## 5.3. Amundsen-Scott South Pole Station (1/10/98–1/11/99)

The 1998-99 season at Amundsen-Scott South Pole Station is defined as the time between the site visits 1/4/98 – 1/9/98 and 1/12/99 – 1/19/99. The season opening and closing calibrations were performed on 1/7/98 and 1/13/99, respectively. Volume 8 solar data comprise the period 1/10/98–1/11/99. During this time, the system operated normally and the responsivity remained stable to within ±5%. This uncertainty could be further reduced during data analysis. About 97% of the scheduled data scans are part of the published dataset; less than 0.5% of all scans were lost due to technical problems.

### 5.3.1. Irradiance Calibration

The site irradiance standards for the 1998-99 South Pole season were the lamps 200W006, M-763, and M-666. As with all other sites, lamp M-874 was the traveling standard, which was used during season opening and closing calibrations. The lamp has two calibrations from Optronic Laboratories, one from August 1995 and one from September 1998. As mentioned in the introduction to Section 5, there are strong indications that the lamp has drifted by 2% between the beginning and middle of 1998. The analysis showed that the 1995 Optronic Laboratories calibration had to be applied for the South Pole Volume 8 opening calibrations. For the closing calibrations in 1999, the Optronic Laboratories calibration from 1998 was used.

Lamp 200W006 was first used at the 1997 site visit and has an irradiance calibration from Optronic Laboratories from November 1996. Lamp M-763 has an Optronic Laboratories calibration from 1992 and has been in use at South Pole Station since 1992. Comparisons with M-874 and 200W006 indicate that M-763 has drifted by about 4% over the years. The lamp has therefore been recalibrated for processing of Volume 7 data and the same calibration was also implemented for Volume 8. The new calibration is based on a comparison with M-874 using absolute scans centered around the 1998 site visit. For M-874, the 1995 Optronic Laboratories calibrations have been used for this cross-calibration. The procedure applied is explained in Section 4.2.1.5.

Lamp M-666 does not have a calibration from an independent standards laboratory and was not used for calibration of the SUV-100 spectroradiometer. The lamp, however, is an important backup in case one of the site standards failed.

Figure 5.3.1 shows a comparison of 200W006 and M-763 with M-874 at the start of the season (day 1/7/98). All three lamps agree on the ±1% level. The good agreement of M-763 with M-874 was expected since M-763 was calibrated against M-874. The validity of the calibration of M-874 is confirmed via the good agreement with lamp 200W006, which has an independent calibration.

Figure 5.3.2 shows the comparison of the site standards at the end of season. The figure also presents lamp 200W021, which was introduced as a standard for South Pole during the site visit in 1999. The lamp was calibrated by Optronic Laboratories in September 1998. Figure 5.3.2 shows that the lamps 200W006, 200W021, and M-763 agree with each other at the ±0.5% level, but there appears to be a difference of about 0.5-1.5% to M-874, dependent on wavelength. In general, however, the agreement of all lamps is well within the typical uncertainties of irradiance standards calibrations both during season closing and opening calibrations, giving confidence in the solar data of the South Pole instrument from the 1998-99 season.

