Notes on work on April 7-May 5, 2022

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Meeting on CLARA

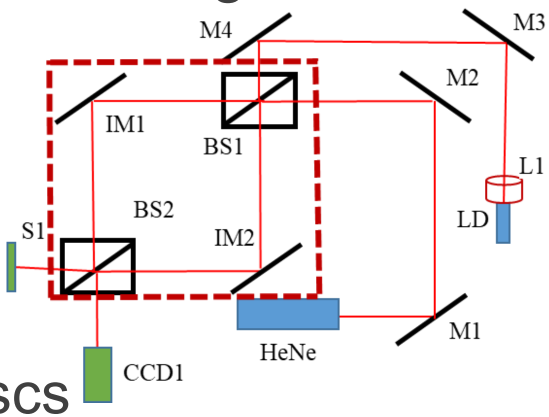
6 May 2022

Content

- Work at ESB
  - Hardware changes and tuning
  - Fringe visibility vs delay
  - MZI stability
  - Minimum angle
- Plans

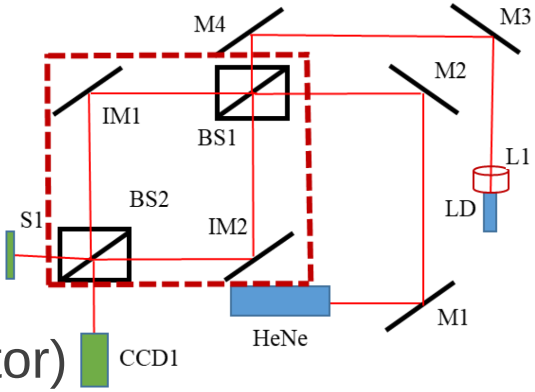
Hardware changes (sequential)

- Have most of components on hand
  - Big help from Jamie!
- Installed a differential micrometer at the linear stage of IM1 mirror of MZI
  - 1 µm graduation instead of 25 µm
  - Much better delay handling
- New optics elements of MZI
  - Cubic beam splitters are replaced by 2” discs
  - 1” mirrors are replaced by new 2”
  - Gimbal mounts for BS2 and IM1 (finer tuning)
- Installed IM2 mirror on a stage with an open-loop picomotor
  - Sub-wavelength delay adjustment



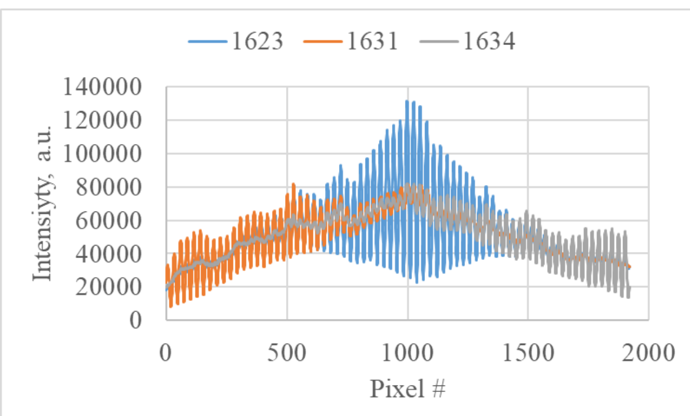
Some impressions

- Spent some time in an intermediate MZI configuration where BS1 was a cube and BS2 was a plate beam splitter
  - The best fringe visibility was 15%. One of possible explanations is an asymmetry in MZI
- In the present configuration with symmetrical 2” optics in MZI, for the first time got visibility ~100% with the laser diode
  - Accurate overlap is important for good visibility
  - Tuning procedure
    - Coarse delay tuning with IM1 position
    - Change angle with BS2
    - Adjust overlap with BS1 or IM1 angle
    - Fine delay tuning with IM2 position (picomotor)
    - Repeat; procedure is converging

