The CNGS Horns Electrical Systems

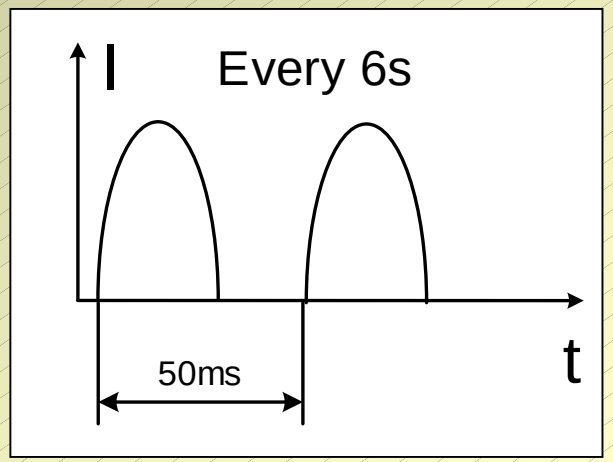
4th workshop on Neutrino Beams and Instrumentation
7 – 11 November 2003 at KEK

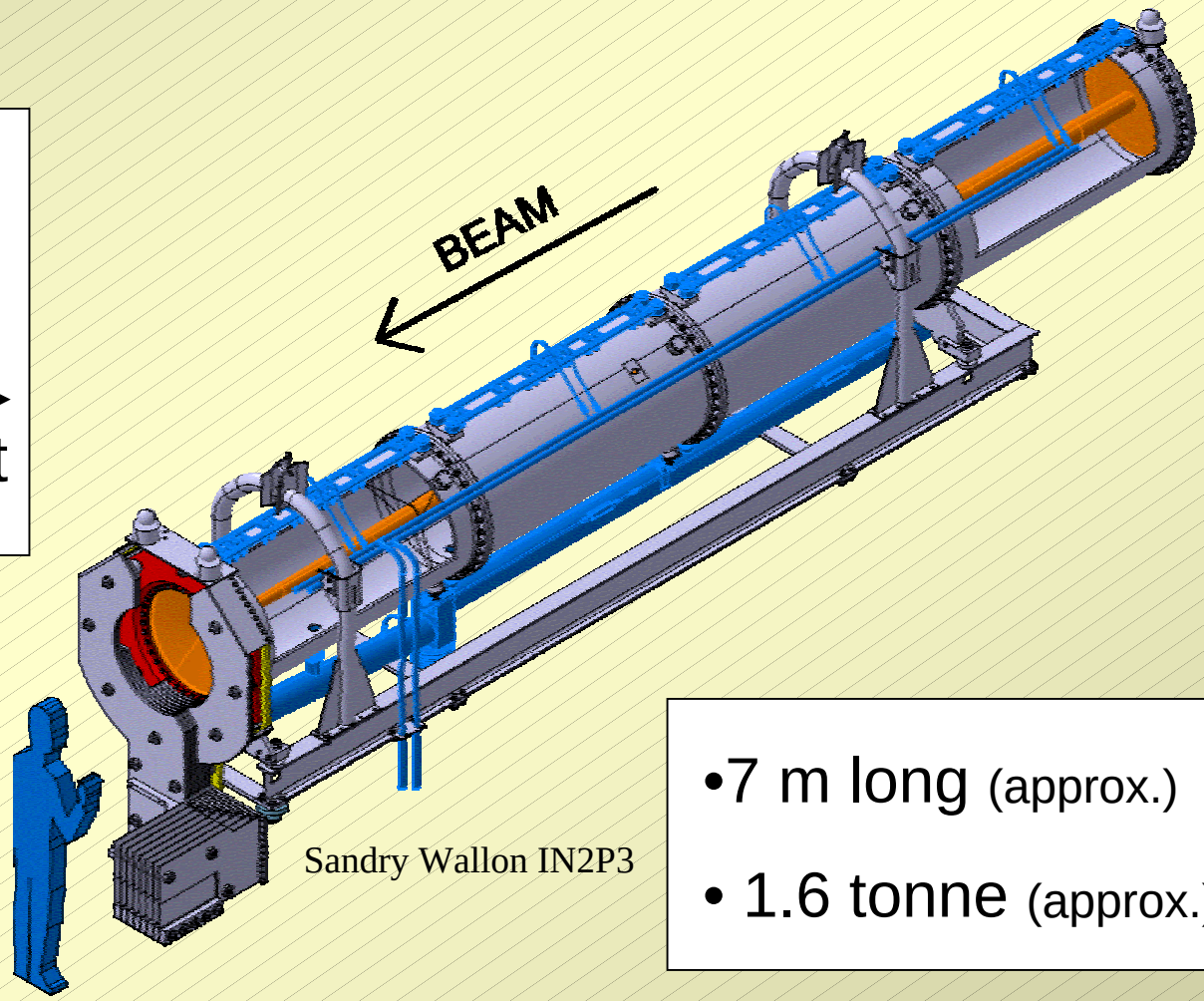
Gilles.Maire EP/TA3

Outline

- Introduction.
- Electrical Circuit.
- Components and Status.
- Test of inner conductor Horn.
- Controls.
- Planning.
- Conclusions.

Introduction
Horn and Reflector (Load)

