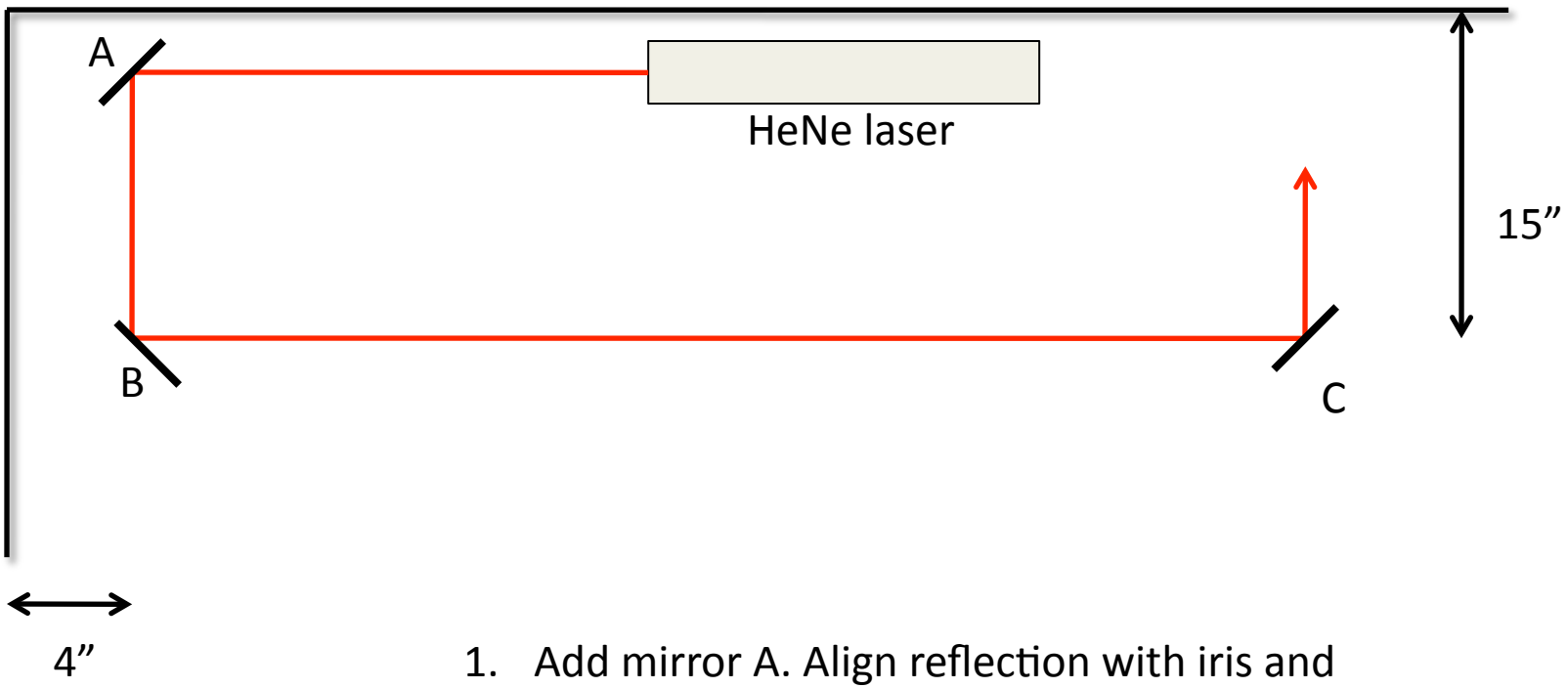
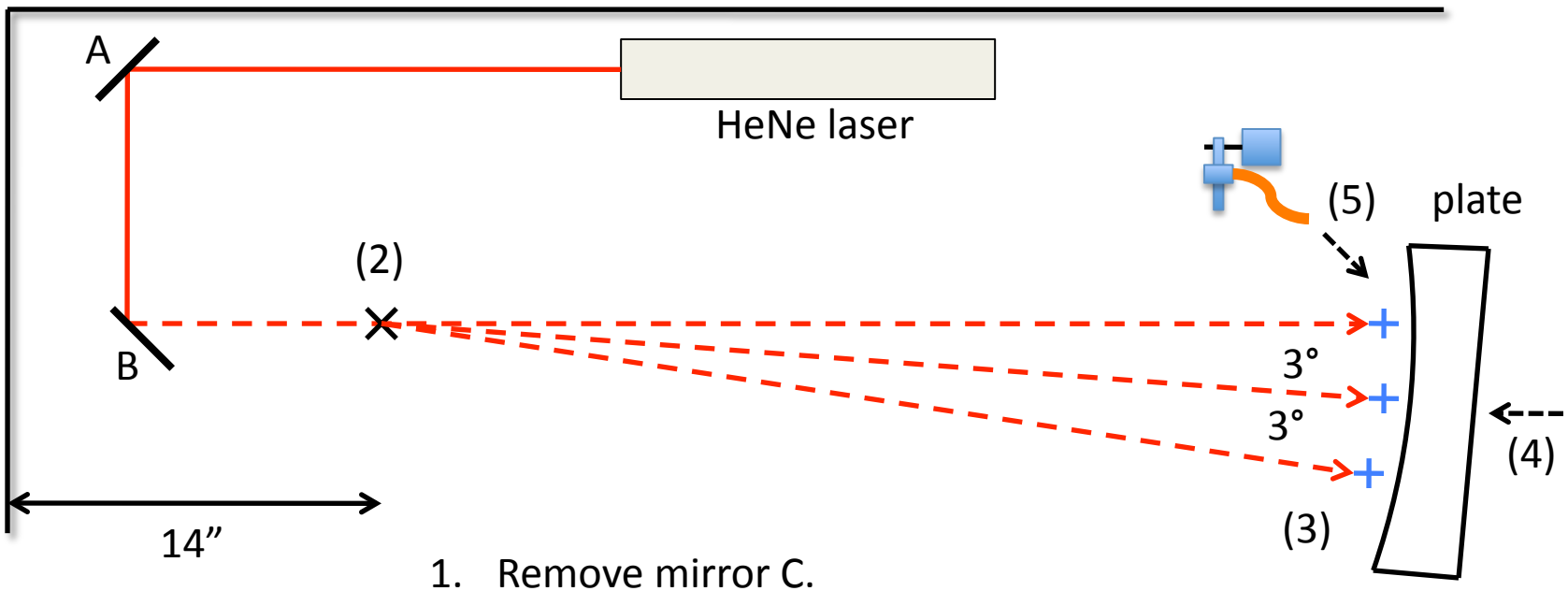
Activity I (MM): Basic Alignment



