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Hybrid detection system for the solar reference UV solar spectrometer QASUME

EMRP ENV03

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The motivation

QASUME is double monochromator (DM) based UV solar reference spectroradiometer.

Pro : minimized stray light

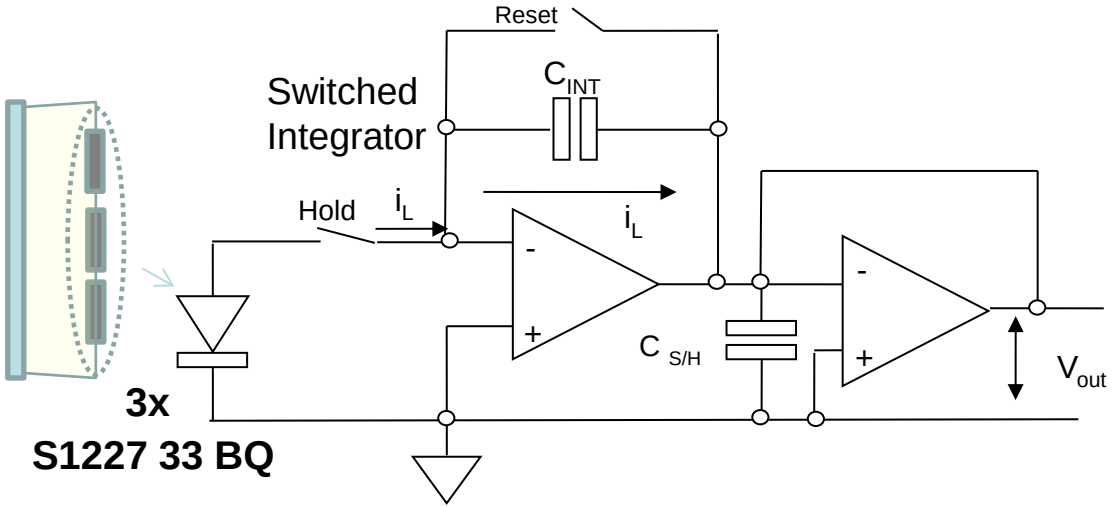
Cons : very low irradiance levels at the DM exit slit output (fW level at 280nm!) ➔ current detector is a photomultiplier ➔ quantum efficiency stability, memory effect ..

Improve the current solar reference UV spectroradiometer QASUME uncertainty (about 4%) using a detection system that includes silicon photodiode and high sensitivity electronics (SSDS)

First prototype and measurement campaign

Three low noise small area Hamamatsu S1227 33 BQ silicon detectors in conjunction with custom made switched integrator amplifier : photocurrent to voltage conversion factor up to 10^{11}

