New detection system for UV solar reference scanning spectroradiometers

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UV solar spectrum

- 6 decades dynamic range in UV from 280 to 400 nm
- 3 decades change over a 20 nm range of wavelength
- Low irradiance below 300 nm
UV solar reference spectroradiometer

- Scanning double-grating-monochromator based systems
- typically:
  - Grating 1200 G @ 250 nm
  - FWHM < 1 nm, scanning step < 0.5 nm
  - Cosine correction diffuser and light guide as an entrance optics

- Measurement must be completed in few minutes (integration time of each reading is limited)
Advantages:
+ reasonable wavelength uncertainty (0.2 nm)
+ excellent spectral purity $> 10^6$ (stray light suppressed)

Drawback:
- Very low optical throughput, attenuation typically $10^4 - 10^6$
Photomultiplier Tube

Pros:
- Very sensitive
- High dynamic range

Cons:
- Non linear in response
- Memory effect
- Responsivity can change up to 5% in one day

*Figure 2* Responsivity changes of B5503 during the intercomparison at RIVM, July 2003

*Julian Gröbner: Progress report of the travelling reference spectroradiometer B5503*
Using PMT as detector for UV solar reference scanning spectroradiometers is a current barrier for improving its measurement uncertainty below 5%.

**Project Target:**

To replace PMT by better detection system to reach the total measurement uncertainty of 1%
Proposed detection system

Based on solid state semiconductors (unbiased detectors) and high sensitive electronics

**Ideal characteristics:**

- High UV sensitivity
- UV stability
- uncertainty 1% (over 90% of the wavelength range)

**Current candidates:**

- Si
- ZnO
- SiC
Si detector

Pros:
- Physics of photon–carrier conversion in semiconductors well known
- Low temperature dependence
- Low intrinsic noise

Con:
- Sensitivity < 0.2 A/W@ 350nm
- Applicability range 1nW-1mW

Current selected candidate – Hamamatsu S1227 33BQ
ZnO detector

Pros:
- Wide band gap (3.1 eV - 3.3 eV) semiconductor ideal for UV
- Higher responsivity (reported typically 2 A/W at 360 nm)
- Low price material.
- Visible blind (*not important for QASUME*)
- UV stable

Cons:
- not easily commercially available

Detectors currently fabricated in INRIM Torino
- 2nd run of detector production in progress
- fabrication process being optimised
Low noise electronics

Switched integrator amplifier (SIA)

- Gain proportional to the integration time
- High dynamic range up to 7 decades
- Gain calibration at very high gain with low uncertainty 0.01%
- Low noise
- Dynamic gain adjustment through software – allows for optimized signal gain
• Linearity measurement (CMI-MSL)
  – NL< 30 ppm

• Noise performances
  – NEP 12 fW @ 400 nm

• Dark current
  – < 0.04 pA

• Temperature dependence
  – 0.03 - 0.04 %.K⁻¹

\[
NL(p_{g+b}) = 1 - \frac{(P_g + P_b)}{P_{g+b}}
\]
Noise Performance SIA + Si

Spectral noise distribution with integration time 0.1 s
Current and future work

- Experimental thorough characterisation of SSDS1
  - optimisation of detection procedure
  - laboratory and in-field measurement campaign (CMI&PMOD September 2012)

- Plan B:
  - fabrication of optimised series of ZnO in INRIM, its optical and electrical characterisation (INRIM, December 2012)