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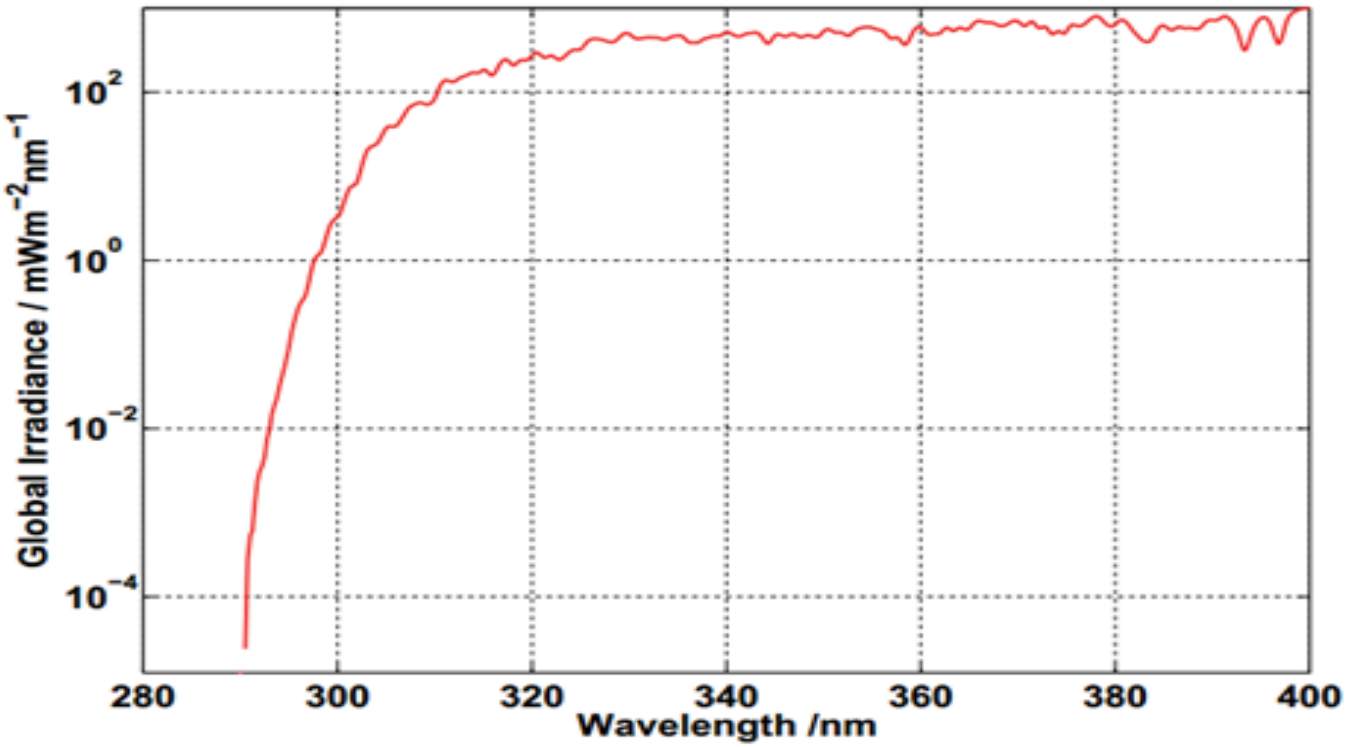
New detection system for UV solar reference scanning spectroradiometers

