Keck Interferometer Auto-Alignment System

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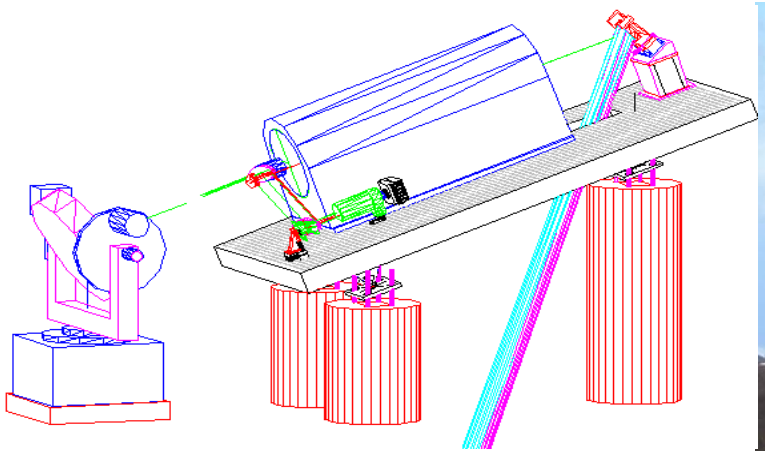
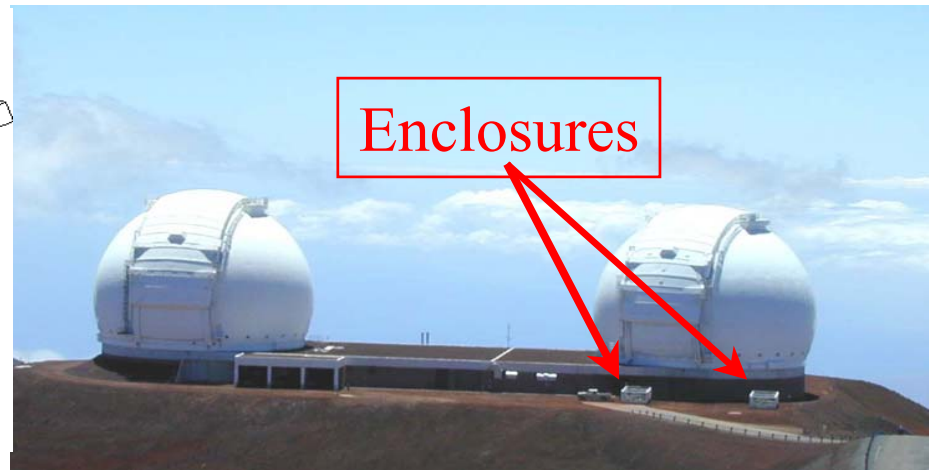
Keck Interferometer Update

- 2 Keck 10m telescopes with full adaptive optics (AO).
- Wavelengths 1.2 um to 10 um (AO operates in visible).
- Science: nulling, differential phase, astrometry, imaging.
- First fringes with Keck Telescopes March, 2001.

First Fringes

- Initial fringes using siderostats were obtained on Feb. 22, 2001.
  - Checked out hardware to be used with Kecks on next run.
  - Two 50-cm siderostats feeding fixed 40 cm telescopes (essentially the same as the Palomar Testbed Interferometer front-end optics).
- EPICS 3.14 alpha SNL sequencer used for sidereal delay line target generation through 2001.





- First fringes using two large Kecks March 12-14, 2001 (3 1/2-nights)

