

Beam Interlock System for Linac4, Transfer Lines & PS Booster

B. Puccio & C. Martin (TE/MPE)

MPP meeting of 31st Aug. 2012

Plan

- Final layout
- Connected systems
 - User Systems
 - Target Systems
- Current status:
 - Preparation phases, 3MeV Test Stand, Prototype for PSB injection...
- Outstanding issues
- Summing up

This presentation based on
the new version of the
Engineering Specification



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.

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Initial objectives

By reusing the BIS solution

❑ Same Hw:

- Fast, Safe, Reliable
- Standardised interface (CIBU)
- Proven solution
- Cost-effective



❑ Same Monitoring Sw:

- Unique application in CCC
- 100% Online test coverage

❑ Operational flexibility

- Software Interlock Inputs
- External Condition signals used as User_Permits
- Masking available on half of input channels

6 machines/zones

~ 60



Controllers

~ 380

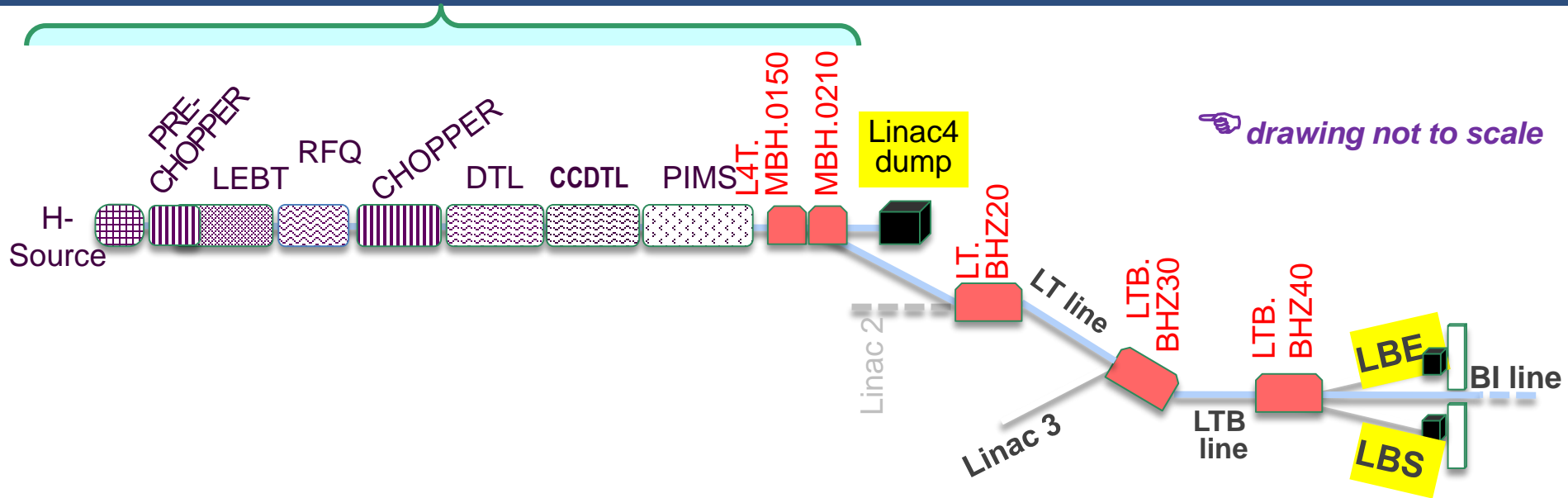


connected systems

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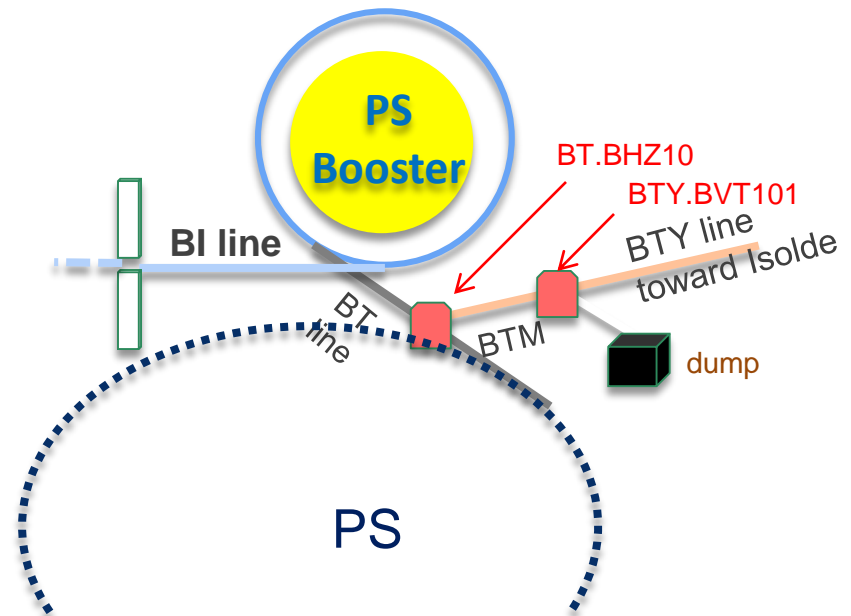
Layout of Linac4, Transfer Lines & PS Booster



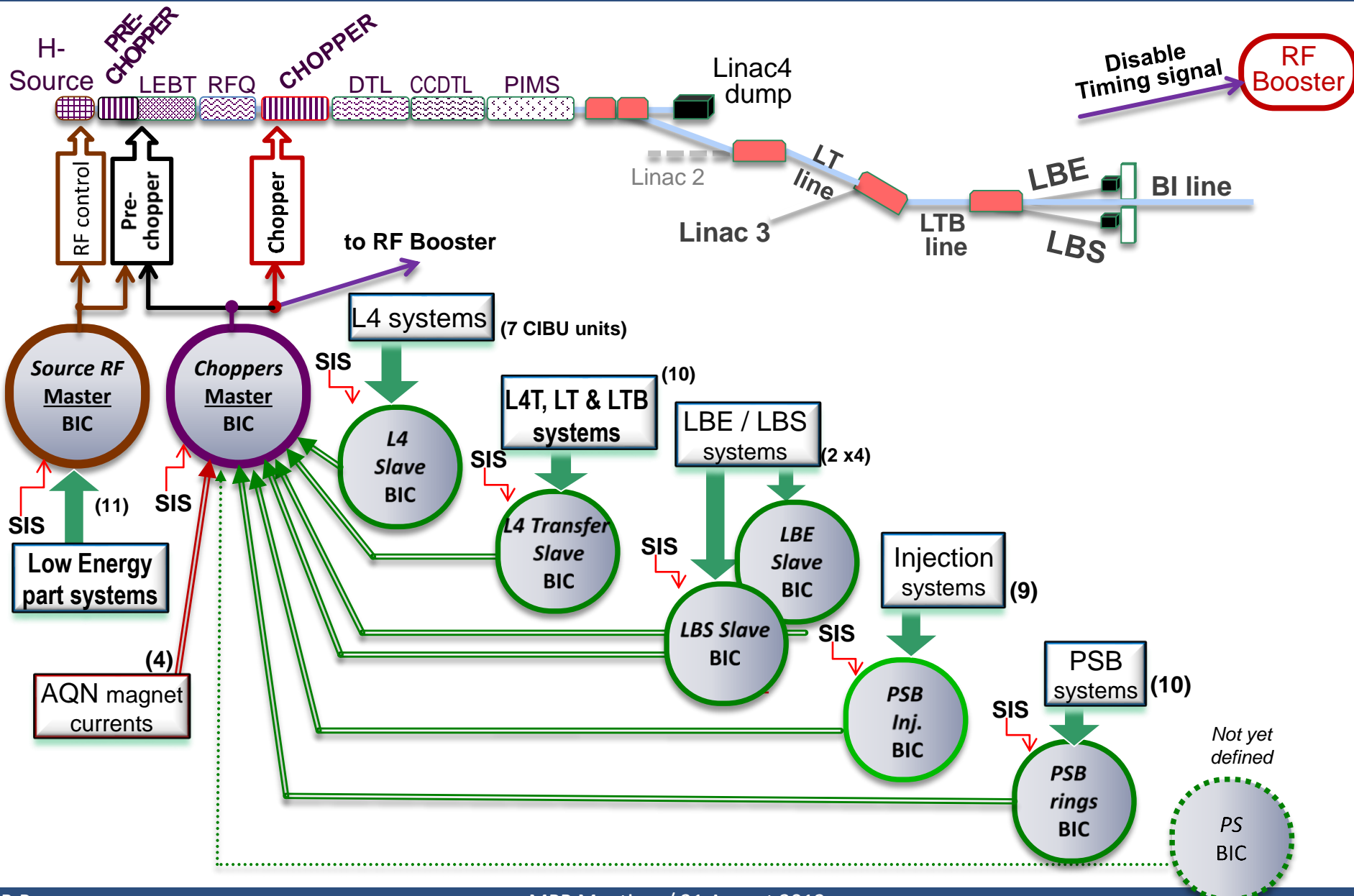
5 possible beam destinations:

