DELTA Imaging Path Turbulence Monitor, PM-02-600

Applications

- Passively monitors turbulence conditions
- Laser propagation path characterization
- Atmospheric imaging diagnostics
- Optical communications link performance
- Evapo-transpiration and water management
- Include turbulence profiles in wave-optics simulations
- Enables custom MATLAB analysis

Unique Advantages

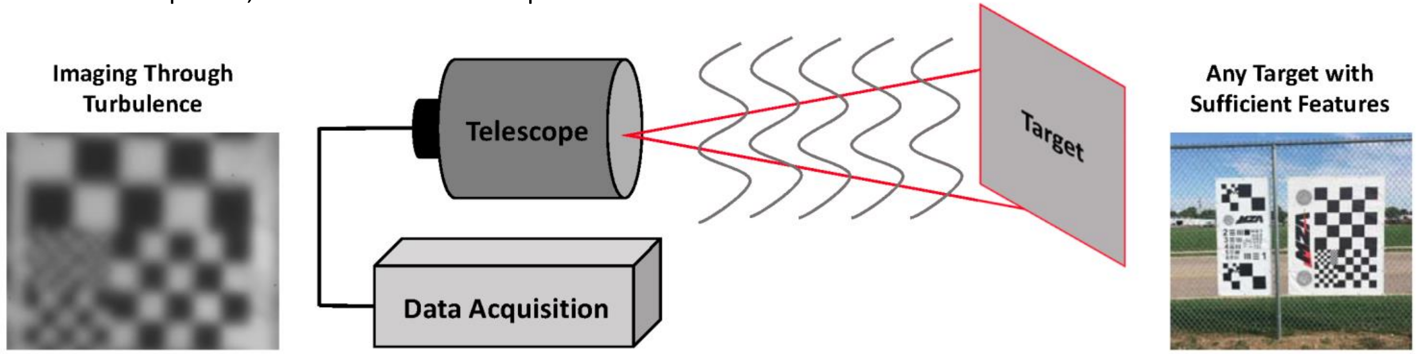
- Bounds C_n^2 turbulence strength along path
- Automatic computation of:
  - Rytov number
  - Scintillation index
  - Fried's coherence diameter
  - Isoplanatic angle
  - Cross-wind speeds
  - Greenwood and Tyler frequencies
- 2 km range from target to receiver
- Automatic collection, processing, and reporting of turbulence diagnostics
- Portable and compact system
- Passive operation—no external sources required for diagnostic target
- Output supports ATMTools and WaveTrain

Description

MZA's Delayed Tilt Anisoplanatism (DELTA) method measures turbulence strength along a line of sight. These turbulent fluctuations, commonly observed as twinkling of distant lights or stars, significantly affect high resolution imaging sensors and can reduce efficiency of laser beam projection for illumination and optical communications. The same phenomena also give insight into other aspects of the atmospheric path, including evapo-transpiration measures critical to water and agricultural management activities.

Operation

The DELTA system is placed at one end of the path, with a target or object with multiple, trackable features on the opposite end. Depending on the size of the target and the optics on the telescope, a range of ½ to 2 kilometers can be achieved. Once initial setup has been conducted, user desired parameters are adjusted such as feedback period, duration of observation and stored output info. A sequence of imagery is collected and the deviation or "dancing" of feature points on the target is recorded. The DELTA method measures the differential jitter of feature pairs as a function of angular separation. Using multiple pairs at various degrees of separation, a non-uniform C_n^2 profile is estimated using additional atmospheric estimation software. Turbulence statistics are calculated from this profile, as well as cross-wind speeds.



2021 Girard Blvd. SE, Suite 150
Albuquerque, NM 87106
505-245-9970

1360 Technology Ct, Suite 200
Dayton, OH 45430
937-684-4100

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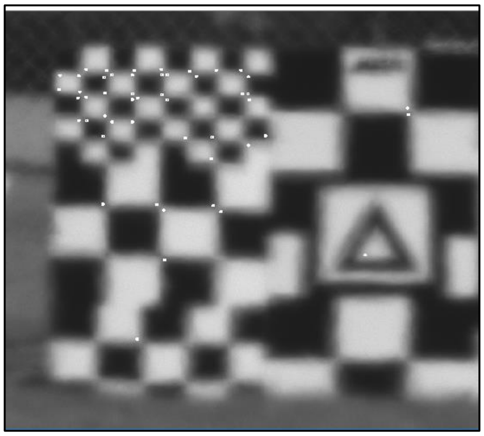
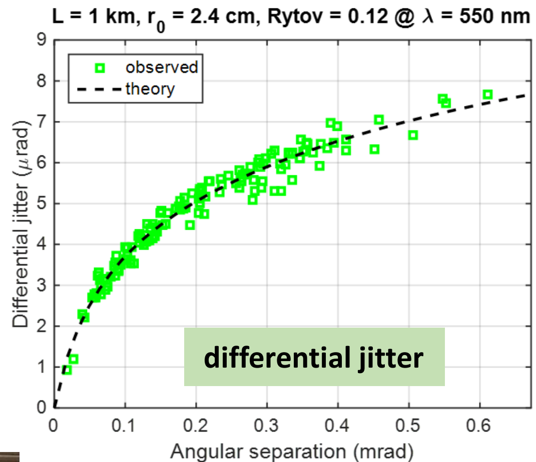
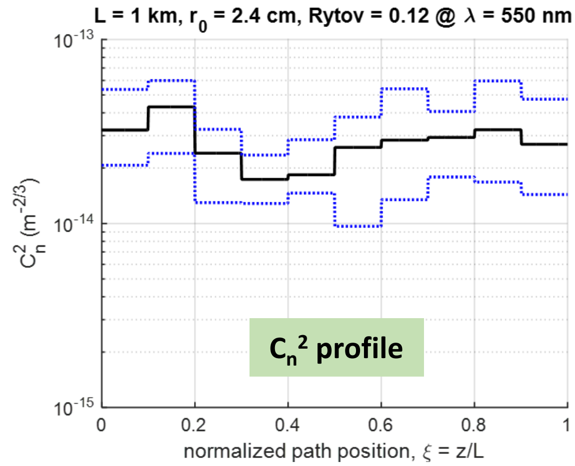
Measured Turbulence Profiles

