Only tune up the spitfire if you *need* to, and do *not* treat it casually - set aside your whole day. Merely opening the spitfire box exposes the optics to dust. Treating the spitfire with the respect it deserves will only save time in the long run.

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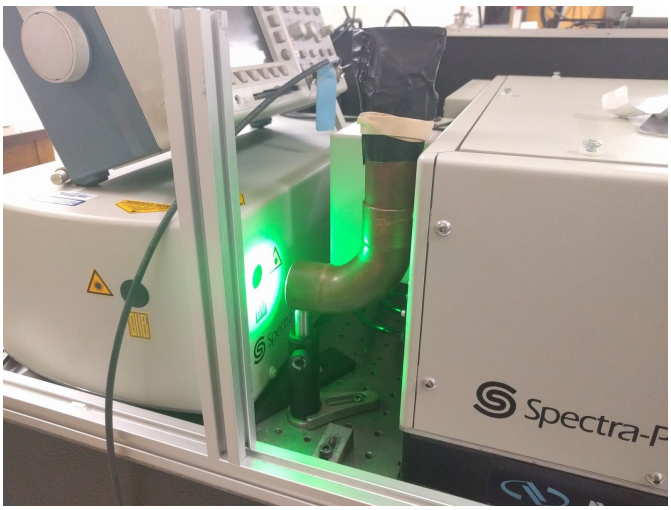
common alignment procedure

These things are done regularly during Spitfire Pro ‘upkeep’.

The spitfire needs 70 charcoal packets. They should be replaced every ~6 months.

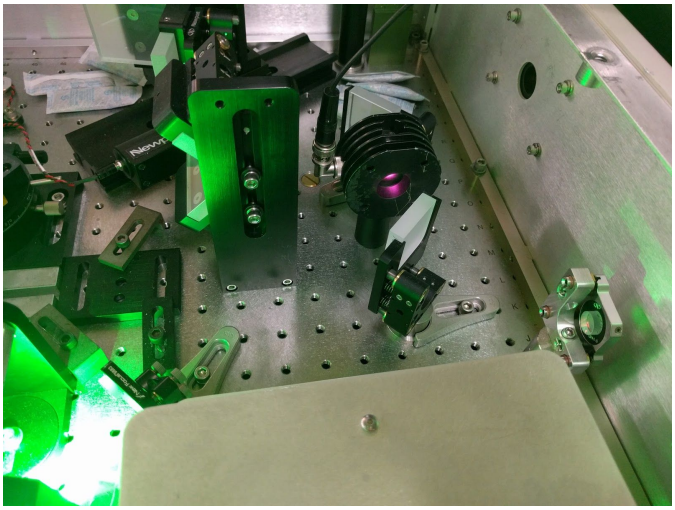
<u>Preparation</u>

1. Check desiccant in temperature control box (blue = good, pink = bad)
2. Connect the fast oscilloscope so that you can see the pulse train
3. If starting up from cold, turn on the Spitfire
    a. Ensure that software is closed on control laptop
    b. Turn on Empower power supply (orange switch)
    c. Turn on Timing and Delay Generator 'TDG' (orange switch)
    d. Turn on temperature control box (orange switch)
    e. Turn key on Empower power supply
    f. Turn key on TDG
    g. Start Spitfire Software
    h. Often have many faults, most will clear immediately
    i. Empower LBO temp fault may take a while before it clears - should clear after 5 minutes
4. If Empower has been off (totally, or just at zero amps), warm up at 20 Amps for 1 hour. Block entry into the spitfire using a *good* beam block during this time.



