

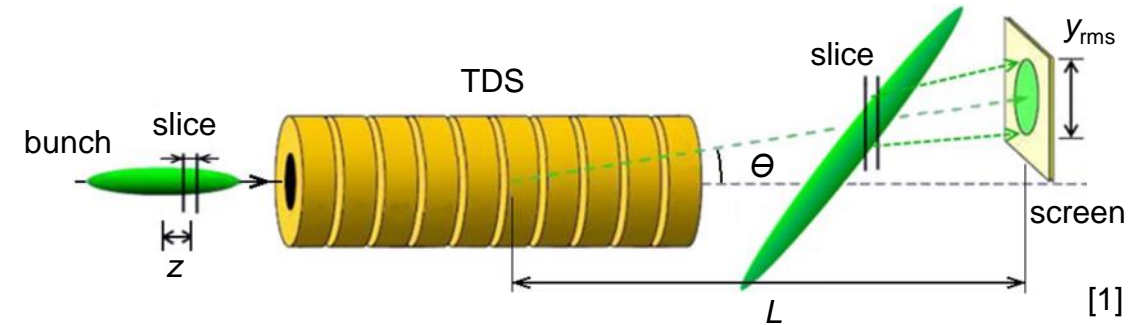
# Bunch length measurements

Bunch length and bunch profile measurements using Chronos.m

Raffael Niemczyk  
PITZ Physics Seminar  
Online, 28.04.2022

# Transversely deflecting structure (TDS)

- Mapping **longitudinal to vertical coordinate ( $z \rightarrow y$ )**
  - Bunch profile
  - Longitudinal phase space
  - Time-resolved transverse phase space (**slice emittance**)
- Properties
  - Eu-XFEL prototype
  - 3 GHz (S band)
  - Pulse length  $\leq 3 \mu\text{s}$
  - Deflection voltage 1.7 MV
  - Resolution  $\geq 200 \text{ fs}$  (typically)

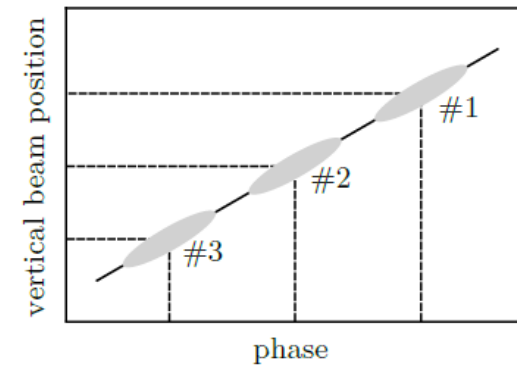
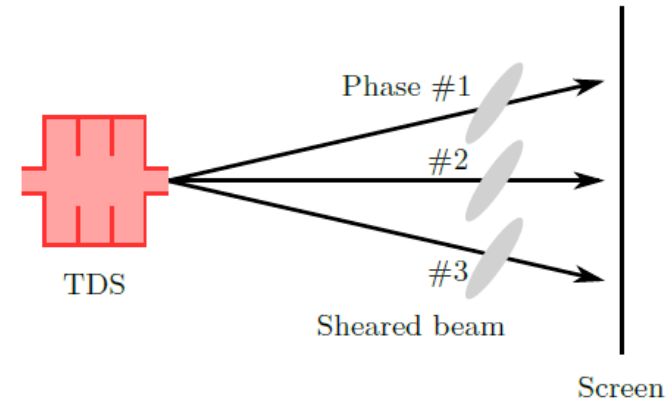


[1] D. Malyutin, Ph.D. thesis, Universität Hamburg, (2014)

# TDS calibration

- Of interest: **zero-crossing phases, shear parameter, temporal resolution**
- Shear parameter is mapping parameter:  $y = S \cdot z$

- Different rf phases  $\rightarrow$  different net streak
- Change of mean position vs. change of TDS phase
- Slope gives streak parameter



- Done at **both** zero-crossing phases
  - Sometimes different streak parameter at each slope



