



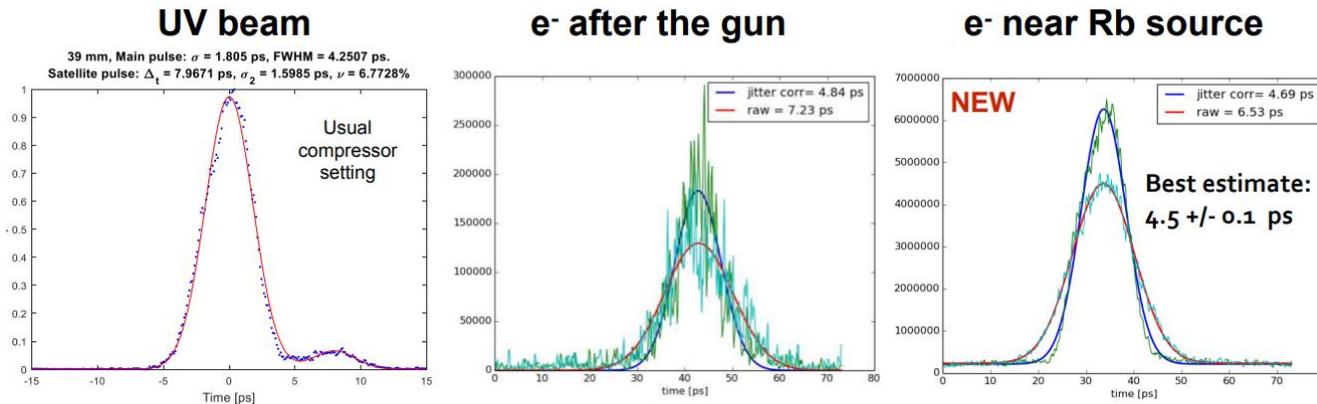
Electron injector measurement: Bunch length

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AWAKE Technical Board Meeting

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Electron source measurement during summer run



S. Mazzone, I. Gorgisyan, E. Granados, H. Panuganti.
See also [Edu's slides @ collaboration meeting](#) and Stefano's slide in backup.

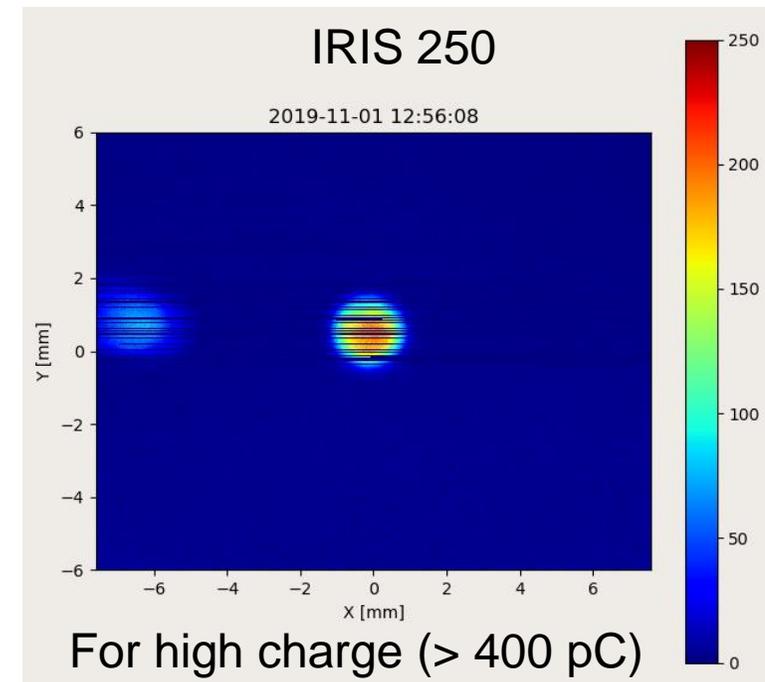
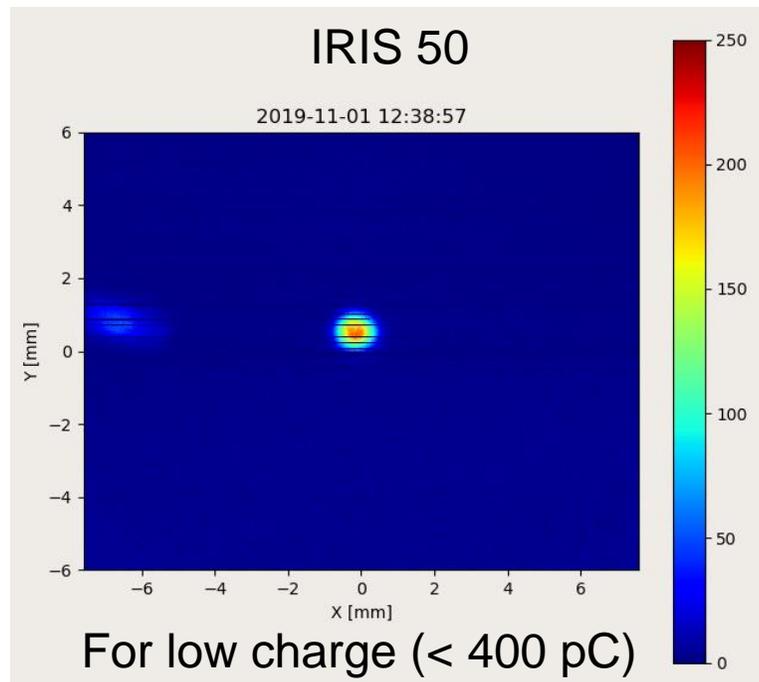
35th TB (G. Porta)

