EOS, bunch spacing, feedbacks

E300 collaboration meeting

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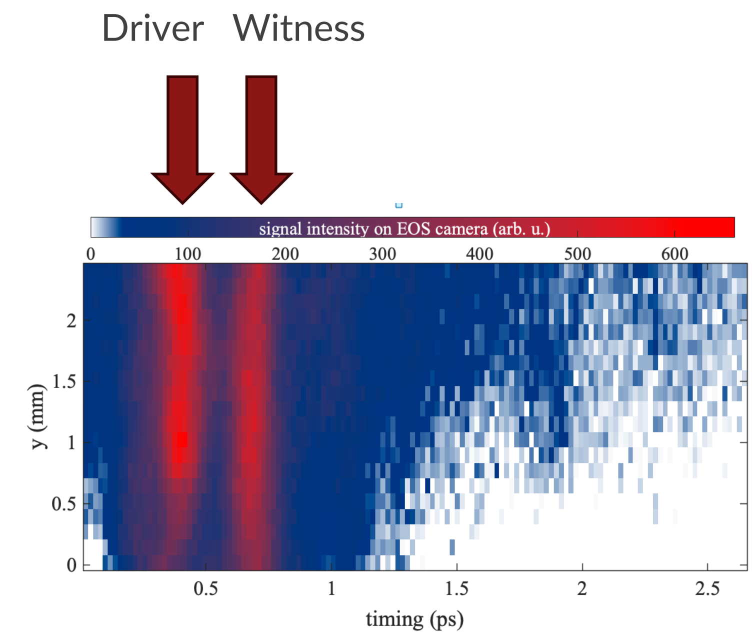
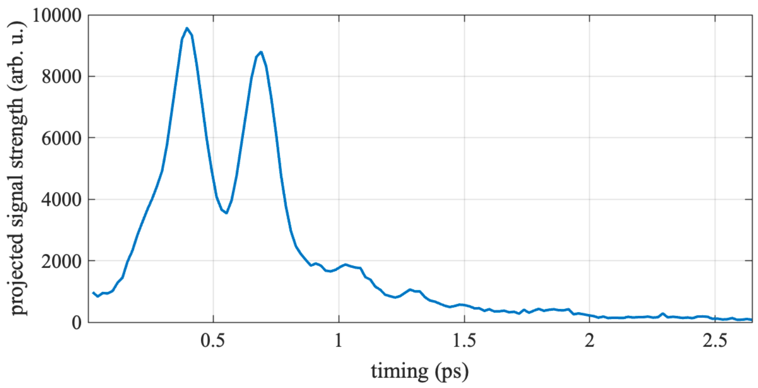
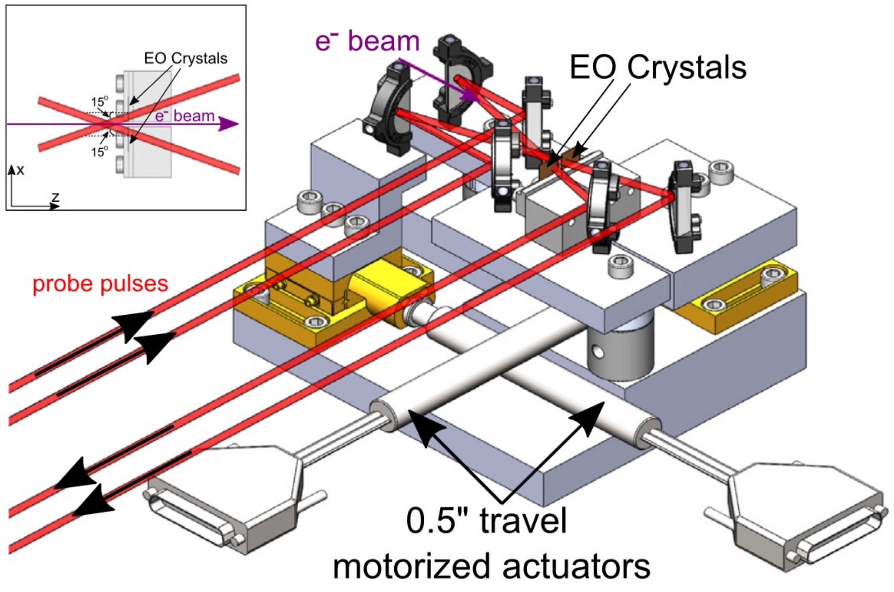
SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Electro-optical sampling can distinguish driver and witness beam





