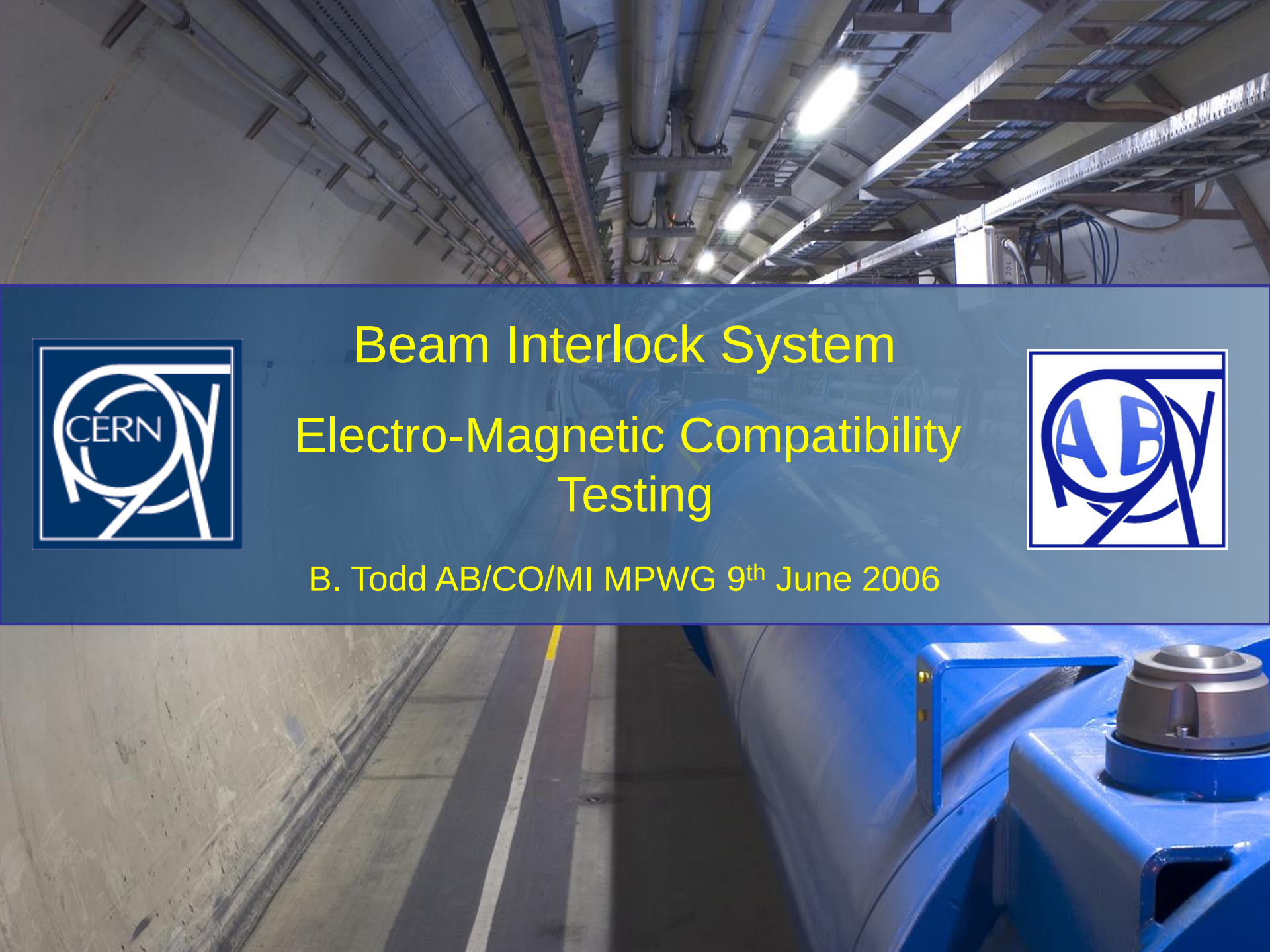

Beam Interlock System

Electro-Magnetic Compatibility Testing

B. Todd AB/CO/MI MPWG 9th June 2006

EMC Testing the BIC

1. System Overview
   - Beam Interlock System
   - Block Diagram
   - Electrical Diagram

2. EMC Tests and Results
   - Beam Interlock Controller to CIBU
   - CIBU to User System
   - Power Supplies

3. Conclusions
   - Areas of Concern

System Overview

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Beam Interlock System Overview

Beam Interlock Controllers (BIC)

