An Evaluation of FITACF3 - Part 2: Fitted Parameters, Errors, and Background Noise Determination

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Abstract

FITACF3.0 was released in January 2018 as part of RST4.1, with major changes relating to data pre-selection, fitting, and error determination. In this talk we compare the fitted parameters (power, velocity, spectral width), and their associated errors, for SuperDARN data processed using FITACF2.5 and FITACF3.0. The method for determining the main parameters is the same for both versions, but in FITACF3.0 the error estimates are calculated using textbook formulas with appropriate weighting for cross-range interference. Fitting errors estimated by FITACF3.0 are shown to be realistic when tested against statistical simulations. We also examine the changes to the background noise estimation in FITACF3.0, in which a correction for the effective number of noise samples has been introduced.

Outline

- Background
- Main parameter comparison
  - Signal-to-noise ratio
  - Velocity
  - Spectral width
  - Velocity errors
- Summary

Algorithmic differences

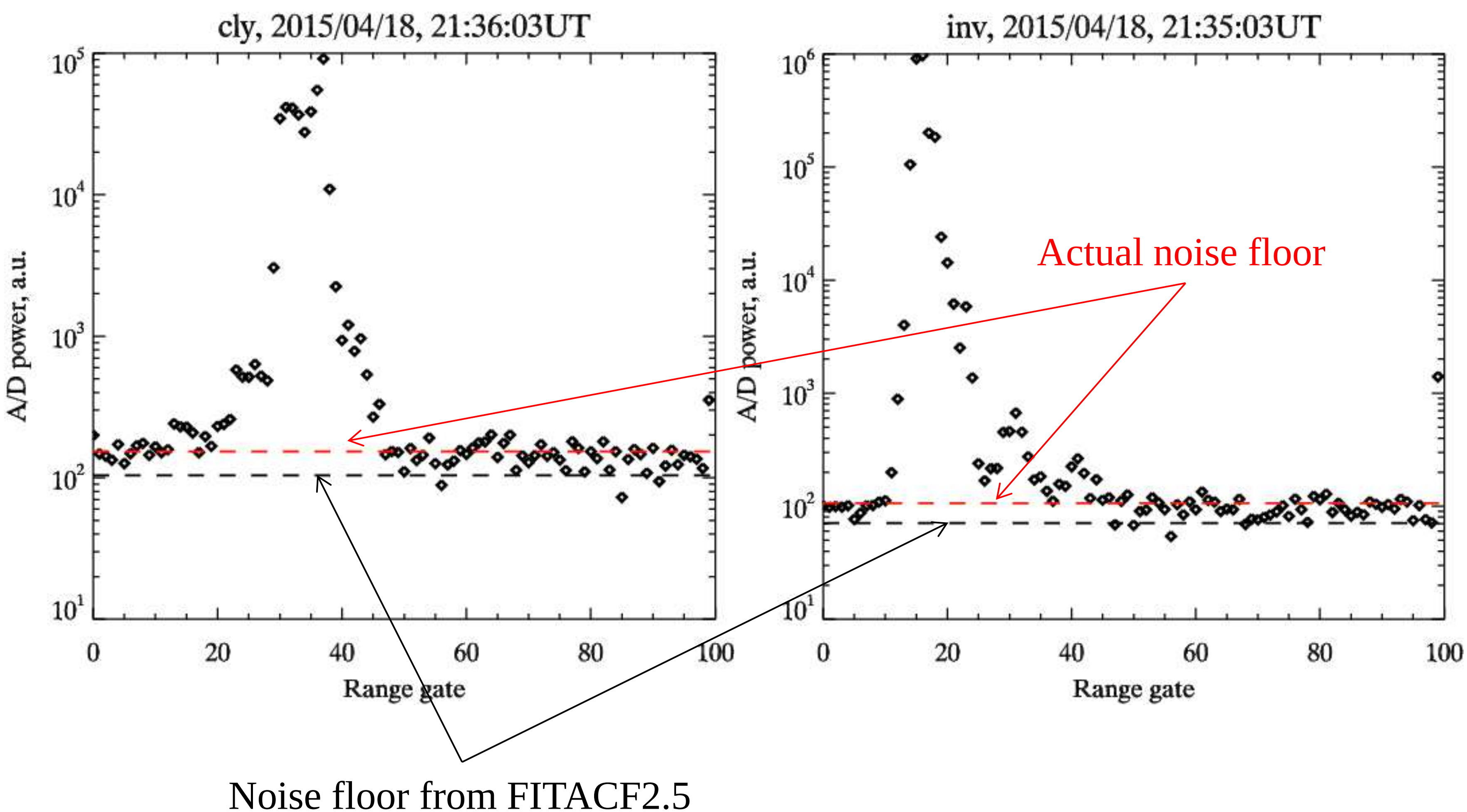
Implementation of the principles outlined in PP's tutorial on velocity errors at SD2013:

- **Textbook least-square method**
  - Phase fitting includes **all available lags** except those affected by Tx-overlap
  - Weighting coefficients:
    - **separate sets** for phase and for power
    - include **cross-range interference terms** instead of rejecting lags with high CRI levels

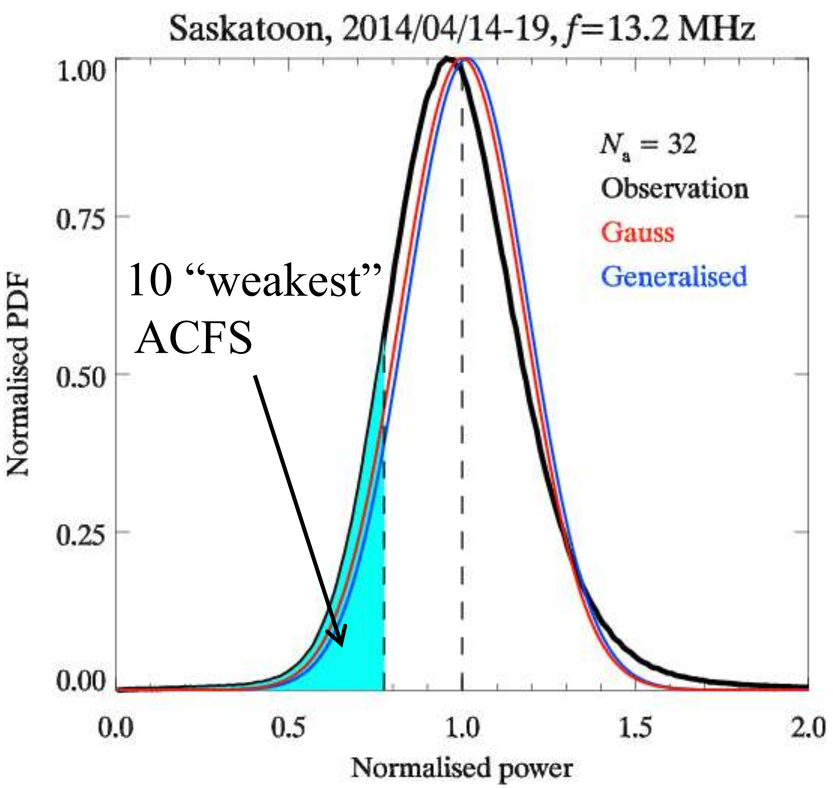
SNR threshold in FITACF2.5 (do_fit.c)

