



Locking of Central Interferometer of Advanced Virgo+

GWADW 2021 Gravitational Wave Detector Workshop

17th May, 21

Priyanka Giri

On behalf of Virgo Collaboration

Outline

- Introduction
- PRMI and DRMI configurations.
- Working point and trigger logic
- 1f error signals
- CITF without TCS
- CITF locked
- Hand off to 3f signals.
- DRMI and CARM offset.

Introduction

Addition of Signal recycling mirror (SRM) for Advanced Virgo+ in O4. Hence, we need to control 5 longitudinal DOFs.

$$DARM = \frac{L_N - L_W}{2}$$

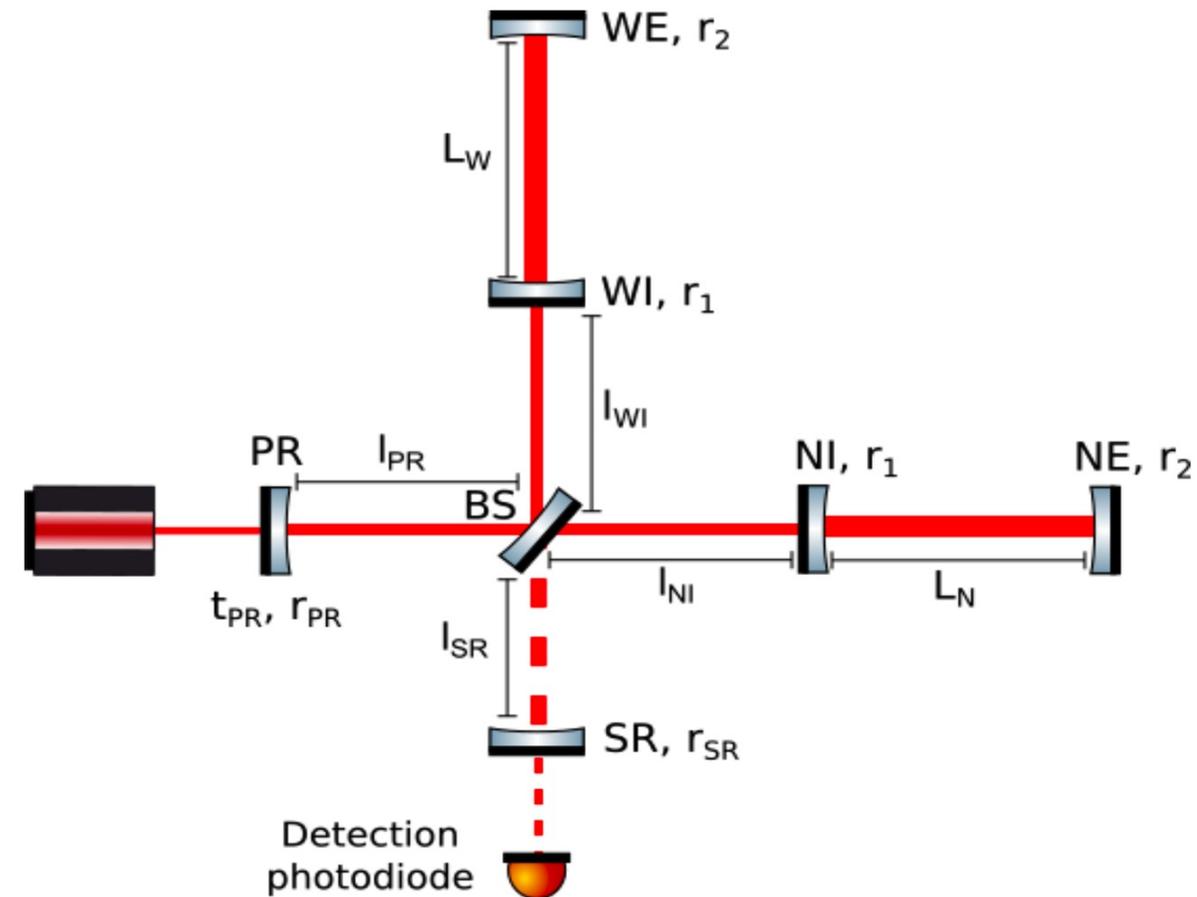
$$CARM = \frac{L_N + L_W}{2}$$

$$MICH = l_{NI} - l_{WI}$$

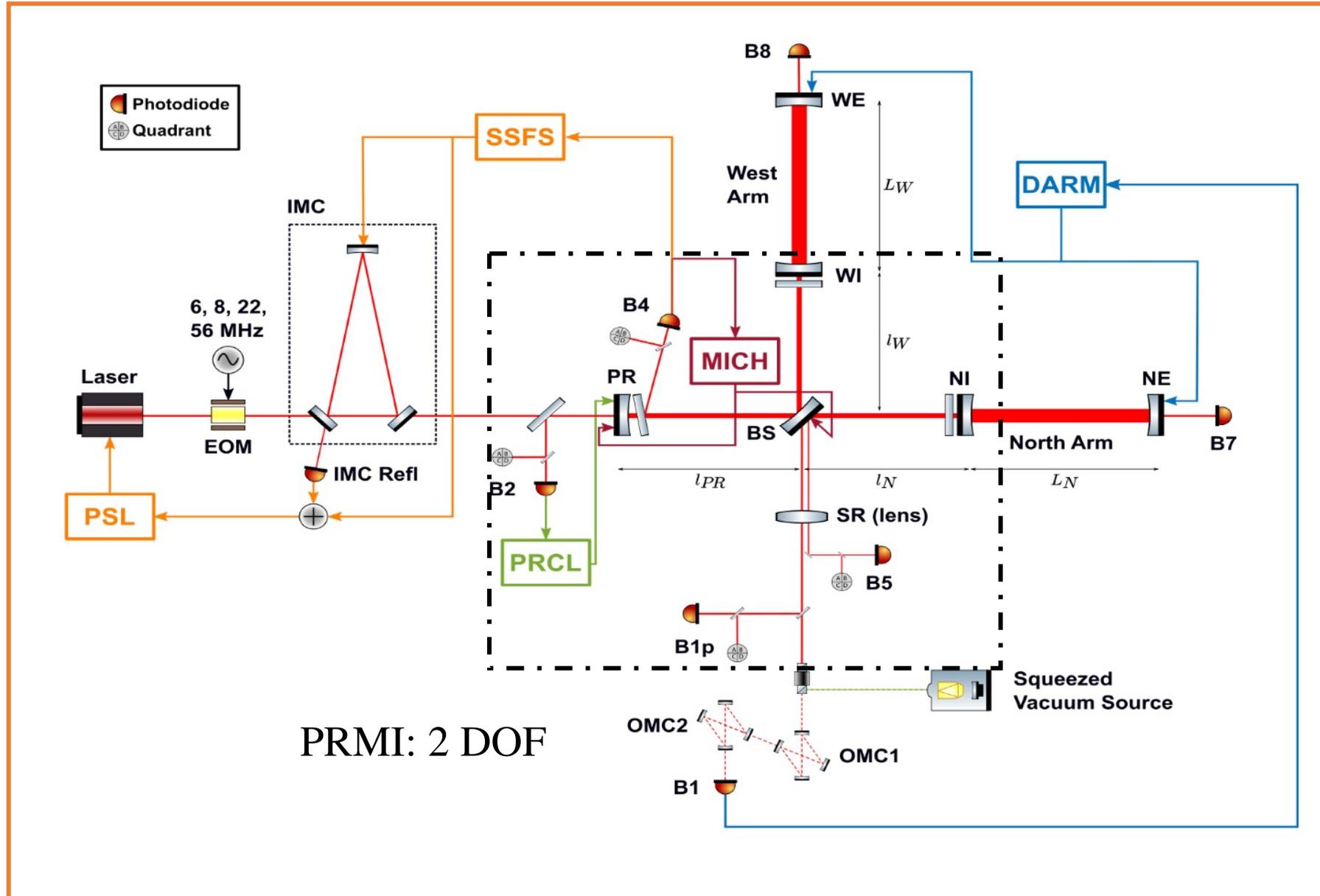
$$PRCL = l_{PR} + \frac{l_{NI} + l_{WI}}{2}$$

