

Beyond ellipsoidal laser shaping

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- Some questions from last PPS
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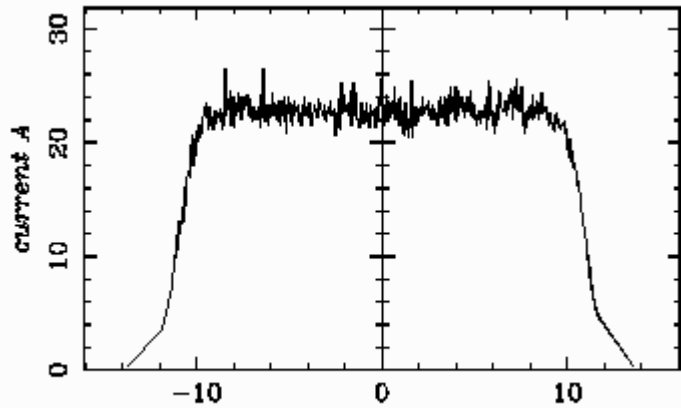
Some questions from last PPS

- > Whether the peak current between Ellipsoidal and Flattop caused the difference of central slice emittance growth? (Mikhail)
- > If a non-uniform ellipsoidal laser, e.g. an ellipsoidal cut from a temporal flattop but spatially truncated Gaussian laser, how the emittance looks like? (Christian)
- > How is the difference of longitudinal phase space (not longitudinal emittance)? (Mikhail)



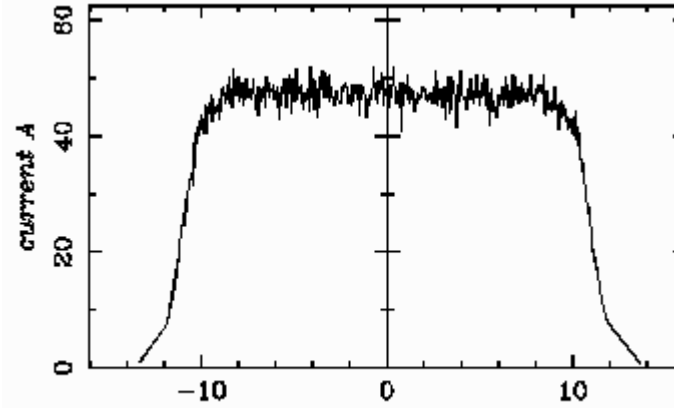
Cathode I_{peak} between flattop & ellipsoidal (last PPS)

