



# Towards a Detector Control System for the ATLAS Pixeldetector



Susanne Kersten, University of Wuppertal  
Pixel2002, Carmel September 2002

Overview of the Detector Control System

The Front End System

The Back End System

Experience with the Testbeam Setup

Summary and Outlook

# Tasks of the DCS

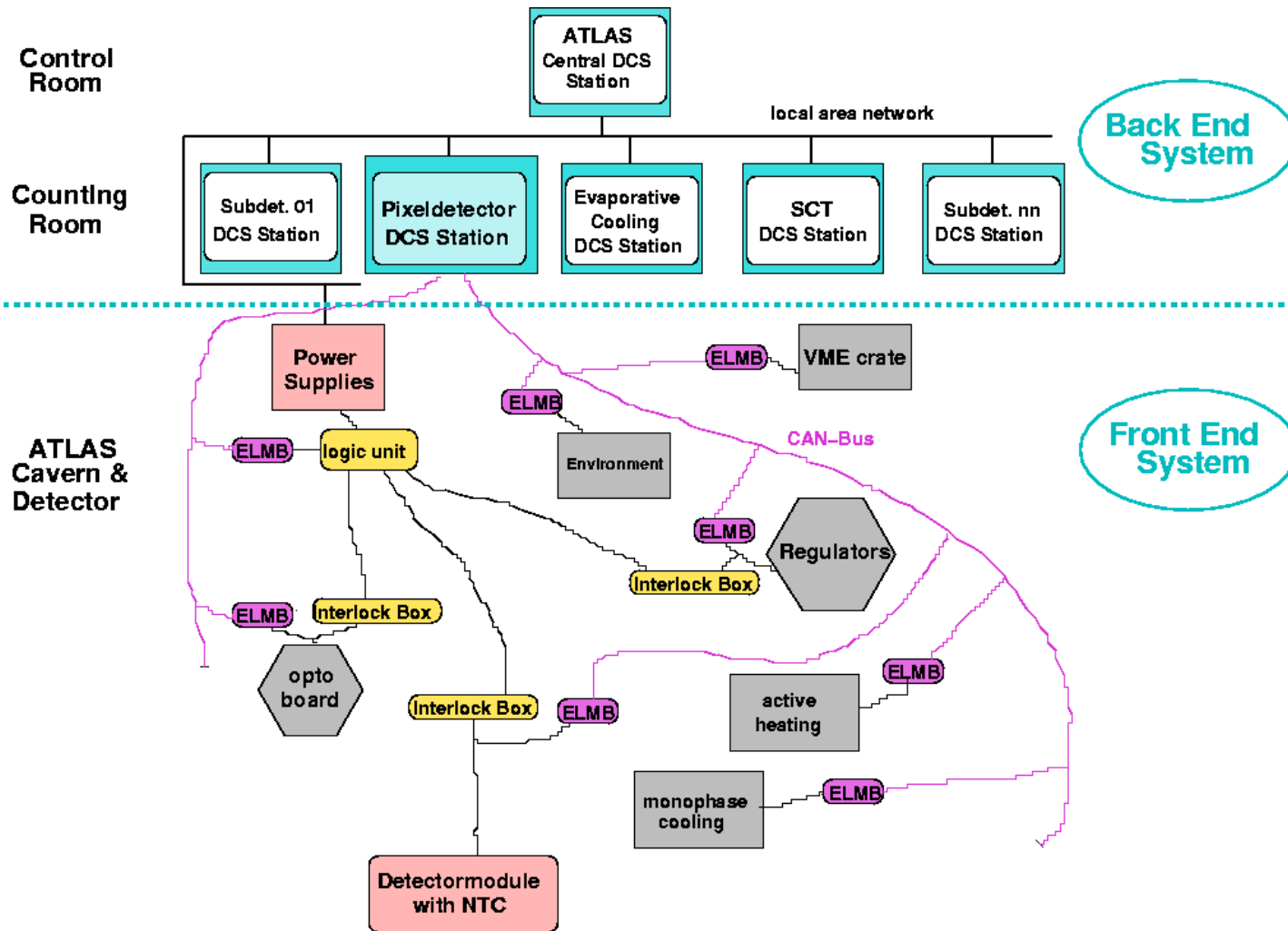
Guarantee reliable data taking + safe operation of the detector

- Monitoring and control of hardware
- User interfaces for experts and shifters
  - Reaction to error conditions and error reporting
  - Histograms for trend analysis
  - Communication to Data Acquisition System .....

+ Our detector specific constraints:

- high power density
- harsh radiation environment
- inaccessibility over long terms

# Overview of Pixel-DCS



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# Front End System

# Power Supplies

- depletion voltage for the sensor
- two low voltages for the front end electronics
- three low voltages for the optolink

Grounding and redundancy considerations → high granularity

ca. 4000 power supply channels

- High level of local intelligence
- Operation of channel groups
- Support interlock system

# Evaporative Cooling System

Ca. 20 kW total power dissipation must be removed  
minimal extra material in the tracker sensitive volume

