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CALIBRATION AND DEPLOYMENT OF SOLID STATE SPECTRORADIOMETERS FOR LONG-TERM SOLAR UV MONITORING

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1: INTRODUCTION

The state of the art instrument for measuring solar radiation at the earth's surface is the traditional scanning spectroradiometer, and its derivatives such as Brewer spectrophotometers. However such instruments suffer some disadvantages: high cost (~€100k), susceptibility to movement, and speed of operation.

Solid state (CCD and photodiode) instruments however are relatively inexpensive, stable and acquire data over a wide wavelength range simultaneously. The disadvantages of these newer instruments is their reduced response at the shortest wavelengths, smaller dynamic range and, due to the intrinsic single-monochromator design, susceptibility to stray light.

This project aims to overcome these issues in order to deploy two dual channel spectrometer systems in conjunction with a stand-alone solar tracker in an atmospheric monitoring setting. The deployed system will acquire simultaneous measurements of direct and global spectral irradiance. These spectra can be processed to derive a continuous data series of ozone and other absorbing species, as well as wavelength-integrated radiometric quantities such as erythemally-weighted UV, PAR, etc – with minimal data loss due to scanning and sampling issues.

2: WEATHERPROOF HOUSING

- Before field deployment weatherproof enclosures are required to ensure a stable temperature, low humidity and prevent water ingress.
- Based on Supercool PR-59 regulator system
- Peltier controls temperature only critical instrument parts; ancillary components remain on warm side
- Tests in Manchester Ice Cloud Chamber show temperature stabilised to ±0.01ºC in steady-state conditions, ±0.05ºC for rapid ambient changes over range from –20ºC to +40ºC

Weatherproof housing for Ocean Optics S2000 dual channel spectrometer

5: FUTURE WORK

- Incorporate stray light determination (following Kreuter and Blumthaler 2009) and absolute calibration (responsivity) tasks into calibration software
- Deploy instruments and automate data back-up and processing
- DOAS retrieval of ozone and long-term intercomparison with Brewer #172 at Manchester surface radiation monitoring site.
- Intercomparison of spectral data against Bentham DTM300

