
fcs-io Documentation

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COMMAND LINE INTERFACE

1.1 *fcs-io*

Access sub-commands for working with FCS files

This command will always need to be followed by an operation command. If the operation is missing, a list of available options will be provided.

```
$ fcs-io -h
```

```
usage: fcs-io [-h] {describe,filter,reorder,strip,view}
Work with FCS files from the command line

positional arguments:
  {describe,filter,reorder,strip,view}
                                Specify which task to execute

optional arguments:
  -h, --help                    show this help message and exit
```

This is the front end of the command line utility. Features can be accessed according to the available commands

1.1.1 *cat*

Concatenate events of FCS files

```
$ fcs-io cat -h
```

```
usage: fcs-io [-h] {describe,filter,reorder,strip,view}
fcs-io: error: argument task: invalid choice: 'cat' (choose from 'describe', 'filter',
↪ 'reorder', 'strip', 'view')
```

1.1.2 *describe*

Summary of FCS file contents

```
$ fcs-io describe -h
```

```
usage: describe [-h] [-o OUTPUT] input
```

Provide a description of the FCS file and its contents

positional arguments:

input	Input FCS file or '-' for STDIN '.gz' files will be automatically processed by gzip
-------	---

optional arguments:

-h, --help	show this help message and exit
-o OUTPUT, --output OUTPUT	Output FCS file or STDOUT if not set (default: None)

Provide a description of the FCS file and its contents

1.1.3 *enumerate*

Add an enumeration channel to the paremeters

```
$ fcs-io enumerate -h
```

```
usage: fcs-io [-h] {describe,filter,reorder,strip,view}
fcs-io: error: argument task: invalid choice: 'enumerate' (choose from 'describe',
↪ 'filter', 'reorder', 'strip', 'view')
```

1.1.4 *filter*

Remove events based on filtering criteria

```
$ fcs-io filter -h
```

```
usage: filter [-h] [-o OUTPUT]
           [--event_range start end | --event_downsample_random count | --gate_
↪short_name]
           [--min MIN] [--max MAX]
           input
```

Provide a description of the FCS file and its contents

positional arguments:

input	Input FCS file or '-' for STDIN '.gz' files will be automatically processed by gzip
-------	---

optional arguments:

-h, --help	show this help message and exit
-o OUTPUT, --output OUTPUT	Output FCS file or STDOUT if not set (default: None)
--event_range start end	get events (cells) in this range (1 indexed) (default: None)
--event_downsample_random count	number of cells to randomly draw (default: None)
--gate short_name	gate on short name. use min and max to define range (default: None)

<code>--min MIN</code>	Remove events less than this number (default: None)
<code>--max MAX</code>	Remove events greater than this (default: None)

Apply various filters to the FCS file

1.1.5 *reorder*

Reorder parameters

```
$ fcs-io reorder -h
```

```
usage: reorder [-h] [-o OUTPUT] [--short_name | --custom CUSTOM] input

Reorder the parameters of an FCS file

positional arguments:
  input                Input FCS file or '-' for STDIN '.gz' files will be
                        automatically processed by gzip

optional arguments:
  -h, --help            show this help message and exit
  -o OUTPUT, --output OUTPUT
                        Output FCS file or STDOUT if not set (default: None)
  --short_name          Only output required fields. Exclude OTHER fields.
                        (default: False)
  --custom CUSTOM       comma separated list of indecies (1-indexed) (default:
                        None)
```

Reorder the parameters of an fcs file

1.1.6 *rm*

Remove parameters

```
$ fcs-io rm -h
```

```
usage: fcs-io [-h] {describe,filter,reorder,strip,view}
fcs-io: error: argument task: invalid choice: 'rm' (choose from 'describe', 'filter',
↪ 'reorder', 'strip', 'view')
```

1.1.7 *strip*

Trim keywords and data segments from a file (but not whole parameters)

```
$ fcs-io strip -h
```

```
usage: strip [-h] [-o OUTPUT] [--essential] input

Strip OTHER fields from the fcs file or more depending on options

positional arguments:
  input                Input FCS file or '-' for STDIN '.gz' files will be
```

```
                                automatically processed by gzip

optional arguments:
  -h, --help                show this help message and exit
  -o OUTPUT, --output OUTPUT
                           Output FCS file or STDOUT if not set (default: None)
  --essential                Only output required fields. (default: False)
```

