An Efficient Vlasov Solver for Microbunching Simulations

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MT ARD ST3 Meeting
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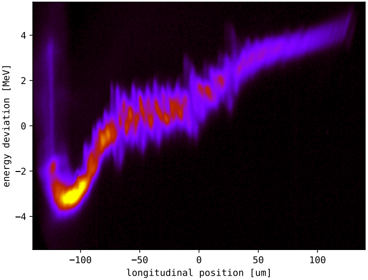
microbunching in free electron lasers



■ free electron lasers require high-current electron beams with a preferably homogeneous longitudinal phase space (LPS)

■ collective interaction in the linac leads to modulations in the LPS

■ microbunching mechanism:

$$\text{density modulation} \underset{\text{longitudinal dispersion}}{\overset{\text{space charge, CSR}}{\rightleftharpoons}} \text{energy modulation}$$

semi-lagrangian vlasov simulation

■ particle tracking codes suffer from numerical shot noise

■ vlasov codes solve the vlasov equation, i.e. they find a solution for the phase space density (PSD) $\Psi(t, z)$

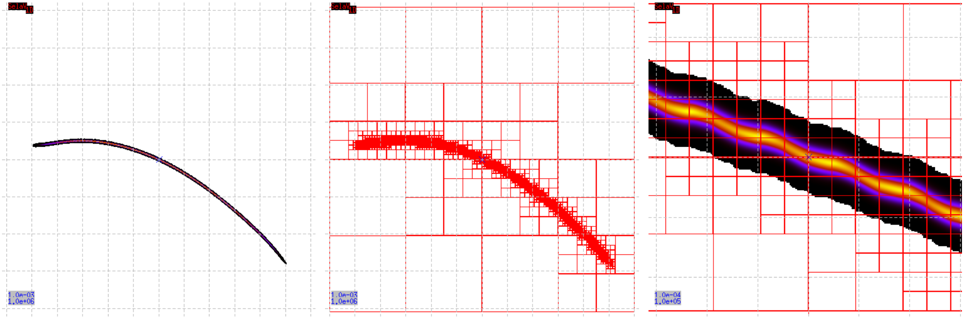
$$\partial_t \Psi - \{H[\Psi], \Psi\} = 0$$

■ semi-lagrangian codes use the method of characteristics to construct the solution using the flow ϕ of the hamiltonian H

$$\Psi(t_1, z) = \Psi(t_0, \phi_{t_0 \leftarrow t_1}(z))$$

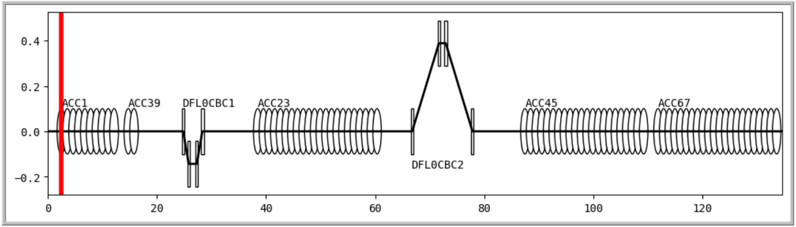
■ store PSD values on a grid, update by back-tracking PS-coordinates and interpolate old PSD

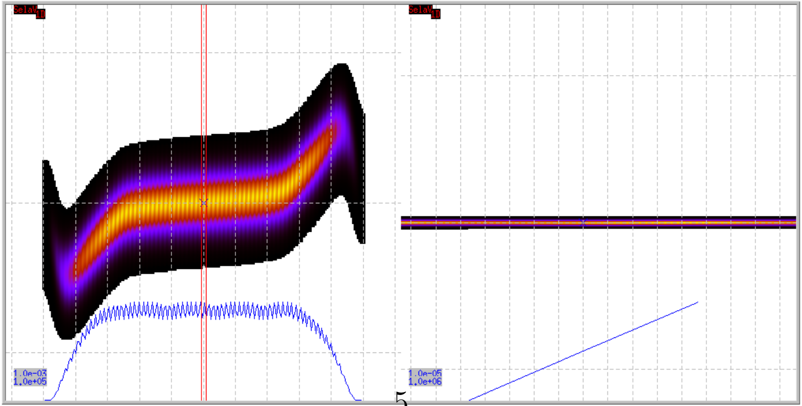
exotic PSDs / tree domain decomposition



- PSDs in FELs have an exotic shape → homogeneous sampling too wasteful
- `SeLaV1D` recursively refines the simulation domain and stores PSD values only on grids covering the smallest cells

