AURIGA II run: stationary gaussian operation of a wideband acoustic gw detector

Massimo Cerdonio INFN Sec. & Phys. Dept. Padua

- one sided $S_{hh}^{1/2} < 4\ 10^{-21}\ Hz^{-1/2}$ over 90 Hz band
- the 3 modes thermal at 4.5 K
- ~ 100% operation (except 3h/month > He transfer)
- veto time intervals under out-of-band triggers:

δ-like events > stationary gaussian over 60% of time
GOAL Gaussian Operation At (thermal) Limit

- GOAL expected to increase after:
  # further improvement of suspensions
  # refinement of the analysis
- GOAL at ~ quantum limit (100mK, 30 h-bar, 20 MV/m)
  one sided $S_{hh}^{1/2} < 4\ 10^{-22}\ Hz^{-1/2}$ over 90 Hz band

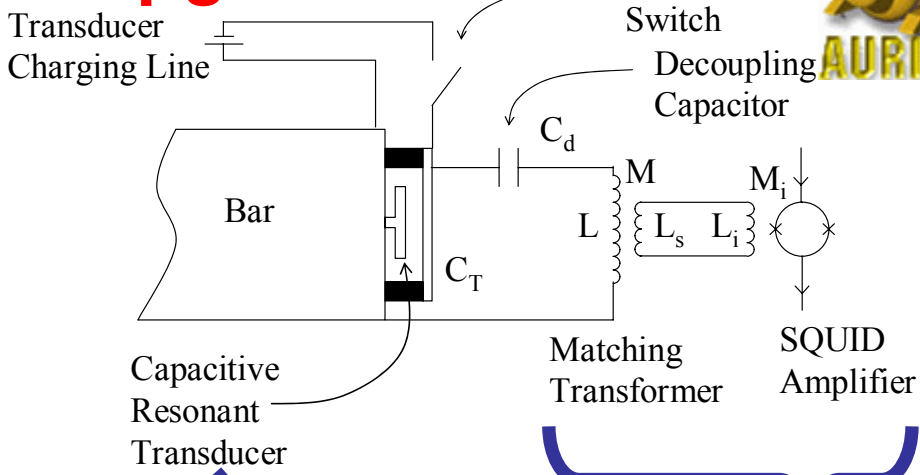
AURIGA run II: upgrades

- new mechanical suspensions:
  attenuation > 360 dB at 1 kHz
  FEM modelled

- three resonant modes operation:
  two mechanical modes
  one electrical

- new data analysis and data acq.:
  C++ object oriented code
  frame data format
  Monte Carlo software injections
  improved noise matching algorithm
  selectable templates

AURIGA run II: upgrades



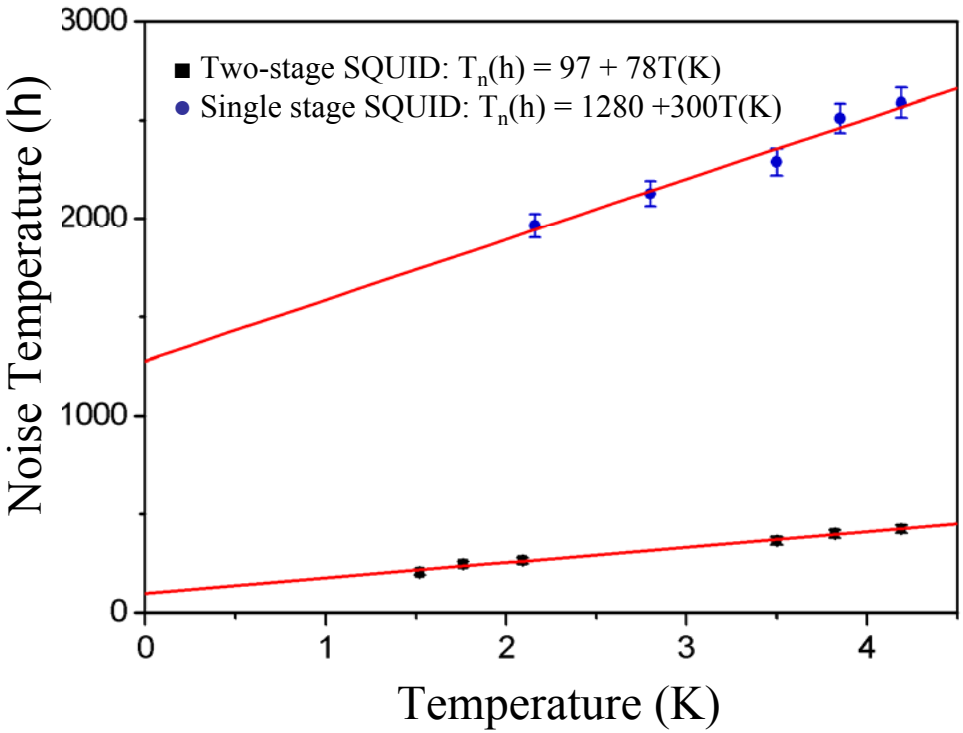
- **three resonant modes operation:**

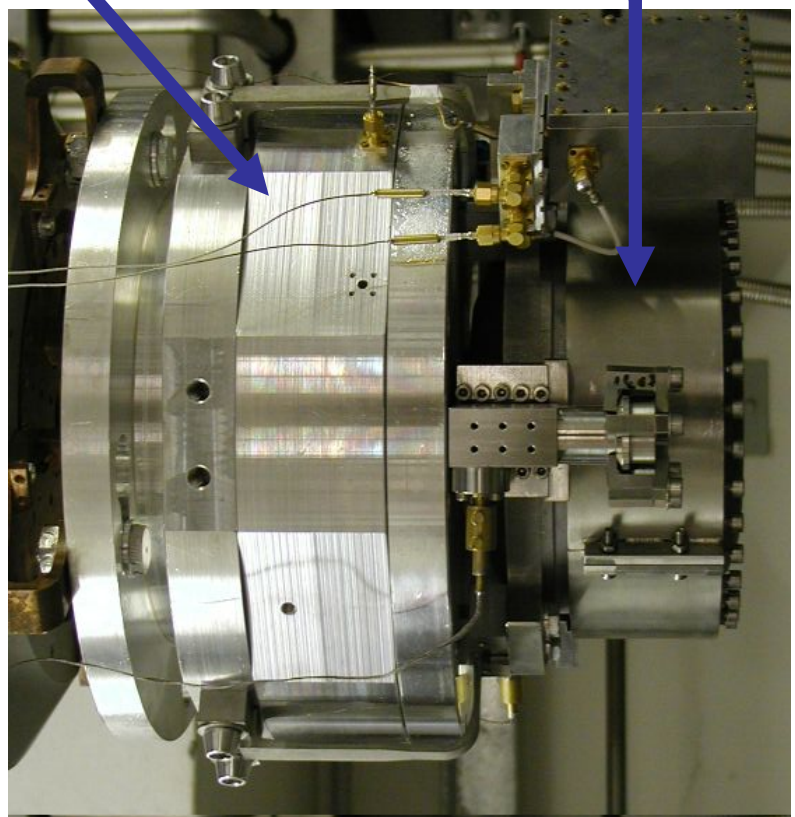
two mechanical modes
one electrical mode