using  $C_3F_8$

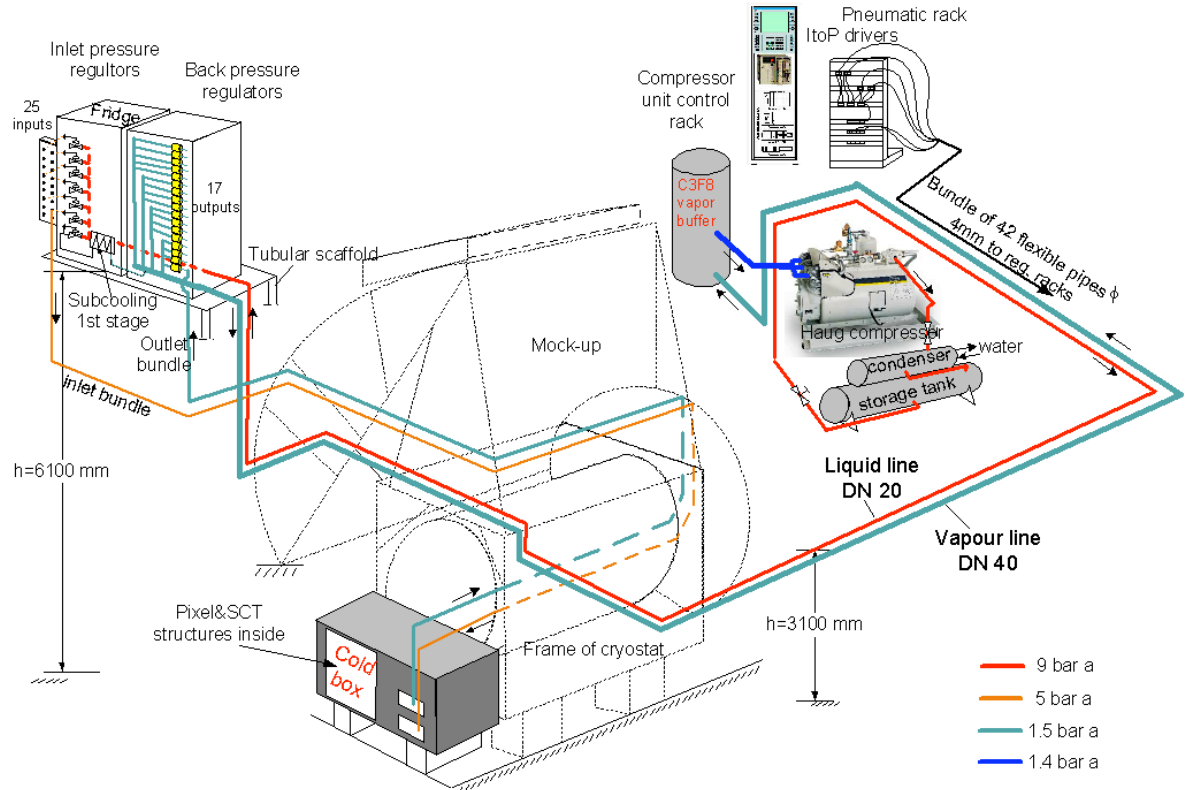
non-flammable

non-conductive

radiation resistant

Detector can be cooled  
down to  $-6\text{ }^{\circ}\text{C}$

Prototype at CERN:

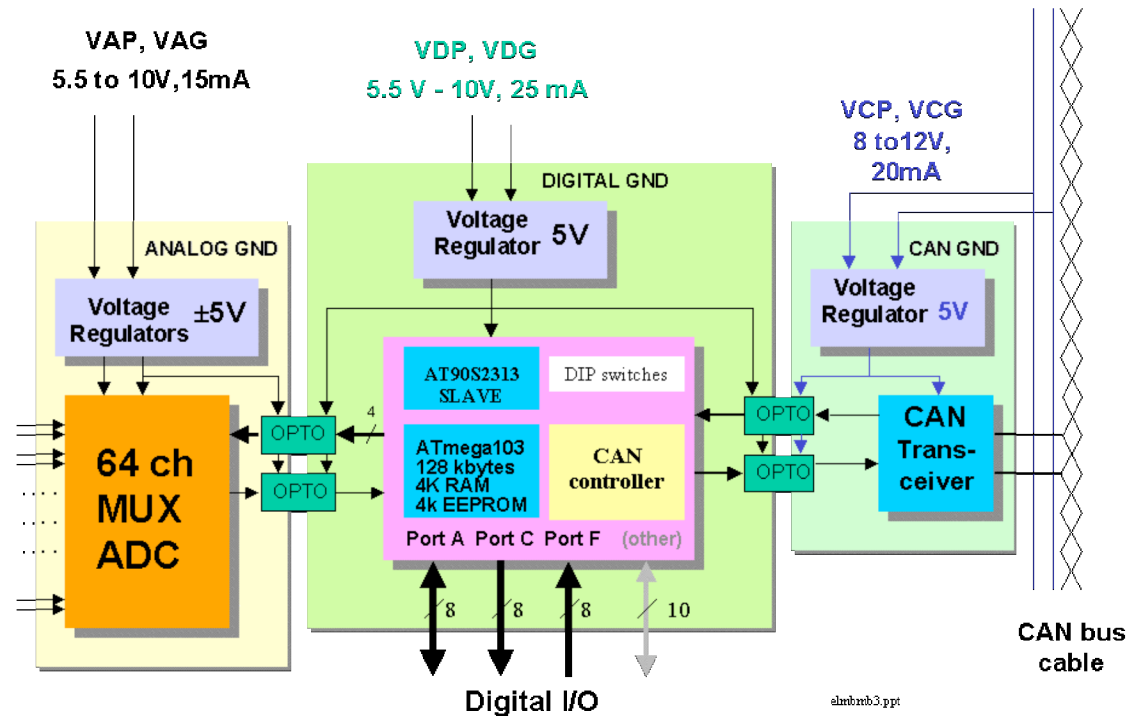


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# Embedded Local Monitor Box

General purpose front end IO device developed by ATLAS DCS group

- 64 ADC channels 16 bit
- 34 digital IO lines
- Radiation tolerant
- CAN serial fieldbus
- CANopen protocol



elmbmb3.ppt  
ATLAS/DCS 8.11.2000

- Pixel: ca. 250 ELMB
- Design of CAN-fieldbus System?

# Thermal Interlock System

Aim: protect detector modules against risks associated with

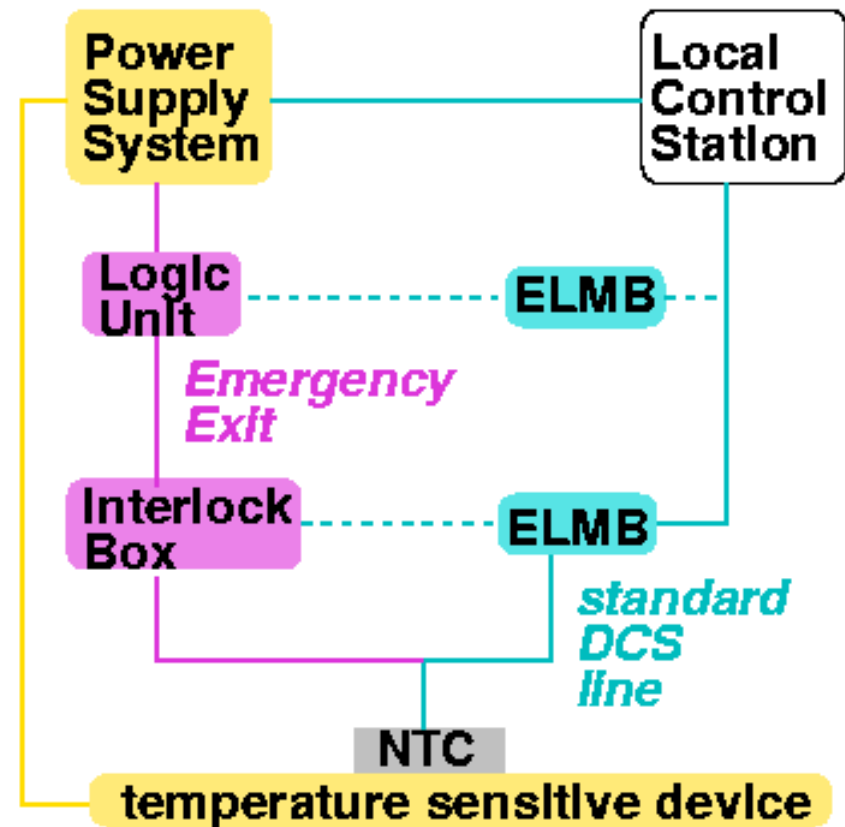
- de-lamination
- latch ups
- failure in cooling system

