

Machine Interlocks in the Injectors

Bruno PUCCIO (TE/MPE)

IEFC workshop

22nd March 2011



Menu

Starter

Reminder on Machine Interlocks

Main course

Warm magnets Interlock system

Beam Interlock system

its Linac4 deployment

Desserts

Wrap-up

What are the “Machine Interlocks”?

for protecting the Equipments
for Beam Operation

Beam
Interlock
System

(VME based)



+



BIS

WIC

for protecting
Normal Conducting Magnets
or Super Conducting Magnets

Warm magnet
Interlock
Controllers

(PLC based)



Safe Machine
Parameters
System

(VME based)



SMP

PIC

Powering
Interlock
Controllers

(PLC based)



+

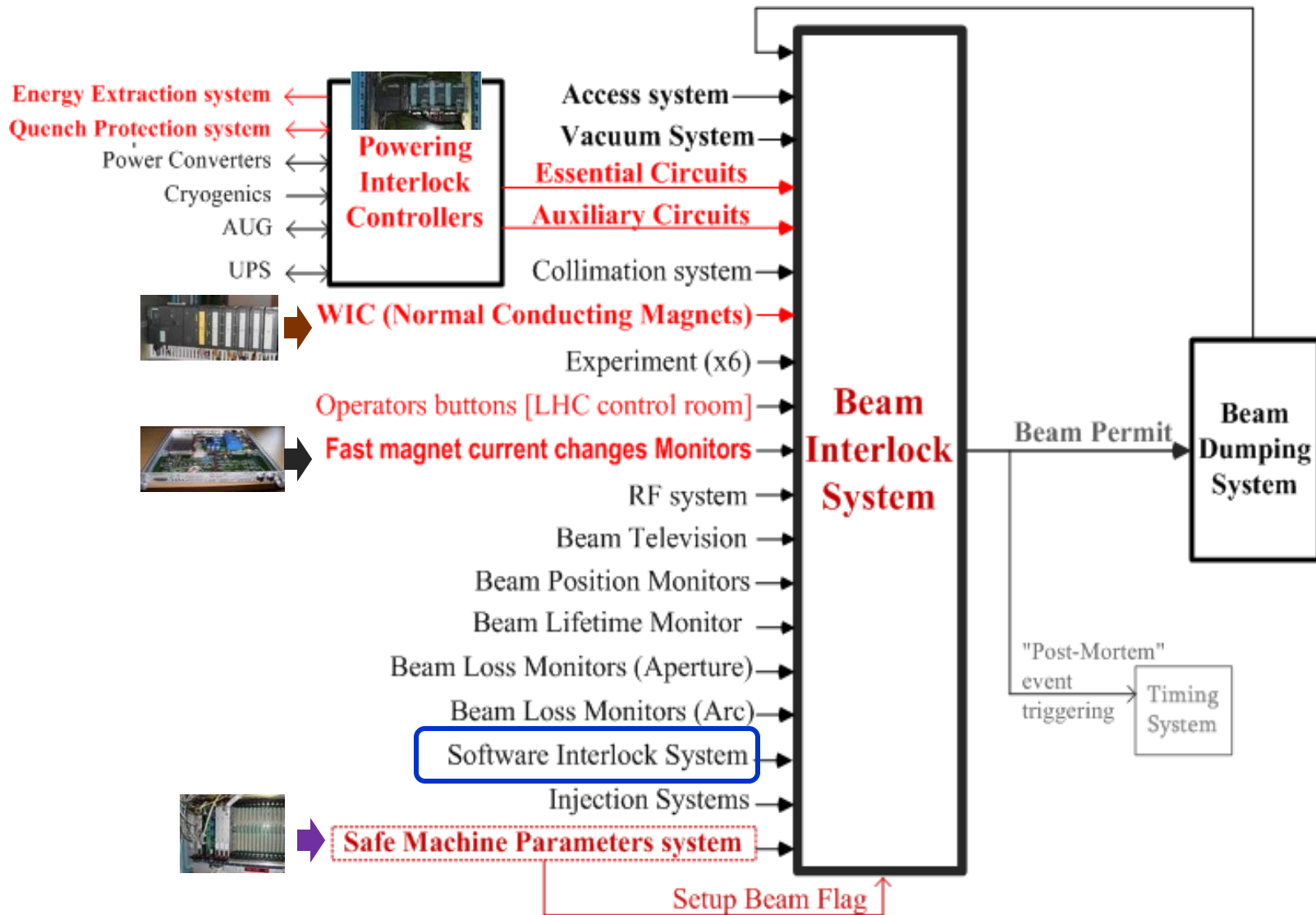


FMCM

Fast Magnet Current change Monitor



Machine Interlocks hierarchy (LHC case)



(TE/MPE systems are in red)

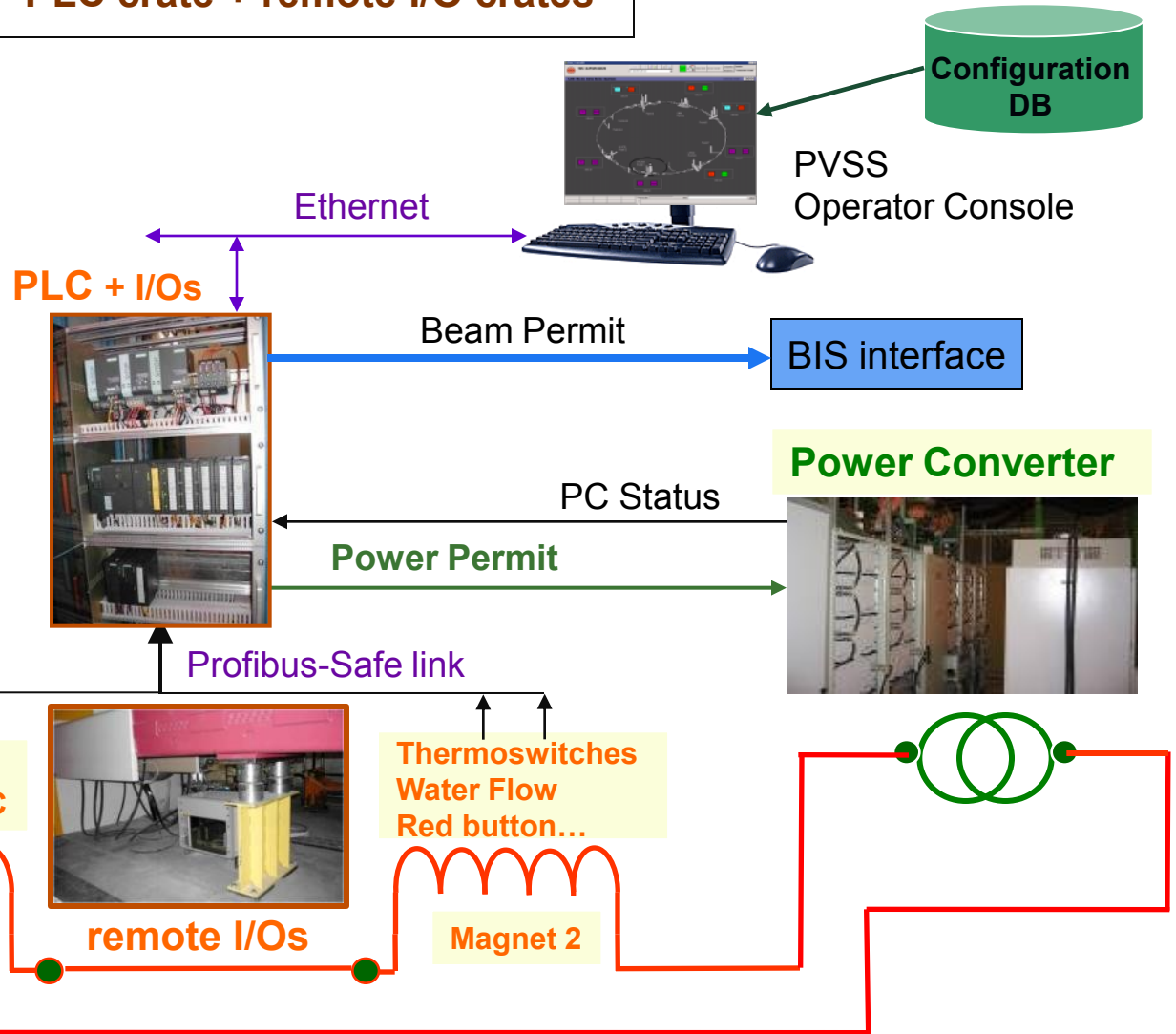
Warm Magnets Interlock (WIC system)

Pierre Dahlen (TE/MPE)

WIC system Overview

WIC solution = PLC crate + remote I/O crates

- ❑ based on Safety PLC
- ❑ collect input signals from:
 - thermo-switches,
 - flow meters,
 - red buttons, ...
- ❑ give Power Permit for the corresponding converter



WIC systems currently in Operation

6 machines/zones

14 Controllers & ~ 300 I/O modules

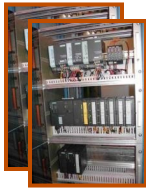
~ 950 magnets are protected

WIC → LHC
(2007)



8 controllers

WIC → TT60
& Ti2
(2005)



2 c.



(2009)
WIC → LINAC3

WIC → LEIR
(2005)



1 c.

