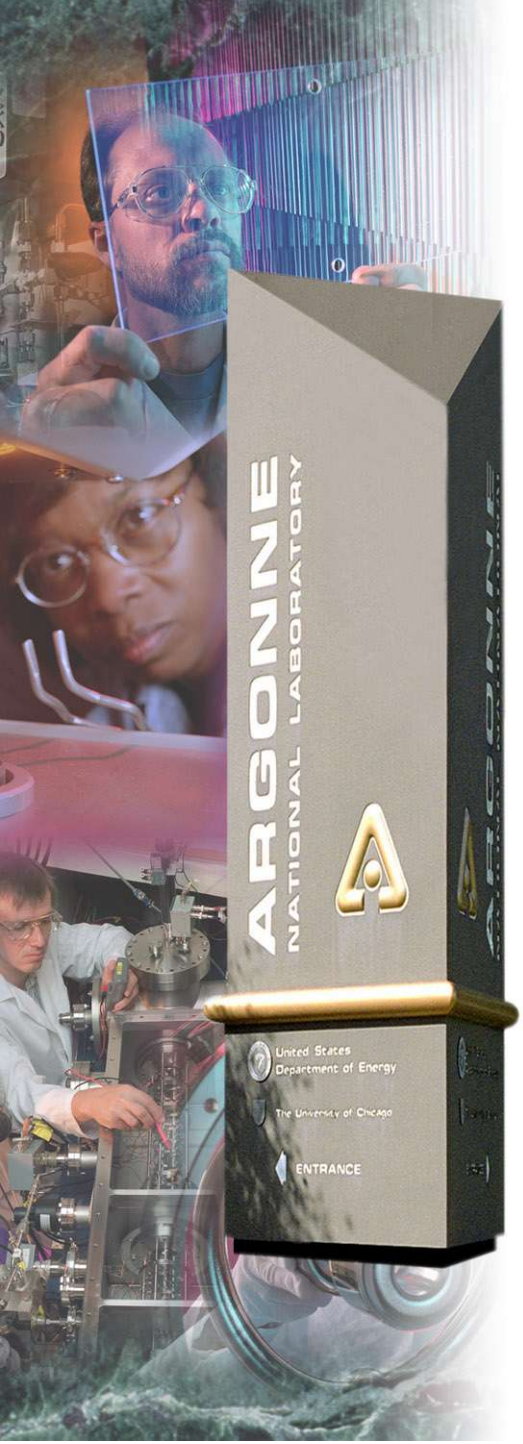

Evaluation of the Possibility of Upgrading the APS to an ERL

Michael Borland
Operations Analysis Group
APS Operations Division
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U.S. Department of Energy

