



# Laser & Injection system (ISYS) status

Virgo week January 2018

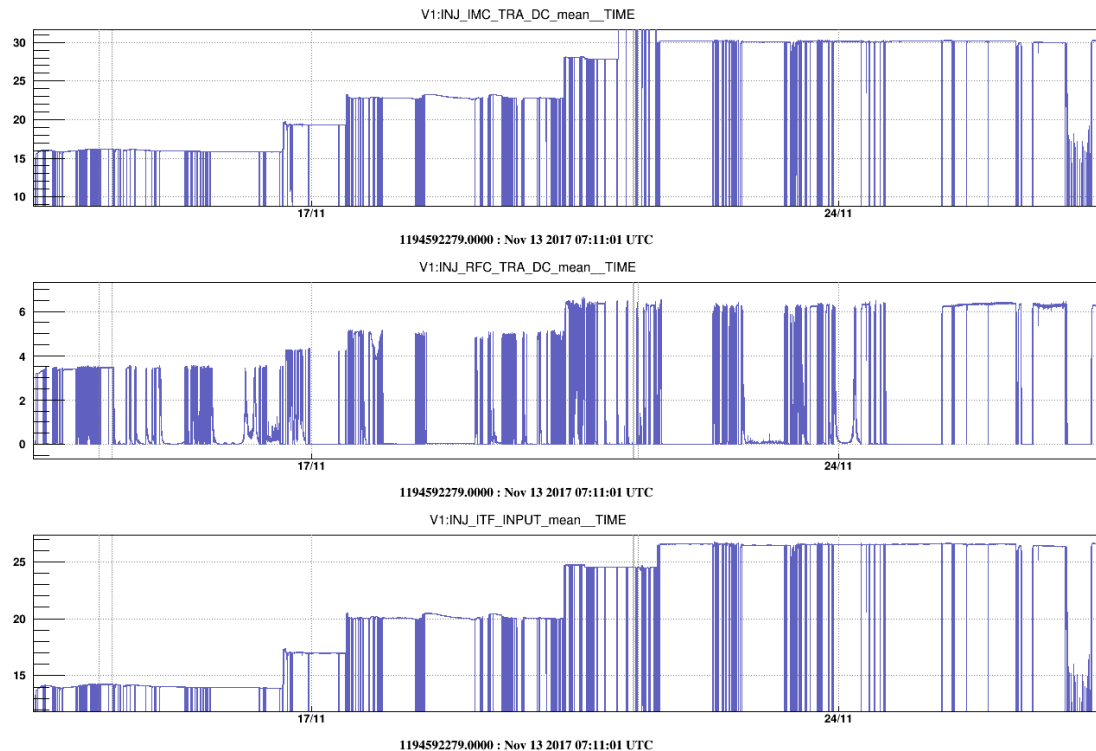
E. Genin, F. Cleva, F. Kéfélian, G. Pillant, J.P. Coulon, C. De Rossi, A. Chiummo, J. Casanueva  
on behalf of the ISYS group



- ❑ Activities around INJ and PSL (ISYS) since Last Virgo week (November 2017)
  - ❑ ITF input power increase
  - ❑ Laser bench upgrade and ISYS commissioning
  - ❑ Next steps: SIB1 IPC upgrade, beam jitter studies, Power stabilization in-vacuum electronics

- The ITF input power has been increased in 3 steps (from 14 to 17W (entry #40056), 17 to 20W (entry #40070) and from 20W to 26.5W).

→ it was quite straightforward. We had just to measure again the IMC AA sensing matrix. The ITF was locked without the need of TCS.

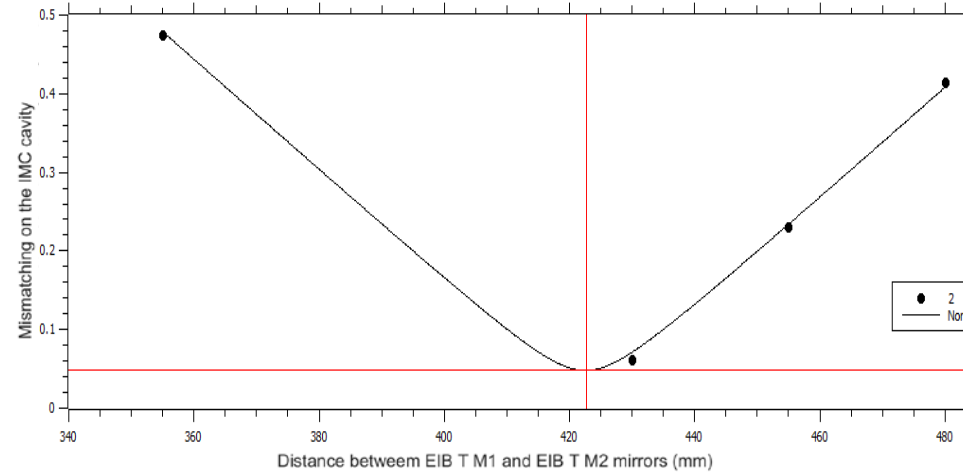
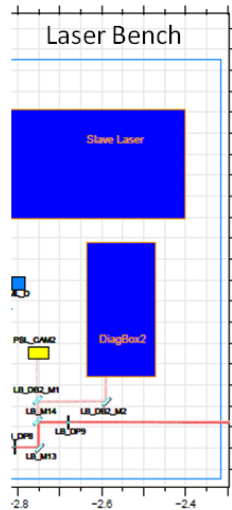
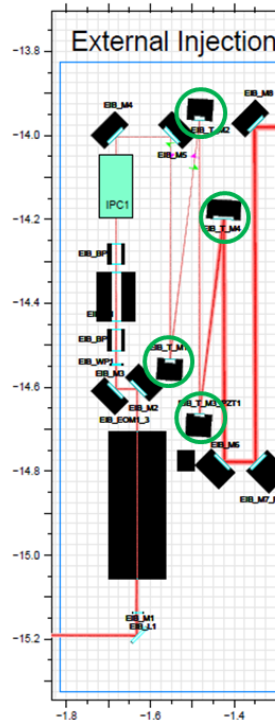


- ❑ The laser bench upgrade has started on December 4. with main tasks completed (\*)  
*(\*) see Nelson's talk for more details (Detector meeting)*
  - PSL disassembly (optics downstream the slave laser)
  - neoVAN-HP integration
  - PMC integration
  - Pstab completion with an Acousto Optic Modulator as a new actuator
  - Diagnostic devices integration for the PMC
  - New signals connected and acquired (electronic group, LAPP, Napoli)
  
- ❑ The IMC has been relocked for the first time on December 18 (see logentries #40258 and #40274)
  
- ❑ We were back to low noise operation on January 16 (see entry #40378).
  
- PSL Performances seems compliant with O2, to be checked during next commissioning run, we pause the PSL integration (non-critical parts) to give place to top-priority activities

# Alignment and matching of the beam in the IMC cavity

The IMC mode matching telescope has been tuned to optimize the mode matching on the IMC (see logentries #40274 and #40365).