- transducer bias field 8 MV/m

- **new SQUID amplifier :**

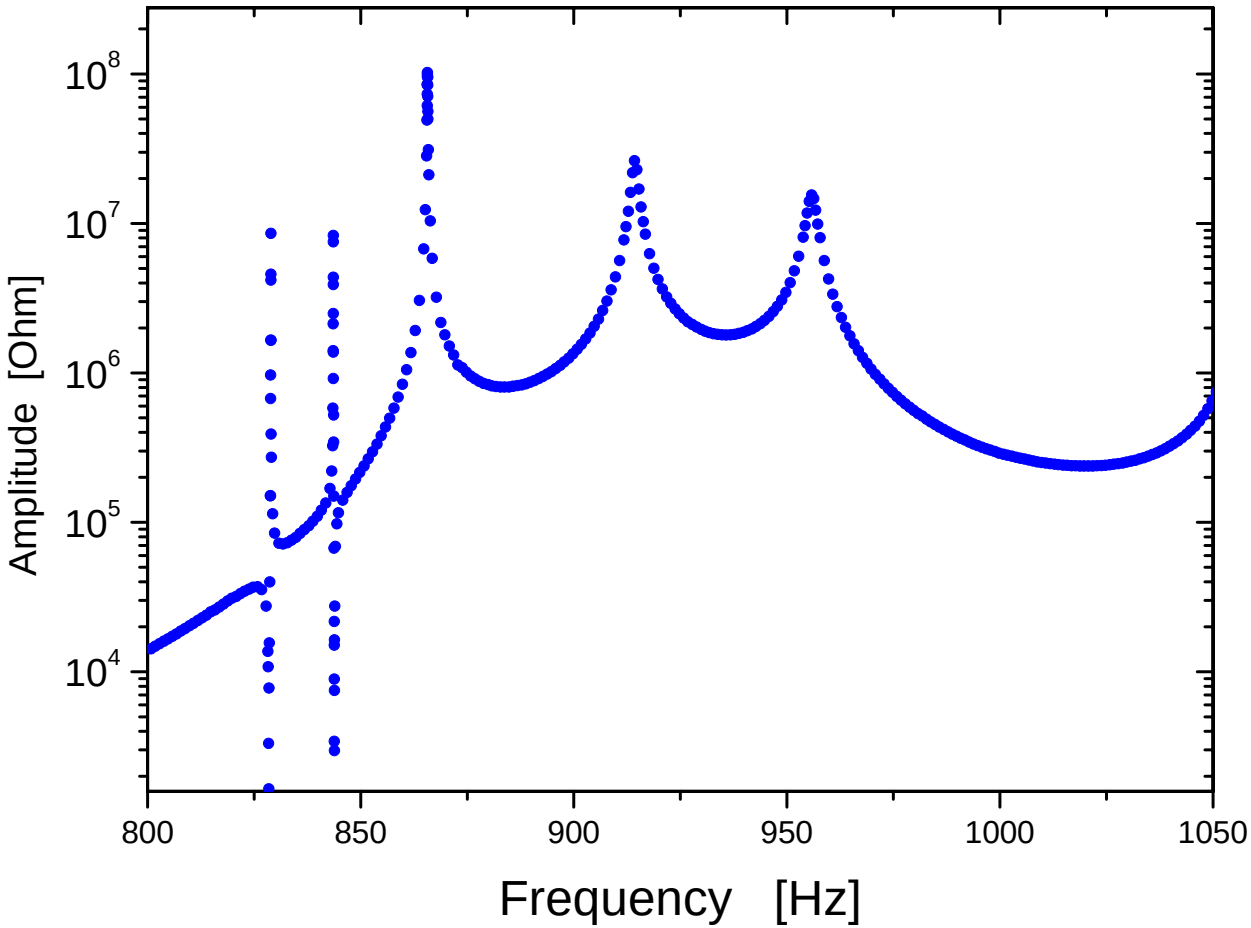
double stage SQUID
650 energy resolution at 4.5 K in the detector





