String-18 Progress Report

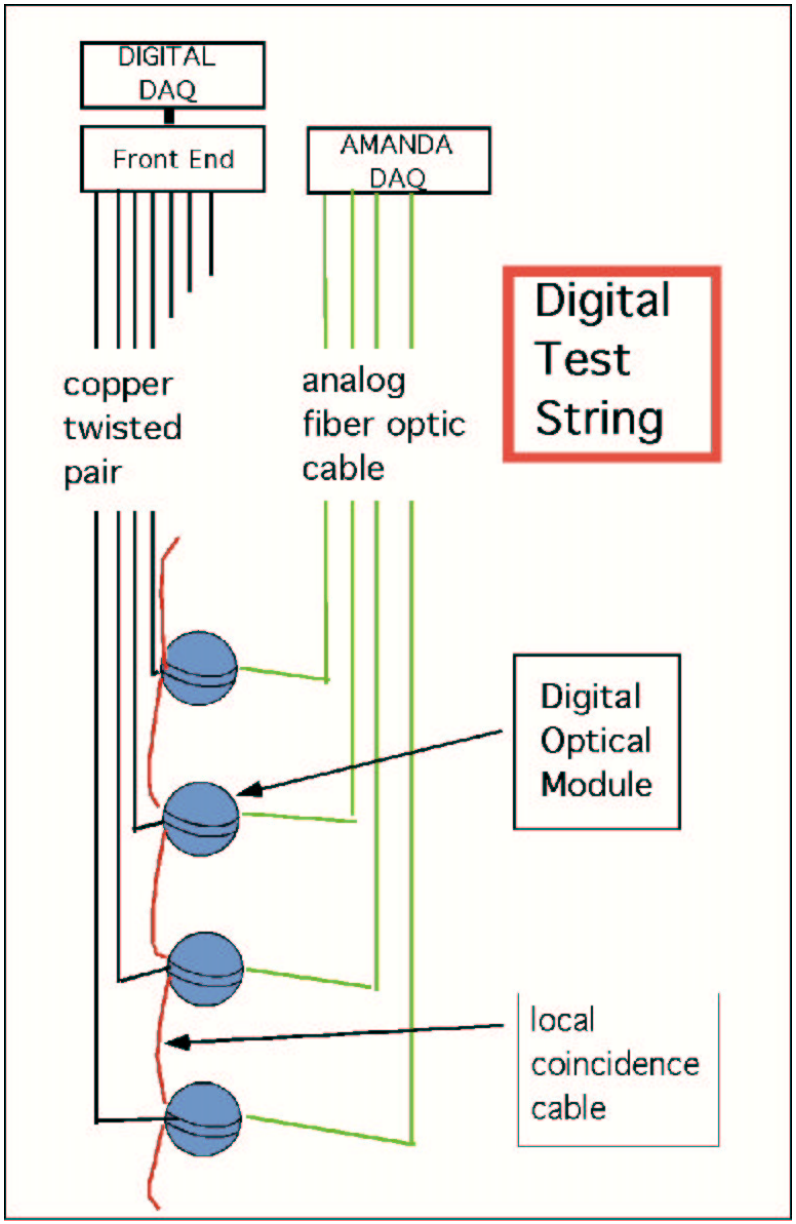
Azriel Goldschmidt

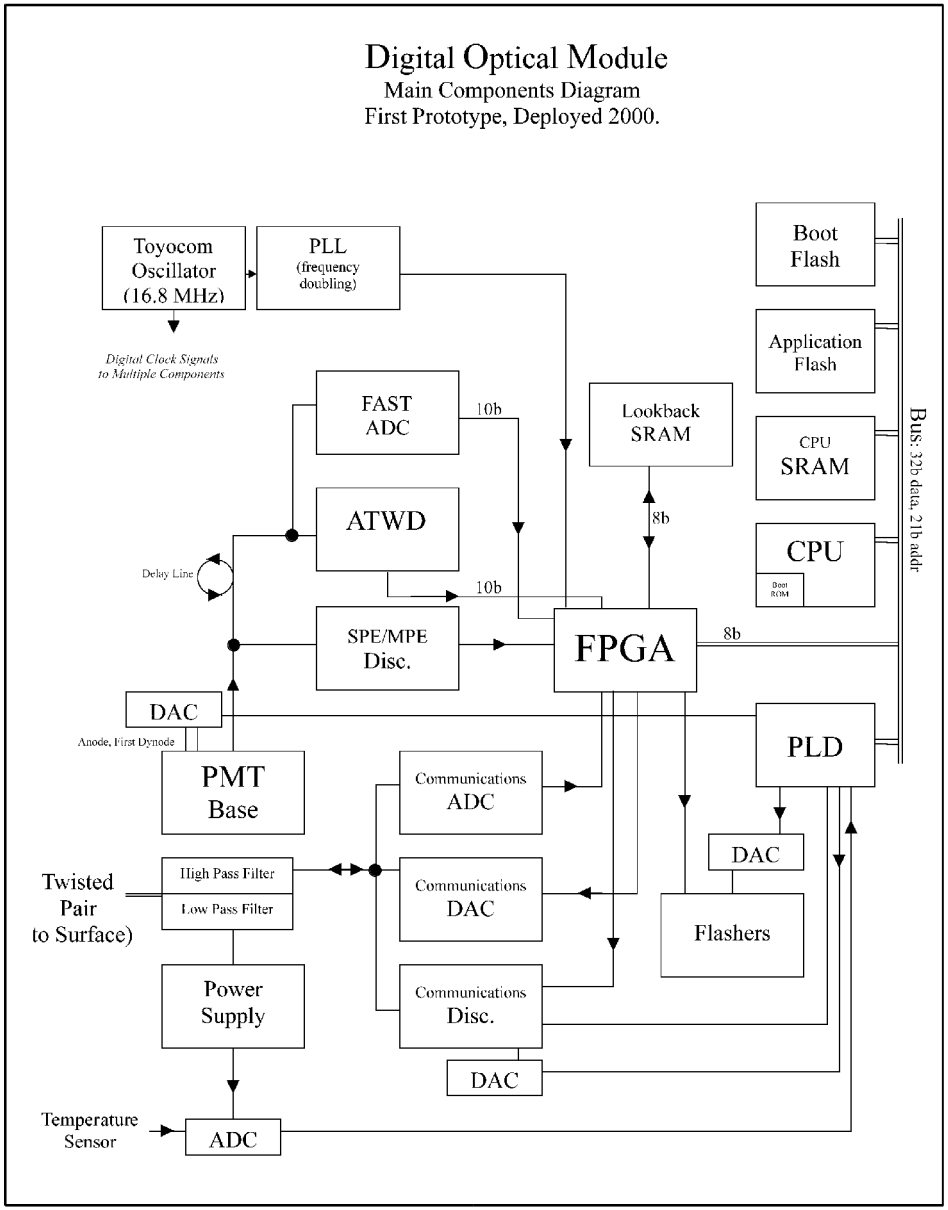
AMANDA/IceCube Collaboration Meeting

Stockholm, June 2002

Presented by Bob Stokstad

String 18


DIGITAL DAQ
Front End
AMANDA DAQ
Digital Test String
copper twisted pair
analog fiber optic cable
Digital Optical Module
local coincidence cable


Digital Optical Module
Main Components Diagram
First Prototype, Deployed 2000.
Toyocom Oscillator (16.8 MHz)
PLL (frequency doubling)
Digital Clock Signals to Multiple Components
FAST ADC
10b
Lookback SRAM
Boot Flash
Application Flash
CPU SRAM
CPU
Boot ROM
Bus: 32b data, 21b addr
ATWD
8b
Delay Line
10b
SPE/MPE Disc.
FPGA
8b
DAC
Anode, First Dynode
PLD
PMT Base
Communications ADC
DAC
Twisted Pair to Surface)
High Pass Filter
Low Pass Filter
Communications DAC
Flashers
Power Supply
Communications Disc.
DAC
Temperature Sensor
ADC

Recent Achievements