WIC → TT40
& Ti8
(2004)

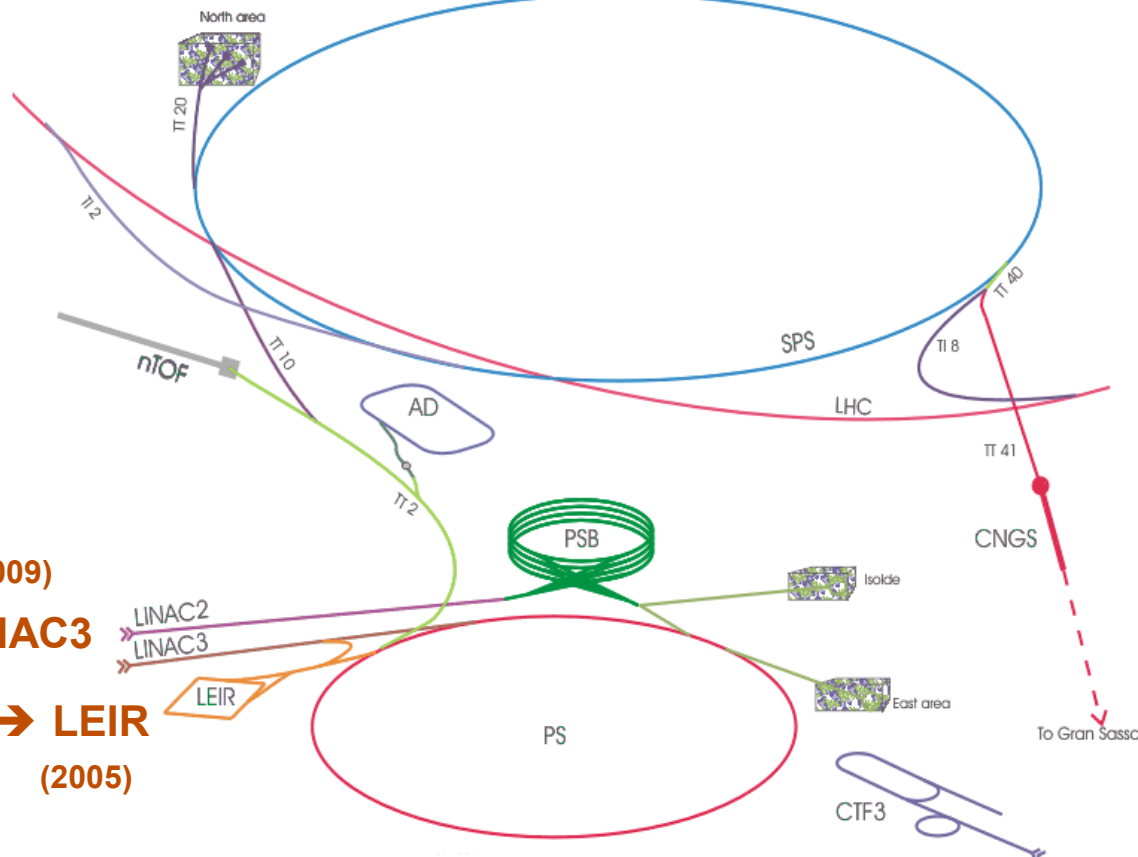


2 c.

WIC → TT41



1 c.



WIC system: the main features

- ❑ **Based of Safety PLC** (Siemens S7-300 F series)
- ❑ (on purpose) **Very simple process for PLC software**
- ❑ **Sensors/Magnets/Converters partition described in Configuration DB**
- ❑ **Reliable solution**
- ❑ **Remote test facility**
- ❑ **Generic solution to be deployed on any type/size of machine**
- ❑ **Dedicated PVSS application to allow supervision of:**
 - ❑ **Magnets & Power Converters Status**
 - ❑ **Interlock process (history buffer)**
 - ❑ **Communication state (Ethernet & Profibus)**

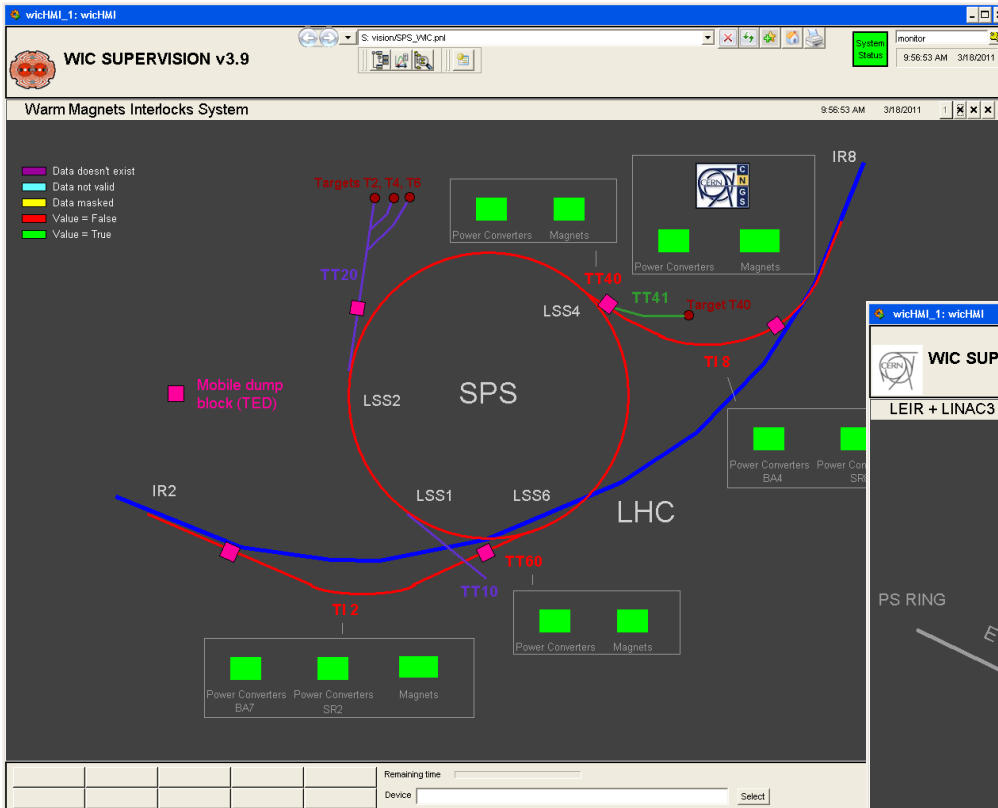
Strong support
from EN/ICE

BE/CO

Developed &
maintained
by EN/ICE

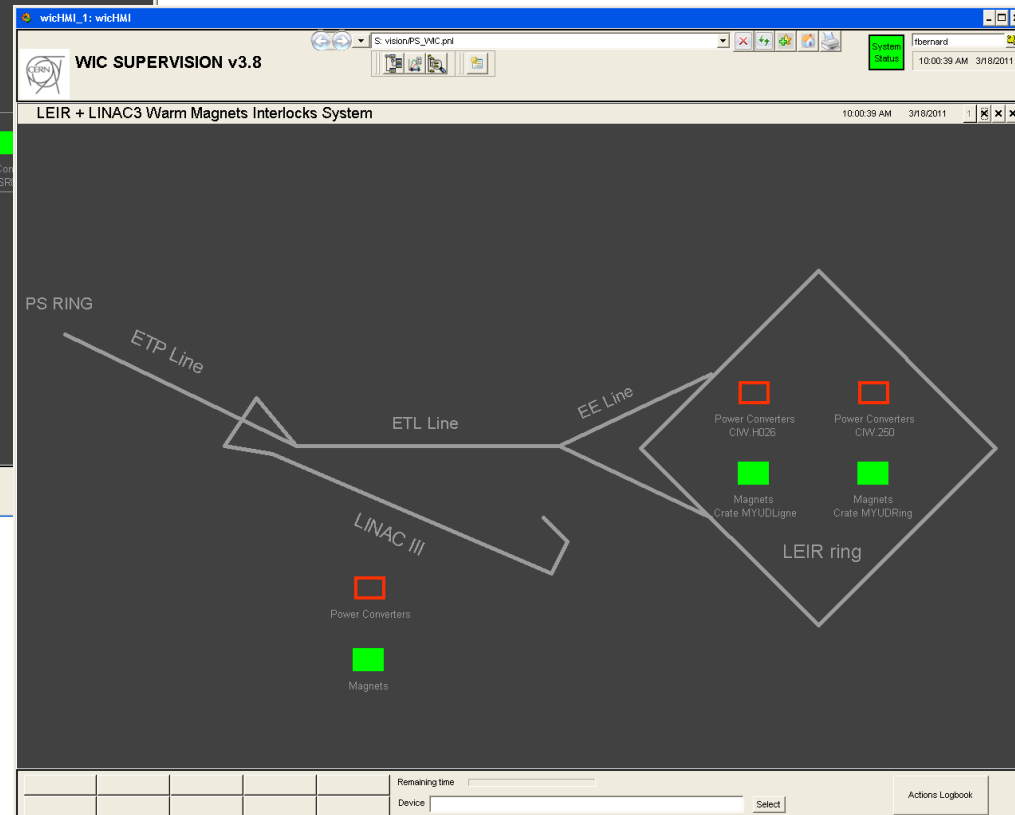
PVSS application: few screen-shots...

SPS Transfer Lines



Courtesy of
F. Bernard
(EN/ICE)

LINAC 3 + LEIR



PVSS application: History Buffer

History Buffer [?] [X]

Mode: History Snapshot Online

Time Filter: From: 2011 / 3 / 13 10:50:39 Now Time zone = LOCAL TIME To: 2011 / 3 / 15 14:19:40 Now *

Buffer: 214 Position 1 to 214

Events: 214

Filter: Type: * Entity: * Quantity: * Status: * Invalid: *

Local Time	Type	Location	Entity	Quantity	Description	Status	Invalid
2011.03.15 14:19:40.122	CMV	LINAC3	CMV.351.LINAC3	ST_PASS	Status of the Safety Passivation 13	BAD	
2011.03.15 14:19:40.122	CMV	LINAC3	CMV.351.LINAC3	ST_PASS	Status of the Safety Passivation 12	BAD	
2011.03.15 14:19:40.122	CMV	LINAC3	CMV.351.LINAC3	ST_PASS	Status of the Safety Passivation 11	BAD	
2011.03.15 14:19:40.122	CMV	LINAC3	CMV.351.LINAC3	ST_PASS	Status of the Safety Passivation 10	BAD	
2011.03.15 14:19:40.122	CMVRA	LINAC3	CMVRA.351.LINAC3	ST_SUPPLY_24V_2	Status of the power supply 24V_2	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	CMVRA.351.LINAC3	ST_SUPPLY_24V_1	Status of the power supply 24V_1	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN02	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN02	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN04	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN04	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN06S	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN06S	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN08	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QDN08	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QFN01	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QFN01	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QFN03S	ST_WATER_PRESS	Water pressure default	OK	
2011.03.15 14:19:40.122	CMVRA	LINAC3	IA1.QFN03S	ST_OVERTEMP	Signal received by the WMC from the thermo-switches mounted on the magnet	OK	

Courtesy of
F. Bernard
(EN/ICE)