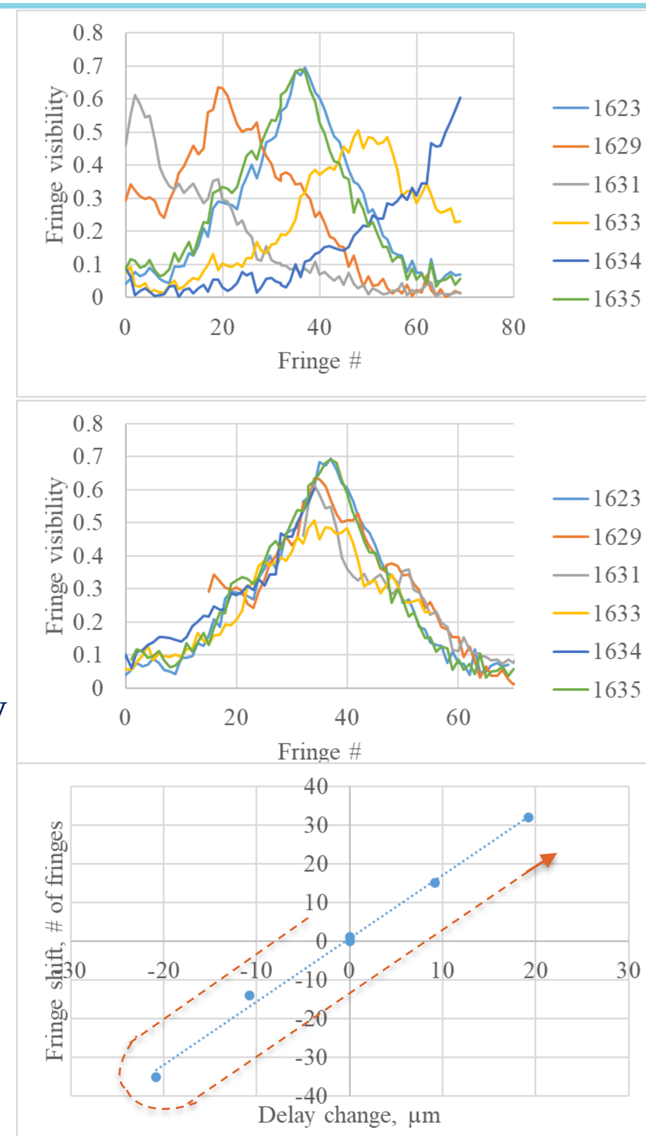


Fringe visibility vs delay

- Sanity check: recording fringes with different delays
  - Calculated the visibility curve for each image; manually moved them to visually coincide; plotted the moves vs delay read by micrometer
    - Slope corresponds to 630 ± 60 nm



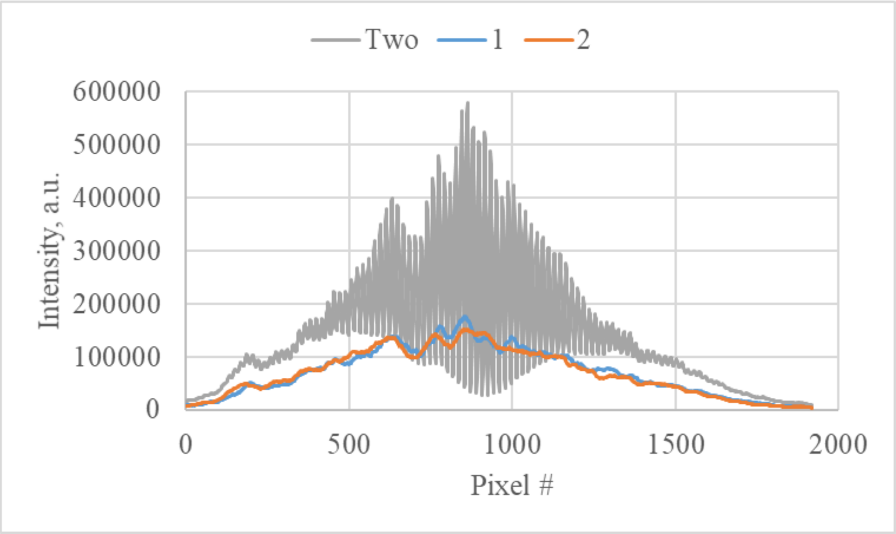
Example of 3 projections with different delays.11-Apr-22; LD.



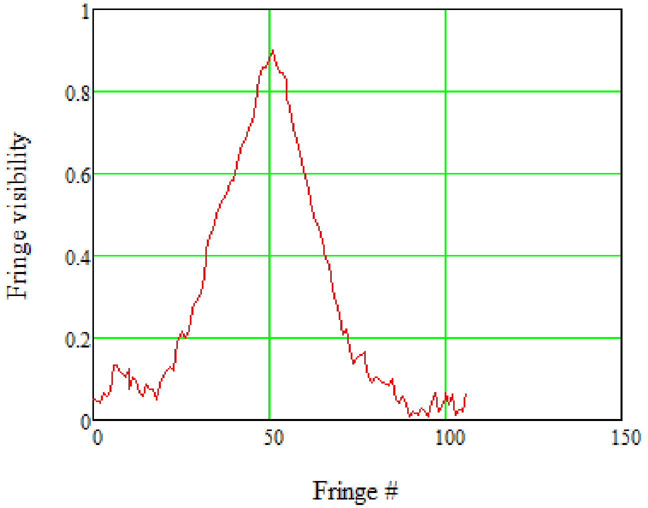
Top – fringe visibility curves for different delays.
Middle- same curves shifted to overlap.
Bottom – number of fringes to shift for each delay value.
11-Apr-22; LD.

