EOS Analysis

Using EOS data to understand TCAV and machine jitter

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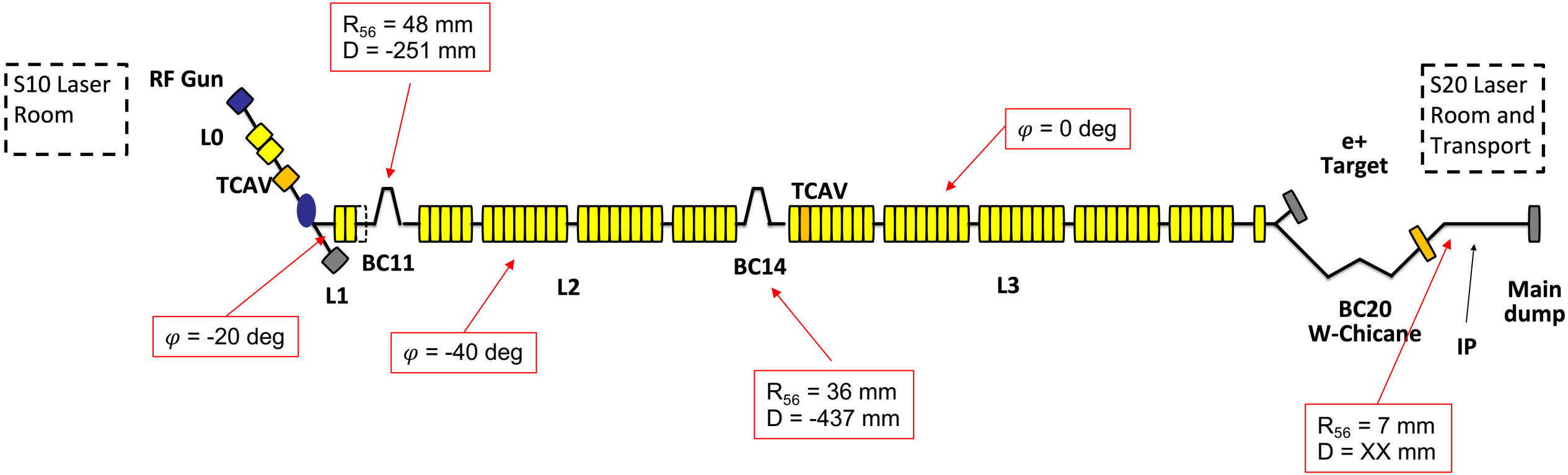
Goals for this Analysis

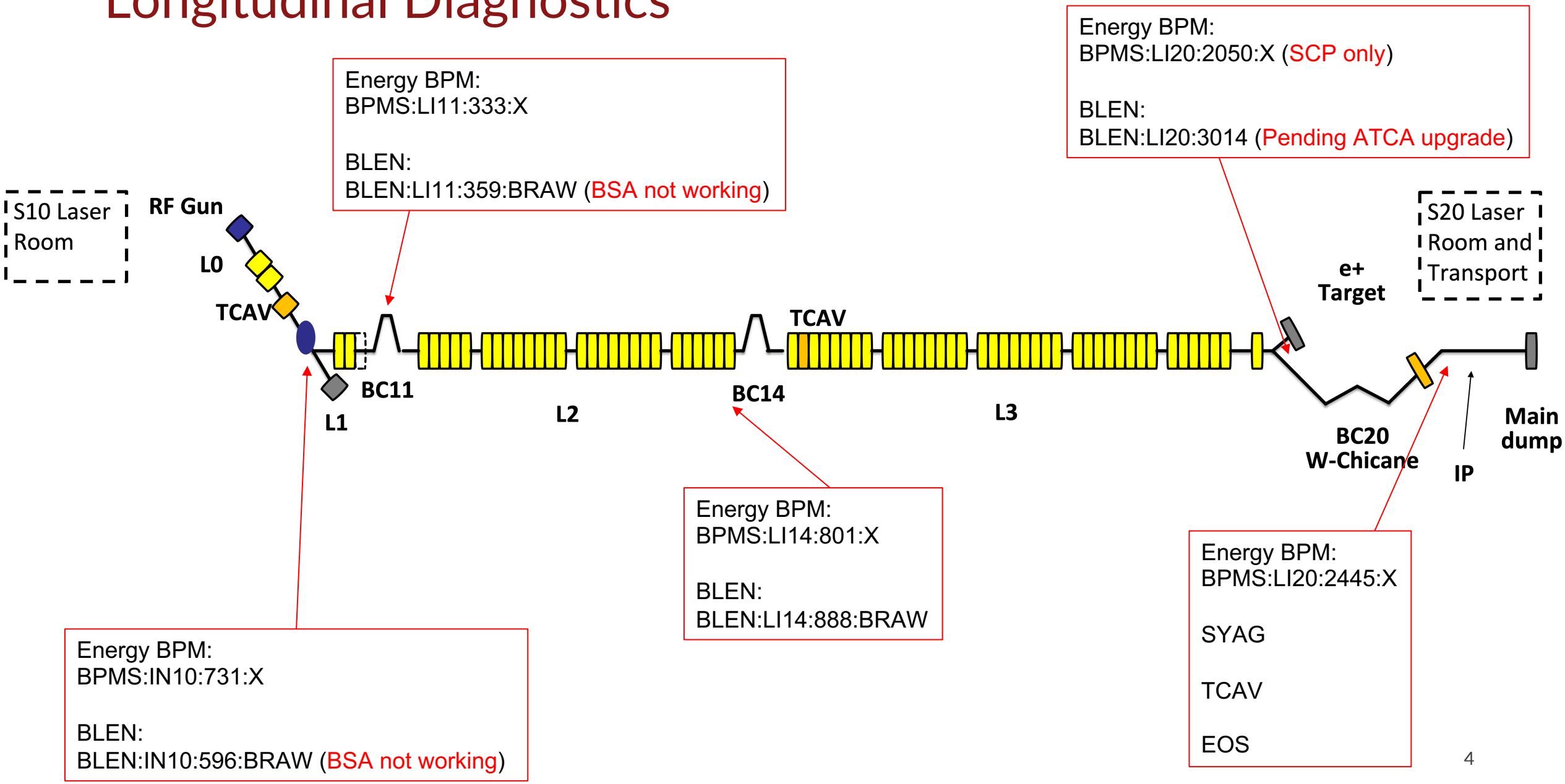
1. Understand if our diagnostics are working correctly
   a) e.g. Can we trust TCAV calibration and bunch length?

2. Is the machine working as anticipated?
   a) Is the measured time-of-arrival jitter consistent with expectations.

Longitudinal Machine Parameters

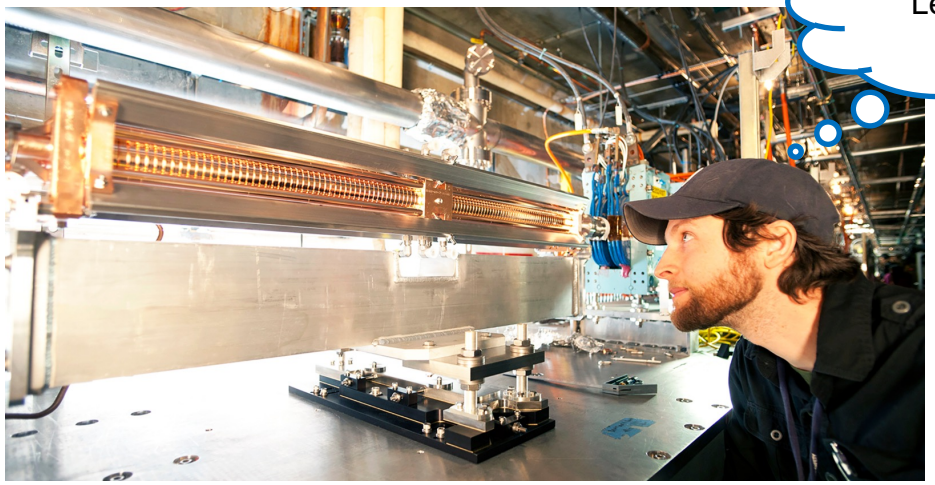


Longitudinal Diagnostics



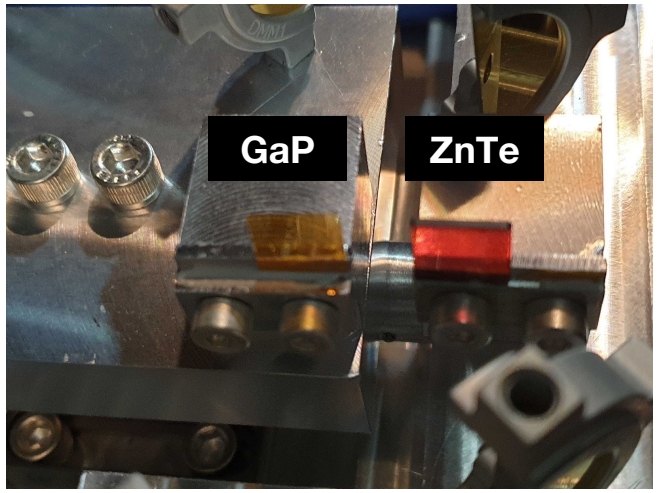
Longitudinal Diagnostics

TCAV



How do I love thee? Let me count the ways. . .

