STATUS OF POWER SUPPLIES

Miquel Teixidó (CITCEA-UPC)

On behalf of the Power Converters Group:
Montse Pont (CELLS)
Roberto Petrocelli (CELLS)
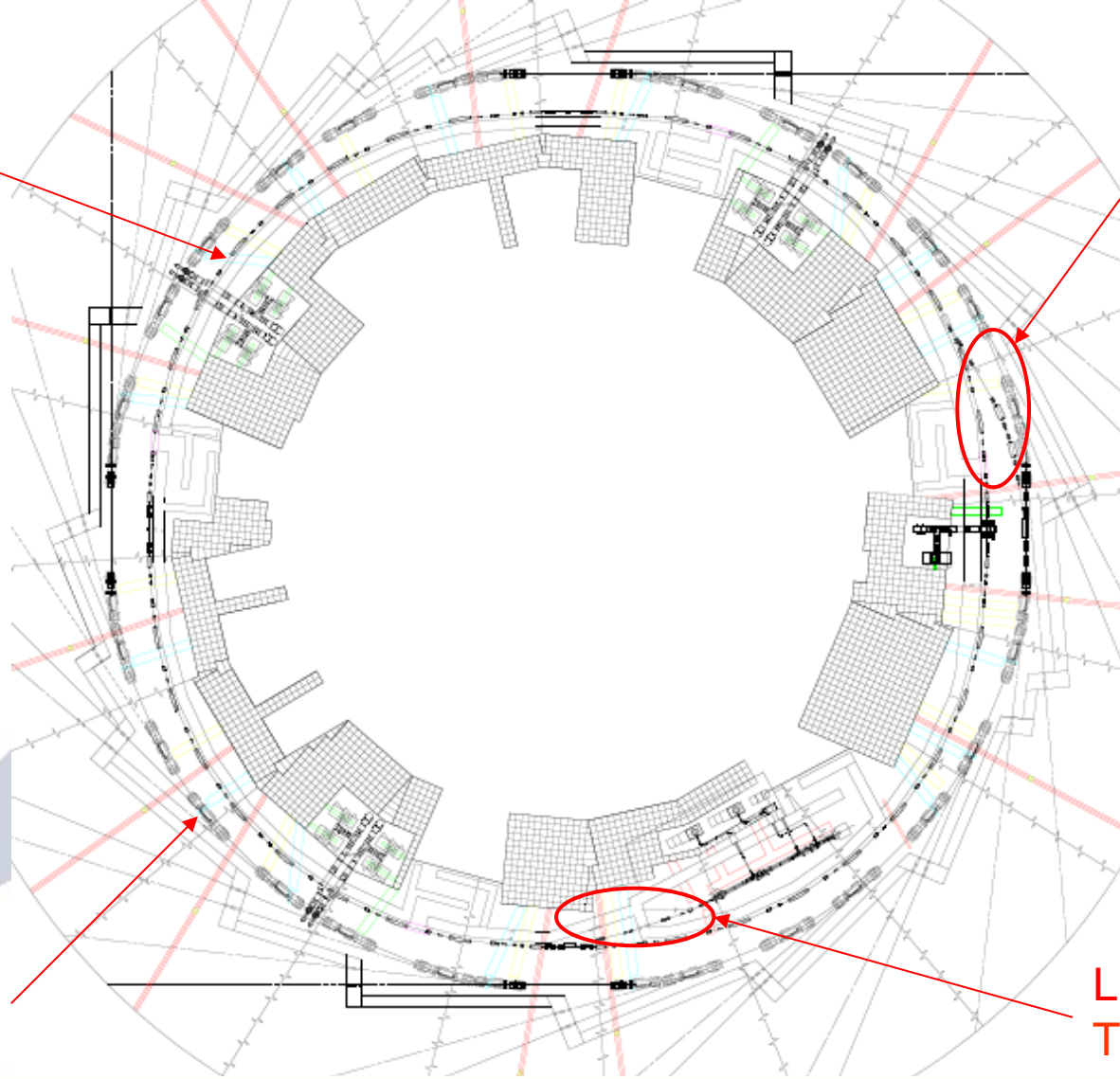Guillermo Martín (CITCEA-UPC)

19th-21th May 2008

OVERVIEW OF ALBA

Booster
(inner)

Booster-to-SR
Transfer line

Storage Ring

Linac-to-Booster
Transfer line

OVERVIEW OF STORAGE RING POWER SUPPLIES

MAGNET	QUANTITY		Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (kW)	STATUS
DIPOLES	33		1	0	600	750	450	ASSEMBLY
QUADRUPOLES	112	16 (Q200)	88	8	200	15	3	FAT&SAT OF PROTOTYPES FINISHED. ASSEMBLING OF THE SERIES
		48 (Q260)						
		24 (Q280)						
		24 (Q500)	24	2	225	25	5,625	IDEM
SEXTUPOLES	120	4 families x 8 magnets (S150A)	4	1	215	100	21,5	FAT&SAT OF PROTOTYPES FINISHED. ASSEMBLY OF THE REMAINING PS STARTED
		2 families x 16 magnets (S150B)	2	0	215	190	40,85	ASSEMBLY
		2 families x 24 magnets (S220A)	2	1	215	350	75,25	ASSEMBLY
		1 family x 8 magnets (S220B)	1	0	215	125	26,875	ASSEMBLY
CORRECTORS	208	Horizontal	88	6	±12	±60	200	AWARDED
		Vertical	88	6	±12	±60	200	AWARDED
		Skew	2	0	±5	±60	200	AWARDED

OVERVIEW OF BOOSTER POWER SUPPLIES

MAGNET	QUANTITY		Nº PS	SPARE	Current (Apeak)	Voltage (Vpeak)	OUTPUT ACTIVE POWER (kW)	STATUS
DIPOLES	40	40 coils	1	0	750	±1000	95	DESIGN REPORT FINISHED
		40 coils	1	0	750	±1000	95	DESIGN REPORT FINISHED
QUADRUPOLES	60	16 (series connection 8+8)	2	0	180	±100	3,5	ASSEMBLY
		8	1	0	180	±200	5,6	ASSEMBLY
		36	1	0	180	±750	24,5	ASSEMBLY
SEXTUPOLES	16 (series connection 8+8)		2	0	±8	±60	0,45	ASSEMBLY
CORRECTORS	72		72	4	±6	±10	0,25	ASSEMBLY

OVERVIEW OF TRANSFER LINES POWER SUPPLIES

LINAC to BOOSTER TL

MAGNET	QUANTITY		Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (W)	STATUS
DIPOLES	2	type 1	1	0	180	20	3600	ASSEMBLY
		type 2	1	0	12	12	150	ASSEMBLY
QUADRUPOLES	9		9	1	15	20	300	ASSEMLY
CORRECTORS	8		8	2	±2	±2	4	ASSEMBLY

BOOSTER to STORAGE RING TL

MAGNET	QUANTITY	Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (W)	STATUS
DIPOLES	2	2	0	180	60	10800	ASSEMBLY
QUADRUPOLES	7	7	1	170	15	2500	ASSEMBLY
CORRECTORS	8	8	2	±6	±10	60	ASSEMBLY

QUADRUPOLES POWER CONVERTERS

I_{OUT}	V_{OUT}	P_{OUT}	Ripple I_{OUT}	Resolution I_{OUT}	Stability I_{OUT}	Efficiency	Dimension
[A]	[V]	[kW]	[ppm]	[ppm]	[ppm]	[%]	[mm]
200	15	3	10	4.6	±10	92	19", 4U, 500mm
225	25	5.7	10	4.6	±10	92	19", 5U, 500mm