WIC system: future deployments



Number of

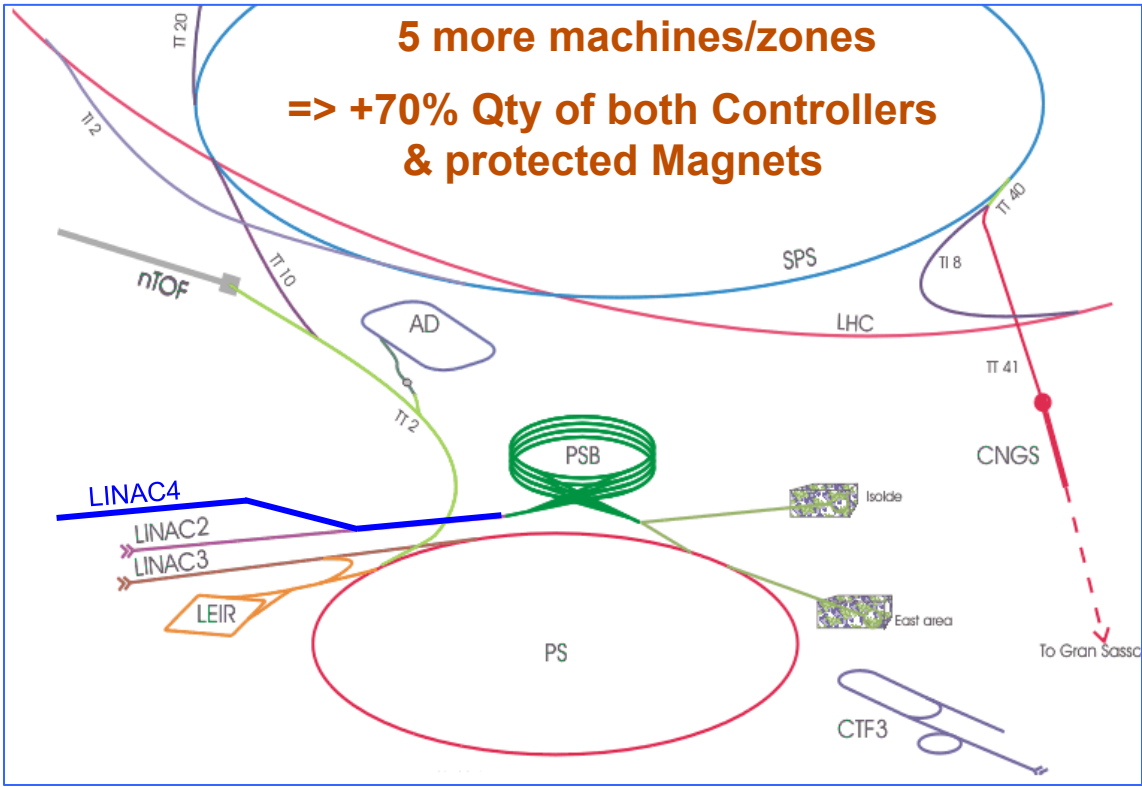
Machine	Number of			Installation date
	Protected Magnets	PLC crate	Remote I/O crates	
HiRadMat	25	2	2	Q1/2011
Booster	172	4	53	during 2011 + Xmas 2011/12
Linac4 & Transfer line	98	2	6	2013

ready for 1st dry run
(April 2011)

Isolde	50	1	1	2013
Elena ring	48	1	1	201x

should match
corresponding
schedules

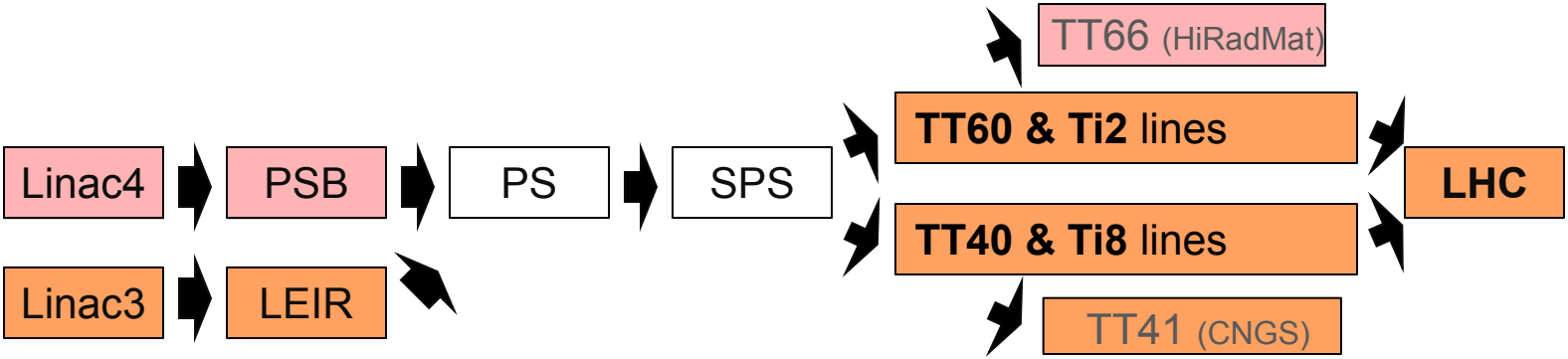
LHC chain status after planned deployments



WIC system

planned deployments

currently in operation



other WIC deployments...?

Machine	Protected Magnets	PLC crate	Remote I/O crates
PS main	~100	1	11
PS Auxiliary	~50	2	1

Not decided on
(first study only)

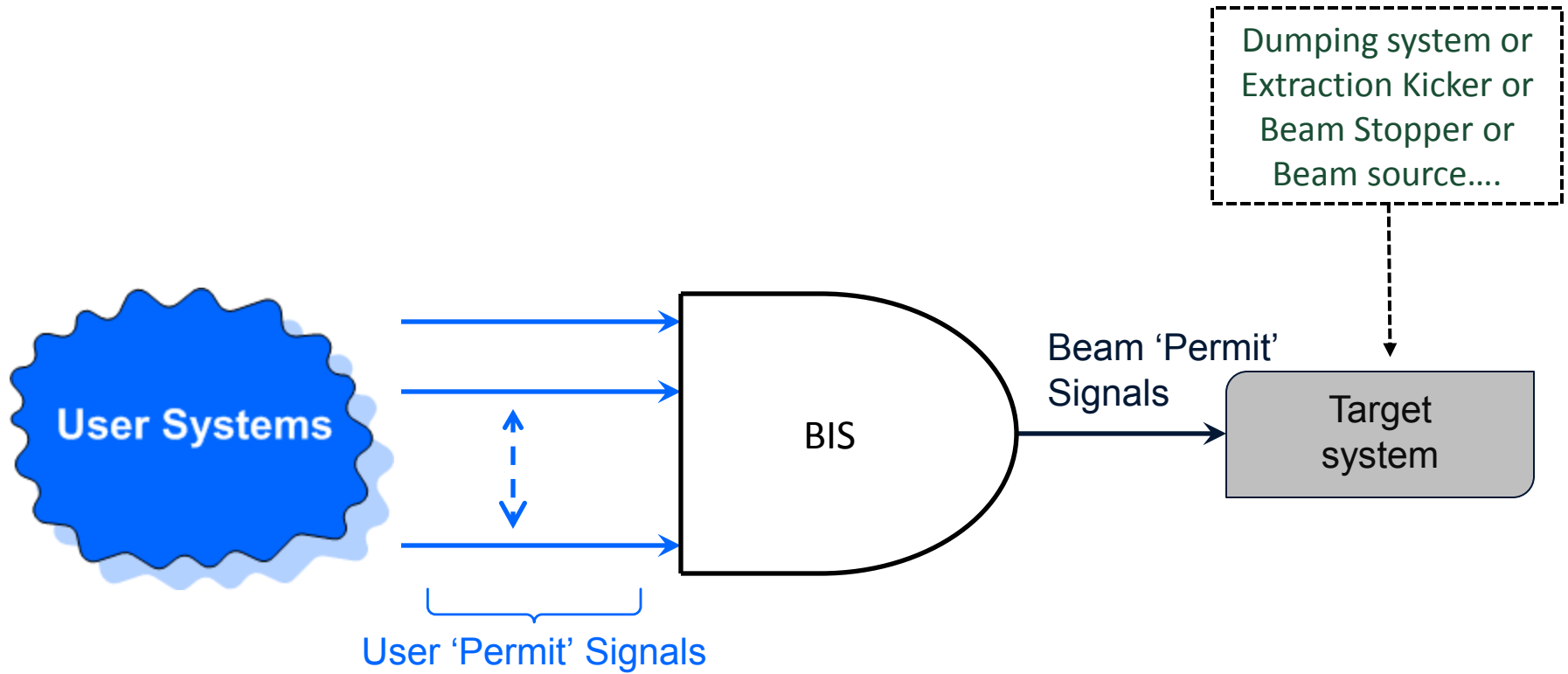
SPS ring +auxiliaries	~900	9	15
--------------------------	------	---	----

(Due to lack of resources) **Not** possible to tackle so large installation....

Beam Interlock System

Benjamin Todd + Christophe Martin (TE/MPE)

