TES detectors and DAQ

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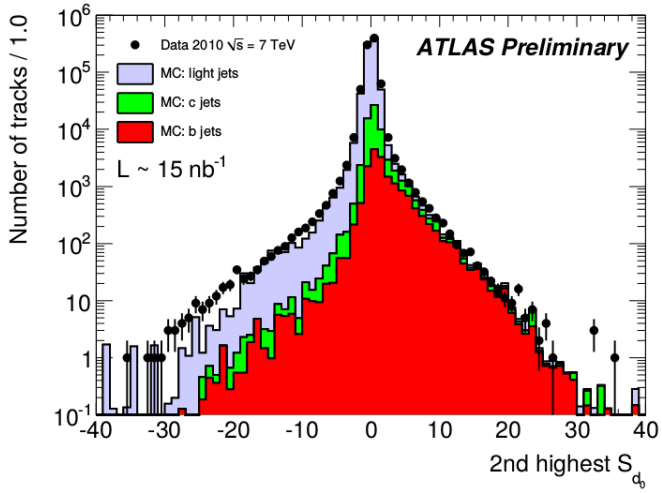
My scientific background

Diploma thesis:

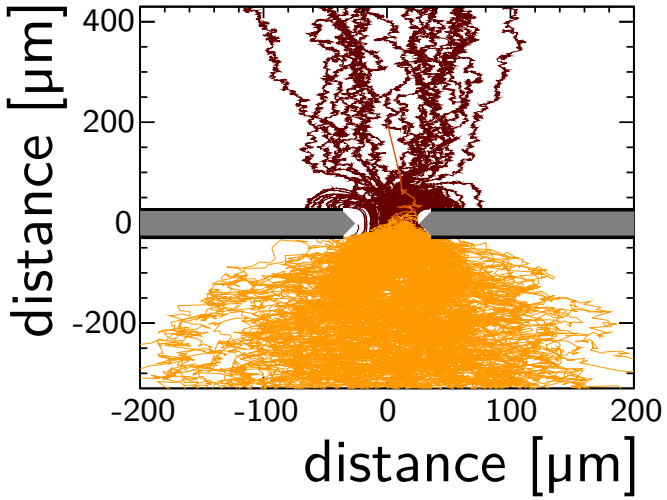
- ATLAS data analysis with first data taken in 2009 and early 2010
- Calibration of algorithms used to select jets that originate from b quarks (b-tagger)

$\Rightarrow$ Commonly used in physics analysis



PhD thesis:

- Detector development for a future linear collider (ILC)
- Optimization of readout modules of a tracking detector that is based on advanced gas-avalanche technologies (Time Projection Chamber + Gas electron multiplier)



ALPS detector

Signal to be detected

- A single photon every few hours
- Photon energy: $E_{532\,\mathrm{nm}} = 2.3\,\mathrm{eV}$ (ALPS I),
  $E_{1064\,\mathrm{nm}} = 1.17\,\mathrm{eV}$ (ALPS II)

ALPS I:

- CCD camera was used for photon detection
- The experiment run with a $\lambda = 532\,\mathrm{nm}$ laser
- A damage of the mirror coating was observed

$\Rightarrow$ ALPS II will use a $\lambda = 1064\,\mathrm{nm}$ laser

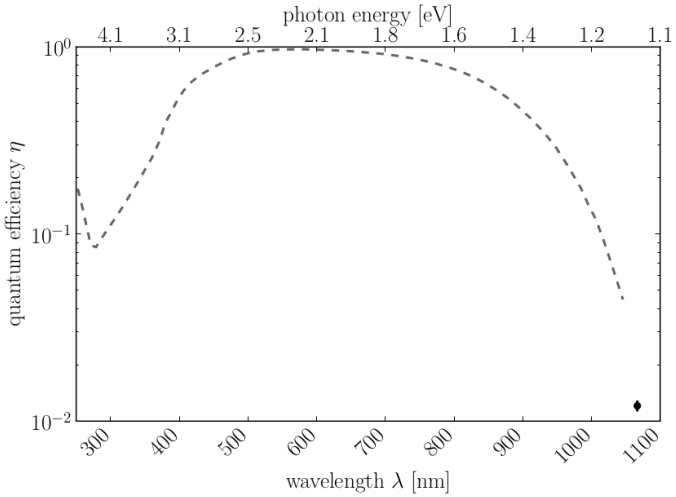


Figure : Quantum efficiency of the PIXIS CCD camera [PhD thesis, Eike v. Seggern].

