Activity on Adaptive power & Calibration at Prague

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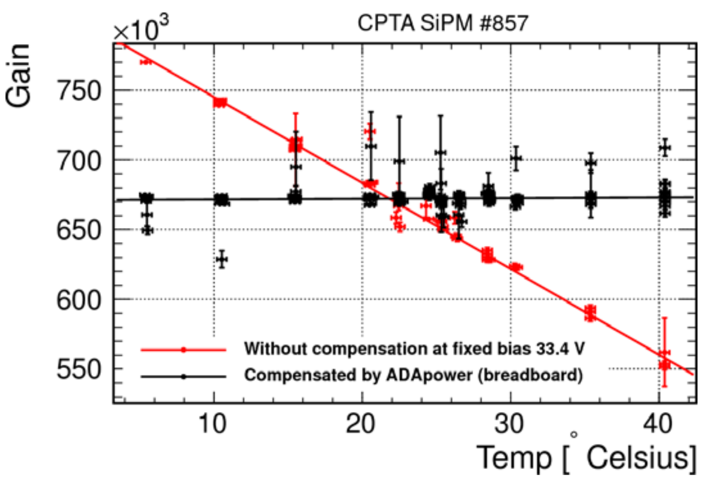
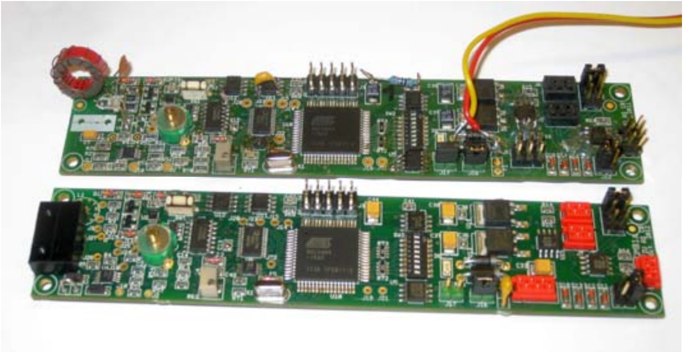


- QMB1A update
- Testboard
- ADApower PCB
- Test results with regulator prototype by Erik
- Conclusions

More info of QMB can be found at previous presentations:

http://www-hep2.fzu.cz/calice/files/20110915-Polak_I.CALICE_Heidelberg.pdf

QMB1(A)



Single power 15V 65mA

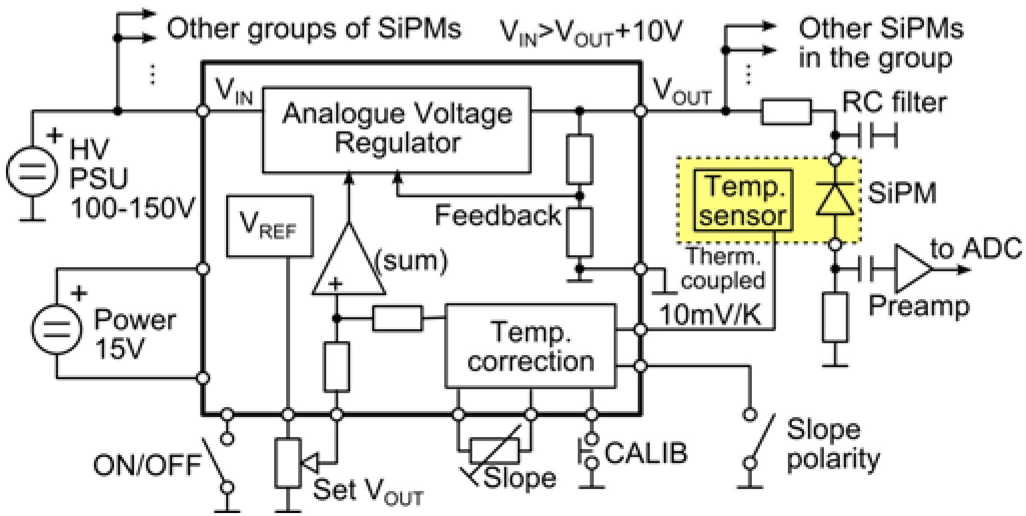
QMB1 Update

- In Autumn 2013 I tested a possibility of shortest LED pulse.
- QMB1 can get 1.6ns with very small loop (3mm dia) at inductor position.
- It is 1.75ns in QMB1A.
- The Limits are switching mosfet transistor (speed, input C & maximal operational voltage), the speed of a mosfet driver and also a layout.
- We tested 35ns version for Compass detector ECAL0.

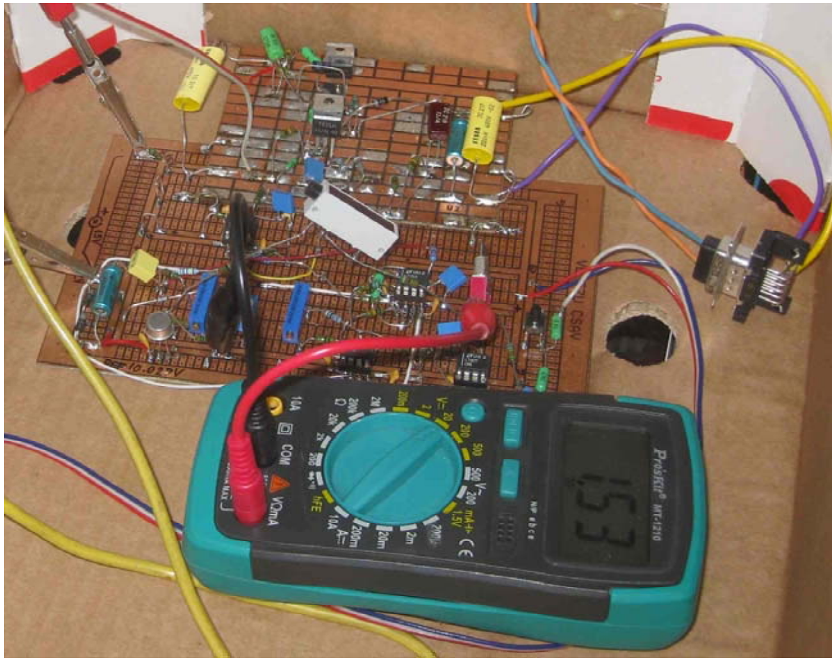
Quasi resonant Main Board

- Modular system, 1 LED per board
- Operation mode:
  - DAQ + CANbus control
  - stand-alone mode
- LVDS Trigger distribution system
- Variable amplitude, zero to maximum (~1Amp) smooth
- Pulse width fixed to ~ 3.5ns STD (UV or blue LED) or ~30ns LONG pulse version (external inductor)
- Voltages and temperature monitoring
- Size of PCB: width 30mm, depth 140mm