$$SRCL = l_{SR} + \frac{l_{NI} + l_{WI}}{2}$$

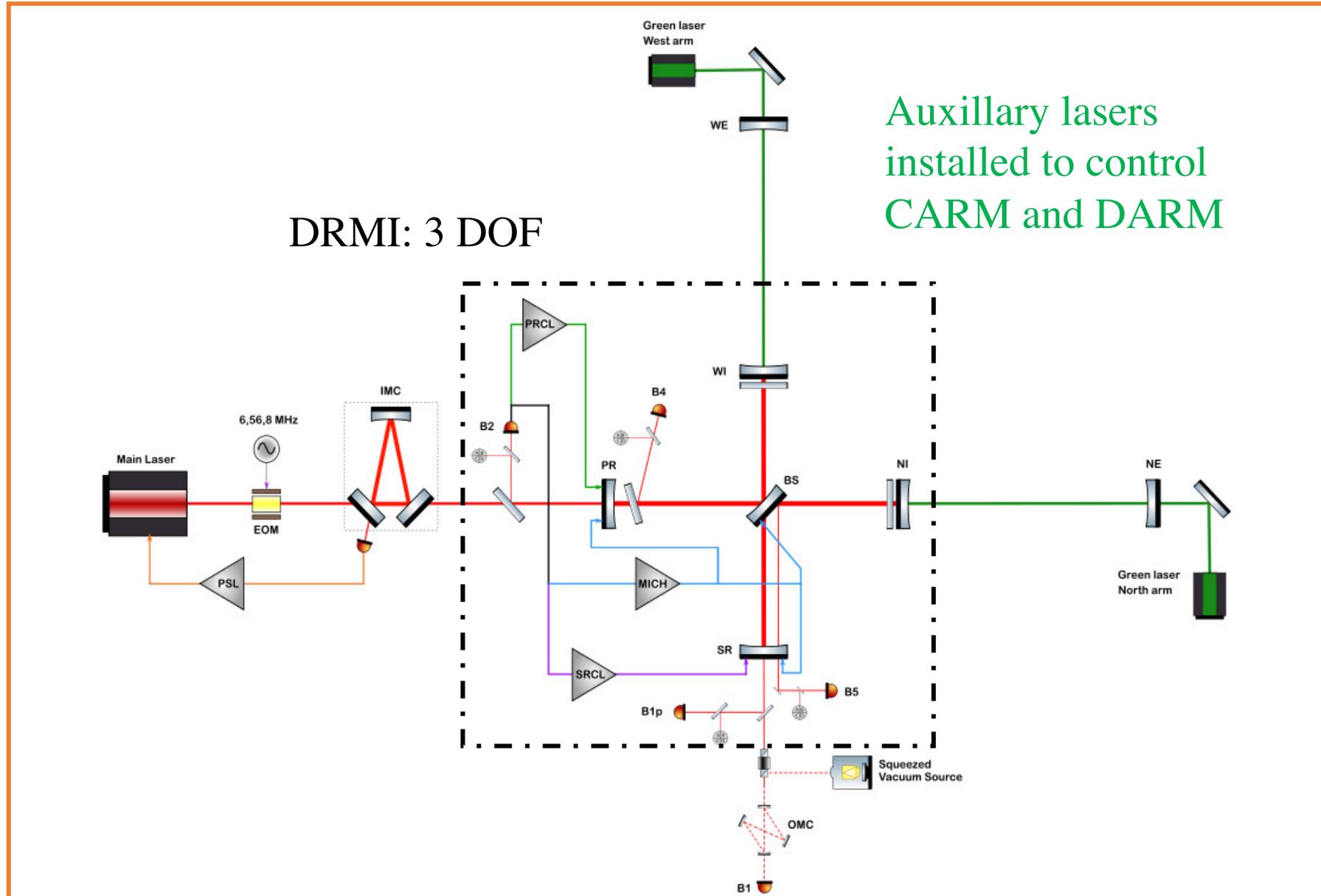
DRMI



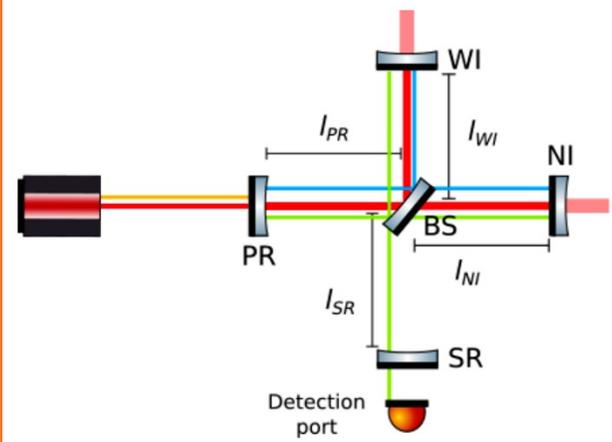
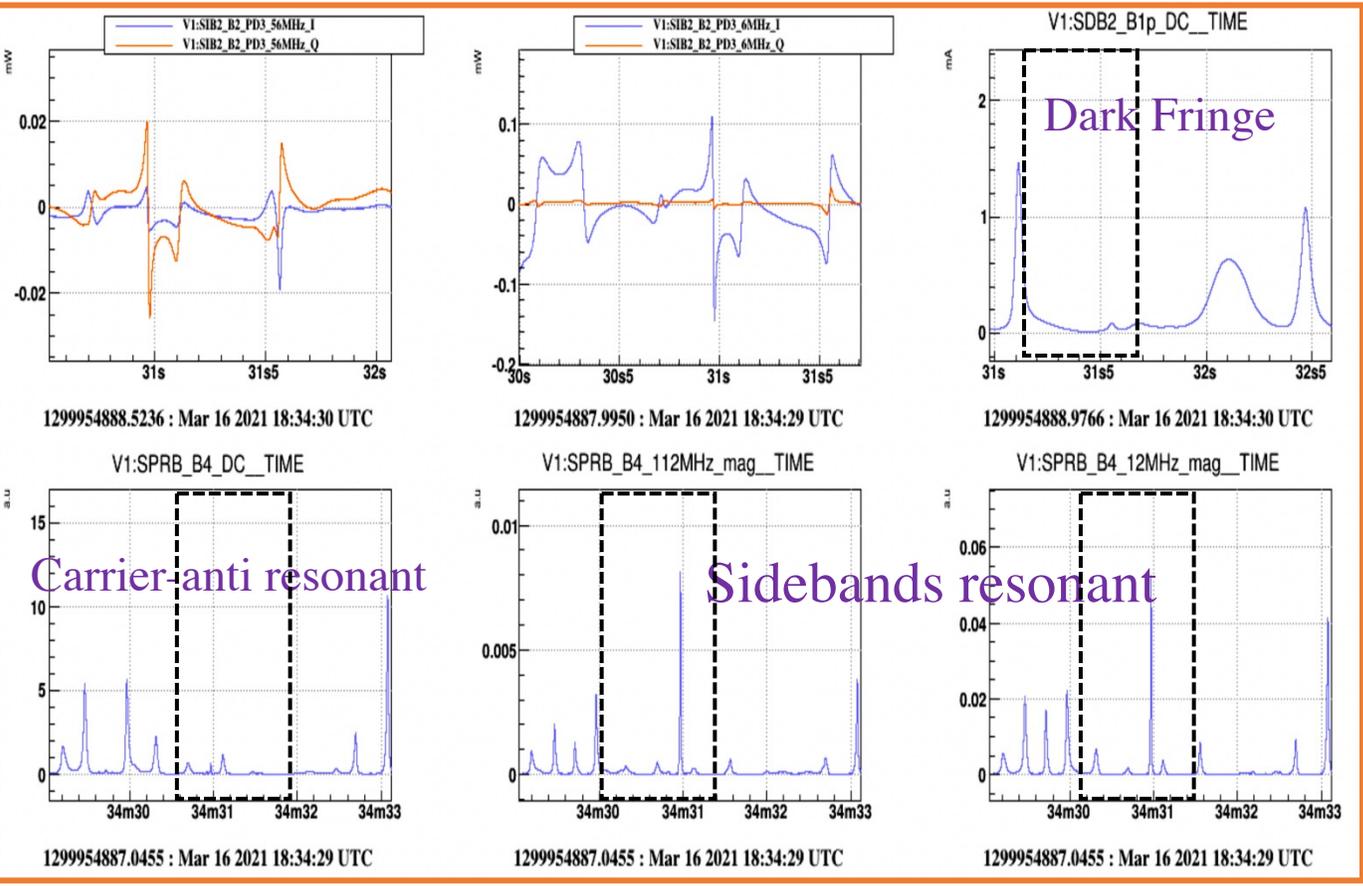
PRMI Controls' Scheme in O3



DRMI Controls' Scheme in O4



Working Point

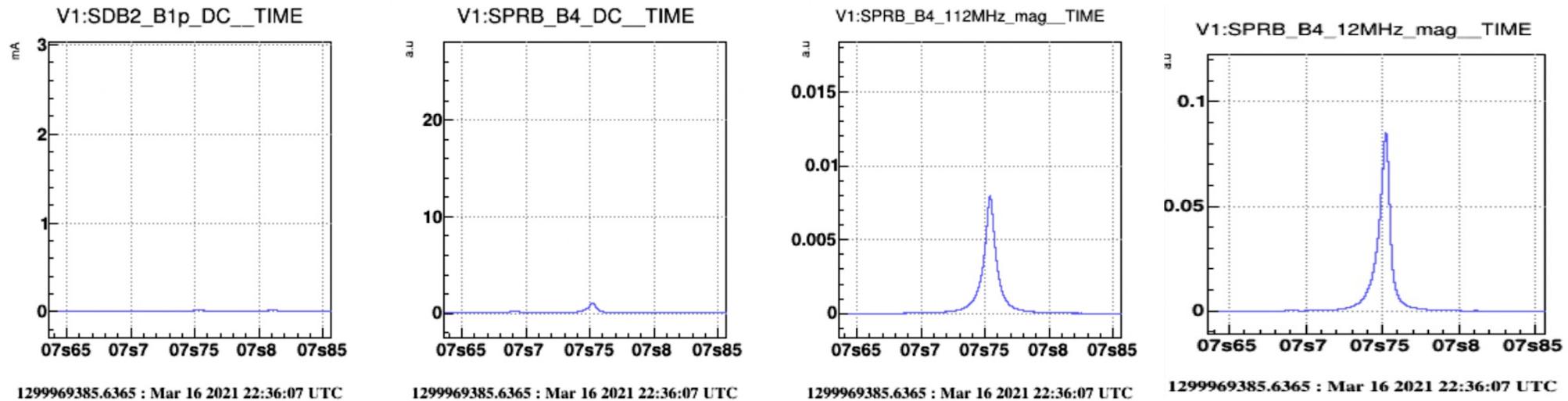
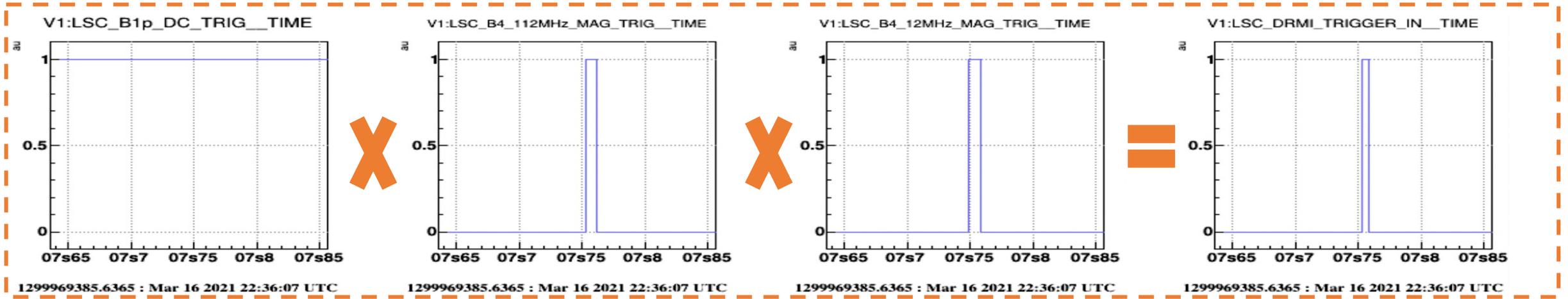


Carrier: resonant on the **PRC** and the **arms** and anti-resonant on the **SRC**
6 MHz: resonant on the **PRC** and anti-resonant on the **SRC** and the **arms**
56 MHz: resonant on the **PRC** and the **SRC** and anti-resonant on the **arms**
8 MHz: anti-resonant on the **PRC**

MICH in dark fringe (DF)
 PRCL in resonance for 6 and 56 MHz sidebands
 SRCL in resonance for 56MHz sideband
 Carrier anti-resonant in PRC.

