Hi everybody!

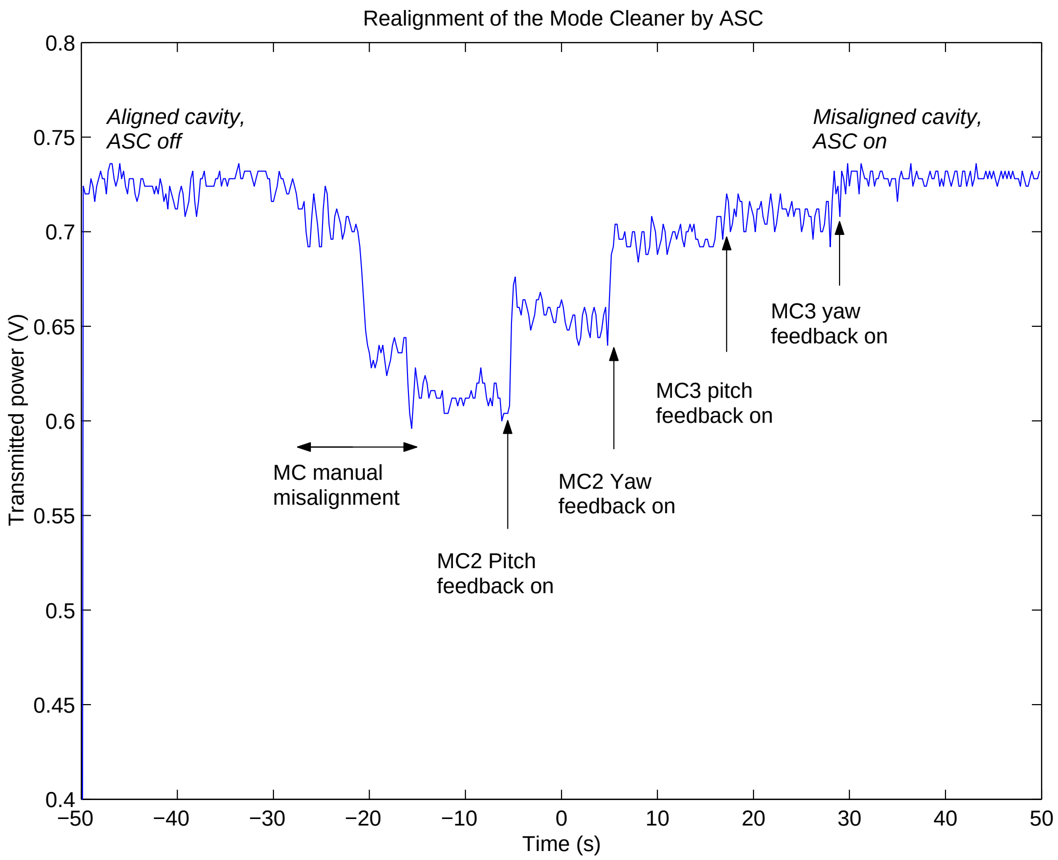
I'll try to summarize the results I got from the ASC system this week so that you know where you'll going to be starting from, and give you a "user manual" (not that I really know how other people use it, but...)