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- **Original bunch length** estimate came from UV measurement of the laser by Micha in Summer 2018 ($\sigma_z = 2.2$ ps)
- Comparing injector data from December 2018 with simulations indicated shorter bunch length
- **2019 measurement campaign**, gave shorter value in the UV, this time measured directly on the beamline ($\sigma_z = 1.6$ ps)
- However, measurements using OTR of the electron beam **at the pepper pot** indicated larger bunch length ($\sigma_z = 4-5$ ps) but were limited by light intensity
- Final campaign, **series of measurements in front of the plasma cell** to hopefully clarify the situation

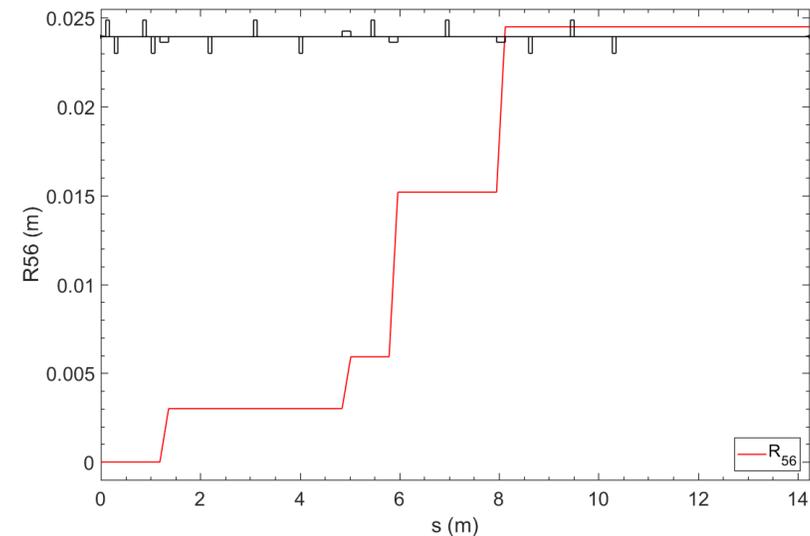
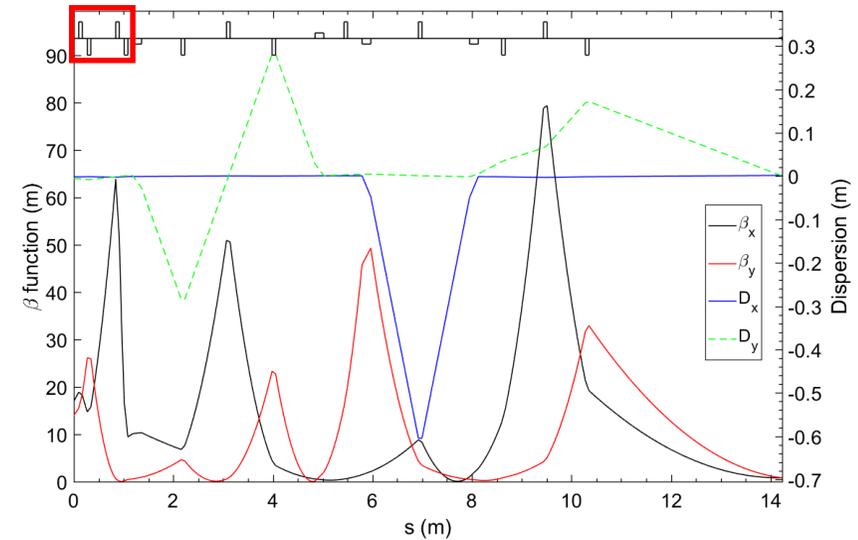
Bunch length measurement during summer run

