Physikalisch-Meteorologisches Observatorium Davos
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T5.3: Report on wavelength dispersion function for Pandora 120

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Wavelength Calibration Procedure

The wavelength dispersion function for the UV (1511216U1) and Visible (1508054U1) Avantes spectrometers of Pandora 120 has been determined with the ATLAS tunable laser and a Laser Spectrum Analyser (LSA).

The Laser Spectrum Analyser has been calibrated by the manufacturer (HighFinesse, http://www.highfinesse.com/en/spectrometer-osa)and its accuracy has been verified using a HeCd laser and HeNe Laser. The LSA of the ATLAS system has an accuracy of 3 pm.

The following measuring procedure has been used for both spectrometers:

1. Selection of ATLAS wavelength
2. Waiting time until the intensity of the laser stable to better than 2% (monitoring pyroelectric detector)
3. 5 Wavelength measurements using the ATLAS-LSA
4. 20 Wavelength measurements Pandora - spectrometer
5. 5 Wavelength measurements using the ATLAS-LSA
6. Dark signal measurements Pandora - spectrometer

For Pandora 120 – UV- 34 wavelengths and 23 lines for Vis were measured covering their spectral operational ranges. The measured lines were normalized to the maximum and for the determination of the central wavelength the centroid method was used. The Full Width at Half Maximum of each spectral line was determined by a first order gaussian fit:

$Fit = a.e^{-\left[\frac{x-\mu}{c}\right]^2}$ where μ is the central wavelength

An example of the Pandora and LSA measurements and the determination of the central wavelength is shown in figure 1.

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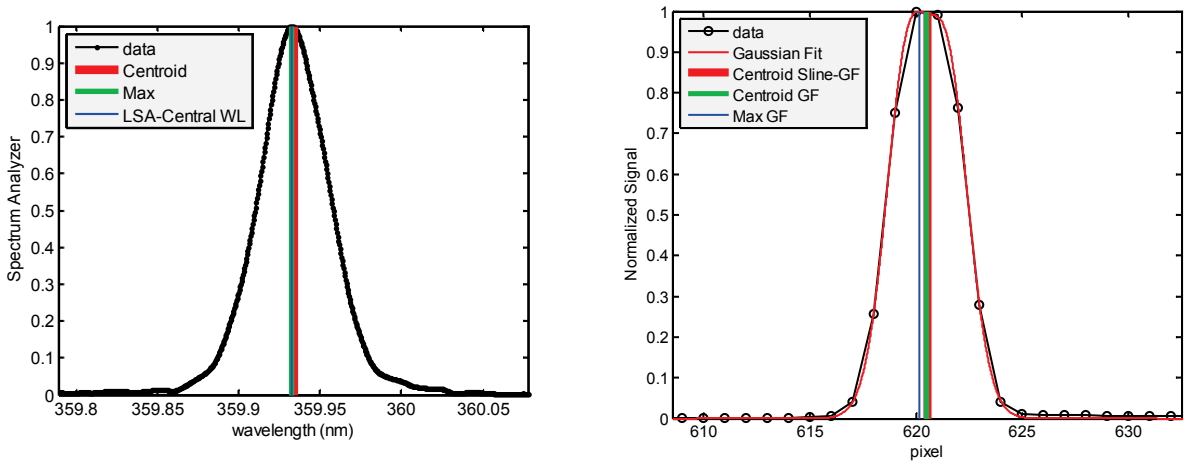

Figure 1 : Example of determination of the central wavelength (LSA) and central pixel (Pandora) for the determination of the wavelength calibration.

