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Retrieving Tip/Tilt from Laser Guide Stars with the LATTE Experiment

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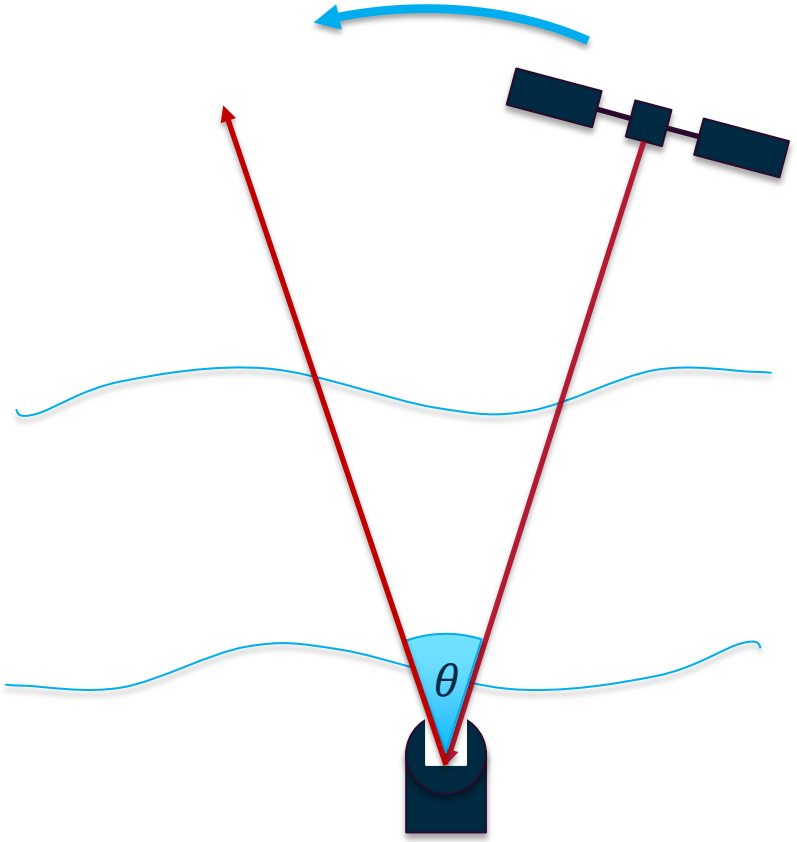
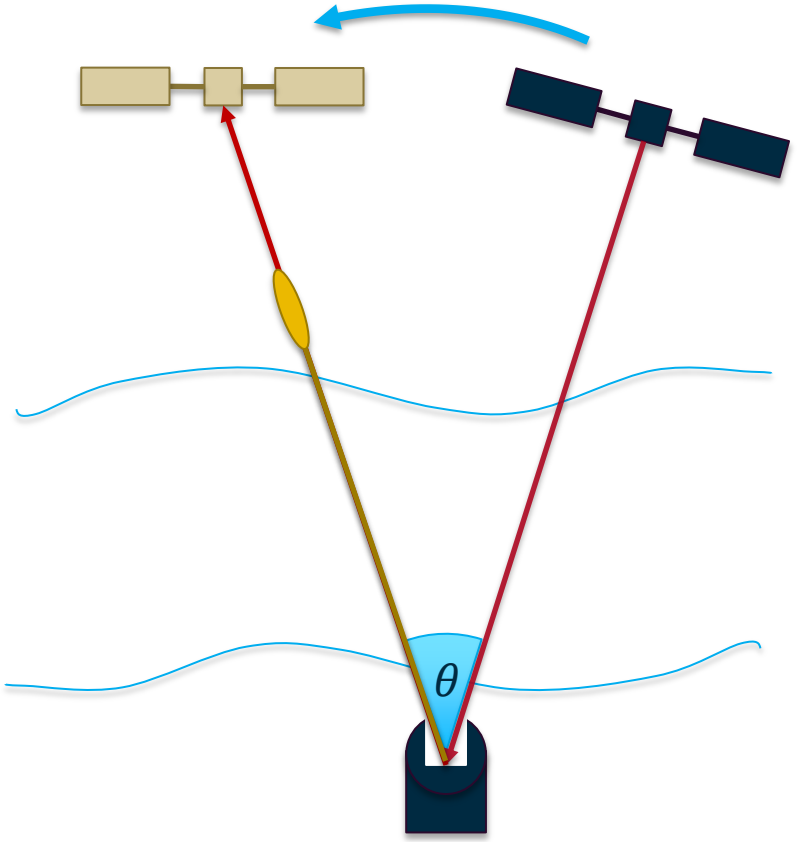
Point Ahead Angle