- Linac4 dump
- LBE line
- LBS line
- PS Booster
- PS

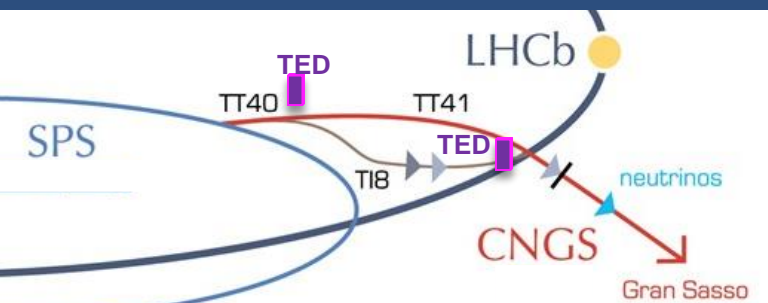
 : bending magnet



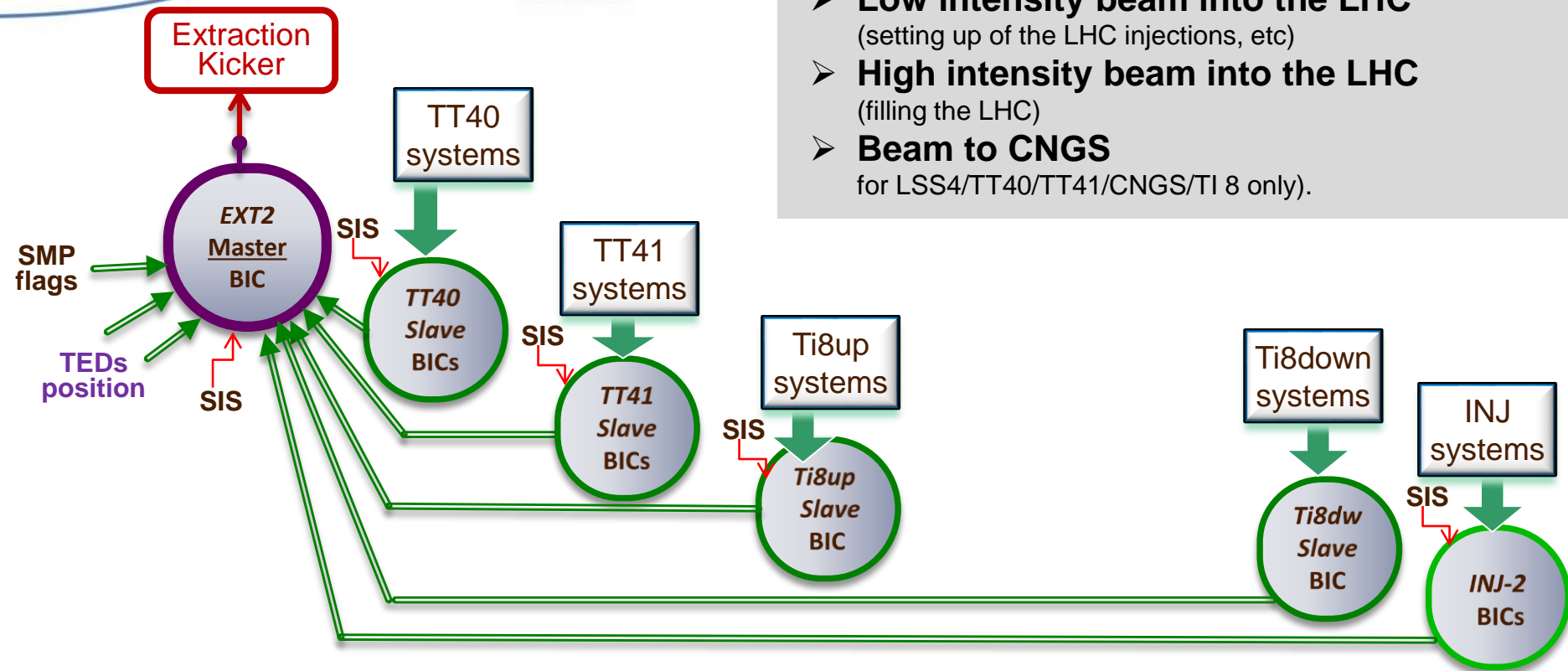
Interlocking Architecture for Linac4 and Transfer lines



Reminder: Interlocking Architecture for SPS Extraction line (beam-2)

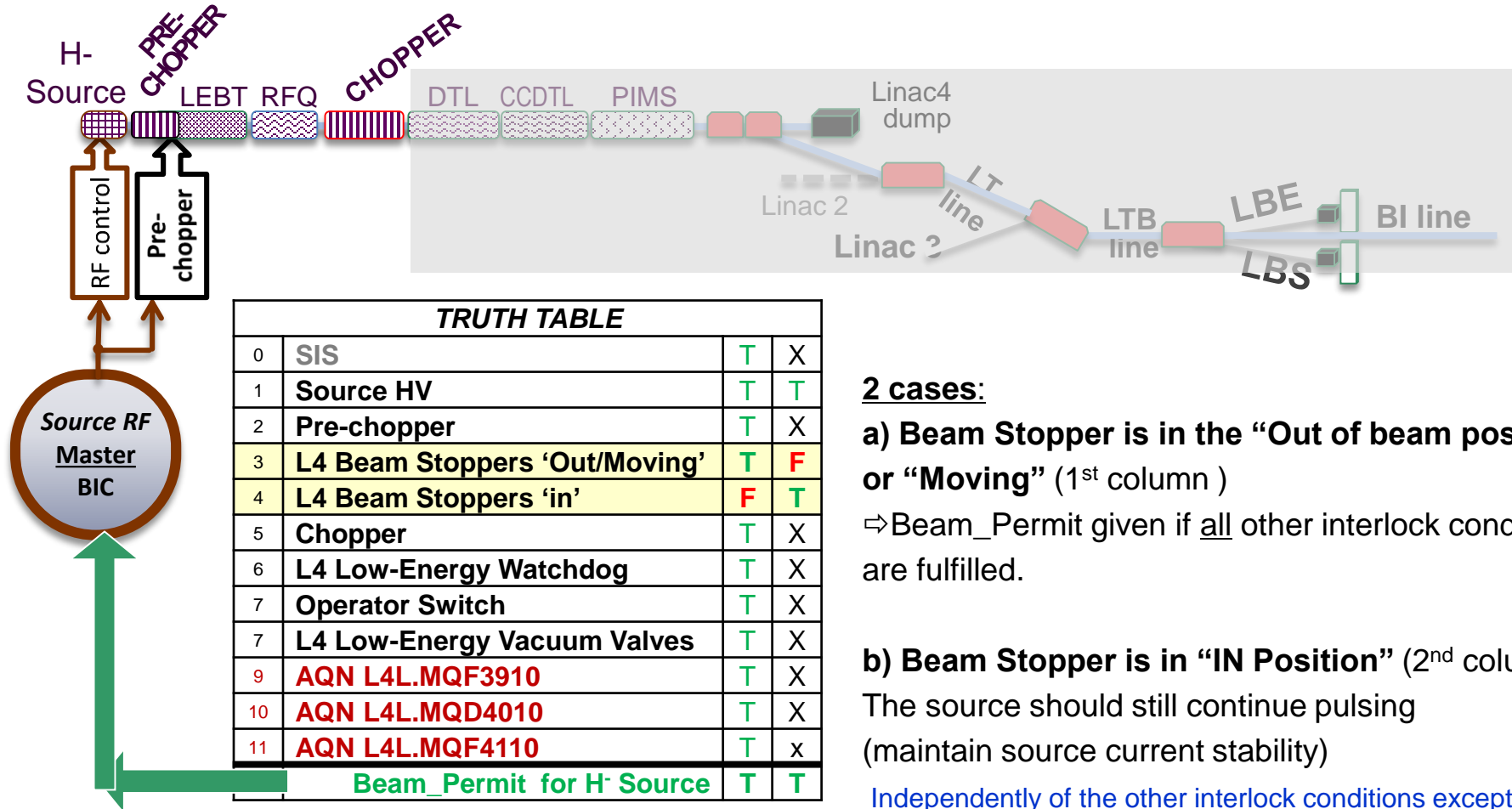


- 5 operational modes are interlocked:**
- **Beam to TT40/60 TED**
(setting up of the SPS extractions)
 - **Beam onto downstream TL TEDs**
(setting up of the transfer lines)
 - **Low intensity beam into the LHC**
(setting up of the LHC injections, etc)
 - **High intensity beam into the LHC**
(filling the LHC)
 - **Beam to CNGS**
for LSS4/TT40/TT41/CNGS/TI 8 only).



