CeC RF System Stability

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Outline

- Short Term Stability (Jitter)

- Long Term Stability (Drift)

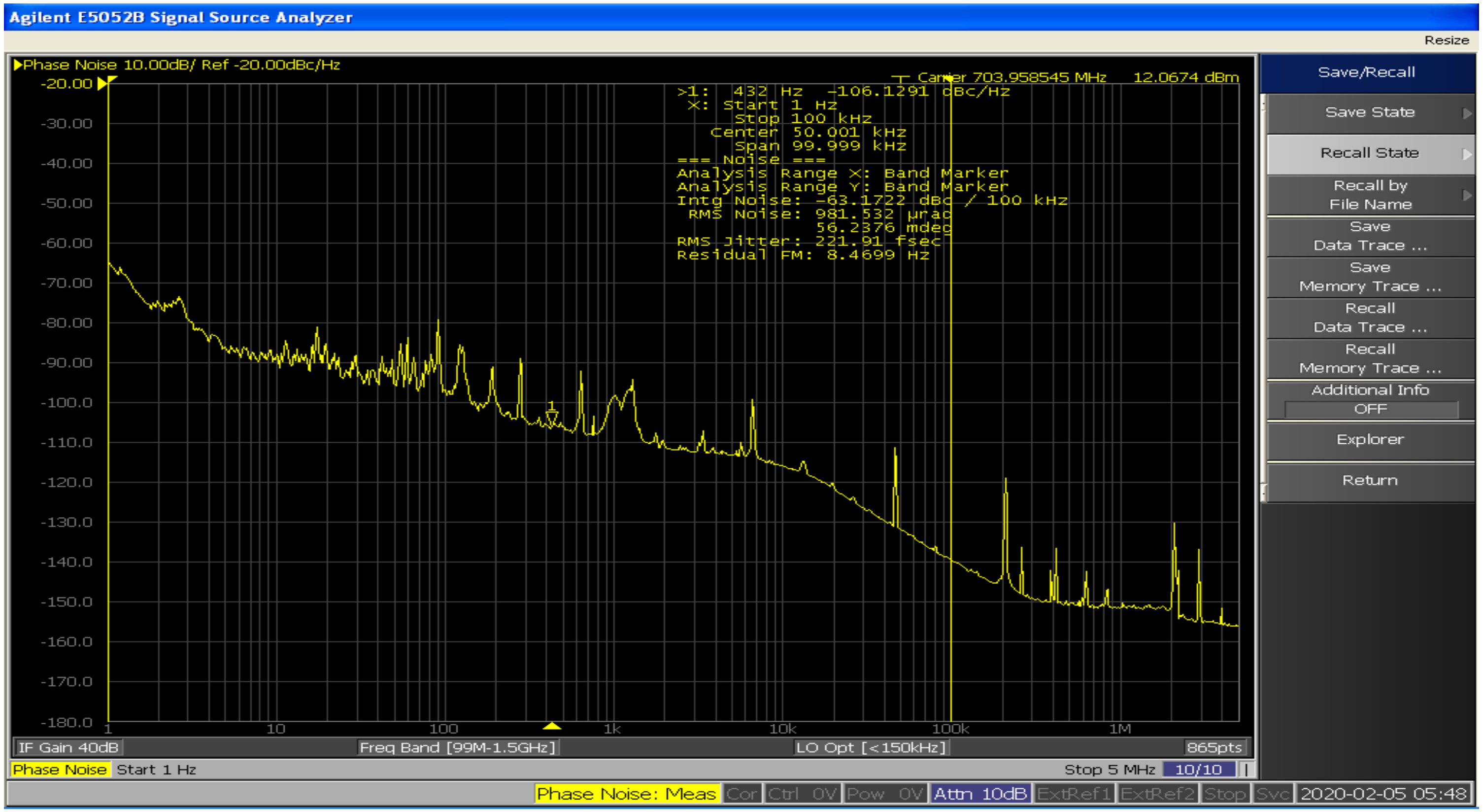
- Laser Timing Stability

Short Term Stability Performance

	Requirement		Achieved	
	Phase (deg RMS)	Amplitude (RMS)	Phase (deg RMS)	Amplitude (RMS)
112 MHz Gun	0.1	1.0E-4	0.06	3.2E-5
500 MHz Bunchers (Vector Sum)	0.1	1.0E-4	0.04	2.0E-4
704 MHz Linac	0.1	1.0E-4	0.05	4.0E-5

