Fermilab

U.S. DEPARTMENT OF ENERGY | Office of Science

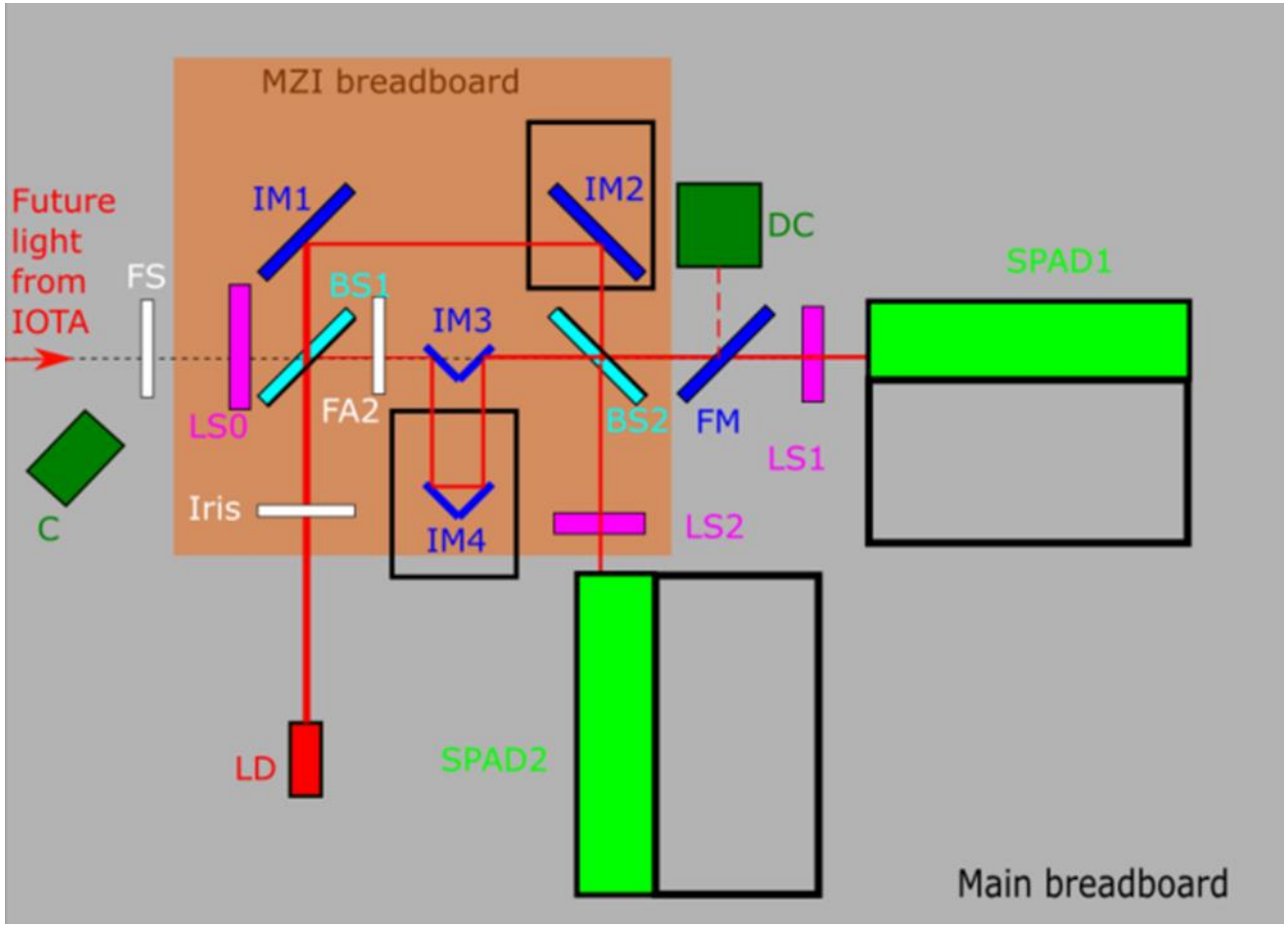
First CLARA shifts

A. Shemyakin, J. Jarvis, I. Lobach, S. Nagaitsev, A. Romanov, G. Stancari

FAST/IOTA meeting

31 March 2023

Apparatus schematic



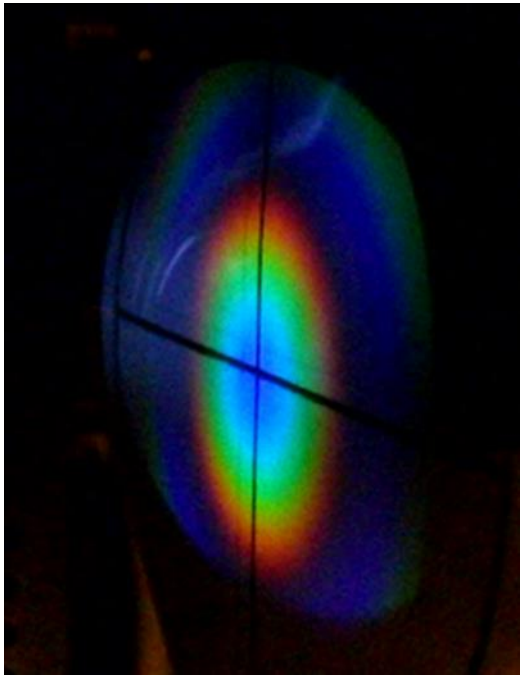
Mach – Zender Interferomer (MZI) is assembled on a separate breadboard isolated from the main one by rubber supports.

As of 9-Feb-2023

- LD- laser diode
- SPAD1,2 –Single Photon Avalanche Detector
- DC – digital camera
- BS1,2 – beam splitters
- IM1, IM2 – Arm1 MZI mirrors
- IM3 – right-angle mirror in Arm2
- IM4 – hollow roof mirror in Arm2
- LS1, 2 – SPAD lenses
