

REGIONAL BREWER CALIBRATION CENTER EUROPE



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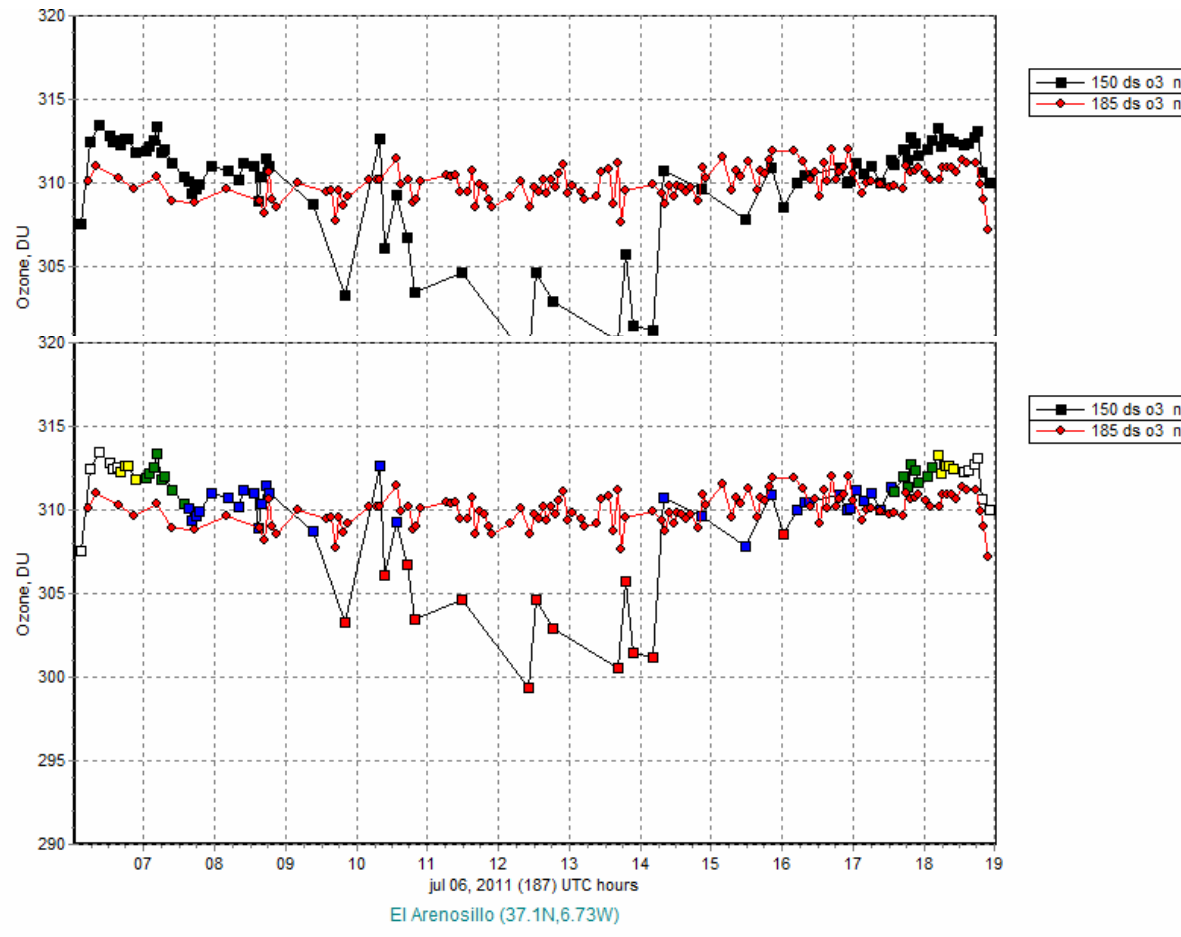
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Attenuation filter issues in Brewer ozone calculations

1. Introduction
2. Ozone algorithm
3. Ozone Filter Correction
4. Methods for Filter issues detection and correction determination

No linearity of the attenuation filter is a known issue on the Brewer ozone calculation

(see for example Volodya Savastiouk Phd Thesis 2008)



$$O_3 = \frac{\sum_{i=1}^4 w_i \cdot \left[\text{Log}(F_i) - \text{Log}(F_{o_i}) - AMF_{SCA} \cdot \frac{p}{p_0} \cdot \tau_{SCAi} \right]}{AMF_{O_3} \cdot \sum_{i=1}^4 w_i \cdot \tau_{O_3i}}$$

weights w_i : $-1, +0.5, +2.2,$ and -1.7

Wavelengths : $310, 313, 317,$ and 320nm .

F_o : extraterrestrial count rates.

F : measured count rates

P_0, p : standard surface air pressure /average station air pressure

τ_{SCAi} : molecular scattering optical depths for each wavelength l at p_o .

τ_{O_3i} : ozone absorption optical depths for each wavelength i .

AMF_{SCA} : direct sun air mass factors for molecular scattering

AMF_{O_3} : direct sun air mass factors for ozone absorption respectively.

$$AMF_x = \sec \left\{ \arcsin \left[\frac{R}{R + h_{EFFx}} \cdot \sin(SZA) \right] \right\}$$

R is the Earth's radius (6370km)
 h_{EFFx} is the effective layer height. (It is set to $h_{EFFSCA} = 5\text{km}$ and $h_{EFFO_3} =$

In a ideal brewer the ozone do not depend of the attenuation filter.

1. Attenuation Filters are “neutral”
2. Nominal wavelengths and weights verify :

$$\sum_{i=1}^4 w_i = 0, \quad \sum_{i=1}^4 w_i \lambda_i = 0$$

If the attenuation is linear with wavelength, do not affect the ozone calculation.

Attenuation Filter : Ozone Algorithm

$$f \equiv \text{Count Rates} , F = \log(f)$$

$$F_i = F_i + Af_{Filter\#} + CT_i * (Temp)$$

$$R6 = \sum_{i=1}^4 w_i F_i$$

$$Af(\lambda) = Af + \lambda \Delta Af + ..$$

$$R6 = \sum_{i=1}^4 w_i F + Af \sum_{i=1}^4 w_i \lambda_i + \Delta Af \sum_{i=1}^4 w_i \lambda_i^2$$

$$\sum_{i=1}^4 w_i = 0 , \quad \sum_{i=1}^4 w_i \lambda_i = 0$$

In a real instrument

a) the filters can not be neutral

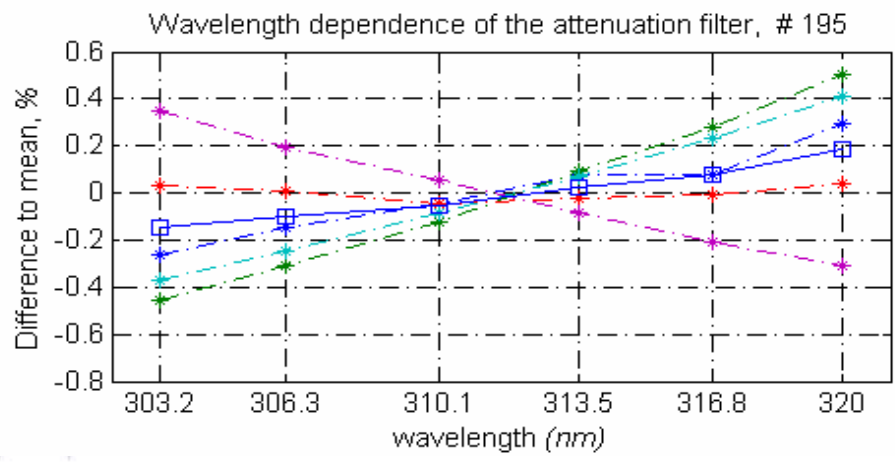
b) Even if there are linear with wavelengths

$$Af(\lambda) = Af + \lambda \Delta Af \quad \sum_{i=1}^4 w_i \lambda_i \approx 0$$

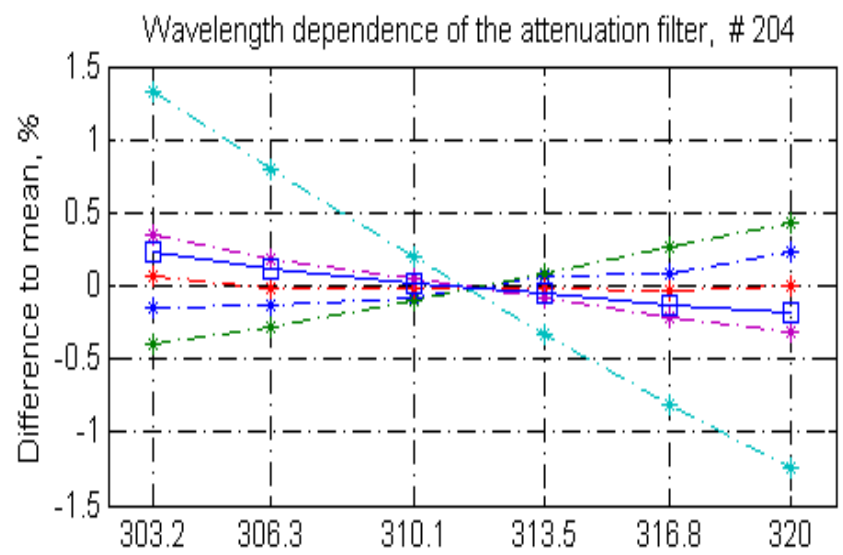
$$R6(f \#) = R6 + \Delta Af \sum_{i=1}^4 w_i \lambda_i$$

If the slope is too big you see the effect in the ozone.

