

# Preparation to data sharing with international partners

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## **Annual LIGO Laboratory NSF Review**

*LIGO Laboratory*

*Caltech, Pasadena*

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Andrea Viceré

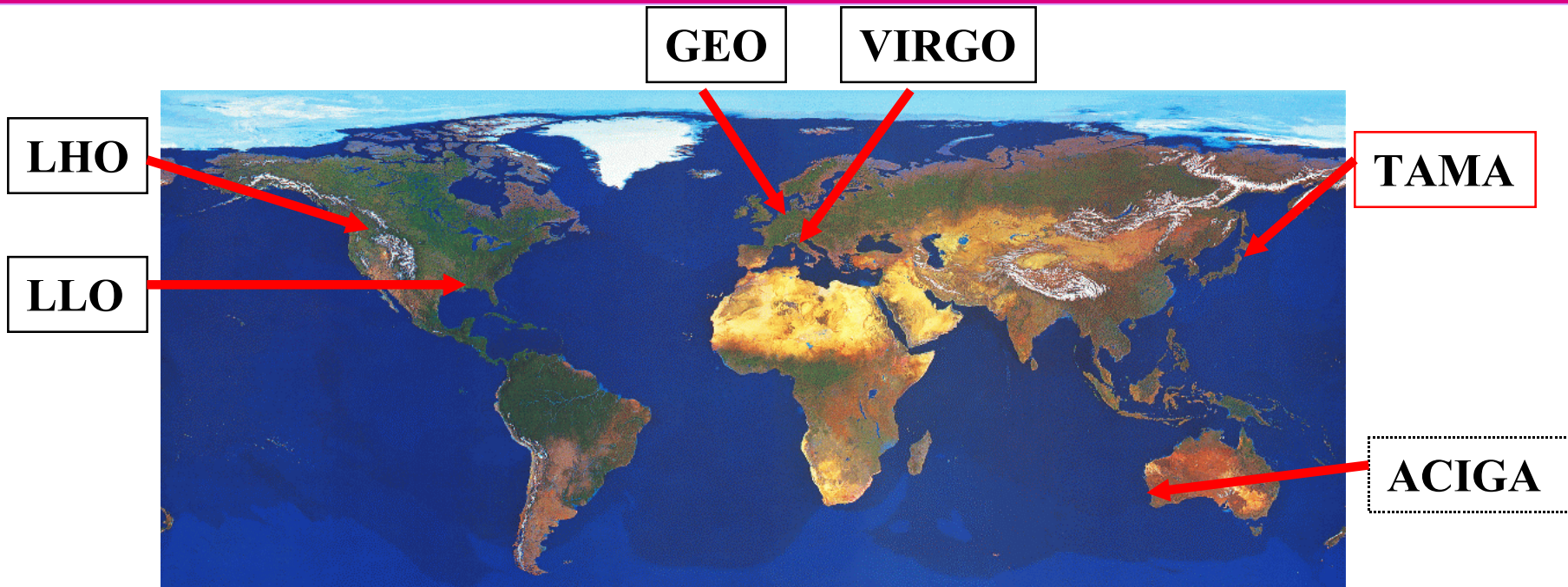
LIGO Laboratory Caltech

# Motivations

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- ✓ In the long term, we expect the observatories to do collaborative data analysis at different levels and cooperate as a network of detectors.
- ✓ This goal requires several steps: we focus here on some of the technical ones, related to data exchange.
- ✓ Lots of data are already being acquired: in particular, environmental monitoring data.
- ✓ Learning to exchange and analyze these data shall give us the experience needed for the future physics data.

## Observatories sites



- ✓ LIGO and GEO will collaborate fully on data analysis
- ✓ LIGO and VIRGO shall start from exchanging physics environmental monitoring data