NTC resistor on each detector

- standard monitoring
- hardwired Interlock-Box

Logic Unit: combine signals

opto couplers, also pattern monitoring, University of Wuppertal





# The Interlock Box

**Robust solution!** Not relying on any software!

**2 bit logic:**

temperature too high,  
temp too low,  
broken cable, short circuit

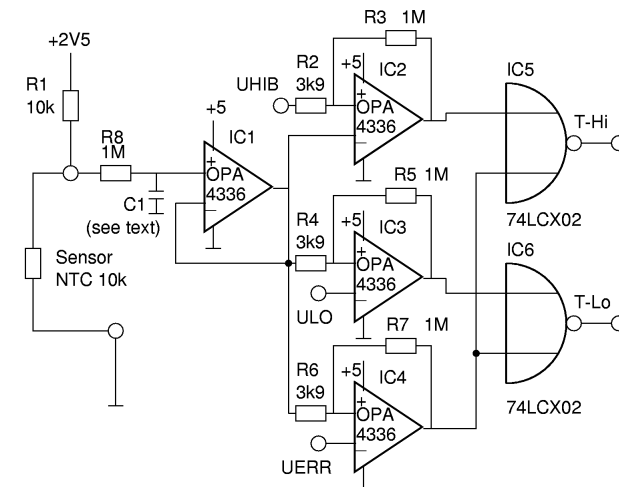
Overall max. error: 1K

**Operation in radiation environment:**

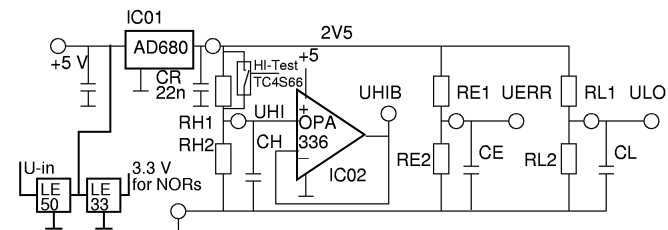
$5 \times 10^{11} \text{ n/cm}^2$

93 Gy

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Discriminator section, one for each channel



Reference section, common for all channels

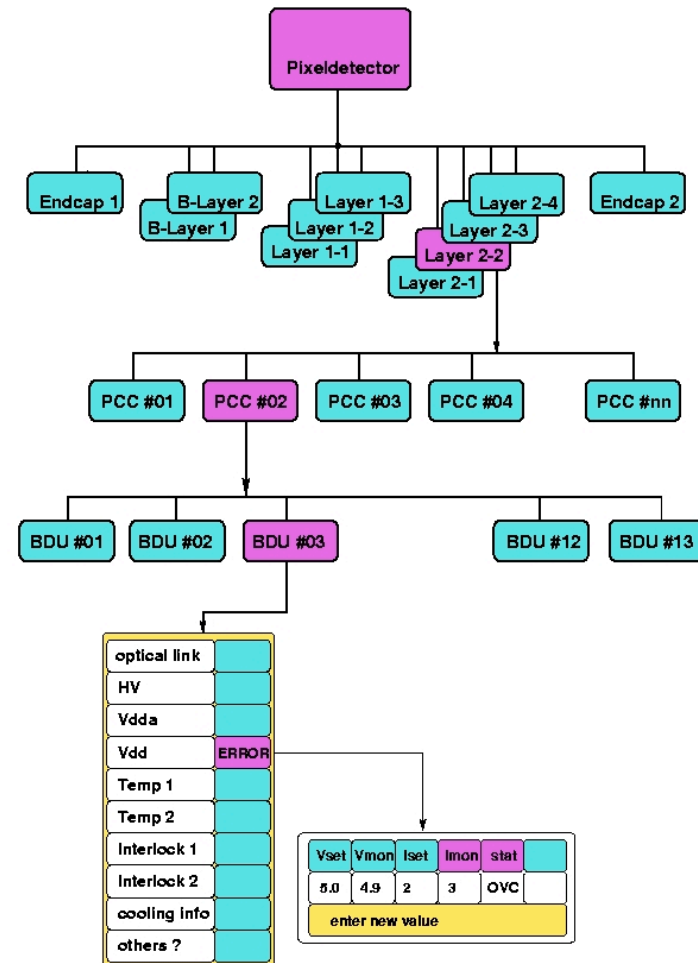
NTC I-Box circuit P. Kind 5.2002 Uni Wuppertal

# Mapping between Hardware components and Software

Motivation: graphical surface,  
make problems evident,  
easy problem tracing

## Geographically oriented tree structure

- Level 1: pixeldetector
- Level 2: shells and disks
- Level 3: parallel cooling circuits
- Level 4: Base Detector Unit



# Back End System

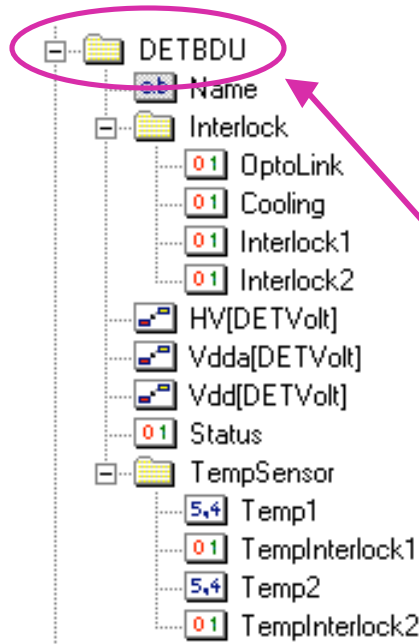
# Supervisory Control And Data Acquisition System: PVSS

