# Slow Control

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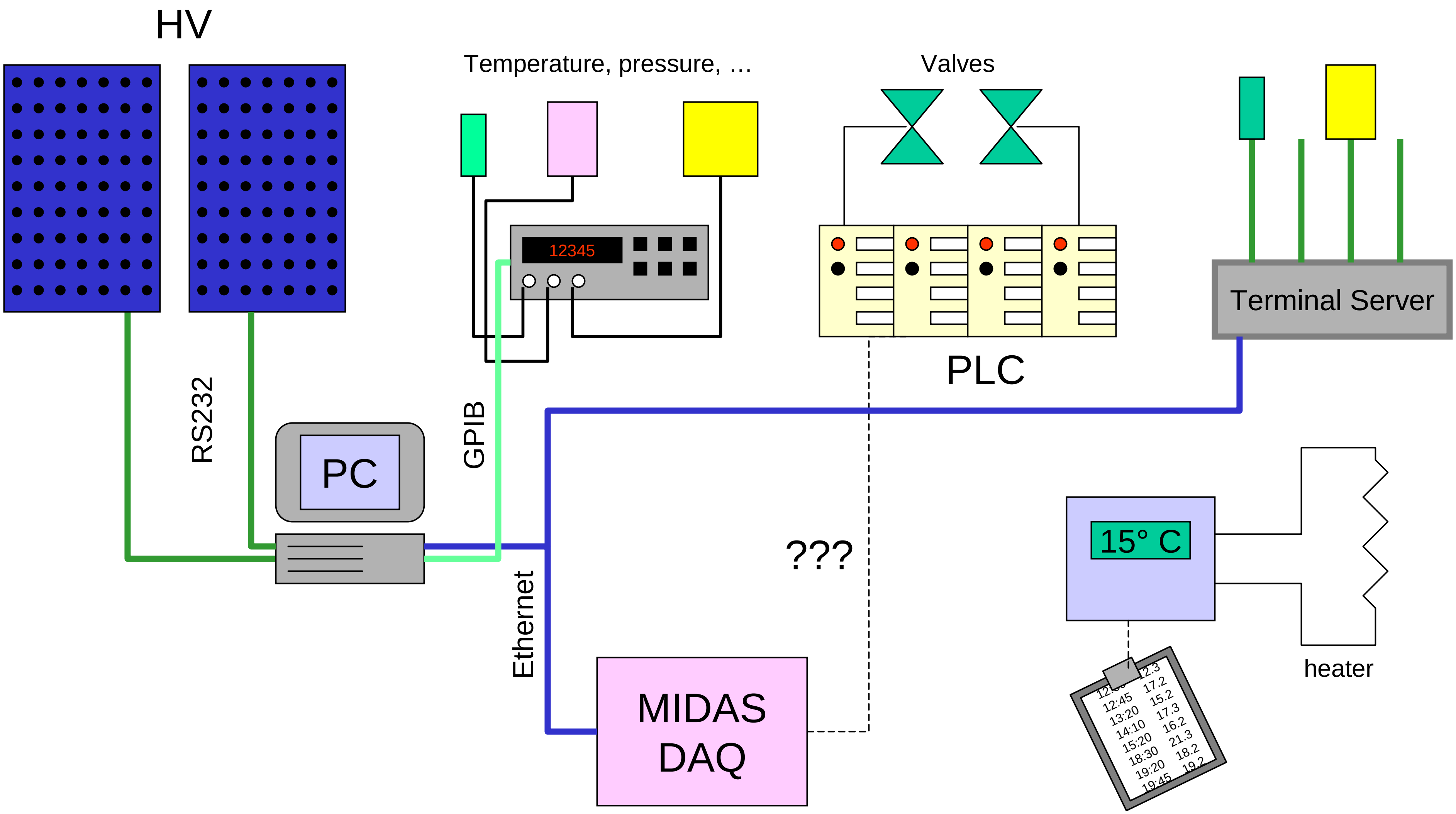
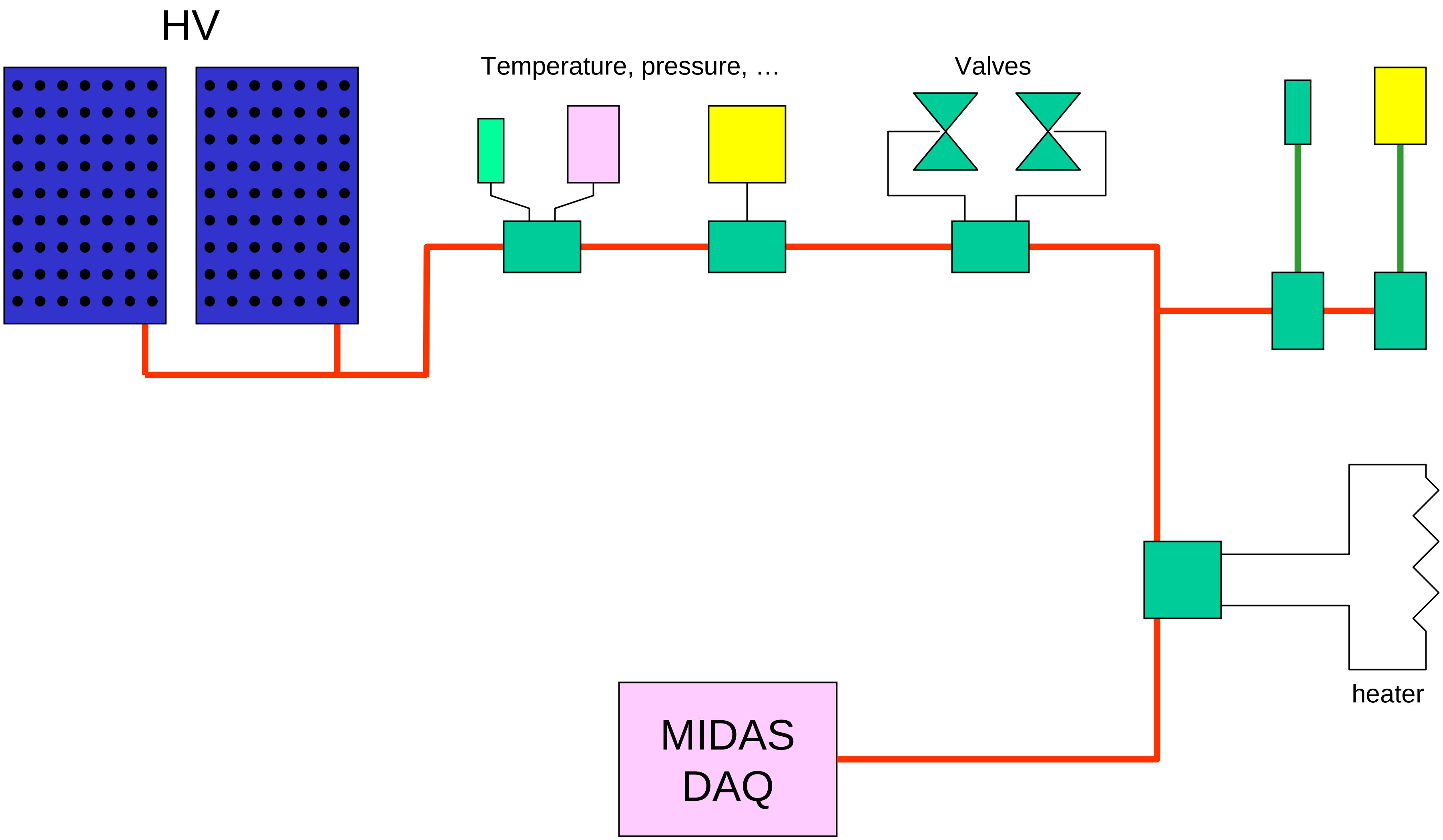


