The Vacuum control system for the TI2 and TI8 SPS-LHC transfer lines and for the CNGS primary proton beam line.

Review of LTI and CNGS Controls

Isabelle Laugier LHC/VAC

TI2-TI8 SPS-LHC transfer lines

- TI2, starting in TT60, 3km long
- TI8, starting in TT40, 2.5 km long
- The required pressure is 3 10^{-6} mbar
- Design and manufacture of all vacuum components (quadrupoles, pumping ports and dipoles) done by the Budker Institute of Nuclear Physics, Novosibirsk.

Details for each transfer line

- 4 vacuum sectors, each 730m long.
- Each sector:
  - 12 Ion pumps (LEP type) every 60.6m
  - 1 mobile turbo-molecular pumping station (6 roughing valves are installed per sector)
  - 1 gauge Pirani/Penning.

CNGS (CERN Neutrino to Gran Sasso)

- The primary proton beam (830 m) starting in TT40 will be used in common with the TI8 TL but continues after 110m under the name TN4.
- The beamline TN4 is composed of 73 new long dipoles, 21 new quadrupoles and 15 other magnets.
- Average pressure is 2 10^{-7} mbar.
- TN4 is divided into 3 Vacuum sectors

TI2-TI8 and CNGS Vacuum control System

Where are we today?

(April 2001)

Production type		**End production date**
Bellows	200	End 2001
MQI	225	All produced
MBI		Summer 2001
Missing corrector chambers		Spring 2002
Standard chambers for LSS		Spring 2001
Supports		Spring 2002
Flanges		Spring 2002

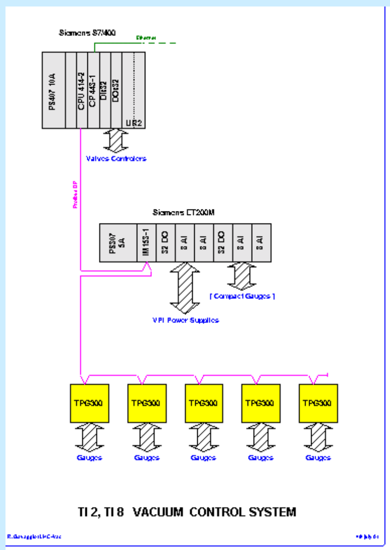
The control system

- Solution adopted is similar to the SPS vacuum control system using:
  - Oracle Database to store equipment list.
  - Scada system (PVSS)
  - Ethernet,
  - 2 Siemens S7/400 PLCs
  - Compact Gauges or TPG300/Gauges type depending on the result of the test with a 3km long cable.

Structure of the control system.

Ion pumps (LEP type)	“Adapted” power supplies	PLC	PVSS
Gauges Compact Gauges	TPG 300	PLC	PVSS
Mobile pumping groups		PLC	PVSS
Sector valves		PLC	PVSS

Chosen Architecture



TI2-TI8 and CNGS Vacuum control System

What do we need from the Controls Group?

- Ethernet network
- Timing system
- Logging and Alarm central system
- 7 racks (3 in BA7 and 3+1 in BA4)
- Connection for mobile equipment (not obligatory)

TI2-TI8 and CNGS Vacuum control System

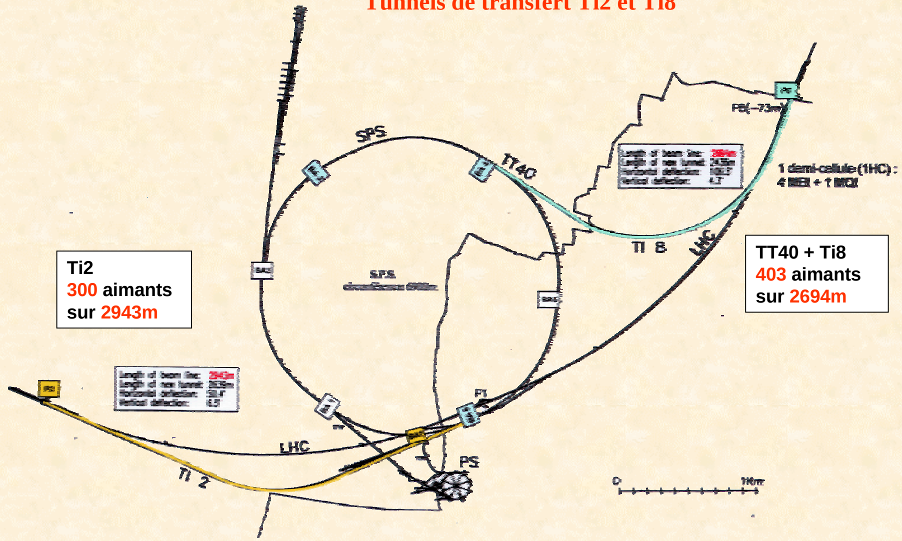
Vacuum group Responsibilities

- Vacuum Equipment:
  LHC/VAC/SL section, Miguel Jimenez
- Vacuum Controls:
  LHC/VAC/IN section, Isabelle Laugier

Protection aimants des lignes de transfert LHC & CNGS

- Lignes Ti2 & Ti8 ⇒ SPS-LHC
- Contrôle de la protection des aimants
- Ligne TT41 ⇒ CNGS
- Remarques
- Conclusions

Tunnels de transfert Ti2 et Ti8



Magnet Quantities in Transfer Lines Ti2 and Ti8

(without spares)

BINP / Novosibirsk → MBI, MQI

BINP / Novosibirsk prototype - end 2001 delivery - 01/02 - 06/03 → MCIA

IHEP / Protvino currently in production → MSIA, MSIB

Magnet type / Line	Required quantities TI2	TT40 + TI8	Total
MBI	112	236	348
MBB	2		2
B280	6	5	11
B340	33	23	56
BHC		3	3
Total dipoles	153	267	420
MCIA	47	43	90
MDS		2	2
Total corrector dipoles	47	45	92
MQI	95	83	178
QTL		3	3
Total quadrupoles	95	86	181
MSIA	2	2	4
MSIB	3	3	6
Total septum magnets	5	5	10
Total	300	403	703

