Enhanced quality indicators for Mie winds

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- simulation of Fizeau transmission and Mie spectrum
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VAMP: Task WP 4a

- Investigate the utilization of MieCore algorithm outputs as quality indicators:
  - Mie line width (FWHM) against wind shear, turbulence and horizontal gradients
  - other MieCore outputs?
- Investigate usefulness of Rayleigh line-width
  - to be retrieved from known amplitude and A,B signal
  - assumption optical properties above well known
- look at differences with LIPAS implementation

Setup of the tool

- dedicated Fortran90 program
  - allows reusing L2BP code modules (reading of atm. DB, Mie Core algorithm, interpolations)
    - much faster (factor 25 per observation)
    - 5.5 days in stead of 140 days of runtime
  - Inputs:
    - Atm. DB scenario
    - range bin definition file
  - Output:
    - ascii file summarising all relevant simulation inputs and all MieCore outputs
    - additional plotting tool for plotting this data

Implementation of the tool (1)

- pre-calculates the transmission curves and stores them in a look-up-table
- takes a rangebin definition and an Atm. DB scenario
- propagates the laser light through the atmosphere
- calculates shear in windspeed and optical properties within each rangebin
- calculates spectrum with sub-rangebin precision (layers of 50 [m])
- rounds the signal to fit in the 2 byte integer range
- calculates each measurement and accumulates to observations (no classification)

Implementation of the tool (2)

- adds poisson noise
- calculates SNR
- calls the Mie Core algorithm from the L2BP software
- writes all relevant inputs and outputs to an ascii file

- the plotting tool then reads this ascii file
  - allows for selection of 2 parameters to be plot
  - can apply selections on the dataset (i.e. SNR>10 etc)

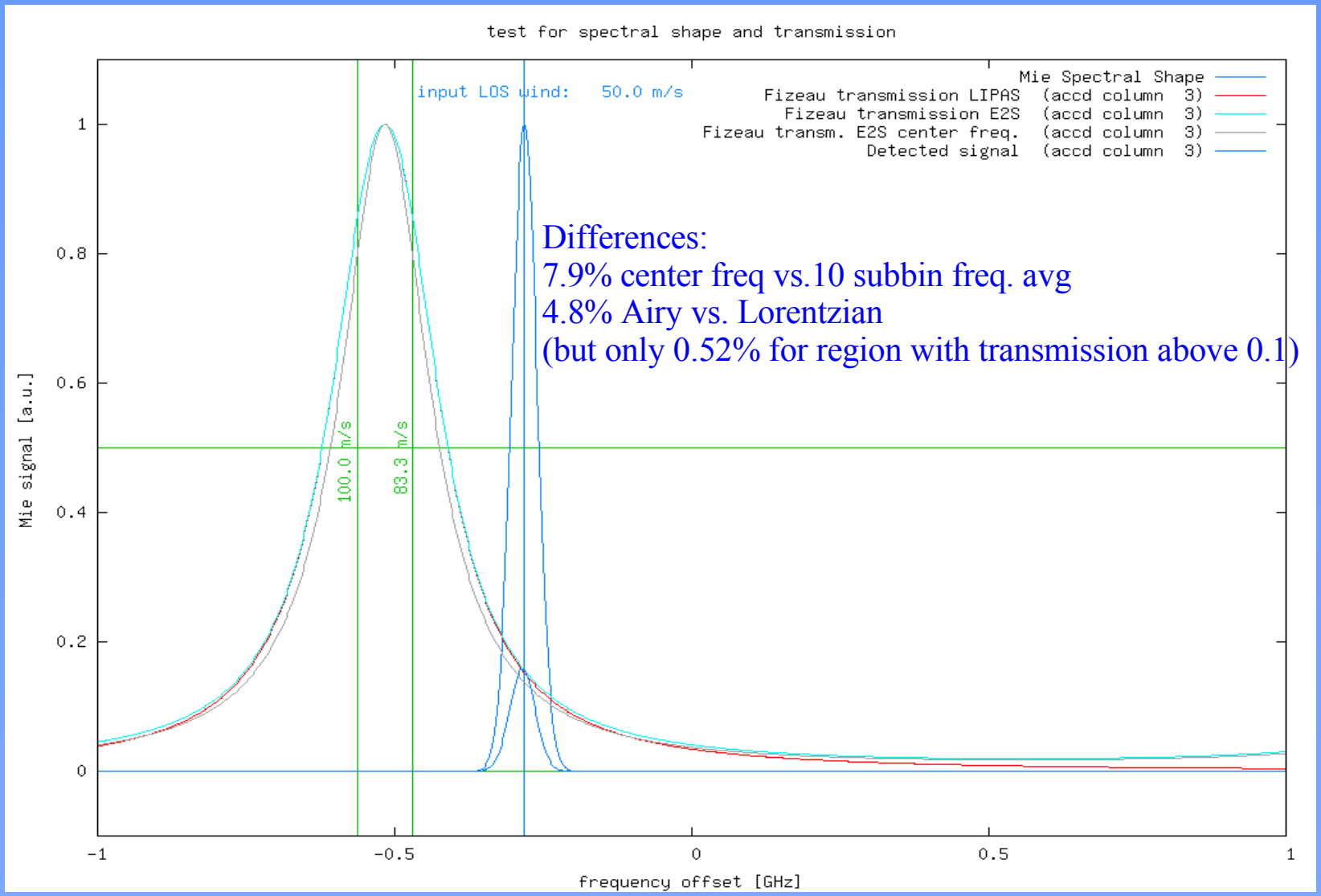
Settings:

Num frequency steps	1001
sub-accd bin steps	10
frequency range	-1 to +1 [GHz]
Mie and Laser line width	50 [Mhz]
Fizeau FSR	2.15 [Ghz]
Fizeau USR	1.502 [Ghz]
Fizeau FWHM	184 [Mhz]
inc. angle	37.5 [deg]
Background level	5 [counts]
peak height multiplication	3555 [times]
ACCD channel width	93.875 [Mhz] =USR/16

MieCore algorithm settings:

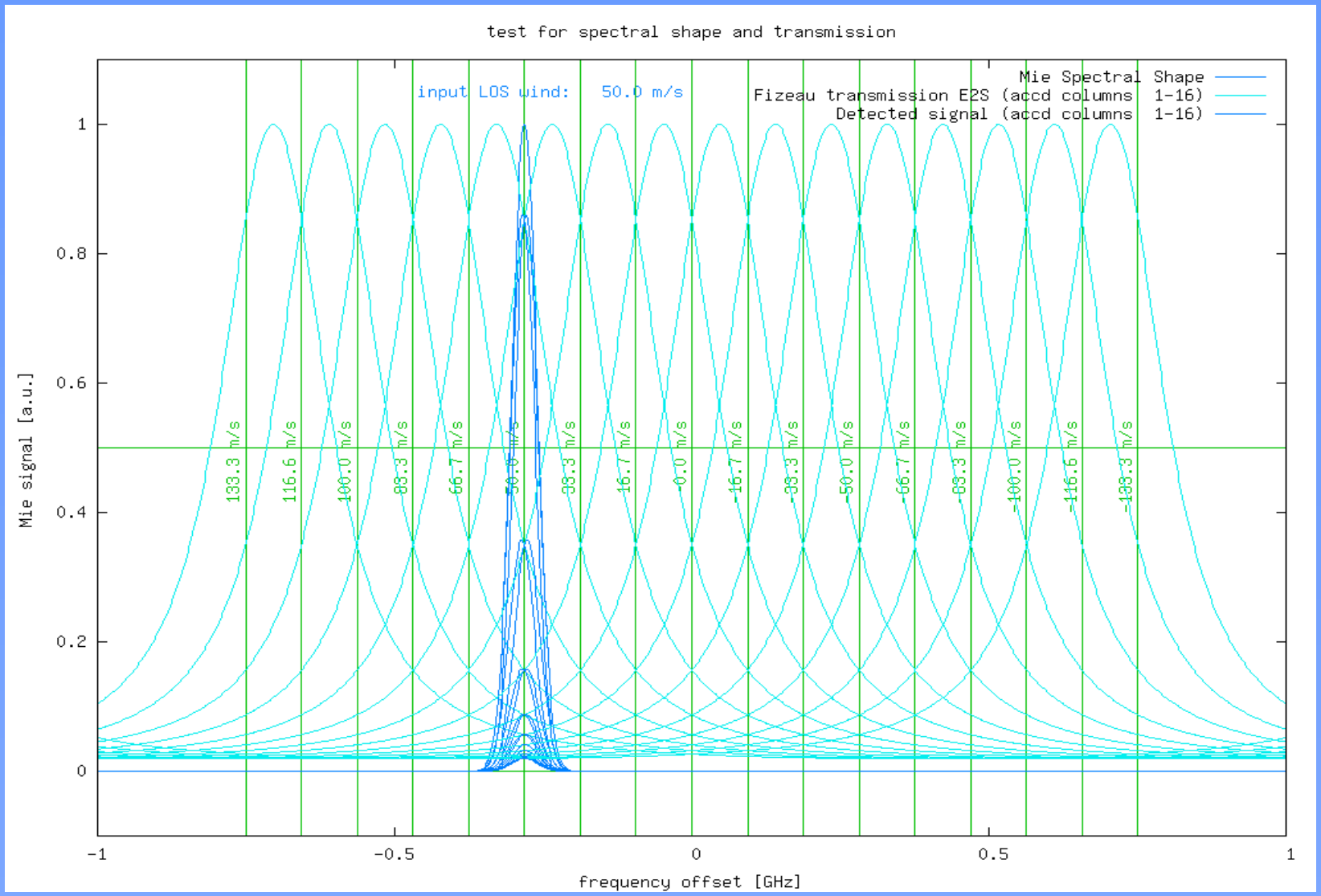
Start FWHM	2.0	
Res.Err. Threshold	0.001	
Max.Iterations Lorentz Fit	30	
FWHM Upper Threshold	2.5	used for val flag
FWHM Lower Threshold	1.5	used for val flag
Peak height Upper Threshold	1.6	used for val flag
Peak height Lower Threshold	0.9	used for val flag
Peak Location Threshold	1.0	used for val flag
Non Lin. Opt. threshold	0.01	
Max. It. Non Lin. Threshold	20	
NumSpecSubSamp	5	
tripod obscuration correction	1.0	

•••• Mie peak and accd column 3 transm.

