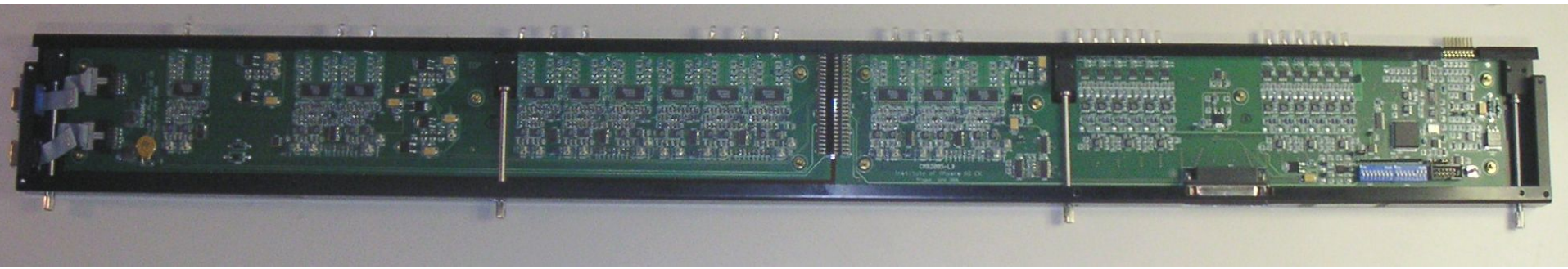
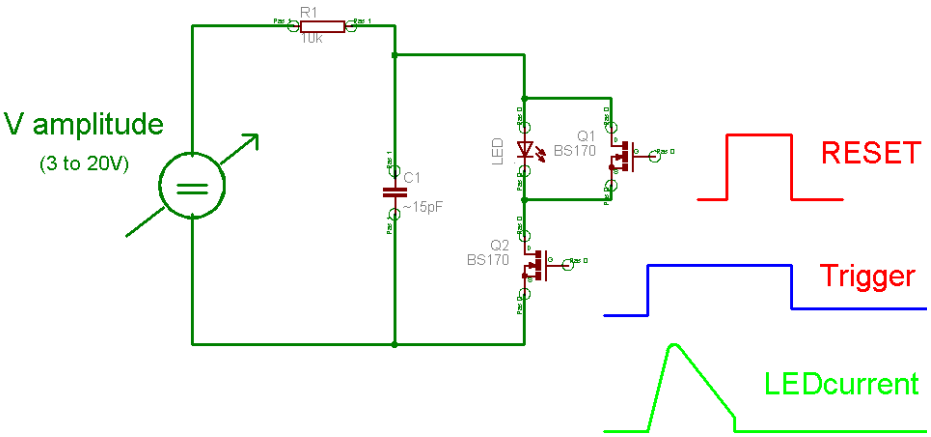
Development of Calibration system for AHCAL



Requirements to calibration system

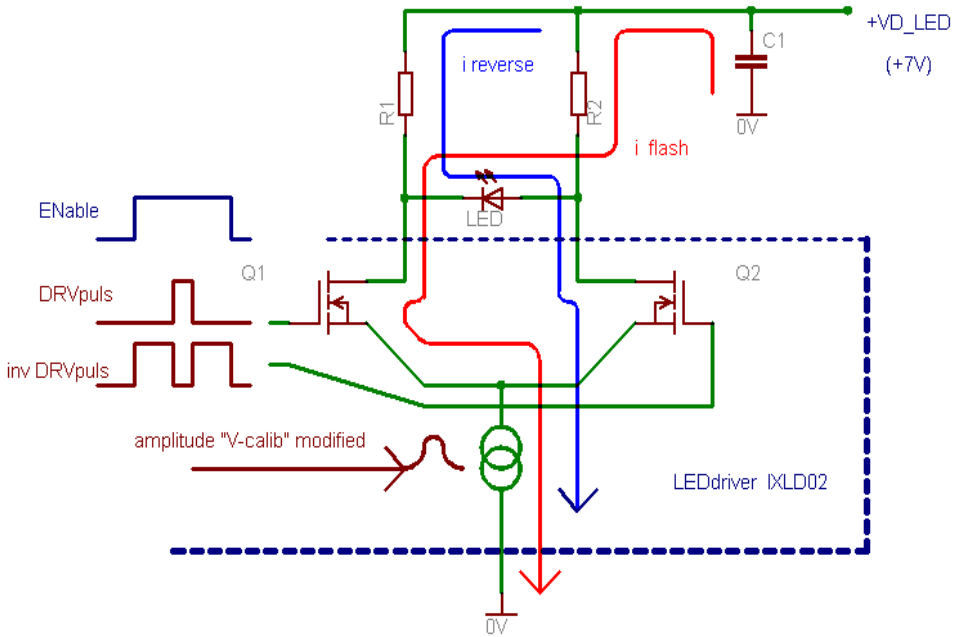
- Generate uniform near-visible UV flashes
  - controllable in amplitude 0 to max = twice SiPM saturation
  - adjustable pulse width (a few ns)
  - enabling each LED individually
  - optical feedback from LED to PIN-PD signal channel
- LED triggering from DAQ
- Readout temperature from 5 sensors placed in the scintilator plane (12bits minimum)
- CANbus interface to Slow-control

Principal schema of LED-driver



Old concept as used
in H1 Spacal calorimeter

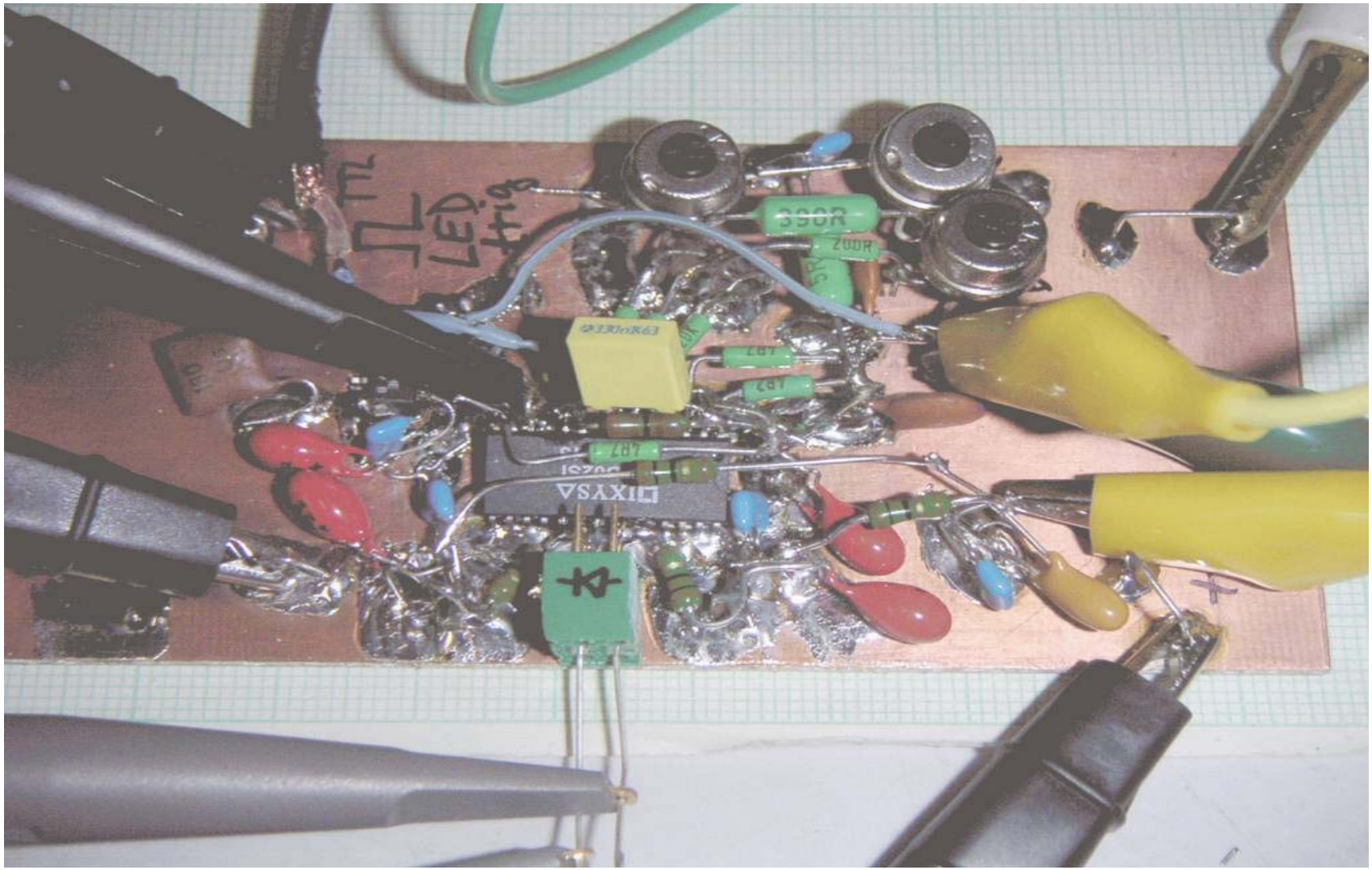
My concept



Short history of the last 2 years

- **CMB** = **C**alibration and **M**onitoring **B**oard
- 2004 Sept/Oct first ideas where to and how to go
- 2004 Dec 1CHannel LED-driver + PIN PD preamp
- 2005 Feb 2CH LED-driver
- 2005 Aug CANbus + Temperature readout /Slow-control interface
- 2005 July/Aug first version of 12CH CMB
- 2005 Dec prepared version of 12CH CMB
- 2006 Jun 1st production of 20pcs CMB
- 2006 Sept 2nd production of 20pcs CMB

Picture of 1CH LED-driver Nov 2004

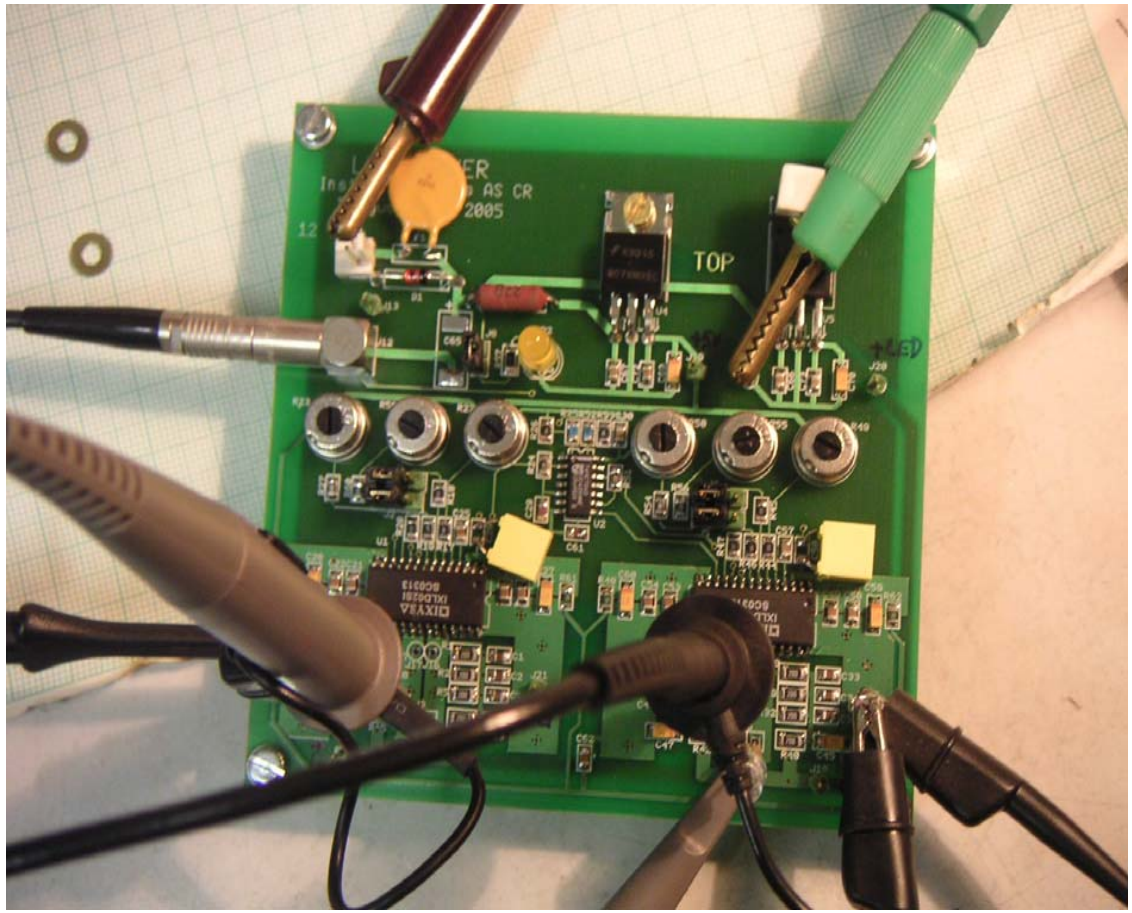


Version of 2CH LED-driver

24feb2005

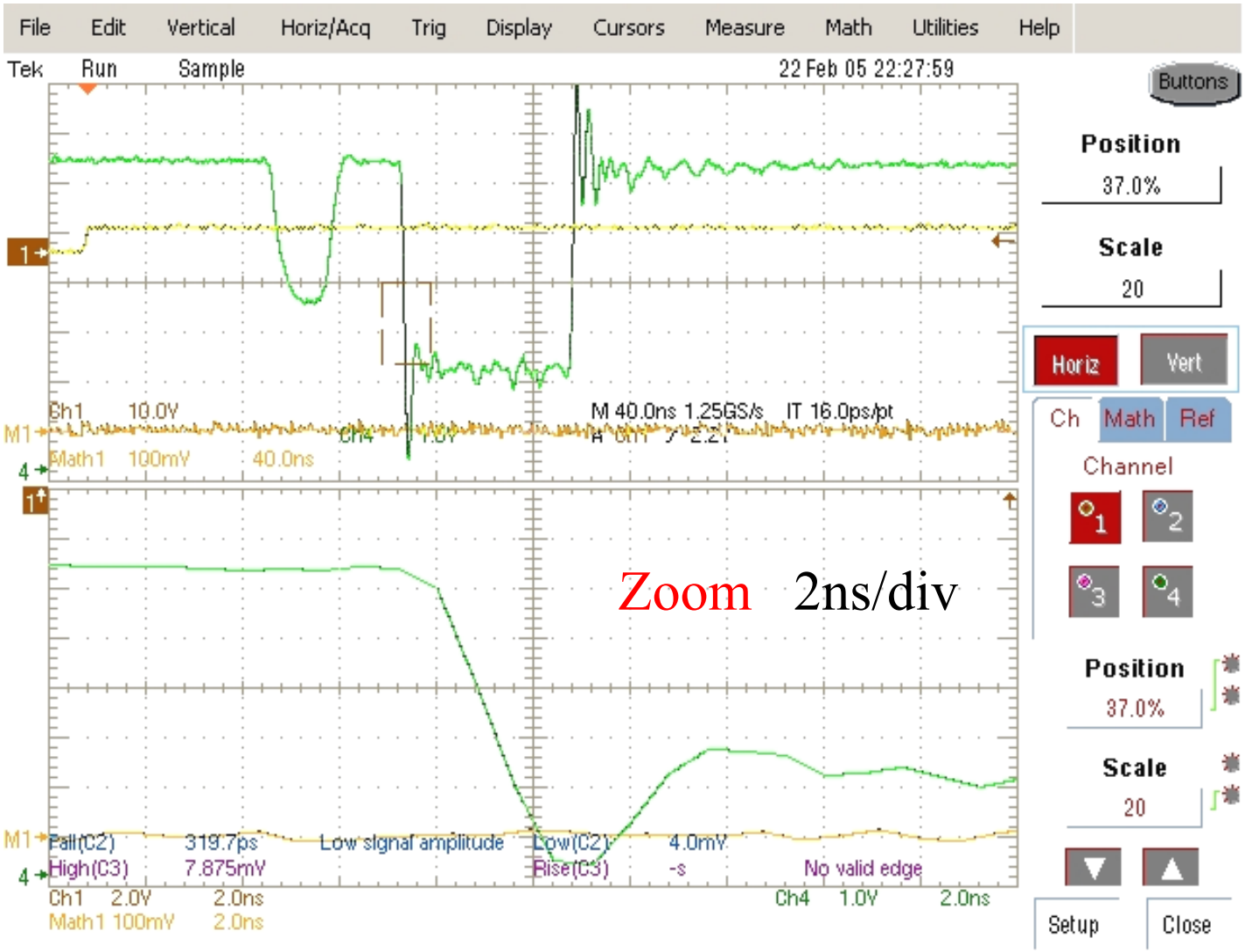
- Common input for signal LED-trigger, lemo, 50Ω
- One 12V (60mA) supply, protection
- Rise time 2ns,

  tested with P5050 scope probe (8pF, 500MHz)
  C=8pF, L=30nH
  f_{res}=290MHz



Output, one LED leg, 500MHz passive probe
this is a true RF technique :)

24feb2005



3 different scope probes, what we see...