- **Sectorization** to minimize “Xtalk” between LHC and CNGS, and allow flexible operation & setup.
- Each sector / zone controlled by one (or more) dedicated BIC.

“Source RF” Master BIC



Beam Permit signal provided to 2 Target systems: RF Control & Pre-Chopper

2 cases:

a) Beam Stopper is in the “Out of beam position” or “Moving” (1st column)

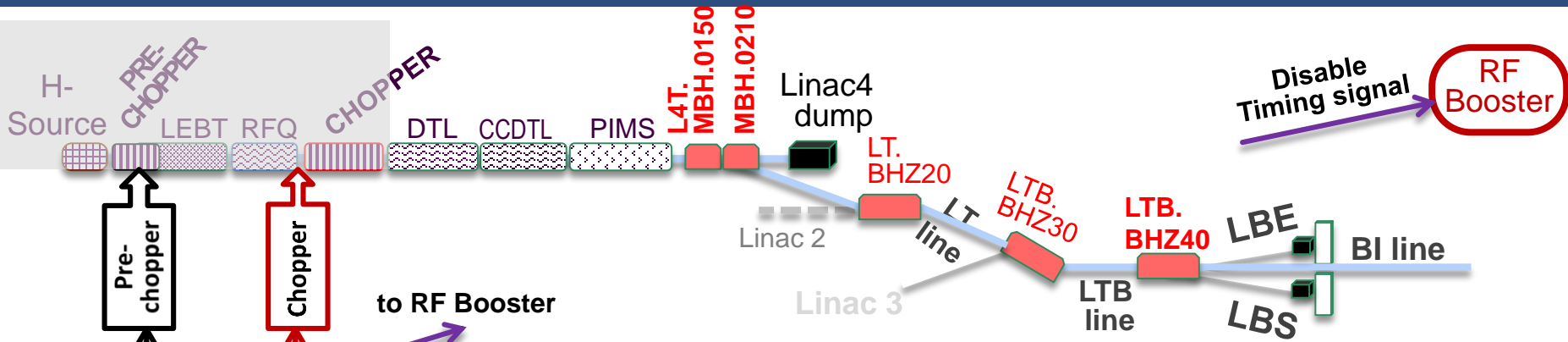
⇒ Beam_Permit given if all other interlock conditions are fulfilled.

b) Beam Stopper is in “IN Position” (2nd column).

The source should still continue pulsing (maintain source current stability)

Independently of the other interlock conditions except for the source high voltage itself.

“Choppers” Master BIC



	TRUTH TABLE	(1)	(2)	(3)	(4)	(5)
0	SIS	T	T	T	T	T
1	Linac4 OK (Slave BIC)	T	T	T	T	T
2	AQN L4T.MBH_DUMP	T	F	F	F	F
3	L4Z line OK	T	X	X	X	X
4	AQN L4T.MBH_LT	F	T	T	T	T
5	L4 Transfer OK (Slave)	X	T	T	T	T
6	AQN LTB.BHZ40_LBE	X	T	F	F	F
7	LBE OK (Slave BIC)	X	T	X	X	X
7	AQN LTB.BHZ40_LBS	X	F	T	X	X
9	LBS OK (Slave BIC)	X	X	T	X	X
10	AQN LTB.BHZ40_PSB	X	F	F	T	T
11	PSB Injection OK (Slave)	X	X	X	T	T
12	PSB OK (Slave BIC)	X	X	X	T	T
13	Destination PS	X	X	X	X	T
14	PS OK (Slave BIC)	X	X	X	X	T
	Beam_Permit	T	T	T	T	T

Beam to:
 (1) Linac4 dump
 (2) LBE line
 (3) LBS line
 (4) PS Booster
 (5) PS

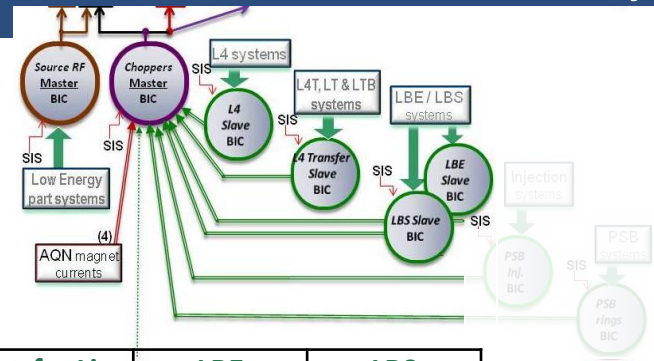
Beam_Permit given to 3 Target systems:

- 1) action on **Pre-chopper**
- 2) For redundancy, action on **Chopper**
 (also deviate beam to chopper dump at 3 MeV)
- 3) **PSB RF** is disabled
 (in case some beam still reaches the PSB)

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User Systems connected to BIS (L4 & Transfer lines)

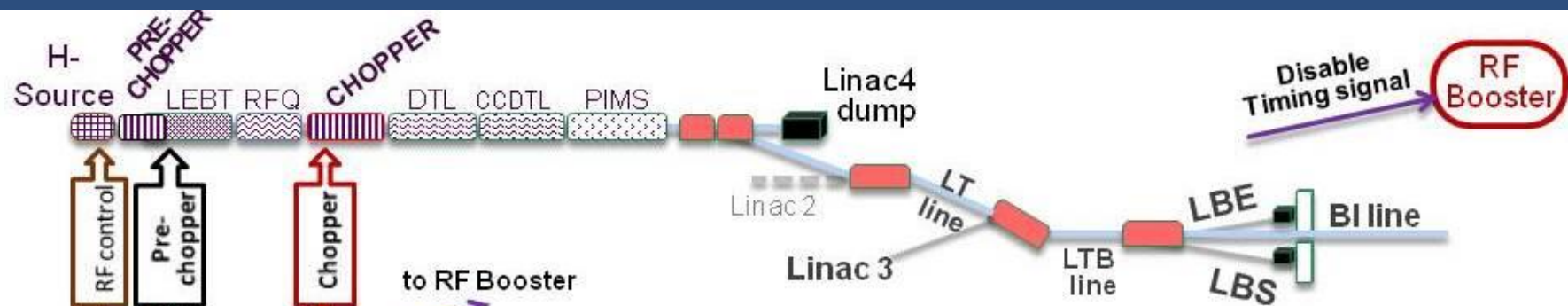


User Systems	Source-RF Master BIS	Choppers Master BIS	Linac4 Slave BIS	Transfer Line Slave BIS	LBE Slave BIS	LBS Slave BIS
Software Interlock	●	●	●	●	●	●
Beam Loss Mon.			●●	●●	●●	●●
“Watch Dog” (i.e. BCT)	●		●●	●●		
Vacuum	●		●	●	●	●
Beam Stopper	●●			●		
AQN (magnet’s current)	●●●	●●●●●		●●●		
Dump		●			●	●
RF			●			
Source HV	●					
Pre-Choppers	●					
Choppers	●					
Operator Switch	●					
Ext Conditions			●			

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Two different Beam_Permits given to 5 Target systems

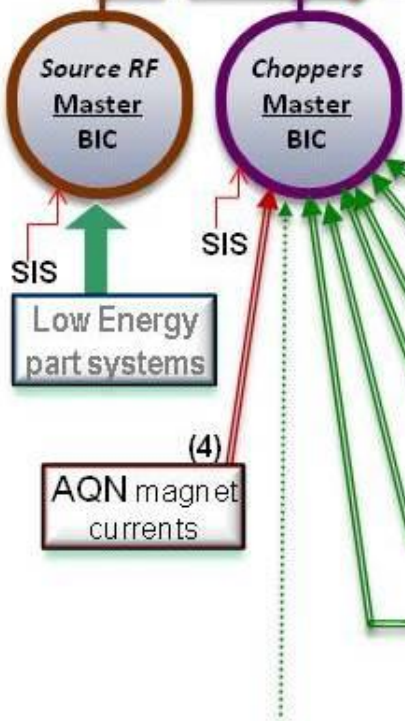


Beam_Permit from "Source-RF" BIC given to 2 Target systems:

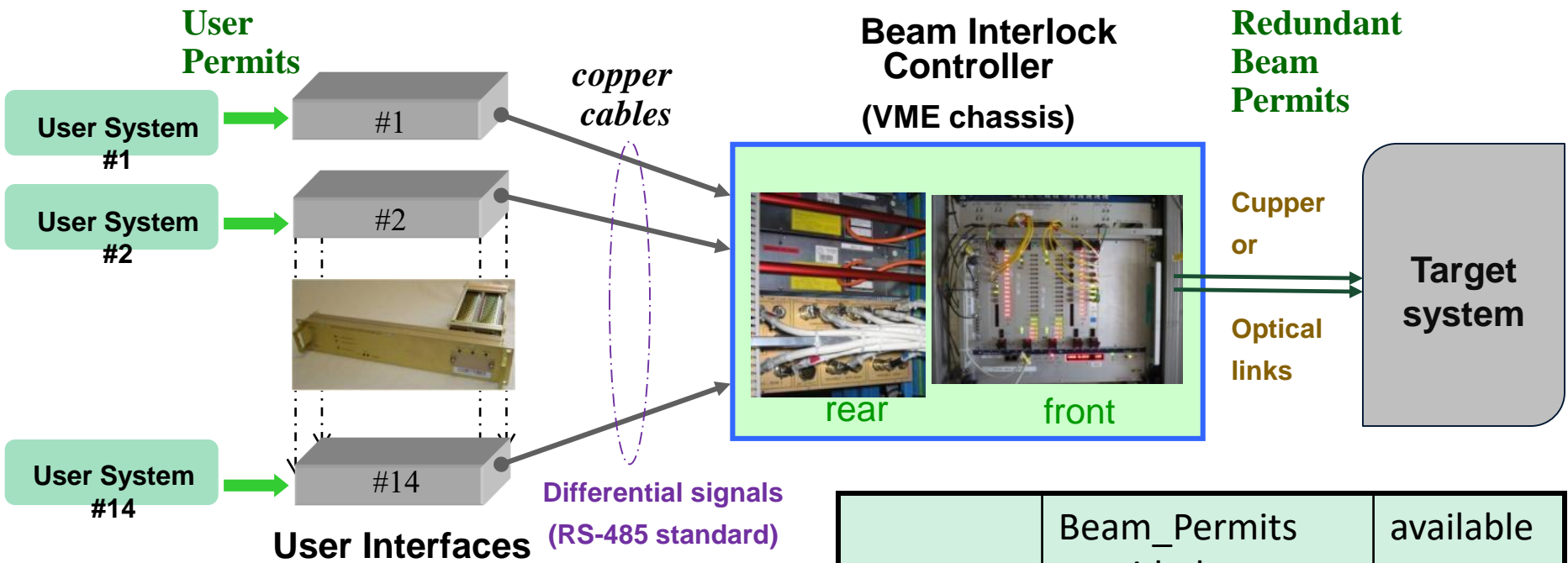
- 1) Action on the **Source RF** in order to switch off the RF voltage
- 2) For redundancy, action on the **Pre-chopper** in order to deflect the beam at 45 keV

Beam_Permit from "Choppers" BIC given to 3 Target systems:

- 1) Action on **Pre-chopper**
- 2) For redundancy, action on **Chopper**
(also deviate beam to chopper dump at 3 MeV)
- 3) **PSB RF** is disabled
(in case some beam still reaches the PSB)



Reminder on BIS Interfaces



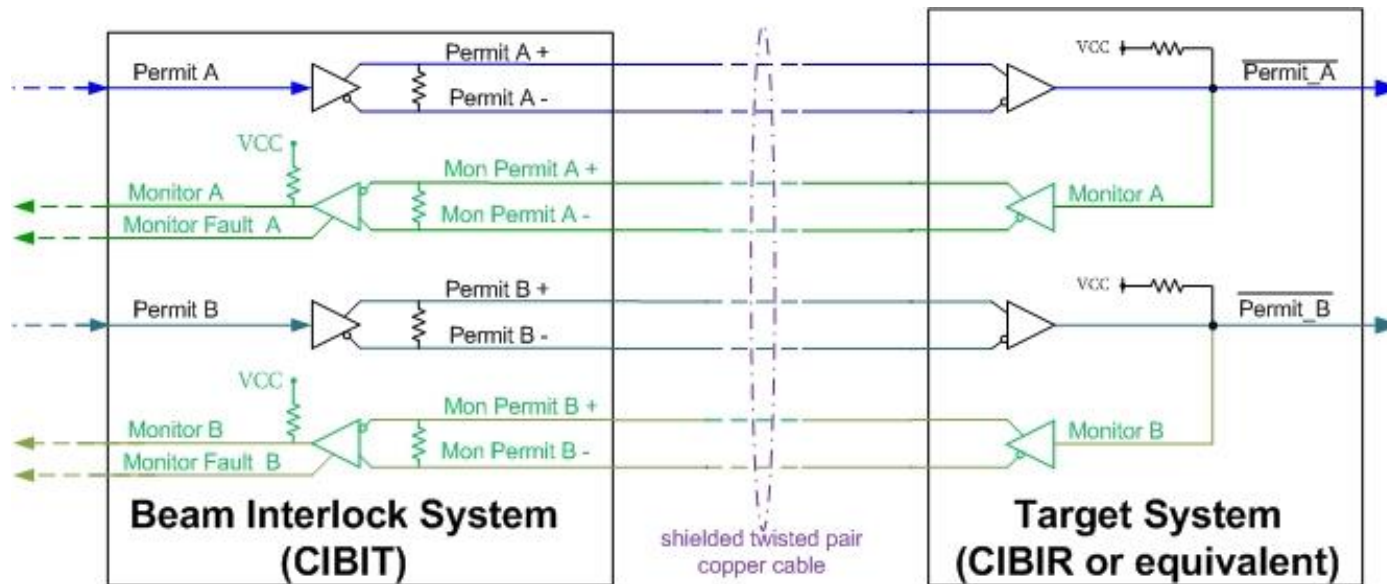
Simplified solution for the Injectors

	Beam_Permits provided as:	available on:
LHC case*	Frequency signals (A= 9.375Mhz, B= 8.375Mhz)	Fiber Optics links
LINAC 4	Flag signals (RS-485 standard)	Copper cables

* and also for SPS, Extractions lines and Injection BIS

Beam_Permit signals: Differential Transmission details (1/2)

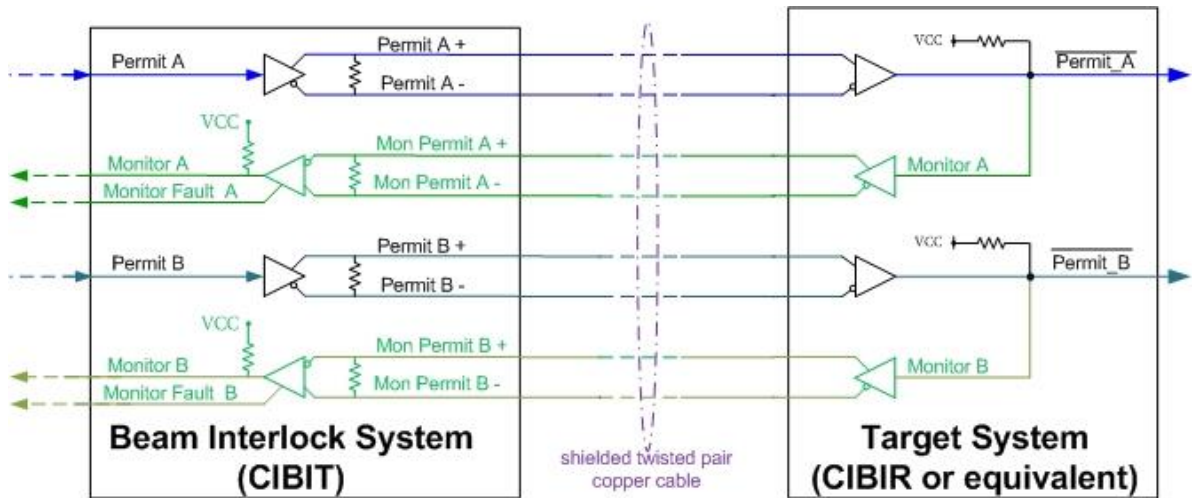
- Conversion Single-ended \Rightarrow Differential \Rightarrow Single-ended
- Redundant signal permit A & B
- Separation Critical/Monitoring signals