- Satellite travels at high (angular) speed



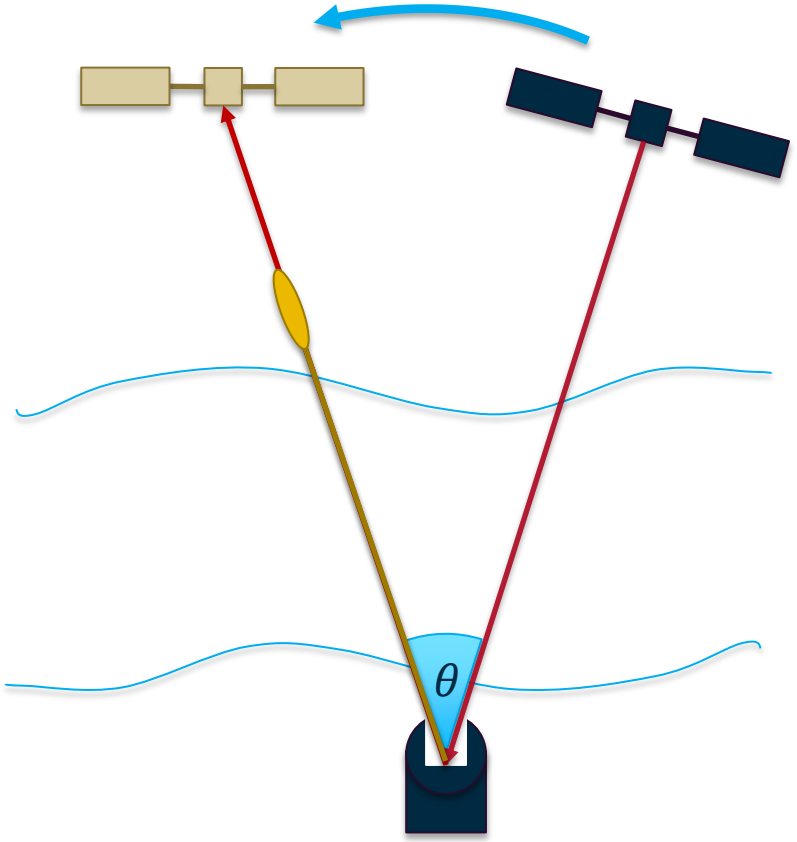
Point Ahead Angle

- Larger than iso-planatic angle
  - Laser Guide Star
- Larger than isokinetic angle
  - …