# Measurement procedure

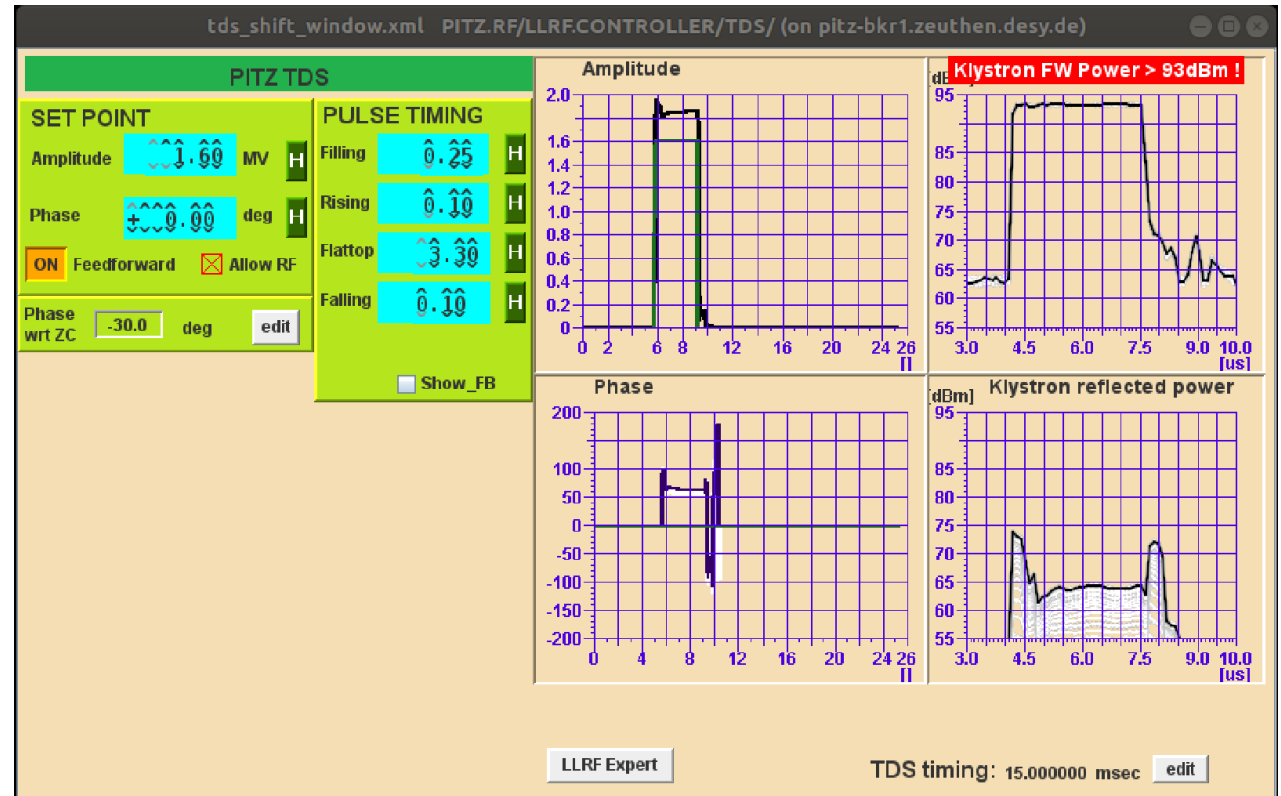
- Klystron & TDS cavity preparations
- Beam requirements
- Software operation & dialogues
  
- New software for bunch length measurements: **Chronos.m**
  - Personification of time in **ancient Greece**
  
