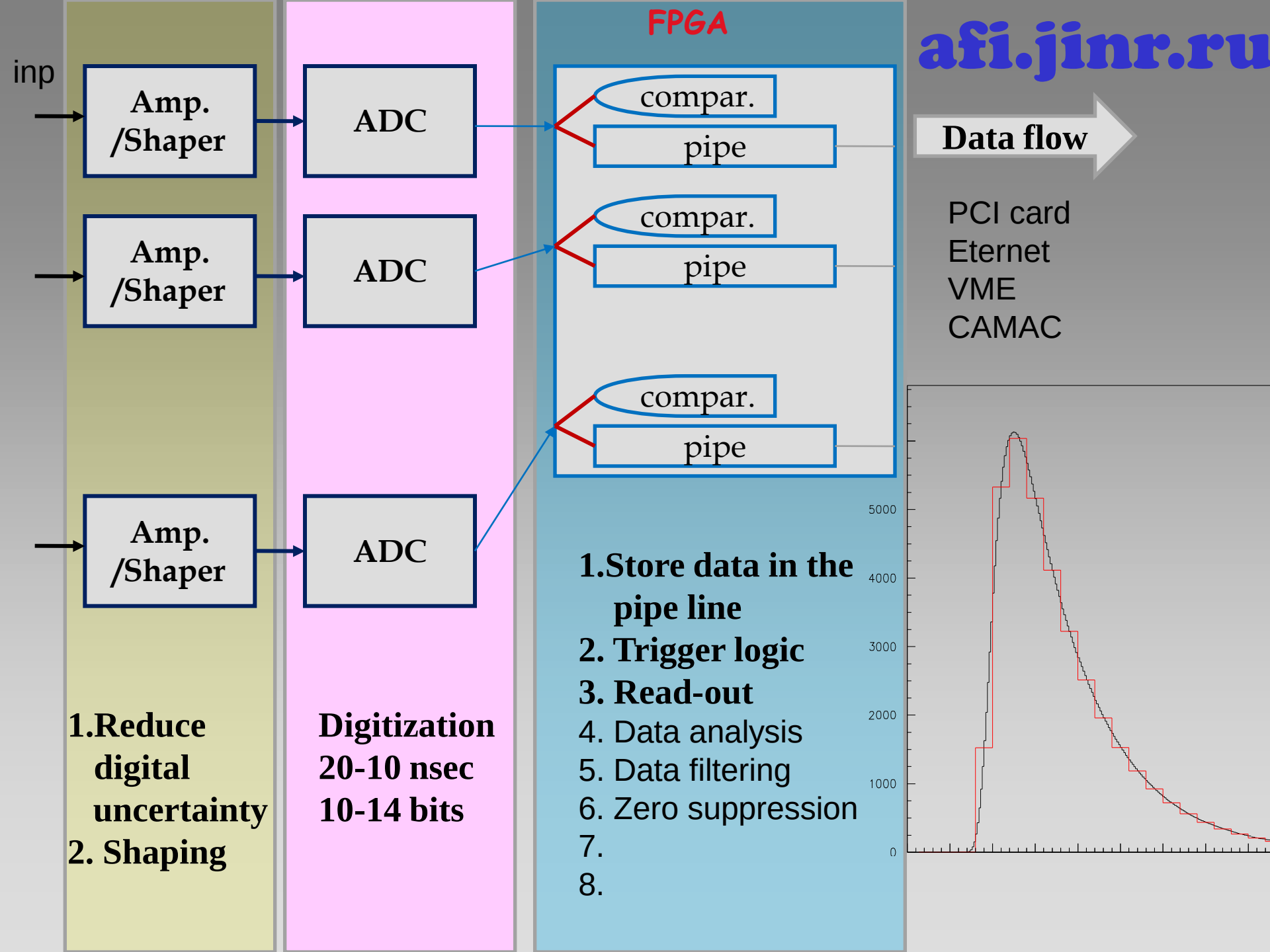
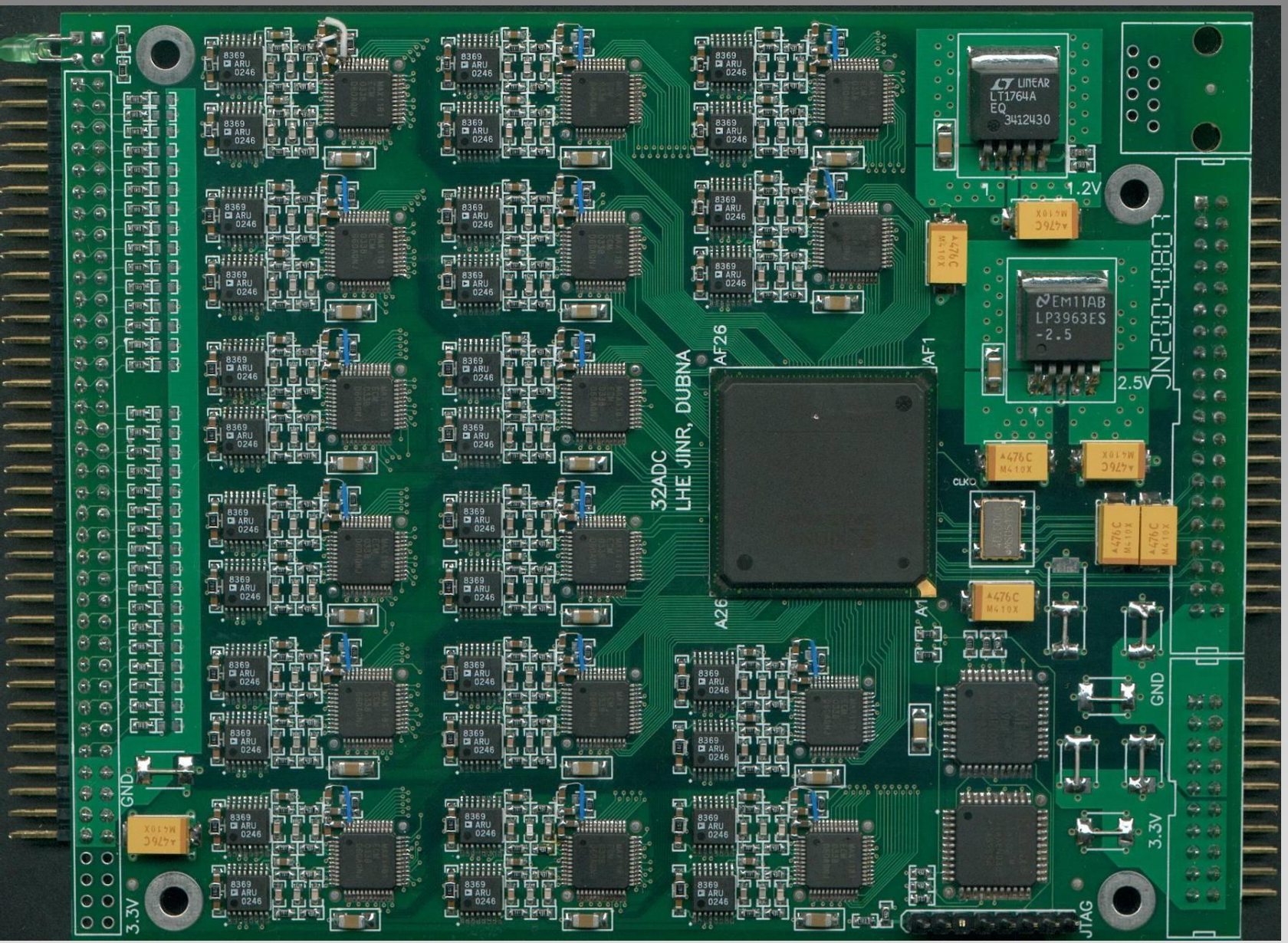
New electronic equipment for the MAPD (SiPM) devices

1. FADC
2. HV
3. LED generator

Casablanca
22-24 September 2010
Igor Tiapkin
JINR


inp
Amp. /Shaper
Amp. /Shaper
Amp. /Shaper
ADC
ADC
ADC
FPGA
compar.
pipe
compar.
pipe
compar.
pipe
afi.jinr.ru
Data flow
PCI card
Eternet
VME
CAMAC
1.Store data in the pipe line
2. Trigger logic
3. Read-out
4. Data analysis
5. Data filtering
6. Zero suppression
7.
8.
5000
4000
3000
2000
1000
0
1.Reduce digital uncertainty
2. Shaping
Digitization
20-10 nsec
10-14 bits

afi.jinr.ru


LINEAR
LT1764A
EQ
3412430
1.2V
EM11AB
LP3963ES
-2.5
2.5V
32ADC
LHE JINR, DUBNA
AF26
AF1
A26
A1
CLKO
GND
3.3V
JTAG

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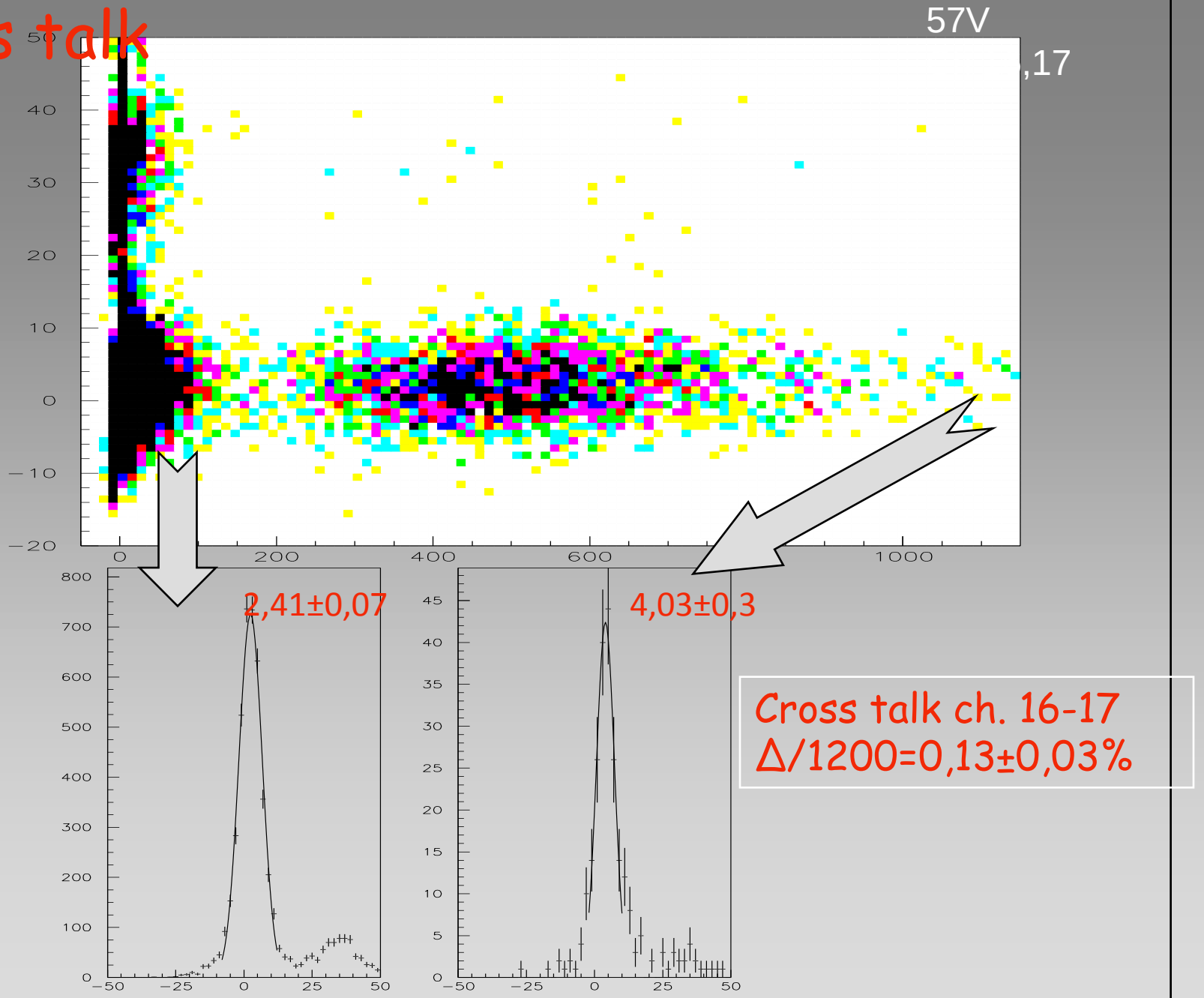
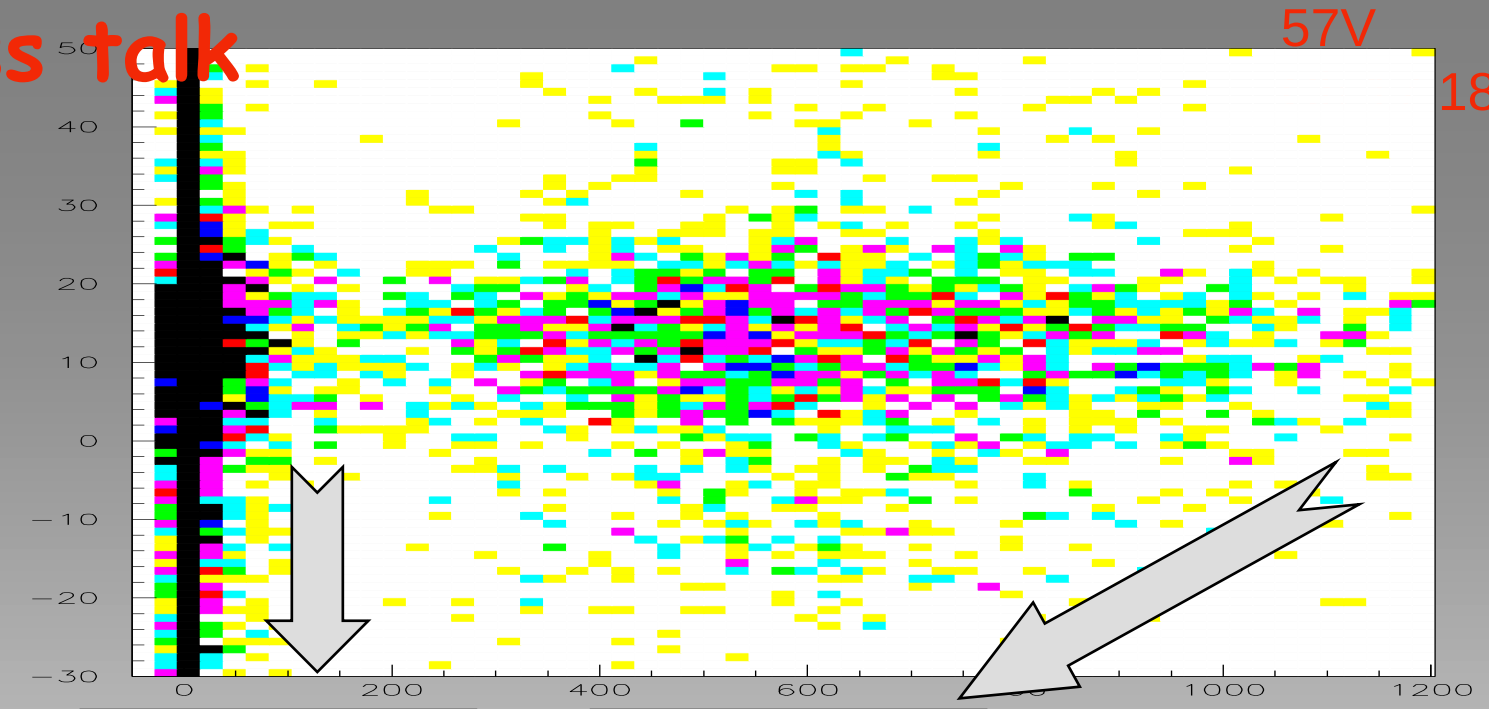
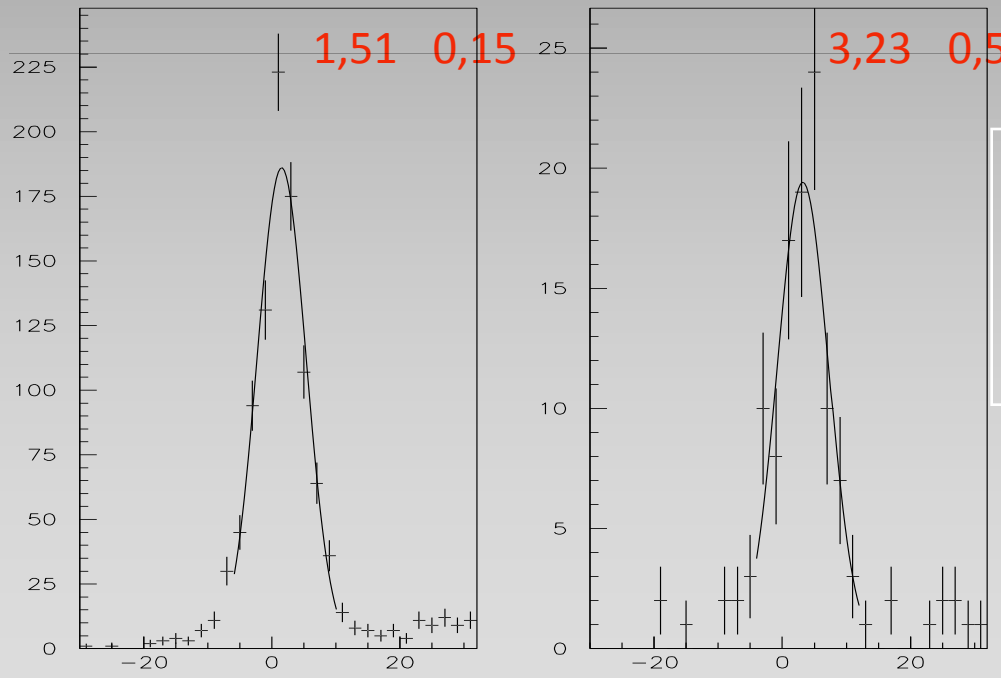
Cross talk



