



# **TTF2 Start-to-End Simulations**

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TESLA COLLABORATION MEETING

**TESLA**

DESY Zeuthen, 22 Jan 2004

# S2E simulation web site (TTF1, TTF2, XFEL)

→ <http://www.desy.de/s2e-simu>



## Start-to-End Simulations TTF1, TTF2 and XFEL

### • TTF1

- Start-to-End Simulations of SASE FEL at the TESLA Test Facility, Phase 1.

### • TTF2

- Optimized version (6.4 nm, 1GeV)
- Operation without 3.9 GHz cavity : Case 0.5 nC, 4 ps sigma, magnetic compression
- Operation without 3.9 GHz cavity : Case 1.0 nC, 4 ps sigma, velocity bunching
- Operation without 3.9 GHz cavity : Case 1.0 nC, 20 ps flat top, velocity bunching

### • XFEL

- Benchmark S2E workshop, August 2003 (20.5 GeV, 3 chicanes, 12 kA peak)
- Revised version of the S2E workshop benchmark with 5 kA peak
- Benchmark ESFRI XFEL workshop, October 2003 (20.0 GeV, 2 chicanes, 5 kA)

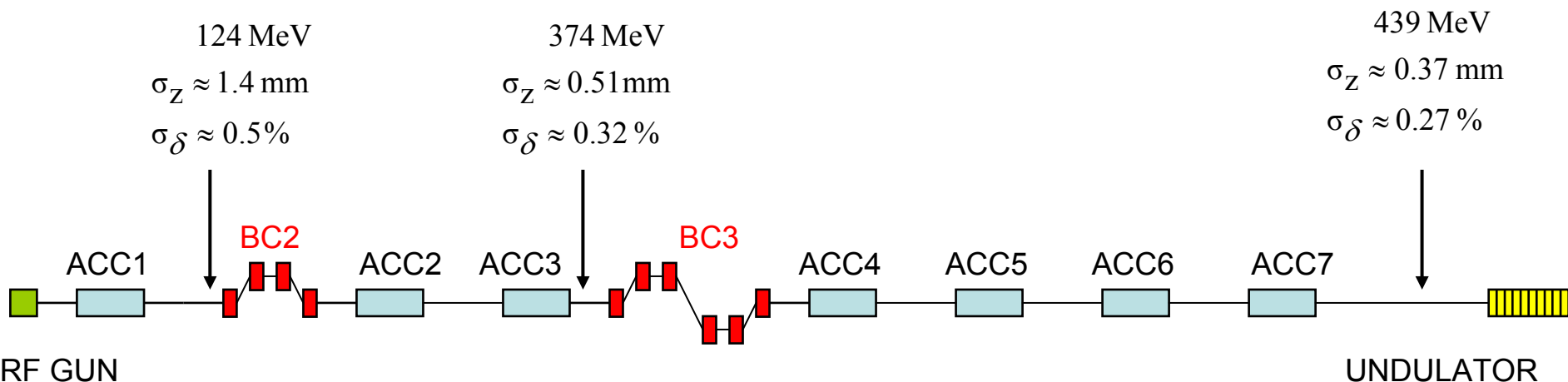
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**TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression**  
 (E. Schneidmiller proposal, Optics optimization by N. Golubeva)

Case No CSR, No Wakefields, ASTRA+ELEGANT, 100k particles, 1000 slices.



**LASER**  
**RF GUN**  
**SOLENOIDS**  
**ACC1**  
**BC2**

**4 ps sigma RMS, 3 mm uniform**  
**40 MV/m , 31 Deg**  
**0.163 T**  
**8 x 14 MV/m, 8 x -8.5 Deg w.r.t on crest**  
**18 Deg**

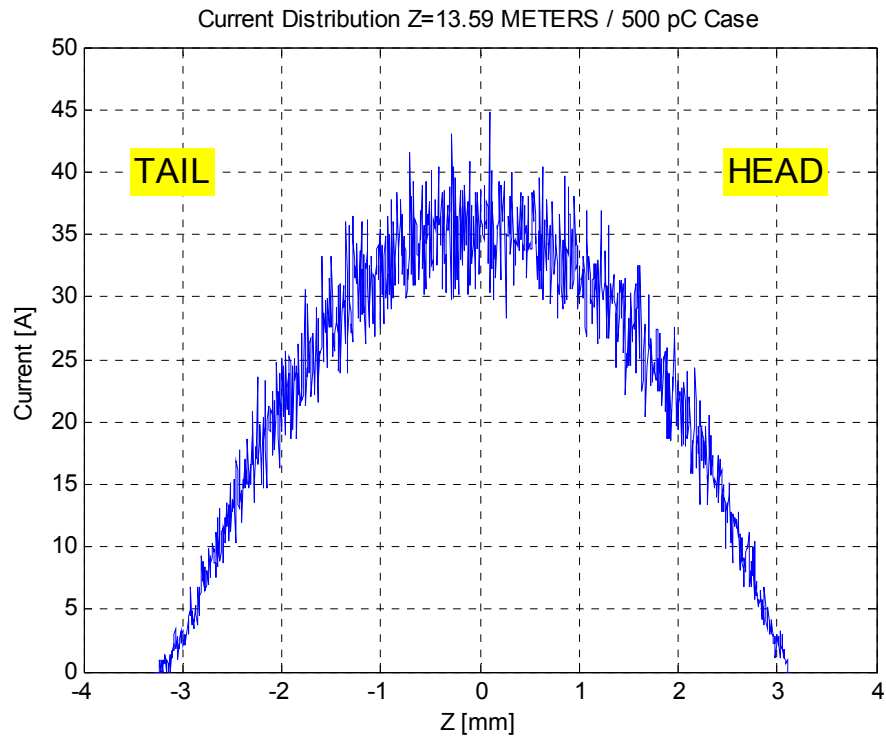
**ACC2 & ACC3**  
**BC3**  
**ACC4**  
**ACC5, ACC6 & ACC7**  
**UNDULATOR**

**15.31 MV/m, 78 Deg**  
**3.8 Deg**  
**7.85 MV/m, 90 Deg**  
**off**  
**???**



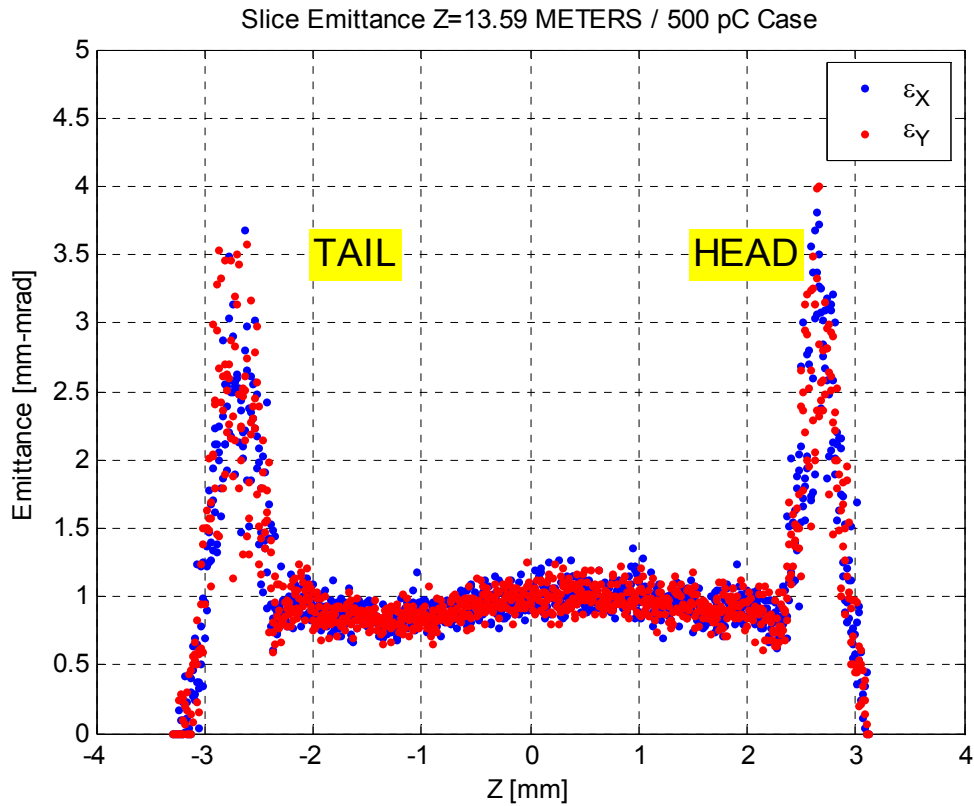
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

