TDS measurements in the EuXFEL

Stuart Walker
DESY, 28.5.2025

HELMHOLTZ

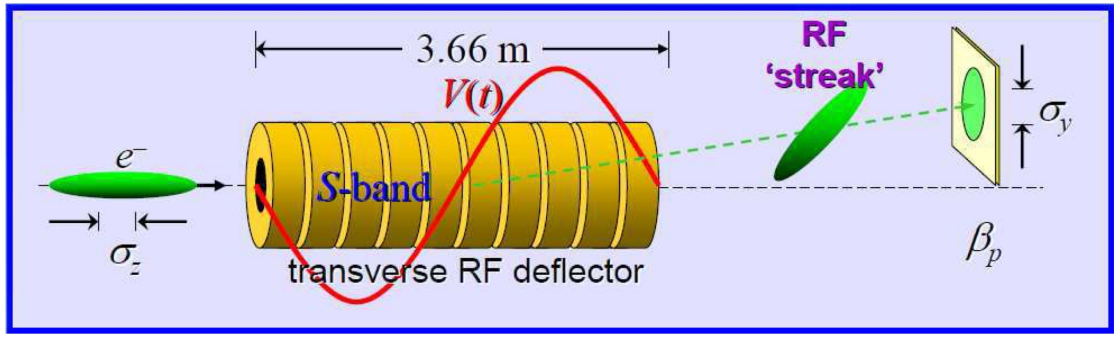
DESY.

Overview

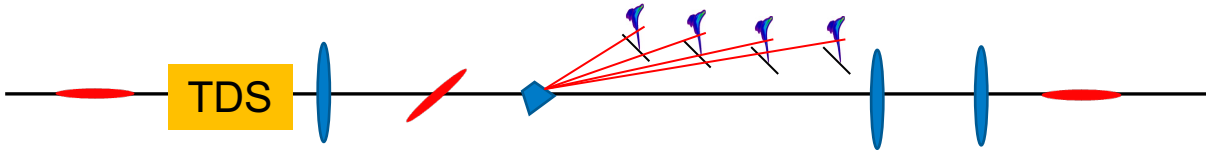
Überblick

- The goal of this talk:
  - Enable you to do parasitic TDS measurements using either of the TDSs.
- Not the goal of this talk:
  - Insights into lots of implementation details.
  - A lengthy treatise on the full set of features of the TDS software.

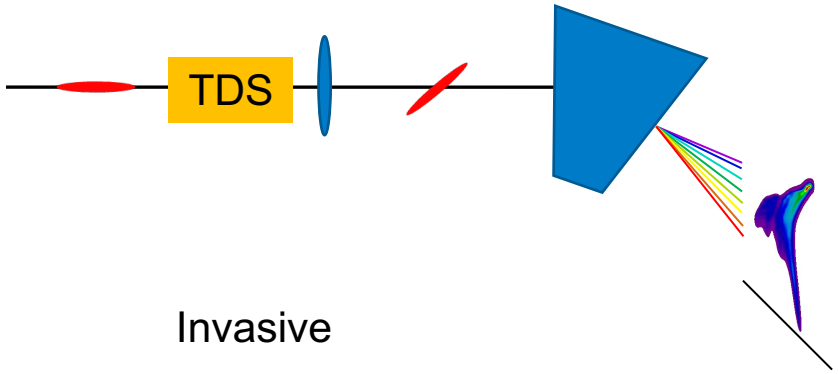
Transverse Deflecting Structures



- Apply kick to a bunch linearly proportional to distance along bunch.
- Two modes at EuXFEL: parasitic and invasive
- Parasitic
  - Individual (streaked) bunches can be extracted from the bunch train using fast kickers.
  - TDS pulse typically longer than bunch spacing—adjacent bunches will be sent automatically to TLD.
- Invasive:
  - Put screen directly in line, limiting operation to 2 bunches.
  - Ideal for LPS measurements in dump sections.
- We have two TDSs: I1 (working) and B2 (hopefully working again imminently)



Parasitic Operation



Invasive

The Measurement

Injector Off-Axis

Screen: **OTRC.58.I1**
Position: OFFAXIS

Beam Region: 1
Bunch Number: 101
Laser: Nepal XD1
Charge: 248 pC

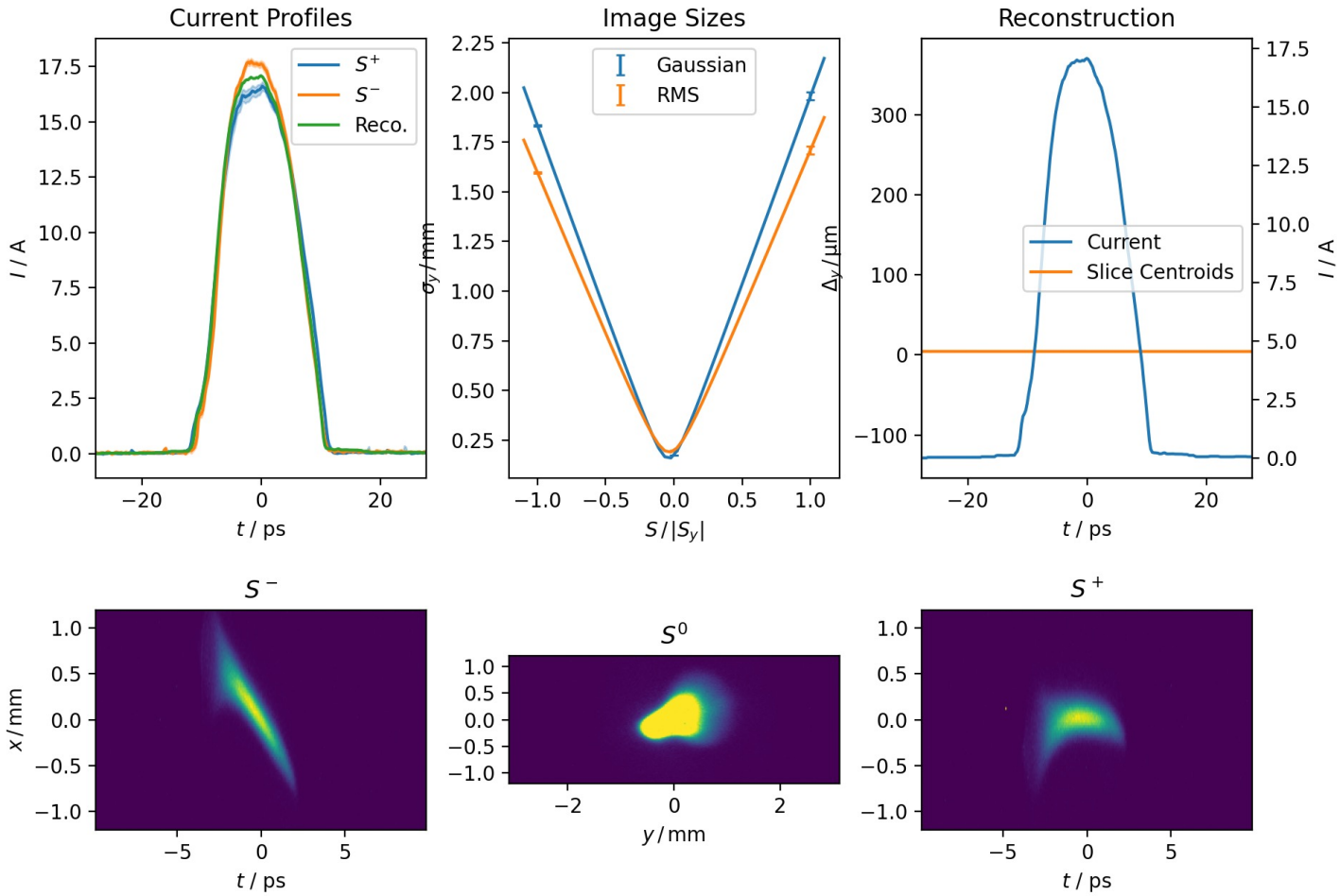
Streak: 343.2 μm/ps

Fitted Beam Parameters

	Gaussian	RMS	Units
Bunch Length	5.54	4.79	ps
Time Resolution	0.439	0.53	ps
Intrinsic Beam Size	0.156	0.188	mm
Initial Streak	13.4	11.9	μm/ps

Peak Current

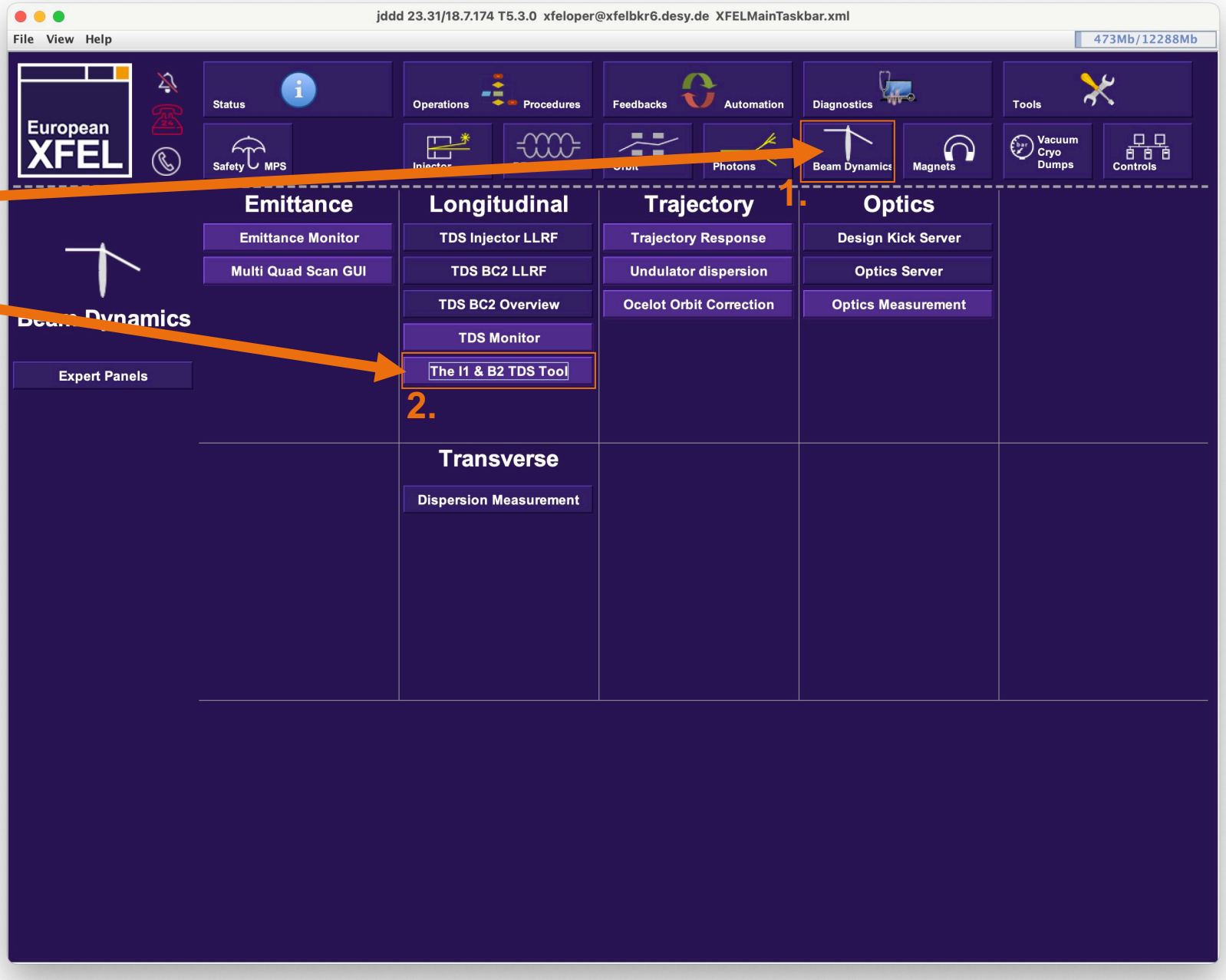
Reconstructed	17.09 A
First Crossing	16.62 A
Second Crossing	17.74 A