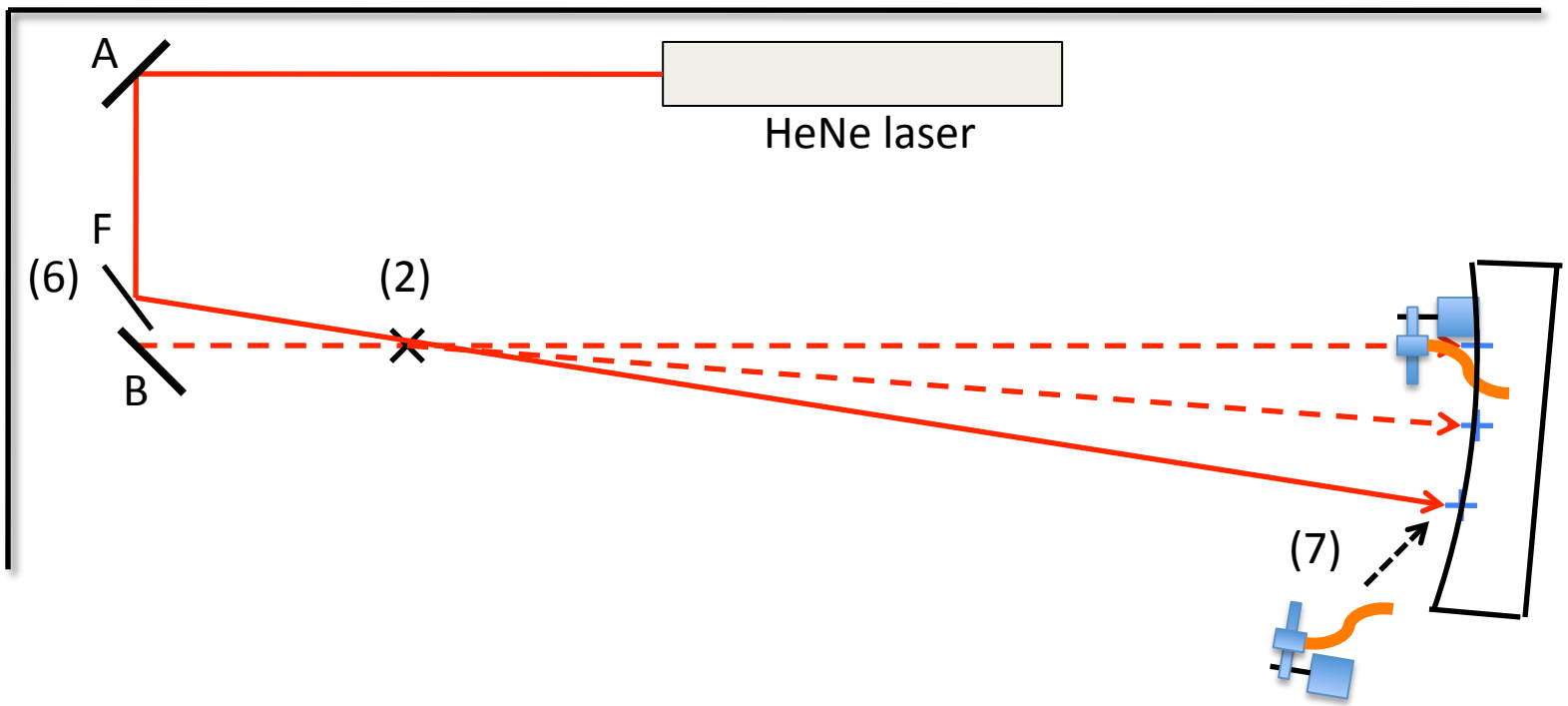
1. Add mirror A. Align reflection with iris and knurled screws.
2. Add mirror B. Reflection must be close to the edge of the mirror. Align reflection with iris and knurled screws.
3. Add mirror C. Align reflection with iris and knurled screws.

Activity II (MM): Parametric Down Conversion



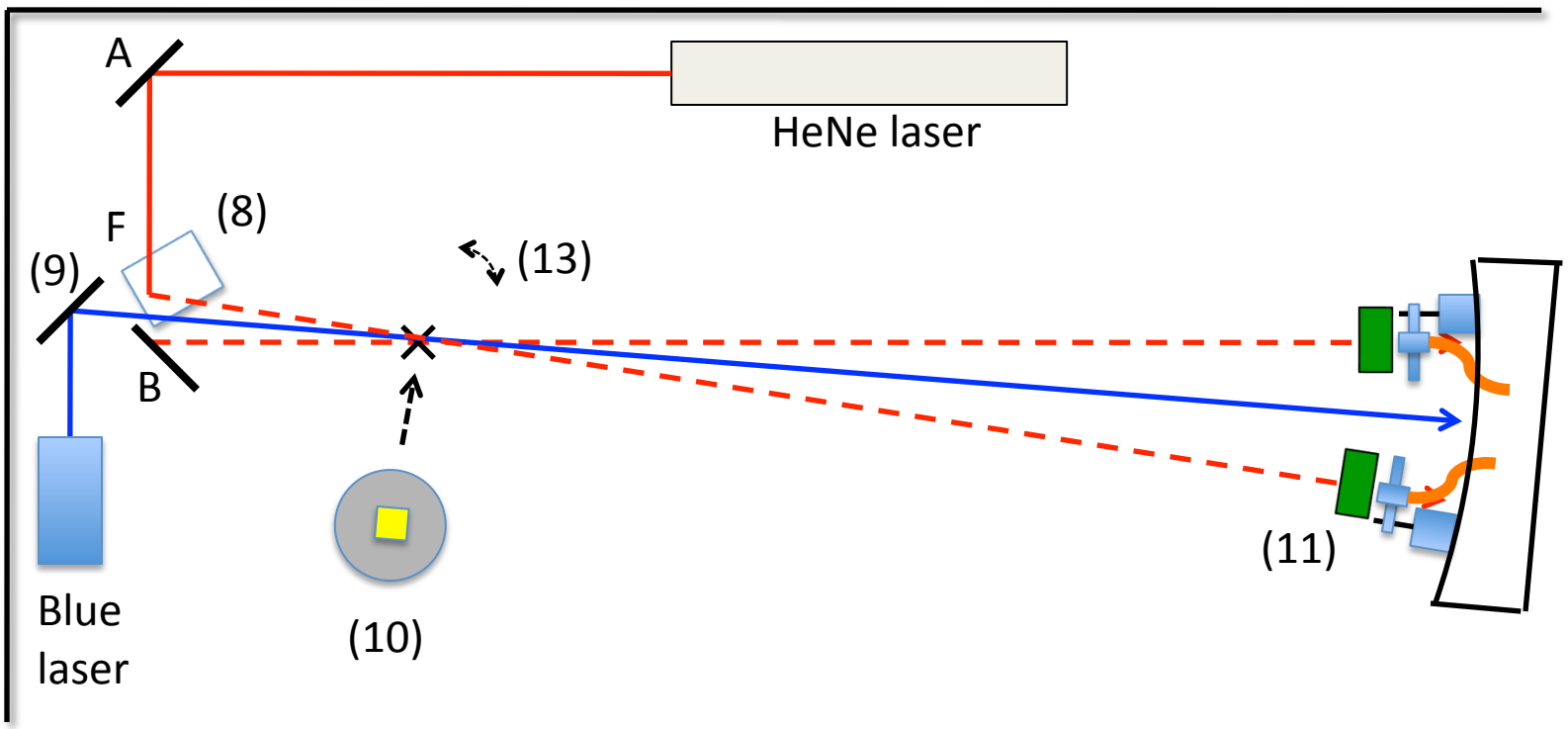
1. Remove mirror C.
2. Make a pencil mark “X” where the crystal will go (in path of the HeNe beam and 14” from left edge of the breadboard).
3. Place three “+” marks 1-m away from “X” as shown (3 degree from each other). Use plumb bob.
4. Place plate over marks.
5. Place collimator with fiber in path of HeNe beam and against the plate, and align it so that light comes out of the other end of the fiber. Use mirrors and iris.

Activity II (MM) cont.