Protection aimants des lignes de transfert LHC & CNGS

- Lignes Ti2 & Ti8 ⇒ SPS-LHC
- Contrôle de la protection des aimants
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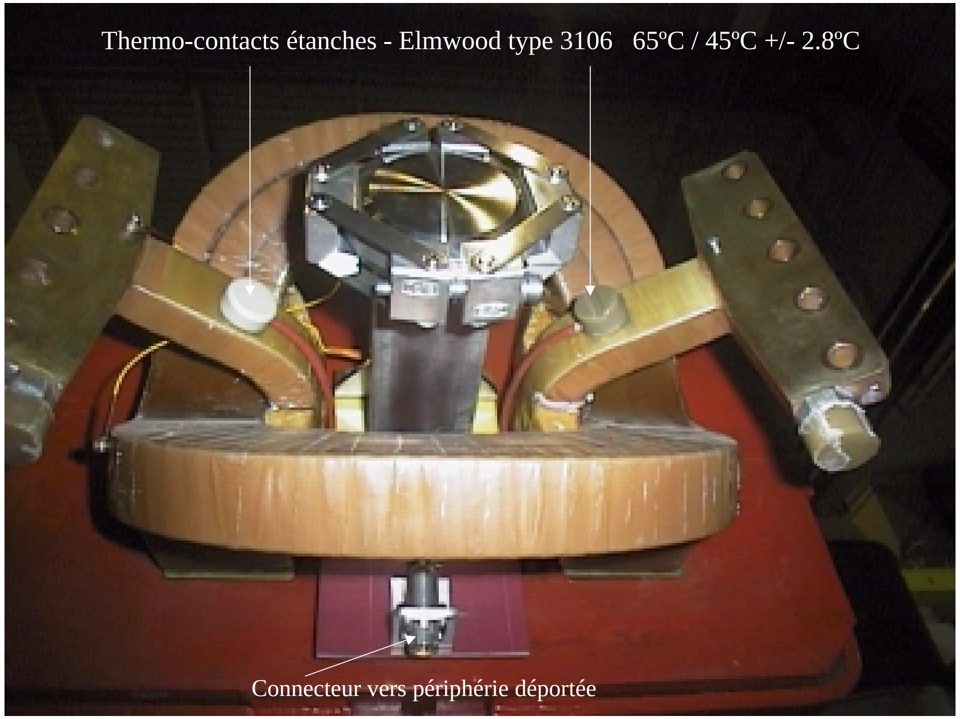
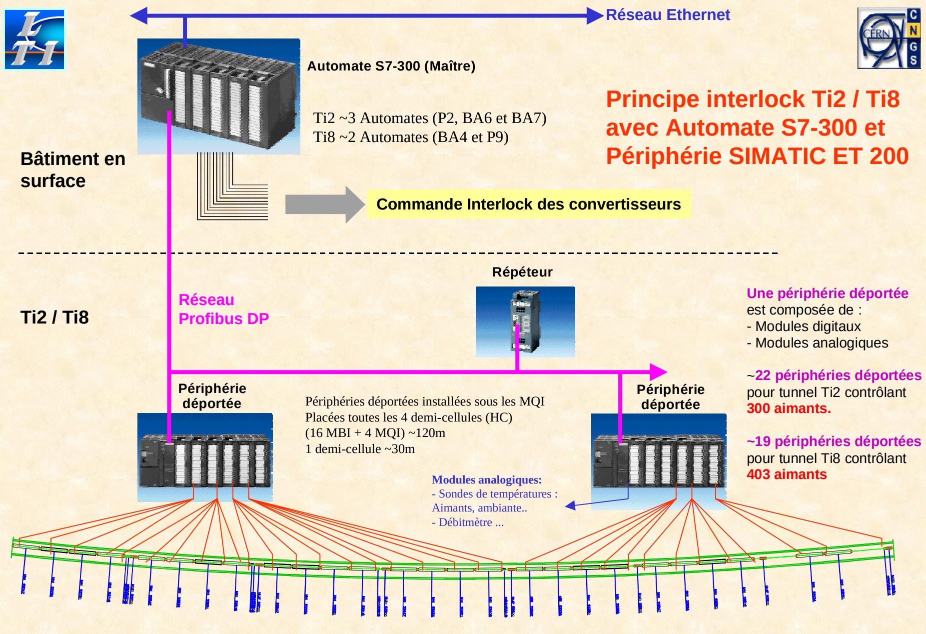
- Remarques
- Conclusions