EOS



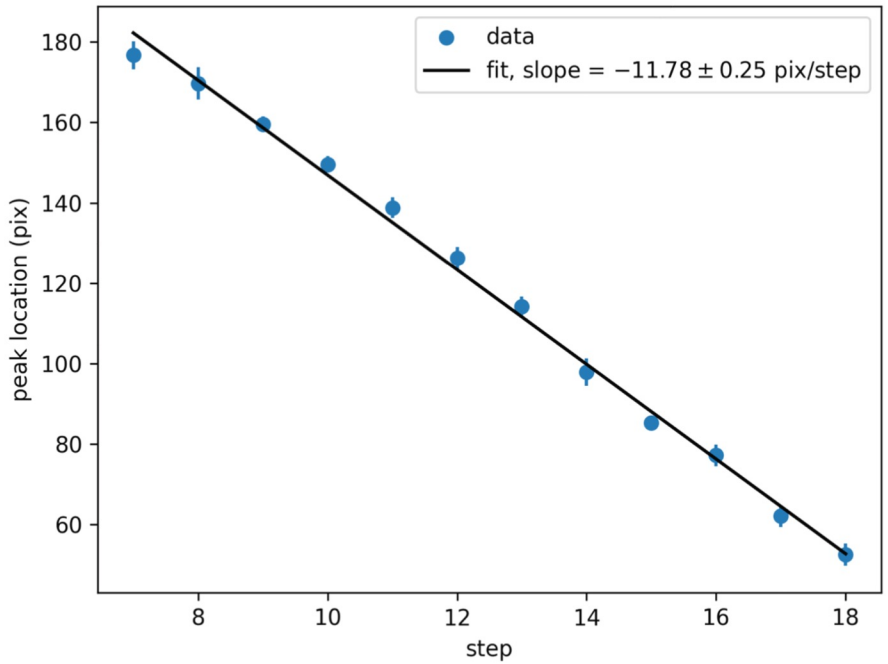
The TCAV and SYAG diagnostics in S20 allow for “direct” measurement of bunch length and time of arrival.

EOS Calibration (C. Hansel)

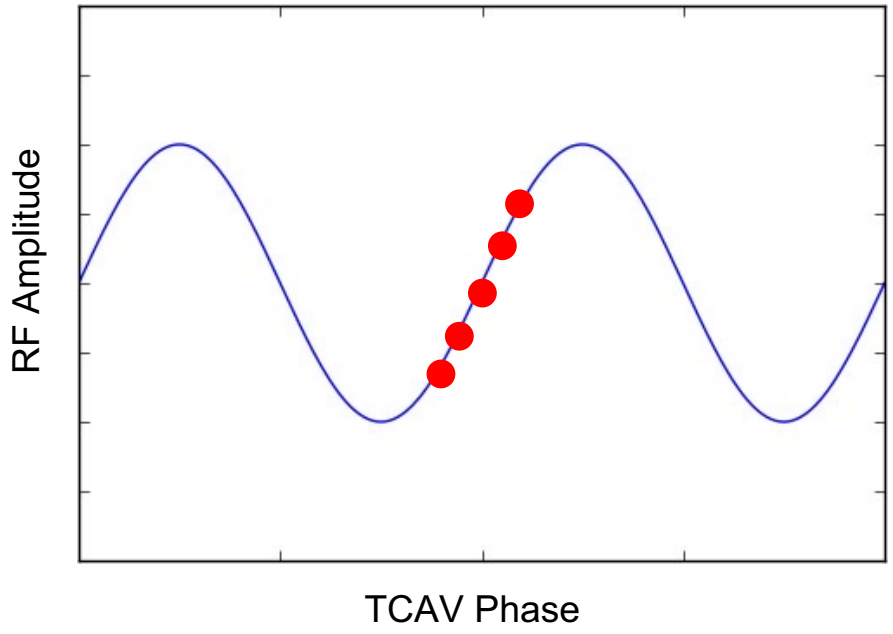
Pixel to fs Conversion

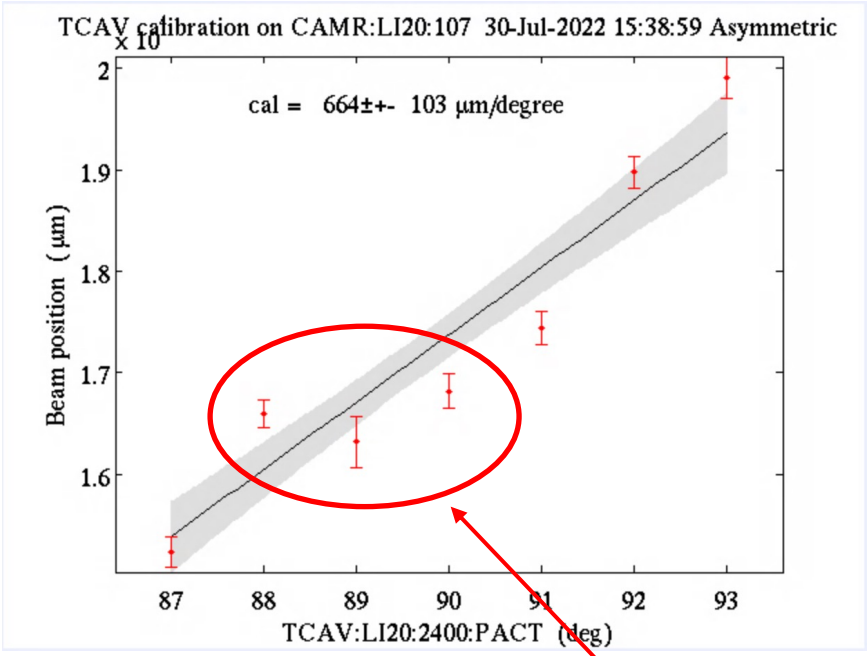
- Dataset 1504 adjusted the laser rf delay by 215fs per step for 20 steps, with 10 shots per step.
- Signal from some steps were non existent or messy, so I chose steps 7 to 18.
- For each of the 10 shots in a step the mean and standard deviation is plotted at right, and a linear fit provided the slope in pixels per step, which was converted to fs per pixel.

- Femtosecond-to-Pixel Conversion Factor
  - 18.26 ± 0.38 fs/pix

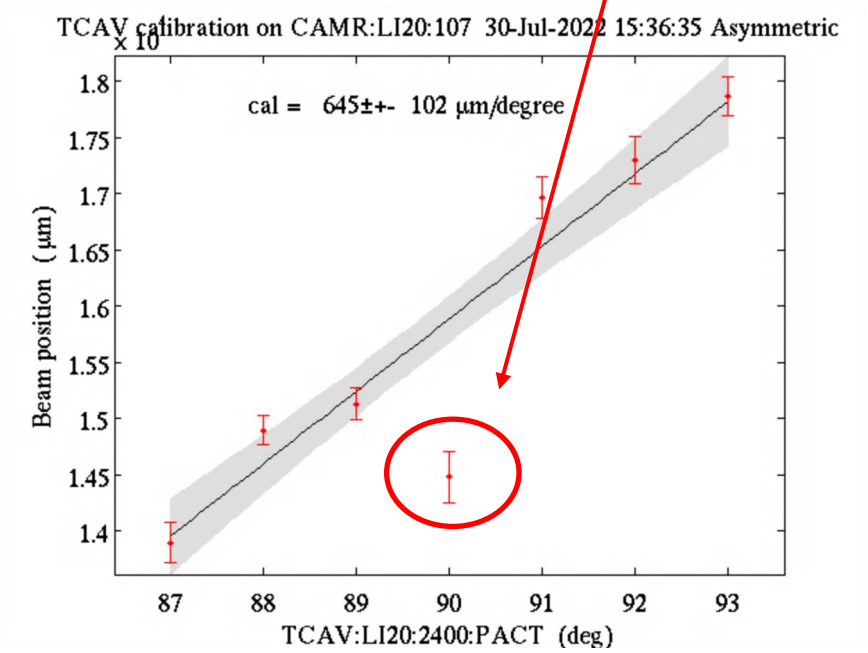


TCAV Calibration Issue





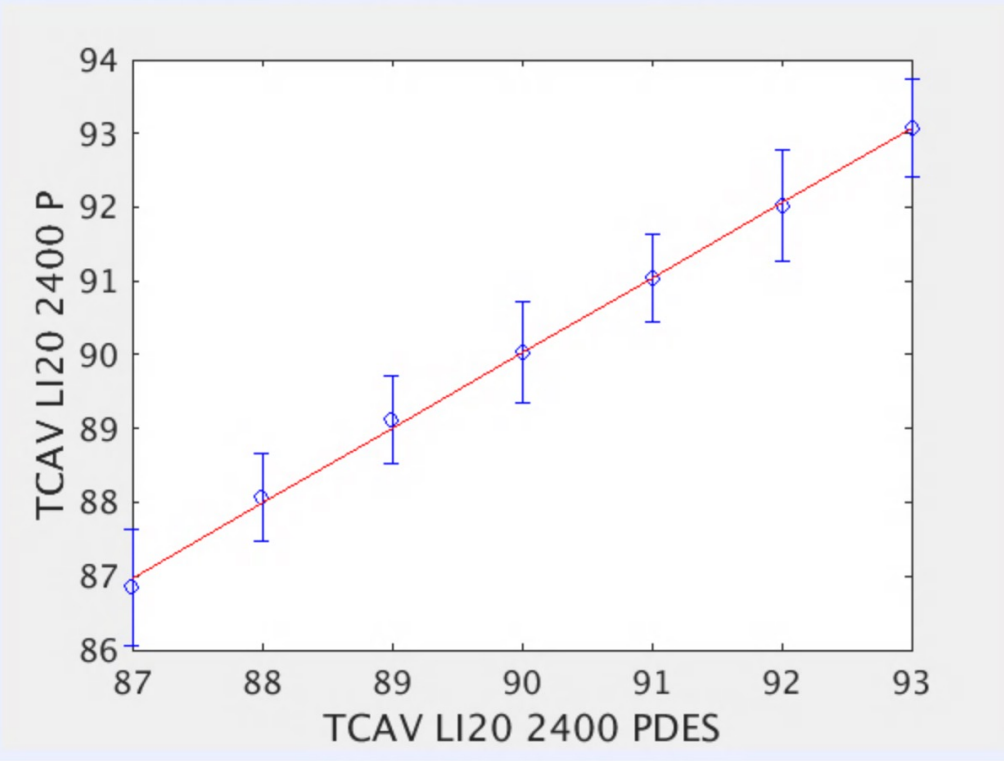
Why?

