LYNRED

Latest electro-optical test means developments for SWIR band at LYNRED

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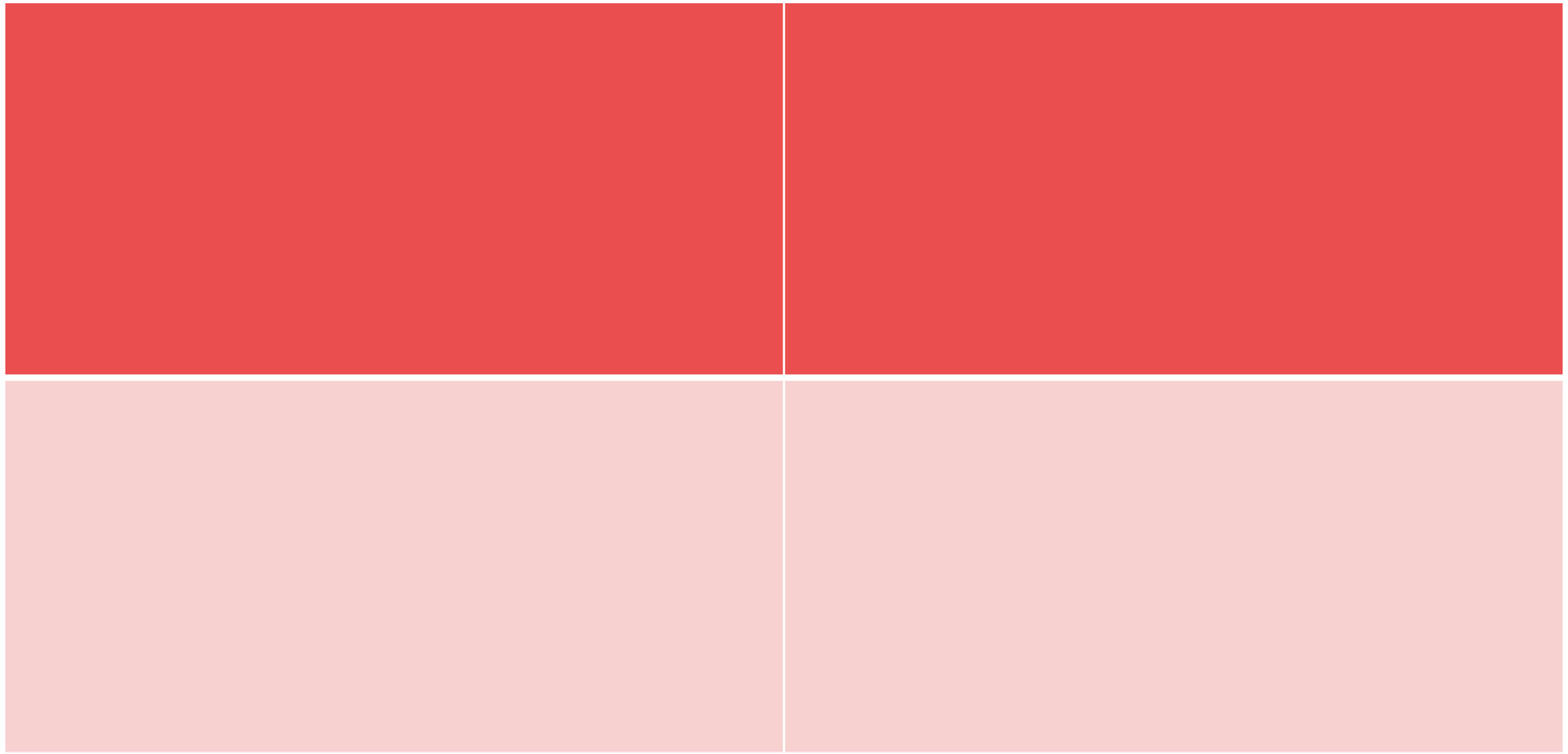
Usual performance measurements



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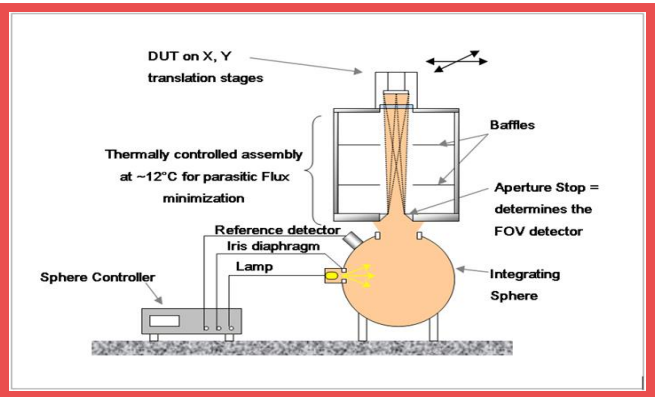
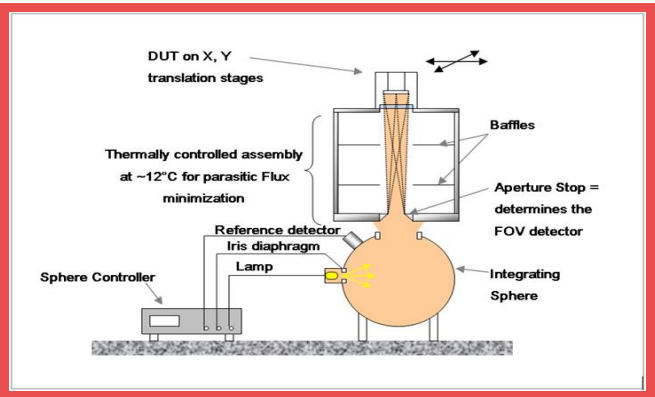
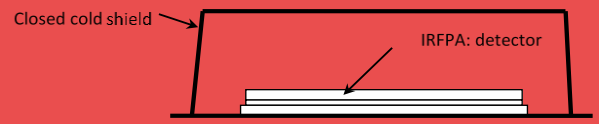


- **Radiometric measurements**

Usual performance measurements



❑ Radiometric measurements



❑ Dark current measurements

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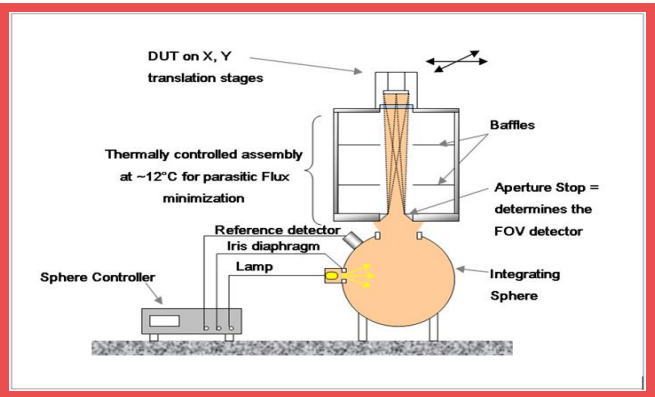

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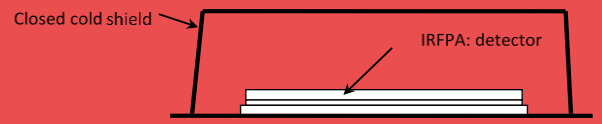

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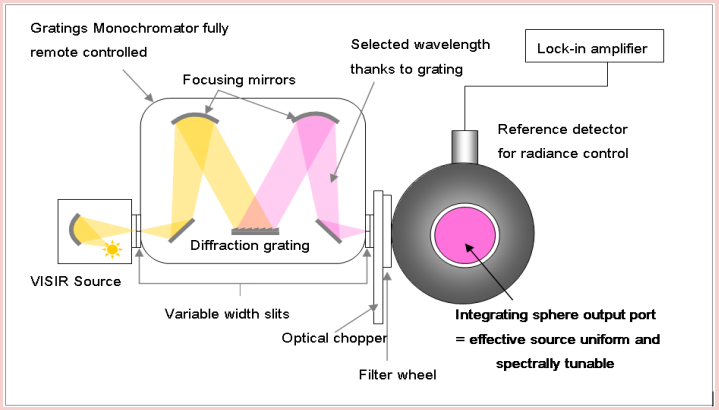
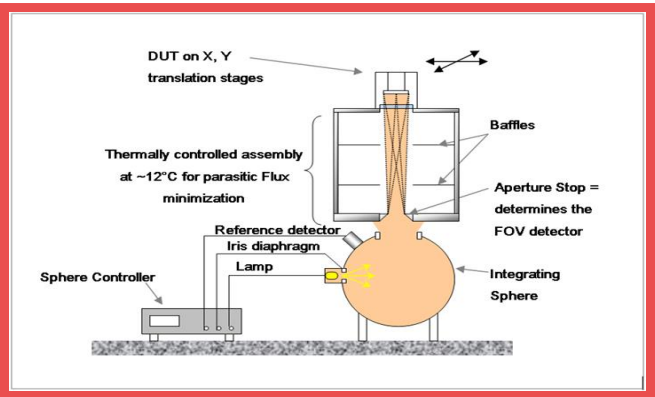


❑ Spectral response measurements

Usual performance measurements



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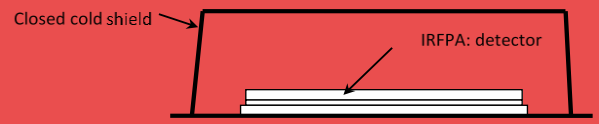

