What's New in 2.1

Changes in Bluestem™ for version 2.1

Contents

1 Miscellaneous Changes

1.1 User Defined Equations

Version 2.1 supports a number of math functions (Table 1) that can be used when specifying an equation for a user defined variable that will carry over to the Excel spreadsheet version of the log file.

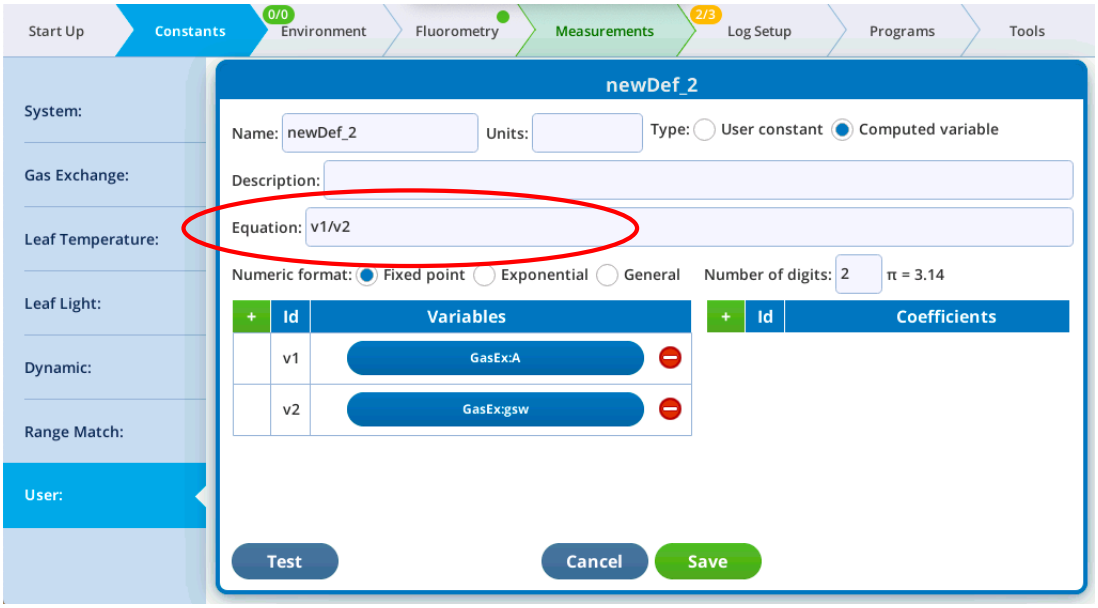


Figure 1: Setting the equation for a user defined variable.

Python	Becomes in Excel
math.ceil(x)	CEILING(x,1)
math.cos(x)	COS(x)
math.degrees(x)	DEGREES(x)
math.e	EXP(1)
math.exp(x)	EXP(x)
math.fabs(x)	ABS(x)
math.log(x)	LOG(x ,EXP(1))
math.log10(x)	LOG10(x)
math.pi	PI()
pow(x,y)	POWER(x,y)
math.radians(x)	RADIANS(x)
math.sin(x)	SIN(x)
math.sqrt(x)	SQRT(x)
math.tan(x)	TAN(x)

Table 1: Python methods that can be used in a user defined variable, and how they appear in the Excel log file.

1.2 Daily Automatic Snapshots

Version 2.1 will take one daily snapshot automatically after the system has been on (and not sleeping) for at least one hour. These automatic snapshots contain a subset of a manually generated snapshot, since the focus is on the system hardware. They can prove useful later when troubleshooting, such as determining when some issue started to appear.

Automatic snapshots are typically 50K bytes in size. If disk space becomes a consideration, use the **Tools** → **Manage Files** → **Trash** utility to see how much space is being used by snapshots (or log files, etc.), and to easily move unneeded files to the trash. (File space is not reclaimed until the trash is emptied.)

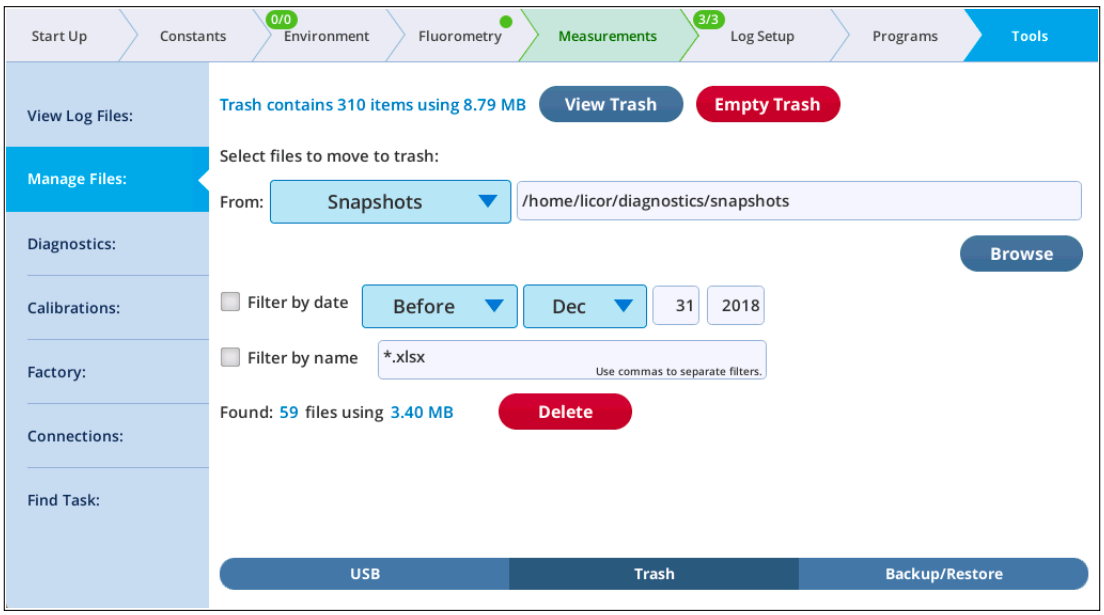


Figure 2: Seeing how much disk space is taken up by snapshots.

2 Summary of Fluorometry Changes

2.1 Tab Names

The **Fluorometry** tabs have a new look, with two additions and several name changes.

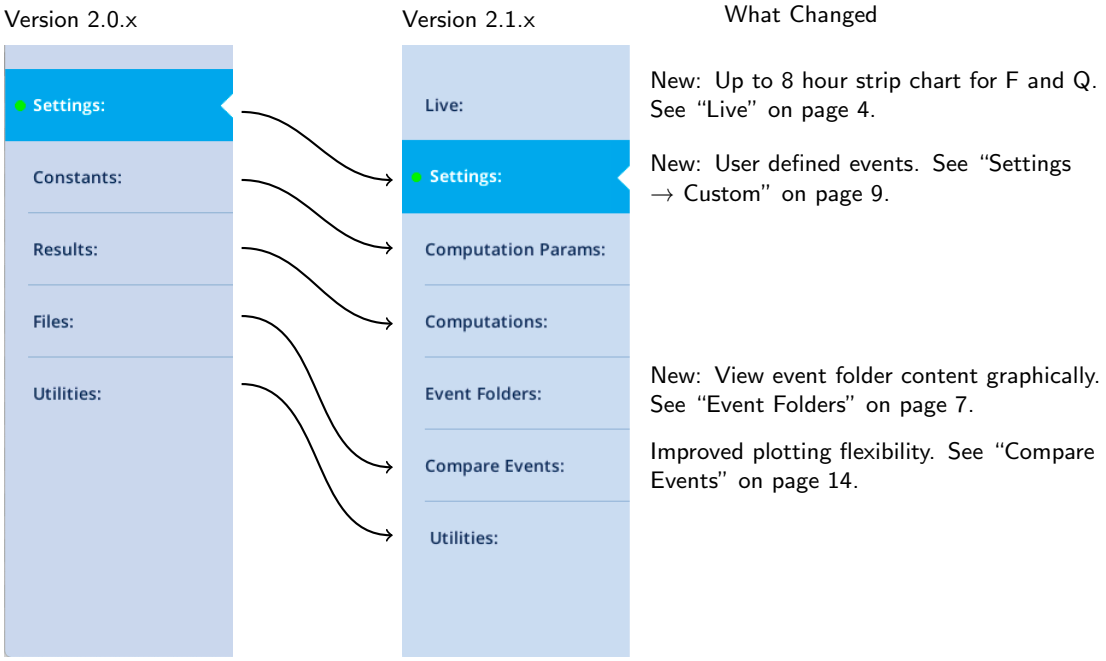


Figure 3: The old and new fluorescence tabs.

