Improvements to the Cosmic Rays Radio Detector System Data Acquisition

by *Denis Oliveira Damazio*
(Brookhaven National Laboratory)

IEEE NSS 2004 conference

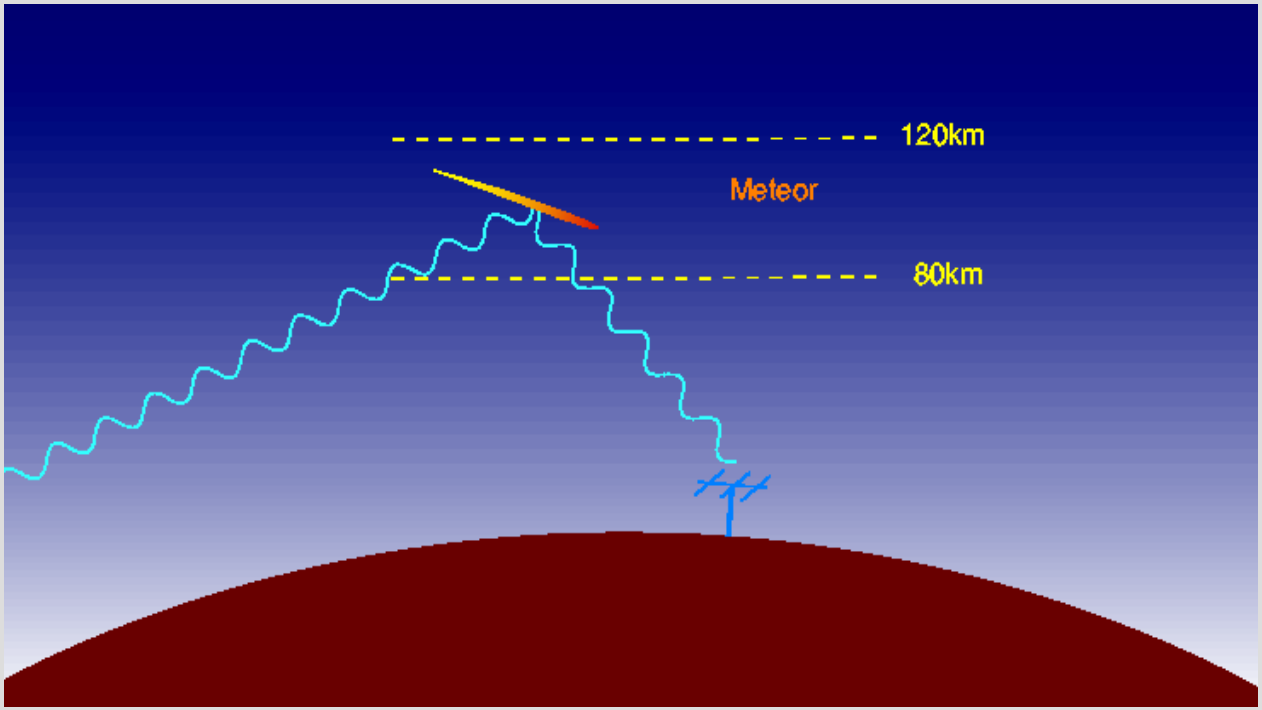
October 20th, 2004

Outline

- Introduction to radio scattering techniques.
- Our experimental setup.
- Improvements to the data acquisition system.
- Experimental results.
- Conclusions.

Radio Scattering

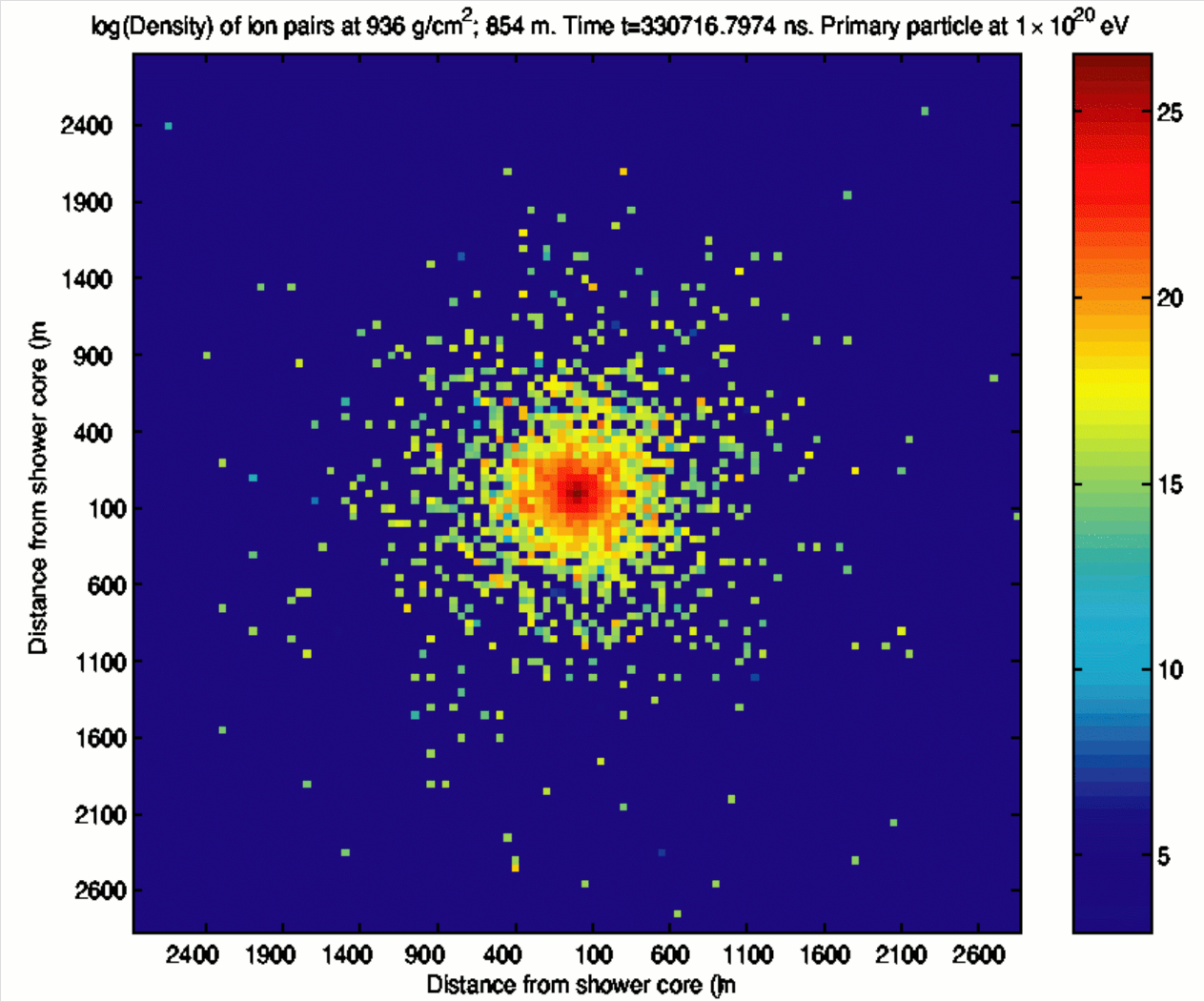
- radio scattering has been used for meteor detection. See www.imo.net



• The burning meteor produces a trail of ionized air. The free electrons reflect below the horizon electromagnetic waves such as those from a TV station.

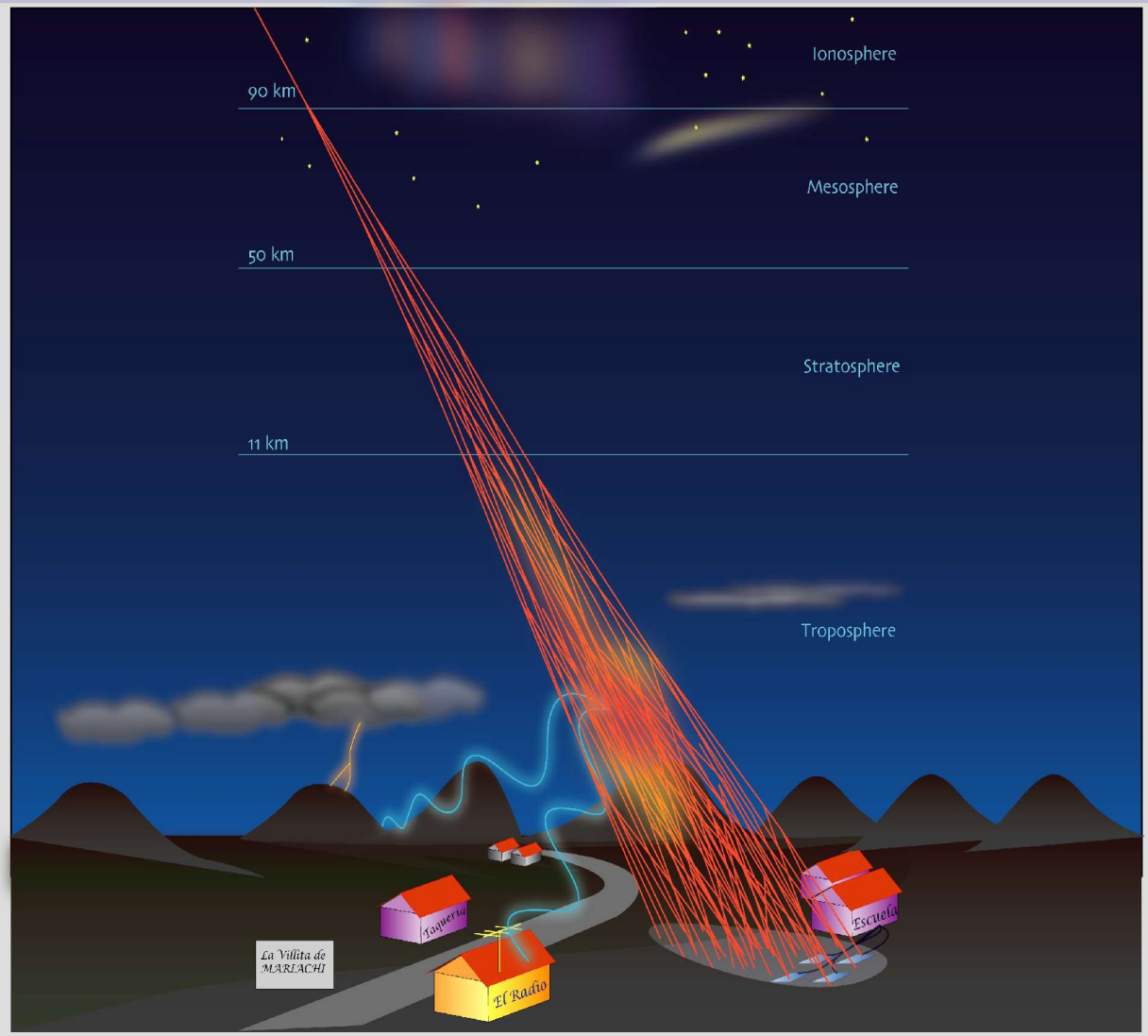
Radio Scattering for Cosmic Rays?!

- Simulations indicate the possibility of using radio scattering for Cosmic rays.
- The height of the events (maximum electron density) is smaller (below 15 Kms).