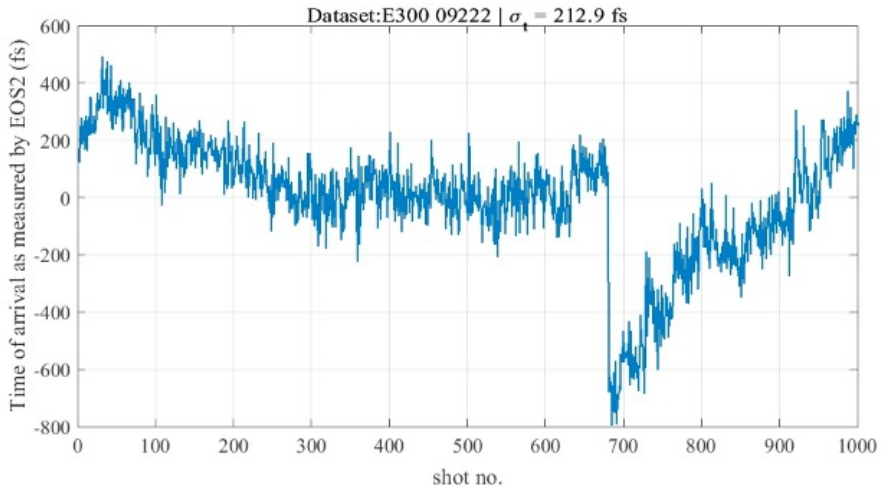


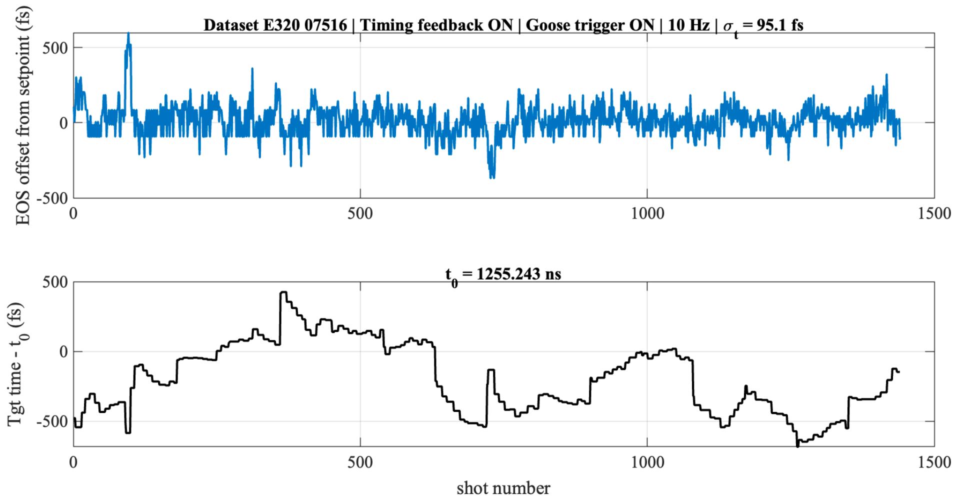
Hunt-Stone, Keenan, et al. "Electro-optic sampling beam position monitor for relativistic electron beams." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 999 (2021): 165210.

Changes from last year

- Improvements on probe references
- Changes to EOS setup and alignment
- EOS commonly used