2.2 Modulation On Automatically

In version 2.1 the modulation beam will be turned ON (if it is Off) automatically in the following circumstances:

- Opening a log file.
- Triggering a fluorescence event, manually or via log.
- Turning fluorescence recording on or off.

For most users, this change represents a certain degree of insurance against inadvertantly logging data with the measuring beam off (which renders all modulated fluorescence values invalid.) A note of caution, however: the F_o (or F'_o) value that is logged is based an averaged modulated F (averaging time set in **Fluorometry → Settings → Measuring**). If you turn off the measuring beam and log or otherwise trigger a flash, the measuring beam will come back on, but averaged F value will be near 0, since the modulation was only just turned on.

If you actually wish to log fluorescence events with no modulation, then the way to achieve that is by setting the modulation setpoint to zero (also in **Fluorometry → Settings → Measuring**). This effectively keeps the modulation LEDs off when the modulation is set to "ON".

2.3 Live

Version 2.1 adds a **Live** screen for monitoring fluorescence. The graph uses a time of day bottom axis, and plots modulated fluorescence F and actinic light Q for up to 8 hours. Fluorescence events (saturating flashes, dark pulses) are also marked on this graph as they happen.

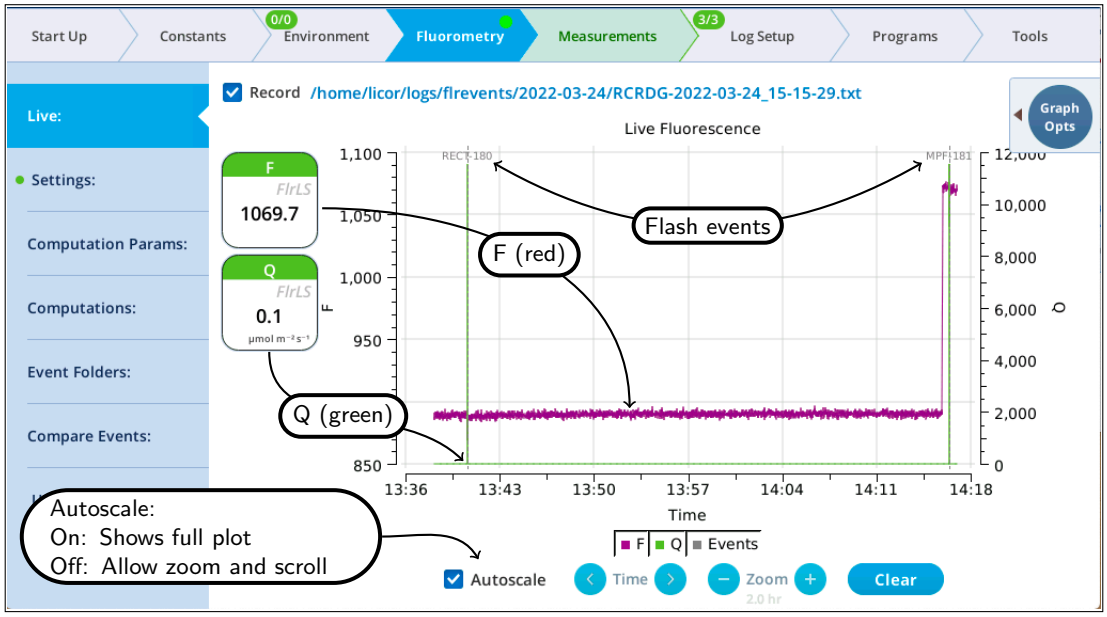


*Figure 4: The **Live** screen shows a time-of-day strip chart of F, Q, and fluorescence events.*

Operational tips:

- While the **Autoscale** box is checked, you can quickly zoom in on a part of the graph by simply tapping the graph at that location. The graph will automatically turn **Autoscale** off and center itself at the tapped time, with the range of the displayed data set by the current **Zoom** setting. Subsequent left/right shifting and zooming in/out is done by the **Time** and **Zoom** buttons. To get back to the full view, check the **Autoscale** box.

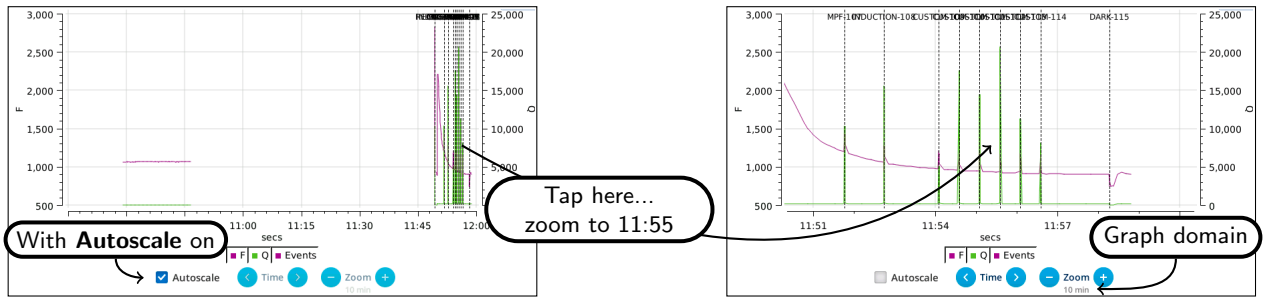


*Figure 5: **Autoscale** on (left) shows whole graph. Tap at 11:55 to zoom in (right).*

- While **Autoscale** is unchecked, the graph will remain unchanged if the newest incoming data is not on screen. If the present time is visible, the graph will automatically scroll left each time the incoming data reaches the right edge, keeping the latest x minutes (x = whatever the zoom is set to) visible on screen.

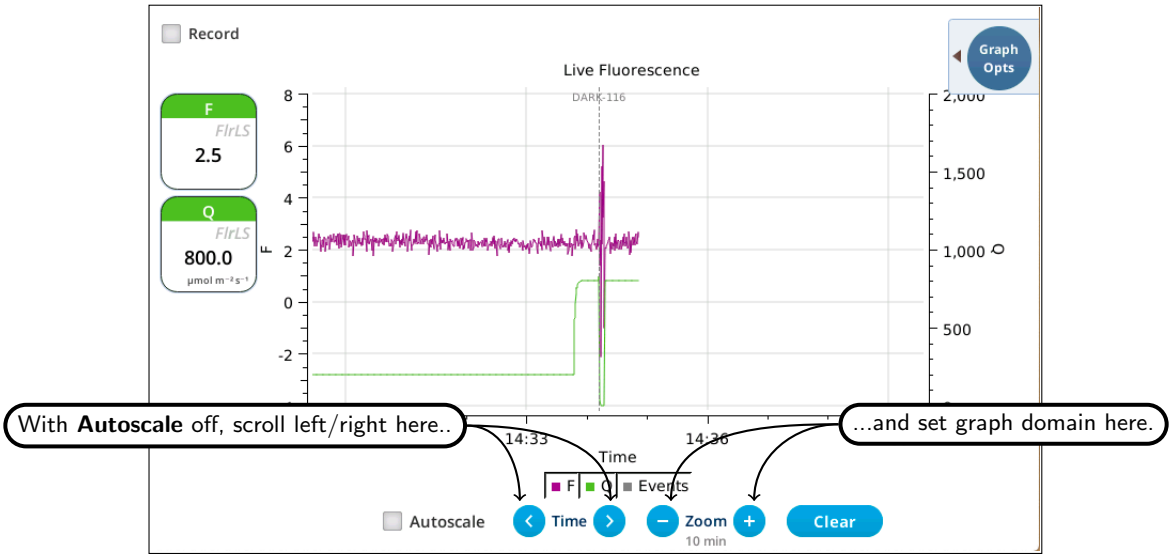


Figure 6: Keeping previous 10 minutes on screen.

- The Q plot is easily dominated by saturating flashes (e.g. max values of 15,000). To maintain a normal actinic scale, open the **Graph Opts** panel, set **Q max** to 2000 and check the **Q max** box.

