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Daylight Process overview

SylSmart Connected Building V3 – SSA – July 2020

Light your world

Pre-requisites

- SSA Luminaires located correctly in a space (i.e away from walls, away from windows (see next slides)

- Lux meter (ideally calibrated for LED light sources)

- Correctly configured profiles (Daylight scenarios with correct target lux)

- SylSmart Connected App (IOS)

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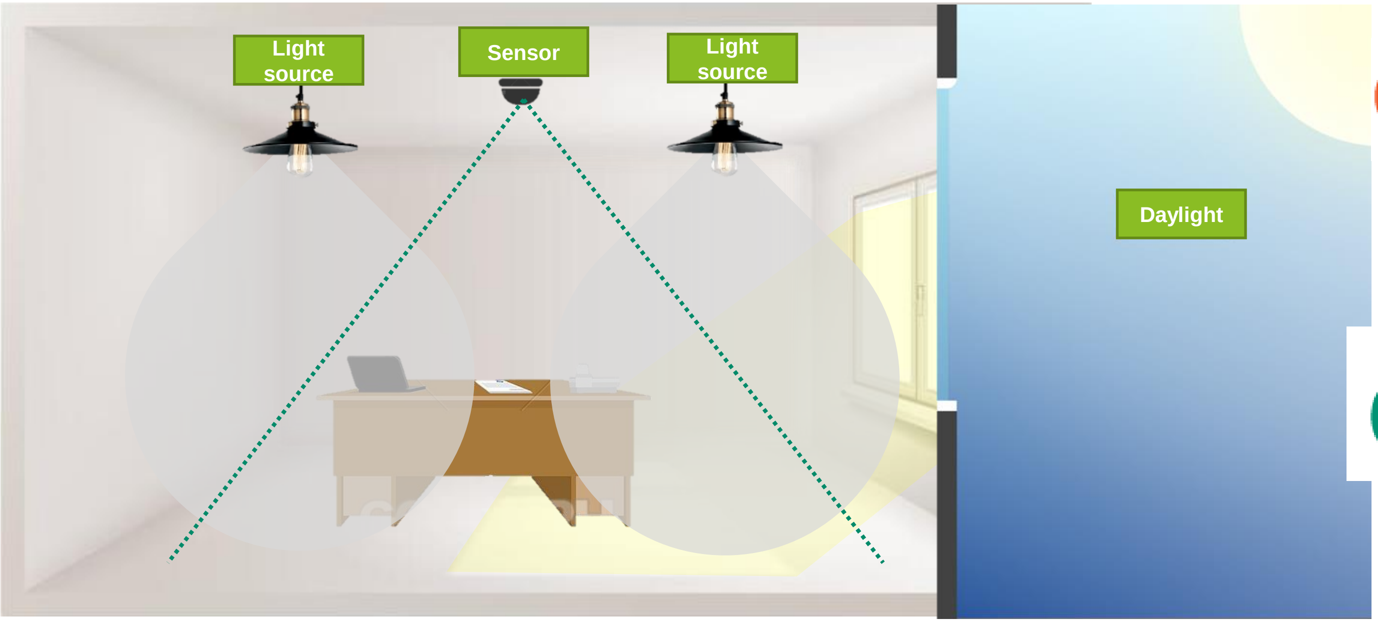
Daylight harvesting

- **Selected light sensor** is used to control **all lights in a zone**
- Light is controlled in a **closed loop** method (mostly indoor applications)
- Each zone with daylight harvesting needs to be calibrated - Without calibration daylight harvesting will not work.
- Not calibrated zones are marked red with error !



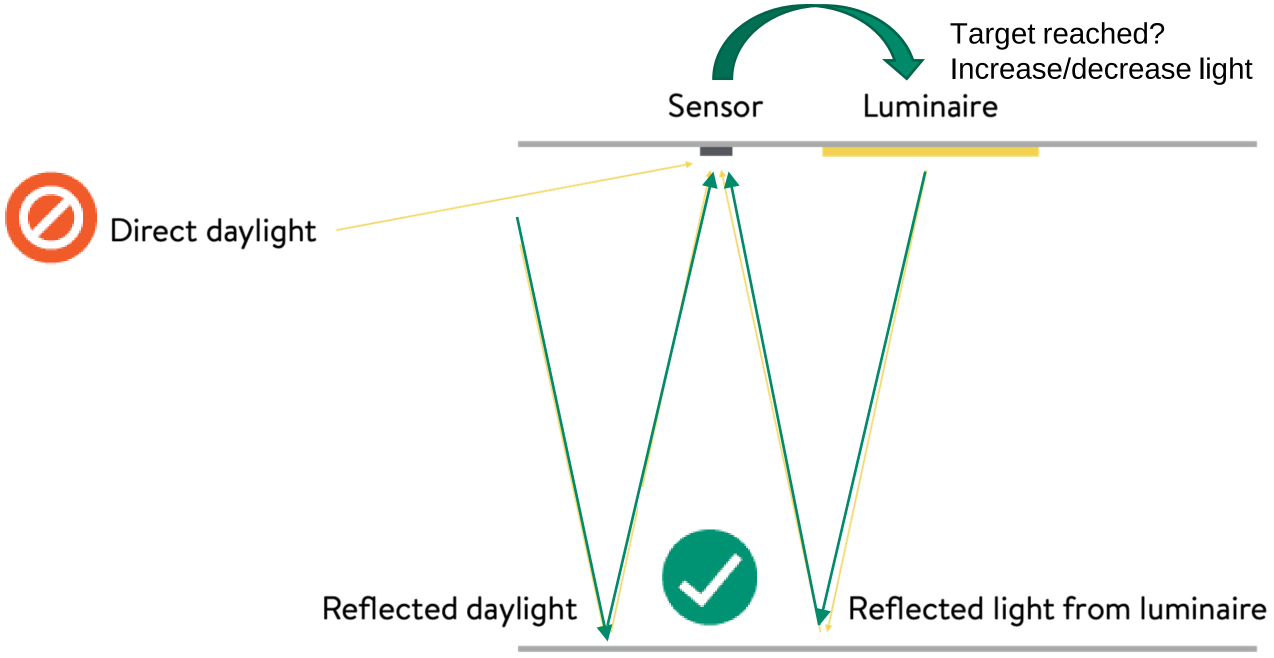
The influence of the direct light on a sensor (light coming outside of field of view) **is strongly affecting the error of the measurements** resulting with the space being over- or underlit.

The sensor should measure (see) **only light reflected from the surface** where the light level should be maintained and **only the light reflected from the controlled fixtures.**

See: SN-209 Daylight Harvesting application note

Closed loop method

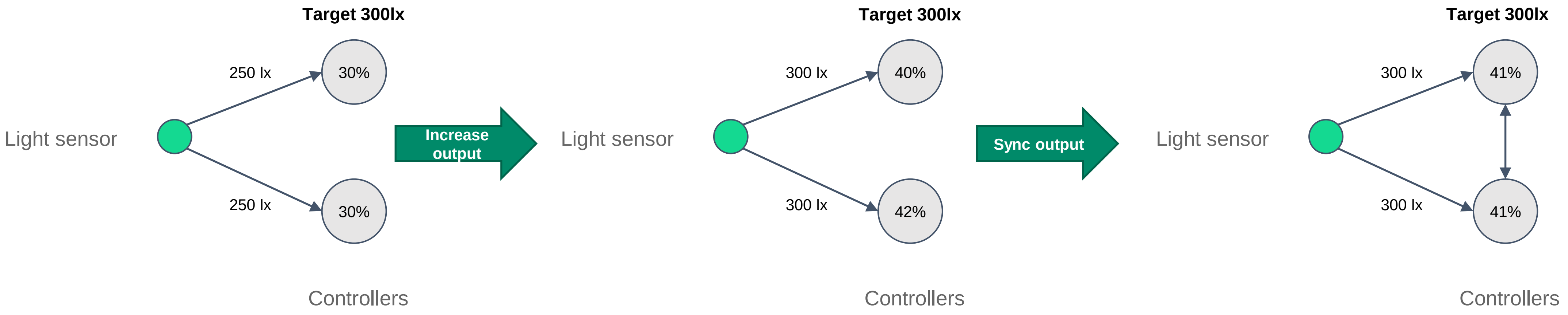
- The light sensors measure the light from **both daylight and electric light**. The feedback from the sensor is used to automatically adjust the light output until desired (defined by the user) light level is achieved.
- The choice and placement of the light sensors are critical as closed-loop require accurate tracking.



How Sensors & controllers work together

- Bluetooth works on a publish/subscribe model

- Light sensor is publishing measured light level to all controllers in the zone.
- Controllers who subscribe to this published data adjusts the light level until the level reported by the sensor meets the required level (incl. accuracy, hysteresis)
- Controllers synchronize with other in order to have consistent light level.



 See: SN-209 Daylight Harvesting application note

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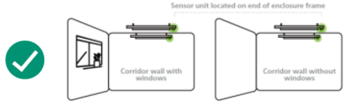
Sensor installation recommendation

- Follow manufacturers recommendations

- Install directly above the surface where light level needs to be maintained

- Make sure there's no direct sunlight falling on the sensor



- Install in the appropriate distance from the window (based on the sensor field of view)

- The sensor should control only the light contributing to the field of view

- Do not install above a highly reflective surface.

- Make sure that the view of the sensor is not obstructed.

- Install at least one sensor per zone.

