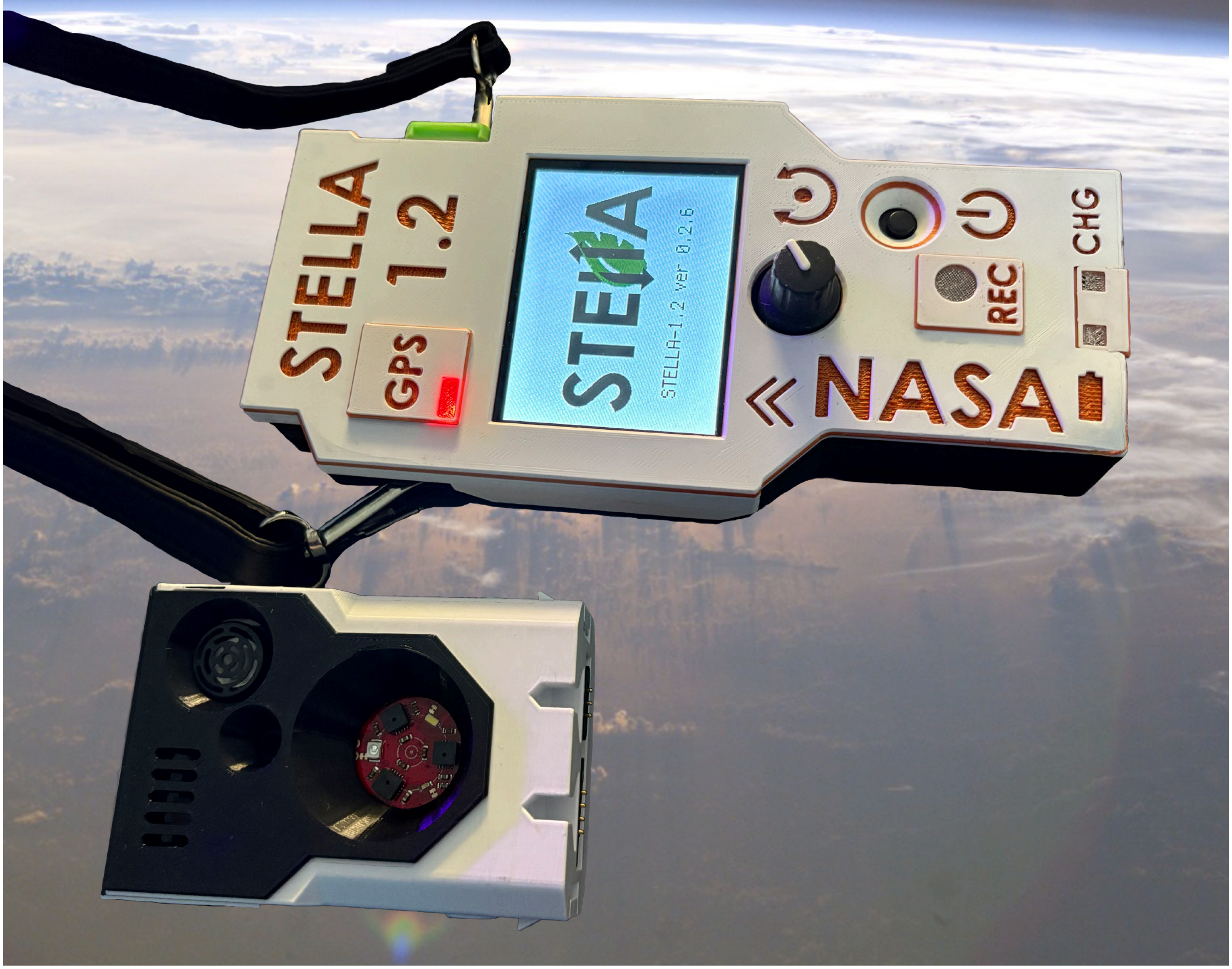
STELLA
Build • Learn • Explore!

NASA

STELLA-1.2

Quickstart Guide



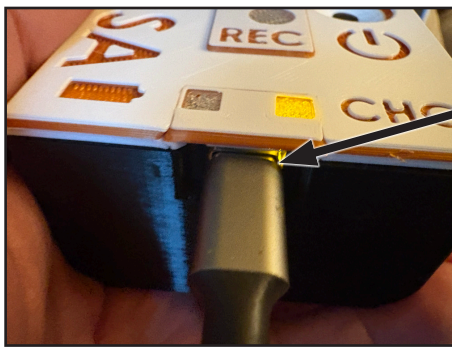
Contents

STELLA
Build • Learn • Explore!

STELLA-1.2 Quickstart

STELLA (Science and Technology Education for Land/Life Assessment) is a force multiplier for NASA Missions and programs–it amplifies their impact by breaking down barriers that make satellite remote sensing seem inaccessible, transforming mission data from abstract numbers into tangible participatory science that develops the technical workforce Earth observation systems depend upon while creating thousands of mission-literate professionals who understand why NASA investments matter.

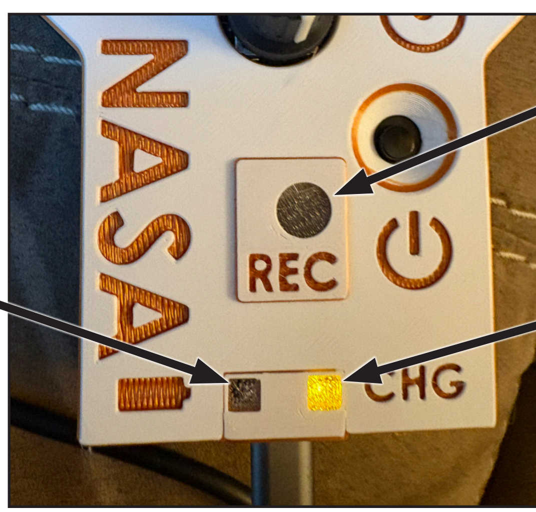
Charging



USB-C Port
Plug in USB-C cable from power to USB-C port to charge

Indicators

GPS Indicator
- Solid Red if GPS Fix
- Red Pulse if no GPS Fix



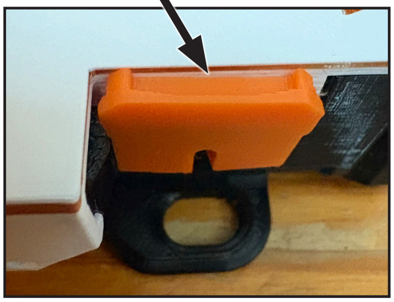
Battery Indicator
- Red flash when battery charge is low

Record Indicator
- Amber during boot sequence
- Green pulse per measurement
- Solid Red if no SD card

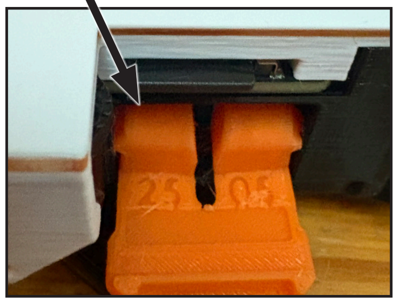
Charging Indicator
- Amber during charging

SD Card

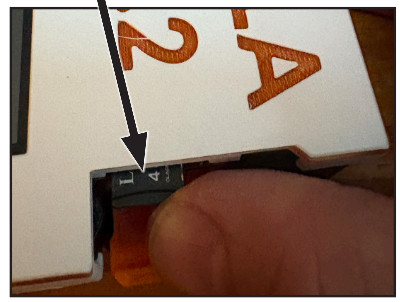
SD Card Retainer Swing Door Closed



SD Card Retainer Swing Door Open



SD Card
Push in to lock/release



Holders

Strap Loops

Universal Screw Mount

*Note that STELLA-1.2 is made out of PLA and should not be exposed to high temperatures for extended periods of time is it will warp. For example - do not leave in car with outside temperatures near 100°F/37.7°C for more than a few hours,