- Measured using 100 ksps data for 1 second
- Measured performance agrees with continuously logged data – available in LogView
- Linac performance >2 times better than last year – switched from direct sampling to using up/down conversion

Short Term Performance Confirmation



- Independent measurement of jitter
- The measured 220 fsec RMS jitter corresponds to 0.045 degrees at 704 MHz
- Confirmation of in system measurement of 0.05 degrees

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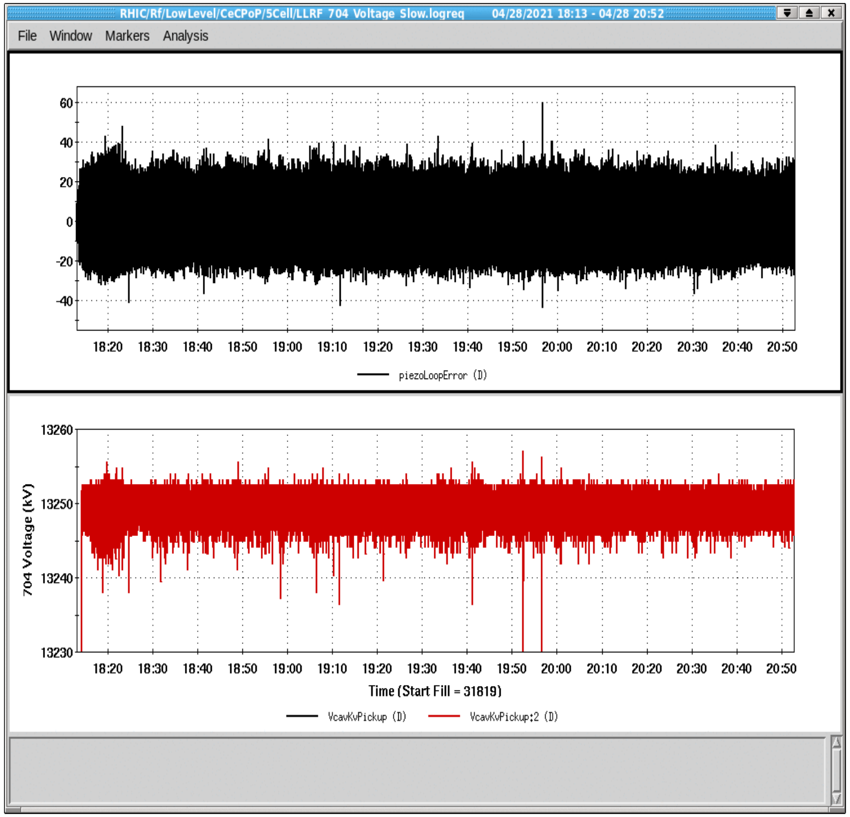
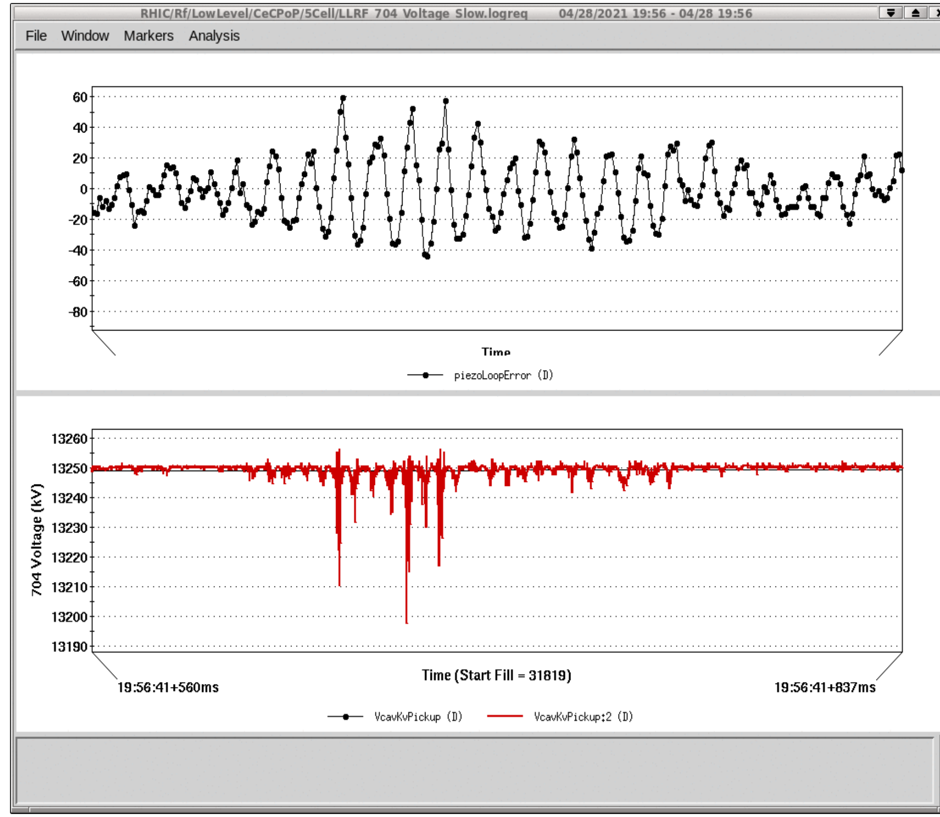
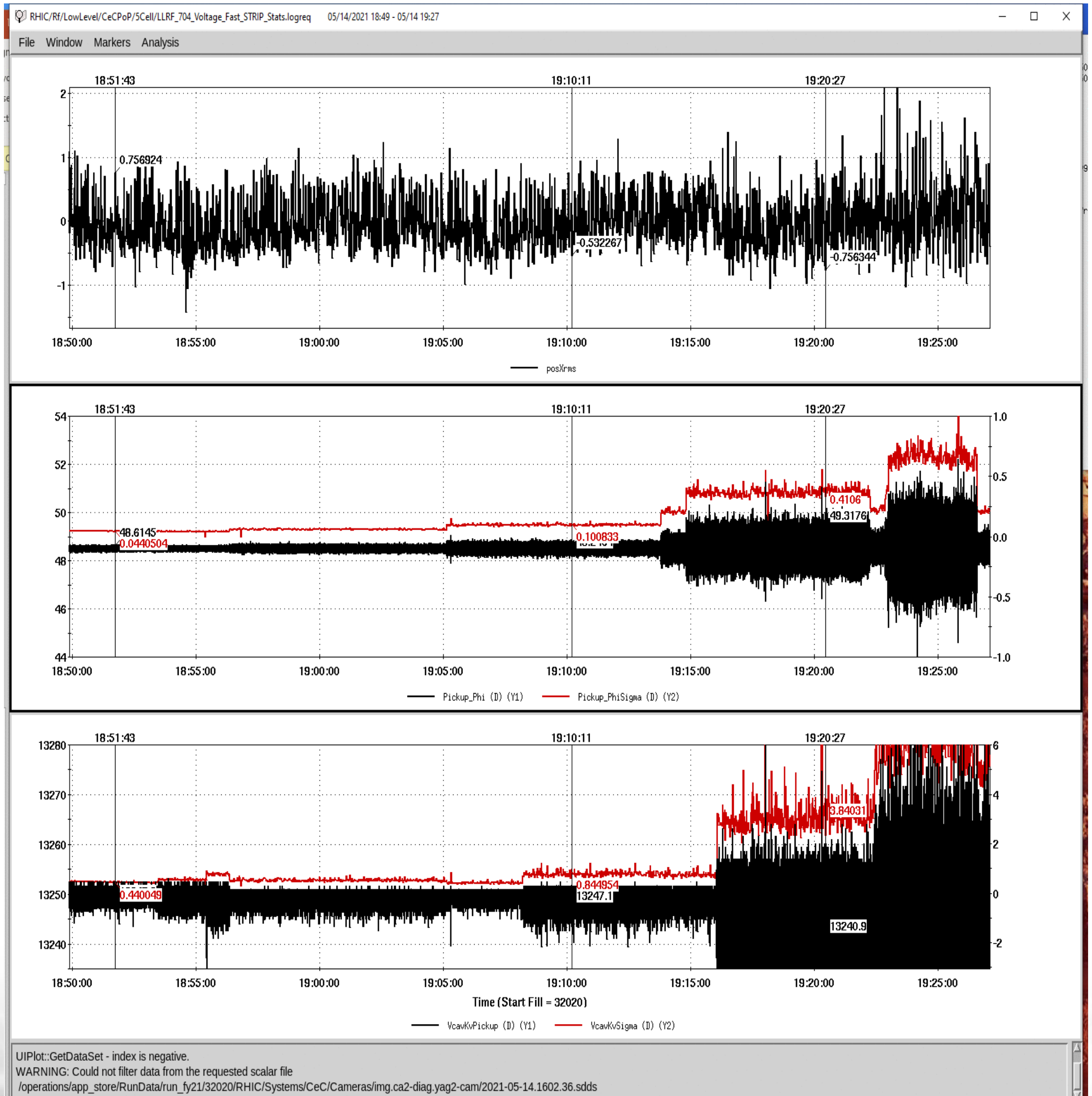
Short Term Performance - Microphonics