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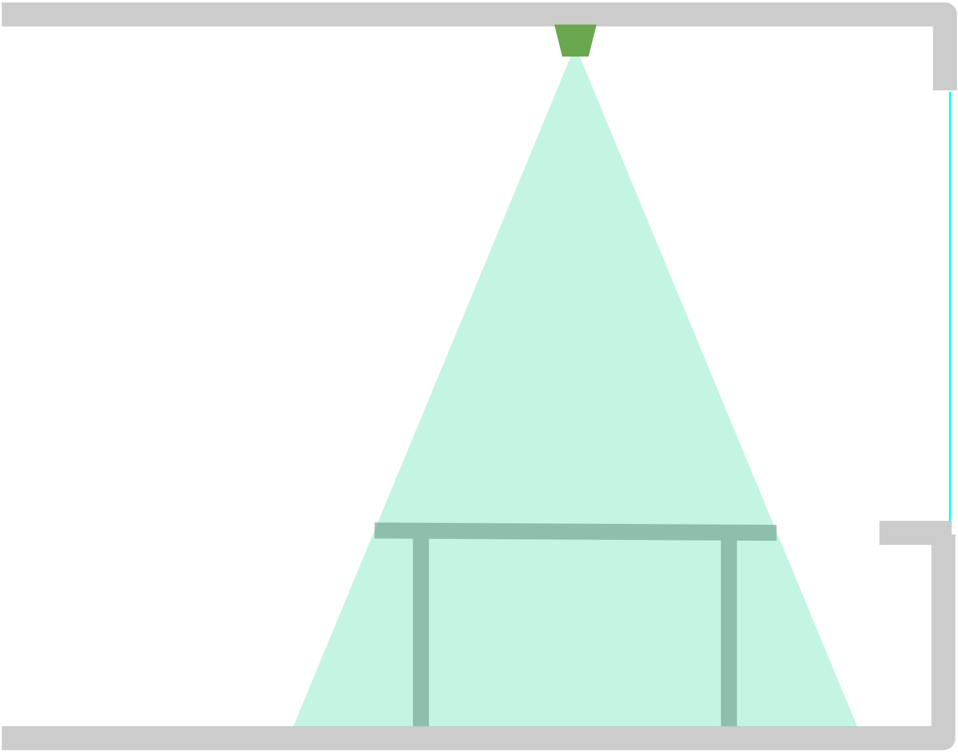
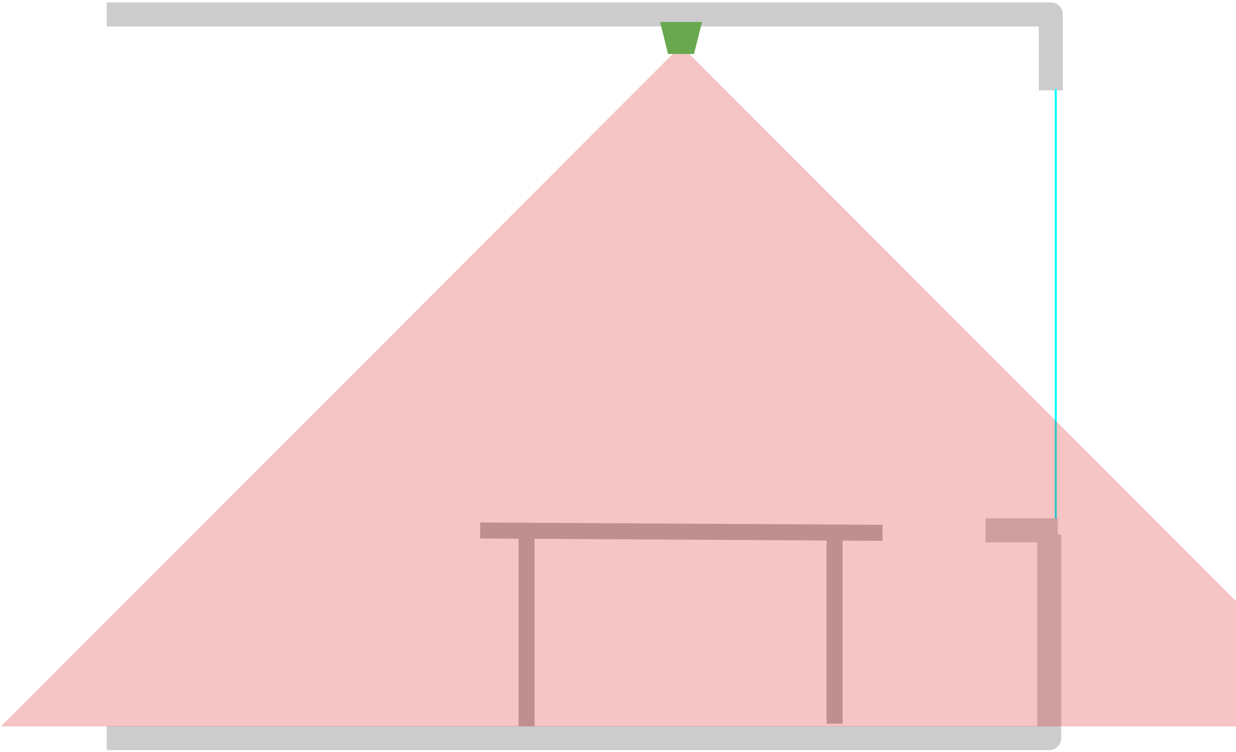
Installation tips

EFFECTIVE



Sensor is installed above the surface where the light level needs to be maintained and is not affected by the external light.

INEFFECTIVE



Sensor is installed above the surface where the light level needs to be maintained BUT due to the wide angle of detection the field of view is affected by the direct light coming out of the space (e.g. light reflected from a car rooftops)

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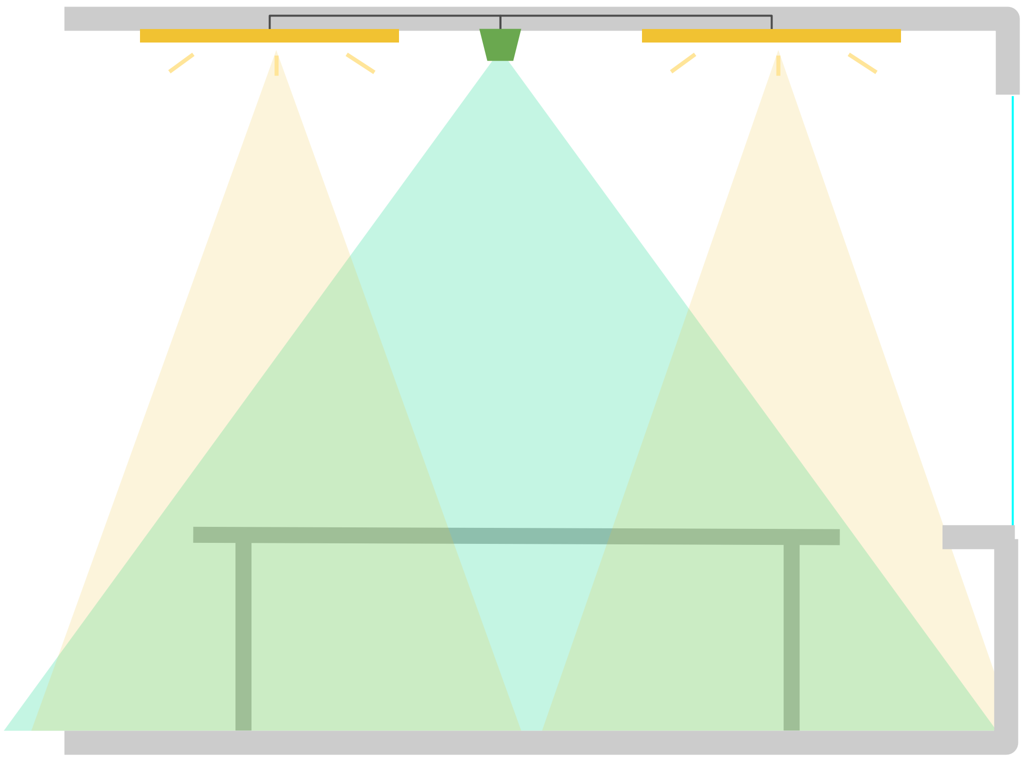
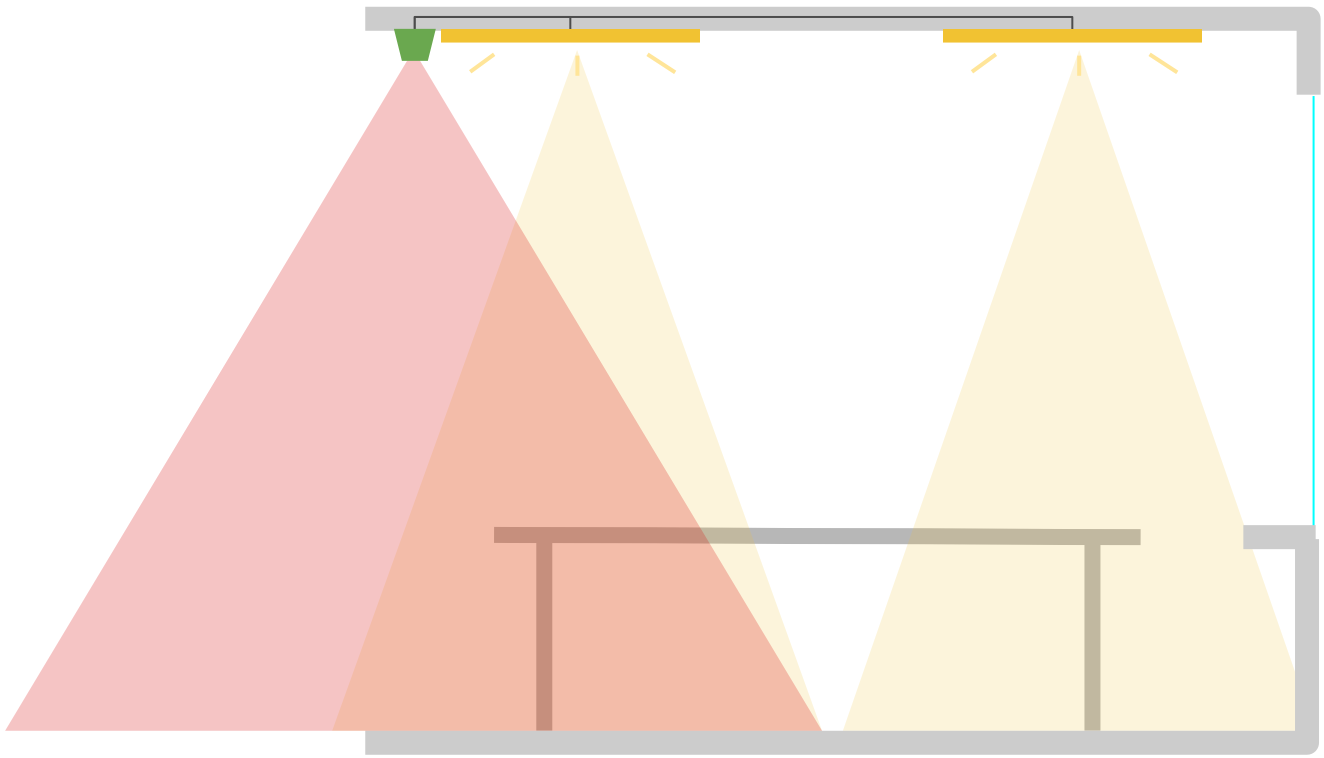
Installation tips

EFFECTIVE



Sensor is controlling the light contributing to the field of view AND the controlled light contribute only to the sensor field of view.