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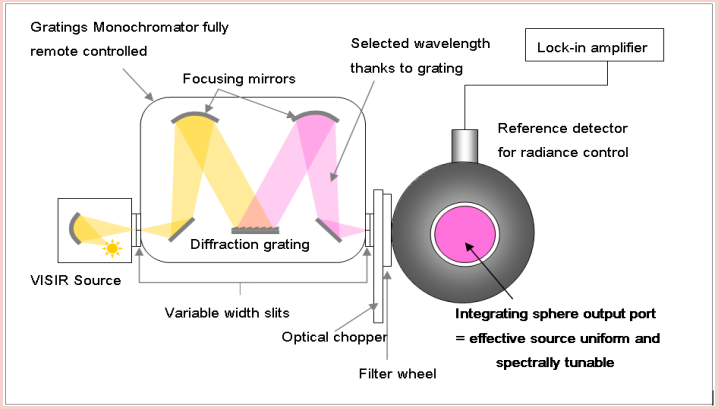

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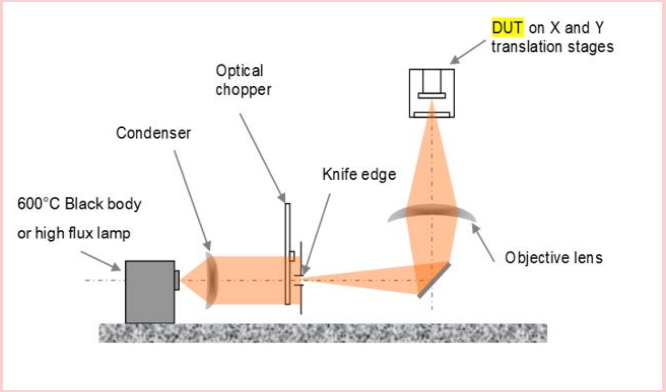


❑ Geometrical measurements

Outline

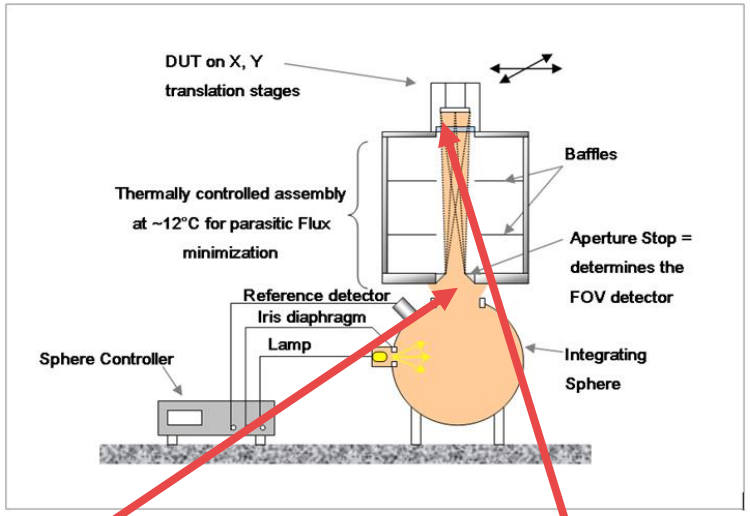
- ❑ Low background bench
- ❑ Spectral reconstruction
- ❑ Straylight analysis
- ❑ New bench concept

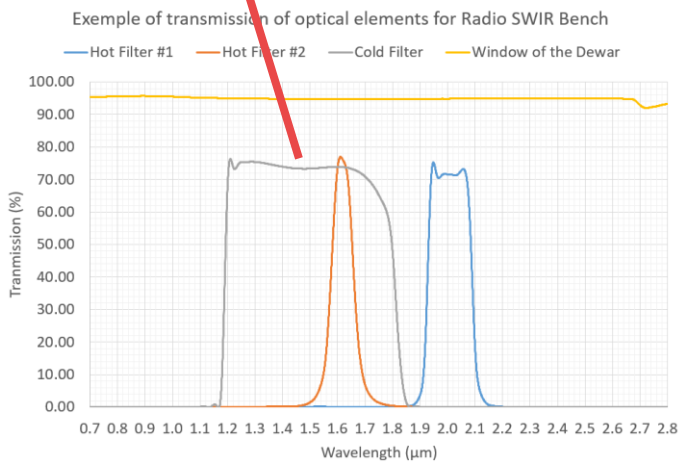
1

Low background bench

Radiometric measurements with low background flux

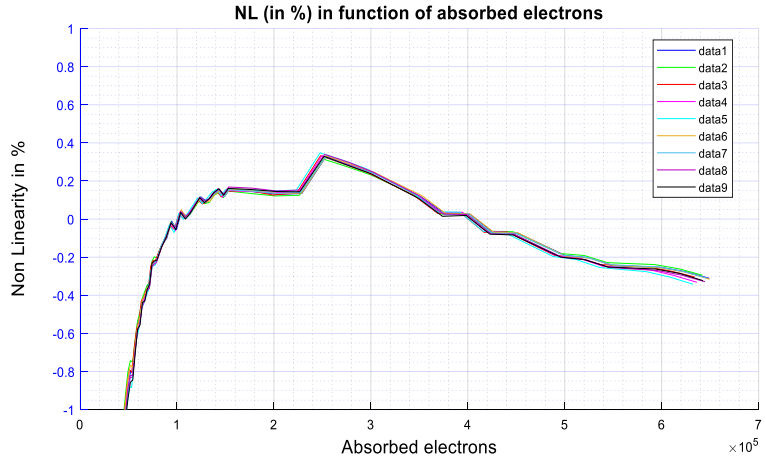
- Space program requires to reduce the background flux
- The solution described here is to insert a cold filter between the source and the detector
- For the lag measurement, a mechanical shutter is inserted between the source and detector to be measured with a typical switching time of 1ms.
- These solutions are compatible with existing SWIR benches and do not require large modifications

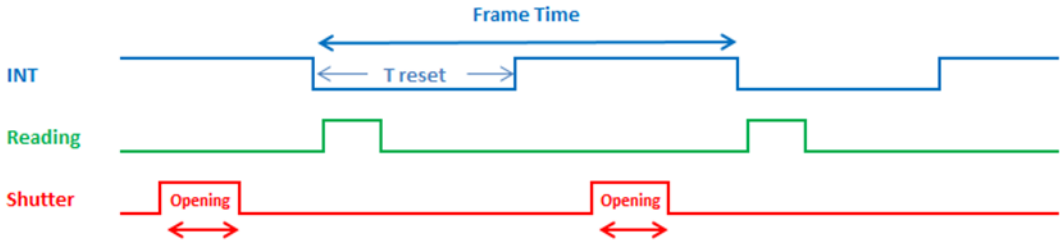


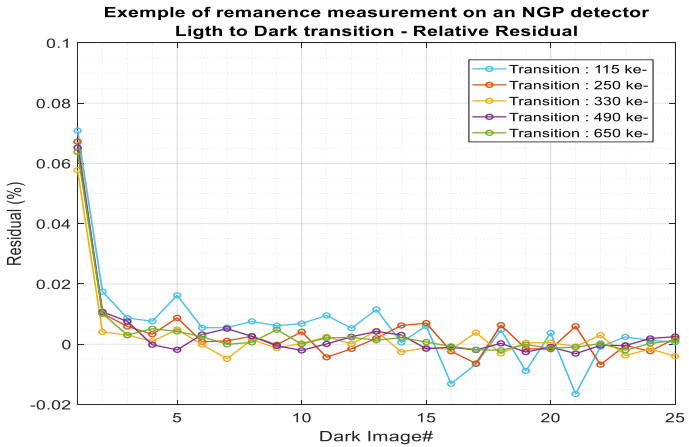


Results from this test configuration

- Background flux is reduced by ≈100 compared to the previous version
- Detector non-linearity is within +/1% on the useful flux range
- Light to dark (close) and dark to light (open) transitions were performed using the shutter on known detector.
- Measurements show lag residual close to measurement noises and are in agreement with expected lag of SWIR lag free detector.







