

# SLR and CCD Dual-Use of the Zimmerwald Tracking System

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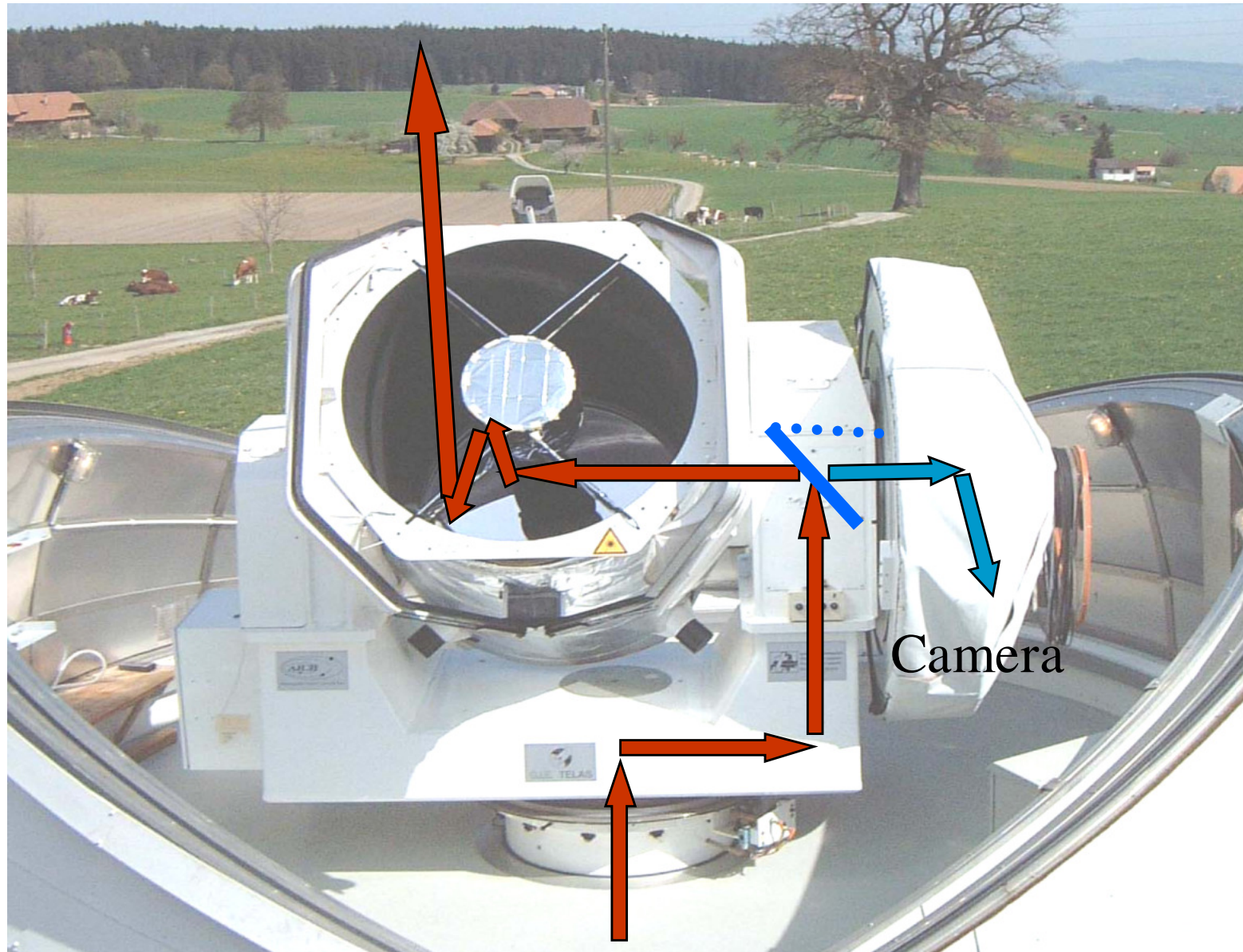
# Zimmerwald Observatory