INEFFECTIVE



Sensor is not controlling the light contributing to the field of view OR the controlled light does not contribute to the sensor field of view.

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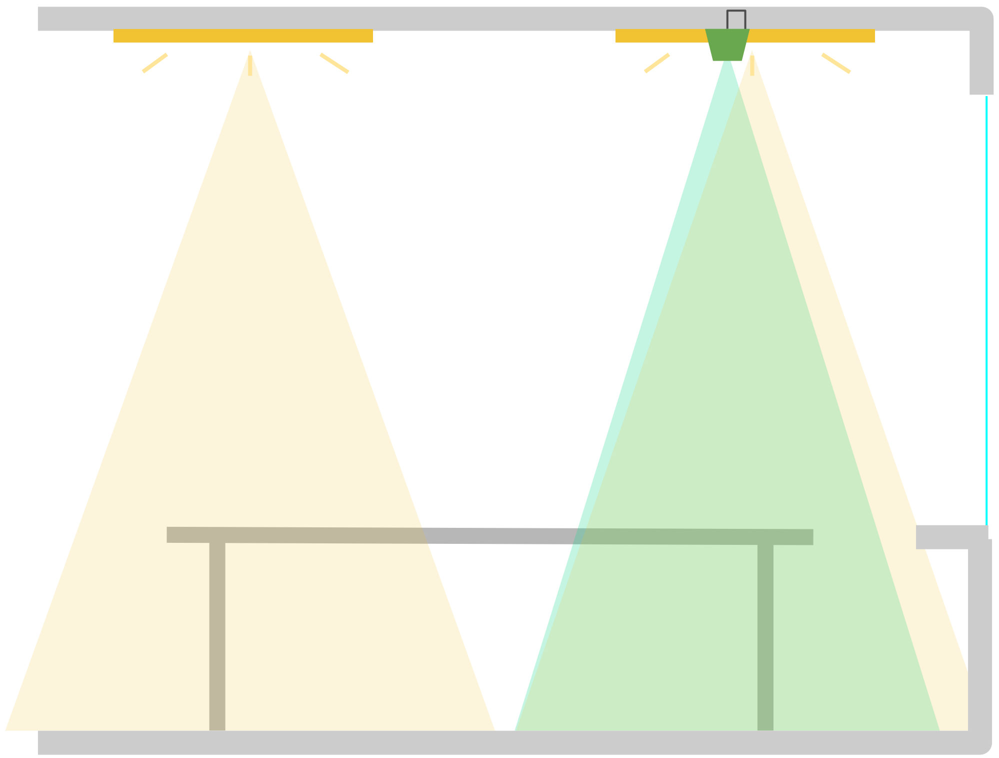
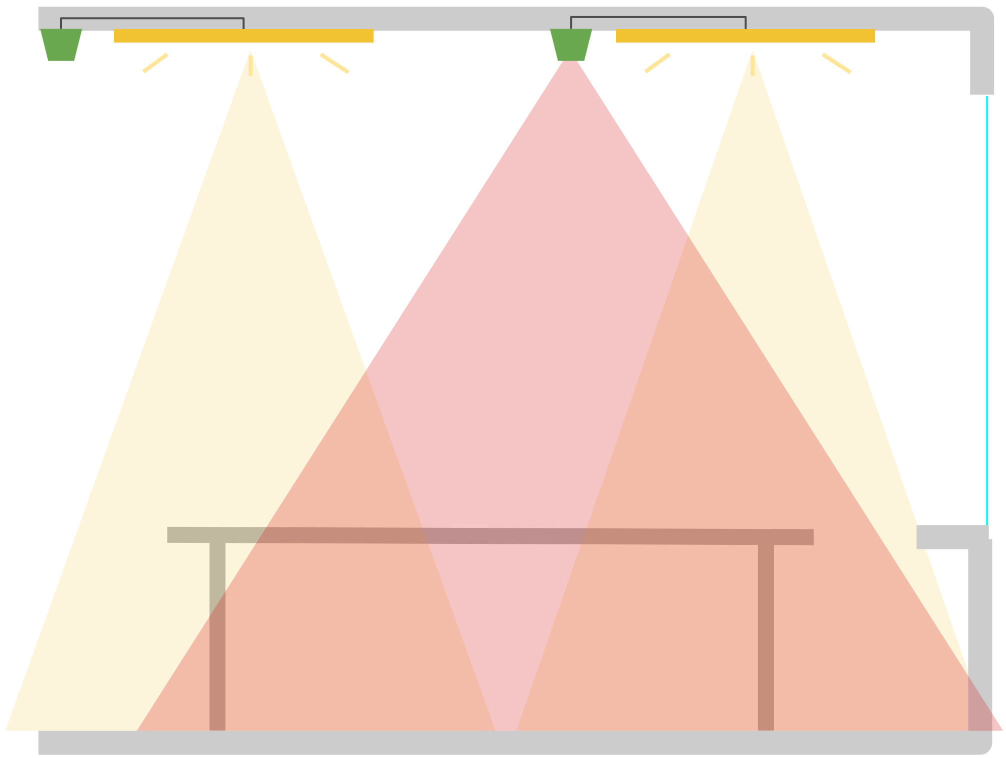
Installation tips

EFFECTIVE



Sensor is controlling the light contributing to the field of view AND the controlled lights contribute only to the sensor field of view. The sensor is not affected by the light coming outside of the desired field of view.

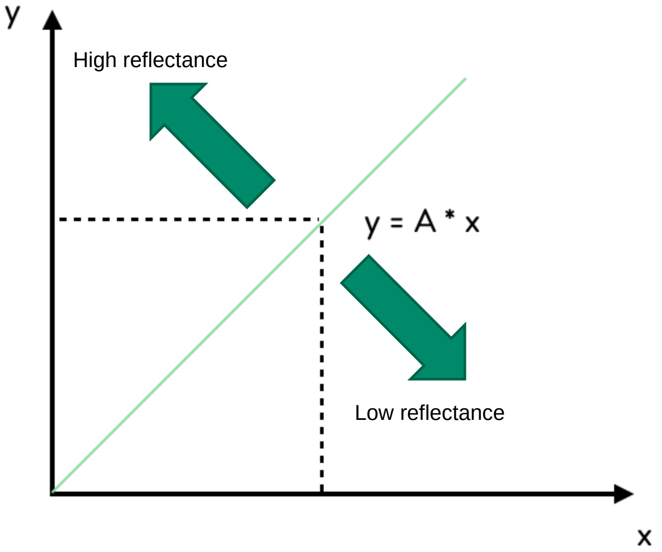
INEFFECTIVE



Sensor is not controlling all the lights contributing to the field of view. The sensor is affected by the light coming outside of the desired field of view, e.g. light controlled by other sensors.

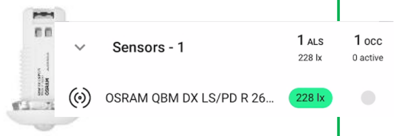
Calibration principles

- A lux sensor has no idea what actual lux it is – it has a range of A to B
- Different lux sensors have different response curves and the angle of the line from A to B will be different
- A lux sensor must be calibrated in order to work correctly and understand how steep the line is
- Calibration is done by calculating the slope parameter (A) of the calibration (linear) function using a single point measurement. The values reported by the sensor (y) are calculated according to the calibration function based on the raw sensor measurements (x).



$$y = A * x$$

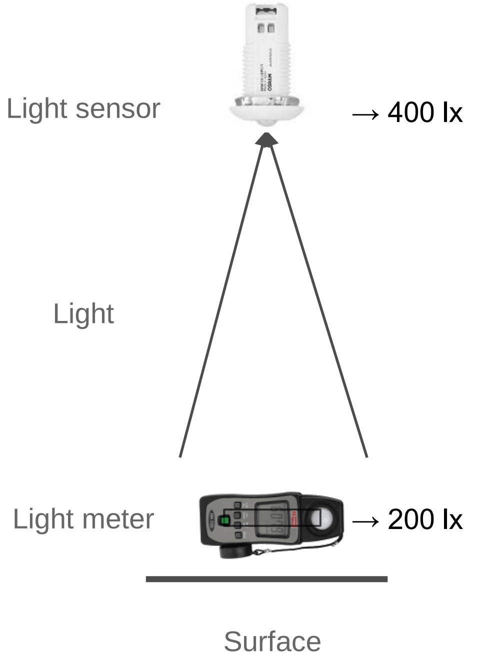
$$A = \frac{\text{Light meter light level}}{\text{Sensor light level}}$$



A = reflectance (%)

