Electronics for the two-bar test.

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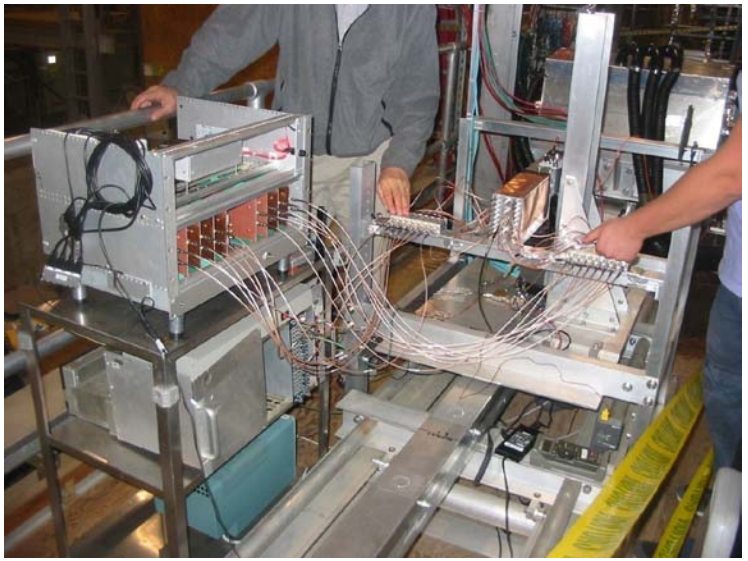
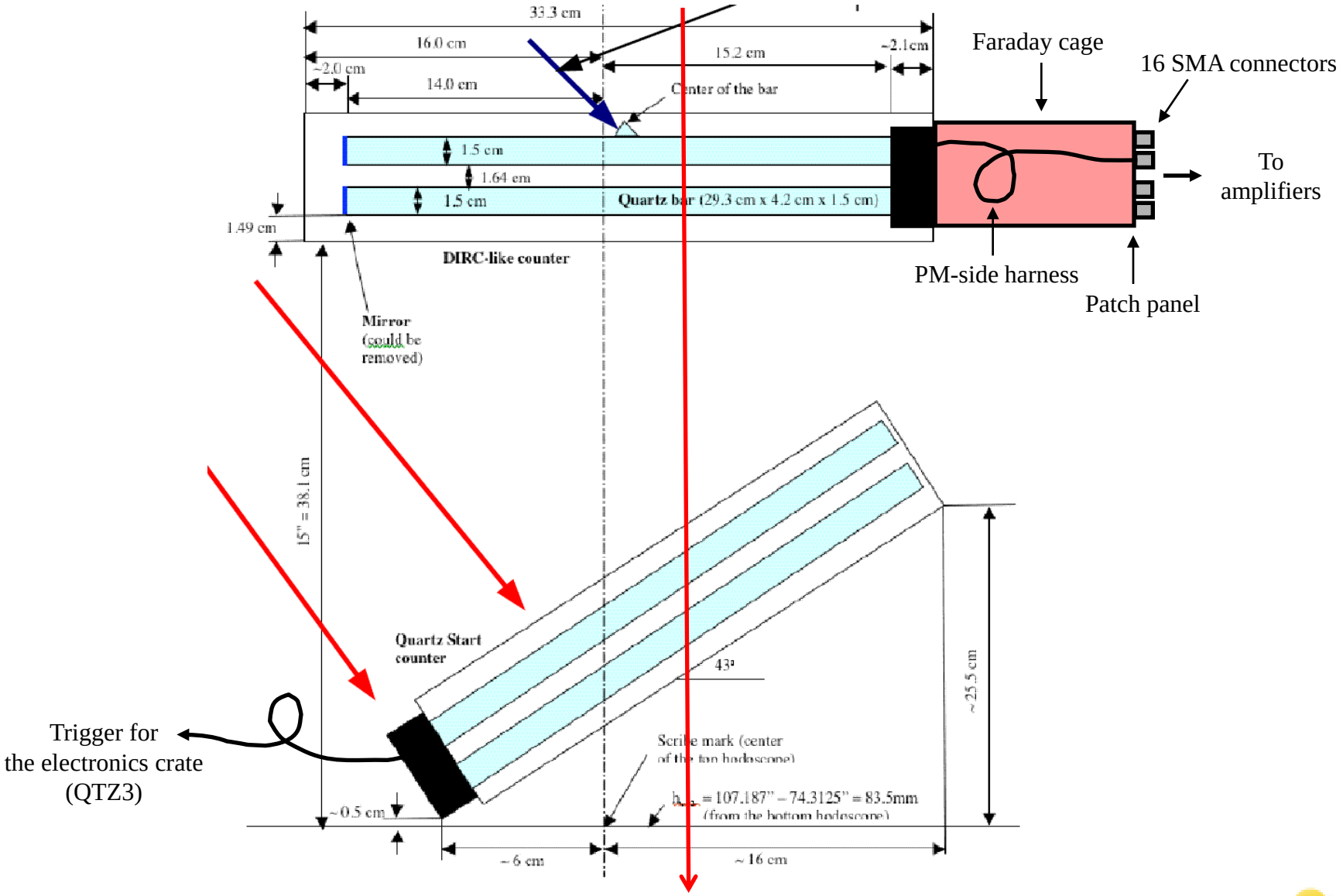


Introduction

For the two-bar test at SLAC, we had to build a synchronous sixteen channel acquisition system based on 8 two-channel WaveCatcher V5 boards:

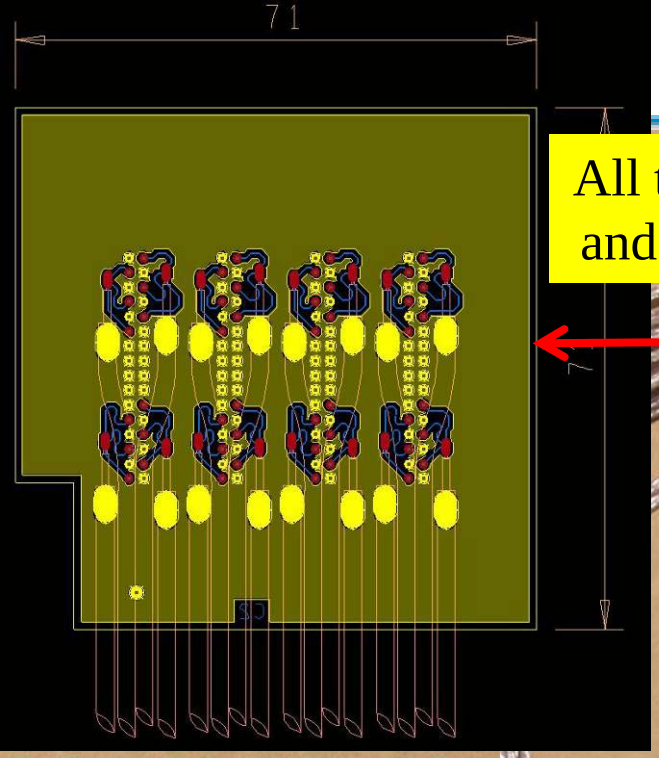
1. The system has to work with a common synchronous clock
   - There we take benefit of the external clock input of the WaveCatcher V5
2. It is self-triggered but it also has to be synchronized with the rest of the CRT
   - True not only for running acquisition but also for time tagging of events
3. Like the WaveCatcher, data acquisition is based on 480Mbits/s USB.