Wavelength dispersion function

The dispersion function for each spectrometer has been calculated using the datasets presented in figure 2 (and Tables 1 & 2, appendix). The selection of the order of the polynomial describing the conversion from pixel number to wavelength is done by:

i. Minimizing the residuals of the fit divided by the order of the polynomial
ii. Avoiding abnormal curvature in the spectral step at the edges of the detector

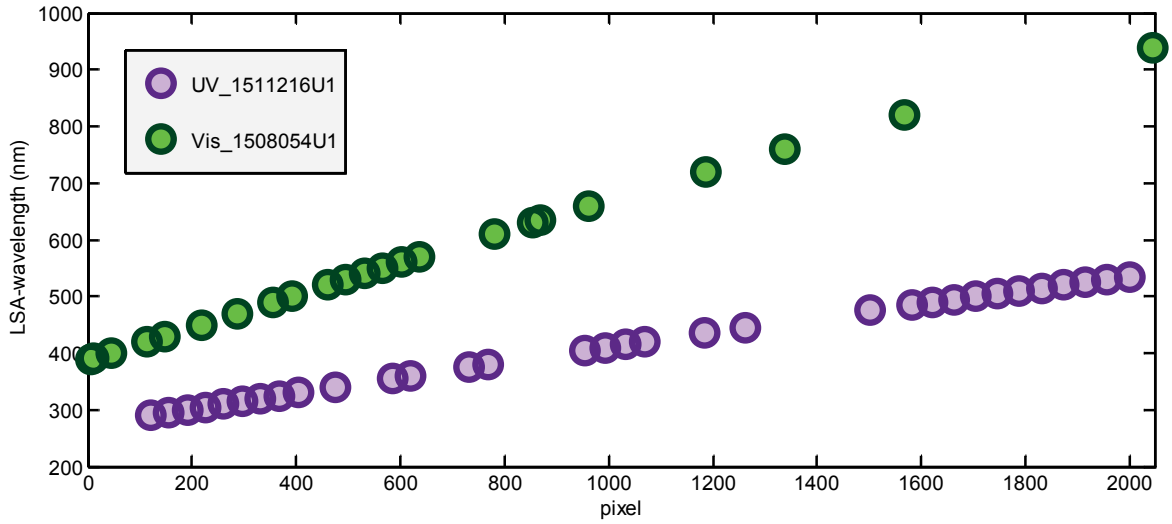

Figure 2: Central pixel and wavelength measurements with the ALTAS system. The datasets were used to determine the dispersion function for Pandora 120.

The following polynomials are proposed for Pandora 120:

$$wavelength = \sum_{n=0}^{8} a_n \cdot pixel^n$$

a_8	a_7	a_6	a_5	a_4	a_3	a_2	a_1	a_0
Pandora120 UV (1511216U1)								
0.0000E+00	0.0000E+00	-2.8507E-19	1.8624E-15	-4.7084E-12	5.1776E-09	-8.8050E-06	1.4501E-01	272.6438291
Pandora120 Vis(1508054U1)								
2.0768E-24	-1.6444E-20	5.3996E-17	-9.5475E-14	9.8722E-11	-6.1934E-08	1.2603E-05	2.8971E-01	386.8355695

