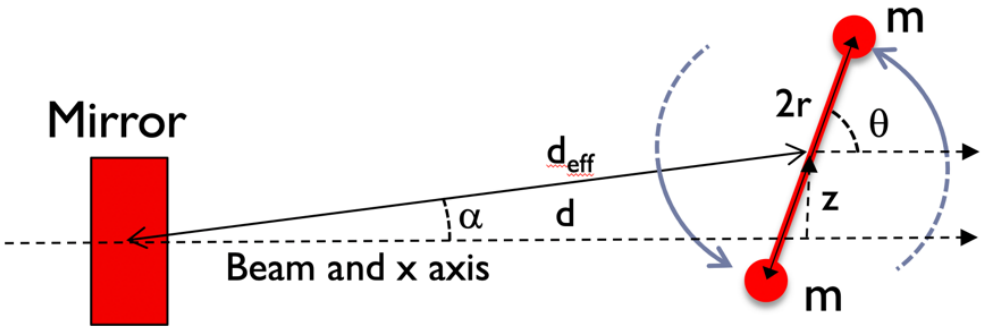

See the note « *Analysis of the NCal data collected during O3b* » VIR-0268A-20
See also this earlier paper for more info on Newtonian Calibration

O3 NCal investigations

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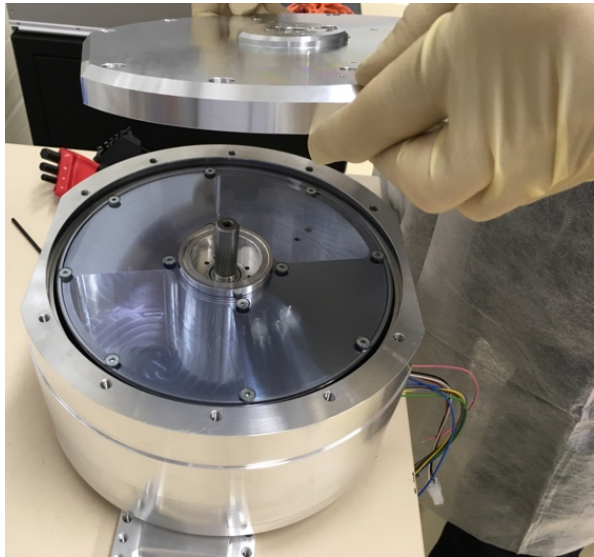
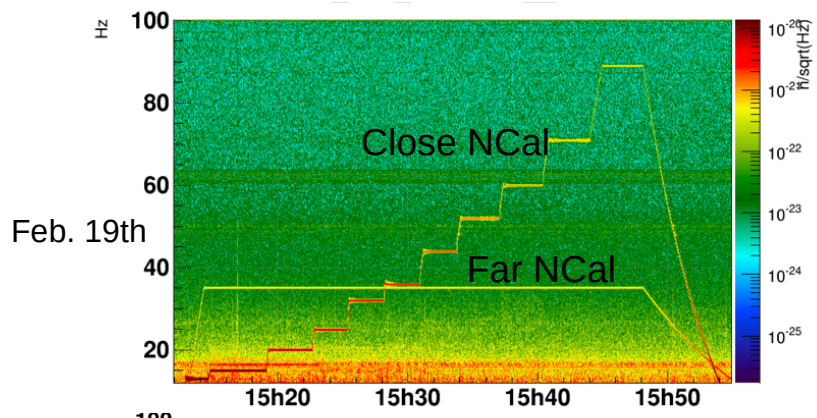
July 6th, 2020 - Virgo Week

