Bundesamt für
Kartographie und Geodäsie

FIRST RESULTS FROM THE SATELLITE OBSERVING SYSTEM WETTZELL

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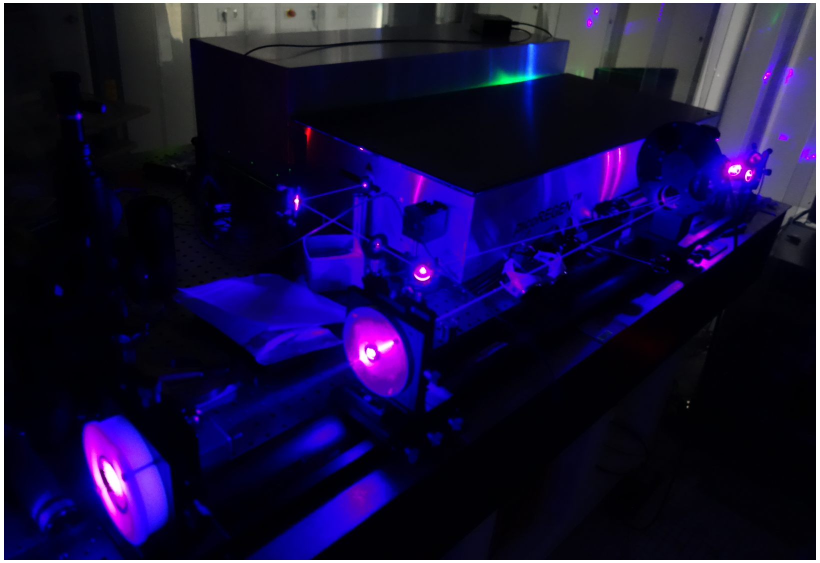
Geodätisches Observatorium Wettzell

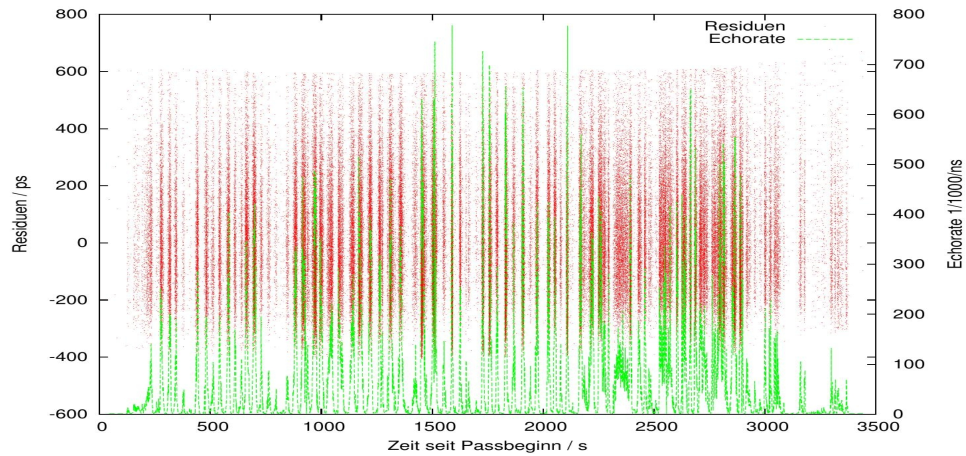
System Overview

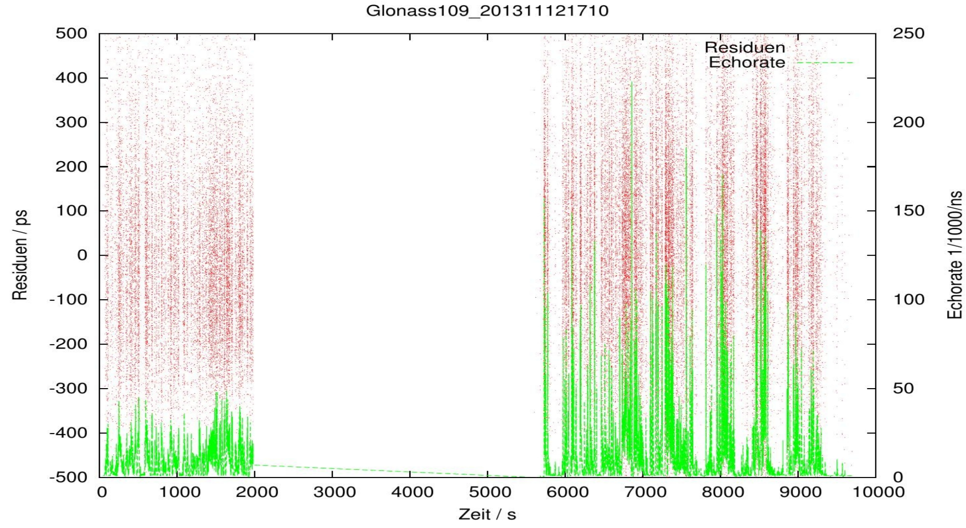
- bistatic kHz-SLR System
- strict single photoelectron mode
- 15 cm transmit, 50cm receive aperture
- support for simultaneous two color measurements @ 849.8nm and 424.9nm
- diverse calibration modes for range and star calibration
- local tie monitoring with paralax compensation
- pointing corrections by active optics
- event timing system
  - based on Dassault counters
  - synchronized to local MASER
- Integrated aircraft safety LIDAR at eyesafe wavelength