IMC MMT optics name  
 EIB\_T\_M1  
 EIB\_T\_M2  
 EIB\_T\_M3\_PZT  
 EIB\_M4



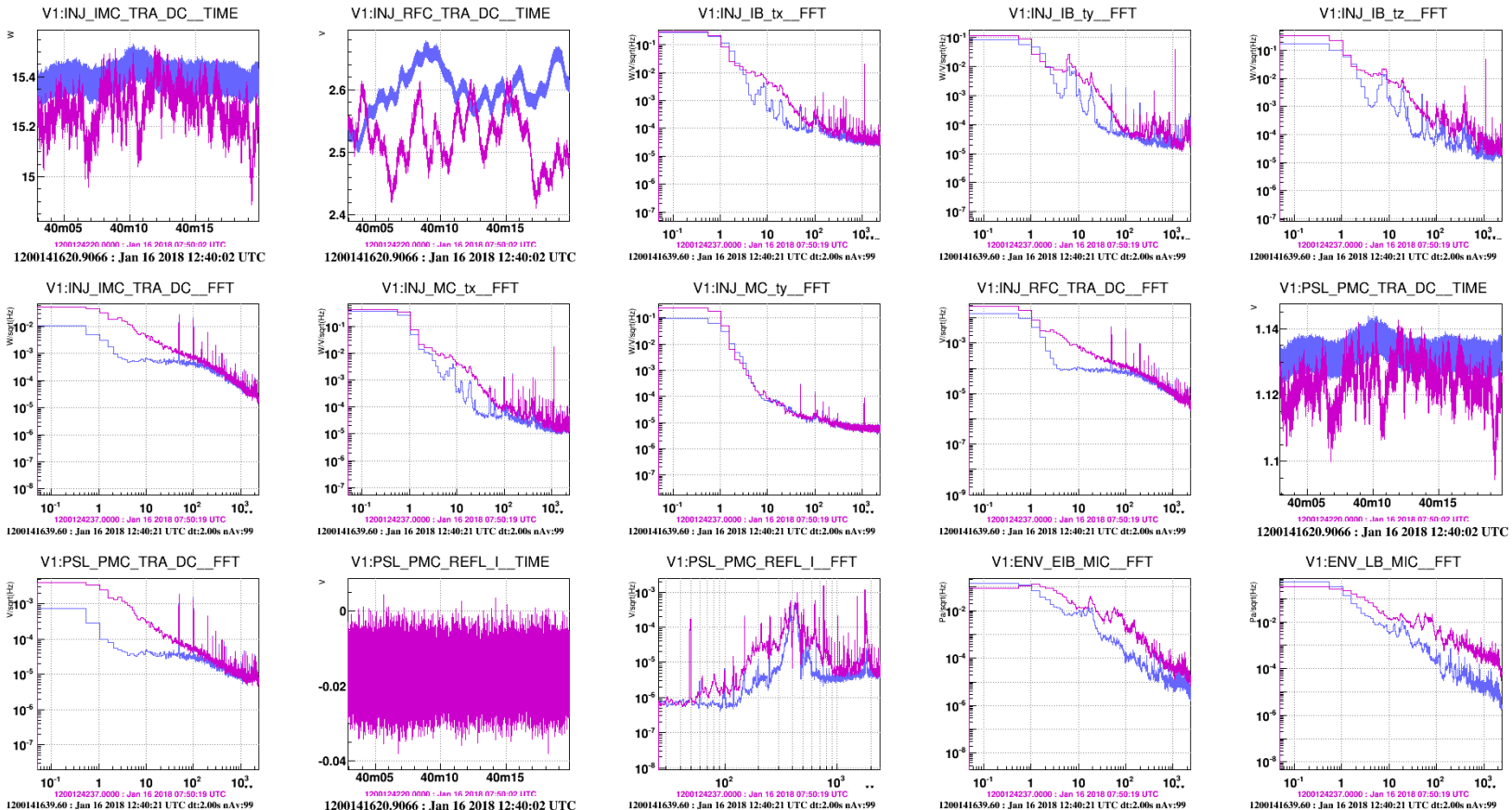
We checked it with 32.5W and 16W transmitted by the IMC cavity

IMC transmitted power	P <sub>IMC_refl</sub> (IMC locked)	P <sub>IMC_refl</sub> (IMC unlocked)	mismatch
32.5 W	0.021 V	0.405 V	5.55 %
16 W	0.008 V	0.181 V	5.26 %

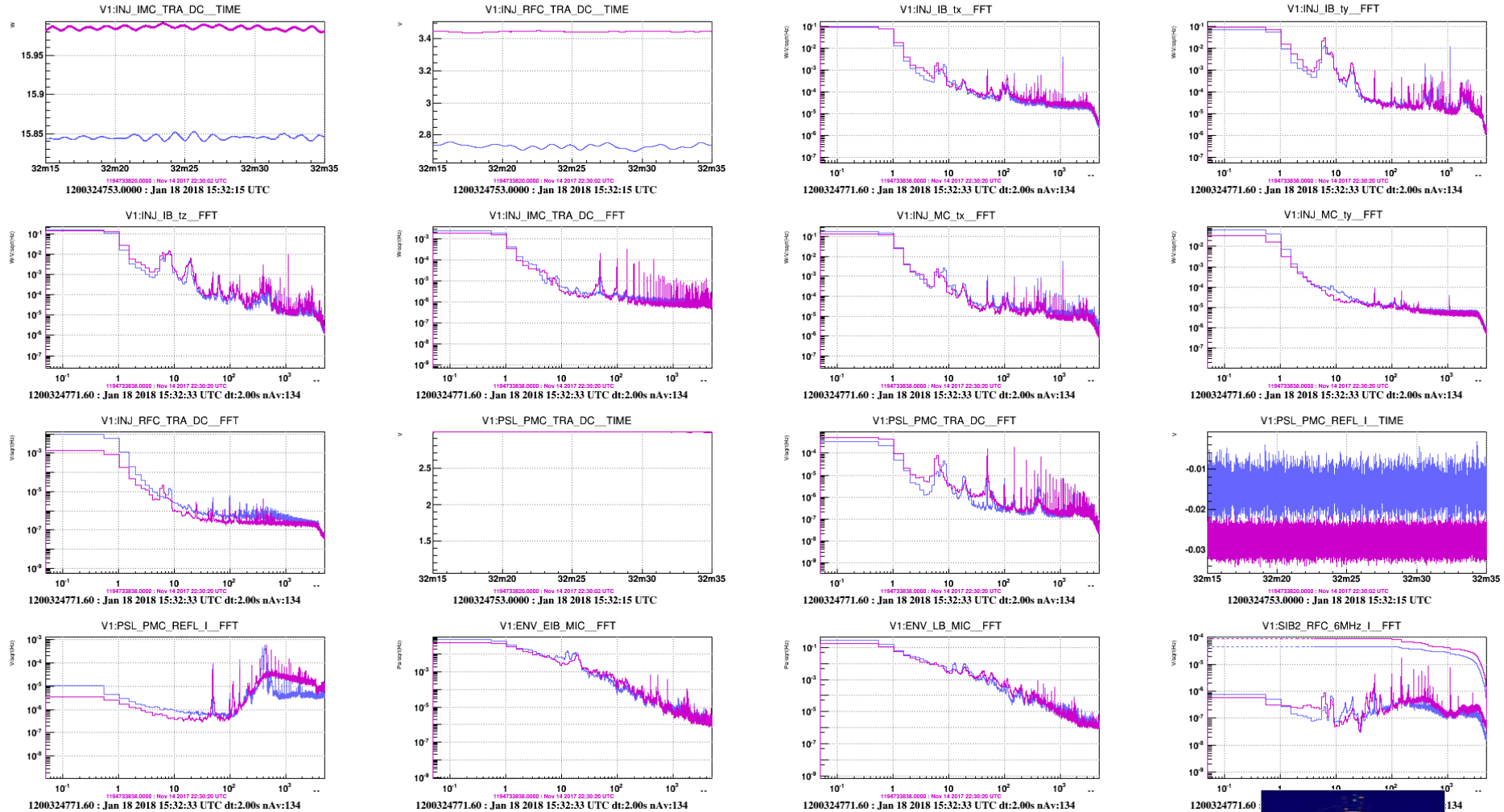
→ It is slightly better wrt what we had with the old LA (6%). We could maybe further optimize it but not yet planned.