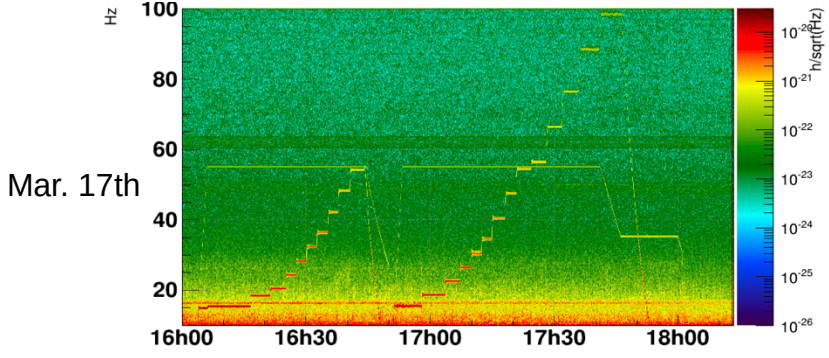


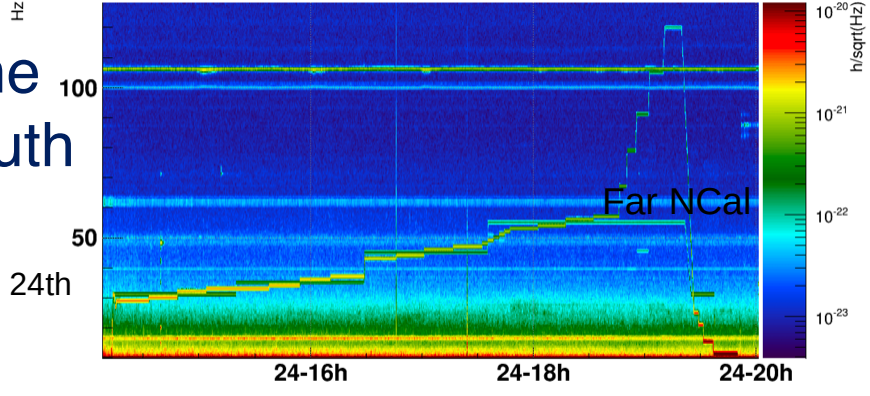
Picture: NCal being assembled at LAPP

Three data sets used

- February 19
  - Described in VIR-0268A-20
- March 17
- March 24
  - The longest scan: 6 hours
  - Going up to 120 Hz
- All data sets are collected with the two NCals suspended on the South Side of the NE tower