END INJECTOR (13.59 m) / RMS Bunch Length  $\sim 1.4$  mm



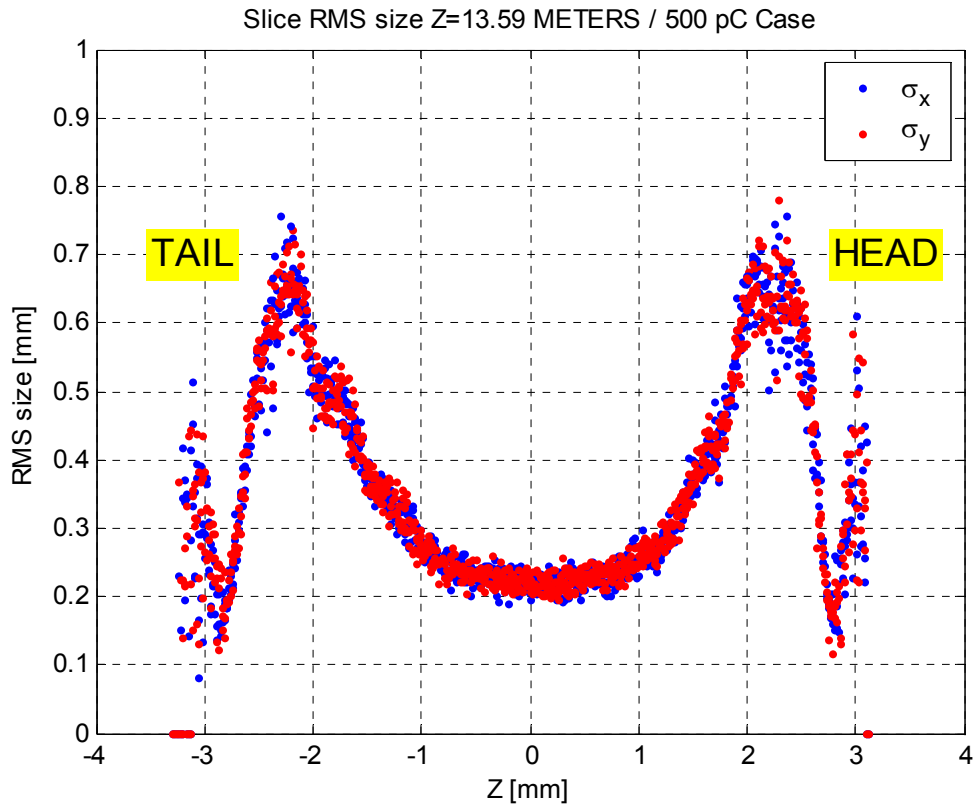
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

END INJECTOR (13.59 m) / Projected RMS Emittance  $\sim 1.6$  mm-mrad



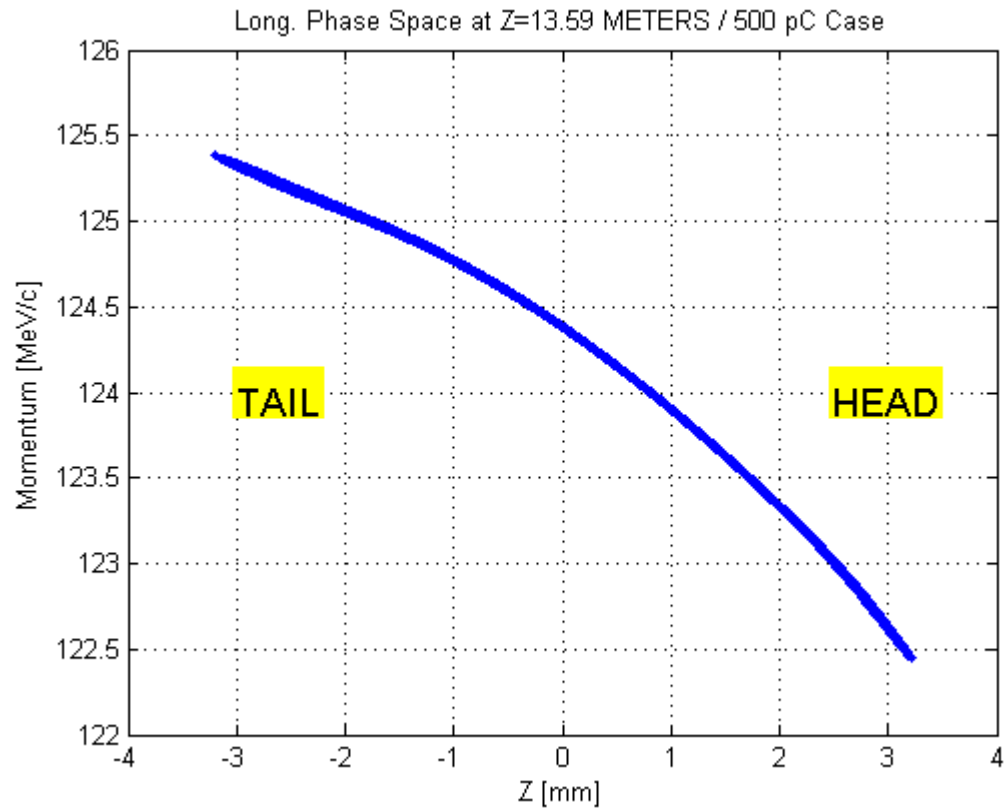
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

END INJECTOR (13.59 m) / Projected RMS Size  $\sim 0.36$  mm



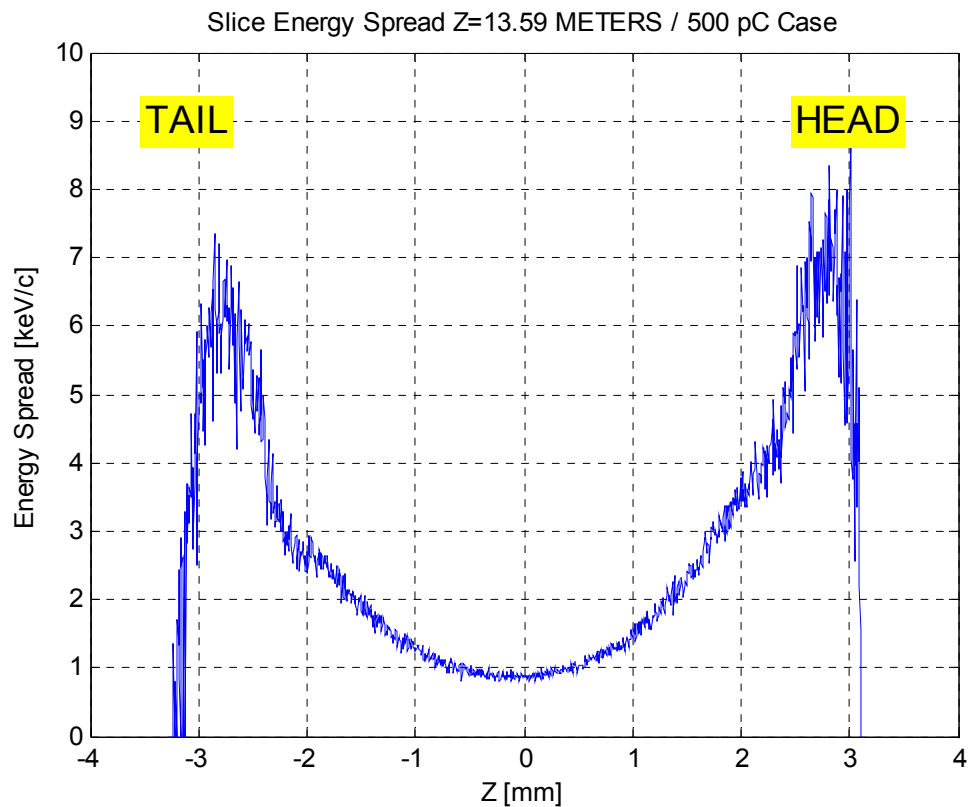
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