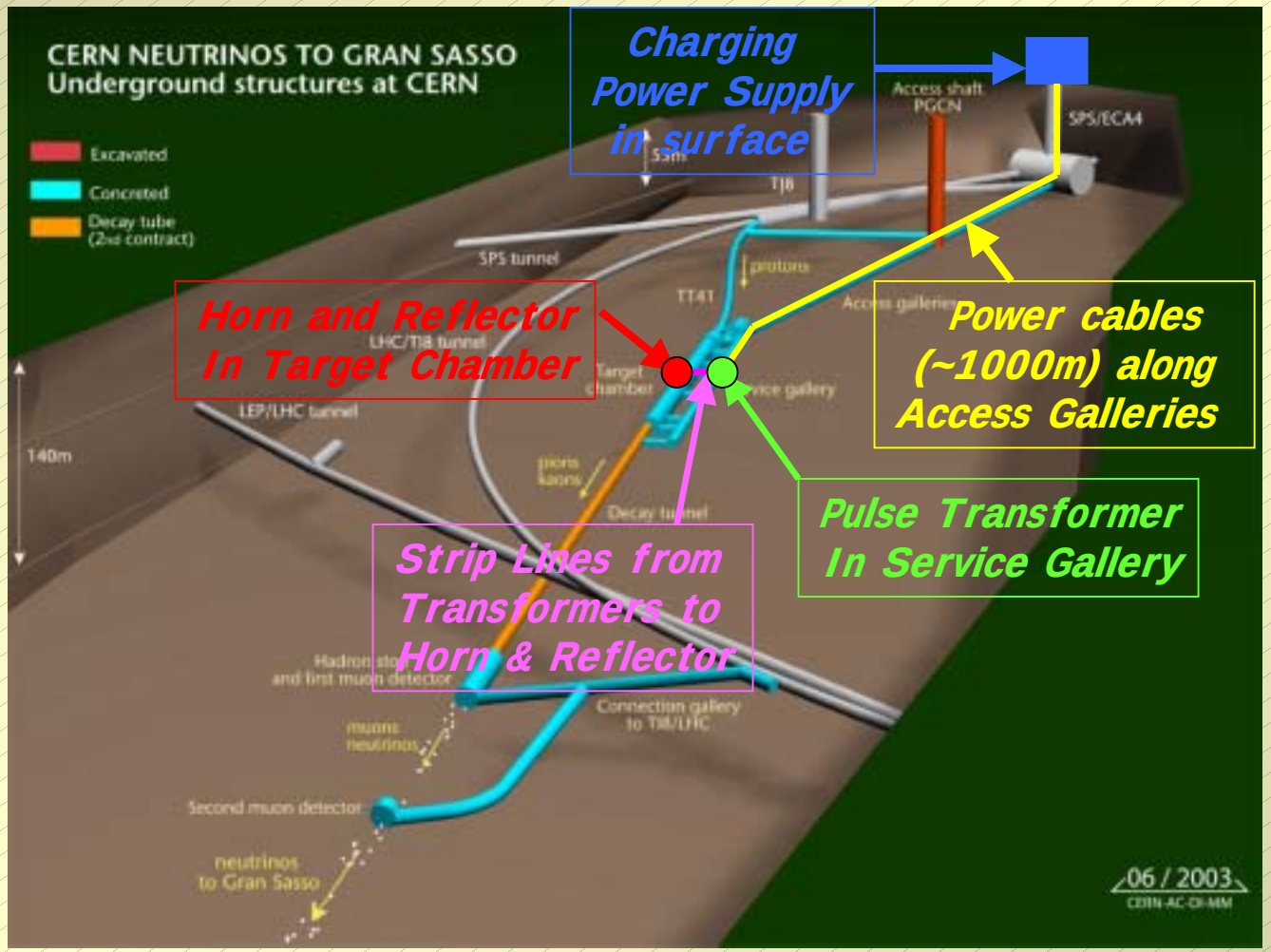




Sandry Wallon IN2P3

- 7 m long (approx.)
- 1.6 tonne (approx.)

