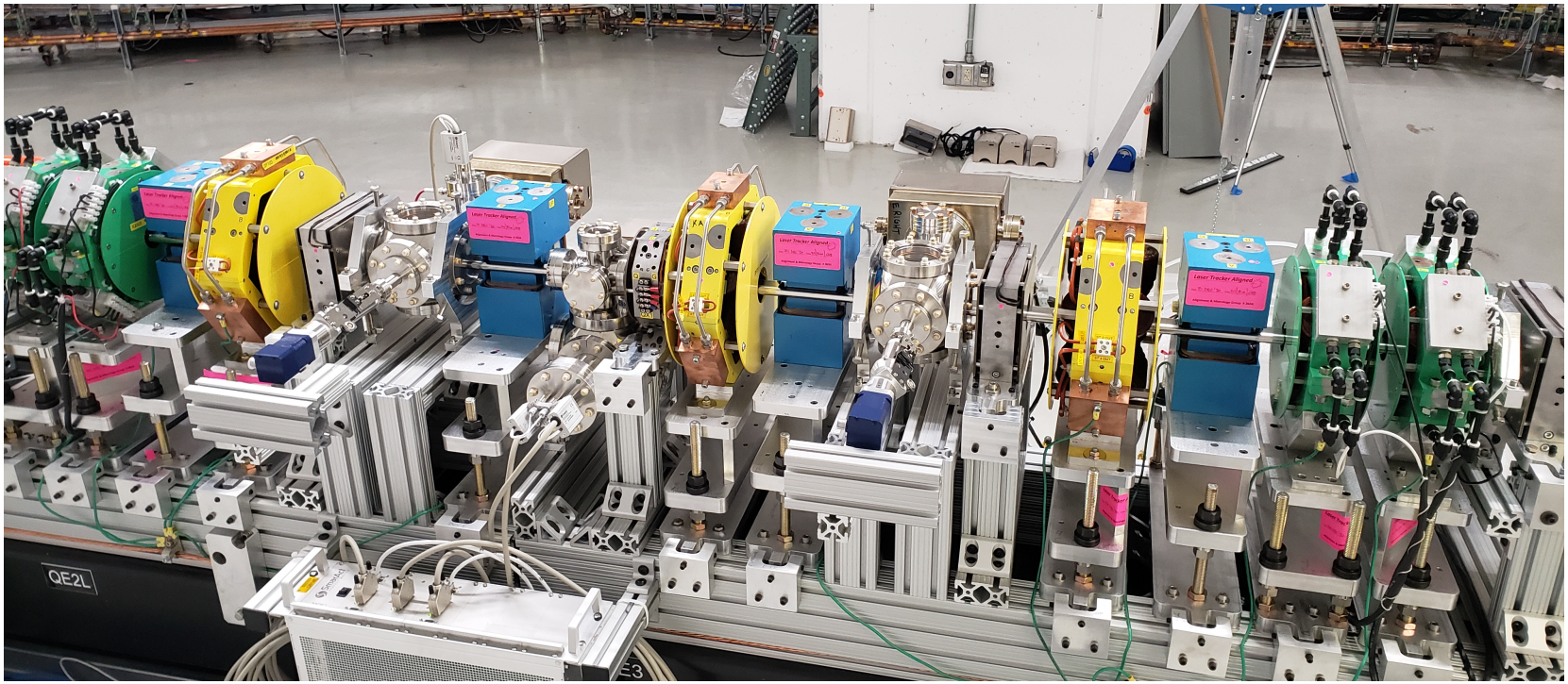
OSC: first interference observations (preliminary report)

Fermi National Accelerator Laboratory, April 9, 2021

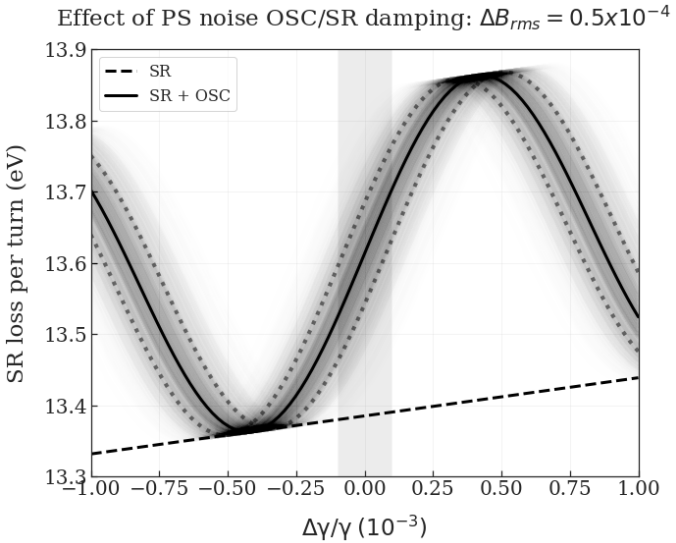
OSC chicane generates a precision delay for the beam