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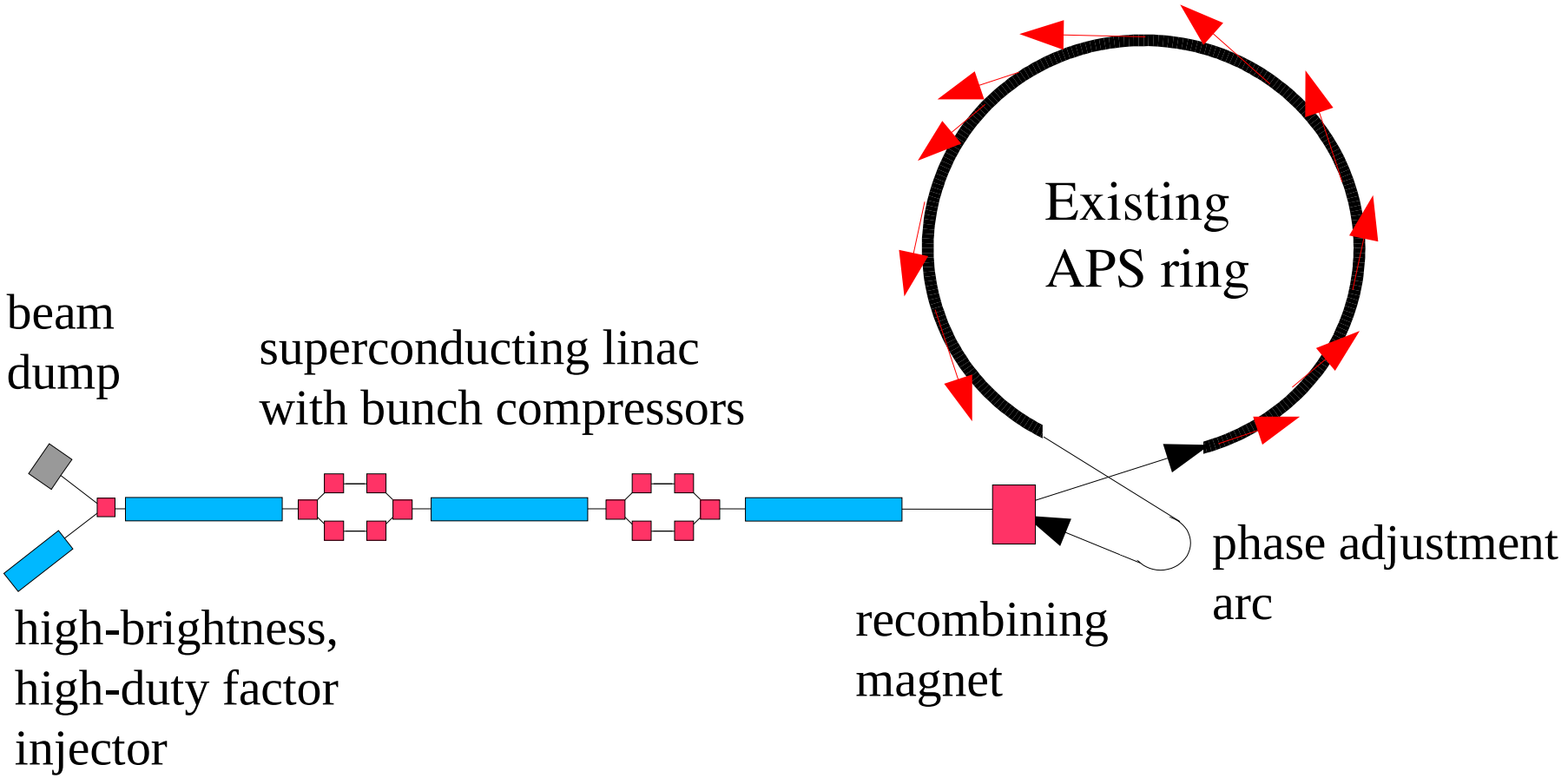
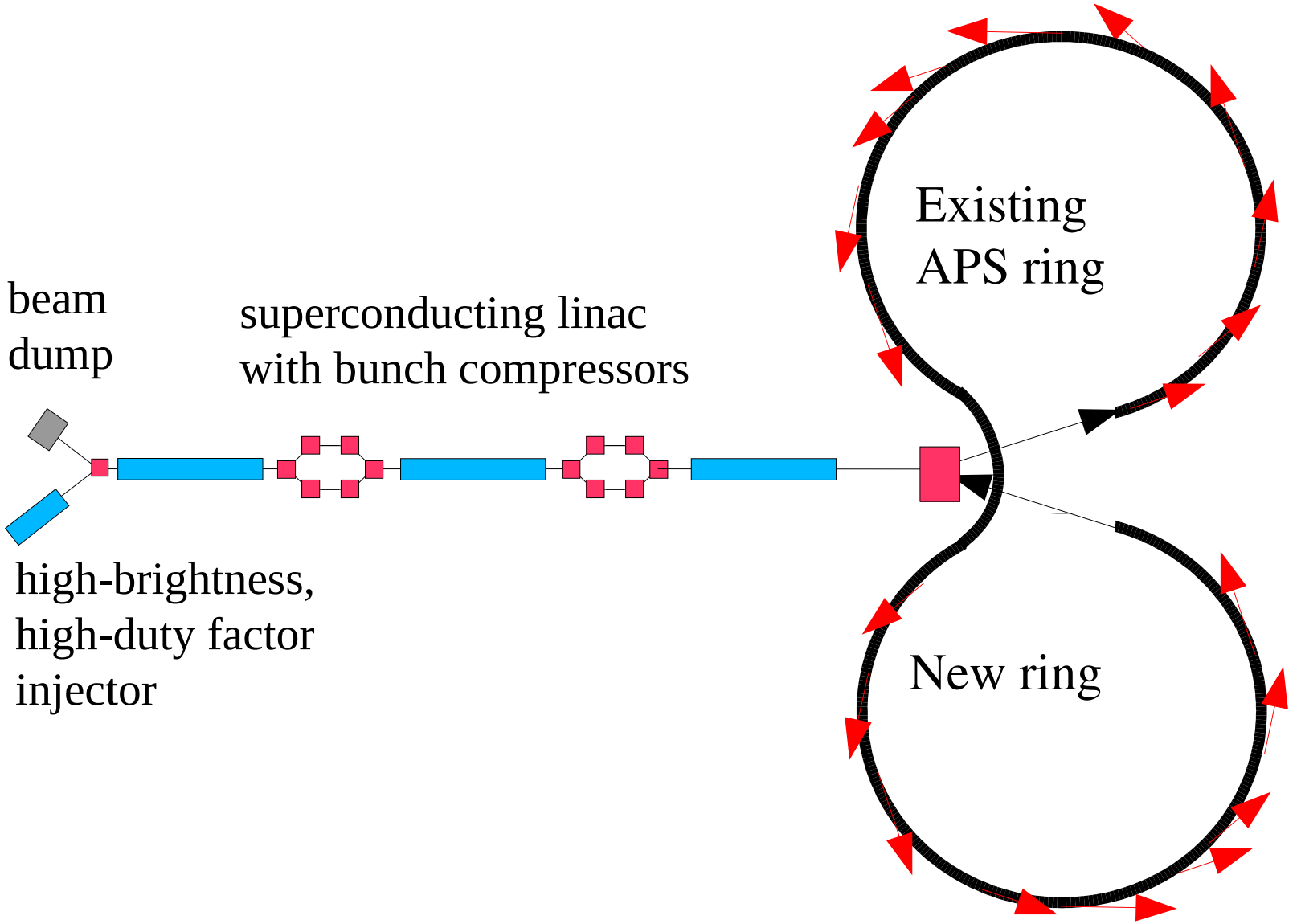
Motivation