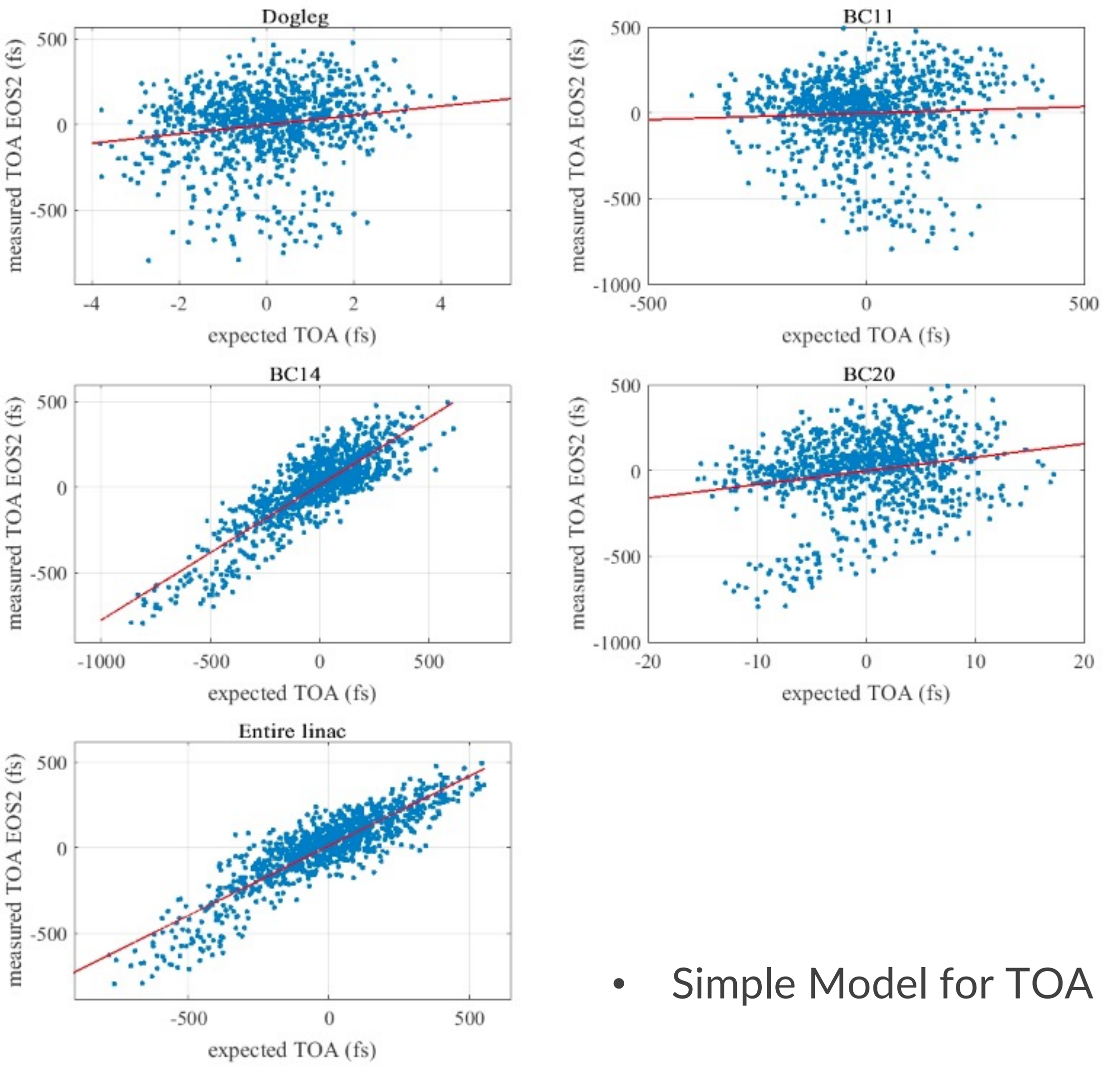
EOS to stabilize laser timing





- Relative time-of-arrival between electron beam and laser can drift by several 100 fs
- Ps drifts can move EOS signal out of field-of-view of EOS diagnostic
- PID on laser target time set point keeps signal on EOS and can stabilize interaction for timing-sensitive experiments such as E-320.

EOS-measured TOA and expected TOA



	R56	R16 @ BPM	BPM	Covariance	Fit slope (fs/fs)
Dogleg	-1.5618 mm	-262.7814 mm	10:731X	0.0048 E4	27.02
BC11	-45.9847 mm	-251.0805 mm	11:333X	0.1424 E4	0.0764
BC14	-36.0141 mm	-437.3561 mm	14:801X	4.196 E4	0.79271
BC20	6.9132 mm	46.5288 mm	20:2445X	0.0255 E4	7.9271
All of the above				4.3692 E4	0.8127

Simple Model for expected TOA

$$\Delta t_{DL}^{\text{exp.}} = \frac{R_{56}^{\text{DL}}}{c_0 R_{16}^{DL}} x_{731} \quad (1)$$

$$\Delta t_{BC11}^{\text{exp.}} = \frac{R_{56}^{\text{BC11}}}{c_0 R_{16}^{BC11}} x_{333} \quad (2)$$

$$\Delta t_{BC14}^{\text{exp.}} = \frac{R_{56}^{\text{BC14}}}{c_0 R_{16}^{BC14}} x_{801} \quad (3)$$