Navigation Controls

Rotary Encoder
The primary navigation device for STELLA-1.2

Turn Encoder:
The primary navigation device for STELLA-1.2

Press Encoder:
Select highlighted item and open that screen

Power Button

Press to Turn On/Off

Control Bar

Batch Number:
Click to increment, auto-increments on restart (same day), resets on day change or SD removal

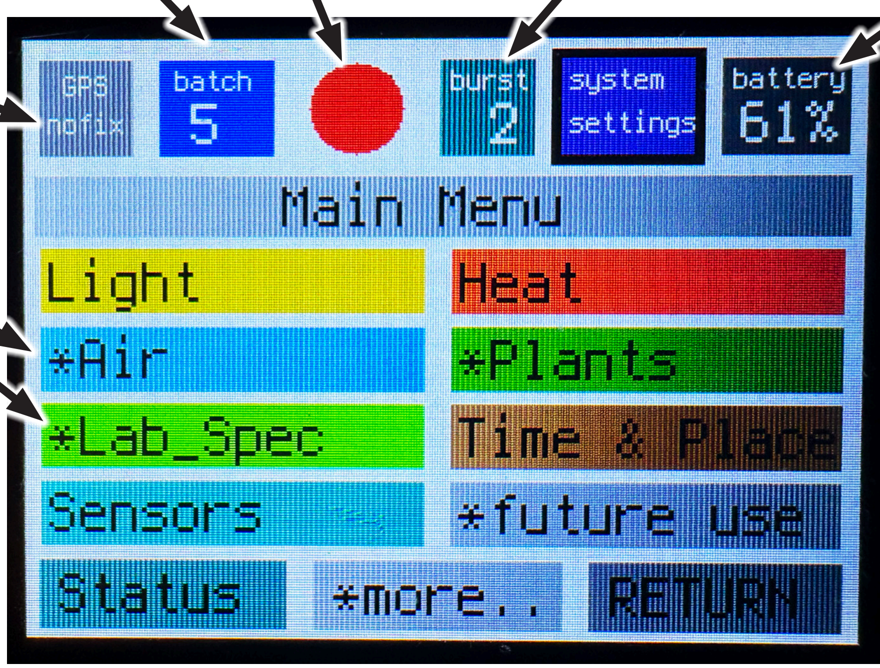
Recording (Red Circle):
Click to pause

Burst Button:
Takes set measurements then stops (default: 2)

Battery %:
Click for Status Page

GPS Square:
Green when locked

✳ (asterisk):
Page is not ready yet



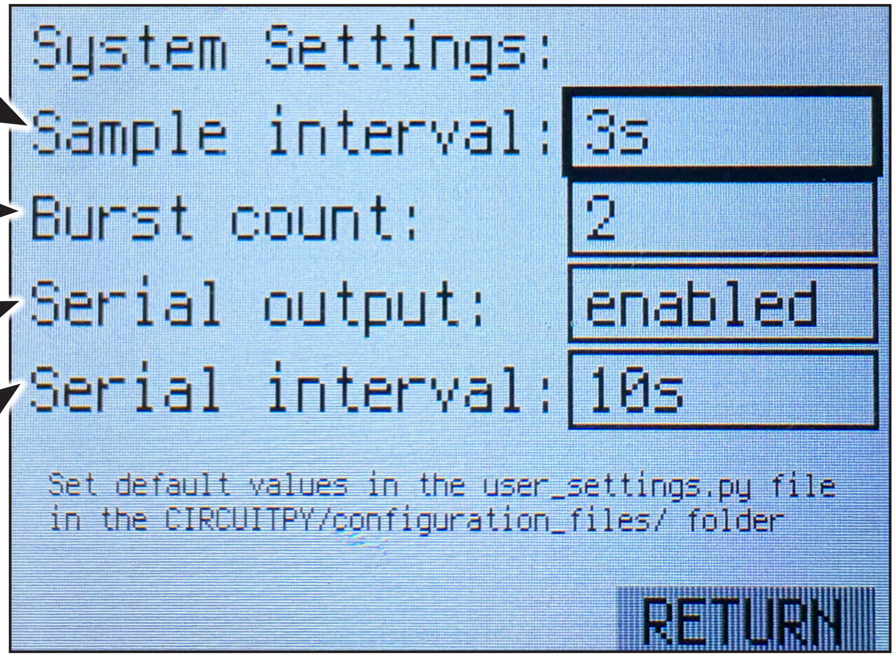
System Settings

Sample Interval:
Time between consecutive measurements during continuous recording.

Burst Count:
Number of measurements taken when burst button is pressed.

Serial Output:
Control data transmission to connected computer via USB

Serial Interval:
Rate of data transmission to computer (independent of SD card recording)



Status

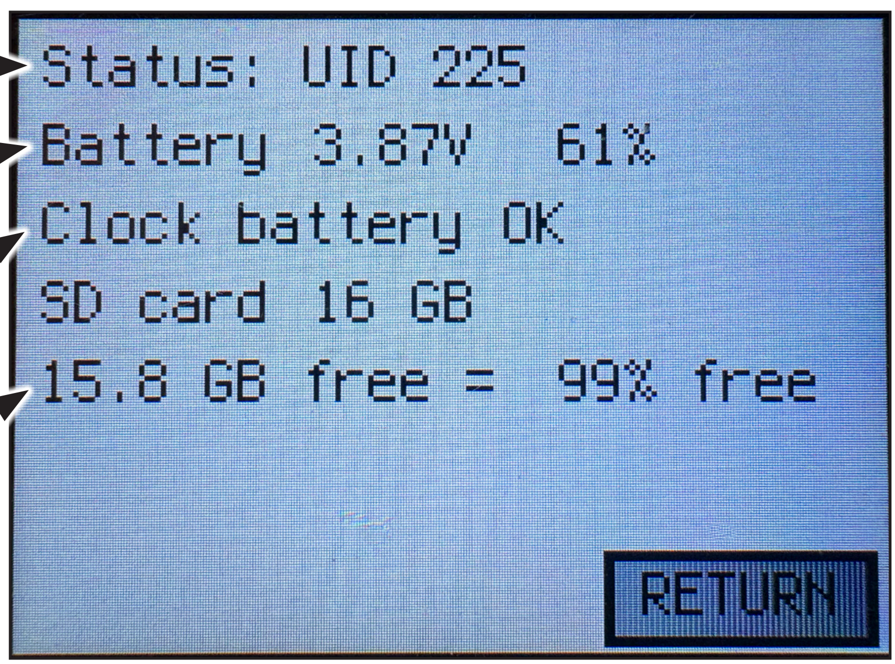
Access: Click battery % on control bar or from main menu

Processor ID:
Last 5 digits of unique 100-digit factory ID. Identifies individual unit.

