Burst wave analysis of TAMA300 data with the ALF filter

and the TAMA collaboration
Abstract

• We present analysis status with ALF filter which is a kind of the slope filter.
• In our work, target signals are burst gravitational waves from stellar core collapses.
• We studied on detection efficiency for the galactic event and the trigger rate.
Contents

1. ALF filter
2. Optimization of window size
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1.1 ALF filter

Alternative Linear Fit filter  P.R.D 63, 042002 (2001)

The filter is expected to be Effective for burst signals.

**Basis idea**

- **slope : low**
  - Random noise

- **slope : high > threshold**
  - Burst signal

Event!
### 1.2 ALF filter

**Mathematical expression**

Fitting the data ($N$ samplings) to a linear function $\text{at} + \text{b}$

- **a** Slope  \hspace{1cm} **b** Offset

   
   **Normalization**

   $$X_a = \frac{a}{\sigma_a}, \quad X_b = \frac{b}{\sigma_b}$$

   $\sigma_a, \sigma_b$ its standard deviation

   
   Correlation between $X_a$ and $X_b$ should be taken into account.

   
   **output of ALF filter**

   $$A = \frac{X_a^2 + X_b^2 - 2\alpha X_a X_b}{1 - \alpha^2}$$

   $\alpha$ is a covariance of $X_a$ and $X_b$

- **example**

1kHz Sine-Gaussian signal + Gaussian noise

Output of ALF filter
2.1 Optimization of window sizes

Effective window size of $N$ depends on waveform and duration time of the signals.

Window size \{ too long, too short \} \rightarrow \text{Decrease of } A

\begin{itemize}
  \item 500Hz sine-Gaussian signal \hspace{1cm} N = 30
  \item 800Hz sine-Gaussian signal \hspace{1cm} N = 20
\end{itemize}

Optimization of $N$ is important for the filter.

We have to find an effective combination of window sizes for burst event search.

\textbf{Parameters to be selected}

1. number of windows; $p$
2. window size; $N_i$ ($i=1,p$)

\textit{For example},

A combination of window size $N=(10,20,30)$ \rightarrow $p=3$
2.2 Optimization of window sizes

Applied signal for parameter optimization → *sine-Gaussian signal 500Hz~2500Hz*

1. Optimal combination of window sizes for a given \( p \)

\[
\begin{align*}
   p & \quad \text{optimal window size } N \\
   2 & \quad (8,12) \\
   3 & \quad (8,12,18) \\
   4 & \quad (8,12,14,20) \\
   5 & \quad \ldots
\end{align*}
\]

2. Dependence of \( p \)

- \( p \) up → Detection probability up
- \( p > 3 \) derivative rate became less
- \( p = 4 \)  
  \[ N = (8,12,14,20) \]
3 Performance

Performance relative to Matched Filtering for the DFM catalogue signals

- burst signal
- background

Dimmelmeier et al. A&A 393 523

white noise

Performance

\[ N = (8, 12, 14, 20) \rightarrow 80\% \]

Detection efficiency for the galactic events

Data

- A part of TAMA300 DT9

Injection signal

- 26 kinds of signals from the DFM catalogue

Model

- A & A 125 1958

Detection efficiency

\[ h_{rss} \]

About 115 pc
4 Trigger rate

Processing data

About **360 hours** data of *DataTaking9* (24/12/2003 ~ 10/1/2004)

- Trigger rate with the filter (Events/sec)

Typical trigger rate \( A = 10^3 \) about 320pc \( \rightarrow 2.6 \times 10^{-2} \) (events/sec)
5 Summary and future work

Summary

• Study of ALF filter which is expected effective for burst event search
• Performance relative to Matched Filtering → 80%
• Typical trigger rate → $2.6 \times 10^{-2} \ (\text{events/sec})$ at 320pc

Future work

Reduction of fake events

Veto analysis

Upper limit