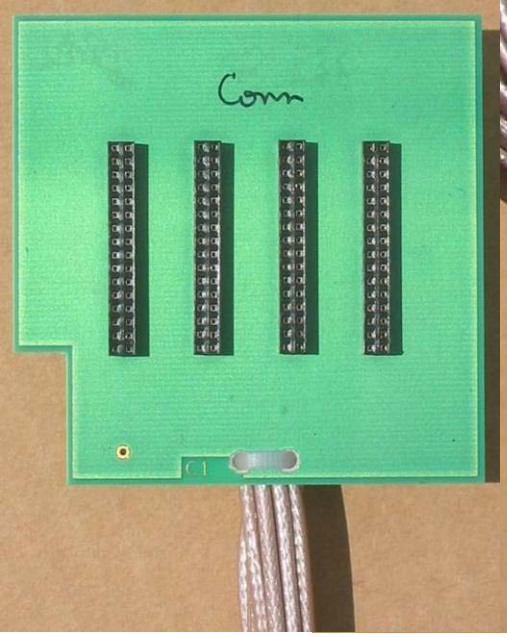
Experimental setup



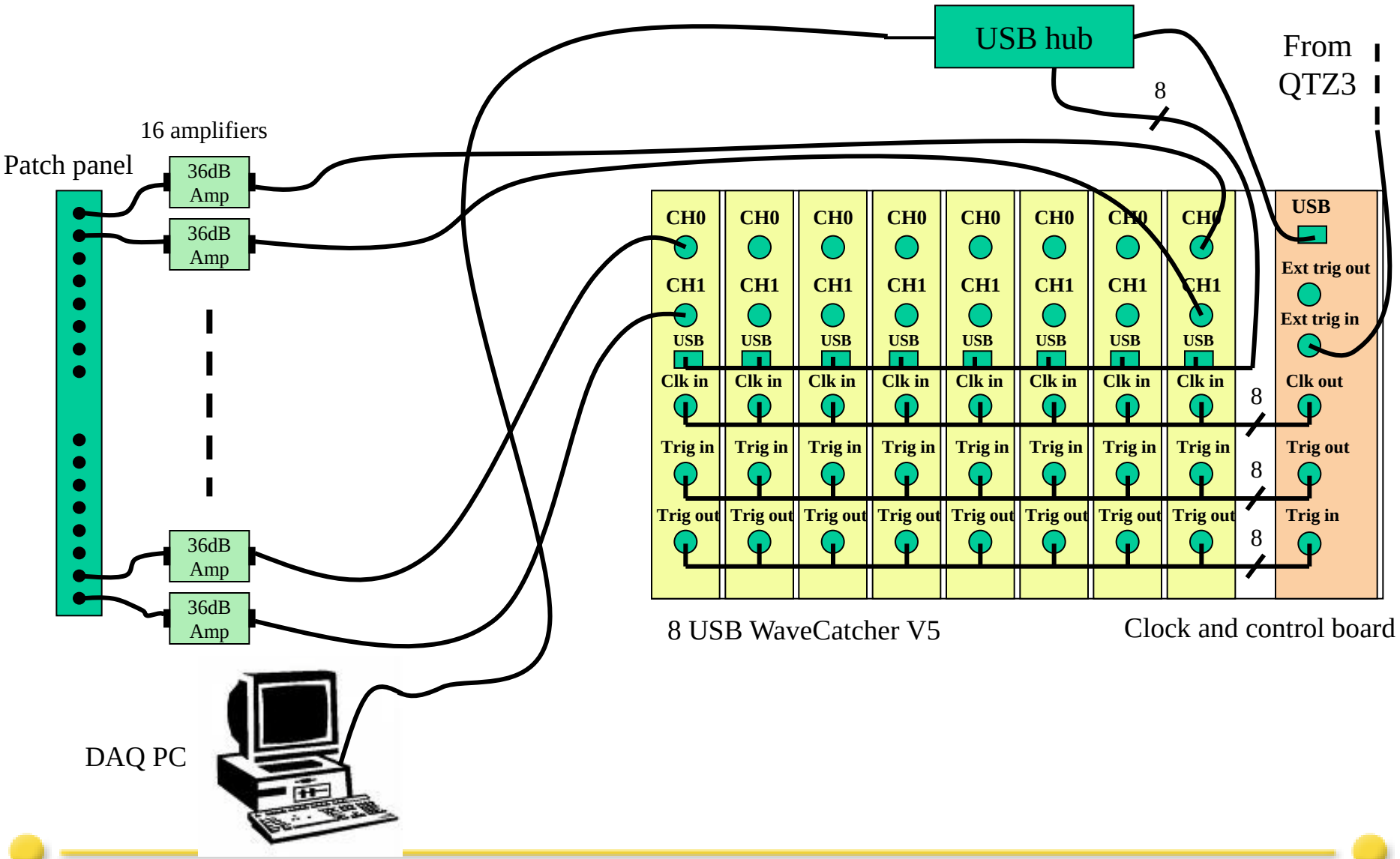
PM-side harness

All the lines between the MCP anodes and the cable inputs are 14.7mm long





Electronics setup

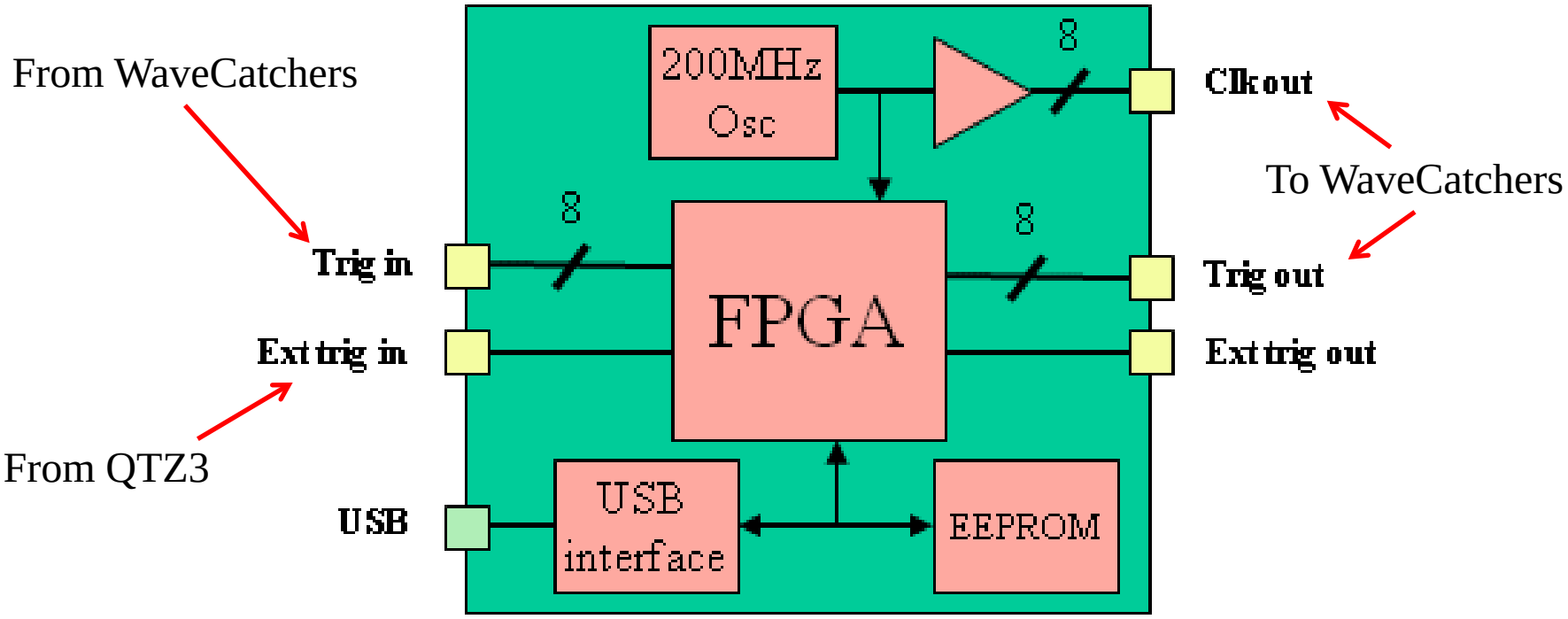


MITEQ amplifier

Model: AM-1687-1000

Input and output connector:	SMA
Frequency Minimum	1 MHz
Frequency Max	1000 MHz
Electrical Specifications	
Gain Minimum	36 dB
Gain Flatness	0.75 dB+/-
Noise Figure	3.3 dB
Voltage 1 (Nominal)	15 V
Current 1 (Nominal)	150 mA
Impedance	50 Ohms
Price:	
Per /1	435 Euros
Per /16	400 Euros