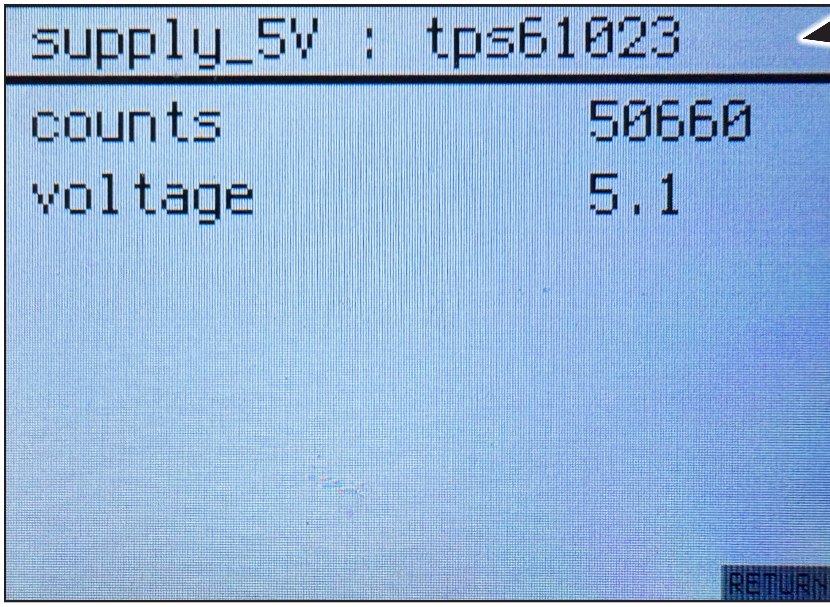
Battery Status:
Voltage (actual) and State of Charge (%). Lookup table converts voltage to percentage.

Clock Battery:
Status: “OK” or “Low”. Critical for timekeeping.

SD Card:
Total capacity and available space.

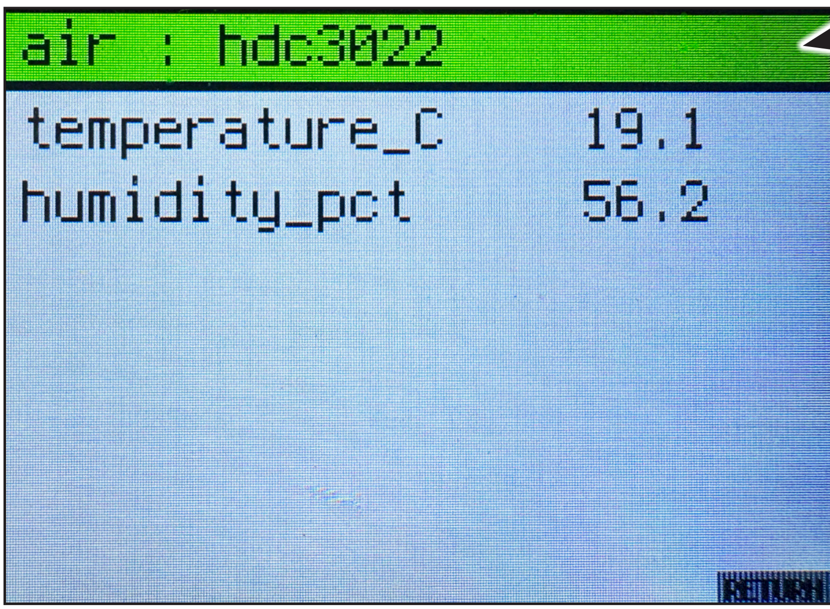


Sensors (example pages)



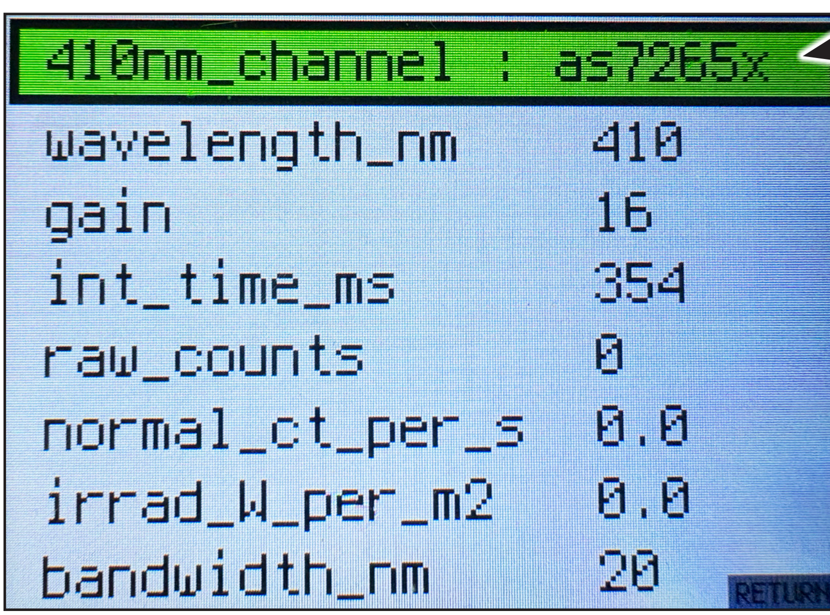
Sensor Type and Sensor:
- 5V supply
- Counts
- Voltage

- Counts refers to the raw analog-to-digital converter (ADC) reading from the analog pin monitoring the 5V supply
- This value ranges from 0 to 65535 (16-bit ADC resolution: 2^16 - 1 = 65536 possible values)
- Represents the digitized voltage reading before conversion to actual voltage



Plugin Required

Sensor Type and Sensor:
- Air temperature
- Humidity percentage



Plugin Required

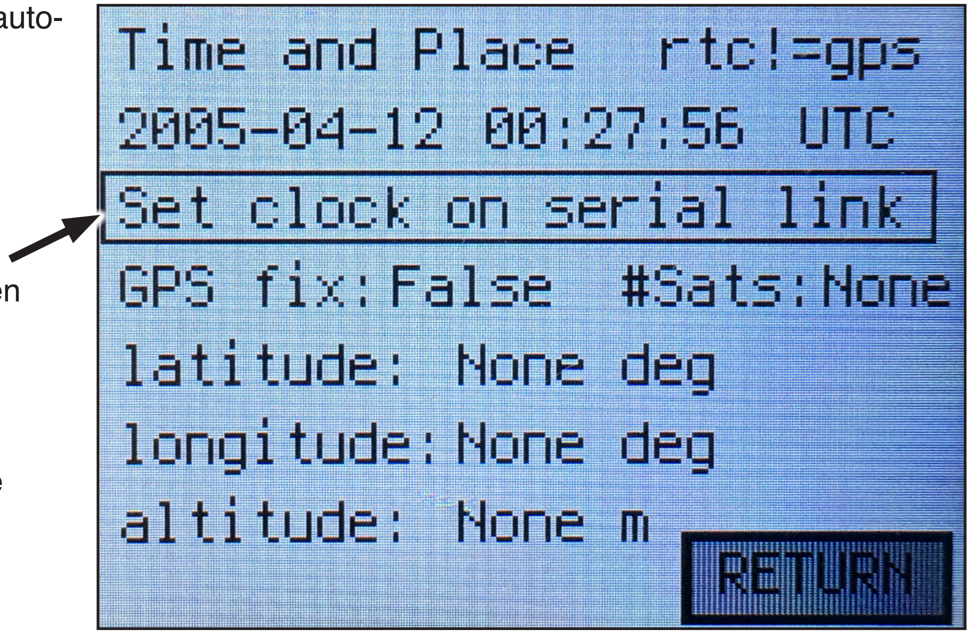
Sensor Type and Sensor:
- Wavelength nanometers
- Gain
- Integration time milliseconds
- Raw counts
- Normal counts per second
- Irradiance Watts per meter squared
- Bandwidth nanometers

Time and Place

System Time:
- Shows date and time from onboard clock
- Accuracy: ±2-3 sec/day drift
- GPS sync: checks once/min, auto-sets time
- Shows “RTC != GPS” when mismatch

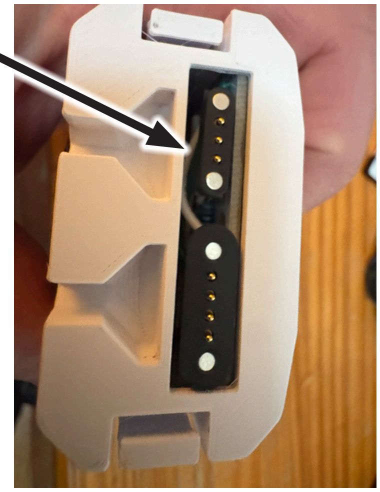
Manual Time Setting:
“Set Clock” button for indoor use via serial link. GPS overrides when fix acquired.

