Summary of previous work on FitACF 3.0

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Background

WHY FITACF3?

Major issues with FITACF2

Confusing organisation of the package

- Lack of transparency ('black box')
- Strong interdependence between different routines

Questionable implementation of some analysis procedures

- Empirical data selection procedures
- Incorrect treatment of cross-range interference
- Non-optimal implementation of least squares fitting
- Meaningless velocity error values

FITACF has been looked at carefully & rewritten from scratch → FITACF3

Structure of the package

Major changes in FITACF3.0

The source code has been completely restructured

- More modularity: easier to add, modify or remove features
- Self-contained data structure (arrays replaced by linked lists)
- Self-explanatory filenames
  e.g. `fitacftoplevel.c`, `preprocessing.c`, `fitting.c`, `determinations.c`

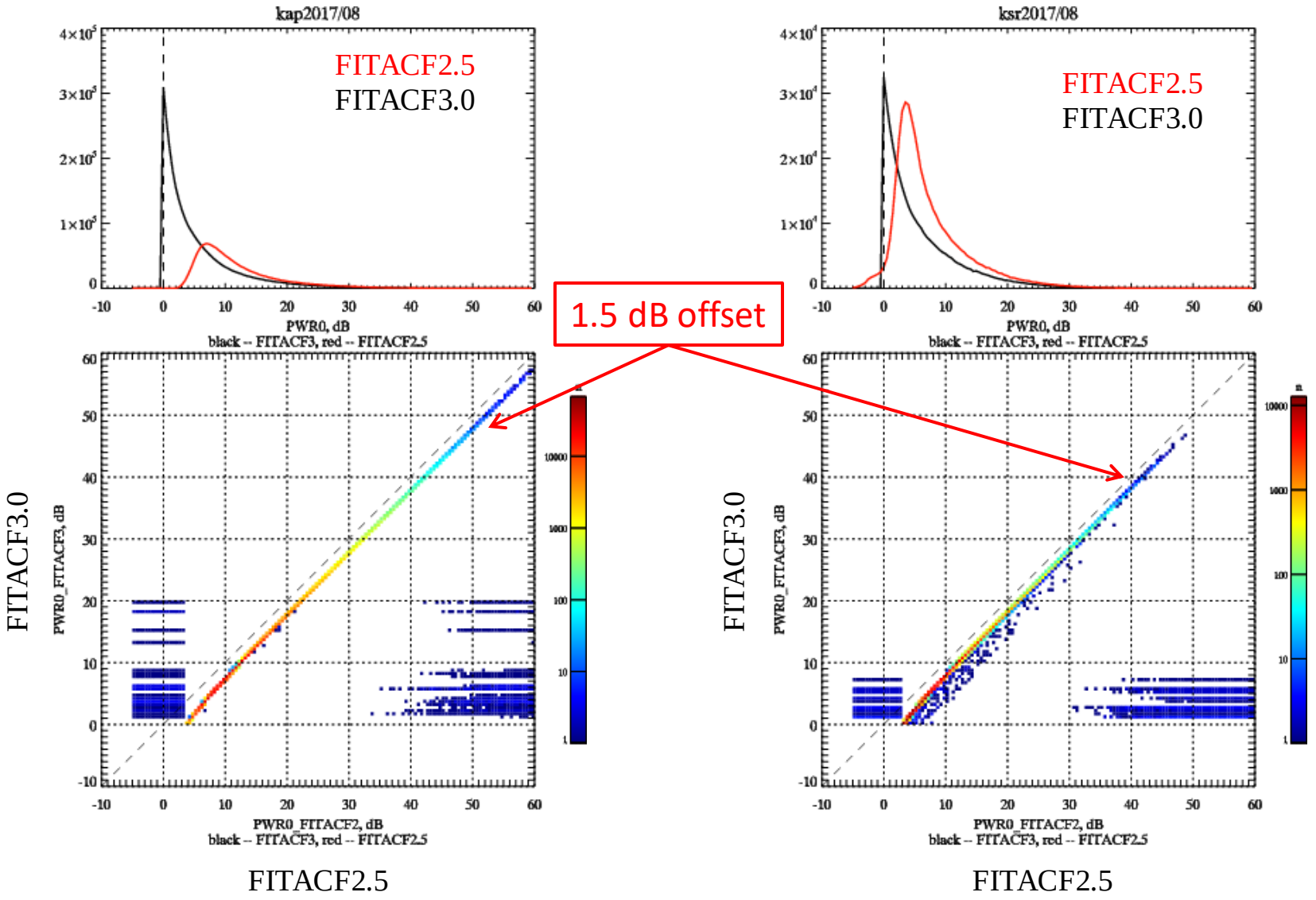
Fitted parameters

DIRECT COMPARISON V2.5 / V3.0

What data are compared

- Data for one month were analysed