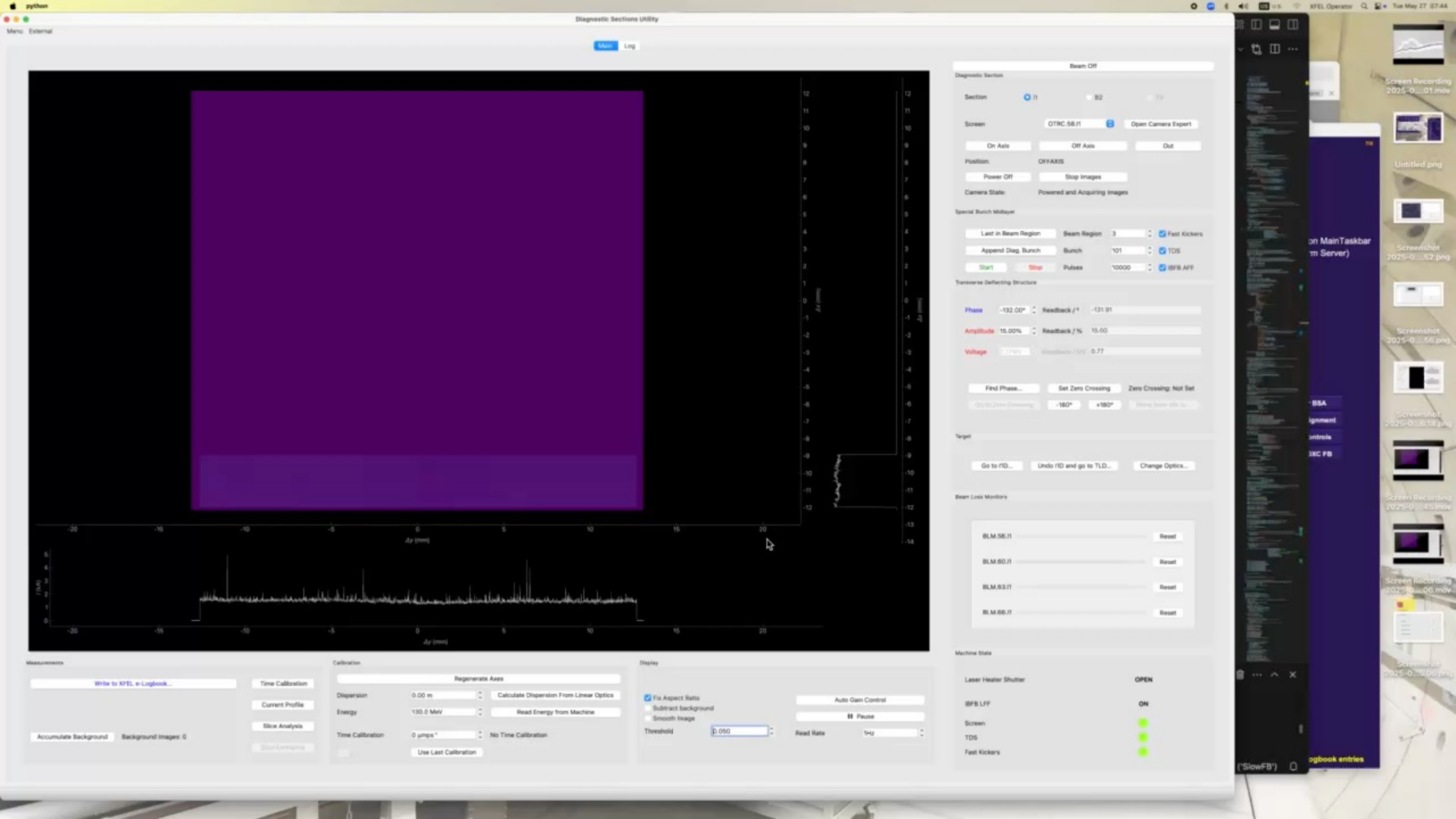


Finding the Tool

Wie man das Tool finden kann

- Beam Dynamics
  - → The I1 & B2 TDS Tool
- On some of the xfelbkr machines it can take up to a minute to start, but it does start, so be patient.
  - I don't understand why.




python
Diagnostic Sections Utility
Menu External
Main Log
Beam Off
Diagnostic Section
Section I1 B2
Screen OTRC.58.I1 Open Camera Expert
On Axis Off Axis Out
Position: OFFAXIS
Power Off Stop Images
Camera State: Powered and Acquiring Images
Special Bunch Midlayer
Last in Beam Region Beam Region 3 Fast Kickers
Append Diag. Bunch Bunch 101 TDS
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Phase -132.00° Readback / ° -131.91
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Find Phase... Set Zero Crossing Zero Crossing: Not Set
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Target
Go to I1D... Undo I1D and go to TLD... Change Optics...
Beam Loss Monitors
BLM.58.I1 Reset
BLM.60.I1 Reset
BLM.63.I1 Reset
BLM.66.I1 Reset
Machine State
Laser Heater Shutter OPEN
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Screen
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Measurements
Write to XFEL e-Logbook...
Time Calibration
Current Profile
Slice Analysis
Accumulate Background Background Images: 0
Calibration
Regenerate Axes
Dispersion 0.00 m Calculate Dispersion From Linear Optics
Energy 130.0 MeV Read Energy from Machine
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Fix Aspect Ratio
Subtract background
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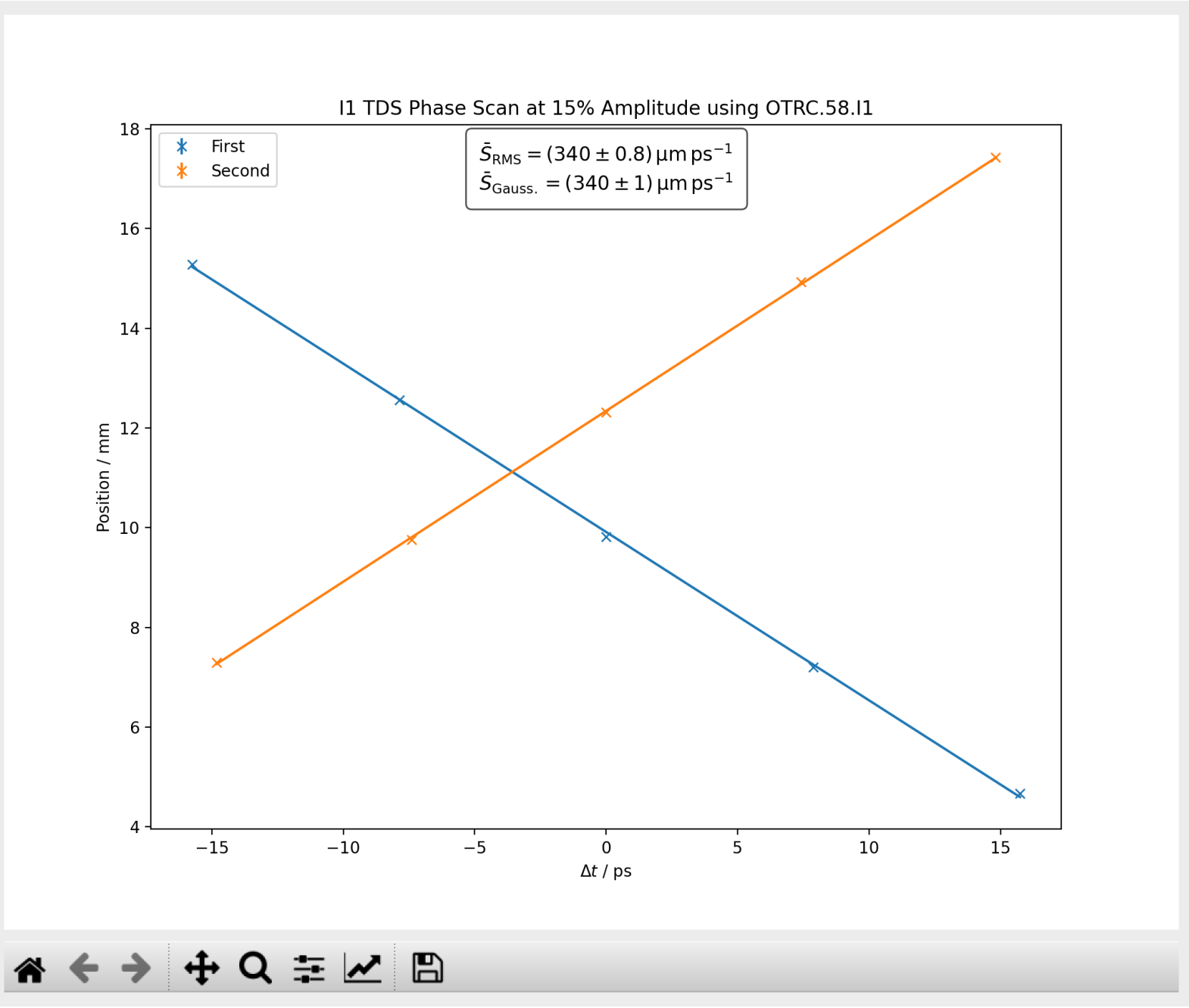
Screen Recording 2025-0...01.mov
Untitled.png
Screenshot 2025-0...52.png
Screenshot 2025-0...56.png
Screenshot 2025-0...6.18.png
Screen Recording 2025-0...45.mov
Screen Recording 2025-0...06.mov
('SlowFB')