fsw=20kHz

fcut1=1100Hz
fcut2=800Hz

DCCT

DCVT
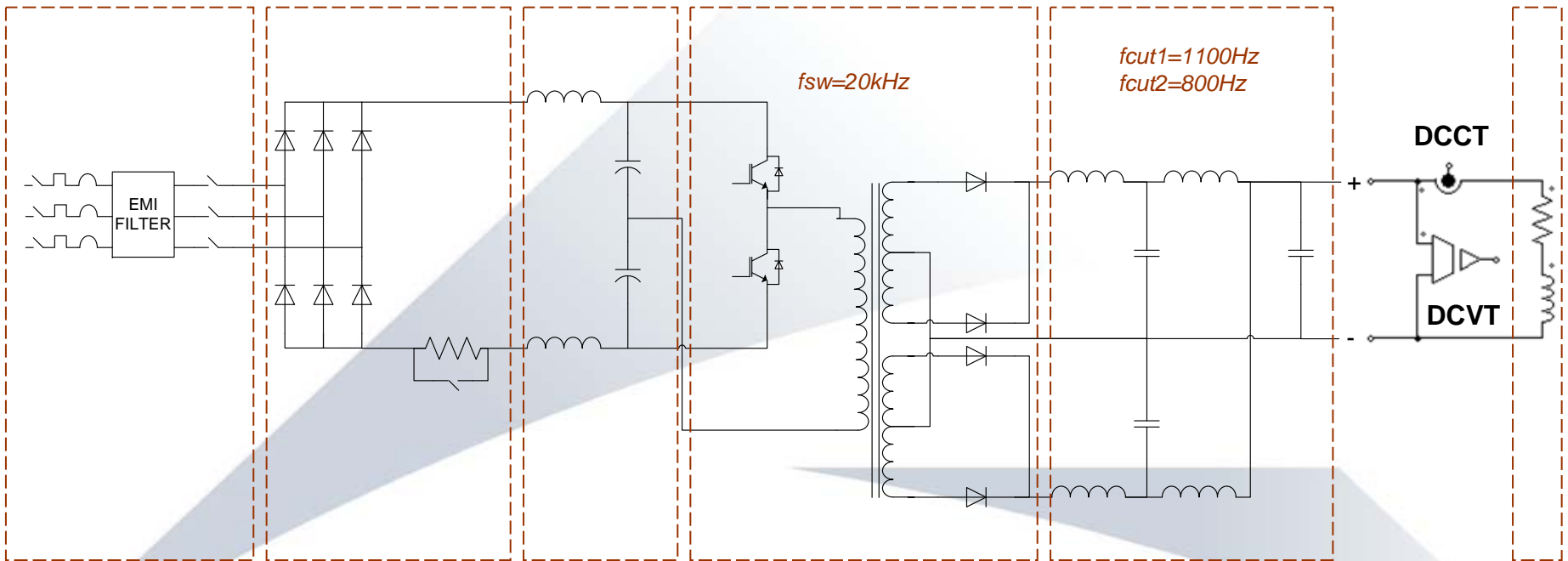
EMI FILTER

Breaker, EMI filter & contactor

6p rectifier & Soft start

DC link filter

IGBT half bridge & HF transformer

Output filter

Magnet

QUADRUPOLE POWER CONVERTERS

SR QUADRUPOLE FAT @ HAZEMEYER

Stability test: error to the reference value in ppm. The oscillation is correlated with the temperature, shown in the figure below
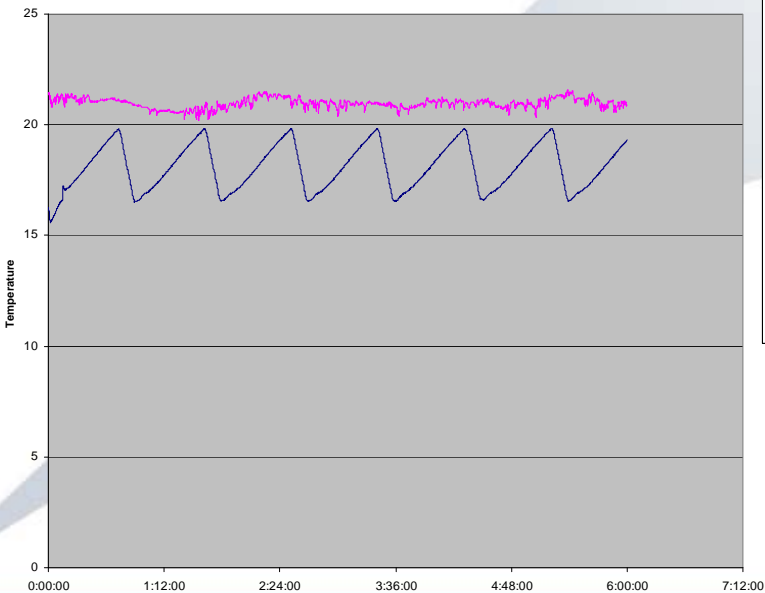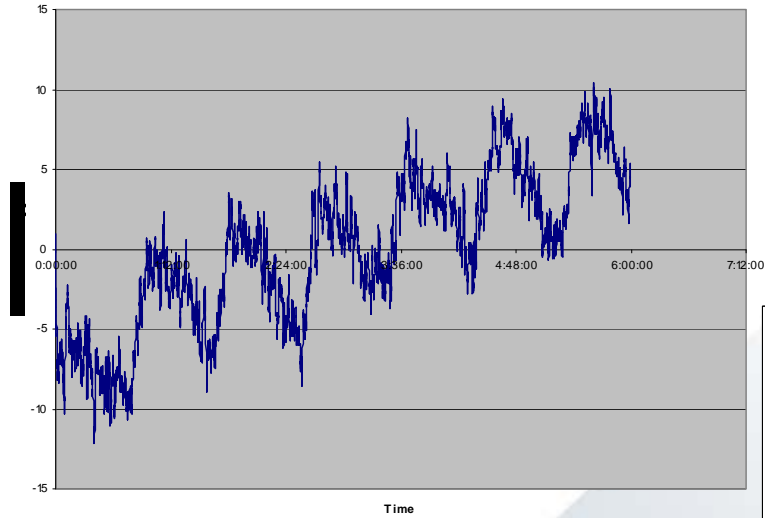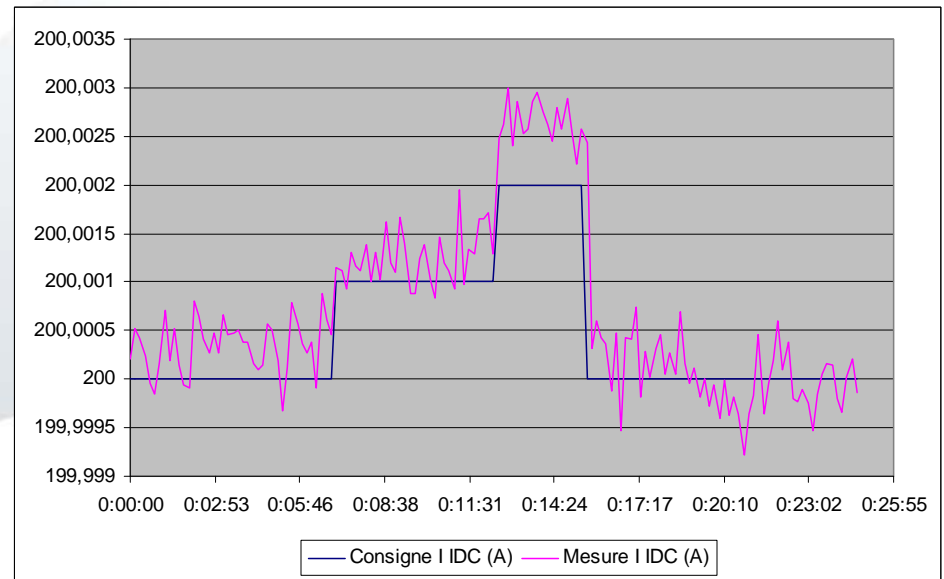
Resolution test

Measurement instruments temperature (blue) and power supply temperature (pink)

SR SEXTUPOLE POWER CONVERTER

I_{OUT}	V_{OUT}	P_{OUT}	Ripple I_{OUT}	Resolution I_{OUT}	Stability I_{OUT}	Efficiency	Dimension
[A]	[V]	[kW]	[ppm]	[ppm]	[ppm]	[%]	[wxhxd mm]
215	100	21.5	10	4.6	±10	89.5	800x2000x1000
215	190	41	10	4.6	±10	90.5	800x2000x1000
215	350	75	10	4.6	±10	92.4	800x2000x1000
215	125	27	10	4.6	±10	90	800x2000x1000

fsw=20kHz
fcut1=1100Hz
fcut2=800Hz

f<35Hz

DCCT

DCVT

Breaker, EMI filter & soft start   12p transformer & rectifier   DC link filter   IGBT buck & output filter   Crowbar   Magnet
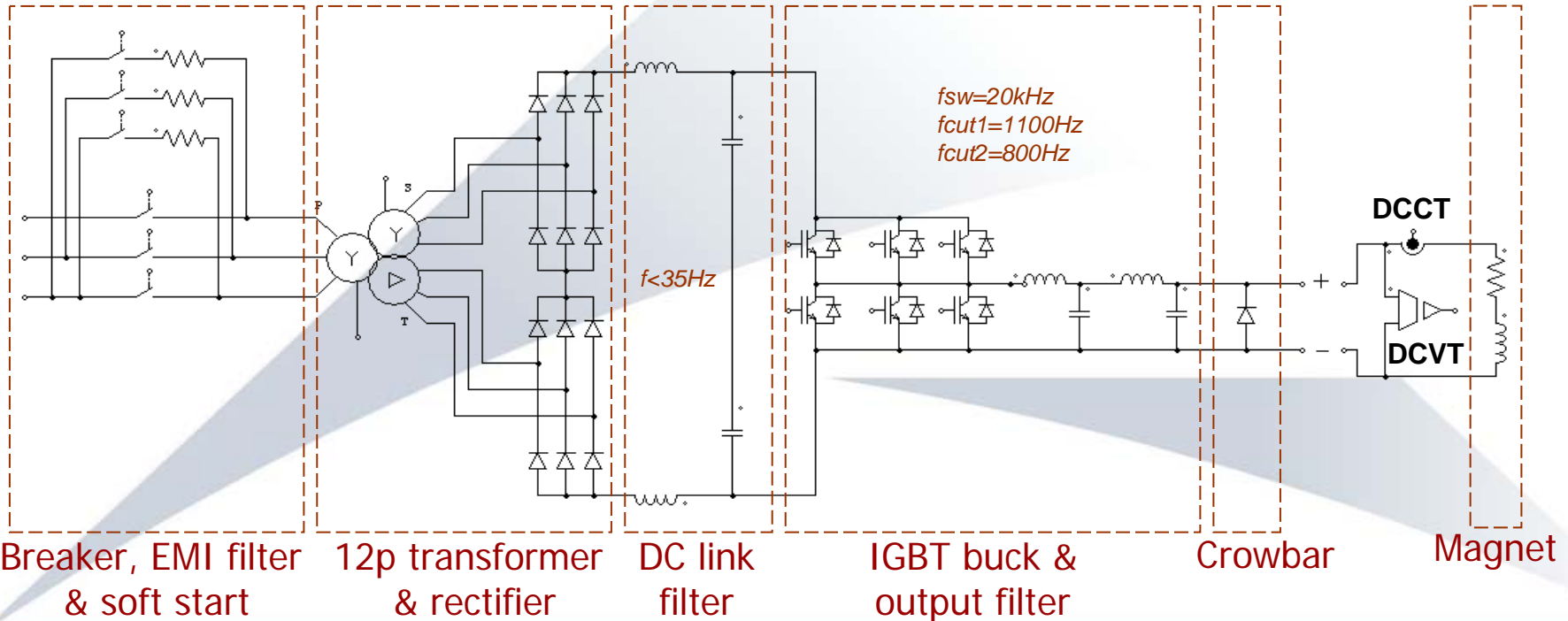
SEXTUPOLE POWER CONVERTERS
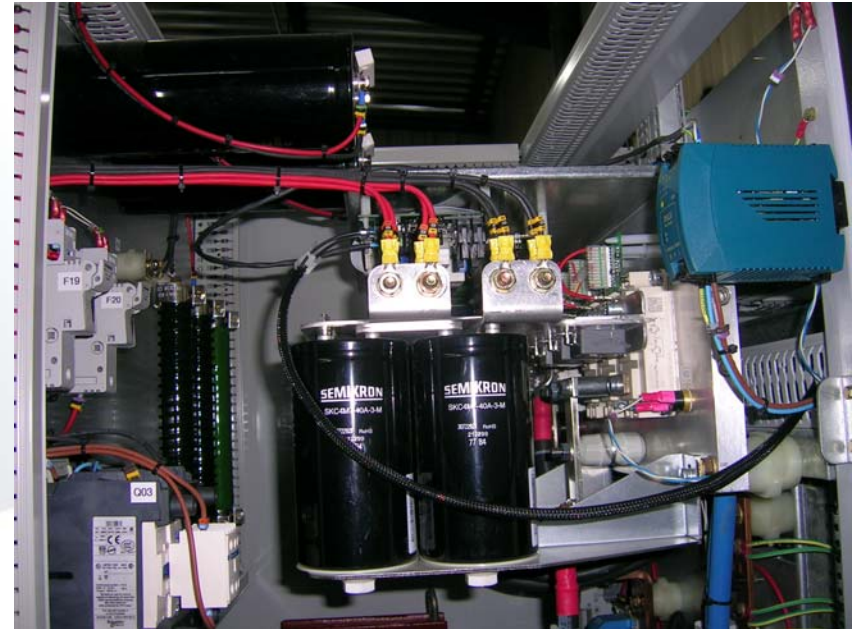
SR SEXTUPOLE FAT @ HAZEMEYER