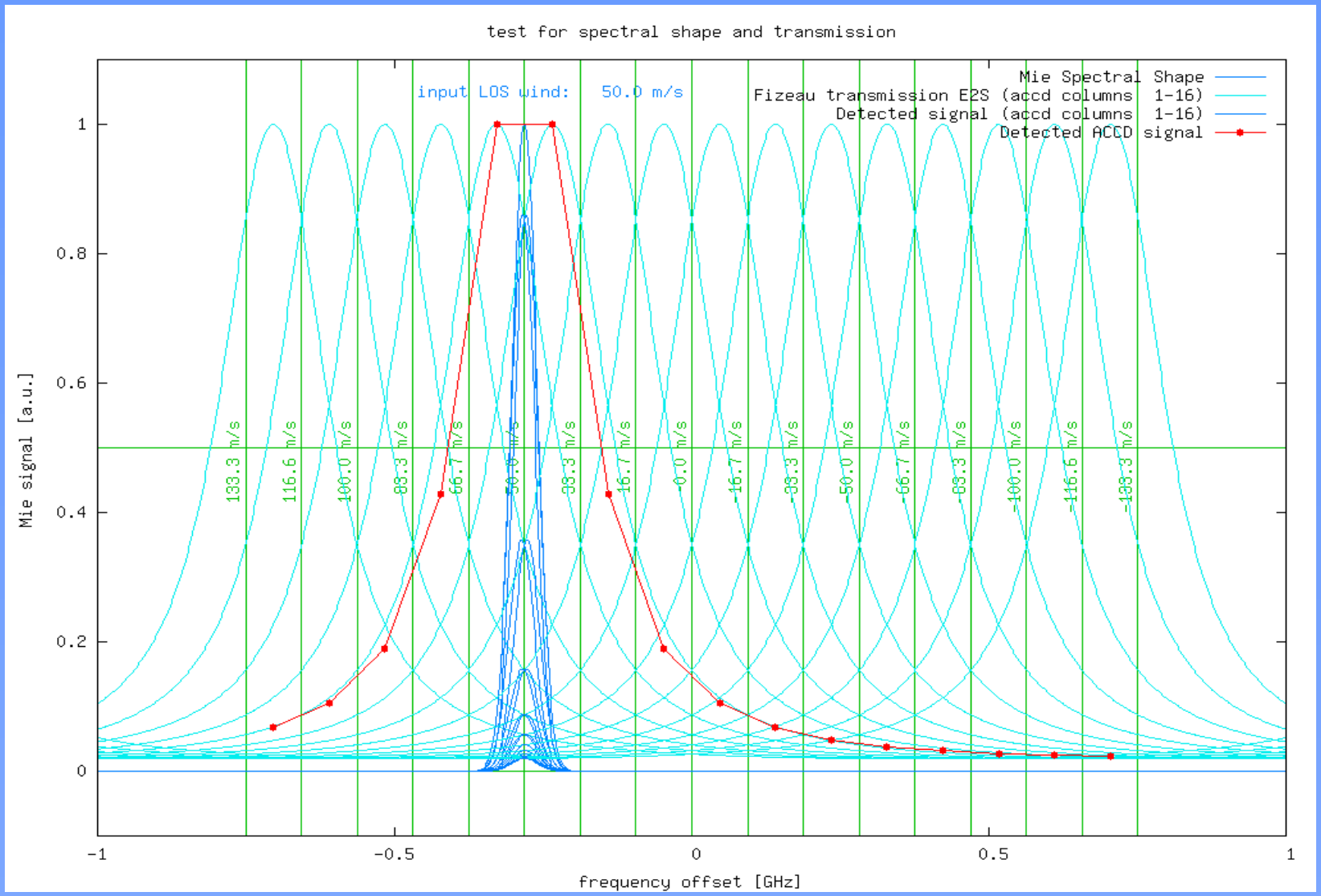


Differences:
7.9% center freq vs.10 subbin freq. avg
4.8% Airy vs. Lorentzian
(but only 0.52% for region with transmission above 0.1)

•••• Mie peak and transm. all accd columns



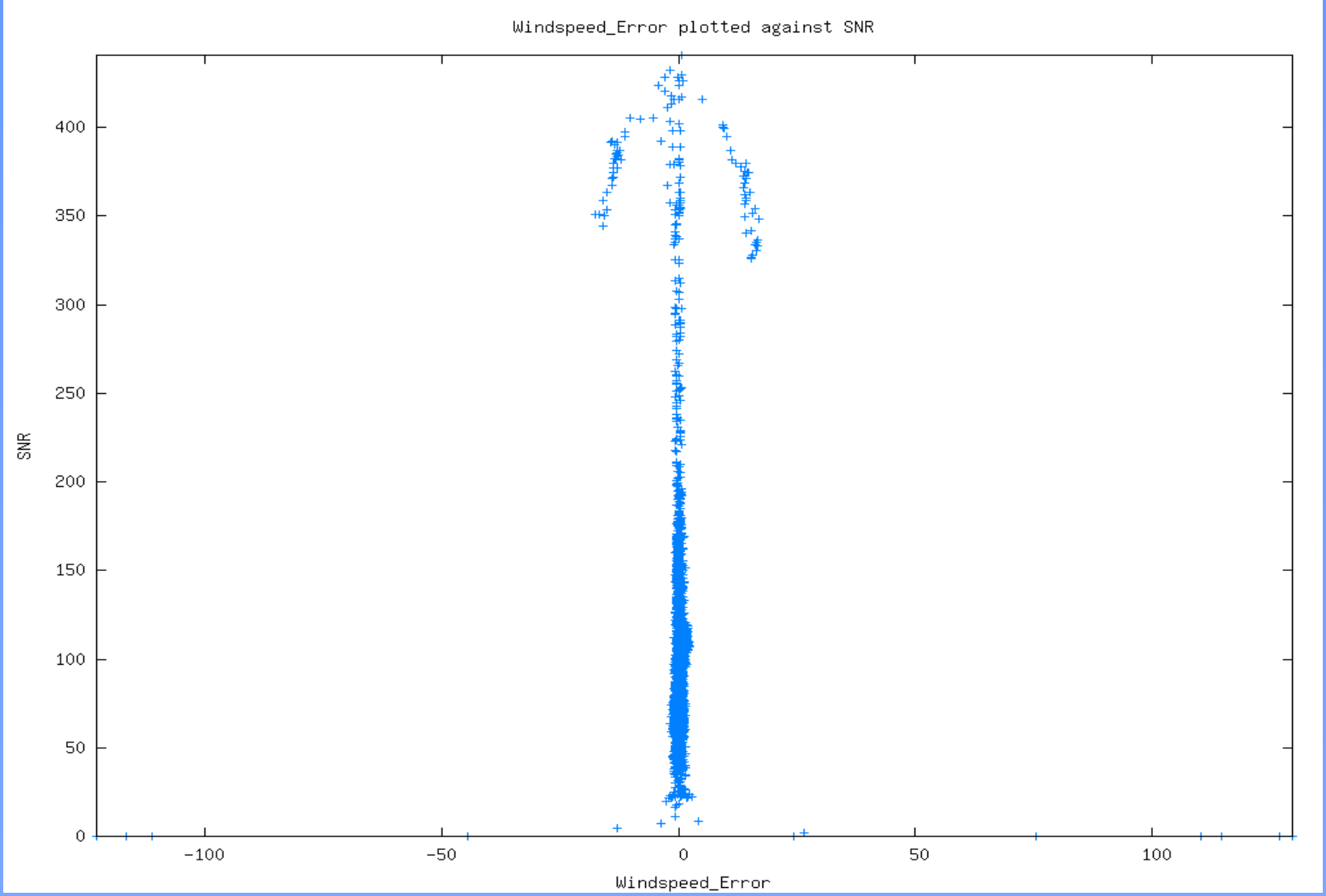
•••• Expected signal for each accd column



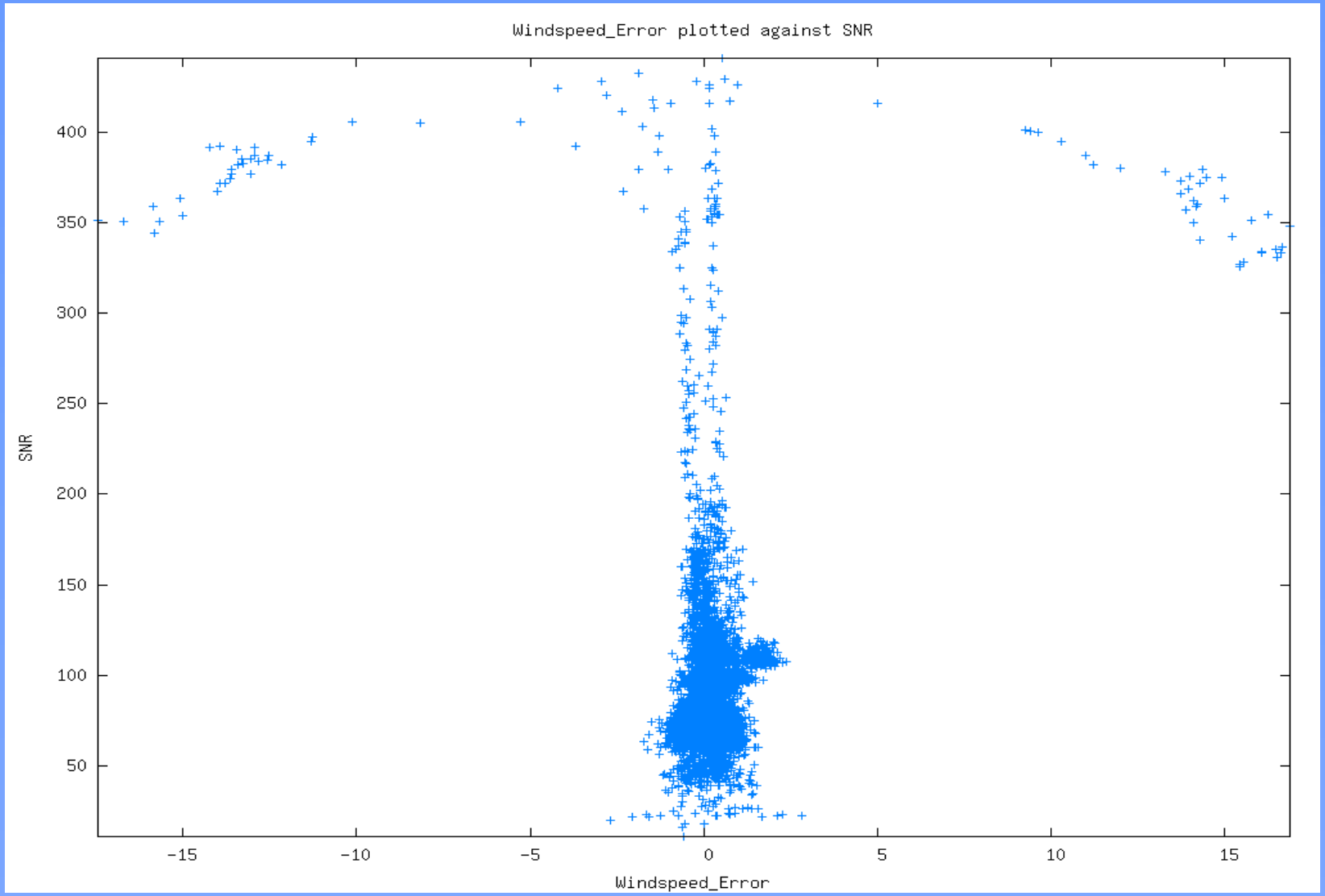
Simulations

- first try:
  - use rangebin definition WVM1
  - use LITE scenario A (864 km of data at 3.6 km steps, so 240 profiles)
  - look at meas. level data