Principe interlock Ti2 / Ti8 avec Automate S7-300 et Périphérie SIMATIC ET 200



Protection aimants des lignes de transfert LHC & CNGS

- Lignes Ti2 & Ti8 ⇒ SPS-LHC
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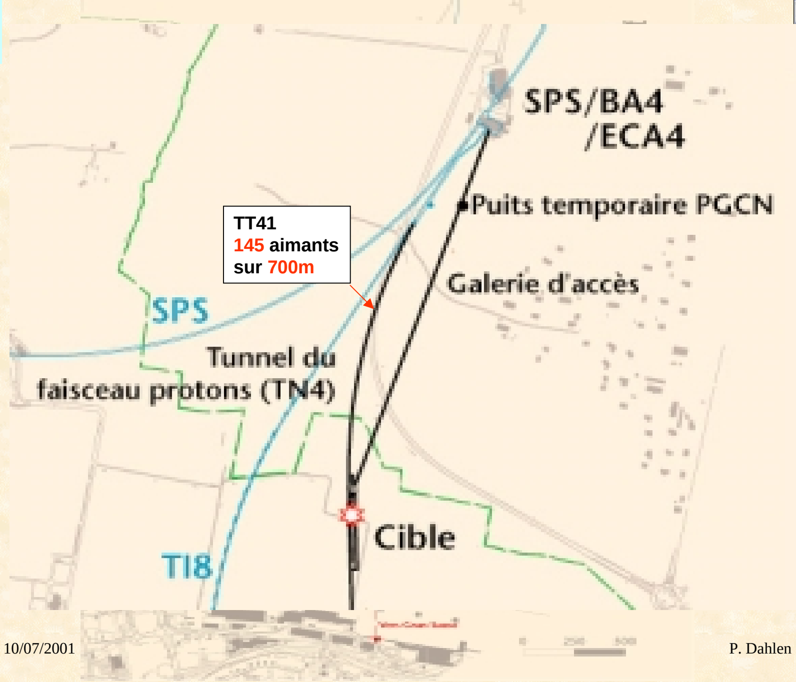
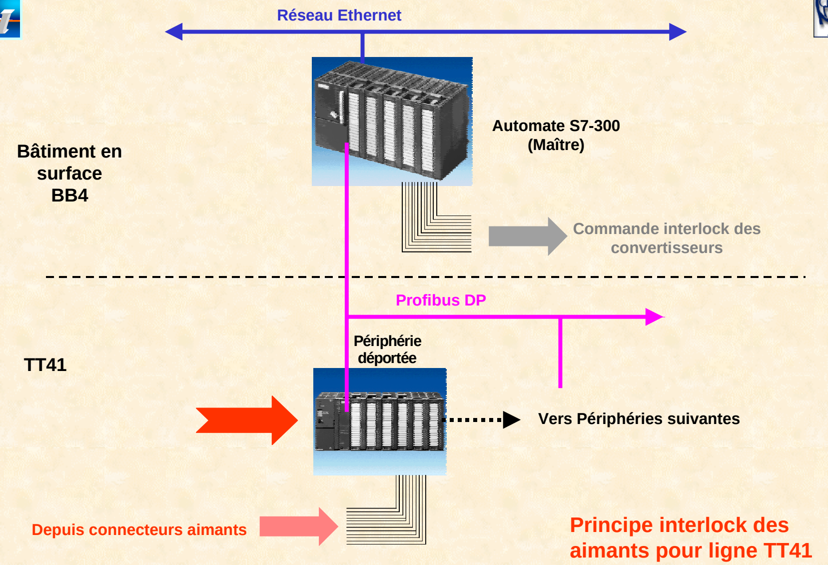
- Conclusions



Magnet Quantities for CNGS

BINP / Novosibirsk → MBG, QTG

Magnet type / Line	Required quantities CNGS
MBG	73
MBHC	3
MBS	8
Total dipoles	84
MDG	20
MDM (MCIA)	3
MDS	5
Total corrector dipoles	28
QTG	20
QTL	10
QTM (MQI)	1
QTS	2
Total quadrupoles	33
Total	145



Protection aimants des lignes de transfert LHC & CNGS

- Lignes Ti2 & Ti8 ⇒ SPS-LHC
- Contrôle de la protection des aimants
- Ligne TT41 ⇒ CNGS
- Remarques
- Conclusions

Remarques

- Electronique dans Ti2 & Ti8 et CNGS
  - Les périphéries déportées ET200 seront implantées à condition qu'il n'y ait pas d'anomalie de fonctionnement dues aux radiations. (Taux de radiations dans Ti2 & Ti8 et CNGS ?).
- Accès Ti2 & Ti8
  - Pourra-t-on intervenir pendant l'opération du LHC ?
- MPWG
  - Machine Protection Working Group.

Protection aimants des lignes de transfert LHC & CNGS

- Lignes Ti2 & Ti8 ⇒ SPS-LHC
- Contrôle de la protection des aimants
- Ligne TT41 ⇒ CNGS
- Remarques
- Conclusions

Conclusions

- **Ti2:**
  - 300 aimants sur 2943m contrôlés par 22 Périphéries déportées.
- **Ti8:**
  - 403 aimants sur 2694m contrôlés par 21 Périphéries déportées.
- **TT41 / CNGS:**
  - 145 aimants sur 700m.
    - Contrôle de la protection des aimants en cours d'étude.

Contrôle des convertisseurs de puissance LTI et CNGS

Les équipements à contrôler

- Les convertisseurs

Environ 230 convertisseurs pour TI2, TI8 & GS, dont 130 correcteurs en BA4, BA6, BA7, BB4, SR2, SR8

dont 130 Correcteurs < (±3.5A 80V)

Puissance apparente installée: **TI2= 18.2 MVA, TI8 = 32 MVA (suivant LHC note 153)**

- Les convertisseurs sont TOUS pulsés, sauf les correcteurs.
- Précision: 10-4 pour la plupart, 2 à 5 10-5 pour les principales et quadrupoles.
- Il y aura 2 DCCT partout, le 2ie DCCT etant destiné au diagnostic précoce et à la prémaintenance

- Le commutateur TI8 / CNGS

C'est un commutateur à thyristors permettant d'utiliser la même alimentation pour les aimants de courbure TI8 / CNGS

Ce module sera piloté au moyen d'un canal standard Mugef

- La fonctionalité "<u>F</u>ast <u>E</u>xtraction <u>I</u>nterlock" (F.E.I. ci dessous)

Cette fonctionalité consiste à vérifier, env 20 mS max avant l'extraction, que le courant de chaque convertisseur est compris dans une plage de tolérance donnée (ordre de 1% pour les correcteurs, 0.1 % pour les dipoles et quadrupoles).

La fonctionalité est identique aux lignes d'extraction Neutrino SPS (Ancien "Channel 6 analog hardware in BA6 & BA7 on MPX system for TT60"). Mais les exigences LTI/CNGS sont très differentes:

- Précision différente: 0.1 % dans de nombreux cas contre 2 à 10% pour Neutrino
- Nombre d'alimentations différent (230 contre 18 pour Neutrino)

Donc la fiabilité de cet équipement pourra nécessiter une optimisation substancielle, surtout pour se protéger des parasites industriels éventuellement présents pendant la fenêtre de mesure (15 mS environ).

<u>Solution de contrôle proposée</u>

1) Solution globale proposée: le Mugef

Contexte et raisons du choix:

- Dès 1998 (LHC note 153 : "Powering the Transfer Lines from SPS to LHC"), on a considéré TI2&TI8 comme ***EXTENSION*** du SPS dans le but d'économies sur les infrastructures et systèmes d'alimentations. TI2 & TI8 réutilisent aussi de nombreux anciens convertisseurs du SPS et du LEP. et sont souvent dans les mêmes batiments BA4, BA6, BA7 .
- L'ensemble des convertisseurs du SPS bénéficie depuis 1999 d'un programme de ***rénovation*** comportant entre autres un nouveau chassis interface unifié avec le Mugef. Ce chassis interface améliore les **performances analogiques**, et permet de nouvelles fonctionalités de **commande** et **monitoring**.
- Par ailleurs, le Mugef bénéficie aussi depuis 1998 d'une vaste campagne de rajeunissement et ***d'améliorations (ROCS).*** Cela permet l'exploitation de nouvelles possibilités, telles la mise à jour permanente en background des status et valeurs analogiques dans la NVram, afin d'améliorer la **disponibilité immédiate** des infos convertisseurs pour le système de contrôle.