- LS0 – entrance lens
- FM – flipping mirror
- FA2 – flipping screen in Arm2
- FS - flipping screen at entrance
- Iris – LD collimator
- C - webcam

CLARA shifts this week

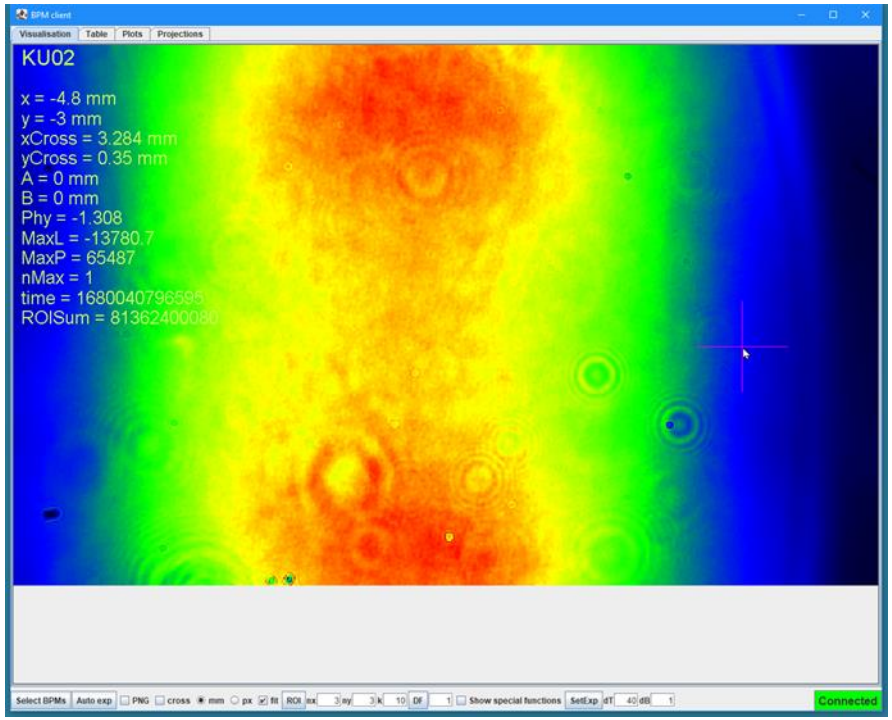
- Preparatory work on March 27
  - Tuning with the laser diode
  - synchrotron light from M4R dipole at the entrance screen
- Two shifts with undulator
  - Tue March 28 PM
    - Moved the undulator in.
    - Adjusted the periscope mirrors to center the undulator light on the entrance screen.
    - Brought the light to camera, observed interference.
    - Observed a signal on SPADs
  - Thu March 30 PM
    - Better MZI alignment
    - Work with SPADs