On January 16, the INJ lab AC system has been put in “low-noise” mode (see logentry #40378). The AA sensing matrix has been remeasured and the control loop retuned.

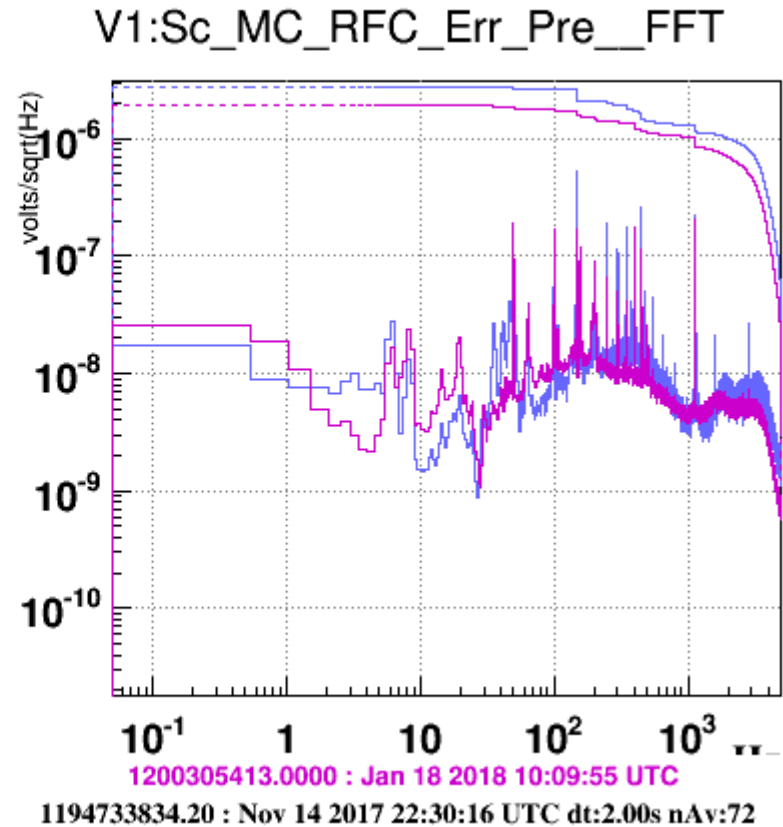
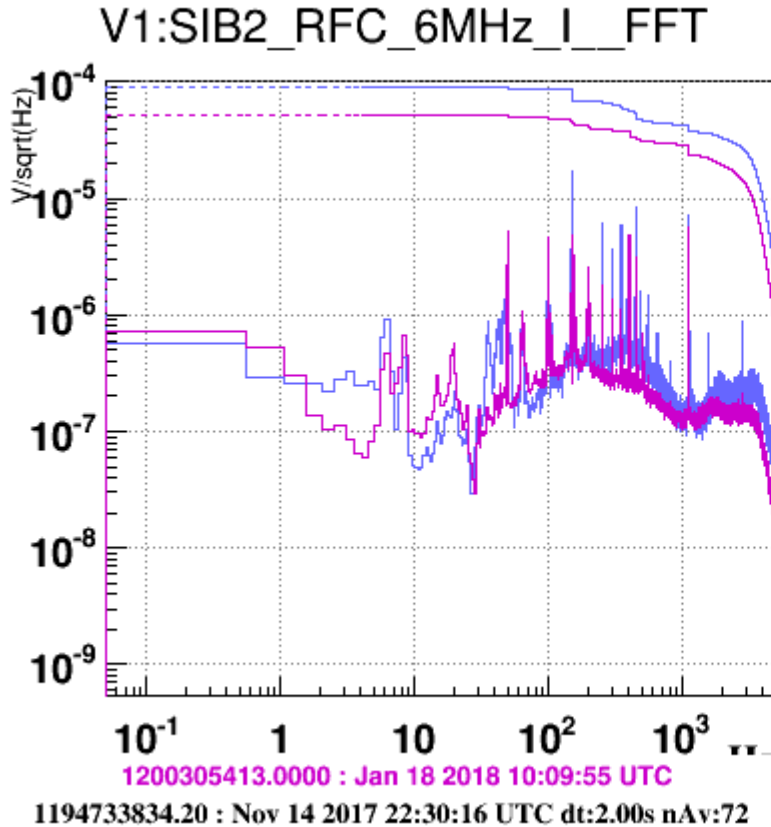
dataDisplay v10r8 : started by genin on Jan 16 2018 13:17:24 UTC



dataDisplay v10r8 : started by genin on Jan 18 2018 15:32:05 UTC



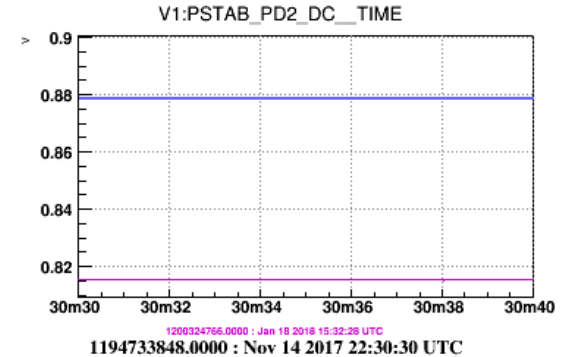
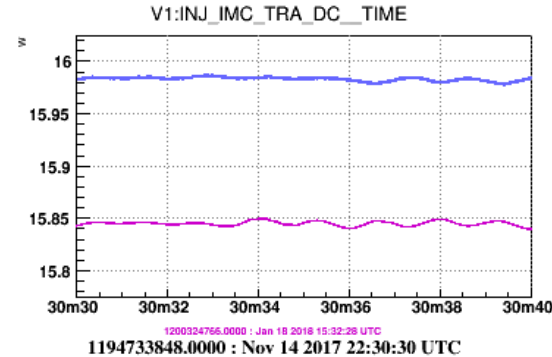
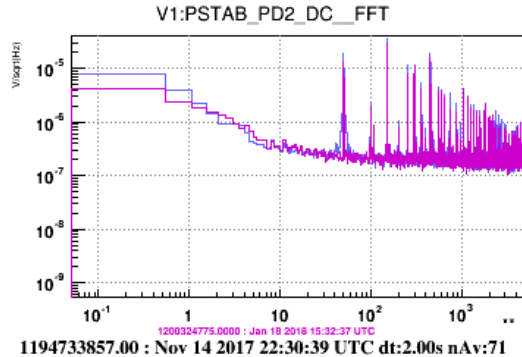
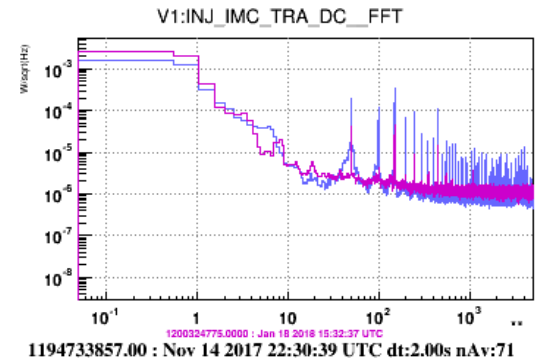
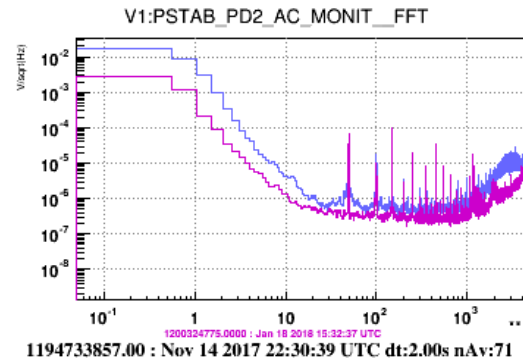
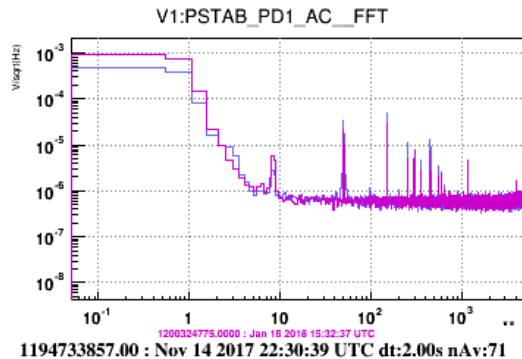
dataDisplay v10r8 : started by genin on Jan 18 2018 10:10:51 UTC



→ using the calibration of  $2e6$  Hz/ $\mu$ m for the MC\_RFC\_err signal (calibrated in  $\mu$ m). We find a frequency noise of the pre-stabilized laser of 4Hz rms (slightly better respect to what we had in Nov 2017).



