Upper Limits from Loudest Events

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See Also:
Outline

- Loudest Event Rate Upper Limit
- Loudest Event Method vs. Fixed Threshold
- Rate vs. Strain Exclusion Curves
- Upper Limit on Strain
- Accounting for a Background
Basic Idea

- Observed Events
- Population Efficiency

Efficiency at Loudest Event $\epsilon$

Loudest Event $\rho_{\text{max}}$
Loudest Event Rate Upper Limit

Assume loudest event is from a signal (conservative upper limit)

Probability that no events would have SNR greater than loudest event SNR $\rho_{\text{max}}$:

$$p = e^{-RT\epsilon}$$

90% confidence (frequentist) upper limit:

$$p = 10\% \rightarrow R_{90\%} = \frac{2.3}{T \epsilon}$$
Loudest vs. Threshold

![Graph showing the relationship between threshold SNR level and 90% rate upper limit. The graph compares the threshold and loudest points.](image-url)
Rate vs. Strain
(Similar to S1 burst analysis)

\[ R_{90\%} = \frac{2.3}{T \epsilon(h)} \]

Rate Limit, \( R_{90\%} \)

Excluded
(90% confidence)

Allowed

Strain, \( h \)
Upper Limit on Strain

- Goal: bound GW flux rather than rate
  (Triggered Bursts, Pulsars)
- Assume only one signal is present
- Probability that this event would not exceed loudest event SNR:
  \[ P = 1 - \epsilon(h) \]
- 90% confidence (frequentist) upper limit:
  \[ P = 10\% \implies h_{90\%} = \epsilon^{-1}(90\%) \]
Background

- Probability that no background event would exceed the loudest event SNR: $P_B$
- Probability that no event (background or signal) would exceed the loudest event SNR:
  $$P = P_B e^{-RT\epsilon}$$
- 90% confidence (frequentist) upper limit:
  $$P = 10\% \rightarrow R_{90\%} = \frac{2.3 - |\ln P_B|}{T \epsilon}$$
Summary

- Upper limits often sensitive to SNR threshold
- Loudest event upper limits are often stronger than threshold-based limits
- Background information can be used to strengthen limit (conservative)
- Setting an upper limit does not preclude claiming a detection