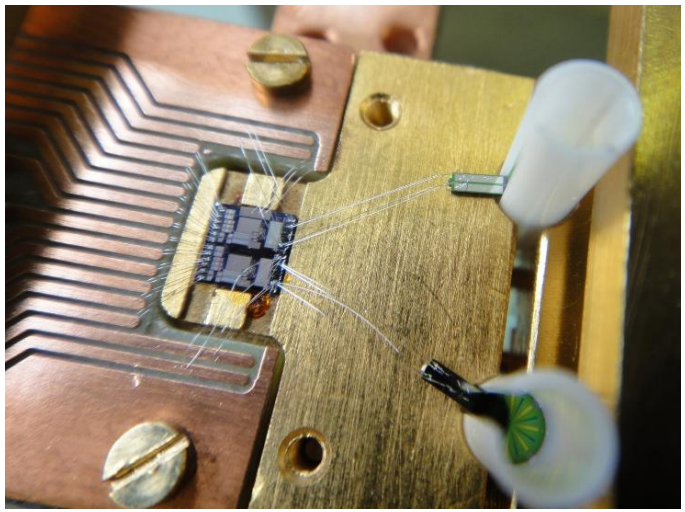
Transition Edge Sensor

Transition Edge Sensor

Microcalorimeter measuring the temperature difference induced by a particle/photon in an absorber material.

Advantages of a TES (NIST):

- High efficiency (95 % at 1064 nm)
- Low dark count rate ($10^{-4}\,\mathrm{s}^{-1}$)
- Long term stability
- Good energy resolution ($< 8\,\%$)
- Good time resolution



NIST TES:

- Sensitive area (tungsten): $25\,\mu\mathrm{m} \times 25\,\mu\mathrm{m}$
- Readout with Superconducting Quantum Interference Devices (SQUID)

TES working principle

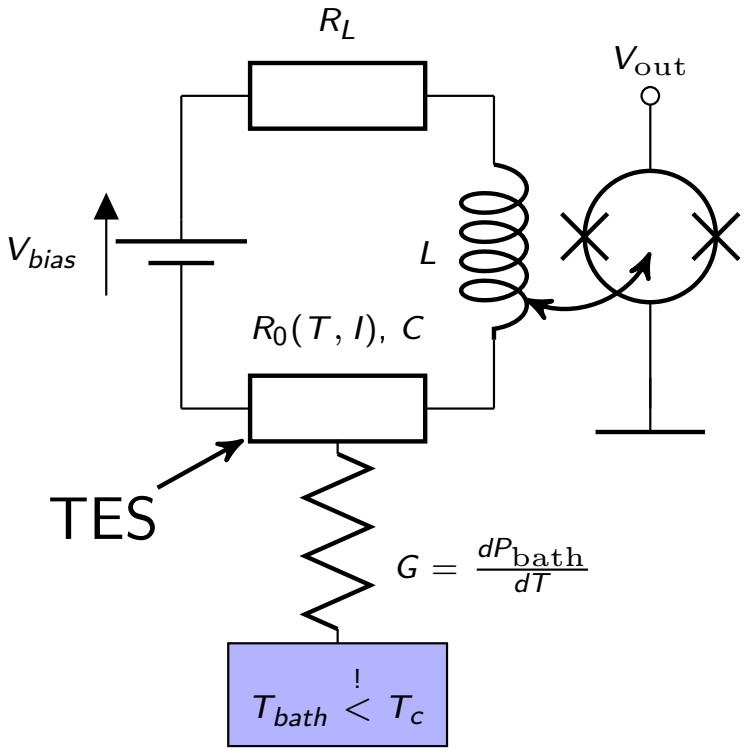


Figure : TES readout circuit.