Clock and control board (1)



CRT mode : when the controller board detects a coincidence between an external trigger from QTZ3 and one of the sixteen channels, it sends through USB a specific interrupt to the PC in order to start the data readout.

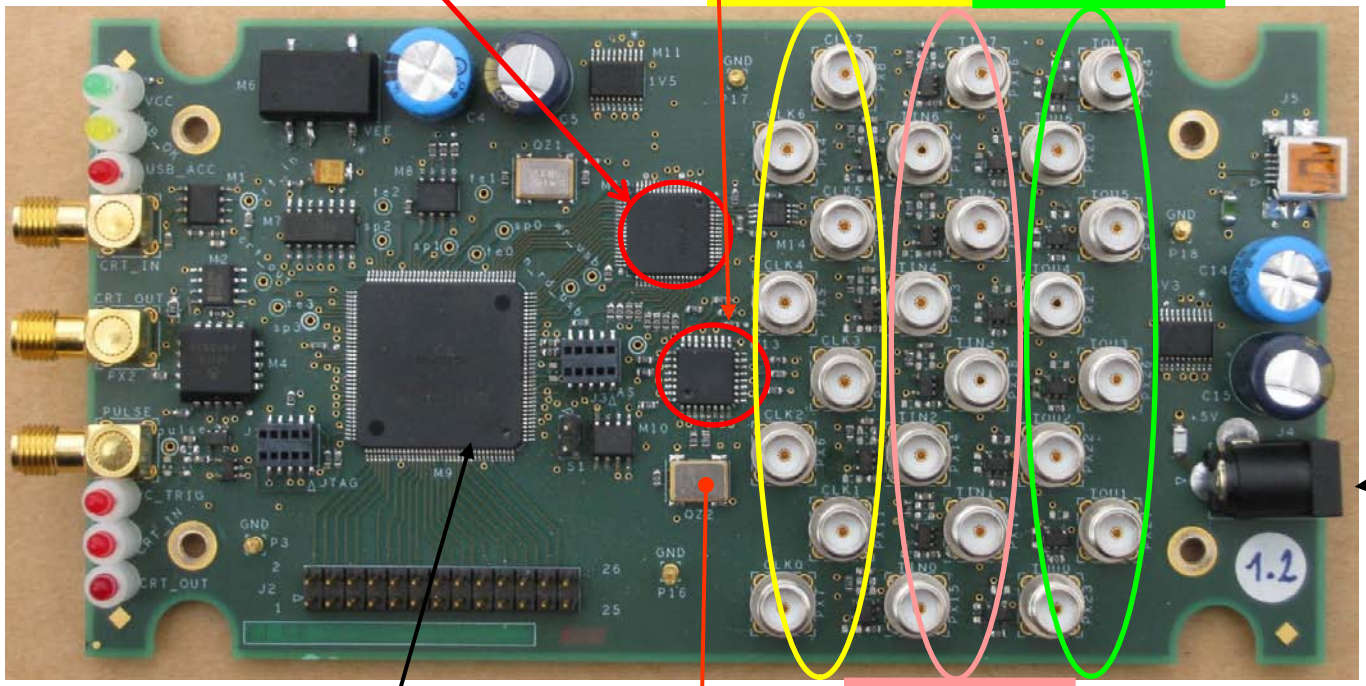
Clock and control board (2)

USB interface
=> **480Mbits/s**

Zero jitter clock buffer

Clock outputs

Trig outputs



Trigger Input (NIM)

Trigger Output (NIM)

Pulse output

µ USB

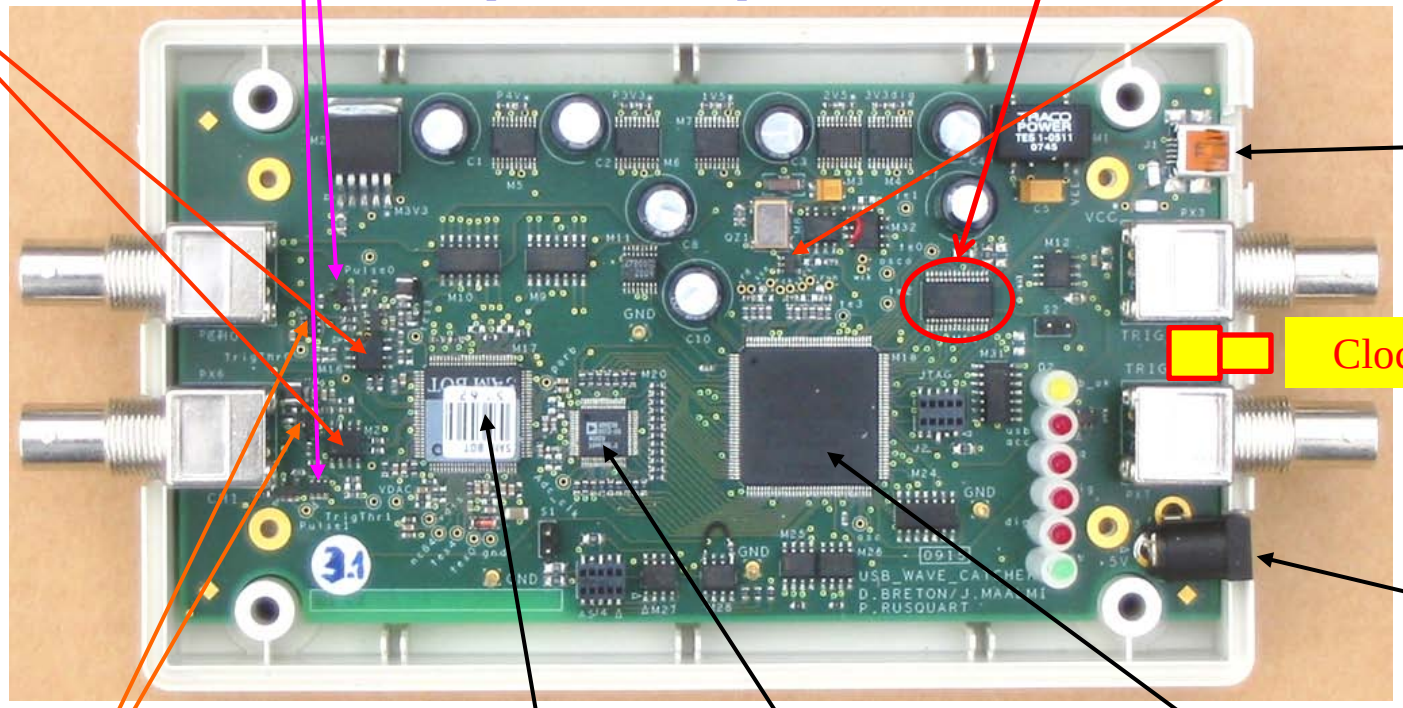
+5V Jack plug

Trig inputs

Cyclone FPGA

Reference clock: 200MHz

The USB WaveCatcher board V5



USB interface
=> **480Mbits/s**

Pulsers for reflectometry applications

Board has to be USB powered
=> power consumption < 2.5W

Reference clock:
200MHz => 3.2GS/s

1.5 GHz BW amplifier.

µ USB

Trigger input

2 analog inputs. DC Coupled.