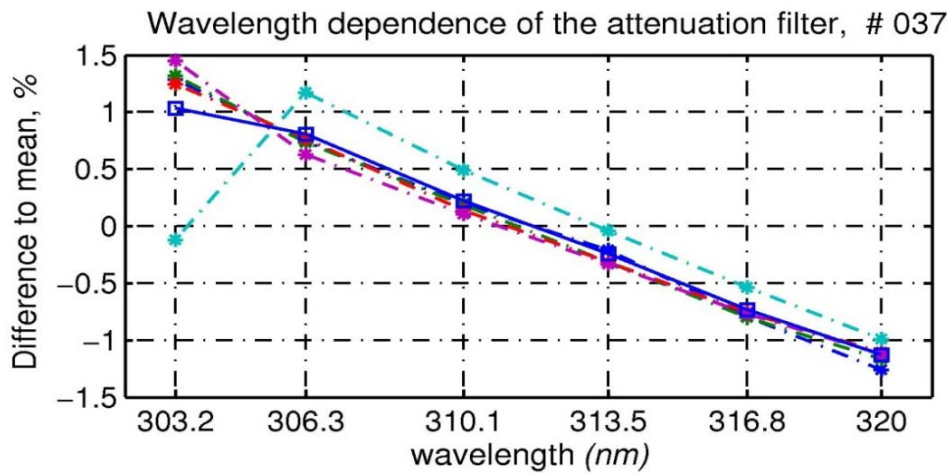
Wavelength dependence of the attenuation filter, # 195



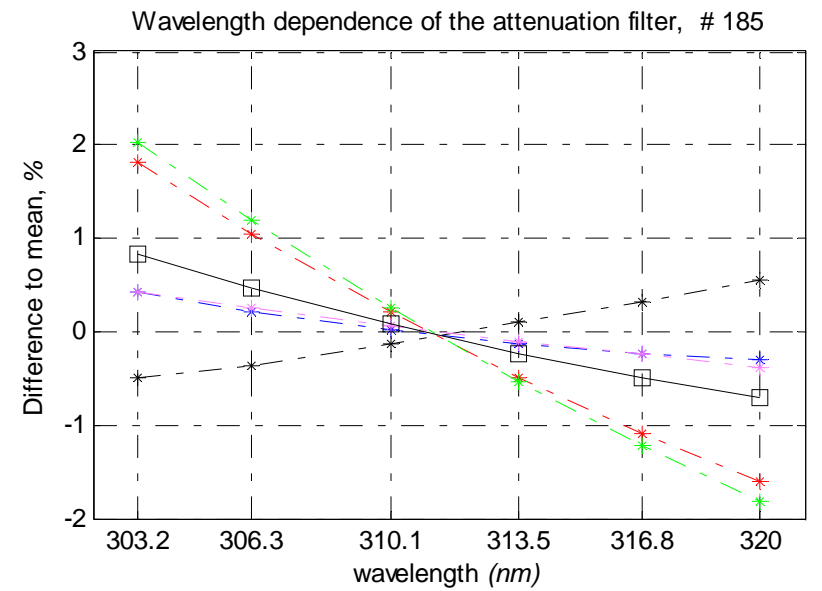
Wavelength dependence of the attenuation filter, # 204

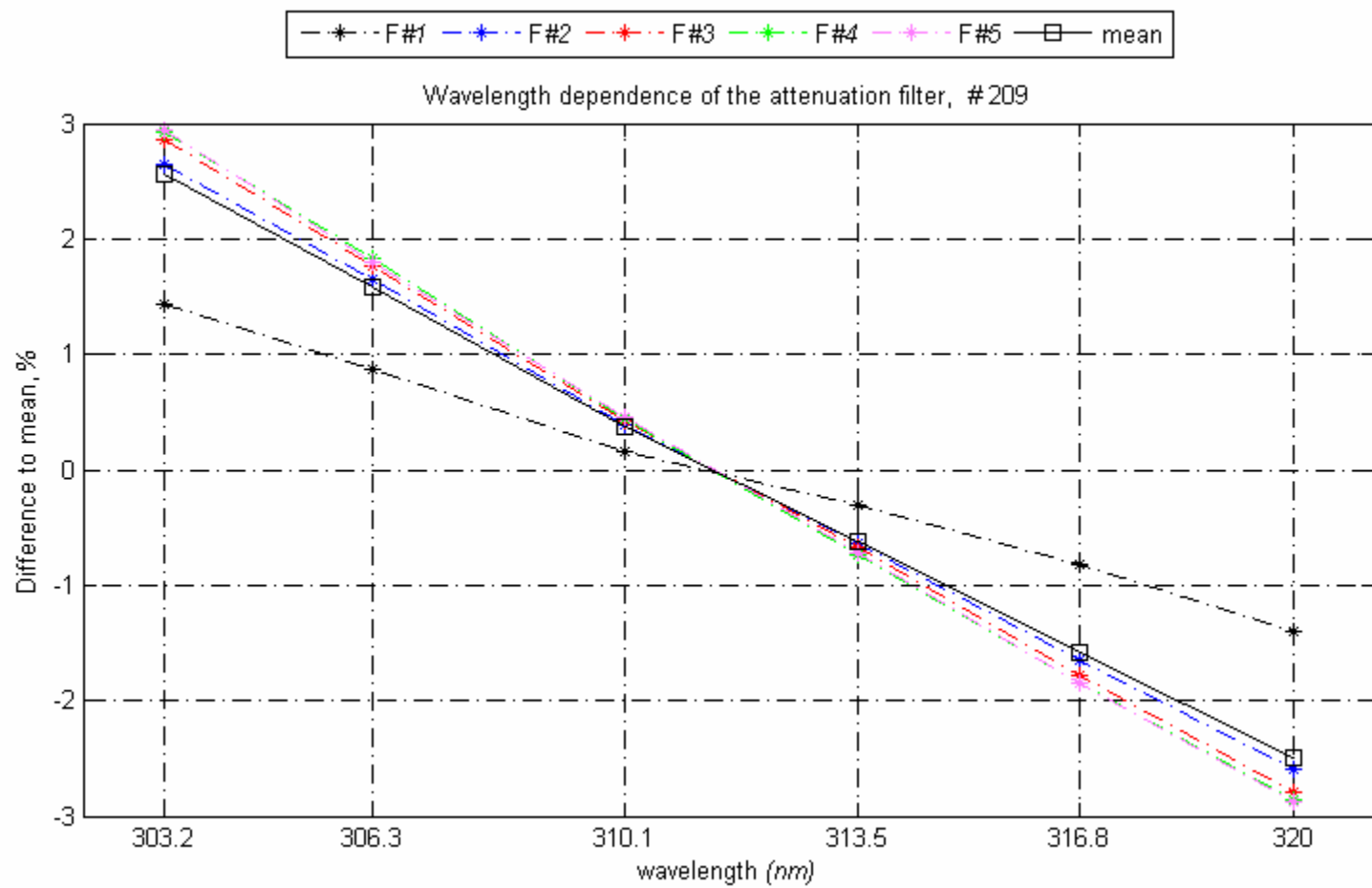


Wavelength dependence of the attenuation filter, # 037



Wavelength dependence of the attenuation filter, # 185





The effect can be accounted using a ETC correction for the affected filter.

If you know the attenuation of every wavelengths

$$ETC_C(j) = \sum_{i=1}^4 w_i Af(\lambda_i, j)$$

The correction in can be implemented as the usual Standard Lamp correction.

Determination of the ETC correction

- a) Internal test using Direct Sun
- b) Filter wavelength dependence
 - a) FI.RTN, FWTEST
 - b) AT.RTN
- c) Calibration
- d) Langley

Internal Test

This procedure check on the data record if one particular brewer is affected by this issue and estimate the correction.

We look in to the ozone differences in simultaneous measurement performed with different filter

Requires a long record (one year) of ozone measurement without changes on the instrument calibration

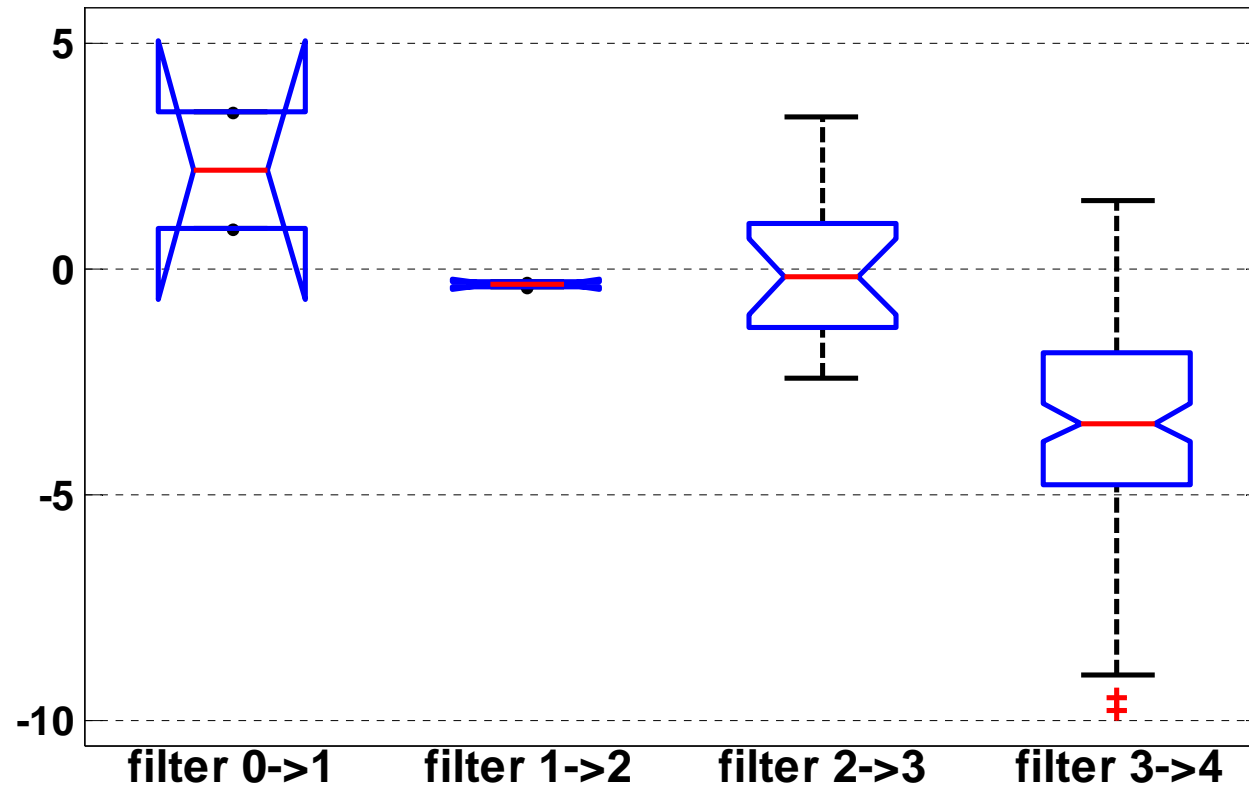
With for example Martin Stanek's O3Brewer produce a report with include : Date , time, filter, airmass, ozone, MS9

Select simultaneous measurements (10 min, airmass <0.05), performed with different filter.