END INJECTOR (13.59 m) / Total Energy 124.25 MeV



# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

END INJECTOR (13.59 m) / Total Energy Spread  $\sim 626$  keV

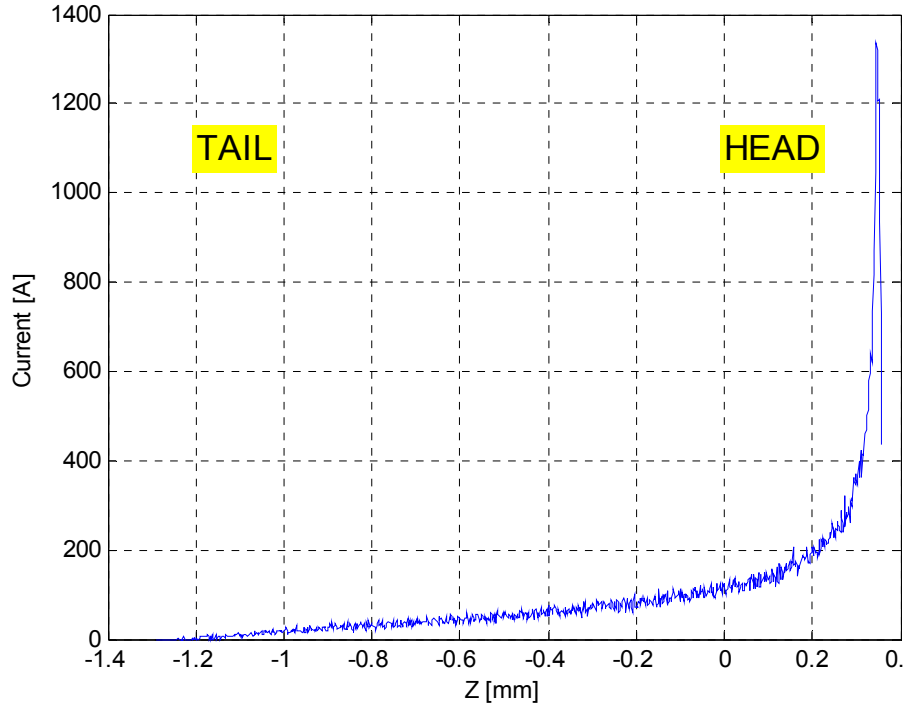




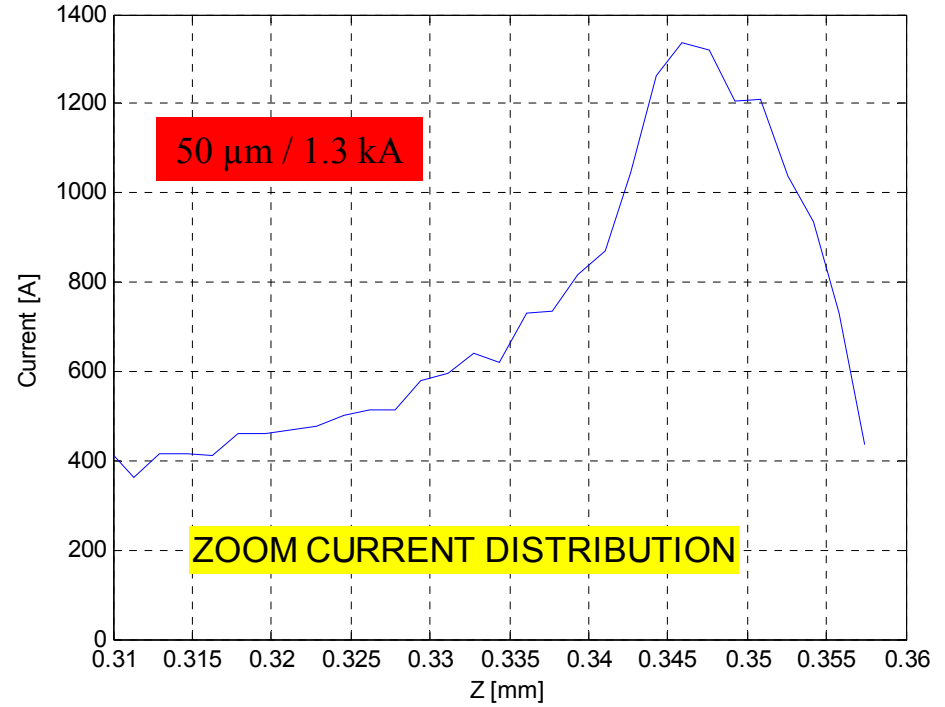
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

## ENTRANCE ONDULATOR

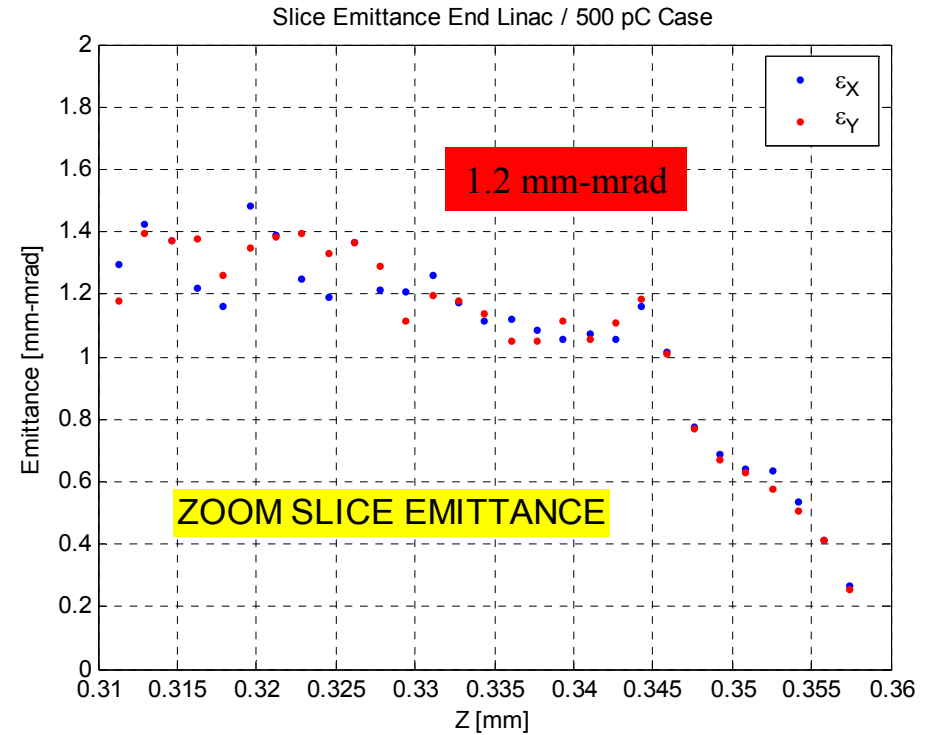
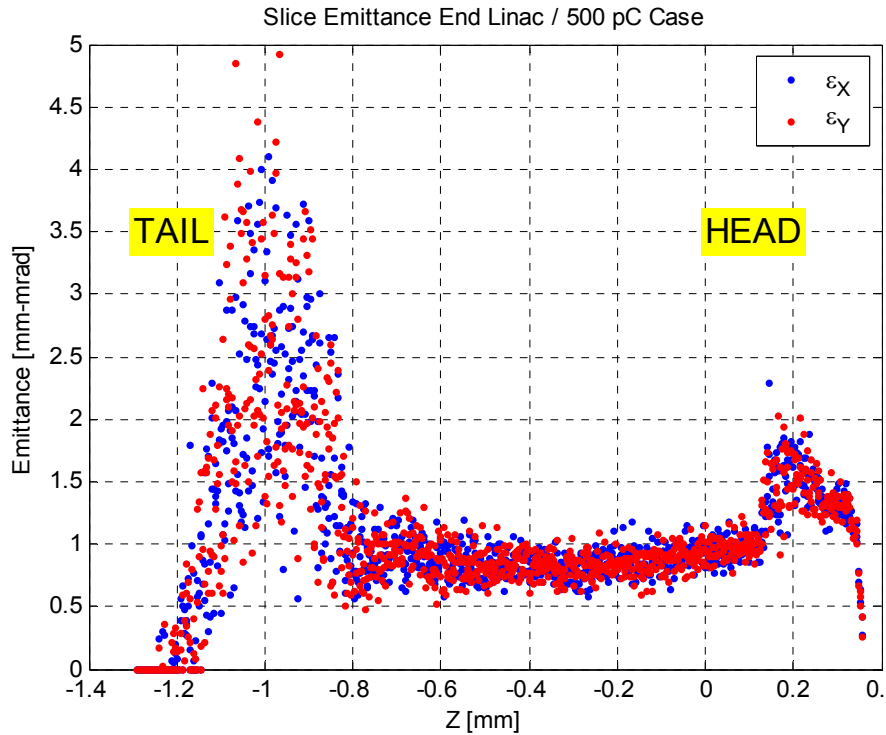
Current Distribution Z=13.59 METERS / 500 pC Case