1 First results

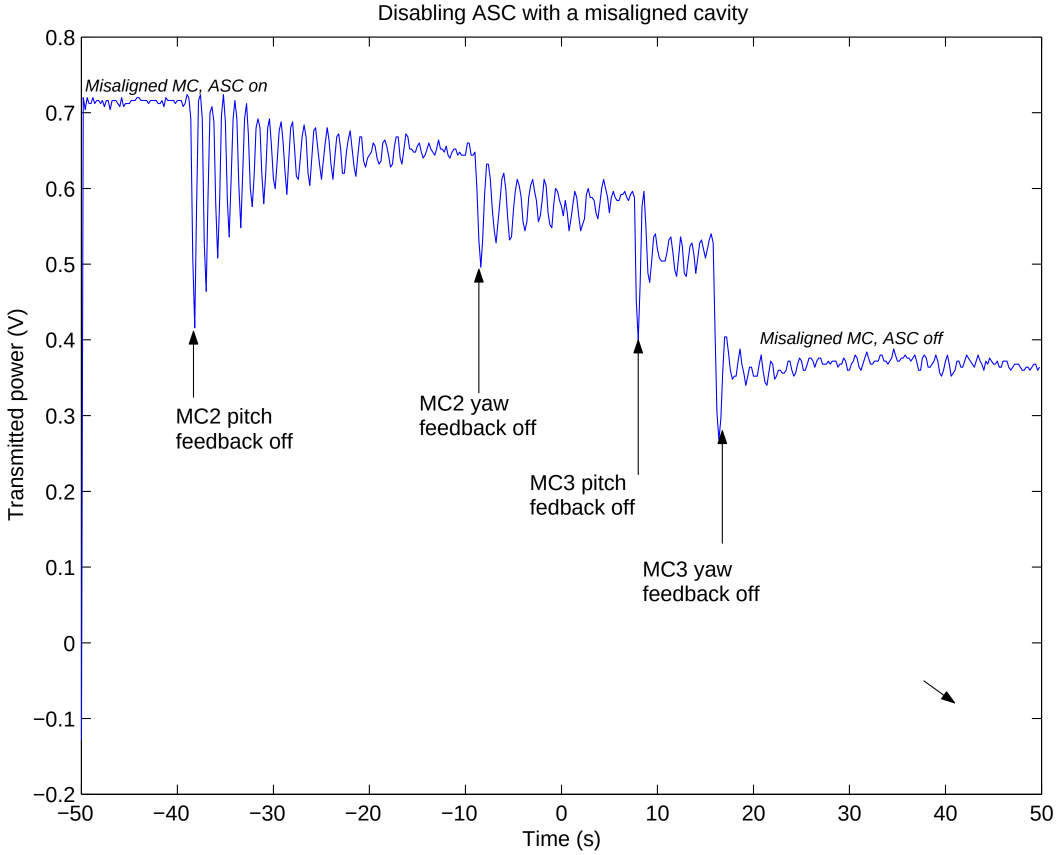
All the data has been taken this week-end, with a fully operational system (pitch and yaw feedback from 2 WFS to MC2 and MC3).

1.1 Realigning a misaligned mode cleaner

If you misalign the mode cleaner "by hand" (changing the offsets on MC2 & MC3, pitch & yaw) and switch the four feedback loops on, you can see the alignment going back to the optimal point, and the transmited signal becomes more stable.

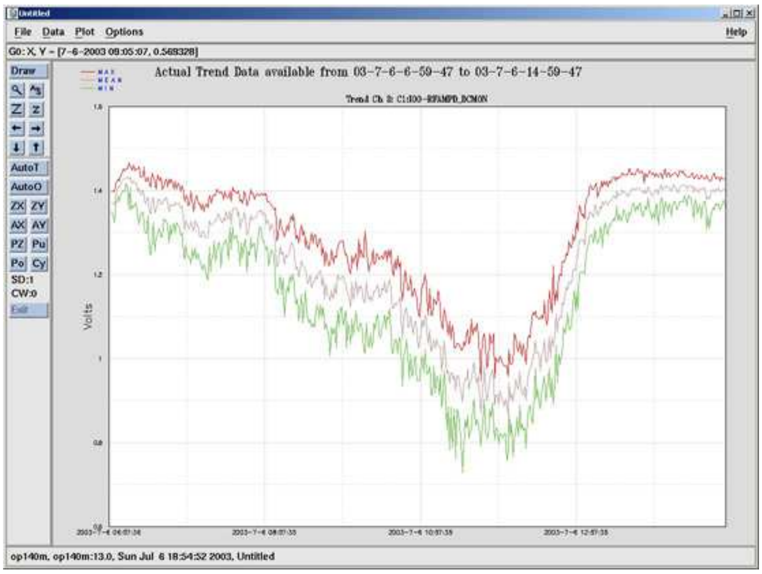


If you do this experiment the other way, i.e. have a manually misaligned cavity kept aligned with ASC feedback, and you switch off the ASC feedbacks, you can clearly see changes in the Q of the suspensions (you can try to play with the gains to modify it if you want)