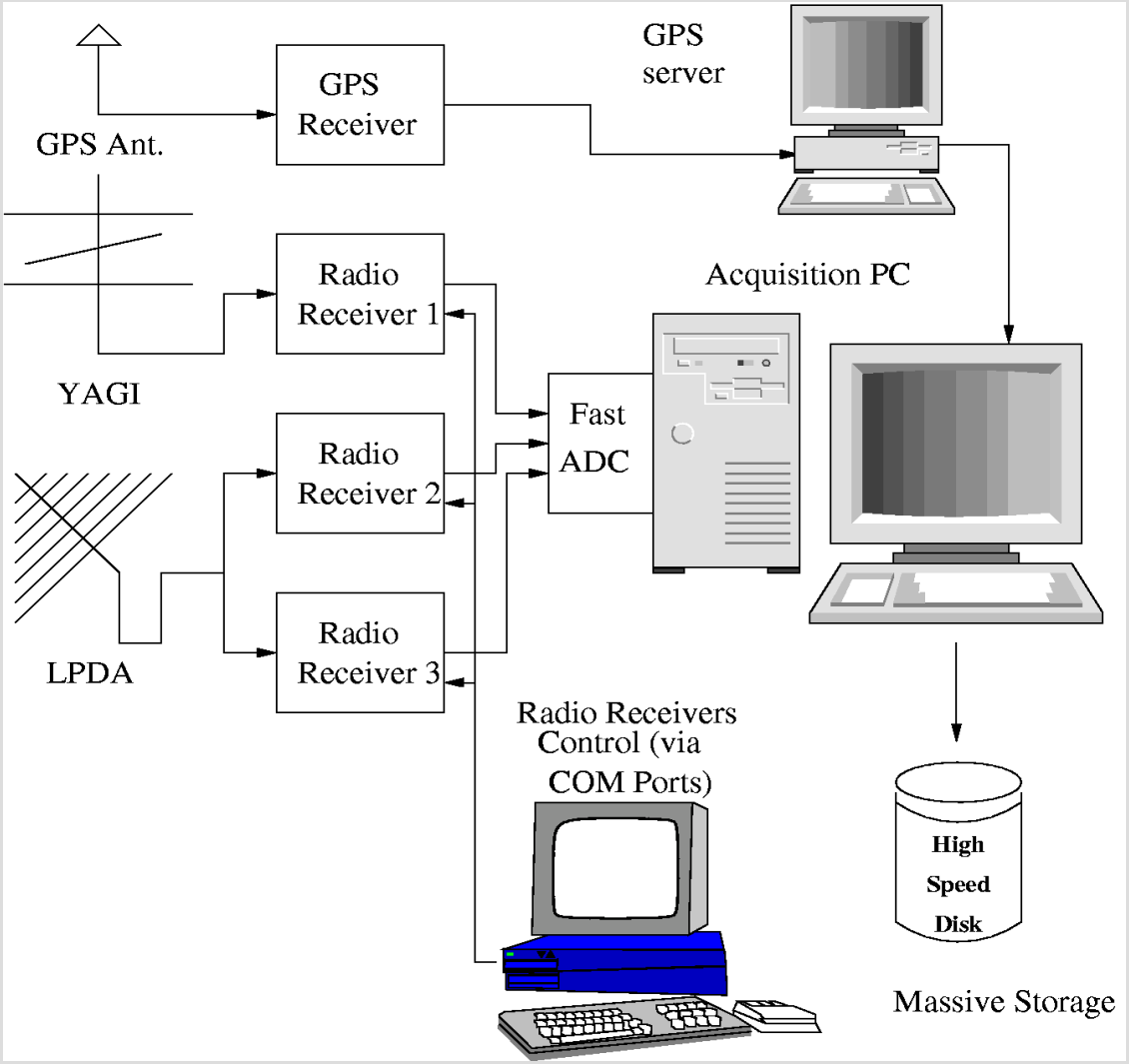
Radio Scattering of CR

- The project MARIACHI was initiated to check the possibility of studying CR through Radio waves.
- Proof of principle experiment.



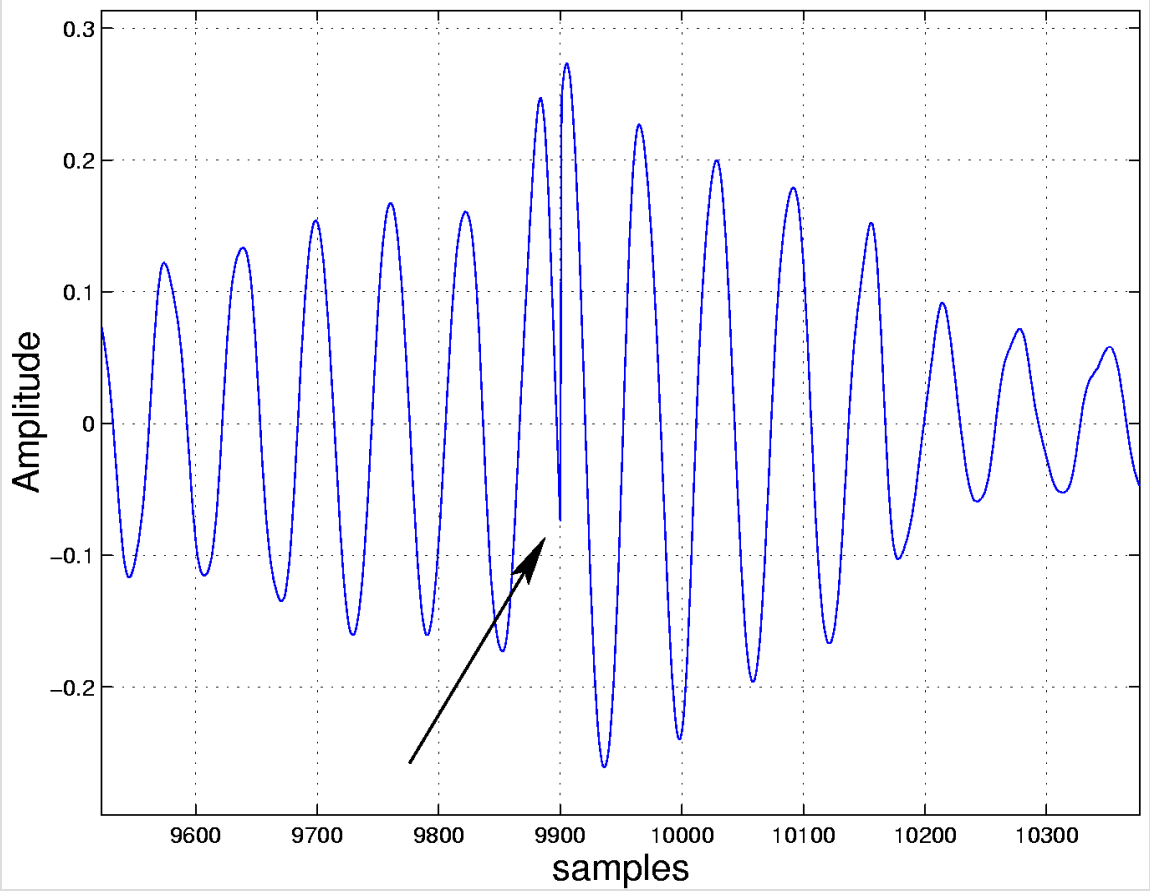
Our Initial Experimental Setup

- Network access for GPS time-stamping.
- Radio receivers to demodulate signal.
- Setup sensible to meteor events.



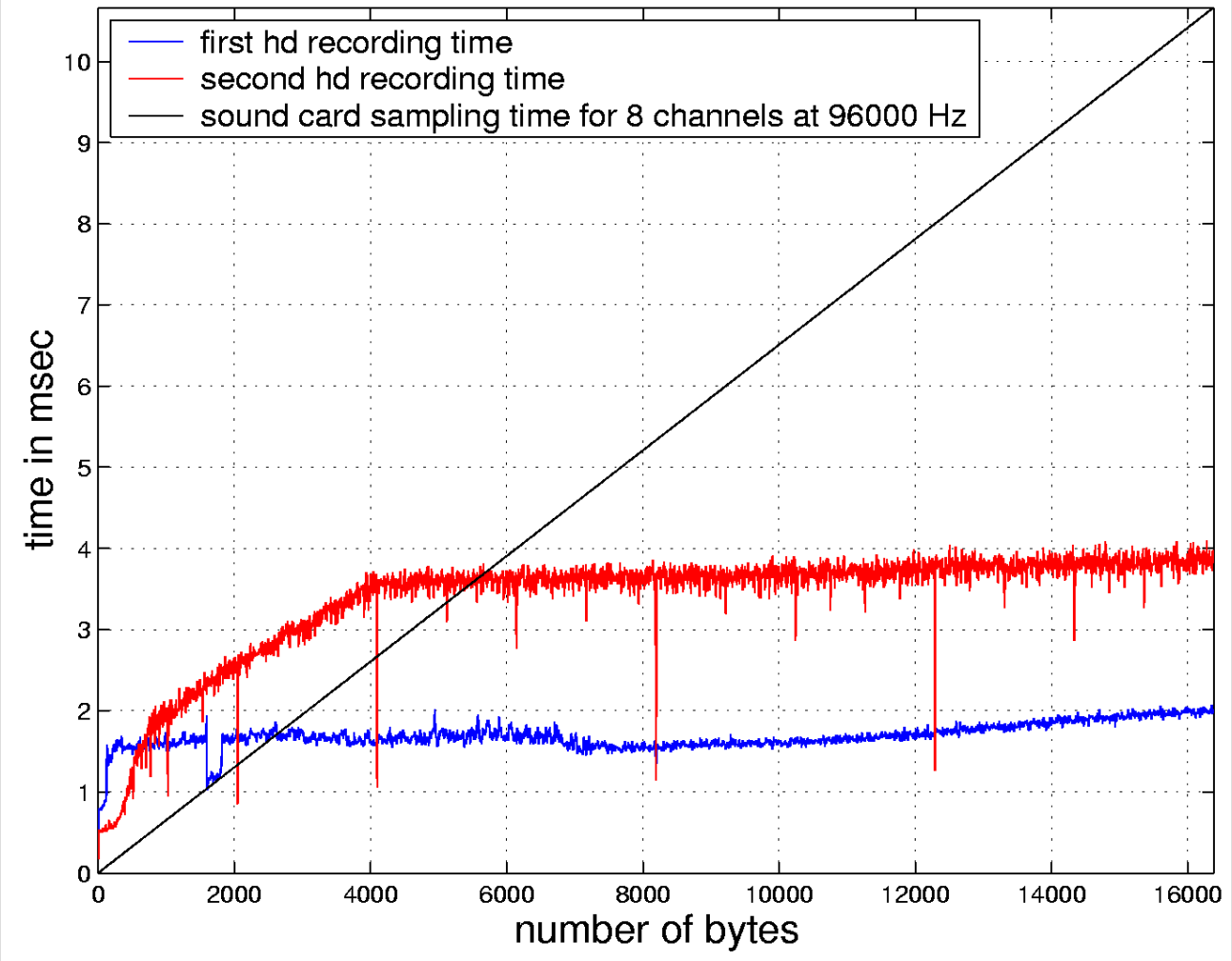
Initial Experimental Setup

- Gaps found in the data sample.
- Impossible to obtain precise time-stamping.
- CPU does “something else” instead of servicing interrupts.



Initial Experimental Setup

- The recording to the hard disk can impose a limit to the minimum size of buffer to be used.
- Number of channels and sampling rate dependency.
- Some latency is unavoidable.