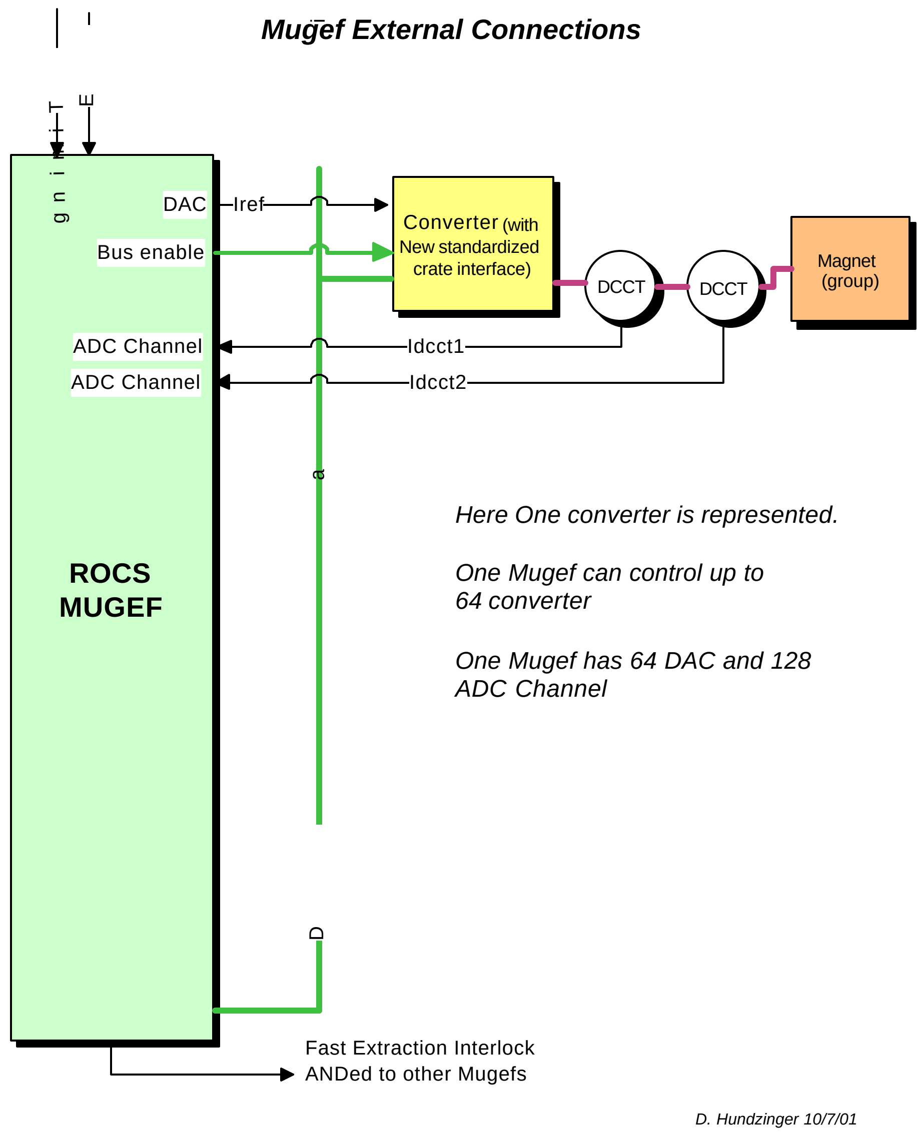
Dès le début des considérations sur le FEI, la centralisation dans un ***hardware unique*** (non distribué) des consignes et mesures des convertisseurs d'un batiment entier, comme sur le Mugef, permettait d'envisager un traitement facile de ces données pour générer le signal FEI à l'echelle de chaque batiment.

Enfin, le fait de choisir un système de contrôle déja existant et prouvé dès 1998 a permis de lancer très tôt la ***fabrication des chassis Mugef*** requis pour TI2,TI8 & CNGS, afin de favoriser la répartition de la charge budgétaire et charge de travail pour le groupe SL-PO.

2) Description très sommaire du Mugef, et additions FEI

- ***ROCS Mugef*** depuis 1998 installé dans tous le SPS (PowerPC, Ethernet direct, LynxOS, Event driven software)
- Contrôle au minimum pour <u>chaque alimentation</u> : 15 bit de ***status,*** 8 bit de ***command***, ainsi qu'une fonction de courant (plusieurs tables descriptives sauvées et commutables). Deux canaux analogiques 16 bit sont lus à chaque milliseconde et mémorisés dans la NVram, afin de rendre les valeurs digitalisées rapidement disponibles aux demandes de lecture de courant.

Connections hardware entre un chassis et le monde extérieur



- Les ***nouveaux chassis AUX PS*** et l'évolution prévue du Mugef devrait permettre un nombre accru de commandes et de Status, au moyen d'une exploitation plus élaborée de la "Daysi Chain 8+16"
- Mugef: fonctions spéciales type ***Haute précision*** comme Main Converter SPS

<u>- Additions dues à la fonctionalité FEI:</u>

  - Hardware: 1 chassis 3U sous le Mugef avec logique , visualisation des défauts constatés et Driver de ligne de sortie FEI vers "Extraction Kicker".
  - Instructions pour initialisation les masques et les tolérances.

- Programme interne pour calculer au mieux pour chaque convertisseur l'erreur entre le courant de référence et le courant mesuré par le DCCT, et comparaison avec la tolérance. Cette tâche est triggerée par le signal de Timing : Extraction Request.

  Cette tâche comporte aussi un moyennage et un filtrage effectués sur plusieurs valeurs mesurées afin de réduire, si possible, les effets des parasites exterieurs sur la génération du signal FEI.
- Instructions pour permettre l'identification (depuis l'exterieur) du convertisseur en défaut (défaut réel ou fausse interpretation due à un parasite lors de la dernière tentative d'extraction).

