LIDARGO: standardization

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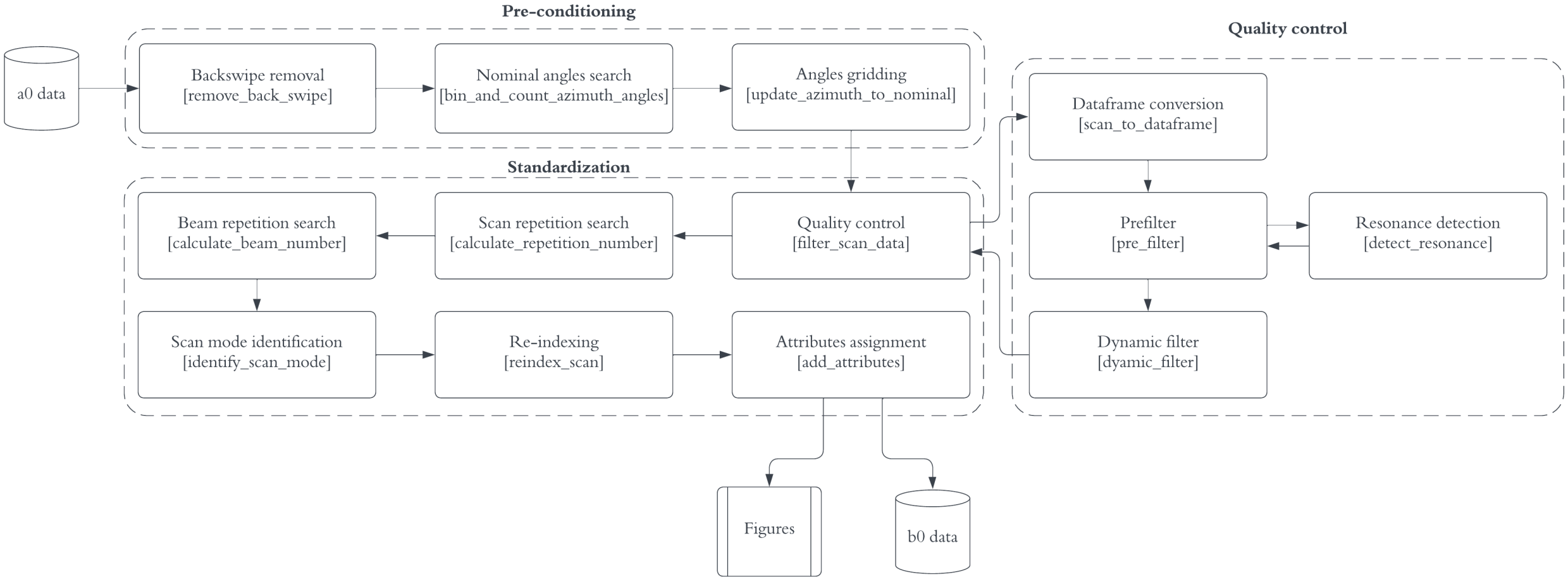
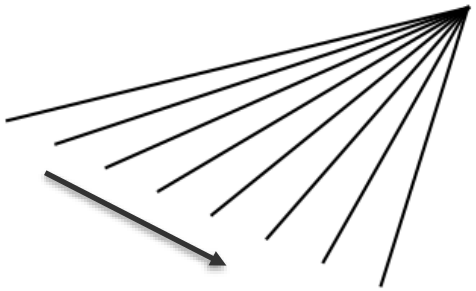
Standardization: overview



Pre-conditioning

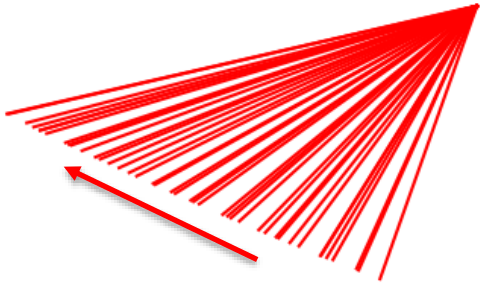
Raw angles would contain **backswipe**, when the lidar scans fast to return to home position



Backswipe is identified by imposing limits on the azimuth and elevation **steps**, calculated both with forward and backward finite differences:

$$\begin{cases} \Delta\theta \in [\text{min\_azi\_step}, \text{max\_azi\_step}] \\ \Delta\beta \in [\text{min\_ele\_step}, \text{max\_ele\_step}] \end{cases}$$

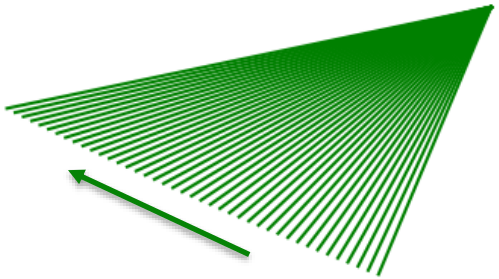
Selected angles would contain **irregular beams** outside the regular geometry