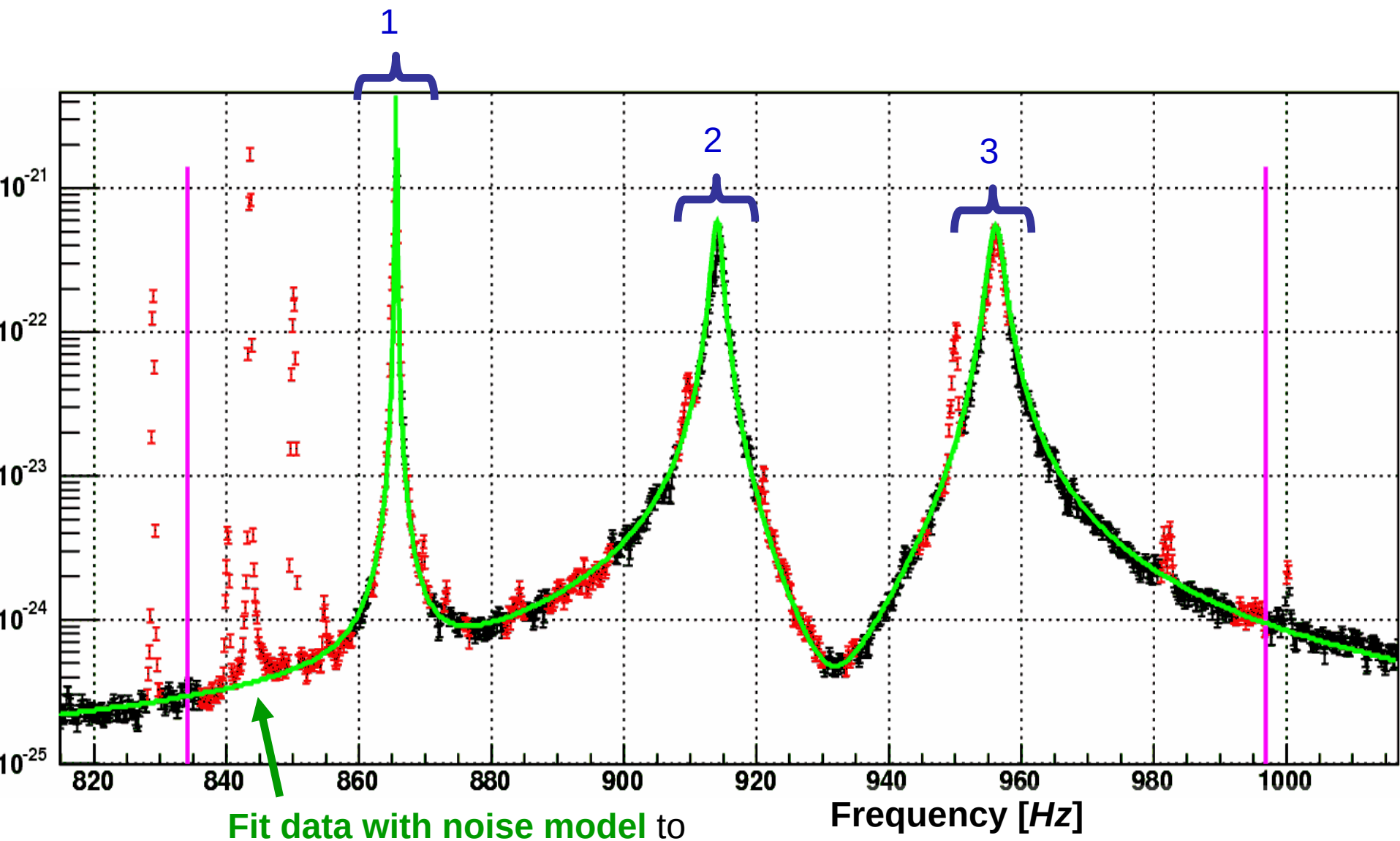
calibration

Measurement of the mechanical transfer function of the bar-transducer system



raw data PSD

three resonant modes

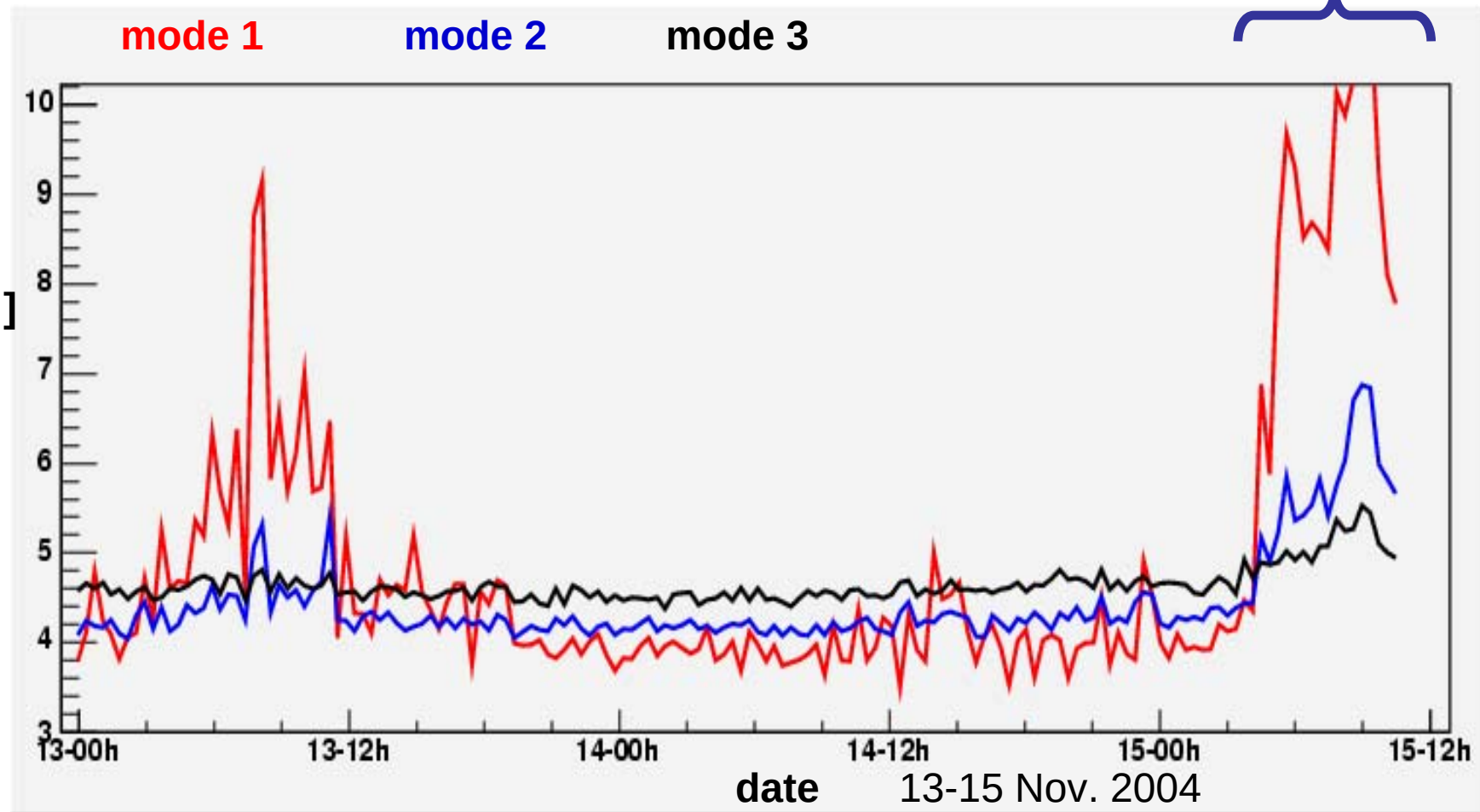


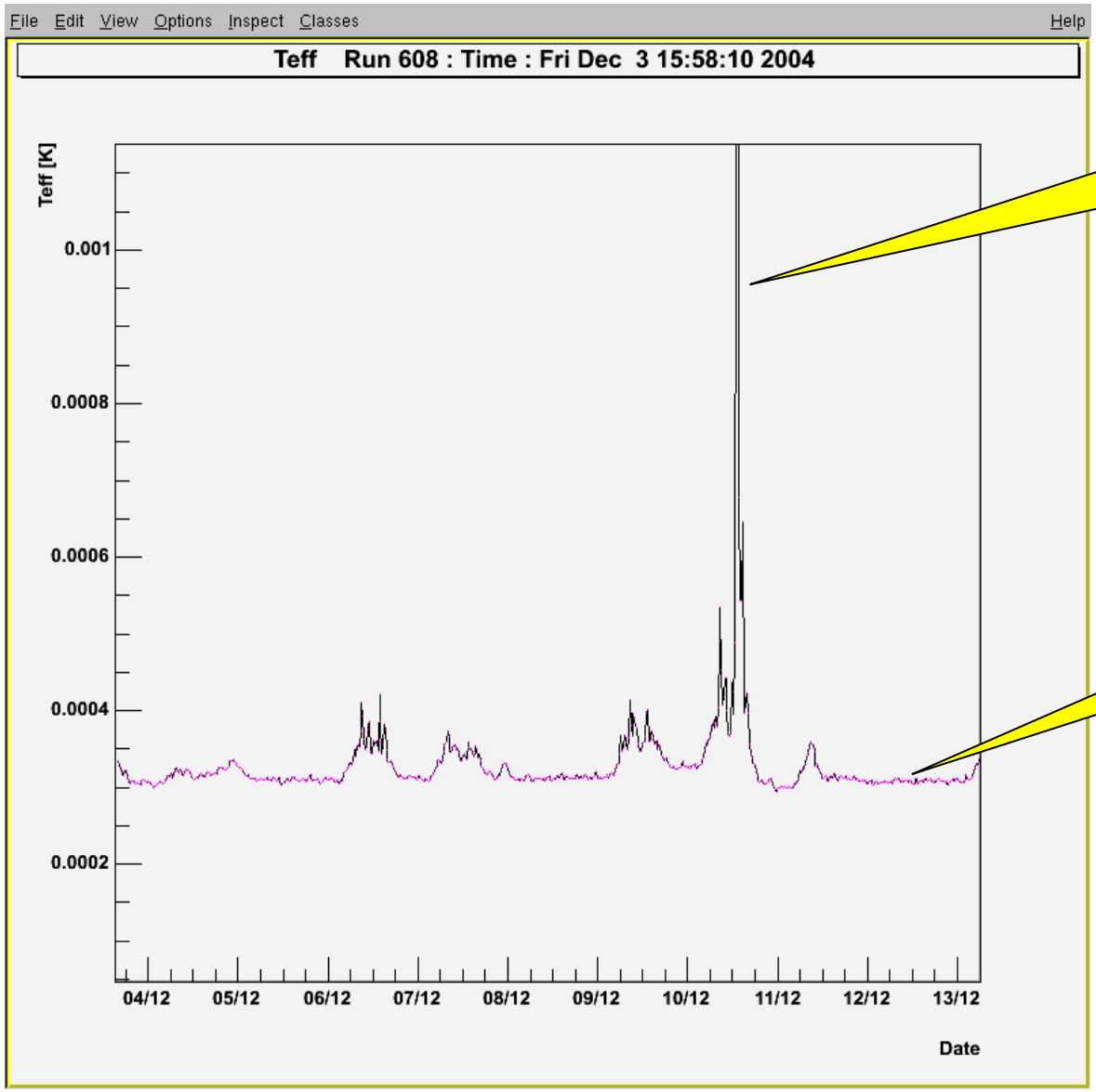
Fit data with noise model to estimate the noise parameters

