PTI

Palomar Testbed Interferometer

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March 23, 1998

PALOMAR
TESTBED
INTERFEROMETER

Jet Propulsion Laboratory
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Acknowledgements

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Overview

- Brief description of the Interferometer
  - Path of star light from first mirror to detector
- Recent upgrades to the initial instrument
  - Addition of H band (1.5-1.8um)
  - IR optical fiber in spectrometer arm
  - Vacuum pipes from pier to main building.
  - Feed-forward of siderostat errors to delay line
  - Addition of third baseline
- Science Observations
  - Overview of ‘97 observations
  - Astrometry

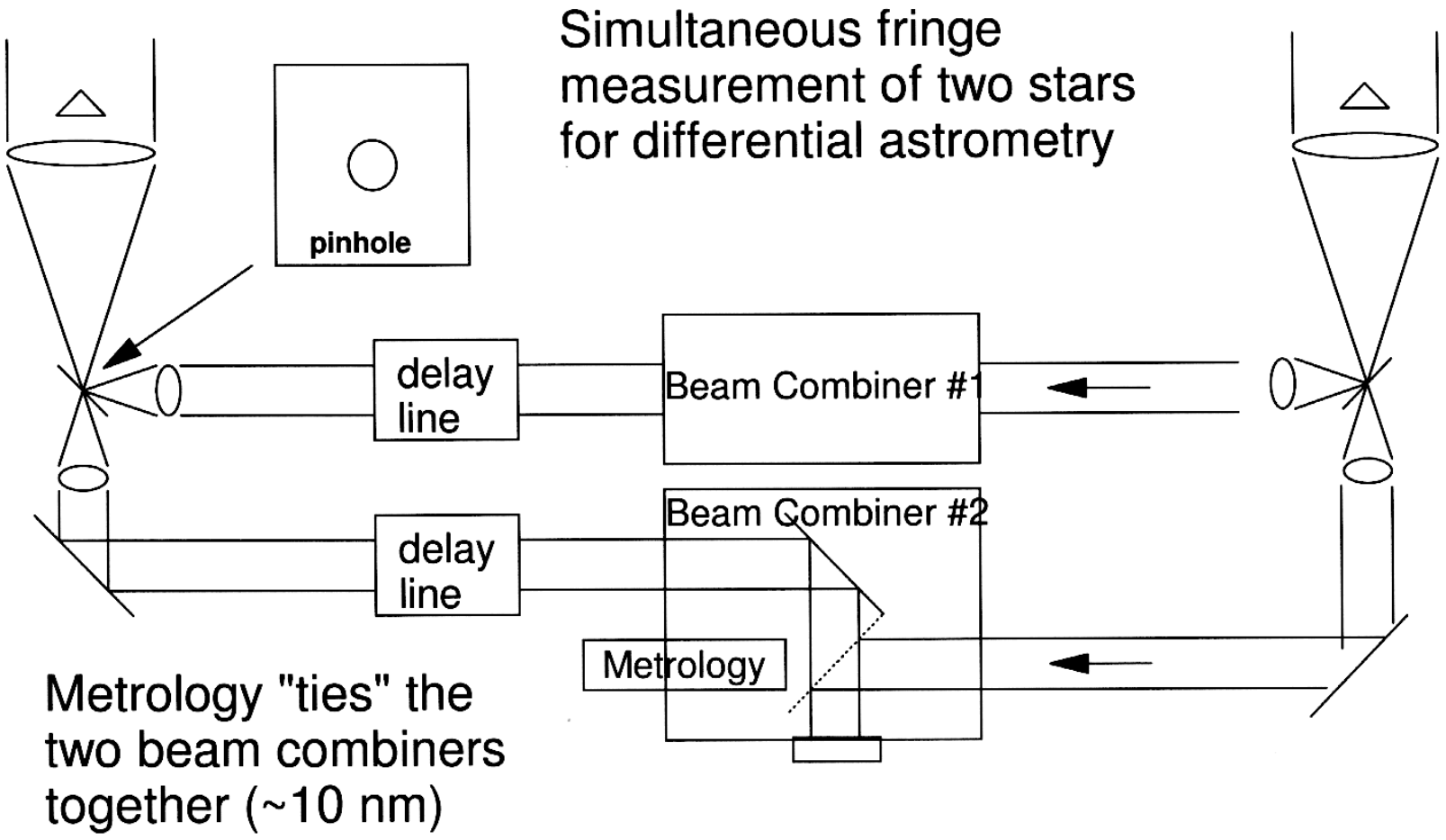
PTI Description

- 110 m maximum baseline
- 40 cm collecting apertures
- +/- 38.3 m of optical delay range
- Fringe tracking at 2.2 um
  - NICMOS III array
  - Custom clocking brings read noise to 15 e-
- Angle tracking at 0.8 um using APD's
- 7 real-time computers for sequencing and automation.

