Update on S2E for slit based slice energy spread measurement

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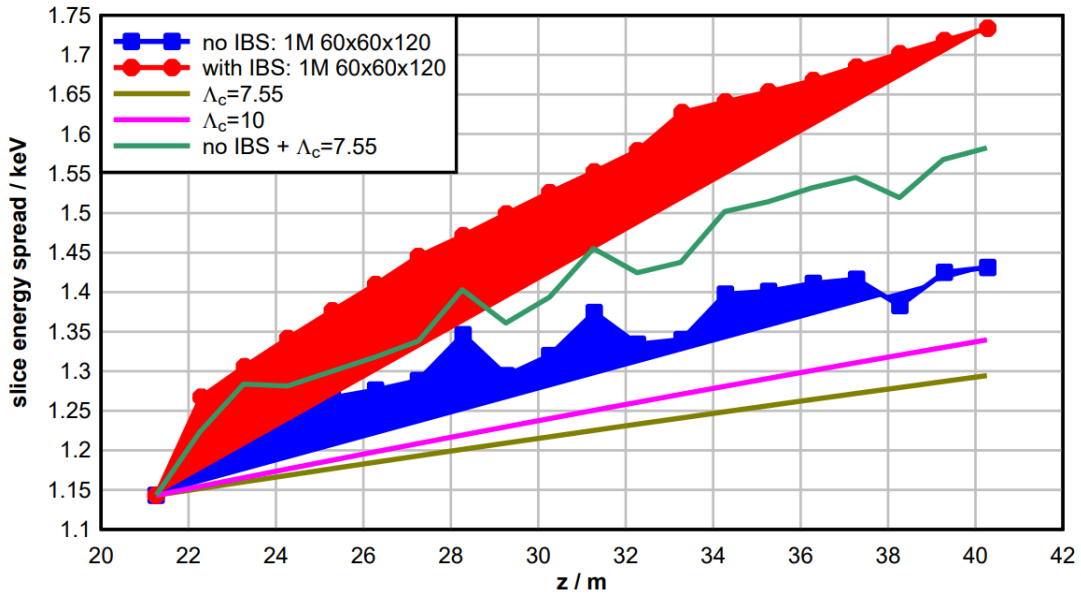