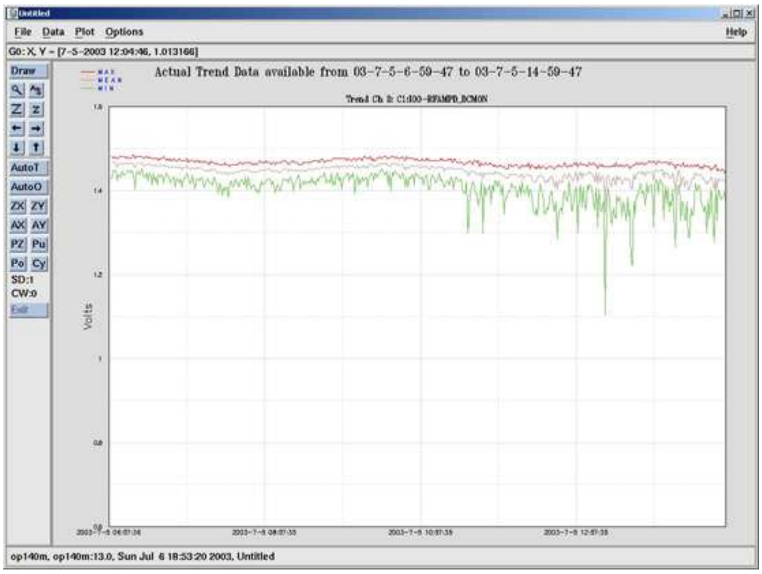


1.2 Keeping the mode cleaner aligned

During the night the transmission changes quite a lot because of thermal variations. The next graph shows the transmission through the mode cleaner the 6th of July from midnight to 8a.m., when the ASC feedback was off. The vertcal scale is from 0 to 1.60V, the maximal signal I've seen lately is 1.50V.

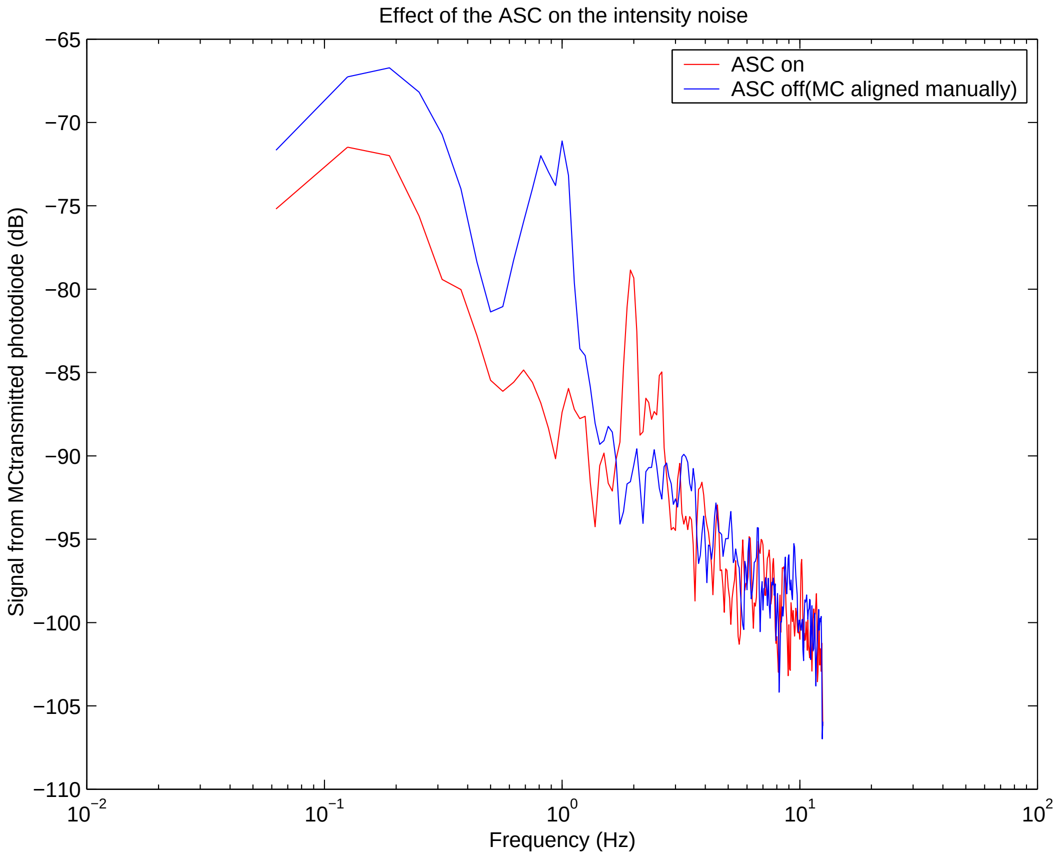


And that's the night before, same time, same scale, with ASC system on.



1.3 Decreasing the noise

This is of course the most difficult thing to do, and that's where most of the work needs to be done. This is the spectrum of the signal from the MC transmitted photodiode (DC output, measured with a spectrum analyzer), with gains of 0.05 to pitch and 0.08 to yaw.



2 "User manual"

I'd like to warn you that I made up a 100% of this procedure and that I never had the time to contact people from the sites (or Nergus) to ask how they work with their WFS systems. So you'd really better ask them before you try to optimize it.

If you are reconfigurating the system, do things in the order that follows.