Cross talk ch. 16-17
Δ/1200=0,13±0,03%

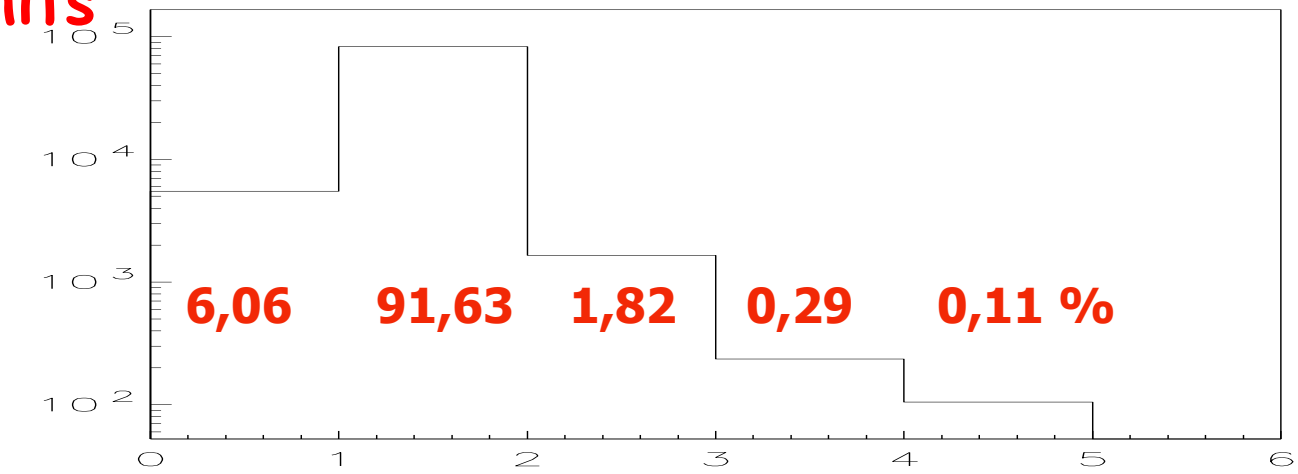
Cross talk

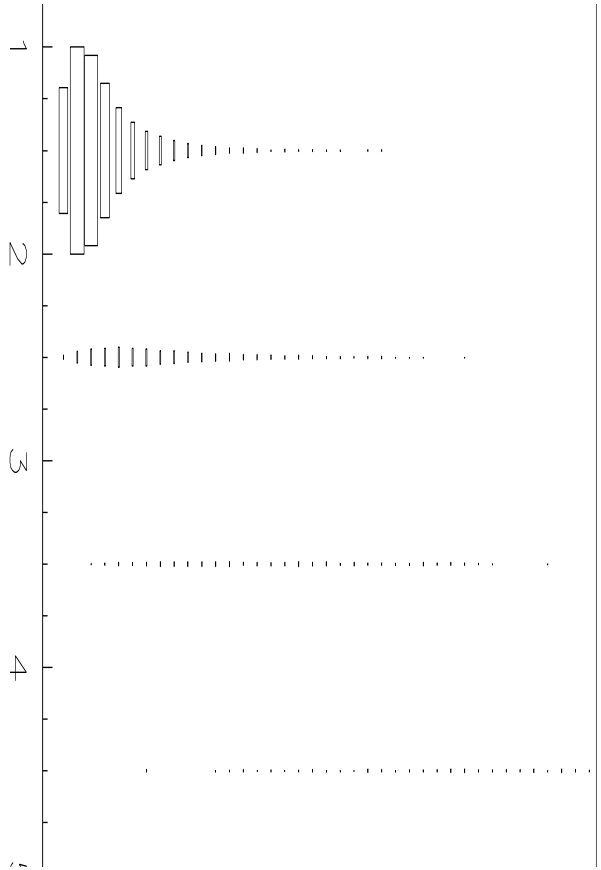


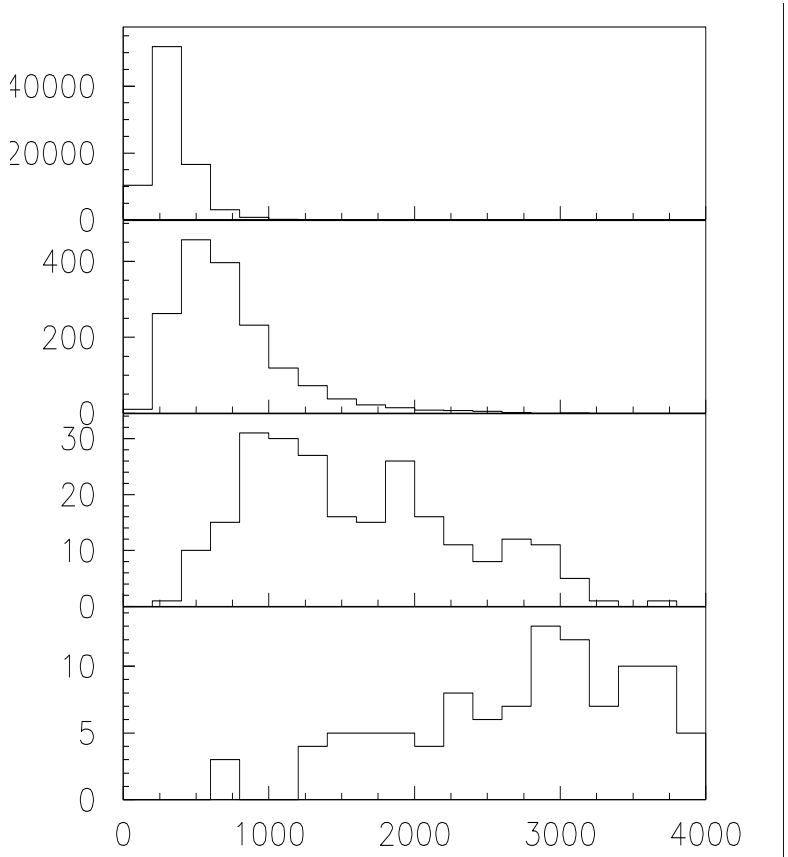


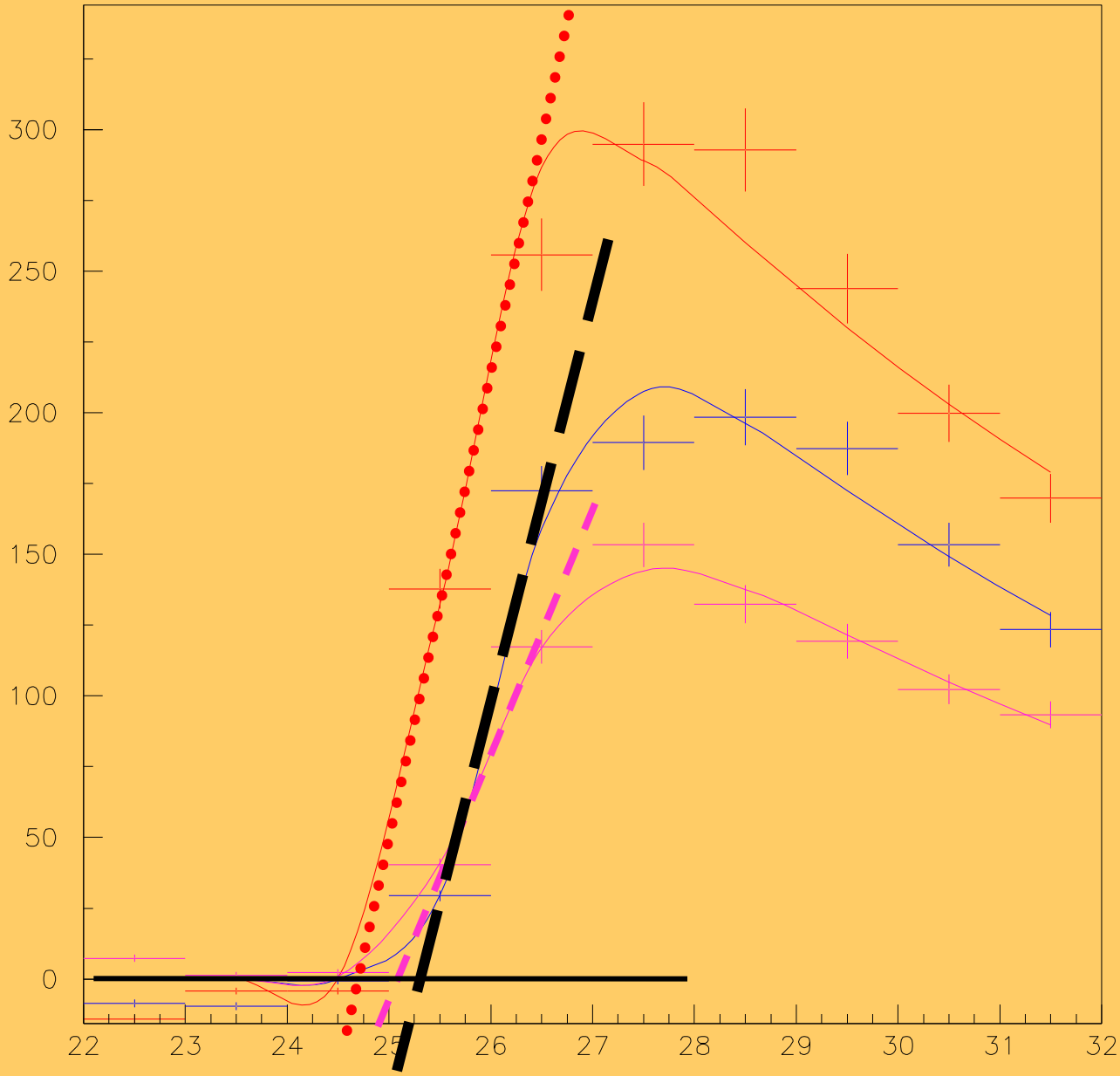
Cross talk ch. 17-18
Δ/1200=0,14±0,06%

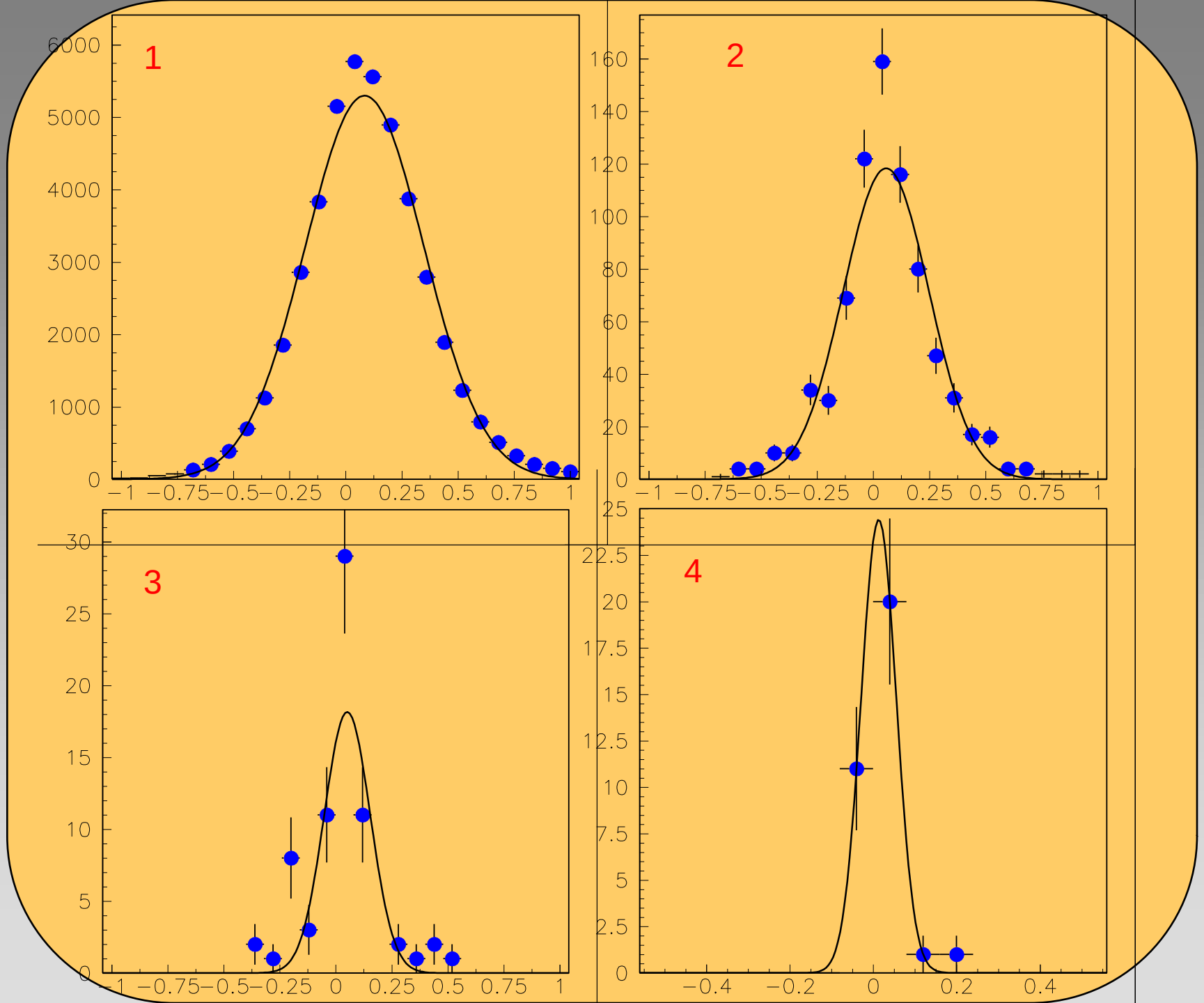
Multi-hits

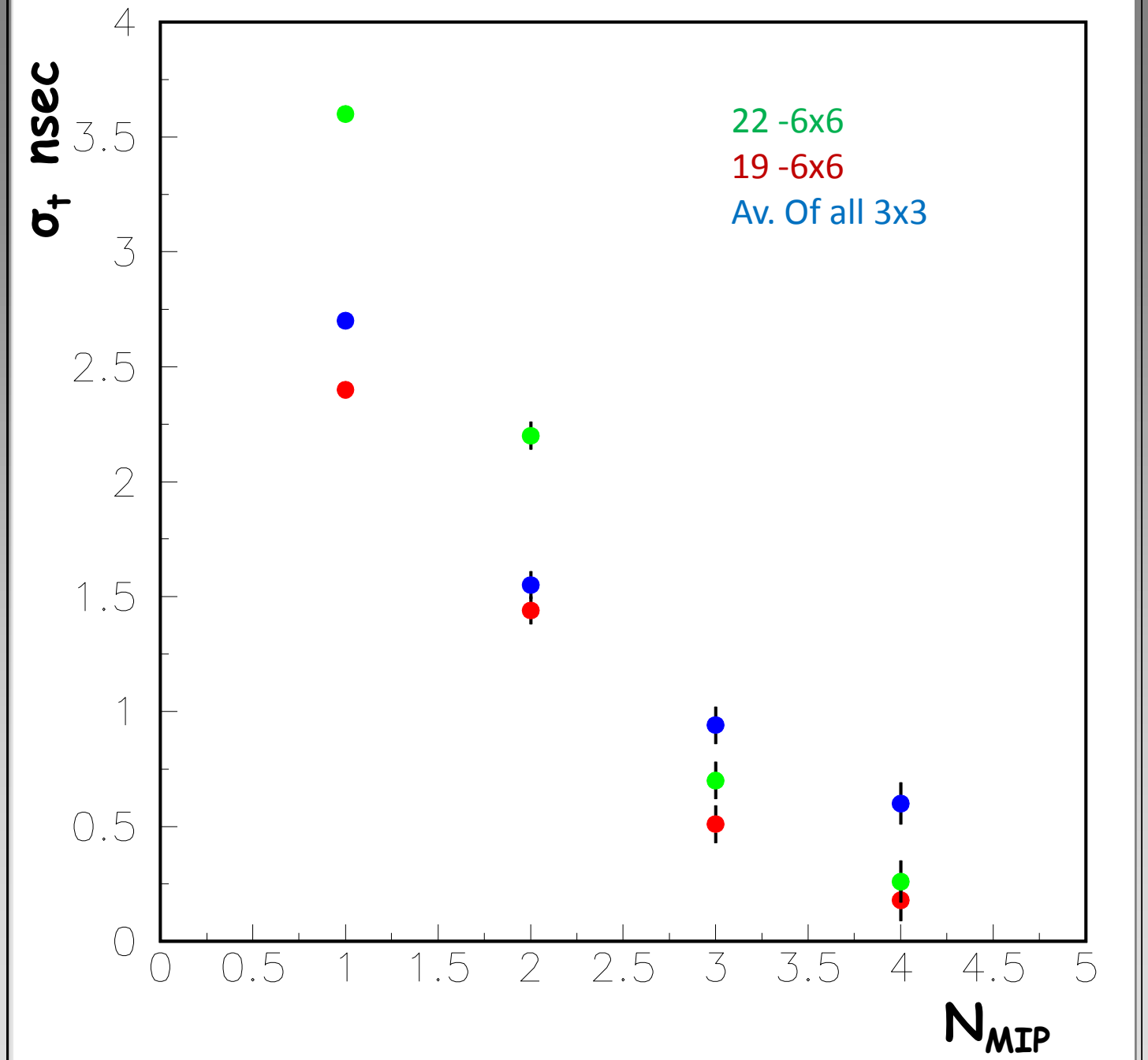


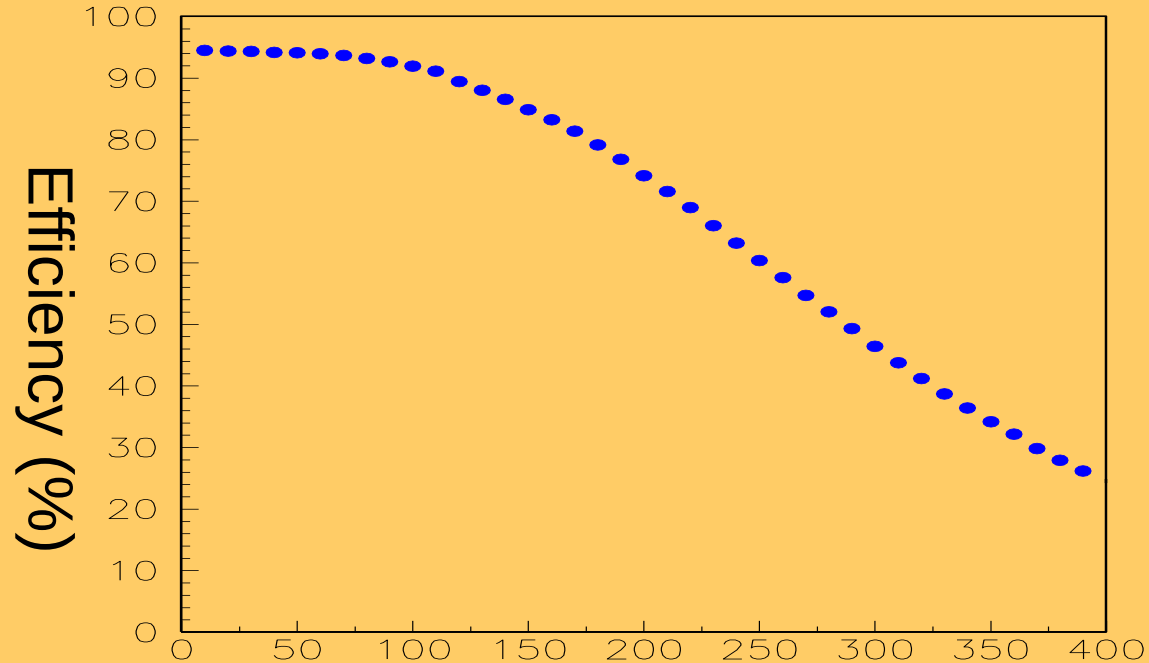


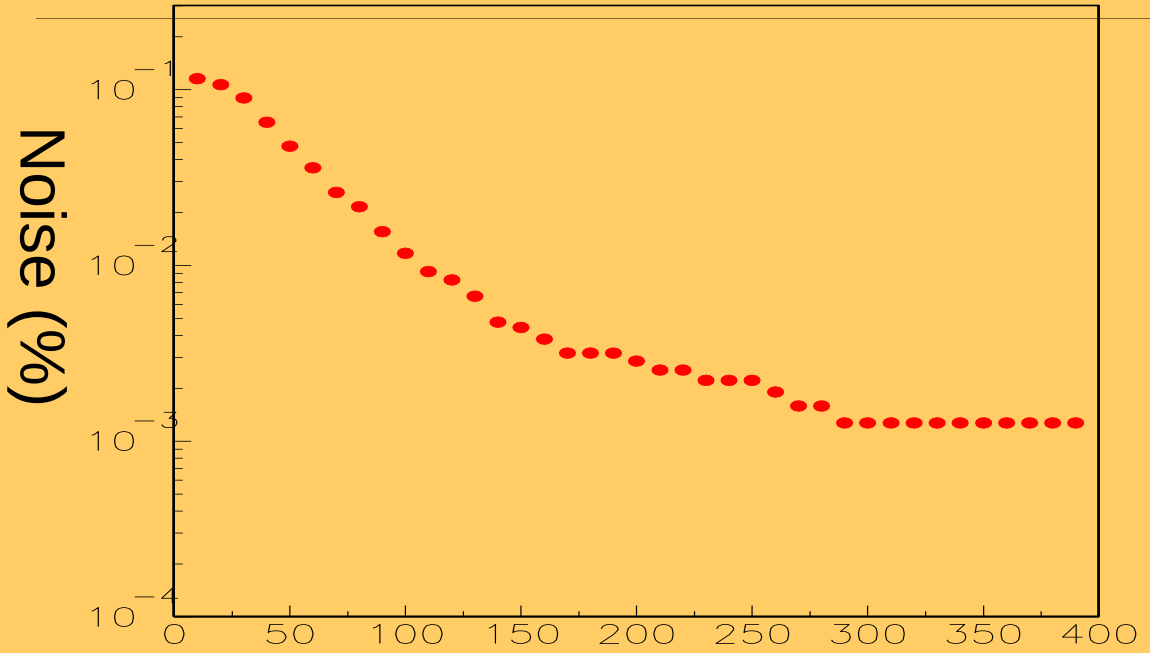



300
250
200
150
100
50
0
22
23
24
25
26
27
28
29
30
31
32

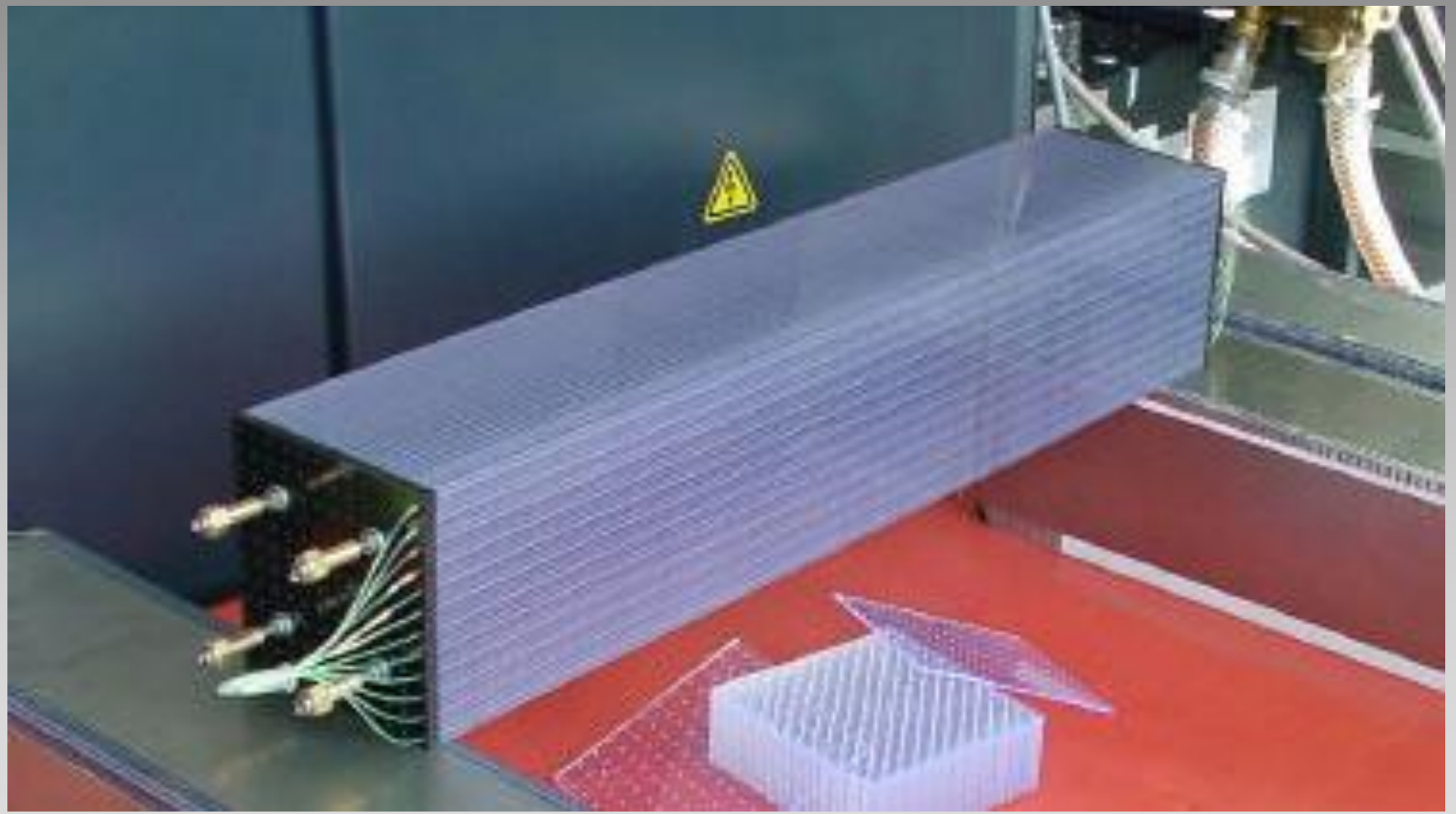

1
2
3
4

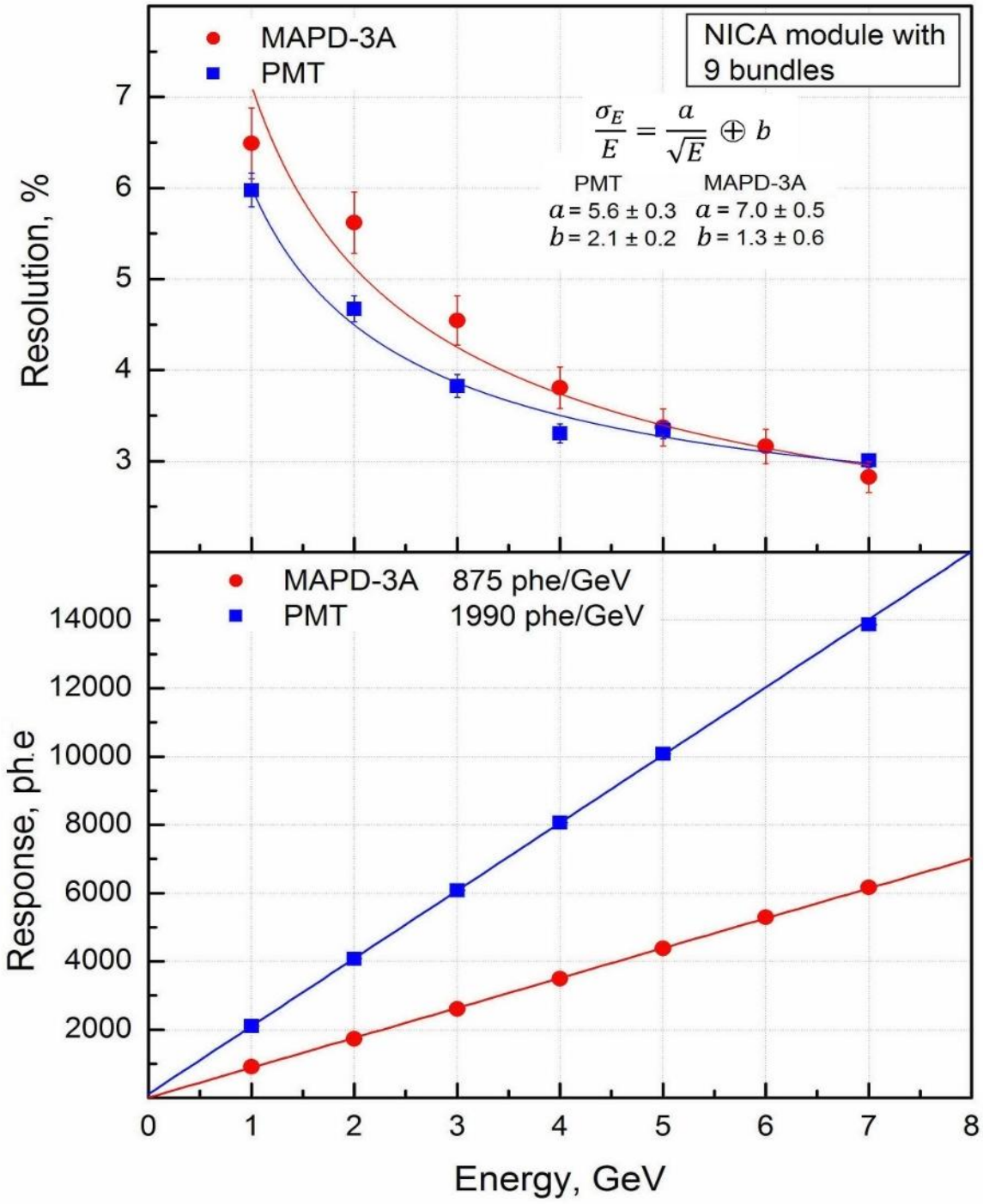