- Combined cost of APS beamlines exceeds cost of accelerator
  - Build-up of beamlines continues
- Upgrading the accelerator and keeping the beamlines is very cost-effective
- Injecting an ERL beam into existing APS is one option
- Another option is a replacement ring (next talk)

Concept: Stage 1



Concept: Stage 2



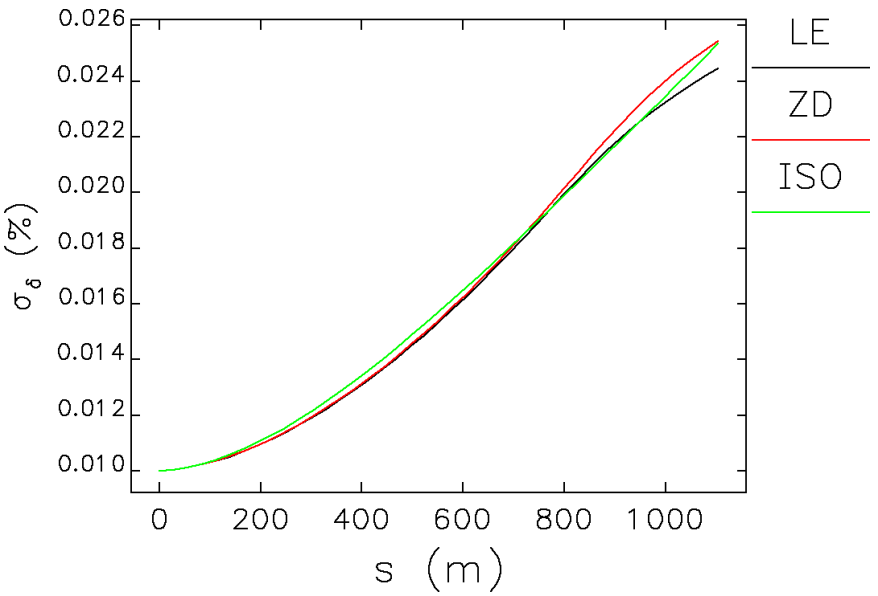
Lattices

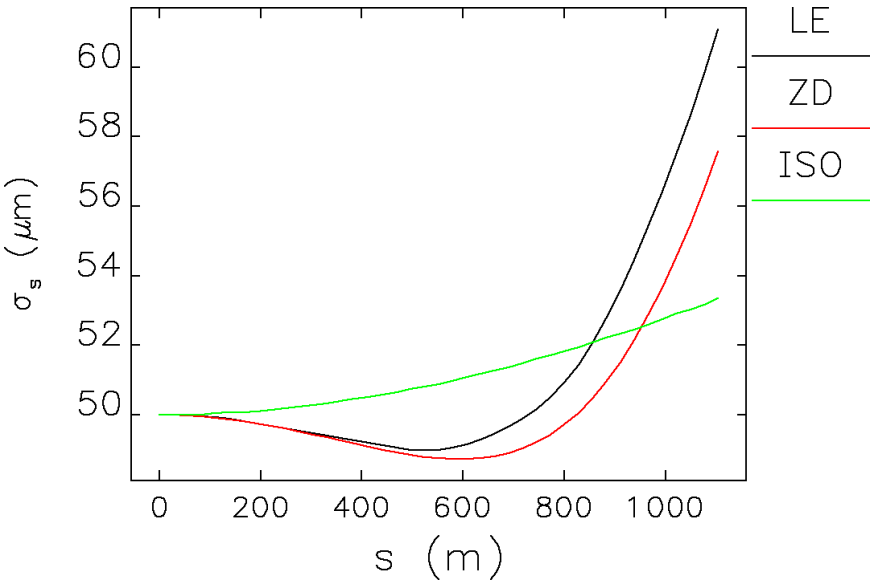
- LE: Present low-emittance lattice
  - 42 μm normalized equilibrium emittance
  - distributed dispersion
- ZD: zero-dispersion lattice
  - Original APS lattice with no dispersion at IDs
  - 105 μm normalized equilibrium emittance
- ISO: Isochronous lattice
  - 356 μm normalized equilibrium emittance