- Charge has been changed with two fixed initial UV pulse lengths ($\sigma_{z,i} = 0.7, 1.6$ ps)
- Since charge was adjusted using OD filter and IRIS, initial beam size was a bit changed as well
- Slightly changed beam size has been considered in the ASTRA simulation
- Bunch length was measured at the end of the electron transfer line (streak camera)



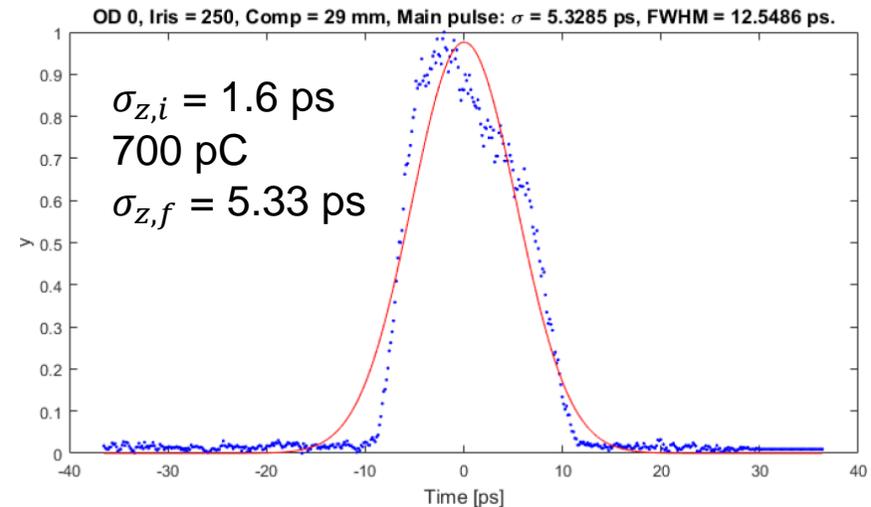
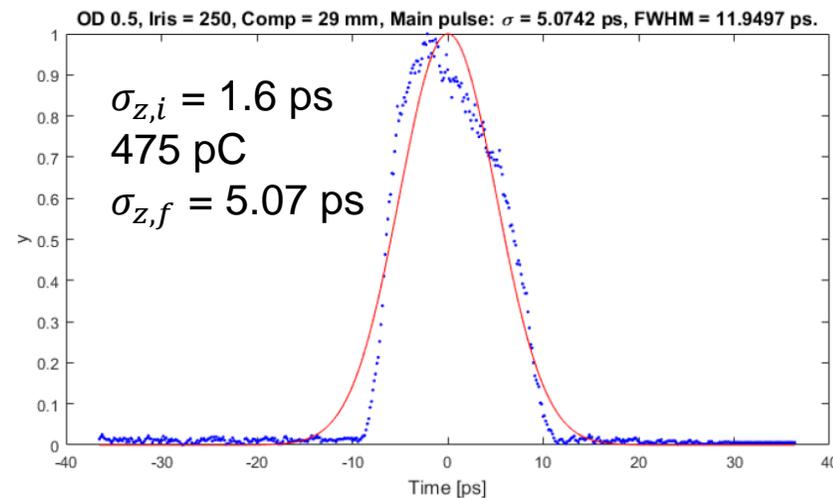
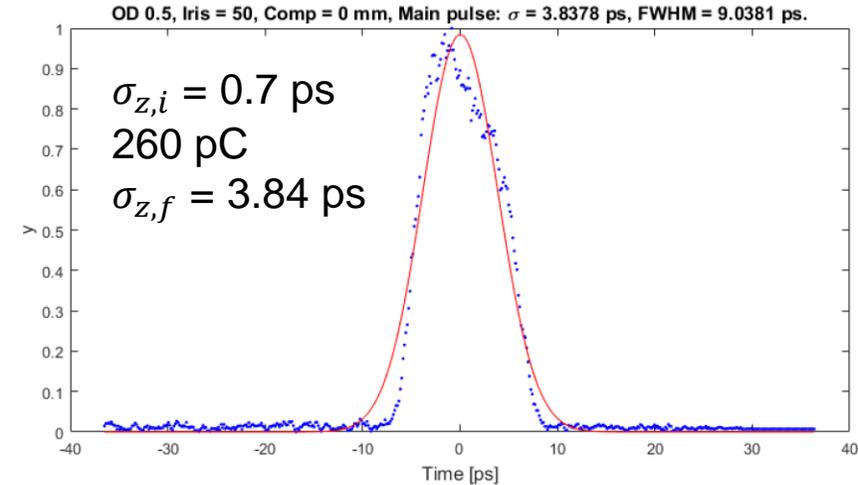
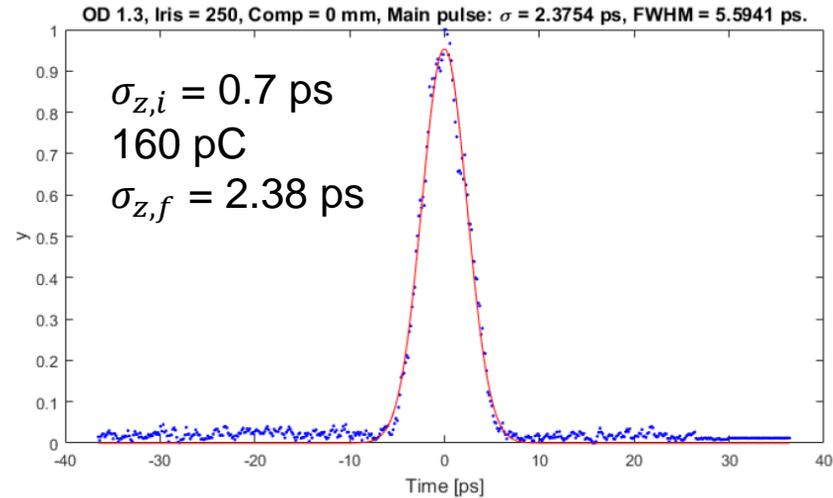
ASTRA // ELEGANT simulation for bunch length study