Remove general features like OTHER segments from an FCS file

1.1.8 *view*

View the data from an fcs file

```
$ fcs-io view -h
```

```
usage: view [-h] [-o OUTPUT] [-s] [-r | -R] input

Provide a description of the FCS file and its contents

positional arguments:
  input                Input FCS file or '-' for STDIN '.gz' files will be
                       automatically processed by gzip

optional arguments:
  -h, --help                show this help message and exit
  -o OUTPUT, --output OUTPUT
                           Output FCS file or STDOUT if not set (default: None)
  -s, --simple                decimal places in float (default: None)
  -r                        Include the header in the output (default: False)
  -R                        Only output the header (default: False)
```

View FCS file contents

MODULES

2.1 FCS

class `fcsio.FCS` (*bytes=None, fcs=None*)

The primary class for working with FCS file data is the FCS class.

Note: Use this class to work with FCS data.

A complete list of classes within the module is included because many of the methods and properties of this class are helper classes and descriptions of those classes will explain their available properties and methods.

Parameters

- **bytes** (*bytearray*) – The raw data of the FCS file
- **fcs** – *fcsio.FCS* object to create a new FCS from. Used by copy.

copy ()

Output an fcs object that is the same content as self

Creates a new object for everything EXCEPT the OTHER fields (for now)

Warning: The copy is neither a perfect copy, nor is it memory independent. OTHER fields are still passed by reference. And no attempt is made at outputting identical bytes as input. If you need a completely new FCS object unlinked to the old, you can use *totally_new = FCS(myoldfcs.output_constructor().fcs_bytes)*

Returns Make a new FCS object that is a copy of this one.

Return type *fcsio.FCS*

data

access the DATA segment

Returns Get an object for accessing the DATA segment

Return type *fcsio.data.Data*

filter

Filter an FCS file through a variety of methods defined by the *fcsio.filter.Filter* class. Filter methods will then return a new FCS object based on a copy of the current, see the Filter class for more information.

Returns an object for filtering the FCS object

Return type `fcsio.filter.Filter`

other

access the OTHER segments (user defined fields specified at the end of the header)

setter: set the value of other with a *list* of *bytearray*

Returns Get the data from OTHER user defined segments at the end of the header

Return type list of bytearrays

output_constructor (*essential=False, adjust_range=True*)

Get the bytes of an actual file for an FCS object through the `output_constructor` method is required to be called.

Note: You can just access this functionally if you like, or you can assign it to a variable if you have some reason to access it multiple times to reduce computation.

Warning: If you need to access multiple propertyys from the factory, you should save the factory and access them all from that same instance of factory. The common use case will only be to access `fcs_bytes`, so this shouldn't usually be an issue.

Parameters

- **essential** (*bool*) – An optional argument, where if set to True, will trim off the OTHER segements. The other objects are passed as references so clearing them may not be generally necessary for conserving memory.
- **adjust_range** (*int*) – An optional argument, default True, to adjust range of parameter to that parameters largest current value

Returns Generate an object with methods necessary for outputing a new FCS file (bytes that can be written)

Return type `fcsio.FCSFactory`

parameters

access to parameters. These are originally defined in keywords but are not accessible through `fcsio.text.Text` by keyword name.

Parameters needs to be accessed after both text and data have been intialized because data is coupled to parameters. Any changes is parameters will also affect data.

setter: reassign the parameters in any order or subset you want from a list of paramters, and they will be automatically indexed appropriately, and the data will be automatically reordered

Returns get an object for accessing/modifying paramters

Return type `fcsio.text.parameters.Parameters`

Note: Parameters can be reassigned. The setter for parameters is the easiest way to subset, remove or reorder parameters.

standard

access and set where possible standard TEXT fields through here. You can access these fields through `fcsio.text.Text` also but are limited to string input and outputs.

Warning: When first read in, these will have original values, but values can change while altering the file, and after the output constructor is called, expect byte ranges to shift.