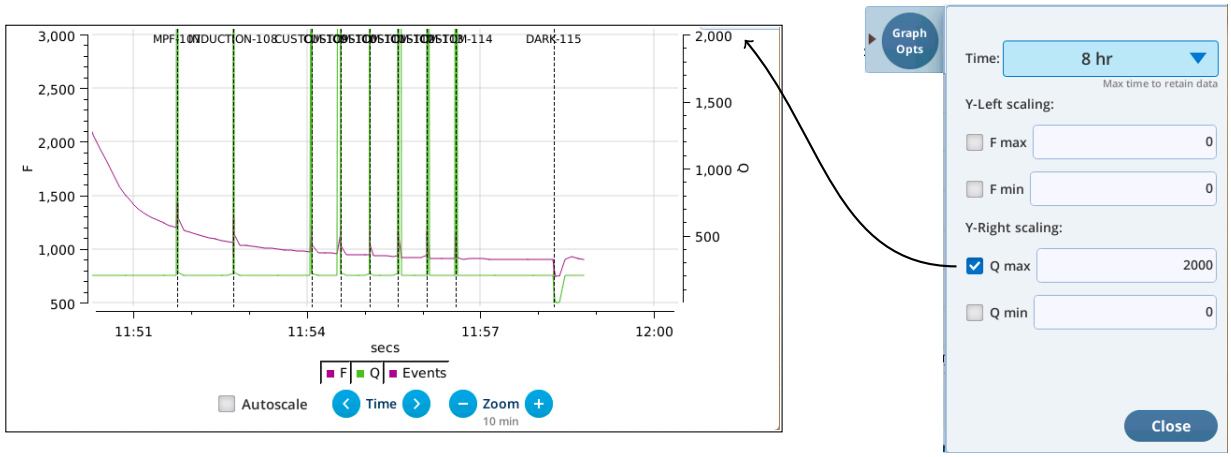


Figure 7: Limit the Q graph to 2000 µmol m^{-2} s^{-1}.

- The **Record** checkbox replaces the **Start**/**Stop** buttons that used to reside on the Measuring Settings page (Figure 8). **Record** has no influence on the realtime graph, which keeps going no matter what (unless you put the instrument to sleep).

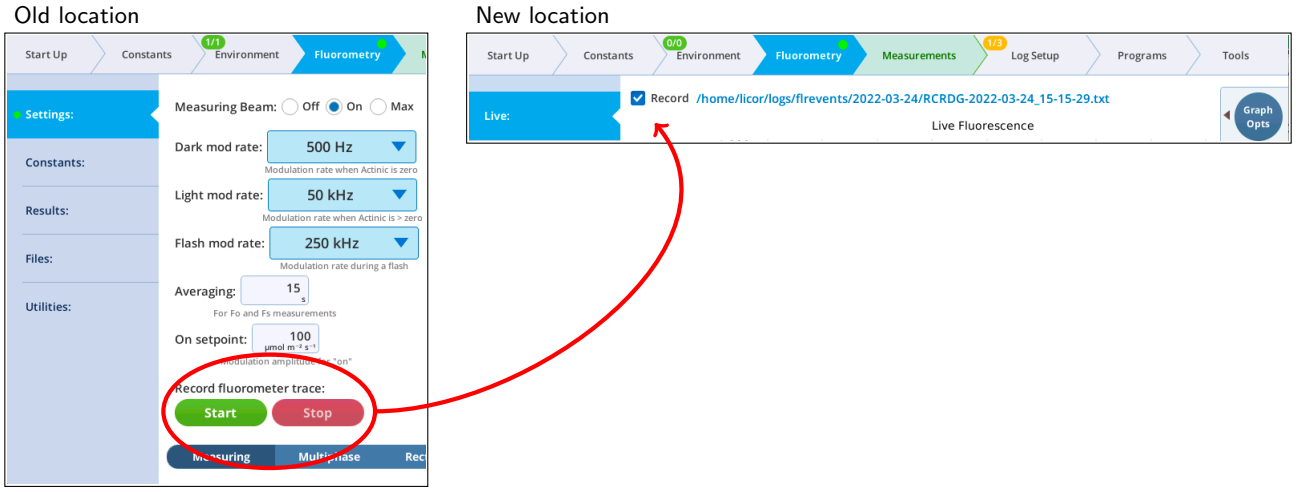


*Figure 8: Trace file recording control has moved to the **Live** screen.*

A fluorescence trace file contains tab-delimited records of 9 fluorometer output values. The first line is always a label line.

```
CODE  TIME  FLUOR DC PFD RED BLUE  FARRED REDMODAVG
1 1642441773.4  951.80 -28.06 0.0499964 0.0 0.0 0.0 0.0499964
1 1642441774.0  949.22 -27.89 0.0499964 0.0 0.0 0.0 0.0499964
1 1642441774.6  945.30 -26.47 0.0499964 0.0 0.0 0.0 0.0499964
1 1642441775.2  943.30 -29.13 0.0499964 0.0 0.0 0.0 0.0499964
1 1642441775.8  938.27 -26.69 0.0499964 0.0 0.0 0.0 0.0499964
1 1642441776.4  939.17 -26.53 0.0499964 0.0 0.0 0.0 0.0499964
```

2.4 Event Folders

The **Event Folders** screen represents a graphical way to explore the contents of `/home/user/logs/flrevents`, which holds daily directories of fluorescence events and recording files. A **date/folder picker** allows the user to pick the daily folder to be viewed. A **label** indicates how many recording or events files are found there, and a **Plot button** causes the contents of the directory to be read and displayed on the graph.

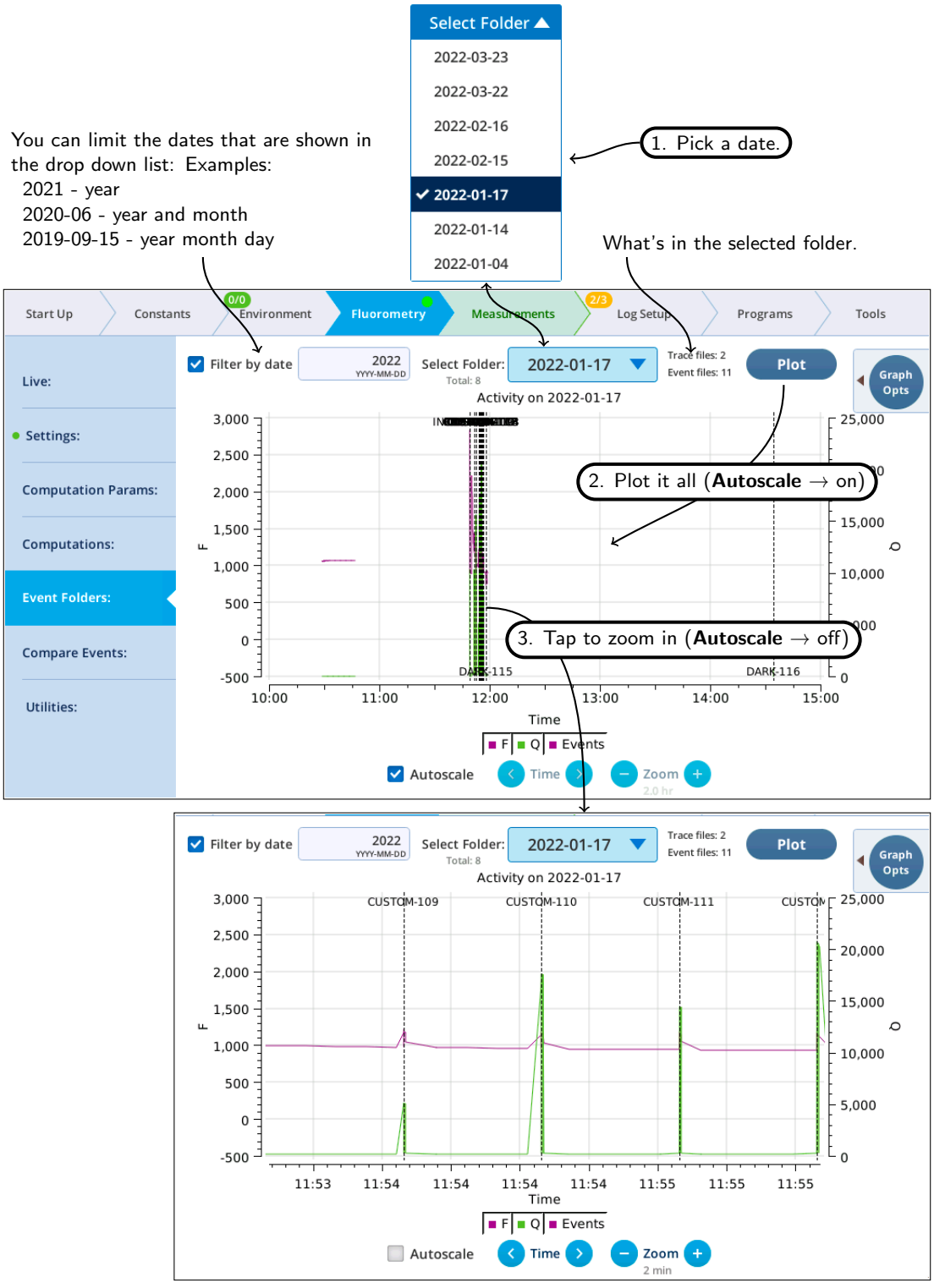


*Figure 9: The **Event Folders** screen in action. The graph controls are the same as the Live graph (Figure 4).*

With **Autoscale** off, tapping the graph close to an event will open a dialog with a plot of the event and related details (Figure 10). If this event is not already in the list of events in Compare Events, you can add it simply by tapping the **Add** button in the dialog. (If it is already there, no **Add** button will be displayed).