Fermilab

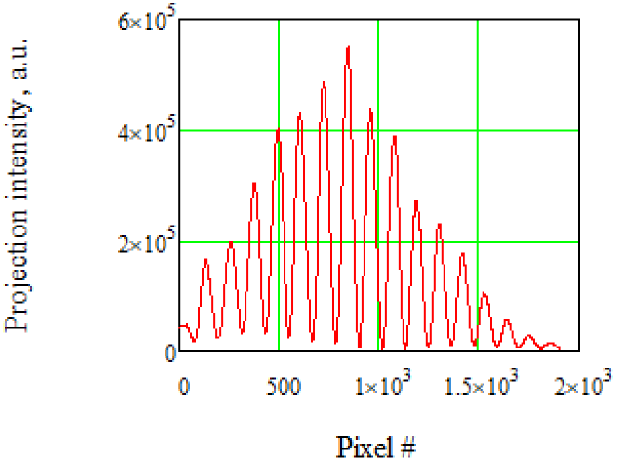
Examples of tuned MZI



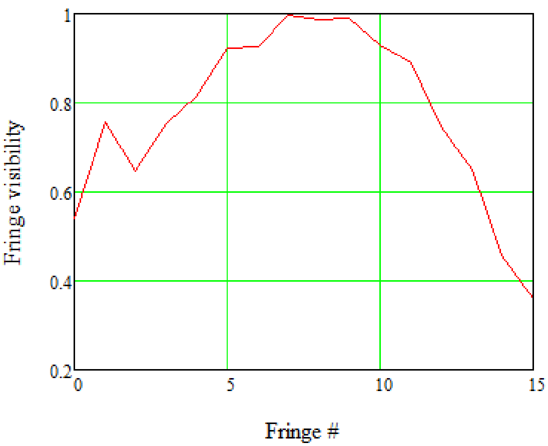
Comparison of projections of image from individual arms (1, 2) with the one from both arms. 3-May-22; LD.



Corresponding fringe visibility curve. Rms width is 18 fringes.