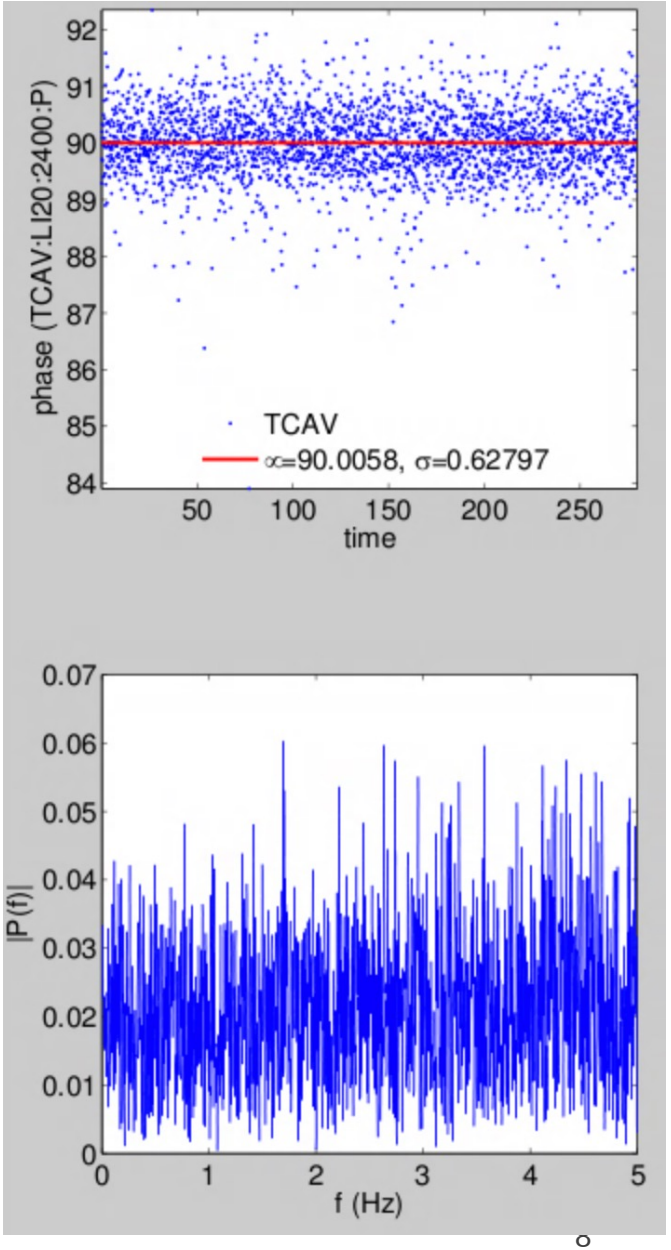


TCAV calibration curves are often non-linear.

Why?

TCAV Phase Setting and Readback

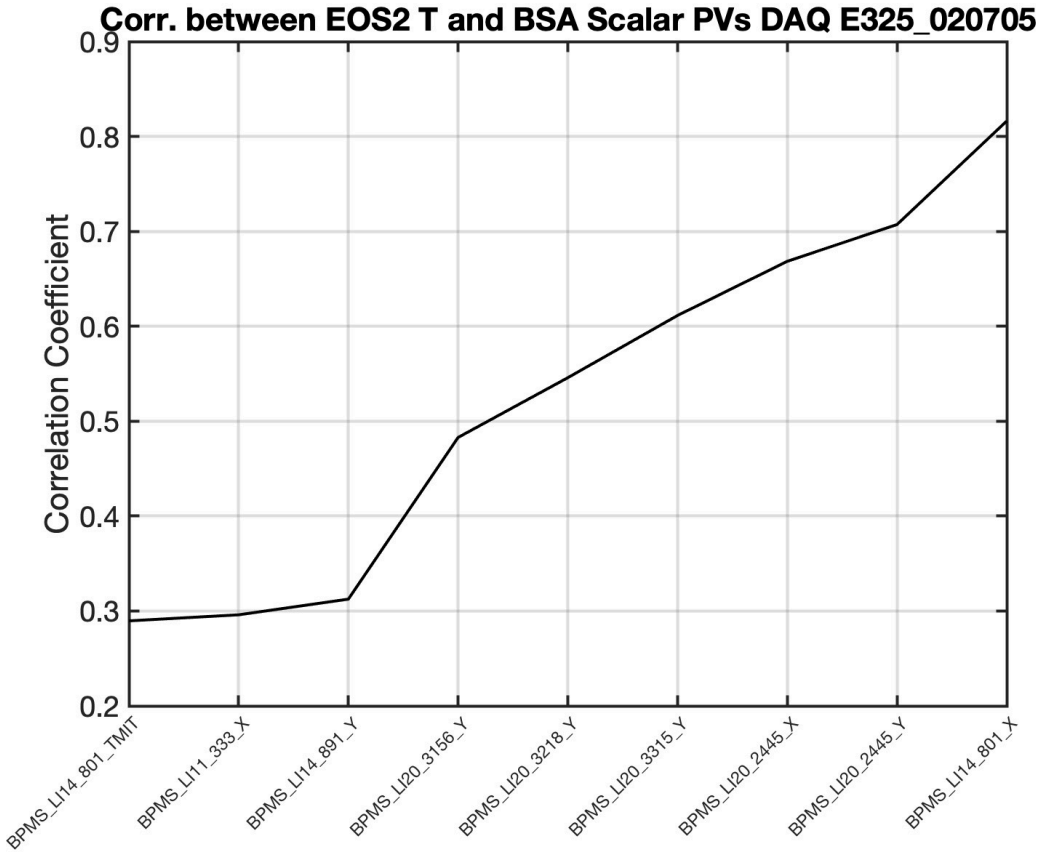




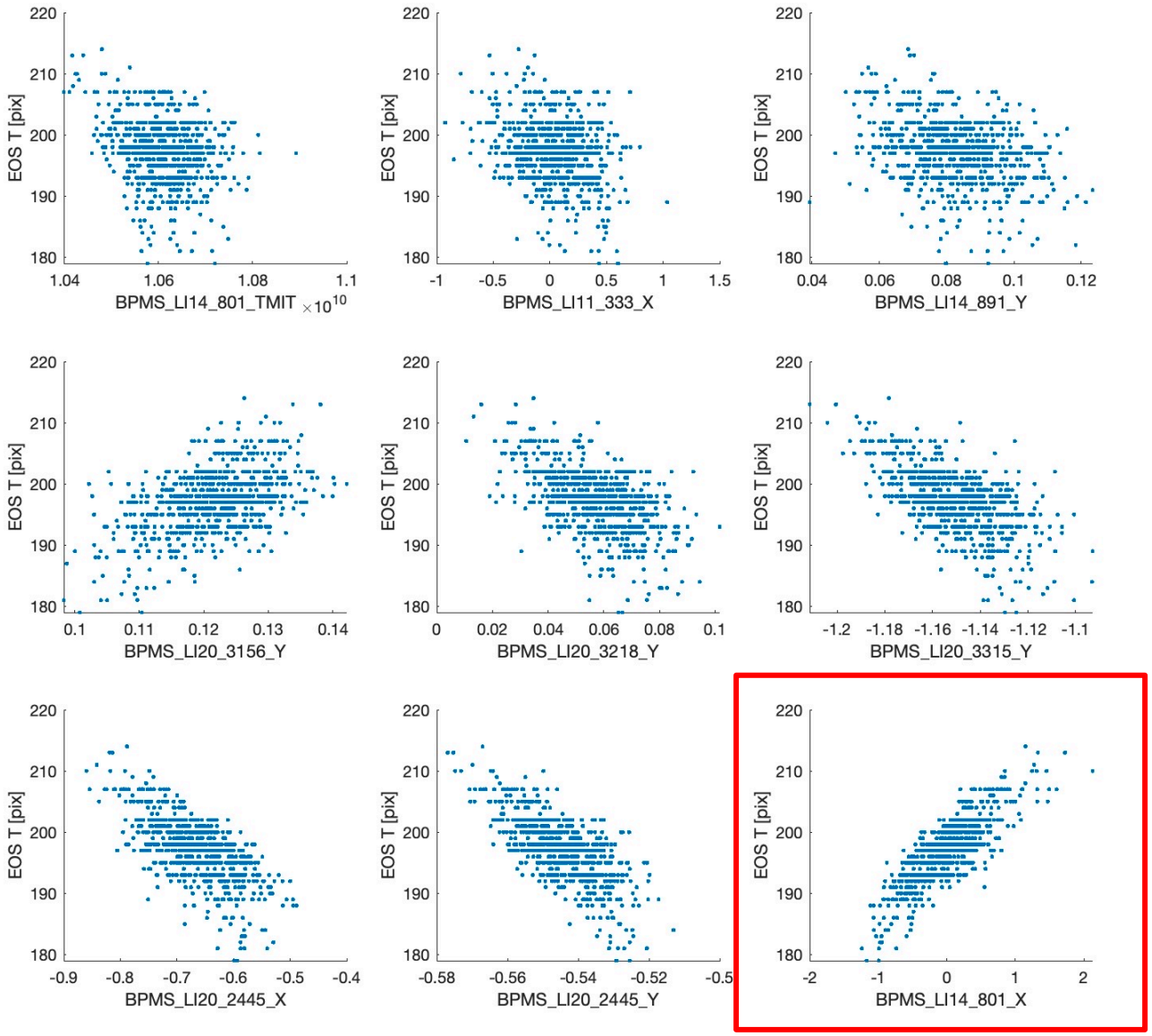
The TCAV klystron reads back it's own phase.

It looks stable ⇒ Something affects the measurement.