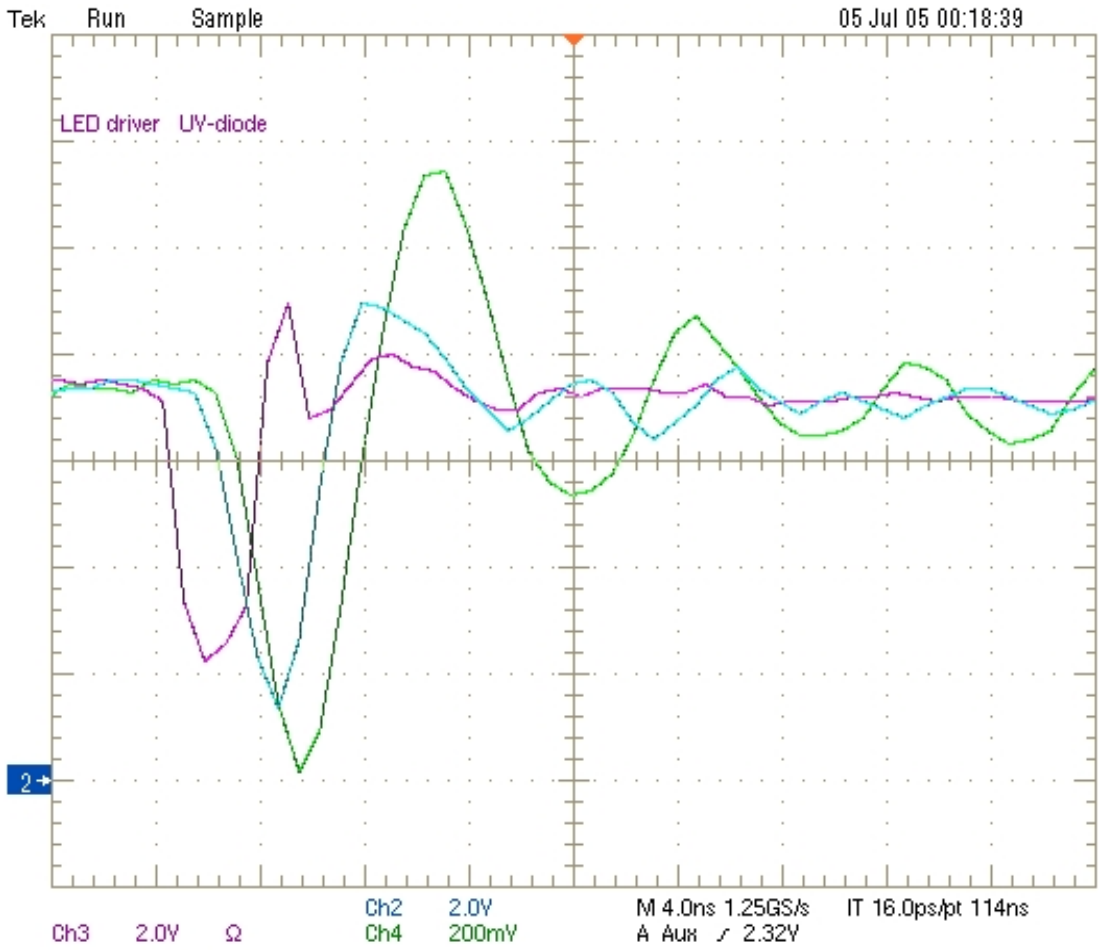
JULY 05

- LED driver
- Oscilloscope TDS5104, 1.5GHz
- Probes TEK
- GRN 16pF 200MHz
- Cyan 11pF 500MHz
- VIO 1.5pF 3GHz
- Same circuit at once

P6185 passive 1kOhm 1.5pF 20x (3GHz)

P5050 passive 10MOhm 11pF 500MHz 10x

P2200 passive 10MOhm 16pF 200MHz 10x

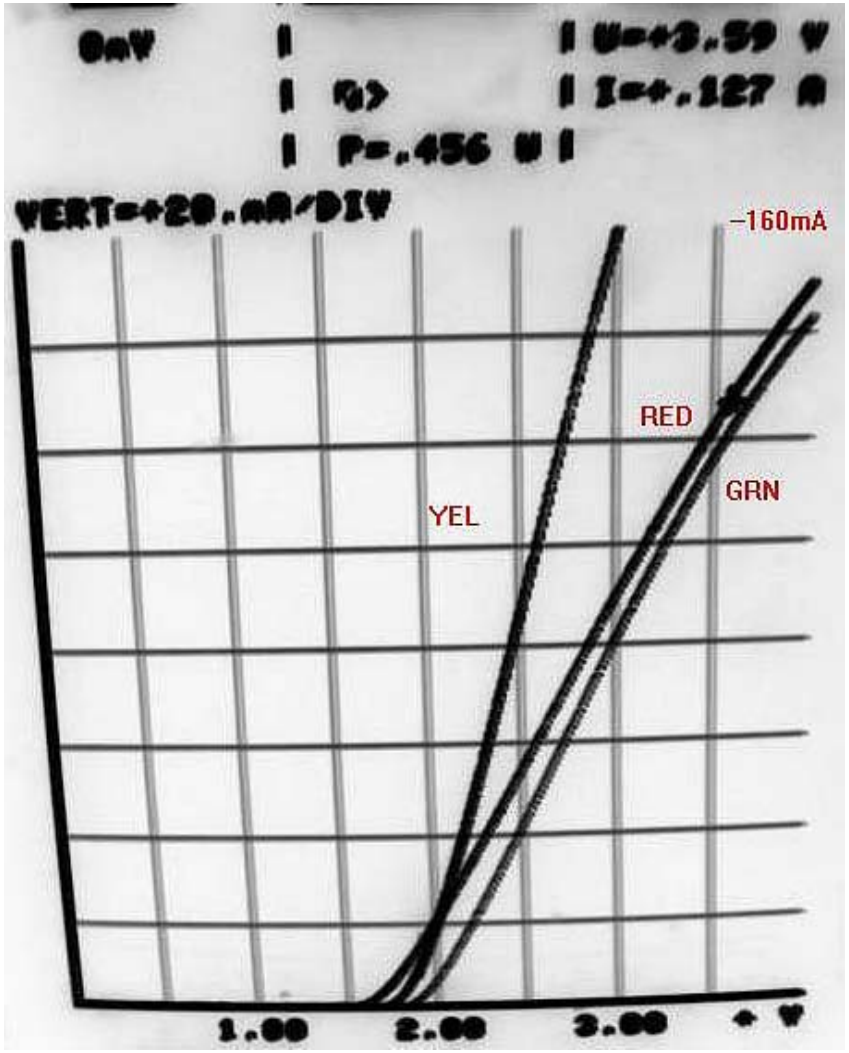


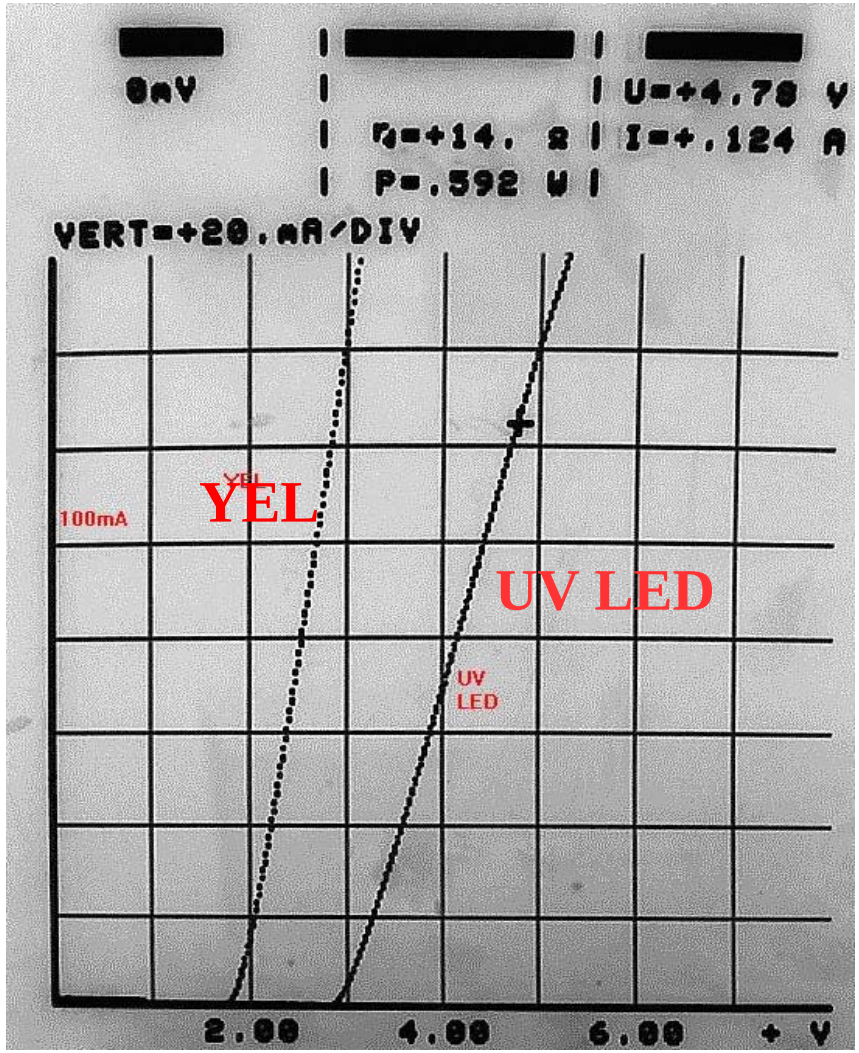
UV-LED parameters

- We have to made own datasheet, due to lack of the information.
- To sort 500 pcs best out of 1000 pcs