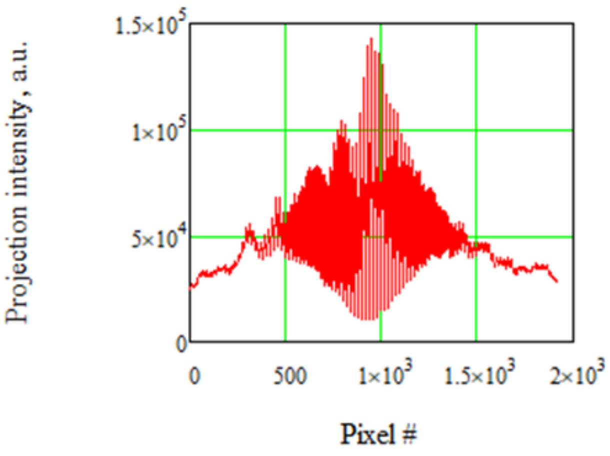


Fringes and the visibility curve at the best tuning.
3-May-22; LD

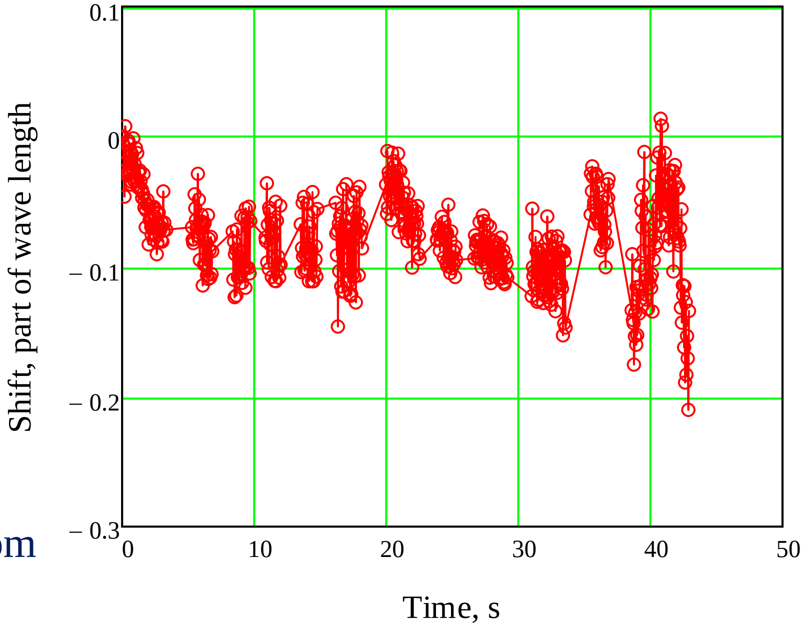


Stability of the image

- Sasha R improved the data acquisition program; now can record longer intervals
  - The program records at ~20 Hz but can be interrupted by switching off triggering
- Recorded 553 projections over 43 sec (with interruptions)
  - Rms jitter is 3.3% of wavelength



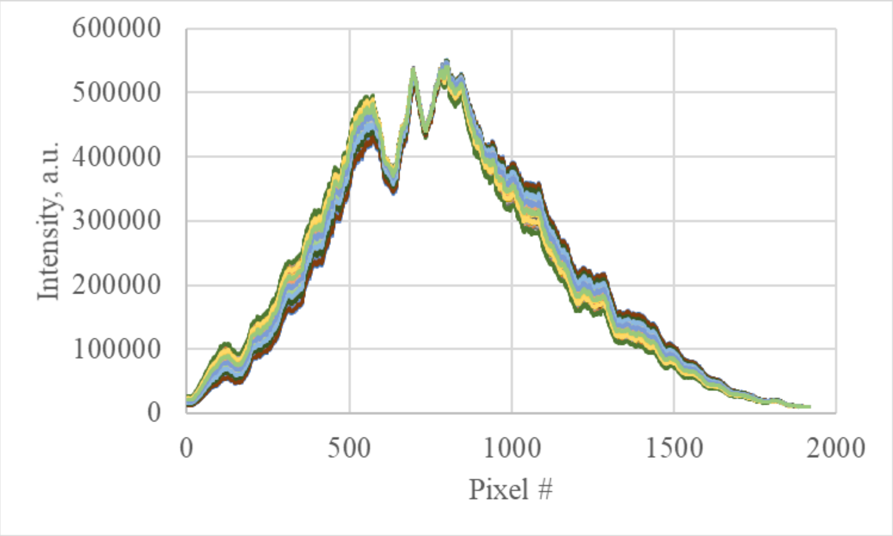
Single frame. 22-Apr-22; LD.



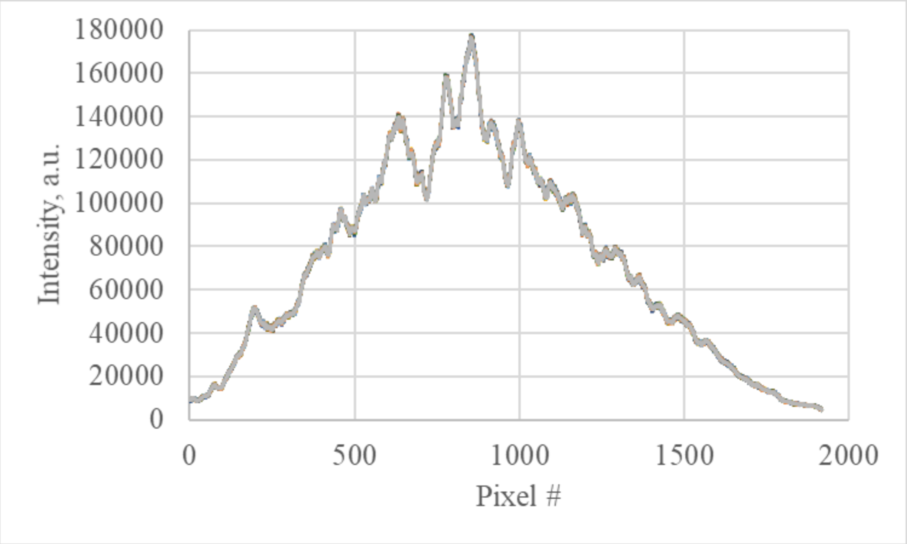
Deviations of 552 frames from the first one. 22-Apr-22; LD.