Alsosee `fcsio.text.Text`

Returns get an object for accessing/modifying standard keywords in TEXT

Return type `fcsio.text.standard.Standard`

text

access the TEXT segment

Note: The object containing the TEXT segment initially separates the keywords from per-parameter keywords. The per-parameter information is better accessed through the FCS property `fcsio.FCS.parameters`. The standard FCS keywords are accessible via properties of the `fcsio.FCS.standard`. This is a better choice for getting and setting values if you want to use more logical types instead of strings for everything. Finally keep in mind that although TEXT may contain information such as DATABEGINS or DATAENDS, these values are not updated until the `fcsio.FCS.output_constructor` method is called. At this point they will be updated.

Warning: When first read in, these will have original values, but values can change while altering the file, and after the output constructor is called, expect byte ranges to shift.

Alsosee `fcsio.FCS.parameters`

Alsosee `fcsio.FCS.standard`

Returns Get the object for accessing the TEXT segment data

Return type `fcsio.text.Text`

version

Version as listed in the first 10 bytes of the header

Returns version

Return type `string`

class `fcsio.FCSFactory` (*fcs*, *essential=False*, *adjust_range=True*)

A class to hold a created header and byte values so that data and text bytes corresponding to the header don't need to be recomputed

Warning: FCSFactory can do some modifications to the TEXT segment defined in the `fcsio.FCS` object used to initialize the class. These are done to set appropriate byte conditions since keywords, parameters, and data may have been modified.

Note: There is a bit of a conundrum. We need to set the TEXT size, but part of the TEXT is the `data_start` and `data_end`. Setting `data_start` and `data_end` could change the size of TEXT, thus changing `data_start` and `data_end`. We deal with this by using buffers that leave enough room between segments to accomodate size changes of segments based on value replacements.

Parameters

- **fcs** (*fcsio.FCS*) – The FCS object being staged for output
- **essential** (*bool*) – optional, False by default, and if True, trim off the OTHER segments
- **adjust_range** (*bool*) – optional, True by default, adjust the range of each parameter to have a max in that is rounded above the or equal to the highest value

data_bytes

get the DATA segment bytes of the FCS object

Returns the bytes in the DATA segment

Return type *bytearray*

fcs_bytes

get the real data as a bytearray from the FCS object

Returns The FCS raw data

Return type *bytearray*

header_bytes

get the header bytes of the FCS object

Returns the bytes bound for the header

Return type *bytearray*

other

get the OTHER segment bytes as a list of bytearrays

Returns any data segments defined as OTHER

Return type list of bytearrays

parameters

get the parameters accessing object from TEXT after adjustments

Warning: This will have different ranges unless you keep them the same by output constructor options

Returns object to access standard keywords and values

Return type *fcsio.text.parameters.Parameters*

standard

get the standard TEXT object after adjustment for output

Warning: This will likely be different than what was read in for byte ranges

Returns object to access standard keywords and values

Return type *fcsio.text.standard.Standard*

text

get the text object after adjustment for output

Warning: This will likely be different than what was read in for byte ranges

Returns Text object ready for output

Return type *fcsio.text.Text*

text_bytes

get the TEXT segment bytes of the FCS object

Returns the bytes in the TEXT segment

Return type *bytearray*

class *fcsio.filter.Filter* (*fcs*)

Filter an FCS class according by various options and output an FCS

Note: This class is should be accessed through the *fcsio.FCS.filter* method.

When filter is called, a copy is created of the FCS class used to initialize it is generated. This copy is subsequently modified as necessary in the filtering process.

Parameters *fcs* (*fcsio.FCS*) – Start filtering from an FCS class.

events (*row_indecies*)

Filter the events (or cells) by index. This is to facilitate subsetting the data with random sampling.

Parameters *row_indecies* (*list*) – A list of indecies (0-indexed) of events to include

Returns A filtered FCS

Return type *fcsio.FCS*

gate (*short_name*, *min=None*, *max=None*)

Filter the FCS file based on values of a parameter

include greater than or equal to min if set include less than or equal to max if set

Parameters

- **short_name** (*string*) – PnN short name
- **min** (*float*) – remove anything less than this
- **max** (*float*) – remove anything greater than this

minimize ()

Trim down the FCS to all but the minimal number of required fields

by its very nature this is a very lossy filter, but could conceivably help with some memory issues that could come up.

none ()

parameters (*short_names=None*)

2.2 HEADER

class *fcsio.header.ByteIndecies* (*start*, *end*, *in_header*)

Bases: *tuple*

1-indexed byte locations of start and end with a bool specifying if it was defined in the header or not

count (*value*) → integer – return number of occurrences of value

end

Alias for field number 1

in_header

Alias for field number 2

index (*value*[, *start*[, *stop*]]) → integer – return first index of value.