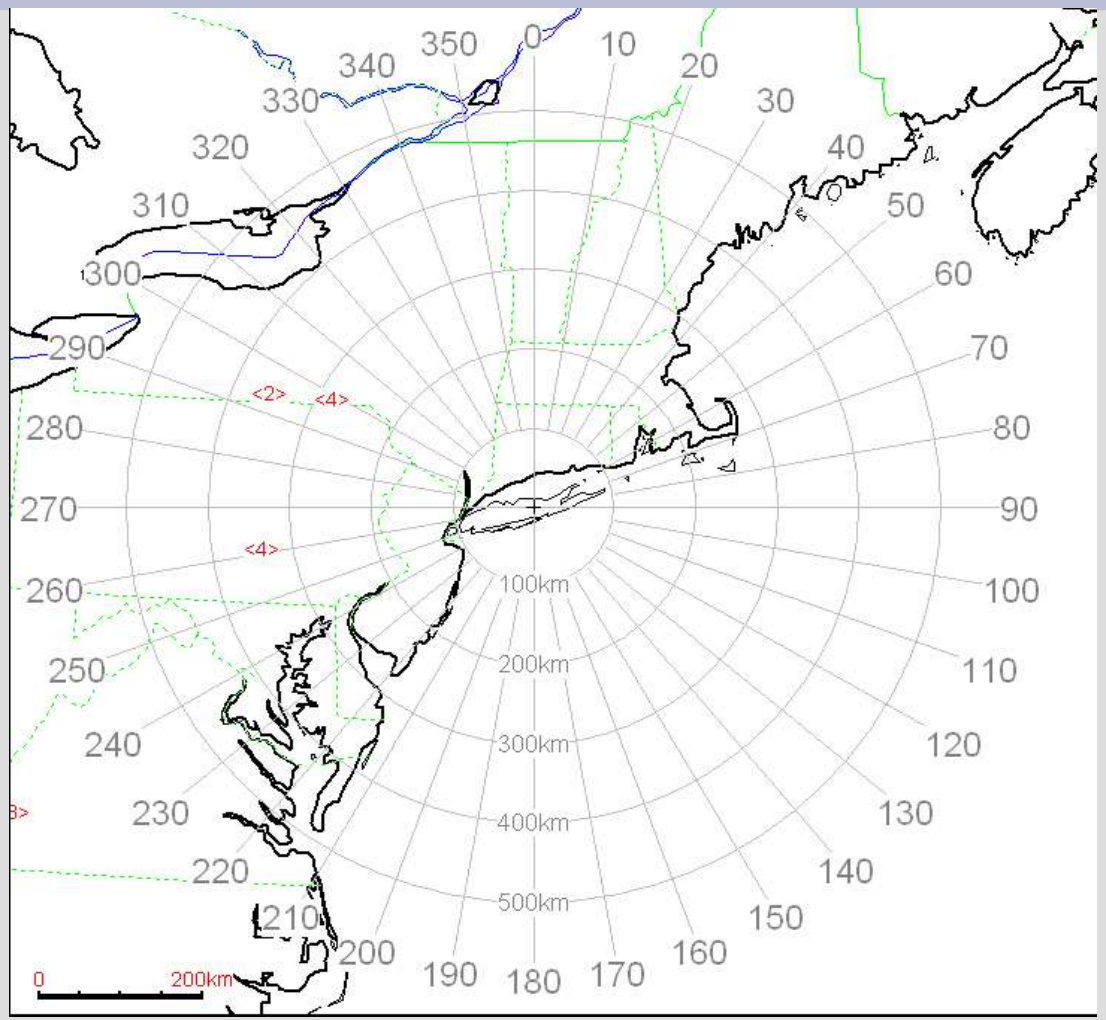


Improvements to the DAQ

- Usage of DTV (fewer and with a carrier).
- Inferior limit assigned to the buffer size.
- Software redesign : thread to capture samples from sound card should be FIFO with highest priority.
- capture thread only perform one OS system call.
- Use of a GPL real time OS (rtlinux). See www.rtlinux.org.
- Performance monitoring with GPS pps directly connected to the sound card.
- Insertion of attenuated GPS bitstream as a signal to sound card the sound card.

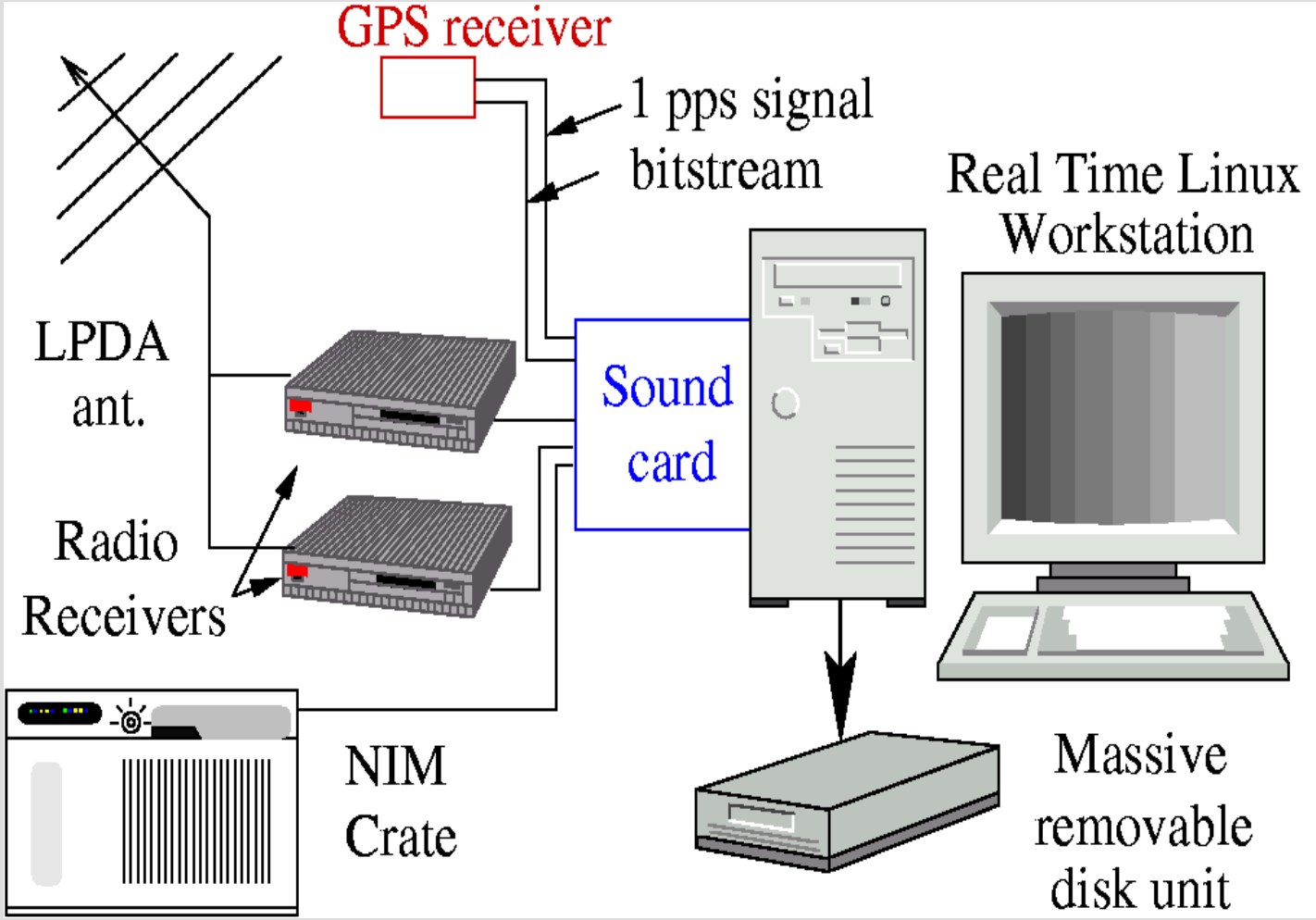
Improvements to the DAQ

- Smaller number of Digital TV stations -> less noise.
- Easier to detect -> non-suppressed carrier.



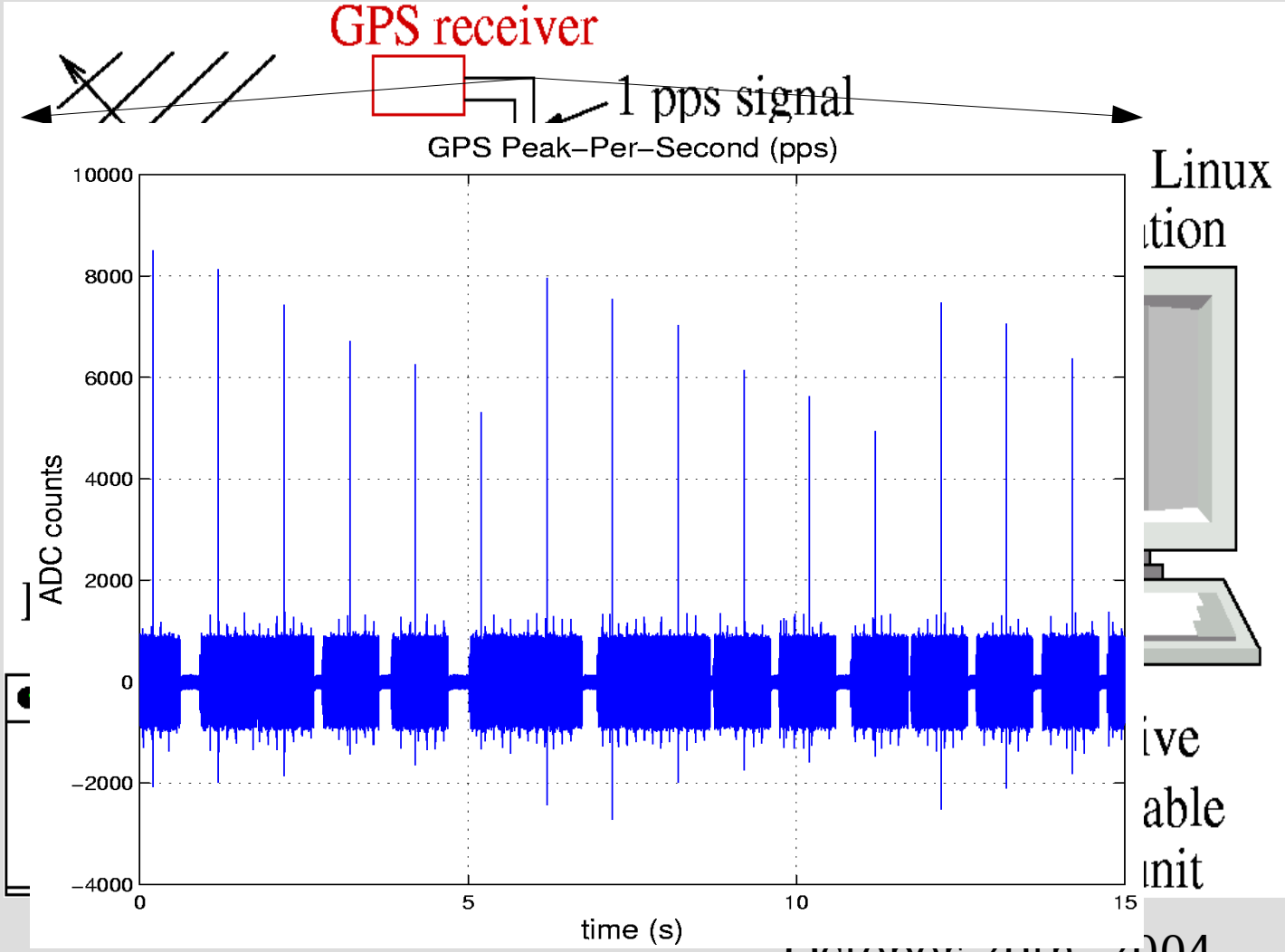
Improvements to the DAQ

- New setup.
- GPS fed directly to the sound card.
- workstation not connected to network (linux single).