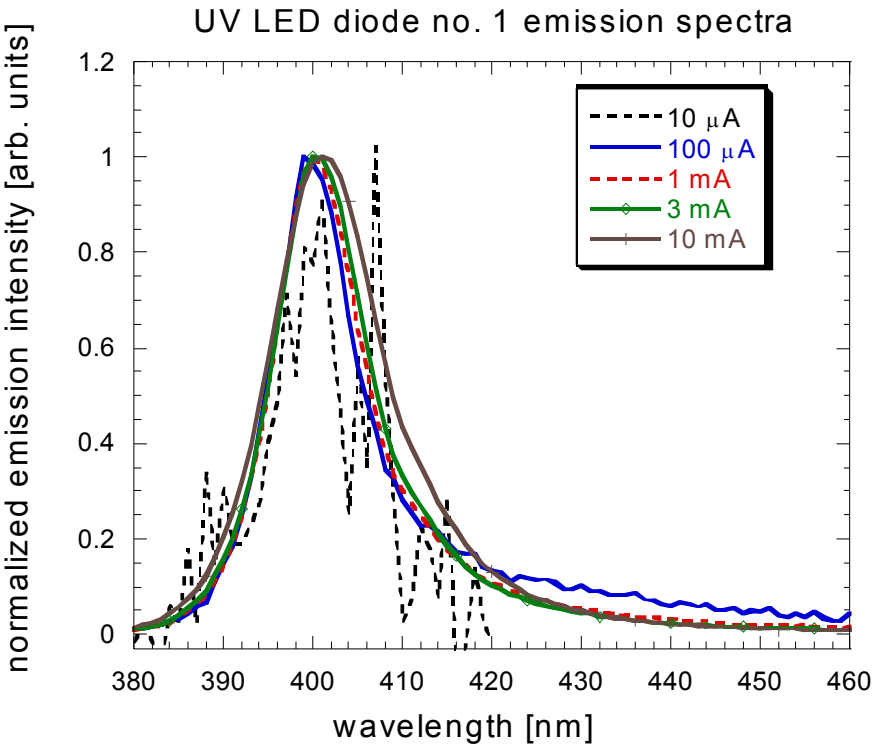
UV LED forward V-A char

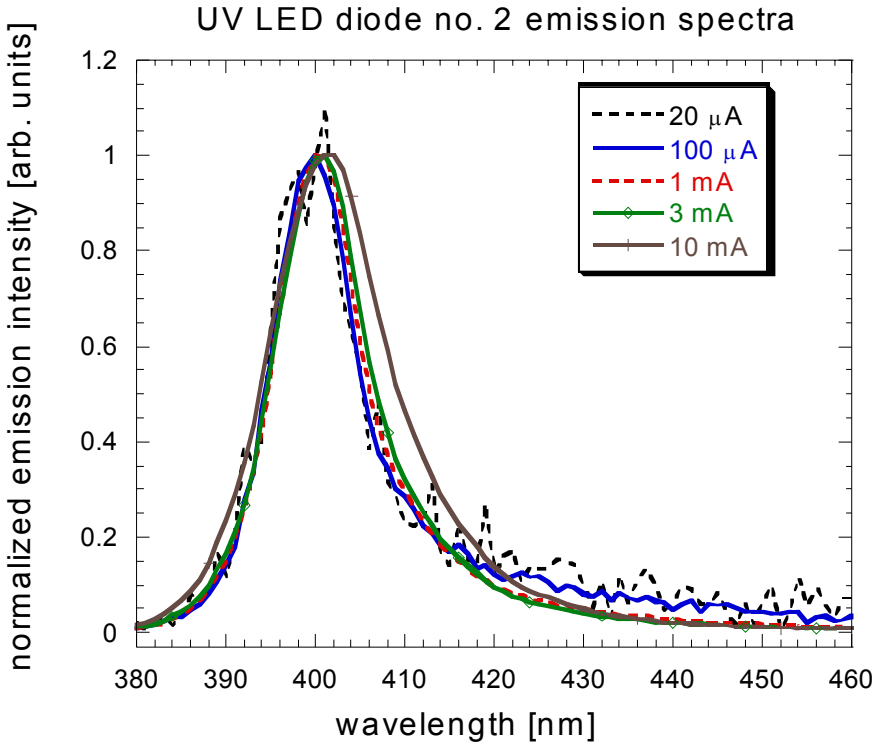
Apr2005



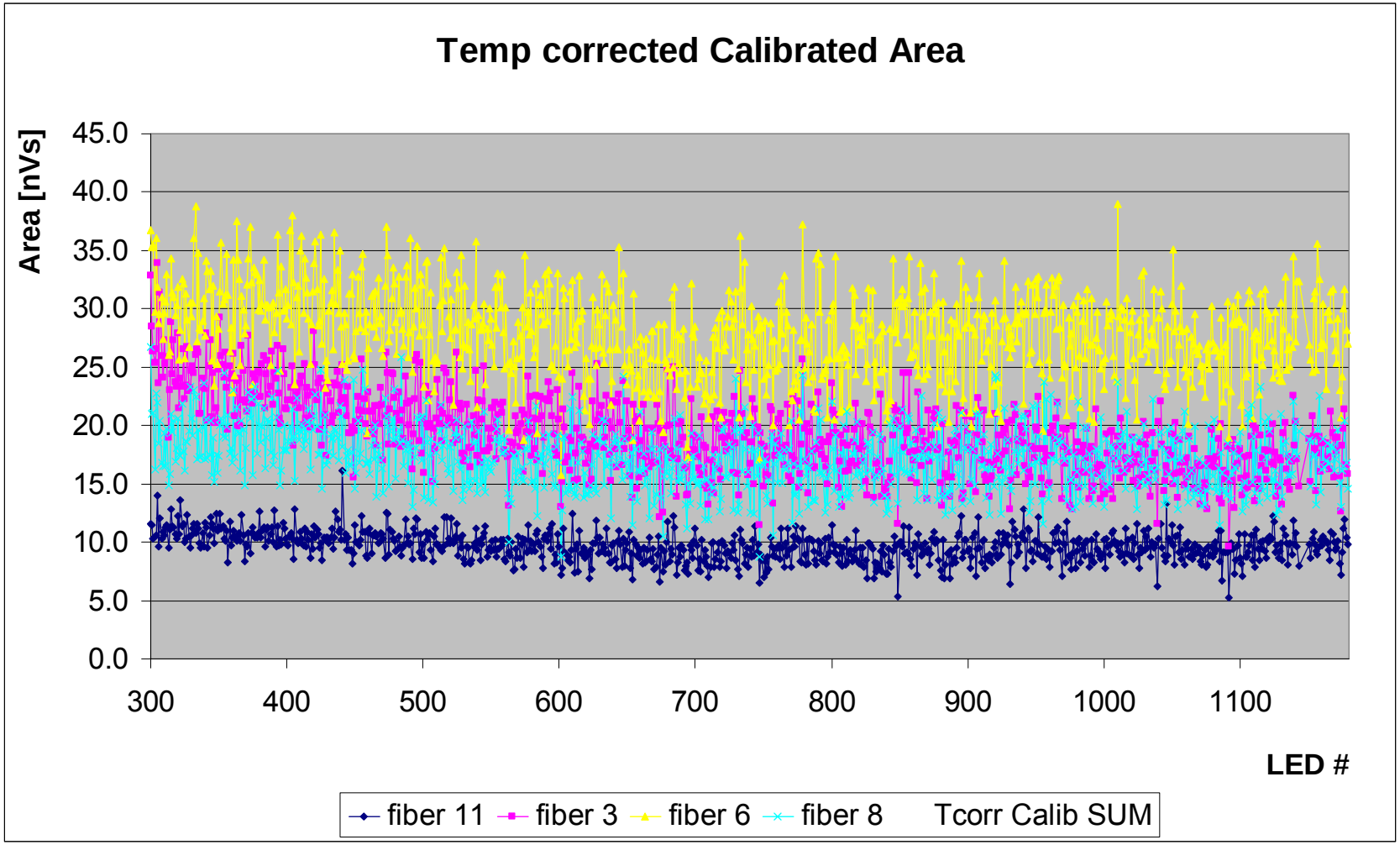


Emission spectra of UV-LED

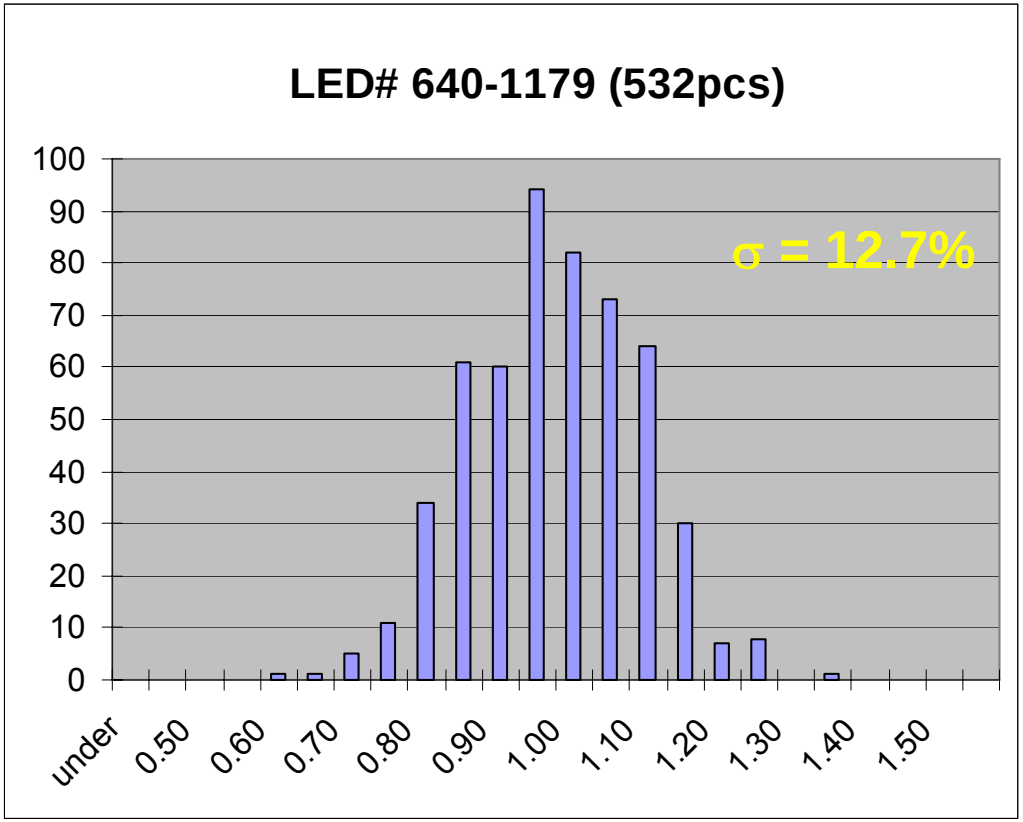




UV LED homogenity measurement – 872 LEDs



Selection criteria



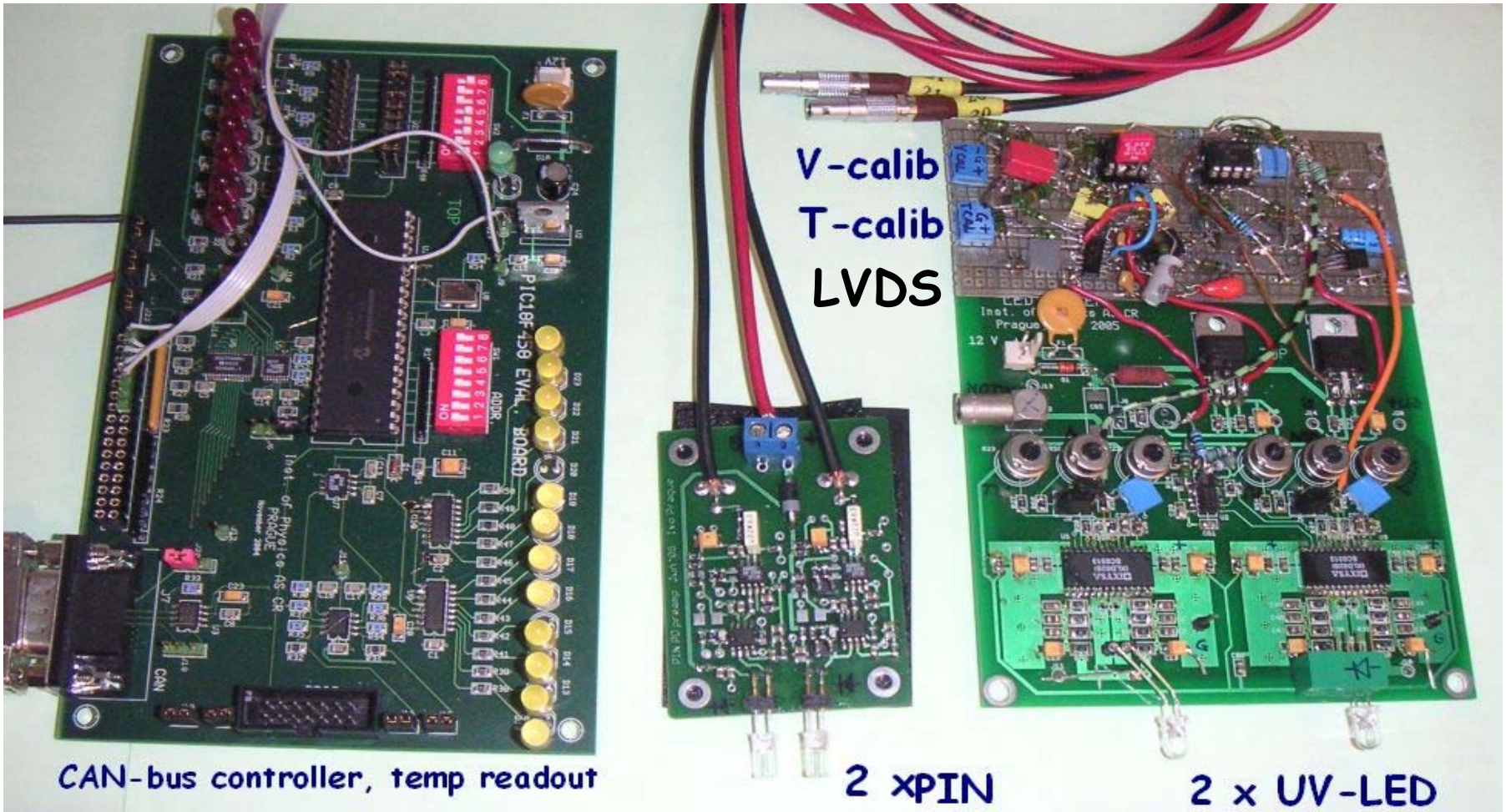
For details see
J. Zalesak, CALICE 2006, Montreal

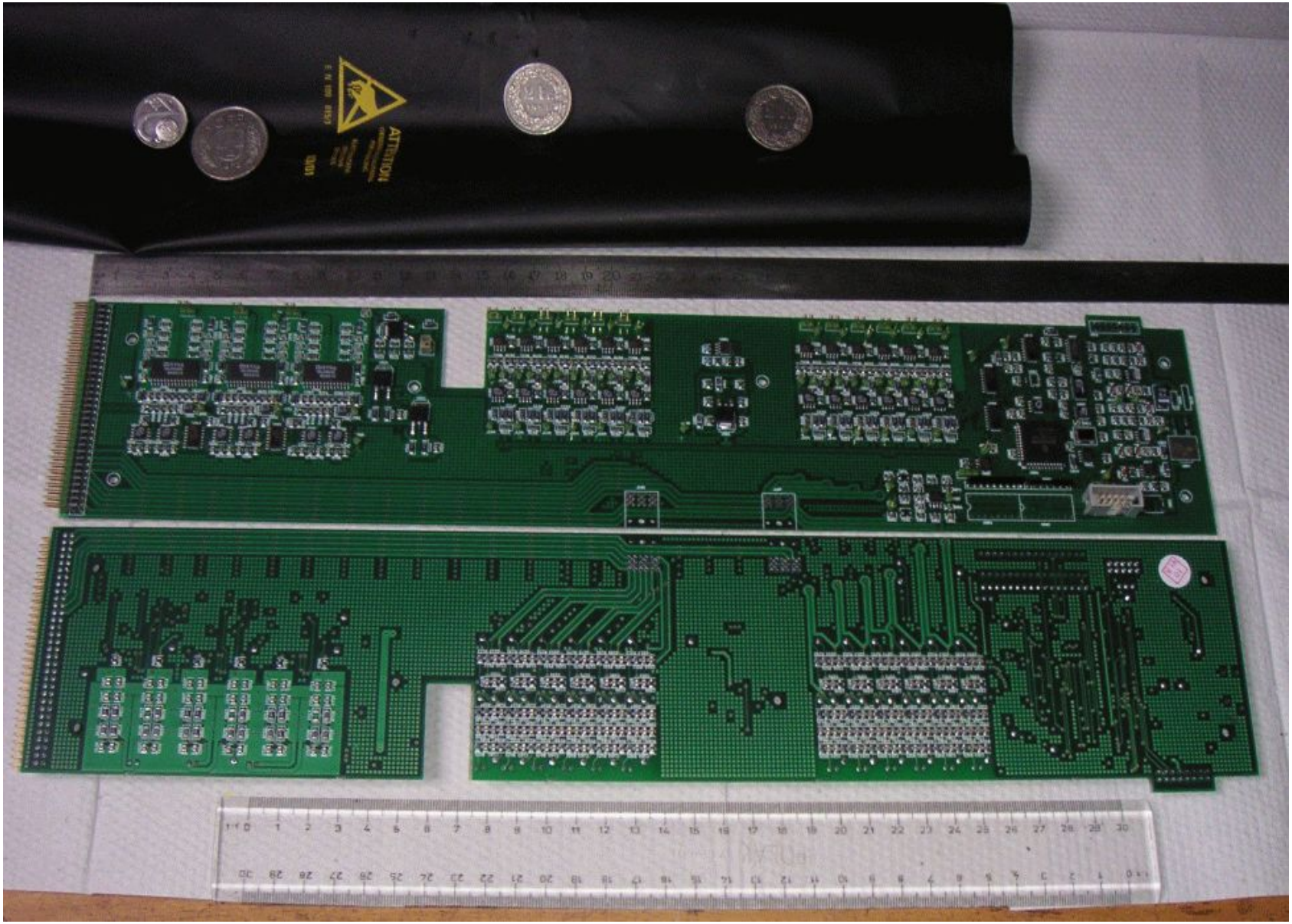
LED #	*koef RMS*	*100%*	*± 20 % 1.5*	*± 15 % 1.35*	*± 10 % 1.22*	*± 5 % 1.11*
all	1.000	872	773	650	498	260
	13.1%	100.0%	88.6%	74.5%	57.1%	29.8%
640--1179	0.955	532	498	434	309	176
	12.7%	100.0%	93.6%	81.6%	58.1%	33.1%

CMB = LEDdrv + PINdiode preamp + CANbus + temp readout

CALICE oct05

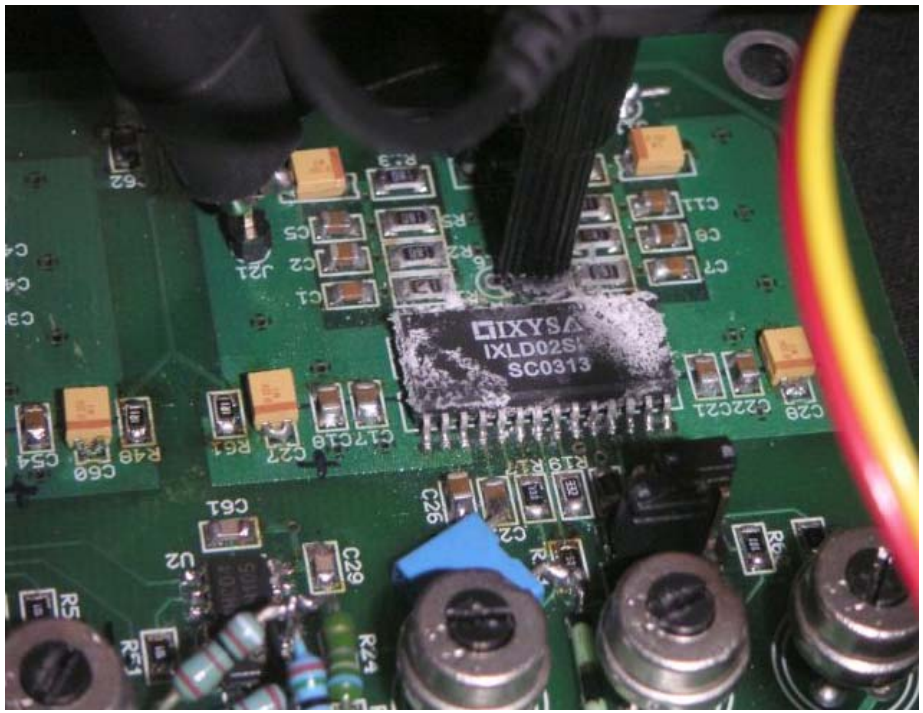
All TESTED





LED driver temperature test

Oct05



- An ice on plastic house of LEDdrv chip
- Cooled by KALTE spray upto -40deg.C
- Warmed by solder tip to different components GND pins
- Uncalibrated, but we know a scale ~200deg.C