GPS Information:
- Coordinates: Lat, Lon, Altitude
- “Fix = True” when locked

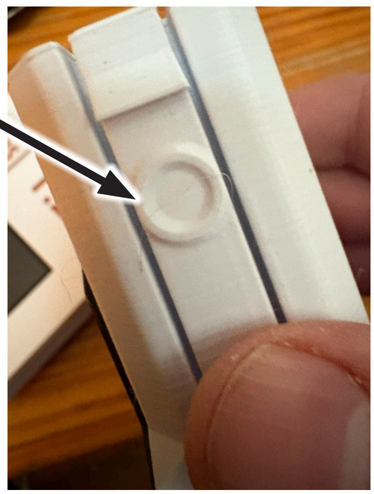


Remote Sensing (RS) Plugin

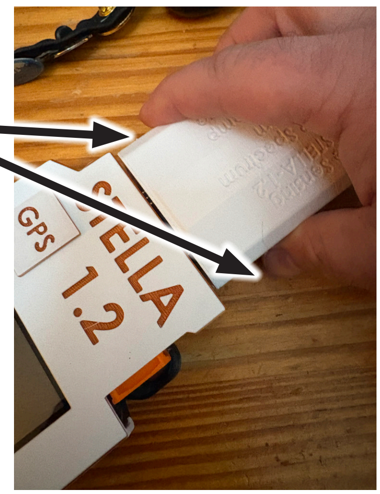
Magnetic Connectors



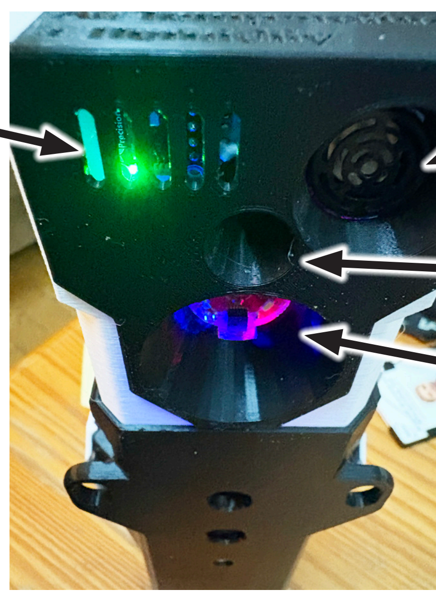
Plugin Clip



Press Both Clips Simultaneously On Each Side to Snap In/ Take Out Plugin



Temperature & Humidity



Ultrasonic Rangefinder

Surface Temperature

18-band Spectrometer

Tips: Do not point spectrometer towards the sun. When taking measurements stay out of the instrument and your own shadow. The spectrometer angular field of view is 40° so the height to swath diameter is approximately 1:1 - at 1 meter high the swath is about 1 meter in diameter.

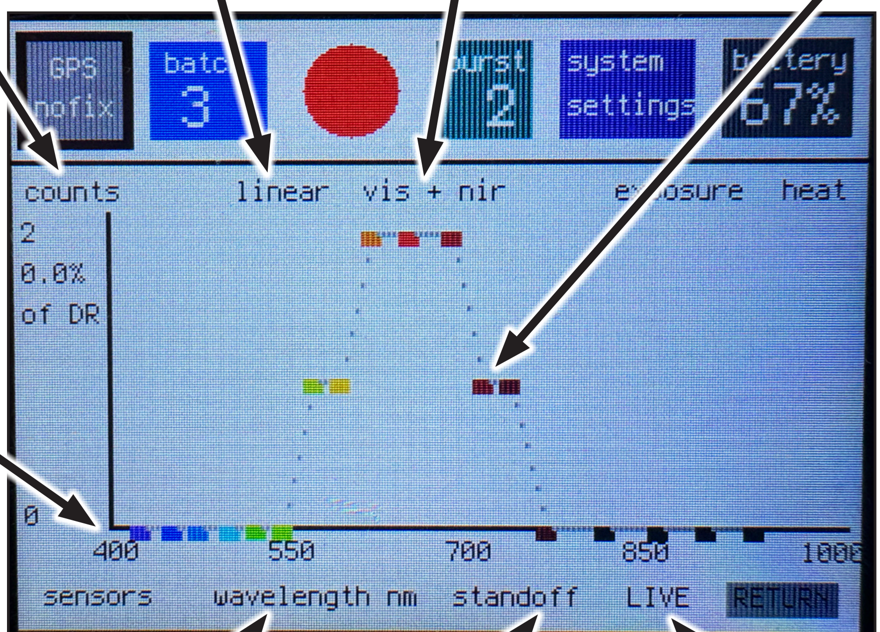
Light

Y-Axis Options:
- Counts
- Normal Counts (normalized)
- Irradiance (W/cm²)

Scale:
- Linear or Log

Spectrum Selection
- Visible only
- NIR only
- VIS + NIR (default)
- UV options if sensor attached

Spectral Plot
- Bar colors match wavelength bands
- NIR bands shown in black
- Bar widths proportional to bandwidth
- Educational: shows measured regions



X-Axis:
- 400-1000nm range

X-Axis Unit Selection:
- Wavelength nm (default)
- Energy eV (electron Volts)
- Frequency THz (Terahertz)
- Wavenumber / cm

Standoff:
Shows distance 0.3-2.5m

Live/Hold:
Update or freeze plot

Exposure

Mode Selection:
Manual: User controls all
Automatic: Optimizes to 50-90% range.
Future: preset modes (sun, indoors, overcast, dark)

Sensor and Sensor Type

Return

Scale toggle:
Linear vs log.

Exposure Output Display:
- Shows lower/ upper counts across channels
- Dynamic range: markers at 50% & 90% (optimal)

Gain:
Like camera aperture, controls signal amplification. Click value to select.