Trigger Logic

Sufficient flashes are checked for B4 photodiode which is located at the pickoff of PR



Trigger logic is also implemented for B4-DC photodiode

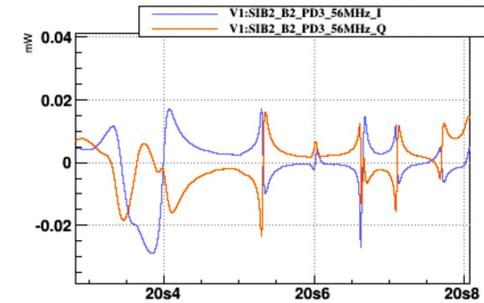
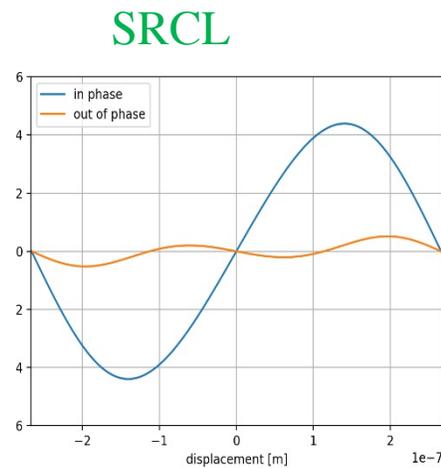
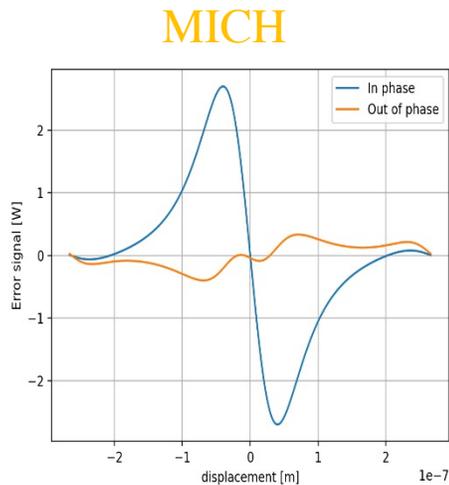
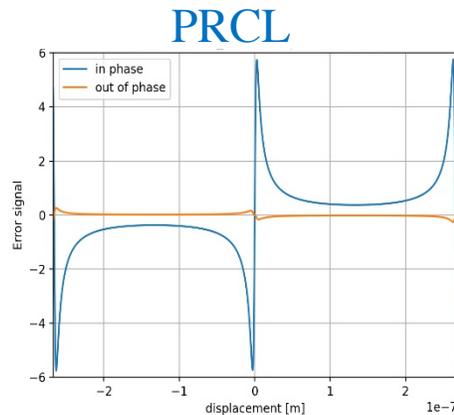
Error Signals

PDH (Pound-Drever-Hall) 1f error signals chosen for CITF lock:

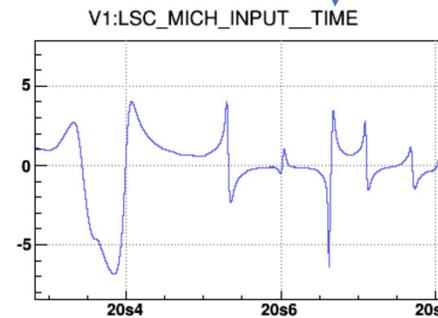
Simulations for Ideal CITF

DATA

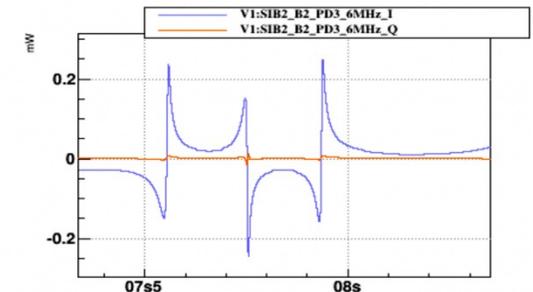
B2 6MHz I ► PRCL
B2 56MHz I ► MICH
B2 56MHz Q Normalized ► SRCL
(B2_56MHz_Q / B4_112MHz_MAG_sqrt)



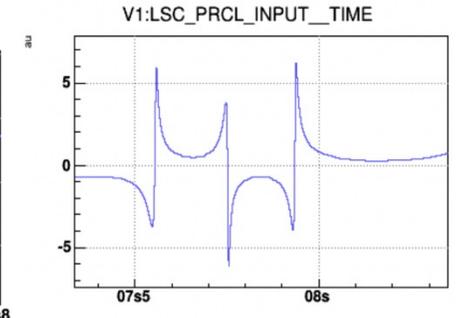
1299867098.2815 : Mar 15 2021 18:11:20 UTC



1299867098.2815 : Mar 15 2021 18:11:20 UTC



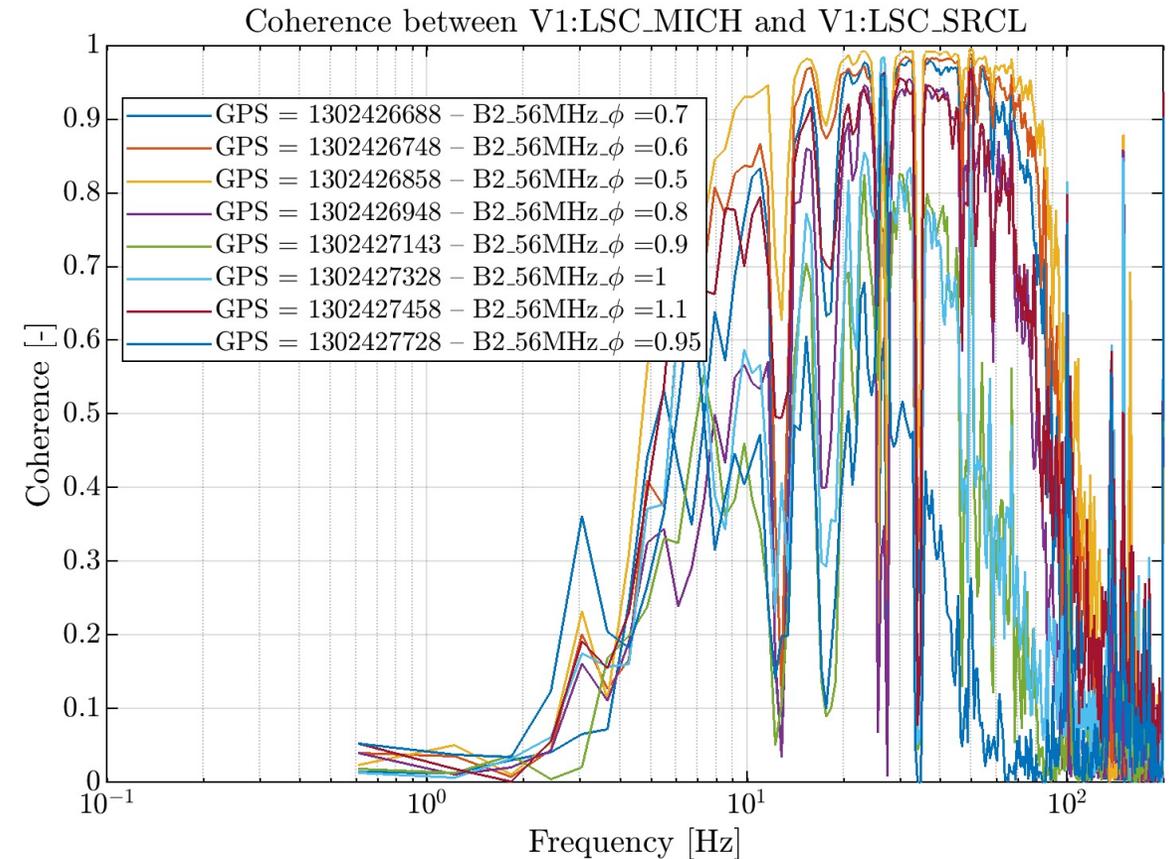
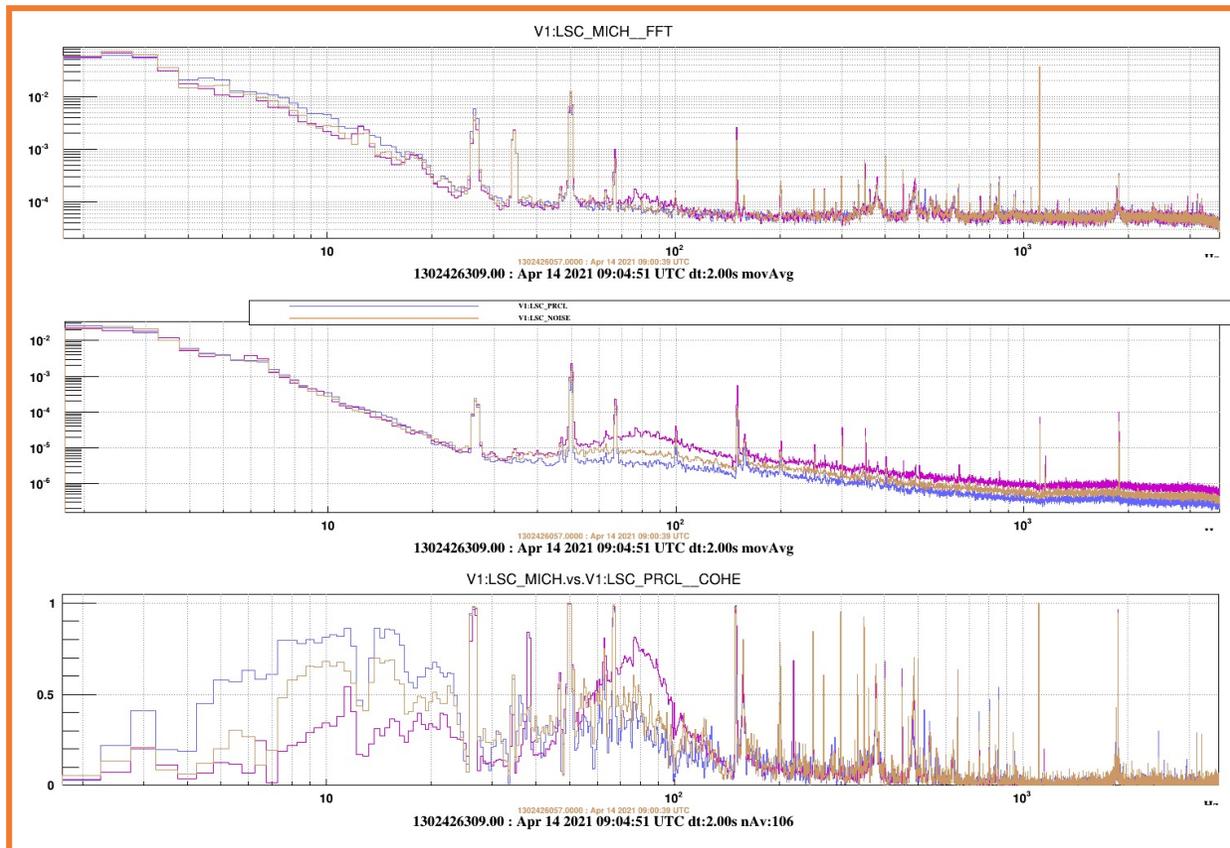
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Decoupling of Longitudinal DOFs