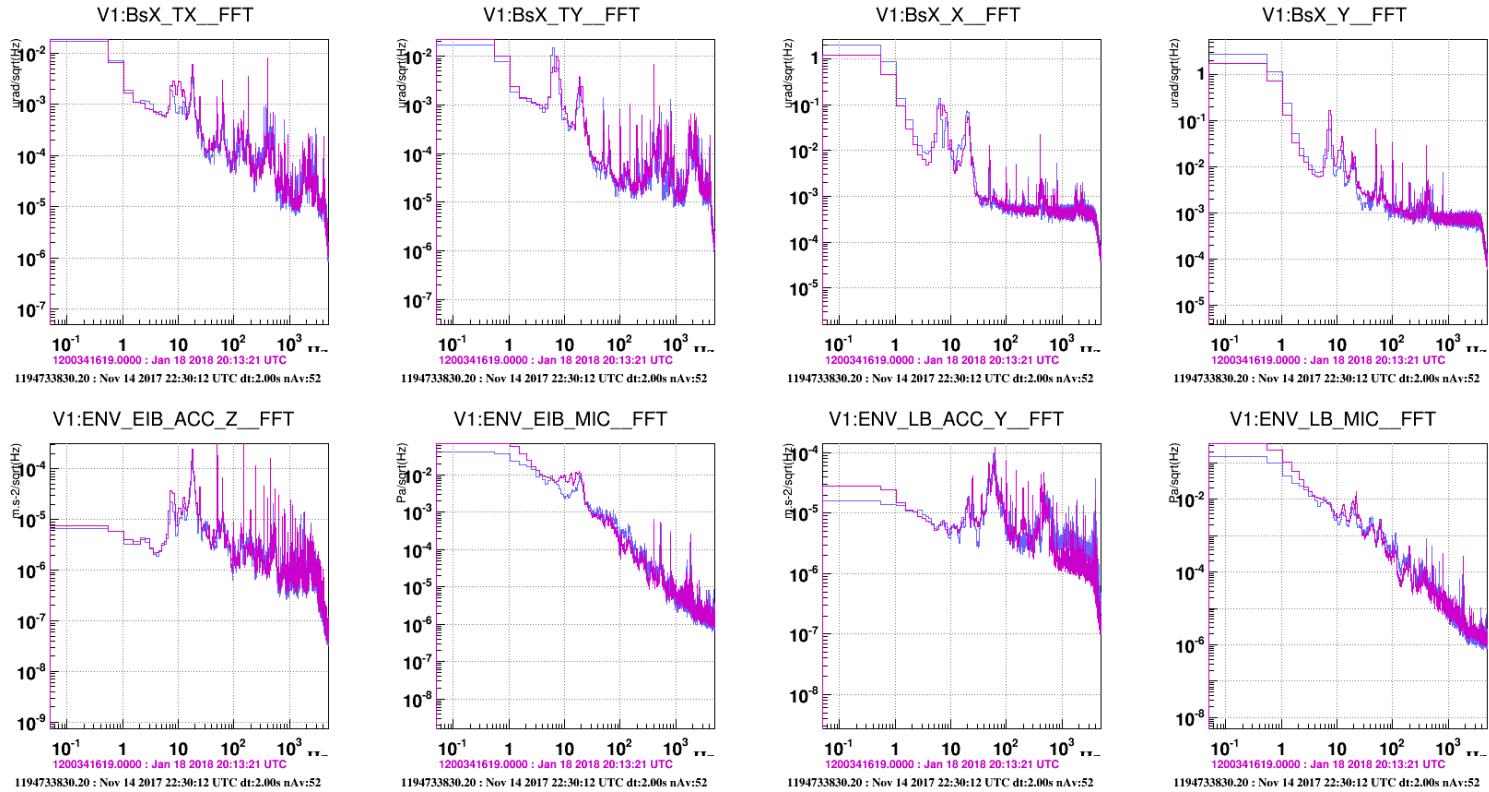
dataDisplay v10r8 : started by genin on Jan 21 2018 20:13:31 UTC



→ works fine for the moment. Some more work is planned during the West arm MS shutdown.

□ We made a comparison between Nov14, 2017 data and last week data.

dataDisplay v10r8 : started by genin on Jan 19 2018 16:25:28 UTC

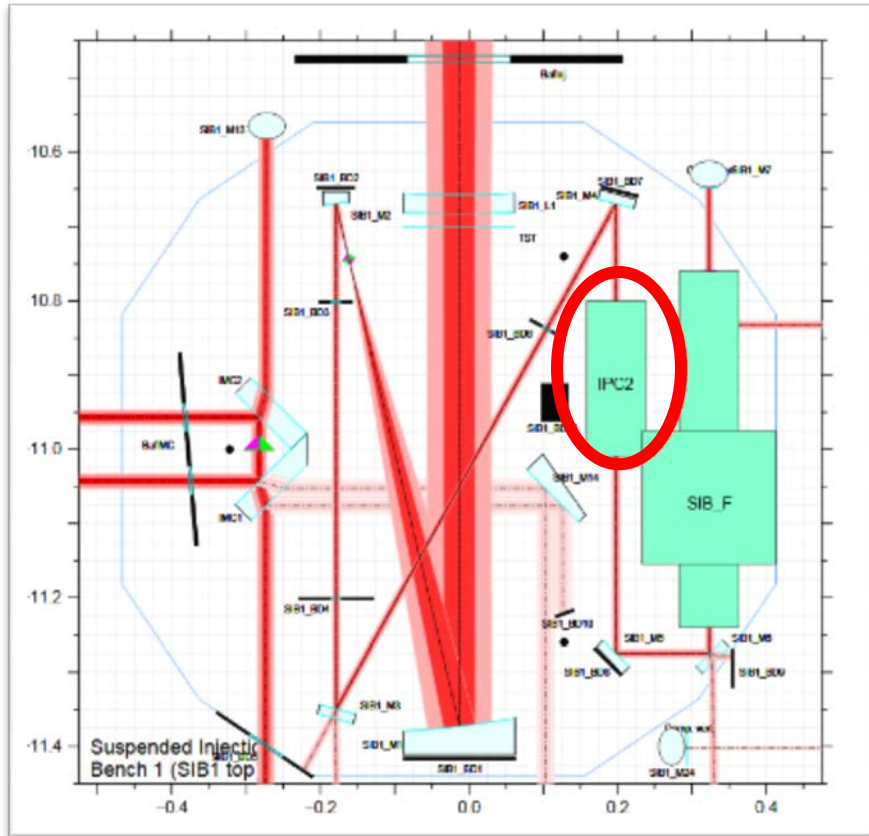


→ A few more peaks can be seen between 500 and 900Hz. Deserves more studies during the commissioning phase.