Real first light with nominal transmit telescope

- Long-cross offsets shifted periodically around satellite position
- Up to 80% returnrate for Lageos, 25% for Glonass
- Lageos observations down to 15° elevation (saftey limit)
- Glonass observations down to 20° elevation possible



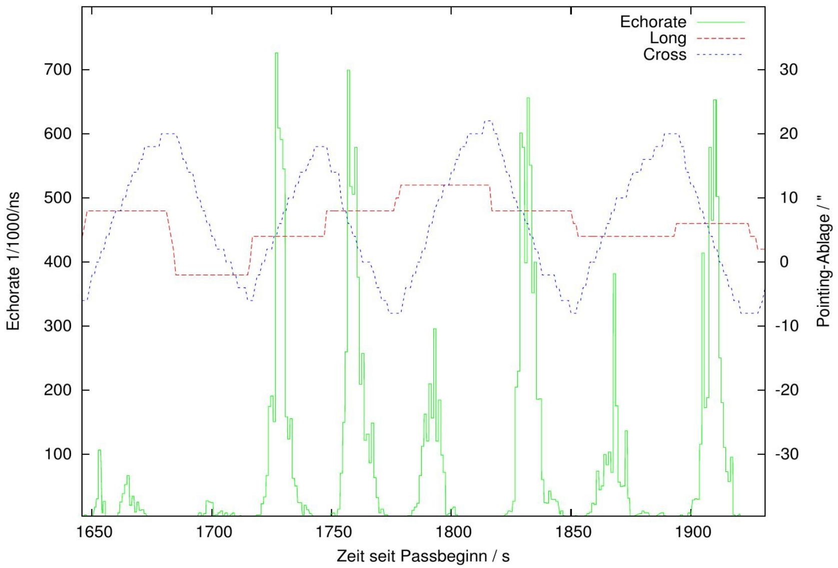


laser collimation / transmit telescope diagnostic

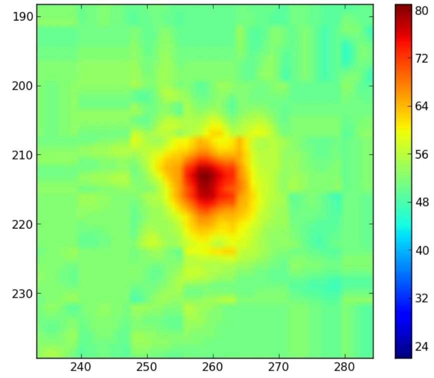
- Laser divergence from signal strength vs. offset measurement < 5''
- Star images (25''x25'') recorded through transmit optics:

  < 3'' FWHM @ 850nm

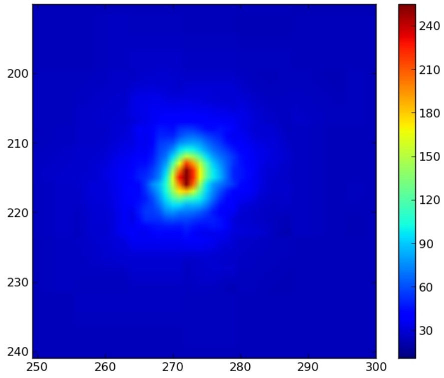
  < 4'' FWHM @ 425nm



Star Image 425nm

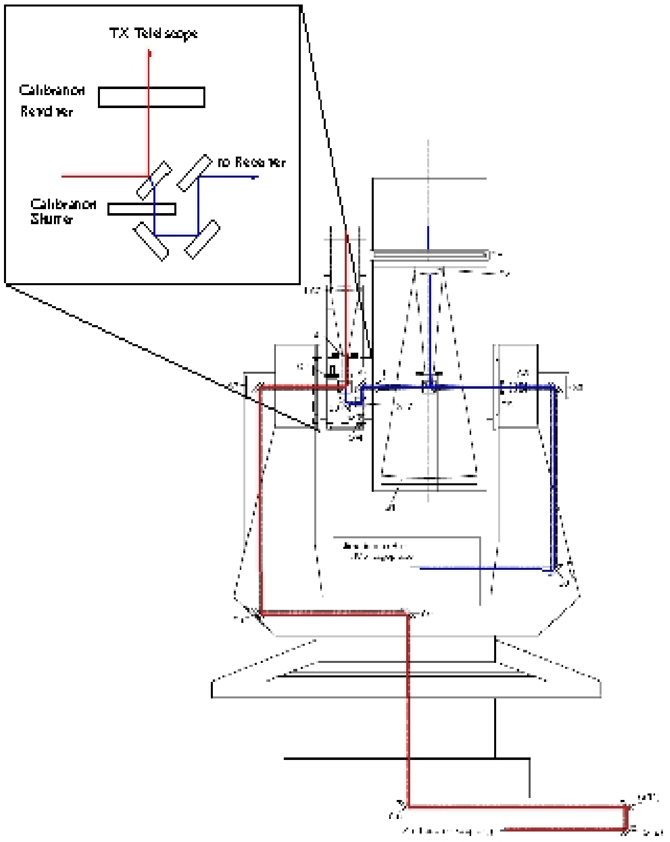


Star Image 850nm



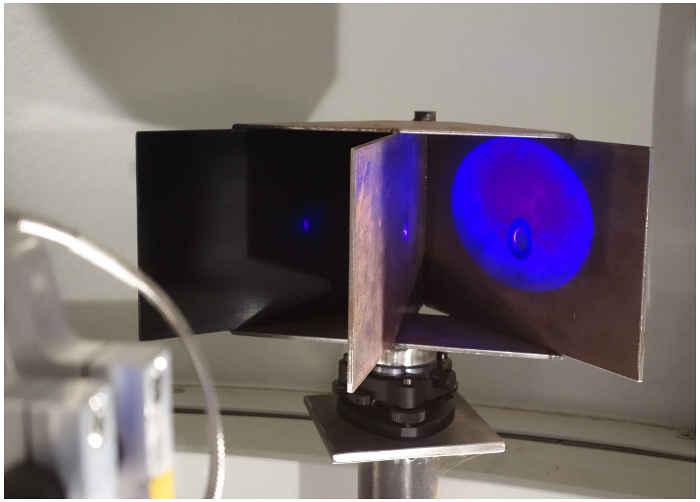
Telescope Design

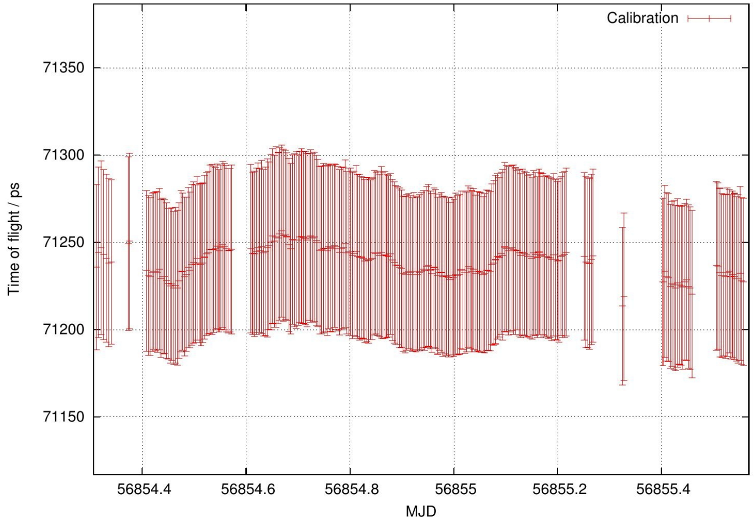
- Optics optimized for 850nm, 425nm and 532nm
- Spectral filtering down to 0.05nm
- Spatial filtering down to 15''
- Piezo elements for
  - Coude/Laser alignment
  - TX/RX alignment
  - aberration compensation
- all alignment monitored by a single camera
- Detectors in Nasmyth climate box