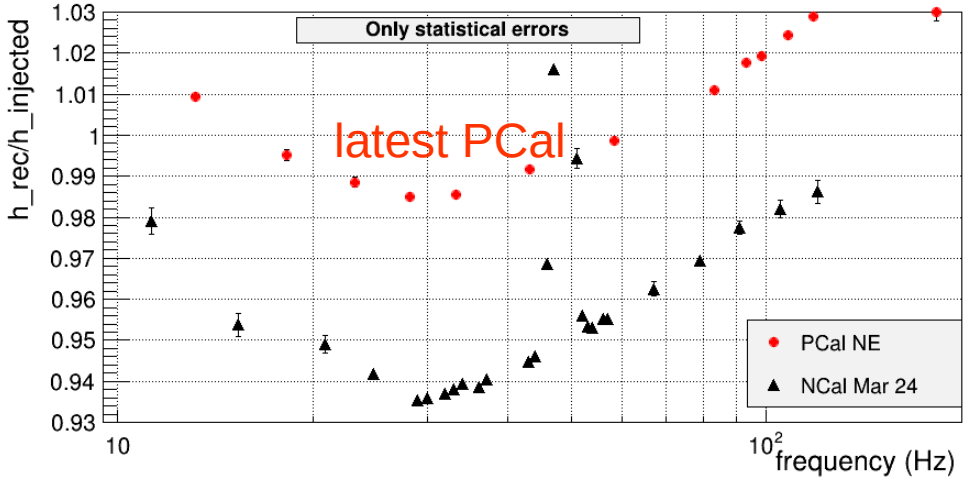




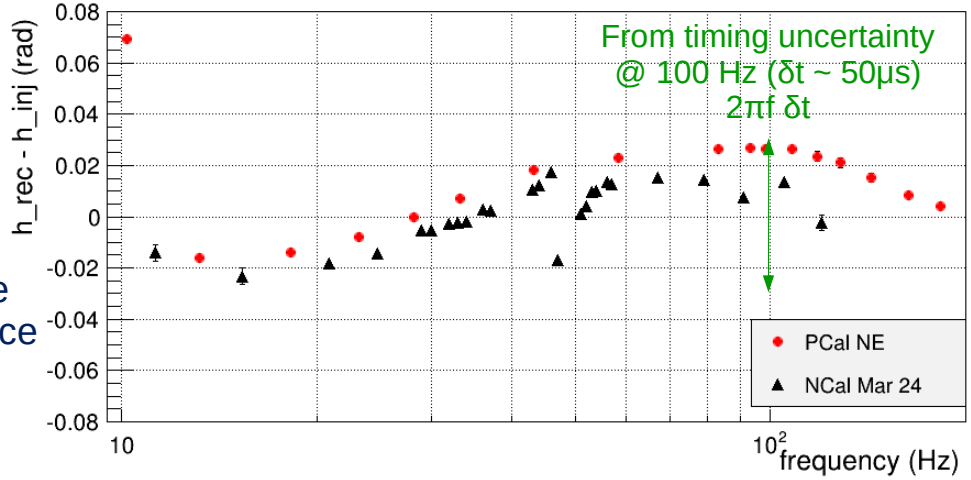
Overview: injected vs recovered signals

- Very similar shape
- Amplitude discrepancy
- 45-51 Hz: strange effect
- Phase: good agreement