Current Distribution End Linac/ 500 pC Case



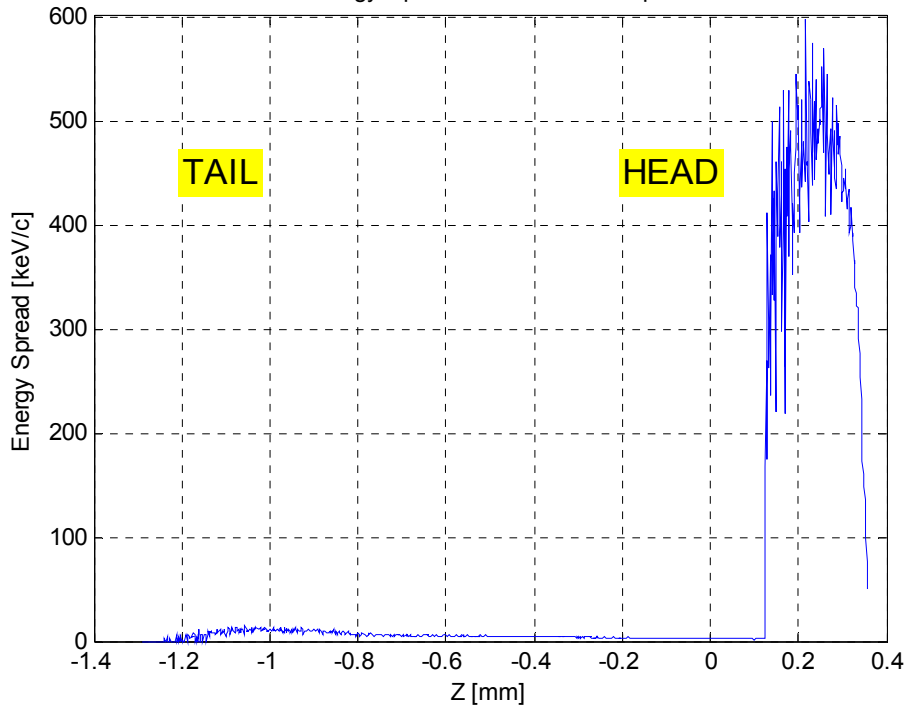
## ENTRANCE ONDULATOR



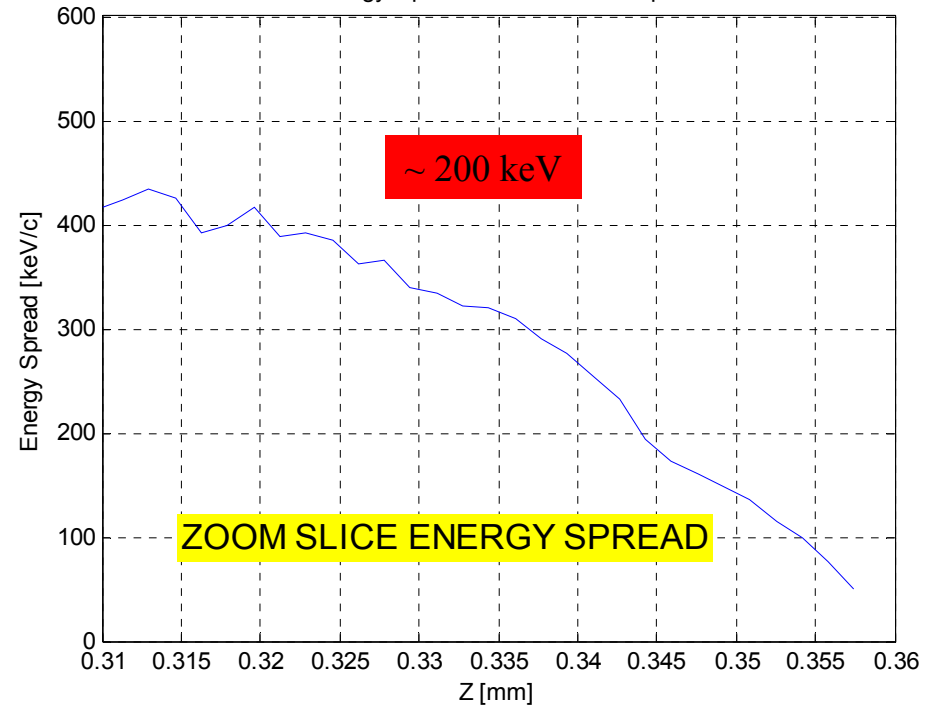
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

## ENTRANCE ONDULATOR

Slice Energy Spread End Linac / 500 pC Case



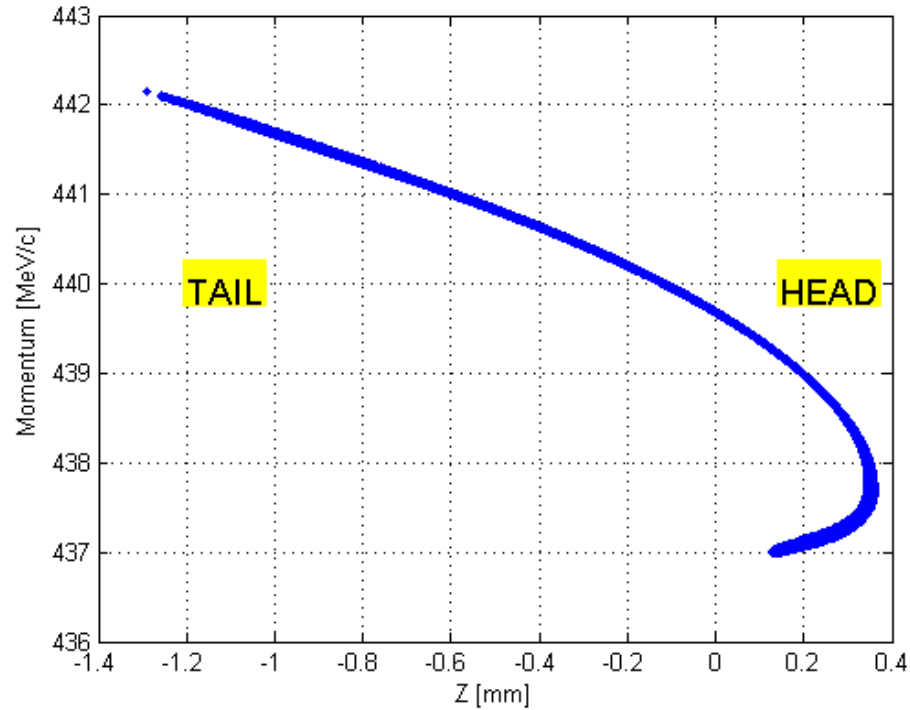
Slice Energy Spread End Linac / 500 pC Case



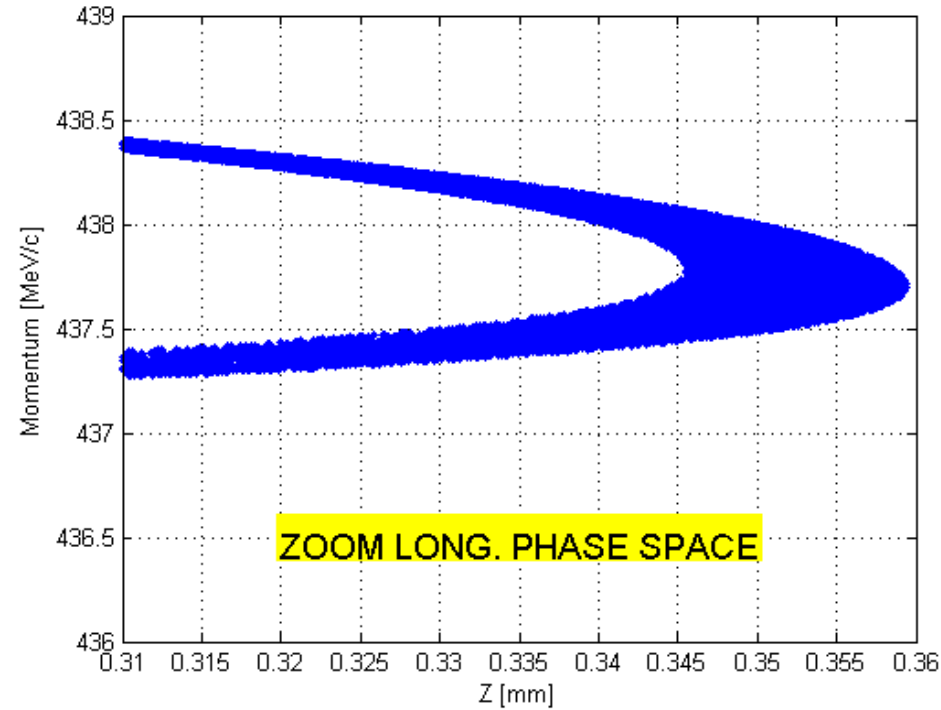
# TTF2 / Case 0.5 C, 4 ps laser pulse, magnetic compression

## ENTRANCE ONDULATOR

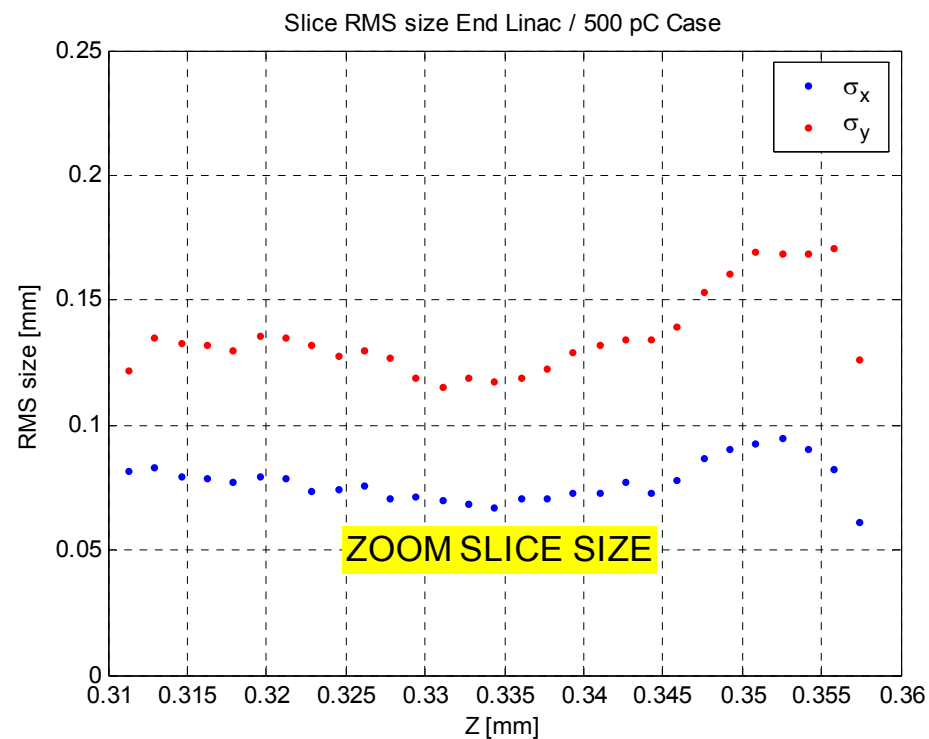
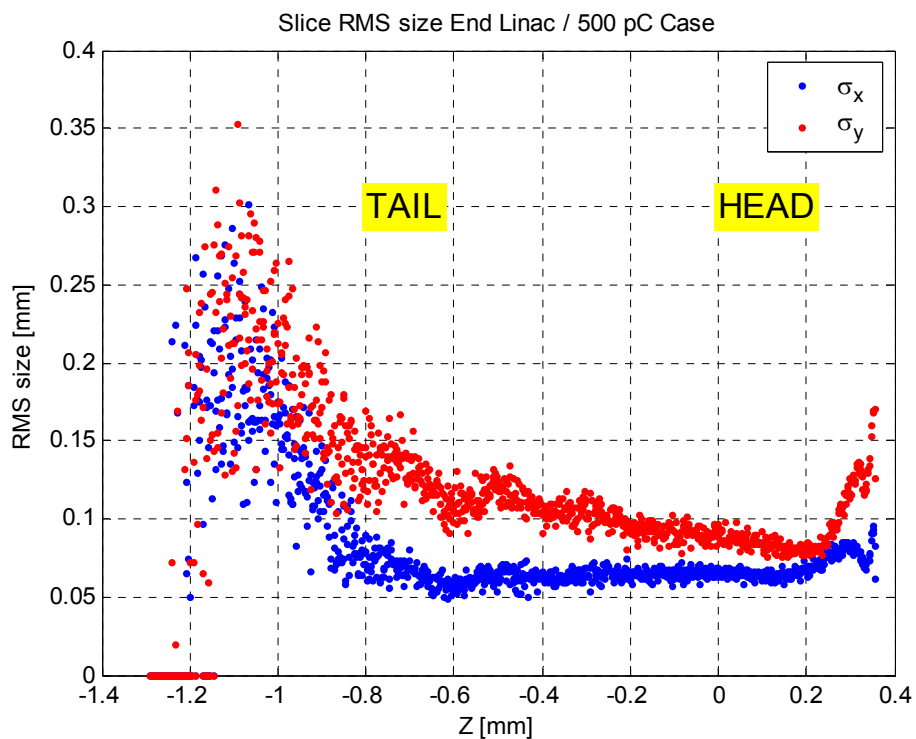
LONG. PHASE SPACE END LINAC TTF2



