A pulsed Tuneable LAser system for the characterisation of Spectrometers (ATLAS).

Julian Gröbner, Stelios Kazadzis, Natalia Kouremeti

Physikalisch Meteorologisches Observatorium Davos, World Radiation Center, PMOD/WRC

pmod wrc

Project Deliverables

Project Duration : March 2015 – June 2016

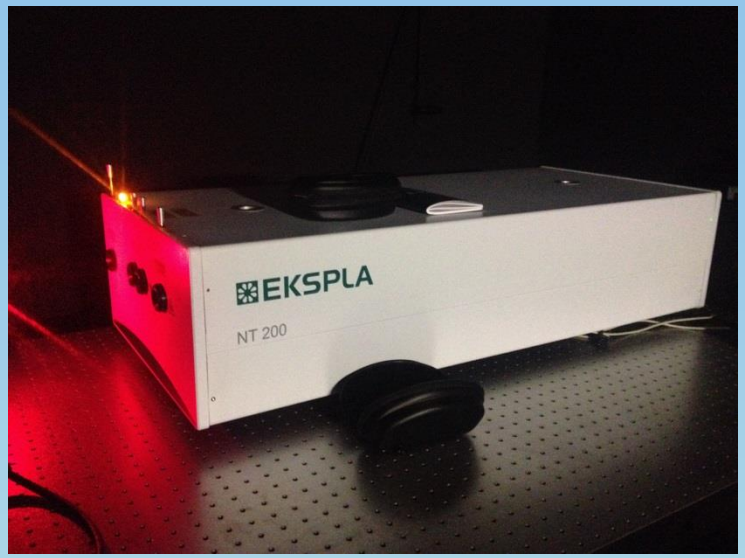
- **WP1:** Commissioning of tuneable laser system.
- **WP2**: Radiometric characterisation of 2 array spectroradiometers using tuneable laser sources
- **WP3**: Development of correction methodologies for stray light and linearity

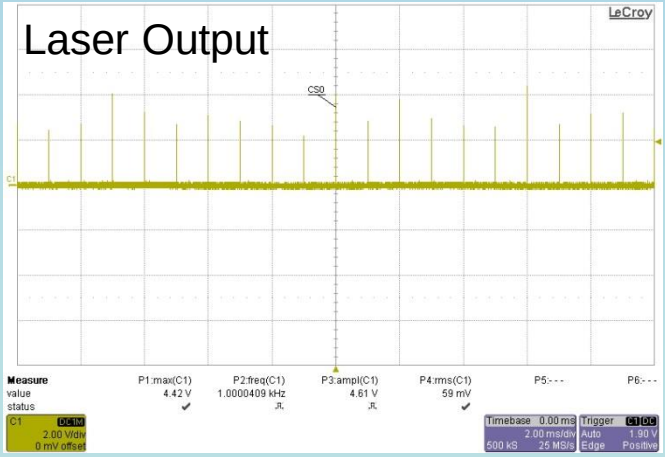
pmod wrc

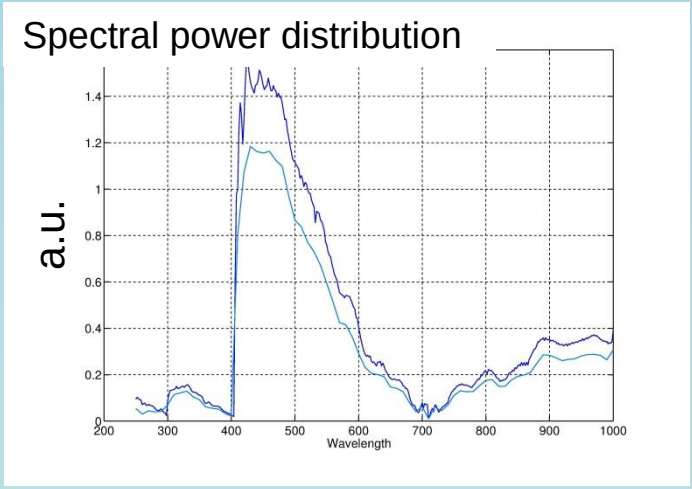
WP1 Commissioning of tuneable laser

Delivered August 2015

- Tuning range 210 -2600 nm
- Pulse 5 ns
- repetition rate 1000 Hz
- Pulse power at 450 nm ~300 mW