•••• LITE scene A, WVM 1, first try



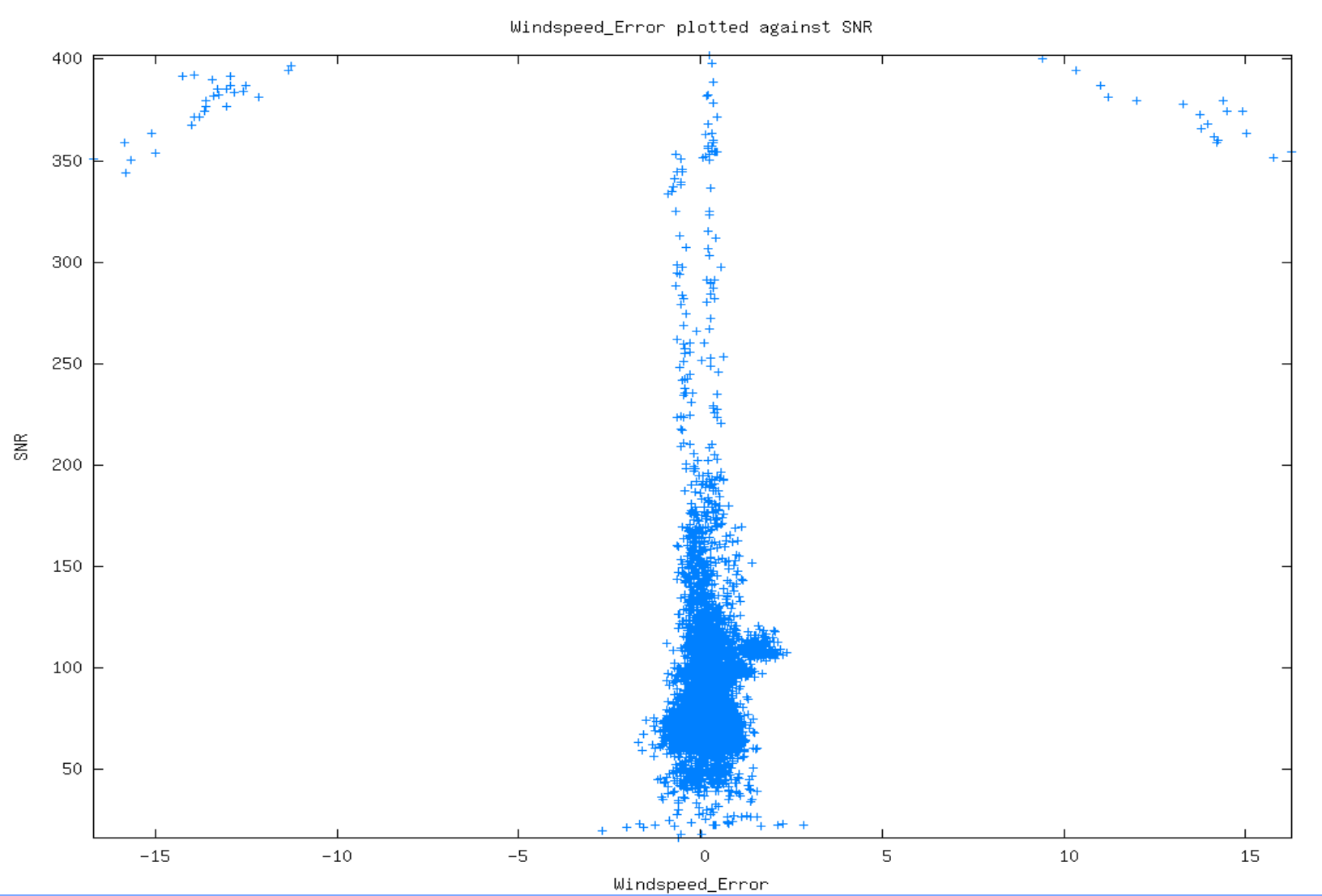
•••• select cases with SNR>10



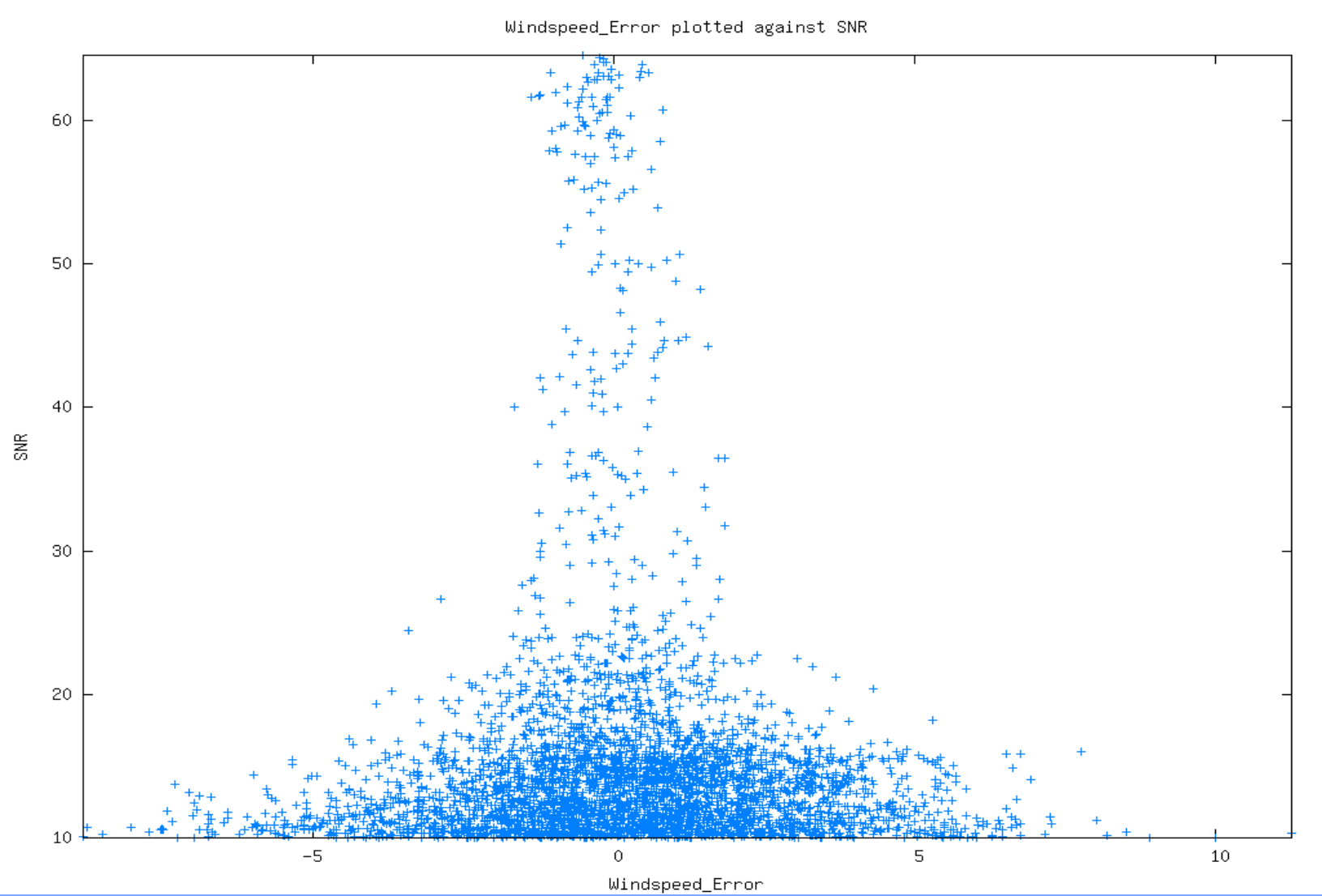
MieCore validity flag

- The MieCore algorithm implements a validity flag based on:
  - threshold on peak height: range 0.9 ... 1.6
  - peak FWHM: range 1.5 ... 2.5
  - peak location vs locations signal maximum: max. diff. 1.0