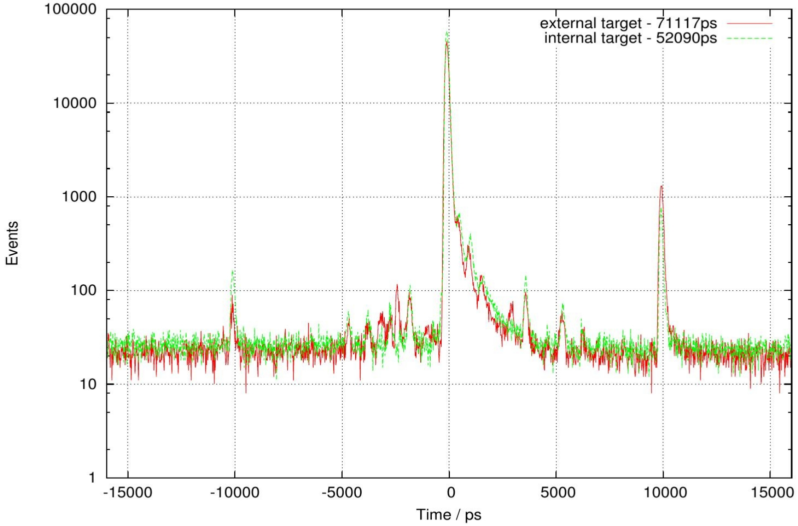


External / Internal Calibration

- absolute calibration by optical square
- primary calibration method
- prepulse and straylight isolation
  < 1:500 at fundamental wavelength !
- maximum drift <10ps/h