500 pC



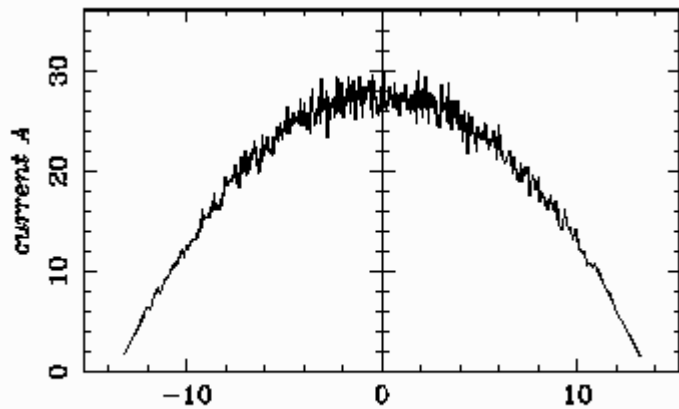
Δt ps

1000 pC

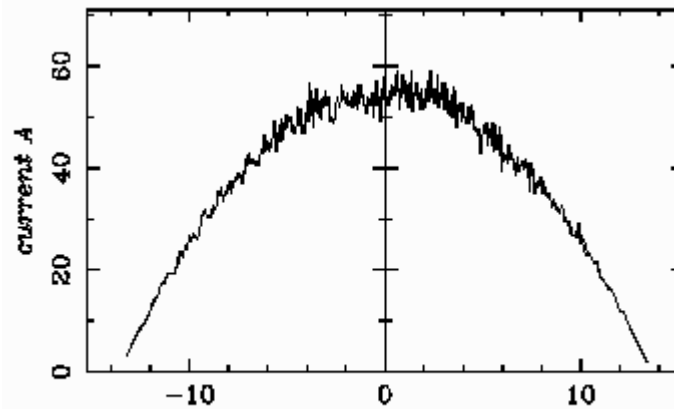


Δt ps

Flattop-G
22 ps



Δt ps



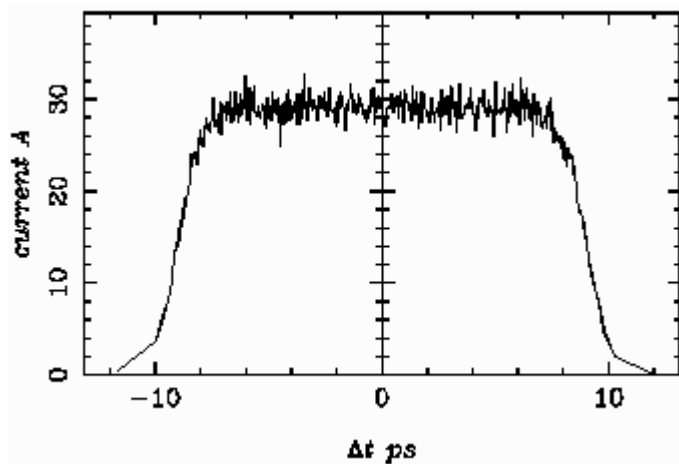
Δt ps

Ellipsoidal-U

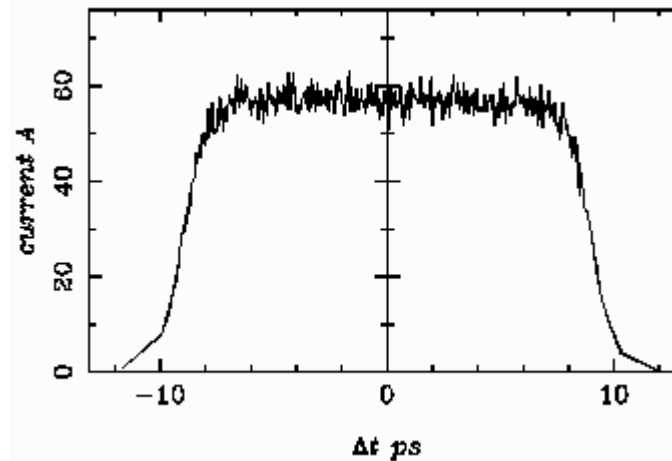


Shorter flattop laser to match I_{peak} at cathode

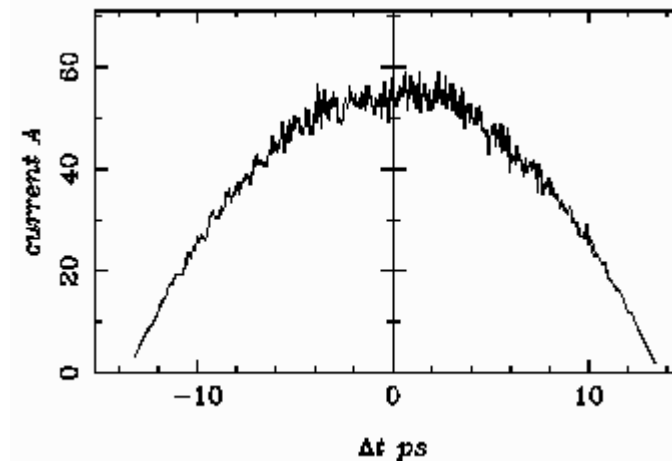
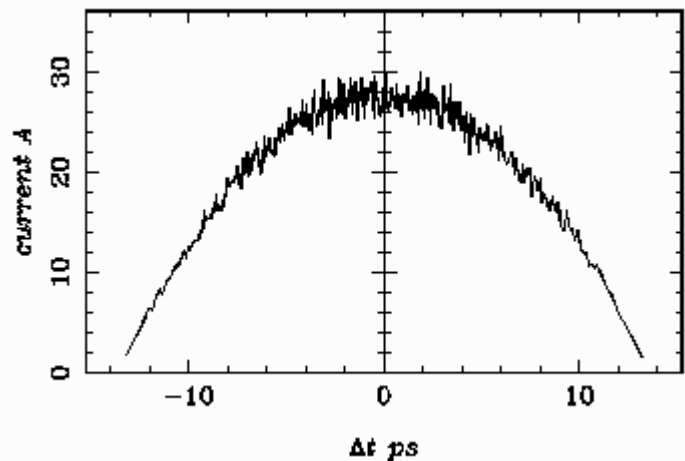
500 pC