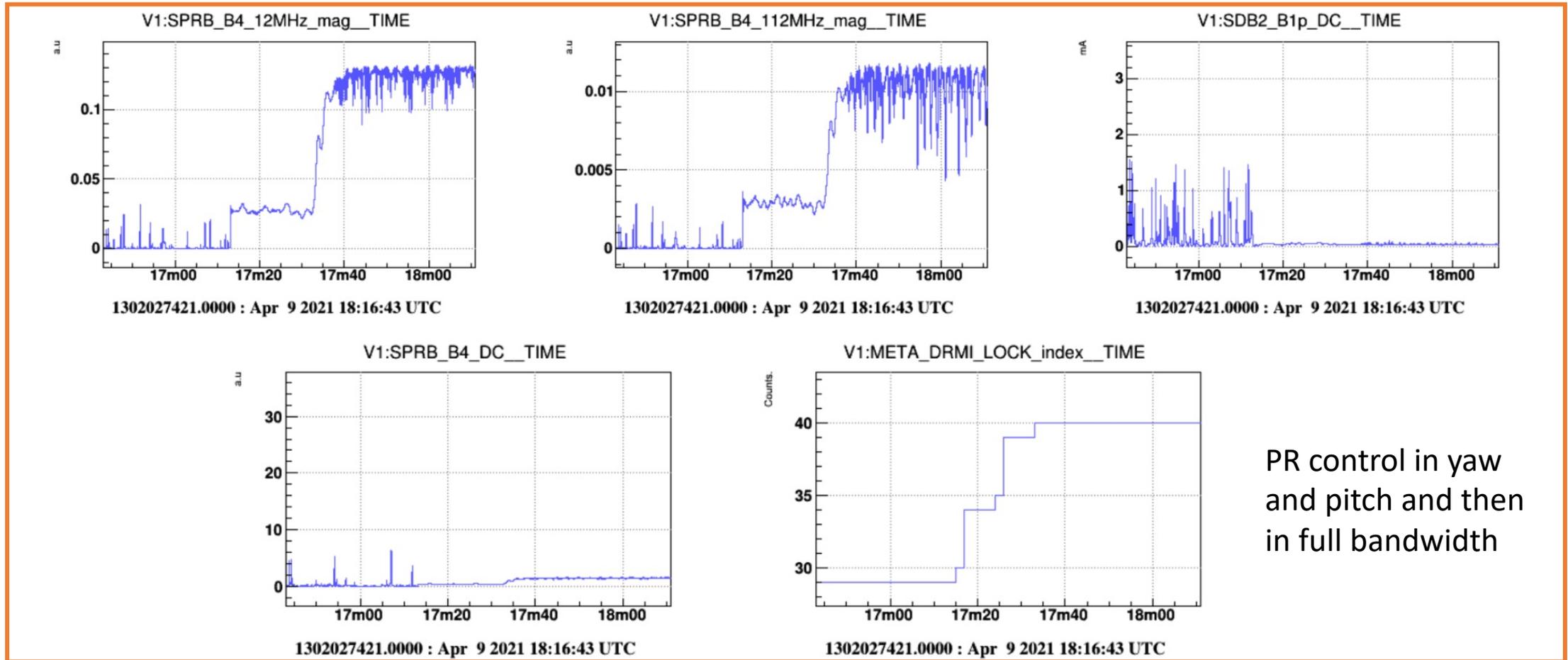
PRCL gains were optimized to decouple MICH and PRCL
Demodulation phases were optimized to decouple MICH and SRCL



Logbook entry no. -[51420](#)

PR Angular Control

PR angular controls were implemented to maximize the power on the sidebands



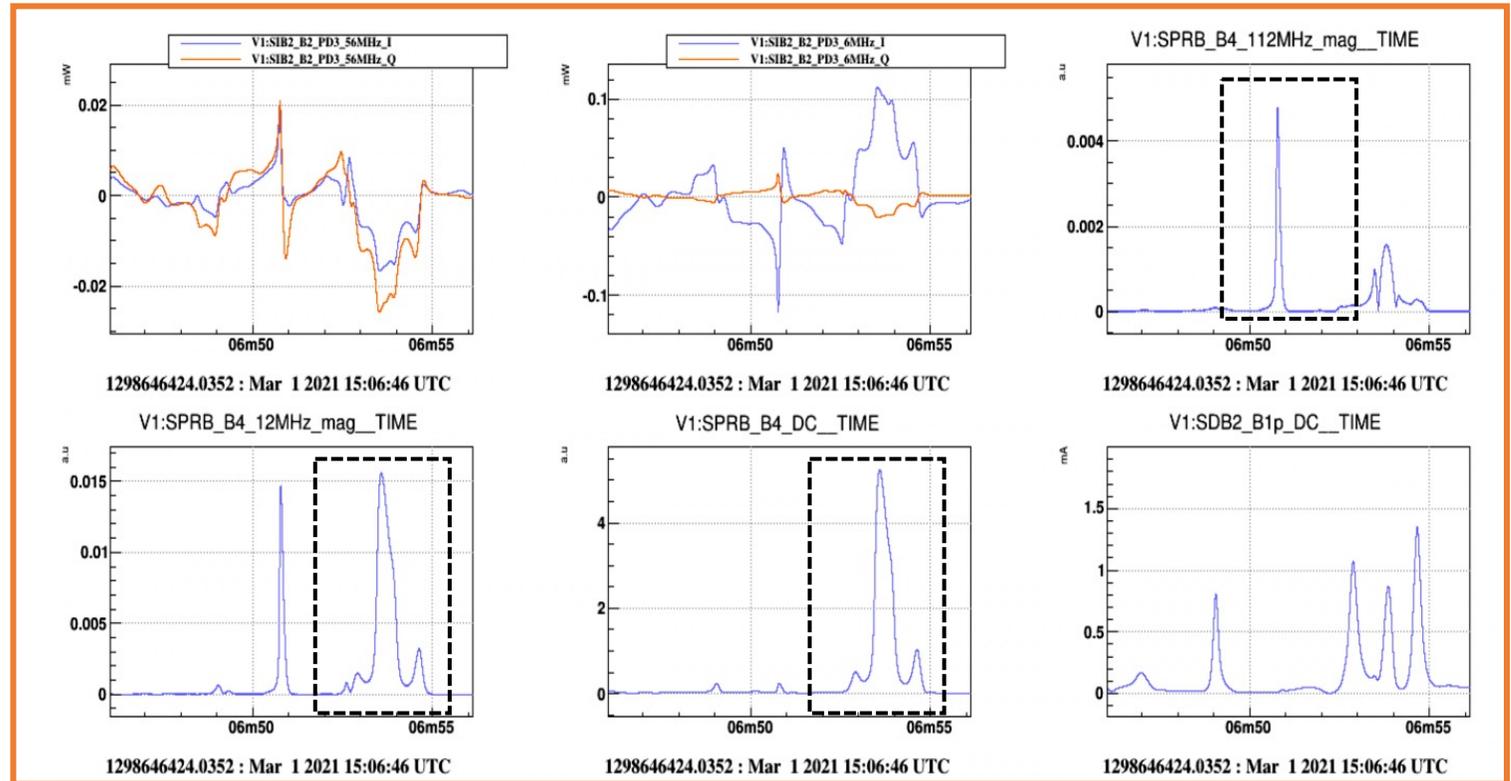
PR control in yaw and pitch and then in full bandwidth

CITF locking Without TCS

Due to the cold abbreviations present in the Advanced Virgo (because of two marginally stable cavities, PRC and SRC, in the CITF), error signals were not reliable.