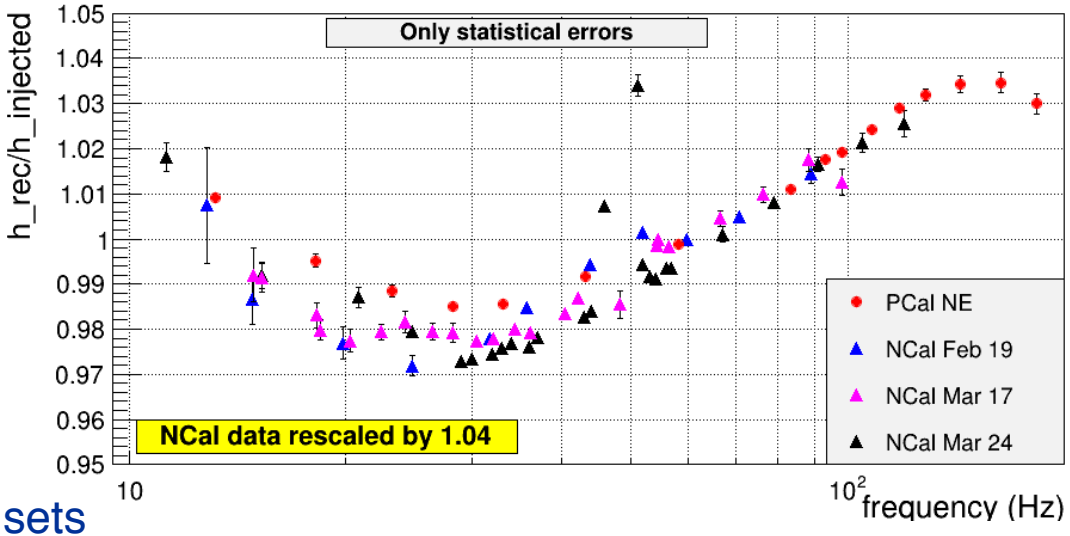
Amplitude ratio



Phase difference

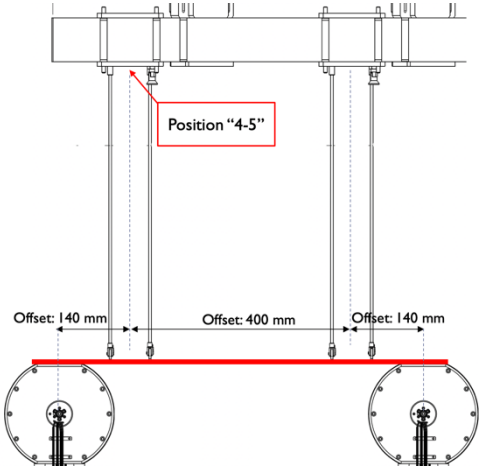


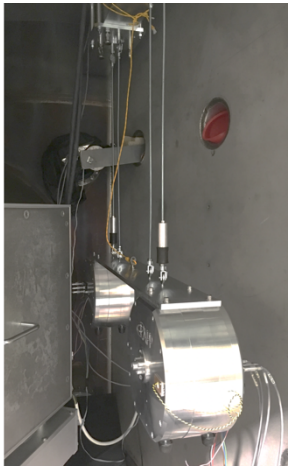
Checking the shape



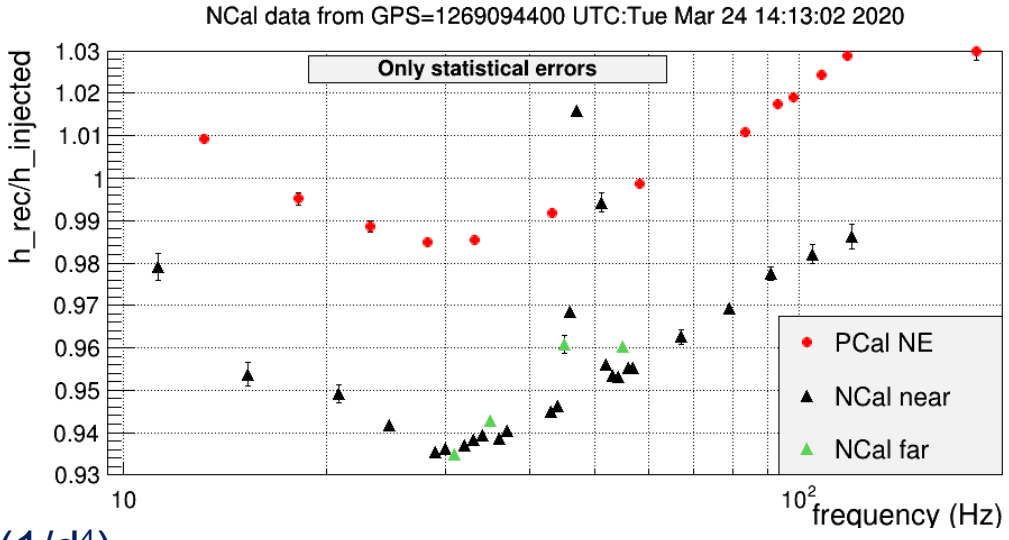
- Rescale NCal data by 4%
  - Same offset for the 3 NCal data sets
- NCal and PCal have similar shape
  - Some fluctuations below 30 Hz
- 4 % offset not incompatible with absolute systematic uncertainties
  - PCal : 1.4%
  - NCal : 3% (from VIR-0268A-20)

Parameter			Relative impact	
name	value	uncertainty	formula	value (%)
distance (m) d	1.26	0.007	$4\delta d/d$	2.3
angle Φ (rad)	0.606	0.004	$\delta\Phi \sin\Phi$	0.23
vertical position z (m)	0	0.02	$5/2(z/d)^2$).	0.06
density ρ (SI)	2805	5	$\delta\rho/\rho$	0.18
thickness b (mm)	74	0.2	$\delta b/b$	0.27
r_{max} (mm)	95	0.1	$4\delta r_{max}/r_{max}$	0.42
model			guess	2
Total			quadratic sum	3.1





Mirror distance: near/far NCal



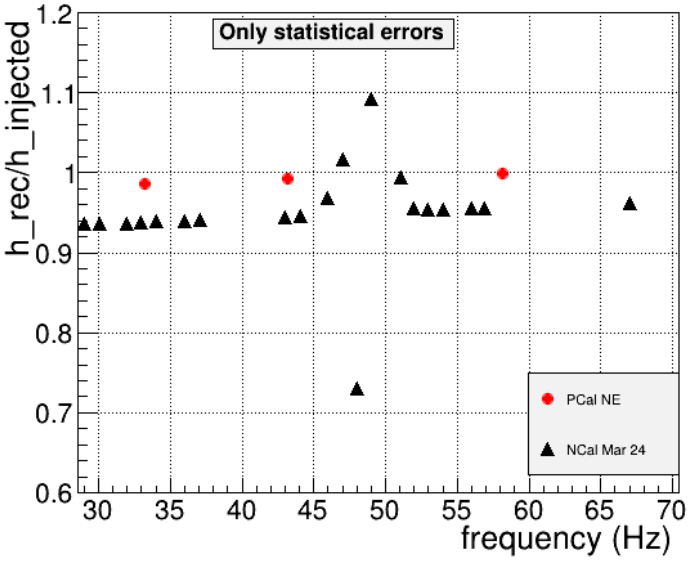
- Two NCals
  - Near: 1.27 m from mirror
  - Far: 1.95 m from mirror
- Strong dependence on the distance ($1/d^4$)
  - Far signal is 5.5 times weaker than near signal
- If 4% amplitude offset for **near NCal** is due to distance offset, then **far NCal** should have a 2.6% offset (from Error = 4δd/d) = 1.4% difference
  - But Far/Near amplitude offsets differ by less than 0.5 %