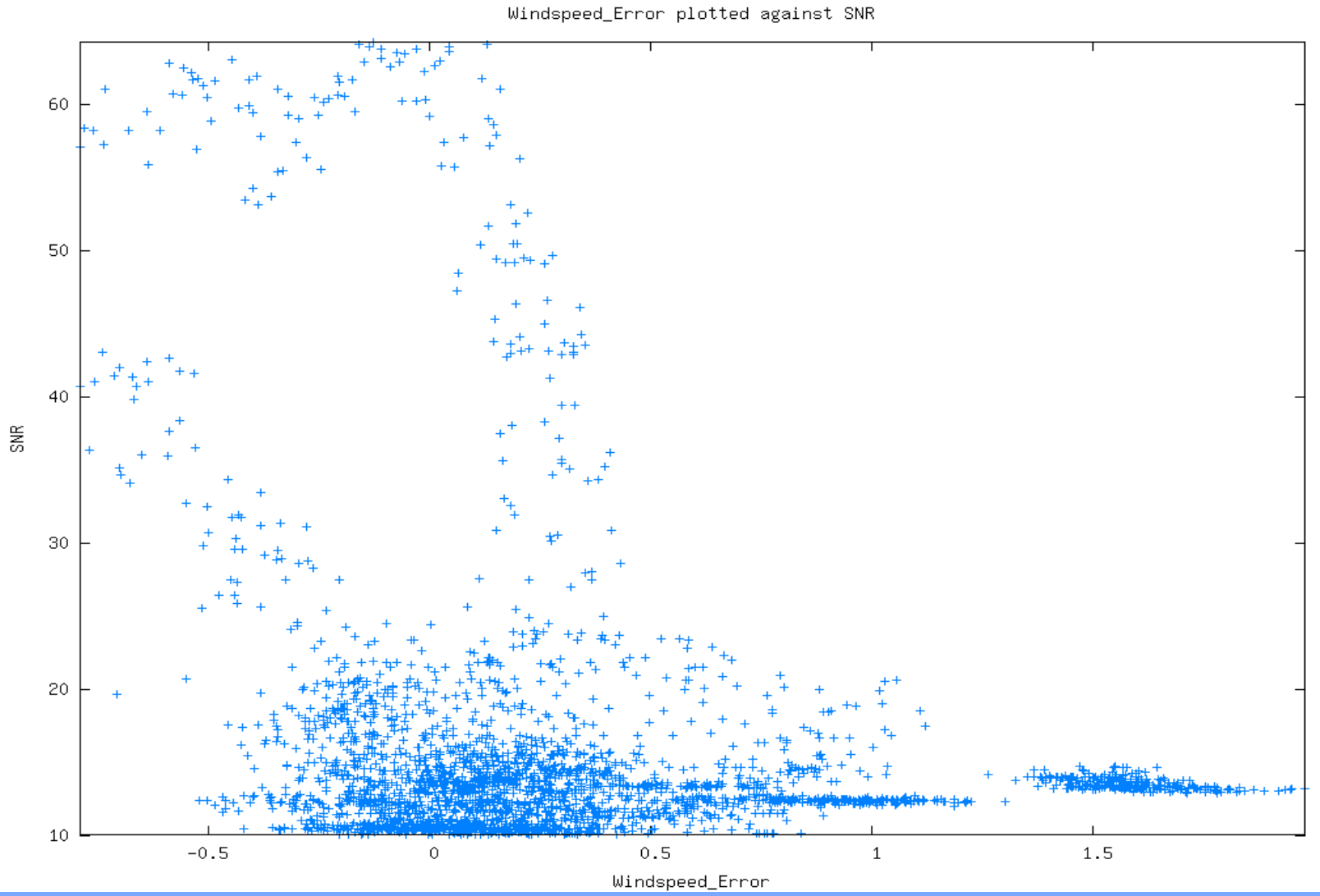
•••• SNR>10 and Valid MieCore result



•••• Scaling corrected to prevent overflows



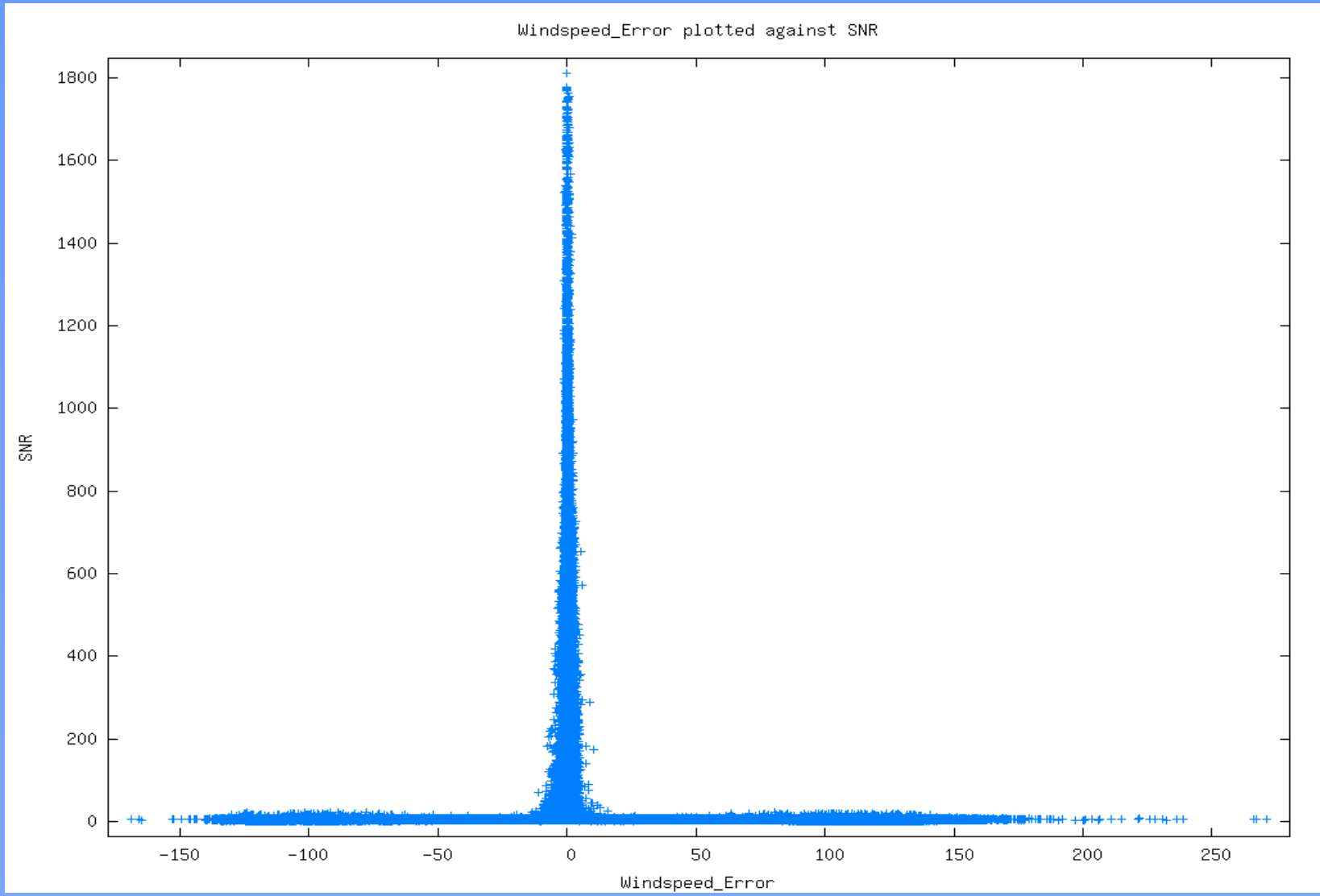
•••• Noise switched off



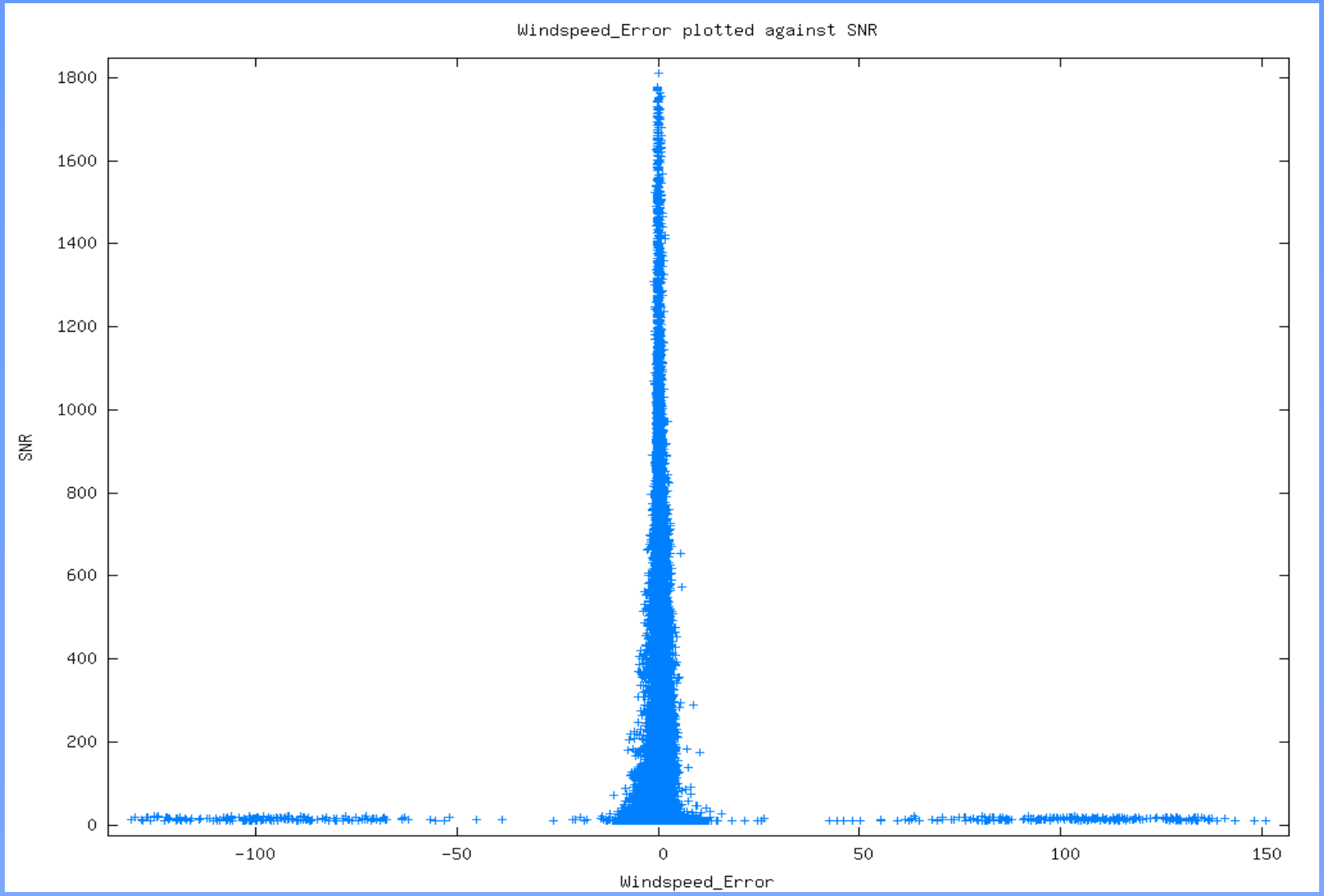
SNR, NumIt, ResErr, FWHM

- accumulate to observation level
- 5 half orbits of CALIPSO data high resolution
  - take one BRC for each input CALIPSO profile (3.3 km)
  - add small wind structures to the profiles using the Error Multiplier method proposed in the VAMP project
  - this yielded 670.458 valid points
- SNR > 10
- this gives 481.217 good results, 189.241 rejected points
- ValFlag criterium rejects another 12.011 points, so 469.206 points remain