Calibration example

BEFORE

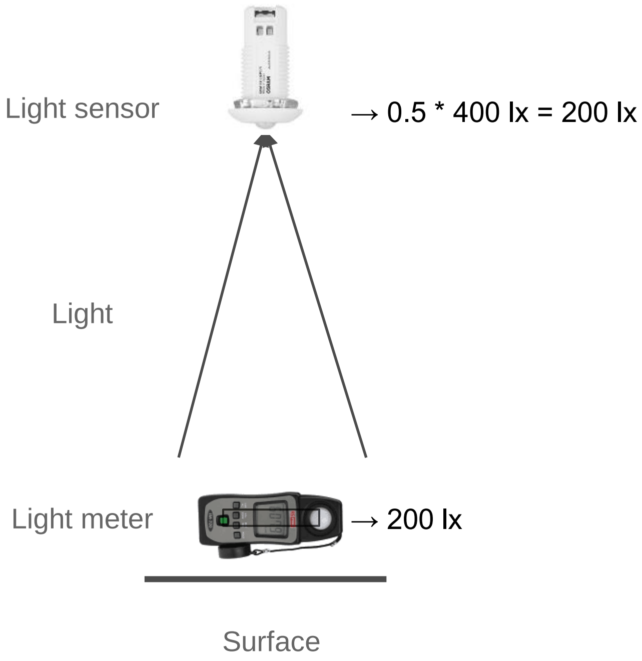


CALIBRATION

$$A = \frac{200}{400}$$

$$y = a(0.5) * x$$

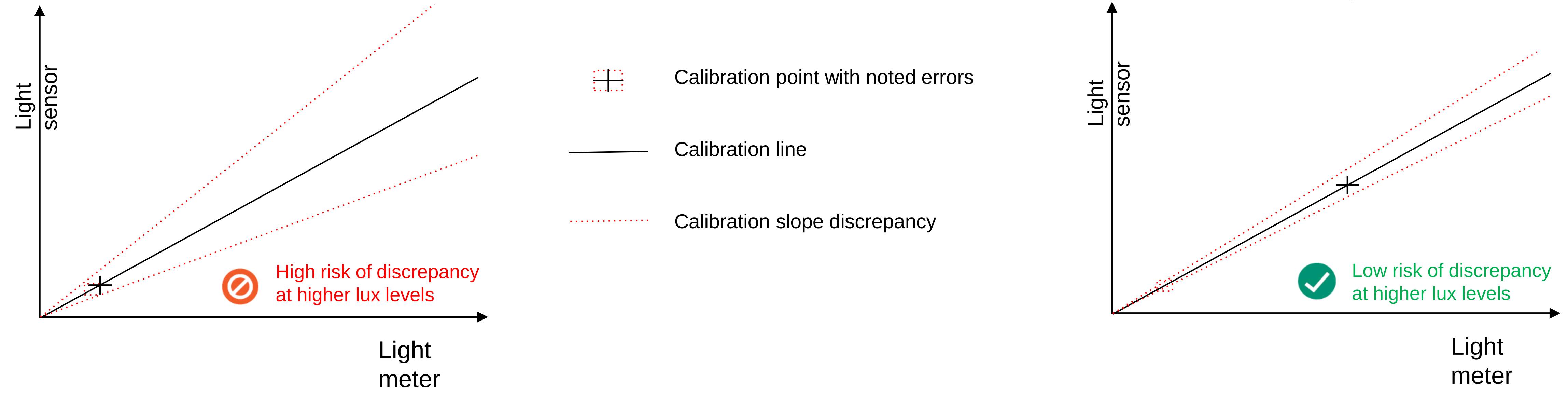
AFTER



Calibration accuracy - minimum level

- If calibration is done at a low light level – you could compound measurement errors
- Calibrating sensors in higher levels of light increase accuracy of calculating the slope parameter.
- Minimum light level required during calibration is recommended (currently 75% of desired lux level & at least 100 lux)

Measured at low room lux **VS** **Measured at high room lux**



Best thing to do is sample as much light as possible close to target

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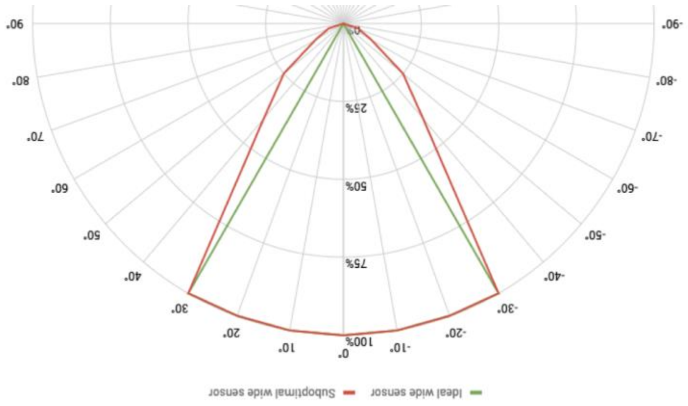
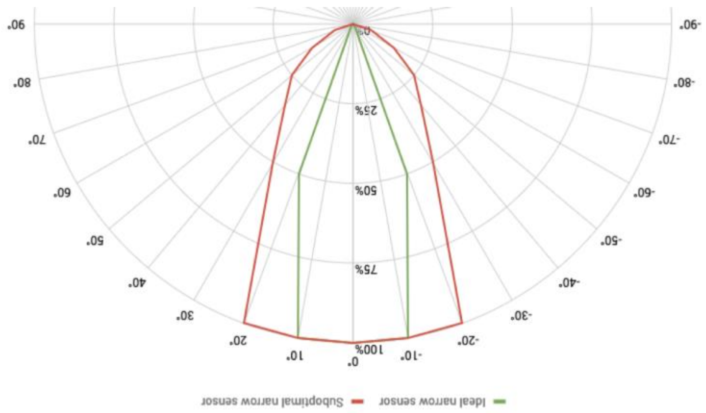
Sensor recommendations

- Closed-loop sensing requires accurate tracking!
- Light sensor should see only the light contributing to the desired field of view
- Cut-off sensitivity below 1% for the angles outside the desired field of view (from external light source)



zone level control



fixture level control

- There are significant issues with maintaining desired lux level on the surface or working plane using inaccurate sensors as there are high errors in levels reported by the sensors vs light meter measurements.
- This results in the space being under-lit or over-lit when conditions are different than when sensor is calibrated.

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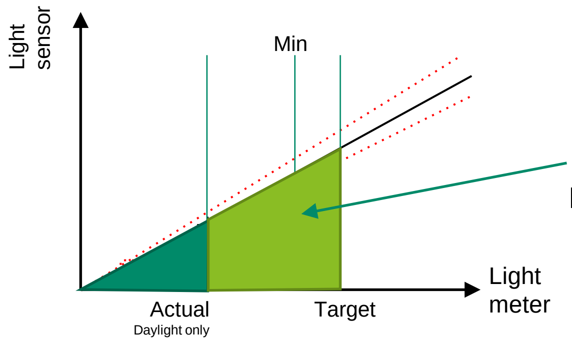
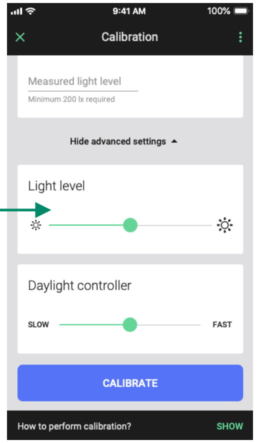
Calibration conditions

- Due to the different specifications of different sensors, the inaccuracy of some sensors being used with our system and in order to keep the light in a space **above required minimum level** we recommend:
  - Performing light sensor calibration in daylight
  - Turn artificial lighting off and increase only if minimum light (75% of target/100lx) not reached or to reach target
  - Using advanced settings in calibration to increase lighting levels until at least min reached
- This approach will result in the space not being underlit, but rather overlit in most cases.



Use advanced setting in Calibration to increase level of lights to meet min level or target



NOTE:

- If you're OK with the space being sometimes underlit you may calibrate in other conditions.
- The calibration should be performed in **higher levels** of the light as well (see calibration accuracy).

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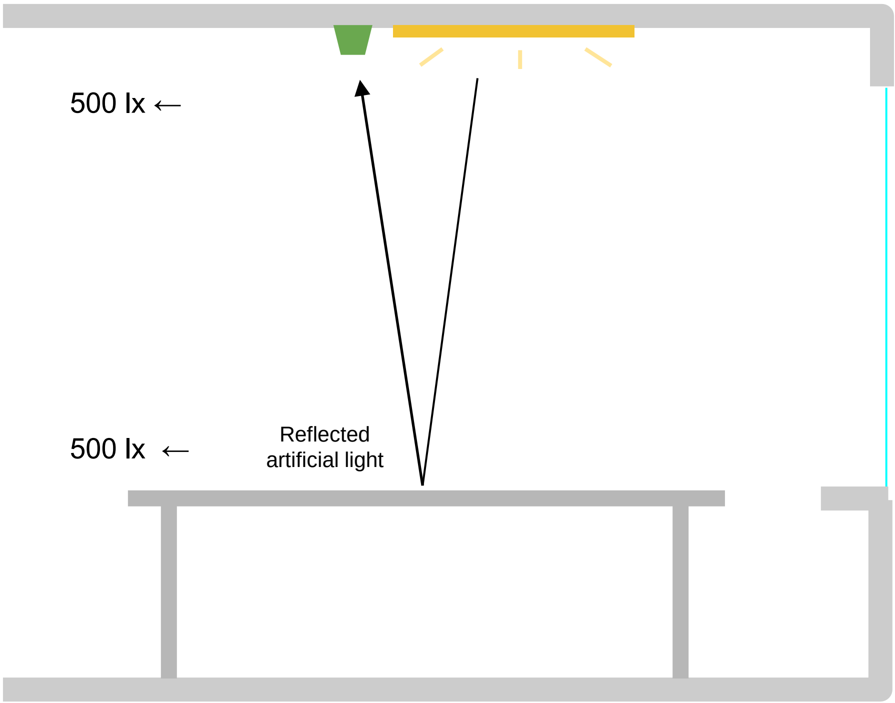
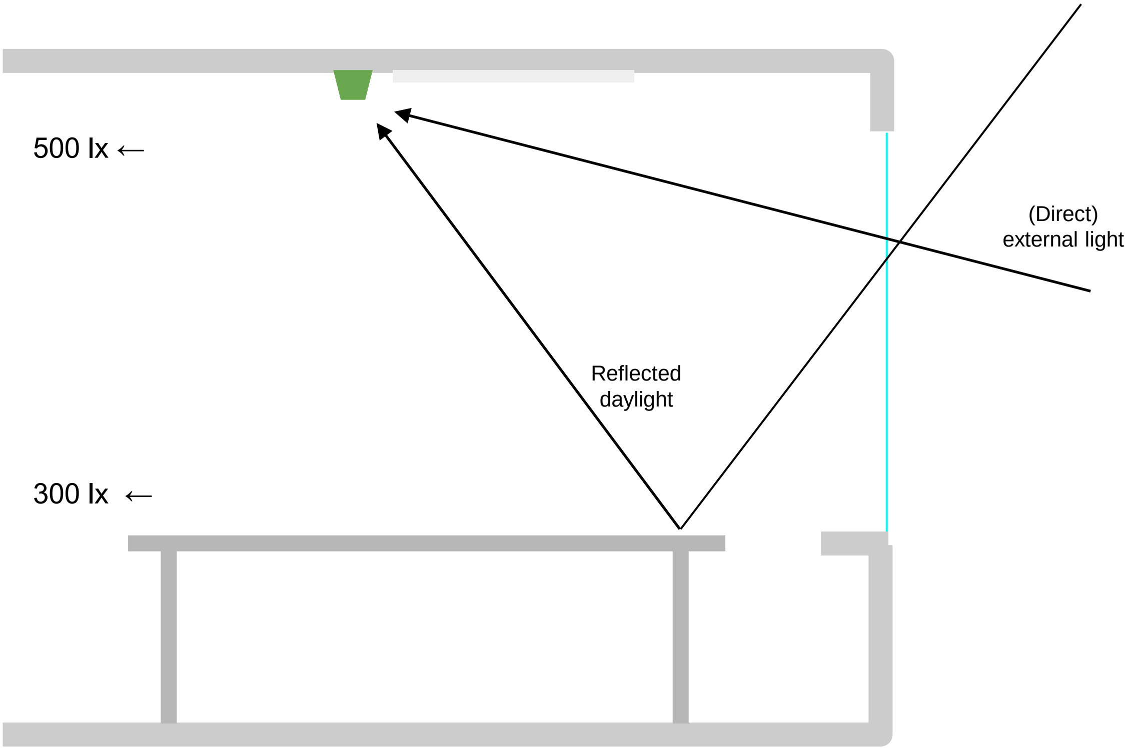
Calibration with artificial light only