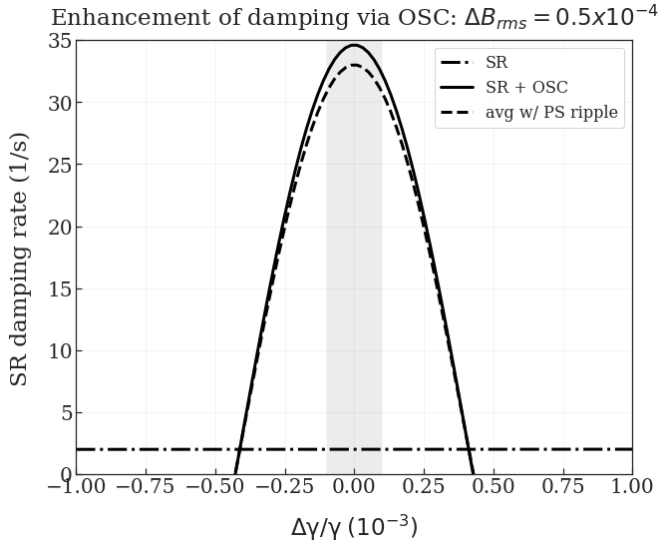
- To enable OSC, the beam delay must match that of the light optics and must be stable to << 1 μm (sub fs)
- To match the delay, we can tune the chicane and a set of optical flats
- When matched, sufficient stability is heralded by interference between KU and PU



Need the chicane's field stability at <1e-4 for OSC

- Ripple in the magnetic field will produce ripple in chicane delay and therefore relative arrival phase for entire beam
- For $\sigma_{\Delta B} \sim 10^{-4}$, path change is a small fraction of the cooling range
- Currently testing systems with more challenging wavelength (~632 nm)
- BiRa PCRC systems @ ripple+noise of 10^{-5} for chicane dipoles
- PCRCs were brought online last Friday; now we can look for KU+PU interference