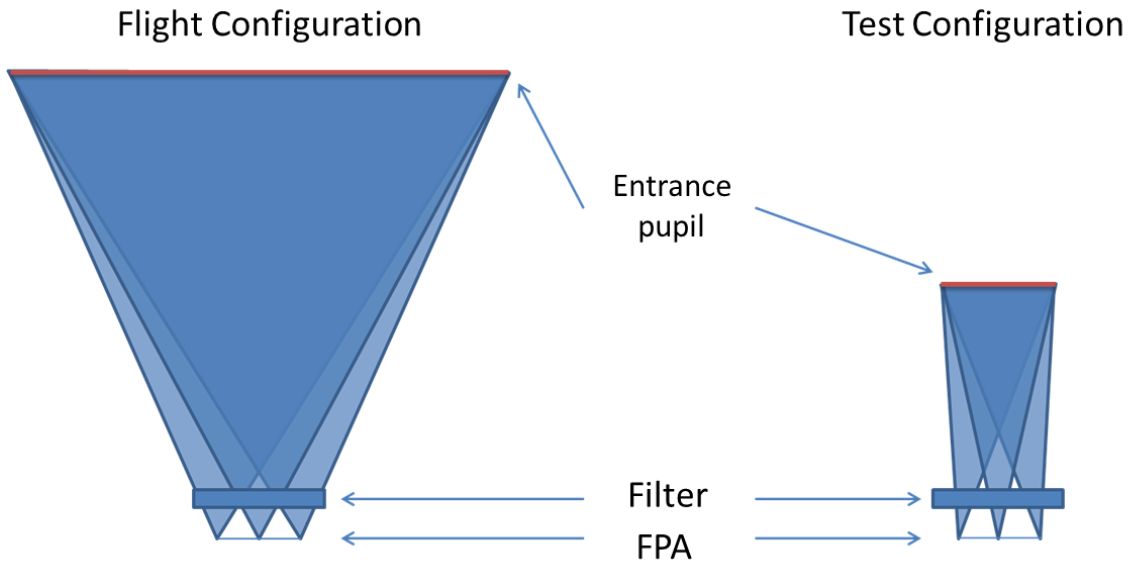
2

Spectral reconstruction

Spectral response problem

- **Spectral responses of the detector with built-in filters are different depending on optical configuration; it is the case between spectral responses obtained on characterization bench and the ones in final use (in flight)**

- **It is difficult to have a test bench adapted to instrument configuration, so one has to find a solution to be representative of the final use**

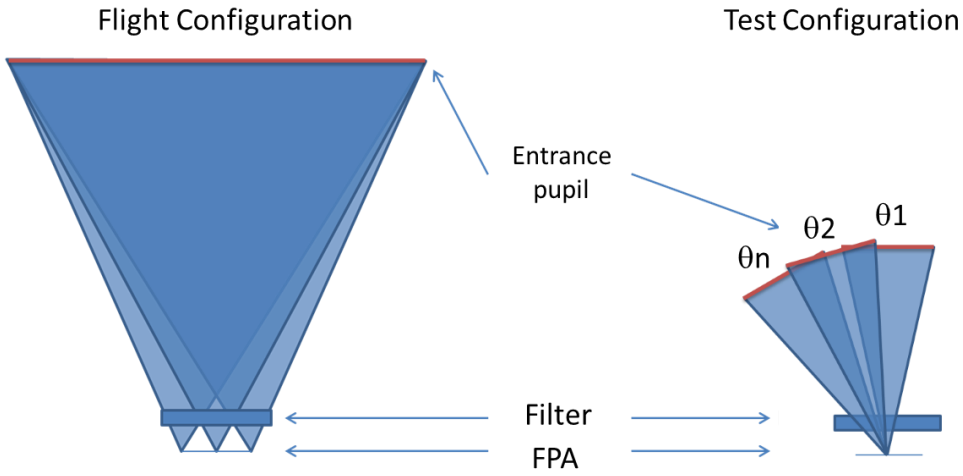


Spectral reconstruction

- As on the bench it is possible to perform spectral response at different angles, we can use a reconstruction method of $S(\lambda)$ to compensate for differences in illumination angles :

$$S(\lambda) = \sum_{\theta} S_{\theta}(\lambda) * w(\theta)$$

- Measurement configuration

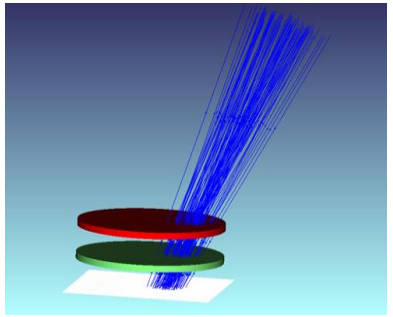


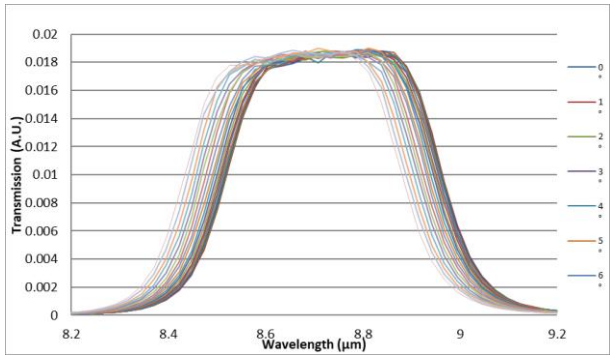
- The weight (w(θ)) is calculated by fitting function (minimization) on angular distributions of each pupil :

$$\min \left[AD_{flight} - \sum AD(\theta) * w(\theta) \right]$$

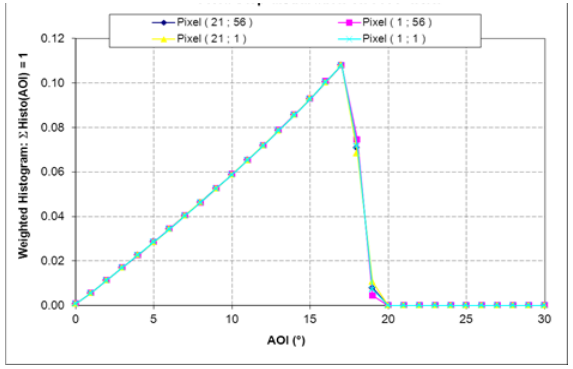
Method demonstration

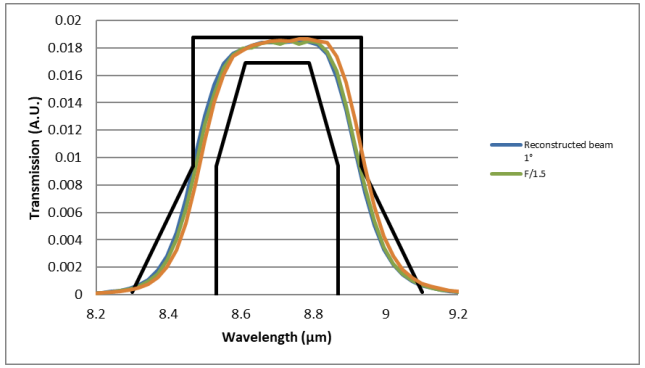
- We use a Zemax model of the filter+window spectral responses to obtain spectral response at regularly spaced angles





- We then calculate the angular distribution of each pixel in flight to obtain the pixel response





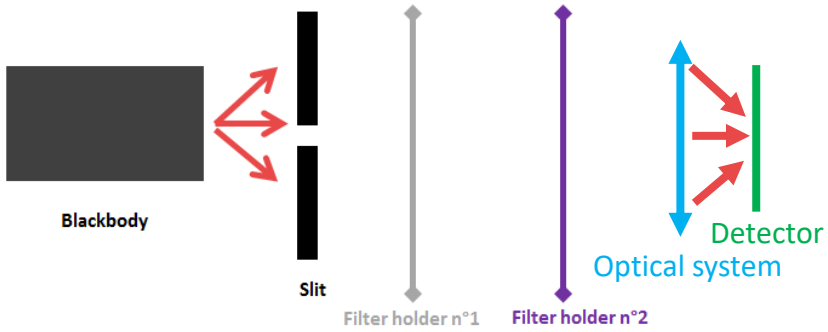
- This method has been applied on flight models and results are consistent with results at instrument level

3

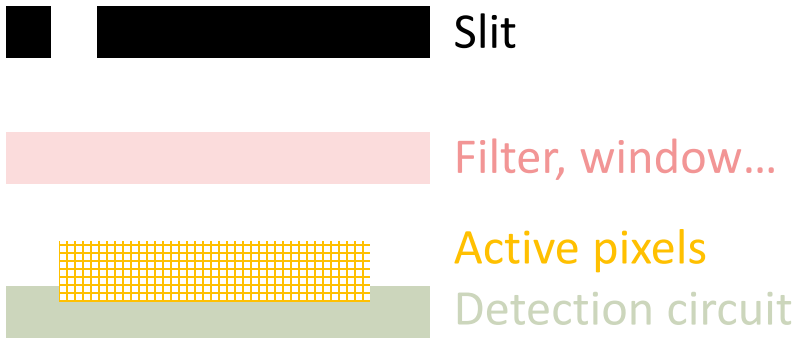
Straylight analysis

Straylight bench and measurement principle

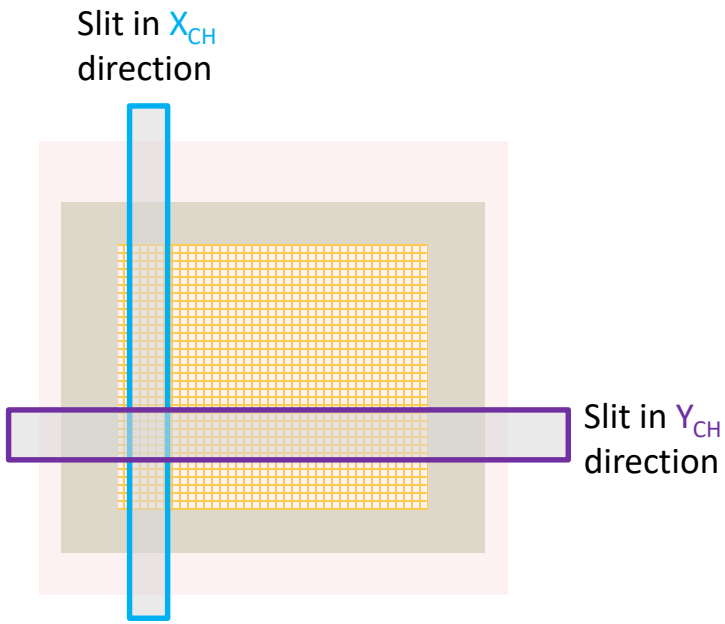
- **Moving slit allows to illuminate part of the detector to verify straylight level**