Look for significant differences on the statistics from f#3 to f#4, (you have only significance for high air mass)

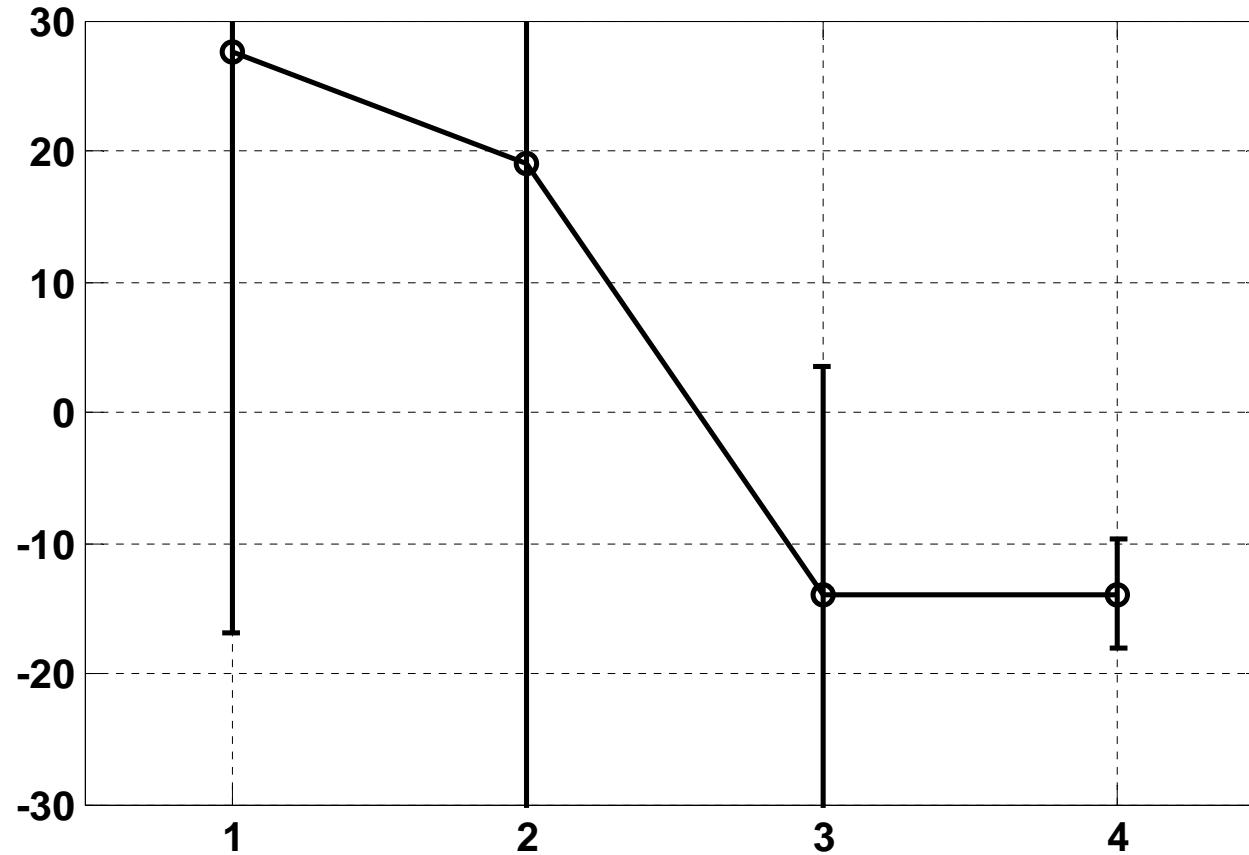
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Ozone (DU) difference by filter change



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FILTER CORRECTION #4 -14 ci=[-18,-10] nobs=104

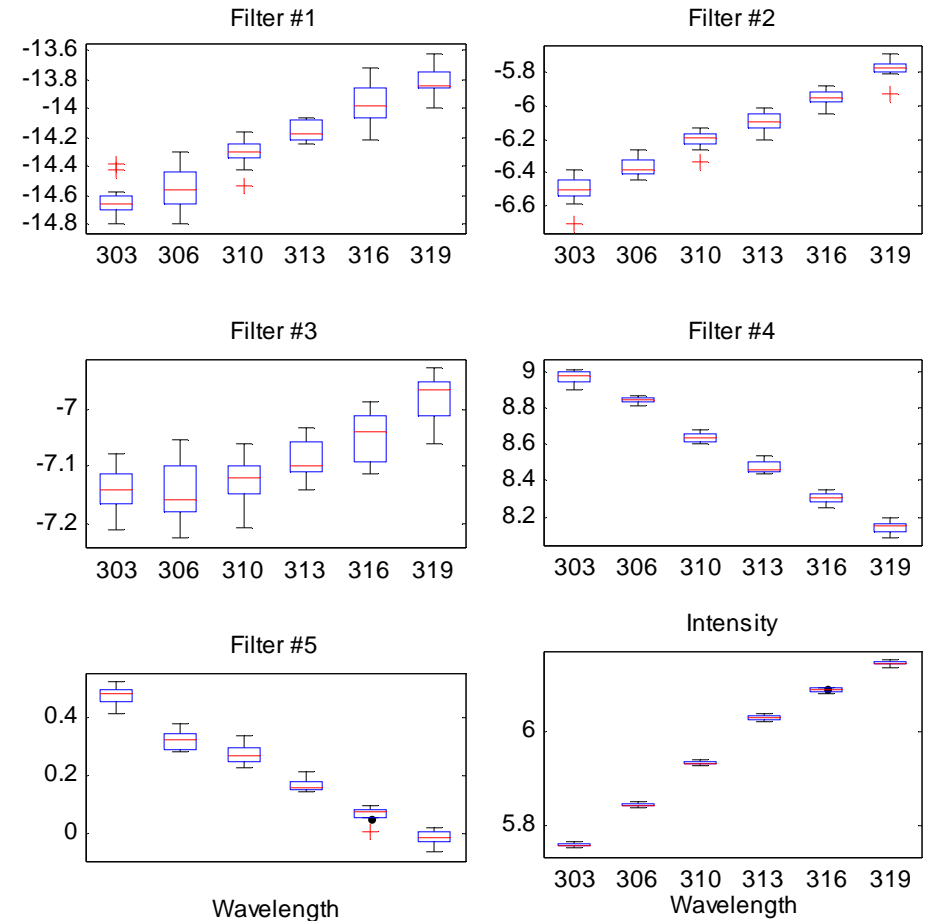


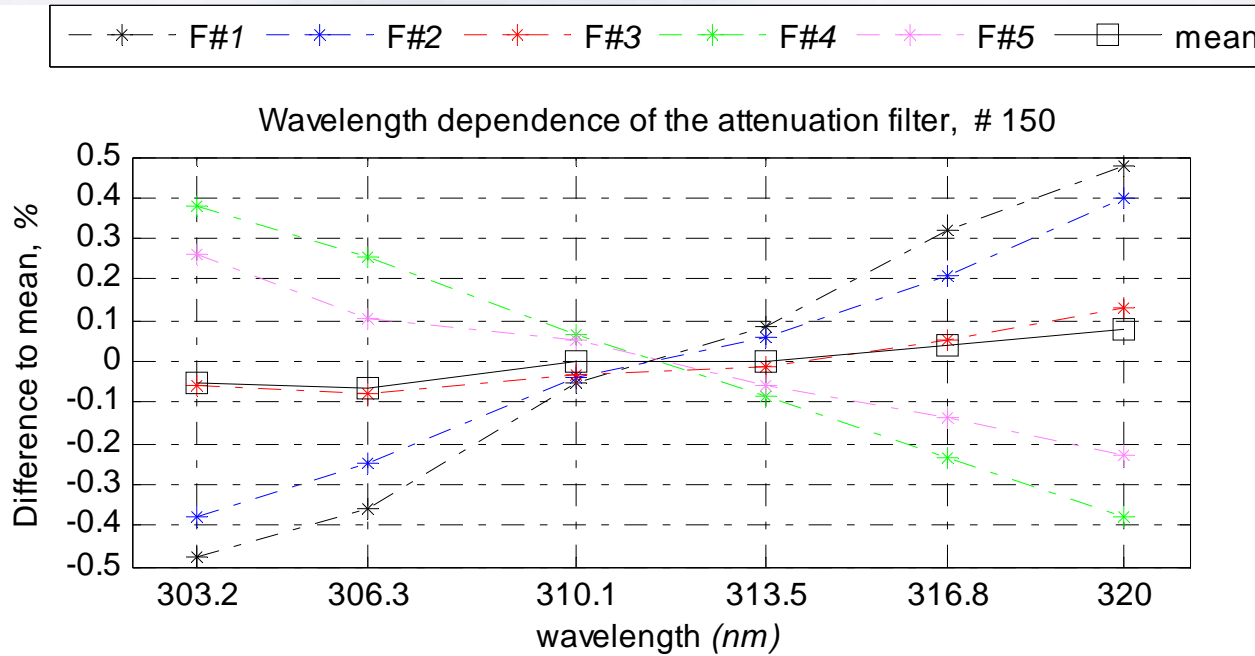
Filter Characterization : FI.RTN

```

% IOS description of the fi test output in fioavg.\#\#\# file
% (created by V. Savastiouk)
%
% date Te AF  CY  N  Slit0 std Slit1 std Slit2 std Slit3 std Slit4 std Slit5 std
% 28003 9  1   1  3  49815 +37 59776 +0  60031 +0  60318 +0  59622 +0  58465
%      2  3  3  4520 +17 4514 +13 4504 +5  4492 +7  4482 +5  4474 +16
%      3  8  3  9386 +16 9338 +24 9296 +3  9245 +7  9211 +6  9186 +22
%      4 30  3 16396 +24 16262 +17 16105 +17 15976 +7  15863 +11 15752 +
%      5 100 3 24598 +55 24357 +9  24155 +18 24003 +9  23873 +9  23736 +
%      6 250 3 25996 +54 25764 +0  25553 +13 25411 +0  25251 +0  25103 +
%
% Te - temperature,
% AF - FW2 position,
% CY-number of cycles for that AF
% N - number of repetition (fi does several loops one inside the other and N
% is the outer most loop).
% Slit0-6 are the values for the attenuations, except for AF=1
    
```