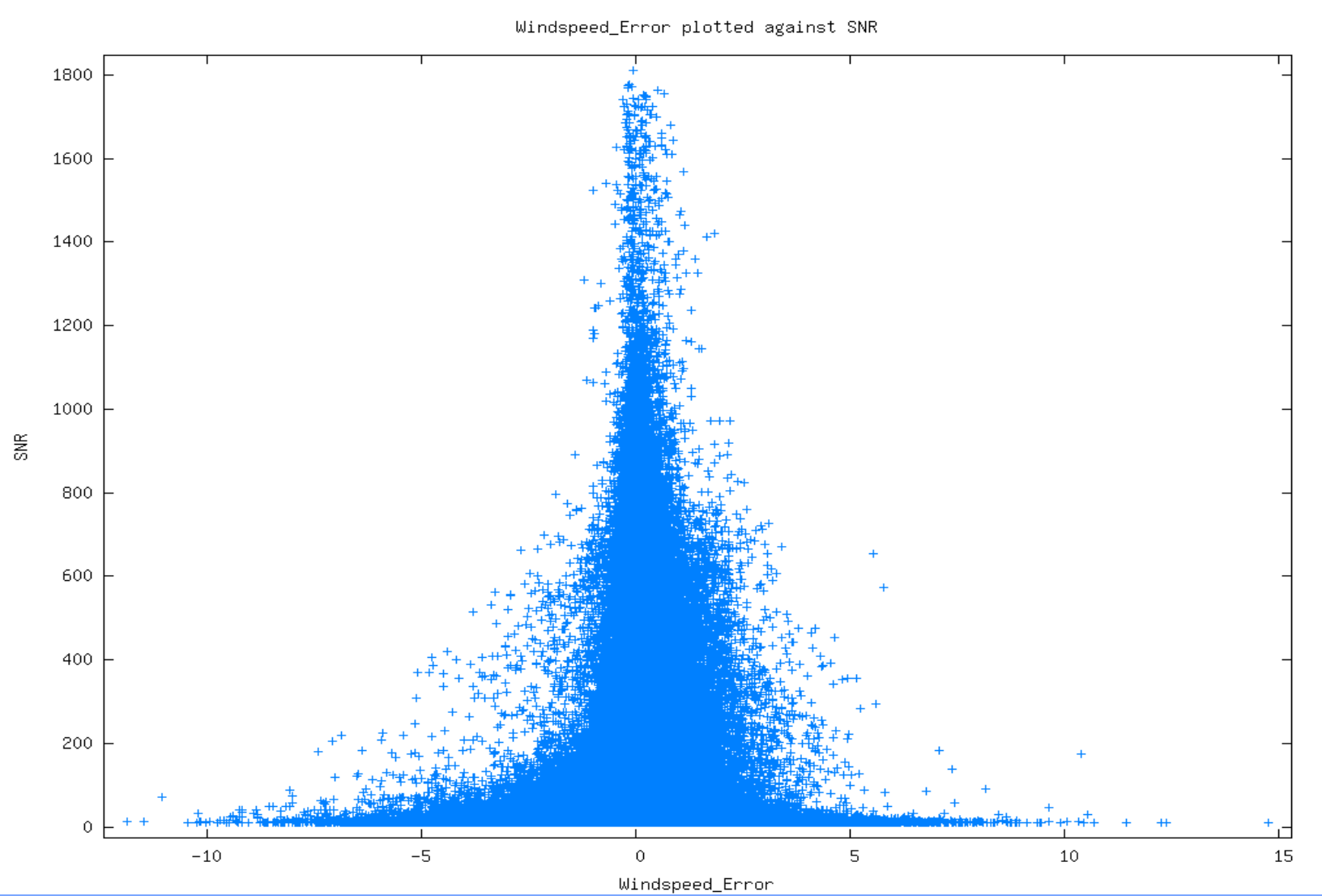
•••• CALIPSO results: all data



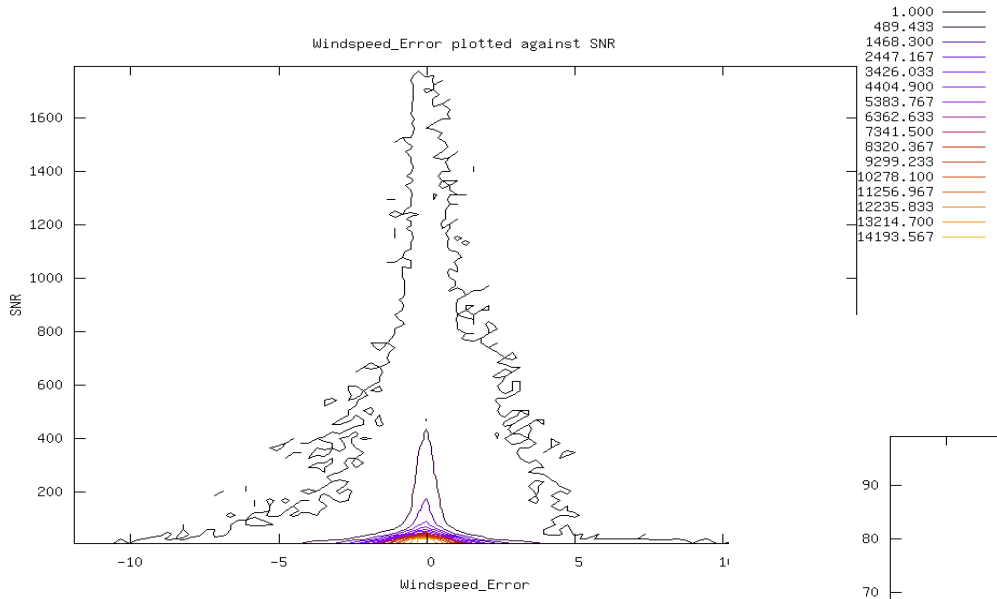
SNR > 10



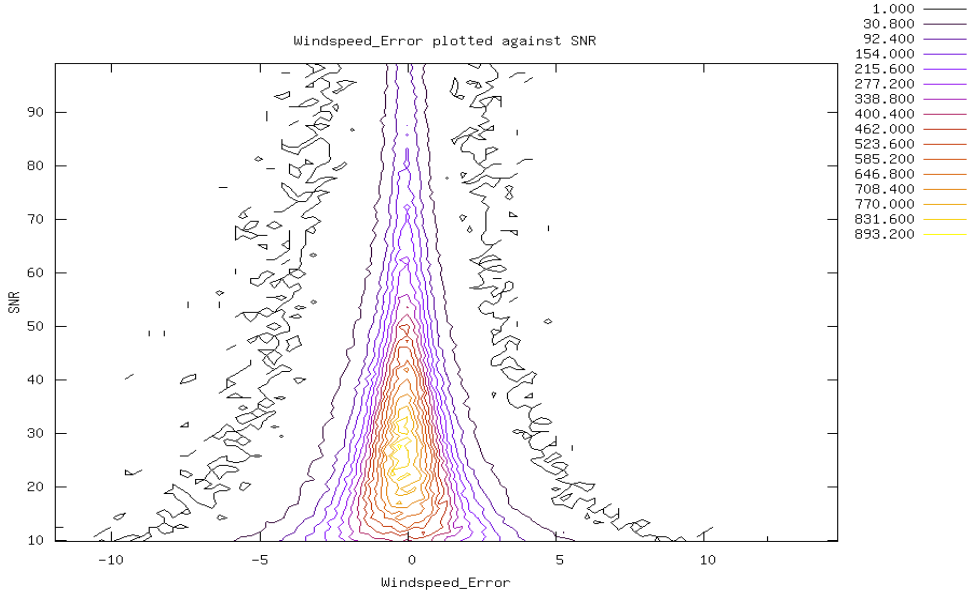
•••• SNR > 10, ValFlag=1



••••SNR > 10, ValFlag=1



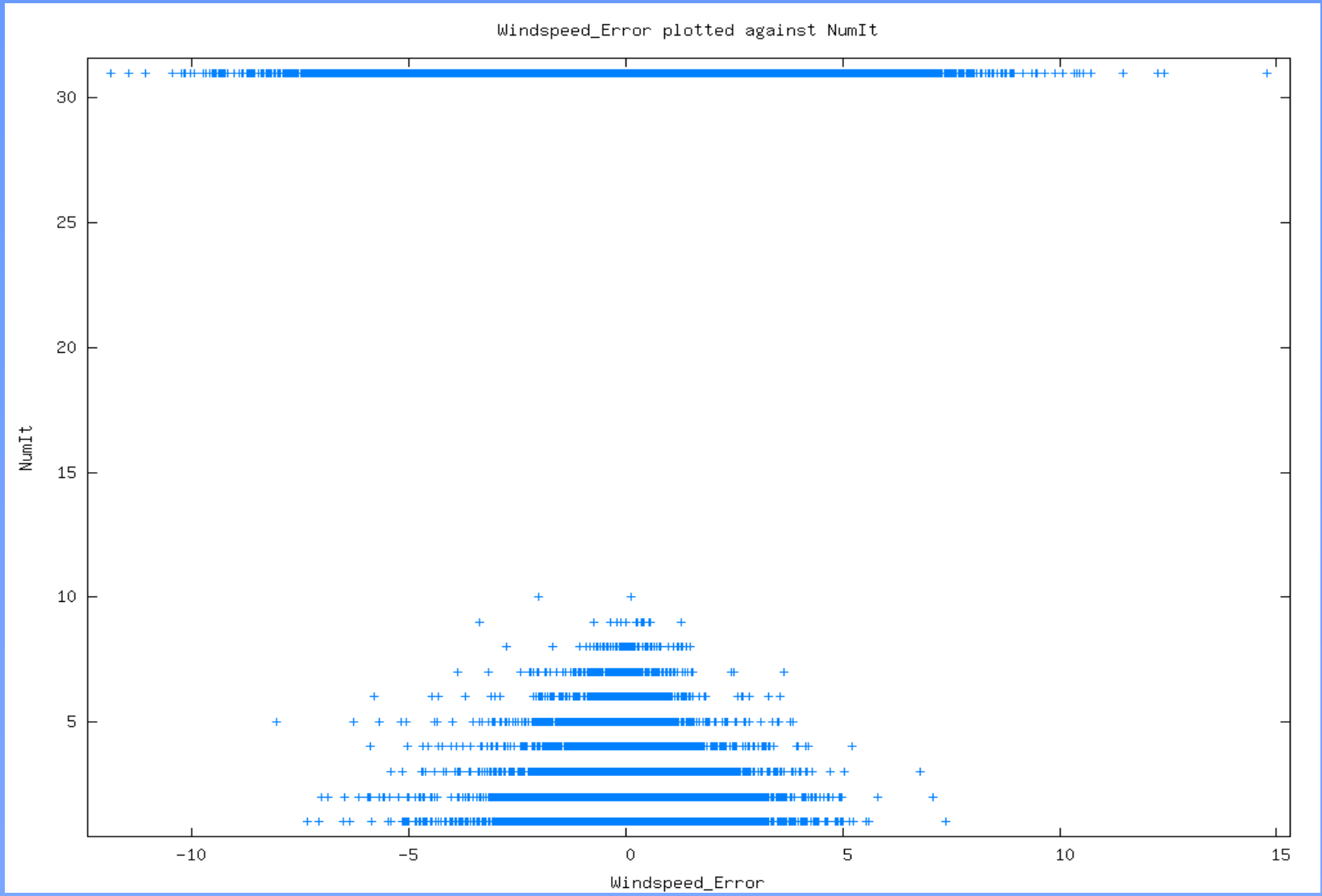
<== all selected points



80% of selected points has SNR<100 ==>

••••

Number of iterations



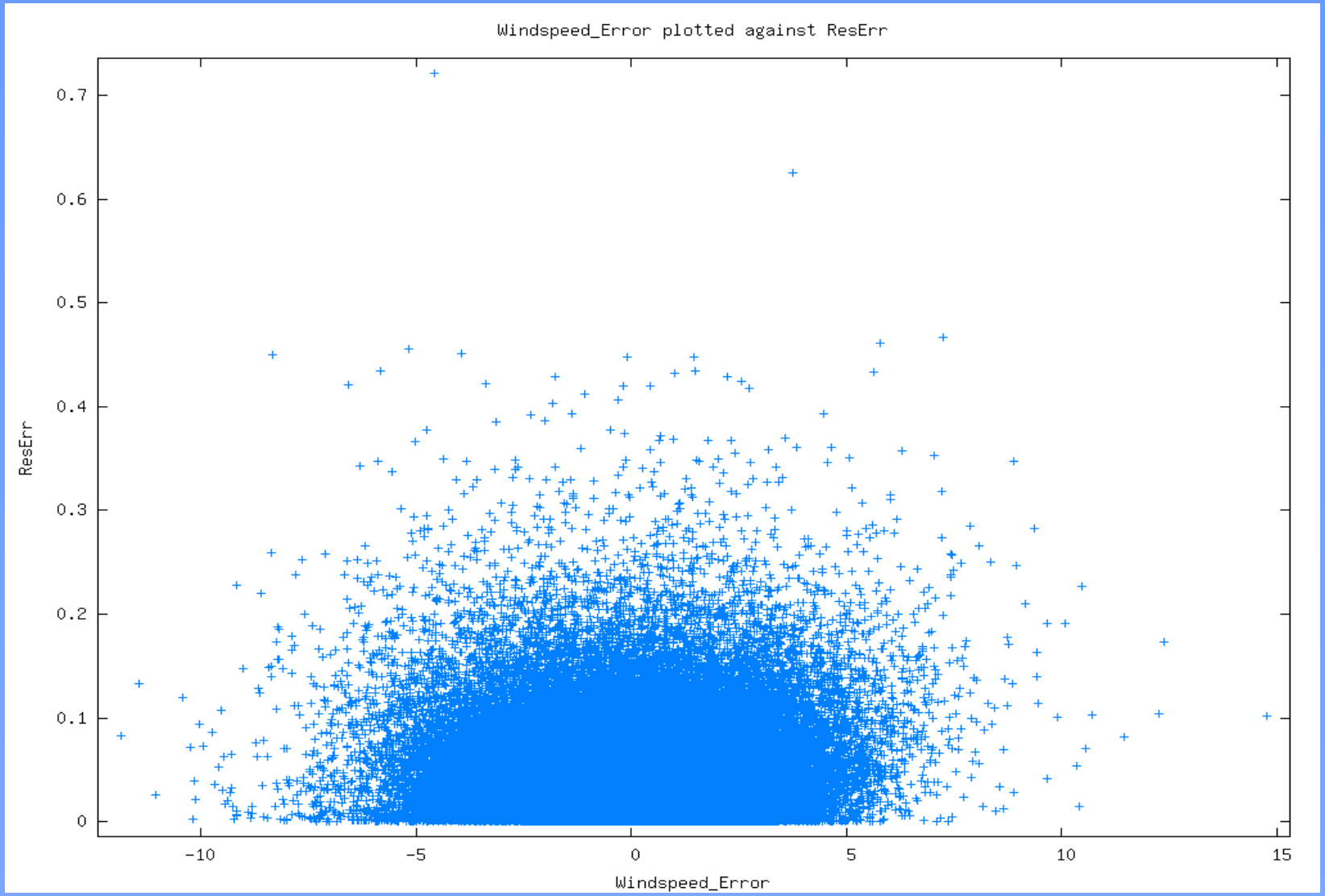
Iterations

- SNR>10
  - 189.241 rejected points, 481.217 points remain
- ValFlag criterium
  - 12.011 points rejected, so 469.206 points remain
- NumIt<25 check
  - MieCore stops iterating when ResError < 0.001
  - 352.441 points rejected, only 116.765 remain
  - so 75% of all good data reach NumIt=31
  - out of these 116.765 a fraction of 22% has SNR<100 and 78% has SNR>100
  - from points with NumIt=31, 99.4% have SNR<100