Stability at 200A
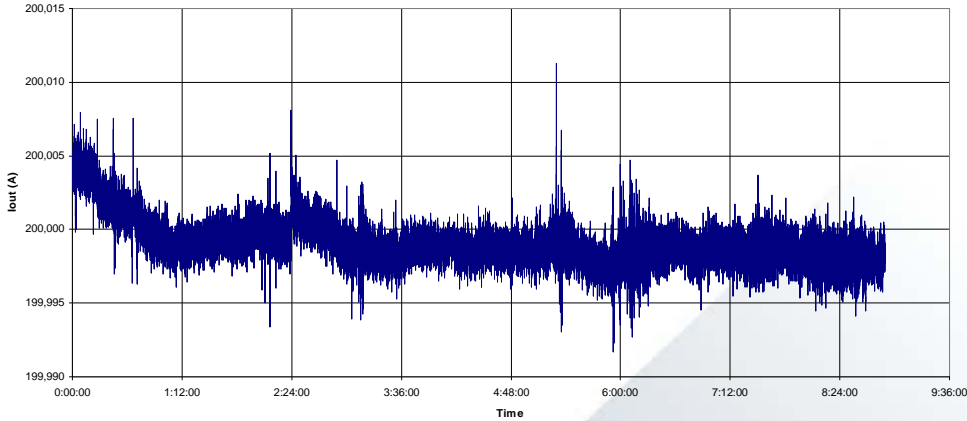
Stability test @ 200A: current variation < ±10mA (± 50ppm)

Resolution test: 3mA steps (<15ppm)
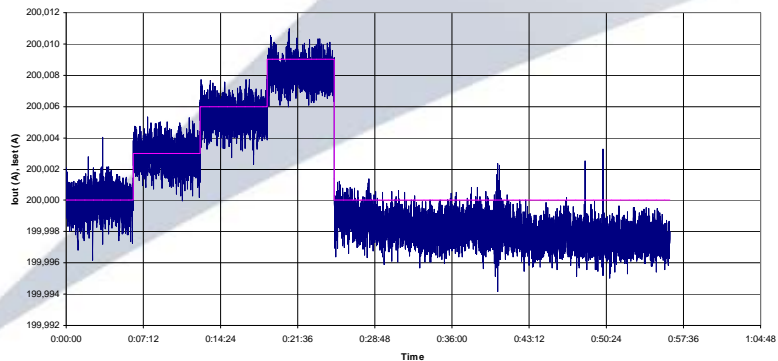
Temperature variation during resolution test

Resolution Iout
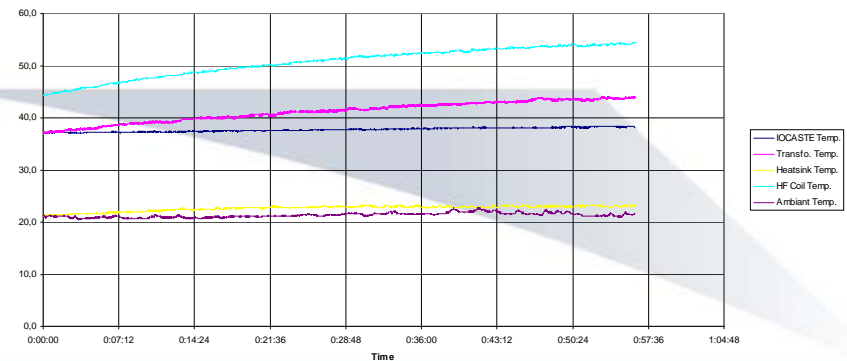
Resolution

TEST BENCH AT CELLS
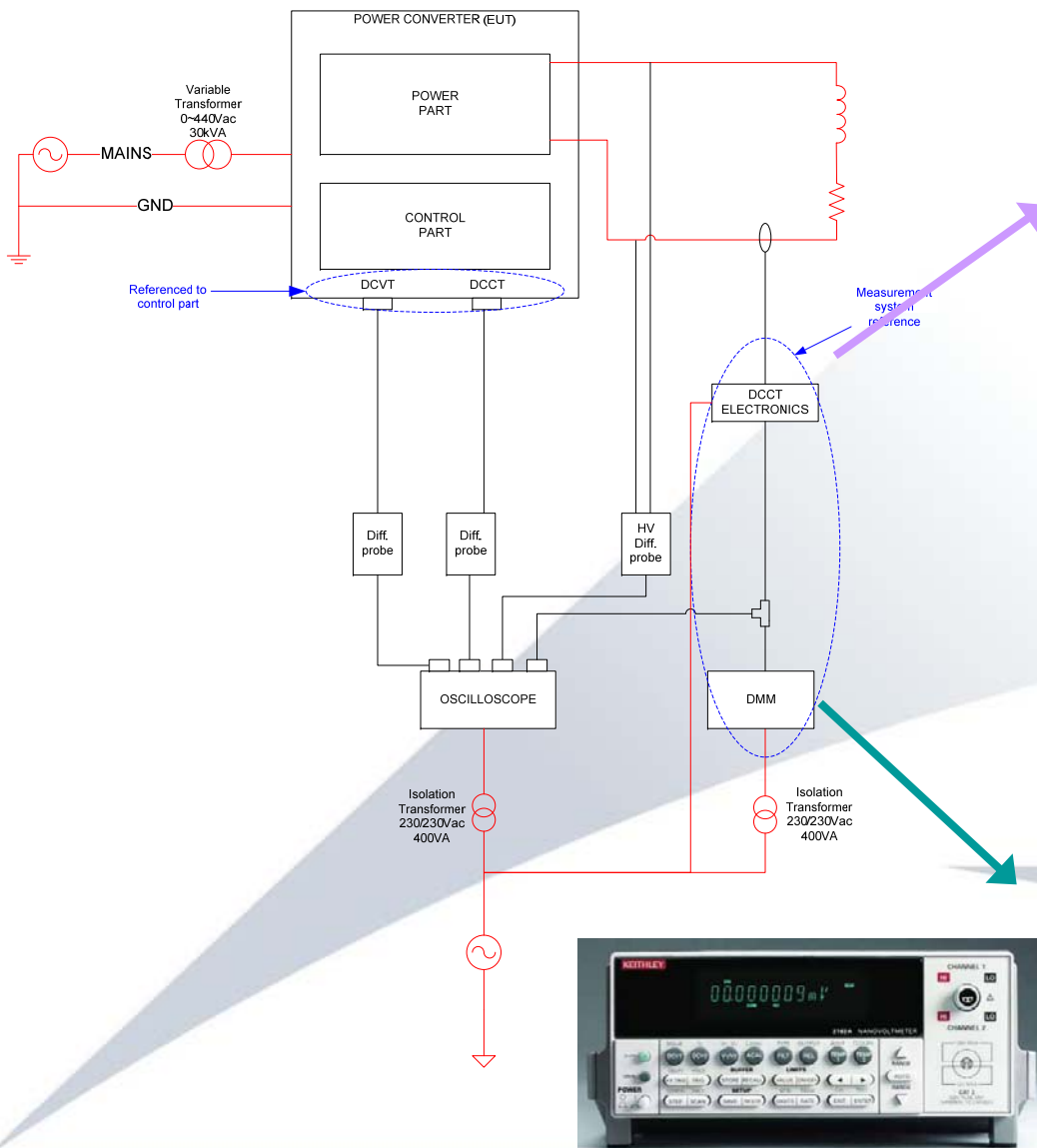
DCCT Danfysik SATURN 2000U:

-Programming steps: 125A

-Drift: <2ppm/K, <1ppm/month

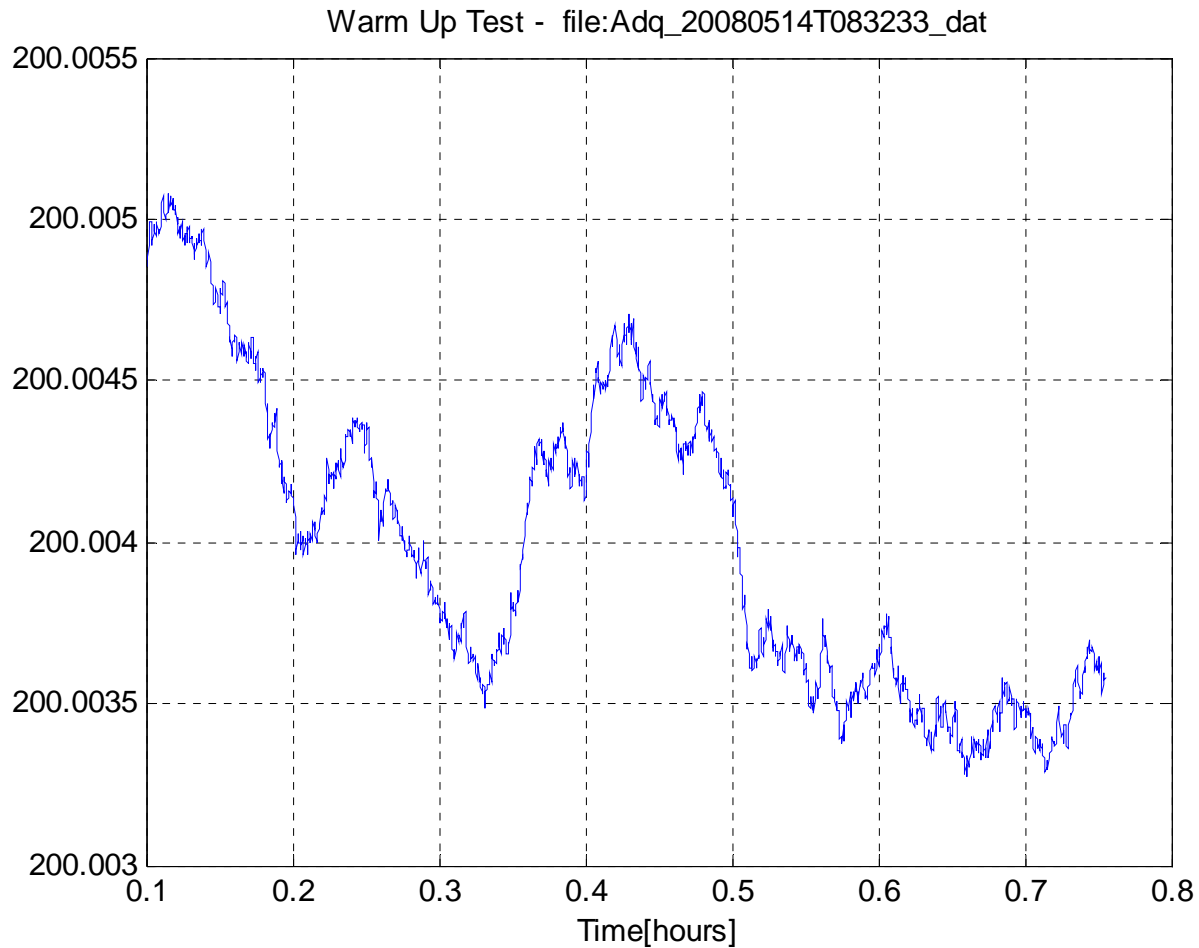Nanovoltmeter Keithley 2182A:

-7.5 digits resolution

-Low noise measurement

-Drift: <1.5ppm/K, <3ppm/24h

TEST BENCH AT CELLS
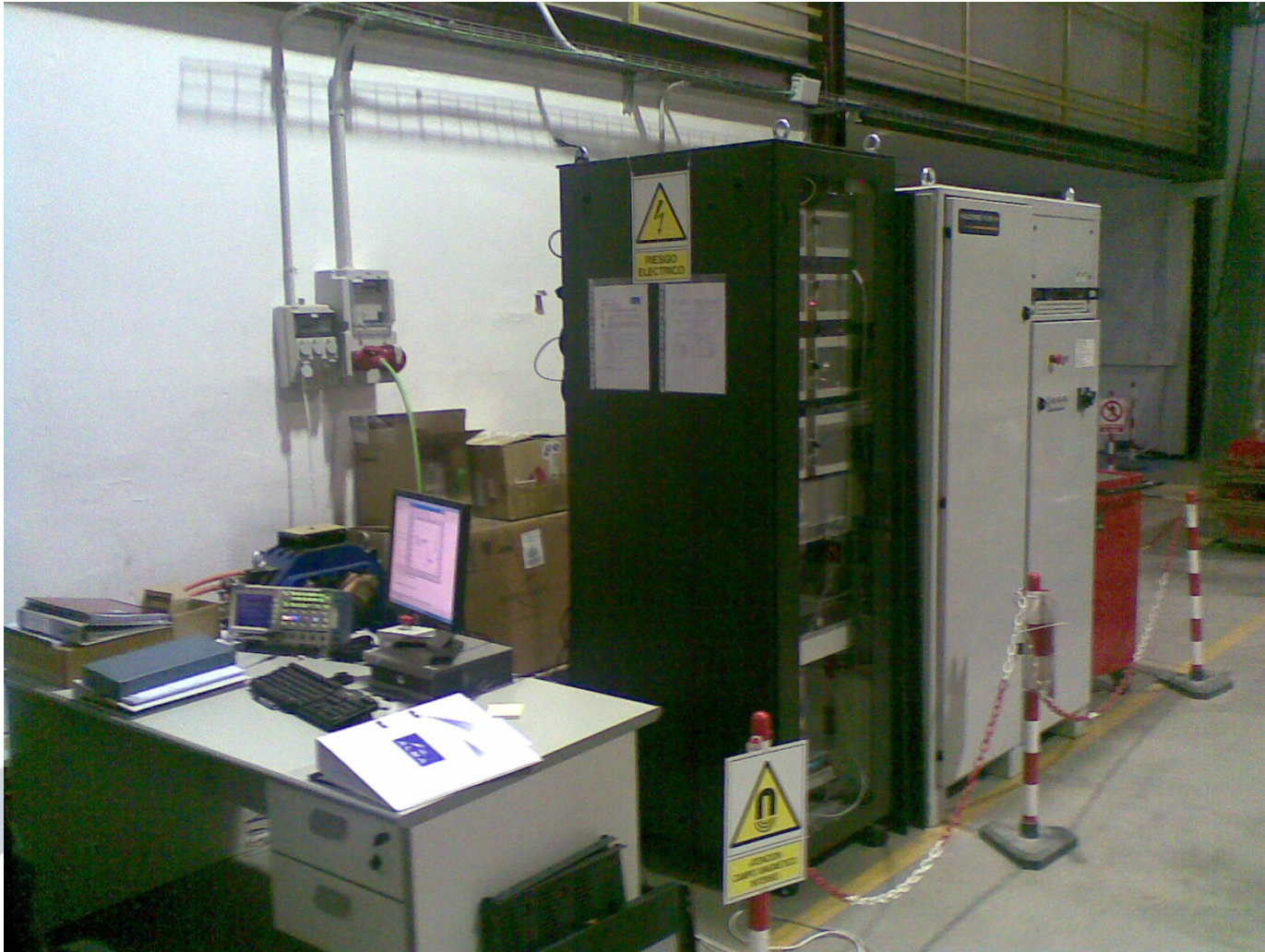
SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Warm-up
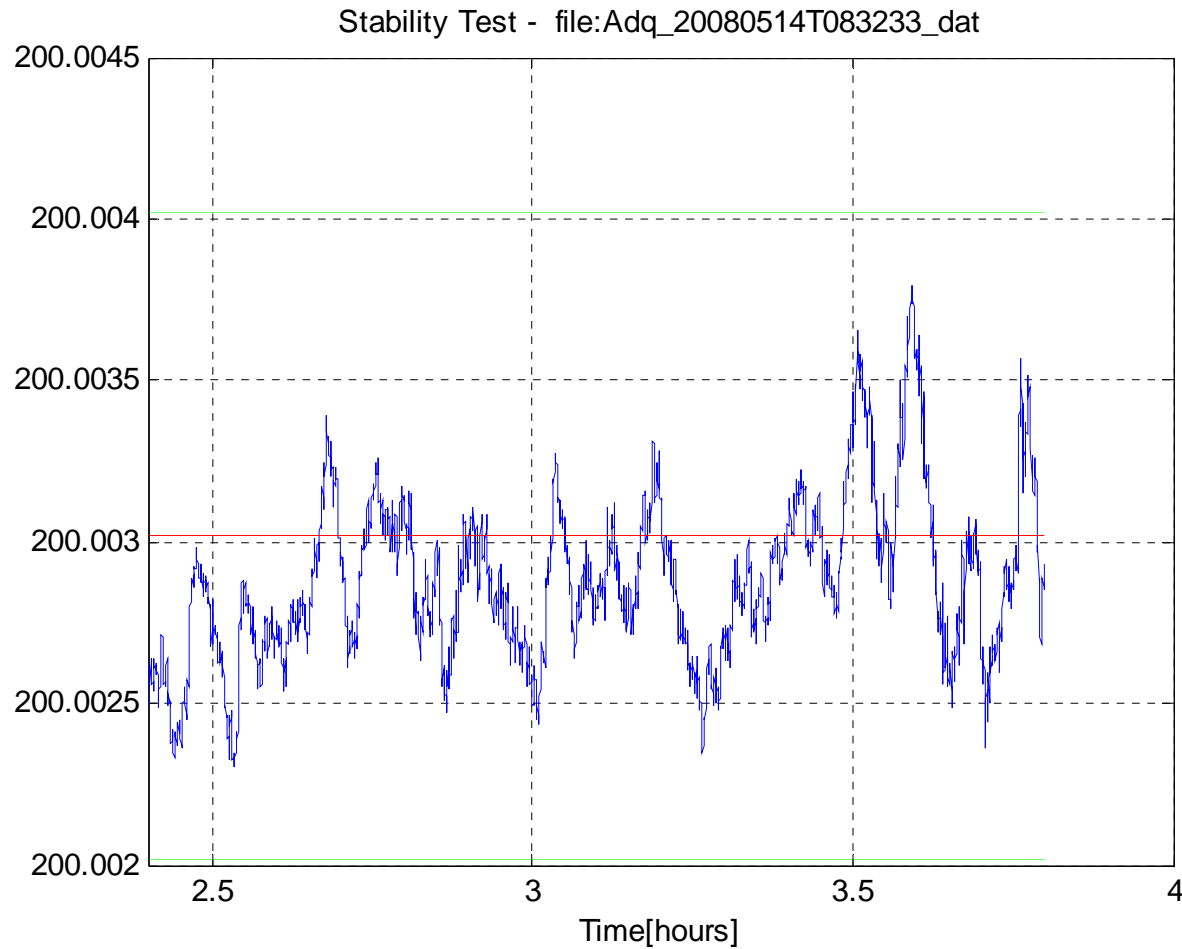
Warm Up Test - file:Adq_20080514T083233_dat

SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Stability test

Stability Test - file:Adq_20080514T083233_dat

SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Stability test (histogram)

