HBT in Your Garage

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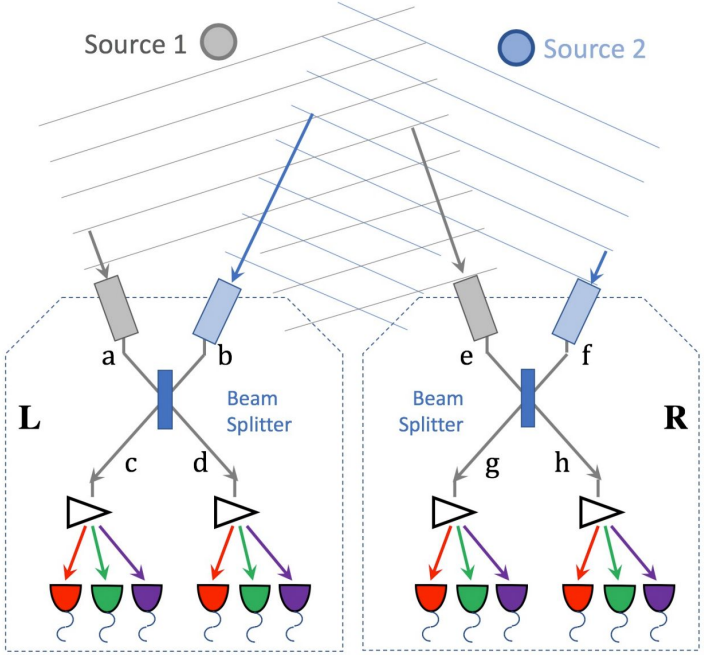
Stellar Intensity Interferometry Workshop 2025
Waischenfeld, Germany

Advisors: Paul Stankus (BNL)
& Anze Slosar (BNL, SBU)

Our project

https://piimaging.com/spad-lambda/

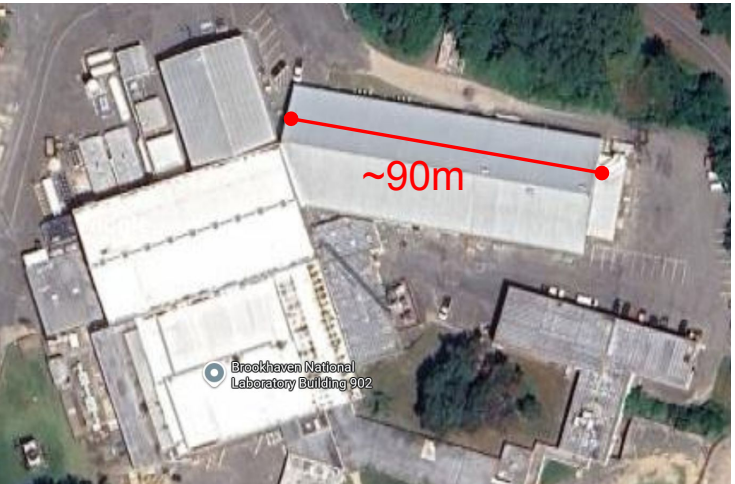
- Long term goal: Two-photon amplitude interferometry
- First need traditional intensity interferometry success
- Building SMF-fed spectrometer
  - Pi Imaging SPADλ
- Started collaboration with CHARA



Stankus et al.(2022)
https://doi.org/10.21105/astro.2010.09100

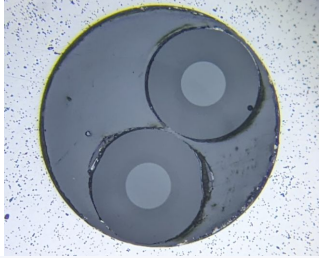
Getting our feet wet

- Original plan: build our own telescopes
- How much can we learn from on-the-ground setup with an artificial star?
    - More than a pinhole and lens in our lab
- Longest building at BNL without radiation hazards