What I will talk about

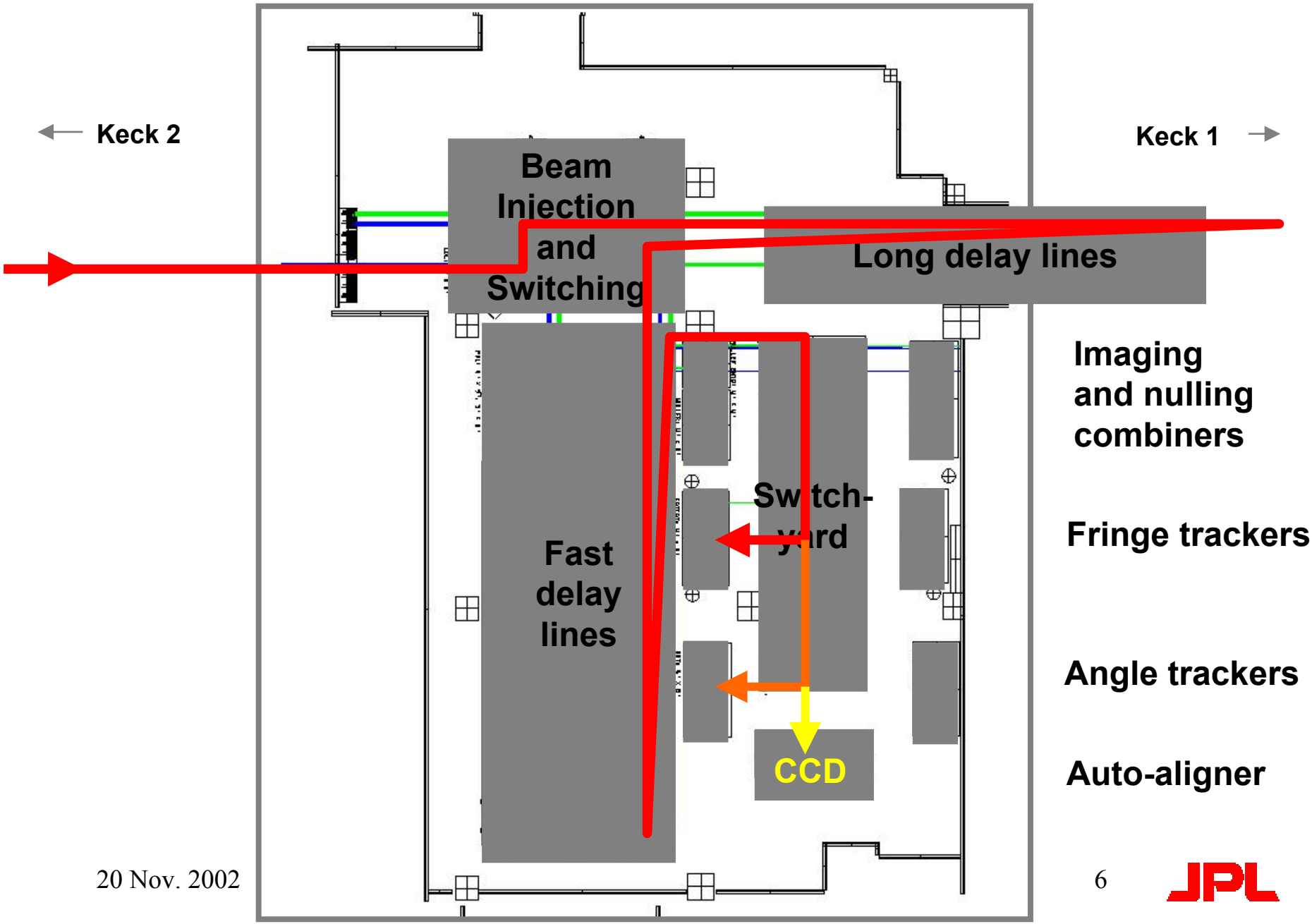
- Interferometer Major Components

- Automatic Alignment Process
  - Sequencers - EPICS State Notation Language (SNL)
    -- Beam Train Alignment Sequencer (btSeq)
    -- Internal Instrument Alignment Sequencer (iiSeq)

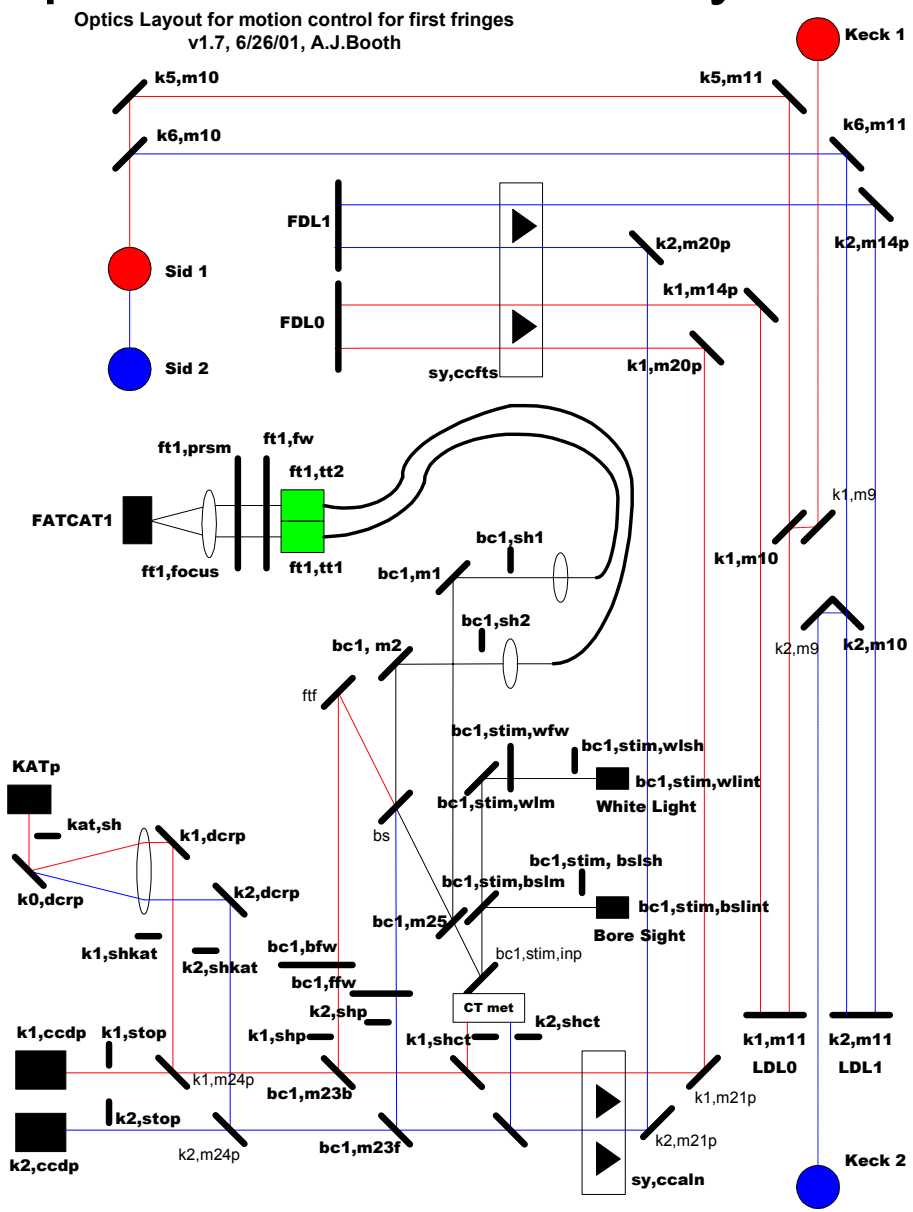
  - Optical alignment control user interface (aligner.tcl)
    -- Manual and automatic

- Sensors/Actuators/Targets and EPICS
  - Device Support and Drivers
  - Use of existing EPICS components (Records, Device Support and Drivers)