QASUME exit slit

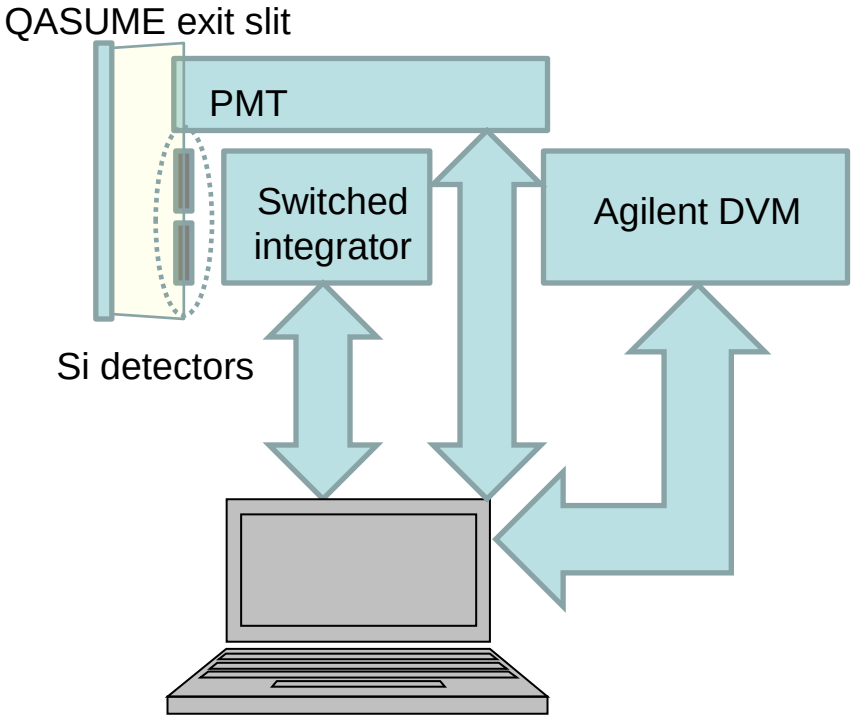


- I/V gain proportional to integration time.
- Linearity better than 5e-4
- Noise close to the thermal fluctuation of the charge carriers generated in the silicon photodiodes at 23 °C

