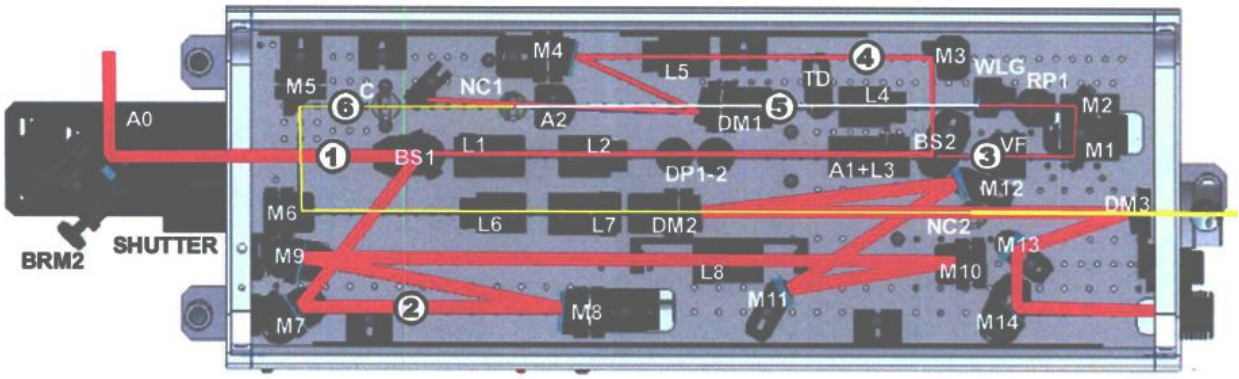
**TOPAS-C internals with labels**




Note that we have an additional aperture installed between BS2 and VF. We refer to this aperture as Awl in this document.

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**Common alignment**

This section discusses common alignment operations that will probably need adjustment on a ~monthly basis to ensure ideal OPA behavior. All fs table users should feel comfortable performing these tuneups.

Tips and tricks

- As a rule of thumb, If you don't need light through the power amp, the light should be blocked to avoid hot spots (→ damage). The light should be blocked before M8.
- Use a fluorescent card to visually get a better idea of the centering of the 800 beam through the apertures.
- Align OPA1 before OPA2. For the sake of consistency, we have agreed that compression should be adjusted for OPA1 best performance. OPA2 will have to 'live with' the compression that best suited OPA1.
- Don't let an unseeded pump into C2 for too long of a period of time. It can damage C2 (as per Light Conversion technicians)

<u>Preparation</u>

1. Ensure that Spitfire is working (between 3.8 and 4.0 W)
2. Ensure that pump is not clipping on any mirrors between Spitfire and OPAs
3. Inspect mode structure of pump for hot spots or diffraction. Clean any dust off of mirrors between Spitfire and OPAs.
4. Open OPA lid.
5. Set OPA to 1300 nm, ensure motors are homed
6. Block pump into poweramp upstream of M8 using block of metal.

<u>Preamp</u>

1. Open OPA shutter
2. Ensure that the WL plate is not drilled - look for ‘sparking’ (this takes an experienced eye, ask if you have a hard time deciding. If drilled, rotate the WL plate.
3. Ensure that input pointing and compression are good for the preamp by iterating through the following adjustments. Stop iteration once all metrics are good without further adjustment.
    a. Iteratively align through A0 and A2. The orange-colored white light should go through A2.
    b. Ensure that your pointing changes have not introduced clipping on external mirrors.
    c. Ensure that white light is good
        i. If you are aligning OPA1, adjust compression such that WLG is maximized. Do not adjust compression to OPA2 WL.
        ii. Adjust Awl until WL is symmetric and stable. Probably need more description, perhaps pictures -BJT
    d. Ensure that no OPG is present in C1.
    e. Manually adjust D1 to maximize seed intensity.
4. Align seed down entire row of holes in which L6, L7, DM2, NC2, and DM3 lie. Alignment is accomplished using M5 and M6.
    a. Alignment tool is useful here.
    b. Low-lights are required in order to see seed well.
    c. An allen key is used to adjust the mirrors (it is metric! 2 mm.)
    d. Note: May block pump into C1 (and pass WL) in order to see what is seed and what isn’t. Blocking is accomplished between L5 and M4.
        i. The goal here is to distinguish between the orangish WL and the redder seed. Seed will disappear when pump is blocked. WL will continue on.
    e. Alignment through C2 may be done by merely centering the (mess of the) beam in the free aperture of the crystal. This alignment is done using M6.