Stability Test Histogram- file:Adq_20080514T083233_dat
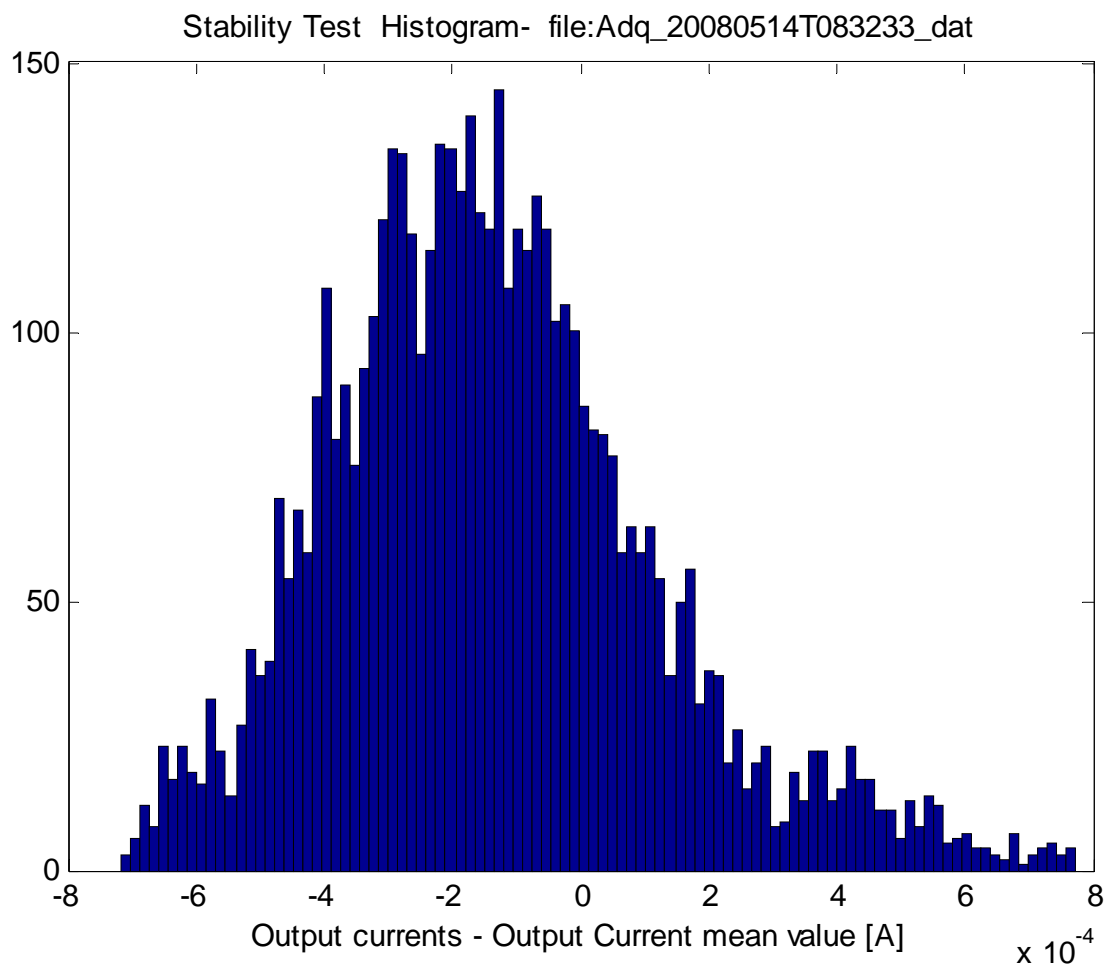
SR QUADRUPOLE PROTOTYPES TEST AT CELLS
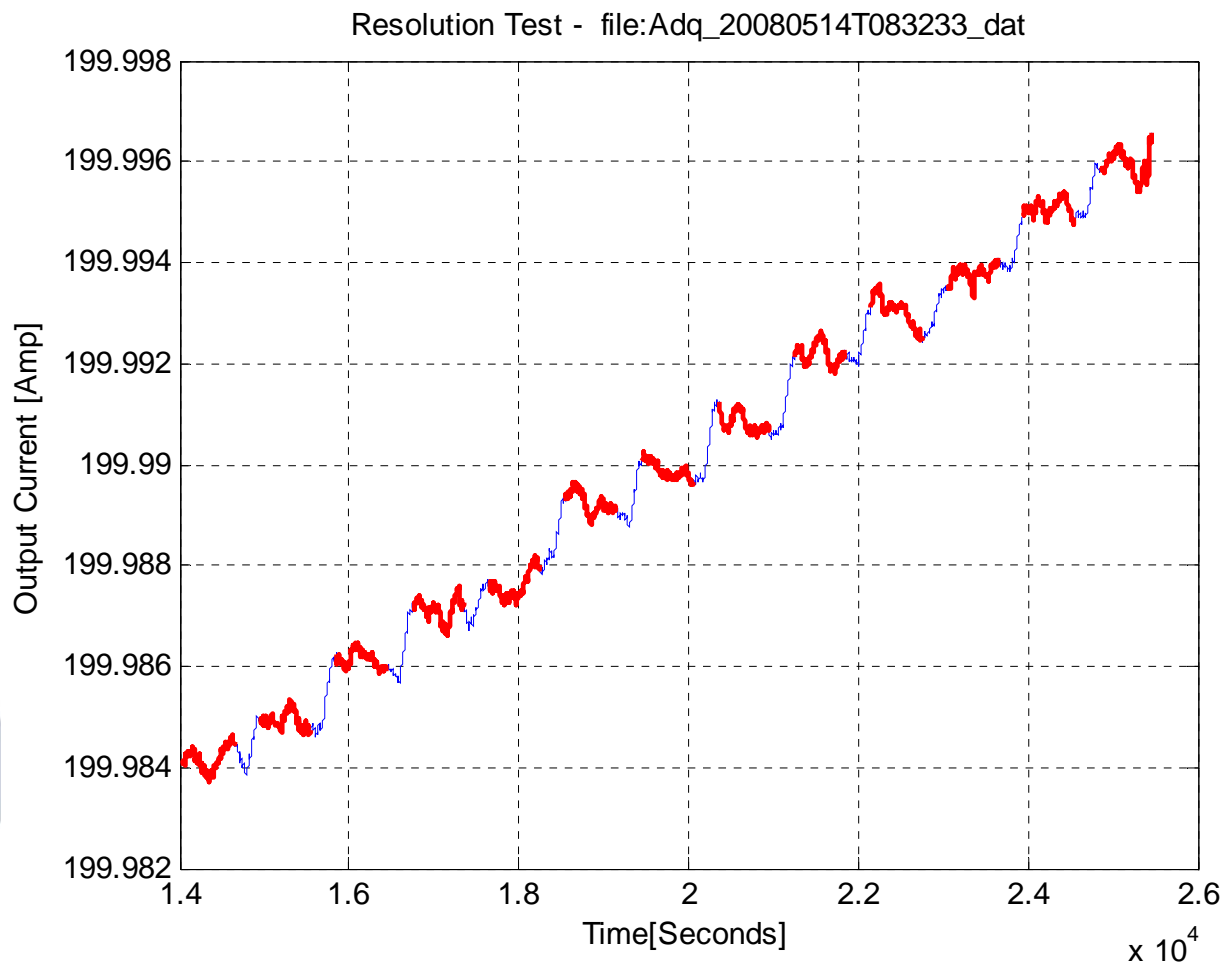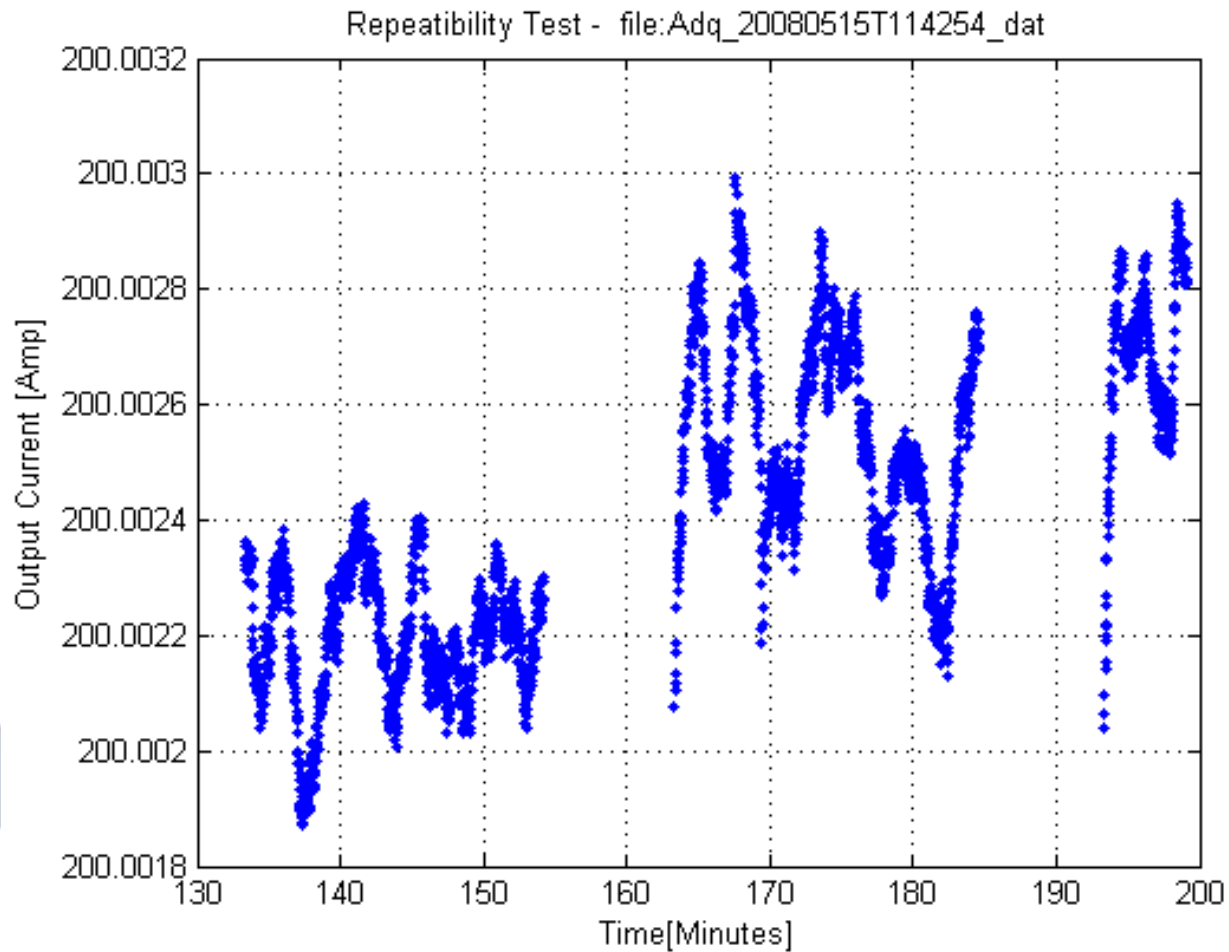
✓ Resolution

SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Resolution (error)
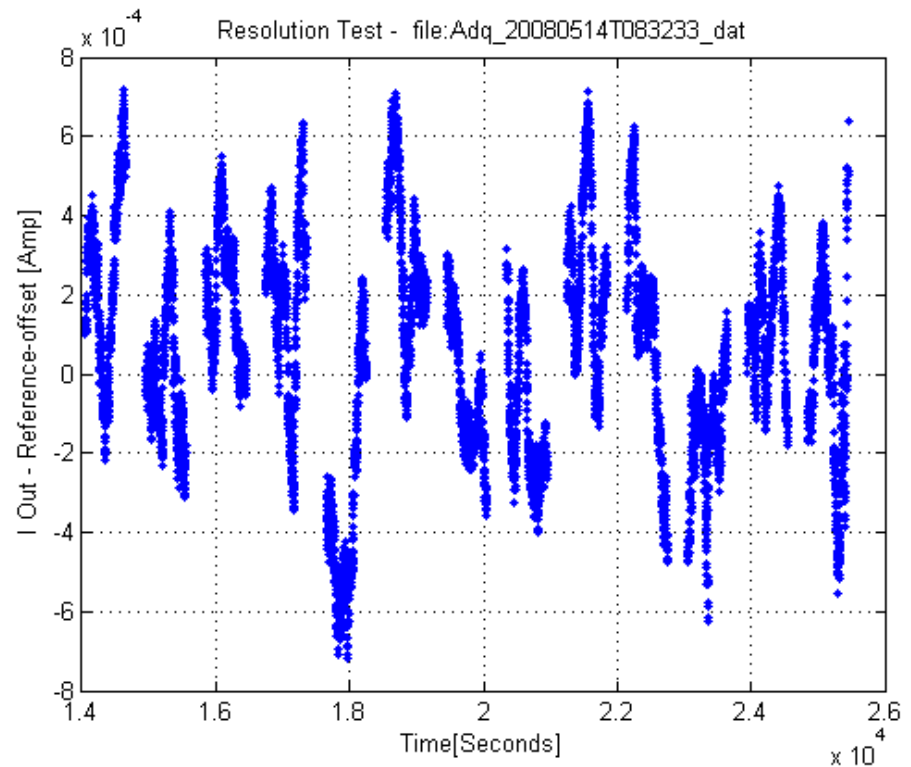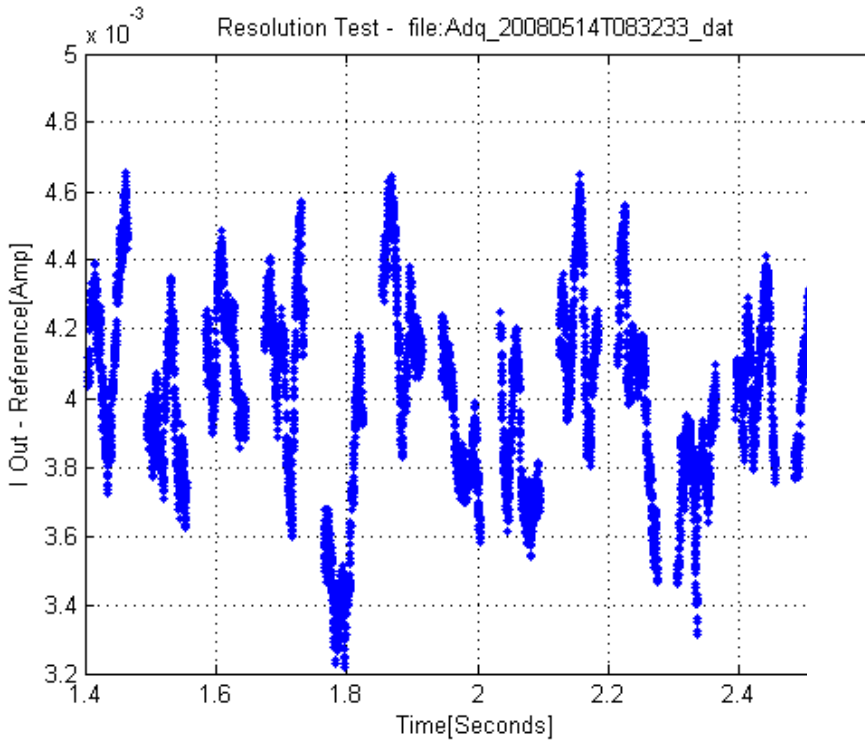
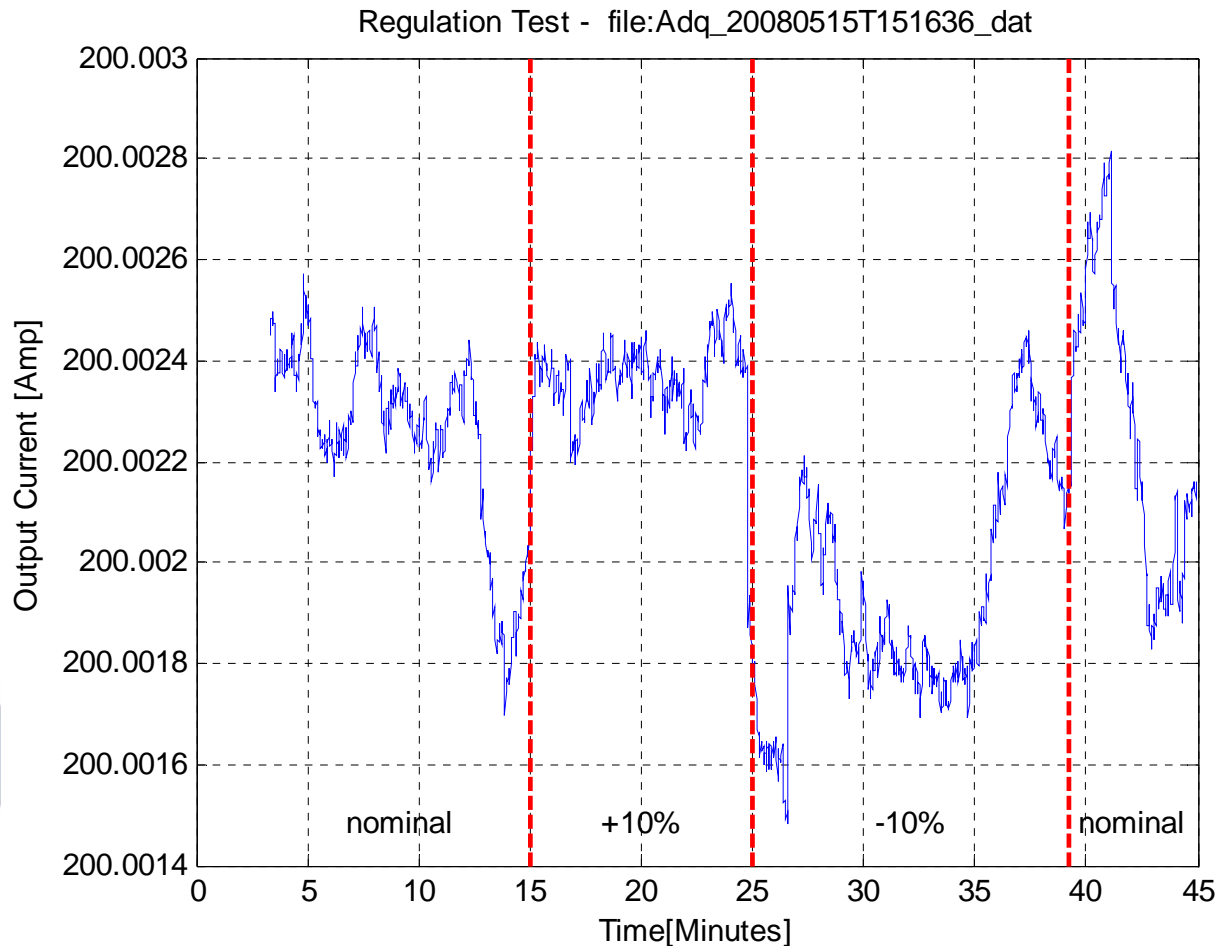# SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Linearity
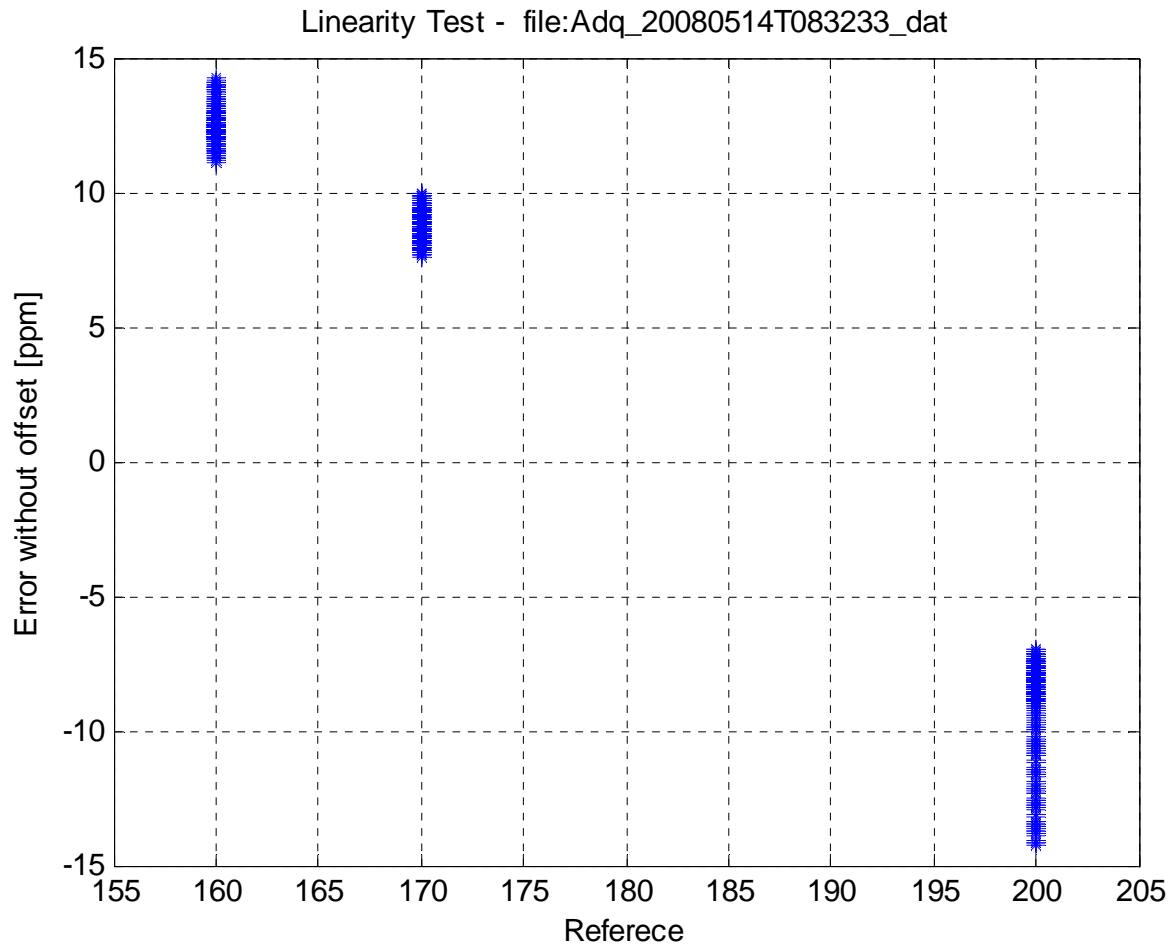
SR QUADRUPOLE PROTOTYPES TEST AT CELLS
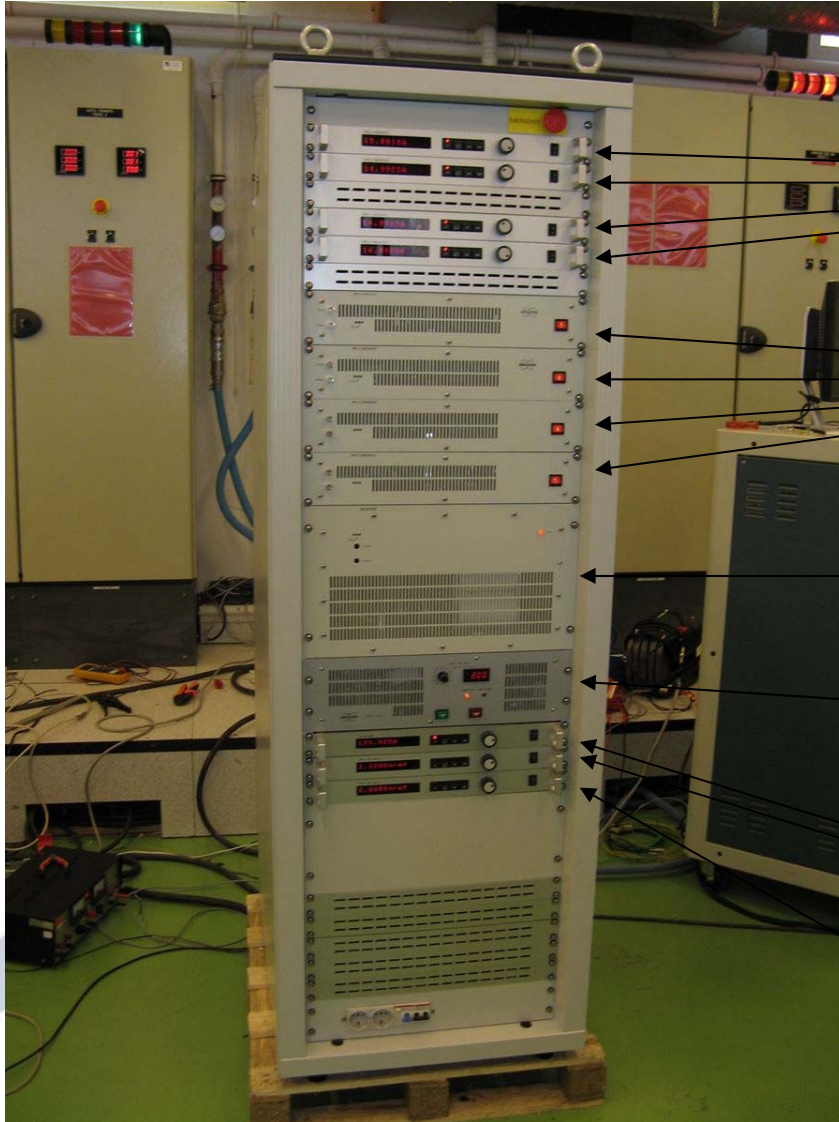
✓ Reproducibility