Thanks to Monitoring part, one can check that :

- Target system board is powered
- Cable is connected to the target system
- Beam_Permit signals are correctly transmitted (& read back)
- (if needed) Logic for the monitoring signal can be more elaborated

Beam_Permit signals: Differential Transmission details (2/2)

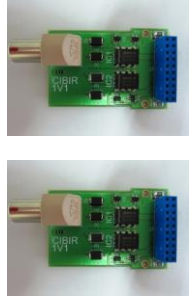


VME card:

- Single ended to differential conversion
- 4 independent output channels
- Fail safe operation [on-board MAX3440 chip]



CIBIR = Mezzanine cards (5 x 3 cm):

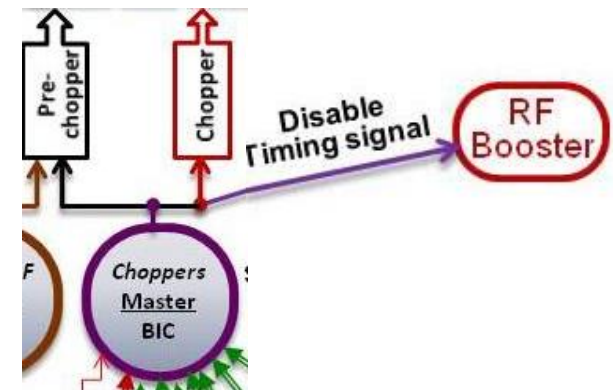
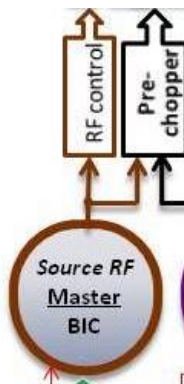
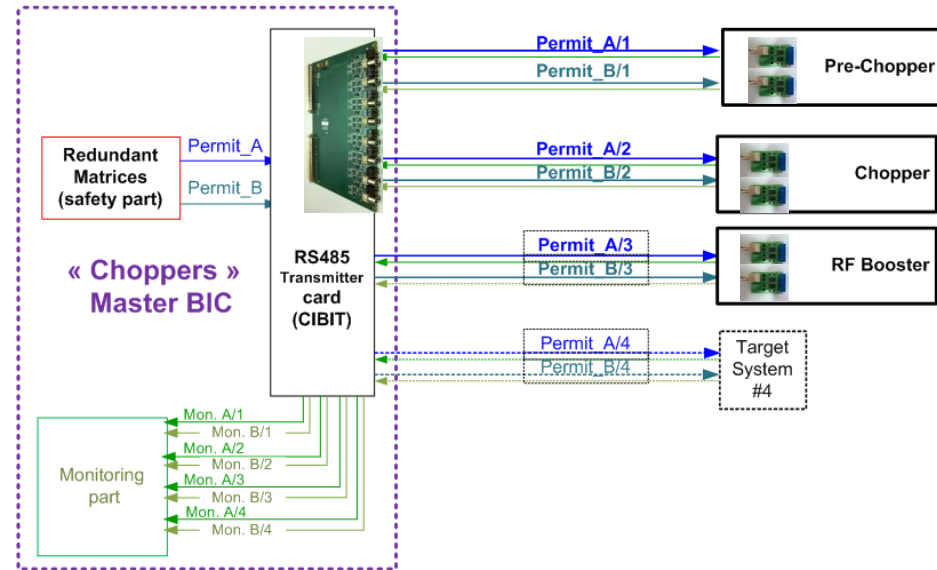
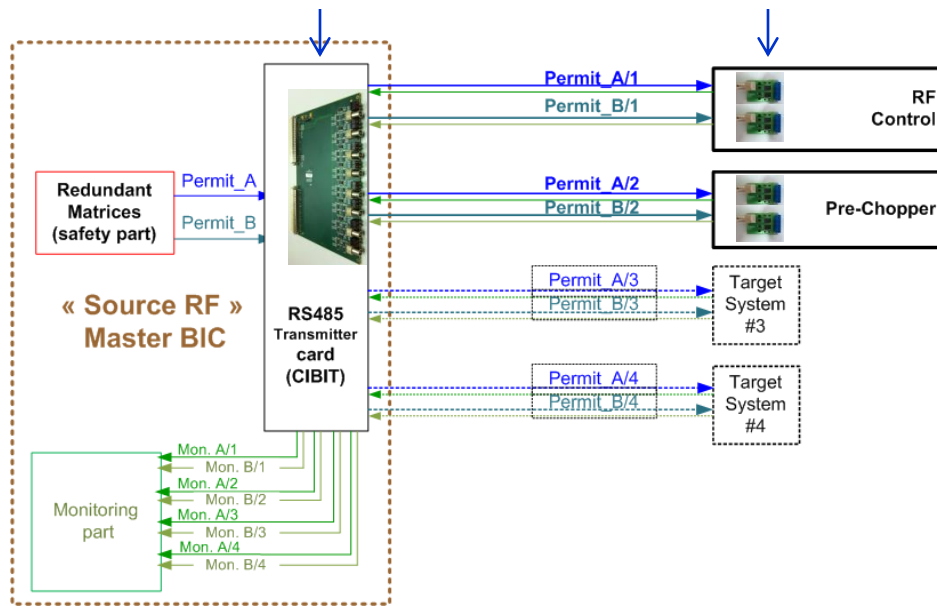


- Differential to single ended conversion
- Fail safe operation [MAX3440]
- 2 cards required for redundancy
- Provided by MPE/EP section.

Beam_Permit signals to L4 Target Systems

CIBIT board installed in BIC crate

CIBIR mezzanine boards (or equivalent)



Beam_Permit signals: Technical Note

CERN TE DEPARTMENT
CH-1211 Geneva 23
Switzerland

Document No.
TE-MPE Note-12-xx

CERN Div./Group or Supplier/Contractor Document No.
TE/MPE/EP

EDMS Document No.
1235601

Date: 2012-08-14

TECHNICAL NOTE

DRAFT THE BEAM PERMIT INTERFACE FOR THE LINAC4, TRANSFERT LINE AND PS BOOSTER

Abstract

This note describes the electrical interface for the Beam Permits signals supplied of the beam interlock system (BIS) to the Linac4/Booster target systems. The binary information is provided as differentials signals over copper cables. Contrary to the LHC, where the information is delivered as Frequency signals over optical links, the required interface is here simpler. This note details its implementation and proposes the two options to safely receive the Beam Permits signals.