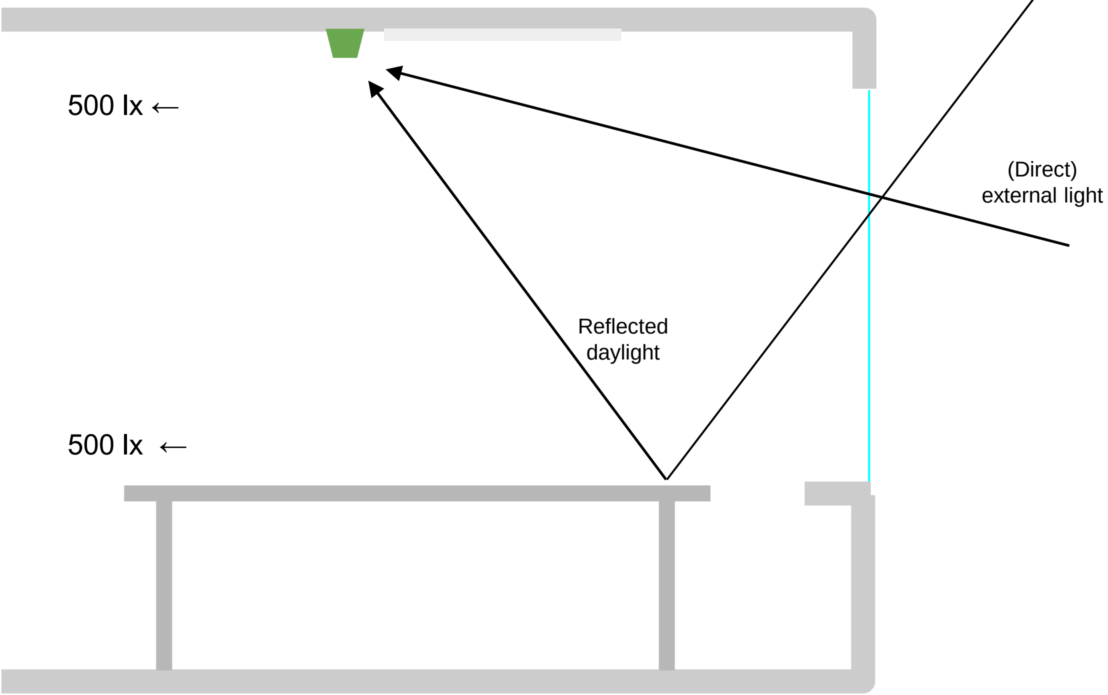


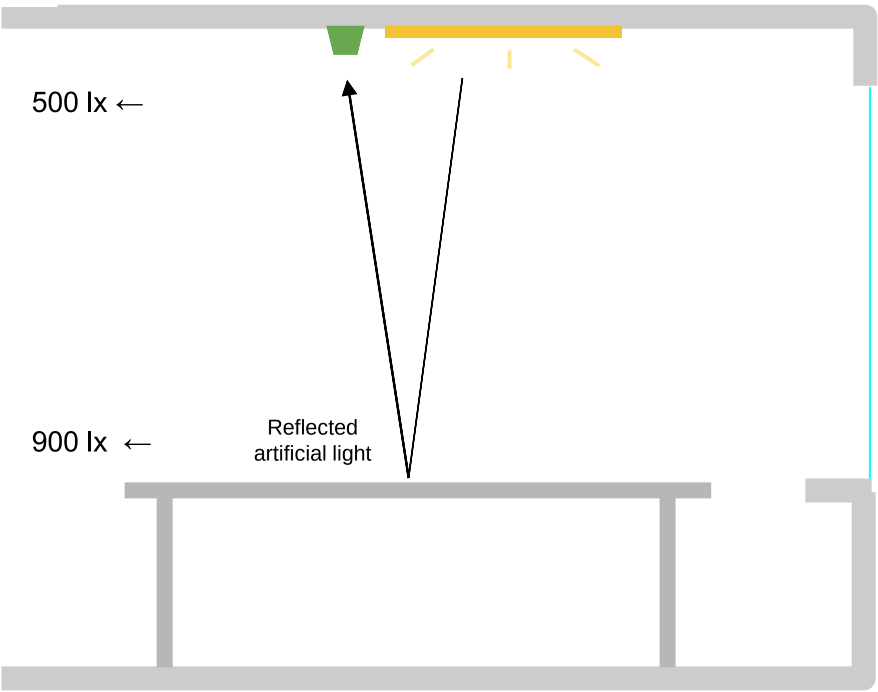
Sensor is **calibrated** with artificial light only **during the night**.

During the day external light is affecting the sensor and provides oversaturation error to the light level measured by the sensor which is higher than the light available on the surface (increased with the influence of the external light) which **leads to space being under-lit.**

During calibration process we can then measure amount of controllable artificial light but would not know how much daylight could be available

Calibration with daylight only





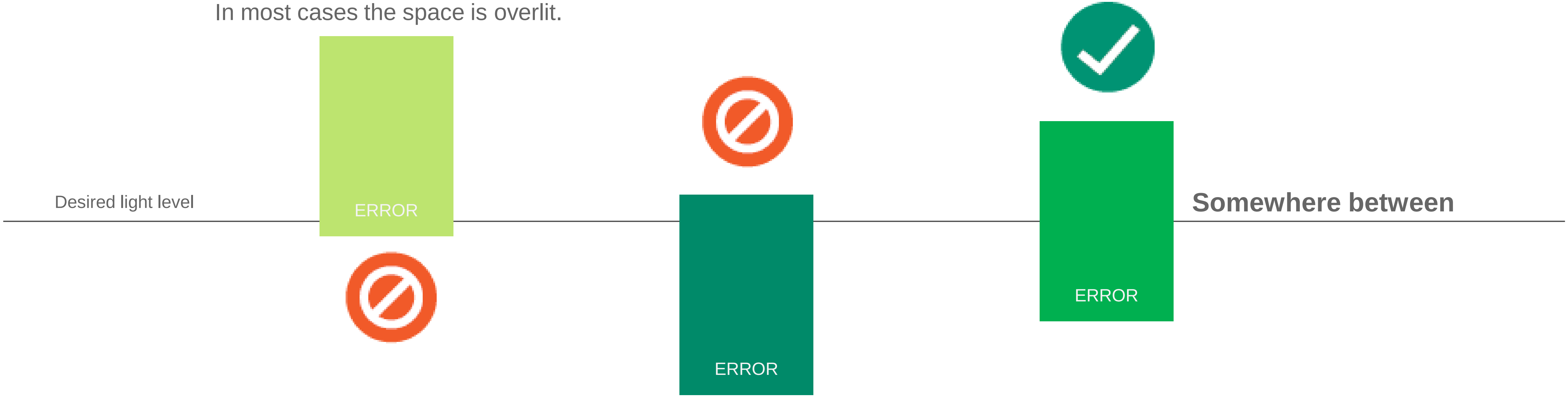
Sensor is calibrated during the day with daylight only including (direct) external light coming out of the field of view and sensor is calibrated with the error.

During the night external light is not affecting the sensor so the level of light measured by the sensor is lower (decreased by the lack of influence of the external light) than the light available on the surface which leads to **space being over-lit.**

During calibration process we can then measure amount of controllable artificial light as a proportion of daylight and take this into account

Calibration vs measurement error

Calibration in daylight only.
In most cases the space is overlit.



Calibration in artificial light only.
In most cases the space is underlit.

Same amount of error but normalised equally between overlit and underlit to get closer to target

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How does the commissioning tool help achieve this?

Built into specification of Bluetooth Qualified mesh is a Light Controller Setup server and includes an illuminance regulator. This complex in built system ensures that errors are accounted for in the set point and also consider tolerances to smooth out operation for a comfortable experience

The illuminance regulator

- complements the light level state machine by adding an ambient illuminance sensor feedback
- Allows the lightness server to adjust its output level that is based on the room's ambient light = conserve energy and achieve more consistent light levels.
- Takes target illuminance level as the reference level and compares it to sensor data
- Compares inputs to establish an error for the regulator and tries to minimise them
- Contains a proportional (P) and an integral (I) component whose outputs are summarized to a light level output.

