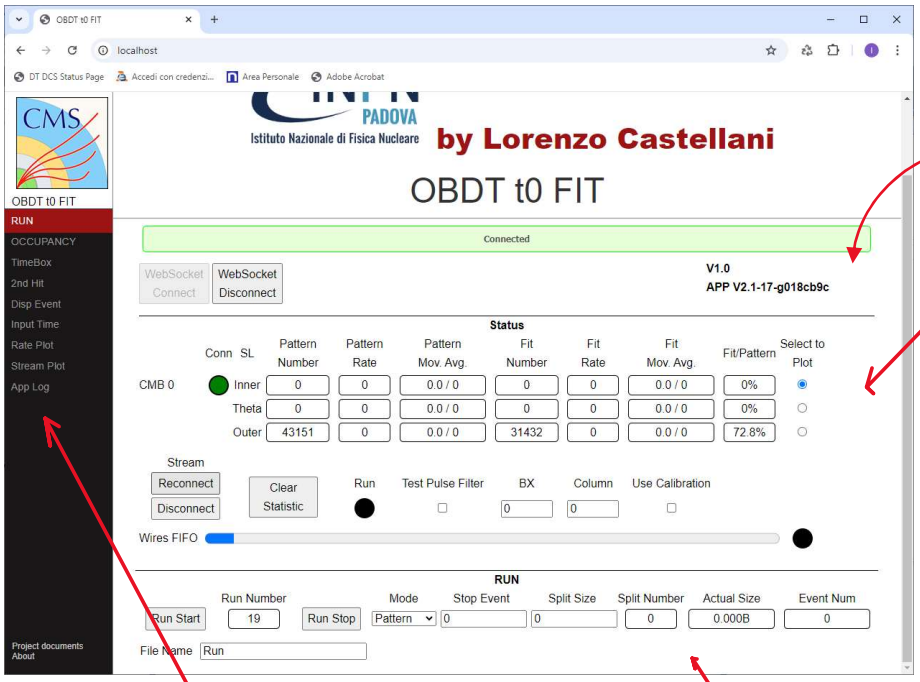
OBDT t0 FIT

INFN sez. Padova

By Lorenzo Castellani

The application for data acquisition from OBDT boards of one or more MINICRATES has been implemented to be compiled on both Linux and Windows operating systems, but the use of the ROUGE library used on the back end for data transfer currently prevents its use on Windows.

The user interface based on the WEB page allows both local and remote use; therefore, a simple WEB server has been implemented in the same application for transferring files to the browser, a WebSocket server (RFC 6455) for the dynamic display of the acquired data. The application can accept multiple clients at the same time, and the visualizations of the data plots are independent between the various clients, except for some controls.



The user interface consists of two status areas that are always visible, the first shows the status of the browser's web-socket connection to the application and the version of the application, while the second shows the counters and the rate of the patterns and traces identified in the various super-layers, the controls of the connection with the back-end, the clear of statistics, the run LED, the test-pulse filter, the wire FIFO fill indicator, and FIFO error led.

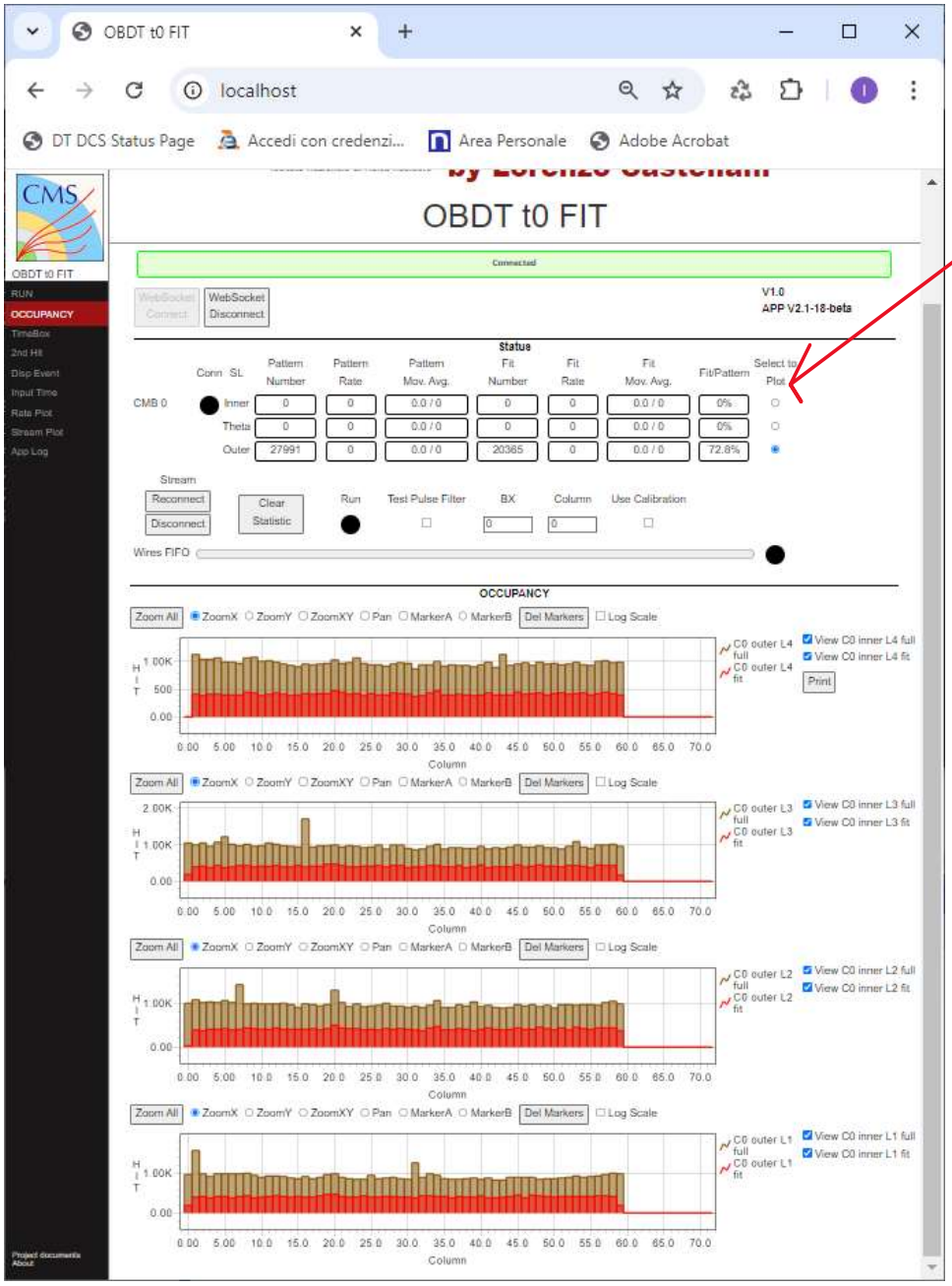
On the left is a menu for viewing the data captured in the area below.

