EVLA Tests Mtg
Moon Compression Test Results

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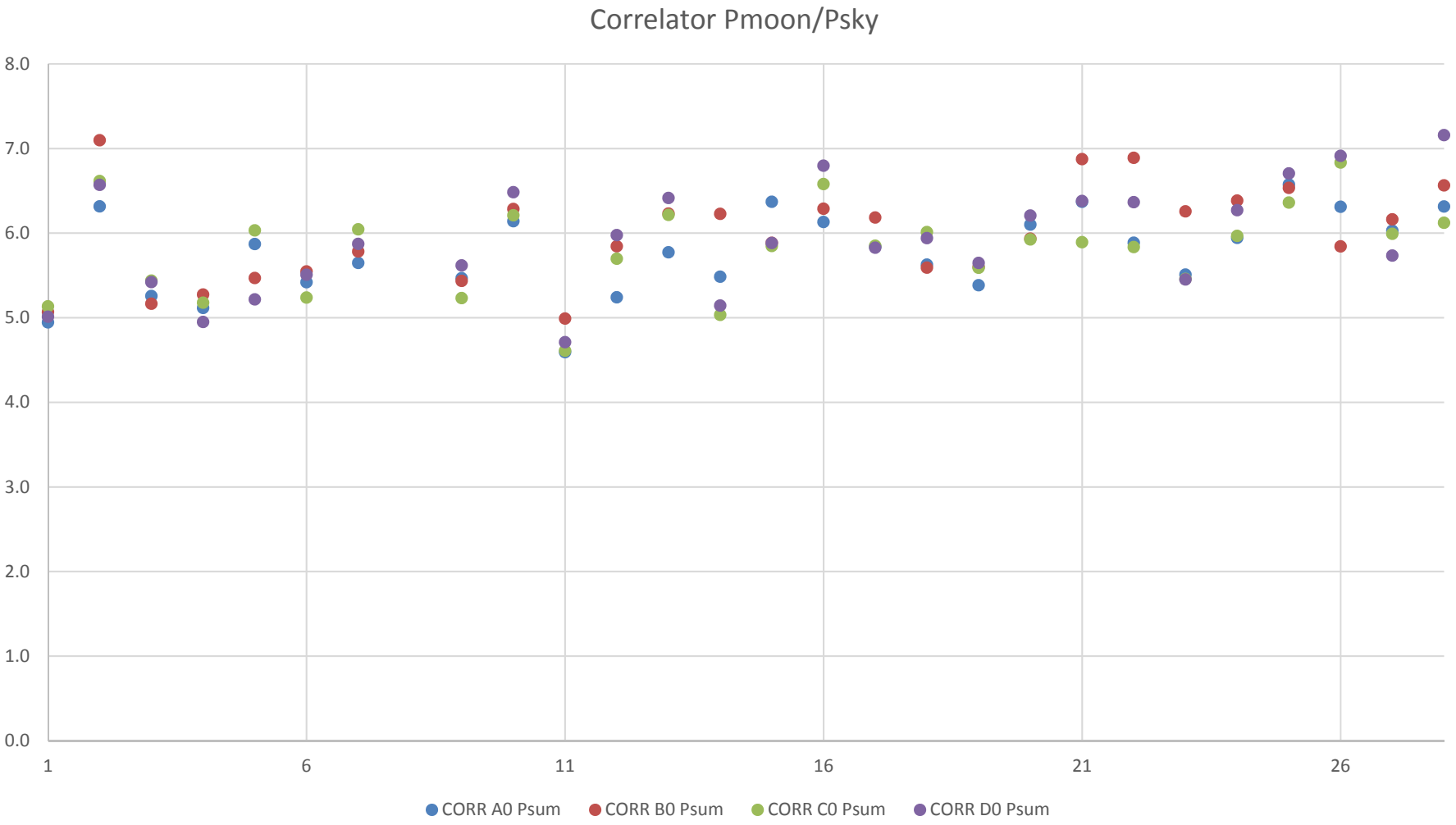
Test Goals

- Gain some insight into the source of the gain compression.
- Determine if the problem is primarily 'analog' or 'digital' in nature.

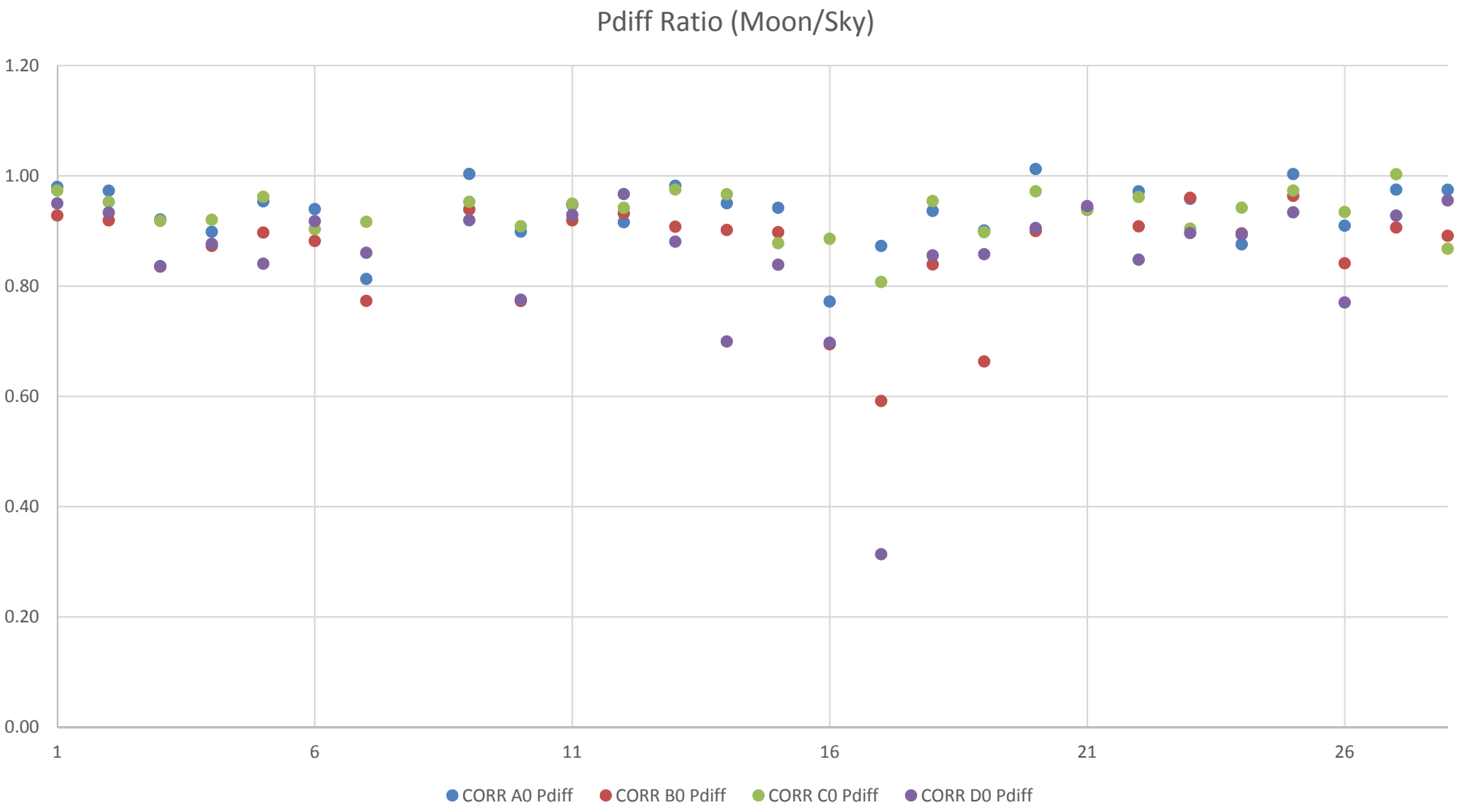
- Pick an intermediate point in the signal path and attempt to measure changes in switched power (Pdiff, Psum) at that point.
  - If results are consistent with the correlator derived switched power, problem is likely upstream of that that point.

