R&D on Control Noises

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- **Motivations**
- **Examples of R&D**

Virgo CITF Sensitivity

- **Improves with time**

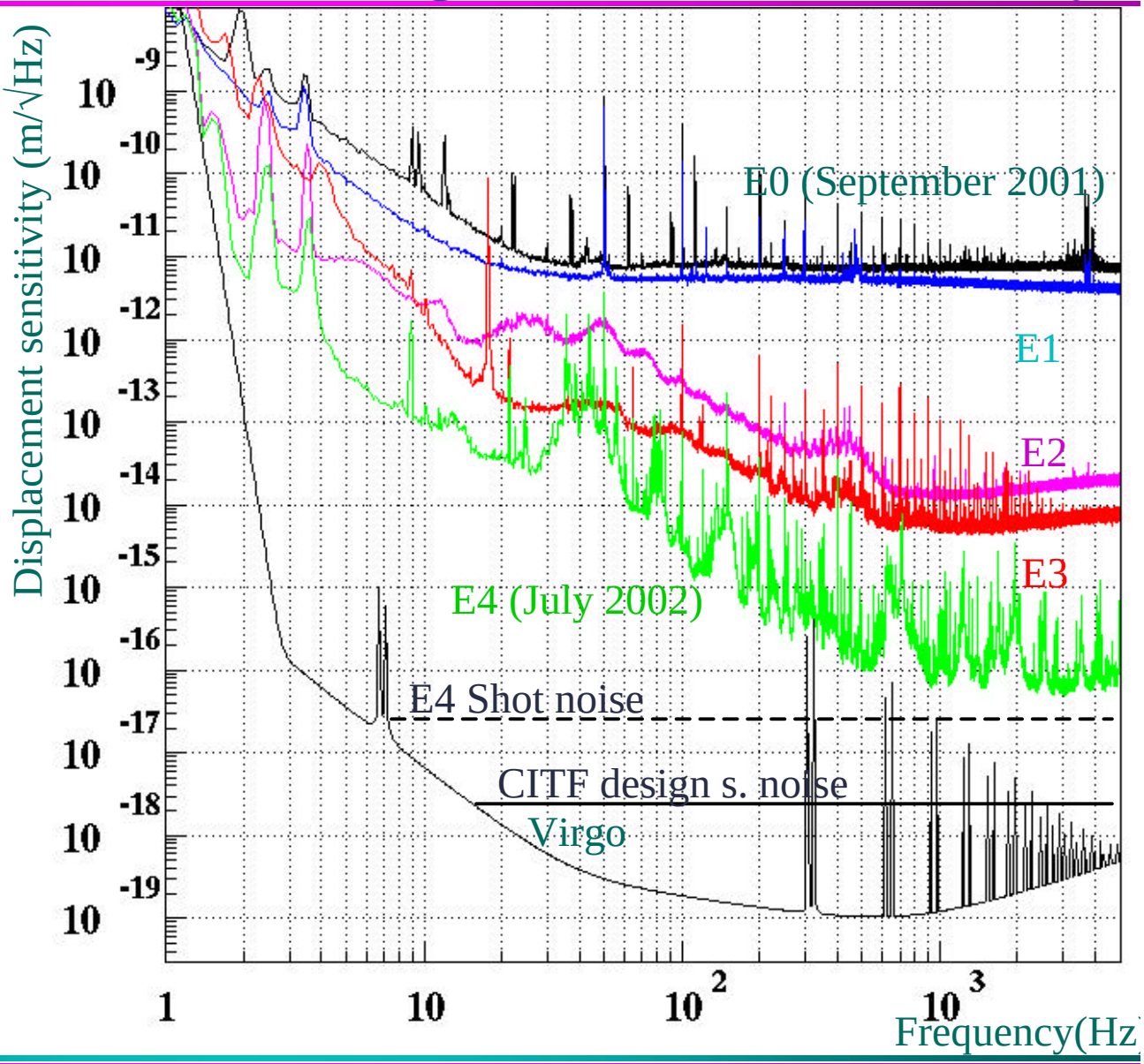
- **CITF Noise Budget**

- f < 10 Hz
Angular control noise

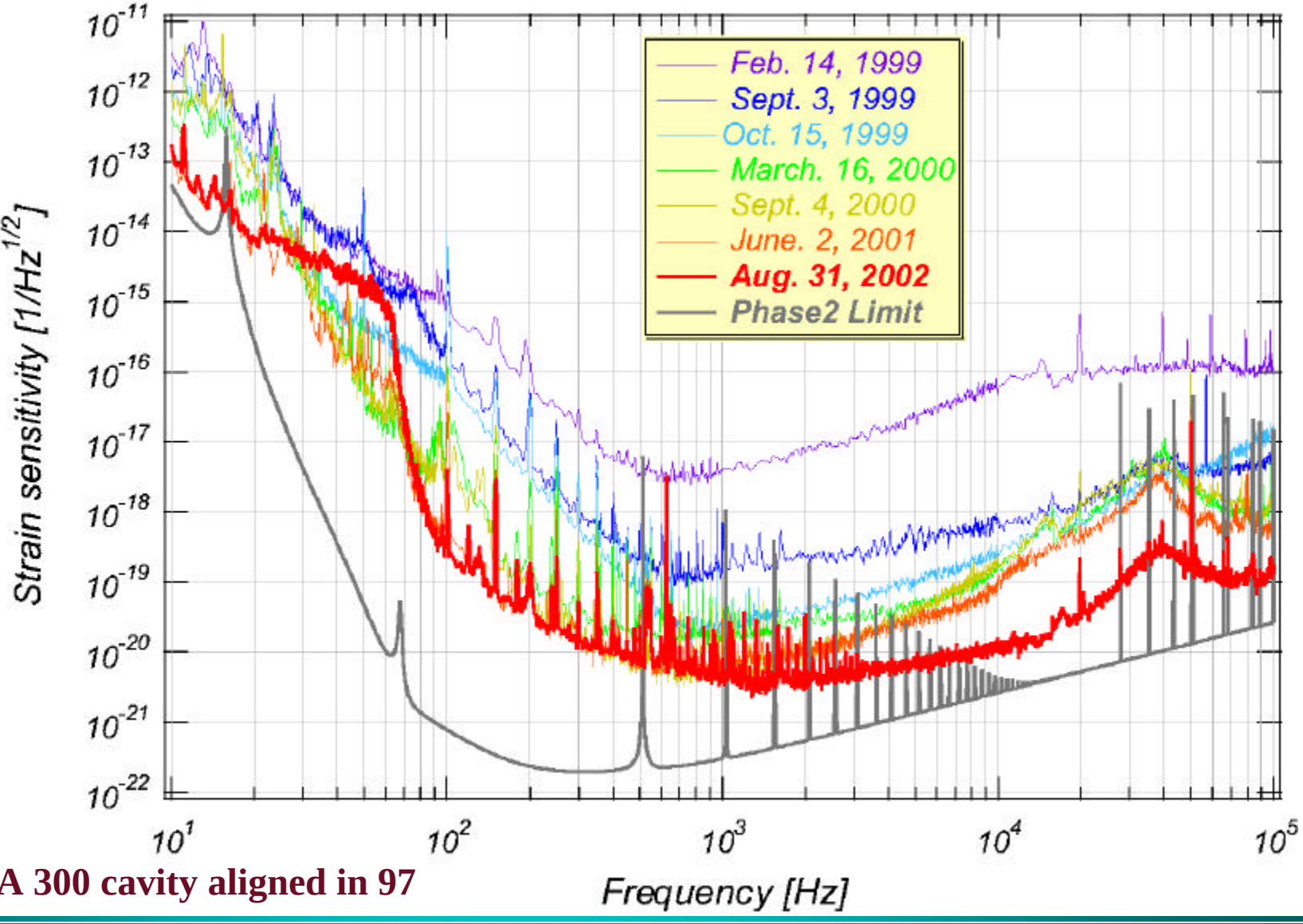
- 10 Hz < f < 200 Hz
Input mode-cleaner noise