G. Porrovecchio, **M. Smid**, J. Groebner, M. Rajteri, C. Portesi, K. Nield and L. Egli

msmid@cmi.cz

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



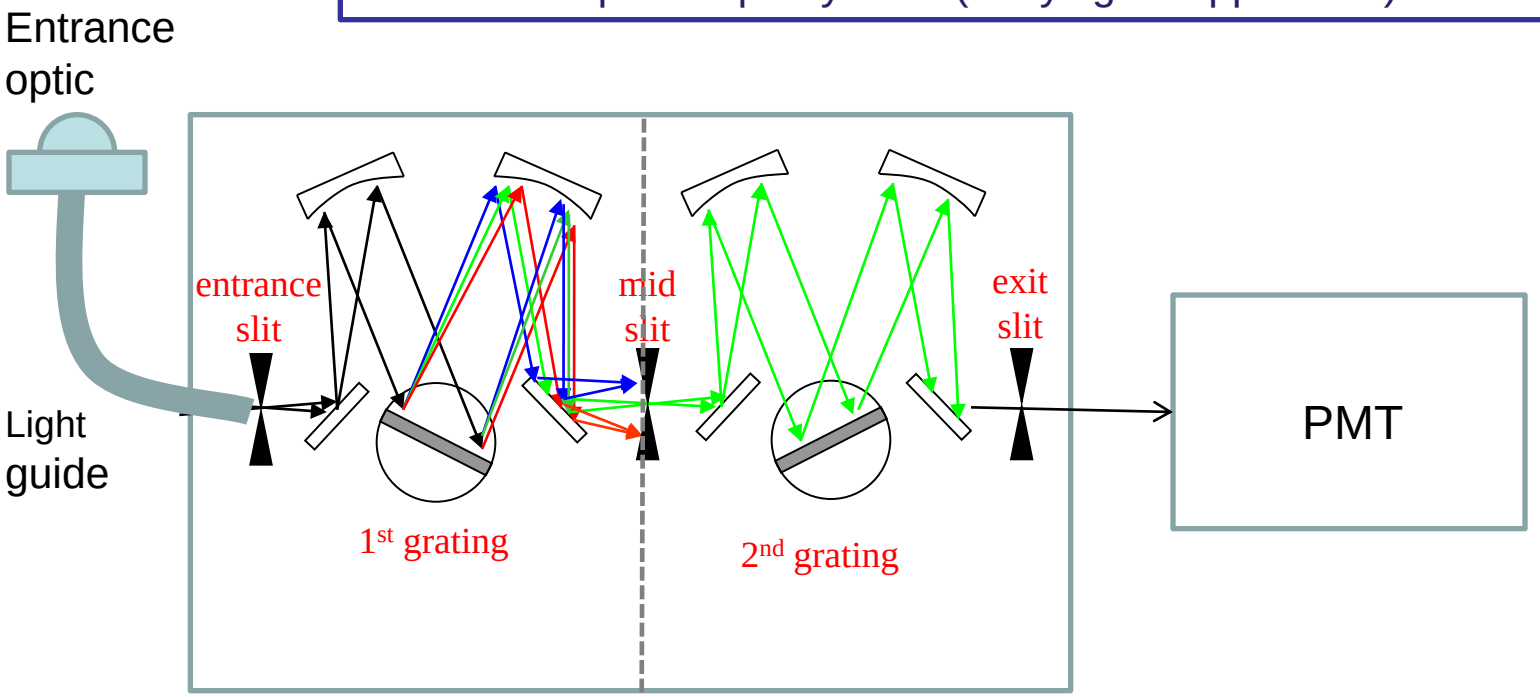
UV solar reference spectroradiometer

- 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)

UV solar reference spectroradiometer

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

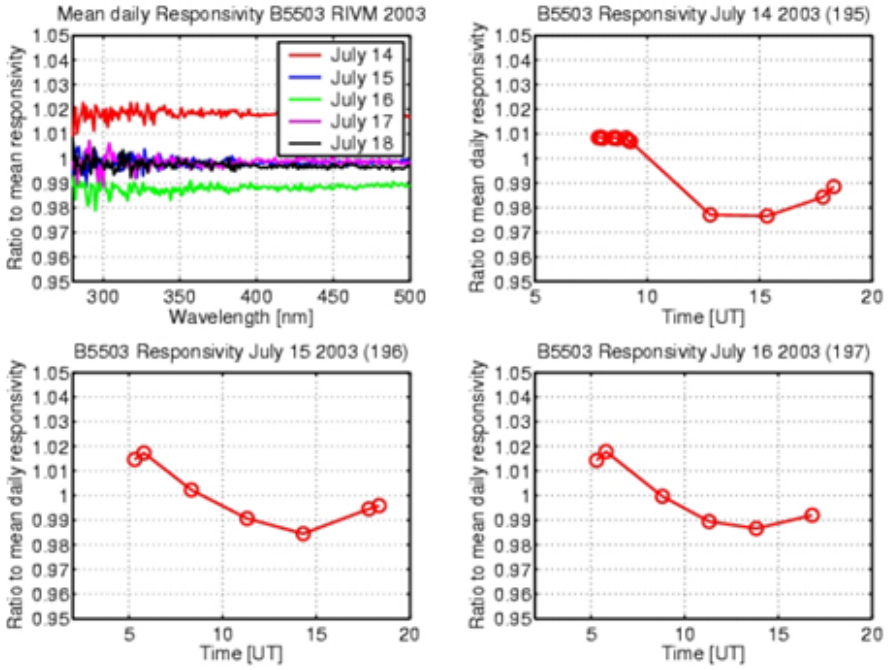


Figure 2 Responsivity changes of B5503 during the intercomparison at RIVM, July 2003