Testboard - breadboard of bias regulator (ADApower)

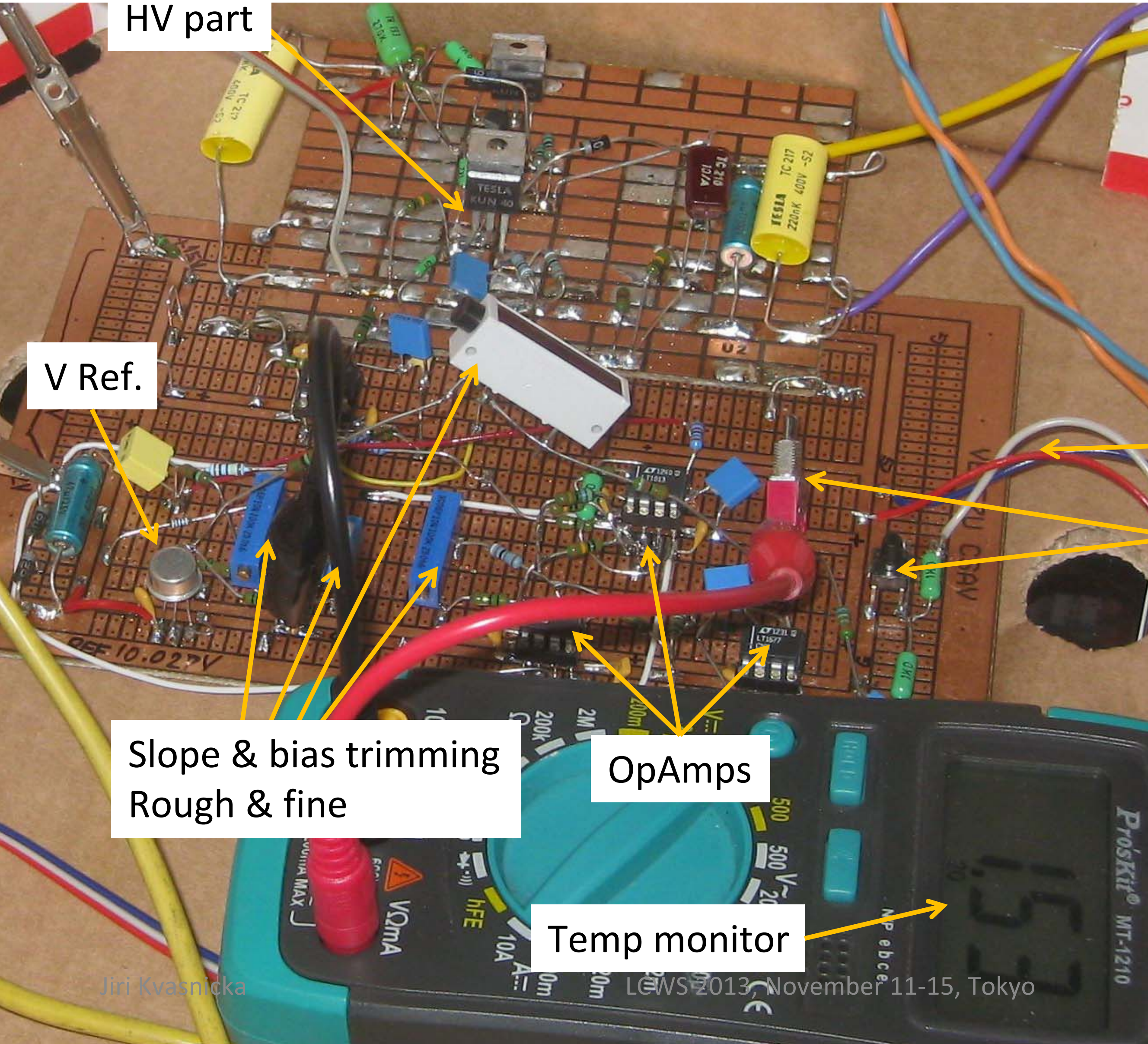


The Regulator is designed for usage of SiPM and also for a compensation of APD. (Vout to 430V)



- **At each temperature setting, also applied testboard.**
- **Board operates in 10V to 80V region.**
- **It regulates V_{bias} with slopes of 10-100 mV/K, according to the temperature measured near the SiPM (LM35).**