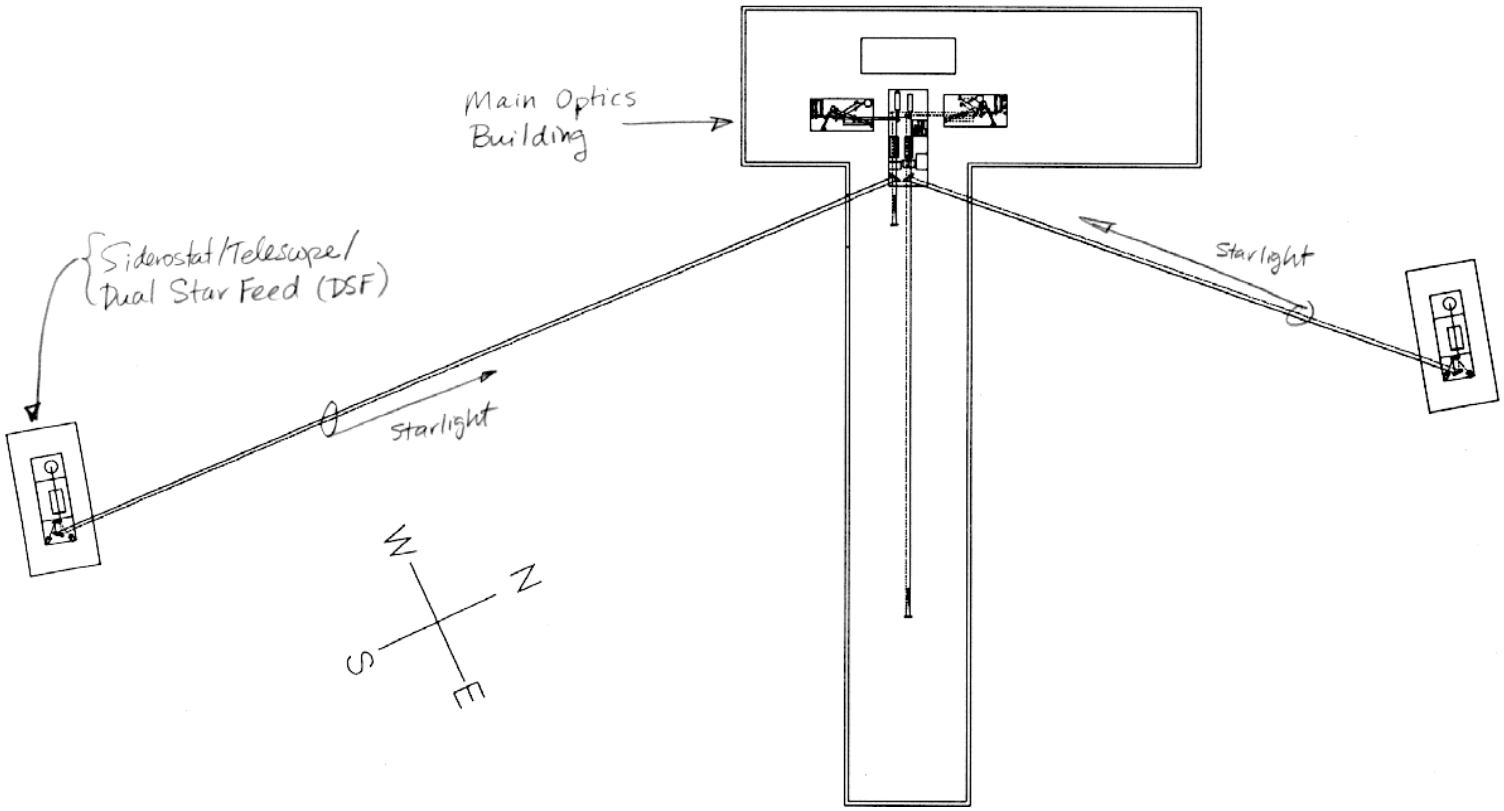
PTI History

- Funded by NASA as engineering testbed for Keck
- Specifically designed with dual star mode for narrow-angle differential astrometry
  - Measure fringes on two different stars simultaneously

