CALET Level1 Format and Distribution of Ground Muon Data

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2015.6.24 CALET-TIM @ Pisa Univ.

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References:

[WCOC-2015-007NC] Overview of CALET Level1 Format
[WCOC-2015-008NC] CALET Level1 Format for CAL Volume
[WCOC-2015-009NC] CALET Level1 Format for COM Volume
[WCOC-2015-010NC] CALET Level1 Format for GBM Volume
[WCOC-2015-011NC] CALET Level1 Format for ASC Volume
[WCOC-2015-012NC] CALET Level1 Format for LOG Volume

[WCOC-2014-001NC] Description of CALET Trigger System
[WCOC-2014-002NC] Description of CALET Coordinate System

Finalized Level1 Format

- GBM, ASC, and LOG volumes are defined and some corrections are made to CAL&COM volumes.
- Please read “Overview of CALET Level1 Format”.
- Changes in CAL&COM volumes:
  1. UTC fractional second is now given in nano second unit.

     To better describes the minimum unit of MDC time (15.625us), we decided to use nano-sec instead of micro-sec. Since unsigned int can hold 10^9, type of the variable did not change. The variable name, however, has to be changed from fEventUsecUTC to fEventFracUTC, etc.
  2. TASC Zero-suppression file size changed

     the file size of TASC Zero-suppression file was changed from 742 words to 746 words.

New!: GBM Volume

Quoted from the description in overview:

3.5 GBM Volume

The cGBM volume includes CALET Gamma-ray Burst Monitor data and it consists of the following data.

1. Energy bin tables for all hisograms;
2. Pulse height History (PH) Data;
3. Time History (TH) Data;
4. GRB Event Data.
5. CGBM Diagnosis Histogram Data;

Energy bin tables are stored only once in the beginning of the volume immediately after the volume header. PH data (0.25Hz) and TH data (8Hz) is periodically available, and GRB event data and diagnosis data are stored when they are available. Details of the volume description can be found in "CALET Level1 Format for GBM Volume" [WCOC-2015-010NC].

New!: ASC Volume

Quoted from the description in overview:

3.6 ASC Volume

The ASC volume includes all the ASC data which are downlinked as ASC Command Response Data, on demand data, and files. Several kinds of data are sent automatically as a response to commands sent by MDC and the ASC volume consists of the following data:

1. Attitude Data (2Hz);
2. Synchronizing Time Data (1Hz);
3. HK Data (once per minute);
4. Event Report Data;
5. Image Data;
6. General Packet Data.

First 3 types of data are periodic data and the others are only stored when they are available. Details of the volume description can be found in "CALET Level1 Format for ASC Volume" [WCOC-2015-011NC]. For understanding "General Packet Data", ASC-DTU-ICD-3004 should be consulted.

New!: LOG Volume Example

```
<?xml version='1.0' encoding='ASCII'?>
<CALET_Level1_LOG_Volume>
 <header>72hr Muon Run using CALET PFM</header>
 <timestamp>15032201</timestamp>
 <note>None</note>
 <statistics>
  <CALVolume>
   <CALTable>1</CALTable>
   <CALEvent>68442</CALEvent>
  </CALVolume>
  <COMVolume>
   <Periodic>3600</Periodic>
   <GPSRPeriodic>3601</GPSRPeriodic>
   <Auxiliary>3600</Auxiliary>
  </COMVolume>
  <GBMVolume>
   <GBMTable>1</GBMTable>
   <PHData>899</PHData>
   <THData>3600</THData>
   <GBMDiagnosis>0</GBMDiagnosis>
   <GRBEvent>3</GRBEvent>
  </GBMVolume>
  <ASCVolume>
   <ASCAttitude>7200</ASCAttitude>
   <ASCSyncTime>3600</ASCSyncTime>
   <ASCHK>59</ASCHK>
   <ASCEventReport>0</ASCEventReport>
   <ASCImage>8</ASCImage>
   <ASCGeneralPacket>14</ASCGeneralPacket>
  </ASCVolume>
 </statistics>
 <log>
  <CommandLog>N/A</CommandLog>
  <OperationLog>N/A</OperationLog>
 </log>
</CALET_Level1_LOG_Volume>
```

- xml file
- Header
- Note
- Timestamp
  - yyyymmddHH
- Statistics of L1 format
  - for example, 3 GRB data is included in this timestamp
- Log (N/A at this time)
  - command log (JAXA)
  - operation log (WCOC)

distribution of command log will be somehow restricted for security issue.

New!: MD5 hash example

```
b367576aad13a7f70272b9505efaa60d  CALET_15032201_L1-CAL.dat
df35c33f8205af8ac1fc1c66f949cb84  CALET_15032201_L1-COM.dat
5e79e3bc5d5e4d5c724c488129cf105c  CALET_15032201_L1-GBM.dat
92f47664eaaff69e7ed4077dcea579e4  CALET_15032201_L1-ASC.dat
53eda71b70998985b5e0a83db1f5fde7  CALET_15032201_L1-LOG.xml
```

$ md5sum [Filename]

To be used to verify the RSYNCed L1 files at LSU/PISA

Overview: L1 Data Download

4.1 Directory Structure

The directory structure to store and distribute the CALET Level1 files is as follows:

```
/mnt/CALET_Level1/[YYYYmm]/[FILE] (all volumes are stored in one dir.)
        [YYYYmm]: 201412, 201501, ...
        [FILE]: 6 kind of files are prepared for every one hour
             - CALET_yymmddHH_L1-CAL.dat
             - CALET_yymmddHH_L1-GBM.dat
             - CALET_yymmddHH_L1-COM.dat
             - CALET_yymmddHH_L1-ASC.dat
             - CALET_yymmddHH_L1-LOG.xml
             - CALET_yymmddHH_L1-MD5.txt
```

WCOC, LSU, and Pisa will distribute L1 data in each country.

It is estimated, that the number of files in one directory will be less than 10000, to facilitate listing the files in each directory.

The Level1 distribution server is implemented within the WCOC calculation server, and can be reached by RSA authentication. The rsync command is used to retrieve Level1 data volumes, and the exact usage is shown in the following:

```
Louisiana State University:
$ rsync -av -e 'ssh -p [PORT] -l lsucsc'  **.**.**.**:/mnt/CALET_Level1/[YYYYmm] .

Pisa University:
$ rsync -av -e 'ssh -p [PORT] -l pisacsc' **.**.**.**:/mnt/CALET_Level1/[YYYYmm] .

Japanese Institutes:
$ rsync -av -e 'ssh -p [PORT] -l caletjc' **.**.**.**:/mnt/CALET_Level1/[YYYYmm] .
```

IP address and port of the server are not shown in this document for security reasons. Please consult the DH&A Japan team for such information.

Overview: Read/Write Routine

4.3 Level1 I/O Interface Library

The Level1 I/O interface library was created using C++ without dependence on other non-standard libraries. It consists of volume classes and data handling classes with the structure as follows:

```
(1) TL1CALVolume
    - TL1CALTable
    - TL1CALEvent

(2) TL1COMVolume
    - TL1Periodic
    - TL1GPSRPeriodic
    - TL1Auxiliary

(3) TL1GBMVolume
    - TL1PHData
    - TL1THData
    - TL1GRBEvent
    - TL1GBMDiagnosis

(4) TL1ASCVolume
    - TL1ASCAttitude
    - TL1ASCSyncTime
    - TL1ASCHK
    - TL1ASCEventReport
    - TL1ASCImage
    - TL1ASCGeneralPacket
```

In the Level1 format as described in detail in [WCOC-2015-008NC]– [WCOC-2015-011NC], the variable names used in the read routine are given in the format list. Each variable has a getter function to retrieve its value. The method name can be obtained by changing the leading "f" character to "Get" and adding brackets () at the end. If the variable is an array, you can get the pointer to the array or the value of the i-th data by inserting the index in the brackets (i) to pass it to the function. A few examples are shown below:

```
fTrigHitPattern      => TL1CALEvent::GetTrigHitPattern()
fLDCountIMC[i][j][k] => TL1CALEvent::GetLDCountIMC(i,j,k)
```

The getter function is a member function of corresponding data handling class. To find the class name of which the variable is a member, please refer to the Table 1 in each volume format. Since variables are defined as protected in data handling classes, it is necessary to use getter function to access their values.

Overview: Description of Git Server

4.4 WCOC Git Server

To distribute the CALET data analysis software, and share its development, a git [4] server was set up at WCOC. All of the CALET science team member are very welcome to register. Here are the instructions on how to use our git server at WCOC:

1. Send us your public key with your name:

```
Subject: ACCESS REQUEST TO GIT REPOSITORIES AT WASEDA UNIV.
To: yoichi.asaoka@aoni.waseda.jp
Cc: torii.shoji@waseda.jp, shunsuke@aoni.waseda.jp
---- attachment ---
[your name].pub
    As file name, [your name].pub is expected (e.g. asaoka.pub).
    You have to make your public key first, using "ssh-keygen -t rsa"
    and copy ~/.ssh/id_rsa.pub to somewhere else and rename it
    as [your name].pub.
```

2. Wait for our response to your request.

3. Clone the repository using the following command:
   `$ git clone ssh://git@**.**.**.**:[PORT]/level1_if.git`

This shows how to retrieve the Level1 interface library from WCOC, as an example of how to retrieve a repository. Many more repositories will be readily available to share development of the analysis software.

Coordinate System Check

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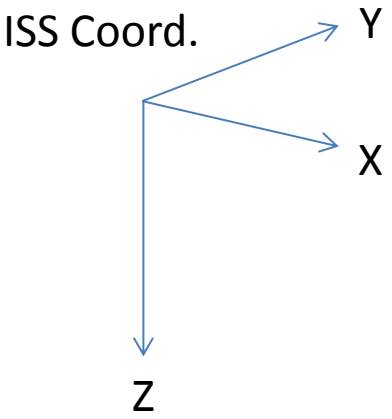
Assignment Issue (SOLVED)

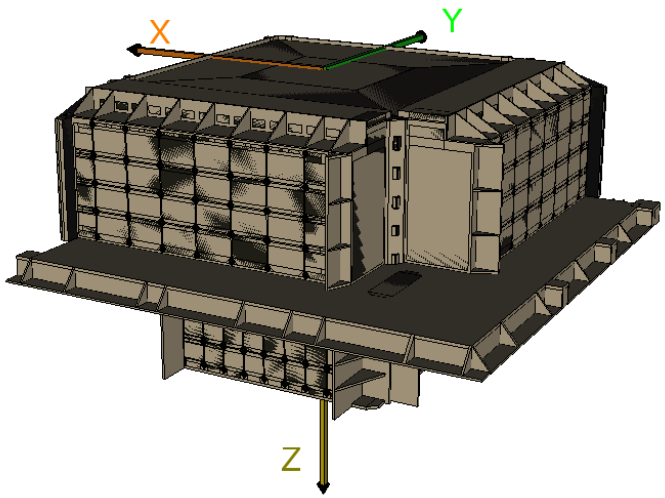
Wrong physical channel assignment

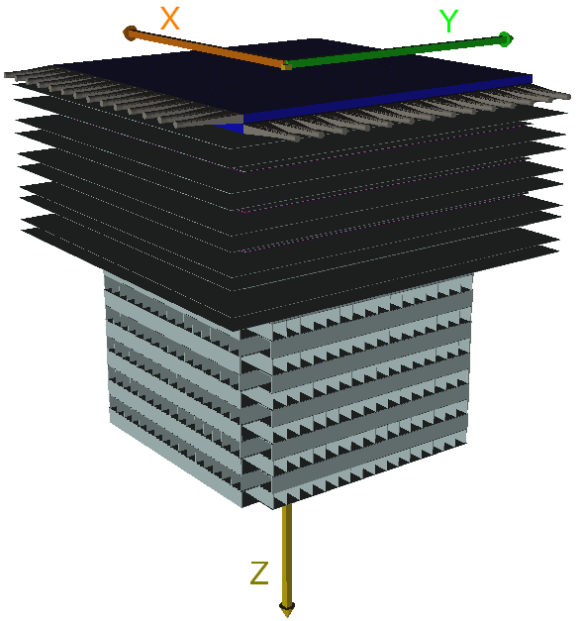
- We found that the directions of physical channel were both opposite in X and Y axes. Accordingly, distributed "CALET_AssignTable.dat" is also wrong and need a fix. We replaced it with the correct one and the original table is renamed to CALET_AssignTable.dat.bug150501 for reference.
- Although physical position of 24-hr simulation data is correct, correspondence between FEC and physical channel is wrong.
- We noticed this issue before the circulation of ground muon data, assignment for ground muon data is correct from the 1st release.
- Now 24hr simulation data are replaced with the data generated using correct FEC-physical channel assignment table (as of June 22).