First ADApower testboard



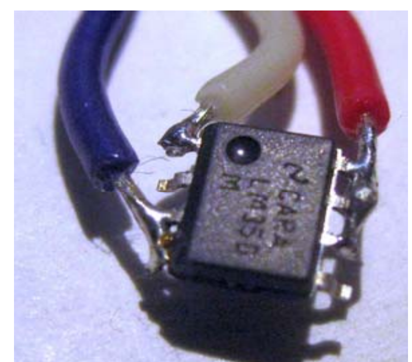
2m cable to temp. sensor

Switches for configuration

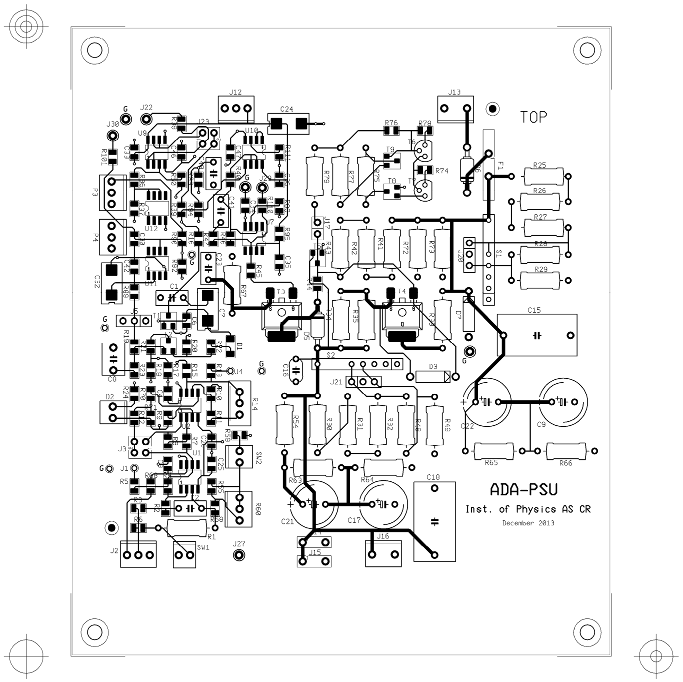
Fully functional

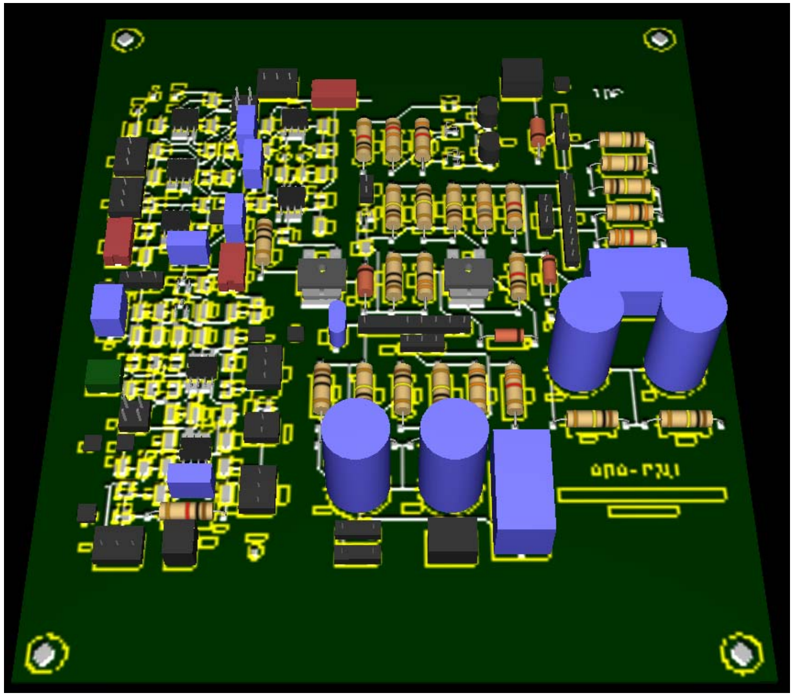
Complete Results: see talk by Gerald or Erik

LM35D temp sensor
10 mV/°C



Layout of ADApower board





ADApower is an acronym for Adaptive power supply for biasing SiPM with temperature compensation.

The PCB is in production phase.   We ordered 6 units. Size is 14 x 12cm

Notes to ADApower board

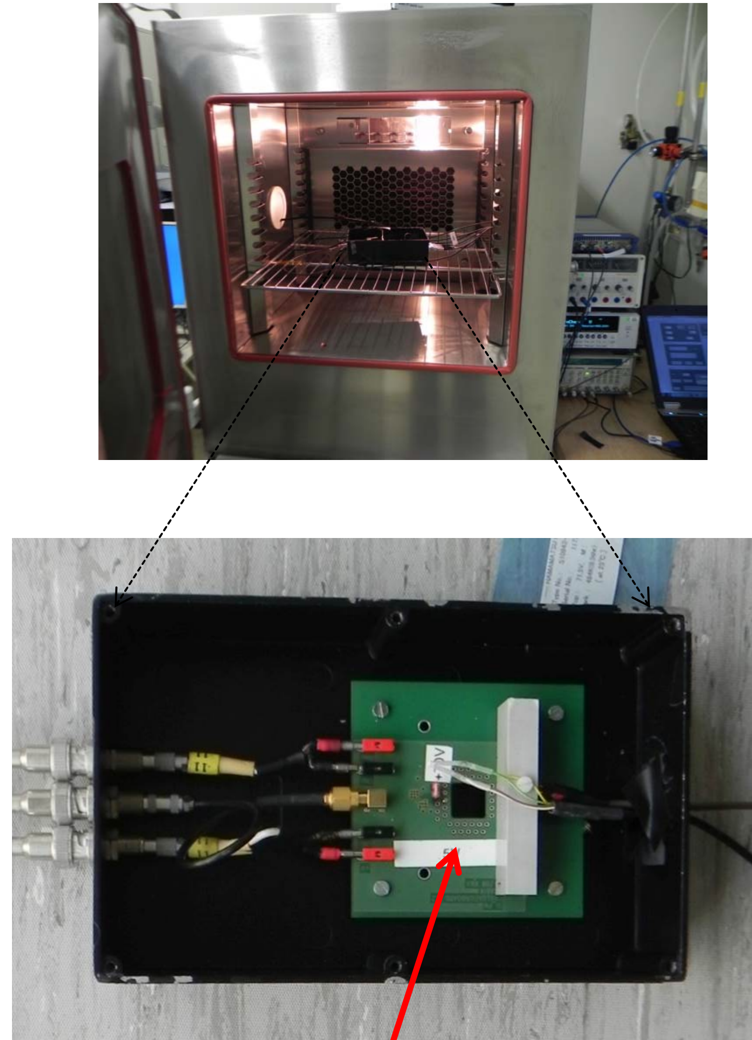
ADApower

- first version is been designed and it will be build as stand-alone unit (box)
- - The box consists complete power supply with setting elements
  - Multiturns potentiometer – Vout setting (fine and coarse), Slope,
  - Switches: Slope polarity, Calibrations

- Later we are ready to update a design for miniaturised version for an integration to the detector prototype. It will be focused for SiPM operation – output bias voltage up to 80V → smaller components than 500V range for APD mode.

- **Overall Vout stability is better than 100ppm, some parameters are far better. Used voltage divider resistors with Temp-coeff 25ppm/K.**
- **Internal Voltage reference LT1021 better than 10ppm/K (typicaly 3ppm/K)**
- **Input Voltage 100 to 500V for board, the box will be powered by 230VAC**

Validation of the SiPM bias compensation



'Climate Chamber'

(Used for stress tests in CERN bondinglab)

Accurate to 0.1C.

