

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY  
- LIGO -  
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Technical Note	LIGO-T1900253-v6	2020/08/03
<b>Record of Real-Time Calibration Pipeline Parameter Changes</b>  <b>O3 (and ER14) – L1</b>		
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## 1 Calibration Line Frequencies

LLO aLOG 42720 Since January 2019, calibration lines at LLO for all of ER14 and O3 were set to:

Pcal Line 1	Pcal Line 2	Pcal Line 3	TST line	Pum Line	Uim Line
16.3 Hz	434.9 Hz	1083.1 Hz	16.9 Hz	15.7 Hz	15.1 Hz
1200 ct	7200 ct	16160 ct	0.15 ct	0.08 ct	30 ct

## 2 A note on Front-End, Hand-Applied kappas and cancellation

In order to facilitate up-to-date calibration in the control room, during ER14 and O3, commissioners would update the gains values of the 1/C and A filter banks in the front-end calibration process in order to apply measured time-dependent correction factor values “by hand.” They would remove the impact of this work around by “cancelling” these gains with an inverse value in the corresponding, downstream, filter bank used for whitening these ERR and CTRL channels prior to storage to frames such the GDS pipeline “wouldn’t see” these hand tweaks and act as if they never occurred. (Recall the in the GDS pipeline is where TDCF’s are traditionally applied, but GDS data is not available for control room consumption.)

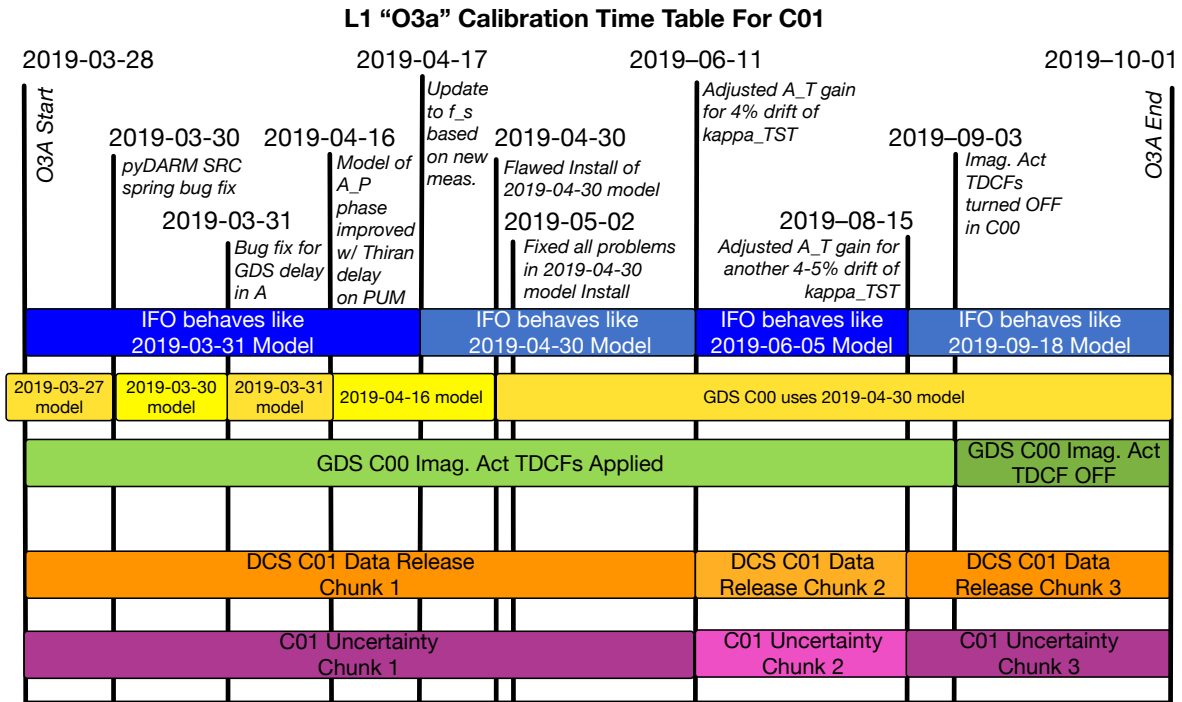
There was a burt restore mistake made during the April 30, 2019 maintenance Tuesday (around GPS 1240680372) which resulted in this cancellation not happening, and producing an incorrect model. The ETMY L3 gain was 0.98 and the ETMX L2 gain was 0.985 until fixed and set to 1.0 at around GPS 1240847412 (i.e. May 02, 2019).

Raw data for other times during ER14 and O3 can be found in the supplementary document,

CALCS\_calibration\_gain\_changes\_ER14\_O3.txt

.