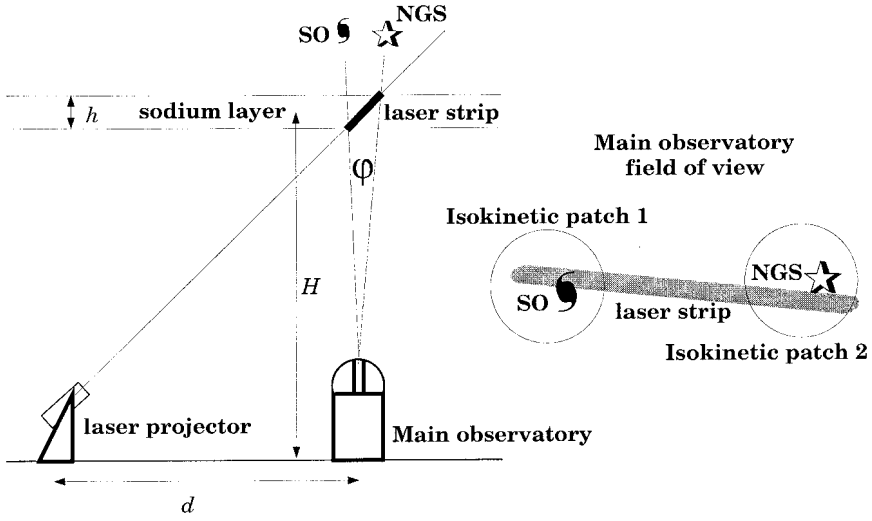
Point Ahead Angle

- Larger than iso-planatic angle
  - Laser Guide Star
- Larger than isokinetic angle
  - Laser Guide Star?
    - Retrieve Tip/Tilt from LGS



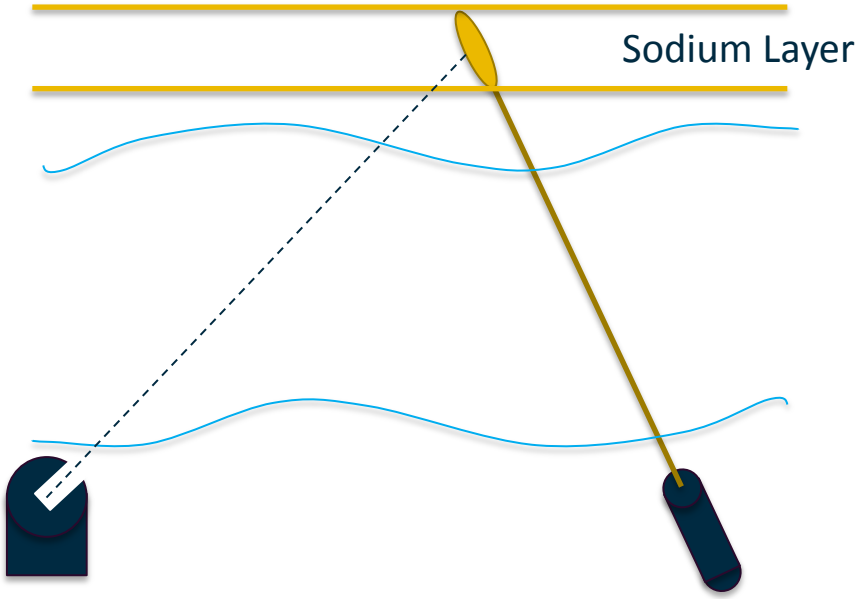
Absolute Tilt from a Laser Guide Star

- Esposito 2000
  - Based on Elongation Perspective (Roddier 1977)
- 2 step
  - Derive downlink tilt from laser & NGS
  - Use all modes of LGS at science object