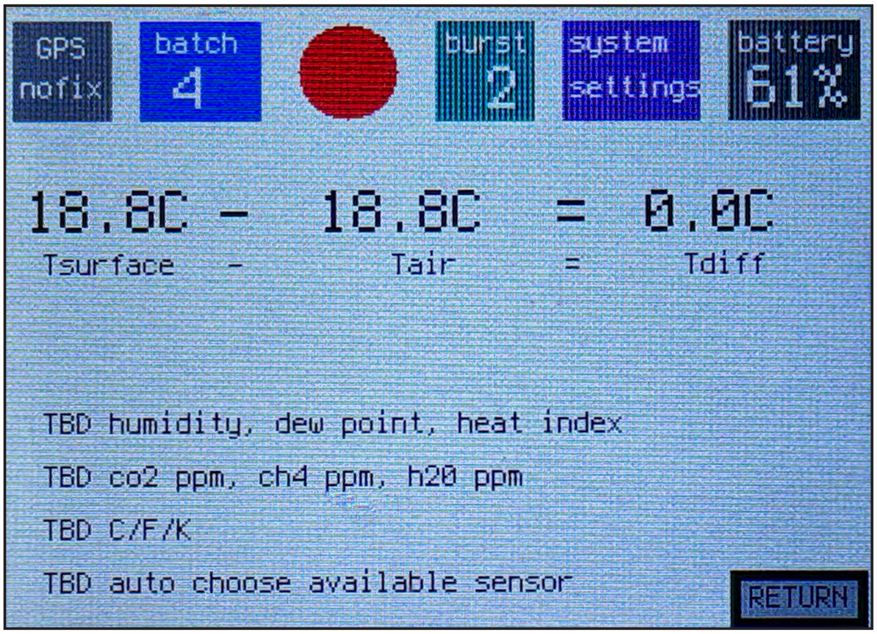
Integration Time:
Inverse of shutter speed. Duration sensor collects photons.

Onboard Lamps:
UV, VIS, NIR options. Click to select type and adjust power.

Exposure: (example)

When measuring a plant leaf indoors, you point STELLA at the target and notice the exposure bar shows only 5% of dynamic range—far too low for quality data. You click on the gain value, currently set to "16," and select "64" from the dropdown to quadruple the signal amplification, then click the integration time and change it from "50ms" to "200ms" to allow more photon collection time. Watching the right side display, you see the bar graph rise as your adjustments take effect, and the highest count value climbs from barely visible to a healthy position between the 50% and 90% triangle markers—now you're in the optimal range for accurate measurements with good signal-to-noise ratio and no saturation.

Heat



Surface Temperature Sensor:

- Measures thermal IR radiation
- Assumes emissivity = 1 (matte surfaces)

Temperature Difference:

- Shows Surface - Air
- Difference = 0: Same temp
- Positive: Surface warmer
- Negative: Surface Cooler

STELLA-1.2 RS Plugin Use Procedure

Calculate Required STELLA Height Above Target:
STELLA height is calculated to ensure only the target is being measured and there are no foreign objects recorded to influence radiance/reflectance.

**STELLA-1.2 has an Ultrasonic Rangefinder to collect height data*

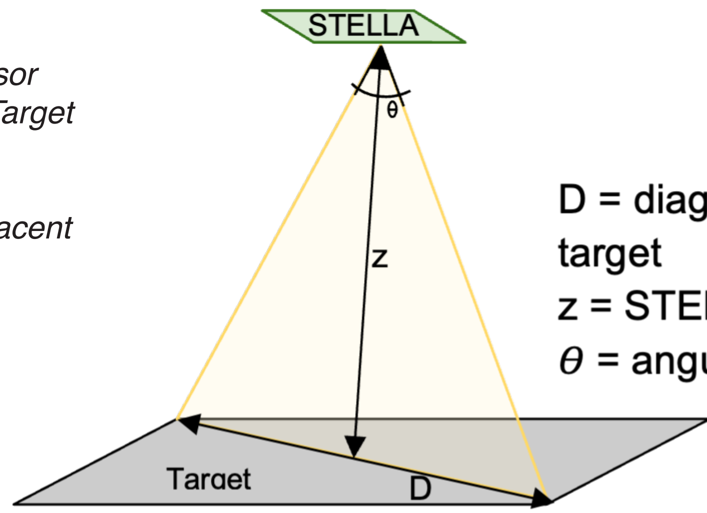
Needed for Calculation:

a. Angular FOV of Sensor

b. Diagonal Length of Target

Equation:

tan(θ) = Opposite / Adjacent



D = diagonal of target
z = STELLA height
θ = angular FOV

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a. The STELLA spectrometer uses the AS7265x Multi Spectral Chipset Sensor. The specs can be found here, including the angular FOV of 41° (Appendix. 1).

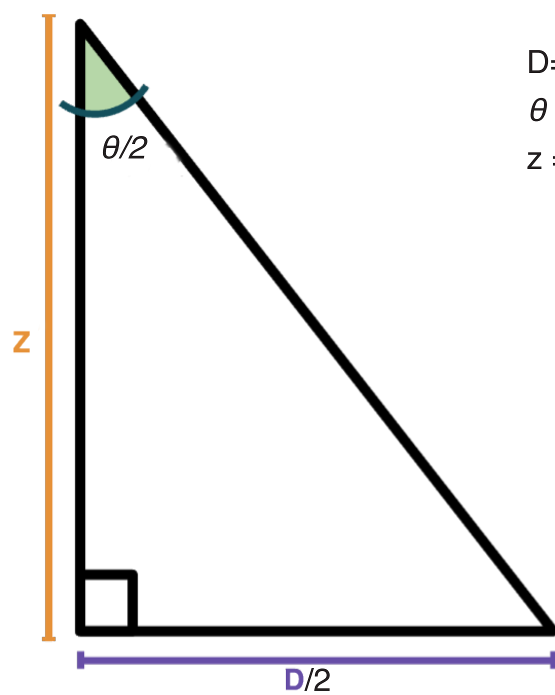
b. Target diagonal can either be measured or calculated using pythagorean.

Calculate the height using the equation below:

$$\tan(\theta) = \frac{Opposite}{Adjacent}$$

$$\tan(\theta / 2) = \frac{\frac{D}{2}}{Z}$$

$$z = \frac{D}{2\tan(\theta / 2)}$$



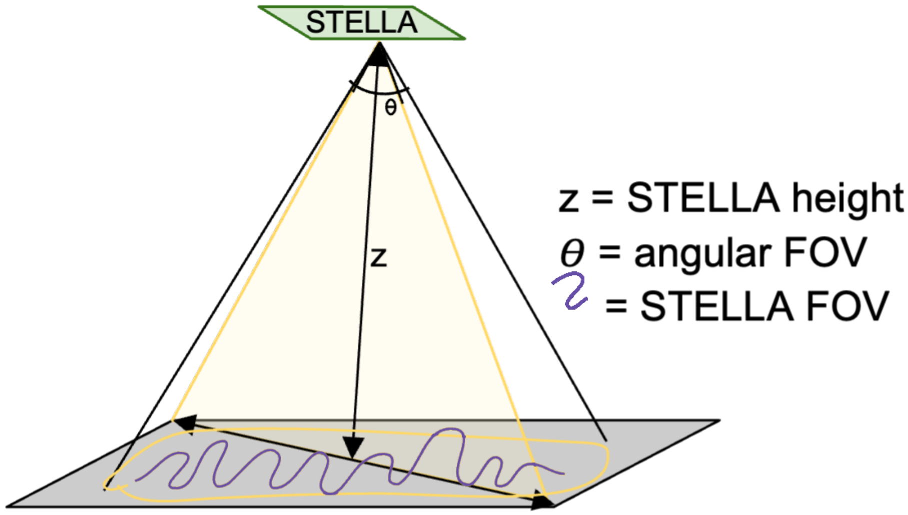
D= target diagonal
θ = angular FOV
z = STELLA Height

Calculate STELLA FOV:
STELLA FOV in area will be used to convert measured irradiance into reflectance, but it can also be used as a check to ensure the height is correct.

