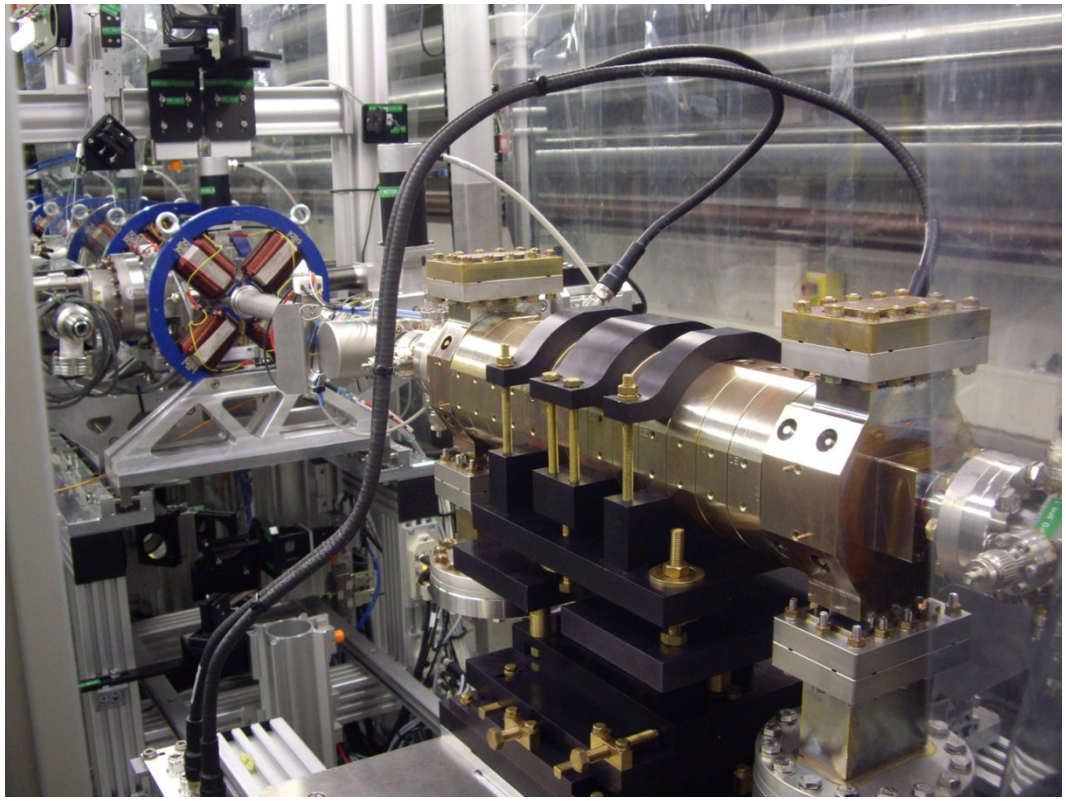
Bunch Length Simulations for PITZ



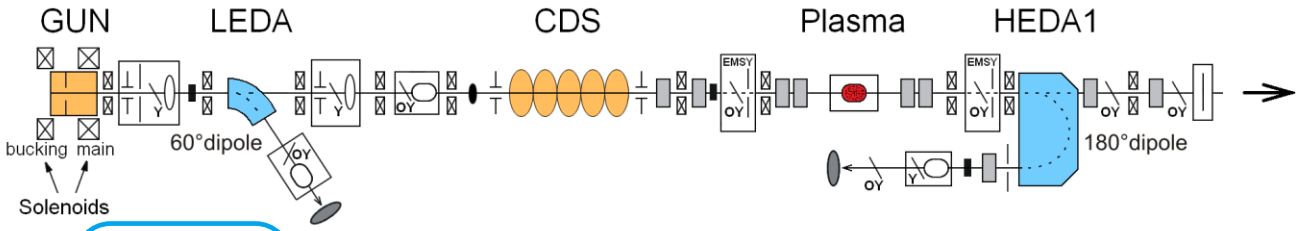
Holger Huck

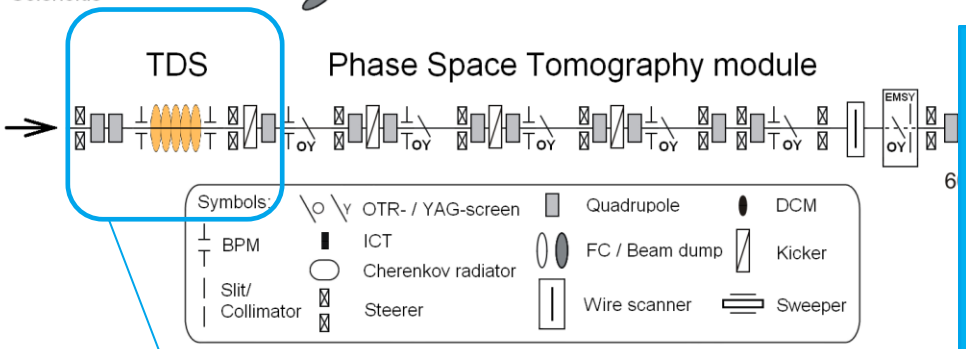
20.11.2015, PITZ K&K seminar

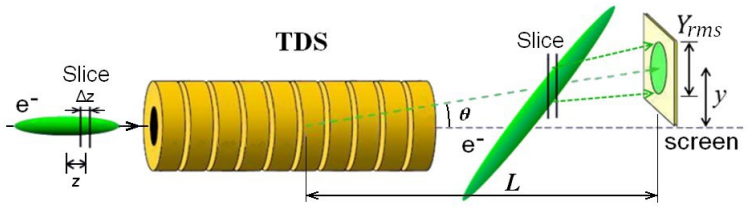
HELMHOLTZ ASSOCIATION

DESY

Transverse Deflecting System (TDS)