Expected locations (θ_0, β_0) are identified as the most likely in the 2D **p.d.f.** $f(\theta, \beta)$ of azimuth and elevation:

$$\frac{f(\theta,\beta)}{\max f(\theta,\beta)} \geq \text{count\_threshold}$$

Regularized angles only include angles corresponding to the **regular geometry**



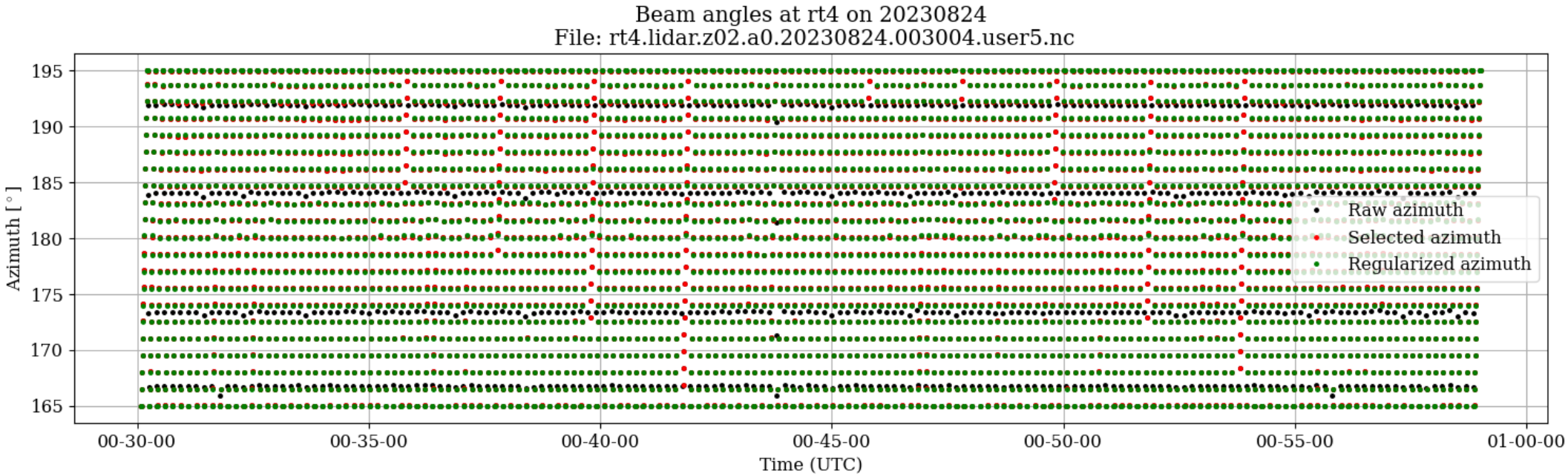
Regular vs irregular beams are flagged by checking their **distance** from the closest regular beam:

$$\min\left(\sqrt{(\theta-\theta_0)^2+(\beta-\beta_0)^2}\right) \leq \text{ang\_tol}$$

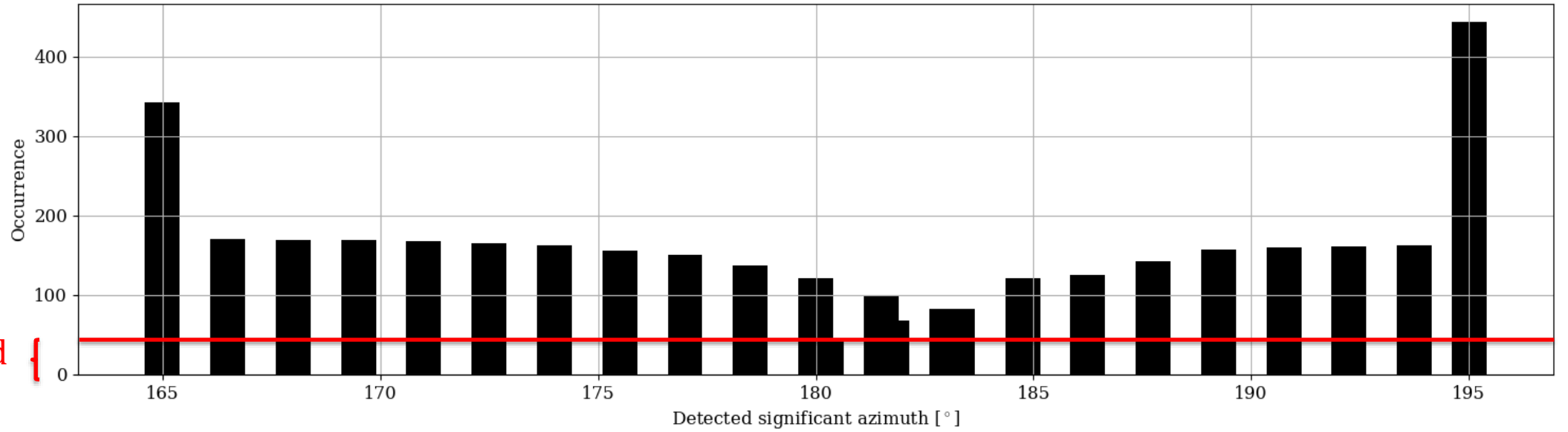
Angles are **regularized** by shifting them to the closed regular angle.