Attenuation Filter Test, FIOAVG.150 Difference with respect to nominal values (%)

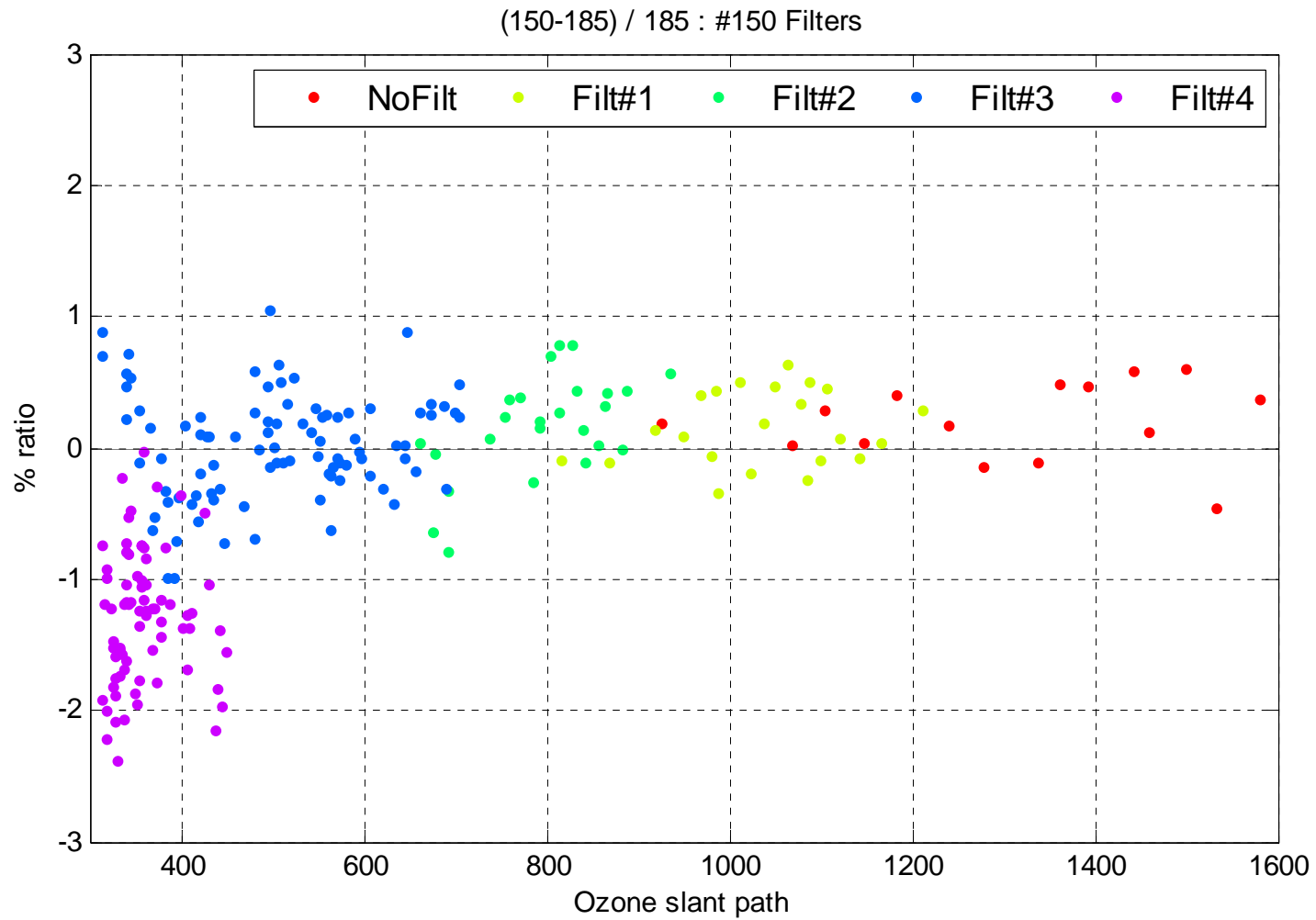


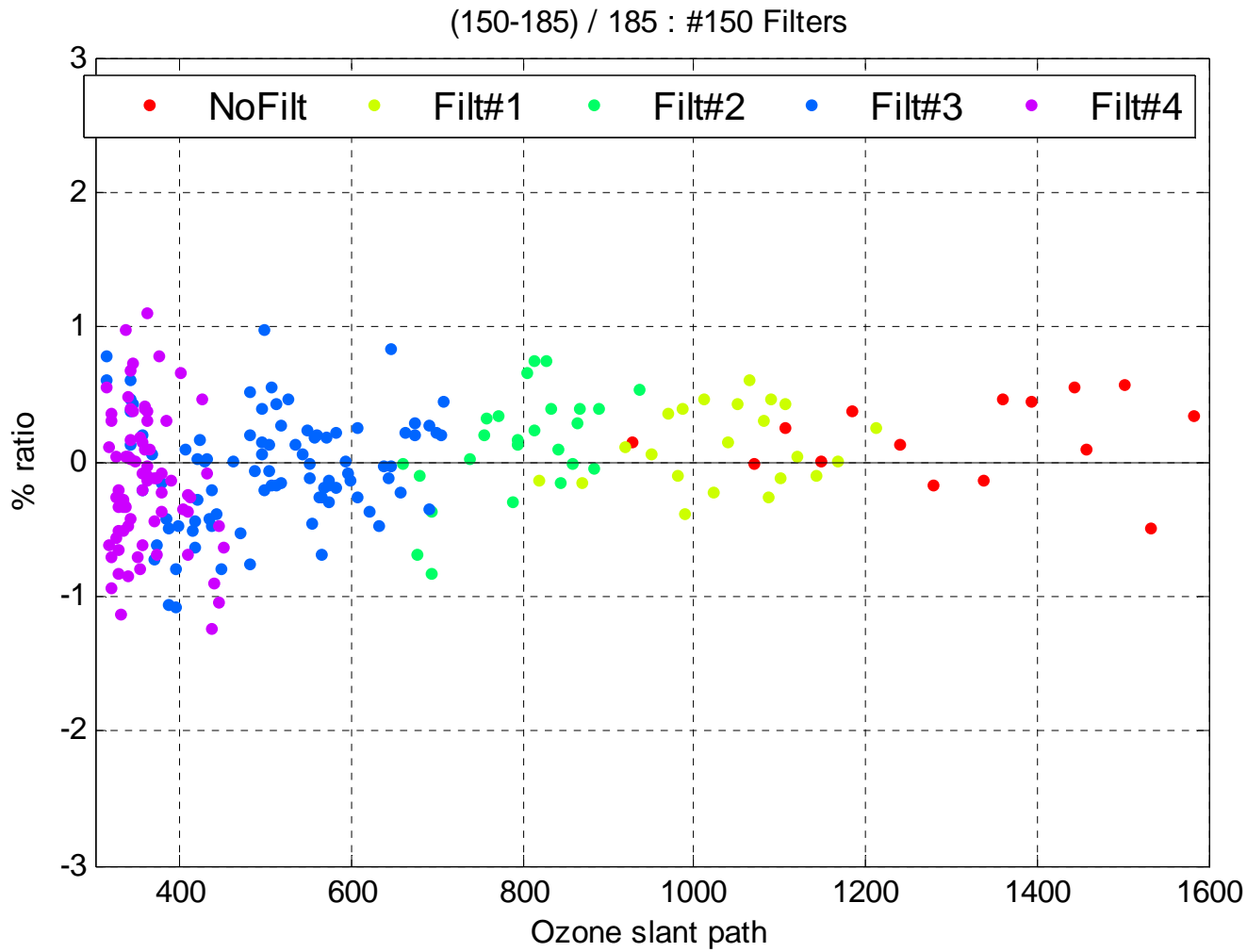


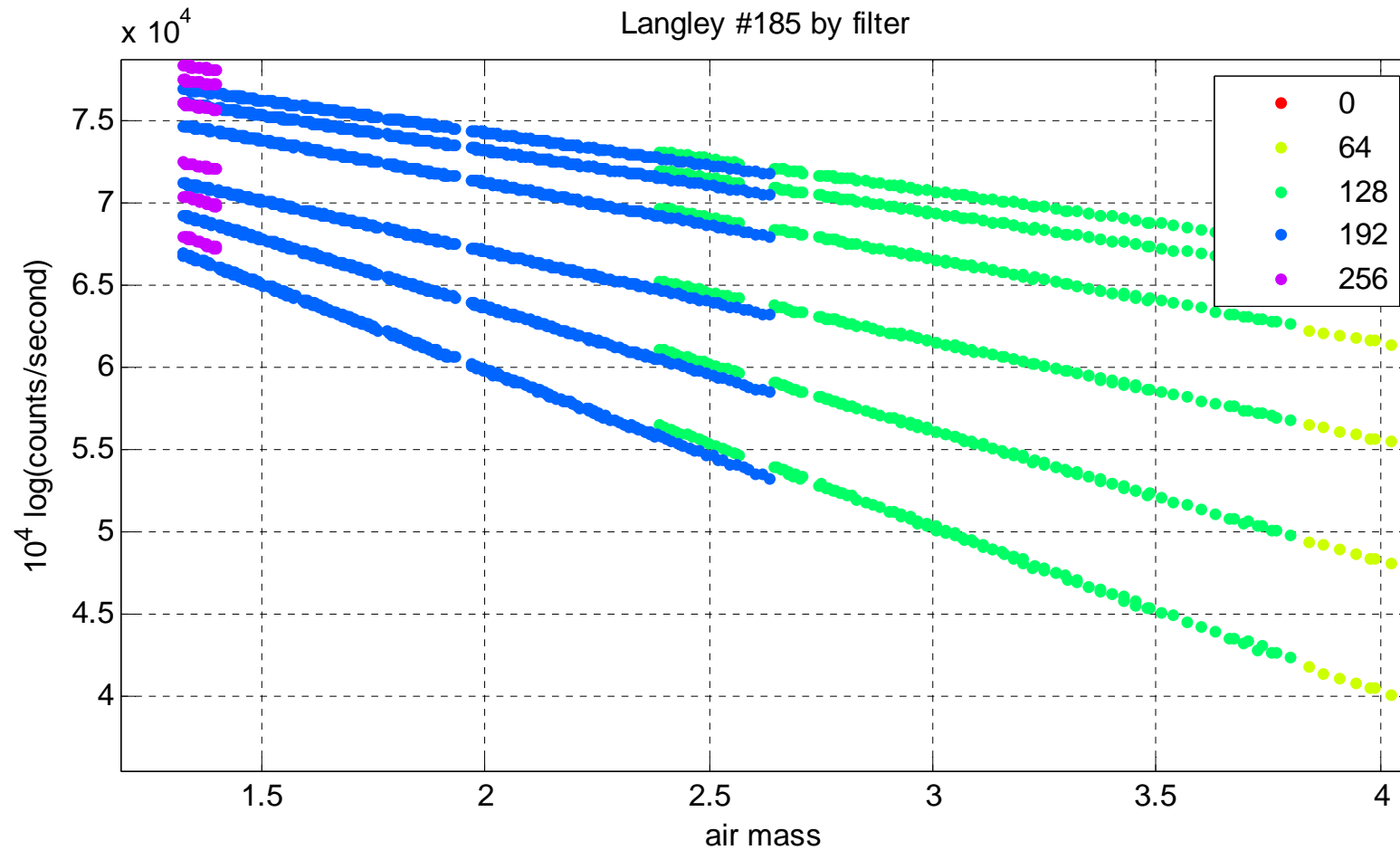
	filter #1	filter #2	filter #3	filter #4	filter #5
slit #0	4267	9349	13929	21794	25120
slit #1	4272	9361	13926	21767	25081
slit #2	4285	9381	13932	21726	25068
slit #3	4291	9390	13935	21693	25040
slit #4	4301	9404	13944	21661	25020