rev. 150616

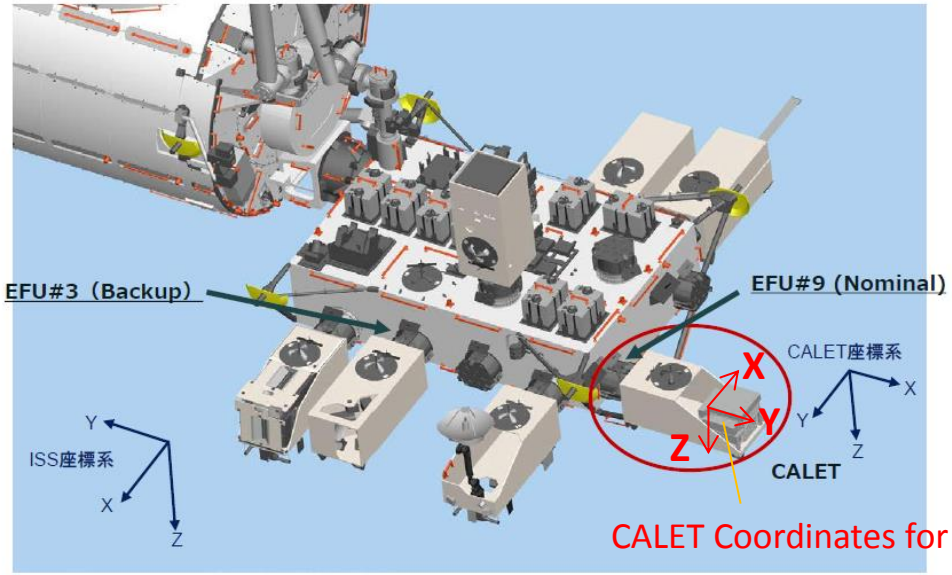
Assignment Relation







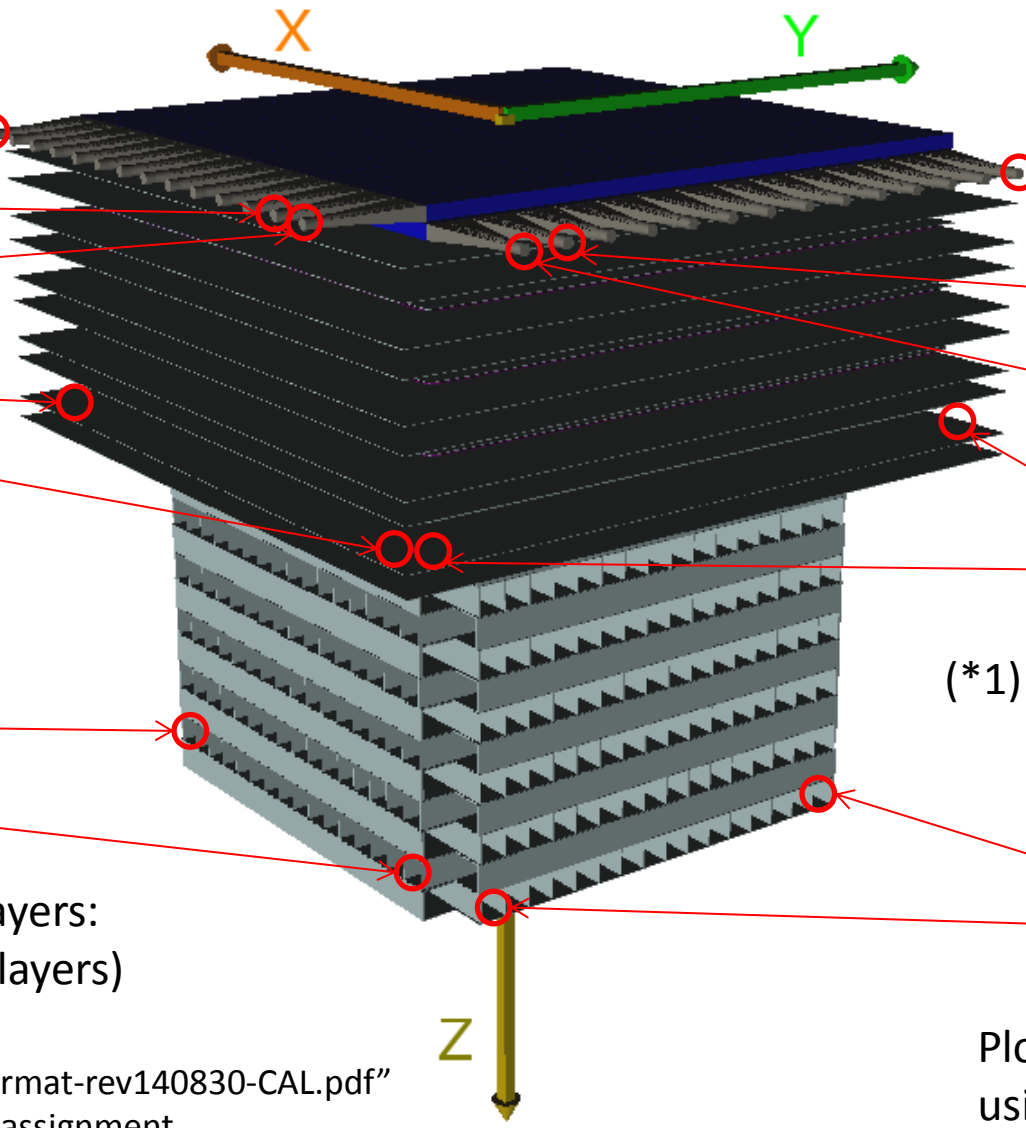
ref: Textbook for Operator Training



CALET Coordinates for Science

-Y direction in ISS coordinate system corresponds to +Y direction in CALET coordinate system for science.

CALET Channel Assignment



CHD-X bar14
CHD-X bar2
CHD-X bar1

IMC-X8 fiber448
IMC-X8 fiber1

(*2) IMC fibers are not displayed.

TASC-X6 log16
TASC-X6 log1

(*3) TASC physical layers: 1-6 (in total 6 layers)

CHD-Y bar14
CHD-Y bar2
CHD-Y bar1

IMC-Y8 fiber448
IMC-Y8 fiber1

(*1) IMC physical layers: 1-8 (in total 8 layers)

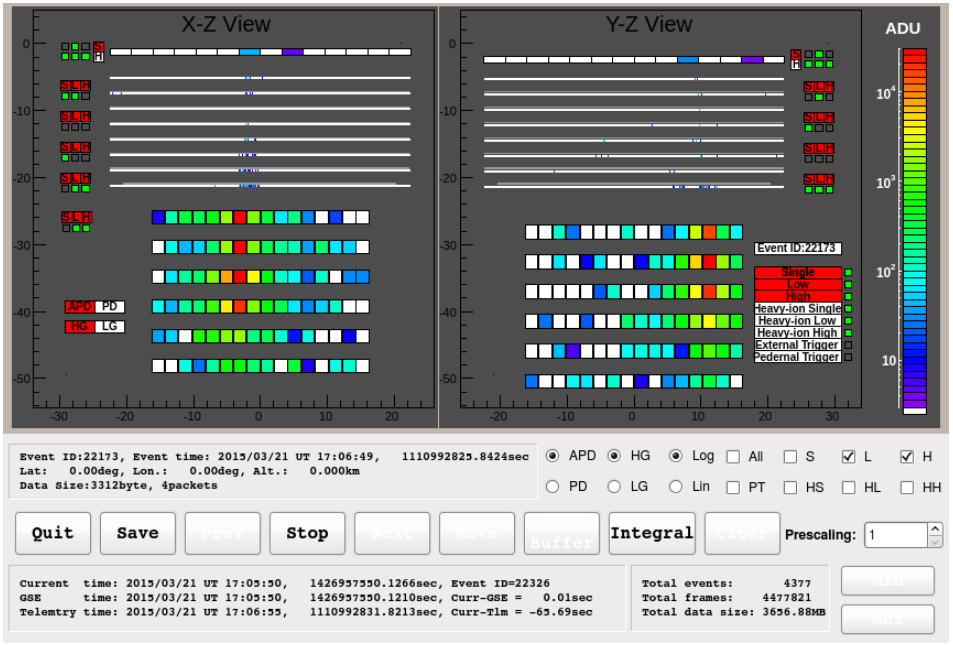
TASC-Y6 log16
TASC-Y6 log1

Refer to "CALET_Level1_Format-rev140830-CAL.pdf" for more details such as bit assignment

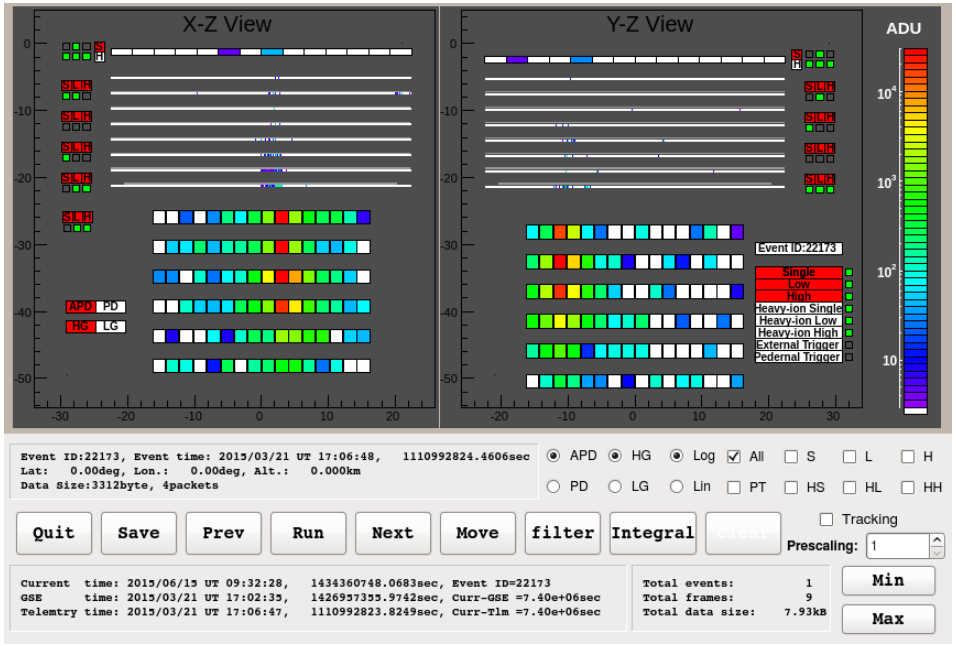
Plot by Y.Akaike using EPICS CAD Model

Before and After Assign Correction

Shower Event retrieved during CALET-PFM 72hr Muon Run



Before (ve.r141218)



After (ve.r150615)

Need cross checks to be sure that there are no more mistakes.

by Takemoto

IMC channel assign and identification of FEC side

- Real Data
  - To connect to MaPMT, the length of SciFi is longer than the other end in FEC Side.

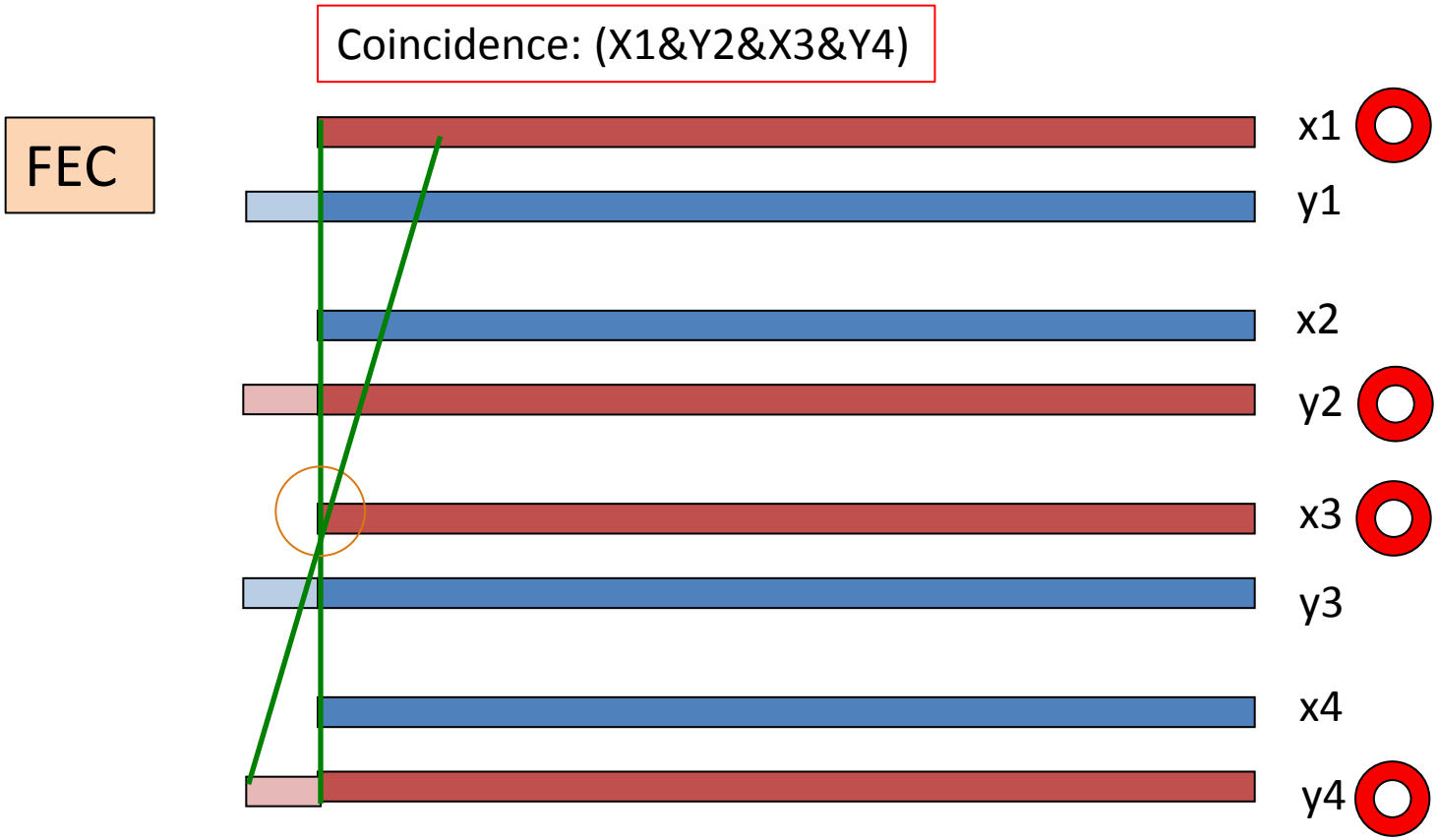
  → Using the specific trigger conditions, the effect can be seen

- Simulation Data
  - Since FEC side has extra material while the other side has nothing but vacuum, it is possible to “see” FEC using HE triggered event penetrating to FEC, not active detectors.