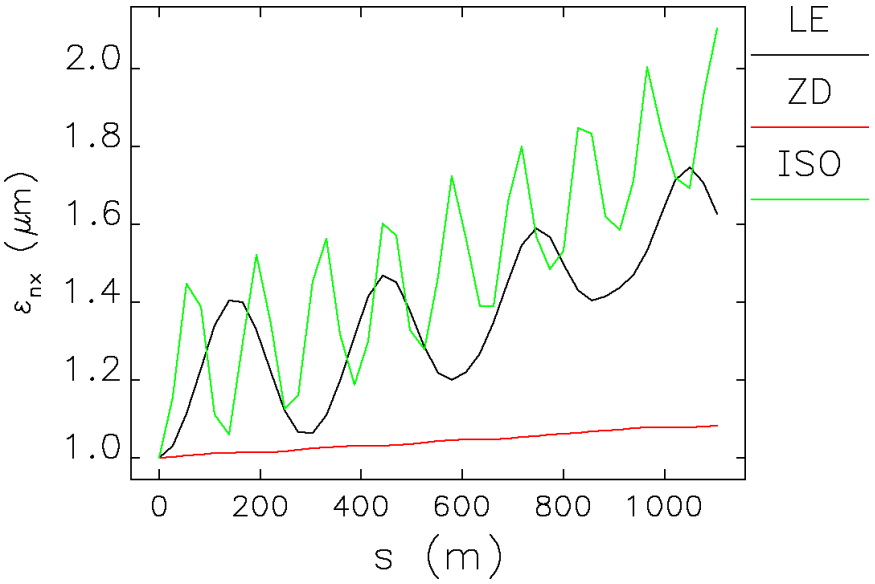
Simulations

- Tracked with **elegant** including
  - Coherent synchrotron radiation (CSR)
  - Incoherent SR (quantum excitation)
  - 1 million particles w/quiet start
- For lack of better input, used gaussian beam
  - Very optimistic assumption (see talk later today)
- Nominal rms parameters at 7 GeV
  - 50 μm bunch length (170 fs)
  - 1 μm normalized emittance
  - 0.01% momentum spread

