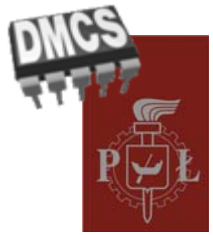
JRA1-SRF
Work Package 8
Tuners

dapnia
cea
saclay

presented by
Przemek Sekalski

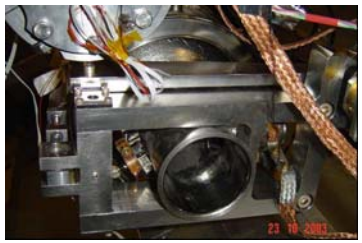


Description

Electromechanical systems for Lorentz force & microphonics compensation and for pre-tuning stage

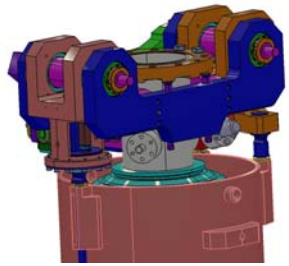
CEA-Sacley current design

- Double lever system
- Stepping motor PHYTRON with Harmonic Drive gear box
- ΔZ=±5mm, Δf=±2.6MHz
- Theoretical resolution 1.5nm
- Stiffness ~100kN/mm
- Ready for piezoelectric and magnetostrictive actuator



CEA-Sacley new design

- Double lever with a screw-nut system
- Stepping motor PHYTRON or SANYO with Harmonic Drive gear box
- Δf=±2MHz @RT, Δf=±460kHz @2K
- Ready for piezoelectric and magnetostrictive actuator
- preload force for active elements is almost decoupled with motor position



task 8.3

UMI Milan tuner Coaxial

- Three coaxial rings connected by blades
- Stepping motor for pre-tuning stage
- Piezos up to 72mm length
- Shorter dead zone between cavities 350→283mm (total accelerator length reduction by 5%)
- Expensive (factor of 2-3)
- Stiffer than others (easily upgradeable)

task 8.1

Description

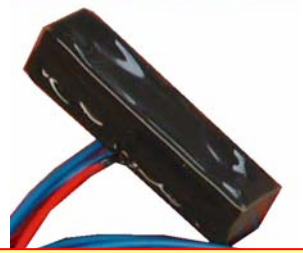
Piezoelectric actuators PZT

Dimensions: **10x10x36mm**
Manufacturer: **PI**

Dimensions: **10x10x30mm**
Manufacturer: **NOLIAC**

Dimensions: **7.5x7.5x50mm**
Manufacturer: **PiezoMechanik**

task 8.4



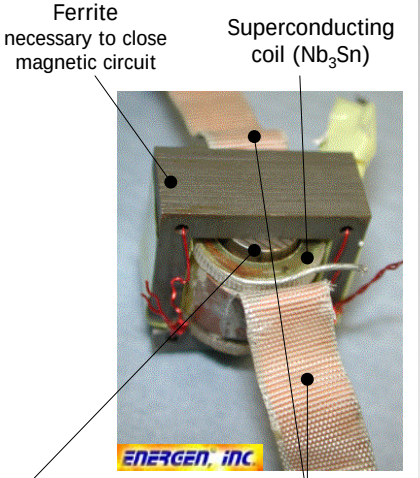
Dimensions: **7x7x30mm**
Manufacturer: **EPCOS**

Magnetostrictive actuators

Plunger & Belleville springs

Niobium Cover

Active magnetostrictive element with ferrite, s.c. coil and thermal connectors



task 8.2

Dimensions: **Φ10x20mm**
Manufacturer: **ENERGEN**
Material: **KELVIN ALL®**

Dimensions: **6x6x20mm**
Manufacturer: **ETREMA**
Material: **GalFeNOL**

Outline

The WP8 – official summary of the 2007 year

- Meetings
- Papers
- Progress

Technical issues

- Coaxial tuner (task 8.1)
- Control system for piezoelements (task 8.2)
- Development on the PTS tuner will be reported in WP 10 (task 8.1)
- Piezostacks characterization (task 8.4)

Meetings organized under JRA1

Date	Title / subject	Location	Number of Attendees	Website Address
21-23 June 2007	14th International Conference Mixed Design of Integrated Circuits and Systems, special CARE session	Ciechocinek, Poland	170	www.mixdes.org

List of talks of JRA1 members

Subject	Speaker/Lab	Event	Date	Web site
Smart Materials as Sensors and Actuators for Lorentz Force Tuning System	P. Sekalski	PhD disortation, DMCS-TUL	Dec 12 2006	
Improved Design of the ILC Blade-Tuner for Large Scale Production, (poster WEPMN020)	C. Pagani (INFN/LASA, Segrate (MI)),	22nd PAC Conference 2007, USA	June 25-29 2007	
FPGA- Based Control System For Piezoelectric Stacks Used For Sc Cavity's Fast Tuner(poster WEPMN052)	K. Przygoda /DMCS-TUL	22nd PAC Conference 2007, USA	June 25-29 2007	

Papers

List of papers	Title	Authors	Journal / Conf.
CARE- pub			
	Measurement of static force in liquid helium temperature	P. Sekalski, A. Napieralski, M. Fouaidy, A. Bosotti, R. Paparella et all,	Meas. Sci. Technol. 2007, 18 2356-2364 doi:10.1088/0957-0233/18/8/009

Papers

List of papers	Title	Authors	Journal / Conf.
CARE-Conf			
	Improved Design of the ILC Blade-Tuner for Large Scale Production,	C. Pagani, A. Bosotti, N. Panzeri (INFN/LASA, Segrate (MI)),	22nd PAC Conference, June 25-29, 2007, USA (WEPMN020)
	FPGA- Based Control System For Piezoelectric Stacks Used For Sc Cavity's Fast Tuner	P. Sękalski, K. Przygoda, A. Napieralski, W. Jałmużna, S. Simrock, L. Lilje, R. Paparella,	22nd PAC Conference, June 25-29, 2007, USA
	Characterization At Cryogenic Temperatures Of Piezostacks Dedicated To Fast Tuners For Srf Cavities	M. Fouaidy, G. Martinet, N. Hammoudi, F. Chatelet, A. Olivier	14th International Conference Mixed Design of Integrated Circuits and Systems Ciechocinek, Poland, 21-23 June 2007
CARE Report			
CARE-Report-2007-015-SRF	Full Characterization of Piezoelectric Actuators used for Superconducting RF Cavities Fast Active Tuning	M. Fouaidy, G. Martinet, N. Hammoudi, F. Chatelet,	**Deliverable 8.4.8: Report on IN2P3 tuner activities**
CARE-Note			
CARE-Note-07-004-SRF	Radiation hardness tests of piezoelectric actuators with fast neutrons at liquid helium temperature	M. Fouaidy, G. Martinet, N. Hammoudi, F. Chatelet, A. Olivier, S. Blivet, F. Galet	

Progress

Nr.	Task	Begin of task	End of task	End 2006	now
8	WP8 TUNERS	01.01.04	31.12.07		
8.1	UMI TUNER	01.01.04	31.12.07	70%	
8.1.1	Control electronics	01.01.04	02.07.04	100%	
8.1.2	Mechanical tuner design, leverage system/motor	03.01.05	29.09.05	100%	
8.1.3	Inte design	03.01	09.05.05	100%	
8.1.4	Cl			%	
8.1.5	Re			%	
8.1.6	Tuner fabrication	10.08.05	07.02.06	100%	
8.1.7	Piezo fabrication and bench tests	07.02.06	06.02.07	30%	100%
8.1.8	Cavity-tuner-coupler integration	04.01.06	30.06.07	0%	100%
8.1.9	Pulsed RF tests	02.07.07	31.12.07	10%	70%
8.1.10	Evaluation of tuner operation	31.12.07	31.12.07	0%	50%
8.2	Magneto-strictive Tuner	01.01.04	31.01.06		
8.2.1	Complete specification	01.01.04	30.01.04	100%	
8.2.2	Conc		31.03.04	10	
8.2.3	Prot				85%
8.2.4	Fin tuner and drive c			%	100%
8.2.5	Test of t		31.01.06	0%	20%
8.2.6	Report on magneto-strictive tuner	31.01.06		50%	50%

On schedule

Almost finished

(waiting for final test with the cavity)

Progress

Nr.	Task	Begin of task	End of task	end 2006	now
8.3	CEA Tuner	05.01.04	01.06.05	100%	
8.3.1	Desi				
8.3.2	Fabr			100%	
8.3.3	Installation RF			100%	
8.3.4	Start of Integrated Experitments	01.06.05	01.06.05	100%	
8.4	IN2P3 Activity	01.01.04	07.08.06	85%	
8.4.1	Characterize actuators/piezo-sensors at low temperature	01.01.04	21.03.05	95%	100%
8.4.2	Report on actuator/piezo sensor	21.03.05	21.03.05	80%	100%
8.4.3	Test r	of piezo tuners	01.07.04	15.	100%	
8.4.4	Rep			80%	100%
8.4.5	Integ	of p		100%	
8.4.6	Cryostat tests	06.12.05	03.02.06	100%	
8.4.7	Tests with pulsed RF	03.02.06	07.08.06	100%	
8.4.8	Report on IN2P3 tuner activities	07.08.06	07.08.06	40%	100%

Finished

Finished

INFN Milan developments

Fast Piezo Blade Tuner (UMI Tuner) for SCRF Resonators Design and Fabrication
WP8.1

C. Pagani, A. Bosotti, P. Michelato, R. Paparella, N. Panzeri, P. Pierini INFN Sezione di Milano LASA, Italy

G. Corniani

ZANON, Schio, Italy

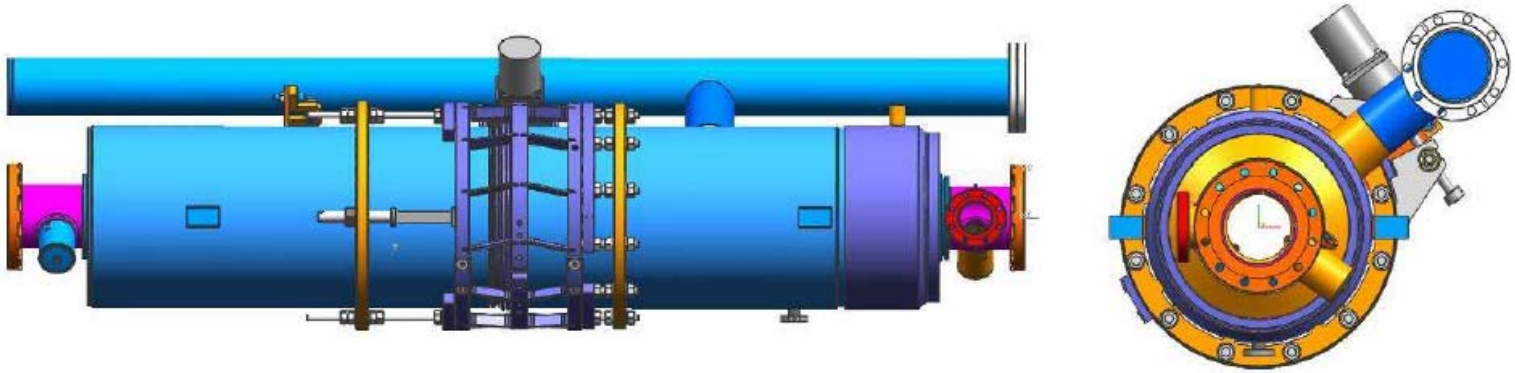
and with the special help of

L. Lilje, R. Lange, C. Albrecht, K. Jensch, W. Maschmann, O. Keller Desy - Hamburg

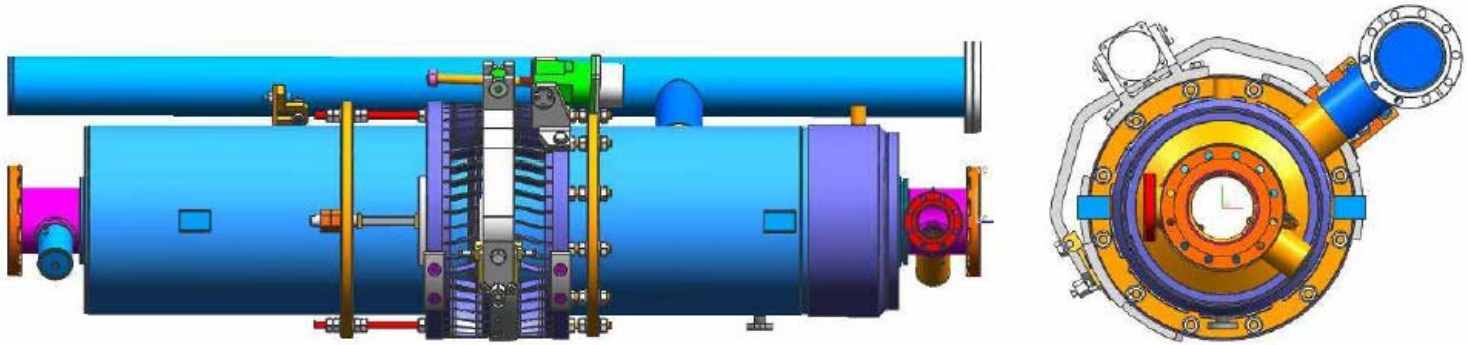
Coaxial Blade Tuner Test in CHECHIA

- The INFN coaxial blade tuner (UMI Tuner) has been successfully tested inside CHECHIA at DESY during week # 36 and 37.
- The device tested is an improved design with respect to the former, cheaper and with improved performances (Slim tuner).
- The tuner has been installed on the Z86 TTF cavity (24 MV/m best E_{acc}) on a modified helium tank, with the insertion of a central bellow to allow the coaxial tuning operation.
- The tuning range achieved is 520 kHz
- Two 40 mm long, 10x10 mm^2 cross section Noliac piezos have been inserted for LFD compensation.
- 300 Hz of LFD has been compensated at E_{acc} = 23 MV/m

Slim tuner vs. standard tuner



The new tuner installed on the old TTF helium tank. Lateral and frontal view. The reduced number of blades used is one of its main characteristics.