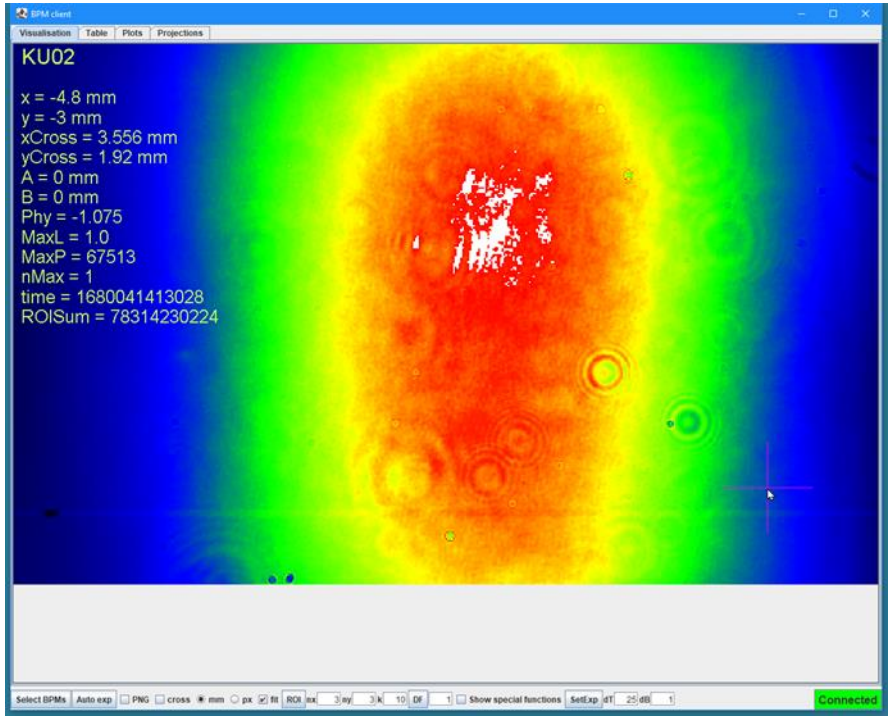


Undulator light at the entrance screen.

Image on the camera far from interference

- Image doesn’t fully fit to camera vertically; elliptical
- Intensity sum in MZI Arm1 is ~40% of the one in Arm2
- Intensity distribution in Arm1 has two “blobs”