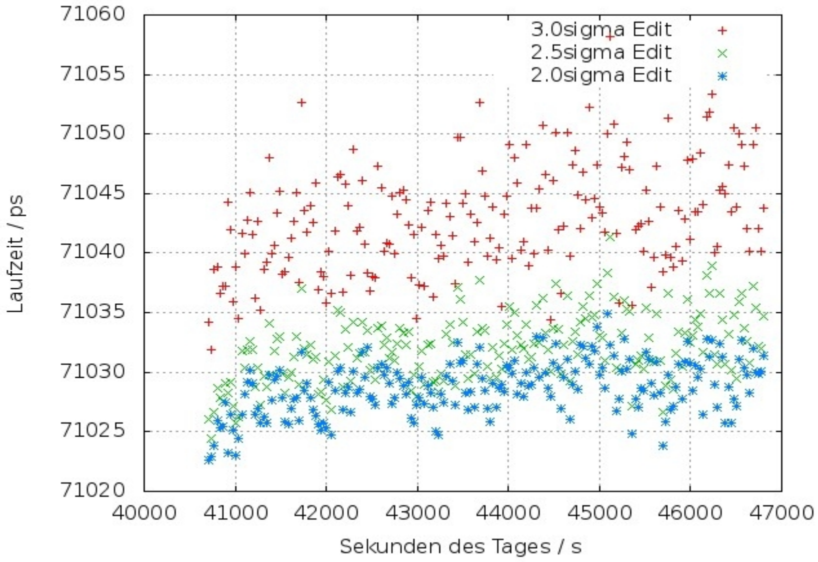


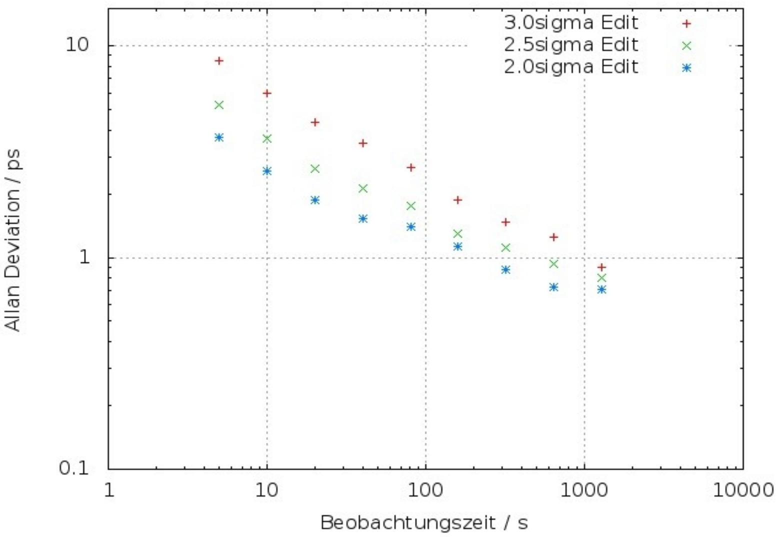




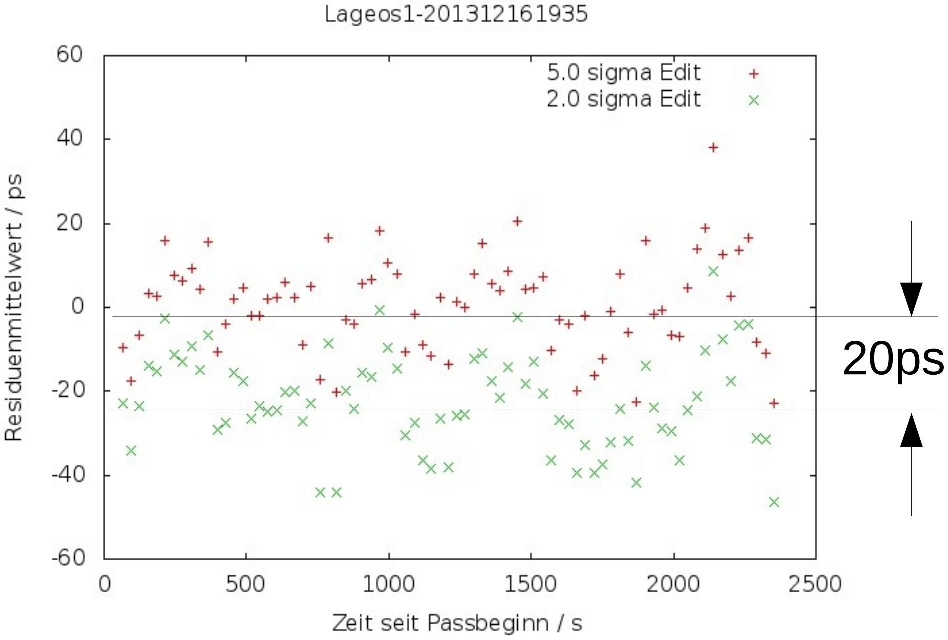
SAP500 - Data Editing

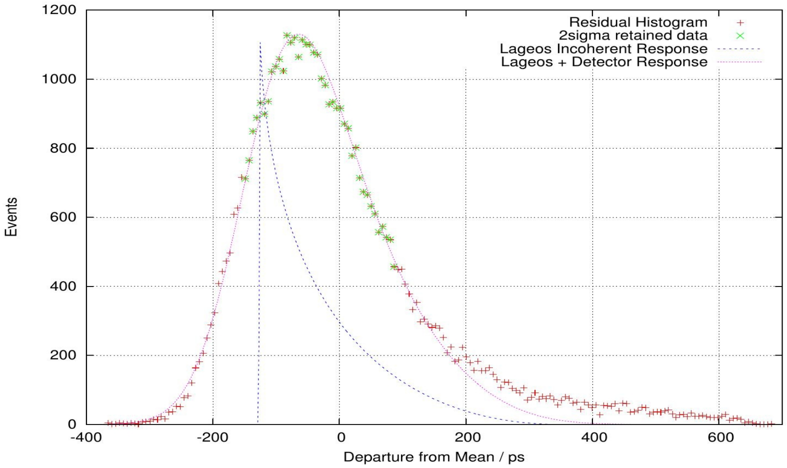
- New avalanche diode with 500µm diameter and sufficient timing characteristics
- 2 sigma editing → 40ps rms
- What is the best averaging time for which editing level ?
- Less than 2 sigma editing leads to instability
- Noise floor ~ 700fs reached in 600s
- submillimetric stability for all current normal point intervals
- Smaller single shot rms highly desireable for two colour ranging





SAP500 - Data Editing(2)