16 BICs
- Two at each Insertion Point

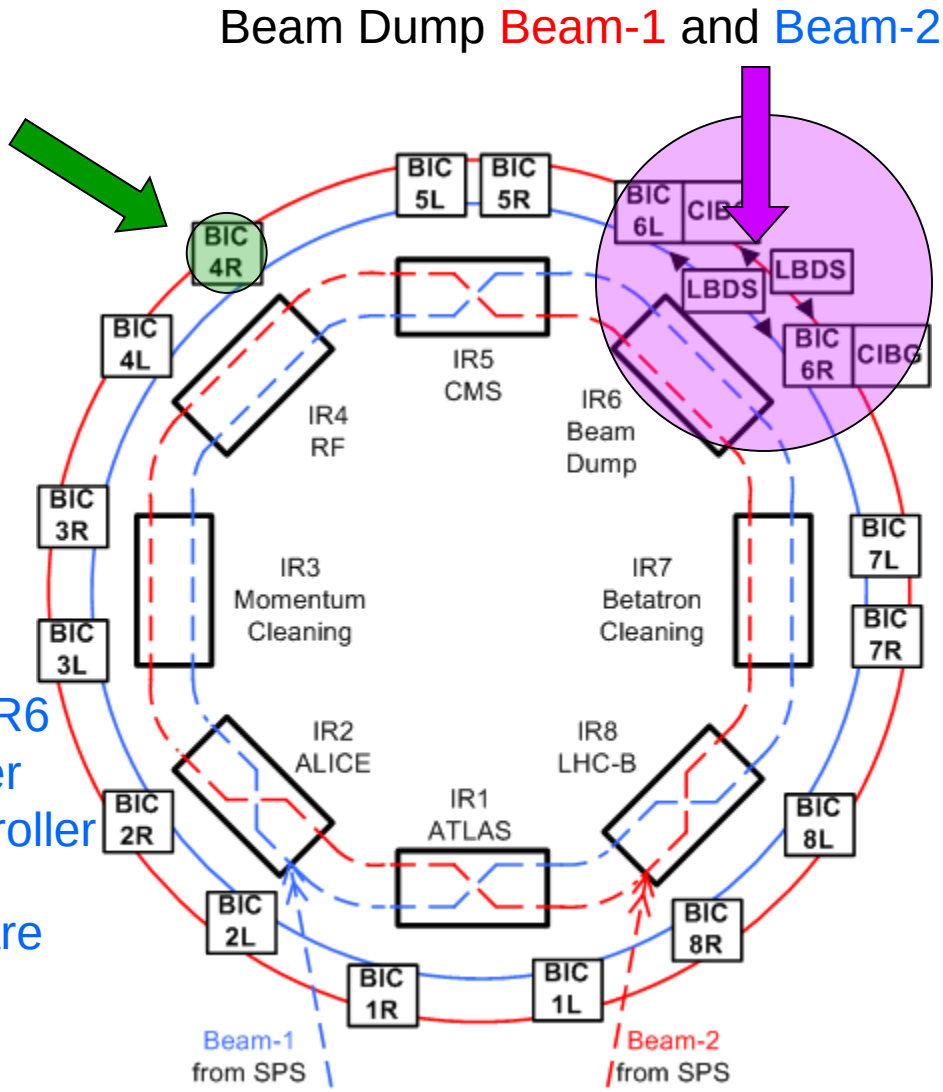
Up to 20 User Systems per BIC
6 x Beam-1
8 x Both-Beam
6 x Beam-2

4 fibre-optic channels from Point 6
1 clockwise &