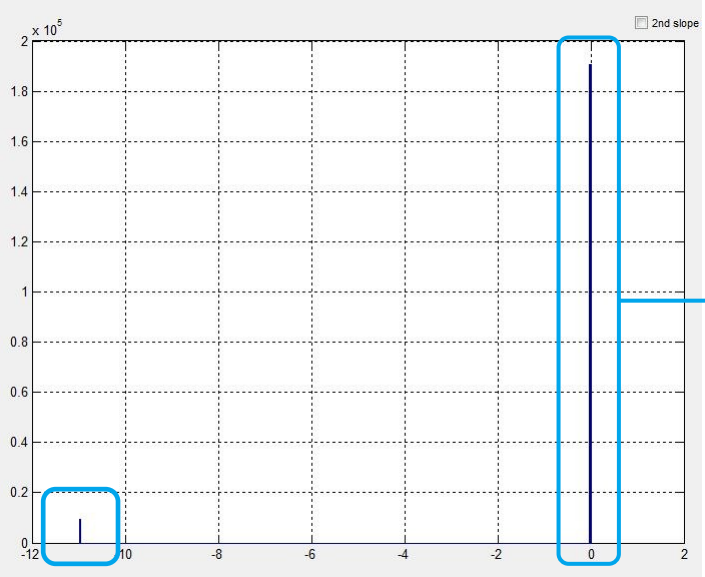


deflecting cavity: bunch length mapped to vertical axis

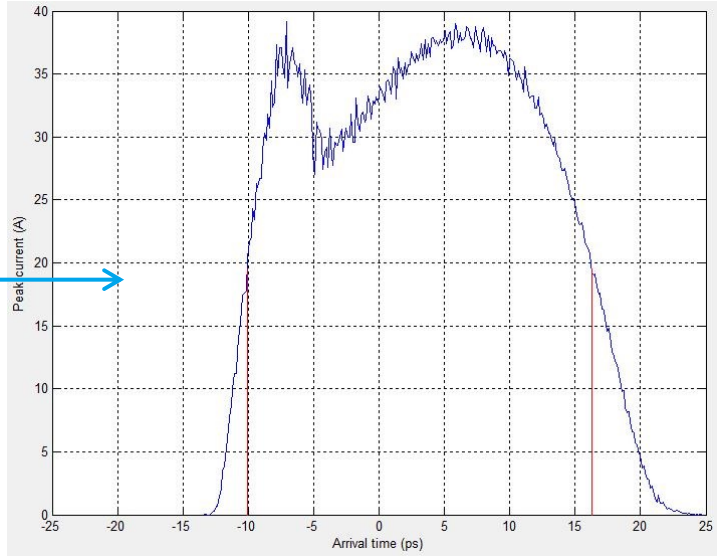
- Goal: understand TDS measurements with the help of ASTRA simulations
- Use VC2 images from experiment as input for Core+Halo generator (CHD_MK.m)
- Track particles until TDS (not until screens!)
- Parameters:
  - Gun: 53.75 MV/m, MMMG phase
  - 21 MeV/c after Booster @MMMG
  - Solenoid: ~350 A (doesn‘t matter much)
  - Long Gaussian laser pulses

ASTRA output…

- ASTRA gives z_rms, but
  - no FWHM calculation
  - no or wrong account for strange shapes / lost particles

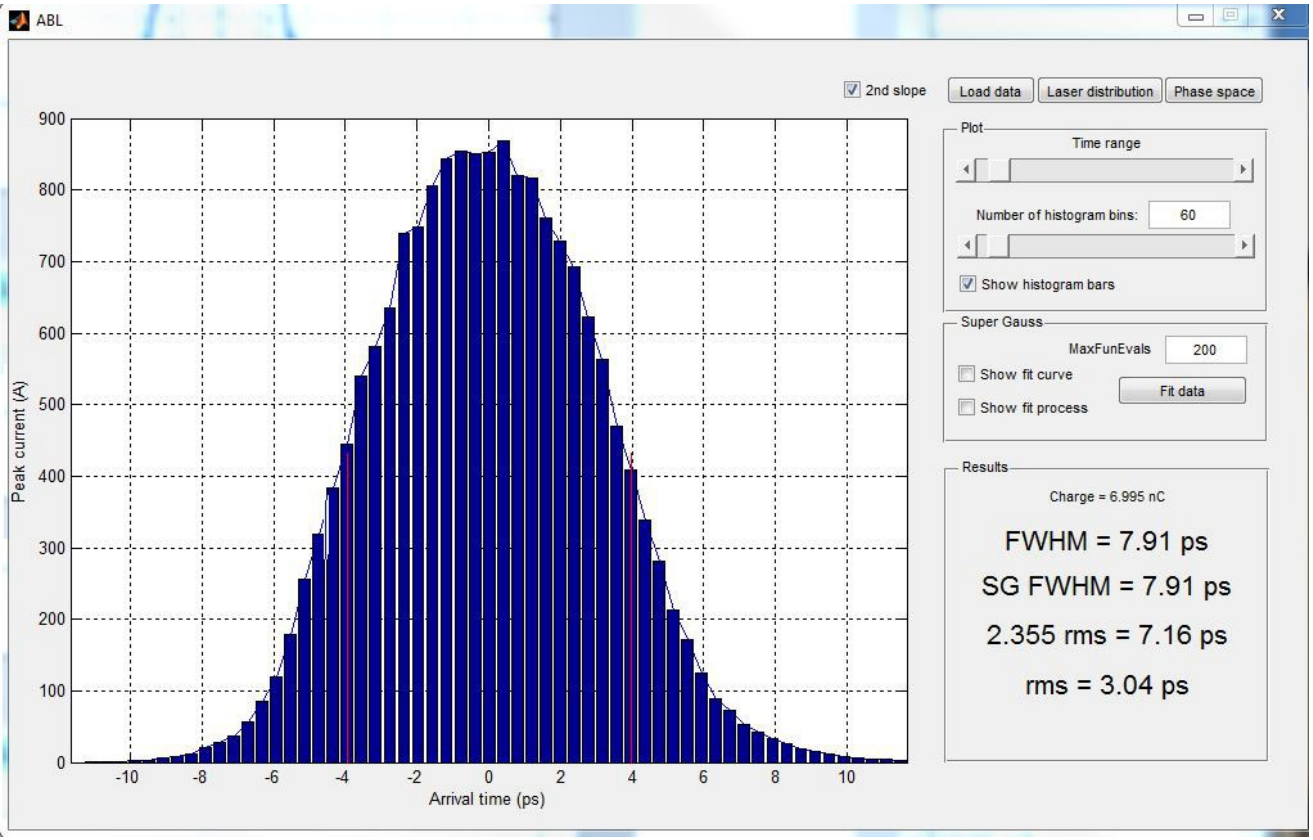


longitudinal zoom



- Manual analysis…or new post processing tool

ABL.m



- Matlab tool for interactive bunch length analysis
- Works with both ASTRA and TDS_tool output
- 3 different methods
- Bonus: viewer for laser input and 2d projections

- At the core: histogram weighted by macroparticle charge

```
edges=linspace(min(zdata),max(zdata),GG.histsize);  % edges of bins
[~, bin]=histc(zdata,edges); % "bin" is of size(data), contains index of the bin where data got sorted
counts=abs(accumarray(bin,qdata)); % weigh by charge
```