Each time the Illuminance regulator runs it:

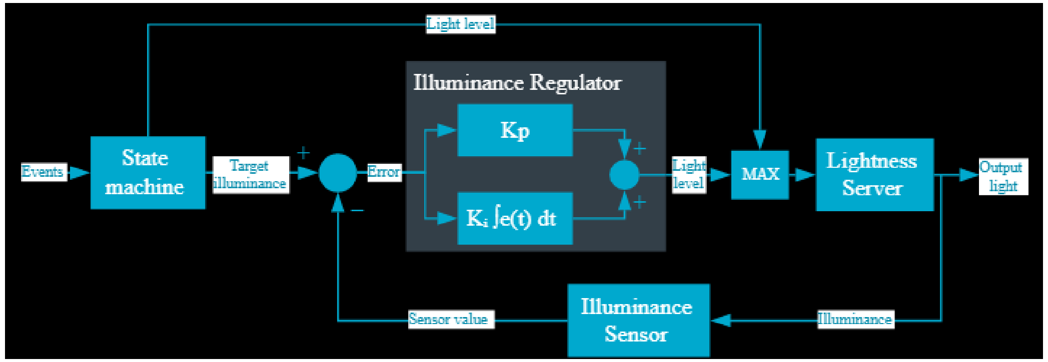
- Calculates the integral of the error since the last step.

- Adds the integral to an internal sum.

- Multiplies this sum by an integral coefficient.

- Summarizes the sum with the raw difference multiplied by a proportional coefficient.

Regulator accuracy – also known as threshold tolerance
To reduce noise, the regulator has a configurable accuracy property, which allows it to ignore errors smaller than the configured accuracy (represented as a percentage of the light level).



- K_{pu} - proportional up; used when target is higher.
- K_{pd} - proportional down; used when target is lower.
- K_{iu} - integral up; used when target is higher.
- K_{id} - integral down; used when target is lower

The value of the coefficients is typically a trade-off between fast response time and system instability:

- If the value is too high, the system might become unstable, potentially leading to oscillation and loss of control.
- If the value is too low, the step response might be too slow or unable to reach the target value altogether.

https://en.wikipedia.org/wiki/PID_controller

How does the commissioning tool help achieve this?

For the calibration to work it is required that the ALS supports the [0x004E Present Ambient Light Level] as a Sensor Setting Property.
Sensor calibration starts with writing to the 0x004E Sensor Setting Property the light level provided by the user as measured with an external lux meter.

PREPARATION

1 LIGHTS OFF - Upon entering the calibration screen, the app is turning off all luminaires in given zone.
This may be changed later by using one of the sliders in the advanced section named "Light level", i.e. if it is too dark to calibrate.

2. Select a device in a zone to be used as an active ALS sensor. This sensor will be publishing the ambient light measurements to the other devices within the zone.

The required lux level needed for sensor calibration is at least 100 lx and at least 75% of the maximum possible scenario state (run /prolong/standby). This level is displayed under the Measured light level field

3. Suspending the node subscriptions - To prevent that internal state of the node from change accidentally the node is 'suspended' (all subscriptions are temporarily removed).

4. Re-starting the Daylight Controllers
The ensure that all controllers in the zone are in the same state, they are restarted by sending a sequence of mode OFF / mode ON messages.

How does the commissioning tool help achieve this?

The Daylight Controller is configured in 30 steps. During this phase, regulator parameters like kpd, kpu, kid, and kiu are calculated and configured for each scene in every device in the zone.

CALIBRATION

Steps 1-3
- Fetching the scenes defined in a device
- Clearing the controller hysteresis
- Fetching from the Cloud the parameters for the run, prolong and standby phases

Steps 4-10
- Recording the light level with luminaires turned off.
- Recording the light level with luminaires turned on at max level.
- Recording the light level with luminaires turned on at min level.
- Validating the measurements (the values reported above must be different, indicating there is a light feedback to the sensor)
- Calculating the hysteresis, and regulator coefficients kpu, kpd, kiu, kid
- Setting the calculated values to the devices (not using scenes)

Steps 11-26
- Repeating the following steps for the 4 scenes: Off, Auto, A, B
  - > recall the scene
  - > set hysteresis
  - > set regulator parameters
  - > store the scene

Steps 27-30
- **Storing the parameters in the Cloud**
- **Restoring subscriptions on suspended devices**
- **Recalling the Auto scene**

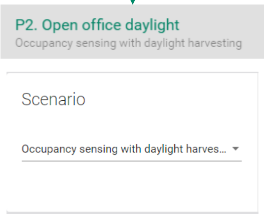
Based on that the sensor internally calculates the coefficient representing the surface reflection ratio (the level reported by the lux meter vs the measured level) and starts shifting the subsequent output values accordingly.

How a user should configure daylight - General overview

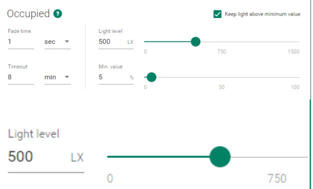
Set room target

Calibrate Sensor response curve

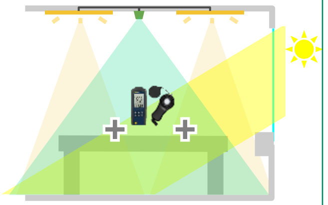
1. **Set Profile for zone**
   Must include "Daylight"



2. **Set Lux target in profile**

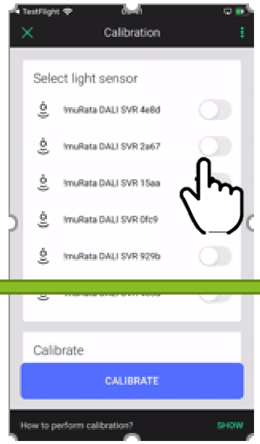


3. **Setup space**
   Ensure lux level measures with both daylight and artificial light

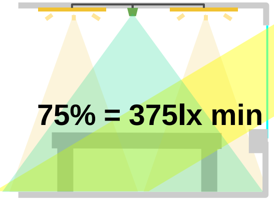


Locate manual lux sensor in space to target location where light should be measured

4. **Identify and Select Lux sensor for zone**

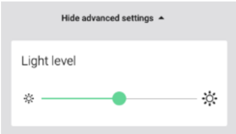


5. **Set Lux reading**
   Lux in room must be at least 75% of target set in profile

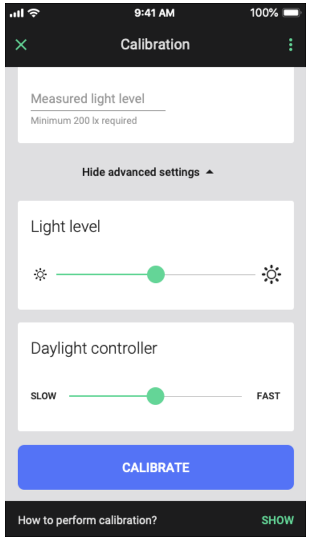


Target = 500lx

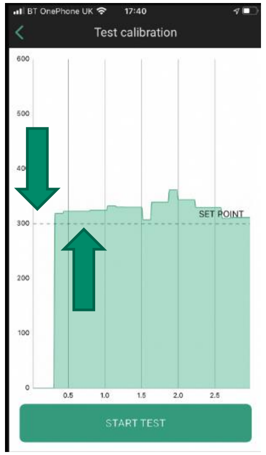
Increase dim level to hit set point if needed



6. **Set Light level and Response speed**
   > CALIBRATE



7. **Change speed to ensure oscillation is minor**



8. **Enable Auto**

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How a user should configure daylight - Tips

- ✓ Calibration should be performed after all furniture, interior finishes and materials have been installed and the building has been occupied
- ✓ Make the calibration adjustments at a distance from the sensor & light meter
- ✓ Step away for a time before taking the readings as your body will interfere with light levels
- ✓ Make sure to calibrate under normal daylight conditions with all lights switched off and do not perform calibration in complete darkness
- ✓ Make sure windows and skylights are uncovered and clean

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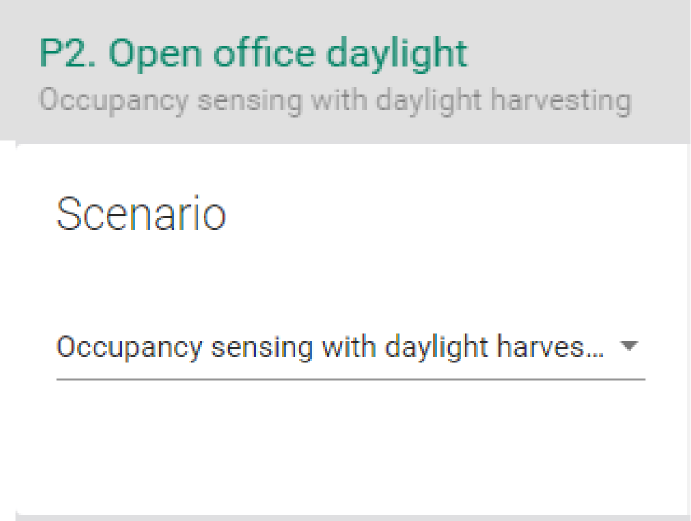
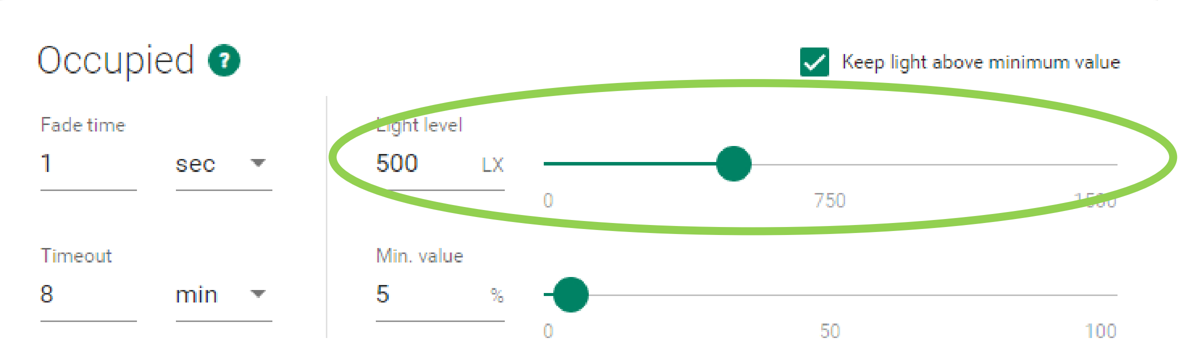
How a user should configure daylight – In detail

1. Ensure you have your zone set to use a “Daylight” scenario



2. Set your lux target for “Run mode” as desired – This will become your lux target (set point) for the closed loop control