Commercial product PVSSII from ETM, Austria

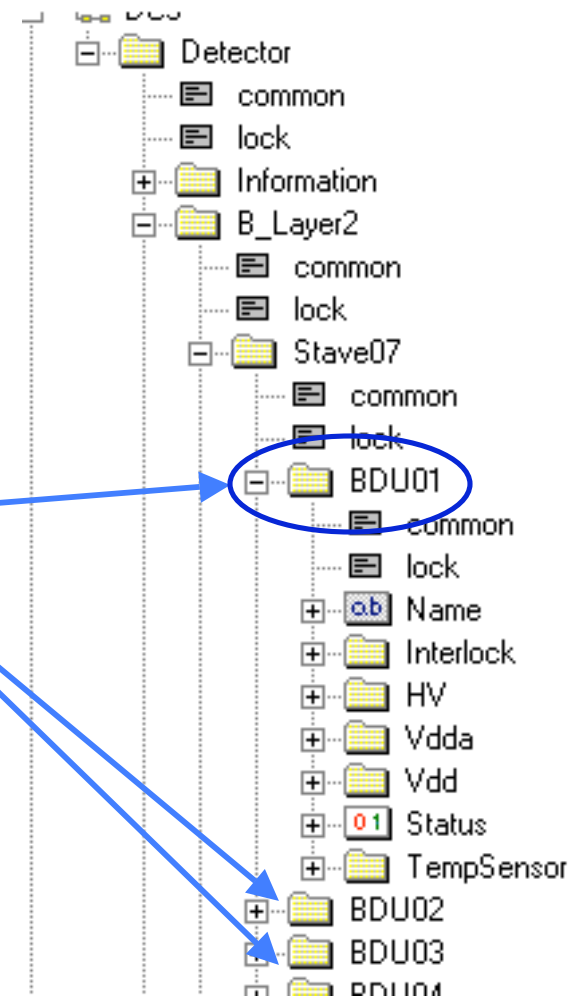
LHC wide decision

- Can be distributed over many stations
- Flexible and open architecture
- Basic functions for automatisisation
- Standardized interface to the hardware
- Application programming interfaces

# Datapoints



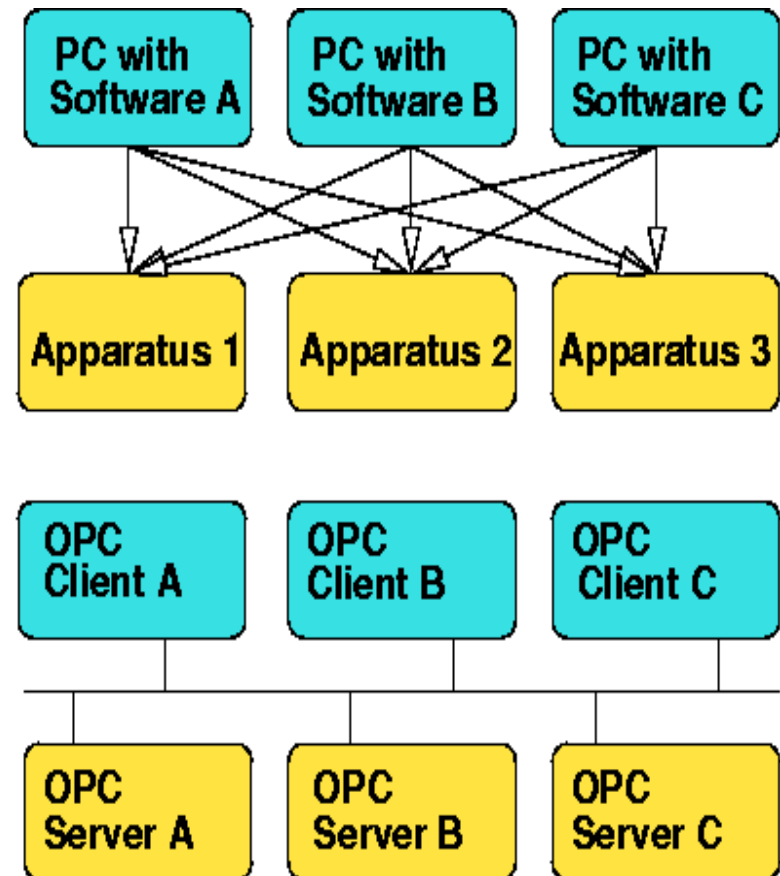
Edit Dp type  
Create Dp type  
Create Dp



- Basic properties defined by the dp type
- Dp = logically related process variable
- Individual configuration attributes in dp
- configuration, reaction, GUI via scripts

# OPC server

- Connection between PVSS and CAN nodes via OPC server
- OLE for Process Control
- Based on Microsoft object
- Model DCOM/ COM
- Industrial standard interface
- No specific driver for each client



# Testbeam Setup

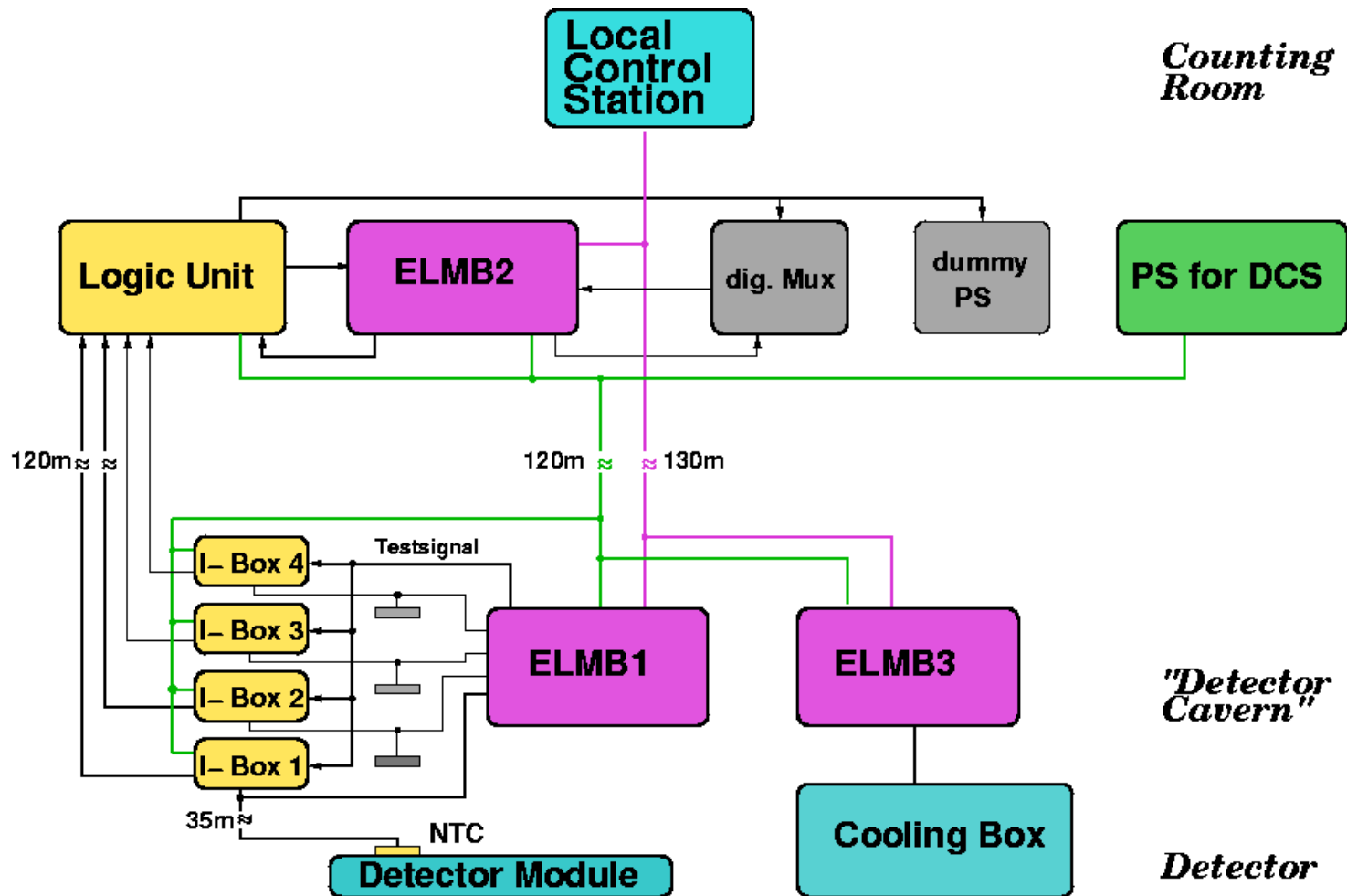
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# Aims and Questions