1000 pC



Flattop-G
18 ps

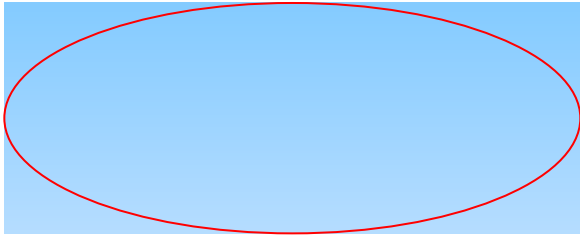


Ellipsoidal-U

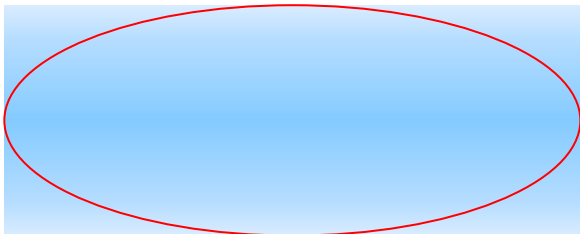


Ellipsoidal laser with spatial shaping

- Ellipsoidal cut from a uniform flattop

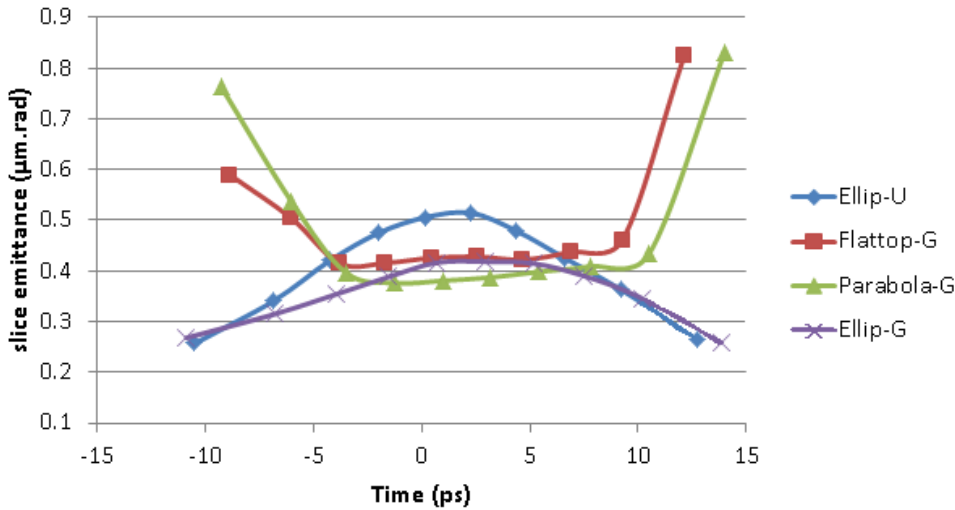


- Ellipsoidal cut from a flattop with spatial shaping: truncated Gaussian

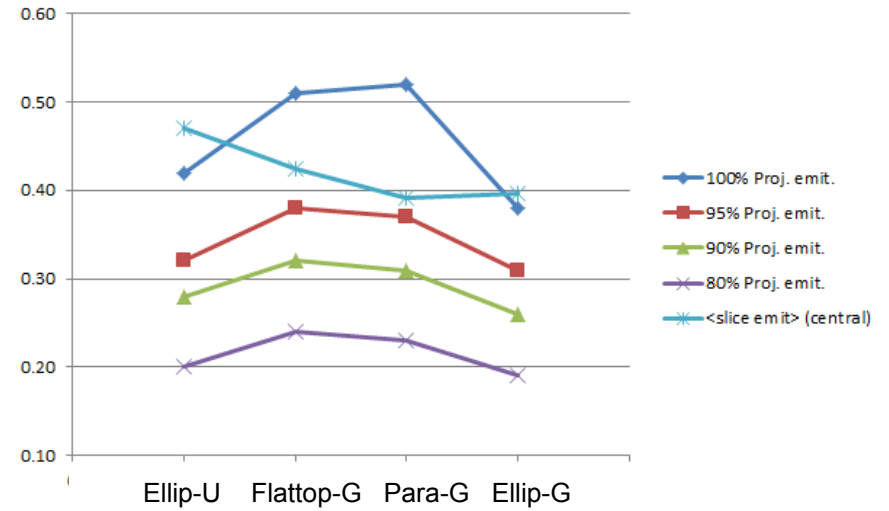


Emittance comparison

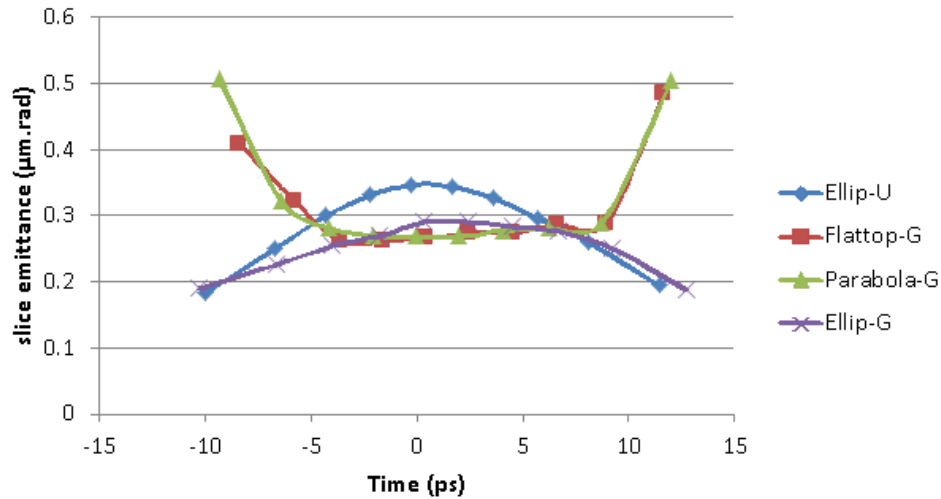