The old blade tuner installed on the TTF helium tank. Lateral and frontal views.

Test Summary

Main parameters of tuner

BLADE TUNER, SLIM VERSION 3.0		
material	stainless steel + INCONEL 718	
tuning range (nominal)	**0-500**	**kHz**

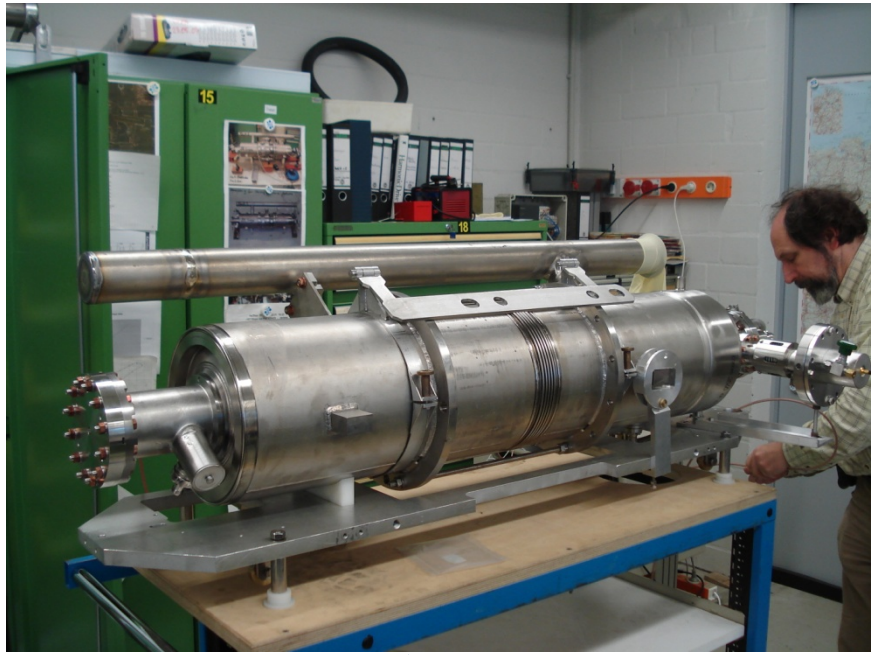
NOLIAC PIEZO FOR Z86		
RT properties		
material	medium soft doped PZT-S1	
length	40	mm
section	10x10	mm
max stroke	60	um
blocking force	4000	N
max load	12000	N
voltage range	0-200	V
nominal C	8	uF
res. Frequency	38	kHz
C after cooldown	2.3	uF

Test Summary

Z86 blade tuner integration activity				
	operation	RF frequency	piezo 1 C	piezo 2 C
		MHz	uF	uF
Monday, 3rd	fill z86 with Ar, 1 bar			
	cleaning of tuner pieces with ultrasound machine,80 °, 15 min			
Tuesday, 4th	unistalling z86 support	1297.427		
	blade tuner on, no motor, no piezo	1297.42		
	blade tuner on, no piezo, motor installed	1297.417		
	blade tuner on, motor and piezo installed, piezo preloaded	1297.562		
	blade tuner on, motor and piezo installed, piezo unloaded	1297.445	9.11	8.81
	blade tuner on, motor and piezo installed, piezo unloaded, + 1/2 turn to motor	1297.47		
	blade tuner on, motor and piezo installed, piezo unloaded, back to initial pos	1297.445		
	blade tuner on, motor and piezo installed, piezo preloaded again	1297.567	9.39	9.04
	blade tuner on, motor installed, piezo installed and preloaded, magnetic shield installed	1297.57		
Wednesday, 5th	T sensor installed and cabling done			
	installation of z86 in chechia, no vacuum		9.46	9.15
Thusday, 6th	ausflugtag!			
	vacuum in beam pipe, measure of piezo_to_piezo TF and piezo Z			
Friday, 7th	vacuum in beam pipe, measure of piezo_to_piezo TF and piezo Z, again.		10.23	10.04
	vacuum in beam pipe, waveguide installed, NA with amplifier connected	1297.827		
	waveguide installed, NA with amplifier connected, more NA resolution and average	1297.842		
Monday, 10	stop conditioning, 4K unstable shield open NA (h: 11:00)	1300.193	4.5	3.5
	repeat f meauseurement 3:00 PM	1300.191	4.15	3.5
	repeat f measurement 17:50		3.87	3.34
	h 18:15 pumping starts	1300.187		
	500 mBar	1300.135		
	h 18:45 200 mBar	1300.045		
	h 19:00 30 mBar	1299.996	3.65	3.1
Tuesday 11	8:00 30 mBar start test	1299.974	2.3	2.3
Friday, 14	Stop test warm-up			

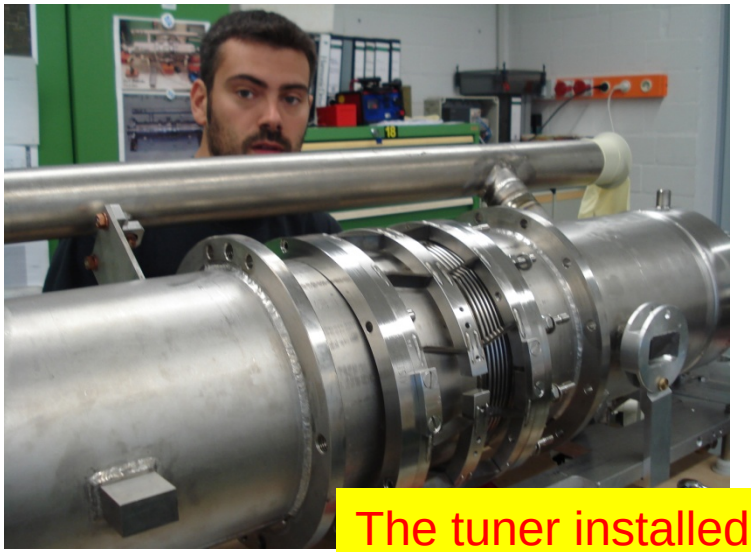
Test Preparation 1/2

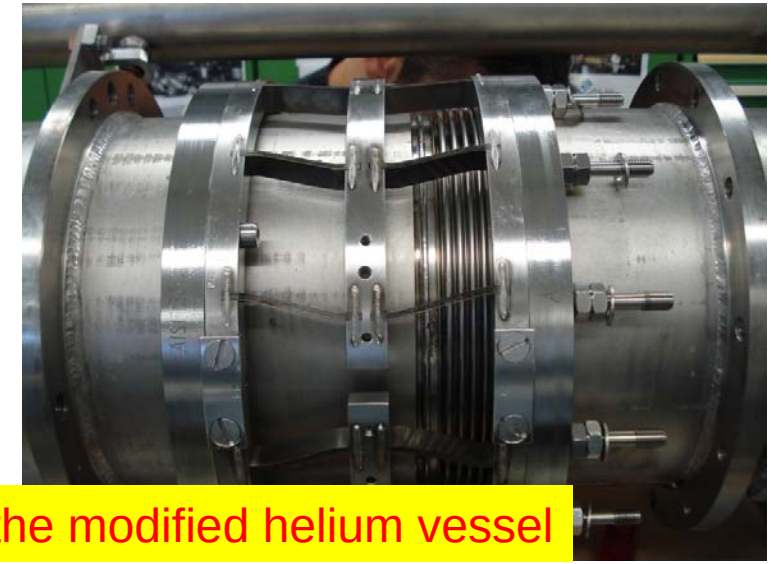
The blade tuner halves in the Halle III machine shop ready to be assembled on the helium tank



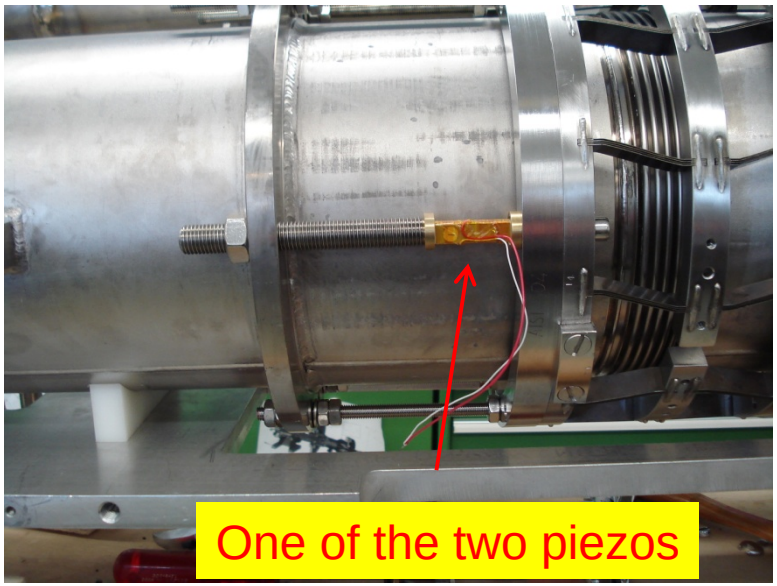
Checking of the frequency and of the field flatness before the installation in CHECHIA.