Time Calibration

Time Calibration

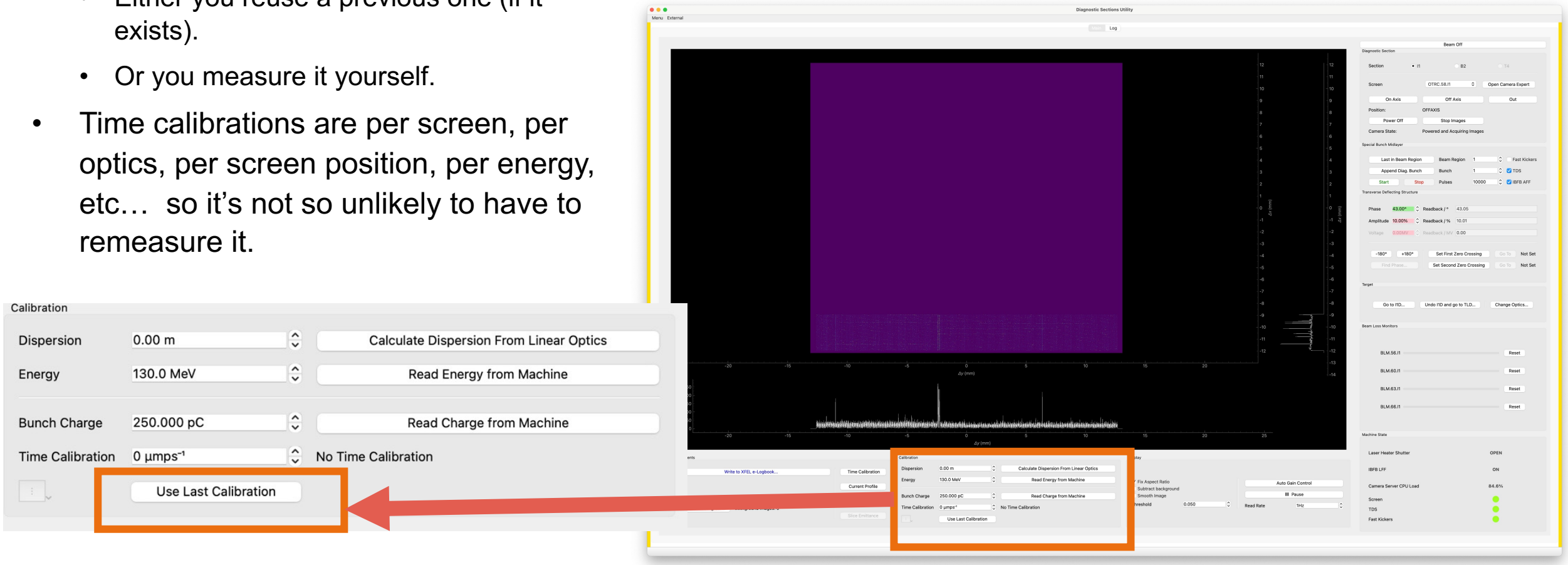
- We need to map pixels on the screen to time.
- To do this we adjust the phase of the TDS and see measure how much the beam moves on the screen. This is possible because we know the optics, the beam energy, and the TDS frequency.



Time Calibration

Reusing a previous time calibration

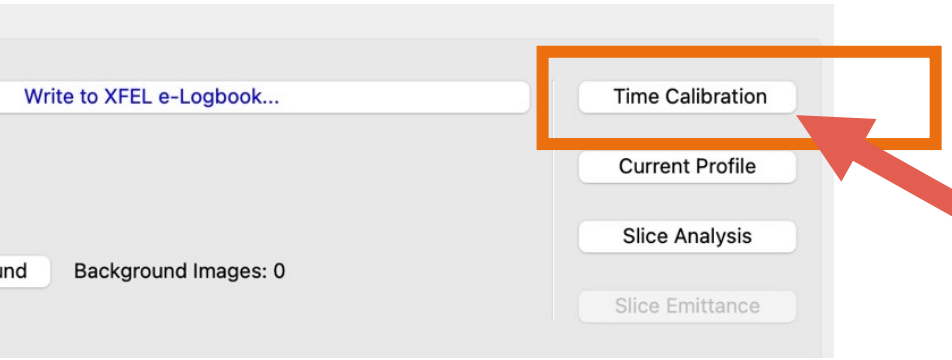
- Two choices:
  - Either you reuse a previous one (if it exists).
  - Or you measure it yourself.
- Time calibrations are per screen, per optics, per screen position, per energy, etc… so it's not so unlikely to have to remeasure it.