Bench geometry



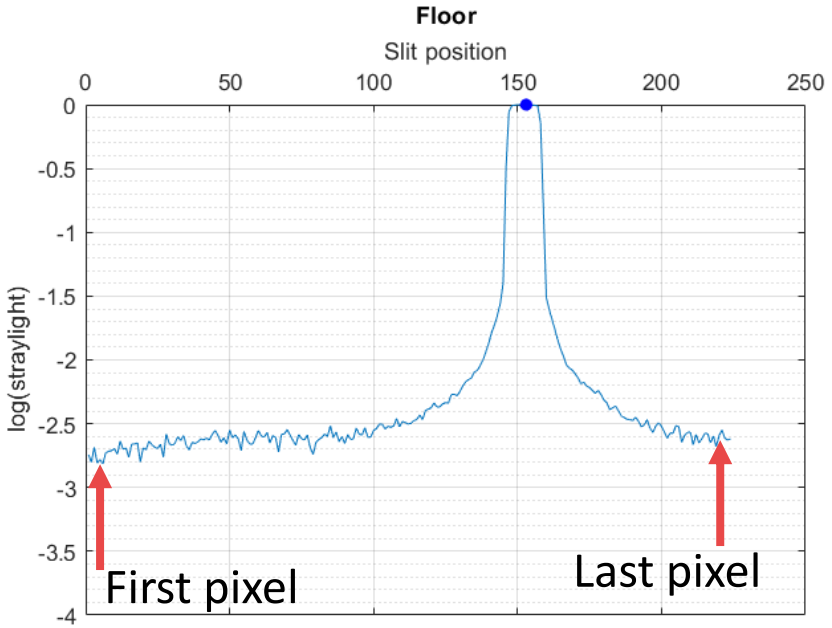
Detector Package side view



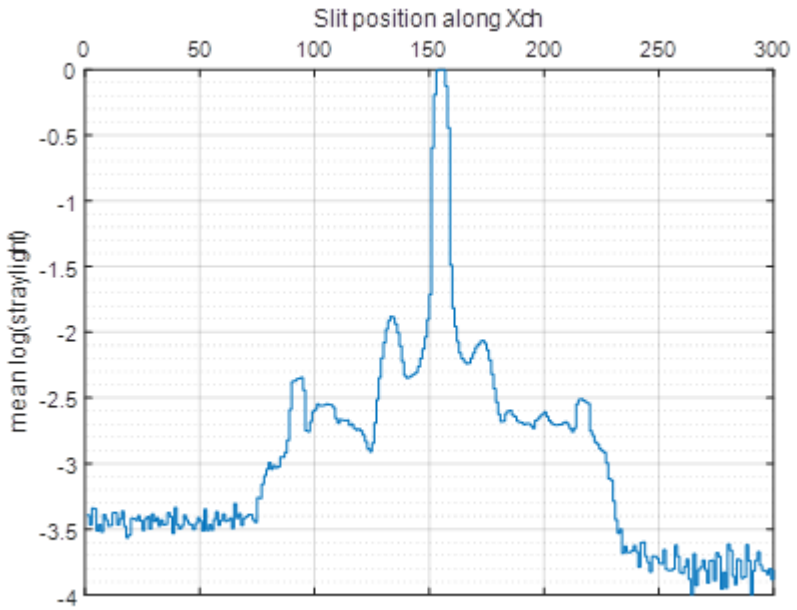
Detector Package top view

Straylight results

- Y_{CH} : Floor level for all pixels not illuminated = no straylight
- X_{CH} : Signal observed at other locations than active area = straylight
- Peaks were studied and associated root cause identified ➔Correction and validation of detector package



Y_{CH} straylight at slit location 153 for all pixels of a column

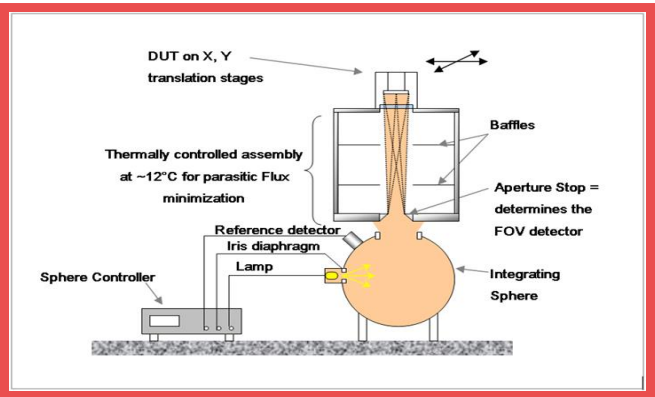


X_{CH} straylight at slit location from 0 to 300 (active area = 153). Mean value of all pixels of a column

4

New bench concept

Ideal bench



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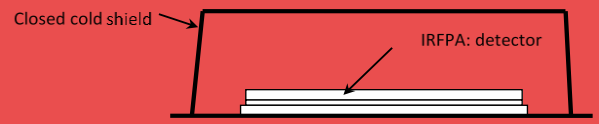

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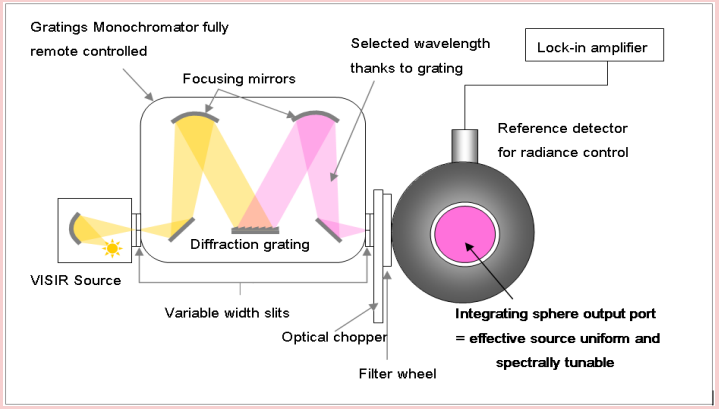

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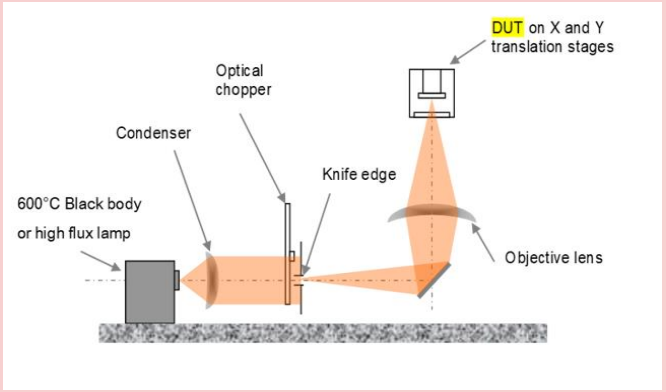
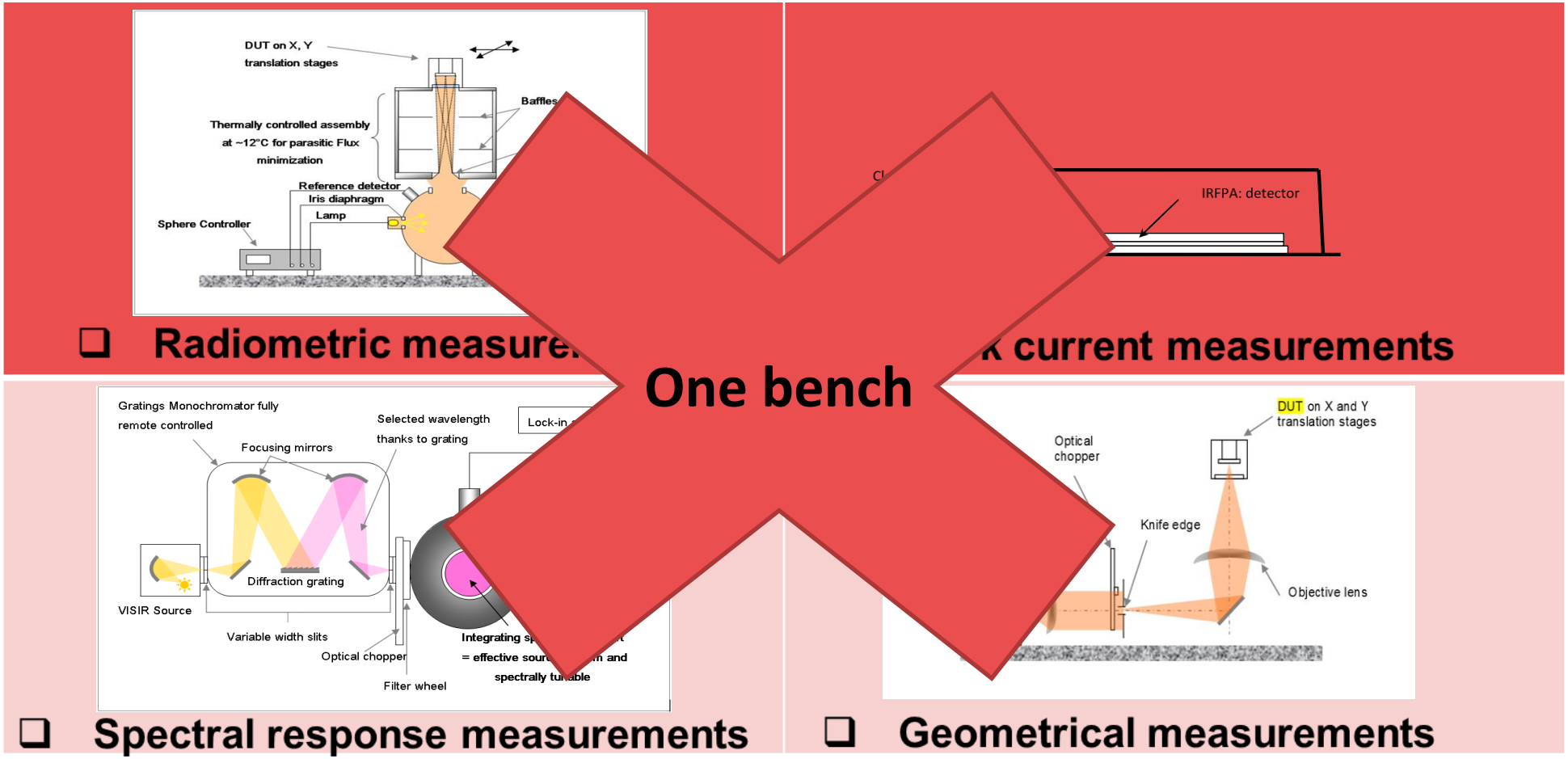