Clock input

Trigger output

+5V Jack plug

Trigger fast discriminators

SAM Chip

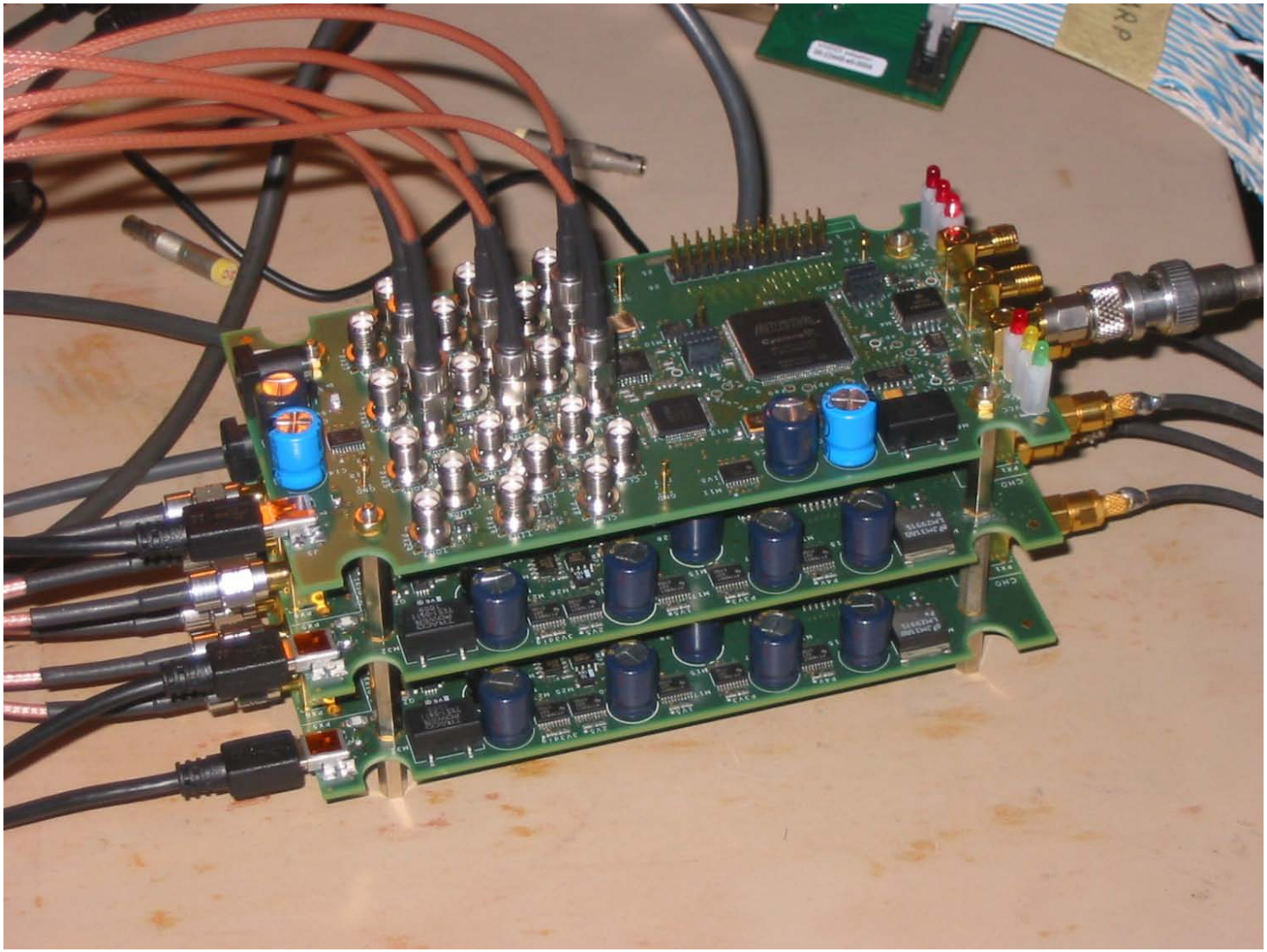
Dual 12-bit ADC

Cyclone FPGA

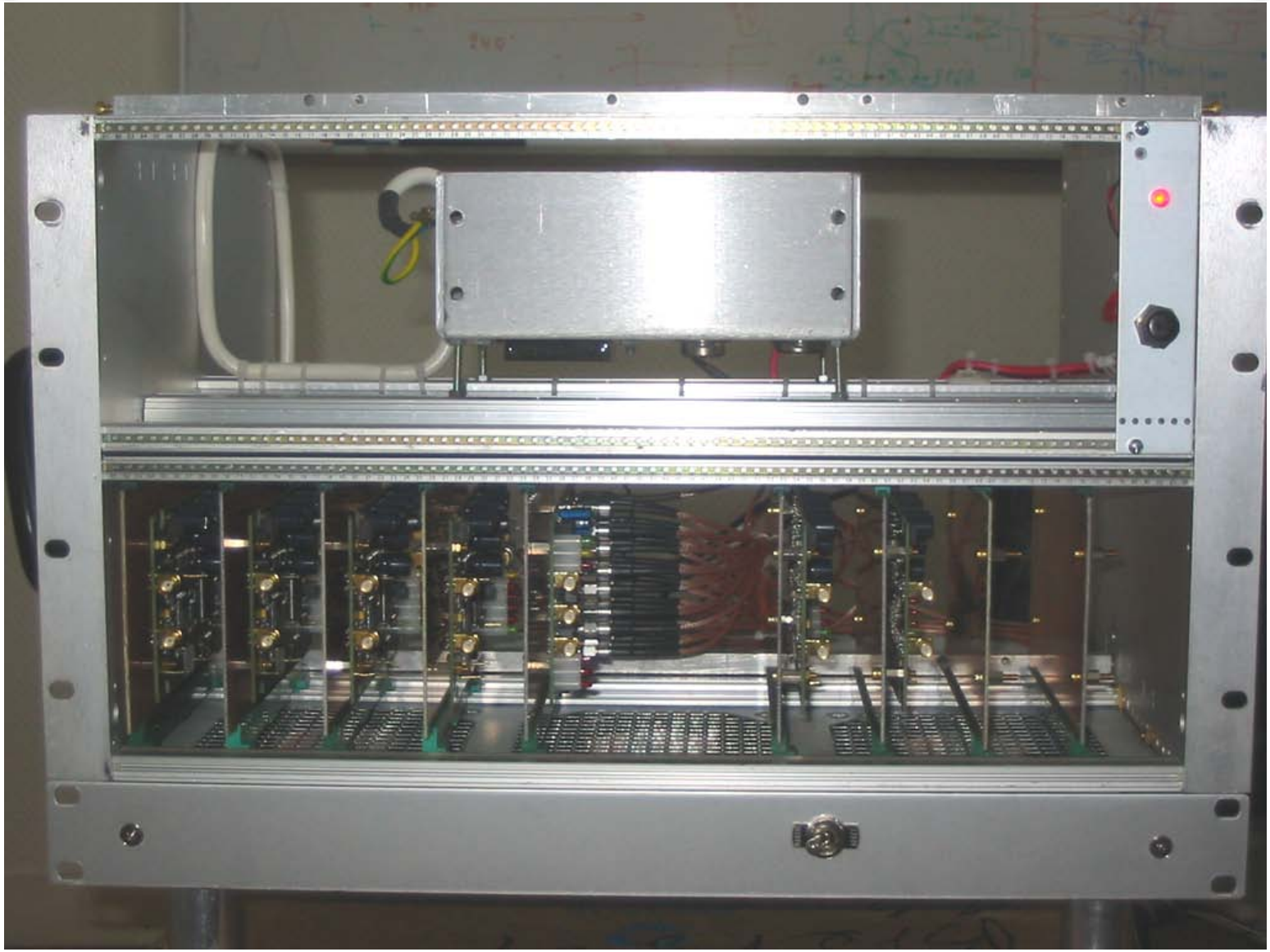
Tests at lab

- Technical challenge: to keep the 10ps precision at the crate level
- Logistical challenge: to have a running system mounted at SLAC the 13th of September
  - The controller board was designed end of June
  - Production of 10 WaveCatchers V5 was launched at the same time
  - A first small system with 4 channels was mounted and succesfully tested at CERN mid July on new high speed MRPCs
- Time measurements showed that even between different boards, the 10ps rms time precicion was still there.