# Design of the ZIMLAT Telescope

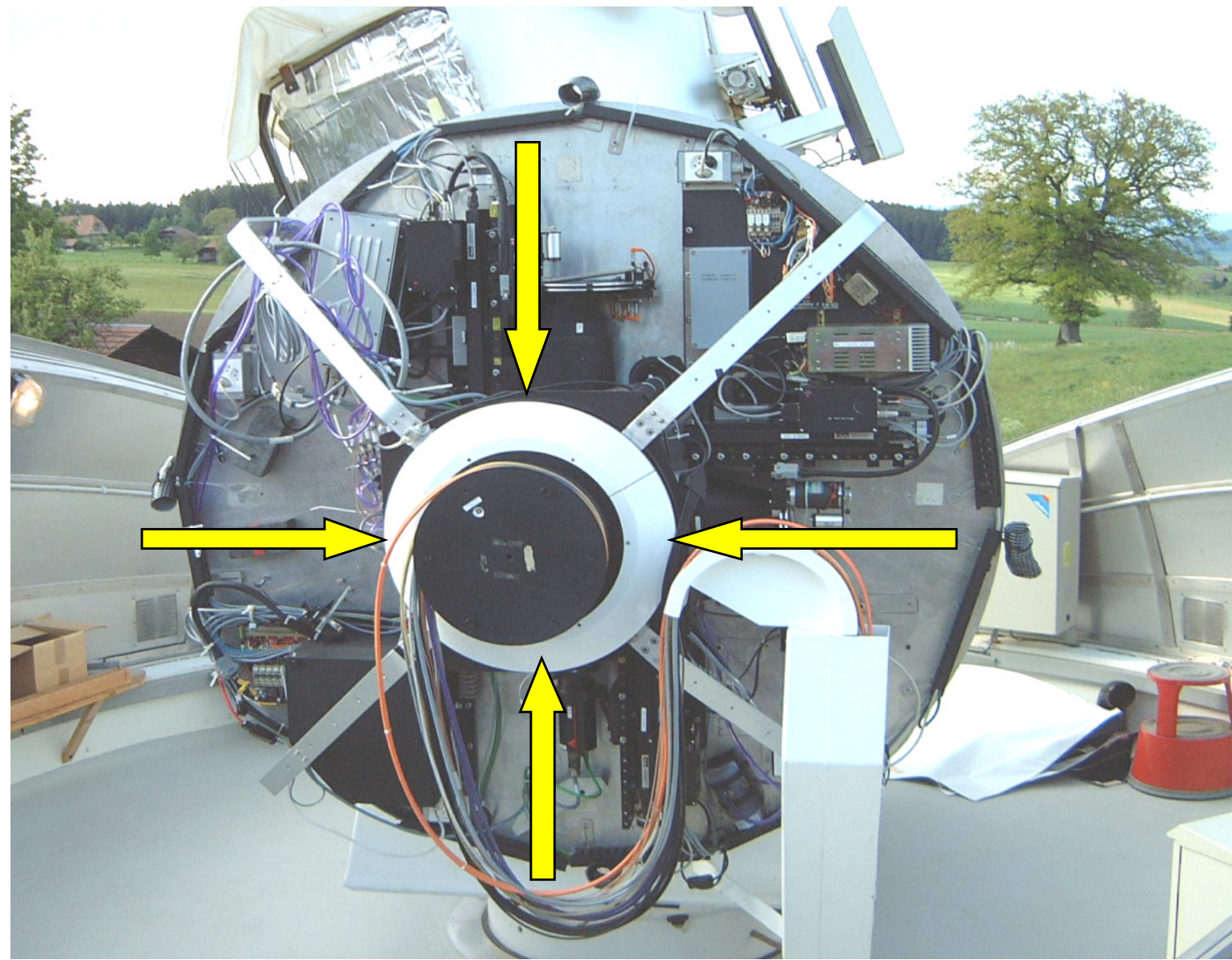
- 1 meter telescope
- CCD
  - Instrument platform
  - Four tables and reduction optics for cameras
  - Image derotation
    - Elevation
    - Declination
    - Along/corss track
- SLR:
  - Coudé path for both transmitting and receiving beams
  - Transmitting beam diameter 15 cm at telecope exit
  - One table on platform used for optical tracking control
- CCD/SLR separation by large dichroic beam splitter