❑ Geometrical measurements

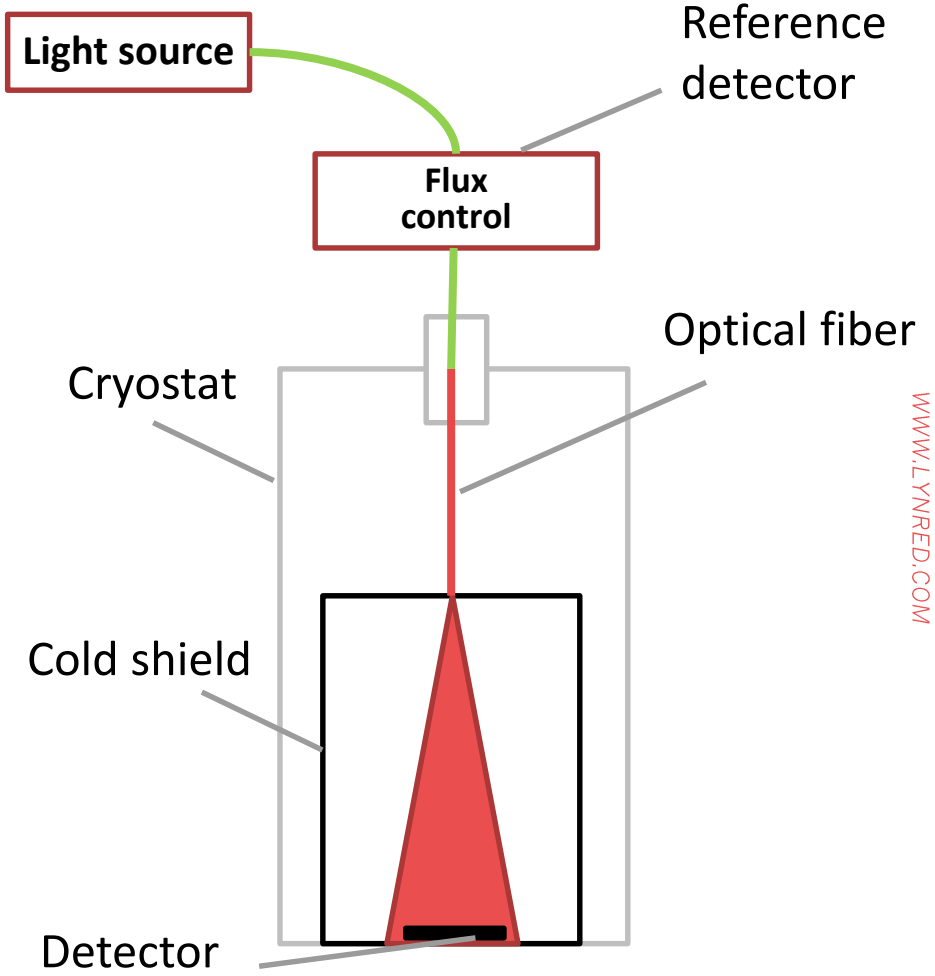
Ideal bench



New bench concept

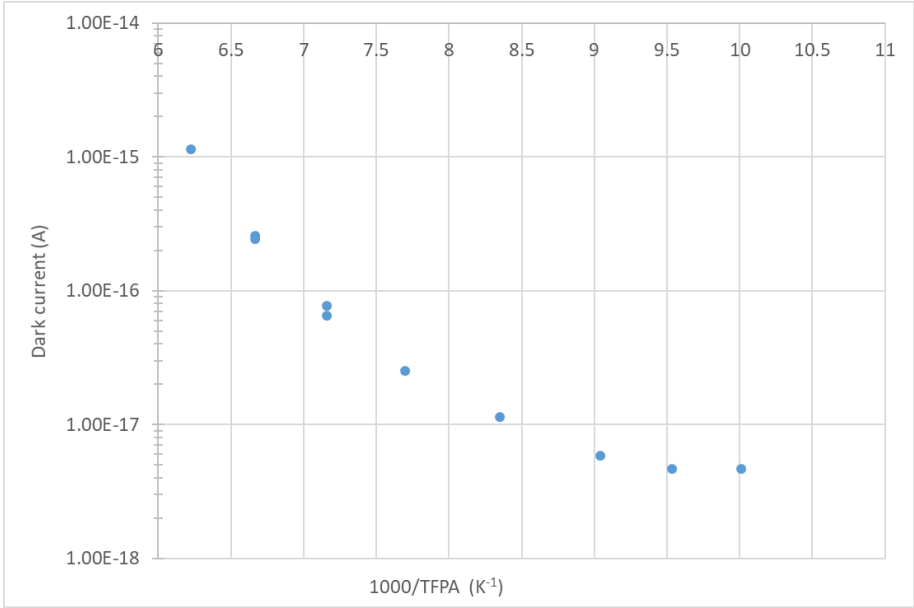
- **Fiber background limited solution**
  - Stable light sources (centered on specified SWIR bands)
  - Flux control module
  - Fibered cold shield
  - Built-in reference detector

- **Advantages**
  - Faster measurements (no configuration change)
  - Low cost (built with cots parts)
  - Compatible with our standard cryostats
  - Reliable (no moving part)
  - Accurate (no background)



Bench background validation

- **To evaluate bench background, we measured the dark current versus temperature when the light source is switched off**



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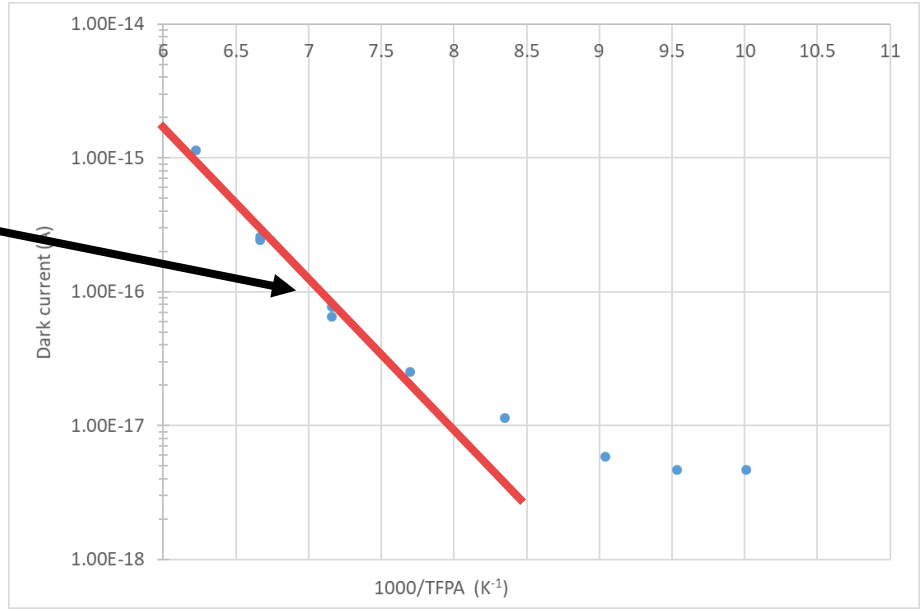
Dark current



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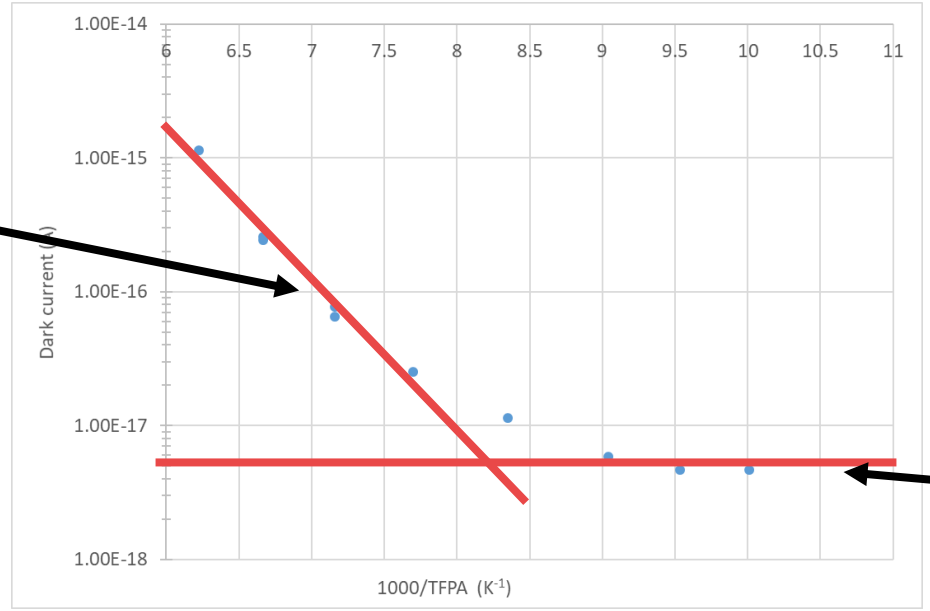