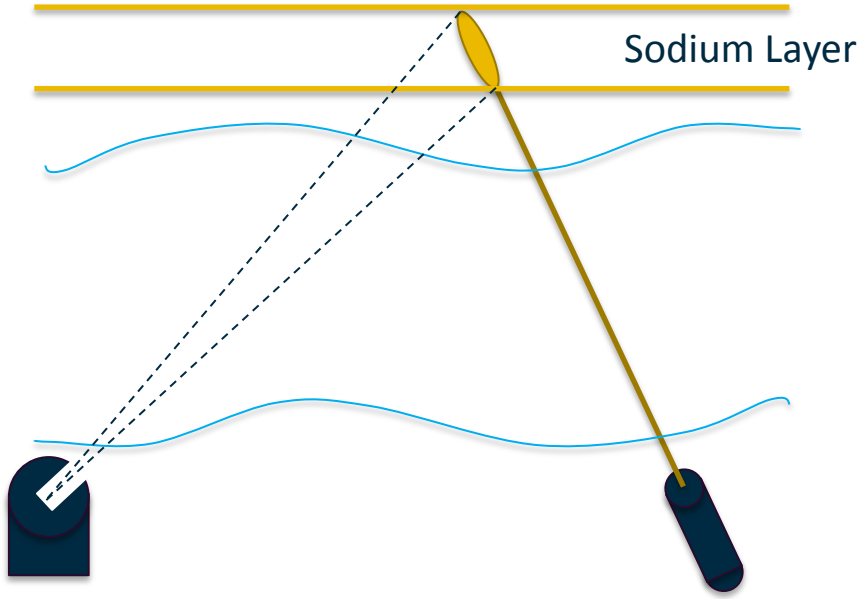
Absolute LGS Tilt

- $[LGS] = [Up] + [Down]$
- Isolate uplink from downlink
  - Bulk motion of plume



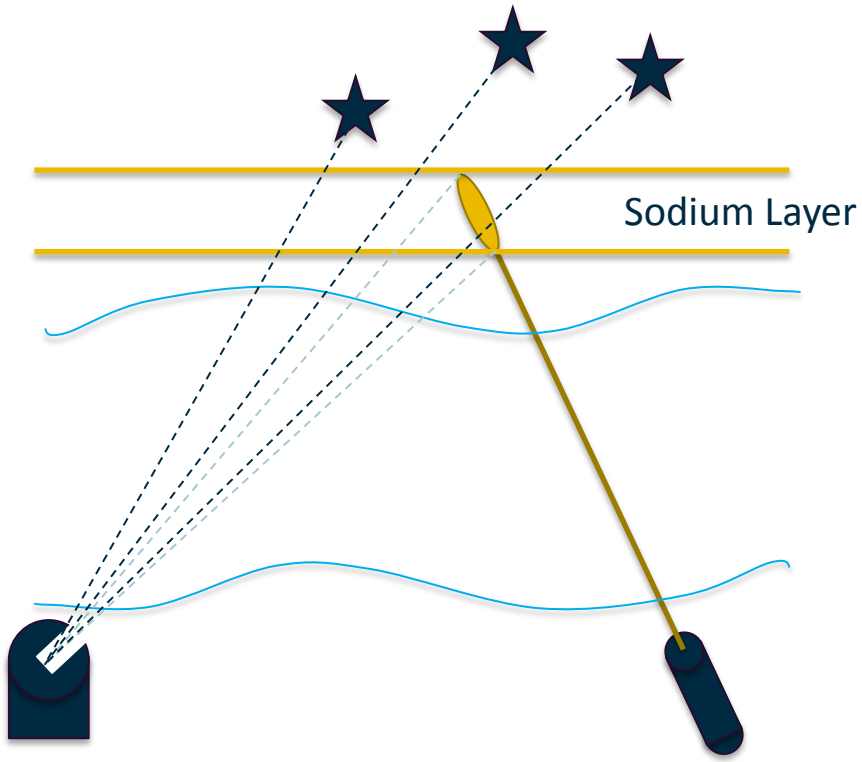
Absolute LGS Tilt

- Uplink
  - Common for all “positions” along the plume
- Downlink
  - Different regions of the plume pass through different turbulence
    - Except the ground



Absolute LGS Tilt

- Ground
  - Turbulence common in all directions
    - GLAO
  - Use average motion of NGS
    - Large FOV