*Figure 10: With **Autoscale** off, tap on an event to see a detailed view.*

2.5 Settings → Custom

LI-6800 Software version 2.1 (and fluorometer/head firmware version 1.4.21 and higher) supports a user-defined custom flash. With this new feature, the user can define up to 38 steps to be executed during a flash, and in each step specify duration, modulation rate, output rate, intensities of red, blue far red, modulation beam peak intensity, and rate of change of red actinic intensity. (We've called this a "flash", but more generally this is an *event*, since it could be a dark pulse, or flash + dark pulse, or anything you'd care to define.)

Custom flashes are described in detail in http://dl.licor.com/projects/6800/UsingCustomEvents.pdf.

For a quick introduction, here is a brief tour, in which we'll make a custom flash that will combine an MPF and a Dark Pulse into one event.

1. In the **Settings → Custom** screen, tap New, pick **Multiphase**, and tap Continue (Figure 11).

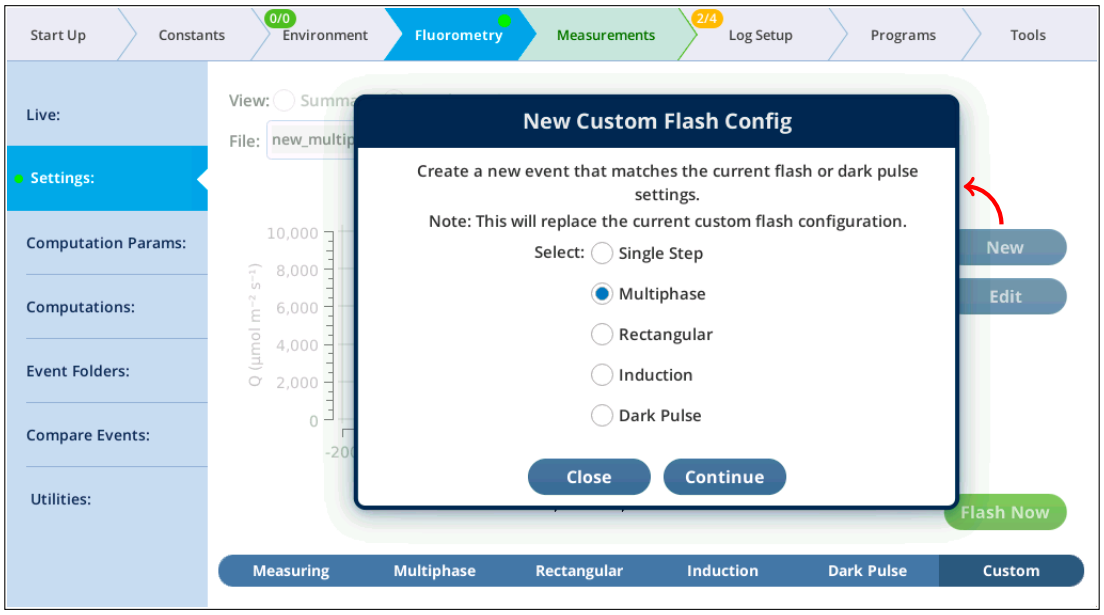


Figure 11: Make a new custom flash event that will match the current settings for the multiphase flash.

2. The **Settings** → **Custom** screen provides three views of the custom flash: text summary (Figure 12), a graphical preview (Figure 13), and an editable table (Figure 14).

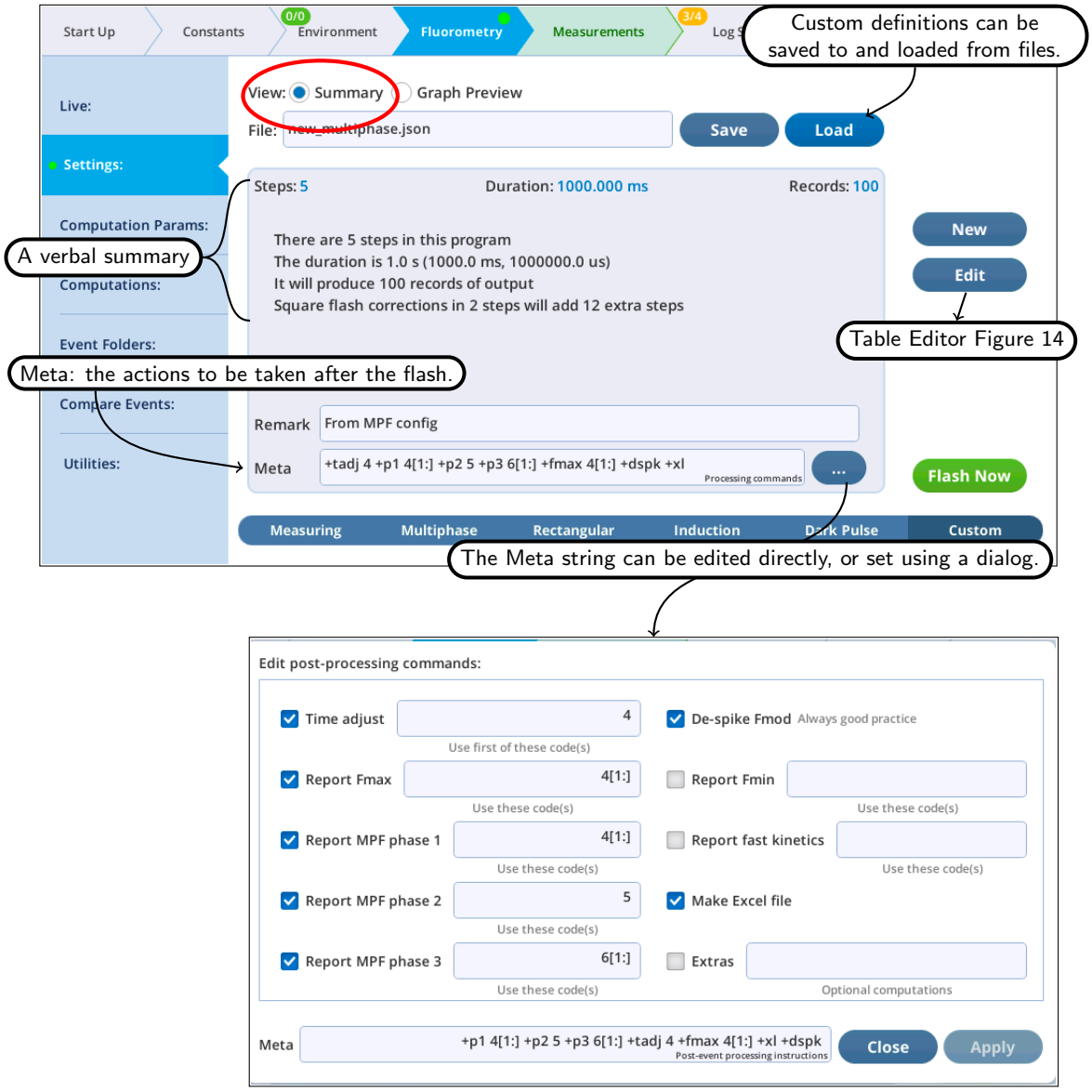


Figure 12: The Summary view provides a textual description, and the Meta string, which defines the post flash computations.