Beam Interlock System Function

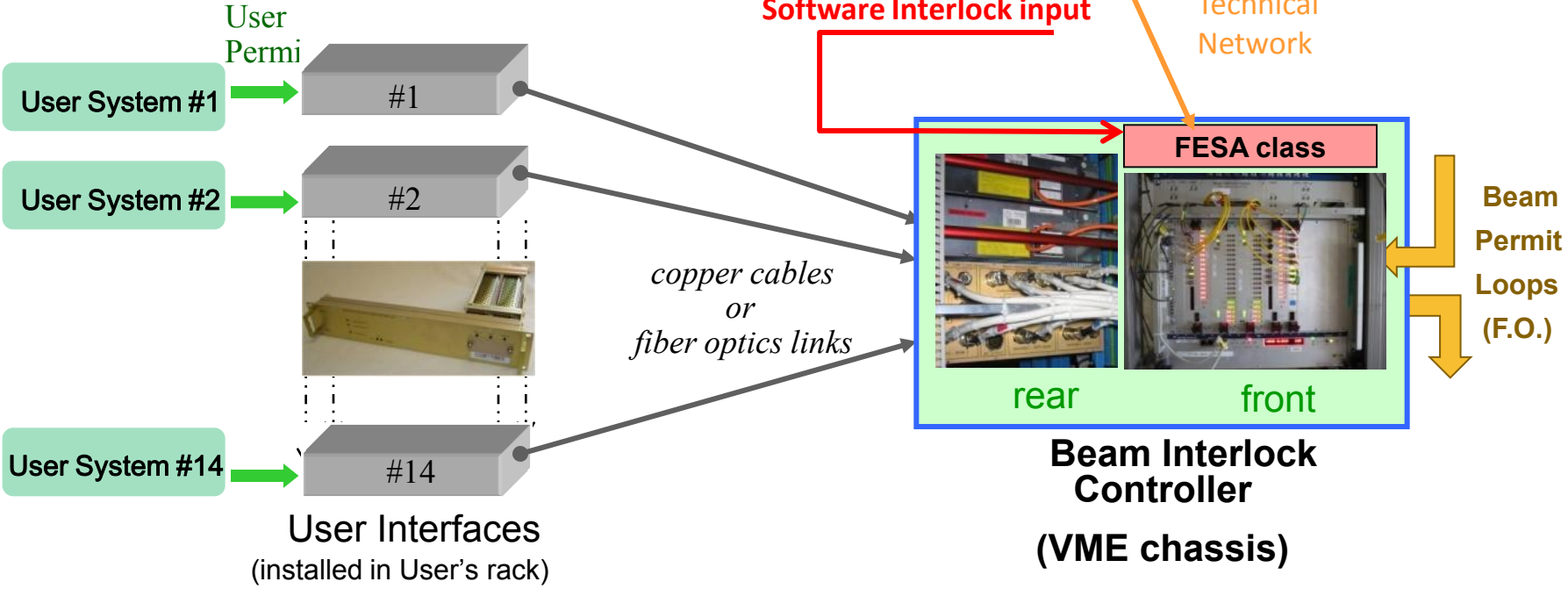
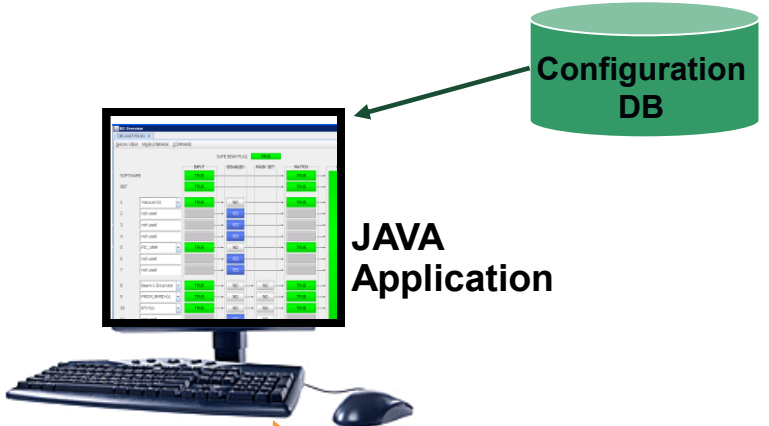


$\Sigma(\text{User Permit} = \text{"TRUE"}) \Rightarrow \text{Beam Operation is allowed}$

$\text{IF one User Permit} = \text{"FALSE"} \Rightarrow \text{Beam Operation is stopped}$

BIS: simplified layout

- Remote **User Interfaces** safely transmit Permit signals from connected systems to Controller
- Controller** acts as a concentrator
- collecting User Systems Permits
- generating local Beam Permit
- Controllers could be **daisy chained** (Tree architecture) or could share **Beam Permit Loops** (Ring architecture)

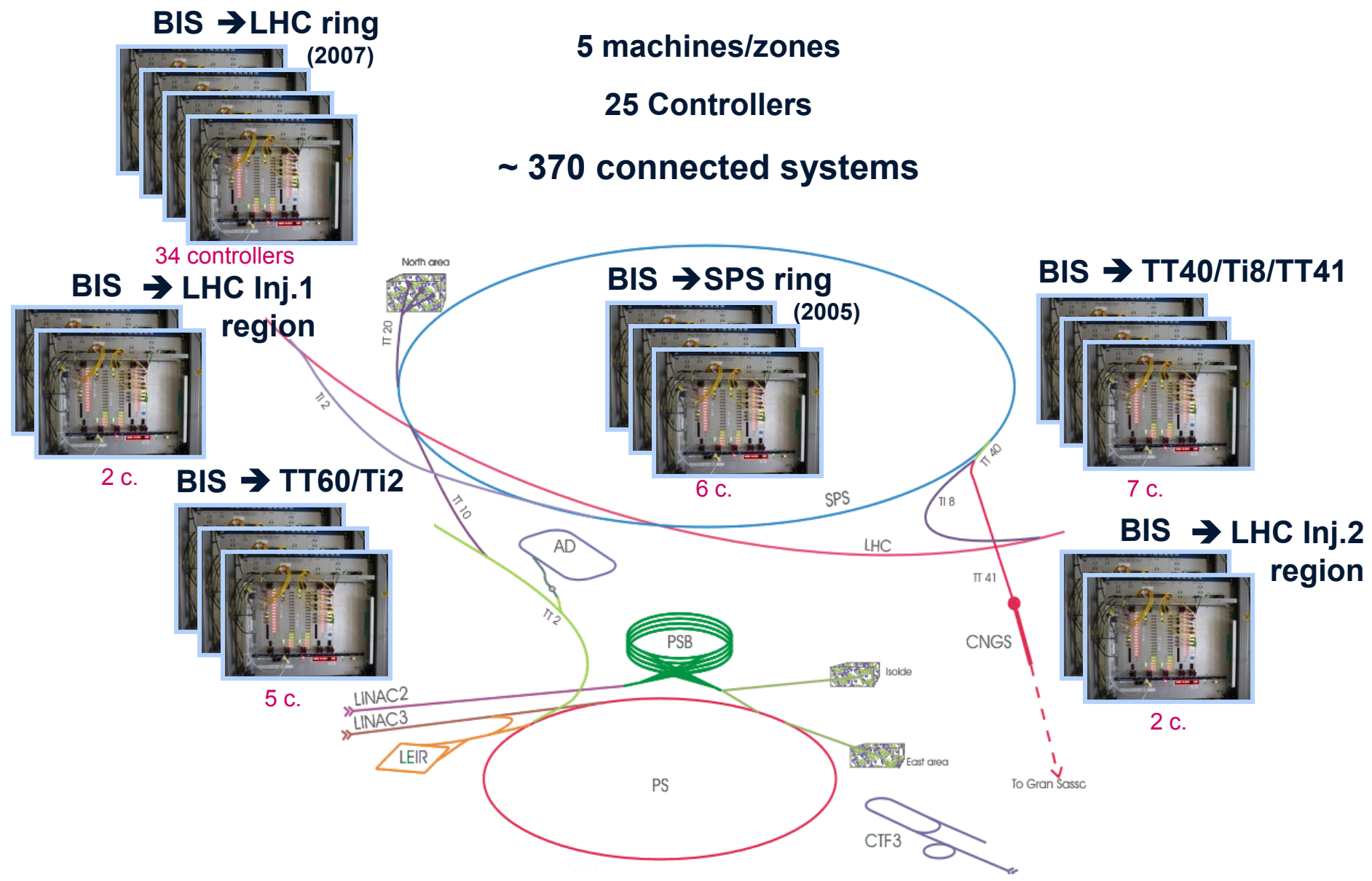


Software Interlock System (SIS)

- ❑ Currently used for interlocking: SPS extractions, LHC Injection regions and circulating LHC beams (=> dump)
- ❑ Subscriptions to thousands control system devices / parameters.
- ❑ Export (among other tasks) signals to the different BIS (update period 2 s)
- ❑ Interlock types:
 - *Initially*: used simple test logic comparison of acquired value to reference value (number or Boolean) – hardcoded into configuration.
 - *Now*: more and more complicated interlocks (JAVA) that pull together multiple signals and DB references. Very flexible, but complex interlocks that are less easy to test.
- ❑ Very high reliability given the number of signals.
 - The SIS processes of SPS and LHC have never failed during operation in the last 2 years.
 - In case of failure, the timeouts (20 sec.) on the SIS inputs to the BICs lead to beam dump/injection or extraction inhibit.

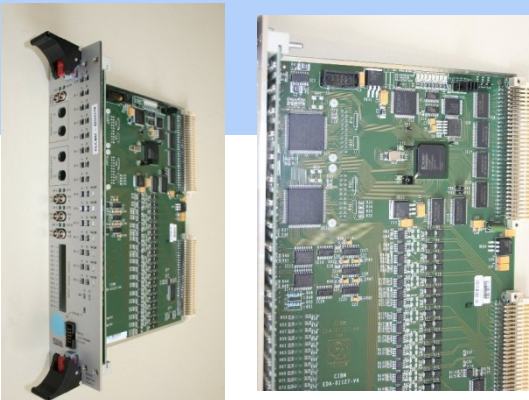
Courtesy of
J. Wenninger

BIS (&SIS) currently in Operation

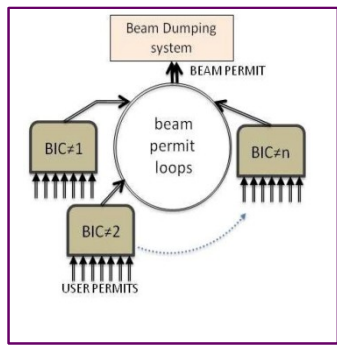


BIS: main features

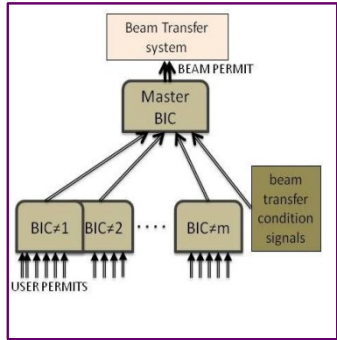
- Fast (~20µs reaction time from *User Permit* change detection to corresponding *Local Beam Permit* change)
- Reliable
 - Fully redundant HW process
 - Fail-Safe concept
- Available (Redundant Power Supplies)
- Maintainable
 - 100% Online Test Coverage
 - History buffer for recording I/O changes
- “Flexible”
 - half of *User Permit* signals could be remotely masked
Masking conditioned by external signal (*Safe_Beam Flag*)
- Modular and Scalable
 - Ring architecture or Tree architecture
 - Daisy chain possible (BIC output connected to input of another BIC)
- Generic solution to any fast and reliable interlock requirement
 - Protect as much as small installation as large machine (27 km ring)
 - Based on BE/CO standard solutions (HW & SW)
- In operation in the SPS since 2005 with an extremely high availability