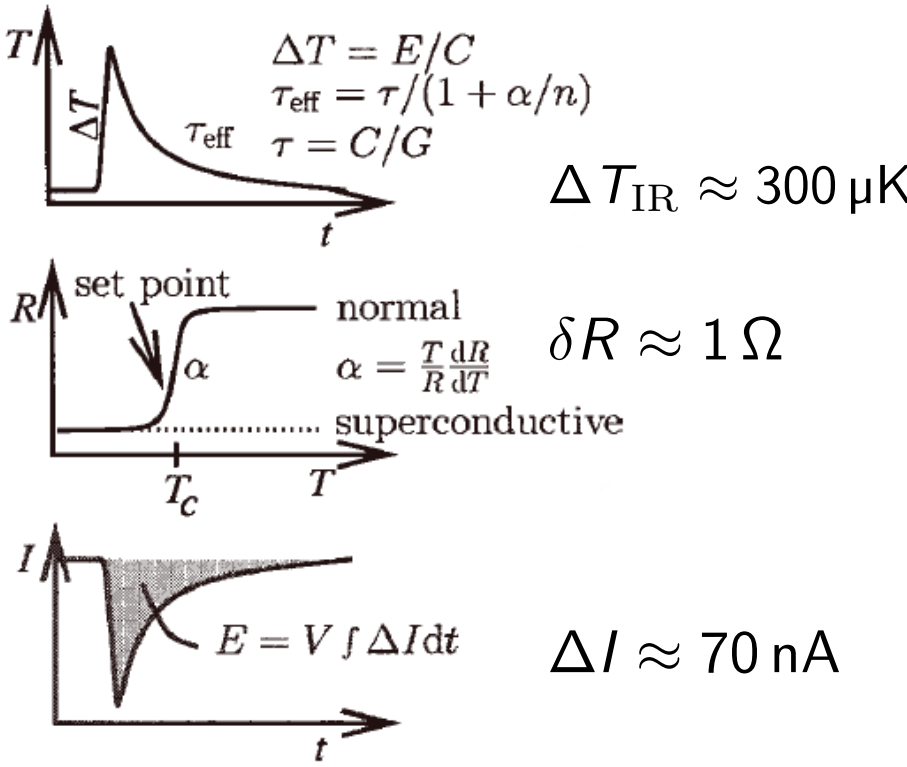


Figure : Sketch of TES characteristics [de Korte et al. (2003), Proc. SPIE 4851].

NIST TES:

- $T_{\mathrm{bath}} = 80\,\mathrm{mK}$, $T_c = 150\,\mathrm{mK}$
- $\tau_{\mathrm{eff.}} \approx 1.5\,\mu\mathrm{s}$

Neg. electrothermal feedback

For $R_0 \gg R_L$: $R_0' = R_0 + \delta R$
$\rightarrow I\downarrow$, $P\downarrow\rightarrow$ TES cools down

Project: TES operation

1. Safe operation of the TES including all subsystems:
   - Water chiller cooling the He compressor
   - He compressor driving the Pulse Tube cooler (reach $\approx 2.5\,\mathrm{K}$)
   - Adiabatic demagnetization refrigerator (reach $\approx 80\,\mathrm{mK}$ at the TES stage)
2. Background study
   - A background rate higher than expected was measured
   - One source are thermal photons

   $\Rightarrow$ Understand the background and suppress thermal photons
3. First data taking end of 2016