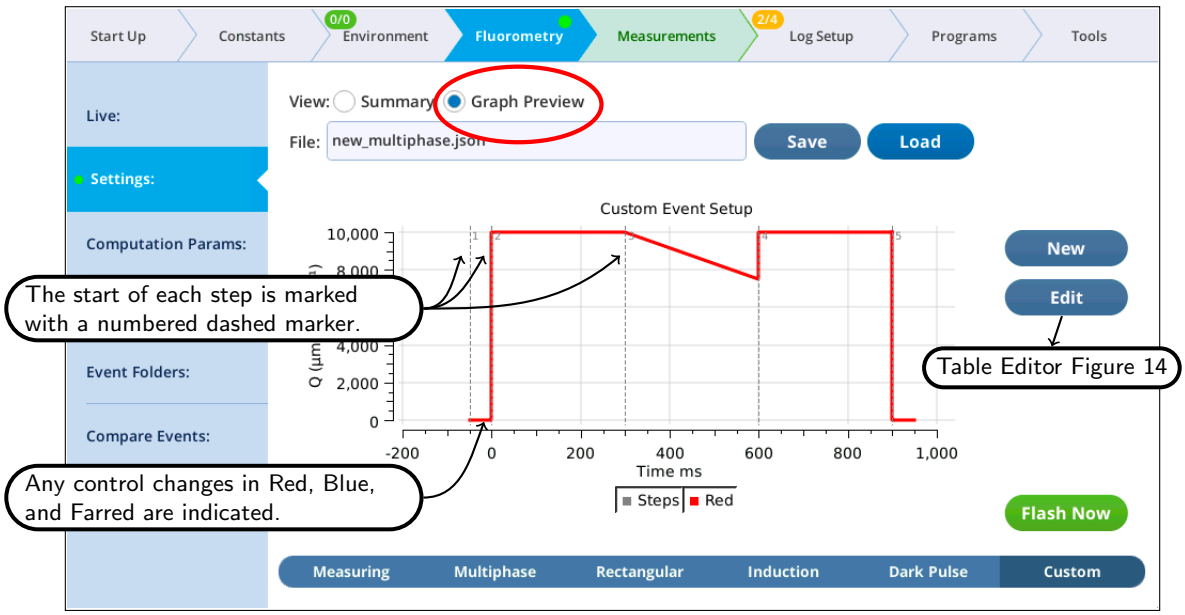


Figure 13: The Graphical view of a custom event shows the start time of each step, and any actinic light changes.

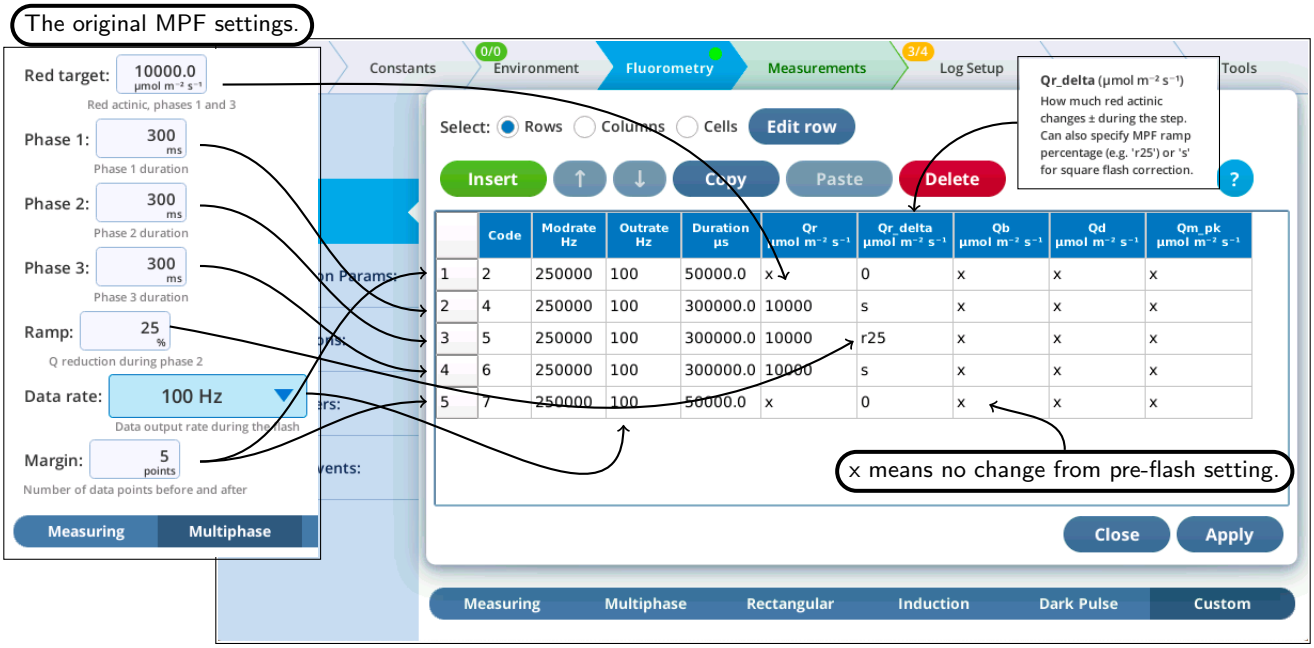


Figure 14: The Table Editor lets you view/edit what happens in the custom event at every step. For reference, we show the MPF settings that were used to generate the custom flash for this example.

3. Now let's modify this event by adding a dark pulse to the end of it to measure Fo' all in one event. Go to the Table view, be sure you are in Row edit mode, tap row 5 to select it, then tap Insert (Figure 15).

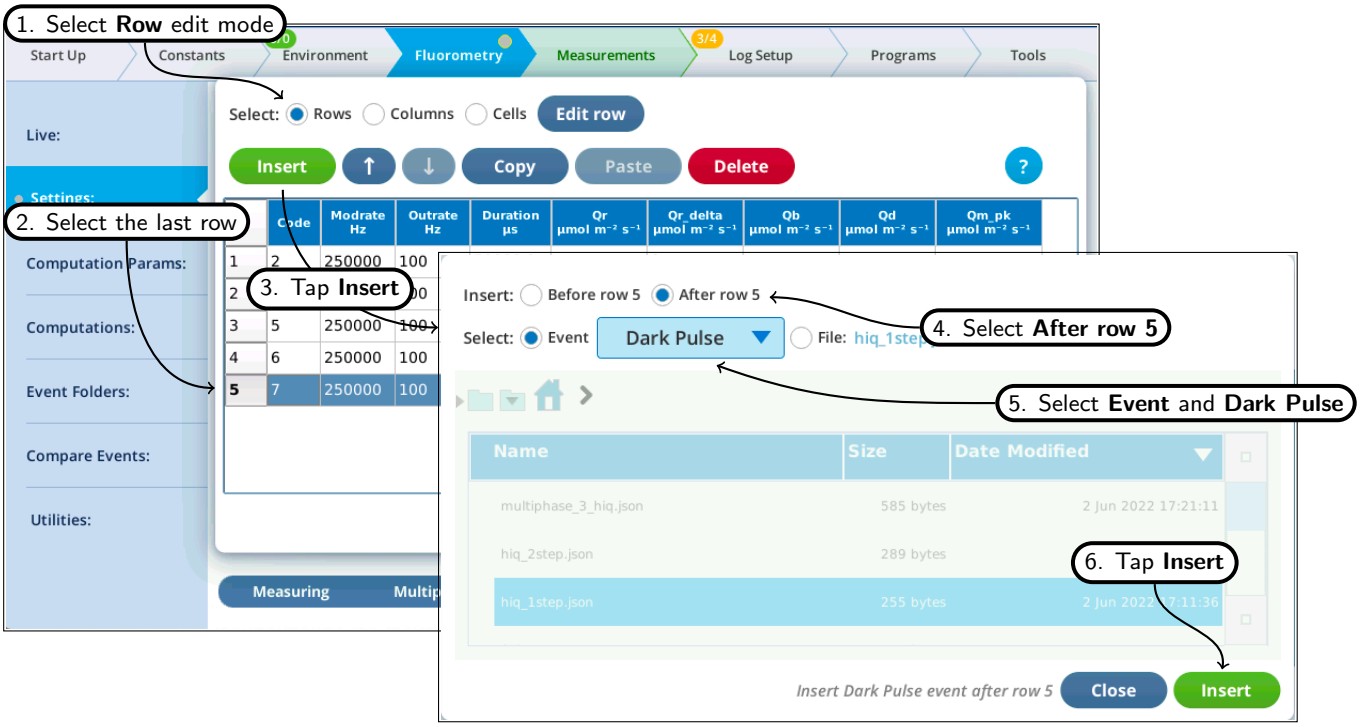


Figure 15: Step 3a. Appending a dark pulse to the custom flash step table.

4. Once the two events are merged, we have to get rid of the final margin for the MPF (row 5, `Code` is 7), and the starting margin step for the Dark pulse (row 6, `Code` is 11). To do this, select them both (tap on row 5, drag down to row 6) and tap[1] Delete (Figure 16). Then tap Apply to keep the changes you made.