Test Preparation 2/2

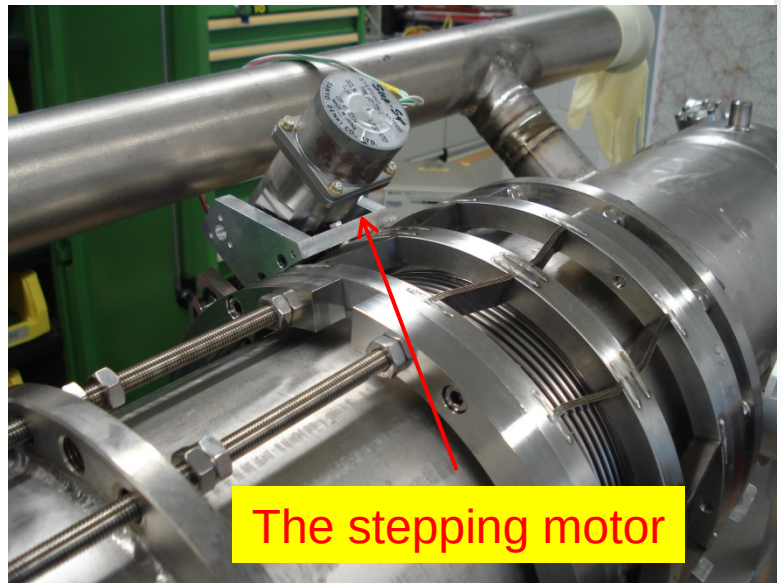




The tuner installed on the modified helium vessel



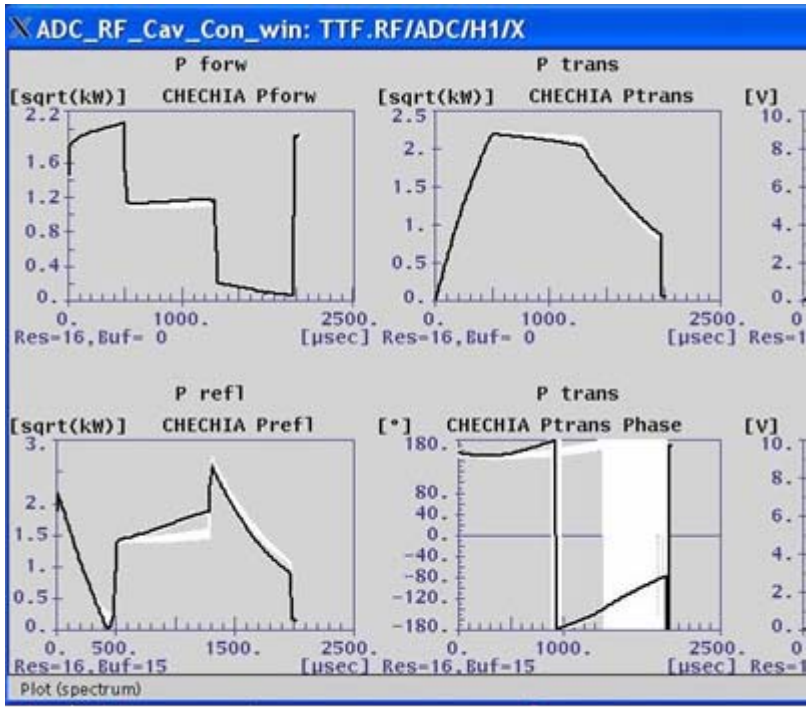
One of the two piezos



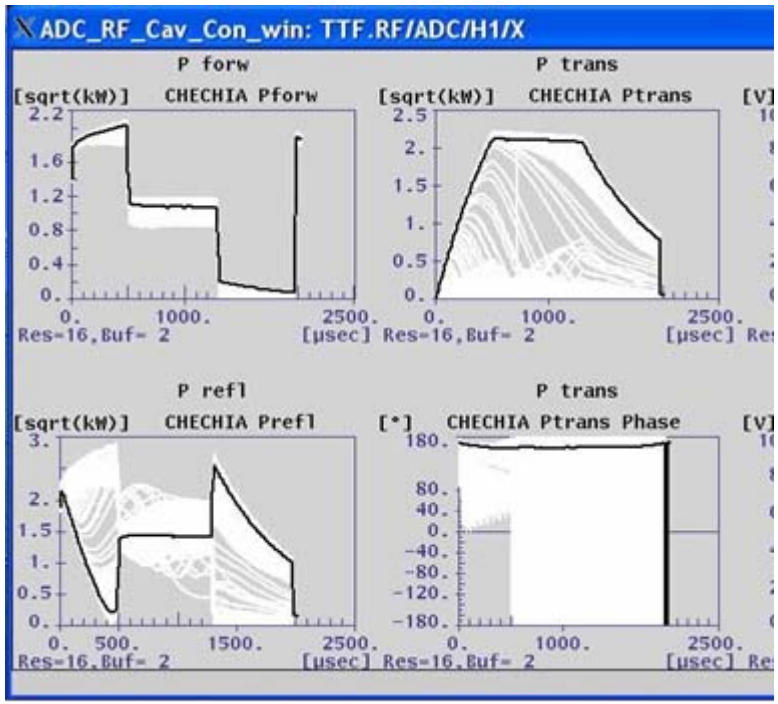
The stepping motor

LFD Compensation

Power pulse shapes with and without the piezos

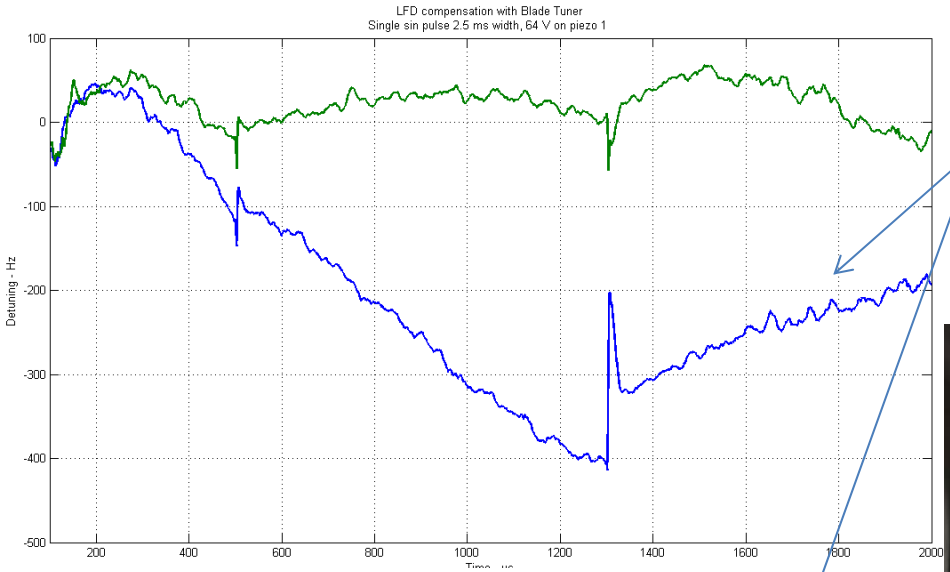


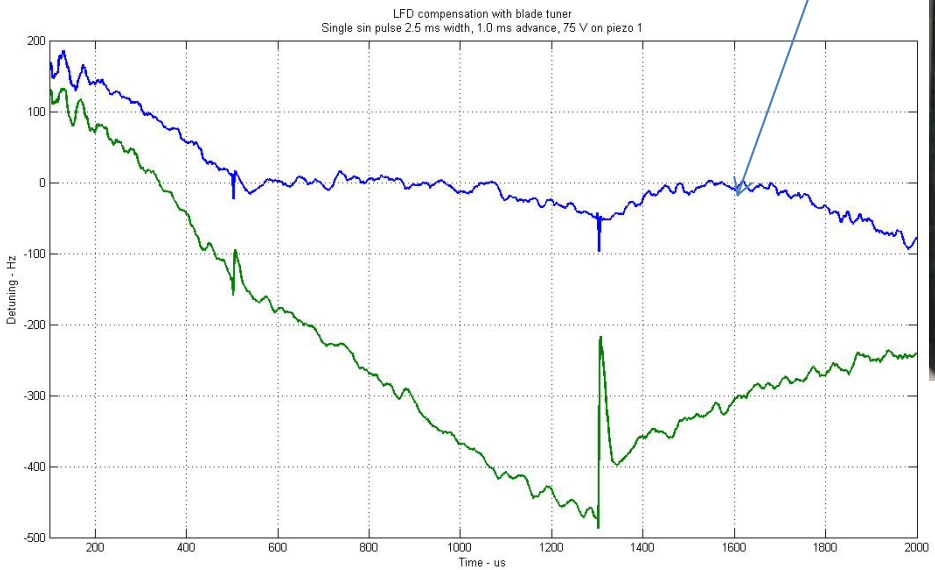
The piezostack is disconnected from the driver



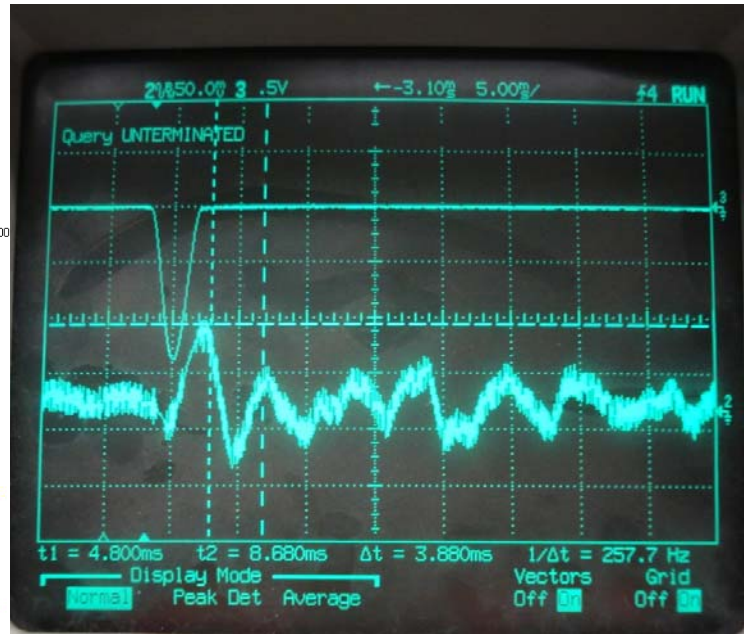
The piezostack is connected

LFD compensation: detuning correction





Cavity detuning compensated with different pulses delay (@ RF pulse) using only one piezo



The output of the Piezo-driver and the ringing of the cavity detected by the other piezo.

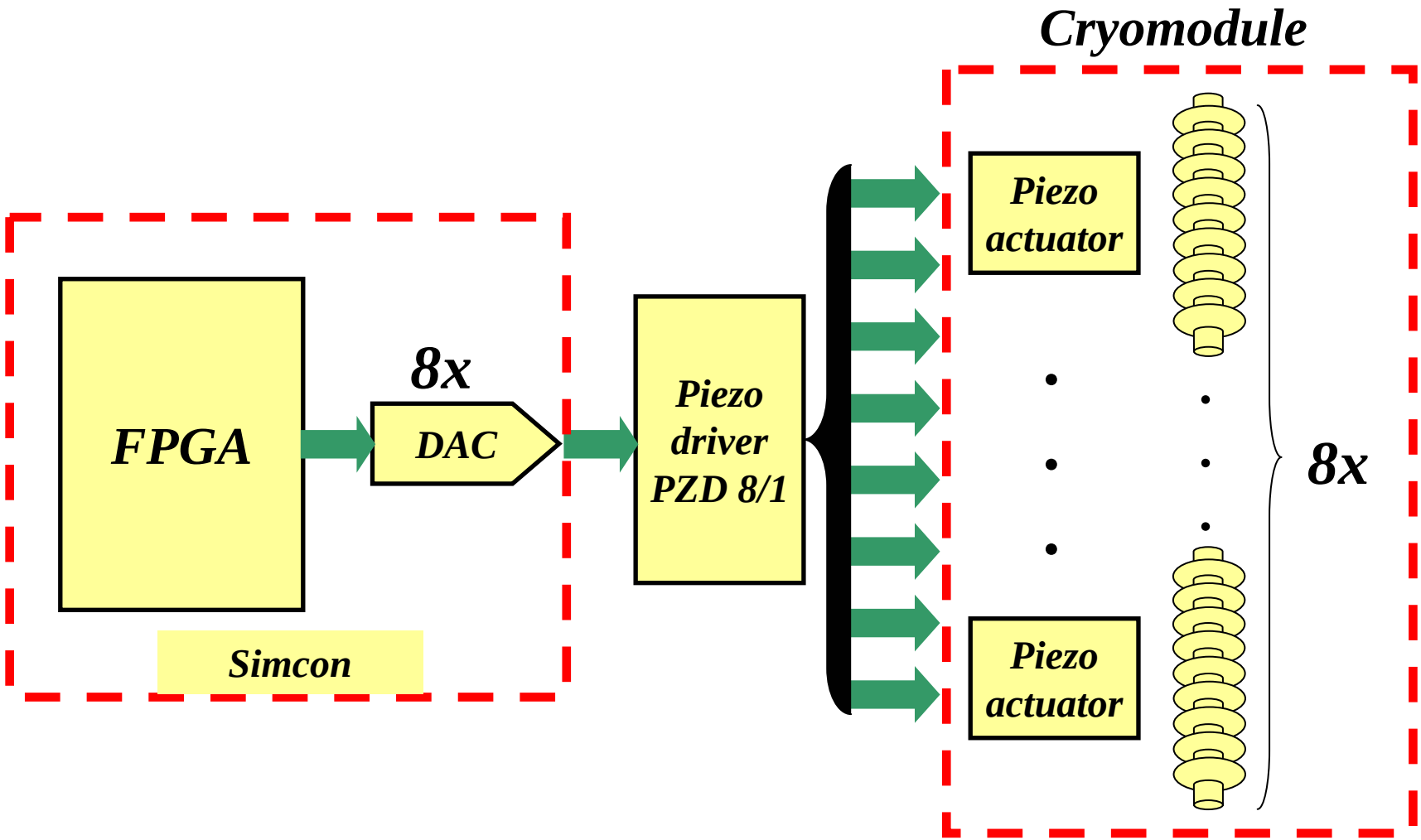
DMCS-TUL developments

Electronic control system for piezoelements (FPGA + new driver)

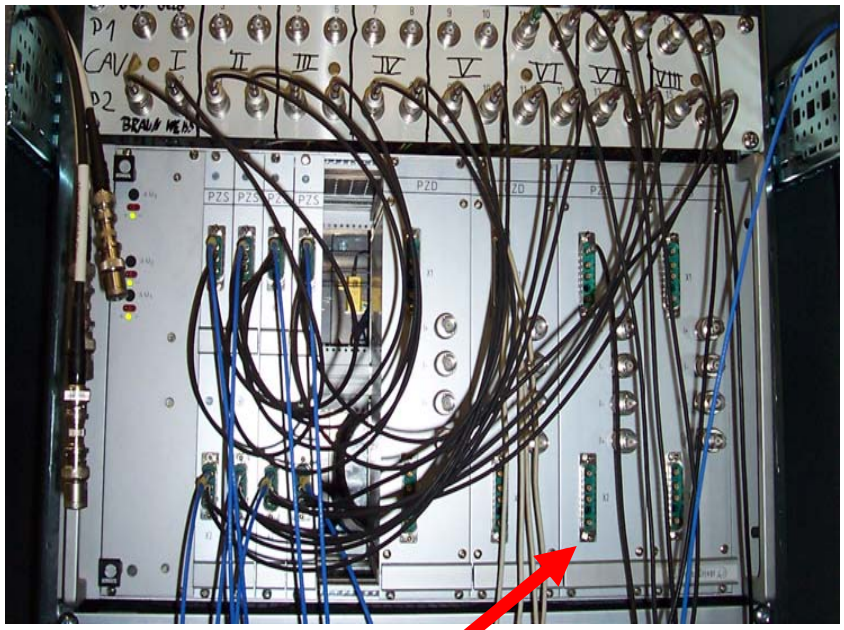
M. Grecki, T. Pozniak, K. Przygoda, A. Napieralski, P. Sekalski