1 anticlockwise for **each** Beam

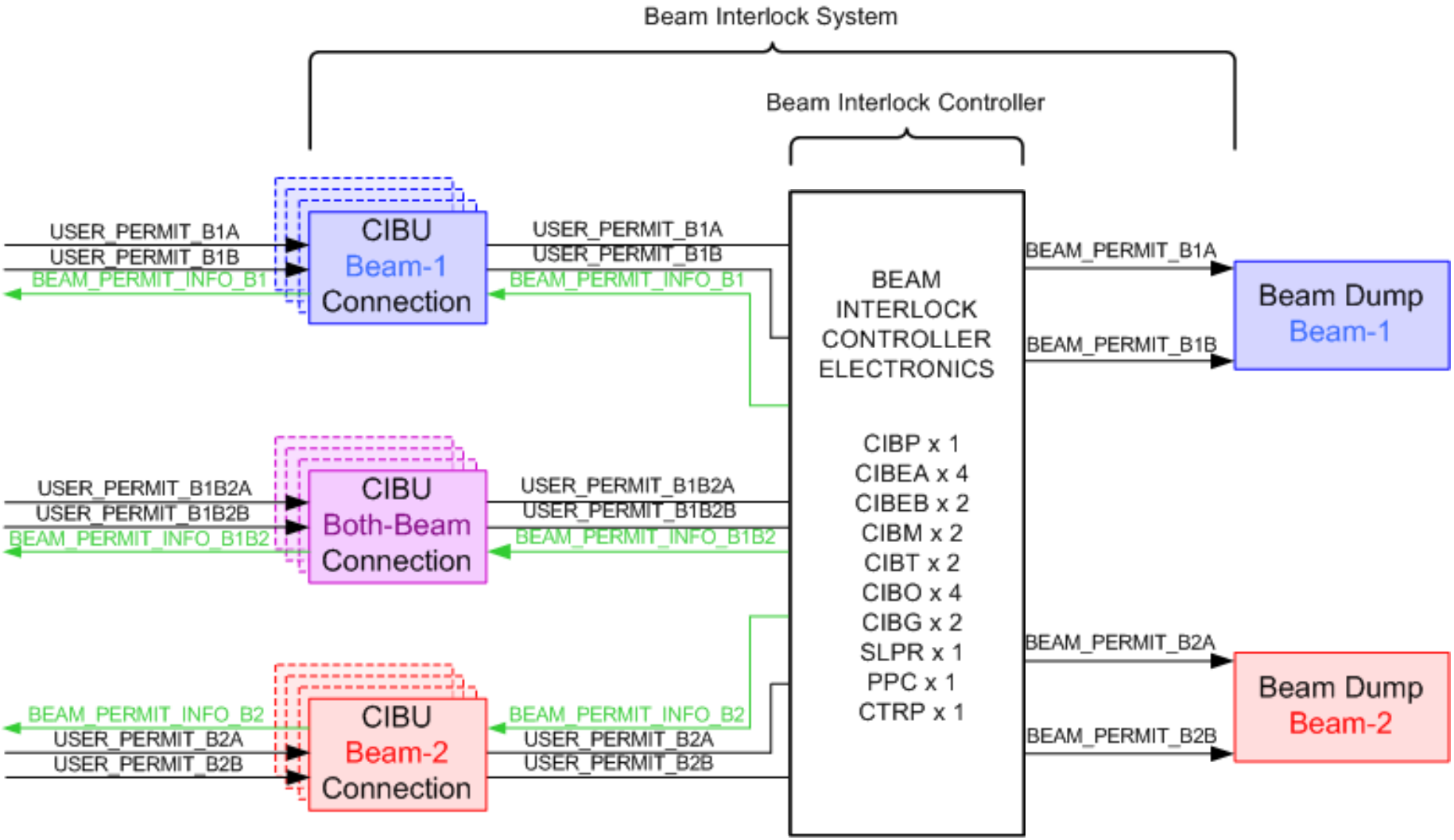
10MHz Square wave generated at IR6
-Signal can be cut by any Controller
-Signal can be monitored by any Controller

