final energy vs bunching

Results summary

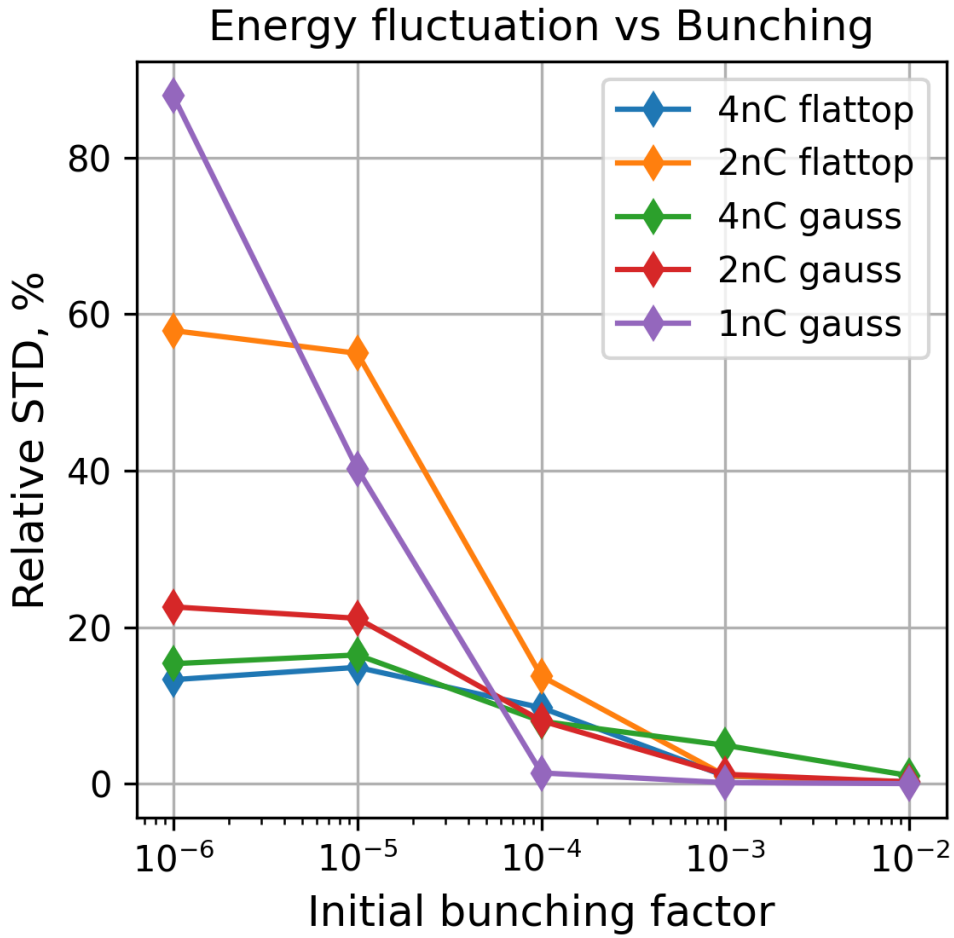
- Final energy – rise or drop is case dependent
- Energy fluctuation decreases



Final energy fluctuation

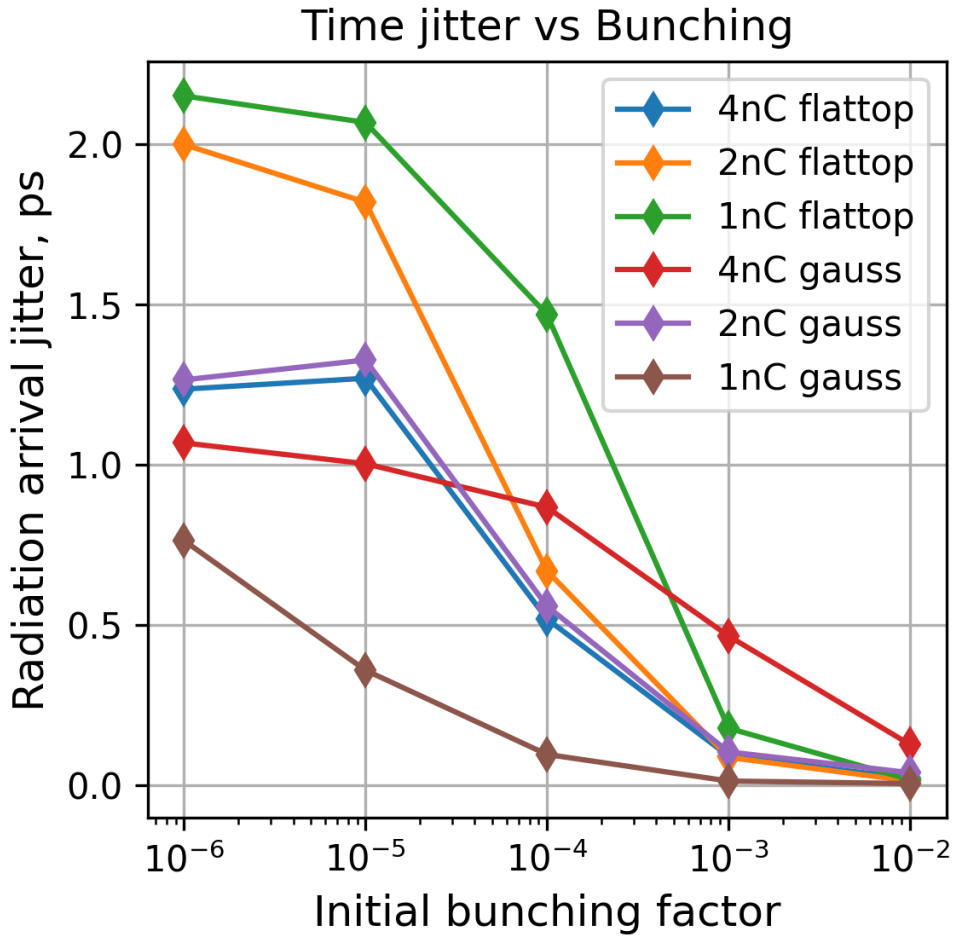
Results summary

- Energy fluctuation decreases with increased bunching factor
  - Converges to stable energy
- Seeding effect
  - Stronger with lower peak current
  - Evident with **bunch=1e-4** and above



Arrival time jitter

- Jitter decreases with increased bunching factor
  - Converges to no jitter
- Seeding effect with **bunch=1e-4** and above
- Under **1/10 radiation period** in some cases



Summary and outlook

Summary

- Investigated important simulation parameters
- Simulations with different charges and profiles
- Internal Genesis 4 pre-bunching
  - Rapid bunching development
  - Possible: radiation absorbed into the beam
  - Stability improvements for final energy and arrival time

Outlook

- Analysis of radiation fields along undulator
- Seeding by energy modulation
- Full beam (ASTRA) import to Genesis 4
- DPG 2022

Thank you!