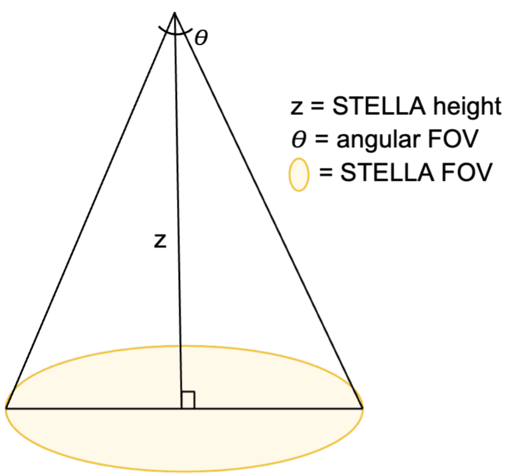
Needed for Calculation:
a. STELLA Height
b. Angular FOV of Sensor

Equation:

$$A = \frac{\pi}{4} \bullet D^2$$



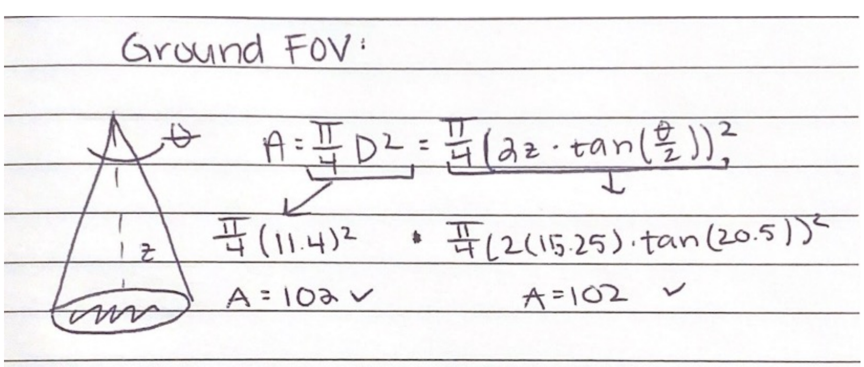
Using the angular FOV and height from the previous step, the STELLA FOV on the ground can be calculated using the equation below:



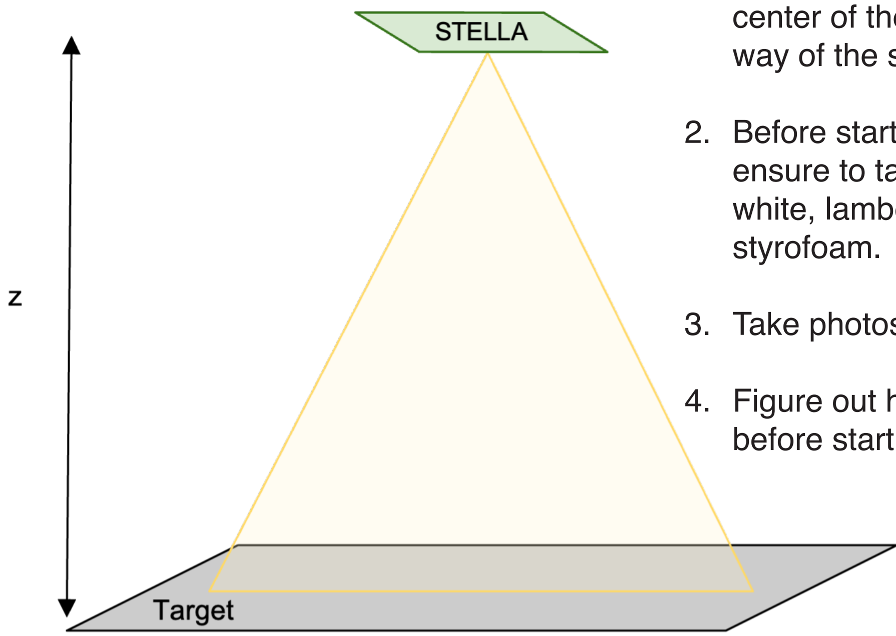
$$A = \frac{\pi}{4} \bullet D^2$$

$$A = \frac{\pi}{4} \bullet \left(2z \bullet \left(\frac{\pi}{4}\right)\right)^2$$

Example:



Collect Measurements:
Following a consistent method/technique for collecting measurements using the STELLA can reduce error. It is also important to take notes during collection to document conditions to look back on as potential causes for outliers.



STELLA spectrometer collection methods

General Good Practice:

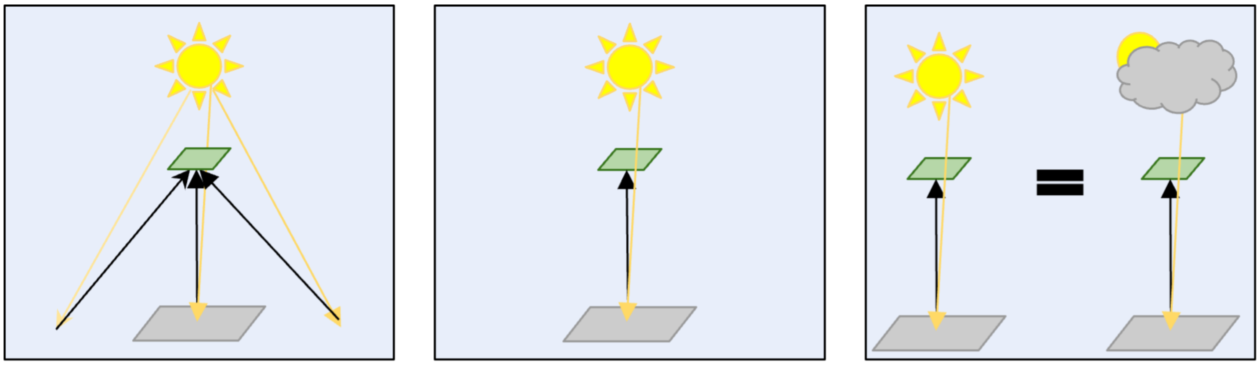
1. Keep the STELLA at a consistent height above the center of the target. Be sure that you are not in the way of the sensor!
2. Before starting and between every new target, ensure to take a few Reference scans of a pure white, lambertian surface such as clean, white styrofoam.
3. Take photos of each target and set up.
4. Figure out how many measurements are needed before starting-- lots of duplicates!

STELLA Collection Records Template:

Date: 7/25/24	**STELLA:** 2544 *tool ID*
Notes: 17°C, slightly cloudy no rain, sunlight, wind speed: 6 mph NW, measurements taken facing N, 38cm above target *conditions, i.e., weather, lighting, temperature, etc*	

Time:	Batch #:	Description:	Time:	Batch #:	Description:
10:42am	31	REF	10:44am	36	Moss Green Gel
10:42am	32	REF	~~10:44am~~	~~37~~	~~Moss Green Gel~~ mistake
10:43am	33	Moss Green Gel	10:45am	38	Moss Green Gel
10:43am	34	Moss Green Gel	10:46am	39-43	REF
10:43am	35	Moss Green Gel	10:48am	44	Primary Red Gel

Convert from Irradiance to Reflectance :
STELLA measurements are recorded in irradiance, but it needs to be converted to reflectance for standardization. Reflectance accounts for area of the target and variation from differences in illumination conditions.



