Quarknet
Data Acquisition (DAQ) Board

H. Berns, G. Wheel and J. Wilkes

Dept. of Physics

U. of Washington, Seattle

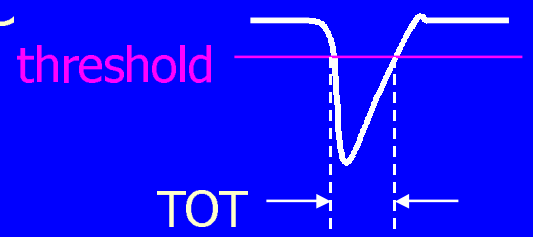
October, 2002

What is it?

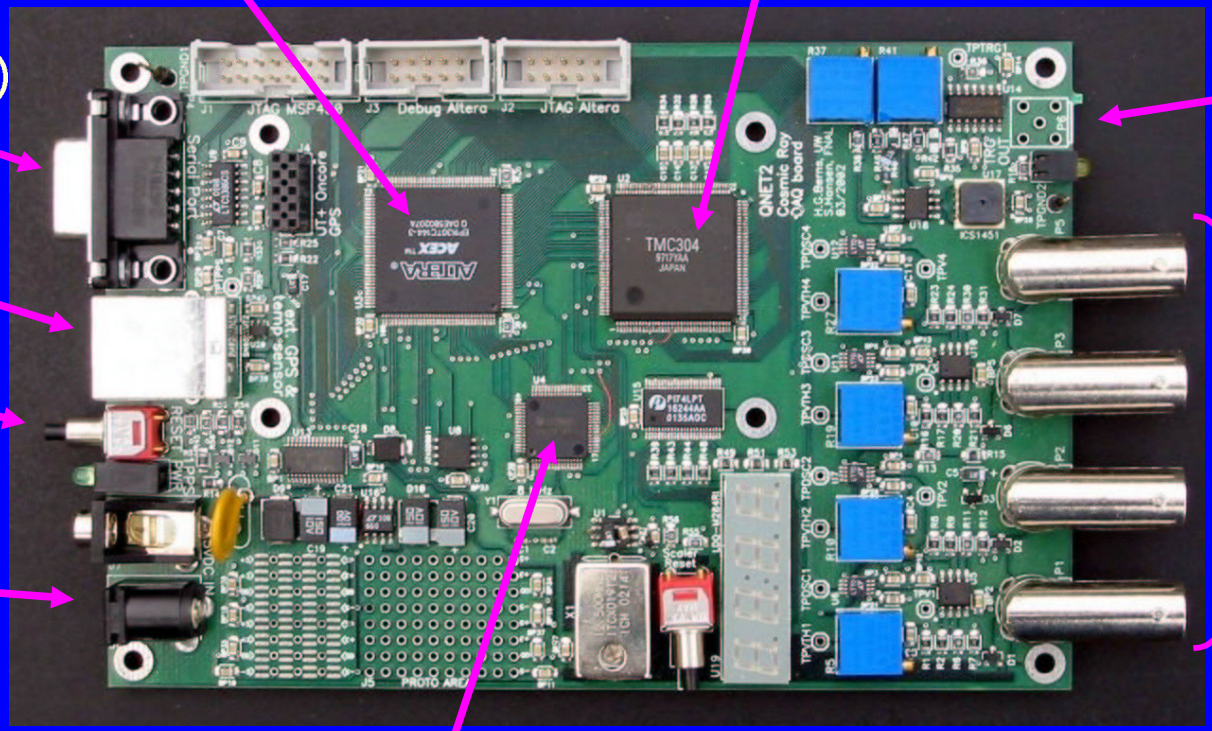
- Input = pulses from PMTs
- Output = data needed for WALTA
  - 4 channels (number of counters at one school)
  - Relative arrival times of pulses with < nanosecond precision
  - Estimates of pulse sizes
  - Arrival times synchronized with GPS time to 50 nanosec
  - Simple digital interface to any PC via serial port
- Low cost (under $500 each for parts)
  - Replaces >$10K of NIM electronics
- Reliable and robust
  - Simple enough so students can assemble it and use it

What does it do?