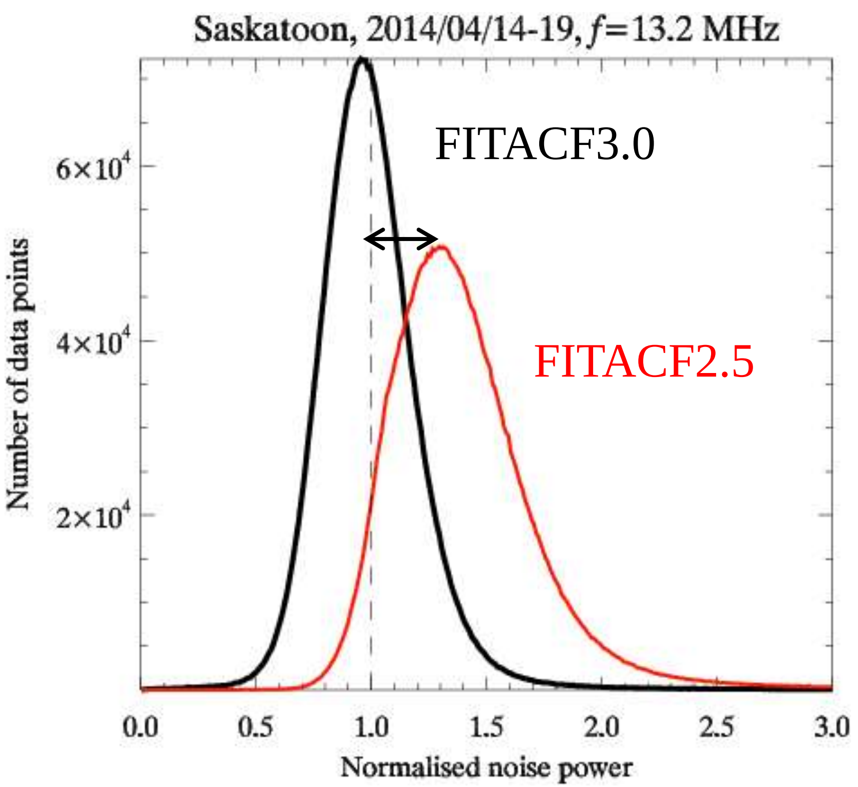
- "Determine the lag_0 noise level (0 dB reference) and the noise level at which fit_acf is to quit (average power in the fluctuations of the acfs which are pure noise)
  - look for the **lowest 10 values of lag0 power** and average to get the noise level [mnpwr]
  - Now determine the level which will be used as the cut-off power for fit_acf. This is the **average power at all non-zero lags** of all acfs which have **lag0 power < 1.6*mnpwr + 1 stnd. deviation** from that average power level…"

Noise level: 10 “weakest” ACFs

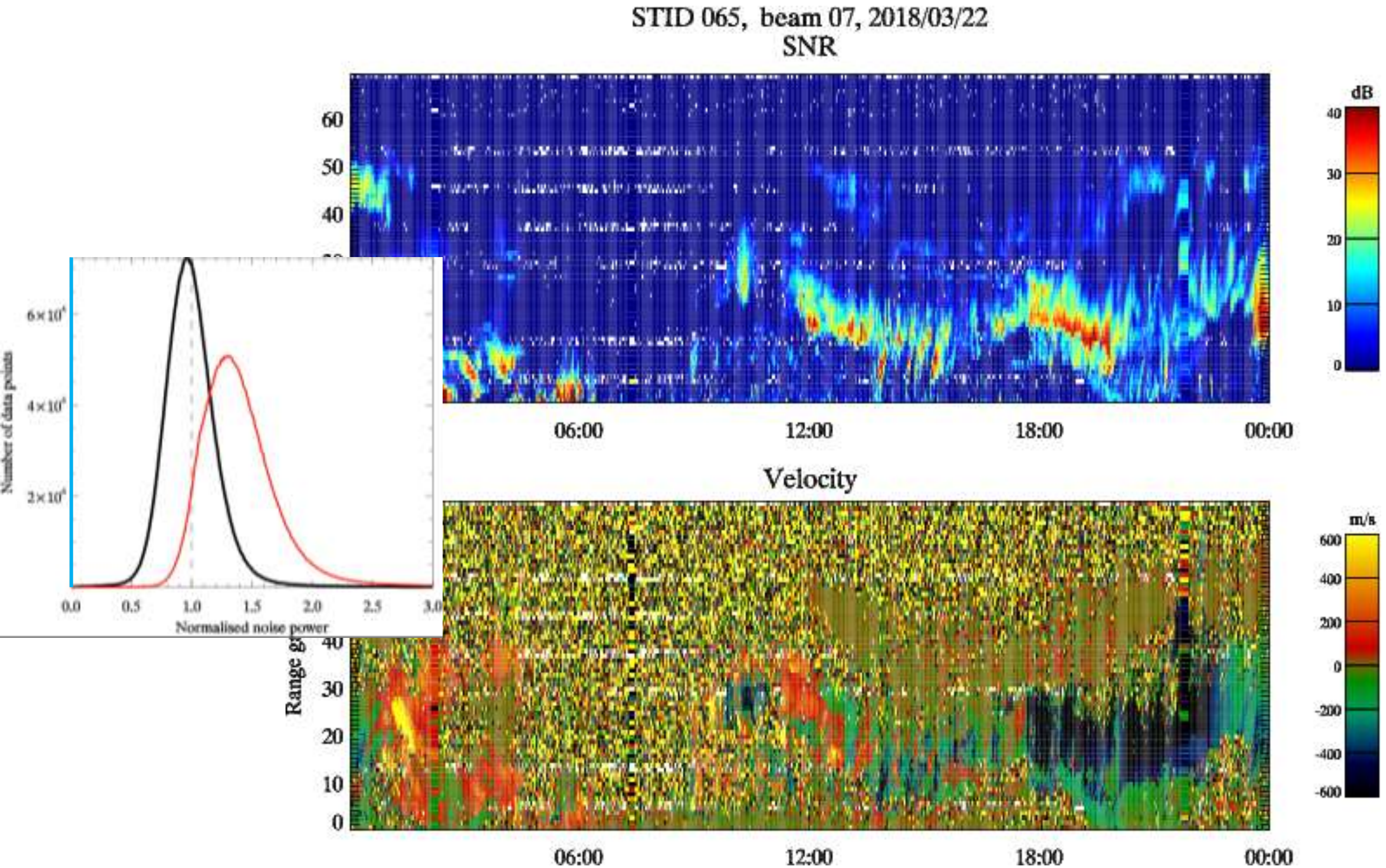


Pure noise (no emission mode)