### 3 O3A Time Table Graphic



**T1900253-v2**

J. Kissel, J. Betzwieser 2019-11-21

Figure 1: Time table summarizing the major events in O3A, and how they impact the final (C01) data releases.

## 4 ER14

### 4.1 Monday March 4 2019

March 4 2019 20:52:11 UTC  
GPS 1235767949

Front end and GDS being using the same model file,

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190117.py
```

LLO aLOG 43859 At this time time dependent correction factors were not applied however, and so uncertainties in C00 will be very large at this time.

### 4.2 Thursday March 7 2019

Mar 7 2019 21:31:41 UTC  
GPS 1236029519

Updated pyDARM to generate kappa calculations correctly for both GDS and front end.

```
~/trunk/Common/pyDARM/src/computeDARM.py
```

LLO aLOG 44005

### 4.3 Friday March 8 2019

Mar 8 2019 16:45:01 UTC  
GPS 1236098719

Time dependent correction factors begin being applied in GDS. Model used was the same as before:

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190117.py
```

LLO aLOG 44035

### 4.4 Thursday March 14 2019

Mar 14 2019 02:02:47 UTC  
GPS 1236564185

Tried to update UIM and PUM coil driver compensation with full fits up to high frequency ( few thousand Hz). Turns out the fits didn't agree with PCAL sweeps, so during this time until being reverted on Wednesday March 20, this data would need a somewhat complicated model to correct.

#### 4.5 Wednesday March 20 2019

**Mar 20 2019 20:45:35 UTC**  
**GPS 1237149953**

Updated the front end delay between actuation and sensing in the CALCS model (which has no effect on GDS). Updated a notch filter from the old PCAL line frequency to 434.9 Hz which had been changed in the actual interferometer controls since the calibration line change back in January. Also corrected the ETMX L2 coil driver compensation to undo the poor PUM coil driver matching in the actual interferometer. [LLO alog 44444](#)

#### 4.6 Wednesday March 27 2019

**Mar 27 2019 22:56:40 UTC**  
**GPS 1237762618**

New front end model pushed, foton gains updated, and a 6700 Hz pole added to the ETMX L2 calibration path to match a time delay seen in sweeps.

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190327.py
```

[LLO aLOG 44683](#) Interferometer ETMX L2 coil driver compensation updated to match fits.  
[LLO aLOG 44656](#) At this point, to recalibrate from this point on until April 17 2019 23:30 UTC (1239579018)

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190331_C01.py
```

#### 4.7 Thursday March 28 2019

**Mar 28 2019 17:20:52 UTC**  
**GPS 1237828870**

GDS switches over to using also using

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190327.py
```

[LLO aLOG 44683](#)

This time also represents the official start of the C01 chunk 1 data reconstruction, using the 2019-03-31 model.

#### 4.8 Saturday March 30 2019

**Mar 30 2019 21:56:40 UTC**  
**GPS 1238018218**

Pushed updated model to front end based on the latest svn checkin of pyDARM at the time, to remove the effects due to bugs in manner in which pyDARM code computed the SRC detuning optical spring response.

`~/trunk/Runs/03/L1/params/modelparams_L1_20190330.py`

LLO alog 44755 and LLO aLOG 44756

HOWEVER:

#### 4.9 Sunday Night, March 31 2019

**Apr 01 2019 01:33:29 UTC**  
**GPS 1238117627**

Introduced an error in the 20190330 parameter file by including an  $60e-6$  unknown actuation delay which should not have been there. That mistake only affected GDS, and was corrected the next day using an nearly identical file:

`~/trunk/Runs/03/L1/params/modelparams_L1_20190331.py`

LLO aLOG 44767

## 5 O3A

#### 5.1 Tuesday April 16 2019

**Apr 16 2019 17:42:11 UTC**  
**GPS 1239471749**

Update of the delay in the ETMX L2 calibration model delay from using a 6700 Hz pole to using a thiran IIR filter with  $18e-6$  seconds delay.

`~/trunk/Runs/03/L1/params/modelparams_L1_20190416.py`

LLO aLOG 45207

#### 5.2 Wednesday April 17 2019

**Apr 17 2019 23:30:00 UTC**  
**GPS 1239579018**

Sweeps made this day indicated 0.6 Hz out of 4.8 Hz shift in the low frequency SRC spring frequency, so we use a new epoch model. To recalibrate from now until the next epoch, use