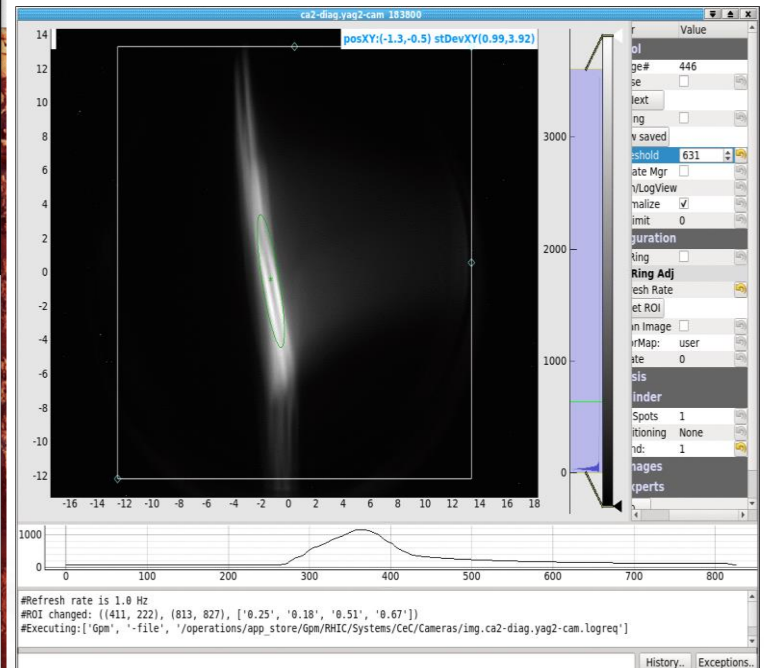


- Occasional, large microphonic detuning can cause cavity to go out of regulation
- Short term events lasting only a few milliseconds
- Identified failure mechanism that greatly increases microphonic events
  - Liquid helium levels too low cause much higher microphonics
  - Alarms generated by low helium levels

Short Term Performance



- Changes in loop gains show degraded regulation as expected but no measurable change in beam energy
- For changes up to a factor of 10 in gain, no change in peak to peak energy variation
- Linac regulation is not limiting performance



Short Term Performance

- Using up/down conversion improved Linac regulation by a factor of 2
- Extensive testing was done to ensure optimal system loop gains
- Expect some improvement in Buncher regulation by removing second cavity. Regulating vector sum with one cavity fully detuned was difficult.