Single Pass Results for Different Lattices



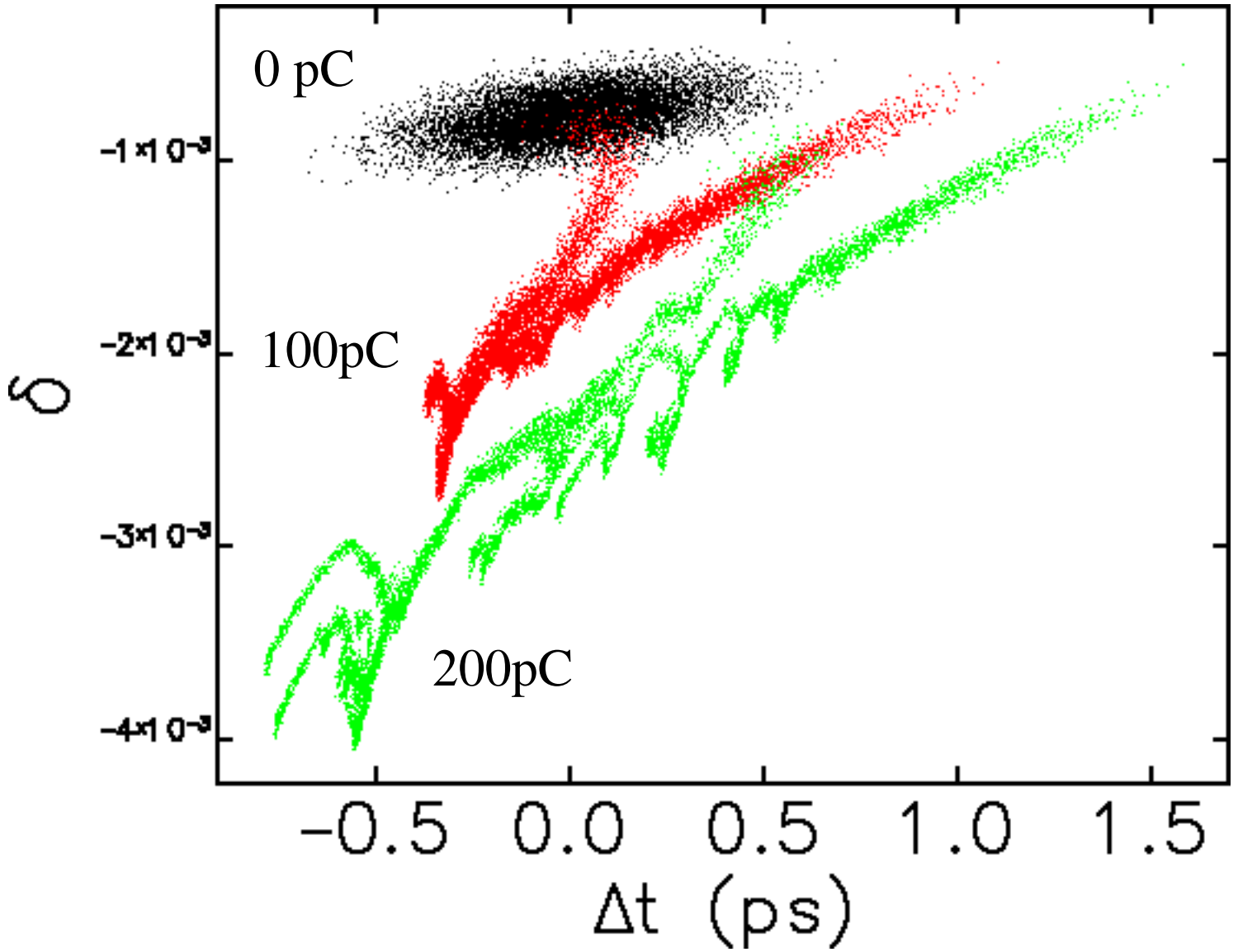




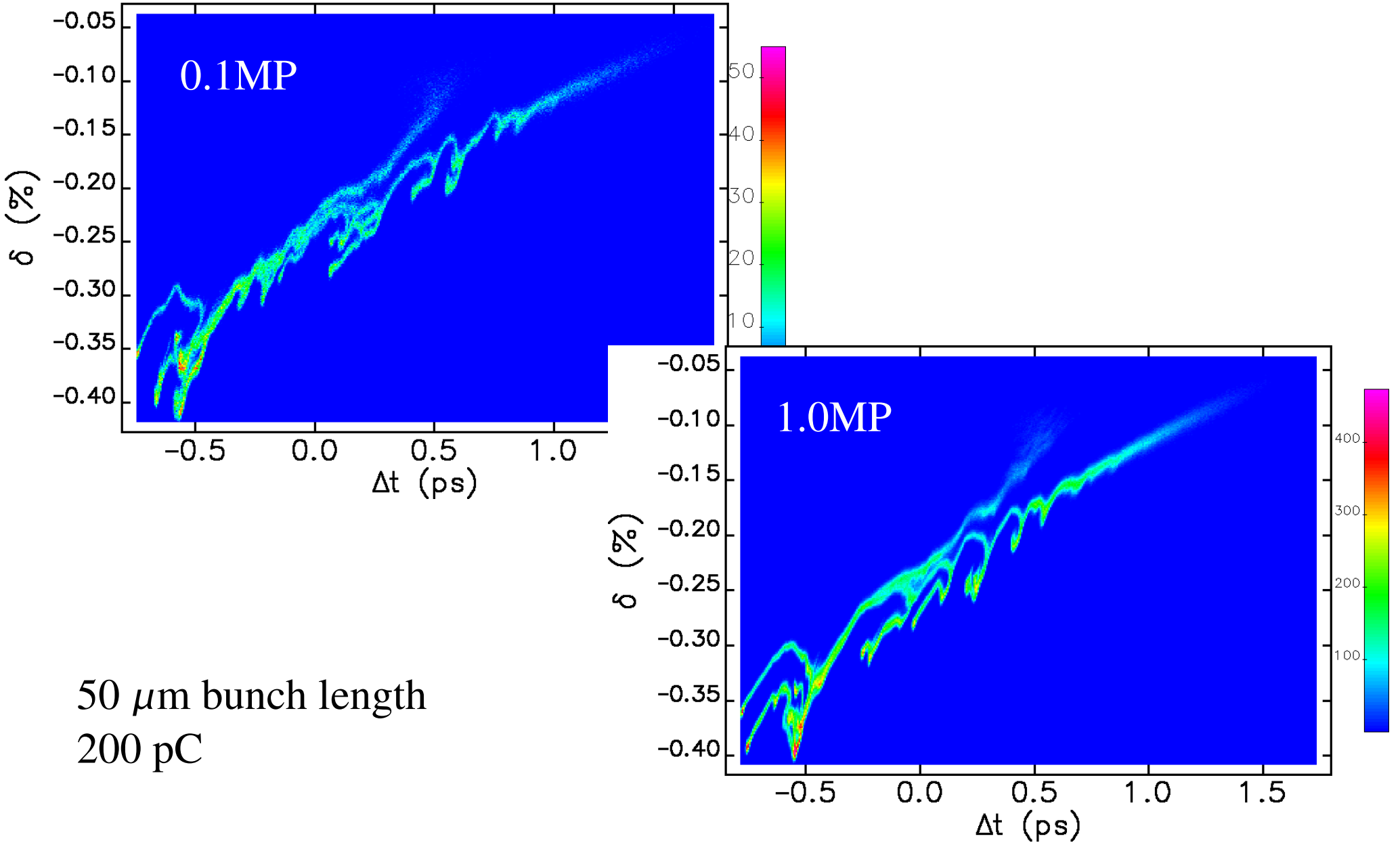
50 pC/bunch

Values sampled at the center of each straight section