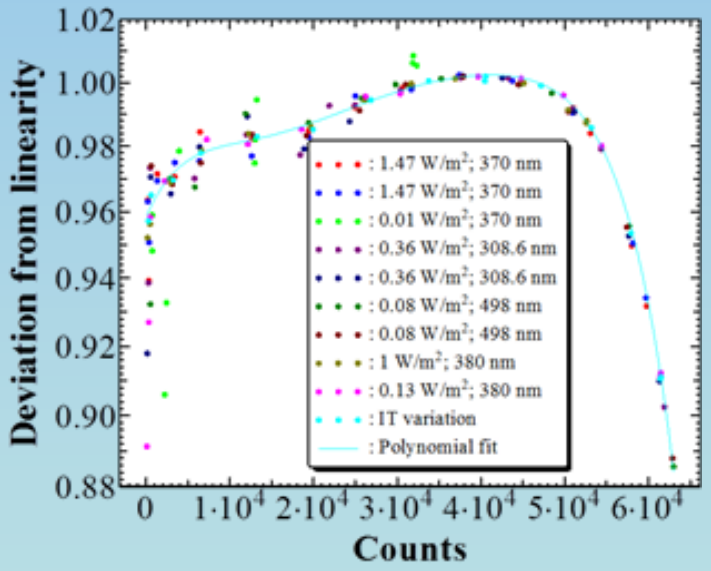


pmod wrc

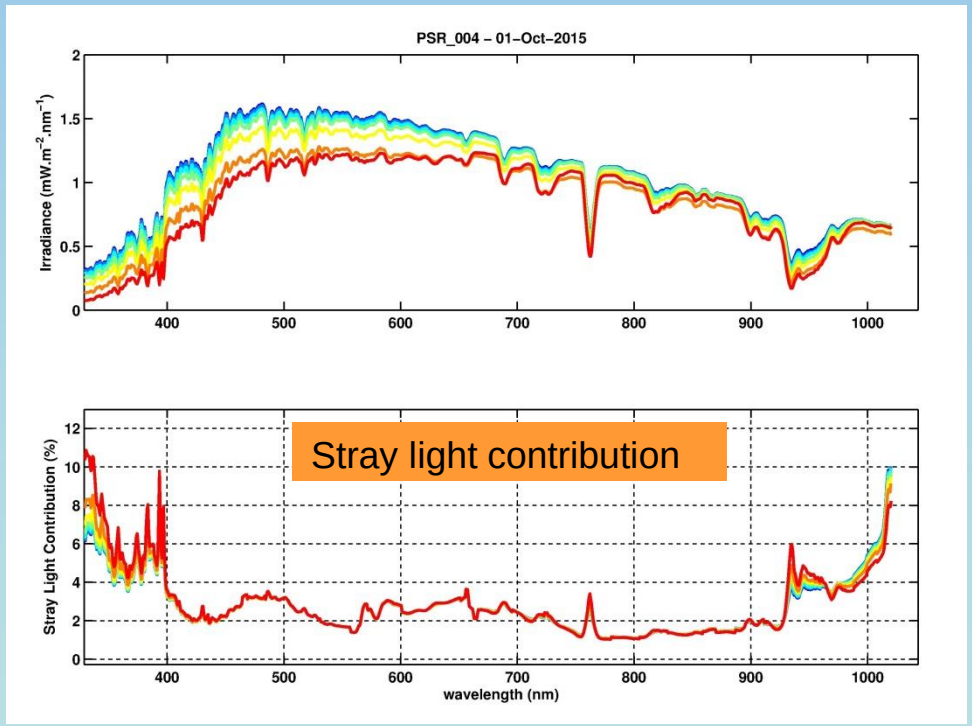
Characterisation of array spectroradiometers

Main radiometric parameters to determine are:

- linearity of system (detector and data acquisition)
- Stray Light, in-range and out-of-range (if applicable)