## Next steps: commissioning and upgrades

- ❑ Next 2 weeks are dedicated to ITF commissioning with MS on North arm. We will look at the subsystem duty cycle and try to improve it if needed.  
→ if possible we will perform the first noise projections (Beam jitter, Laser intensity noise).
- ❑ Then, there are a few important things to be done during the shutdown for West arm (SIB1 IPC upgrade, Pstab electronic box replacement, EIB-SAS operation,...

# task	Sub system	Earliest start	Duration	Before / after MS upgrade	Reference person	Commissioning action	Expected benefit	Needed preparations	Needed ITF configuration
2	INU		1 shift + vac	during MS	E. Genin	substitution of the SIB1 polarizers+ opening/closing of the power stabilization electronic box	decrease of 5% of laser power losses introduced by the IPC polarizers/ avoid damaging the power stabilization electronics located in the IB tower.		SIB1 in air
3	INU/SBE		1w	during MS	E. Genin/ A. Bertolini	EIB suspension	reduce the 20Hz noise		North arm available
4	INU		1 shift	during MS	E. Genin	IMC RF QPD substitution	50 Hz reduction and standardization of the hardware		IMC available
5	INU/Elect		0.5 shift	during MS	E. Genin/F. Nocera	Rampeauto substitution	old electronics		IMC available
8	PSL/INU		4h	during MS	E. Genin	New SL power supplies installation			
10	INU		4h (installation 2hours+ ITF relocking 2hours)	Before MS/during MS	G.Pillant	22/56MHz EOM replacement	be able to monitor the modulation index amplitude		ITF will have to be relocked with the new modulator we can expect the need to retune some demodulations phases



- ❑ Replace the lossy polarizers by new ones from LMA → reduce by 5% the throughput losses



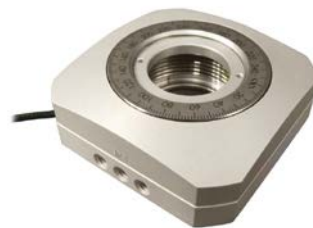
Brewster Polarizers at 1064 nm (55\*20 mm) for the Advanced Virgo Input Bench

Surface 1 : HR coating for polarizer with extinction >40 dB at 55.4° inc. (Ts<0.01%, Rp<0.1%)

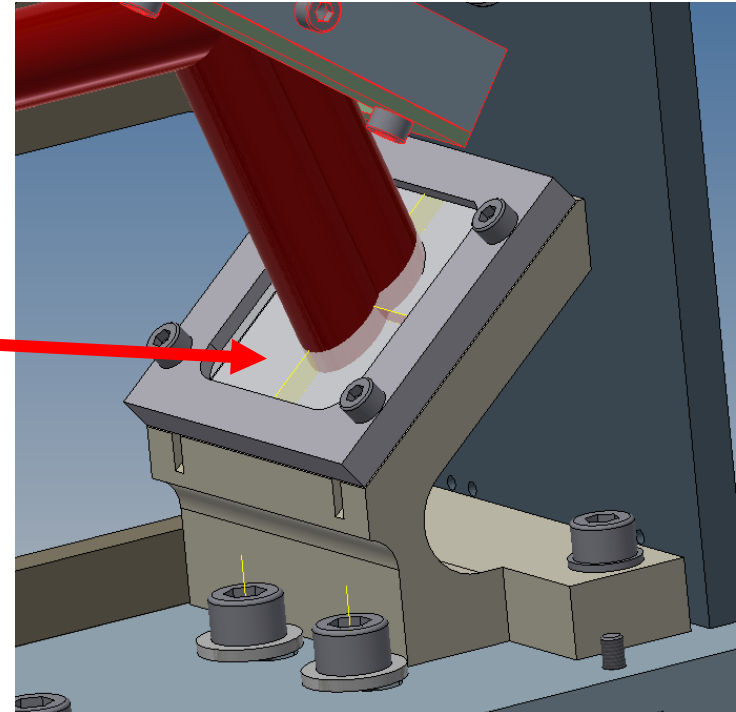
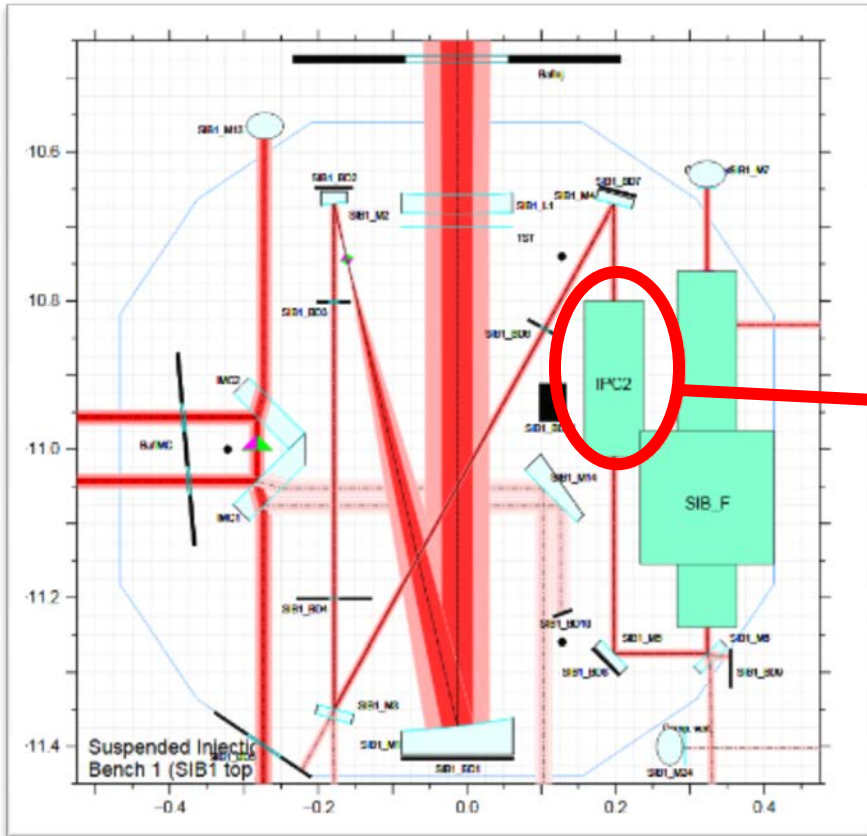
LMA reference	Transmission S polarization (%)	Reflexion P polarization (%)	Extinction $10 \cdot \log(Tp/Ts)$ in dB
S17073/1	0.0009	0.282	50.4
S17073/2	0.0009	0.260	50.4
S17073/3	0.0009	0.286	50.4

July 2017

- ❑ Replace the Micos rotator (not reliable) by a Newport agilis one.