Example: FLASH2020+





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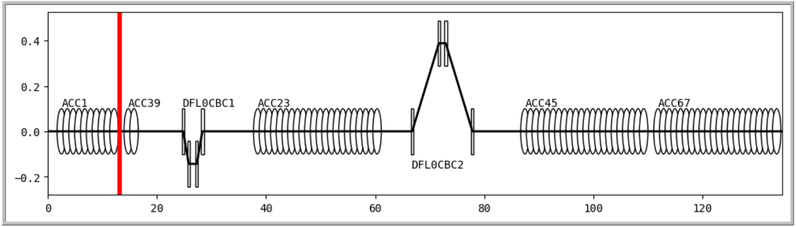

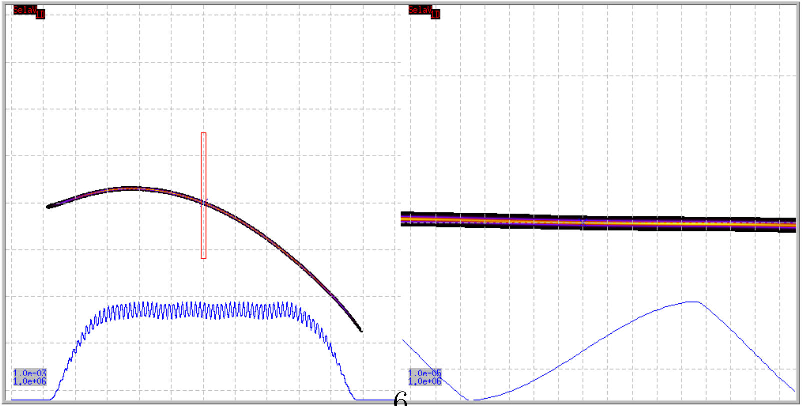

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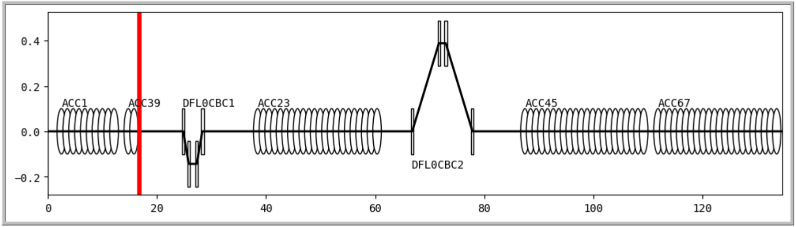