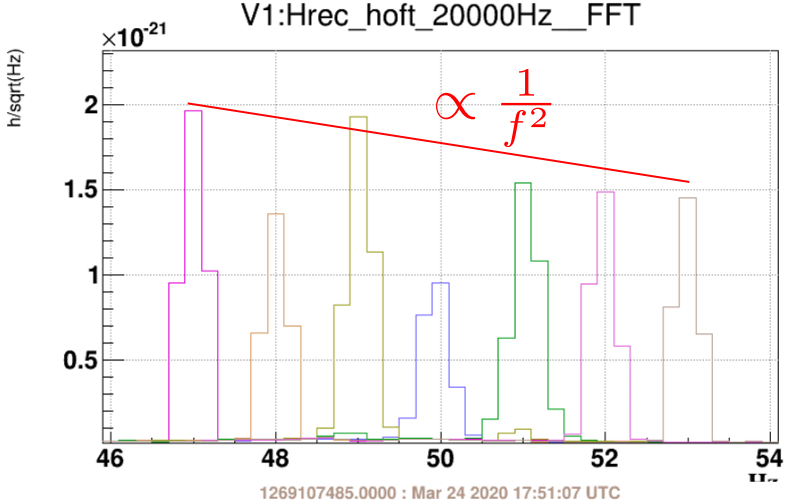
➡ Distance uncertainty is **not** the **main** source of discrepancy

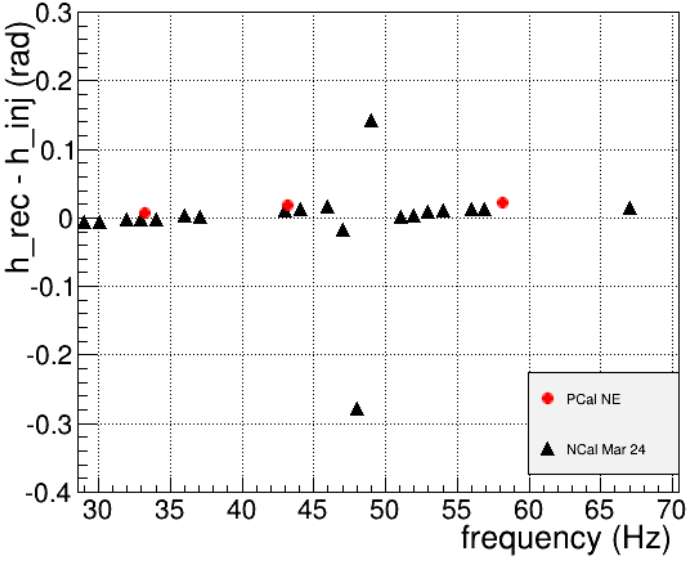
- Remark: swap of the two NCals to confirm result not done due to the pandemic