```
~/trunk/Runs/03/L1/params/modelparams_L1_20190430.py
```

This time also defines the start of the second Epoch within Chunk 1 of the C01 reconstructed data, using the 2019-04-30 parameter file.

### 5.3 Tuesday April 30 2019

**Apr 30 2019 17:26:41 UTC**  
**GPS 1240680419**

Pushed a model update using 20190427 sweeps. The model file was:

```
~/trunk/Runs/03/L1/params/modelparams_L1_20190430.py
```

However, several mistakes were made pushing this model. The foton file for L1CALCS.txt still matched the previous model, namely 20190416. Secondly, a gain of 0.98 was applied to the ETMY L3 path and a gain of 0.985 was applied to the ETMX L2 path. [LLO aLOG 45207](#)

### 5.4 Wednesday May 1 2019

**May 01 2019 16:29:54 UTC**  
**GPS 1240763412**

Loaded the correct foton file for L1CALCS.txt corresponding to the 20190430 model. Gains of 0.98 for ETMY L3 and 0.985 for ETMX were still present. [LLO aLOG 45608](#)

### 5.5 Thursday May 2 2019

**May 02 2019 15:49:54 UTC**  
**GPS 1240847412**

Fixed ETMY L3 gain and ETMX L2 gain to match model. [LLO aLOG 45627](#)

### 5.6 Tuesday June 11 2019

**Jun 11 2019 16:57:18 UTC**  
**GPS 1244307456**

Start of C01 chunk 2 for LLO. After C00 was generated, we realized the kappa generation and application when the ETMY L3 ESD strength time dependent correction factor was 4 percent or more off from 1.0, so for C01 switched to the most recent measurement set, made on June 5, 2019. This is valid until Thursday, August 15 2019 18:00:00 UTC, GPS 1249927218. This is mostly a by eye observation of the time dependent value drift over time.

`^\trunk/Runs/03/L1/params/modelparams_L1_20190605.py`

To see the C00/C01 difference, look at [LLO aLOG 48928](#)

We also officially turned off the imaginary correction for C01 on this date going forward.

## 5.7 Thursday August 15 2019

**Aug 15 2019 18:00:00 UTC**

**GPS 1249927218**

Start of C01 chunk 3 for LLO. The ETMY L3 ESD strength time dependent correction factor had drifted approximately 4-5 percent off from the 20190605 model, so we pushed a new model for use in C01.

`^\trunk/Runs/03/L1/params/modelparams_L1_20190918.py`

To see the C00/C01 difference, look at [LLO aLOG 48929](#)

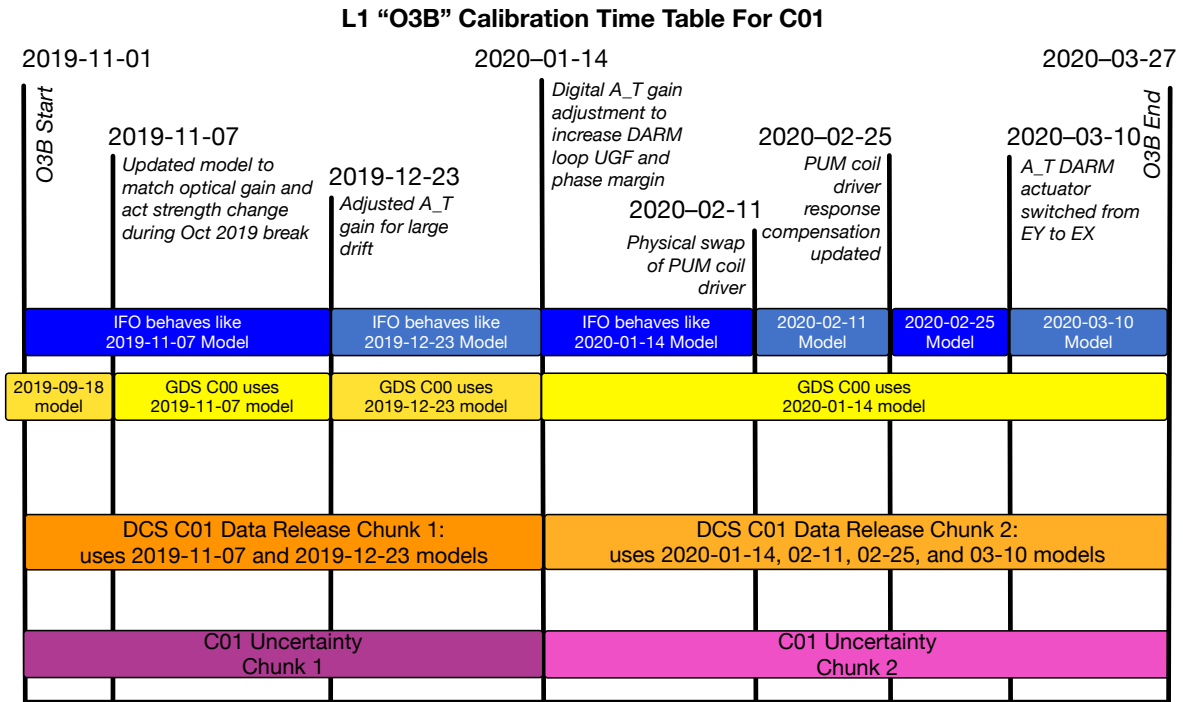
## 5.8 Tuesday September 3 2019

**Sep 03 2019 19:08:03 UTC**

**GPS 1251572901**

We realized the imaginary components were not calculating the correct time delay for the actuation, and so turned them off for C00 on this date. For C01, this effectively is turned off at GPS 1244307456. [LLO aLOG 48308](#)

## 6 O3B Time Table Graphic



**T1900253-v6**

J. Kissel, J. Betzwieser 2019-06-11

Figure 2: Time table summarizing the major events in O3B, and how they impact the final (C01) data releases.

## 7 O3B

### 7.1 Tuesday November 12 2019

**Nov 12 2019 16:00:00 UTC**

**GPS 1257609618**

After the October commissioning break, a new model was needed to match the loss of optical gain and changes in the actuator strength. See [LLO aLOG 49851](#). The model was