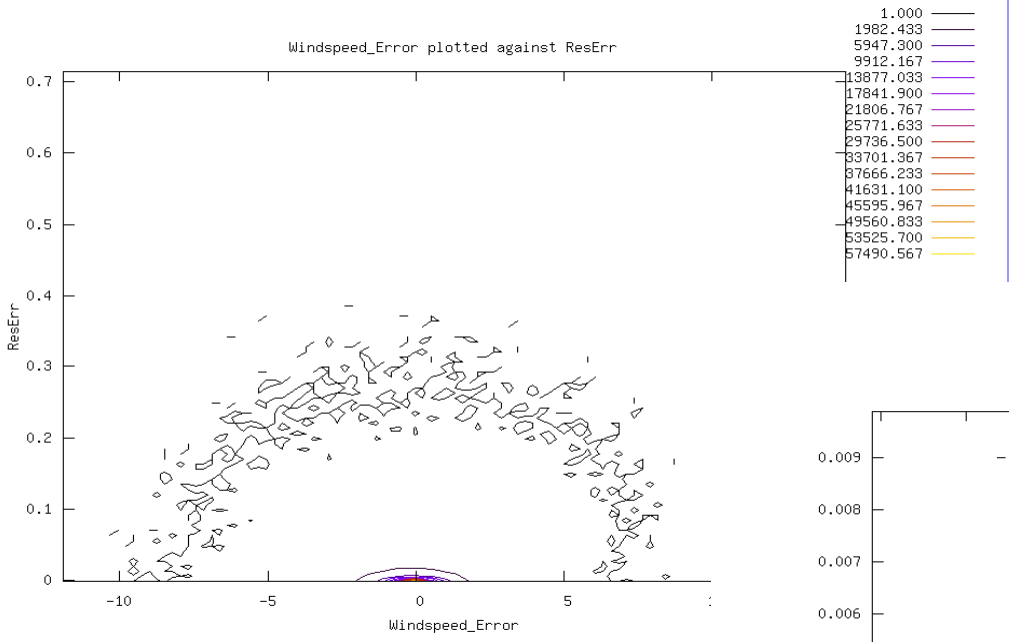
Iterations

- For a small LITE testcase, setting MaxItLorFit to 10, only changed 11 out of 2881 points (0.004%)
- The actual L2BP processor has exactly the same behavior:
  - noisy simulations give for 99% of all cases 31 iterations
  - no-noise simulations give for 10% of cases 31 iterations
  - tested on one half orbit of CALIPSO data, without applying the Error Multiplier method