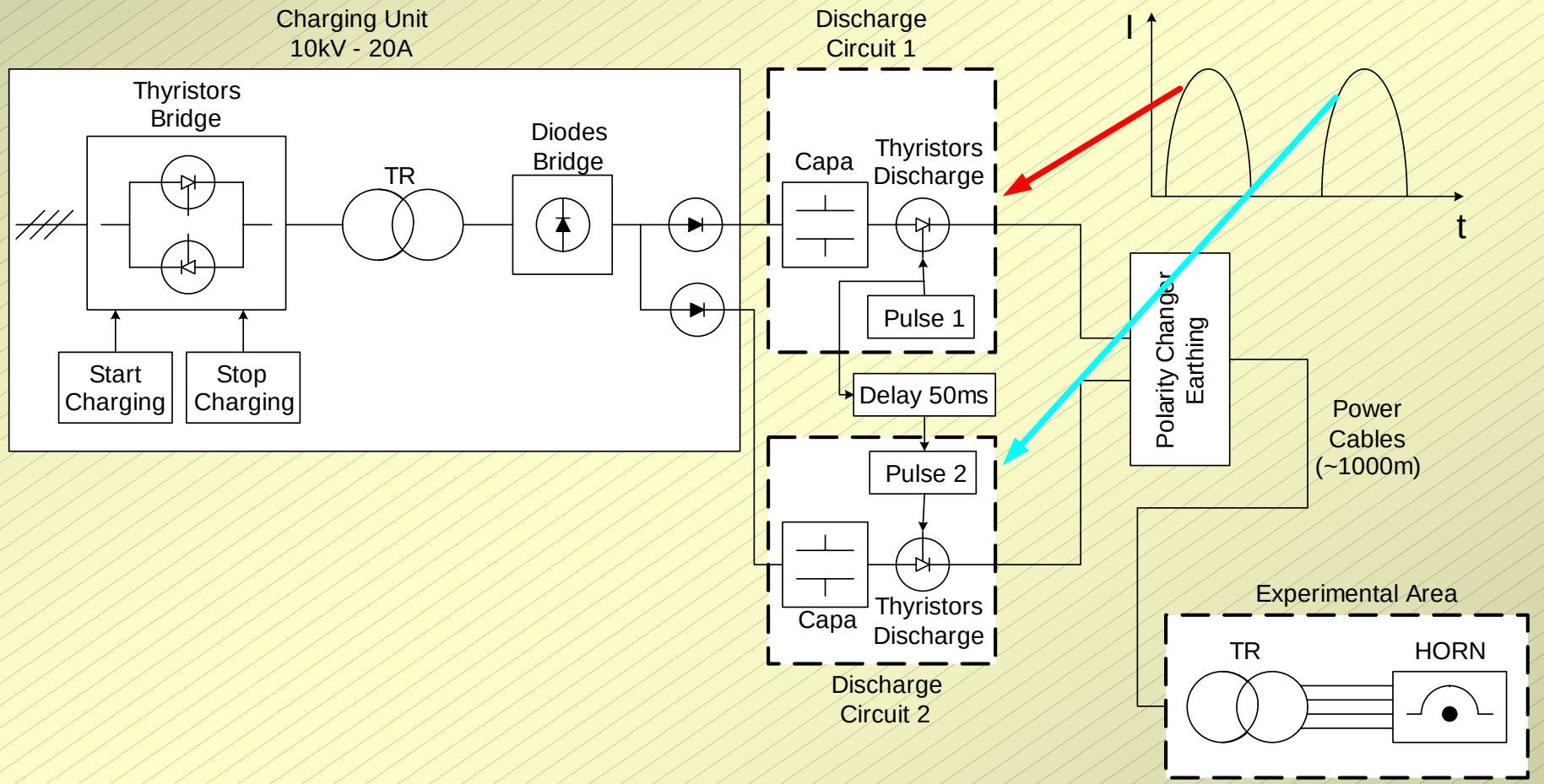
Introduction
General View



Introduction Parameters

	Unit	HORN System	REFLECTOR System
Load Peak current	kA	150	180
Transformer ratio		16	32
Primary current peak	A	9375	5625
Load inductance	µH	2,7 X 16 X 16 = 691	1,5 X 32 X 32 = 1540
Total inductance with 4 cables	µH	1210	2046
Load resistance	mΩ	0,6 X 16 X 16 = 154	0,21 X 32 X 32 = 215
Total resistance with 4 cables	mΩ	328	495
Total capacitance for one pulse	µF	4080	4080
Pulse duration	ms	7,5	10
Charging voltage	V	7700	6300
Total stored energy	kJ	2 X 119 = 238	2 X 80 = 160
Load max. voltage	V	280	150
Mean power dissipated by current only (2 pulses)	kW	16	10,5
Total power dissipated (with beam)	kW	26	16,5
Water flow for delta T=5C	l/min	70	70
Pressure	bar	1,2	1,2

Electrical Circuit Diagram



Electrical Circuit
WANF Recuperation or NEW ?

		Beginning of Project	NOW
Power Supply	Thy. Bridge	WANF Recuperation	WANF Recuperation
	Transfo. LV/HV	NEW	NEW
	Electronics	WANF Recuperation	NEW
Capacitors		WANF Recuperation	NEW
Discharge Switches		NEW	NEW
Power Cables		NEW	NEW
Pulse Transformers		NEW	WANF Recuperation

Components and Status
Charging Power Supply

- *Need to increase charging voltage to 10kV.*
  - *Buy new transformer (LV/HV), first delivery in July 2003 and second for July2004.*
  - *All other power components can work at 10kV.*

Components and Status
Charging Power Supply

- *Electronic regulation and interlocks.*
  - *Old and obsolete regulation (25 years old). We had spare cards but electronic components didn't exist on the market.*
  - *The Power Group will take in charge this installation after commissioning. We will install a standard electronics of this group. The study and installation will be done for the end of 2003.*

