A Brief Report from KGWG-DetChar

J. J. Oh (NIMS-KGWG)

2015. 4. 7 (Tue)

KGWG-KAGRA DetChar Telecon.

Contents

- iDQ implementation : Shallow? or Deep?
- ETGs based on HHT
- CAGMon - Correlation Analysis based Glitch Monitoring

KGWG-DetChar Member

- Member

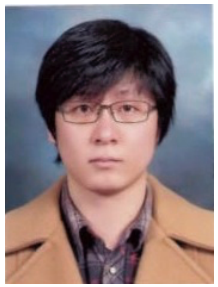
John J. OH (NIMS)
CAGMon/ Deep Learning / ETG-HHT

Sanghoon OH (NIMS)
CAGMon/ Deep Learning / ETG-HHT

Edwin J. SON (NIMS)
ETG-HHT / CAGMon / Deep Learning

Hwansun Kim
Deep Learning/ CAGMon / ETG-HHT

Hyoungseok CHU (NIMS)
ETG-HHT/ Deep Learning / CAGMon



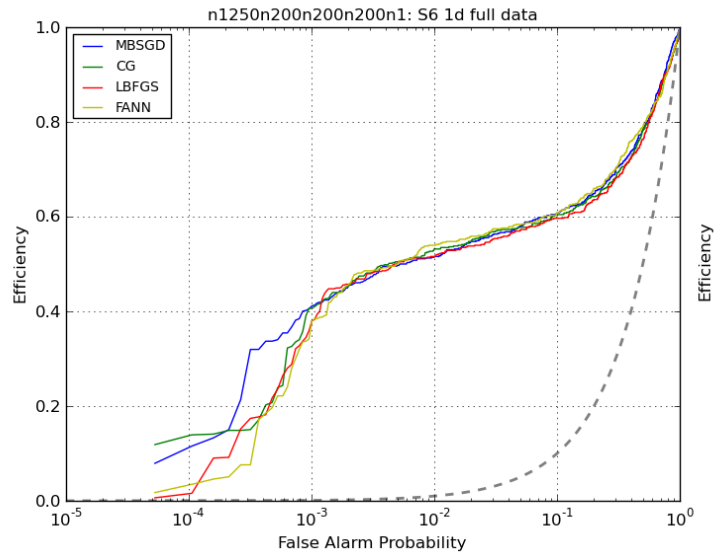
Young-Min Kim (PNU)
iDQ/ Deep Learning/ CAGMon

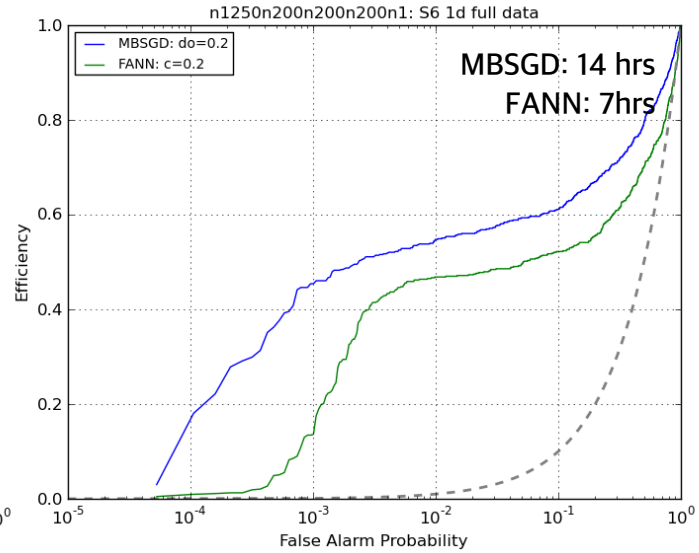
Chang-Hwan LEE (PNU)
iDQ/ Deep Learning/ CAGMon

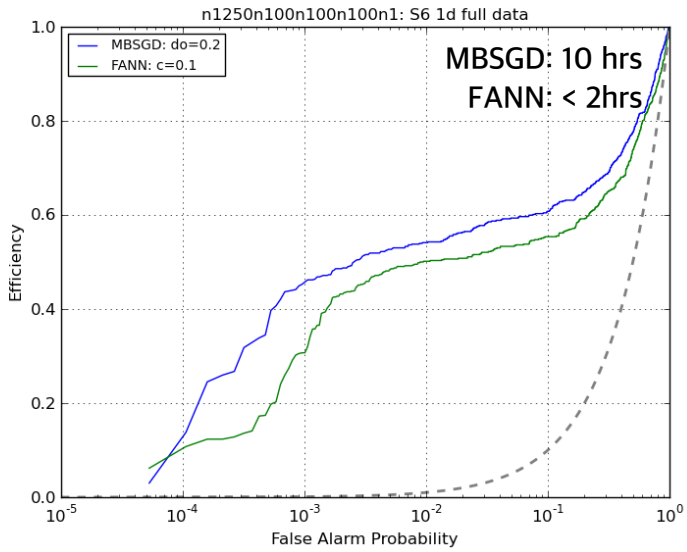
iDQ Pipeline

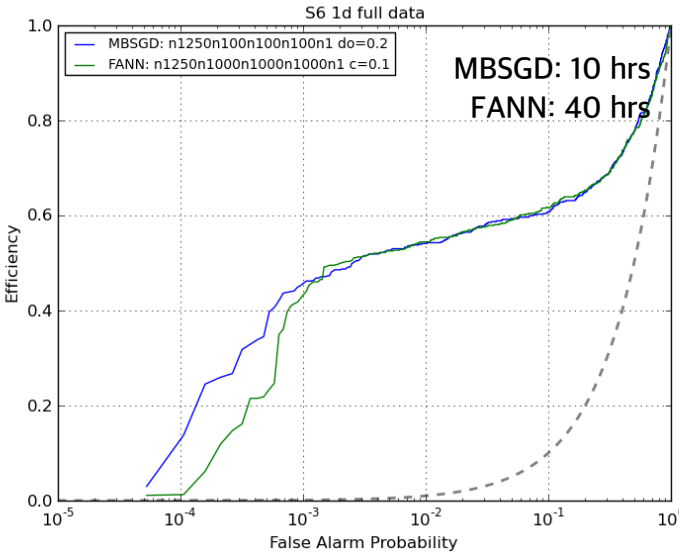
- **iDQ** is an online pipeline for glitch identification used in LIGO-Detchar
- Recently tested in ER6 but ANN is not implemented because we have an important issue to be determined before making decisions
- Current ANN code made by FANN package, which is using a conventional (old-fashioned) multilayered perceptron (MLP) based iRPROP algorithm
- However, "Deep learning" is a newly developed algorithm, which is a "hot issue" in "BIG DATA" community. Deep learning uses various technical methods and breakthroughs that are not implemented in FANN.
- So we have been testing whether or not Deep learning should be implemented in iDQ instead of FANN-based MLP.
- Recent test shows that we can make a decision on this issue:
  - iDQ online: FANN-based MLP is proper for speed-up
  - Offline Glitch Identification: Deep learning is more powerful!

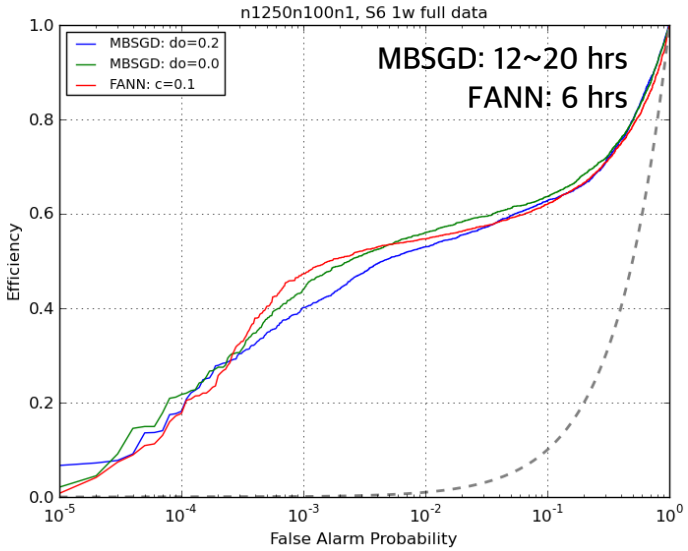
iDQ Pipeline











FANN:

- Relatively poor performance at FAP~0.1%
- Faster than MBSGD (Deep Learning)
- For comparable performance, FANN is slower

Deep Learning:

- Better performance than FANN
- Slower because of highly nested and complex network structure
- Better performance at FAP~0.1%

iDQ Pipeline

- Strategy:
  - FANN will be implemented in the current iDQ software
  - It will be tested in coming ER7 and/or ER8 before O1
  - This version of iDQ can be implemented for KAGRA use
  - Deep learning software can be proposed for offline glitch identification
    - Need dedicated cluster (high CPU nodes and memory/core)

HHT-based ETG

- Many ETGs algorithms are used in LIGO and Virgo:
  Omicron, Excess Power, DMT-Omega, PCAT, BayesWave, Kleine-Welle

- HHT can extract abnormal signals in Aux. and DARM_ERR channels using its nature of adaptive basis transformation (Some uses fixed basis transform such as Wavelet Transform)

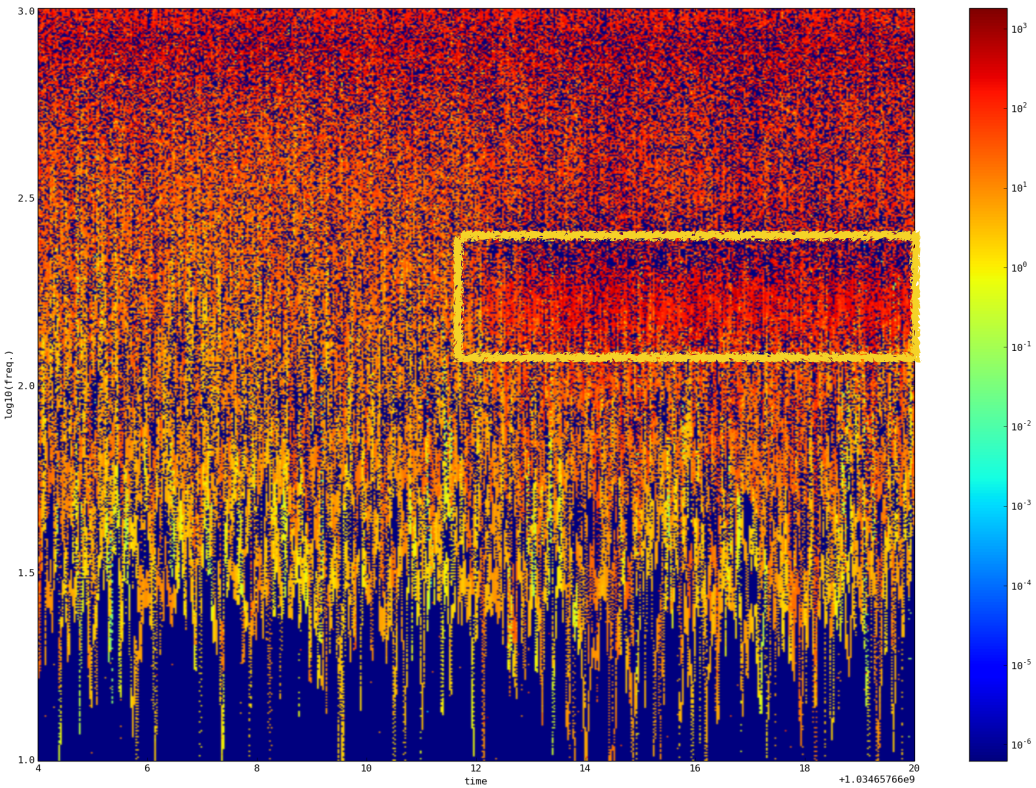
- HHT can generate Triggers from a certain ETG algorithm, which can be used as "NEW" aux. channel trigger generator

- We are developing ETG-HHT codes and testing some significant events in LIGO science runs - BIG DOG, Equinox, and other H/W injections

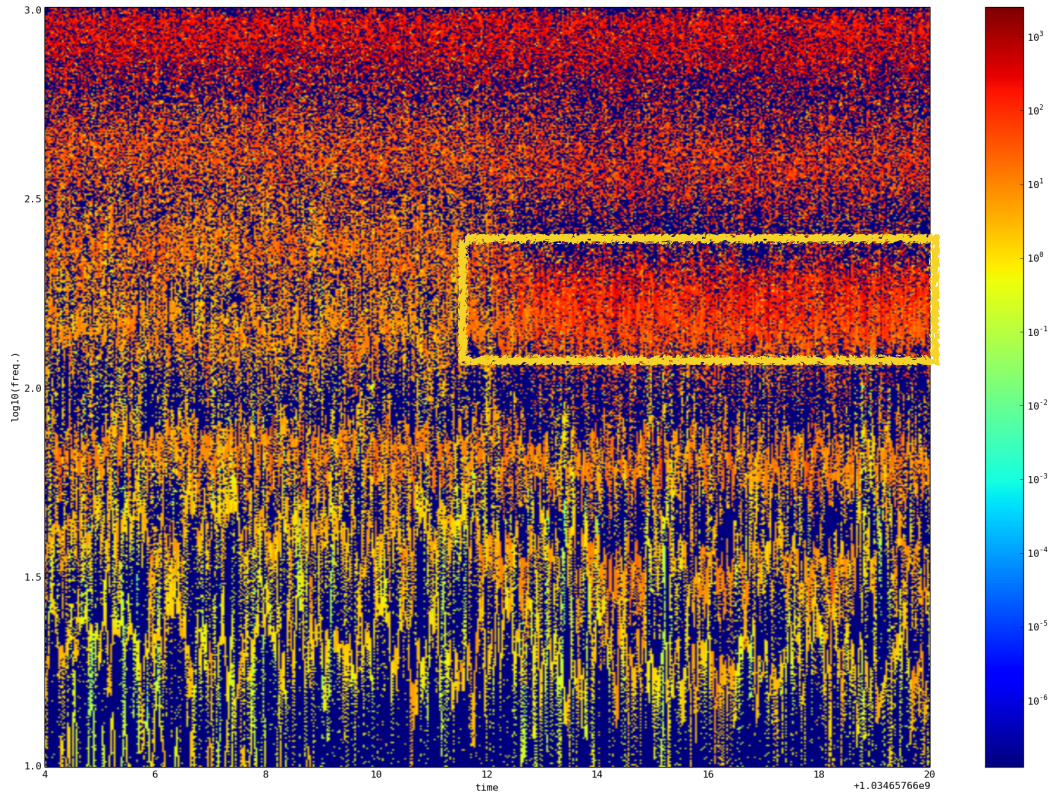
- ETG-HHT code: EEMD, HSA, TriGen, Clustering

HHT-based ETG

EMD



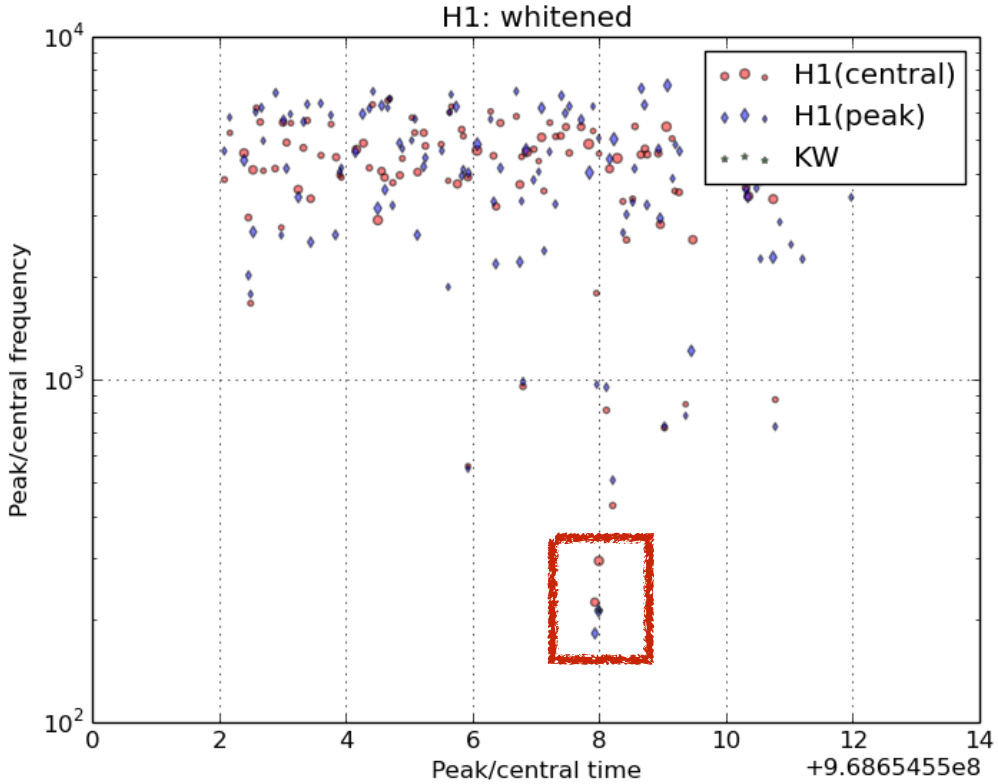
Ensemble EMD



CLIO_1034657664 data:
- 160Hz 8 seconds transient is shown

HHT-based ETG

Big Dog Event



S6: 968654557.955 (H1_RDS_R_L1)

At 8 sec, KW and HHT can generate Big-Dog trigger but significance of HHT is bigger than that of KW

Equinox Event

S5: 874465554.715 (H1_RDS_CO3_L2)

—-

Stay tuned.
Analysis in progress

HHT-based ETG

- Strategy:
  - Code Frozen
  - Join **ETGPerformanceStudy** in ***LIGO DetChar*** (led by Jessica McIver)
  - Propose NEW Tools for Event Trigger Generators

CAGMon

- **CAGMon** is a glitch monitoring tool between multi-channel using correlation analysis

- It is trigger-based and compute "Correlation Value" between DARM_ERR and Aux. channels at a certain Trigger time

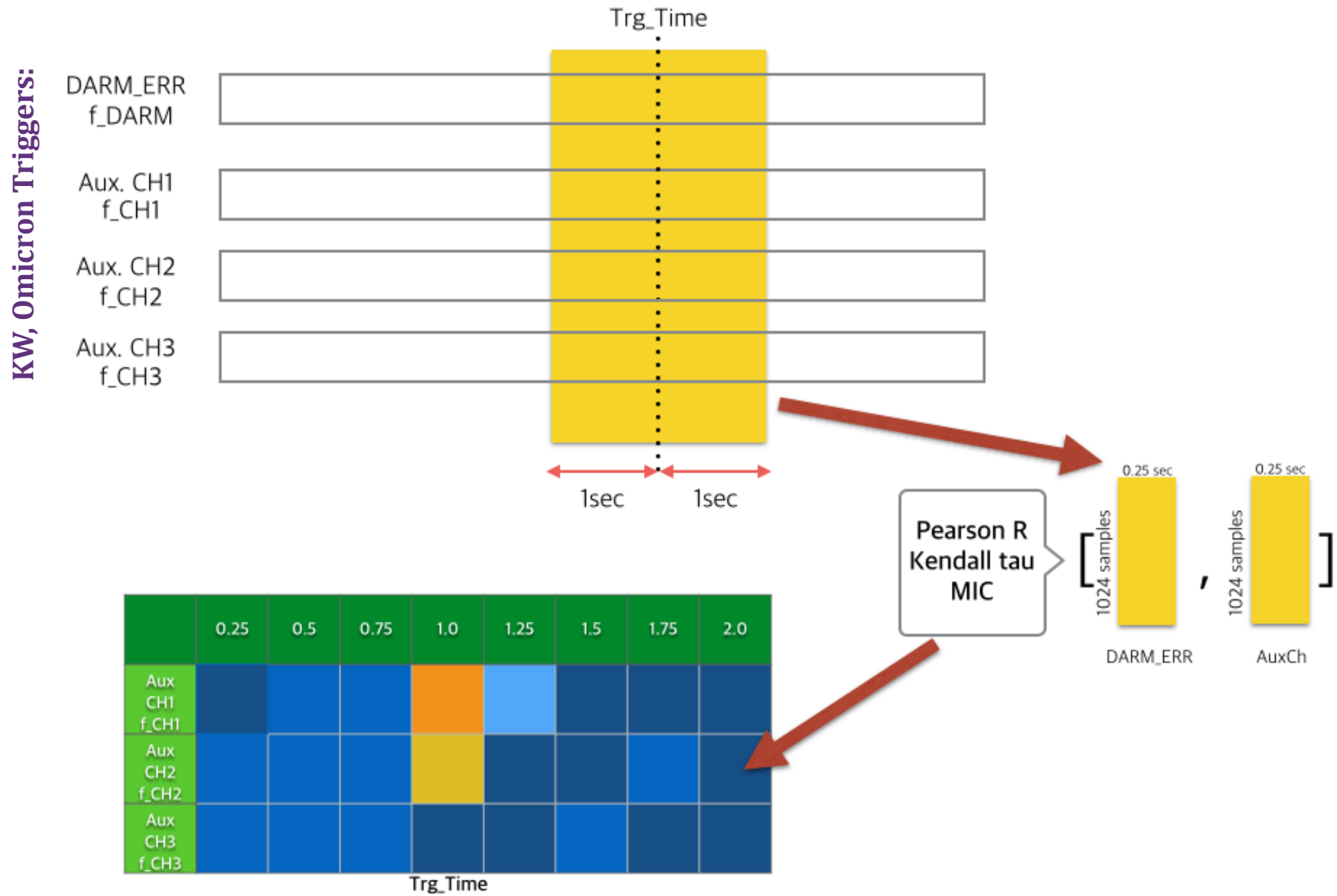
- With these values, one finds which aux. channels among many channels proposed by ETGs are actually involved with the correlation to DARM_ERR glitch

- Basic correlation algorithms are
  - Pearson's R correlation : famous linear correlation measure
  - Kendall's tau correlation : another linear measure by ranking
  - Maximal Information Coefficient : nonlinear measure

- Time-Frequency-Correlation Map (TFCMap) at a given trigger time
  - Correlation information between DARM_ERR and Aux Channels
  - Linear and Nonlinear correlation information (Up/Down conversion?)

CAGMon

CAGMon : Trigger-based Multi-channel Correlation Analysis



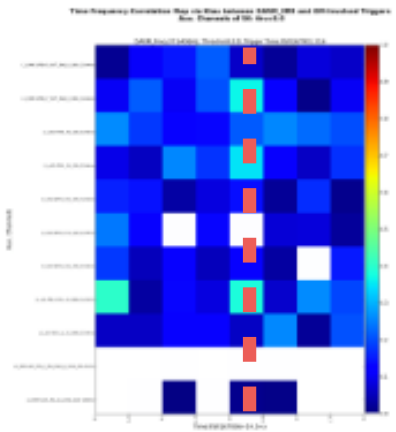
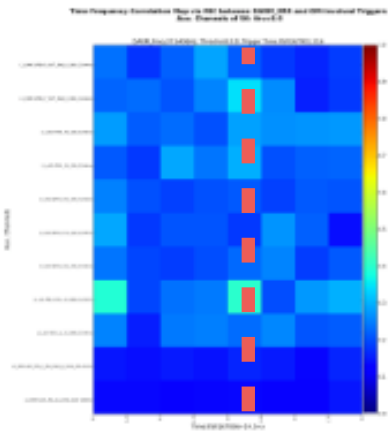
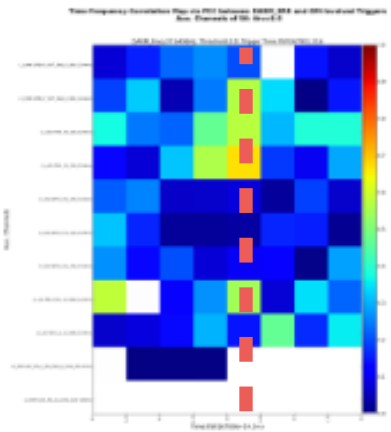
CAGMon

```
GPS(sec+ms) 959167951.0 516.0 SNR 0.0 signf 11.006
ChIndx ChName signf dt dur freq npts
48 L0_PEM-LVEA_MIC 8.775 -0.073 0.003 1352.3 711.0
72 L1_OMC-ASC_POS_X_IN1_DAQ 9.483 -0.063 1.862 269.8 966.0
78 L1_OMC-QPD1_P_OUT_DAQ 18.733 0.031 1.019 24.9 901.0
80 L1_OMC-QPD2_P_OUT_DAQ 14.756 0.046 0.769 29.3 39.0
86 L1_OMC-QPD4_P_OUT_DAQ 14.982 0.031 0.85 32.7 40.0
87 L1_OMC-QPD4_Y_OUT_DAQ 8.222 0.046 0.103 32.6 9.0
149 L1_ASC-ETMX_P 35.749 0.015 1.432 26.2 46.0
151 L1_ASC-ETMY_P 35.745 0.015 1.394 26.2 46.0
152 L1_ASC-ETMY_Y 8.862 0.0 0.094 26.2 22.0
153 L1_ASC-ITMX_P 29.763 0.0 1.357 34.0 46.0
155 L1_ASC-ITMY_P 31.797 0.0 1.59 34.0 46.0
160 L1_ASC-RM_P 42.557 0.015 1.443 26.2 46.0
161 L1_ASC-RM_Y 12.17 0.015 0.327 26.2 32.0
164 L1_ASC-WFS2_IP 20.648 0.031 1.341 26.2 32.0
165 L1_ASC-WFS2_IY 8.883 0.031 0.114 26.2 18.0
168 L1_ASC-WFS3_IP 54.079 -0.016 1.482 34.0 46.0
169 L1_ASC-WFS3_IY 13.848 -0.016 0.264 34.0 32.0
170 L1_ASC-WFS4_IP 53.882 -0.016 1.41 34.0 49.0
181 L1_LSC-POB_I 10.407 0.046 0.331 29.3 55.0
183 L1_LSC-PRC_CTRL 10.752 0.015 0.331 32.0 55.0
187 L1_LSC-REFL_Q 18.932 -0.016 0.746 41.2 102.0
```

- **GPS: 959167936** **Omicron generates 11 aux. channel triggers in 32-4096 Hz**
  - Trigger time: 959167951.516, f_DARM = 37.6406Hz
  - AuxChannel Triggers : OM_TRGS_959167951.516.txt
  - Vetoed Triggers by Hveto

central time	central frequency	SNR
959167951.563458	43.000000	14.231304

  - Correlation Matrix by CAGMon

Kendall's tau	MIC	Pearson R
 trg_time	 trg_time	 trg_time

  - Channel List by CAGMon

Channel Name	Frequency Range	Pearson R	Ktau	MIC
L1_OMC-QPD4_Y_OUT_DAQ_8_1024	32-64	0.57	0.37	0.35
L1_ASC-ITMX_P_8_256	32-64	0.57	0.21	0.28
L1_ASC-ITMY_P_8_256	32-64	0.67	0.35	0.30
L1_LSC_PRC-CTRL_32_2048	32-64	0.55	0.38	0.40

https://kgwg.nims.re.kr/cbcwiki/CAGMonOM

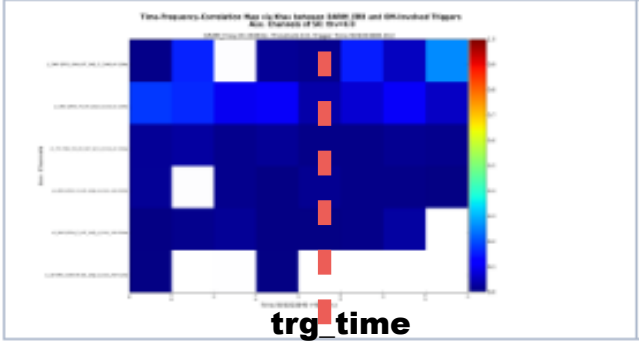
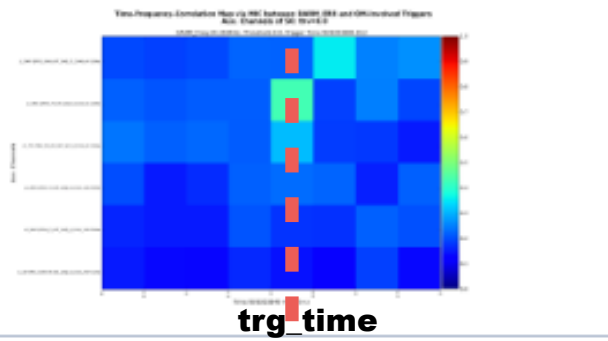
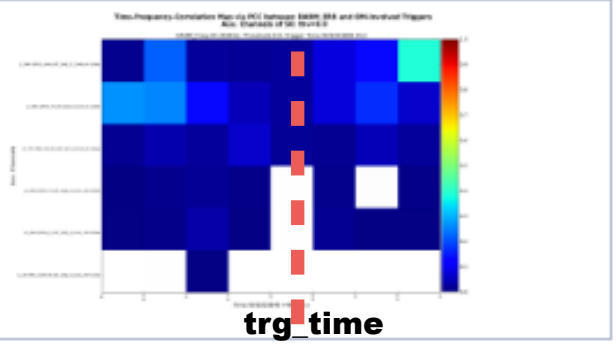
CAGMon

```
GPS(sec+ms) 959203889.0 812.0 SNR 0.0 signf 25.918
ChIndx ChName signf dt dur freq npts
58 L1_ISI-OMC_CONT_RY_IN1_DAQ 8.409 0.04 0.011 344.8 228.0
72 L1_OMC-ASC_POS_X_IN1_DAQ 14.263 0.032 0.978 11.7 14.0
74 L1_OMC-DUOTONE_OUT_DAQ 15.402 -0.062 1.093 11.7 20.0
79 L1_OMC-QPD1_SUM_OUT_DAQ 647.327 -0.093 6.28 80.7 1893.0
84 L1_OMC-QPD3_P_OUT_DAQ 607.505 -0.046 2.983 100.2 984.0
85 L1_OMC-QPD3_Y_OUT_DAQ 673.485 -0.099 2.14 151.7 984.0
86 L1_OMC-QPD4_P_OUT_DAQ 754.049 -0.042 2.328 195.9 982.0
145 L1_TCS-ITMX_PD_ISS_OUT_AC 8.822 -0.007 0.02 70.4 49.0
148 L1_ASC-BS_Y 8.801 0.063 0.359 5.5 6.0
149 L1_ASC-ETMX_P 16.727 0.0 1.127 29.7 44.0
151 L1_ASC-ETMY_P 16.888 0.063 1.202 29.7 44.0
204 L1_SUS-ITMX_OPLEV_PERROR 9.278 -0.062 1.204 3.9 2.0
205 L1_SUS-ITMX_OPLEV_YERROR 31.714 -0.062 18.148 7.2 44.0
207 L1_SUS-ITMY_OPLEV_YERROR 29.223 -0.062 16.418 5.5 53.0
```

- **GPS: 959203840** **Omicron generates 6 aux. channel triggers in 32-4096 Hz**
  - Trigger time: 959203889.812, f_DARM = 34.3594Hz
  - AuxChannel Triggers : OM_TRGS_959203889.812.txt
  - Vetoed Triggers by Hveto

central time	central frequency	SNR
959203889.719662	343.000000	42.642584
959203889.732216	513.000000	22.154909

  - Correlation Matrix by CAGMon

Kendall's tau	MIC	Pearson R
		

trg_time trg_time trg_time

  - Channel List by CAGMon

Channel Name	Frequency Range	Pearson R	Ktau	MIC
L1_OMC-QPD3_P_OUT_DAQ_8_1024	64-128	0.02	0.04	0.43
L1_TSC-ITMX_PD_ISS_OUT_AC_8_1024	64-128	0.02	0.01	0.31

https://kgwg.nims.re.kr/cbcwiki/CAGMonKW

CAGMon

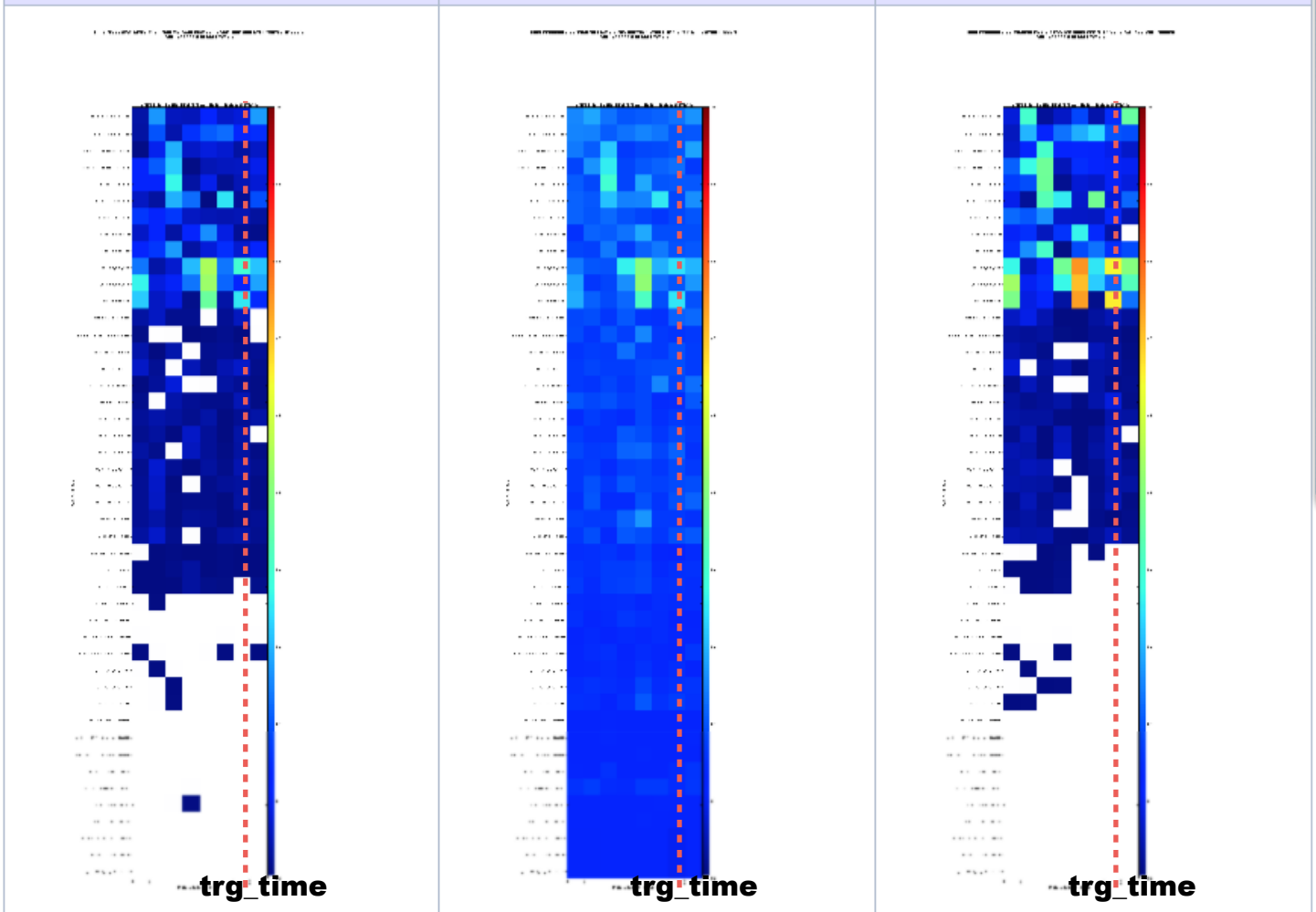
Kleine-Welle generates 46 aux. channel triggers in 32-4096 Hz

- **GPS: 95930604**
  - Trigger time: 959306063.410, f_DARM = 41.25Hz
  - AuxChannel Triggers : KW_TRGS_959306063.41.txt
  - Vetoed Triggers by Hveto

central time	central frequency	SNR
959306063.406043	69.000000	24.056600

  - Correlation Matrix by CAGMon

Kendall's tau	MIC	Pearson R



GPS(sec+ms) 959306063.0 410.0 SNR 9.07 signf 38.25
ChIndx ChName signf dt dur freq npts
84 L0_PEM-BSC2_ACCY_8_1024 15.02 -1.227 0.002 1024.0 2.0
101 L0_PEM-LVEA_MAGY_1_1024 17.9 1.55 0.016 88.0 2.0
102 L0_PEM-LVEA_MAGZ_1_1024 31.61 0.686 0.125 51.0 6.0
103 L0_PEM-EX_MAGX_1_1024 17.2 -0.117 0.008 184.0 3.0
104 L0_PEM-EX_MAGY_1_1024 17.21 1.898 0.5 4.0 3.0
105 L0_PEM-EX_MAGZ_1_1024 31.57 1.554 0.062 44.0 4.0
110 L0_PEM-EY_V1_8_1024 20.76 2.663 0.004 383.0 2.0
111 L0_PEM-RADIO_ROOF_8_1024 19.41 0.224 0.002 512.0 1.0
115 L0_PEM-LVEA_MIC_32_2048 15.01 -0.33 0.004 256.0 1.0
116 L0_PEM-LVEA_MIC_1024_4096 19.99 0.07 0.001 3516.0 3.0
121 L1_OMC-PZT_VMON_DC_OUT_DAQ_8_256 16.6 -0.449 0.016 108.0 2.0
123 L1_OMC-ASC_POS_X_IN1_DAQ_8_1024 28.47 -0.329 0.018 356.0 5.0
125 L1_OMC-QPD3_Y_OUT_DAQ_8_1024 15.11 4.557 0.002 1024.0 2.0
134 L1_ISI-OMC_GEOPF_V1_IN1_DAQ_8_1024 21.07 -0.313 0.008 325.0 3.0
140 L1_ISI-OMC_CONT_RX_IN1_DAQ_8_1024 17.77 4.246 0.002 823.0 2.0
141 L1_ISI-OMC_CONT_RY_IN1_DAQ_8_1024 18.17 -0.125 0.003 744.0 3.0
144 L1_OMC-DUOTONE_OUT_DAQ_1024_4096 16.14 0.306 0.001 2770.0 3.0
153 L1_OMC-QPD1_P_OUT_DAQ_32_2048 19.1 -0.006 0.062 49.0 3.0
154 L1_OMC-QPD2_P_OUT_DAQ_32_2048 63.01 -0.005 0.078 59.0 7.0
155 L1_OMC-QPD2_Y_OUT_DAQ_32_2048 16.68 0.84 0.001 2048.0 2.0
158 L1_LSC-POB_Q_32_2048 24.9 -2.774 0.055 75.0 3.0
159 L1_LSC-POB_Q_1024_4096 16.15 -2.134 0.001 2048.0 2.0
160 L1_LSC-POB_I_32_2048 24.7 0.037 0.078 39.0 3.0
162 L1_LSC-REFL_Q_32_2048 118.15 -0.058 0.062 74.0 8.0
163 L1_LSC-REFL_I_32_2048 44.66 -0.001 0.023 344.0 6.0
164 L1_LSC-REFL_I_1024_4096 33.03 -0.015 0.004 1590.0 6.0
165 L1_LSC-MICH_CTRL_32_2048 23.08 -2.774 0.055 76.0 3.0
166 L1_LSC-PRC_CTRL_32_2048 22.3 0.038 0.078 39.0 3.0
167 L1_LSC-MC_L_32_2048 39.22 -0.001 0.023 295.0 6.0
172 L1_LSC-ETMX_CAL_32_2048 15.66 -0.311 0.001 1704.0 3.0
175 L1_LSC-ETMY_CAL_1024_4096 15.41 -0.005 0.001 2048.0 2.0
181 L1_ASC-WFS1_QY_8_256 17.72 1.619 0.062 46.0 4.0
182 L1_ASC-WFS1_QP_8_256 17.79 -0.32 0.062 58.0 3.0
184 L1_ASC-WFS2_IP_8_256 16.65 0.022 0.047 61.0 3.0
186 L1_ASC-WFS2_QP_8_256 21.53 -3.54 0.047 74.0 4.0
187 L1_ASC-WFS3_IY_8_256 23.06 -0.039 0.031 64.0 2.0
188 L1_ASC-WFS3_IP_8_256 307.44 -0.051 0.098 75.0 10.0
189 L1_ASC-WFS4_IY_8_256 17.82 0.194 0.004 256.0 1.0
190 L1_ASC-WFS4_IP_8_256 264.25 -0.048 0.094 72.0 10.0
194 L1_ASC-ETMX_Y_8_256 21.23 -0.036 0.031 64.0 2.0
195 L1_ASC-ETMX_P_8_256 243.61 -0.031 0.133 60.0 12.0
196 L1_ASC-ETMY_Y_8_256 17.87 -0.047 0.031 64.0 2.0
197 L1_ASC-ETMY_P_8_256 228.3 -0.042 0.113 71.0 13.0
198 L1_ASC-ITMX_Y_8_256 15.52 -4.545 0.016 166.0 3.0
199 L1_ASC-ITMX_P_8_256 178.05 -0.023 0.156 52.0 13.0
200 L1_ASC-ITMY_Y_8_256 18.12 0.193 0.012 214.0 3.0
201 L1_ASC-ITMY_P_8_256 264.66 -0.004 0.156 69.0 17.0
202 L1_ASC-RM_Y_8_256 41.98 -0.041 0.047 64.0 3.0
203 L1_ASC-RM_P_8_256 281.89 -0.046 0.25 60.0 16.0
206 L1_SUS-ETMX_OPLEV_PERROR_8_256 15.5 -3.326 0.125 13.0 2.0

https://kgwg.nims.re.kr/cbcwiki/CAGMonKW

CAGMon

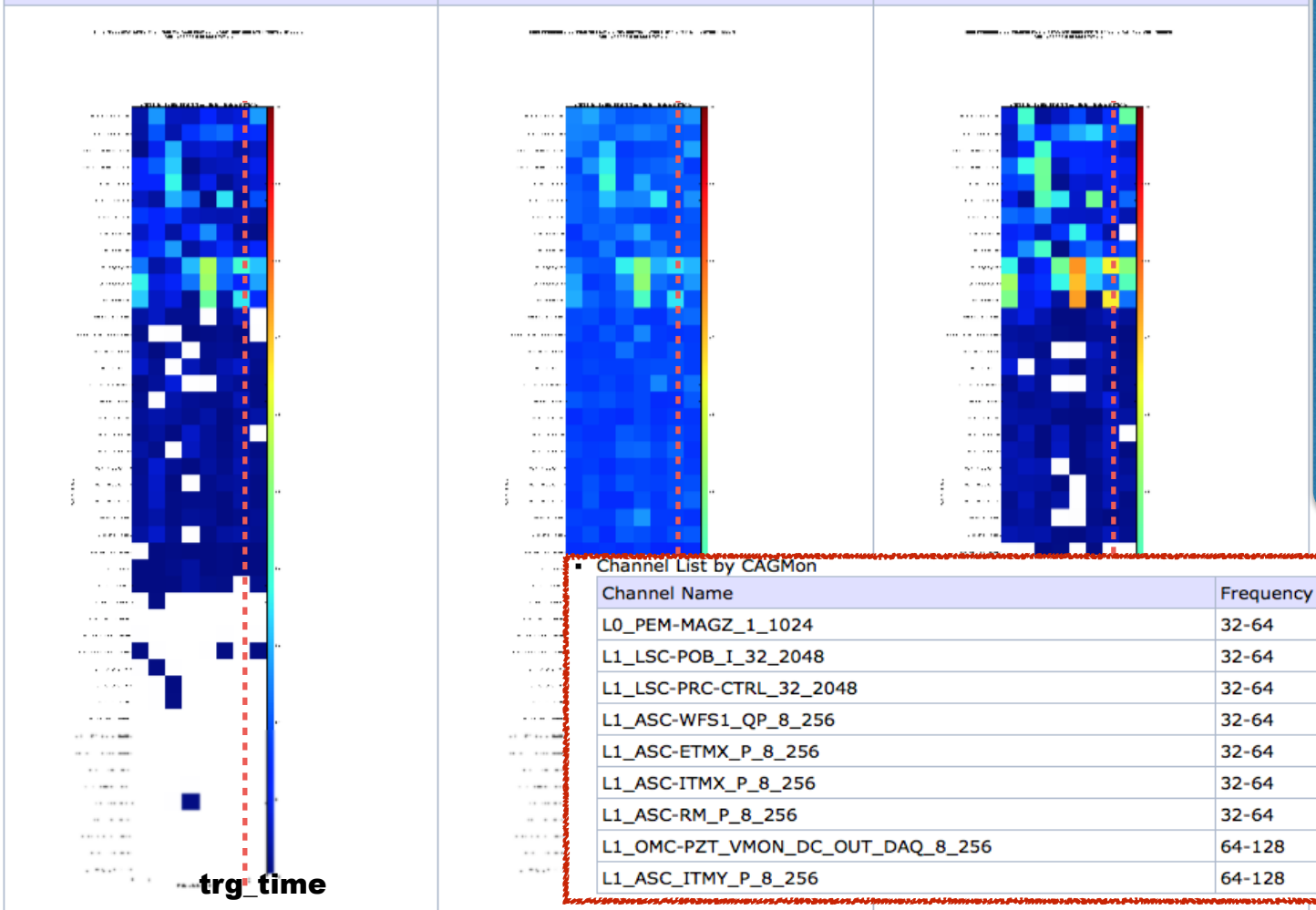
Kleine-Welle generates 46 aux. channel triggers in 32-4096 Hz

- **GPS: 95930604**
  - Trigger time: 959306063.410, f_DARM = 41.25Hz
  - AuxChannel Triggers : KW_TRGS_959306063.41.txt
  - Vetoed Triggers by Hveto

central time	central frequency	SNR
959306063.406043	69.000000	24.056600

  - Correlation Matrix by CAGMon

Kendall's tau	MIC	Pearson R



GPS(sec+ms) 959306063.0 410.0 SNR 9.07 signf 38.25
ChIndx ChName signf dt dur freq npts
84 L0_PEM-BSC2_ACCY_8_1024 15.02 -1.227 0.002 1024.0 2.0
101 L0_PEM-LVEA_MAGY_1_1024 17.9 1.55 0.016 88.0 2.0
102 L0_PEM-LVEA_MAGZ_1_1024 31.61 0.686 0.125 51.0 6.0
103 L0_PEM-EX_MAGX_1_1024 17.2 -0.117 0.008 184.0 3.0
104 L0_PEM-EX_MAGY_1_1024 17.21 1.898 0.5 4.0 3.0
105 L0_PEM-EX_MAGZ_1_1024 31.57 1.554 0.062 44.0 4.0
110 L0_PEM-EY_V1_8_1024 20.76 2.663 0.004 383.0 2.0
111 L0_PEM-RADIO_ROOF_8_1024 19.41 0.224 0.002 512.0 1.0
115 L0_PEM-LVEA_MIC_32_2048 15.01 -0.33 0.004 256.0 1.0
116 L0_PEM-LVEA_MIC_1024_4096 19.99 0.07 0.001 3516.0 3.0
121 L1_OMC-PZT_VMON_DC_OUT_DAQ_8_256 16.6 -0.449 0.016 108.0 2.0
123 L1_OMC-ASC_POS_X_IN1_DAQ_8_1024 28.47 -0.329 0.018 356.0 5.0
125 L1_OMC-QPD3_Y_OUT_DAQ_8_1024 15.11 4.557 0.002 1024.0 2.0
134 L1_ISI-OMC_GEOPF_V1_IN1_DAQ_8_1024 21.07 -0.313 0.008 325.0 3.0
140 L1_ISI-OMC_CONT_RX_IN1_DAQ_8_1024 17.77 4.246 0.002 823.0 2.0
141 L1_ISI-OMC_CONT_RY_IN1_DAQ_8_1024 18.17 -0.125 0.003 744.0 3.0
144 L1_OMC-DUOTONE_OUT_DAQ_1024_4096 16.14 0.306 0.001 2770.0 3.0
153 L1_OMC-QPD1_P_OUT_DAQ_32_2048 19.1 -0.006 0.062 49.0 3.0
154 L1_OMC-QPD2_P_OUT_DAQ_32_2048 63.01 -0.005 0.078 59.0 7.0
155 L1_OMC-QPD2_Y_OUT_DAQ_32_2048 16.68 0.84 0.001 2048.0 2.0
158 L1_LSC-POB_Q_32_2048 24.9 -2.774 0.055 75.0 3.0
159 L1_LSC-POB_Q_1024_4096 16.15 -2.134 0.001 2048.0 2.0
160 L1_LSC-POB_I_32_2048 24.7 0.037 0.078 39.0 3.0
162 L1_LSC-REFL_Q_32_2048 118.15 -0.058 0.062 74.0 8.0
163 L1_LSC-REFL_I_32_2048 44.66 -0.001 0.023 344.0 6.0
164 L1_LSC-REFL_I_1024_4096 33.03 -0.015 0.004 1590.0 6.0
165 L1_LSC-MICH_CTRL_32_2048 23.08 -2.774 0.055 76.0 3.0
166 L1_LSC-PRC_CTRL_32_2048 22.3 0.038 0.078 39.0 3.0
167 L1_LSC-MC_L_32_2048 39.22 -0.001 0.023 295.0 6.0
172 L1_LSC-ETMX_CAL_32_2048 15.66 -0.311 0.001 1704.0 3.0
175 L1_LSC-ETMY_CAL_1024_4096 15.41 -0.005 0.001 2048.0 2.0
181 L1_ASC-WFS1_QY_8_256 17.72 1.619 0.062 46.0 4.0
182 L1_ASC-WFS1_QP_8_256 17.79 -0.32 0.062 58.0 3.0
184 L1_ASC-WFS2_IP_8_256 16.65 0.022 0.047 61.0 3.0
186 L1_ASC-WFS2_QP_8_256 21.53 -3.54 0.047 74.0 4.0
187 L1_ASC-WFS3_IY_8_256 23.06 -0.039 0.031 64.0 2.0
188 L1_ASC-WFS3_IP_8_256 307.44 -0.051 0.098 75.0 10.0
189 L1_ASC-WFS4_IY_8_256 17.82 0.194 0.004 256.0 1.0
190 L1_ASC-WFS4_IP_8_256 264.25 -0.048 0.094 72.0 10.0
194 L1_ASC-ETMX_Y_8_256 21.23 -0.036 0.031 64.0 2.0
195 L1_ASC-ETMX_P_8_256 243.61 -0.031 0.133 60.0 12.0
196 L1_ASC-ETMY_Y_8_256 17.87 -0.047 0.031 64.0 2.0
197 L1_ASC-ETMY_P_8_256 228.3 -0.042 0.113 71.0 13.0
198 L1_ASC-ITMX_Y_8_256 15.52 -4.545 0.016 166.0 3.0
199 L1_ASC-ITMX_P_8_256 178.05 -0.023 0.156 52.0 13.0
200 L1_ASC-ITMY_Y_8_256 18.12 0.193 0.012 214.0 3.0
201 L1_ASC-ITMY_P_8_256 264.66 -0.004 0.156 69.0 17.0
202 L1_ASC-RM_Y_8_256 41.98 -0.041 0.047 64.0 3.0
203 L1_ASC-RM_P_8_256 281.89 -0.046 0.25 60.0 16.0
206 L1_SUS-ETMX_OPLEV_PERROR_8_256 15.5 -3.326 0.125 13.0 2.0

- Channel List by CAGMon

Channel Name	Frequency Range	Pearson R	Ktau	MIC
L0_PEM-MAGZ_1_1024	32-64	0.29	0.21	0.25
L1_LSC-POB_I_32_2048	32-64	0.07	0.10	0.29
L1_LSC-PRC-CTRL_32_2048	32-64	0.07	0.01	0.25
L1_ASC-WFS1_QP_8_256	32-64	0.37	0.27	0.29
L1_ASC-ETMX_P_8_256	32-64	0.75	0.55	0.50
L1_ASC-ITMX_P_8_256	32-64	0.71	0.53	0.52
L1_ASC-RM_P_8_256	32-64	0.74	0.46	0.42
L1_OMC-PZT_VMON_DC_OUT_DAQ_8_256	64-128	0.01	0.01	0.25
L1_ASC_ITMY_P_8_256	64-128	0.00	0.02	0.27

CAGMon

- Strategy:
  - More studies on Triggers, Up-conversions?
  - Code automation
  - Visual Interface for Monitoring tools
  - …