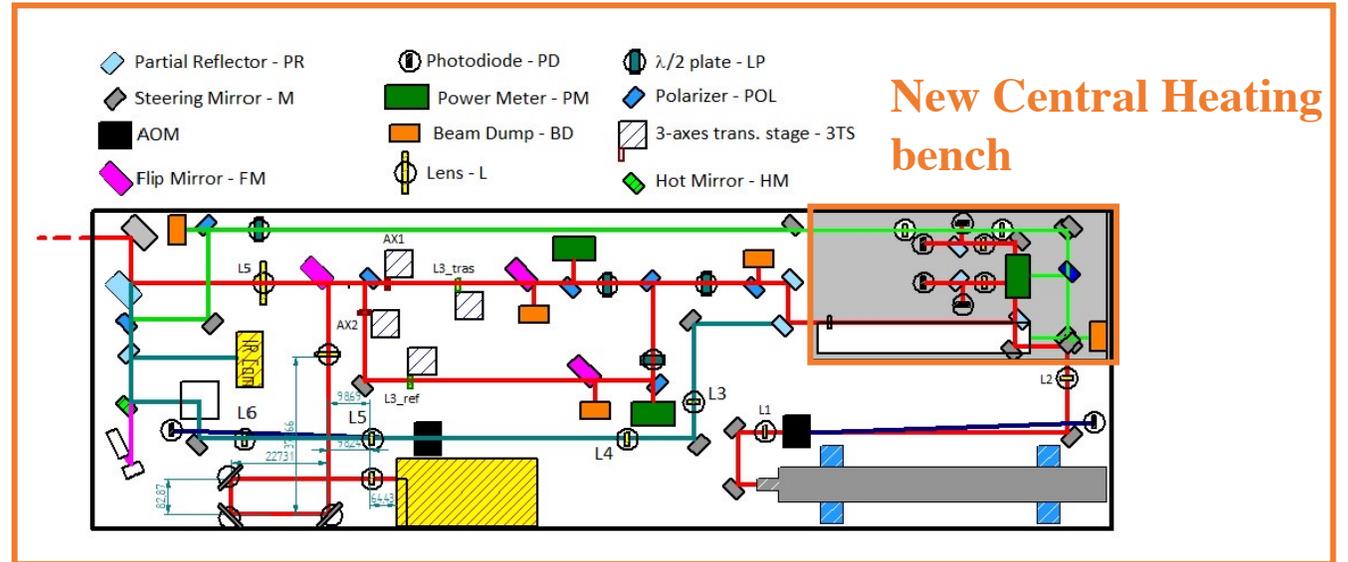
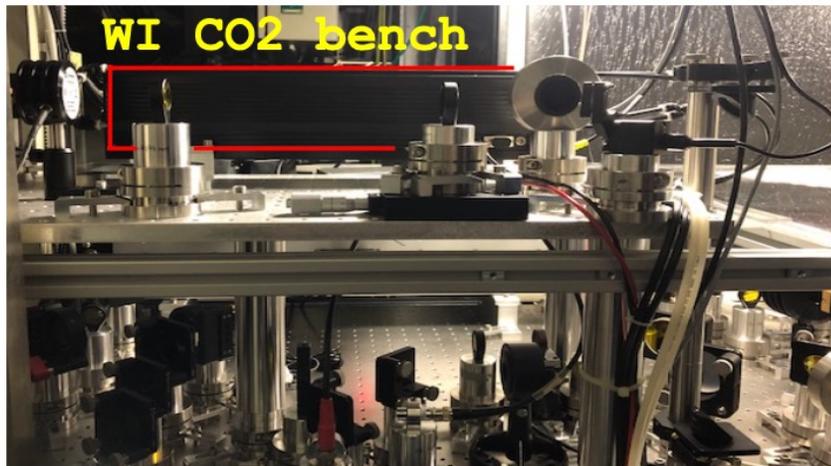
No zero-crossing PDH error signal

Low power on sidebands



TCS New Benches

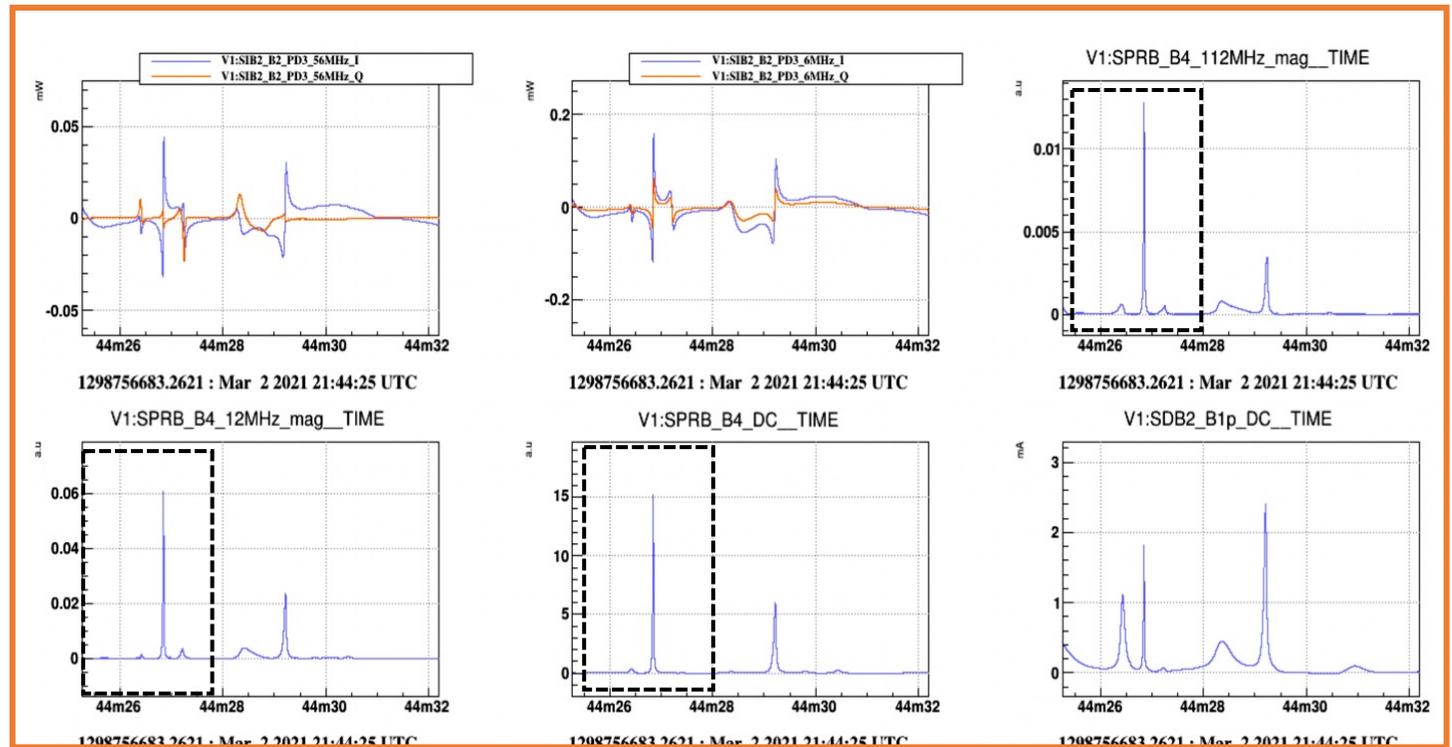
New central heating (CH) benches were installed to compensate the (cold) optical aberrations for both input mirrors to achieve the beam size 50mm (same as IR).



TCS Tuning

Central Heating was switched on 2nd March, 21 to improve quality and optical gain of the error signals for PRC and SRC for the CITF/DRMI lock (Logbook entry no.- [50951](#)).

Zero-crossing PDH error signal

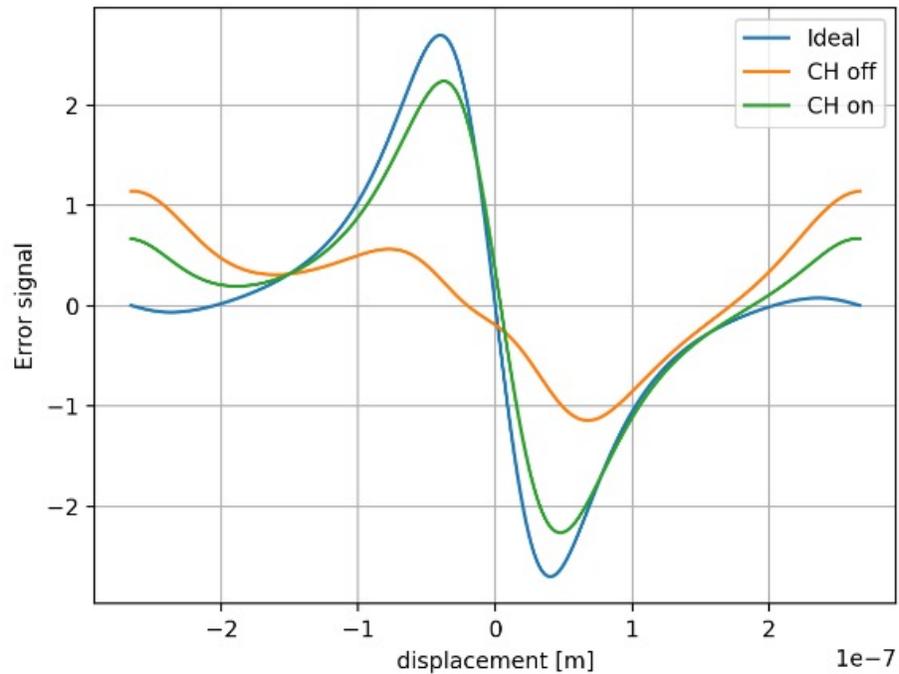


Significant power on sidebands

Central Heating Effect

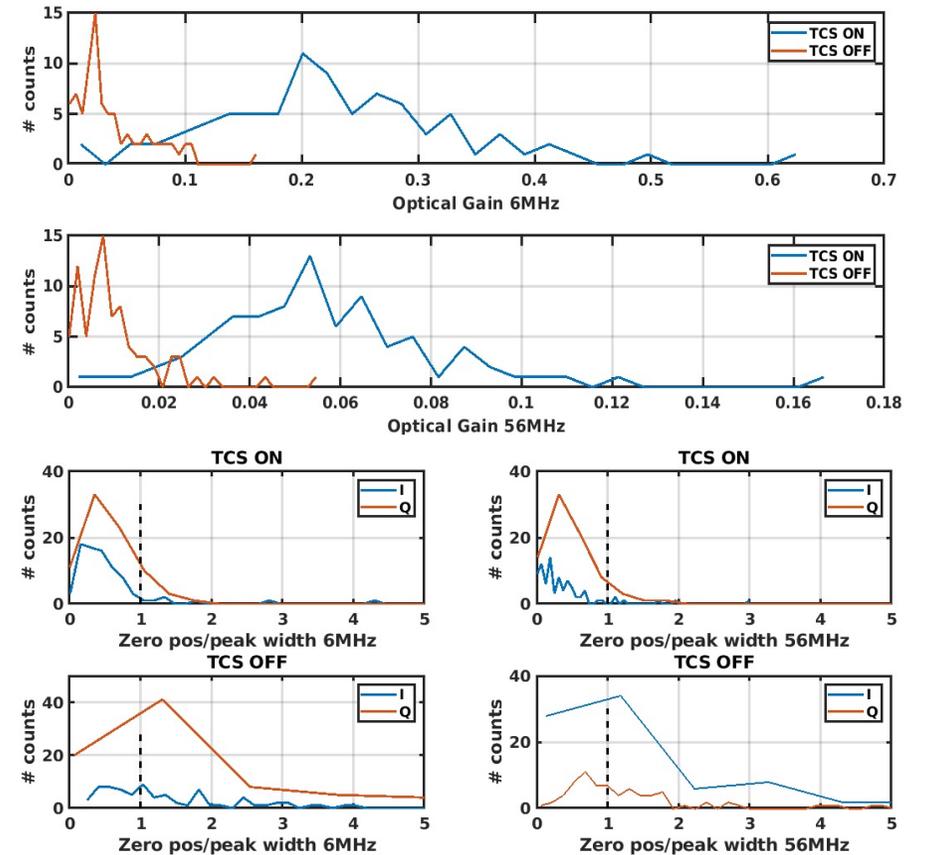
Improvement in the Optical gains were observed in PRCL and MICH when Central Heating was turned on while demodulation phases were unchanged.