•••• Residual Error

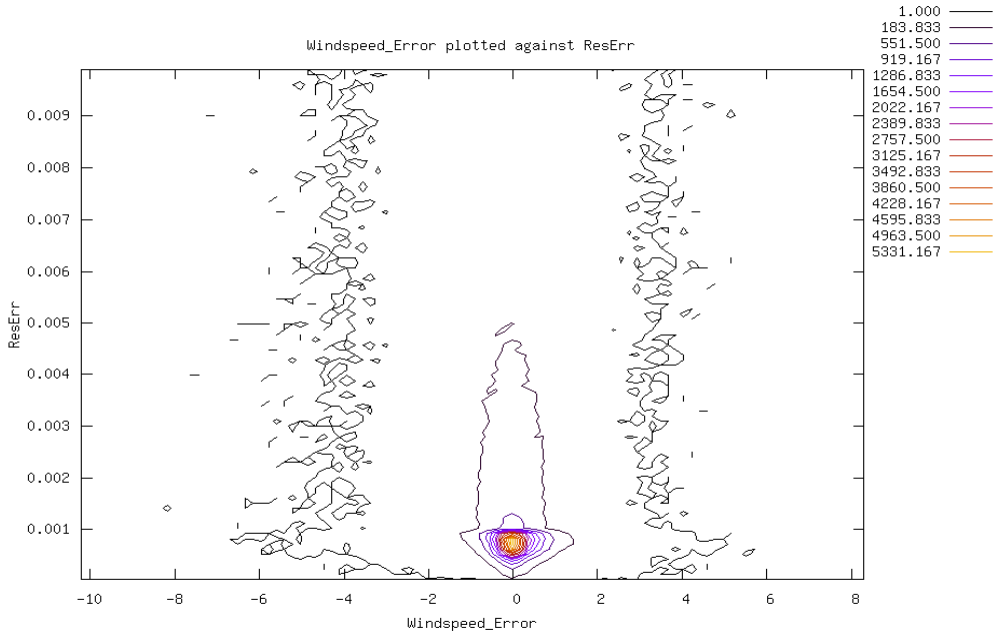


Residual Error



<== all selected points

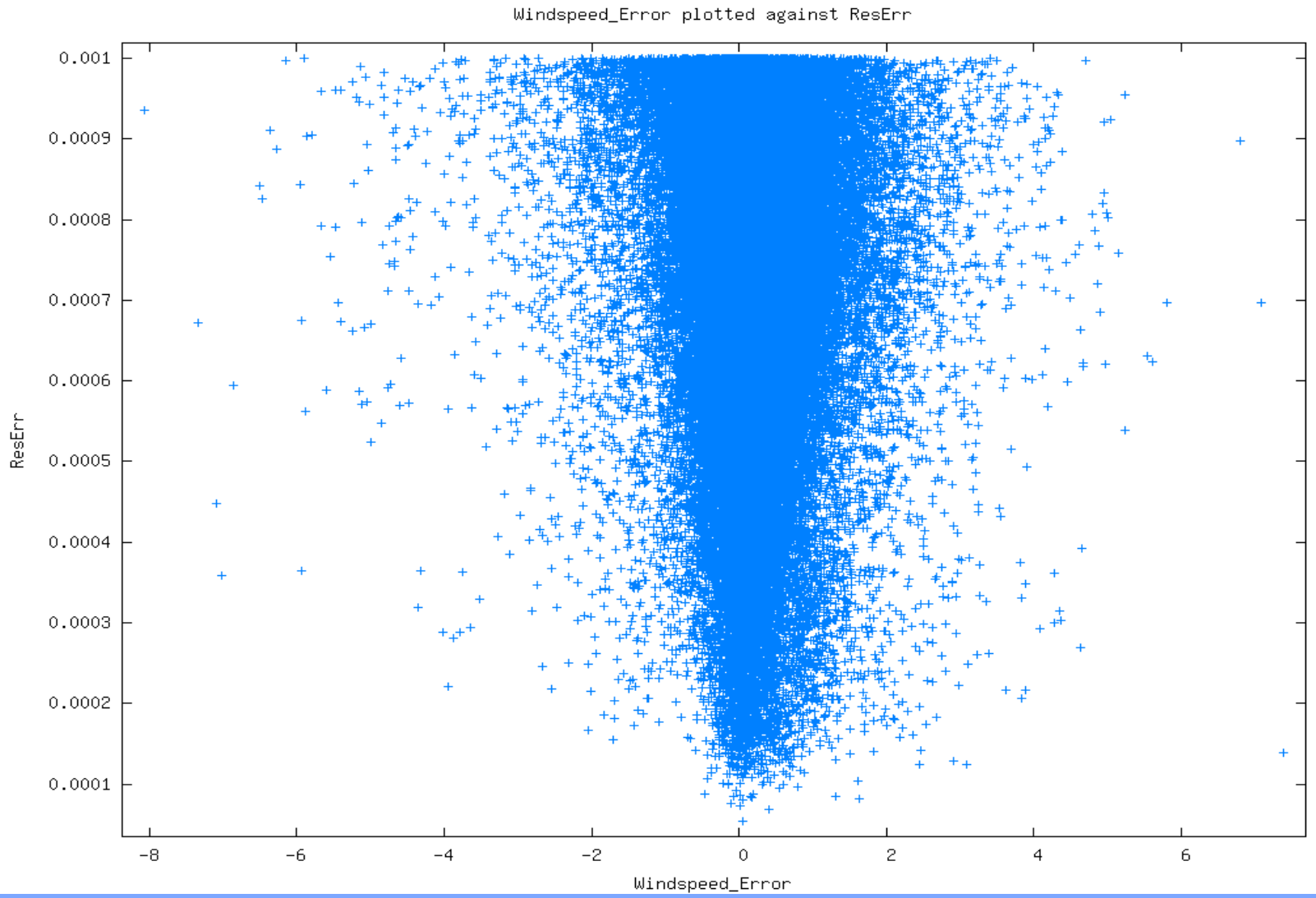
2% of data has ResErr>0.1



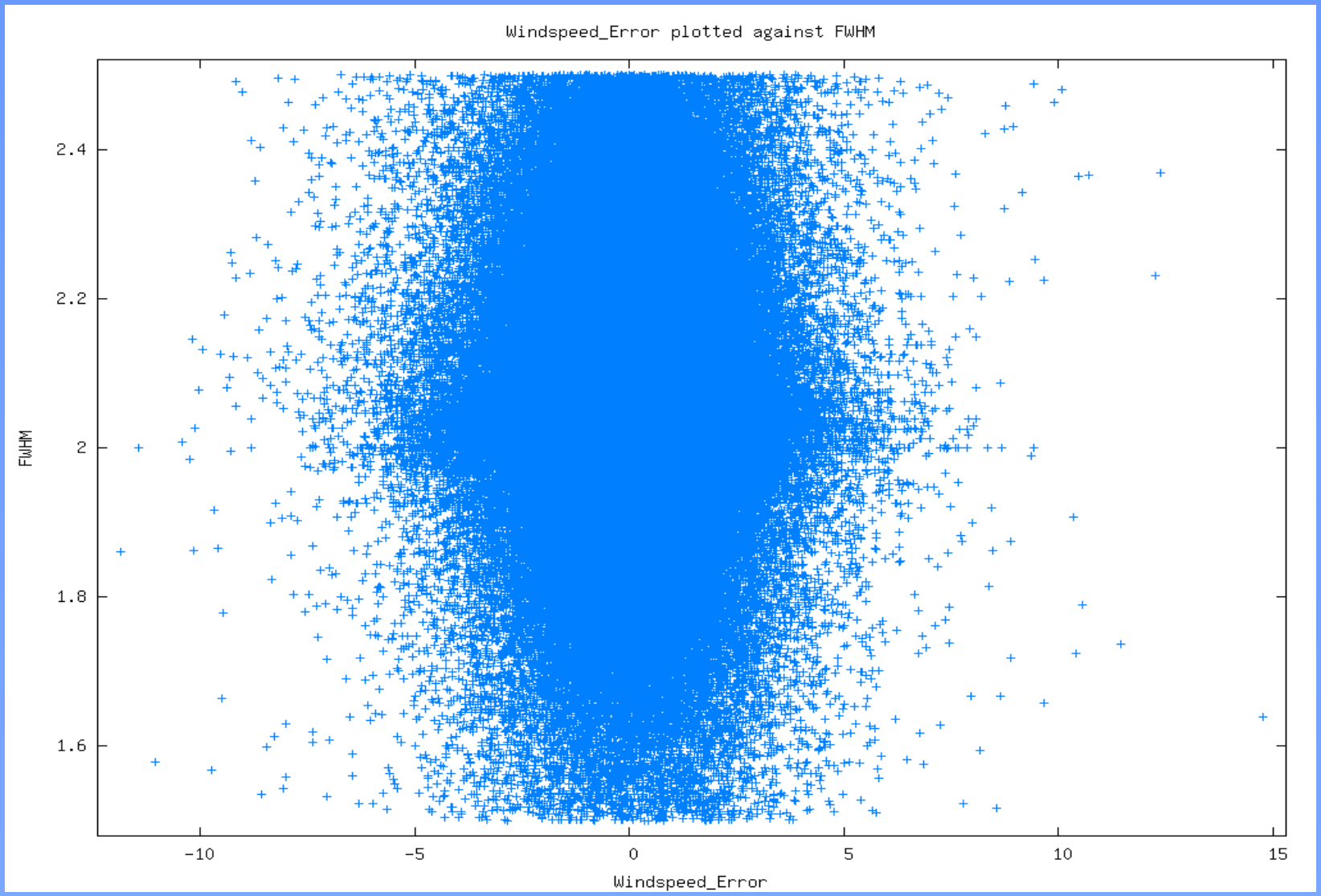
33% has ResErr>0.01

75% has ResErr>0.001 ==>

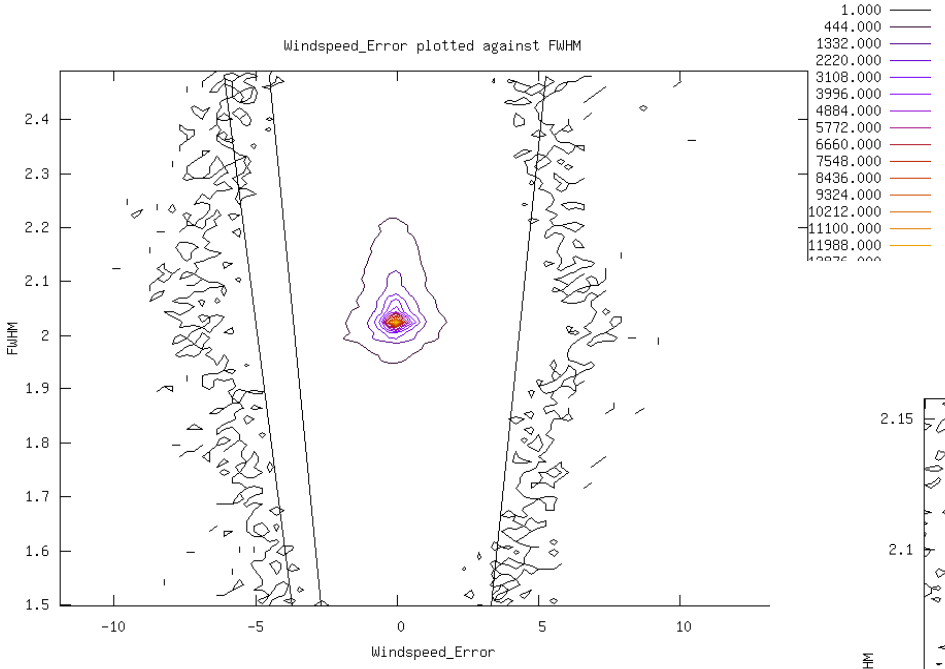
•••• Residual Error for NumIt<25

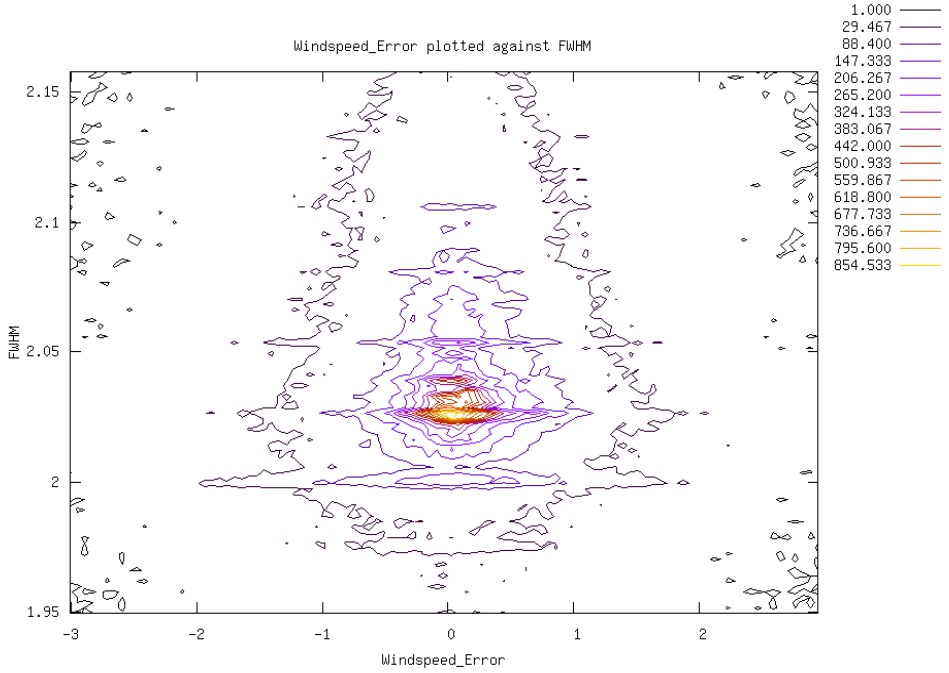


FWHM

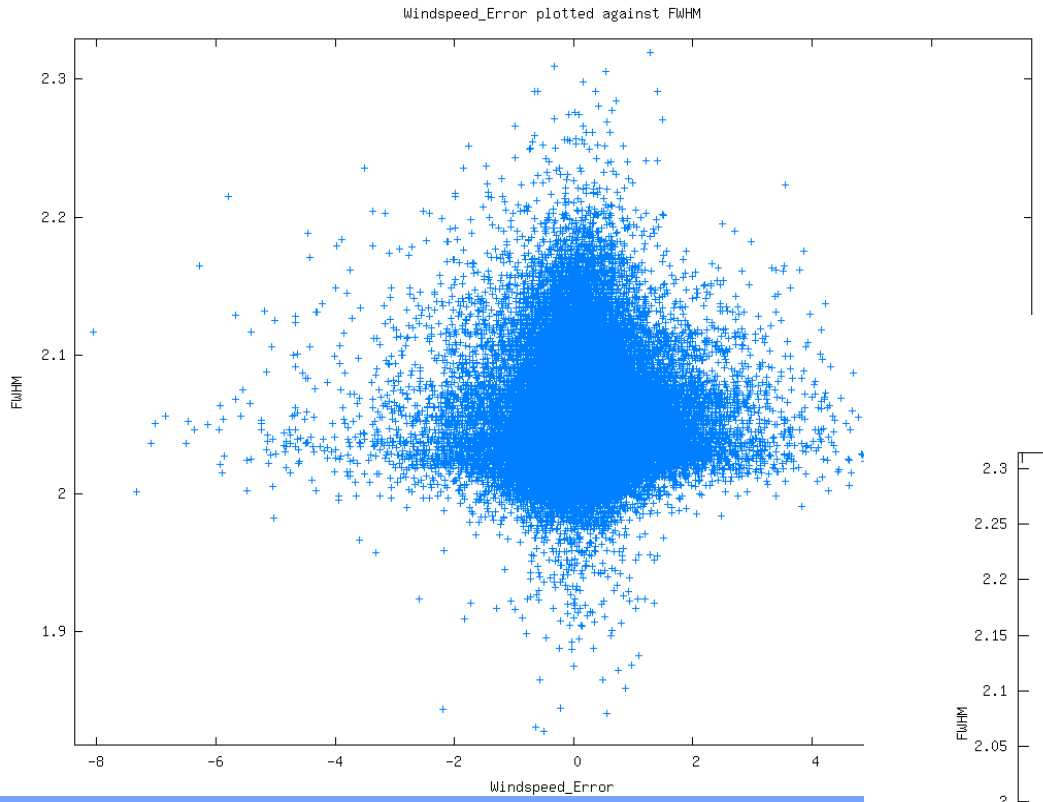


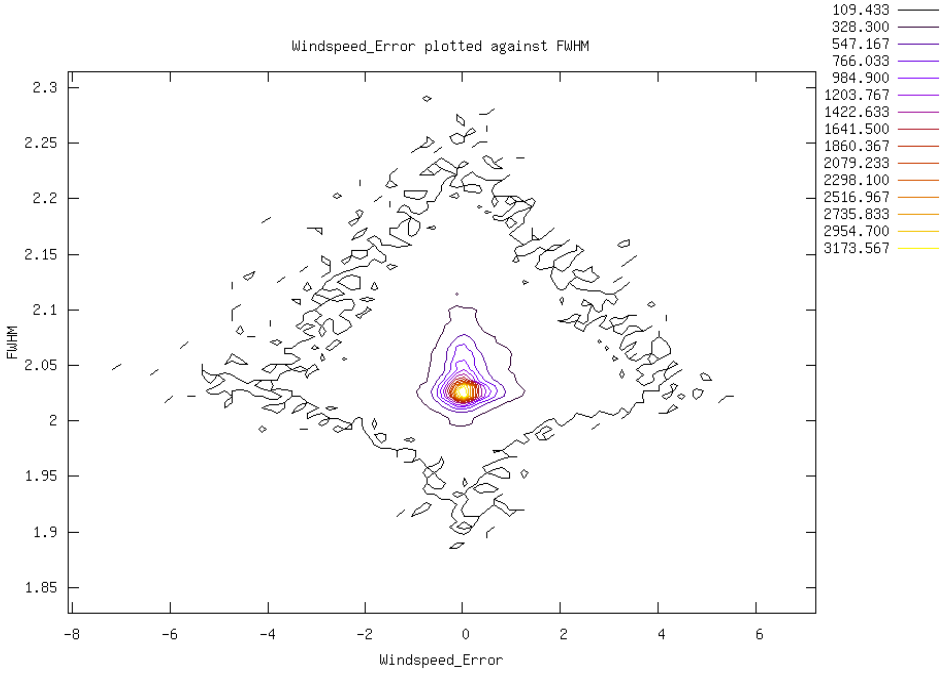
FWHM


Windspeed_Error plotted against FWHM
1.000
444.000
1332.000
2220.000
3108.000
3996.000
4884.000
5772.000
6660.000
7548.000
8436.000
9324.000
10212.000
11100.000
11988.000
FWHM
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
-10
-5
0
5
10
Windspeed_Error


Windspeed_Error plotted against FWHM
1.000
29.467
88.400
147.333
206.267
265.200
324.133
383.067
442.000
500.933
559.867
618.800
677.733
736.667
795.600
854.533
FWHM
2.15
2.1
2.05
2
1.95
-3
-2
-1
0
1
2
Windspeed_Error