Significant nonlinearity of up to 12%

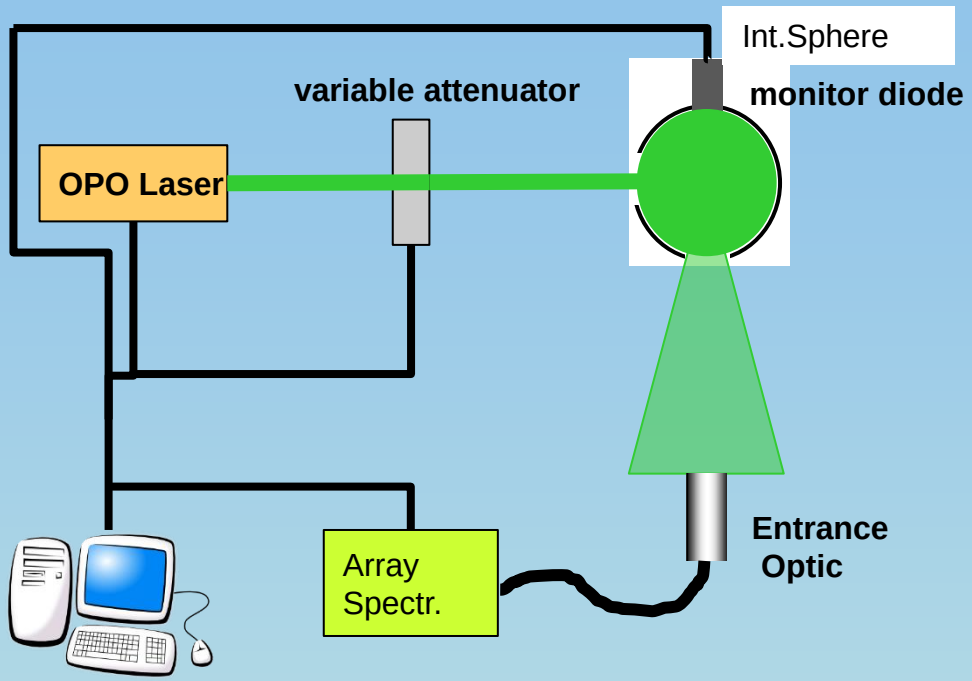


EMRP
European Metrology Research Programme
Programme of EURAMET
The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union
EURAMET

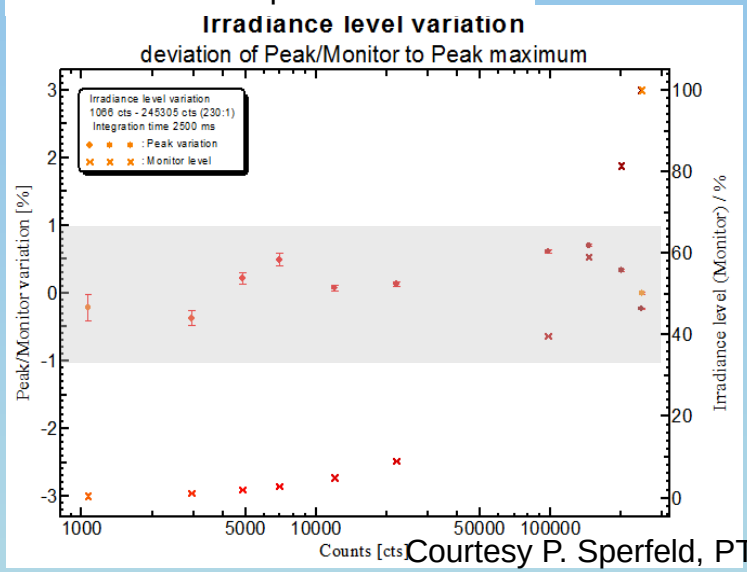
Example AvaSpec Spectroradiometer characterised in EMRP JRP SolarUV