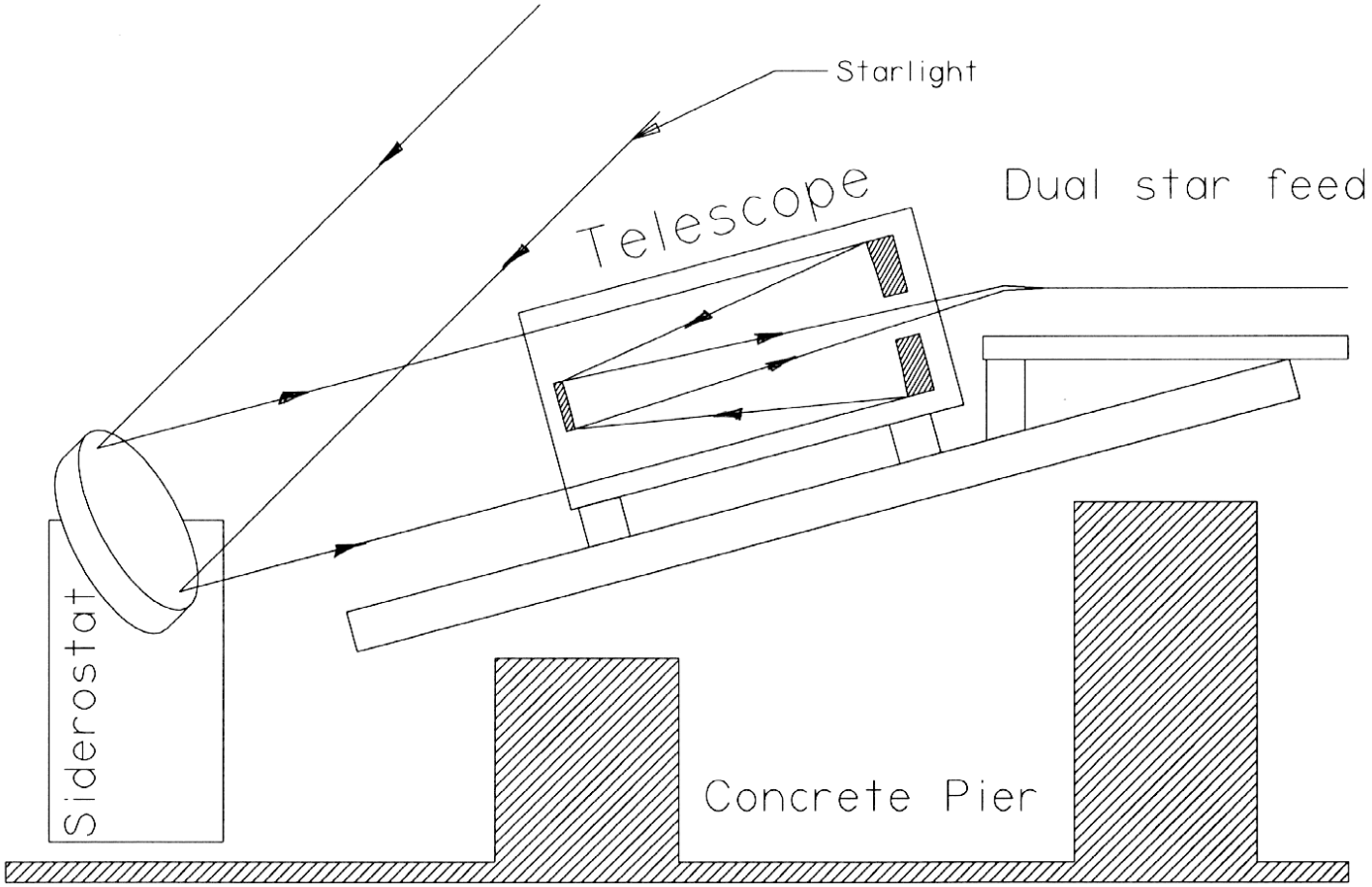
Dual-star Concept



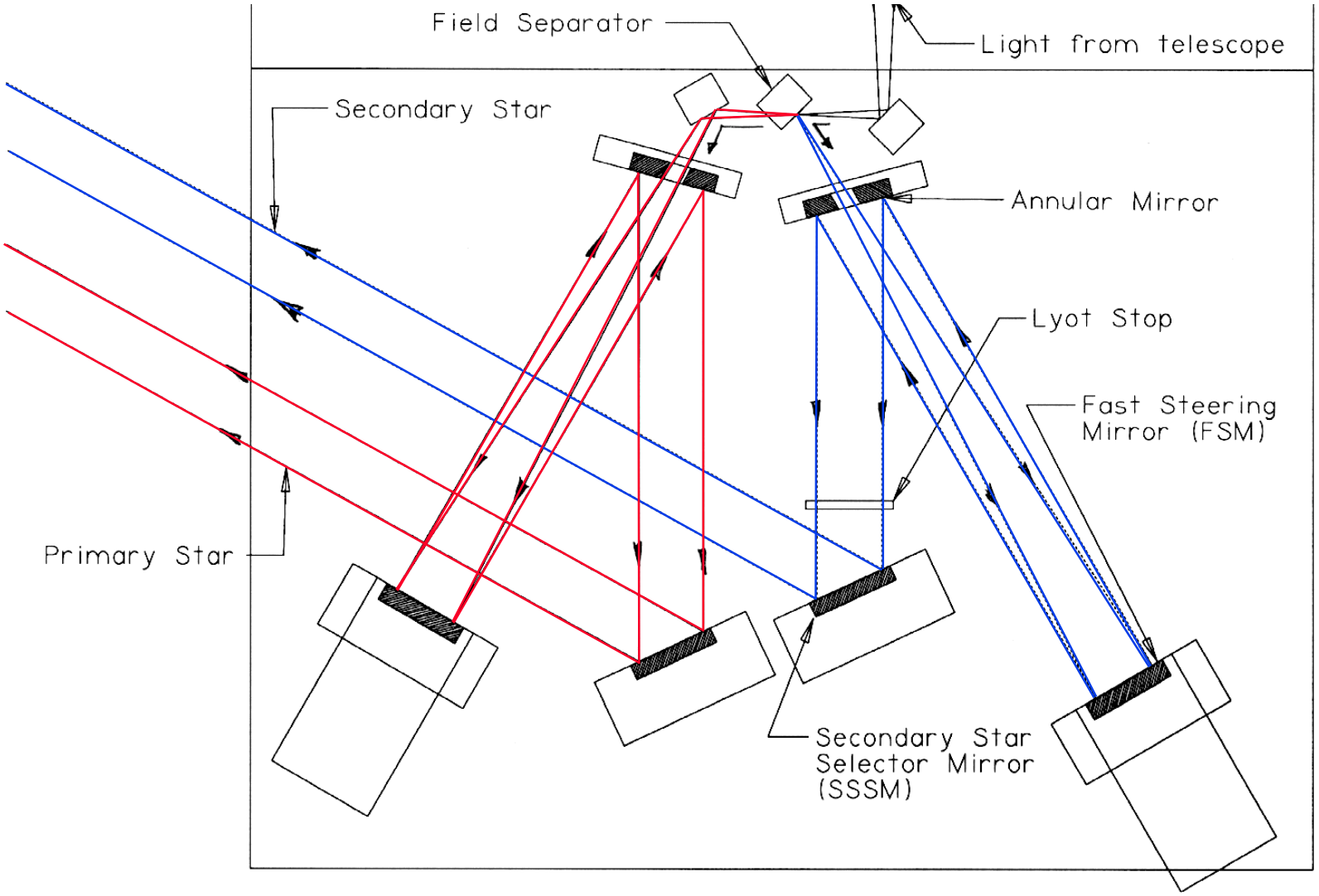
Layout of the Interferometer



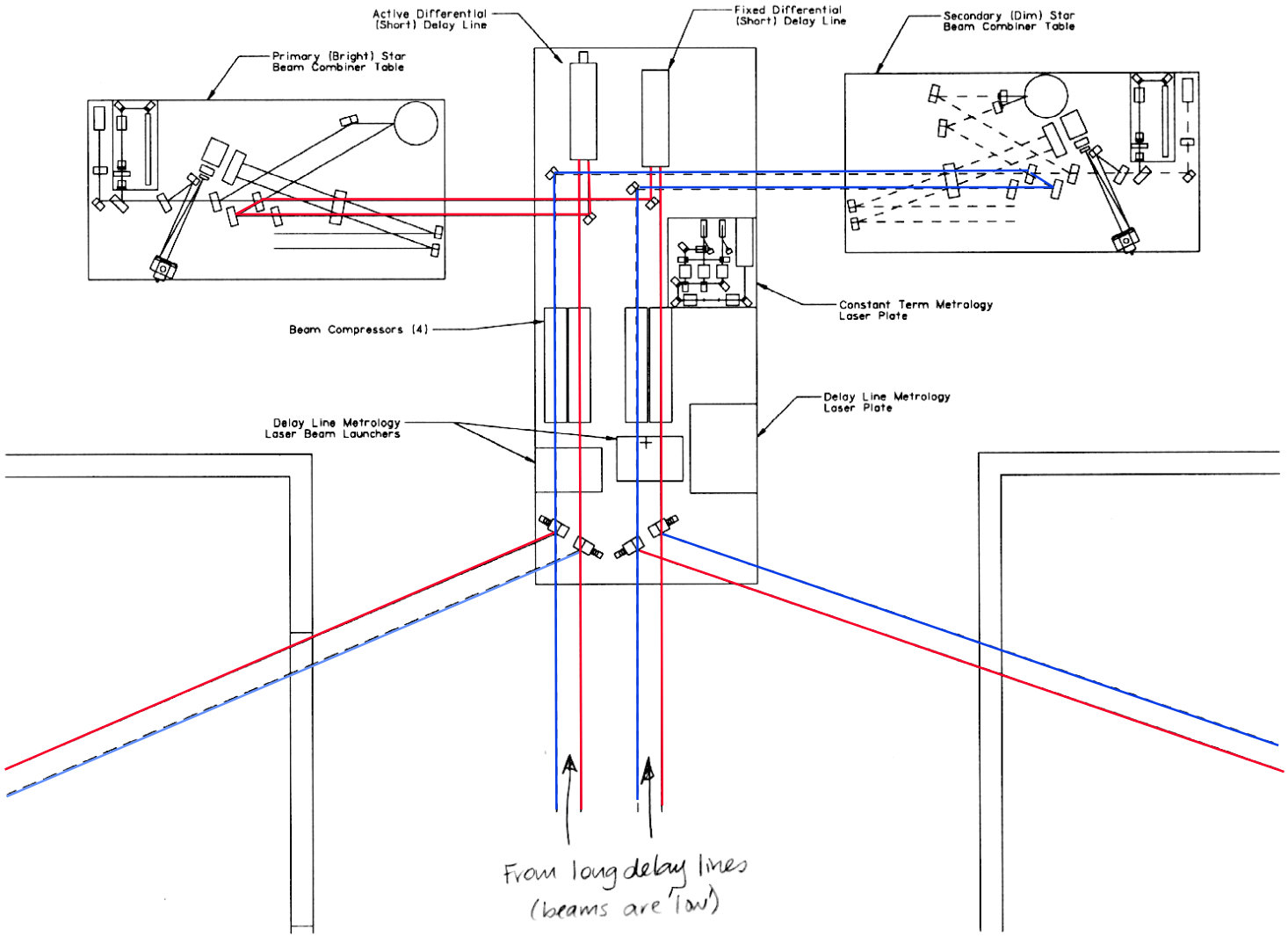
Layout of Optics at the Pier



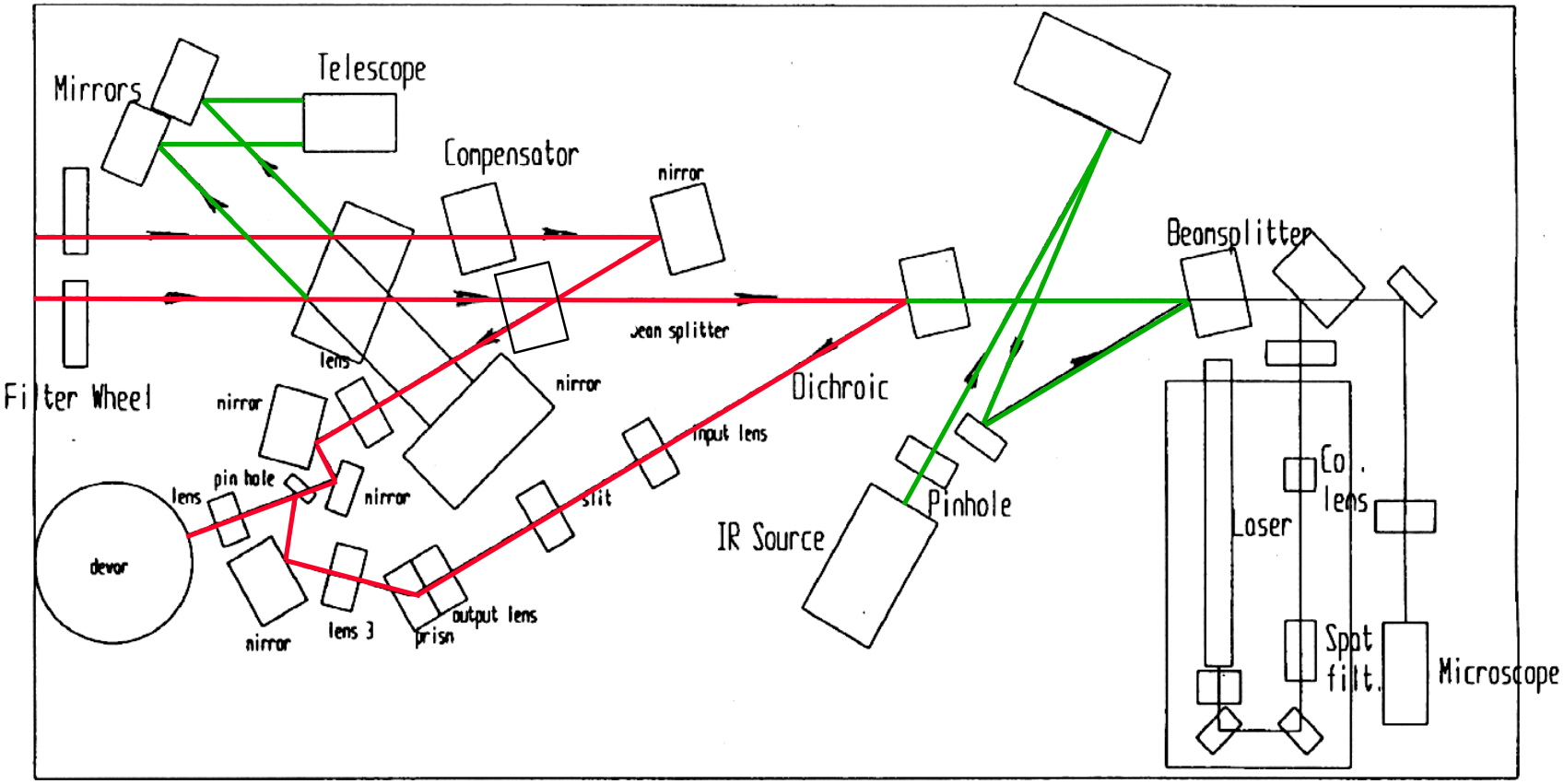
Dual Star Feed



Beam Switchyard



Primary Beam Combiner Table



Star Tracker

- Frame rate of 100 Hz
- Four photon counting Silicon APD's configured as a quad cell