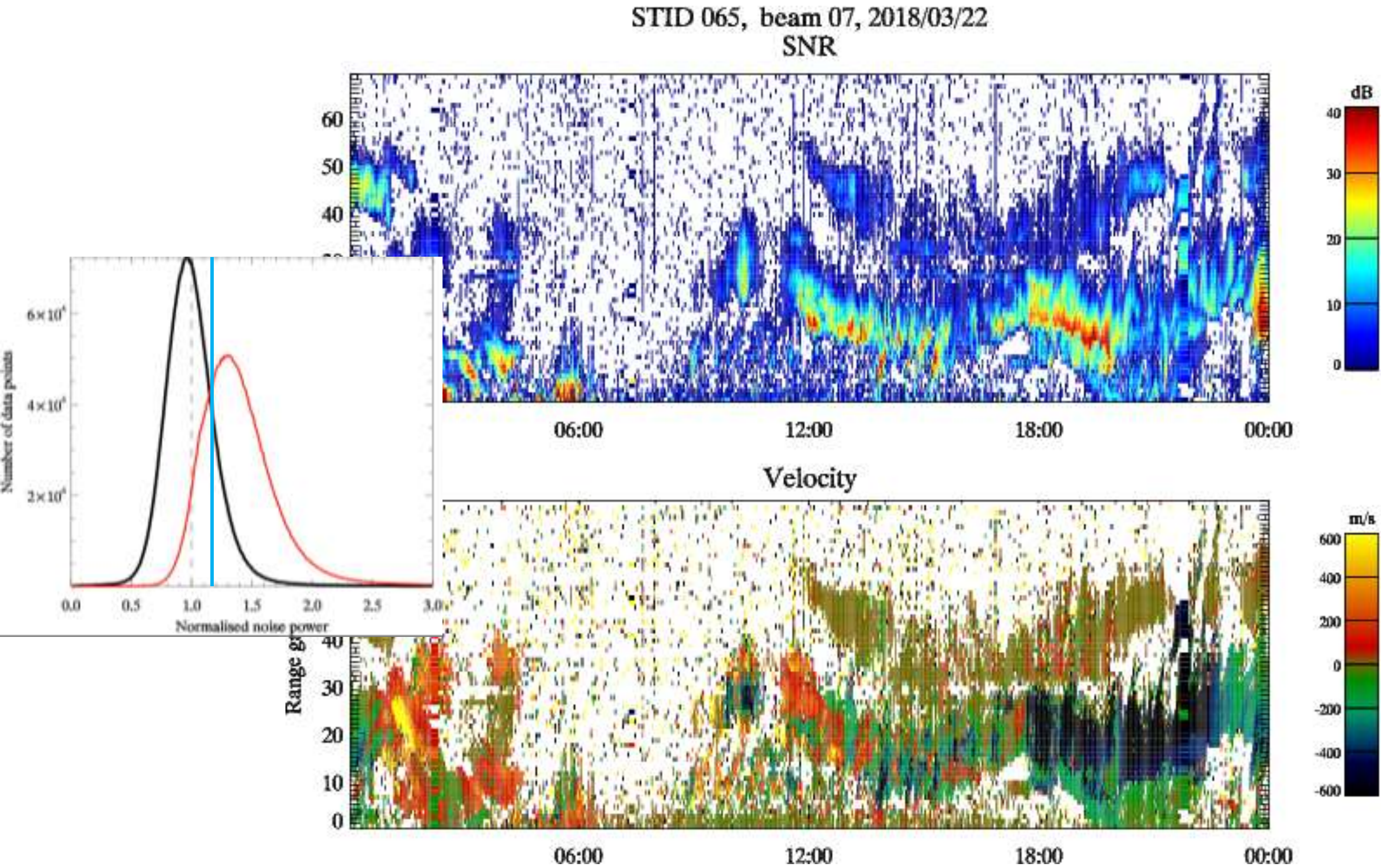




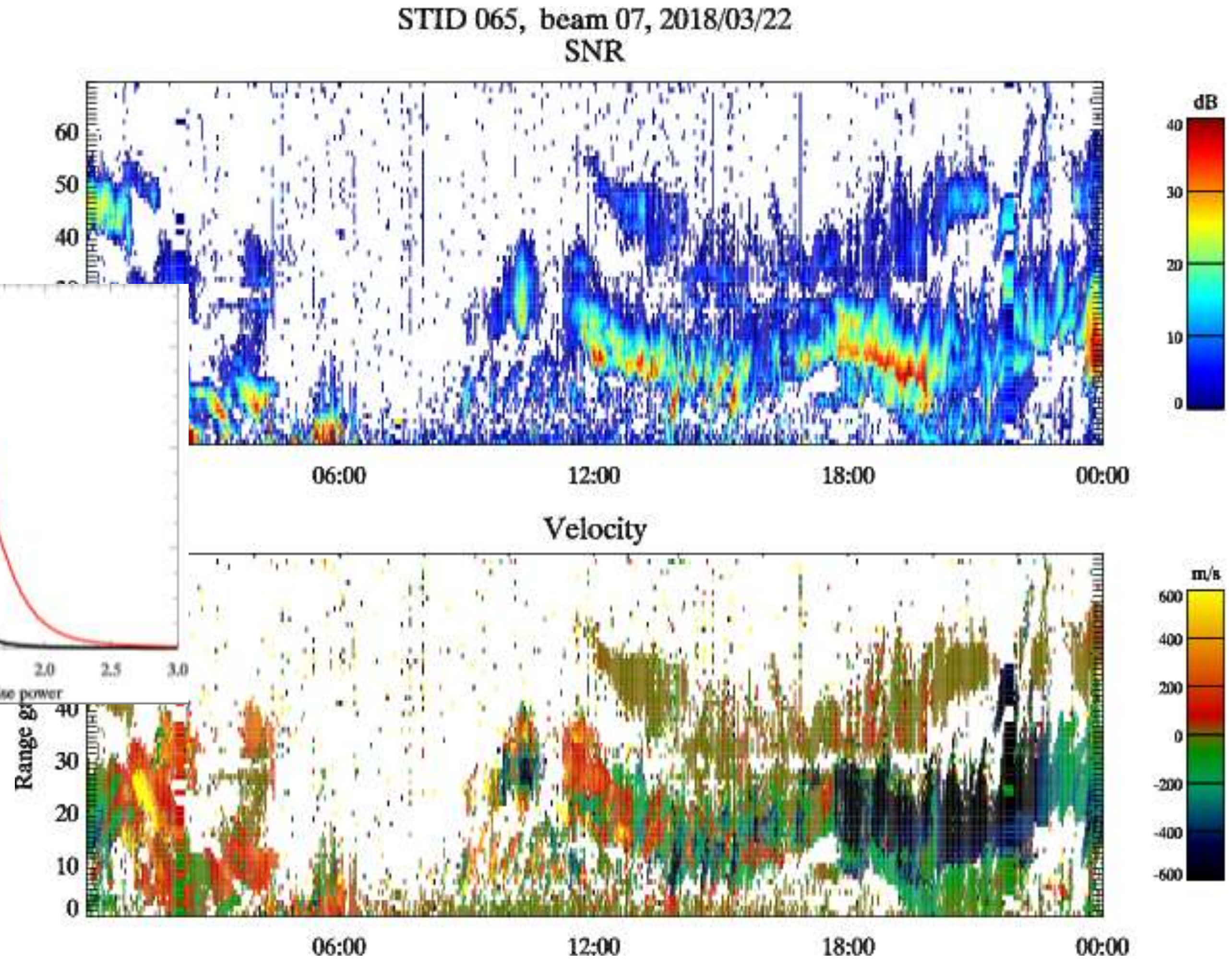
What about SNR threshold?