- The full crate was assembled at LAL end of August.
  - We had a very little time to test it because of the shipping delay
  - Difficulties appeared to be mostly linked to USB because of the high number of slaves (7 is a key number for USB)
- We were lucky to get the amplifiers on time (they left LAL the 6th and arrived at SLAC the 9th after visiting Sacramento!)

4-channel prototype



Crate for WaveCatcher boards



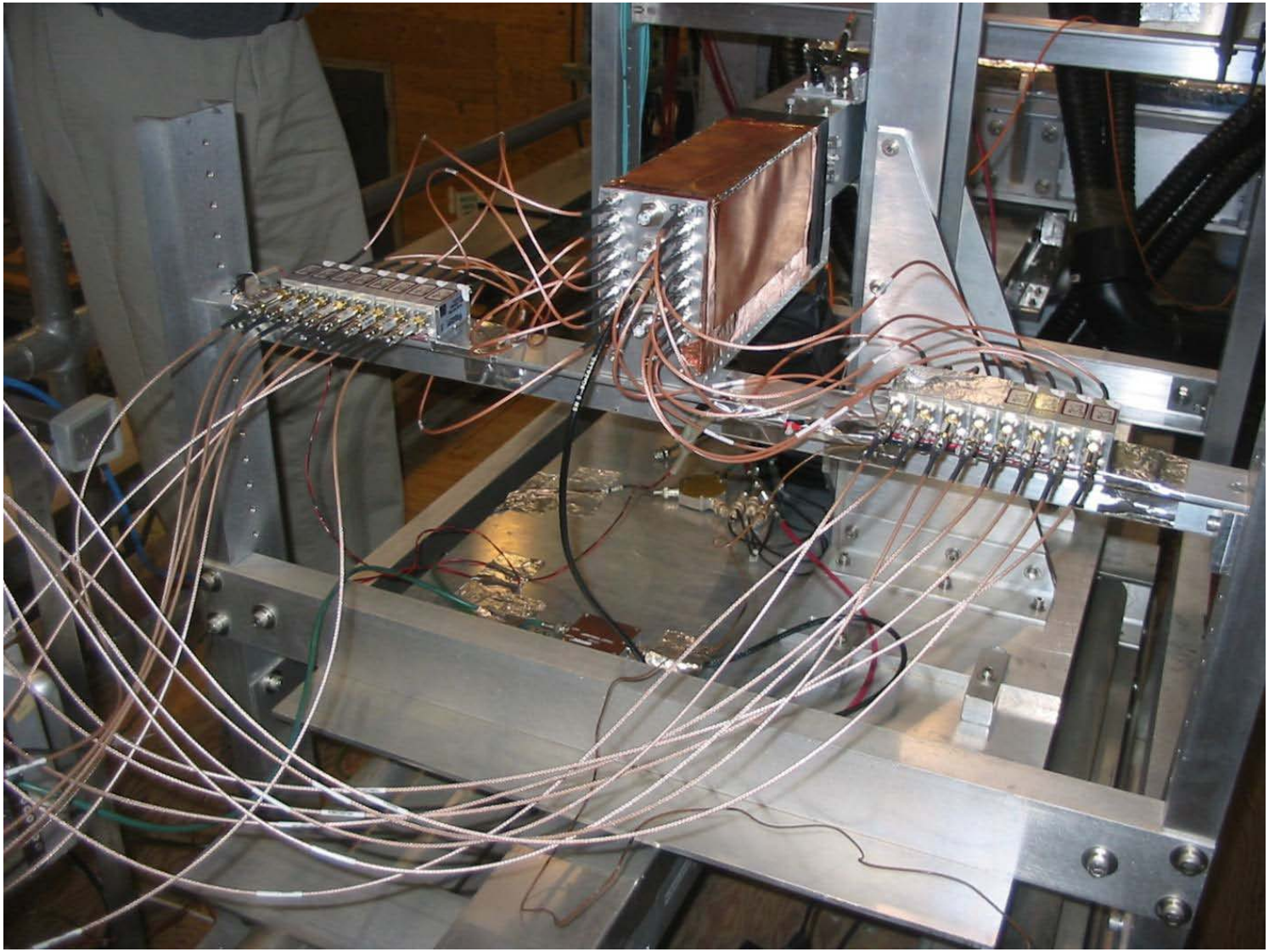
Comments about electronics

- Baseline uses sixteen individual 36 dB amplifiers but a solution with a board housing 16 amplifiers with programmable gain is under study
  - It could be used for the second step based on SL10
  - It is necesssary to test it in view of the final design