- Replaces NIM crates and modules
  - Discriminators
  - Trigger logic
  - Time to Digital converters (TDCs)
  - Scaler
- Additional features
  - Estimates pulse height by measuring time-over-threshold (TOT)
  - GPS time receiver is built in
  - Simple serial-port interface to any PC



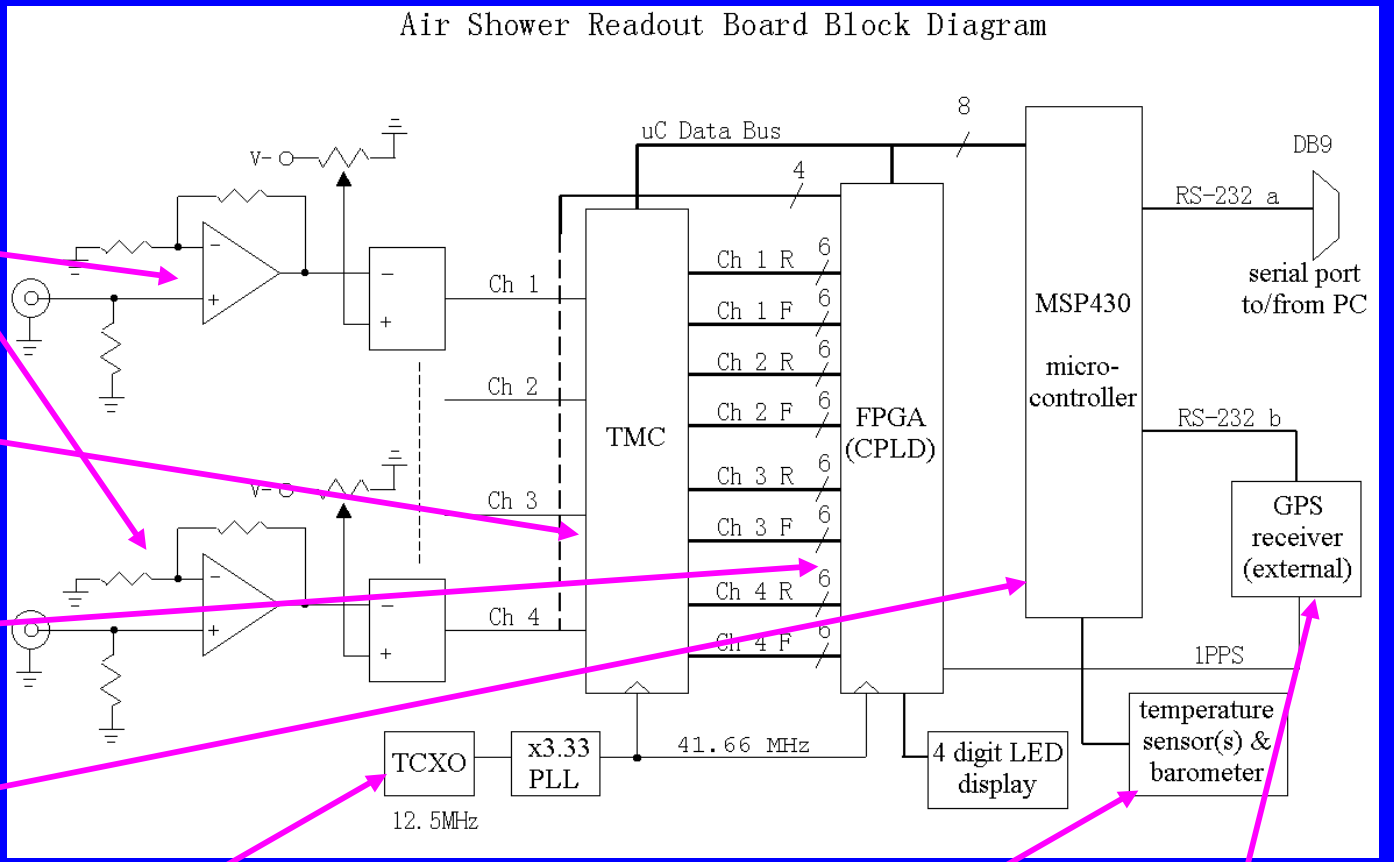
Board layout



Block diagram of Q'Net2 board

only 2 of 4 channels shown

- discriminators
- relative time digitizer
  - same used in ATLAS, K2K
- control logic
  - programmable logic chip
- onboard CPU