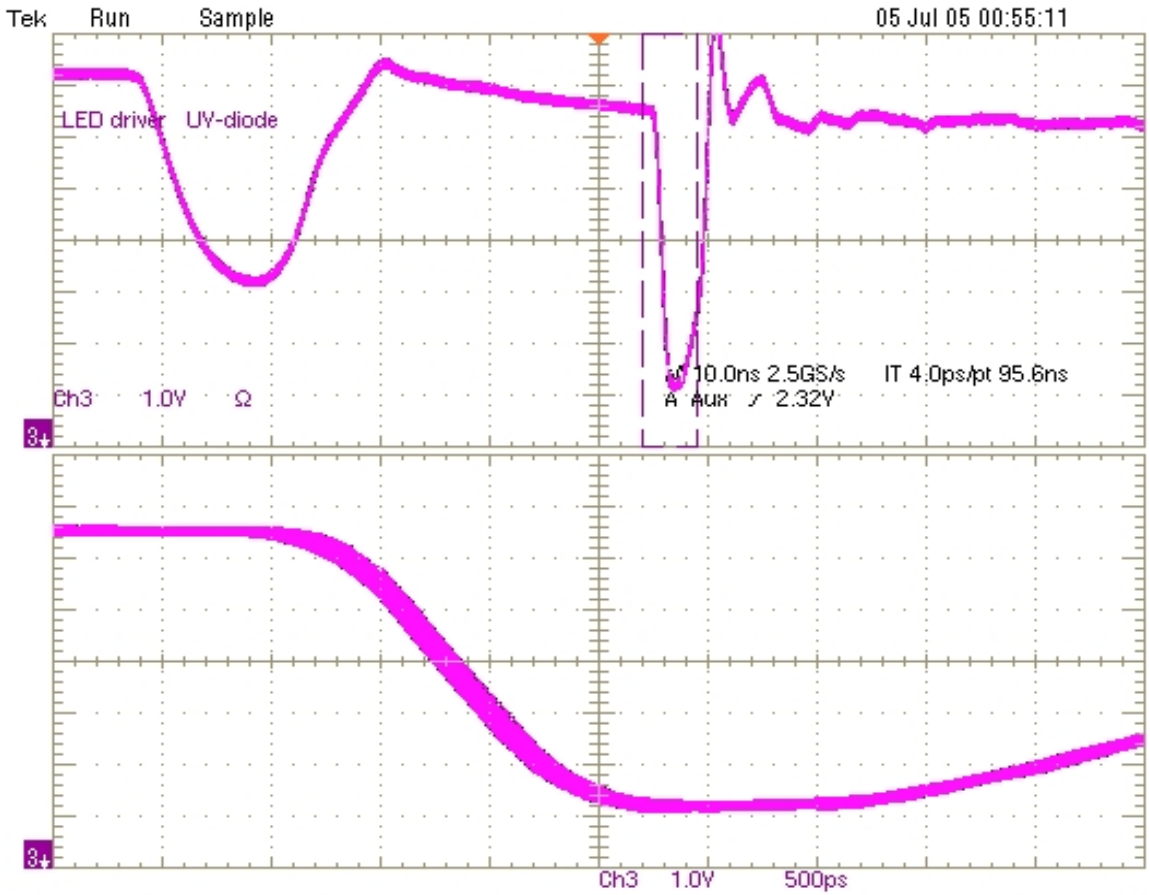
LED driver jitter

JULY 05

- TDS 5104
  2.5Gs
  oscilloscope
- Fast probes

Jitter = 200ps

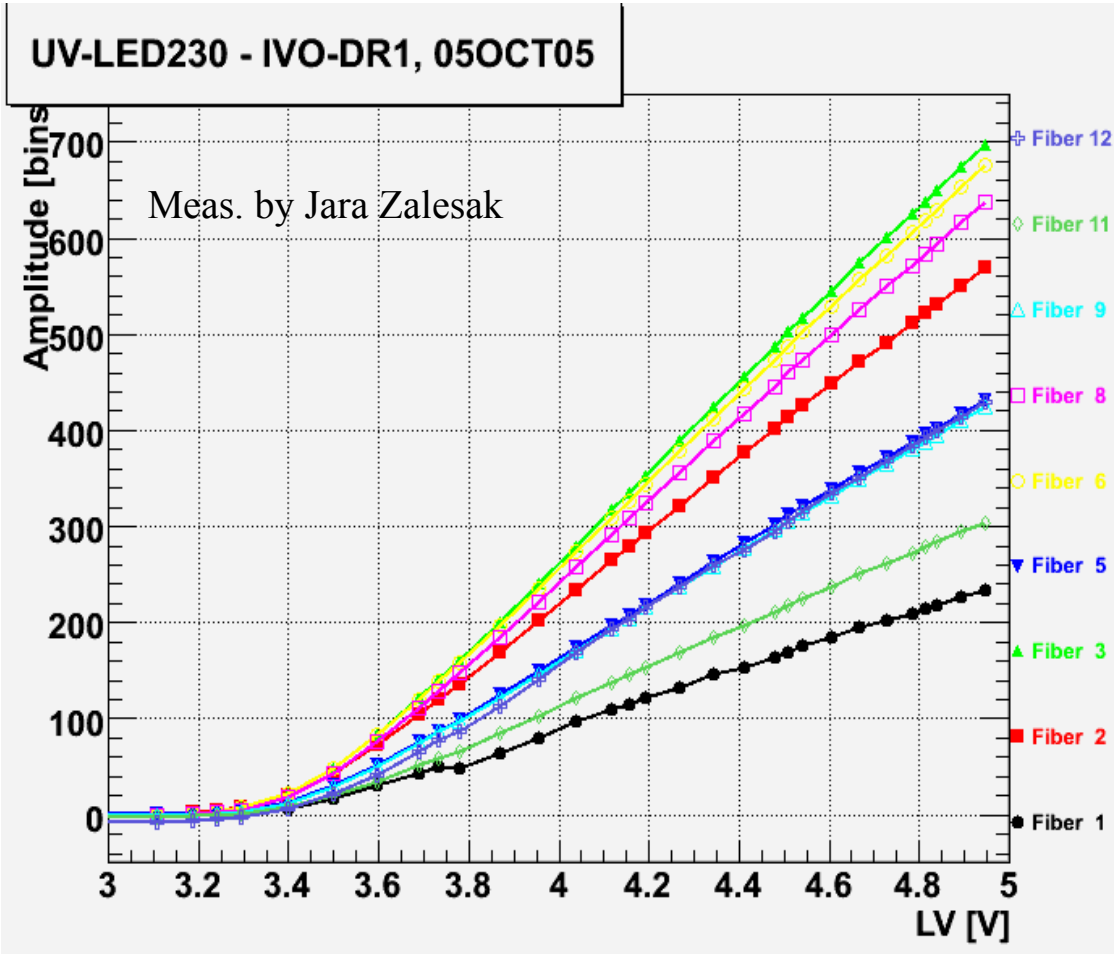
1hr at 10kHz, same jitter as running
15min on picture



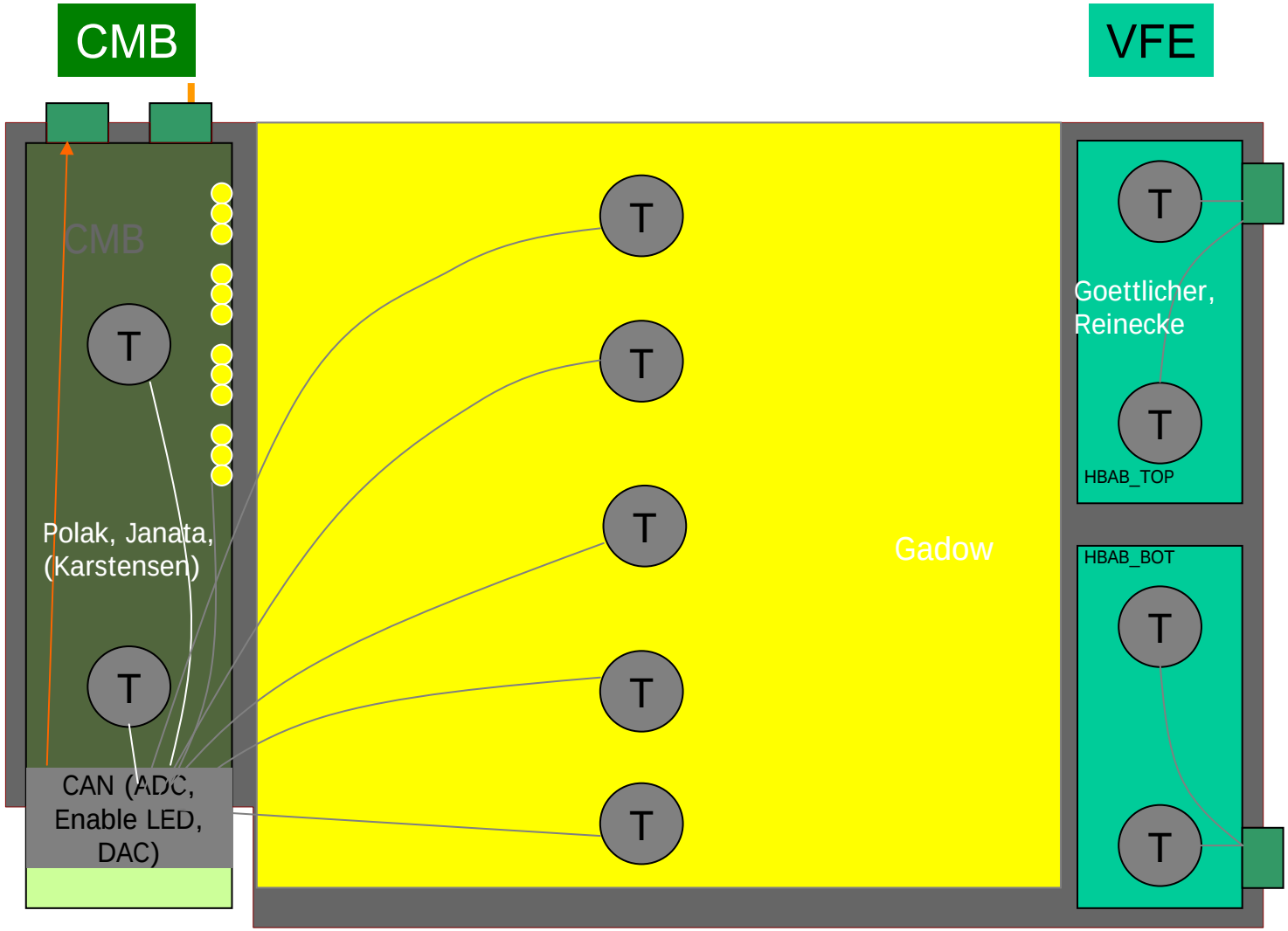
Zoom 500ps / div

LED-driver test at Prague

Oct 2005



- Single UV-LED response to LEDdrv "linearity test"
- 9 of 12 fibres measured by very low gain APD @190V M~2 to 3
- Preamp + DAQ 10bit ADC Camac
- LV[V] is a recent controlling voltage


CMB
VFE
CMB
T
Polak, Janata,
(Karstensen)
T
CAN (ADC,
Enable LED,
DAC)
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Gadow
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Goettlicher,
Reinecke
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HBAB_TOP
HBAB_BOT
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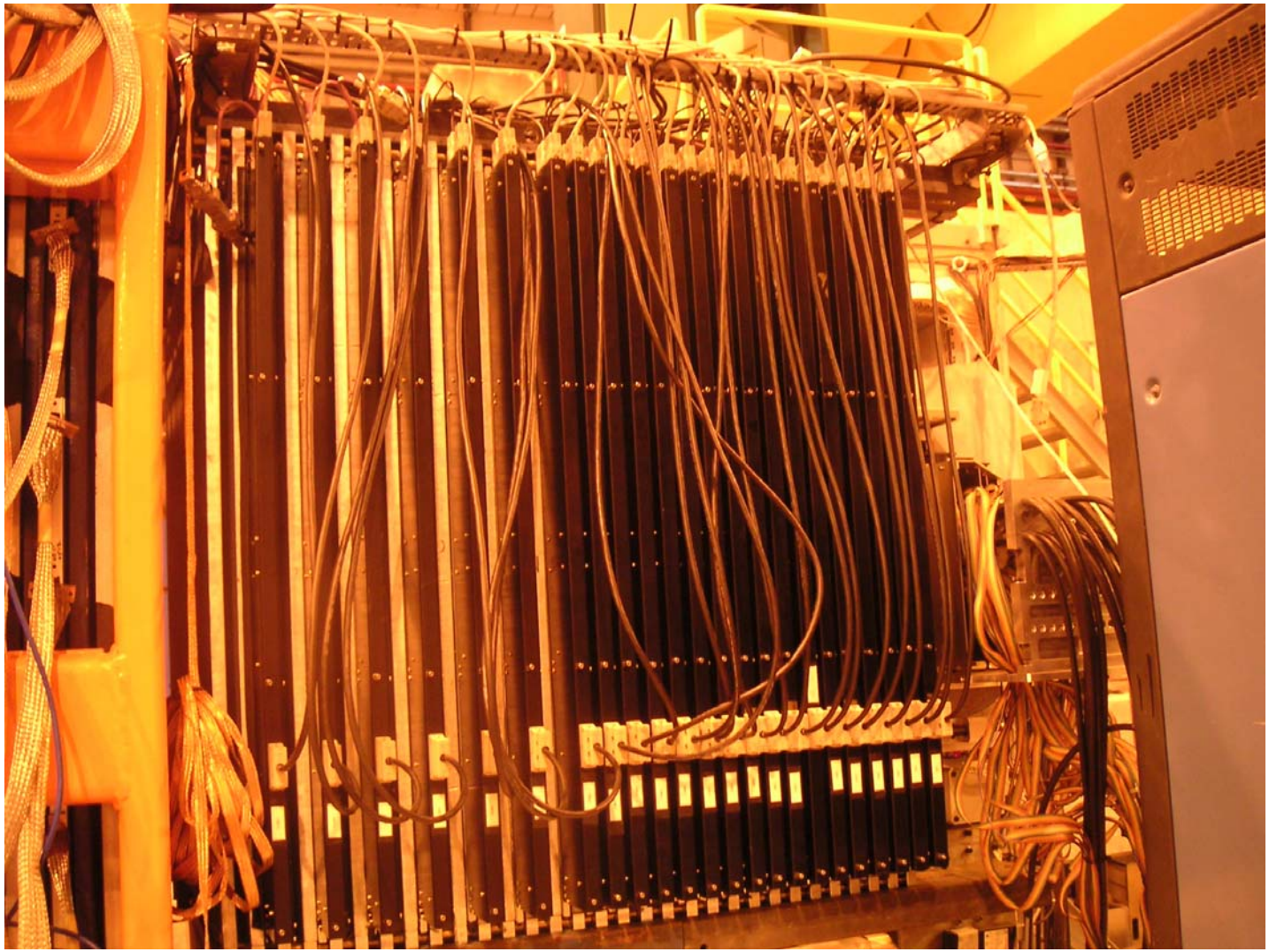
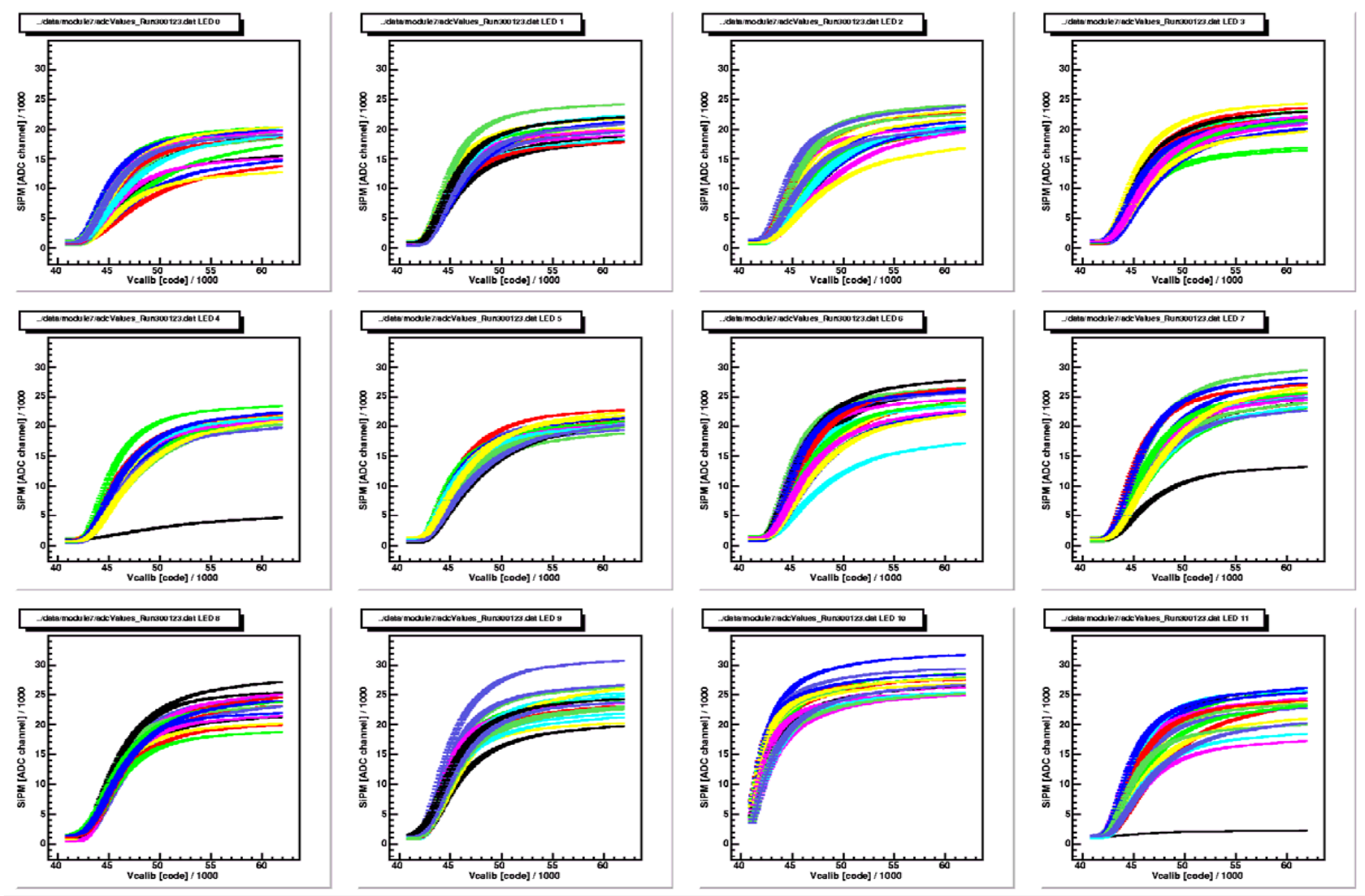
T