Selecting the RUN menu shows the following controls:

- **Run Start**, clears the statistic and starts data acquisition on disk.
- **Run Stop**, stops data acquisition.
- **File Name**, the name of the file to which the RUN number is added which is automatically incremented at each start.
- **Mode**, selects the type of data saved, i.e. in PATTERN mode it saves all the hits taken in the floating window if a valid pattern of four wires is found in any of the super-layers, while in FIT mode it saves all the hits taken in the floating window but only if a track is found and the times are referred to the t0 calculated +1000 TDC counts.

- **Stop Event**, if non-zero, defines the number of events to be saved.
- **Slip Size**, if different from zero, defines the maximum size to which the capture file should be divided.
- The next three indicators show the current division number of the data file, the current file size, and the number of events currently captured, respectively.

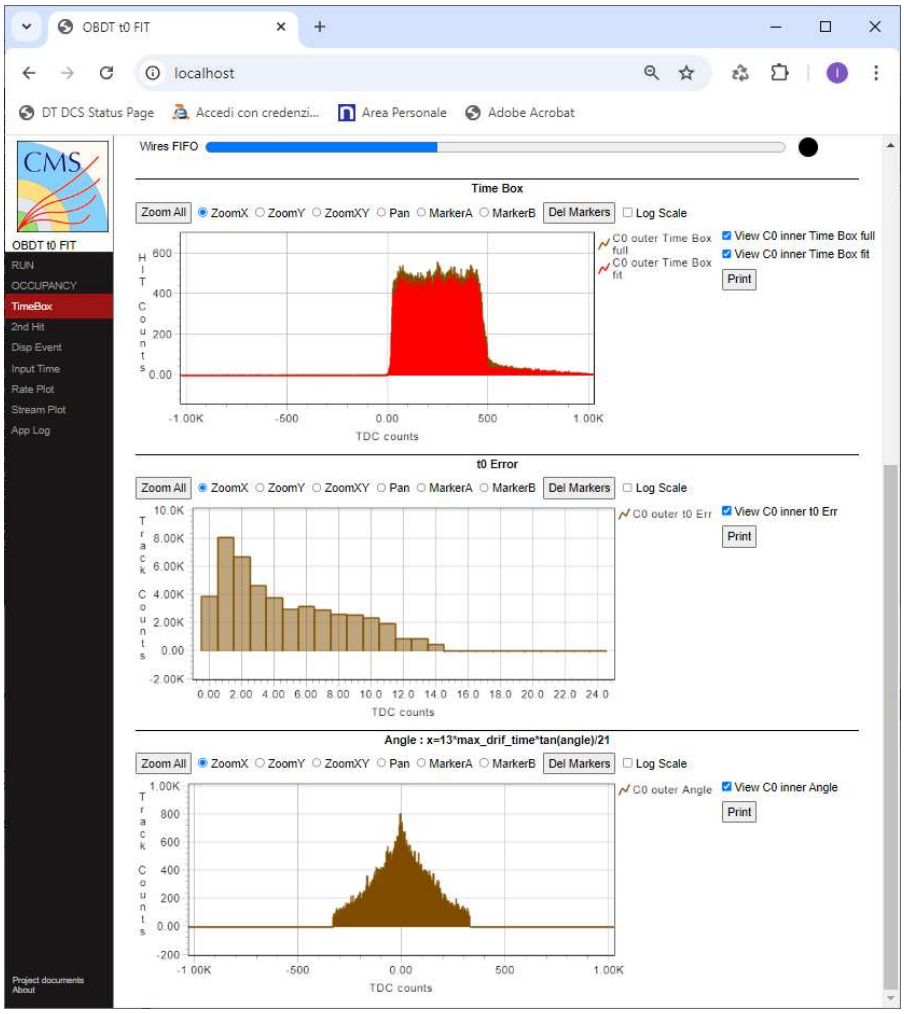
Selecting the **OCCUPANCY** menu displays four plots, one for each layer, showing the number of hits per wire (the column number is displayed in x), the selection of the superlayer to be displayed is made using the Select to Plot radio boxes.



All hits are displayed in brown, while only hits that identify a track are considered in red.

All plots are interactive by selecting the controls above them, and by placing the mouse on the top end of the column of interest, the relative values are shown via tooltip.