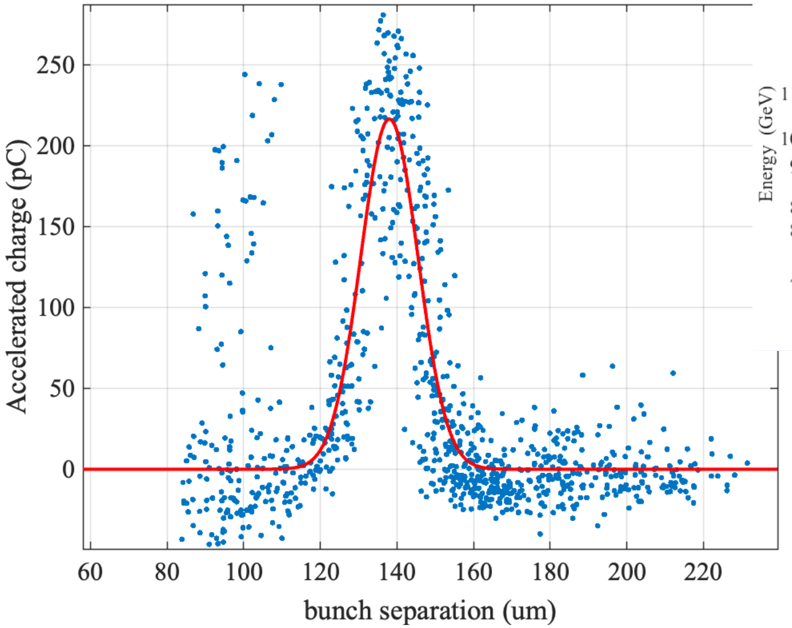
$$\Delta t_{BC20}^{\text{exp.}} = \frac{R_{56}^{\text{BC20}}}{c_0 R_{16}^{BC20}} x_{2445} \quad (4)$$

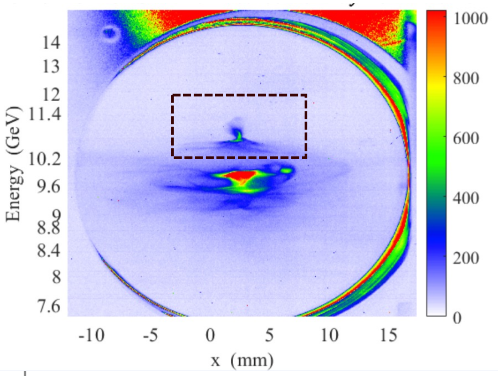
$$\Delta t_{\text{exp}} = \Delta t_{DL} + \Delta t_{BC11} + \Delta t_{BC14} + \Delta t_{BC20} \quad (5)$$

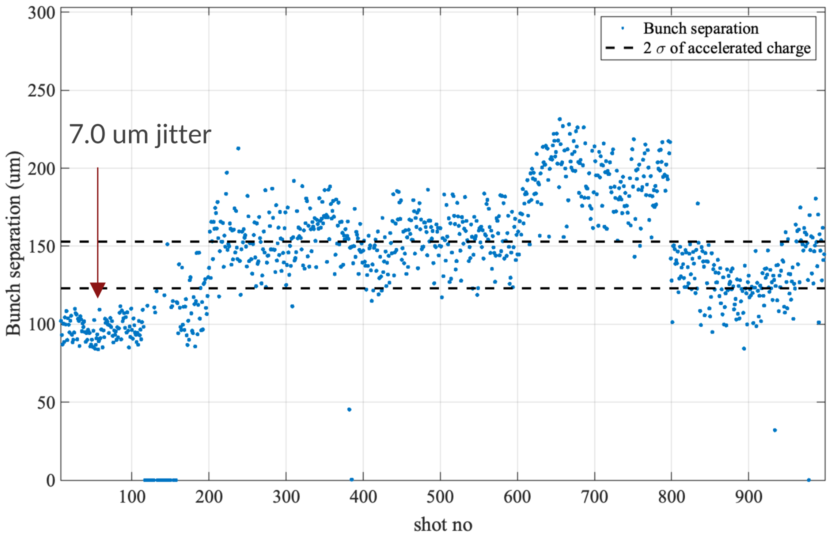
- Simple Model for TOA in good agreement with measurements
- TOA in this case dominated energy-variations in BC14

EOS to measure bunch separation

Dataset E300_08356







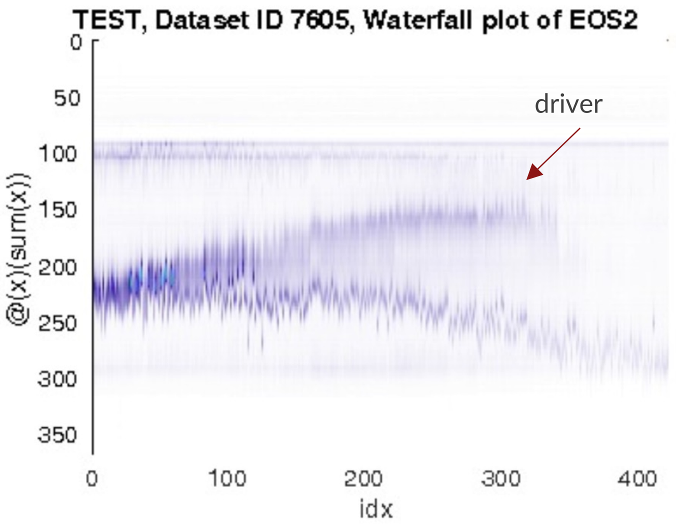
- Expected plasma wavelength 161 um
- Optimal bunch separation 138 um | 0.85 λ_p
- Width of Distribution (rms) 7.5 um | 0.047 λ_p