- To simplify simulation, an additional quadrupole magnet was added in the matching triplet section (And using only first 4 quads, optics has been optimized)
- Beta function at the end is 0.8 m, and dispersion is 0
- One can see that the R56 is always positive along the transfer line: note that it is with the manner; beam tail = $z > 0$, head = $z < 0$
- ELEGANT does not support space charge calculation while CSR can be calculated
- For the space charge, Mohsen produced simulation using PARMELA



Bunch length measurement during summer run

300 shots, jitter corrected, point spread function not considered

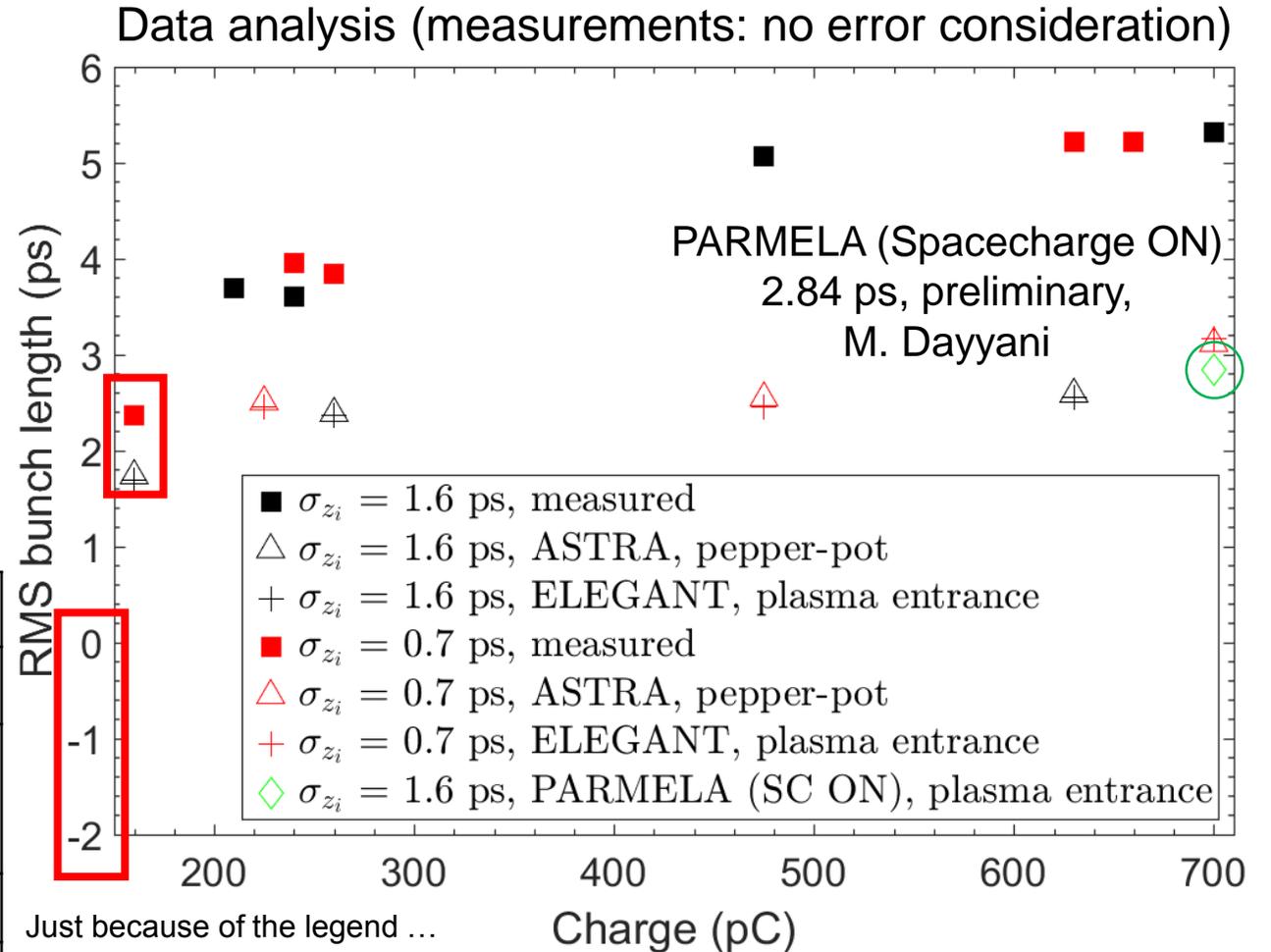


Courtesy of E. Granados

ASTRA // ELEGANT simulation for bunch length study

Measured data (at the end of the line)			
$\sigma_{z,i} = 0.7$ ps		$\sigma_{z,i} = 1.6$ ps	
Beam charge (pC)	Avg. bunch length (ps)	Beam charge (pC)	Avg. bunch length (ps)
160	2.38		
240	3.96	210	3.70
260	3.84	240	3.61
630	5.22	475	5.07
660	5.22	700	5.33