Selecting the **Time Box** menu displays three plots:

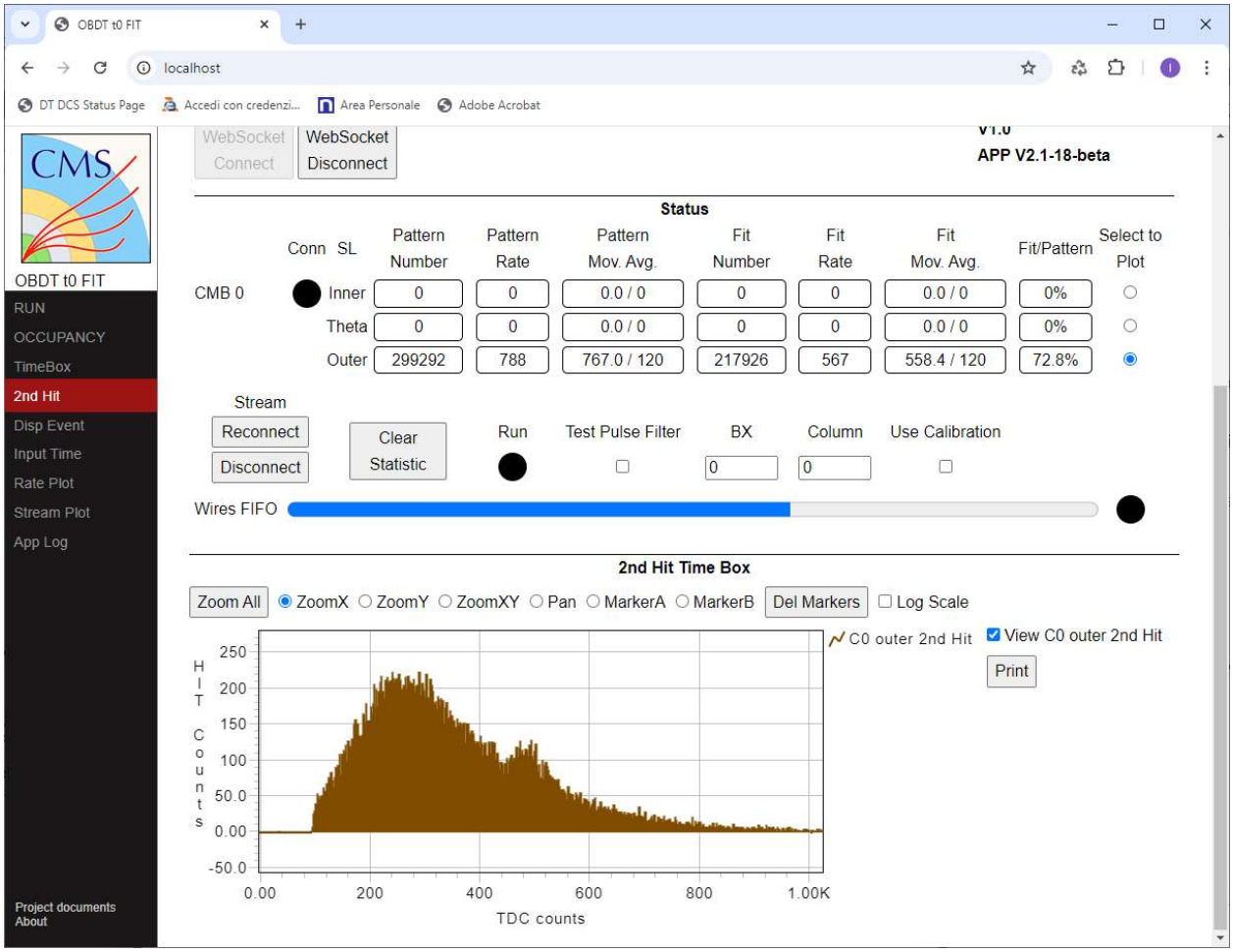


Time Box plot shows the distribution of times, the plot in brown includes the hits present in the floating window when a track is identified, while in red it includes only the hits of the four wires of the track including second hits and more.

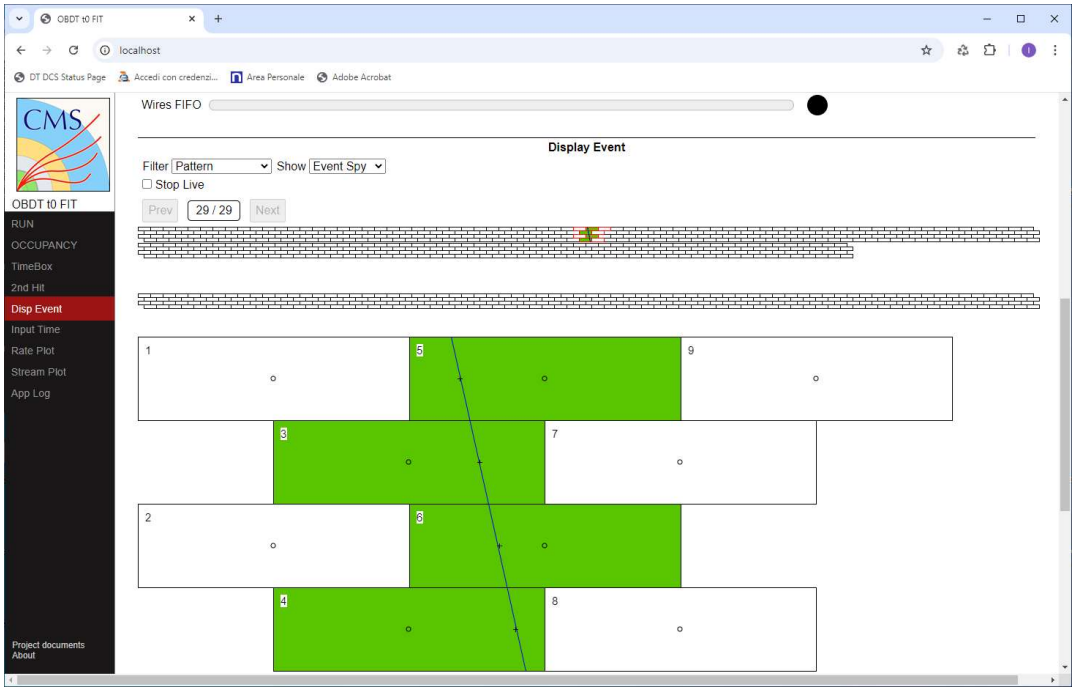
t0 Error plot is the distribution of the error in the trace discovery (the algorithm accepts a maximum error of 16 TDC counts as the maximum standard deviation).

Angle plot is the angle distribution of the identified tracks, to minimize the presence of ghosts the algorithm cuts the tracks that exceed an angle of about 47° (the parameter is configurable).