# ZIMLAT: Optical Paths

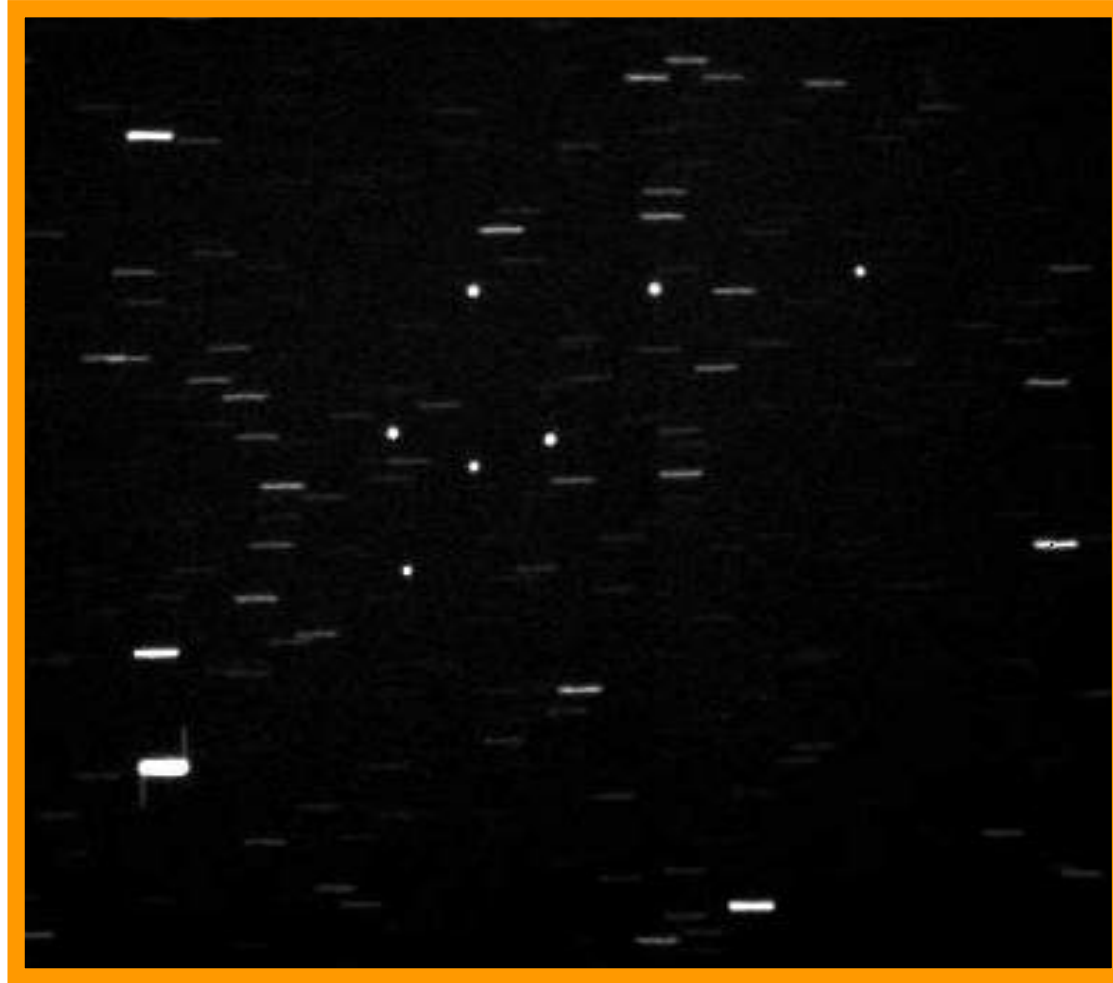


Camera

# Instrument Platform

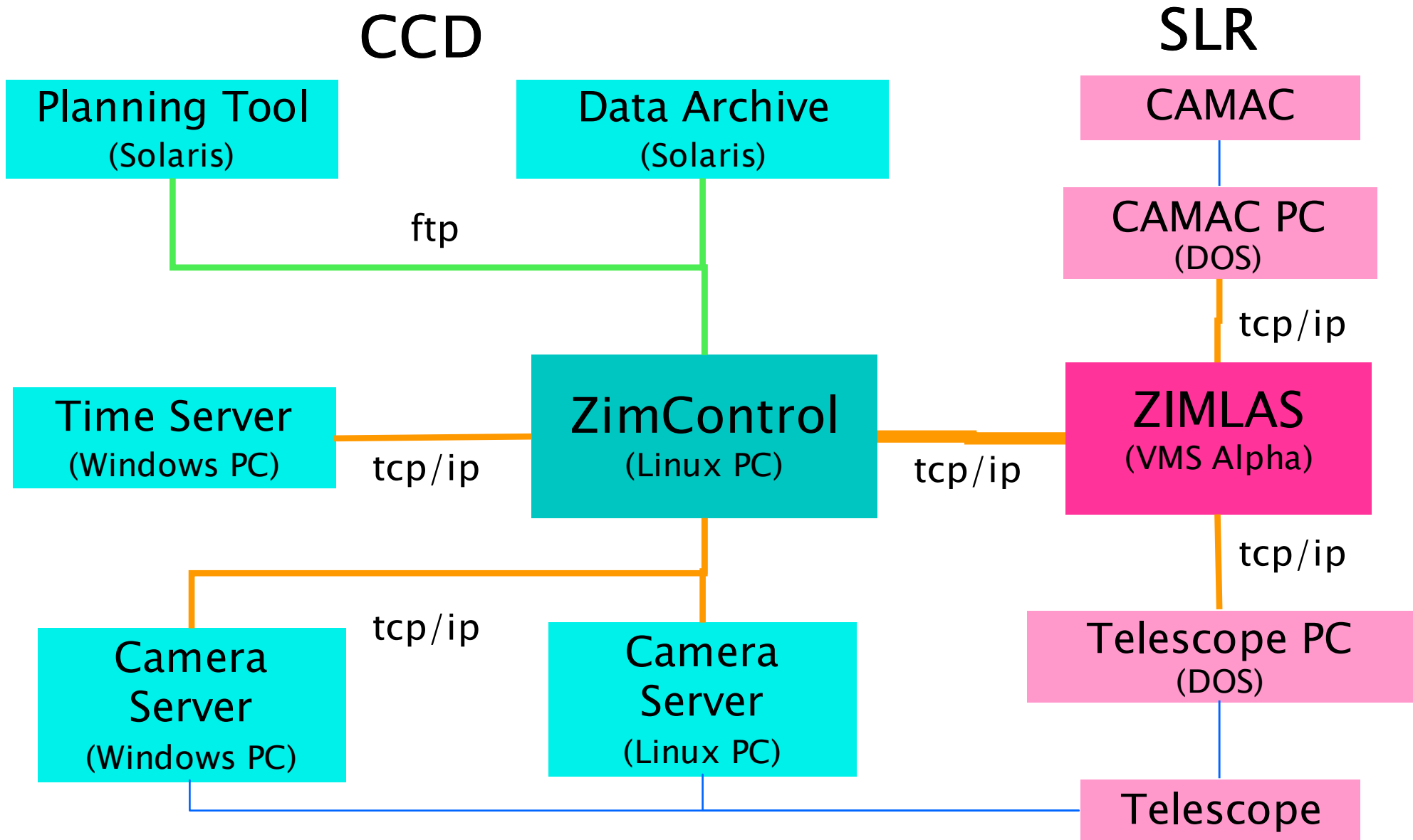


# CCD Image



7 Geostationary Astra Satellites (Field of View 12x12')

# SLR and CCD Control System



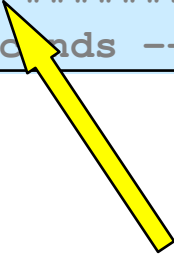
# SLR: Pass Scheduling

- Automatic assignment of pass segments
  - User-defined session length
  - About 6 priority classes for satellites
    - Dynamic priority corrections
  - Satellite-dependent minimum segment lengths (30 seconds to 8 minutes)
  - External calibration segments inserted every 30 to 45 minutes
- Operator interaction if necessary or desired
- Daylight: Automatic sun avoidance (critical segments below 25 deg from sun removed)



# SLR Pass Schedule

#	Satellite	14:42:44	15:15:45	15:47:45
01	CALIBRATE	=====+###=====	=====+###=====	=====+###=====
02	GPS-35	+++++	+++++	+++++
03	GLONASS-89	+++++	+++++	+++++
05	LAGEOS-2	#####++#####++##++#####++	#####++#####++##++#####++	#####++#####++##++#####++
06	GPS-36	-----	-----	-----
07	ETALON-2	-----	-----	-----
08	LAGEOS	-----+##++##++++#####-#-----#####++#####	-----+##++##++++#####-#-----#####++#####	-----+##++##++++#####-#-----#####++#####
		----- 1 char = 60 seconds -----		



Too close to sun

# CCD Control System

- Linux PC
- Separate from SLR control system
- Handles
  - Observation plan
  - Communication with CCD camera servers
  - Communication with SLR control system
  - Image pre-processing
  - Data transmission to image processing/archiving system
- Communication between systems and servers: TCP/IP