Long Term Stability

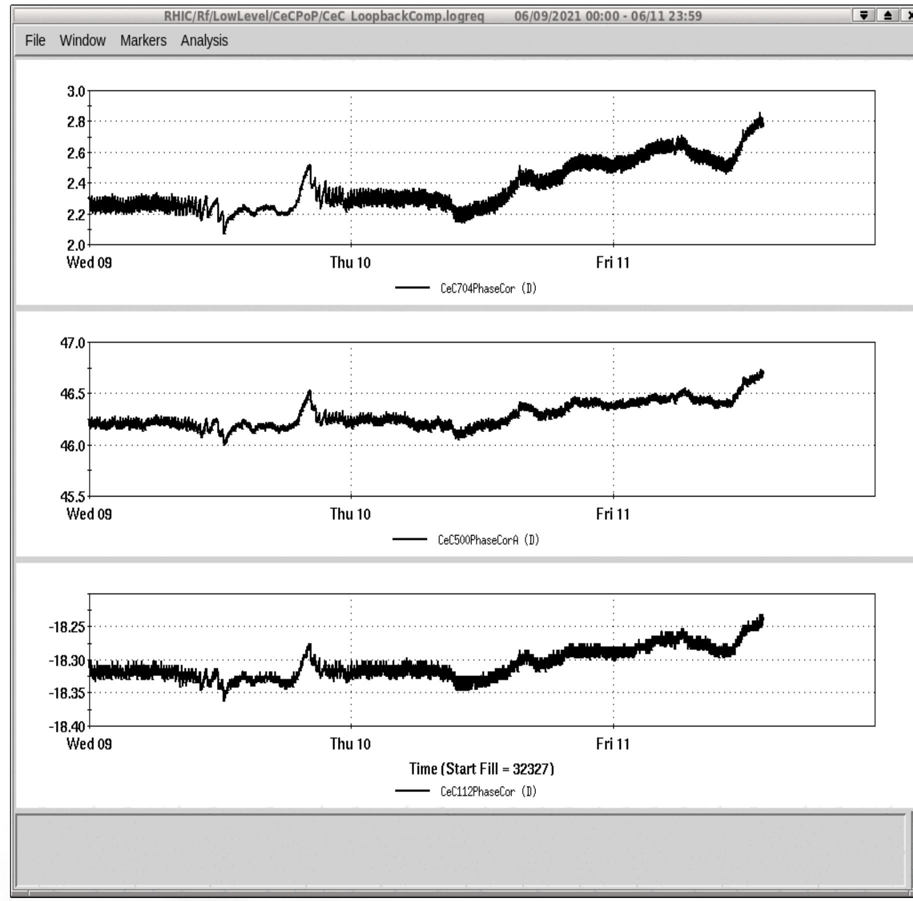
Drift Control Measures

1. Temperature Controlled Racks
2. Temperature Controlled Outdoor Conduits for Pickup Cables
3. Loopback Correction
   - Pickup cables tightly bundled with a pair of cables used for loopback measurement
   - Measured pickup signal is compensated based on changes in the loopback signal

