

The AURIGA-LIGO Joint Burst Search

L. Cadonati, G. Prodi, L. Baggio, S. Heng,
W. Johnson, A. Mion, S. Poggi, A. Ortolan,
F. Salemi, P. Sutton, G. Vedovato, M. Zanolin

GWDAW-9 December 18, 2004 Annecy, France

AURIGA-LIGO

First Coincidence Run

AURIGA AU1 run: Dec 24 2003 – Jan 14 2004

LIGO S3 run: Oct 31 2003 – Jan 9 2004

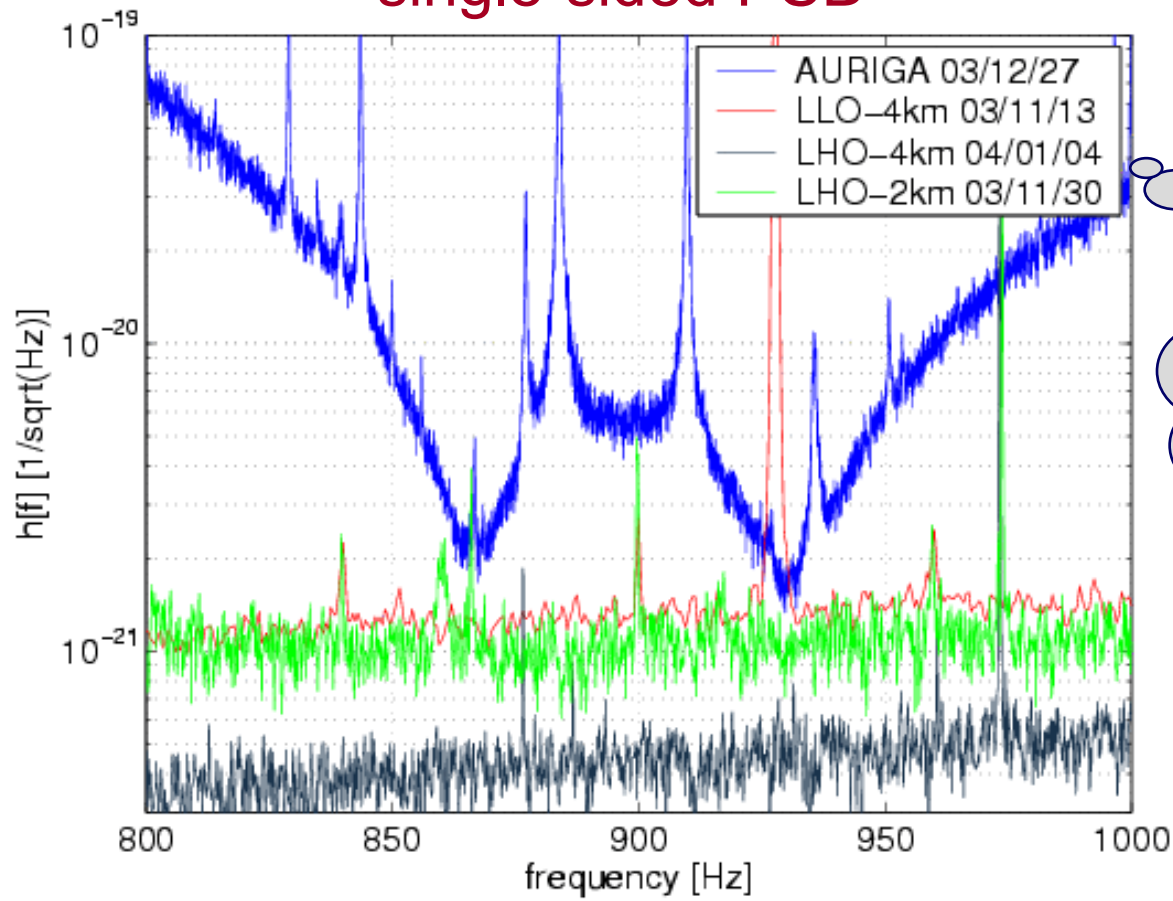
92 hours 4-fold coincidence

175 hours 3-fold coincidence

- MOU for S3/AU1 burst analysis signed in July 2004
 - » develop methodologies for bar/interferometer searches
 - » implement on real data a time coincidence, triggered based searches
 - » explore coherent methods
- Joint Working Group composition:
 - » AURIGA: G. Prodi, L. Baggio, A. Mion, A. Ortolan, S. Poggi, F. Salemi, G. Vedovato
 - » LSC: L. Cadonati, S. Heng, W. Johnson, P. Sutton, M. Zanolin
- Target analysis completion: spring 2005