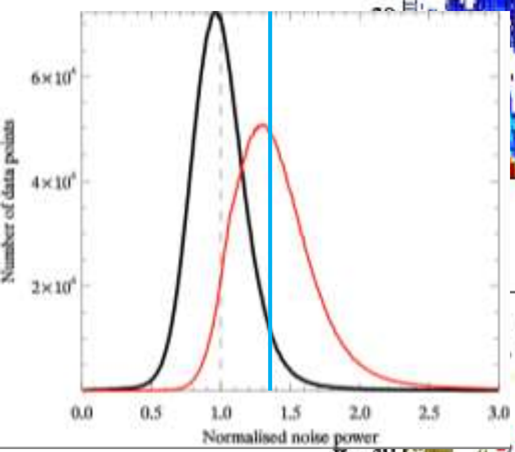


One sigma above noise floor

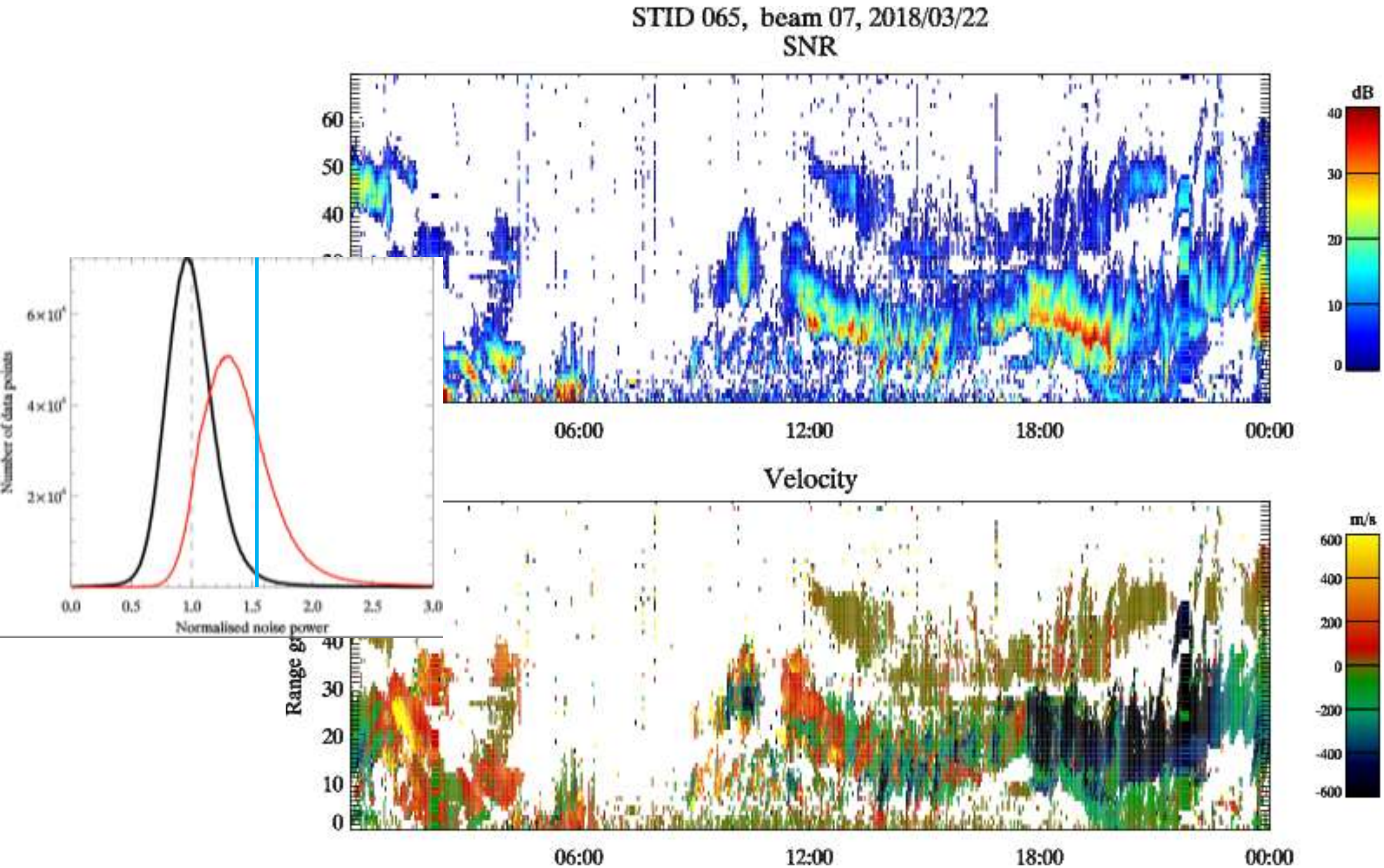


Two sigmas above noise floor

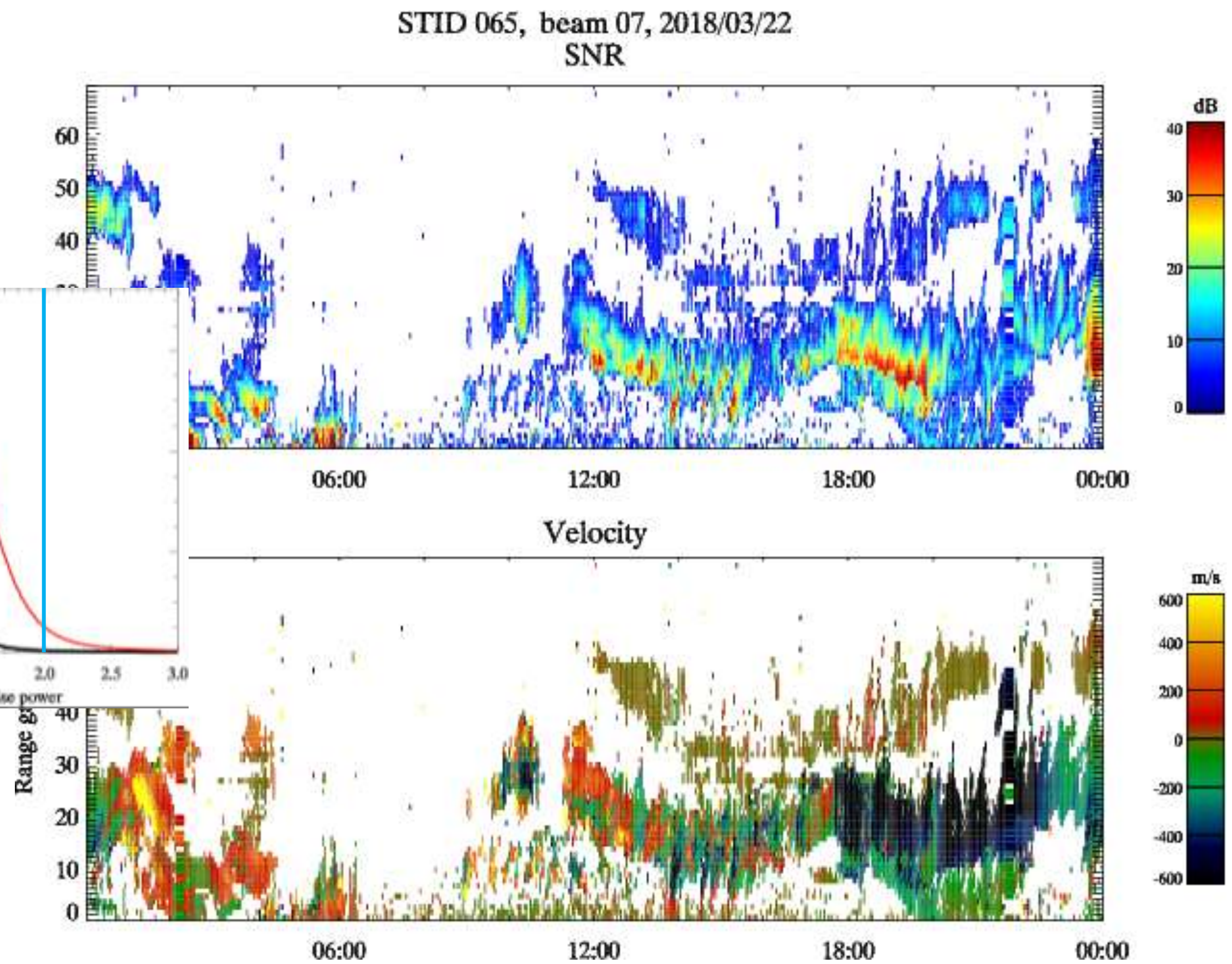