Components and Status
Charging Power Supply

Old Electronic

24U

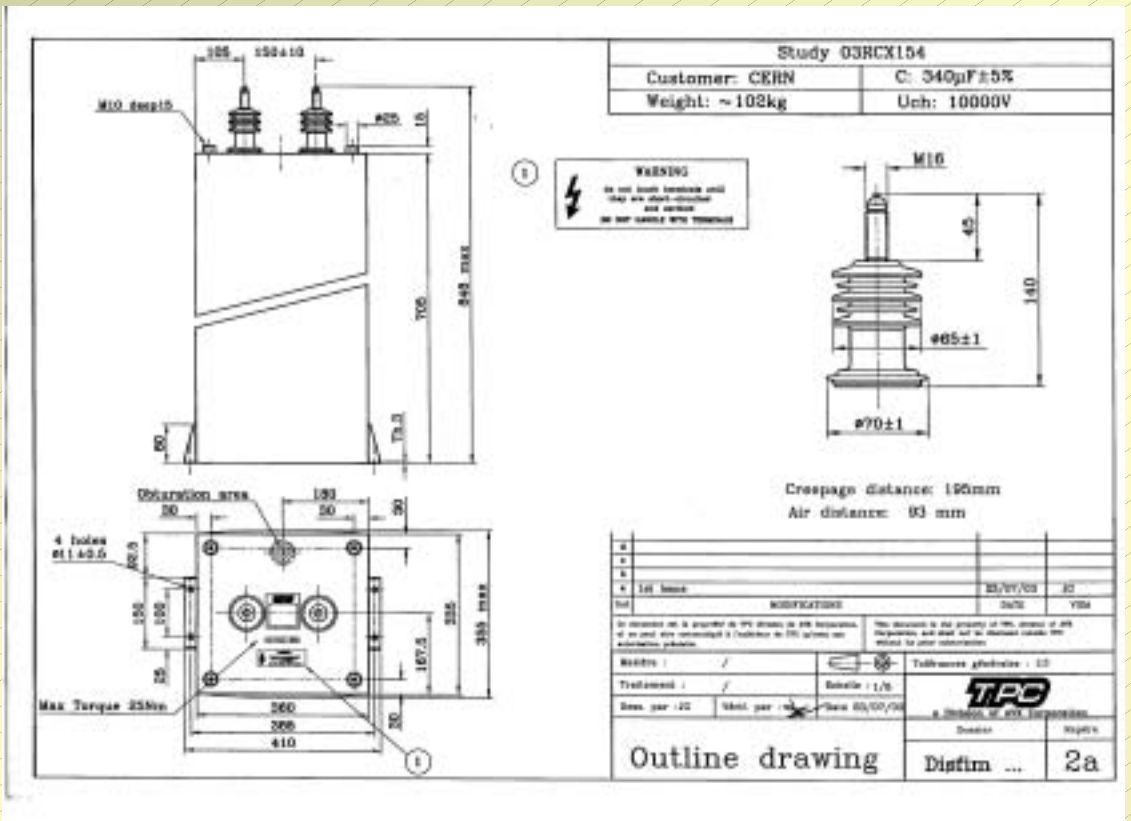
New Electronic

6U

Components and Status
Capacitors Discharge

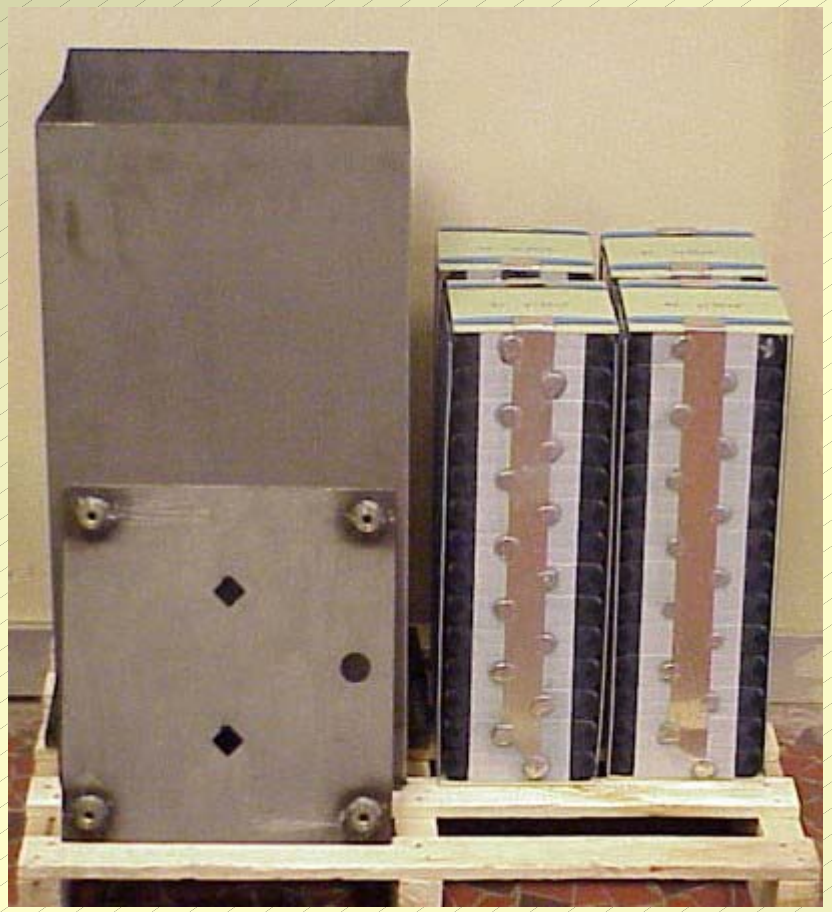
- *At the beginning of Project*
  - *We wanted to reuse WANF capacitors.*
  - *For safety and infrastructure constraints, Safety Division of Cern forced to us to install this equipment in a new building. The estimate cost of this new building was 650kCHF.*
- *Now*
  - *After new study, we will buy new capacitors (self healing technology) for a cost of 200kCHF.*
  - *We will install equipment in an existing building.*
- *Call for Tender*
  - *Result of the Call for Tender was in June 2003, AVX-TPC (FR).*
  - *Pre-Series in December 2003 and series in September 2004.*

Components and Status
Capacitors Discharge



Capacitance	340µF +/-5%
Operating Voltage	10000Vdc
Reverse Voltage	50%
Maximum Peak Current	1300A
Energy	17kJ
Repetition Rate	6sec
Life Time	$2x10^7$ pulses
Serial resistance	<3.3 mΩ
Capacitor inductance	<100 nH
Dielectric Stress	206 V/µm
Ignition temperature of dielectric fluid	Rape seed oil: 344°C
Dielectric system	Rough polypropylene film metallized
Dimensions	L=360mm W=335mm H=705mm
Weight	102kg

Components and Status
Capacitors Discharge



Components and Status
Capacitors Discharge

Rack with WANF capacitors

- WANF capacitors
  - 36 racks with a total of 360 capacitors.
- New capacitors
  - 12 racks with a total of 48 capacitors.
- Results
  - Space saving. Number of racks divided by 3.
  - Important cost saving for infrastructure and cabling.

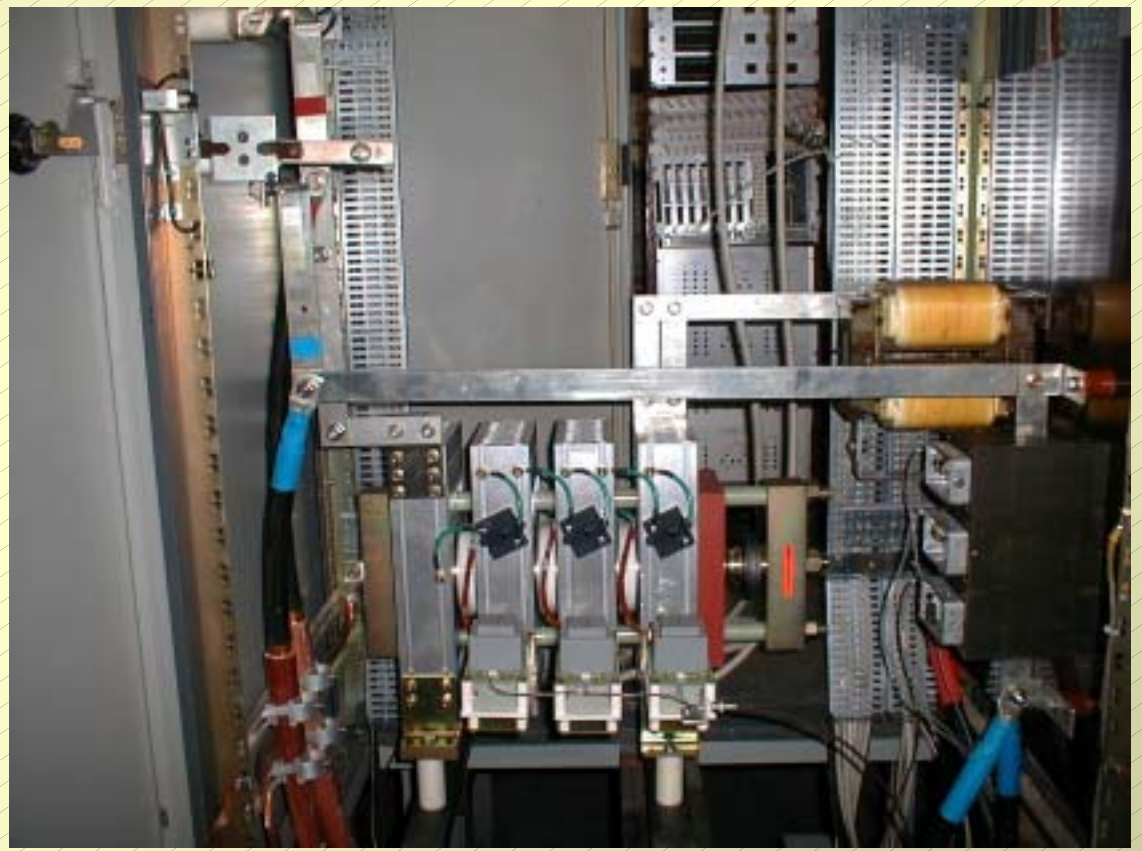
Components and Status
Thyristor Switches (20kV, 18kA)

- *All Th. Switches needed have been bought and delivered by ARCEL (FR).*
- *3 thyristors in series, sharing resistor, RC snubber and impulse transformer.*

Components and Status
Thyristor Switches (20kV, 18kA)