- Support shifter with information
- Experience with PVSS, are our needs covered by the program
- Temperature behaviour of detector module
- System test for thermal interlock system
- DCS and DAQ together
  
- Build a system which can be used for performance tests (operating parameters ..)
- Build a system which can easily be expanded
- create basis for hierarchical structure - BDU

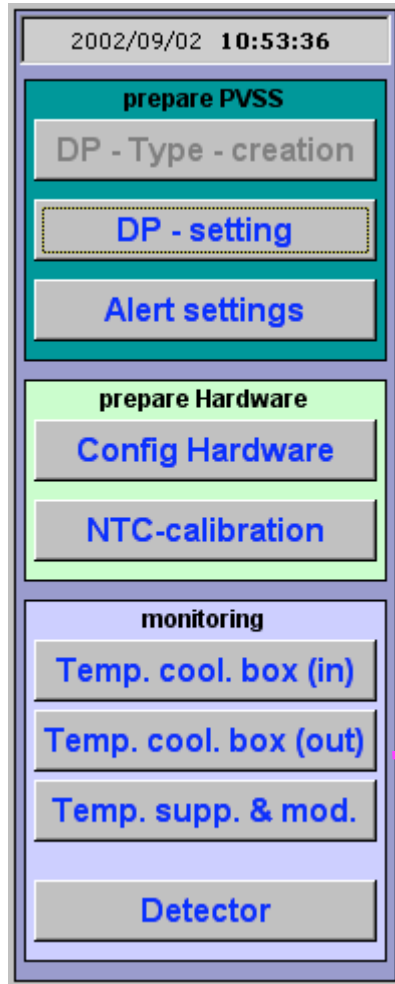


# Testbeam DCS Setup



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# PVSS Startpanel



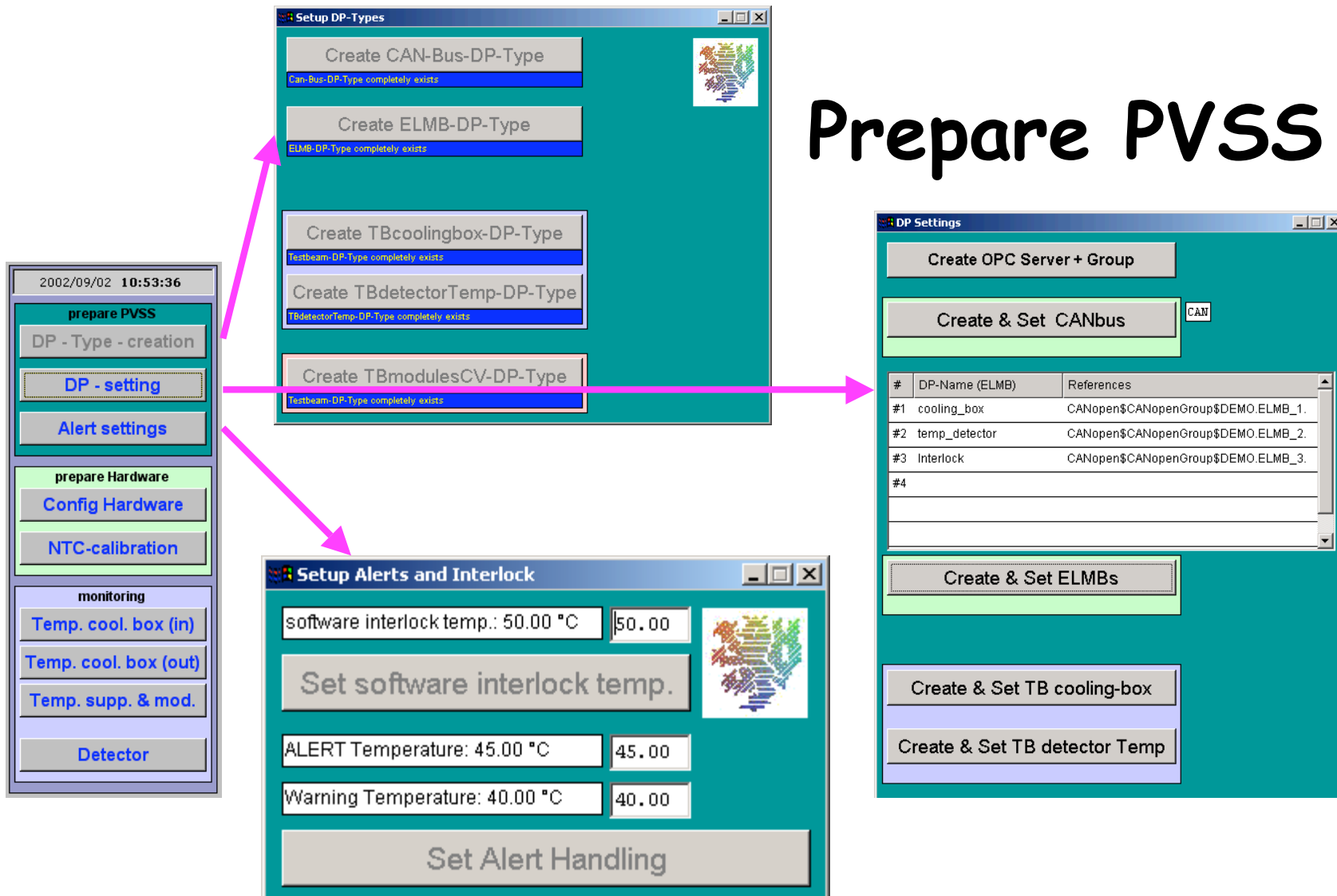
For DCS Operator

- apparatus oriented -

For Shifter

- geographical or application oriented -

# Prepare PVSS



# Configure the Hardware

2002/09/02 10:53:36

prepare PVSS

DP - Type - creation

DP - setting

Alert settings

prepare Hardware

Config Hardware

NTC-calibration

monitoring

Temp. cool. box (in)

Temp. cool. box (out)

Temp. supp. & mod.