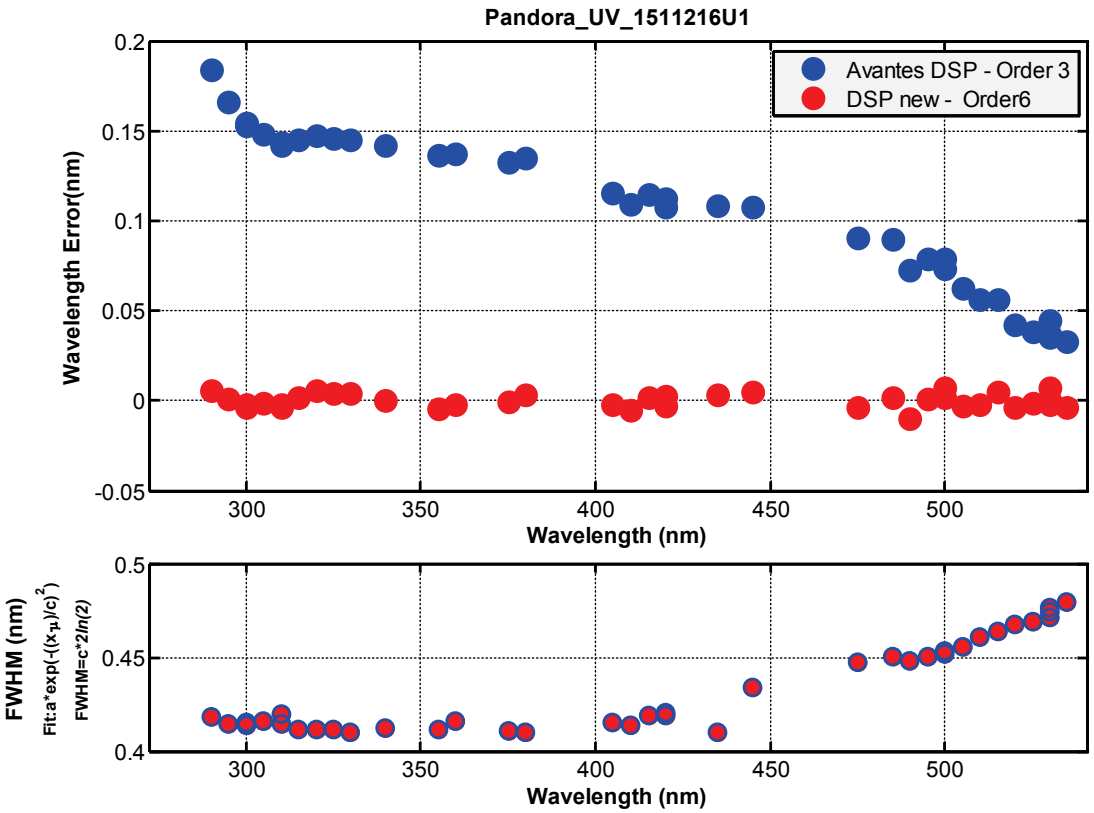

Figure 3: Pandora 120 UV (1511216U1): Wavelength error using the manufacturer and ATLAS dispersion function (upper panel). Spectral FWHM of the Pandora 120 UV (1511216U1) over the spectral range 290-535 nm, defined as FWHM= c* 2ln(2) where the line spread function measurements are simulated by a 1st order gaussian fit.