- Overall: Software follows closely previous software



Chronos and His Child  
by Giovanni Francesco Romanelli

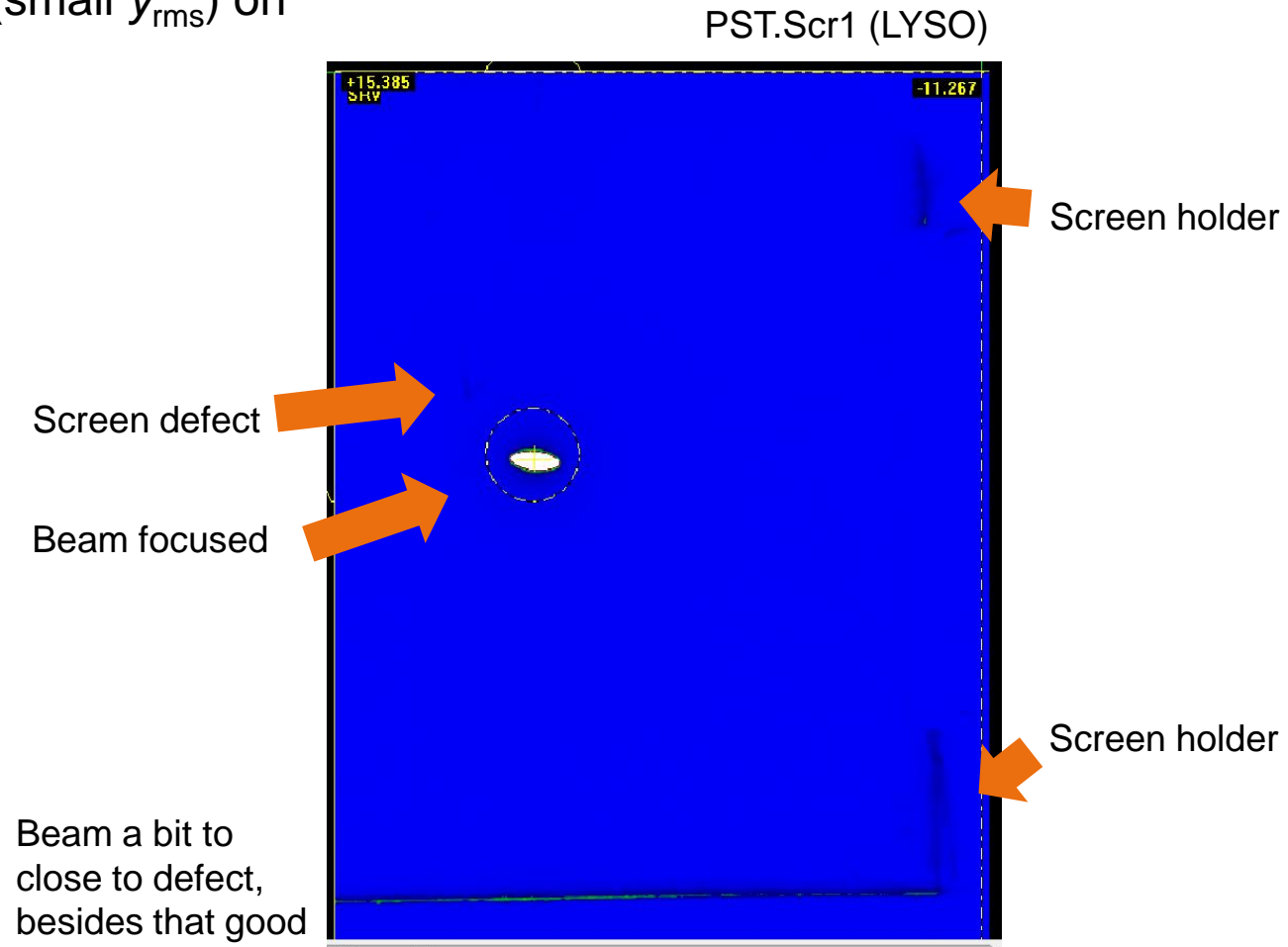
# TDS GUI

- Use manual in [confluence/control room](#) for RF5 ramp up/down
- Other than gun & booster:
  - Feedforward can be turned on & off rapidly
  - Feedbacks masked