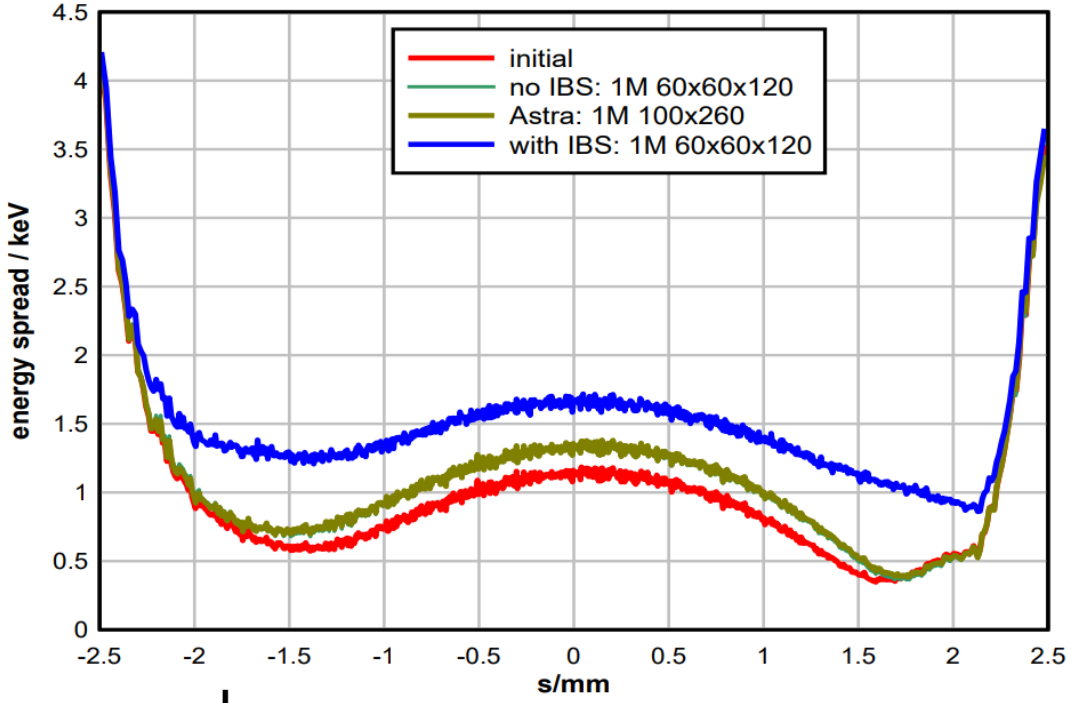
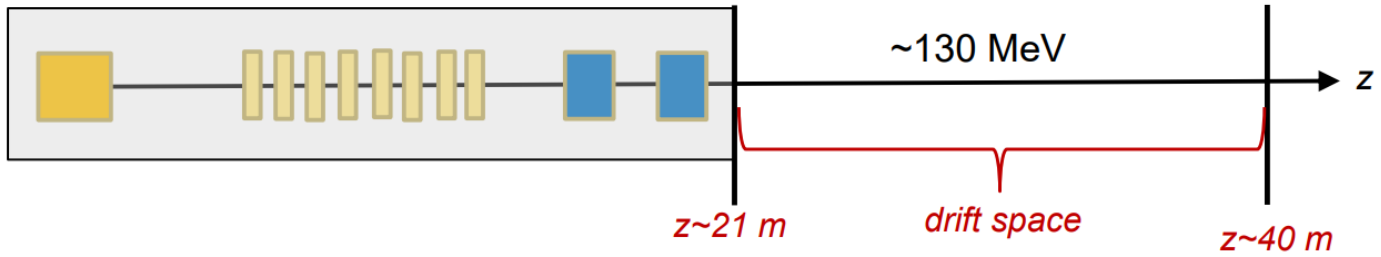
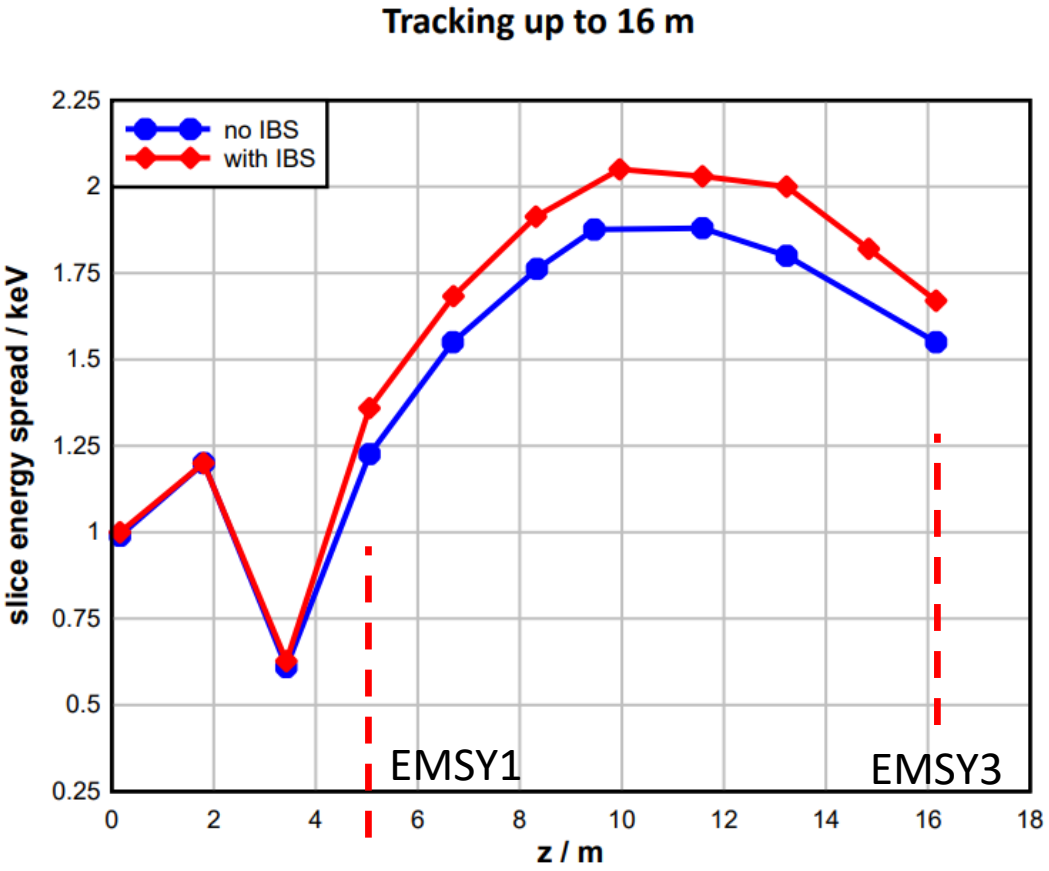
Erion Gjonaj simulations for XFEL with IBS