$$V_{out}(t) = -\frac{t_{INT}}{C_{INT}} I_{IN}$$

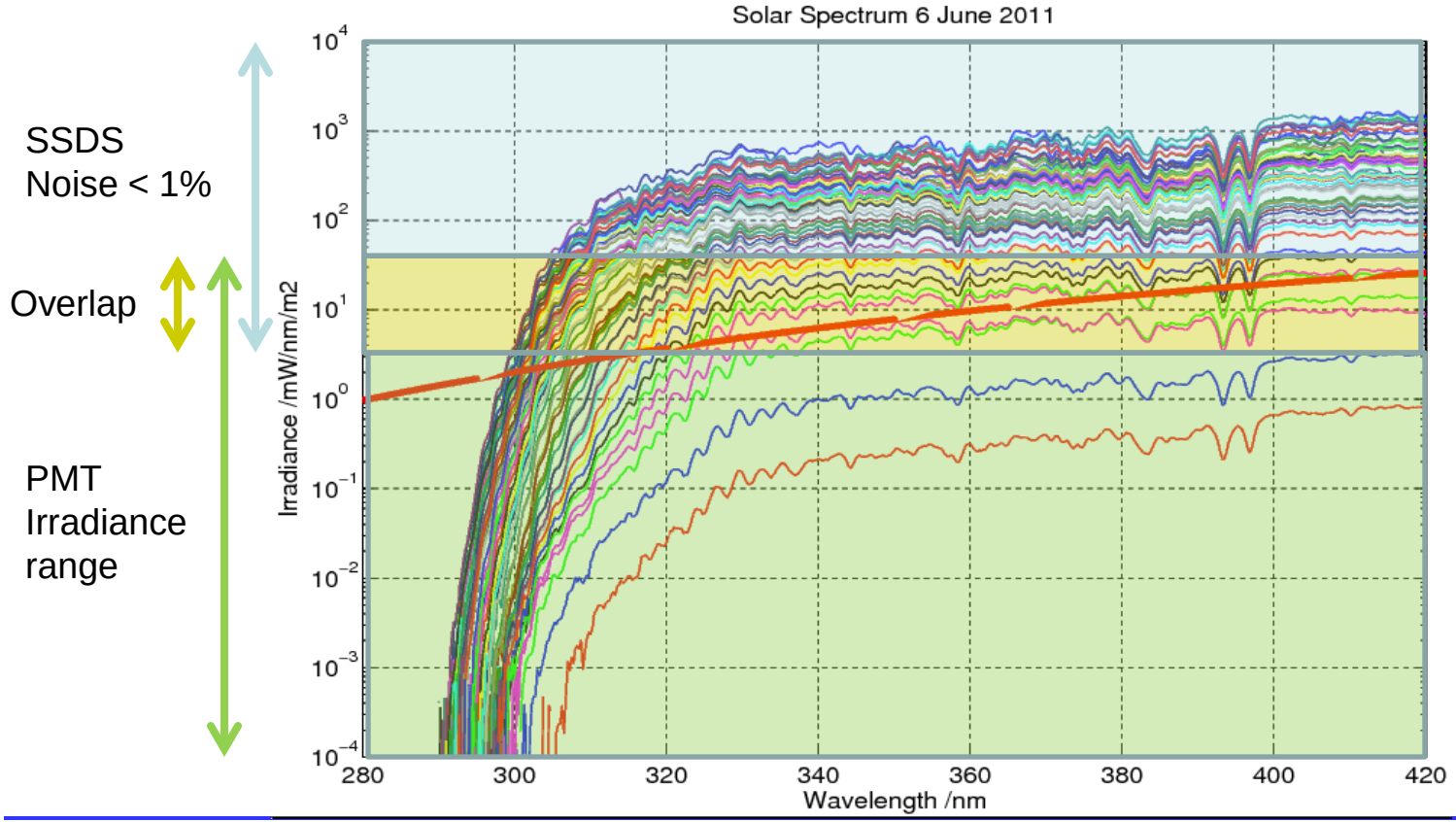
Baseline (dark current detector + input bias current amplifier + leakage currents) variations during a solar spectrum measurement (~15 minutes) are significant