3) Etat de l'implémentation

- Un prototype de système complet Fast Extraction Interlock a été testé.
- La fabrication et l'approvisionnement de l'ensemble des modules Mugefs sont très avançée
- L'installation commencera mi-2002 début 2003 parallèlement à l'installation des convertisseurs.

Support et services necessaires

- Racks physiques supportant le Mugefs?
- Distribution Ethernet nouveaux batiments (BB4, SR2, SR8)
- Programmes de contrôle TI2 TI8 & GS, incluant l'initialisation du système FEI dans tous les Mugef, et l'initialisation des évènements TIMING requis par FEI
- Programmes supplémentaires de prémaintenance destinés à anticiper l'identification de défauts de convertisseurs afin de fiabiliser les réponses du système FEI (repose en partie sur des nouvelles fonctionalités Chassis de contrôle convertisseurs / Mugefs ROCS
- Exploitation du signal FEI sortant des Mugef (relais? Optocoupleur ?)

LTI/CNGS Controls Review
10 July, 2001

Beam Instrumentation
Low Level Controls Session

[J-J Gras]

- BI Organisation
- Requirements so far.
- Needs in Terms of Controls
- BI Responsibilities
- Planning
- Remarks

BI Organisation

Like for the LHC, the LTI and CNGS instrumentation is defined and monitored by the 2 following BI boards:

- ### The Specification Board:

  This team consists of 3 BI members and representatives of other concerned Group. They are in charge of the identification and publication of the needs and constraints of the LHC/LTI/CNGS in the domain of Beam Instrumentation.

  The LTI and CNGS Functional Specifications are in progress and the first drafts should be delivered this Autumn. We work there in close collaboration with Malika Meddahi (SL/BT)

  The following presentation will be based on the requirement described today.

  The final requirements for LTI will be decided during a BI Review (~October) were the main proposal and possible options will be discussed.

- ### The Technical Board:

  This team consists of the SL/BI Group Leader, the SL/BI Section Leaders, the SL/BI Project Leaders and the SL/BI linkmen in other boards or WG.

  They have to insure that the LHC Beam Instrumentation is built according to the specifications given by the 'Specification Board", on time and in a cost effective manner.

Requirements so Far
(See Malika's Presentation)

Instrument	Person Responsible	Number of Items per Transfer Line					Total
		TT40	TT60	TT41	TI 8	TI 2	
BPM	D. Cocq	4 (40MHz) + 4 (200 MHz)	4 (40MHz (*))	24	42	56	134
Profile	F. Ferioli	3	2 old + 1	6	13	14	39
Fast BCT	R. Jones	1	1	1	1	1	5
BLM	F. Ferioli	6	6	18	30	30	90
TBIU/TBID	F. Ferioli			2			2

(*) Probably Blind for Slow Extraction. (Current Situation).

Consequences in Terms of Controls

Use	Transfer Line	Instrument	Nb of Requested Channels	Crate Location	Crate Nb	Prepulse Needed	MTG Needed	SPS BST Needed			Gives Alarms	Gives Interlocks	Network BandWidth per Pulse	Crate Space State	Cable State	Extras
								Rev Fr	40 MHz	Msg						
LHC & CNGS	TT40	BPM	4 (40 Mz) + 4 (200 Mz)	0 (with TI8 & TT41)	0 (with TI8 & TT41)	Yes	Yes	Yes	Yes	Yes	?	?	8 * 1K	see TI8	see TI8	see TI8
		Profile	3	BA4	1	No	Yes	No	No	No	?	?	3 * 65 K	Existing	TBR	
		BCT	1	ECX4 or BA4	2	Yes	Yes	Yes	Yes	Yes	?	?	1K	TBR	TBR	Front End Electronic in the Tunnel (~1m near BCT)
		BLM	6	BA4	1	No	Yes	No	No	No	Yes	?	1 K	Existing	TBR	
LHC & Slow Extraction	TT60	BPM	4	0 (with TI2)	0 (with TI2)	Yes	Yes	Yes	Yes	Yes	?	?	4 * 1K	see TI2	see TI2	see TI2
		Profile	2 old + 1	BA6	1	No	Yes	No	No	No	?	?	3 * 65 K	Existing	TBR	
		BCT	1	BA7	2	Yes	Yes	Yes	Yes	Yes	?	?	1K	TBR	TBR	Front End Electronic in the Tunnel (~1m near BCT)
		BLM	6	BA6	1	No	Yes	No	No	No	Yes	?	1 K	Existing	TBR	
CNGS	TT41	BPM	24	?? ECX4 or BA4 ??		Yes	Yes	Yes	Yes	Yes	?	?	20 * 1K	TBR	TBR	
		Profile	6	BA4	1	No	Yes	No	No	No	?	?	6 * 65 K	Existing	TBR	
		BCT	1	CNGS access Gallery	2	Yes	Yes	Yes	Yes	Yes	?	?	1K	TBR	TBR	Acquistion electronic as close as possible to the BCT
		BLM	18	BA4	1	No	Yes	No	No	No	Yes	?	1 K	Existing	TBR	
		TBIU/TBID	2	BA4	1	No	Yes	No	No	No	?	?	1 K	Existing	TBR	
LHC	TI2	BPM	56	BA7	2 Racks	Yes	Yes	Yes	Yes	Yes	?	?	56 * 1K	TBR	TBR	WorldFIP needed 1 cable per 16 BPM + Front End Electronic in the Tunnel
		Profile	14	BA6 & UA23	2	No	Yes	No	No	No	?	?	14 * 65 K	Ex/TBR	TBR	
		BCT	1	UA23	2	Yes	Yes	Yes	Yes	Yes	?	?	1K	TBR	TBR	Front End Electronic in the Tunnel (~1m near BCT)
		BLM	30	BA6 & UA23	2	No	Yes	No	No	No	Yes	?	1 K	Ex/TBR	TBR	
LHC	TI8	BPM	42	ECX4 or BA4	2 Racks	Yes	Yes	Yes	Yes	Yes	?	?	42 * 1K	TBR	TBR	WorldFIP needed 1 cable per 16 BPM + Front End Electronic in the Tunnel
		Profile	13	BA4 & UA87	2	No	Yes	No	No	No	?	?	13 * 65 K	Ex/TBR	TBR	
		BCT	1	UA87	2	Yes	Yes	Yes	Yes	Yes	?	?	1K	TBR	TBR	Front End Electronic in the Tunnel (~1m near BCT)
		BLM	30	BA4 & UA87	2	No	Yes	No	No	No	Yes	?	1 K	Ex/TBR	TBR	
LHC	All	BST Master	2	PCR	2	Yes	Yes	Yes	Yes		?	?	1 K			