pmod wrc

Tuneable laser setup at PMOD/WRC



Precision Solar Spectroradiometer

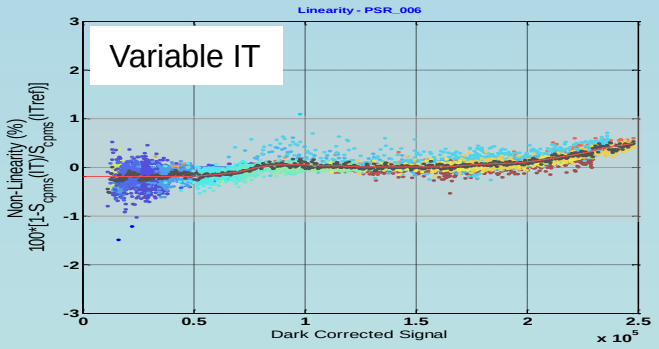


Courtesy P. Sperfeld, PTB

Linearity Characterisation

1) Versus Intensity change

2) Versus integration time



pmod wrc

Stray-Light correction of array spectroradiometers

Problems

- Spectral stray light is a major challenge for array spectroradiometers measuring solar UV radiation (300-400 nm), and for deep absorption lines (e.g. O_2 at 762 nm, water vapour).
- Out-of-range (Oor) stray light generates background radiation across the whole sensitivity range of the detector (up to 1100 nm for Si-Detector)

Solutions

- Matrix method (Zong et al., AO 2006), based on measured Line spread function
  - corrects SR up to 2 orders of magnitude
- Oor stray light can be corrected but is very complex and needs knowledge of spectrum which is not measured by the instrument.
- Hardware solution: Use of cut-off filters to reduce Oor radiation

pmod wrc

Stray-Light correction of array spectroradiometers

Methodology for in-range and out-range stray light correction from Zong et al., 2006, and Nevas et al., 2014.

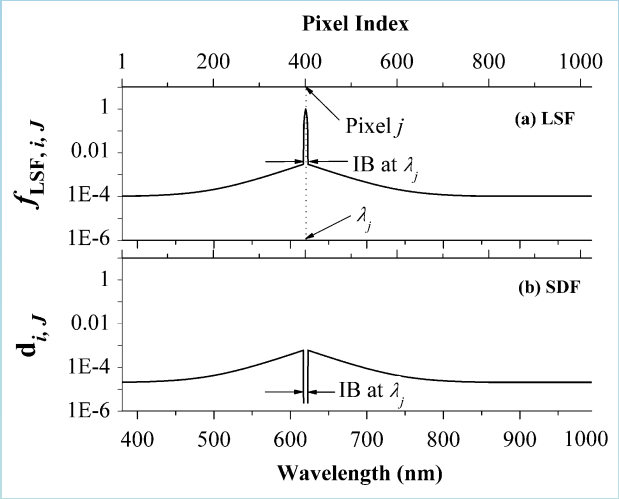
$$\mathbf{Y}_{\mathrm{s\_spec}} = \mathbf{D} \cdot \mathbf{Y}_{\mathrm{IB}} + \Delta,$$

- D stray light distribution function
- Y_{IB} the in-band signal
- Δ Oor contribution

$$\Delta = \mathbf{s}_{\mathrm{OoR}} \cdot \mathbf{E}_{\mathrm{OoR}} \cdot \delta\lambda,$$

Nevas et al., 2014

E_{Oor} is the spectral radiation outside the spectral range of the spectroradiometer



Use of matrix inversion to retrieve the in-band signal

$$\mathbf{Y}_{\mathrm{IB}} = [\mathbf{I} + \mathbf{D}]^{-1} \cdot [\mathbf{Y}_{\mathrm{meas}} - \Delta] = \mathbf{A}^{-1} \cdot [\mathbf{Y}_{\mathrm{meas}} - \Delta].$$