LONG. PHASE SPACE END LINAC TTF2



## ENTRANCE ONDULATOR



# RESUME Case 0.5 nC

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For this configuration (No CSR effects, No Space Charge from BC2 to end linac, No Wakefields :

• Peak Current	: 1.3 kA	→	Saturation at $\lambda = 31$ nm	} From PARMS B. Faatz
Slice Emittance	: 1.2 mm-mrad		Saturation Length $L \sim 11$ m	
Slice Energy Spread	: 200 keV		Saturation Power $P \sim 1.8$ GW	
Total Energy	: 439 MeV			

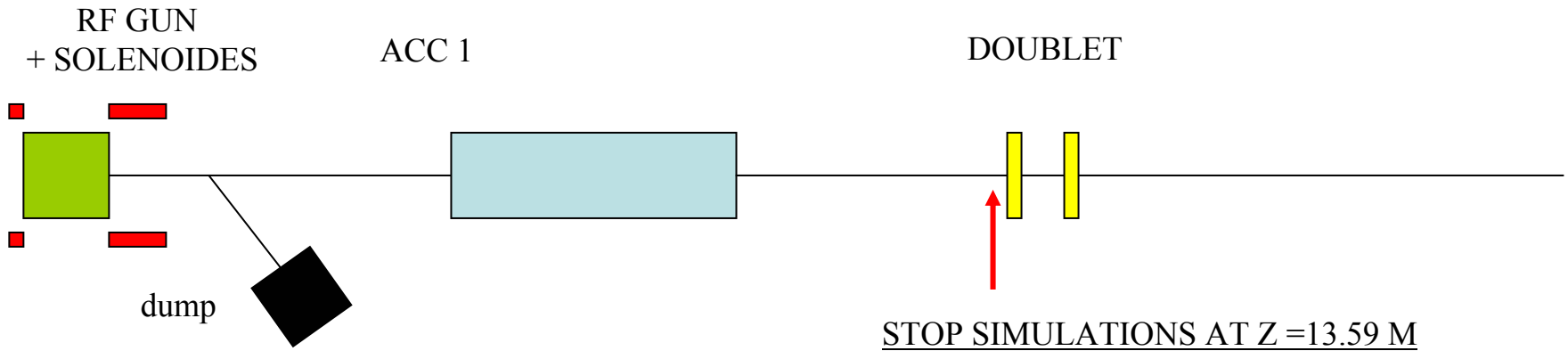
If energy increases to 1 GeV →  $\lambda = 6.1$  nm,  $L \sim 19$  m,  $P \sim 2.3$  GW

- Case 500pc looks promising. Need to add CSR, Wakefields effects and Space Charge in the linac.



# TTF2 Velocity Bunching

(K. Floettmann proposal)

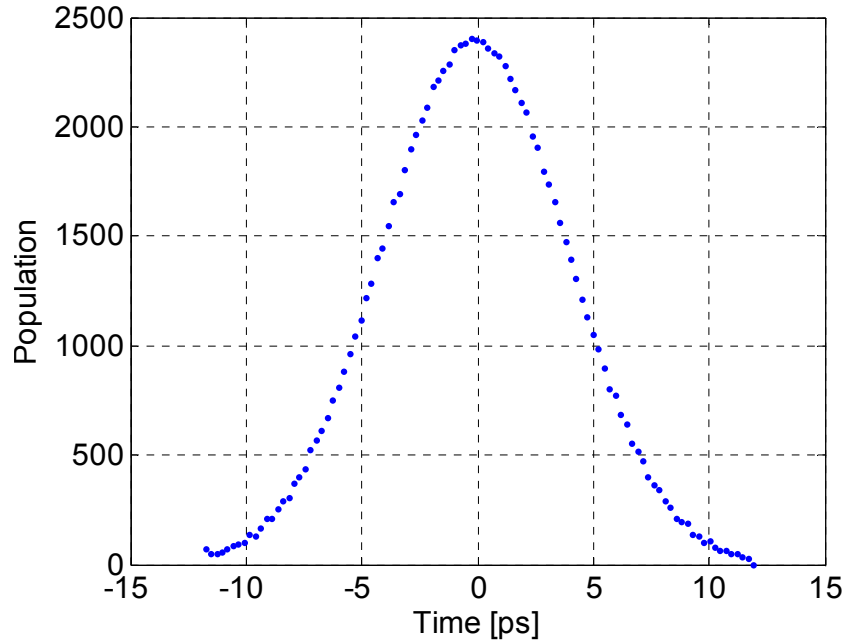


Bunch Charge	1 nC
Laser Diameter	3 mm (uniform)
Laser pulse length	Case 4 ps gaussian and 20 ps flat top
Solenoid Bmax	163 mT
Phase Gun	~ 31 Deg
Field Cathode	40 MV/m
ACC1 (cav 1 to 8)	14 MV/m
Phases ACC1	Change Phase First Cavity and run other 7 cavities at max energy.