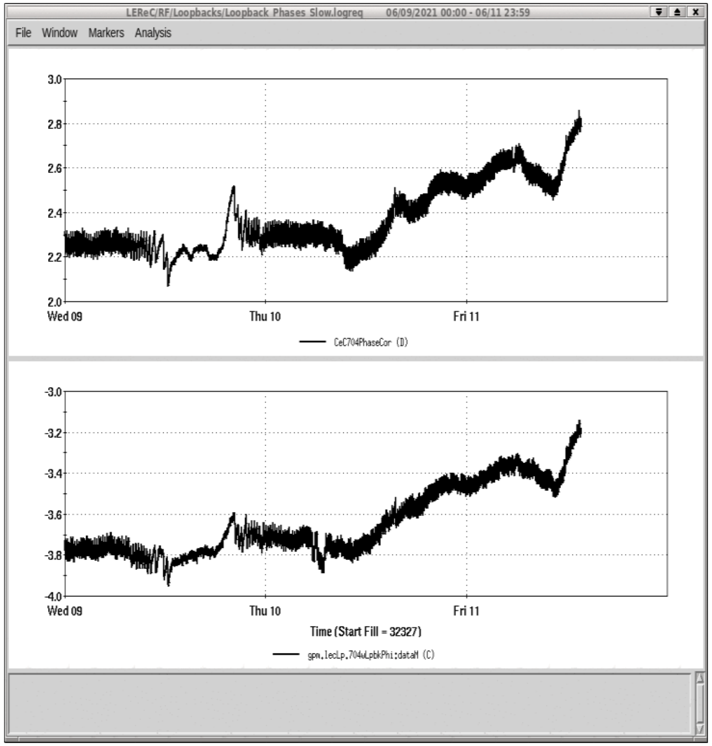
Long Term Stability

Loopback Compensation

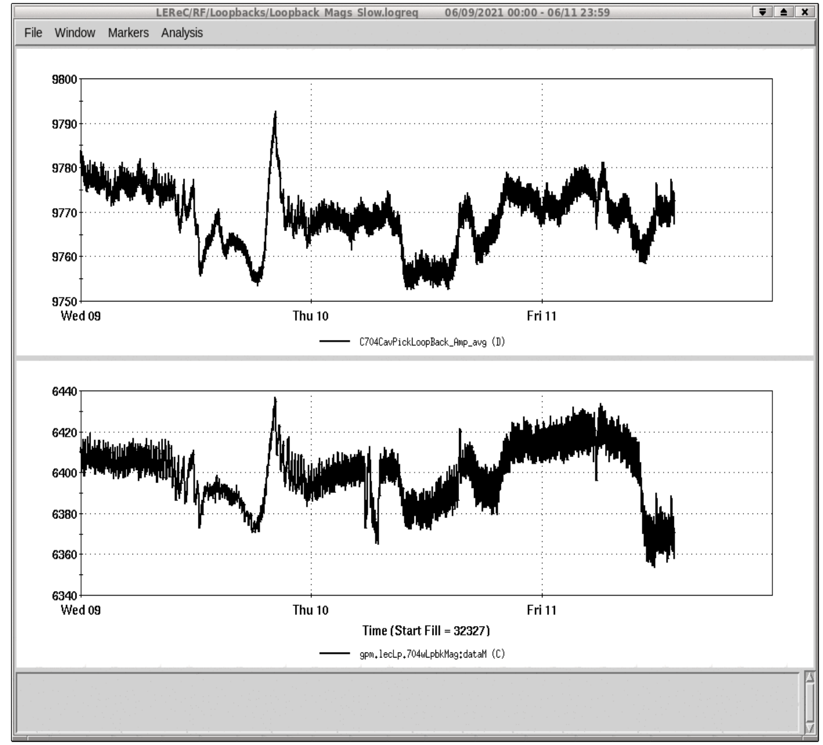
- Reference signal used to measure drift in cavity pickup cable
- Measured amplitude and phase changes used to correct measured pickup signal



Loopback Compensation – LEReC Comparison



Phase



Amplitude

- LEReC lives in same building and has same correction mechanism
- Shows very similar corrections

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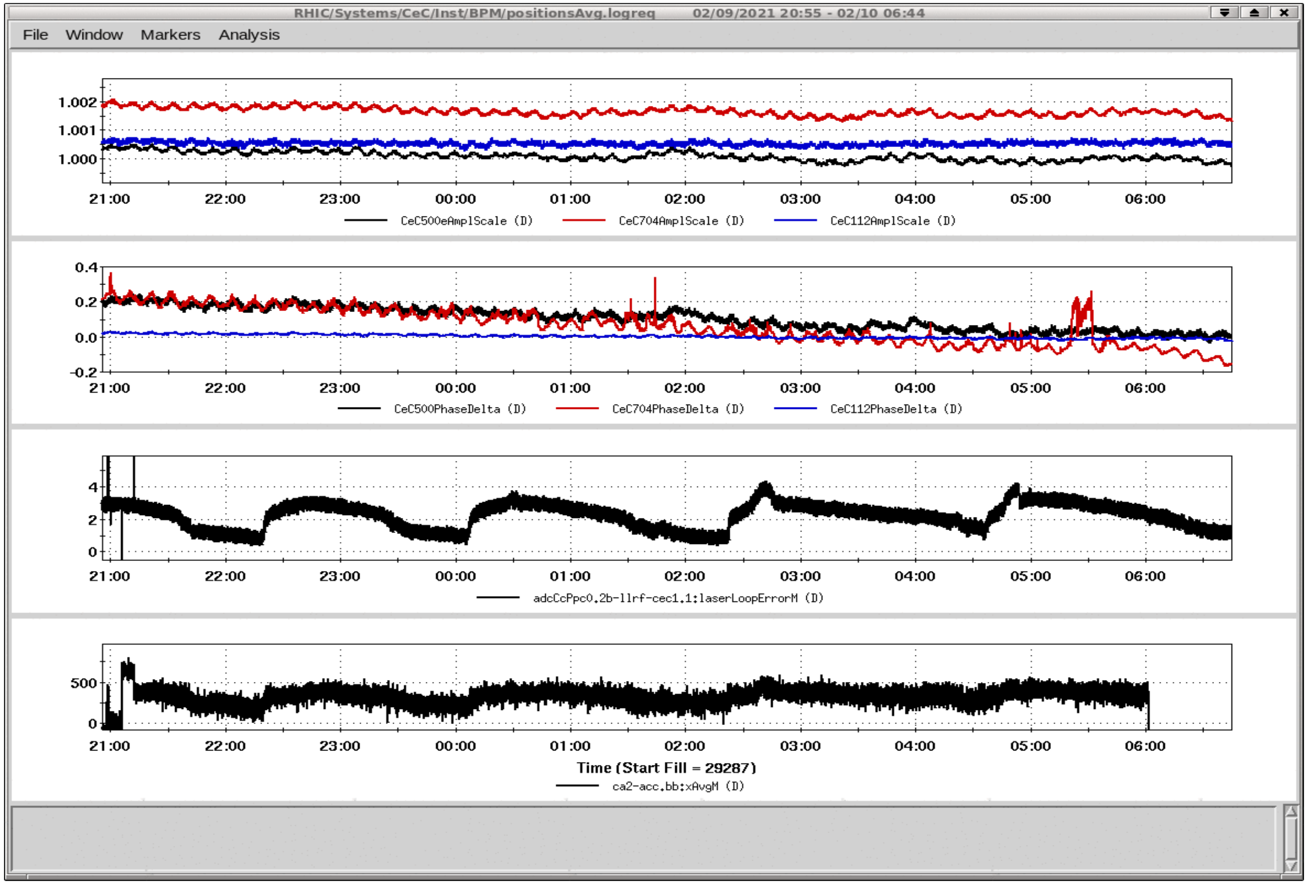
Loopback Compensation