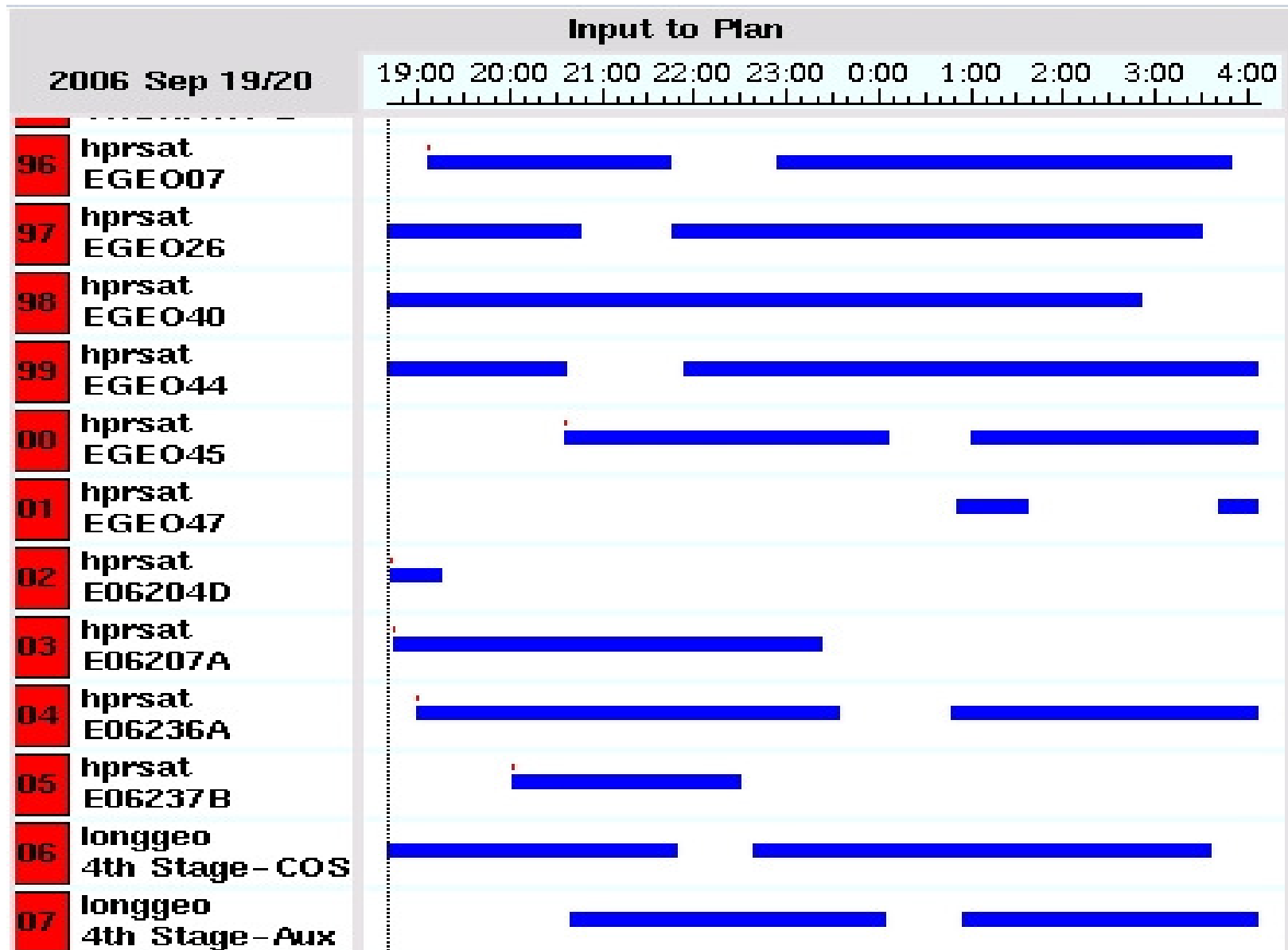
# CCD Targets

- GEO (geostationary objects)
  - Active satellites
  - Space debris
- GTO (geostationary transfer orbit)
- Minor planets: Confirmation exposures for Near–Earth Objects
- GPS to check system status (e.g., timing system)
- **Photometry: Change of magnitude due to rotation of object**
- Bias and dark current exposures
- Projection parameters, image distortions
- Focussing

# CCD Operation: Observation Plan

- List of possible targets
  - Object
  - Observation period
  - Number of sequences
  - Sequence duration
  - Sequence separation
  - Number of images per sequence
- Selection criteria
  - Priority
  - Minimum elevation
  - Phase of the moon  $\leftrightarrow$  Minimum distance from the moon
  - Angular velocity (highly eccentric objects)
  - Vicinity to reference stars (catalogue-dependent)

# CCD Observation Plan



# CCD Operation: Sequence of Events

- CCD PC requests observation time at the station computer
  - Starts requesting 10 minutes
  - Steps down to 3 minutes if not granted
  
- If granted:
  - Requests station computer to enter CCD tracking mode
  - Sends commands for telescope to station computer
  - Sends commands to camera server
  - Image acquisition, epoch registration
  