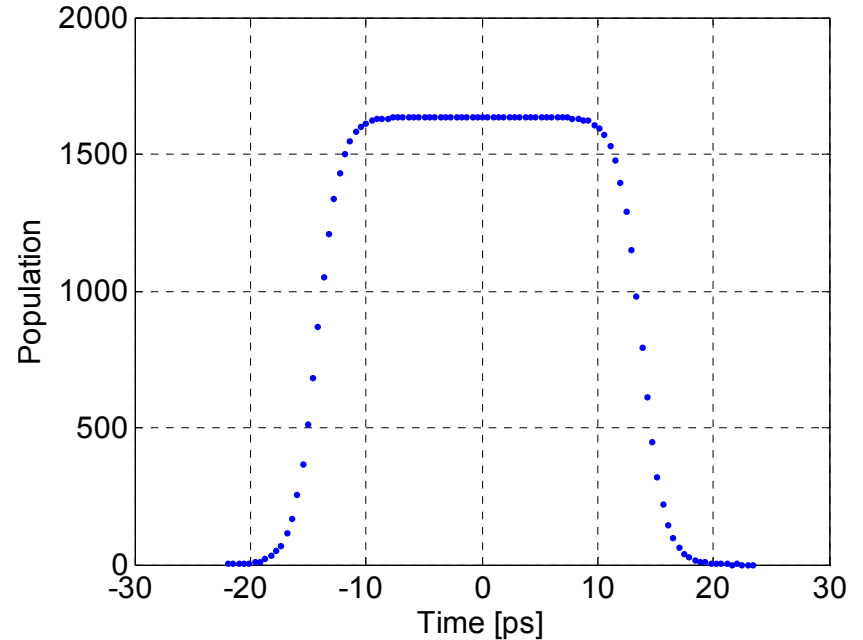


# TTF2 Velocity Bunching

Case 4 ps sigma RMS  
4 ps RMS laser pulse cut at 3 sigma  
Therm. Emit. 0.55 eV



Case 20 ps flat top  
4 ps RMS laser pulse cut at 3 sigma  
Therm. Emit. 0.55 eV

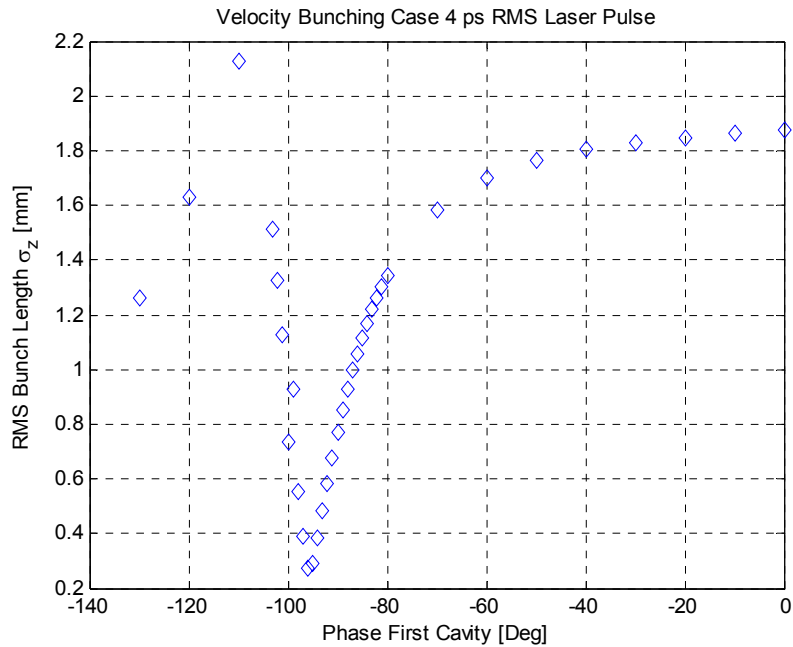




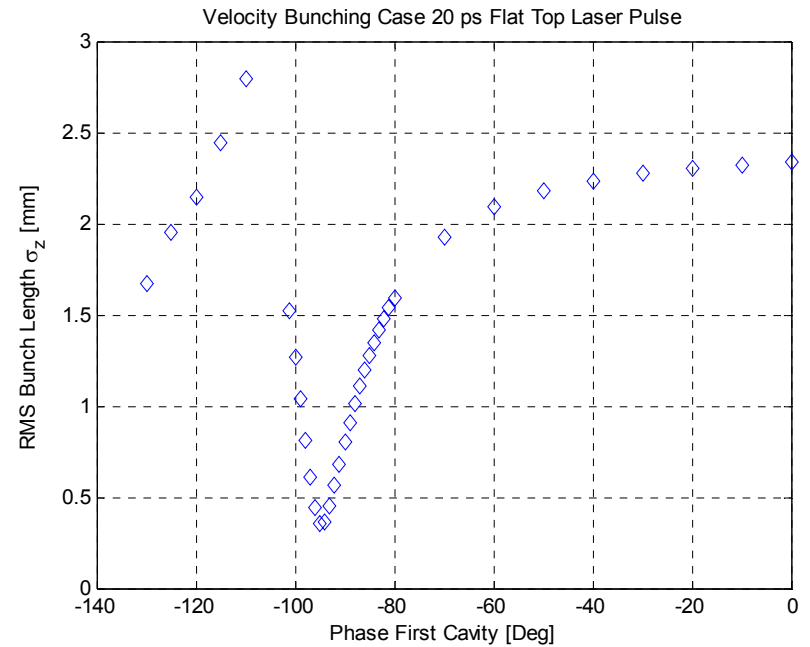
# TTF2 Velocity Bunching

END INJECTOR (13.59 m)

**Case 4 ps**



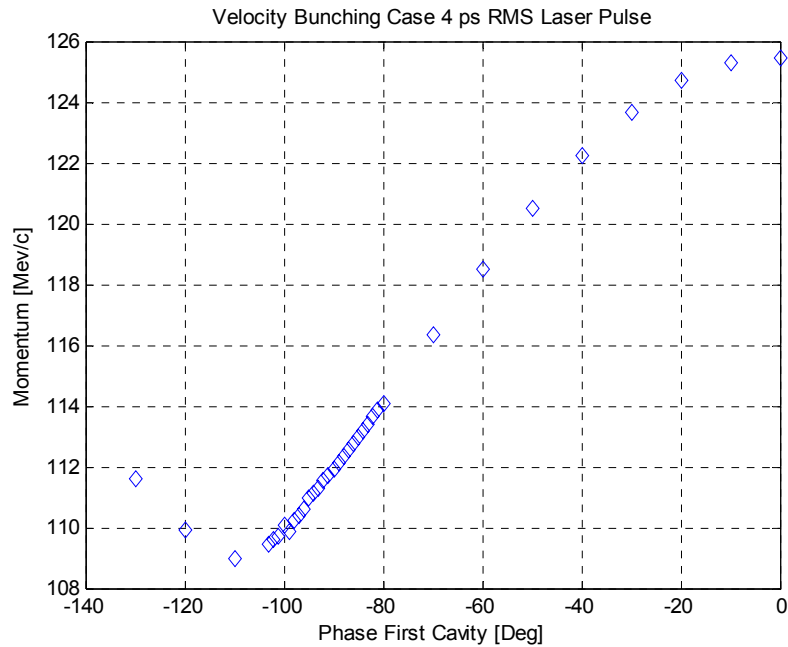
**Case 20 ps**



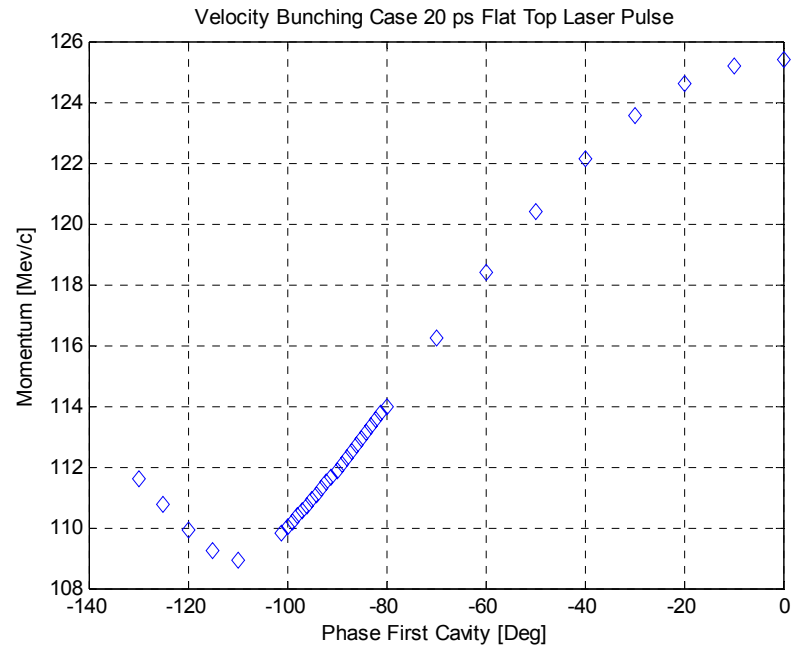
# TTF2 Velocity Bunching

END INJECTOR (13.59 m)

**Case 4 ps**



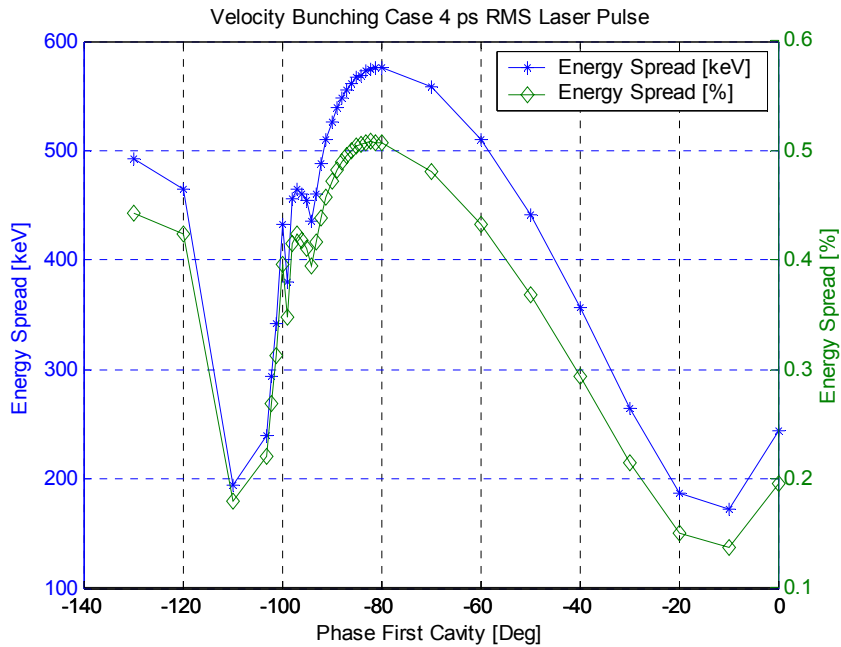
**Case 20 ps**



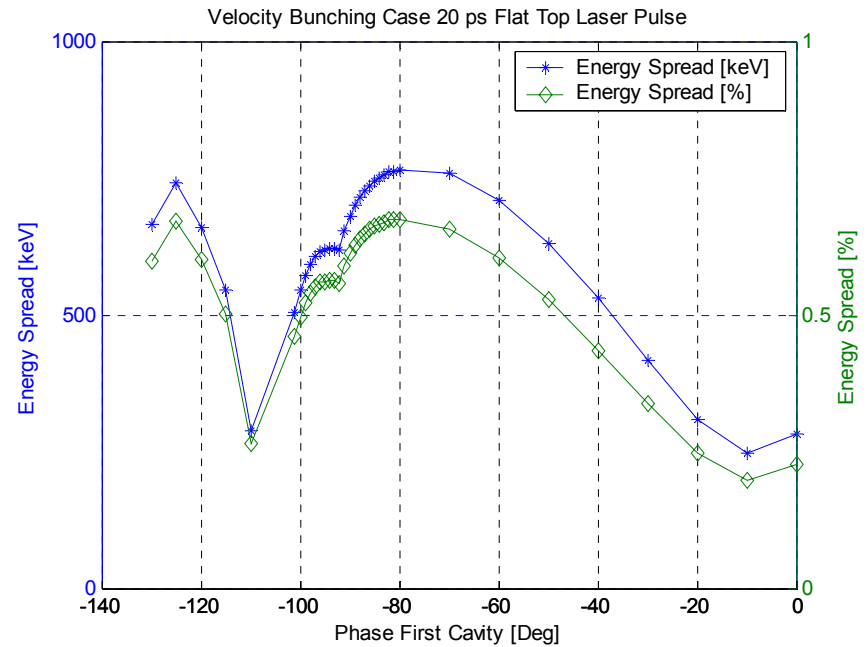
# TTF2 Velocity Bunching

END INJECTOR (13.59 m)