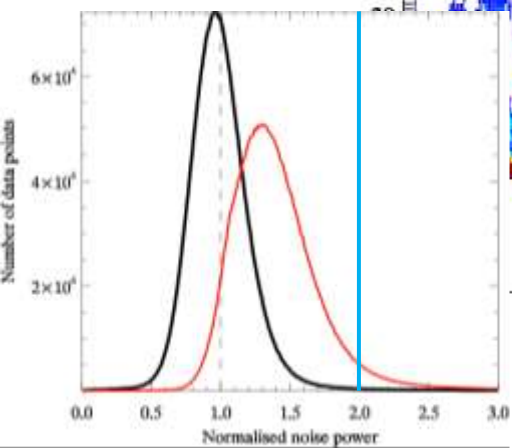


Three sigmas above noise floor

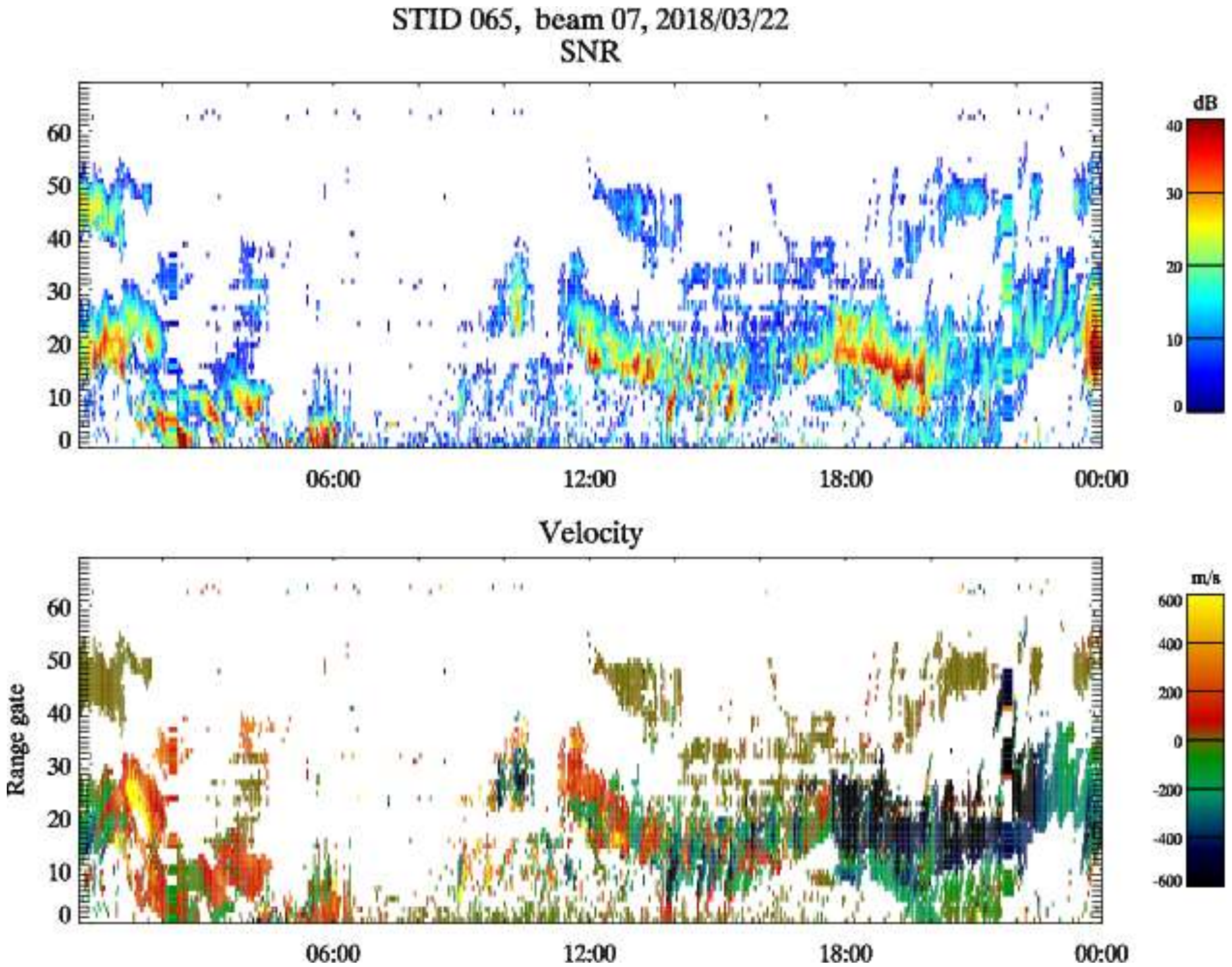


FITACF3.0 (SNR=1, 5.5 sigmas)

