Quarknet
Data Acquisition (DAQ) Board

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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

- Programmable logic
- Time-to-digital converter
- Serial port (output to PC)
- GPS input
- Reset switch
- 5V-DC input
- Microcontroller
- Trigger output
- Inputs for 4 counter signals
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 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 milliseck

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)

- 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:

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1.000 sec       2.000 sec       3.000 sec
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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
    » \( T_{CLOCK} \sim 24 \text{ nanosec} = 1 \text{ sec} / \langle \Delta N_{1PPS} \rangle \) (avg \( \Delta N \) 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) + \( N_{TRG} \times T_{d\text{ock}} \) nanosec
Data from the card

- Raw data format:
  - Hit channels (as binary code):
    "1" = 0001 = only channel 1 was active
    "2" = 0010 = only channel 2 was active
    "3" = 0011 = channels 1 and 2 were active
    etc.
  - 8-bit TMC/clock time when rising and falling edges of one channel occurred in trigger gate window (24 … 192 nanosec)
  - number of satellites in view
  - GPS fix quality: A=OK, V=bad
  - Data status: 0=OK
  - Date: ddmmyy
  - GPS time: hhmmss.ddd
  - Clock count when last GPS second rollover occurred
  - Upper 28 bits of clock when trigger occurred

3 9415C2D 3B 62 3E 65 00 00 00 00 48AA3F82 203038.615 180902 V 03 0
3 975DEC9 3E 71 45 6D 00 00 00 00 4A8462D0 203103.614 180902 V 04 0

GPS fix quality:
A = OK, V = bad
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!