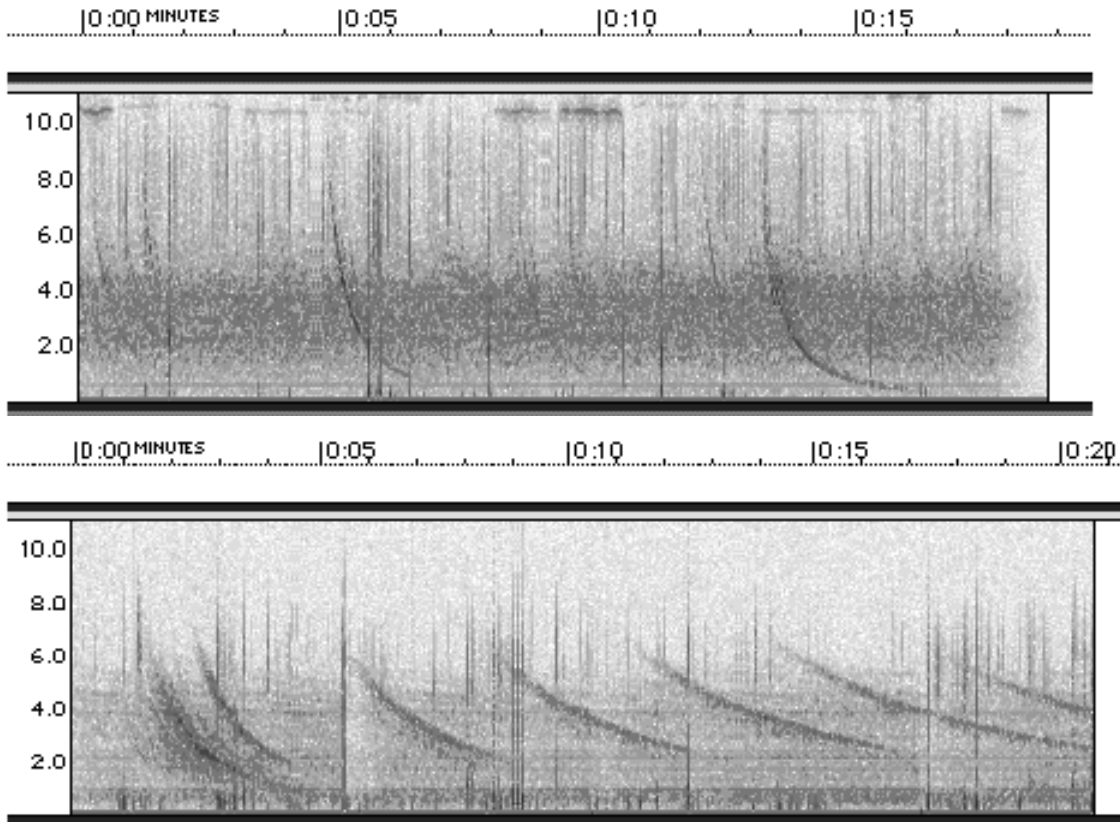
# Challenges of the network analysis approach

- ✓ Different instruments → specific data streams
  - ✓ Define common denominators, agree on the meaning of things
  - ✓ Scientists need to build an understanding of each other dataset.
- ✓ Widely separated sites → transport issue
  - ✓ Define bandwidth requirements, optimize information/cost
  - ✓ Verify effective band, availability, robustness
  - ✓ Address issues of usability, security
- ✓ Multi-instrument analysis → new value, added costs
  - ✓ Need to understand the better way to perform common analysis
  - ✓ Wide range of options, from event list comparison to full multi-dimensional analysis: need experience

# Science issues

- ✓ PEM data convey already some physics!
- ✓ Seismic events can correlate on the LIGO-VIRGO distance
  - ✓ Events originating close to the equidistant plane can correlate within the narrow ( $\pm 40$  ms) window common with GW detection
- ✓ Electromagnetic events are transported to long distances ionosphere
  - ✓ In particular the interaction of lightnings and the magnetosphere causes VLF EM signals potentially affecting LIGO band as *whistlers*
- ✓ Coincidences in these data can serve in the future as *vetos* for the network analysis

# Candidates: the whistlers



- ✓ Typical natural radio signals
- ✓ A spectrogram reveals the nice “chirping” waveform
- ✓ Luckily enough, unmistakable for inspirals!