## Case 4 ps



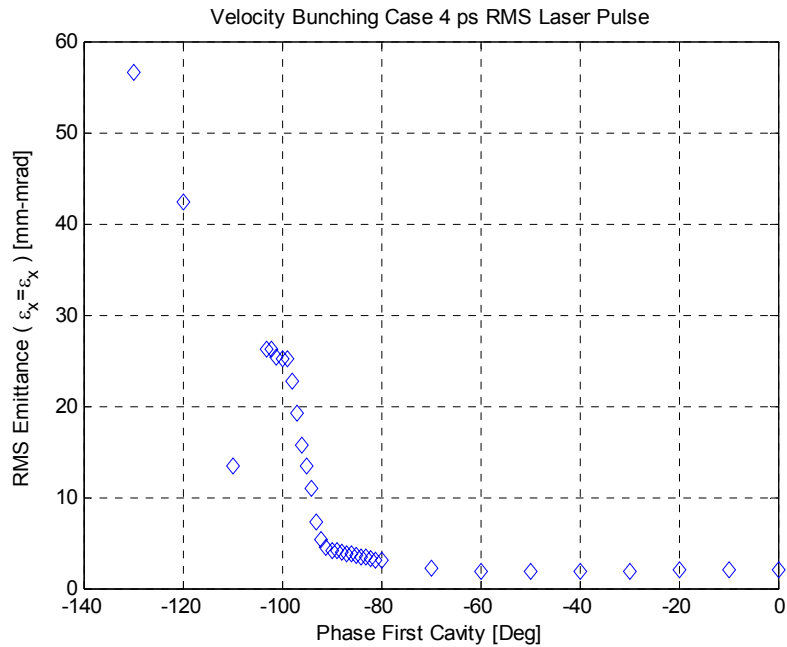
## Case 20 ps



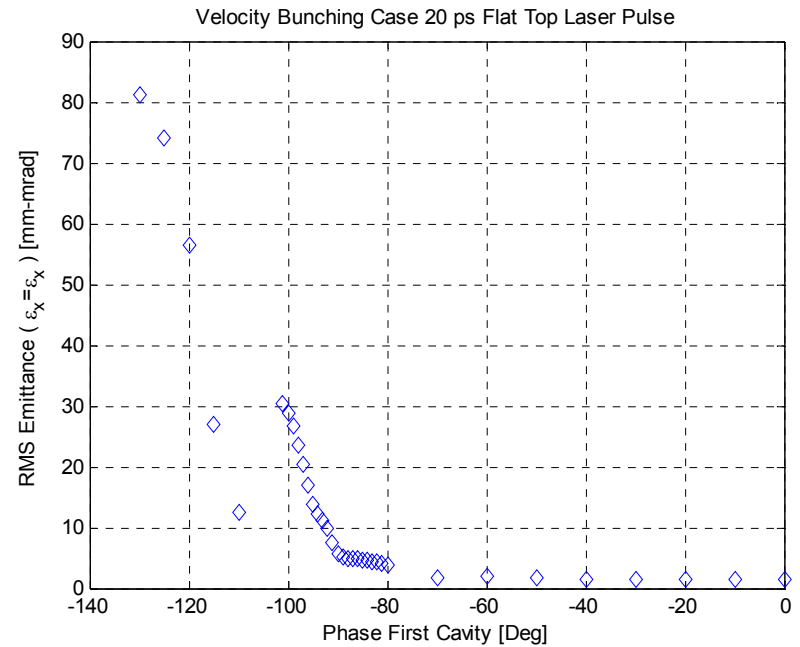
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END INJECTOR (13.59 m)

**Case 4 ps**



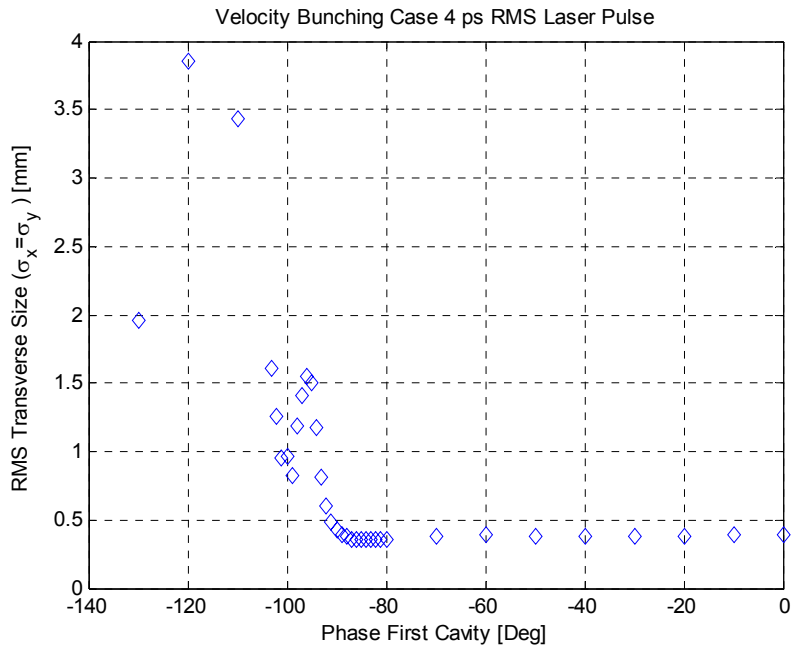
**Case 20 ps**



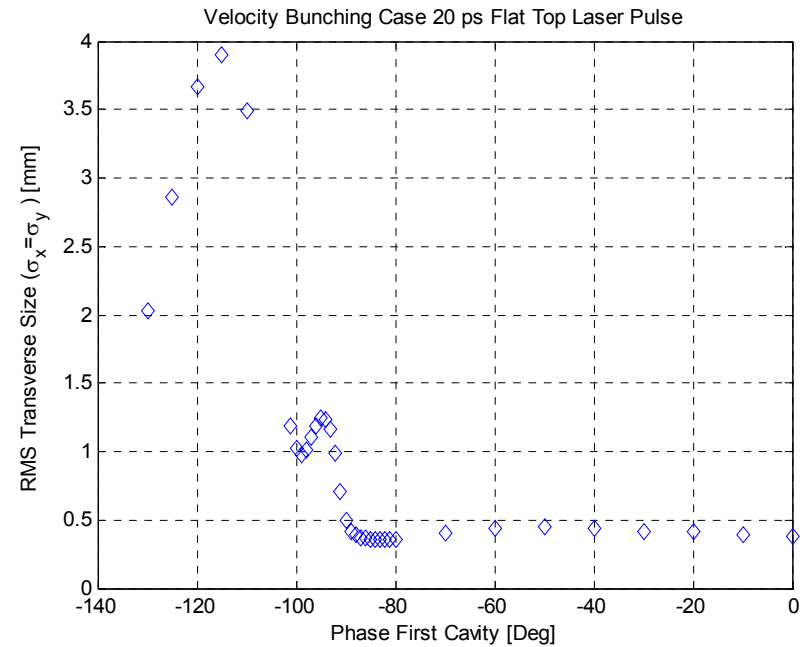
# TTF2 Velocity Bunching

END INJECTOR (13.59 m)