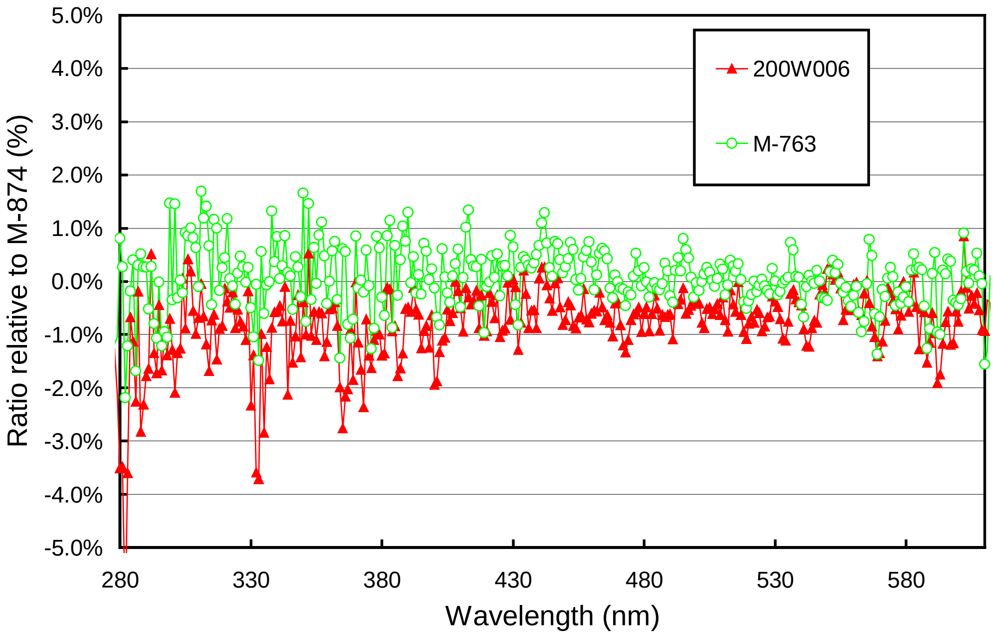


**Figure 5.3.1.** *Comparison of South Pole lamps 200W006 and M-763 with the BSI traveling standard M-874 at the start of the season on 2/7/98.*

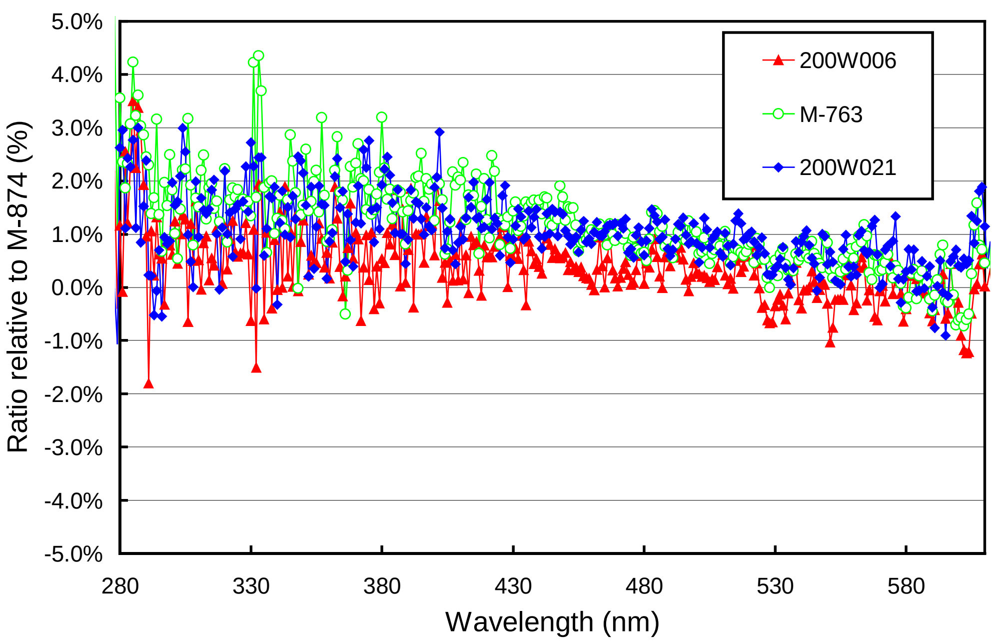


**Figure 5.3.2.** *Comparison of South Pole lamps 200W006, M-763, and 200W021 with the BSI traveling standard M-874 at the end of the season on 1/13/99.*

### 5.3.2. Instrument Stability

The stability of the spectroradiometer over time is primarily monitored with bi-weekly calibrations utilizing the site irradiance standards and daily response scans of the internal irradiance reference. The stability of the internal lamp itself is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts. When TSI measurements indicate that the internal lamp has drifted by more than 2%, a new irradiance is assigned to the lamp, based on the bi-weekly calibrations with the site standards (see Section 4.2.1.2). By logging the PMT currents at several wavelengths during response scans, changes in the instrument responsivity can be detected.