<http://image.gsfc.nasa.gov/poetry/inspire/advanced.html>

# Experience: LIGO-LIGO data exchange

- ✓ 4-day test during E3 run
  - ✓ Real time generation & merge

Benoit Mours  
Szabolcs Marka

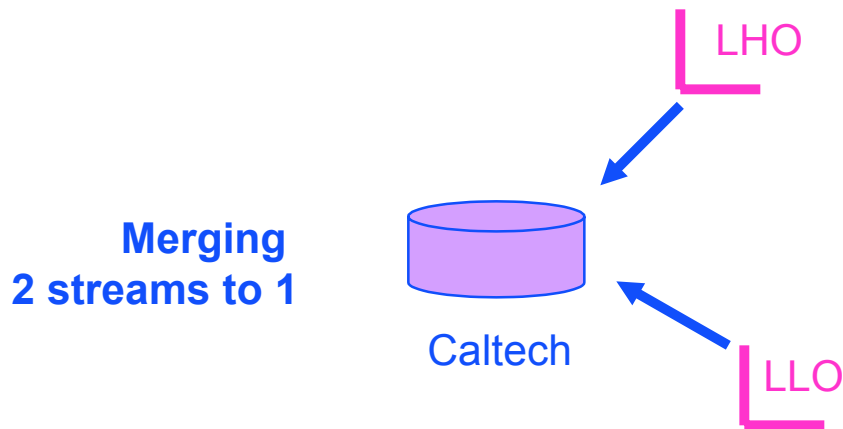


**Technologies exercised:**  
RDSwriter (channel selection)  
ssh (secure transmission)  
cron (timing)  
rsync (Unix replication)