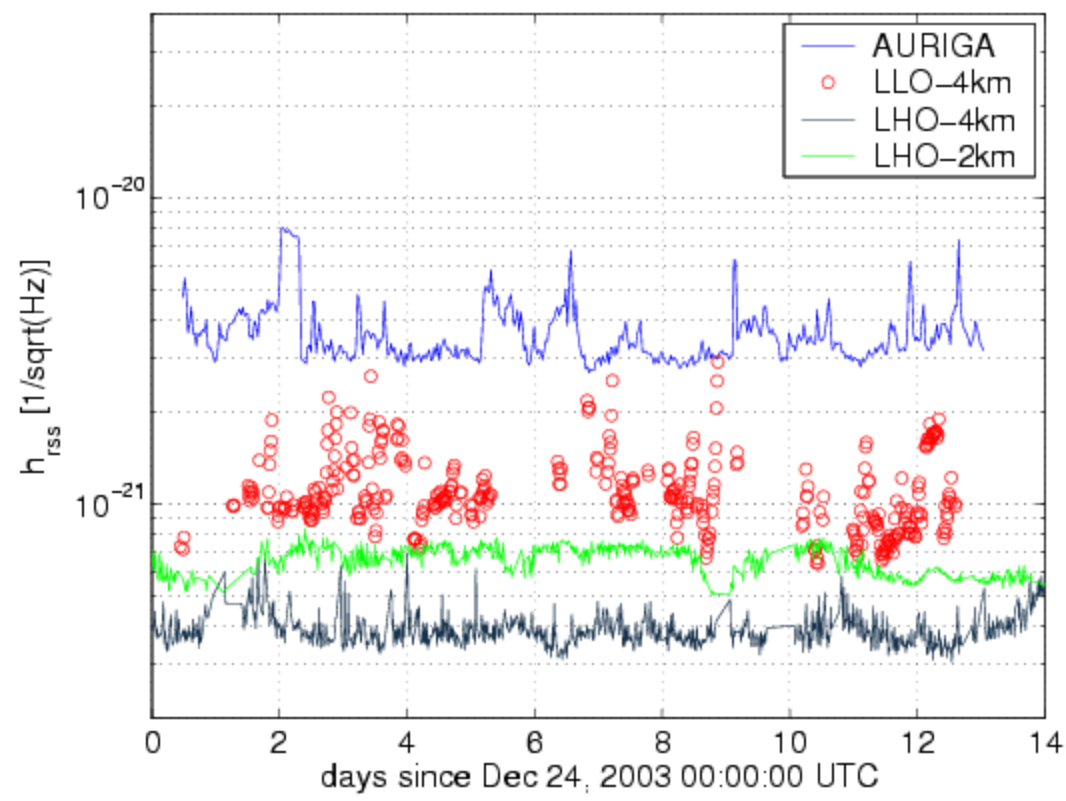
Sensitivity Spectra

single-sided PSD



best performance during the AU1 and the S3 run

Time Variability



$$h_{rss} = \sqrt{\int_0^{\infty} |h(t)|^2 dt} = \sqrt{\int_{-\infty}^{\infty} |\tilde{h}(f)|^2 df}$$

h_{rss} of Sine-Gaussian pulses with:
 $f_0 = 900\text{Hz}$
 $Q = 9$
 $\text{SNR } \rho = 1$