σ_t nsec
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
N_{MIP}
22 -6x6
19 -6x6
Av. Of all 3x3

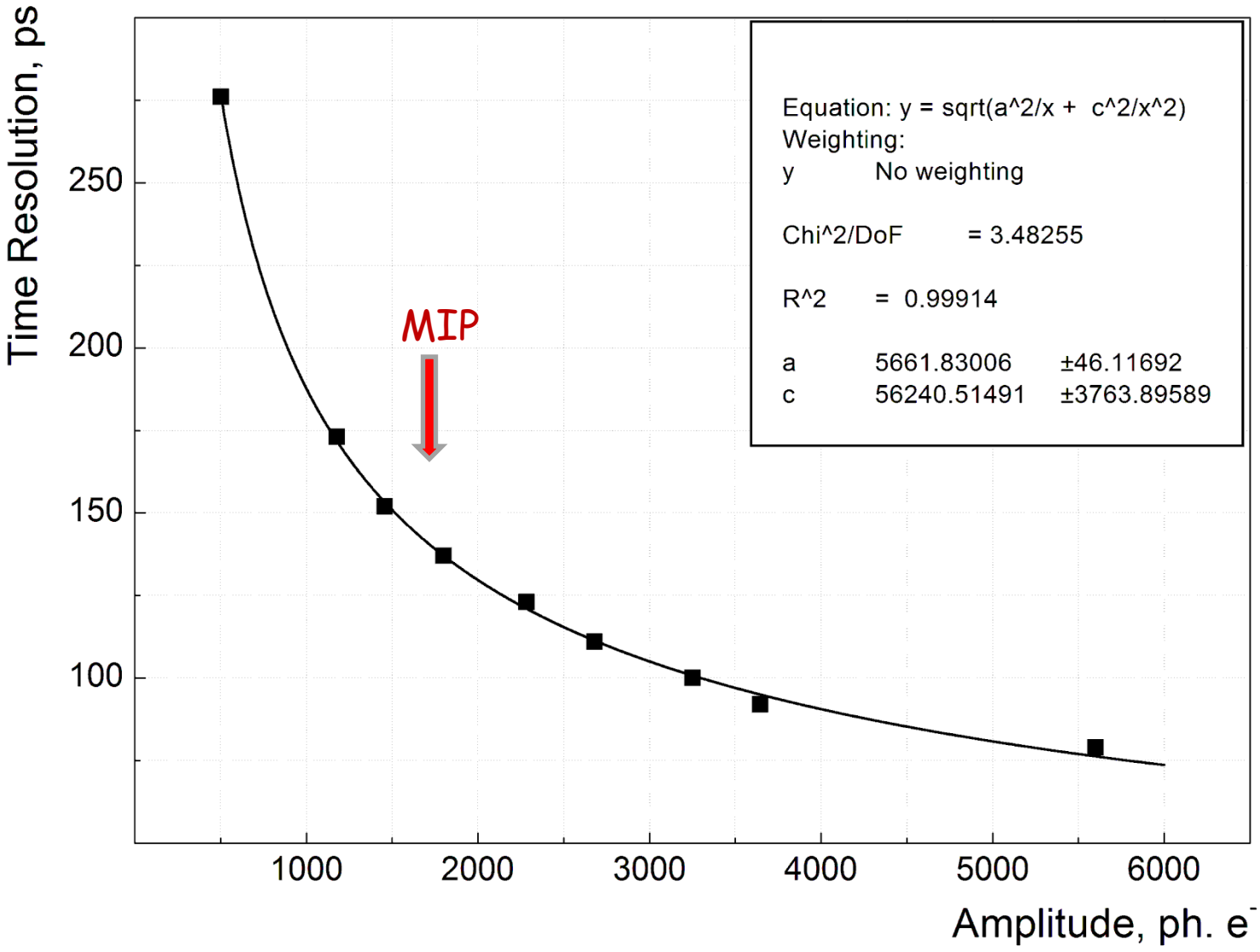

Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400

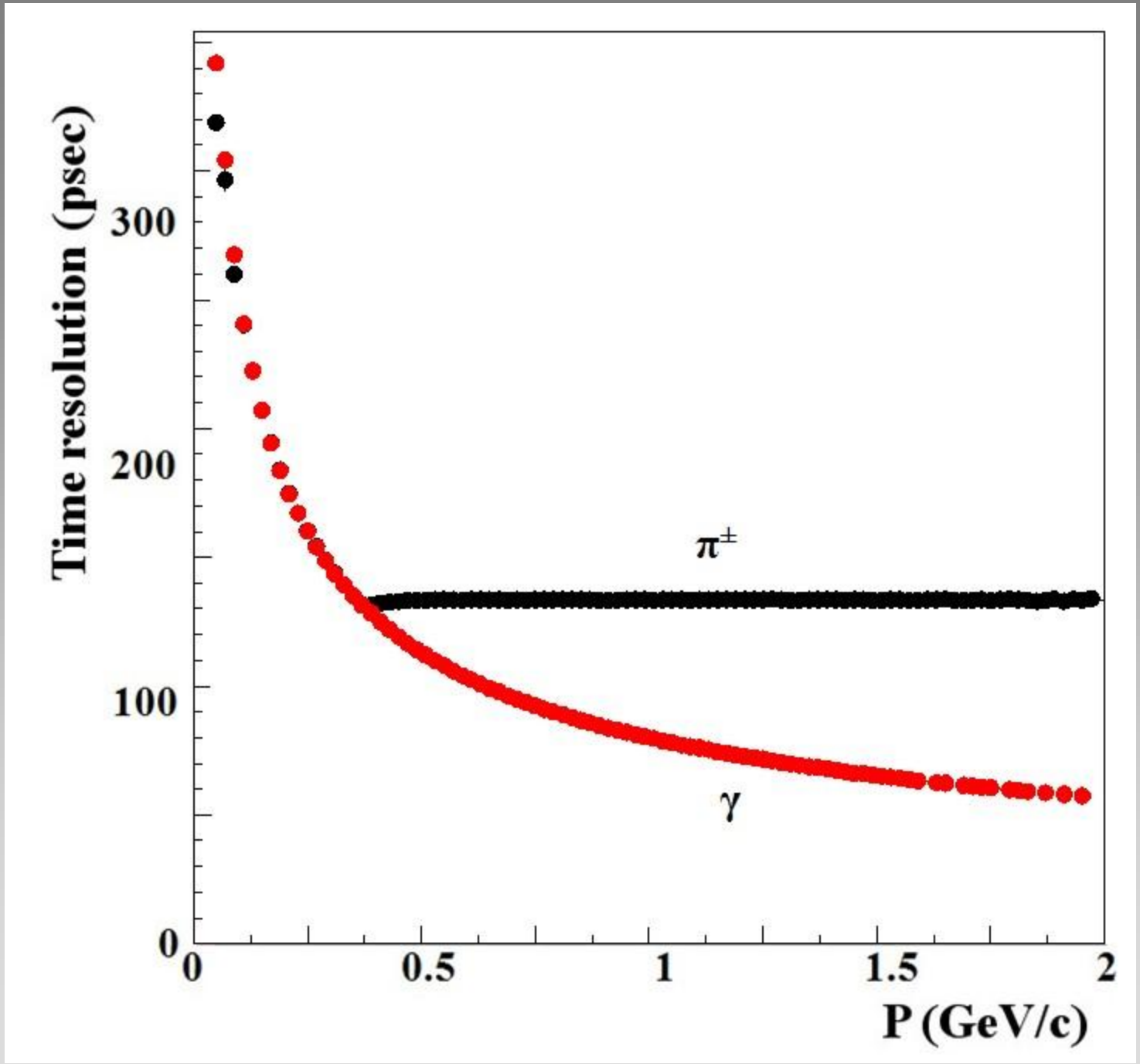

Noise (%)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
250
300
350
400

Energy resolution ~ (2.9 0.1)%/√E(GeV).
Time resolution ~(80 10)psec / √E(GeV).




MAPD-3A
PMT
NICA module with
9 bundles
$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E}} \oplus b$
PMT
$a = 5.6 \pm 0.3$
$b = 2.1 \pm 0.2$
MAPD-3A
$a = 7.0 \pm 0.5$