Optical Path Through the Basement

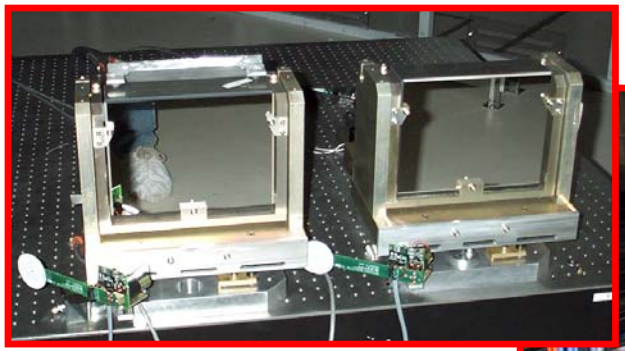


Optics and Control Layout for First Fringes

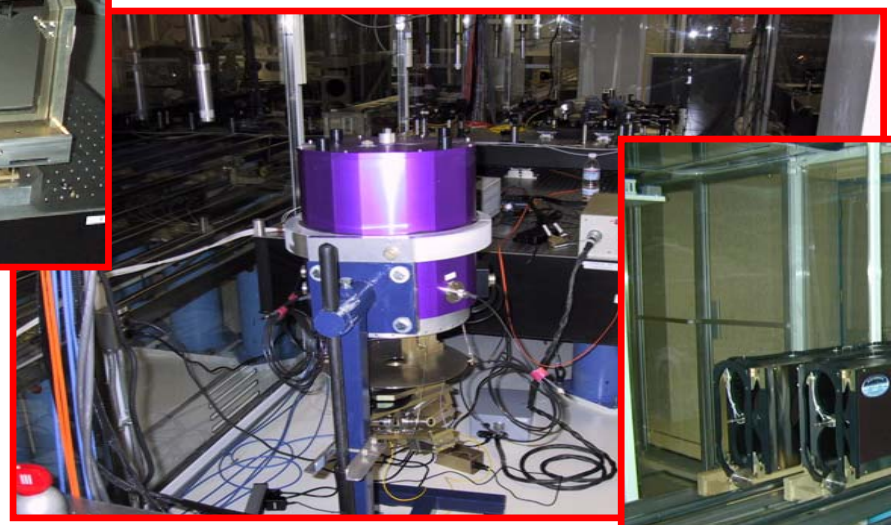


- AA Sequencers:
  - 6 Beam Train
  - 4 Internal
- Sensors:
  - 2 C.T.
  - 4 Cameras
- Stimuli Targets:
  - White Light
  - Laser Boresite
  - 12 LEDs
- Actuators:
  - 20 Newport 850G
  - 26 Pico Motors
  - 16 Shutters
  - Other Misc.

Interferometer Major Components



Beam Transport Optics (Coude Train)



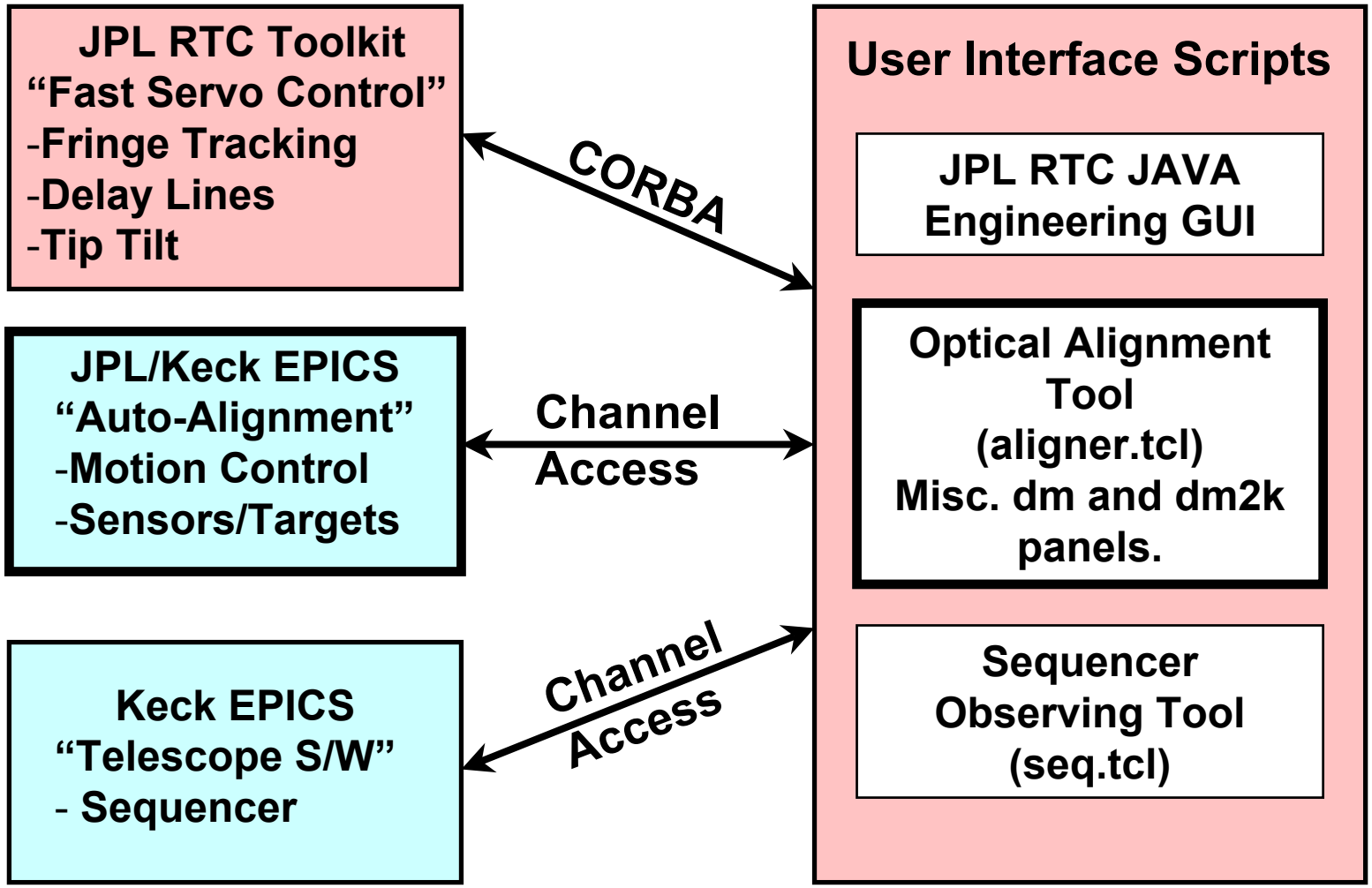
Fringe Tracker (FATCAT)