- Buffering of PMT hits
- Readout of ADC waveforms
- New DAQ software with "full rate" capability (domserver)
- Run controller and monitor software (domexec)
- Muon data (at full instantaneous rate)

People Involved:

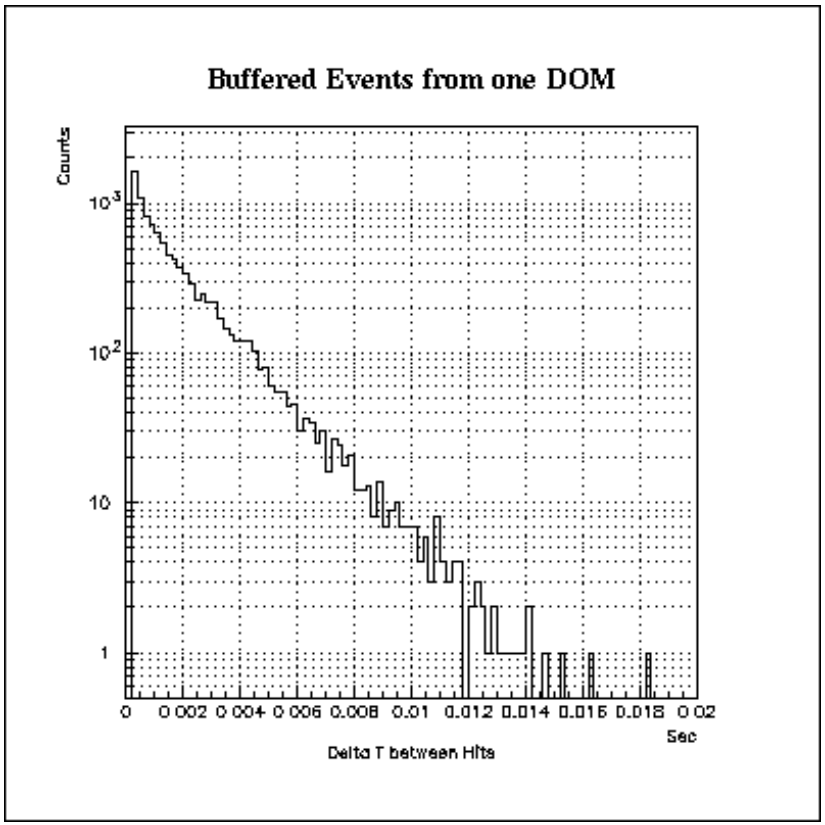
Gerald Przybylski (firmware)
John Jacobsen (DAQ software)
Chuck McParland (DOM software)
Cecile Roucelle (visiting student, analysis)
Azriel Goldschmidt (DAQ software, tests, coordination)

PMT-Hits Buffering

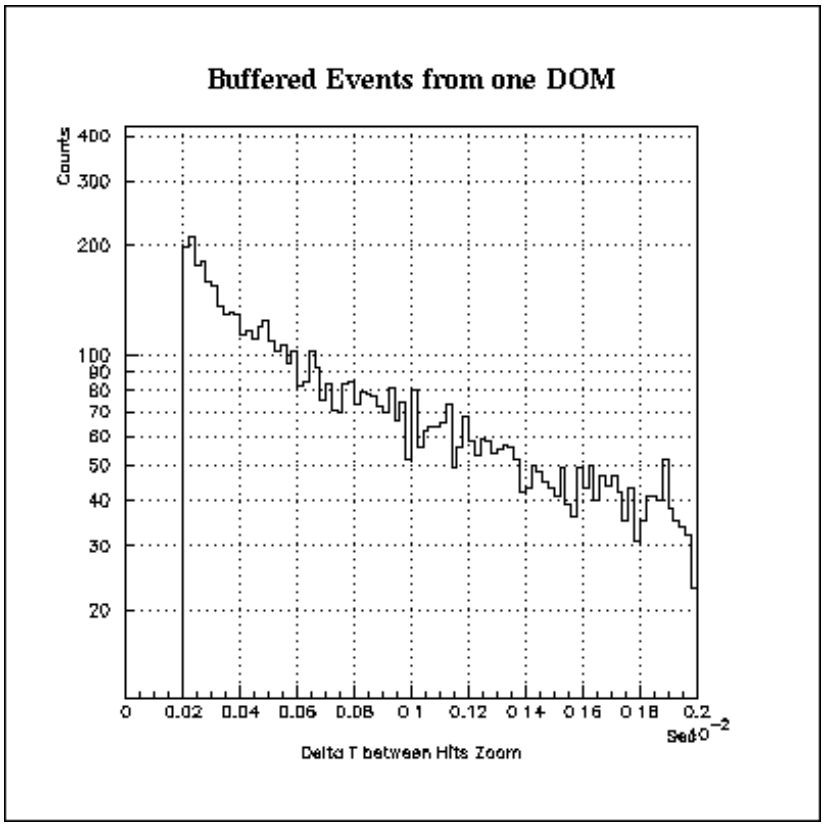
- Accumulate hits in DOM memory (DOM FPGA)
- Send chunks of memory to DAQ on request (application)
- Currently saving ALL (some redundancy) the hit information: (ATWD -4 channels-, ADC and time stamps)
- Can take the “full” instantaneous rate without the use of the hardware Local Coincidence
- Currently at 1kHz singles-rate: 15% deadtime
- With future ping-pong between two ATWDs and sparse readout expect: 0.2% deadtime.