  - Allows station computer to enter SLR tracking mode again

# SLR Station Computer: CCD activities

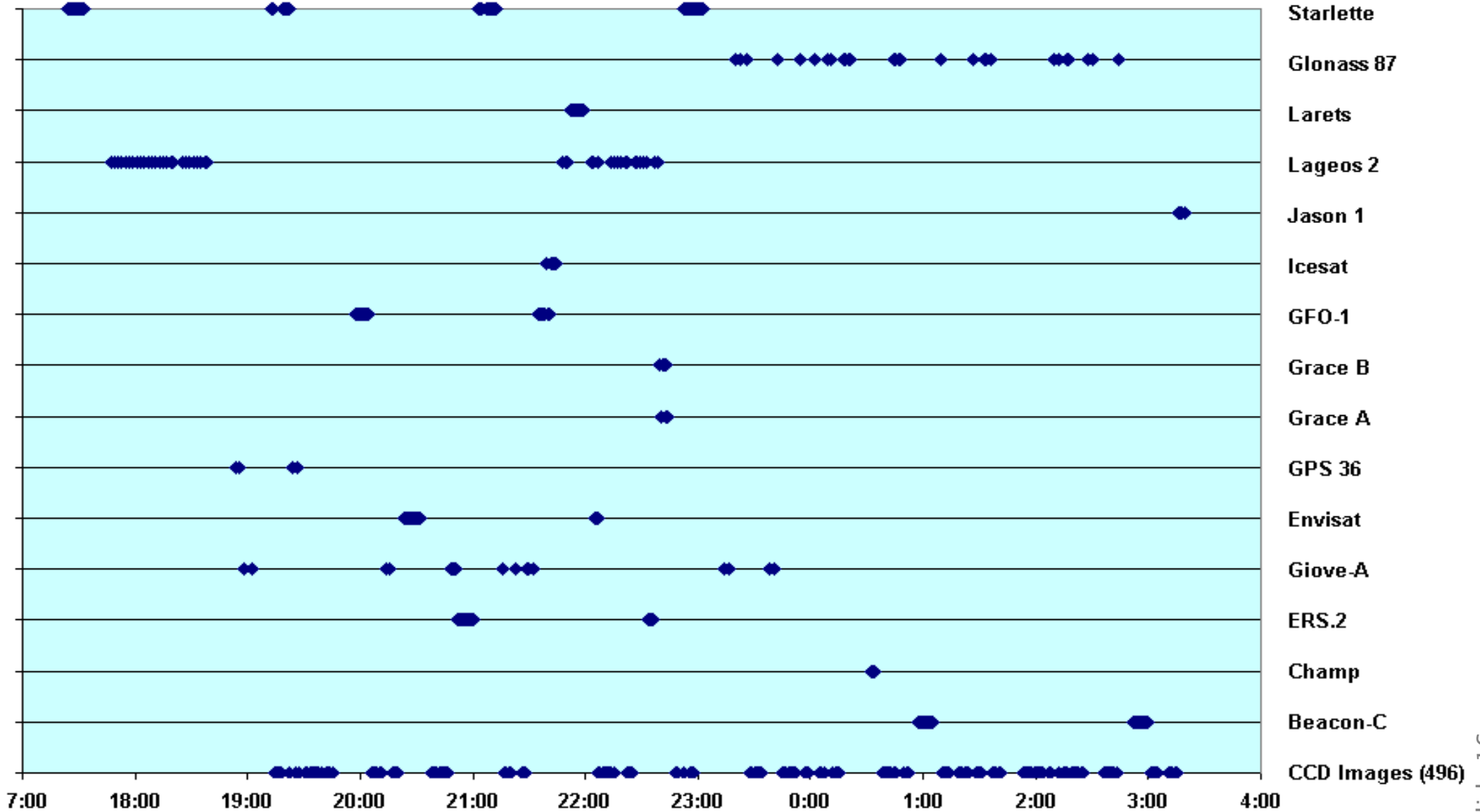
- Receives requests for CCD tracking
- Grants request if
  - Not calibrating
  - Time since last CCD tracking long enough
  - Remaining time of current SLR pass segment large compared to requested time interval
  - Current number of SLR observations for high-priority satellites large enough
  - Decision levels are CCD priority-dependent
- CCD priorities
  - None, low, medium, high, absolute
- If request granted
  - Interrupts SLR tracking
  - Puts system into CCD tracking (removes beam splitter, rotates deflection mirror to CCD camera, sets filter wheel)

# SLR/CCD Interleaving

1 Sep 2006

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# Automation

- SLR/System control and CCD control are independent programs (run on two different systems)
- Either one or both can run fully automated or under operator control
- CCD control program is always running
- If it's dark enough (sun below  $-12$  deg elevation):  
Checks if SLR/Telescope is in operation
- If yes: Starts requesting observation time