Partnership of Universität Hamburg and DESY

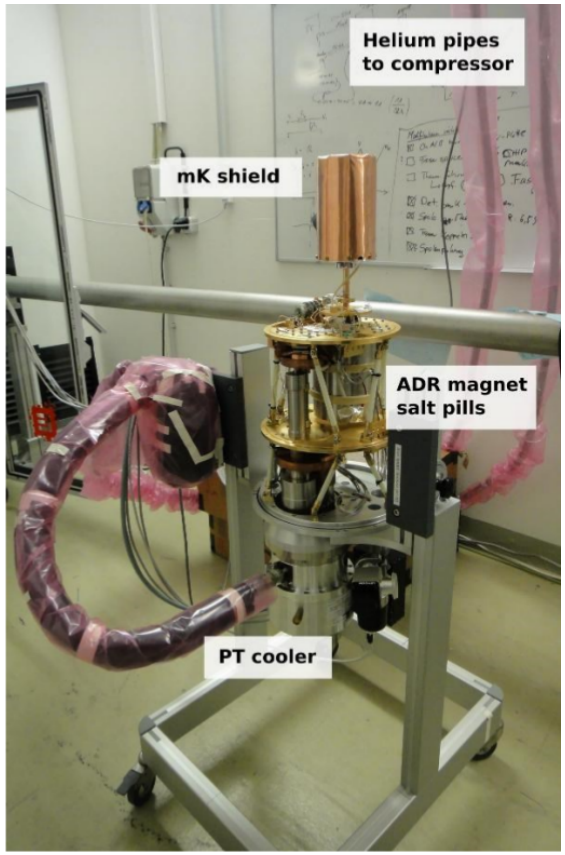


Figure : Picture of the opened ADR in the ALPS laboratory.

The system is operated in close collaboration with the University of Hamburg (Dieter Horns).

Project: Data aquisition

Current status of TES data acquisition:

- Data is recorded with an Oscilloscope
- Sampling rate: 50 MSamples/s
- Maximum record length: 2 s
- Data size: 700 MB/s

Forseen data aquisition:

- Alazar ATS9626 card
- Sampling rate: up to 250 MSamples/s
- ADC: 16 bit
- Hardware triggering and data handling via FPGA possible

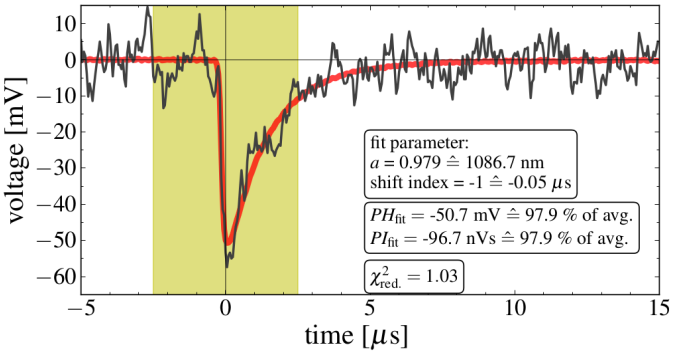


Figure : Single signal pulse
[PhD thesis, J. Dreyling-Eschweiler].

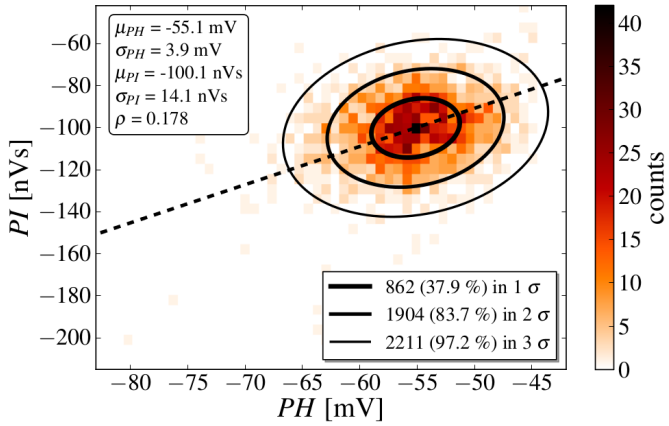
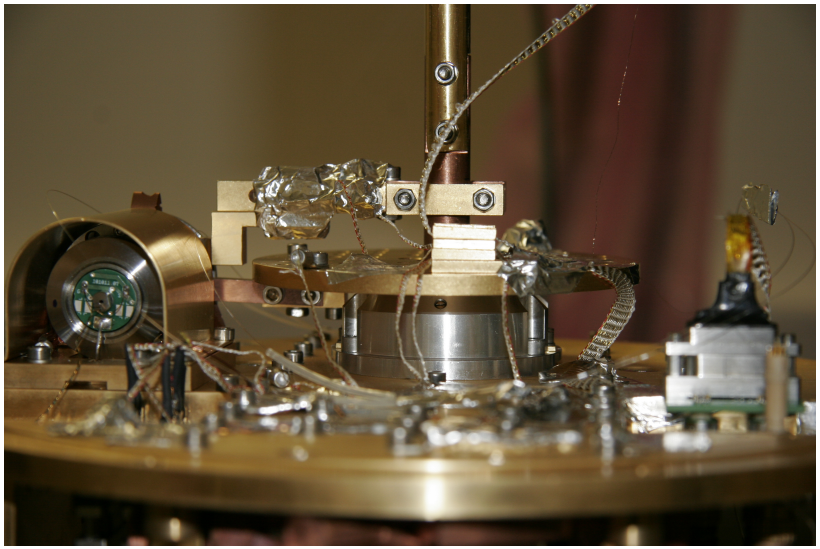