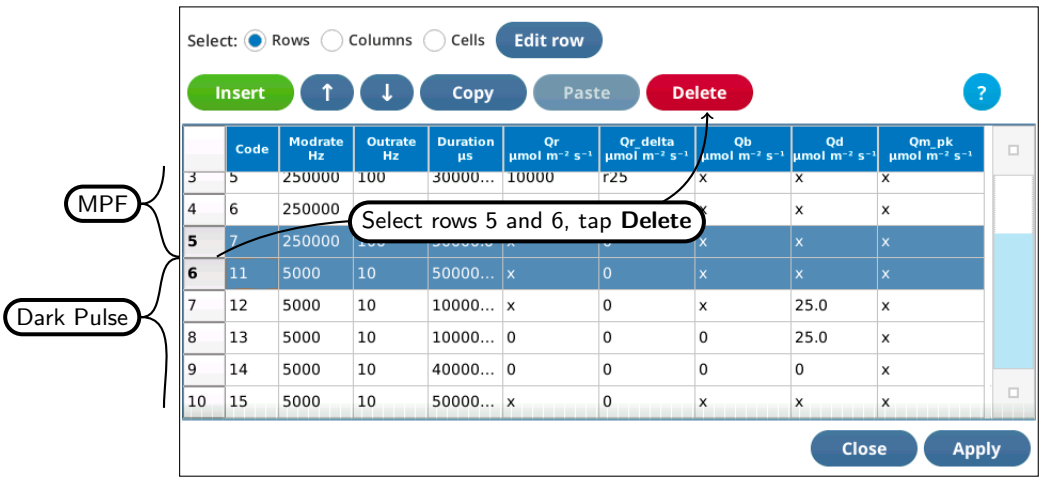


Figure 16: Delete the final margin of the MPF, and the starting margin of the just-appended Dark pulse.

[1]Note: we coul also get rid of these two steps by setting the `Duration` value for rows 5 and 6 to 0, since 0 duration steps are simply skipped.

5. The graphical preview shows a combined MPF and dark pulse event (Figure 17).

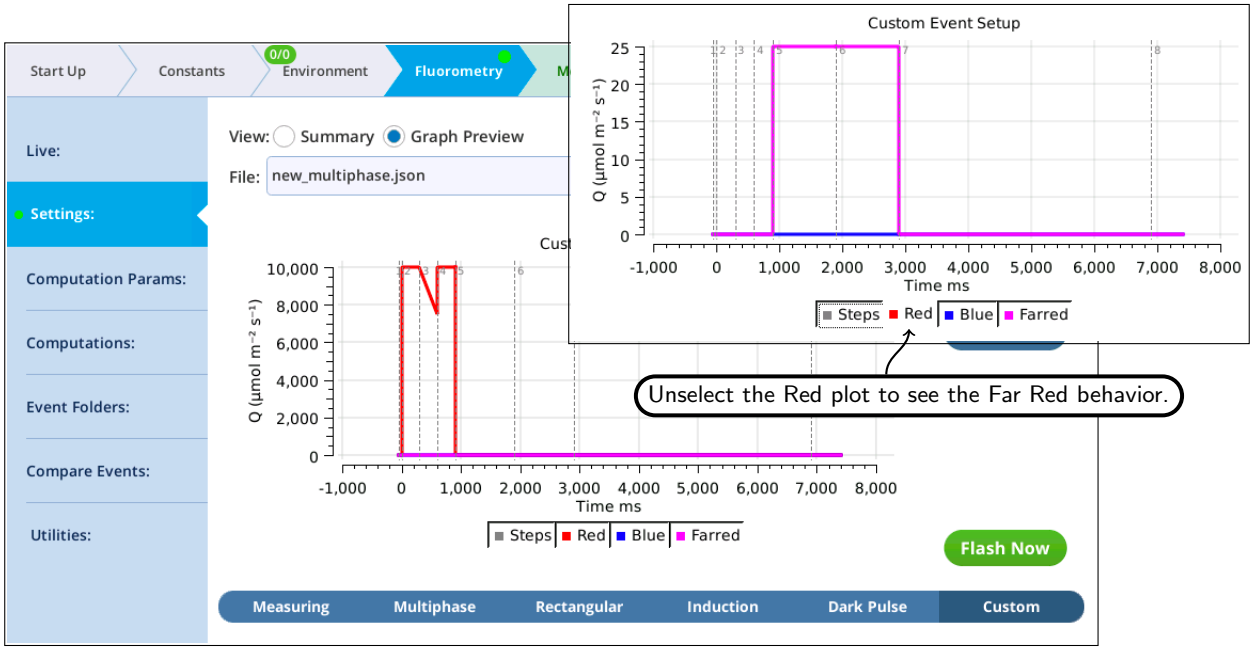


Figure 17: Preview of the custom MPF and dark pulse event.

6. Test the custom event by tapping Flash Now , and examining the results in the Compare Events screen (Figure 18).

Figure 18: The custom event results. The event has results for its MPF part and the dark pulse part.

2.6 Compare Events

Graph View

The **Fluorometry** → **Compare Events** section has some changes to better support viewing fluorometer event files.

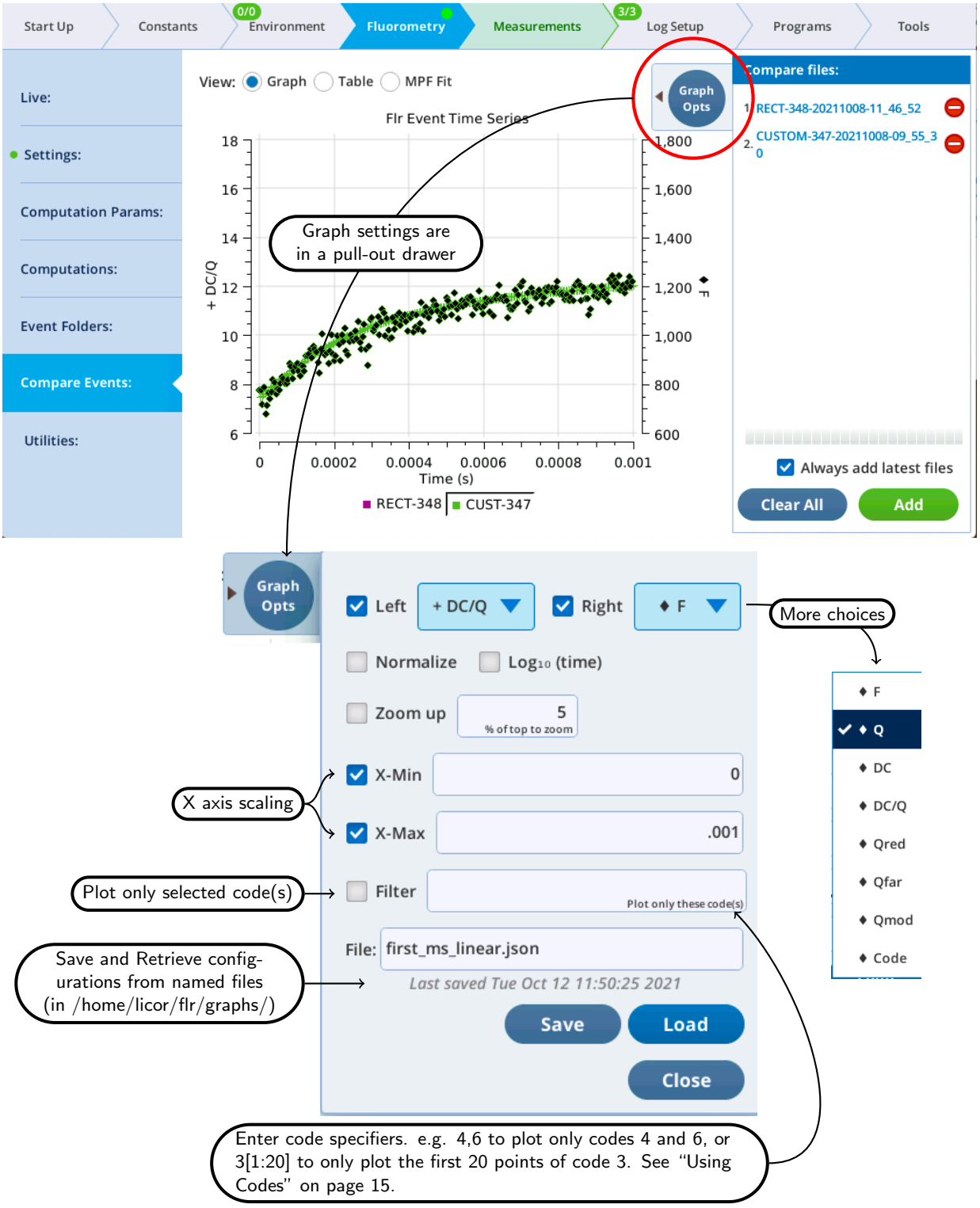


Figure 19: New graphing options for fluorometer event files.

Using Codes

The Filter field in Figure 19 also allows you to specify parts of a flash event to graph. For example, to see a RECT flash without the margin points, specify `3`. To plot just the first and third phases on an MPF, specify `4,6`. Table 2 below shows code value usage.

Code	Description
2	Pre-flash margin
3	RECT or INDUCTION flash
4	MPF Phase 1
5	MPF Phase 2
6	MPF Phase 3
7	Post-flash margin
8 - 10	unused
11	DARK pre margin
12	DARK part 1
13	DARK part 2
14	DARK part 3
15	DARK post margin
16 - 53	CUSTOM

Table 2: Step code usage.

