

TES: status and next steps

ALPS collaboration meeting in Mainz

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Overview

For the TES detection scheme the following hardware is needed:

Interface to the experiment

- ▶ Filter for green light
- ▶ Coupling to fiber
- ▶ Fibers

Tools

- ▶ Splicer
- ▶ Clever

Detector system

- ▶ Cryostat
 - ▶ He compressor
 - ▶ (Cooler for the water supplied to the He compressor)
 - ▶ Vacuum pump
- ▶ TESs
- ▶ SQUIDs
- ▶ Computer with software
- ▶ SQUID electronics
- ▶ SQUID software
- ▶ 2 channel ADC board

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New cryostat

We checked the market for a ADR replacement:

- ▶ Dilution refrigerators are comparable in terms of price and cool down time
- ▶ Advantage: continuous operation, high cooling power, no magnet

We contacted the following companies:

- ▶ Entropy (Germany)
- ▶ Bluefors (Finland)
- ▶ Lyden (Netherlands)
- ▶ CryoConcept (France)
- ▶ Janis (USA)
- ▶ Oxford Instruments (UK)

Tender process

We received funding for a new cryostat and will start a Europe wide tender soon.

- ▶ 35 days time window to hand in quotes
 - ▶ 15 days quote review by us and the purchasing department
 - ▶ 10 days to raise objections by outgunned companies
 - ▶ 3 days contract signing
 - ▶ typical delivery time: 6 months
- ⇒ No cryostat before November 2017

Detector and readout

TES:

- ▶ Jörn Beyer promised it will be no problem to get TES from NIST and SQUIDs from PTB
- ▶ We might have to buy new SQUID electronics O(10K€)

Readout:

- ▶ Alazar dual channel card with up to 250 MSPS and 16 bit resolution is ready to be used
- ▶ Hardware (high rate) and software (low rate) trigger are set up
- ▶ Onboard FPGA option for triggering not yet exploited

Green light filter

Why?

Avoid dead time and heating of the TES.

Aim: $R_{\lambda=532\text{ nm}} \approx R_{\text{background}} \approx 10^{-6} \text{ s}^{-1}|_{\text{TDR}} (10^{-4} \text{ s}^{-1}|_{\text{current}})$

We started working on the attenuation unit again:

- ▶ Following Rezas approach and using components from him
- ▶ 4 new HR1064HT532/45 were bought from LaserComponents
⇒ Move from transmission of infrared to reflection ⇒ possible fluorescence light is produced in transmission

Green light filter

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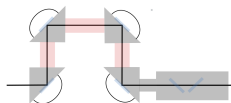
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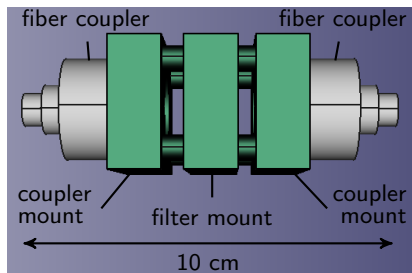
First results:

- ▶ Mirrors perform as specified by the manufacturer
- ▶ Better performance (reflection of infrared and transmission of green) can be achieved by using an angle different from 45
- ▶ 7×10^{-5} (3×10^{-6} for tuned angle) attenuation of green shown for 98% IR transmission



Black-body radiation filter

- ▶ Measured fiber-to-fiber coupling efficiency: 82 %
- ▶ Expected coupling efficiency with anti-reflective coating on fiber tips: 89 %



- ▶ Filter option: band-pass filter for (1064 ± 10) nm with transmission for 1064 nm of $\geq 95\%$ and else a blocking of $\geq OD4$

To be shown: Is the alignment maintained when cooling the bench

- ▶ Test at -80°C with dry ice
- ▶ Final test at 70 K in some cryostat

Overview

The current software frame work is written in C++. ROOT is mainly used in the analysis package and optional for the alpsIO and alazar package.