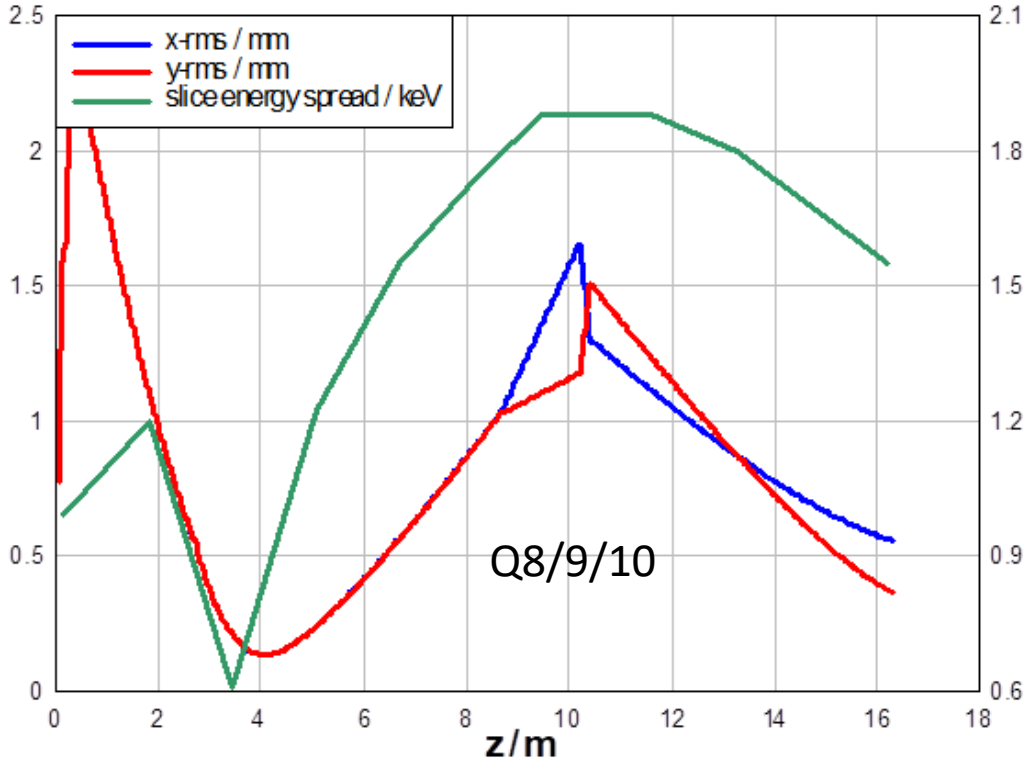






Erion Gjonaj simulations for PITZ with IBS





IBS effect @EMSY1 is about ~0.7 keV

Slice energy spread is not really uncorrelated for the low energy beam, it still has energy exchange with space charge potential field.

S2E simulation of the slit based experiment

- ASTRA: from cathode to EMSY1
  - 2M macro particles
  - VC2 laser profile with radial intensity non-uniformity included
- OCELOT: from EMSY1 to HEDA2
  - Quads, TDS, slit, dipole
  - 3D space charge