- Angle tracking wavelength: 0.7-1.0 um
- Chopping mirror
  - share angle tracker between two apertures
  - 50% duty cycle
- Limiting magnitude: fainter than10 m_R

Fringe Tracker

Primary

- 100 Hz frame rate
- Fringe-scanning (ABCD) demodulation
- NICMOS III detector
  - pixels arranged on a single line
  - 1 white light pixel, 7 spectrometer pixels
  - timing varies by pixel so each scan is one wavelength
- Read noise:
  - single read: 40 e-
  - multiple read (16 - 64): 12 - 16 e-
- White light used for active tracking
  - 10 Hz closed loop BW
- Spectrometer used to estimate Group Delay for fringe centering and to measure precise visibilities for science measurements
- Limiting magnitude: 4.5 m_K

Fringe Tracker (cont.)

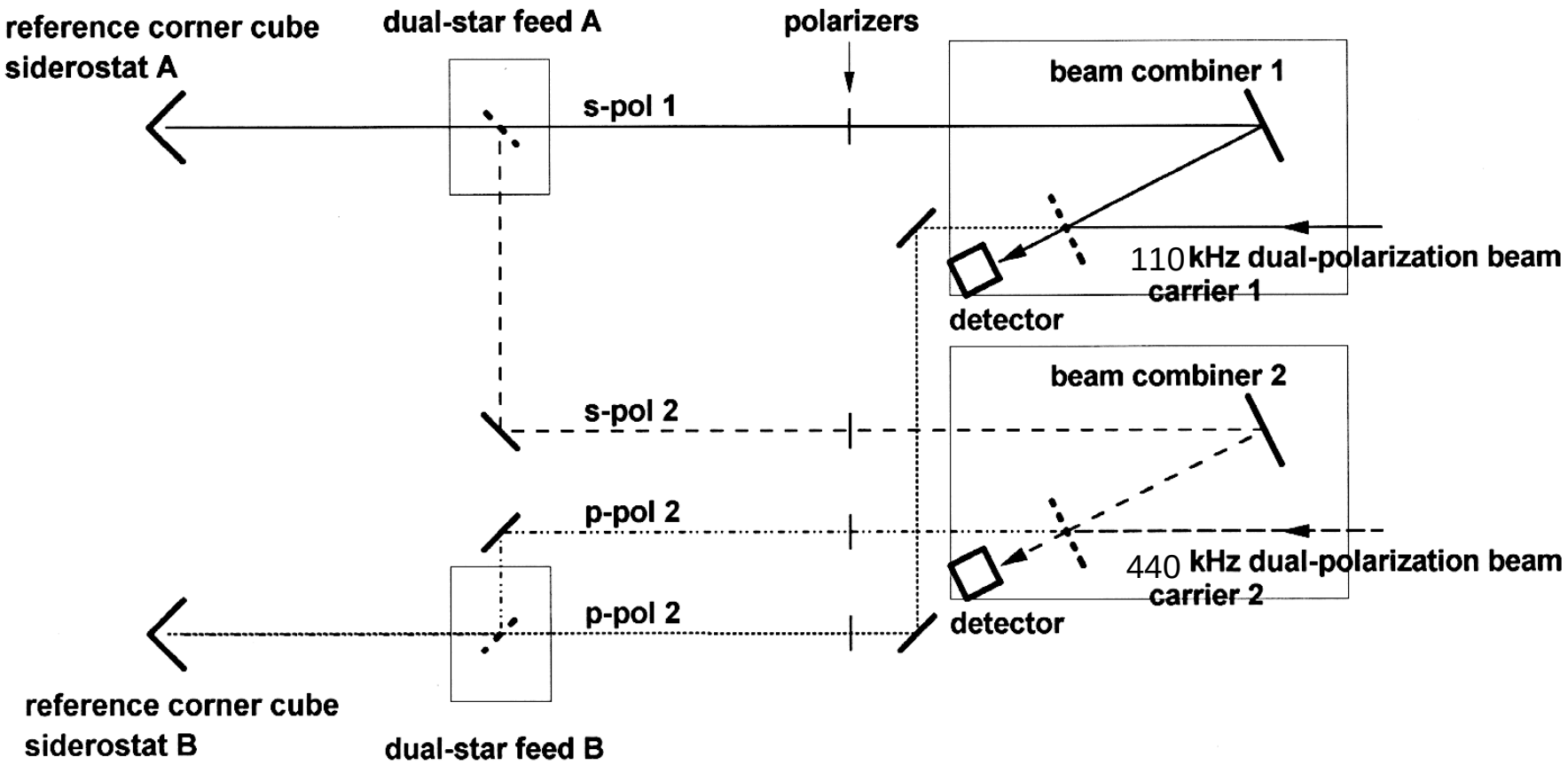
Secondary

- Can work in fast fringe scan mode
- Will also do slow fringe scan mode when co-phased.