Figure 5.3.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the South Pole 1998-99 season. In addition, the variation in temperature in the upper part of the instrument is depicted. The TSI measurements show that the internal lamp was stable to within ±1% during the whole season.

The PMT currents at 300 and 400 nm indicate that the instrument was stable to within ±5% during the entire season. The instrument responsivity at both wavelengths gradually increased by 2-4% between the start of the season and the beginning of April. During the polar night, the responsivity decreased by approximately 3%. From mid-September 1998 onward, the responsitivity increased again 5-7% until the end of the season. A similar annual cycle has also been observed in McMurdo, both in the 1997-98 and 1998-99 seasons and could be caused by temperature variations of the instrument. Figure 5.3.3 also shows that the increase in responsivity in the last part of the South Pole 1998-99 season correlates well with the change in temperature of the upper part of the instrument, which is close to the cover of the roofbox. Since the thickness of the thermal insulation of the roofbox is limited for physical reasons it can be expected that the annual cycle in ambient temperature at South Pole is not completely compensated for by the instrument's temperature stabilization. The records of the different temperature sensors integrated in the system show that the temperature in the lower part is stable to within ±1°C during the season whereas the variation in the upper part is ±3°C. Note that the monochromator and the PMT are independently temperature stabilized; the monochromator temperature, measured at its base plate, was stable to within ±0.15°C.

The observed change in instrument responsivity does not affect solar data because the daily response scans are not only performed for monitoring drifts, but also for correcting these drifts. Changes from day to day, which would affect solar data, are below 0.5%.

Because of the good stability of the internal irradiance reference only one irradiance spectrum was assigned to this lamp for the whole season. This spectrum was calculated by analyzing 17 calibrations with the site irradiance standards carried out during this period, excluding scans performed during the polar night. From each of the 17 calibrations, irradiance values for the internal lamp were calculated and the mean-irradiance for this period was derived by averaging over the individual calibration functions, according to the procedure outlined in Section 4.2.1.2. The ratio of the standard deviation and average mean-irradiance, both calculated from the 17 calibrations, is a useful tool for estimating the variability of the calibrations during the season. As shown in Figure 5.3.4, the standard deviation is usually less than 1.5% of the average and slightly higher for wavelengths below 300 nm. Thus the calibrations are consistent to the ±1.5% (±1σ) level.