- Only data with *qflg* = 1 assigned during the fitting process were compared
- In the comparison plots any extra data obtained by FITACF3 were excluded from the analysis
- 2D histograms FITACF2.5 vs FITACF3.0 were calculated, accompanied wherever needed by the respective 1D histograms.

PWR0 comparison



FITACF2.5

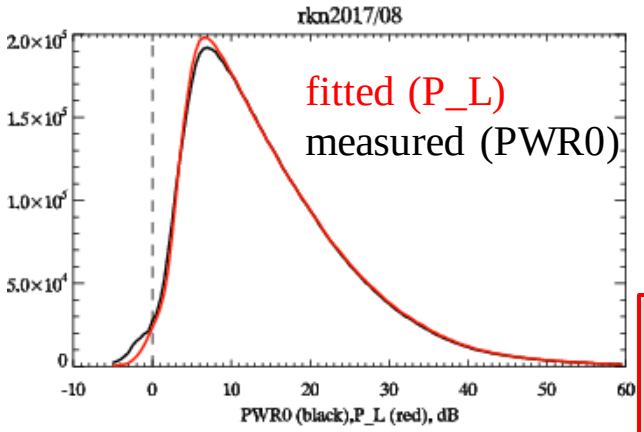
FITACF2.5

PWR0 explanation

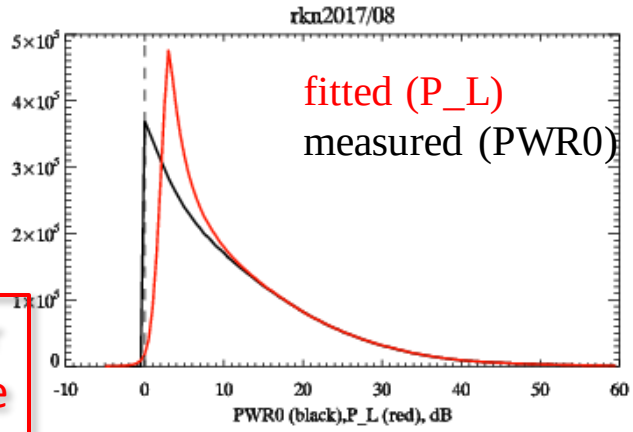
- 2D histograms: FITACF3 pwr0 values show an expected linear relationship with those from FITACF2.5. The systematic offset ≈-1.5 dB is due to the background noise level being underestimated by FITACF2.5. This issue has been resolved in FITACF3.
- 1D histograms: FITACF3 has a sharp edge at SNR = 1 as this is the main criterion for data preselection. FITACF2.5 shows a much smoother distribution peak. This happens due to the multi-component process of pre-selection based on the *ad hoc* criteria like, e.g.,
  - average non-zero lag power of the low-power ACFs
  - non-increasing ACF power *vs* time lag
  - positive and negative spike removal
  - low-power "tail" removal