Fast Delay Lines (FDL)

Angle Tracker (KAT)

Long Delay Lines (LDL)

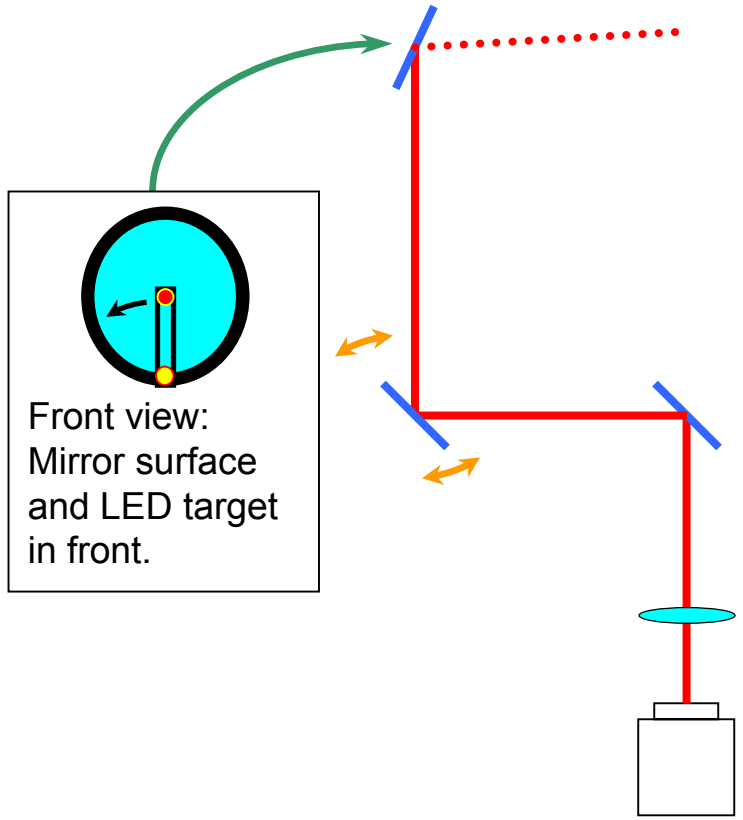
Keck Interferometer Software



Automatic Alignment Approach

1. Align “backwards” from detector to telescope.
2. Threading optical axis from instrument internal combiner out through beam train to optical telescope.

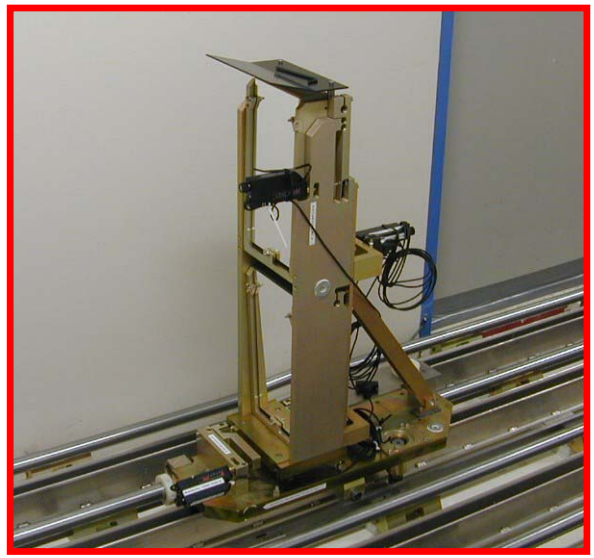
- Use camera at back end of system.
- Use LEDs mounted on swing arm and positioned in front of mirror as alignment targets.
- Illuminate LEDs, and align prior mirror in beam train.
- Repeat from inside instrument up to telescope to thread beam along optical axis.