ASTRA

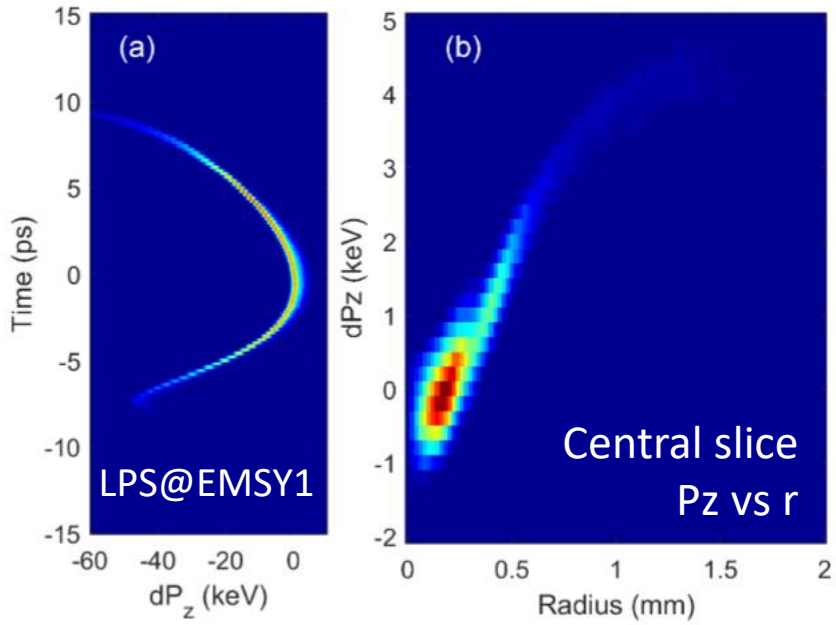


FIG. 3. Beam distribution from ASTRA simulations, right before the first slit. The reference beam momentum is 19.5 MeV/c. (a) longitudinal phase space, (b) correlation between beam energy and radial beam position in the central temporal slice (-0.5 ps to 0.5 ps).

This Pz-r correlation can be diluted through betatron oscillation for emittance dominated beam, e.g. 130 MeV XFEL beam, but we suffer from it.

S2E simulation of the slit based experiment

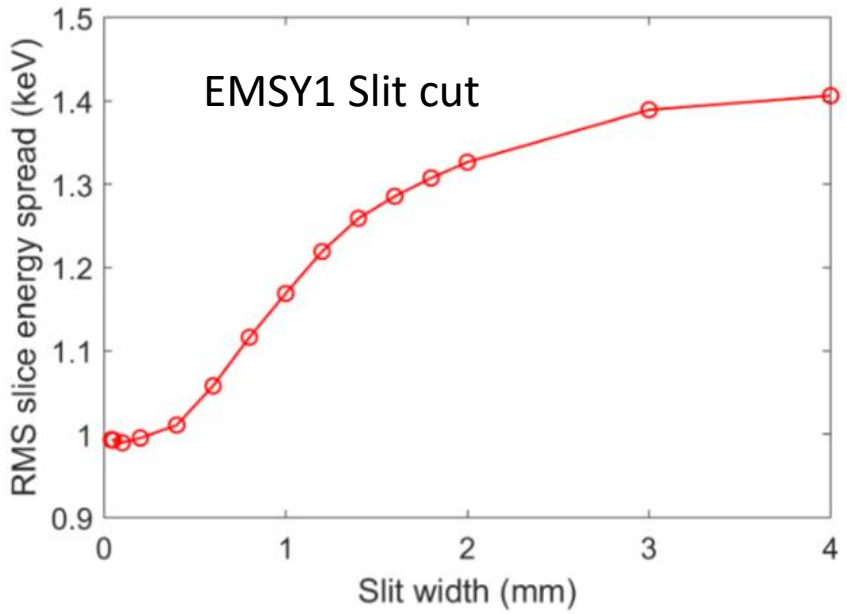


FIG. 4. ASTRA simulations of beam cut by the first slit. Slice energy spread of the central temporal slice (-0.5 ps to 0.5 ps) versus the slit width. Intra-beam scattering and other heating effect are not included in the simulations. The slit width in the experiment is 0.05 mm.