1 nC slice emittance



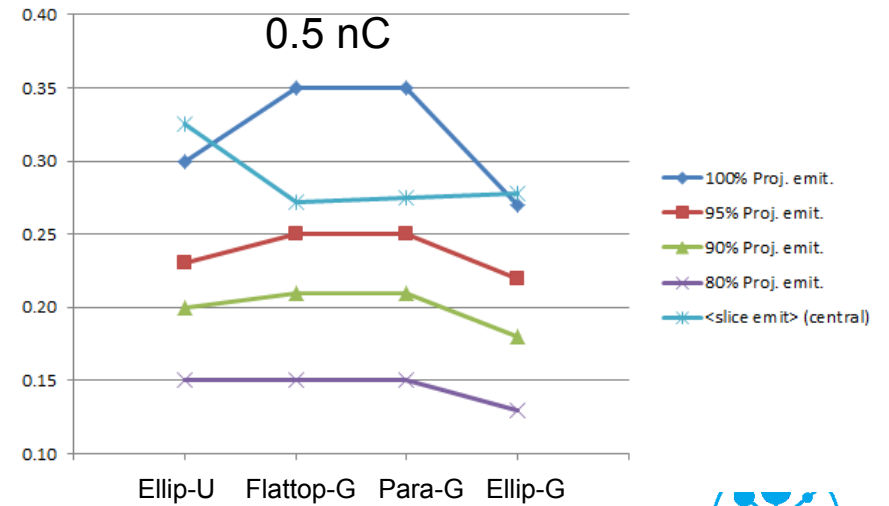
1 nC



0.5 nC slice emittance

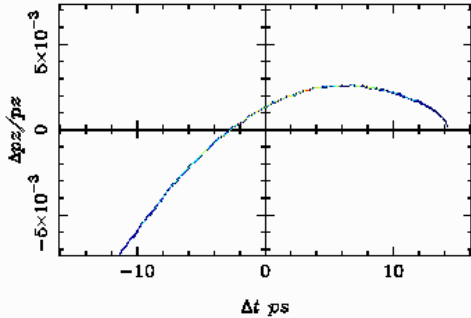


0.5 nC

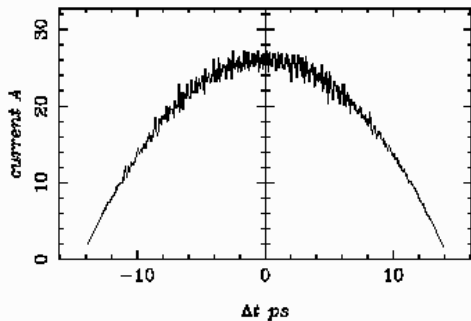


Longitudinal phase space: 0.5 nC

Ellip-U

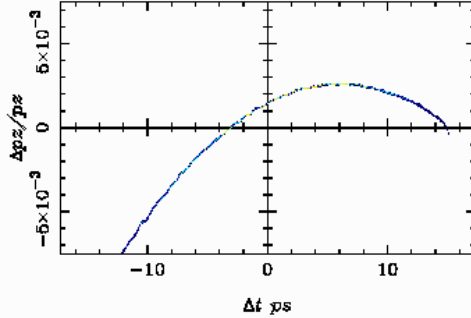


Longitudinal Distribution

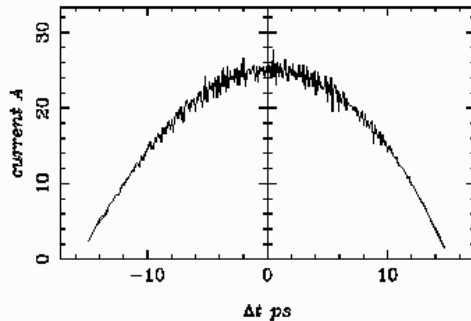


45 keV.mm
49 keV
0.7 keV

Ellip-G

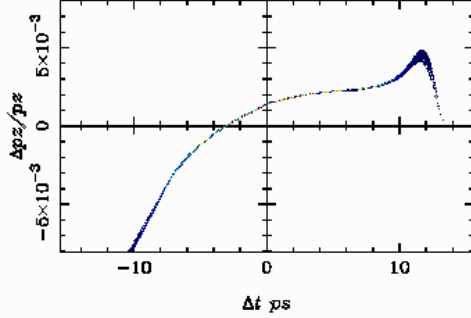


Longitudinal Distribution