<u>Poweramp</u>

1. Unblock pump into power amp.
2. Setup 407A power meter outside of OPA.
3. Adjust manual D2 until over 600 mW is achieved.
    a. If this is not successful D1 may be adjusted.
    b. If this is not successful upstream compression may be adjusted.
        i. Note: if this is done WL must be checked to ensure it has correct structure.
            1. For optimal WL one may increase ND at VF until WL is just cut out. Compression may be adjusted until WL is regained. ND may then be backed-off. Then compression should be fine-tuned for symmetry of WL structure.
4. Put “Caution fs OPA free to coldwave” sign on doors.

5. Remove all optics downstream of mixer 3—filter periscopes (wavelength selector), periscope, beam splitter, beam dump.
6. Iterate the following until optimal power and collinearity are reached:
    a. Adjust collinearity of three beams using DM2.
        i. Observe beams on coldwave using surveyor's telescope.
        ii. All beams should be spatially overlapped in the far field.
    b. Maximize 407A power using manual D2.
    c. Maximize 407A power using M10.
7. Reassemble optics downstream of Mixer 3.
8. Close OPA lid.
9. Allow to equilibrate.
10. Measure and record power.

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**Tuning**

Once the OPA is aligned well (see above) it is appropriate to tune. Always start with base tuning and then tune on top of that if desired.

**Base (signal)**

1. Home OPA motors
2. Align OPA to monochromator with F0 in place.
    a. Activate array detector. → PyCMDS/devices/devices.ini
    b. Set monochromator to 1300 nm. Grating 1
    c. Measure output power of OPAs with 407A. Touch up compression and pointing if desired.
    d. Ensure beams are through pinhole at sample position. Pinhole now defines point source (leave pinhole in). This source must be imaged onto the entrance slit of the monochromator.
    e. BOTH Slits on the monochromator are generally 150 um.
    f. With pinhole at sample position, place card over grating (monochromator must be opened). Optimize focusing mirror pointing and position until all three beams are incident on card at same alignment of mirror. Intensities on the card should go in and out of existence in unison as beams are horizontally slid over slit.
    g. Remove pinhole from sample position.
3. Choose a single OPA to calibrate. Block other. If tuning OPA2, block one of the split beams. Tradition says to block -2 (the transmitted beam) and couple the reflected beam (2') into monochromator.
4. Flip monochromator into array detector mode using knurled ring in back.
5. Using height degree of freedom on monochromator coupling mirror to maximize power onto array detector.
6. Preamp
    a. Set monochromator and OPA to 1300 nm

b. Block poweramp inside of OPA and replace OPA cover.
c. Achieve ~2 units of peak signal on InGaAs.
    i. Maximize signal on detector with vertical degree of freedom of focusing mirror, and then increase OD using ND stick and automated ND wheels.
    ii. Note, it is easy to land on a local minimum on the array. Move vertical degree of freedom of focusing mirror a fair distance away from the perceived equilibrium to ensure you are not on a local minimum.
d. Ensure motors are homed and OPA lid is on.
e. You will now need to do a MOTORTUNE.
    i. Correct parameters are:
        1. Use Tune Points
        2. Scan Delay_1 0.5x51
        3. All other options 'set'
        4. Do not process
        5. Use InGaAs.
    ii. Following the MOTORTUNE, process the data using the script located at C:\Users\John\Documents\myscripts\workup_of_motor_tune_data.py
        1. Ensure correct filepaths are in use.
        2. After processing, copy new .crv and .png into the PyCMDS OPA folder and load it into PyCMDS.
    iii. Now, perform a tunetest. We currently do this in a backwards manner using MOTORTUNE. All parameters in MOTORTUNE are merely 'set'.
        1. Data may be worked up using a script like:

```
import os
import WrightTools as wt
p = r'C:\Users\John\Desktop\PyCMDS\data\2017-01-10 58150 tuning\002 MOTORTUNE\000 [w1]\000.data'
d = wt.data.from_PyCMDS(p)
artist = wt.artists.mpl_2D(d)
artist.plot('array_signal', output_folder=os.path.dirname(p), autosave=True)
```

7. Poweramp
    a. Achieve ~2 units of peak signal on InGaAs array with OPA poweramp unblocked. Will need to use ND to decrease intensity. Will also need to slightly adjust vertical pointing into monochromator. OPA should be set to 1300 nm.
    b. Ensure OPA lid is on
    c. Perform two MOTORTUNEs (after each successive motor tune, process and load in the new, resulting .crv into PyCMDS)
        i. Delay 2 3x51
        ii. Crystal 2 0.5x51
    d. In the same manner as the preamp, perform a TUNETEST.
8. Restart PyCMDS without InGaS array.