# Bunch profile measurement

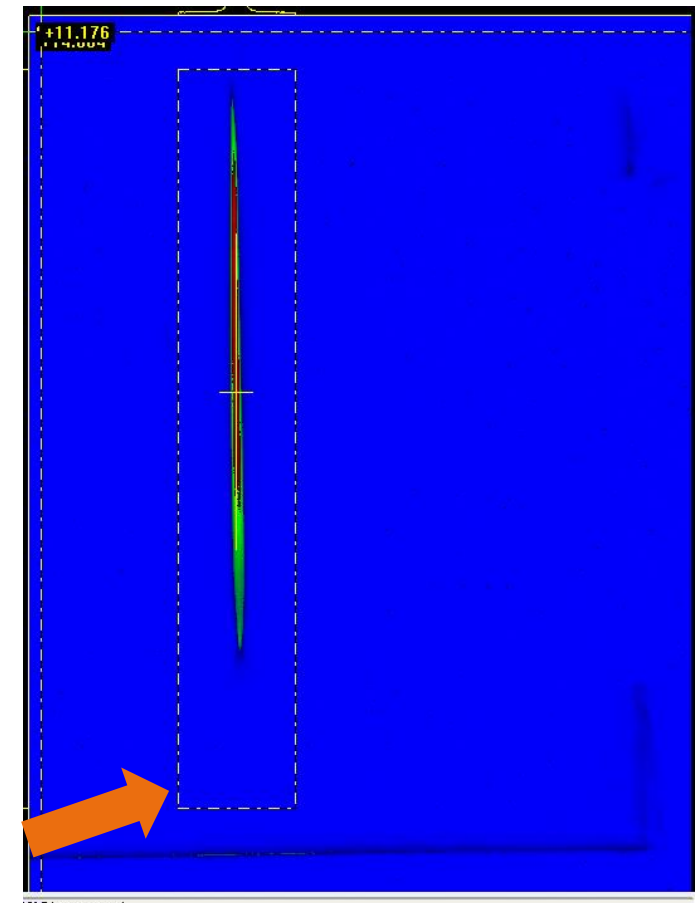
- Keep TDS off at the beginning
- Use quadrupole magnets to focus beam vertically (small  $y_{rms}$ ) on screen (usually PST.Scr1)
- Usually use High1.Q09 & Q10
  - Currents ~ +/- 4.0 Amps
- Steer beam to vertical centre of beam
  
- Use 1 bunch & 0 gain to reduce/avoid saturation



# Bunch profile measurement

- TDS power for strong streak (keep margin for phase scan)
- Centre position ~ same as unstreaked beam
  - Almost zero-crossing phase
- High signal, no saturation
  - Up to three bunches
- Adjust power for phase range
  - Range: Zero crossing +/- 3 deg
  - Stepsize: 1 – 2 deg

PST.Scr1 (LYSO)