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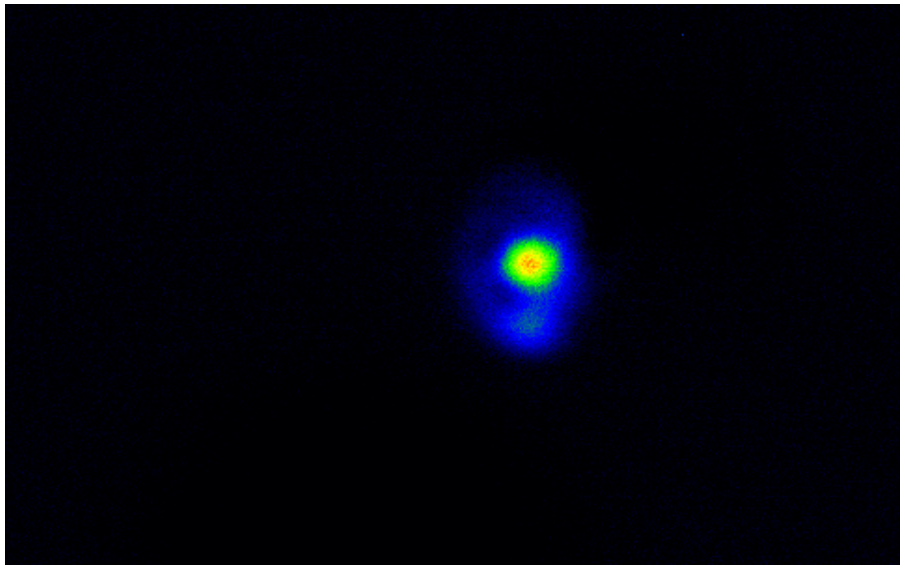
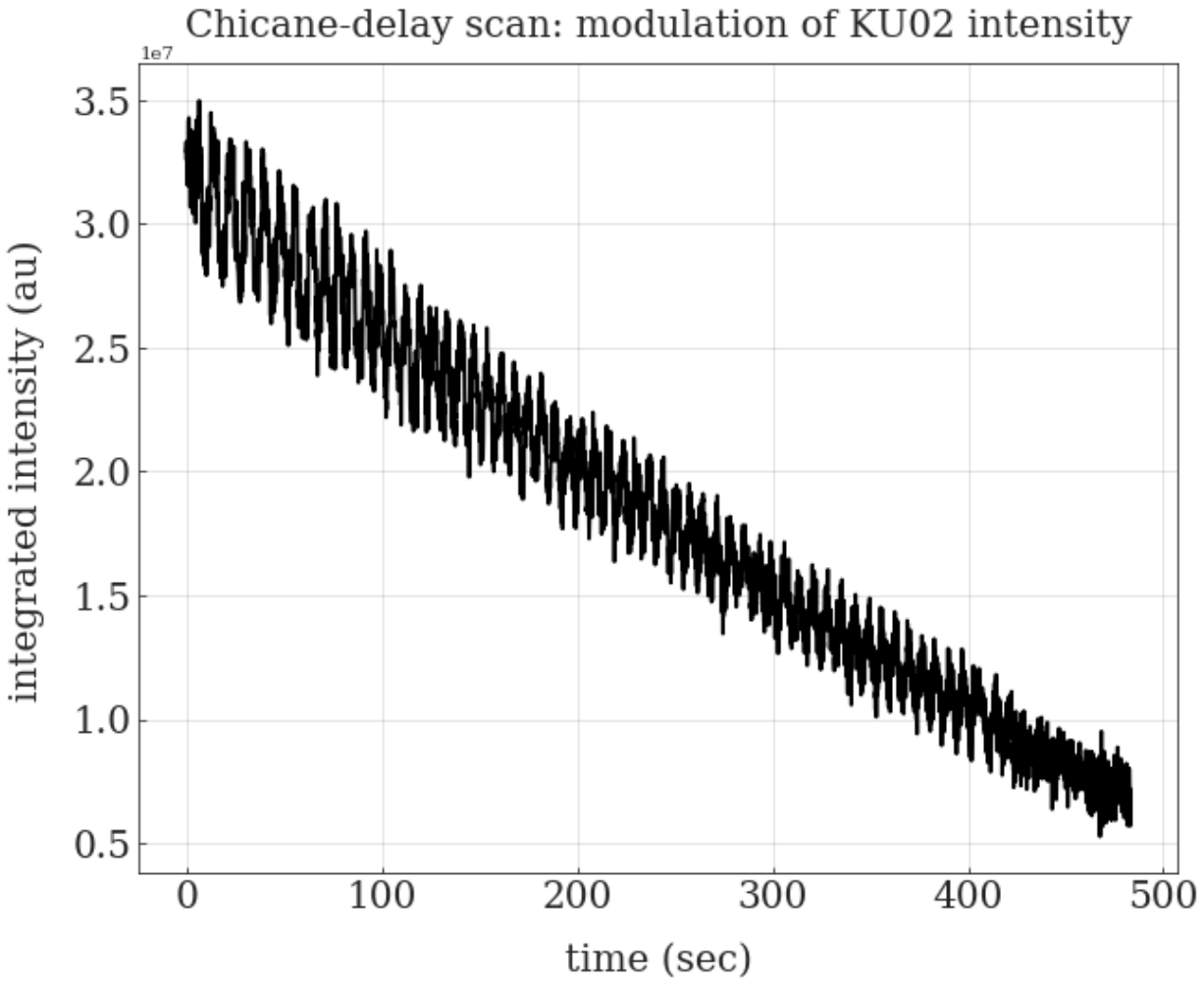
Interference has been observed in the OSC system

- We have successfully observed interference between the two OSC undulators and have modulated that signal using both delay systems (chicane and delay plates)
- This interference suggests that the chicane is stable to the desired level for OSC.
- (below) Realtime video of the KU + PU radiation intensity being modulated periodically via a scan of the optical-delay plates