$b = 1.3 \pm 0.6$
Resolution, %
MAPD-3A 875 phe/GeV
PMT 1990 phe/GeV
Response, ph.e
Energy, GeV

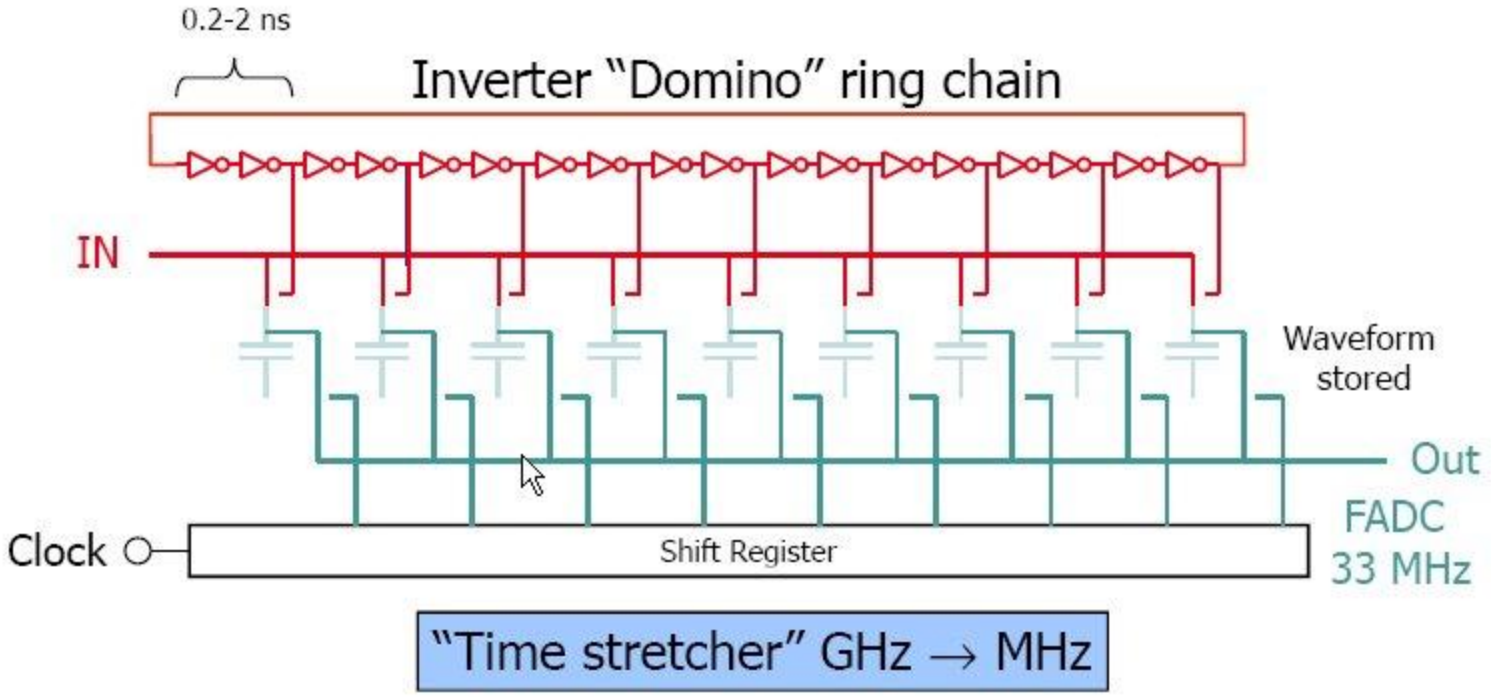

Time Resolution, ps
250
200
150
100
1000
2000
3000
4000
5000
6000
Amplitude, ph. e-
MIP
Equation: y = sqrt(a^2/x + c^2/x^2)
Weighting:
y No weighting
Chi^2/DoF = 3.48255
R^2 = 0.99914
a 5661.83006 ±46.11692
c 56240.51491 ±3763.89589


Time resolution (psec)
300
200
100
0
0
0.5
1
1.5
2
P (GeV/c)
$\pi^{\pm}$
γ

- Fast data transfer
- Small cross-talk
- Easy to build trigger
- High time resolution

- High selectivity – noise suppression
- .
- .