9. Use 407A to measure power curve of OPA directly following OPA output.
    a. Plug 407A into BNC splitter that preamp generally plugs into.
    b. Ensure ‘use baseline’ on DAQ is not engaged. Use Signal mean and have choppers off.
    c. Ensure 407A output is zeroed according to DAQ.
    d. Perform scan. 6200 - 8700 wn x 51. 3000 ms waittime on 407A. 100 shots

**SHS**

1. Place mixer 2 in place.
2. In PyCMDS choose the interaction string for the OPA to be NON-SH-NON-Sig.
3. If desired place a thin film polarizer after mixer 2 to reject extra signal.
4. Align OPAs through mask, pinhole, and into monochromator.
5. Attach silicon photodiode to preamp and DAQ. Attenuate intensity until potential on the shot level is ~2V.
6. Perform MotorTune: M2 5x21, spec -5000x51. Workup. Apply curve in PyCMDS.
7. Perform TuneTest.

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**Full alignment**

The following discussion endeavors to be as complete as possible. The goal is to have a procedure that produces a well-aligned OPA regardless of initial conditions. Experienced OPA users may find only pieces of this guide necessary to solve their particular problem.

Preparation

1. Ensure that Spitfire is working well (between 3.8 and 4.0 W)
2. Ensure that pump is not clipping on any mirrors between Spitfire and OPAs
3. Inspect mode structure of pump for hot spots or diffraction. Clean any dust off of mirrors between Spitfire and OPAs.
4. Open OPA lid.
5. Set OPA to 1300 nm, ensure motors are homed
6. Block pump into poweramp upstream of M8 using block of metal.
7. Block seed between compensating crystal and M5
8. (Recommended) remove all side walls from OPA

Input pointing

Input pointing is adjusted to ensure good alignment through L1 and L2 into D1.

1. Remove A1/L3, VF, WL aperture.
2. Place D2 at nominal position (45 degrees) is this correct? - BJT
3. Using external mirrors, ensure that beam propagates through the alignment tool at the holes just after L2 and just before M1 (in D1).
4. Ensure that you have not introduced clipping external to the OPA

5. Ensure that the L1/L2 telescope is outputting a collimated, undistorted beam

D1 alignment

1. If you haven't already, remove A1/L3, VF
2. Ensure that you are blocking light between compensating crystal and M5
3. Remove WLG plate, L4, TD, DM1, knife edge
4. Set C1 to surface normal (should be 0 degrees if affix is set correctly in software)
5. Using M1 and M2, ensure that beam propagates through the alignment tool at the holes just after M2 and just before M5

White light

1. Block preamp pump after M3 during this procedure
2. Remove WL plate if it is present
3. Replace/adjust A1/L3, adjusting focus to be at white light plate desired position how? - BJT
4. Replace VF and Awl if they are absent
5. Place the WL plate - ensure the plate is normal to input beam by visual inspection
6. Optimize WLG using VF, Awl, and plate position
    a. Begin with Awl close
    b. Open Awlg +10%
    c. Adjust VF to just allow for onset of WLG
    d. Adjust position of sapphire plate to maximize visible component of continuum
    e. Adjust VF to attenuate WLG pump to lowest WLG threshold where central mode and first outer rings are visible
    f. Adjust compression for WLG symmetry
    g. Continue to open Awl and adjust VF until Awl is as open as possible and VF is as dark as possible (while maintaining stable WLG)
2. Replace/adjust L4
    a. Remove DM1 if it is present
    b. Adjust L4 so that the *visible* component of the WL continuum is focused on A2. This will ensure that the *NIR* component focuses at NC1
    c. Ensure that the WL remains centered on the alignment tool / A2
        i. L4 may be rotated to adjust height
    d. Replace DM1

Preamp pump

1. Remove L5, M4
2. Adjust M3, to alignment tool in holes near edge of OPA to M5 mount. Note that M3 may be rotated to change height.
3. Ensure that beam is passing through alignment tool near M3. If not, consider translating M3 or moving BS2. Before making these adjustments ensure that the beam is true into BS2 (see input pointing section above).
4. Replace L5. Ensure that beam through L5 is on-axis with alignment tool in far field.

5. Replace M4. Point pump so that it intersects with the first red ring in the WL at DM1.
6. Adjust DM1 to spatially overlap pump with WL in NC1
7. Adjust L5 so pump focus is in C1. If OPG in C1 is seen 'back off' L5 by moving towards M3 until OPG disappears.