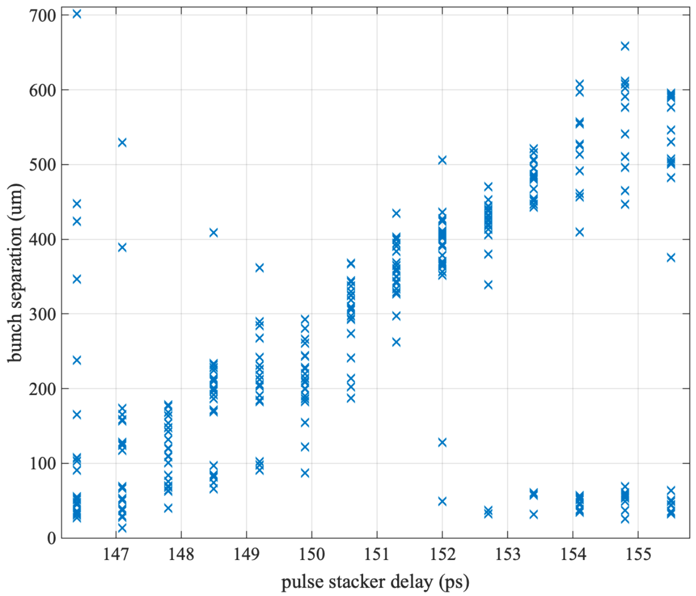
- 303/998 shots within 2 sigma
- Accelerator drifts and jitters in and out of phase matching
- Jitter can be smaller than phase acceptance
- What to do about drift ?

Assumptions:

- EOS calibration = 19.75 fs/px
- Spectrometer imaging Plasma entrance+27 cm to LFOV
- Imaging Energy = 11 GeV