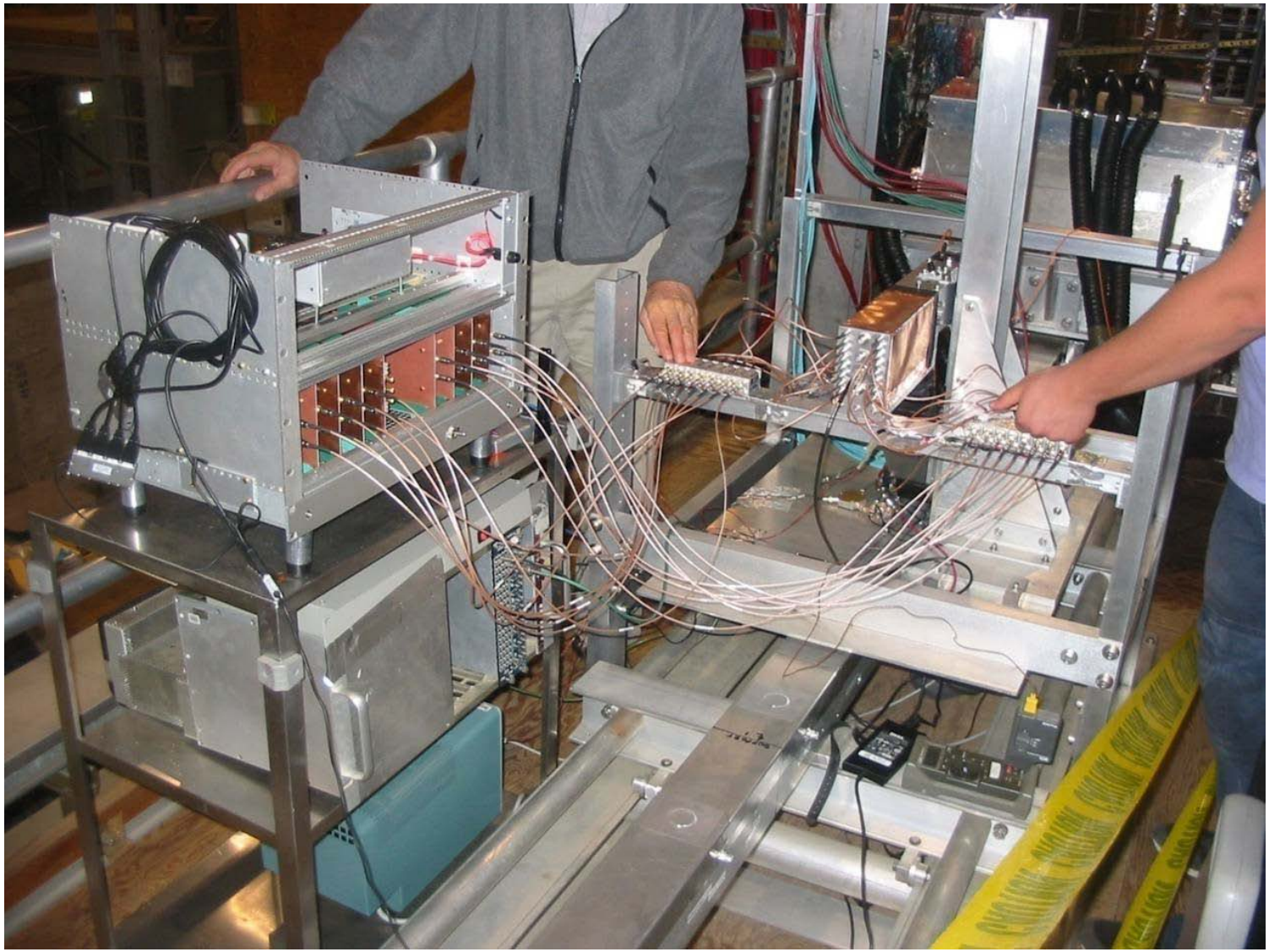
- Common trigger for the WaveCatcher boards is the signal produced by QTZ3:
  - This will stop the signal recording into the analog memory
  - but readout is performed only if at least one of the two-bar channels were hit (done through a OR of the individual triggers on signal)

- Upon each event, the acquisition software adds the event time in the data file
  - => synchronization of events with the CRT µPC
  - time is regularly (once per minute) synchronized with SLAC time server (as µPC also does) via NTP time server.