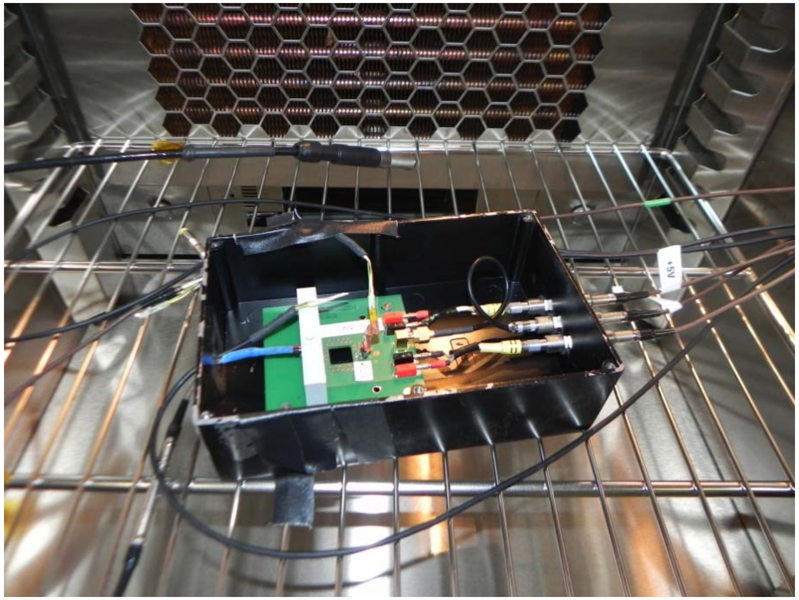
Digital oscilloscope readout by laptop

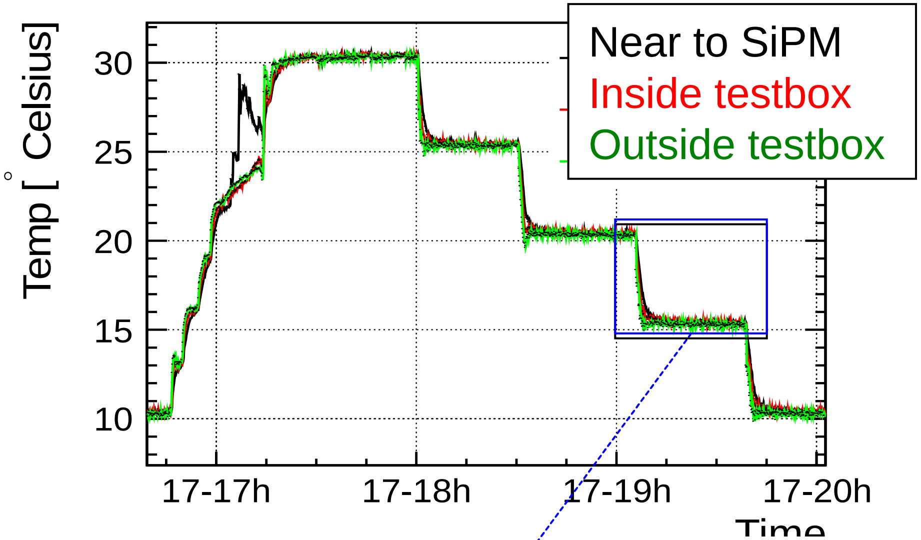
LV and bias voltage supply

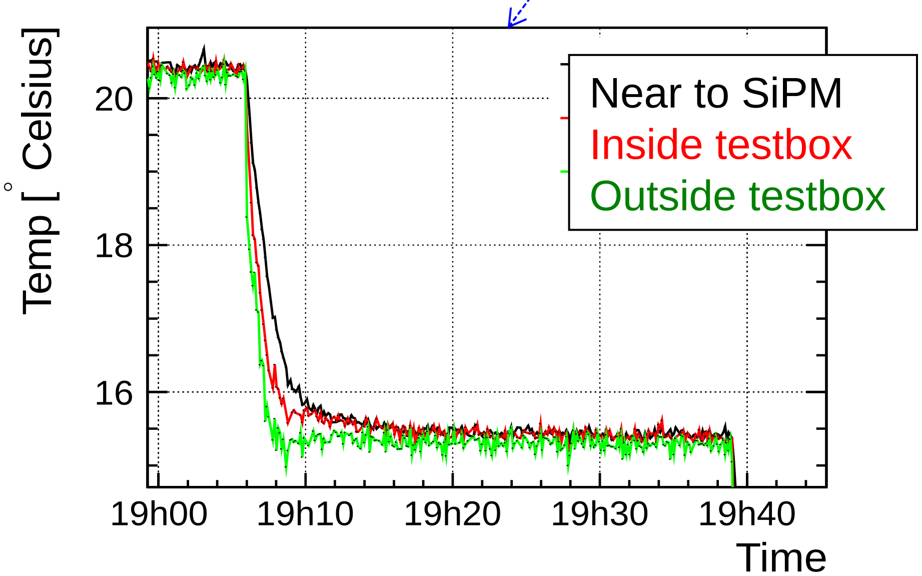
Pulse generator for LED

SiPM + preamp + T-sensor + LED

Temperature measurement







3 Pt1000 sensors:

Nearby SiPM

Inside black testbox

Outside black testbox

T set to 10, 15, 20, 25 & 30C.

$T_{SiPM} \sim T_{SET} + 0.4C$

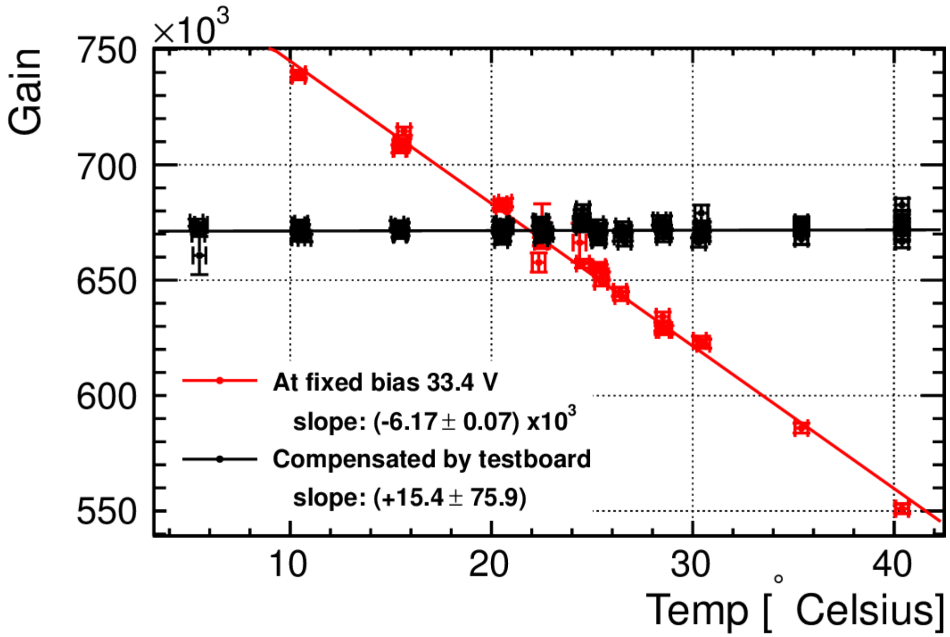
Offset consistent over full range.