- Use Total Power Detectors (TPDs) in T304. Secondary goal of finding new applications for these tools.
- Data collected on 04-07-2016

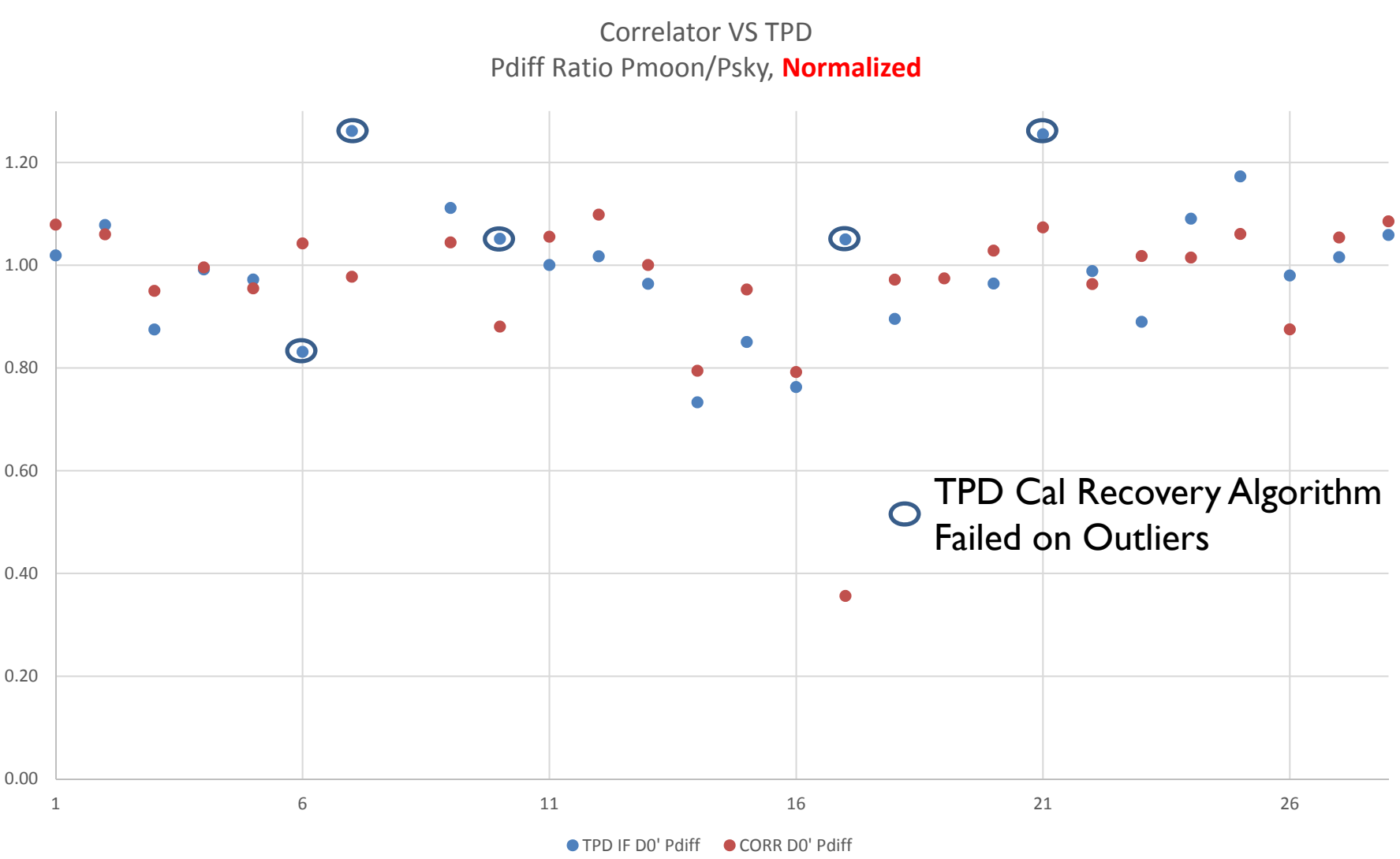
Array Performance – Gain Variations