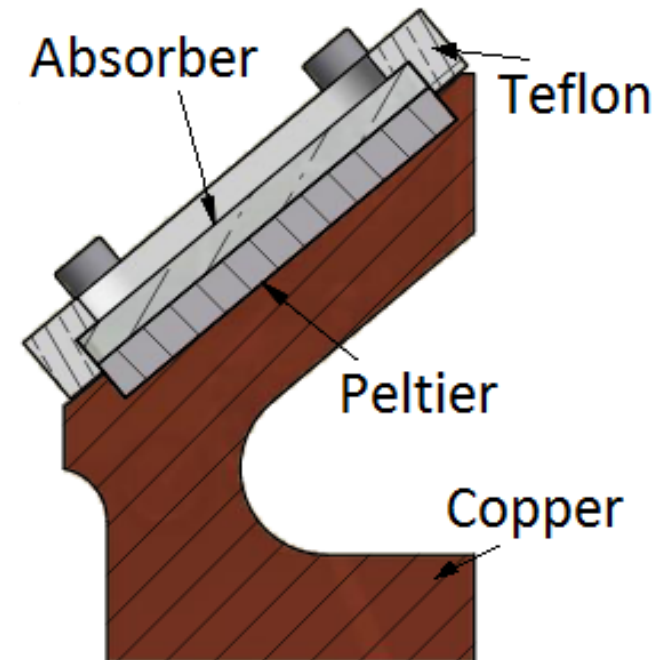
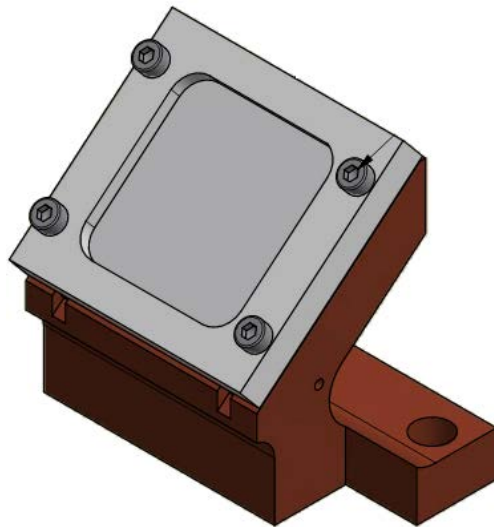


- ❑ Install monitor of the laser power we inject closer to the ITF.

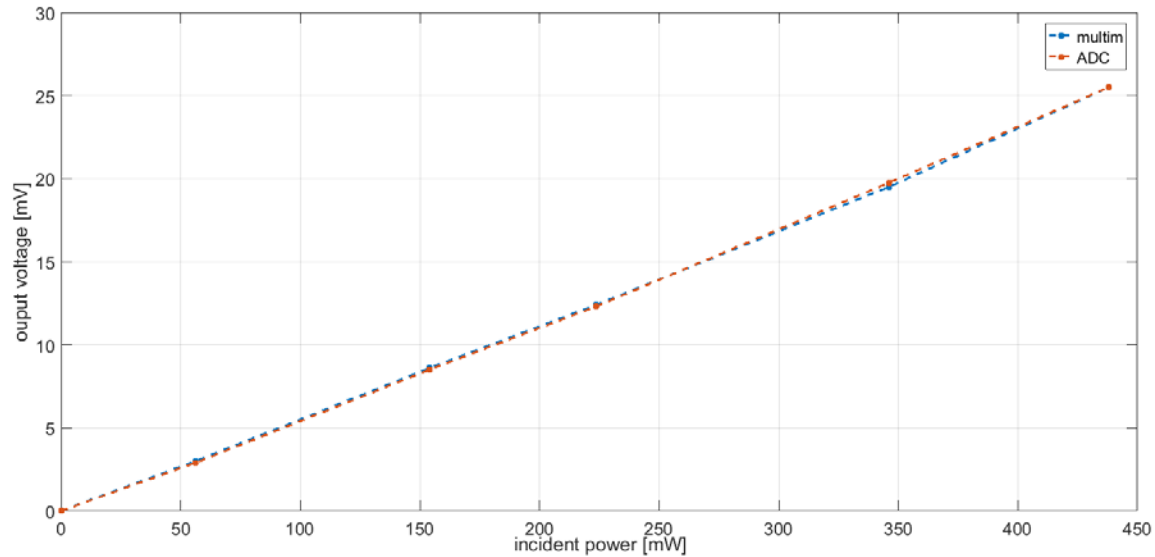


❑ Because of the too high incident power density (up to  $3.5 \text{ W/cm}^2$ ), we will use a **Peltier element** instead of the PSD (max =  $1 \text{ mW/cm}^2$ )

- Seebeck effect: it converts  $\Delta T$  into  $\Delta V$
- Executive design done (by T. Zelenova)