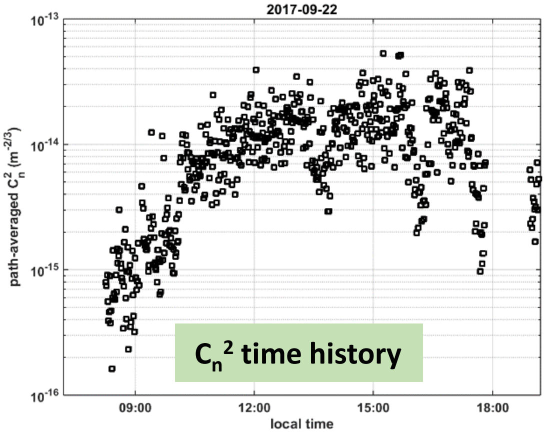
Examples of the DELTA imaging turbulence monitor during normal operation are shown below. Here, features are extracted off a target board with unique patterns (left). Sub-pixel positions are recorded for each of the features over the full sequence, which is used to compute differential jitter measurements (middle). The C_n^2 profile is then estimated from these values (right), as well as additional turbulence statistics.

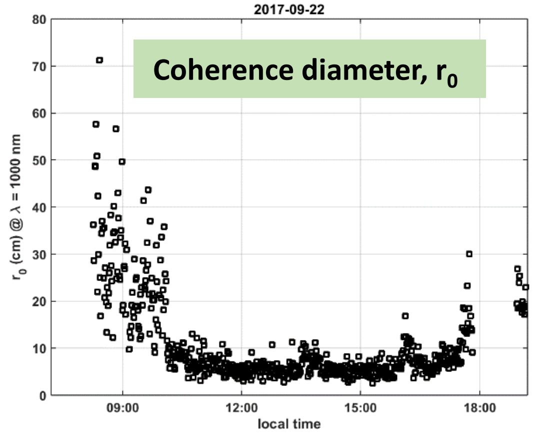
Data acquisition is scheduled at regular intervals using the operator control interface. Image processing, data reduction, and C_n^2 calculations are completed automatically. A results log allows the user to inspect turbulence measurements as the system operates. Profile summary files are generated automatically on a daily basis, or when initiated by the operator. Turbulence profiles and propagation parameters saved to the results files can be used for analyzing propagation conditions with ATMTools, and included in WaveTrain wave-optics simulations.











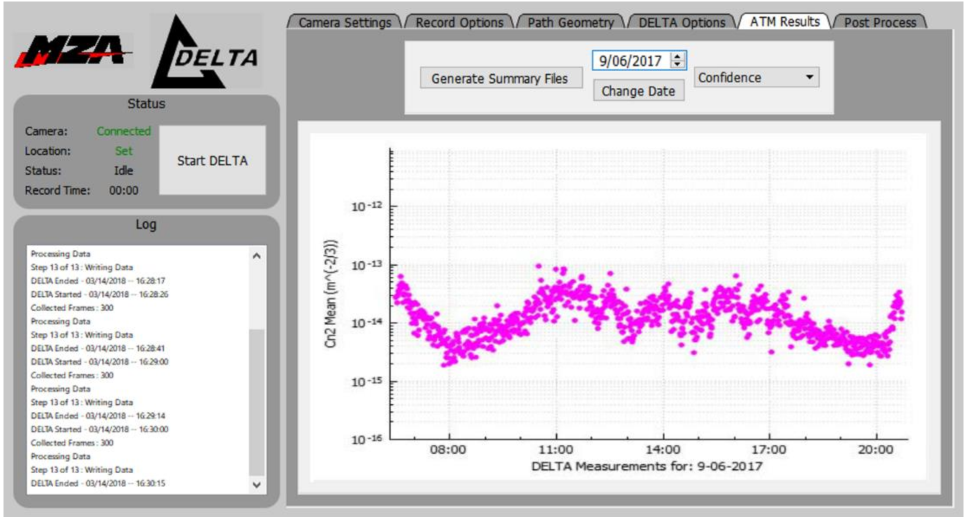


Image and Feature Data	Initial positions, subpixel locations over full image sequence, differential jitter measurements, optional raw images
C_n^2 Profile	Turbulence statistics including C_n^2 profiles, Rytov number, and r_0, isoplanatic angle, and wind speed
Scene & Additional Information	Range, IFOV (~2µrad), embedded camera information (gain, shutter, etc.), wind speed estimates, timestamps, etc.
System Hardware	6” aperture telescope, tripod, camera, and laptop ~30 pounds in 4’ diameter footprint. ~100 W max power. Modular target board and transport cases.

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