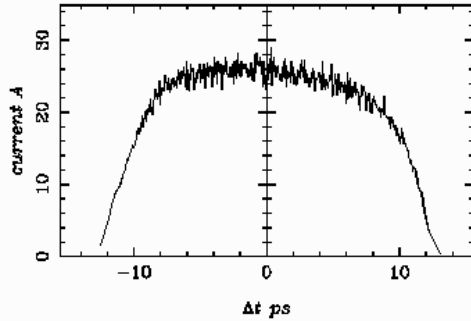


50
47
0.8

Flattop-G



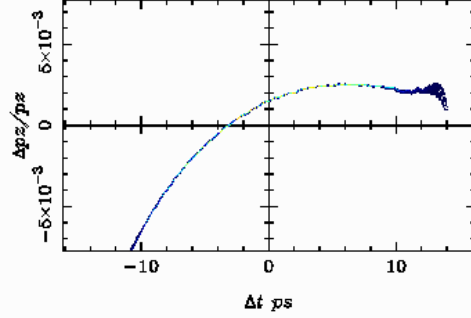
Longitudinal Distribution



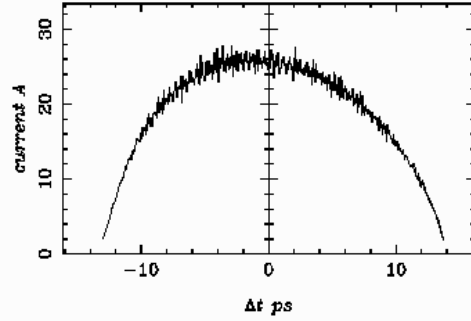
Emit_z
dE
High order dE

41
50
10

Para-G



Longitudinal Distribution



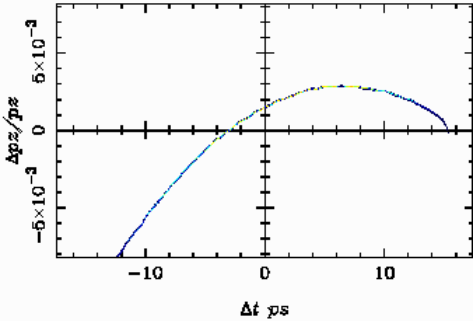
46
48
5

Projected longitudinal emittance comparison is misleading, high order energy spread shows the advantage of uniform ellipsoidal laser.