TBR = To Be Requested

Done | To Do | To Discuss | To Approve

Consequences in Terms of Controls

- **Control Standard Services Requested:**
  - Remote Reboot - Remote Console
  - MTG - Prepulses
  - Middleware and Remote API
  - Development and Operational Front End Platforms, RTOS and standard drivers and libraries
  - Development and Operational Client Platforms
  - Configuration and Measurement DB
  - Alarm and Interlock Interfaces and Strategy.
  - LHC Beam Description...
- **Extras**
  - WorldFIP (31.25 kHz)
  - BST distribution

BI SW Responsibilities

Instrument	Front End SW	Expert and Operational remote API	Expert/R&D GUI	Operation GUI	DB Black Boxes
BPM	SL/BI/SW	SL/BI/SW	SL/BI/SW	?OP/CO/BI?	?OP/CO?
Profile	SL/BI/SW	SL/BI/SW	SL/BI/SW	?OP/CO/BI?	?OP/CO?
BCT	SL/BI/SW	SL/BI/SW	SL/BI/SW	?OP/CO/BI?	?OP/CO?
BLM	SL/BI/SW	SL/BI/SW	SL/BI/SW	?OP/CO/BI?	?OP/CO?
TBIU/TBID	SL/BI/SW	SL/BI/SW	SL/BI/SW	?OP/CO/BI?	?OP/CO?
BST (if Msg necessary)	SL/BI/SW	SL/BI/SW	SL/BI/SW	SL/BI/SW if any	None

Planning for CO Services

- **Control Standard and Extra Services:**
  - Remote Reboot - Remote Console
  - MTG - Prepulses
  - Middleware and Remote API
  - Development and Operational Front End Platforms and RTOS.

  Are physically requested 6 months before beam.
- **Control Standard and Extra Service Stable Interfaces**

  Are requested 1 year before beam with prototypes or simulators.
- **BI will know its exact mandate this Automn but the current requirements in terms of Controls should be pretty accurate**

Remarks

- **We do NOT foresee (due to lack of resources) to have the 4 CNGS BPM available in TT40 for Q4 2003.**
- **TT60 BPMs are not designed for Fixed Target beam observation (-> current situation remains).**
- **All our acquisitions will be based on the SPS revolution frequency and 40 MHz up to UA's.**
- **BI will transmit the 'To Be Requested' to**
  - Alan Spinks for Rack Space
  - Volker Mertens for Cable Description

Remarks

- All our LTI/CNGS SW (Front End SW and Expert GUI's) will be developed with our common base (BISCoTO).
- This base, triggered by the Themis/OS9/TG3 elimination, solves for all our systems the problems encountered by BI in its Front End in a common and pragmatic manner:
  - TG8 handling and sharing.
  - Process tracing and debugging
  - Configuration and Setting Handling
  - Expert GUI's, drivers code automatic generation...
- Despite close contact with SL/CO, the only 'standards' available on time for us where PPC/LynxOS, Tg8msTim HW&SW, STOPMI, JDV and SLEquip. We used them all.
- It has NOT been possible to link to SPS2001 because our requirements are still not covered. If this is not solved during the next shutdown, SPS2001 will have to be BISCoTO compliant for LTI and CNGS (and not the other way around)!

Extraction, Injection and Beam Obstacles

Etienne CARLIER
SL/BT/EC

Outline

- Glossary
- Equipment
- Functionality
  - Kickers
  - Septa
  - Beam obstacles
- Architecture
  - Slow control
  - Fast control
  - Software
- Operation

Glossary

Kicker	Fast pulsed magnet used to deflect the injected / extracted beam on / from the closed orbit.	MKE, MKI
Septum	Electro-static and electro-magnetic magnet used to deflect the extracted beam into the transfer lines.	ZS, MST & MSE
Beam dump	Moveable block able to absorb repetitively the full energy of a particle beam.	TED, TDI
Beam stopper	Moveable block used mainly for personal safety and able to absorb occasionally the full energy of a particle beam.	TBSE
Target	Equipment used to produce secondary beams.	T40
Collimator	Moveable block used to protect equipment against uncontrolled beam behaviour.	TCDI, TCDD

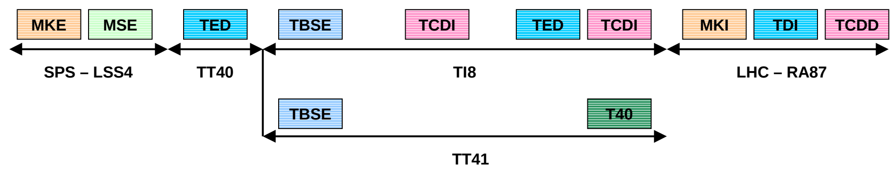
General

- Control electronics will be located either in the surface buildings (BA or SR), in the ECA4 cavern or in the LHC “klystron” gallery (UA).
- No electronics will be installed in the LHC or in the transfer line tunnels.
- No real-time capacities and/or deterministic solutions are required.
- Avoid to do specific hardware development when standard interface cards are available directly from industry.
- Solutions *used* for the upgrade of SPS equipment control (SPS proton injection kicker, SPS North extraction septa and SPS beam obstacles sector) will be *re-used* for the control of transfer line equipment.