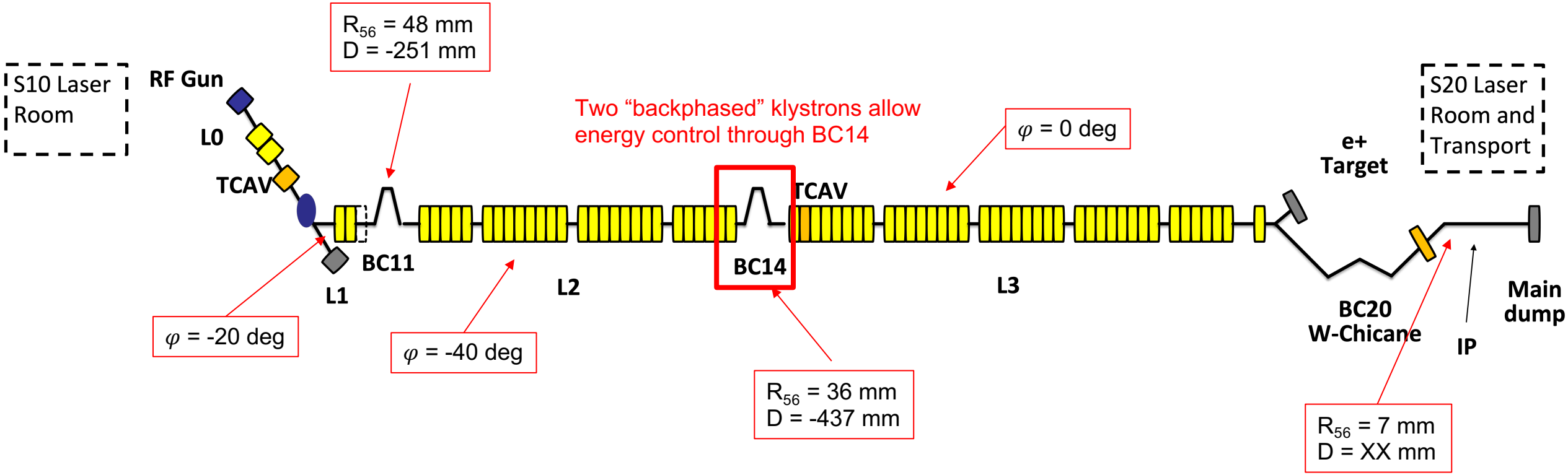
Correlation between EOS and upstream PVs (C. Emma)



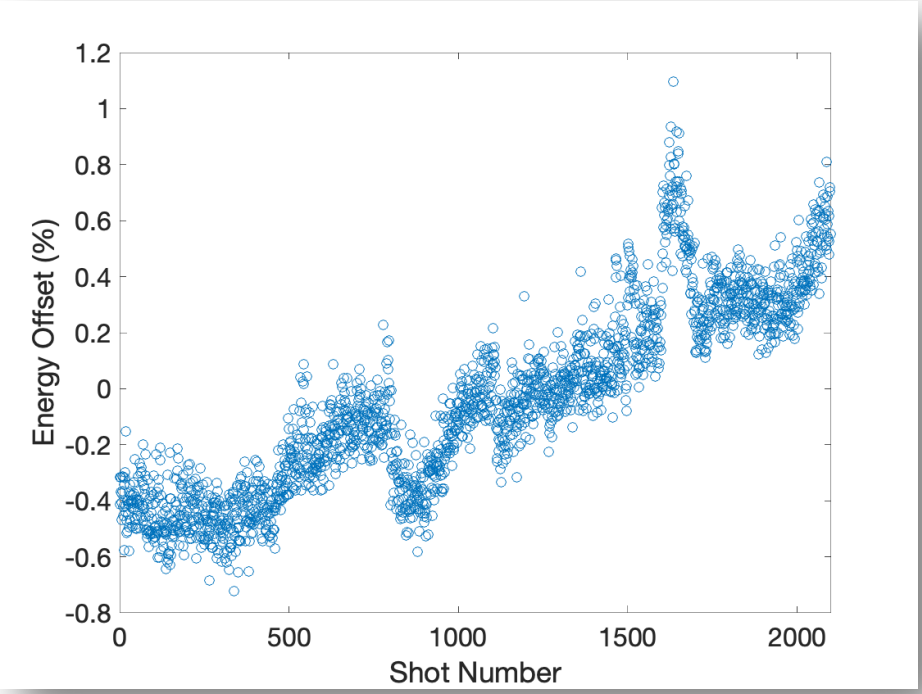
Strong correlation with energy BPMs but also horz & vertical BPMs in LI14/LI20 (dispersion leaking out of compressors?)

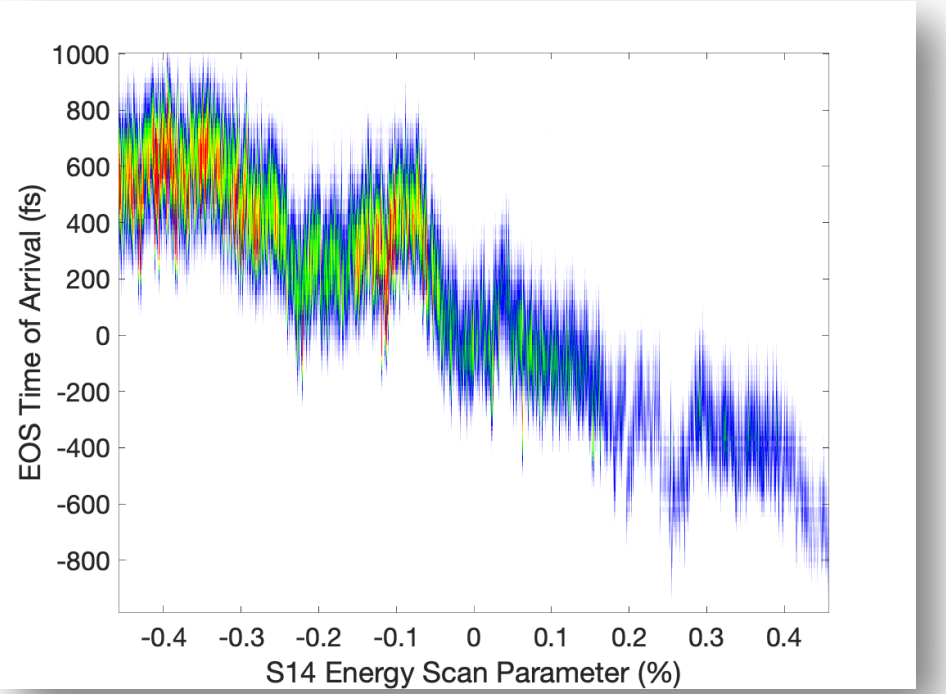


Longitudinal Machine Parameters



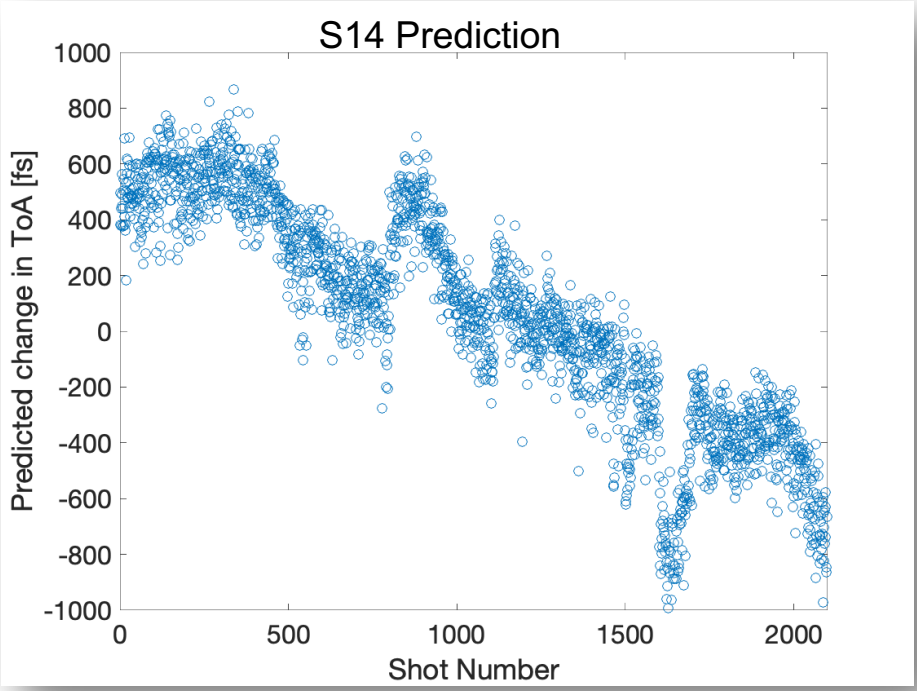
Scan of LI14 Energy Setpoint

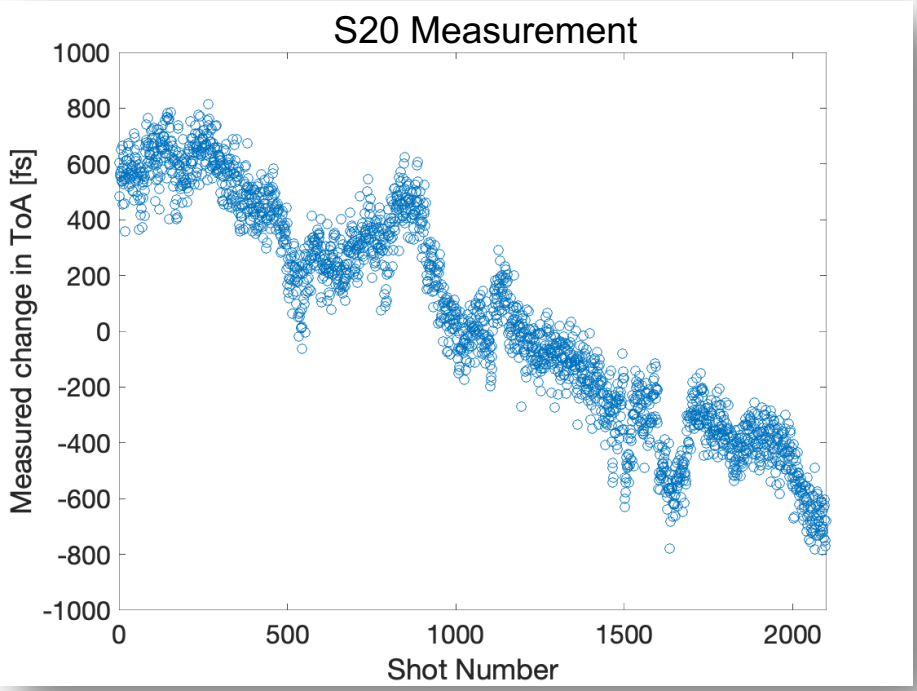




Deliberately changing LI14 energy setpoint leads to drift in S20 Time-of-Arrival. We also see the effects of random jitter/drift.