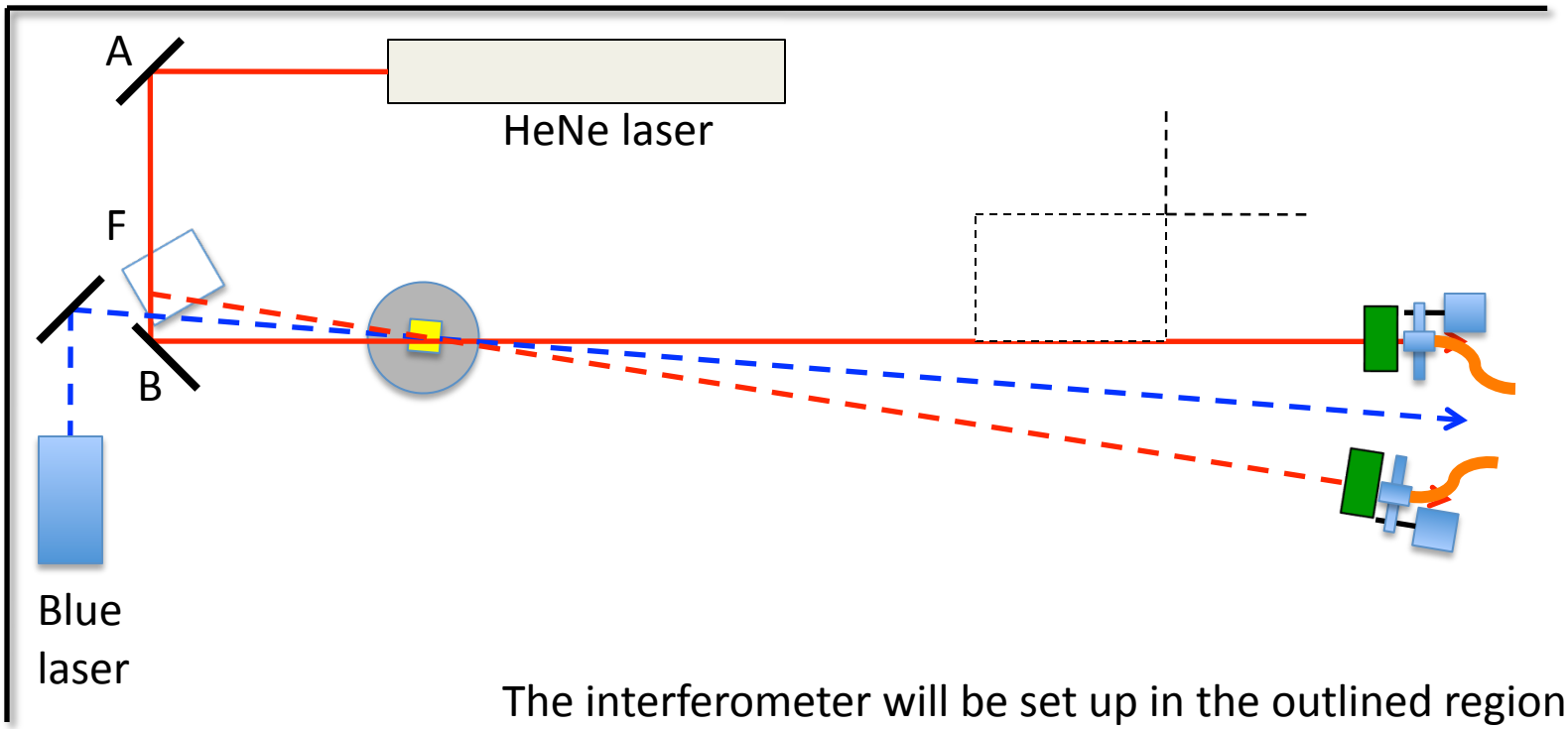
6. Insert Flipper mirror (F) and align the beam to go over the widest "+" mark. Use plumb bob and iris.
7. Place second collimator in the path of the beam and against the plate so that the light comes at the other end of the fiber.

Activity II (MM) cont.



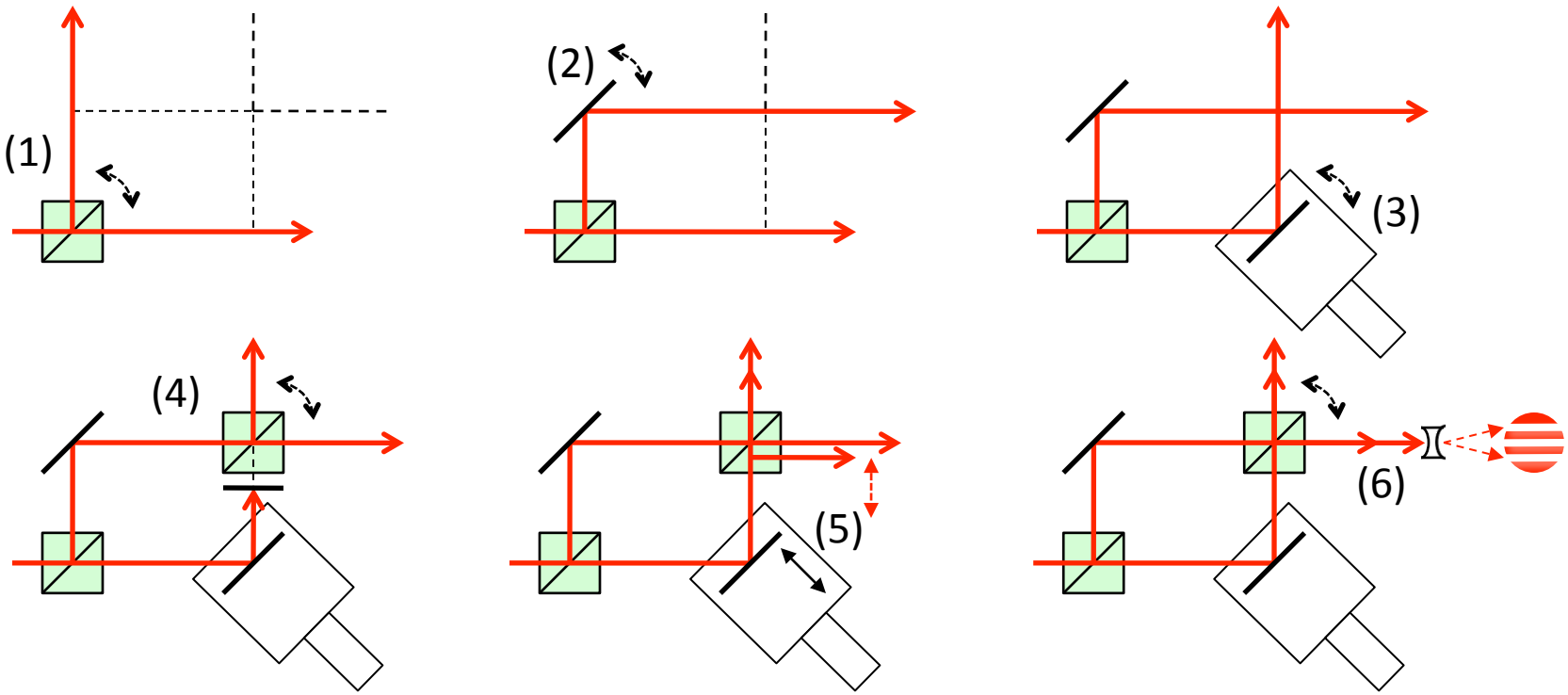
8. Flip the mirror.
9. Place blue laser and mirror to send the beam through the middle path shown. Use plumb bob and iris.
10. Place the down conversion crystal over the “x”.
11. Place filters in front of the collimators.
12. Turn off the lights. Turn on the electronics. Look for coincidences.
13. Maximize coincidences. By tilting collimators and crystal.

Activity III (MA): Setting up an interferometer.



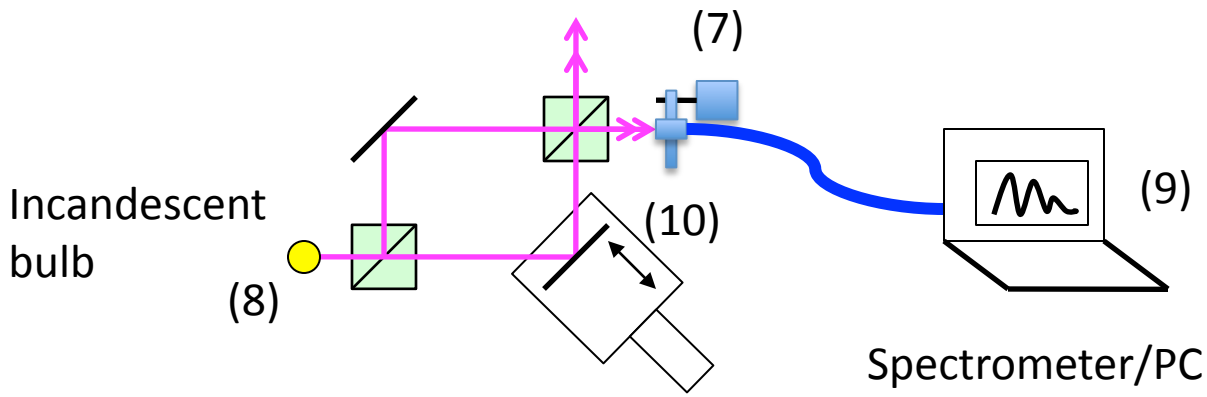
The interferometer will be set up in the outlined region.
See next steps in setting up the interferometer.

Activity III (MA): Setting up an interferometer.