- onboard clock (crystal controlled oscillator + phase-locked loop) with 24-nanosecond "ticks"
- environmental sensor inputs
- GPS receiver (external)

GPS receiver (H. Berns)

Leadtek®

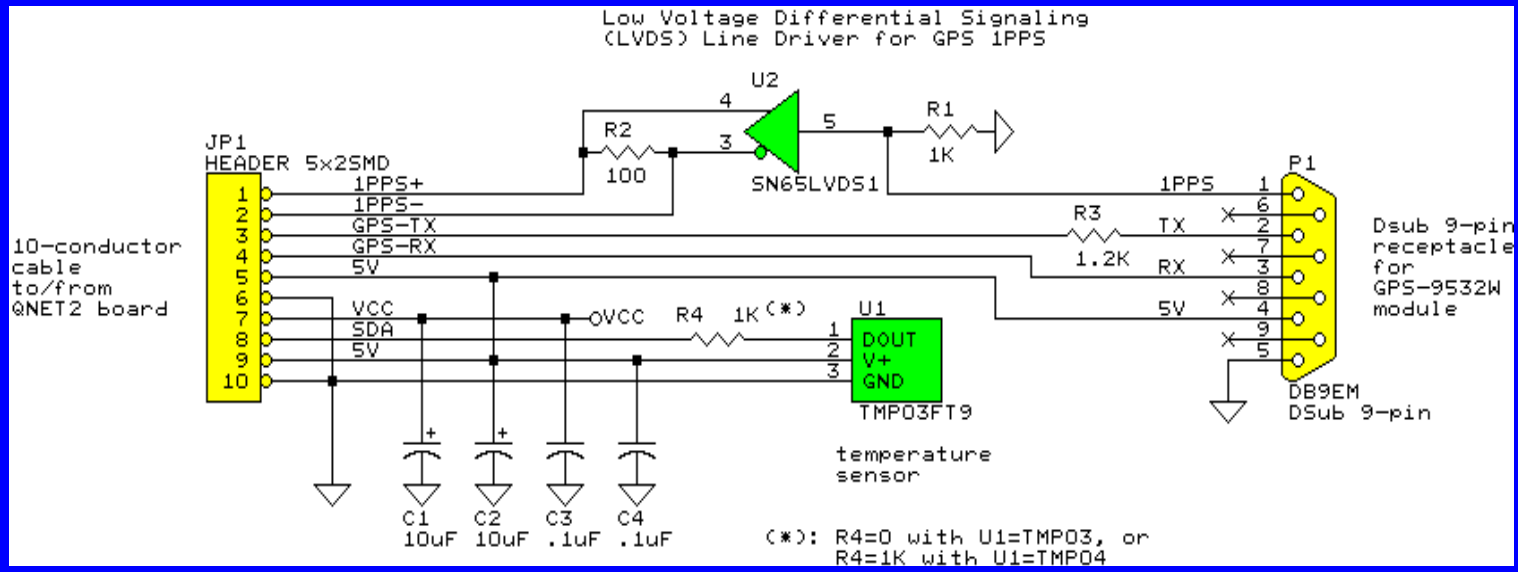
Leadtek GPS Smart Antenna GPS 9532 (SiRFstar II)