slit #5	4308	9422	13955	21630	24998
mean	4287	9384	13936	21711	25054

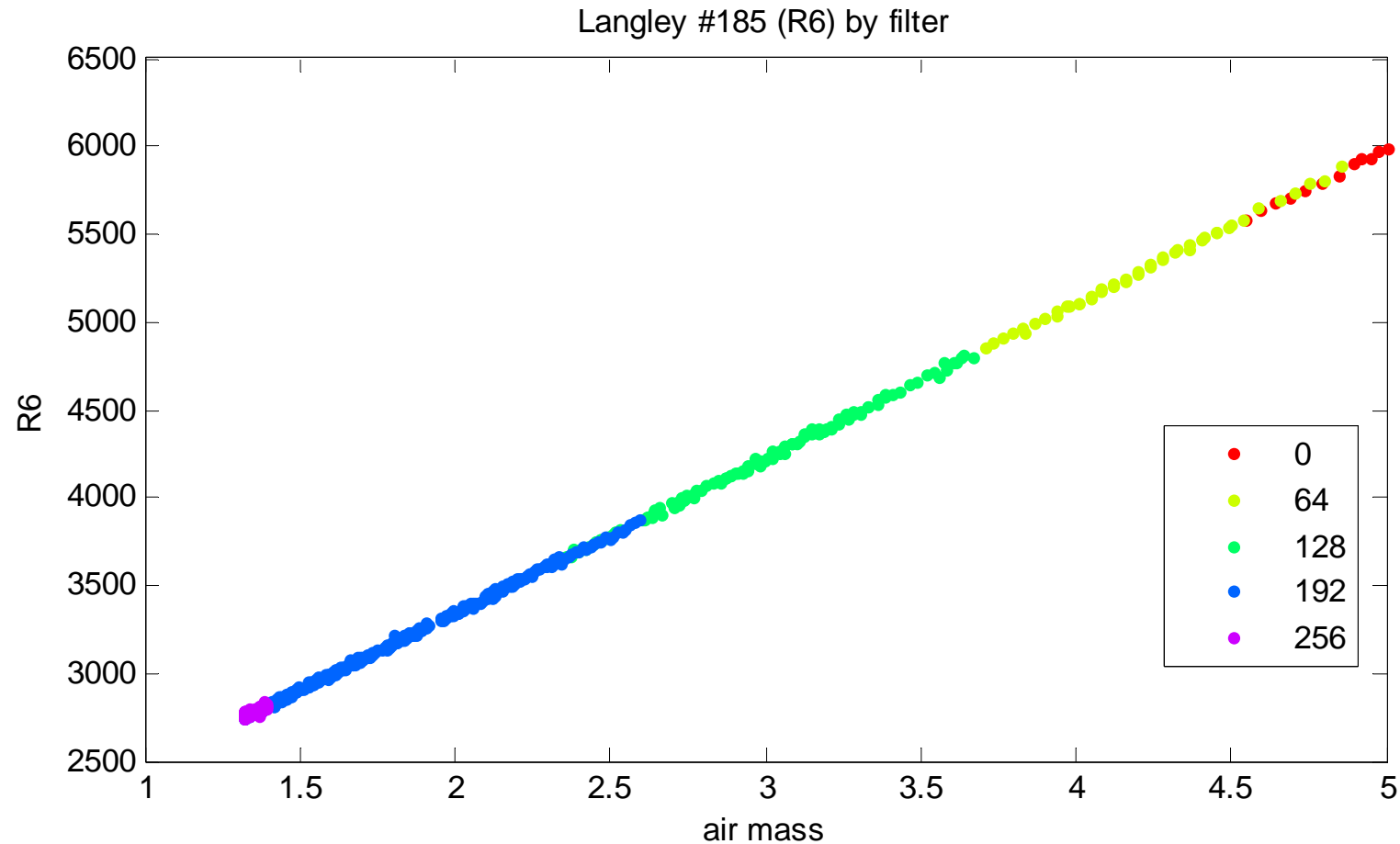
$$ETC_C(j) = \sum_{i=1}^4 w_i Af(\lambda_i, j)$$

	filter #1	filter #2	filter #3	filter #4	filter #5
ETC Filt. Corr. (median)	-1	-15	-11	4	-1
ETC Filt. Corr. (mean)	-1.17	-12.03	-7.9	8.7	-3.86
ETC Filt. Corr. (CI)	-10.78	-18.79	-15.74	3.3	-13.08
ETC Filt. Corr. (CI)	7.27	-3.60	-0.46	11.7	3.67