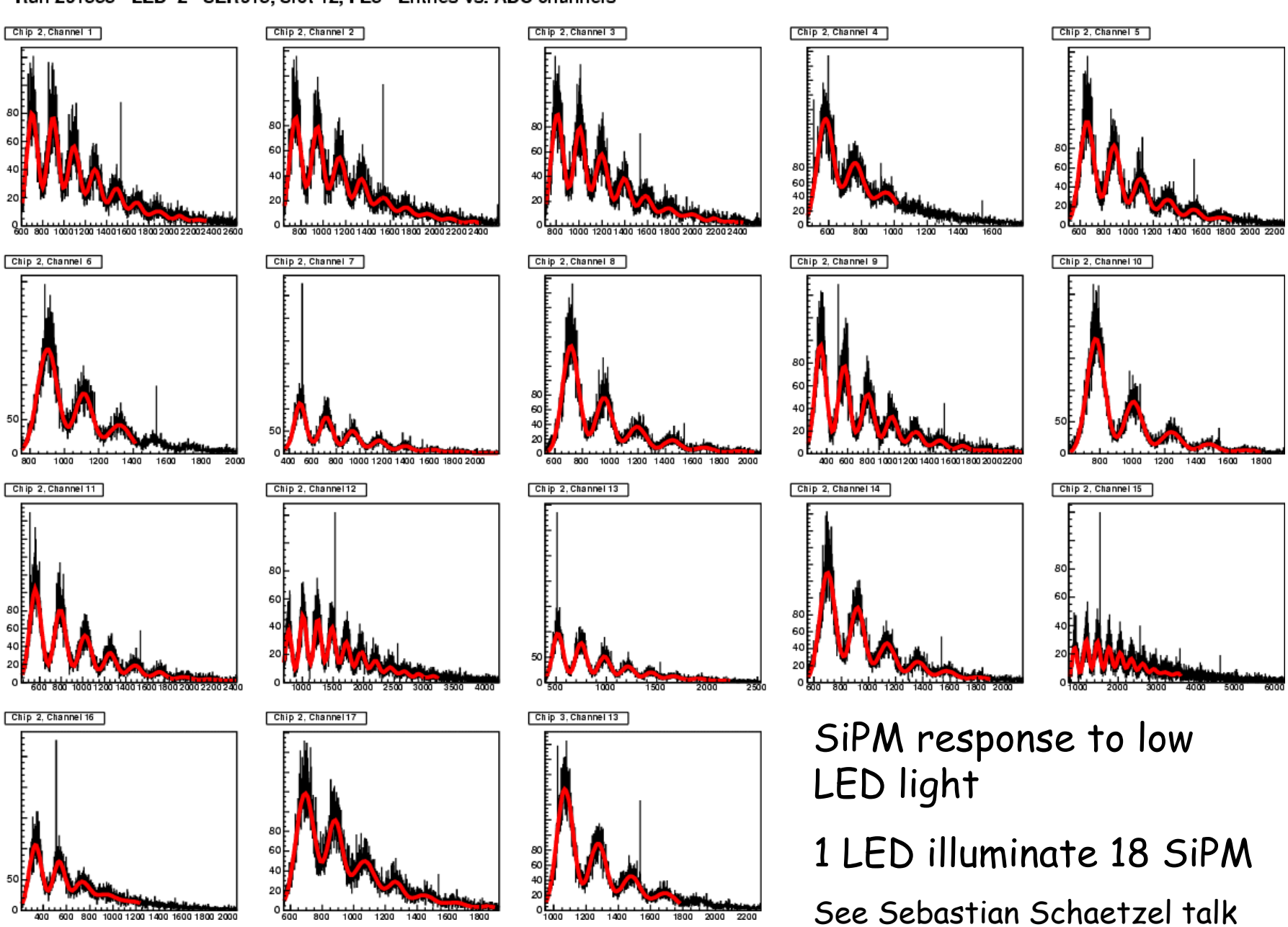
CMB Installation to AHCAL at CERN



Saturation curve of SiPM (linearity test of one plane) LED -> SiPM



Made by Nanda Wattimena



SiPM response to low LED light

1 LED illuminate 18 SiPM

See Sebastian Schaetzel talk

Conclusions

- **LEDdriving** system is **temperature pretty stable** , well bellow 1ns @ normal range (40degC)
- Cooled each one adds -300ps delay, heated some +300ps each
- Total delay is in range of -1ns to +1ns for estimated temp. range 200deg.C
- Spread of the Delay in one plane (12LED) around 1ns
- 1hr Jitter is in range 300ps

- 23 CMB installed into HCAL prototype
- CMB fullfil requirements – details see in S. Schaetzel talk

Acknowledgment

- Inst. Of Physics Prague

  - Jaroslav Cvach
  - Milan Janata
  - Jan Šťastný
  - Jaroslav Zalešák

- DESY Hamburg

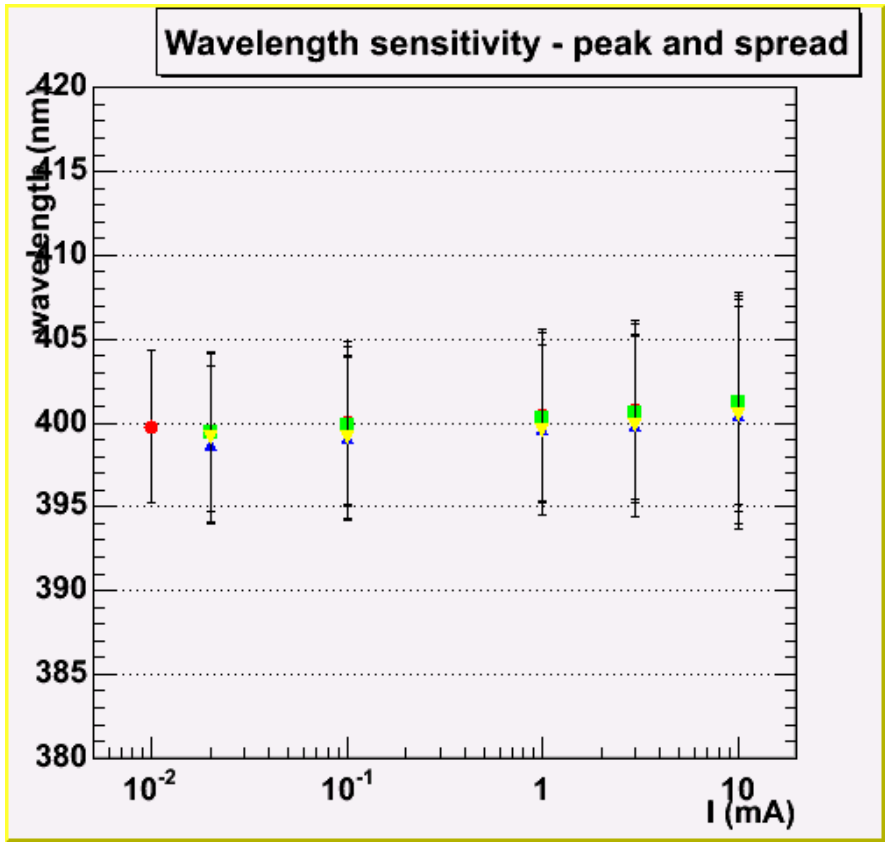
  - Karsten Gadow
  - Sven Karstensen
  - Hendrik Meyer
  - Sebastian Schaetzel
  - Nanda Wattimena

BACKUP

UV-LED tests Apr 2005

- Volt-Amp characteristics DC-mode
  - Forward and reversed characteristics
  - Tested with Characteroscope, 300μs pulses at 1kHz
  - Compared with precise 6.5 digits DMM at lower current
- Optical spectrum, linearity test DC-mode
  - Measured tnx to Martin Nikl, Inst. of Physics Prague
  - Test equipment spectrometer ORIEL 50540
- Small statistics
  - 4 pcs of UV LED only

Wavelength emission of UV-LEDs



- Peak and spread derived from Gaussian fit on LED emission frequency spectrum (-2,+1)*σ
- Peaks @ (400±1) nm for all 4 UV-LEDs and all light intensities
- Spread of emission (1 sigma from fit) in average:

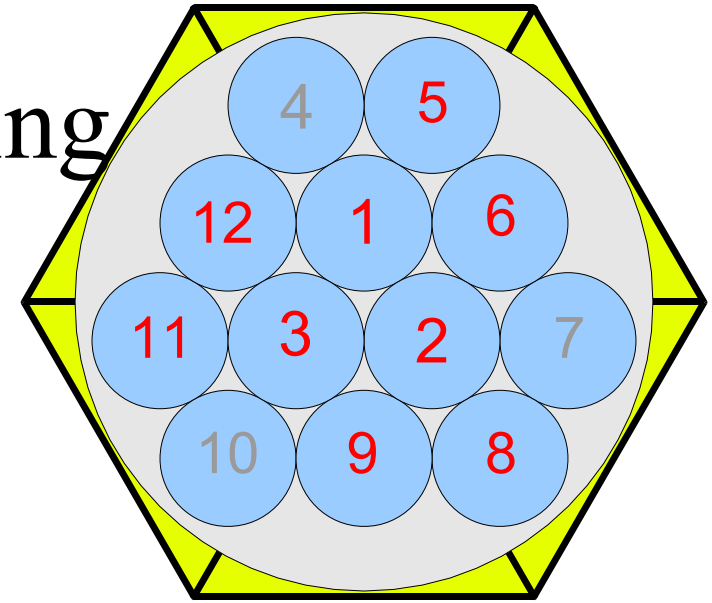
  (4.8), 4.9, 5.1, 5.4, 6.6 nm for

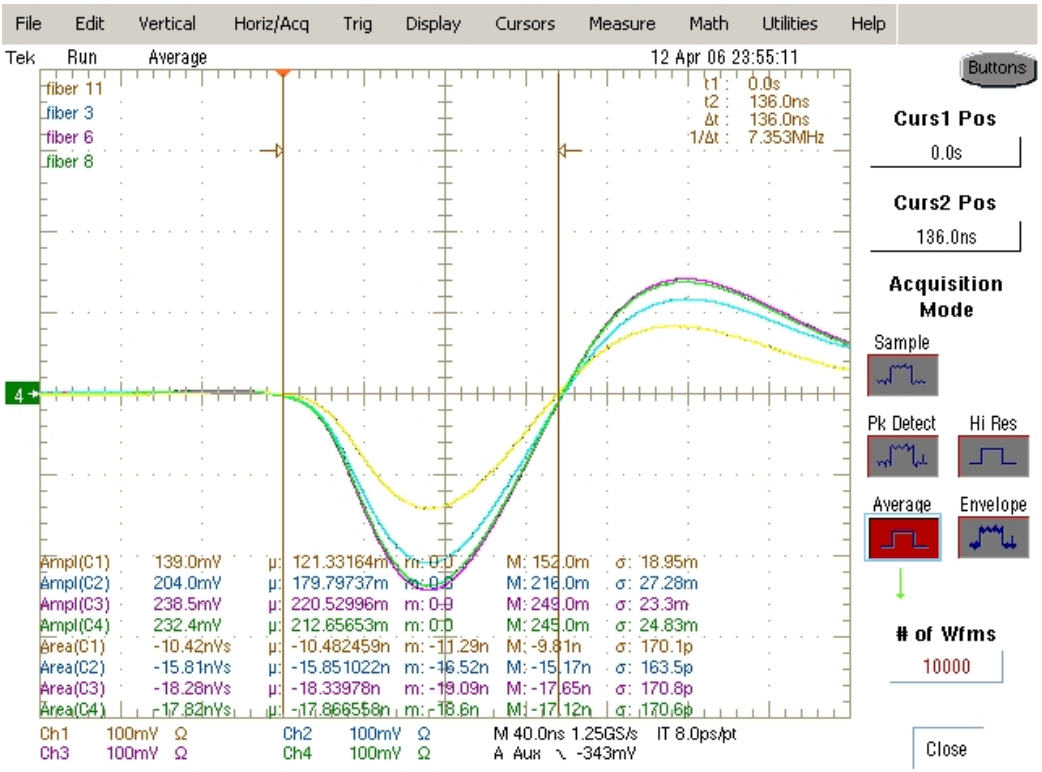
  (0.02), 0.1, 1.0, 3.0 10.0 mA

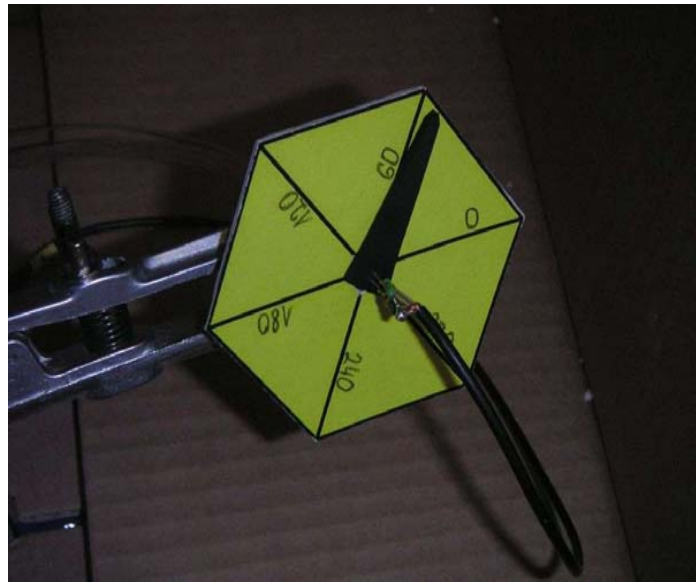
ns technique is not trivial

UV-LED sorting

fibre profile

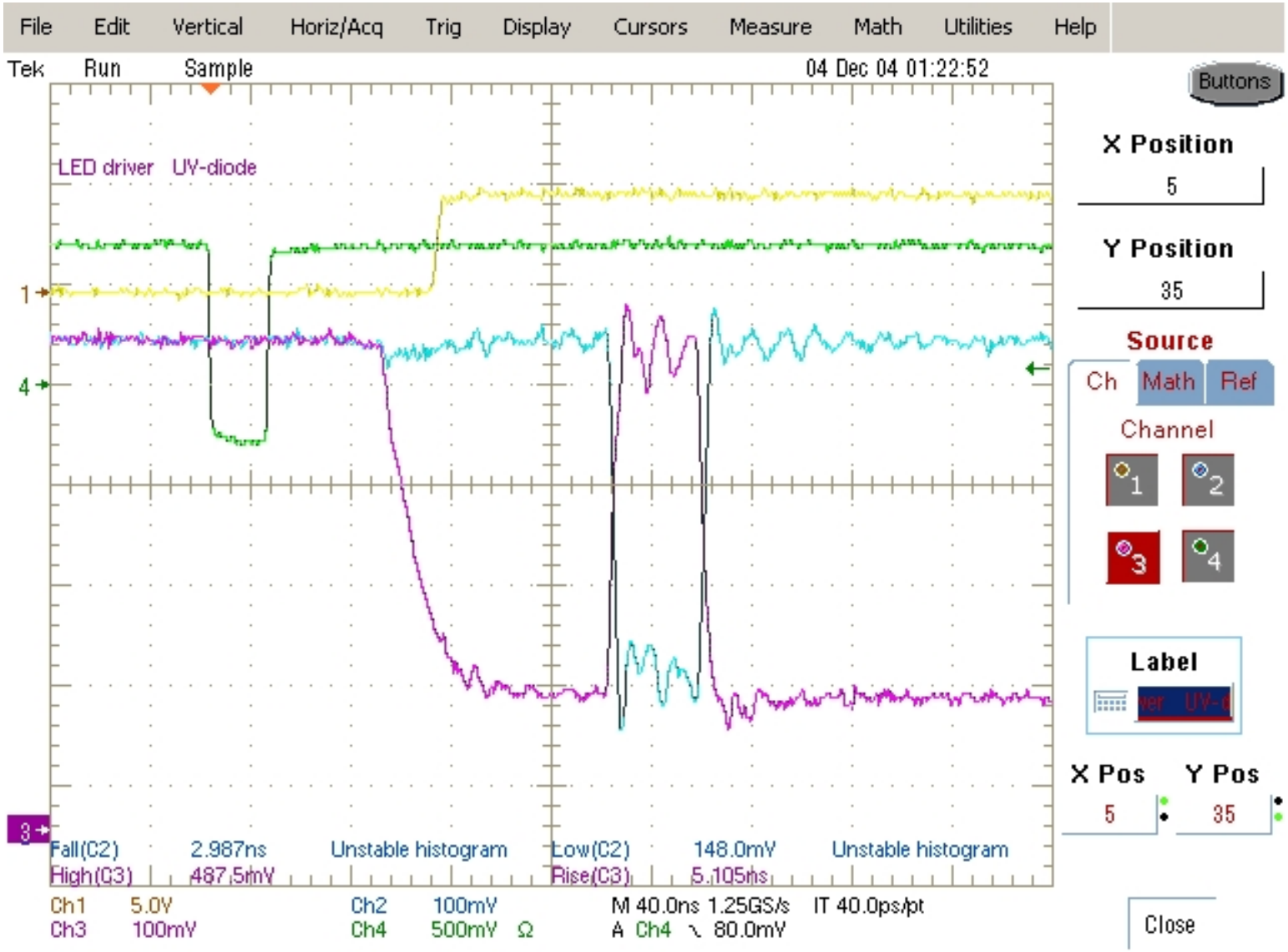




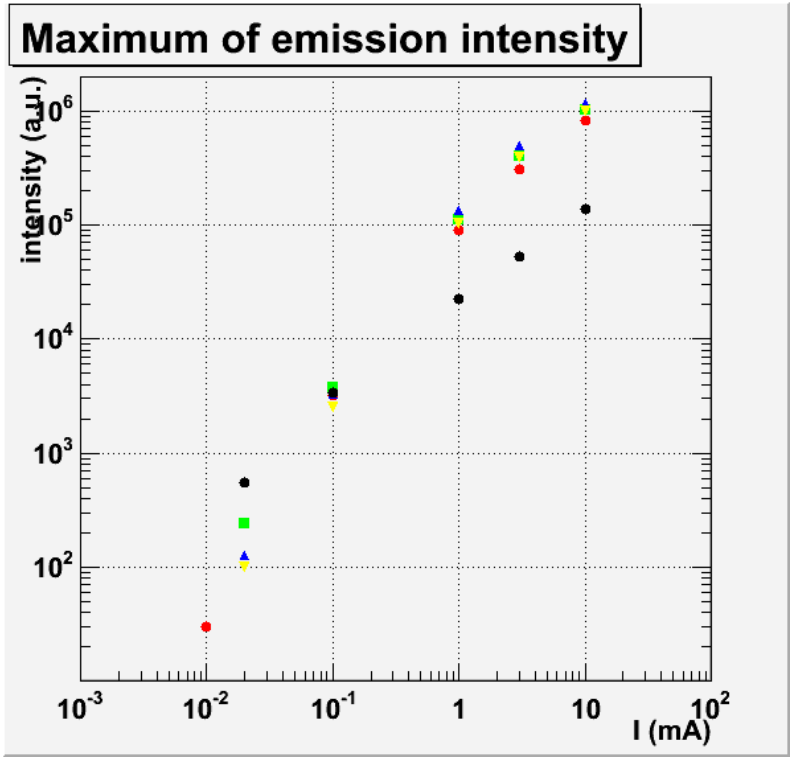


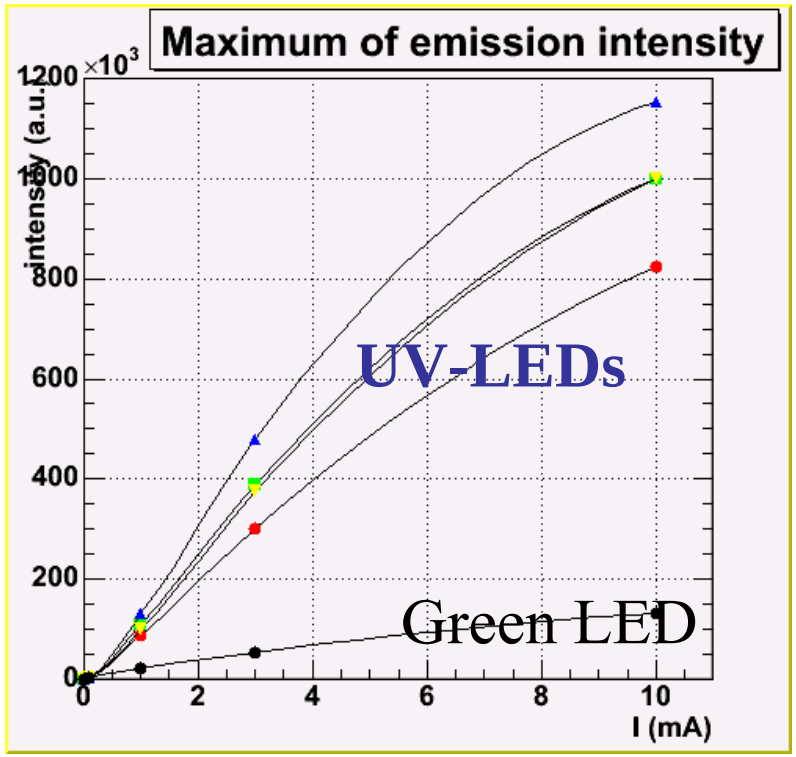
made by Jara Zalesak

LED pulse: blue & red in coincidence UV led



LED intensity vs current (coarse measurement)





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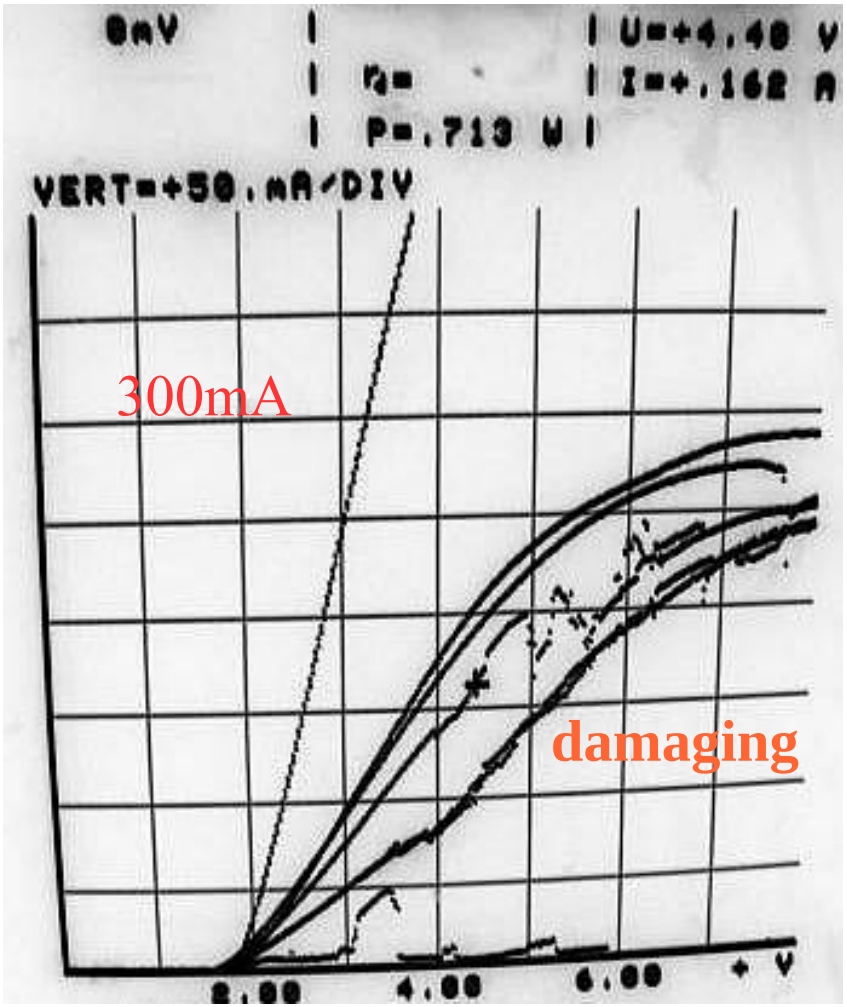
  → light intensity at spectrum peak position)
- Assumption of same spectrum shape (peak position and width as well)
  in all currents, else needed integration in some freq. range (~20% variation 1-10 mA)

➢ Not fully comparable absolute light intensity (adjustment of measurement uncertainty, small variation in spectrum shape, few points)

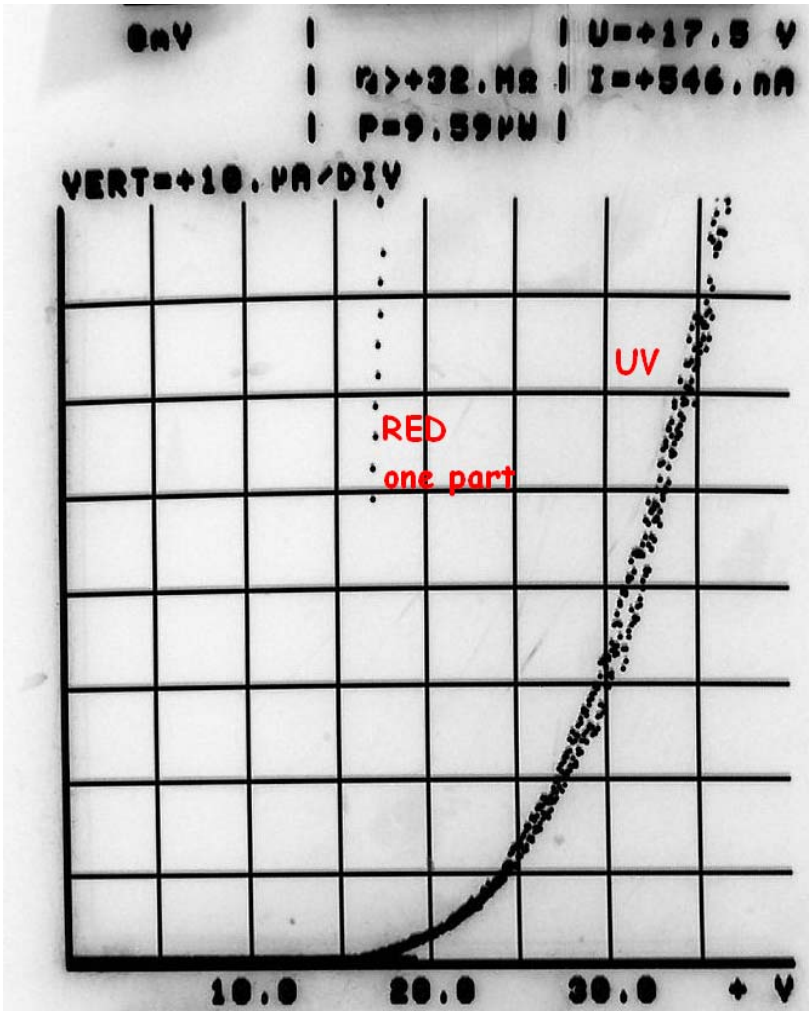
UV LED forward V-A char

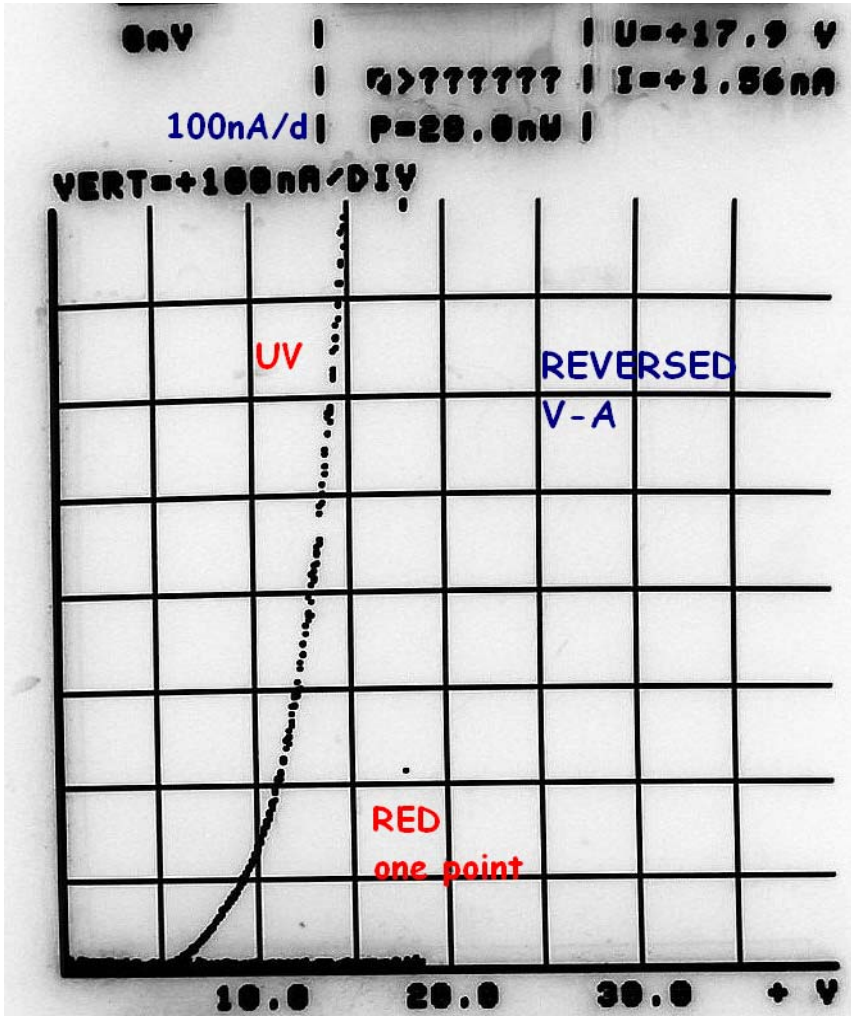


300 μs pulses at 1kHz rate
i.e. 33% duty factor

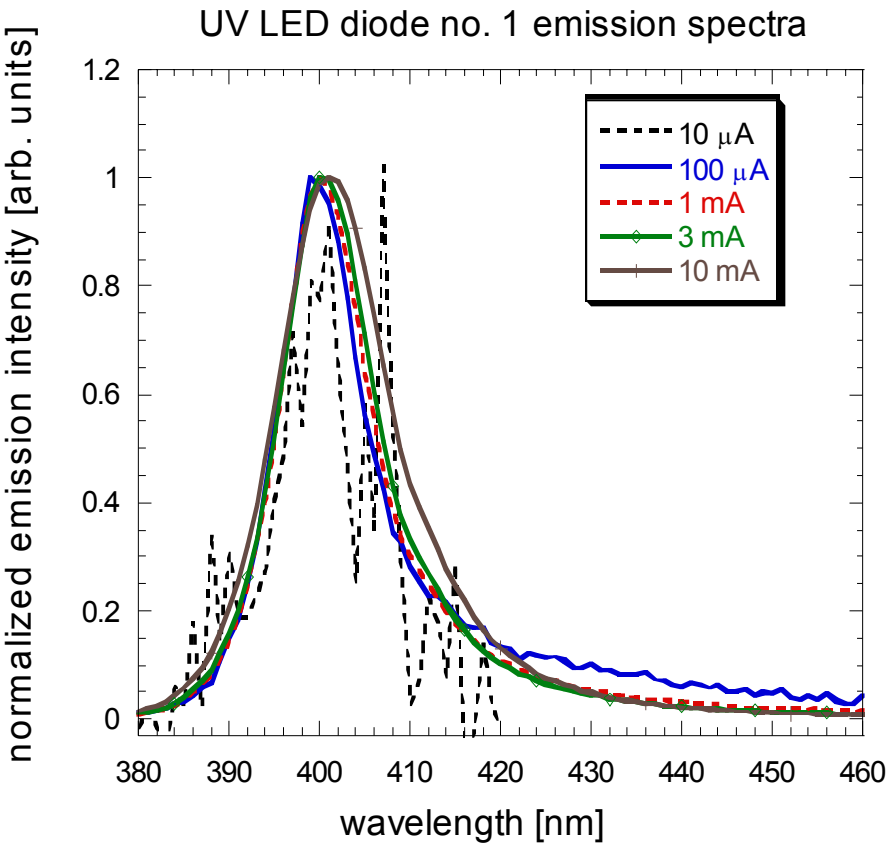
UV LED is more sensitive to the overheating than common LED