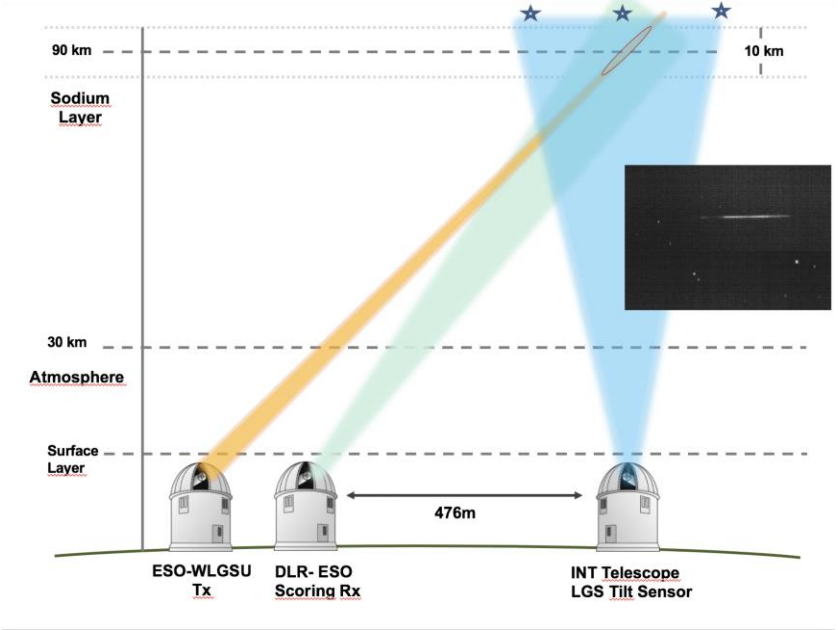


Absolute LGS Tilt

- Bulk motion of plume over many θ_0
  - Removes high altitude turbulence
- Average NGS Motion
  - Removes low/ground layer turbulence
- $[Uplink] = \langle LGS \rangle_{plume} - \langle NGS \rangle$

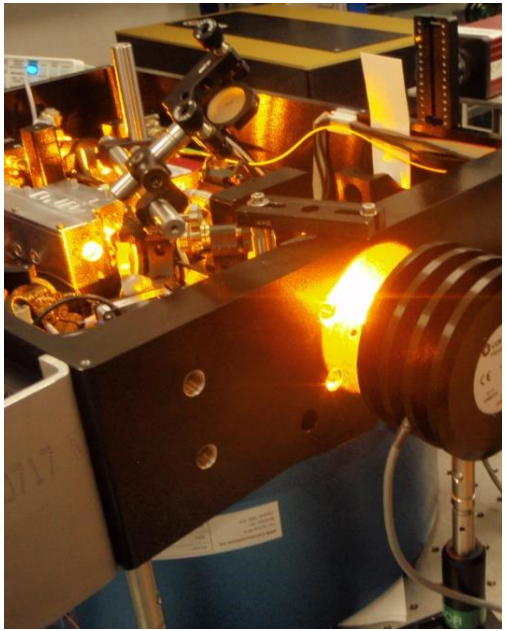
LATTE

- Compensate for uplink jitter
  - Laser launch telescope
    - Sodium Beacon
  - LGS Tilt Sensor
    - Closed loop system
  - Scoring camera
    - Monitors LGS jitter