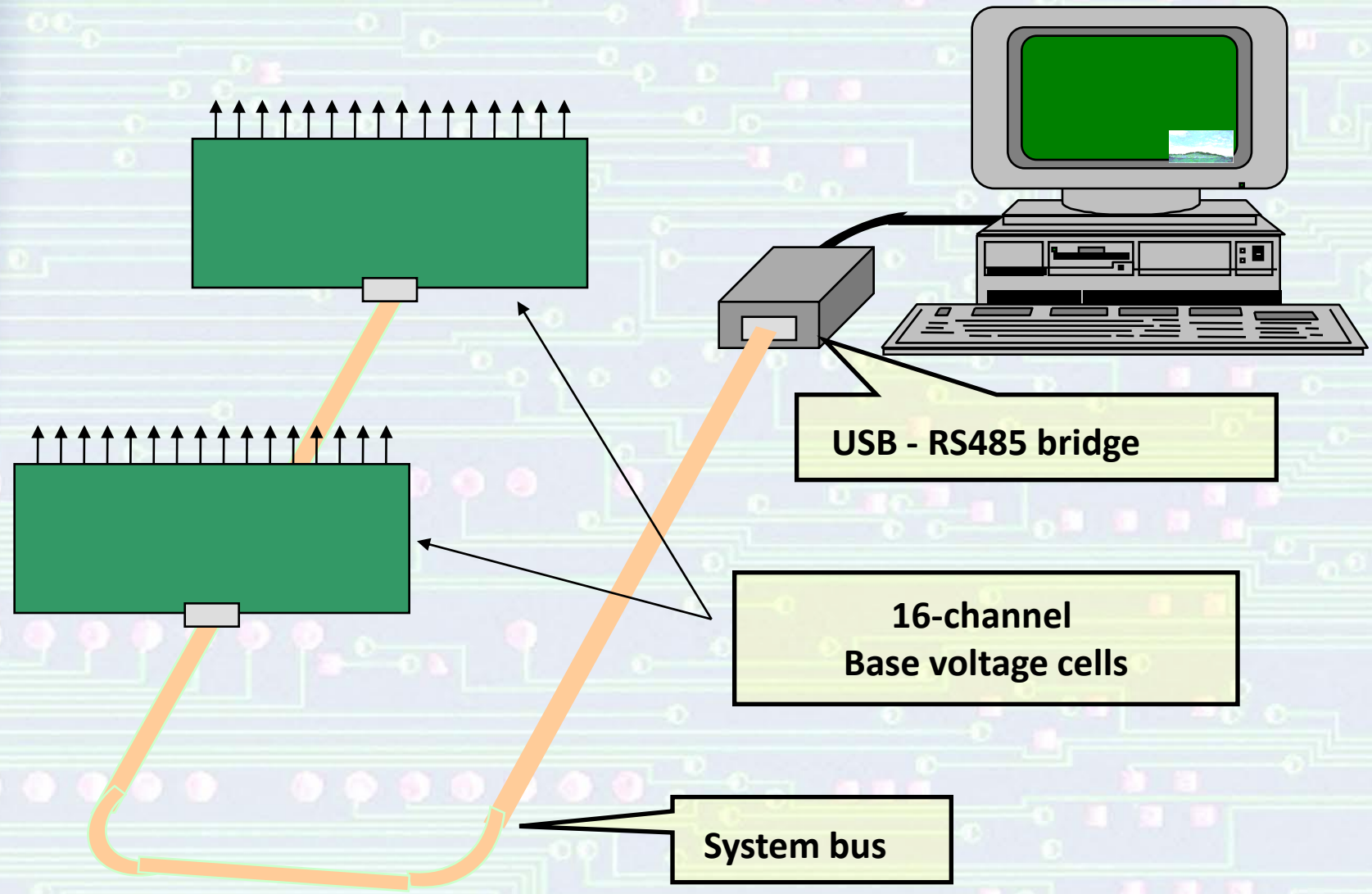
The Domino Principle



"Time stretcher" GHz → MHz

High Voltage Systems Company

HVSys core activity is **development** of **custom designed** equipment for scientific research. Main direction is **multi-channel** high voltage systems for powering of scientific equipment.



High Voltage Systems Company

High Voltage Systems Company

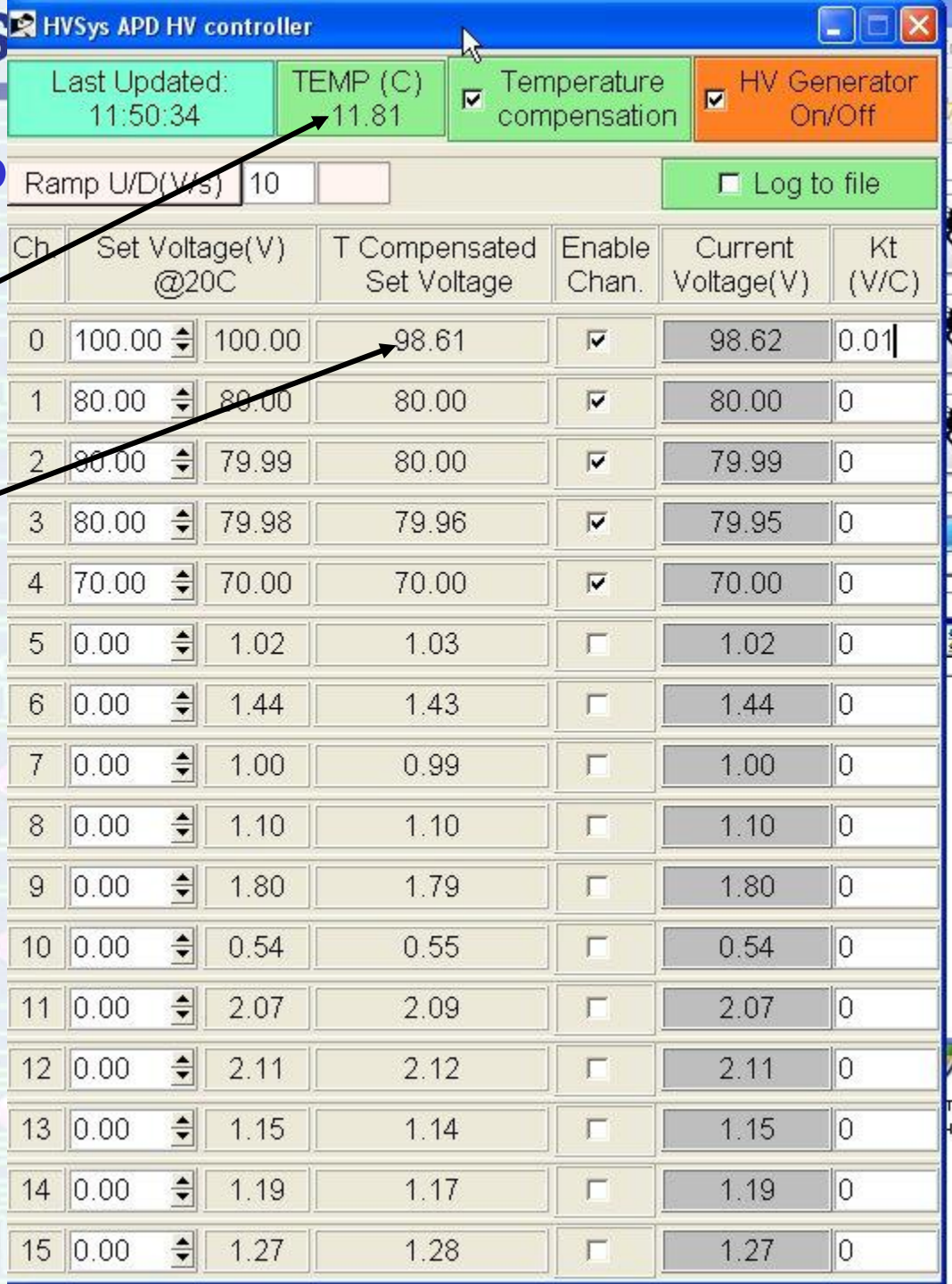
1	Range of max output voltage	Up to 250V
2	Range of output voltage regulation	Umin - Umax
3	Precision of output voltage regulation	10 bit or 12 bit
4	Output voltages spread (channel from channel)	1%
5	Stability of an output voltages	0,005 %
6	Temperature coefficient of an output voltage	200 ppm/K
7	Maximal average output current	Up to 100 mkA
8	Self-diagnosis of the BV channel	Yes
9	Current measurements	Possible
10	System bus	6 line flat cable
11	Max length of system bus	Up to 100 m
12	Number of cells per system bus	Up to 127
13	Number of cells per system controller SC508	508 (8128 channels)