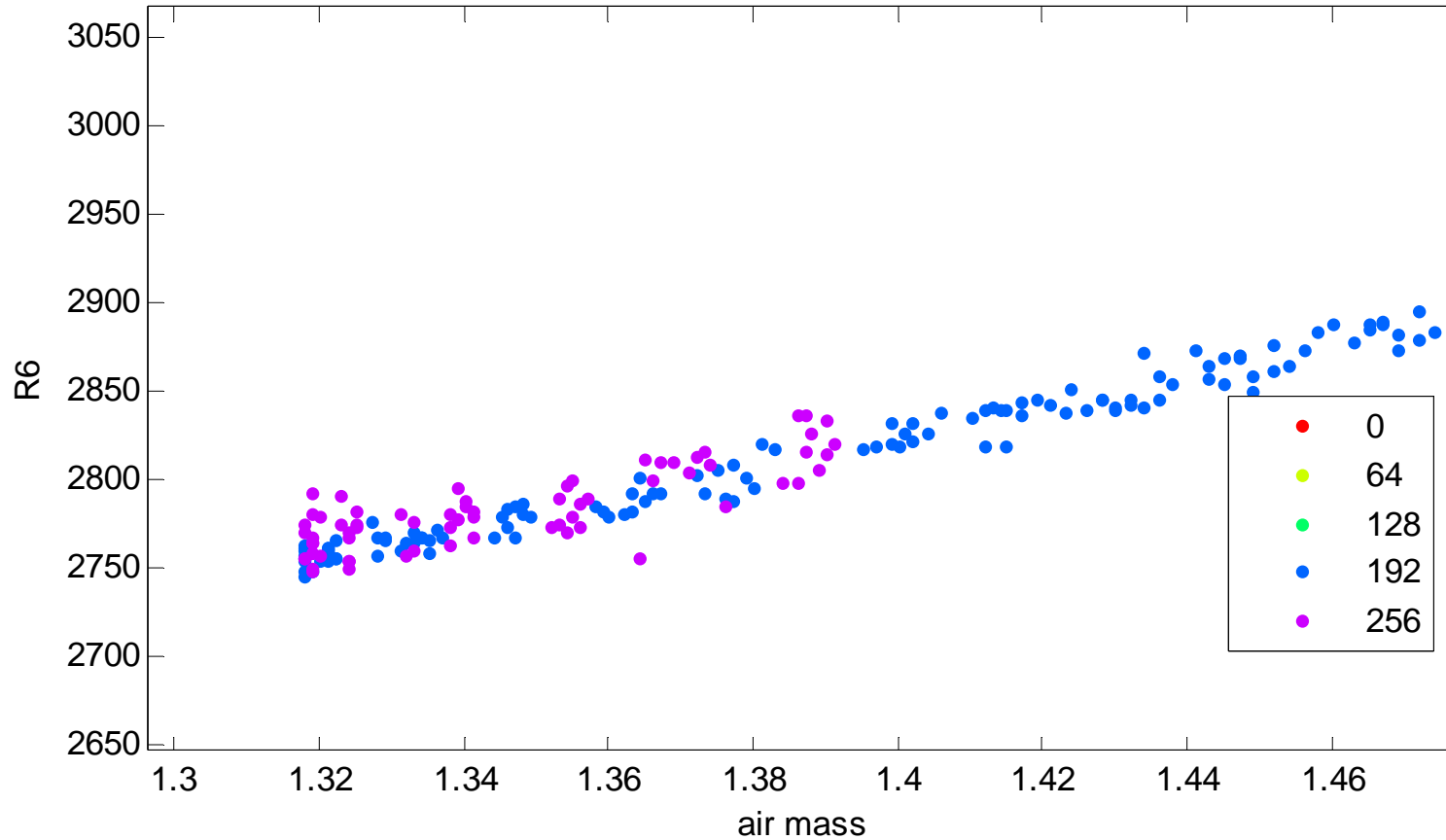




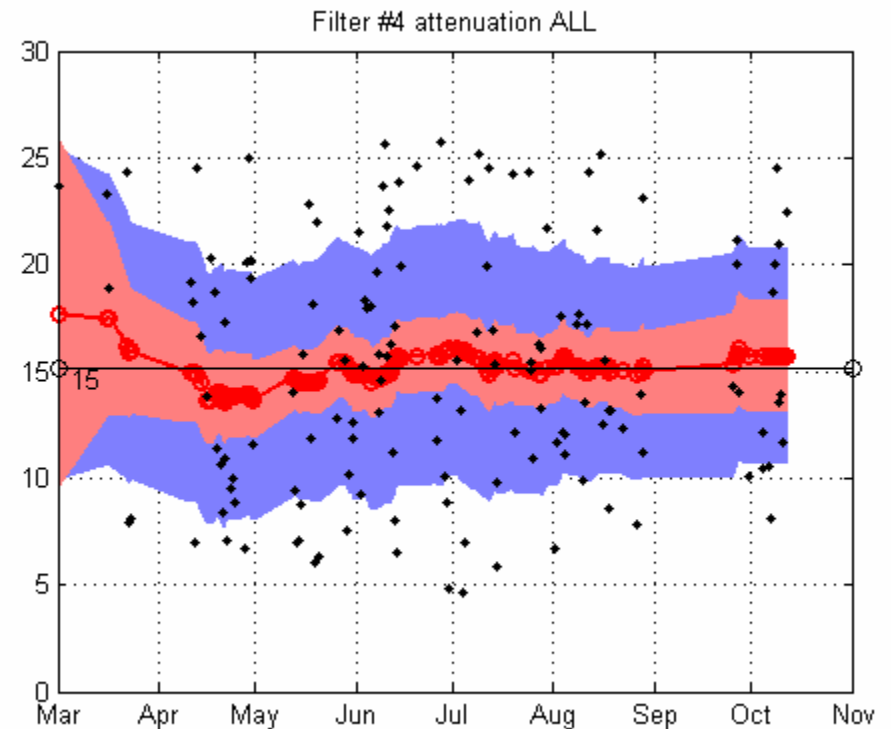
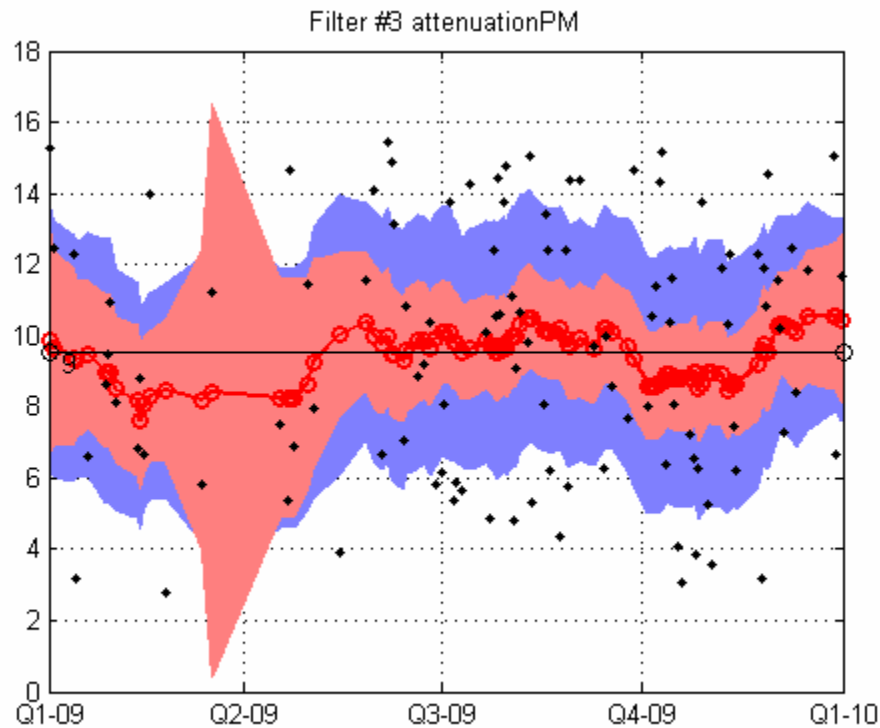




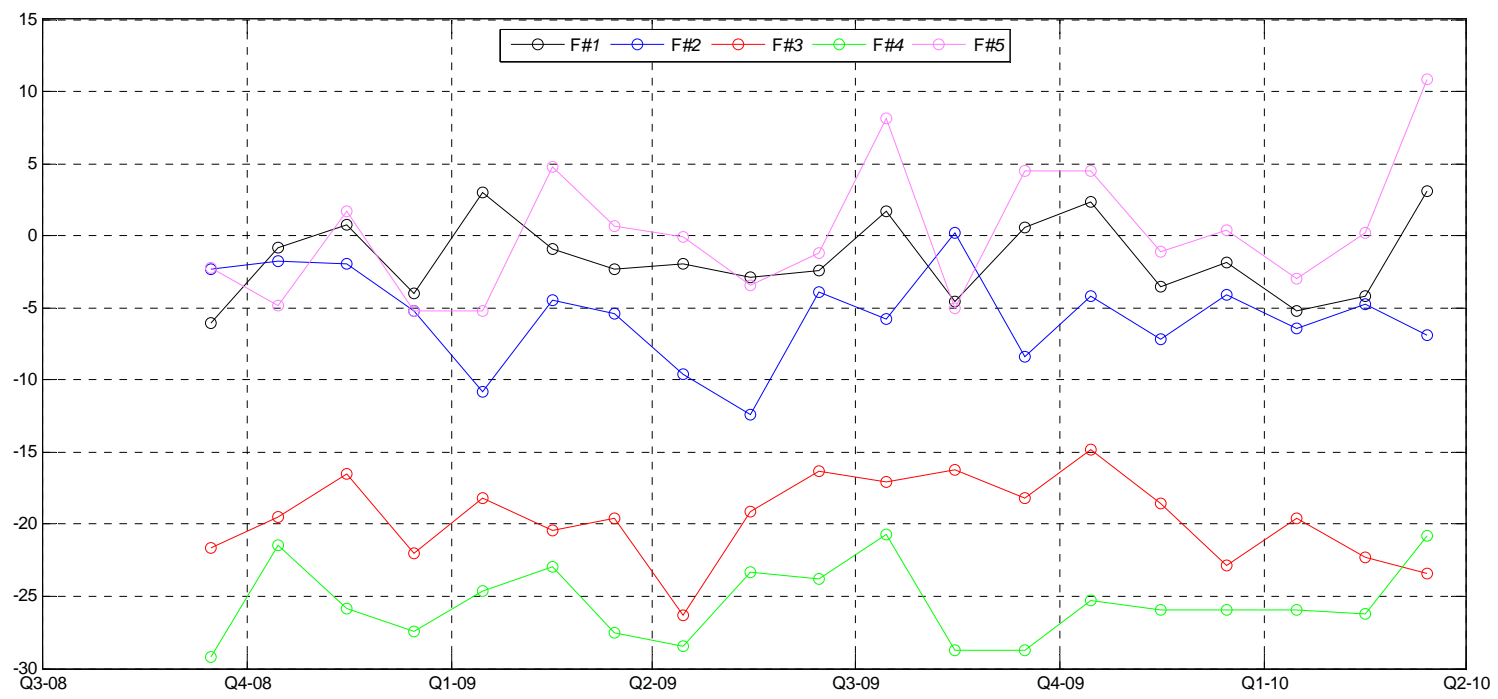
Langley #185 (R6) by filter



- Langley determination of the ETC correction



185 ETC correction factor time evolution



	F1	F2	F3	F4	F5
Median	-2.	-7.	-22.	-25.	-0.
Mean	-2.	-5.	-20	-26	-0.
ci	-3.	-7.	-21	-27	-2.
ci	-0.	-4.	-18	-24	2.

Attenuation Filter Check

Method		Contras	
FI		Requires a large number of measurements	
AT		Need evaluation	
Reference Comparison		Error in reference	
Internal comparison		Enough data during intercomparison ?	
ETC calculation		Filter & airmass are correlated, sometimes regression fail	

Filter

TODO LIST

Explain the difference Langley- FI

Evaluate the performance of AT routine

Evaluate for every instrument

Dead Time - Filter dependence

$$\sum_{i=1}^4 w_i \lambda_i \approx 0$$

Recommendations:

When produce the summary of your data ,
don` t forget to store the filter.

