Slow Control
Slow Control

- HV
- Temperature, pressure, ...
- Valves
- PLC
- Terminal Server
- PC
- MIDAS DAQ
- RS232
- GPIB
- Ethernet
- 15°C
- heater

Temperature data:
- 12:30: 12.3
- 12:45: 17.2
- 13:20: 15.2
- 14:10: 17.3
- 15:20: 16.2
- 18:30: 21.3
- 19:20: 18.2
- 19:45: 19.2
Slow Control Bus

HV

Temperature, pressure, ...

Valves

MIDAS DAQ

heater
Generic node

- ADuC812 / C8051Fxxx Micro controllers with 8x12 bit ADC, 2x12 bit DAC, digital IO
- RS485 bus over flat ribbon cable
- Powered through bus
- Costs ~30$
- Piggy back board

www.cygnal.com
2 Versions

**BUS Oriented**

- Generic node with signal conditioning
- Sub-master with power supply and PC connection (Parallel Port, USB planned)
- Integration on sensors, in crates
- RS232 node with protocol translator

**Crate Oriented**

- 19" crate with custom backplane
- Generic node as piggy-back
- Cards for analog IO / digital IO / °C / 220V
- crate connects to parallel port (USB)
Midas Slow Control Bus

- 256 nodes, 65536 nodes with one level of repeaters
- Bus length ~500m opto-isolated
- Boards for voltage, current, thermo couples, TTL IO, 220V output
- Readout speed: **0.3s for 1000 channels**
- C library, command-line utility, Midas driver, LabView driver
- Nodes are “self-documenting”
- Configuration parameters in EEPROM on node
- Node CPU can operate autonomously for interlock and regulation (PID) tasks (C programmable)
- Nodes can be reprogrammed over network

http://midas.psi.ch/mscb
HV System Design

- Cheap and stable (<0.3V) HV system
- Regulate global external voltage
- Use series of opto-couplers
- Compensate non-linearities of opto-couplers by regulation loop
- ADC and DAC from slow control node
High Voltage System

Opto-couplers

µC node
HV performance

- Regulates common HV source
- 0-2400V, ~1mA
- DAC 16bit, ADC 14bit
- Current trip ~10µs
- Self-calibration with two high accuracy reference voltages
- Accuracy <0.3V absolute
- Boards with 12 channels, crates with 192 channels
- 30$/channel (+ext. HV)

Prototype
DAQ

Hardware and Software
DAQ Requirements

- $\gamma$'s hitting different parts of LXe can be separated if $> 2$ PMTs apart (15 cm)
- Timely separated $\gamma$'s need waveform digitizing $> 300$ MHz
- If waveform digitizing gives timing $< 100$ps, no TDCs are needed

$\mu \rightarrow e\nu\nu\nu\gamma$

$\mu \rightarrow e\gamma$

$\mu \rightarrow e\nu\nu\nu$
πβ Domino Sampling Chip

**Existing:**
- 0.5 - 1.2 GHz sampling speed
- 128 sampling cells
- Readout at 5 MHz, 12 bit
- ~ 60 $/channel

**Needed:**
- 2.5 GHz sampling speed
- Circular domino wave
- 1024 sampling cells
- 40 MHz readout
- < 100ps accuracy

C. Brönnimann et al., NIM A420 (1999) 264
Domino Ring Sampler (DRS)

- Free running domino wave, stopped with trigger
- Sampling speed 2 GHz (500ps/bin), trigger gate sampling gives 50ps timing resolution
- 1024 bins → 150ns waveform + 350ns delay
July 16/17, 2002  MUEGAMMA review PSI

- 0.25µm Process
  (“CERN is using”)
- 768 cells
- Wafer back July '02
Domino Simulation “Analog Extracted”

