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# Automation: Prerequisites

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# Prerequisites: General

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- All necessary functions are basically controllable through/by computers, including
  - Power-up of the system (telescope, laser, dome, …)
  - Emergency procedures
  - Controlled shut-down of the system
- Minimum monitoring of the weather (esp. precipitation → *emergency closing of the dome*)
- Security and safety procedures according to local requirements

*Presentation based on experiences with the Zimmerwald system*

# Power-up

- Telescope
  - Initialization of the angle encoders
  - Protection caps
  - …
- Laser
  - Power-up sequence: YAG pump laser, cooling, Ti:Sapphire laser, auxiliary equipment
  - Adjustment of doubling crystal, delays
  - Safety shutters
- Auxiliary computers (PCs) and devices (aircraft detection radar, receivers, rotating shutter, [event timers],…)

# Predictions management

- Fully automated management of the prediction generation
- Short update cycle (hours) to account for subdaily CPFs and maneuvers
- Management of restricted satellites
  - Go-nogo flag file
  - Pass segment lists
- (Time biases)

# Operation: Sessions start

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- Session definition
  - Determine start- and stop-times manually according to pass list
  - Avoid interrupting low satellites passes
  - Batches of 1-3 hours
  - Several batches at a time
  - *Mount Stromlo (1): 7/24 uninterrupted tracking*
- Submit batches
  - Interactively
  - Command line

```
auto_slr 12:25 14:05 wg sms
auto_slr 14:10 16:00 wg sms
```

  - Wap page (mobile phone)

# Pass scheduling within a session

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- Automated, according to simplified priority lists
- Takes into account:
  - Actual horizon
  - Sun interference
- Inserts 3-min calibration blocks at low priority and every 30-50 minutes
- Could be defined beforehand (automatically or manually)
- Include cloud cover information? Suitable cloud mapper available?
- Feedback regarding tracking success?

# Satellite acquisition: Echo detection



- "Track detection" or "echo identification" or "signal/noise separation" by
  - Histogramming
  - Majority voting

  using
  - Residuals w/r to predictions ("observed – predicted")
  - Time biases w/r to predictions (range residuals expressed as time biases)
  - Combination of the two
- Automated adjustment (shift/size reduction) of the range gate window upon successful acquisition
- *→ Paper by Matthew Wilkinson*

# Satellite acquisition: Search procedures

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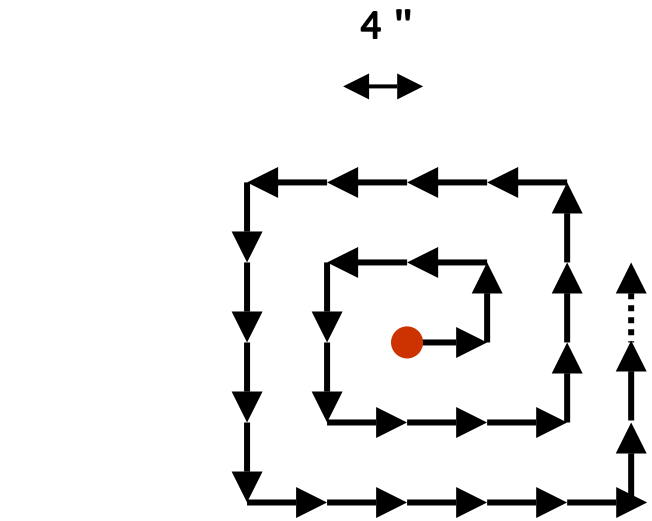
- Pointing corrections to account for
  - Telescope / laser beam misalignments
  - Prediction errors (mainly along track)
- Search algorithmes
  - Circular spiraling around predicted direction
  - Elliptic spiraling (elongated in along-track direction)
  - Along-track only
- Adjustment of the range gate according to along-track offset
- Step size and search width depending on
  - Satellite (e.g., prediction accuracy)
  - Divergence
  - Day time

# Search pattern during acquisition






- Azimuthal
- Horizontal on camera screen
- Along-track

# Keeping track

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- Use range residuals or (better) time biases to continually reposition range gate
- Maintain optimal tracking by
  - Maximizing return rate (folded with single photon regime!) → empirical small corrections in all directions
  - Using quadrant photo diode ? (SLR 2000)
- Real-time update of the predictions to improve *re-acquisition*:
  - Use time bias to improve initial position of range gate
  - Use time bias to improve initial pointing direction (for large time biases)

# Safety and Emergency Procedures

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- Watch dog program
  - Checks rain detector
  - Checks for tracking program crash or time out
  - Closes dome, stops tracking program
  - Sends alert to operator per SMS or calls phone number in case of abnormal conditions
- Motion detector in dome
  - During laser tracking in unattended mode: Stops laser pulse generation
  - Interrupts dome closing
- Aircraft detection
  - Small radar parallel to telescope
  - Air traffic control data. Aircraft positions every few seconds

# Shut down procedures

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- Moves telescope to park position
- Verifies that dome is closed
- Powers down laser if requested
- Sends SMS to operator if requested

# Postprocessing

- Automatic (night only, day and night?)
  - Apply calibration values
  - Noise removal
  - Normal point generation
  - Quick look format generation
  - Submission per e-mail to data center
- Various plausibility checks
  - Calibration RMS
  - Observation RMS (satellite-dependent baseline)
  - Number of normal points
  - Number of observations within normal points
- Tight conditions: Do not submit questionable passes
- Reporting

# Experiences in Zimmerwald

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- A few hours per day unattended operation
- A certain percentage of interactive operation actually run in automatic mode ("accoustic supervision")
- Some course statistics don't show significant differences in performance (either way…)
- Satellite acquisition may be faster in manual mode
- But: Automatic mode does not miss satellites and does not get tired…
- Some hours per month may be lost because of system crashes during unattended operation
- Weather conditions are a limiting factor: No cloud mapper available