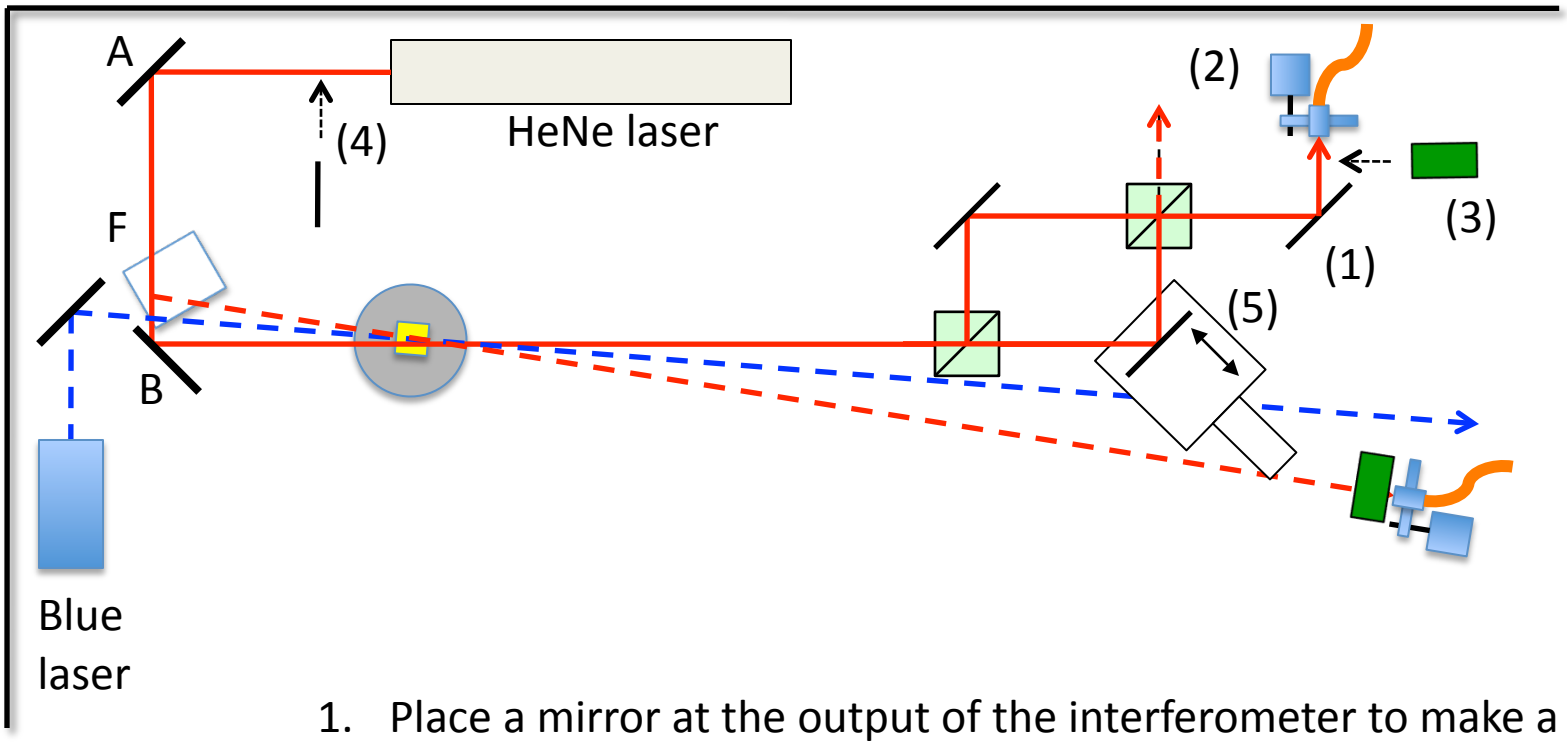
1. Insert beam splitter. Align reflection with irises and knurled knobs.
2. Insert mirror. . Align reflection with irises and knurled knobs.
3. Insert mirror on translation stage. . Align reflection with irises and knurled knobs.
4. Insert beam splitter. Align reflection with irises and knurled knobs.
5. Adjust translation stage so that reflections at the second beam splitter overlap.
6. Add diverging lens to expand the beam and adjust tilt of second beam splitter for broadest fringes

Activity III (MA): Setting up an interferometer- cont.



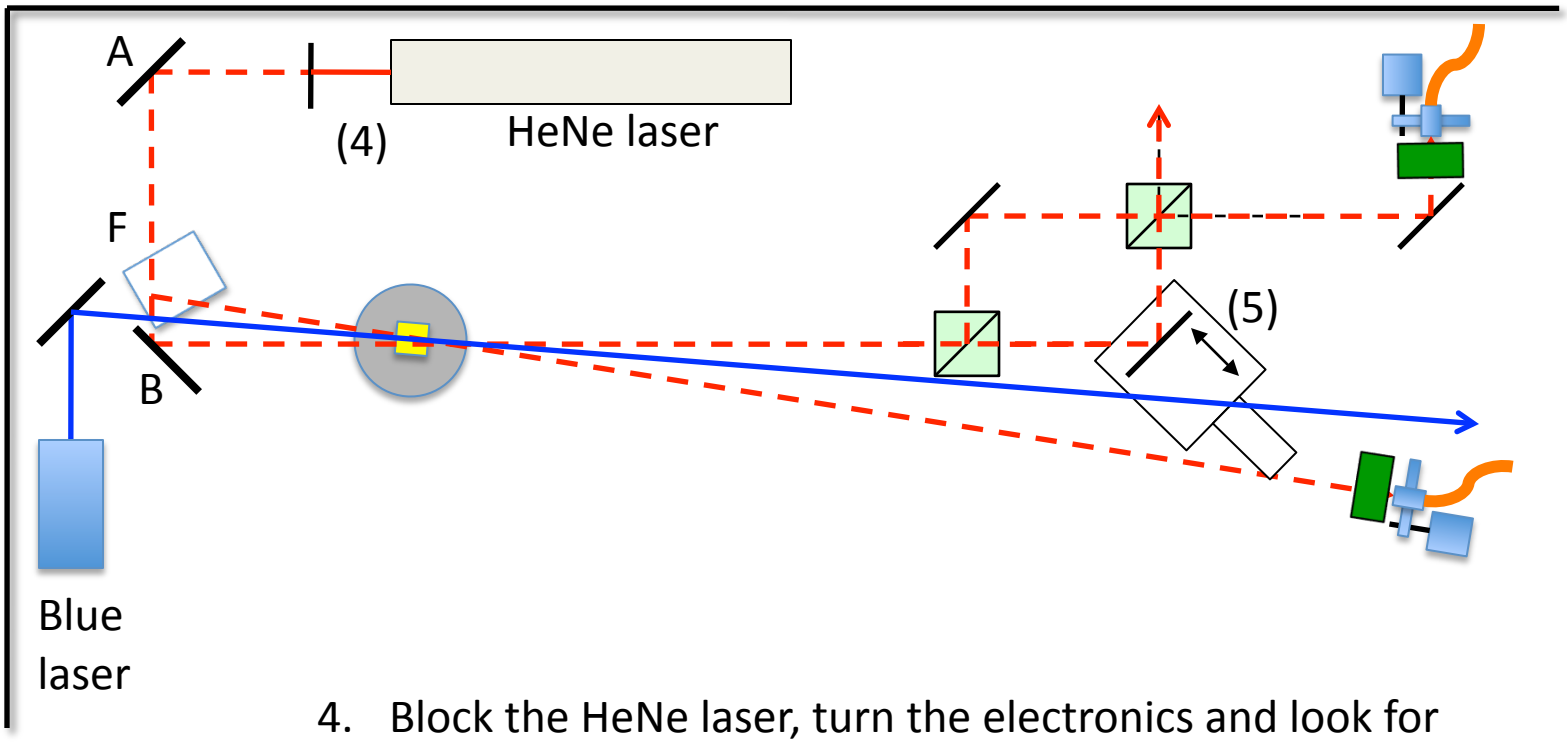
7. Place the fiber mount and spectrometer looking into the output of the interferometer.
8. Place an incandescent bulb at the input of the interferometer.
9. Observe the fringes of the spectrum.
10. Broaden the fringes by translating the stage.
11. Remove the bulb and spectrometer and allow HeNe beam to go through the interferometer. Check that the interferometer is still aligned.
12. If previous is negative, align and repeat (7)-(10).