2 Th. Switches are already installed and tested inBA7.

- *8,2kV, 170kA with ratio 32*
- *6,5kV, 150kA with ratio 10*



Components and Status
Power Cables

- *Important parameters for the choice of the power cables.*
  - *Resistance and inductance cable must be much smaller than load impedance (Transformer, Strip Lines and Horn).*
    - ✓ *To minimize the voltage drop in the cable.*
    - ✓ *Not to increase too much the duration of the pulse.*

- *Our choice.*
  - *Four 18kV cables in parallel (each with 2 twisted 150 mm2 CU conductors) will be installed per system.*
  - *For 4 cables in parallel, the resistance and inductance (Nexans data sheet) will be : R = 100mΩ, L = 160 µH.*
  - *Measurements have been performed on the existing WANF cables. The impedance of this cable was R = 110mΩ, L = 130µH.*

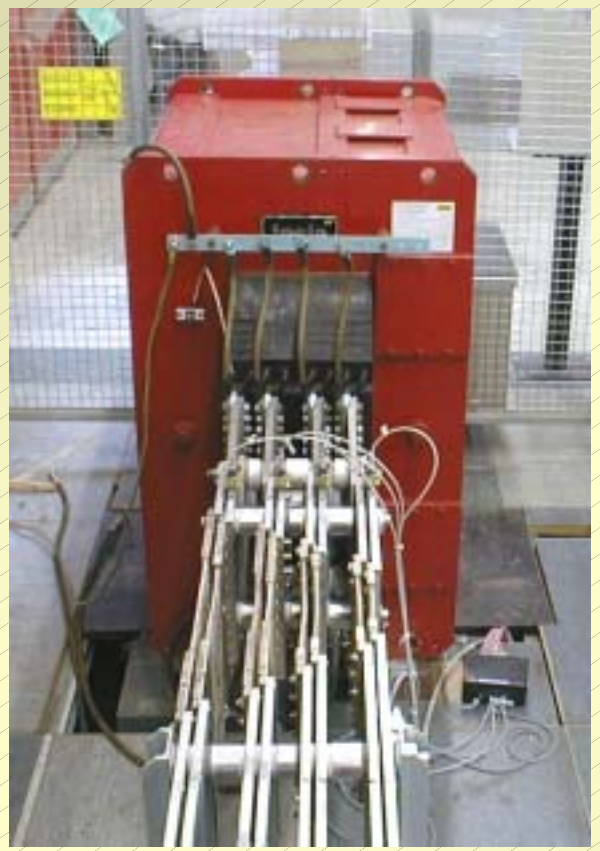
Components and Status
Pulse Transformers

- *At the beginning of the project*
  - *We wanted to buy 2 new transformers with ratio 14 for an estimate cost of 580kCHF.*

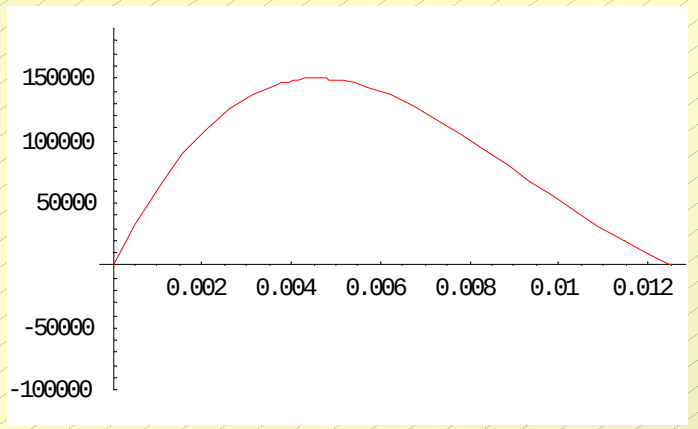
- *Now, reusing of WANF transformers*
  - *A test program has been realized to validate the reusing of the 2 Tesla pulse transformers of WANF.*
  - *We can reuse this transformers in ration 32 or 16 (special coupling in the secondary side.*