```
~/trunk/Runs/03/L1/params/modelparams_L1_20191107.py
```

For C01, this model should be applied to the start of O3b, Nov 01 2019 15:00 UTC or GPS 1256655618 through until Dec 23 2019 17:46 UTC or GPS 1261158378.

### 7.2 Monday December 23 2019

**Dec 23 2019 17:46 UTC**

**GPS 1261158378**

To keep the ETMY L3 ESD strength time dependent correction factor close to 1.0, to minimize overall uncertainty, we updated the calibration model again. See [LLO aLOG 50639](#).

```
~/trunk/Runs/03/L1/params/modelparams\_L1\_20191223.py
```

For C01, this model should be applied from GPS 1261158378 until GPS 1263060018.

### 7.3 Tuesday January 14 2020

**Jan 14 2020 18:00 UTC**

**GPS 1263060018**

The strength of the ETMY ESD actuator had drifted weaker over the course of the O3 run. In combination with the loss of optical gain after the October commissioning break had lead to the reduction in the DARM OLG UGF frequency and phase margin. See [LLO aLOG 50900](#). In addition, the calibration had become more sensitive to small changes in the ETMY ESD/ETMX PUM. A 1% increase in the ETMY ESD actuation would result in almost a 7% increase in the actuation. So to compensate, we increased the digital gain on the ETMY ESD path by a factor of 1.3. This required a new calibration model:

```
~/trunk/Runs/03/L1/params/modelparams_L1_20200114.py
```

For C01, this model should be applied starting at GPS 1263060018.

## 7.4 Tuesday February 11 2020

**Feb 11 2020 16:00 UTC**  
**GPS 1265472018**

The ETMX PUM coil driver was swapped, but without updating the digital compensation. Live calibration was not updated either, although the expected differences are expected to be small. See LLO alogs [51564](#) and [51729](#). The C01 calibration model to be used during this period, from GPS 1265472018 to GPS 1266685218, is

```
~/trunk/Runs/03/L1/params/modelparams_L1_20200211.py
```

## 7.5 Tuesday February 25 2020

**Feb 25 2020 17:00 UTC**  
**GPS 1266685218**

The ETMX PUM coil driver fitted poles and zeros were pushed to the front end, which eliminates the need to correct for it in the calibration pipeline, as we assume they are close enough to cancel. See LLO alogs [51729](#) and [51823](#). The C01 calibration model to be used during this period, from GPS 1266685218 until GPS 1267891218 is

```
~/trunk/Runs/03/L1/params/modelparams_L1_20200225.py
```

## 7.6 Tuesday March 10 2020

**Mar 10 2020 16:00 UTC**  
**GPS 1267891218**

LLO switch from using ETMX L1, L2 and ETMY L3, to using ETMX L1, L2 and L3 for DARM feedback. This is a fairly major change, and required an updated to which suspension calibration line to use (i.e. from the ETMY L3 line to the ETMX L3 line). See LLO alog [52080](#). The C01 calibration model to use during this period to the end of O3b is

```
~/trunk/Runs/03/L1/params/modelparams_L1_20200310.py
```

## 7.7 Friday March 27 2020

**Mar 27 2020 17:00 UTC**  
**1269363618**  
Official end of O3B.