EPICS Alignment Control of Major Components

Beam Transport Optic
As Seen from Coude
Tunnel

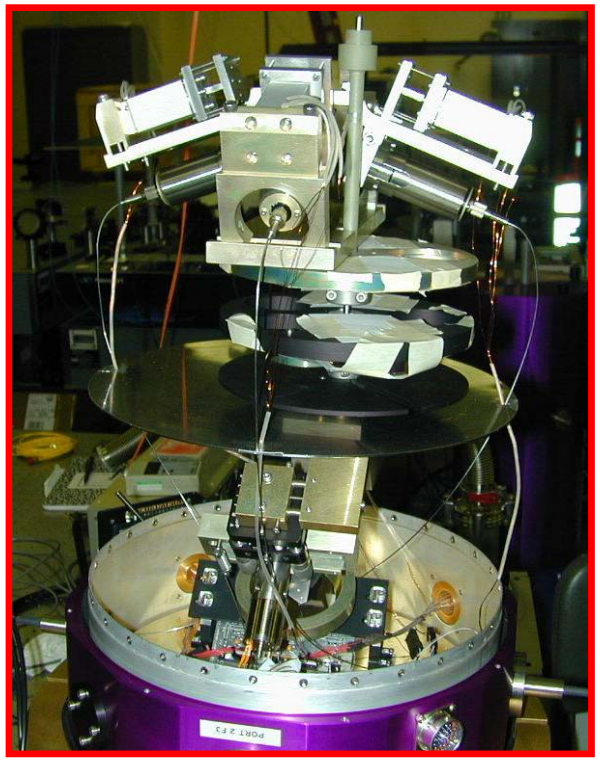
Beam Transport Optic



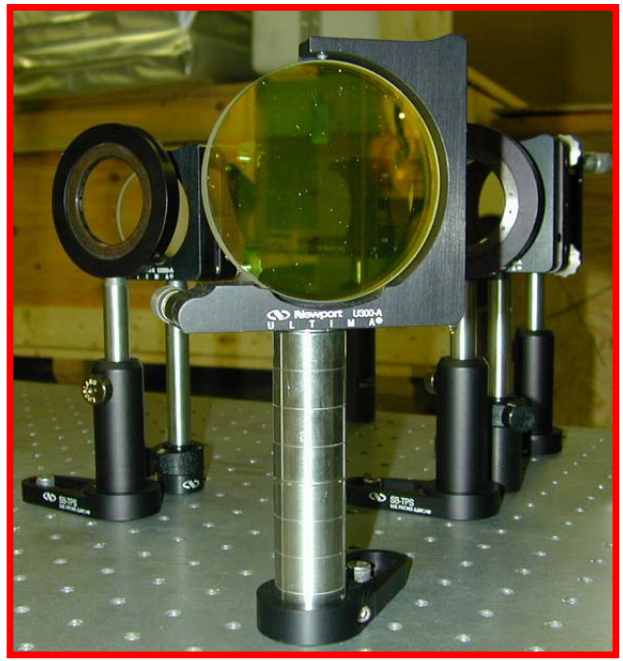
Long Delay Lines Sled

- Beam Transport Optics (Coude Train) and Long Delay Lines (LDL) auto-alignment via SNL sequencer implementation (btSeq).

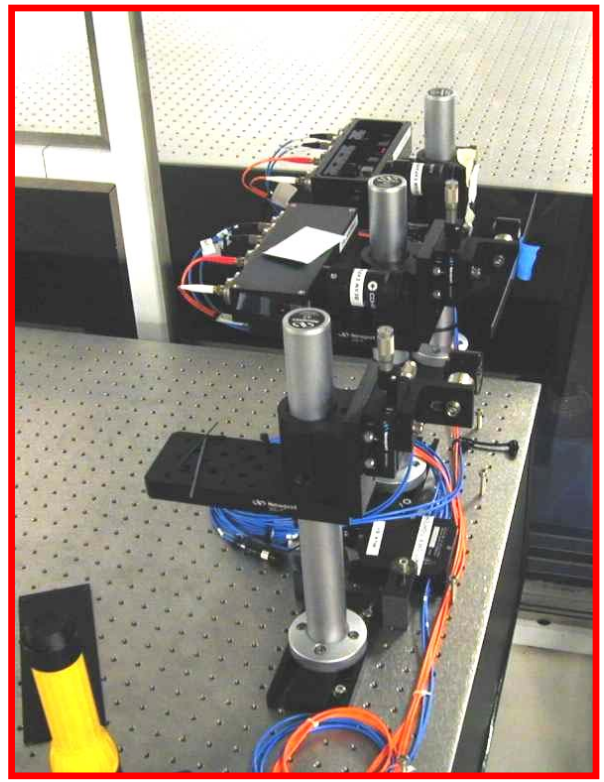
EPICS Alignment Control of Major Components