Simulations



MICH

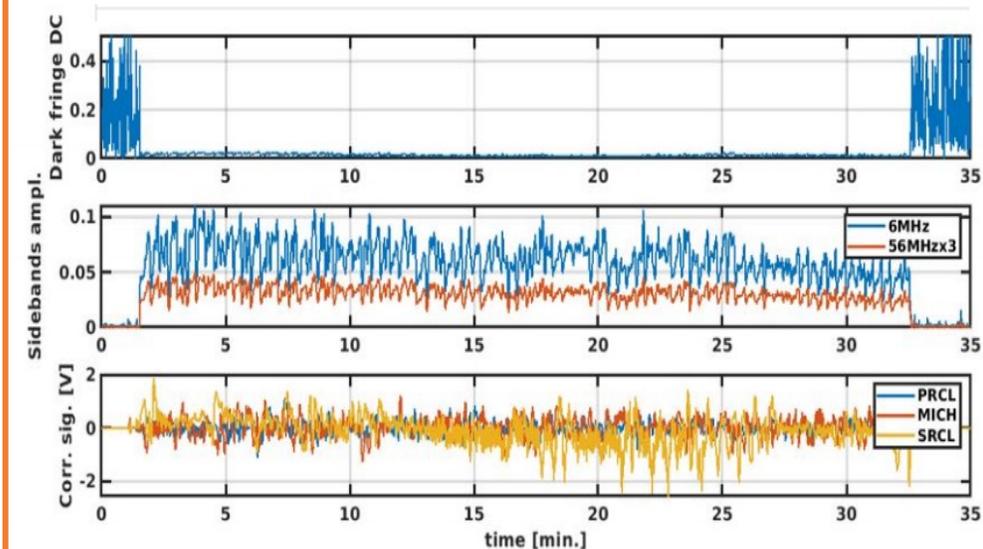
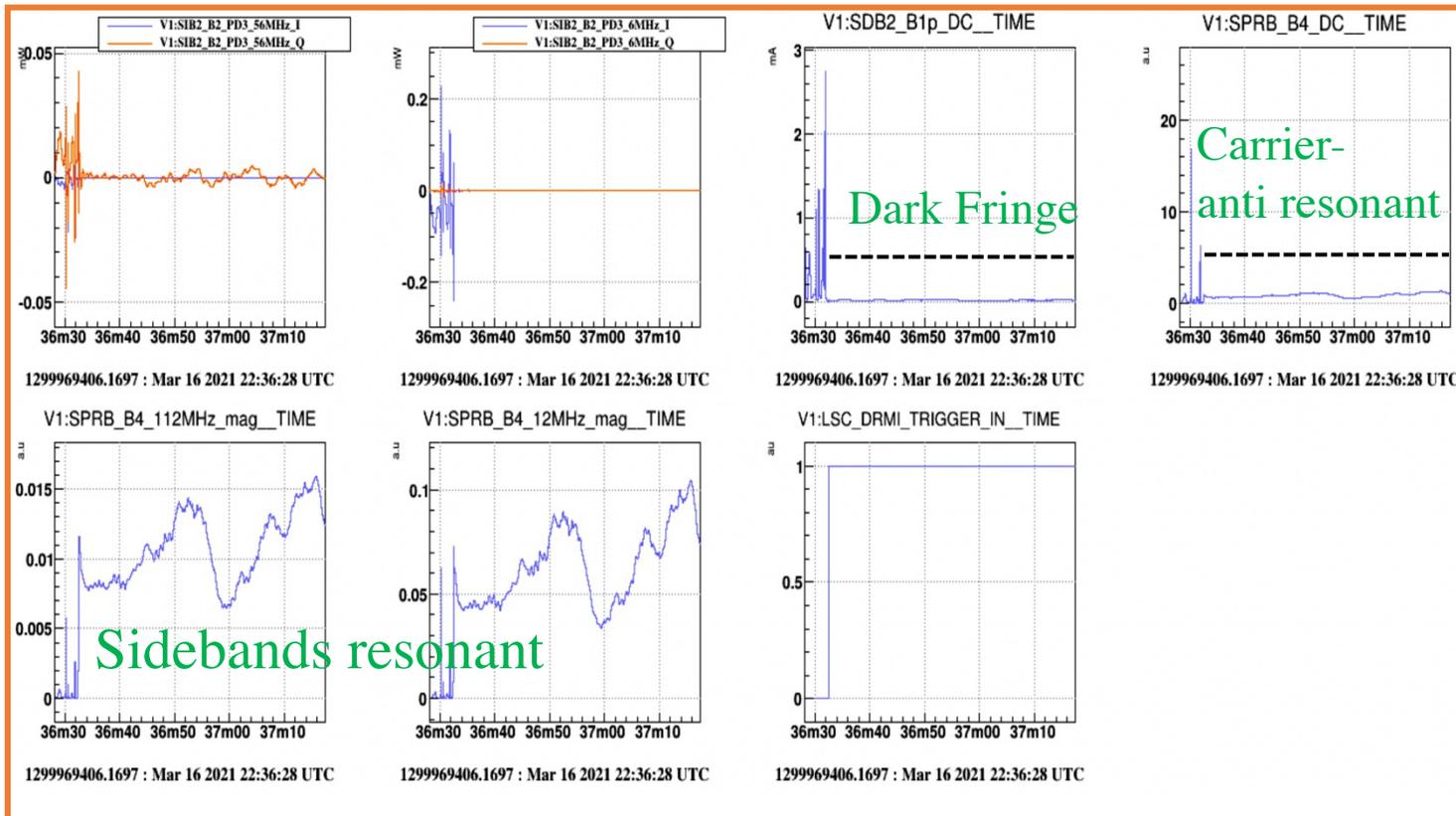
Analysis



M.Mantovani

CITF Lock

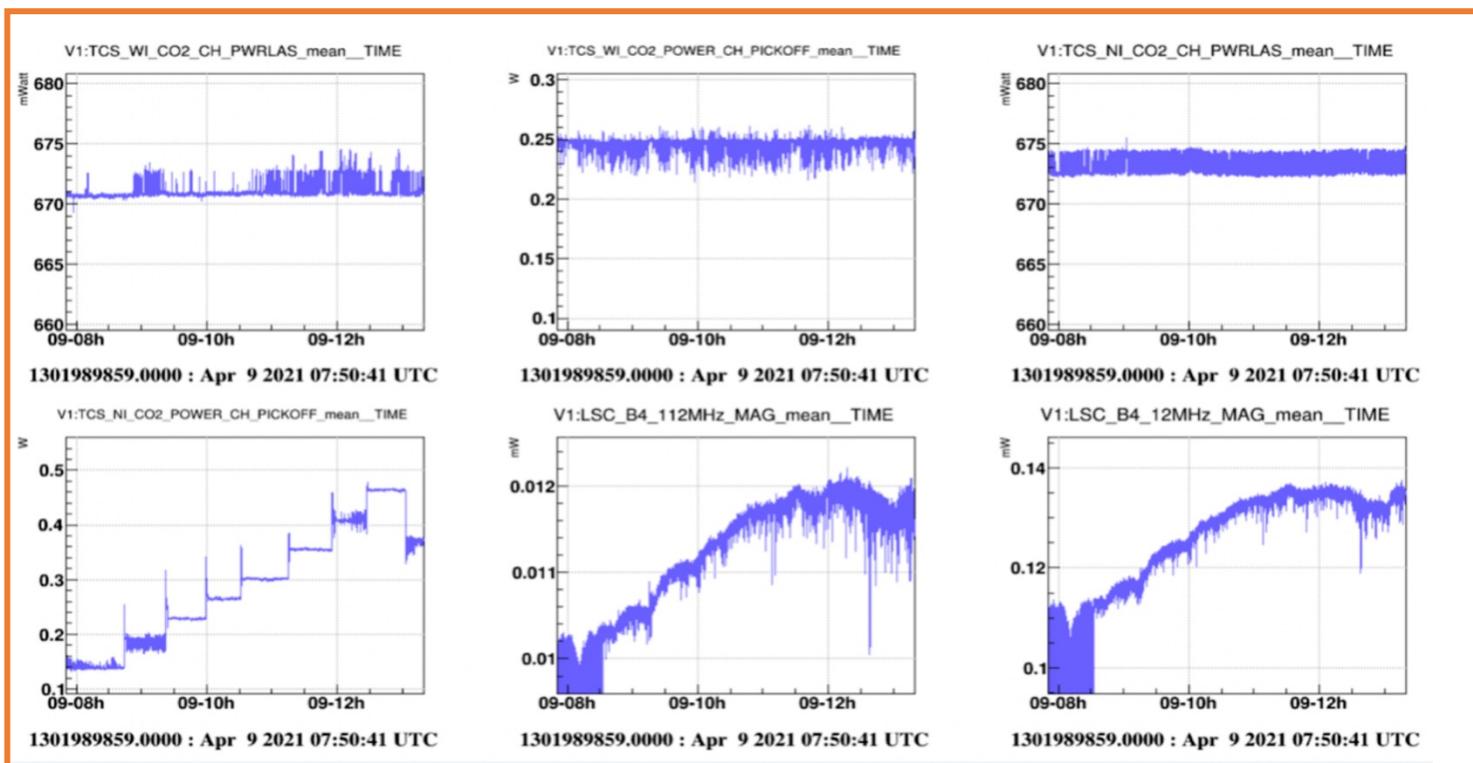
First robust DRMI lock was achieved on 16th March, 21 (Logbook entry no.-[51118](#)) with marginally stable cavities and was stable for ~ 30 mins.