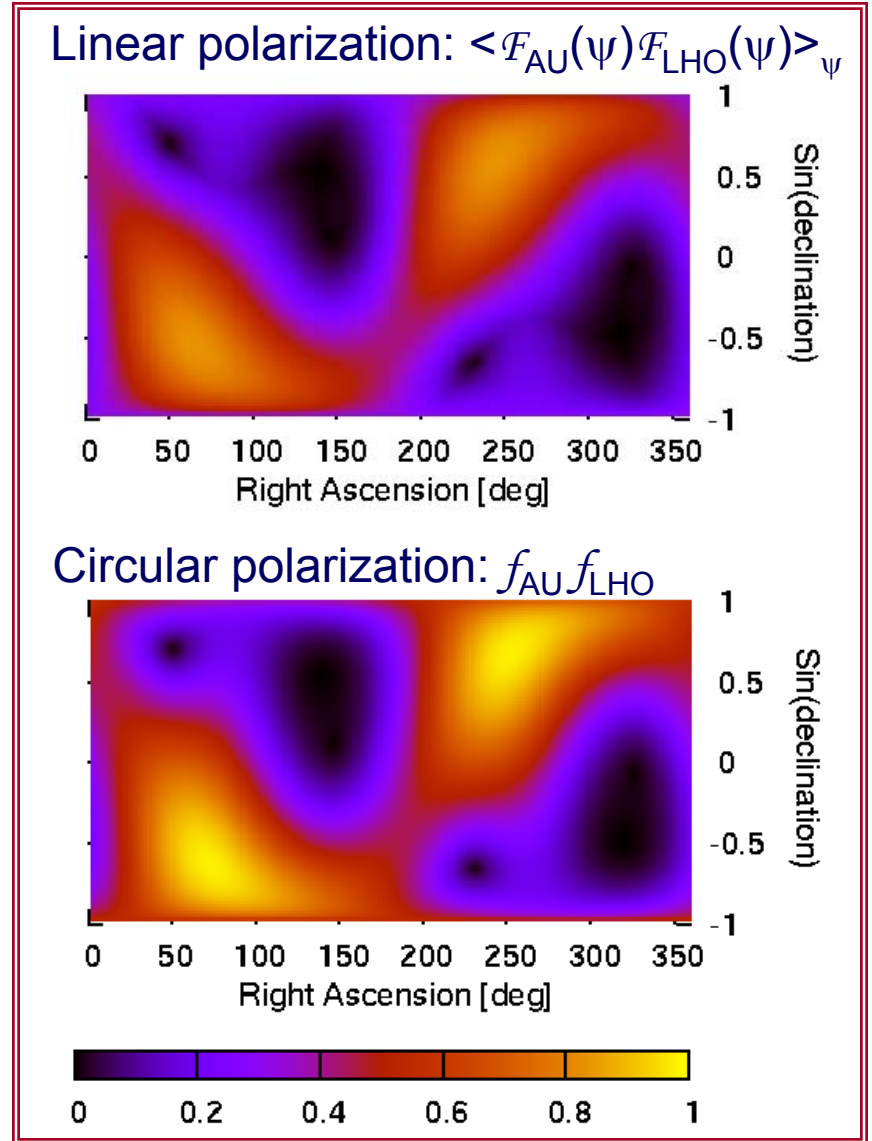
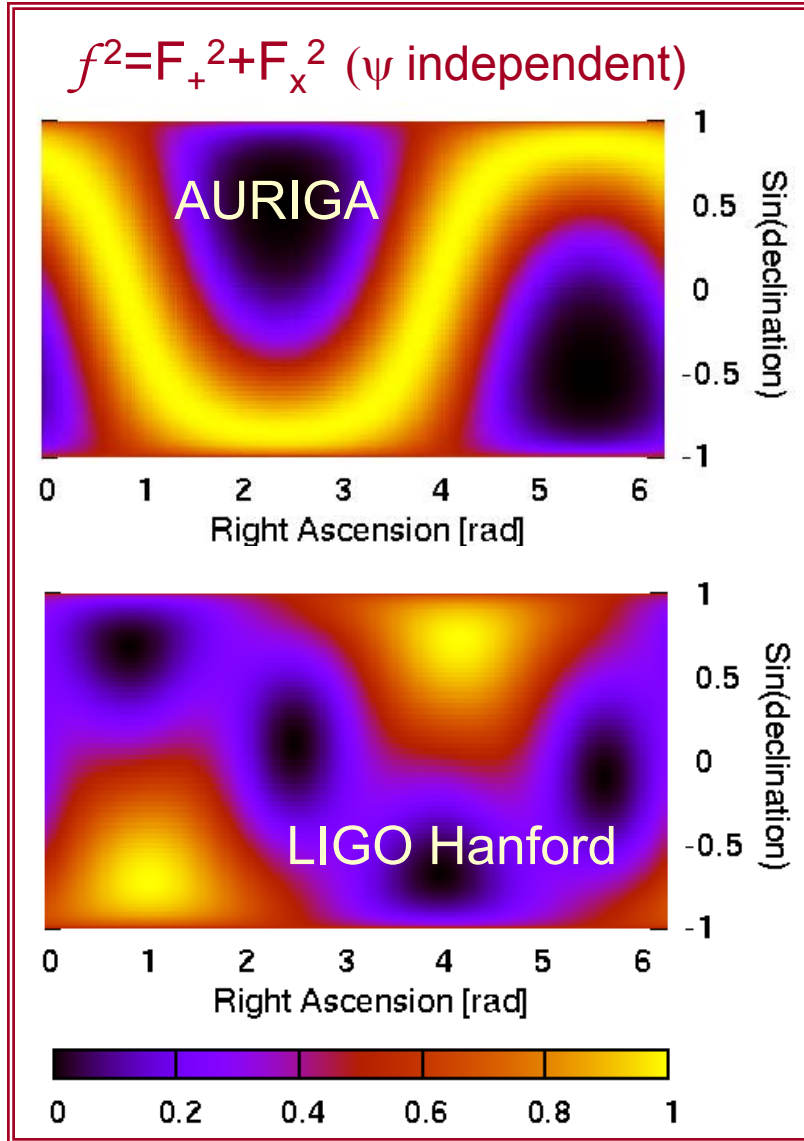
$$\rho = \left[4 \int_0^{\infty} df \frac{|\tilde{h}(f)|^2}{S(f)} \right]^{1/2}$$