  → Check those events

Check FEC side in Real Data

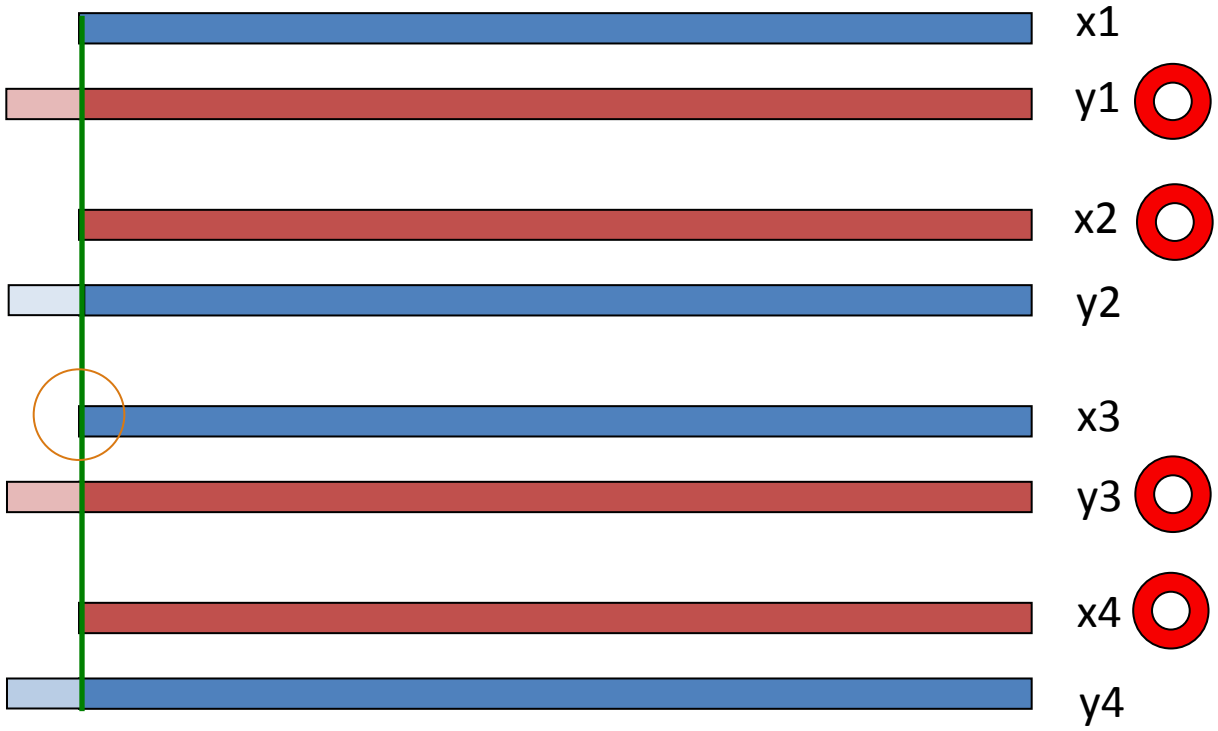
In the trigger condition between (X1&Y2&X3&Y4) and (Y1&X2&Y3&X4), there's a difference in solid angle for fibers in the edge.



Solid angle for the edge channel in Y2 is larger in the FEC side than that in the other side.

Coincidence: (Y1&X2&Y3&X4)

FEC



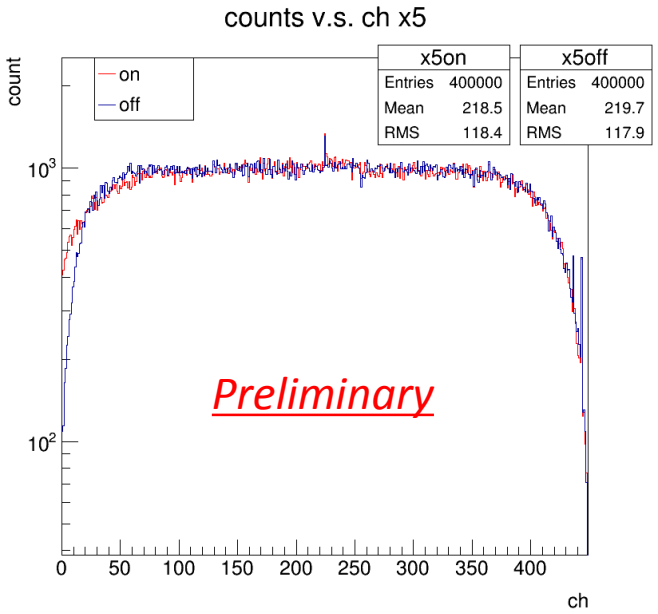
In this condition, the solid angle is smaller than the previous condition.

It makes the difference in count rate for the edge fiber.

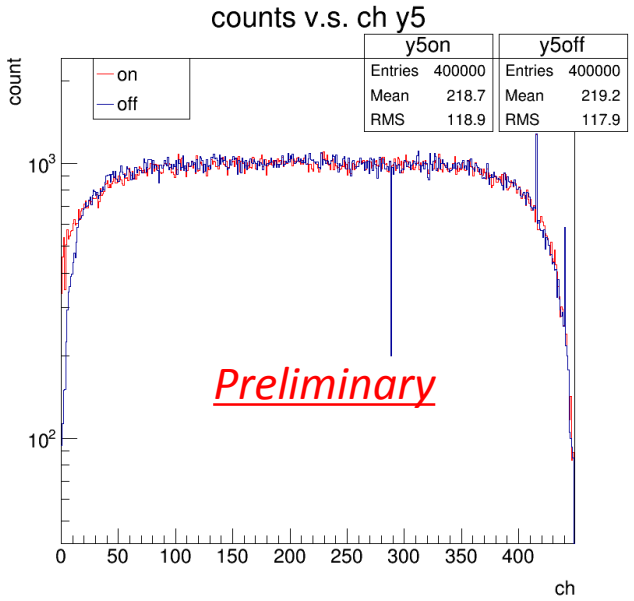
In the side where the difference is seen, FEC is attached.

Real Data Layer X5, Y5 (FEC X3, Y3)

Histogram of Number of hits in each fiber (filled until 400,000 events).
Hit Condition: Energy Deposit > 0.3MIP



ON : Larger Solid Angle (X1&Y2&X3&Y4)
OFF: Smaller Solid Angle (Y1&X2&Y3&X4)



ON : Larger Solid Angle (Y1&X2&Y3&X4)
OFF: Smaller Solid Angle (X1&Y2&X3&Y4)

The difference in counts can be seen in the region of smaller fiber numbers.

FEC is attached at the side of fiber number =0
in both of X and Y axes ### CORRECT SIDE

In 150501 version,
it was the other side

Simulation Data

In the condition that there's no detector incidence, the cross point of true track with IMC FEC in X-Y plane is shown in the right plot (Z=10 in CALET coordinates), where High energy shower trigger is required.

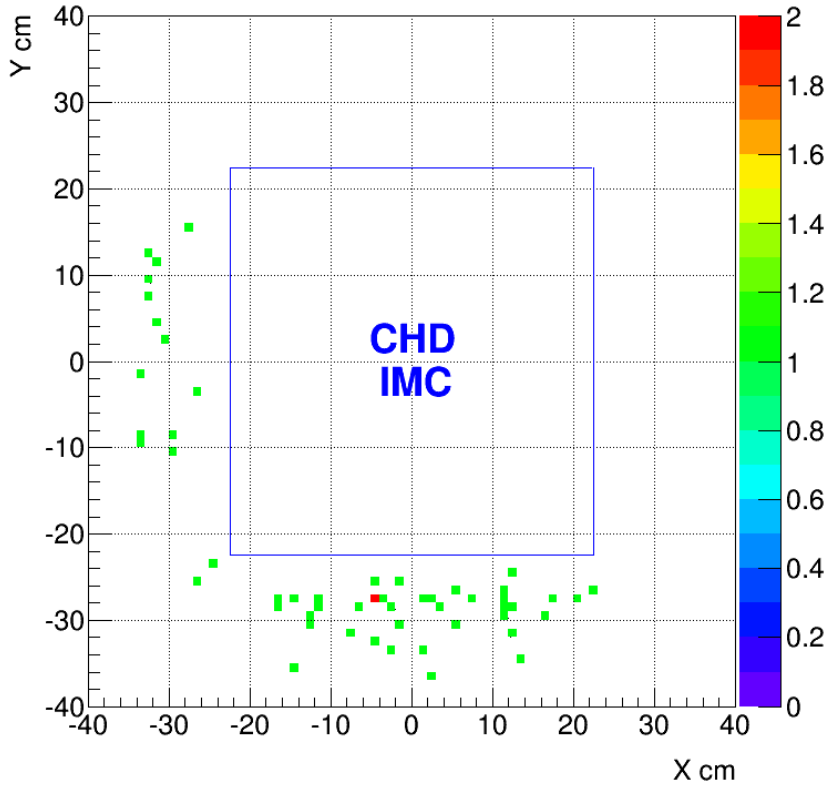
Event sample:
24hr simulation data

Condition:

Track of incident particle satisfies the following conditions:
- |x|>24 at z=0cm AND
- |x|>24 at z=-22cm AND
- zenith < 45deg

OR
- |y|>24 at z=0cm AND
- |y|>24 at z=-22cm AND
- zenith < 45deg

=> trying to see the interacted events in FEC. Without FEC, they cannot fulfill the HE trigger condition.



Both have events only in negative side.

FEC is attached in the negative side in both axes AS EXPECTED.

(same result for previous and replaced simulation data, as expected)

Ground Muon Data for CALET PFM Calibration

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Level1 volumes for Ground Muon Data can be retrieved via rsync:

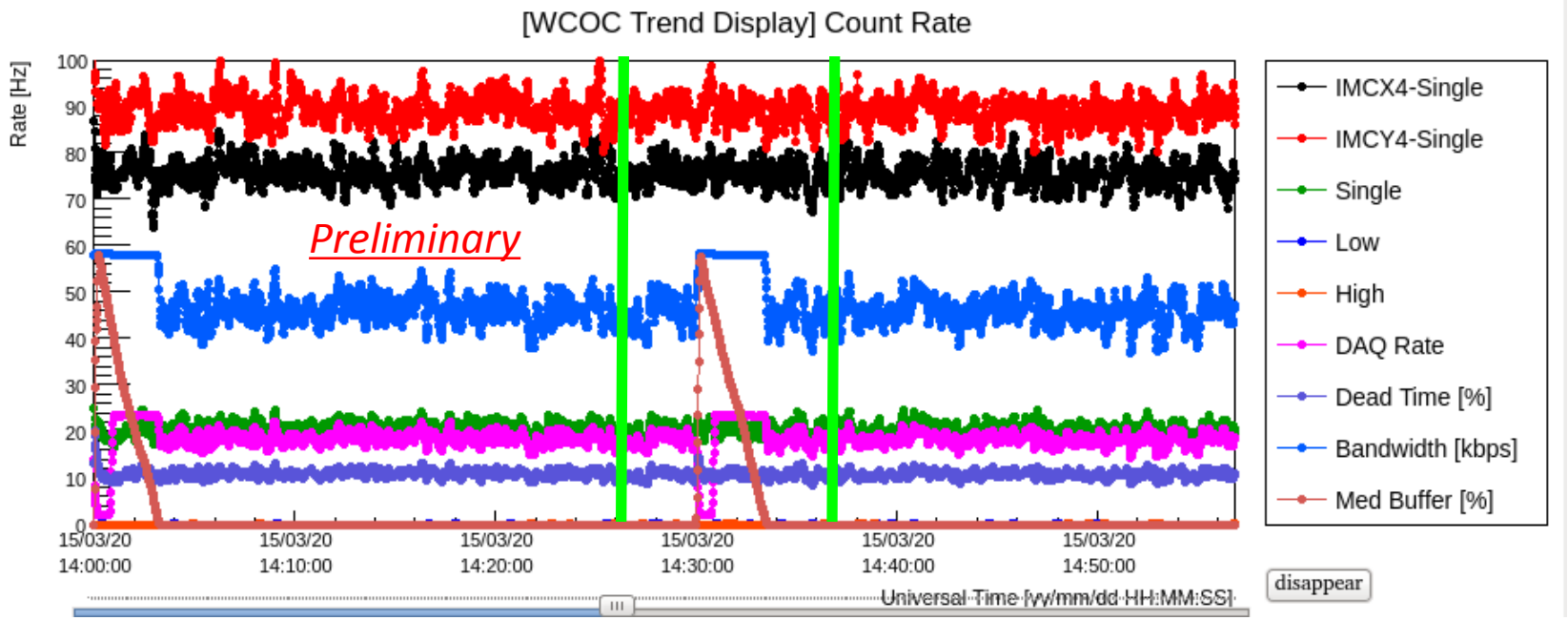
```
LSU: $ rsync -av -e 'ssh -p [PORT] -l lsucsc'
      [L1_Server_IP_ADDRESS]:/ mnt/CALET_Level1/PFMVolume .
Pisa Univ.: $ rsync -av -e 'ssh -p [PORT] -l pisacsc'
      [L1_Server_IP_ADDRESS]:/ mnt/CALET_Level1/PFMVolume .
JC:  $ rsync -av -e 'ssh -p  [PORT]-l caletjc'
      [L1_Server_IP_ADDRESS]:/mnt/CALET_Level1/PFMVolume .
```

Data Summary

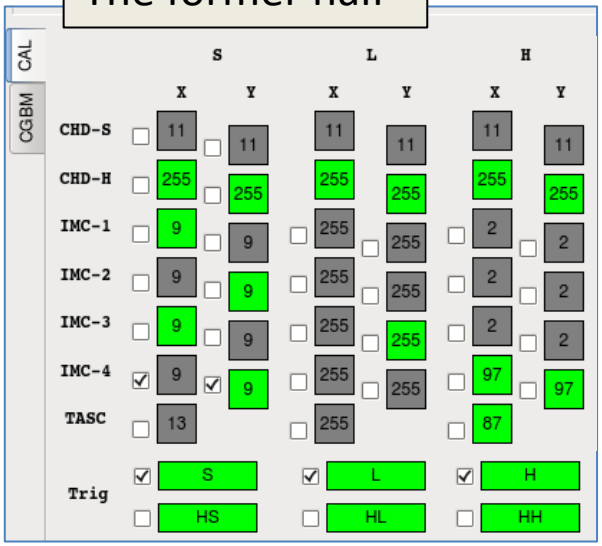
- RUN1: Single + HE
  - 150320 10:00—24:00
- RUN2: IMC XY4 lower HV for nominal HE events data collection on orbit
  - 150321 00:00—12:00
- RUN3: Single + LE + HE
  - 150321 12:00—24:00
- pedestal data is taken for 2 sec (100 events) every 30 minutes

[Run1] Single + HE

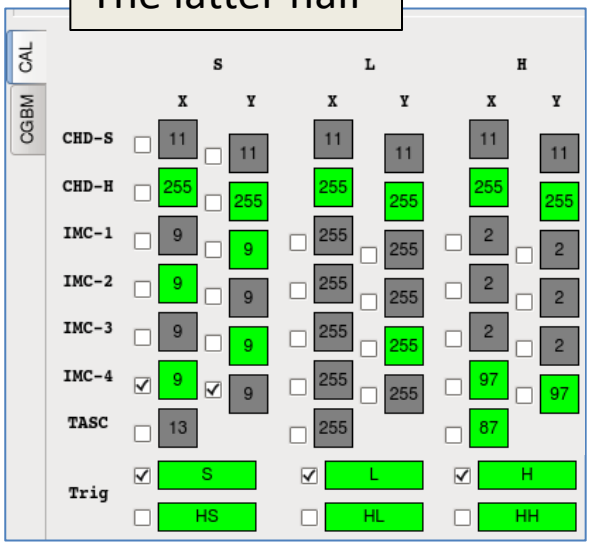
by Yamaguchi



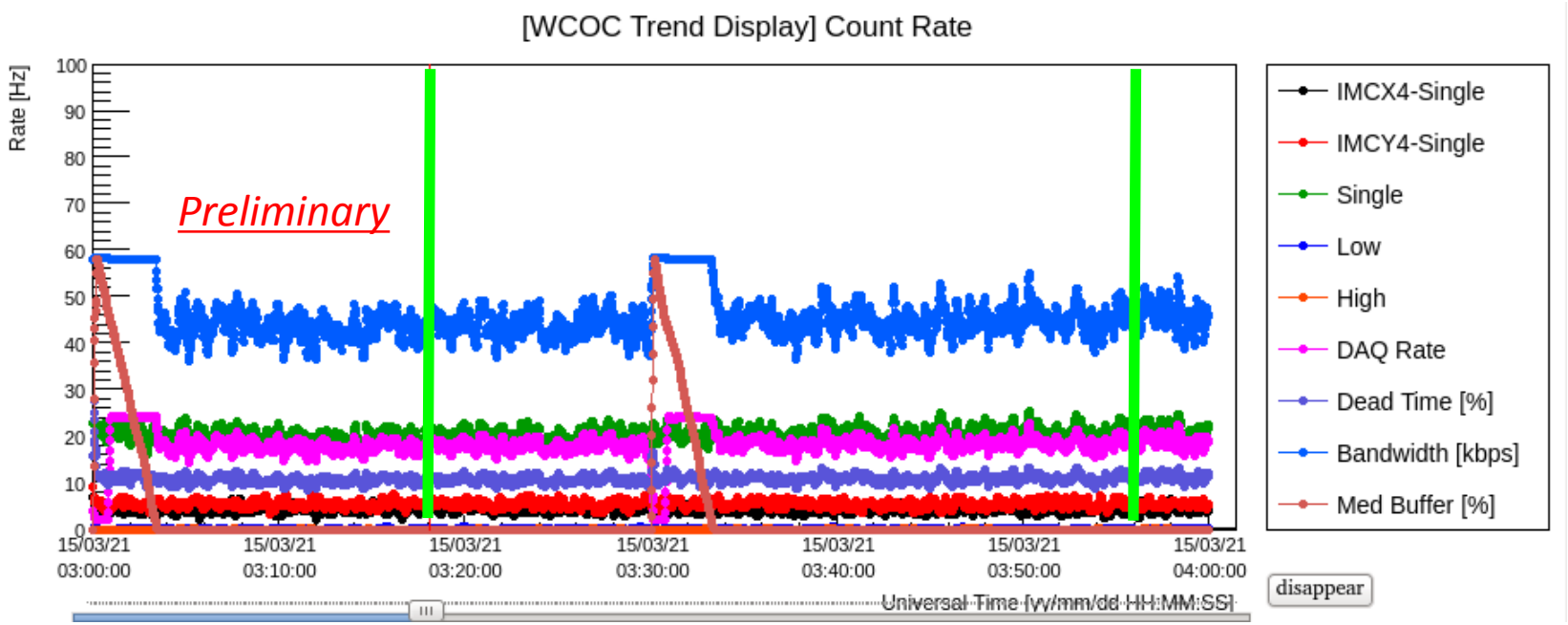
The former half



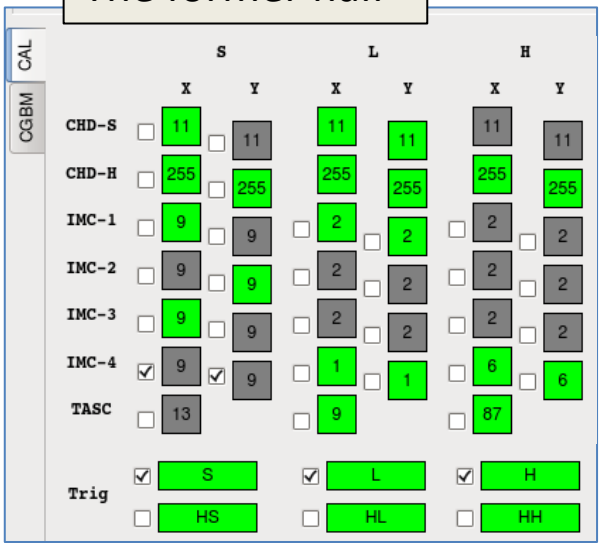
The latter half



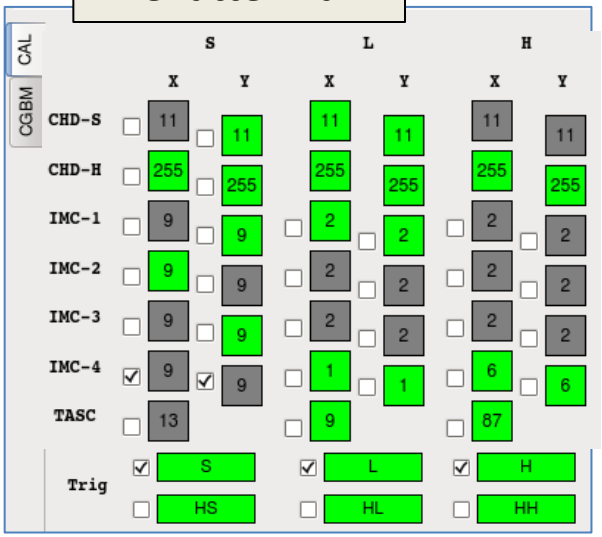
[Run2] IMC X4,Y4 Lower HV Setting



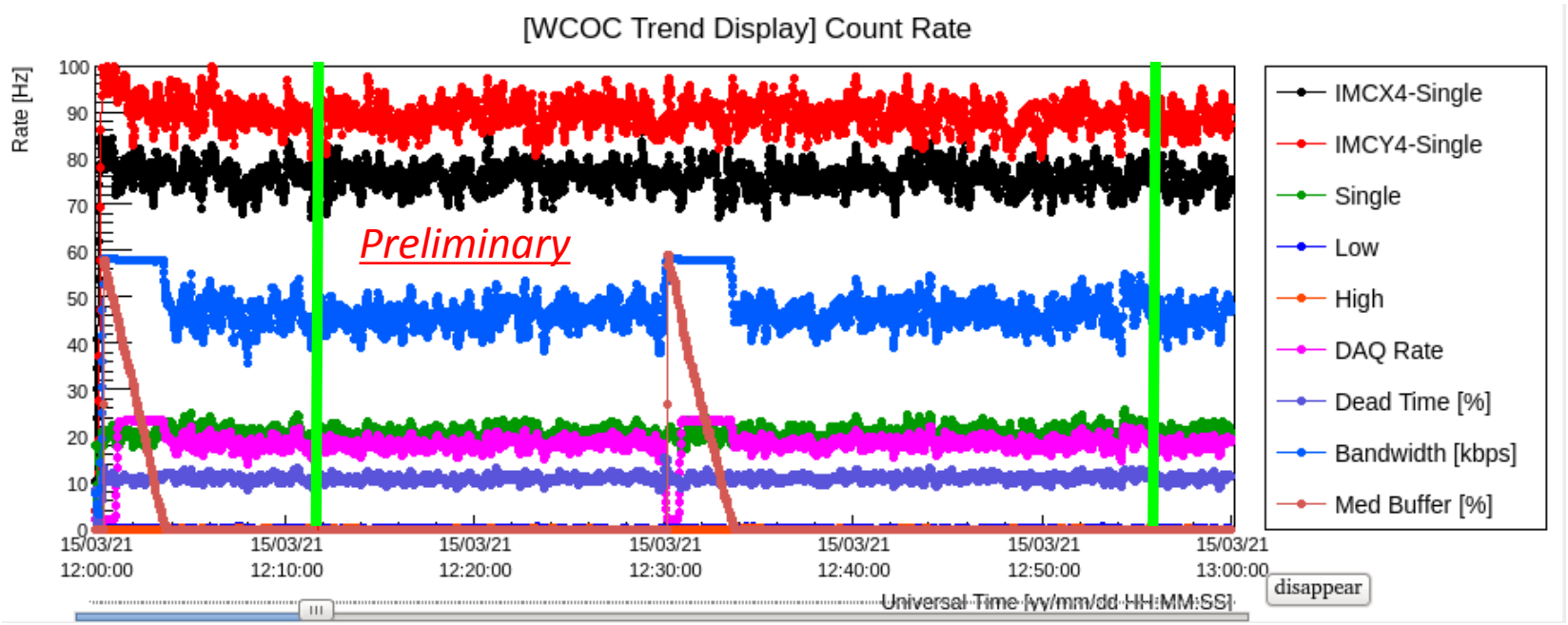
The former half



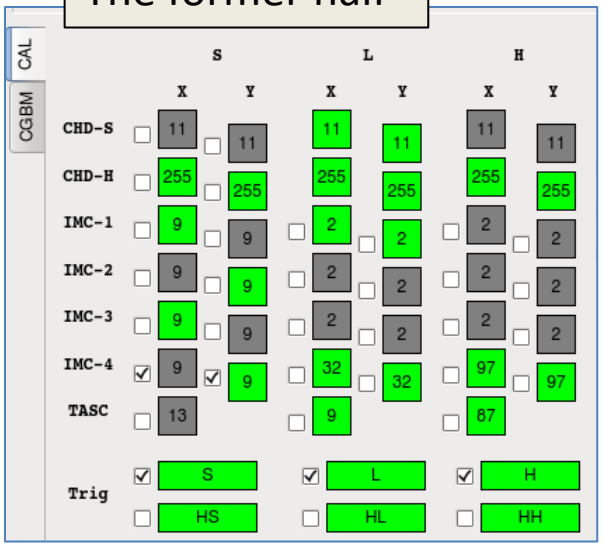
The latter half



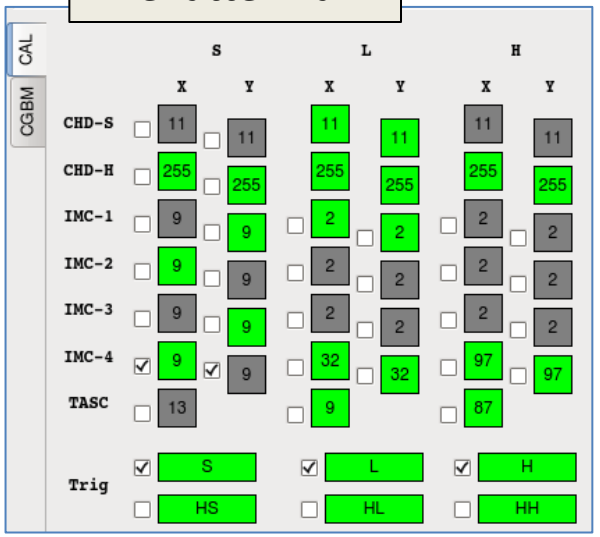
[Run3] Single + LE + HE



The former half

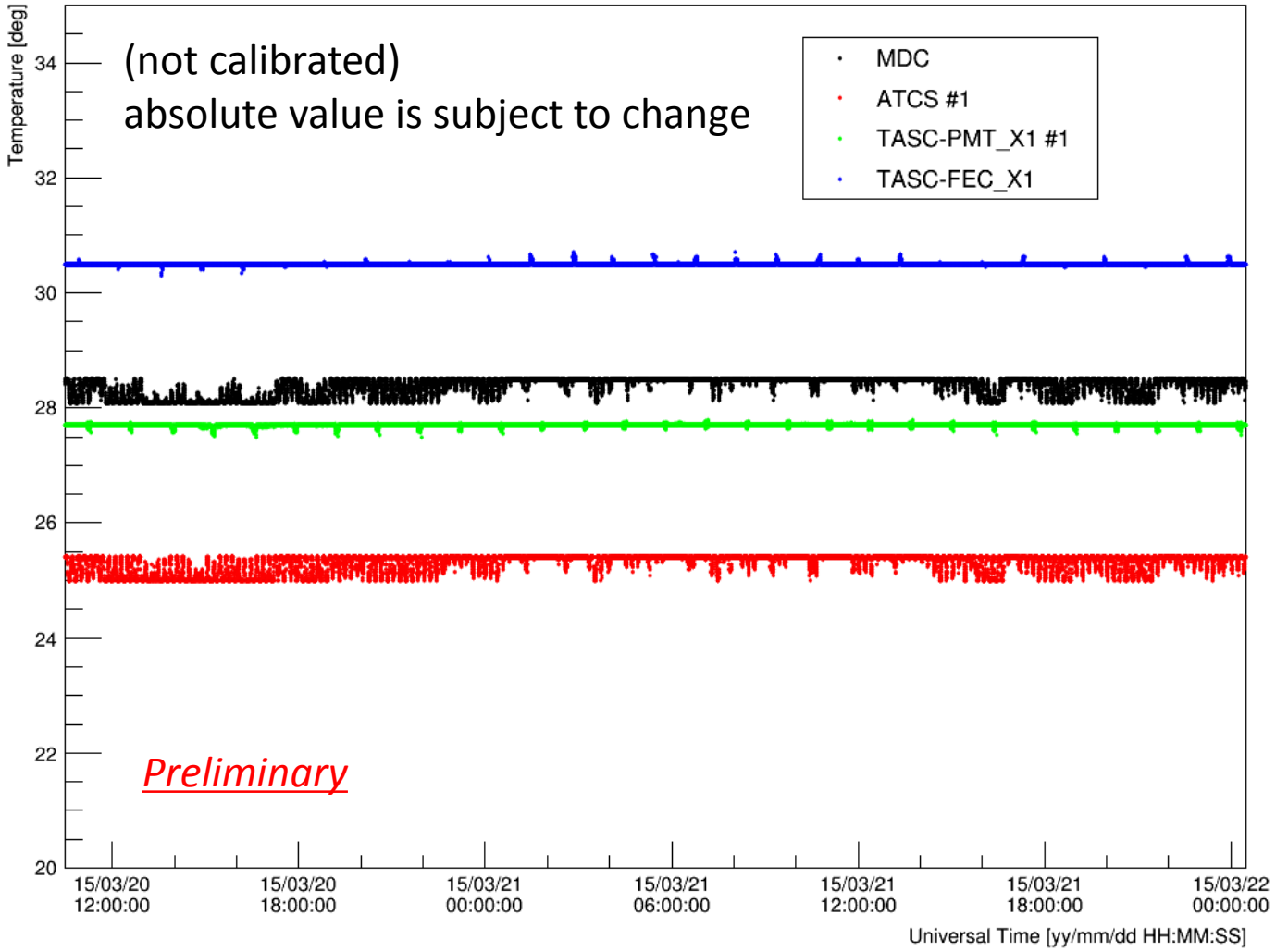


The latter half

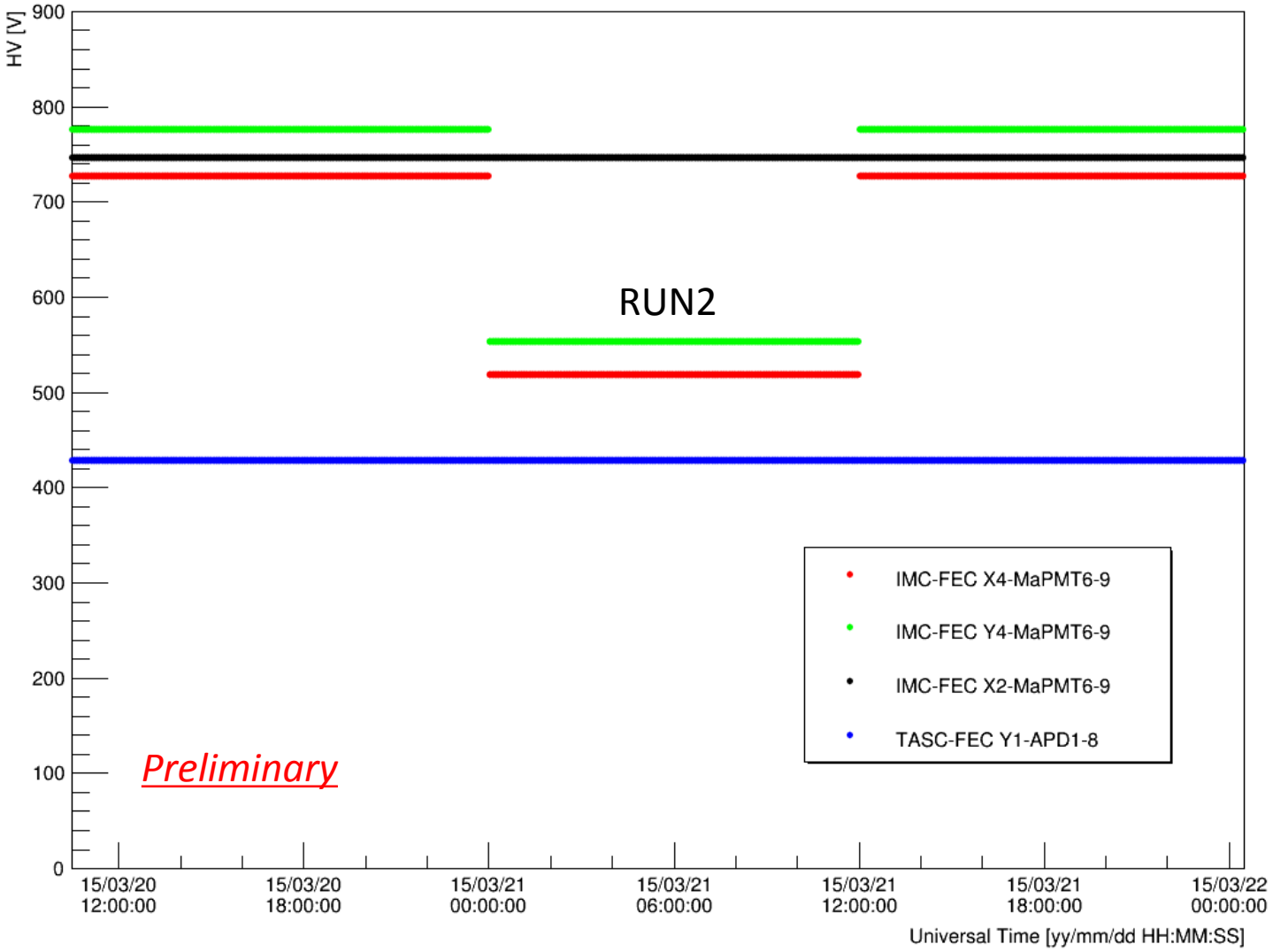


Example of Temperature Trend

by Kamio



Example of HV Trend



Preliminary

HV Setting (800V/600V)

800V Setting for Calibration

CHD-PMT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
X	-464.8	-464.8	-444.7	-446.4	-469.2	-477.0	-463.9	-455.2	-456.9	-452.5	-481.4	-469.2	-479.6	-488.4
Y	-449.1	-438.6	-406.2	-399.2	-429.8	-436.8	-439.4	-446.4	-442.9	-455.2	-452.5	-519.0	-533.0	-448.2

IMC-MaPMT

	1-5	6-9	10-14		1-5	6-9	10-14
X1	-724.4	-720.0	-740.1	Y1	-735.7	-732.2	-731.4
X2	-749.7	-747.1	-755.8	Y2	-760.2	-756.7	-767.2
X3	-779.4	-782.1	-771.6	Y3	-794.3	-793.4	-797.8
X4	-734.9	-727.9	-734.0	Y4	-760.2	-776.8	-761.1

DCDCPMT

	0	1
Brick0	-879.8	-879.8
Brick1	-879.8	-879.8

TASC-PMT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
X1	-642.2	-670.2	-623.9	-606.4	-626.5	-587.1	-684.2	-595.0	-646.6	-640.5	-668.4	-658.8	-662.3	-602.9	-663.2	-623.9

DCDC APD

	1-8	9-16		1-8	9-16		1-8	9-16		1-8	9-16
			Y1	-423.2	-447.4				Y1	-423.9	-447.0
X2	-429.3	-414.1	Y2	-415.1	-427.7	X2	-429.9	-414.7	Y2	-415.9	-428.3
X3	-437.3	-416.6	Y3	-420.2	-411.1	X3	-437.8	-417.2	Y3	-420.9	-411.6
X4	-411.1	-406.0	Y4	-406.0	-440.4	X4	-411.7	-406.5	Y4	-405.6	-439.9
X5	-413.1	-419.2	Y5	-419.7	-428.2	X5	-412.5	-418.6	Y5	-419.3	-427.5
X6	-411.1	-393.4	Y6	-396.4	-398.5	X6	-410.5	-392.9	Y6	-396.1	-398.0

Mon APD

CGBM

	HXM#1	HXM#2	SGM
Monitor	0.0	0.0	0.0
Setting	720.3	828.1	867.3

HV-Box Unused Channel

	1	2	3	4	5	6
Brick0	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8
Brick1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8

Telemetry time : 2015/03/20 UT 00:02:00, 1110844936sec

Raw Save Close

600V Setting for Calibration

CHD-PMT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
X	-464.8	-464.8	-444.7	-446.4	-469.2	-477.0	-463.9	-455.2	-456.9	-452.5	-481.4	-469.2	-479.6	-488.4
Y	-449.1	-438.6	-406.2	-399.2	-429.8	-436.8	-439.4	-446.4	-442.9	-455.2	-452.5	-519.0	-533.0	-448.2

IMC-MaPMT

	1-5	6-9	10-14		1-5	6-9	10-14
X1	-724.4	-720.0	-740.1	Y1	-735.7	-732.2	-731.4
X2	-749.7	-747.1	-755.8	Y2	-760.2	-756.7	-767.2
X3	-779.4	-782.1	-771.6	Y3	-794.3	-793.4	-797.8
X4	-523.3	-519.0	-522.5	Y4	-541.7	-553.9	-542.6

DCDCPMT

	0	1
Brick0	-879.8	-879.8
Brick1	-879.8	-879.8

TASC-PMT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
X1	-642.2	-670.2	-623.9	-606.4	-626.5	-587.1	-684.2	-595.0	-646.6	-640.5	-668.4	-658.8	-662.3	-602.9	-663.2	-623.9

DCDC APD

	1-8	9-16		1-8	9-16		1-8	9-16		1-8	9-16
			Y1	-423.2	-447.4				Y1	-424.1	-446.5
X2	-429.3	-414.1	Y2	-415.1	-427.7	X2	-430.5	-414.5	Y2	-416.1	-428.1
X3	-437.3	-416.6	Y3	-420.2	-411.1	X3	-438.5	-416.9	Y3	-420.9	-411.3
X4	-411.1	-406.0	Y4	-406.0	-440.4	X4	-412.1	-406.5	Y4	-404.9	-440.1
X5	-413.1	-419.2	Y5	-419.7	-428.2	X5	-412.9	-418.5	Y5	-419.3	-427.3
X6	-411.1	-393.4	Y6	-396.4	-398.5	X6	-410.5	-392.9	Y6	-395.3	-397.7

Mon APD

CGBM

	HXM#1	HXM#2	SGM
Monitor	0.0	0.0	0.0
Setting	720.3	828.1	867.3

HV-Box Unused Channel

	1	2	3	4	5	6
Brick0	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8
Brick1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8

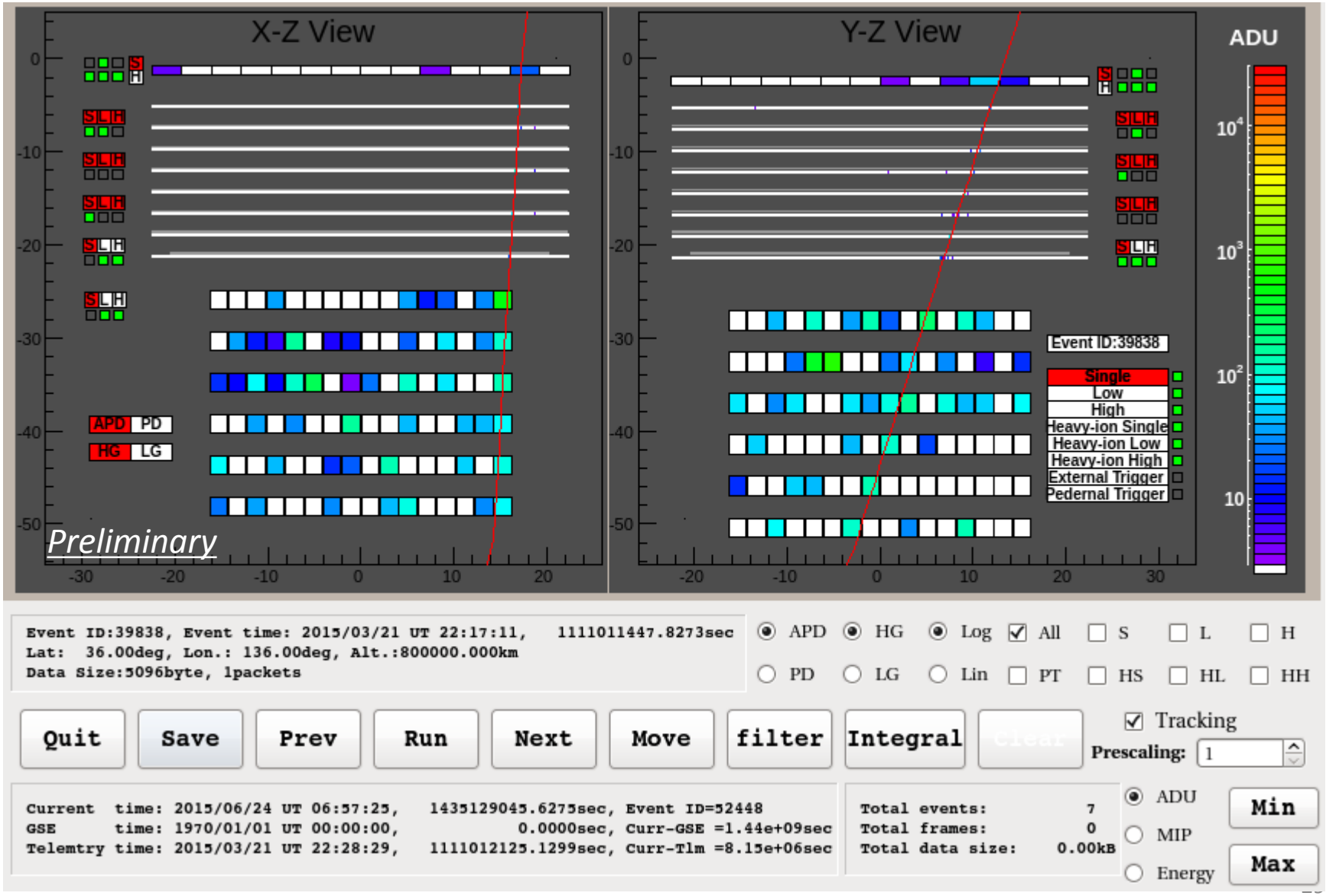
Current time: 2015/06/16 UT 03:14:40, 1434424480.399892sec
GSE time: 1970/01/01 UT 00:00:00, 0.000000sec, Curr-GSE =1.43e+09sec
Telemtry time: 2015/03/21 UT 06:04:01, 1110953057.205563sec, Curr-Tlm =7.51e+06sec

Raw Save Close

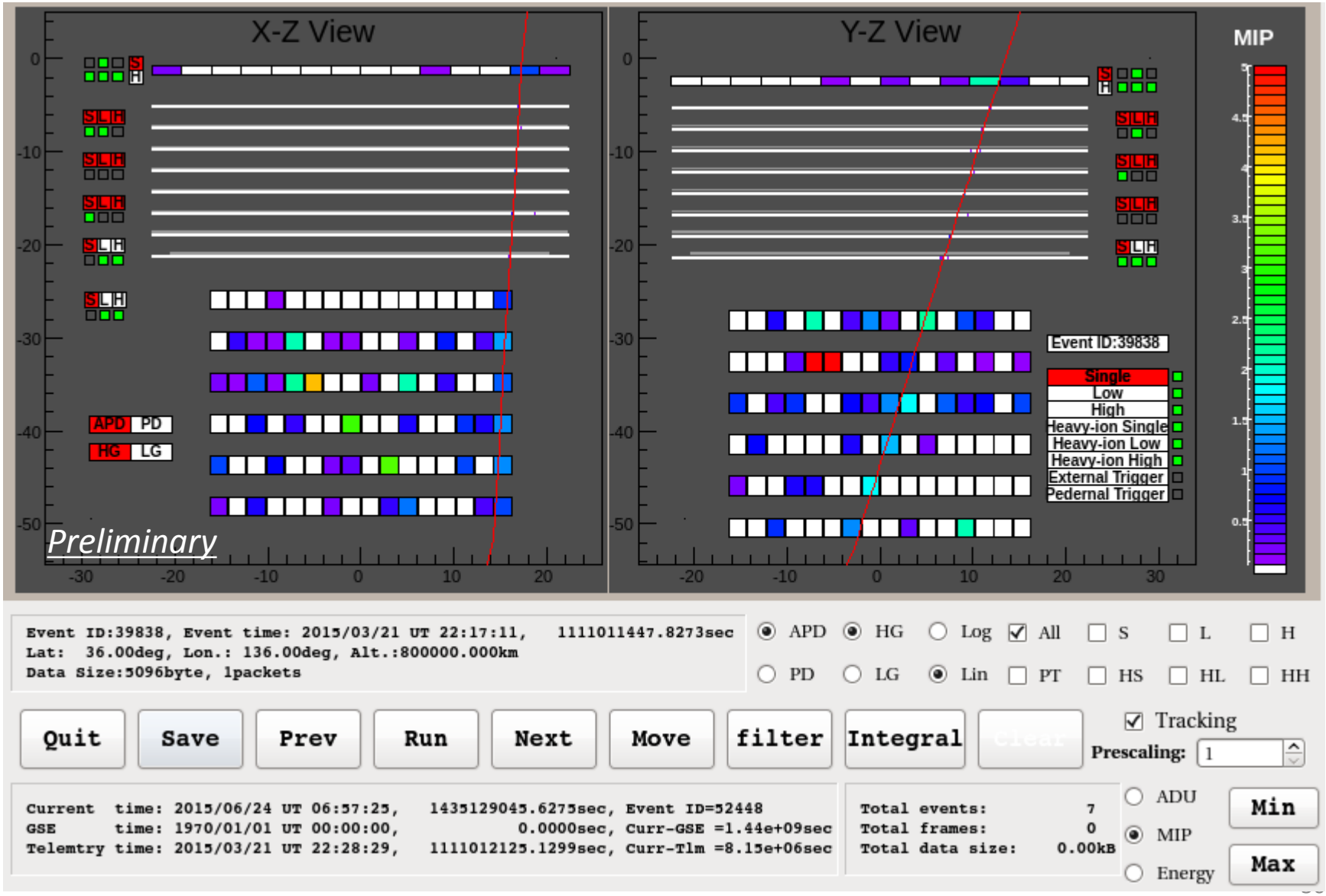
600V setting is the same setting as 800V except for IMC-FEC X4, IMC-FEC Y4

Muon Like Events (1) in ADU

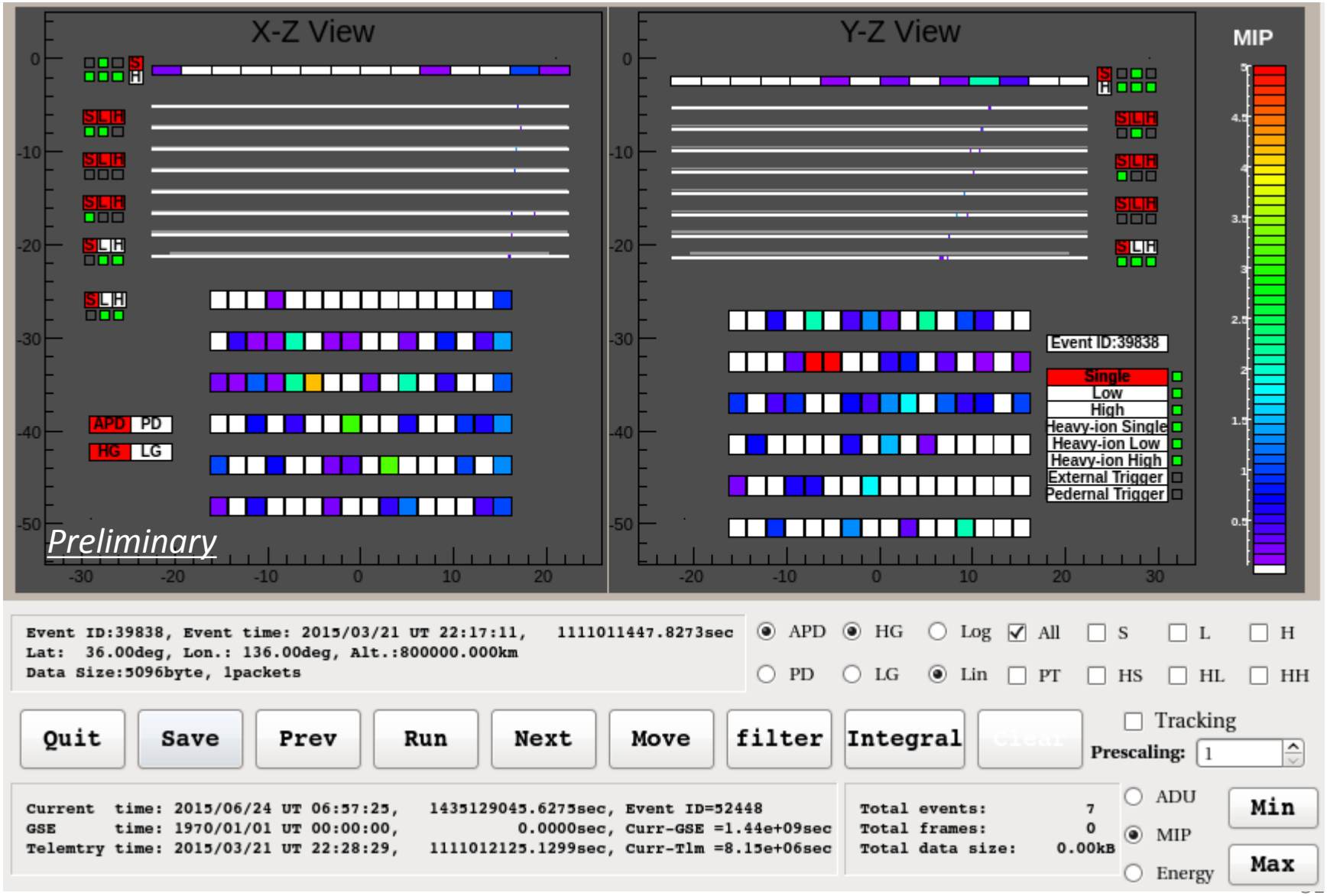
by Miyata



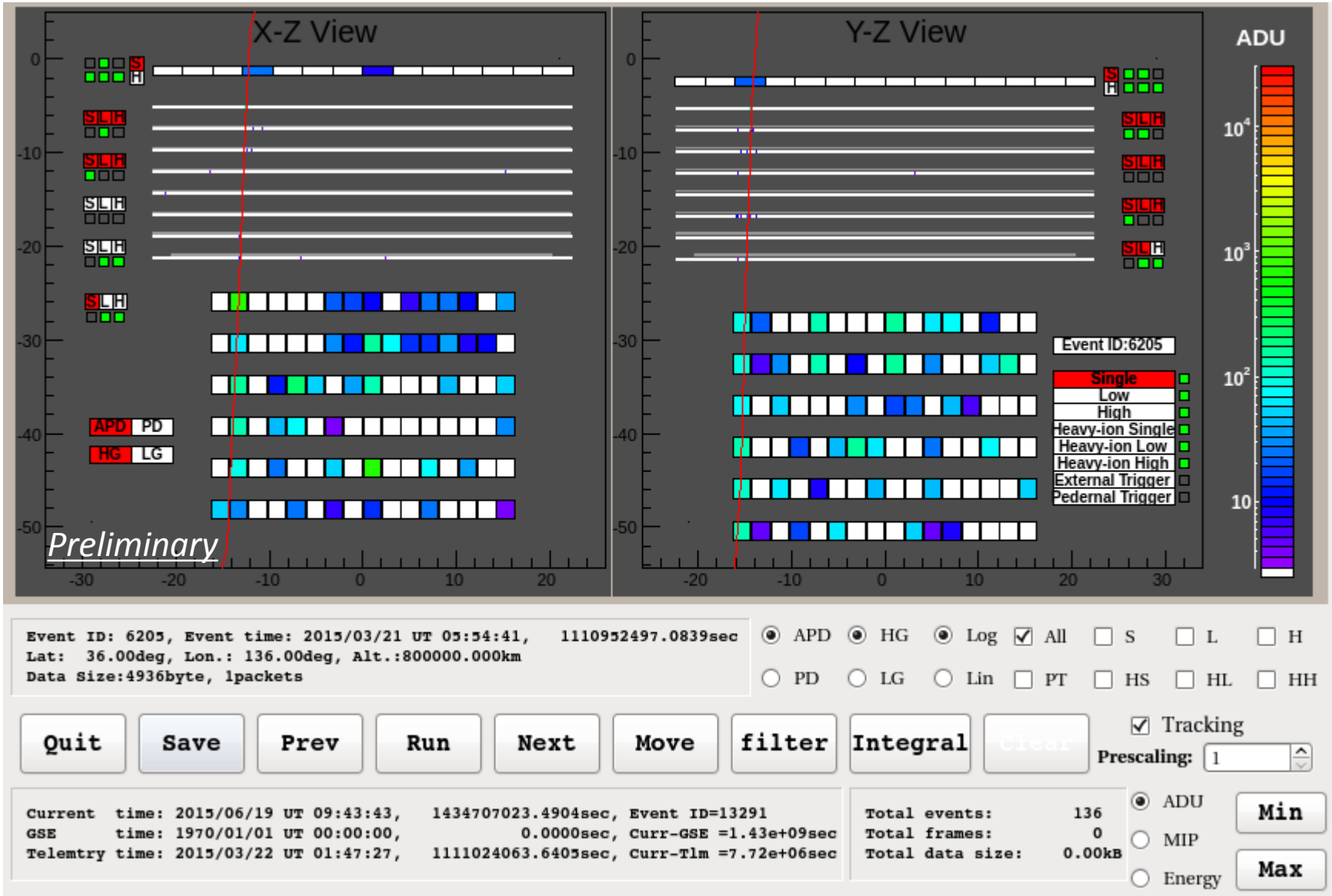
Muon Like Events (1) in MIP (0-5MIP; linear)



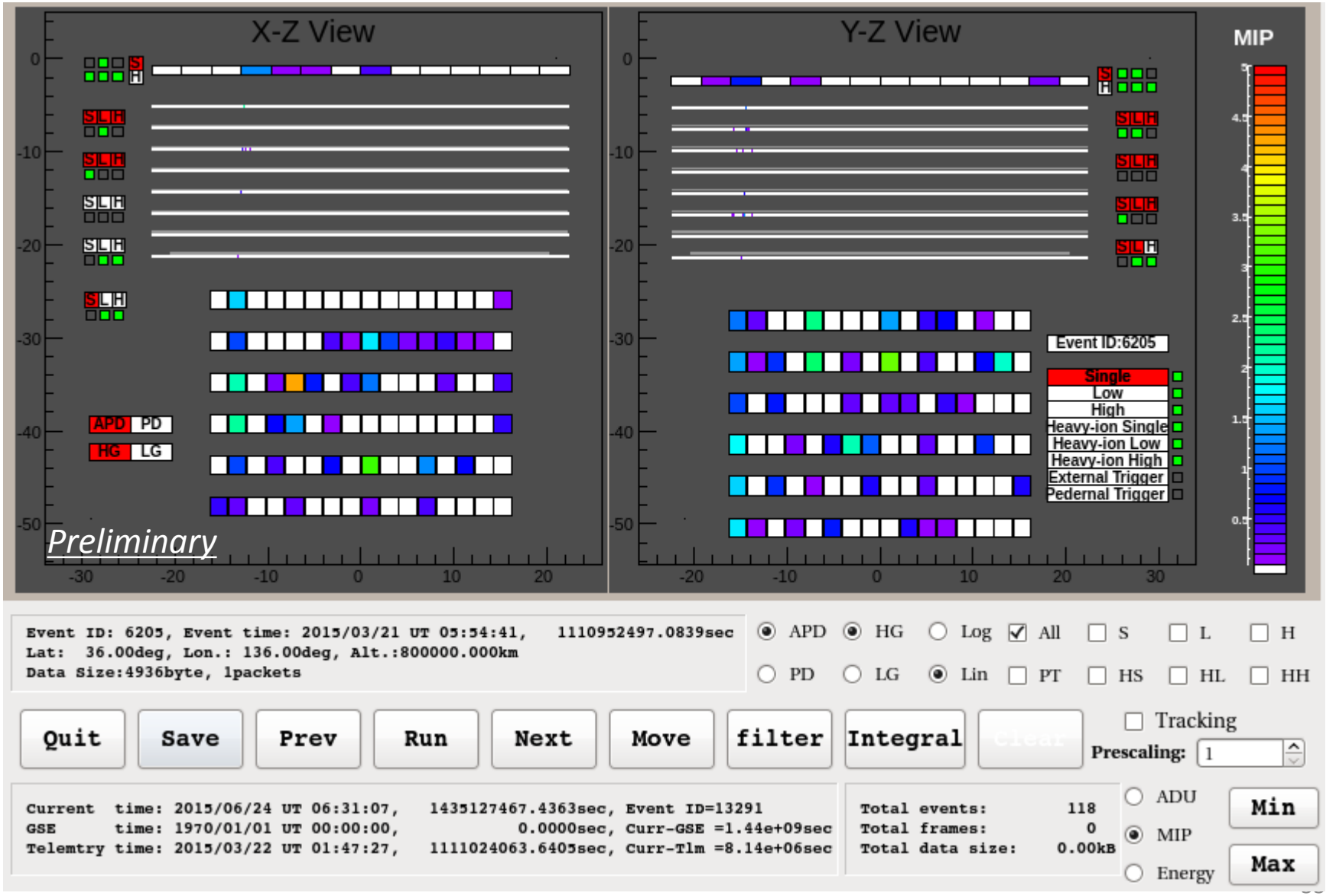
Muon Like Events (1) in MIP (0-5MIP; linear)



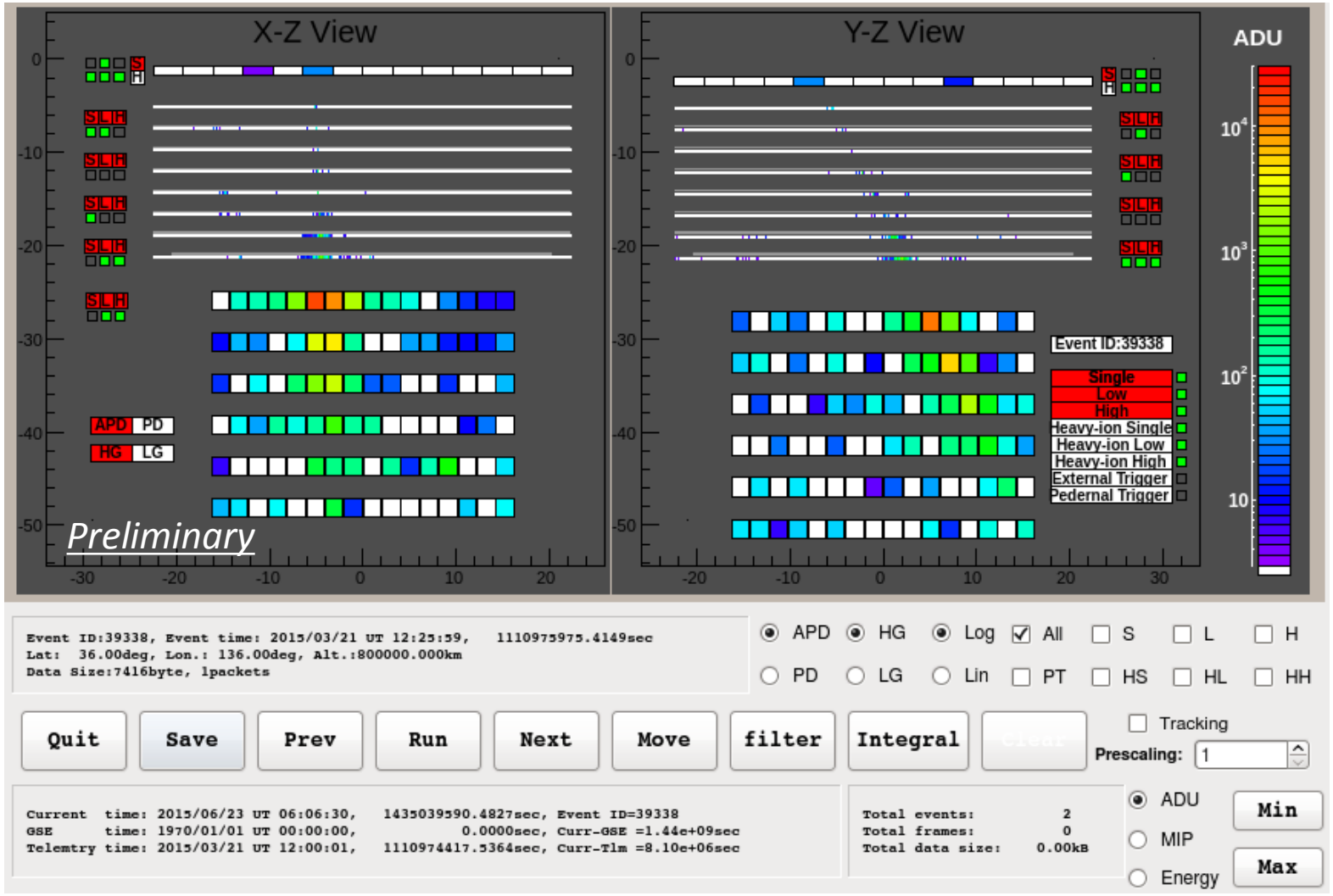
Muon Like Events (2) in ADU



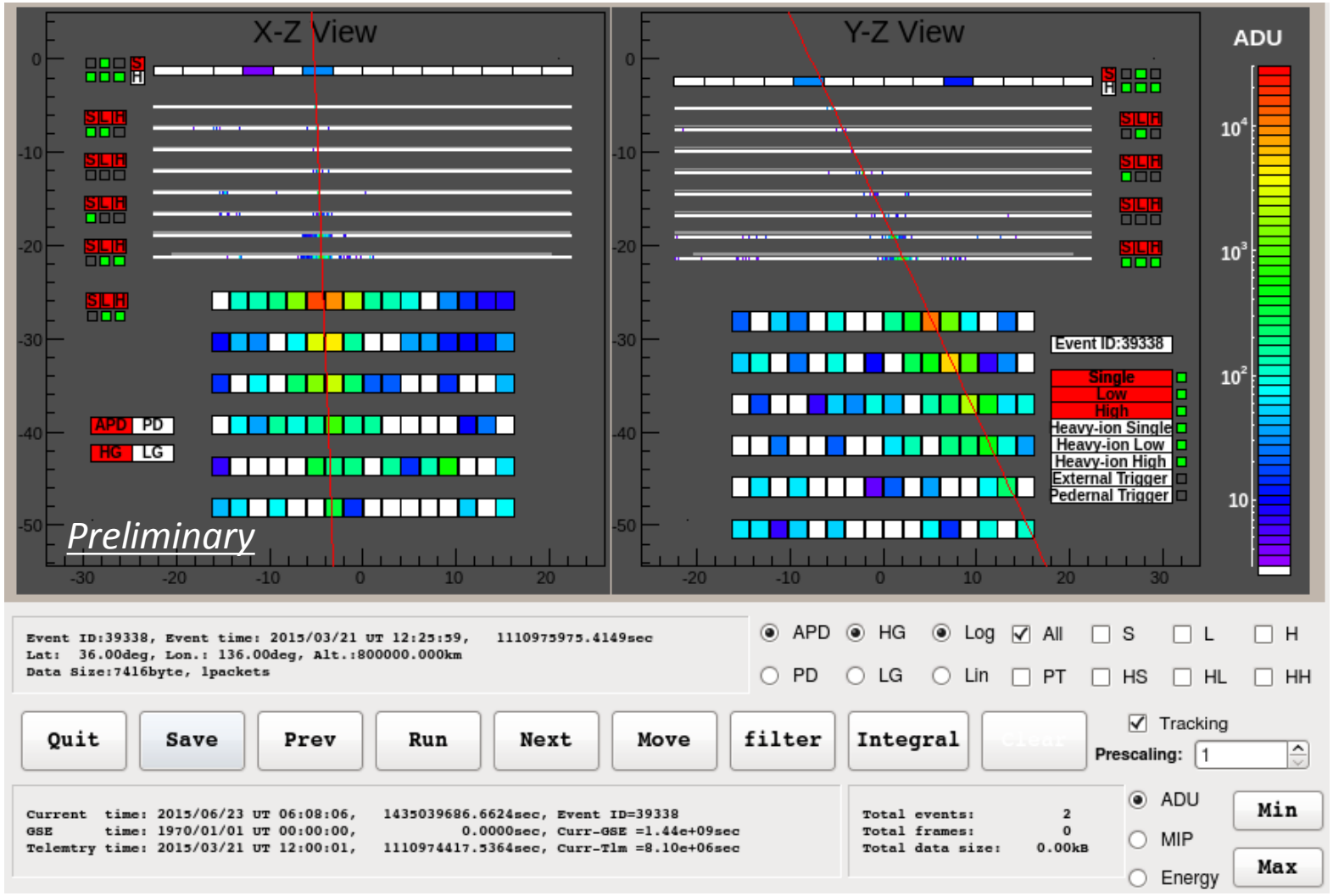
Muon Like Events (2) in MIP (0-5MIP; linear)



Shower Like Events (1) in ADU by Tanaka

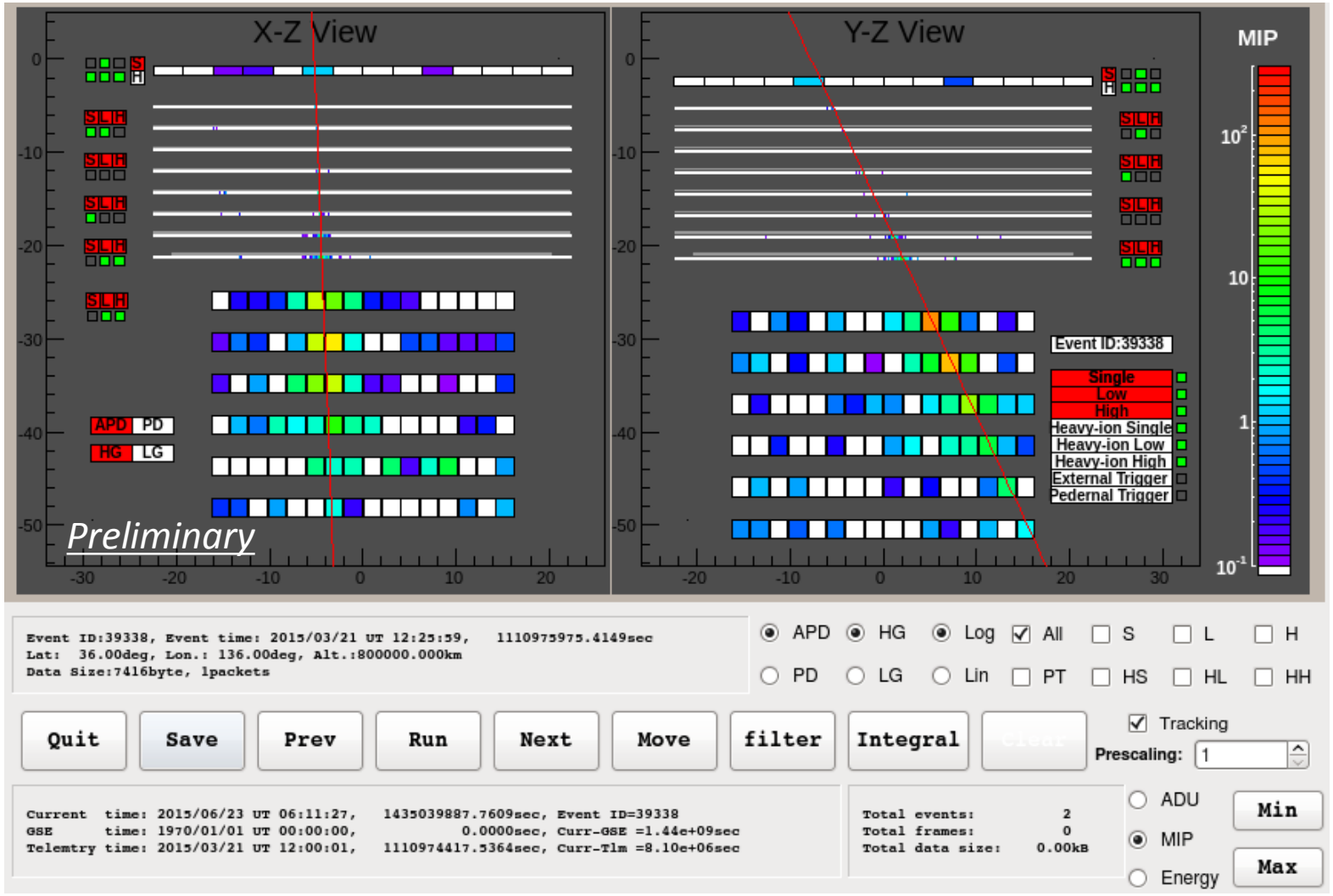


Shower Like Events (1) in ADU w/ Track



Shower Like Events (1) in MIP

Shower Like Events (1) in MIP w/ track

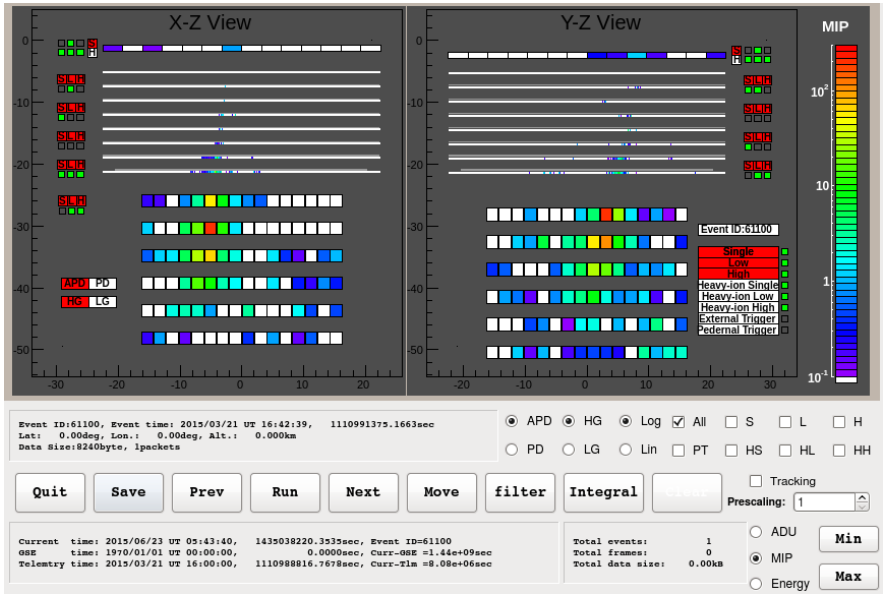


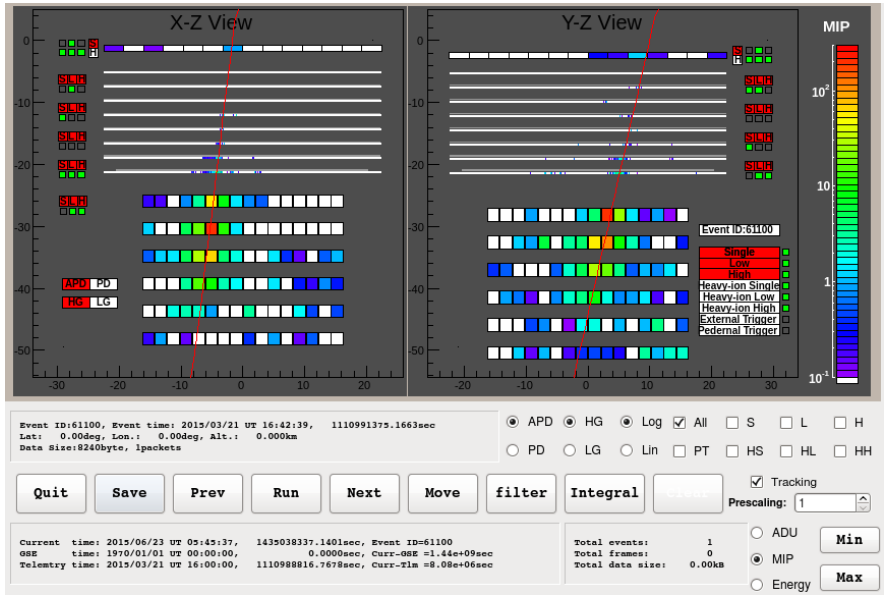
Shower Like Events (3)

in ADU

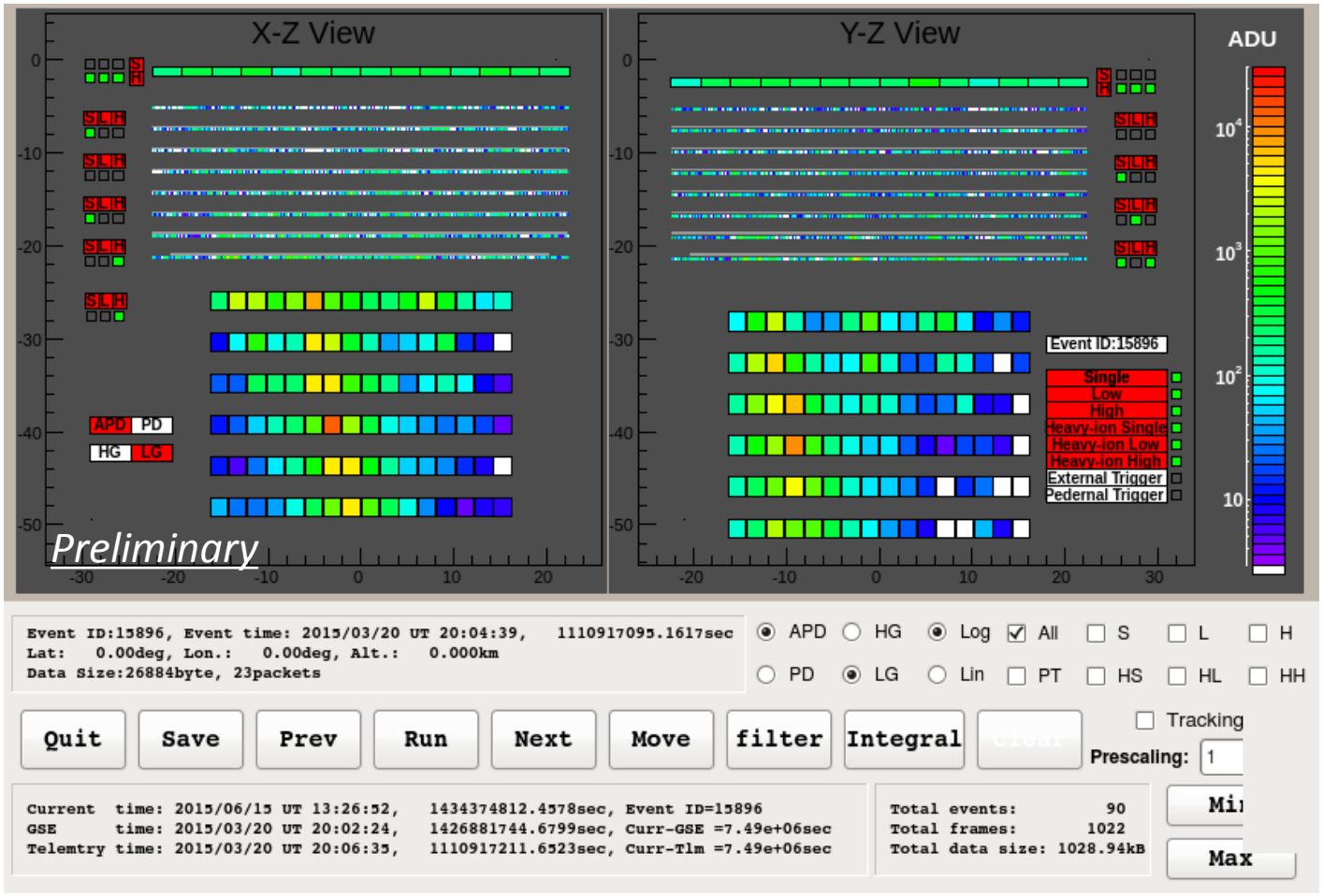
in MIP

Preliminary





Shower Like Events (3)



APD/PMT Low gain outputs are shown for TASC channels

Conclusion

- CALET Level1 Format is finalized with extensive documentation and support for read/write routines
- Assignment issue is solved and the definition is confirmed from both of the PFM and simulation data.
- Ground muon data with PFM are distributed as a full CALET Level1 format.