Stability at the best angular alignment

- At the best angular alignment and the delay set to maximum intensity, the image stays reliably around maximum intensity
  - Still might be the main factor defining the depth of the first minimum



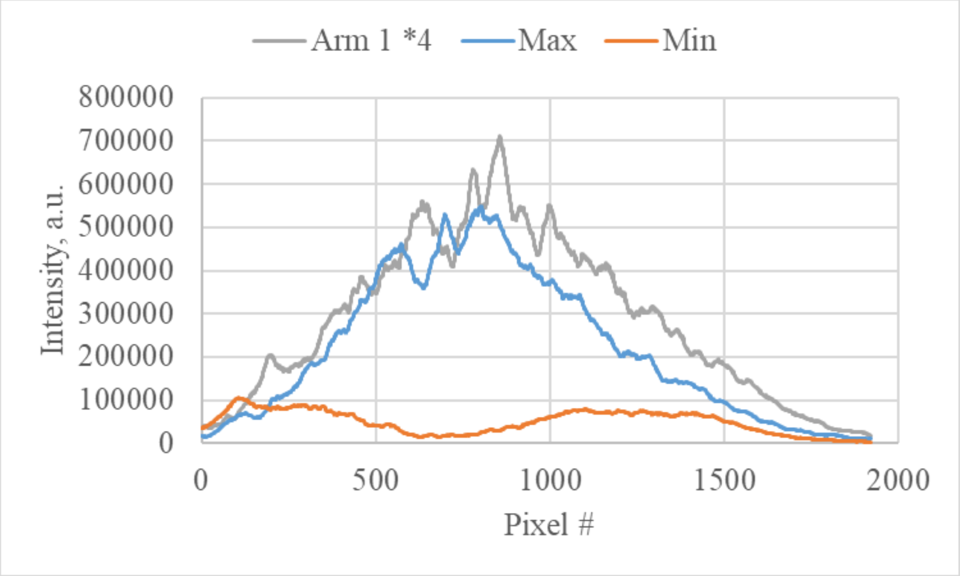
204 overlapped frames in the case of tuning to minimum angle and delay set to maximum intensity. Total recording time 9.7 sec.
3-May-22; LD. Note no blurring at the center.



For comparison, 69 overlapped frames when one of arms is blocked. Total recording time 3.3 sec.
3-May-22; LD

Minimum angle

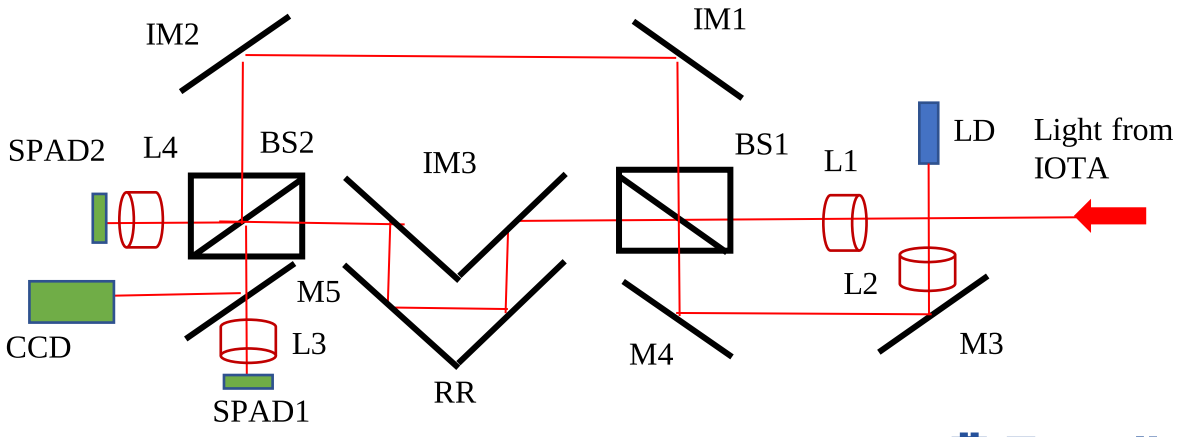
- With a stable MZI and capability to sub-wavelength delay tuning, attempted to make the best angular alignment
  - Best ~80 μrad; max/min ratio of the total intensity is 4.4
  - To increase the ratio to 100, need < 5 μrad (and delay <15 nm)
    - Can't be done manually; need to install picomotors to beam spitter
    - Need to develop an alignment procedure



Projections with the same angular alignment and the delay corresponding to maximum and minimum total intensity. A one-arm projection multiplied by 4 is shown for comparison (though recorded at a different alignment). 3-May-22; LD

