Status of calibration and characterisation of h(t) reconstruction for VSR2

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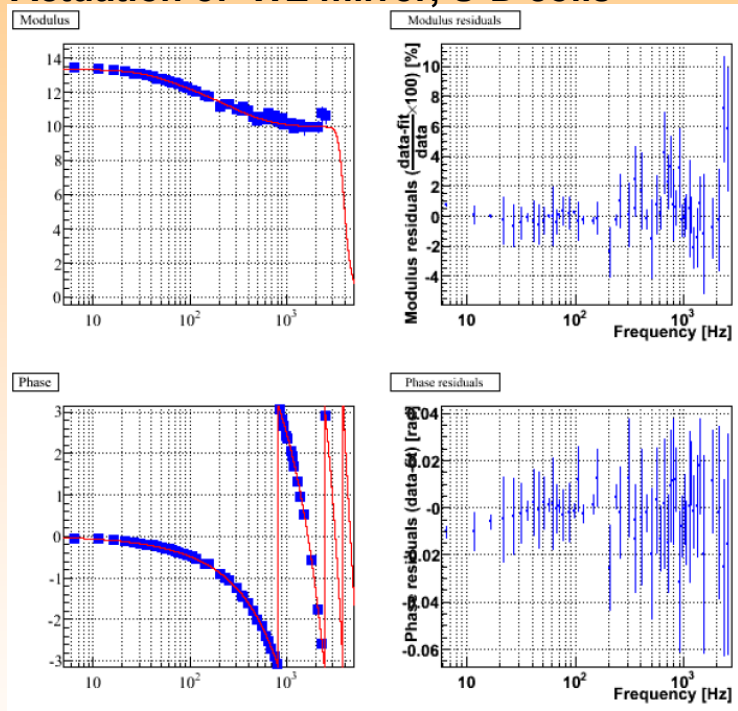
Outline
- Final VSR2 calibration parameters
- Estimation of the errors of the VSR2 hardware injections
- Characterisation of reprocessed h(t) (V2)

Final VSR2 calibration parameters

- Sensing of the dark fringe channel
  - timing within 4 μs systematic errors
- Actuation of the mirrors below 2 kHz
  - stat. errors: <2%/20 mrad (f<1 kHz)
  - syst. errors: 3%/10 μs
- Actuation of the marionettes below 200 Hz
  - stat. errors: errors: <2%/20 mrad
  - syst. errors: < 5%/50 mrad