PMT-Hits Buffering
Time Between Hits: single DOM at ~ 1kHz

Good Poisson behavior



Zoomed: 200 μsec deadtime



ADC Waveforms

- DOMs were designed/built with an ADC to capture long waveforms (~ few μsec)
- The PMT pulse is shaped to match the target sampling rate of ~30 ns/sample (currently using 60 ns/sample)
- Nice-looking waveforms with info on late photons!

ATWD and New ADC Info
a single photoelectron in both

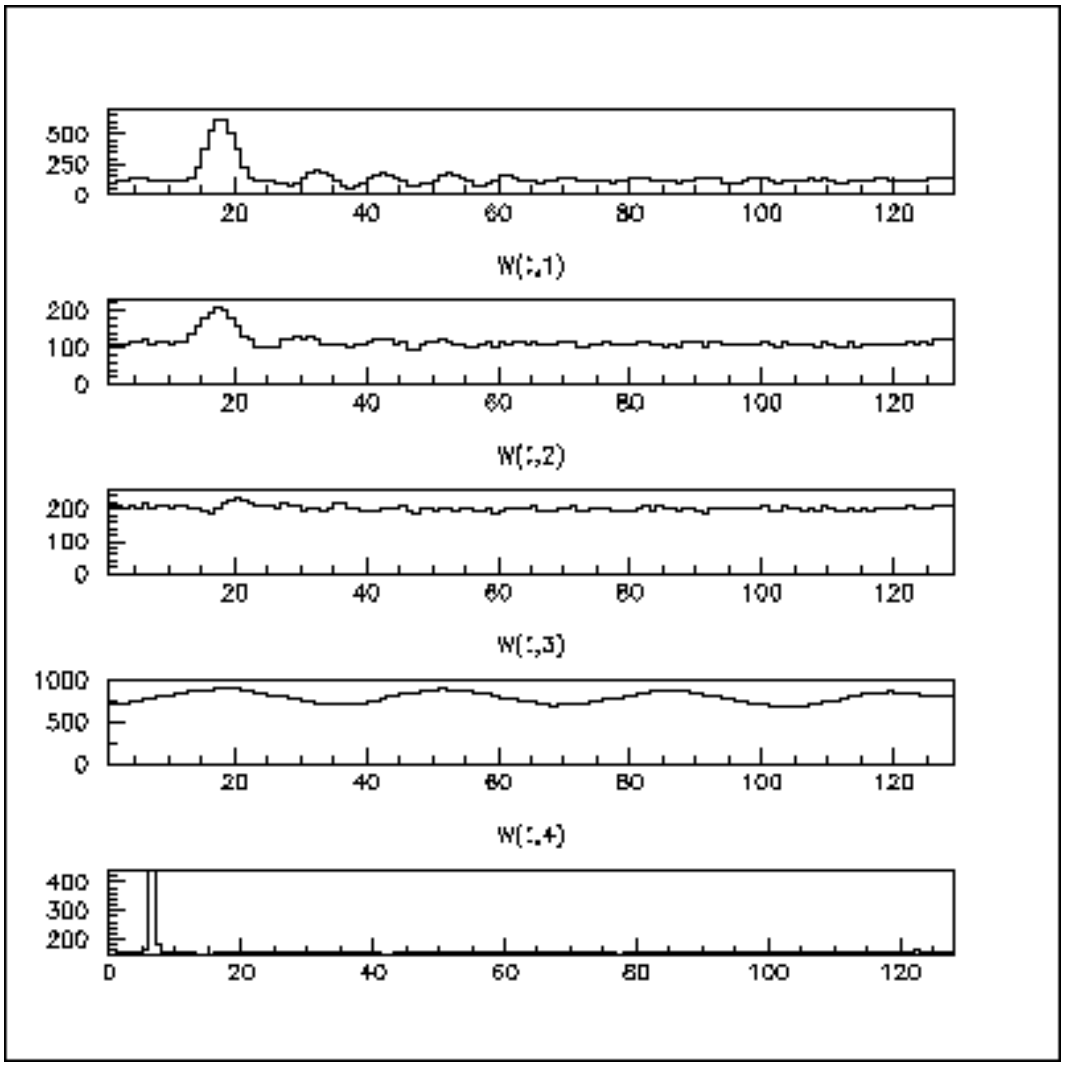
ATWD0 High GAIN

ATWD1 Low Gain

ATWD2 Nothing

ATWD3 Clock

ADC



1.7 ns/smp

total: 217 ns

" "

" "

" "

" "

" "

" "