Zong et al., 2006

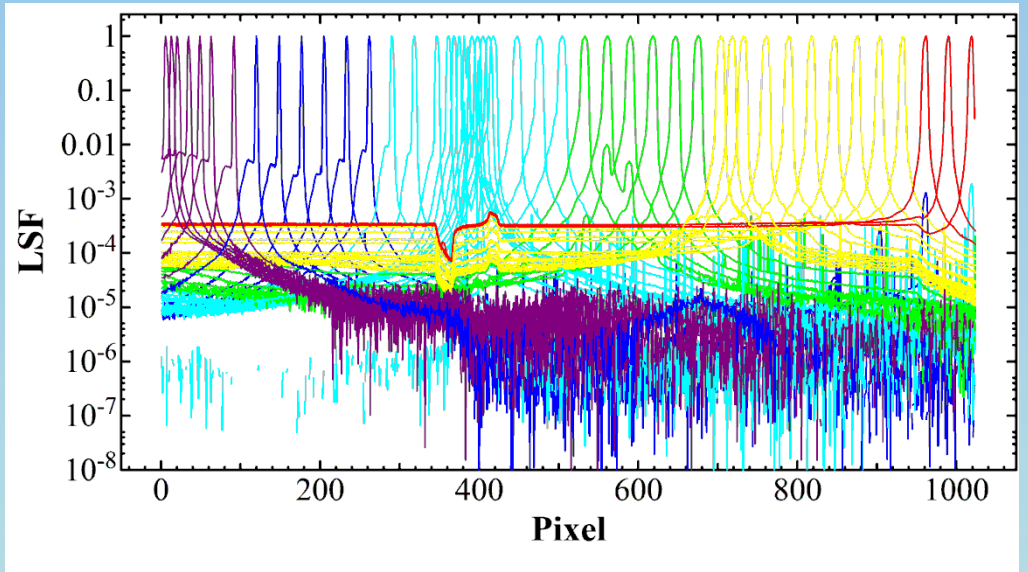
pmod wrc

In-range stray light

The line spread functions (LSF) are determined using tuneable laser facilities in the operational range of the spectroradiometer.

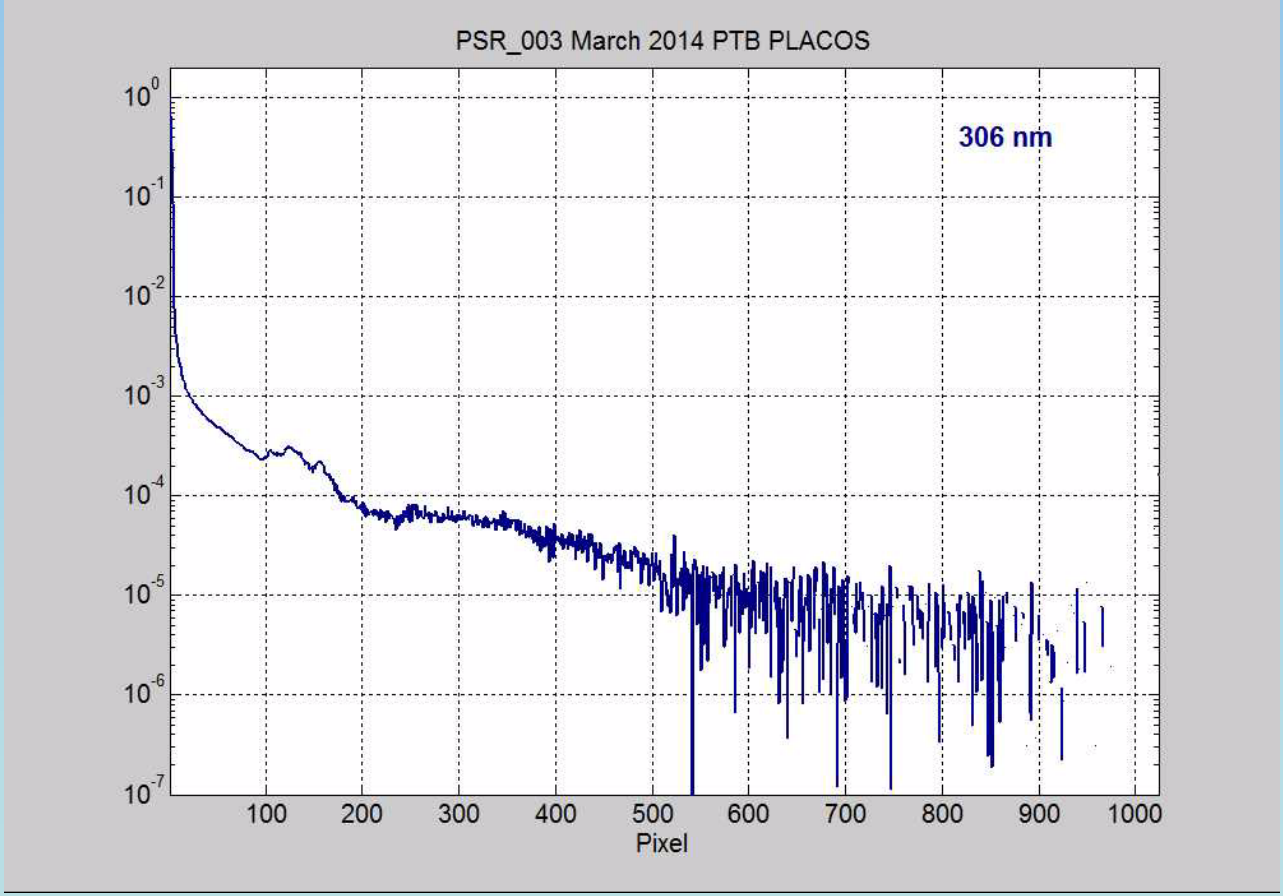
The stray-light corrected signal $\mathbf{Y_{IB}}$ can be retrieved from the measurement by applying a stray-light correction matrix $\mathbf{A^{-1}}$ to the measured signal, following the method of **Zong, 2006**.