Department of Microelectronics and Computer Science
Technical University of Lodz, Poland

Detuning compensation system



The previous state of Piezo Driver boards



2 channels
Piezo Driver

Main parameters:

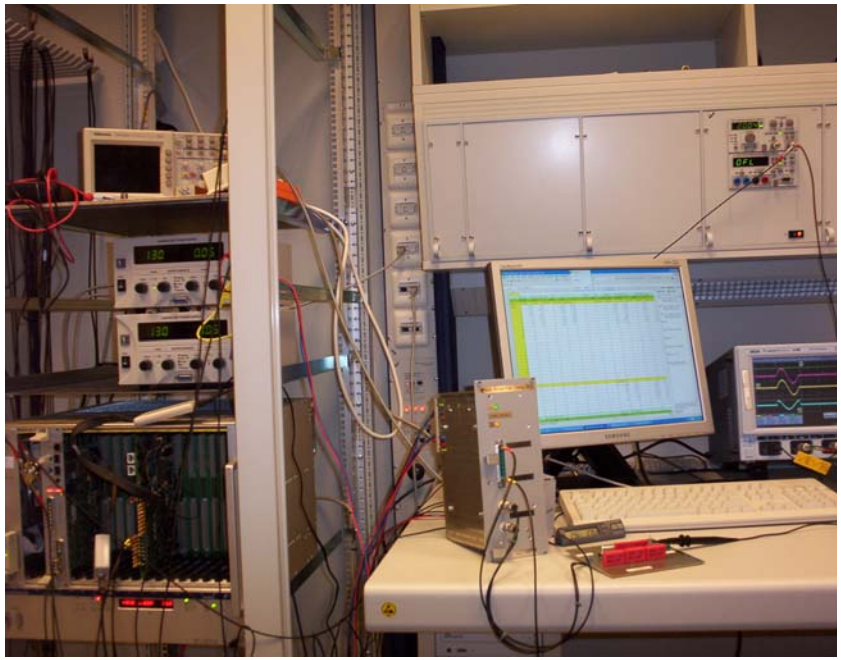
- 4 amplifiers from APEX (PB58A) designed in bridge configuration
- Outputs gain G_u = 40 V/V
- Current, voltage and temperature sense outputs
- 50 Ohm terminated inputs

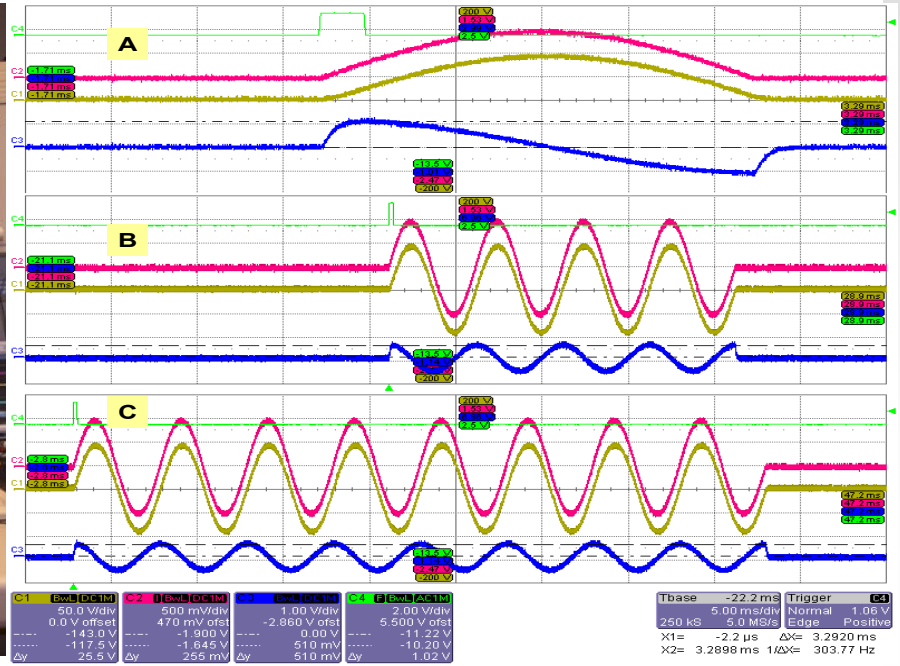
Noticed problems:

- Cross-talks between outputs
- Luck of over-voltage circuits
- Maximum outputs' voltage amplitude(60 V) using SimCon boards

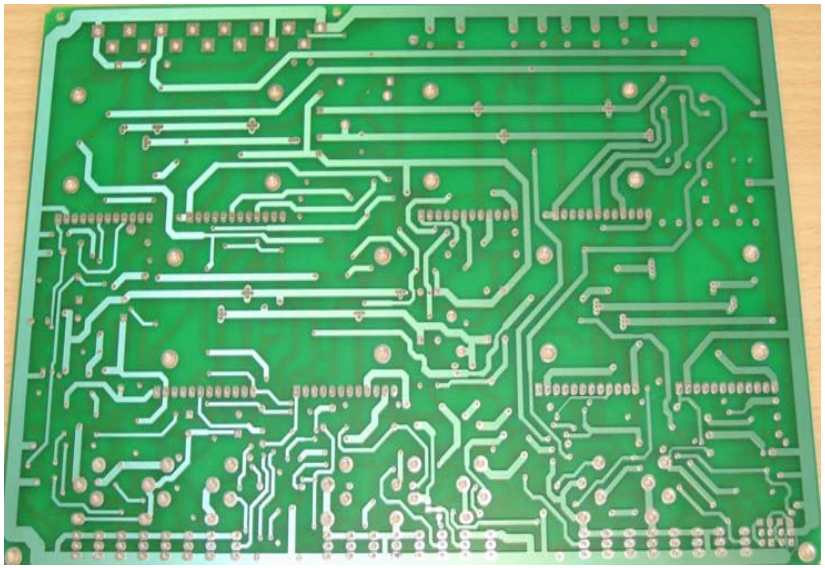
1 **channel Piezo Driver prototype board**

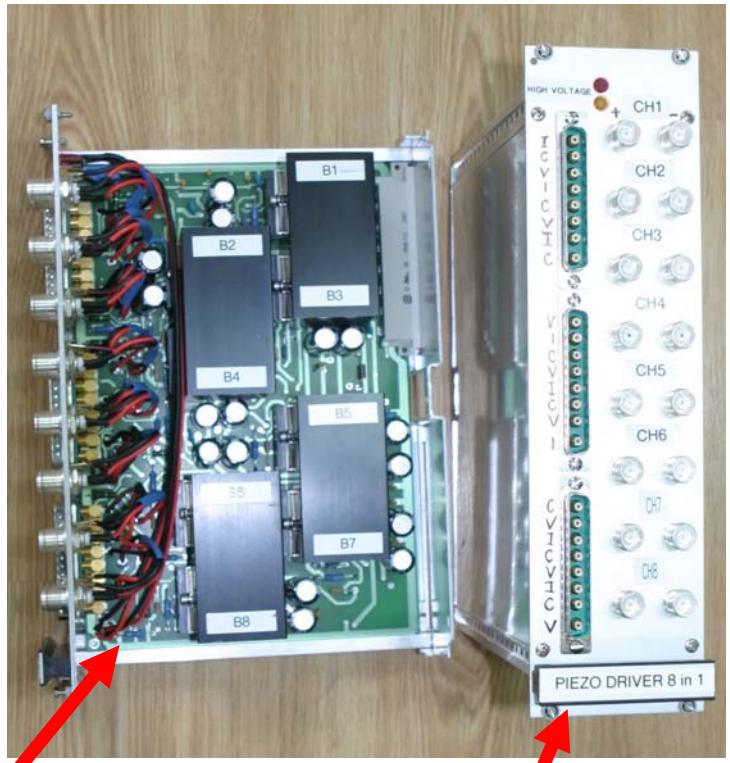
- Single channel Piezo Driver with Power Booster PB58A was tested
- The termal tests confirmed the possibility to design 8 channels PZD with PB51





