

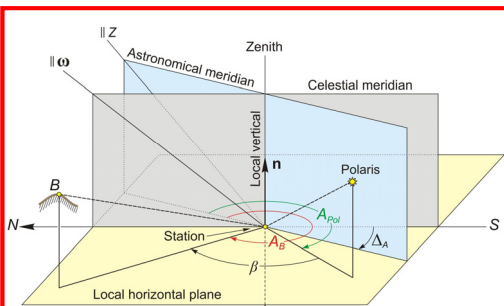
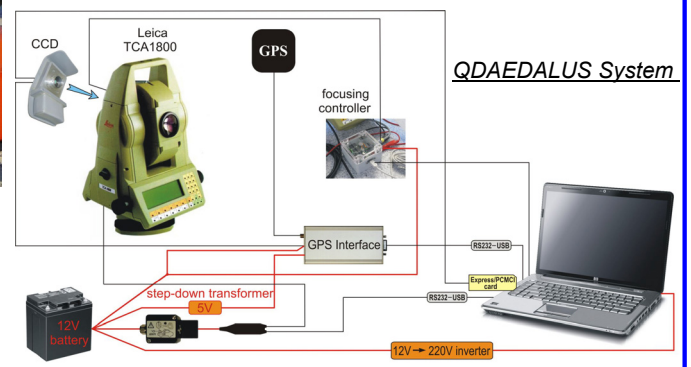
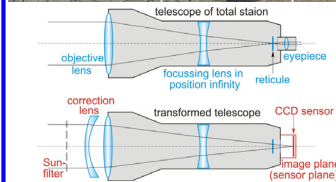
# Precise Astronomical Azimuth Determination by QDAEDALUS System to the Sun, Moon, and Planets in Daytime Conditions

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Traditional method of astronomical azimuth determination involves measurements at night to stars (Polaris). QDAEDALUS, developed by the team of the Geodesy and Geodynamics Lab (GGL, led by Prof. M. Rothacher) of ETH Zürich is a unique system combining Total Stations and modern CCD technique. It provides precise astronomical azimuths within 15 minutes of observation time at night. Furthermore, observations in daytime conditions are a challenging requirement in practice of Astro-geodetic azimuth determination. In order to perform daylight measurements, the QDAEDALUS system has been improved by allowing precise azimuth measurements to Sun, Moon, and Planets in daylight conditions by expanding the processing software with precise solar, lunar, and planetary ephemerides. With such functionality the system has a unique capability to measure astronomical azimuths with an accuracy of 0.3-0.5 arcsecs in normal daylight conditions within 15 to 20 minutes of measurement time.



Principle of astronomical azimuth determination

## Solar azimuth measurement with QDAEDALUS

New Astronomical Observation

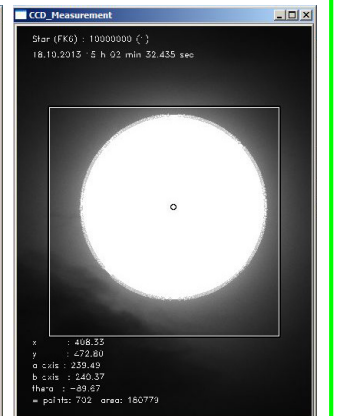
stars  next star auto. zenith angle [deg]: 30.00 +/- [deg]: 2.00  
 stars & terrestrial marks azimuth min [deg]: 0.00 azimuth max [deg]: 360.00  
 range scale max: 0.00  
 dag/dt max [arcsec/deg]: 2.00  
 Sun, Moon and Planets update

No. (FK6)	Name	Azimuth	Zen Angle	Magnitude
10000000	Sun	239° 01' 01.79"	76° 45' 58.74"	-26.74
10000001	Mercury	215° 37' 36.66"	75° 22' 38.68"	-3.00
10000002	Venus	190° 54' 17.25"	73° 27' 50.86"	-4.00
10000003	Moon	62° 53' 43.52"	101° 34' 10.88"	-12.74
10000004	Mars	290° 40' 52.25"	92° 13' 21.96"	-1.00
10000005	Jupiter	311° 07' 57.73"	105° 34' 17.64"	-4.00
10000006	Saturn	222° 38' 29.16"	71° 02' 52.31"	0.50
10000007	Uranus	74° 22' 27.96"	99° 35' 56.44"	5.50

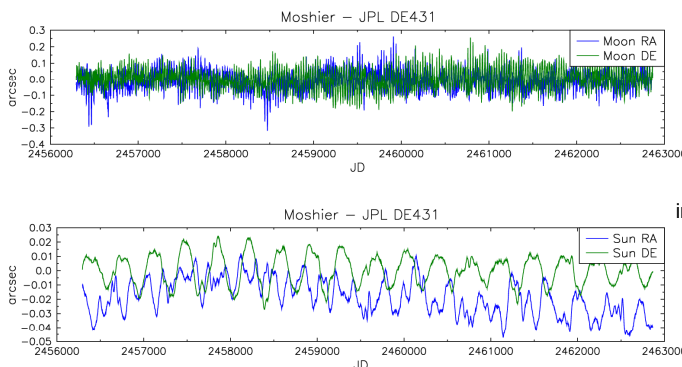
Star Extraction Parameters  
 Cent tol: 300 HW ROI: 800 Big fact: 15 Big thres: 0

Sun, Moon and Planets Extraction Parameters  
 ELLIPSE\_MATCHING  
 Cent tol: 300 HW ROI: 800 Big fact: 15 Big thres: 0  
 Min Pts: 180 Min Area: 8 Max Res: 10

Start Show CCD  
 Stop Orientation Exit



CCD image of the Sun with solar filter (matching ellipse shown)



Steve Moshier's C algorithm ([www.moshier.net](http://www.moshier.net)) has been implemented for QDAEDALUS and compared to NASA JPL DE431 solar, lunar and planetary ephemerides, RA (right ascension), DE (declination)

**GYROMAT 5000**  
gyrotheodolite (DMT GmbH)  
measurement time: 6-9 min  
accuracy:  $\pm 2.5''$  (1 $\sigma$ )  
[www.dmt.de](http://www.dmt.de)

**QDAEDALUS**  
measurement time: 10 min  
accuracy:  $\pm 0.3'' - \pm 0.5''$  (1 $\sigma$ )

**Summary** Determination of the astronomical azimuths is not very popular, due to the difficulty of the calculations and the need for night observations. In order to perform daylight measurements, the QDAEDALUS system has been improved by allowing precise azimuth measurements to Sun, Moon, and Planets in daylight conditions.

Accuracy of azimuth determination with QDAEDALUS (to Polaris):  $\pm 0.3''$   
 Time of azimuth measurement: approx. 10-15 minutes  
 Expected accuracy of solar azimuth determination:  $\pm 0.3'' - \pm 0.5''$   
 Expected measurement time: 15-20 minutes