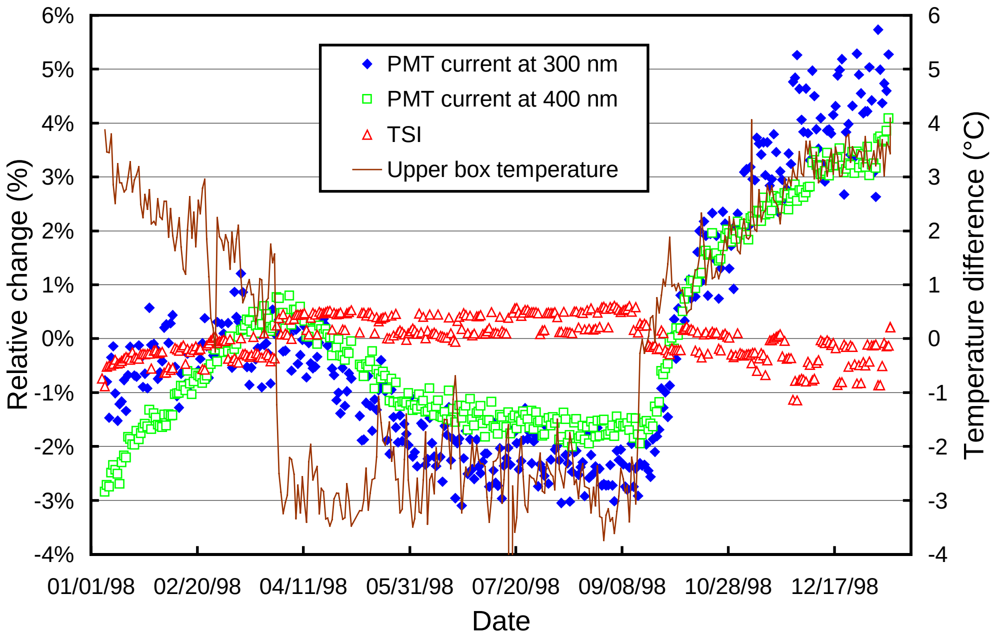


**Figure 5.3.3.** *Time-series of PMT current at 300 and 400 nm, instrument temperature, and TSI signal during measurements of the internal irradiance standard performed during the South Pole 1998-99 season. The data are normalized to the average of the whole period.*

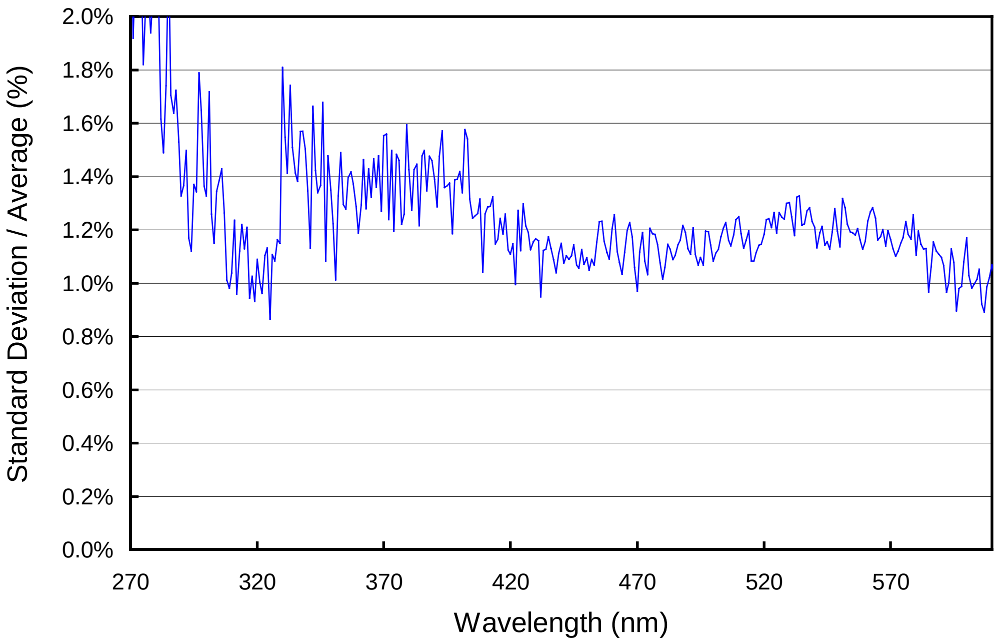


**Figure 5.3.4.** *Ratio of standard deviation and average calculated from the absolute calibration scans of the South Pole 1998-99 season.*

### 5.3.3. Wavelength Calibration

Wavelength stability of the system was monitored with the internal mercury lamp. Information from the daily wavelength scans was used to homogenize the data set by correcting day-to-day fluctuations in the wavelength offset. After this step, there may still be a deviation from the correct wavelength scale, but this bias should ideally be the same for all days. Figure 5.3.5 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 358 scans were evaluated. For 84% of the days, the change in offset was smaller than ±0.025 nm; for 99.7% of the days the shift was smaller than ±0.075 nm. The offset-difference was only larger than ± 0.1 nm for two scans on 11/19/98 due to communication problems between the computer and stepper motor control unit. The "pairing" of wavelength and data scans was adjusted appropriately.