Results of temperature scan/compensation with 3 types of SiPM

Erik van der Kraaij (UiB) provides me with following slides.
It is based on tests made at CERN with the prototypes of regulator (ADApower).

Erik made the analyze of the data.

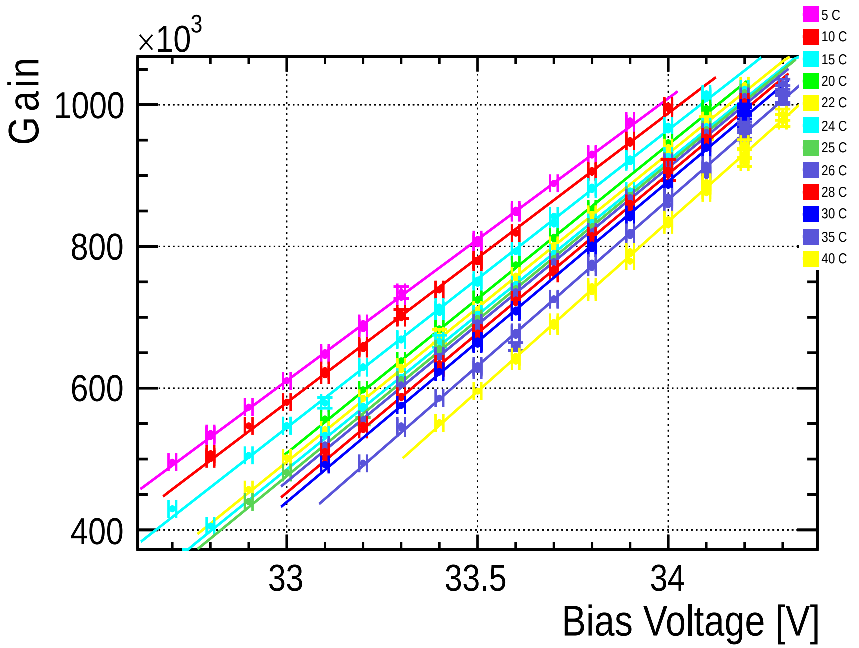
The Effective Result with the testboard



← **With** compensation

← **Without** compensation

Gain vs voltage for different temperatures – CPTA (#857)



Each entry is the gain extracted from 50k waveforms

From these distributions you fit a linear function, which results in a breakdown voltage and a dG/dV

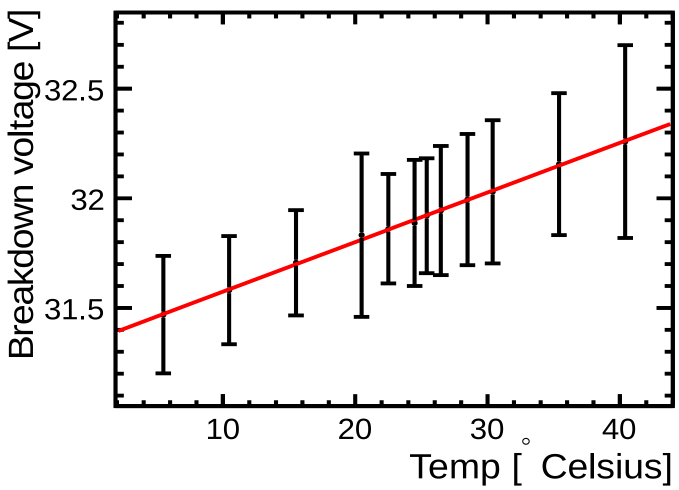
Clear systematic dependence is visible for dG/dV (see below).

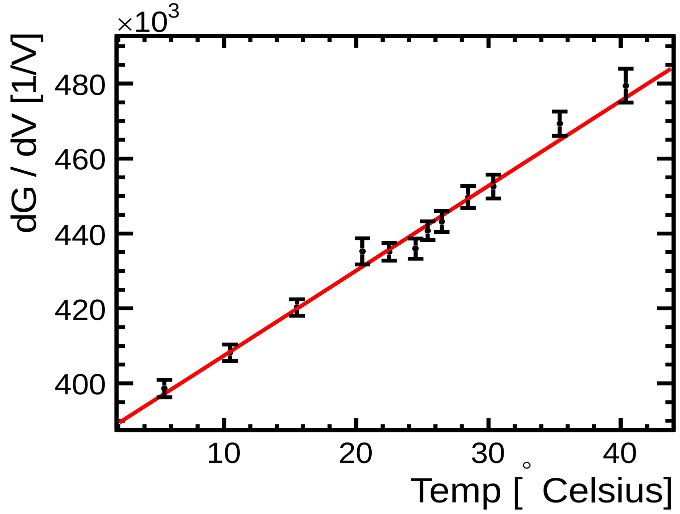
0th order polynomial fit yields:

$$dG/dV = (4.32 \pm 0.01_{stat}) \times 10^5/V$$

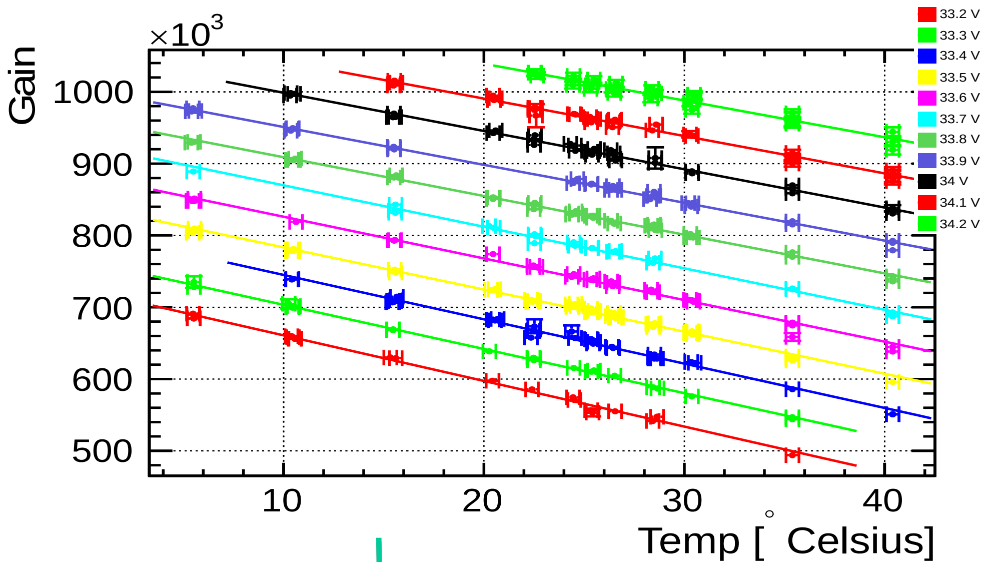
1st order polynomial fit yields:

$$dG/dV = (4.41 \pm 0.11_{sys}) \times 10^5/V$$



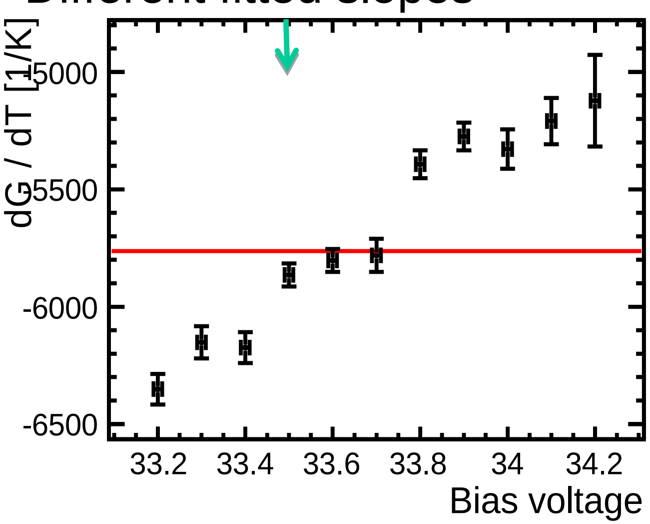


Gain vs temperature for different V – CPTA (#857)



← Same data as previous slide.

Different fitted slopes



← 0th order polynomial fit yields:

$dG/dT = (-5.76 \pm 0.02_{stat}) \times 10^3/K$

For a constant gain:

dV/dT = <dG/dT> / <dG/dV>
= 13.33 ± 0.35 mV / K

Expected gain stability:
σ(dV/dT)/(2G × dG/dV) = 0.12%

Gain vs T – taken with breadboard CPTA (#857)

With the breadboard the voltage was continuously adapted.

The color coding in this plot only give the range of voltage applied.

For example: blue means $33.35 < V_{bias} < 33.45$ V

At each temperature about 10 samples were taken (each 50k events).

For each sample you obtain one gain value.