Opened Fringe Camera



Dichroic Optic



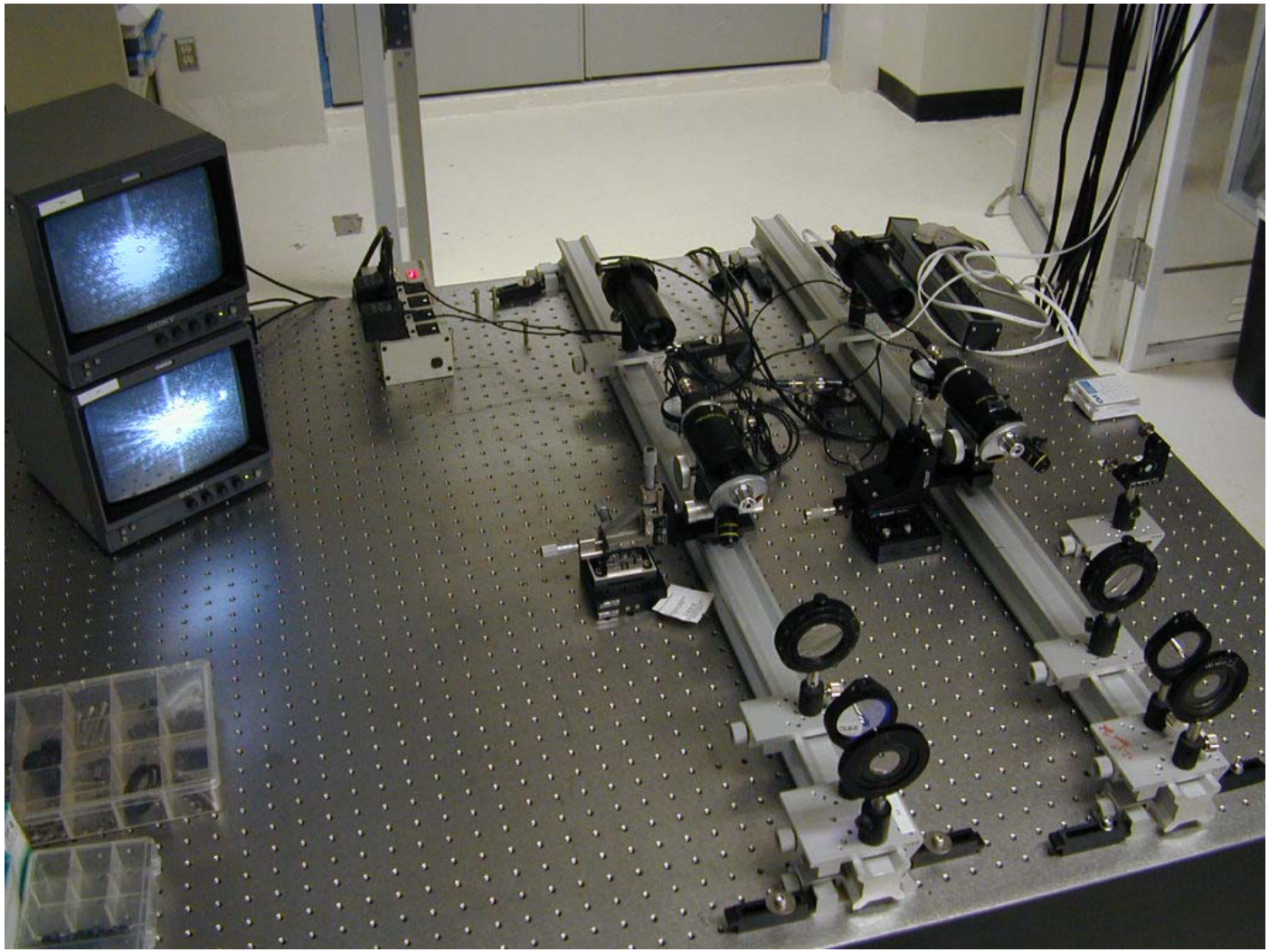
Fiber-fed laser metrology

- Fringe Tracker (FATCAT)
  - PZTs driven by JPL custom device support for alignment.
  - Focus and filter wheel control, white light stimulus adjustment, etc.
- Angle Tracker (KAT) and Constant Term Metrology SNL seq. alignment

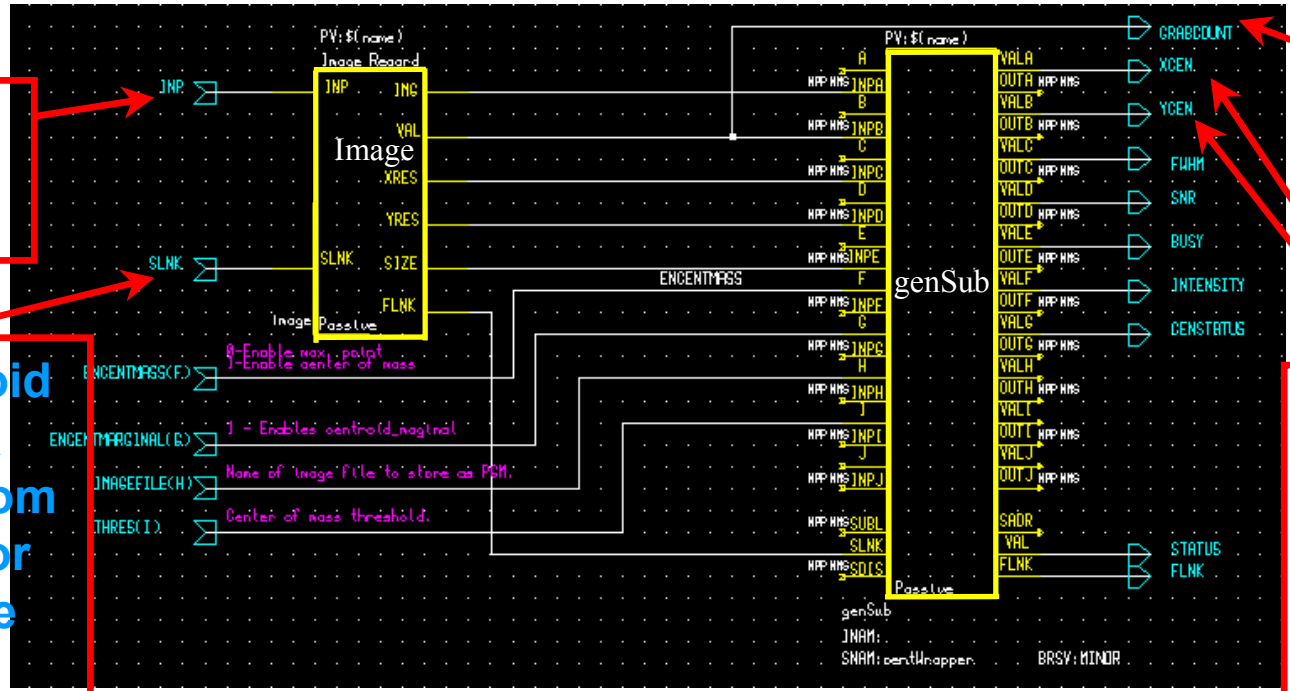
EPICS Automatic Alignment Sequencers

- Implemented in VxWorks using SNL.
- One instance of sequencer per mirror to align.
- Internal Instrument Alignment Sequencer (iiSeq)
  - Alignment of back end sensor components (KAT, FATCAT, CCD).
  - Auto-align constant term metrology.
- Beam Train Alignment Sequencer (btSeq)
  - Large transport optic mirrors.
  - LDLs and Coude Train.

Autoaligner Camera System



Frame Grabber/Centroiding



INP link to Select Snapper 24

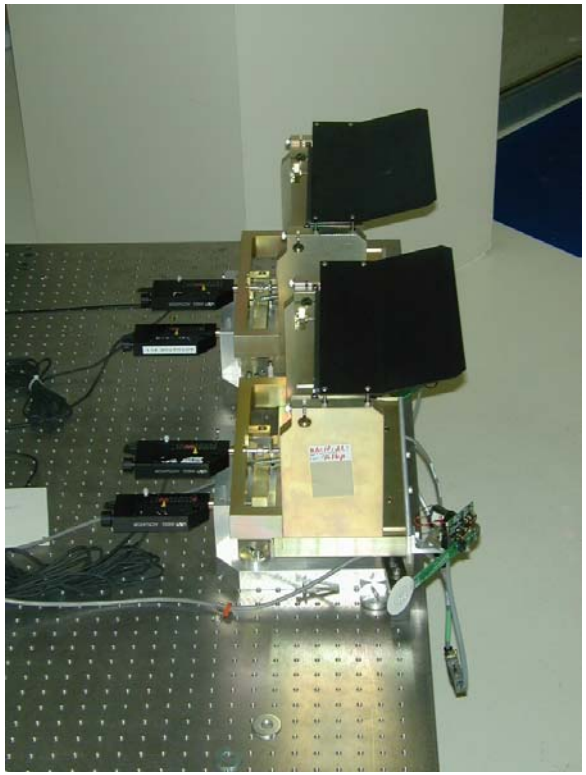
Grab/Centroid forward link triggered from sequencer or periodic rate scan.

