S5 calibration: time dependent coefficients α, γ

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http://blue.ligo-wa.caltech.edu/engrun/Calib_Home/
http://ligo.phys.lsu.edu/sung/Factors/S5/V2/index.html

LIGO-G060117-00-Z

The formulas

Calibration for Fourier domain:

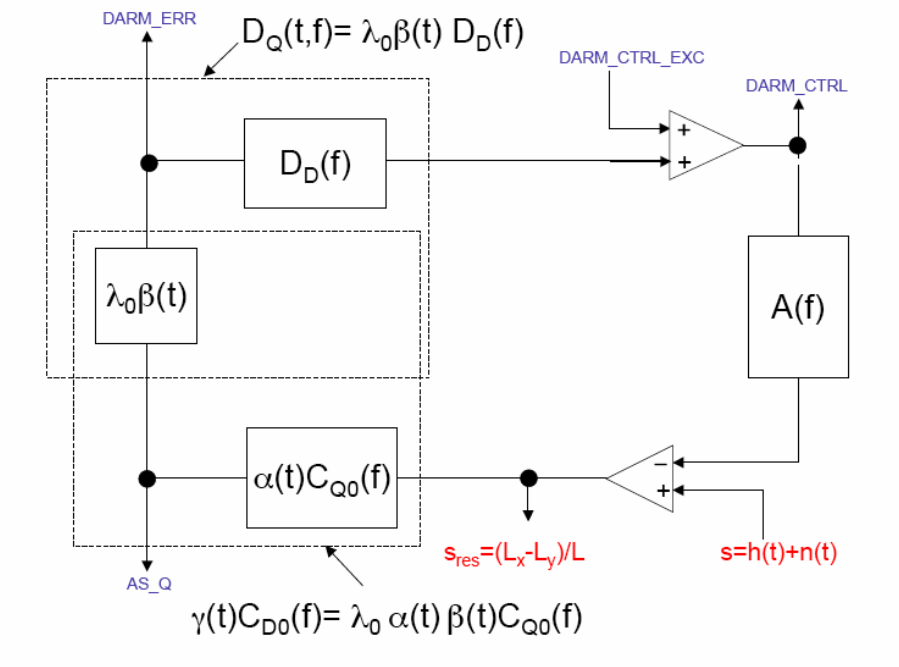
$$h(f) = R(f)GW(f)$$

$$\text{If } GW = ASQ, \quad R_{ASQ}(f) = \frac{1+\gamma G_0(f)}{\alpha C_{ASQ,0}(f)}$$

$$\text{If } GW = DARM\_ERR, \quad R_{DERR}(f) = \frac{1+\gamma G_0(f)}{\gamma C_{DERR,0}(f)}$$

Calibration Coefficients are measures of loop gain (γ) and of sensing gain (α) relative to the “reference time”; they vary in time.

More formulas



$$\gamma = \frac{1}{G_0(f_{cal})}\frac{DCTRL - EXC}{EXC}$$

$$\alpha = \frac{D_0(f_{cal})}{G_0(f_{cal})}\frac{ASQ}{DCTRL}$$

We use X. Siemen's code to get estimates for DARM_CTRL, DARM_CTRL_EXC and AS_Q at the frequency of the calibration line: by demodulation, we obtain complex time series, sampled at 60 sec sampling time (and 1 sec too).

We "only" need knowledge of open loop gain *G(f)* and digital filter *D(f)* at the calibration line frequency, at the reference time.