2.1 Guoy phase adjustments

- Before installing the Guoy phase telescopes I simulated them with my program, "beam", which can be found in Desktop/Alexei/mat/guide/ (beam.mat and beam.fig). Start it by typing "beam" in matlab, go to "optical layout", "open", and load "Wfs90.mat" or "Wfs180.mat" (they are in the same directory as "beam"). Then you can move the last lens and check the beam propreties at the position of the WFS head. In the actual configuration, without the last diverging lenses (G90 and G180), the waist is approximately 5cm further than it should be (we measured it with Beamscan).

- Position the lens where you think it should be. It largely determines the Guoy phase, which does not change too much after it

- Position the heads : their position has little effect on the Guoy phases, but the spot size (1/e of the maximal power) has to be of about 2mm according to the design. Center roughly the spot on the PD.
- Move the mirrors and look at the signals on C1:IO_WFS1_SETTINGS (in cvs/cds/caltech/medm/ioo). Don't forget to look at I and Q signals
- It you think they could be improved, do this procedure again.

2.2 Alignment

The main EPICS screen you'll have to use is C1IOO_MC_IOWFS.adl. It shows the DC signals from the quadrants of the WFSs. It is also used for adjusting the RF and DC electronic gains.

- Mark the positions of the last lens and the head, take them out.
- Bring the mode cleaner out of lock by disabling MC2 offsets to have a nice TEM00 beam.
- Make the beam parallel to the table and to a row of holes, 4 inches from the table.
- Put the head in place, as well centered as possible on the beam (equalize the signals from the opposite quadrants by moving the head, and the mirror for the last fine adjustments if necessary.
- Put the lens in place, adjust the position to equalize the signals from the opposite quadrants. It is extremely sensitive, but this way you know that the beam is centered on the lens and the PD. Once again, use the mirror only when you're really fed up with moving the lens by fractions of a millimeter.

2.3 Offsets adjustment

The beam reflected from the mode cleaner has a lot of ihgher order modes from the PSL. They produce signals on the WFS, they can be cancelled using the offsets (C1:IO_WFS1_SETTINGS)

2.4 Gains adjustments

Now, the gains compensate for the differences in the gains of the different channels in the heads and in the demod boards, averaged to 1. They can be modified but should stay proportionnal.

2.5 Phase adjustments

The system uses the I signals, which should therefore be maximized: move the mirror which should be sensed by the channel you are adjusting, and adjust the phase to maximize the signal in I. The signal from the opposite quadrant should be maximazed in absolute value, with the opposite sign.

3 Build a matrix

Move the mirror by changing the offset by a known amount, measure the output signals (C1:IO_WFS1_SETTINGS), divide by the mirror displacement. You get a matrix : invert it, take the opposite, and normalize to about 0.1. Set the mirror gains to approximately 0.05 to begin with. They could probably be optimized.

4 Close the loop

Go to MC2&3 creens and switch ASC feedback on

5 What could be improved

There is probably a lot of it, but here are the few things I have in mind :

5.1 Alignment

Right now, the beam is ≈ 4.1 inches from the table when it arrives to the last mirror (beamsplitter for WFS1) before the WFS heads. After the vent, you should take an hour and realign it to 4 inches from the table (which means realigning the length sensing path and the EOS, the alignment procedure is in the EOS file on my desk, document called "User's guide for KD*P, RTP & Lithium-Niobate Q-switches & modulators", pages 3 to 5). Then you can probably follow the same alignment procedure as I was using. It should decouple pitch and yaw better.

5.2 Output matrix diagonalisation

If I enable only the MC2 yaw feedback loop with a sufficiently big gain (mirror gains = 0.20, WFS gains ≈ 1, matrix norm ≈ 0.1), I can see an oscillation in pitch. Since no pitch feedback is enabled, I think it comes from a bad output matrix diagonalization and not from pitch/yaw coupling on the WFSs.

5.3 Filters

None of the filters I tried had a real positive effect (I didn't try too hard, though). It's probably worth asking Jay about it.

5.4 Feedback to MC1

I never tried it, because it would move the carrier and the sidebands on the WFS, whereas MC2 and MC3 only affect the carrier. So MC2 and MC3 were following MC1 which was moving "freely". You could feedback to it from the WFS, and eventually implement a third signal (from the IMCT QPD for example) into the loop to control all 3 mirrors.

5.5 Feedback to the PZT mirrors

We moved them with a signal generator plugged into the back of the PZT driver, but never with Epics, I don't know if it works.

All right, I hope it helps. Good luck, don't hesitate to ask me questions (ourjoumtsev@normalesup.org is my permanent email address, i don't know how long aourjou@ligo.caltech.edu is going to be working)

Alexei