Summary of status

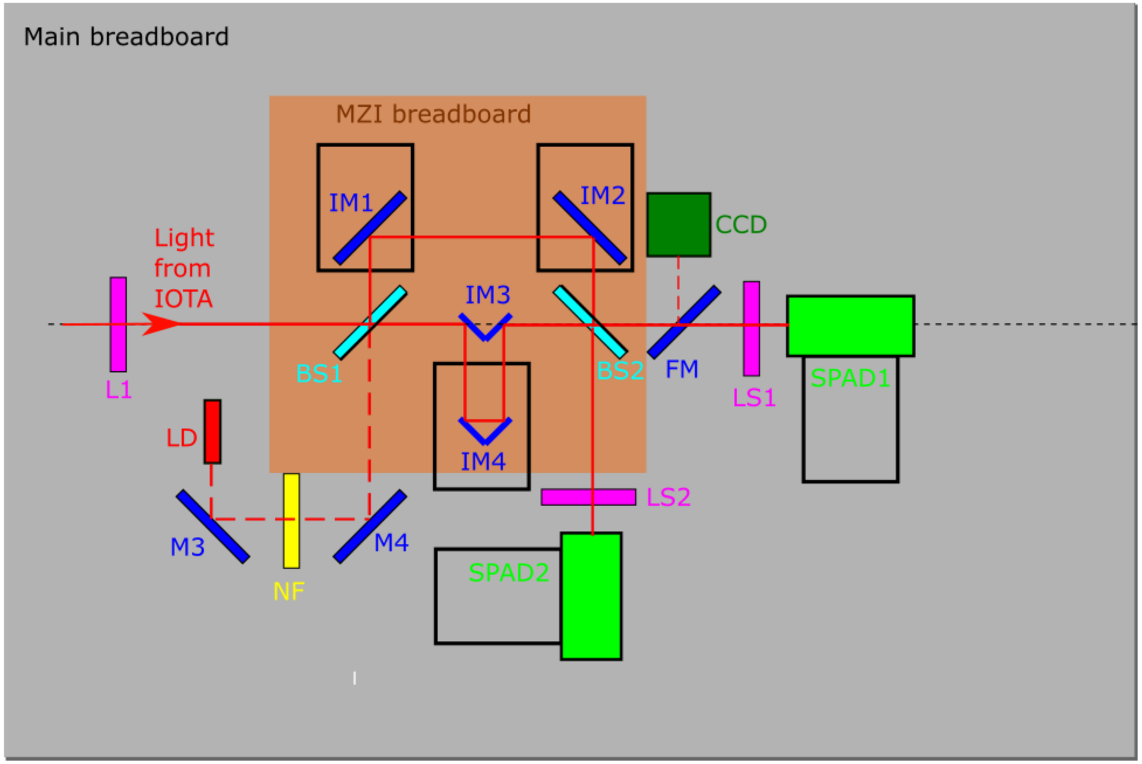
- If measuring the coherence length of a full e-beam light with fringes were the only goal, would be ready to make a design
  - Understand how to tune MZI; have all components
- For single – electron measurements
  - MZI stability is satisfactory
  - The biggest obstacle is the delay of the precise stage delivery to June; discussing a “Plan B” (see the last slide)
    - Also, do not have the reflector and the flipping mirror



Near plans

- ESB
  - Install picomotors to the beam splitter and try to align the MZI to 5 μrad level
  - Try to measure (image intensity) = f(delay) with the existing stage driven by a open-loop picomotor
  - When successful, proceed to decreasing the light intensity
    - Install SPADs when it is low enough
- Try to find a solution for assembling optics elements similar to what is presently assumed as the final scheme
  - May be with a worse accuracy
  - If doable with available equipment, may assemble at ESB and test (before proceeding with the measurements above)

Possible scheme



M1, M2 – existing motorized mirrors directing light from IOTA (not shown). Replicated by HeNe light at ESB.
IM1, IM2 – MZI mirrors mounted on stage(s) with micrometer
IM3- right-angle mirror
IM4 – hollow roof mirror; might be replaced initially by 2 mirrors
LD – laser diode
M3, M4 –mirrors to direct LD light
BS1, BS2- beam splitters on motorized mounts
L1- future lens to focus IOTA light

SPAD1, SPAD2 – existing SPADs on 3D stages with their lenses LS1, LS2
CCD – existing CCD
NF – neutral filter for SPAD tuning

- Need to figure out how to align

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