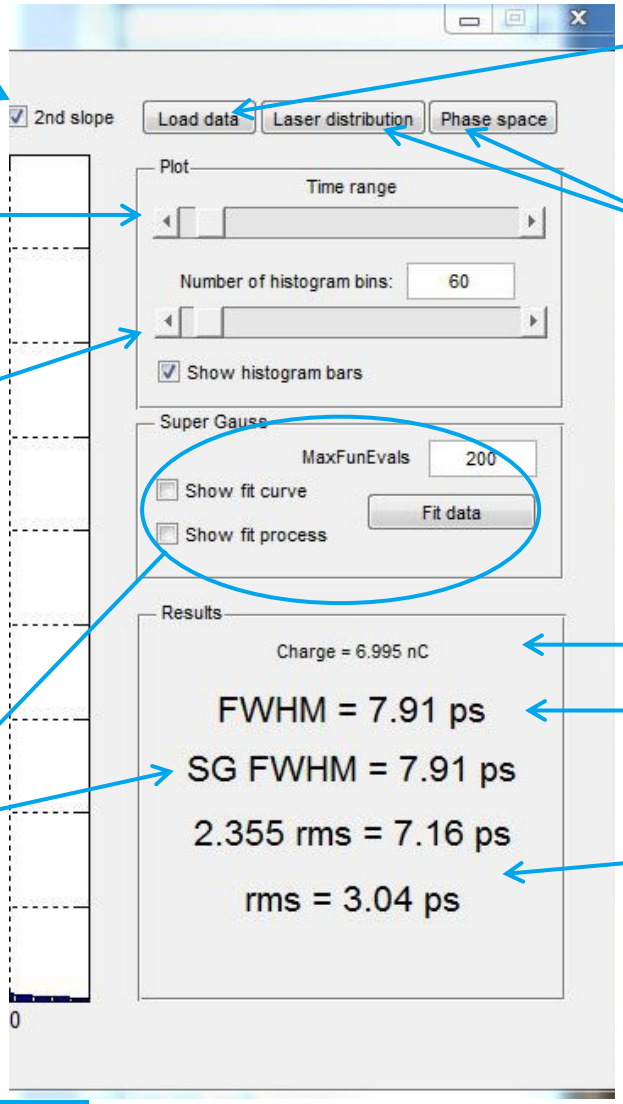
- Where to find (currently): doocs/data/huck/sim/ASTRA/ChargeBSA/ABL.m

ABL.m

choose which RF slope to load (for TDS data, not for ASTRA)

Zoom in/out; only visible particles are used for calculations

Change binning for plots and calculations



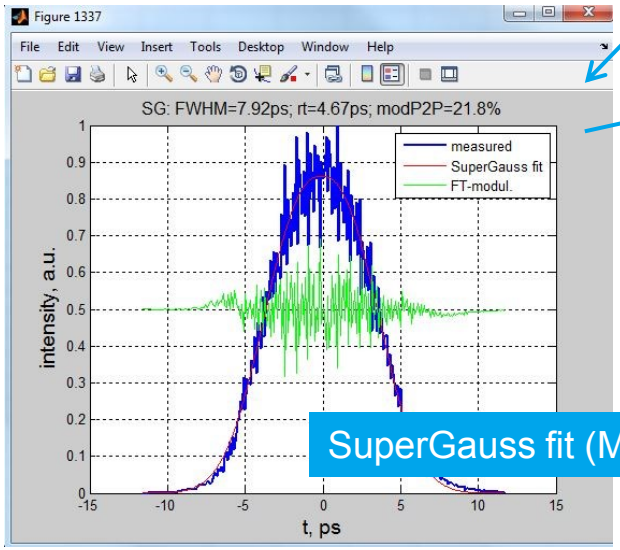
Load ASTRA (.001) or TDS_tool output (.mat)