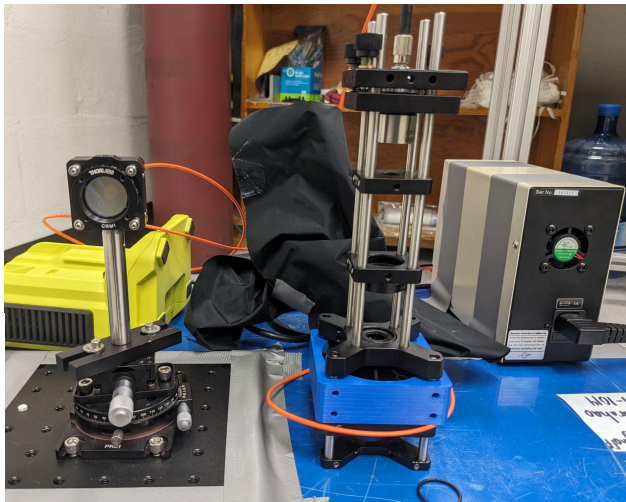


The artificial star(s)

- Source: red LED, filtered with Alluxa Hα ultranarrow filter (FWHM 0.1nm)
- Fibers emit through only a polarizer, no focusing optics
- Output from one or two 50µm fibers (single or binary stars)
- Located 70m or 80m from telescopes



https://www.thorlabs.com/Images/GuideImages/7510_YCable_7.jpg



Horticulture LED

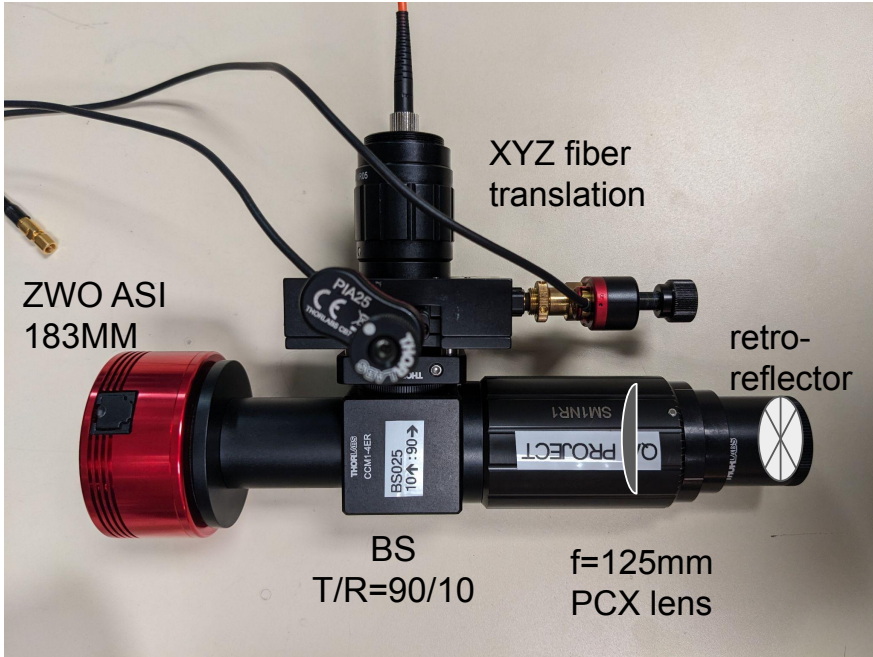
The telescopes

- 4 inch SVBONY refractor telescopes
- Collect onto 50um step-index fibers
    - 2 and 5 meters long: ~15ns delay
- Thorlabs single spads and qutag
- Work during the night when the building is unoccupied
    - setup and tear down each time
- Measure baselines and star distance with measuring tape (consistent with laser range finder)