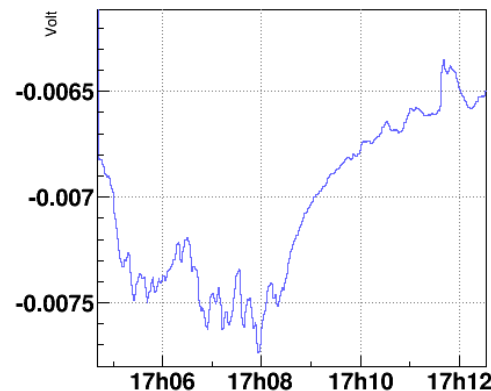


□ Linearity of the output voltage with the incident power

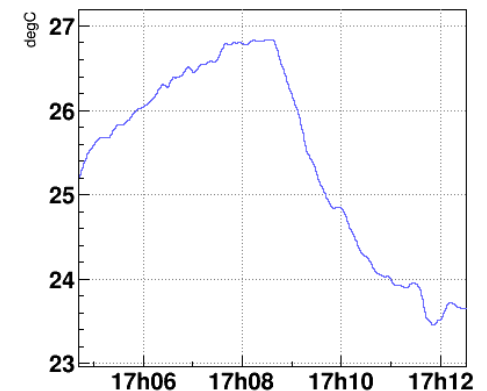


□ No large dependency from environmental temp. fluctuations

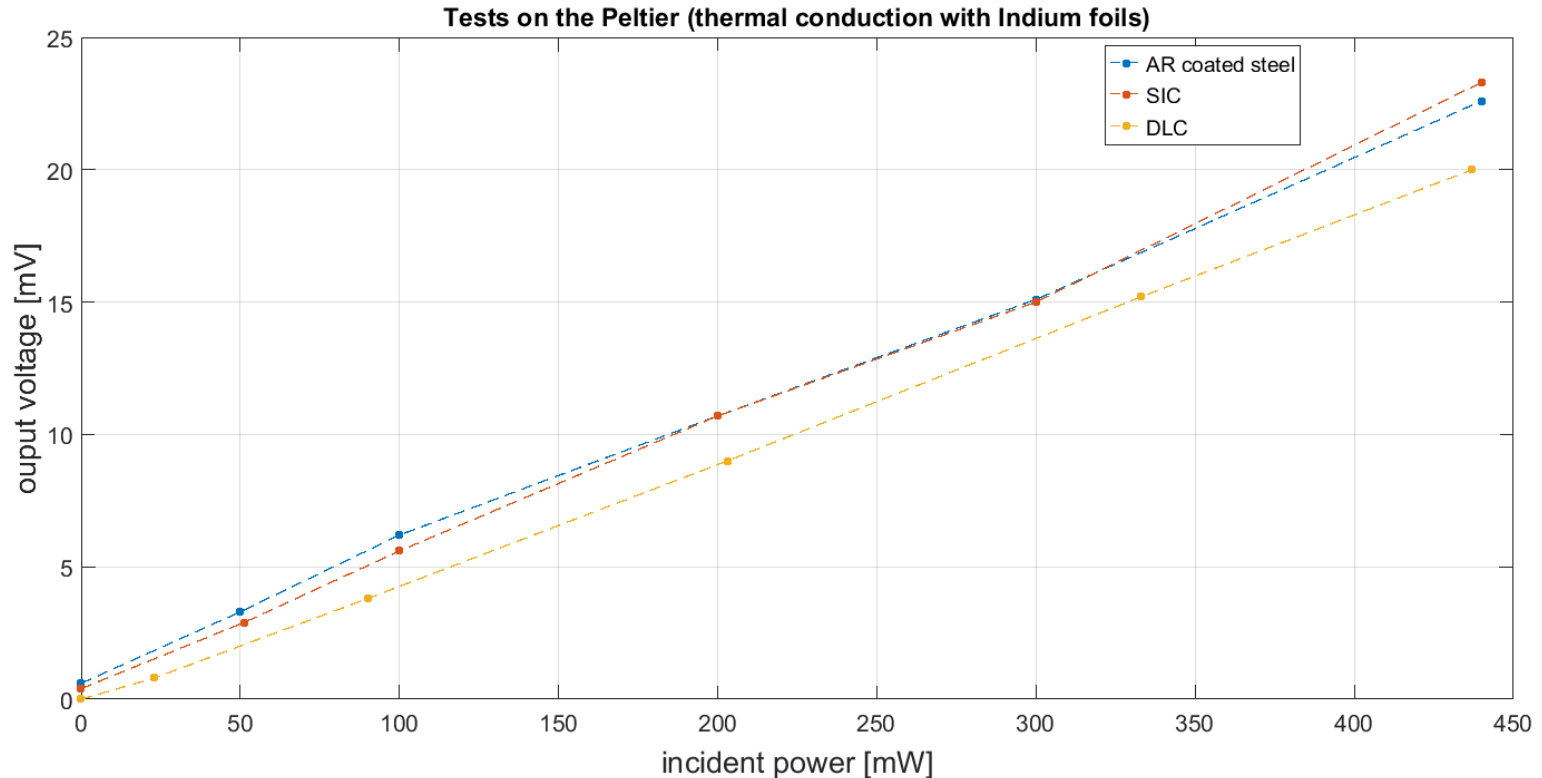
V1:Opt\_Channel\_Test\_mean\_\_TIME



V1:Opt\_ENV\_TEMP\_ROOM\_V\_Bavigadde\_\_TIME



- Choice of the absorber: **superpolished AR-coated steel**

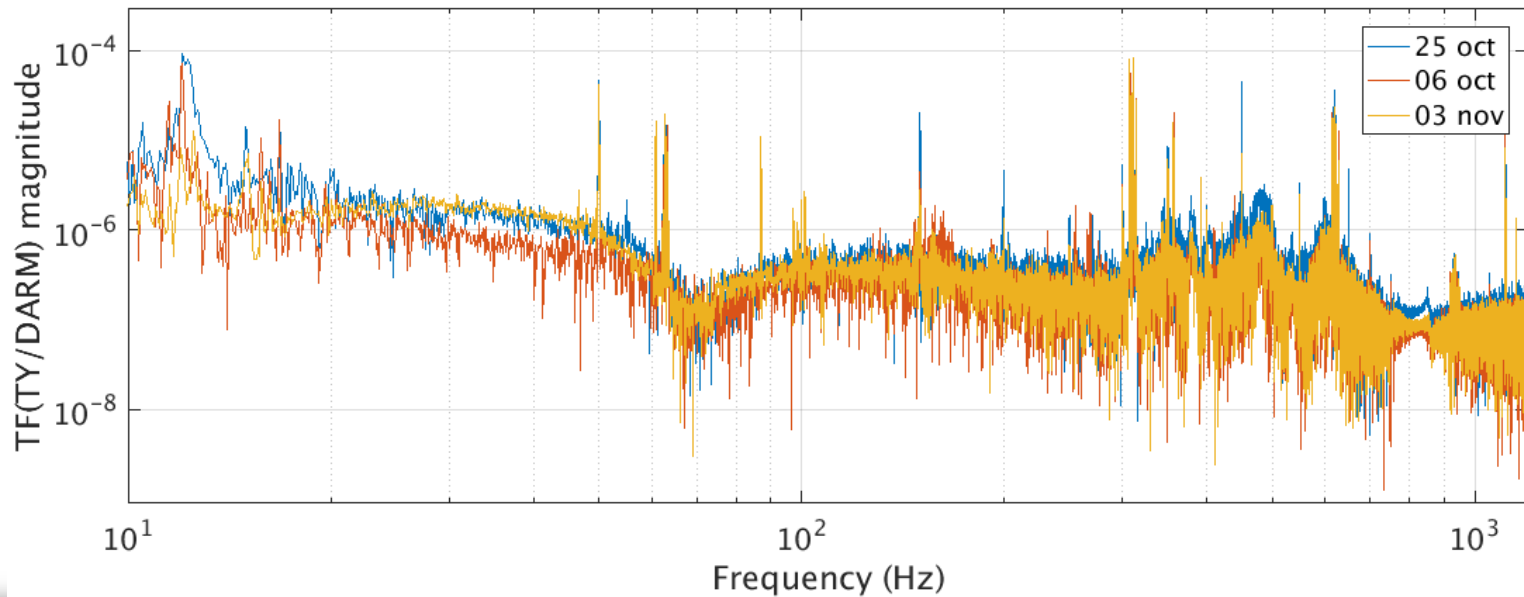
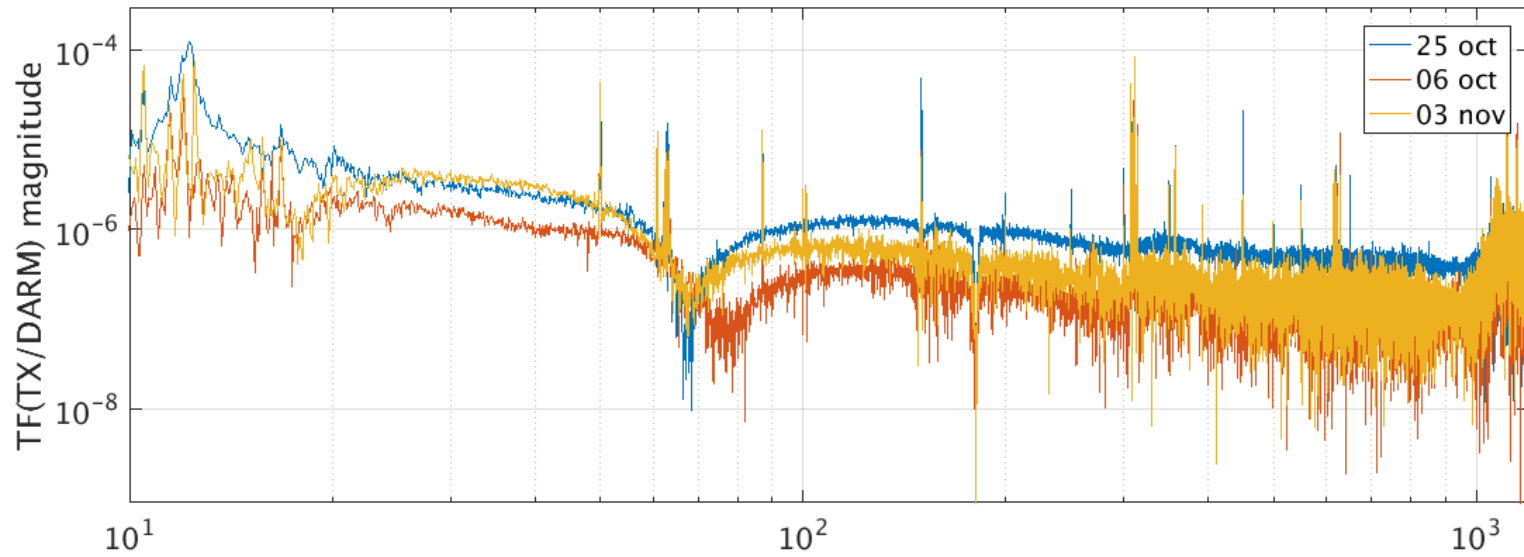


- Good behavior **under vacuum** (already used for Virgo baffles)  
→ installation planned for the week of February 26.