Constant-Term Metrology

- Measures difference in optical path between the two arms for each beam combiner
  - difference in metrology measurments between the beam combiners (plus fringe phase) gives star separation
- Heterodyne metrology starting at main beamsplitter to corner cubes at the dual star feed
- Heterodyne at separate carriers to avoide interference

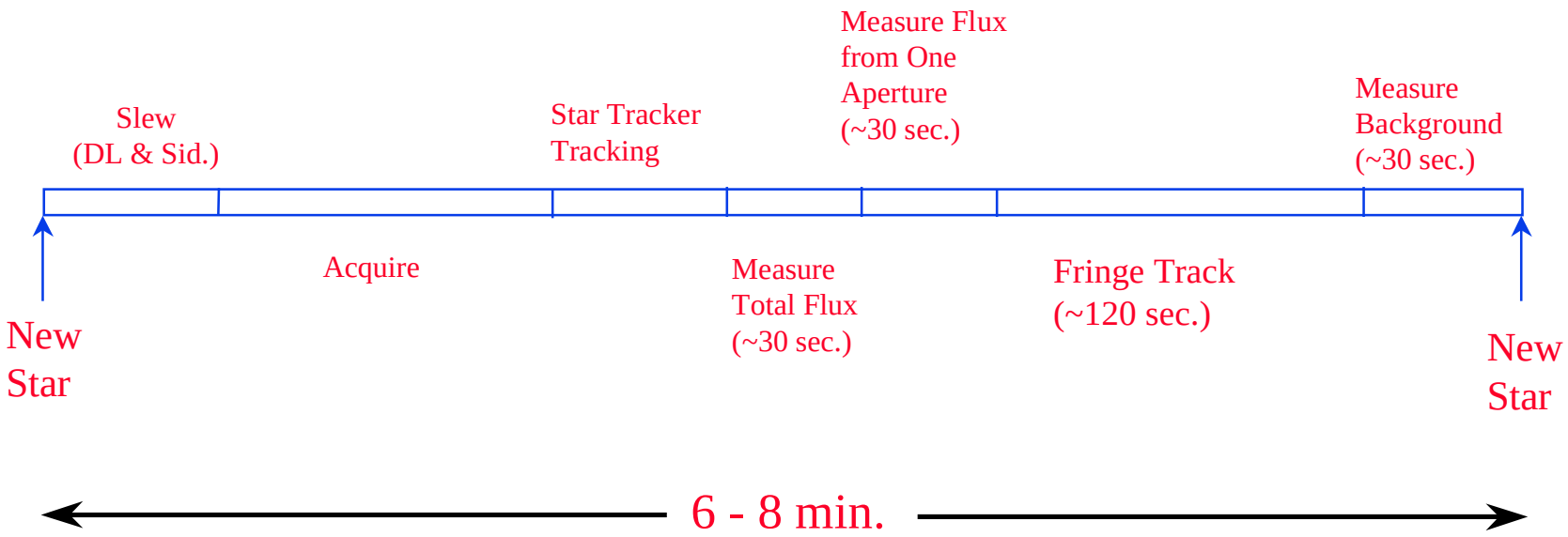
Palomar Constant-Term Metrology Layout



Software and Control System

- VME Real-time Control System
  - VxWorks development platform
  - 7 VME single board computers in 3 crates
  - reflective memory for inter-processor communication
- Sun Workstation
  - Graphical User Interface
  - Data recording
- Observing Process
  - Observer creates star list
    - science objects, calibrations objects, and time per object
  - Highly automated, very efficient
    - ~100 of independent observations per night

Observing Sequence



Upgrades (Completed in 1997)

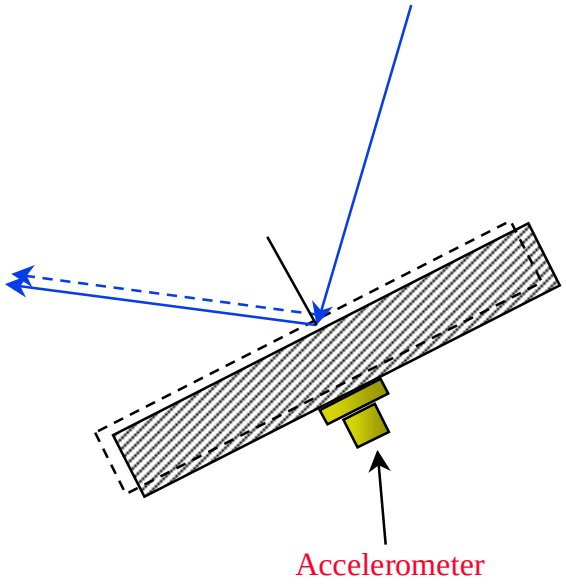
- Modification of optics to extend observations to H band
  - New lenses on beamcombiner table
  - New beamsplitters and couplers
- In-line infrared optical fiber in spectrometer arm to improve visibility measurement
  - post-combination
  - Provides raw $V^2 \sim 0.9$ for unresolved sources
    - used for science measurements
  - No fiber on tracking channel
    - avoids loss of SNR due to mode matching
    - Whitelight channel used only for tracking

Upgrades (cont.)

- Vacuum Pipes to replace the insulated aluminum pipes
  - added to minimize effects of turbulence on end-to-end laser metrology

Upgrades (cont.)