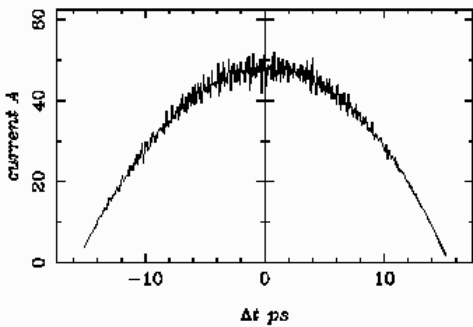


Longitudinal phase space: 1 nC

Ellip-U

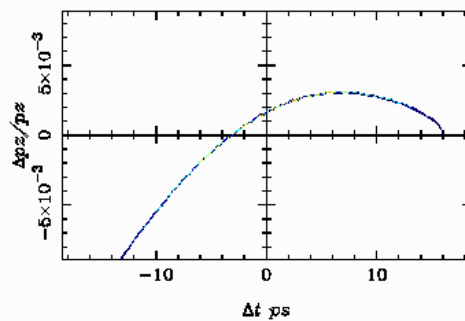


Longitudinal Distribution

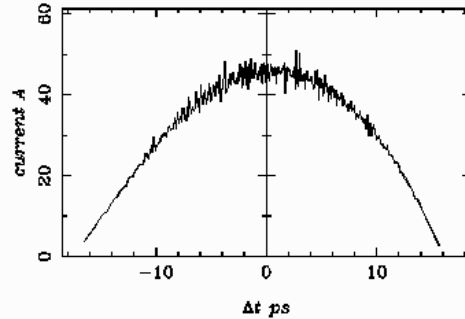


76 keV.mm
74 keV
1 keV

Ellip-G

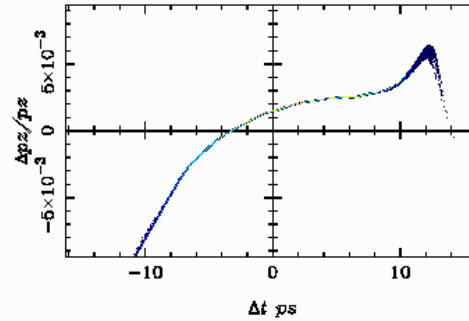


Longitudinal Distribution

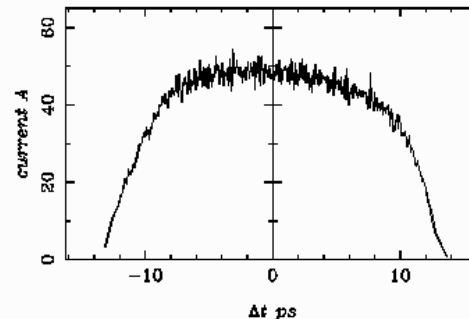


80
75
1.6

Flattop-G