Controlling bunch separation with Pulse stacker delay

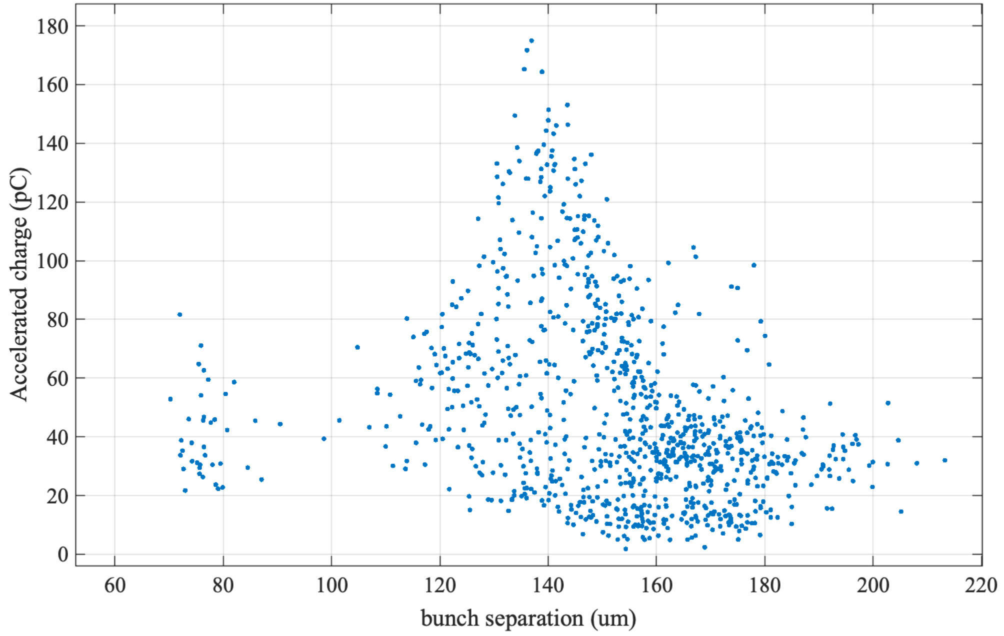


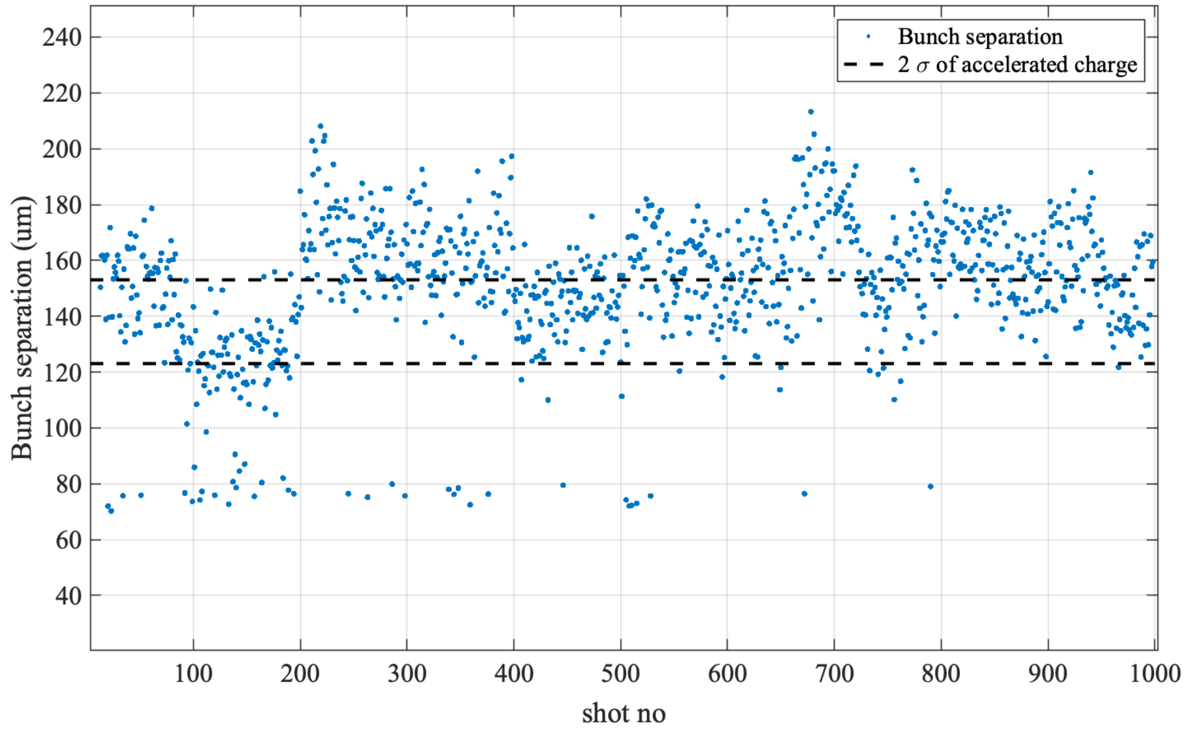


- Pulse stacker delay line can set delay of witness beam with respect to driver
- Suitable control knob to stabilize bunch separation ?

Stabilizing bunch separation on Pulse stacker delay

Dataset E300_08369.

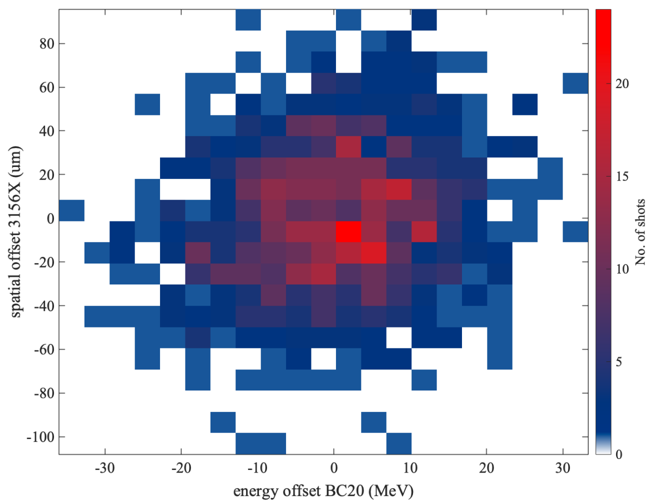




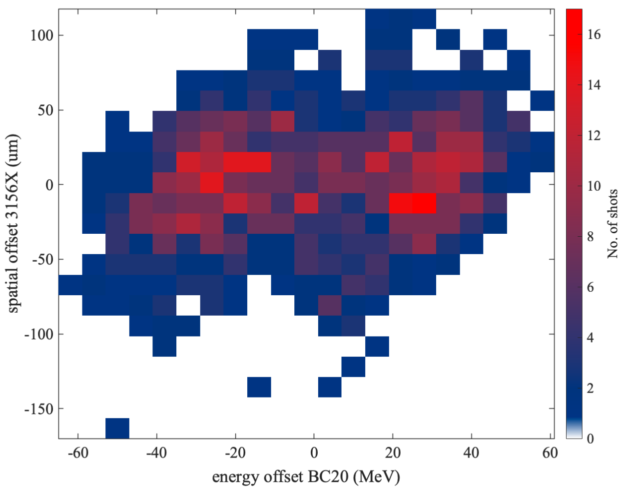
- Minimally improved Bunch separation stability
- No more clear charge peak as function of bunch separation
- 372/998 shots within 2 sigma
- DTOTR2 filter IN
- PSDL varies witness-beam energy