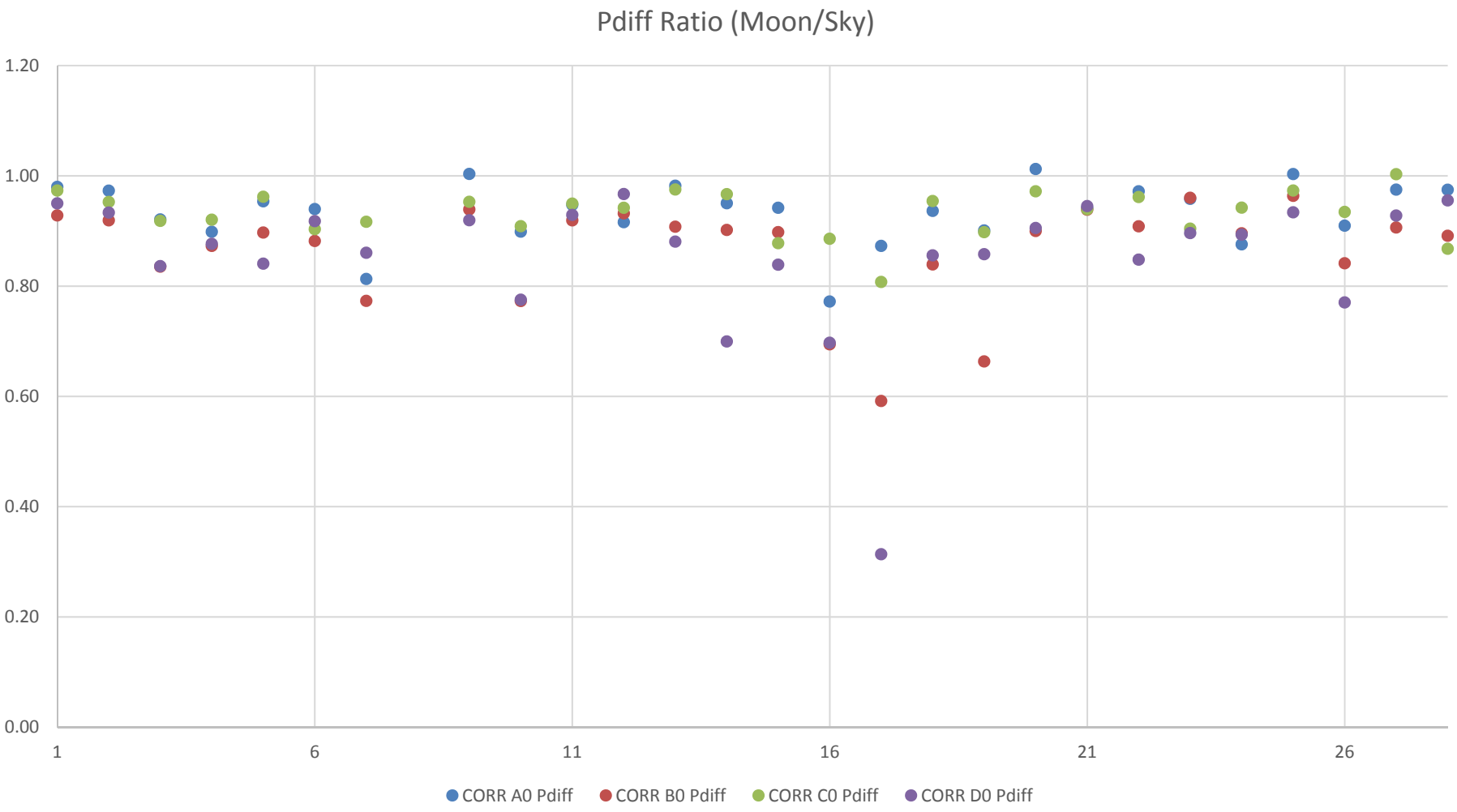
Array Performance – Gain Compression



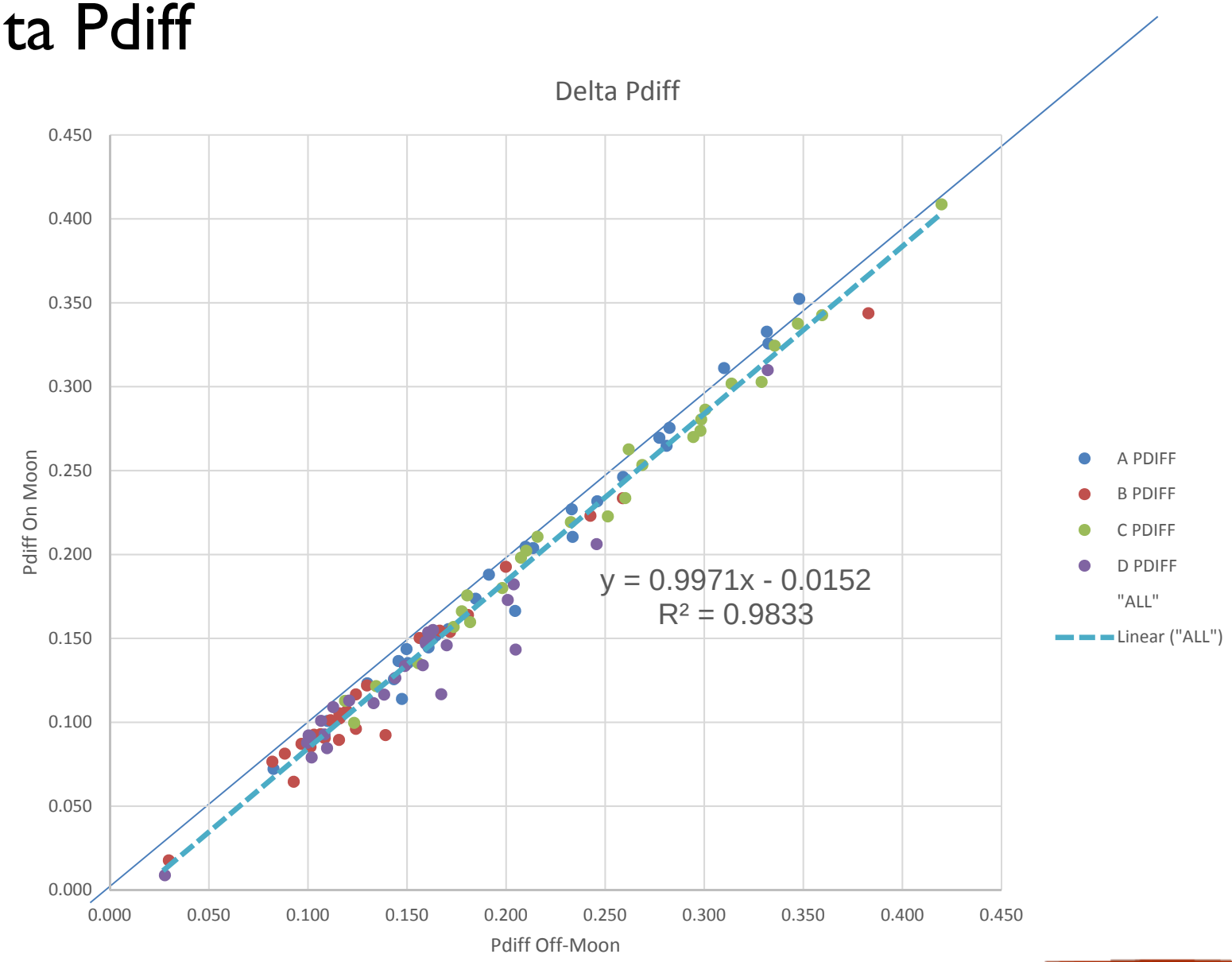
Gain Compression – TPDs vs. Correlator



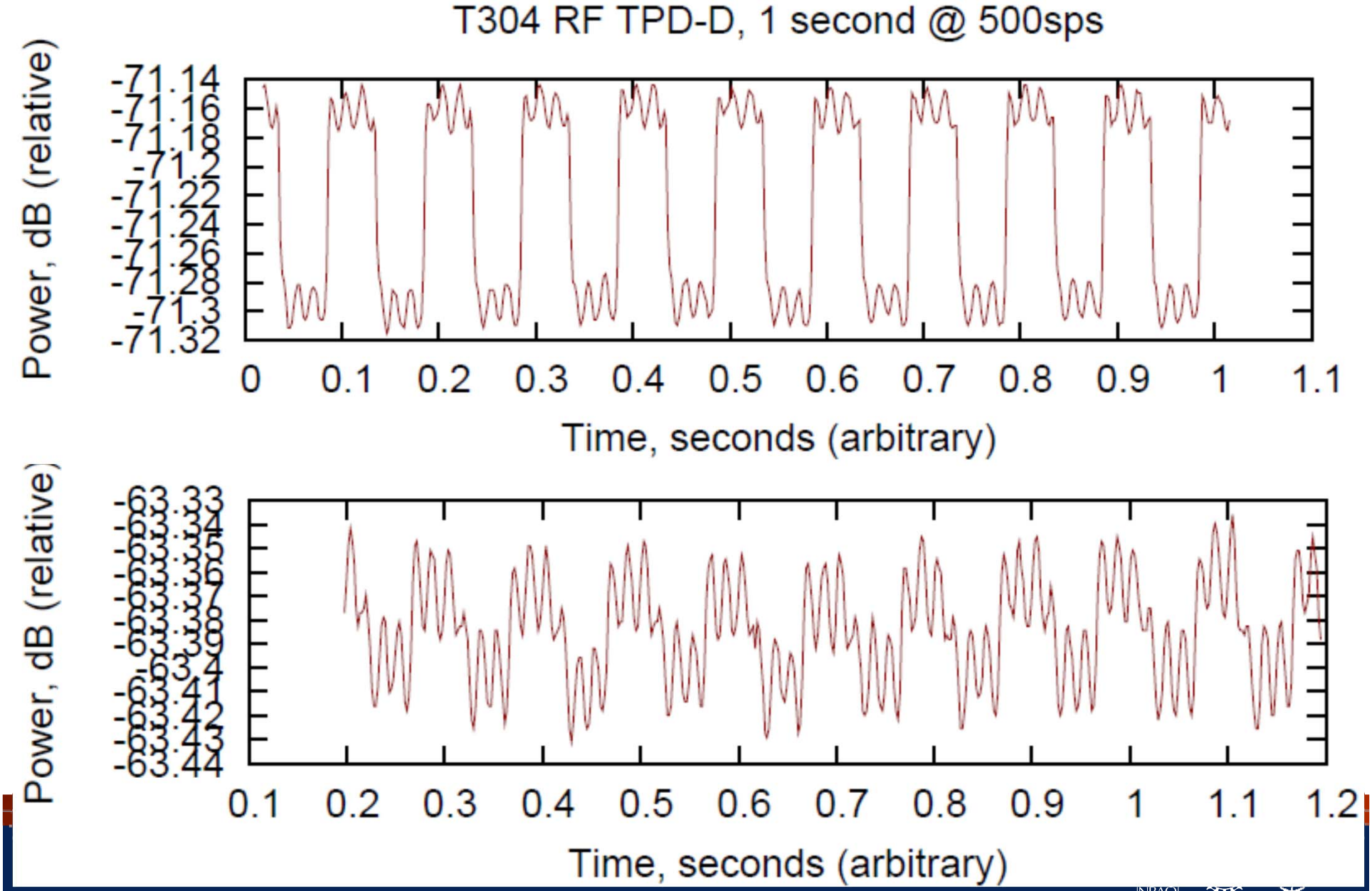
Array Performance – Gain Compression