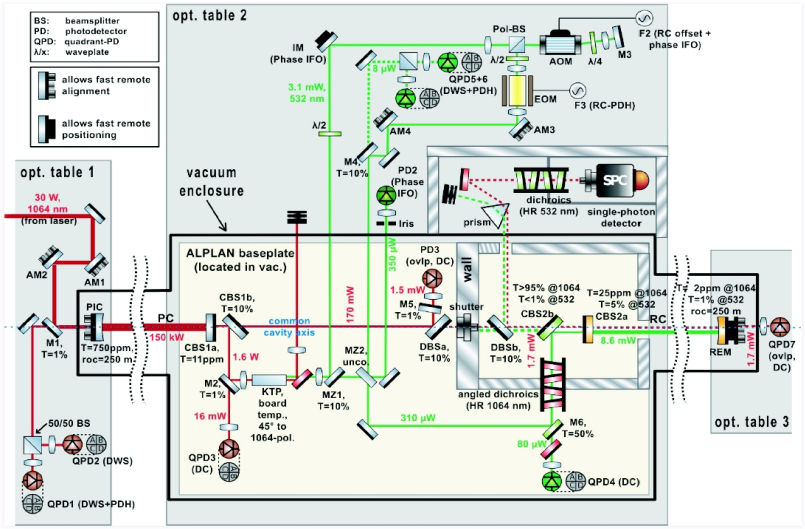
Figure : Signal region in the pulse height - pulse integral plane
[PhD thesis, J. Dreyling-Eschweiler].

Project: System monitoring and control

System monitoring includes all subsystems of the ALPS experiment:

1. Detector
   - Water chiller
   - He compressor
   - ADR
2. Optics
   - Laser parameter
   - Temperature
   - Mirror positions
3. Magnets
   - Temperature
   - Current





Project: System monitoring and control

System monitoring based on DOOCS

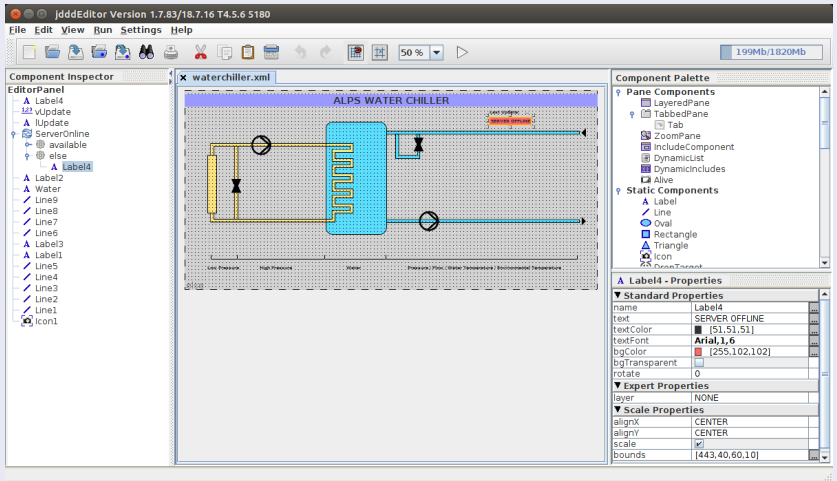
Server:

- Use DOOCS class library to actually read data from the device
- Communication with devices is very different (RS232, log files, . . .)