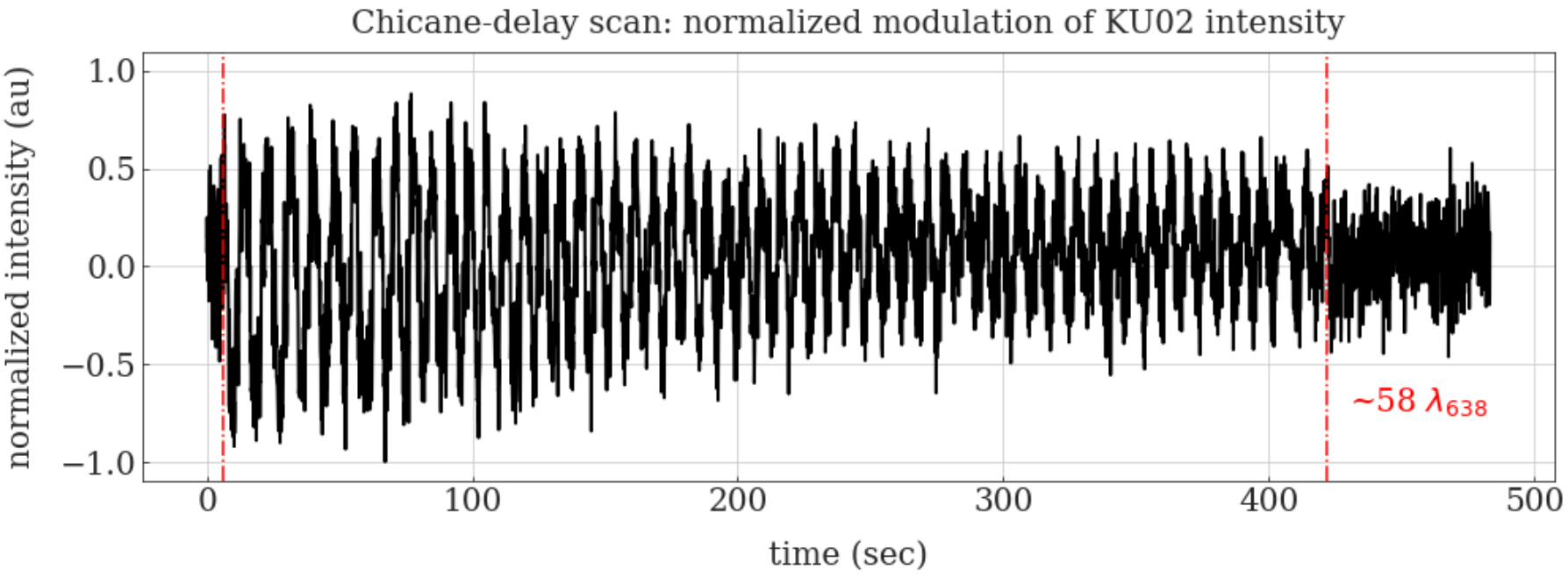
Chicane-delay scan: 3.1036A - 2.9989A

- Manual scan of the chicane strength using “discrete” steps at ~250 μA every 2 sec; 420 sec total