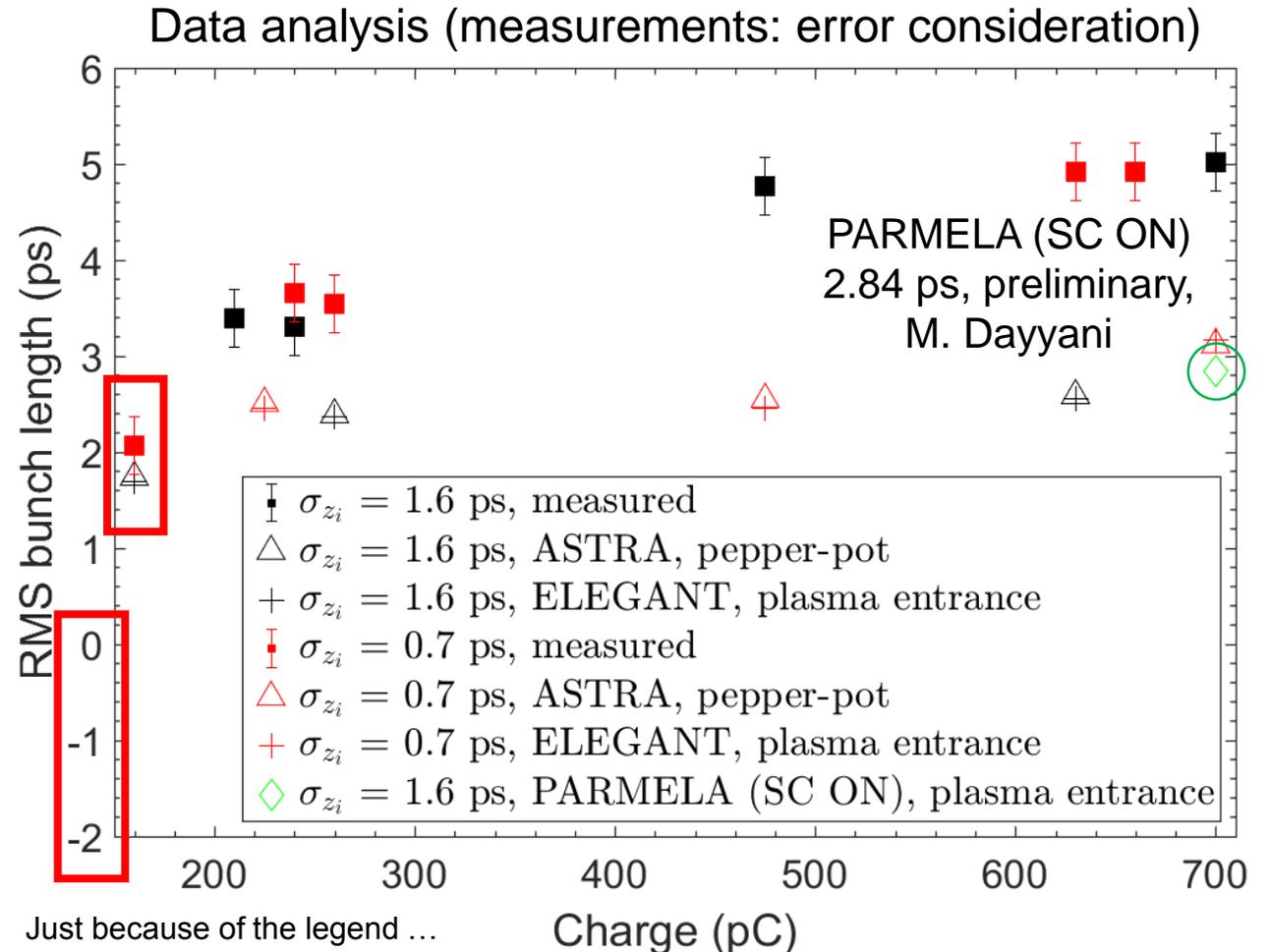
ASTRA (SC) // ELEGANT (CSR)					
$\sigma_{z,i} = 0.7$ ps			$\sigma_{z,i} = 1.6$ ps		
Beam charge (pC)	At pepper-pot	At plasma	Beam charge (pC)	At pepper-pot	At plasma
160	1.74	1.70	225	2.51	2.46
260	2.39	2.37	475	2.55	2.46
630	2.59	2.56	700	3.12	3.17