Packages:

- alpsIO**: Handling of acquired and simulated data.
- alazar**: Data taking with ALAZAR boards used by the TES data acquisition system and the fast monitoring discussed above.
- analysis**: TES data simulation, TES data analysis, time line analysis.

alpsIO package

Supported data formats:

- ▶ ROOT files (offers good data compression)
- ▶ Binary files (useful for fast readout)
- ▶ Text files (support is only given for reading them in order to convert old TES data)

alpsIO package

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Data structure:

- ▶ Vector of data samples (2 byte for RAW and 8 byte for converted data) per buffer and channel
- ▶ Timestamp and trigger information per buffer and channel
- ▶ Meta data like sampling frequency, acquisition type (time line/triggered data), acquisition device (ATS9626, ATS9416, DPO7104C)

alazar package

General:

- ▶ Effort was put into this package to write it as generic as possible \Rightarrow Supporting all ALAZAR boards
- ▶ It makes use of the ALAZAR SDK
- ▶ We implemented only dual port *Direct Memory Access* \Rightarrow While data taking data is already transferred to host memory

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Readout modes:

- ▶ Continuous acquisition \Rightarrow Limited by the host memory and data transfer rate from the board to the host memory and finally by the time needed to write data to disk
- ▶ Software triggered
- ▶ External triggered

Analysis package

Simulation:

- ▶ Pulse simulation according to small signal theory (pulse parameter are taken from data)
- ▶ Noise \Rightarrow Sampling noise from a measured noise spectrum includes also the bandwidth of the SQUID electronics

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Reconstruction:

- ▶ Pulse finder based on low pass filtered first derivative
- ▶ Pulse fitting based on small signal theory pulse shape

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Misc:

- ▶ FFT including different window function of time line data
- ▶ Fixing the desired frequency resolution allows to split the time line and calculate an average noise per frequency bin \Rightarrow Averaging is either done by considering the median or the arithmetic mean

Example: Data acquisition and analysis

The screenshot shows the jddd software interface. The title bar reads "jddd 1.8.64/18.7.39 T4.5.10 alps1@alpsdaq1 alazar.xml". The menu bar includes "File View Help" and a memory indicator "22Mb/1820Mb".

Configuration fields include:

- Channels: A-D
- Readout mode: continuous
- Sampling rate: 10MSPS Board: AT59416
- Output file: data/size_test/test_100Hz_Cha_100MSPS_0.1s_raw.root
- Acquisition time [s]: 0.50

Status and control elements:

- Status: Ready
- Buffers completed: 0
- Time elapsed: 0.00 s
- Write Raw data:
- root:
- Buttons: Start Readout, Stop Readout, Plot data