Screen resolution and slice beam divergence measurement @H2.scr2

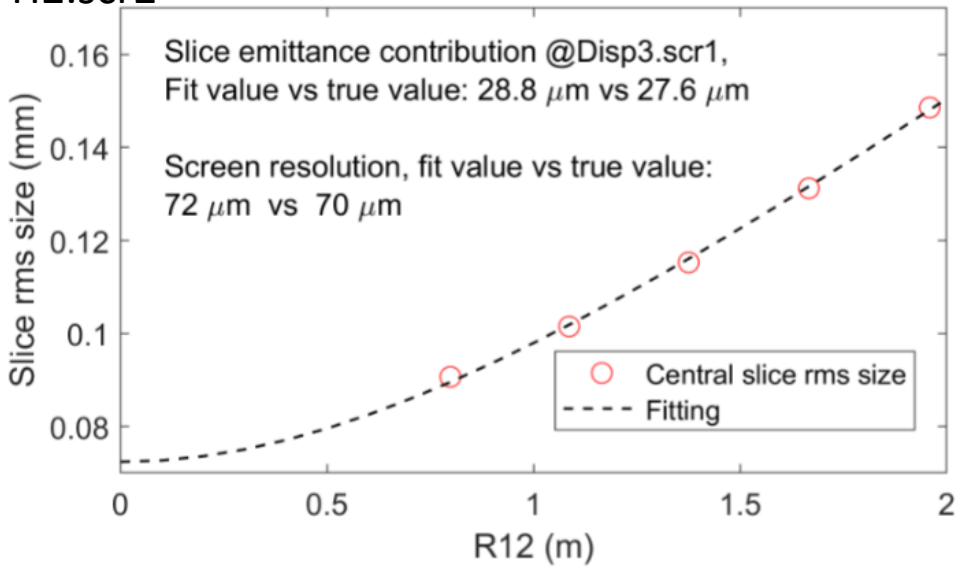
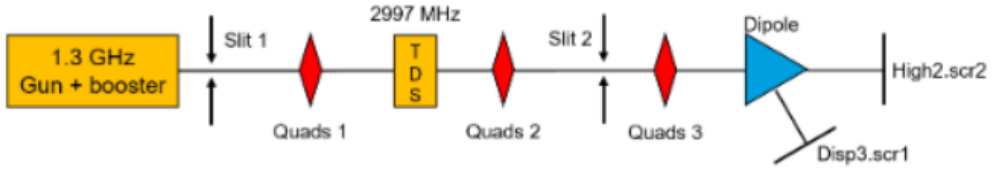
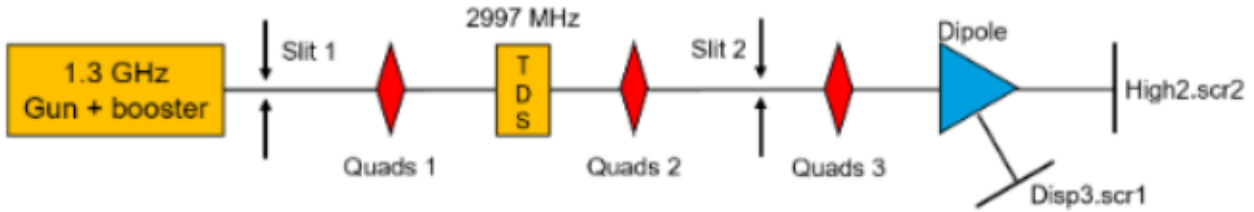


FIG. 5. OCELOT simulation of slice beam divergence measurement based on Eq. (10) at High2.scr2



PITZ S2E slice energy spread experiment



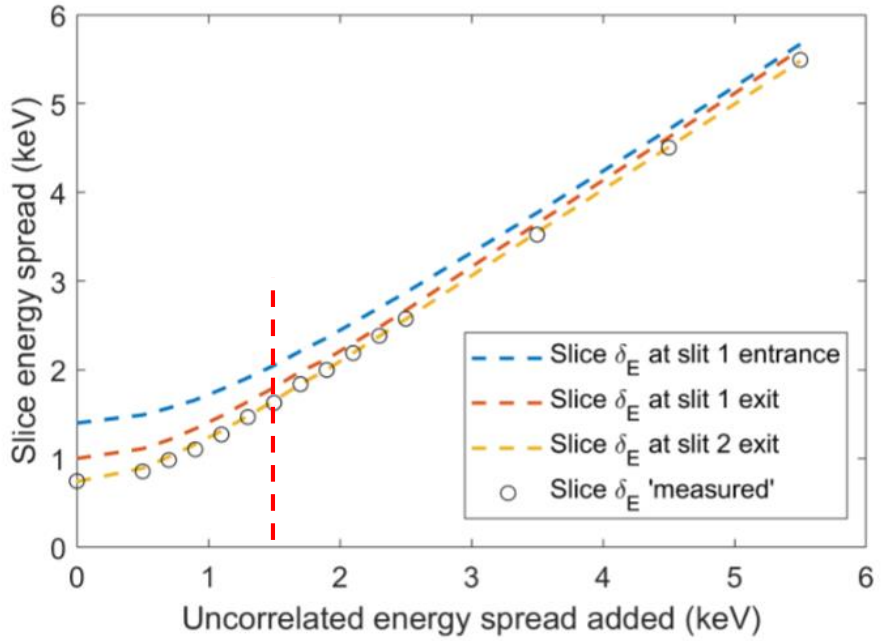
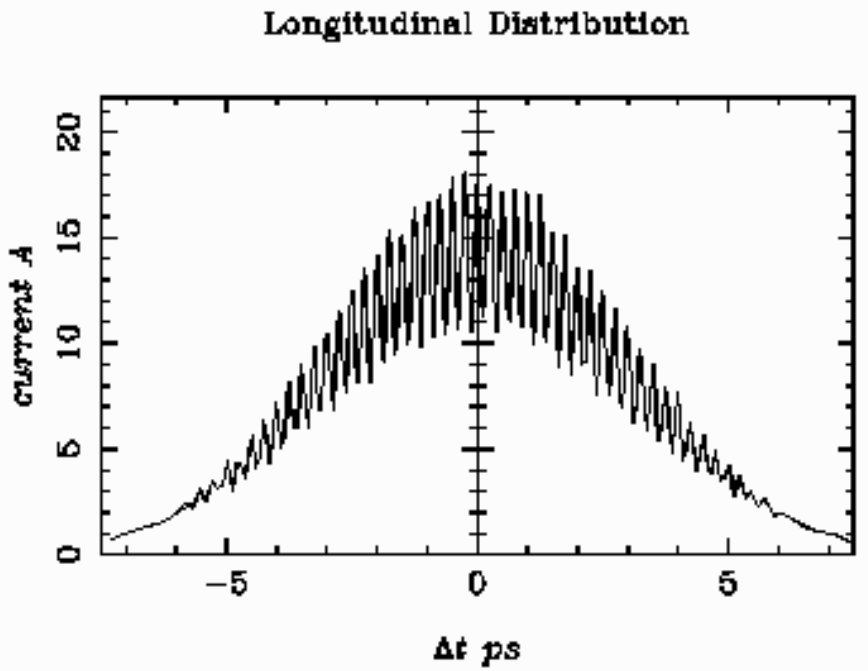