ASTRA // ELEGANT simulation for bunch length study

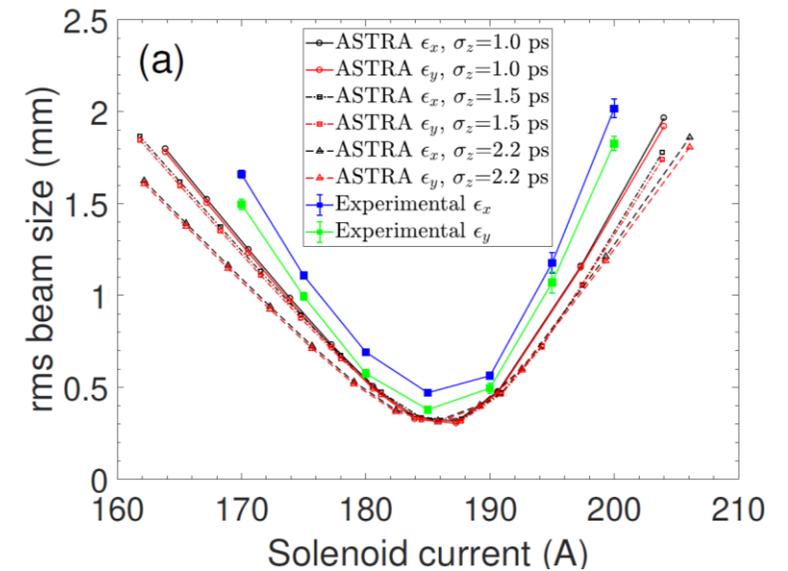
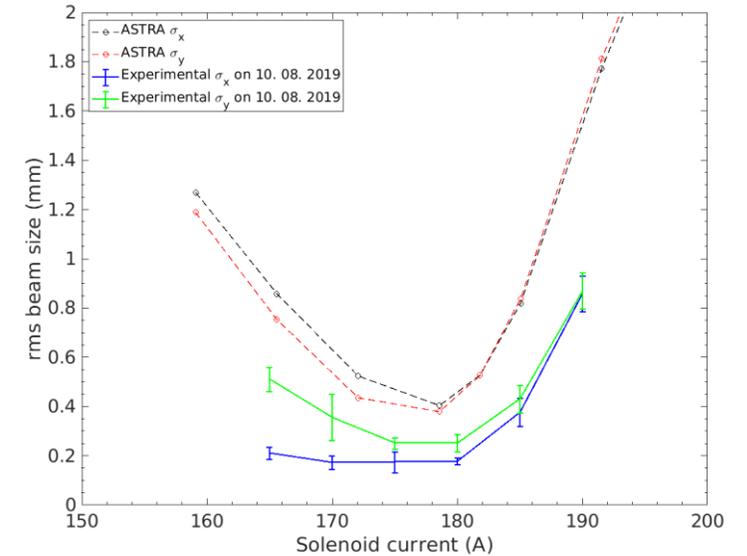
What else to be considered?

- Bunch length measurement did not deconvolve the point spread function of the streak camera (> 0.3 ps),
- Resolution of the streak camera: > 0.7 ps
- If two factors are considered from the initial values, then the bunch length is similar with the simulation results for low charge case (160 pC)
- Still there is discrepancy except for the lower charge case, and even if the space charge is considered, bunch length is compressed



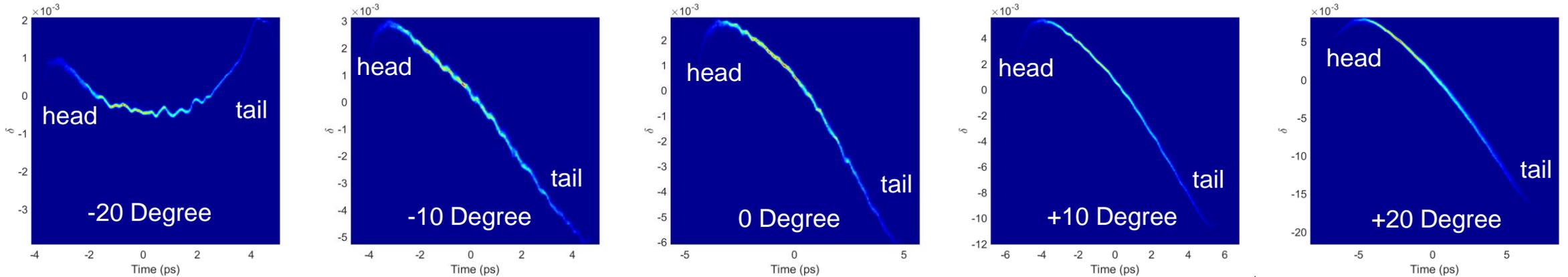
Summary and future works

- Bunch length was measured again by changing the RF gun phase, and beam charge with fixed initial UV pulse length
- Bunch length is independent of UV fluence illuminating cathode for saturated condition
- The bunch length not correlated with UV pulse duration in either experiment or simulation
- The bunch length correlated with the charge; this is true in both data and simulation, but stronger in data. Therefore, data // simulation agreement gets worse at higher charge
- Simulation issue? Fringe field of the dipole magnet?
- Apart from the bunch length measurement, for the beam size discrepancy, new measurement of the beam size at the pepper-pot screen is planned



ELEGANT results: 150 pC, $\sigma_z = 1.5$ ps rms

including CSR effects



- Longitudinal phase spaces with changing RF gun phase are shown (at 3 m from the cathode)
- Except for the -20 Degree case, all phase spaces have similar shape (head // tail)
- Due to the longitudinal phase space, particles at head are moving positively due to positive R56 term, while the particles at tail are moving negatively due to negative R56 term; it is actually compressed