Longitudinal Phase Space After One Pass

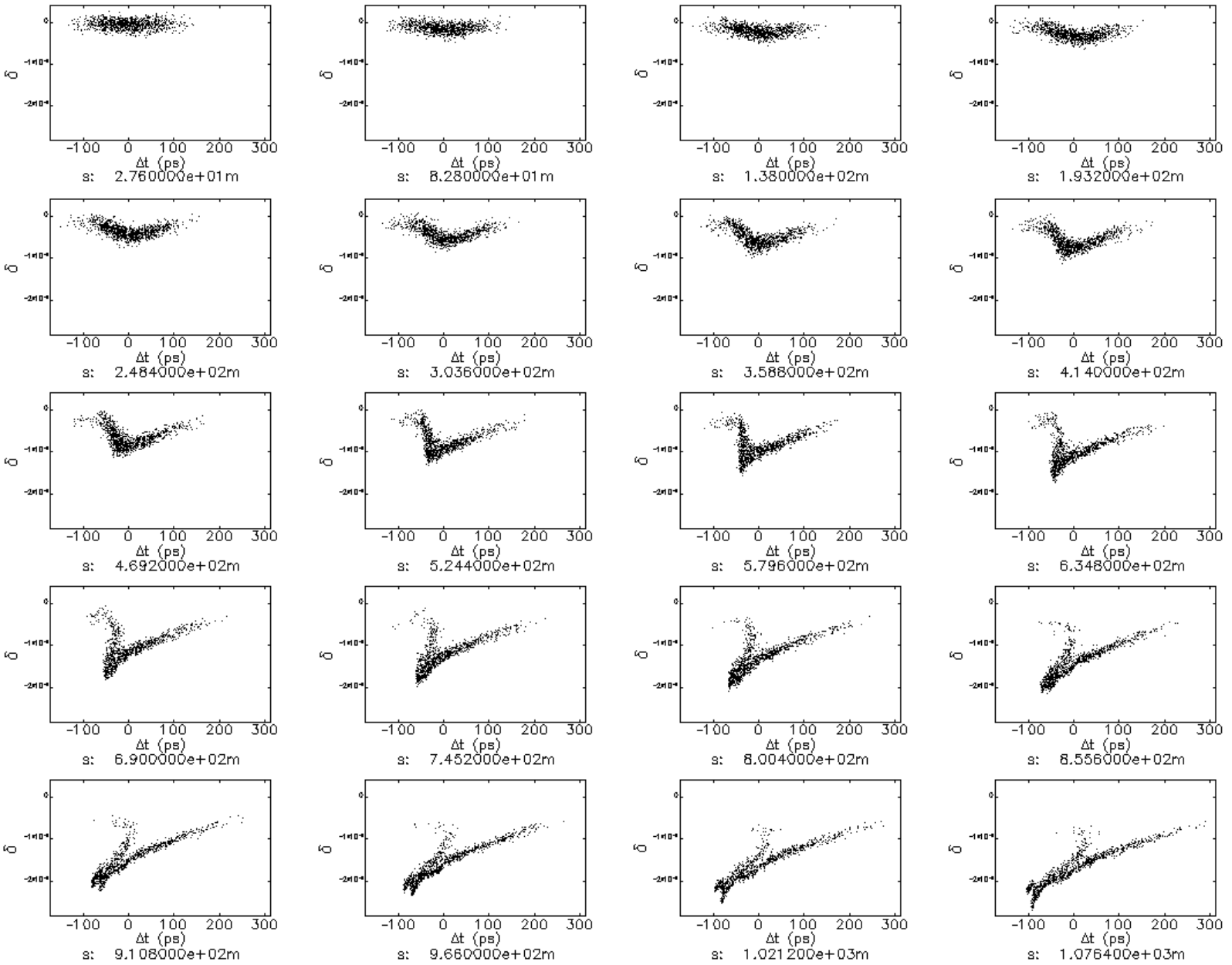


Effect of Number of Macroparticles

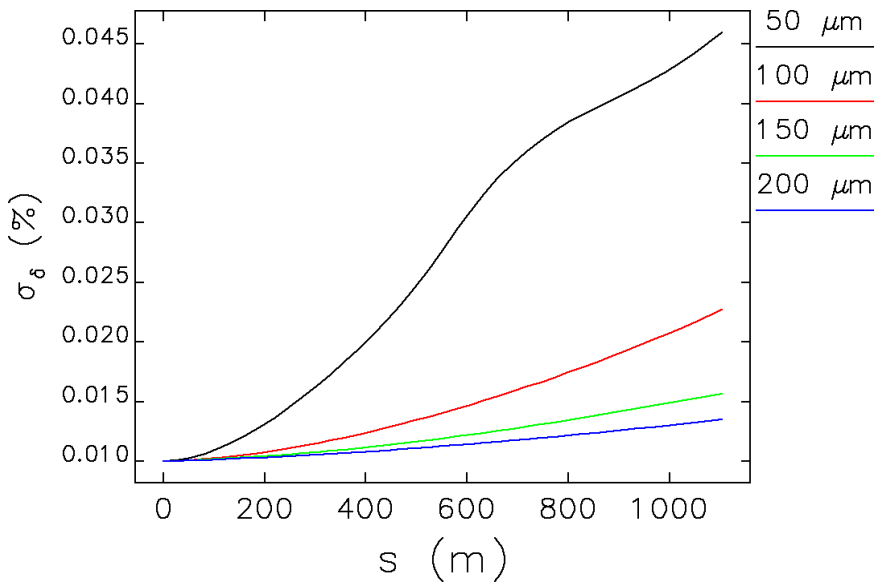


