# REPORT FROM THE DETECTOR CHARACTERIZATION GROUP
# LSC 3 MEETING
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# DETECTOR CHARACTERIZATION

LSC Boulder Meeting, August 1998

- Data Reduction
- Transient Analysis
- Performance Characterization
- Simulated Data Sets



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# DATA REDUCTION

- reduced data sets
  - definition of reduced channel list
  - preprocessing: algorithm and methods
  - front-end decimation
- statistical description of auxiliary data
  - mean, std. dev., max/min, etc.
  - band-limited r.m.s. and ???
- data trending and averaging
  - reduced data rates
  - on-line vs. off-line
  - plots
- removal of cross-coupling terms
- artifact removal (e.g. lines)
- events and veto analysis
  - triggers, multiple sensor trigger logic
  - history

# TRANSIENT ANALYSIS

- detection of bursts, damped sine waves, glitches, digital errors, etc.
  - servo instabilities
    - short term oscillations
    - gain peaking
    - damped sine waves
  - digital artifacts
    - missing data & duplicated data
    - bit errors & 'sticky' bits
    - discontinuities
  - events in the physical environment
    - earthquakes in seismic sensors
    - peaks in the acoustics sensors and accelerometers
    - lightening strikes in el.magn. sensors
    - wind burst / extreme rain showers (?)
    - cosmic showers
    - ...
- event classification
- coincidence analysis



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# TRANSIENT ANALYSIS METHODS AND ALGORITHMS

- methods:
  - band-limited r.m.s
  - time-frequency analysis (short FFTs)
  - wavelets
  - matched filters
  - threshold on derivatives
  - ???
- tools:
  - histograms
  - sonagrams
  - pulse height statistics
  - Matlab, C, FORTRAN, and ???

# PERFORMANCE CHARACTERIZATION

- ❑ overall measures
  - ○ max. viewing distance for standard inspiral
  - ○ strain sensitivity at 150 Hz
  - ○ frequency of glitches/loss of lock (?)
  - ○ multiple sensor summaries (?)
- ❑ monitoring of dark port noise coupling coefficients
- ❑ compare real-world performance with models
  - ○ E2E model
  - ○ ISC servo models
  - ○ SEI stack models
  - ○ etc.
- ❑ system identification for adaptive control (?)
- ❑ calibration

# PERFORMANCE CHAR. METHODS AND ALGORITHMS

- ❑ principle value decomposition
- ❑ stimulus-response tests
  - ❍ global diagnostics system
- ❑ real-time analysis
- ❑ 'executive' summaries (?)
- ❑ overall performance monitor screen (?)
  - ❍ web accessible (?)

# SIMULATED DATA SETS

- time series of standard detector noise
- 'fake' sources: real and background
- detector response & astronomical position corrections

# SIMULATED DATA SETS POSSIBLE PROBLEMS

- investigation of background (events/signals produced by non GW sources)
  - triggers and subtraction of artifacts:
    - spikes (ADC errors, etc.)
    - steps (e.g. due to a state transition)
    - discontinuities (e.g. due to saturations)
    - lines (looks like everybody is doing this already!)
    - increased r.m.s. in a frequency band (e.g. due to gain peaking)
    - bursts (e.g. due to a hammer)
    - hardware malfunction
  - non-gaussian analysis (e.g. pulse height statistics)
  - algorithms/templates to identify whee-dwangies (damped sine waves)
  - environmental cross-correlations / vetos
  - advantage/disadvantage of whitening/dewhitening
  - classification
    - suitability of algorithms (e.g. wavelet)
    - strategy for identification
    - catalogue format

# SIMULATED DATA SETS POSSIBLE PROBLEMS (2)

- detector sensitivity improvements by subtracting seismic
  - how good can it be done?
    - limits due to non-linear effects
    - limits due to knowledge of exact excitation
  - are PEM sensors at the right location?
  - the usefulness of principle value decomposition
  - what effect has it on the S/N of inspirals
- to support the search for periodic sources
  - effects of windowing and data splicing (due to ifo lock sequences)
  - best way to do Doppler corrections in time series
  - effect of whitening/dewhitening
  - improvements due to artifact removal(?)
  - improvements due to frequency cut-offs(?)
  - directional information
  - multiple detector analysis



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# SIMULATED DATA SETS POSSIBLE PROBLEMS (3)

- to support the search for burst events
  - detector antenna functions
  - GW polarization effects
  - algorithms to identify burst sources
  - detector correlations
  - effects of adding time series of different detectors (e.g. for correlation with gamma-ray bursts)
  - rejection strategies (vetos)
  - candidate classification
- stochastic background (non GW)
  - detector cross-correlation analysis algorithms
  - non-gaussian noise probabilities & histograms
  - classification strategies
- calibration
  - corrections applied before or after analysis?
  - strategies for verification and monitoring
  - analysis problems induced by drifts

# DATA REDUCTION

- Reduced data sets
  J.B. → couple of important channels
  + everything else at 1Hz rate

- Trending
  - statistical descr. : mean, std. dev., min, max, r.m.s., etc.
  - decimation methods

- Subtraction of artifacts
  - lines
  - cross-coupling terms (PVD)

- Visualization tools
  - standard package:
    K. R. → Matlab / Root

# TRANSIENT ANALYSIS

- Waveform analysis
  - band-limited ms.
  - time freq. analysis
  - wavelets
  - matched filters
  - threshold on derivatives

- Classification
  - event data format
  - event organization (database) look-up table

- Visualization Tools
  - histograms
  - sonagrams
  - pulse height statistics

# SIMULATED DATA SETS

- standard noise
  - seismic
  - thermal
  - shot
  - wire resonances
- 'fake' sources
  - spikes
  - steps
  - glitches/wiggles
  - lines / oscillations
  - increased rms.
  - burst: short sine / peak
  - damped sine waves
- realistic GW sources
  - work with coordinate ASIS

o Utilities

- source trigger module
- ifo optical response
- whitening / dewhitening filters
- digitization module
- file input module
- file output module
- event capture
- event logic
- event history file out
- fan-out
- scanning function
- random noise generator
- general purpose digital filter
- time series slicer
- drift function generator

# PERFORMANCE CHARACTRIZATION

- Measures
  - seen volume for Hd. inspiral
  - strain sens. at 150Hz
  - frequency of glitches / loss of lock
  - multiple sensor summaries
  - web summary
- Monitoring of clock port noise coupling coefficients
  - PVD
  - ~~periodic~~ swept sine
- Calibration
  - arrival time
  - amplitude
  - drift
- System identification for adaptive control (?)

*Note 1, Linda Turner, 08/20/98 11:43:50 AM*
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