Load / view ASTRA input distributions or phase space / 2d projections

Visible charge

FWHM bunch length

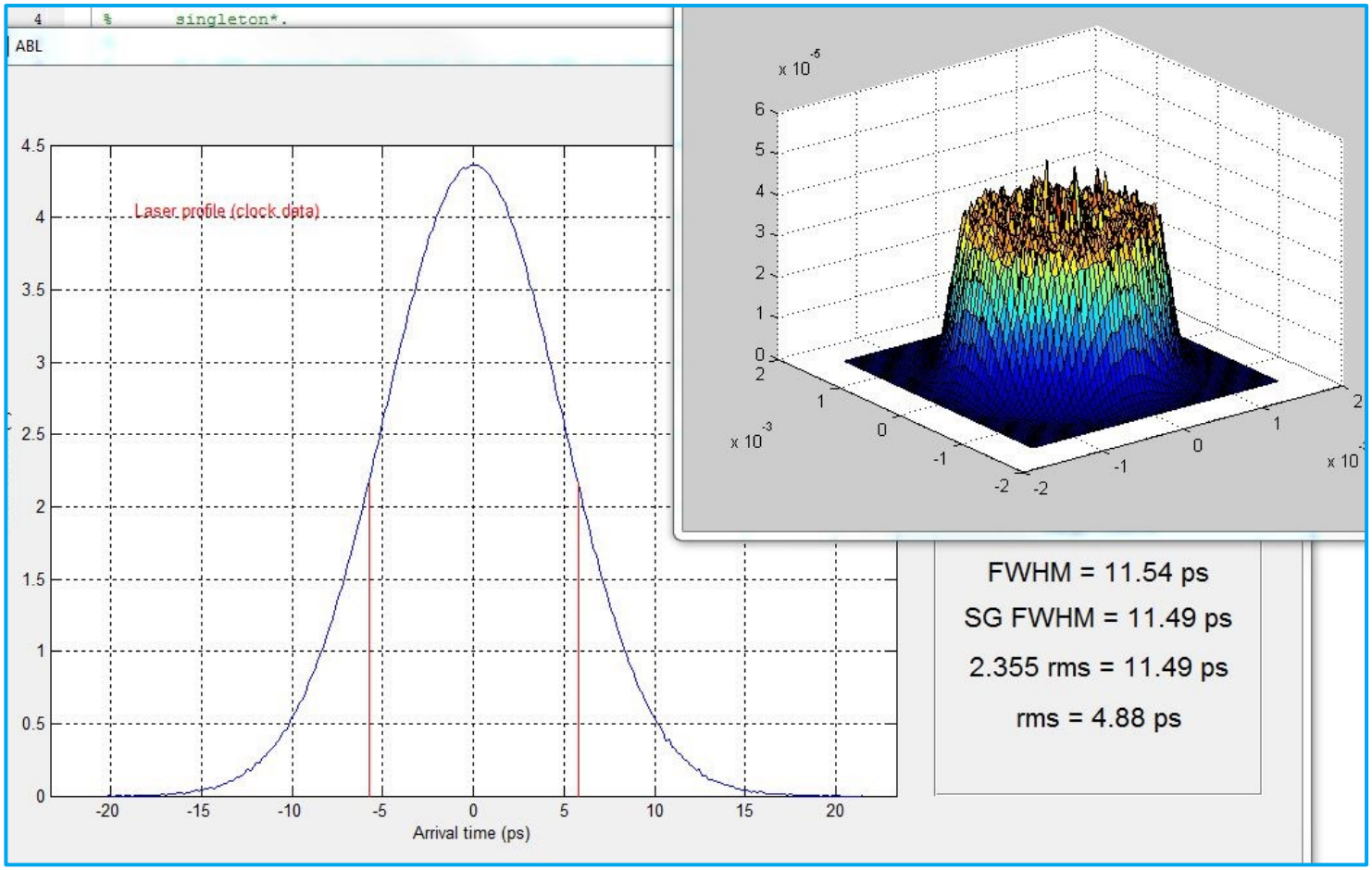
rms bunch length



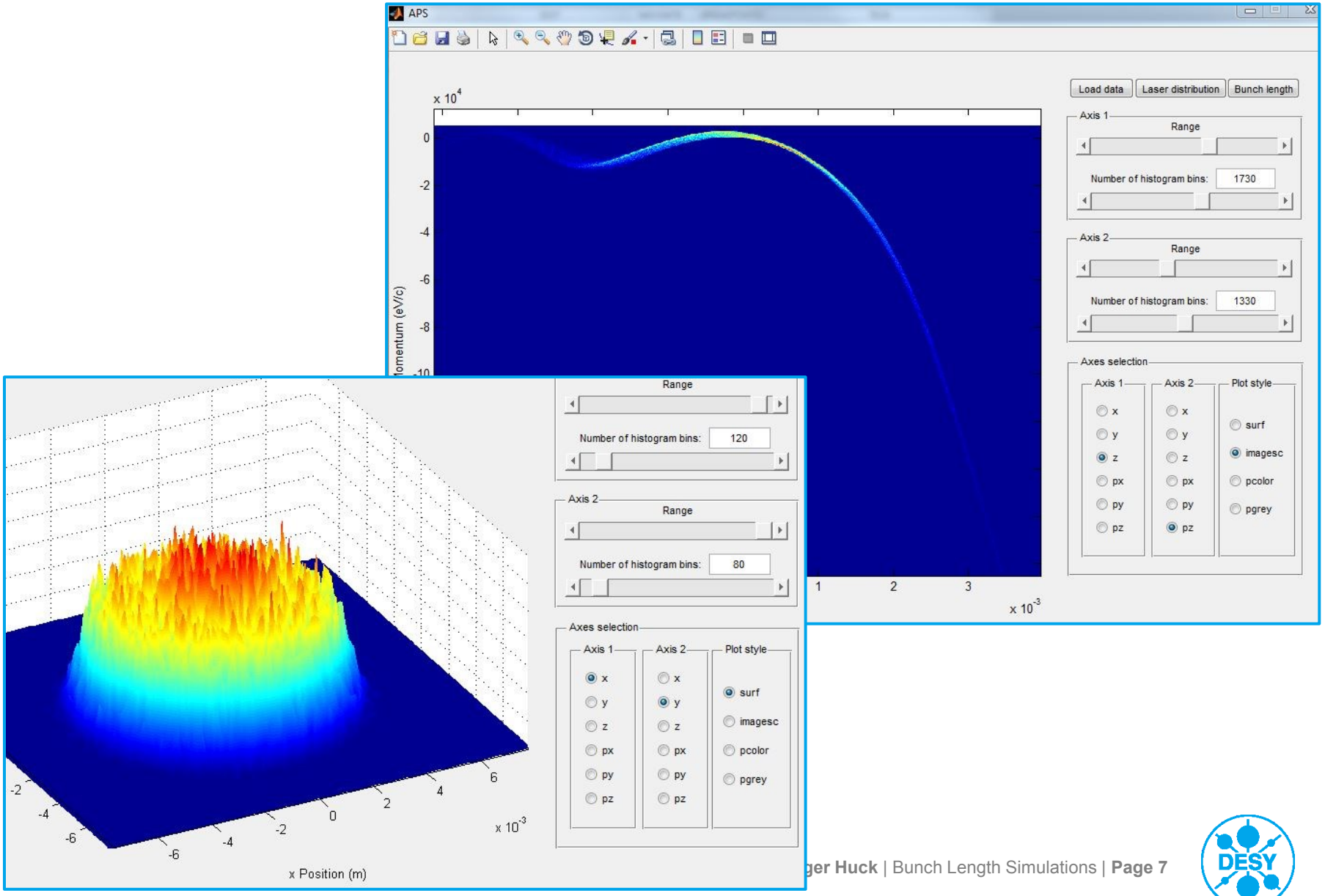
SuperGauss fit (MK)

ABL: Laser Distribution

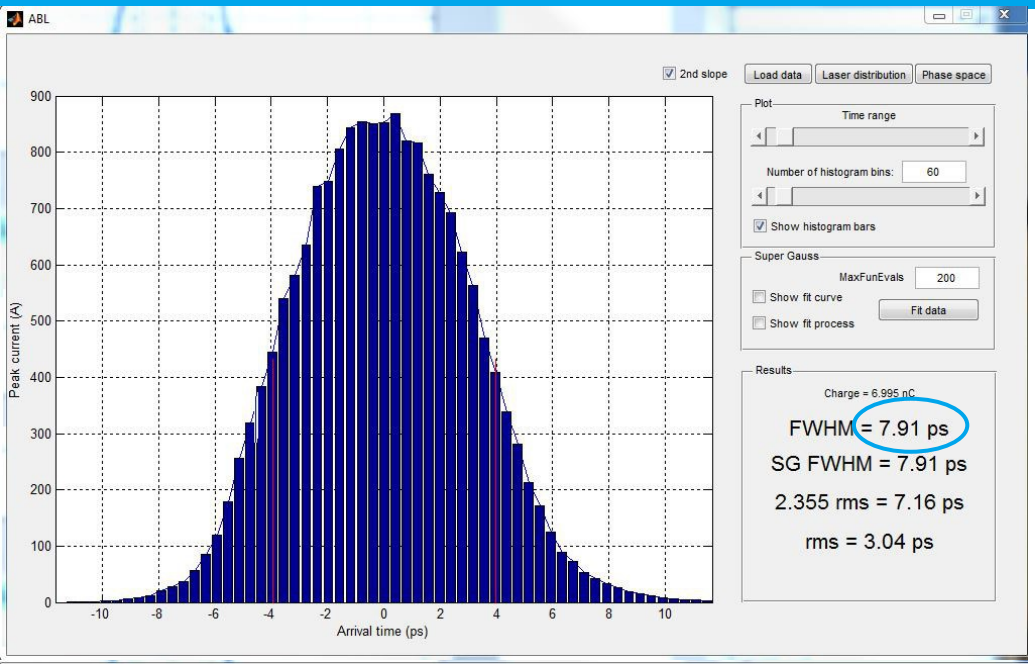
- Load ASTRA input distribution to cross-check CHD (displays transverse and also longitudinal profile / clock data)