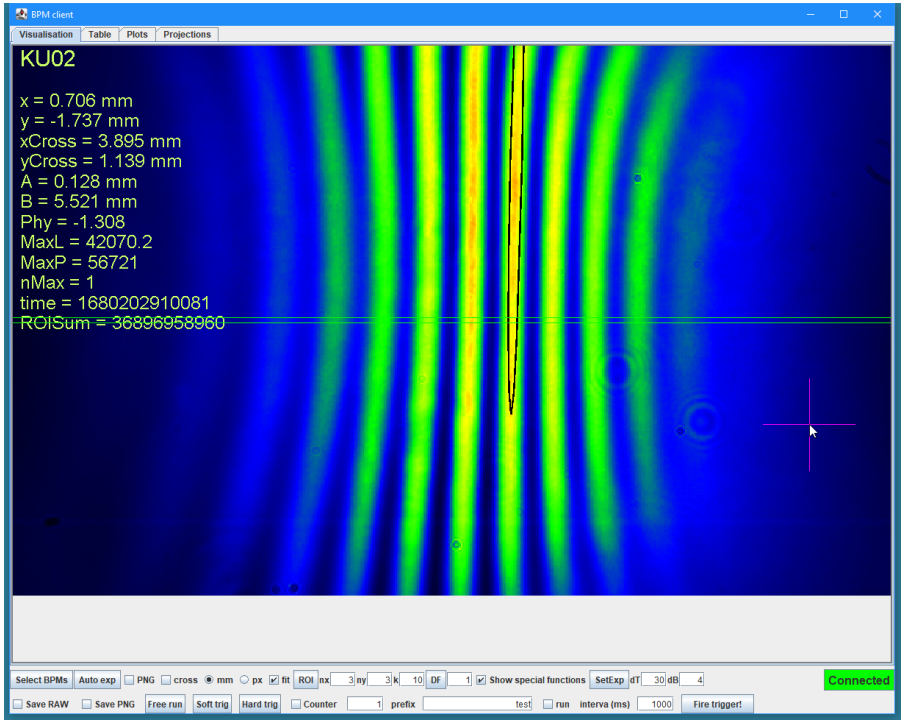


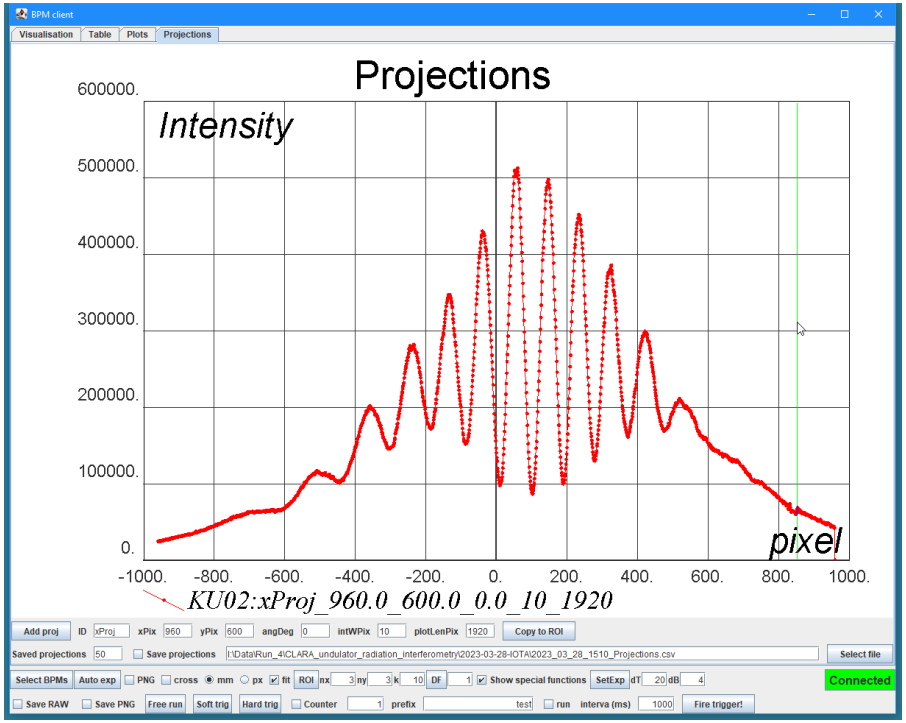


Images from Arm1 only (left) and both arms (right). Intensity scales are different.

Interference on camera with a large angle

- After MZI alignment, visibility in the camera image with a large angle between light from arms is ~70%.