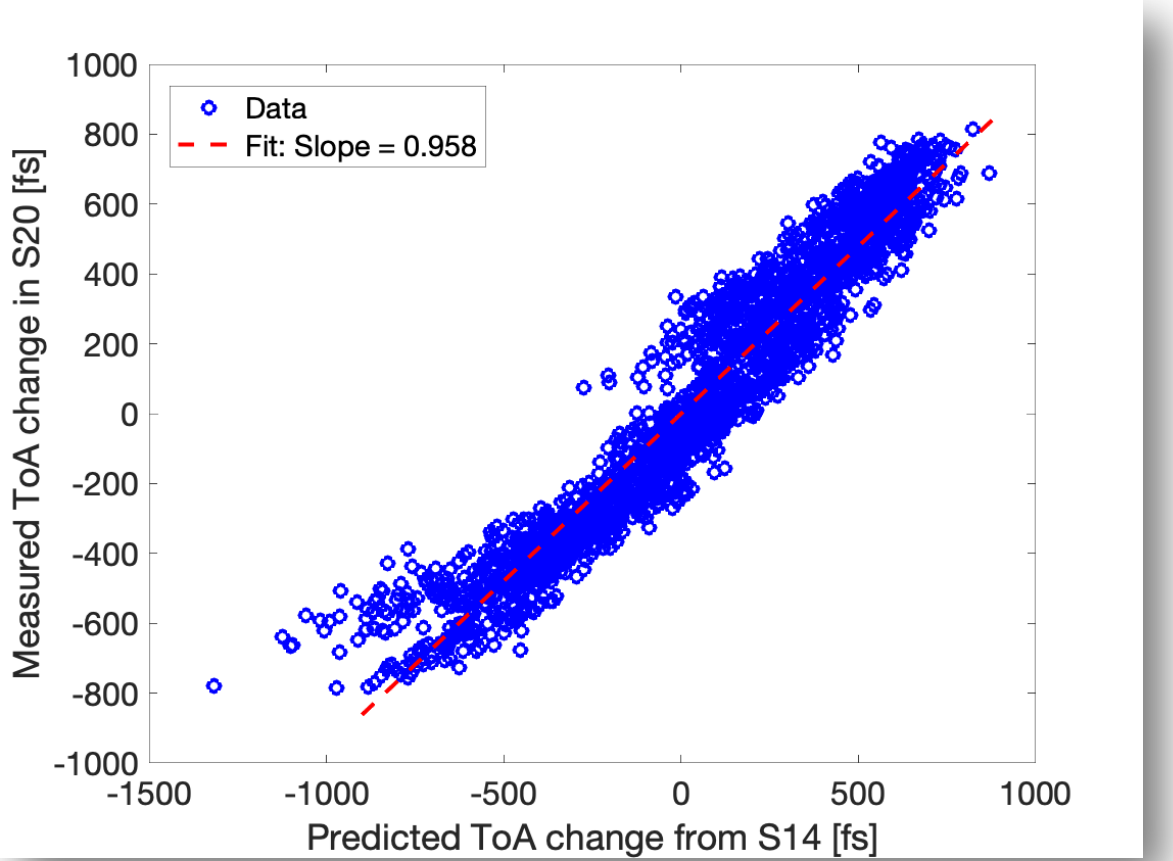
Scan of LI14 Energy Setpoint





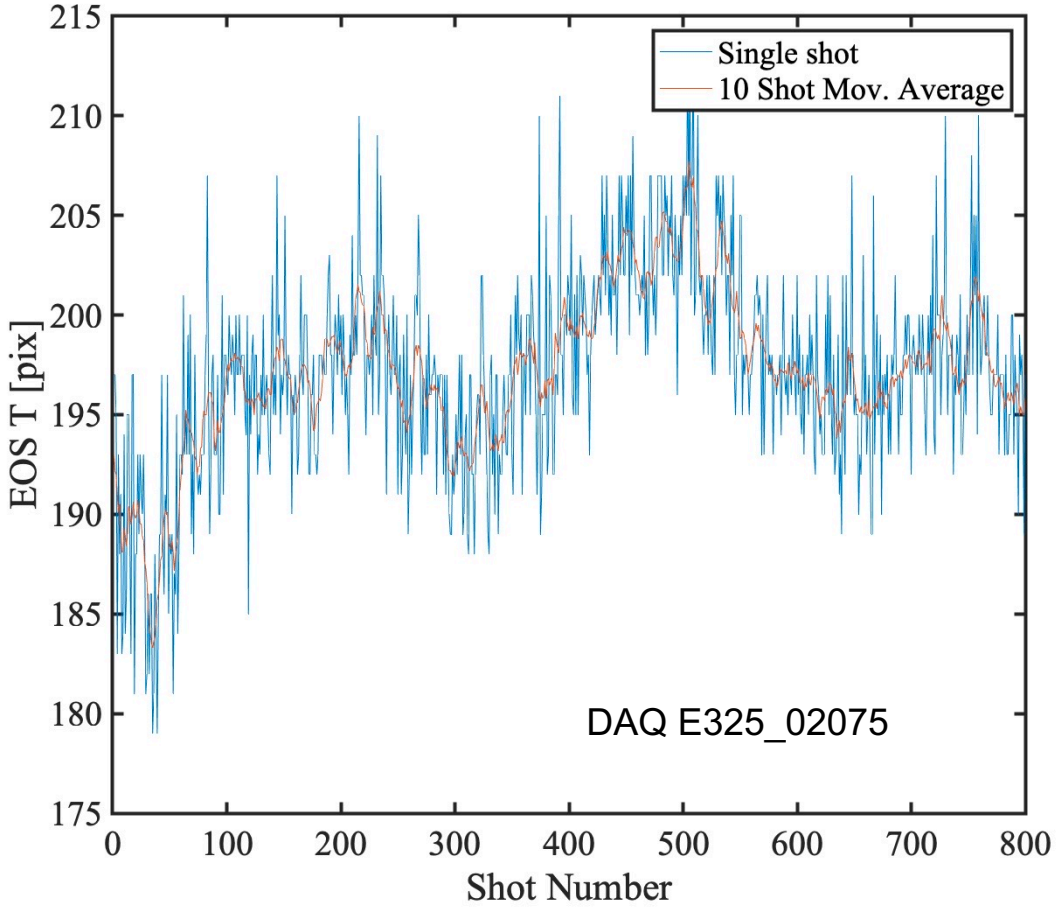
Using design machine parameters, we can use the energy BPM to “predict” time-of-arrival in S20.

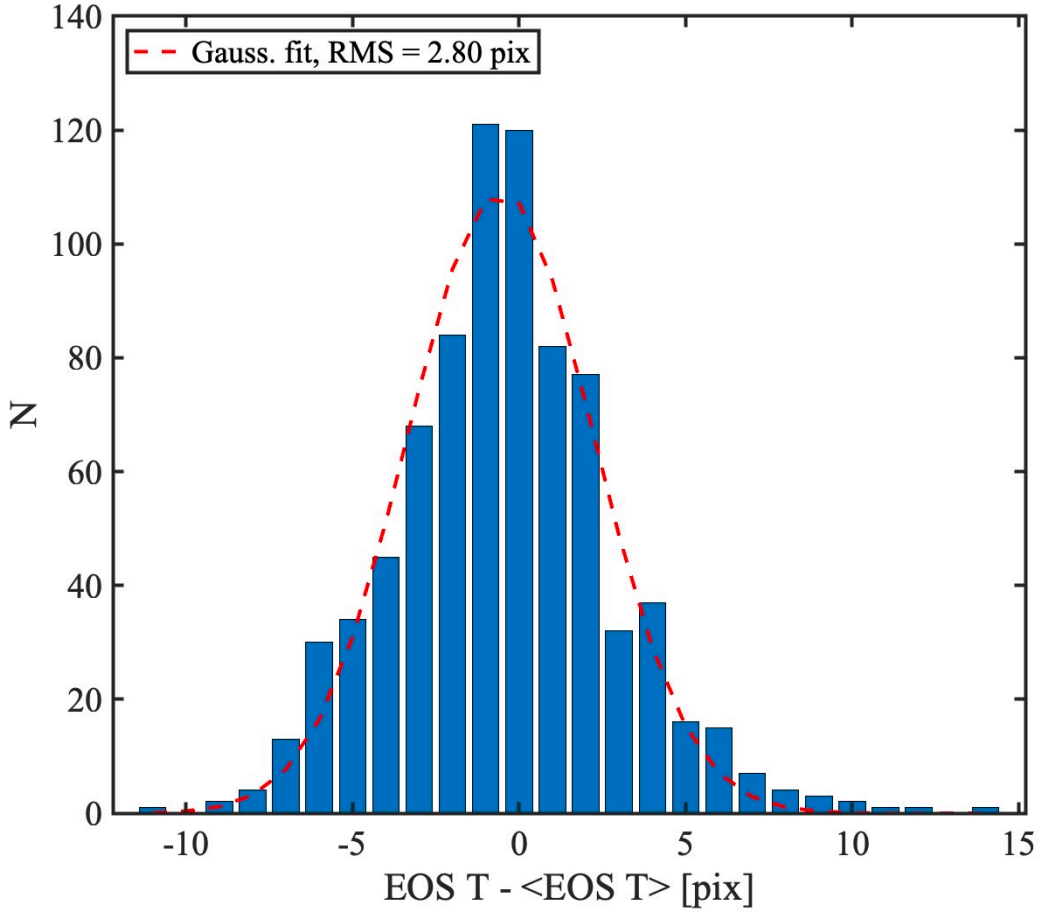
Scan of LI14 Energy Setpoint



96% correlation between predicted/measured ToA.