5. If it hasn't been done in awhile, measure and record an empower power curve
6. Open Spitfire

7. Place the 407A after the telescope between the large square mirrors on the empty mount



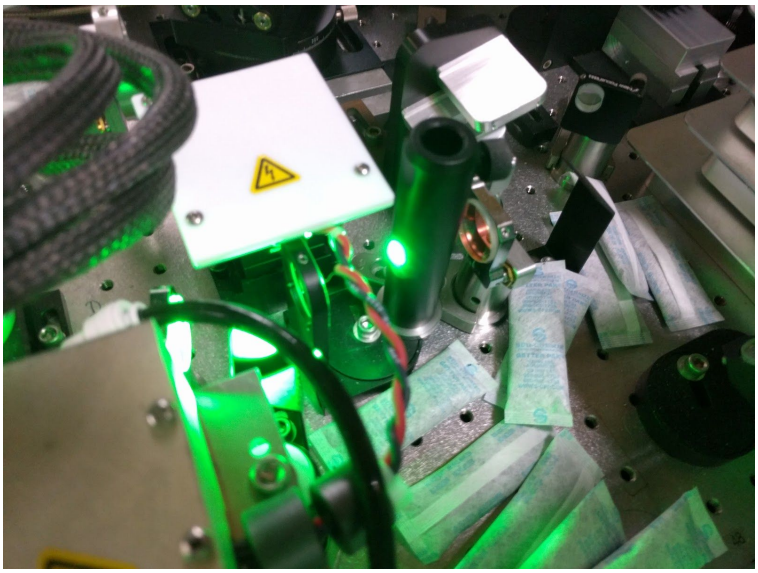
8. The Empower current should be set to output ~20 W power. When pump optics are clean (see below), we want 20 W incident on the crystal (first pass).

Cavity and pump

Your first goal in alignment will be to ensure that the cavity and pump are healthy without the seed (5 to 5.2 W output). Do not move on to seeded operation until ns lasing mode is healthy.

1. Switch to ns lasing mode
    a. block seed at output of stretcher - seed alignment must be at least good enough to defeat the bandwidth detector. Seed must also be let into the stretcher.
    b. activate Pockels Cell (PC) 2, 3 (=CH2,3)- do not use PC 1 (for more info on pockels cells channels and their roles, see Spitfire Pro manual pp. 7-4,5,6)
    c. Expect 20 to 30 ns (to 40 ns?) (2 to 3 (to 4?) round trips) additional build up time in ns operation (means you must change channel 3 when you are working in ns lasing mode). Operate the laser at its ideal switch out time when aligning ns lasing. Refer to the records to see if your switch out time is unusual for recent performance. (if no power at 407A, increase switch out time and ensure Pockels cells are firing)
        i. Ensure triggering off of Tsunami delay generator.
2. Clean all green optics in order of light hitting them, including brewster windows around crystal. Cleaning these *each time* (regardless of current performance) is done as an attempt to counteract the contamination introduced merely by opening the laser.
    a. You must get new spectrophotometric grade methanol from the wet-lab. You will need to use a disposable syringe and needle.
3. Do the following until you have over 5 W ns lasing, but stop once you have enough power. Ideally you will not need to do anything. Touching the cavity is a very last resort.
    a. Check to ensure no optics are damaged, have dust on them, etc.

b. Clean optics. Check power after each cleaning - at the very least you don't want to *lose* power. When cleaning optics wait at least a second before letting the light hit the optic after cleaning.
    i. All cavity mirrors
    ii. Thin film polarizer
    iii. Clean transmissive optics (lenses, polarization rotator, wave plate) only when dirt can be seen - coatings may be damaged. The polarization rotator may be removed for cleaning (use a piece of tape to get it out of the mount).
c. Align pump.
    i. Decrease the pump power to ~17 A. This should decrease the ns lasing output to around 2 Watts, so you can increase the sensitivity on the 407A if you wish.
    ii. Find the ideal switch out (CH 3) time. It will be still later that the aforementioned ns lasing switch out time. Back off the ideal ns switch out time by ~2 round trips for optimization.
    iii. Typically the two mirrors on either side of the cavity (immediate to the lenses) are the only pump mirrors touched during alignment. The first pump mirror may be touched in special cases but not for regular touch-up.
    iv. Block the back reflection with the mirror mount when aligning the second pump mirror



    v. Align the back reflection mirror (without beam block)
    vi. Iterate through the mirrors until you are satisfied that pump pointing is ideal
d. Align cavity
    i. Ask somebody who has done it before.
    ii. NEVER TOUCH ANYTHING SAVE THE END MIRRORS!

iii. NOTE: alignment tool poor to cavity mode 2016/03

Seed

Now that the cavity is good, you must couple the seed into it. If you have just aligned the oscillator you should wait at least 10 hours before attempting to align the seed.