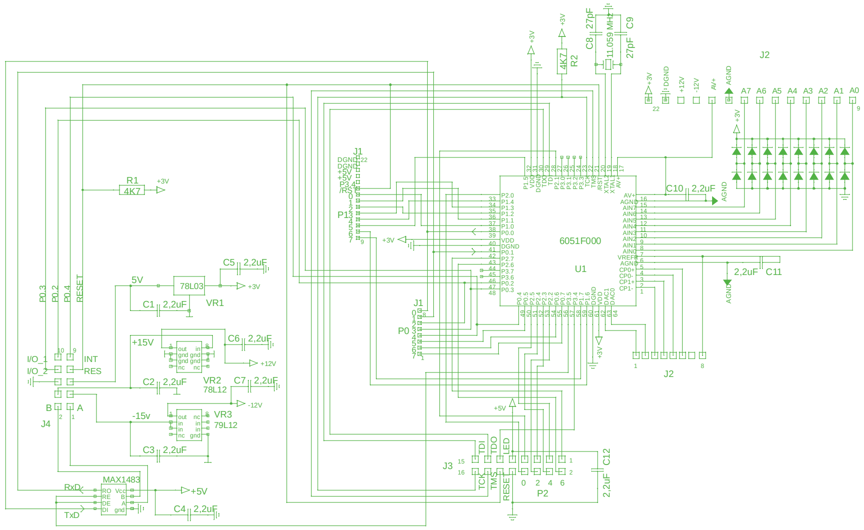
# Slow Control Bus

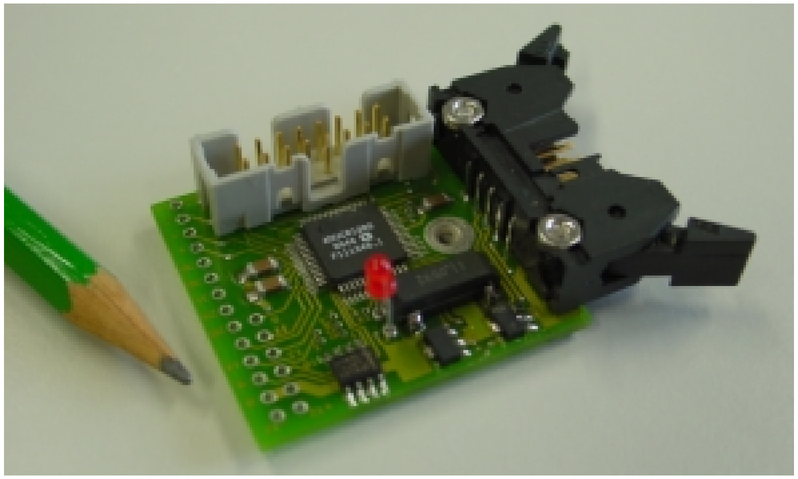


# Generic node

- 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

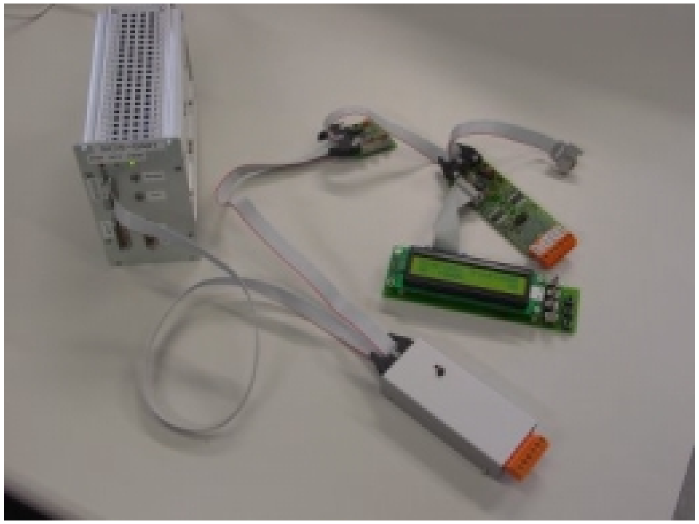
www.cygnal.com





# 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)

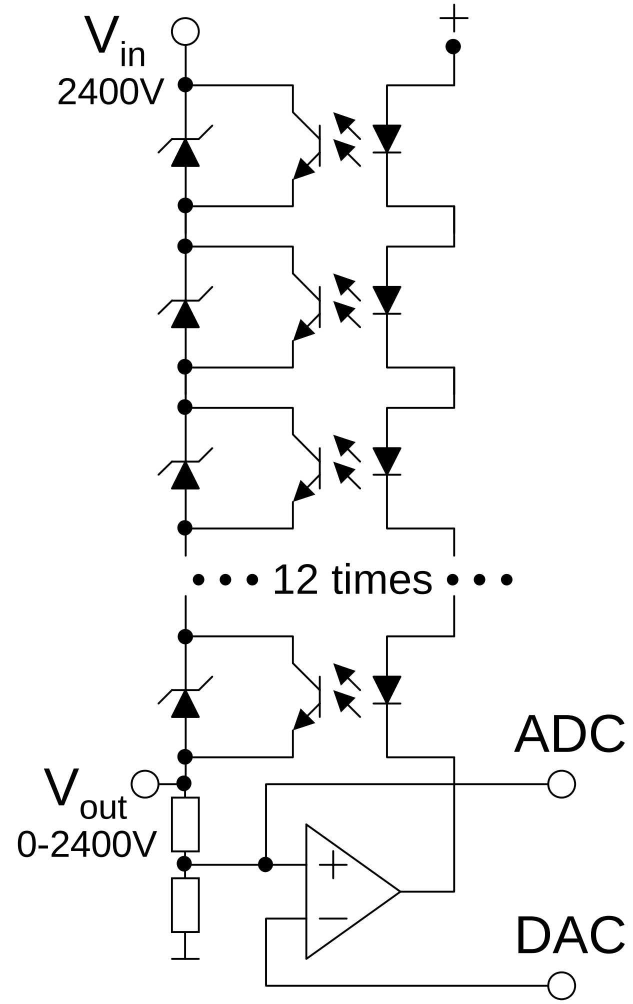
# Midas Slow Control Bus

- 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

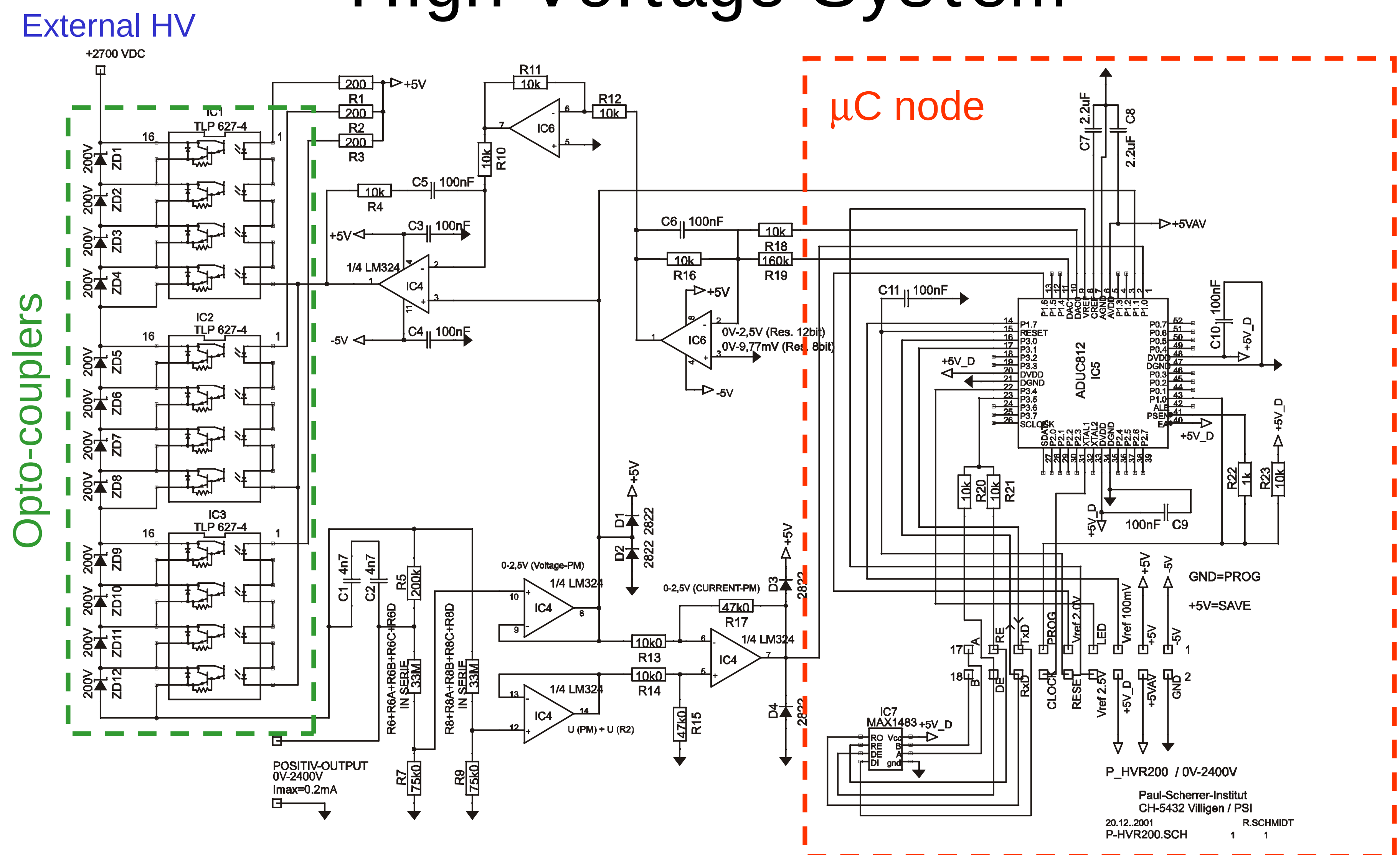
**http://midas.psi.ch/mscb**

# 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



# HV performance

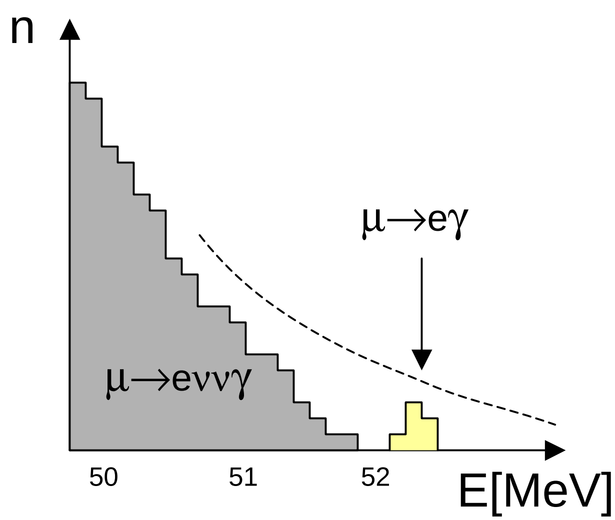
- Regulates common HV source
- 0-2400V, ~1mA
- DAC 16bit, ADC 14bit
- Current trip ~10µs
- Self-calibration with two high accuracy reference voltages
- Accuracy <0.3V absolute
- Boards with 12 channels, crates with 192 channels
- 30$/channel (+ext. HV)