Features Summary

- 12 Channels "All-In-View" Tracking
- Cold/Warm/Hot Start Time: 45/38/8 Seconds
- Reacquisition Time: 0.1 seconds
- Support Standard NMEA-0183 and SiRF Binary protocol
- Support Accurate 1PPS Output Signal Aligned with GPS Timing
- Trickle Power Enabled for Power Saving
- Multi-path Mitigation Hardware
- Superior Sensitivity for Urban Canyon and Foliage Environment
- On-board RTCM SC-104 DGPS and WASS Demodulator
- SiRFStar 2 chipset with embedded ARM7TDMI CPU available for customized applications in firmware
- 2 user customizable GPIO pins on serial port connector
- Field Software Upgrade Supported
- Fully water-proof
- Support DB-9/USB/Pocket PC/PDA serial port connectors
- Virtual COM port driver supported for USB version
- Magnet base for mounting on the car
- Various color upon request
- Connectors available for Serial Port or special Hand Held PC or Palm Device connectors. (call for detail)

Add-ons to Leadtek module

- Special cable supplies power and takes off 1 pps (1 pulse per sec = GPS seconds sync marker)
  - Mini-board inserted in module's DB-9 connector provides needed interface



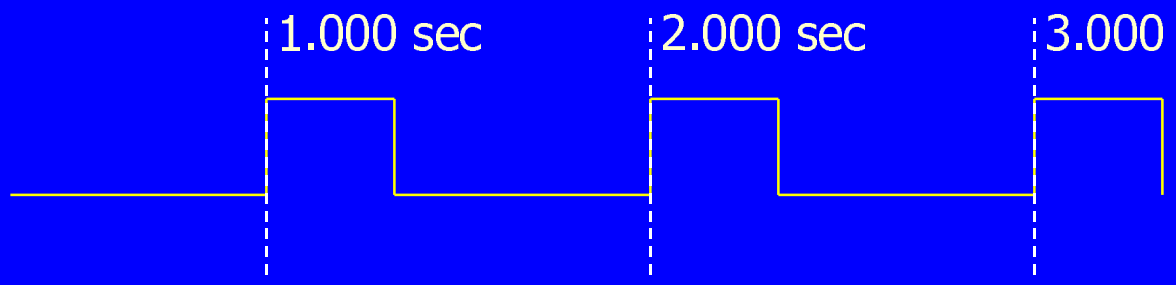
GPS time synch method

- GPS module delivers 2 kinds of data:
  - Serial data: 1 line (ascii text string) per second or on request
    - » date and time in UTC (Universal Time) down to the millisec

```
SAMPLE DATA STRING:
$GPRMC,075609.207,A,4739.2385,N,12218.6464,W,0.19,,251002,,*06

INTERPRETATION:
Time (UTC)   Date       Latitude    Longitude    (housekeeping data)
07:56:09.207 25/10/2002 47:39.2385N 122:18.6464W  A=valid 0.19 - - -
```

  - 1PPS = 1 pulse per second
    - » analog square pulse whose leading edge is accurately aligned with the beginning of each UTC second on the GPS System Master Clock:

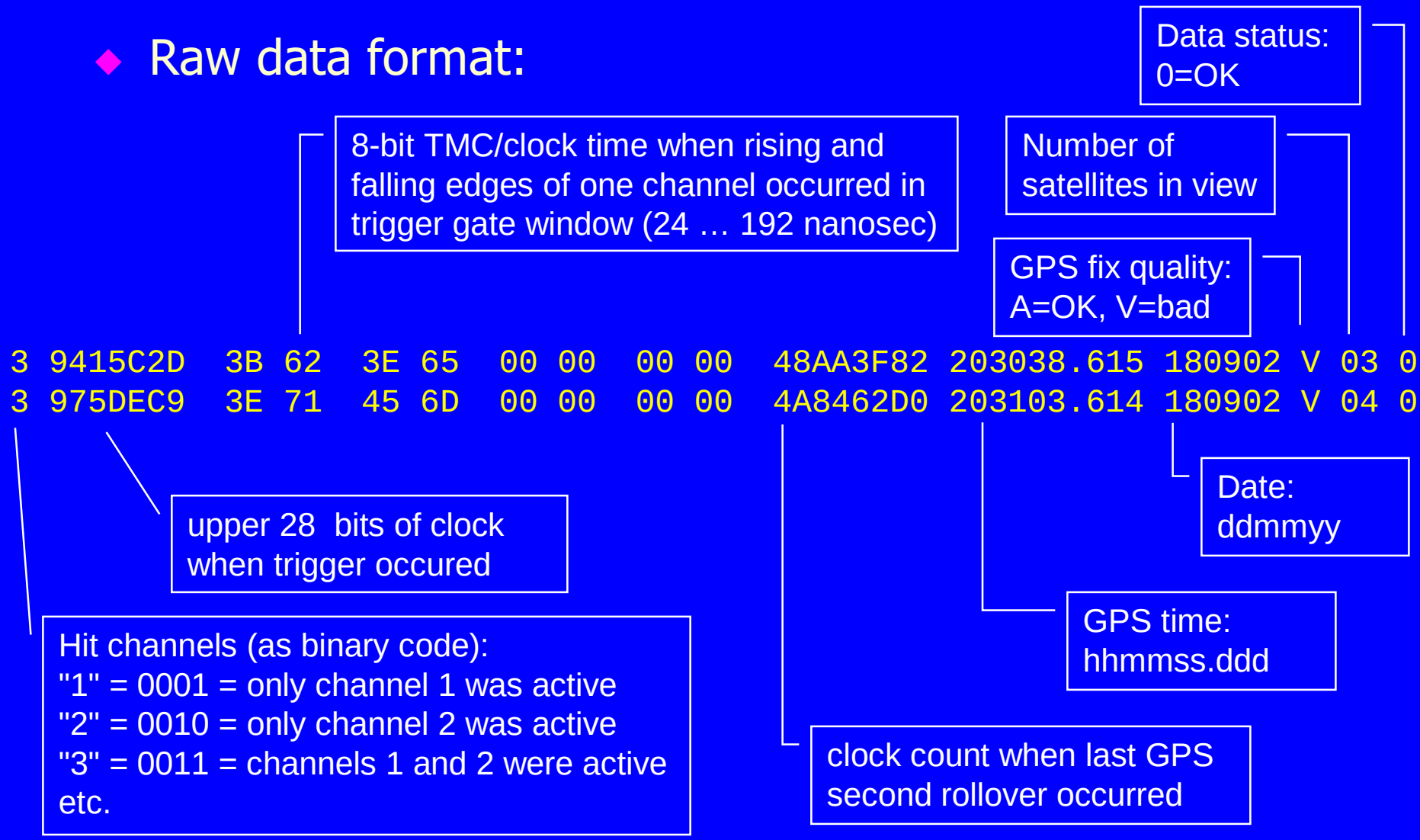


GPS time synch method

- Method:
  - log value of onboard 41.7 MHz clock counter (1 tick ~ 24 nanosec)
    - » for every event trigger (clock reading = N_{TRG})
    - » for every 1 PPS pulse (clock reading = N_{1PPS})
  - Difference between 1 PPS values calibrates the 41.7 MHz clock
    - » T_{CLOCK} ~ 24 nanosec = 1 sec / < ΔN_{1PPS} > (avg ΔN over 60 sec)
  - Difference between count at last 1 PPS and at trigger gives time in units of clock period since last second began
    - » Event timestamp = (yy/mm/dd) + (hh:mm:ss) + N_{TRG}*T_{clock} nanosec

Data from the card

- Raw data format:



LabView Interface (G. Wheel)

- Labview provides a convenient environment for interfacing the Quarknet DAQ board:
  - LabView = National Instruments product
    - » visual programming environment
    - » National supplies hardware interfaces
    - » realtime data logging, analysis and display system
    - » easy to create GUIs for unique applications
  - Widely distributed at low cost to students and educators
  - Widely used in industry
    - » Stable and well supported by National
    - » Many users, many help and source code websites
    - » Learning to use LabView is a useful vocational skill!