8 channels Piezo Driver prototype board



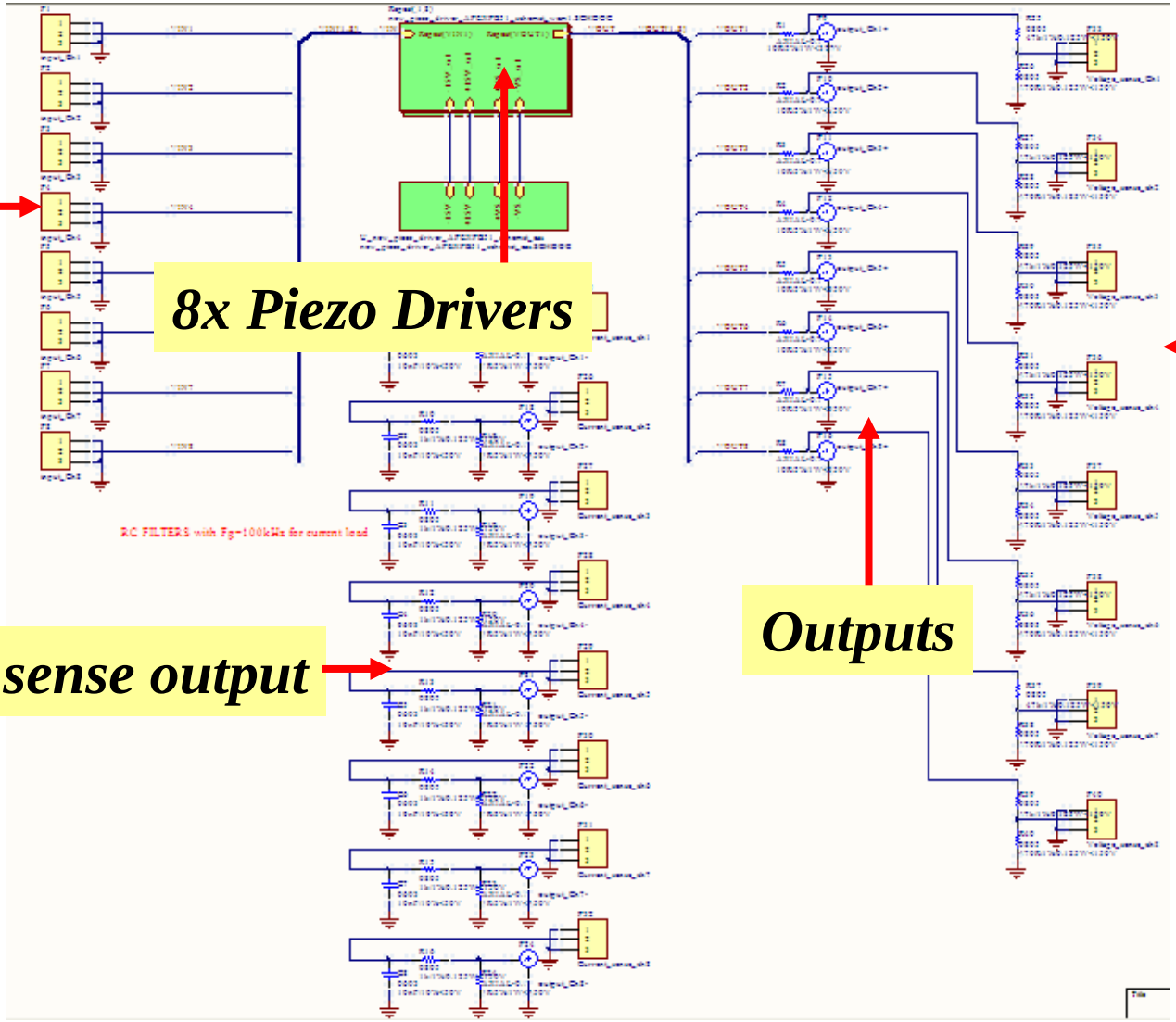


PCB board

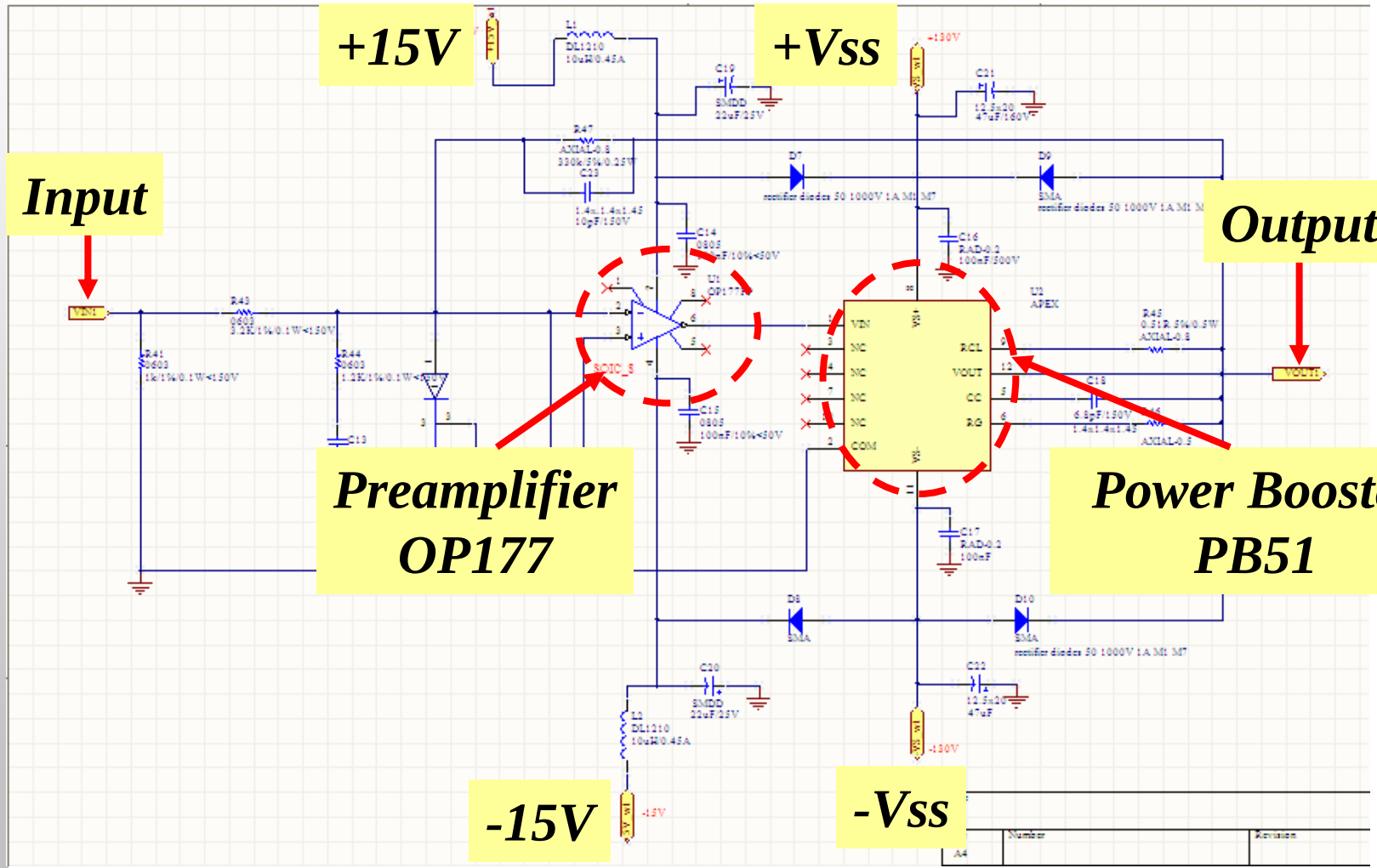
Inside PZD box

PZD box

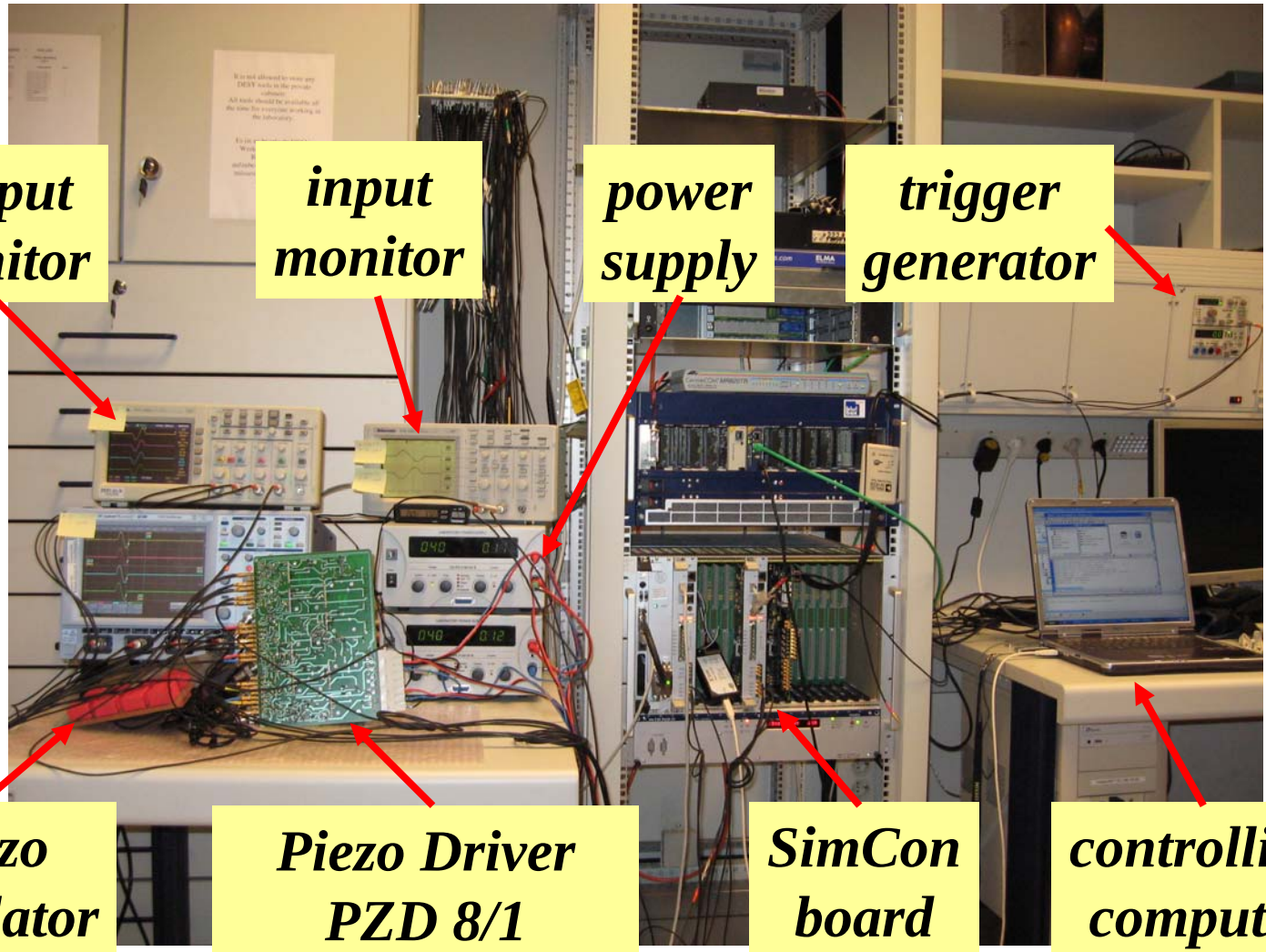
Schematic of PZD 8/1 Amplifier



Schematic of PZD 8/1 Amplifier (2)



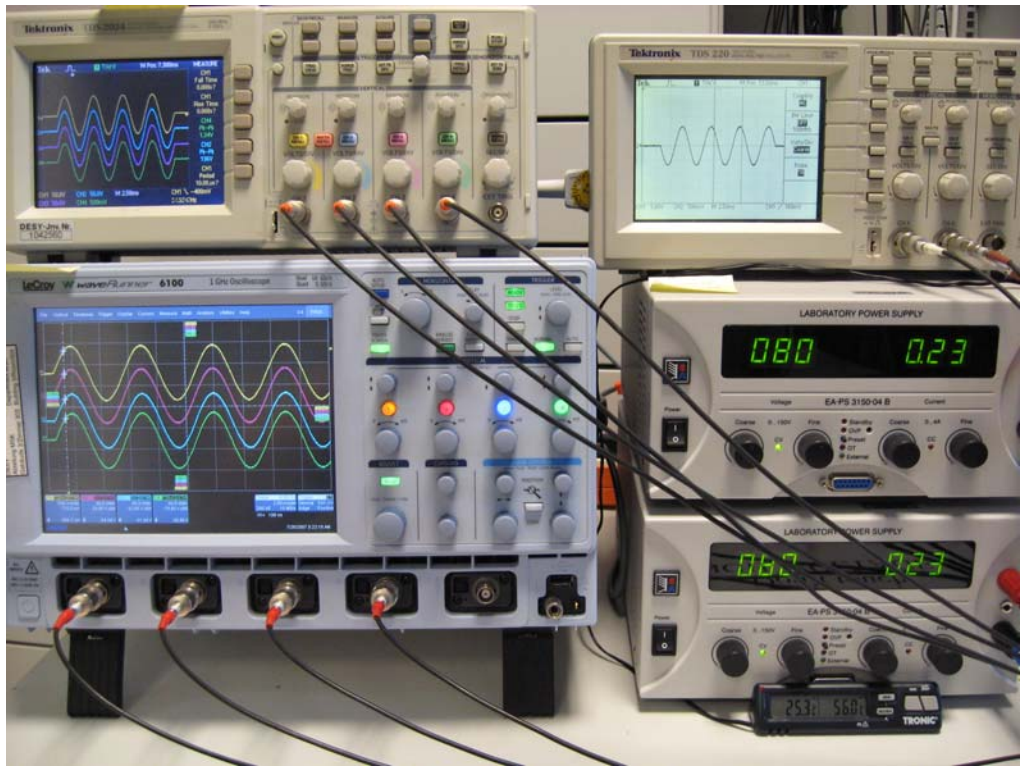
Measurement Stand at DESY



Laboratory tests (1) at DMCS

For foreseen nominal operating conditions:

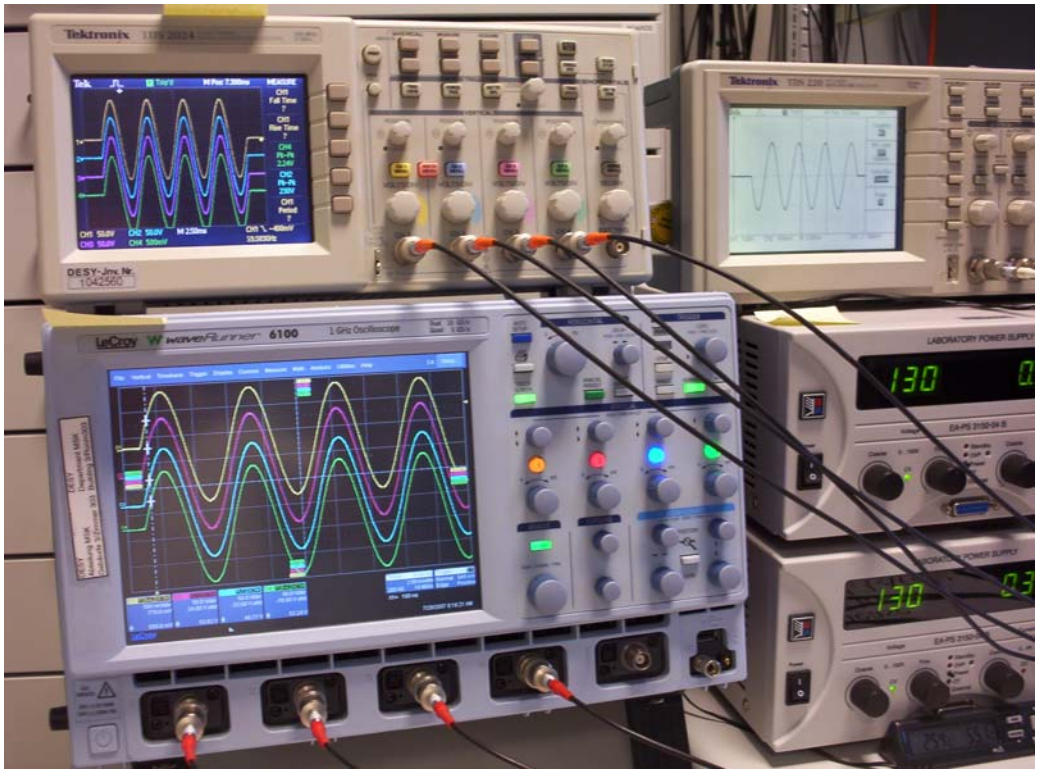
- without cooling system:
  - Gu=100V/V, Vss=±80V, 4 periods of sinusoidal wave input signal 200Hz, 10Hz repetition rate, Vmo=±70 V, **Tc=59°C**
- with cooling system:
  - Gu=100V/V, Vss=±80V, 4 periods of sinusoidal wave input signal 200Hz, 10Hz repetition rate, Vmo=±70 V, **Tc=43°C**