High Voltage S

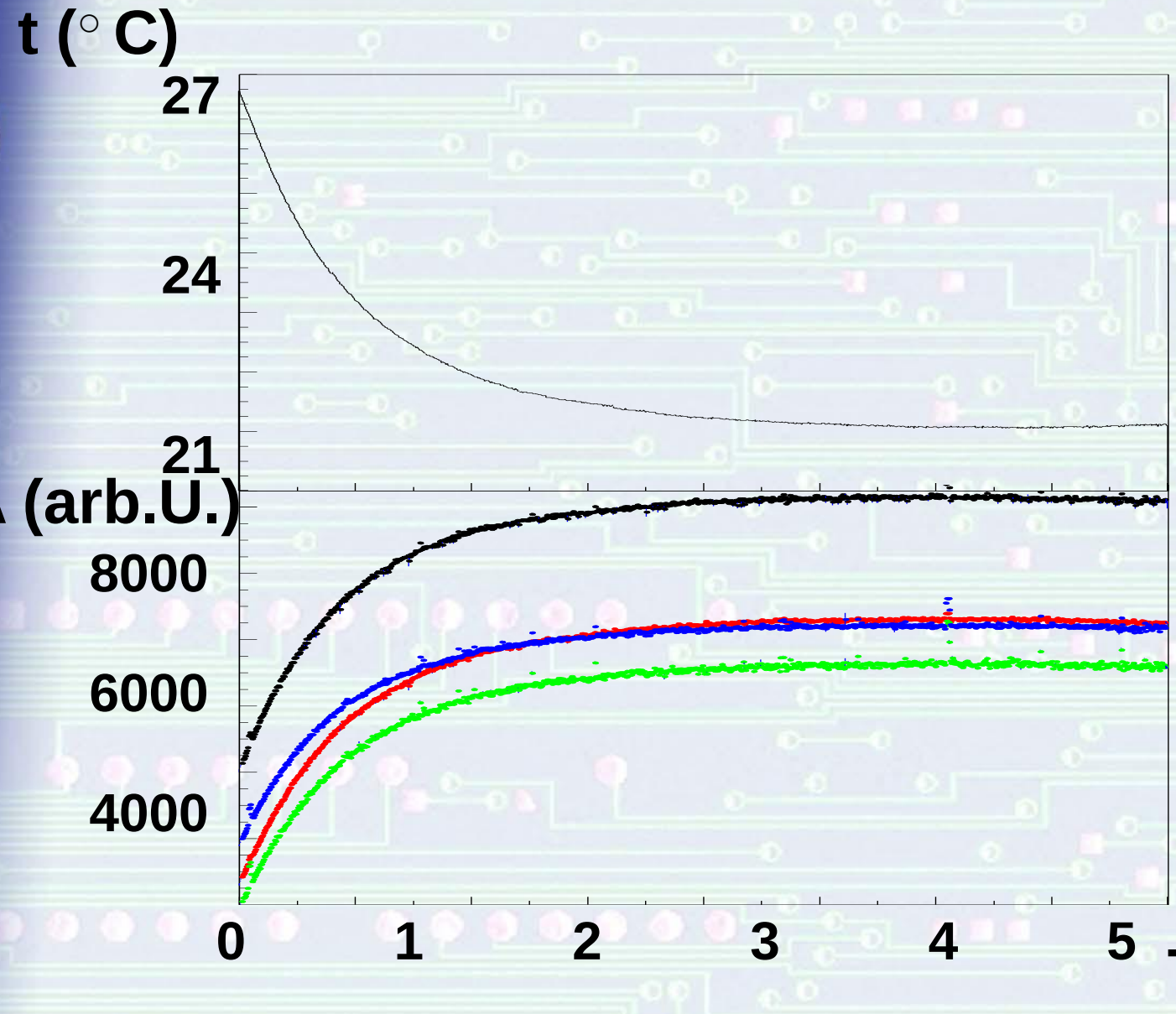
Temperature contro

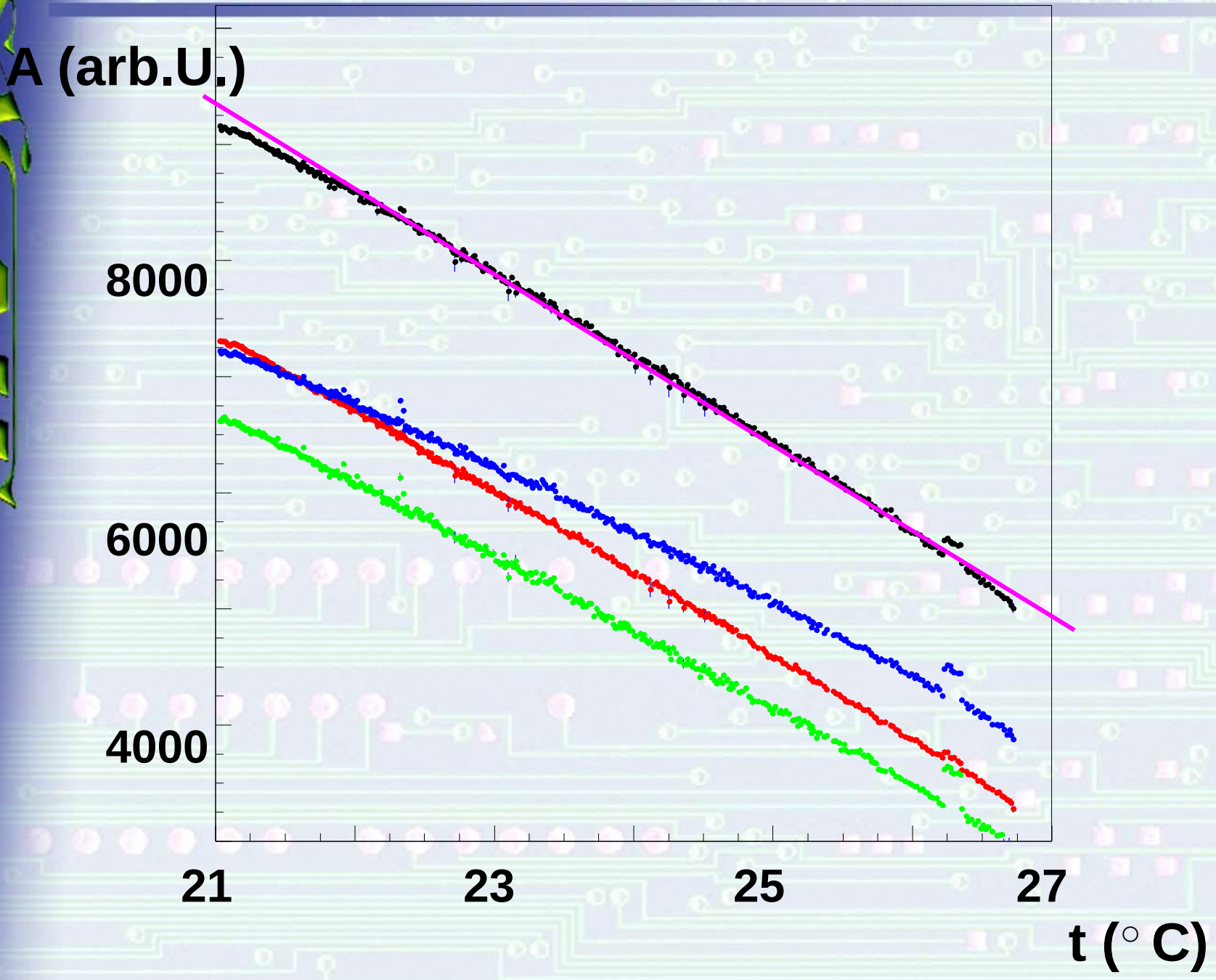
Temperature measurements

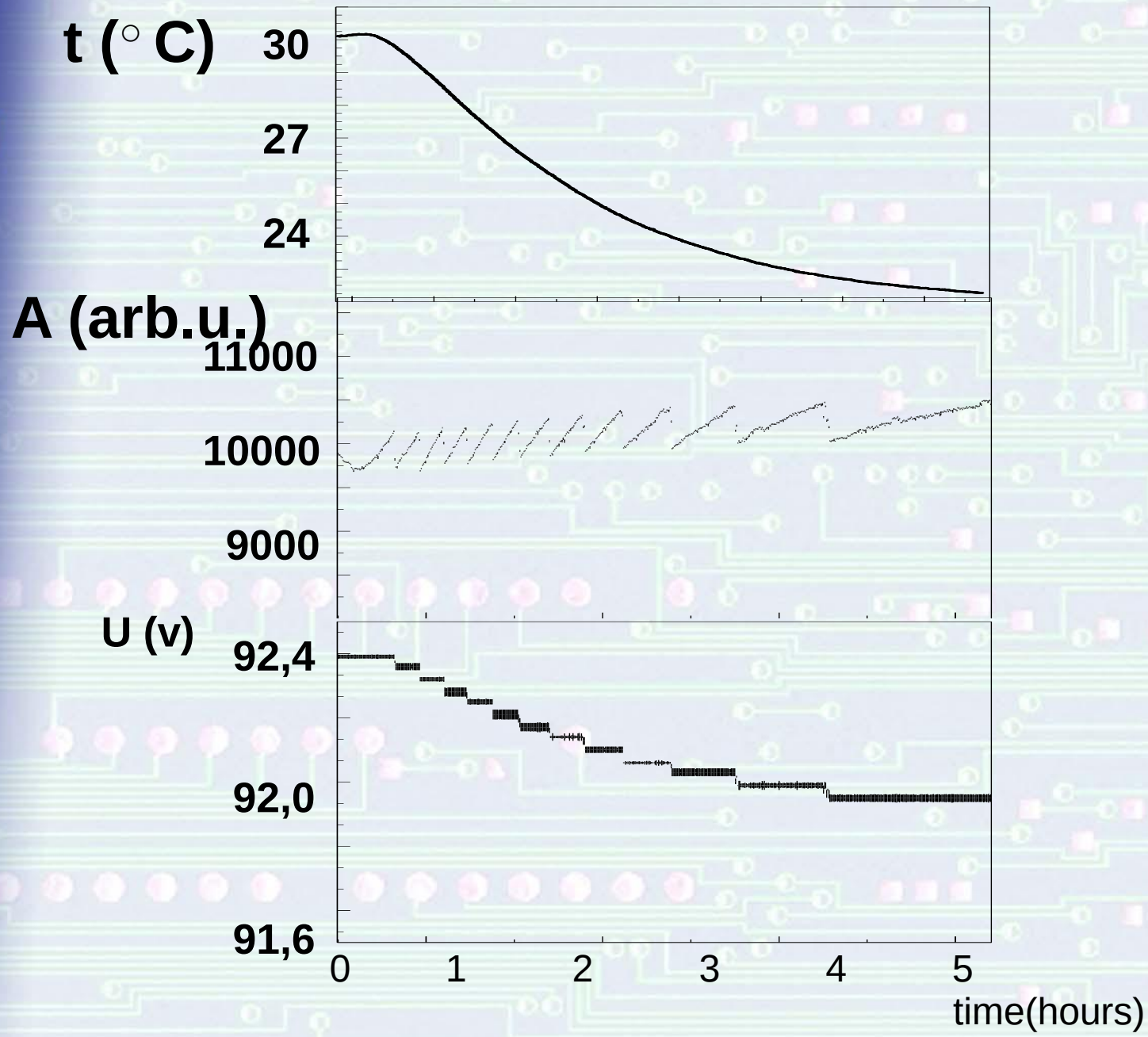
Voltage corrections



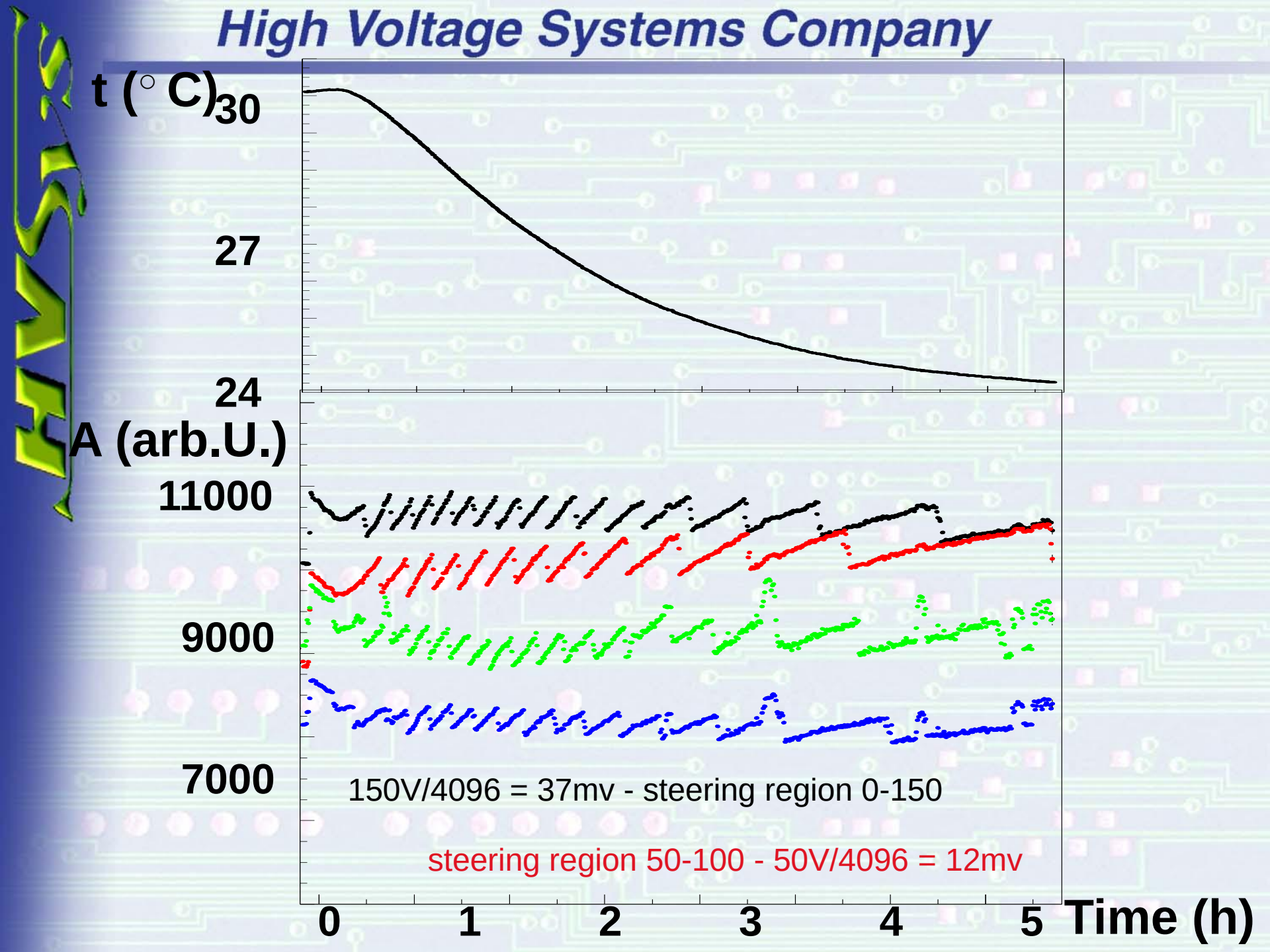
Ch	Set Voltage(V) @20C		T Compensated Set Voltage	Enable Chan.	Current Voltage(V)	Kt (V/C)
0	100.00	100.00	98.61	☑	98.62	0.01
1	80.00	80.00	80.00	☑	80.00	0
2	80.00	79.99	80.00	☑	79.99	0
3	80.00	79.98	79.96	☑	79.95	0
4	70.00	70.00	70.00	☑	70.00	0
5	0.00	1.02	1.03	☐	1.02	0
6	0.00	1.44	1.43	☐	1.44	0
7	0.00	1.00	0.99	☐	1.00	0
8	0.00	1.10	1.10	☐	1.10	0
9	0.00	1.80	1.79	☐	1.80	0
10	0.00	0.54	0.55	☐	0.54	0
11	0.00	2.07	2.09	☐	2.07	0
12	0.00	2.11	2.12	☐	2.11	0
13	0.00	1.15	1.14	☐	1.15	0
14	0.00	1.19	1.17	☐	1.19	0
15	0.00	1.27	1.28	☐	1.27	0


t (° C)
27
24
21
A (arb.U.)
8000
6000
4000
0
1
2
3
4
5
Time (h)

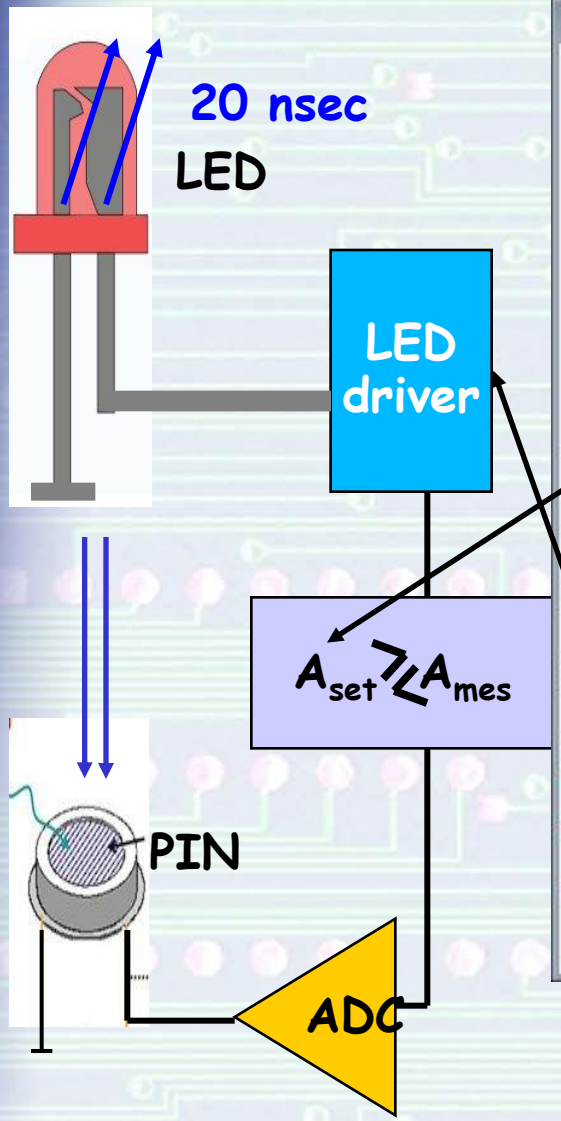

A (arb.U.)
8000
6000
4000
21
23
25
27
t (° C)