Fiber Injection

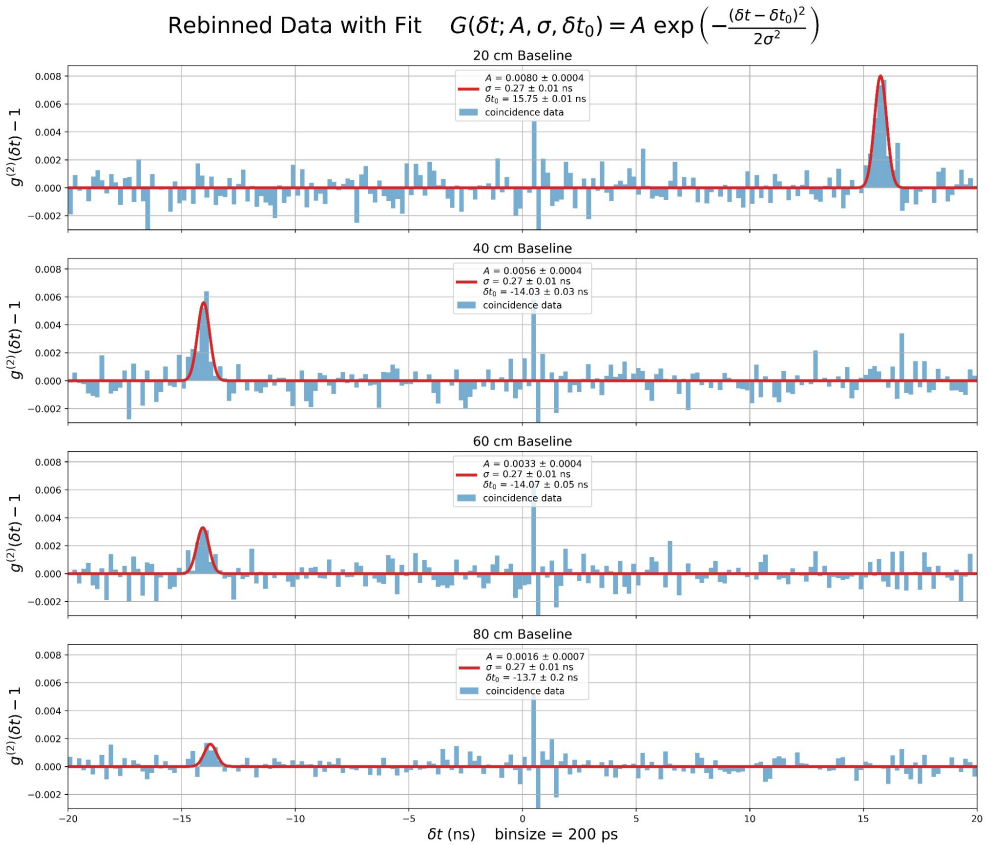
- Injecting into 50µm fibers that run to single-pixel ThorLabs SPADs
- Motorized XY translation of fiber
- See back-illuminated fiber in camera using lens and retroreflector

https://www.thorlabs.com/thorproduct.cfm?partnumber=PS975-A



Single star

- 50μm at 79m = 0.13 arcsec
- Visibility vs baseline
- No pesky issues with weather or baseline changing over time due to earth's rotation
- Conservative measurement uncertainties
- Agree well with manufacturer (ThorLabs)on diameter, given distance