Activity IV (MA/TM?): Single-photon interference.



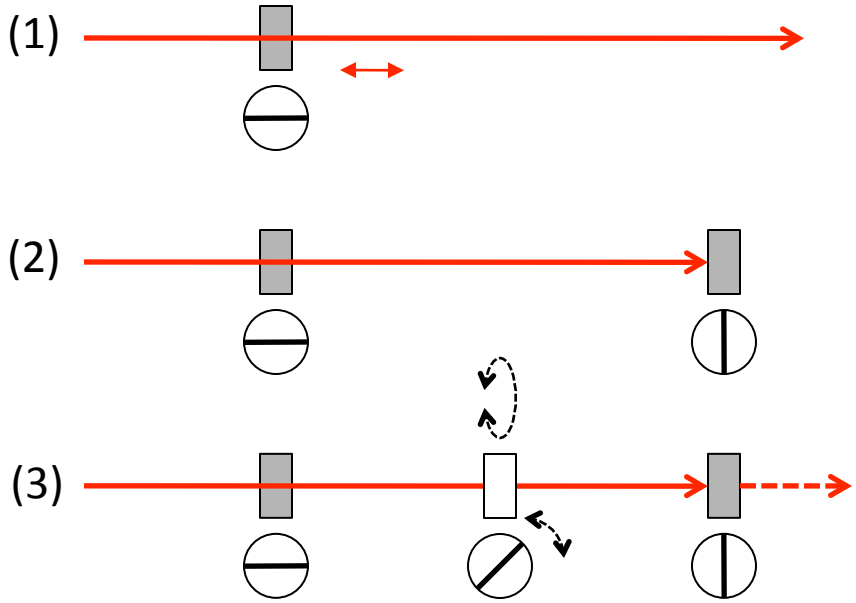
1. Place a mirror at the output of the interferometer to make a the beam turn 90 degrees.
2. Place the collimator and fiber, and align it so that the laser goes through the fiber.
3. Place the filter in front of the interferometer.
4. Block the HeNe laser, turn the electronics and look for coincidences.
5. Do piezo scans with labview program “DynamicalPhaseCounter”.

Activity IV (MA/TM?): Single-photon interference.



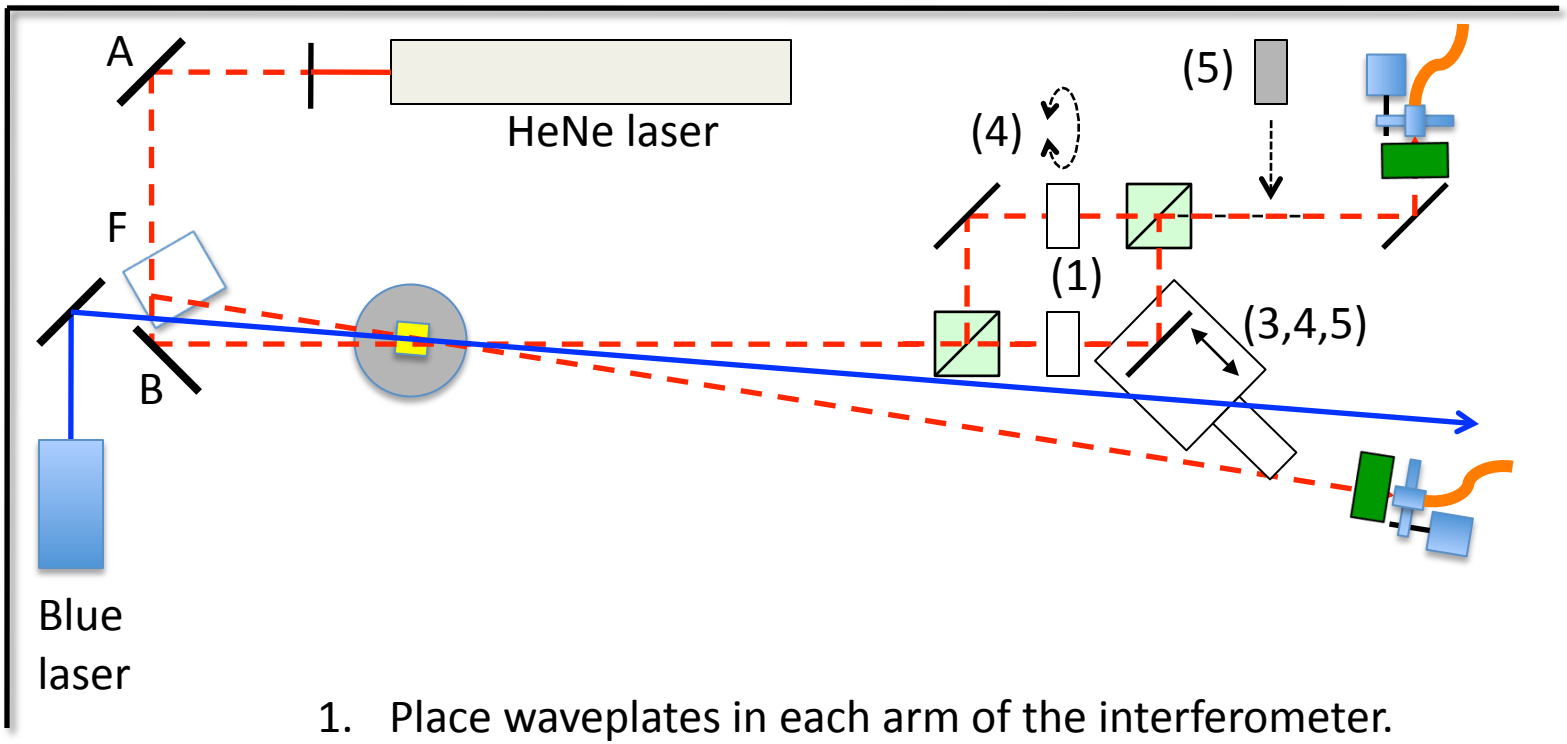
4. Block the HeNe laser, turn the electronics and look for coincidences.
5. Do piezo scans with labview program “DynamicalPhaseCounter”.

Activity V (MA): Setting up waveplates.