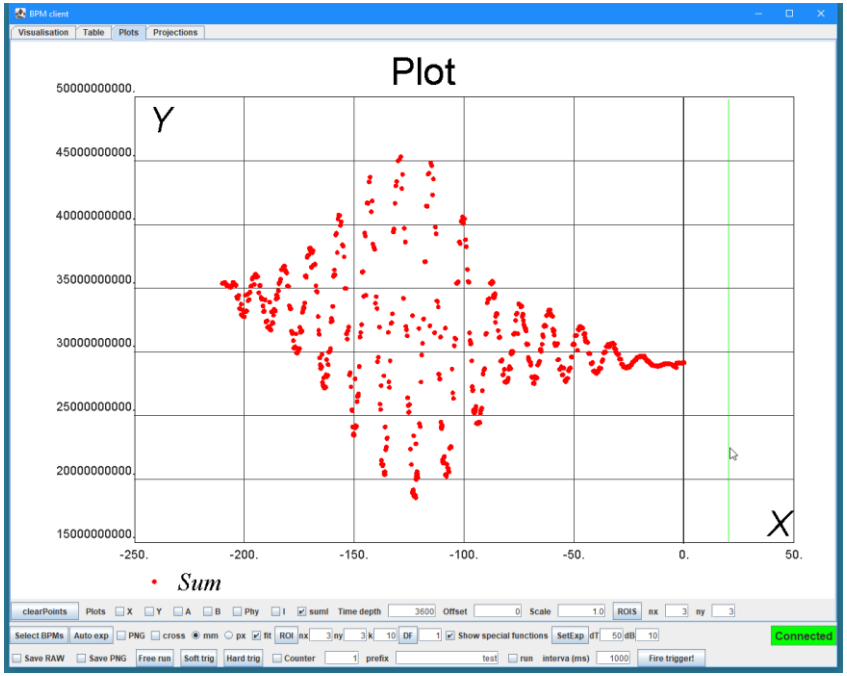


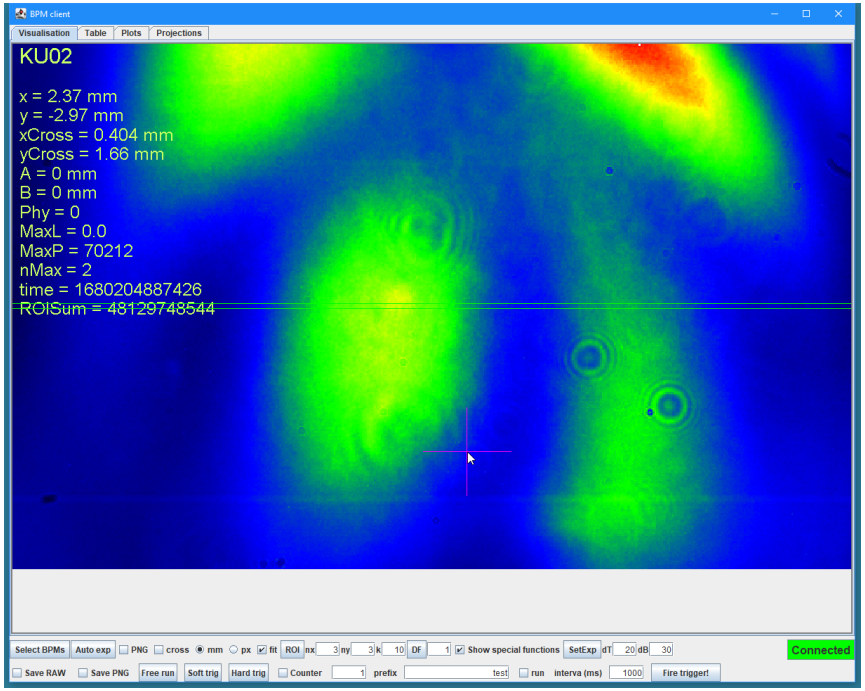


Interference pattern (left) and its horizontal projection after MZI alignment. 30-Mar-23.

Camera signal at aligned angle

- Variation in camera total intensity when the stage is moving show the interference pattern. Visibility ~40%.
  - Image at the stage position corresponding to minimum total intensity looks different from the one observed with LD





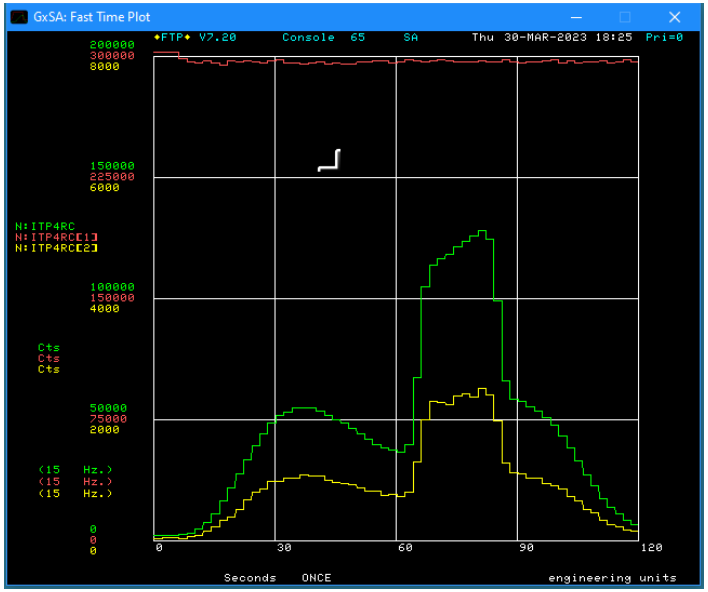
Left: Variation in camera total intensity when the stage is moving. Right: Image at the stage position corresponding to minimum total intensity. 30-Mar-23.