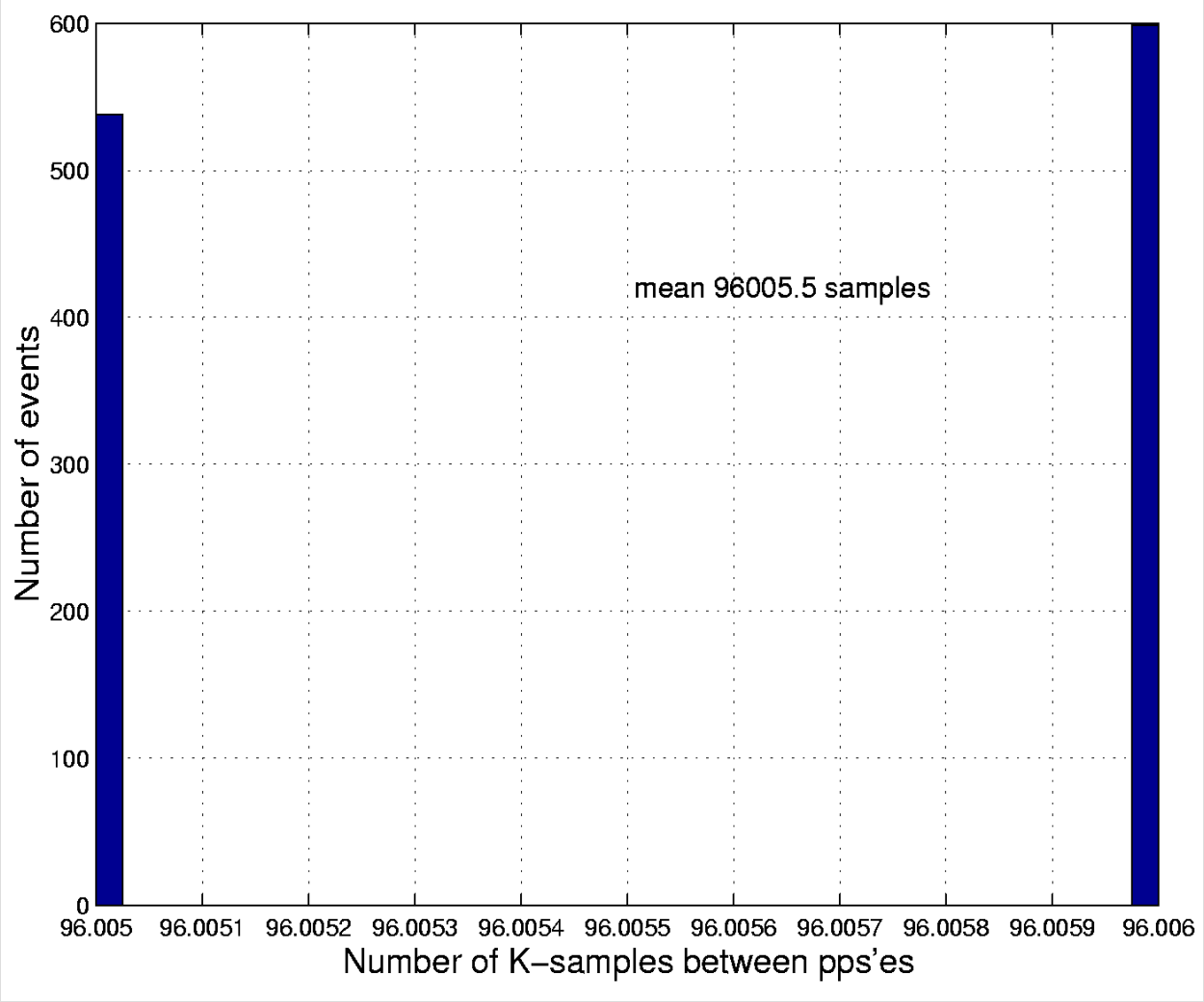
Improvements to the DAQ

- the peak per second (pps) signal allows to check for data loss.
- The number of samples should be constant between pps'es.



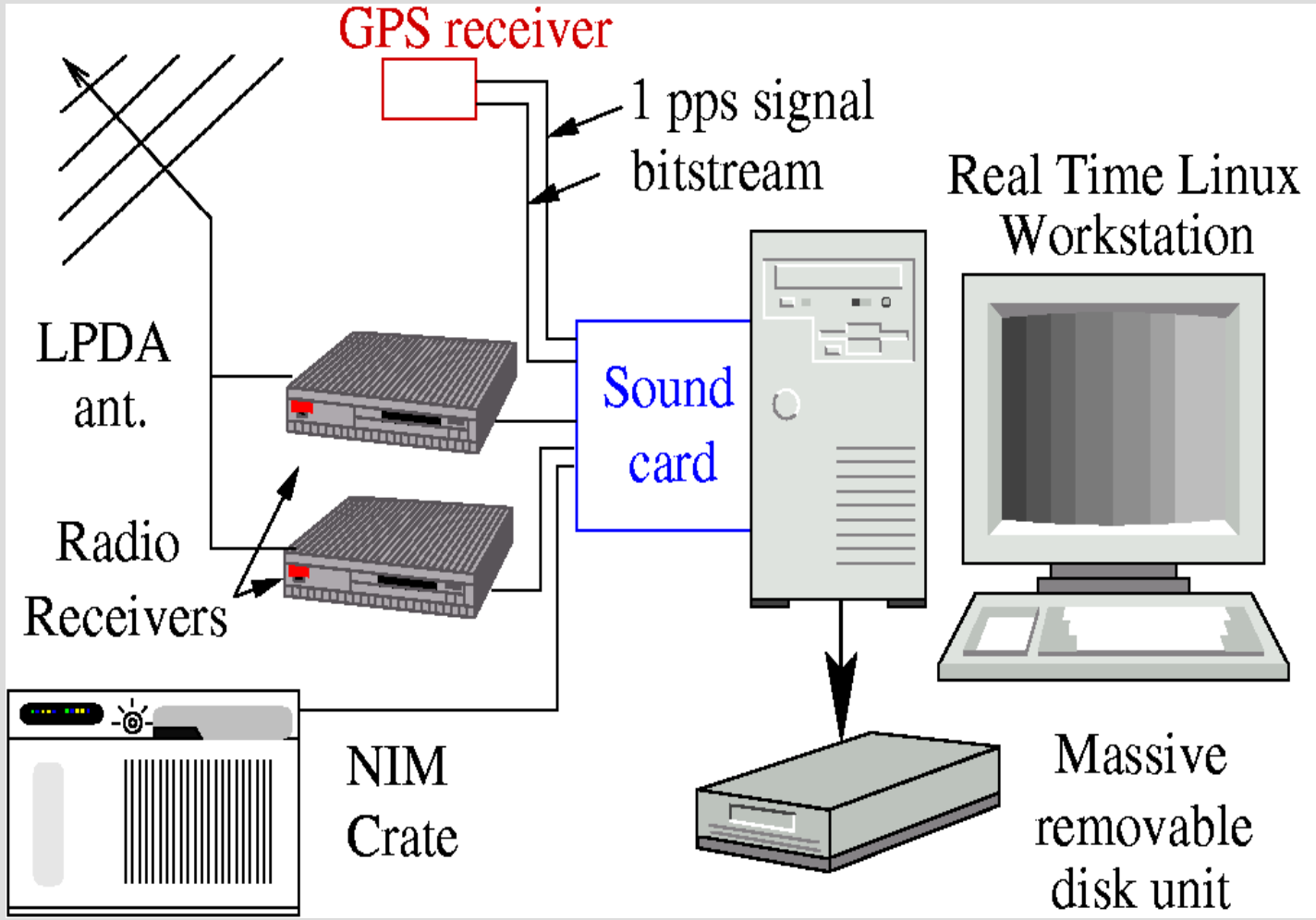
Improvements to DAQ

- Number of samples between pps'es shows improvement of the system.
- Is time stamping of individual samples now possible?



Improvements to the DAQ

- Bitstream also fed to sound card.
- Serial standard signal (baud 9600).



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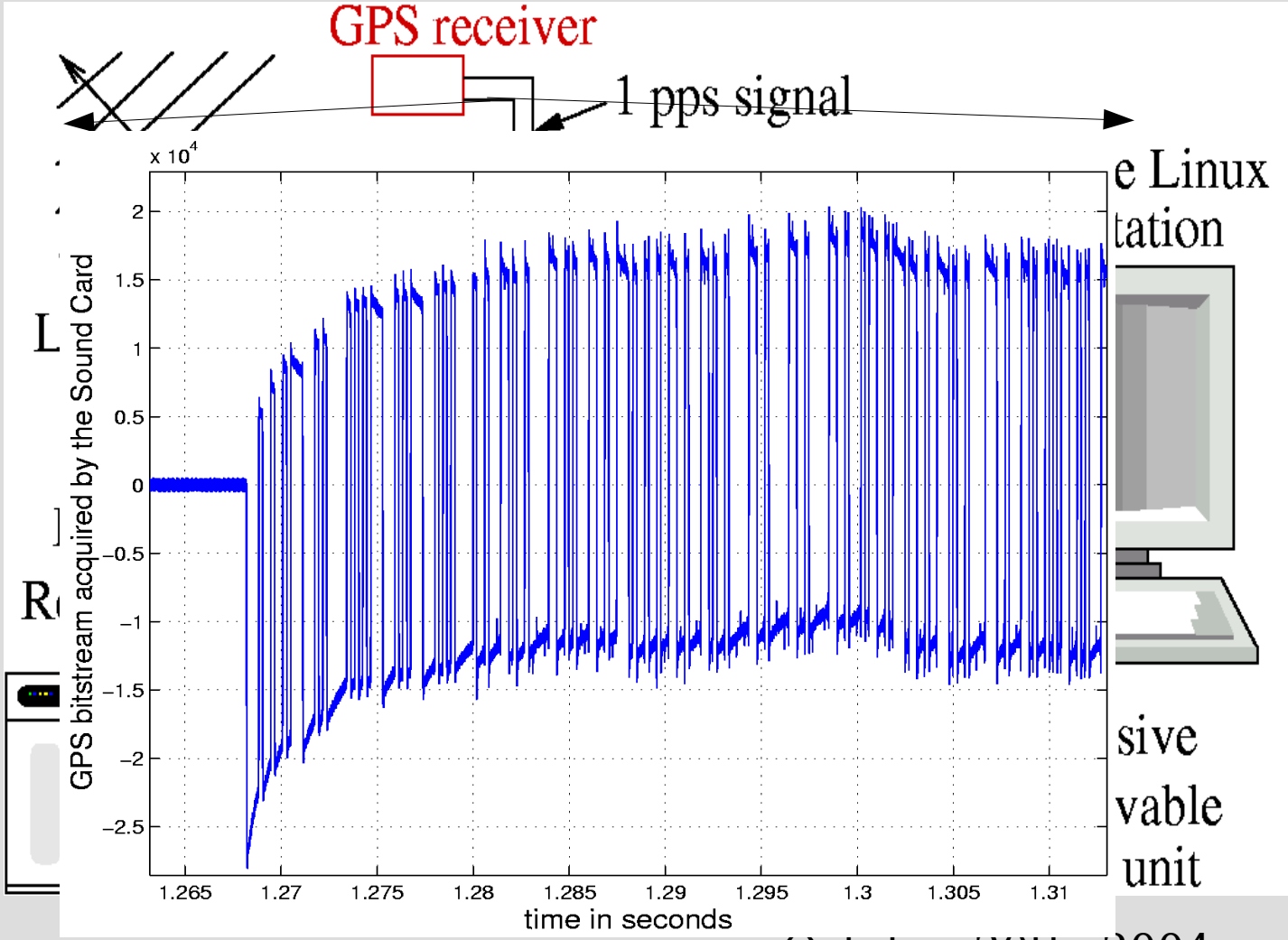
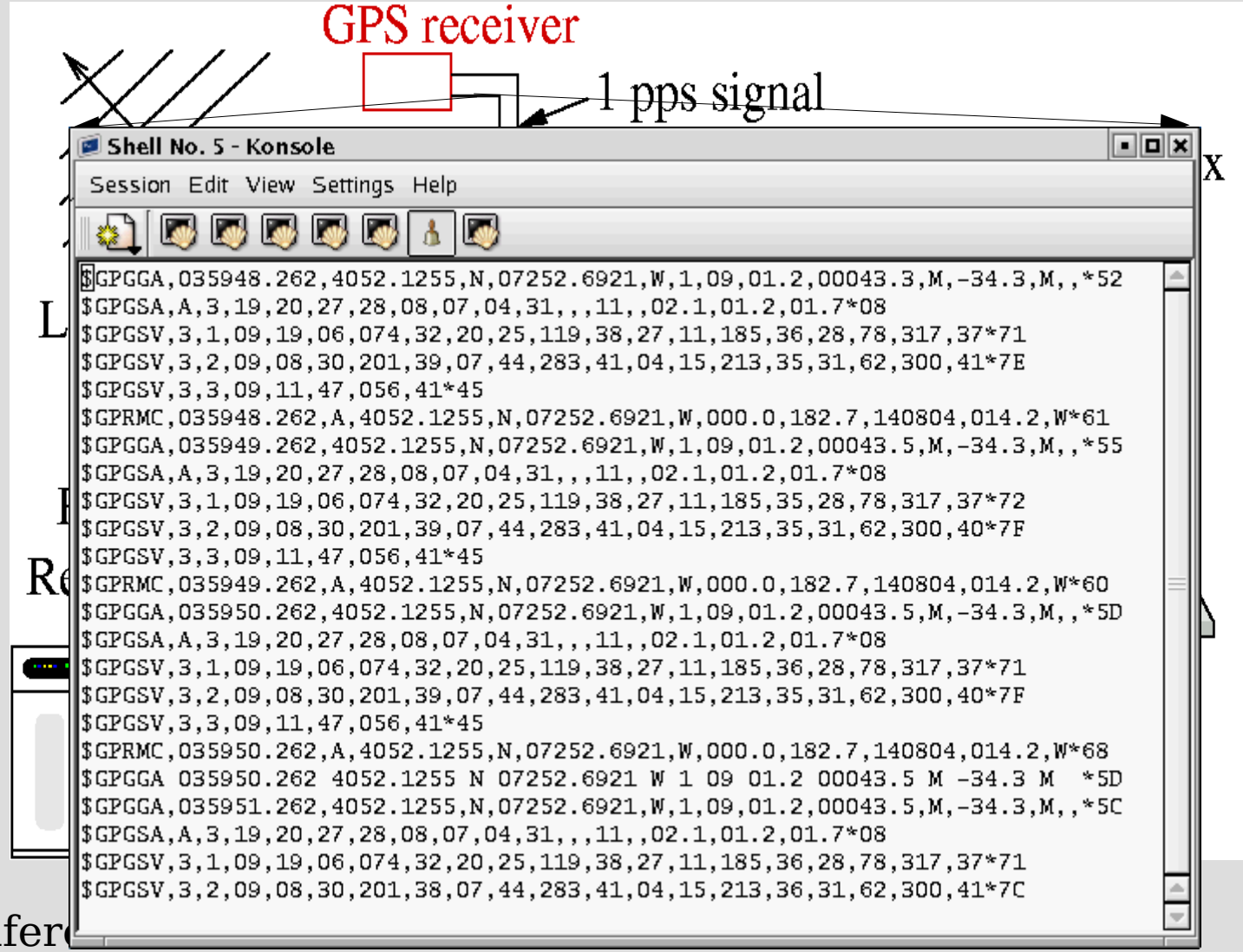