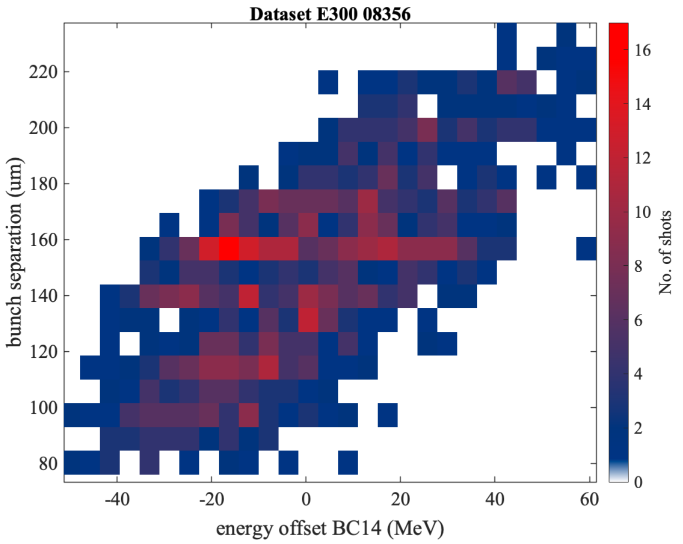
What is different ?

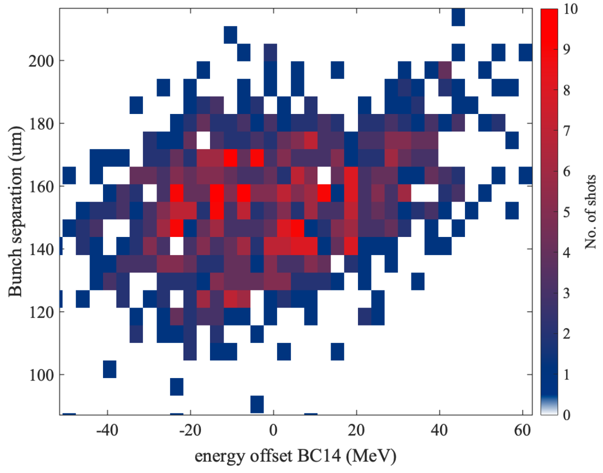
Dataset E300_08356 | No feedback



Dataset E300_08369 | PSDL feedback







No-feedback case

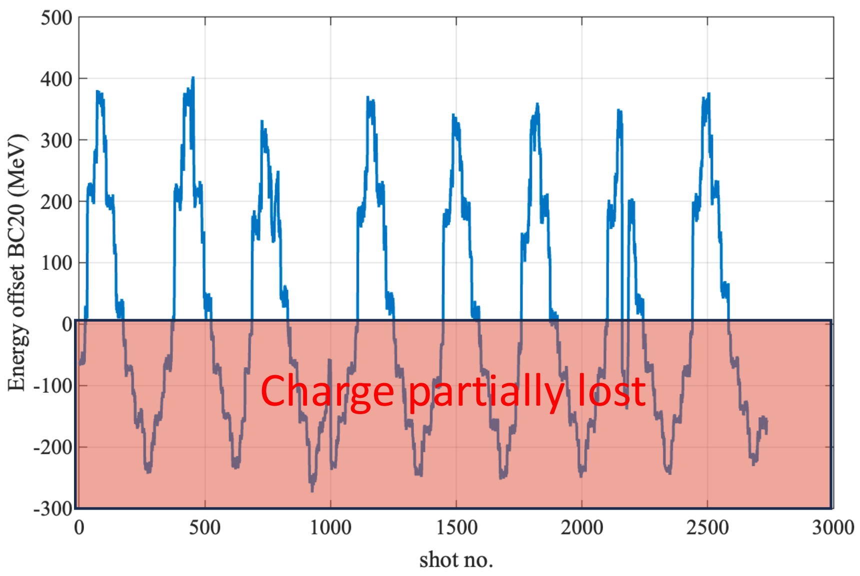
- Bunch separation dominated by Linac 2 energy
- Weak correlation between x and BC20 energy