45-51 Hz band

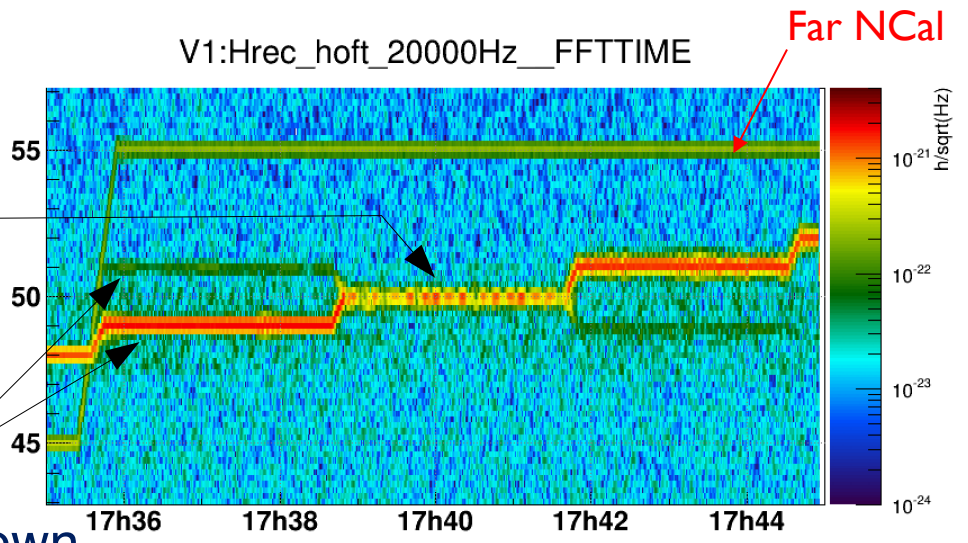
- Large effect in the 45-51 Hz band
  - Amplitude **and** phase
- **Remark:** PCal is not testing this frequency band
- Scanning by 1 Hz steps
- Effect visible on simple FFTs
  - **Not** an NCal analysis artefact



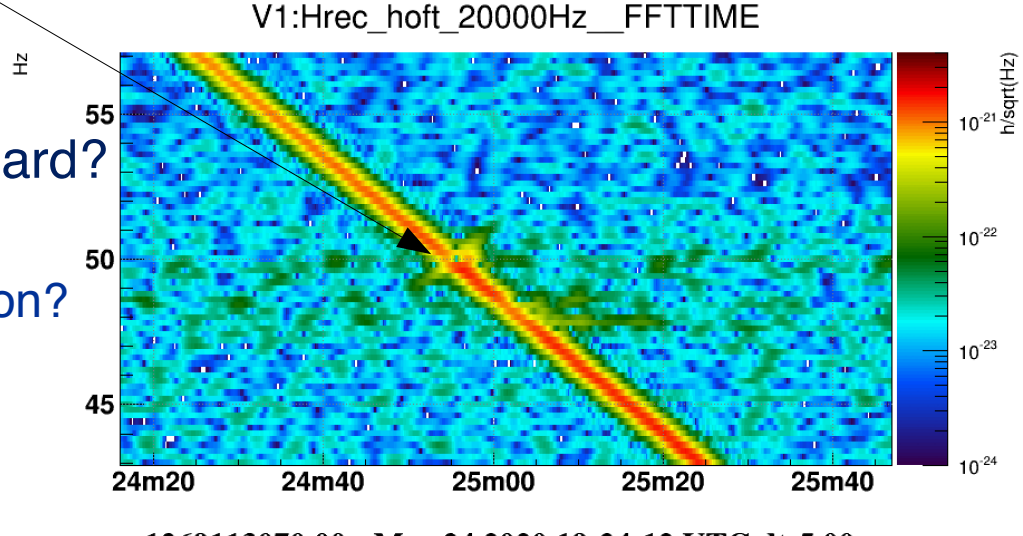




45-51 Hz time frequency



- Not a stable line at 50 Hz
- Line splitting near 50 Hz
- Effect visible when NCal spinning down



- Weird effect of the 50 Hz feedforward?
  - Should it be changed?
  - How to include it in h(t) reconstruction?

Summary

- NCal has provided Calibration information in the 10 -120 Hz band
- 4 % amplitude offset vs PCal
  - Not explained by mirror to NCal distance error
  - NCal model not correct/complete ?
  - NCal rotor not as expected ?
  - Part of the offset coming from an h(t) bias ?
- Strange effect in the 45-51 Hz band: feedforward ?
- To be further investigated for O4
  - Will need **new NCal** (better controlled geometry),
  - **More** modelling,
  - **More** data taking