- f > 200 Hz
Several peaks due to payloads internal resonance's

Þ Technical Noises

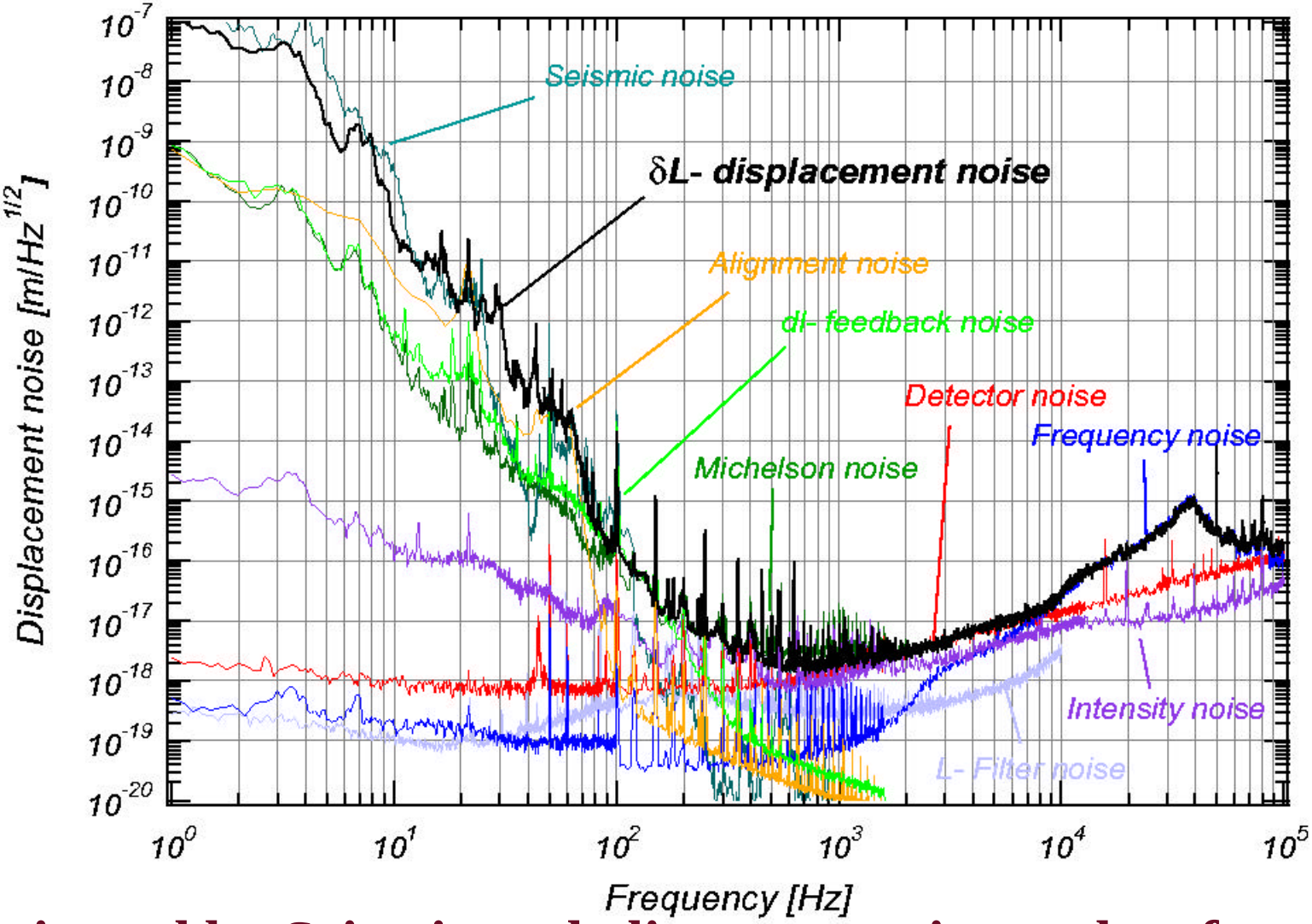


TAMA Sensitivity



First TAMA 300 cavity aligned in 97

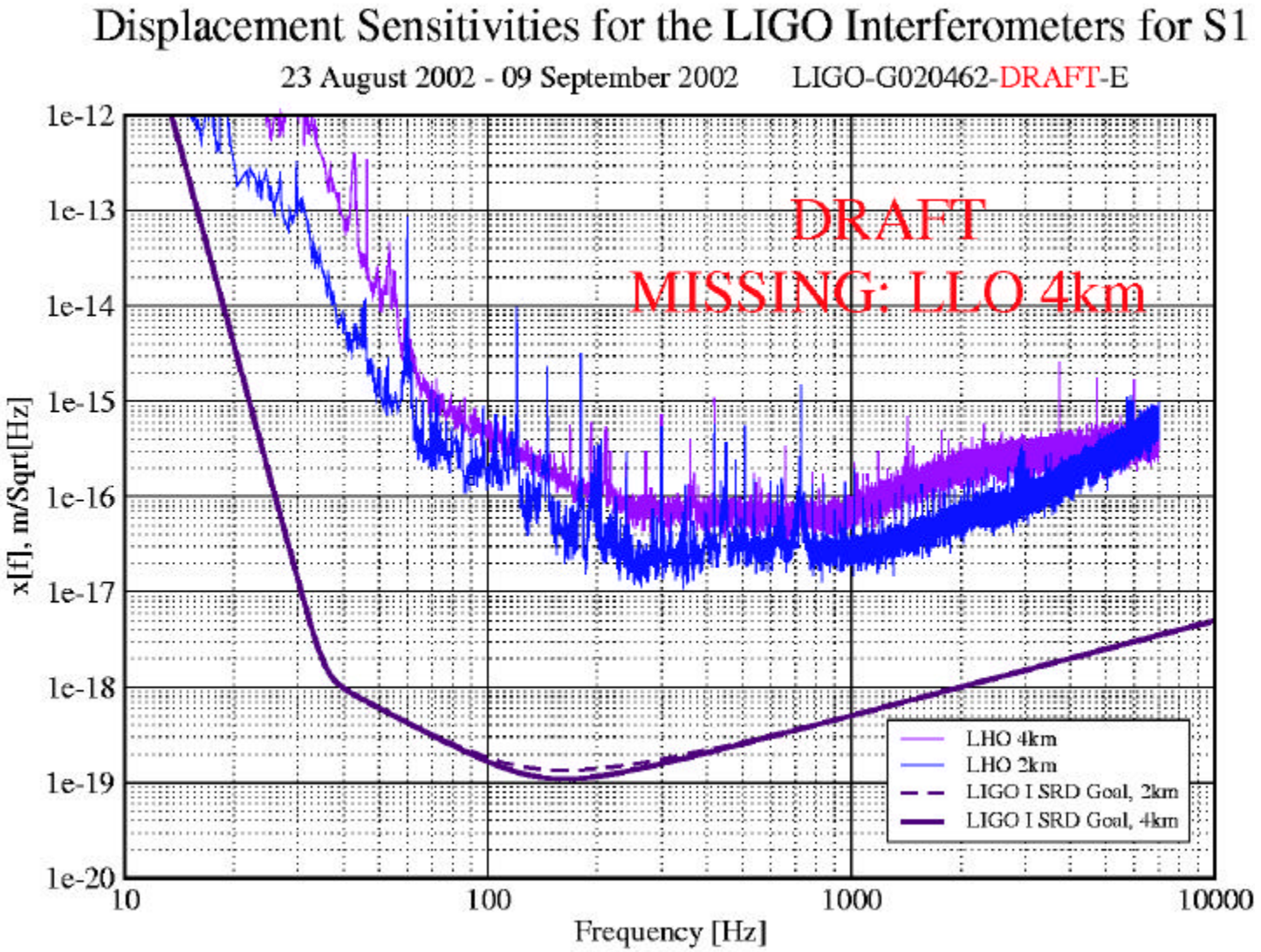
TAMA 300 Noise Budget



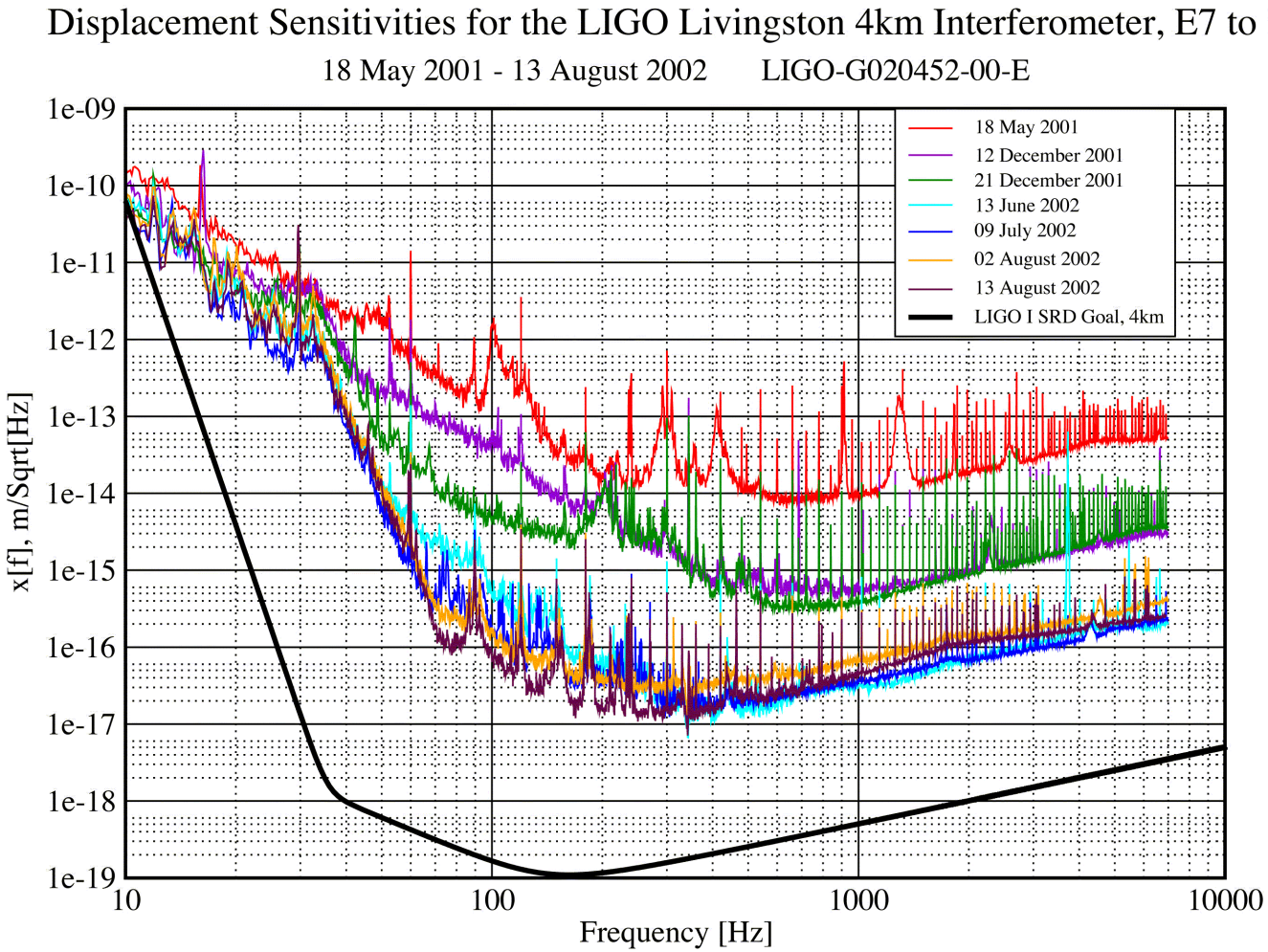
DT6
June 2001

Dominated by Seismic and alignment noises at low frequency