**Case 4 ps**



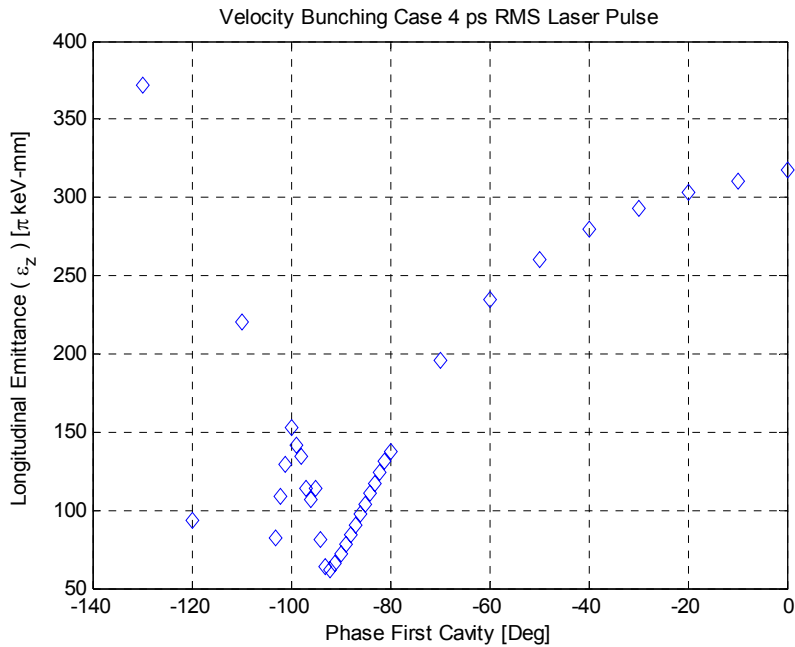
**Case 20 ps**



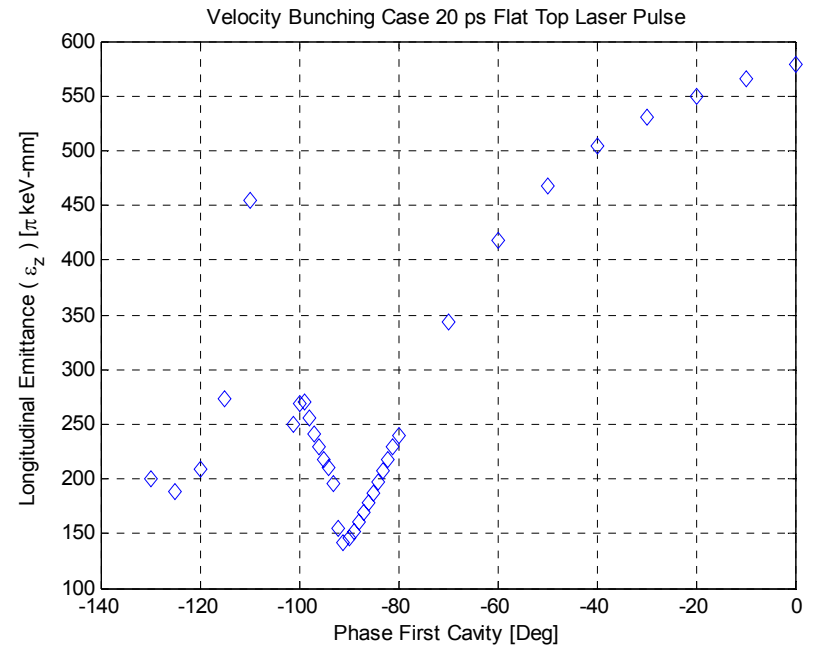
# TTF2 Velocity Bunching

END INJECTOR (13.59 m)

## Case 4 ps

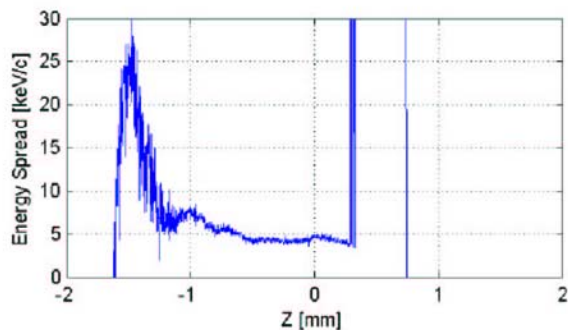
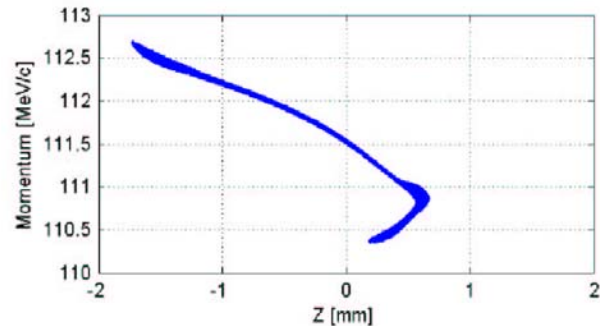
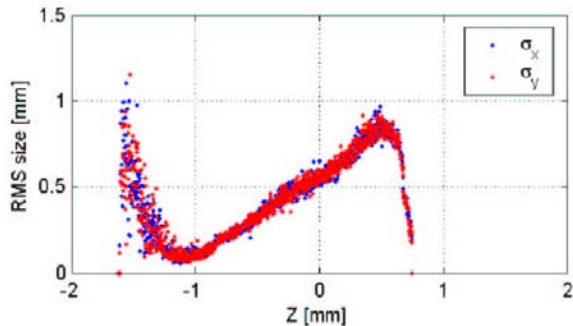
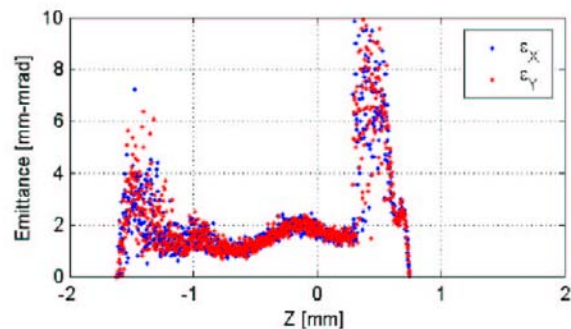
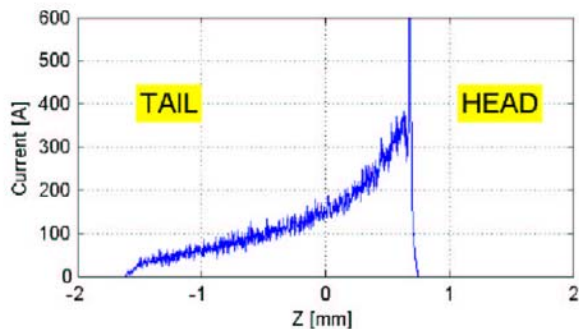


## Case 20 ps



# TTF2 Velocity Bunching

- Case 4 ps  
Phase -92 Deg



PROJECTED PARAMETERS /  $\Phi = -92$  Deg

$I_p = 882.487$  A,  $\sigma_z = 0.58414$  mm

$E_k = 111$  MeV,  $\Delta_E = 487.42$  keV

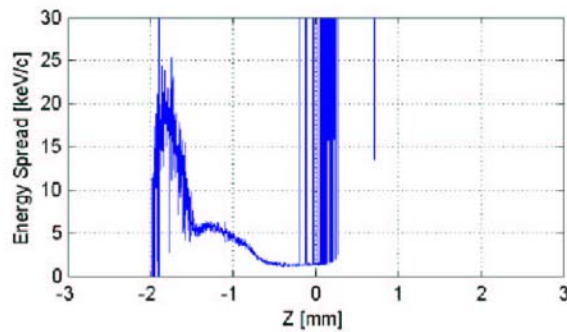
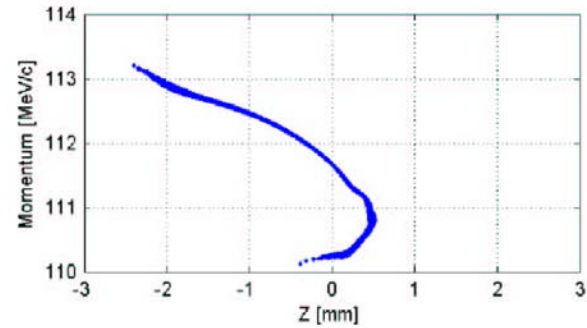
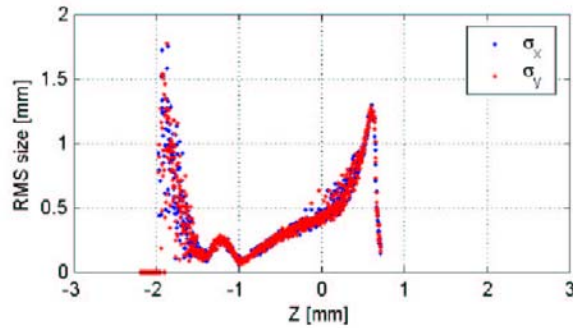
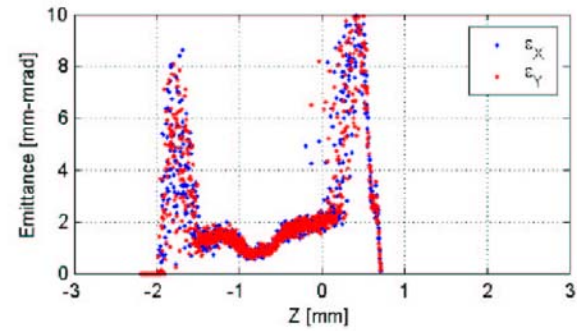
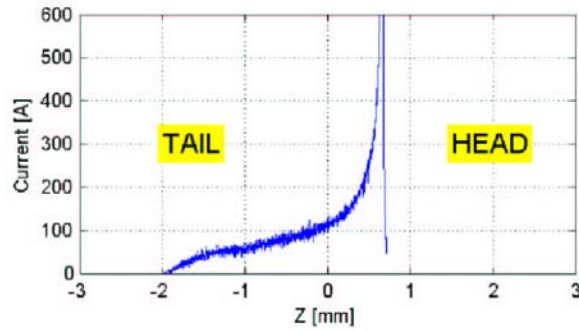
$\sigma_x = 0.60362$  mm,  $\sigma_y = 0.60508$  mm

$\epsilon_x = 5.381$  mm-mrad

$\epsilon_y = 5.4495$  mm-mrad

# TTF2 Velocity Bunching

- Case 20 ps  
Phase -91 Deg



PROJECTED PARAMETERS /  $\Phi = -091$  Deg

$I_p = 1897.7597$  A,  $\sigma_z = 0.68368$  mm

$E_k = 111.15$  MeV,  $\Delta_E = 654.9$  keV

$\sigma_x = 0.7086$  mm,  $\sigma_y = 0.70828$  mm

$\epsilon_x = 7.4897$  mm-mrad

$\epsilon_y = 7.4782$  mm-mrad



# RESUME Velocity Bunching

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- Velocity Bunching needs much more studies (s2e, jitter,...)