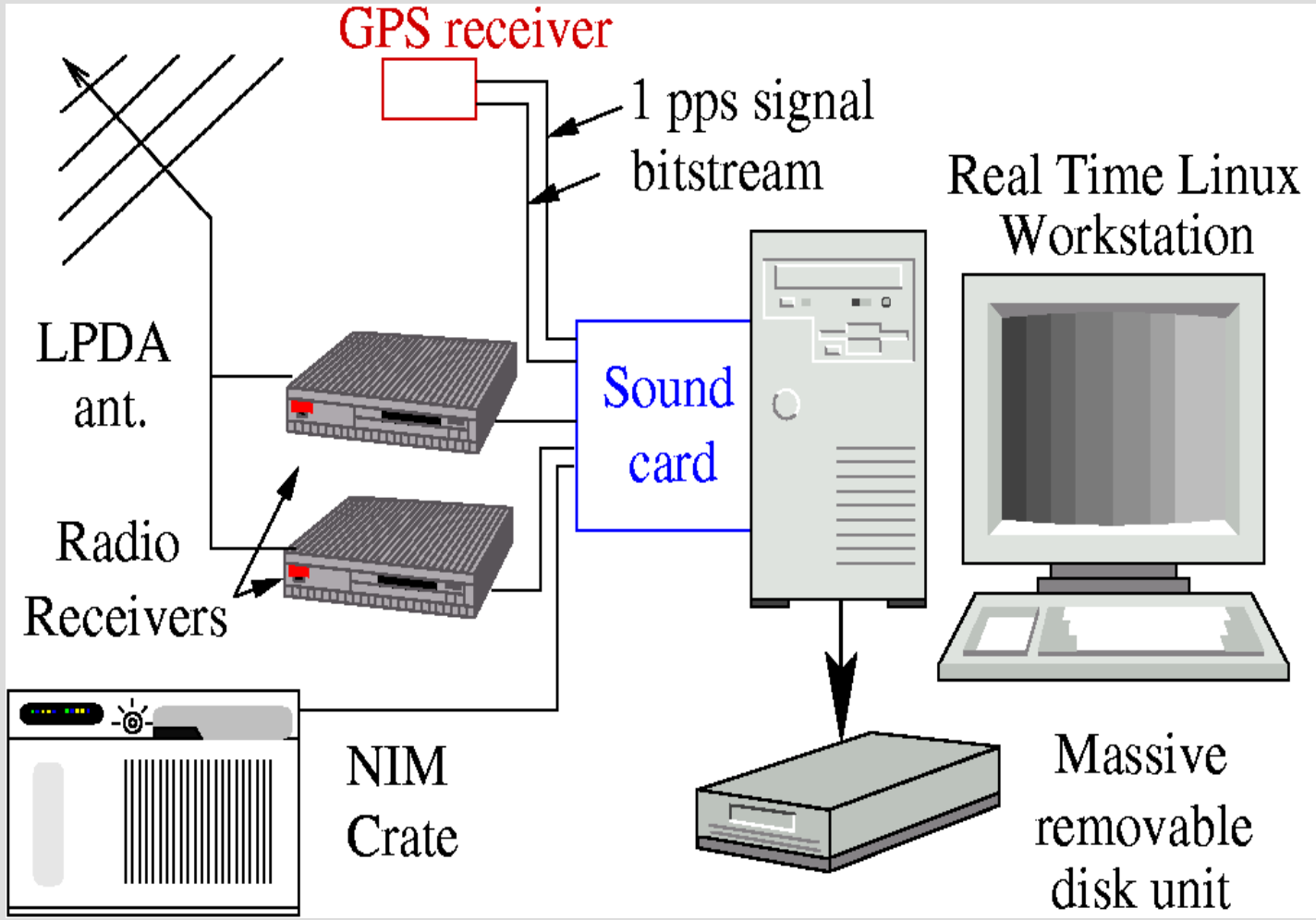
Improvements to the DAQ

- When the bitstream is decoded offline, the NMEA code is found.
- Time precision is in the millisecond order.



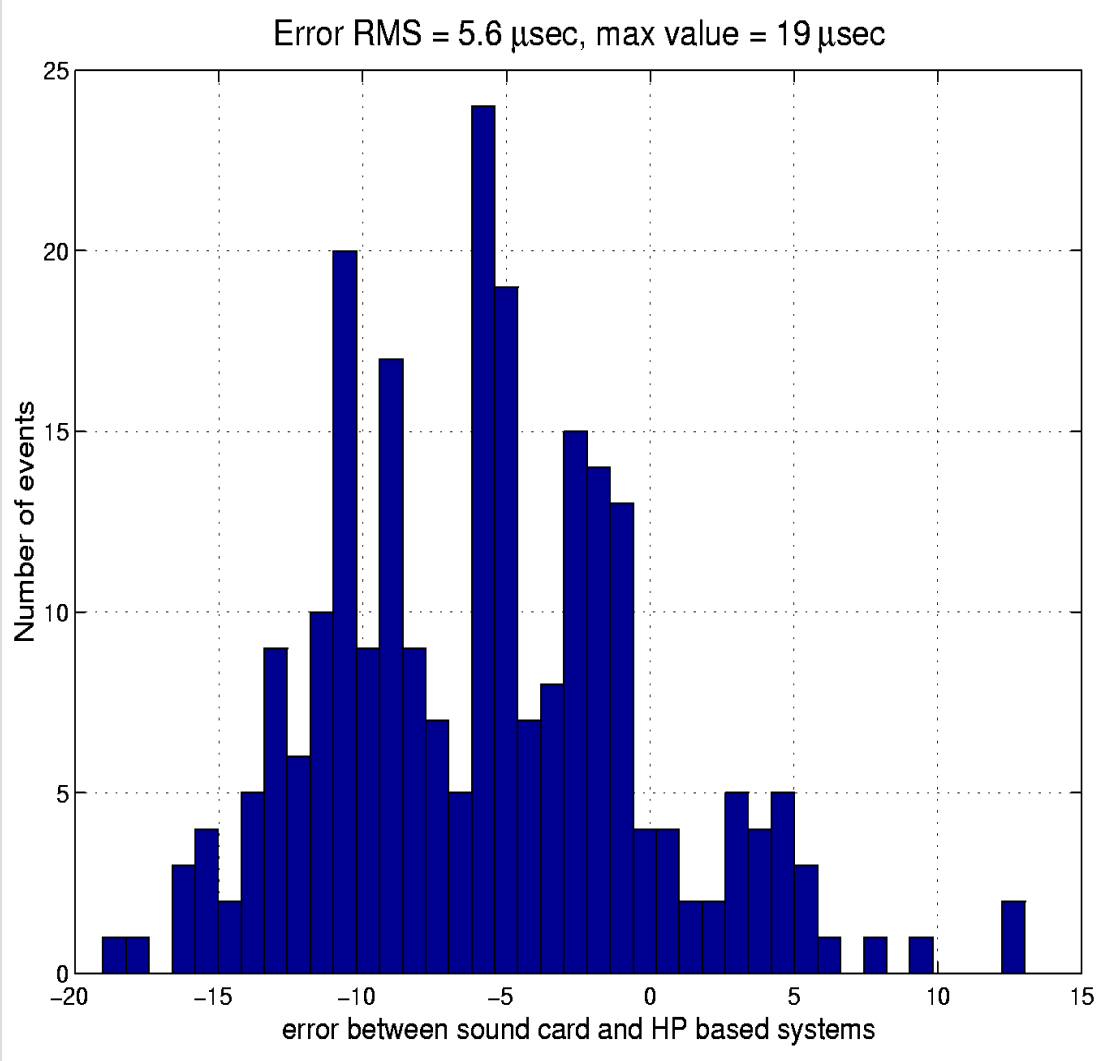
Improvements to the DAQ

- Usage of a NIM crate (four fold coincidence of scintillating pads) for offline CR trigger.
- NIM crate output fed to the sound card.



Improvements to the DAQ

- The NMEA millisecond mark is updated of 1 msec at around 150/180 seconds.
- Using this one can interpolate and get a higher precision.
- A comparison with a HP+expensive GPS (ns precision) was performed.