Margin for phase scan

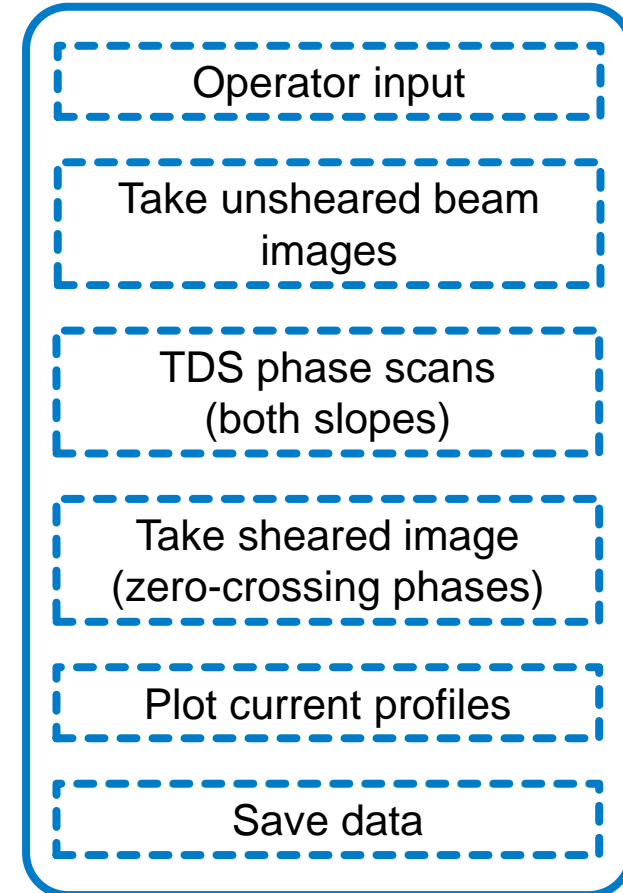
# New software implementation

- New software for bunch length measurement: Chronos.m
  - Previous version hard to maintain & introduce new features
  - Data loading was awkward
- Code slim, easy to read
- Raw data saved dapperly
  - Automatically
  - Same folder structure & naming as before

## New software features

- Scan range +/-180 deg
- Non-integer phase step
- Take bunch profiles at zero-crossing phases

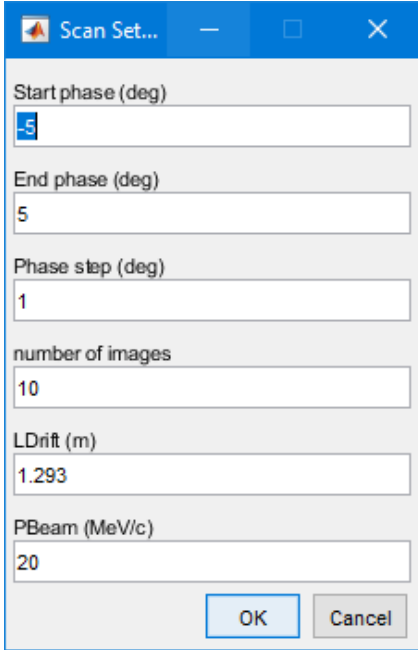
Chronos.m



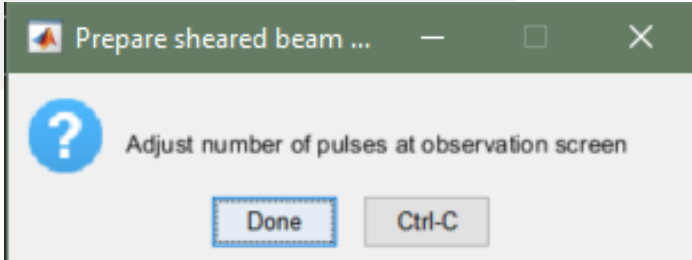
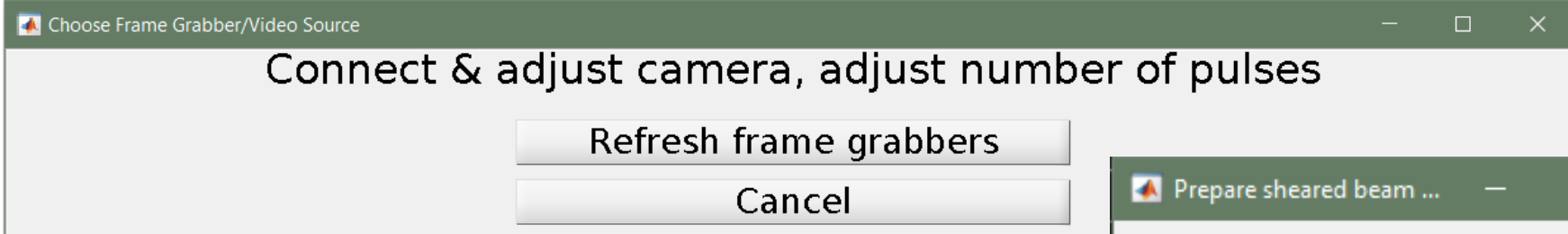