Laboratory tests (2) at DMCS

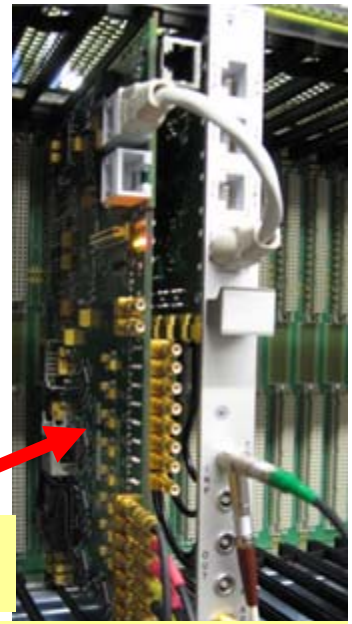
For maximum operating ratings during long time power tests:

- without cooling system:
  - Gu=100V/V, Vss=±130V, 4 periods of sinusoidal wave input signal 200Hz, 10Hz repetition rate, Vmo=±120 V, **Tc=70°C**
- with cooling system:
  - Gu=100V/V, Vss=±130V, 4 periods of sinusoidal wave input signal 200Hz, 10Hz repetition rate, Vmo=±120 V, **Tc=67°C**



FLASH tests(1)

Debug Scope

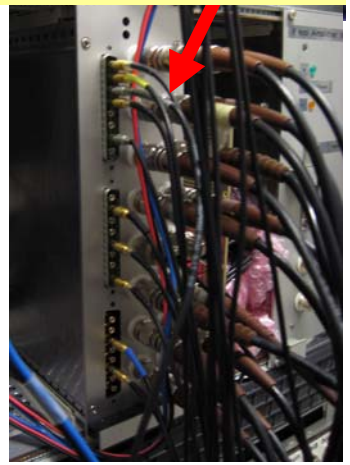


SimconDSP

PZD 8/1

Piezo Panel

Test stand



FLASH tests(2)

Producent ratings	Noliac	PI ceramic
Model:	SCMAS/S1/A/10/10/30/200 /42/6000	P-888.90
Cells	8	8
Voltage:	<200 V	<120
Blocking force:	6kN	3kN
Size:	10 mm x10mm x 30 mm	10 mm x10mm x 35 mm
Capacity:	6uF	12uF

Capacitance Measurements

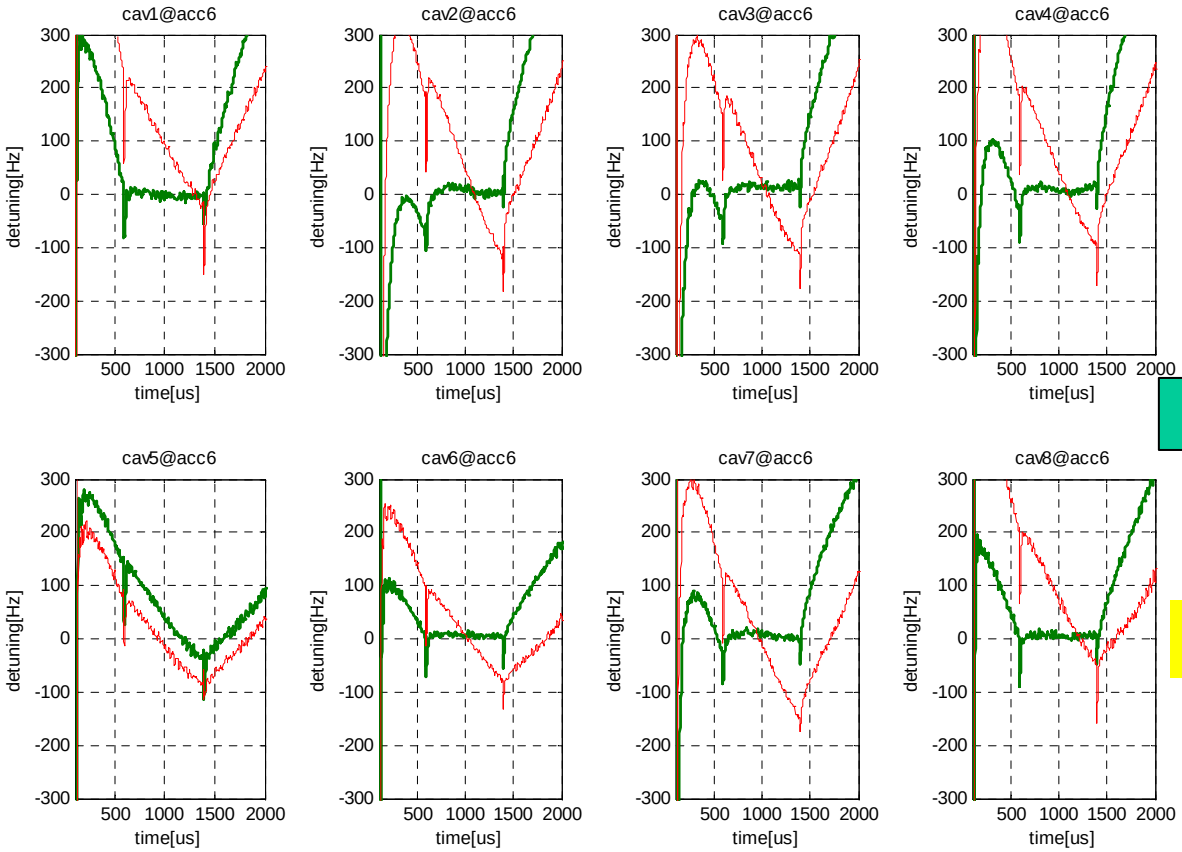
- Piezostack configuration – FLASH operating ratings at Cryo Temp. 2K

$I_{Load\text{-}PI}$ = 0,4 A; $I_{Load\text{-}NOLIAC}$ = 0,22 A

cavity	piezo	model	Acc3/M7	model	Acc5/M5	model	Acc6/M6
1	1	PI	4,93uF	noliac	2,1uF	PI	4,13uF
	2	-	Unavailable	-	Unavailable	PI	4,45uF
2	1	PI	4,61uF	noliac	2,22uF	PI	4,4uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
3	1	PI	4,91uF	noliac	2,28uF	PI	4,21uF
	2	-	Unavailable	-	Unavailable	PI	4,1uF
4	1	PI	4,6uF	noliac	3,12uF	PI	3,86uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
5	1	noliac	2,6uF	noliac	2,2uF	PI	4,22uF
	2	-	Unavailable	-	Unavailable	PI	4,28uF
6	1	noliac	2,13uF	noliac	2,13uF	PI	3,73uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
7	1	noliac	2,22uF	noliac	2,19uF	PI	4,69uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
8	1	noliac	2,21uF	noliac	2,17uF	PI	4,31uF
	2	-	unavailable	-	unavailable	PI	4,2uF

Results(1)

- ACC6 LFD compensation
  - (SP 22 MV/m, Pfor = 280 kW, Trg = 5 Hz)



Cav(1-3)
Amp: 34V
Dly: -4100 us

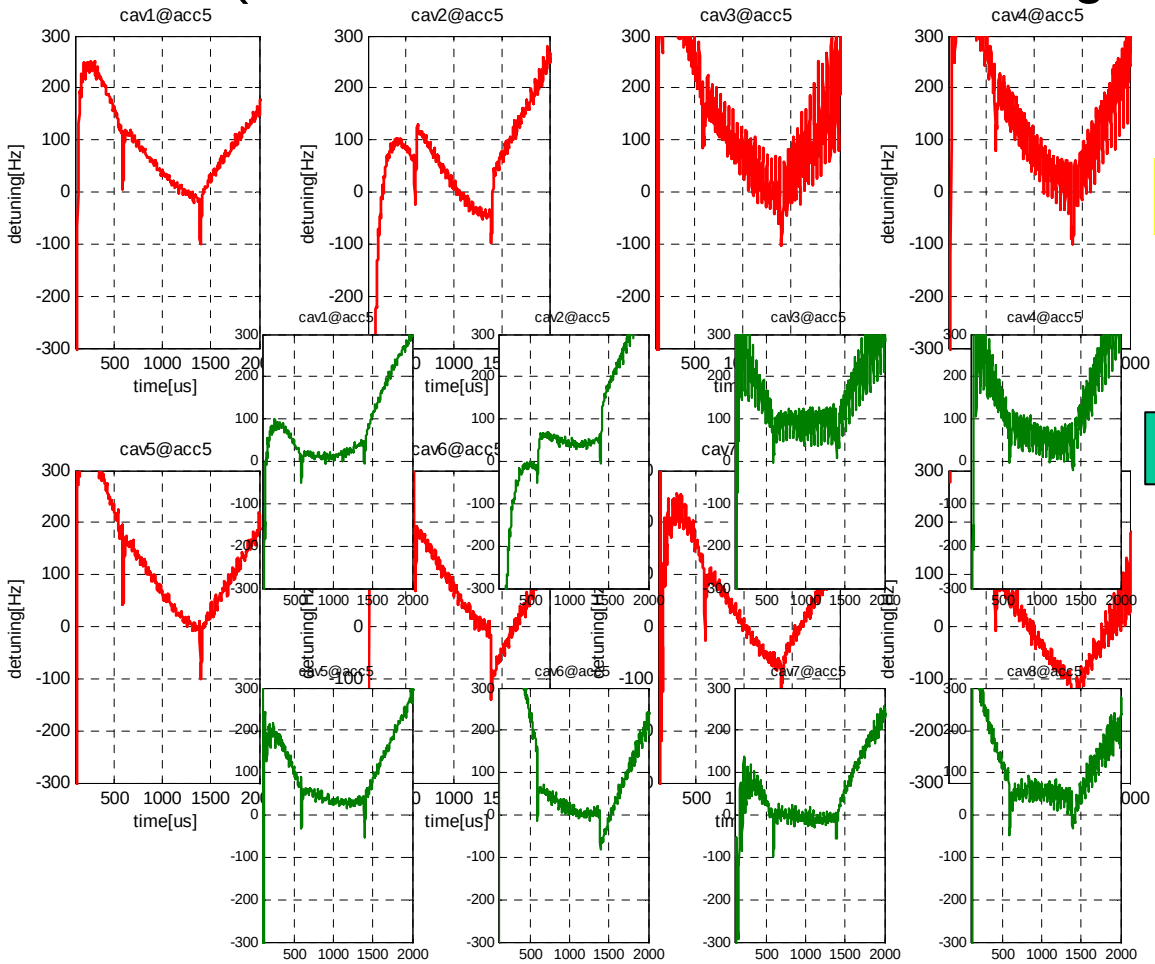
Cav(4-8)
Amp: 23V
Dly: -4000us

(Amp,Dly)

problem with tuner assembling

Results(2)

- ACC5 LFD compensation
  - (SP 22 MV/m, Pfor = 280 kW, Trg = 5 Hz)