Geometry Considerations

$$f^2 = F_+^2 + F_x^2$$

antenna pattern $F(\psi) = f \cos(2\psi + \delta)$

ψ = angle between wave frame and earth frame



Sky Coverage for LLO+LHO+AURIGA

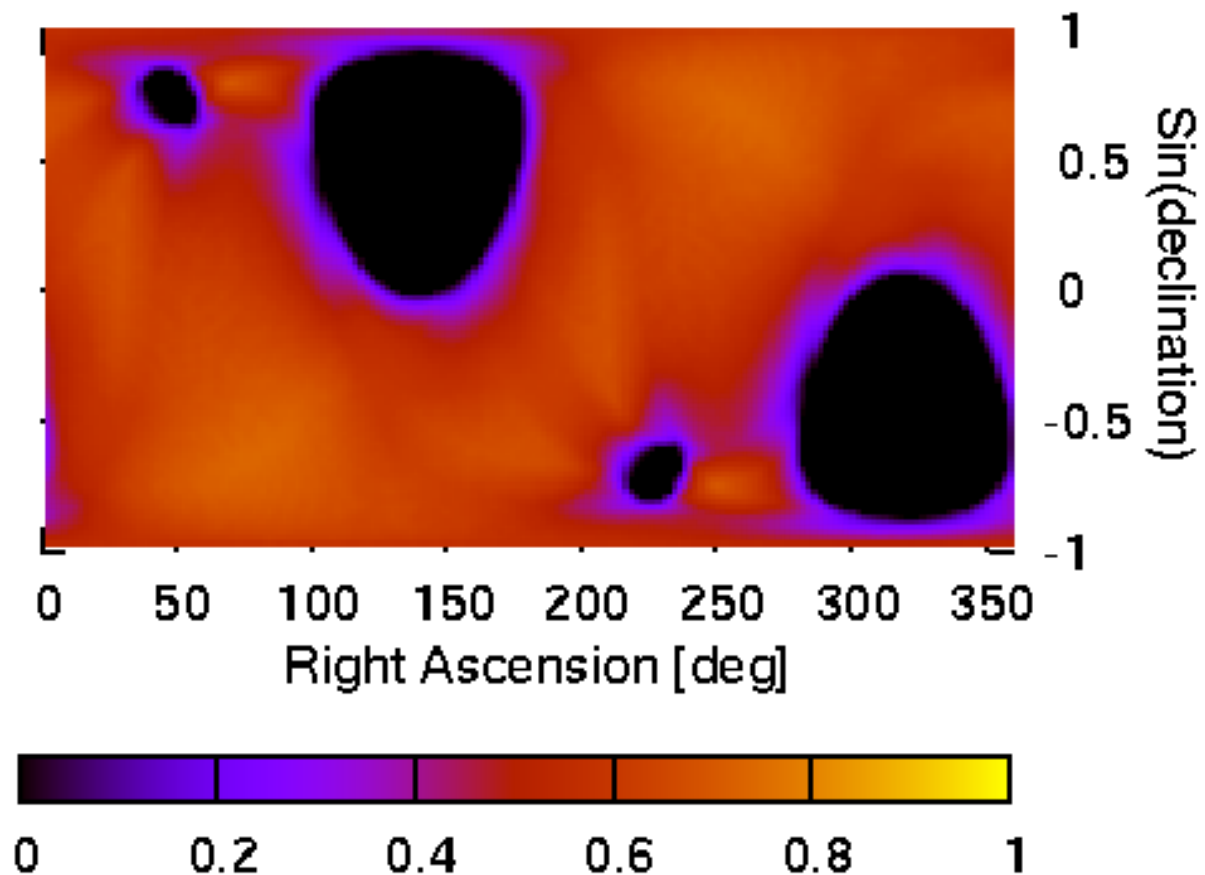
assumption:

1. gravitational waves are linearly polarized
2. AURIGA sensitivity is 1/3 of the LLO/LHO sensitivities

required:

1. $F(\psi) > 0.1$ at LLO, LHO
2. $F(\psi) > 0.3$ at AURIGA

the color scale represents the percentage of detectable polarizations



Scientific Motivation for a Joint Burst Analysis

1. False alarm rate suppression
2. Increased effective observation times
 - » i.e. combining all possible coincidences of 3 out of 4 or more detectors
3. Increased detection confidence
 - » waveform parameters can be estimated with at least 3 locations and enough time resolution (Gursel-Tinto, 1989)

General Strategy for a Trigger-based Analysis

- Data quality and veto performed “at home”
- Exchange SINGLE DETECTOR triggers
 - » peak time and its error
 - » homogenously defined amplitude A (BW 850-950Hz and broadband) and its error
- Exchange A_T (minimum detectable) versus time
- Blind analysis
 - » all tuning is performed on time-shifted data before “opening the box”
- Compare the measured test statistic to its background distribution
 - » background measured on a different set of time shifts
- Result interpretation
 - » directional analysis (optimized)
 - » all-sky search (using Monte Carlo for source position distribution)
 - » Results interpreted for sine-gaussians, damped sinusoids, Lazarus waveforms for BH-BH mergers ($10-20 M_{\odot}$)

Method 1: Directional Analysis

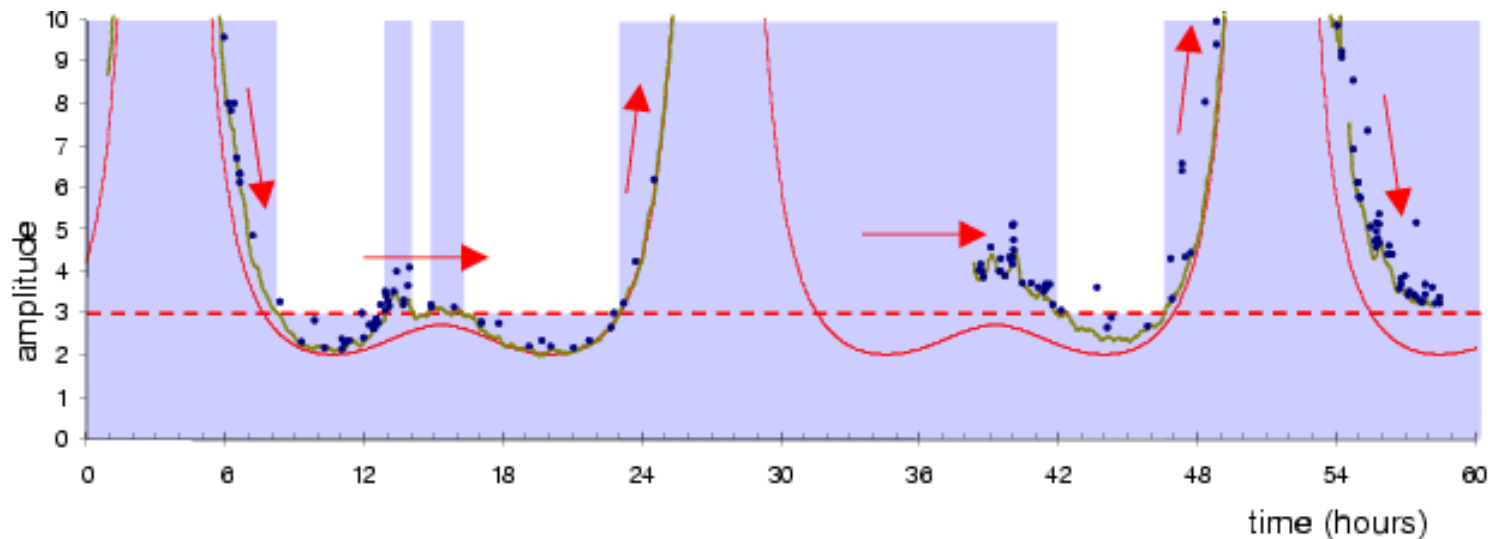
IGEC-style analysis, on a telescope of directions (see talk by Poggi)