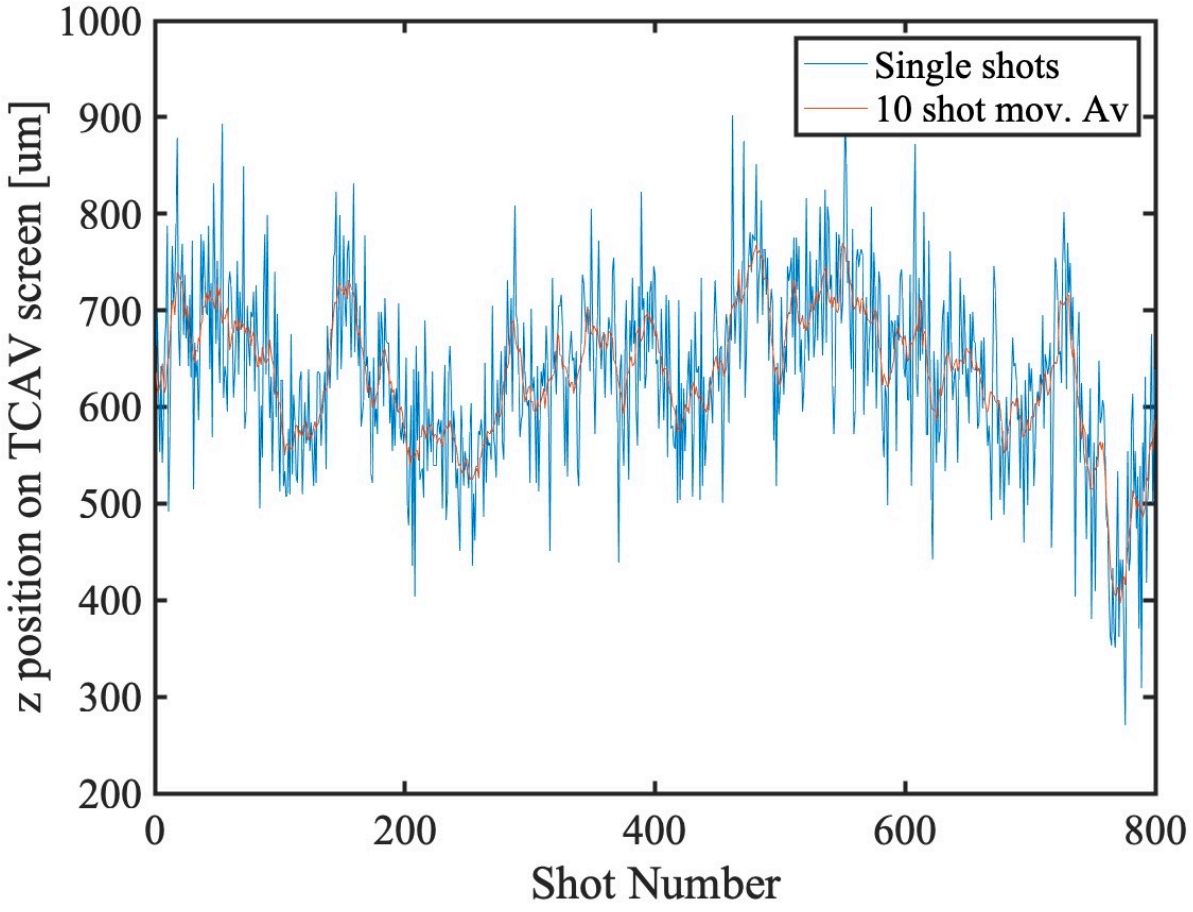
Measurement of EOS ToA jitter (C. Emma)

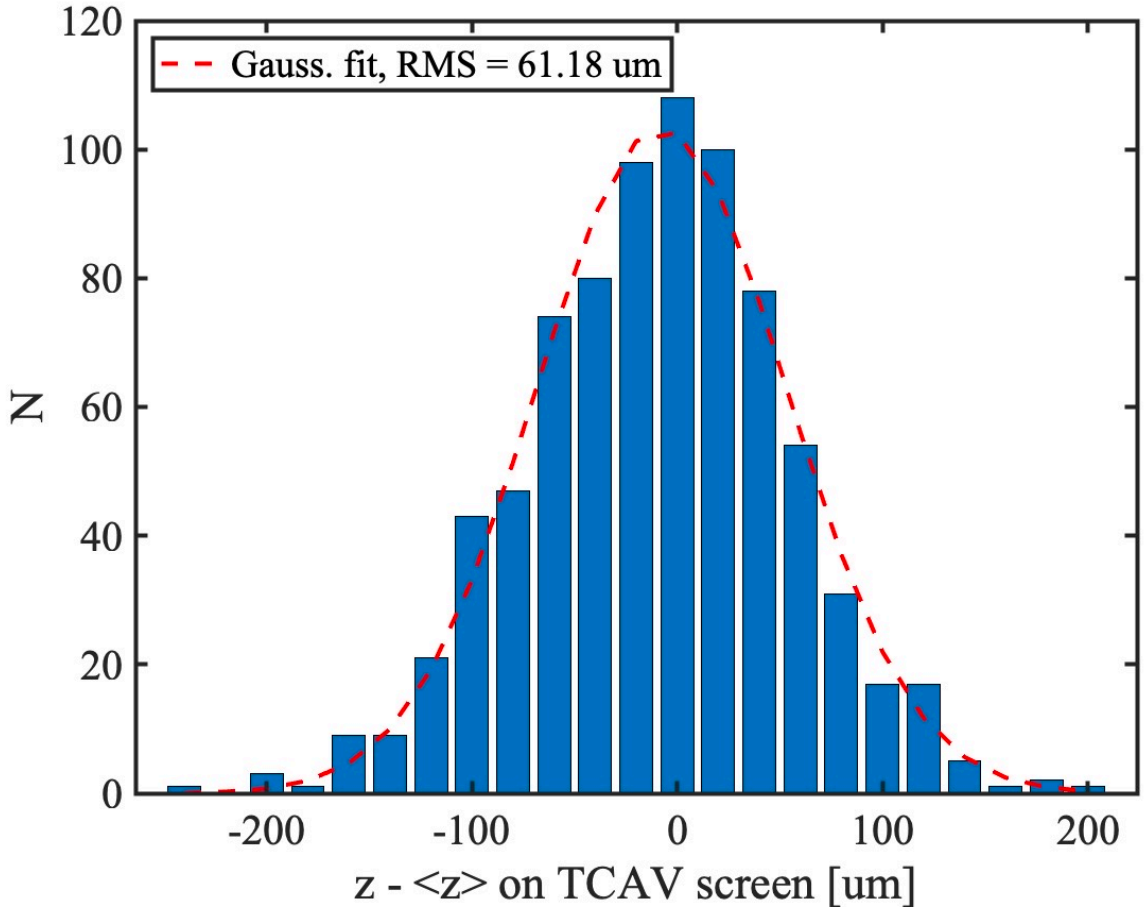




RMS jitter between electron beam and laser = 2.8 pix * 17 fs/pix = 48 fs

Measurement of TCAV ToA jitter (C. Emma)





RMS timing jitter between e-beam and TCAV = 61 um = 200 fs.

That's 4x larger than the laser to e-beam jitter on the same data set

Conclusion

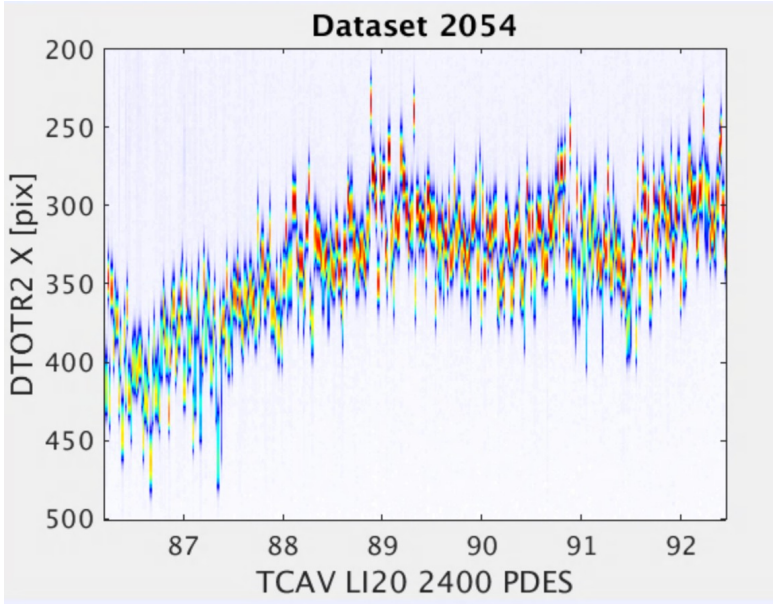
- Good news: machine appears to follow design parameters and we can measure that with longitudinal diagnostics.
- Bad news: we are extremely sensitive to upstream parameters in the machine and we need to “lock-down” S14 energy for stable Time-of-Arrival.
- Future work: How does this ToA jitter translate to bunch length jitter (single-bunch case) or bunch separation jitter (two-bunch case)?
- Future work: Implement upstream ToA jitter correction in S20 TCAV calibration procedure.