Complex coefficients

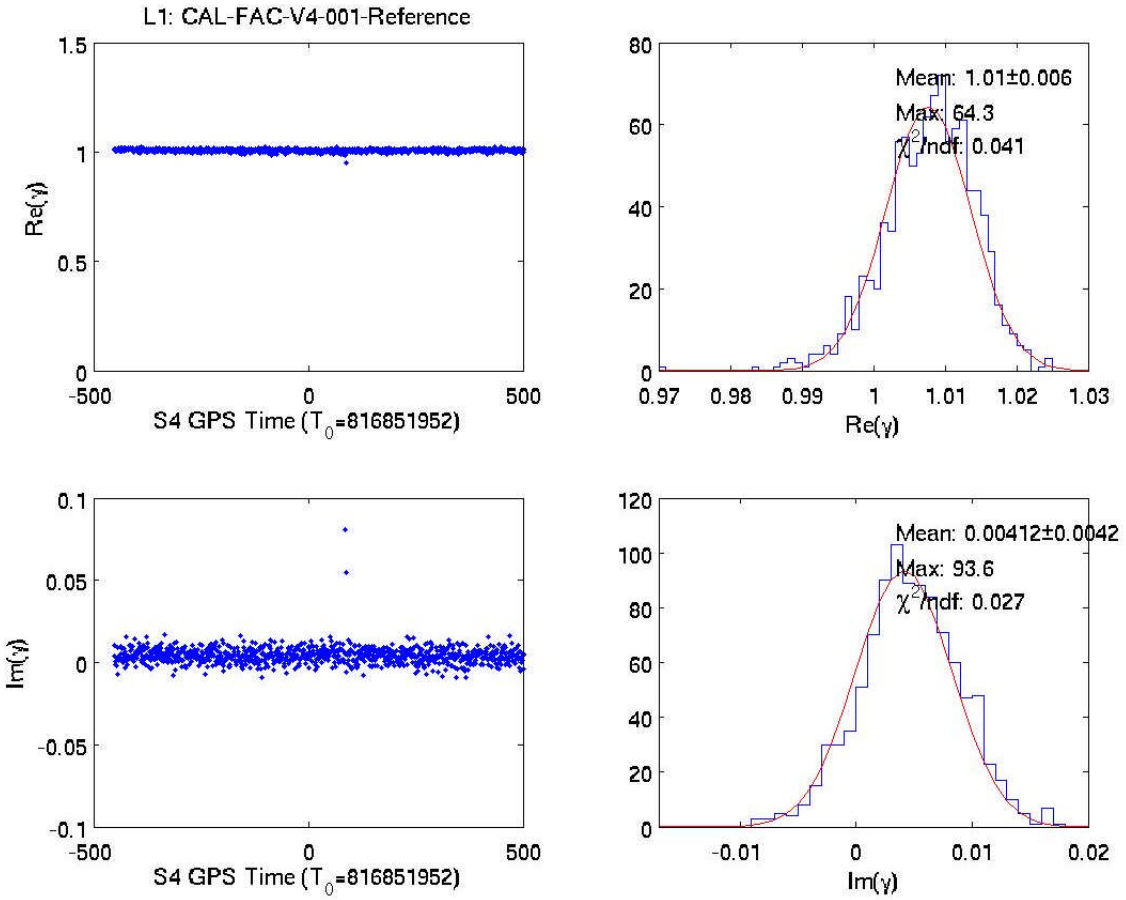
$$\gamma = \frac{1}{g_0}\frac{DCTRL - EXC}{EXC}$$

$$\alpha = \frac{d_0}{g_0}\frac{ASQ}{DCTRL}$$

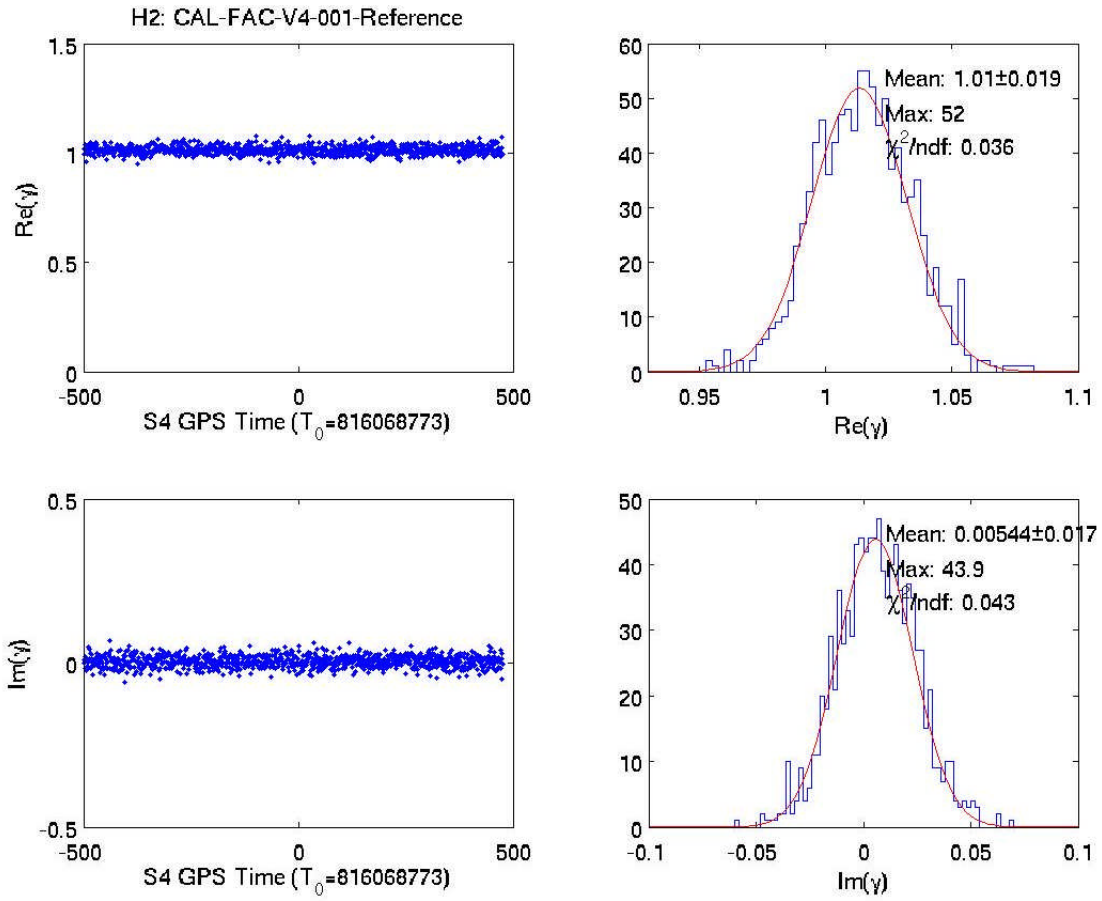
Ideally (no noise in ASQ, g_0 and d_0 perfectly known), coefficients are real, and identically equal to one at the reference time.