60 ns/smp

total:7.7 μs

ATWD and New ADC Info
~3 photons in 2 microseconds

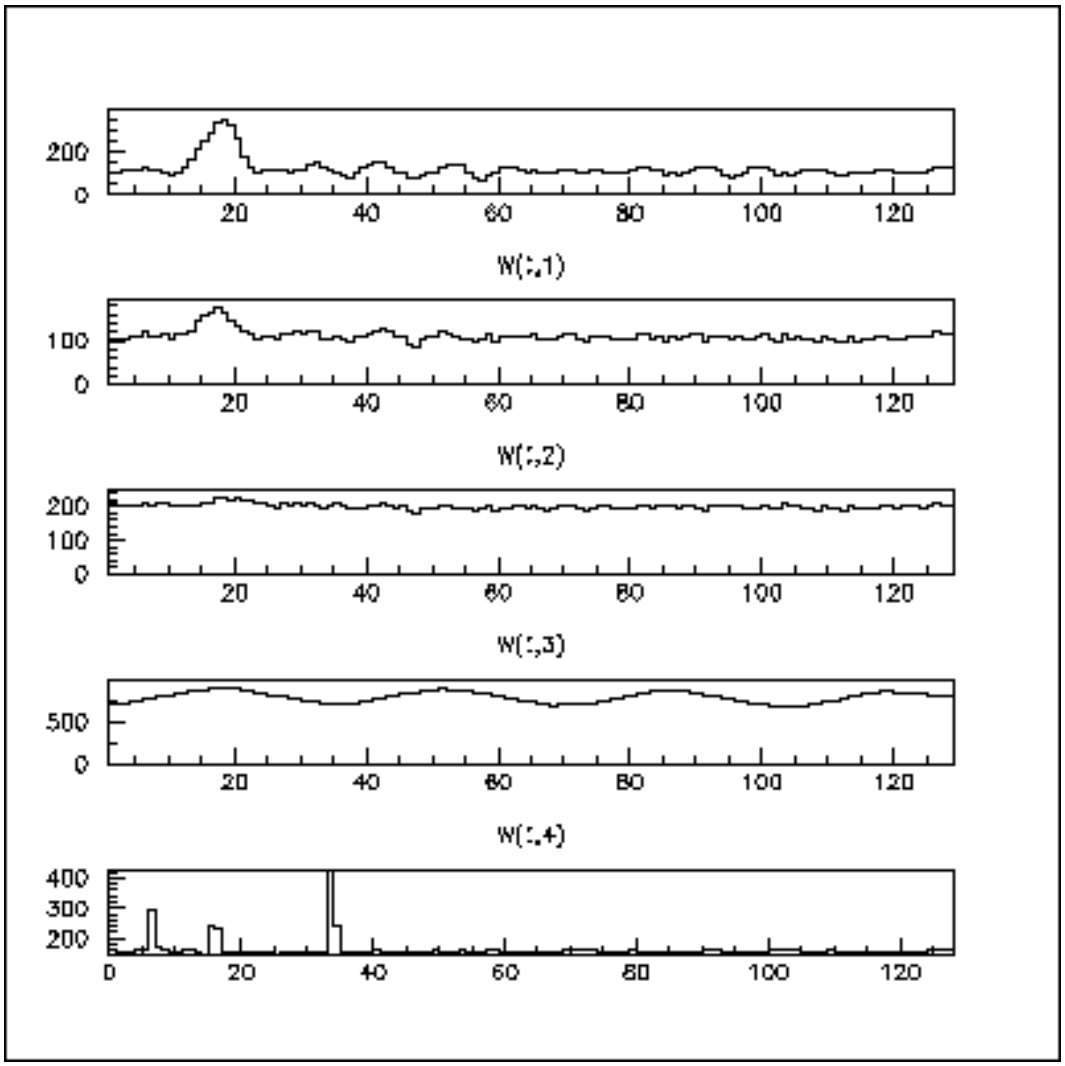
ATWD0 High GAIN

ATWD1 Low Gain

ATWD2 Nothing

ATWD3 Clock

ADC



1.7 ns/smp

total: 217 ns

" "

" "

" "

" "

" "