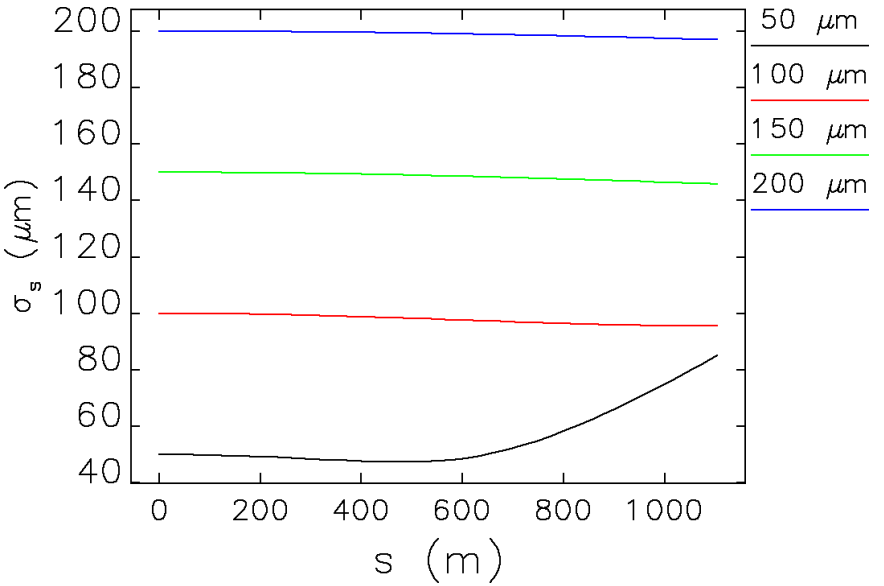
50 μm bunch length
200 pC

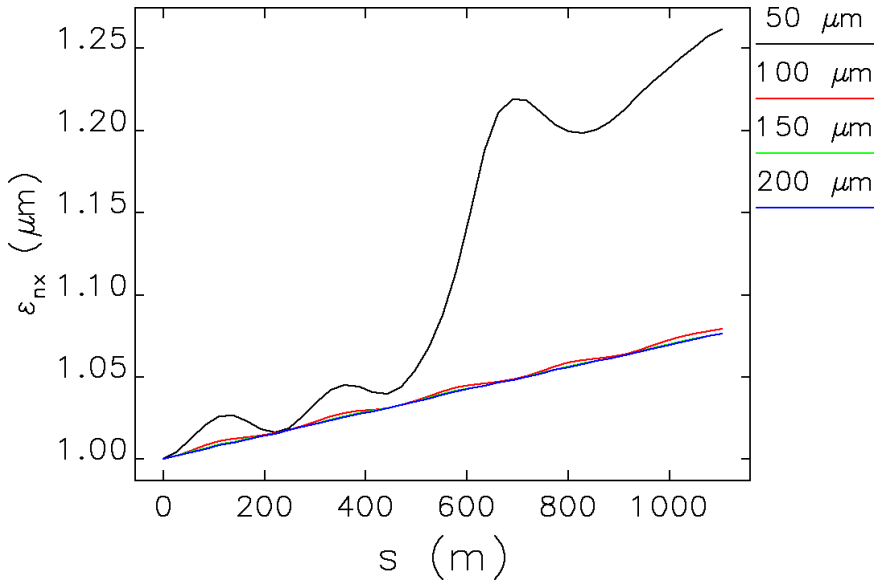
Longitudinal Phase Space Evolution for 100pC Case