- If the amplitude of g_0 is off, we'll notice a deviation from unity γ calculated at the reference time.
- If the phase of g0 is off, we'll see a systematic imaginary part in γ at all times.
- If there is random noise in ASQ at the calibration line frequency, there will be a random imaginary component in γ.
- The true coefficients are real; we estimate them from the real part of the complex calculated coefficients.
- The imaginary parts are used to estimate systematic and random errors in our estimates.

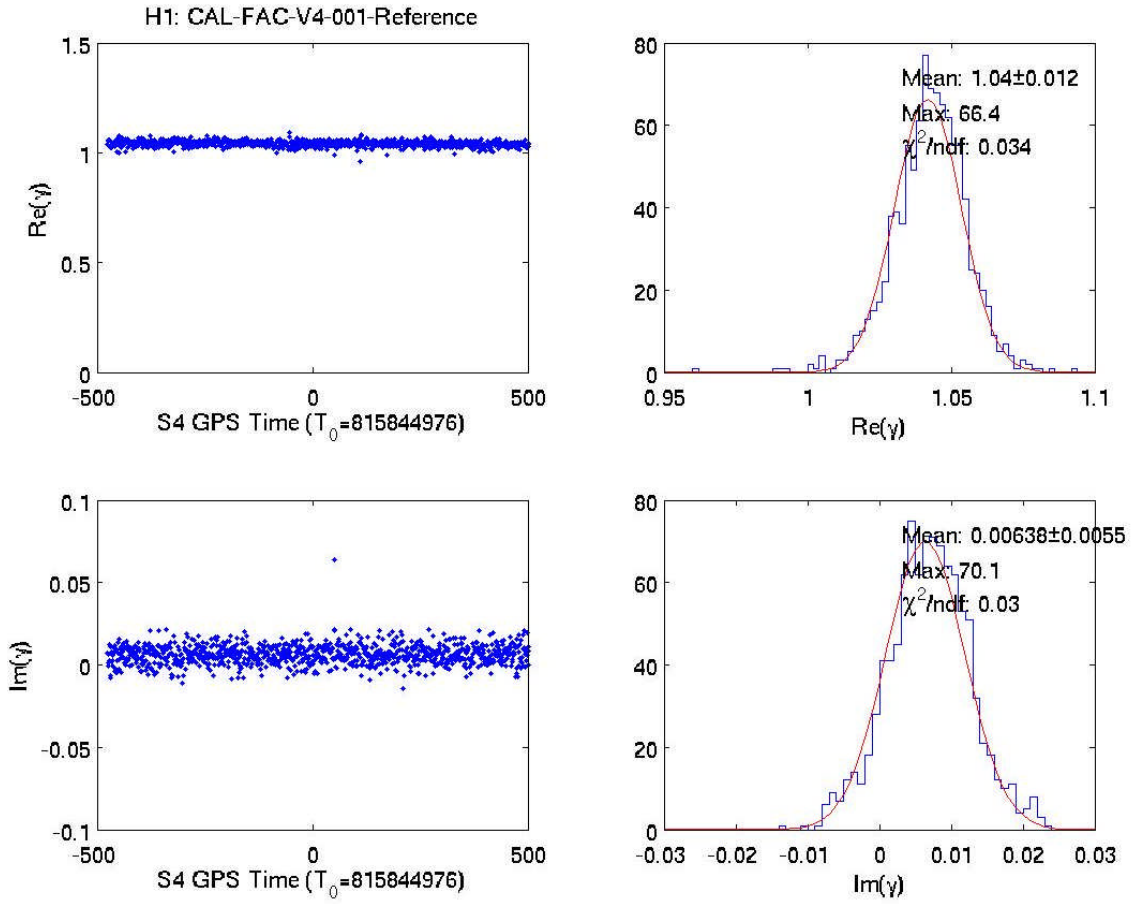
S5 calibrations: L1 reference time



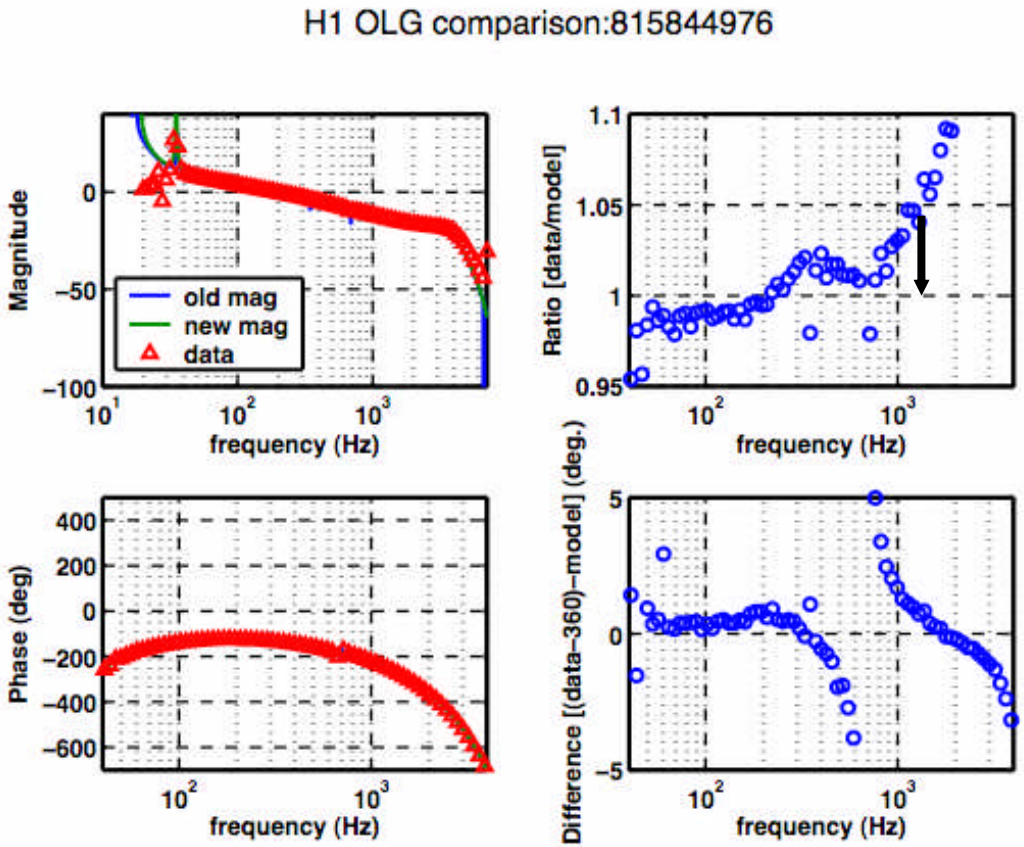
S5 calibrations: H2 reference time



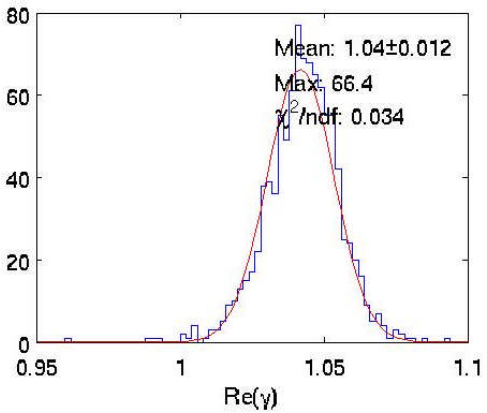
S5 calibrations: H1 reference time



H1 “features”