LIGO Sensitivity



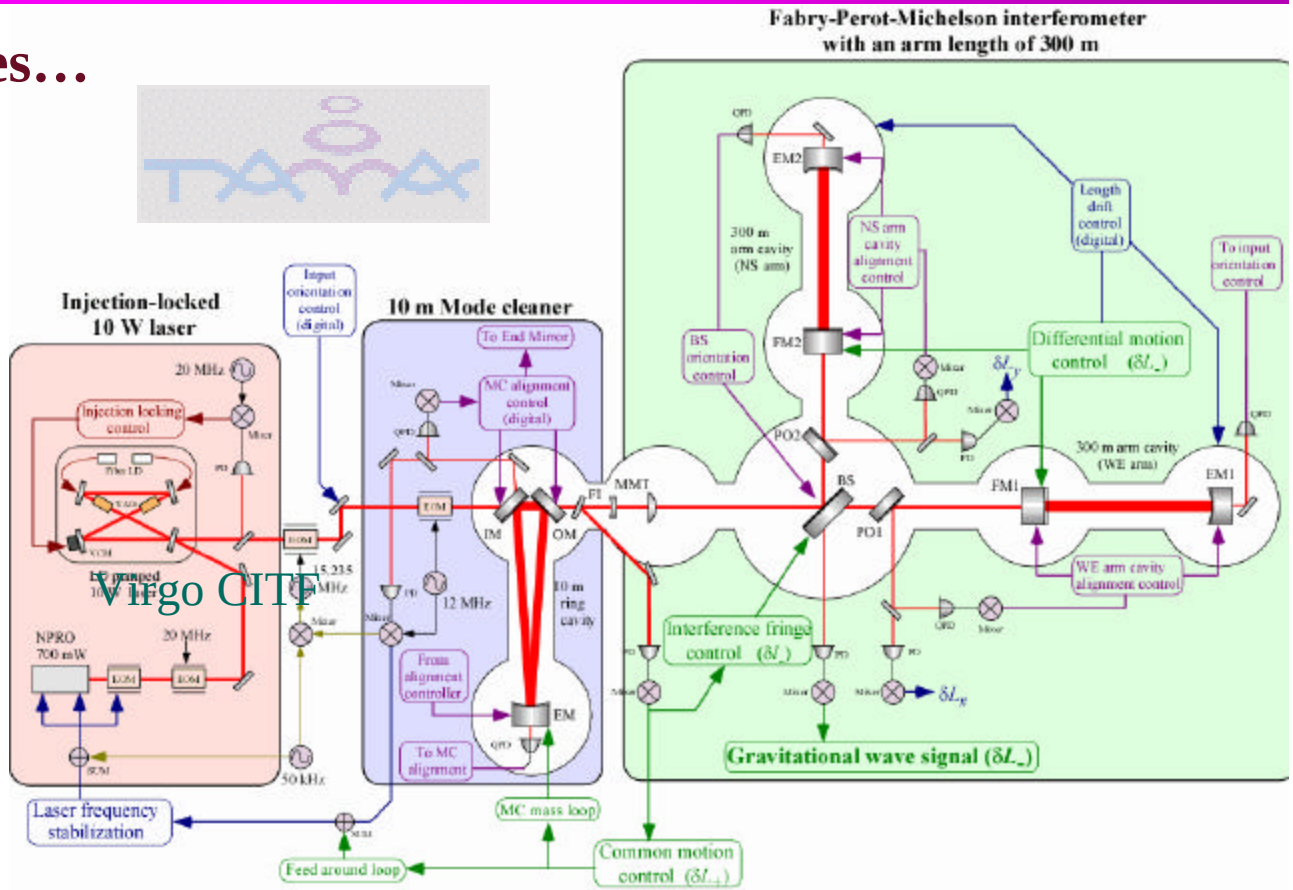
LIGO (Livingston) Sensitivity



- **Designed sensitivity not yet reached, especially at low frequency.**
- **The Low frequency is the most interesting part for the G.W. physics**

Why do we have technical noises?

- **Simple Control schemes…**