Equipment Contibuted by SL/BT to LTI

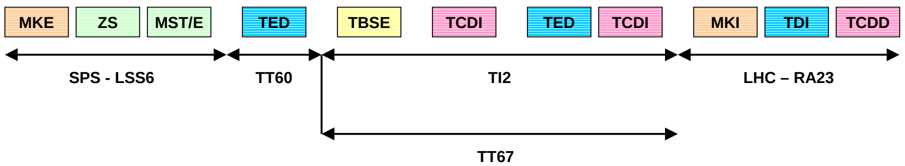
- SPS extraction and LHC injection kicker systems.
- SPS extraction electromagnetic septa.
- Transfer lines TI2, TI8 and TT40 beam dumps, beam stoppers and collimators.
- LHC injection dumps and collimators.
- Neutrino target.

TI8 / TT40 – SL/BT Equipment



Electronics	Equipment		Location
ECA4	SPS extraction kicker SPS extraction septa TI8 beam dump upstream TI8 beam stopper Neutrino target T40	MKE4 MSE TED TBSE T40	SPS – LSS4 SPS – LSS4 TT40 TI8 TT41
SR8/UA87	LHC injection kicker	MKI8	LHC – RA87
SR8	TI8 beam dump downstream LHC injection dump TI8 collimator LHC injection collimator	TED TDI TCDI TCDD	TI8 LHC – RA87 TI8 & LHC – RA87 LHC – RA87

TT60 / TI2 – SL/BT Equipment



Electronics	Equipment		Location
BA6	SPS extraction kicker SPS extraction septa TI2 beam dump upstream TI2 beam stopper	MKE6 ZS, MST, MSE TED TBSE	SPS – LSS6 SPS – LSS6 TT60 TI2
SR2/UA23	LHC injection kicker	MKI2	LHC – RA23
SR2	TI2 beam dump downstream LHC injection dump TI2 collimator LHC injection collimator	TED TDI TCDI TCDD	TI2 LHC – RA23 TI2 & LHC RA23 LHC – RA23

Kickers - Functionality

- Slow control
  - Elementary cycle independent, Machine mode dependent
  - Equipment state control
- Fast control
  - Elementary cycle / Beam process dependent
  - Timing system: slow (MTG) & fast timing (prepulses)
  - Analogue setting reference signals (DAC) and pulsed analogue measurements (S/H + ADC)
- Waveform acquisition
  - Elementary cycle / Beam process dependent
  - Simultaneous acquisition of up to 7 signals with respect to an external trigger

Electromagnetic Septa - Functionality

- Slow Control
  - Elementary cycle independent, Machine mode dependent
  - Magnet and bus-bar cooling control (magnet and coil temperature, water flow and water pressure control)
- Septa deflection strength is determined by an SL/PO external power supply driven through a standard « Mugef » system
  - Elementary cycle dependent
  - Measurement of the septa deflection strength must be integrated in the the extraction interlock chain.
- Septa compensation coils (circulating beam) power supplies will be connected to the « Mugef » system
  - Elementary cycle dependent

Beam Obstacles - Functionality

Beam stopper (TBSE)	• Vertical « inout » positioning • Two positions per equipment : In or Out • Equipment cooling control
Beam dump (TED)	• Horizontal « servo » positioning • Four predefined fixed positions per equipment : In, Out, Retracted & Installation • Two motors per displacement • Equipment cooling control
LHC injection dump (TDI)	• Vertical « servo » positioning • Two displacements (up and down) / equipment • Two motors / displacement • Required positioning precision: 0.05mm
Transfer line & LHC injection collimators (TCDI & TCDD)	• Horizontal « inout » positioning • Two positions / equipment : In, Out • Equipment cooling control
Neutrino target	• « servo » positioning for target alignment and target selection • Helium station cooling control • TBIU and TBID position control

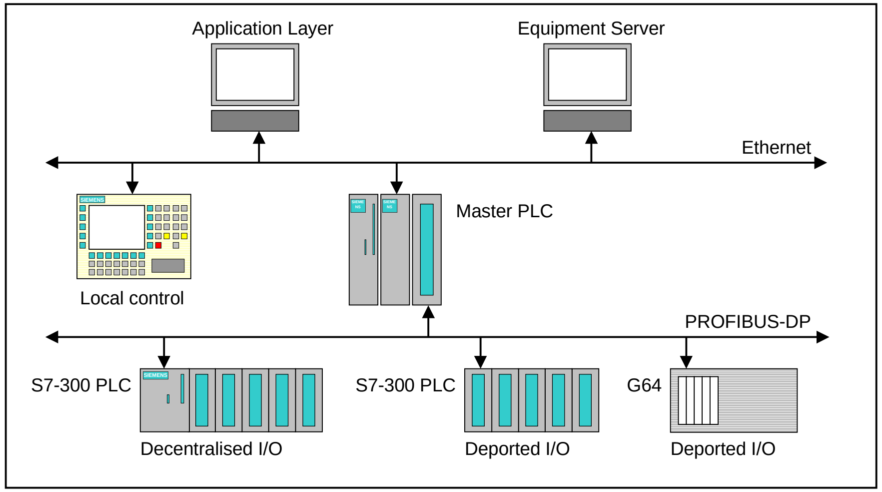
Functionality - Summary

	Machine Mode Dependent	*Elementary Cycle Dependent*	
	Slow Control	Fast Control	
		Timing	Mugef
Kicker	■	■	
Septa	■		■
Beam Obstacles	■		
Target	■		

Slow Control

- Slow control is machine mode dependent and elementary cycle independent.
- Completely based on industrial components:
  - SIEMENS PLC S7-300 and/or S7-400,
  - PROFIBUS-DP field-bus used for low level communication,
  - SCADA or Operator console for local control.
- Slow control partially sub-contracted to industry. Integration must be done on the basis of industrial standards.
- Slow control will be integrated in the SPS2001 framework through SPS2001 compliant device server communicating with the PLC through SIEMENS SOFNET-S7 Protocol.