- 16 cells
- All parasitics included
- Domino speed: 1.5-2.2 GHz
**DAQ Board**

- 9 channels × 1024 bins / 40 MHz = 230 µs → acceptable dead time
- Zero suppression in FPGA
- QT Algorithm in FPGA (store waveform if multi-hit)

**Diagram:**
- 8 inputs
- Trigger gate
- Shift register
- Domino wave
- 3 state switches
- 40 MHz 12 bit
- FADC
- FPGA
- SRAM
- VME Interface (Cypress)
- 3.3V 2.5V
- 8 channel DRS
- 8 channel DRS
- 8 channel DRS
- Trigger Input
- Board inter-connect
- Trigger BUS (2nd level tr.)
DAQ Topology

- PMT
- LXe
- e+ counter
- wires
- strips
- DC
- CPU
- Waveform or QT readout

Diagram:
- PMT connected to Trigger Board
- Trigger Board connected to DSC and FPGA
- DSC connected to 2GHz and 100MHz signals
- FPGA connected to 40MHz signal
- CPU connected to Waveform or QT readout
- DAQ board with trigger signals
- 2nd level trigger to CPU

Legend:
- Trigger Board
- FPGA
- DSC
- CPU
- DAQ board
- PMT
Pile-up rejection

From (g-2):
- 400 MHz sampling
- Rise time ~5ns
- 3.5ns dead time
- 5ns separation

1GHz sampling

100MHz sampling

Deadtime of algorithm is about 3.5 ns.
Times and energies of individual pulses are determined reliably for separations of at least 5 ns.
Sample Averaging

- Rise time ~10ns
- Pile-up rejection ~10ns
- Shower fluctuations get averaged by sample averaging
Cross-Talk

- Not so critical for calorimeter
- For DC: careful design of on-chamber preamps
- Flash ADC (100MHz) AD9218 has internal cross talk of -75 dB (2 x 10^{-4})
- ADC resolution
  - DC: 10bit + bin averaging $\rightarrow$ 13.5 bit (10^{-4})
  - PMT (DRS): 12bit + bin averaging $\rightarrow$ 15.5 bit (2x10^{-5}), dominated by external noise
- Manual charge injection at DC preamp to measure cross talk
- Residual cross talk can be corrected off-line
Schedule on electronics

- Slow control system: ready by Sept. 02
- HV system:
  - Prototype system debugged by Oct. 02
  - Mass production by end of year
- DRS
  - First prototype back in ~weeks
  - Prototype tested by Nov. 02
  - Second prototype designed by Jan. 03
  - Second prototype produced by May 03
  - Production run in fall 03
  - Board production winter 03/04
DAQ System

- Use of MIDAS system
  - Standard DAQ system at PSI and TRIUMF
  - Used at the large prototype
  - Event building added recently
- Integration into ROOT: Planned until spring 2003
- Distributed DAQ with Linux cluster
MIDAS Analyzer

- Modular system
- Modules can be developed independently
- Version control via CVS
- MC data can be “injected” between modules
- Analyzer attached to Online Database
- Same analyzer can be used online and offline

Full physics analysis online!
Various issues
Electronics setup (ideas)

Outside (Trigger): Where present Sindrum II electronics is located, but with air conditioning. Similar to $8\pi$ experiment @ TRIUMF

On platform (DAQ, HV): like in pibeta
Running the experiment

- Highly automatized experiment reduces human mistakes, increases stability of experiment and reduces required manpower
- For the $\pi\beta$ data taking, 1-2 people at PSI and remote control from U.S. was enough
- Expected data rate: 2MB/s @ 100Hz
- Local tape library and PSI archive reduces tape changing requirements
- Offline analysis: Merlin Linux cluster at PSI archive
- Operational costs (without “upgrades“): $LN_2$, Gas, tapes, small repairs: estimated 15k$/year
Safety issues

- $p\cdot V$ below critical level
- Oxygen detector required
- No CE certification for Japanese magnet & power supplies (only inspection)
- "No principal problem"
- LXe storage tanks under investigation