- Feed forward from siderostat accelerometers
  - compensates for some residual vibrations in the siderostat gimbal that can cause in some V^2 biases
  - accelerometers measure component along mirror normal
  - calculate motion along optical axis and feed forward to delay line
  - 2 kHz update rate



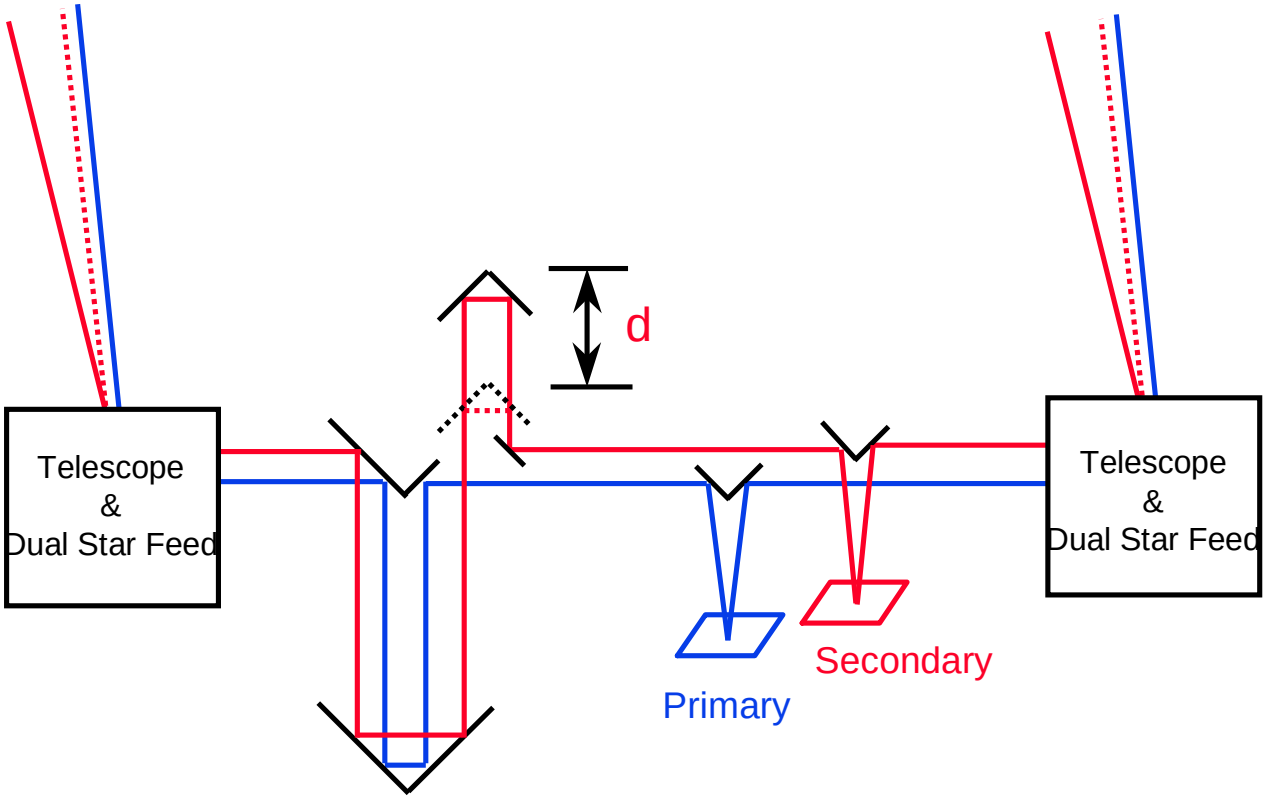
Upgrades (cont.)

- North-West baseline
  - 86.5 meters
  - Roughly orthogonal to other baseline
  - Designed for quick reconfiguration between the North-South and North-West baselines

Review of Recent Science with PTI

- Diameters of ~130 stars
- Binary orbit of Iota Peg
- RS CVn systems
- Astrometry