Raises ValueError if the value is not present.

start

Alias for field number 0

class `fcsio.header.Header` (*data*)

The header class is only used temporarily when reading the FCS from data. The version is the only value that doesn't change depending on how the data is altered.

3.0 from the spec 1997 Seamer Current Protocols in Cytometry

1. FCS 3.0 followed by spaces 00-09
2. ASCII-encoded offset to first byte of TEXT segment 10–17
3. ASCII-encoded offset to last byte of TEXT segment 18–25
4. ASCII-encoded offset to first byte of DATA segment 26–33
5. ASCII-encoded offset to last byte of DATA segment 34–41
6. ASCII-encoded offset to first byte of ANALYSIS segment 42–49
7. ASCII-encoded offset to last byte of ANALYSIS segment 50-57
8. OTHER segments 58 to start of TEXT

`fcsio.header.ByteIndecies` tell the 'start', the 'end' and whether or not (bool) a numerical range was read from the header. If no numerical range was reported it is likely either absent from the file or coded in the TEXT

Parameters **data** (*bytearray*) – The FCS file data (not just the first 58 bytes)

analysis_range

Can be zero if the end exceeds 99,999,999. To indicate it is set within the TEXT segment. or that its absent.

Returns get the analysis range. it is required to be present.

Return type `fcsio.header.ByteIndecies`

data_range

Can be zero if the end exceeds 99,999,999. To indicate it is set within the TEXT segment.

Returns get the data range. it is required to be present.

Return type `fcsio.header.ByteIndecies`

other_ranges

If there is extra data in the header return it

Assume pairs of coordinates for now as the only thing we'll see for one or more user segments.

Returns Get the coordinates of OTHER segments

Return type list of `fcsio.header.ByteIndecies`

text_range

Should be between the end of the header and less than 99,999,999

Returns get the text range. it is required to be present.

Return type `fcsio.header.ByteIndecies`

validate (*verbose=True*)

Validate for 3.0 and 3.1 together for now

Returns Is it a valid header?

Return type `bool`

version

get the version

Returns version string from the beginning of the header with whitespace removed

Return type `string`

2.3 TEXT segment

Core for dealing with the TEXT definitions

Note that byte-offset fields may change, and these will need be set during the process of preparing an output FCS file. These fields will be available for reading prior to this but they will not have meaning until output.

The `fcsio.StageFCS` class will do all this cleaning up of coordinates prior to outputting the FCS file.

class `fcsio.text.KeyWordDict` (*kvs=[]*)

A dictionary for accessing keywords that

1. Preserves the original keywords
2. Provides case-INSENSITIVE access to keywords as per the spec
3. Does not allow empty strings as keywords or values

Since keywords are case insensitive, take them to uppercase,

Parameters *kvs* (*list of key-value pairs*) – key-value pairs

keys ()

Keywords of TEXT that can be accessed and modified. This does not include the parameter keywords, because they must be accessed through the `fcsio.FCS.parameters` property, or through the property here of `fcsio.text.Text.parameter_data`

Returns list of keywords

Return type `list`

parameter_data

Parameter data keyed by index then generic keyword

Returns dict of parameters keyed by their index and generic keyword

Return type `dict`

class `fcsio.text.RegexDescriptor` (*regex_string, keyword, regex*)

Bases: `tuple`

Store regular expressions that describe documented keywords

count (*value*) → integer – return number of occurrences of value

index (*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises `ValueError` if the value is not present.

keyword
Alias for field number 1

regex
Alias for field number 2

regex_string
Alias for field number 0

class `fcsio.text.Text` (*data=None*)
Bases: `fcsio.text.KeyWordDict`

Parse the TEXT portion of the file. Assumes that the header has been processed in set in `self._header`.

In version 3.0 of the FCS specification, the TEXT must fit entirely in the first 99,999,999 bytes of data.

Text object can be accessed as a dictionary, as it is composed of key/value pairs, but these will all be strings keys and string values.