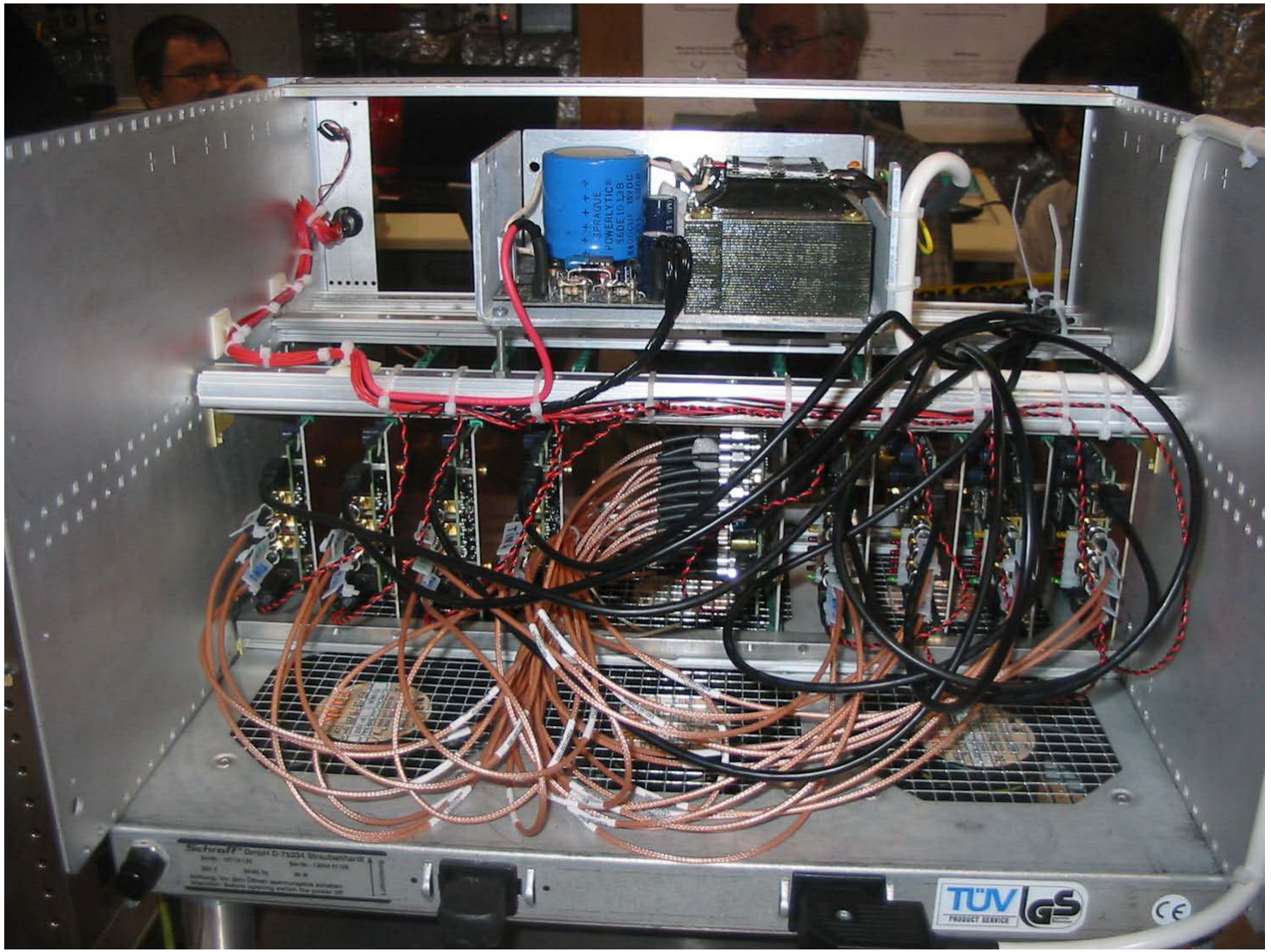
Setup at SLAC



The whole system



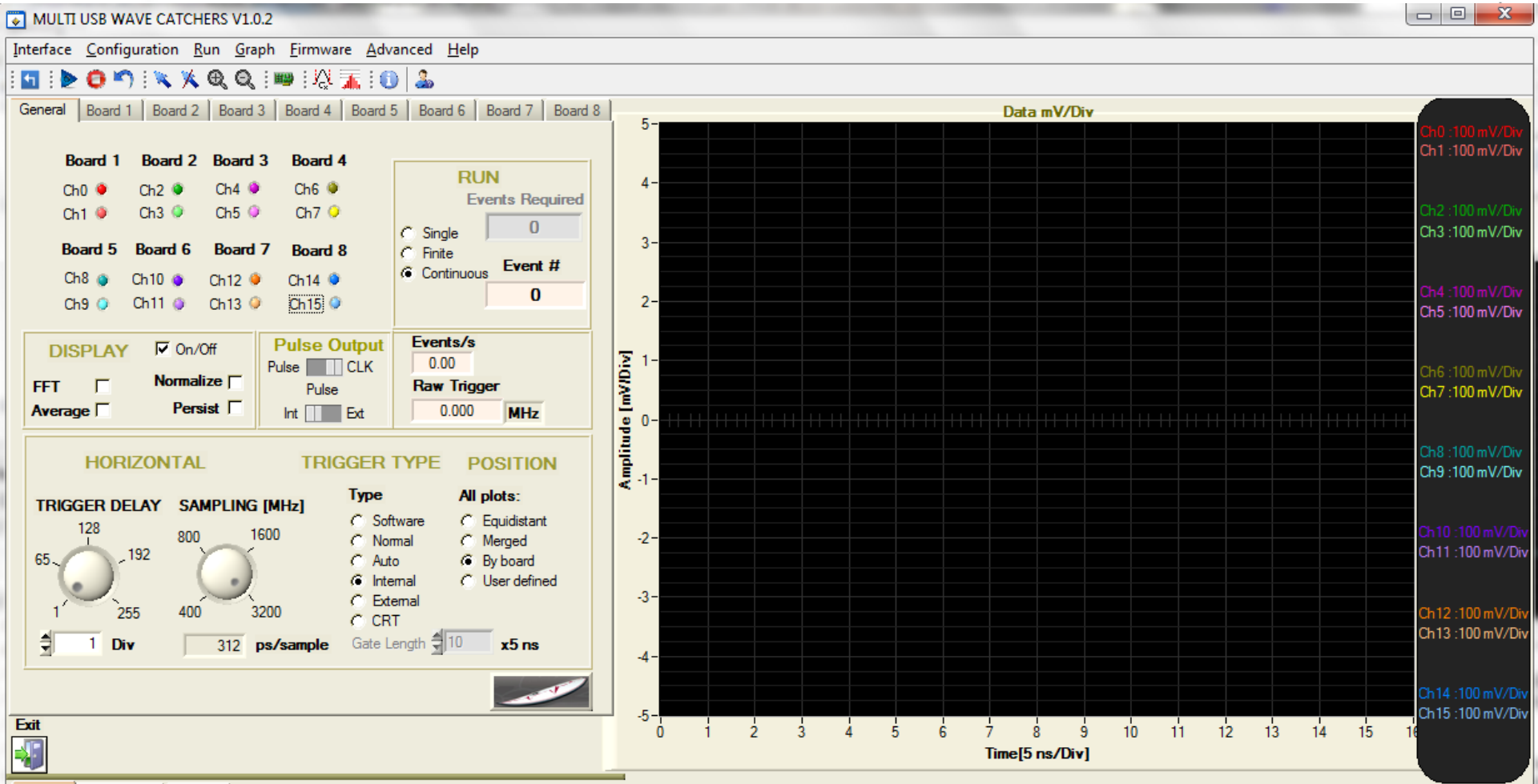
Back of the crate



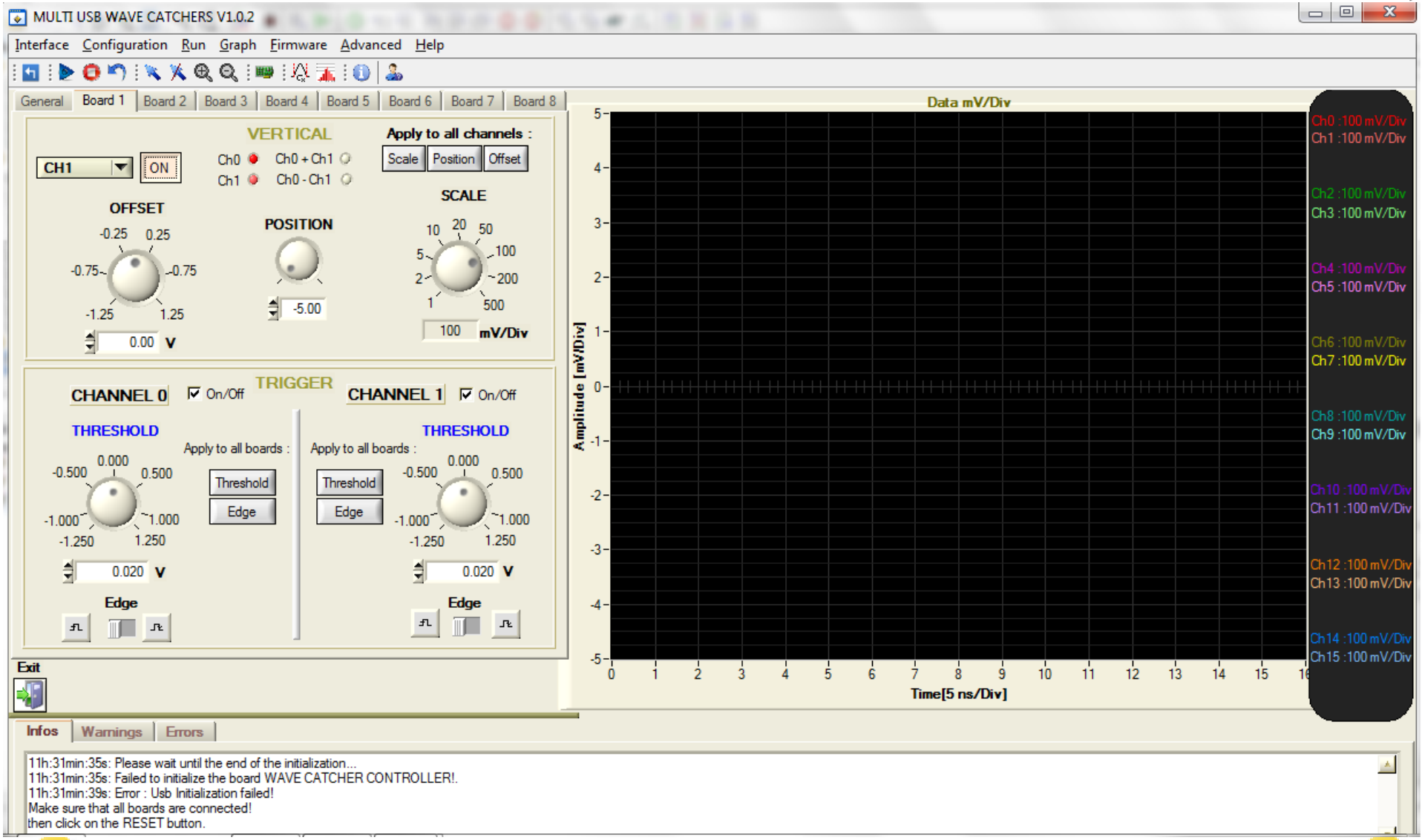
Acquisition software

- Extension of the WaveCatcher software to 16 channels
  - Each board can be set up independently
  - All channels can be displayed simultaneously
  - Run data can be split into multiple fixed size files (based on the user defined number of events) => permits run survey
  - A log file stores all messages generated during acquisition.
- Soon available: real time histogramming of inter-channel pulse time difference
- With the laptop we use at SLAC, there was no way to run all the 9 boards on the same USB port
  - => we had to share the boards between the 3 ports
  - Once the acquisition launched, USB looks stable (we can take very long runs => one week)