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60 ns/smp

total:7.7 μs

ATWD and New ADC Info
~4 p.e.s: first two, 80 nsec apart

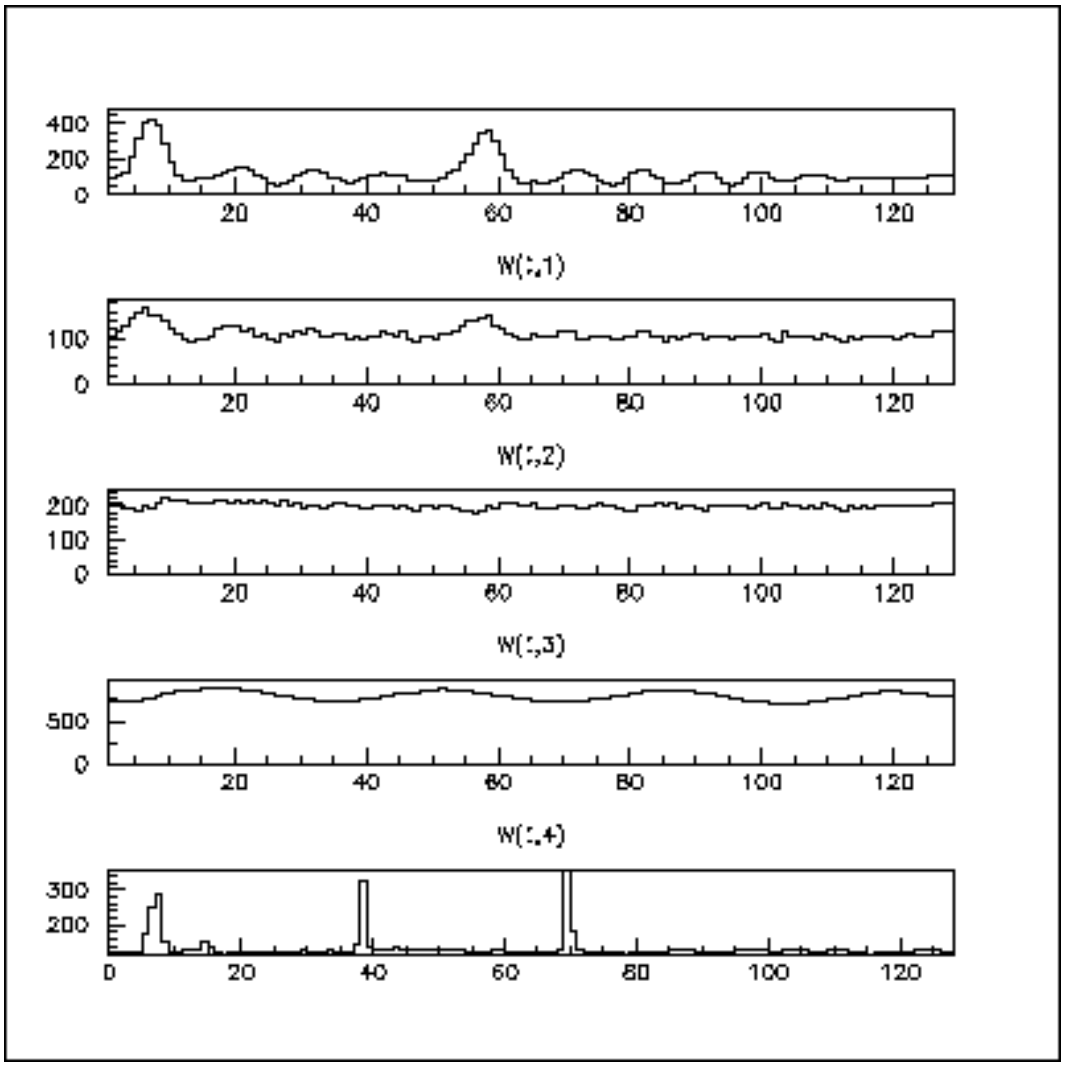
ATWD0 High GAIN

ATWD1 Low Gain

ATWD2 Nothing

ATWD3 Clock

ADC



1.7 ns/smp

total: 217 ns

" "

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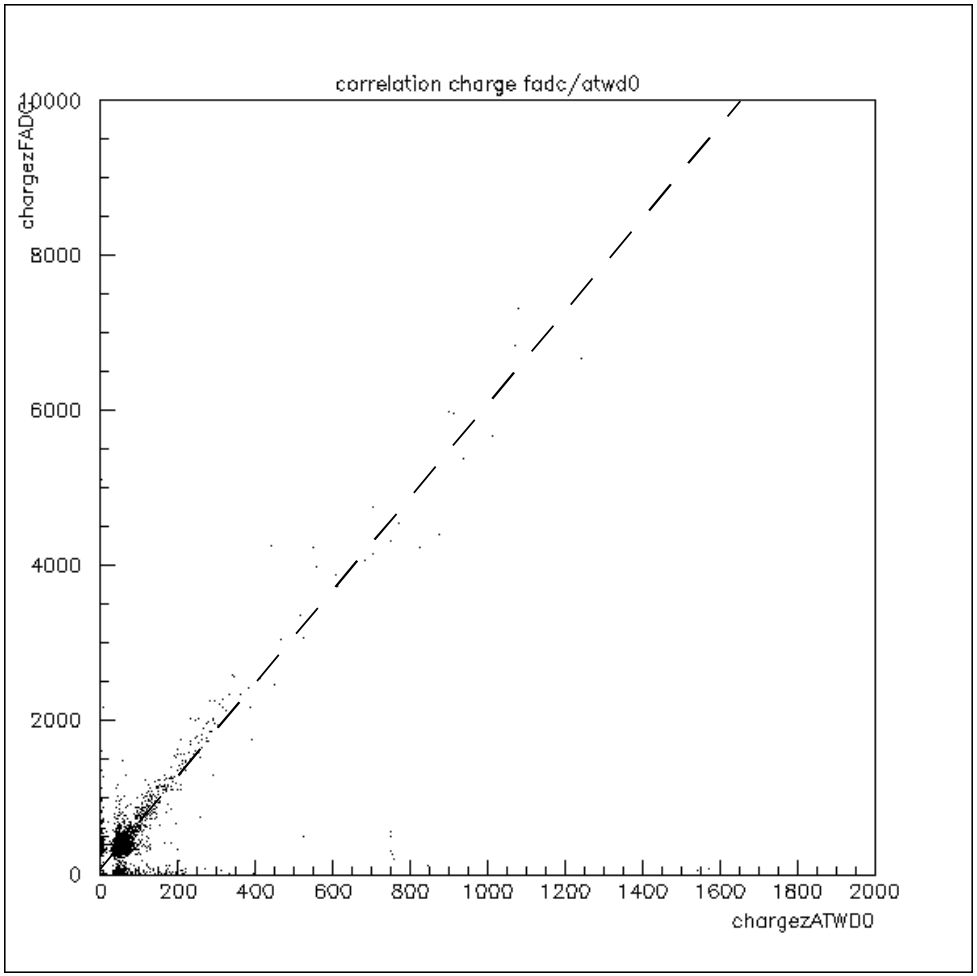
60 ns/smp

total:7.7 μs

ATWD vs ADC charge



New DAQ Software **-domserver-**

- Multithreaded C program running on each of the 5 dom PCs (tbdaq-1…5).
- Can handle the full expected (fast communications) data rate from all channels in that PC.
- Delivers data through network sockets for trigger/event building… (ready for RAPCal program and EBTrig).

New DAQ Software **-domexec-**

- Turns on-off the HVs (and sets other DOM parameters -LC, thresholds, etc-)
- Controls the ready/idle/running state of the **domserver**s in all DOM PCs
- Resets all surface clock counters on all DAQ boards on all PCs (at the same time)
- Requests monitoring (mostly low level) information from the string to be stored in a DB.

Muon Data: a Test Run

- 29 DOMs triggering on SPE discriminator
- Typical “singles” rates of ~500 Hz (No Local Coinc.)
- ~30 secs of continuous livetime (currently limited by data volumes -no software trigger in place + no feature extraction - and by slow communications)
- An excellent data set to develop all the software tools for Trigger, Event Building and Analysis

Muon Data: Analysis steps

- Analyze time-synchronization pulses
- Translate DOM-timestamp to universal units (including cable delays, frequency ratios, GPS UTC time, etc)
- Sort hit times from different OM's in a single list
- Create "events" by accumulating all hits that are within a short time window

Muon Data: Checking the timestamps with coincidences from consecutive OMs

T (DOM N)