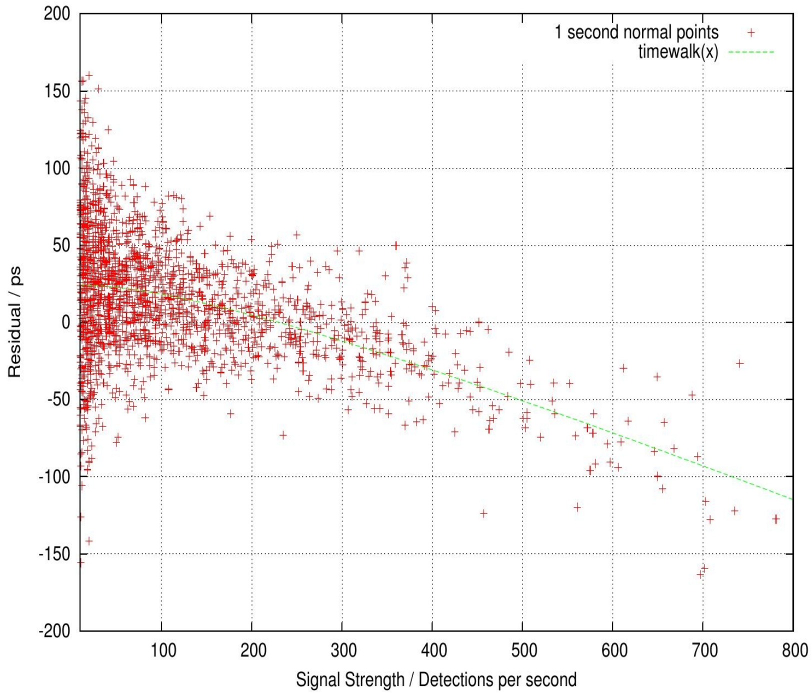




- Lageos single pe rms 120ps
- iterative 2 sigma editing → 60ps
- mean shift of 20ps betwen 5 and 2 sigma edit
- agreement with incoherent response (Fitzmaurice 1977)
- deduced center of mass correction 247mm @850nm
- Poisson statistics contribution ~ 0.6mm

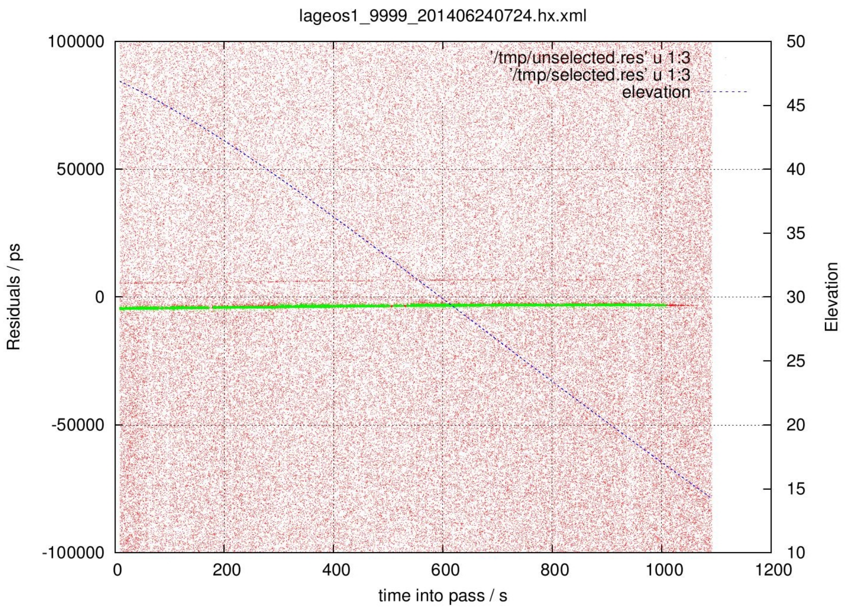
SAP500 - Timewalk analysis within a second

- Lageos 1 second normal points
- logarithmic model
  - TW(1%,..,10%)~6ps
  - TW(10%,..,20%)~13ps
  - TW(20%,...,100%)~165ps
- current return rate filter accepts signal levels from 1% to 20% return rate (strict SPE mode)
- calibration signal level kept at 10% return rate