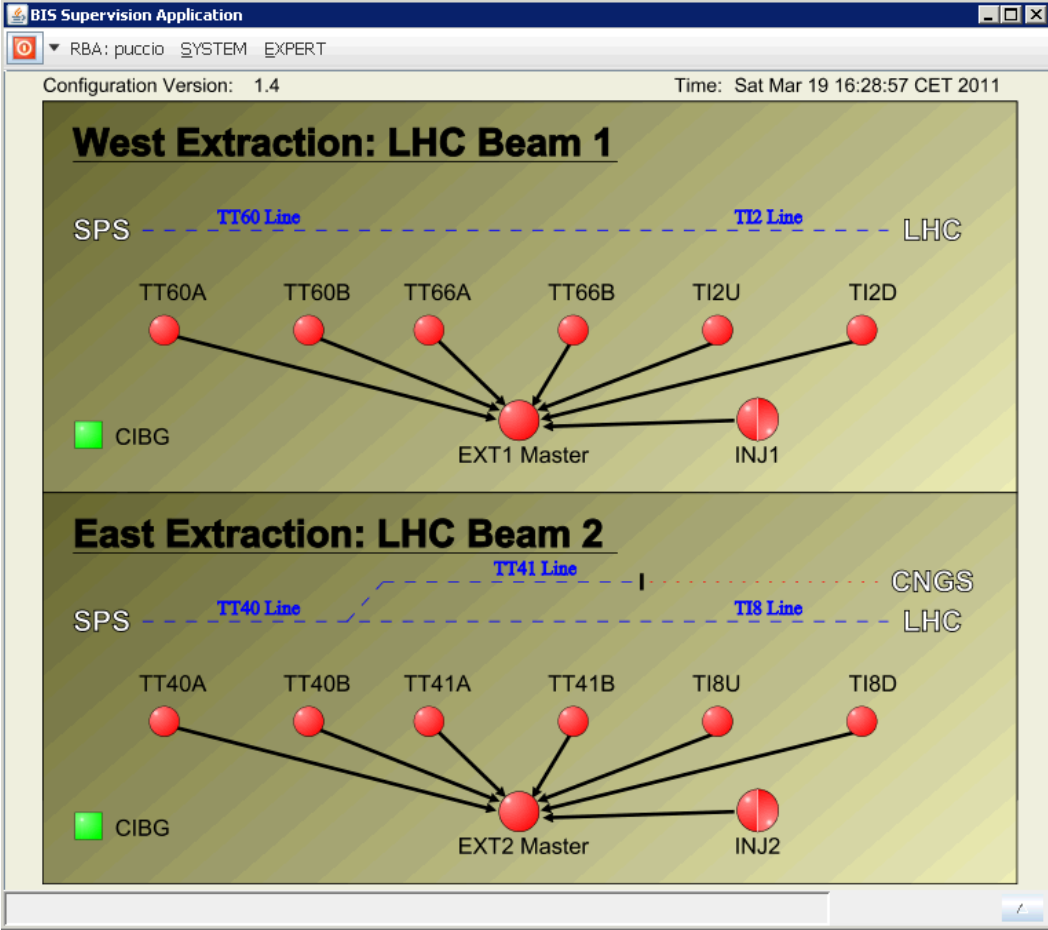
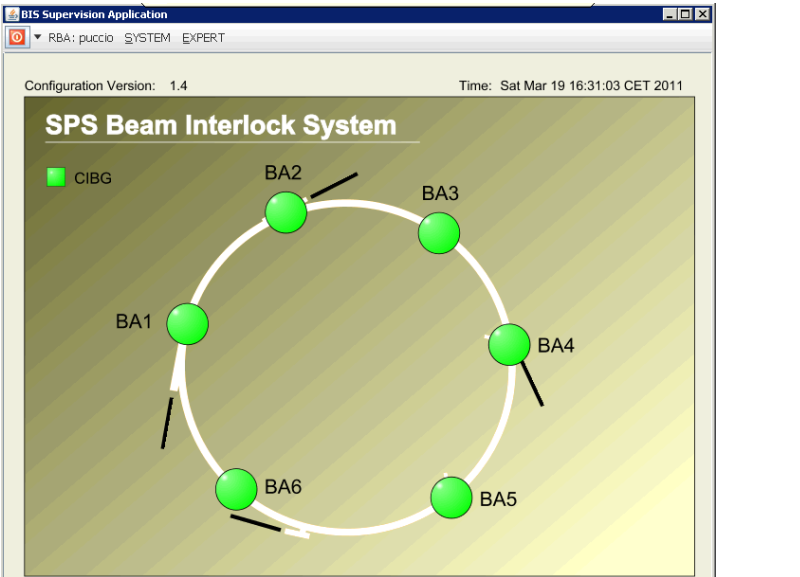
Manager board



Ring Architecture
Tree Architecture



BIS Application for CCC



BIC Overview

CIB.BA3.S3

SHOW VIEW MASK/UNMASK COMMAND

SOFTWARE	INPUT	DISABLED	MASK SET	MATRIX	PERMIT
INIT	TRUE			TRUE	TRUE
1 Vacuum LSS3	TRUE	NO		TRUE	
2 ACCESS Chain-1	TRUE	NO		TRUE	
3 Operators Buttons	TRUE	NO		TRUE	
4 MPS Dipoles	TRUE	NO		TRUE	
5 MPS Quadrupoles	TRUE	NO		TRUE	
6 MPS Sextupoles	TRUE	NO		TRUE	
7 not used		YES			
8 not used		YES	NO		
9 BCT	TRUE	NO	NO	TRUE	
10 RF	TRUE	NO	NO	TRUE	
11 Vacuum TT80	TRUE	NO	NO	TRUE	
12 ROCS interlock	TRUE	NO	NO	TRUE	
13 not used		YES	NO		
14 not used		YES	NO		

SAFE BEAM FLAG: TRUE

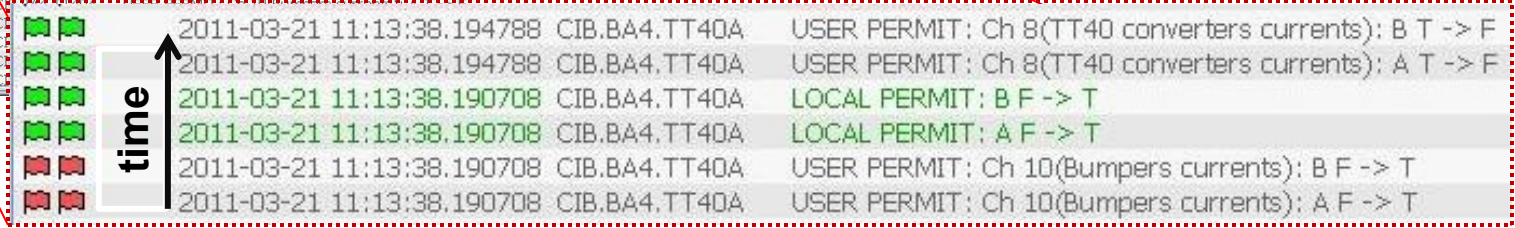
BIS Application: History Buffer

New History Buffer: CIB.BA4.TT40A

History Buffer | Memory Map

FILTER: OPERATOR | Logging | USE SNAPSHOT

PERMIT	TIMESTAMP	DEVICE	DESCRIPTION
2011-03-21 11:13:39.736001	CIB.BA4.TT40A	MARKER: 1 us	
2011-03-21 11:13:38.28238	CIB.BA4.TT40A	USER PERMIT: Ch 11(FMCM_MSE4183M): B T -> F	
2011-03-21 11:13:38.282378	CIB.BA4.TT40A	USER PERMIT: Ch 11(FMCM_MSE4183M): A T -> F	
2011-03-21 11:13:38.253337	CIB.BA4.TT40A	USER PERMIT: Ch 12(FMCM_RBIH.400107): B T -> F	
2011-03-21 11:13:38.253336	CIB.BA4.TT40A	USER PERMIT: Ch 12(FMCM_RBIH.400107): A T -> F	
2011-03-21 11:13:38.251756	CIB.BA4.TT40A	USER PERMIT: Ch 13(FMCM_RBIH.400309): B T -> F	
2011-03-21 11:13:38.251755	CIB.BA4.TT40A	USER PERMIT: Ch 13(FMCM_RBIH.400309): A T -> F	
2011-03-21 11:13:38.207343	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): A T -> F	
2011-03-21 11:13:38.207343	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): B T -> F	
2011-03-21 11:13:38.207236	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): B T -> F	
2011-03-21 11:13:38.207236	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): A T -> F	
2011-03-21 11:13:38.20679	CIB.BA4.TT40A	LOCAL PERMIT: B T -> F	
2011-03-21 11:13:38.20679	CIB.BA4.TT40A	LOCAL PERMIT: A T -> F	
2011-03-21 11:13:38.206788	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): B T -> F	
2011-03-21 11:13:38.206788	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): A T -> F	
2011-03-21 11:13:38.206002	CIB.BA4.TT40A	MARKER: 2 us	
2011-03-21 11:13:38.202741	CIB.BA4.TT40A	LOCAL PERMIT: A F -> T	
2011-03-21 11:13:38.20274	CIB.BA4.TT40A	LOCAL PERMIT: B F -> T	
2011-03-21 11:13:38.20274	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): B F -> T	
2011-03-21 11:13:38.20274	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): A F -> T	
2011-03-21 11:13:38.202664	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): B F -> T	
2011-03-21 11:13:38.202664	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): A F -> T	
2011-03-21 11:13:38.202225	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): B F -> T	
2011-03-21 11:13:38.202225	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): A F -> T	
2011-03-21 11:13:38.195243	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): A T -> F	
2011-03-21 11:13:38.195243	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): B T -> F	
2011-03-21 11:13:38.195136	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): B T -> F	
2011-03-21 11:13:38.195136	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): A T -> F	
2011-03-21 11:13:38.19479	CIB.BA4.TT40A	LOCAL PERMIT: B T -> F	
2011-03-21 11:13:38.19479	CIB.BA4.TT40A	LOCAL PERMIT: A T -> F	
2011-03-21 11:13:38.194788	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): B T -> F	
2011-03-21 11:13:38.194788	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): A T -> F	
2011-03-21 11:13:38.190708	CIB.BA4.TT40A	LOCAL PERMIT: B F -> T	
2011-03-21 11:13:38.190708	CIB.BA4.TT40A	LOCAL PERMIT: A F -> T	
2011-03-21 11:13:38.190708	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): B F -> T	
2011-03-21 11:13:38.190708	CIB.BA4.TT40A	USER PERMIT: Ch 10(Bumpers currents): A F -> T	
2011-03-21 11:13:38.190624	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): B F -> T	
2011-03-21 11:13:38.190624	CIB.BA4.TT40A	USER PERMIT: Ch 9(MSE septum current): A F -> T	
2011-03-21 11:13:38.190253	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): B F -> T	
2011-03-21 11:13:38.190253	CIB.BA4.TT40A	USER PERMIT: Ch 8(TT40 converters currents): A F -> T	
2011-03-21 11:13:38.157244			
2011-03-21 11:13:38.157244			
2011-03-21 11:13:38.157236			
2011-03-21 11:13:38.157236			
2011-03-21 11:13:38.15689			