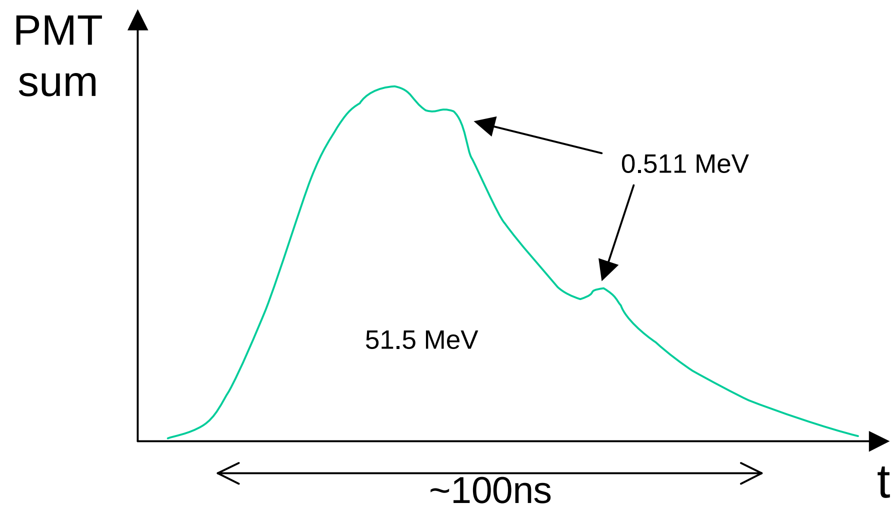
Prototype

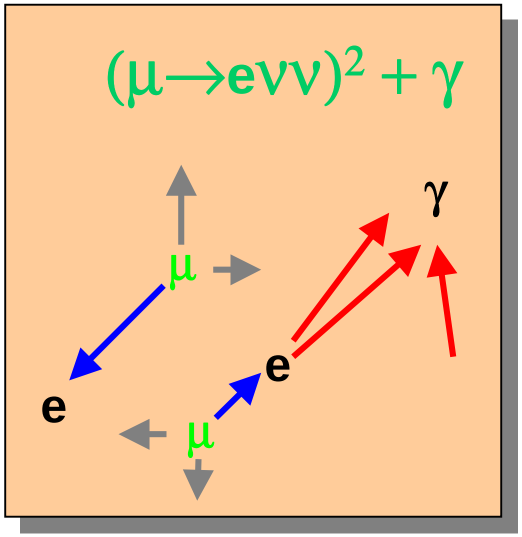
# DAQ

Hardware and Software

# DAQ Requirements

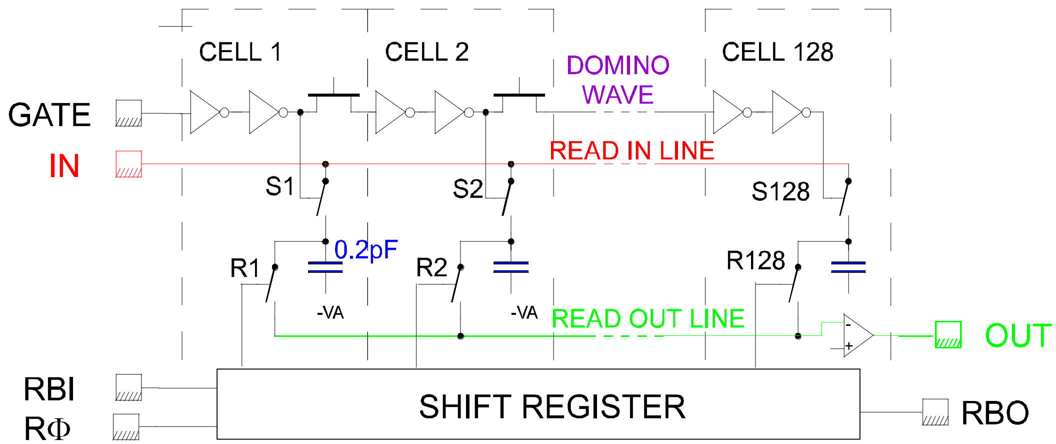


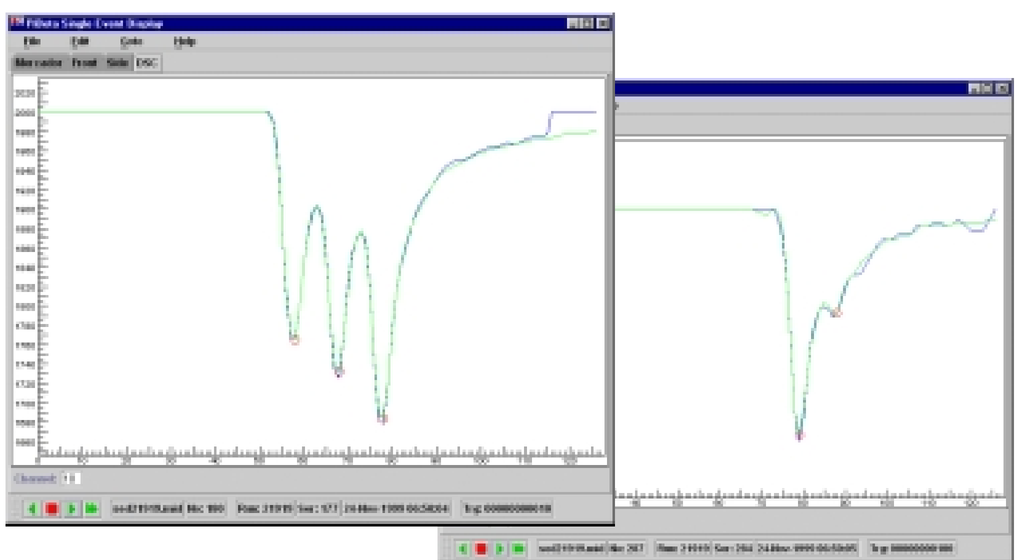




- γ's hitting different parts of LXe can be separated if > 2 PMTs apart (15 cm)
- Timely separated γ's need waveform digitizing > 300 MHz
- If waveform digitizing gives timing <100ps, no TDCs are needed