Hybrid concept



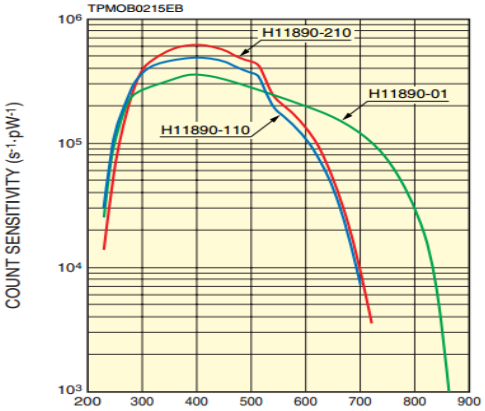
- The QASUME DM exit slit illuminates PMT and Silicon detectors at the same time.
- The PMT will cover the solar spectrum part that is below the sensitivity threshold of the silicon detectors
- The SSDS will provide stable reference for most of the spectrum of interest
- New electronics with ultra low input bias current and improved layout to have better baseline stability
- Number of diodes (1 to 3) as tradeoff between signal to noise ratio and baseline stability

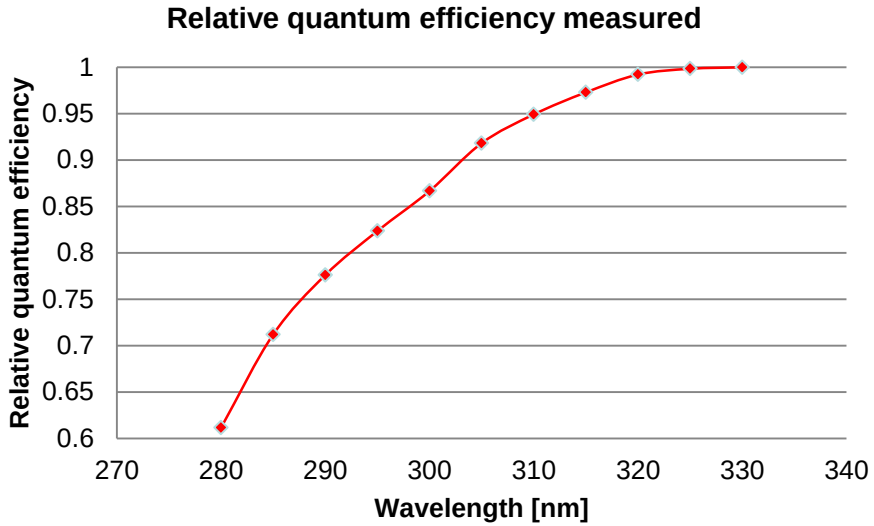
Hybrid strategy



Photomultiplier

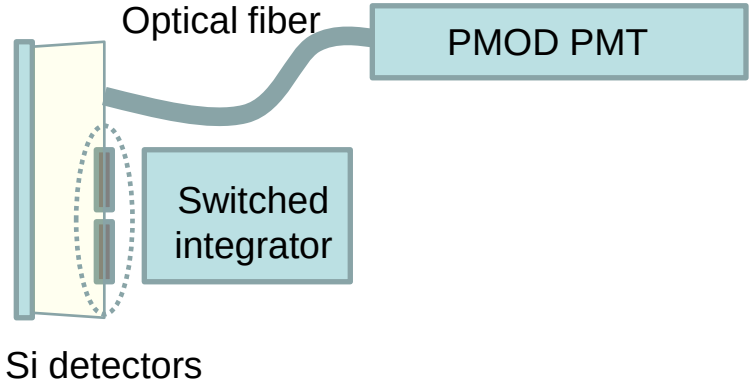
- New Hamamatsu model H11890 (USB interface)
- Peak sensitivity @400 nm ~$6 \cdot 10^5$ counts/pW
- Sensitivity area diameter 8mm
- Low dark counts <100 counts/s





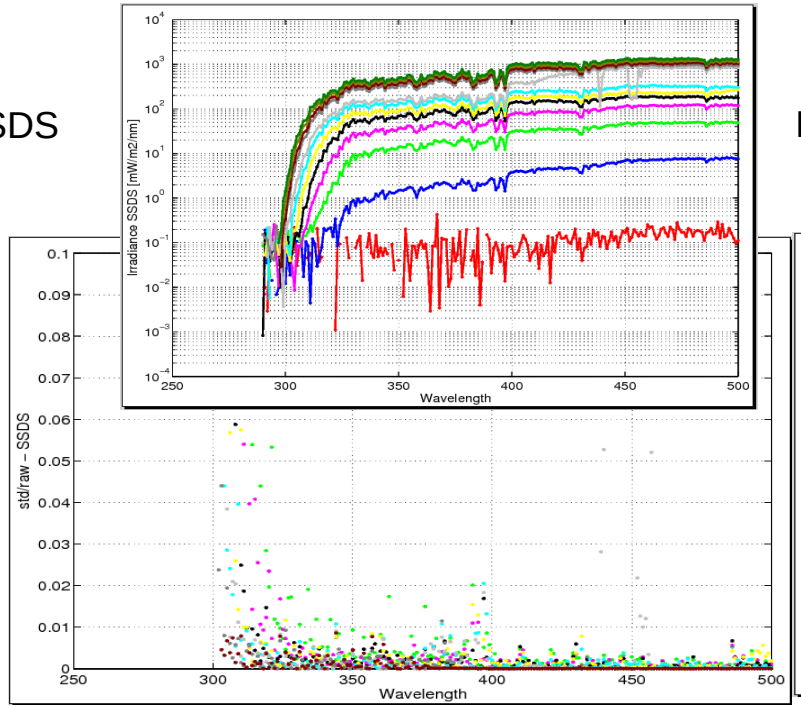
Hybrid prototype and 2nd measurement campaign

- PMT USB interface failed !!
- Fiber coupled PMOD PMT
- SSDS baseline stability better than 3 fA/12h
- Integration time 1s ➔ I/V 10^{12}
- Noise <10 fW/Hz^{½} @ 450 nm
- Wavelength shift between SSDS and PMT