# Background Operation

- Fully automated session:

**AUTO\_SLR 20:00 22:00 WG MEDIUM PROC**

start time end time observer CCD priority SLR postprocess

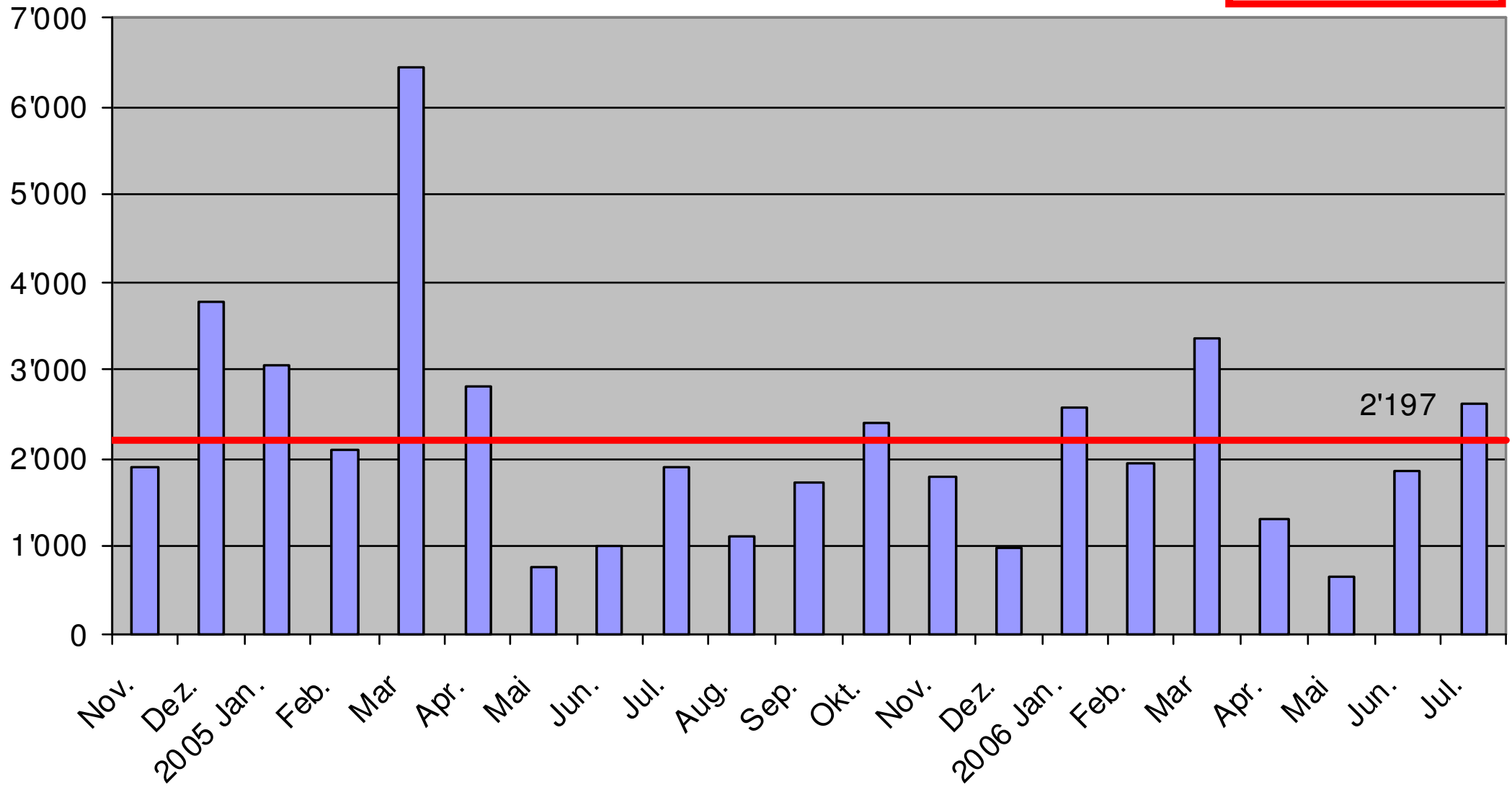
- Submission of several sessions in advance
- Postprocessing SLR
  - Apply averaged calibration values
  - Data screening
  - Normal point generation
  - Transfer to the Eurolas data center (e-mail)