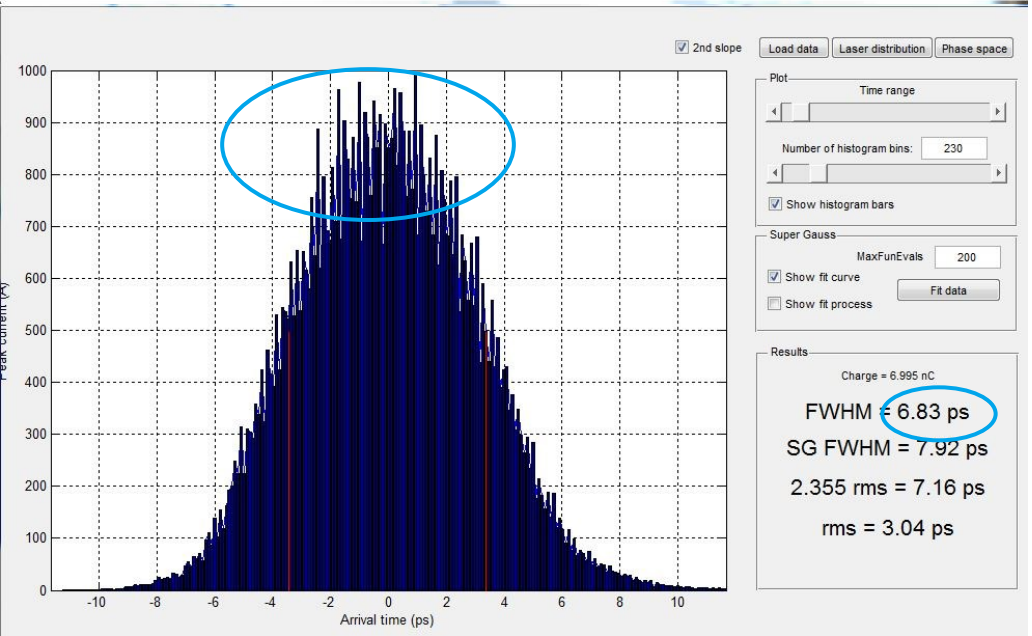


APS: Phase Space / Projections Viewer



Effect of binning

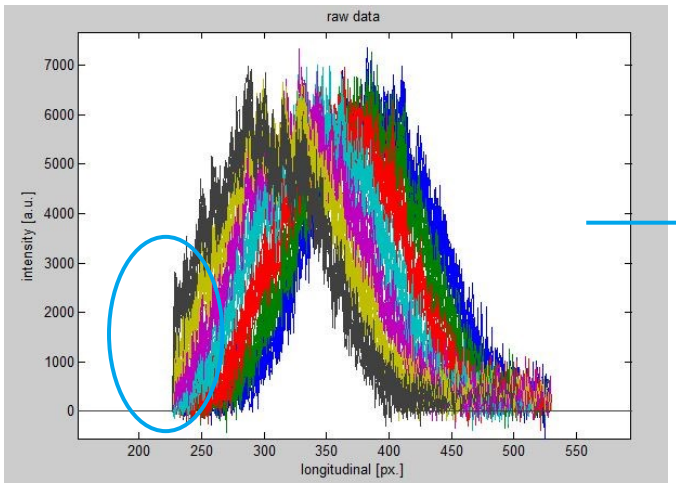


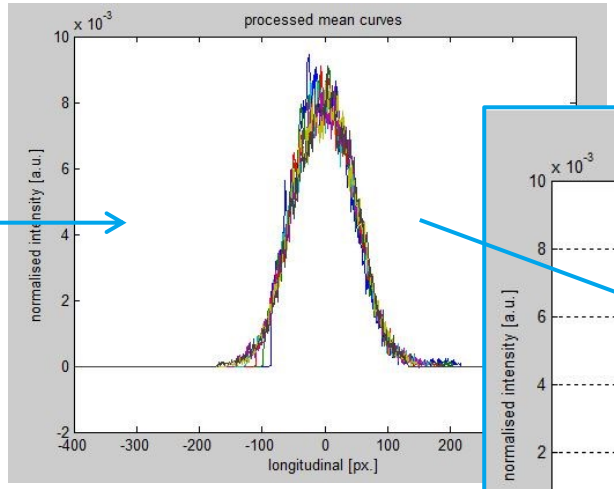


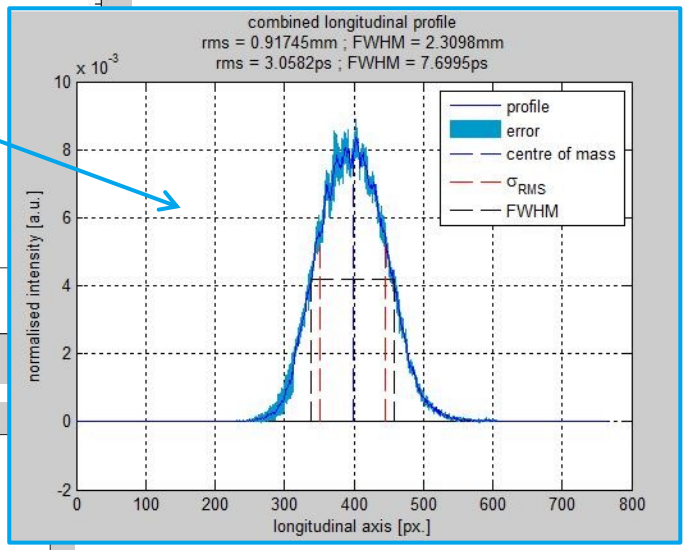
- FWHM calculation very sensitive to binning due to noise
- Noise on top: Systematic underestimation of FWHM
- Noise on edges and too large bins: random effect
- SG fit and rms much more robust
- But rms sensitive to noise outside of bunch

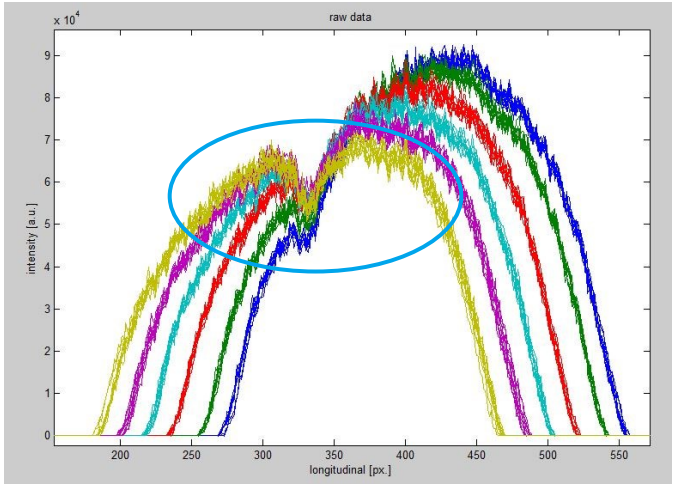
Loading experimental data from TDS_tool (*.mat)

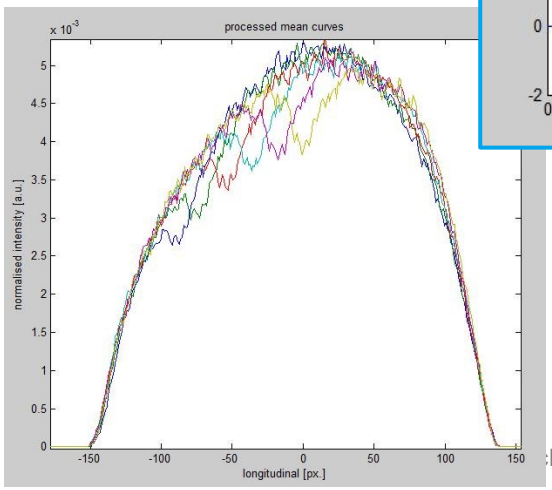
- Re-evaluate FWHM and rms with appropriate binning and z-range
- Check for systematic errors/problems (e.g. ROI cuts, screen damage, screen gradient…)