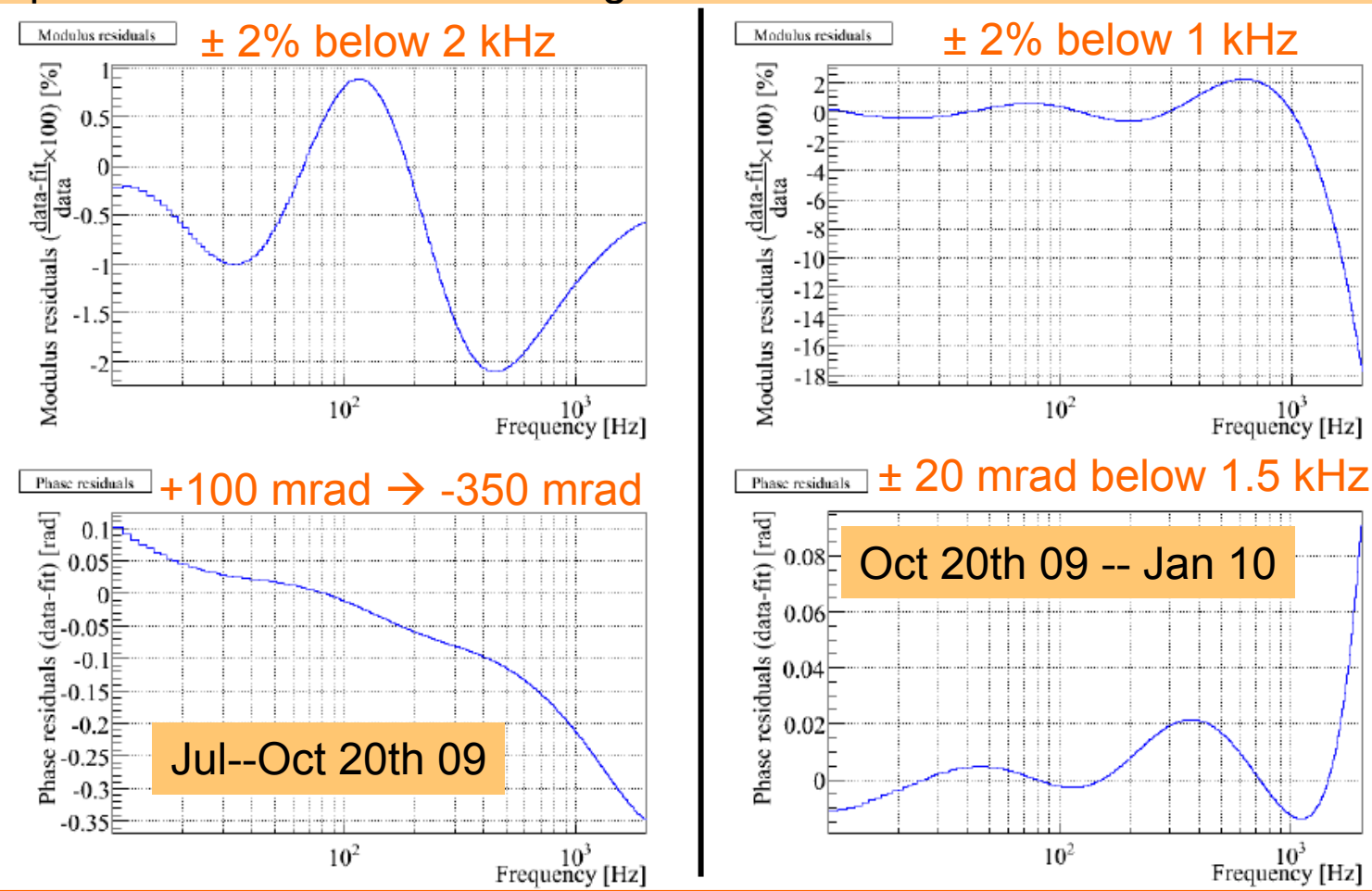
→ notes VIR-0576A-09 and VIR-0076B-10

Actuation of WE mirror, U-D coils



Hardware injections error budget

- Comparison of the final mirror actuation parameterization for WE, coils L-R with the parameterizations used during VSR2



WE, L-R actuation uncertainties: 3% in amplitude, 20 mrad in phase and 10 μs in timing

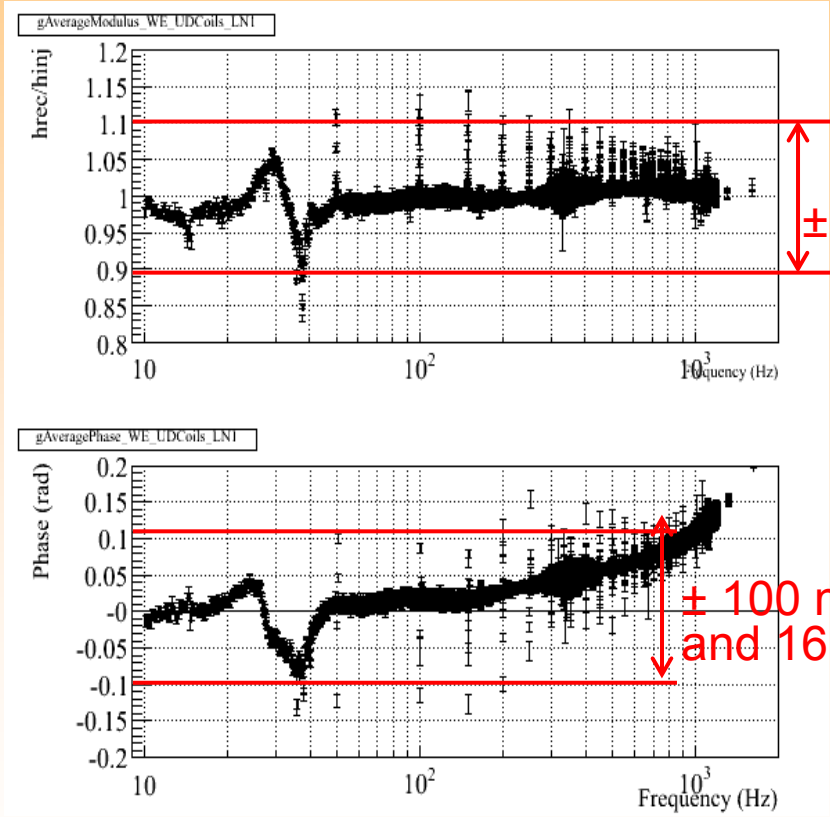
h(t) check with mirror actuation injections

Comparison of h_{rec} with h_{inj} through mirror WE, L-R actuation

Online h(t):
- Jul → Sep 10th:
  use pre-VSR2 parameters
- Sep 10th → Jan:
  use preliminary VSR2 parameters

V2 reprocessing (March 5th):
- Final timing, dark fringe and mirror, marionette actuation parameterizations (note VIR-0076B-10)

- Hrec-Online (from Sept. 10th)



h(t) check with mirror actuation injections

Comparison of h_{rec} with h_{inj} through mirror WE, L-R actuation

➢ Hrec-V2

Online h(t):