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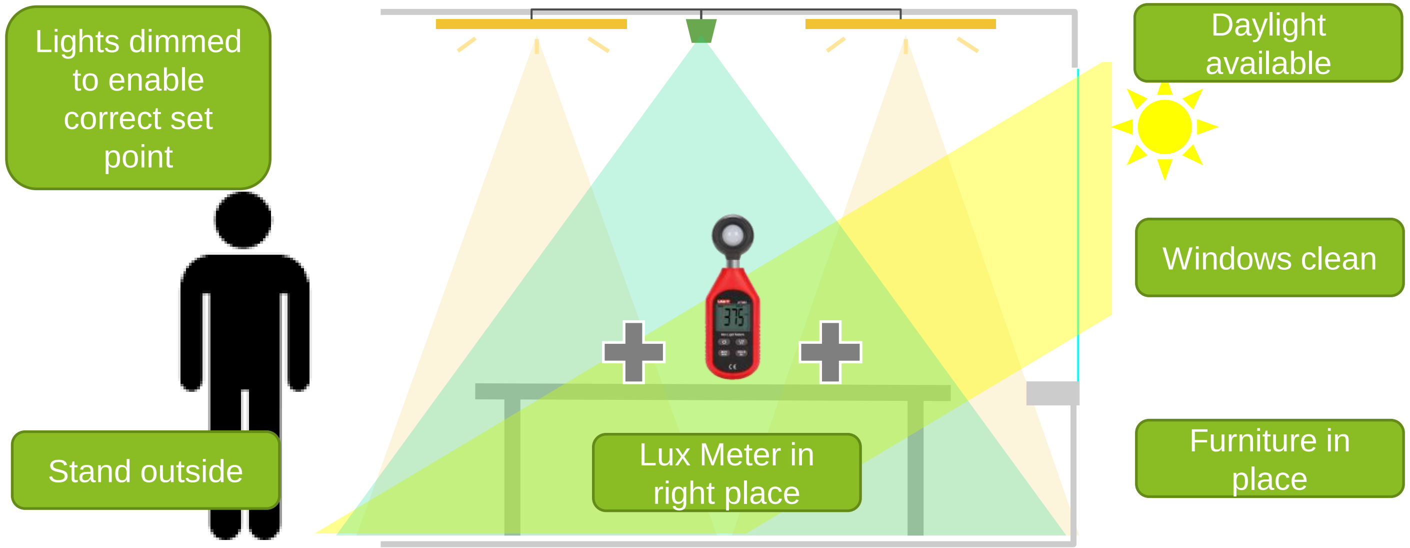
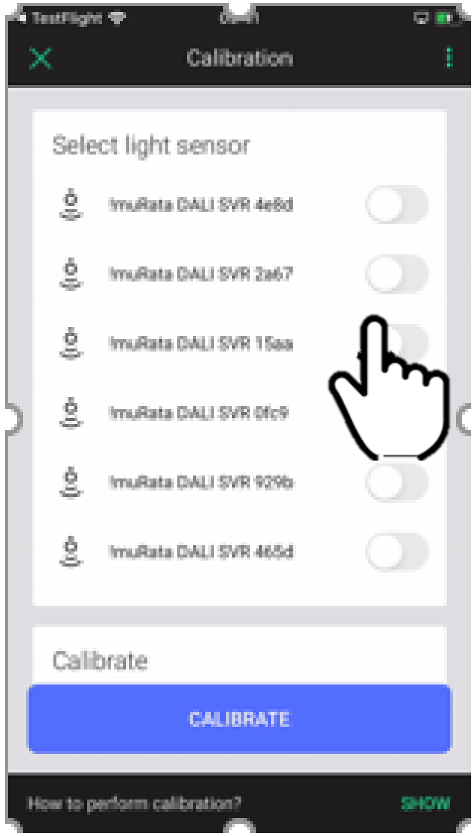
How a user should configure daylight – In detail

3. In the room – set up your calibration setup



LUX = >75% of set point

4. Set which sensor is in charge for zone



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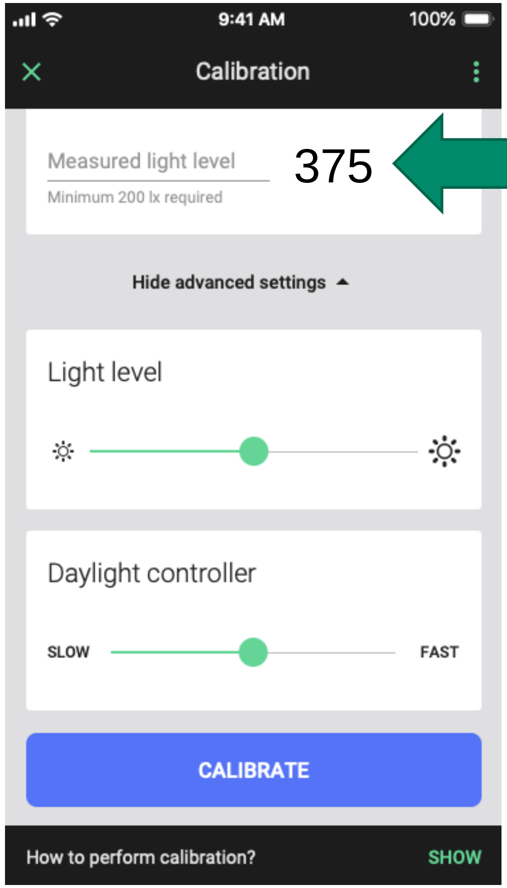
How a user should configure daylight – In detail

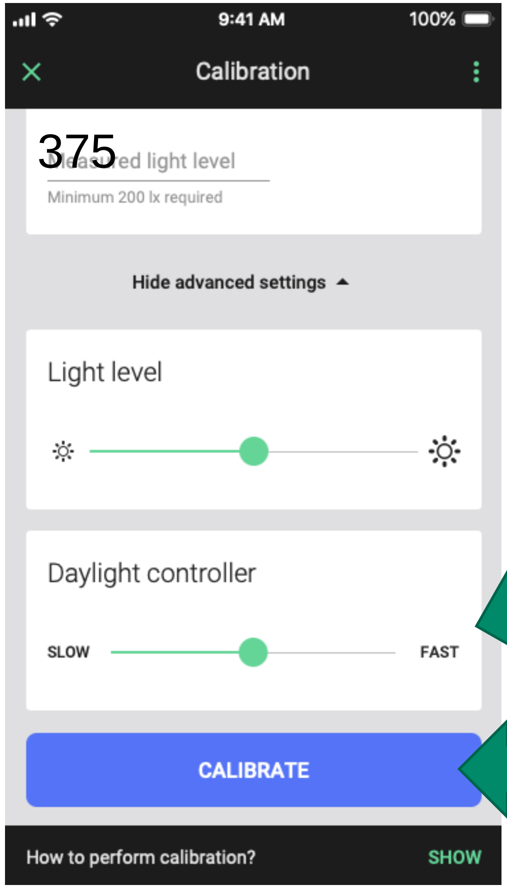
4. Set lux reading for room – must be >75% of target



Use Light level to increase artificial light until minimum reached

How a user should configure daylight – In detail

5. Set response speed and calibrate



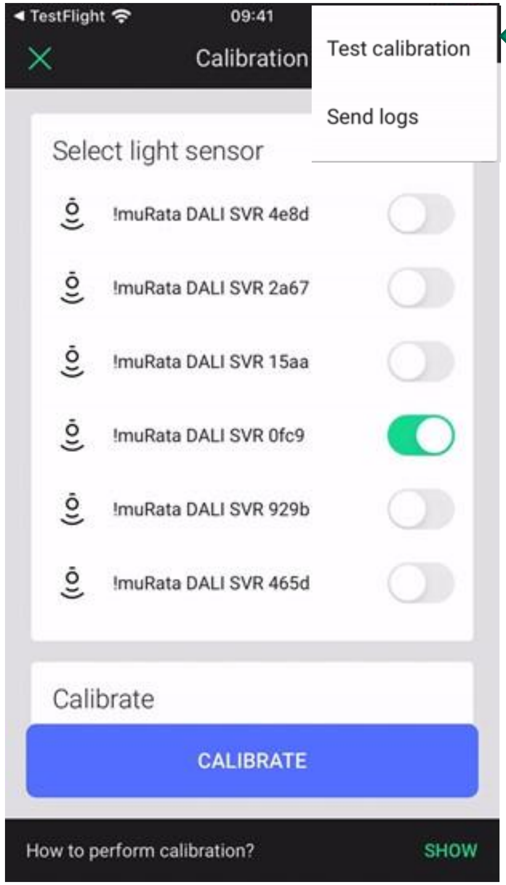
This will govern how the Lux controller reacts to changes in ambient light
FAST or SLOW – Use "Test calibration" to refine

Start calibration – Make sure you step outside the room

29 calibration steps begin

How a user should configure daylight – In detail

6. Test calibration and check Controller speed



In CALIBRATE menu – use the context menu and select “Test calibration”