Frame count

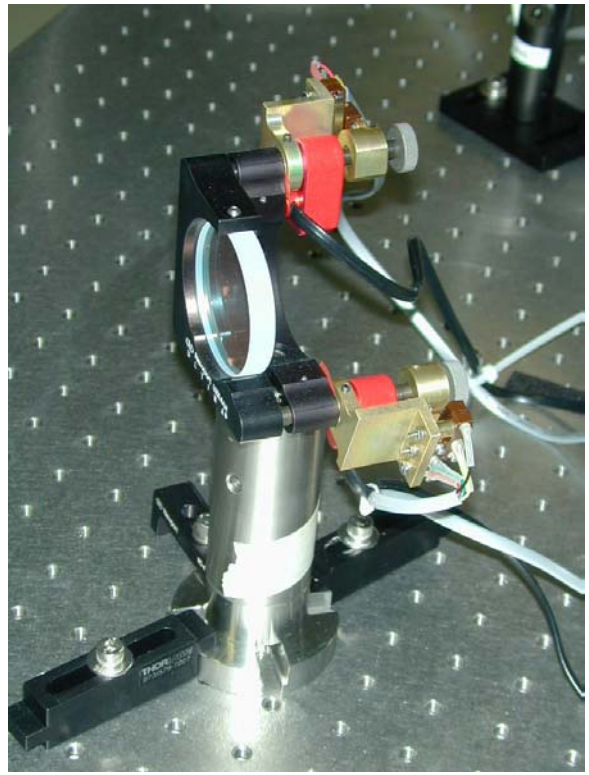
XCEN, YCEN coordinate of alignment target.

- DataCell Snapper 24 PLC frame grabber used with modified version of driver written by Miroslaw Dach (dach@psi.ch) at the Paul Schere Institute.
- Device support links driver and Image Record written by Ned Arnold (nda@aps.anl.gov) LANL. Image Record is glue between EPICS IOC and genSub record.
- genSub record used to wrap alignment target centroid estimation algorithm.

Actuated Optics



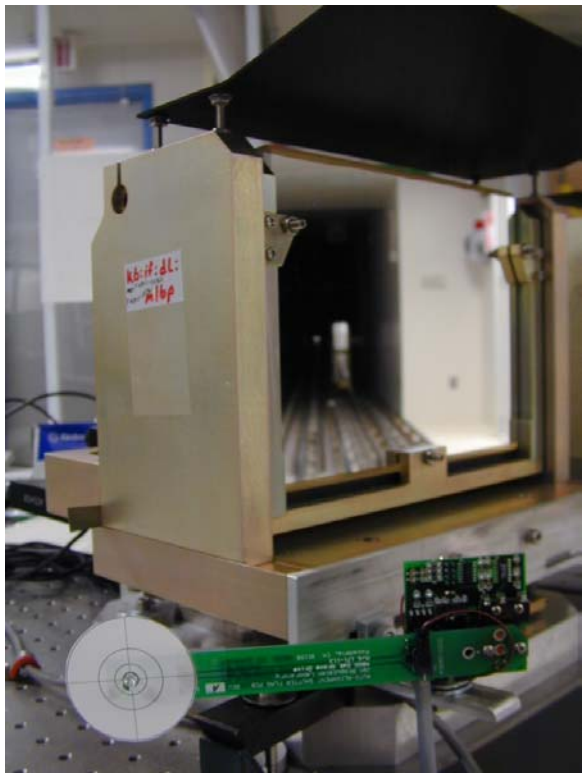
Transport Optic w/850G



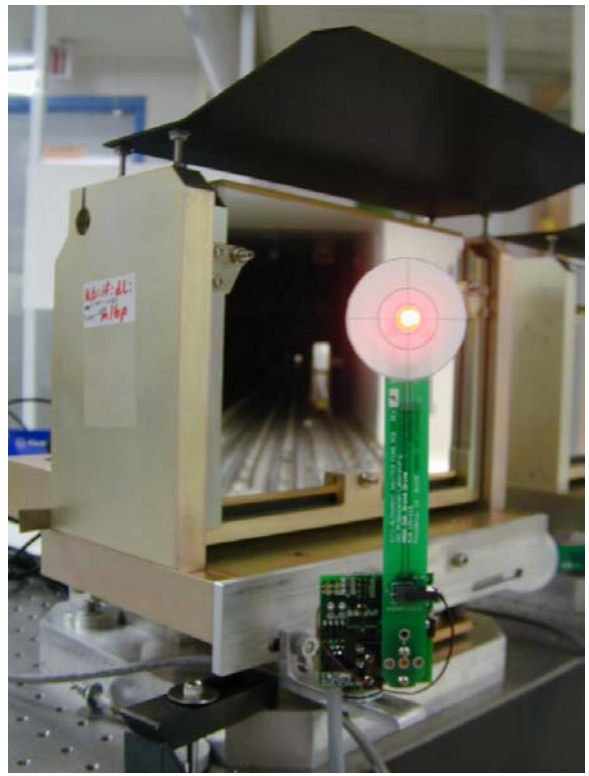
Dichroic Optic w/Picomotors

- Common actuators used: two kinds throughout system.
- Beam Train Transport Optic driven by Newport 850G DC servo long travel actuators.
- Piezoelectric New Focus Picomotors used on smaller optic.