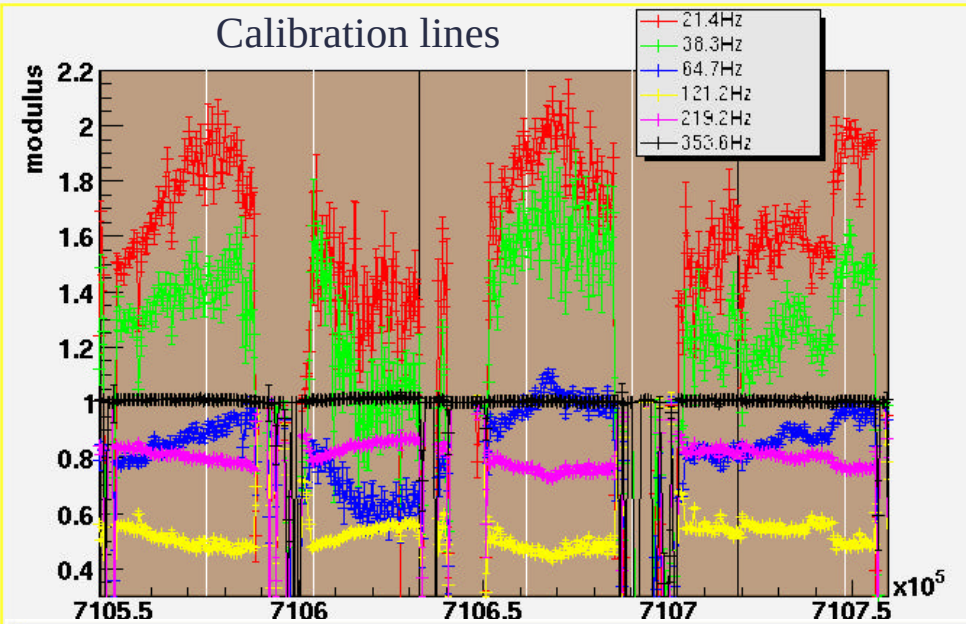
…are not so simple:

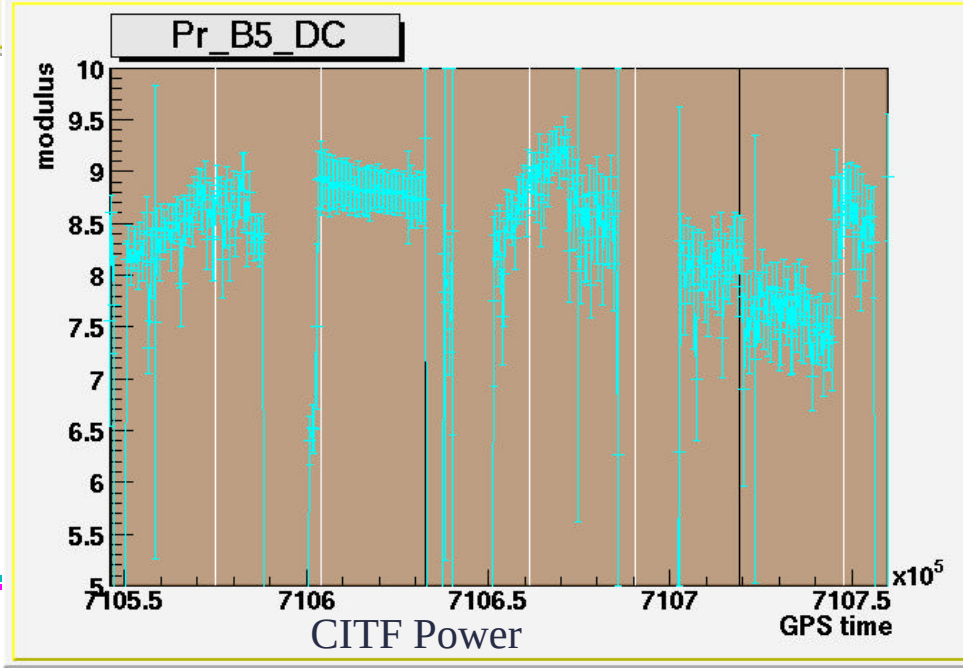
- Many addition loops : several hundred fast control channels digitized

- **The low frequency is the most difficult area**
  - Many controls act in the low frequency part
  - Steep slope at low frequency

CITF Calibration Changes

- **Calibration line monitoring:**
- Up to a factor 2 change over 3 days.
- Calibration lines amplitude correlated with power fluctuations.
- Power fluctuations and other effects induce variations in the shape of the closed loop Transfer Function:
  - **Challenge for the data analysis**
  - **Sensitivity losses due to 'technical noise'**