Single Pass with Various Initial Bunch Lengths







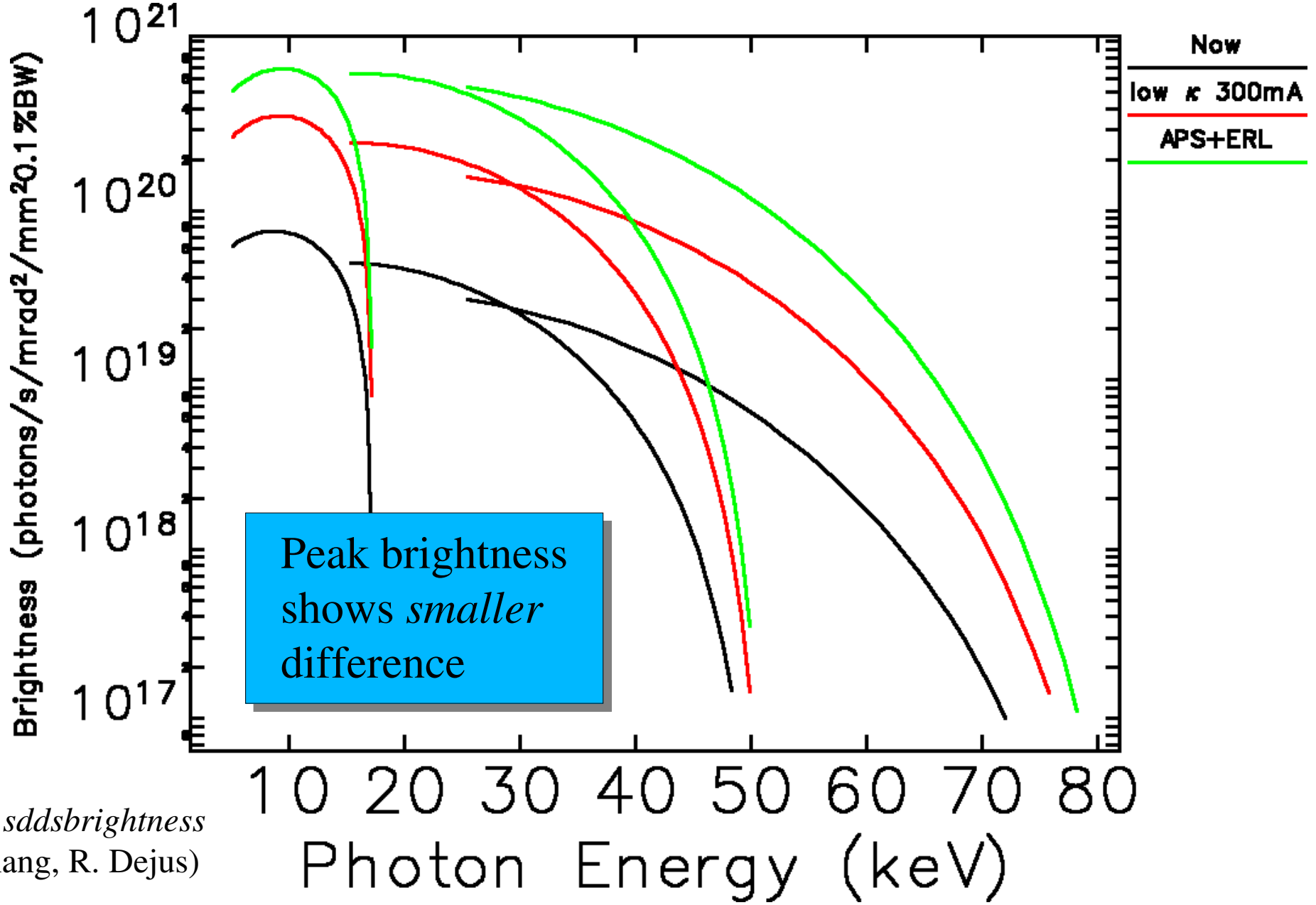
100 pC/bunch

Apparent threshold
for 50 μm bunch length

Comparison with Present APS

- Now:
  - Typically 15 nC/bunch with ~10 mm rms bunch length
  - Peak current of 170 A
  - 100 mA with bunches typically 153 ns apart (24 bunch mode)
  - Energy spread 0.1 %
  - Horizontal emittance of 105 μm with 1% coupling
- ERL: Mostly preserve beam properties for <100 pC and >100 μm
  - Peak current of 120 A
  - Filling every 1300 GHz bucket gives 130 mA
  - Energy spread < 0.025 %
  - Emittance <1.1 μm

Average Brightness Improvement



Using *sddsbrightness* (H. Shang, R. Dejus)

Conclusions

- Appears feasible for <100 pC and >100 μm
  - Average brightness improvement of about 10x *assuming* 130mA
  - Peak brightness improvement is less
- Doesn't look remarkable compared to
  - APS low coupling (0.3%) at 300mA
  - Possible ring upgrade
- Results may be much worse with realistic input beam
- May be better for lower charge, lower emittance