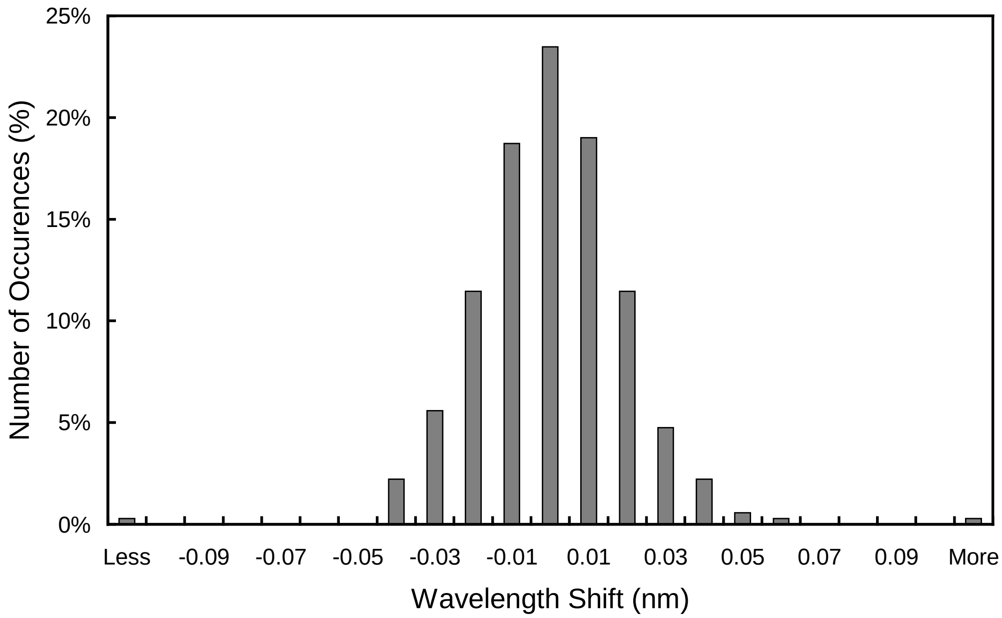


**Figure 5.3.5.** *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

After the data was corrected for day-to-day wavelength fluctuations, the wavelength-dependent bias between this homogenized data set and the correct wavelength scale was determined with the Fraunhofer-correlation method, as described in Section 4.2.2.2. The thick line in Figure 5.3.6 shows the resulting correction function that was applied to the Volume 8 South Pole data. The function clearly depends on wavelength, which is caused by non-linearities in the monochromator drive. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied, Figure 5.3.6 also includes a correction function that was calculated with the "old" method, i.e., the function is based on internal wavelength scans only. The average difference between both methods is 0.08 nm. As explained in Section 4.2.2, this bias is caused by the different light paths for internal wavelength scans and solar measurements.

After the data was wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Fraunhofer method. The results are shown in Figure 5.3.7 for four UV wavelengths. The residual shifts are generally smaller than ±0.1 nm. No data exist during the polar night from 3/21/98 – 9/23/98 because during this time, irradiance levels are too small for achieving a good-quality correlation. The actual wavelength uncertainty may be slightly larger due to wavelength fluctuations of about ±0.02 nm throughout a given day, and possible systematic errors of the Fraunhofer-correlation method (see Section 4.2.2.2).

Although data from the external mercury scans do not have a direct influence on the data products, they are, however, an important part of instrument characterization. Figure 5.3.8 illustrates the difference between internal and external mercury scans collected during both site visits. The wavelength scale of the figure is the same as applied during solar measurements; the scale is based on a combination of the Fraunhofer-correlation technique and wavelength-offset determination with internal mercury scans. The peak of the external scans, which have the same light path as solar measurements, agrees well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.13 nm to shorter wavelengths. External scans have a bandwidth of about 1.05 nm FWHM, whereas the bandwidth of the internal scan is only 0.78 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans. During the 1998 site visit, the wavelength setting of the spectroradiometer was not changed between the internal and external wavelength scans. During the 1999 site visit, however, it was adjusted between both scan types by -0.052 nm. The data plotted in Figure 5.3.8 have been adjusted for this shift but the uncertainty is larger than usual for comparisons of internal and external scans. This might explain why internal scans in Figure 5.3.8 appear to be shifted by 0.03 nm. Since external scans are used for instrument characterization only, this shift has no impact on solar measurements.