BIS Application: Extraction cycles view

SPS BIS Monitor V6.0.9/Mar 11

File BIC Details MKE & BETS LTIM & Prepulse Inits & Resets Help

LHCB1 RBA: jwenning LHC2 >> SPS_DUMP # 57638

Timing

Extraction Overview MKE6 Status BIC Overview Active Intlks Masks

BIC Permit Status LHCB1

Time	User	EXT1	TT60A	TT60B	TI2U	TI2D	INJ1.1	INJ1.2
15:27:00	LHC3	Green	Green	Green	Green	Green	Green	Green
15:26:52	LHCFAST1	Green	Green	Green	Green	Green	Green	Green
15:26:28	LHC2	Red	8	Green	Green	Green	Green	Green
15:26:10	LHC3	Green	Green	Green	Green	Green	Green	Green
15:26:03	LHCFAST1	Green	Green	Green	Green	Green	Green	Green
15:25:39	LHC2	Red	8	Green	Green	Green	Green	Green
15:25:21	LHC3	Green	Green	Green	Green	Green	Green	Green
15:25:14	LHCFAST1	Green	Green	Green	Green	Green	Green	Green
15:24:50	LHC2	Red	8	Green	Green	Green	Green	Green
15:24:32	LHC3	Green	Green	Green	Green	Green	Green	Green
15:24:25	LHCFAST1	Green	Green	Green	Green	Green	Green	Green
15:24:01	LHC2	Red	8	Green	Green	Green	Green	Green
15:23:43	LHC3	Green	Green	Green	Green	Green	Green	Green
15:23:36	LHCFAST1	Green	Green	Green	Green	Green	Green	Green
15:23:12	LHC2	Red	8	Green	Green	Green	Green	Green

Courtesy of J.Weninger

BIC Details

CIB.BA6.TT60A

Extraction

Extraction times [ms] : 5345

Channel Mapping

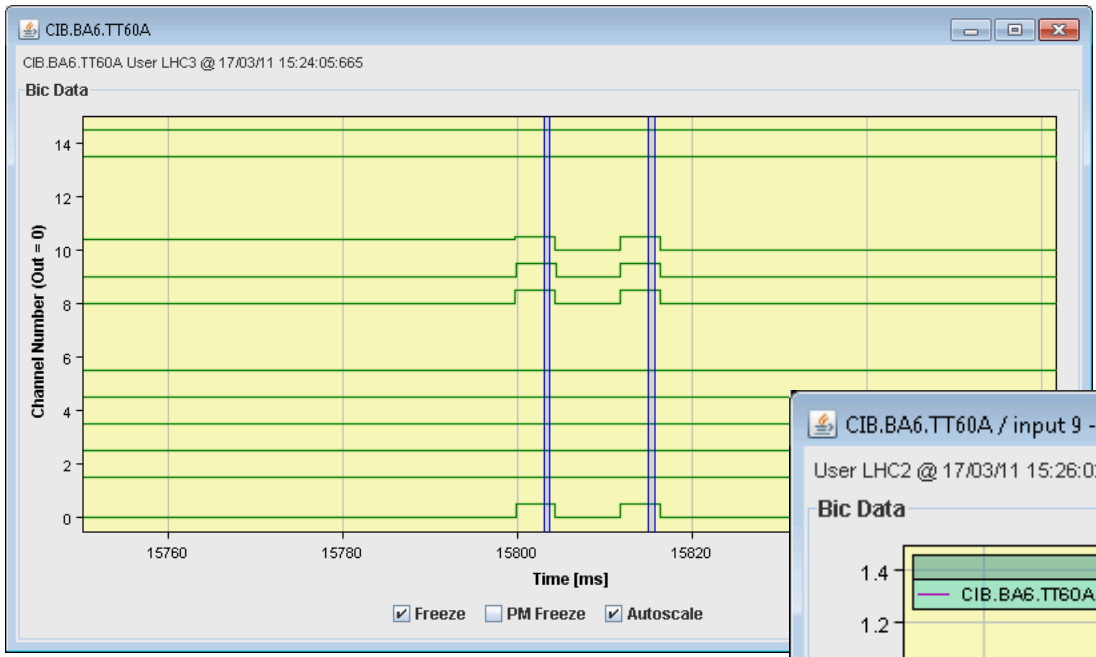
- 1 : Vacuum TT60
- 2 : WIC TT60
- 3 : OP Switch
- 4 : MKE6 Status
- 5 : MSE/MST Girder & Magnet
- 6 :
- 7 :
- 8 : PC FEI TT60
- 9 : PC FEI MSE/MST/LSS6 Bumpers
- 10 : PC FEI MBB TT60
- 11 :
- 12 :
- 13 : FMCM MSE618M
- 14 : FMCM MST617M

All Channels Overview Mask Control Debug

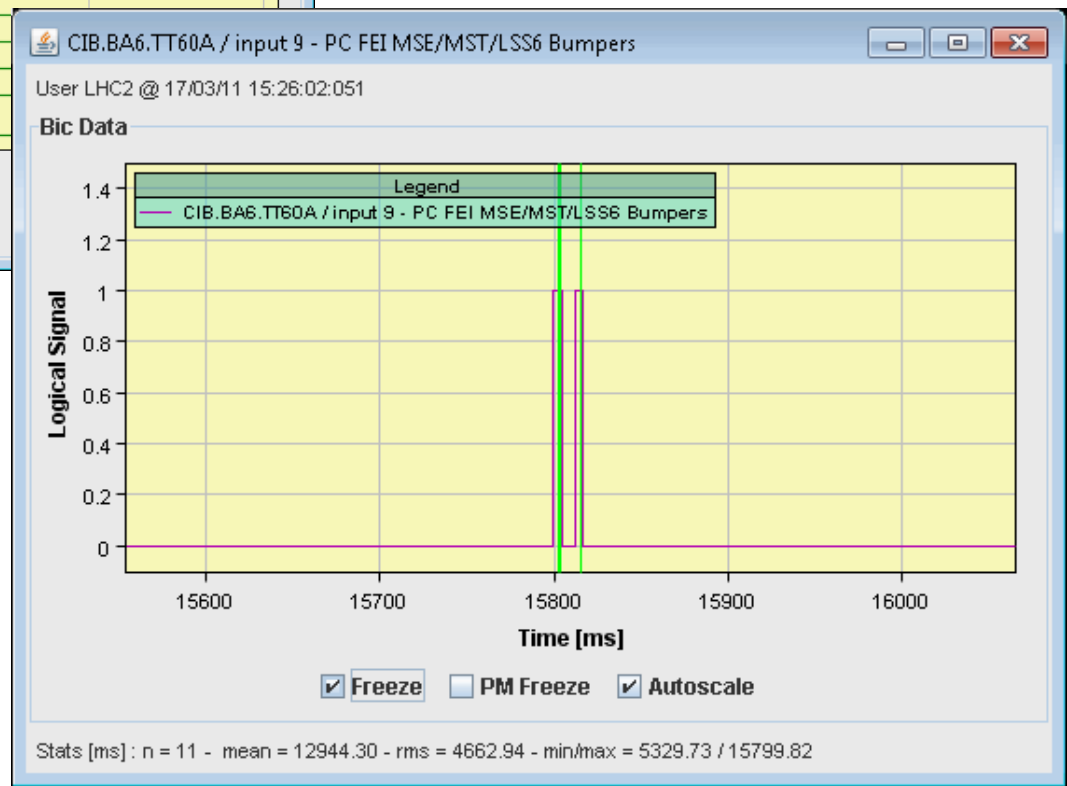
Summary CIB.BA6.TT60A

Time	User	In1	In2	In3	In4	In5	In6	In7	In8	In9	In10	In11	In12	In13	In14	Sw	SBF	Out
15:26:52	LHCFAST1	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green
15:26:28	LHC2	Green	Green	Green	Green	Green	Blue	Blue	Red	Green	Green	Blue	Blue	Green	Green	Green	Green	Red
15:26:10	LHC3	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Red	Green
15:26:03	LHCFAST1	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green
15:25:39	LHC2	Green	Green	Green	Green	Green	Blue	Blue	Red	Green	Green	Blue	Blue	Green	Green	Green	Green	Red
15:25:21	LHC3	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Red	Green
15:25:14	LHCFAST1	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green
15:24:50	LHC2	Green	Green	Green	Green	Green	Blue	Blue	Red	Green	Green	Blue	Blue	Green	Green	Green	Green	Red
15:24:32	LHC3	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Red	Green
15:24:25	LHCFAST1	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green
15:24:01	LHC2	Green	Green	Green	Green	Green	Blue	Blue	Red	Green	Green	Blue	Blue	Green	Green	Green	Green	Red
15:23:43	LHC3	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Red	Green
15:23:36	LHCFAST1	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green
15:23:12	LHC2	Green	Green	Green	Green	Green	Blue	Blue	Red	Green	Green	Blue	Blue	Green	Green	Green	Green	Red
15:22:54	LHC3	Green	Green	Green	Green	Green	Blue	Blue	Green	Green	Green	Blue	Blue	Green	Green	Green	Green	Green