Temperatures of resonant modes

Detector operating at 4.5 K:
the 3 modes achieve the thermal noise level

Monday morning



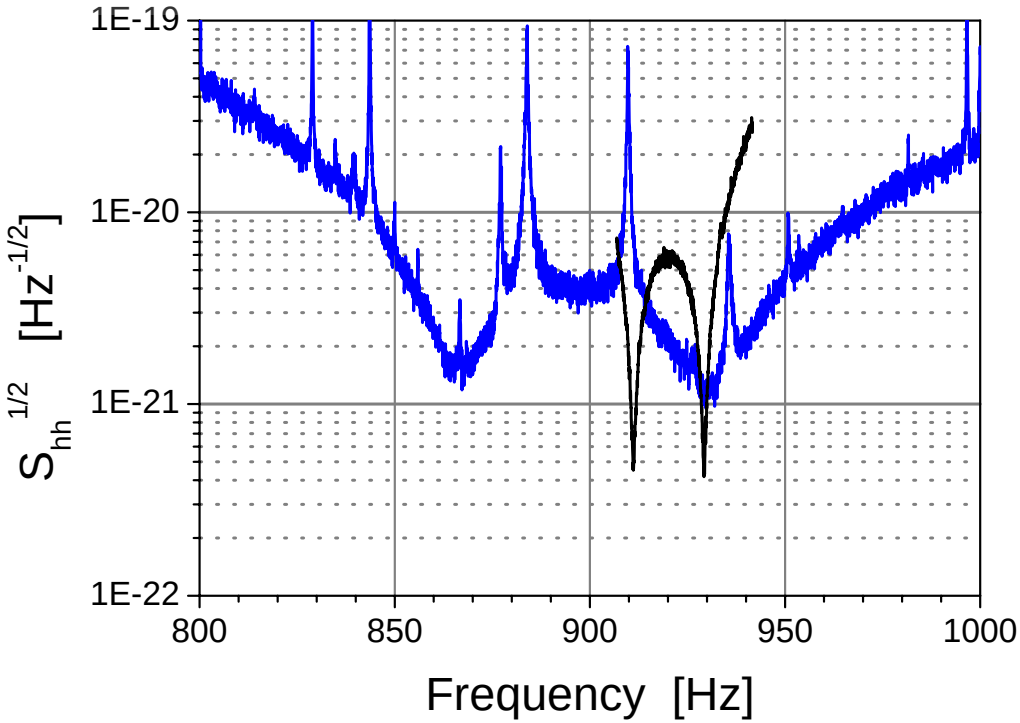


Liq. He Transfer

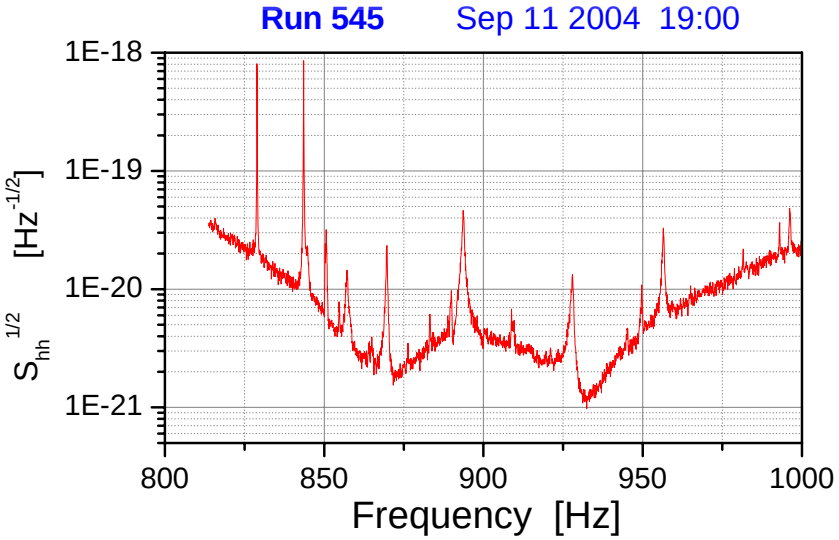
Teff = 300 μk

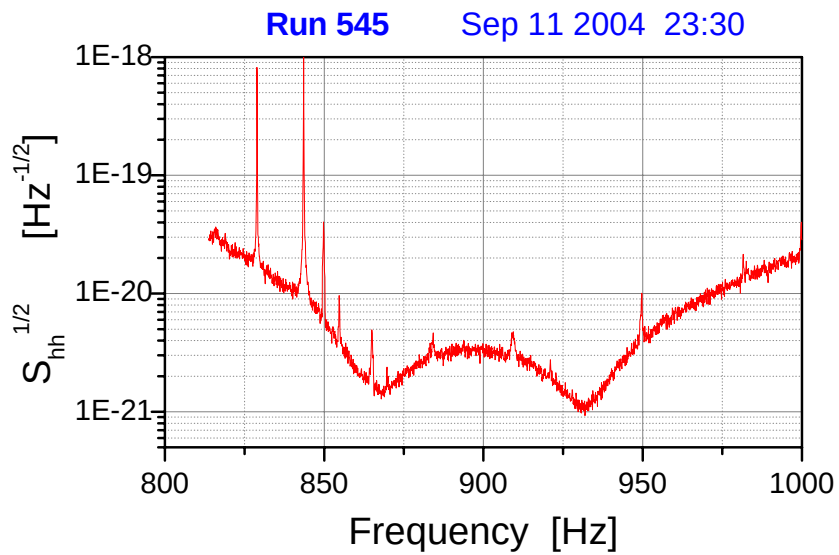
S_{hh} sensitivity (1)

initial operation at 4.5 K started on Dec. 24th 2003



… months of diagnostic measurements and noise hunting **…**



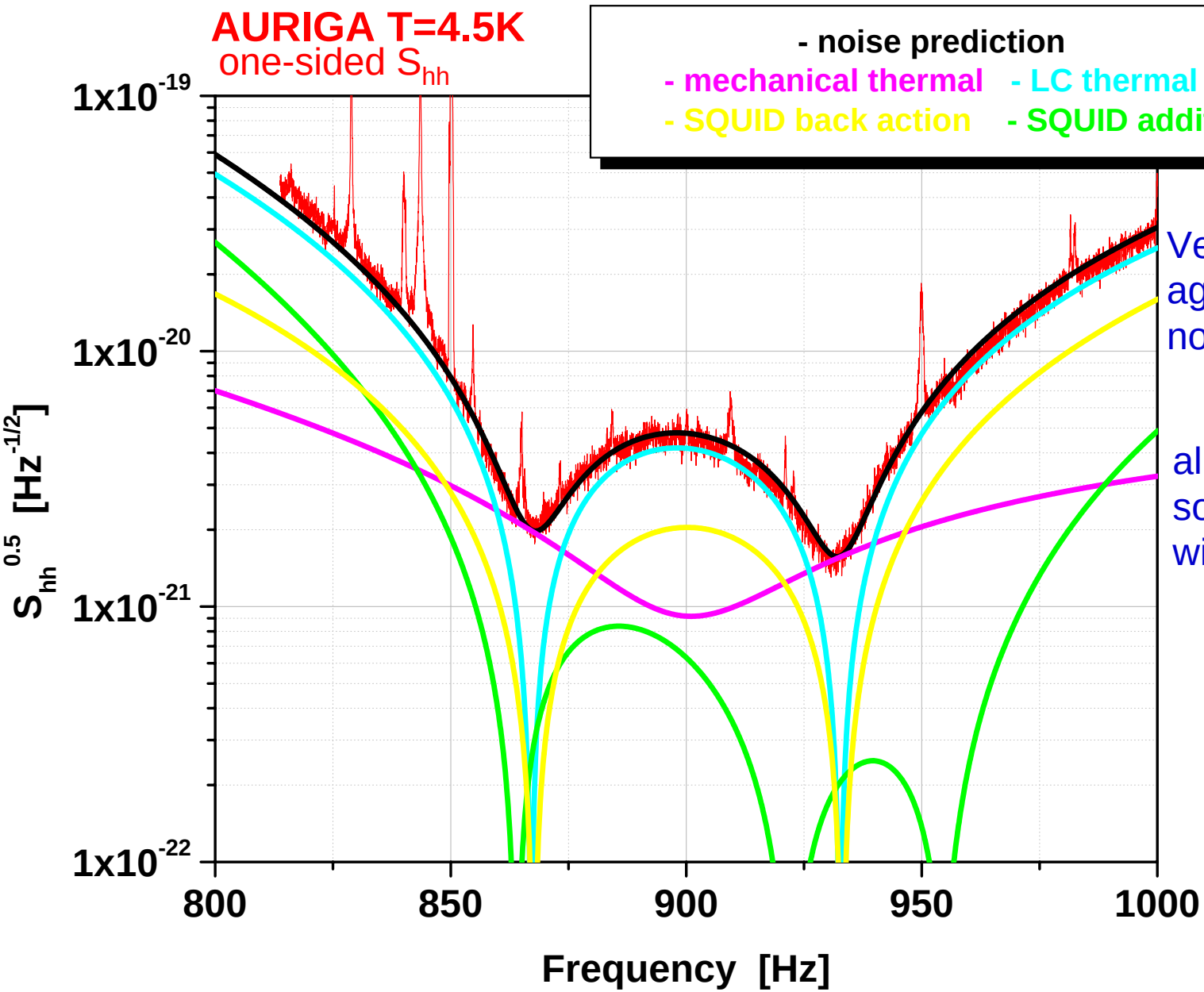


unmodeled spurious noise peaks within the sensitivity bandwidth

- not related to the dynamical linear response of the detector
- non gaussian statistics
- related to mechanical external disturbances

up-conversion of low frequency noise

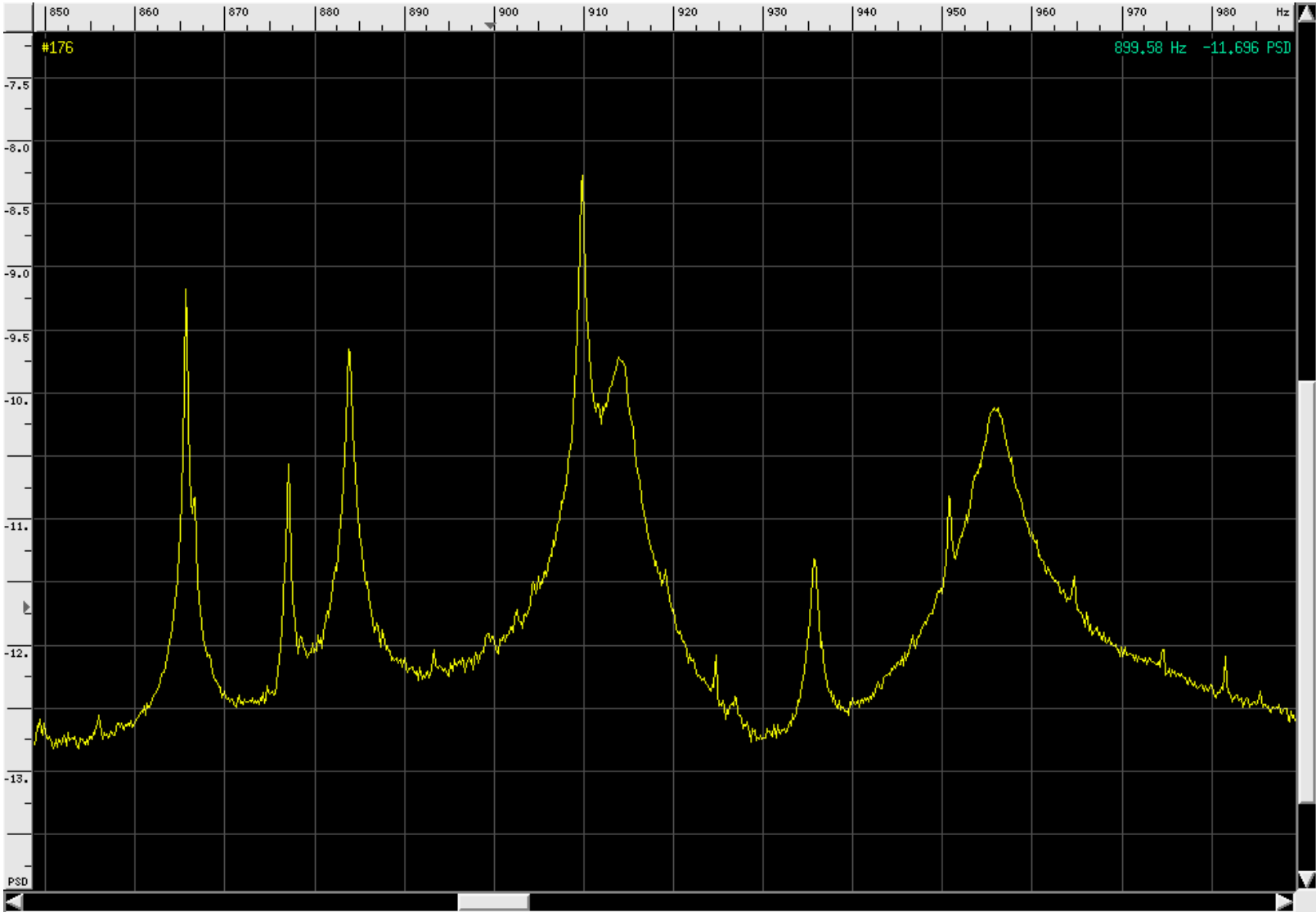
S_{hh} sensitivity (2)