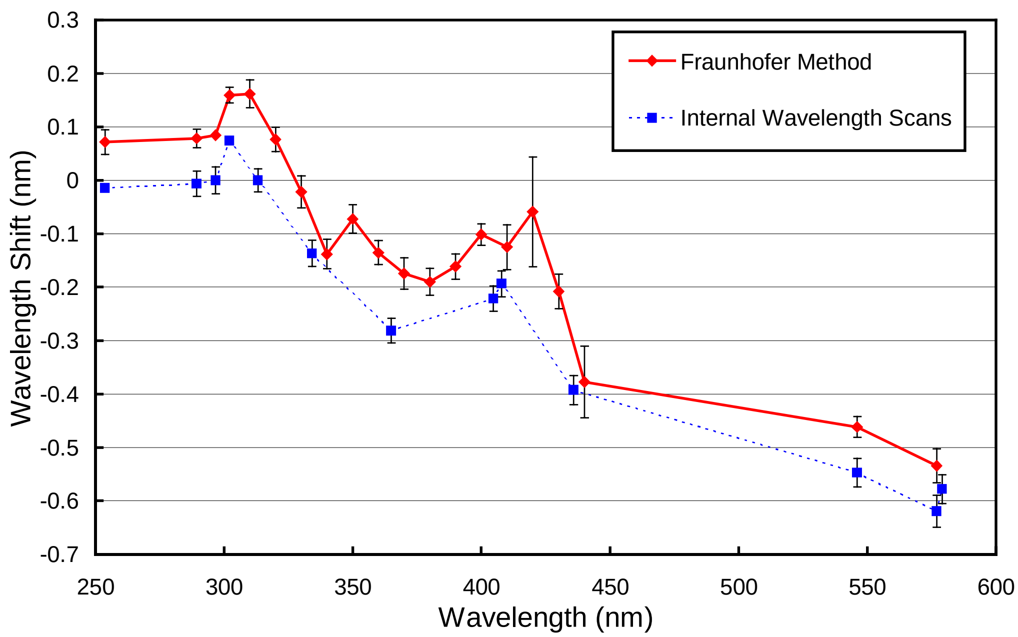


**Figure 5.3.6.** *Monochromator non-linearity for the South Pole 1998-99 season. Thick line: Correction function calculated with the Fraunhofer-correlation method, applied to correct the South Pole Volume 8 data. Thin broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is 0.08 nm. The error bars show the 1σ standard deviation of the wavelength shift for the season.*