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

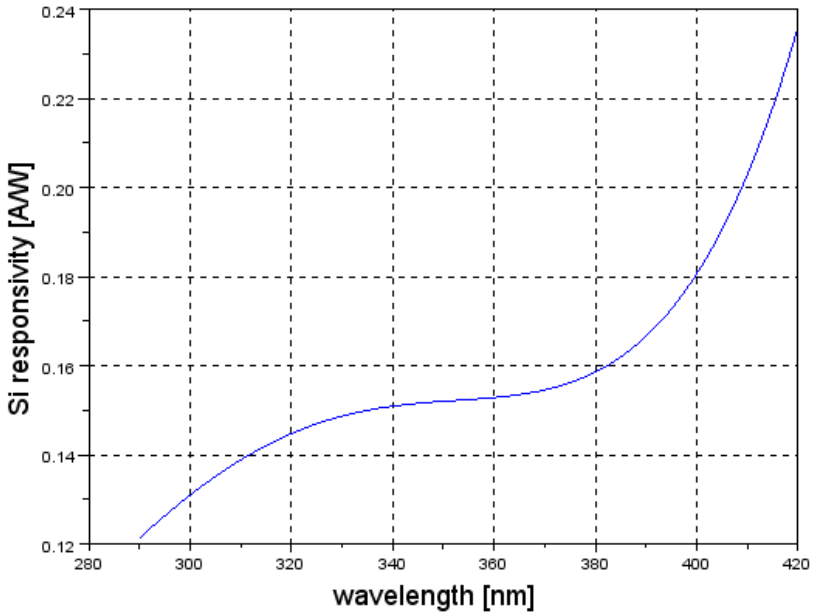
Si detector

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

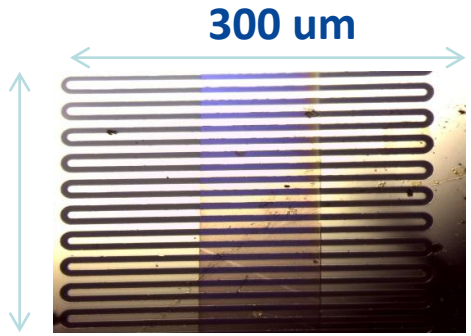
ZnO detector

Pros:

- Wide band gap (3.1 eV - 3.3 eV) semiconductor ideal for UV
- Higher responsivity (reported typically2 A/W at 360 nm)
- Low price material.
- Visible blind (*not important for QASUME*)
- UV stable

Cons:

- not easily commercially available

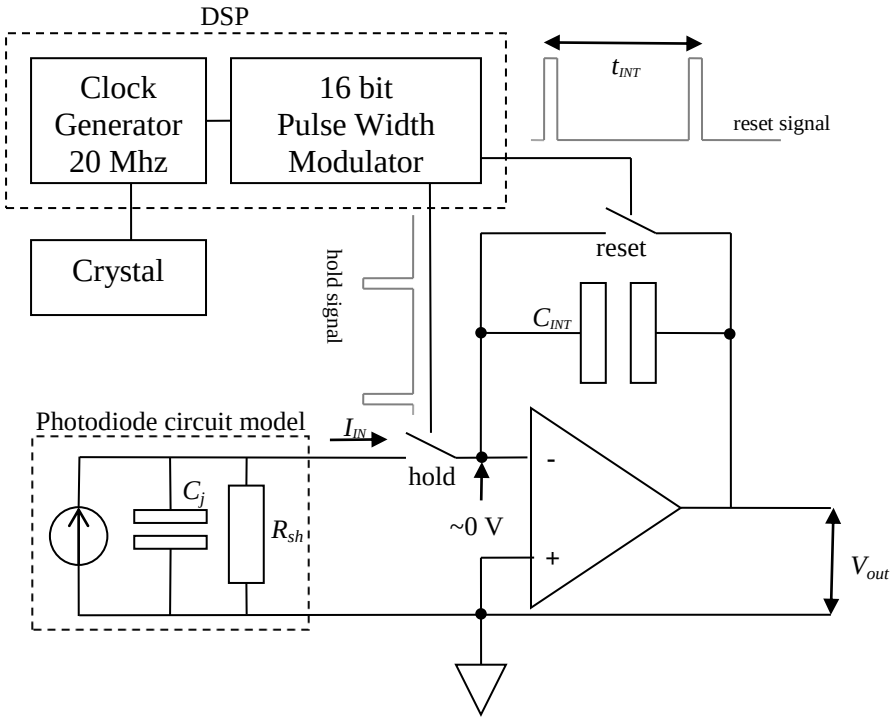


Detectors currently fabricated in INRIM Torino

- 2nd run of detector production in progress
- fabrication process being optimised