# πβ Domino Sampling Chip



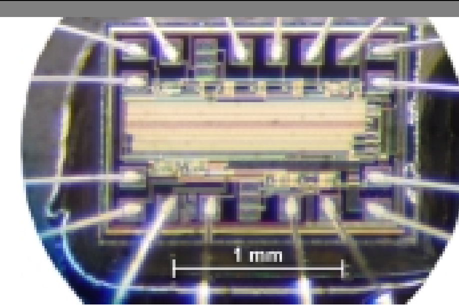



**Existing:**

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

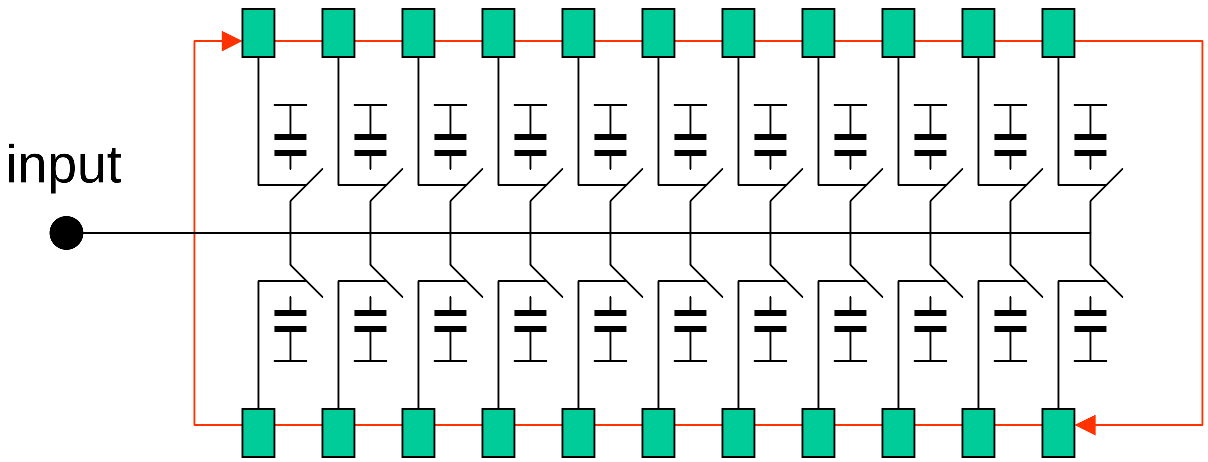
**Needed:**

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




C. Brönnimann *et al.*, NIM A420 (1999) 264

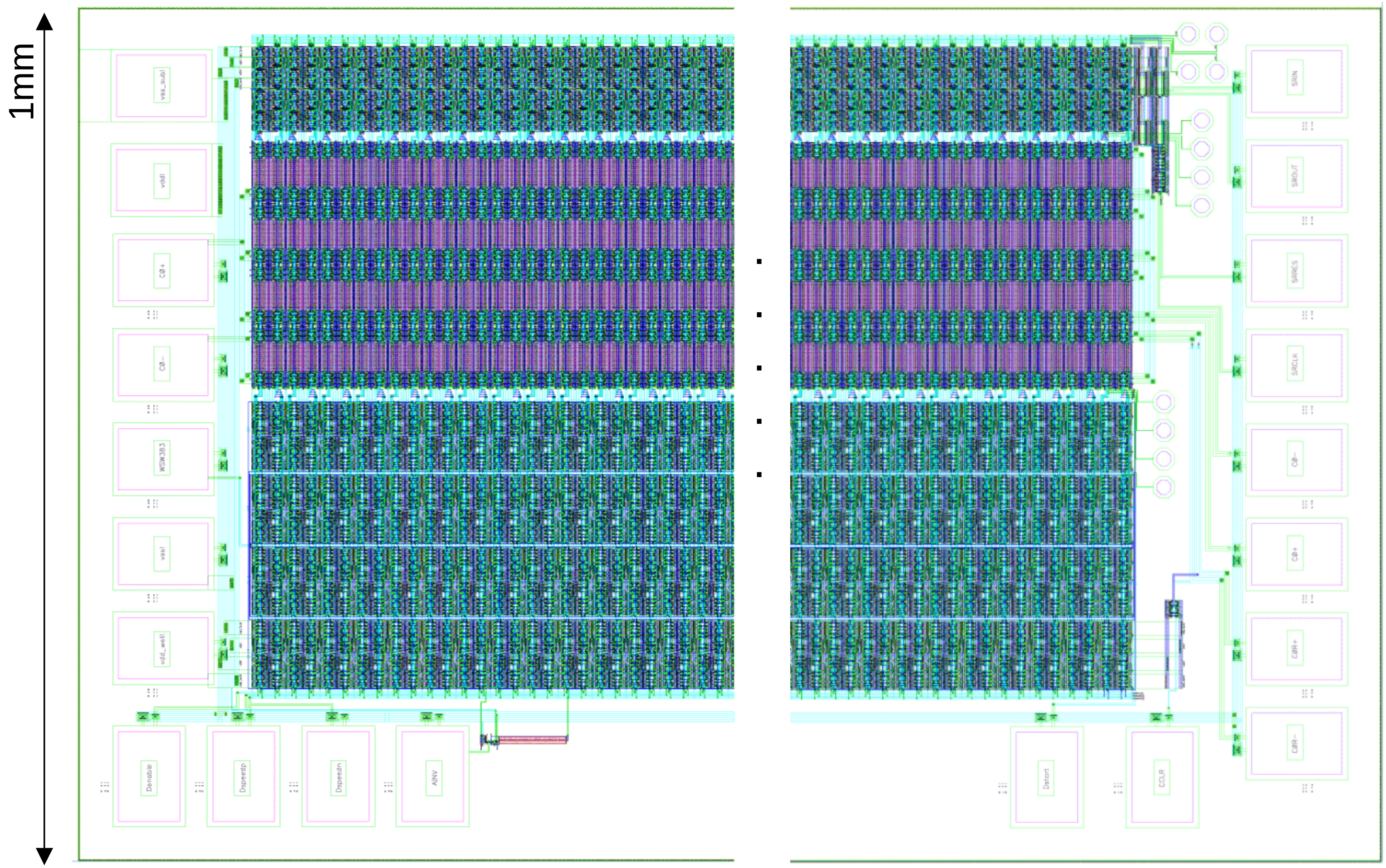
# Domino Ring Sampler (DRS)