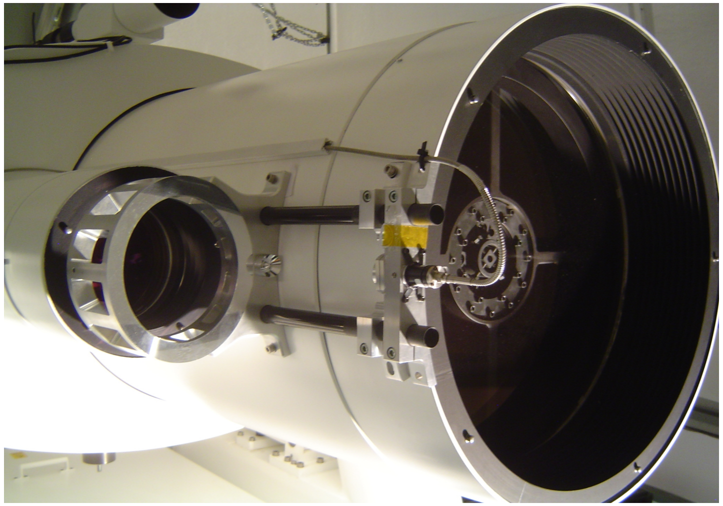
Daylight tracking

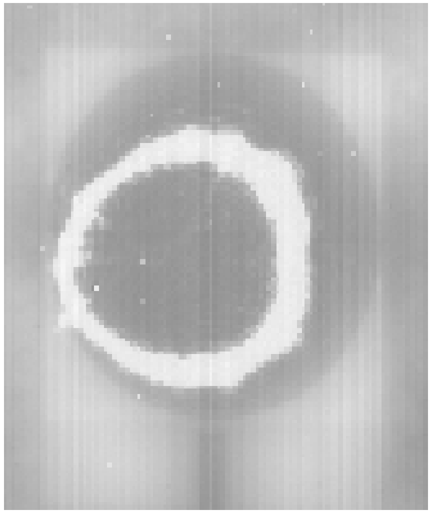
- 1nm FWHM spectral filter
- 15'' spatial filter, close to velocity aberration angle
- daylight noise < 0.5% per 1 ns binwidth
- repetition rate kept constant
- transmit/receive time overlap backscatter reduced to minimum
- with sufficient Coude-alignment satellites are acquired without pointing corrections



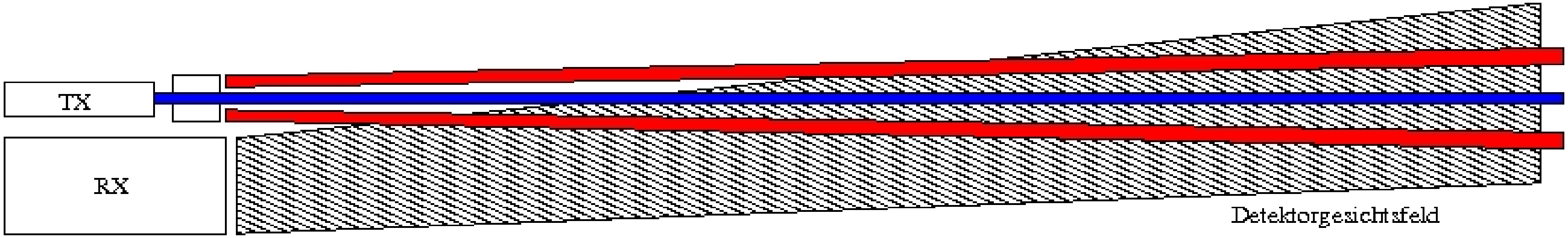
Aircraft Safety Concept

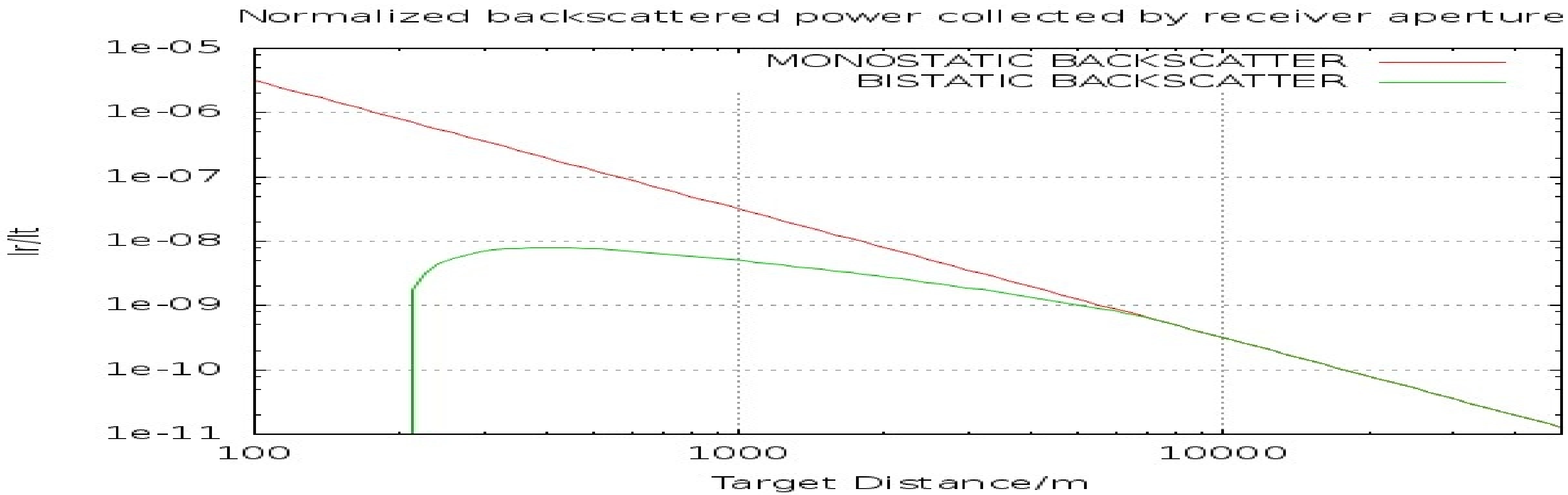
- Aircraft position and velocity data from Federal Aviation Office
- ADS-B data
- Aircraft Safety LIDAR (ASL)
  - primary safety device
  - VLBI 2010 compatible
  - hardwired circuits only
  - maximum object distance 25km (projected)