When any of the four 10MHz signals are absent at IP6, BEAM DUMP!

Beam-1 / Beam-2 are Independent!

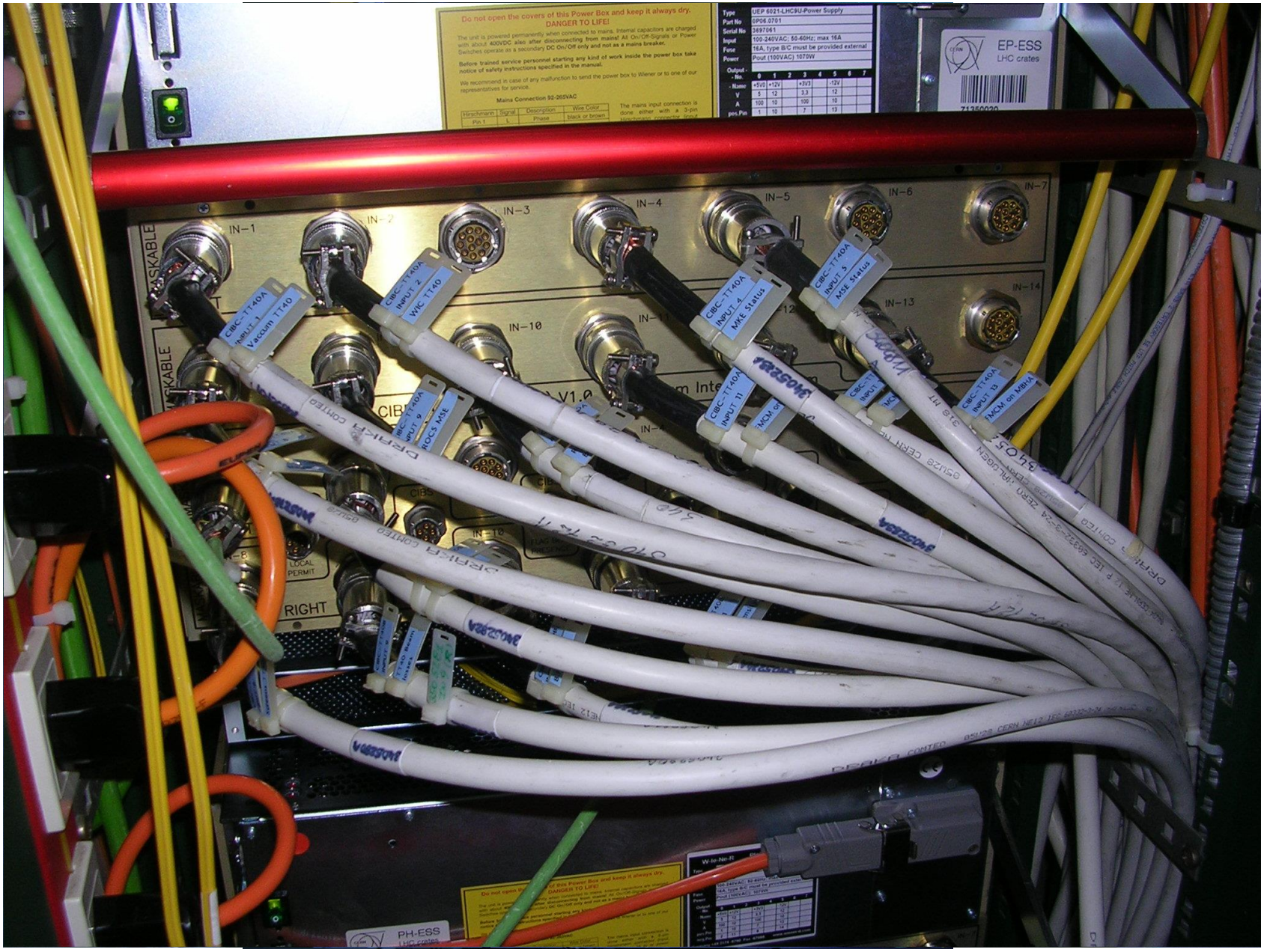


Block Diagram

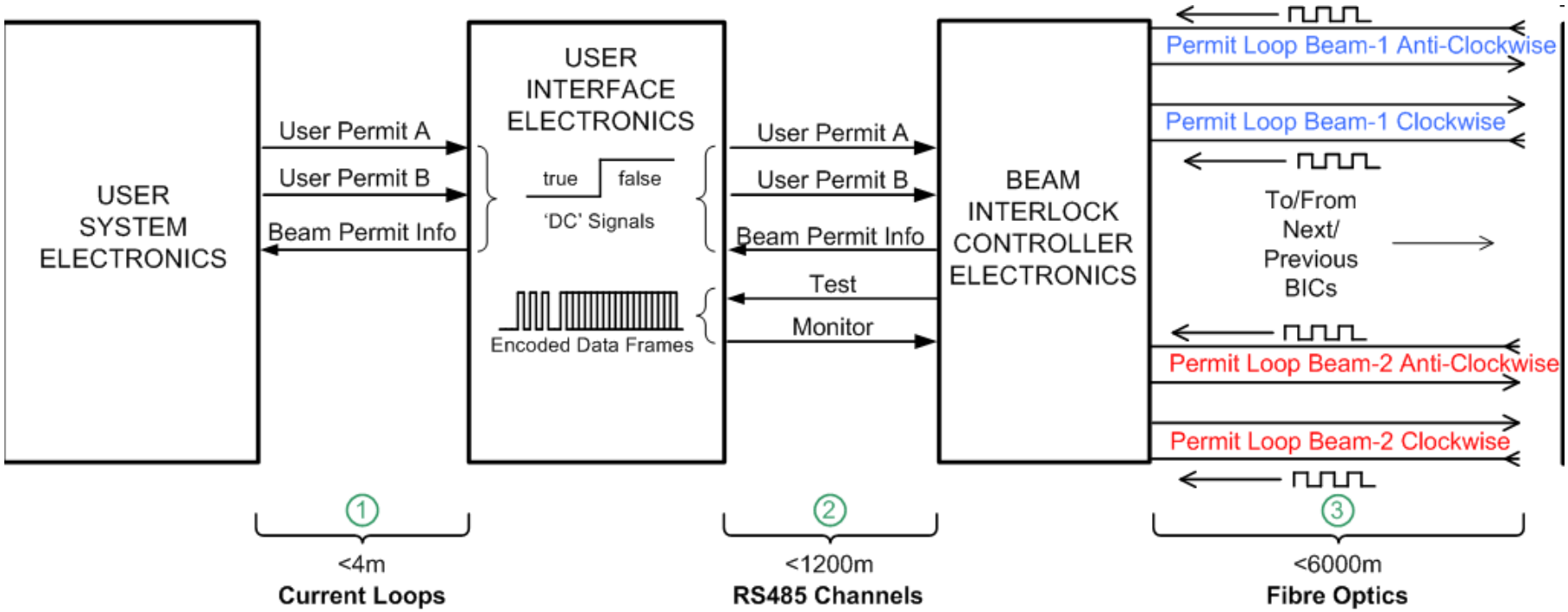


Based on VME – Has a *few* sub-components

TT40 BIC in BA4… Yesterday



Electrical Connections



EMC Testing

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Testing Criteria

Tests according to the IEC-61000 for electrical systems:

Severity Level	Power and Grounds
1	0.5kV
2	1.0kV
3	2.0kV
4	4.0kV

Ideally: A at 4.0kV

Results categorised into four different types:

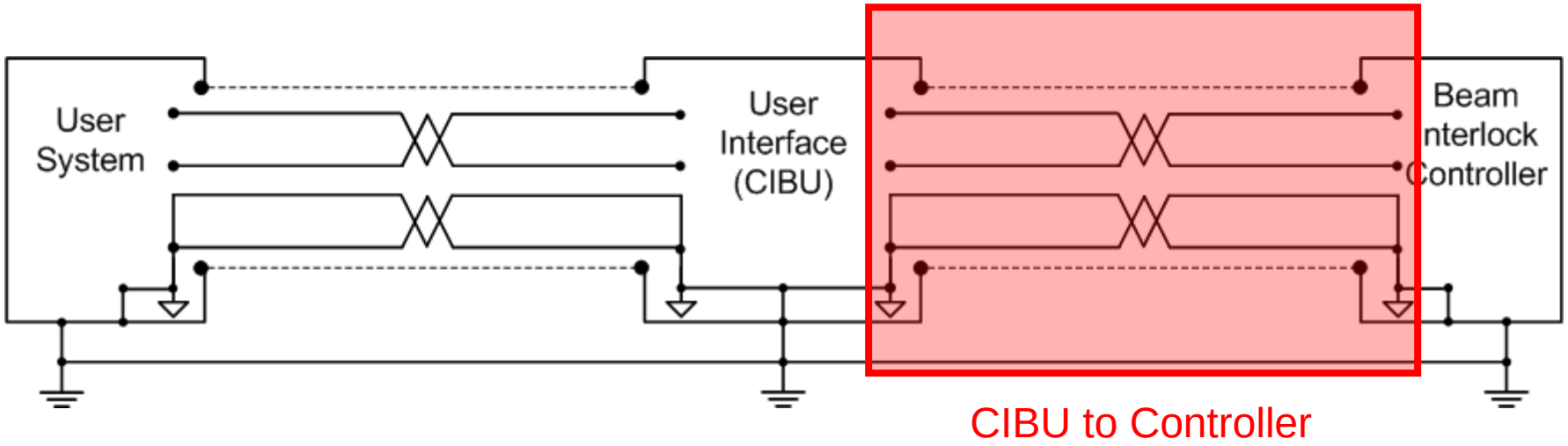
Test Result	Description	Example
A	No Noticeable Fault	No signals are seen to be perturbed
B	Corrected Fault	Critical Signal error, corrected by BIC
C	Fault	Critical Signal error, not corrected by BIC
D	Complete Failure	Loss of power / control

Unsafety

1. User Permit set to FALSE = see if EMC makes it TRUE
2. User Permit set to TRUE = see if EMC makes it FALSE

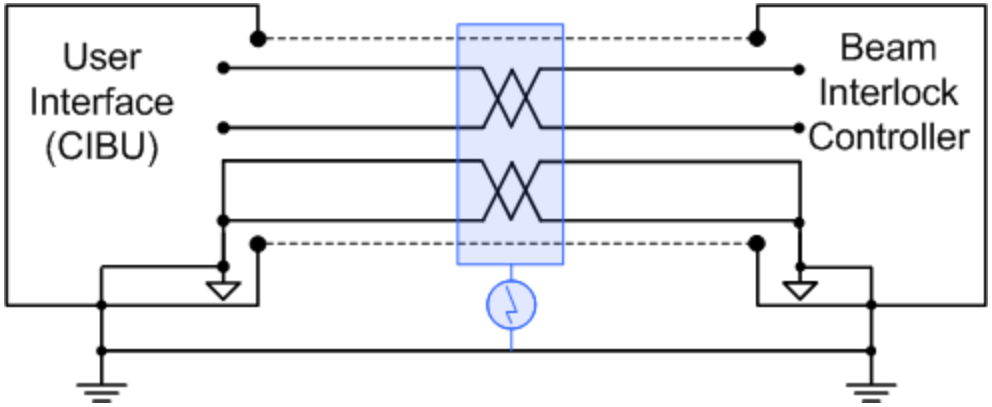
False dumps

Recommended Interconnect



CIBU to Controller 1/2

Cable with FULL Shields FULL Grounds

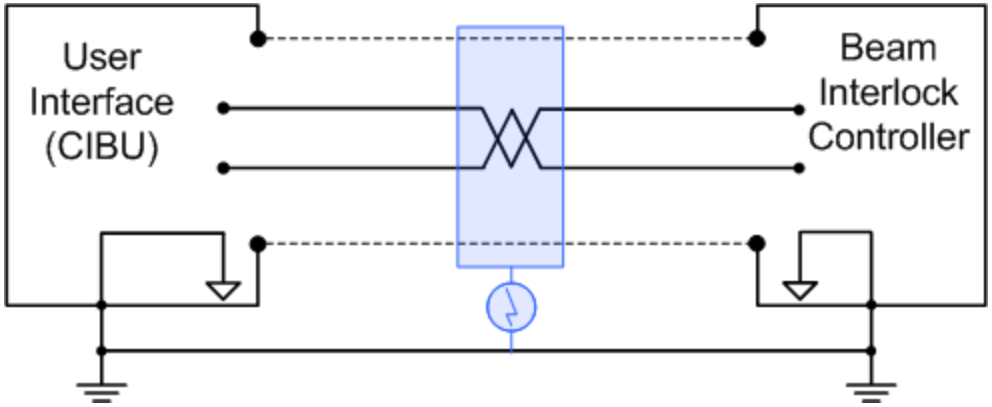


Results

Full Shield, Full Ground	Severity Level			
User System Output	**0.5kV**	**1.0kV**	**2.0kV**	**4.0kV**
TRUE	A	A	A	A
FALSE	A	A	A	A