Client:

- Several ways to read data from the server (command line, python, java, . . .)
- jddd is a user friendly java application to create control panel

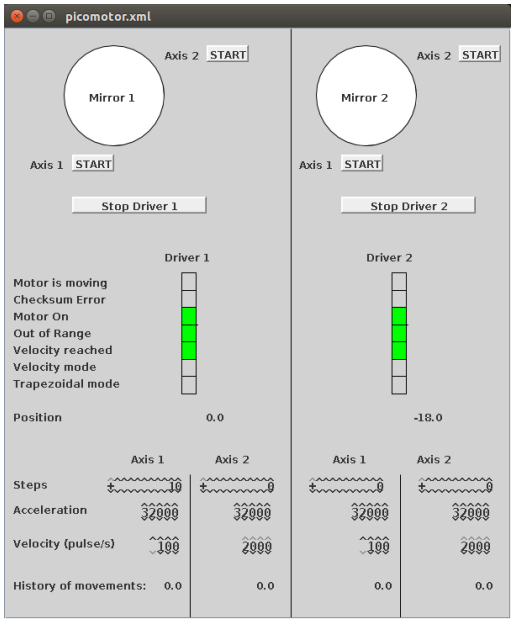
```
#include "eq_fct.h"
#define CodeWaterChiller 10

class EqFctWaterChiller : public EqFct{
private:
  // The environment temperature
  D_floathist TEnvironment;
  // Temperature of the incoming water
  D_floathist TWaterIn;
  // Pressure on the outgoing line
  D_floathist PressureWaterOut;
  // Workload of the chiller fan
  D_int       Fan;
  // Water level in the chiller
  D_int       Waterlevel;
```

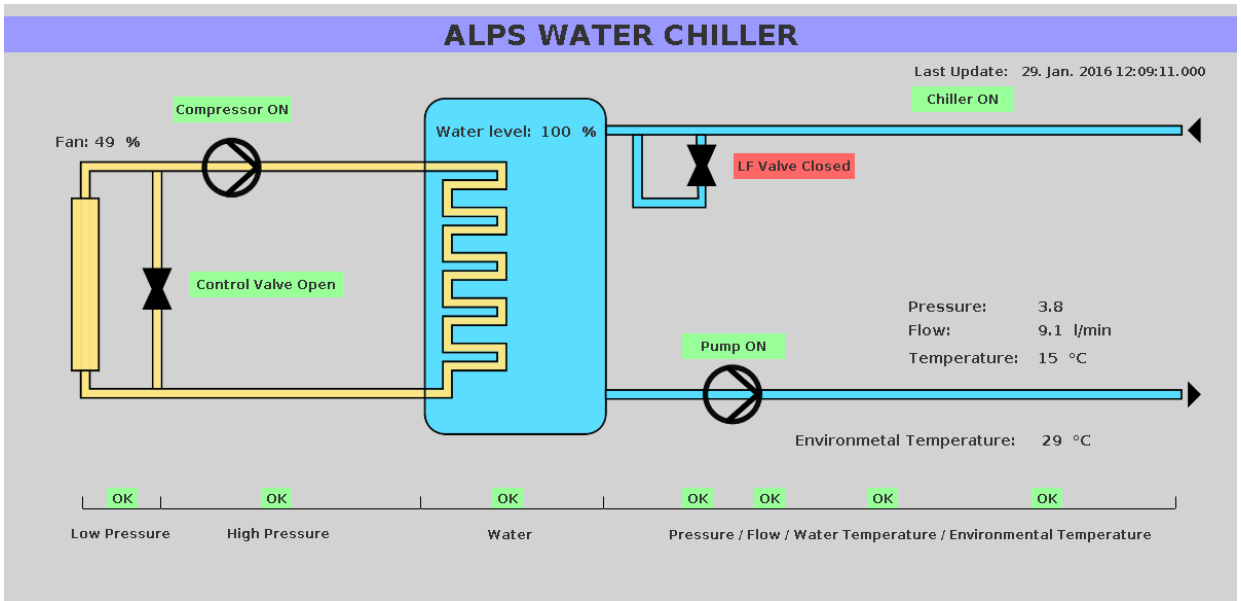


Project: System monitoring and control

DOOCS server implemented so far:

- ADR monitoring
- Water chiller monitoring
- Mirror control

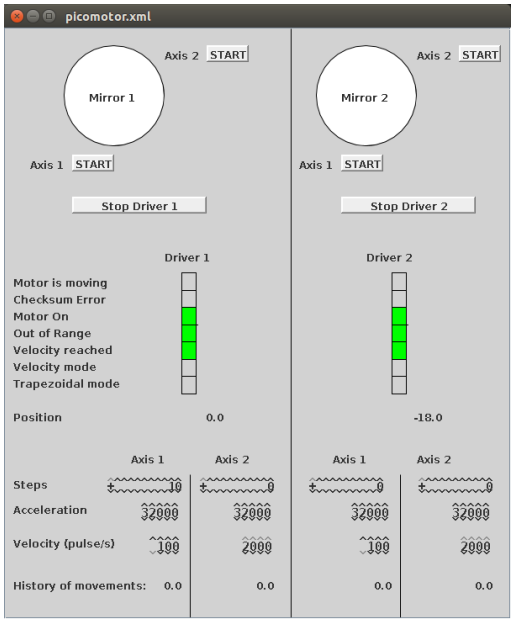


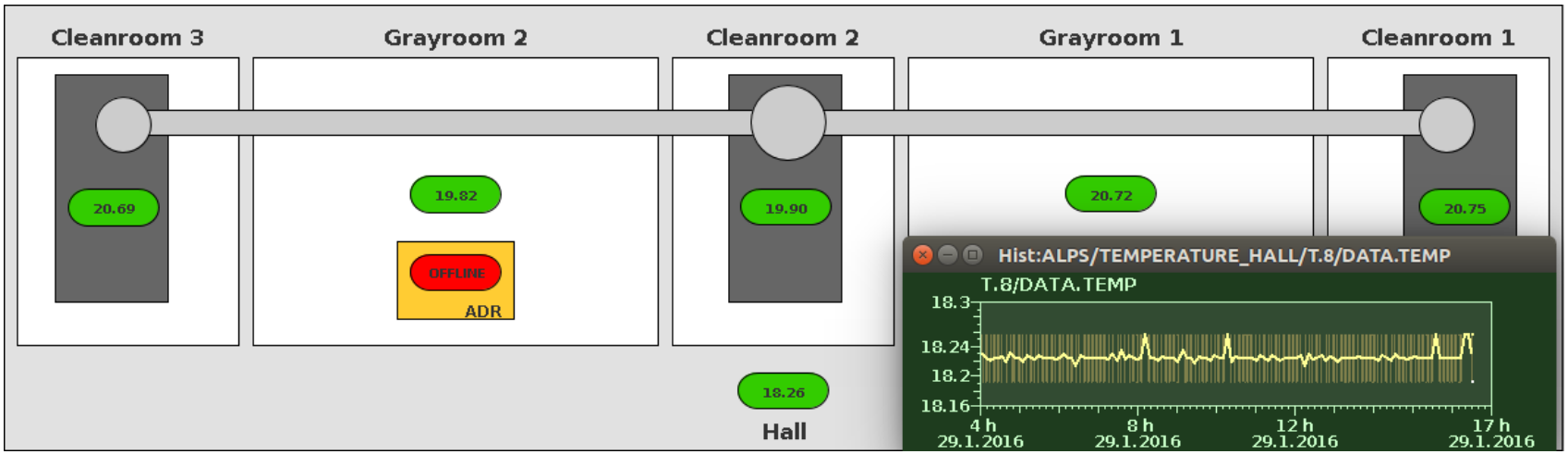


Project: System monitoring and control

DOOCS server implemented so far:

- ADR monitoring
- Water chiller monitoring
- Mirror control
- Temperature monitoring based on DS18B20 sensors





Summary

Project summary:

- For the upcoming ALPS data taking we plan to use a TES
- This needs to be operated stable and reliable
- The background needs to studied and understood
- TES data acquisition and hardware trigger will be set up
- More systems will be integrated in DOOCS

General:

- DOOCS can be used to monitor any system
- . . . we are not talking about the alps ;)

[http://www.onelight.com]