Irradiance — Measure of light off a surface per unit area (W/m2)

Radiance — Measure of light coming off a surface from a solid viewing angle (W/m2/Sr)

Reflectance — Standardized measure of light coming off a surface, consistent across illumination conditions (unitless)

Needed for Conversion:

a. *Irradiance Measurement of Target*
b. *Irradiance Measurement of White Reference*
c. *Ground FOV Area*
d. *Distance from STELLA to Target*

Equations:

*Irradiance to Radiance: irradiance * (distance2/Area)*
Radiance to Reflectance: target radiance / white reference radiance

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Example:

Target Irradiance = 1149 uW/cm^2
Reference Irradiance = 20358 uW/cm^2
FOV Area = $102in^2$ = $259cm^2$
Height (Distance) = 15.25in = 38cm

Target Radiance = Target Irradiance * $\frac{Height^2}{Area}$

= 1149 * 38^2/259
= 6406

Radiance = $\frac{Target\ Radiance}{Ref.\ Radiance}$

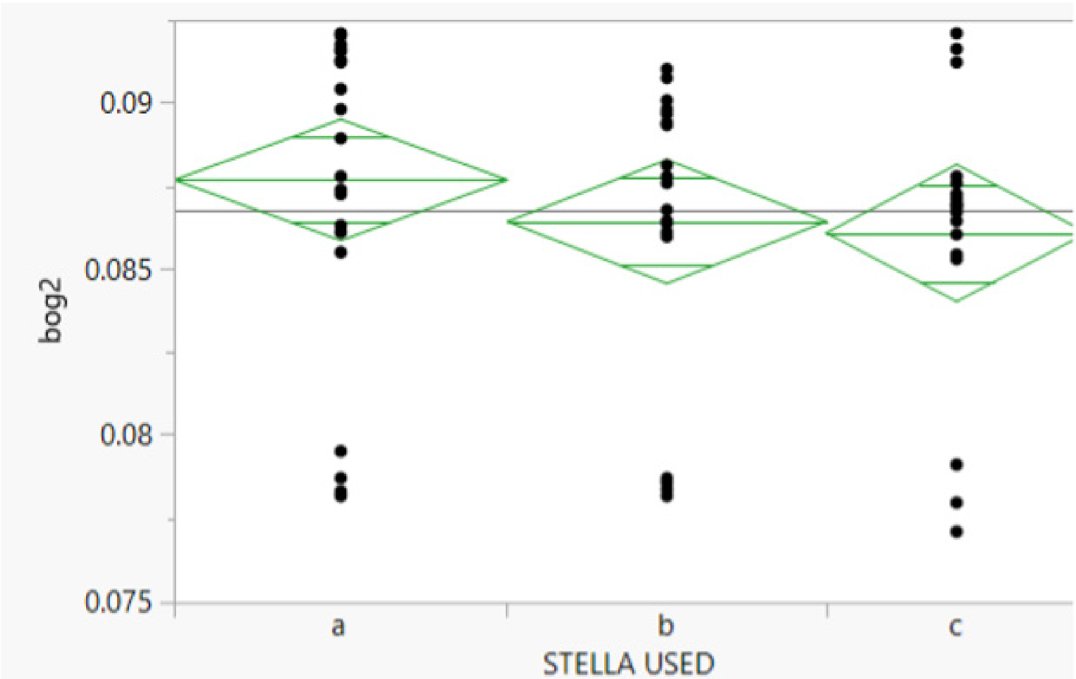
= 6406/13501.7
Radiance = 0.056

Reference Radiance = Reference Irradiance * $\frac{Height^2}{Area}$

= 20358 * 38^2/259
= 13507.7

Data Processing and Statistics:
Running statistics on collected data will allow for determining the separation between measurements of the same target and see if there are any statistically significant differences between the samples.

ANOVA Example:



Oneway Anova

Summary of Fit

Rsquare	0.025626
Adj Rsquare	-0.00685
Root Mean Square Error	0.004363
Mean of Response	0.086784
Observations (or Sum Wgts)	63

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
STELLA USED	2	0.00003003	0.000015	0.7890	0.4590
Error	60	0.00114195	0.000019		
C. Total	62	0.00117198			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
a	23	0.087677	0.00091	0.08586	0.08950
b	22	0.086423	0.00093	0.08456	0.08828
c	18	0.086084	0.00103	0.08403	0.08814

STELLA -1.2 Data Sample

Measurement Number:
Instrument ID-Time UTC-session-session number

session number = measurement for the day

Timestamp:
Time in UTC (Coordinated Universal Time)

Decimal Hour:
hours, minutes and seconds can be handled as a unified value

Batch Number:
all measurements within continuous measurement collections and individual burst measurement

Burst Counter:
number of measurements taken per recording

Integration time in milliseconds:
the duration the detector collects photons to generate a single spectrum, acting similar to a camera's shutter speed

Irradiance Watts per Meter Squared: (spectral measurements)
quantifies the solar power incident on a surface per unit area

Sensor rows:
GPS Sensor: (example)
divides the parameter units and values into understandable measurements

Instrument ID:
Unique ID derived from microprocessor

instrument_id	measurement_number	timestamp	decimal_hour	batch_number	burst_counter	sensor_name	part_number	parameter_units	value	parameter_units	value	parameter_units	valu	parameter_units	value	parameter_units	value	paramet units	value						
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	supply_5V	tps61023	counts	50084	voltage	5.04														
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	gps	pa1616d	fix	False	latitude_deg	None	longitude_deg	No	altitude_m	None	timestamp	None	satellites	None						
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	battery	max1704x	voltage_V	4.08	energy_pct	87.6														
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	air	hdc3022	temperature_C	-45	humidity_pct	0														
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	surface_therm	mlx90614	T_surface_C	21.8	T_ambient_C	15														
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	rangefinder	lv_ez_mb1013	range_m	0.77																
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	410nm_channel	as7265x	wavelength_nm	410	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.008	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	435nm_channel	as7265x	wavelength_nm	435	gain	16	int_time_ms	354	raw_counts	4	normal_ct_per_s	0.035	irrad_W_per_m2	0.04	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	460nm_channel	as7265x	wavelength_nm	460	gain	16	int_time_ms	354	raw_counts	2	normal_ct_per_s	0.018	irrad_W_per_m2	0.019	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	485nm_channel	as7265x	wavelength_nm	485	gain	16	int_time_ms	354	raw_counts	7	normal_ct_per_s	0.062	irrad_W_per_m2	0.06	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	510nm_channel	as7265x	wavelength_nm	510	gain	16	int_time_ms	354	raw_counts	2	normal_ct_per_s	0.018	irrad_W_per_m2	0.015	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	535nm_channel	as7265x	wavelength_nm	535	gain	16	int_time_ms	354	raw_counts	4	normal_ct_per_s	0.035	irrad_W_per_m2	0.028	bandwidth_nm	20	chip_number	3	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	560nm_channel	as7265x	wavelength_nm	560	gain	16	int_time_ms	354	raw_counts	6	normal_ct_per_s	0.053	irrad_W_per_m2	0.038	bandwidth_nm	20	chip_number	2	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	585nm_channel	as7265x	wavelength_nm	585	gain	16	int_time_ms	354	raw_counts	7	normal_ct_per_s	0.062	irrad_W_per_m2	0.041	bandwidth_nm	20	chip_number	2	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	610nm_channel	as7265x	wavelength_nm	610	gain	16	int_time_ms	354	raw_counts	24	normal_ct_per_s	0.212	irrad_W_per_m2	0.271	bandwidth_nm	20	chip_number	1	chip_temp_C	15
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	645nm_channel	as7265x	wavelength_nm	645	gain	16	int_time_ms	354	raw_counts	5	normal_ct_per_s	0.044	irrad_W_per_m2	0.026	bandwidth_nm	20	chip_number	2	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	680nm_channel	as7265x	wavelength_nm	680	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.01	bandwidth_nm	20	chip_number	1	chip_temp_C	15
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	705nm_channel	as7265x	wavelength_nm	705	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.005	bandwidth_nm	20	chip_number	2	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	730nm_channel	as7265x	wavelength_nm	730	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.008	bandwidth_nm	20	chip_number	1	chip_temp_C	15
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	760nm_channel	as7265x	wavelength_nm	760	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.008	bandwidth_nm	20	chip_number	1	chip_temp_C	15
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	810nm_channel	as7265x	wavelength_nm	810	gain	16	int_time_ms	354	raw_counts	1	normal_ct_per_s	0.009	irrad_W_per_m2	0.009	bandwidth_nm	20	chip_number	1	chip_temp_C	14
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	860nm_channel	as7265x	wavelength_nm	860	gain	16	int_time_ms	354	raw_counts	0	normal_ct_per_s	0	irrad_W_per_m2	0	bandwidth_nm	20	chip_number	1	chip_temp_C	14
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	900nm_channel	as7265x	wavelength_nm	900	gain	16	int_time_ms	354	raw_counts	0	normal_ct_per_s	0	irrad_W_per_m2	0	bandwidth_nm	20	chip_number	2	chip_temp_C	17
225	225-20260211T141216Z-session-0	20260211T141342Z	14.2283	0	0	940nm_channel	as7265x	wavelength_nm	940	gain	16	int_time_ms	354	raw_counts	0	normal_ct_per_s	0	irrad_W_per_m2	0	bandwidth_nm	20	chip_number	2	chip_temp_C	17