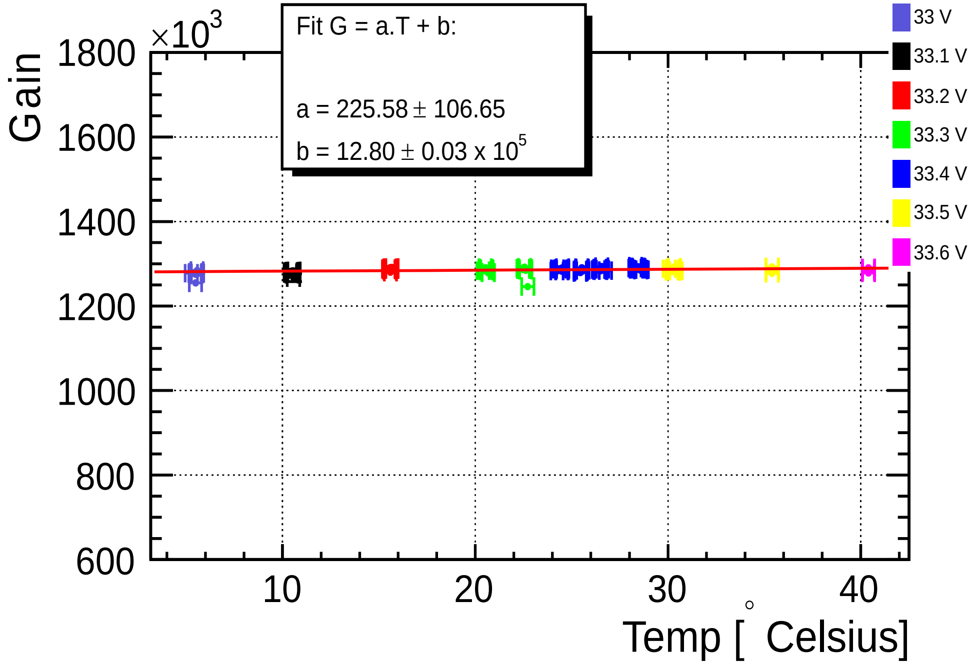
Linear fit to all data points

offset: $(6.71 \pm 0.02)\ \times 10^5$

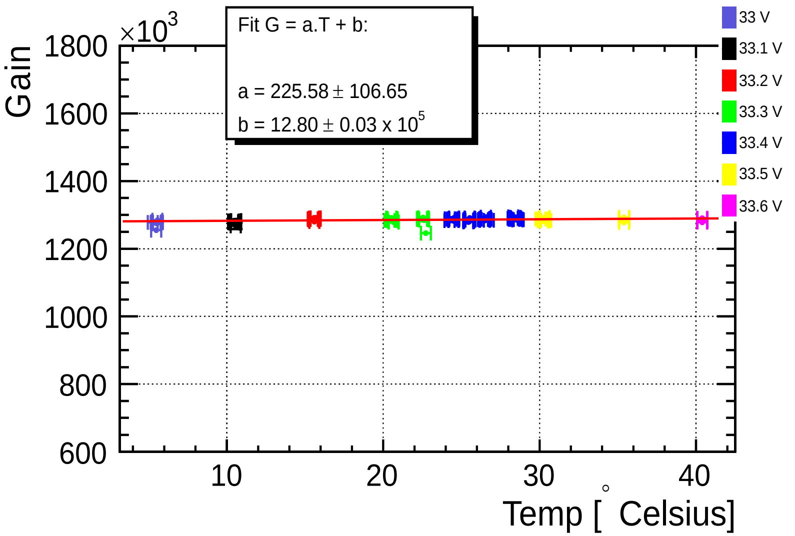
slope: 15.38 ± 75.87 / K

Gain is uniform in range of 5°-40° C

Measured non-uniformity in 20-30C range: < ±0.01%



Gain after V_{bias} adjustment for other SiPMs



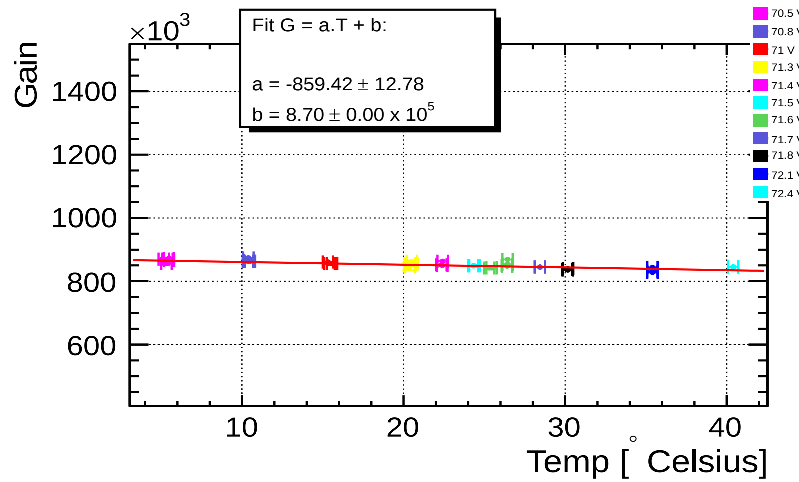
CPTA 1677

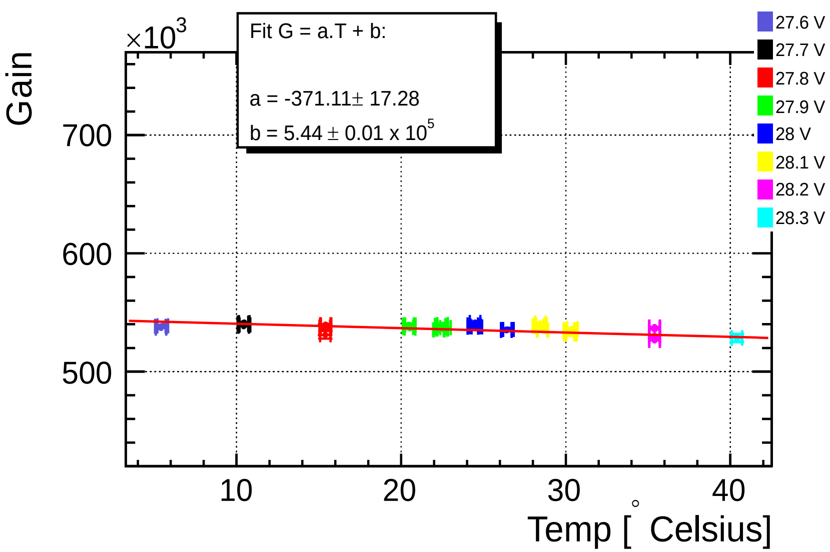
Non-uniformity ~ ± 0.1%

(20°C < T < 30°C)

Hamamatsu 11759

Non-uniformity ~ ± 0.5%





KETEK W12

Non-uniformity < ± 0.3%

Conclusion on SiPM Gain stabilization analalyze

- **dV/dT is similar for CPTA & KETEK (15-20 mV/K)**
  Hamamatsu sensors yield larger values ~55 mV/K
- **For CPTA & KETEK (Hamamatsu), the maximum voltage adjustments are less than ΔV=0.7 (1.9) V for range 5°C < T < 40°C**

- **The gain stabilization with the V_{bias} regulator prototype works well.**
- **Non-uniformity of gain vs T after compensation is better than ±0.5% for all detectors (20°C < T < 30°C)**

- **Dependence of dG/dV (=capacitance) on the temperature is visible for some of the SiPMs.**
  - **For temperature range of interest, dV/dT is approximately linear.**