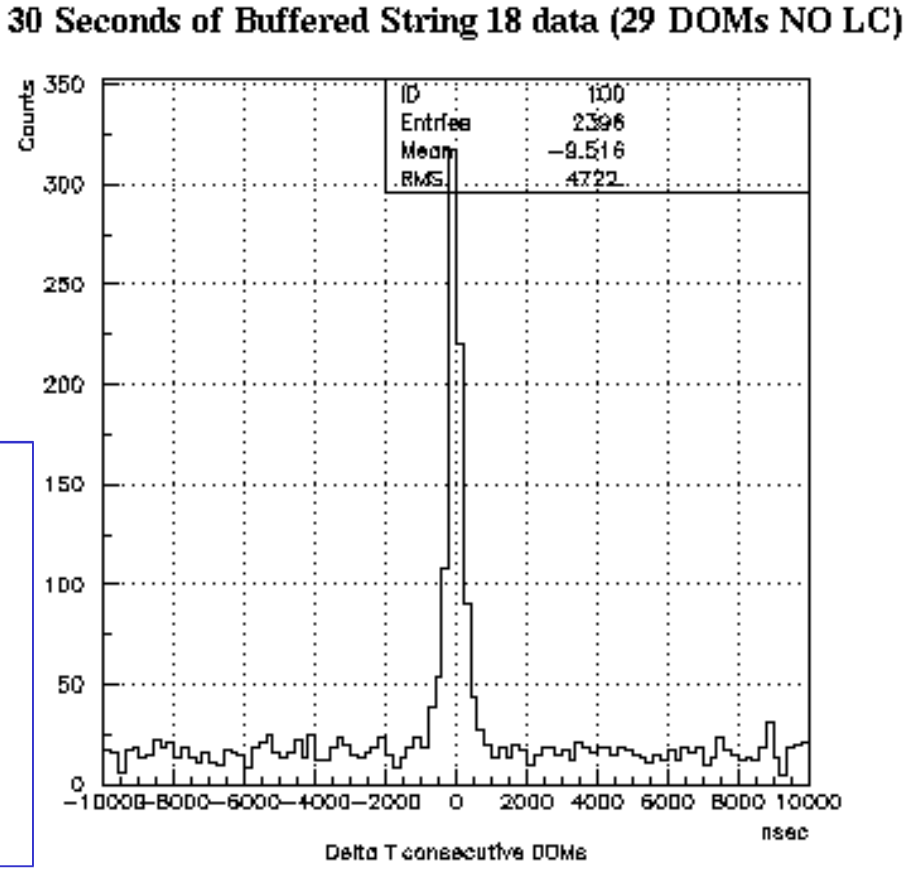
12 m

T (DOM N+1)

DeltaT = T (DOM N) - T (DOM N+1)

Two clear components:

- random coincidences (flat)
- correlated light (peak at ~ 0)



Muon Data: Checking timestamps with coincidences from consecutive OM's (cont)

T (DOM N)

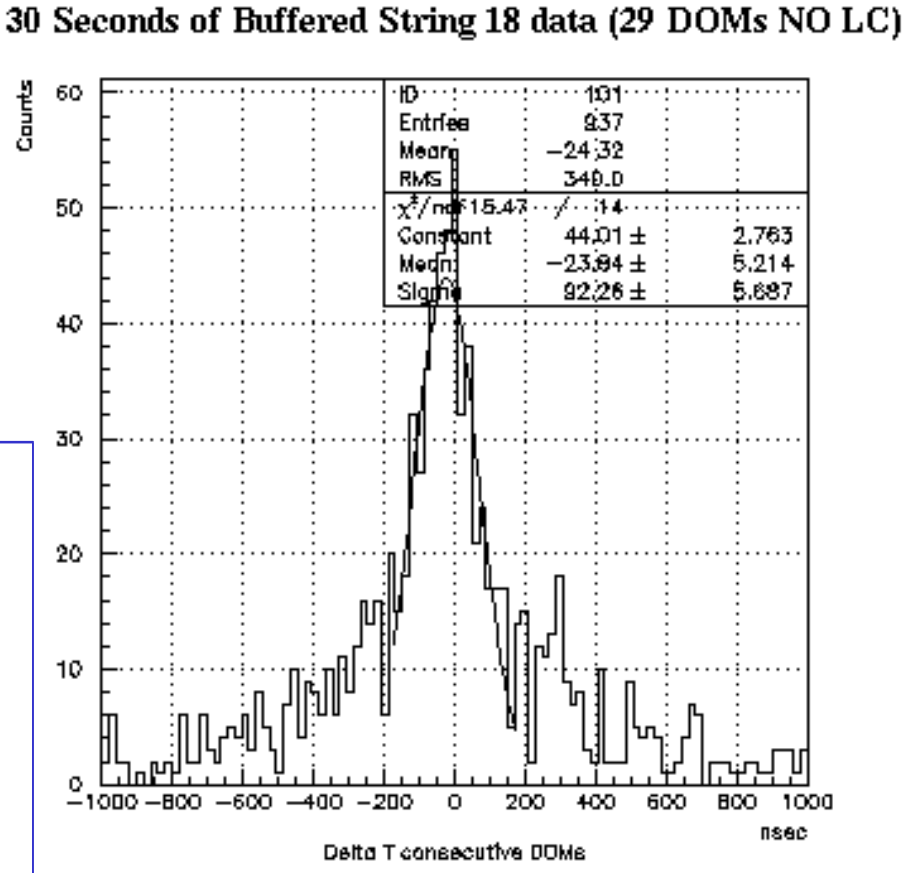
12 m

T (DOM N+1)