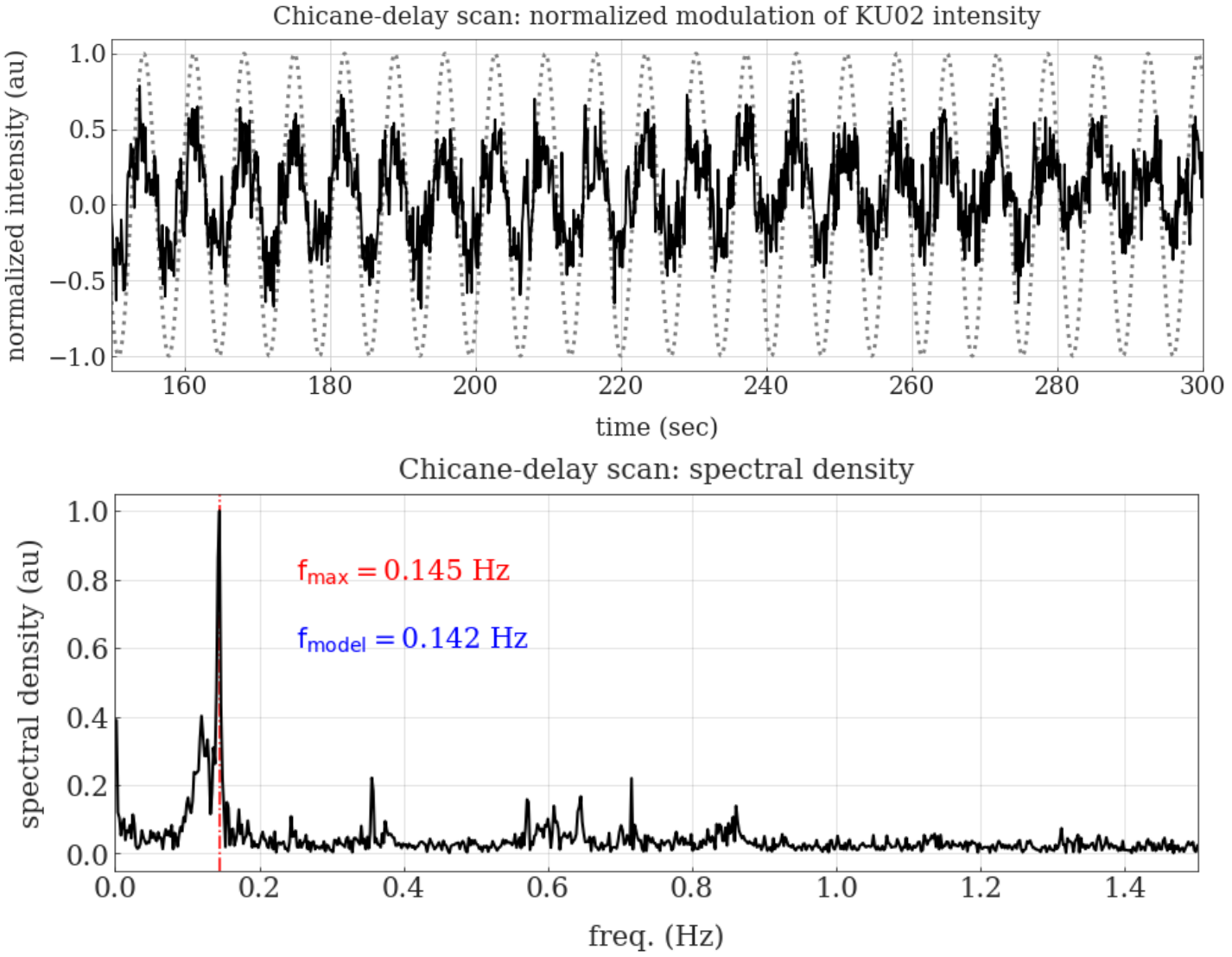


Observe the exact # of periods expected from model

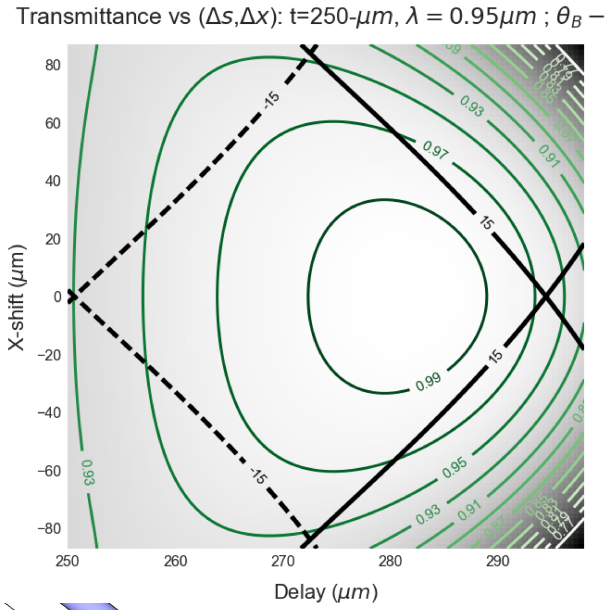
- 6dsim gives a path lengthening of ~0.0908 μm/sec for this rate
- One wavelength (638 nm) in ~7.026 sec (0.142 Hz)
- With 58 periods expected and observed

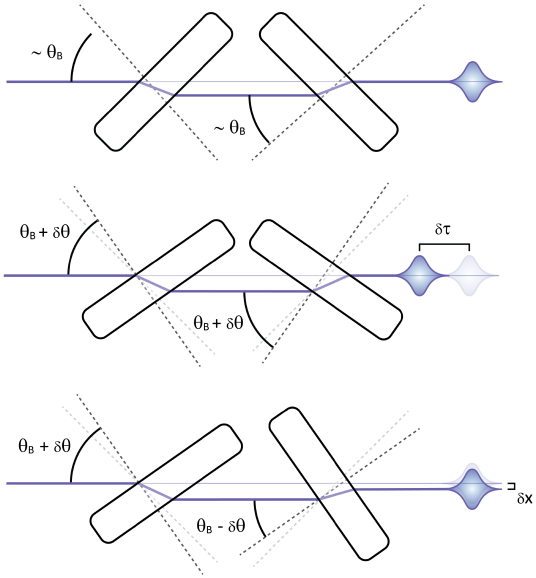


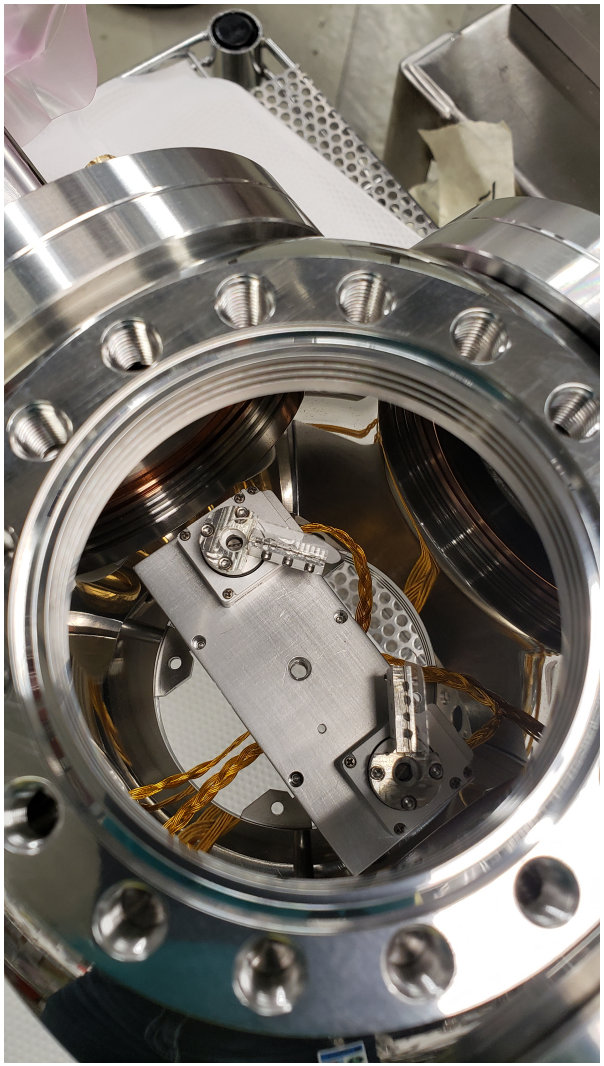
Modulation frequency agrees with expected rate