Detector

config Hardware (CAN-Bus &...)

Config CAN-Bus

ELMB: cooling\_box

ELMB: temp\_detector

ELMB: Interlock

Config ELMB

Config ELMB

Config temp\_detector

temp\_detector

Type of measurement

read Value: 0

set value to:

bipolar (0)

unipolar (1)

Conversion Rate

read Value: 2

set value to:

5.0 Hz (0)

30.0 Hz (1)

61.5 Hz (2)

84.5 Hz (3)

101.1 Hz (4)

1.88 Hz (5)

3.76 Hz (6)

7.51 Hz (7)

ADC gain

read Value: 4

set value to:

100 mV (0)

55 mV (1)

25 mV (2)

1000 mV (3)

5000 mV (4)

2500 mV (5)

PORT

C

8 6 4 2

7 5 3 1

F

8 6 4 2

7 5 3 1

A

8 6 4 2

7 5 3 1

Network management ELMB

read Value: 1

set value to:

stop (0)

start (1)

reset (129)

CAN - Bus

Sync Interval

read Value: 5000

set value to:

Network management

read Value: 1

set value to:

stop (0)

start (1)

reset (129)

Plug Nr. 1		Plug Nr. 2		Plug Nr. 3		Plug Nr. 4	
Ch_1	19317 counts 2.4934 V	Ch_17	10240 counts 1.3212 V	Ch_33	16852 counts 2.1751 V	Ch_49	16852 counts 2.1751 V
Ch_2	19323 counts 2.4942 V	Ch_18	10248 counts 1.3222 V	Ch_34	16859 counts 2.1869 V	Ch_50	14072 counts 1.8160 V
Ch_3	9395 counts 1.2107 V	Ch_19	10187 counts 1.3117 V	Ch_35	16859 counts 2.1760 V	Ch_51	1736 counts 0.2229 V
Ch_4	19321 counts 2.4939 V	Ch_20	10191 counts 1.3148 V	Ch_36	16858 counts 2.1758 V	Ch_52	19316 counts 2.4933 V
Ch_5	19318 counts 2.4935 V	Ch_21	10155 counts 1.3102 V	Ch_37	16860 counts 2.1761 V	Ch_53	16853 counts 2.1752 V
Ch_6	19315 counts 2.4932 V	Ch_22	10222 counts 1.3188 V	Ch_38	16862 counts 2.1764 V	Ch_54	14078 counts 1.8169 V
Ch_7	19320 counts 2.4938 V	Ch_23	10234 counts 1.3204 V	Ch_39	16860 counts 2.1761 V	Ch_55	1736 counts 0.2229 V
Ch_8	19315 counts 2.4932 V	Ch_24	10216 counts 1.3181 V	Ch_40	16854 counts 2.1753 V	Ch_56	19316 counts 2.4933 V
Ch_9	19313 counts 2.4929 V	Ch_25	10176 counts 1.3129 V	Ch_41	16856 counts 2.1756 V	Ch_57	16844 counts 2.1740 V
Ch_10	19323 counts 2.4942 V	Ch_26	10203 counts 1.3164 V	Ch_42	16854 counts 2.1753 V	Ch_58	14072 counts 1.8160 V
Ch_11	19312 counts 2.4928 V	Ch_27	10176 counts 1.3129 V	Ch_43	16850 counts 2.1748 V	Ch_59	1736 counts 0.2229 V
Ch_12	19313 counts 2.4929 V	Ch_28	10205 counts 1.3166 V	Ch_44	16856 counts 2.1756 V	Ch_60	19314 counts 2.4930 V
Ch_13	19325 counts 2.4945 V	Ch_29	19328 counts 2.4948 V	Ch_45	16851 counts 2.1749 V	Ch_61	16866 counts 2.1769 V
Ch_14	19321 counts 2.4939 V	Ch_30	19322 counts 2.4941 V	Ch_46	16858 counts 2.1758 V	Ch_62	14082 counts 1.8173 V
Ch_15	19313 counts 2.4929 V	Ch_31	19322 counts 2.4941 V	Ch_47	16855 counts 2.1755 V	Ch_63	1737 counts 0.2230 V
Ch_16	19314 counts 2.4930 V	Ch_32	19328 counts 2.4948 V	Ch_48	16846 counts 2.1743 V	Ch_64	19306 counts 2.4920 V

used correction Value:

cf: os:

Voltage = 0.846353 \* Counts / 65.536+ -0.001316

Calibration (4 Uref)

Calibration (16 Uref)

Config CAN-Bus

CAN

SYNC

Sync Interval

read Value: 5000

set value to: 5000

Network management

read Value: 1

set value to:

stop (0)

start (1)

reset (129)

Config all ELMBs

# Operation Parameters for ADC and CAN-Bus

No operation close to the limits!

max. noise of ADC

→ Conversion rate:

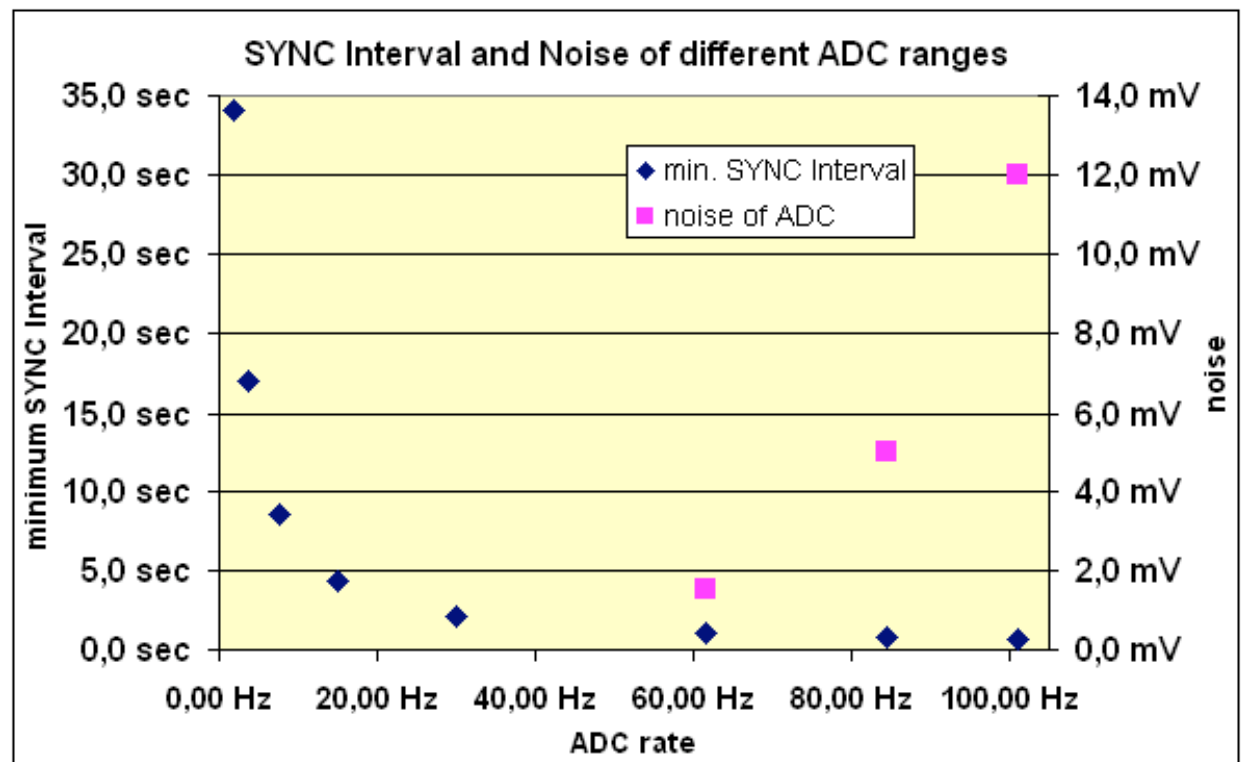
61.6 Hz

→ Synch Interval:

5 sec

→ Bus speed:

125 kBit/sec



# Monitoring: Cooling Box

2002/09/02 10:53:36

**prepare PVSS**

DP - Type - creation

DP - setting

Alert settings

**prepare Hardware**

Config Hardware

NTC-calibration

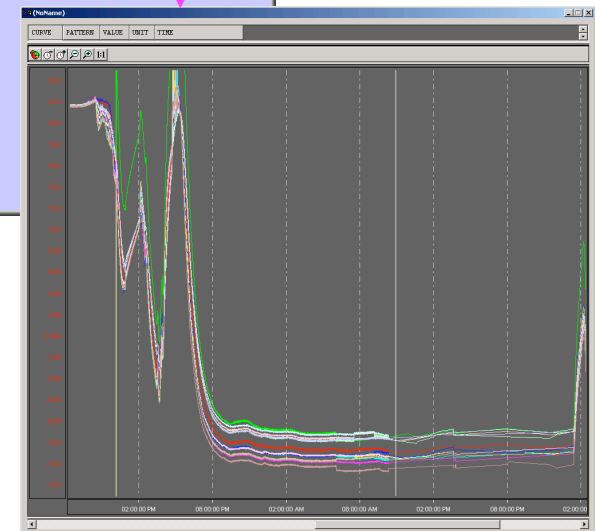
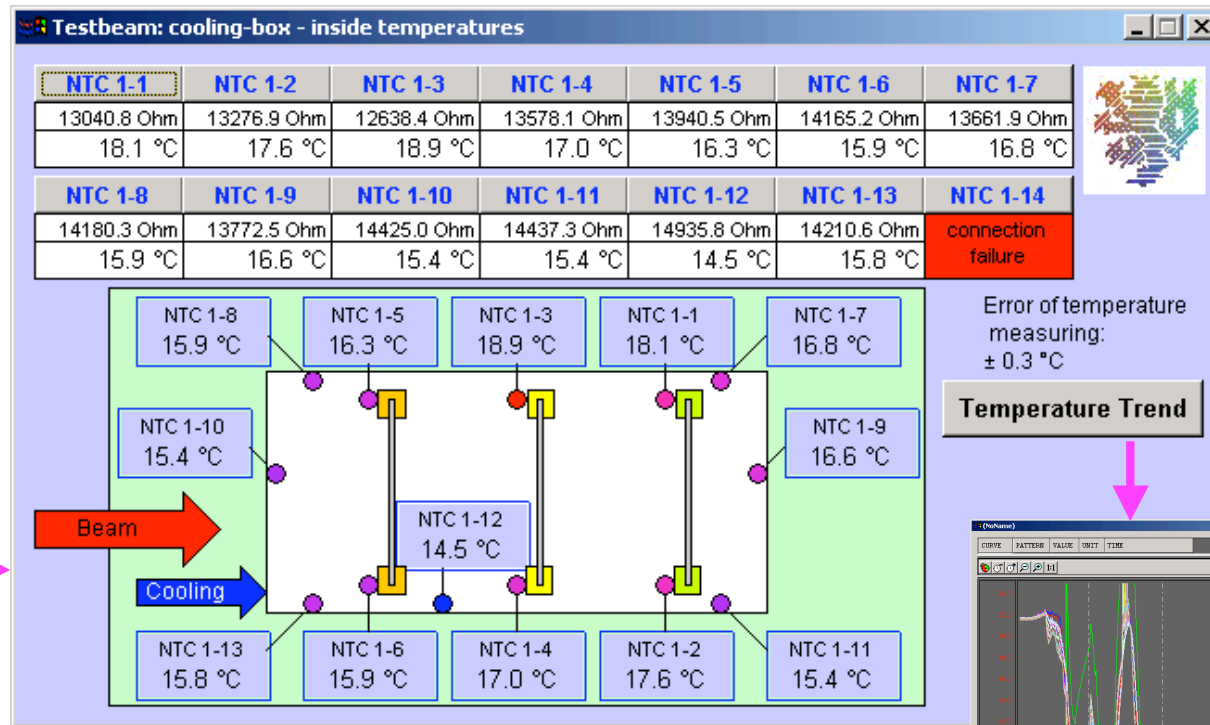
**monitoring**

Temp. cool. box (in)

Temp. cool. box (out)

Temp. supp. & mod.

Detector



# Monitoring: Base Detector Unit

2002/09/02 10:53:36

**prepare PVSS**

DP - Type - creation

DP - setting

Alert settings

**prepare Hardware**

Config Hardware

NTC-calibration

**monitoring**

Temp. cool. box (in)

Temp. cool. box (out)

Temp. supp. & mod.