Low noise electronics

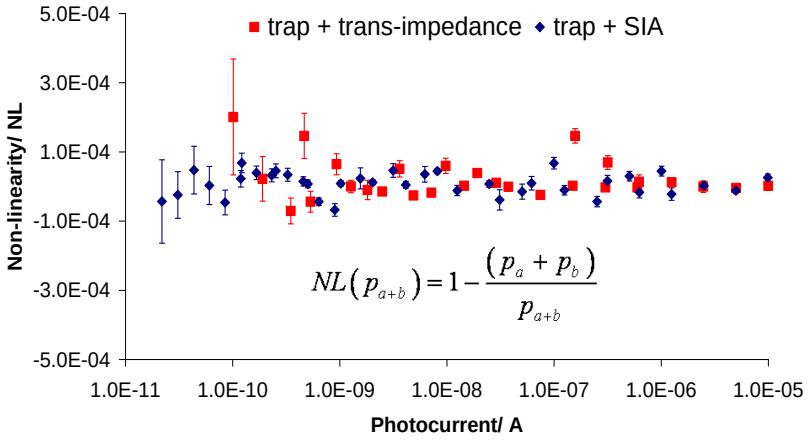
Switched integrator amplifier (SIA)



- 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

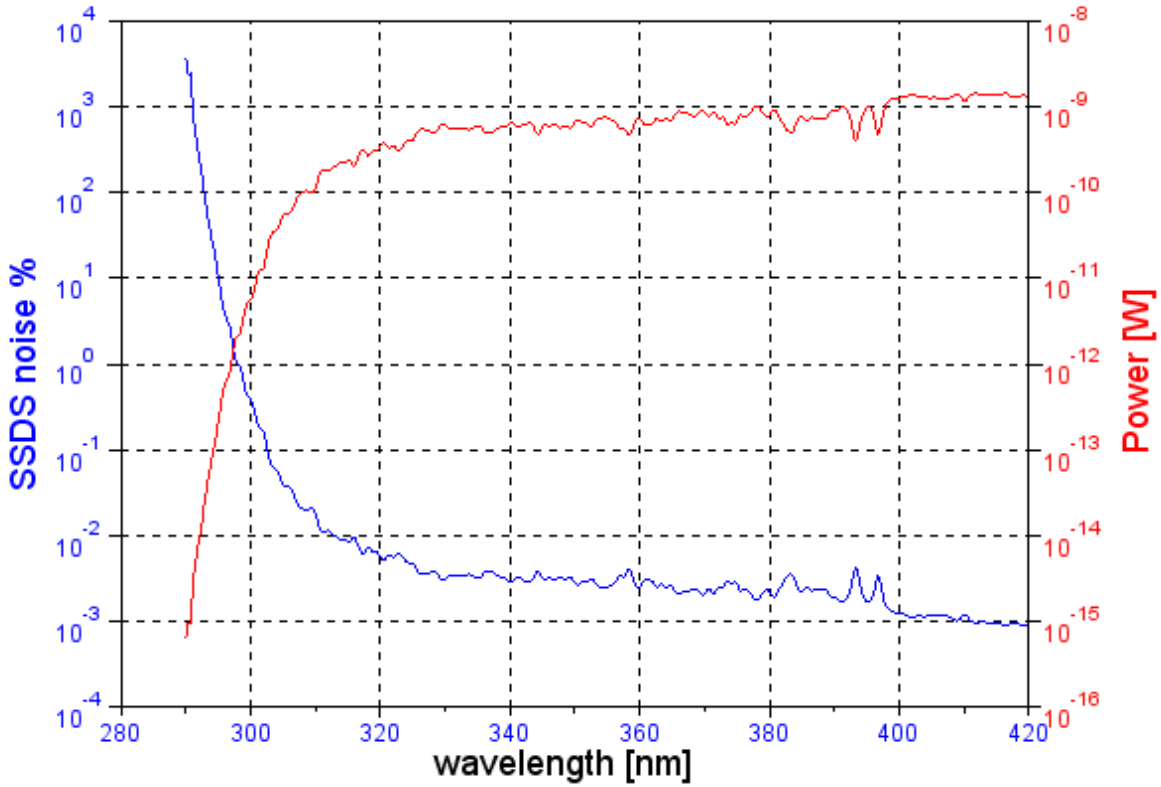
SIA + Si detector (SSDS 1)

- Linearity measurement (CMI-MSL)
  - NL< 30 ppm
- Noise perfomances
  - NEP 12 fW @ 400 nm
- Dark current
  - < 0.04 pA
- Temperature depencence
  - 0.03 - 0.04 %.K^{-1}



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-filed measurement campaign (CMI&PMOD September 2012)
- Plan B:
  - fabrication of optimised series of ZnO in INRIM, its optical and electrical characterisation (INRIM, December 2012)