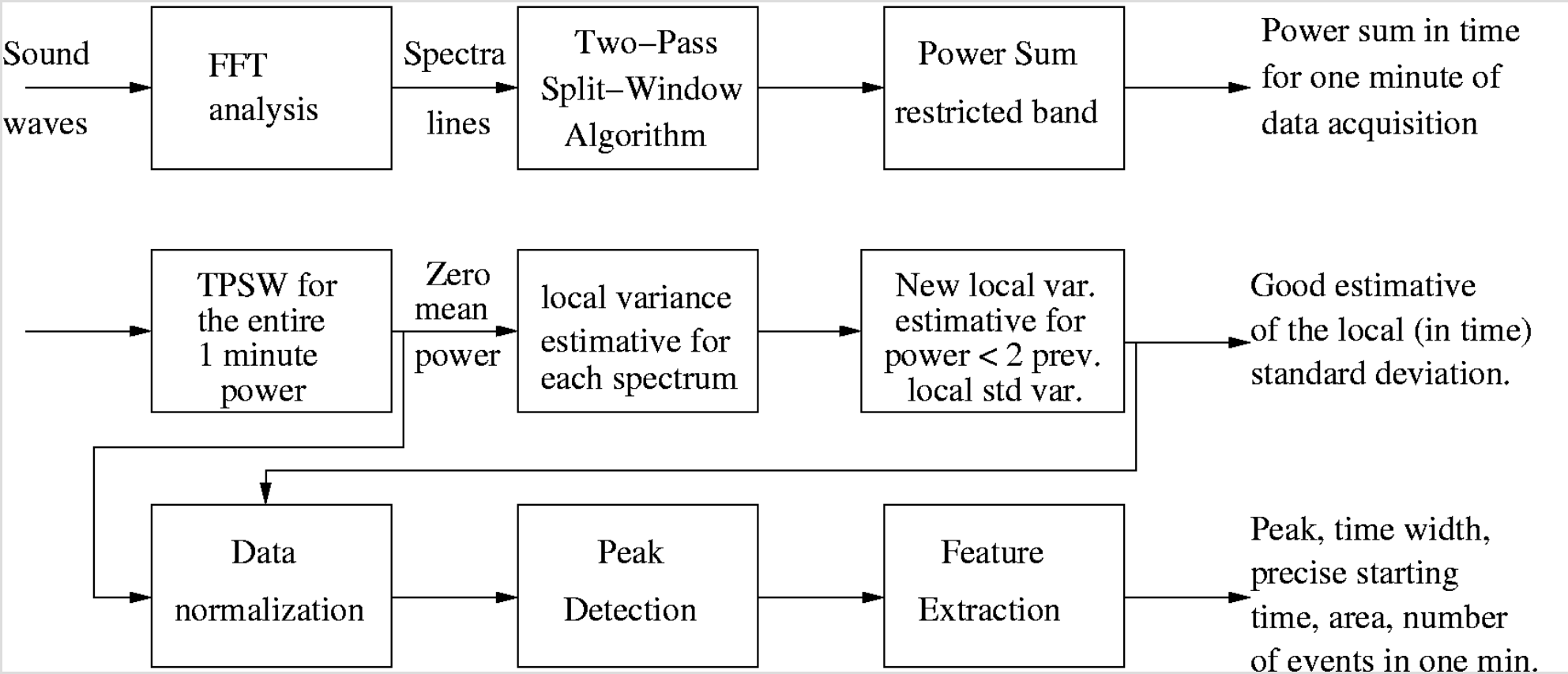


Experimental Results

- two receiving stations (BNL and SCCC) were assembled in Long Island.
- DTV channels 2 and 4 were studied in both receiving stations.

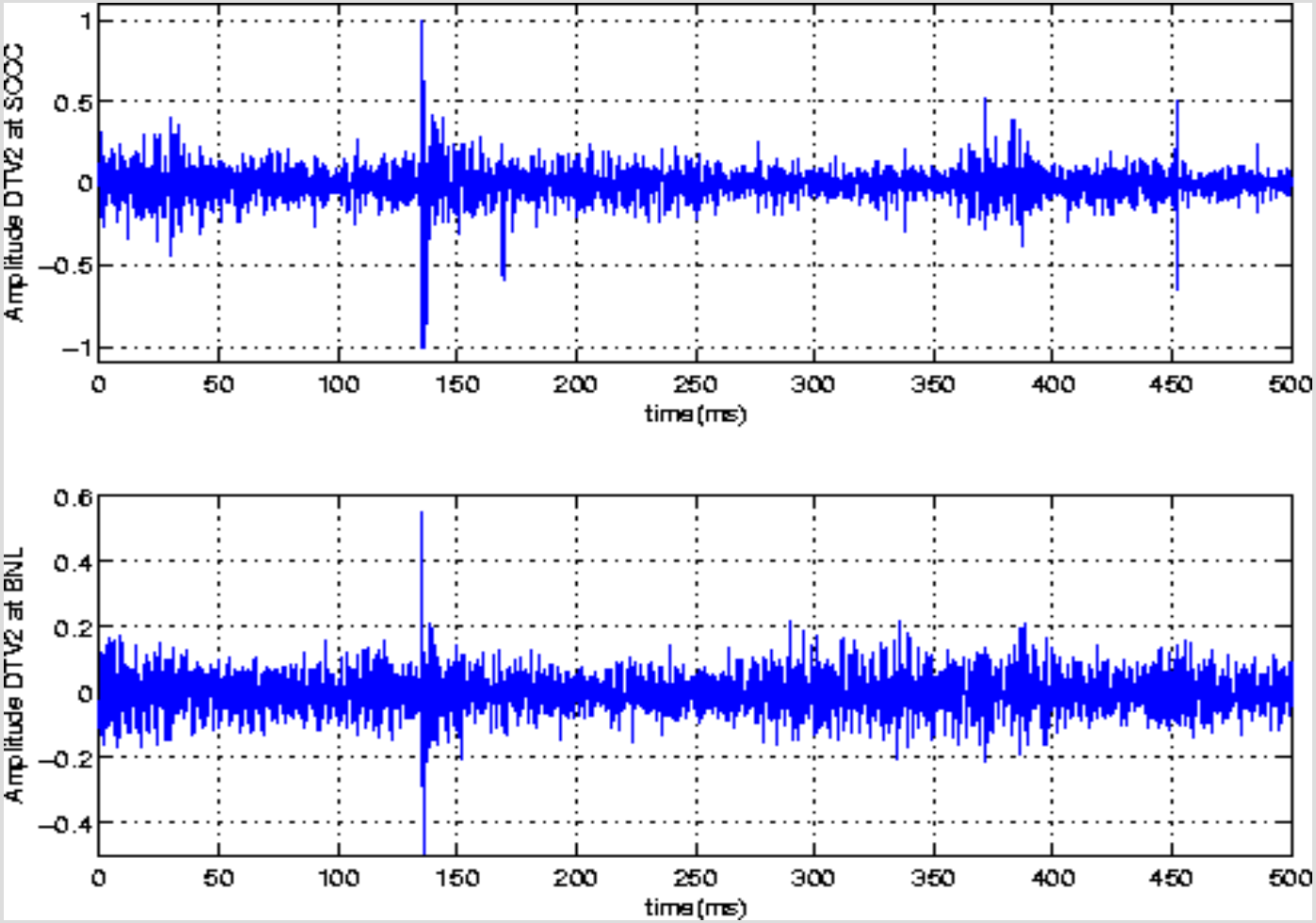
Experimental Results

Offline Analysis performed



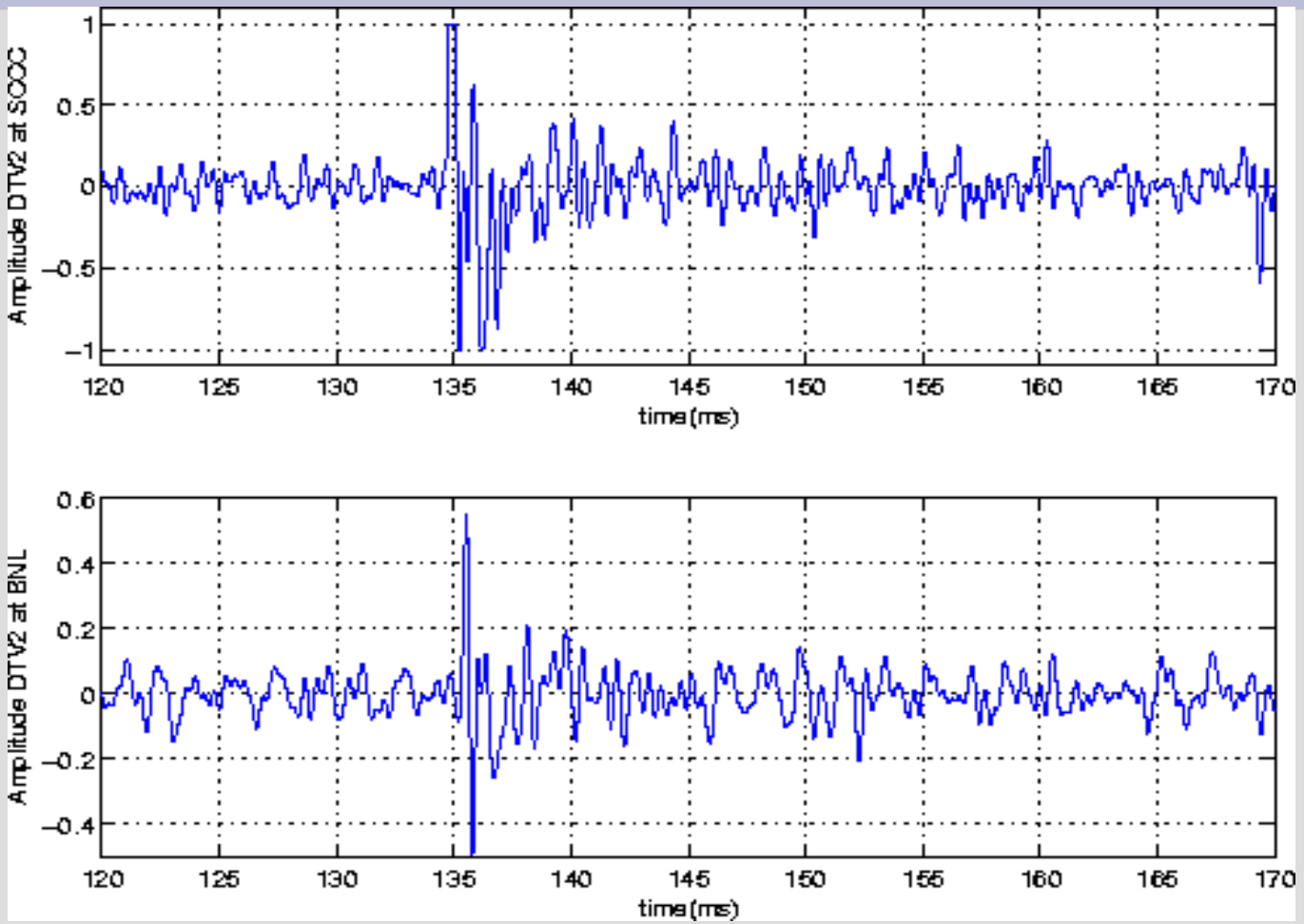
Experimental Results

- Coincidence event found between stations 19 Kms apart.
- No local noise can be the source.
- Same situation on channel 4 receiver. No transmitter effect possible.