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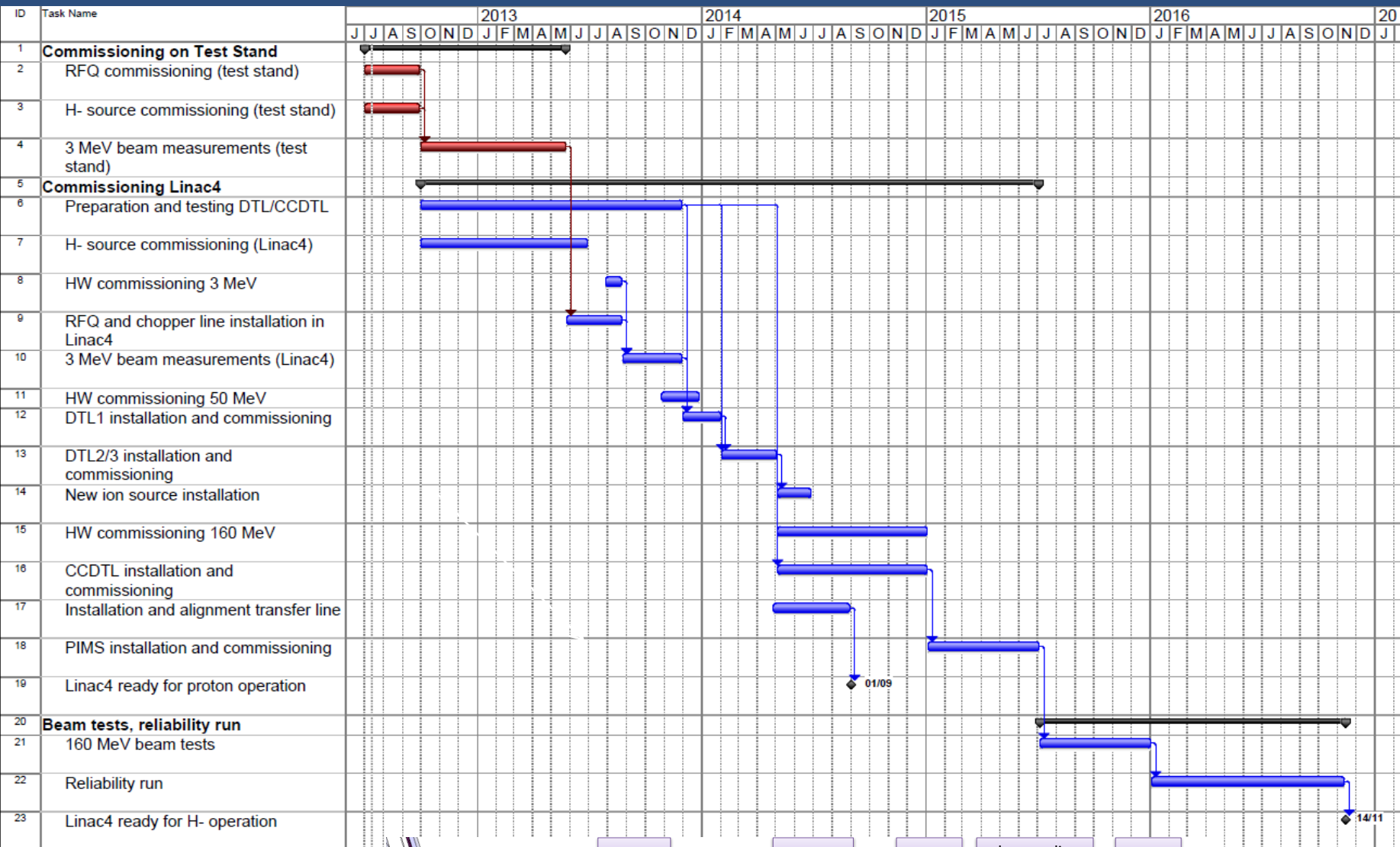
B. Todd

(TE/MPE)

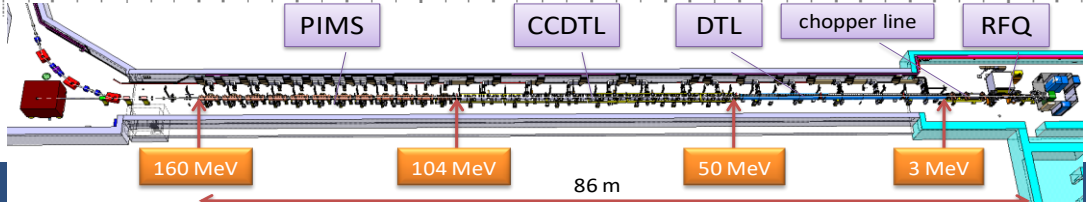
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Linac4 Master Plan



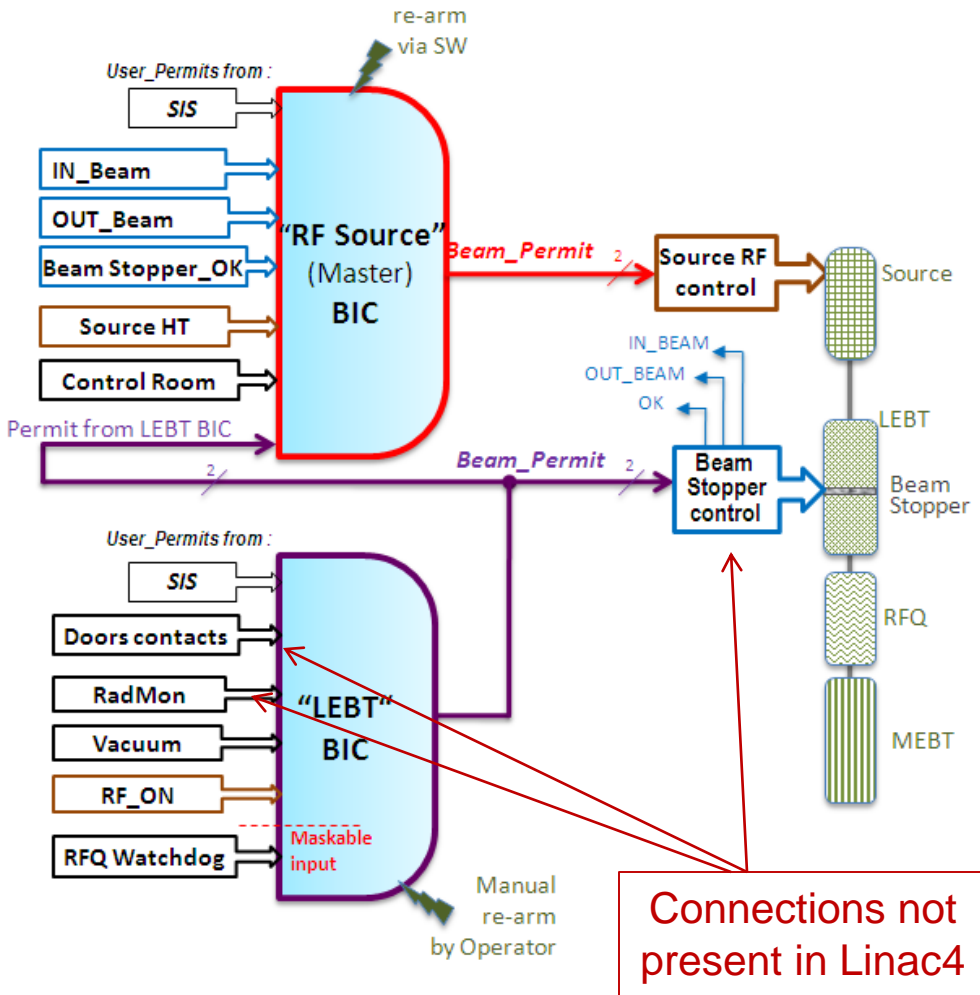
Version 12/07/2012



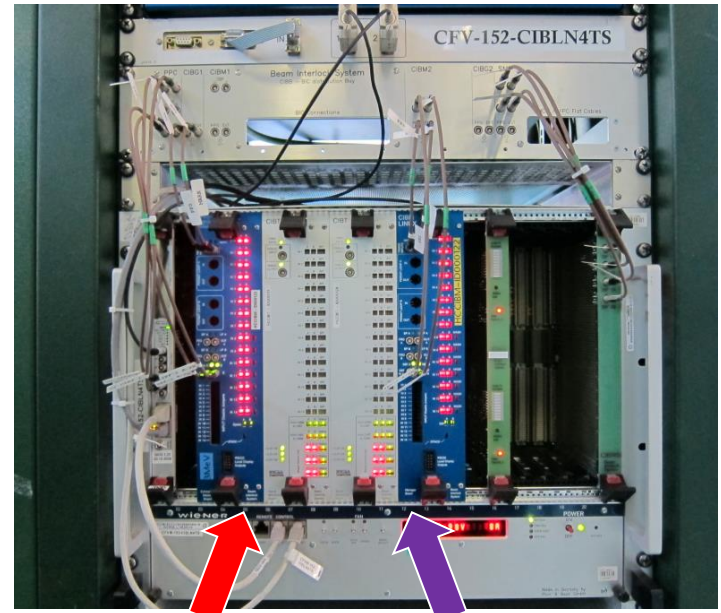
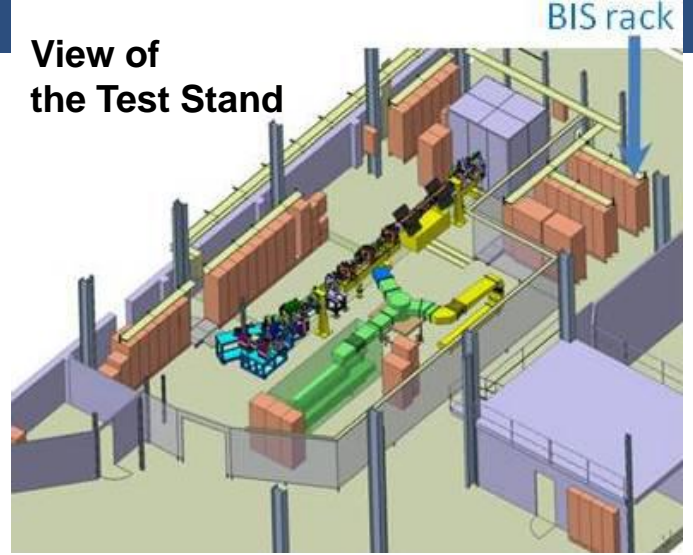
Status of the deployment

- BIS for 3MeV Test Stand fully installed and almost ready for commissioning
- For additional and internal tests: a dedicated BIC will be deployed in the Booster during next TS
- Material specific to Linac4 deployment (VME crates, BIC boards, CIBU units) ordered
- Monitoring Software and JAVA Application already available
 - Adaptation to fast cycling machine and specific screens are on going
(will be tested with “Test BIC” and with the BICs in 3MeV Test Stand)
- Most* of the cables have been ordered
 - (*) in some cases,, the rack numbers have been unfortunately not provided by the User_System responsible.