Pre-conditioning

Angles classification for a PPI scan



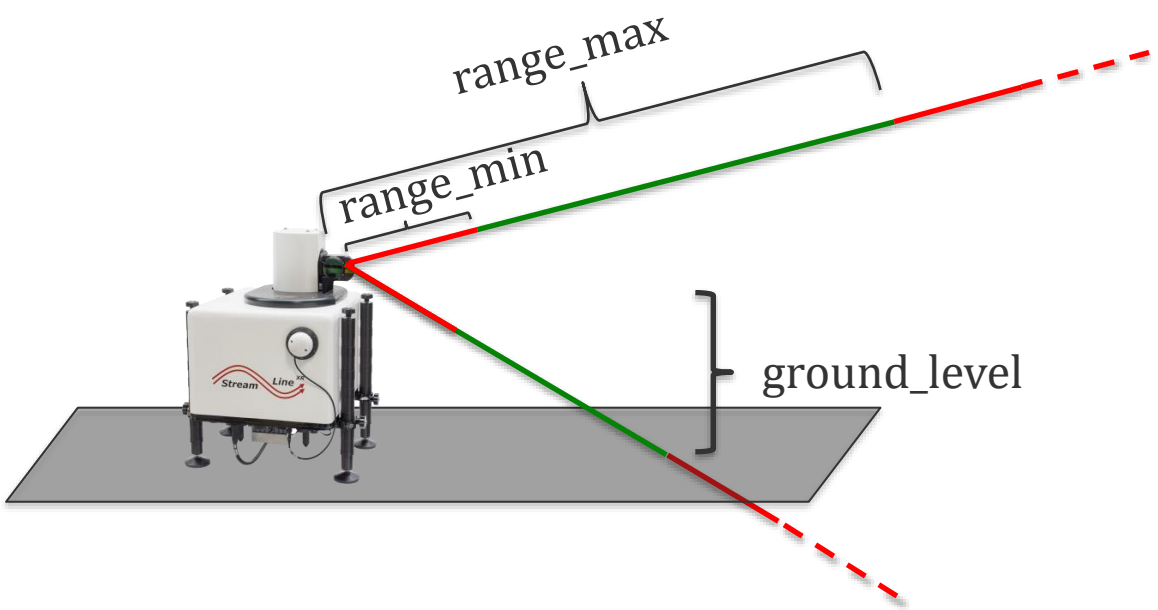
2D pdf for the selection of the regular angles