CIBU to Controller 2/2

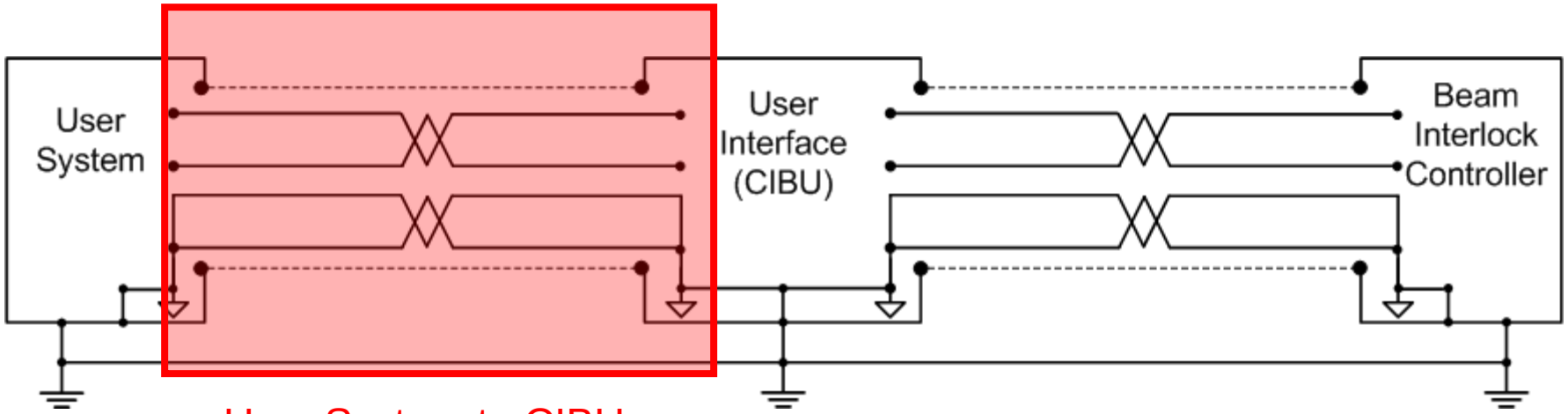
Cable with FULL Shields NO Grounds



Results

Full Shield, No Ground	Severity Level			
User System Output	**0.5kV**	**1.0kV**	**2.0kV**	**4.0kV**
TRUE	A	A	A	A
FALSE	A	A	A	A

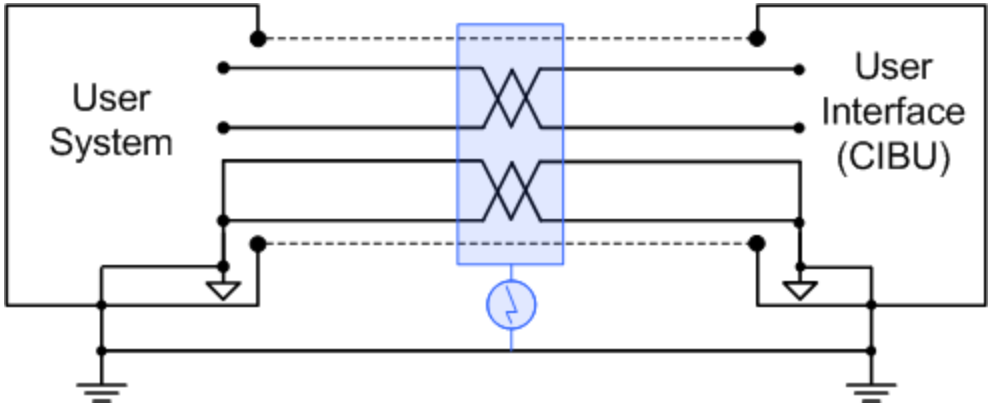
Recommended Interconnect



User System to CIBU

User System to CIBU 1/3

Cable with FULL Shields FULL Grounds



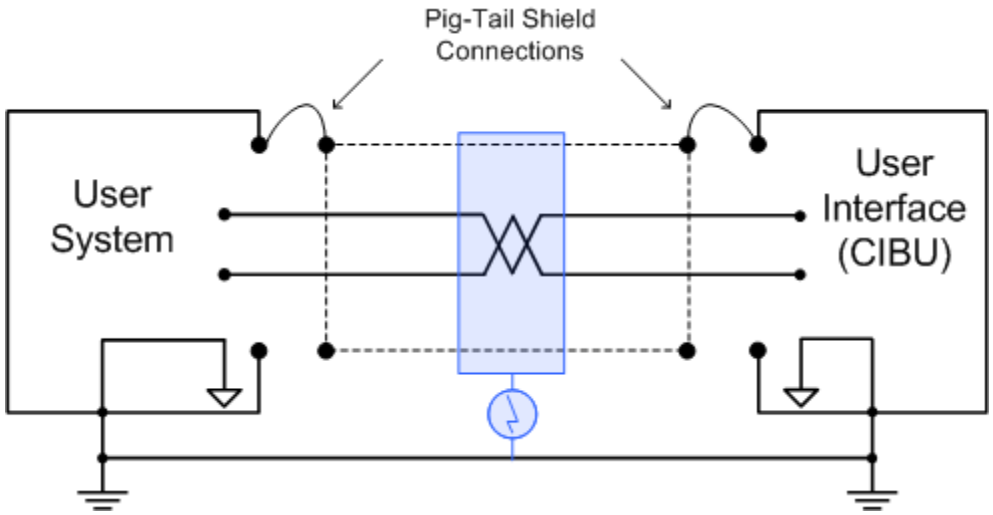
Results

Full Shield, Full Ground	Severity Level			
User System Output	**0.5kV**	**1.0kV**	**2.0kV**	**4.0kV**
TRUE	A	A	A	A
FALSE	A	A	A	A