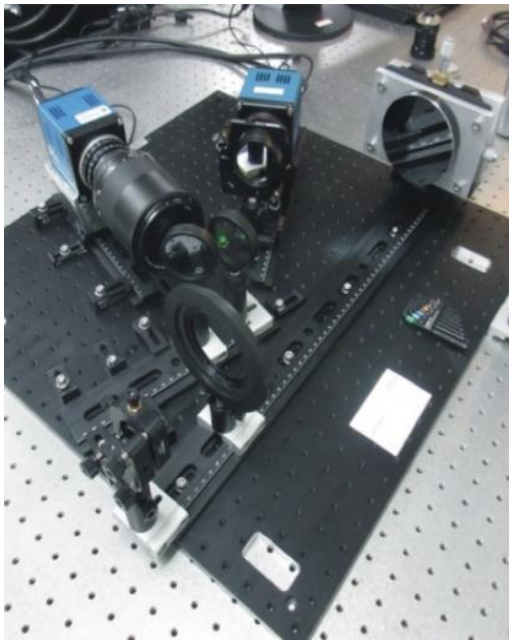
Laser Launch Telescope

- ESO WLGSU
  - 20W Sodium Laser
  - Upgraded with tip/tilt piezo actuator



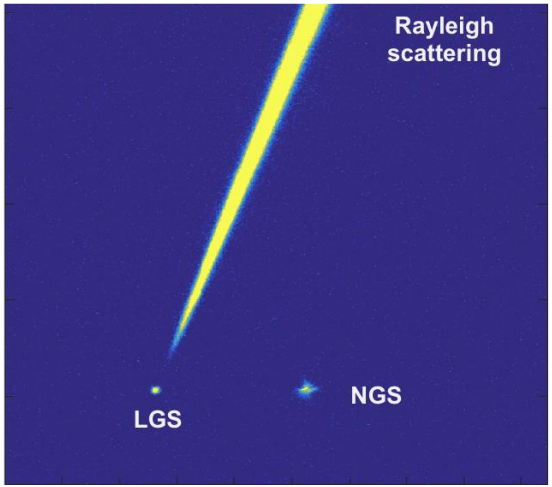
LGS Tilt Sensor

- INT
  - 2.5m diameter
  - 476m off-axis
- Measures LGS position
  - Estimate Tilt from Laser uplink



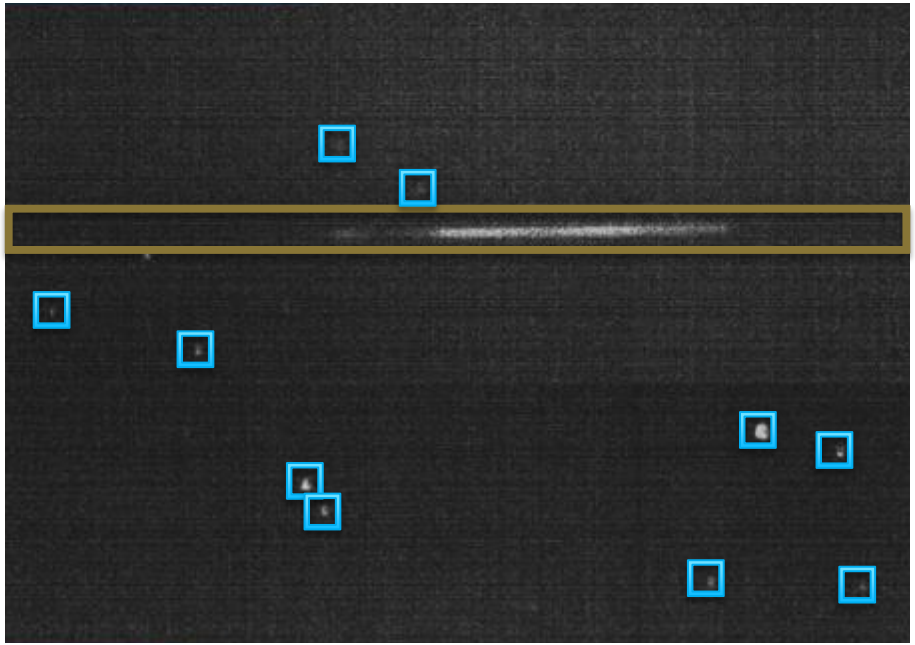
Scoring Camera

- Small Cassegrain telescope
  - Monitors LGS position
  - High frame rate
- NGS reference
  - Measure telescope vibrations