Seed

1. Ensure that both WL and pump are entering C1 properly. See above sections for more information.
2. Remove M5 if present
3. Manually adjust D1 to optimize seed generation.
4. Make *fine* adjustments to M4 and DM1 to ensure that the seed travels along alignment tool all the way to the wall. If large adjustments need to be made something upstream must be wrong.
5. Replace M5
6. Replace knife edge, if absent
    a. Ensure you are not clipping the red seed profile
7. Remove L6 and L7 if present
8. Use M5 and M6 to align the seed to the alignment guide through C2 and out of the OPA
9. Replace L6 and L7 how? - BJT

Poweramp

1. Ensure that pump is not clipping on BS1, M7.
2. Center pump on M8 using M7
3. Remove L8 if present
4. Using M8, M9, alignment tool ensure that pump travels along holes from M9 to M10
5. Replace L8 how? - BJT
    a. Back of L8 mount to front of M10 should be ~15 cm
6. Without clipping, place M11 and point M10 to minimize off-axis angle at M10. (This requires us to put the pump ¼" right of center as viewed while facing M11)
7. Center pump on M12 using M11
8. Center pump on DM2 using M12
9. Overlap with seed in NC2 using DM2
10. Make small adjustments to M10, DM2 to perfect collinearity and overlap
11. Adjust manual D2 until over 600 mW is achieved.
12. Put "Caution fs OPA free to coldwave" sign on door.
13. Remove all optics downstream of motor 3—filter periscopes (wavelength selector), periscope, beam splitter, beam dump.
14. Iterate the following until optimal power and collinearity are reached:
    a. Adjust collinearity of three beams using DM2.
        i. Observe beams on coldwave using surveyor's telescope.
        ii. All beams should be spatially overlapped in the far field.
    b. Maximize 407A power using manual D2.
    c. Maximize 407A power using M10.

15. Reassemble optics downstream of motor 3.
16. Close OPA lid.
17. Allow to equilibrate.
18. Measure and record power.

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**OPA1 (10743) status notes**

**OPA1 (10743) known *active* problems - roughly in order encountered**

| first noticed | description / notes |
|---|---|
| 2016.05.20 | L4 has a hot spot slightly above center. May be notice 1 mm after lens. |
| 2016.05.20 | L7 has a hot spot in center. May be noticed 2 cm after lens. |
| 2016.05.20 | L6 has a hot spot high of center. May be noticed 2 cm after lens. |

**OPA1 (10743) optics replaced**

| date | optic(s) |
|---|---|
| 2016.03.15 | M5, M6 |

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**OPA2 (10742) status notes**

**OPA2 (10742) known *active* problems - roughly in order encountered**

| first noticed | description / notes |
|---|---|
| 2016.03.14 | Cloudiness in C1<br><br>Cleaned 2016.03.15 - looks a lot better but still noticeably cloudy |
| 2016.05.19 (DJM) | Observed hot spot in seed after C2. Traced spot back to L7.<br>Moved knife edge a tiny bit to ensure that seed was not being clipped. Hot spot still there. Kyle thinks this is not a problem. |
| 2016.05.21 | Two drill spots on M8 due to accident involving M10. |

**OPA2 (10742) optics replaced**

| date | optic(s) |
|---|---|
| 2016.03.15 | M5, M6, C2 |

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**Notes:**

The cylinder that the sapphire WL plate is attached to is 5/16 in in diameter. -DJM

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**ORIGINAL NOTES BY DARIEN AND KYLE**

Notes for May 18, 2016 (6 pm) -- Darien writing, Kyle aligning.
Starting from scratch on OPA1. Power-amp mode was non-Gaussian in a dimension in the far field (kold-wave).
**Took picture of OPA2**