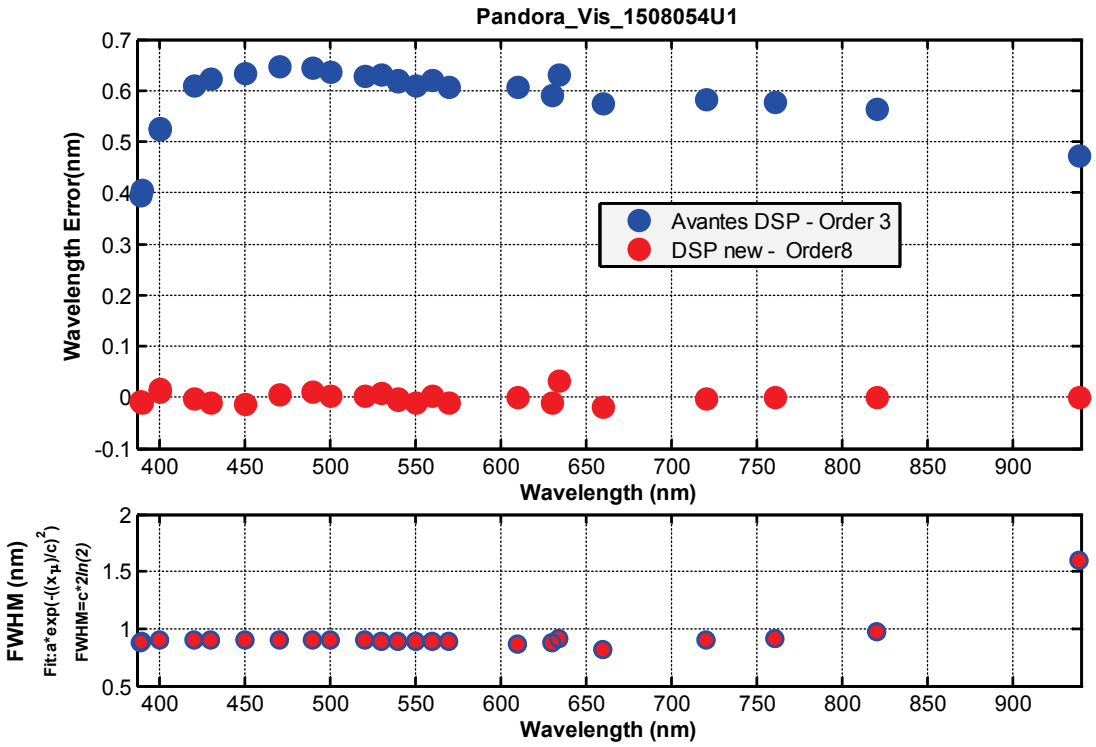

Figure 4: Pandora 120 Vis (1508054U1): Wavelength error using the manufacturer and ATLAS dispersion function (upper panel). Spectral FWHM of the Pandora 120 Vis over the spectral range 389-940 nm, defined as FWHM= c* 2ln(2) where the line spread function measurements are simulated by a 1st order gaussian fit.

Conclusions

The dispersion functions for Pandora 120 have been determined with an uncertainty of the order of 10 pm (1σ). The uncertainty of the dispersion functions is represented by the mean absolute residuals between the fit and LSA data (UV_ : 3±2 pm , Vis_: 7.6±5.2 pm). Differences from the manufacturers dispersion functions (not used by LuftBlick) are ranging between 0.01 nm and 0.15 nm for the UV spectrometer and 0.4 nm to 0.75 nm for the Visible. The FWHM of the spectrometers, described by a 1st order gaussian fit is quite constant over the detectors wavelength range and on average is 0.43 nm ± 0.02 nm and 0.92 nm ± 0.14 nm for the UV and Vis spectrometers respectively.

Data Available at

\\ad.pmodwrc.ch\Institute\Projects\ATLAS\ATLAS \characterization\Pandora_UV_1511216U1

\\ad.pmodwrc.ch\Institute\Projects\ATLAS\ATLAS \characterization\Pandora_Vis_1508054U1

Appendix

Pandora 120 UV (1511216U1)		
	LSA wavelength (nm)	Pixel
1	289.986	120.451
2	294.984	155.411
3	300.015	190.726
4	305.006	225.916
5	310.009	261.284
6	315.021	296.885
7	319.987	332.247
8	325.002	368.039
9	329.976	403.663
10	339.989	475.675
11	354.971	584.283
12	359.934	620.520
13	374.958	730.927
14	380.005	768.302
15	404.968	955.054
16	409.984	993.010
17	415.019	1031.352
18	420.013	1069.482
19	420.016	1069.464
20	435.011	1184.992
21	444.982	1262.661
22	474.962	1500.581
23	484.964	1581.616
24	489.968	1622.361
25	494.911	1663.020
26	500.001	1705.067
27	499.983	1704.871
28	504.963	1746.164
29	510.003	1788.241
30	515.059	1830.758
31	519.984	1872.310
32	524.958	1914.632
33	529.908	1957.041
34	534.885	1999.938

Pandora 120 Vis (1508054U1)		
	LSA wavelength (nm)	Pixel
1	388.958	7.301
2	389.980	10.818
3	399.959	45.268
4	420.025	114.248
5	430.022	148.629
6	450.028	217.602
7	469.984	286.732
8	489.954	356.183
9	499.954	391.060
10	519.940	461.071
11	529.841	495.914
12	539.852	531.178
13	549.888	566.647
14	559.879	602.123
15	569.902	637.723
16	609.946	781.190
17	629.811	852.957
18	633.820	867.652
19	659.785	962.142
20	720.434	1186.696
21	760.292	1337.011
22	820.537	1568.925
23	939.240	2045.481