Detector

**detector monitoring**

PCC\_1

PCC\_2

PCC\_xx

PCC\_xx

PCC\_xx

see Interlocks

**Temperature of PCC\_1**

Stave Nr 1		Stave Nr 2	
Half Stave Nr. 1	Half Stave Nr. 2	Half Stave Nr. 1	Half Stave Nr. 2
<b>BDU IL</b>	<b>BDU IL</b>	<b>BDU OK</b>	<b>BDU OK</b>
S1.HS1.BDU_1.M1 connection failure	S1.HS2.BDU_1.M1 connection failure	S2.HS1.BDU_1.M1 21.7 °C	S2.HS2.BDU_1.M1 21.8 °C
S1.HS1.BDU_1.M2 connection failure	S1.HS2.BDU_1.M2 connection failure	S2.HS1.BDU_1.M2 21.6 °C	S2.HS2.BDU_1.M2 22.1 °C
<b>BDU IL</b>	<b>BDU IL</b>	<b>BDU OK</b>	<b>BDU OK</b>
S1.HS1.BDU_2.M1 26.2 °C	S1.HS2.BDU_2.M1 connection failure	S2.HS1.BDU_2.M1 22.0 °C	S2.HS2.BDU_2.M1 21.8 °C
S1.HS1.BDU_2.M2 connection failure	S1.HS2.BDU_2.M2 connection failure	S2.HS1.BDU_2.M2 22.0 °C	S2.HS2.BDU_2.M2 22.0 °C
<b>BDU IL</b>	<b>BDU IL</b>	<b>BDU OK</b>	<b>BDU IL</b>
S1.HS1.BDU_3.M1 connection failure	S1.HS2.BDU_3.M1 connection failure	S2.HS1.BDU_3.M1 22.1 °C	S2.HS2.BDU_3.M1 21.8 °C
S1.HS1.BDU_3.M2 connection failure	S1.HS2.BDU_3.M2 connection failure	S2.HS1.BDU_3.M2 21.8 °C	S2.HS2.BDU_3.M2 connection failure
<b>BDU IL</b>		<b>BDU OK</b>	
S1.HS1.BDU_4.M1 connection failure		S2.HS1.BDU_4.M1 21.7 °C	

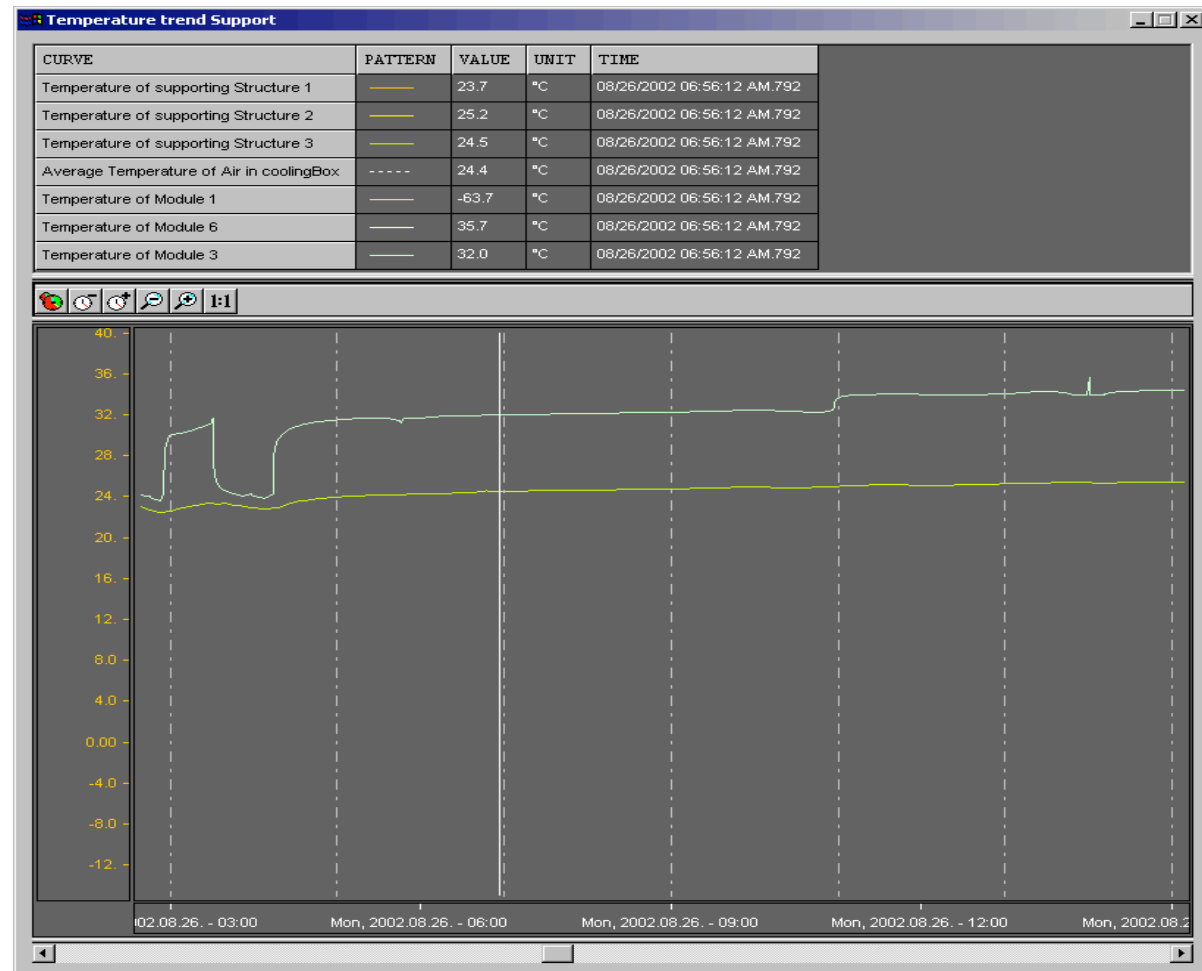
software interlock temp.: 50.00 °C software Alarm temp.: 45.00 °C software Warning temp.: 40.00 °C

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# Temperature Behaviour of a Detector Module

@ Environ.Temp  
of 24 °C

$\Delta T \approx 8 \text{ K}$   
with an active  
front end  
electronics





# Summary and Outlook

- Complete chain for thermal interlock system
- Long cable no problem, no cross talk DAQ - DCS
- PVSS covers our needs
- Vision manager instable
- trending pure → separate tool for histogramming

We now have a system

- for further DCS system studies (several CAN Busses, ...)
- where further quantities (LV, HV..) can easily be added
- which can be used for the control of larger detector parts

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