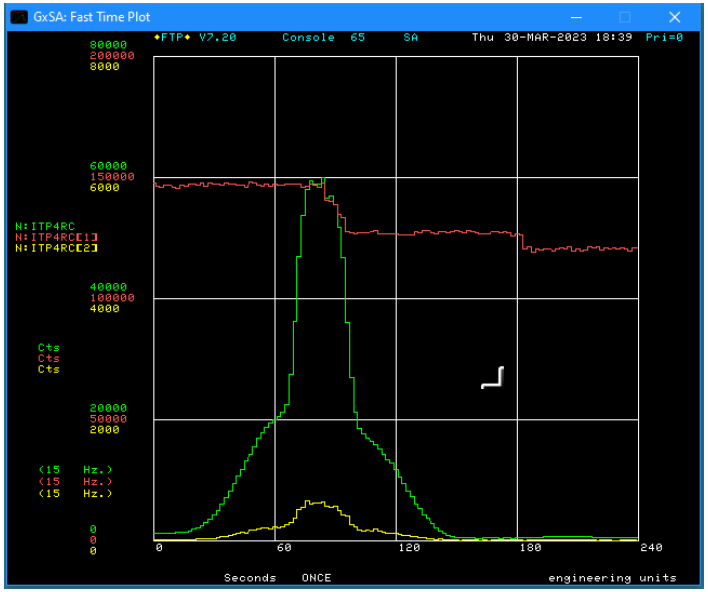
Work with SPADs

- Procedure (all work at 150 MeV)
  - “scrape” the beam by decreasing the RF voltage
  - Observe the signal at PMT and CLARA’s camera
    - Clearly see one-electron steps
  - At low enough intensity, turn on SPADs (~300 electrons)
    - One electron produces ~10 kHz on each SPAD
  - Align signals in time
- Measurements
  - Attempts to align SPADs in 3D (far from interference)
  - Measure SPAD signals vs stage position
  - Record time stamps of incoming photons in different configurations

SPAD alignment

- At proper focusing, transverse position scans show a region where a significant part of the light is focused into the sensitive part of SPAD.
  - Still, a big portion of the light remains outside.
  - Could focus practically all LD light into the sensitive area.

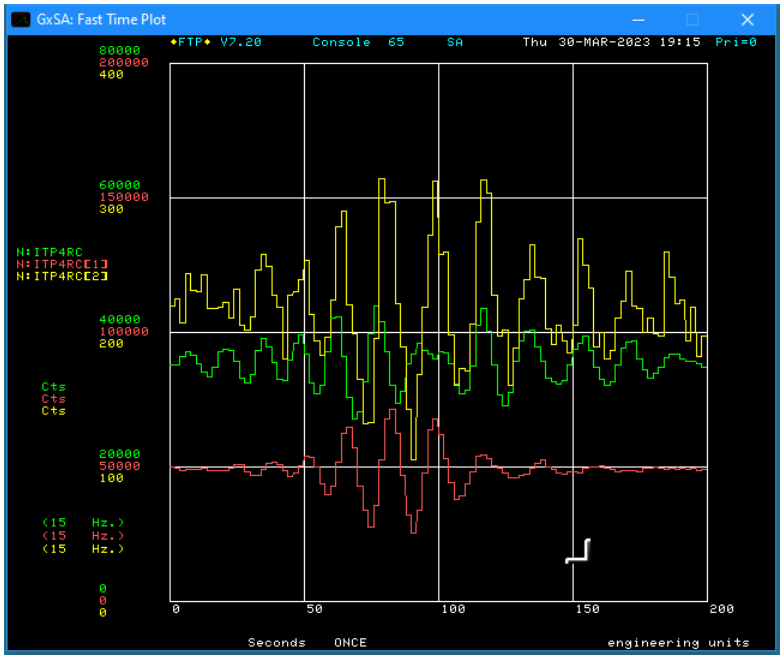




SPAD1 signal (green line) vs vertical position (left) and horizontal position (right). Steps in SPAD2 signal (red) corresponds to loosing of one electron. 30-Mar-23. Yellow- coincidence rate.

Stage scans

- Made several stage scans. Roughly what was expected, but:
  - Far from interference, SPAD2 signal remained by 1.5 – 2.5 times higher than SPAD1 (don't know yet why)
  - SPAD signals are expected to be out of phase (light goes either to SPAD1 or SPAD2) but they are not
  - Coherence length (number of visible fringes) is different
- It feels that each is sensitive to a different light component



SPAD1 (green), SPAD2 (red), and coincidence (yellow) rates while the stage position change. 30-Mar-23.