Introduce the FI routine in your schedule , at
the end of the day.

$R_i = \text{stored readings for slit } i$

$$R_{oi} = \frac{2 * R_{ri} - R_{dark}}{Cy * IT} \text{ counts / seg}$$

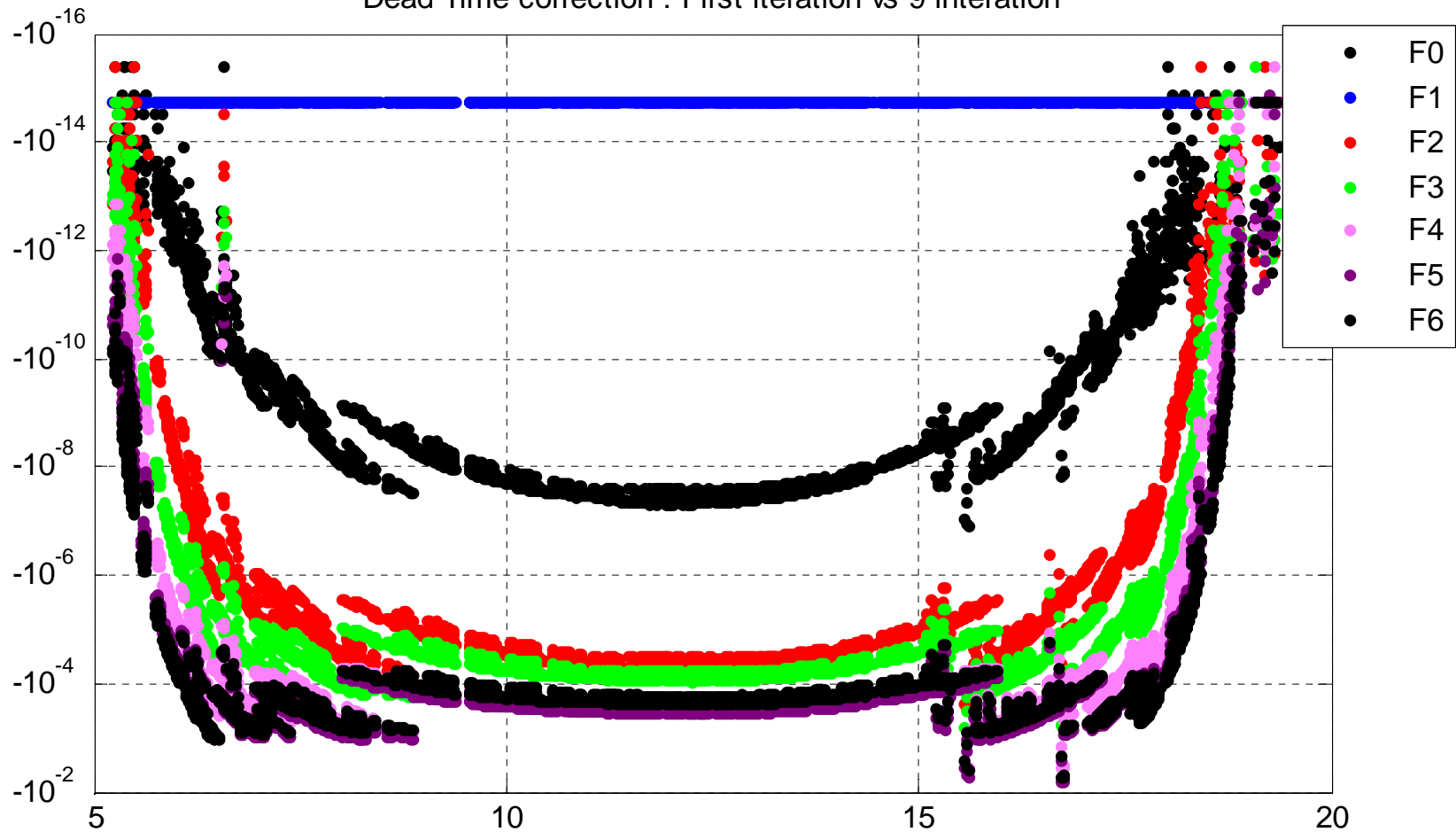
$$R_{di} = R_{oi} \exp(R_{di} * DT)$$

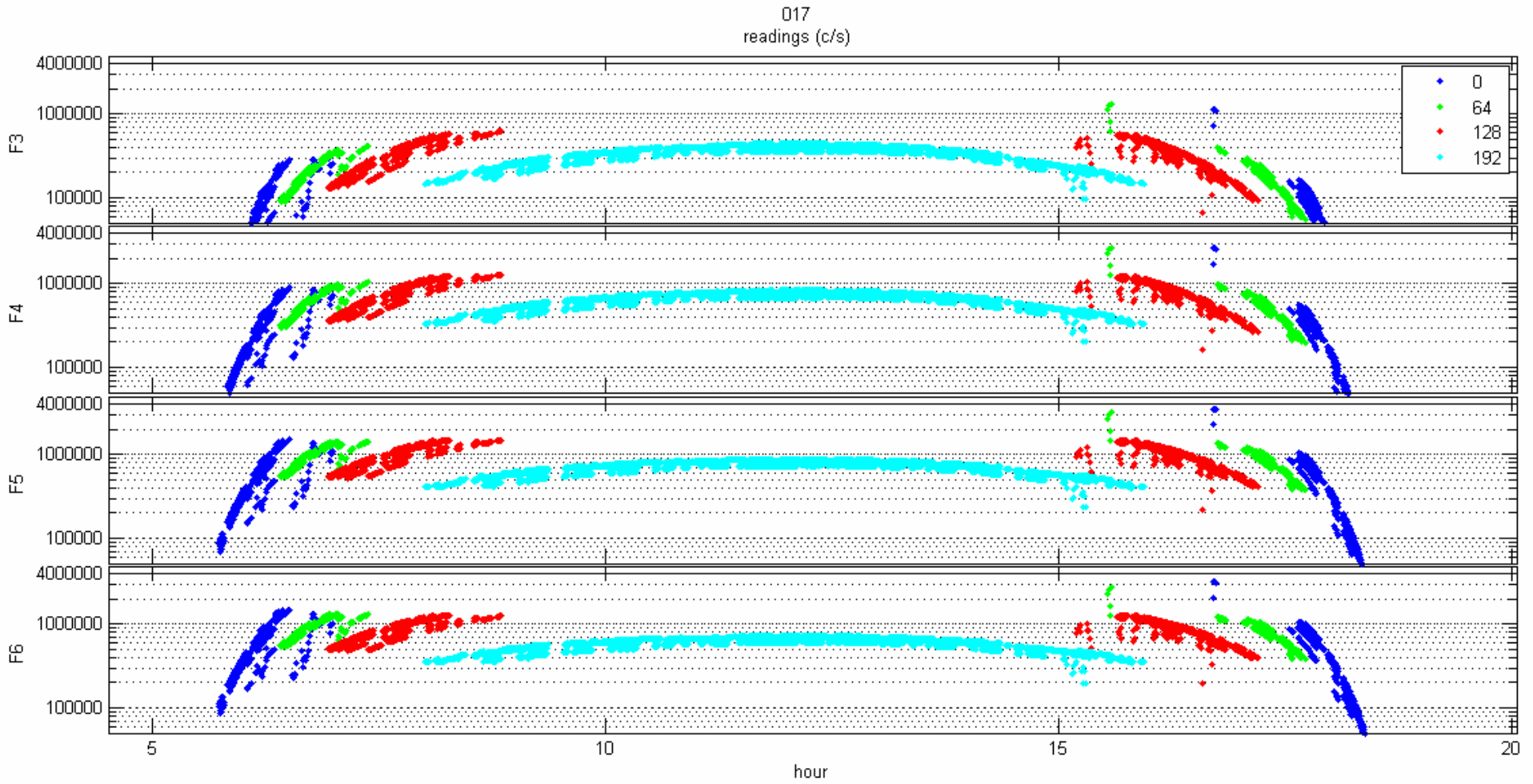
$$F_s = \log(R_{di}) * 10^4 \approx 10^4 * \log(R_o) + R_o * DT$$