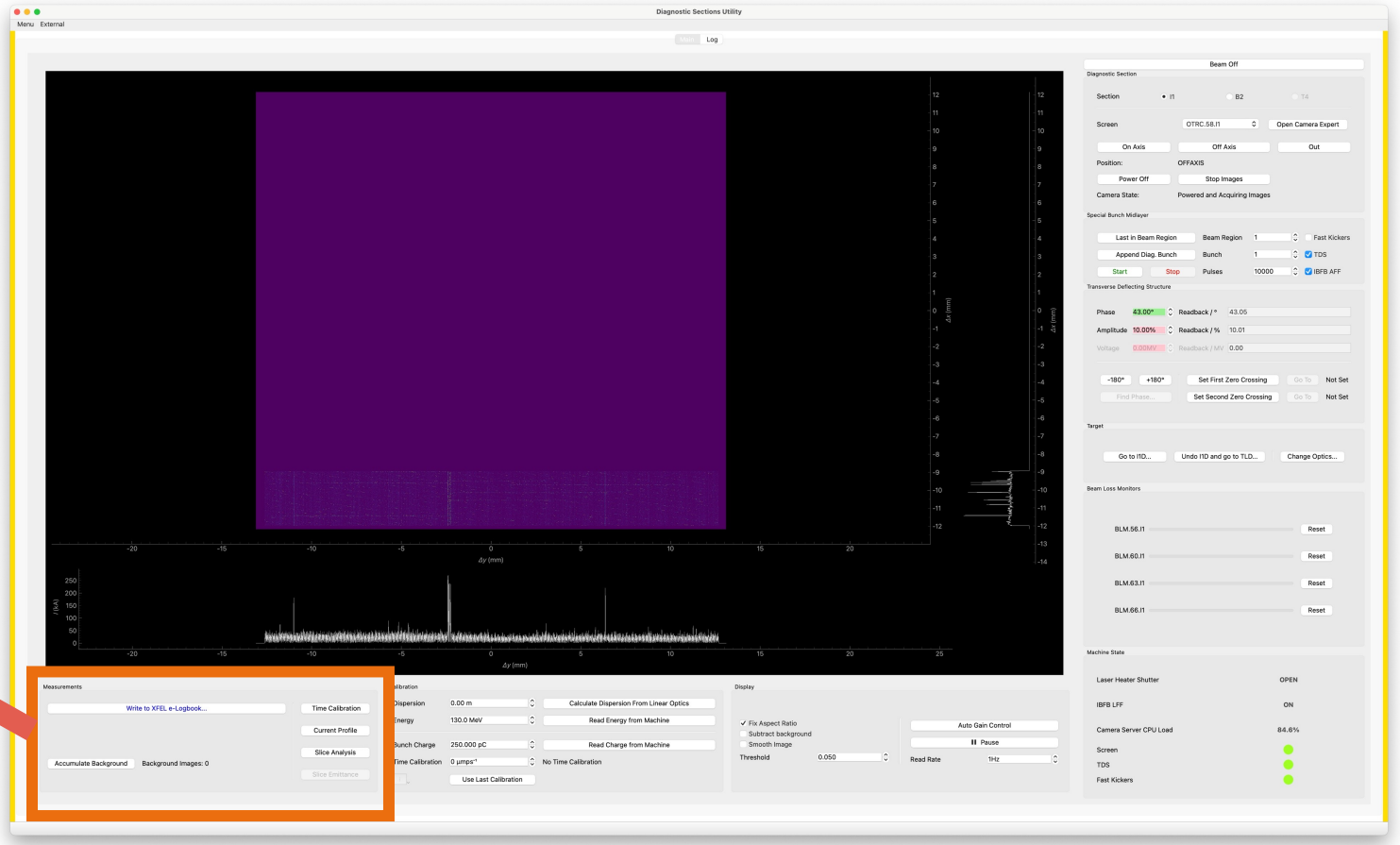


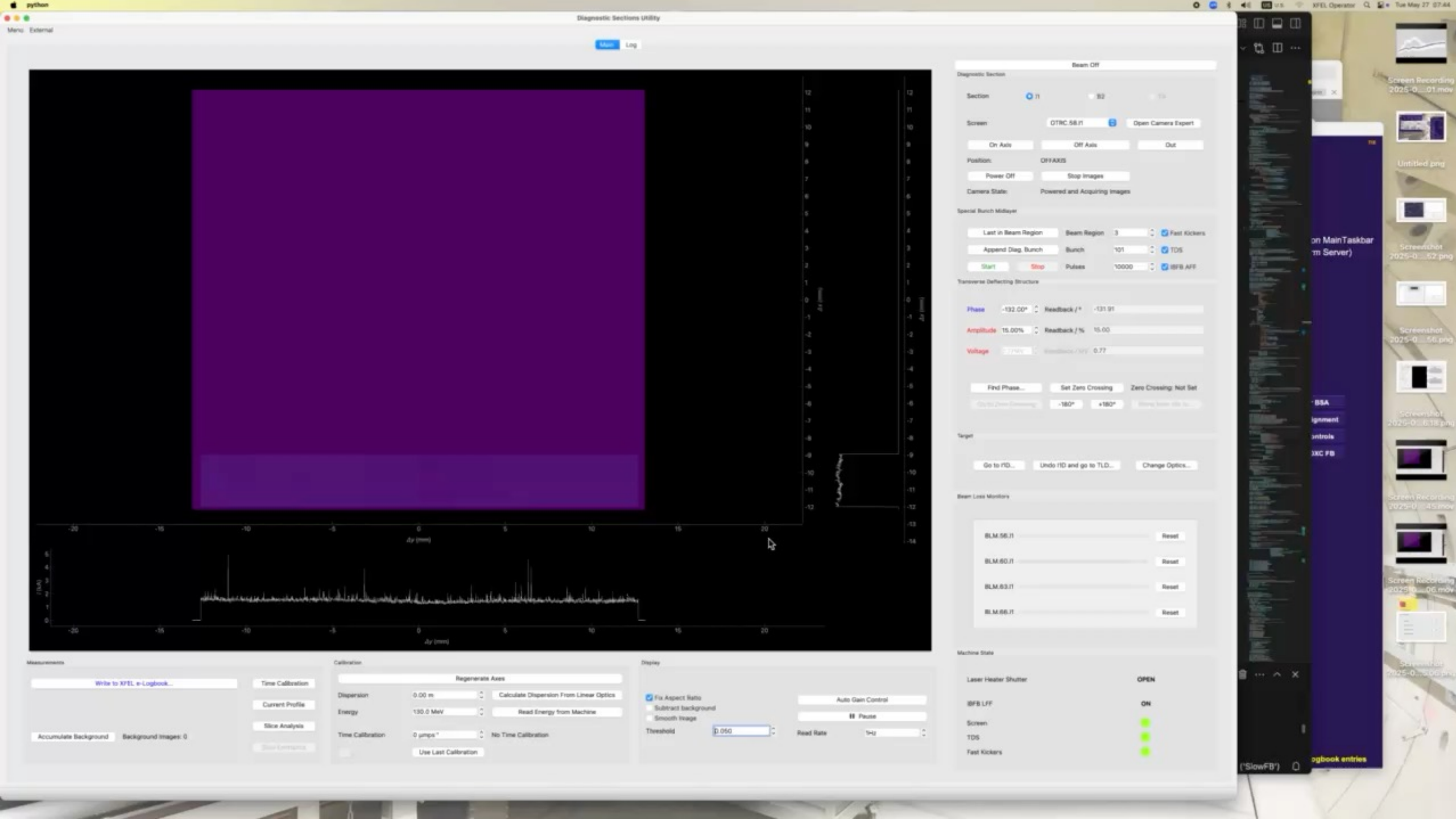
Time Calibration

Measuring it yourself

- Measuring it yourself is slightly more involved, but still only should take a minute or so.



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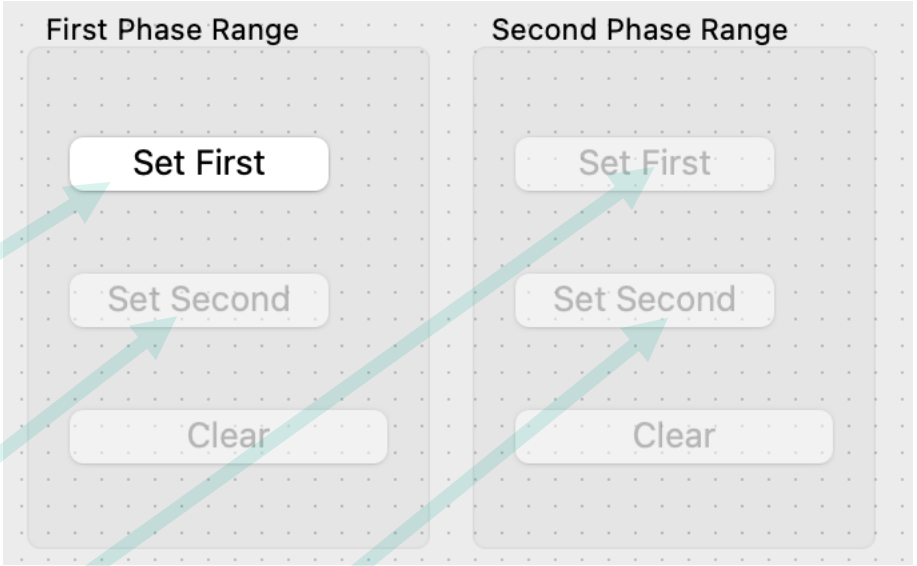
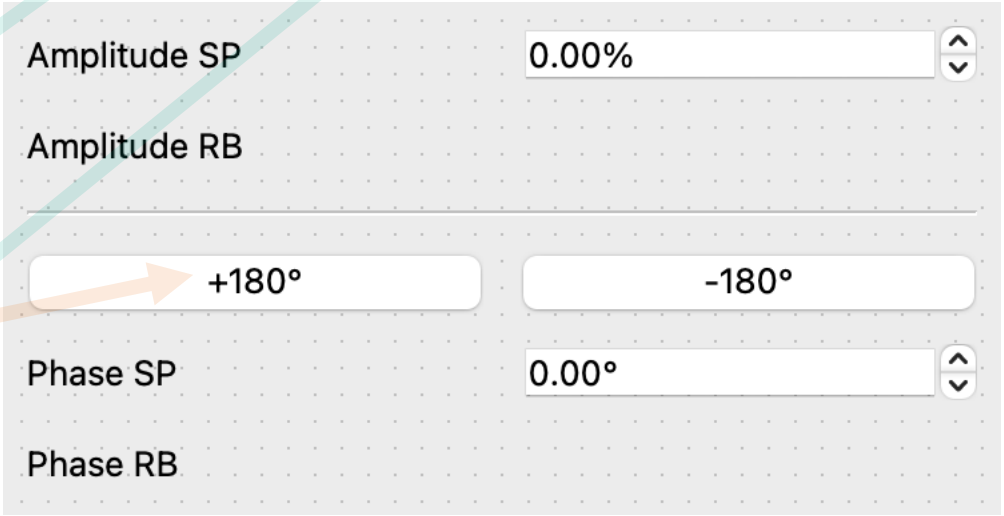
Screenshot 2025-0...2.06.png
Logbook entries

Setting the Phase Ranges

- Two TDS phase zero crossings, one phase either side of each crossing corresponding to the edge of the screen = 4 phases to be set.

1. Start the special bunch midlayer so that the beam is streaked on the screen.
2. Adjust the TDS phase to move the beam to one side of the screen. Press: Set First.
3. Adjust the TDS phase to move the beam to the other side of the screen. Press: Set Second.
4. Move to the other zero crossing with +180°.
5. Adjust the TDS phase to move the beam to one side of the screen. Press: Set First.
6. Adjust the TDS phase to move the beam to the other side of the screen. Press: Set Second.





7. Press “Start Calibration”.

Current Profile Measurement

Current Profile

- We must take beam images with the beam streaked in both directions, as well as unstreaked.
- This allows us reconstruct the current profile, extract the time calibration, and incoming tilt.