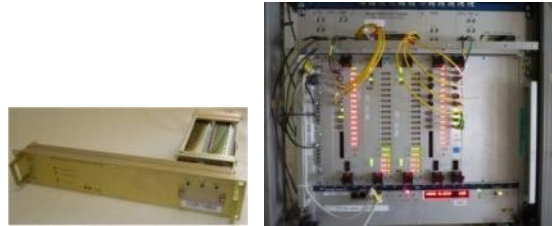
BIS Application: Timing Diagram



Courtesy of J.Weninger



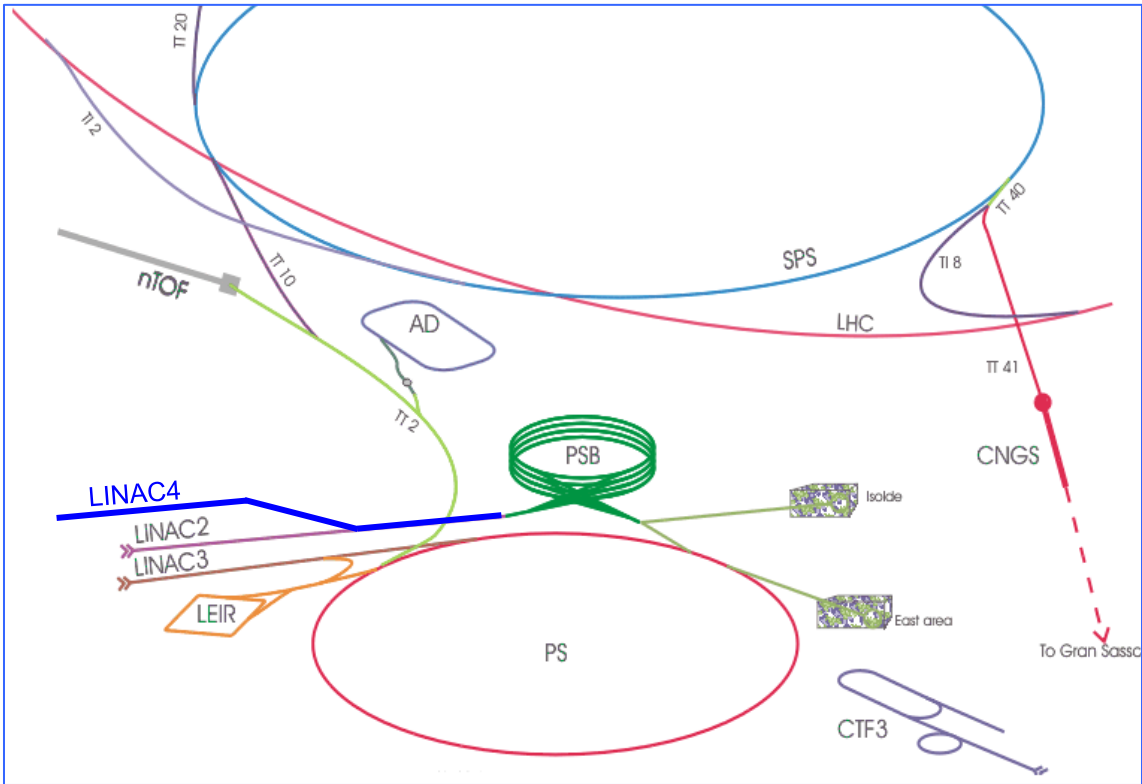
BIS: Future deployments



Machine	Number of		Installation date
	User Interface	Controller	
HiRadMat	10	1	Q1/2011
3 MeV Test Stand	7	1	Mid 2011
Linac4 & Transfer line	23	3	2013
Booster ring & ejection	24	2	2013

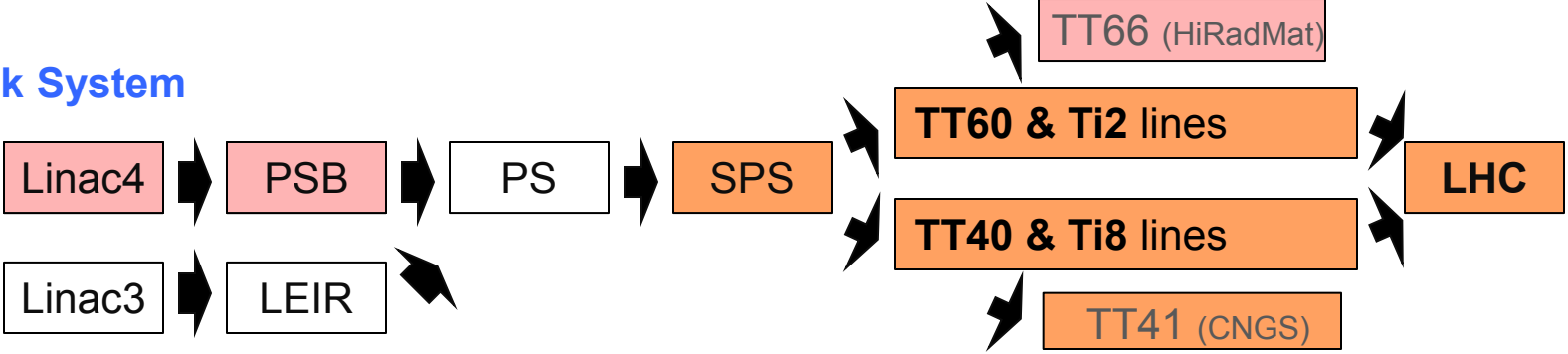
ready for 1st dry run
(April 2011)

LHC chain status after planned deployments



Beam Interlock System

- planned deployments
- currently in operation



Beam Interlock System

for LINAC4 and PSB

BIS Engineering Specifications

CERN
CH-1211 Geneva 23
Switzerland



LINAC4 Project Document No.

L4-CIB-ES-0001 rev.0.3

CERN Div./Group or Supplier/Contractor Document No.

BE/OP

EDMS Document No.

1016233

Date: 2011-01-18

Engineering Specification

BEAM INTERLOCK SPECIFICATIONS FOR LINAC4, TRANSFER LINES AND PS BOOSTER WITH LINAC4

Abstract

The beam interlock system for Linac4 and its transfer lines to the PSB will be based on a mixed system comprising hardware interlocks provided via the BIS (Beam Interlock System), software interlocks based on the SIS (Software Interlock System) and the concept of External Conditions used currently in the PS complex. This document summarises the beam interlock specifications to safely operate Linac4, the Linac4-to-PSB transfer lines and the PSB with Linac4 injection.

Prepared by:

Bettina Mikulec
BE/OP
Bettina.Mikulec@cern.ch

**Jose-Luis Sanchez
Alvarez**
BE/OP

Bruno Puccio
TE/MPE

Checked by:

O. Aberle
M-E. Angoletta
L. Arnaudon
J-C. Bau
P. Baudrenghien
G. Bellodi
C. Bertone
A. Blas
Y. Body
J. Borburgh
J. Broere
O. Brunner
M. Buzio
C. Caril
E. Carlier
D. Chapuis
A. Dalloccchio
B. Dehning
N. Dos Santos
K. Foraz
F. Gerigk
B. Goddard
P. Gomes
L. Hammouti
K. Hanke
M. Jones
I. Kozsar

A. Lombardi
L.A. Lopez
C. Maglioni
A. Masi
S. Mathot
S. Maury
V. Mertens
G. Metral
D. Nisbet
M. Paoluzzi
S. Pittet
U. Raich
S. Ramberger
C. Rossi
J. Schipper
R. Scrivens
A. Siemko
R. Steerenberg
M. Tavlet
B. Todd
G. Vandoni
M. Vretenar
S. Weisz
W. Weterings
T. Zickler

Approved by:

Maurizio Vretenar
Mike Lamont

Distribution list: S. Myers, F. Bordry, R. Saban, P. Collier, R. Garoby, J. Wenninger, R. Schmidt

Linac4, Transfer Lines and Booster

CERN
CH-1211 Geneva 23
Switzerland



LINAC4 Project Document No.

L4-CIB-ES-0002 rev.0.2

CERN Div./Group or Supplier/Contractor Document No.

BE/ABP

EDMS Document No.

1106405

Date: 2011-02-08

Engineering Specification ref. WP 2.14

BEAM INTERLOCKS SPECIFICATIONS FOR THE 3 MEV TEST STAND OPERATION

Abstract

Prepared by :

Giulia Bellodi

BE/ABP
Giulia.Bellodi@cern.ch

Bruno Puccio
TE/MPE

Checked by :

A. Masi
C. Rossi
L. Arnaudon
R. Scrivens
M. O'Neil
M. Paoluzzi
A. Lombardi
M. Witorski
M. Tavlet
G. Vandoni
C. Maglioni
S. Weisz
P. Baudrenghien
B. Mikulec
J. Marquez Balula
F. Roncarolo
U. Raich
A. Siemko
R. Schmidt

Approved by:

Maurizio Vretenar

Distribution list: S. Myers, P. Collier, F. Bordry, R. Saban, R. Garoby

3Mev Test Stand

BIS for LINAC4 & PSB: Design Principle (1)

Courtesy of
B.Mikulec

- Main constraints:
 - Multiple ‘interlock zones’ due to several destinations
 - for Linac4: L4DUMP, LBE, LBS, PSB
 - for Booster: BDUMP, ISOGPS, ISOHRS, PS
 - PSB is (timing) master of Linac4
 - Maximize proton delivery to the experiments via ‘**External Conditions**’; the user (+beam destination) is calculated for the current cycle depending on some necessary conditions;
 - This analysis takes up to 3 basic periods and yields the decision if the ‘normal’ or ‘spare’ (or none) cycle should be executed
 - Beam stoppers and bending magnet rise-time too slow
- Must consider PSB and Linac4 interlock systems in parallel (also due to new PSB injection with Linac4)

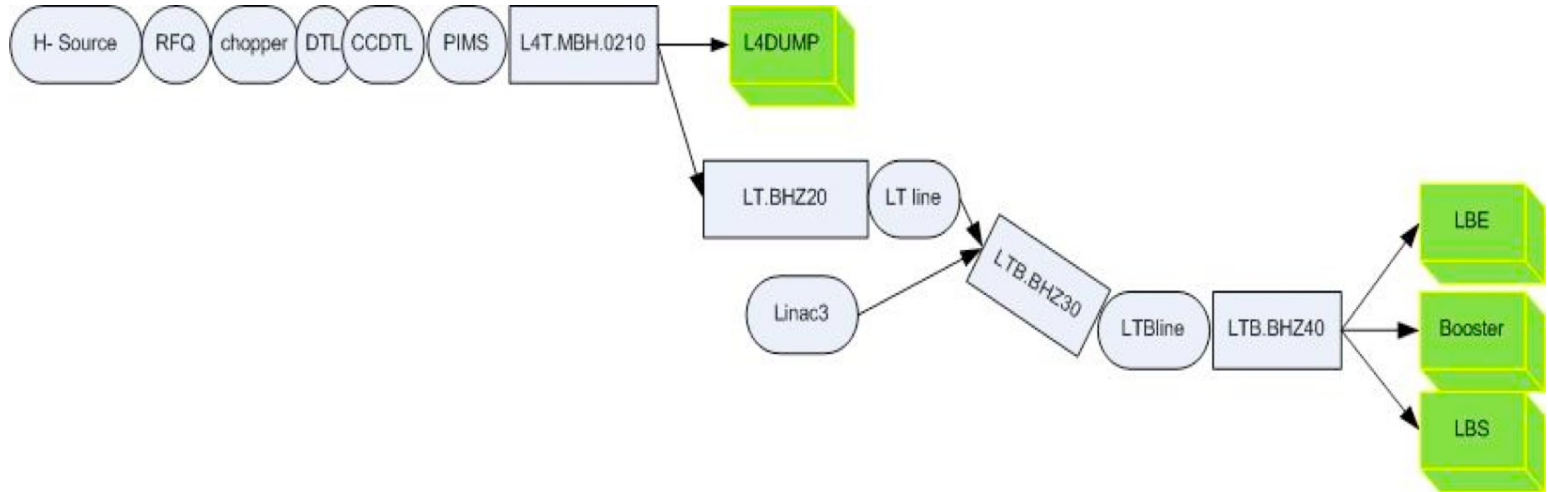
BIS for LINAC4 & PSB: Design Principle (2)