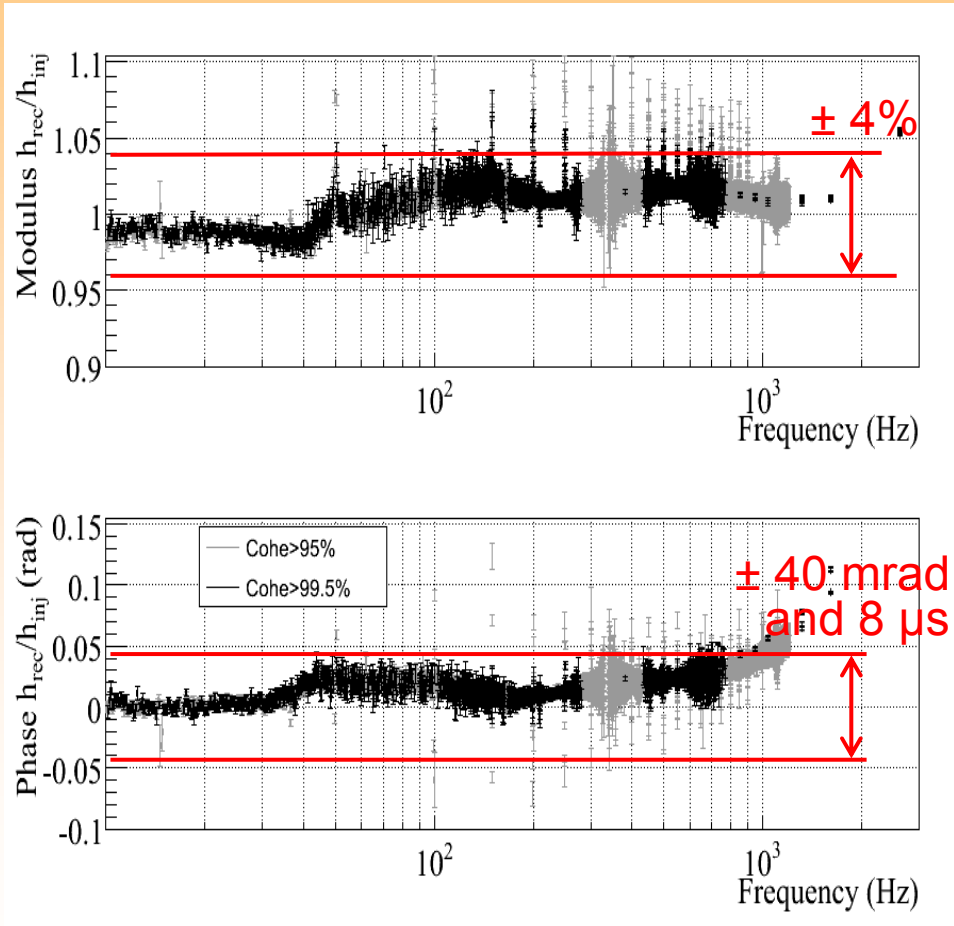
➢Jul → Sep 10th:
use pre-VSR2 parameters

➢Sep 10th → Jan:
use preliminary VSR2 parameters

V2 reprocessing (March 5th):

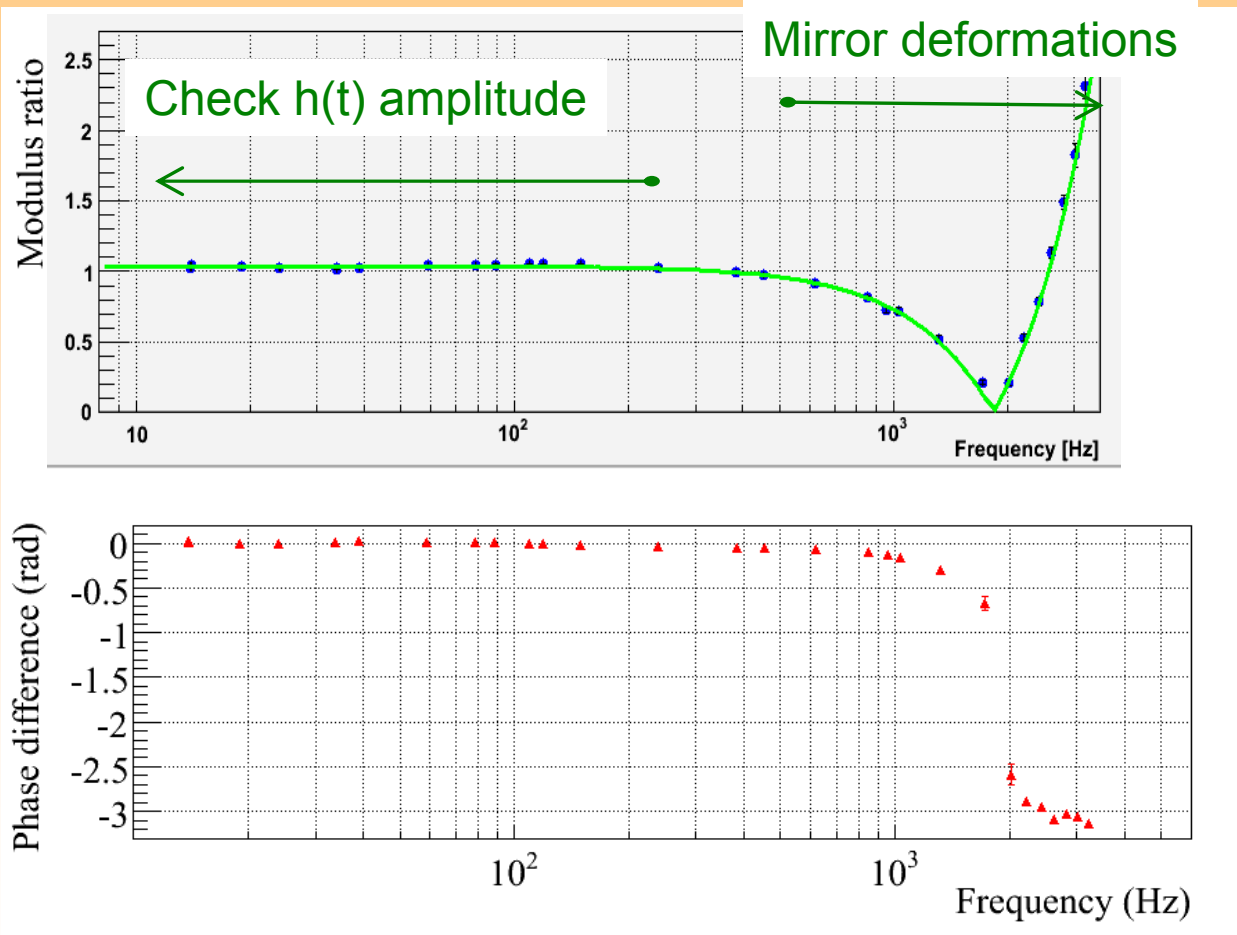
➢Final timing, dark fringe and mirror, marionette actuation parameterizations (note VIR-0076B-10)