- 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

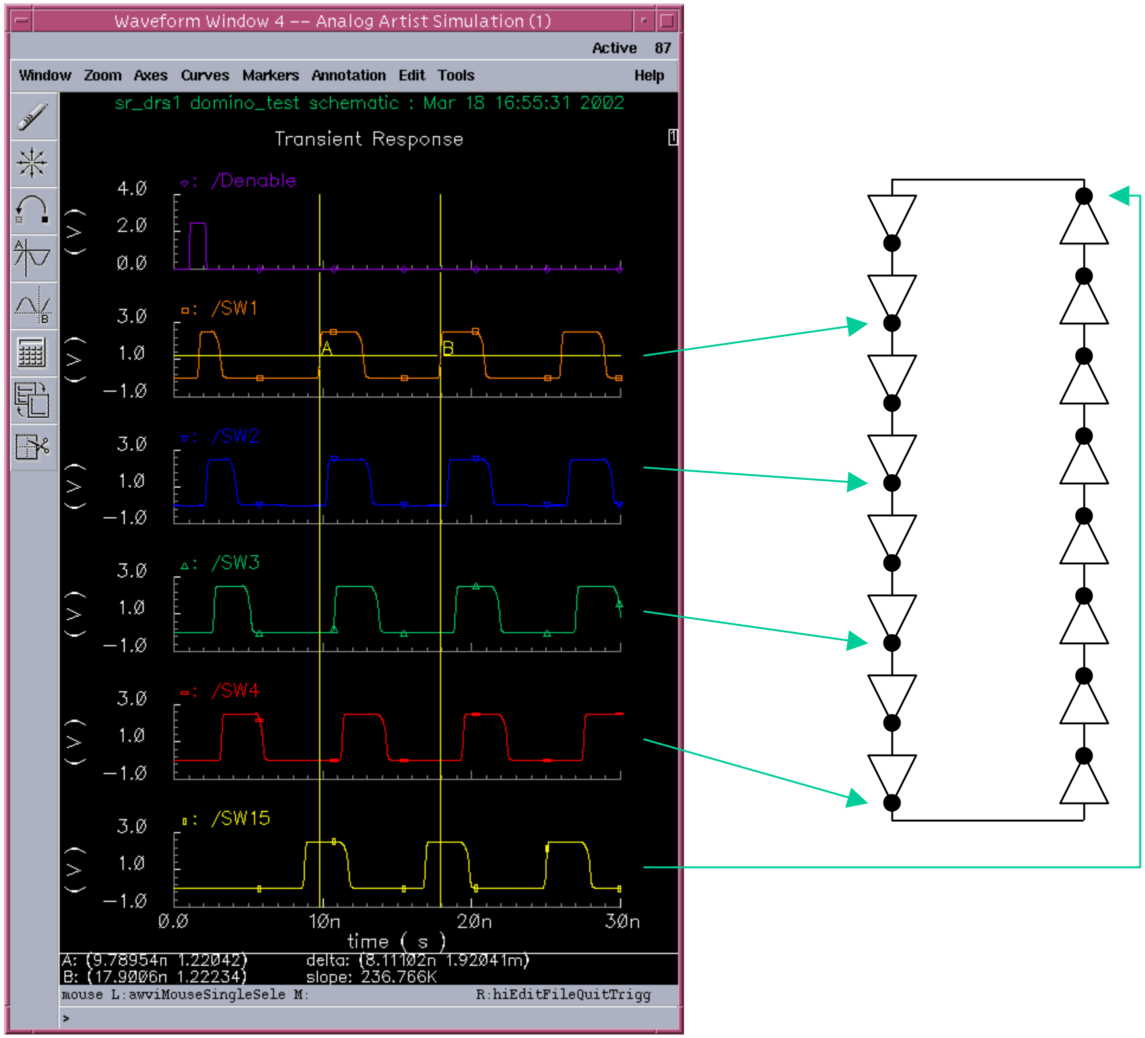
# DRS Prototype

4mm




- 0.25µm Process ("CERN is using")
- 768 cells
- Wafer back July '02

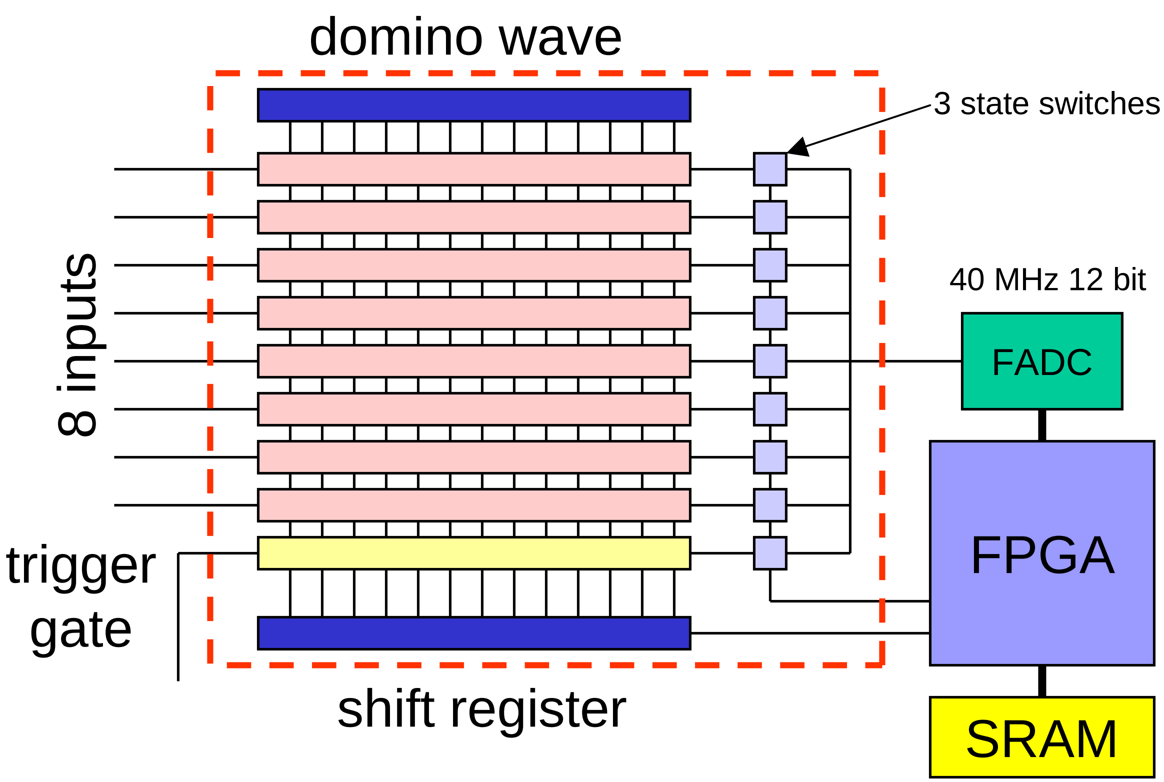
# Domino Simulation “Analog Extracted”