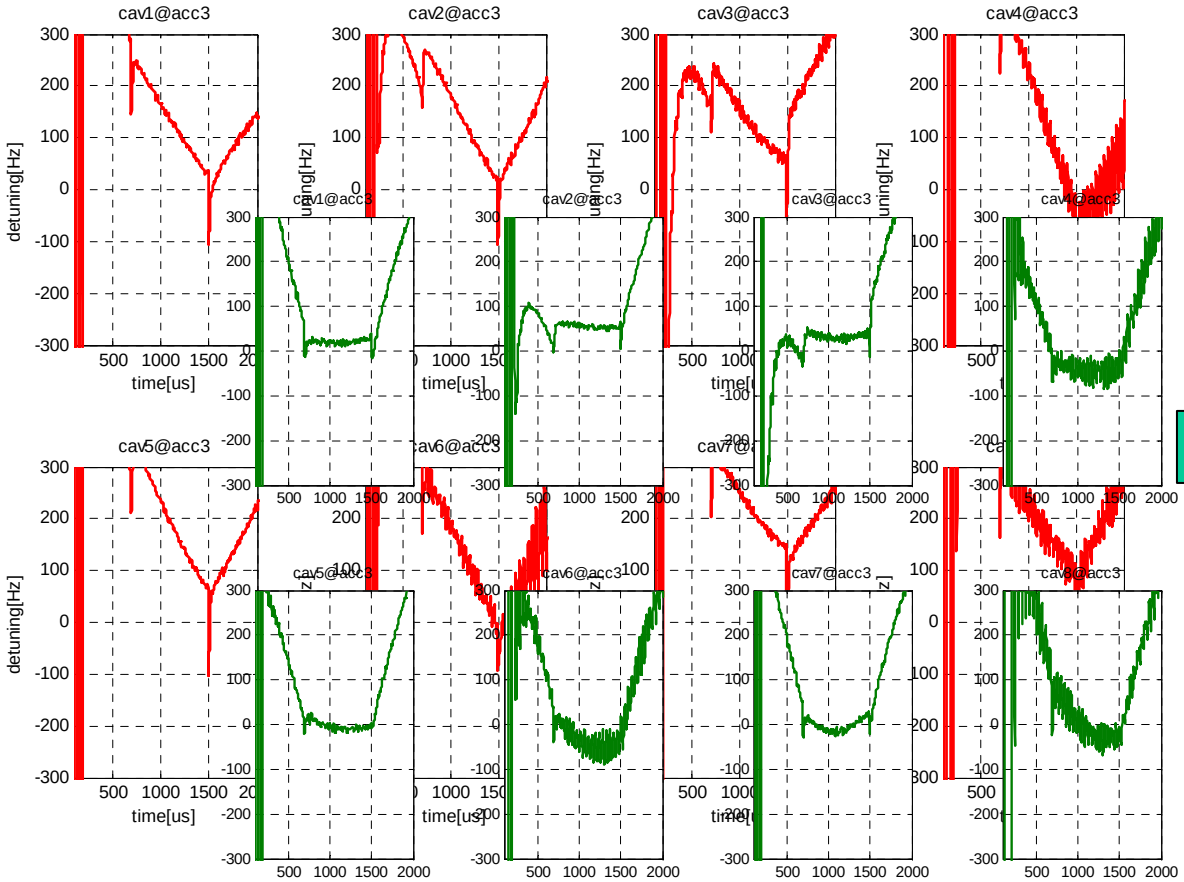


(Amp,Dly)

Cav(1-8)
Amp: 29,3V
Dly: -3625 us

Results(3)

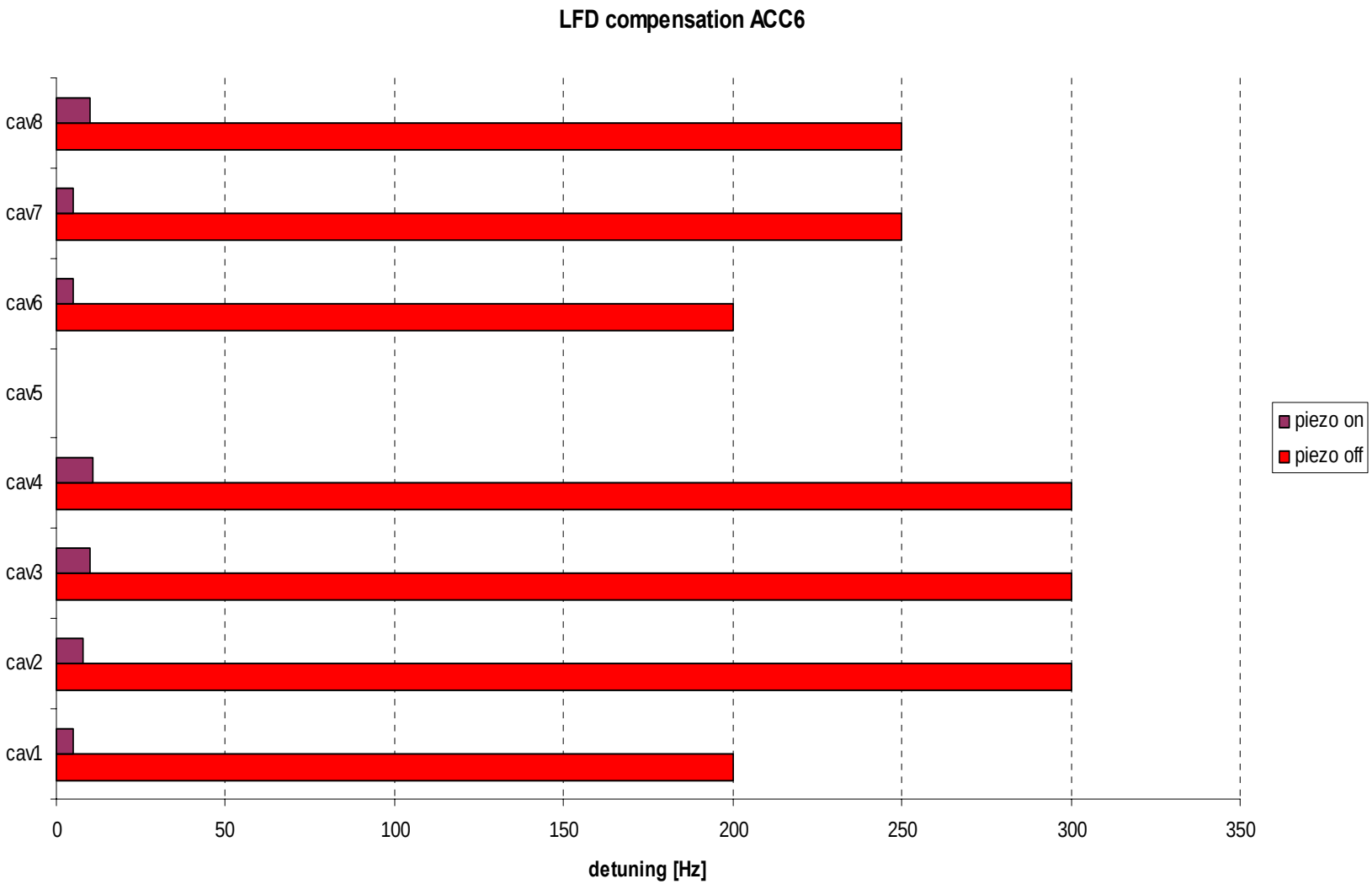
- ACC3 LFD compensation
  - (SP 22 MV/m, Pfor = 280 kW, Trg = 5 Hz)



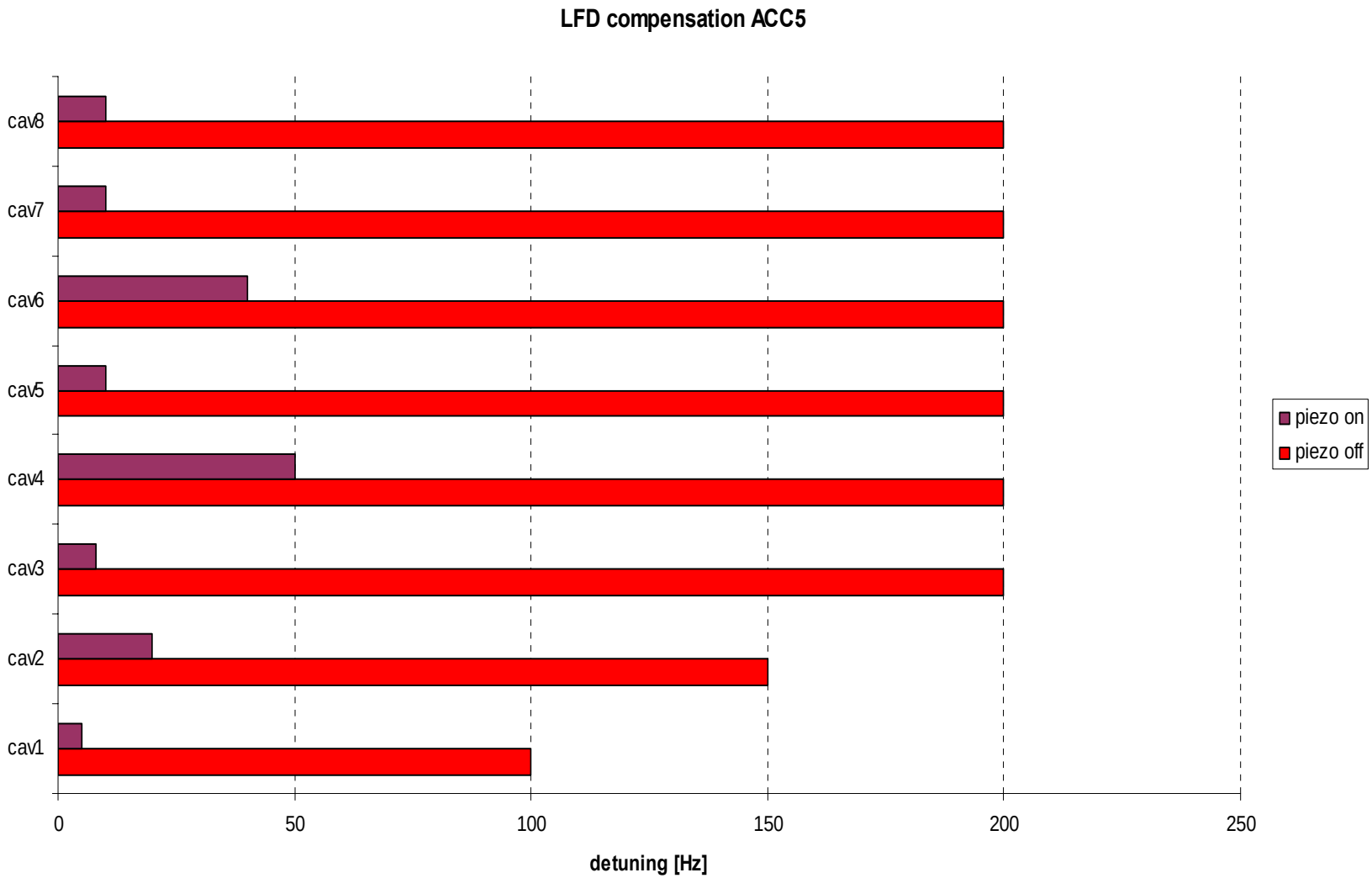
(Amp,Dly)

Cav(1-4)
Amp: 23,7V
Dly: -3750 us
Cav(5-8)
Amp:42,5V
Dly: -3250

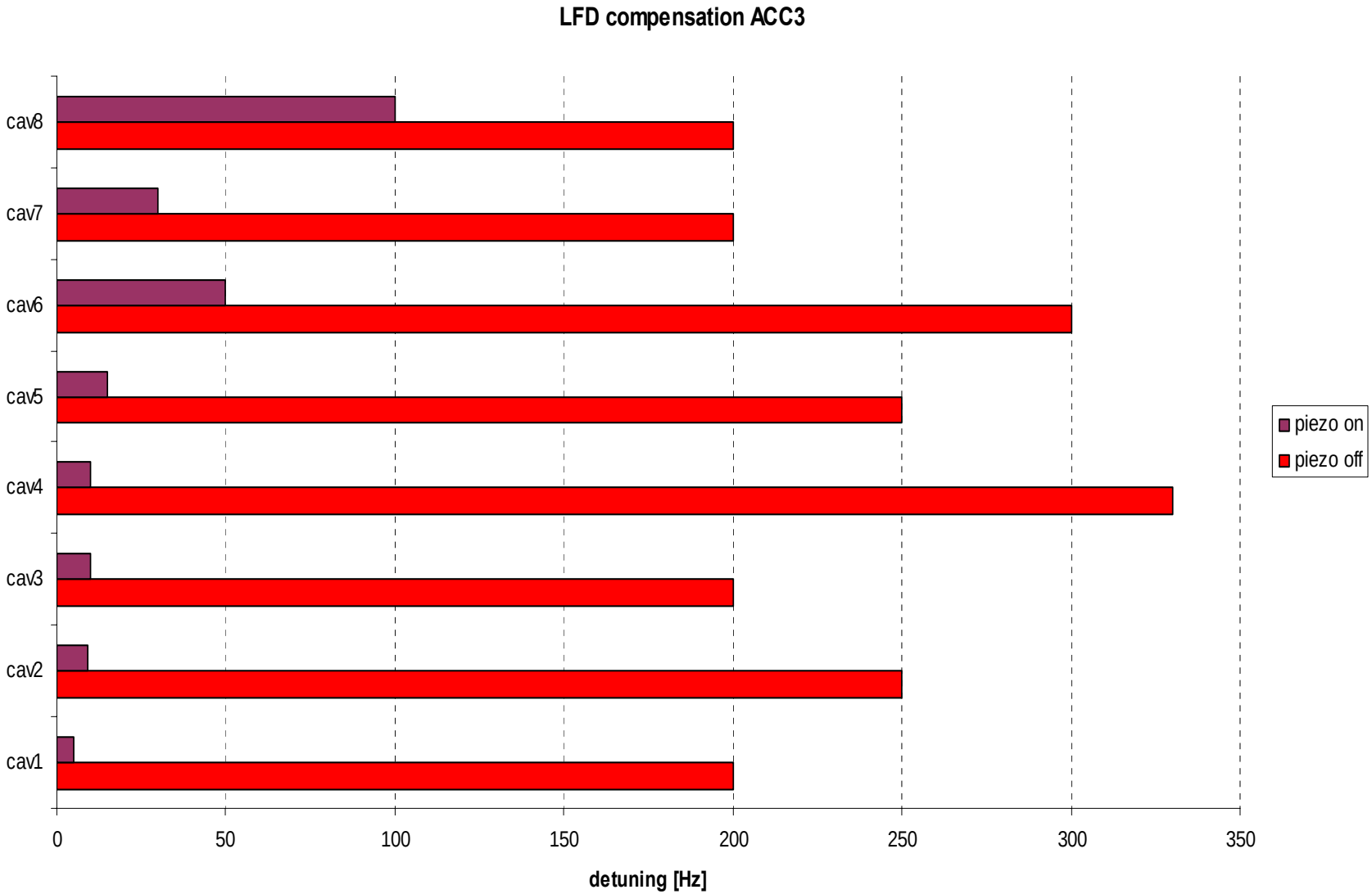
Results(4)