Dark current

Background current

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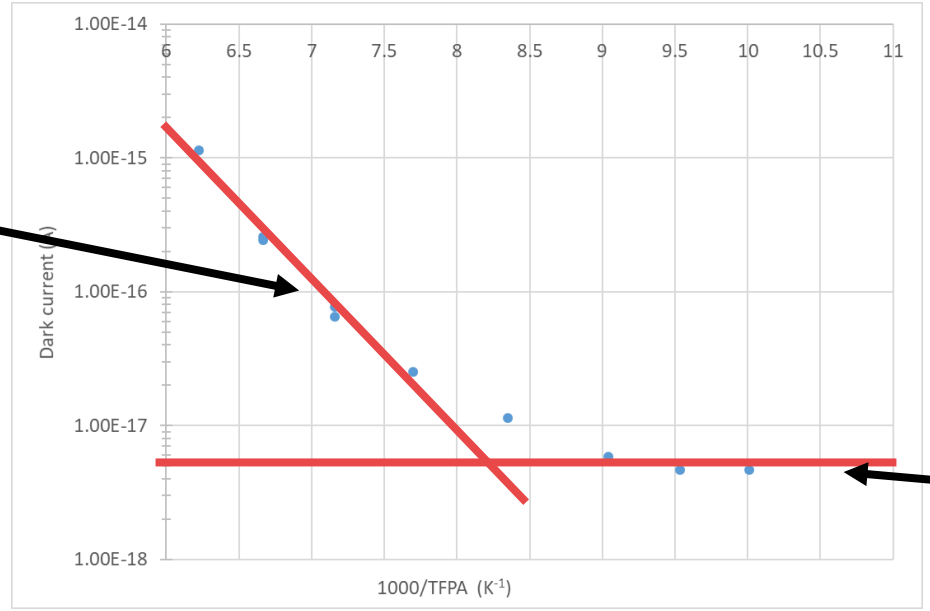
Dark current

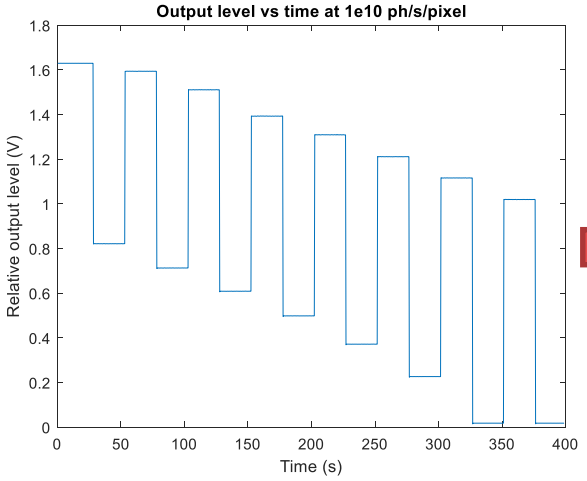


Background current

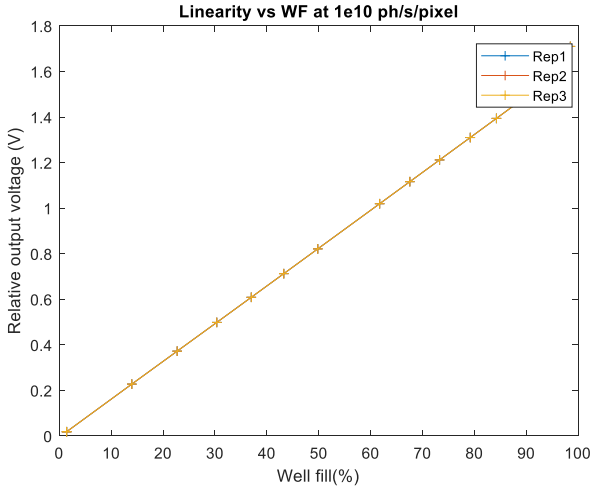
- Background current around 30e-/s, so ≈100x gain compared to cold filter configuration
- Accurate dark current measurements down to 300e-/s
- Flux measurements between 100 to 10^10 ph/s/pixel for 15µm pitch

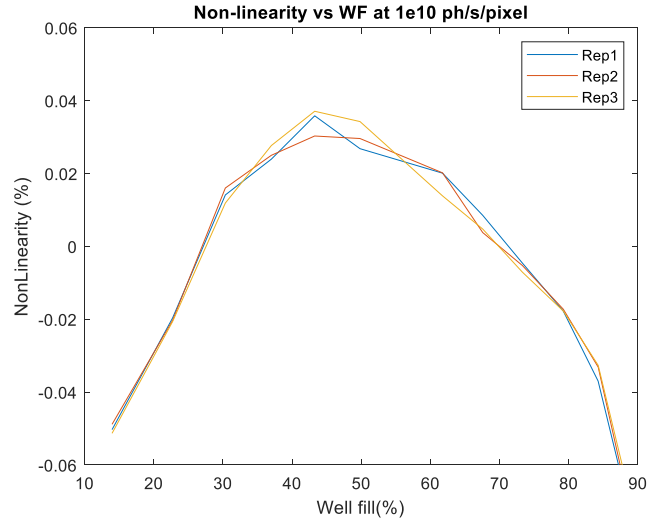
Linearity validation

- To evaluate linearity, we performed linearity measurements on a linear detector



$$\text{Non} - \text{linearity} = \frac{\text{Vmeasured} - \text{Vfit}}{\Delta\text{Vmax}}$$





- Good reproducibility (between 0.001% to 0.01%)
- Good accuracy (in accordance with simulation)
- Fast measurement time: frame limited time (no delay between flux change)

For 16 irradiances averaged over 70 frames of 350ms, linearity measurement time is approximately 400s

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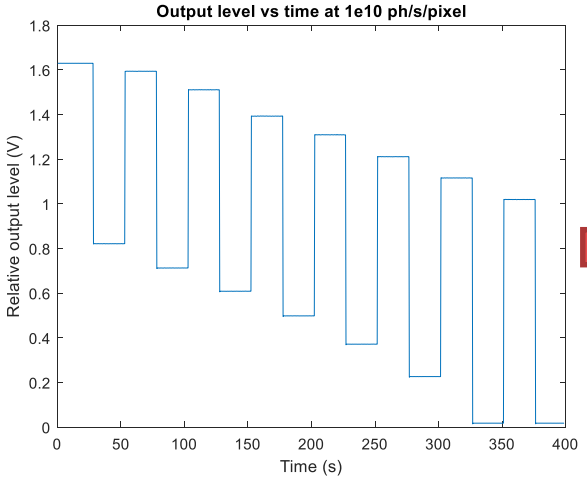

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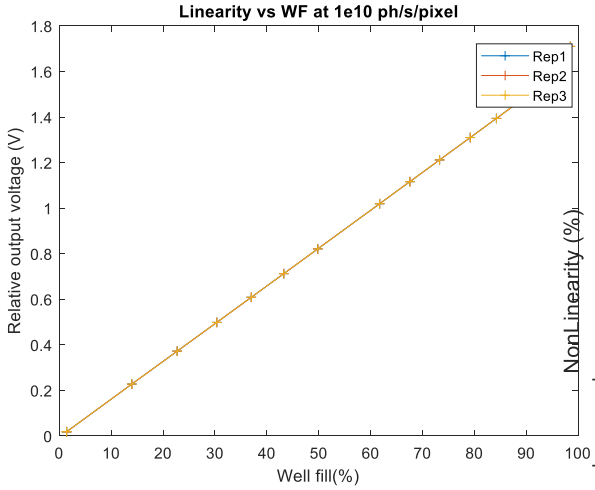