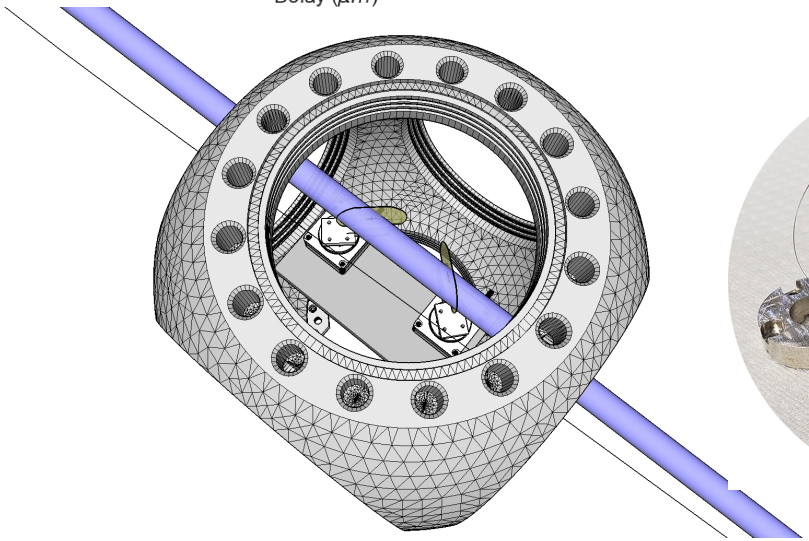


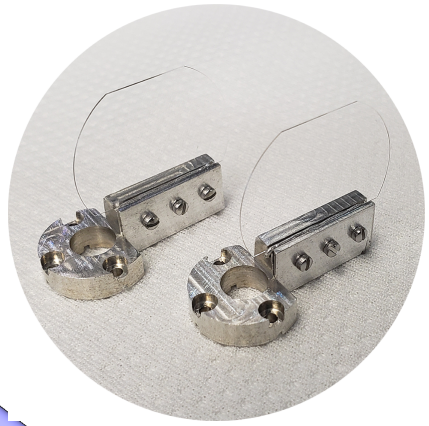
Delay plates provide fine tuning of optical delay