BIS in the 3MeV Test Stand



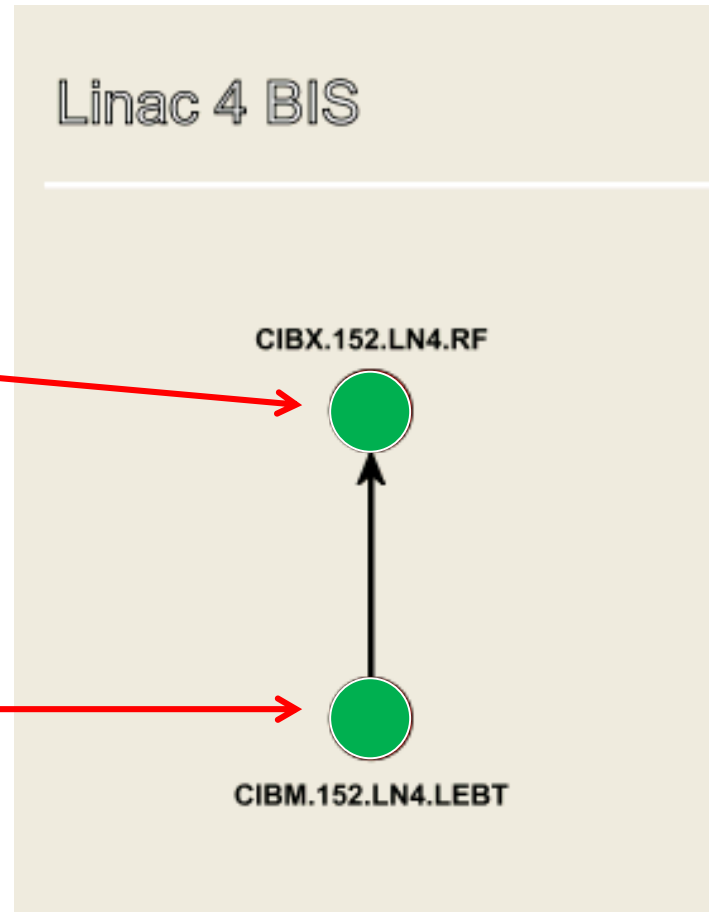
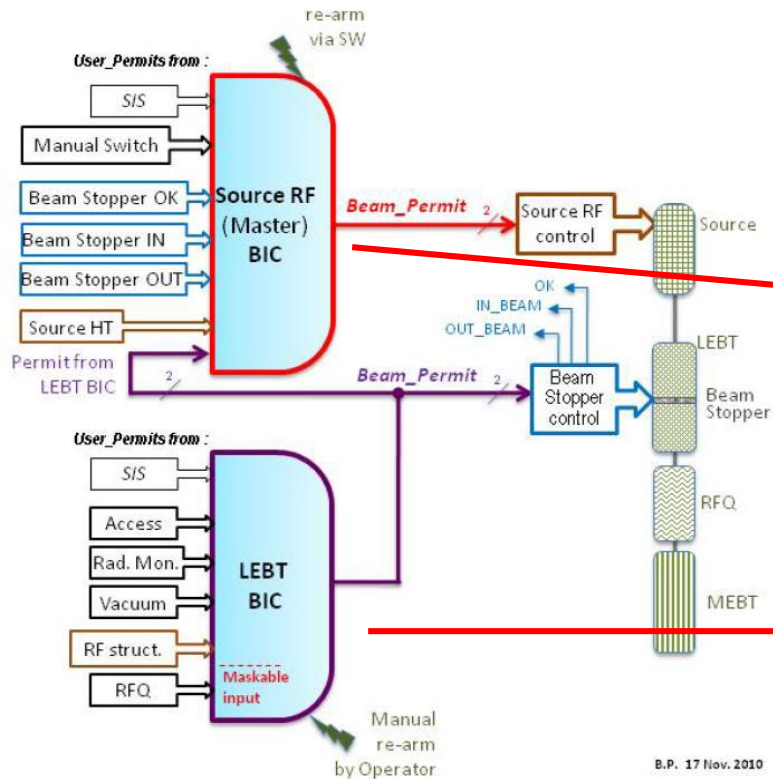
BIS layout for the 3MeV Test Stand



"RF Source" BIC

"LEBT" BIC

3MeV Test Stand: BIS Application



Beam Permit

BIS Application: inputs view for "Source-RF" BIC

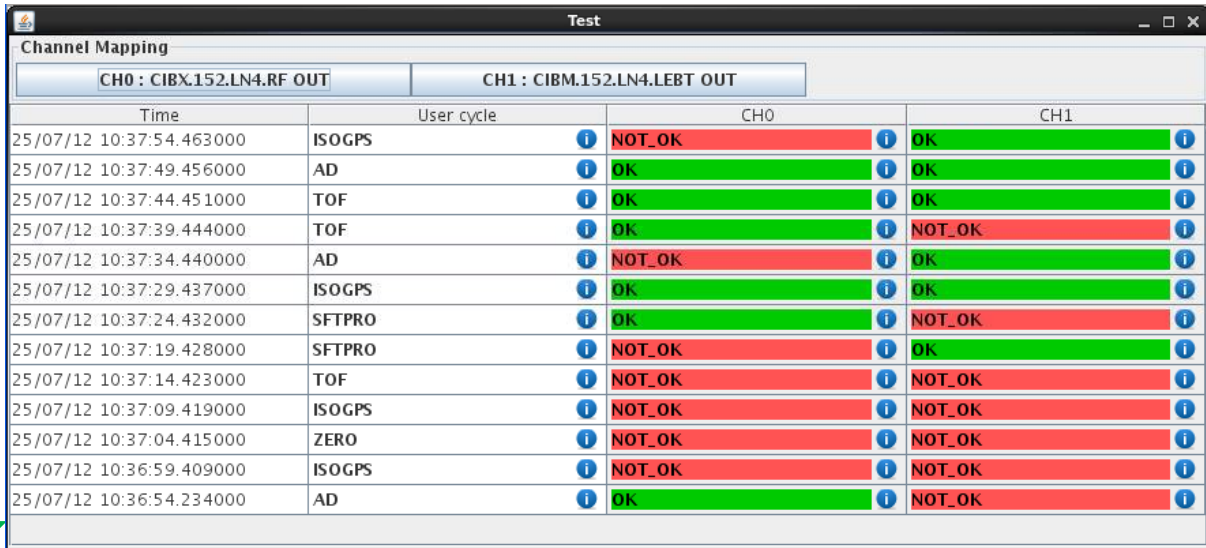
The screenshot shows the 'CIBX overview : CIBX.152.LN4.RF' application window. It features a menu bar with 'VIEWS' and 'COMMANDS'. The main area displays the 'SAFE BEAM FLAG' as 'TRUE' and 'Initialized'. Below this is a table with four columns: 'INPUT', 'DISABLED', 'MATRIX', and 'PERMIT'. The 'PERMIT' column is currently red and contains 'FALSE'. A 'Re-Armed' button is visible at the bottom right.

	INPUT	DISABLED	MATRIX	PERMIT
SOFTWARE INPUT	FALSE		FALSE	FALSE
1 LEBT_BIC	FALSE	NO	FALSE	
2 Source_Inhibit	FALSE	NO	FALSE	
3 Beam-Stopper_OK	FALSE	NO	FALSE	
4 Beam-Stopper_IN	TRUE	NO	TRUE	
5 Beam-Stopper_OUT	FALSE	NO	FALSE	
6 Source-HT	FALSE	NO	FALSE	
7 Not used		YES		
8 Not used		YES		
9 Not used		YES		
10 Not used		YES		
11 Not used		YES		
12 Not used		YES		
13 Not used		YES		
14 Not used		YES		

BIS Application: the cycles view

- Same cycle user panel for one or multiple BICs,
- Information on masked/disabled/OK/NOK inputs,
- Future functionalities: filter, pause, and charts:
 - Signal evolution around injection and extraction
 - From W10 to AMC timing events!