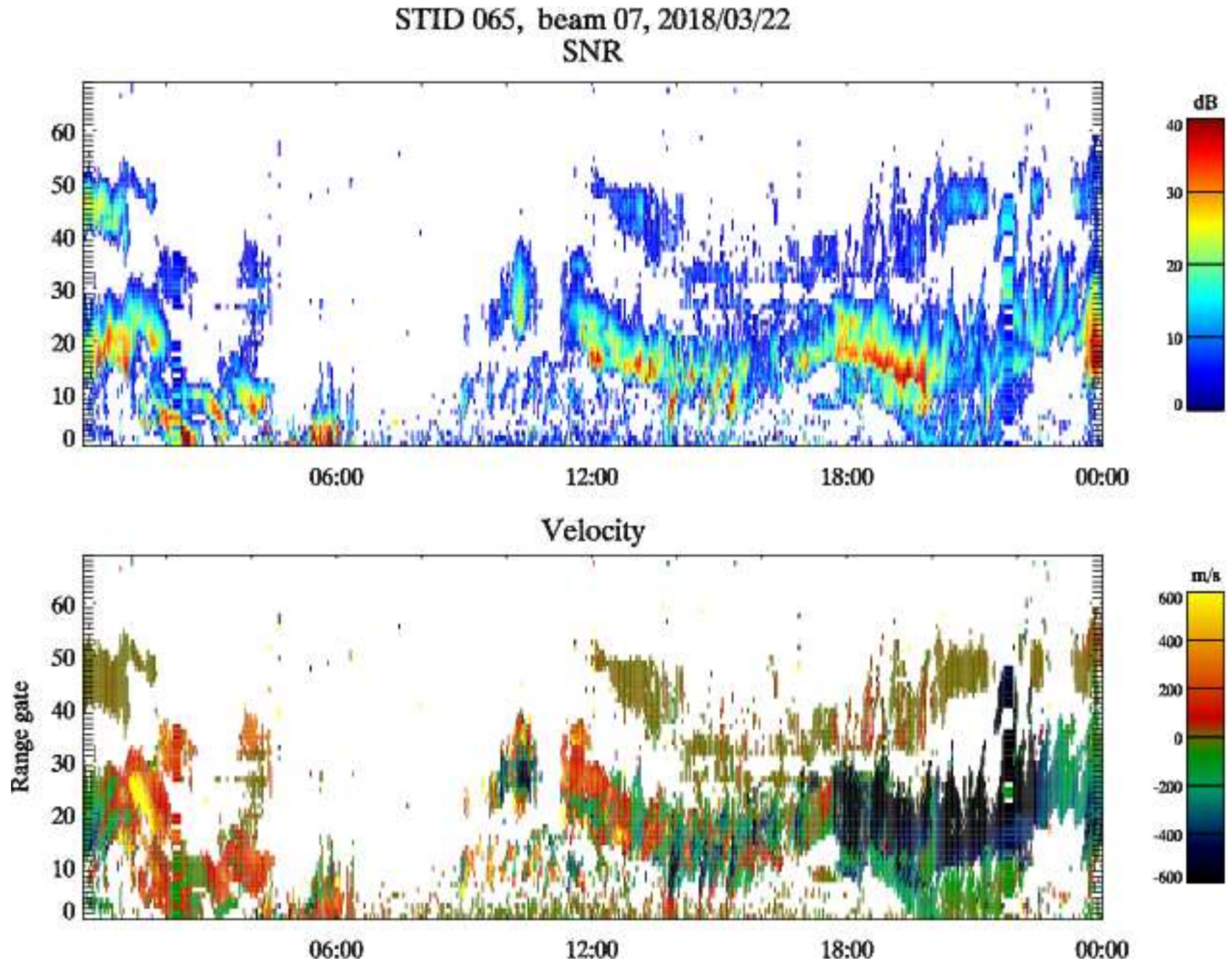




FITACF2.5

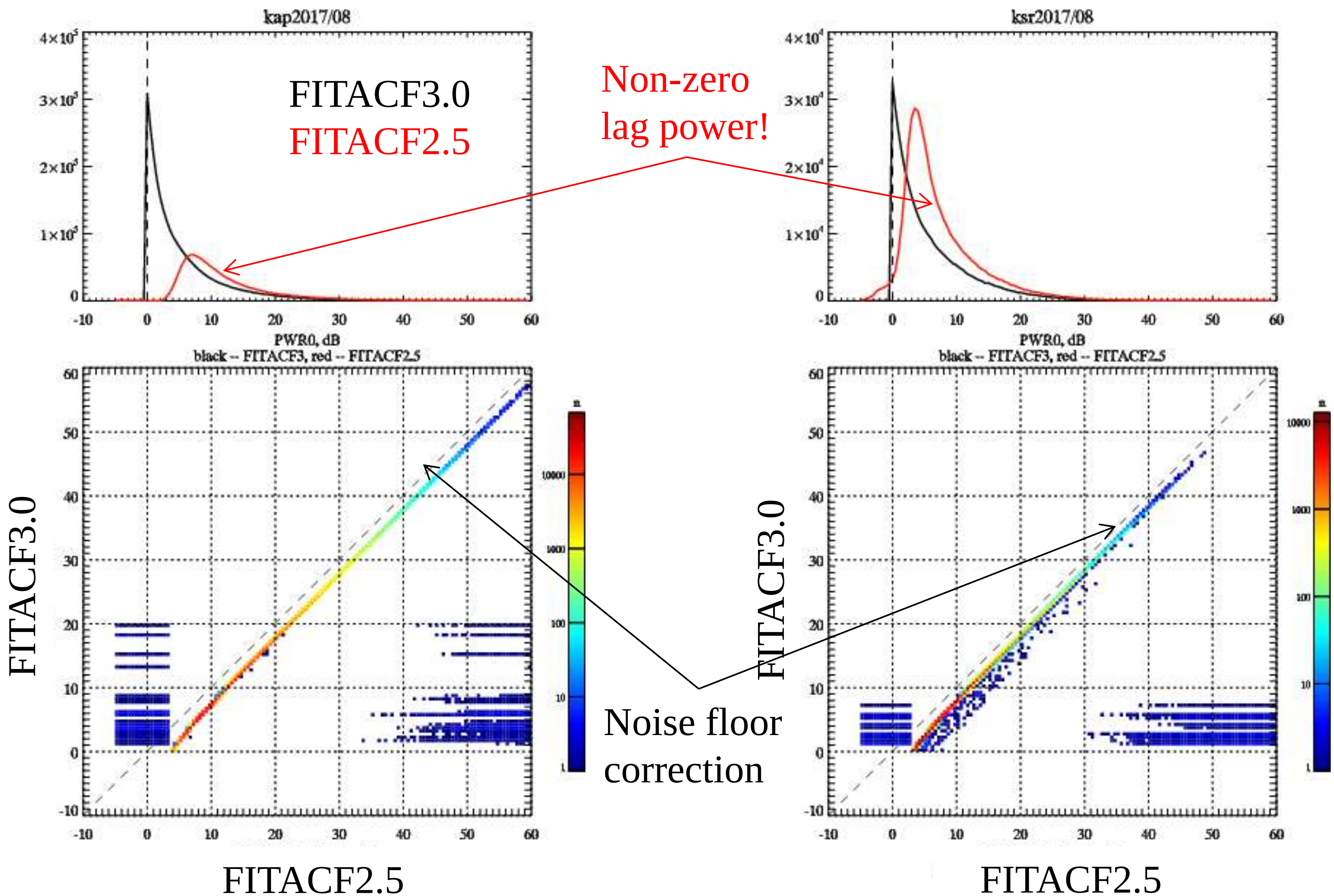

STID 065, beam 07, 2018/03/22
SNR
dB
40
30
20
10
0
60
50
40
30
20
10
0
06:00
12:00
18:00
00:00
Velocity
m/s
600
400
200
0
-200
-400
-600
Range gate
60
50
40
30
20
10
0
06:00
12:00
18:00
00:00

FITACF3.0 (SNR=1, 5.5 sigmas)



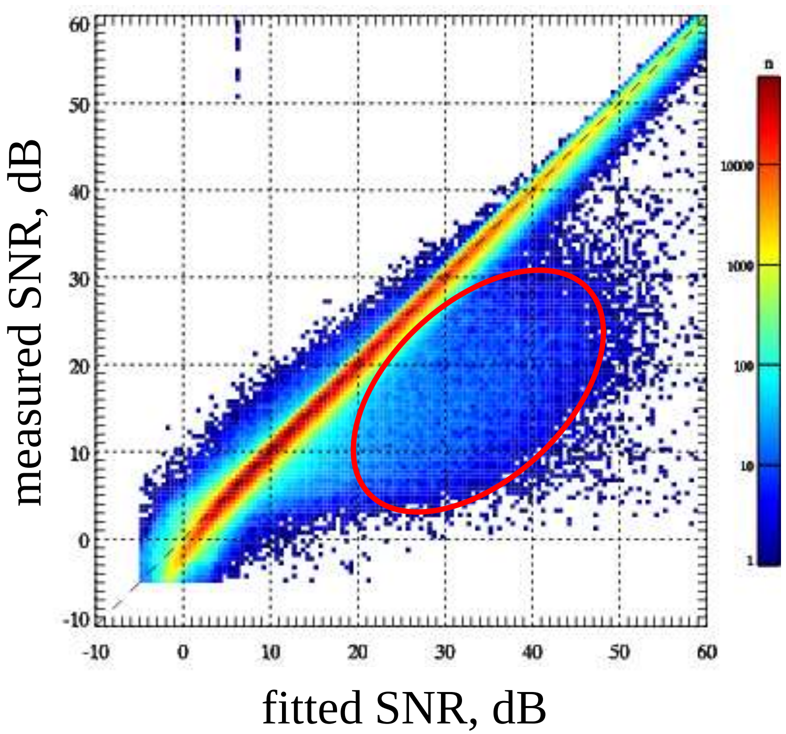
Comparative statistics for August 2017

Measured SNR (PWR0)

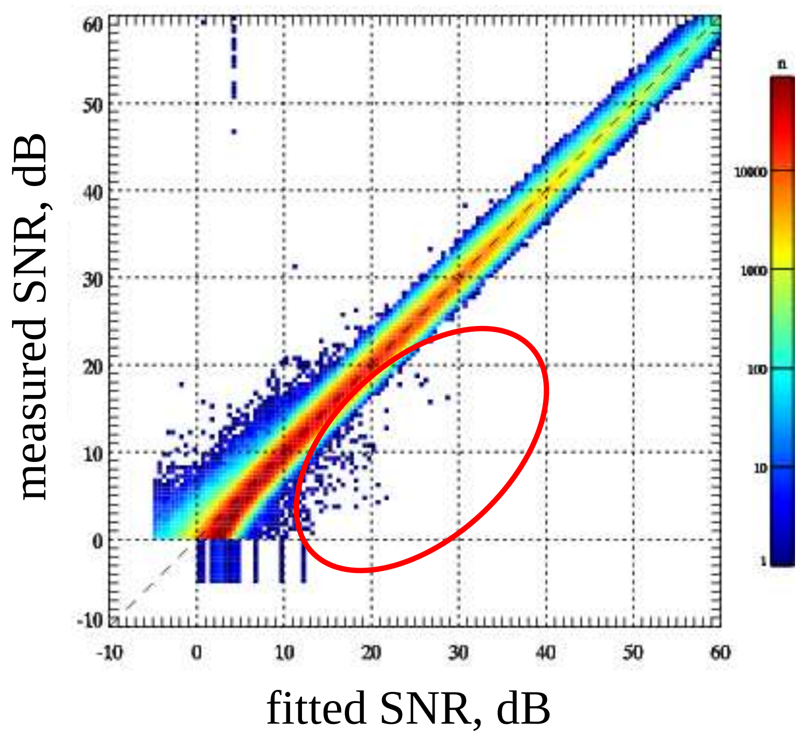


Measured (PWR0) *vs* fitted (P_L)