Code number(s) represent a list of indices. For example, consider a hypothetical flash data set that includes these time series data:

```
:
"FLUOR":[91,  92,  93,  94,  95,  96,  97,  98,  99,  100]
"CODE": [16,  16,  17,  17,  17,  17,  17,  18,  18,  18]
:
```

Suppose the filter code is `17`. This means the plot will be of data whose 0-based indices (potentially 0 thru 9) are where `CODE` is 17. The list of indices where this condition is true is

`[2, 3, 4, 5, 6]`

so whatever is being plotted, it will be only those indices.

Code specifiers can include slice information (using the Python slicing convention), allowing you to further filter the list of indices. The syntax is (no spaces!)

code`[`*start*`:`*stop*`:`*step*`]`

where *code* is the code number, *start* is starting index, defaults to 0, *stop* is stopping index, defaults to `None`, and *step* is the step count, defaults to 1. *start* and *stop* can be positive (count from the left end) or negative (count from the right end).

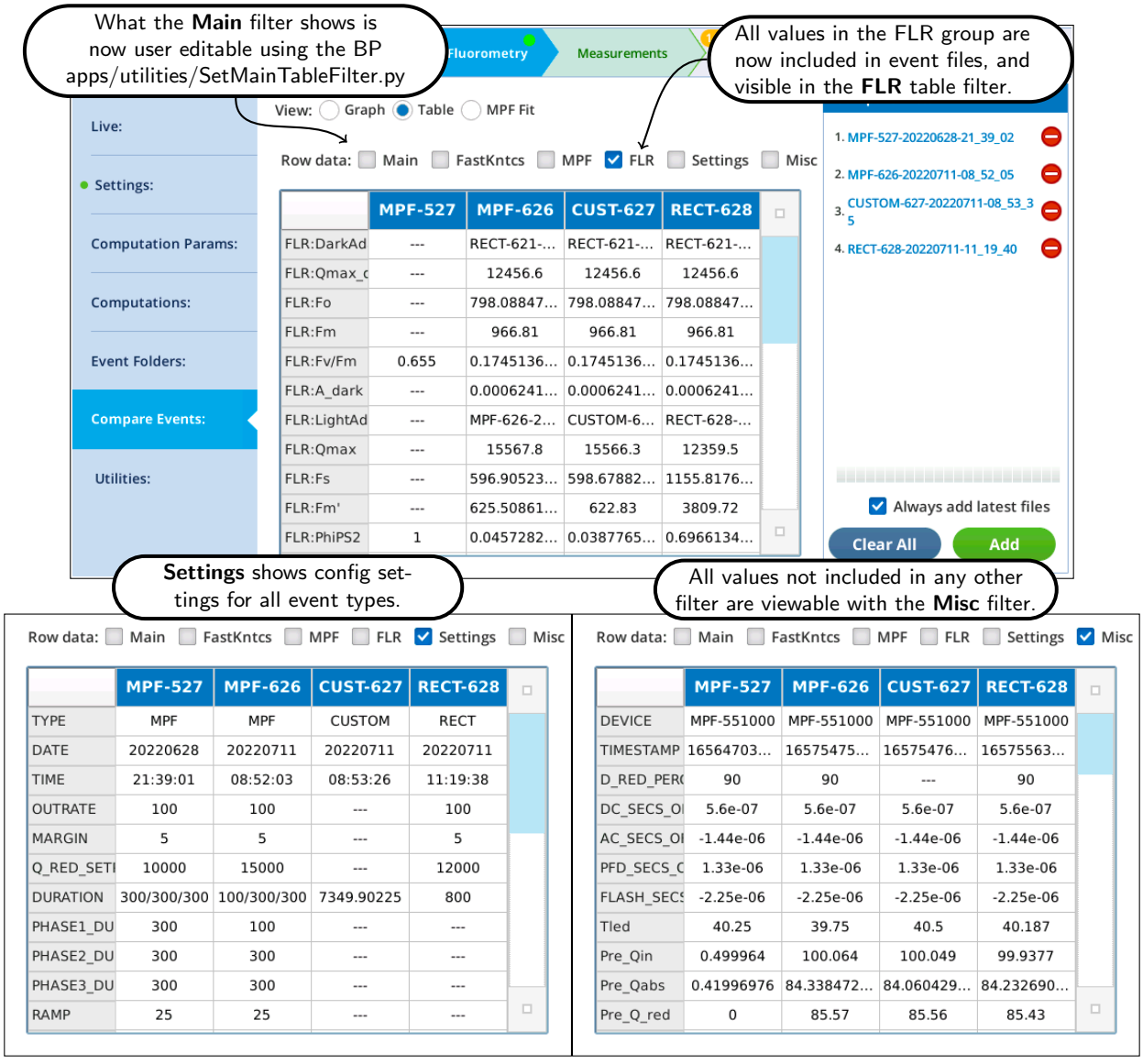
Examples using the above hypothetical flash data are shown in Table 3.

Specifier	Resulting Indicies	Description
16,17,18	[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]	Use just those three codes
17	[2, 3, 4, 5, 6]	All code 17s
17[1:]	[3, 4, 5, 6]	Skip the first one
17[:-2]	[2, 3, 4]	Skip the last 2
17[0:4]	[2, 3, 4, 5]	Use only the first 4
17[::2]	[2, 4, 6]	Use every other one
16[0],18[-1]	[0, 9]	Use first of 16, last of 18

Table 3: Code specifier examples and results.

Table View

The Table view has a couple of enhancements (Figure 20).



	MPF-527	MPF-626	CUST-627	RECT-628
FLR:DarkAd	---	RECT-621-...	RECT-621-...	RECT-621-...
FLR:Qmax_c	---	12456.6	12456.6	12456.6
FLR:Fo	---	798.08847...	798.08847...	798.08847...
FLR:Fm	---	966.81	966.81	966.81
FLR:Fv/Fm	0.655	0.1745136...	0.1745136...	0.1745136...
FLR:A_dark	---	0.0006241...	0.0006241...	0.0006241...
FLR:LightAd	---	MPF-626-2...	CUSTOM-6...	RECT-628-...
FLR:Qmax	---	15567.8	15566.3	12359.5
FLR:Fs	---	596.90523...	598.67882...	1155.8176...
FLR:Fm'	---	625.50861...	622.83	3809.72
FLR:PhiPS2	1	0.0457282...	0.0387765...	0.6966134...

Row data: Main FastKntcs MPF FLR Settings Misc

	MPF-527	MPF-626	CUST-627	RECT-628
TYPE	MPF	MPF	CUSTOM	RECT
DATE	20220628	20220711	20220711	20220711
TIME	21:39:01	08:52:03	08:53:26	11:19:38
OUTRATE	100	100	---	100
MARGIN	5	5	---	5
Q_RED_SETI	10000	15000	---	12000
DURATION	300/300/300	100/300/300	7349.90225	800
PHASE1_DU	300	100	---	---
PHASE2_DU	300	300	---	---
PHASE3_DU	300	300	---	---
RAMP	25	25	---	---

Row data: Main FastKntcs MPF FLR Settings Misc

	MPF-527	MPF-626	CUST-627	RECT-628
DEVICE	MPF-551000	MPF-551000	MPF-551000	MPF-551000
TIMESTAMP	16564703...	16575475...	16575476...	16575563...
D_RED_PER(	90	90	---	90
DC_SECS_OI	5.6e-07	5.6e-07	5.6e-07	5.6e-07
AC_SECS_OI	-1.44e-06	-1.44e-06	-1.44e-06	-1.44e-06
PFD_SECS_C	1.33e-06	1.33e-06	1.33e-06	1.33e-06
FLASH_SECS	-2.25e-06	-2.25e-06	-2.25e-06	-2.25e-06
Tled	40.25	39.75	40.5	40.187
Pre_Qin	0.499964	100.064	100.049	99.9377
Pre_Qabs	0.41996976	84.338472...	84.060429...	84.232690...
Pre_Q_red	0	85.57	85.56	85.43

*Figure 20: **FLR**, **Settings**, and **Misc** filter options are new in version 2.1. The **Main** filter is user editable.*

2.7 Fluorometer File Changes

The addition of custom flash events has caused some minor changes to the fluorometer event file structure. These changes will not impact most users, except those that are analyzing event files with their own software.