LFD compensation ACC6
cav8
cav7
cav6
cav5
cav4
cav3
cav2
cav1
0
50
100
150
200
250
300
350
detuning [Hz]
piezo on
piezo off

Results(5)


LFD compensation ACC5
cav8
cav7
cav6
cav5
cav4
cav3
cav2
cav1
0
50
100
150
200
250
detuning [Hz]
piezo on
piezo off

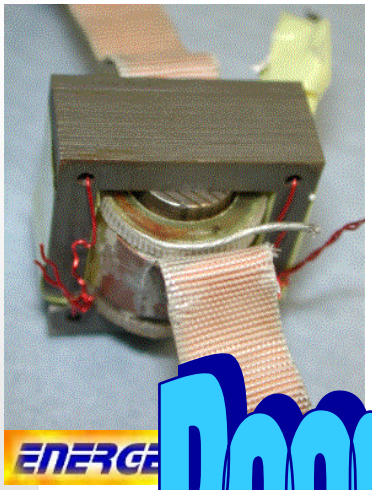
Results(6)

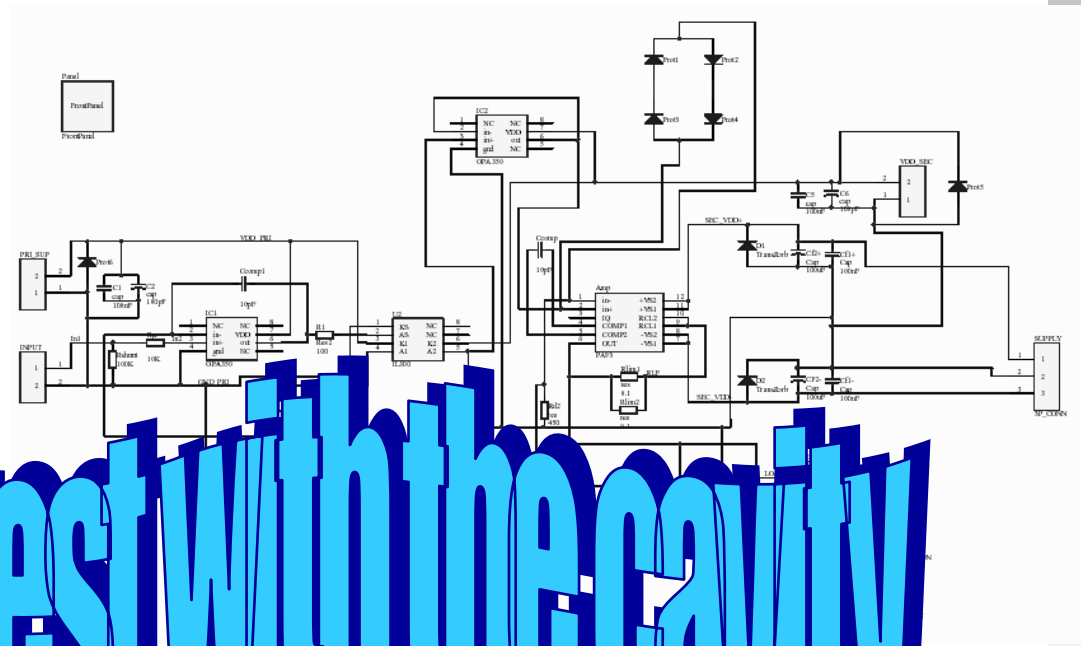

LFD compensation ACC3
cav8
cav7
cav6
cav5
cav4
cav3
cav2
cav1
0
50
100
150
200
250
300
350
detuning [Hz]
piezo on
piezo off

Future Plans

- Redesign of PZD 8/1 PCB board with more attention to cross-talk possibilities between outputs (temperature sense inputs)
- Detuning measurements for 8 cavities using 3 SimConDSP boards and OPTO link connections
- Digital feedback control implemented in SimConDSP board for 8 cavities

Magnetostrictive tuner prototype

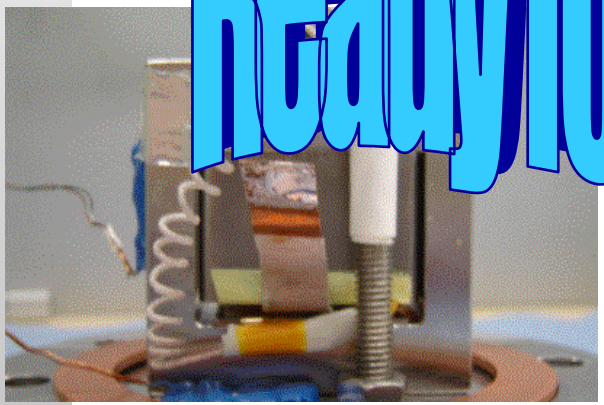




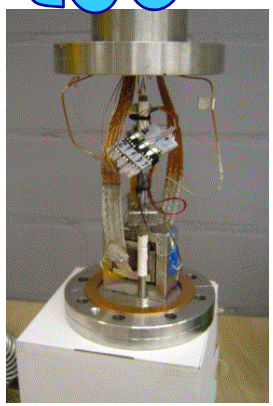
Ready for test with the cavity

3 APEX

Power Operation



Fast tuner with Kelvin All rod from ENERGEN

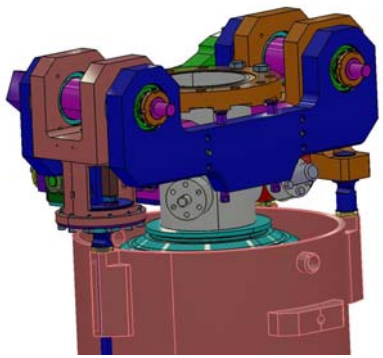


Experimental setup

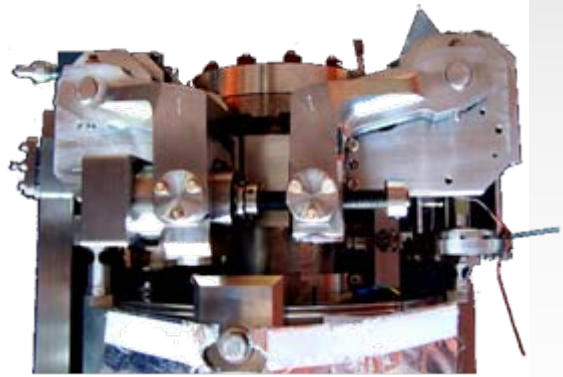
GalFeNOL rod from ETREMA

CEA developments

New Piezo Tuning System
WP 8.3



P. Bosland , G. Devanz and all



The task is finished
The results will be shown in **WP10**

IPN Orsay developments

Piezostacks characterization
WP 8.4

M. Fouaidy and all

The task is finished

Final report was supplied to CARE Management

Active elements - summary

Dimensions: **10x10x36mm**
Manufacturer: **PI**

Dimensions: **10x10x30mm**
Manufacturer: **NOLIAC**

Maximum displacement (stroke) at 2K >3μm

Actuators suited for **VUV-FEL**, **X-FEL** and even **ILC** (≈1kHz⇔~35MV/m)

No [illegible] **sts**

[illegible] ars

Final report was published in Spring 2007

No damage caused by neutron irradiation, only heating observed

Dose of 2÷3*10^{14} neutrons in 8h

Facilities for piezostack investigation are set in IPN Orsay and INFN Milan

WP8 summary

- In the new module ACC6, each cavity is equipped with the CEA tuner (WP8.3). Each has 2 piezostacks characterized previously by IPN (WP8.4). The control electronics is developed by TUL (WP8.2).
- The Lorentz force is compensated by 90% for field gradient of 22 MV/m for all cavities in ACC 3, ACC 5, ACC 6.
- Final reports for piezostack characterization submitted to CARE management (WP8.3).
- The first test of coaxial tuner in CHECHIA shows it capability to reduce the LFD from 300 Hz down to ~40 Hz for field gradient up to 23 MV/m (WP8.1)

Partners

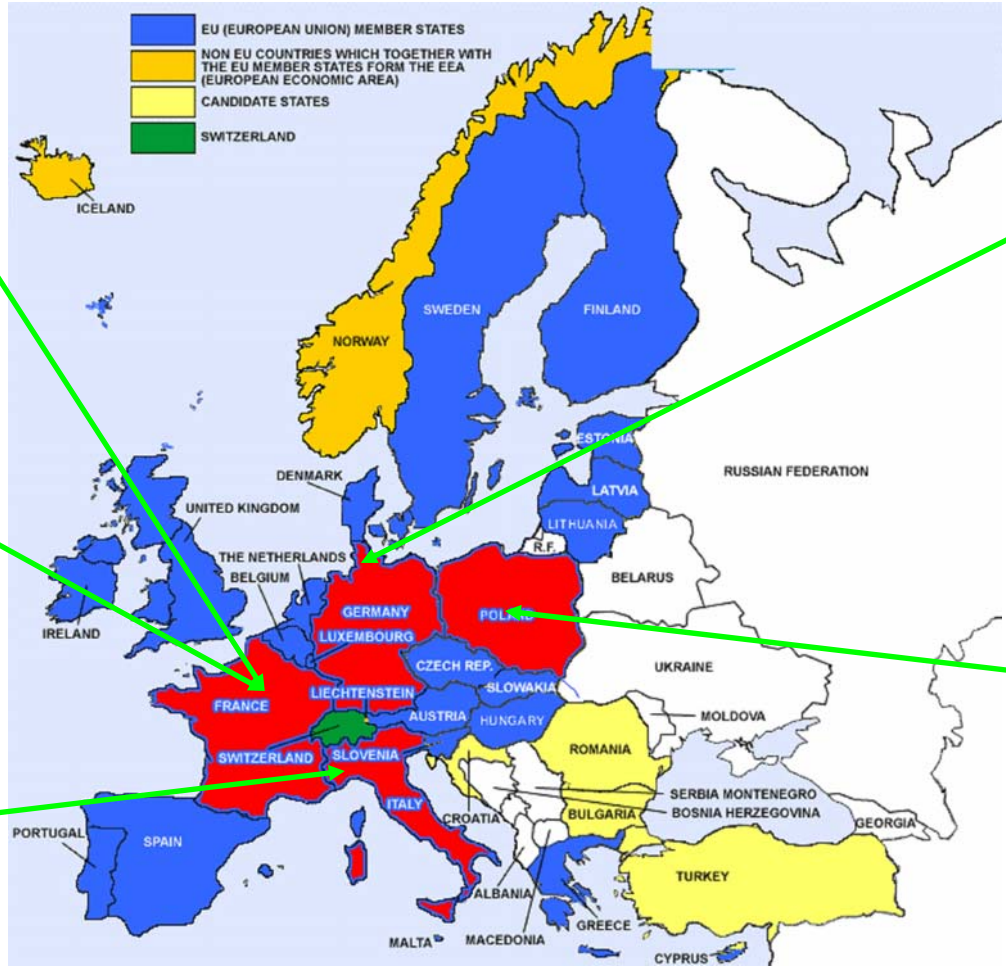
dapnia

cea

saclay

IPN Orsay

INFN

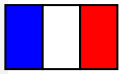


DESY

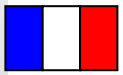
DMCS

I would like to thank to the co-workers...

C. Pagani, A. Bosotti, P. Michelato, R. Paparella, N. Panzeri, P. Pierini, F. Puricelli, INFN Sezione di Milano LASA, Italy
G. Corniani, ZANON, Schio, Italy



Bo Wu, G. Devanz, P. Bosland, E. Jacques , S. Leducq, J.F. Denis, M. Luong, CEA-Saclay, France
and B. Visentin from the CryHolab Group



M. Fouaidy, G. Martinet, N. Hammoudi, F. Chatelet, A. Le Goff, A. Olivier, M. Saki, N. Gandolfo, H. Saugnac, L. Simonet, S. Blivet, F. Galet, S. Rousselot, S. Bousson, IPN-Orsay, France

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DESY-Hamburg

T. Schilcher et all, Paul Scherrer Institute

and many others...

Thank you for your attention