Screen: **OTRC.58.I1**
Position: OFFAXIS

Beam Region: 1
Bunch Number: 101
Laser: Nepal XD1
Charge: 248 pC

Streak: 343.2 μm/ps

Fitted Beam Parameters

	Gaussian	RMS	Units
Bunch Length	5.54	4.79	ps
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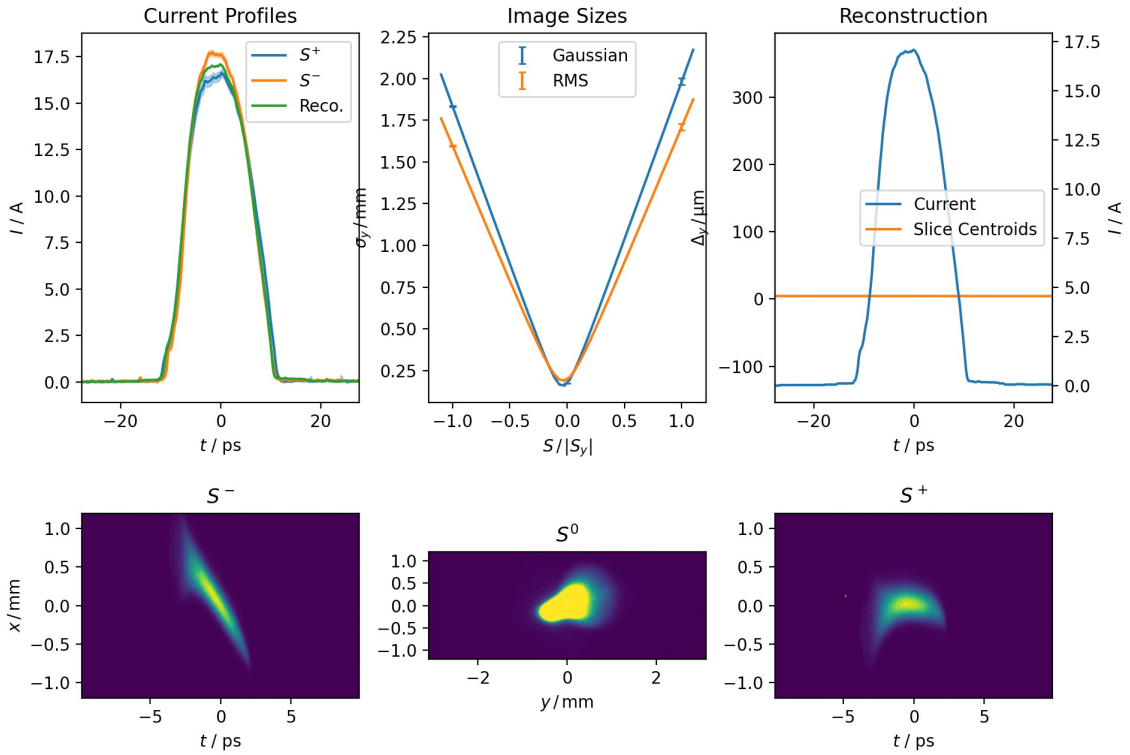
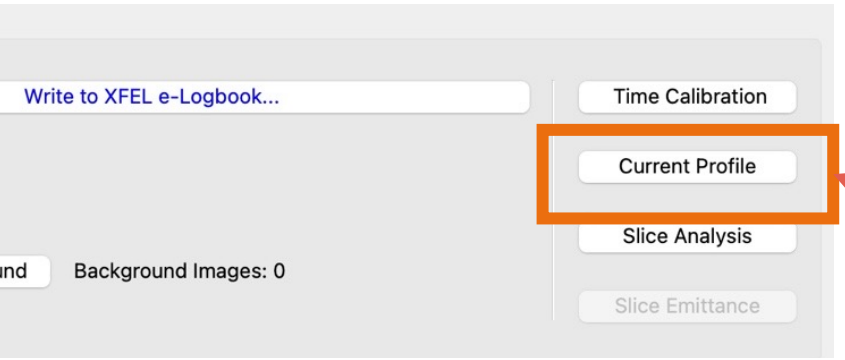
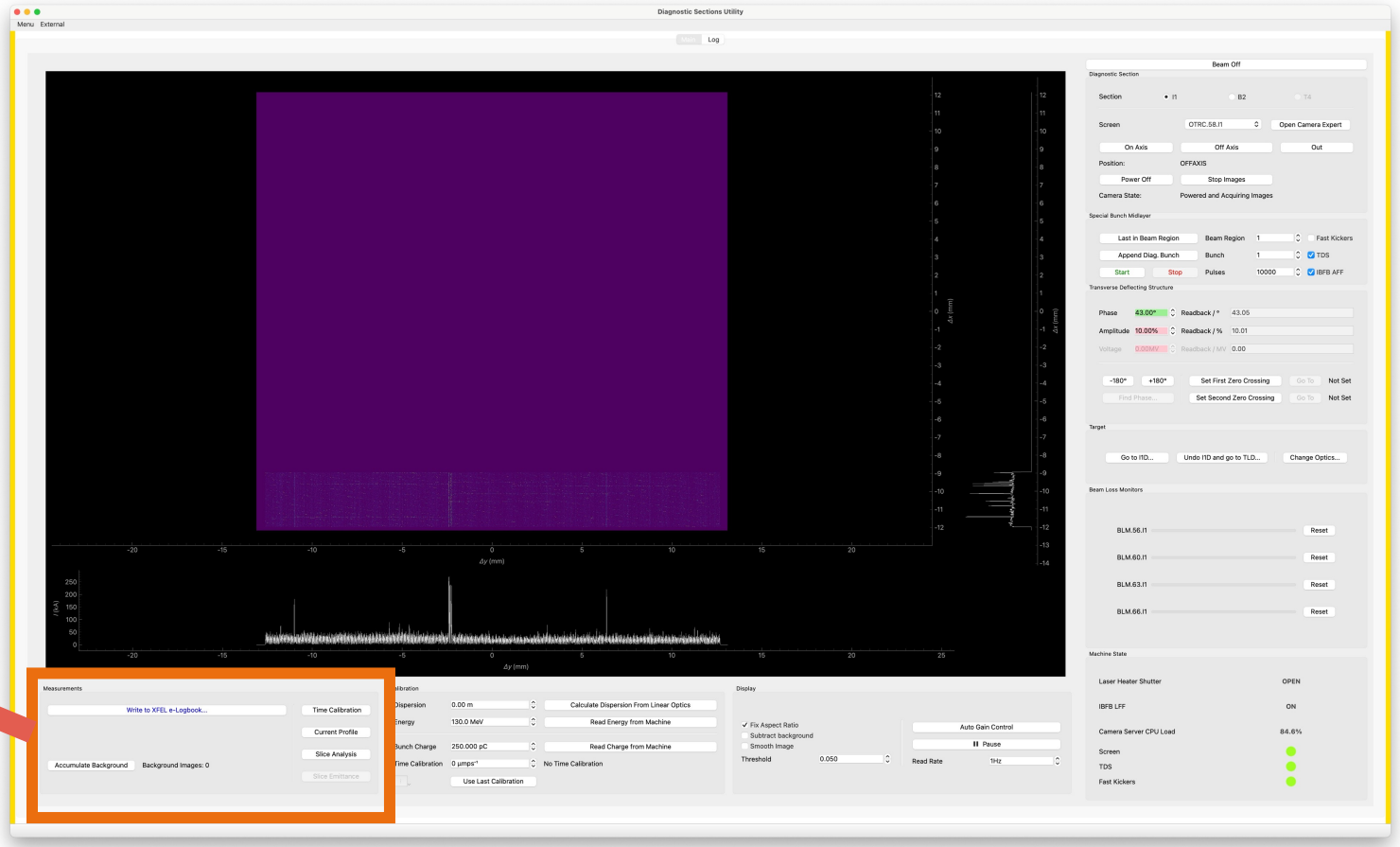
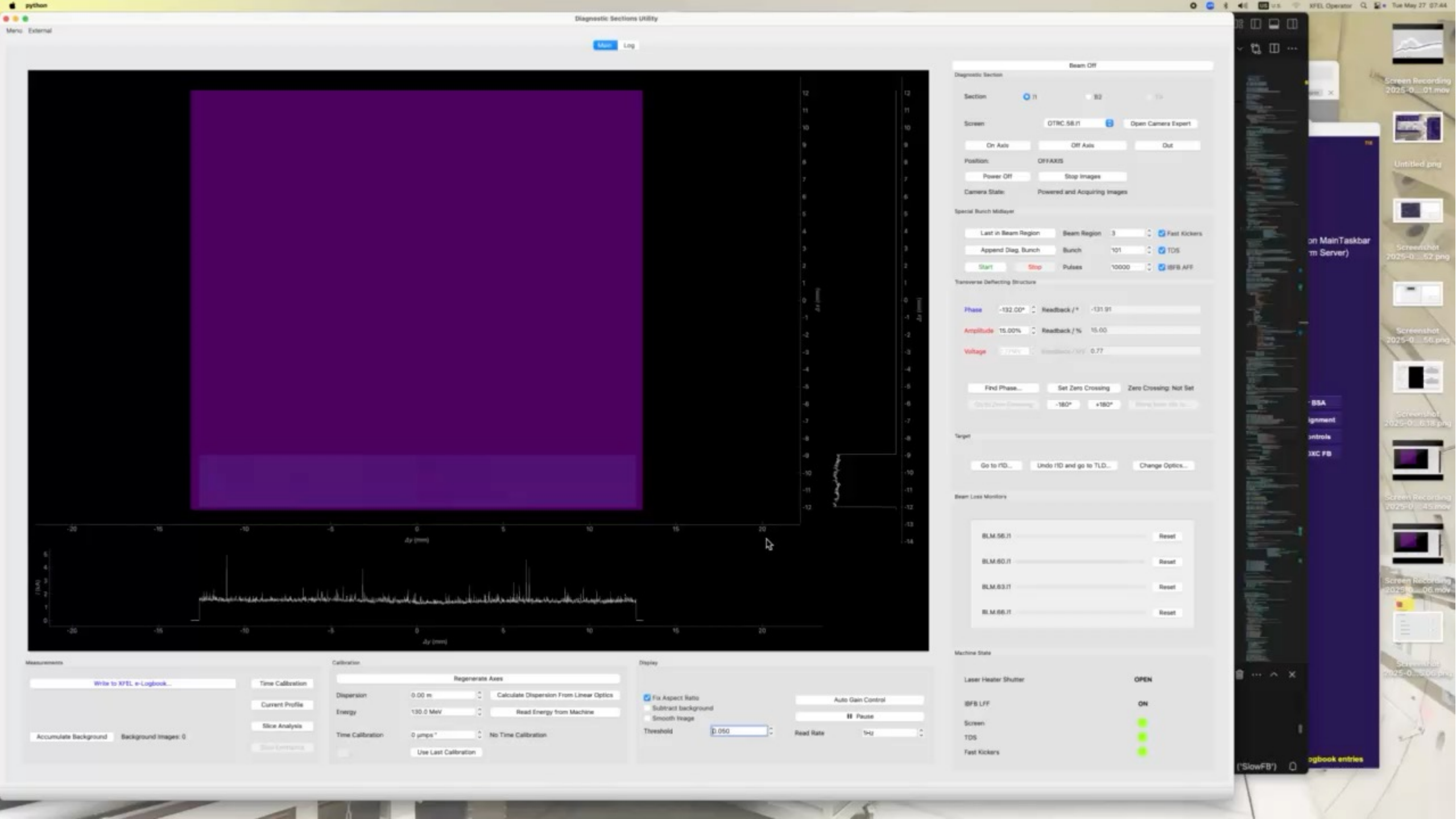


Current Profile Measurement

Finding the subwindow



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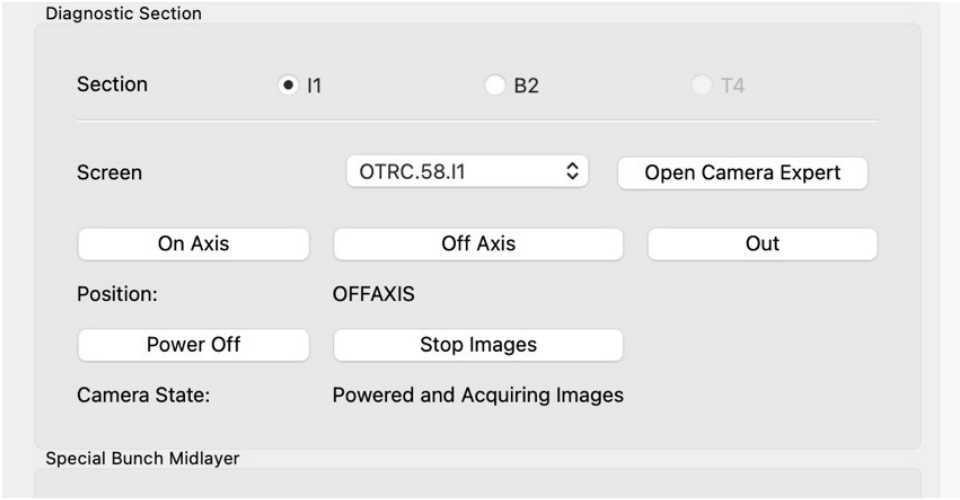
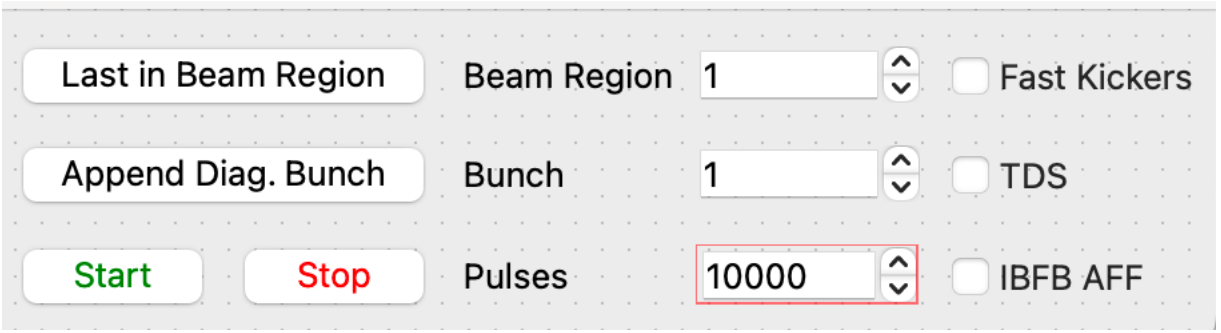
Basic Workflow