Can take an input data from an FCS file, but this object is mutable.

bytes
Get the data bytes from TEXT.

Warning: To properly prepare the TEXT data with the byte ranges set correctly, you should not call `fcsio.text.Text.bytes` property directly. Rather you should use `fcsio.FCS.construct_fcs`

Returns the data

Return type `bytearray`

keys ()
Keywords of TEXT that can be accessed and modified. This does not include the parameter keywords, because they must be accessed through the `fcsio.FCS.parameters` property, or through the property here of `fcsio.text.Text.parameter_data`

Returns list of keywords

Return type `list`

miter = None
Bake removing the escape characters into generating the key value pairs

parameter_data
Parameter data keyed by index then generic keyword

Returns dict of parameters keyed by their index and generic keyword

Return type `dict`

`fcsio.text.get_required_keywords` ()
Return a dictionary of the required keywords

Returns keywords that are required, as keys to their description

Return type `dict`

class `fcsio.text.standard.Standard`(*text*)
 interact with text fields through standard key words, these EXCLUDE parameters which are available in ‘parameter’

Warning: While you may be able to read and alter parameters here, any byte ranges will hold very little meaning except when first read and describing an original file or after an `output_constructor` has been called and you

BEGINANALYSIS

Get the byte offset for BEGINANALYSIS

Setter: assign an *int* to the keyword

Returns the BEGINANALYSIS value

Return type *int*

BEGINDATA

Get the byte offset for BEGINDATA

Setter: assign an *int* to the keyword

Returns the BEGINDATA value

Return type *int*

BEGINTEXT

Get the byte offset for BEGINTEXT supplemental text

Setter: assign an *int* to the keyword

Returns the BEGINTEXT value

Return type *int*

BYTEORD

Get the byte order type as either ‘little endian’ or ‘big endian’

Setter: set the key word from either ‘little endian’ or ‘big endian’ string

Returns the BYTEORD description

Return type string that is either ‘little endian’ or ‘big endian’

DATATYPE

Type of the DATA in the data segment

Setter: assign an *char* to the keyword

Returns the DATATYPE

Return type *char*

ENDANALYSIS

Get the byte offset for ENDANALYSIS

Setter: assign an *int* to the keyword

Returns the ENDANALYSIS value

Return type *int*

ENDDATA

Get the byte offset for ENDDATA

Setter: assign an *int* to the keyword

Returns the ENDDATA value

Return type *int*

ENDSTEXT

Get the byte offset for ENDSTEXT supplemental text

Setter: assign an *int* to the keyword

Returns the ENDSTEXT value

Return type *int*

MODE

Get the MODE of data layout

Setter: assign an *char* to the keyword

Returns the MODE value

Return type *char*

NEXTDATA

Get the byte offset for NEXTDATA the next fcs data

Setter: assign an *int* to the keyword

Returns the NEXTDATA value

Return type *int*

PAR

Get the number of parameters

Warning: You cannot set the PAR, as it is inferred from the parameters present

Returns the PAR value

Return type *int*

TOT

Get the number of events

Warning: You cannot set the TOT, as it is inferred from the parameters present

Returns the TOT value

Return type *int*

class `fcsio.text.parameters.Parameter` (*i*, *pdata*)

A class defining a single Parameter. These are attributes being recorded by the machine for each event, and they come with a number of keywords describing each one.

Parameters

- **i** (*int*) – index of the parameter (0-indexed)

- **pdata** (*dict*) – The dict keyed by index, then generic parameter keyword accessible through *fcsio.text.Text*

Note: Can be accessed as a dictionary by keyword. Use `get_keywords()` to get available keywords, e.g. ‘\$PnS’

amplification_gain

\$PnG gain used to amplify the value of this parameter

Setter: assign a *float* to \$PnG

Returns \$PnG

Return type *float* or *None*

amplification_type

\$PnE attribute for this paramete.

REQUIRED ATTRIBUTE

Specifies whether the the parameter data is stored on linear or logarithmic scale. For a linear scale, (0,0) will be used. When floating point storage is used, this linear scale will be used

Here it returns as a tuple pair of floats and the first float is the number of log decades and the second is the linear value that would have a log value of 0

Note: Can be converted with the formula $10^{(f1*xc/r)}*f2$ where xc is the channel value.