New: account for polarizations

Use consistent definition of amplitude in all detectors.

Threshold on the event amplitude at each detector, scaled by the antenna pattern for the given direction.

Require coincidence of at least 3 detectors.



Method 2: “Eyes Wide Open”

No assumptions are made on direction or waveform.

A *CorrPower* search (see poster) is applied to the LIGO interferometers around the time of the AURIGA triggers.

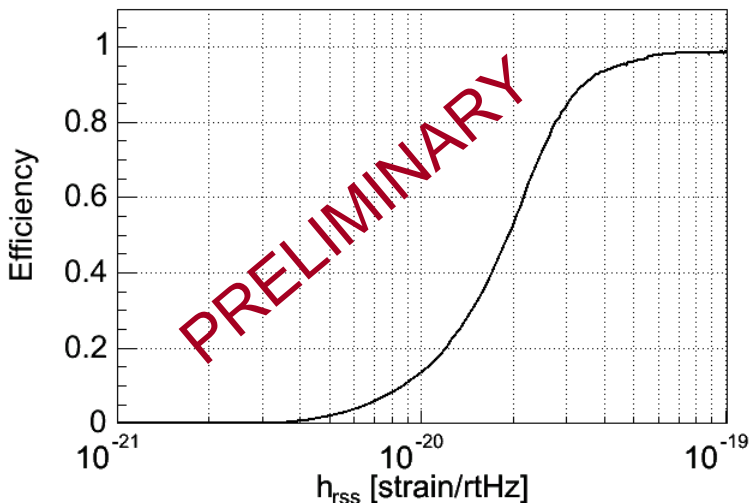
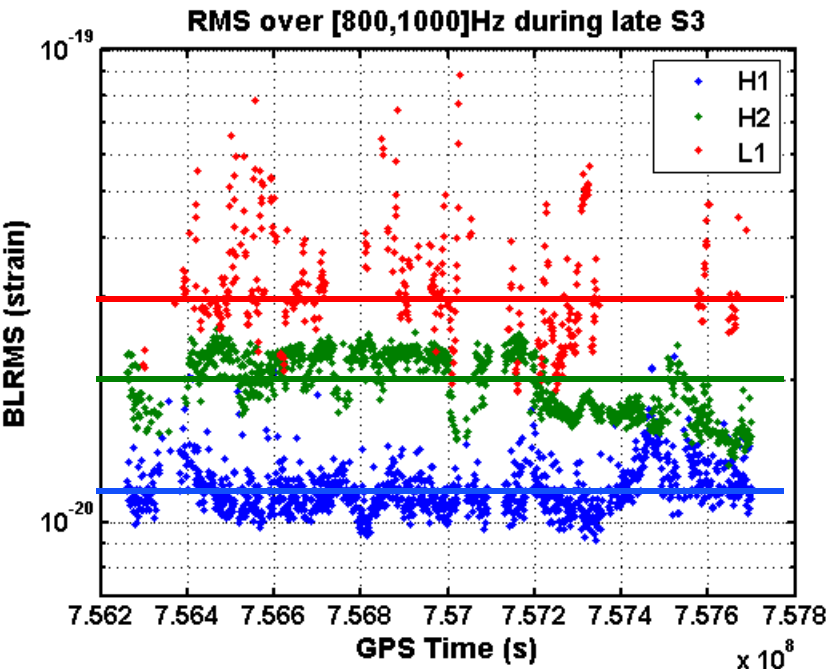
Efficiency for classes of waveforms and source population is performed through Monte Carlo simulation, LIGO-style (see talks by Zweizig, Yakushin, Klimenko).