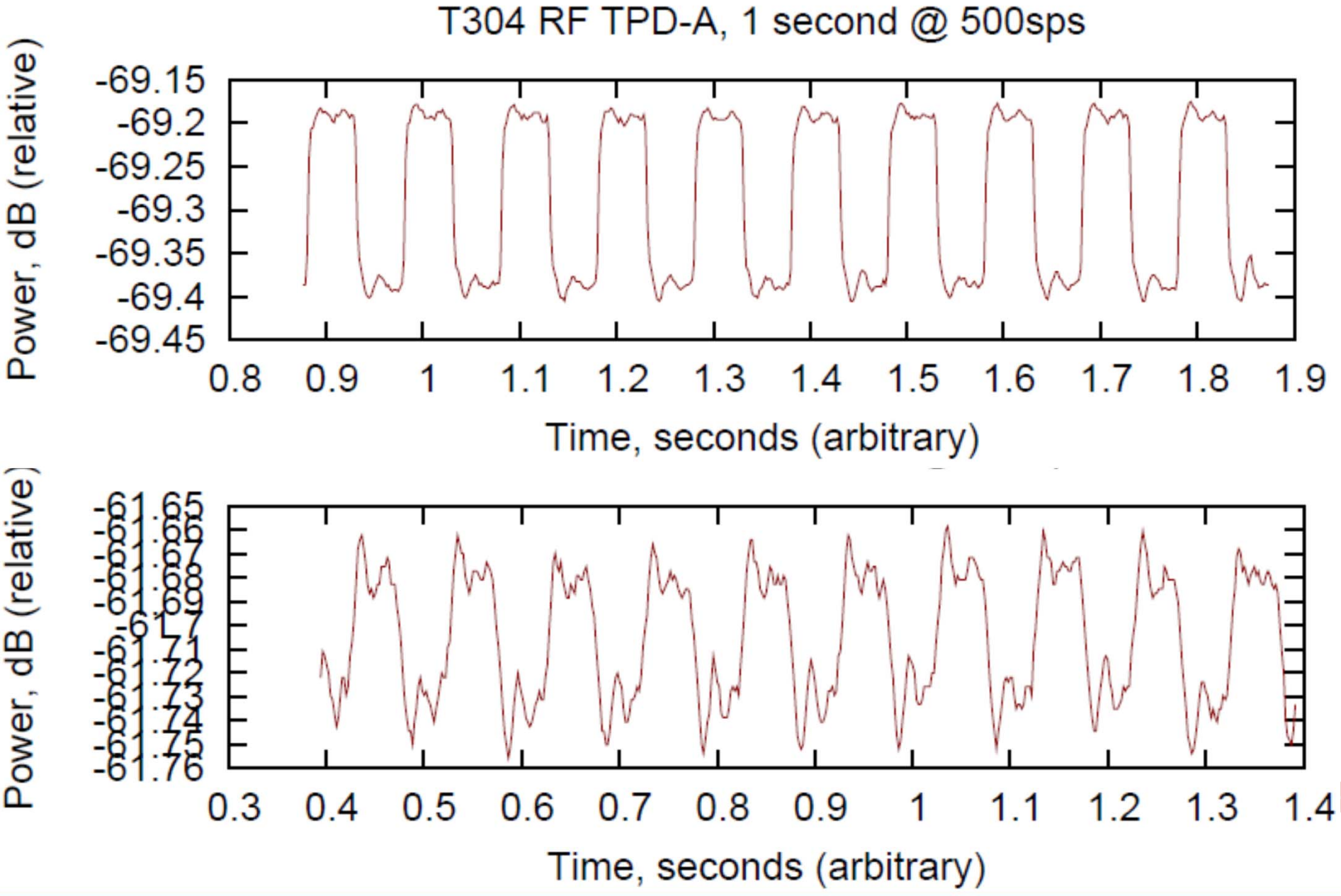
Delta Pdiff


Delta Pdiff
Pdiff On Moon
Pdiff Off-Moon
0.000
0.050
0.100
0.150
0.200
0.250
0.300
0.350
0.400
0.450
y = 0.9971x - 0.0152
R² = 0.9833
A PDIFF
B PDIFF
C PDIFF
D PDIFF
"ALL"
Linear ("ALL")