LabView interface (I):

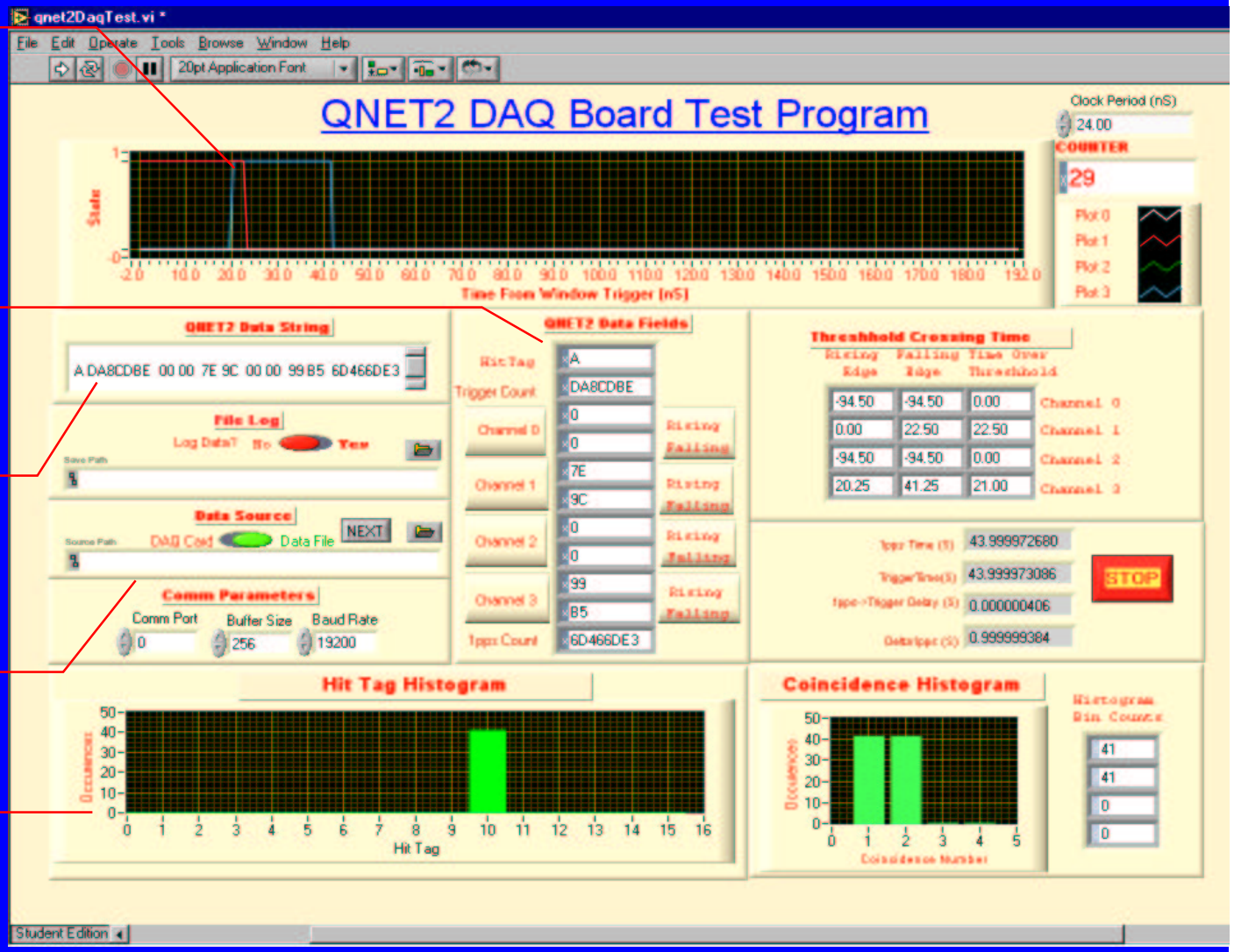
"Scope": running display showing rising and falling edges for all channels