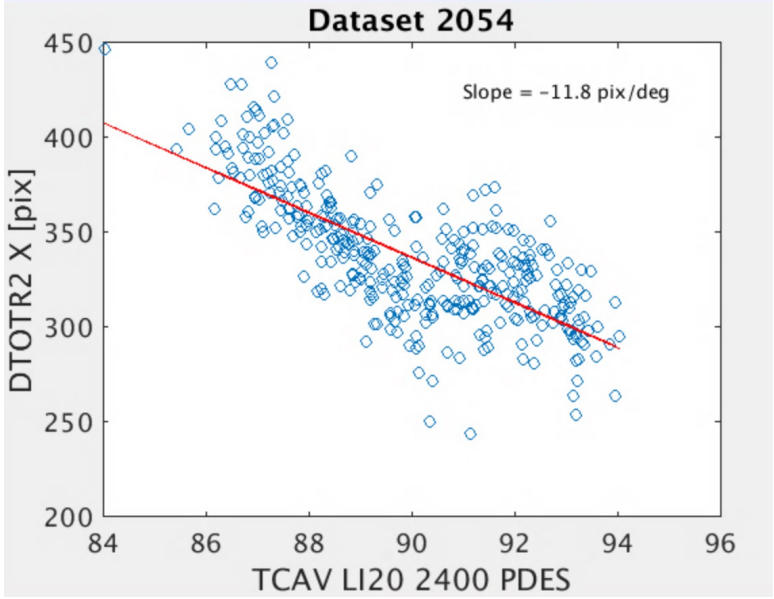
Backup

Numbers to keep in mind

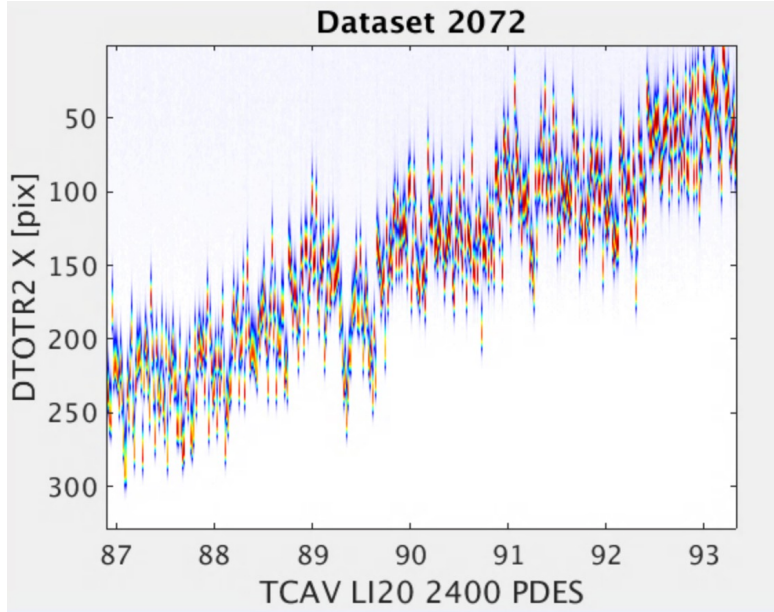
- SLAC s-band RF freq = 2856 MHz
  - 1 degree s-band = 291.6 um = 972.6 fs
- SLAC x-band RF freq = 11424 MHz
  - 1 degree s-band = 72.9 um = 243.2 fs
- EOS calibration ~ 20 fs/pixel

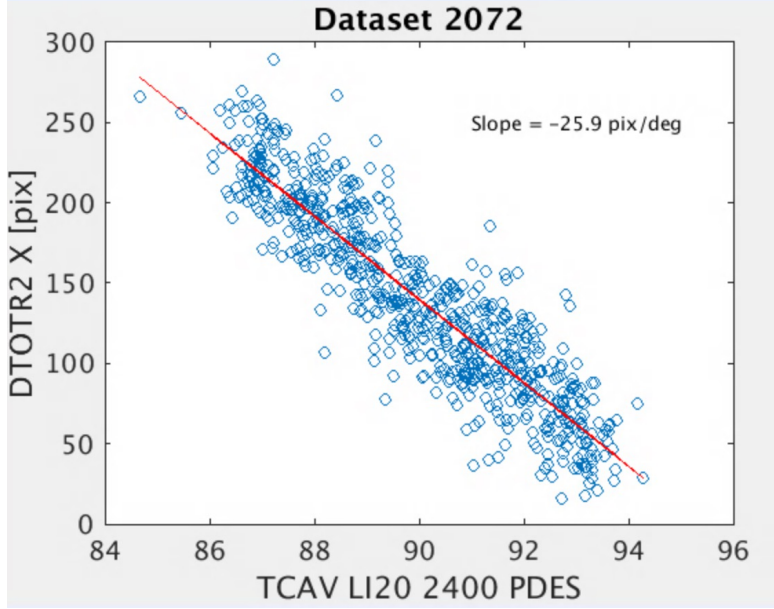
TCAV Phase Scans with DAQ





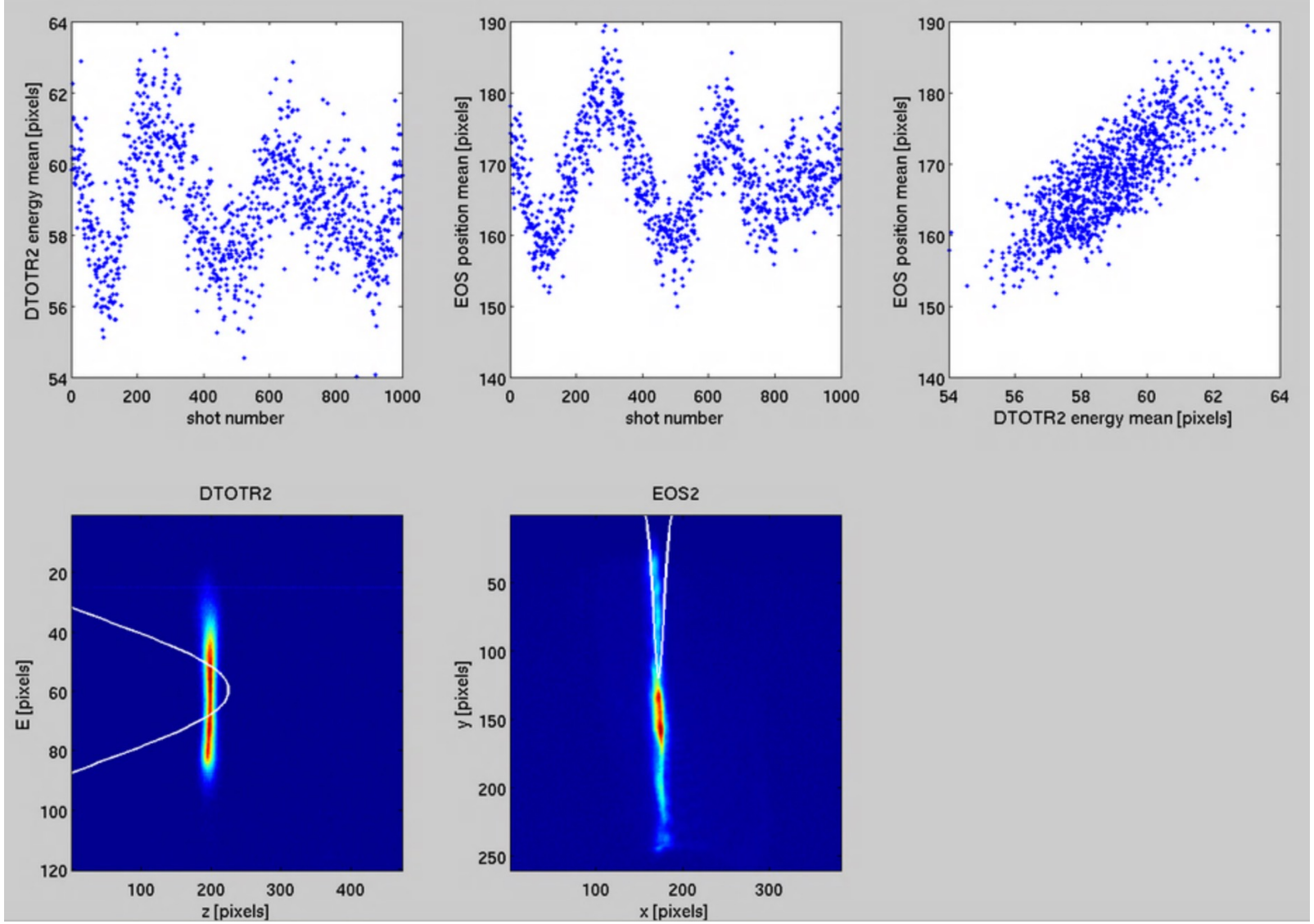
6.15 um_z /pix
20.5 fs/pix
359 um_z /deg