Listing 1 shows the .json file for a standard rectangular flash. The red sections of the header, and the in the computations, depend on event type. The green section is new, and contains all of the FLR group values following this event).

```
{
"EVENT_ID":628,
"DEVICE":"MPF-551000",
"DATE":"20220711",
"TIME":"11:19:38",
"TIMESTAMP":1657556378.6,
"TYPE":"RECT",
"OUTRATE":100,                          This section depends of the flash TYPE
"MARGIN":5,
"DURATION":800,
"Q_RED_SETPOINT":12000,
"D_RED_PERCENT":90,
"MODRATE":250000,
"DC_SECS_OFFSET":5.6e-07,                                   See ‘‘Fluorometry Timing Details’’ on page 18
"AC_SECS_OFFSET":-1.44e-06,                                 See ‘‘Fluorometry Timing Details’’ on page 18
"PFD_SECS_OFFSET":1.33e-06,                                 See ‘‘Fluorometry Timing Details’’ on page 18
"FLASH_SECS_OFFSET":-2.25e-06,                              See ‘‘Fluorometry Timing Details’’ on page 18
"SECS":[-0.04000175, -0.03000175, -0.02000175, -0.01000175, ...,                    Relative time (s)
"FLUOR":[1346.83, 1355.88, 1357.69, 1357.92, 1357.19, 3648.42, ...,          Modulated (AC) fluroescence
"DC":[1070.89, 1077.75, 1079.17, 1079.27, 1079.2, 370121, ...,                       DC fluroescence
"PFD":[124.202, 124.211, 124.206, 124.202, 126.516, 12335.9, ...,    Photon Flux Density (Q) µmol m-2 s-1
"RED":[84.7424, 84.7505, 84.7456, 84.7419, 86.8248, 12296.3, ...,                    Qr µmol m-2 s-1
"REDMODAVG":[30.0601, 30.0601, 30.0601, 30.0601, 30.0601, ...,                  Qm_peak µmol m-2 s-1
"FARRED":[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ...,                   Qd µmol m-2 s-1
"CODE":[2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, ...,                            Step code numbers
"Tled":45.312,                                          LED tile temperature (C) at time of flash
"Pre_Qin":99.9377,                                   Pre-flash PFD (LeafQ:Qin) µmol m-2 s-1
"Pre_Qabs":84.23,                                        Pre-flash LeafQ:Qabs µmol m-2 s-1
"Pre_Q_red":85.43,                                     Pre-flash FlrLS:Q_red µmol m-2 s-1
"Pre_Q_blue":9.5,                                     Pre-flash FlrLS:Q_blue µmol m-2 s-1
"Pre_Q_farred":0.0,                                  Pre-flash FlrLS:Q_farred µmol m-2 s-1
"Pre_Favg":1155.817,                                          Pre-flash FlrStats:F_avg
"Pre_dFdt":-3.5539215322752034,                               Pre-flash FlrStats:dF/dt
"VERSION":4,                                                        This file format
"Starts":[0, 5, 85],                                      Indicies that start a step
"Stops":[4, 84, 89],                                       Indicies that end a step
"T_OFFSET":0.04499975,                  This section depends of the flash TYPE / meta commands
"Dspk_indices":[0, 5, 85],
"Dspk_values":[1130.92, 3074.12, 2937.76],
"FMAX":3809.72,
"T@FMAX":0.38500025,
"QMAX":12359.5,
"Fs":1155.8,
"FLR:DarkAdaptedID":"RECT-621-20220710-20_20_54",          The state of the FLR group after this event
"FLR:Qmax_d":12456.6,
"FLR:Fo":798.0884705882354,
"FLR:Fm":966.81,
"FLR:Fv/Fm":0.17451363702461142,
"FLR:A_dark":0.0006241274473727851,
"FLR:LightAdaptedID":"RECT-628-20220711-11_19_40",
"FLR:Qmax":12359.5,
"FLR:Fs":1155.8176470588237,
"FLR:Fm’":3809.72,
"FLR:PhiPS2":0.696613492052218,
"FLR:PS2/1":0.5,
"FLR:Qabs_fs":84.23269098717378,
"FLR:A_fs":-0.0013443312108192432,
"FLR:ETR":29.33881450676526,
"FLR:PhiCO2":-2.3369295639525135e-05,
"FLR:NPQ":-0.7462254443896139,
```

```
"FLR:alt._Fo'":2078.349590362122,
"FLR:DarkPulseID":"-",
"FLR:Fmin":0,
"FLR:Fo'":2078.349590362122,
"FLR:Fv'/Fm'":0.4544613277715627,
"FLR:qP":1.5328333776342227,
"FLR:qN":2.5576326967119765,
"FLR:qP_Fo":0.8812174819605304,
"FLR:qN_Fo":-16.849716867264068,
"FLR:qL":2.756285674133975,
"FLR:1-qL":-1.756285674133975
}
```


Listing 1: A standard rectangular flash. The red highlighted sections will change with event TYPE.

Fluorometry Timing Details

The relative timing of the modulation, various measurements, and actinic change ("Saturating Flash") is shown in (Figure 21).

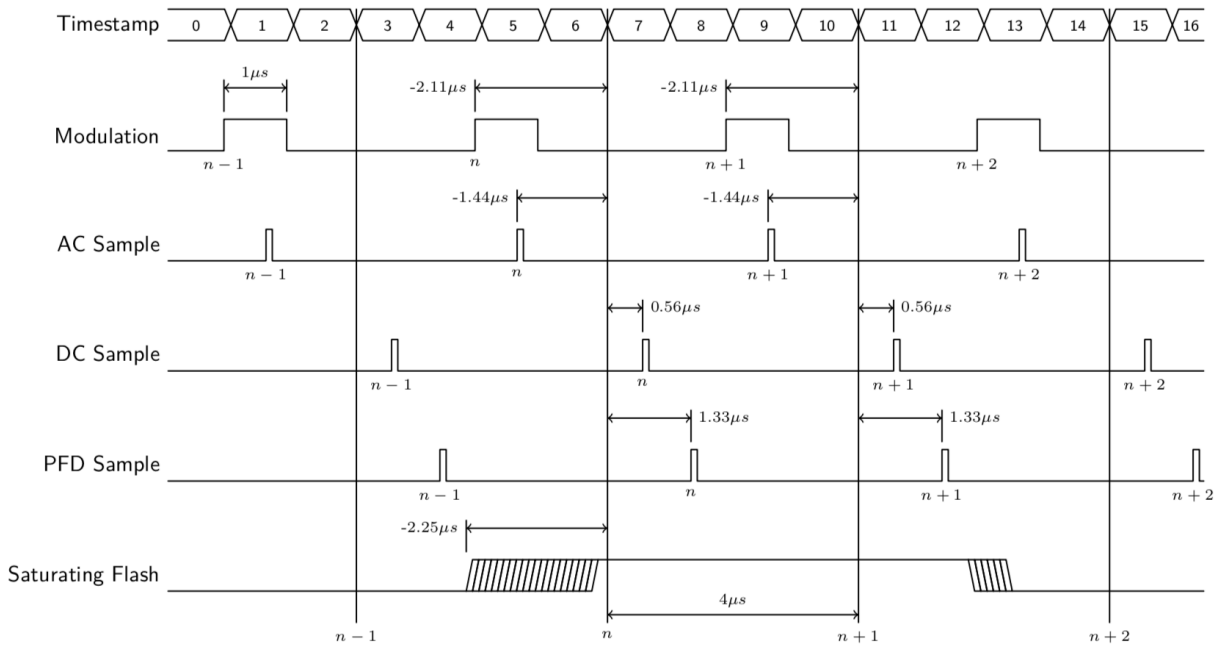


Figure 21: Timing when the modulating is set to 250000 Hz.

The vertical lines marked $n-1$, n, etc. represent data output at a common time stamp. The measurements made associated with that stamp differ slightly from the actual time stamp by small amounts. For example, the PFD (actinic) measurement is made 1.33 μs after the reported time, while the modulated fluorescence is measured 1.44μs prior to the reported time. These offset values appear in each flash event file, so any firmware updates that change timing will be documented in the fluorometer's output (Listing 2).


```
{
"EVENT_ID":308,
"DEVICE":"MPF-551000",
"DATE":"20211005",
"TIME":"15:03:15",
"TIMESTAMP":1633464195.5,
```

```
        :
"DC_SECS_OFFSET":5.6e-07,
"AC_SECS_OFFSET":-1.44e-06,
"PFD_SECS_OFFSET":1.33e-06,
"FLASH_SECS_OFFSET":-2.25e-06,
"SECS":[-0.04000175, -0.03000175, -0.02000175, -0.01000175, ..., 0.63999825, 0.64999825],
"FLUOR":[1346.83, 1355.88, 1357.69, 1357.92, 1357.19, 3648.42, 4133.55, ..., 1559.26],
        :
}
```

Listing 2: Timing information.