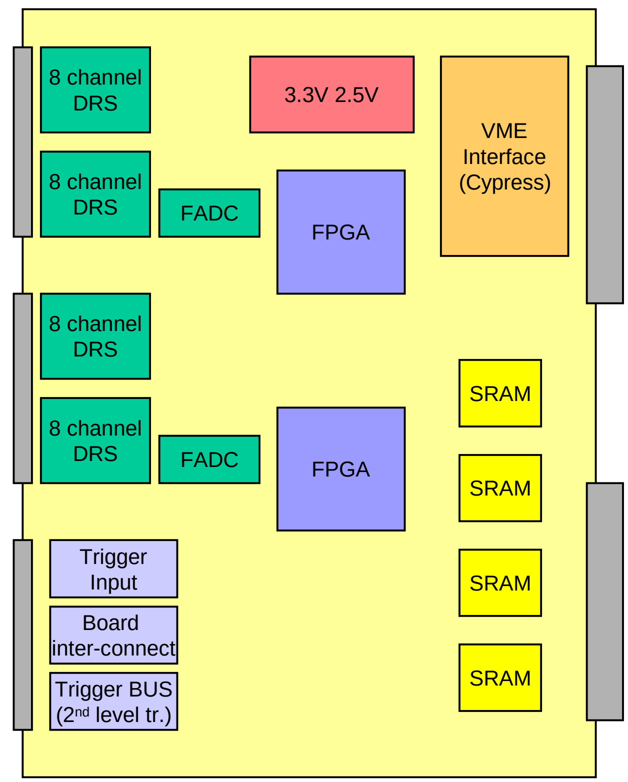



- 16 cells
- All paracitics included
- Domino speed:
  1.5-2.2 GHz

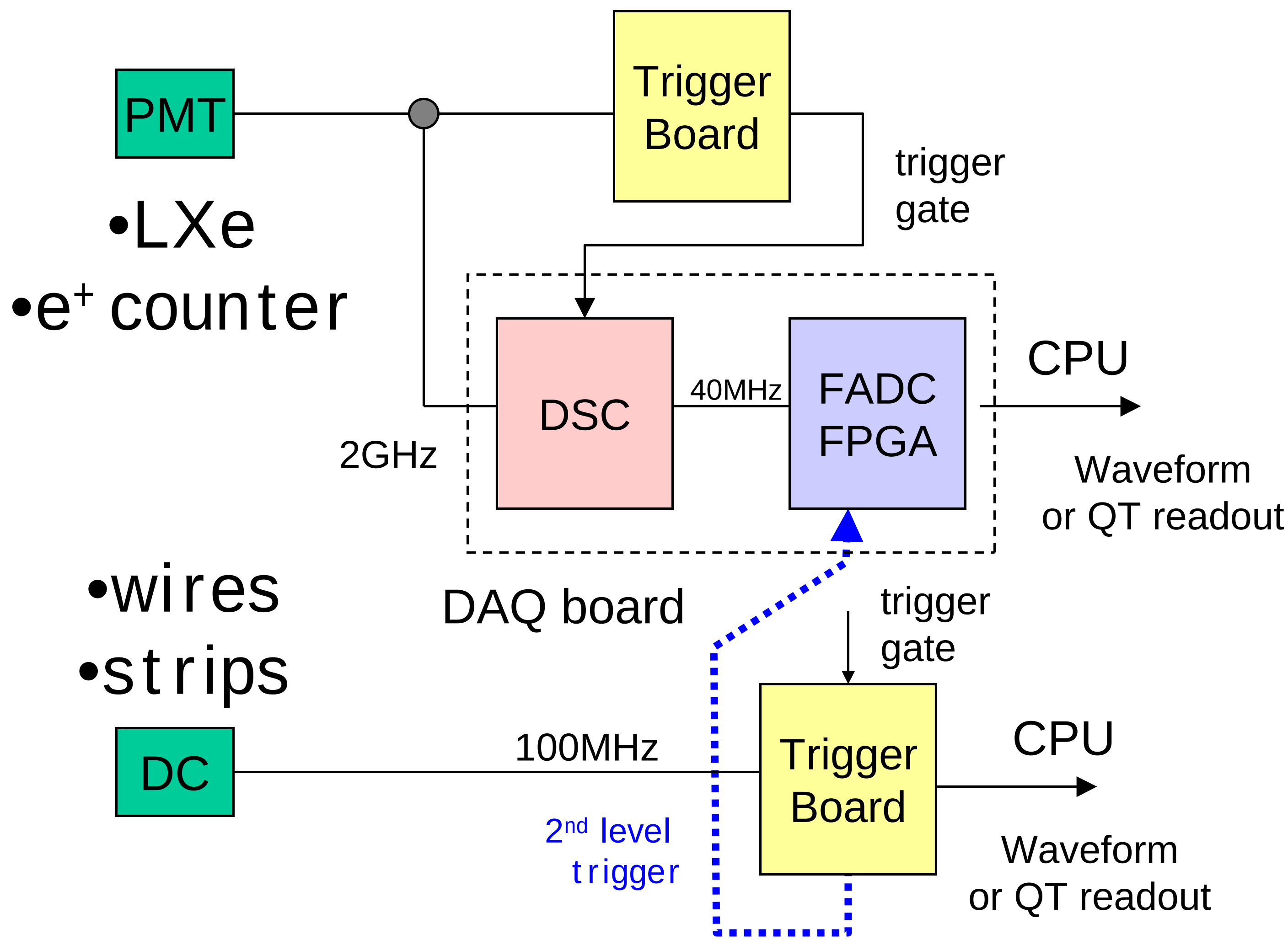
# DAQ Board

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

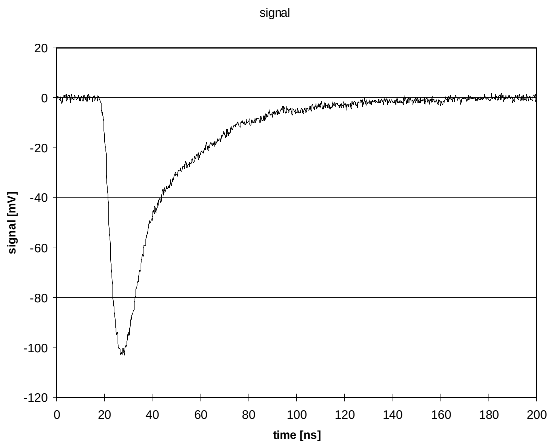


# DAQ Topology



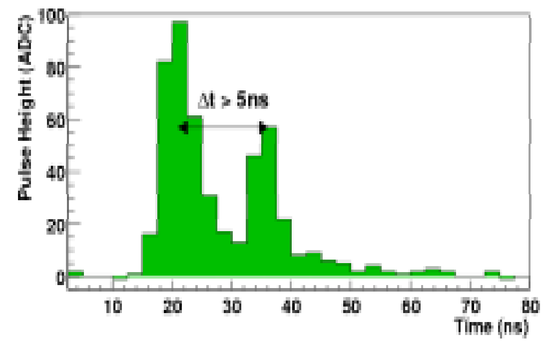
# Pile-up rejection

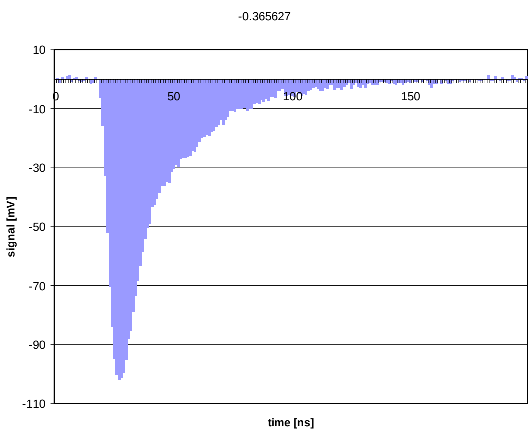



scope

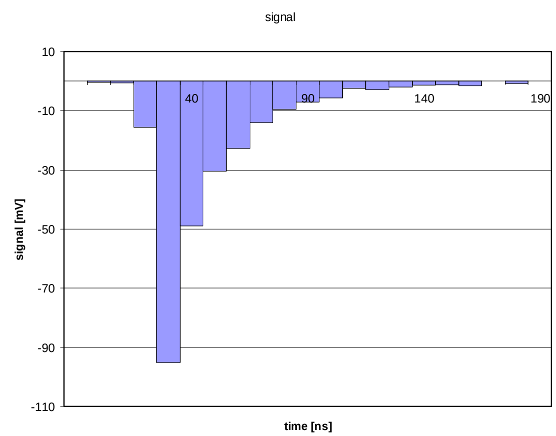
From (g-2):

- 400 MHz sampling
- Rise time ~5ns
- 3.5ns dead time
- 5ns separation

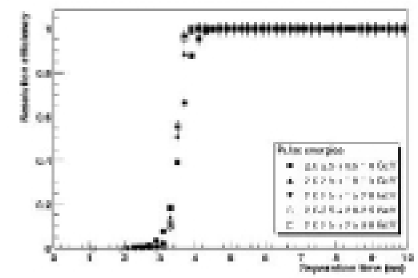