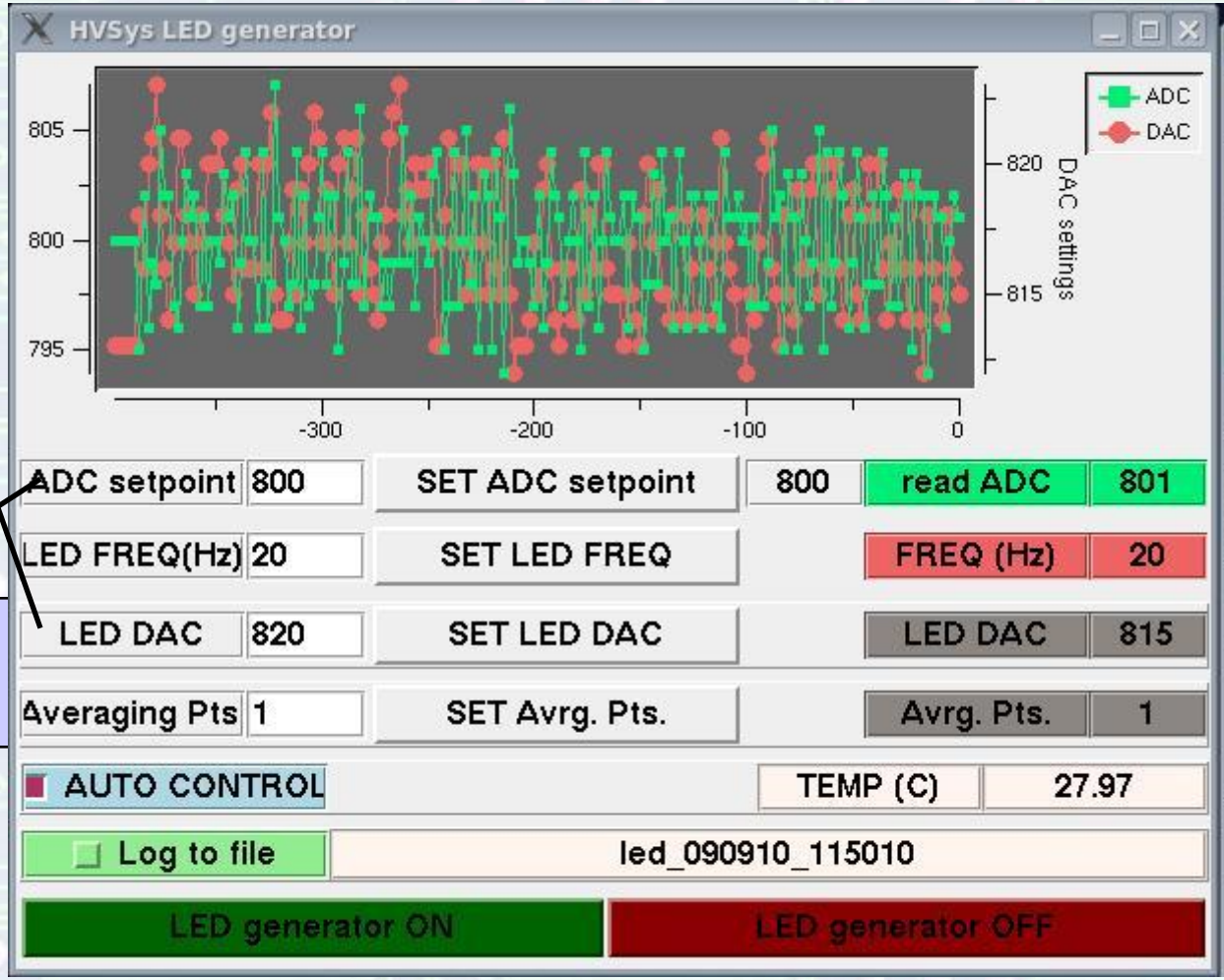

t (° C)
30
27
24
A (arb.u.)
11000
10000
9000
U (v)
92,4
92,0
91,6
0
1
2
3
4
5
time(hours)