Last acquired user cycle :



Time	User cycle	CH0	CH1
25/07/12 10:37:54.463000	ISOGPS	NOT_OK	OK
25/07/12 10:37:49.456000	AD	OK	OK
25/07/12 10:37:44.451000	TOF	OK	OK
25/07/12 10:37:39.444000	TOF	OK	NOT_OK
25/07/12 10:37:34.440000	AD	NOT_OK	OK
25/07/12 10:37:29.437000	ISOGPS	OK	OK
25/07/12 10:37:24.432000	SFTPRO	OK	NOT_OK
25/07/12 10:37:19.428000	SFTPRO	NOT_OK	OK
25/07/12 10:37:14.423000	TOF	NOT_OK	NOT_OK
25/07/12 10:37:09.419000	ISOGPS	NOT_OK	NOT_OK
25/07/12 10:37:04.415000	ZERO	NOT_OK	NOT_OK
25/07/12 10:36:59.409000	ISOGPS	NOT_OK	NOT_OK
25/07/12 10:36:54.234000	AD	OK	NOT_OK

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Outstanding issues?

We have to clarify or to pay attention to the following points:

- Cables:
 - EN/EL has defined priorities for LS1 => missing cables will be not installed in 2013?
- BLM connections:
 - for the Linac4 and TL zones, 8 different signals are expected but only 2 can be provided by the BLM crate. Discussions with BLM team are on going to find a solution.
- AQN connections (i.e. Power Converters Interface for current measurements):
 - Proposal made in Nov'11 promising but still no Eng. specification
 - A prototype would have been helpful for the "Test BIC"
- Signals from Dumps:
 - Implementation details not known; EDMS specification expected
- Software Interlocks
 - Who will manage them? BE/OP?
- Machine Commissioning (*see next slide*)

Commissioning phases

- BIS layout has been defined for a complete Linac4 installation but:
 - For each step of the commissioning phases, a different part of the BIS shall be (safely) “masked”
 - The User_systems (like RF) have also to adapt their User_Permit signals to the commissioning progression.
 - Some elements will be only present during commissioning phases (like emittance measurement line); some others (BLM) will be ineffective at 3 MeV...

The above constraints have to be discussed and later on have to be clearly described in a dedicated specification.

The end date of L4 commissioning is mid-2015. It will be followed by a long reliability run in 2016. But Linac4 will also be a back-up solution in case of problems with Linac2 in the period between the two long shut-downs

=> impact on BIS has to be also studied.

Summing-up

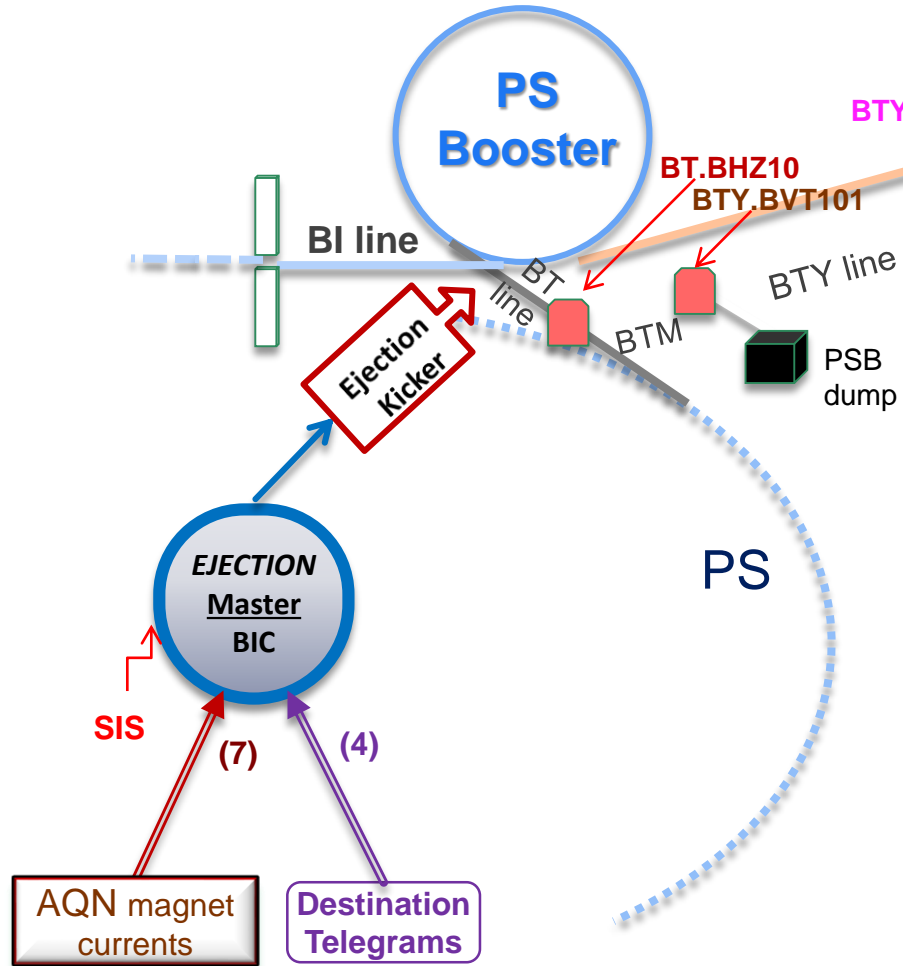
- BIS solution (Hw & Sw) re-used for interlocking Linac4, Transfer Lines and Booster
- Simplified solution to interface the Beam_Permit signals
- BIS ready for 3MeV Test Stand commissioning
 - Additional “Test BIC” will be installed in Booster
- Possible issue for new cables
- Some points have to be clarified with some User_Systems (BLM, Power-Converters, Dump)
- New version of Engineering specification will go soon to “Check procedure”
- Commissioning steps and their impact on BIS have to be detailed in a dedicated document

Fin

Thank you for your attention

Spare slides

Interlocking of the Booster Ejection line



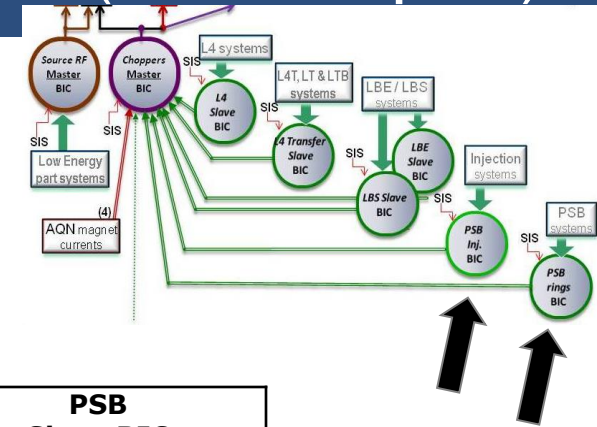
Ch.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	OUT
Interlock Element	SIS	Destination PSB Dump	Destination ISOGPS	Destination ISOHRS	Destination PS	AQN BT.BHZ10 BDUMP/ISOLDE	AQN BT.BHZ10 PS	AQN BTM.BHZ10	AQN BTY.BHZ301 GPS	AQN BTY.BHZ301 HRS	AQN BTY.BVT101 BDUMP	AQN BTY.BVT101 ISOLDE	not used	not used	not used	PSB Ejection Beam_Permit
	1	1	0	0	0	1	0	1	x	x	1	0	x	x	x	1
	1	0	1	0	0	1	0	1	1	0	0	1	x	x	x	1
	1	0	0	1	0	1	0	1	0	1	0	1	x	x	x	1
	1	0	0	0	1	0	1	x	x	x	x	x	x	x	x	1

row#1: Beam to Dump
row#2: Beam to GPS
row#3: Beam to HRS
row#4: Beam to PS

Beam_Permit given to only one Target system:
The planned action is to **disable the extraction kickers**

drawing not to scale

User Systems connected to BIS (Booster part)



<i>User Systems</i>	PSB Injection Slave BIC	PSB Slave BIC
Software Interlock	●	●
RF		●
Beam Loss Monitors		● ● ● ● ●
“Watch Dog” (i.e. BCT)	● ●	
Vacuum		●
Beam Stopper	●	
BCM	● (H ⁰ /H ⁻)	
Power Converter status	● ● BI.SMV & BI.BSW	● ● ● MPS, BE.BSW, & BE.SMH
Pulse Magnets	● ● Distributor, BI.KSW	
Injection Foil Status	●	