1GHz sampling



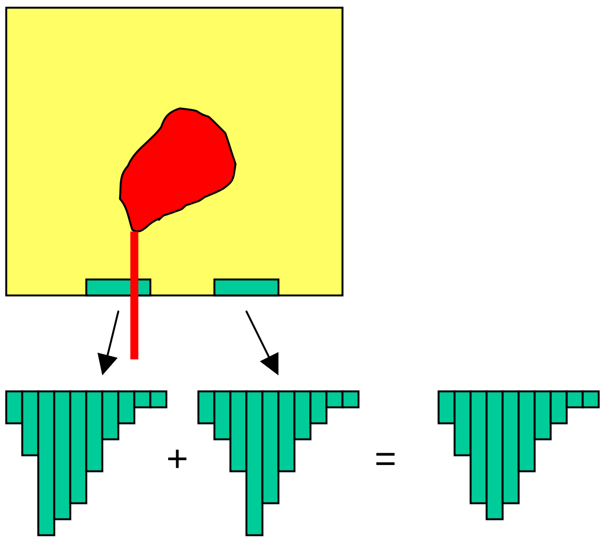

100MHz sampling



- 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

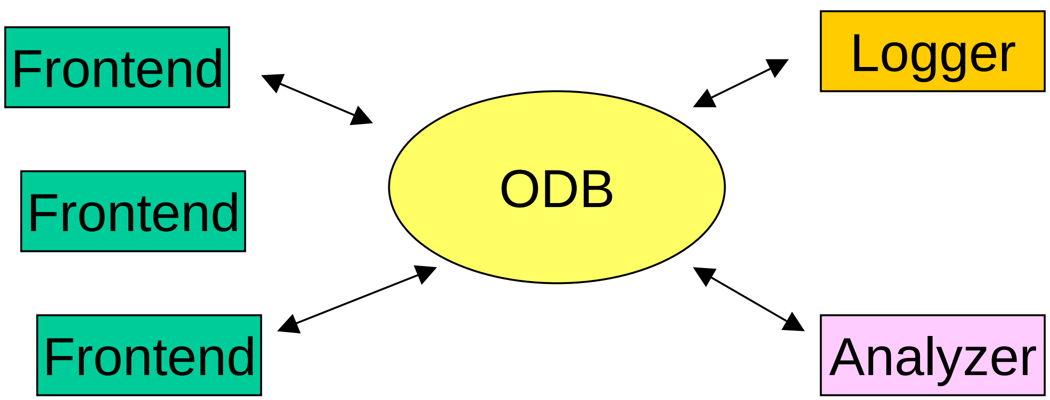
- Not so critical for calorimeter
- For DC: careful design of on-chamber preamps
- Flash ADC (100MHz) AD9218 has internal cross talk of –75 dB ($2 \times 10^{-4}$)
- ADC resolution
  - DC: 10bit + bin averaging $\rightarrow$ 13.5 bit ($10^{-4}$)
  - PMT (DRS): 12bit + bin averaging $\rightarrow$ 15.5 bit ($2 \times 10^{-5}$), 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