Log window output:

```
ALPSDAQ1_SVR 12:31:20 1.03.2017 Setup new data acquisition scheme.
ALPSDAQ1_SVR 12:31:38 1.03.2017 ok
ALAZAR 12:31:38 1.03.2017 Waiting for data taking.
ALAZAR 11:49:01 3.03.2017 Card type AT59416 does only support continu
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ALAZAR 11:49:11 3.03.2017 Waiting for data taking.
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Example: Data acquisition and analysis

The screenshot displays the Alazar readout GUI with the following configuration:

- File View Help:** jddd 1.8.64/18.7.39 T4.5.10 alps1@alpsdaq1 alazar.xml
- Channels:** A-D
- Readout mode:** continuous
- Sampling rate:** 10MSPS
- Board:** ATS9416
- Output file:** data/size_test/test_100kHz_ChA_100MSPS_0.1s_raw.root
- Acquisition time [s]:** 0.50
- Status:** Ready
- Buffers completed:** 0
- Time elapsed:** 0.00 s
- Buttons:** Start Readout, Stop Readout, Plot data
- Log:**

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ALPSDAQ1 12:31:29 1.03.2017 Setup new data acquisition scheme.
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```

The GUI also features a control panel on the right with options for Event, Navigation, Layout, FFT, and Averaged samples.

Four data plots are shown:

- Data of channel ChA:** A noisy signal fluctuating between approximately 0.087 and 0.091 V over a time range of 0 to 0.1 s.
- Data of channel ChB:** A noisy signal fluctuating between approximately 0.084 and 0.095 V over a time range of 0 to 0.1 s.
- Data of channel ChC:** A linear ramp signal increasing from 0 to approximately 0.4 V over a time range of 0 to 0.1 s.
- Data of channel ChD:** A noisy signal fluctuating between approximately 0.084 and 0.089 V over a time range of 0 to 0.1 s.

Example: Data acquisition and analysis

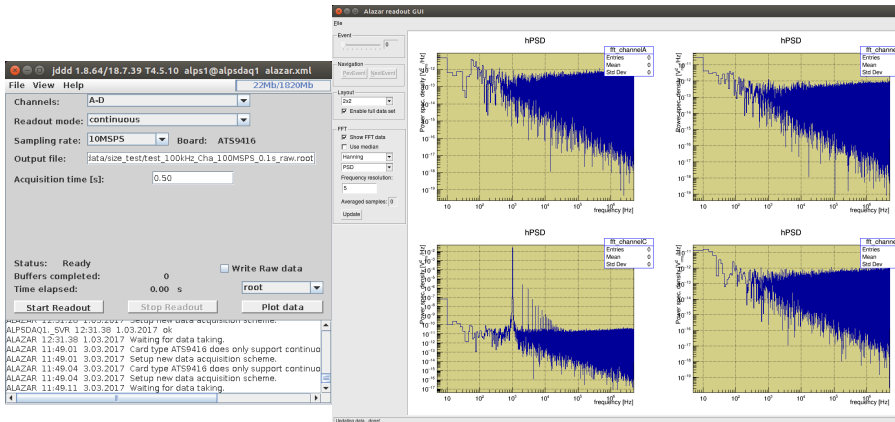
The screenshot displays the Alazar readout GUI with the following configuration:

- File View Help:** 22Mb/1620Mb
- Channels:** A-D
- Readout mode:** continuous
- Sampling rate:** 10MSPS
- Board:** ATS9416
- Output file:** data/size_test/test_100kHz_ChA_100MSPS_0.1s_raw.root
- Acquisition time [s]:** 0.50
- Status:** Ready
- Buffers completed:** 0
- Time elapsed:** 0.00 s
- Buttons:** Start Readout, Stop Readout, Plot data
- Log:** Shows acquisition progress and messages such as "ALPSDAQ1_SVR 12:31:38 1.03.2017 ok" and "ALAZAR 11:49:01 3.03.2017 Card type ATS9416 does only support continuou".

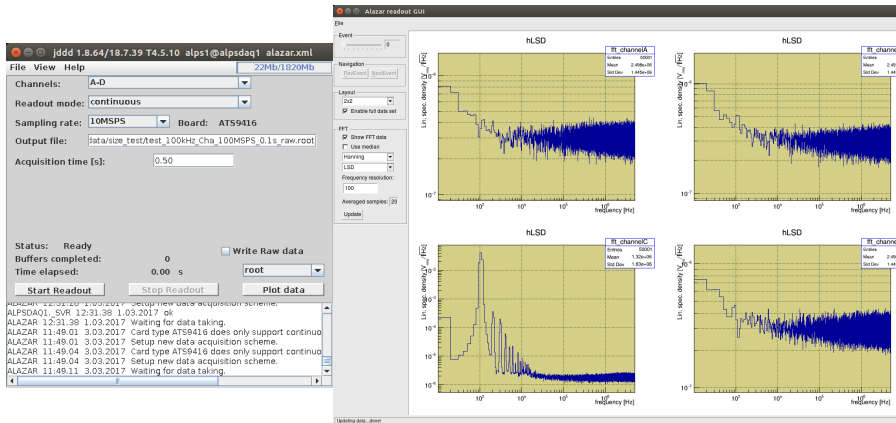
Four data plots are shown:

- Data of channel ChA:** A noisy signal fluctuating between approximately -0.01 and 0.01 V over 0.2 seconds.
- Data of channel ChB:** A noisy signal fluctuating between approximately -0.005 and 0.005 V over 0.2 seconds.
- Data of channel ChC:** A clear sinusoidal wave with an amplitude of approximately 0.6 V and a period of about 0.04 seconds.
- Data of channel ChD:** A noisy signal fluctuating between approximately -0.005 and 0.005 V over 0.2 seconds.

Example: Data acquisition and analysis



Example: Data acquisition and analysis



Example: Data acquisition and analysis

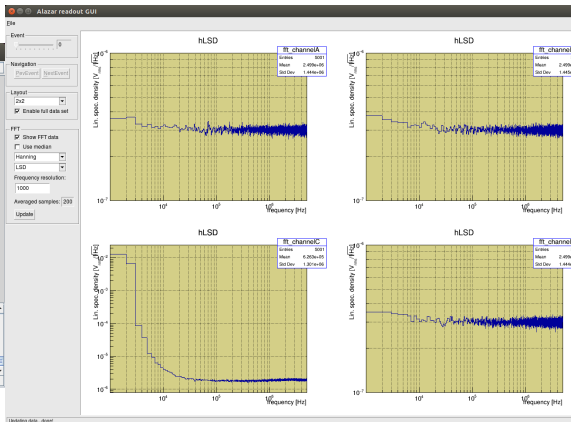
Terminal window showing the Alazar GUI interface:

```

jddd 1.8.64/18.7.39 T4.5.10 alps1@alpsdaq1 alazar.xml
File View Help 22Mb/1820Mb
Channels: A-D
Readout mode: continuous
Sampling rate: 100MSPS Board: ATS9416
Output file: /data/size_test/test_100kHz_Cha_100MSPS_0.1s_raw.root
Acquisition time [s]: 0.50

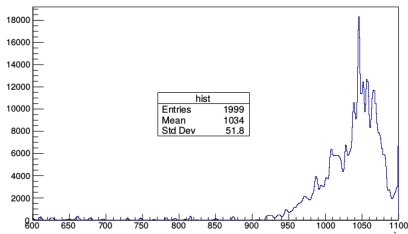
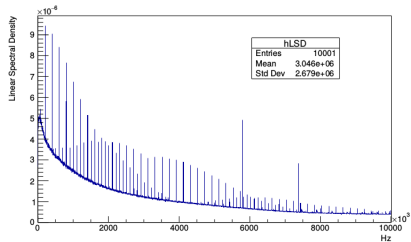
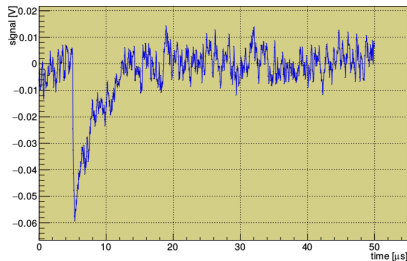
Status: Ready Write Raw data
Buffers completed: 0
Time elapsed: 0.00 s root
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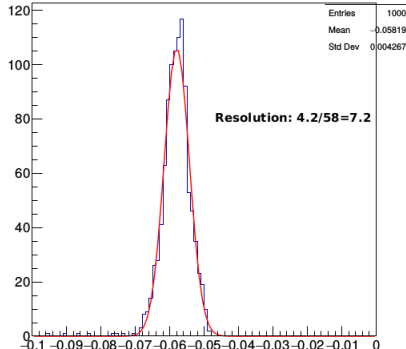
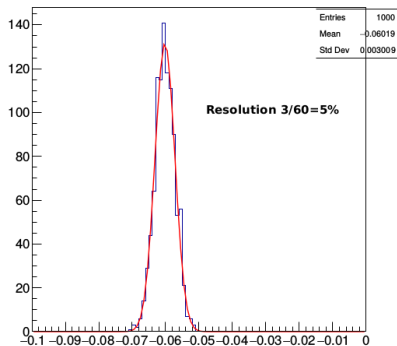
Example: Energy resolution

We estimated the energy resolution assuming a realistic laser spectrum.



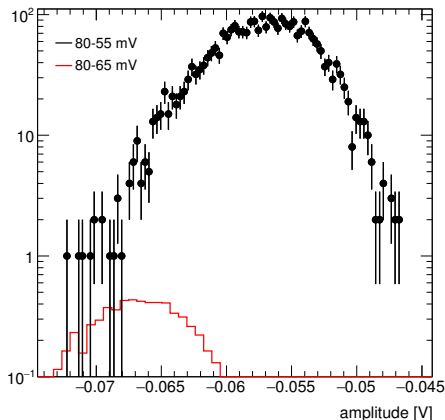
Example: Energy resolution

We estimated the energy resolution assuming a realistic laser spectrum.



Estimation of black-body photon reduction by the filter bench

- ▶ Filter cut-off is set to -65 mV
- ▶ 1 order of magnitude suppression in the signal region (around -65 mV)



Summary

- ▶ We will have a new cryostat by the end of 2017
- ▶ TES detection scheme should be operational in 2018 again
- ▶ Optimization of background reduction is ongoing
- ▶ Software for data acquisition and analysis is in place to be tested