# Software dialogues

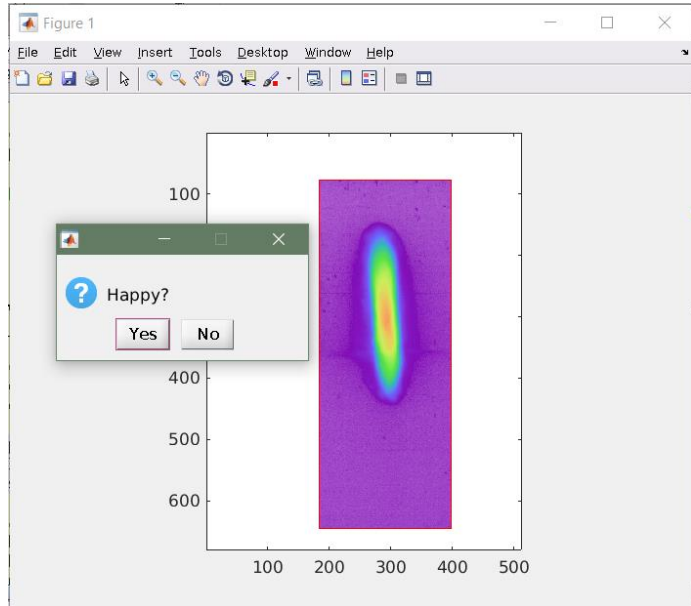
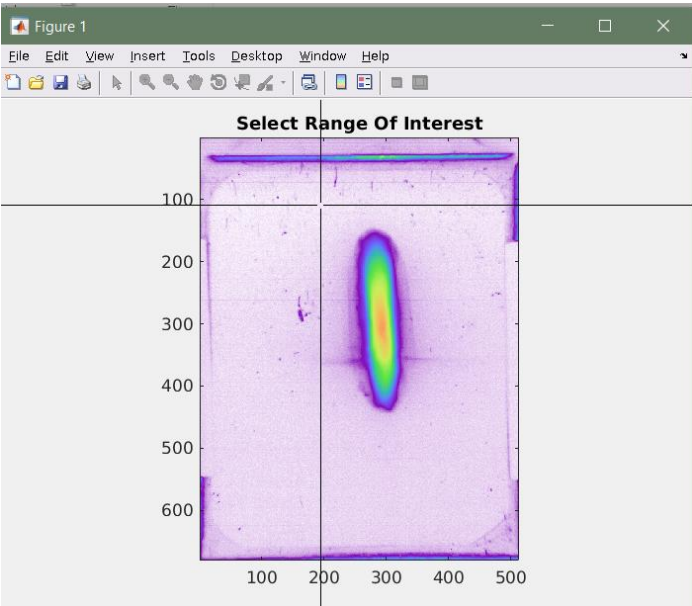
## Overall settings



## Frame grabber selection



## Select MOI for image analysis



Approve correct number of pulses

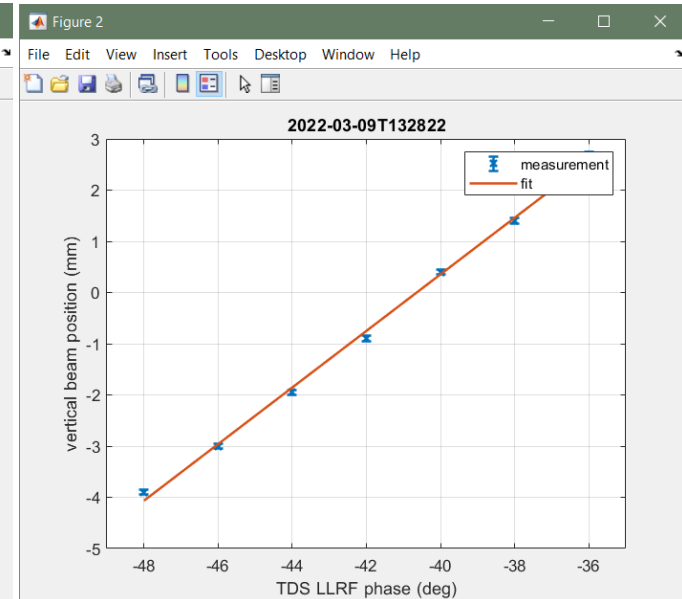
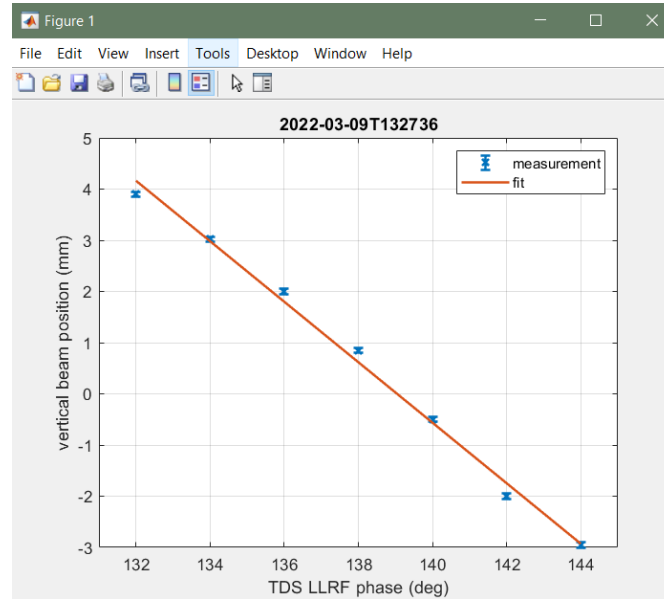
And possibly: Enter bunch charge by hand (if it is low)