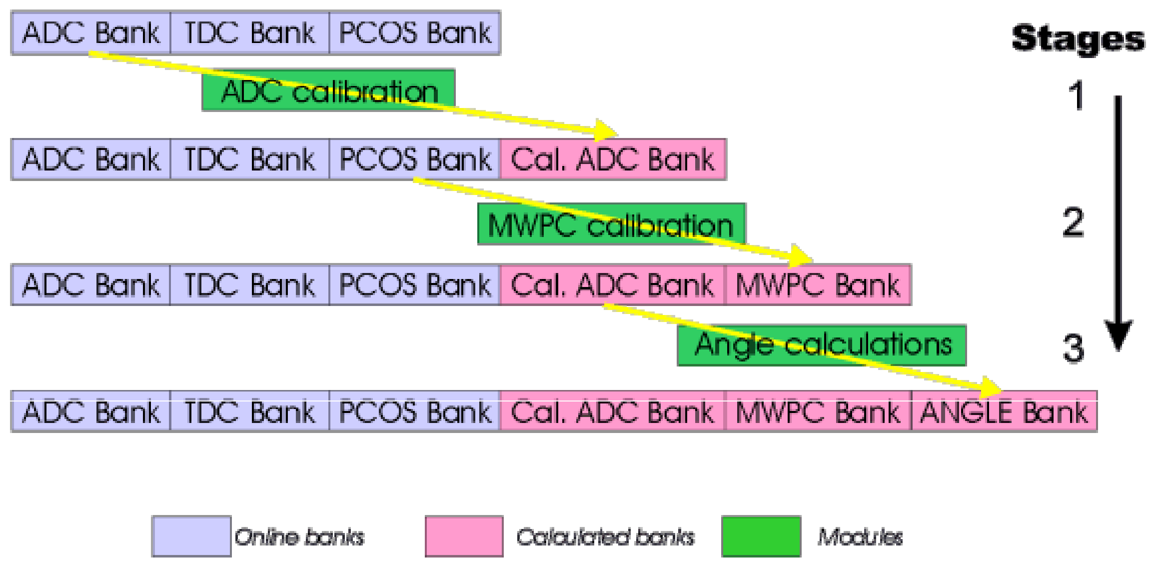
# DAQ System

- 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

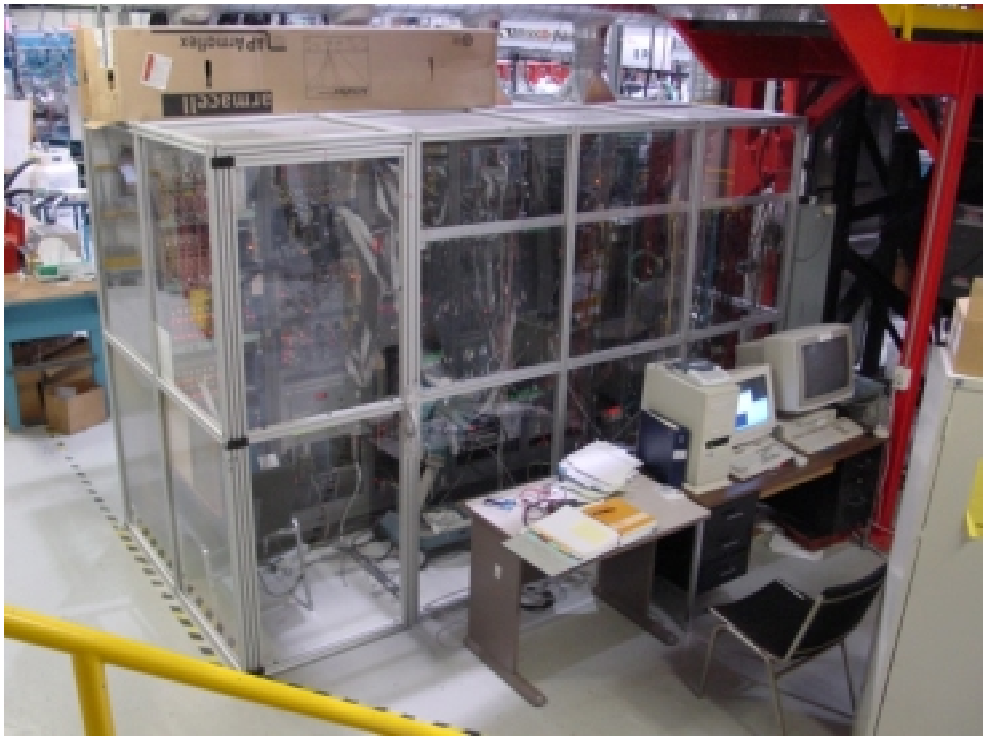
- Modular system
- Modules can be developed independently
- Version control via CVS
- MC data can be “injected” between modules
- Analyzer attached to Online Database
- Same analyzer can be used online and offline



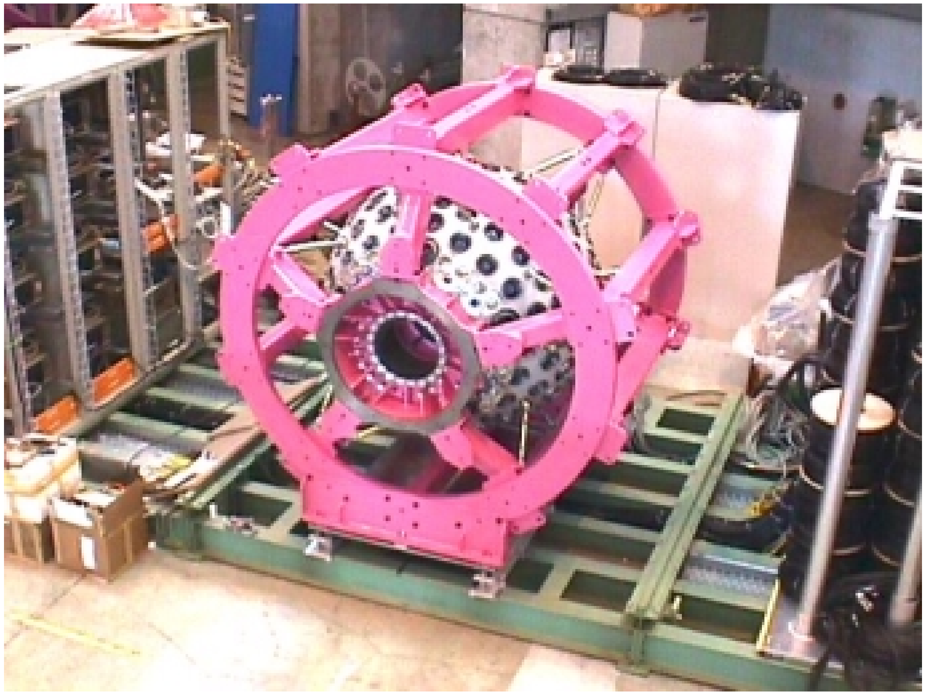

**Full physics analysis online!**

# Various issues

# Electronics setup (ideas)



Outside (Trigger): Where present Sindrum II electronics is located, but with air conditioning. Similar to 8π 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

PAUL SCHERRER INSTITUT

PSI

# Memorandum

Date: July 3, 2002

From: W. Bertl
Phone: 3651
Loc.: OFLG/001
E-mail: bertl@psi.ch

To: Stefan Ritt

cc: Jürg Schefer (chairman SIKOBA)

**On safety issues of the $\mu \to e + \gamma$ experiment at PSI**

As requested by the $\mu e \gamma$-collaboration the safety committee SIKOBA of PSI made an investigation on safety issues of this experiment.

The following experimental components with potential safety concerns were brought to our attention and discussed at the last SIKOBA meeting from June 26, 2002:

- A liquid Xenon-detector of 800 liter volume and a maximum pressure of 2 bar.
- Magnet power supplies manufactured at Japan missing a CE certification
- A superconducting solenoid again manufactured in Japan.

Xe-detector: The product of volume times pressure is below the legitimate limit which would require a special certification from authorities outside PSI (information by R.Maeg, phone 2960). The pressure resistance of the container obviously has to be tested within proper safety margins and relief valves have to be installed, dimensioned such that the gas can expand from the container in case of an unexpected warm-up without going above the pressure limit. In addition, the large amount of heavy Xenon gas itself was a concern. In order to avoid danger of suffocation it is suggested to install an oxygen monitor close to the detector which should raise an alarm if the oxygen concentration in air becomes too low.

Power supplies: no CE certification is needed for PSI. However, on arrival of the instruments at PSI a check by the electricity experts should be foreseen. (Current contact person : F. Jenni, phone 3117)

Solenoid : According to our cryogenic expert no principle problems are expected. As in the case of the power supplies a check of PSI specialists on arrival should be planned. (Contact: W. Gloor, 3732).

Reminder: As usual a safety sheet has to be filled out and handed in together with the formal final proposal. More detailed safety measures might be deduced from that, but SIKOBA does not see a problem in principle to run this experiment safely at PSI.

Yours sincerely,

W.Bertl (member of SIKOBA)

# Safety issues

- p*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