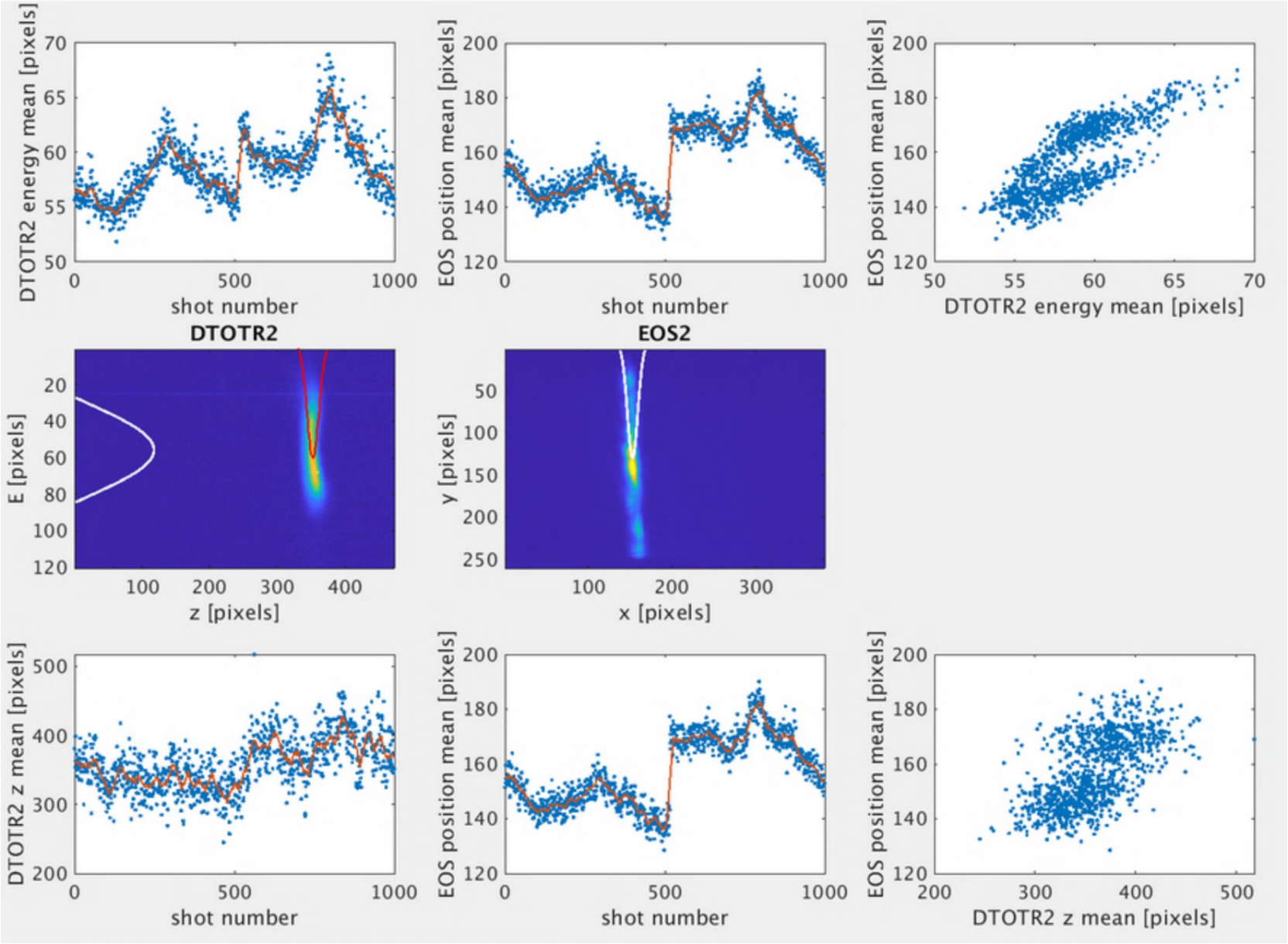
2.81 um_z /pix
9.38 fs/pix
785 um_z /deg

Upstream Energy Correlates with Time of Arrival



A. Scheinker

Upstream Energy Correlates with Time of Arrival



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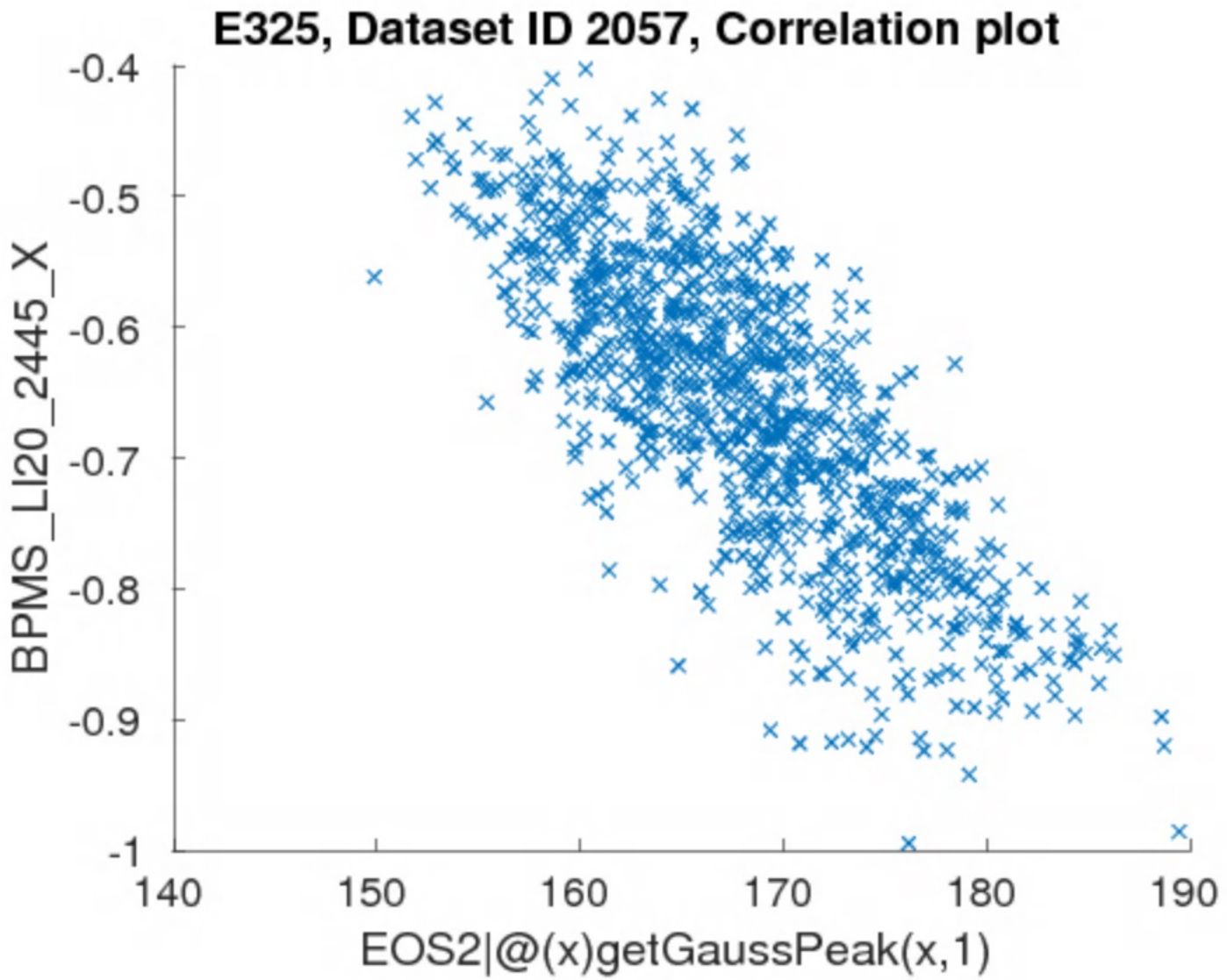
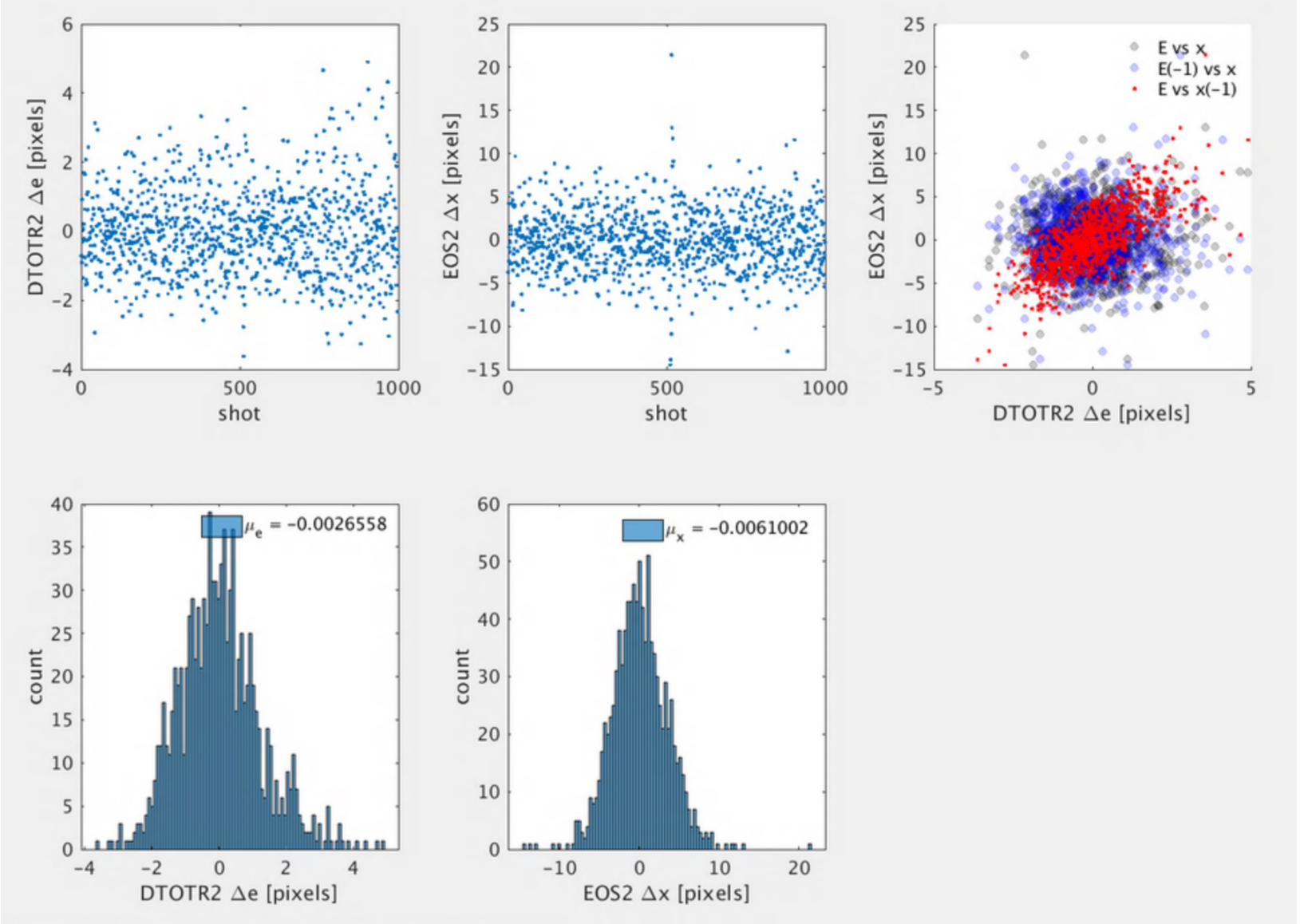
Upstream Energy Correlates with Time of Arrival



Upstream Energy Correlates with Time of Arrival



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