Selecting the **2ndHit** menu displays a plot with the time distribution of the second hits of the tracks identified



Selecting the **Disp Event** menu shows the structure of the camera (selected via the Select to Plot radio boxes) in which various information can be shown using the show control:

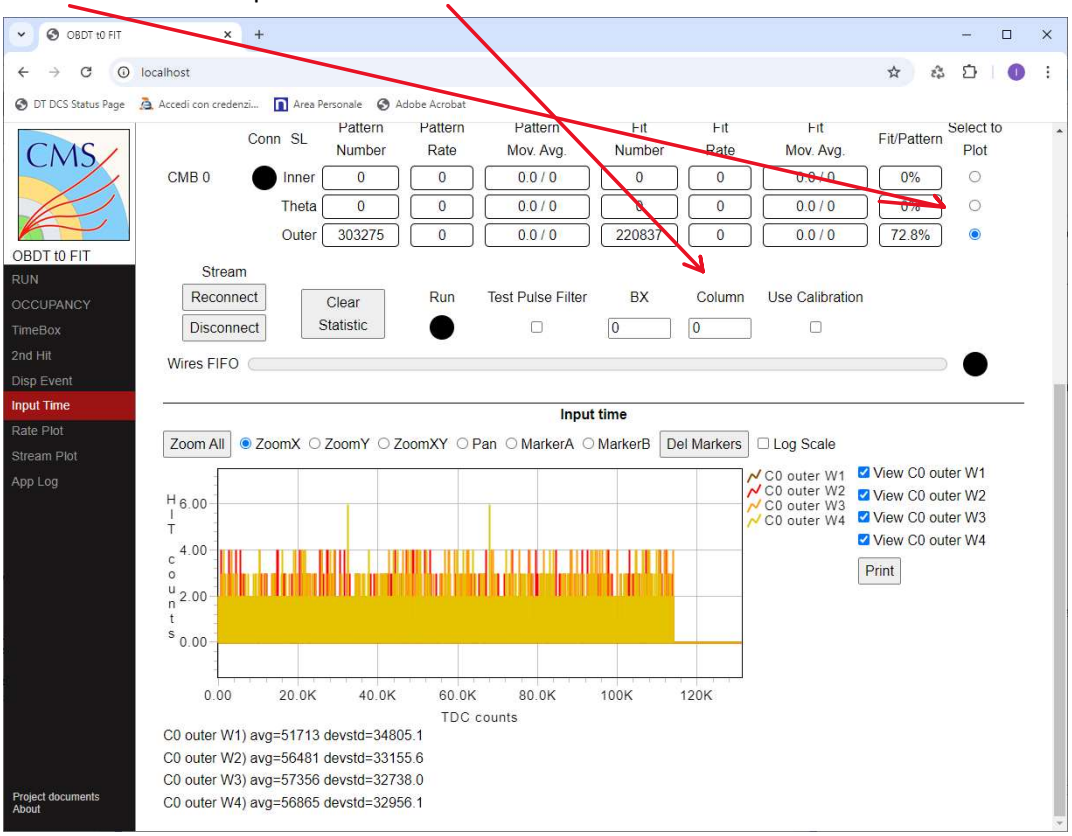


- **Event Spy**, shows the position of the event on the camera and enlarged on the 9-wire macro-cell, the position of the macro-cell is displayed on the camera with red borders, then the cells affected by the track are colored in green while any gray cells represent hits extraneous to the track present in the floating window.
  The Filter control allows you to select various types of events:
  - Pattern: displays both traces and the presence of patterns only.
  - Pattern Fit H: displays only traces of 4 wires.
  - Pattern not Fit H: displays only tracks with 3 wires or patterns where a trace is not detected.
  - Pattern mask: through the appearance of another SL Bits Mask control, allows you to display concurrent patterns on several super-layers and on several chamber so each bit at 1 enables a super-layer (bit 0 = inner, bit 1 = theta, bit 2 = outer, the subsequent bits represent the super-layers of the next chamber), so for example 011 indicates that there must be the simultaneous presence of the SL-inner and SL-theta;
  - Fit H mask: as above but only 4 wires track.
  - No Fit H mask: as above but only tracks with 3 wires or patterns where no trace is detected.

  The spied events are put in a 30 deep buffer, then by clicking the stop live check-box it is possible to stop the display of the events and scroll through the stored events using the Prev and Next buttons, also by clicking on the cells of the camera it is possible to select the macro-cell and view the printout of the results of the calculations made by the algorithm to locate the trace.

- **Occupancy**: shows the cells with the presence of hits on the camera by coloring them brown
- **Test pulse**: shows the cells in which the test-pulse hits have been identified by coloring them green, on the contrary they will be colored gray (see paragraph Calibration Procedure). A Calibration button also appears to have you perform the calibration.
- **Calibration:** shows green the cells that have been calibrated, on the contrary they will be gray. A button to export calibration data in CSV format also appears.

Selecting the **Input Time** menu displays a plot containing the 4 wires of the camera specified in Select to Plot and the column specified in Column.



The visualization is mainly used to see the test-pulse data for calibration.