FIG. 6. OCELOT simulation of measured slice energy spread vs true slice energy spread at both slits. The uncorrelated energy spread is added to the beam distribution at slit 1 entrance to simulate the additional heating not included in the modelling.

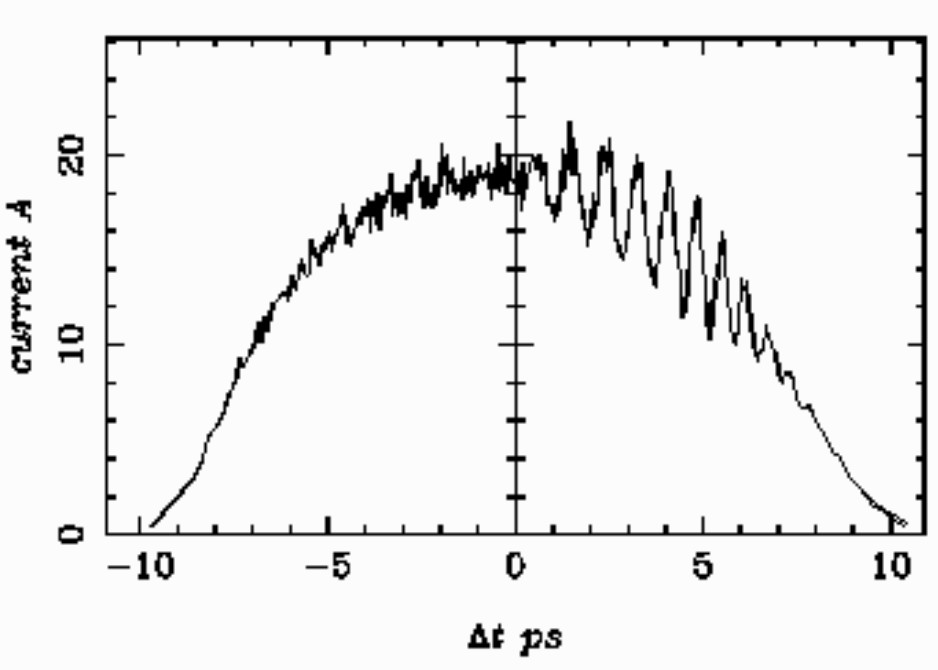
- Major change to the draft
  - Add S2E simulation chapter for 250 pC
  - Remove 500 pC experiment results, no S2E, no time for further analysis
  - Conclusion change
    - We only measure the slice energy spread after the 2nd slit, which is about ~5 pC beam, not for the 250 pC beam
    - If simulations and assumptions are correct, full beam slice energy spread before 1st slit is ~2 keV, ~1.5 keV beam heating missing from ASTRA modelling
    - If the beam is dominated by uncorrelated slice energy spread at slit 1 entrance, the measurement result is also for full beam.

Laser temporal modulation effect



Assuming laser temporal modulation

Actual peak current 40 A



@EMSY1, half side has the modulation
But slice energy spread did not increase?!