User System to CIBU 2/3

Cable with Pig-tail Shield No Grounds

E.G. Vacuum System



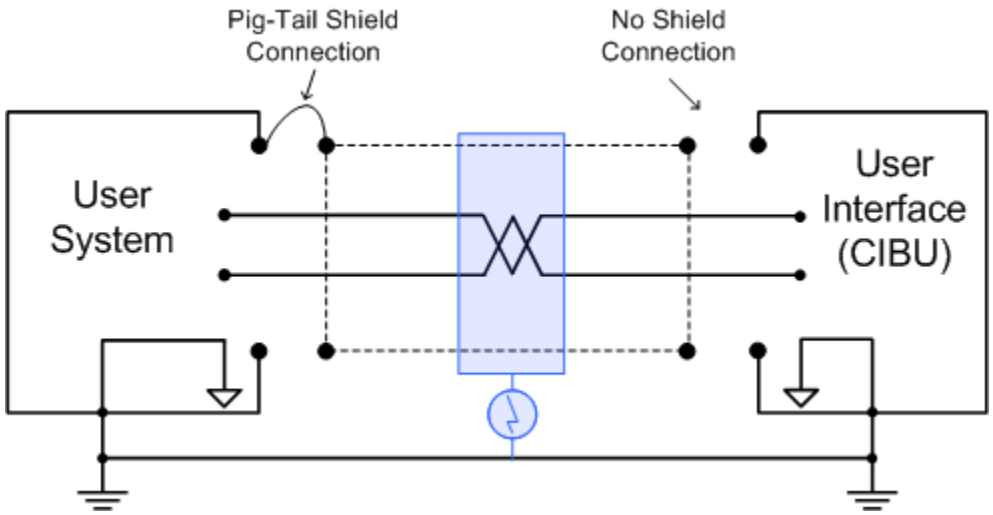
Results

Two Pig-tails, No Ground	Severity Level			
User System Output	**0.5kV**	**1.0kV**	**2.0kV**	**4.0kV**
TRUE	A	A	A	D
FALSE	A	A	A	D

Power PC Crashed – Ethernet Controller Stopped responding

User System to CIBU 3/3

Cable with One Pig-tail Shield No Grounds
E.G. BLM System



Glitches recorded in History Buffer

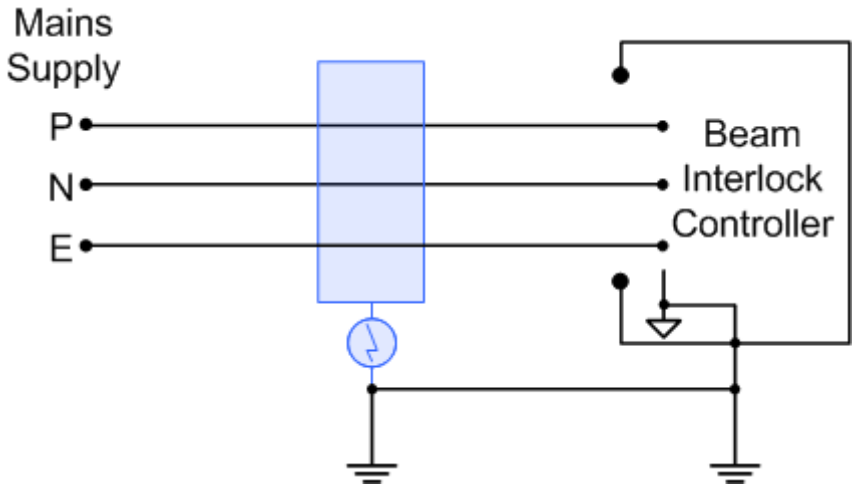
One Pig-tail, No Ground	Severity Level			
User System Output	**0.5kV**	**1.0kV**	**2.0kV**	**4.0kV**
TRUE	A	B	B	C
FALSE	C	C	C	C

Permit FALSE on each salvo

Permit TRUE on each salvo

VME Power Supply

VME PSU, Specified as “IEC-61000 Tested”