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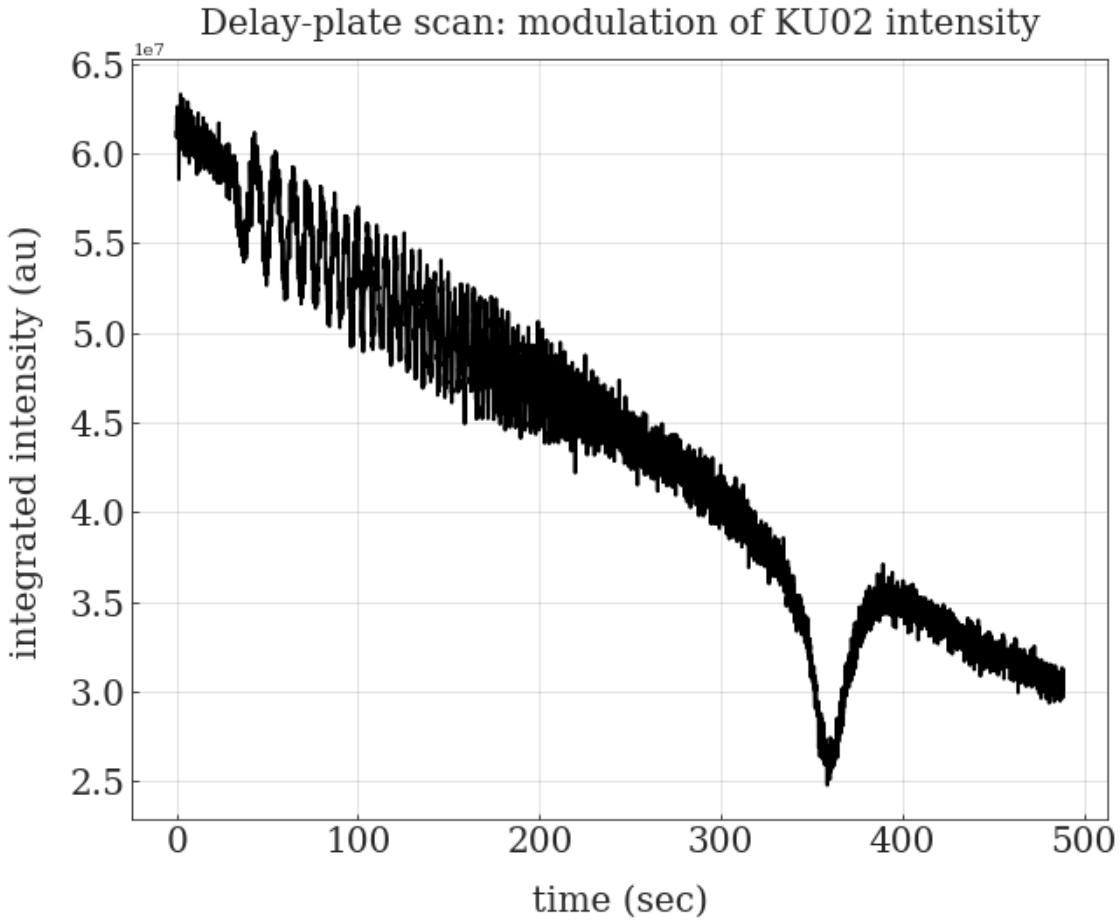
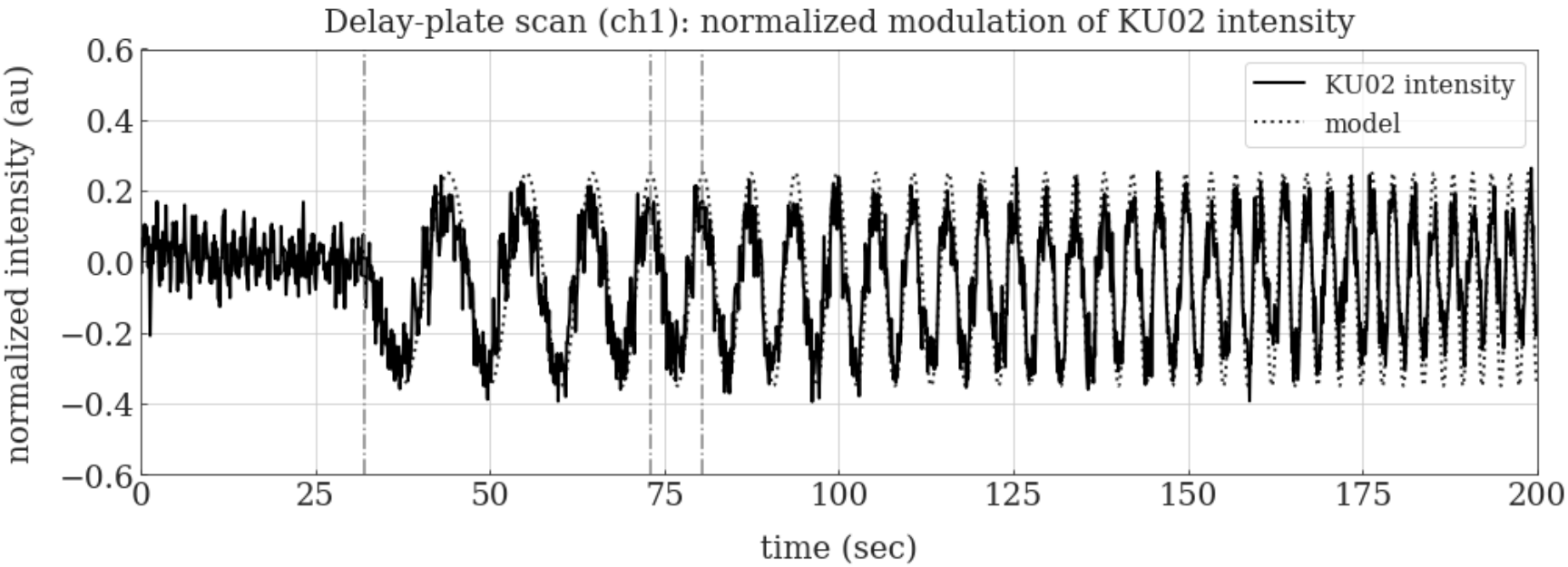
+/- 40 deg scan with a single plate