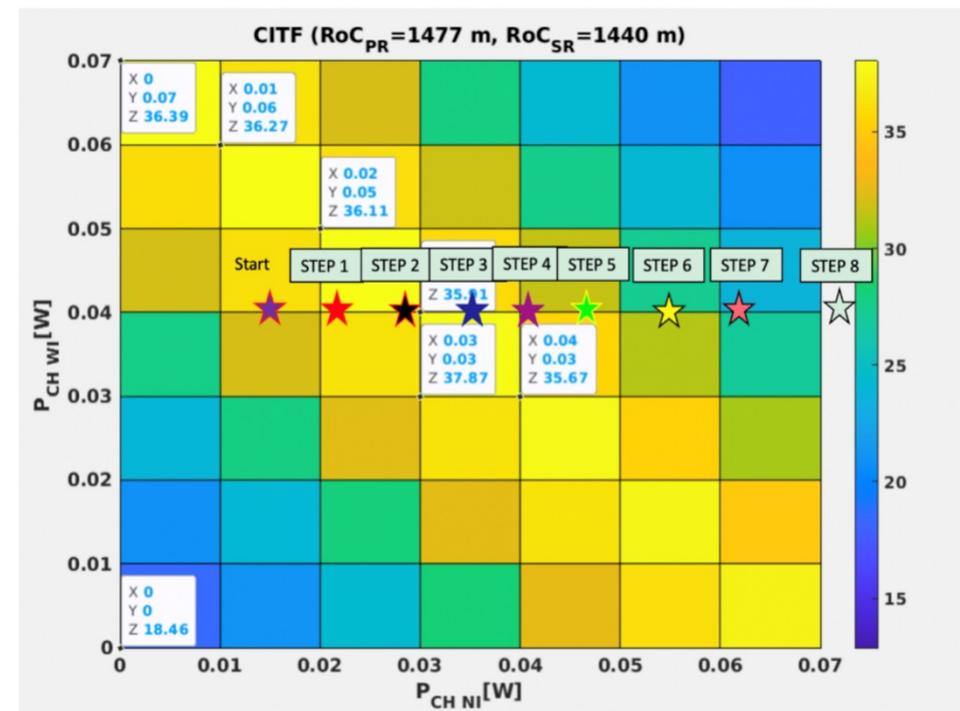
Optimize Power in Sidebands

To further improve the power in sidebands to robust the lock of DRMI, NI CH was tuned and gains were adjusted to have almost constant UGF. (Logbook Entry no-[51373](#)).

Data



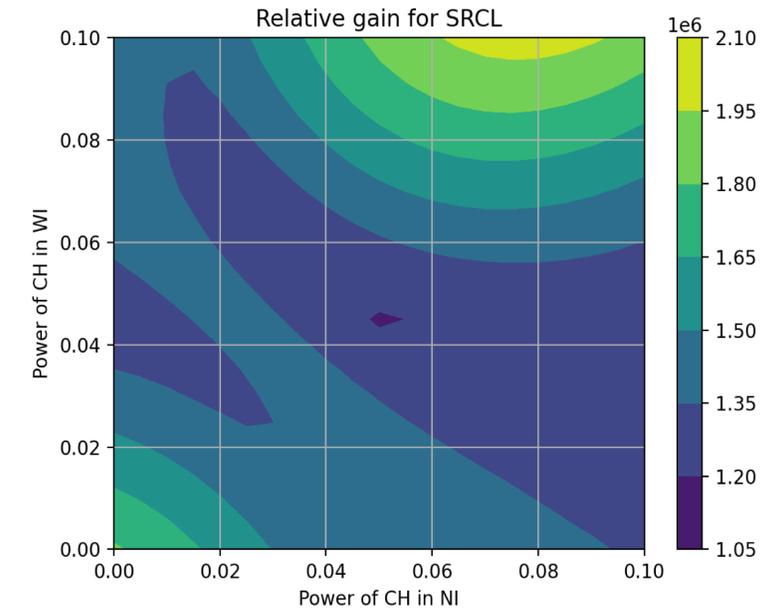
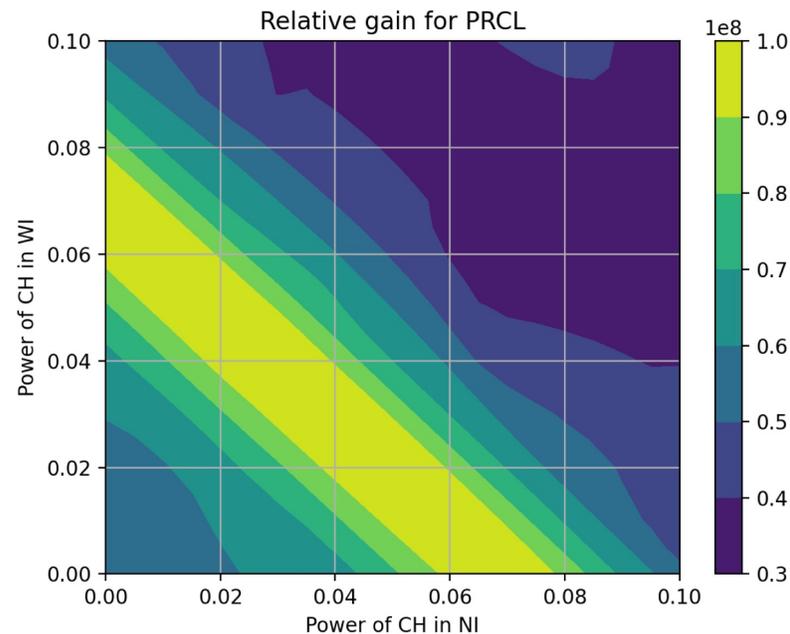
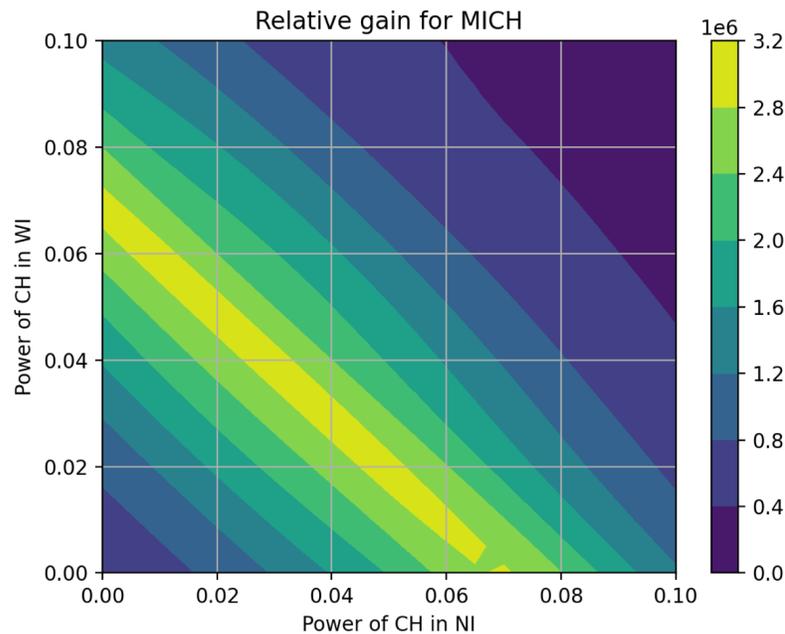
Simulations



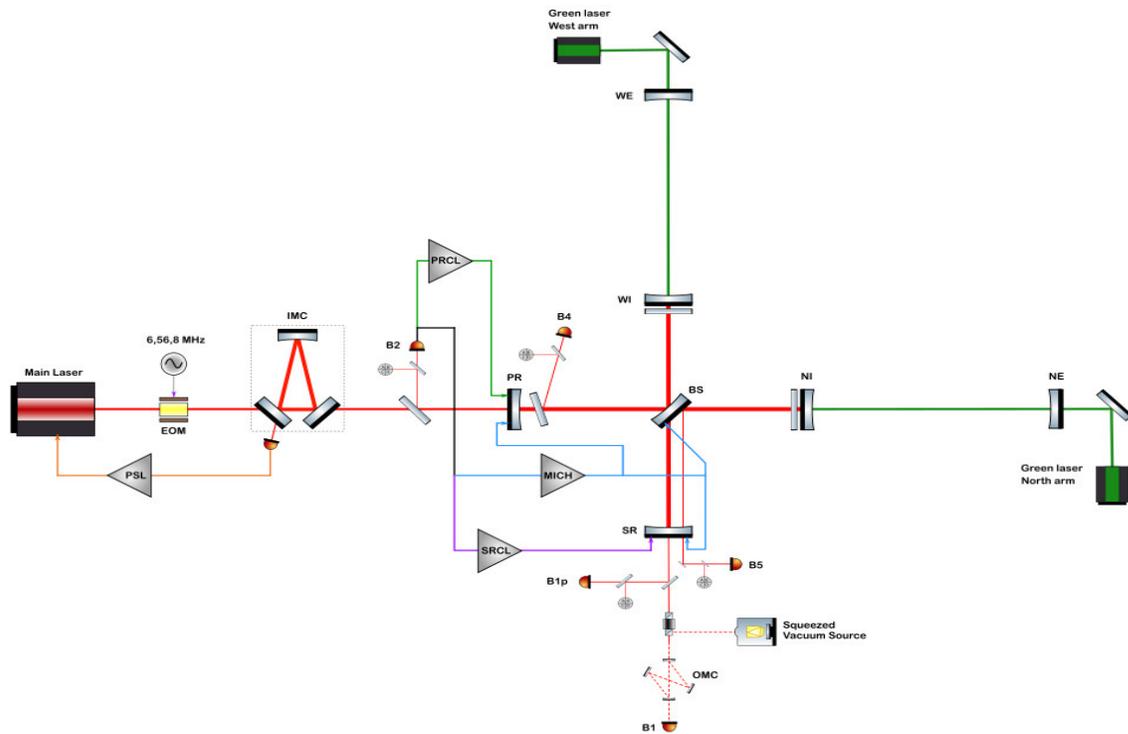
I. Nardecchia

Maximize Optical Gains

Preliminary results while maximizing optical gain for MICH, PRCL, and SRCL with Central Heating power.