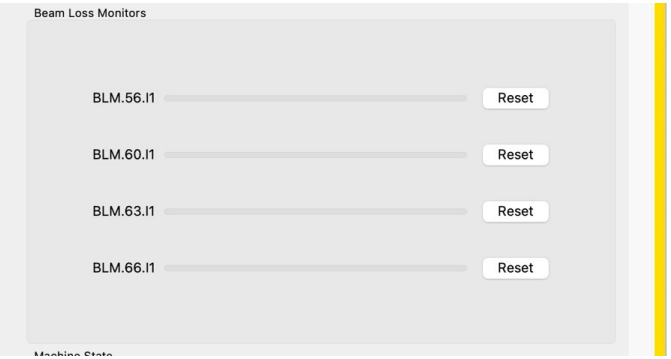


1. Select BC2 or I1 (and screen, default is normally fine)
2. Select a bunch of interest.
3. Kick onto a screen without the TDS.
4. Try with the TDS on. hopefully the phase is approximately correct (if not you won't see anything). Else: adjust the TDS phase until you see the beam on the screen.
5. Get the TDS time calibration. Either:
   - Load the last, cached calibration (fast), or
   - measure it (again).
6. Check the phase.
7. Measure the current profile.



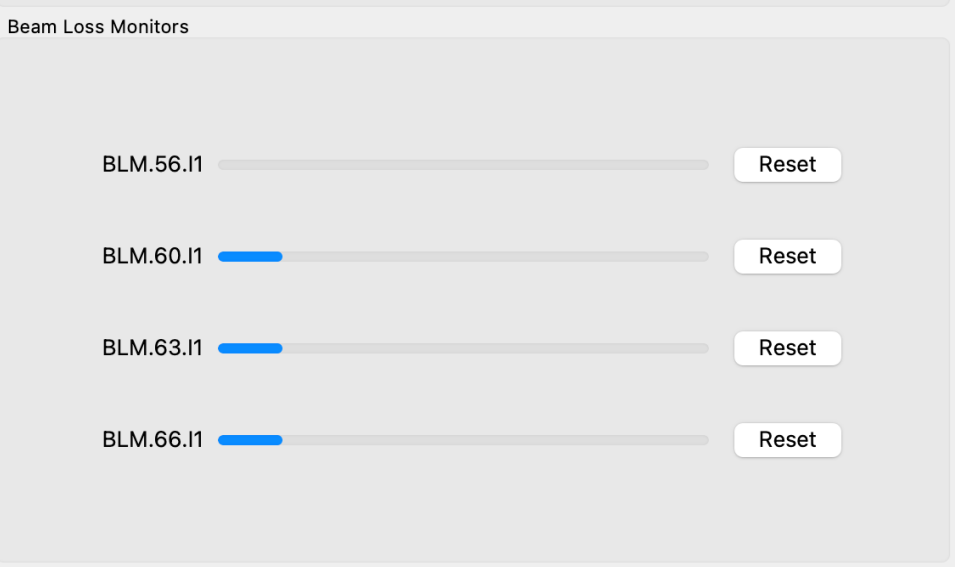
Losses

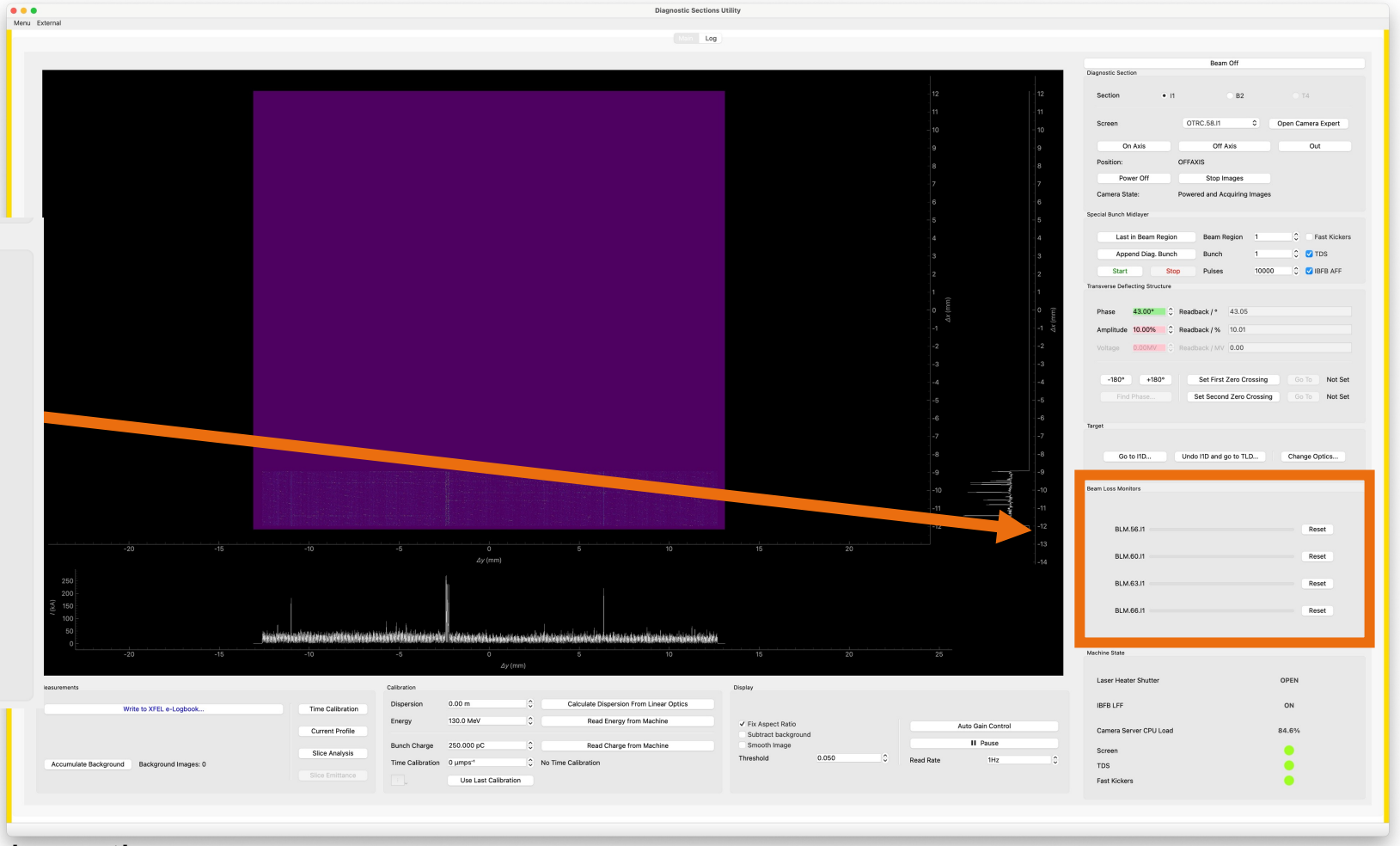
- One is naturally inclined to panic when one sees the panels go red with losses.
- EuXFEL designed for off-axis parasitic operation. Losses are OK!
  - Indeed, the EuXFEL was originally designed for permanent parasitic measurements of this kind.
  - The occasional current profile measurement is therefore *very* OK.
  - If we spend 10 minutes a day measuring the current profiles, that's still <1% of possible operation losses.
- Fast losses during the operation are masked in the MPS.
  - No train cuts if everything is configured correctly (Thomas Wamsat).
- One must nevertheless keep an eye on slow losses in the main panel.



Beam Loss Monitors

Beam Loss Monitors





- List of typically relevant BLMs for each section
- Watch them fill up during streaking
  - reset them manually before they max out
  - Else beam will be lost!

Conclusion

- Parasitic current profile measurements with the TDS that are easy to do are here.
- Basic operation of the fast kickers and TDS should “just work”. Even if it doesn’t (sometimes), we’ll only get to “it just works” by repeated and routine usage.
- The only involved step is measuring the time calibration (which can also just be skipped if it’s been done before). General operation of the TDSs, measuring the current profile, etc., are all straight forward.
- There are other features that I’ve not touched upon (on-axis measurements, LPS measurements in dump sections, dump switching, optics changing, slice analysis).