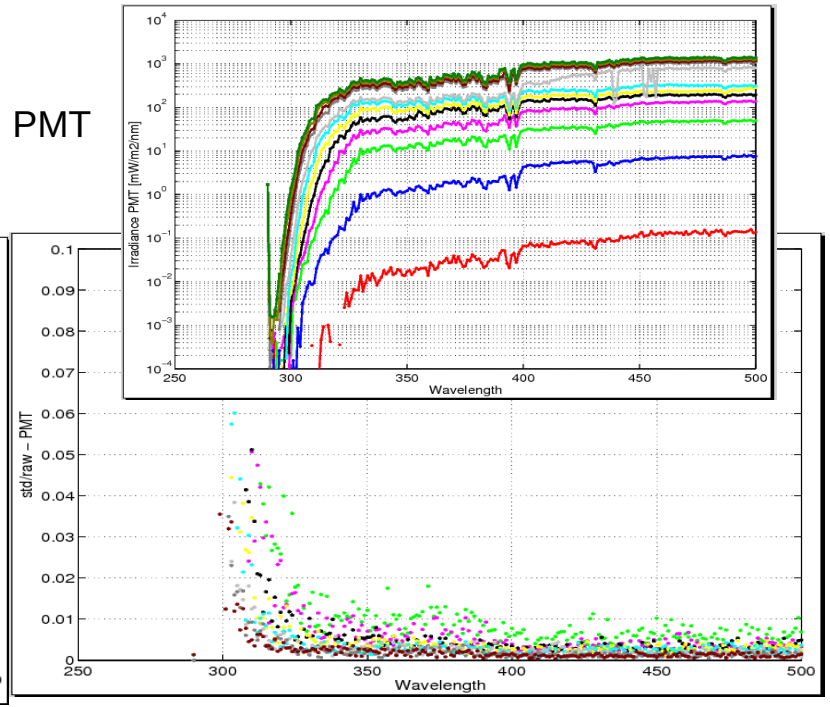


Solar measurement results

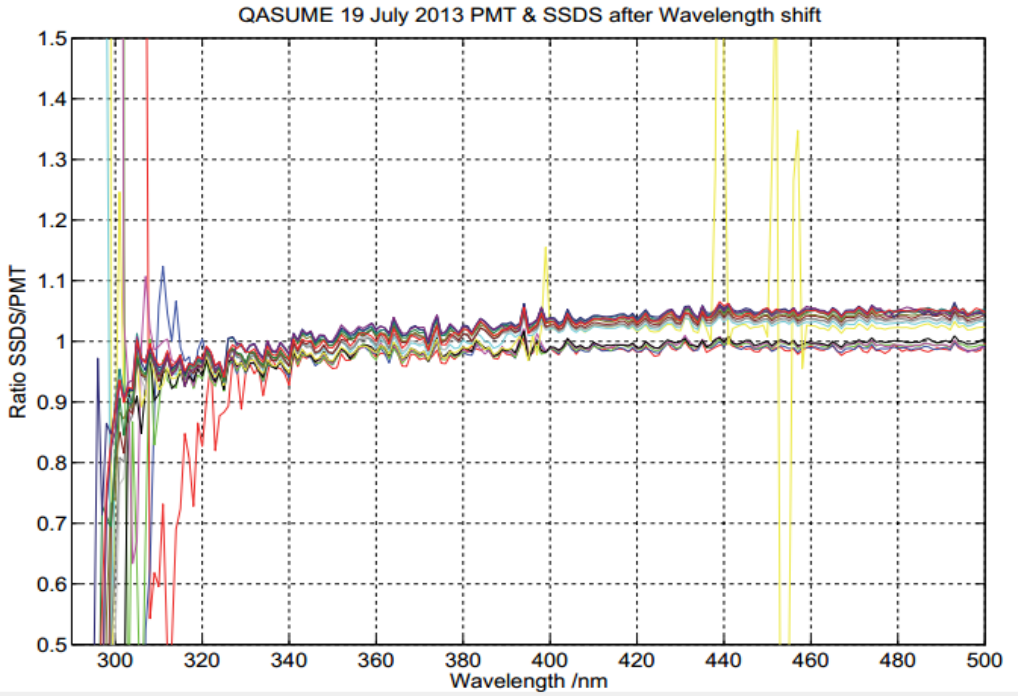
SSDS



PMT



Ratio irradiance SSDS/PMT



New challenges & future work

- 3rd Measurement campaign in autumn 2013
  - Hybrid detection system with H11890
  - Wavelength shift between PMT and SSDS
  - SSDS baseline measurement optimization
  - Improvement SSDS integration time selection strategy