→Error in amplitude: 4+3=7%
→Error in phase: 40+20 = 60 mrad
8 + 4 = 12 μs



h(t) check with photon calibrator

Comparison of h_{rec} with h_{inj} through (single beam) pcal

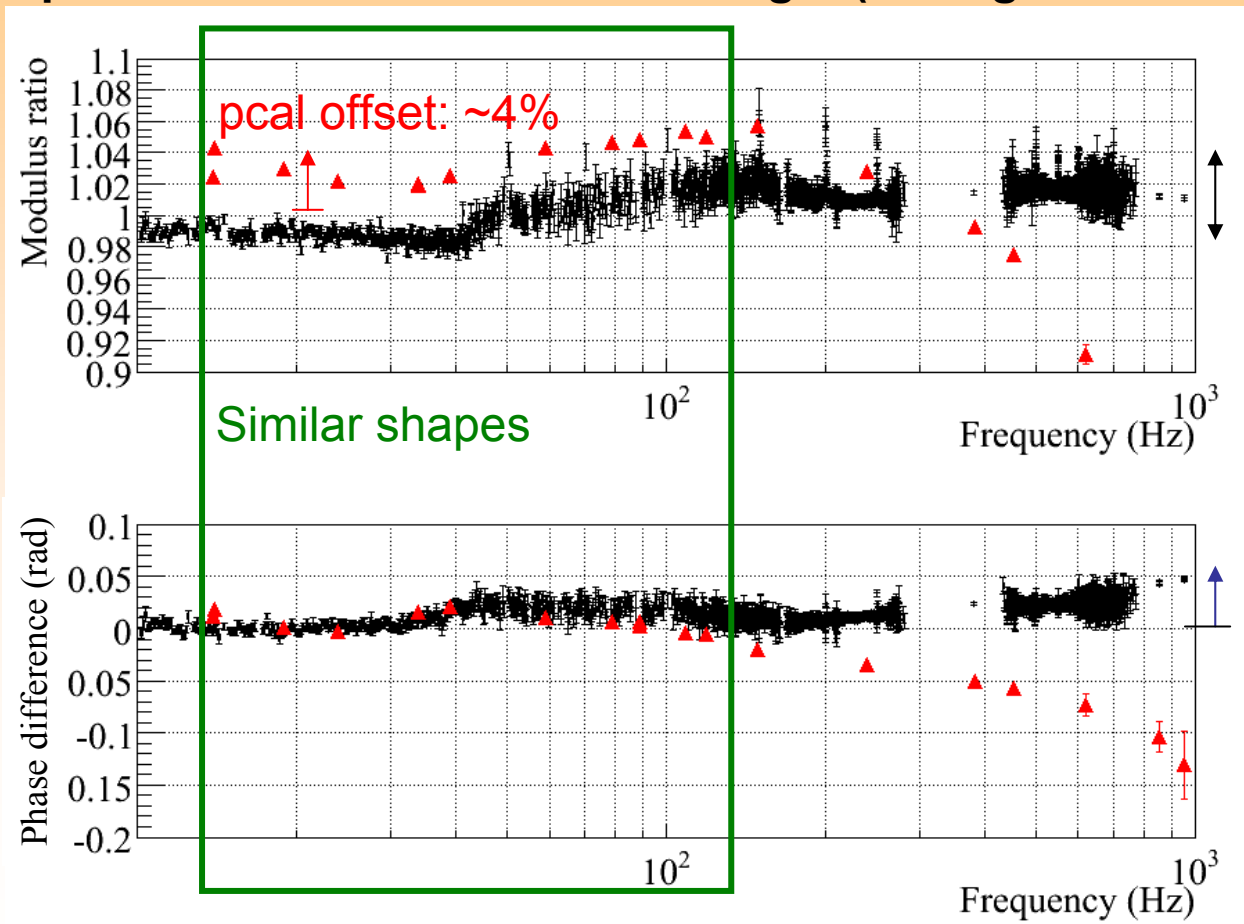


→ See talk from T. Accadia (Monday DetChar parallel session)

h(t) error budget from pcal

Comparison of h_{rec} with h_{inj} through pcal

Comparison with standard error budget (through WE mirror)