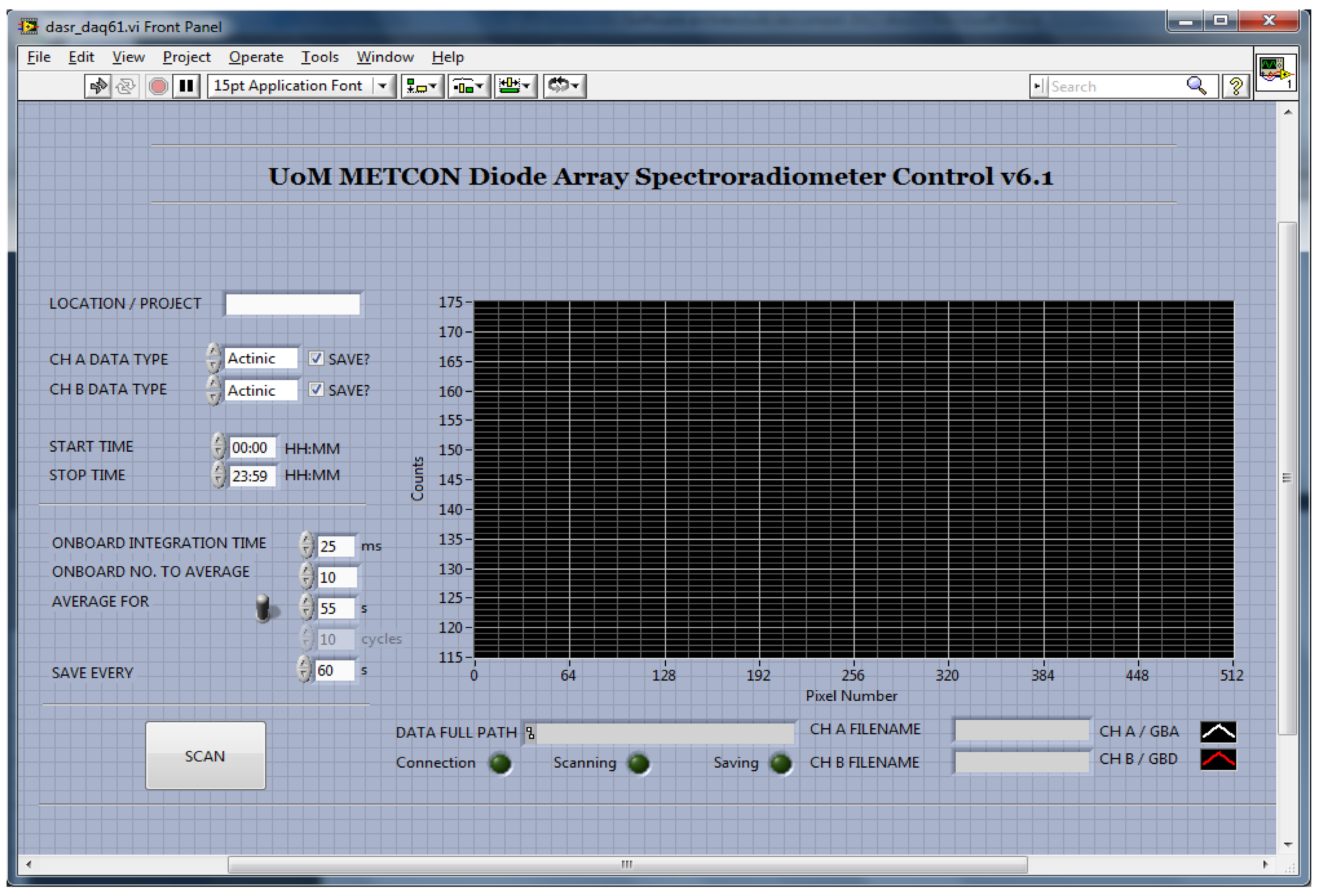
REFERENCES

Shortis MR, Clarke TA, Short T. (1994). *A comparison of some techniques for the subpixel location of discrete target images.* Videometrics III. SPIE **2350**, 239-250..

Kreuter A, Blumthaler M. (2009). *Stray light correction for solar measurements using array spectrometers.* Review of Scientific Instruments **80,** 096108

3: CONTROL SOFTWARE + CALIBRATION

- Custom software designed to separate day-to-day data acquisition of level_0 (raw) data from calibration procedure
- Integration time selected so that CCD is never saturated; two-stage signal averaging used to improve SNR
- Common integration time used for calibration and DAQ
- Task-centric approach used for calibration control software to ensure long-term consistency
- Dark current determination as first stage of calibration procedure (especially important at UV wavelengths and can exhibit structure)
- Combined Hg and Ar pencil lamp emission lines for wavelength calibration (253.6nm to 826.3nm); sub-pixel peak position found using centroid method (Shortis et al 1994)



LabView front panel showing MetCon data acquisition module

4: INSTRUMENT CHARACTERISATION

Quantity	Recommended	Ocean Optics (GBO)	Metcon PDA (GBA)
Max. Irrad. at 400 nm	> 2 $Wm^{-2}nm^{-1}$	Yes	Yes
Detection (*) threshold	< 10^{-3} W $m^{-2}nm^{-1}$	< $2.5x10^{-2}$ W $m^{-2}nm^{-1}$	< $1.0x10^{-2}$ W $m^{-2}nm^{-1}$
Stray light (**)	< 10^{-3} W $m^{-2}nm^{-1}$	< $2.5x10^{-2}$ W $m^{-2}nm^{-1}$	< $1.0x10^{-2}$ W $m^{-2}nm^{-1}$
Bandwidth (FWHM)	< 1 nm	1.19 nm	2.2 nm
Slit function	< 10^{-3} of maximum at 2.5 FWHM away from centre	No ($5.0x10^{-3}$)	Yes ($0.5x10^{-3}$)
Sampling wavelength Interval	< 0.2 FWHM (> 5 pixels/FWHM)	No (4 pixels/FWHM)	No (< 2 pixels/FWHM)
Wavelength precision	< ±0.05 nm	< ±0.01	< ±0.01
Wavelength accuracy	< ±0.1 nm	< ±0.1	< ±0.1
Nonlinearity	< 2%	< 6%	< 4%
Instrument temperature	Sufficient to maintain overall instrument stability	< 0.1° C	< 0.1° C
Measurement frequency	> 0.1 Hz	Yes	Yes
Overall calibration uncertainty	< ±10% (unless limited by detection threshold)	< ±6%	< ±6%
Scan date and time	Recorded with scan time is known to within 1 s	Yes	Yes
Cosine error: incidence angles <60° azimuth error	< ±5 % < ±3 %	< ±? % < ±3 %	< ±3 % < ±3 %
Levelling accuracy	< 0.2°	Yes	Yes

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