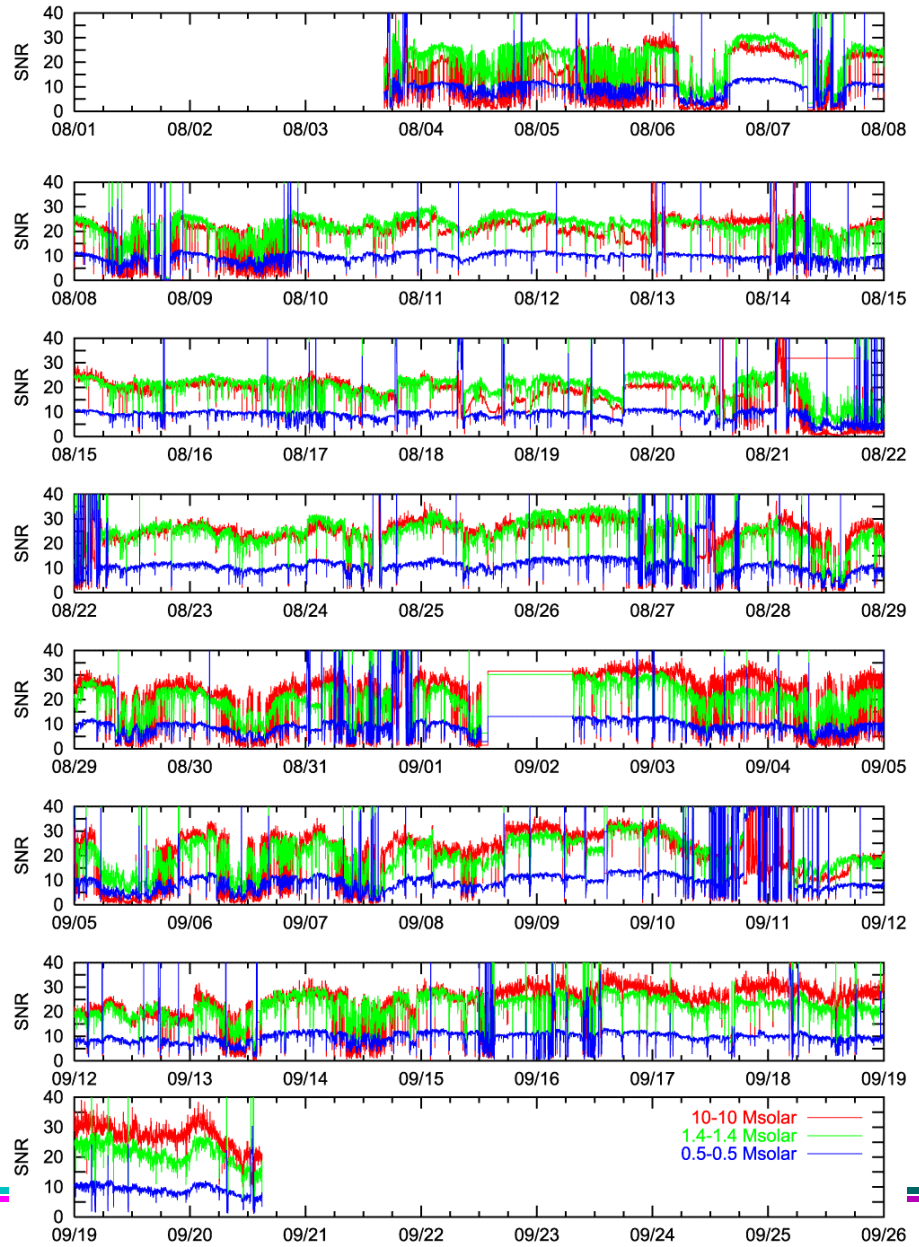




TAMA 300 SNR Variation

- **TAMA 300 SNR Variation:**

(August-September 2001 run)



The problems

- **It takes time to tune a detector**
- **It is difficult to reach the designed sensitivity**
- **The operation condition are not so stable**
- **We do have a full list of technical noises, especially at low frequency**