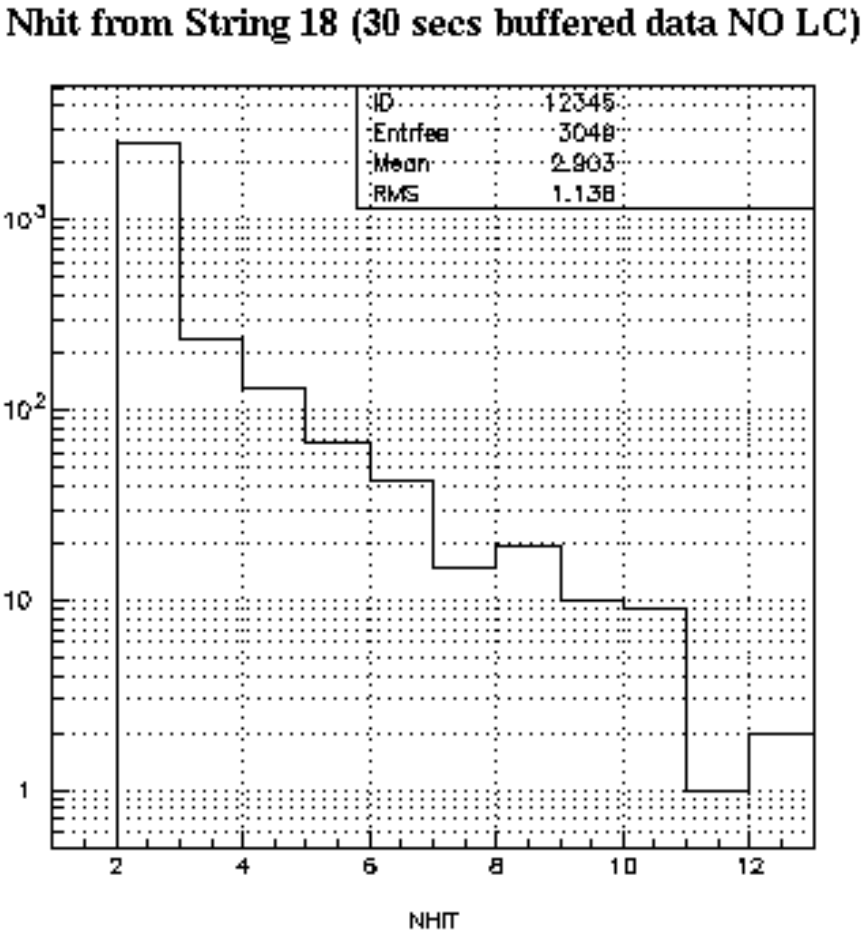
DeltaT = T (DOM N) - T (DOM N+1)

Zoom around [-1,+1] μsec :

- Mean at ~ -24 nsec
- Consistent with expectations form downgoing muons



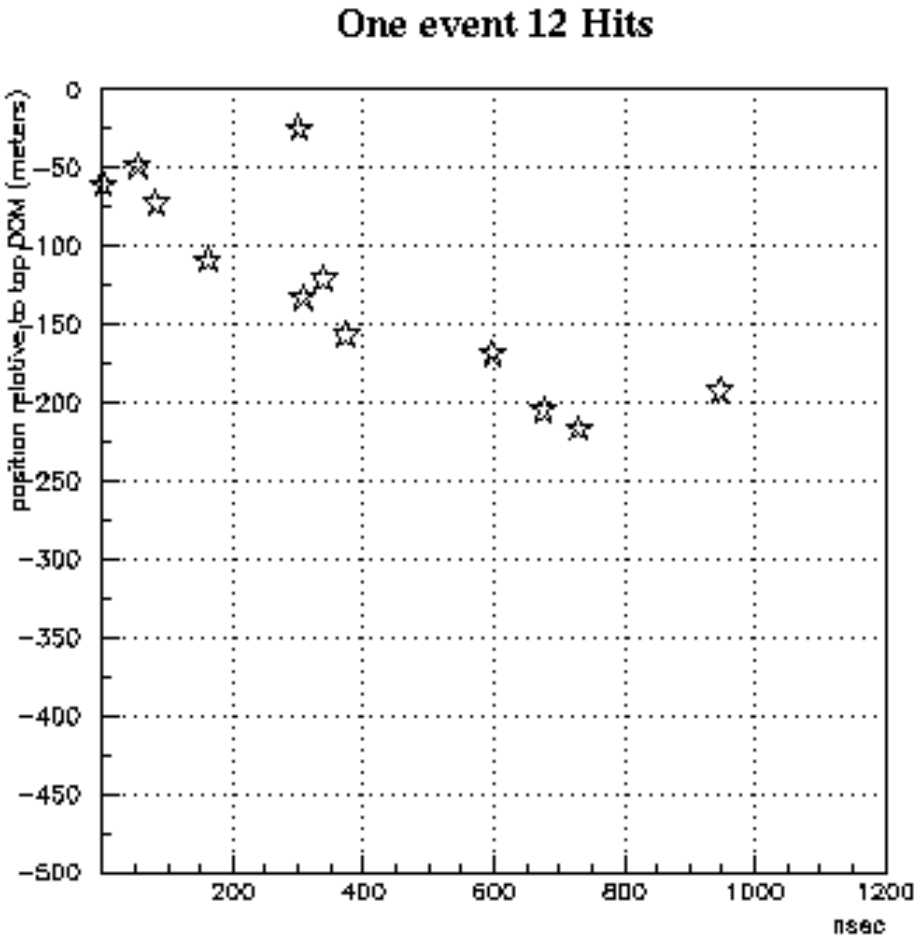
Muon Data: Nhit distribution
<1 μsec between time-consecutive hits



Nhit = 2 : dominated by random coincidences

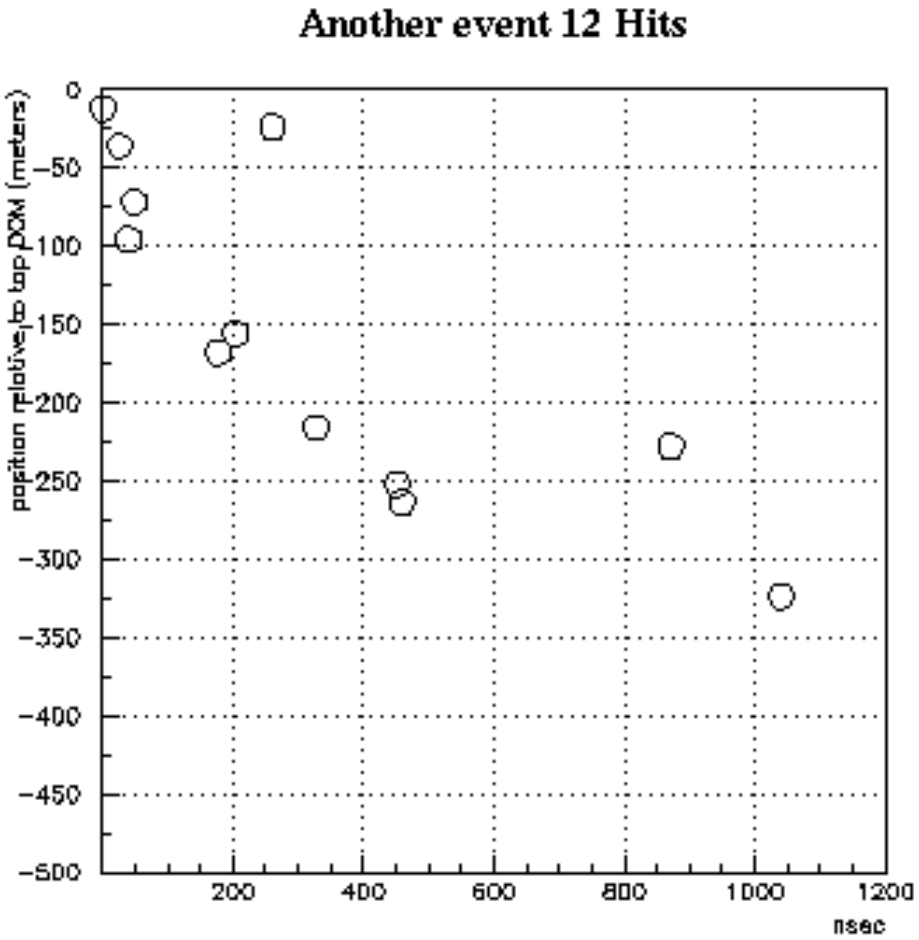
Nhit > 2 : dominated by correlated light: Muons