Calibration Procedure:

The procedure involves the use of the test-pulse which must always be generated at the same BX. therefore:

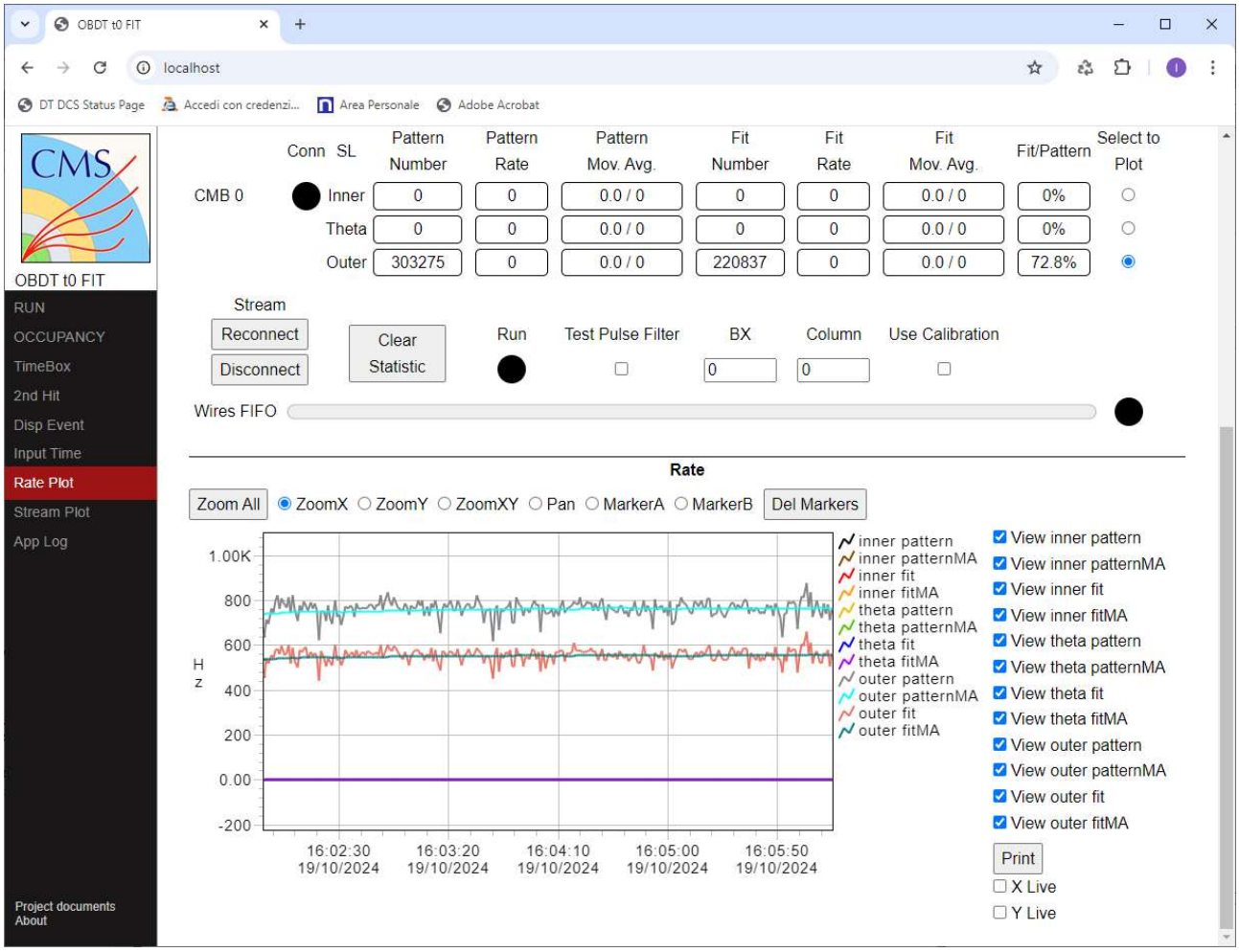
1) Enable the Test Pulse Filter and set the correct BX (the filter has an acceptance of two BX).
2) After the Wires FIFO indicator has emptied, clear the statistic.
3) Enable only one column of wires at a time per OBDT connectors (the number of columns that can be enabled at the same time depends on the amount of data and the rate of the test-pulse, and in any case it is not possible to keep all the wires enabled at the same time), then activate the test-pulse.
4) Accumulate data so that the peak hit exceeds 1000 counts.
5) Move the column of enabled wires and repeat step 4 until all the columns are complete.
6) Stop the test-puse, then click the calibrate button to perform the calibration.

The calibration process considers valid data accumulated on the wire if the number of hits exceeds 1000 counts and the sigma is less than 3.

The calibration result can be viewed by selecting calibration on the Show control on the Disp Event page, and the offset values can be exported to CSV file.

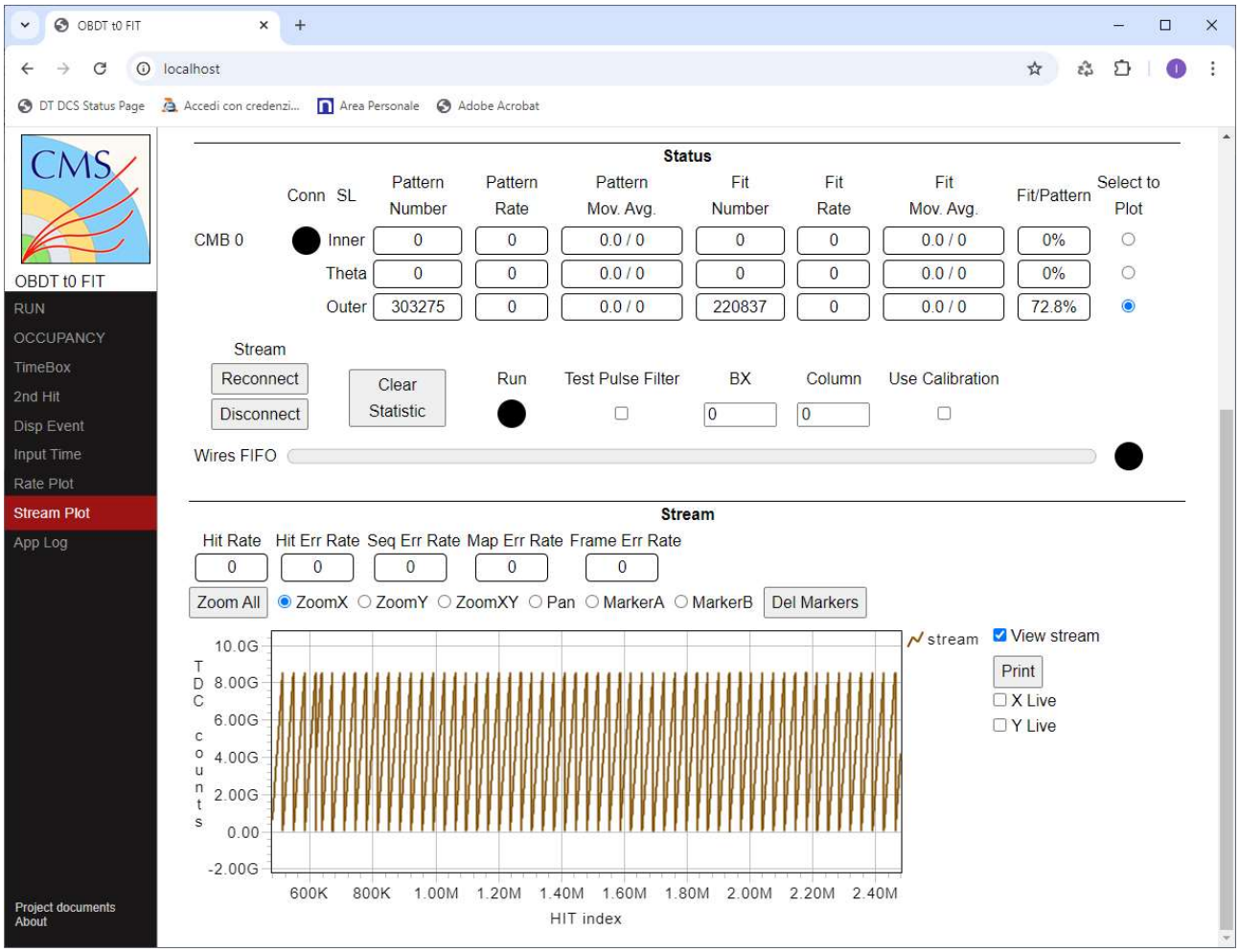
To use the calibration data in the algorithm, activate the Use Calibration checkbox.

Selecting the **Rate Plot** menu displays a plot with the trend of the rates over time, the plot can accumulate data for more than 24 hours with one given every second.



Selecting the **Stream Plot menu** displays information about the stream received, which is primarily useful for debugging. In the plot on the Y-axis is represented the time of the hits and on the X-axis the index of the hit, in the first indicator is displayed the rate of hits received, then a series of rates relating to the receiving of the data. The received stream is affected by errors on the orbit counter essential for the floating window algorithm, and by other errors in the presence of a very high data rate, higher than the processing rate.

The algorithm is capable of processing about 7K events per second across two chambers.



Configuration:

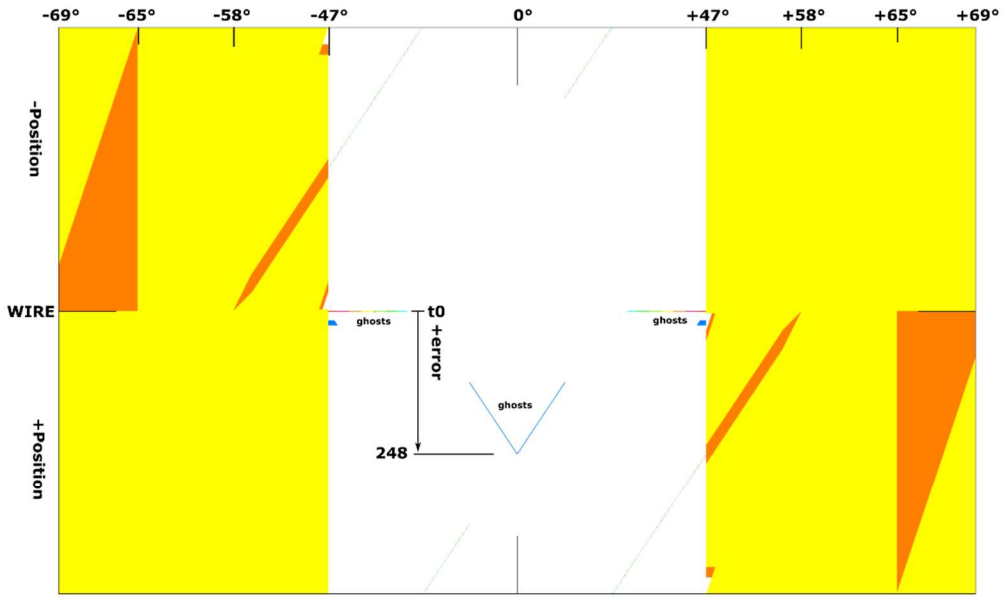
If the application is launched without arguments, it looks for the configuration file obdt_fit.config first in the local folder then in the installation folder, or a file can be specified with the option -c=<file name>. The configuration file is a JSON-formatted file with the following variables:

- **WebRootDir**: specifies where the HTML page files are.
- **DataFolder**: specifies where to save the capture data.
- **httpport**: specifies the port number of the web server.
- **wsport**: specifies the port number of the websocket server.
- **localhostonly**: specifies whether to accept connections only from localhost.
- **AcceptHosts**: specifies which hosts to accept the connection from, only if localhostonly=false, and if the list is empty, it accepts connections from all hosts.
- **readout**: specifies the name of the pipe from which to read the steam data.
- **maxangle**: specifies the maximum cutting angle of the algorithm.
- **OBDT_map**: OBDT Connectors Map.
- **chambers**: list containing the mapping of the chambers.
  and contains the following variables:
  - **type**: type of chamber.
  - **ros25_robid_map**: ROS25 id map legacy-minicate.
  - **read_out**: readout ID link map.
  - **inner**: map of the channels of the super-layer inner.
  - **theta**: map of the channels of the theta superlayer.
  - **outer**: channel map of the outer superlayer.

Below is an example of a configuration file

```
{
  "WebRootDir":"../www",
  "DataFolder":"../",
  "httpport":80,
  "wsport":4444,
  "localhostonly":true,
  "AcceptHosts":[
    "wxlecastellani.pd.infn.it"
  ],
  "maxangle":330,
  "readout":"pipe:/tmp/pipe",
  "OBDT_map":{
          "J31": [ 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185 ],
          "J26": [ 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201 ],
          "J32": [ 202, 203,   0,   1,   2,   3,   4,   5,   6,   7,   8,   9,  10,  11,  12,  13 ],
          "J37": [  14,  15,  16,  17,  18,  19,  20,  21,  22,  23,  24,  25,  26,  27,  28,  29 ],
          "J34": [  30,  31,  32,  33,  34,  35,  36,  37,  38,  39,  40,  41,  42,  43,  44,  45 ],
          "J29": [  46,  47,  48,  49,  50,  51,  52,  53,  54,  55,  56,  57,  58,  59,  60,  61 ],
          "J24": [  62,  63,  64,  65,  66,  67,  68,  69,  70,  71,  72,  73,  74,  75,  76,  77 ],
          "J30": [  78,  79,  80,  81,  82,  83,  84,  85,  86,  87,  88,  89,  90,  91,  92,  93 ],
          "J35": [  94,  95,  96,  97,  98,  99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109 ],
          "J25": [ 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125 ],
          "J28": [ 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141 ],
          "J33": [ 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157 ],
          "J23": [ 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 204, 205, 206, 207 ],
          "J36": [ 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223 ],
          "J27": [ 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239 ]
  },
  "chambers" : [
          {
                    "type": "mb3",
                    "ros25_robid_map" : [ 0, 1, 2, 6, 3, 4, 5, -1],
                    "read_out":[
                              {"OBDT" : 1 ,"ch" :[0,22]},
                              {"OBDT" : 2 ,"ch" :[7,8]},
                              {"OBDT" : 3 ,"ch" :[10,11]}
                    ],
                    "inner":[ {"OBDT":1,"J":33},{"OBDT":1,"J":35},
                              {"OBDT":1,"J":37},{"OBDT":1,"J":31},
                              {"OBDT":1,"J":29},{"OBDT":1,"J":23},
                              {"OBDT":1,"J":25},{"OBDT":2,"J":29},
                              {"OBDT":2,"J":23},{"OBDT":2,"J":25},
                              {"OBDT":2,"J":27},{"OBDT":3,"J":35},
                              {"OBDT":3,"J":33},{"OBDT":3,"J":32},
                              {"OBDT":3,"J":29},{"OBDT":3,"J":23},
                              {"OBDT":3,"J":25},{"OBDT":3,"J":27}
                    ],
                    "theta" :[],
                    "outer":[ {"OBDT":1,"J":34},{"OBDT":1,"J":36},
                              {"OBDT":1,"J":32},{"OBDT":1,"J":30},
                              {"OBDT":1,"J":28},{"OBDT":1,"J":24},
                              {"OBDT":1,"J":26},{"OBDT":2,"J":30},
                              {"OBDT":2,"J":28},{"OBDT":2,"J":24},
                              {"OBDT":2,"J":26},{"OBDT":3,"J":36},
                              {"OBDT":3,"J":34},{"OBDT":3,"J":31},
                              {"OBDT":3,"J":30},{"OBDT":3,"J":28},
                              {"OBDT":3,"J":24},{"OBDT":3,"J":26}
                              ]
          },
          {
                    "type": "mb3",
                    "ros25_robid_map" : [ 12, 13, 14, 24, 15, 16, 17, -1],
                    "read_out":[
                              {"OBDT" : 1 ,"ch" :[1,3]},
                              {"OBDT" : 2 ,"ch" :[4,5]},
                              {"OBDT" : 3 ,"ch" :[6,9]}
                    ],
                    "inner":[ {"OBDT":1,"J":33},{"OBDT":1,"J":35},
                              {"OBDT":1,"J":37},{"OBDT":1,"J":31},
                              {"OBDT":1,"J":29},{"OBDT":1,"J":23},
                              {"OBDT":1,"J":25},{"OBDT":2,"J":29},
                              {"OBDT":2,"J":23},{"OBDT":2,"J":25},
                              {"OBDT":2,"J":27},{"OBDT":3,"J":35},
                              {"OBDT":3,"J":33},{"OBDT":3,"J":32},
                              {"OBDT":3,"J":29},{"OBDT":3,"J":23},
                              {"OBDT":3,"J":25},{"OBDT":3,"J":27}
                    ],
                    "theta" :[],
                    "outer":[ {"OBDT":1,"J":34},{"OBDT":1,"J":36},
                              {"OBDT":1,"J":32},{"OBDT":1,"J":30},
                              {"OBDT":1,"J":28},{"OBDT":1,"J":24},
                              {"OBDT":1,"J":26},{"OBDT":2,"J":30},
                              {"OBDT":2,"J":28},{"OBDT":2,"J":24},
                              {"OBDT":2,"J":26},{"OBDT":3,"J":36},
                              {"OBDT":3,"J":34},{"OBDT":3,"J":31},
                              {"OBDT":3,"J":30},{"OBDT":3,"J":28},
                              {"OBDT":3,"J":24},{"OBDT":3,"J":26}
                    ]
          }
  ]
}
```

Algorithm errors analyses



black line are reference and note

green points are iniected tracks with double result and error=0

yellow points are iniected tracks widthout result (algorithm cut)

orange points are iniected tracks with invalid result (ghosts)

blue to red gradient points are the distribution of angle and t0 results of the orange iniected tracks (ghosts) blue=1count red=500counts

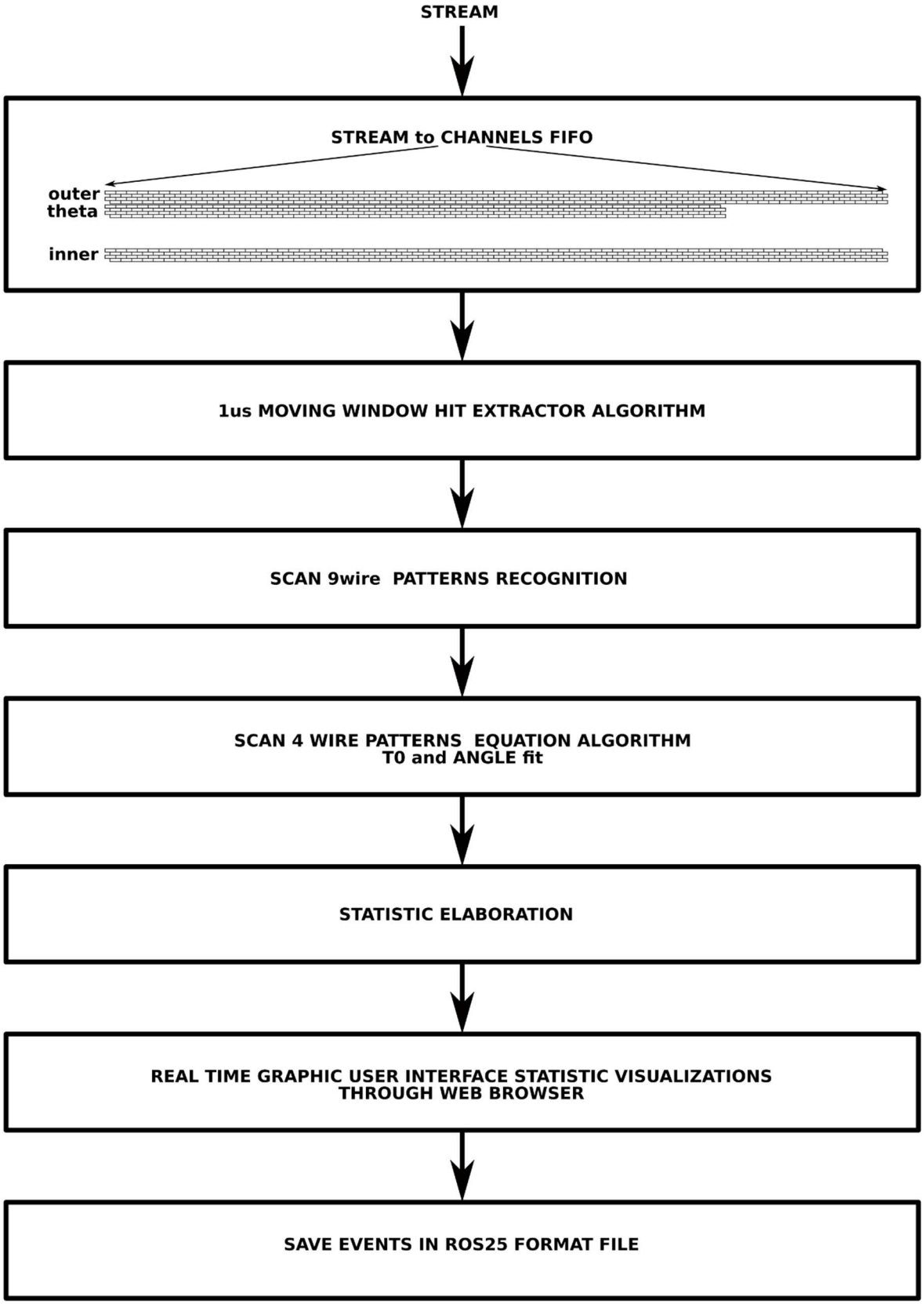
The image below shows the results of scanning ideal traces of the image above, and the results by adding noise with various sigma values to the ideal trace, scan position and angle are expressed in TDC counts, the cell tmax=496, angle TDC counts=13*cell_tmax*tan(angle)/21, 13mm is layer distance and 21mm is the cell width/2 .

scan position +-495 (tdc counts)	cell_tmax=496 (tdc couts)											
scan angle range (+- tdc counts)	accept error range (+- tdc counts)	tot scan tracks	dbl res	bad found	good found	not found	algor. valid tracks	algor. angle limit (+- tdc counts)		bad/good (%)	(bad+good)/valid track (%)
329	16	652077	246	0	651832	0	652077	330	47°	0.00	99.96
800	16	1585599	246	89433	653443	842478	652077	330		13.69	113.92
495	16	981089	494	152005	828591	0	981089	496	58°	18.34	99.95
800	16	1585599	494	476885	829269	278952	981089	496		57.51	133.13
noise sigma 1.0											
329	16	652077	27	523	648924	2604	652077	330		0.08	99.60
800	16	1585599	21	89460	650514	845605	652077	330		13.75	113.48
noise sigma 3.0											
329	16	652077	9	1611	639494	10964	652077	330		0.25	98.32
800	16	1585599	5	89773	642067	853755	652077	330		13.98	112.23
noise sigma 5.0											
329	16	652077	6	3878	628325	19869	652077	330		0.62	96.95
800	16	1585599	4	91104	632131	862361	652077	330		14.41	110.91
noise sigma 10.0											
329	16	652077	4	33807	554734	63533	652077	330		6.09	90.26
800	16	1585599	4	113370	558510	913716	652077	330		20.30	103.04
noise sigma 16.0											
329	16	652077	1	100957	396615	154505	652077	330		25.45	76.31
800	16	1585599	0	166609	398827	1020164	652077	330		41.77	86.71

dbl res: indicate two possible results with error=0, so it is not possible to determine which of the two tracks is the right one.

The percentage of ghosts (bad found) must be scaled to the percentage of cosmic rays with angles greater than about 47°.

Below is a description of the algorithm.


STREAM
STREAM to CHANNELS FIFO
outer
theta
inner
1us MOVING WINDOW HIT EXTRACTOR ALGORITHM
SCAN 9wire PATTERNS RECOGNITION
SCAN 4 WIRE PATTERNS EQUATION ALGORITHM
T0 and ANGLE fit
STATISTIC ELABORATION
REAL TIME GRAPHIC USER INTERFACE STATISTIC VISUALIZATIONS
THROUGH WEB BROWSER
SAVE EVENTS IN ROS25 FORMAT FILE