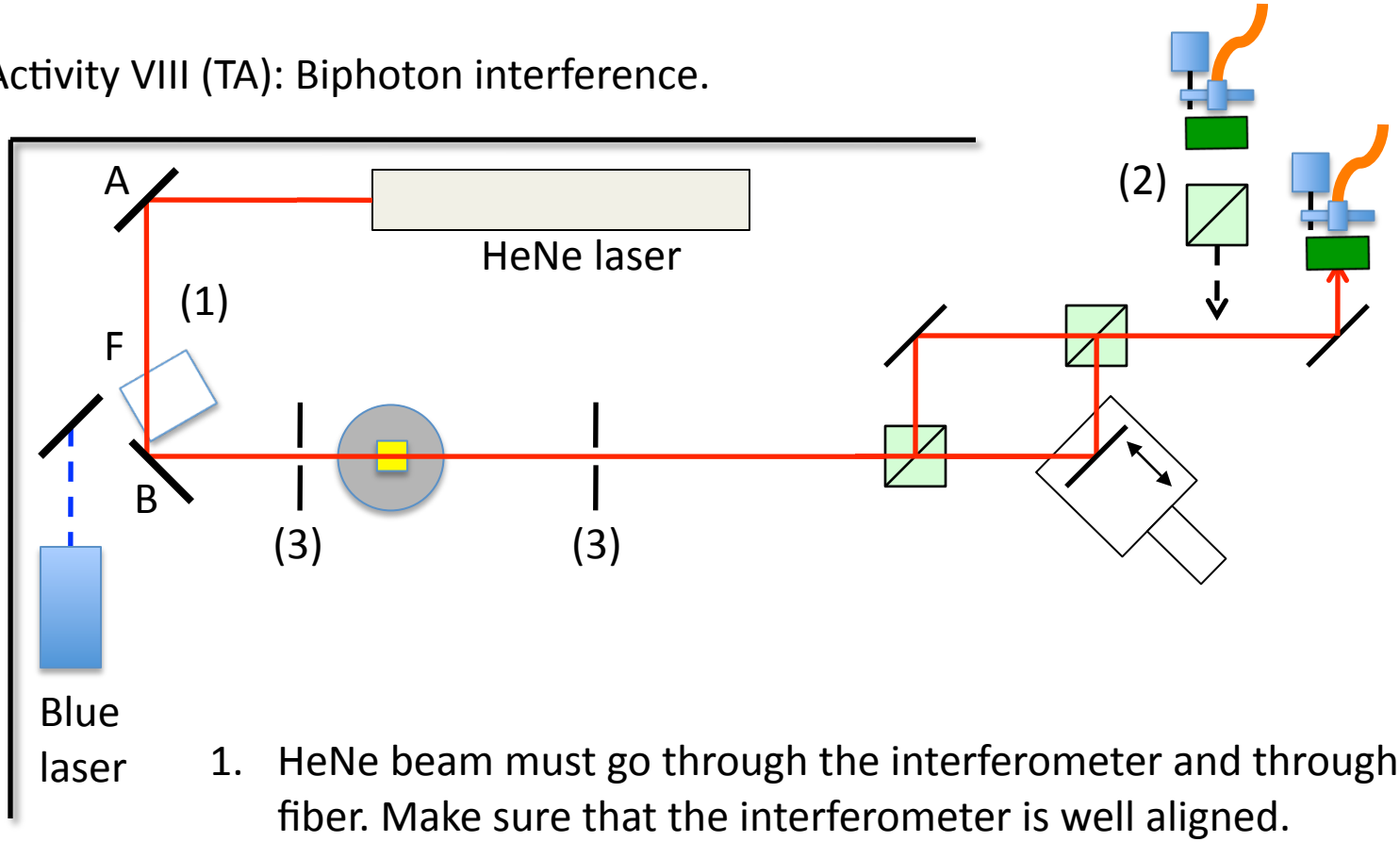
1. Set a polarizer with its transmission axis horizontal.
2. Insert a second polarizer with its transmission axis vertical. No light should be transmitted.
3. Insert the half-wave plate in between the polarizers. When the axis of the waveplate is aligned with either polarizer (it does not matter which), there should be no light transmitter through the waveplate.
4. Use this method to find the axes of both waveplates.

Activity VII (TM): Quantum Eraser.



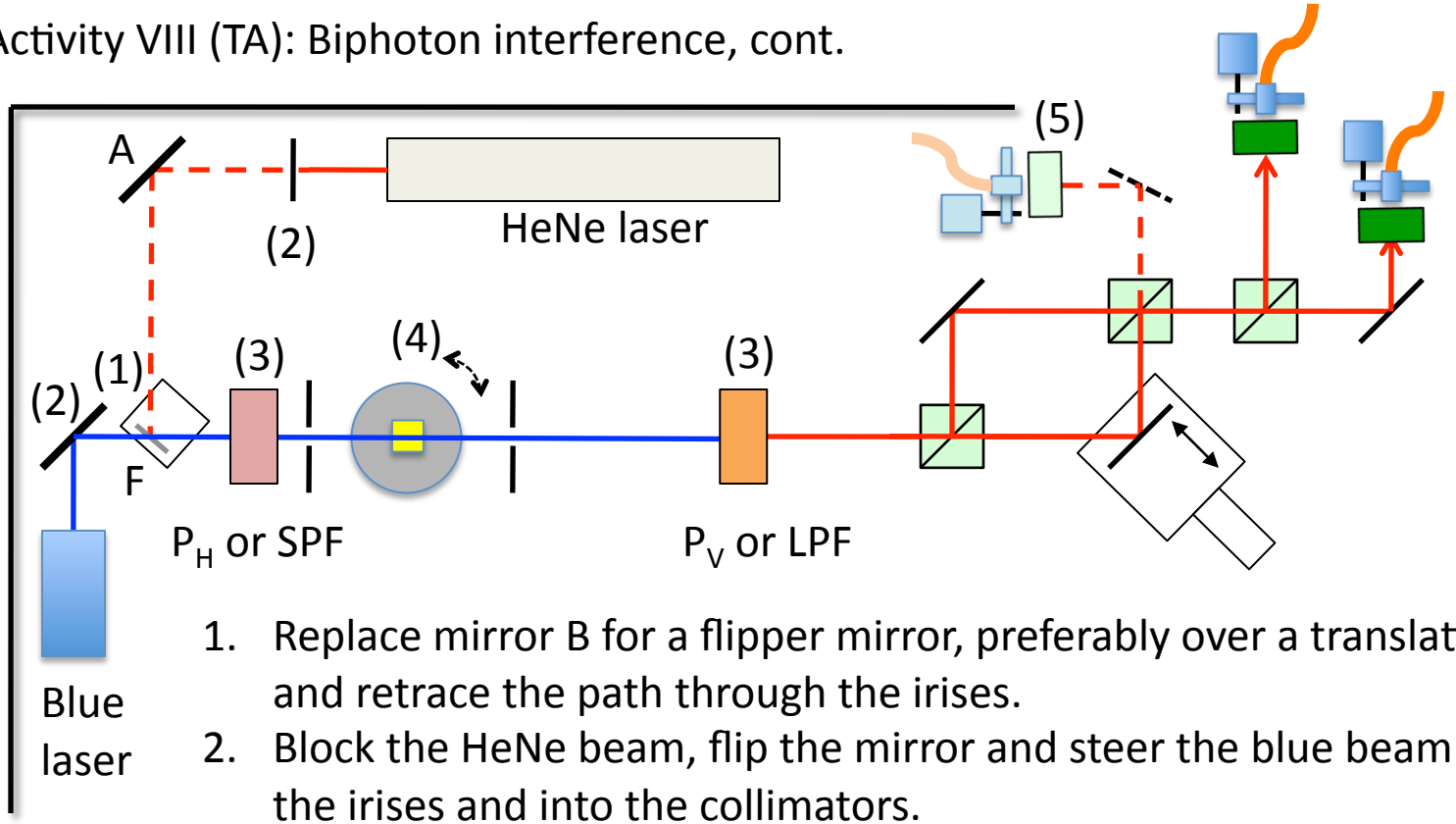
1. Place waveplates in each arm of the interferometer.
2. Redo the white-light fringes adjustment.
3. Do a piezo scan. It should show high-visibility fringes.
4. Rotate one of the waveplates by 45 degrees. Redo the scan. It should show no fringes.
5. Place a polarizer tilted 45 degrees after the interferometer. Redo the scan. Fringes should reappear at half the amplitude.

Activity VIII (TA): Biphoton interference.