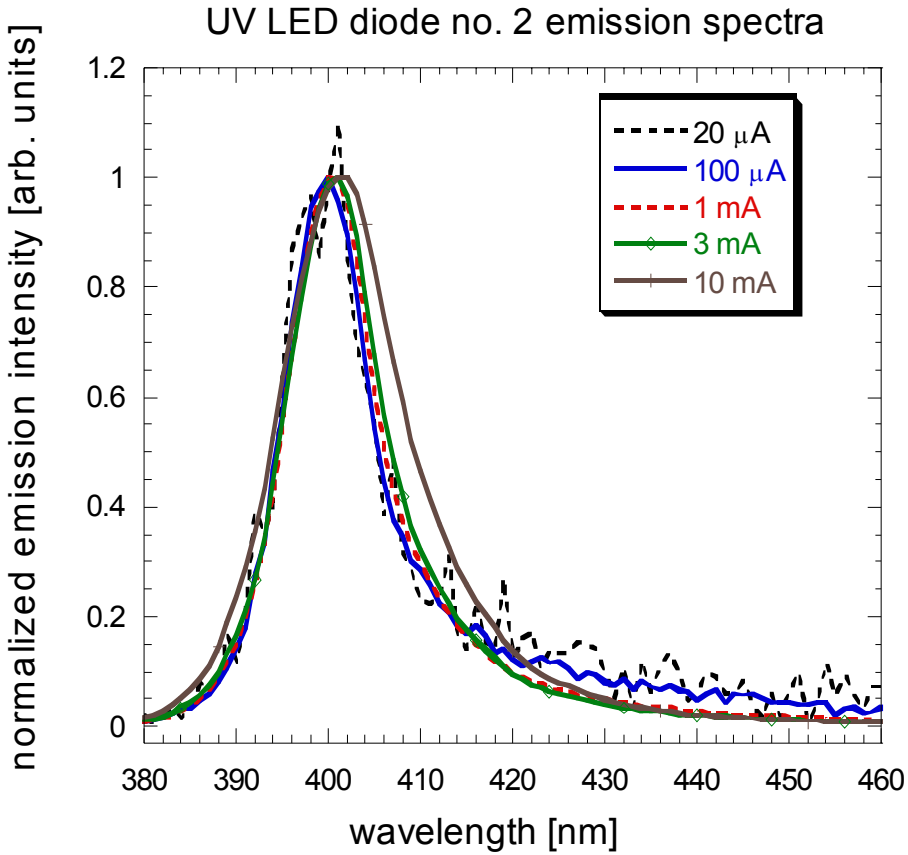
UV LED reversed V-A char



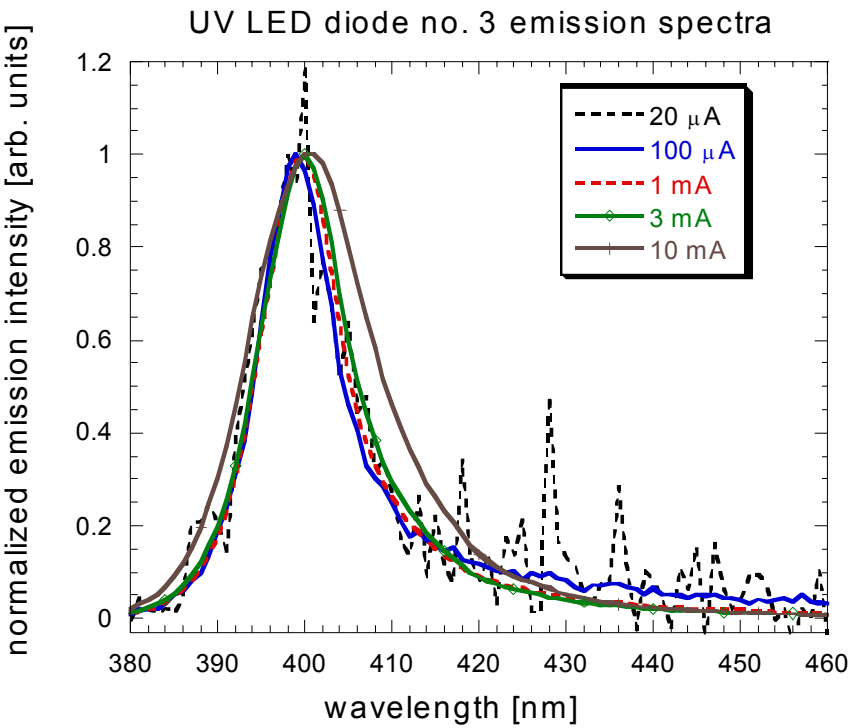


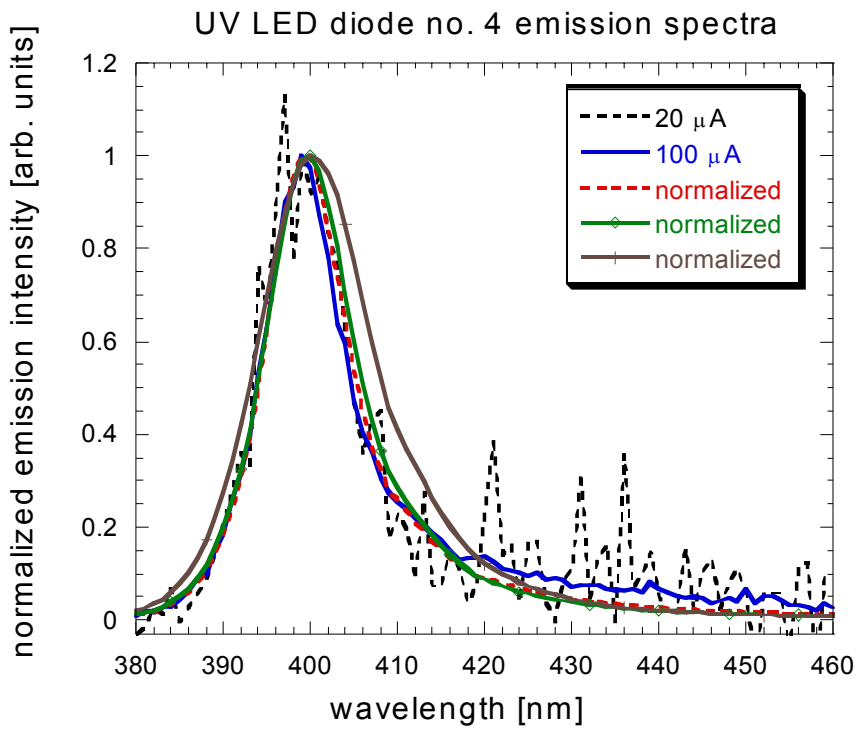
Spectra of UV-LED



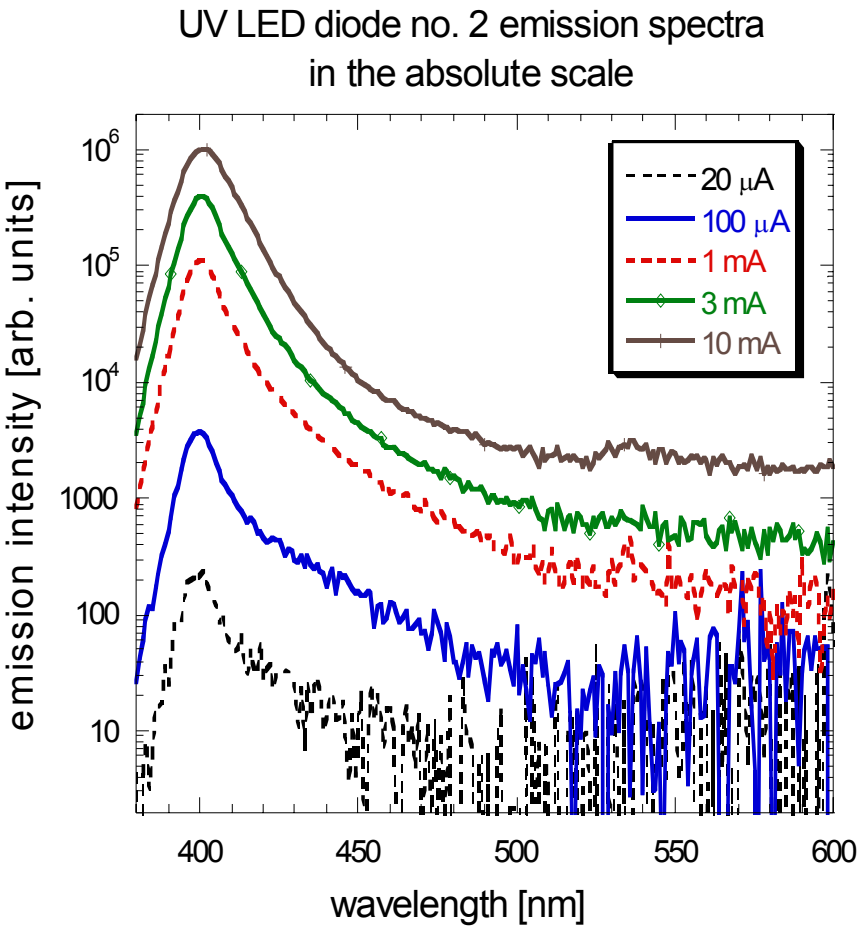


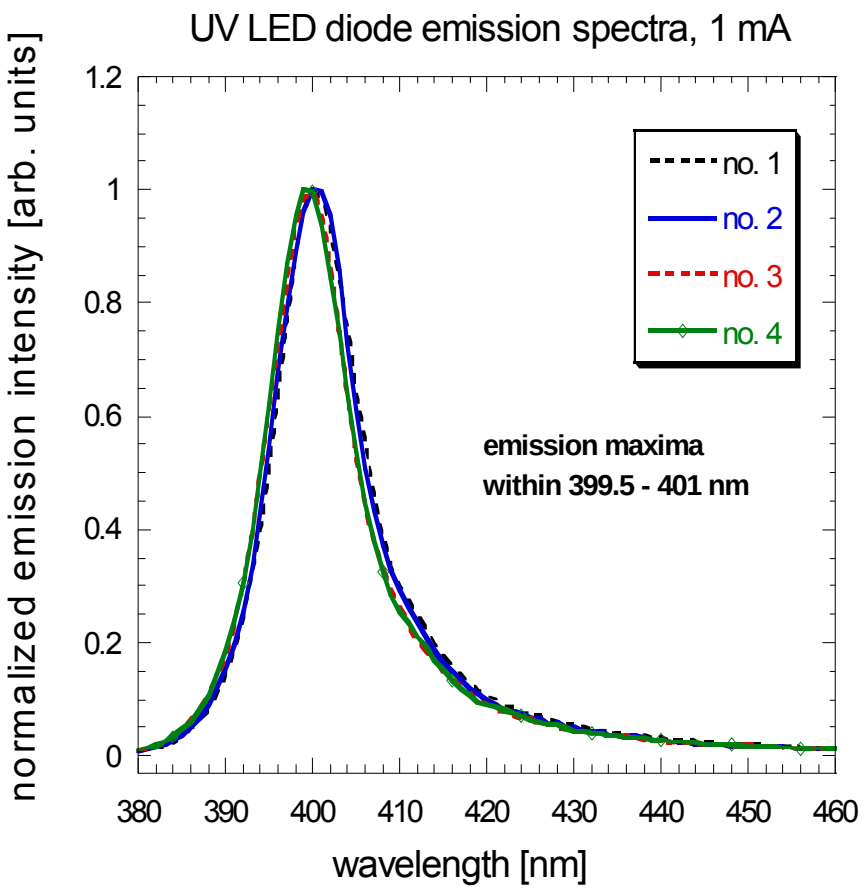
Spectra of UV-LED



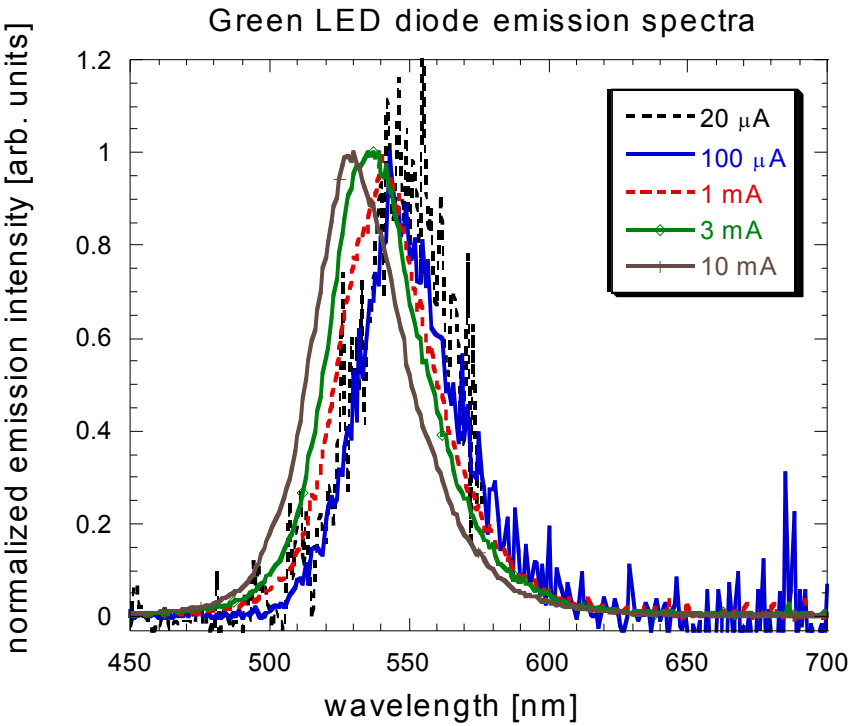


Spectra of UV-LED

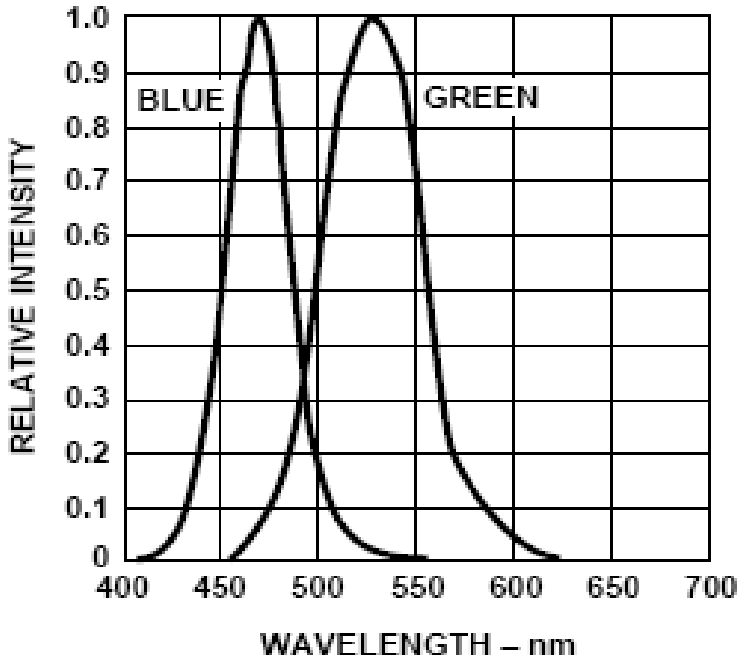




Spectra of GRN-LED Agilent HLMP-CM15

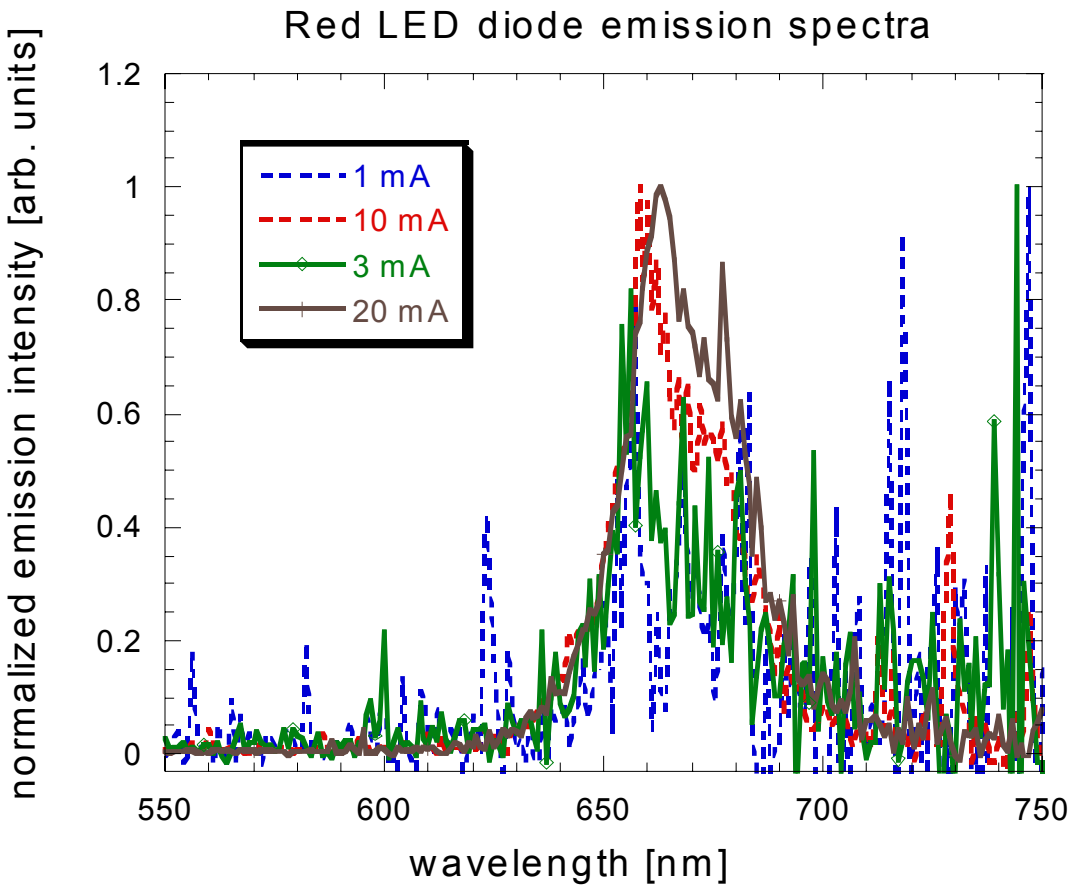


Pic from Agilent datasheet



Spectra of RED-LED

Ivo Polak, Prague Apr05

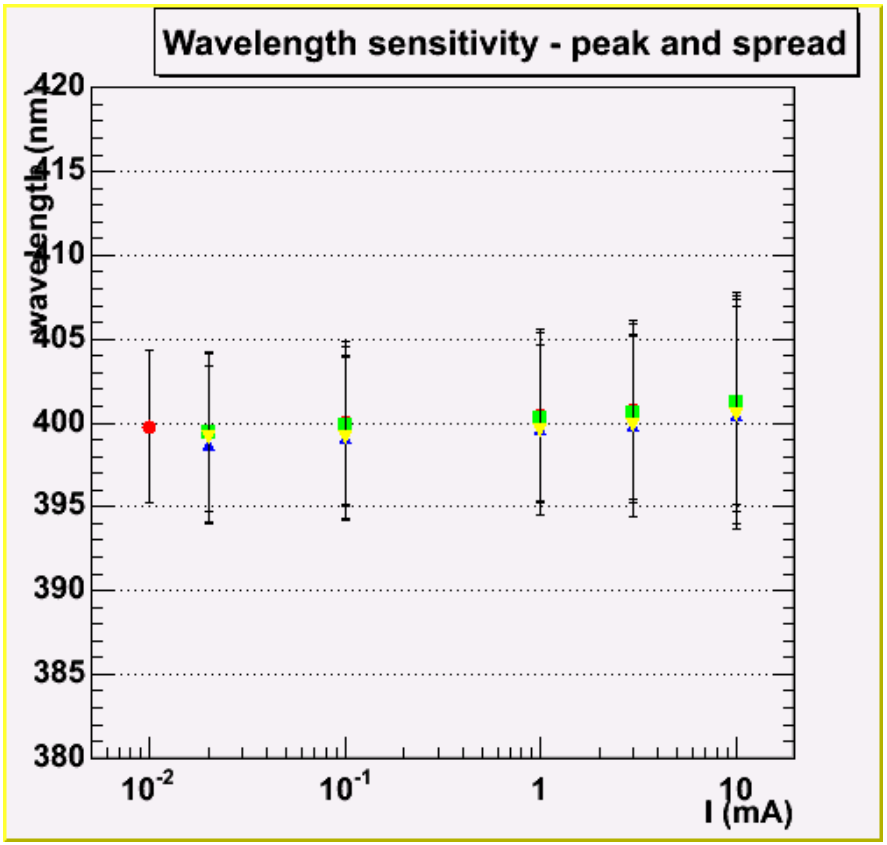


Not a nice spectrum

it was chosen **no-name LED**

Wavelength emission of UV-LEDs

Jaroslav Zalesak, Apr05



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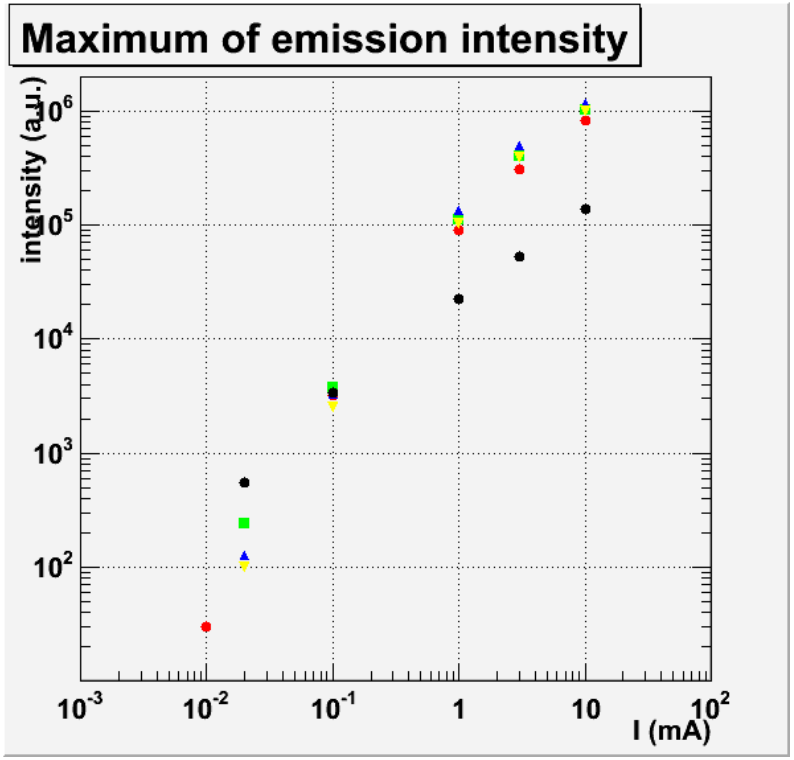
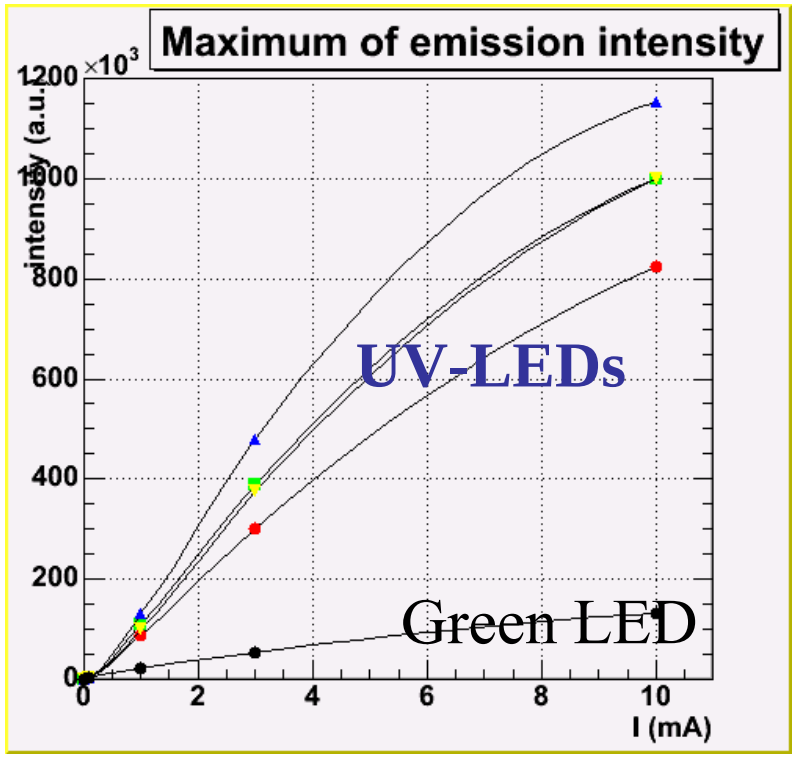
LED intensity vs current (coarse measurement)

Jaroslav Zalešák, apr05





- Intensity determined as height of gauss. fit on emission freq. spectrum
  → light intensity at spectrum peak position)
- Assumption of same spectrum shape (peak position and width as well)
  in all currents, else needed integration in some freq. range (~20% variation 1-10 mA)

➢ Not fully comparable absolute light intensity (adjustment of measurement uncertainty, small variation in spectrum shape, few points)

Large LED Quality test in Prague

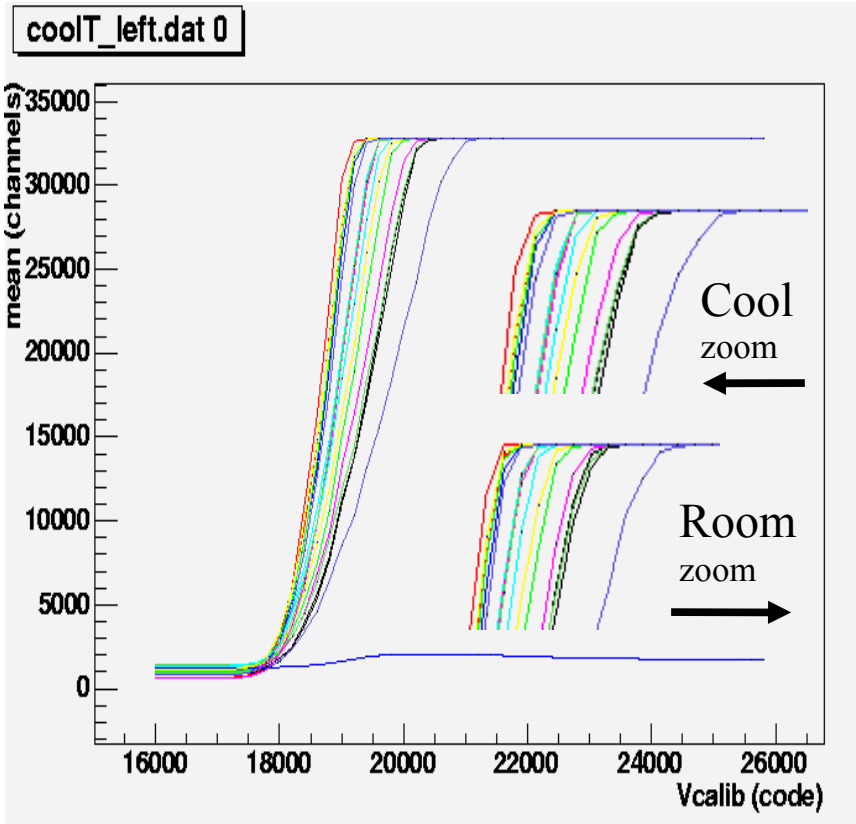
- **Setup:**
  - Ivo's LED driver, tested UV-LEDs
  - Light adapter (~2-3 mm air gap), fiber bundle (glued one end)
  - APD mask holding fibers on 9 APDs (small gain ~10) + 1 PIN
  - Preamp + Camac / oscilloscope readout
- **Measurements:**
  1. "Qualitative" -- 9 chosen fibers from bundle with 9 APDs for each UV-LED, sub-sample 30 (50?) pieces
     a) Light cone homogeneity – turning led around axis, 9 fibers in cross average values and spread for each position (same current)
     b) Variation light intensity – measure at low-medium-high LED currents
  2. "Qualification test" – selection 500 good LEDs of all
     - Using 4 channels oscilloscope measurement of signal shape satisfying some criteria (amplitude, width,..) derived from 1.
  3. "Ageing test"
- **General problems:**
  - How to determined 'good' value of LED current in MIP units
  - How to figure out what amplitude corresponds to 1 or 10 MIPs

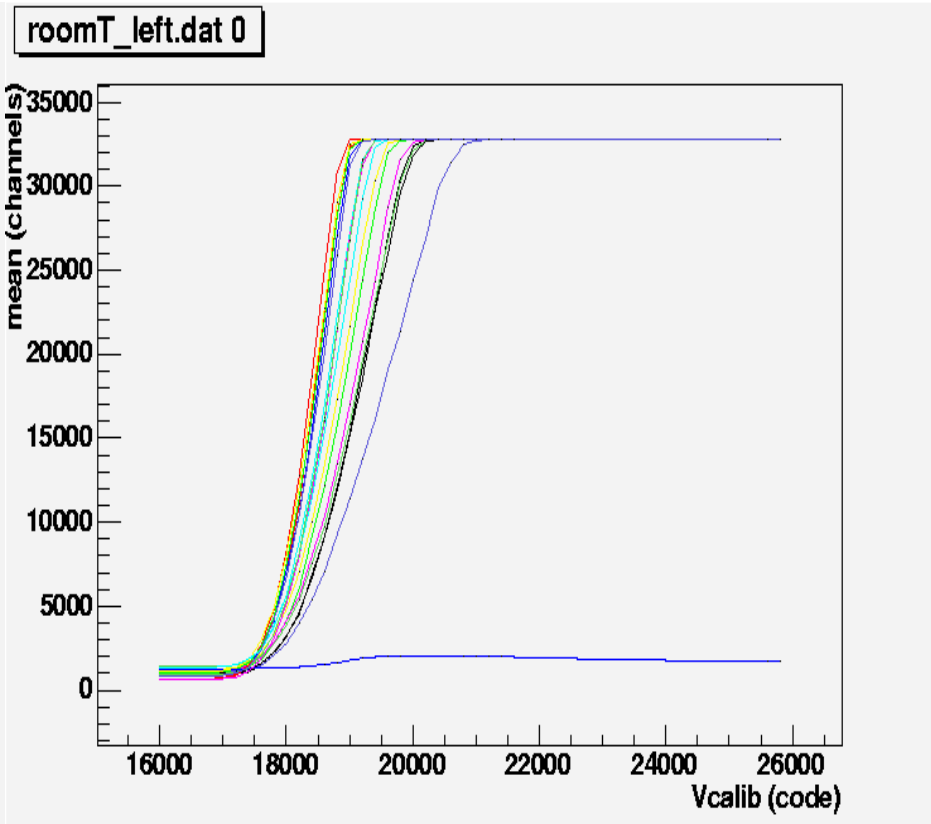
Completed by Jaroslav Zalesak, apr05

TEMPERATURE sensitivity

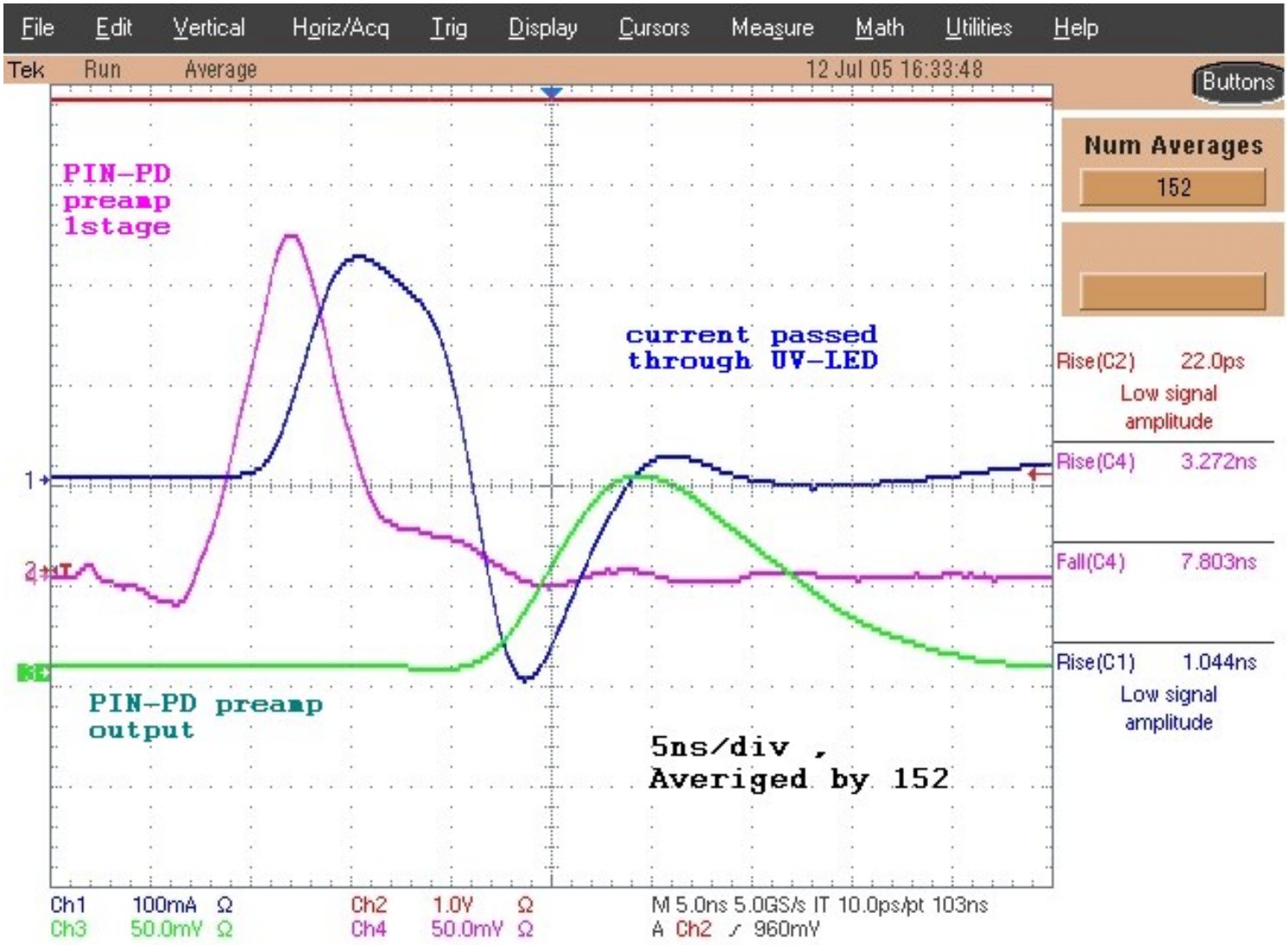
One CH LEDdrv, SiPM, linearity

- Calibration mode (high gain), ADC is saturated
- Small effect on temperature, will be estimated





PIN photodiode response to LEDpulse with fiber feedback



Stability parameters of CMB

- Cooled each one add -300ps delay, heated some +300ps each
- Total delay is in range of -1ns to +1ns for estimated temp. range 200deg.C
- **LEDdrv** system is **temperature pretty stable** for our purposes.
- Measured by oscilloscope TDS3054
- Temperature stability is very good, well bellow 1ns @ normal range (40degC)
- 1hr Jitter is in range 300ps
- Spread of the Delay in one plane (12LED) around 1ns