Measured *vs* fitted SNR comparison

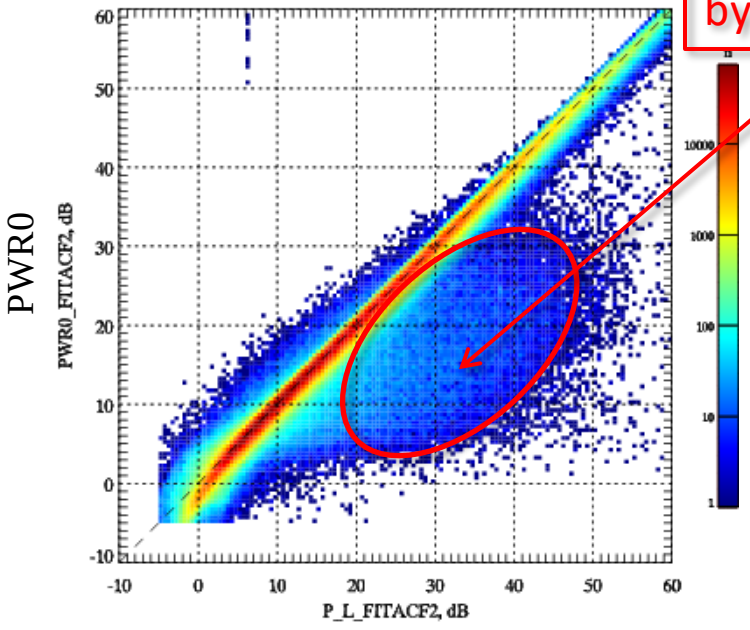
FITACF2.5

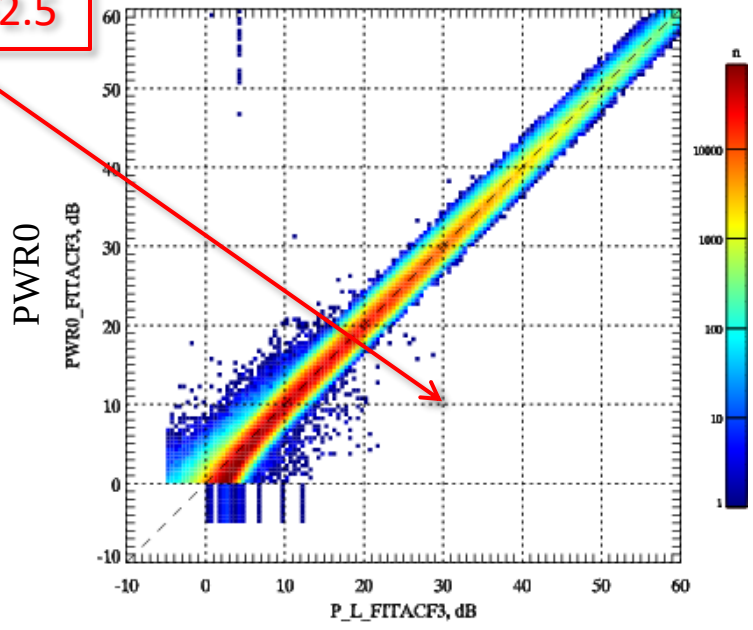


FITACF3.0



Fitted power overestimate by FITACF2.5

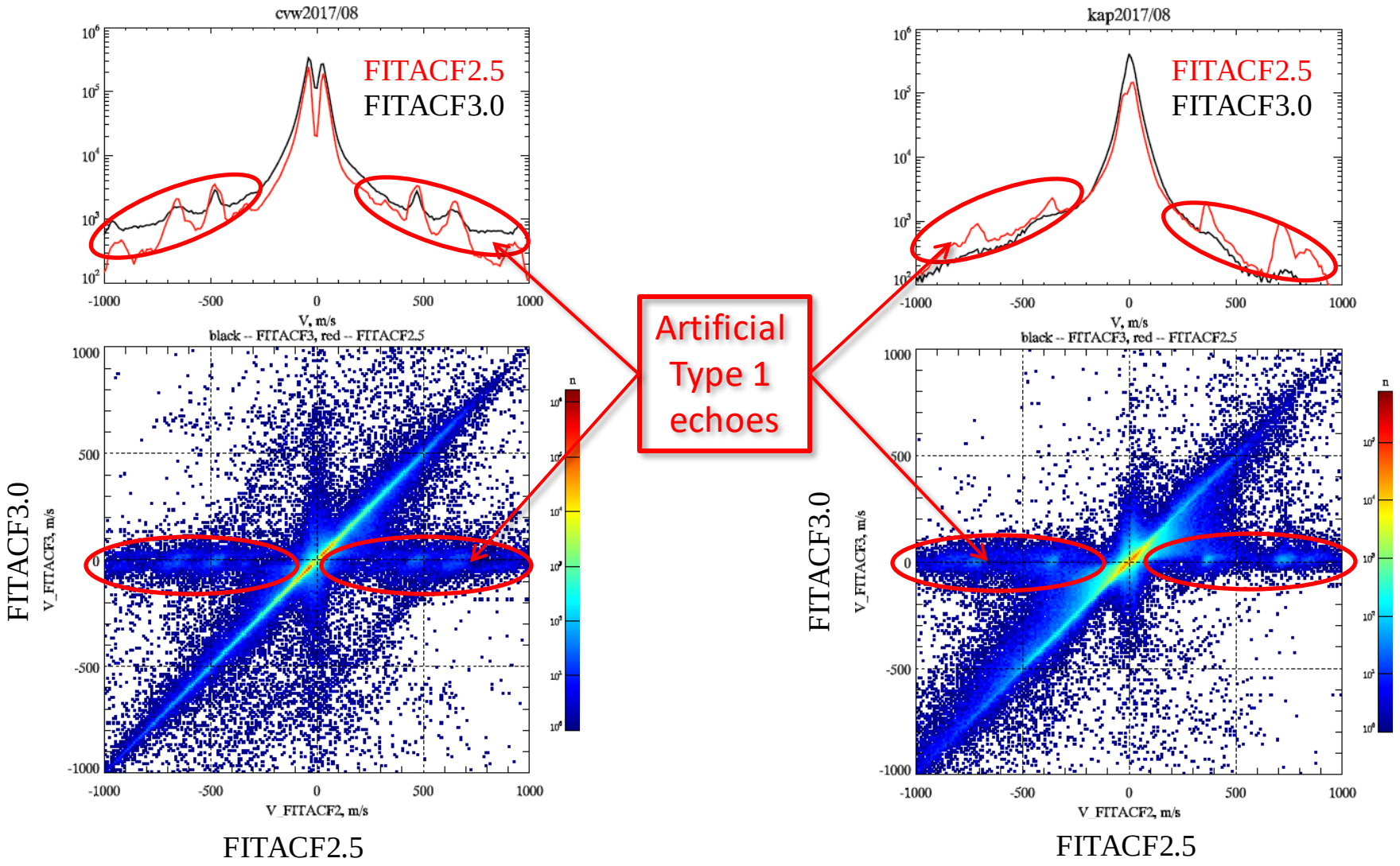




PWR0 *vs* P_L explanation

- The observed (*pwr0*) and fitted (*p_l*) SNR values should cluster along the *pwr0 = p_l* line with some variability related to the statistic uncertainty of he fitting process.
- FITACF2.5 output generally shows the expected behaviour but a noticeable amount of data below 30 dB is biased towards higher values, most probably due to the sub-optimal weighting of the power data during the fitting process
- FITACF3.0 keeps the fitted power values in line with the observed ones, i.e., shows the expected behaviour