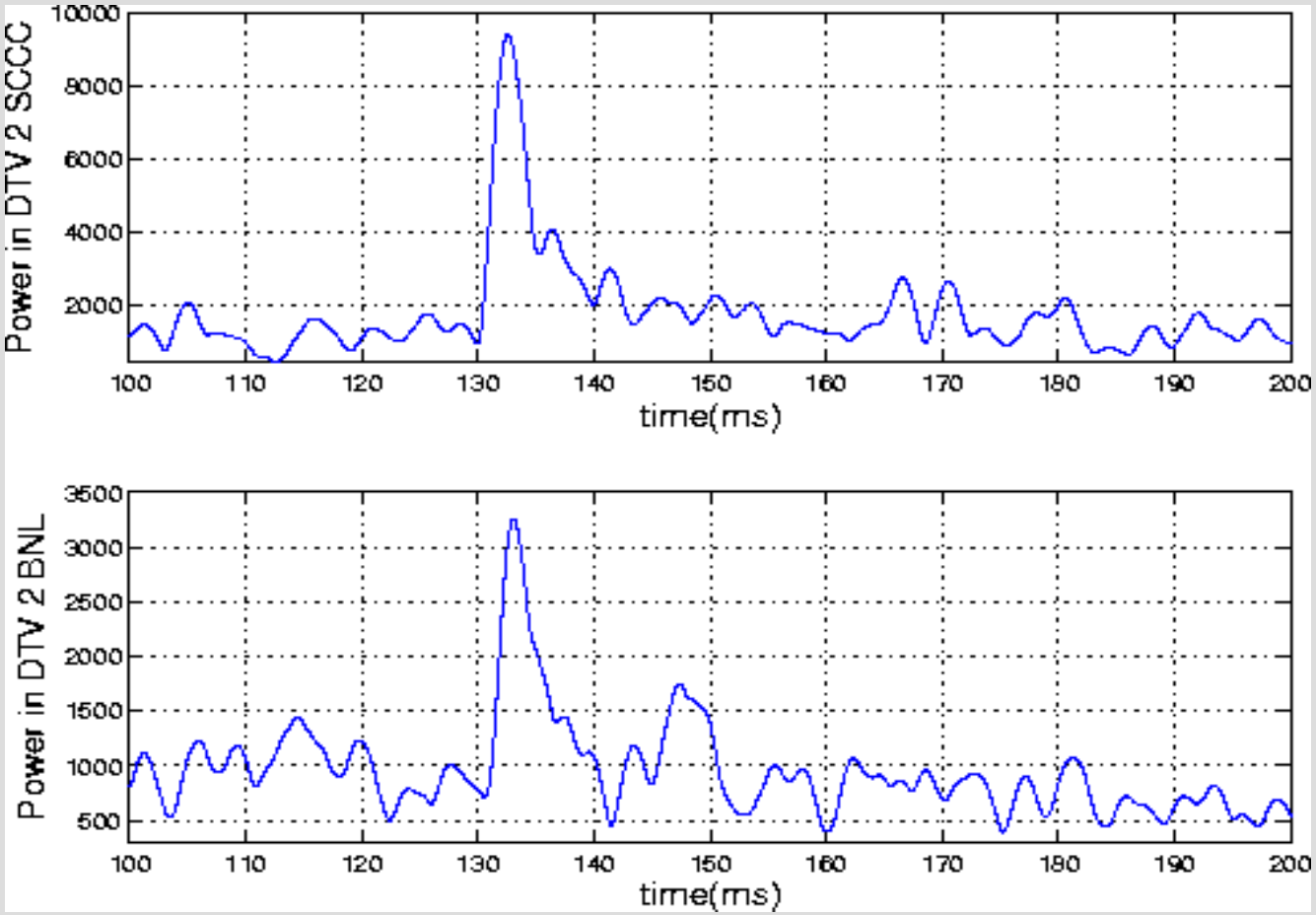
Experimental Results

- Detail of the same event.
- The event took a few milliseconds to finish.
- saturation in DTV channel 2.



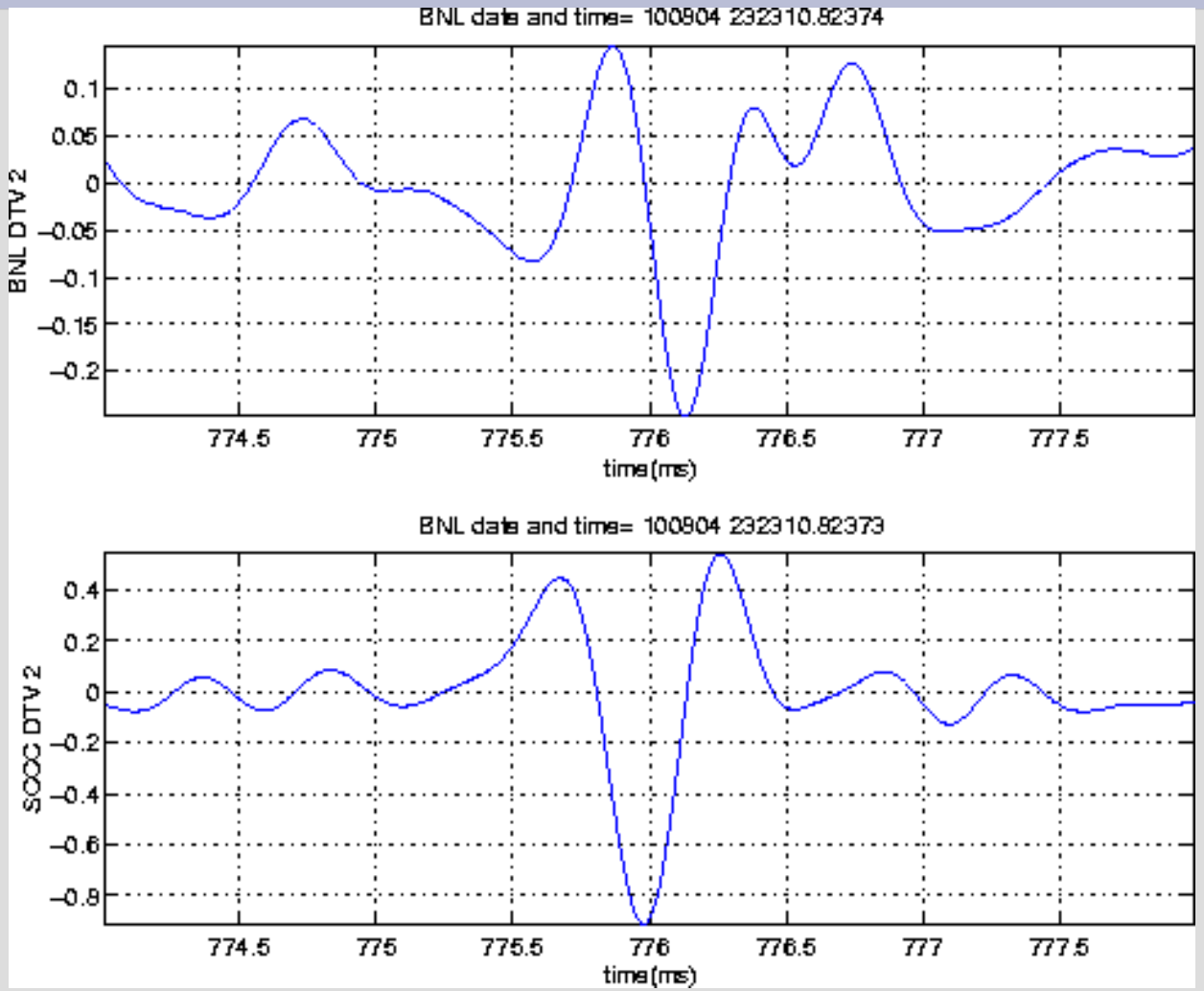
Experimental Results

- Power of the event spectra.
- This is our trigger variable.
- Similar results found for DTV channel 4.



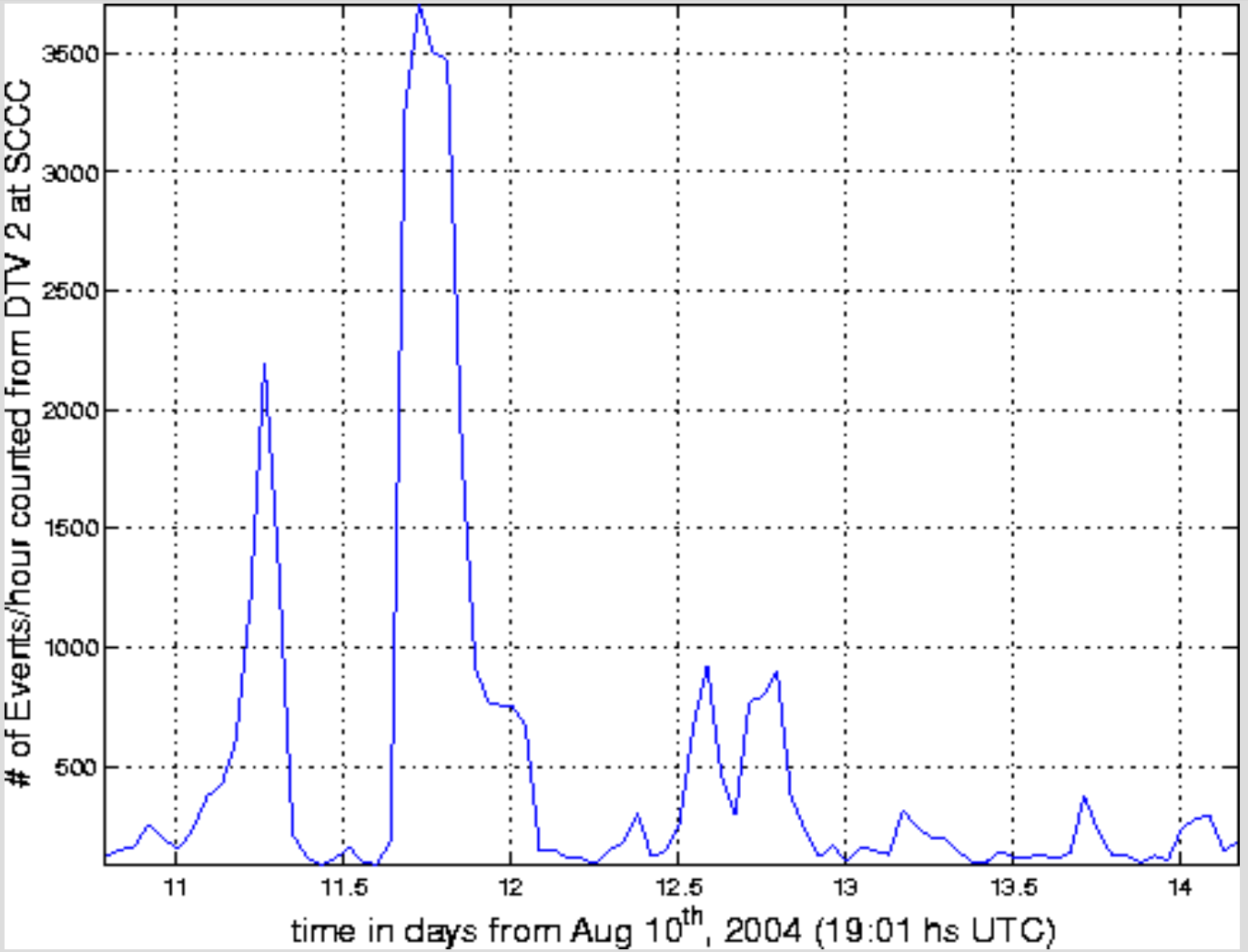
Experimental Results

- We also looked for events in coincidence with the NIM crate signal.
- NIM crate trigger received at 0.5s.
- Event duration ~= 1ms -> Cosmic Ray?!
- Large delay with relation to the NIM Crate (PCR delay?!).