1. Align to the two apertures either side of the faraday isolator using mirrors external to spitfire.
2. Align to two 'A' mask positions in stretcher
3. Align to three 'F' mask positions on the way to cavity (this mirror system is under-constrained; consider using the final mirror of the 'A' mask alignment as a tweaking mirror)
4. Let seed into cavity by turning channel 1 on.
5. Optimize (mirror at D18 and periscope) to output power before compressor - often useful to go one or two round trips less (~210 ns on CH3) when aligning seed to power (output depends on seed more sensitively and you want to optimize for largest buildup reduction time) - expect 100 to 150 mW less in seed operation
6. Can adjust quarter waveplate to minimize post-pulsing if necessary but be very careful to not send the output back into the stretcher
7. Ensure pulse is let out of the cavity at the optimal time (check oscilloscope and power). Power should be maximized and oscilloscope should read with the last tall pulse being the one right before the tallest possible pulse (tallest possible pulse should not be on oscilloscope screen when done)
8. Ensure there is no residual pulse after pulse is let out of cavity (check tail of oscilloscope trace)
9. Remove 407A (replace small post)
10. Put flange back on stretcher cavity.

Output

Now you must ensure that the cavity output is properly routed through the telescope and compressor before leaving the Spitfire.

1. Align to compressor positions (two 'H') using backwards alignment tool. You will need to unplug the compressor stage cable (REMEMBER TO PLUG BACK IN) TODO: more info
    a. Currently we are allowing this to be slightly misaligned because output qualities are adequate
2. If the cavity / pump was touched, align compressor TODO: more info
3. NOTE: only ~80% of power gets through the compressor due to absorbance into the grating etc.

Finish

1. Make sure you have taken all of your tools out of the laser
2. Make sure you remembered to plug the compressor stage back in

3. Wait for at least 2 hours before moving on to downstream alignment - best to wait overnight if you can. It's OK to make a first pass at rough alignment, but compression and pointing will probably change slightly as the laser equilibrates
4. It's normal to change by ~50 to ~100 mW in the first days after alignment. After that initial change things tend to be stable for weeks

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Stretcher alignment

This is our current best strategy for stretcher alignment. Use caution and keep your brain in gear when working on this. Since we have not messed with the stretcher frequently this guide cannot trusted blindly. Please improve if you find yourself needing to align the stretcher.

Preparation

1. Ensure that the spitfire is off (no pump present in cavity, pockels cells powered down)
2. Force upstream oscillator to go CW, adjust output color to be at center of mode-locked bandwidth
3. Use external mirrors to align through Faraday isolator
4. Use first two mirrors after isolator to alignment tool prior to stretcher grating

Adjustment

1. Adjust the stretcher grating until the four dots are overlapped
2. Use pickoff mirror after stretcher to get the beam to alignment tool

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Compressor alignment

1. Use the first telescope mirror to align to the alignment tool before the first square mirror preceding the compressor
2. Use the second telescope mirror to align to the alignment tool when placed between the square mirrors preceding the compressor

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Known *active* problems - roughly in order encountered by seeded beam

first noticed	description / notes
before records	Easily visible cloudiness on thin polarizer. Laser can work even with this problem. We should watch to see if it gets worse.
Before records	Intercavity pockles cell (PC2) drilled. Currently cavity mode goes through pockles cell off center to avoid drills.

	2016.03.14 Pockels cell cleaned and translated by Dave - got much more power Intercavity pockles cell is probably at end of life. Dave says that otherwise well aligned / clean spitfires will get worse and worse due to loss in PC starting around 5 years old.
Before records	Quarter waveplate drilled. Currently cavity mode goes through waveplate off center and seems to avoid the drills 2016.03.14 Waveplate translated by Dave
2016.03.14	Cavity mirror near crystal on seed side has highly scattering spot on it. 2016.03.14 Mirror rotated by Dave
before records	Compressor grating problems - 'Water spot' on lower left of compressor grating, various scratches etc. Spitfire seems to behave reasonably well with these problems - have aligned grating to miss damage spots as much as possible We have a replacement for this optic ready to install.
2017-11-03	Cleaned grating with methanol and N2. Then flipped grating. Gained 50 mW more output. Took microscope and phone images of damage spots. https://drive.google.com/drive/folders/0BzJTClorMBuwRTZIM2ZDQTI4NTQ

Optics replaced

date	optic(s)
2016.03.14	First mirror in output telescope (TM1) Left-hand mirror in horizontal compressor retroreflector