Components and Status
Pulse Transformers

Ratio 32

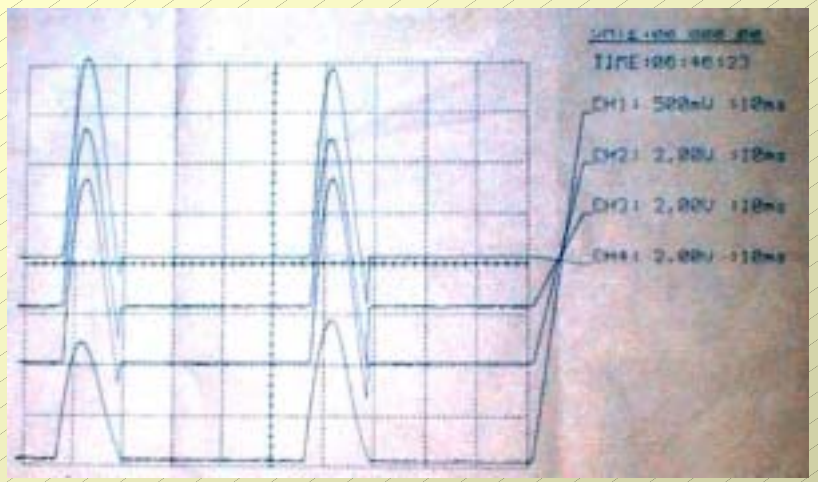


Simulation



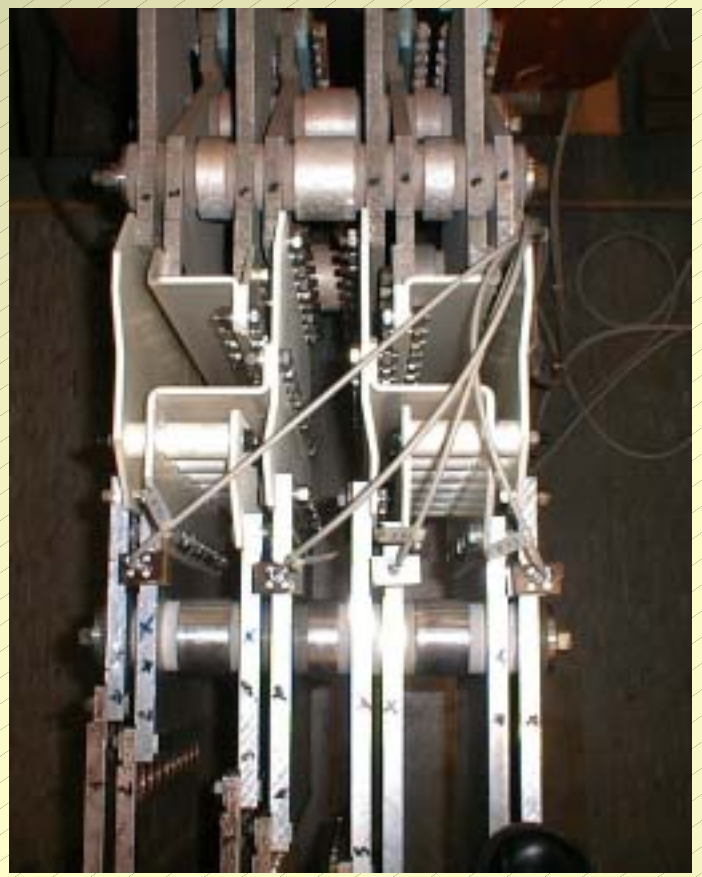
SL Current

Primary Current

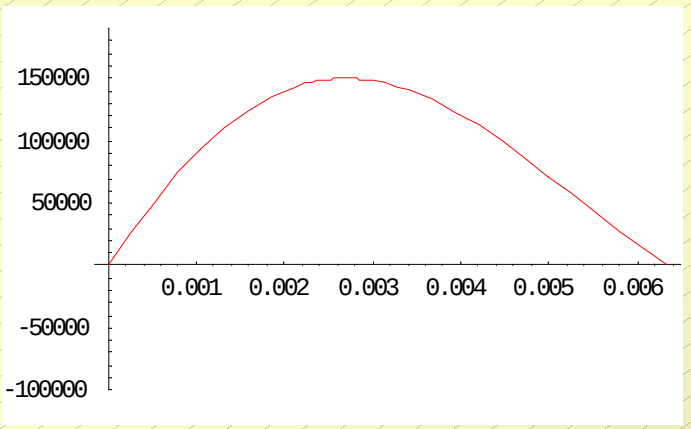


Components and Status
Pulse Transformers

Ratio 16

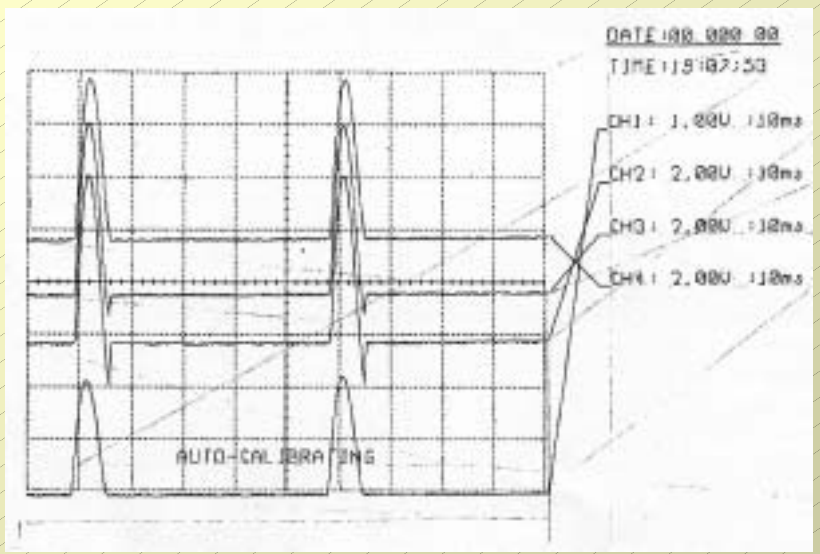


Simulation



SL Current

Primary Current



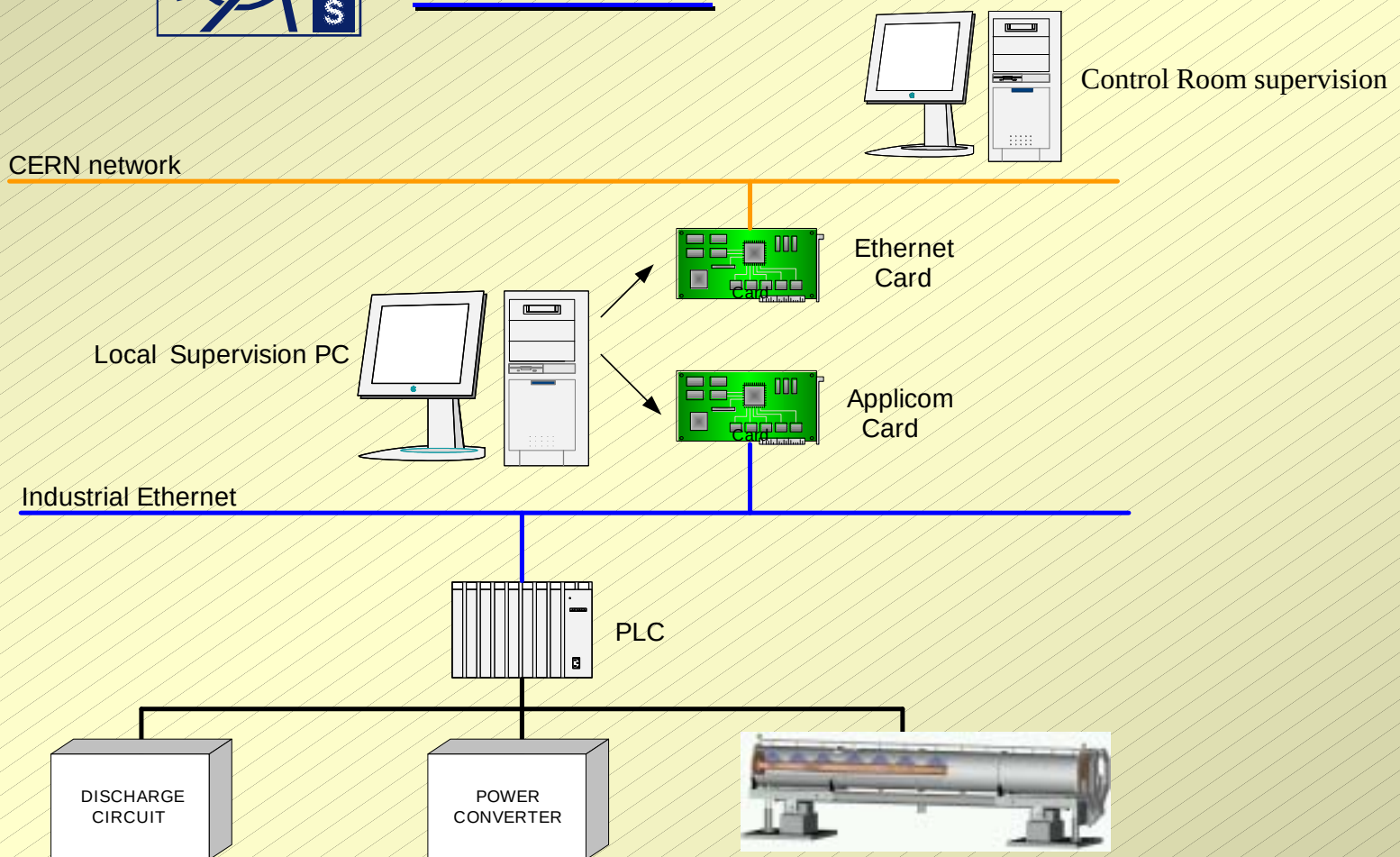
Test of inner conductor Horn
100.000 double pulses in Oct. 2003