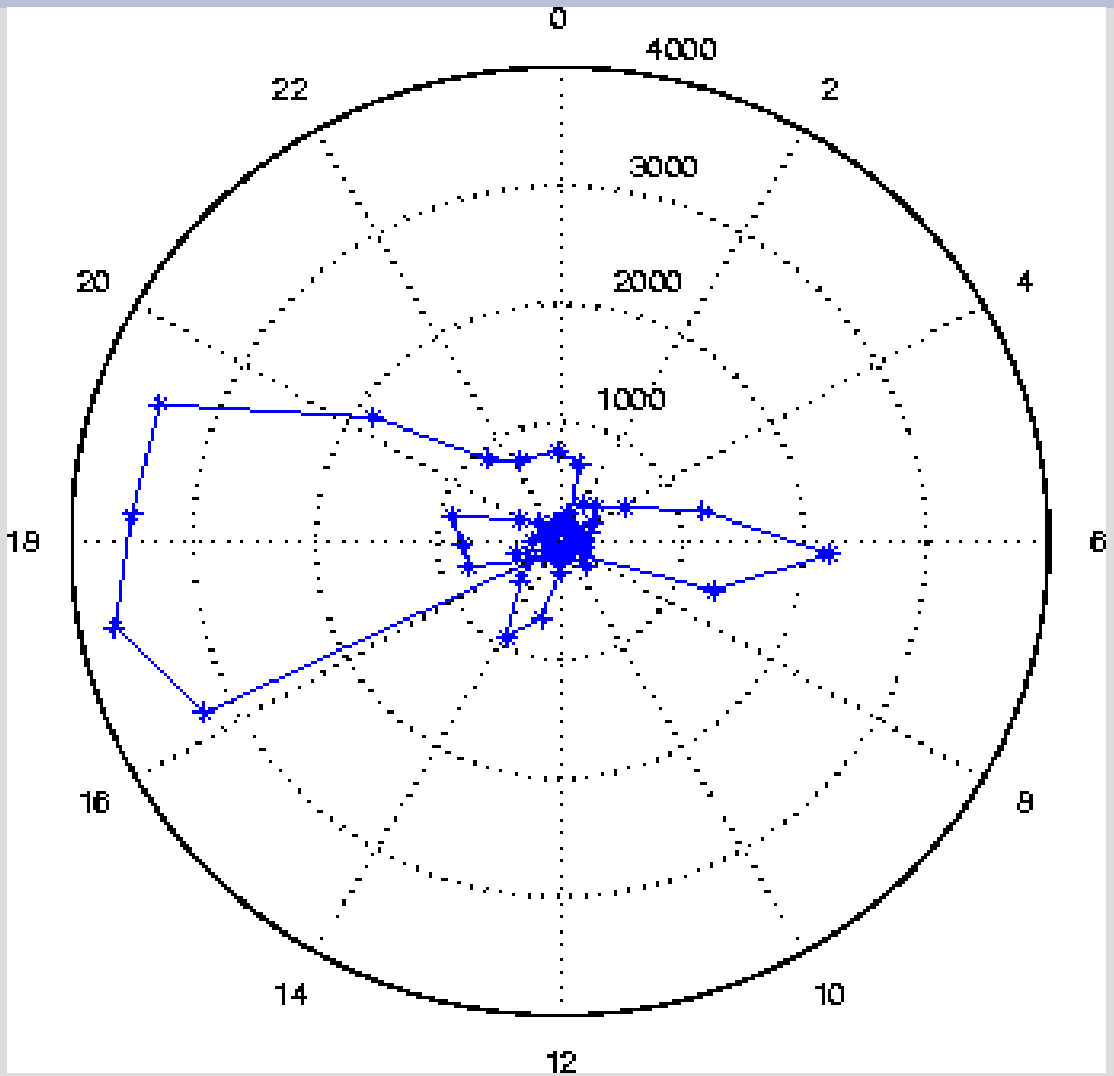
Experimental Results

- Detection during the Perseids meteor shower.
- Earth hides us from meteor shower.



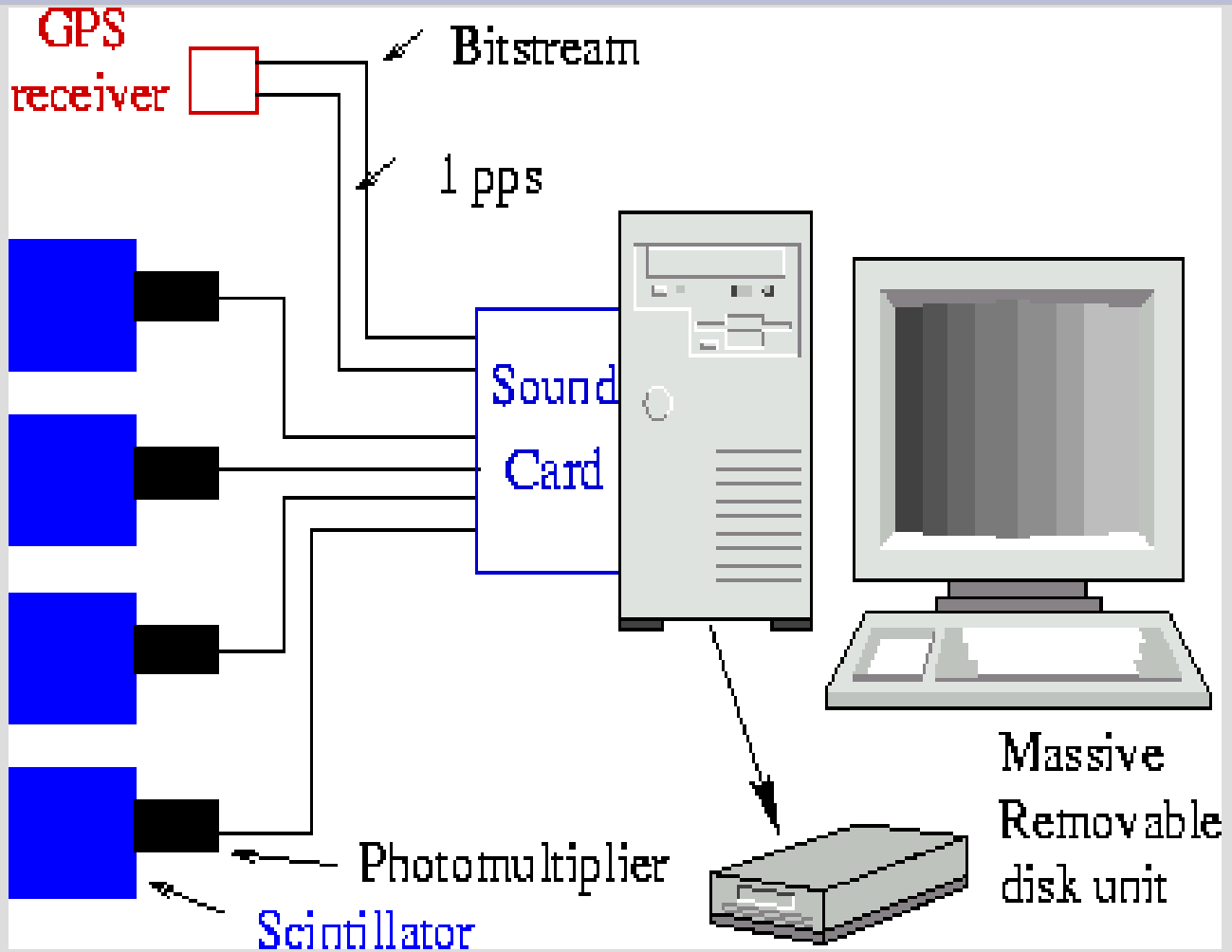
Experimental Results

- Earth's rotation effects can be seen.



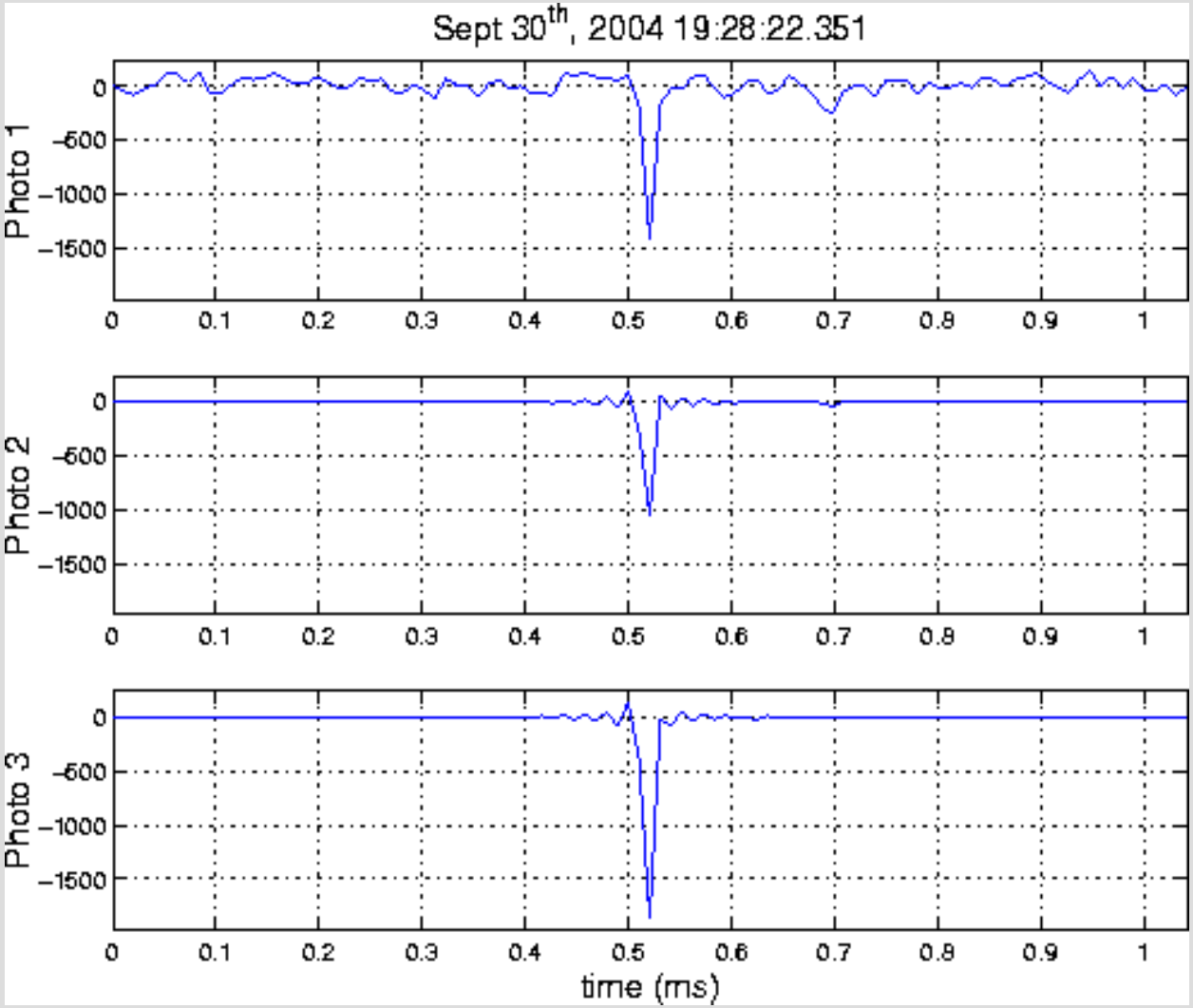
Experimental Results

- Same DAQ technology (RT OS, software design, GPS usage)
- Online coincidences between photomultiplier signals.



Experimental Results

- A mean of 48.33 events per minutes
- Scintillating pads of 0.25 m^2 one on top of other.
- Three fold coincidence required.



Conclusions

- Two systems that can be used to investigate Extreme Energy Cosmic Rays were presented within the framework of the MARIACHI project.
- For the radio scattering detector system, major improvements to assure data quality and the capacity to measure such quality were performed.
- A real time operating design was studied.

Conclusions

- Time stamping with a precision of two sampling periods was achieved.
- Two radio receiving stations 19 Km apart were assembled and operated for 14 days.
- Many signals were received in coincidence between both stations (non-local signals) by both stations (no particular transmitter problem).
- Tens of millisecond or less events found -> discrimination.

Conclusions

- The Perseids meteor shower was detected.
- A four receiving stations run is being envisaged to find meteor/EECR position.
- MARIACHI is associated with Quarknet -> GRID like experiment being developed.
- Setup with phototubes can be acquired in the sound card.
- Setup cheaper than US$ 4000.
- http://www.cosmicray.bnl.gov.
- http://www2.bnl.gov/~damazio/log/.