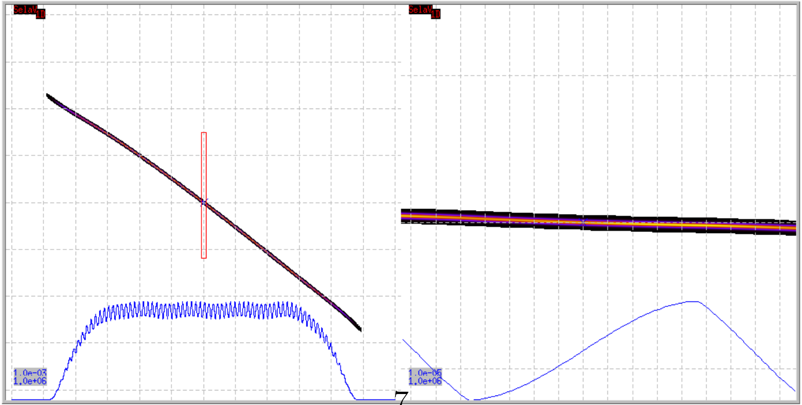

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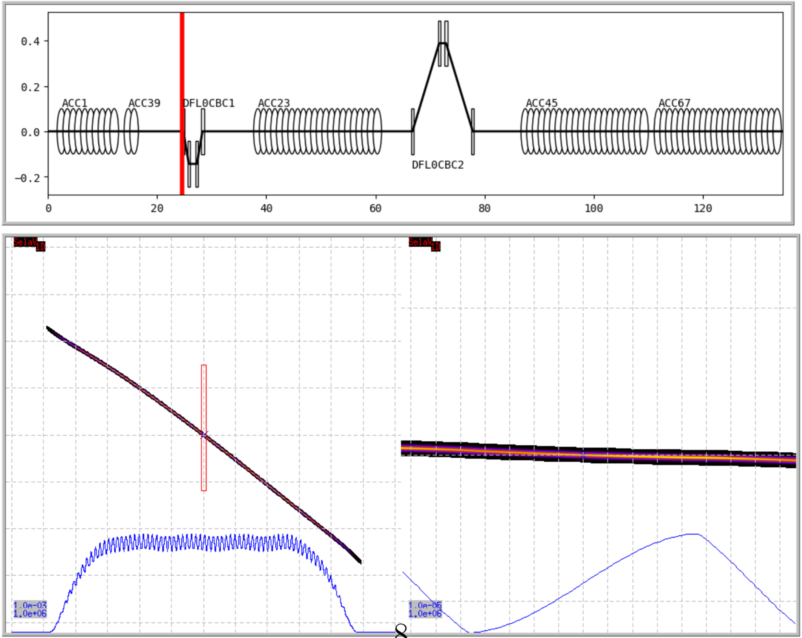

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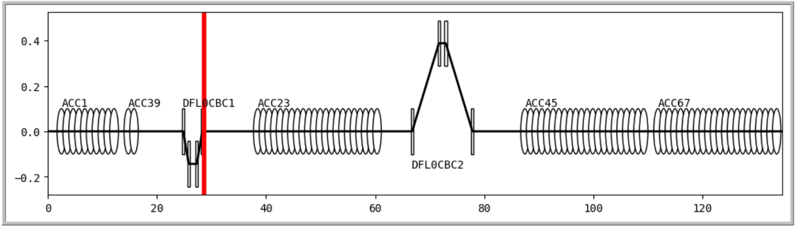

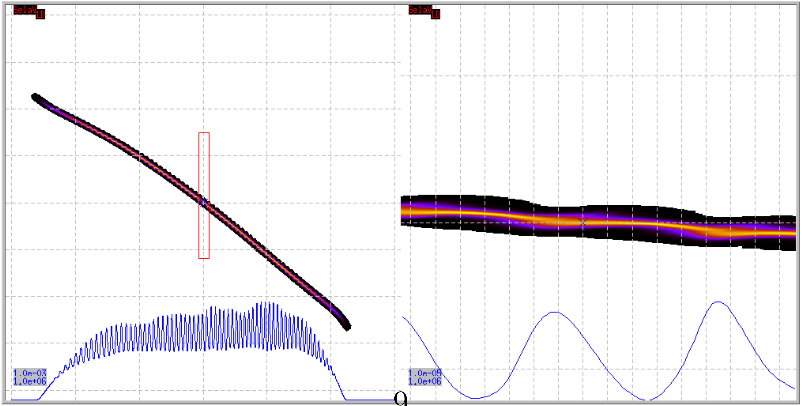

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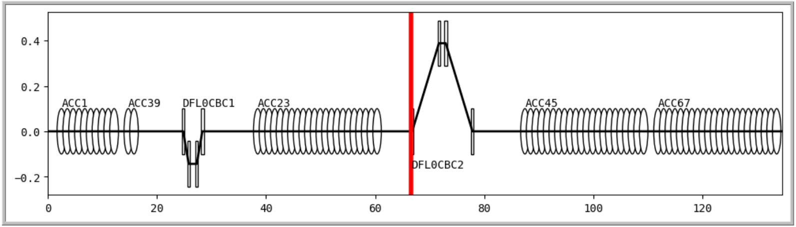