pcal syst: 8%

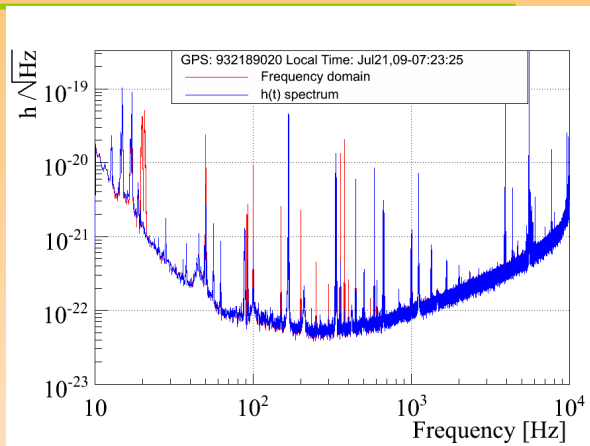
mirror syst: 3%

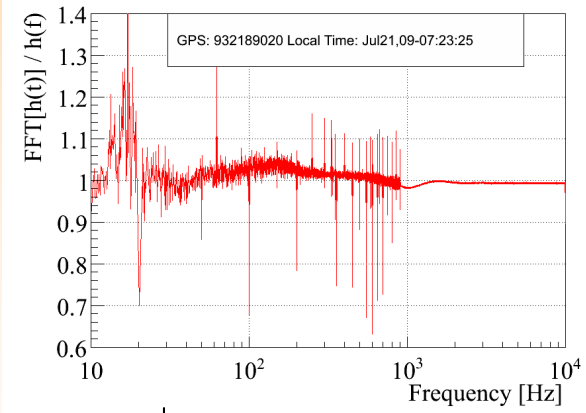
~-8 µs

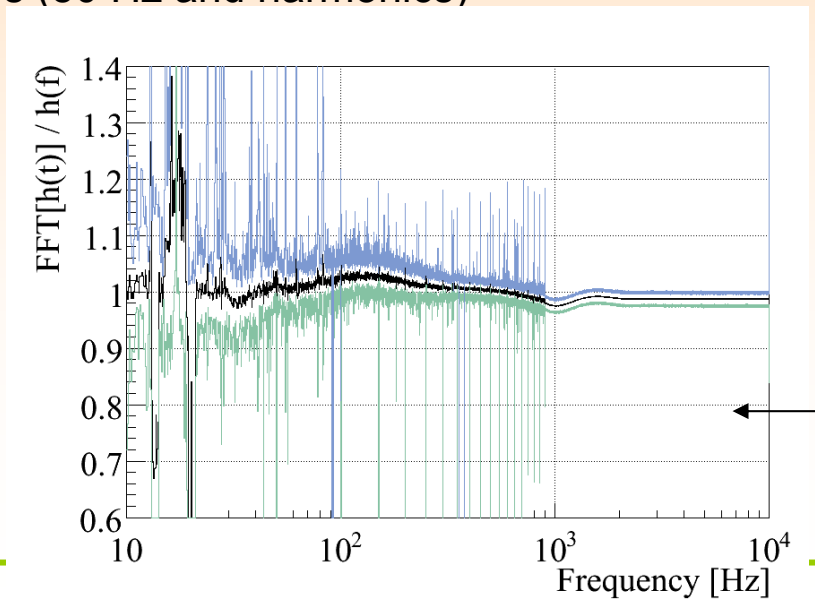
Time-domain vs frequency-domain sensitivity

- Sensitivity measured in the frequency domain (red)
- Sensitivity: FFT of h(t) (blue)

- Ratio of FFT[h(t)] / h(f)
  - Could highlight errors in one of the process
  - Highlight noise difference or Virgo TF differences
    - agreement within 5% above 20 Hz
    - some extra-noise below, up to ~10%
  - Highlight noise subtracted in h(t)
    - calibration lines
    - power lines (50 Hz and harmonics)







Mean, min and max
from weekly measurements

Cavity finesse in hrec and timing error ?

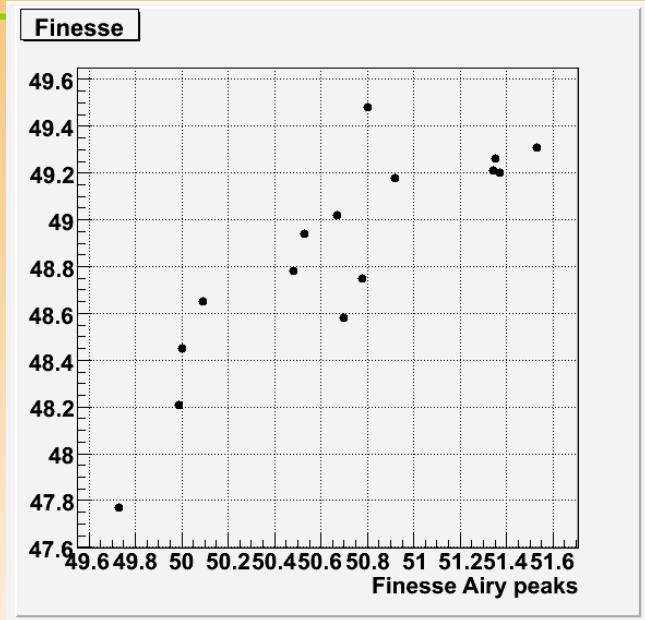
- Comparison of finesses:
  - estimated in hrec (phase of cal. lines)
  - estimated with free swinging cavities