Þ R&D on control noises would help

Noise Control R&D

- **The Detector commissioning is the prime R&D activity**

…But additional R&D in the labs are need

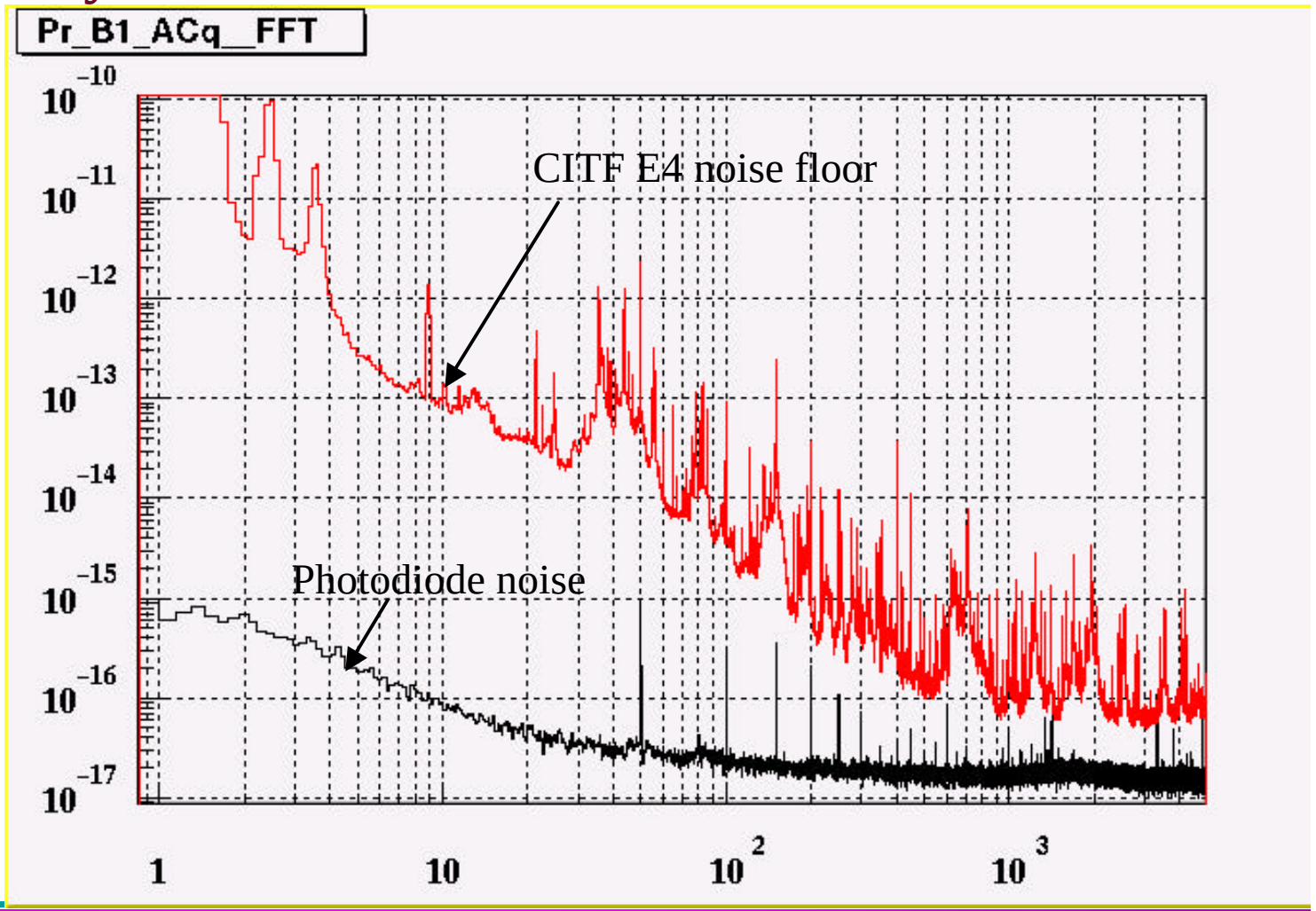
An Example of Noise Control R&D

Redesign the main locking loops of Virgo:

- **Improve the analog electronic:**
  - Better immunization to E.M. noise
  - Better dynamic
- **Improve the digital front end:**
  - ADC with more bits and less noise
- **Reduce the time delay between sensing and actuators:**
  - Increase the frequency of the control loops
  - Reduce the number of elements in the pipeline
- **Increase the computing resources to support:**
  - more complex filters
  - more complex strategies

Photodiode Noise

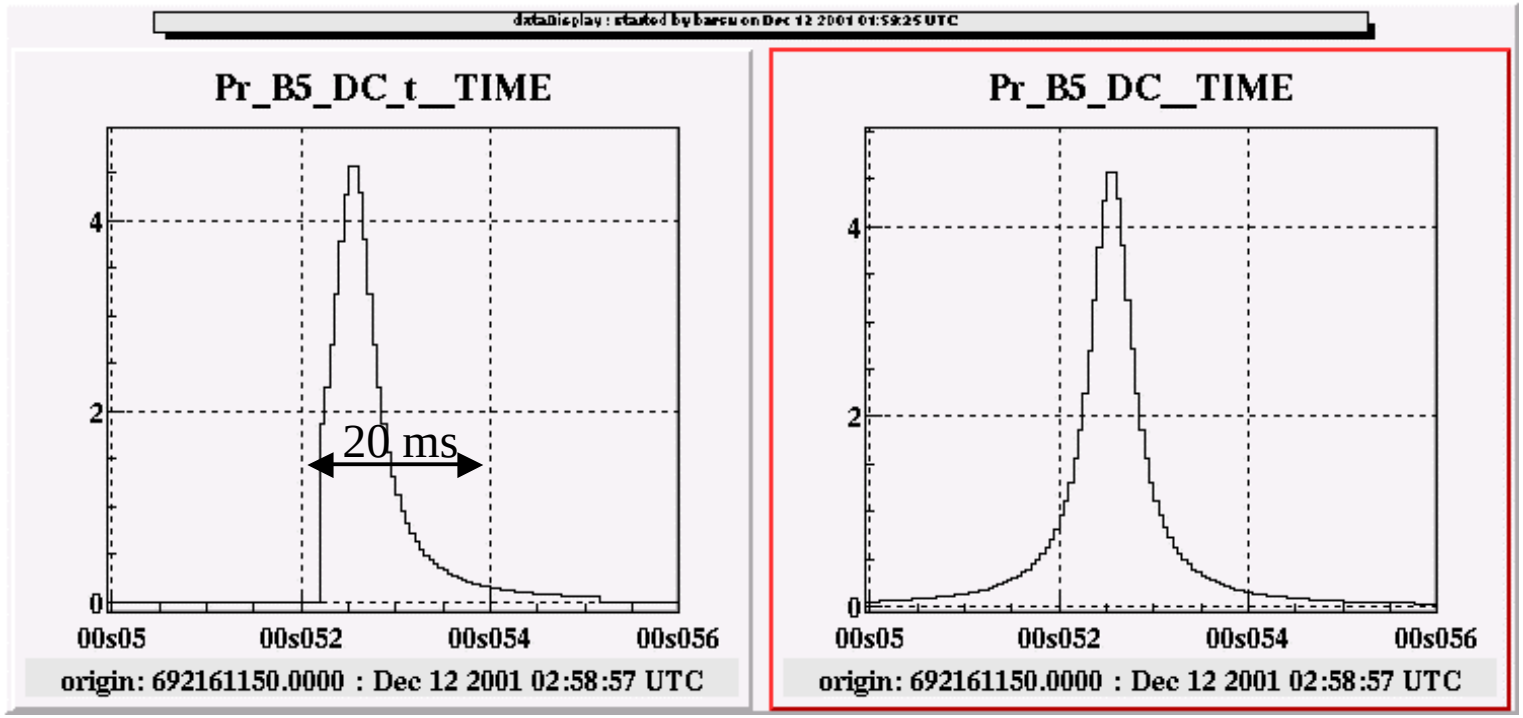
- **The Photodiode electronic noise did not limit the Virgo CITF sensitivity:**