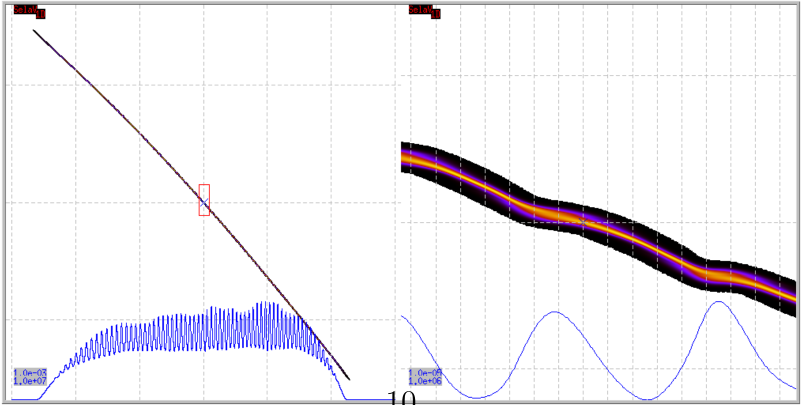

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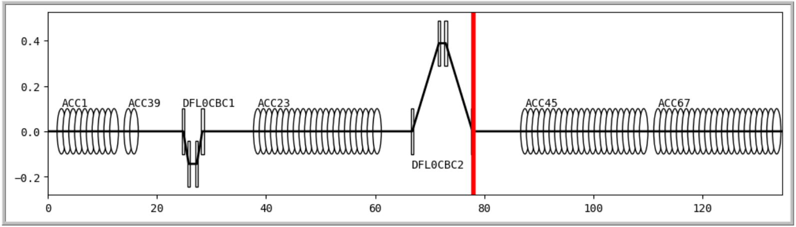

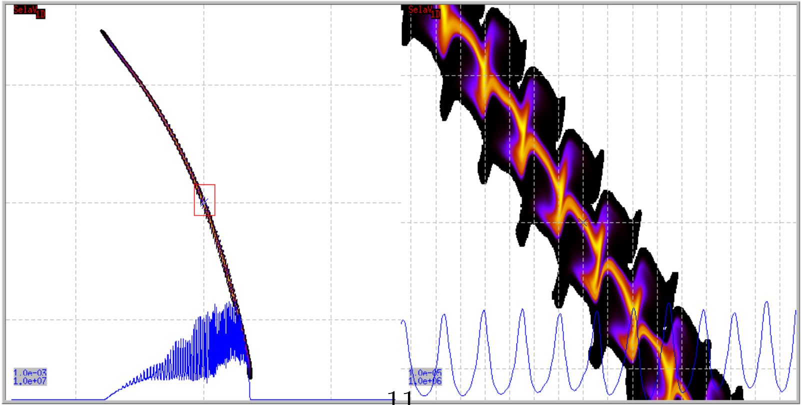

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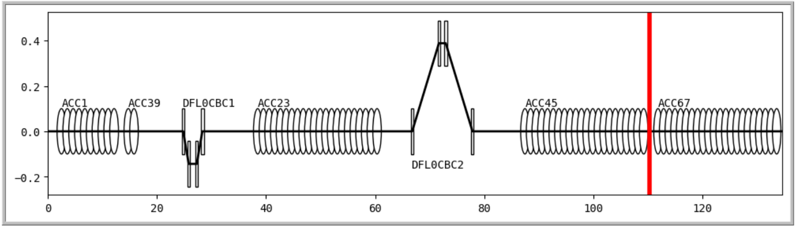

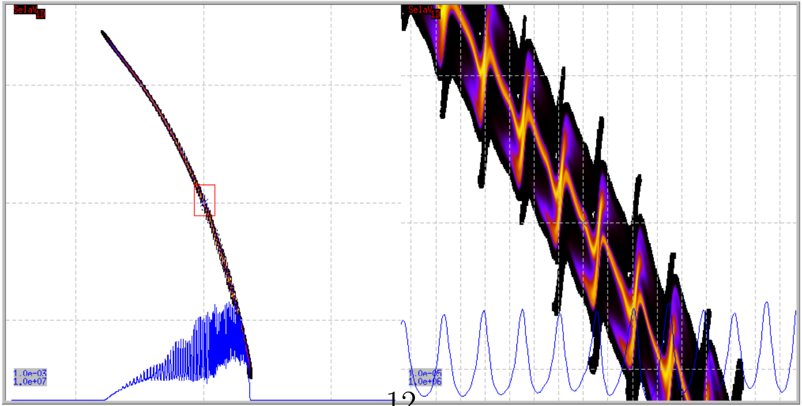

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