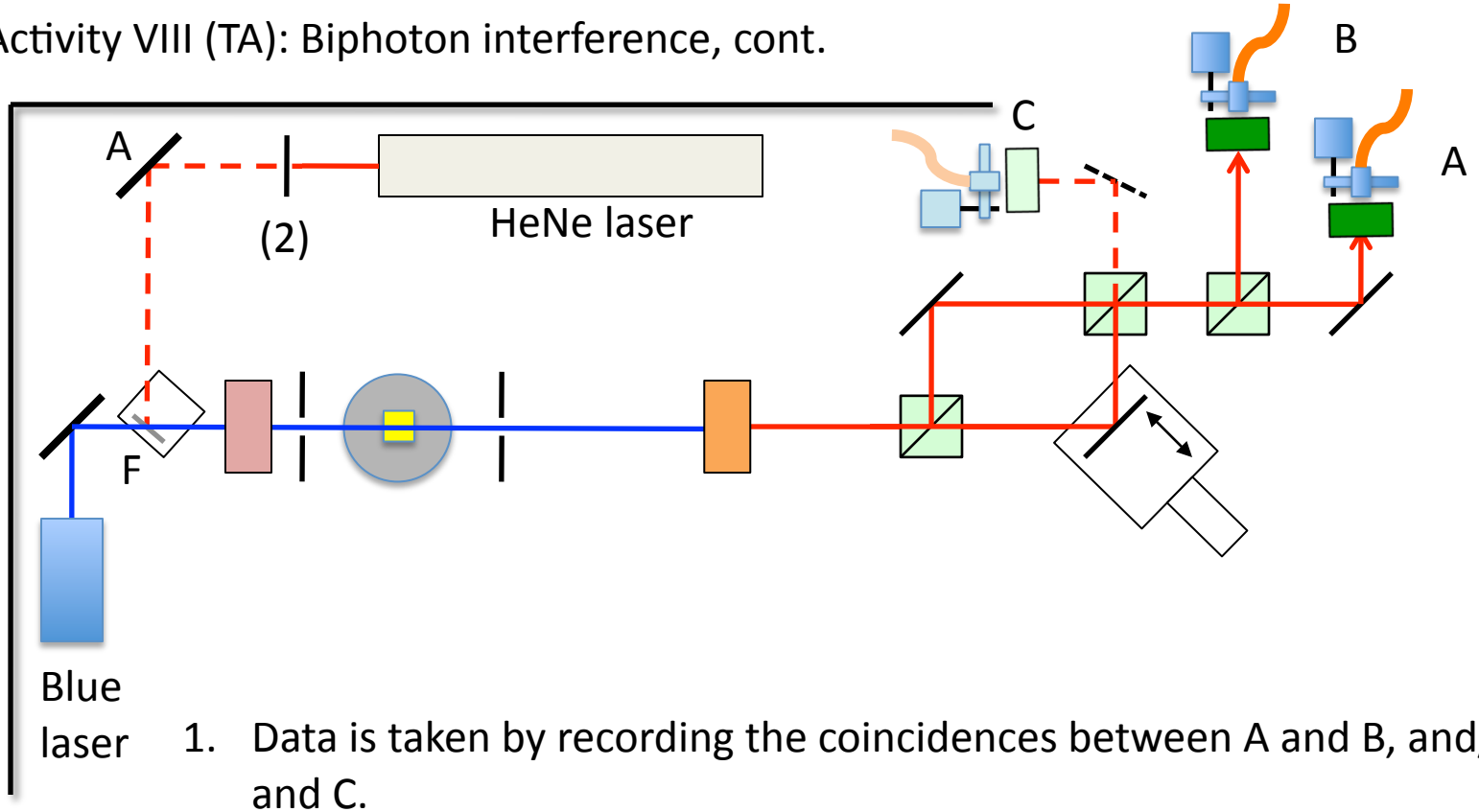
1. HeNe beam must go through the interferometer and through the fiber. Make sure that the interferometer is well aligned.
2. Place a beam splitter and a second collimator after the interferometer so that the output of the interferometer goes into two fibers. Good alignment is very important.
3. Place two irises very accurately so that you can define the path of the HeNe beam VERY WELL.

Activity VIII (TA): Biphoton interference, cont.



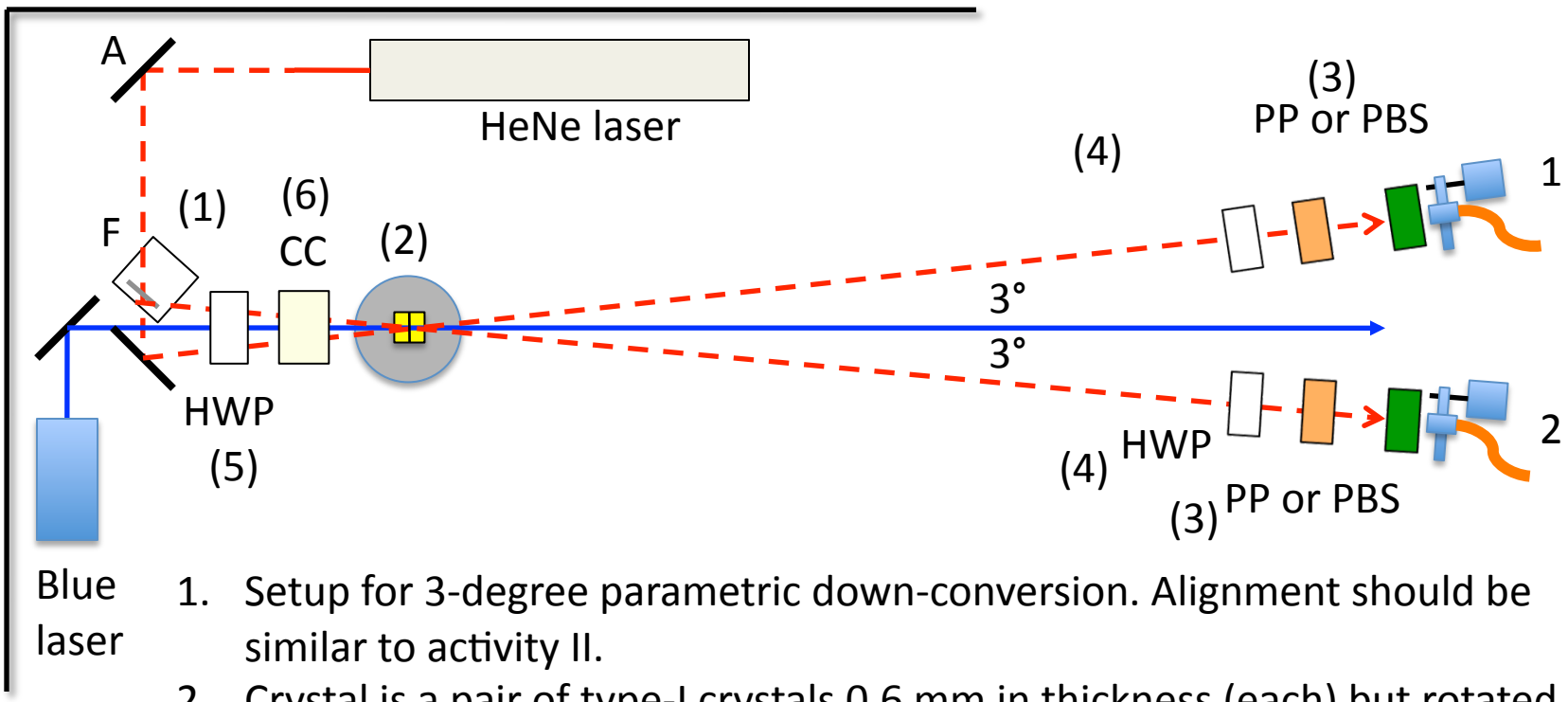
1. Replace mirror B for a flipper mirror, preferably over a translation stage and retrace the path through the irises.
2. Block the HeNe beam, flip the mirror and steer the blue beam through the irises and into the collimators.
3. Place two crossed Glan-Thompson polarizers before and after the crystal. Alternatively, put a short-pass and long-pass filters before and after the crystal, respectively. This is so that the Blue beam produces down-conversion. After the crystal the blue beam is blocked but the down-conversion photons are allowed through.
4. Rotate and tilt the crystal by degrees so that it will produce down conversions for the new path.
5. Optional third collimator can be added after the second port of the interferometer. Alignment of this is critical.

Activity VIII (TA): Biphoton interference, cont.