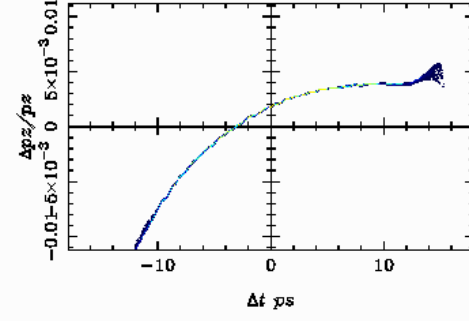
Longitudinal Distribution



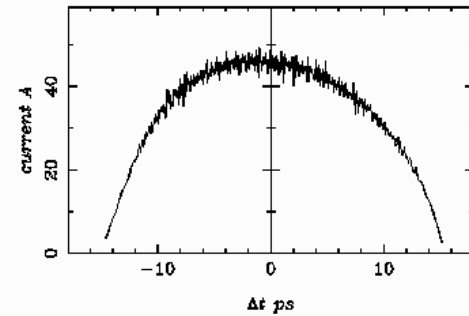
Emit_z
dE
High order dE

57
70
15

Para-G



Longitudinal Distribution



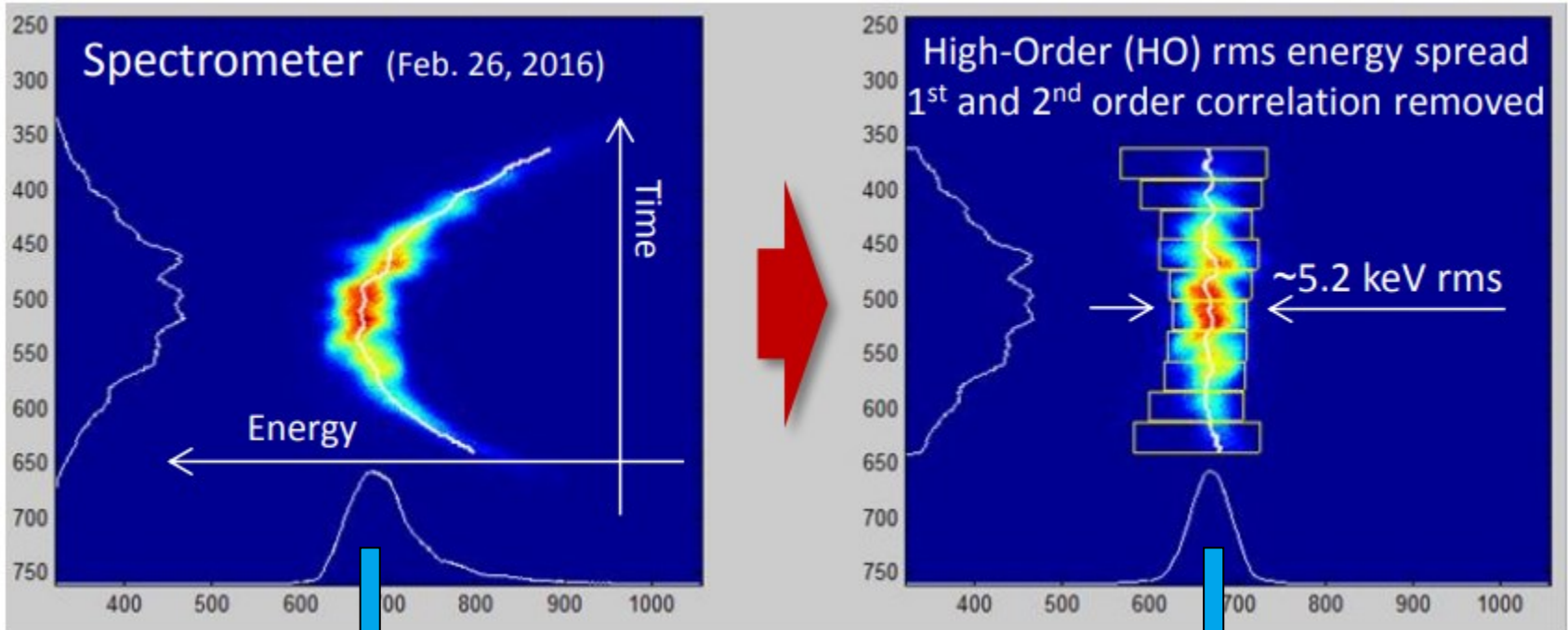
65
70
8

Projected longitudinal emittance comparison is misleading, high order energy spread shows the advantage of uniform ellipsoidal laser.