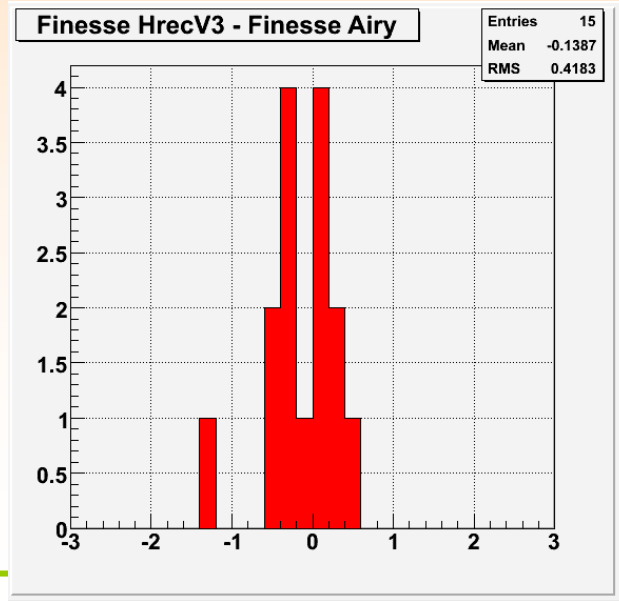
→Correlated but with offset of ~1.8

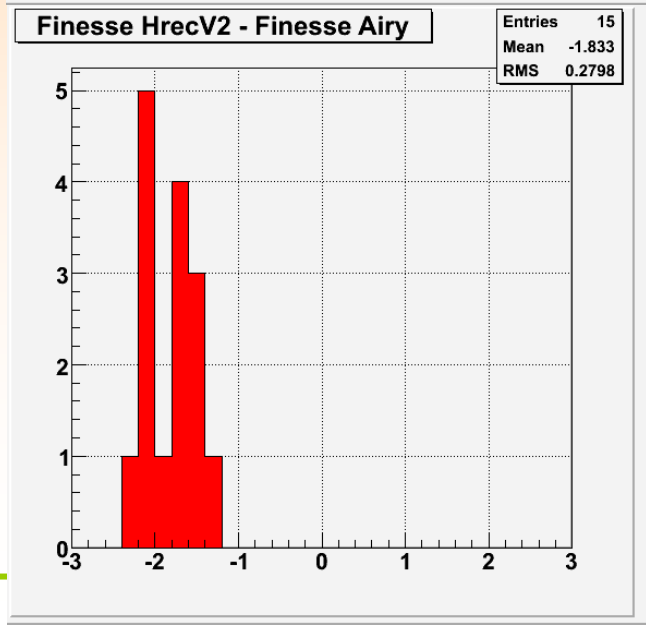
→ ~7.8 µs error in **relative timing** between sensing and actuation ?

- Reprocessed h(t) with
  - 7.8/2 µs 'added' to the sensing
  - 7.8/2 µs 'added' to the actuation

→ V3 version of h(t) ?