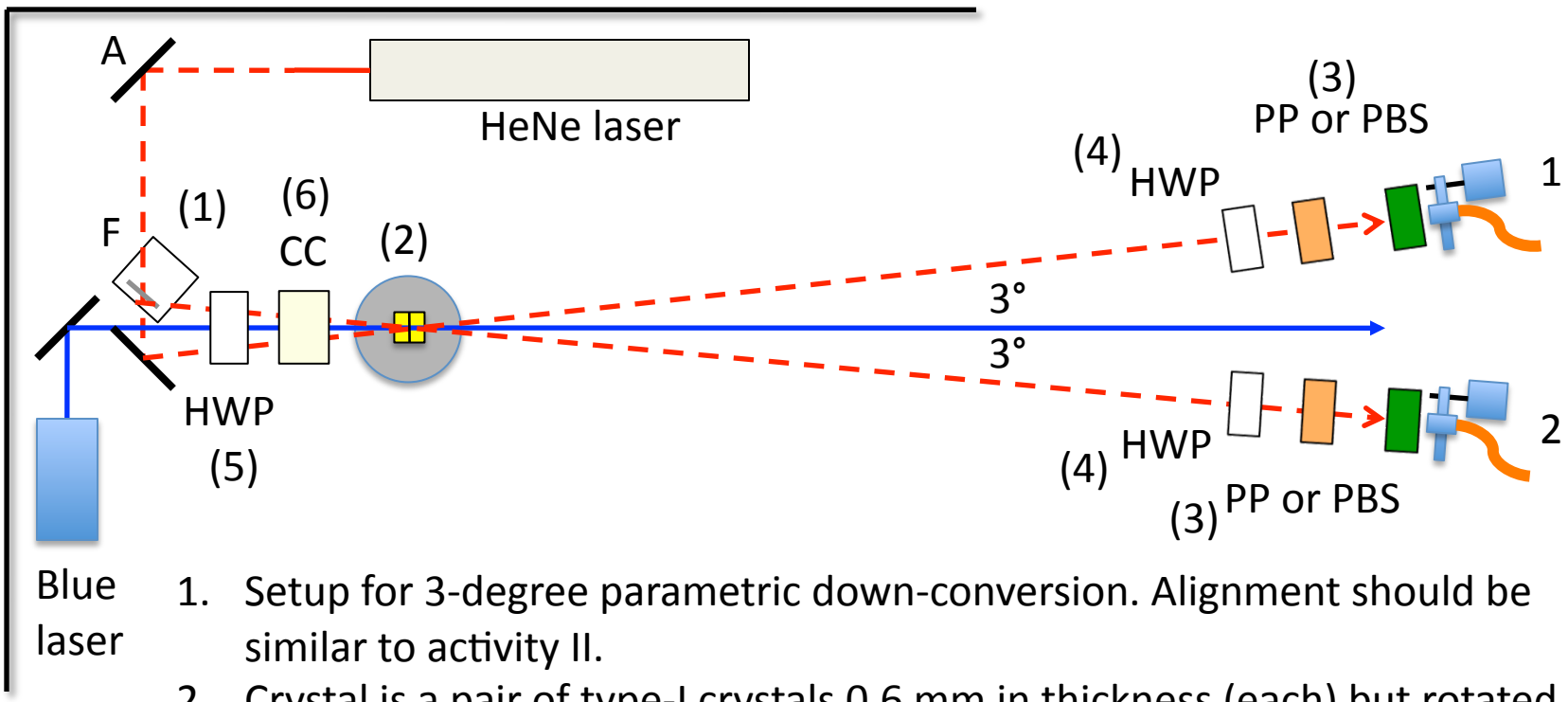
1. Data is taken by recording the coincidences between A and B, and/or A and C.
   a) A, B or C fringes alone are sinusoidal.
   b) AB fringes have sharp peak but flat bottom.
   c) AC fringes are sinusoidal but have twice the frequency.

Activity IX (WM): Entanglement.



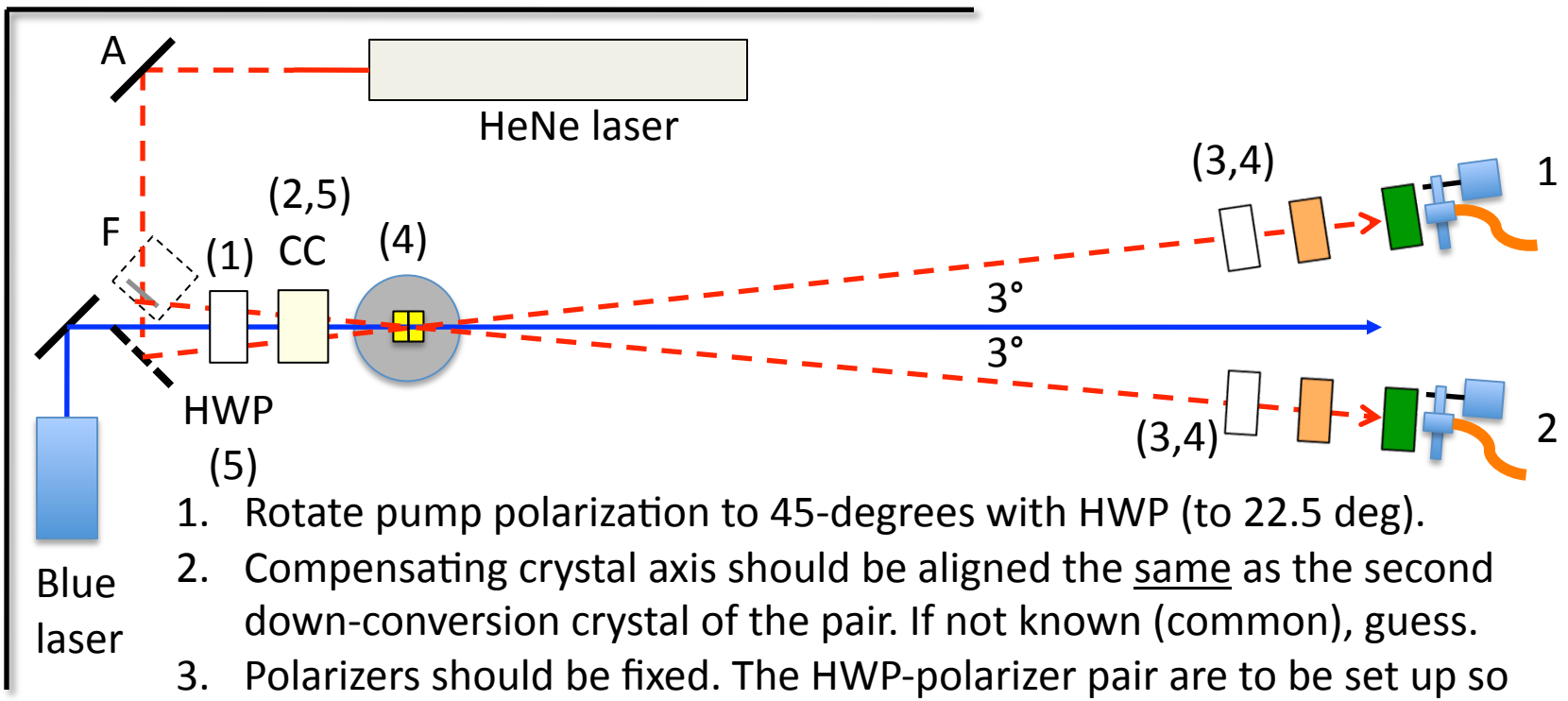
1. Setup for 3-degree parametric down-conversion. Alignment should be similar to activity II.
2. Crystal is a pair of type-I crystals 0.6 mm in thickness (each) but rotated 90 degrees to each other.
3. Place prism polarizers or near-IR polarizing beam splitters before the filters.
4. Place zero-order half waveplates (for design wavelength near the down-conversion wavelength (e.g. 800-nm is fine for 810-nm down-converted photons) before the polarizers.
5. Place zero-order half waveplate (for 405 nm) before the crystals.
6. Place compensating crystal before the down-conversion crystal.

Activity IX (WM): Entanglement.



1. Setup for 3-degree parametric down-conversion. Alignment should be similar to activity II.
2. Crystal is a pair of type-I crystals 0.6 mm in thickness (each) but rotated 90 degrees to each other.
3. Place prism polarizers or near-IR polarizing beam splitters before the filters.
4. Place zero-order half waveplates (for design wavelength near the down-conversion wavelength (e.g. 800-nm is fine for 810-nm down-converted photons) before the polarizers.
5. Place zero-order half waveplate (for 405 nm) before the crystals.
6. Place compensating crystal before the down-conversion crystal.

Activity IX (WM): Entanglement, cont.



1. Rotate pump polarization to 45-degrees with HWP (to 22.5 deg).
2. Compensating crystal axis should be aligned the <u>same</u> as the second down-conversion crystal of the pair. If not known (common), guess.
3. Polarizers should be fixed. The HWP-polarizer pair are to be set up so that the act as a rotating polarizer (remember that HWP rotates at twice the angle).
4. Measure coincidences and tilt the crystal pair so that:
   - HH and VV should be maximum (nearly equal)
   - HV and VY should be a minimum (ideally zero)
5. Tilt the compensating crystal so that:
   - DD and AA are maximum (as much as HH or VV)
   - DA and AD must be minumum (ideally zero) – if no success, then rotate CC by 90 degrees about beam axis.