# CCD Post-processing

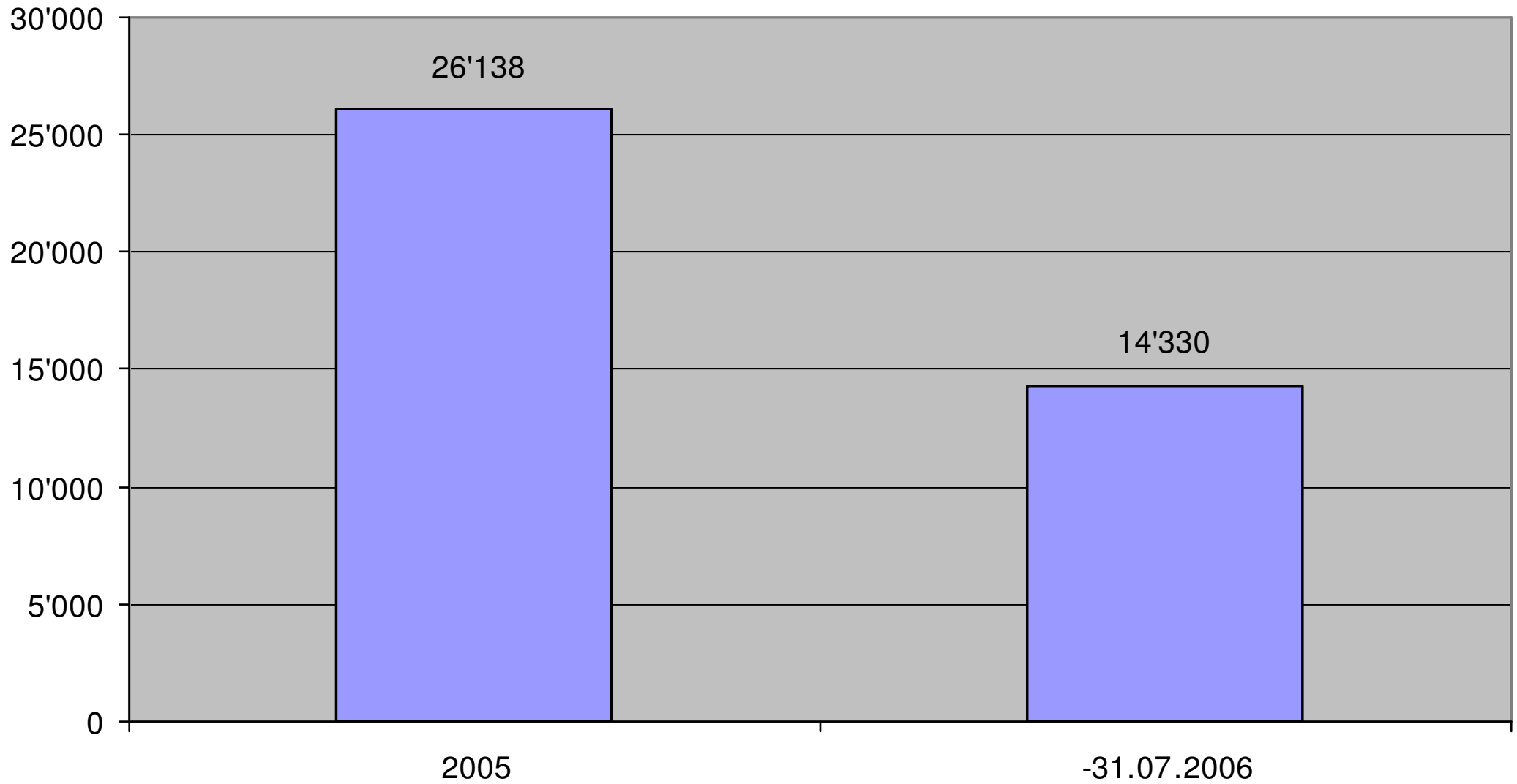
- Image processing is **automated** and runs in the **background**
  - On Linux system at the university
  - Object recognition
  - Reference star selection
  - Determine image positions of stars and objects
  - Astrometric position of objects
  - Image archiving
- **Interactive check** of automatic processing of previous night
- **Interactive processing** of problematic cases
- **Interactive** generation of next night's observation schedule

# Number of CCD Images per Month

Summe: 46'139



# Number of Exposures per Year



# Conclusions

- Dual-use design increased system complexity
- Many functions had to be developed only once (telescope control)
- Fast pass-interleaving capabilities extended to CCD observations
- Full integration of CCD operations into SLR: No additional observer necessary
- If SLR out of operation: Use of the same system, just without SLR satellites
- Astrometric CCD runs fully automated, photometry still needs operator intervention
- System in operation during 24 hours, no significant reduction of SLR performance

# Observed SLR Passes per Month