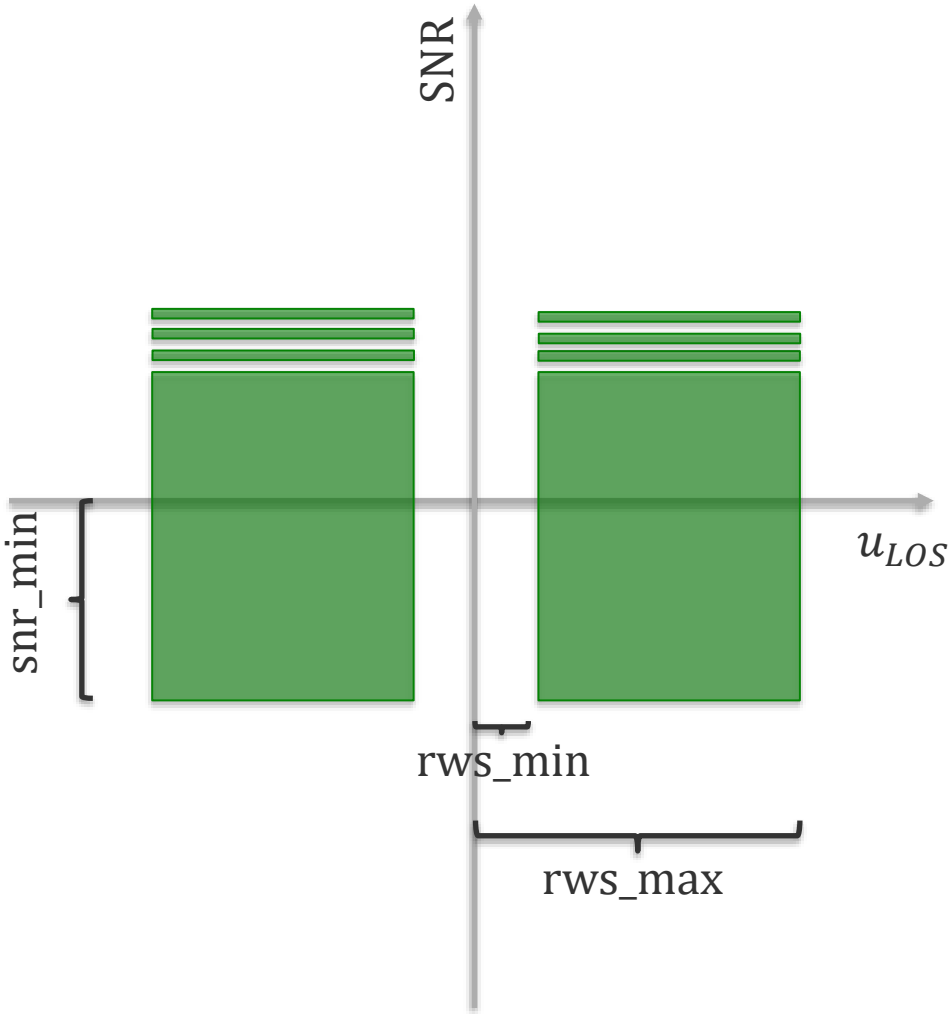
count_threshold

Quality control: pre-filter

Geometrical constraints

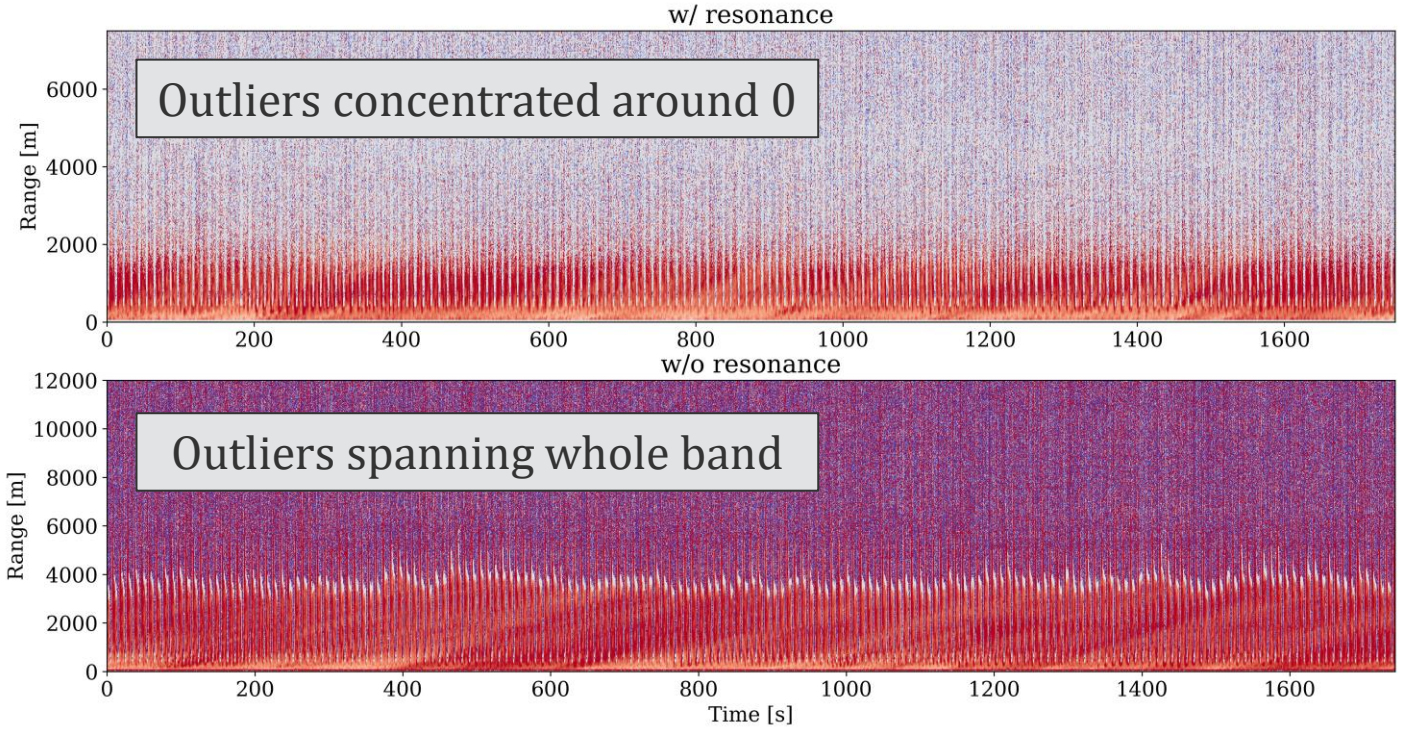


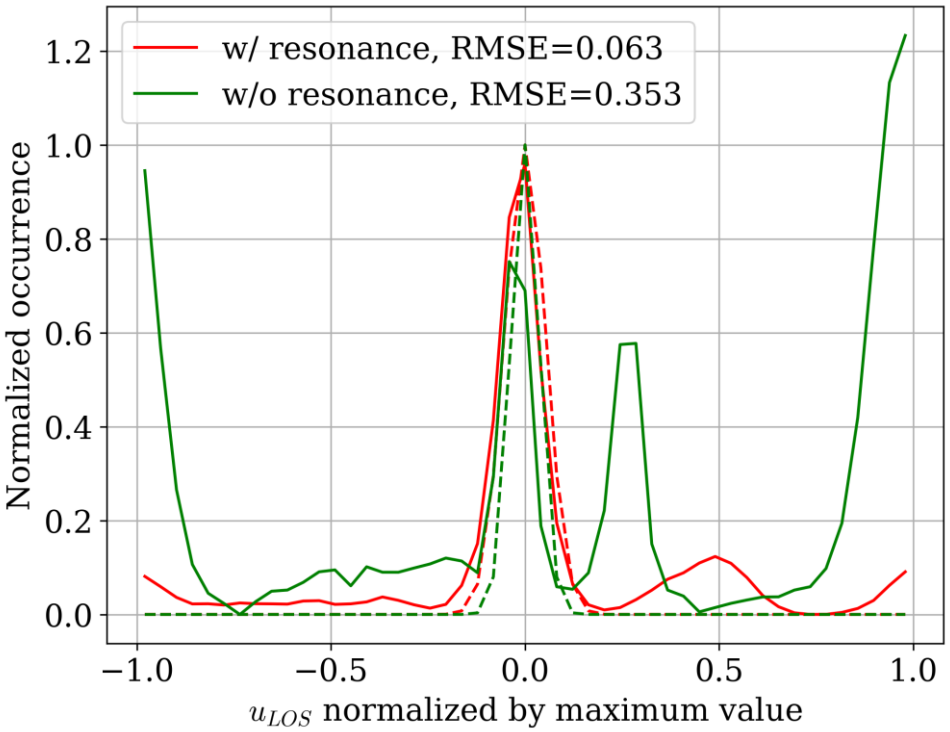
Physical constraints



The **pre-filter** applies general geometrical and physical limits to the data that do not depend on the flow. It precedes the subsequent dynamic filter and speeds up/facilitates its operation.

A special problem: the “resonance”

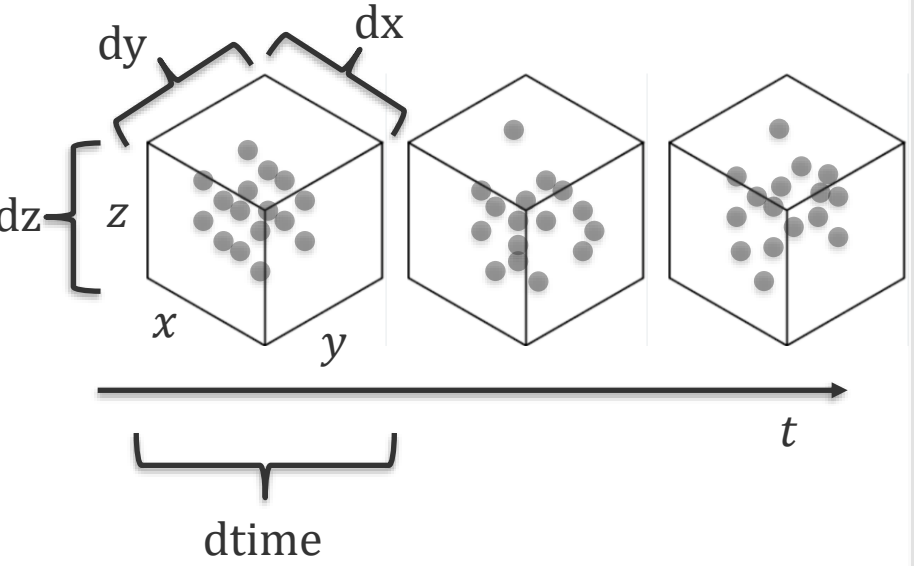




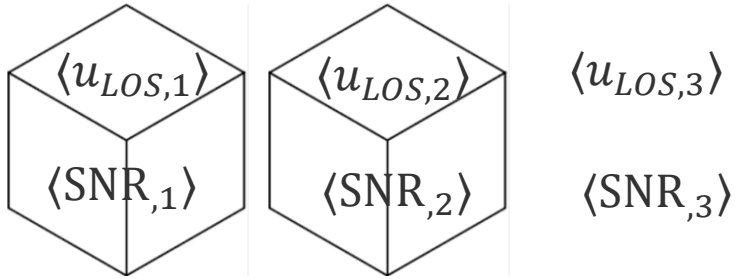
- Some lidar models have far range outliers that instead of spanning the whole band are concentrated or “**resonate**” around 0
- The rws_min threshold removes those value and is identified by fitting a **Gaussian** on the histogram of the u_{LOS} values that do NOT pass the prefilter (i.e., likely bad values)
- If the **RMSE** of the fitting is below max_resonance_rmse, then the resonance is detected and rws_min takes as **twice the st.dev. of the fitting Gaussian**