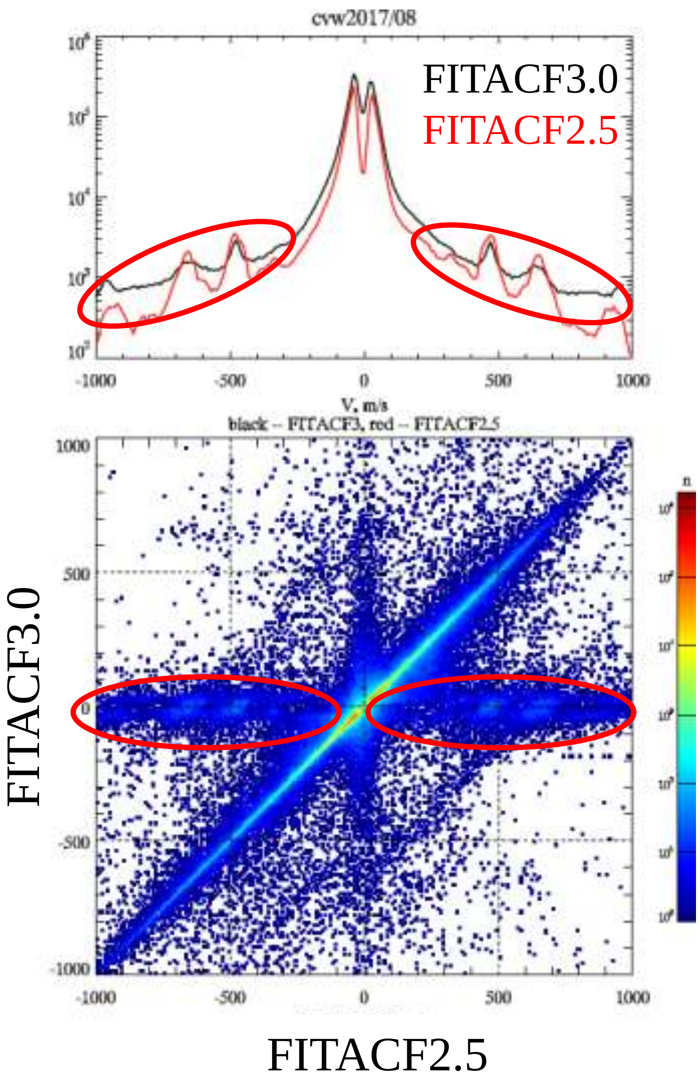
FITACF2.5

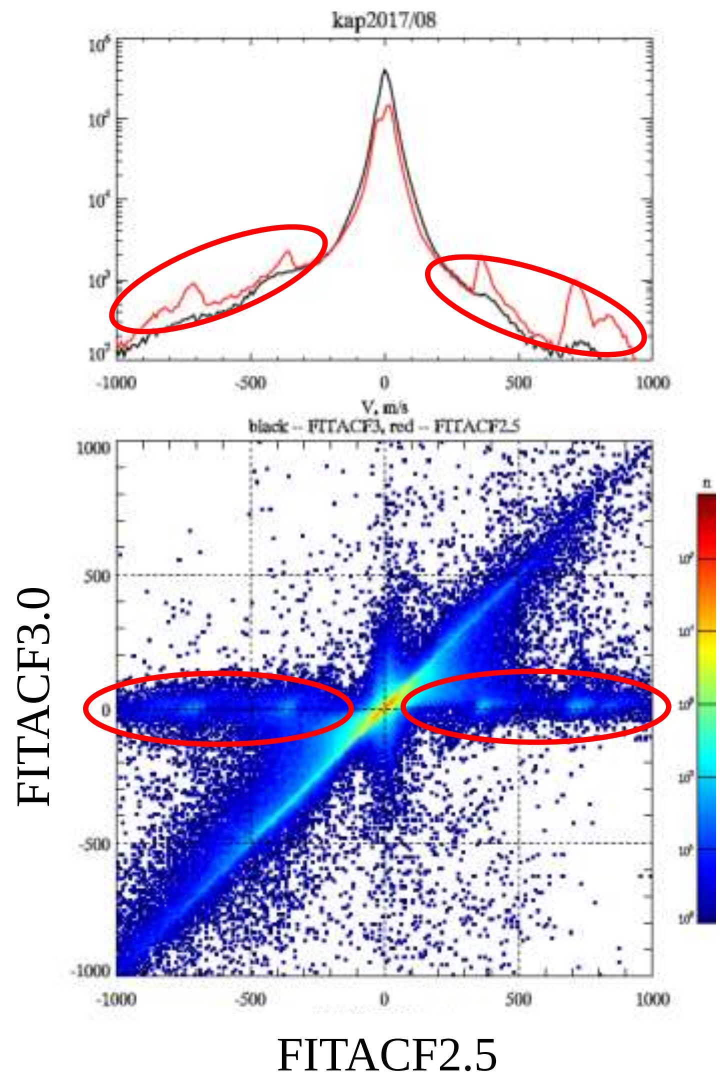


FITACF3.0

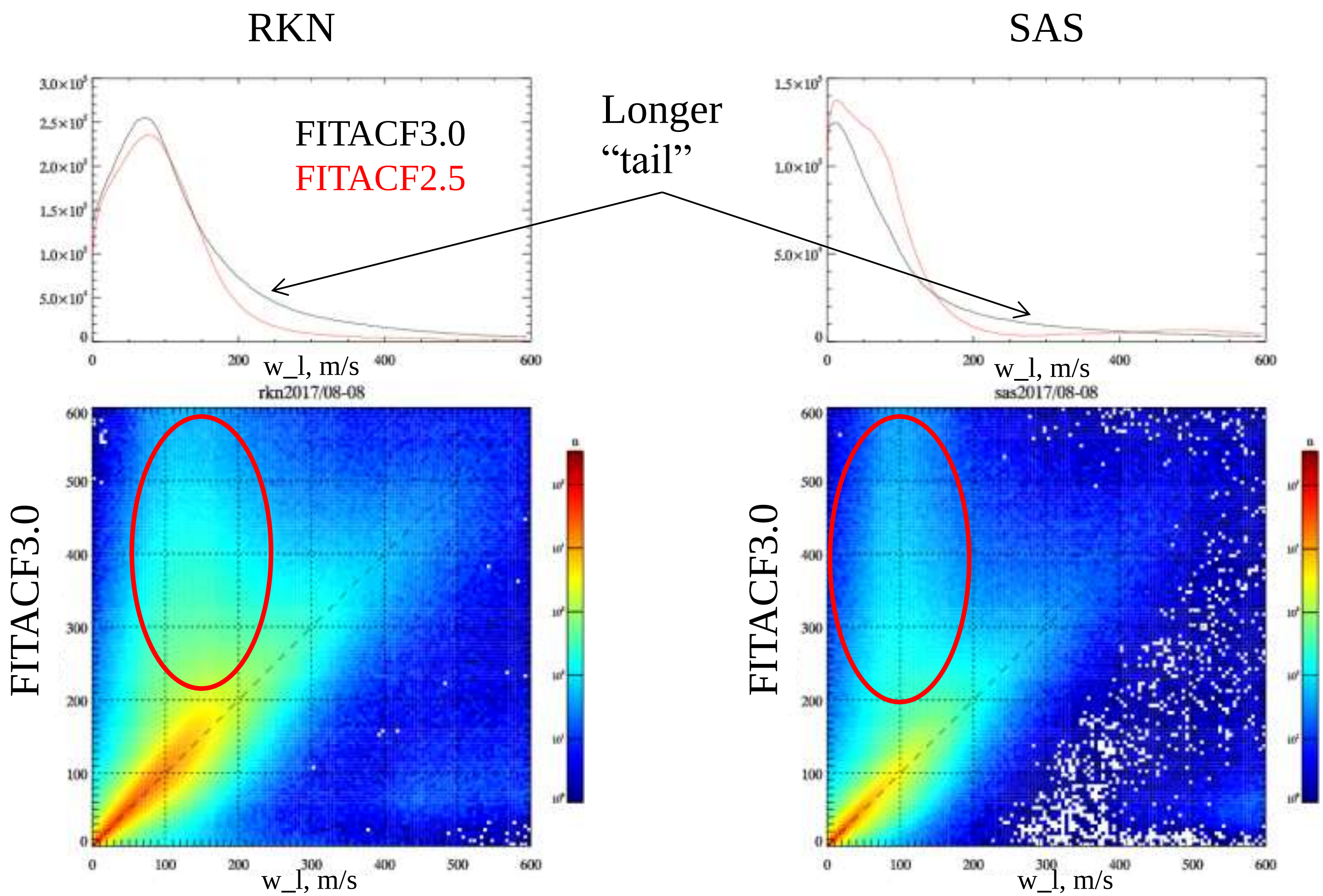


Velocity: "type 1" artifact (overdoing 2π unwrap)