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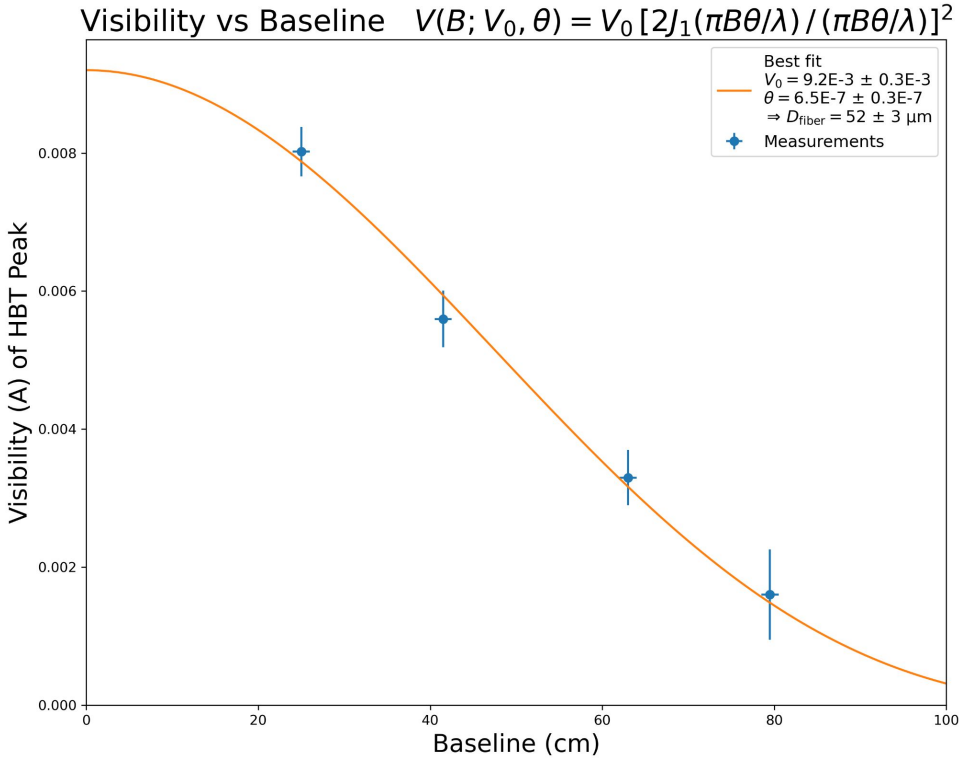
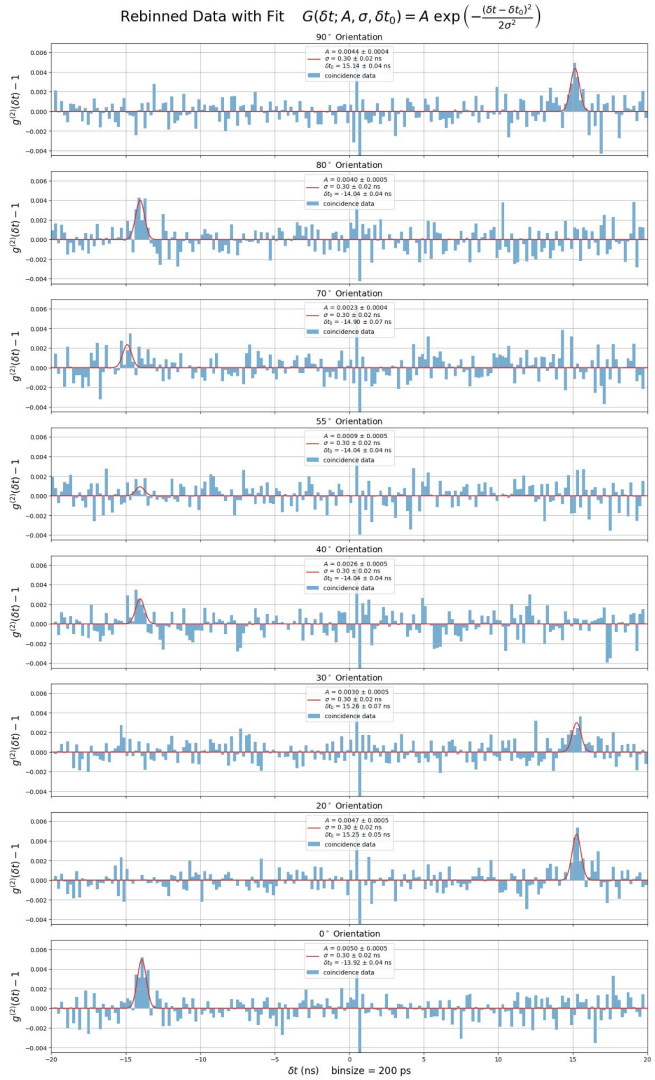


Binary star

- Bifurcated 50μm fiber at 69m
  - Two in one ferrule, separated by ~130μm
- “Close binary” but true uniform discs
- Fixed 30cm baseline: rotate fiber orientation and measure effect on visibility
- Clear noise floor
  - 55° orientation not usable