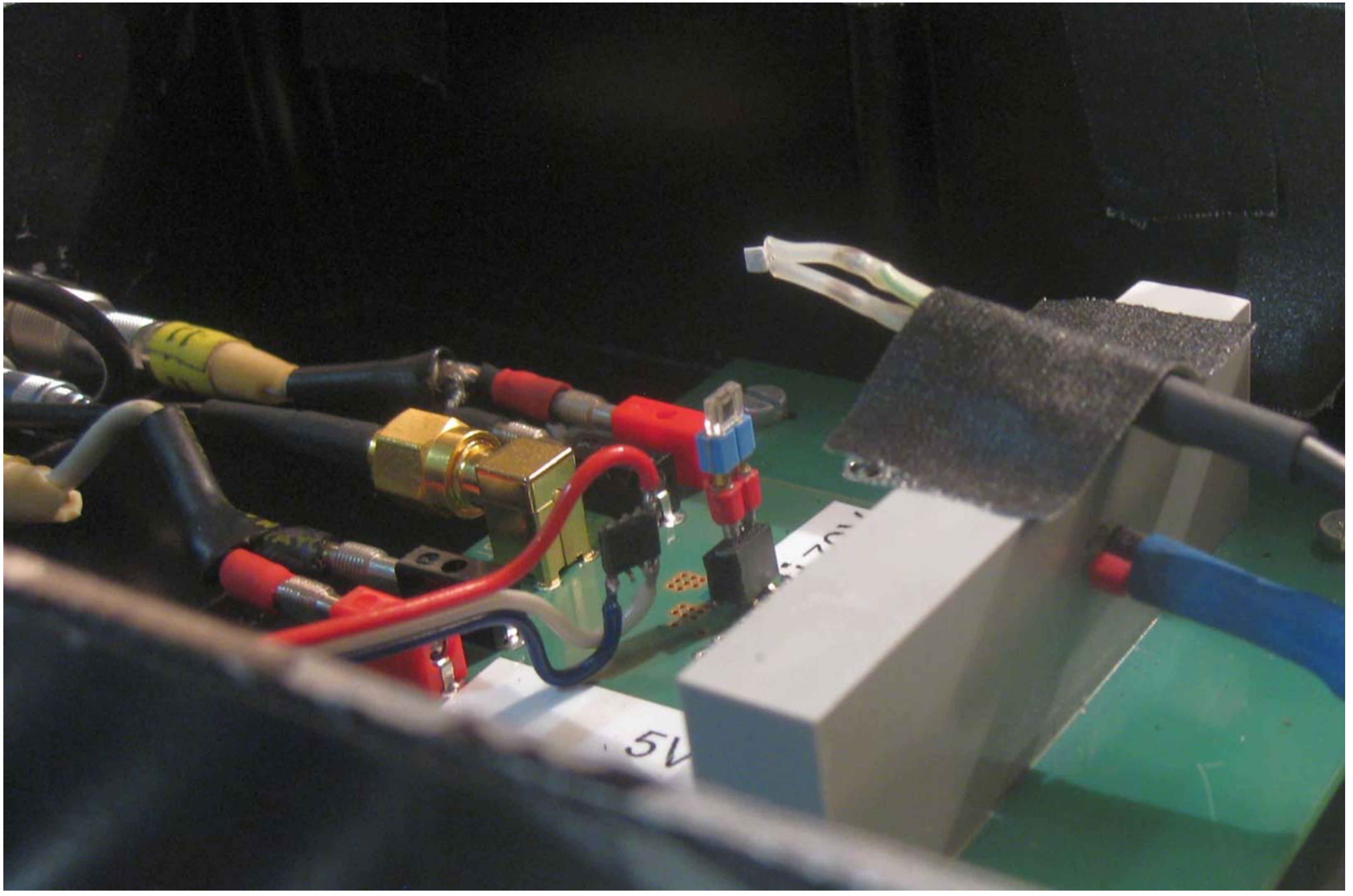
Conclusions

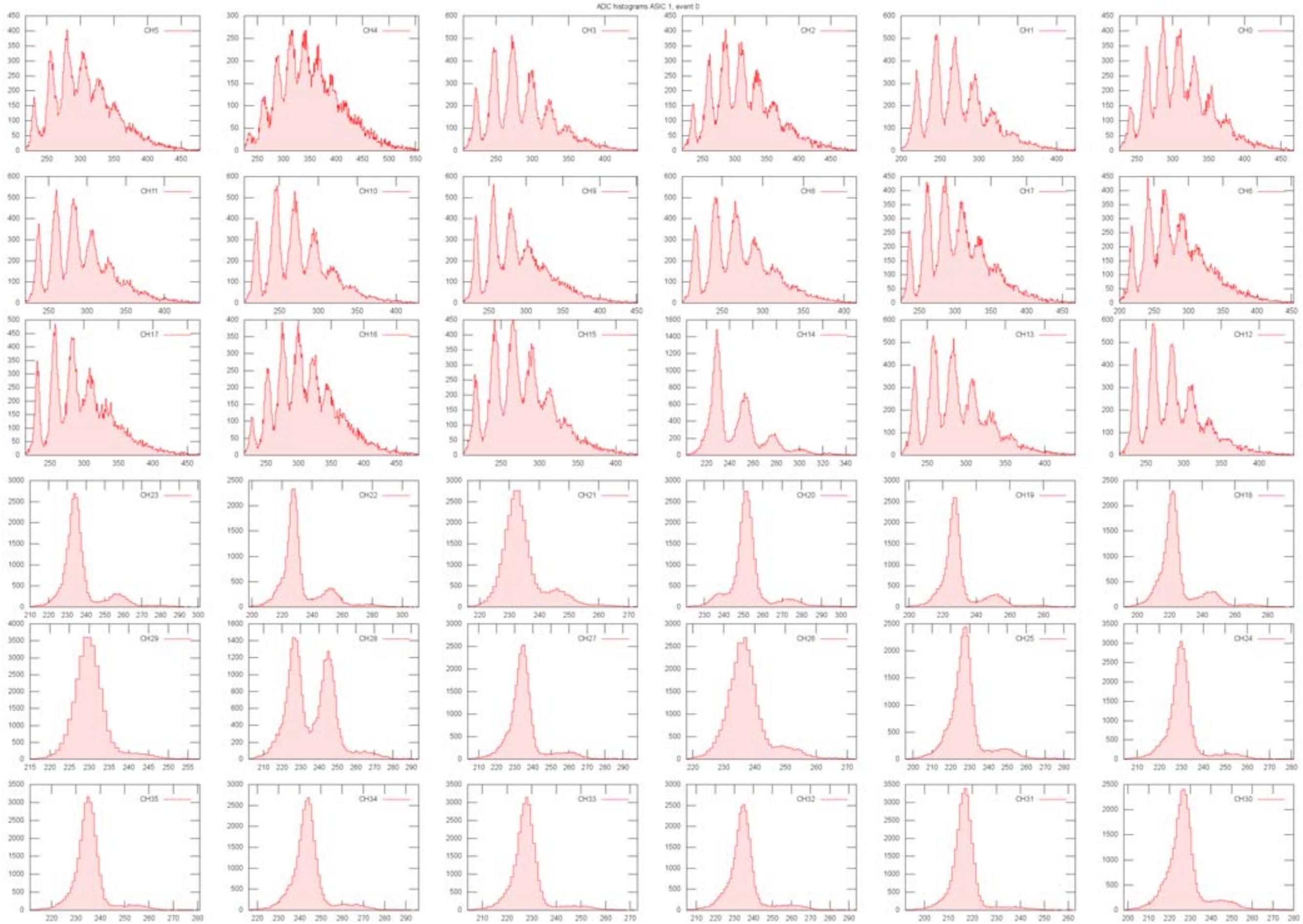
- **Bias regulator (ADApower) is tested successfully with several SiPM types**
  - It is working stable, even breadboard (prototype) is reliable and proved principals of gain stabilization
  - Production of 6 units is ongoing
  - Gain stabilization system can be used also for APD

- **Analysis is ongoing, presented preliminary plots**
- **We will repeat the temperature scan with ADApower box**
- **Later an Upgrade to miniature SiPM version according to requirements to integrate to detector.**

Back-up slides

Temperature sensor coupling





2011 QMB1 linearity, amplitude scan

Standard LED pulses 3ns,

PWR measured by optical power meter ThorLabs PM100D

Approved in december 2012 as well.

Differential Nonlinearity