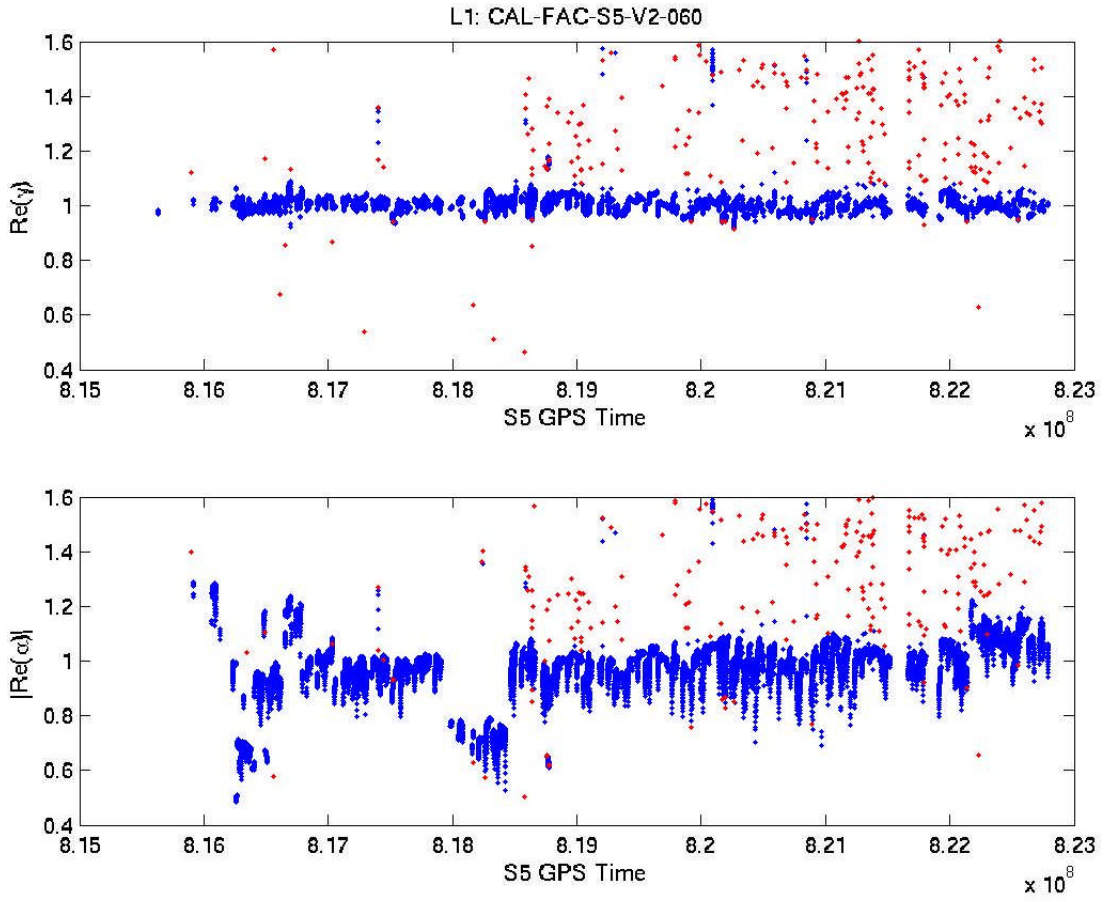


Choose $g_0=G_0(f_{cal})$ from reference model, but with a 4% correction.

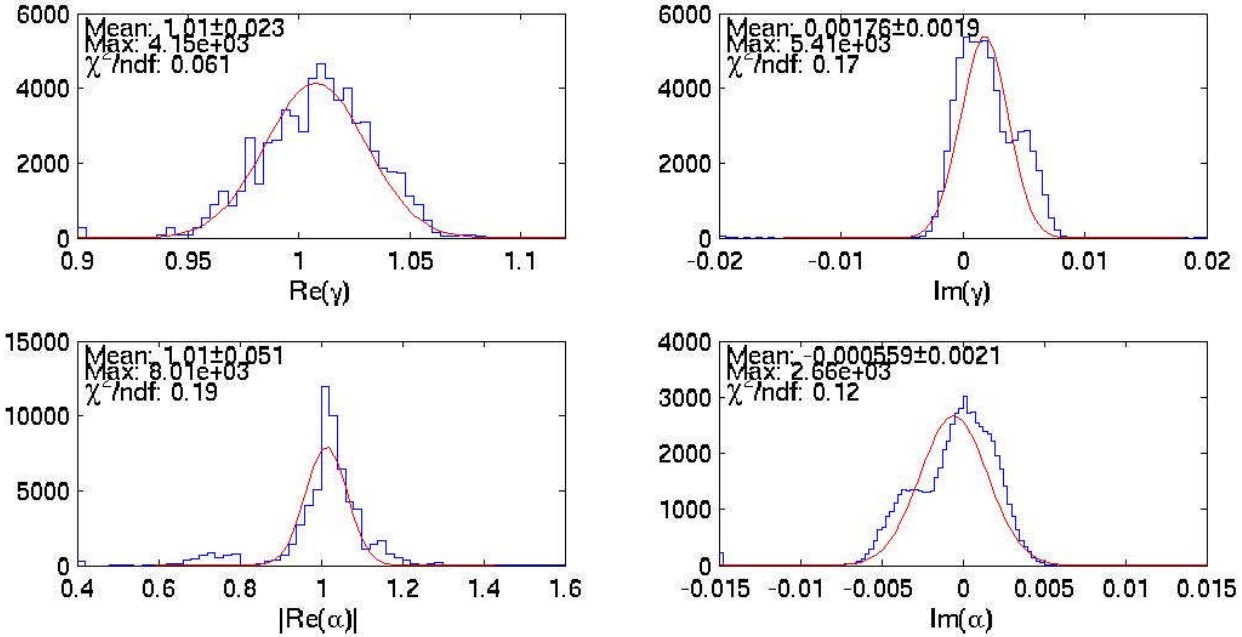


L1, H2 are within 1%: leave them alone.