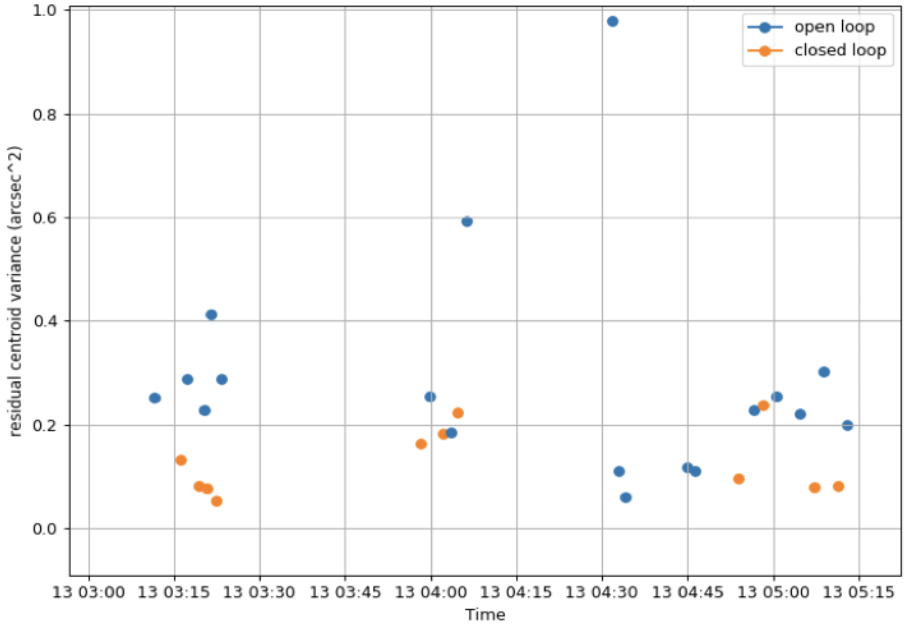
Data Processing

- Centroiding
  - Centre of mass
    - Plume
    - Stars
- Ground layer
  - Average star centroids
- Uplink
  - $\langle LGS \rangle_{plume} - \langle NGS \rangle$



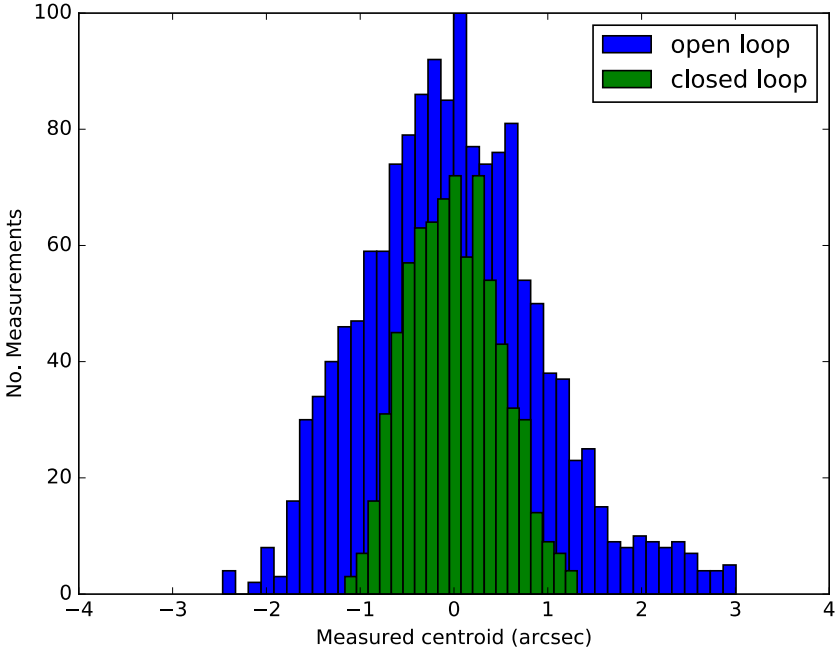
Preliminary Data Analysis

- May & September
  - Commissioning
  - Open/Closed comparisons
- Closed loop reduces measured centroid variance



Preliminary Data Analysis

- Histogram of centroids
  - Measured at INT (Tilt Sensor)
- Closed Loop reduces centroid variance
  - × 1.4



Summary

- Point ahead angle
  - Reduces AO performance
  - Lack of sources
- Laser Guide Stars
  - Sensing Tilt from LGS
- Proof of concept experiments
  - Seem to work
  - Further analysis ongoing