- Chirped modulation with angle
- fringe amplitude reduced at higher delay, possibly due to integration time

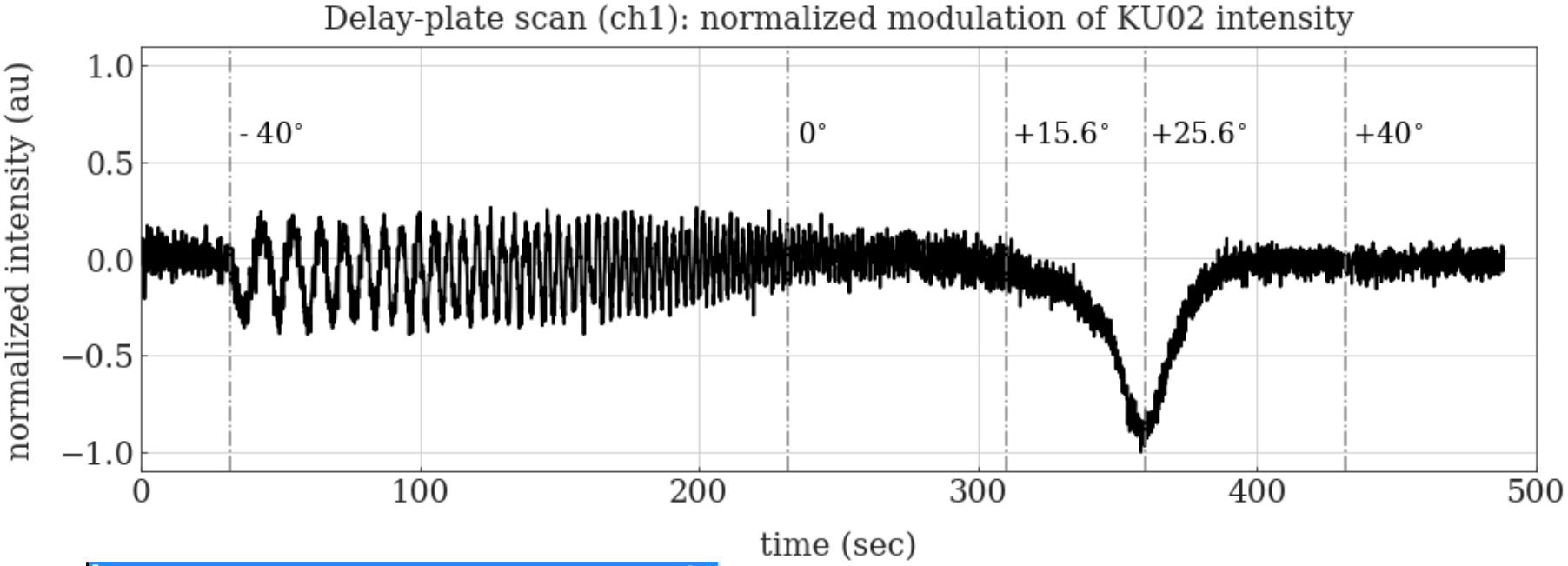


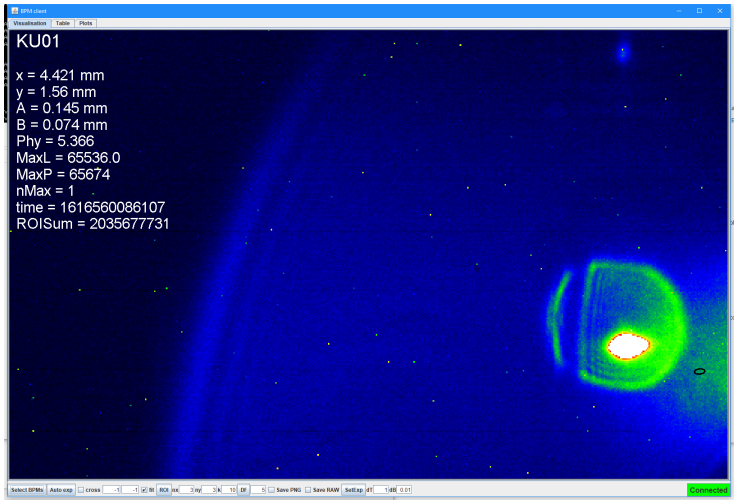
Excellent agreement in delay change vs angle

- One plate is fixed at the Brewster angle while the other is scanned at 0.2°/sec
- Chirped modulation with angle agrees very well with model



Key features signal good alignment of the system





- Clearly see the effect of breaching the light envelope with the plate edge (~16°)
- Occurs very close to the correct value; measurement and model
- (left) SR image when KU01 is focused at the downstream chicane dipole (bx2l); the underfocused PU radiation is being breached by the edge of the delay plate