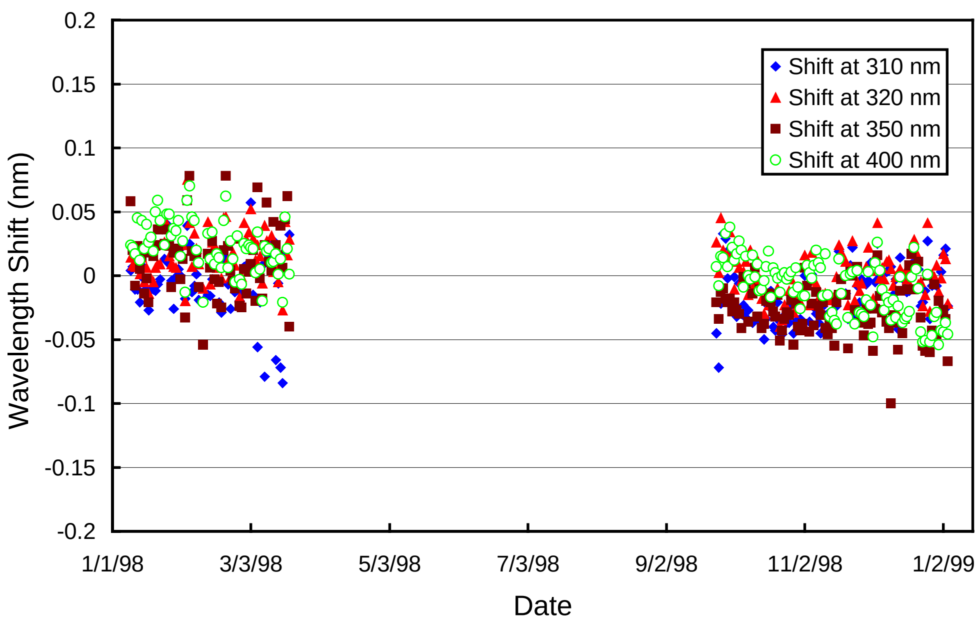


**Figure 5.3.7.** *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No data exist during polar night from 3/21/98 – 9/23/98.*

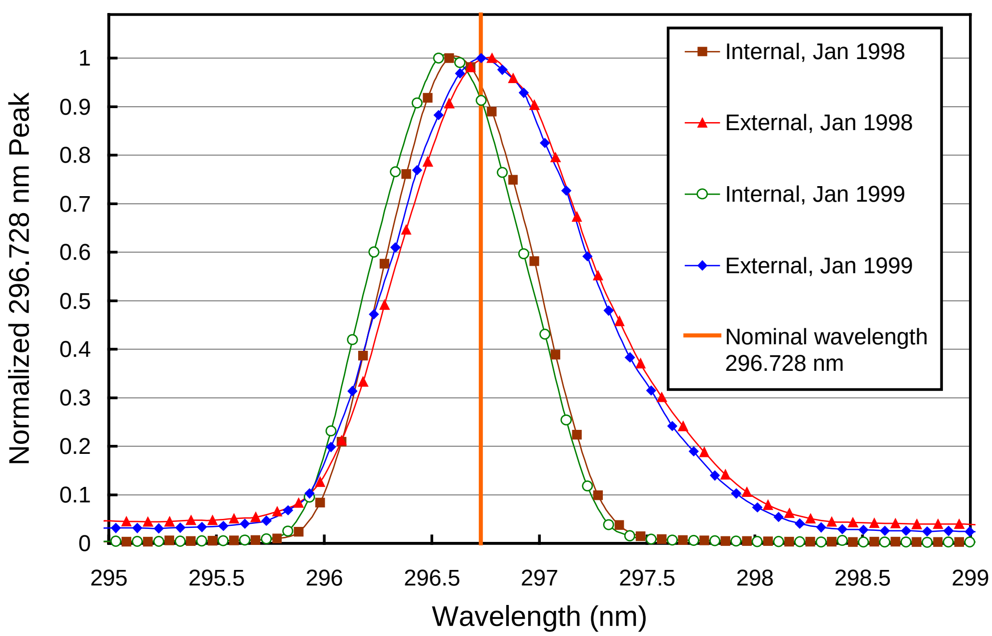


**Figure 5.3.8.** *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method.*

### 5.3.4. Missing Data

A total of 18318 scans with solar zenith angles smaller than 92° were scheduled to be measured in the South Pole Volume 8 season. Of these scans, 17787 (97.1%) were found to be of good quality and are therefore part of the published dataset. Of the missing scans, 55, 200, and 197 were superseded by absolute, wavelength, and response scans, respectively. Since South Pole Station has 24 hours of sunlight per day during the austral summer, a loss of data scans cannot be avoided. Approximately 17 scans were lost on day 11/19/98 because of communication problems between the system control computer and one of the electronics modules (SpectraLink). Although they had been scheduled, a total of eight scans were not started during the season by the computer for unknown reasons. A total of 49 scans were found to be defective, 30 of which occured on 11/19/98. The reason is also related to communication problems. Both incomplete and defective scans were excluded from the dataset. A total of 18245 scans are listed in the published databases, including 456 scans with solar zenith angles between 92° and 95°.