Control of Full Interferometer

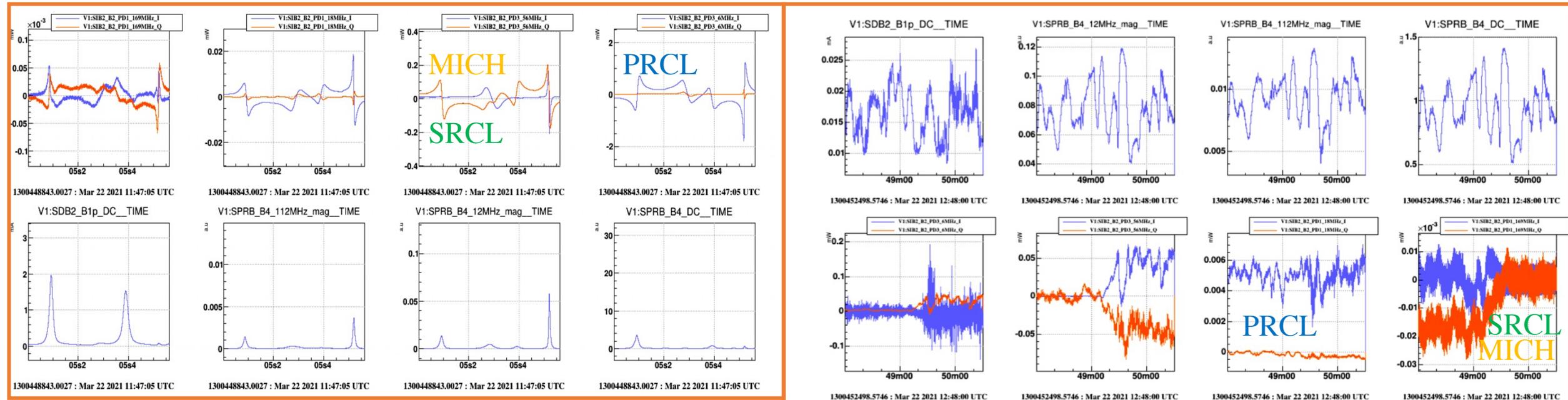


- Locking full ITF requires control over all 5 DOFs simultaneously → CARM offset reduction
- Since we are far from IR resonance, we use the beating signal for the auxiliary beam while keeping DRMI locked.

DRMI Hand off to 3f

For controlling DARM, and CARM with DRMI, 3f error signals are chosen for locking the DRMI instead of 1f as they are insensitive to CARM offset reductions.

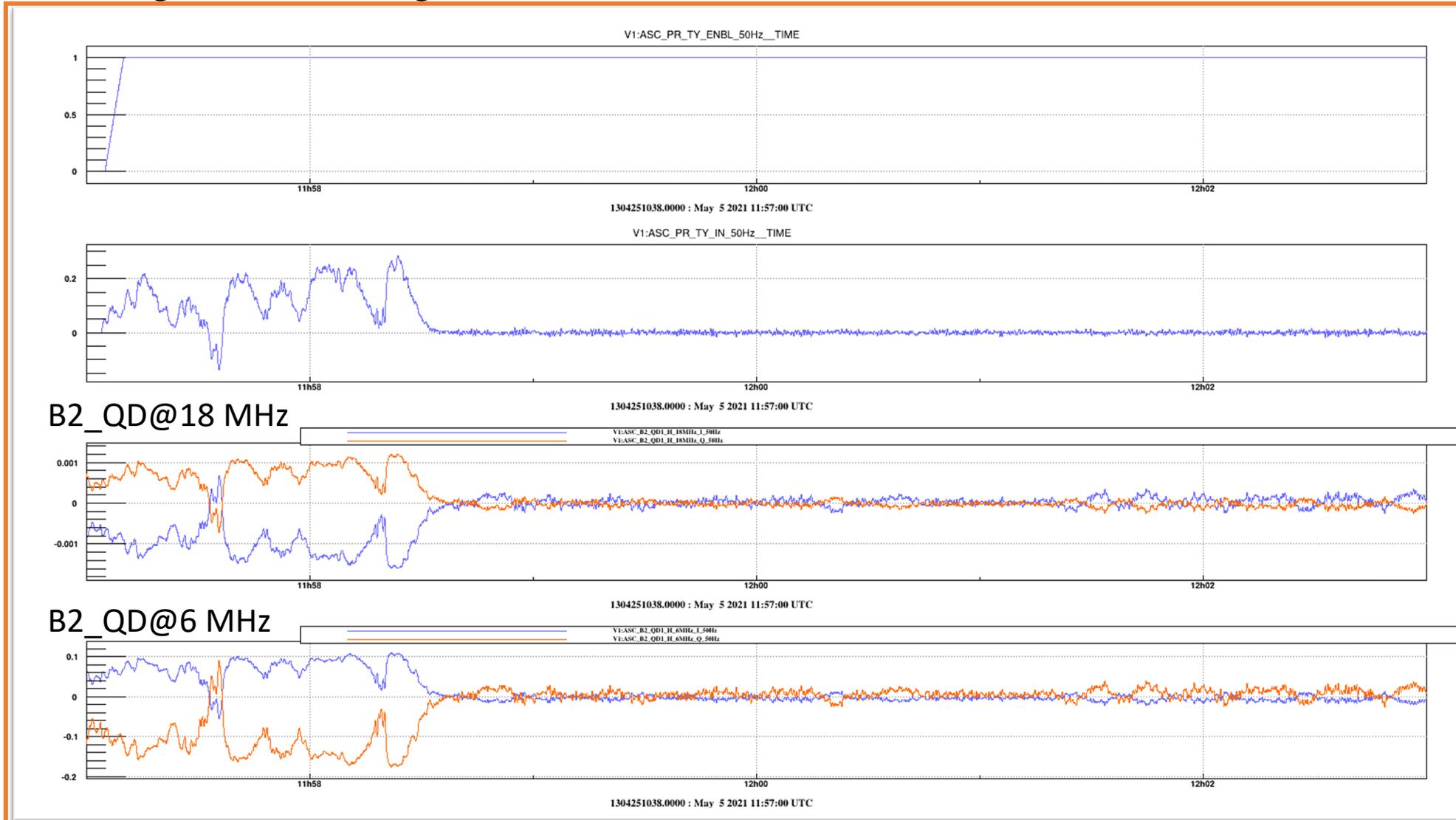
PRCL : 6MHz I → 18MHz I
MICH : 56MHz I → 169MHz I
SRCL : 56MHz Q Normalized → 169MHz Q



Logbook entry no.- [51170](#)

PR Hand off to 3f

PR angular control signals were also handed off to 3f for the CARM offset reduction.



Logbook entry
no.- [51669](#)

Future Work

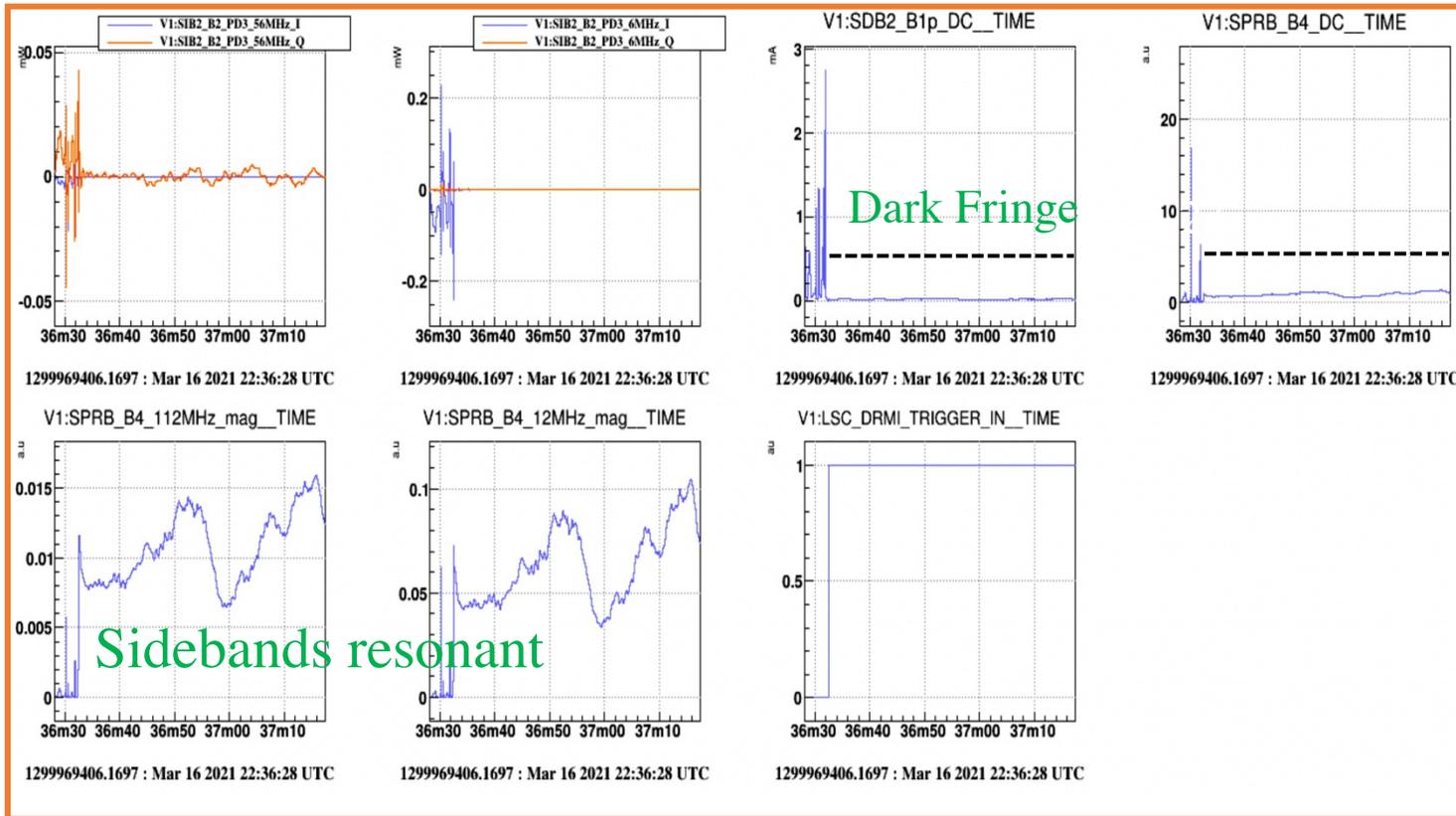
- Improve robustness for DRMI when arms are locked on green beam.
- Tuning of the compensation for the two input mirrors.
- DRMI and CARM offset reduction close to 7Hz.
- Hand off Longitudinal DOFs to its final steady state signals.

THANK YOU!

Summary



DRMI lock with marginally stable cavities



Effect of Central Heating