Very good agreement with noise predictions

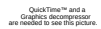
all these noise sources will scale with temperature

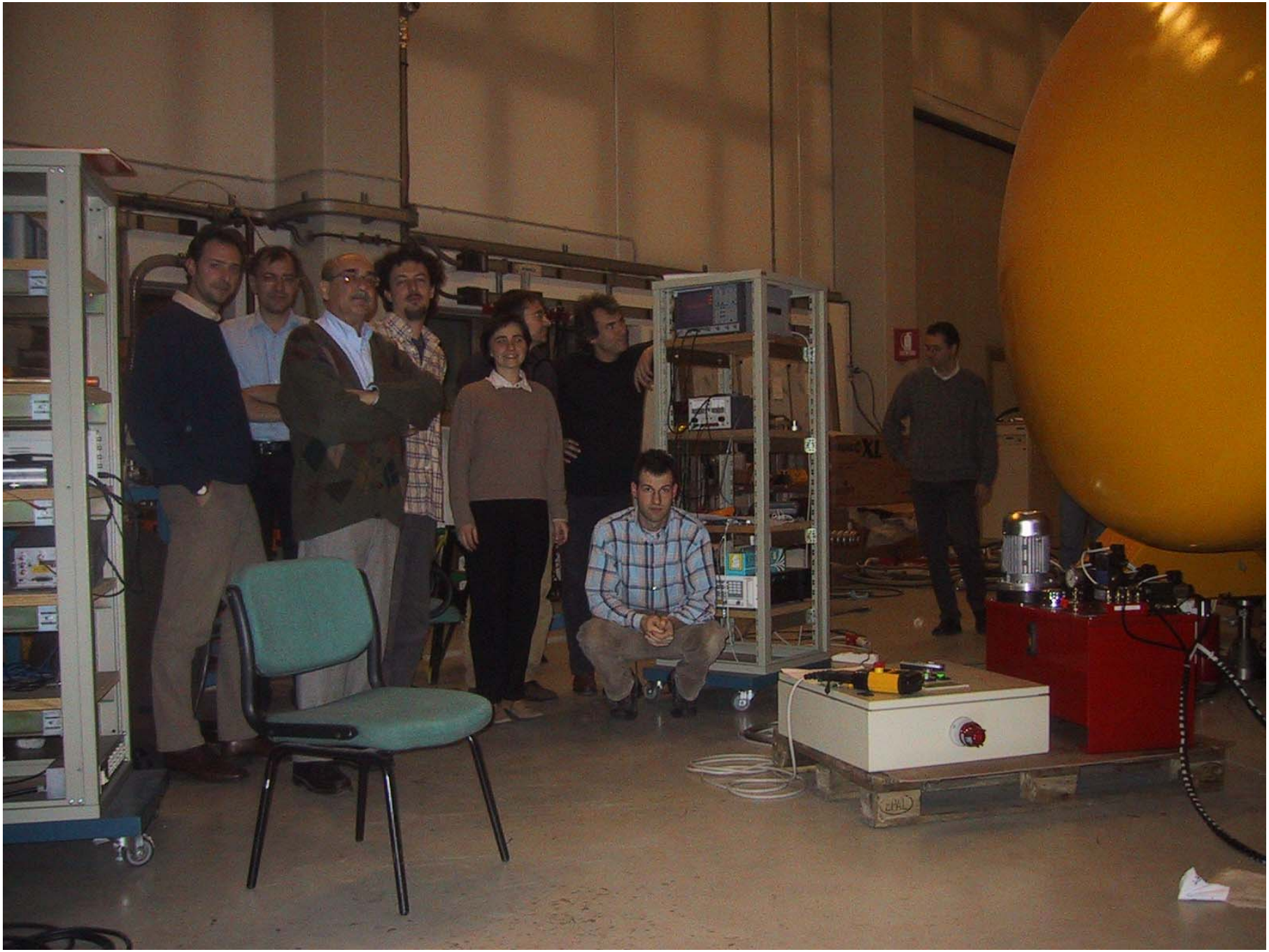
Typical FT output in the period Jan-March 04 with strong spurious lines of the “family” F1



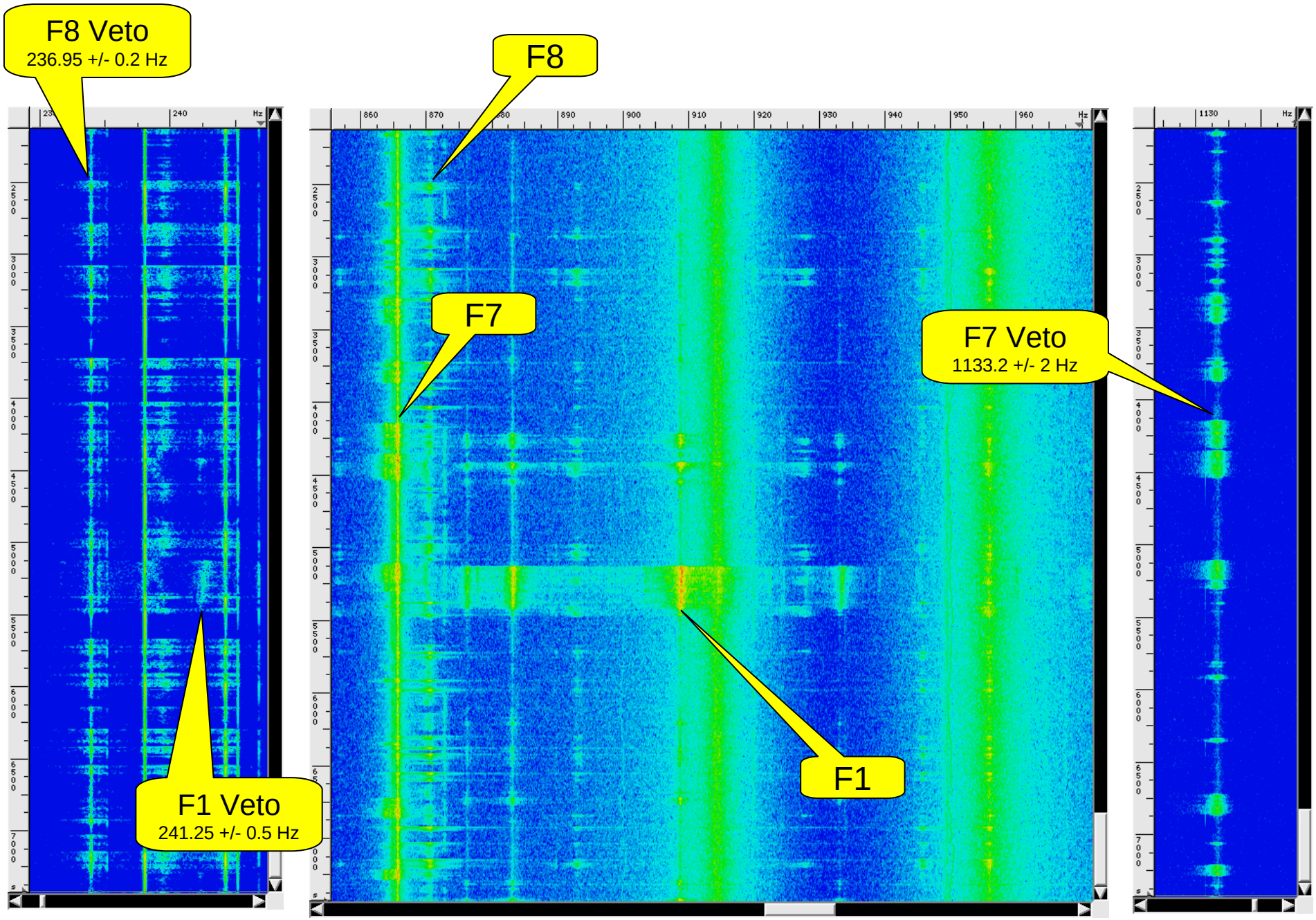
the 3 modes
(with a few spuria going on/off and one all-band glitch)

“bar” “transducer” “electrical”