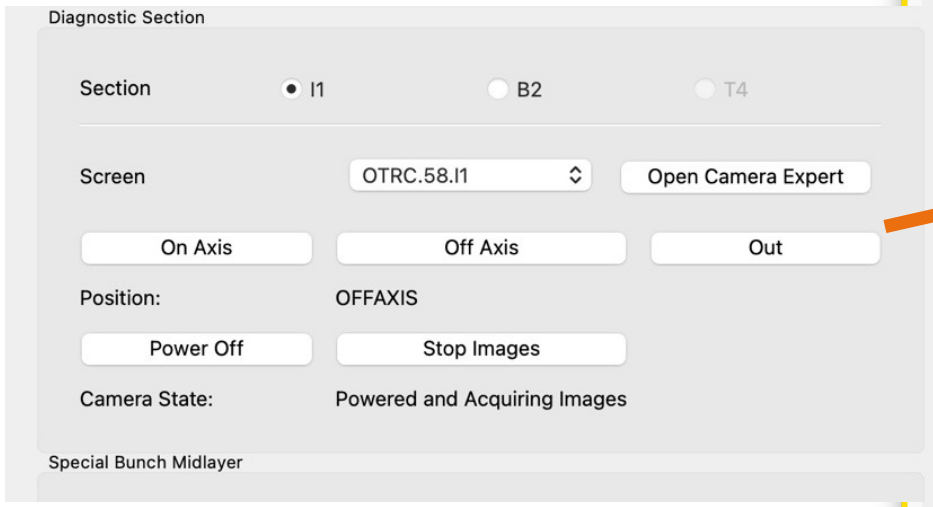
Future

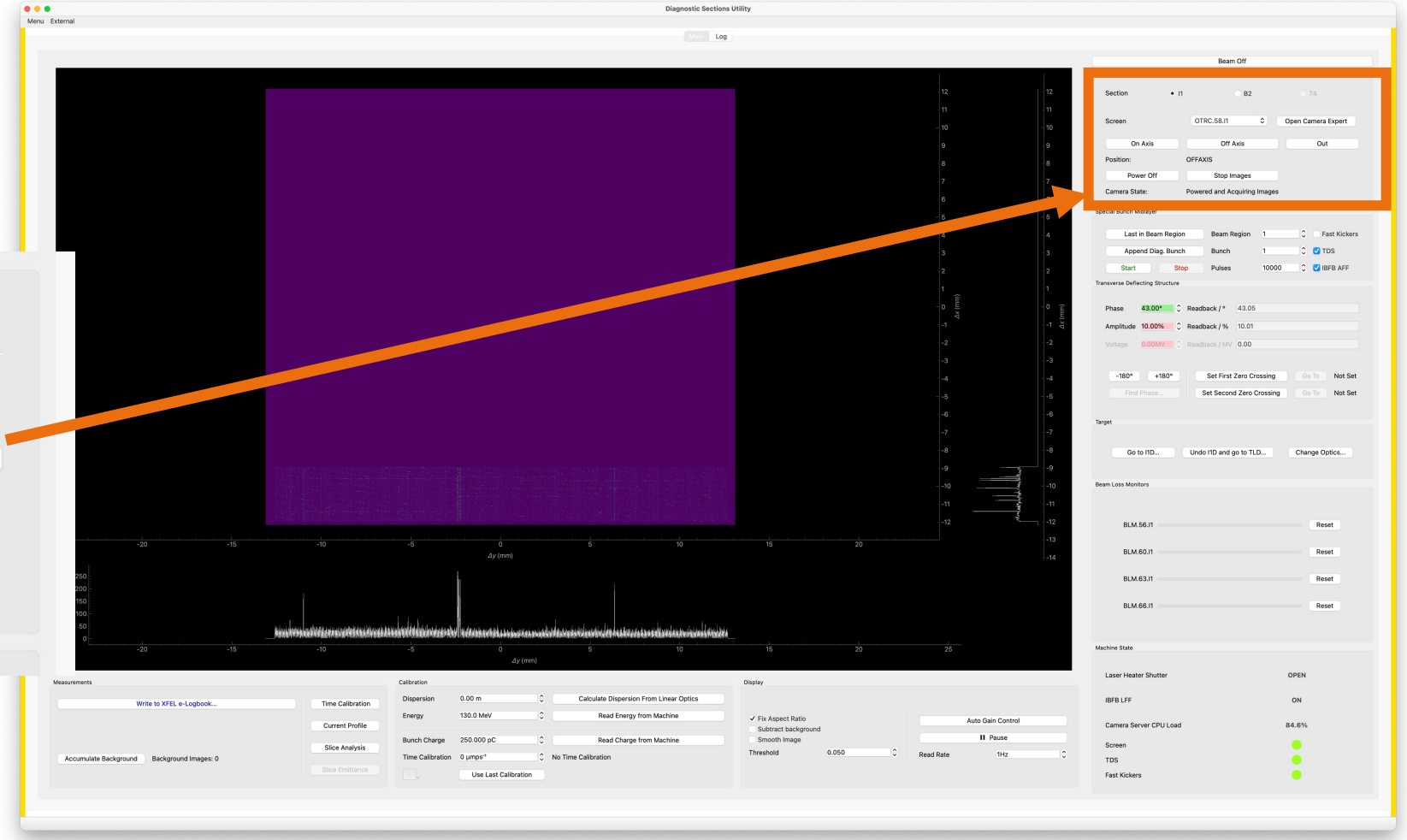
- The policy for usage: the EuXFEL is designed for it, so we just do them, and if we briefly disturb the users then so be it. Don’t ask the RC to do them, instead inform them that we are going to do them.
- With the expected return of the BC2 TDS we would like to return to daily or near-daily current profile measurements for each beam region.
  - Goal should be operators do these daily routine measurements themselves, e.g. at 7am during tune up.
  - (Not my call, though)
- I encourage you to use it and give me feedback. I want you to use it and I will be happy also to show you personally how to use it. So just ask.

Backup

Subpanels

Area and Camera Control

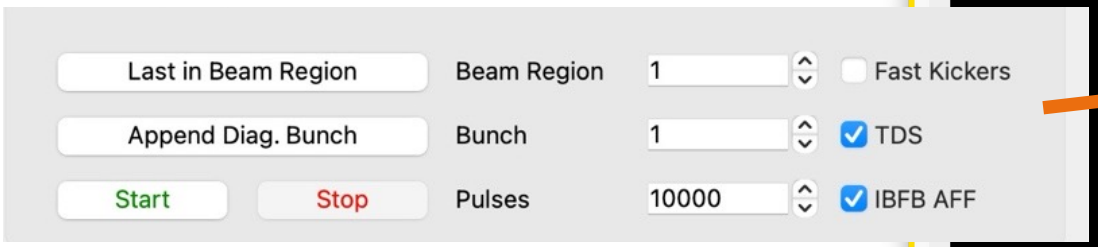


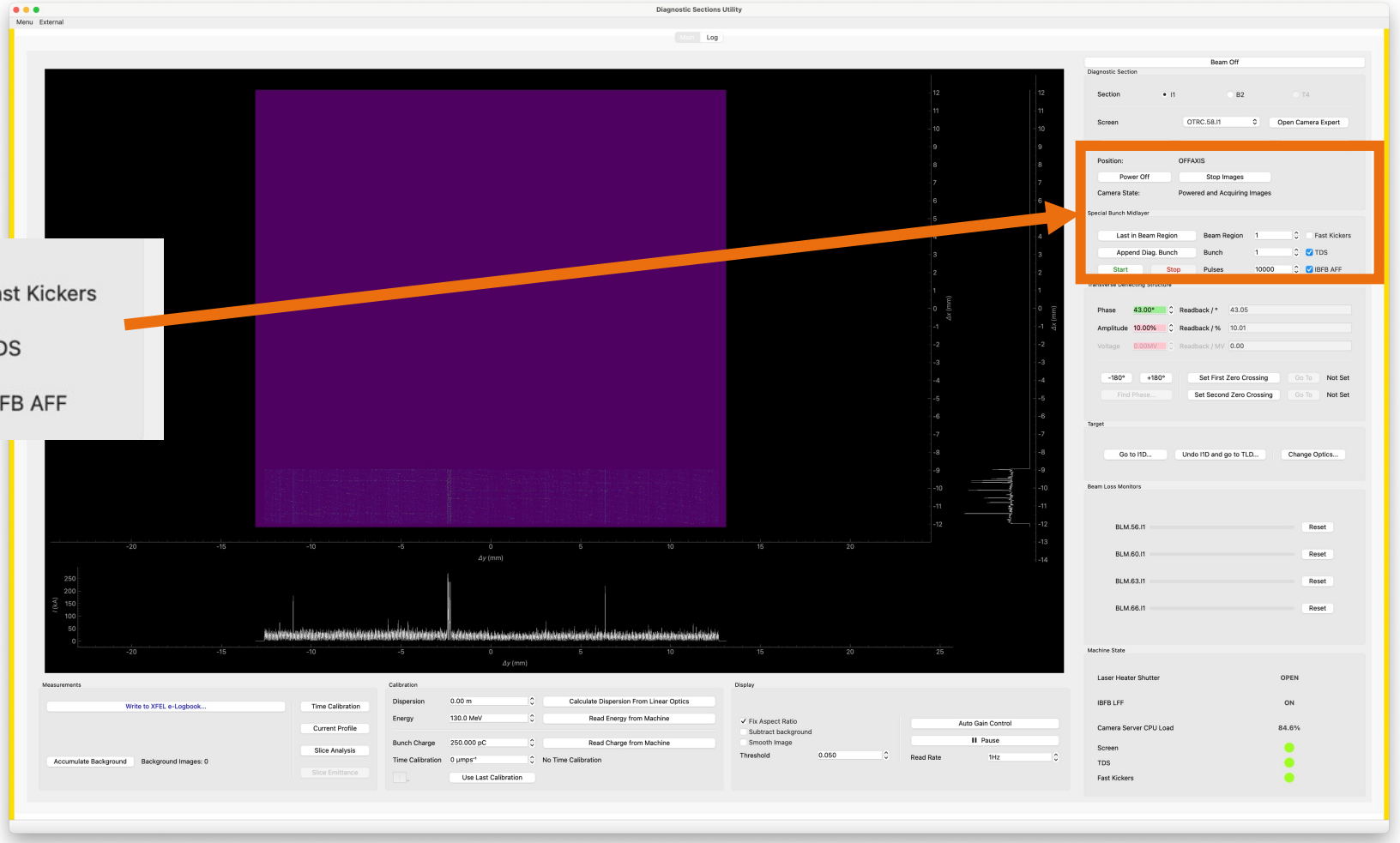


- Switch region (I1 or B2)
- Change screen
- Put screen in/off-axis or out (generally should be off-axis). Warning: will interrupt beam whilst moving
- Modify camera data taking state
- Camera expert button for more details