# Multiple Observatory Prototype

- ✓ Combining Data Streams
  - ✓ real time generation, transfer, merge

Benoit Mours  
Szabolcs Marka



**Technologies exercised:**  
DMT (realtime data stream transform)  
ssh  
cron  
rsync

Achieved 12 - 80 kbyte/sec



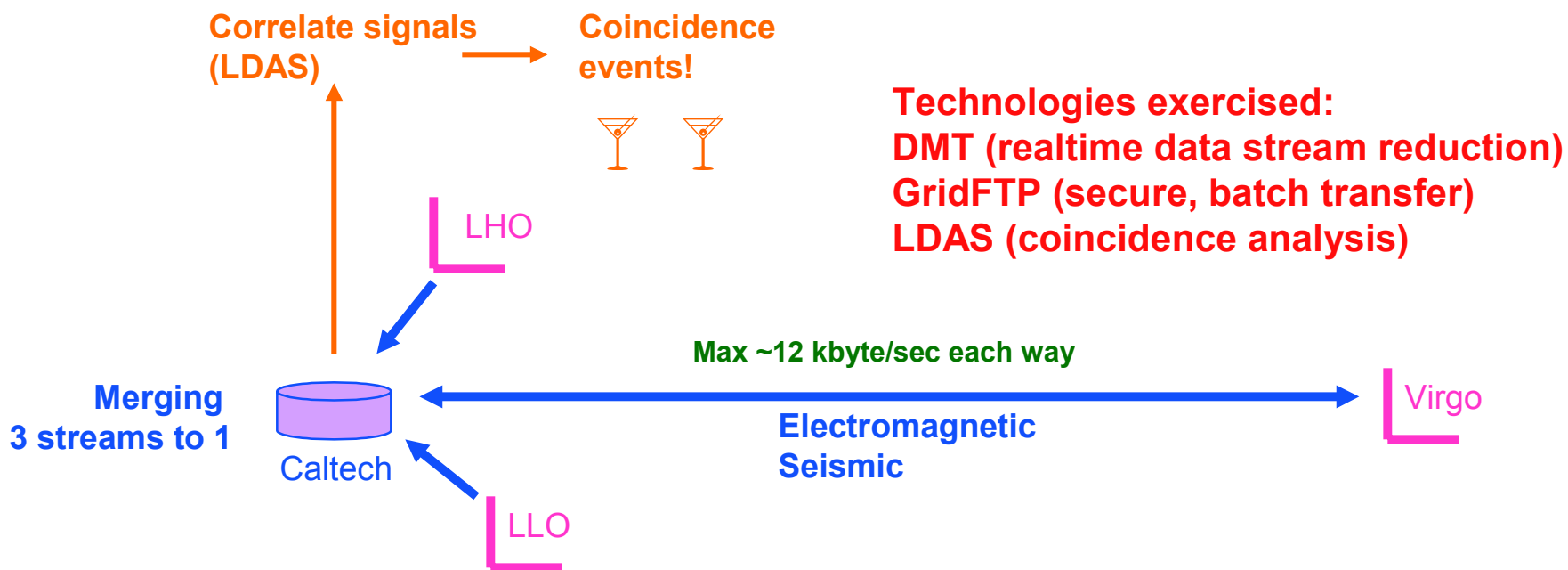
# LIGO-Virgo data exchange

- ✓ Background
  - ✓ LIGO-Virgo meeting on the concept [2/10/2000]
  - ✓ LIGO-Virgo meeting focused on PEM details [2/11/2001]
- ✓ PEM channels
  - ✓ Sites involved: Cascina [VIRGO], Hanford & Livingston [LIGO]
  - ✓ Seismometers: 1/site, 256 Hz sampling, 1 Kbyte/sec
  - ✓ Magnetometers: 4096 Hz sampling, 8 Kbyte/sec [compressed!]
- ✓ Data rates necessarily limited
  - ✓ Start by June 1<sup>st</sup> 2001, exchanging few tens of Kbytes

# LIGO-Virgo projected exchange architecture

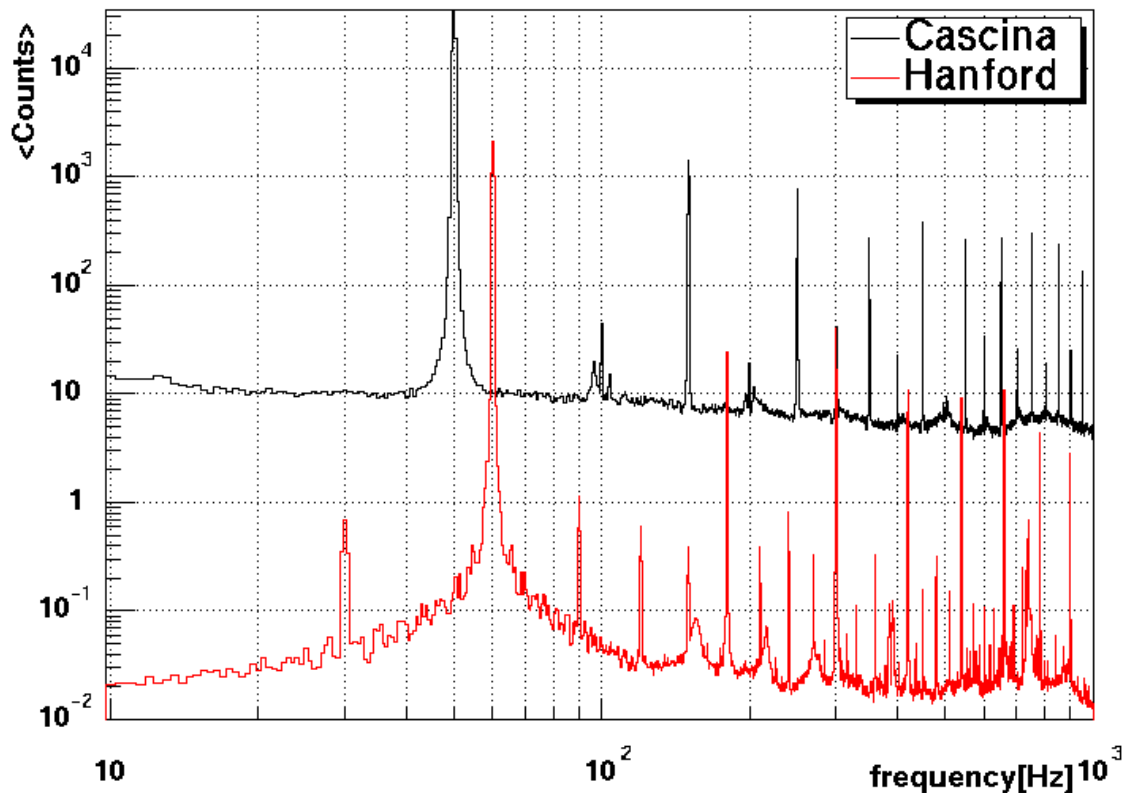
- ✓ No strain data for the moment:  
limit to seismic and  
electromagnetic sensors

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Roy Williams  
.....



# Example of analysis using two sources

FFT <amplitude>{LrDbpower50}(Time origin: local=Sat Feb 3 16:03:40 2001 GPS=665251401)



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- ✓ Power line monitor
- ✓ Just an example of what scientists might want to monitor continuously