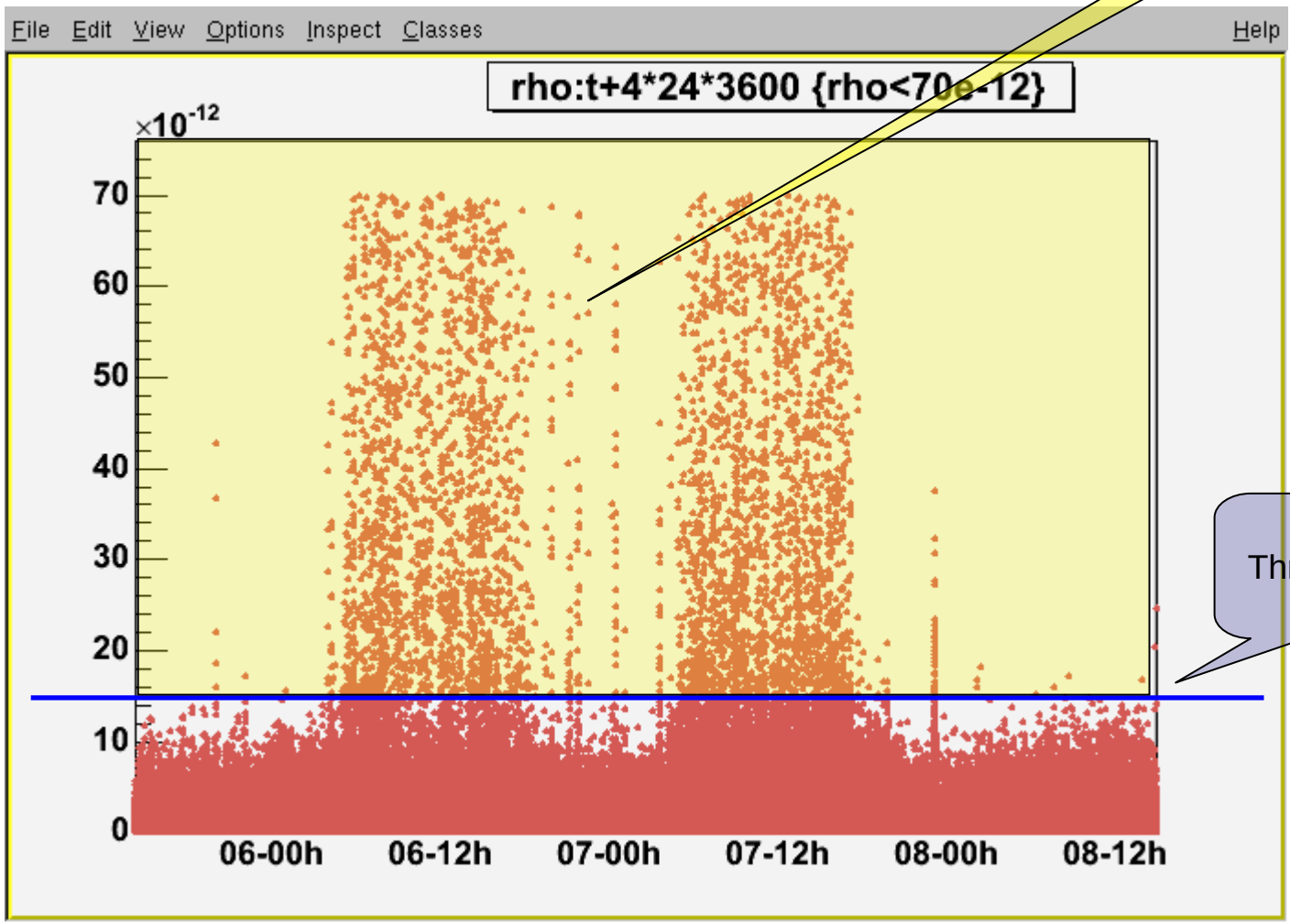



IV

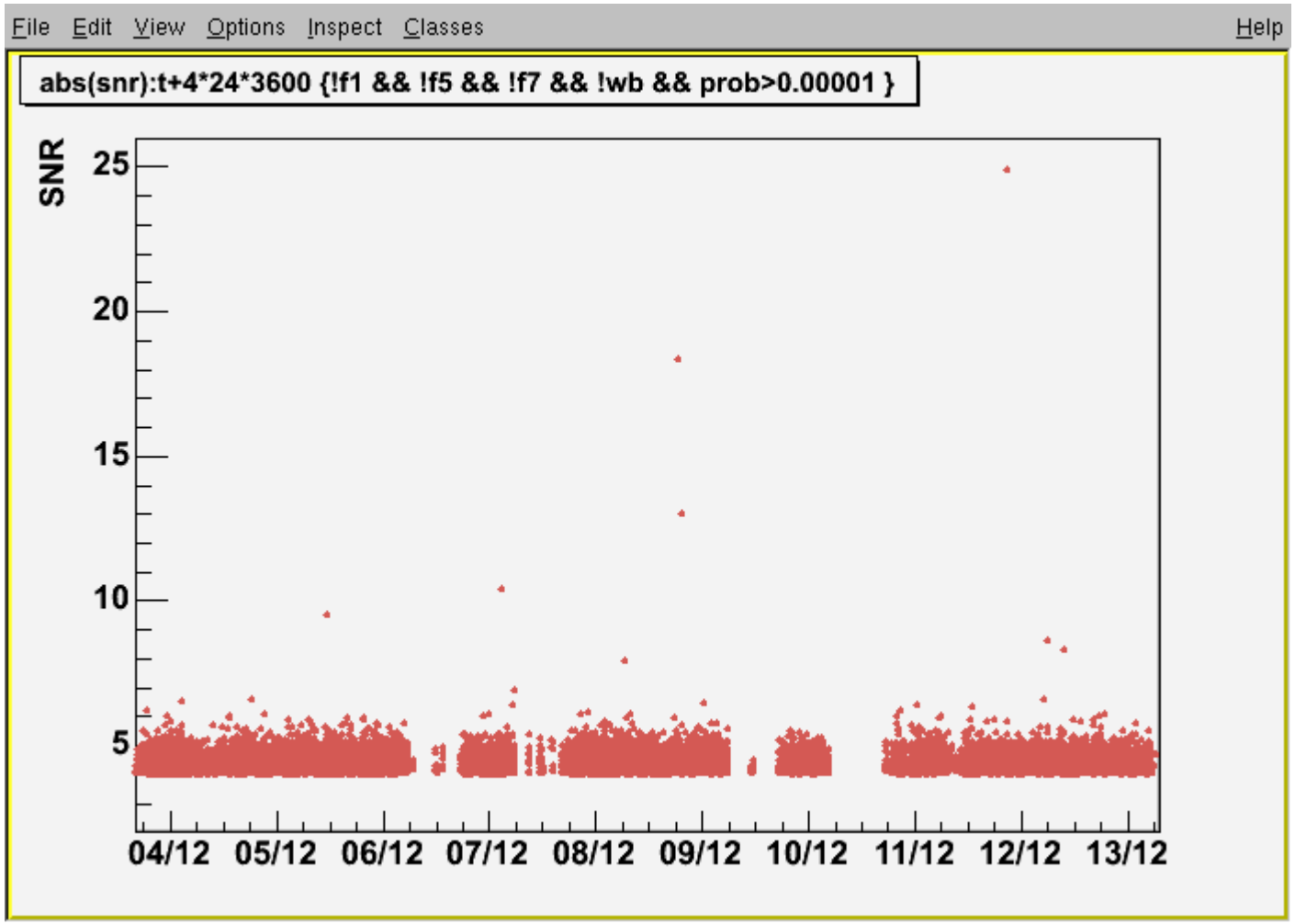

F8 Veto
236.95 +/- 0.2 Hz
F8
F7
F7 Veto
1133.2 +/- 2 Hz
F1
F1 Veto
241.25 +/- 0.5 Hz