FWHM NumIt<25

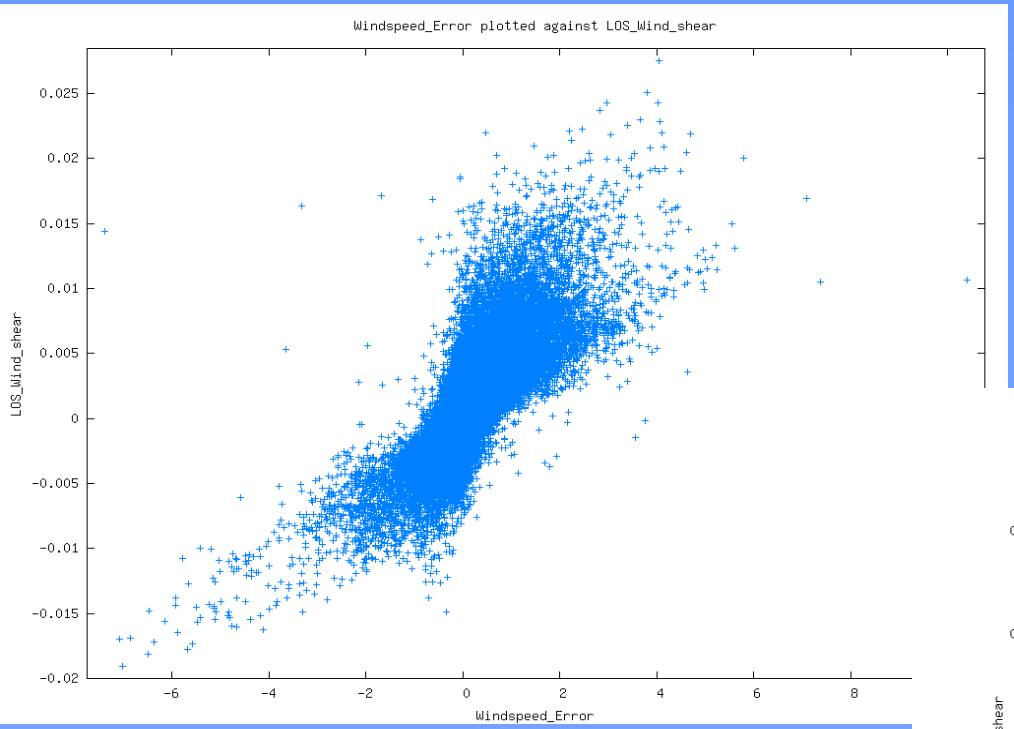


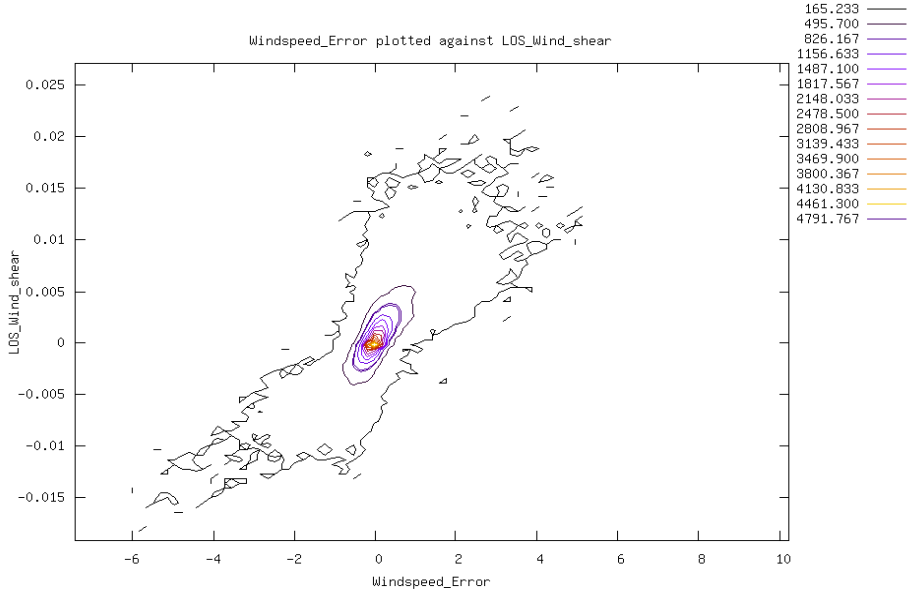


Shear

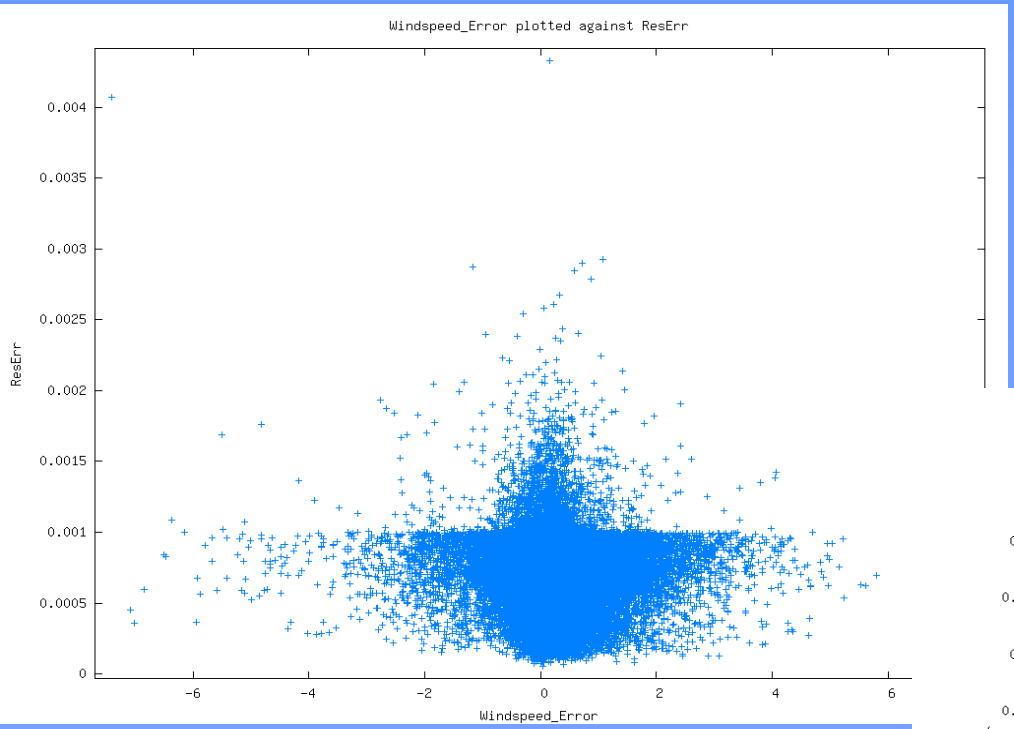
- Take 5 half orbits of CALIPSO data
- select strong reflections on cloud tops:
  - SNR > 100
- this selects 92.973 points out of 469.206 valid simulation results

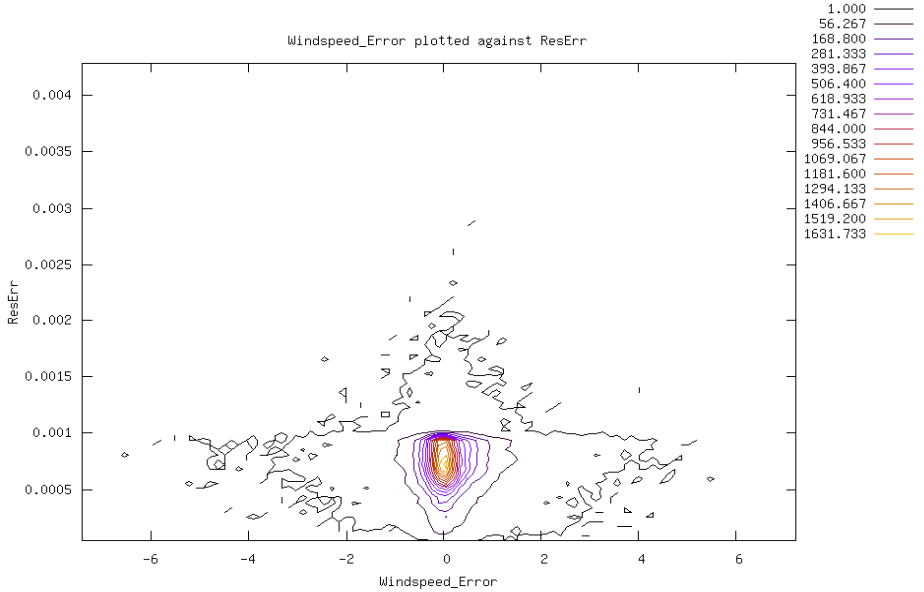
Wind shear


Windspeed_Error plotted against LOS_Wind_shear
LOS_Wind_shear
Windspeed_Error
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-6
-4
-2
0
2
4
6
8

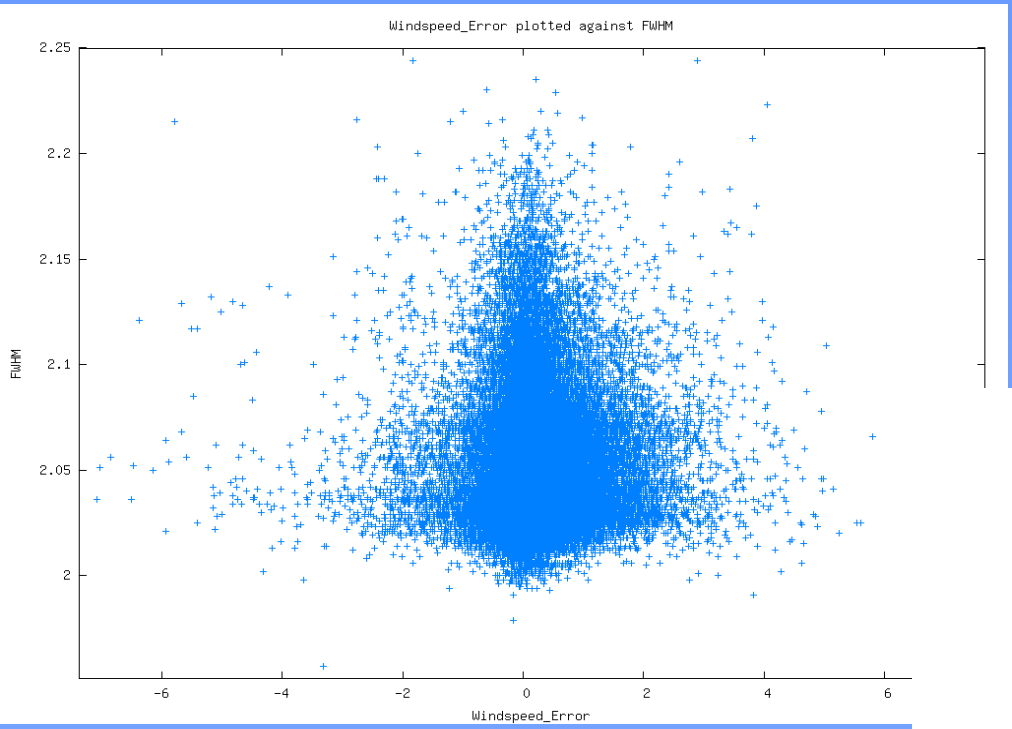

Windspeed_Error plotted against LOS_Wind_shear
LOS_Wind_shear
Windspeed_Error
165.233
495.700
826.167
1156.633
1487.100
1817.567
2148.033
2478.500
2808.967
3139.433
3469.900
3800.367
4130.833
4461.300
4791.767
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-6
-4
-2
0
2
4
6
8
10

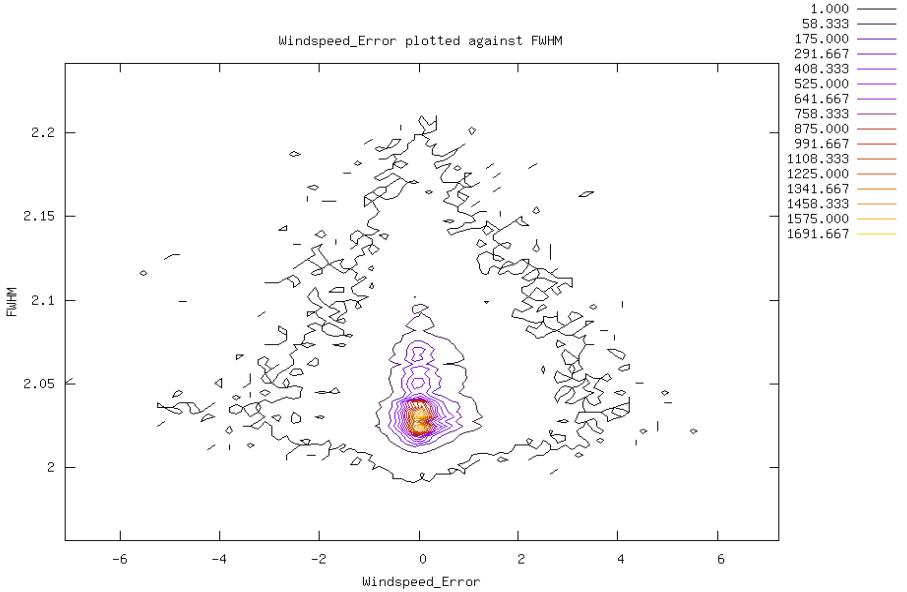
Res. Err. for SNR>100





FWHM for SNR>100





Conclusions

- From these results it is clear that:
  - windshear combined with a sharp gradient in optical properties (cloud top) does cause significant errors in the retrieved windspeed
  - MieCore outputs like FWHM, ResErr, Validity Flag and NumIt cannot be used to discriminate between good and bad results
  - The MieCore Validity Flag does help to discard cases without proper signal. However it does not reliably screen bad from good results AND cannot prevent from wrong results due to integer overflows.

Todo's:

- look at horizontal wind gradients
- look at convective cases
- look at the possibilities for QC on the Rayleigh channel

The end

- questions ?