Quality control: dynamic filter

1: u_{LOS} and SNR data are binned into 4D spacetime bins

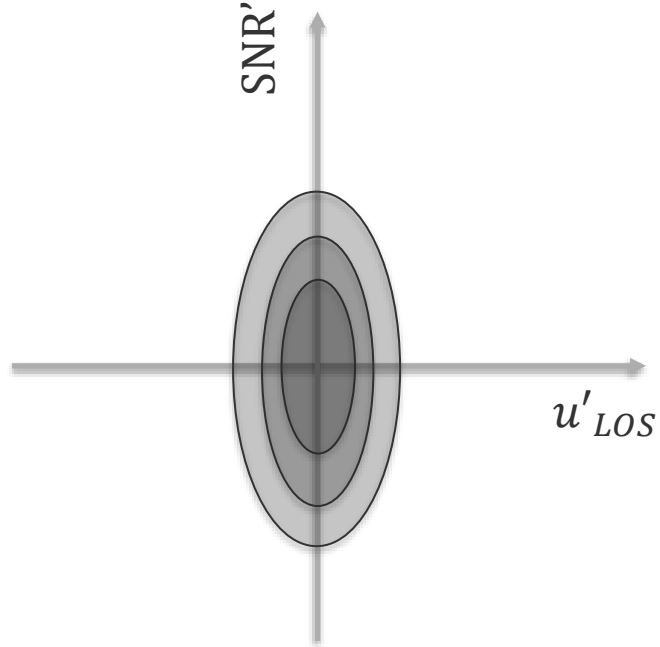


2: the bin-median is calculated, and its statistical significance checked

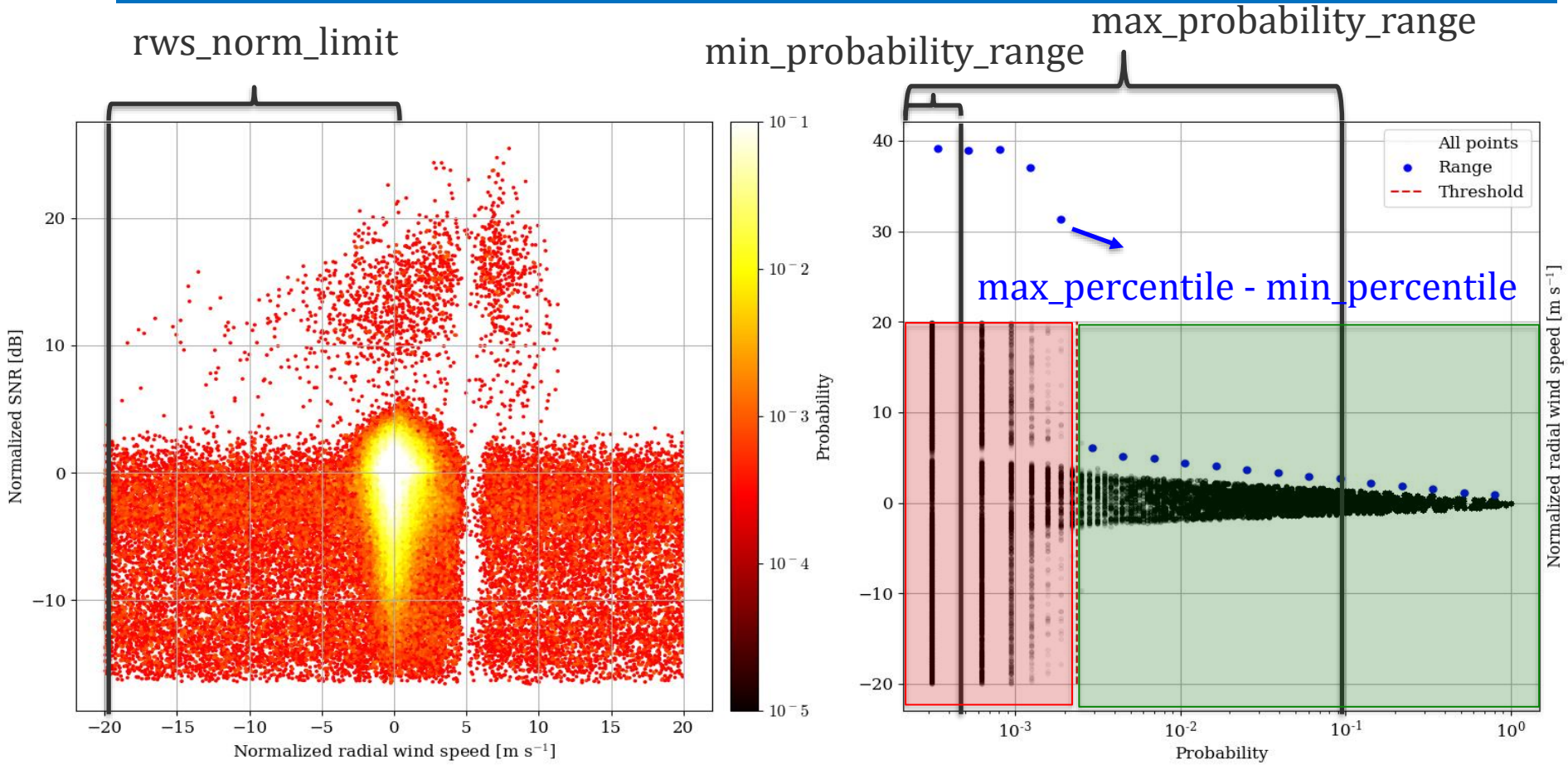


- $N \geq$ local_population_min_limit
- $\sqrt{\frac{\pi}{2}}\frac{\sigma_{u_{LOS}}}{\sqrt{N}} \leq$ rws_standard_error_limit
- $\sqrt{\frac{\pi}{2}}\frac{\sigma_{\mathrm{SNR}}}{\sqrt{N}} \leq$ snr_standard_error_limit