Vetoes

Ada lck psp plugin @ 1133.2 +/- 2 Hz



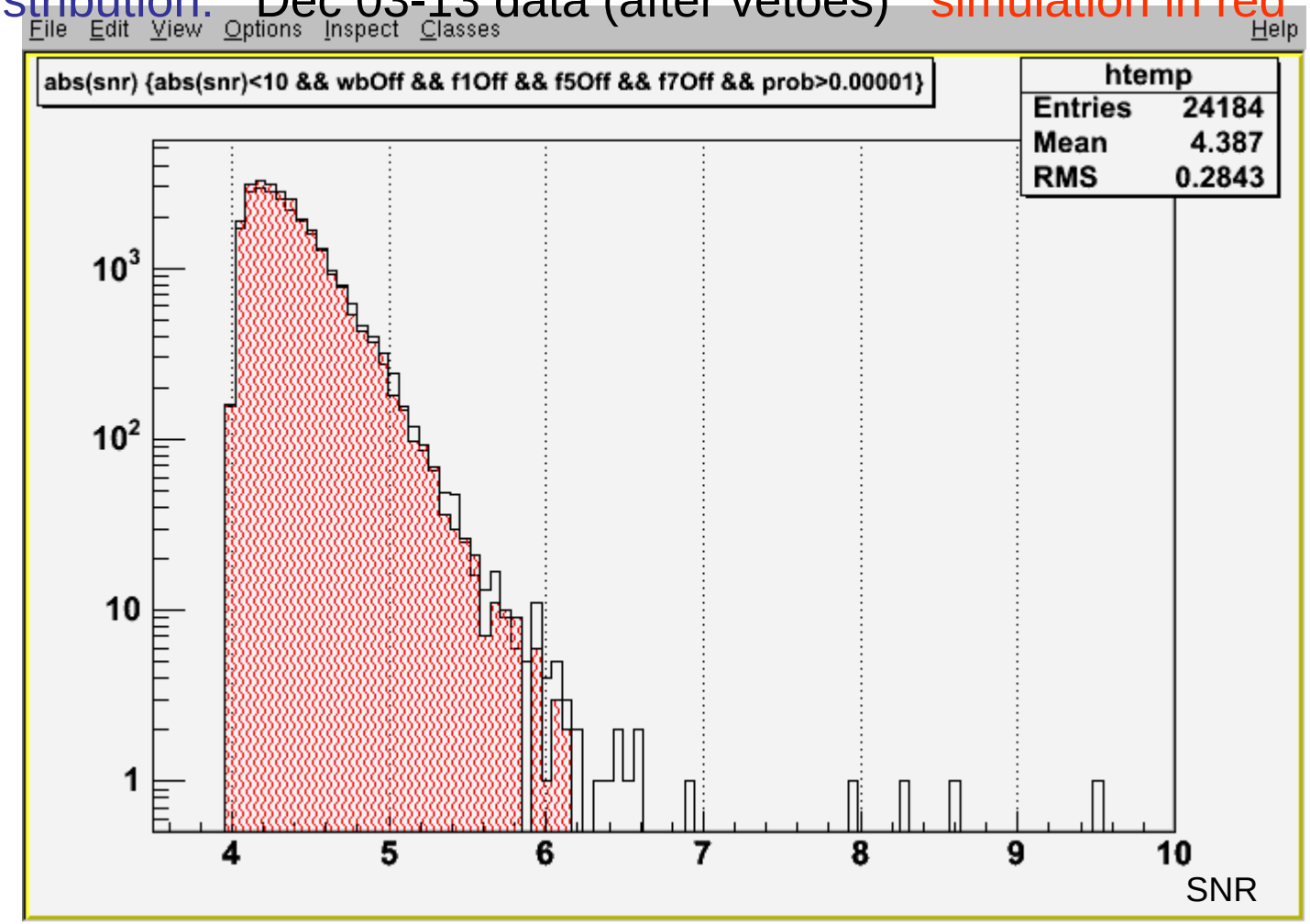
10 days of events after vetos and χ^2 test



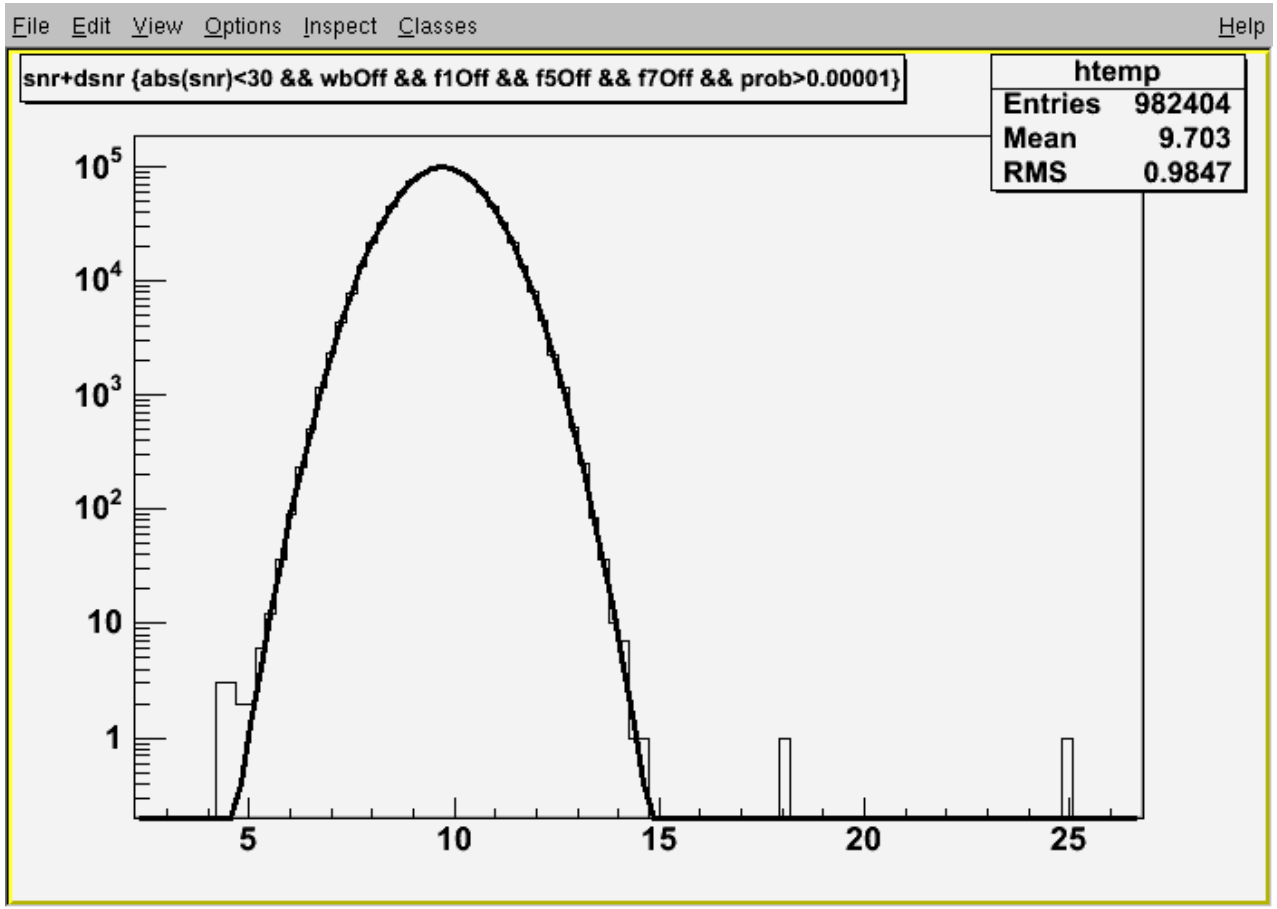
SNR = 5 corresponds to $h_{burst} = 7\ 10^{-19}$

10 days of stationary gaussian operation:
< 2 outliers/day ~60% duty cycle

SNR distribution: Dec 03-13 data (after vetoes) simulation in red



Montecarlo injecting SNR=10 events: efficiency after vetoes



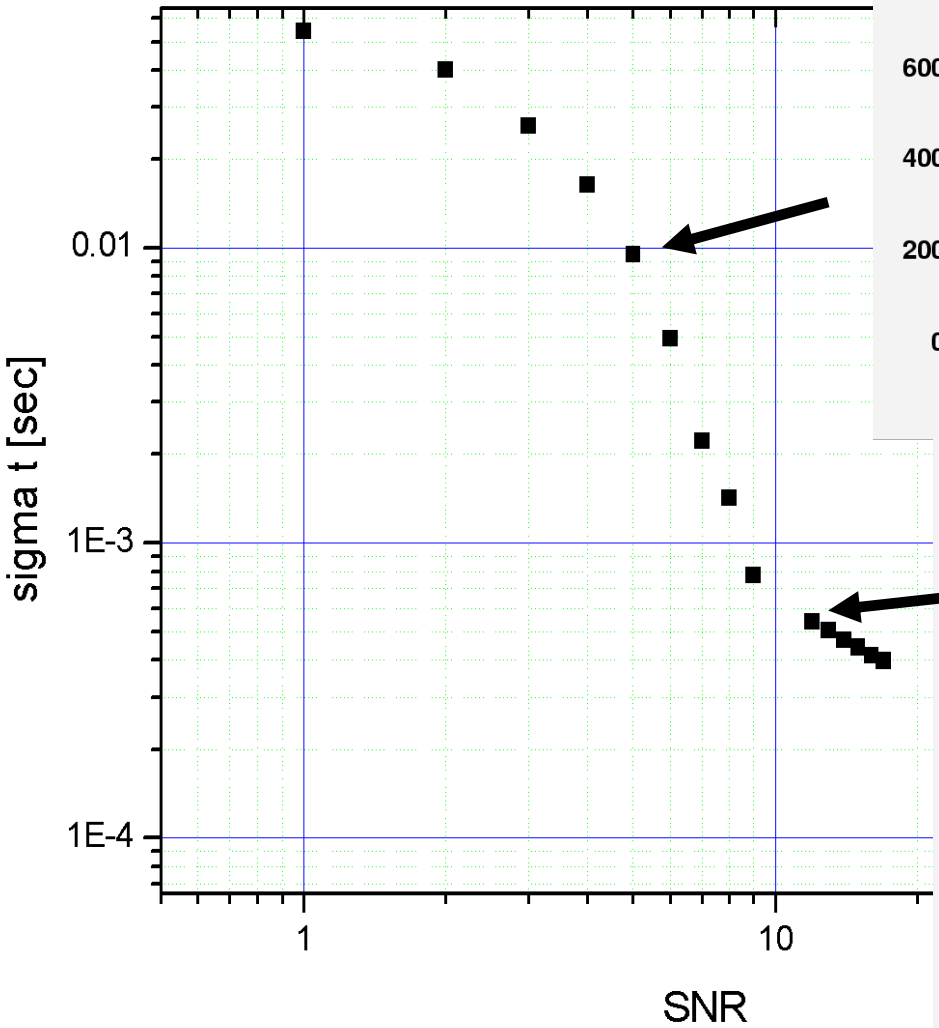
SNR distribution as predicted by gaussian statistics

