

Intersite Environmental Transients

E5, E6, and E7 investigations



lightningphotography.com

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Power grid details

- LHO and LLO sectors connected by 6 AC-DC-AC ties.
- Both sides reference frequency to GPS
- When a clock tied to the generated frequency deviates from a GPS clock by 10s (Eastern Interconnection) or 2s (Western), time error correction is initiated.
- Target of 60.02 Hz or 58.98 Hz implemented until time error is within 6s (east) or 0.5s (west), then restored to 60.00 Hz.
- Time error correction is often initiated and terminated by telephone contact with power plants (variable delay).
- Operators may postpone correction for several reasons.
- Range from several corrections per day to once per month.
- Time error correction procedure is in a state of flux

Concerns

- Glitches may leak through AC-DC-AC ties.
 - Glitches or increased coherence may be produced by human and natural events that affect both sides (auroras, work schedules, lightning).
 - Long term coherence due to GPS frequency reference
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An algorithm for detecting the presence of temporally correlated bursts

- **Coincident event rates for aligned and offset LHO and LLO time series are compared.**
- **Skeleton: Masahiro Ito's glitchMon**
- **Signals that exceed sigma thresholds increment coincidence tables**
- **Coincidence tables are incremented into the future to allow for propagation delays (about 15 ms is used here).**
- **Multiple thresholds (and coincidence tables) to allow search for low-amplitude intersite events**
- **Time series are output for high threshold events**

Motivation

- **Know your enemy**
 - **Such bursts could produce coherence that drops off as LHO and LLO time series are misaligned**
 - **Event tool was not yet ready**
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Greater than chance coincidence for coil magnetometers but not voltage monitors

LLO and LHO Z-axis coil magnetometers:

L1:GDS-EY_TO2; H0:PEM-COIL_MAGZ

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
7.5	38	22	16	6.3
6.3	119	80	39	14
5.1	457	355	102	28
3.9	1892	1518	374	58
2.7	20765	19095	1670	200

LLO and LHO line voltage monitors:

L0:PEM-EX_V1; L0:PEM-LVEA_V2; L0:PEM-LVEA_V1; H0:PEM-MY_V1; H0:PEM-LVEA2_V2; H0:PEM-LVEA2_V1

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
16	27	29	-2	7.5
13.1	45	40	5	9.2
10.2	73	68	5	11.9
5.85	133	132	1	16
2.95	30318	30350	-32	246

210630 s of E5 data; only 1 event allowed each second; only 1 signal in excess of threshold demanded from each site.

Only chance coincidence for seismometers and MC control

210630 s of E5 data; only 1 event allowed each second; only 1 signal in excess of threshold demanded at each site.

LLO and LHO seismometers:

H0:PEM-LVEA_SEISX; H0:PEM-LVEA_SEISY; H0:PEM-LVEA_SEISZ; L0:PEM-LVEA_SEISX; L0:PEM-LVEA_SEISY; L0:PEM-LVEA_SEISZ

Threshold (sigma)	Events exceeding threshold	Offset time series events	(on - off)	sqrt(on+off)
6	15	10	5	4.6
5.1	21	15	6	6
4.2	100	96	4	14
3.3	14873	14687	186	172

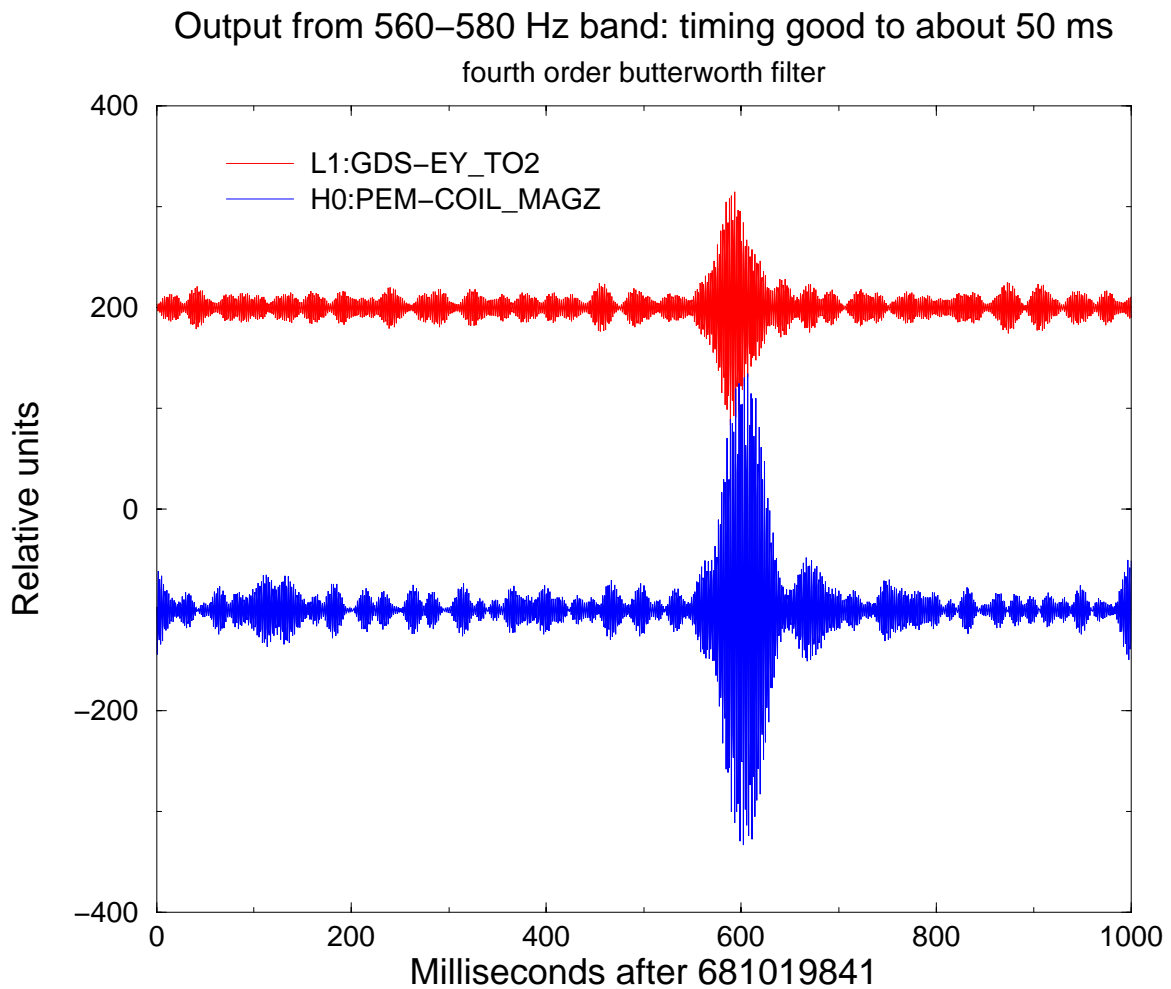
LLO and LHO mode cleaner control signals:

L0:PEL1:IOO-MC_F; H2:IOO-MC_F1

Threshold (sigma)	Events exceeding threshold	Offset time series events	(on - off)	sqrt(on+off)
6	61	59	2	11
5.1	91	80	11	13
4.2	168	146	22	18
3.3	3160	3176	-16	80
2.85	24168	24099	69	220

Intersite coil magnetometer event

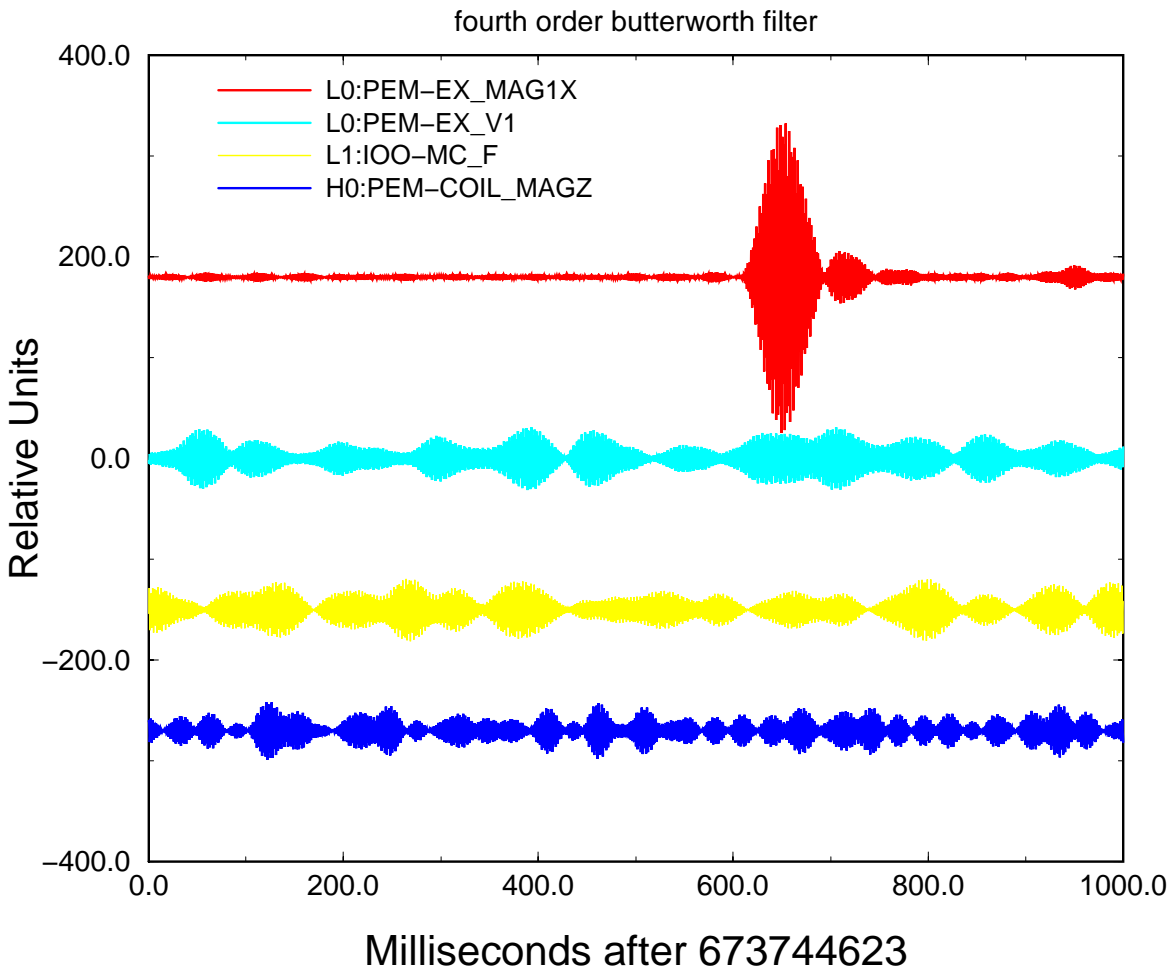
Possible lightning strike



Largest tabulated i/r during E4 (129kA, 20km)

Lightning strike on fluxgate magnetometer but not other channels.

Output from 560–580 Hz band: timing good to about 50 ms.



Summary

- **Stand alone code has been developed to search for correlated intersite events by comparing coincidences (15 ms window) for aligned and misaligned time series.**
 - **Detected high rates of intersite bursts on coil magnetometers (probably lightning)**
 - **Did not detect intersite bursts for voltage monitors, seismometers, MC_F, fluxgate magnetometers**
 - **No evidence yet of lightning strikes on other channels**
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