An measurement example from APEX

- 20 pC – longitudinal phase space linearization



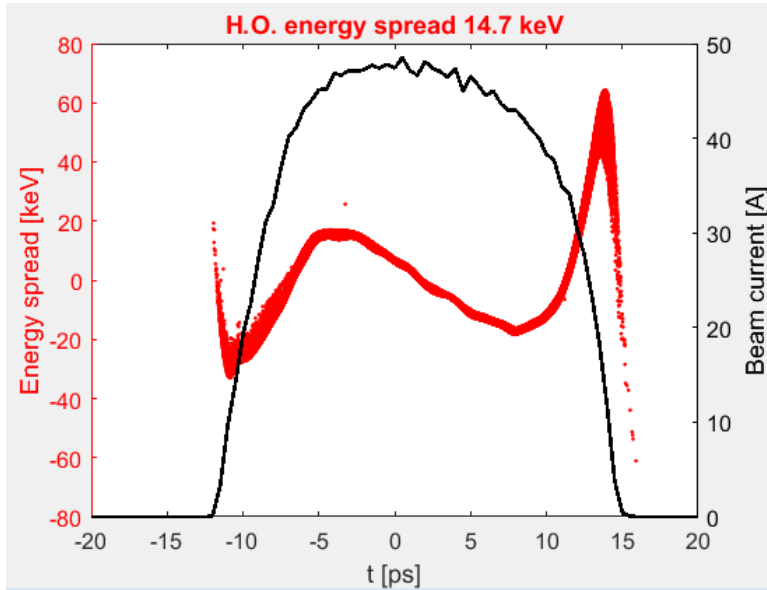
Projected energy spread

High order energy spread

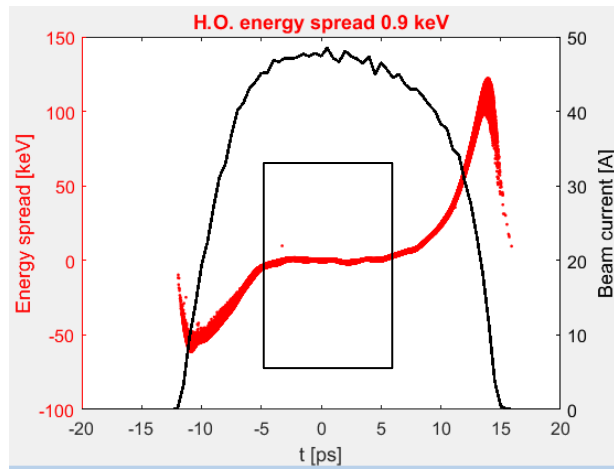
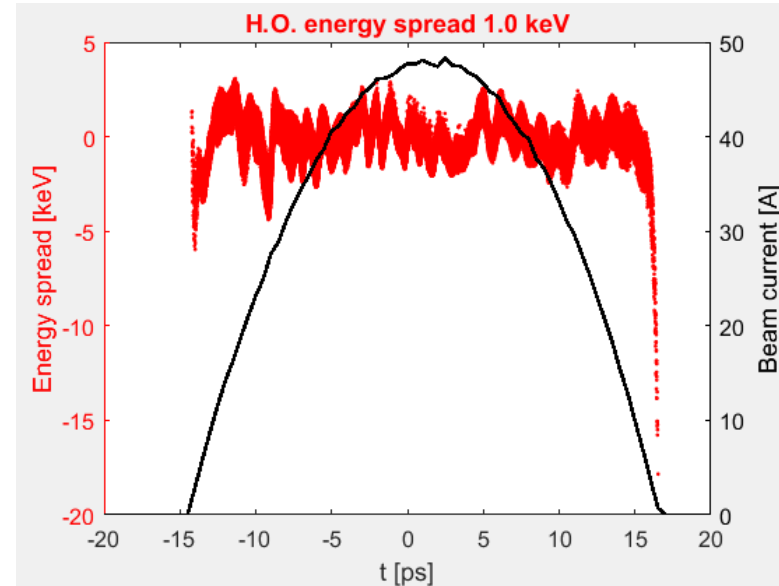
1 nC longitudinal phase space comparison

- Longitudinal phase space after 2nd order energy chirp removal

Flat-top laser with parabolic spatial shaping



Uniform ellipsoidal laser



Core part H.O. energy spread is still low.

Summary

- Peak current at cathode is not the cause of higher central slice emittance growth of uniform ellipsoidal laser case.
- Ellipsoidal laser with more spatial shaping can further improve beam emittance.
- In terms of transverse emittance, the advantage of ellipsoidal shaping is small for PITZ.
- Due to space charge linearization, ellipsoidal laser shaping has the minimum high order energy spread, i.e. minimum high order longitudinal phase space curvature, which should help beam compression in main linac.