$$\mathbf{Y_{IB}=A^{-1}\,Y_{meas}}$$



pmod wrc

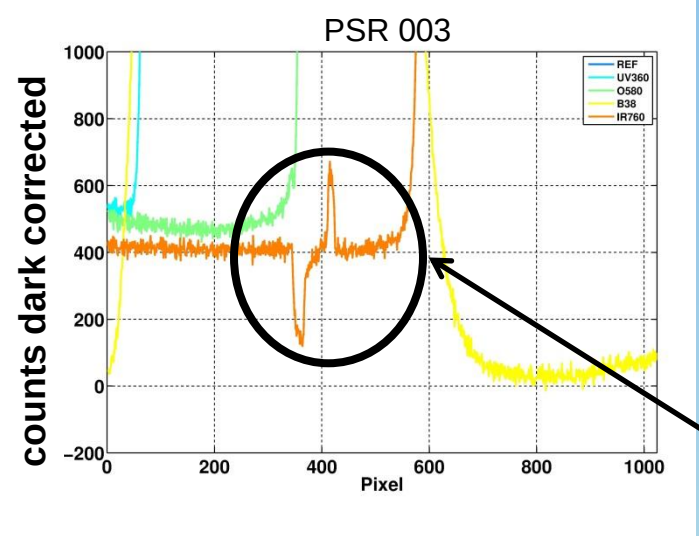
Example line spread functions of PSR 003 measured at the tuneable laser facility PLACOS of PTB