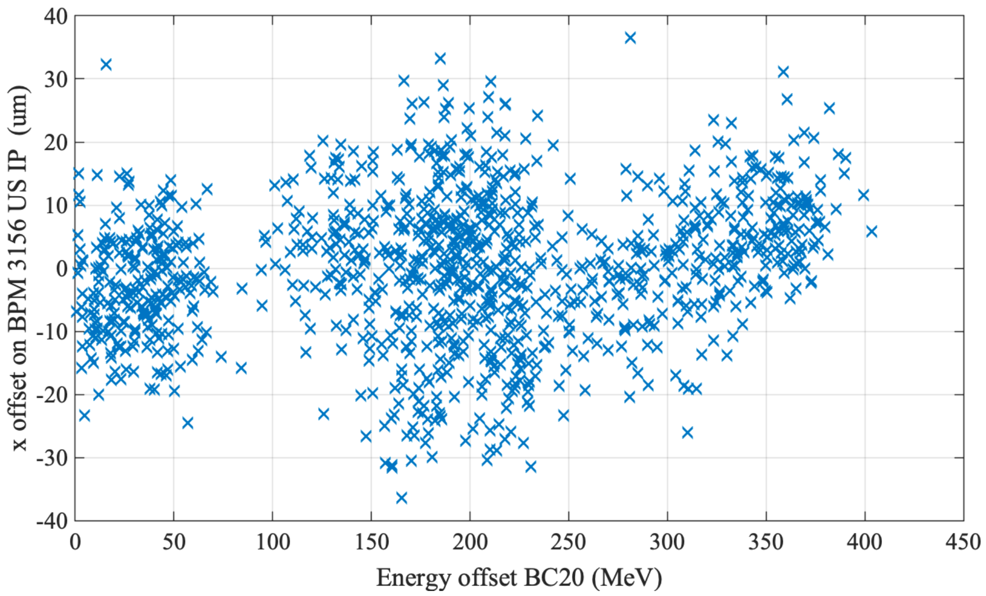
PSDL feedback case:

- Weaker dependency of bunch separation and BC14 energy
- More complex correlation correlation between x and BC20 energy

Did we really improve things ?

Dispersion-response to linac 3 energy offsets





- Dispersion at IP can be a complex function.
- Varies strongly with sextupole settings
- Ideal case:
  - No dispersion on 3156 (US BPM)
  - No dispersion on 3218 (DSBPM)
  - Round and small beam at IP
- Preliminary testing: Achieving all three together is extremely challenging

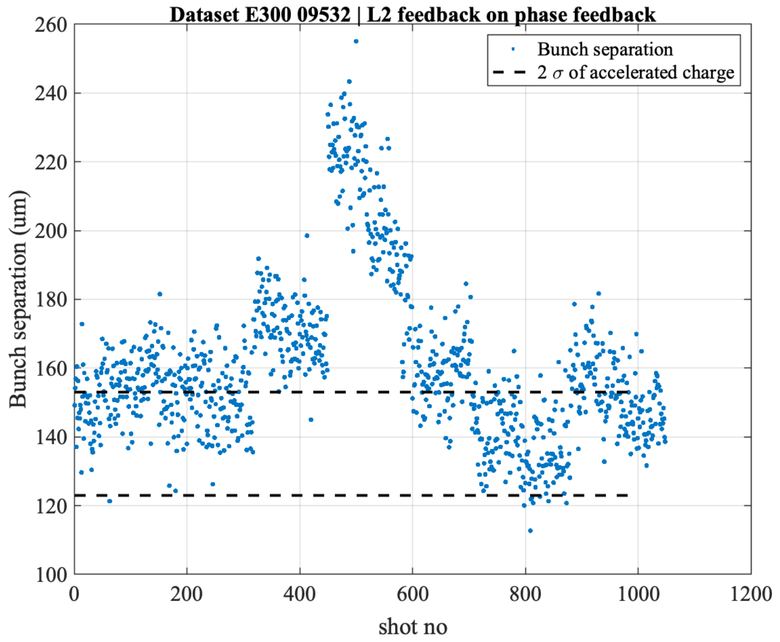
- **Dispersion correction requires more studies**

Feedback on L2 phase

Feedback directly onto L2 phase:

- Every attempt destabilized Accelerator
- Development might be possible with more effort

- **Feedback on input onto L2 phase feedback :**
- Spoofing BC14 bunch length monitor readback to mislead BC20 feedback
- Slow effect due to indirect modification
- Accelerator remained stable



Summary

- EOS excellent tool for our needs to measure shot-to-shot bunch spacing
- Variations in energy out of Linac 2 can dominate time-of-arrival and bunch separation
- Accelerator can be set up such that bunch separation remains the only issue for injection
- Data suggests we need a bunch-separation jitter < 7.5 um | 25 fs
- All of this needs more work

Thank you !