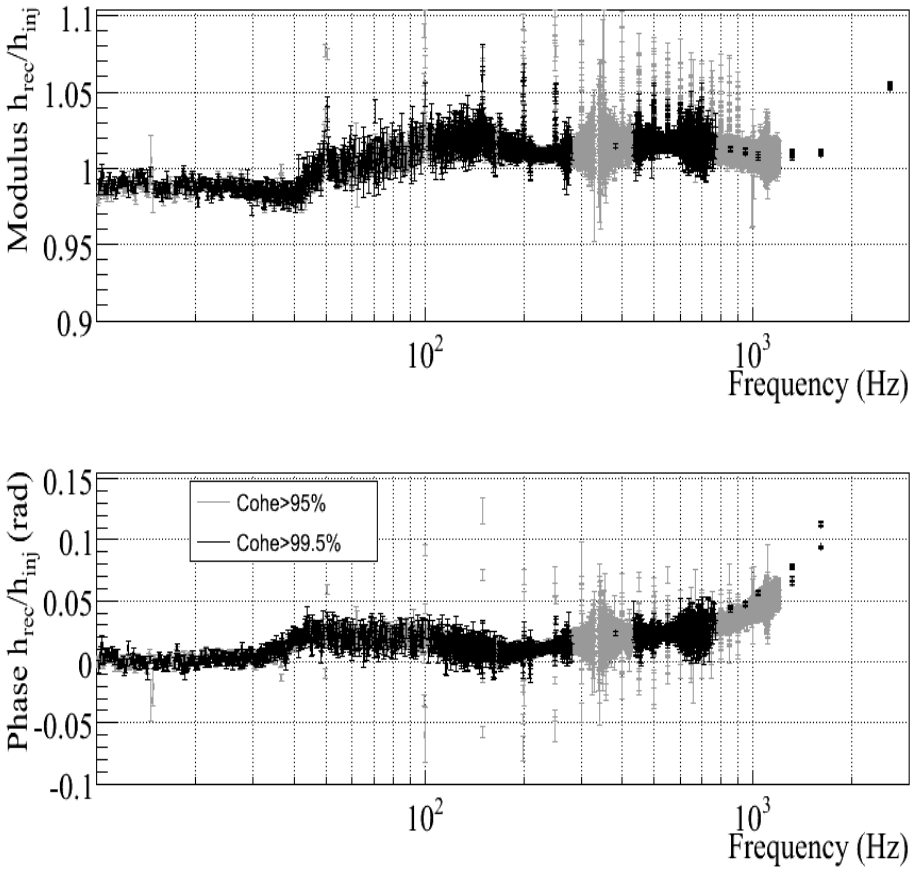


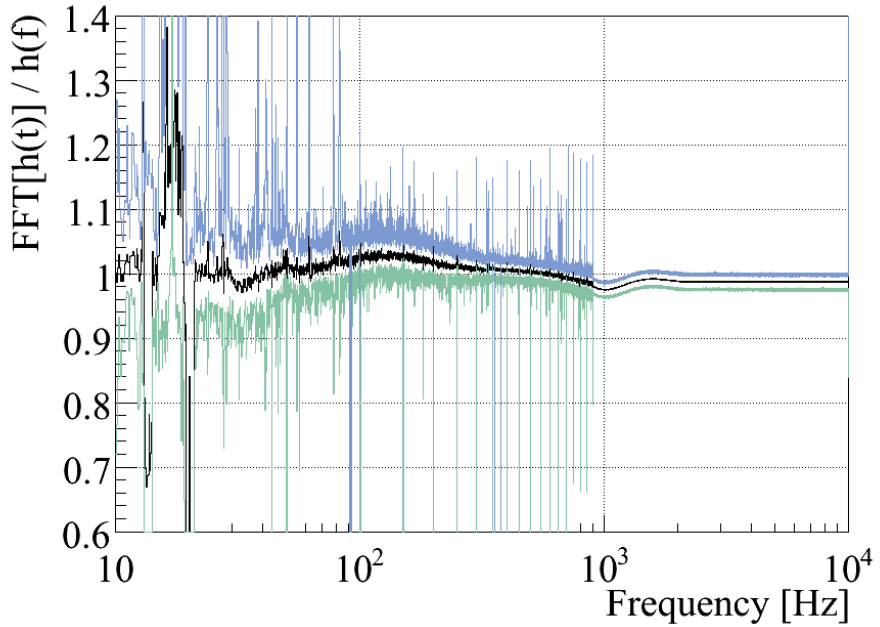


Comparison of h(t) V3 vs V2…

Check with mirror injections (h_{rec}/h_{inj}) V2

FFT[h(t)] vs h(f)



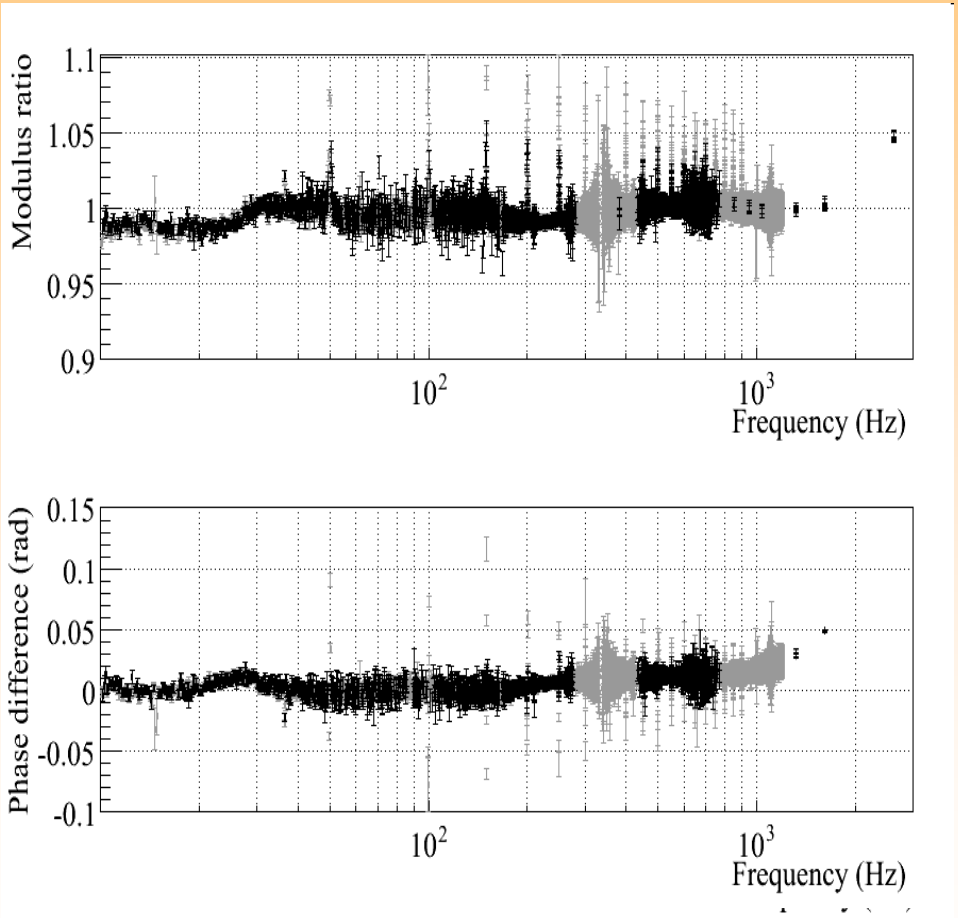


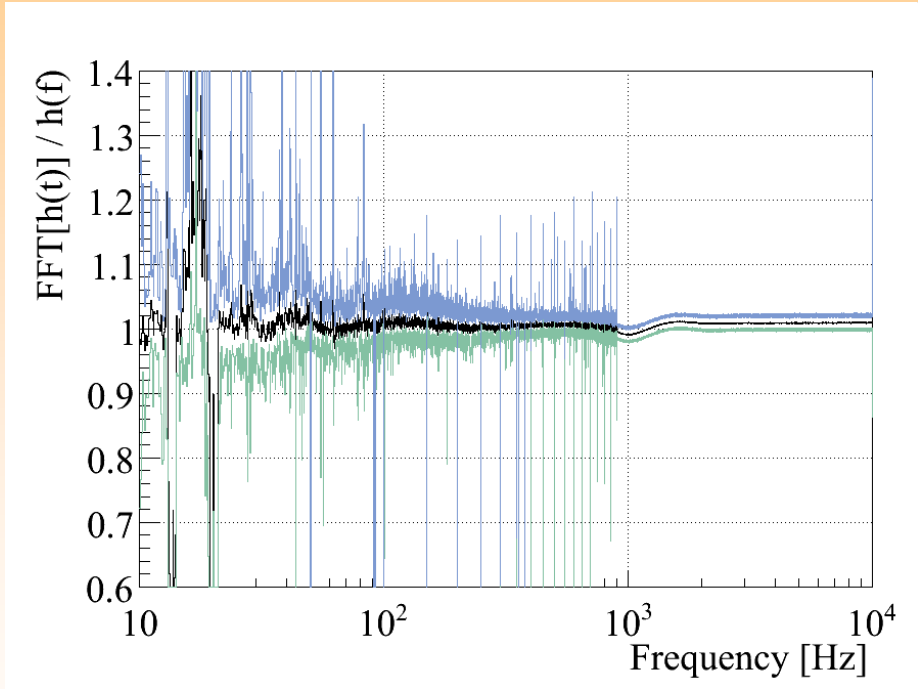
→check plots are flatter in V3… → lower errors