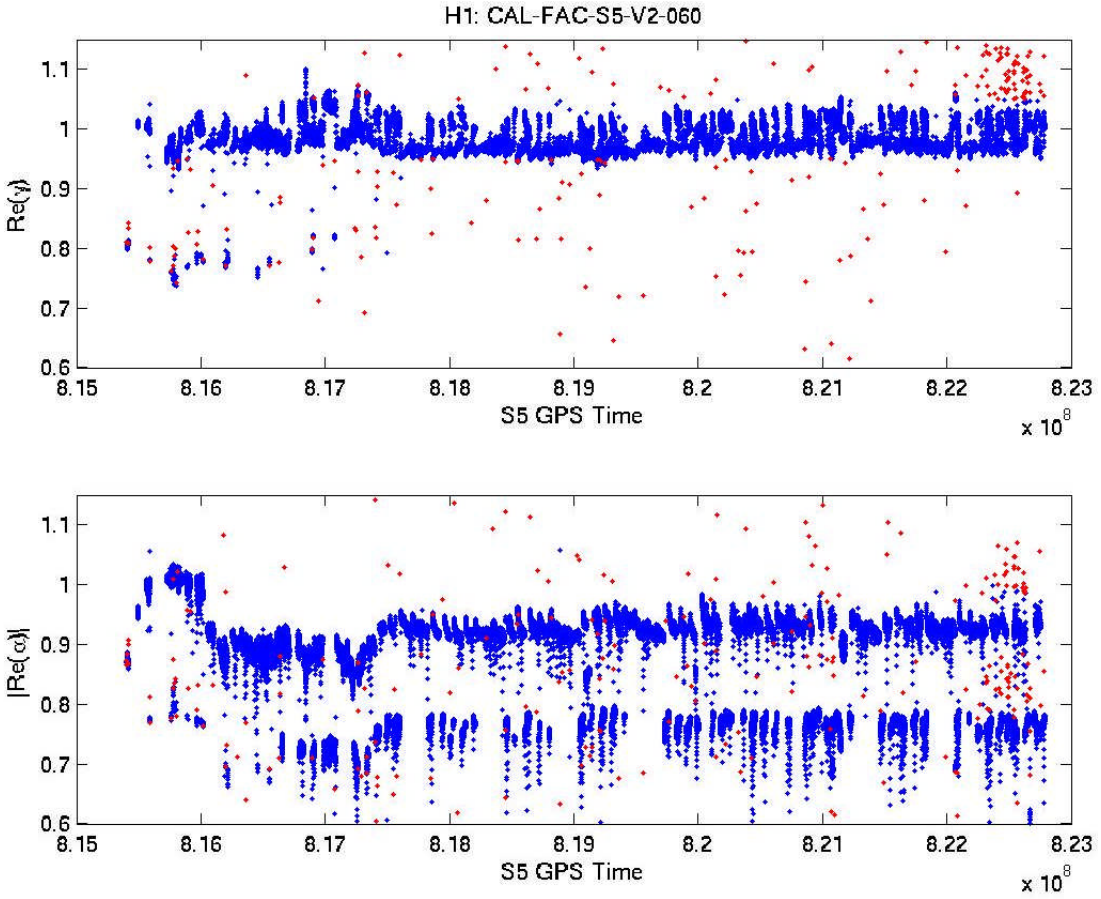
L1 γ, α coefficients S5 up to Feb 1



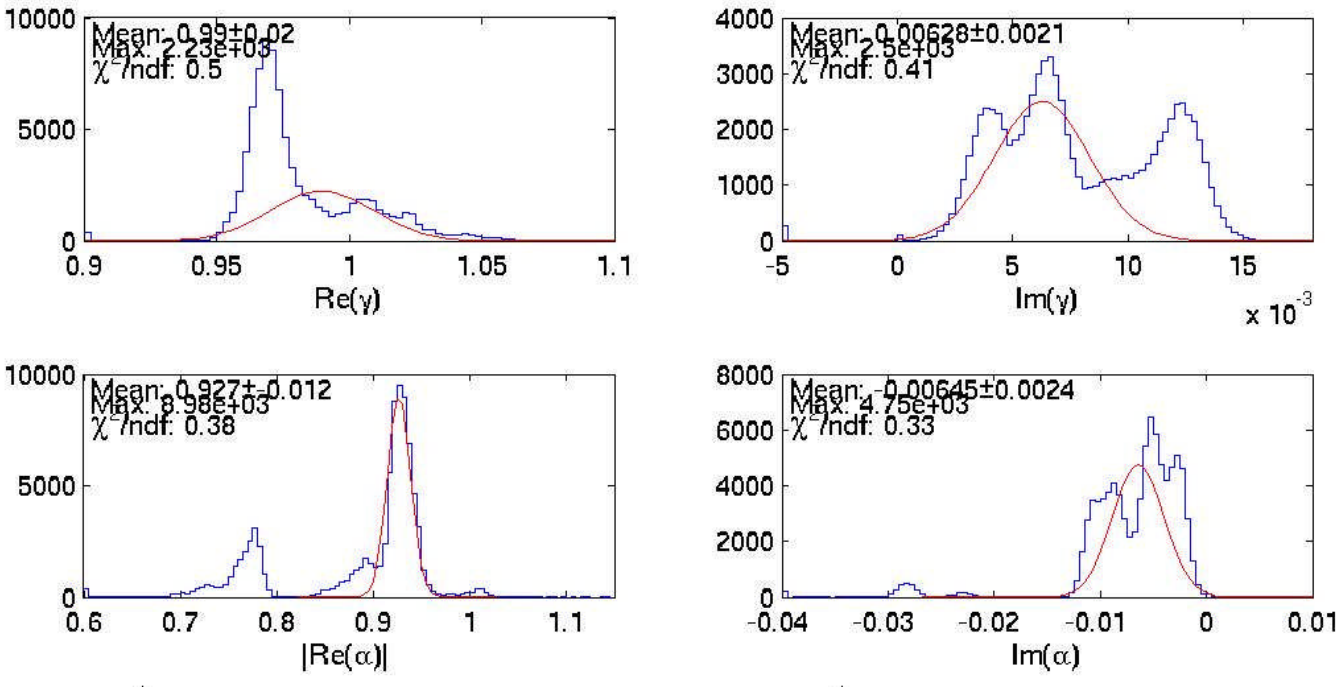
L1 γ, α coefficients S5 up to Feb 1



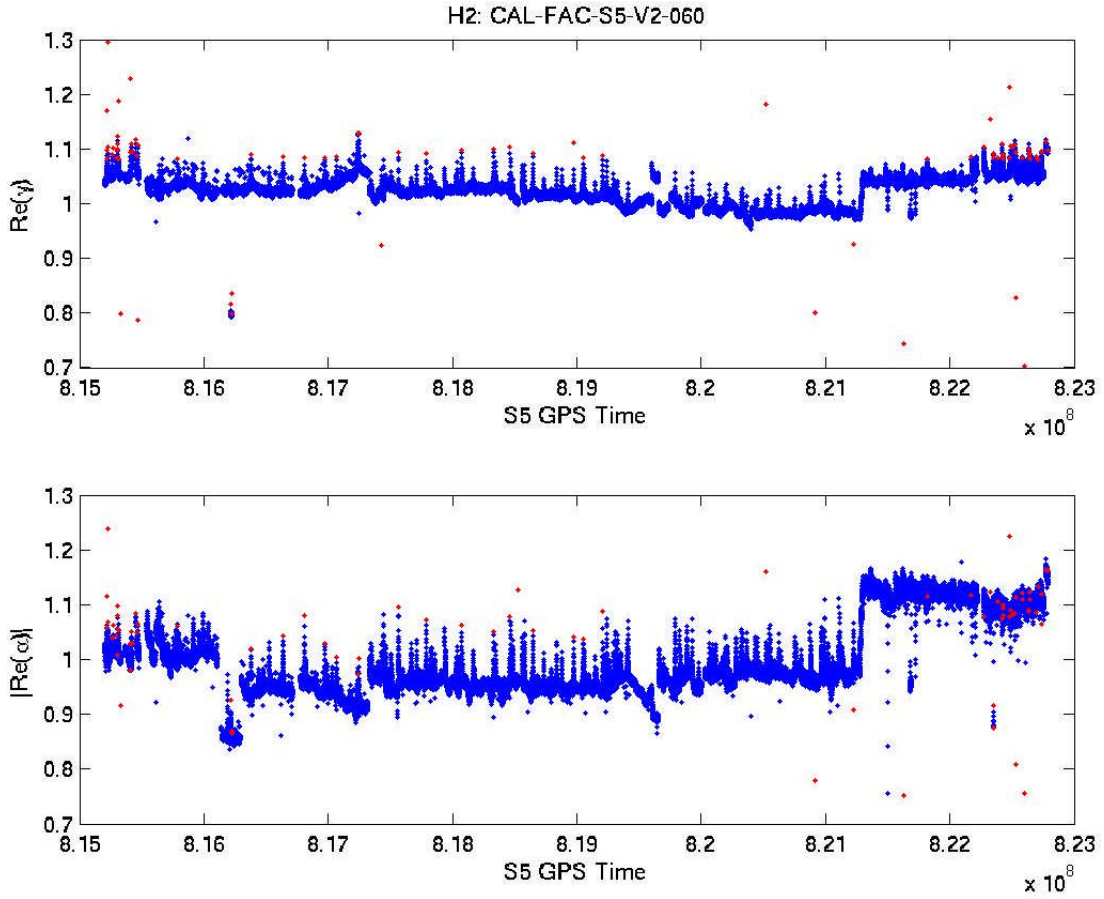
H1 γ, α coefficients S5 up to Feb 1



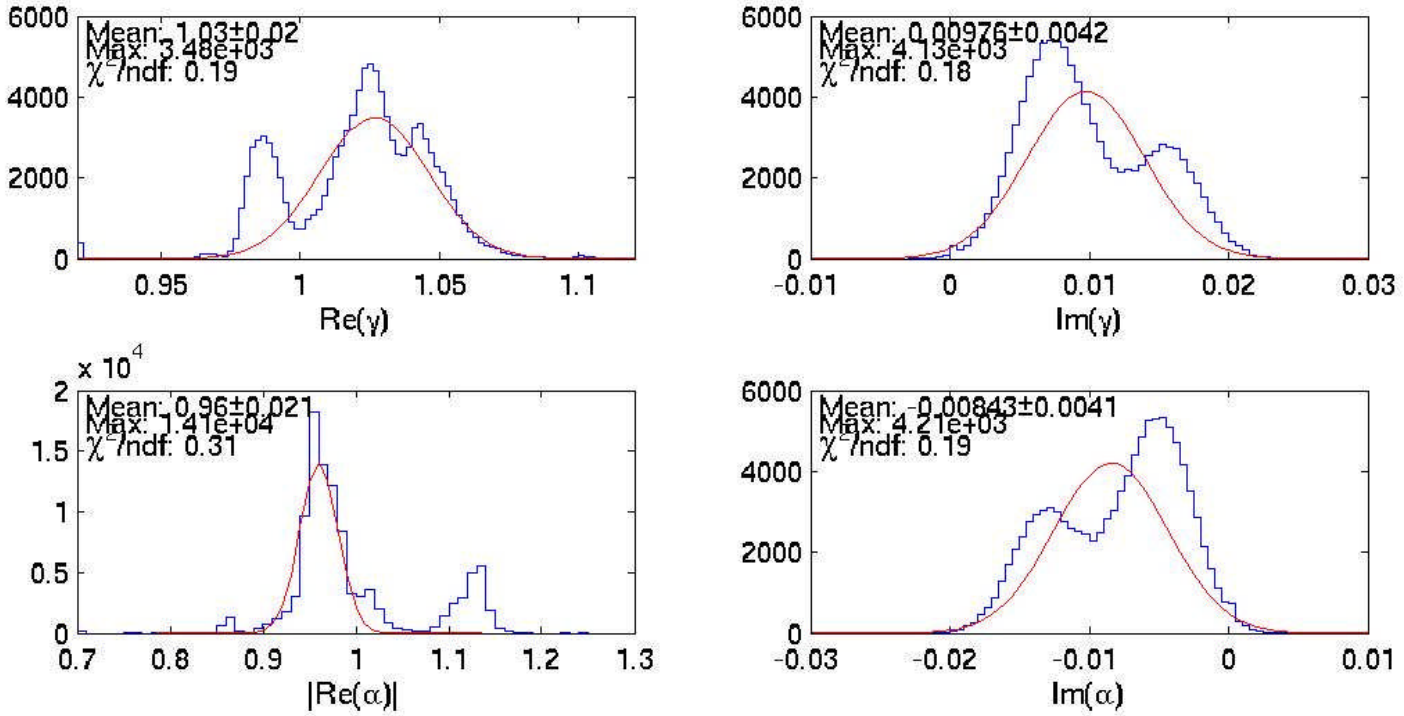
H1 γ, α coefficients S5 up to Feb 1



H2 γ, α coefficients S5 up to Feb 1



H2 γ, α coefficients S5 up to Feb 1



How different is γ from unity?

- H1 :
  - From estimates: median=0.97, std=2%
  - Error in estimates: 0.6% systematic, 0.2% random
- H2:
  - From estimates: median=1.02, std=3%
  - Error in estimates: 1% systematic, 0.4% random
- L1:
  - From estimates: median=1.01, std=3%
  - Error in estimates: 0.2% systematic, 0.2% random

What's next?

- DQ flags have been produced, most at ends of segments.
- We are investigating some noticeable changes in coefficient values and errors.
- Will regenerate coefficients when a better loop model is available (hopefully without ad hoc corrections)
- Will generate coefficients for Feb 1 onwards. Files will be weeks to months long.
- Hope to generate 16 Hz time series to find fast fluctuations (if any)
- Will explore spectral content of time variations.