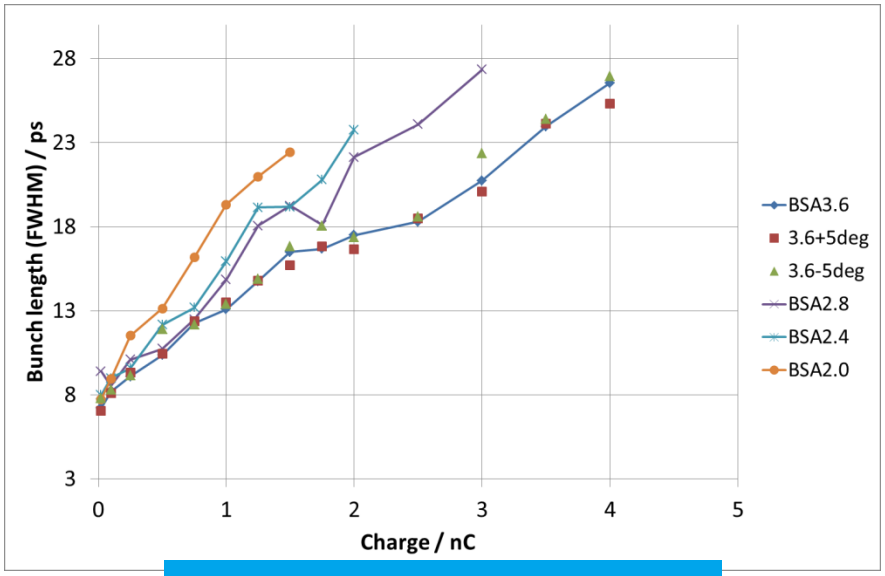


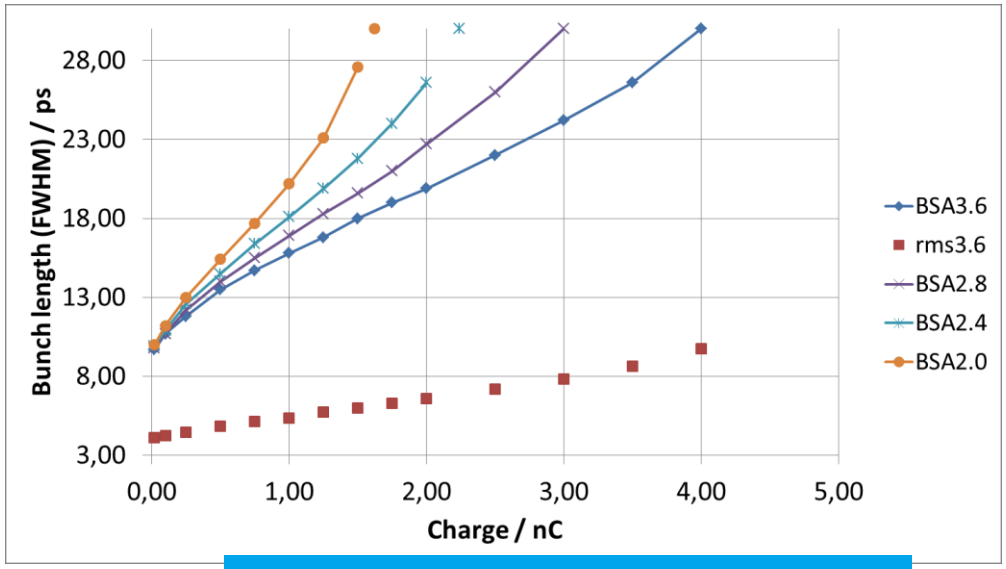




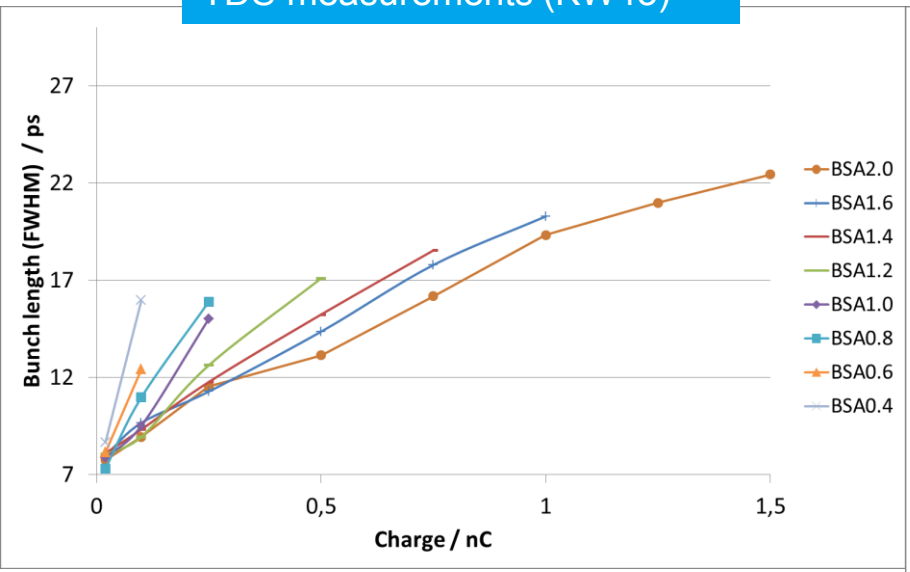


Preliminary Results: Bunch Length vs. Charge & BSA

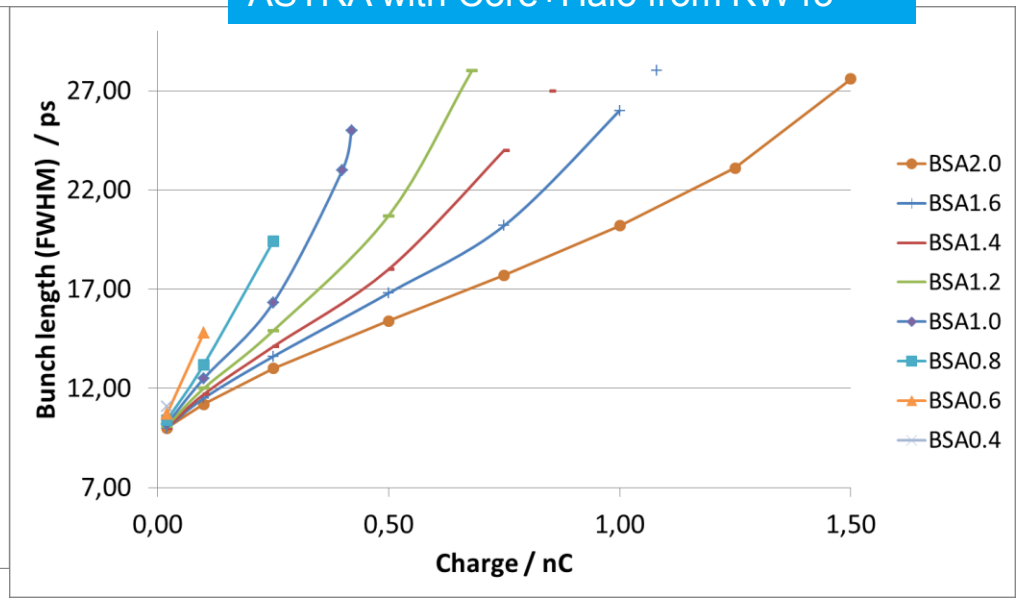




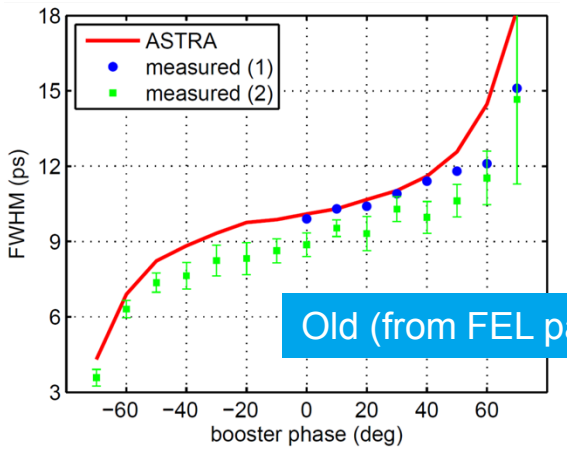
TDS measurements (KW43)