A response graph is created

Press START TEST - An automated test will be performed

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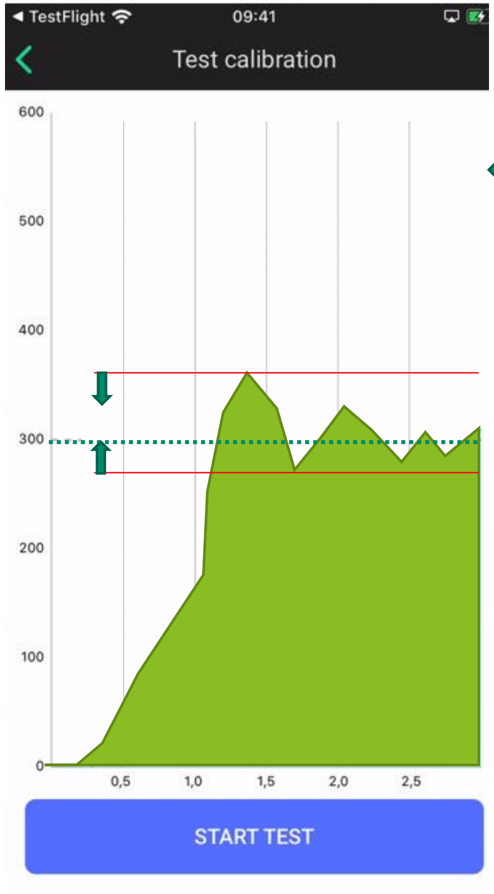
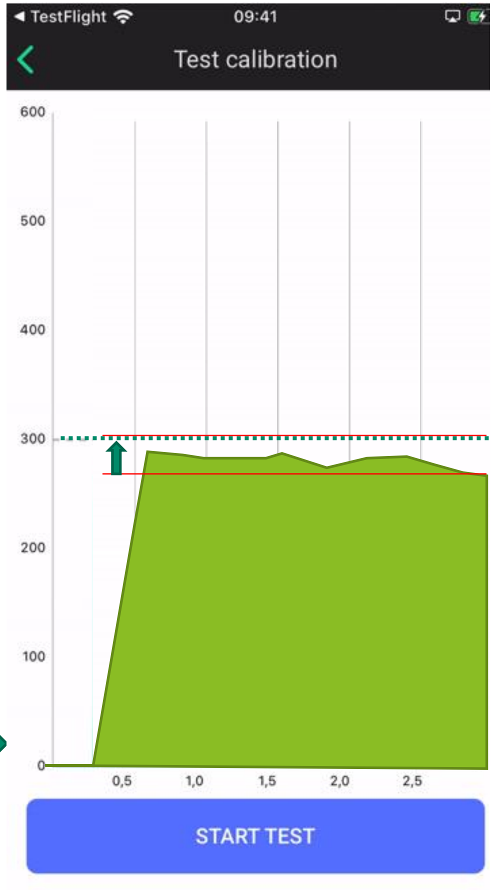
How a user should configure daylight – In detail

6. Test calibration and check Controller speed

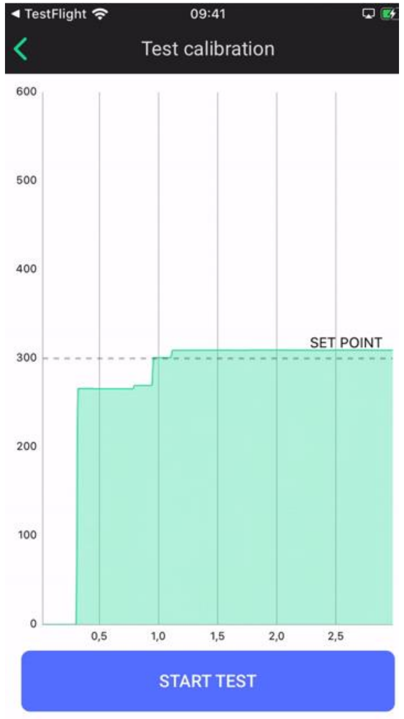


If profile has too many oscillations = slow controller down

If set point not reached – check light levels and increase controller speed



IDEAL



Set point reached
Low oscillation

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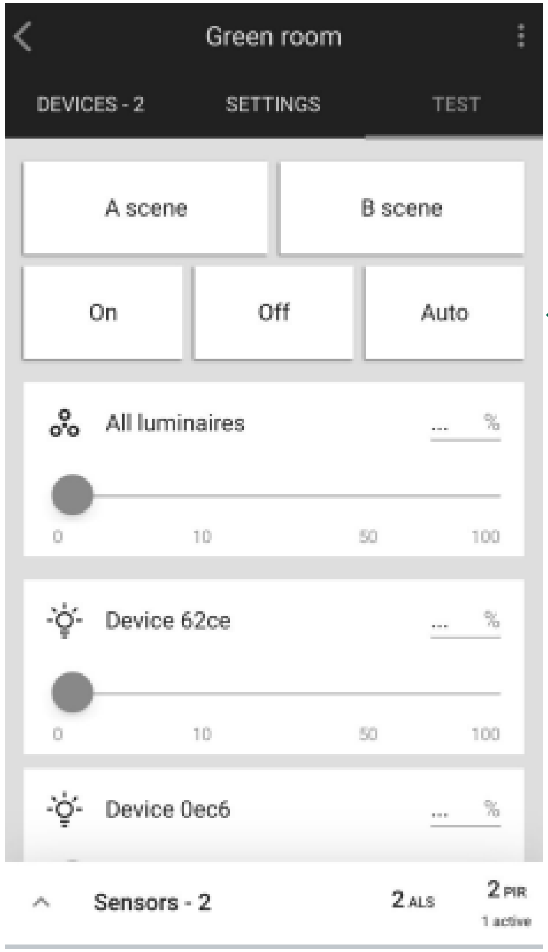
How a user should configure daylight – In detail

7. Enable auto



Just to ensure all is back on AUTO

On TEST tab – Press “AUTO”

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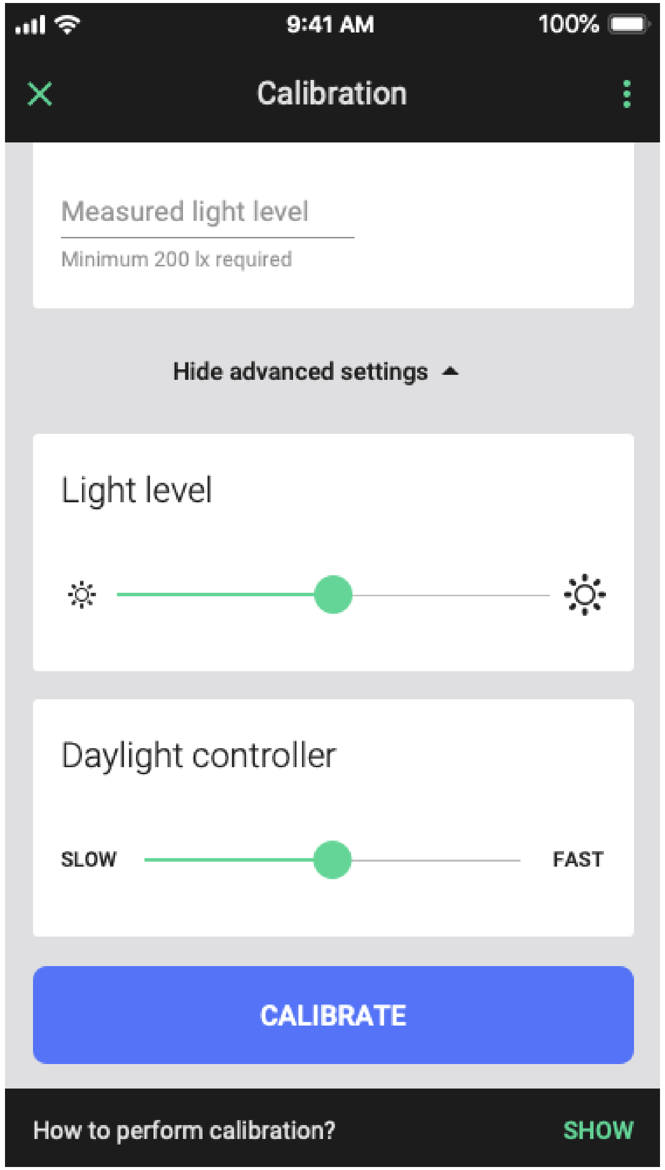
Troubleshooting – Calibration at night

- If you cannot perform calibration in recommended conditions, e.g. have to calibrate daylight harvesting during night, please follow these steps:
  - In the Calibration view expand Show advanced settings
  - Adjust light level in the space using the slider to achieve minimum level required in the space (as measured by the light meter)
  - Enter the level measured by the light meter
  - Press CALIBRATE



See: SN-209 Daylight Harvesting application note in the Knowledge base

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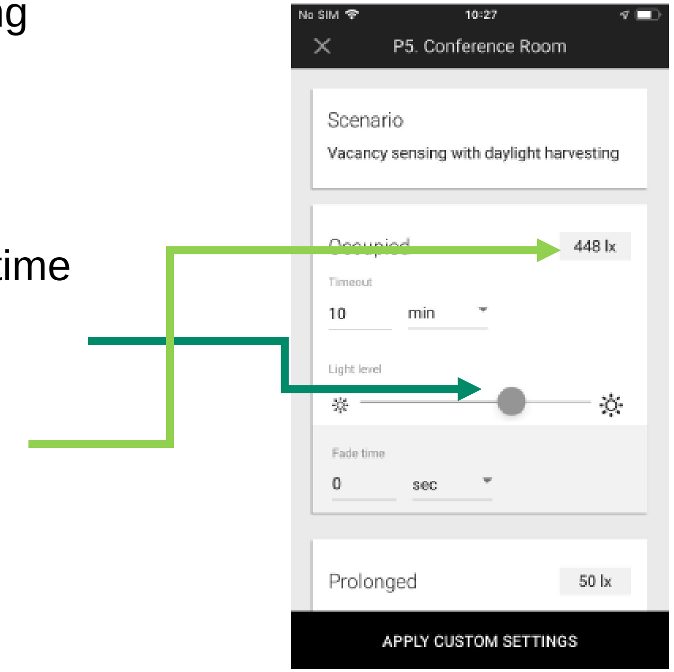
Troubleshooting – Real time profile adjustment

- If you are struggling to calibrate – recommend making adjustment to profile using app using "CUSTOMISE"
- As you change the target lux in real-time using the slider bar you will get a real time reading of what the sensor can see
- Once you have the profile target lux set correctly – go back and calibrate



When should I re-calibrate?

- Environment e.g. interior has changed (walls moved, new furniture/carpets)
- Sensor has been replaced or any light has been added to or removed from the zone.
- If the driver in the luminaire is changed
- There are some issues with the previous calibration
- External factors changed – new building build across road

BONUS: advanced parameters

For any given device you can use the mobile app to check extended parameters of the daylight server service.

- Sensor cadence
  - Publish period - interval of the regular publishing
  - Delta up/down - min. change of light level to be reported
  - Min interval - interval between 2 sensor reports
  - Fast cadence high / low - range of fast cadence
- PI Controller parameters
  - Accuracy - accuracy of the controller feedback (5%)
  - Hysteresis - min difference between setpoint & measured level to switch on/off the light
  - Proportional & Integral coefficients: Kpu, Kpd, Kiu, Kid

All info can be found in: device > select device > Diagnostics > Element 1 – Light Controller Server

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Thank you