PREAMP SEED GENERATION  ALIGNMENT

1. Removed poweramp wall, preamp wall1, preamp wall2.
2. **Blocked light before M5** and before M3 using metal blocks.
3. Moved M12 foot to new correct position to allow for aperture that is currently being shipped. In doing so accidentally turned mirror, will need to be corrected at a later time tonight.
4. Removed: A1/L3, L4, TD, M12, knife edge (pump blocker) in pre-amp.
5. **Took pictures of OPA1. 6:09 pm.**
6. Removed VF (put in optics cabinet).
7. Removed Sapphire WLG plate.
8. Removed DM1.
9. **Took picture of OPA1. 6:19 pm.**
10. Defined pre-amp alignment tool positions.
    a. Near-field: after L2 before D2.
    b. Far-field: after BS2 before M1.
    **c. Took pictures of OPA1. 6:21 pm.**
    **d. Took picture of OPA1. 6:29 pm.**
11. D2 was set to be ~brewster's angle using Win-TOPAS software. (55.4 degrees)
12. Blocked output downstream of M3 to prevent loose preamp pump from M4.
13. Opened shutter.
14. Went low-lights. Used two external mirrors to iteratively align to near-field and far-field pre-amp alignment points. This effectively aligned the input pointing.
    a. **Took picture of OPA1. 6:40 pm.**

    b. Note: used alignment tool directly after shutter to ensure that input pointing was in the generally correct alignment.
    c. One should not close down on A0 in this step. This assumes mode structure through A0 is ideal—this may not be the case.
    d. Note: flat side of alignment tool was used for easier spotting of light.
    e. Ensure calf stretch is accomplished after this alignment. Sudden cramping is detrimental to OPA mirrors.
15. Aligned to alignment tool before A2 using M2.
16. Sent C1 to 0 degrees. Then decided to pull out crystal from mount.
17. Aligned to just after L2 and just after M2 using external mirrors.
18. Then aligned to just after M2 and just before A2 using last external mirror and M2.
19. Went high-lights. **Took pictures of OPA1. 8:03 pm.**
20. Blocked pump light into BS2.
21. Removed L5 and M4.
22. Blocked light after BS2.
23. Aligned M3 and BS2.
    a. Near-field movement was accomplished by rotating BS2 in its mount.
    b. Far-field movement was accomplished by rotating M3.
        i. Height was slightly off. So rotated mirror slightly in mount.
    **c. Took pictures of OPA1. 8:18 pm.**
24. Replaced L4.
    a. Mount was ensured to be parallel to the optical axis (holes)
    b. Alignment tool in front of A2 was used to ensure lateral position and height of beam was correct.
        i. At this point the light out of L4 fills the alignment tool.
    c. Focus of beam was watched to ensure that a symmetric collapsing on the focal point was accomplished.
        i. This was done by shifting the lens left-and-right in the mount.
    d. Lens was rotated in mount to ensure the correct height was achieved at the alignment tool.
25. Replaced L5.
    a. Alignment tool was placed down by M5.
    b. Lens mount was approximately put parallel to optical axis.
    c. WL was generated in air around where M4 would be.
    d. Airy disk pattern was centered into alignment tool.
        i. Correct height was accomplished by rotation of lens.
        ii. Fluorescent card was used to ensure that a symmetric WL mode was accomplished.
        iii. Iterated through (i) and (ii) to optimize WL.
        iv. NOTE: WL mode is rather divergent, so alignment tool may be moved along the optical axis to ensure optimum mode quality. Different rings of the airy disk may be used.
26. Replaced A1/L3.

    a. Placed lens. Found where focus of WL pump would be.
27. Replaced VF.
    a. Ensured beam passed through free aperture of VF.
28. Replaced Sapphire plate. Note A1 was closed down and ND was high (large attenuation).
    a. OPA2 was opened up. Compression of Spitfire was optimized for WL generation mode symmetry in OPA2.
        i. This effectively constrains us to have to make a good ( left-right symmetric and stable) WL mode by tweaking A1/L3 and the sapphire plate.
            1. Twisting the plate doesn't change much. So plate was set normal to optical axis.
            2. Adjusted mount position to ensure beam intersected the sapphire plate close to the edge of the plate (maximized potential surface area to rotate through)
        ii. Opened A1 to ~10%. Decreased VF attenuation until just saw WL being generated.
        iii. Pulled/pushed the sapphire plate through the optical axis to get the maximum WL intensity.
        iv. Aperture size was increased with VF attenuated also. Iterated until WL intensity was maximized whilst maintaining a single filament.
    b. A combination of rotation of A1/L3 and walking the lateral adjustment (all whilst keeping the mount in the same place) gave bright and symmetric WL.
29. Replaced DM1.
    a. Made sure to be roughly on center with WL mode.
30. Blocked with card where a beam reflecting from M4 could strike DP1-2.
31. Fixed L5.
    a. Rotated lens in mount until vertical alignment was correct through alignment tool down by M5.
    b. Also translated LR very slightly.
32. **Ensure Light is blocked at M5**!
33. Replaced M4.
    a. Merely replicated positioning of M4 in other OPA.
    b. Macroscopic pointing out of M4 was adjusted to ensure pump was nearly horizontally overlapped with WL mode at DM1.
34. Adjusted kinematic mounts of M4 and DM1 to optimize overlap of pump with WL where C1 would be.
    a. Note, cards should be placed in beam path very fast to ensure that partial chopping of beam is not taking place.
35. Blocked WL pump by M1.
36. Blocked pump by L5.
37. Closed down A1.
38. Replaced C1.