# Results: Output & plots

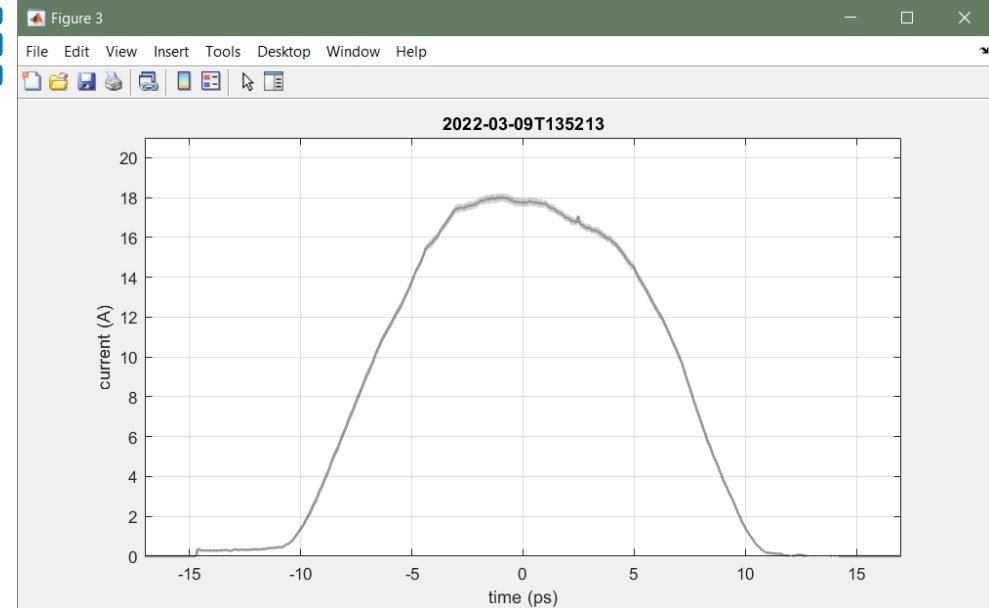
- Results of phase scan
  - Zero-crossing phases
  - Shear parameter
- Values printed to MATLAB console

```
zero-crossing phases = 139.0 deg and -40.6 deg  
shear parameter = -2.13 and 1.99  
Finished TDS calibration!
```

- Current profile
  - Both zero-crossing phases
  - Uncertainty as gray 'tube'
- Summary printed to e-logbook
- Data saved automatically without further inputs



Examples



**Thank you**

## Contact

Deutsches Elektronen-  
Synchrotron DESY

[www.desy.de](http://www.desy.de)

Raffael Niemczyk  
PITZ Group  
[raffael.niemczyk@desy.de](mailto:raffael.niemczyk@desy.de)  
+49 33762/7-7280