Setter: assign an (*float1, float2*) to \$PnE

Returns \$PnE

Return type (*float*, ‘float’)

bits

\$PnB attribute for this parameter

REQUIRED ATTRIBUTE

Please keep in mind that bits is required to be 32 for type F. If \$DATATYPE is F this will represent the number of characters for each data value

Setter: assign an *int* to \$PnB

Returns \$PnB

Return type *int*

calibration

\$PnCALIBRATION short name attribute for this parameter

Parameter has 1 per *float* scale units.

Setter: assign a tuple (*float*, ‘string’) to \$PnCALIBRATION

Returns \$PnCALIBRATION

Return type (*float*, ‘string’) or *None*

detector_type

\$PnT detector type for this parameter

Setter: assign a *string* to \$PnT

Returns \$PnT

Return type string or *None*

detector_voltage

\$PnT detector type for this parameter

Setter: assign a *string* to \$PnT

Returns \$PnT

Return type string or *None*

emitted_light

\$PnP amount of light collected by dector for a parmeter as a percentage of emitted light

Setter: assign an *int* to \$PnP

Returns \$PnP as an integer percent

Return type int or *None*

excitation_power

\$PnO power of lightsource in mW used to excite the parameter

Setter: assign an *int* to \$PnO

Returns \$PnO

Return type int or *None*

excitation_wavelengths

\$PnL excitation wavelength(s) for parameter N

Setter: assign a list of ints to \$PnL

Returns \$PnL

Return type list of ints or *None*

get_keywords ()

Get all the keywords available for this parameter

Returns keywords available

Return type *list* of strings

index

get the 0-indexed order number of the parameter :return: index (0-based) :rtype: int

keys ()

an alias for get_keywords

Alsosee `fcsio.text.parameters.Parameter.get_keywords`

long_name

\$PnS defines a long name for the parameter

Setter: assign a *string* to \$PnS

Returns \$PnS long name

Return type string or *None*

optical_filter

\$PnF optical filter attribute for this parameter

Setter: assign a *string* to \$PnF

Returns \$PnF

Return type string or *None*

range

\$PnR max range attribute for this parameter

REQUIRED ATTRIBUTE

Holds the maximum value that data for this parameter can reach. The value stored can exceed the true max.

Setter: assign an *int* to \$PnR

Returns \$PnR

Return type int

short_name

\$PnN short name attribute for this parameter

REQUIRED ATTRIBUTE

Setter: assign a *string* to \$PnN

Returns \$PnN

Return type string

visualization_scale

\$PnD short name attribute for this parameter

visualization scale recommendations for parameter

Setter: assign a tuple (*string*, 'float', 'float') to \$PnD

Returns \$PnD

Return type (*string*, 'float', 'float') or *None*

class fcsio.text.parameters.**Parameters** (*text*, *data*)

class to access and modify the parameters defined by the TEXT segment with data stored in the DATA segment

input values are usually accessed through FCS properties

Parameters

- **text** (*fcsio.text.Text*) – the text object associated with an FCS object
- **data** (*fcsio.data.Data*) – the data object associated iwth an FCS object

delete (*short_names=[]*)

Remove a list of parameters defined by the list of short names

Parameters **short_names** – the PnP short names as a list

indexOf (*short_name=None*)

Get the index in a list of parameters according to a short_name of a parameter

Parameters **short_name** (*string*) – the PnN short name

Returns get he index of the short name

Return type int

reassign (*parameters*)

reassign the parameters from a list. the ordering of the list will dictate the new order of parameters in the file.

Parameters **parameters** (list of *fcsio.text.parameters.Parameter* or *fcsio.text.parameters.Parameters*) – parameters

2.4 DATA segment

class *fcsio.data.Data* (*data, standard, text*)

The class for working with the data attached to an fcs object

Parameters

- **data** (*bytearray*) – bytes of the Data segment
- **standard** (*fcsio.text.standard.Standard*) – class for interfacing with the TEXT
- **text** (*fcsio.text.Text*) – main TEXT class

bytes

Get the data

Returns constructed data

Return type *bytearray*

event_count

Get the number of events

Returns the event count

Return type *int*

matrix

Get the data matrix

Returns stored data matrix

Return type 2D matrix list of rows, rows are lists of float

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