3: the normalized u_{LOS} and SNR are calculated as fluctuations over the local median and their 2D p.d.f analyzed

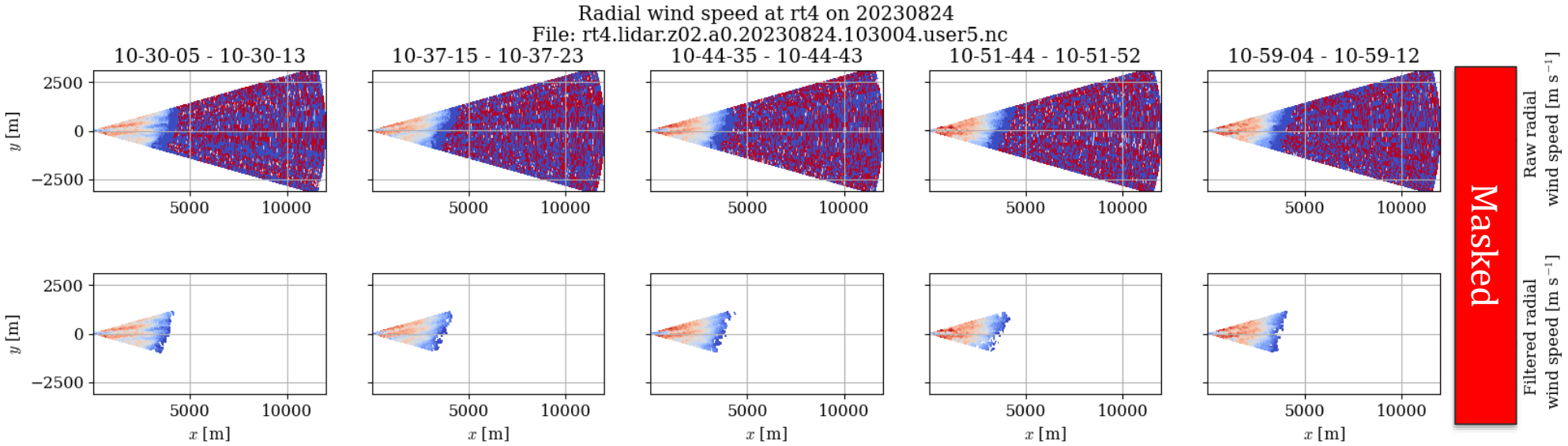


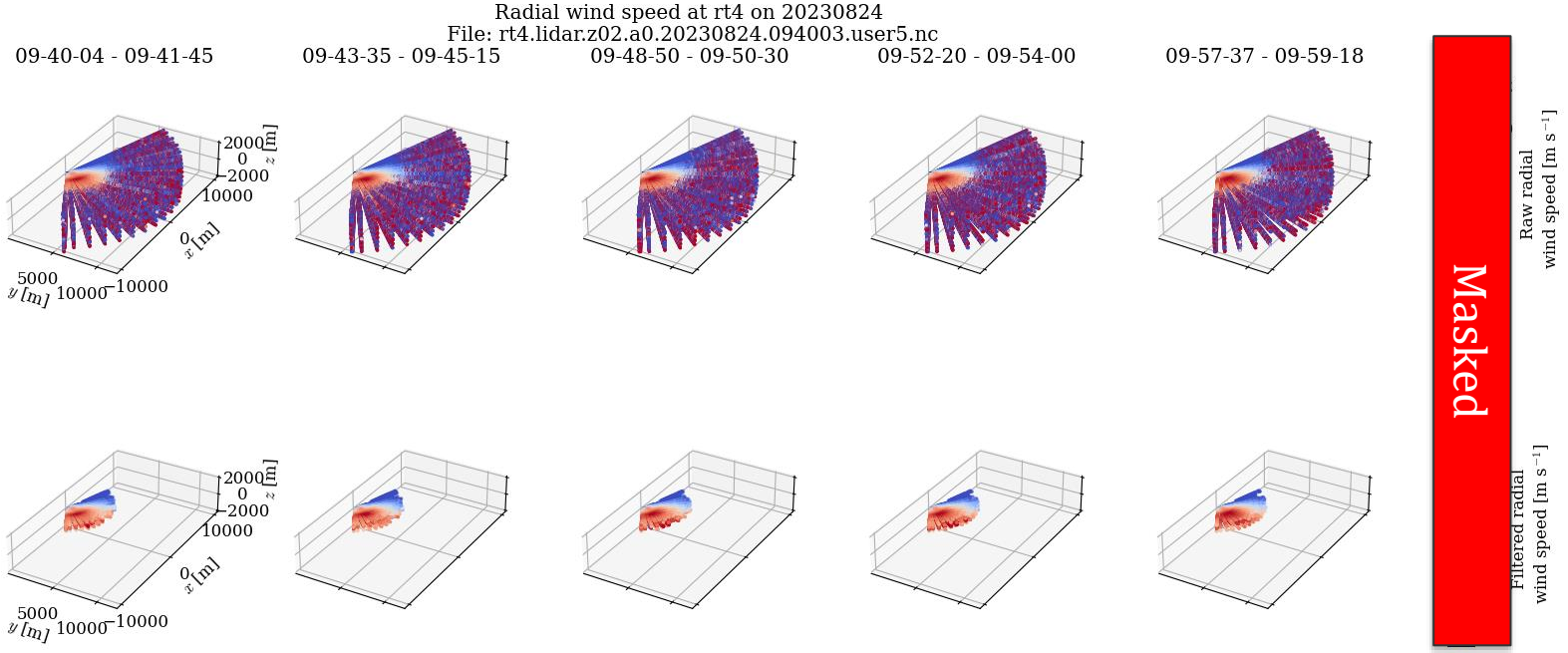
Quality control: dynamic filter



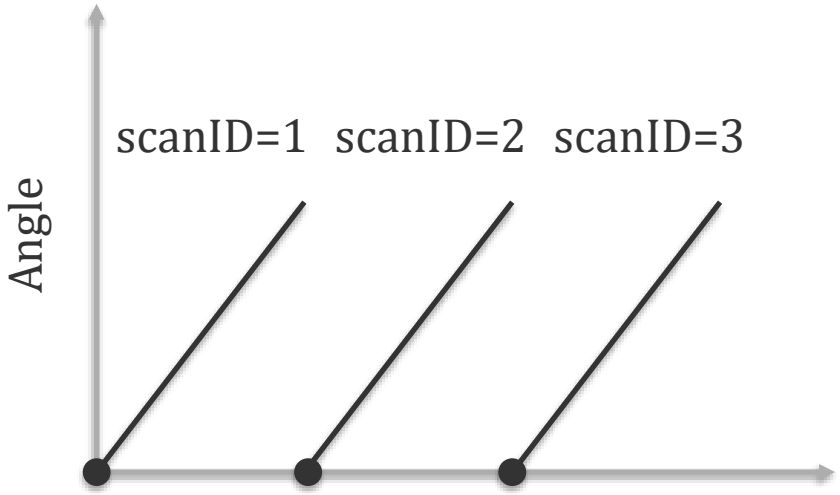
- Data are rejected if their **probability** in the $u'_{LOS} - SNR'$ plane is below threshold
- To find the **threshold**, the variability of u'_{LOS} as a function of probability is checked by calculating the range of max_percentile minus min_percentile in N_probability_bins bins
- The threshold is defined as the probability where the **bin-variability** exceeds the fraction rws_norm_increase_limit of the whole range of u'_{LOS}