Actuated LED Targets



Retracted



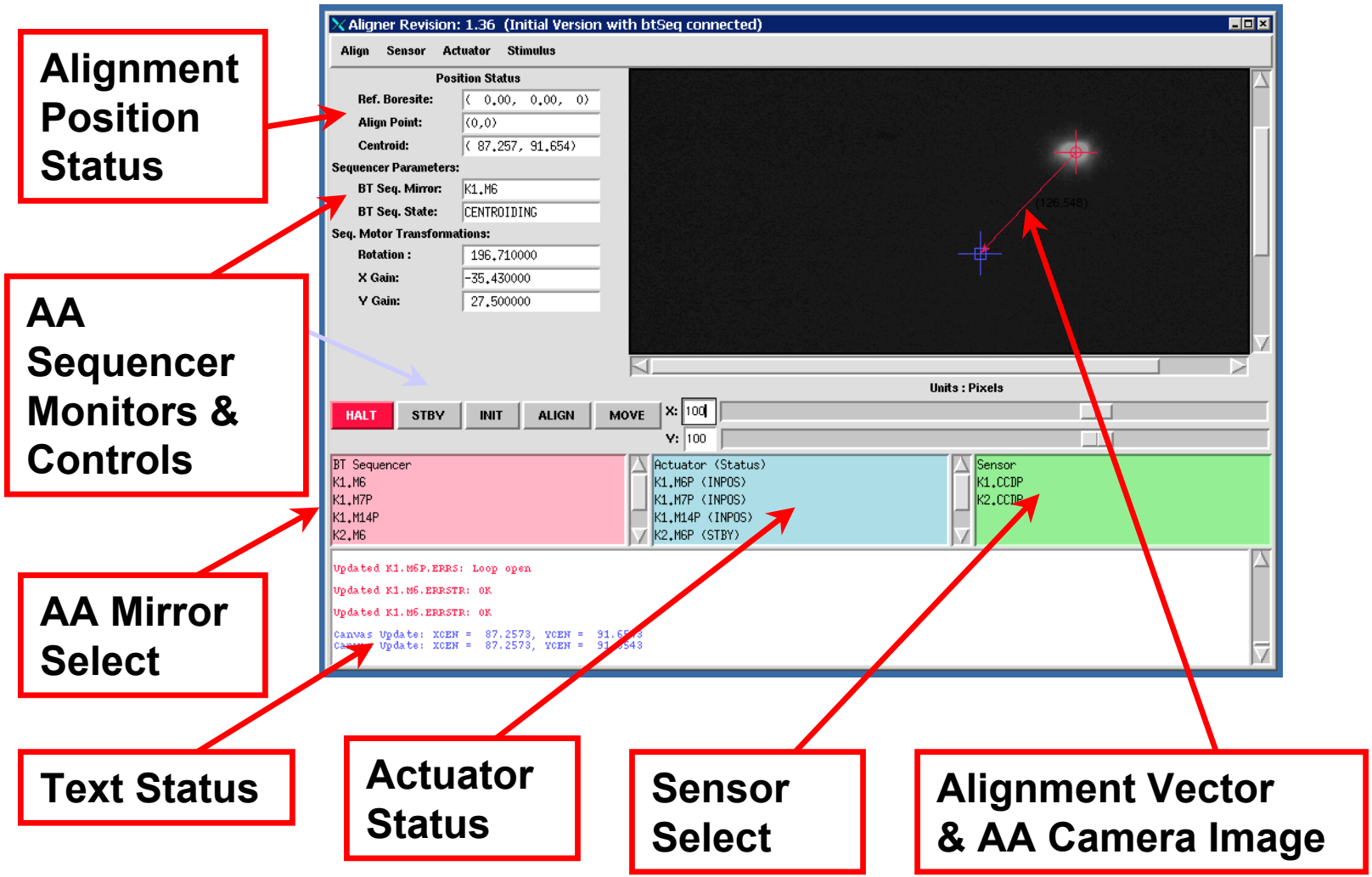
In position and illuminated

- AA Targets position and illuminate with a high degree of repeatable motion: 0.25mm
- Limit switch feedback state of target to EPICS device support.

EPICS Device Support and Drivers

- Datacell Snapper 24 Frame Grabber image record support.
- Delta Tau Turbo PMAC device support and motion control sequencing used on Keck AO bench is used for beam train transport optic positioning.
  - Originally written by Thomas Coleman, ANL
  - Updated by Kevin Tsubota and Paul Stomski, Keck
- Industry Pack device drivers support utilizing Andrew Johnson's Industry Pack Driver Software (drvIpac).
  - Acromag IP480, IP230, IP330 modules
  - Greenspring IP-Digital24, IP-Driver40 modules
  - Generic device support for bi, bo, ao, ai, longin, longout
- JPL specific device support implemented.
  - Picomotors, cryo focus motor, laser attenuator, etc.

Automatic and Manual Optical Alignment User Interface TCL Application (aligner.tcl)



Summary

- KI is taking “shared risk” science data (since June).
- Automatically aligning parts of interferometer.
  - Angle Tracker (KAT).
  - CT Metrology.
  - Fringe Tracker (FATCAT).
  - Beam Train Mirrors.
- Refinement of Frame Grabbing Technology and Centroiding for better beam train auto-alignment is needed (presently ~ 1.5 pixels, requirement 0.1 pixels).
- A top level sequencer to orchestrate all alignment is next major development effort.
- More info about Keck Interferometer go to web site: http://planetquest.jpl.nasa.gov.
- Device support codes available from reder@huey.jpl.nasa.gov.

W. M. Keck Observatory: Feb. 2002