Spectral width: more high width values



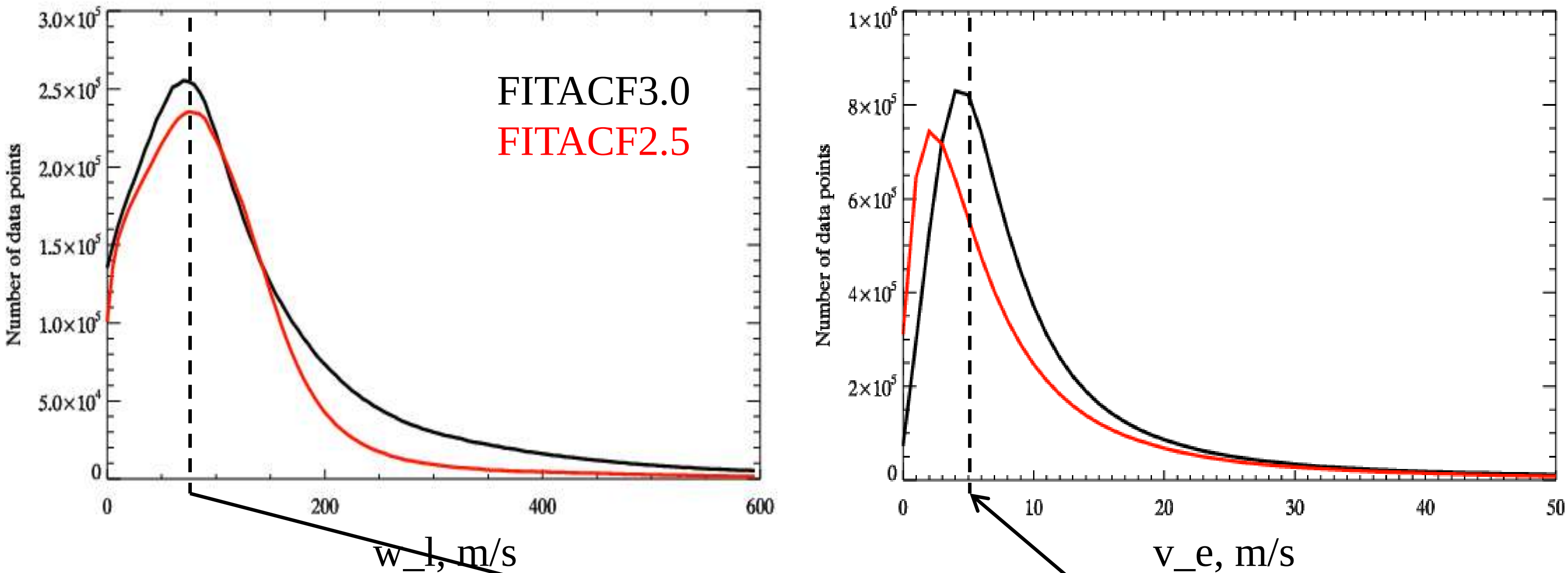
Velocity errors: expected behaviour

- Previous analysis (2013 tutorial) showed that the velocity error is proportional to the spectral width and decreases with increasing number of averages and effective number of pulses

$$\sigma_v \approx \frac{w}{\sqrt{N_{ave}}\sqrt{n_{pul}-1}}$$

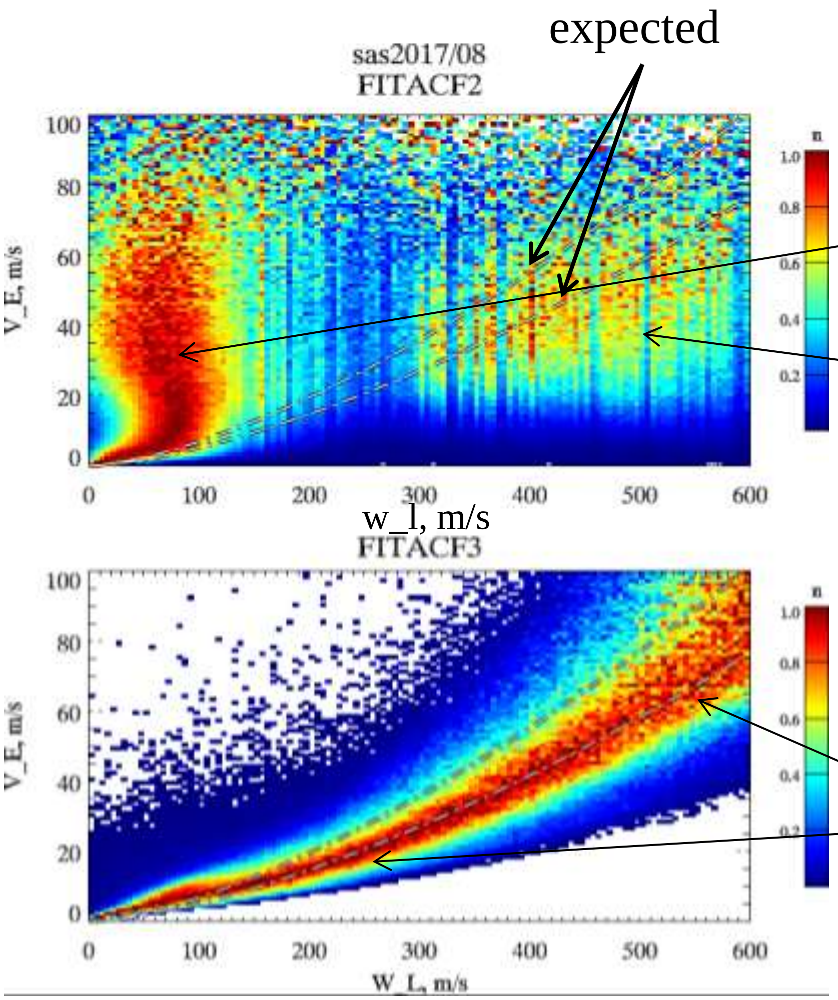
Velocity errors

2017/08, RKN



$$\sigma_v \approx \frac{w}{\sqrt{N_{ave}}\sqrt{n_{pul}-1}} = \frac{70\,m/s}{\sqrt{30}\sqrt{6}} = 5.2\,m/s$$

Normalised V_E vs W_L histograms



- FITACF2.5
  - saturation at W_L=80-100 m/s
  - unstructured population at W_L> 300 m/s
- FITACF3.0:
  - monotonous increase of V_E with W_L close to the expected rate

Summary

- There is a good general agreement between the two versions.
- FITACF3 improvements:
  - SNR:
    - more accurate noise floor determination
    - no overestimation of lag 0 power
  - Velocity:
    - decreased amount of fake “Type 1” echoes
  - Spectral width:
    - no high spectral width cut-off
  - Velocity errors:
    - realistic error values
    - expected proportionality to spectral width