SR QUADRUPOLE PROTOTYPES TEST AT CELLS

✓ Line regulation

Regulation Test - file:Adq_20080515T151636_dat

PROVISIONAL LTB CABINET

CONTROLS ARE PROVISIONAL

**QUADRUPOLE CONTROL
(based on BEC-1)**

**QUADRUPOLE POWER
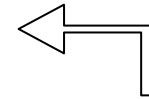PART (20V/15A)**

**DIPOLE POWER PART
(30V/200A)**

**CORRECTOR POWER
SUPPLY (2V/2A)**

**CORRECTOR REFERENCE
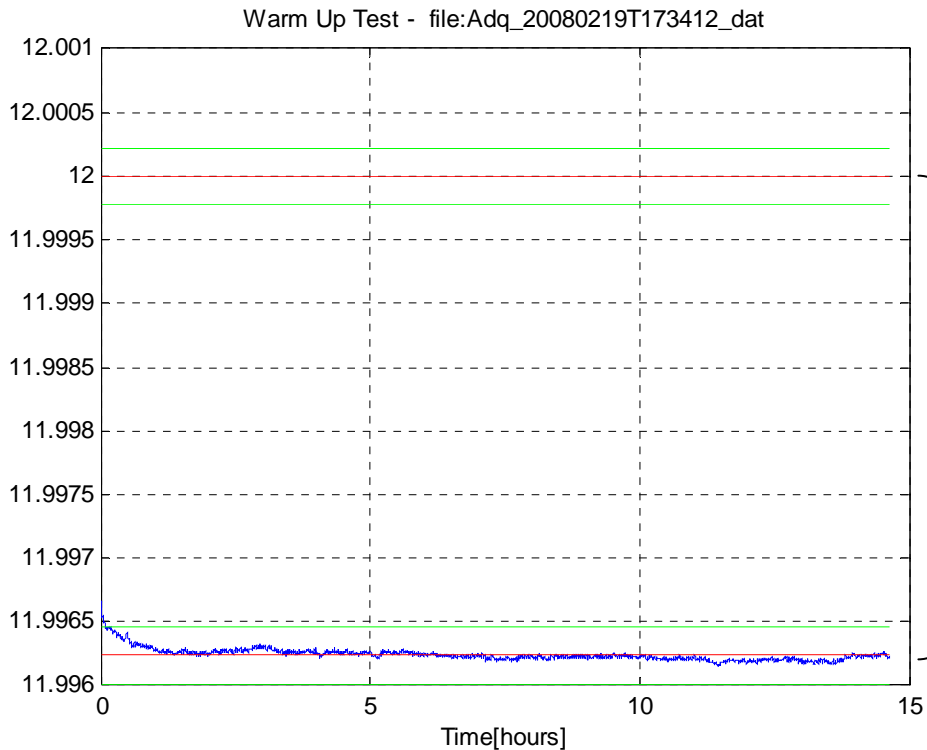GENERATOR**

**DIPOLE CONTROL PART
(based on BEC-1)**

LTB QUADRUPOLE TESTS AT CELLS

I_{OUT}	V_{OUT}	P_{OUT}	Ripple I_{OUT}	Resolution I_{OUT}	Stability I_{OUT}
[A]	[V]	[kW]	[ppm / uA]	[ppm / uA]	[ppm / uA]
15	20	0,3	15 / 225	15 / 225	±15 / ±225
15	20	0,3	<15 / 225	30 / 450	<±15 / <±225

Test results

✓ Warm-up

Warm Up Test - file:Adq_20080219T173412_dat
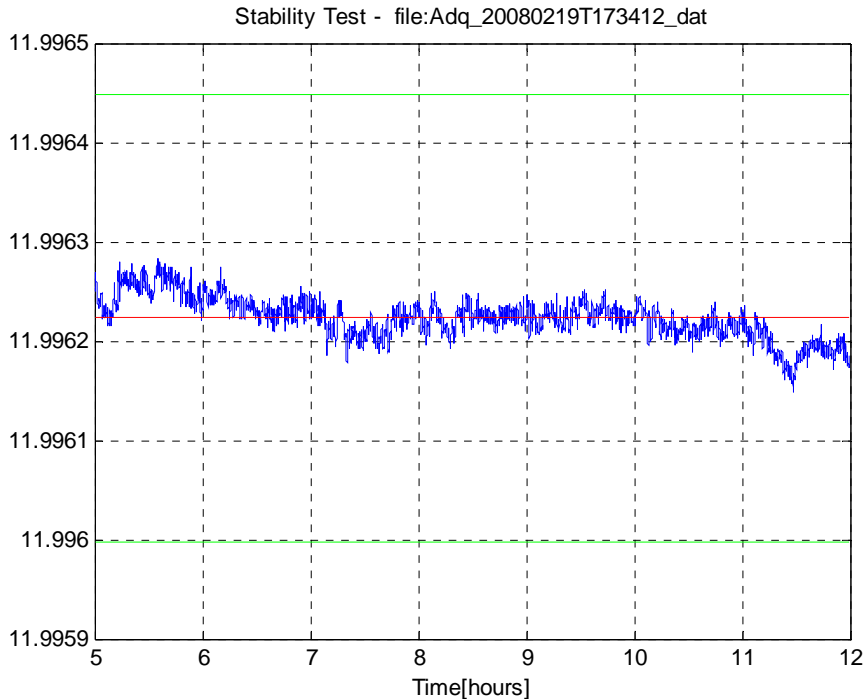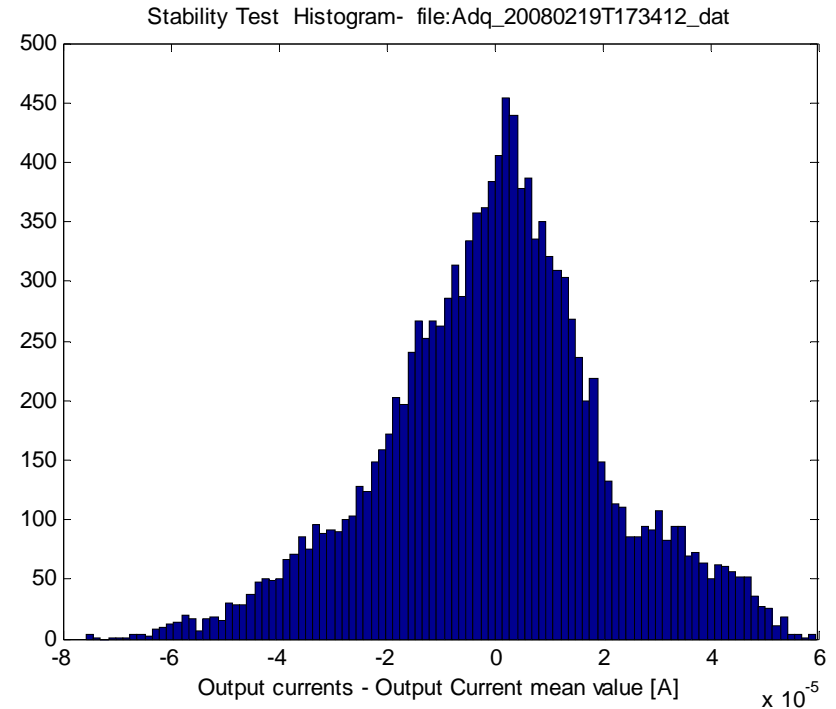
Constant offset error due to "cold" calibration at factory