Courtesy of
B.Mikulec

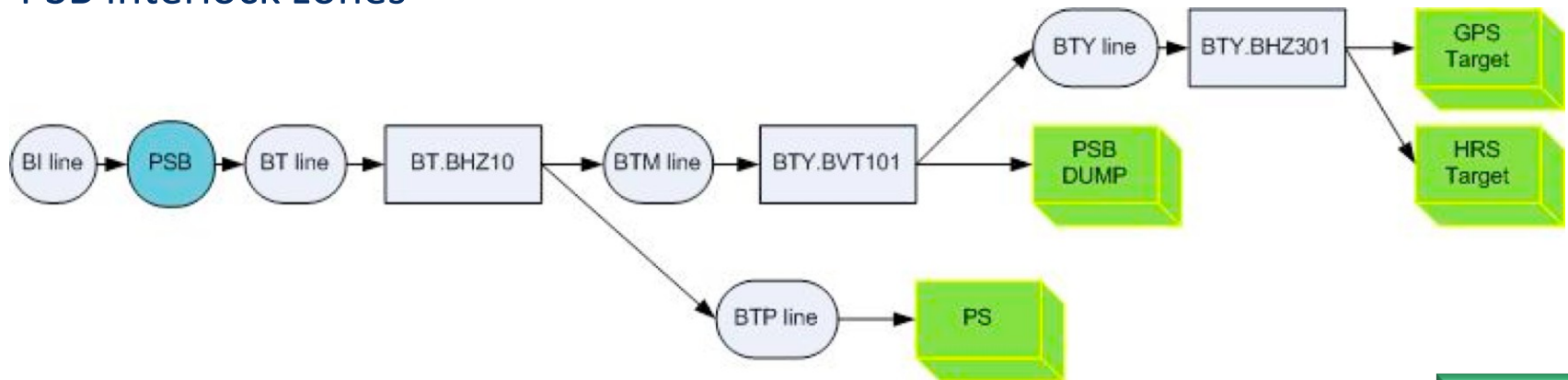
- Three actors:
 1. Hardware interlock system (BIS): **reliable, fast**
 - For fast reaction times
 - If considered useful to avoid machine activation
 2. Software interlock system (SIS): **flexible**
 - For slow-changing parameters
 - If some more complex logic needs to be adopted
 3. External conditions (EC): **for proton optimization**
 - Consider user requests
 - Method also useful for ring-specific interlocks

Interlock Zones

- Linac4 interlock zones

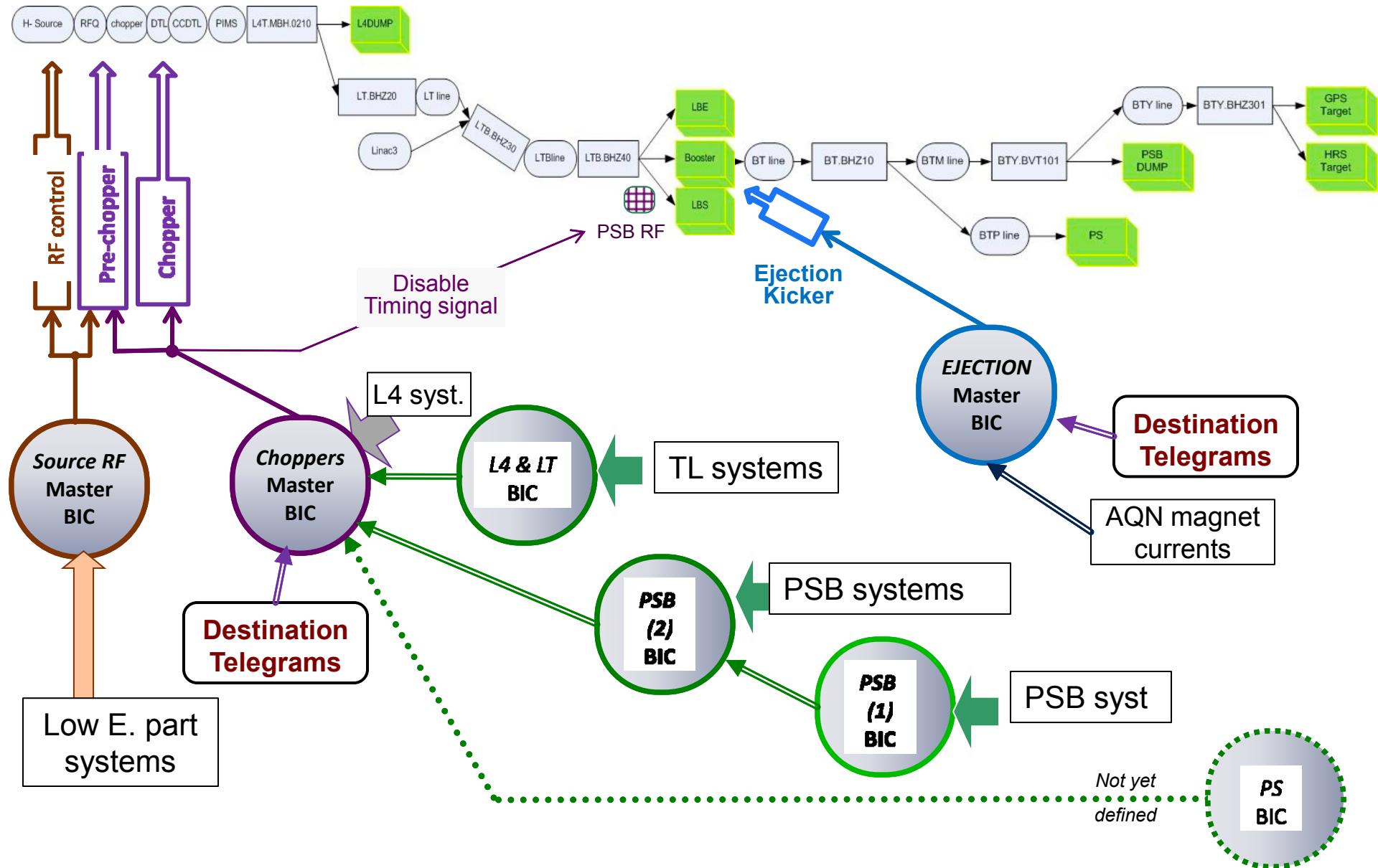


- PSB interlock zones



Courtesy of
B.Mikulec

BIS Linac4 & PSB layout



Truth table example: "Choppers" BIC

In	Name	State
1	SIS	1 1 1 1 1
2	Destination LBE	1 0 0 0 0
3	Destination LBS	0 1 0 0 0
4	Destination PSB	0 0 1 0 0
5	Destination PS	0 0 0 1 0
6	Destination L4DUMP	0 0 0 0 1
7	L4 and L4 T-Lines OK	1 1 1 1 1
8	PSB OK	X X 1 1 X
9	PS OK	X X X 1 X
10	L4T+LT+LTB Vacuum V.	1 1 1 1 X
11	LBS.VVS10	X 1 X X X
12	LBE.VVS10	1 X X X X
13	L4T Beamstopper Out	1 1 1 1 X
Output	Linac4 Transfer OK	1 1 1 1 1

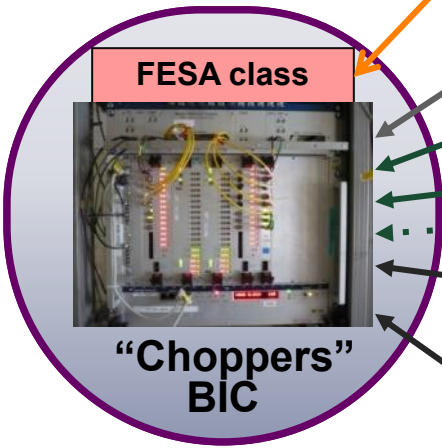
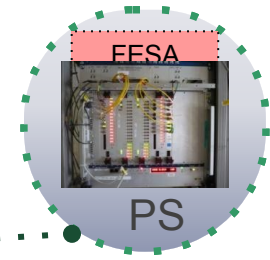
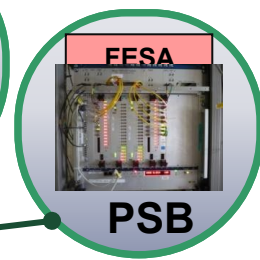
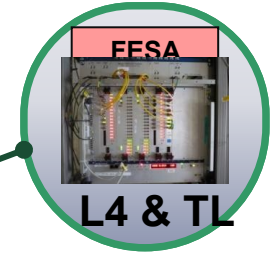
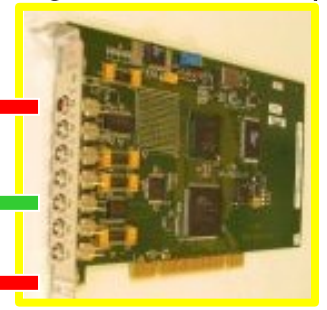
Sw Interlock

Timing Receiver card(s)

BIS User Interfaces



(1 per Destination)



Vacuum valves (L4 & TL)
 Vacuum valves (LBS)
 Vacuum valves (LBE)



Beam-Stopper OUT

Permit for beam transfer to 5 destinations:
 Linac4 dump, LBE, LBS, PSB and PS

/ 5

/ 3

Wrap-up (WIC)

- ❑ WIC = improved system
- ❑ Generic solution to protect resistive magnets
- ❑ Rely on partnership with EN-ICE group
- ❑ After the long shutdown:
 - WIC system will be present in two ends of the LHC injectors chain
 - => Not deployed in PS & SPS
- ❑ Resources issue
 - Minimal level of staffing for coming deployments (and subsequently the Maintenance)
 - Not possible to tackle large installations in the near future



Wrap-up (BIS)

- ❑ Fast & reliable
- ❑ Modular & scalable
- ❑ BIS (&SIS) = CERN Generic solution
- ❑ For Linac4 & PSB: Timing provides more flexibility
- ❑ Maximize efficiency for Beam Operation
- ❑ After the long shutdown:
 - BIS installed in two ends of the LHC protons chain
 - No decision has been made for deployment to PS
- ❑ (f.t.b.) There are no plans to deploy BIS elsewhere...



+



Fin

Thank you for your attention