Comparison of h(t) V3 vs V2…

Check with mirror injections (h_{rec}/h_{inj}) V3

FFT[h(t)] vs h(f)





→check plots are flatter in V3… → lower errors

Summary

- Final calibration parameterizations: notes VIR-0176A-09, VIR-0076B-10
  - Dark fringe sensing / timing / actuation

- Hardware injections: error budget described in the note

- h(t) reconstruction (V2):
  - Complete reprocessing March 5th

Amplitude	7% (10 Hz—10 kHz)	
Phase/timing	60 mrad (3.5°) (f<800 Hz)	12 μs (f>800 Hz)

  - Presence of some extra-noise below 40 Hz, but less than 10%

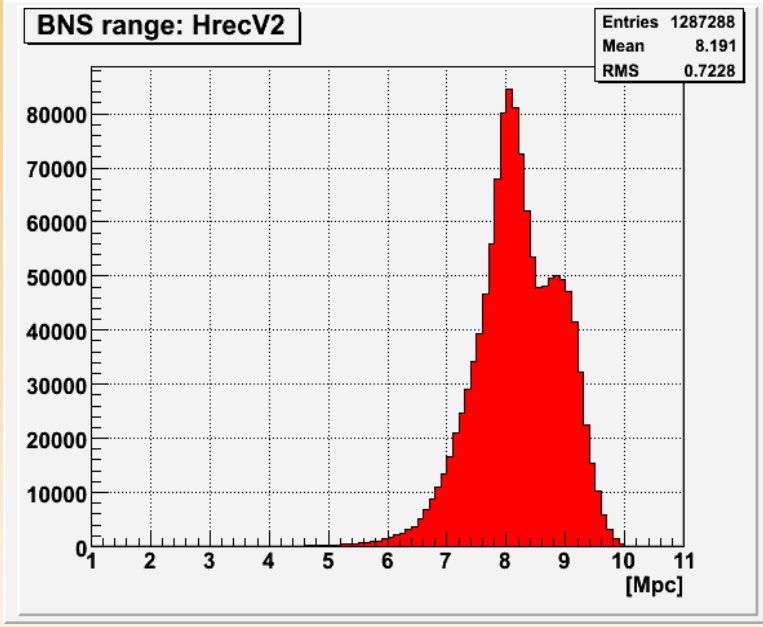
PRELIMINARY

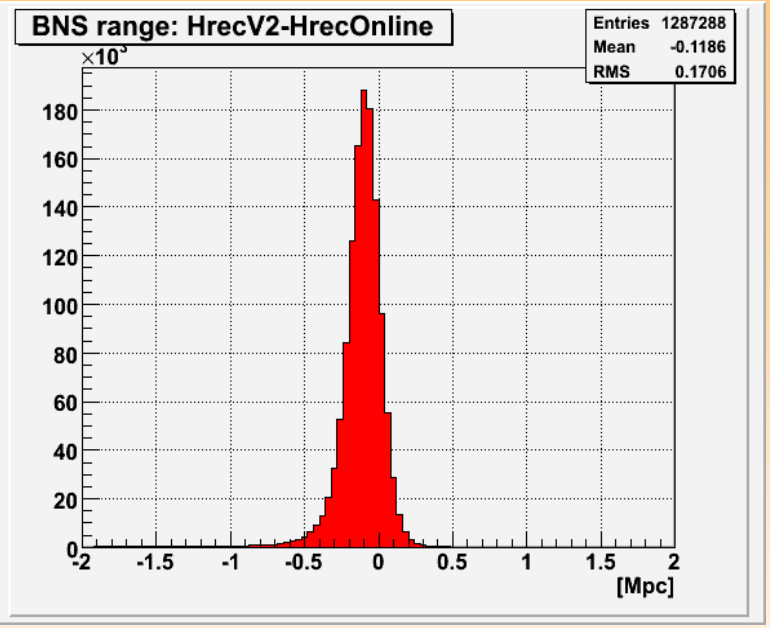
- Release of V3 h(t)
  - Start feeding to LDR by tomorrow

Amplitude	~5.5% (10 Hz—10 kHz)	
Phase/timing	~45 mrad (f<1 kHz)	12 μs (f>1 kHz)

- Approaching the end of the review…

BNS range of h(t) V2 during VSR2





Average BNS during VSR2: 8.2 Mpc
Lower compared to online h(t) by 0.12 Mpc