LTB QUADRUPOLE TESTS AT CELLS
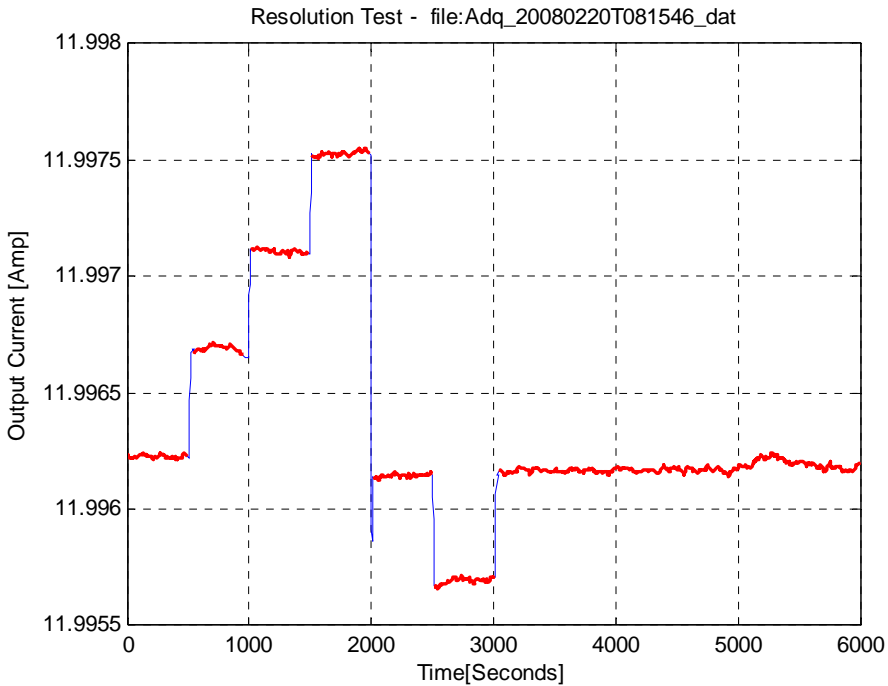
✓ Stability test

Output current (blue), reference current (red) and stability limits (green). Yaxis is in amperes.
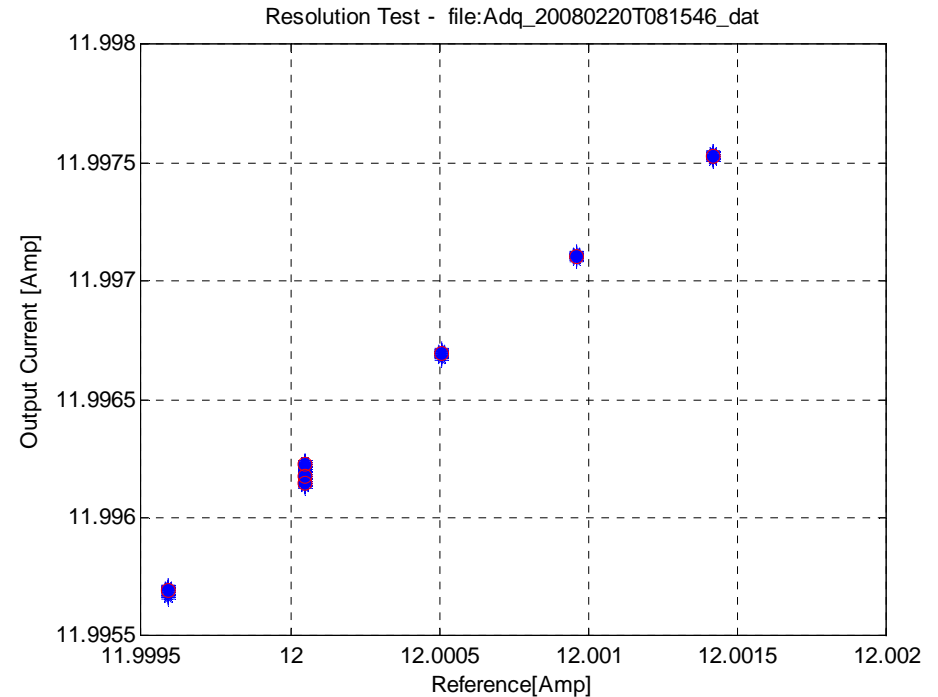
Histogram of the output current error (real – reference). Xaxis in amperes x 10^-5

LTB QUADRUPOLE TESTS AT CELLS

✓ Resolution

Output current (read), reference current (blue). Yaxis is in amperes, Xaxis in seconds.

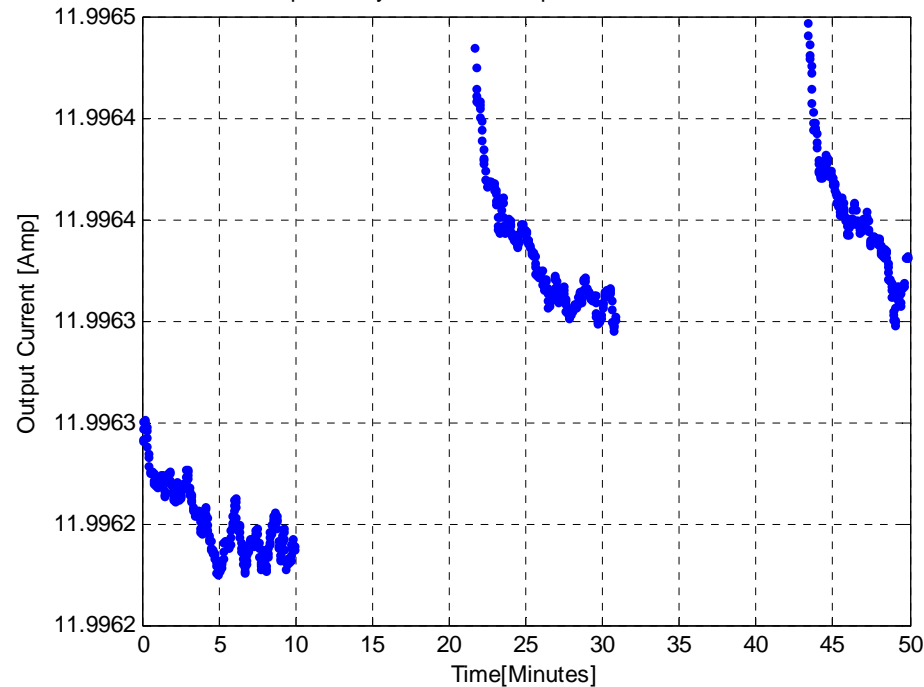Output current (real) versus Reference current. Both axis are in amperes
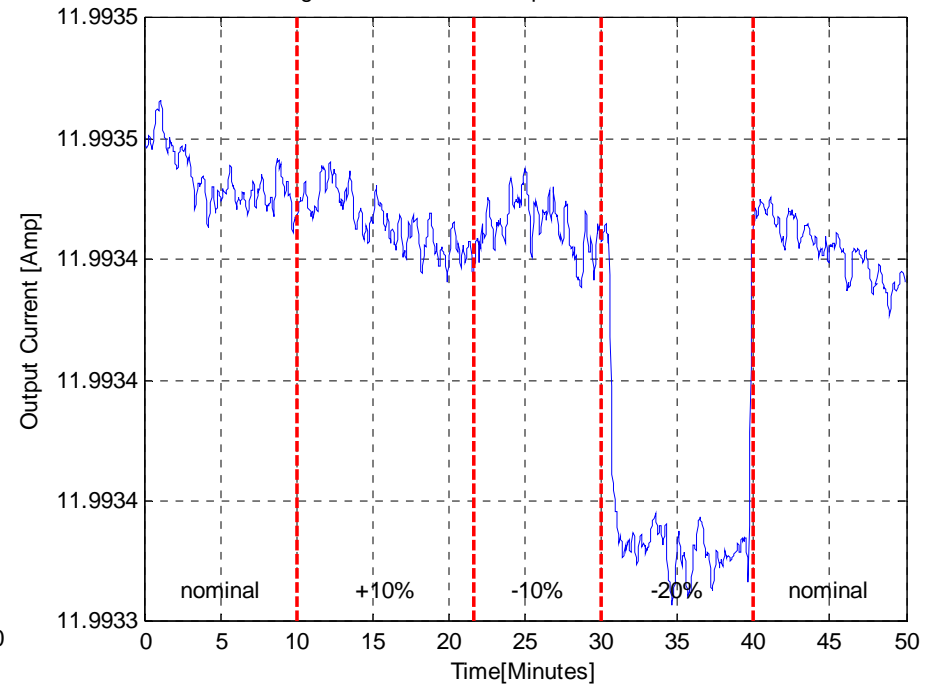
LTB QUADRUPOLE TESTS AT CELLS

✓ Reproducibility & Line regulation

Output current (blue) in amperes is shown after a 10min and 15min switch off, while the reference current is constant

Output current (blue) in amperes is shown during a line variation of +10%, -10%, -20% and return to rated line voltage

EPE 2009 8 -10 September. **Barcelona, Spain**

13th European Conference on Power Electronics and Applications

Topic 18: Operating quality of systems

18a. Reliability
18b. Diagnostics
18c. Electromagnetic compatibility
18d. Power management

Topic 21: Energy conversion and conditioning technologies in physics research and related applications

21a. Power converters for particle accelerators
21b. Application of power electronics to pulsed power (f.e. nuclear fusion research, microwaves, etc…)
21c. Other related applications

THANK YOU VERY MUCH FOR YOUR ATTENTION

Questions?
Suggestions?