MultiWaveCatcher Main Panel

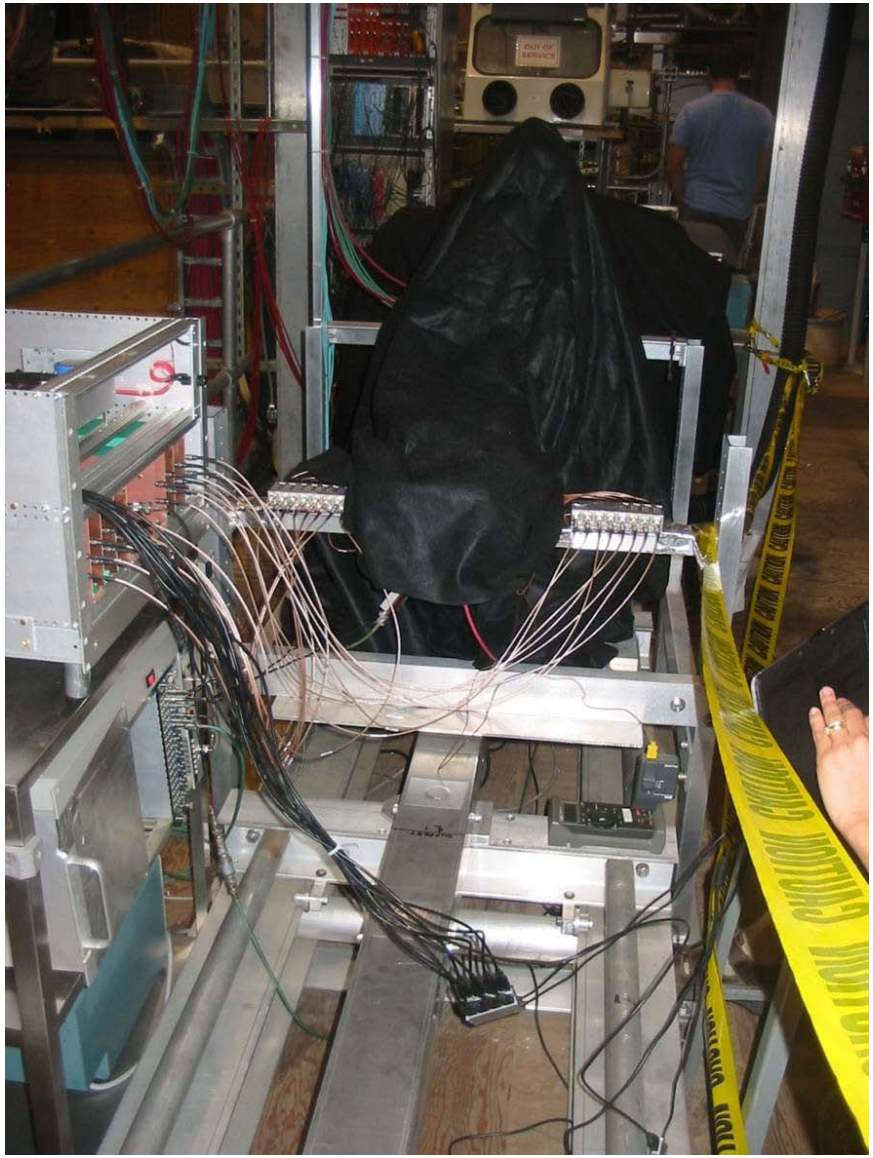


MultiWaveCatcher Board Panel

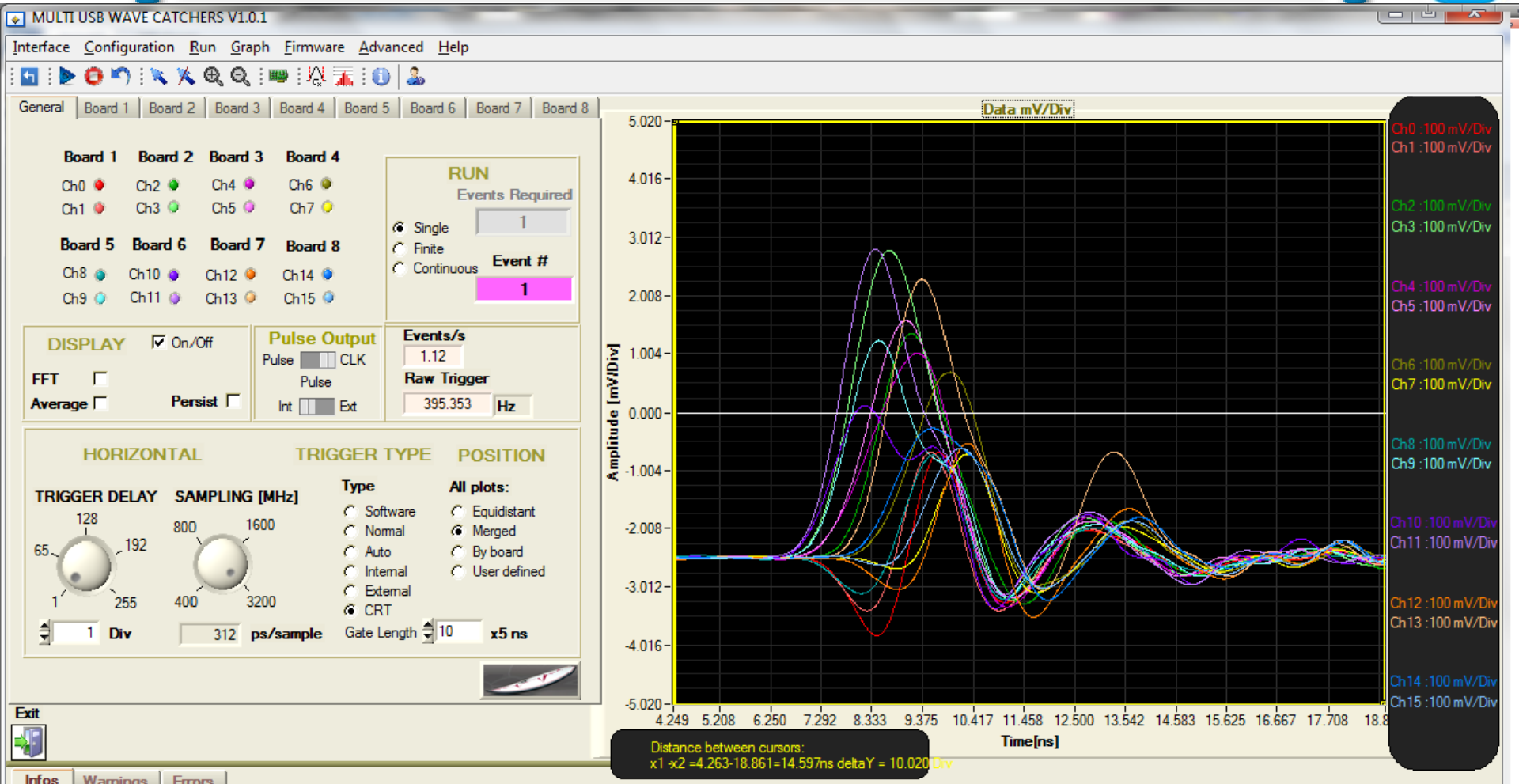


Setup with computer

Running conditions



One cosmic event



Conclusion

- We extended the WaveCatcher system up to 16 channels (hardware + software)

- The performance of the single board seems to be maintained despite the increased complexity (noise, jitter, …)

- Cosmic data taking has already started on the two bars at SLAC, in coincidence with the CRT data

- We are currently building a second 16-channel system for our own PMT test bench at LAL, plus a portable 4-channel one for travelling

- We will design a new 16-channel board, housing USB and high speed optical link, which will permit an easy upscaling of the number of channels