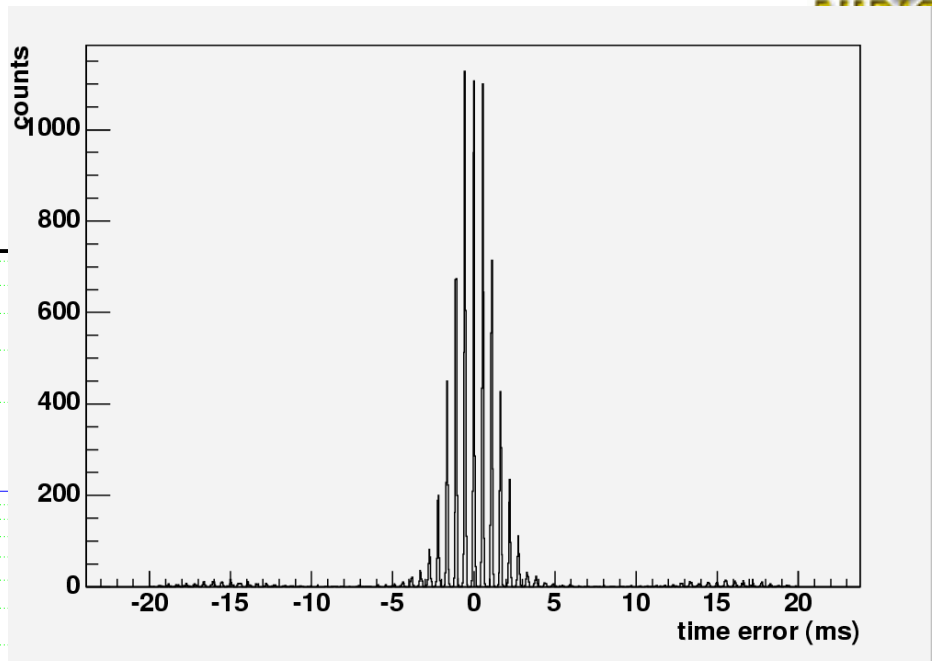
mean $SNR_{recoverd} = 9.7$

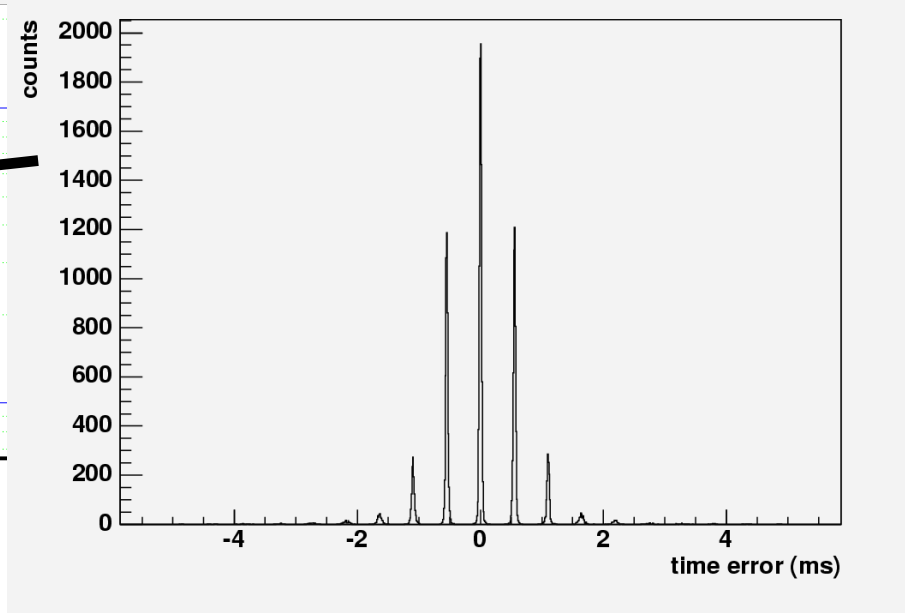
$N_{recoverd} / N_{injected} = 0.59$ checks with fraction of time accepted after vetos

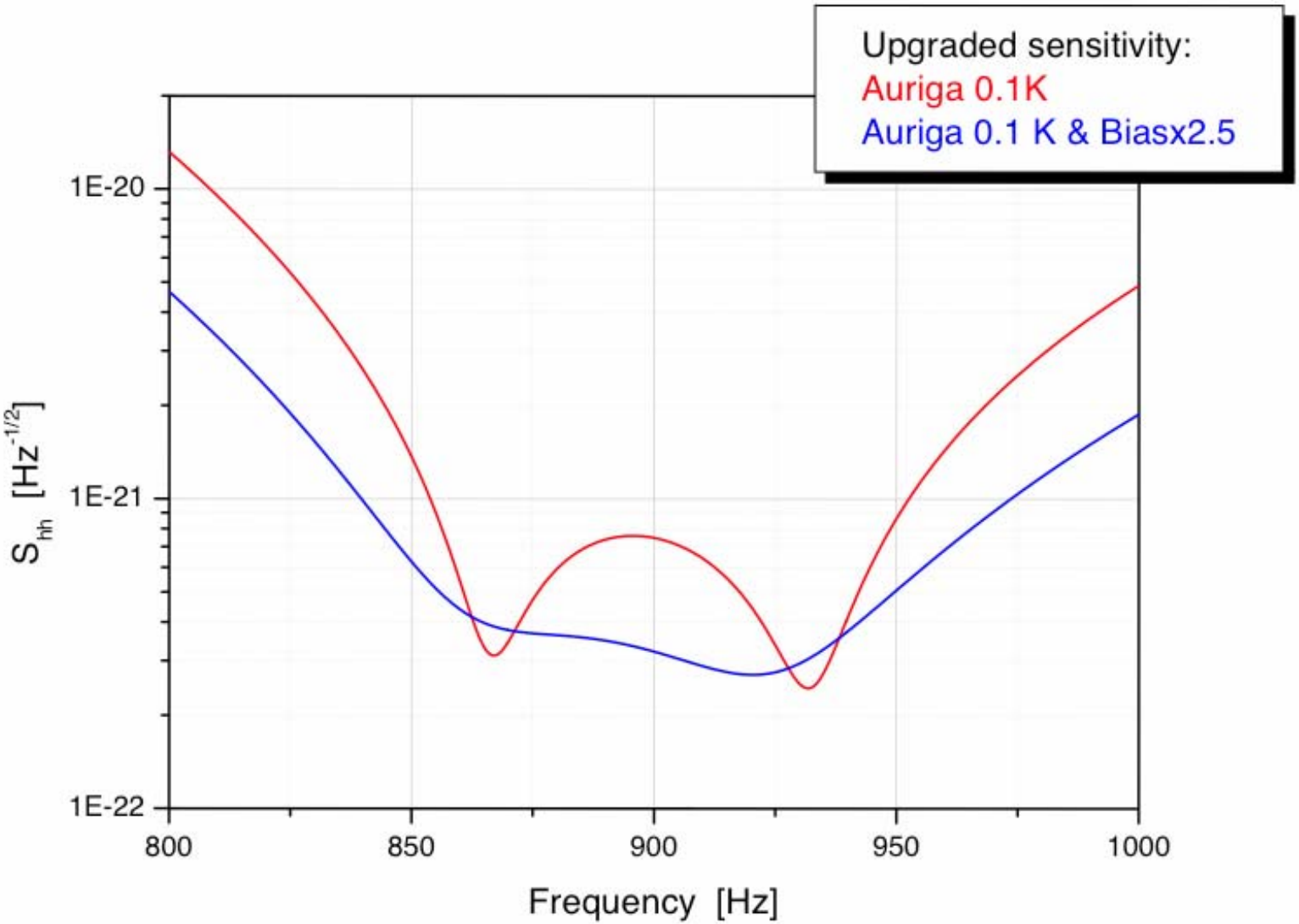
uncertainty on arrival time estimates

for δ-like bursts








Upgraded sensitivity:
Auriga 0.1K
Auriga 0.1 K & Biasx2.5
1E-20
1E-21
1E-22
S_{hh} [$Hz^{-1/2}$]
800
850
900
950
1000
Frequency [Hz]