39. Unblocked pump at L5.
40. If WL is generated in C1 by pump, block pump again and translate L5's tube lens back away from M4.
    a. Block in front of C1.
    b. Close down A2.
        i. Ensure L5 has not been rotated.
    c. Iterated through these steps until WL is no longer generated. Note, once strong WL is not being generated then L5 may be slid back and forth until ideal position is reached.
    d. Once maximum pump intensity is reached with no WL lock things down.
41. Blocked C1. Opened up A1 whilst watching WL generated by sapphire plate.
    a. Open up A1 until previously optimized WL modes is returned to.
        i. Note, if AWLG was in place, this type of step would be very different.
42. Unblock C1 quickly.
    a. If: pump generates WL in C1, move L5 tube lens backwards (away from M4).
    b. Else: Move L5 towards tube lens forward (towards M4) until OPG (greenish light on side of pump, diffuse mode) observed prior to compensator.
        i. Then: move L5 tube lens back slightly until OPG stops.
        ii. Note: if OPG cannot be generated then L5 is macroscopically in the wrong place. Hence, will need to be moved and totally realigned. One should cry at this point.
43. Block pump prior to M3.
44. Replaced TD.
    a. Ensured WL mode is passing through the free aperture of TD.
45. Optimized focusing of WL into C1.
    a. L4 was rotated until height of WL was correct at A2.
    b. Ensure WL mode is not distorted all along beam path from L4 until C1. If it is distorted than the horizontal position of L4 will need to be changed.
    c. Center of WL mode ought to be able to pass through A2. THis entails that the visible component of the WL ought to be focused pretty much at A2. This means the IR component (what we want) will be focused into C1.
46. Ensure spatial orientation of pump and WL are what they should be on DM1. If not adjust M4.
47. Ensure spatial orientation of pump and WL are what they should be in C1. If not adjust DM1.
48. Now we have correct overlap of pump and WL in C1! YAY!!!!
49. Set C1 to 0 degrees.
50. Scan Manual D1 to look for SFS (green) between pump and WLC. Once it is located maximize SFS intensity using Manual D1. This ensures temporal overlap between pump and WLC.
    a. If SFS is not present, ensure pump and WL are overlapped in C1.
51. Iterate C1 angle with steps of -2 degrees until seed (red) is observed at form at center of WL mode after C1.

    a. At each step maximize SFS using Manual D1.
    b. Brightest seed will be yellow at more negative C1 values. Brightest seed will be red at less negative C1 values.
52. Introduce knife-edge to cut out all processes but pass seed (red).
53. Congratulations the Preamp has been aligned! Woot!

PREAMP COLLINEARITY ALIGNMENT

1. Remove L6 and L7 tube lens assembles from optical mounts.
2. Unblock M5.
3. Ensure seed is hitting near center of M5. If not move M5.
4. Adjust kinematics of M5 to center seed onto M6.
5. Use alignment tool post-M6 and post-C2 to iteratively adjust M5 and M6.
    a. Ensure pump is not clipped with alignment tool.
6. Replace L6.
    a. Rotate lens tube until seed passes through alignment tool in near and far field positions.
7. Replace L7.
    a. Rotate lens tube until seed passes through alignment tool in near and far field positions.
8. Congratulations, the Preamp has been aligned for collinearity!

POWERAMP ALIGNMENT

1. Remove doubled walled guard.
2. Remove L8.
3. Ensure pump light off of BS1 is centered on M7.
4. Ensure pump light off of M7 is centered on M8.
5. Ensure pump light off of M8 is centered on M9.
6. Cover C2 with card.
7. Align light off of M9 using alignment tool (raised with a nut).
    a. Near field is in trough. Far field is pre-M10.
    b. Move M9 if far field is incorrect.
        i. This can be a pain because it is not a kinematic mount.
8. Replace L8.
    a. From back of L8 mount to front of M10 should be ~15 cm.
9. Moved M11 so that off-axis angle on M10 is smaller. M11 barely clears pump beam between L8 and M10.weaeweaweatwedfd
10. Moved M10 back slightly to be ~15.1 cm away from L8 mount.