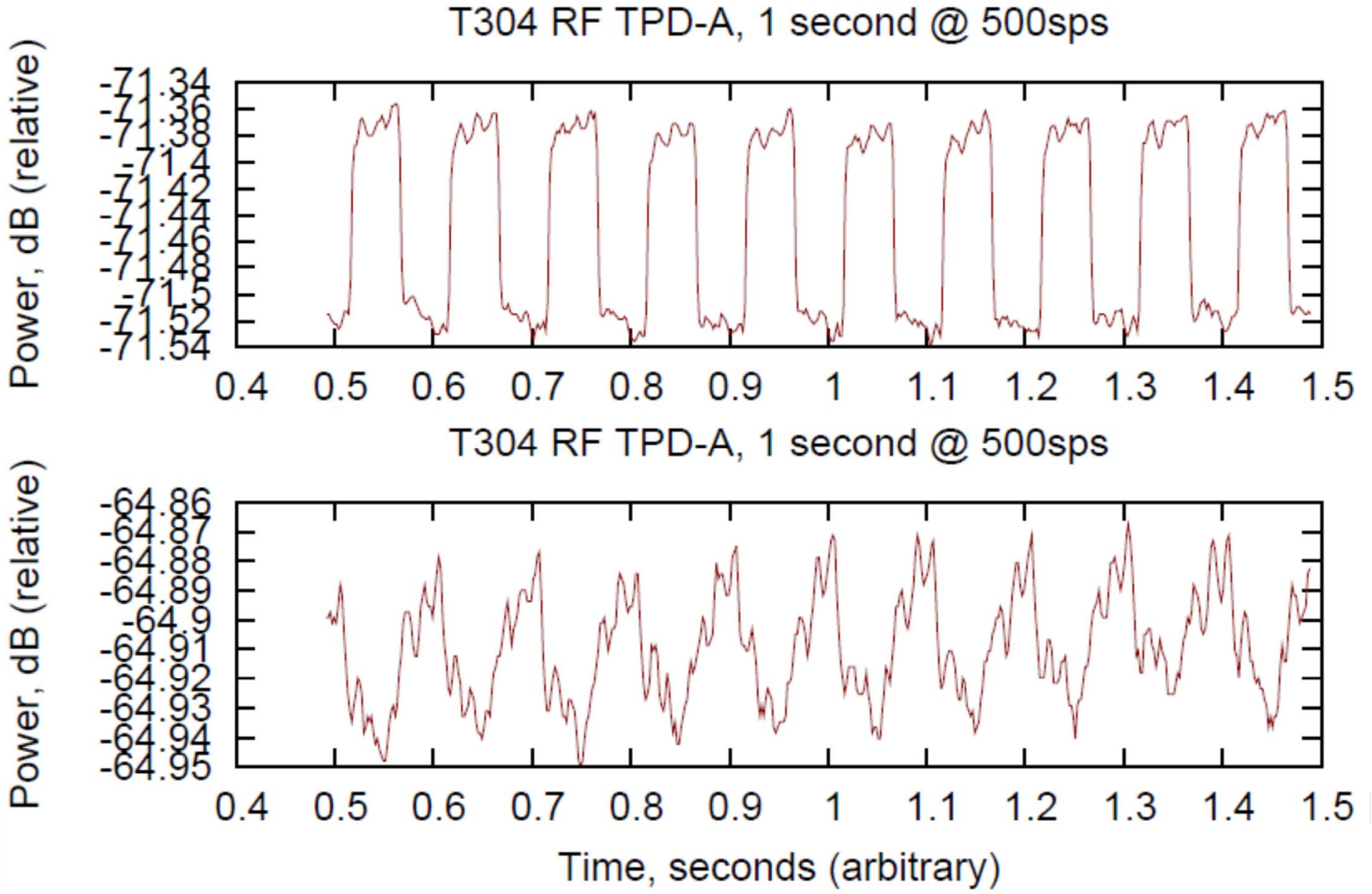
Gain Modulation – OFF/ON MOON (e.g EA06)



Gain Modulation – CAL Ringing (e.g EA02)



Gain Modulation (e.g EA07)



Pdiff with Gain Modulation

$P_{off} = G_a (P_{ant} + P_{rx})$

$P_{on} = G_a (P_{ant} + P_{rx} + P_{cal})$

$P_{diff} = P_{on} - P_{off}$

$P_{diff} = G_a P_{cal}$

…but P_{ant} seems to create more gain modulation, so P_{cal} may too:

$P_{off} = G_{off} (P_{ant} + P_{rx})$

$P_{on} = G_{on} (P_{ant} + P_{rx} + P_{cal})$

$P_{diff} = G_{on} P_{cal} + (G_{off}-G_{on})(P_{ant} + P_{rx})$

If $G \approx C + G_{mod}$, then $G_{off}-G_{on}$ is dominated by the change in gain modulation.

Pdiff with Gain Modulation

$$P_{diff} = G_{on} P_{cal} + (G_{off} - G_{on})(P_{ant} + P_{rx})$$

$$\ldots \text{if } P_{cal} \approx 3\% \, P_{sky}, \text{ and } P_{moon} \approx 6P_{sky}$$

$$G_{sky} \approx C + \langle G_{mod(t)} \rangle \qquad G_{sky\text{-}off} \approx C + \langle G_{mod(t)} \rangle$$

$$G_{moon} \approx C + \langle 6G_{mod(t)} \rangle \qquad G_{sky\text{-}on} \approx C + \langle 1.03G_{mod(t)} \rangle$$

$$G_{moon\text{-}off} \approx C + \langle 6G_{mod(t)} \rangle$$

$$G_{moon\text{-}on} \approx C + \langle 6.03G_{mod(t)} \rangle$$

$$P_{diff\text{-}sky} = C \cdot P_{cal} + \langle 1.03G_{mod(t)} \rangle P_{cal} + \langle 0.03G_{mod(t)} \rangle (P_{sky} + P_{rx})$$

$$P_{diff\text{-}moon} = C \cdot P_{cal} + \langle 6.03G_{mod(t)} \rangle P_{cal} + \langle 0.03G_{mod(t)} \rangle (6P_{sky} + P_{rx})$$

Delta Pdiff Model

- Real Data fit:

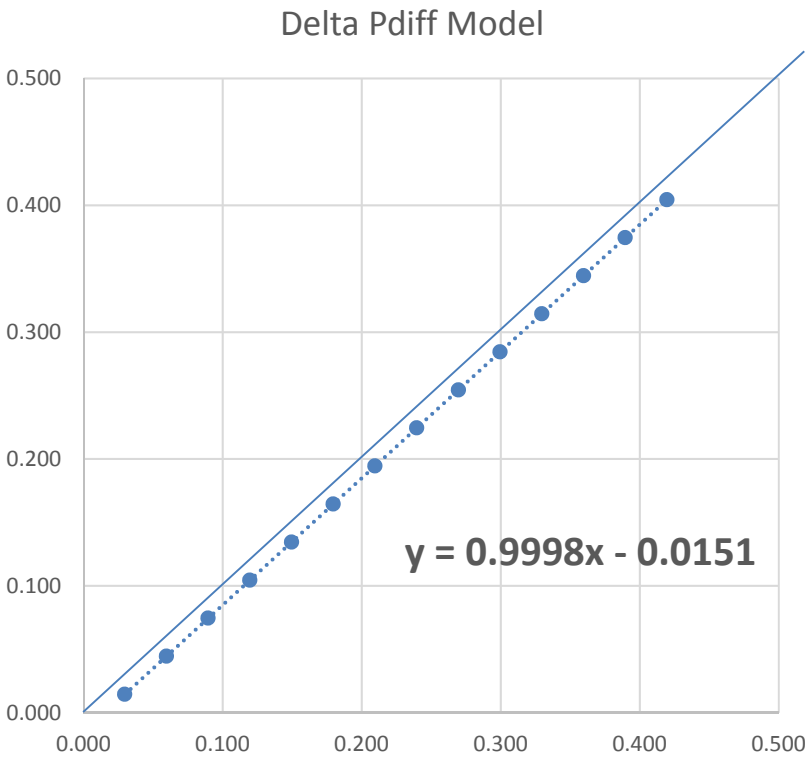
y = 0.9971x - 0.0152

Let <Gmod> be:

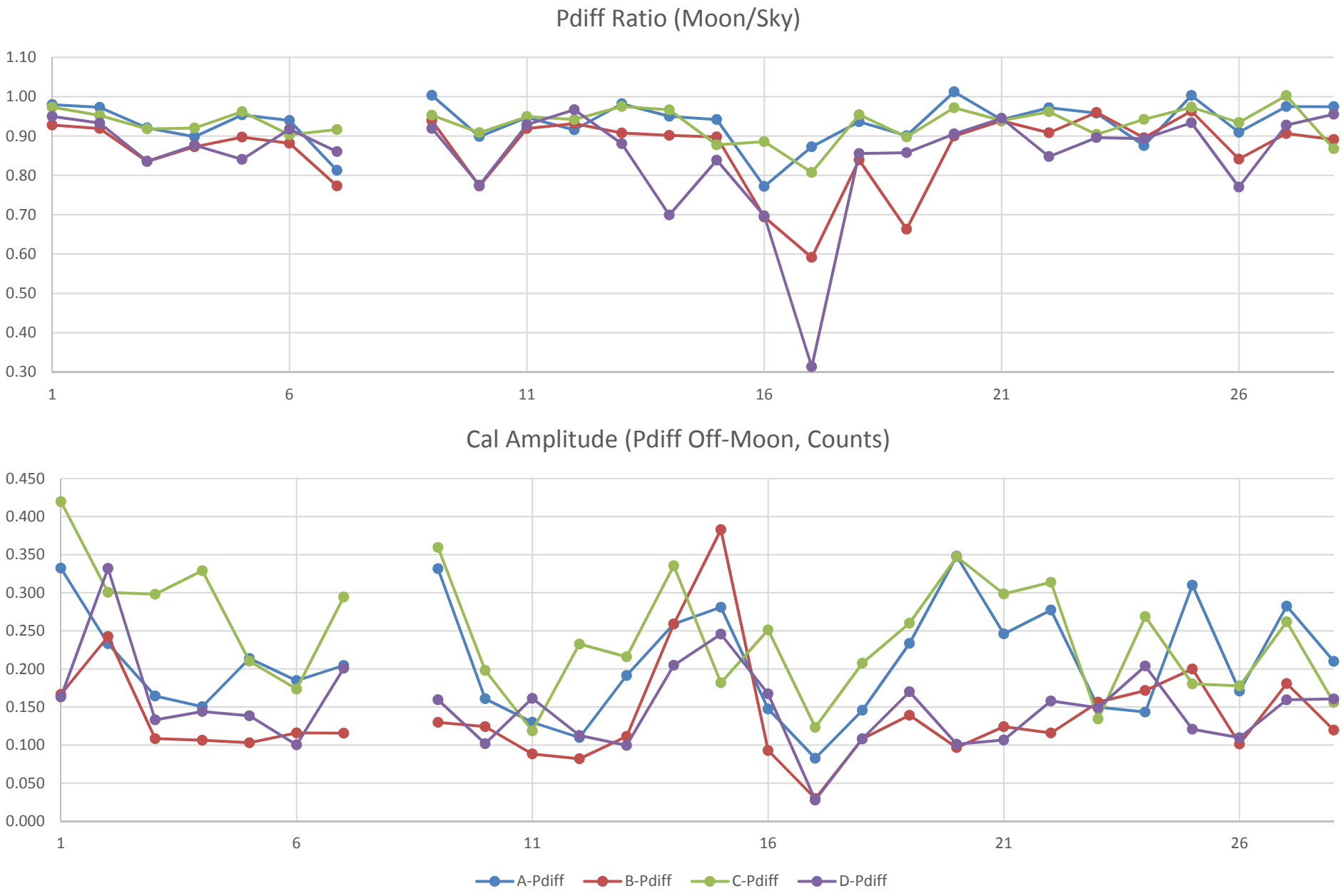
-0.0018% for Cal ON
0.0018% for Cal OFF

model Pdiff response:

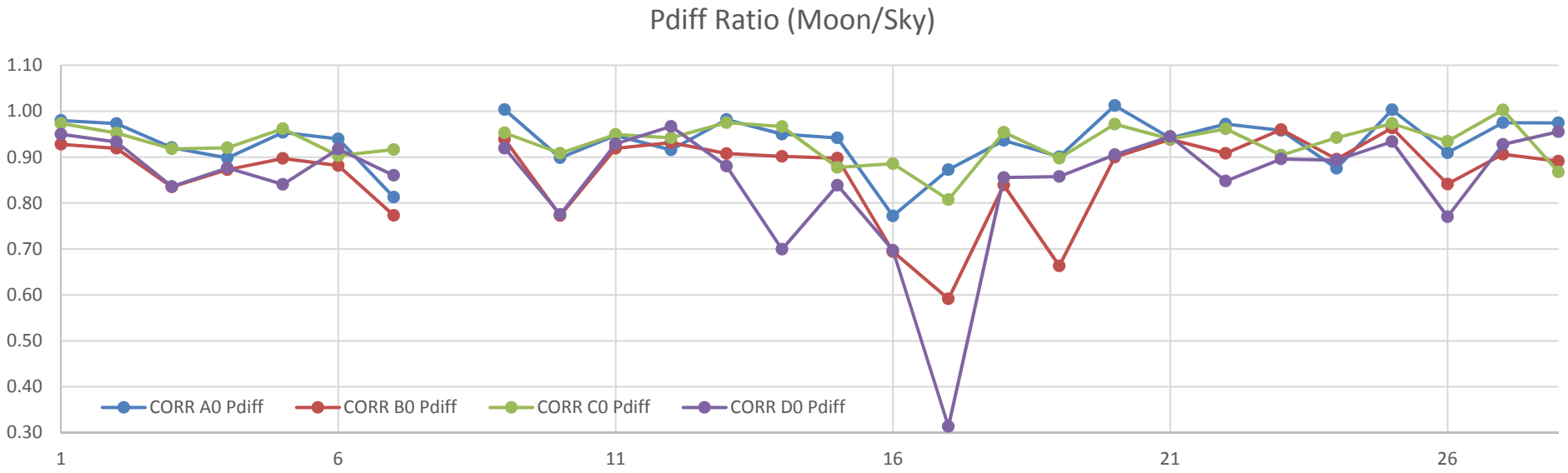
y = 0.9998x - 0.0151

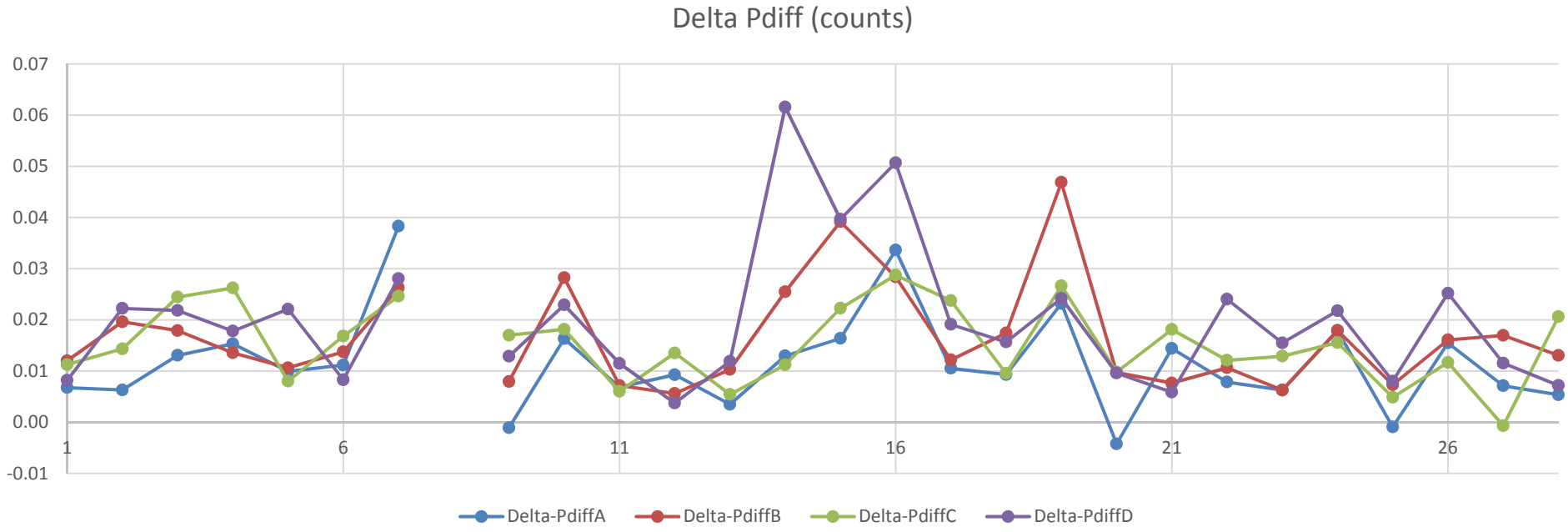


Gain Mod + Low Pcal = More Pdiff Compression

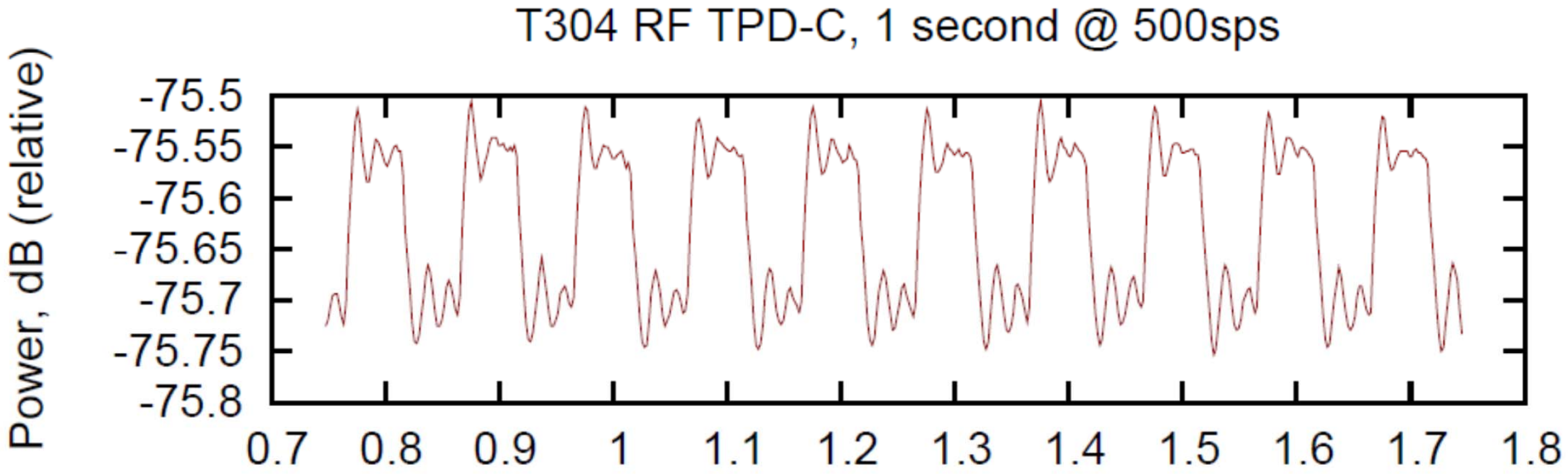


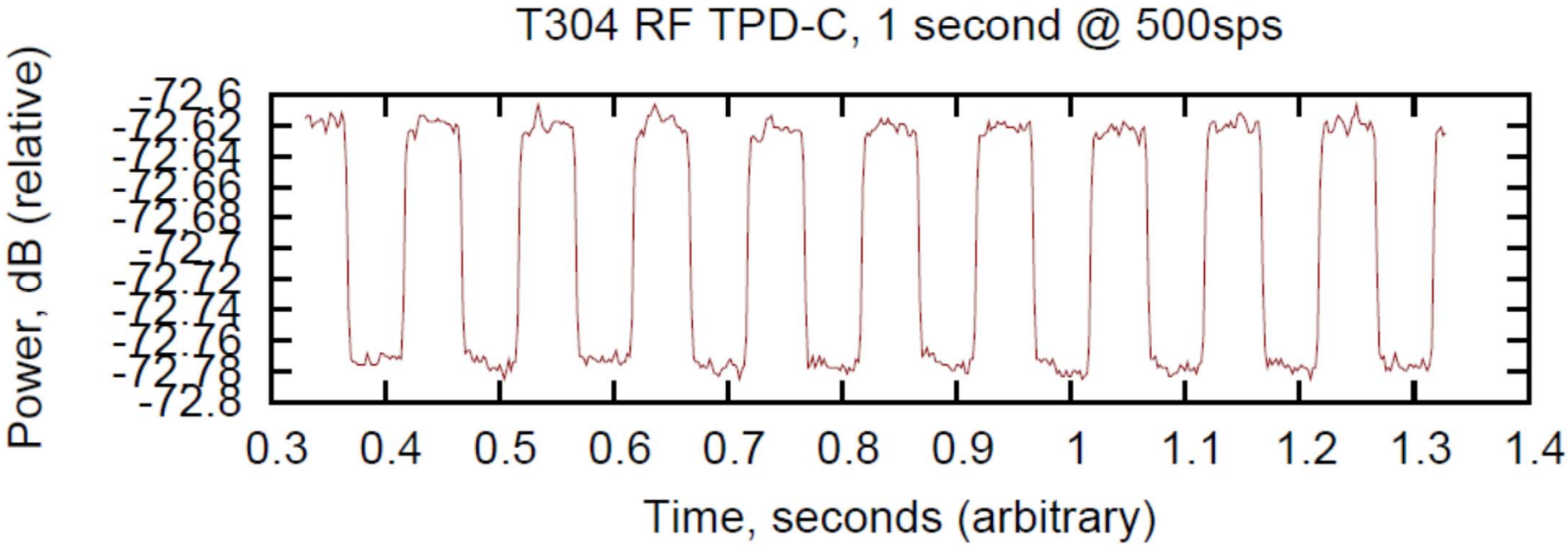
Variations in <Gmod> & Frequency Dependence





SN14 S-Band – Bias Card Capacitors





HEMT Bias & Frequency Dependence

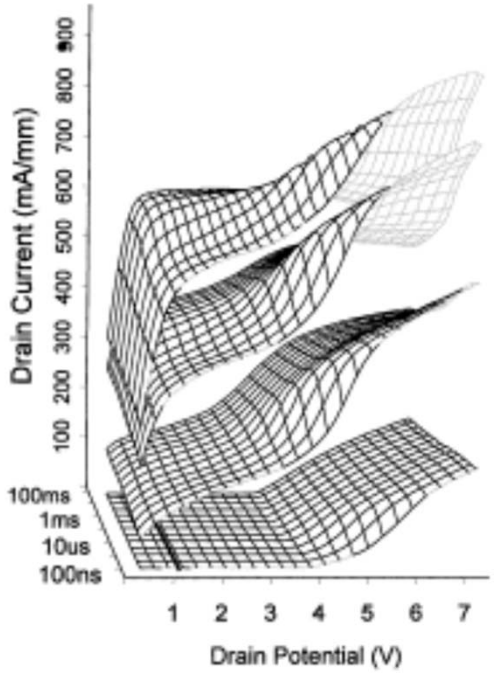


Fig. 3. Time-evolution view of the characteristics shown in Fig. 2.

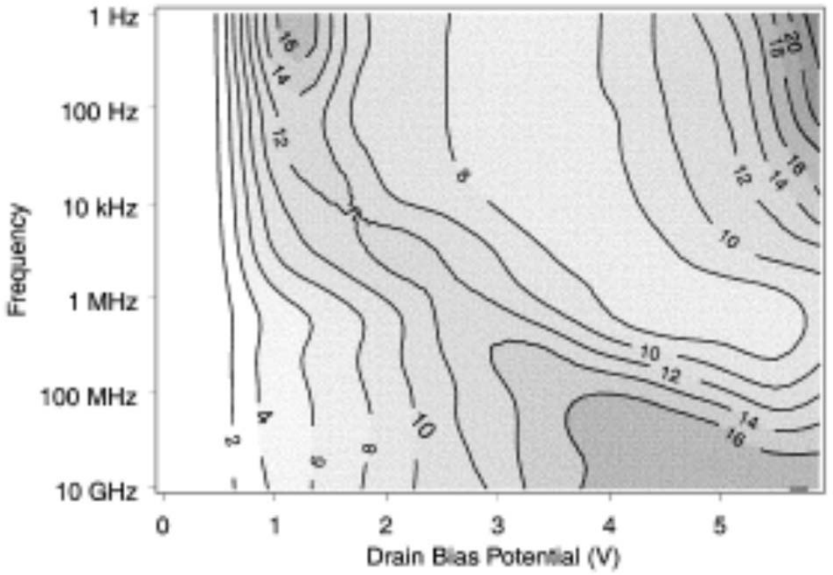


Fig. 4. Intrinsic gain versus drain bias for the HEMT in Fig. 1 operating at 25 °C with $V_{GS} = -0.4$ V. Darker areas correspond to regions of higher gain.

Parker & Rathmell, Bias and Frequency Dependence of FET Characteristics.
IEEE Transactions on Microwave Theory and Techniques, Vol 51, No. 2, Feb 2003

Conclusions & Next Steps

- Main source of the gain compression is likely in the antenna analog electronics, before the attenuator at the input to the T304.
- Majority of the Pdiff compression at X-band may be attributable to the gain modulation, which is likely a modulation of the LNA or post-amp bias.
- Differences *within* A-B and C-D pairs are partly due to differences in cal power as a function of frequency, but gain modulation appears be frequency dependent too.
- Focus investigations into gain modulation as a function of antenna power. (Modulation gets progressively worse with increased antenna power.)
- Follow up test with T304s tuned to same frequency (isolate T304 tuning from any frequency-dependent effects in the front end). Include multiple spectral windows within each IF.

Next Steps

- Work with Front End Group to inspect an Rx - Hot load test.
  - Attempt to see gain modulation at a selected X-band front-end output and intermediate gain stages.
  - Look for modulation in bias signals to the LNAs and post-amps.
  - Look for changes in gnd. and other reference voltages
    - Ground loops?
  - Remove filter caps on bias lines and note changes.
- Work with Paul Demorest to look at the gain modulation with the correlator time domain tools (e.g., pulsar binning mode).
  - Quantify magnitude of Cal ringing / gain modulation.
  - Confirm that magnitude of the modulation is affected by Pantenna (vs. just Pcal radiated by other receivers).
  - Look for correlation between gain changes and Pdiff compression.
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