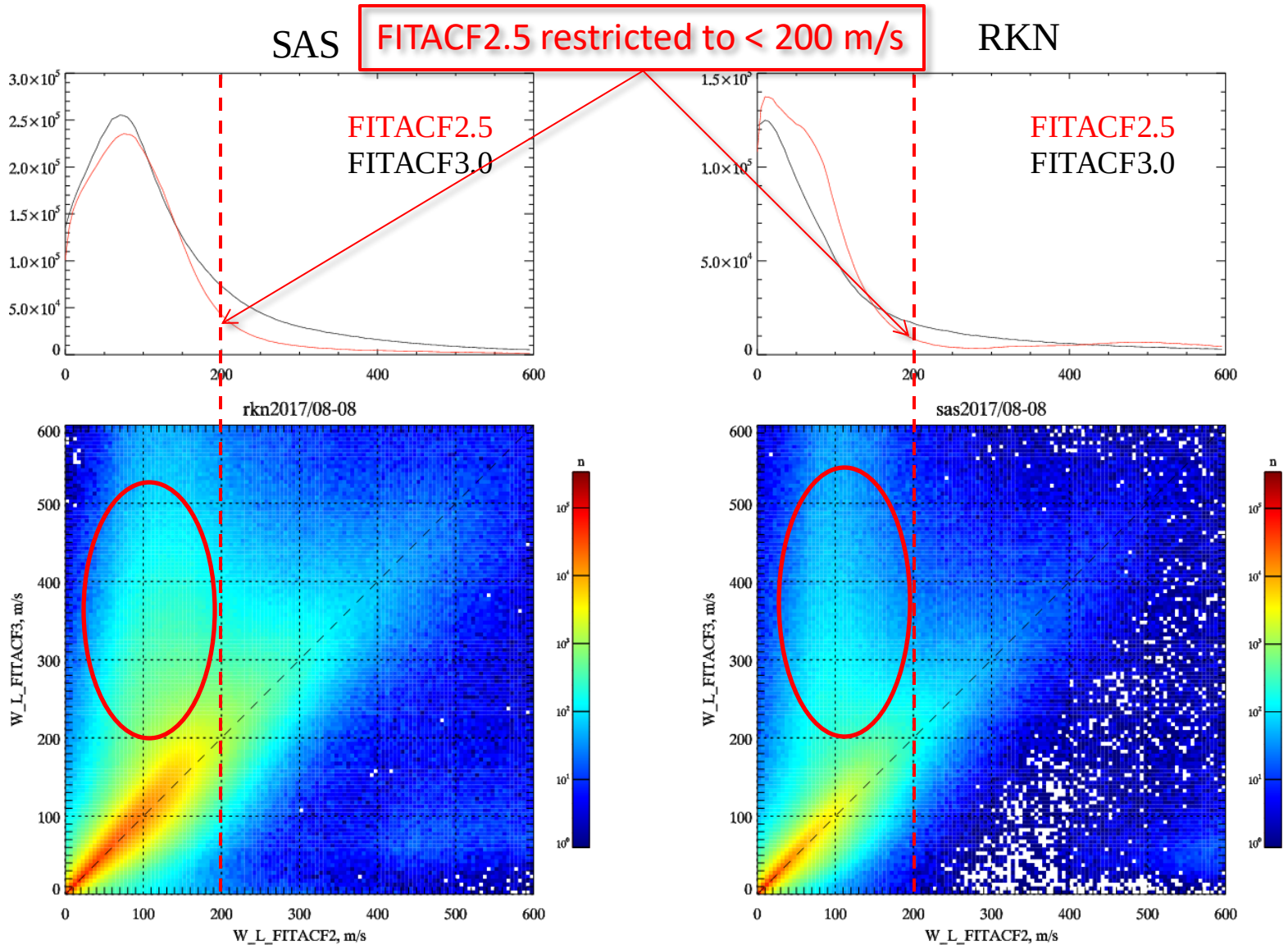
Velocity comparison



Velocity explanation

- There is a general agreement between the versions, but FITACF2.5 tends to overdo phase “unwrapping” for the low-SNR ground scatter echoes. Due to the step-like nature of the “unwrapping” process this produces periodic artificial maxima in the velocity histograms.
- FITACF3.0 minimises this effect through its improved “unwrapping” procedure.