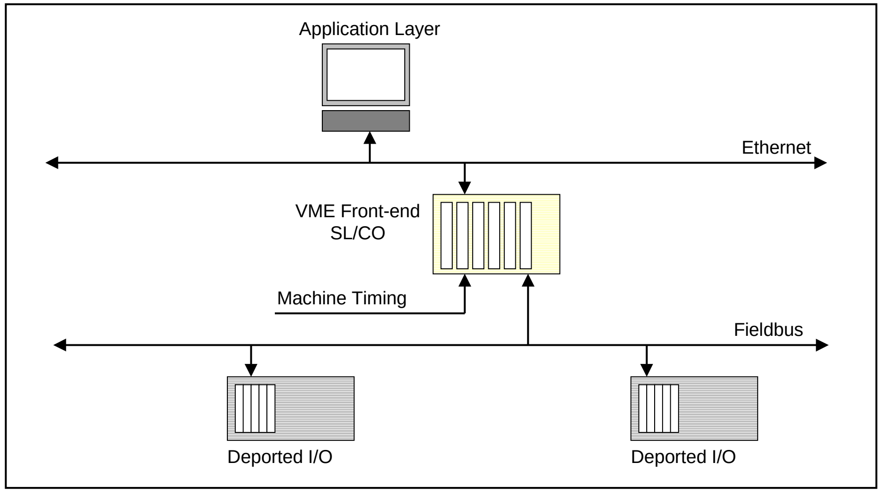
Architecture – Slow control



Fast Control

- Fast control is elementary cycle / beam process dependent.
- Fast control will be based on standard SL/CO front-end and synchronised with machine timing through TG8 modules.
- Timing control of SPS extraction kicker and LHC injection kicker will be based:
  - VME timing modules from « Berkeley Nucleonics » and standard VME DAC/ADC cards integrated inside the SL/CO front end, or
  - G64 timing modules connected to the front-end through MIL1553 field-bus (backup solution).

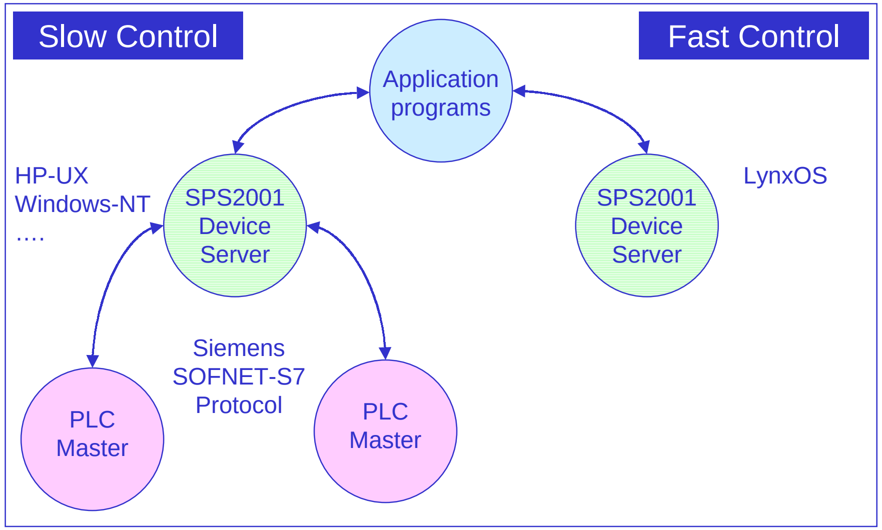
Architecture – Fast control



Architecture - Software

- Equipment below SL/BT responsibility will be integrated inside the LTI control architecture, up to and including the target T40, through the SPS2001 framework.
- Slow and fast control integration will be done through independent SPS2001 compliant device servers.
- Subscription mechanism between different SPS2001 device servers appears to be necessary (mandatory) in order to obtain a correct control homogeneity between the different device servers of an single equipment.
- A clear separation between the industrial environment and the SL/CO control architecture must be kept. This separation will be realised within the SPS2001 slow control device server through the SIEMENS SOFNET-S7 communication protocol.

Architecture - Software



Planning

06/2001	Control of the SPS injection kicker integrated within the SPS2001 framework. First contracts for data (settings and measurements) and state management available.
12/2001	Control of beam obstacles (TED and TBSE) for North and West extraction integrated within SPS2001 framework.
03/2002	Control of North and West electromagnetic septa integrated within SPS2001 framework.
03/2002	Templates for integration of each type of SL/BT equipment within the SPS2001 framework available.
03/2003	Control of extraction kicker and electromagnetic septa in LSS4 integrated within SPS2001 framework.
06/2004	Control of transfer line TI8 beam obstacles, LHC injection kicker and injection dumps integrated within SPS2001 framework.

Some Figures

SL/CO VME Front-end	4
PLC Master	11
S7-400	*6*
S7-300	*5*
Ethernet connection	15
PROFIBUS-DP Segment	30
PROFIBUS-DP Node	100
Decentralised I/O	*25*
Deported I/O	*75*

Operation - Interlocks

- TED and TBSE will be interconnected and interlocked with the **SPS / LHC access systems**.
- MKE will be interconnected with **SPS interlock system** as server for extraction inhibition and as client in case of internal failure.
- MKI will be interconnected to **LHC machine protection system** as server through the beam permit signal and as client in case of internal failure.

Operation - SPS Fast Extraction

- Fast extraction must be monitored on beam process basis. Beam losses of each beam process must be acquired independently.
- Generation of the kick strength must be done through the transfer line steering program. An internal tracking interlock based on an external measurement of the beam energy (dcct) will be provided in order to control that the requested kick strength fit within the extraction aperture.
- Waveform visualisation tools are needed in order to check remotely and continuously the correct synchronisation of the extraction kicker pulse with the circulating beam.
- Extraction post-mortem & logging system (kick, extraction trajectories…) must be available in order to record extraction instabilities and to detect long term degradation.

Operation - LHC Injection

- During injection, LHC will be seen, from the injection kicker, as a cyclic machine.
- During this period, LHC injection kicker timing system (fast and slow) will be synchronised / locked with SPS extraction kicker timing.
- If other operation modes of the LHC injection kicker system are requested (dump last injection…), two independent distribution timing systems (slow and fast) appear necessary for SPS extraction and LHC injection kicker systems.

Summary

- Basic technical choices for the control of SL/BT equipment are already done.
- They have been successfully implemented for the control of the new SPS proton injection kicker this year and will be re-used for the control of the different SL/BT equipment involved in the LTI project.
- Integration of these choices within the SPS2001 framework has also been realized with success this year. Different software frameworks between SPS, LHC and EA has to be avoided in order to profit of the acquired knowledge and optimise resources.
- Operational requirements still to be identified.
- Analog waveform visualization system appears to be one of the issue to be solved rapidly.