Science - Astrometry



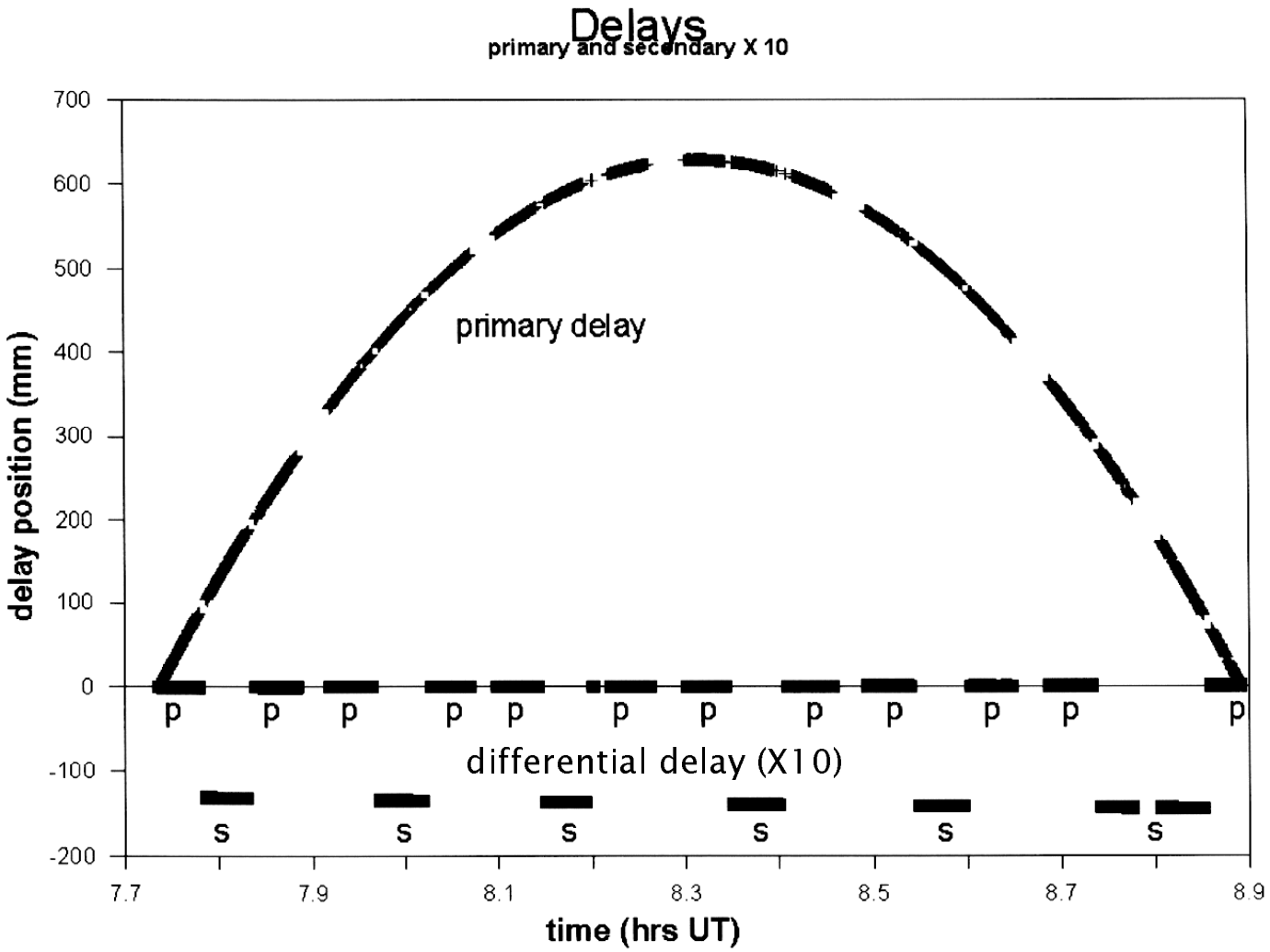
Astrometry Observation

Primary Combiner

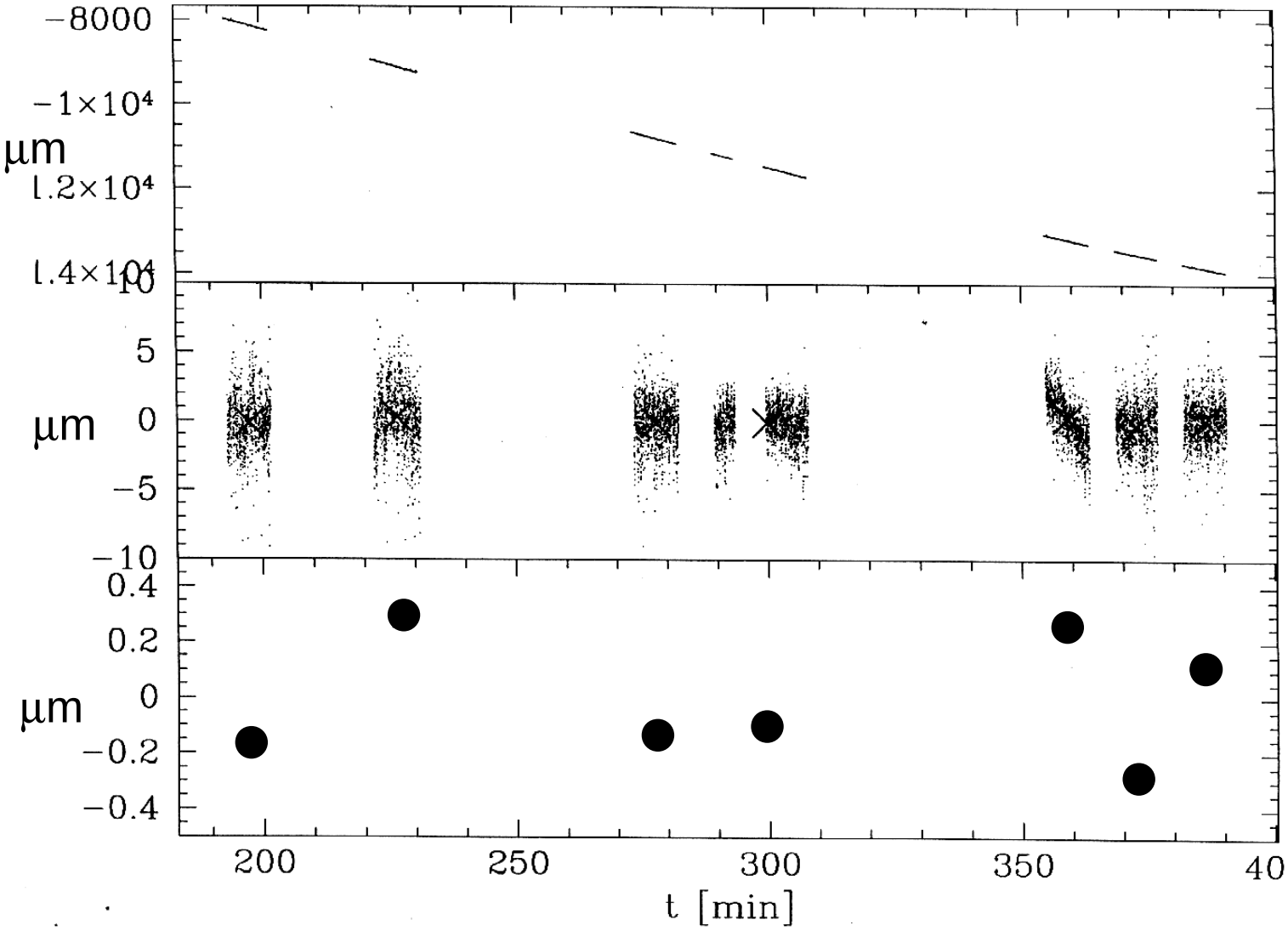
Secondary Combiner
(chops between primary and secondary)

repeat...

Science - Astrometry



Astrometry (cont.)



calibrated difference in delay

calibrated difference - sidereal motion

RMS residual = 100 nm = 200 µarcsec

Astrometry Summary

- Errors are white out to ~ 5 minutes at ~ 100uas/ Hr
- Sets chop needed by secondary
- Noise floor currently set by read noise in group delay estimator
  - atmospheric limit is lower
- Still to do: identify long term drifts to allow slower chop rates

Future Work

- 1998 observing season begins in a few weeks
- More tests to examine long term astrometry stability
- Science observations
- Observations with new capabilities:
  - N-W baseline
  - H-band
  - Phase referencing