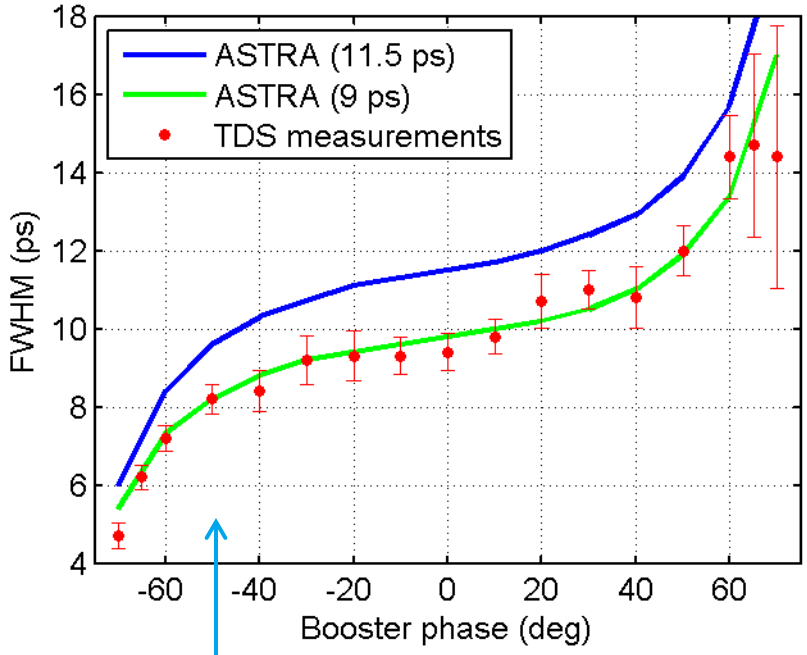
ASTRA with Core+Halo from KW43

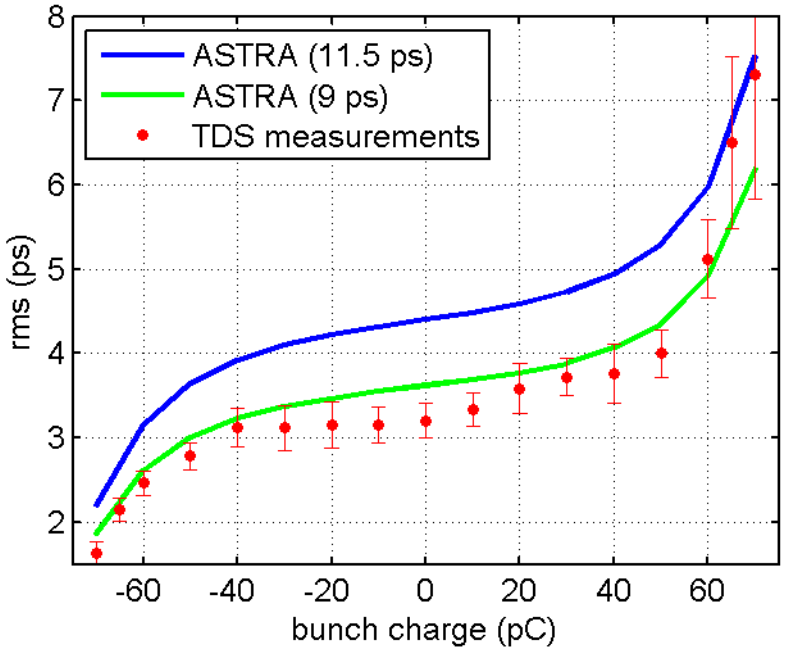


Booster Phase Scan (100 pC)



Old (from FEL paper)

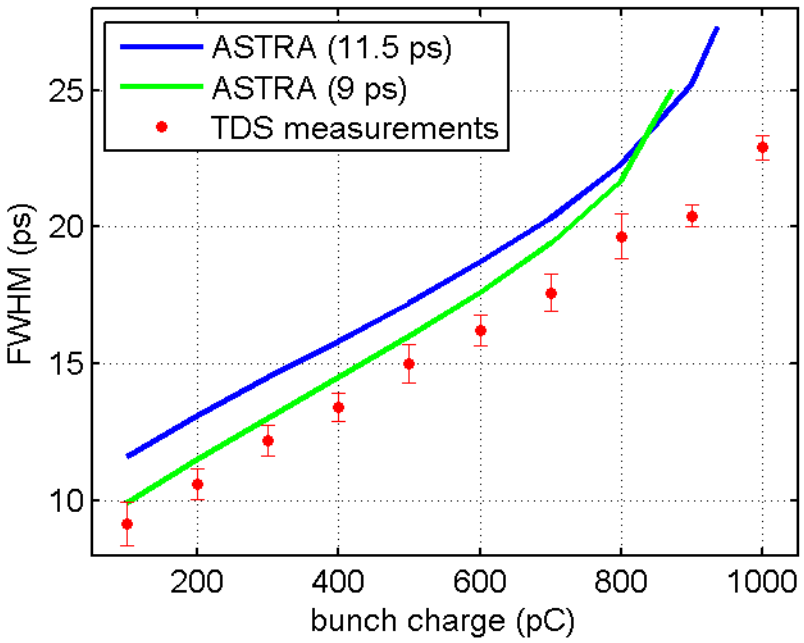


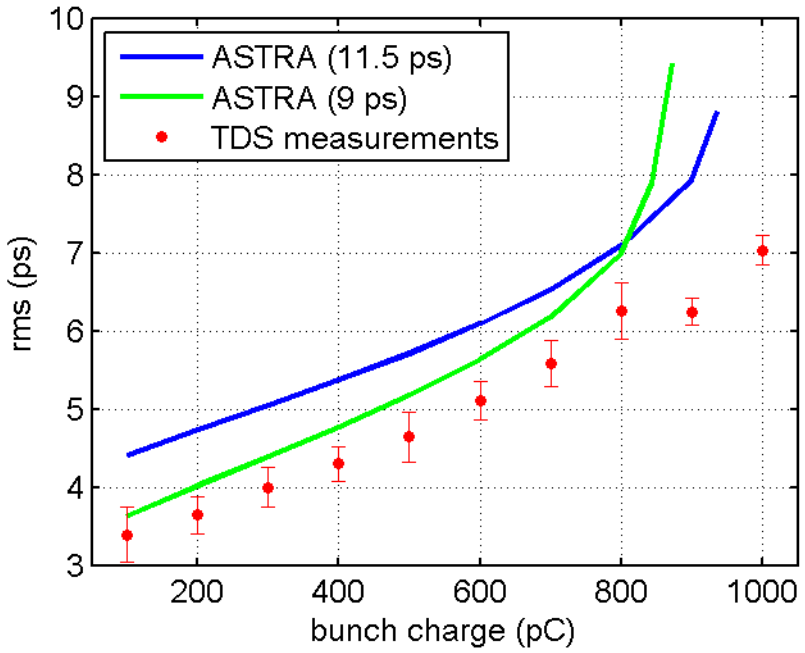


New version – experimental data are the same as green dots in FEL paper (and were used now for Core+Halo generation)