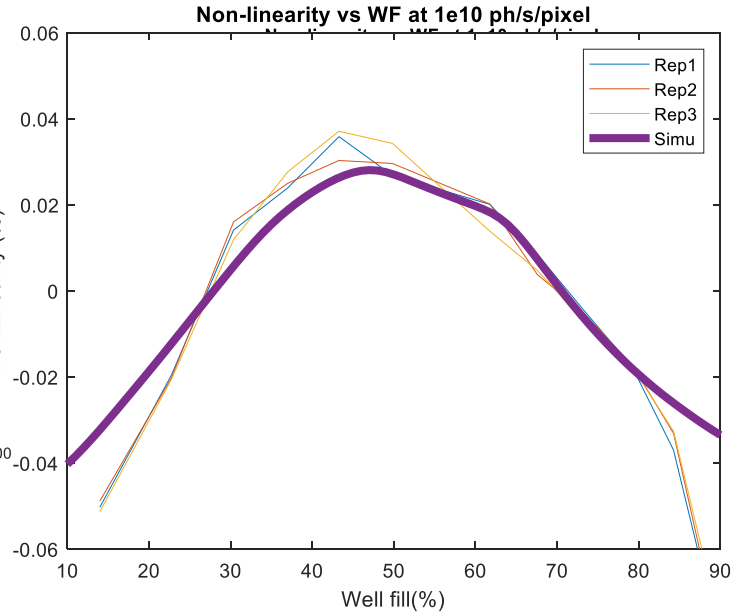

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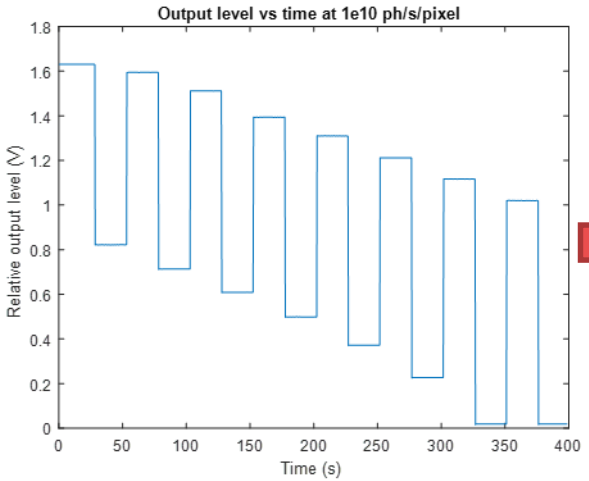
- Good accuracy (in accordance with simulation)
- Fast measurement time: frame limited time (no delay between flux change)

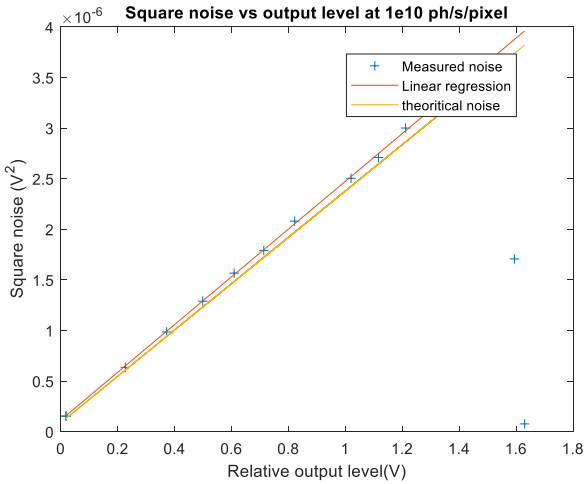
For 16 irradiances averaged over 70 frames of 350ms, linearity measurement time is approximately 400s

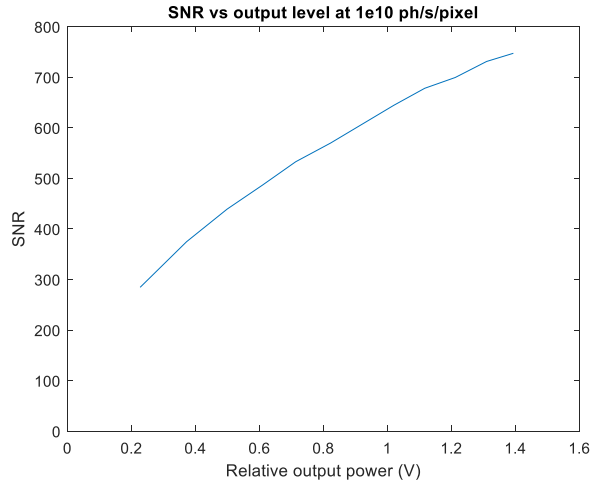
SNR validation

- To evaluate SNR , we measured noise and compared it to the theoretical noise of the detector



Standard deviation

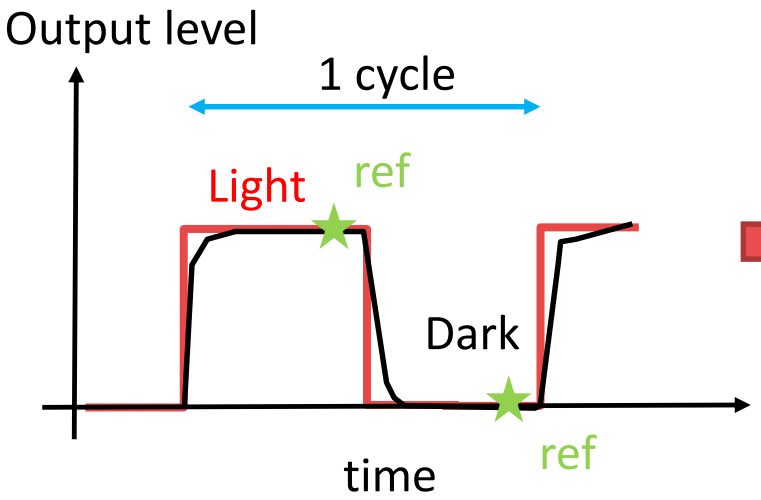




- Performed at the same time as linearity measurements
- Measured noise closed to theoretical noise
- Relative accuracy close to few %

Lag validation

- **To evaluate the lag, we perform a lag measurement on known detector with no lag.**



Light to dark transition

$$\text{Residual (trame n)} = \frac{\text{Dark(n)} - \text{Dark(ref)}}{\text{Light (ref)} - \text{Dark(ref)}} \ [\%]$$

Dark to light transition

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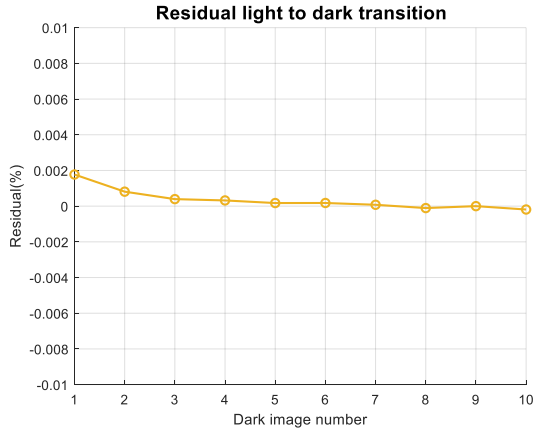
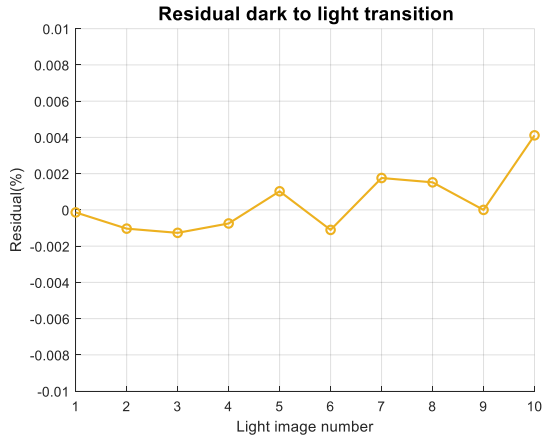
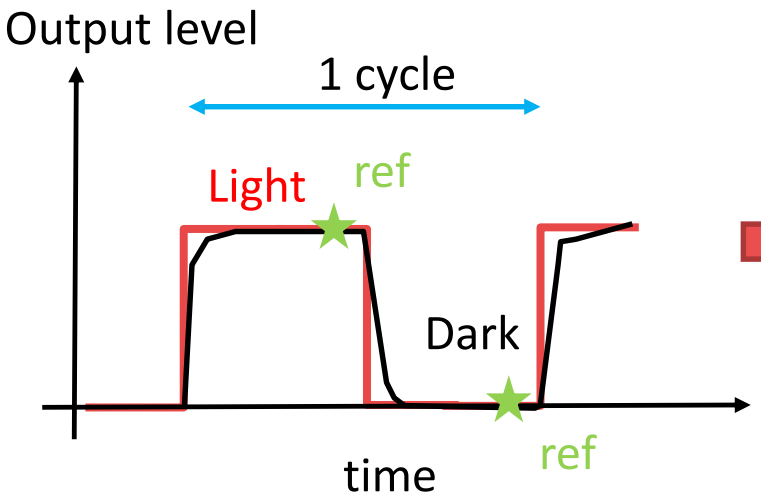




- **10x gain on measurement limits**
- **Fast switching time (down to 1µs) of the flux module**
- **Possible to have any kind of irradiance transition**
- **Possible to choose excitation wavelength**

Lag validation

- **To evaluate the lag, we perform a lag measurement on known detector with no lag.**



Light to dark transition

$$\text{Residual (trame n)} = \frac{\text{Dark(n)} - \text{Dark(ref)}}{\text{Light (ref)} - \text{Dark(ref)}} \quad [\%]$$