I = 150kA

Water Flow = 50l/min at 1.5 bars
Ambient temp. = 20°C
Primary Water temp. = 20°C

	Start	End
Neck Small diam.	20°C	32°C
Neck Big diam.	20°C	34°C
Water IN Horn	20°C	26°C
Water OUT Horn	20°C	30°C
Transformer	20°C	50°C

Controls



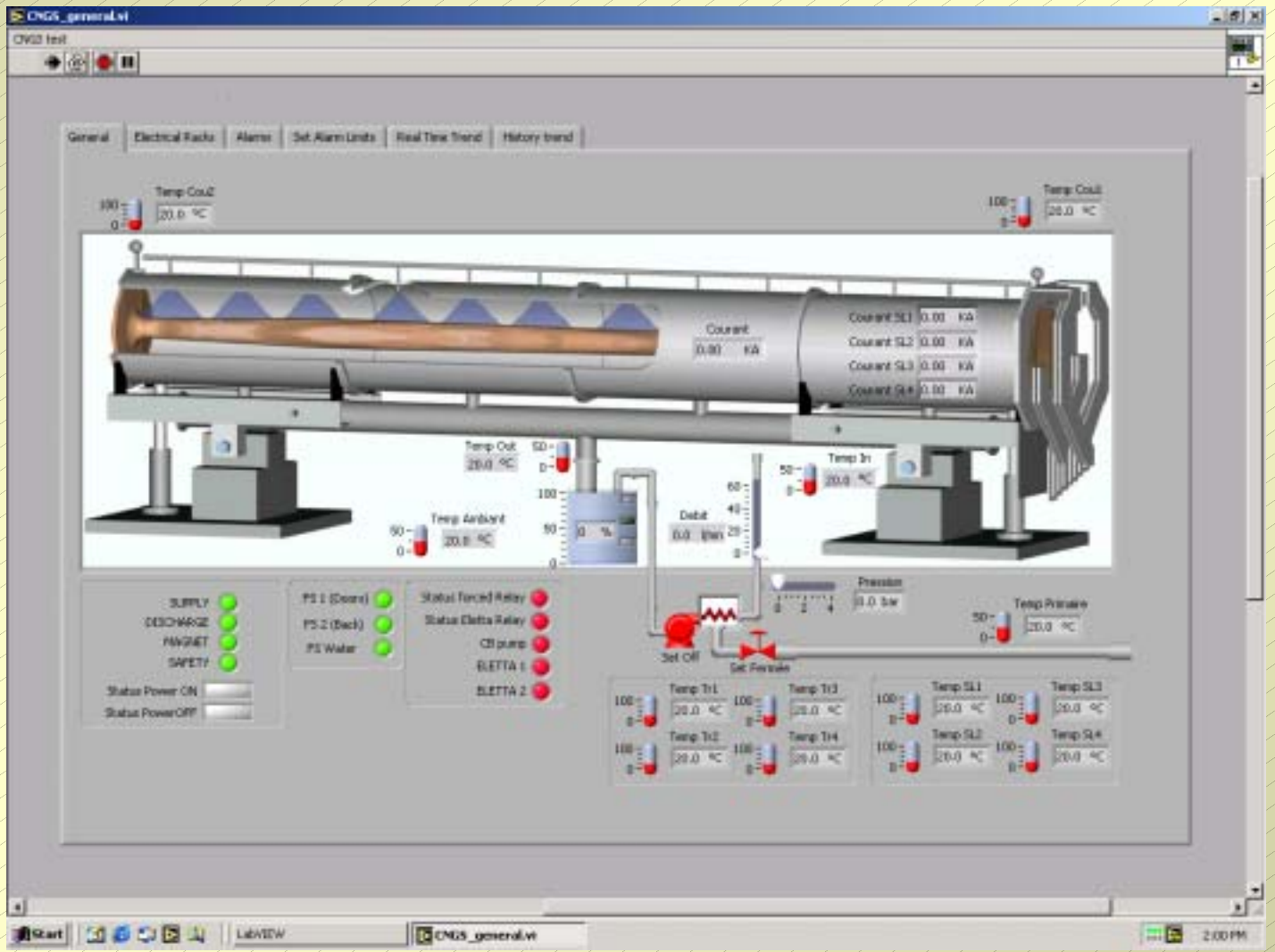
Designed by Sylvain RAVAT EP/TA3

Controls

PLC Racks

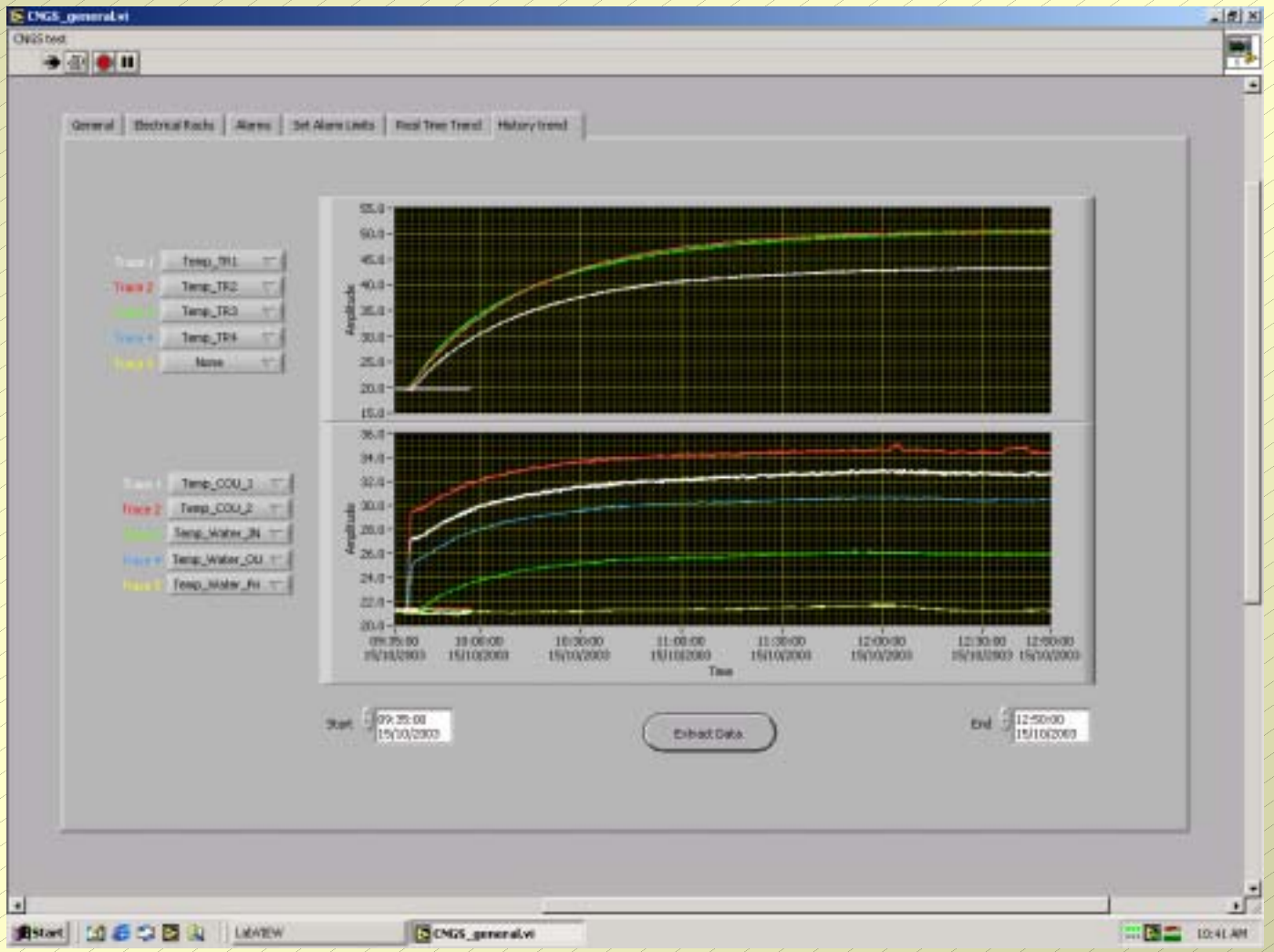
Controls

General View



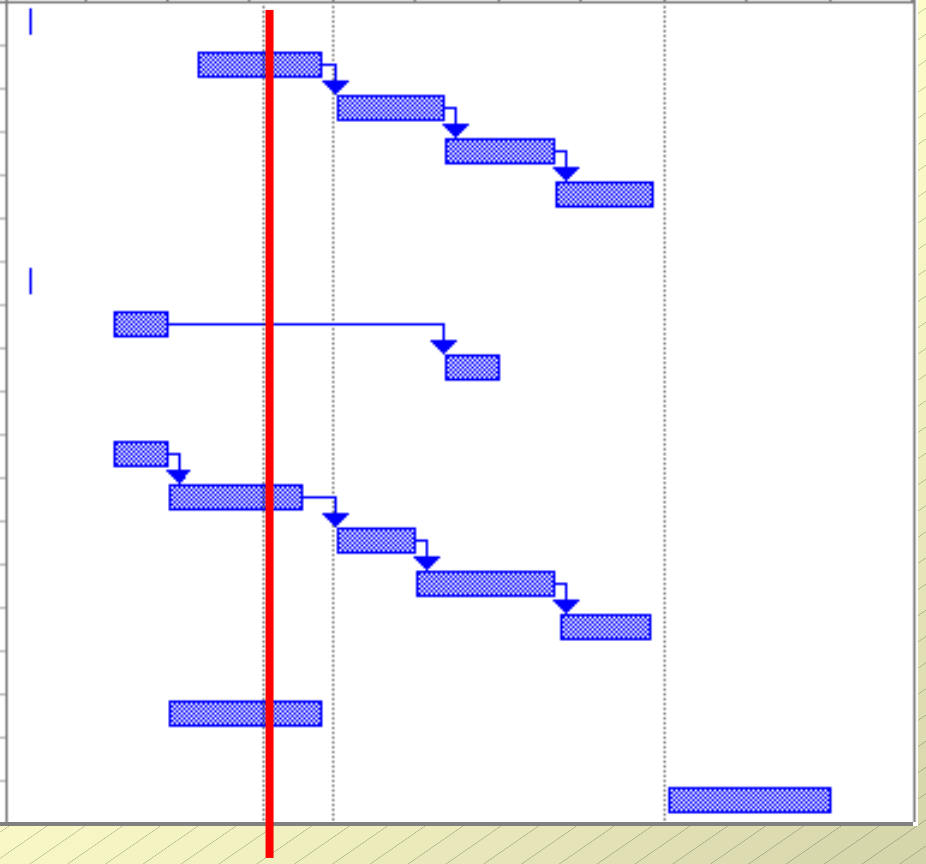
Controls

Historical View



Planning

ID	Task Name
1	MECHANICAL PART
2	Test of inner conductor Horn
3	Test of 1st Horn
4	Test of 2nd Horn
5	Test of Reflector
6	
7	ELECTRICAL PART
8	1st PC transformer
9	2nd PC Transformer
10	
11	Capacitors Discharge CFT
12	Pre-series Capacitors Discharge
13	Test of the Pre-series
14	Series Capacitors Discharge
15	Installation capacitors in the racks
16	
17	Electronic Regulation
18	
19	Moving in BHA4



Conclusions

- *Electrical circuit*
  - *Good progress since the beginning of the project with the validation of the electrical circuit.*
- *Cost Saving of 750kCHF since the beginning of project.*
  - *Migration to an existing building with new capacitors.*
  - *Reusing of the pulse transformers.*
- *Test and Key date*
  - *Validation of the first Horn inner conductor with 100.000 double pulses during October 2003.*
  - *Test of the two Horns and Reflector before the end of 2004.*
  - *Power cables will be installed at the beginning of 2005.*
  - *Moving electrical circuit in BHA4 at the beginning of 2005.*