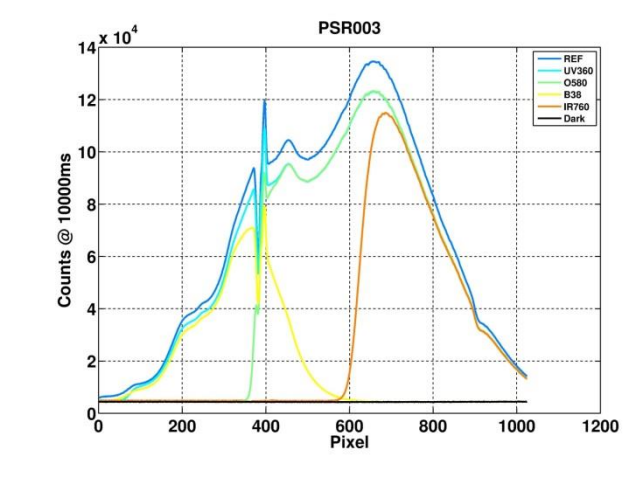


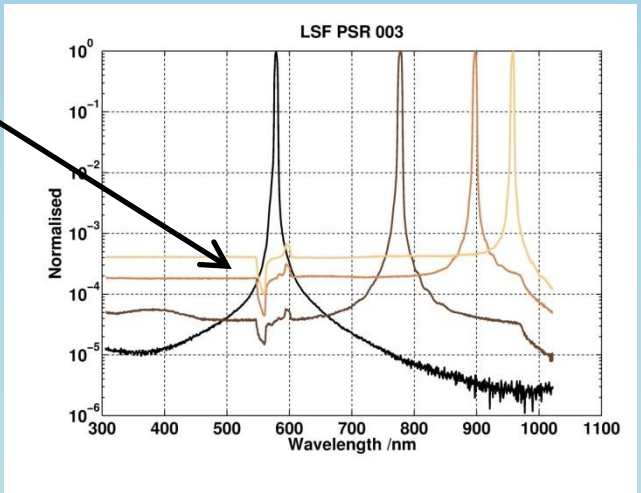
pmod wrc

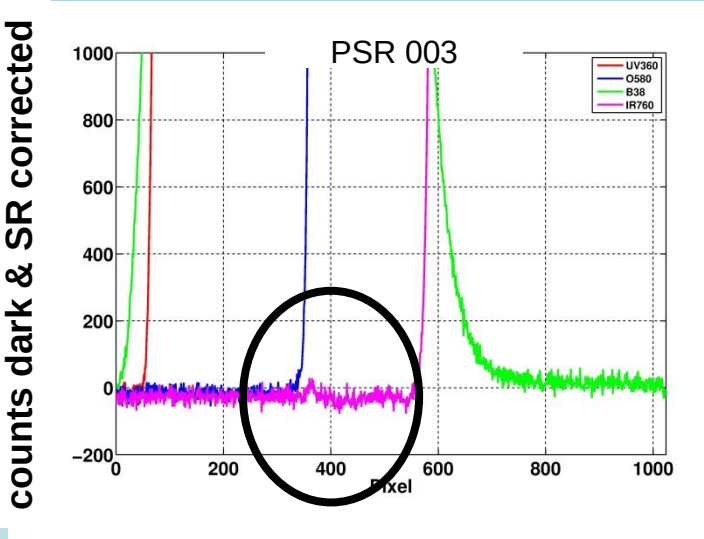
Stray-light correction validation

1) Using band-pass filters and halogen lamp





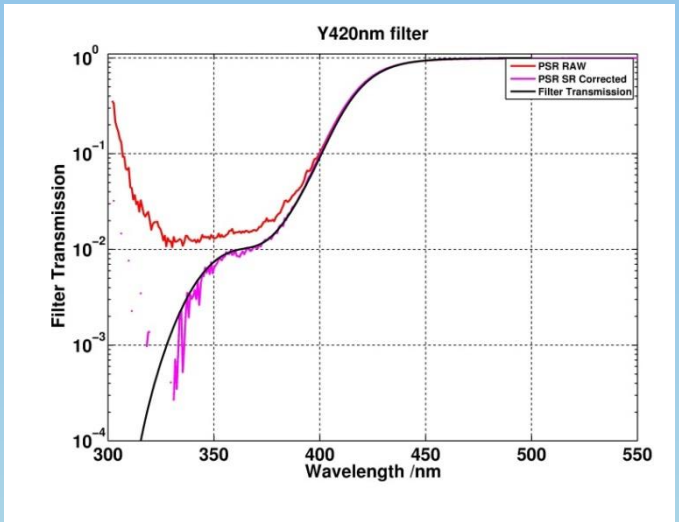


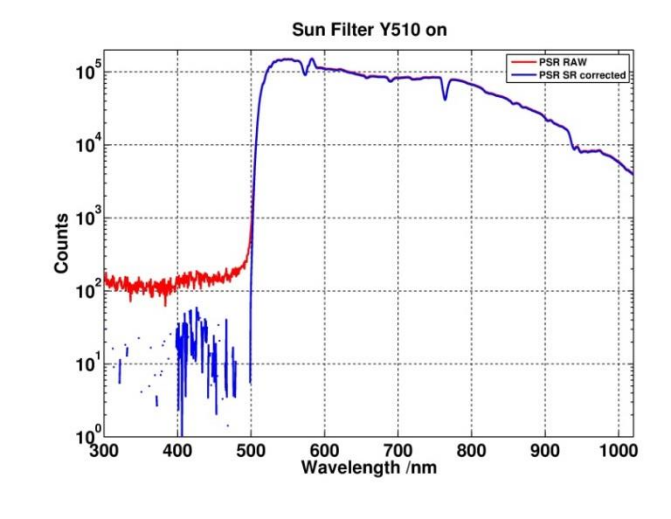


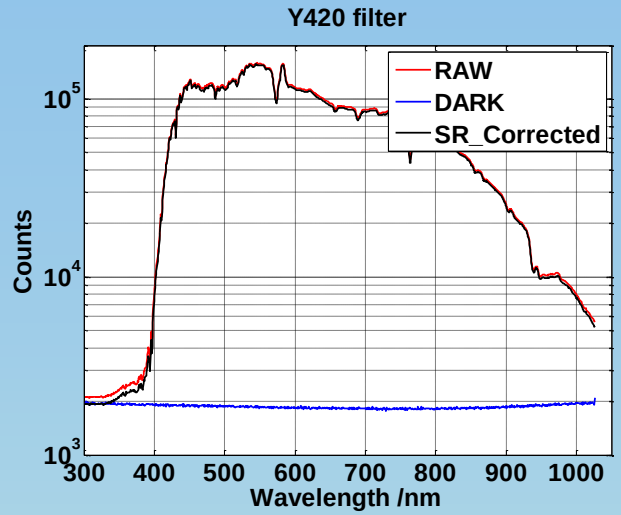
The Stray-light correction using the appropriate SR-Matrix is effective in removing more than 95% of the SR-Signal

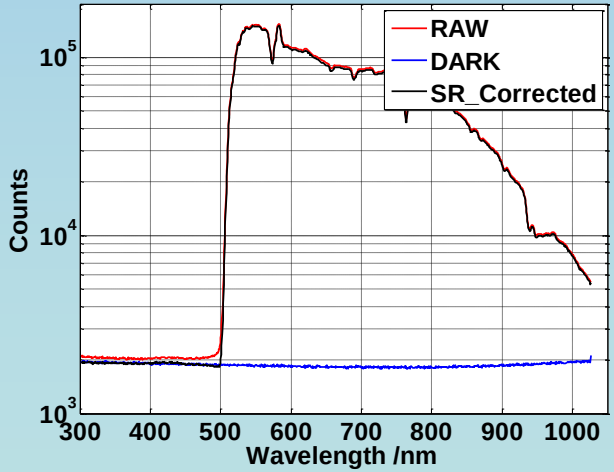
pmod wrc

Validation of stray-light correction
Using solar measurements and cut-off filters









The Stray-Light can be reduced by ~ factor 10

pmod wrc

Project schedule Kick-Off (KO) 22 June 2015

Deliverable number	Deliverable Description	Due Date (KO+#month)	Work Packages	Progress
TD0	Brief Monthly Reports	**Monthly**	all	√
TD1.1	Tuneable laser system operational	**12.2015**	WP1	**completed**
TD1.2	SOP for LSF and Oor stray light	**2.2016**	WP1	**in progress**
TD1.3	SOP nonlinearity	**3.2016**	WP1	**in progress**
TD2.1	LSF, Oor stray light and linearity determined for System 1.	**6.2016**	WP2	**scheduled 1.2016 (Pandora)**
TD2.2	LSF, Oor stray light and linearity determined for System 2.	**9.2016**	WP2	**scheduled 3.2016 (Phaeton)**
TD3.1	Report on nonlinearity correction method	**6.2016**	WP3	**5.2016**
TD3.2	Report on In-range and out-of-range stray light method	**10.2016**	WP3	**5.2016**
TD4	Final report, Presentation	**10.2016**	all	**6.2016**

pmod wrc