Dark to light transition

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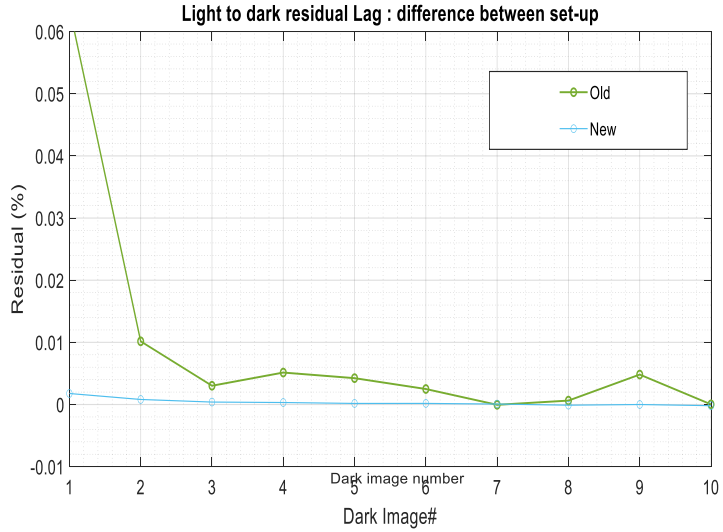

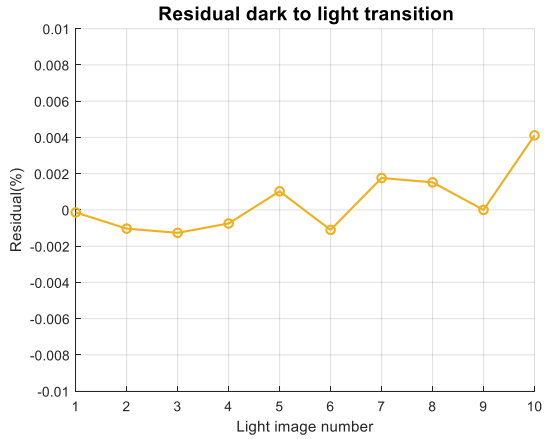

- **10x gain on measurement limits**
- **Fast switching time (down to 1µs) of the flux module**
- **Possible to have any kind of irradiance transition**
- **Possible to choose excitation wavelength**

5

Conclusion

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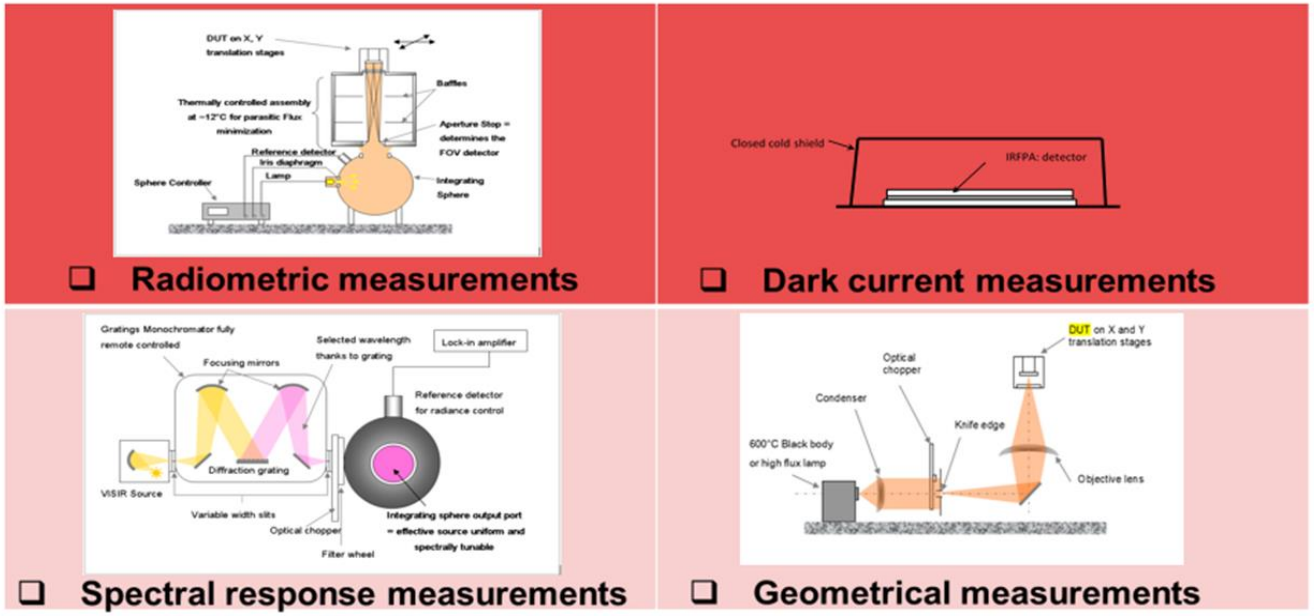

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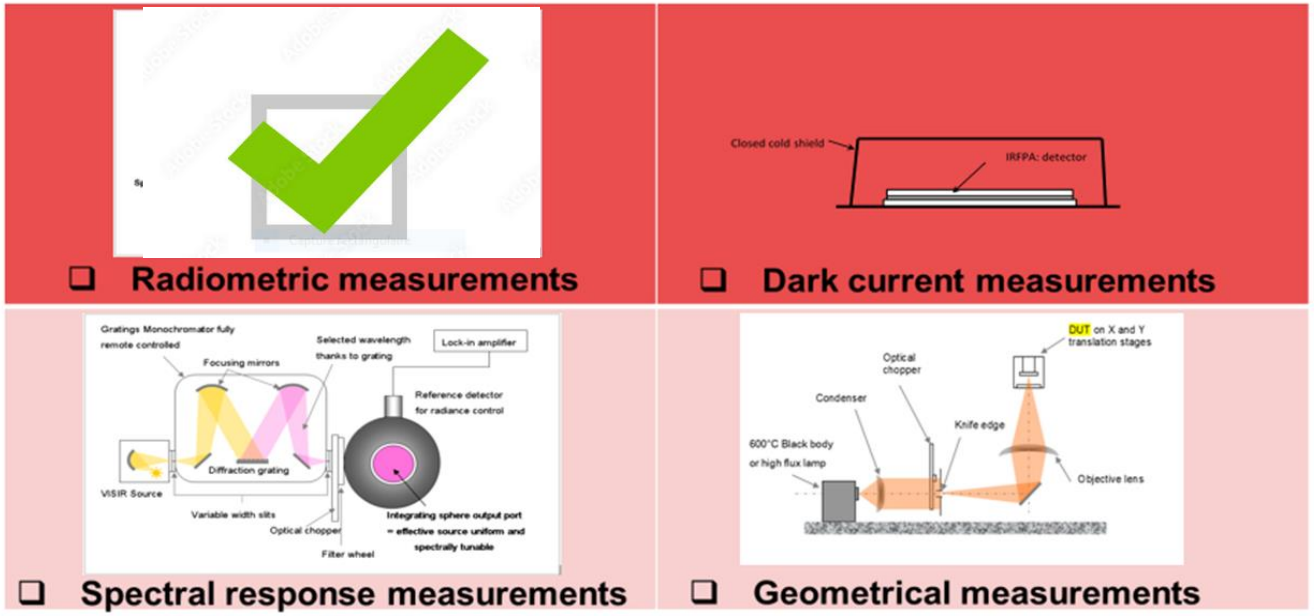

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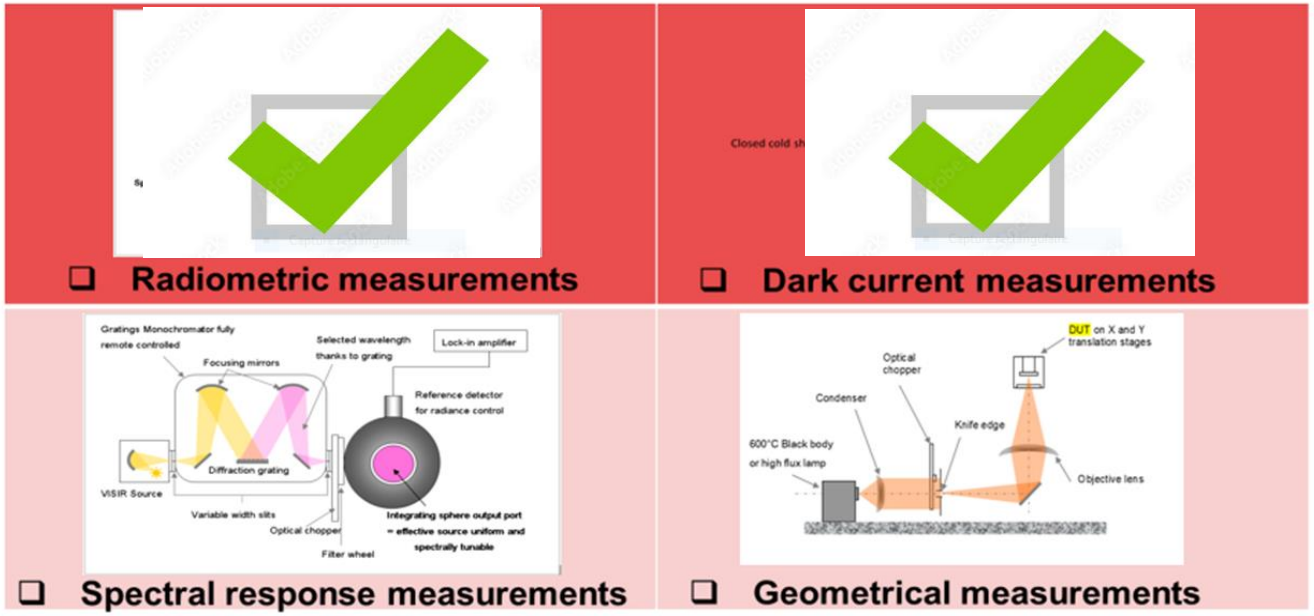

THANK YOU
FOR YOUR ATTENTION

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