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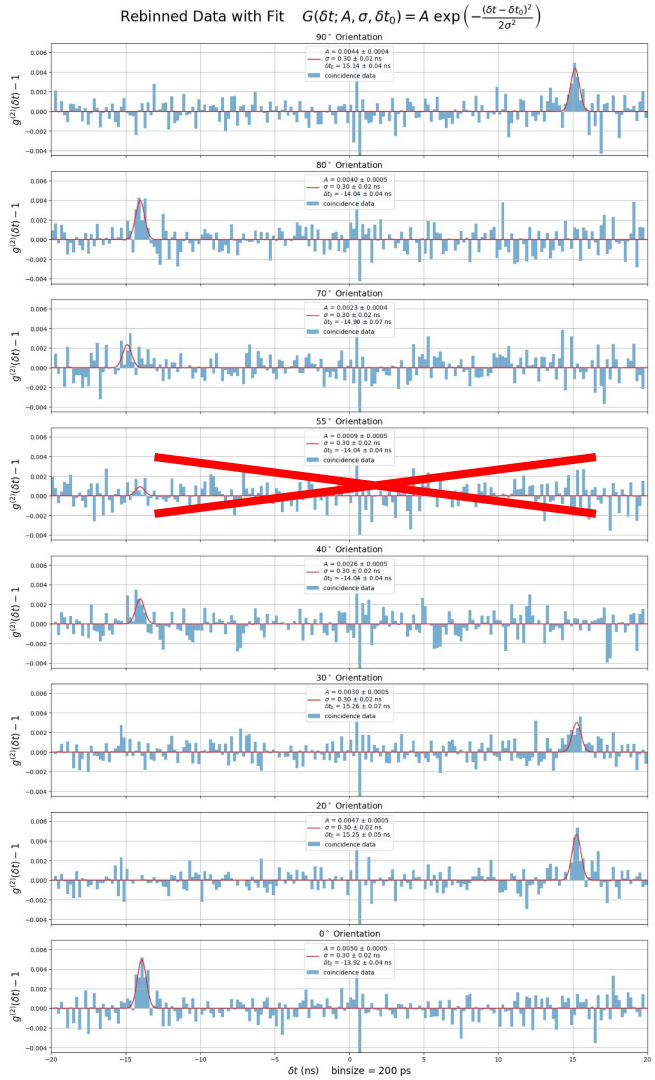
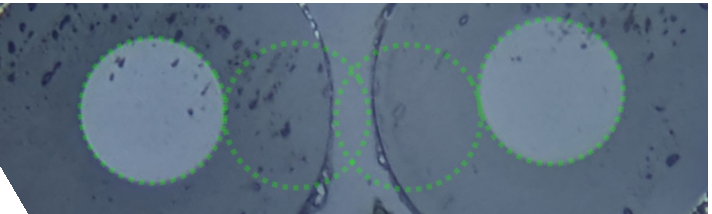
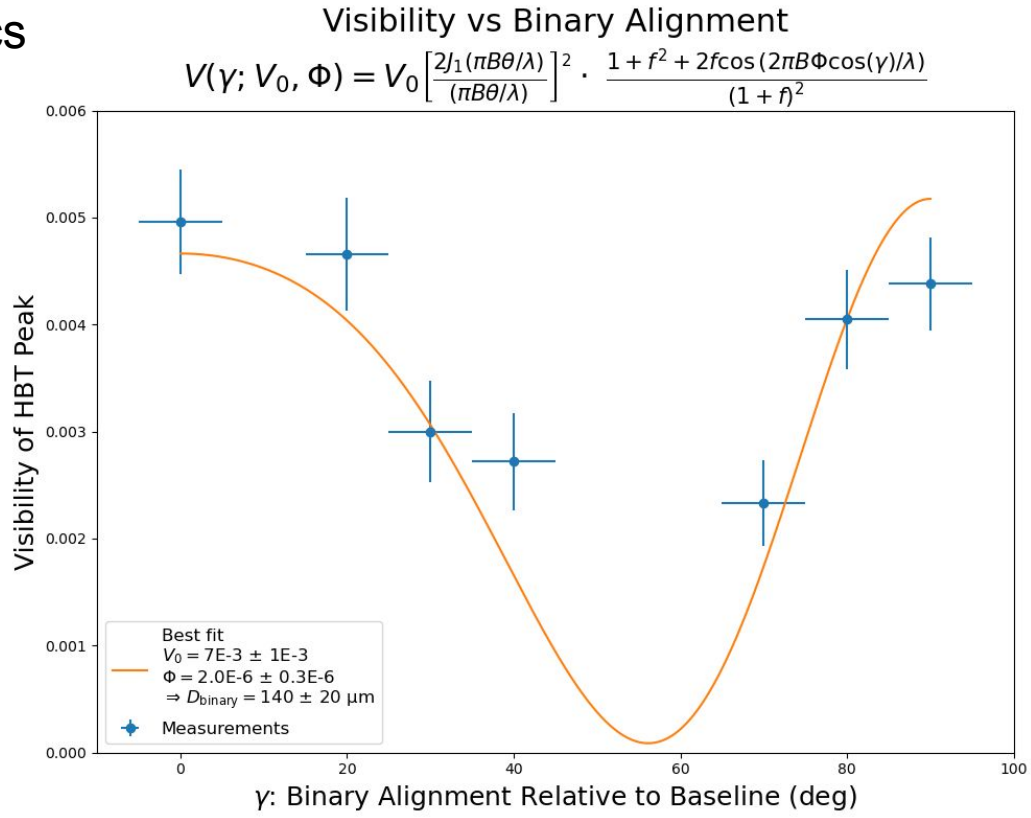


Binary star cont.

- Fit two equally-sized uniform discs
- Allow angular separation and zero-baseline visibility to vary
  - Fiber diameter fixed
- Microscope-measured value: 137 ± 1 μm





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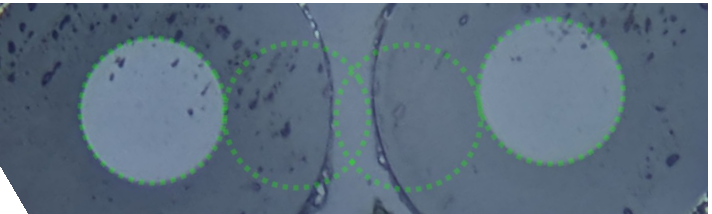

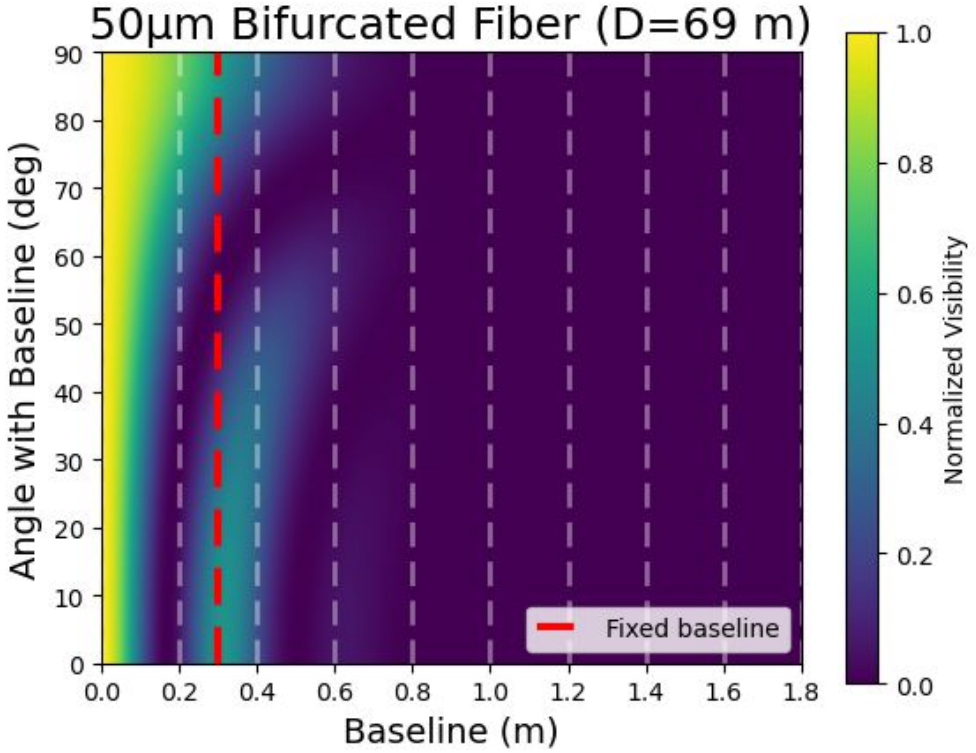

Quick and dirty HBT

- Measured diameter of one fiber and separation of two
- Nice way to get started in intensity interferometry
    - Intermediary between in-lab and on-sky
- LED is usable source once it is filtered

Thank you to the organizers of this conference, my advisors Paul Stankus and Anze Slosar, and also Raphael Abrahao, Ethan Bailes, and Camila Toomey-Hellman.