Aircraft Safety LIDAR - Linkbudget

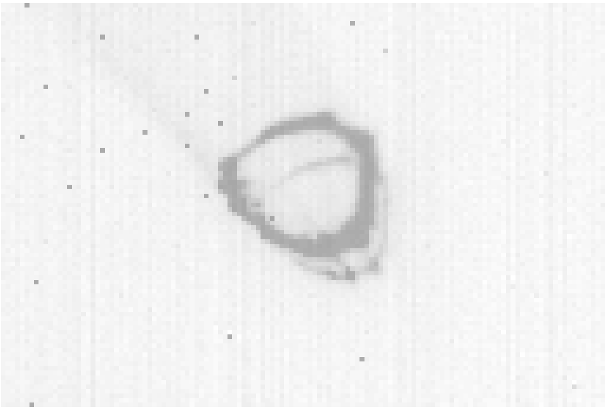


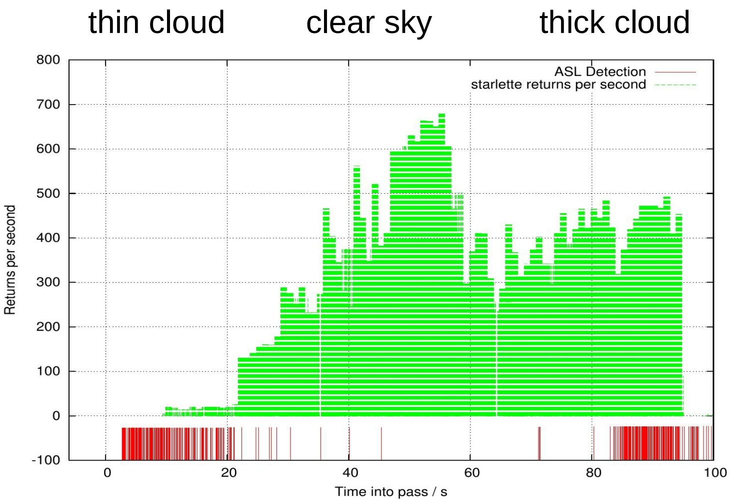


- Detector NEP 0.4pW @ 1kHz, uncooperative target backscatter @ 4.8km distance → 5mV
- geometric compression by limited detector field of view, near field sensitivity via secondary scattering
- integrated Rayleigh backscattering (1.2-50km) <1.5E-14
- integrated MIE backscattering (1.2-50km) approx. 8E-10 (light haze)

Aircraft Safety LIDAR - Verification

- basic verification on distant groundtarget
- cloudtracking
- tracking Starlette through cloud fields
- aircraft or UAV tracking to verify far field sensitivity and detection delay





Conclusion and Outlook

- collected more than 200 passages in 2014, analysis by Horst Müller and Daniela Thaller
- data delivery quarantine status
- all ILRS satellite missions observed consistently
- linkbudget for 850nm ensures GNSS observations down to 20° Elevation
- still waiting for
  - final redesign of transmit optics
  - final replacement of elevation drive
- expected to be operational in early 2015
- subsequent implementation of two colour ranging mode