The accidental rate (background) is obtained with unphysical time-shifts between data streams.

Sample Performance for Method 2



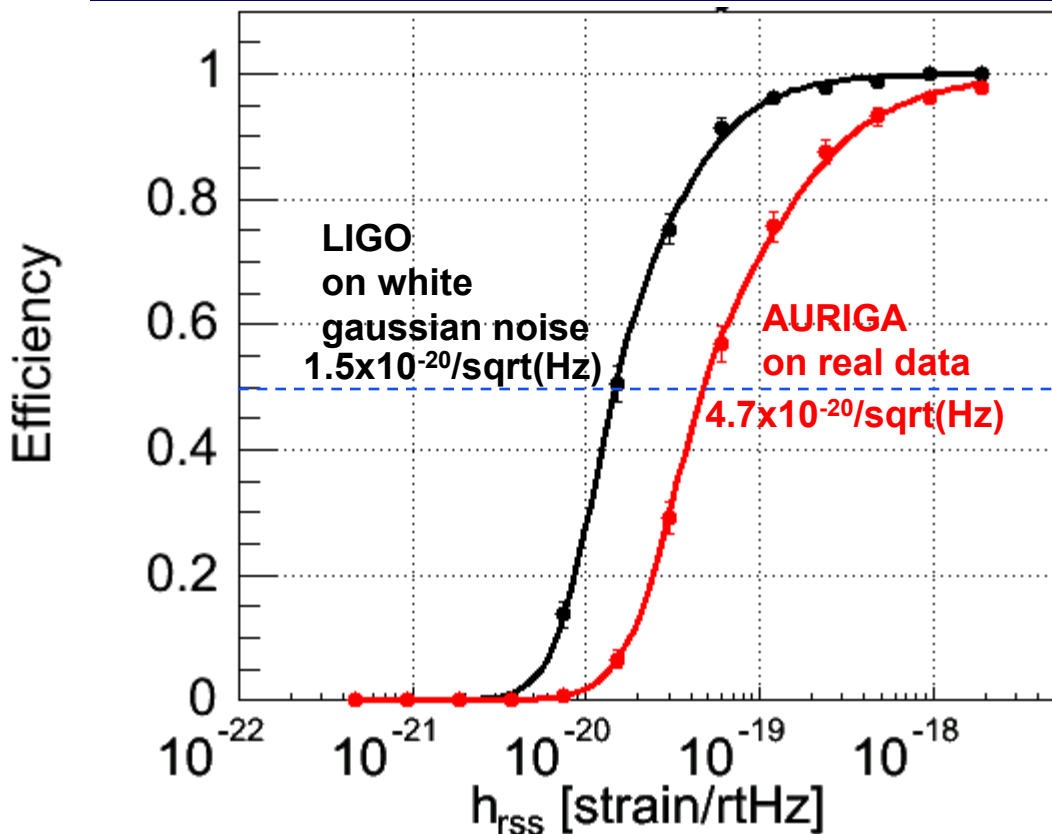
LIGO:
SIMULATED white gaussian noise matching median BLRMS during the AURIGA-LIGO coincidence run



AURIGA:
Monte Carlo average detection efficiency using δ -filter on sine-gaussians with $f_0=900\text{Hz}$ $Q=9$ and $\text{SNR}>4$ using **ACTUAL DATA** (no epoch veto)

Sample Performance for Method 2

LIGO and AURIGA efficiency for sine-gaussians with $f_0=900\text{Hz}$ $Q=9$



uniform polarization
all-sky distribution
over the AU1/S3 2-week period

SNR=4 threshold on AURIGA

Correlation confidence threshold on
CorrPower as in the S2 analysis
($\Gamma > 4$)

Network efficiency \sim product of the
two curves

The LIGO curve was
obtained on simulated data:
a performance degradation
is expected on real data

Summary and Outlook

A working group for the joint burst search in LIGO and AURIGA has been formed, with the purpose to:

- » develop methodologies for bar/interferometer searches, to be tested on real data
- » time coincidence, triggered based search on a 2-week coincidence period (Dec 24, 2003 – Jan 9, 2004)
- » explore coherent methods

Simulations and methodological studies are in progress.

Planning on first event list exchange within the next two months, for a trigger-based burst analysis.