Subpanels

Special Bunch Midlayer



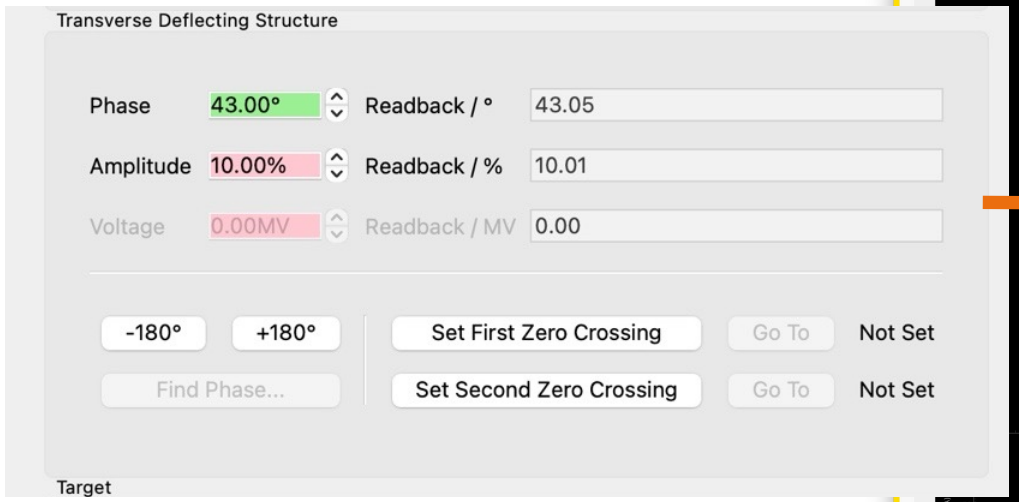


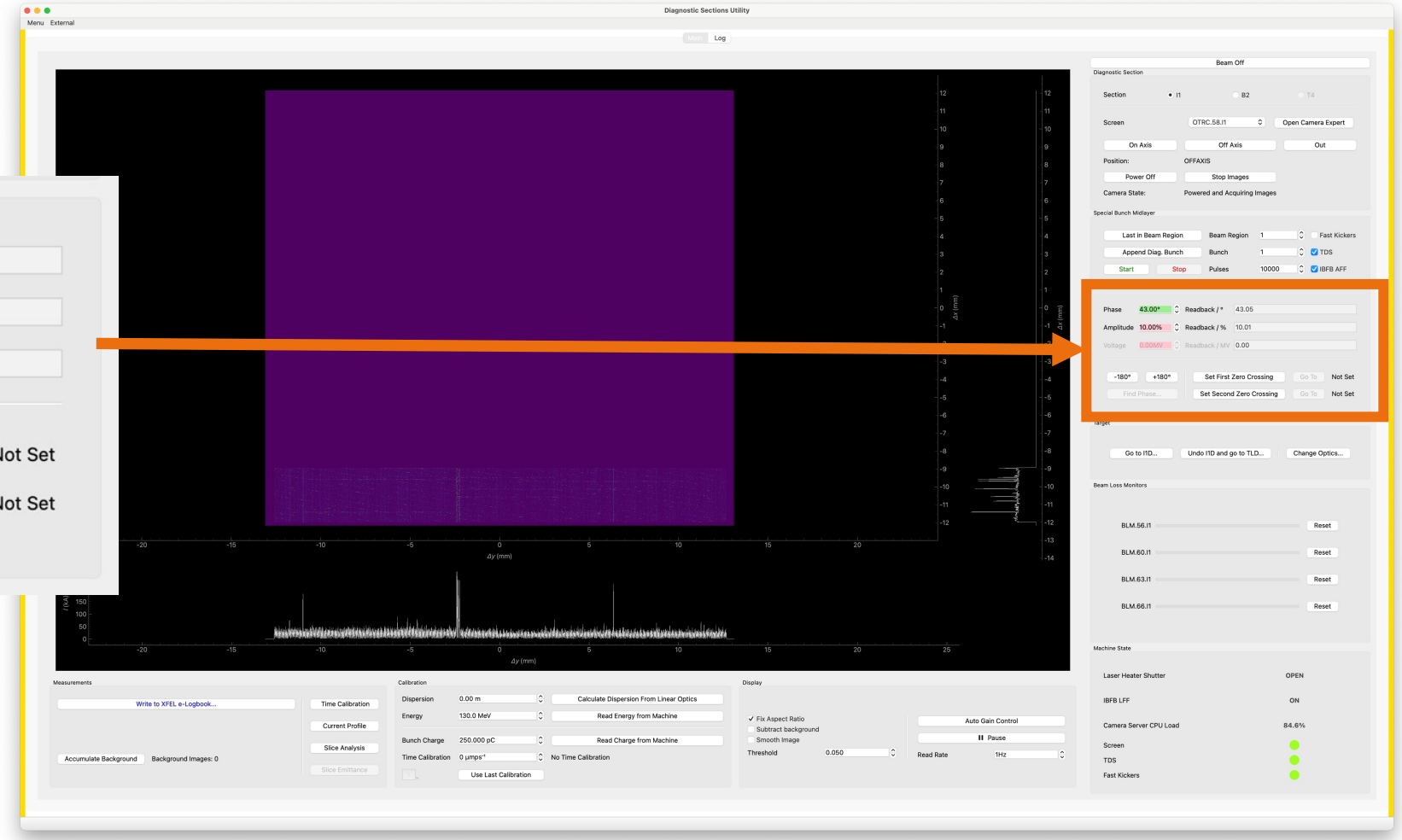
- Start/stop kicking
- Whether would fire TDS if started
- Extracted bunch selection.
  - “Append Diag. Bunch” puts one bunch at end of bunch train and kicks it.
  - A good button to click to quickly get some streaking!*
- IBFB AFF state (handled automatically, does not require manual use here)

*Careful when RF window is completely occupied.

Subpanels

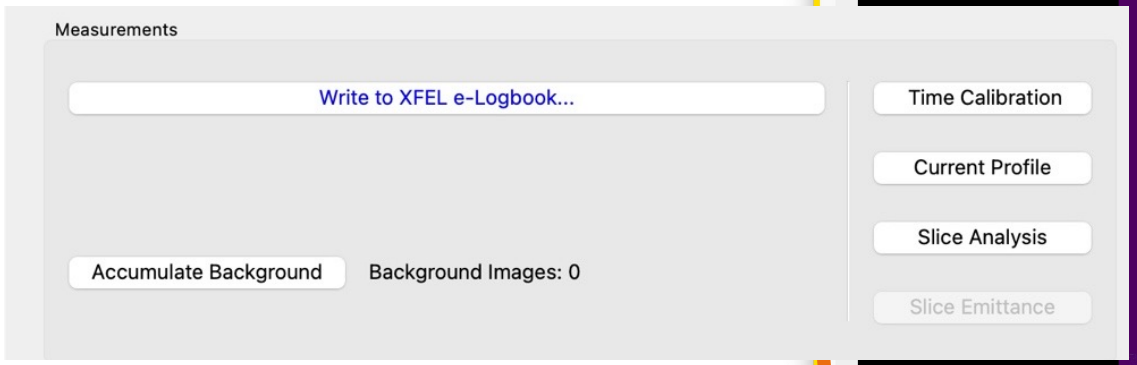
TDS

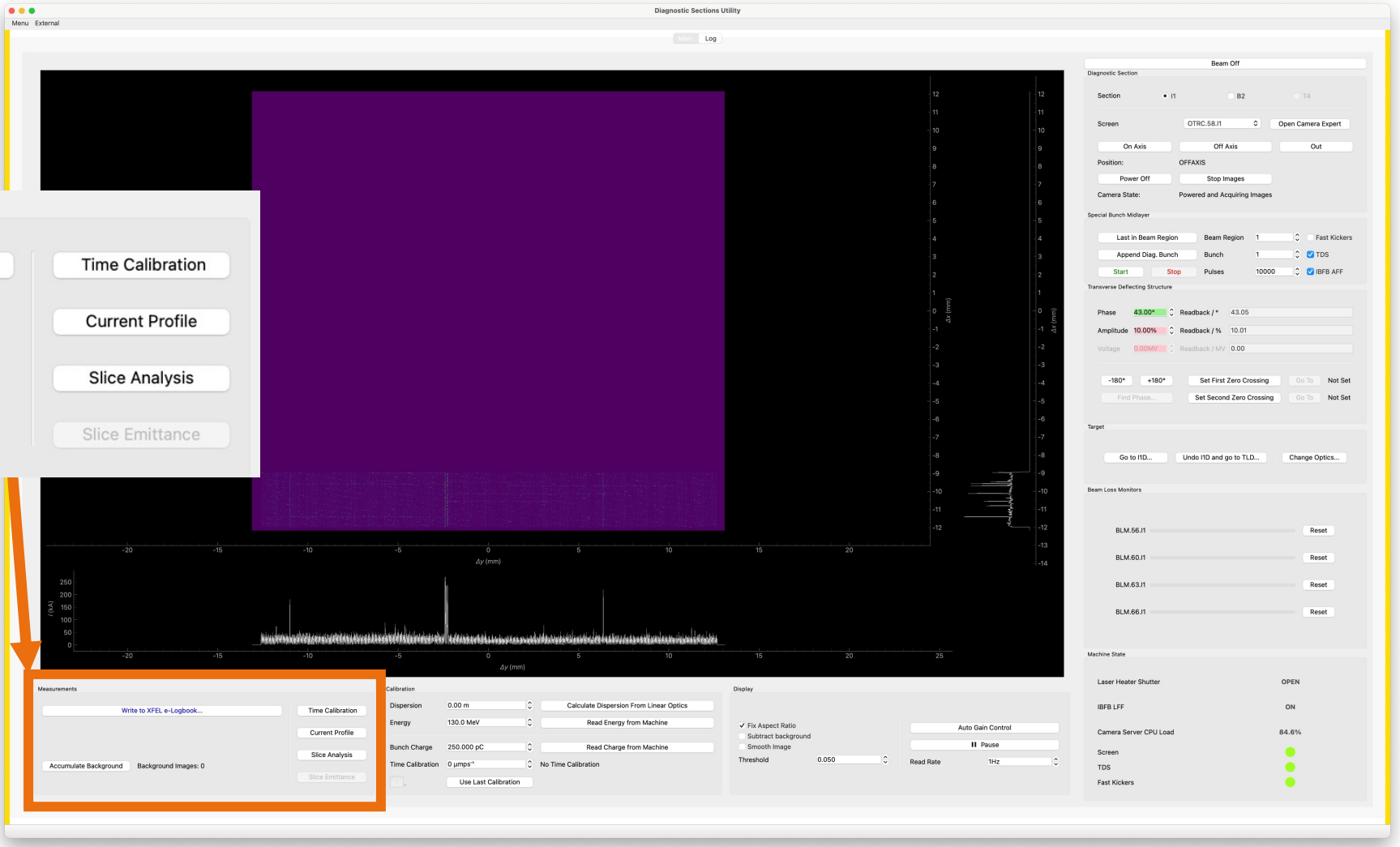




- Phase
- Amplitude
  - Careful putting this too high: will trip if put above 30% in either TDS.
  - Often little reason to go above about 15% in I1.
- Zero crossings

Measurements





- Open subtools:
  - Time Calibrator
  - Current Profiler
  - Slice Analyser
- Logbook writer
- Accumulate background (used for background subtraction in main display)
  - Also written to logbook if logbook writer used