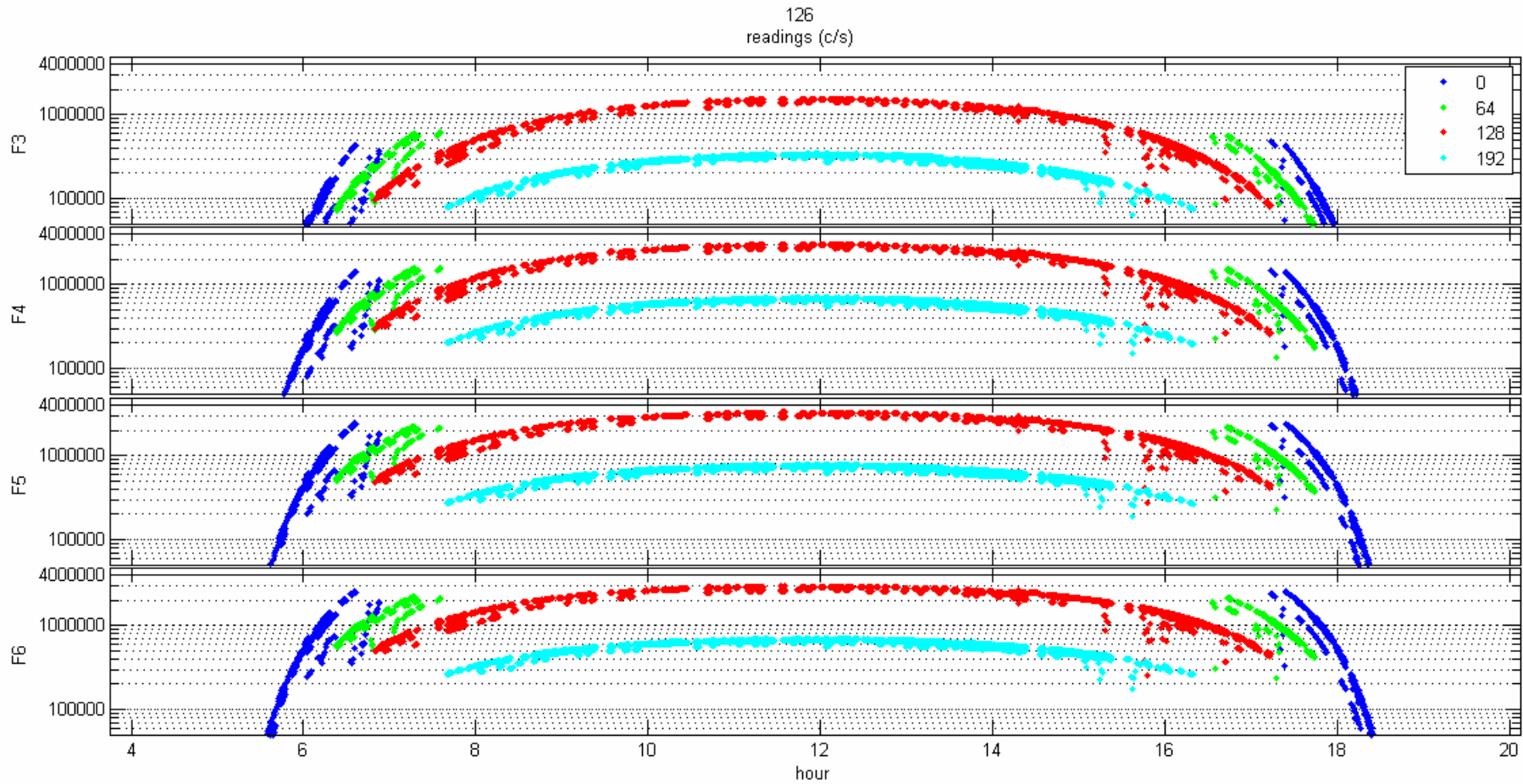
$$F = F + T_{ci} * temp + AF_f (\text{filter})$$

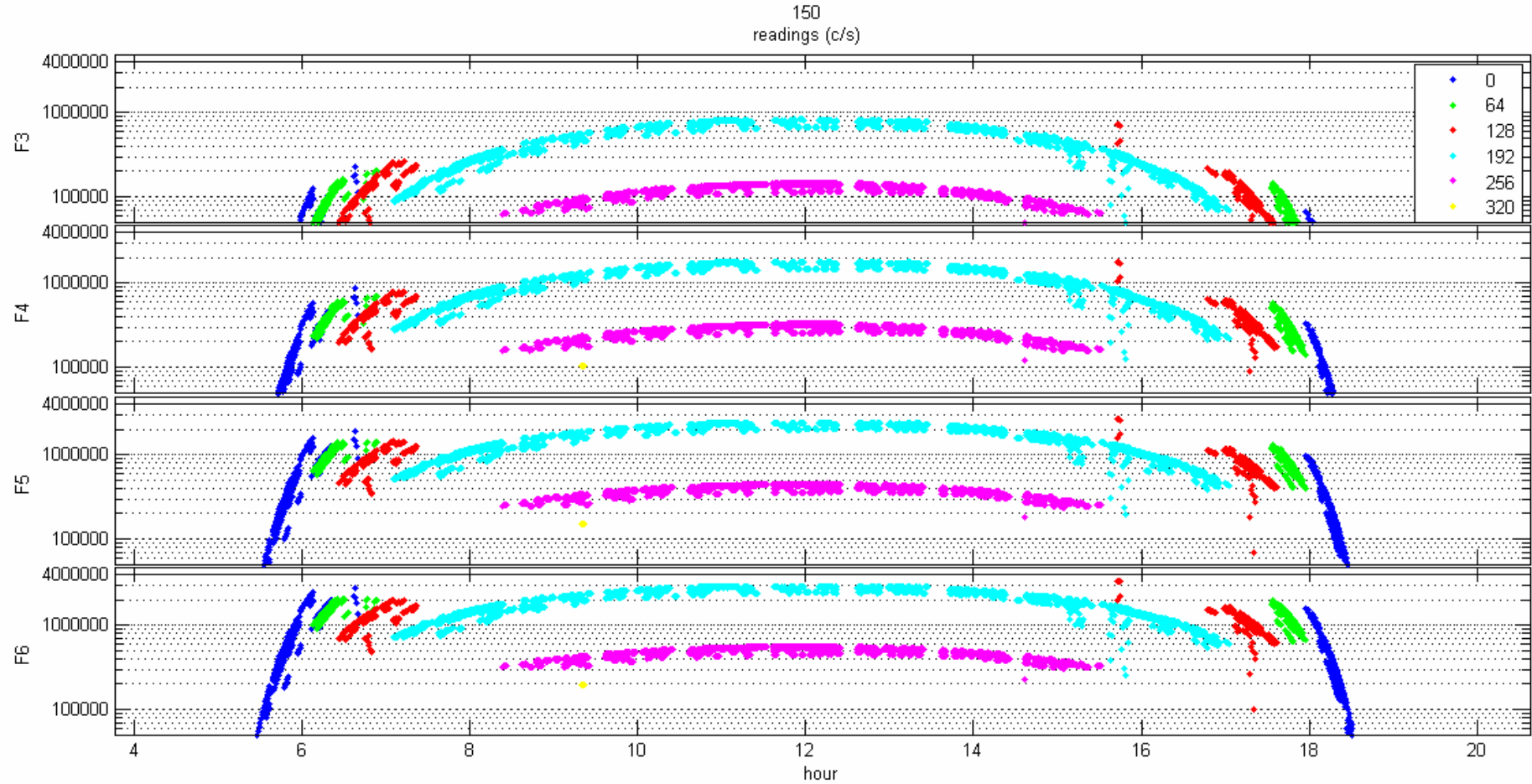
$$F = F_d + T_{ci} * temp + AF (\text{filter}) + R_i * m_a$$

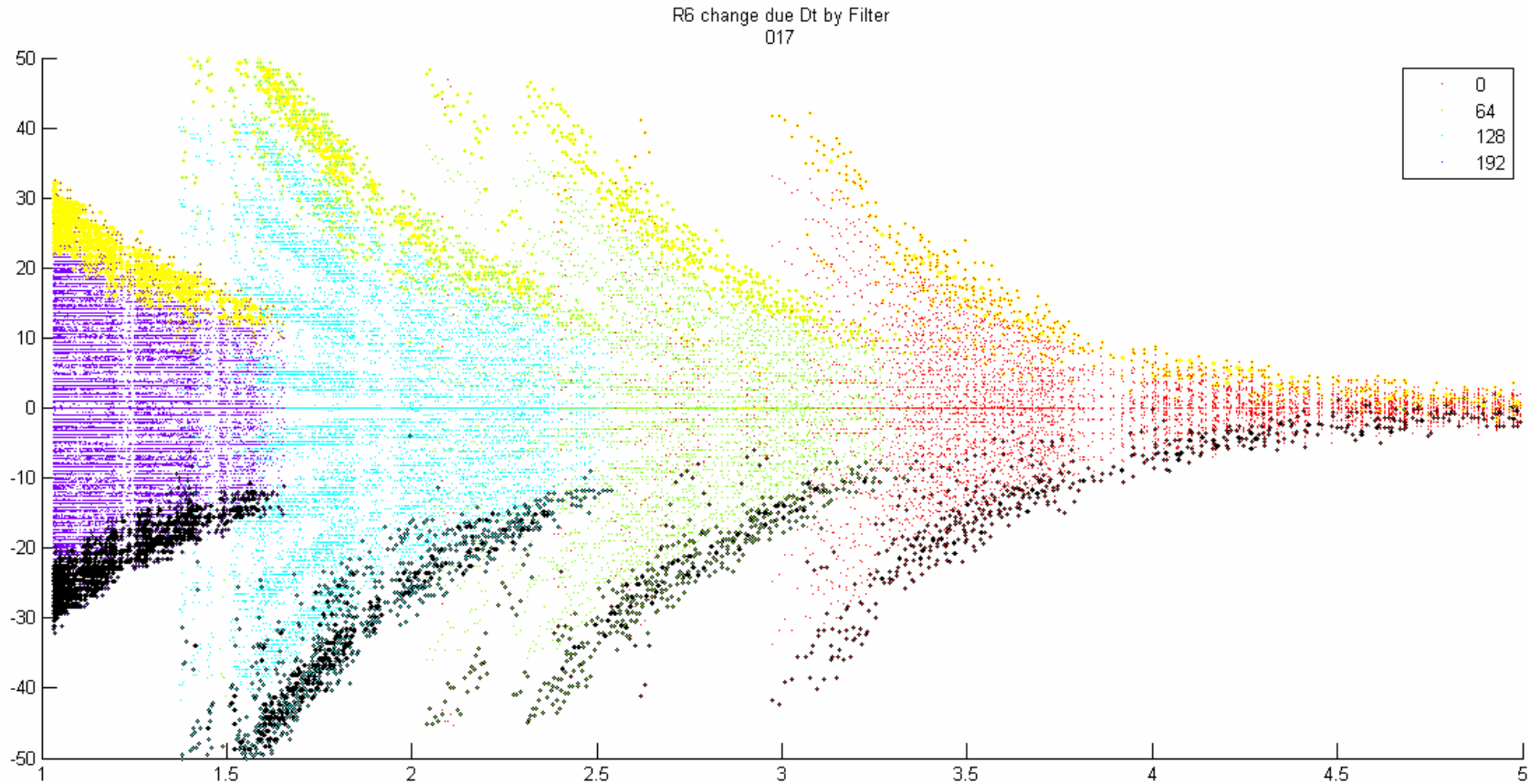
Dead Time correction : First iteration vs 9 iteration











R6 change due Dt by Filter
150