> 9 ps Gaussian laser seems to fit nicely to experiments…

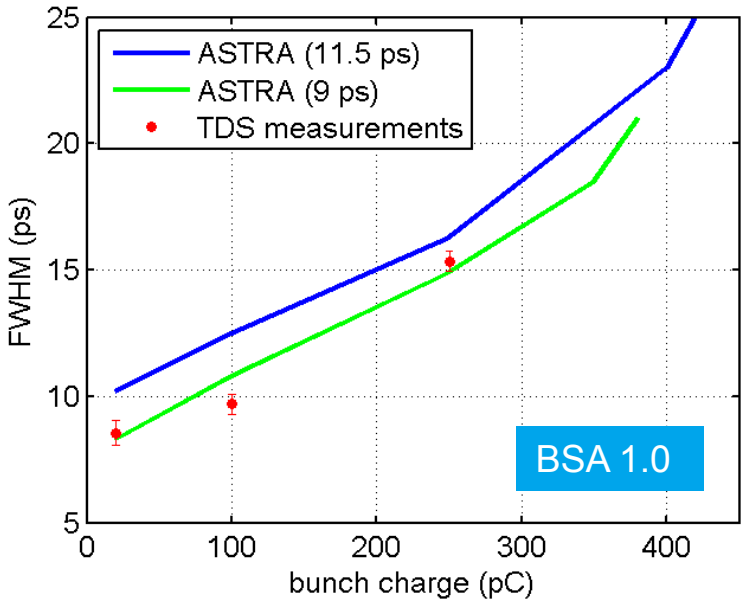
Charge Scans (BSA 1.5 mm)

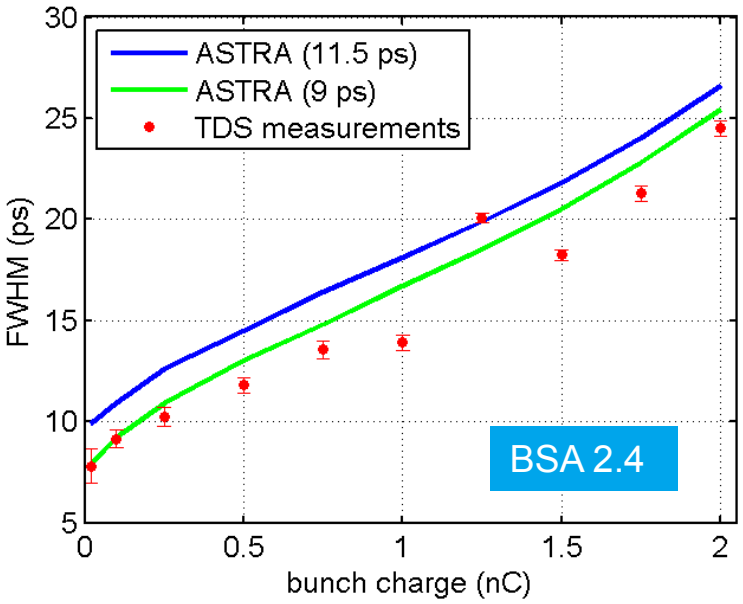


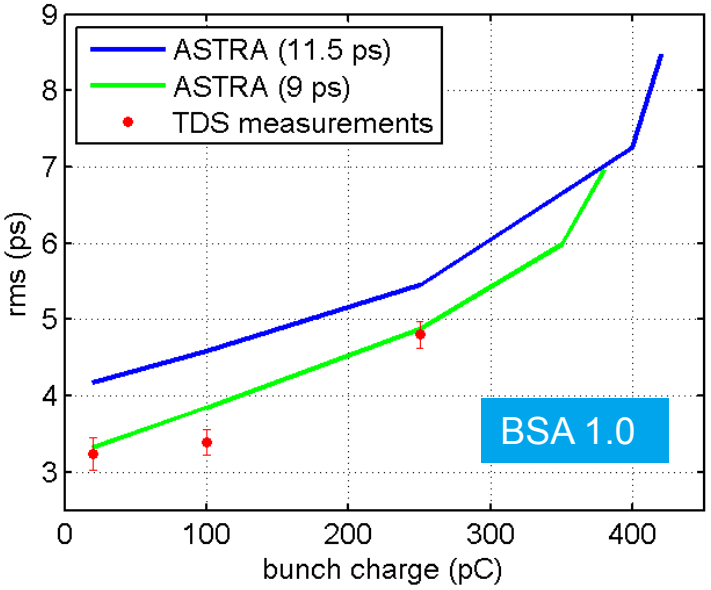


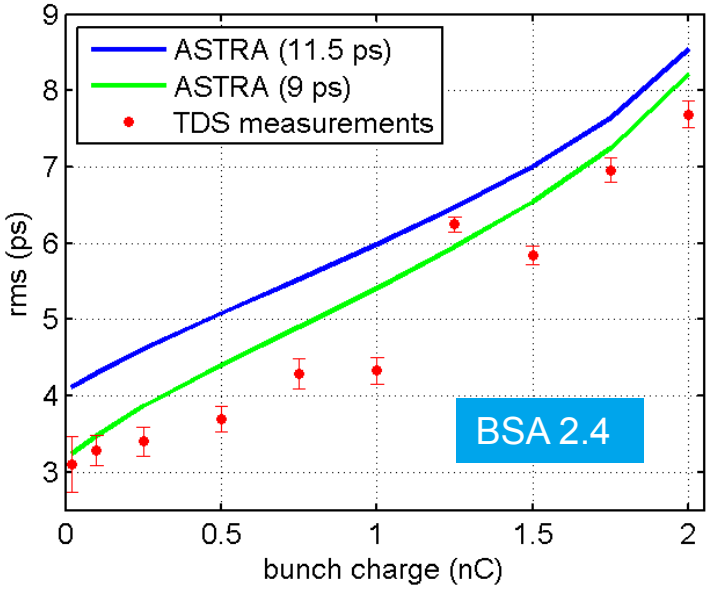
- 9 ps Gaussian laser seems to fit nicely to experiments**…or not?**

Charge Scans (BSA 1.0 and 2.4 mm)









Summary & Outlook

- Qualitativley, ASTRA simulations fit quite nicely to TDS measurements (e.g. trends of bunch length vs. Charge and BSA).
- But simulated bunches are consistently longer than in experiment (~10% to 20%), not explainable by error bars.
- 9 ps long Gaussian laser (instead of 11 ps) can explain discrepancies perfectly at low charges.
- More exp. Charge scans need to be re-evaluated
- Main error source is probably the damaged PST.scr1

Thank you for your attention!

DESY