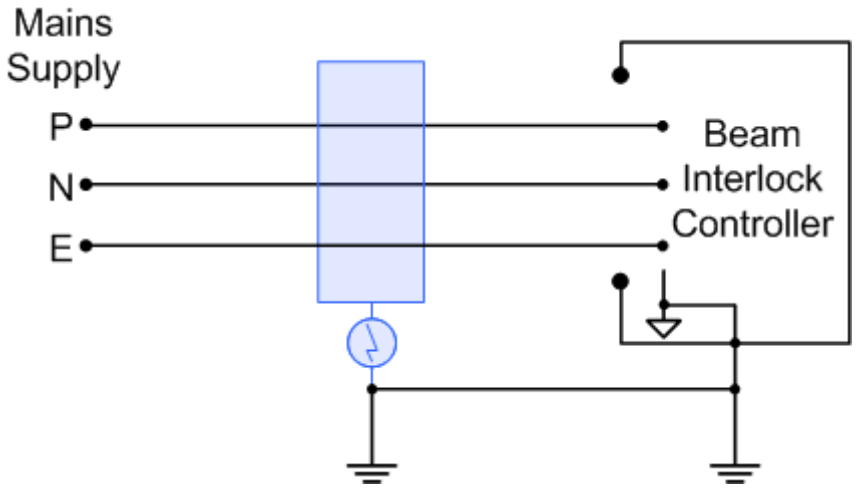


Results

	Severity Level			
	0.5kV	**1.0kV**	**2.0kV**	**4.0kV**
VME PSU	A	A	A	A

CIBU Power Supply

CIBU PSU (CIBD), Specified as “IEC-61000 1kV”



Supply has been double encased, and has mains filter

Results

	Severity Level			
	0.5kV	1.0kV	2.0kV	4.0kV
CIBU PSU	A	A	A	D

Power PC Crashed – Ethernet Controller Stopped responding, SW Permit FALSE

Conclusions

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Areas of Concern

The current loops from CIBU to User System are the weakest link

- If USER SYSTEMS don't follow the rules… it doesn't look good…

The CIBO

- Events seen on the Permit Loop, to be investigated – this was already planned

The Power PC

- Having to power cycle to wake it up… this will be corrected (so I am told)
- The software permit… Does every BIC need one?

The Timing (we also tested Timing Cables with Pablo from AB/CO/HT)

- VME bus errors recorded
- Safe Beam Flag dropped out
- I haven't the complete results, maybe not an EMC problem, but a supply integrity issue?? (Pablo)

The Beam Interlock System was designed for maximum EMC…

The system performance is EXCELLENT if simple rules are obeyed!

A second sequence of tests will be done in the summer
-with upgraded CIBO & complete chassis shielding
-AB/CO/MI will report back to the MPWG then

Lessons Learned from CNGS so far

The CNGS experiment has been excellent for testing the design of the BIS..
And for finding out where we (AB/CO/MI) can improve

In just over two weeks, an interlock system ~1/4 the size of LHC was installed…
…without major issue. (two cables wrong, some fibres missing)

Lesson	Example	
1. Changing things at the last minute is a headache	new CIBM initialisation routine	Lots of extra work. For not much benefit… If it isn't broken, don't fix it
2. Changing things without fully testing them is a bigger headache	new CIBM initialisation routine	Another debug iteration, moving cards back and forth. Wasting time. Every change (no matter how small) means 100% has to be retested
3. Users don't read documents 100%	CIBU to User Cabling	Cabling is not as requested, probably because document is a bit long 30pg Make a single page guide, with accompanying document to explain make EDMS approval for document
4. Documentation is key! 4b. Everyone should agree on work before it's started	CIBM Matrix functionality	Agreed upon, but not everyone understood the same thing Make a paper trail for everything important, even if it squashes "artistic freedom"

Lessons Learned from CNGS so far

5. Installation of a CIBU is not trivial, it needs 4 people	Installing CNGS	Coordination suffers, as everything has to be done by mobile phone… Agree on a rough course of action beforehand… stick to it… plan!
6. User Systems appearing at the last minute are a nightmare	Hadron Stop Cooling	Resource management is hard, because everyone is already busy… and of course everything is urgent Agree beforehand! No more things like this, please!
7. The implementation of the Safe Beam Flag is unclear		Because everyone has their own ideas… And not everything is clear about how it will work… And everyone has already a lot to do, so SLP has suffered. Let's agree on a course of action for the hardware, ASAP
8. The Timing System		For me it is unclear how it all fits together, we need to understand what is possible and what isn't.. and how the necessary safety requirements are achieved See the SLP…!
9. The Software		Software has been tough to debug for the CNGS system, it's never clear if the software is at fault… or the driver's wrong… or the hardware is wrong… or the understanding is missing at some point in the chain. Let's write some simple software specifications.

One last thing…

10. Things that aren't clear

Some questions still remain unanswered, at the system level. If we aren't careful this is going to lead to a 'bricolage' when LHC starts…
Examples are:

-How are we to dump both beams when the LHC is above a certain energy?
We need to break all 4 beam permit loops…

-How do we disable the software interlocks on the BICs that shouldn't use them?

-How do we test the BEAM_PERMIT_INFO – by design it's untestable…

-Beam Permit Loops? Is the 10M vs DC the final solution?

-LBDS Interface collaboration…

These kinds of question, influencing the system level design need answering soon!

FIN