STELLA RS 18-bands:
this will repeat for each measurement, each are considered a sensor

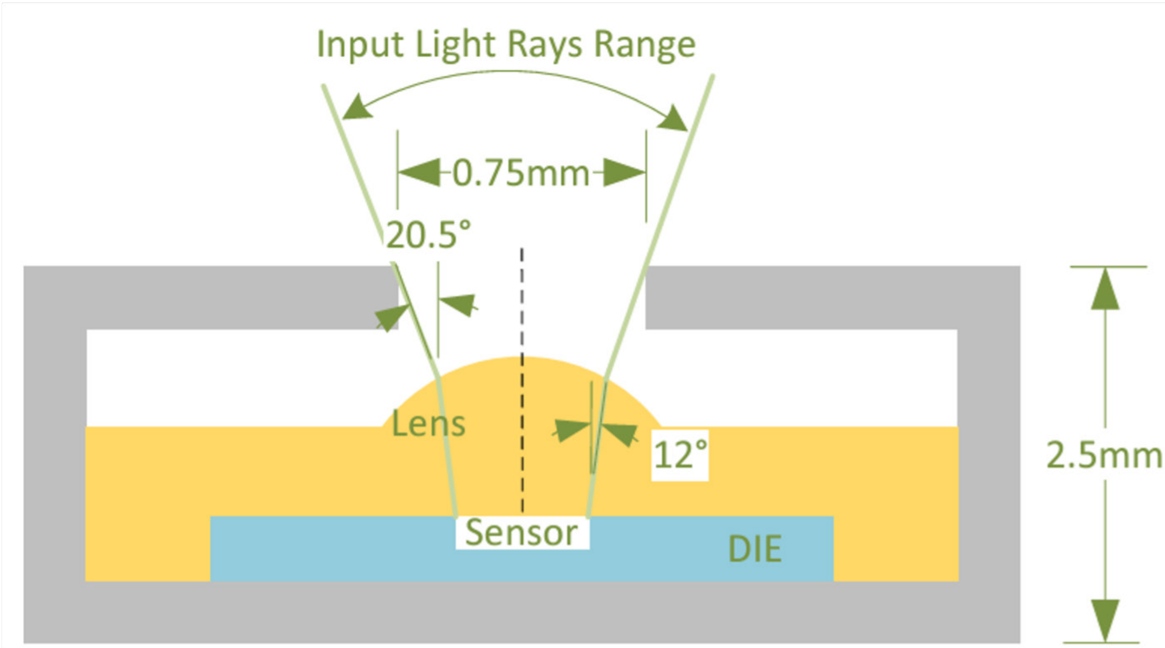
Wavelength in nanometers

Gain:
the amplification factor applied to a detected signal (light intensity) by the detector's electronics, increasing its sensitivity to faint light

Raw Counts:
direct, unprocessed signals (photons, ions, or electrons) detected by an instrument, representing the raw data output before normalization

Normal Count per Second:
the duration the detector collects photons to generate a single spectrum, acting similar to a camera's shutter speed

Appendix:



Appendix 1. AS7265x Multi Spectral Chipset Design Considerations, Optic Considerations

STELLA Instruments Across Spheres

As a boundary-crossing complement to NASA's sphere-focused Earth science missions, STELLA multiplies their impact by creating the technical workforce that will design, build, calibrate, operate, and analyze data from the next generation of atmospheric, hydrospheric, biospheric, geospheric, and cryospheric observation satellites. Through participatory science, STELLA makes underlying mission principles accessible and achieves mission success through real-world, sphere-specific skill building.

GEOSPHERE

Mission: GEMx, EMIT, NISAR, LAGEOS
Application: Mineralogy Field Campaigns

STELLA Tech: STELLA-Q2 ✓ | STELLA-1.2 RS + thermal ✓ | STELLA-AQ ✓ | Helio-STELLA ✓
Variables: Spectral curves for mineral ID, thermal properties, surface composition
Cross-Sphere: STELLA-AQ ✓ for aerosol/dust correlation

HYDROSPHERE (Cross-sphere)

Mission: Landsat, NISAR, SMAP, GPM, SWOT, ECOSTRESS, CYGNSS, Jason-3
Application: Soil Moisture & Agriculture

STELLA Tech: STELLA-SM 🔧 | STELLA-SM/R 🔧 | STELLA-DLS 🔧 | STELLA-1.2 RS ✓ | STELLA-Q2 ✓
Variables: Soil moisture profiles, agricultural yield, vegetation stress, ET (beyond NDVI)
Cross-Sphere: Integration with GPM precipitation validation

BIOSPHERE

Mission: Landsat, PACE, MODIS, GEDI
Application: Vegetation, Water, Surface Reflectance

STELLA Tech: STELLA-Q2 ✓ | STELLA-1.2 RS + thermal ✓ | STELLA Blue 1 🔧 | STELLA Blue 2 🔧 | STELLA DLS 🔧
Variables: Leaving radiance, CDOM, water quality, phytoplankton/algae, HAB detection
Cross-Sphere: Coastal interface connecting ocean-land

ATMOSPHERE

Mission: TEMPO, Aura, Terra/Aqua, Suomi NPP, TROPICS
Application: Air Quality Monitoring

STELLA Tech: STELLA-AQ ✓ | Helio-STELLA ✓ | STELLA Cloud Base 🔧 | STELLA-AM ✓
Variables: PM2.5/PM10, CO_2, aerosol optical depth, PBL dynamics
Cross-Sphere: Mobile AERONET simulation (Helio + AQ)

CRYOSPHERE

Mission: Landsat, ICESat-2, NISAR, SMAP, GRACE - FO, PREFIRE, ECOSTRESS, GPM
Application: Snow/Ice Properties & Permafrost

STELLA Tech: STELLA-Q2 ✓ | Helio-STELLA ✓ | STELLA-SM/R 🔧+ sensors 💡
Variables: Albedo, freeze-thaw, active layer thickness, permafrost carbon release
Cross-Sphere: GPM precipitation phase (rain vs snow)

NASA Earth Science Spheres

STELLA Website

STELLA Community Forum

Let's Build STELLA together!

Credit
Mike Taylor - Layout, Author
Bianca Cilento - Layout, Author
Paul Mirel - Author