- Cable loopback compensation enabled
- Laser compensation disabled
- Beam energy variation correlated with laser error only

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Long Term Stability – Known Issues

- Air conditioner for building 1002B failed
- Rack temperature control chiller failed
- Rack doors were opened for configuration change
- Loose connector
  - All rack connections will be checked during shut down
- Change in loopback correction implementation

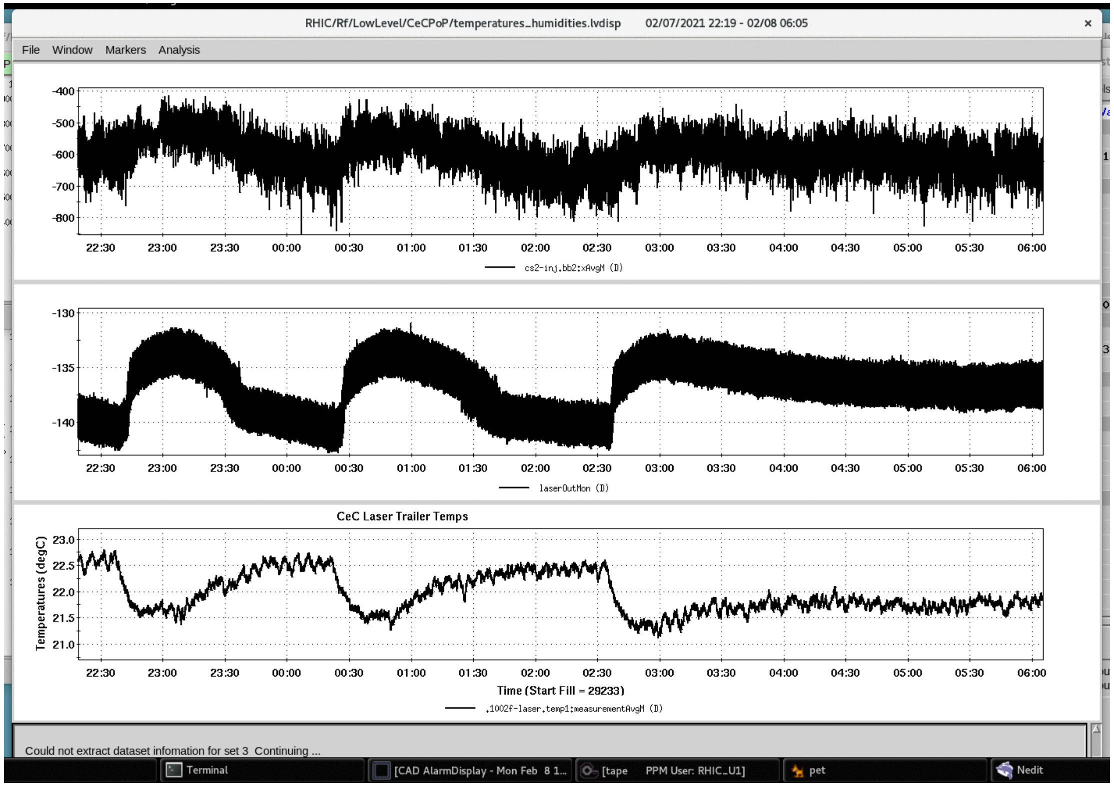
Long Term Stability

- Ultimate stability should be determined by beam based measurements
- Hooks exist to control the Linac voltage to adjust for slow beam energy drift based on beam measurements

Laser Timing

- Corrections based on photodiode phase measurements
- Laser step corrections
- Fast drift corrections
- Slow temperature/humidity drift corrections
- Cable loopback corrections