- **But…**

Lock Acquisition Issue

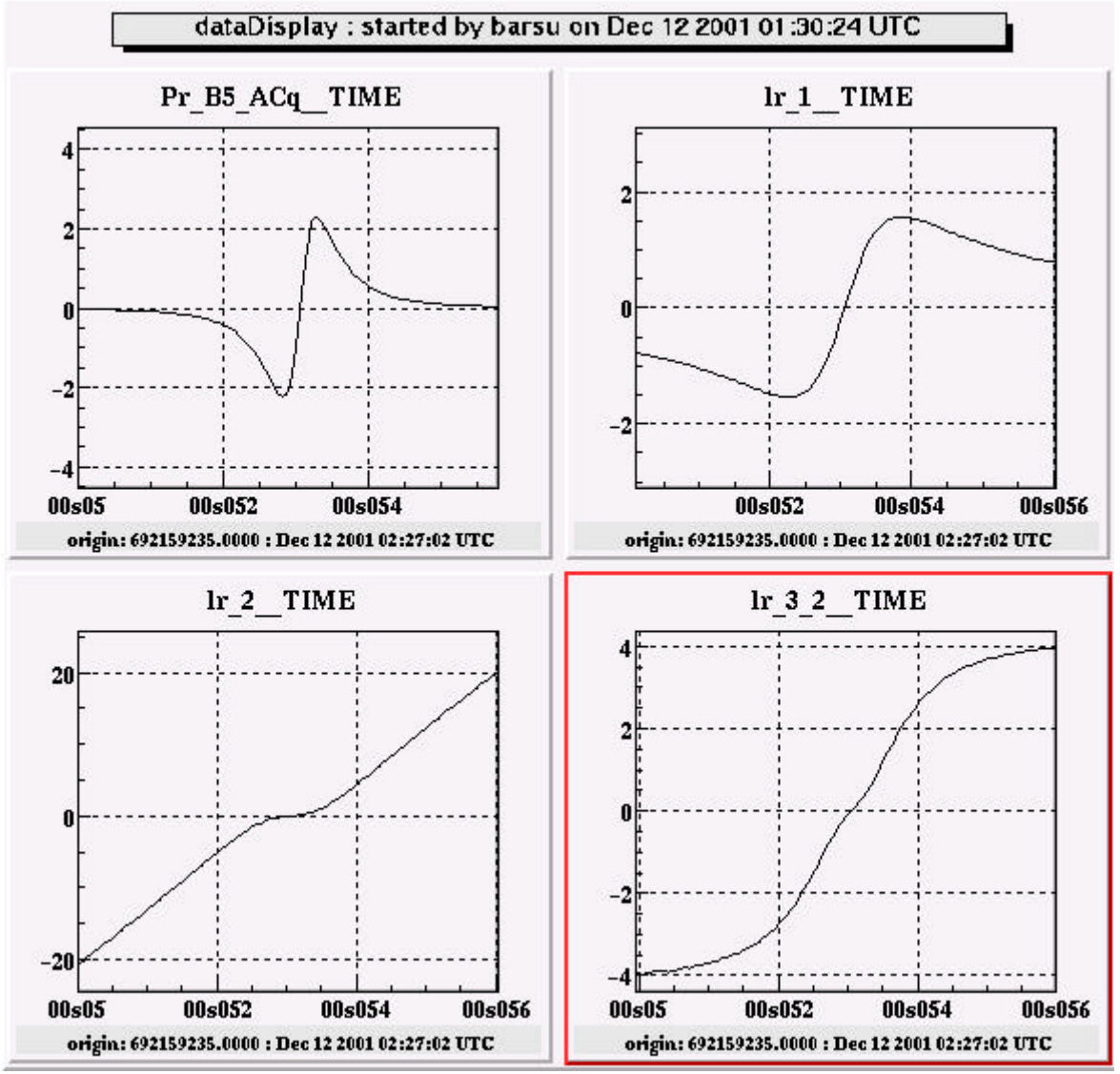
- **Signals to lock cavities are available only for short time**
  - Example CITF lock:



  - Solution: Try to extend the time when the error signal is available

Increase the error signal availability

- **Signal availability could by increased by**
  - ‘linearization’ (see plots)
  - Reducing the sensing noise
- **Benefit: relax the actuator constrains**
  - Reduce the noise introduce



Other examples of R&D

- **Reduce the noise coming for misalignments:**
  - Better electronic (analog and digital)
  - Removing some seismic noise at the sensor level?
  - Better model for the alignment coupling
- **Reduce the various offsets in the control loop**
  - Using better electronic
  - By developing procedures to monitor them
- **Better electronic to allow interferometer DC readout?**

Summary

- **It takes time to reach the design sensitivity**
- **To see the fundamental noises, we need to solve the control noises**
  - Better sensor
  - Better electronic
  - Better computer
  - Better procedure
  - Better models
- **R&D on the control noises are needed**