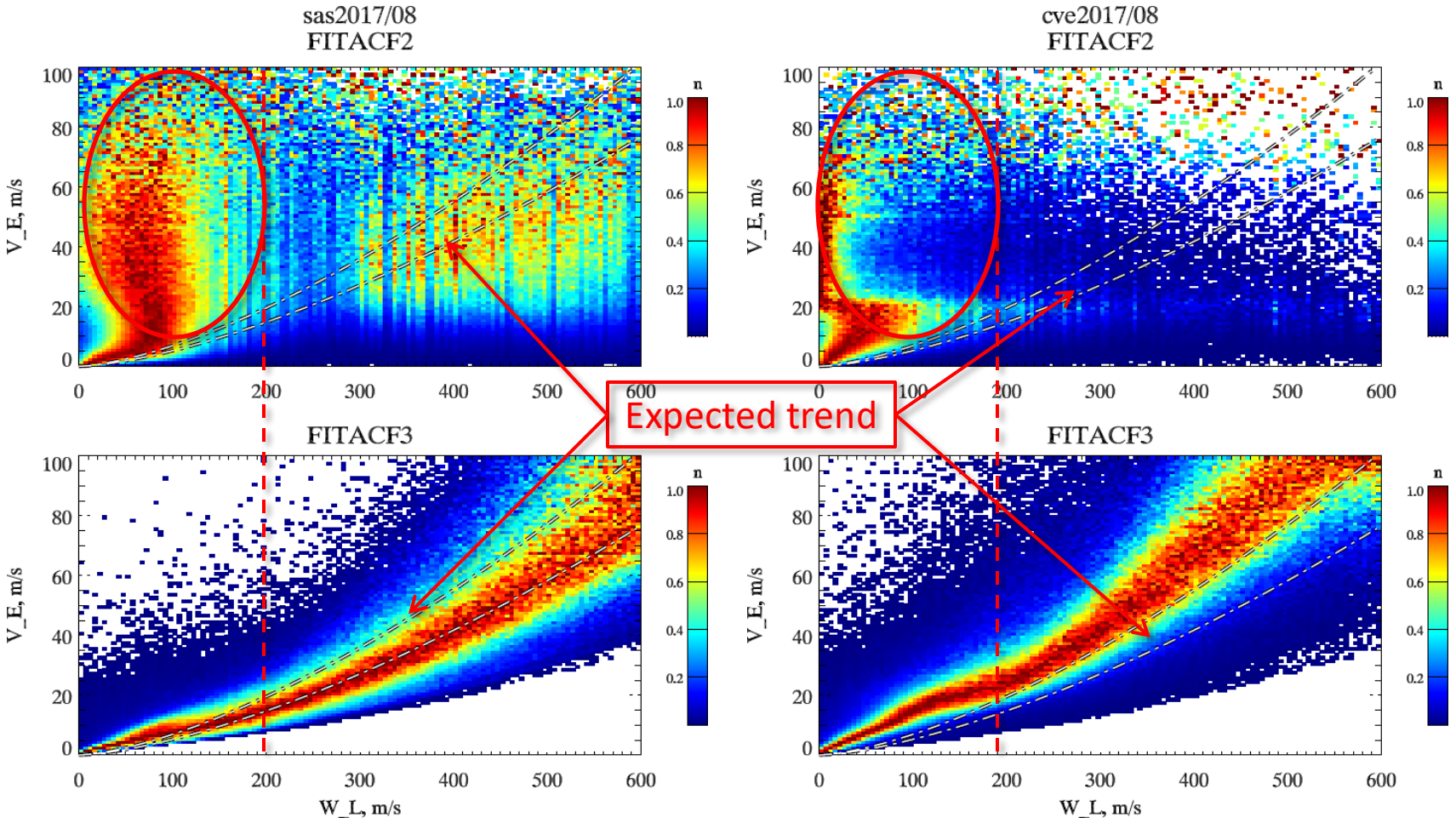
Spectral width comparison



Spectral width explanation

- FITACF2.5 tends to restrict spectral width values for ionospheric scatter to below 200 m/s
- FITACF3.0 histograms show longer “tail” which occurs to represent the reality better (see the next slides on the relationship between spectral width and velocity errors).

Normalised V_E/W_L histograms



Velocity error explanation

- Theoretically, velocity errors should increase with increasing spectral width as the effective spectral maximum in Doppler frequency domain broadens
- FITACF2.5 shows spectral width saturation at 200 m/s which is most probably related to the sub-optimal weighting of power data during the fitting procedure
- FITACF3.0 shows the expected behaviour

Summary on direct comparison

- There is a good general agreement between the two versions
- FITACF3 improvements:
  - SNR:
    - more accurate noise floor determination
    - no overestimation of fitted lag 0 power
  - Velocity:
    - effective elimination of the “Type 1” artifact
  - Spectral width:
    - more data with larger spectral width due to elimination of an artificial threshold at ~200 m/s
    - expected proportionality to velocity errors