- The threshold is **constrained** within min_probability_range and max_probability_range
- Finally, **scarcely populated** bins where a fraction more than local_scattering_min_limit of points where entirely rejected are discarded

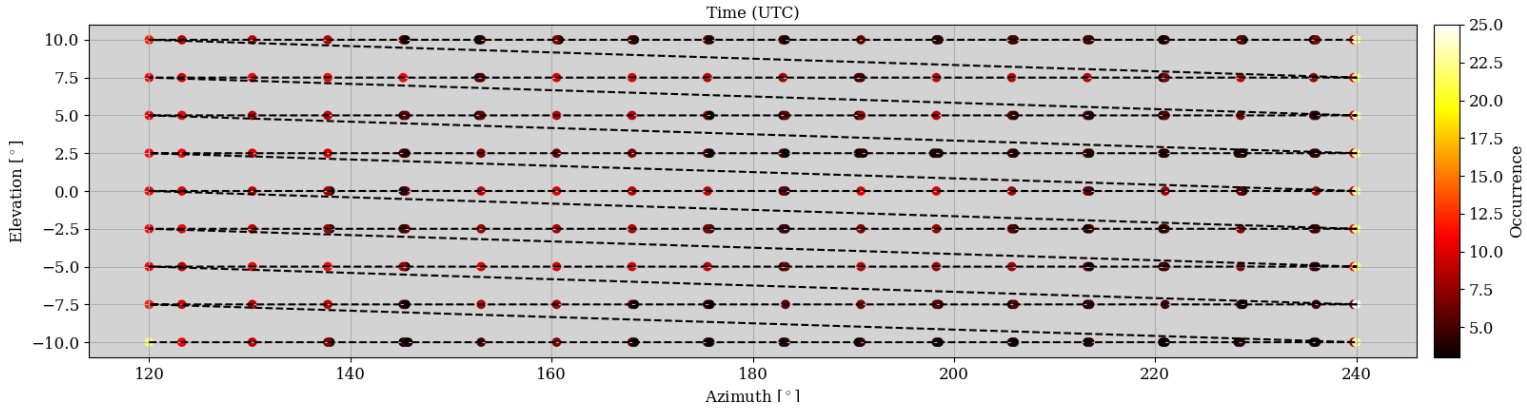
Quality control: examples





Standardization





The scan repetition is found by checking the nearest previous time the beams scan the initial angular position

The beam repetition (i.e. the scan trajectory in time) is found by the median time it takes for the beams to reach every angular position, which is a tricky task since many beams may have been filtered out at this stage.

Finally, scans a classified in three categories that are useful for plotting: