LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

- LIGO –

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Update on analysis methods for externally triggered search with S2 data

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Types of triggered searches

- Single trigger
  - Upper limits / Interval estimates
  - Detection
- *Combining multiple triggers*
  - Improves SNR
  - But can only infer GRB population averaged properties
- Single trigger analysis important for experience
  - Main emphasis at present on single trigger analysis (with good directional error box).

Triggered search strategy

- Fundamental feature: Ability to distinguish ‘off-source’ data allows modeling of noise.
- Accuracy of the noise model constrains reliability of inference
  - non-stationarity (~ minutes) is the main problem
- Sensitivity depends on the prior information available about signals
  - Astrophysics input

S1

Conditioning

•Identify / remove major lines (scatter reduced)
•Identify / remove bands to make cc distribution more stationary

Cross-correlation indicator χ

•$\Sigma x_i\, y_i$
•Conditioned data
•Parameter space: integration length, GW-GRB delay (FIXED). Also lag.

Confidence Interval

• FC98 table X
•Obtained Upper limit on h_{rms} (function of signal duty cycle)

S2

Several modifications.

Noise Study

•Monitors of non-stationarity
    •Individual time series
    •*Correlated time series*
•Model & simulate non-stationary noise

•Cross-correlation coefficient ("r-statistic")
•Optimum Kernel based cross-correlation (coefficient)
•Parameter space scan
    •Fix subset? $\Rightarrow$ optimization of fixed set
    •Maximize
•CORRGRAM: integration length / delay plane
    •Unifies all scanning type analyses
•Sensitivity tradeoffs

•Confidence belts for new indicators
    •dependence on SNR for optimized χ; Maximized χ case easier
•Frequency wise breakup
•Upper limits (non-unified) using injected signals
•Hypotheses tests (detection)
•on- & off-source ETG behavior

Cross-correlation coefficient

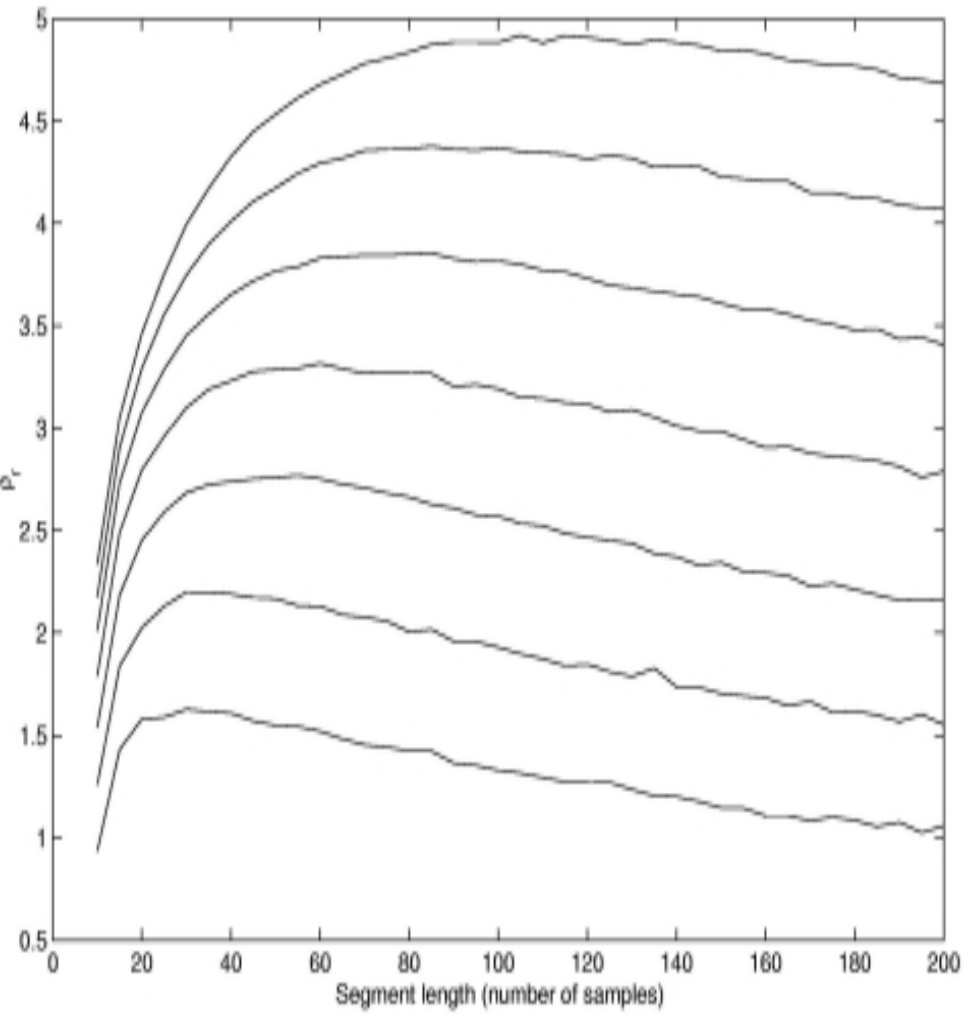
- Immune to rms fluctuations in individual time series.
  - Does not address non-stationarity of correlated component.
- Sampling distribution depends on integration length and signal properties.
  - T.W.Anderson, *An introduction to multivariate statistical analysis.*
- Optimum integration length depends on signal duration and SNR.
- Construction of FC confidence belt in progress.

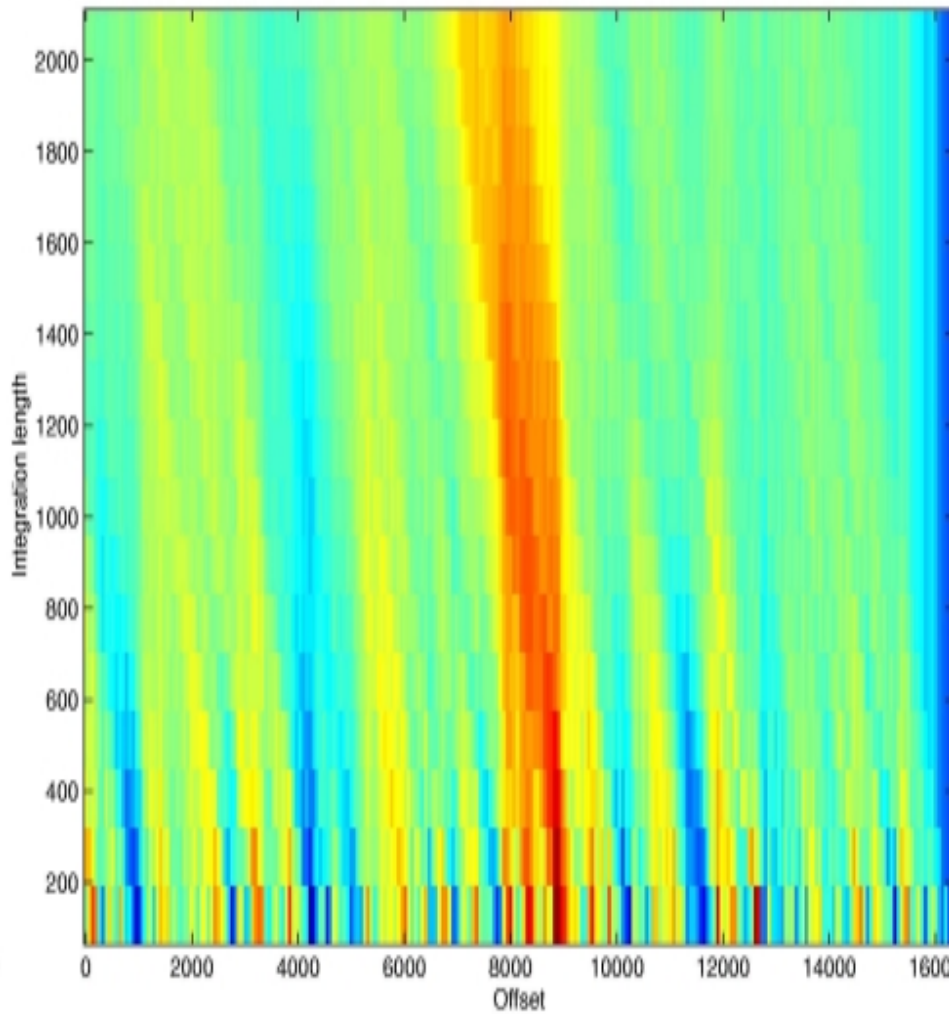
Scanning parameter space

- Integration length & delay between GW and GRB.
  - Lag, if directional errors are significant
- CORRGRAM: integration length – delay plane
  - Maximize over a sub-region of corrgram plane
  - Maximize along a line
- Where is the tradeoff point in sensitivity between scanning and non-scanning (S1) approaches?

Some results

- Dependence of optimum integration length on snr
- Sample Corrgram





Optimum kernel

- *Equivalent to first running matched filters and then cross-correlating outputs.*
- Allows introduction of prior signal information (upto power spectrum).
- Optimally weighs noise spectral density.
  - A matched filter first whitens the data
- Best implementation in non-stationary noise: time or FFT domain?

Signal injection

- Distribution of observable, χ, depends only on h_{rms} (after dc removal).
- Implication: a few waveforms are sufficient when using cross-correlation indicators.

S2 analysis – Noise study

- Effect of lines studied via simulations in S1.
  - Tolerance needs to be quantified
- Non-stationarity
  - of individual time series noise floor
  - of possible broad band cross-correlated component
- Monitoring tools in place
  - cc histograms (S1 analysis), BLRMS, MNFT.
  - Adapt tools to monitor broad band cross-correlation
- Model and Simulate to understand tolerance.

Details ...

- Informal notes at exttrigg web site.
  - Under CVS control.
  - Marked “in progress” if not final version.
  - LIGO tech note on methods to be submitted.
- Codes used for investigative studies also available.