# Beam jitter coupling into DARM

The TF between TX and DARM slightly changed



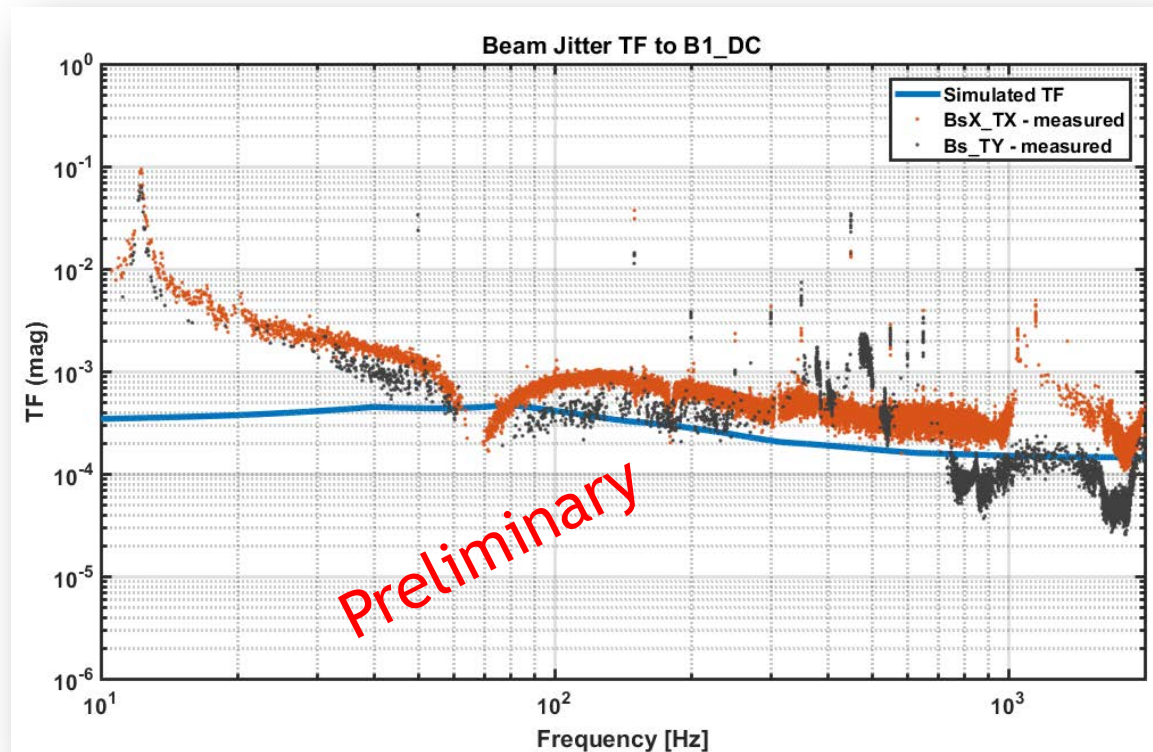
# Beam jitter coupling into DARM

- Model the Beam Jitter coupling to DARM

Using *Finesse*:  
configuration with  
measured parameters  
and expected angular  
loop accuracy

Comparing simulation to  
data from entry 39870  
(De Rossi - Genin)

Order of magnitude  
estimate works fine



# Beam jitter coupling into DARM

- ❑ Model the Beam Jitter coupling to DARM

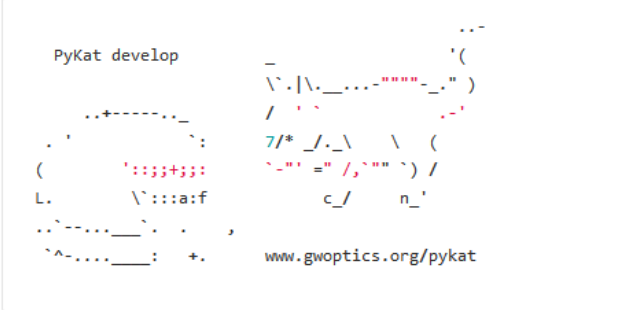
Several features to add / tune:

- FP asymmetries
- Short arm asymmetries
- OMC misalignment wrt ITF
- Add radiation pressure to Finesse simulation
- ...

Currently switching to PyKat  
(Finesse python wrapper) to speed-up tuning of simulation

```
import numpy as np
import matplotlib.pyplot as plt
from IPython.display import display

Out [1]:
```



PyKat develop [www.gwoptics.org/pykat](http://www.gwoptics.org/pykat)

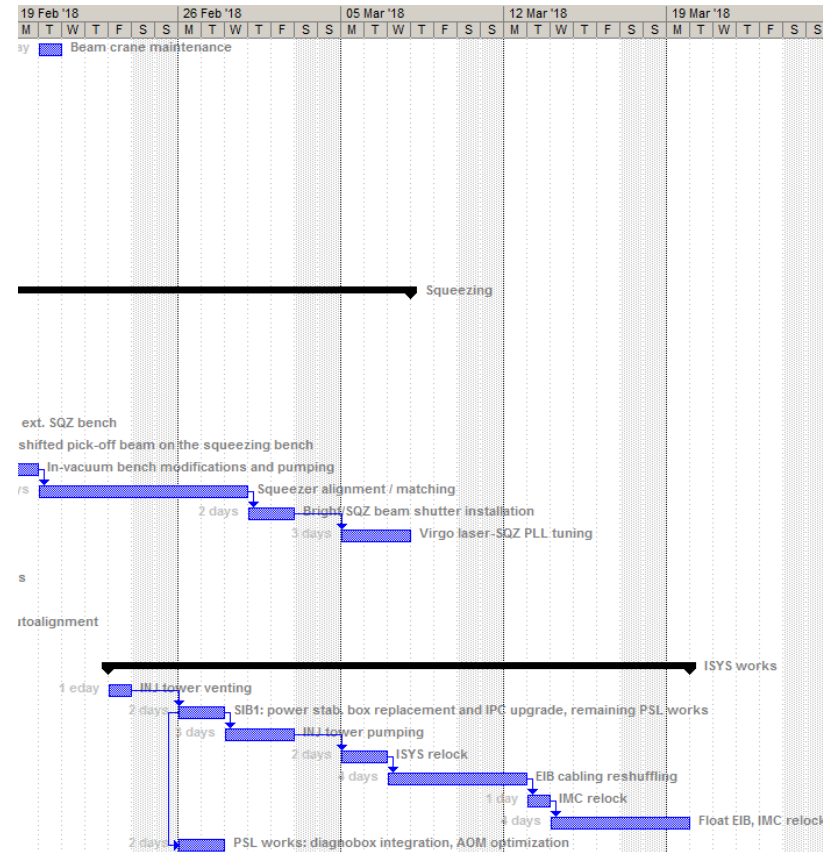
Preparing Advanced Virgo file

❑ We need to fix the leak of the power stabilization electronics box (to be done during SIB1 intervention and during monolithic suspensions upgrade to minimize ITF down time). It will be done during the shutdown for the West arm MS installation (already inserted in the planning).

❑ The idea is to replace the currently used box by the spare one which has already been tested in air and in vacuum. Some optimization work still on-going.

❑ We will have to substitute at least the slave laser pumping diodes and the master laser (before O3 run)  
→ after the laser system upgrade.

❑ We have to replace the “very old” laser chillers. We are currently finalizing the purchase of 2 new chillers.



- IB tower intervention: SIB1 IPC upgrade and power stabilization electronic. box substitution (end of February)
- Finish PSL leftovers (diagnostic boxes installation, AOM/PSTAB optimization,..)
- EIB cabling reshuffling
- Suspend EIB (mid-march).
  
- Mid term (before O3 run):
  - Install the new power supply for the slave laser.
  - Master laser and slave laser pumping diodes replacement.
  - Further raise up the laser power (up to 50W) if required.

We need to conclude the document motivating the replacement of MC end mirror during O3/O4 break.

→ there are many reasons to replace it. Improve the actuation and the mechanics. Optical losses reduction. Replacement could be made at the end of 2019.

Auxiliary lasers hardware installation in the laser lab and on the EIB (TBC)

Further increase of the laser power?