Data items are decoded here

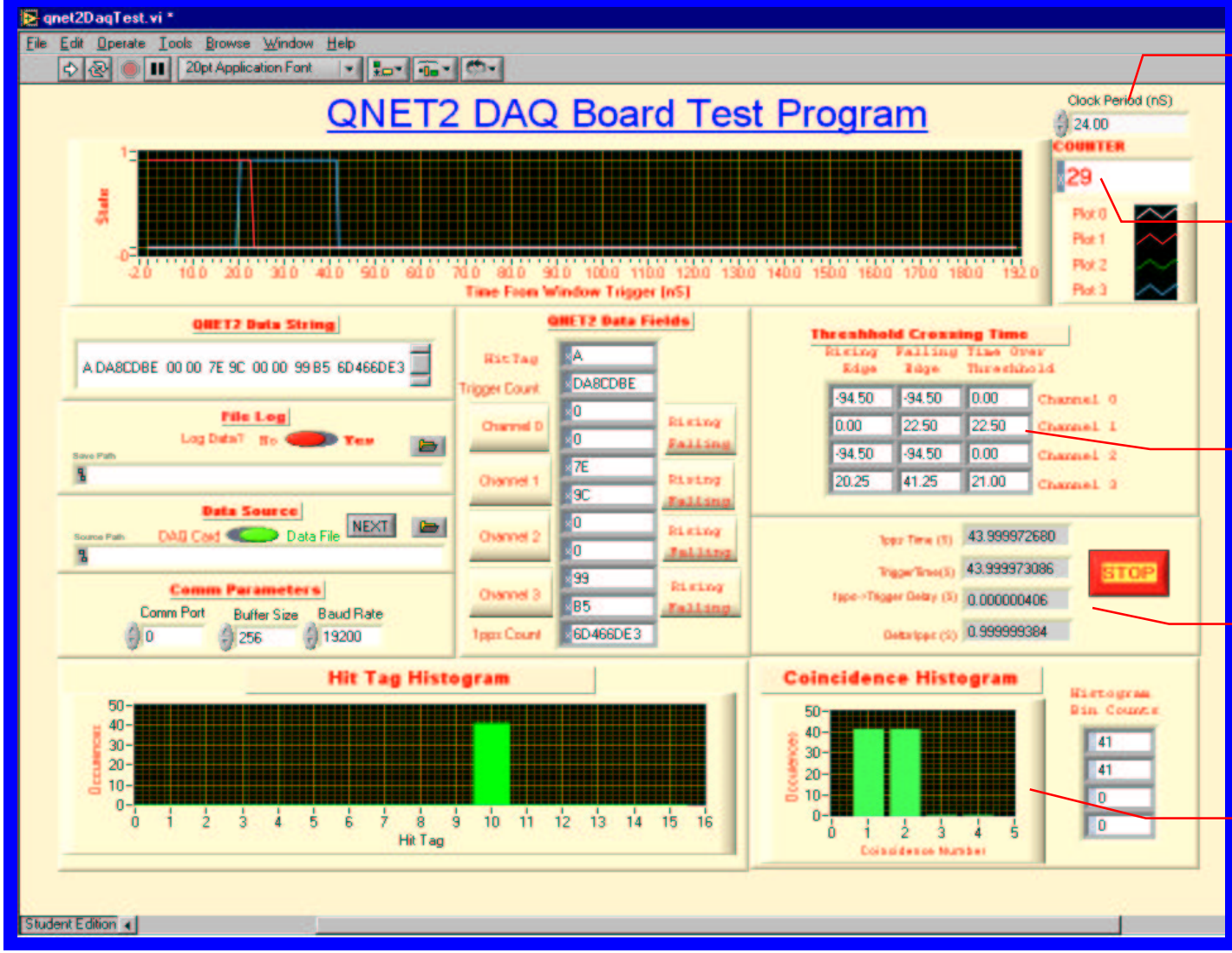
Raw data string shown here

PC interface: log file and COM* specs

Hit tag histogram: here all events have $10_{10} = 1010_2$



LabView interface (II):



clock period can be set

Number of triggers (matches LED display on board)

Rising and falling edge times for all channels

1PPS info (time calibration) and STOP button

Coincidence level histogram

When do we get them?

- Testing and debugging prototype boards here and at Fermilab and U. Nebraska
- Revise and make version 2
- Hope to have kits to WALTA-2001 schools before end of autumn
- At least for now, cost is covered by Quarknet!