High Voltage Systems Company



High Voltage Systems Company

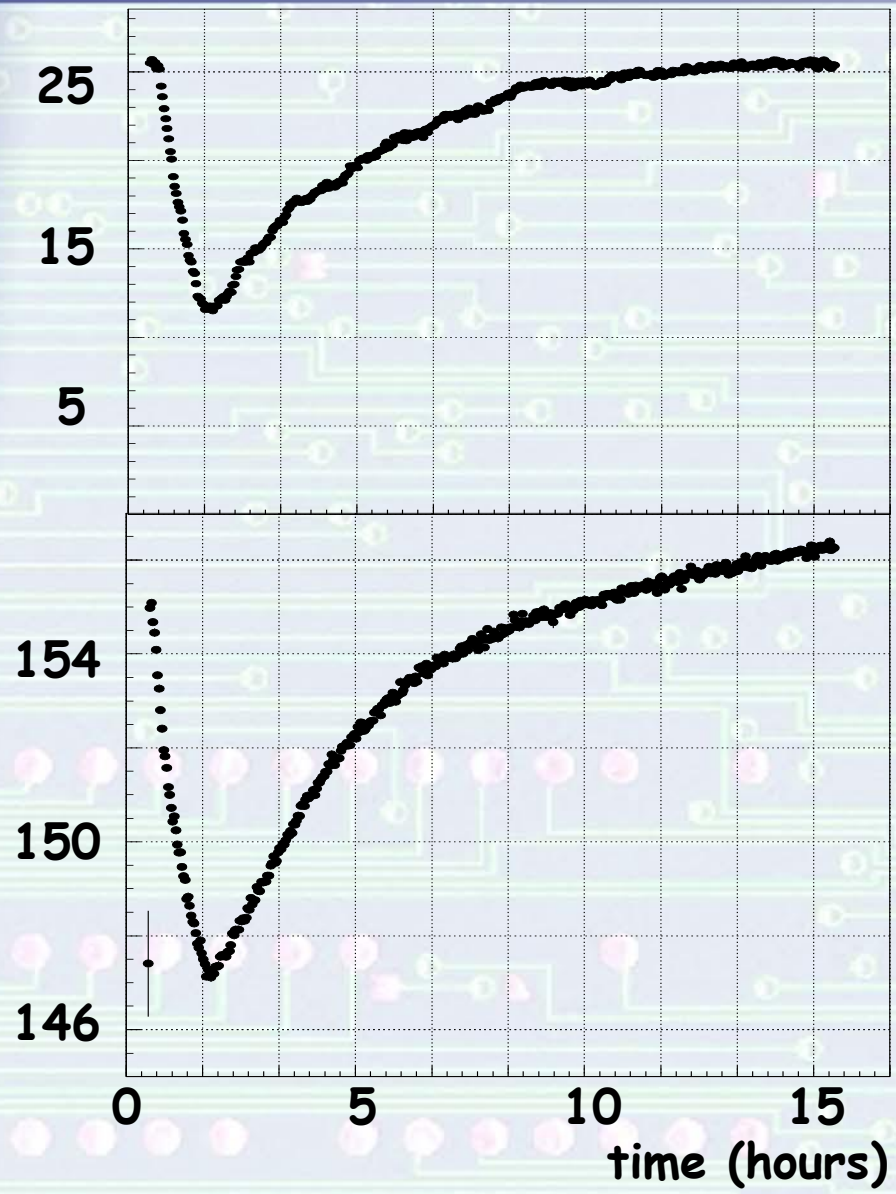


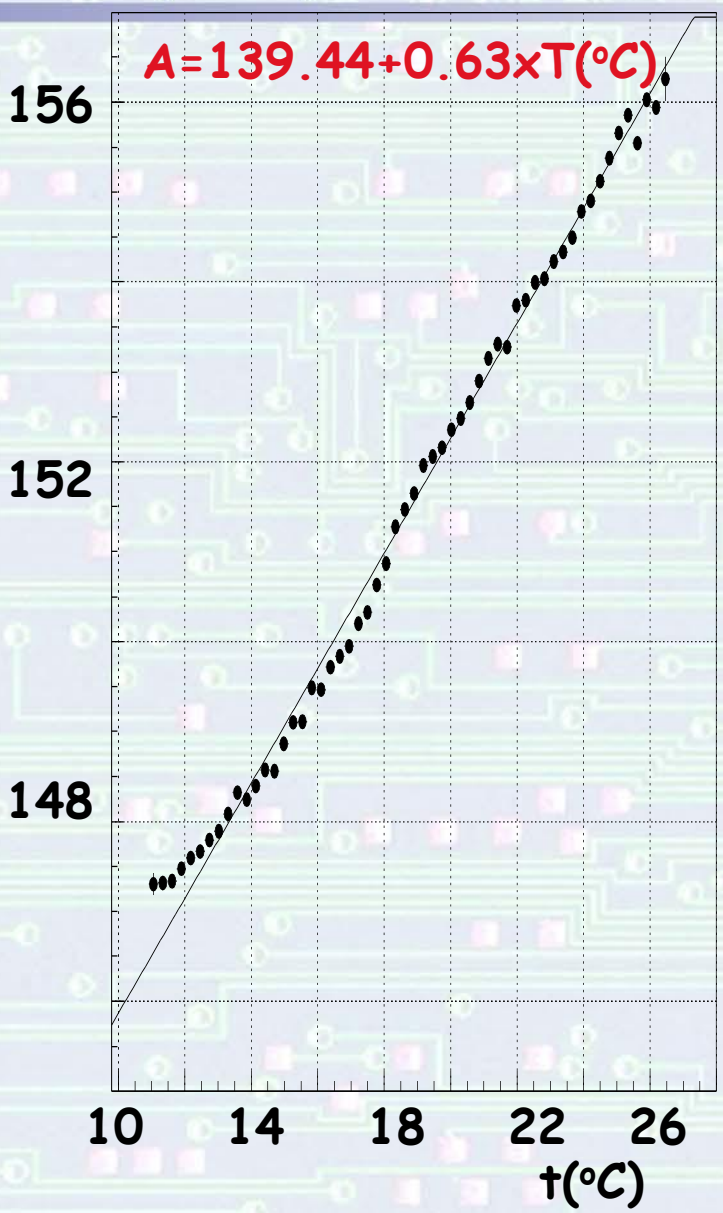


High Voltage Systems Company

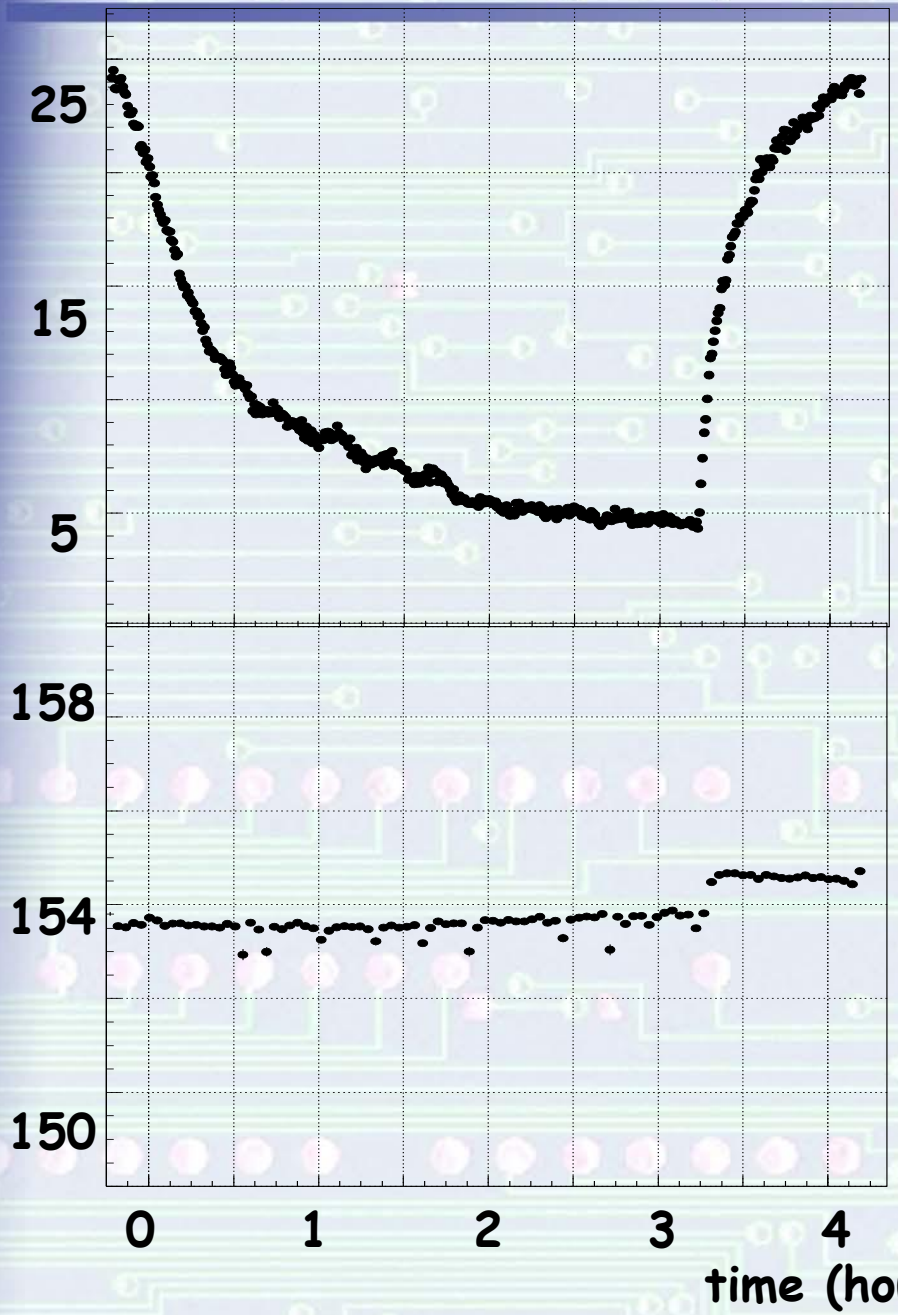
5 cm

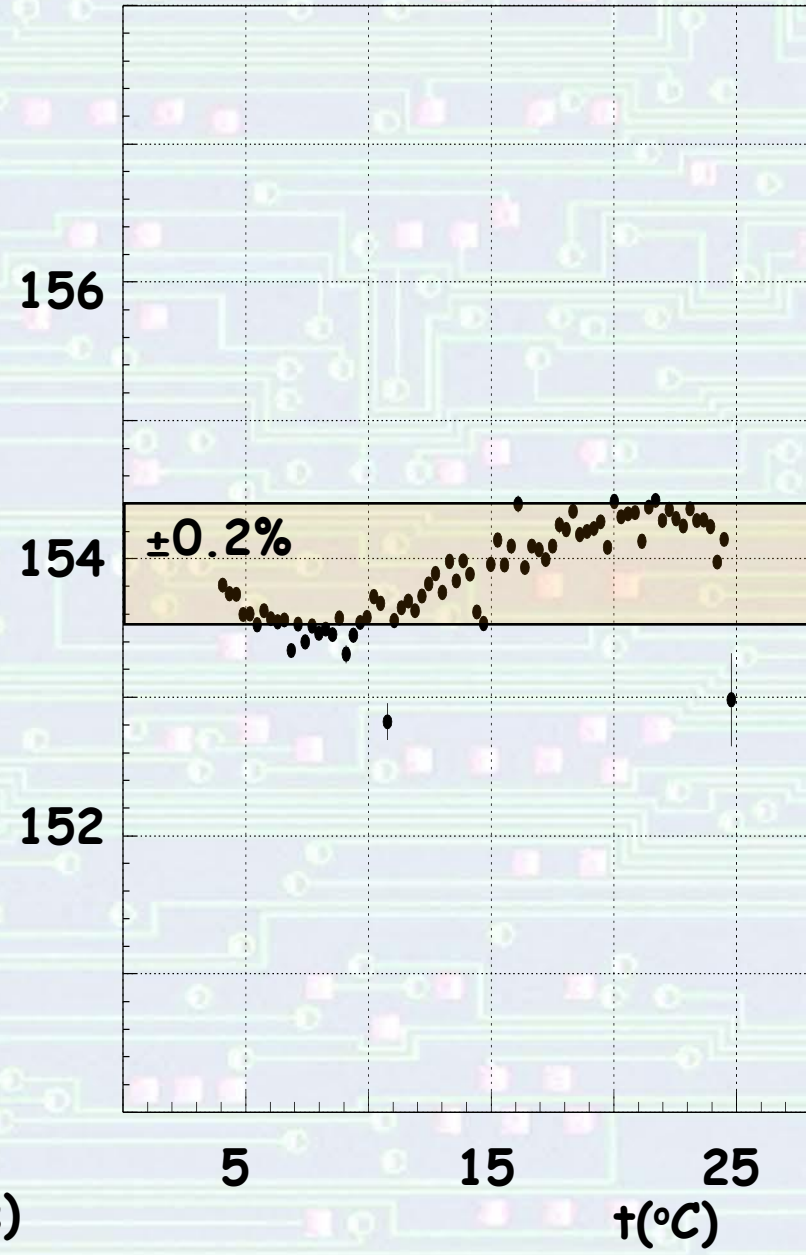
High Voltage Systems Company





High Voltage Systems Company





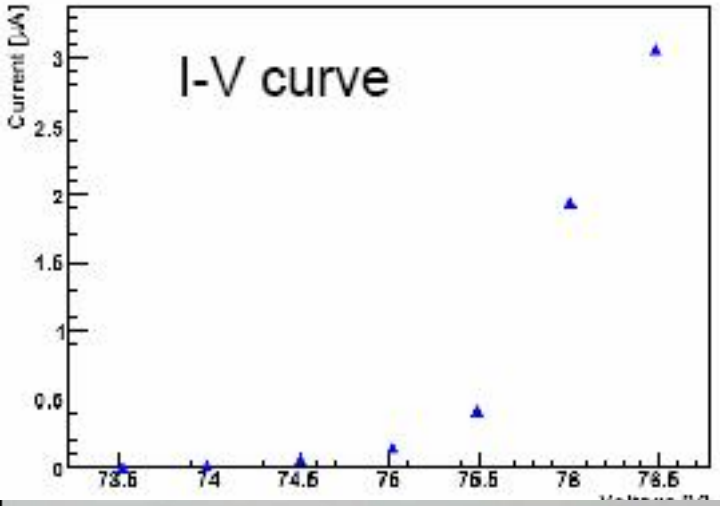
SiPM bias and r/o

LED light

Easy to exchange SiPM
Mechanic support for extra material c
be added (on request)SiPM

Single channel adjustable bias

GUI programmed in tcl



temperature controlled bias stabilization

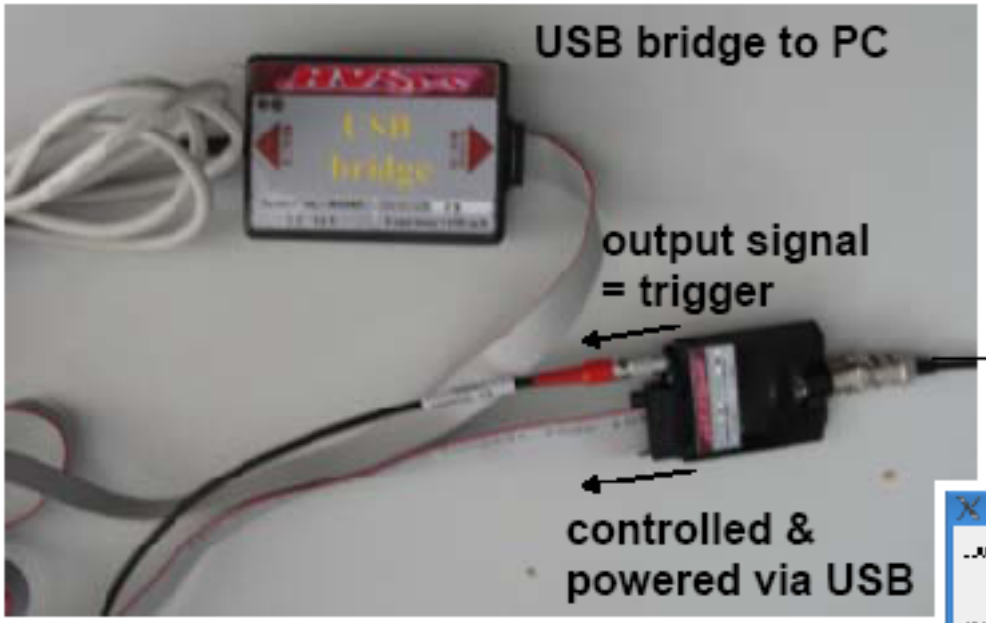
HVSys APD HV controller. Cell=2

Last Updated: 14:11:50	TEMP (C) 25.92	Temperature compensation	HV Generator On/Off

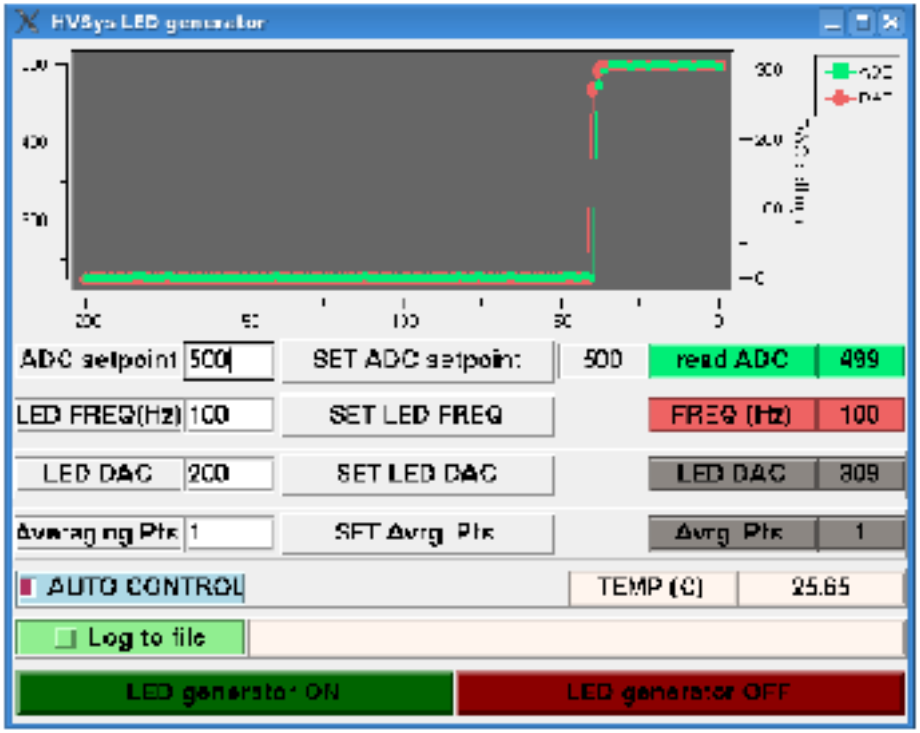
Ramp U/D(V/s) 10 — Log to file

Ch.	Set Voltage(V) @20C		T Compensated Set Voltage	Enable Chan.	Current Voltage(V)	Measured Current(nA)	Kt (V/C)
0	75.49	75.49	75.49	■	75.49	482	0
1	0.00	0.00	0.00		0.00	-2	0
2	0.00	0.00	0.00		0.00	-2	0
3	0.00	0	0.00		0.00	7	0
4	0.00	0	0.00		0.00	-12	0
5	0.00	0	0.00		0.00	-10	0
6	0.00	0	0.00		0.00	-10	0
7	0.00	0	0.00		0.00	-17	0

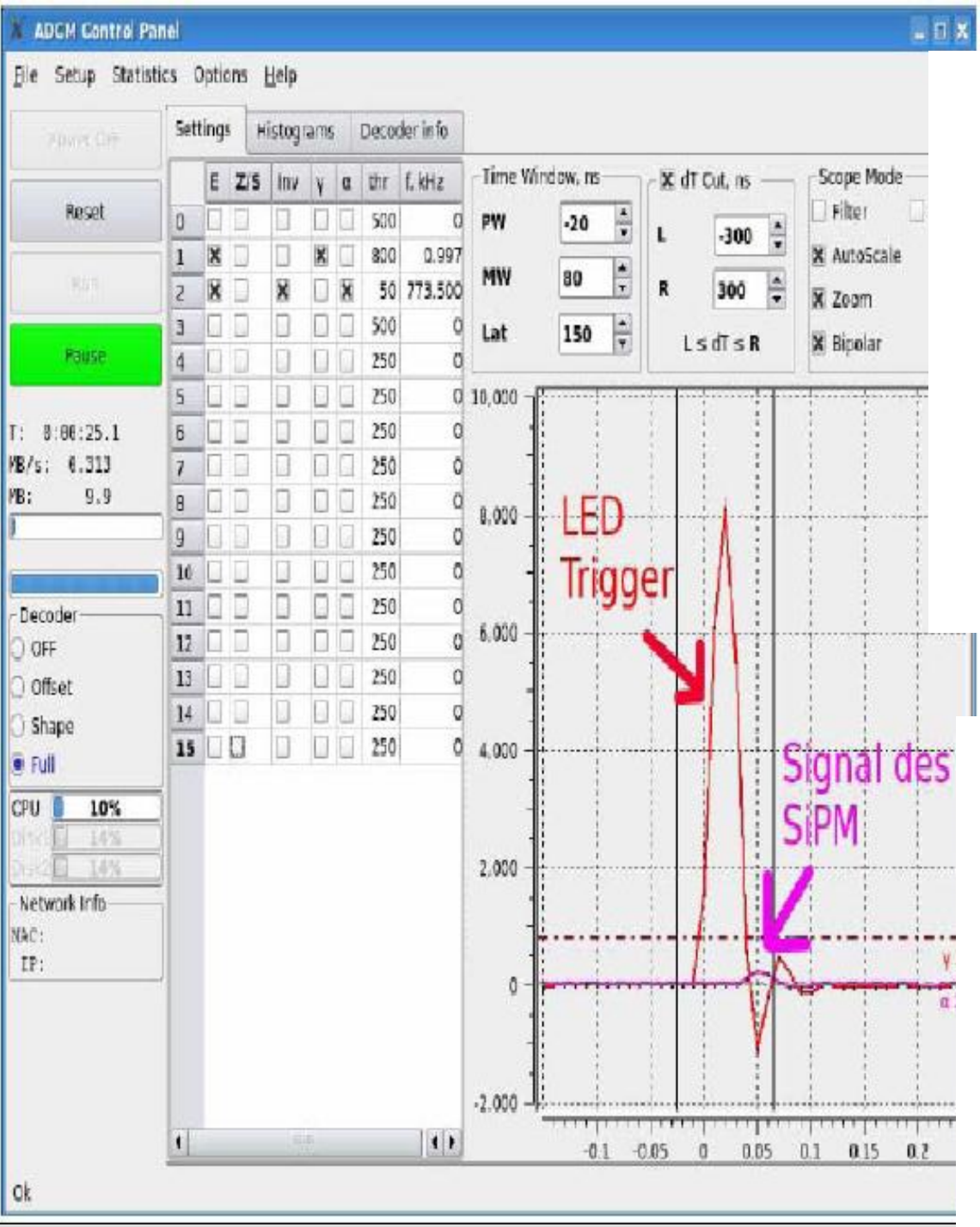
USB controlled LED pulser



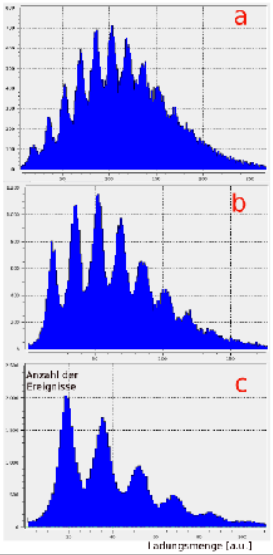
GUI programmed in tcl



Variable LED intensity (DAC)
Variable pulser frequency
Internal PIN diode to monitor light output



SiPm single photoelectron peak spectrum



Example study (I):

- Extract characteristic single photoelectron peak spectrum

- tune light intensity by varying the pulser amplitude

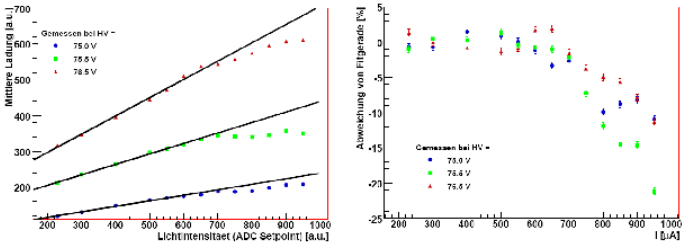
- extract SiPM gain for various bias voltages

measurements taken by practicum students in our lab

SiPM response curve

Example study (II):

- Increase light intensity by varying the pulser amplitude
- study SiPM response for various bias voltages



measurements taken by practicum students in our lab
(low stat. / no errors)

Conclusions

- **Several FE - DAQ boards was successfully tested during last years at the test beams. of CERN and DESY**
- **Boards with different ADC speed and resolution was developed.**
- Cross-talk between neighbor channels is measured on the level of 0,1-0,2%.
- Random coincidence of the noise signals even in the gate of 30 nsec is measured on the level of 0,02-0,3%
- **Time resolution up to 100 psec has been reached with the FADC board of 100 MHz frequency and 14 bit resolution.** It is shown that this time resolution determined by the detector but not by the electronics channel.

- **Several HV modules with different parameters has been developed.**
- **HV module with automatic compensation of the output voltage depending on temperature was developed and successfully tested.**

- **LED driver with internal stabilisation of the light signal has been developed and tested.**