Laser Timing



- Measured laser phase (and beam energy) correlated with slow temperature changes in laser trailer

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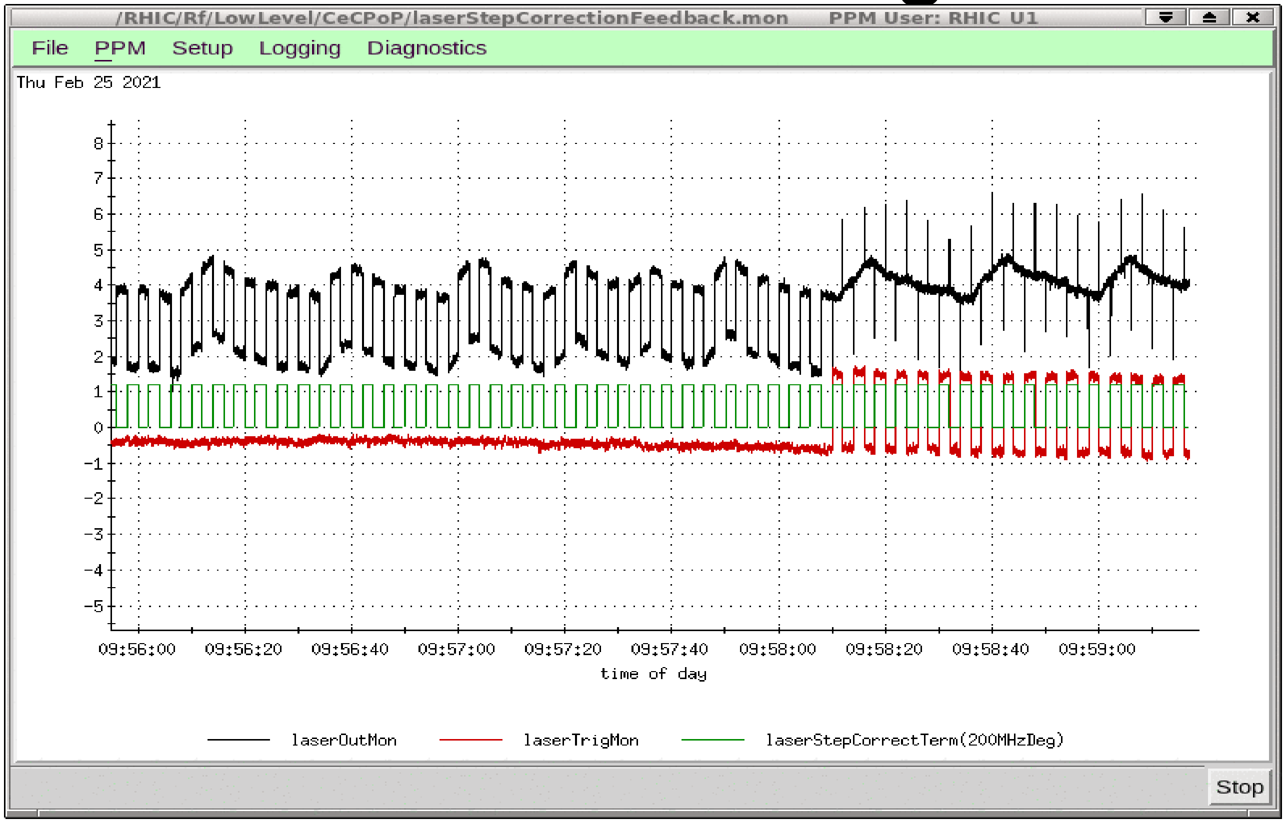
Laser Timing



- Laser has ~2 deg, peak to peak steps at a 4 second rep rate
- Phase is measured in degrees of 350 MHz
- Fast drift with a period of ~25 seconds

Laser Timing – All Corrections Enabled

- Bottom trace shows laser phase measured at the photodiode
- Top trace shows phase monitor of the trigger to laser

Summary

Improvements for this year

- Linac switched to using up/down conversion
- Cable compensation loopbacks enabled
- Laser stabilization
  - Feedforward to correct phase steps
  - Fast feedback to correct measured drifts

Conclusion

- Short-term cavity regulation is excellent
- Significant efforts have been expended to stabilize the laser and they have been extremely successful
- If long term stability needs to be improved, beam based feedback is the only option left