Example Muon Event #1



- Only first hit in each OM shown
- Down flow of light
- Late hits consistent with light scattering

Example Muon Event #2



Next Steps

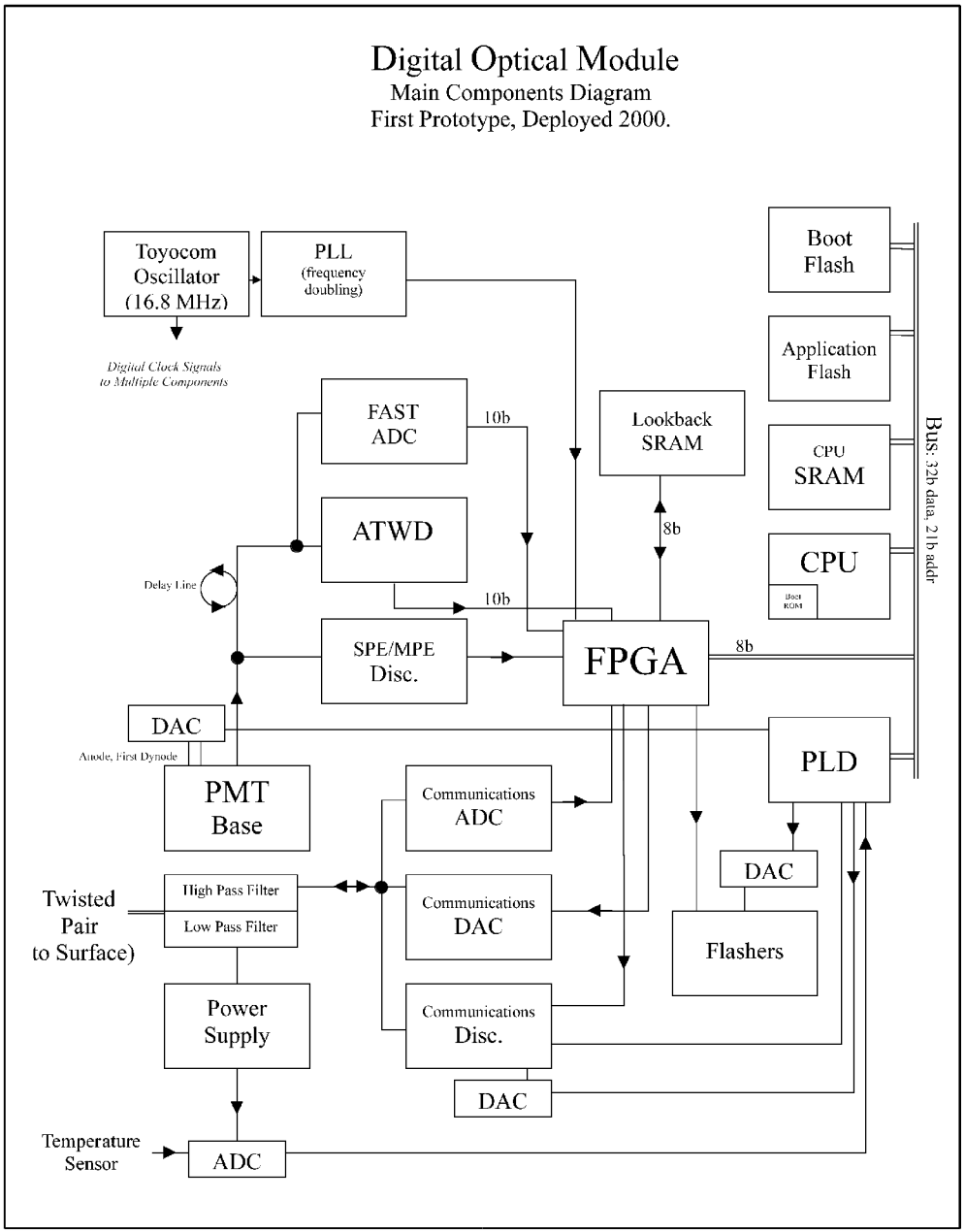
- Fast Communications: around the corner
- Feature Extraction: in progress at Sweden
- Online “trigger”: RAPCal & EBTrig preparing for test/commissioning by Kael/Doug
- Flasher calibrations
- Ice Studies/relative efficiencies/other...

Hardware Status

- Two surface CPUs have gone belly up - one was replaced by the only spare. Further debugging to determine reason will be done. (This does not affect analog-fiber operation.)
- CPU replacements in 02/03 season
- Stable behavior of analog output - no new dead modules-

Summary

- New firmware/software enables full instantaneous-rate hit collection
- Muons and (single string) Nhit distribution from a short test run
- Getting close to the goal a “dead-time free” digital DAQ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Bus: 32b data, 21b addr
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Anode, First Dynode
PMT Base
Communications ADC
PLD
DAC
Twisted Pair to Surface)
High Pass Filter
Low Pass Filter
Communications DAC
Flashers
Power Supply
Communications Disc.
DAC
Temperature Sensor
ADC