



# Xilinx 9500/9500XL CPLD Testing CNGS 2009



TE/MPE/MI

Radiation Working Group

20<sup>th</sup> August 2009

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## 2004: LHC interlock systems = proto phase

Fast, dependable, simple function

XC9500 CPLD chosen for some parts of interlock system

XC95288 in CIBU (Beam Interlock System) x 300 in LHC

XC95288XL in CIBM (Beam Interlock System) x 34 in LHC

XC95144 in CIP (Power Interlock Controller) x 36 in LHC

AB/PO - each FGC has several

## 2005-9: Reliability campaigns

XC95288 tested in PSI

½ LHC system used in SPS for 4 years

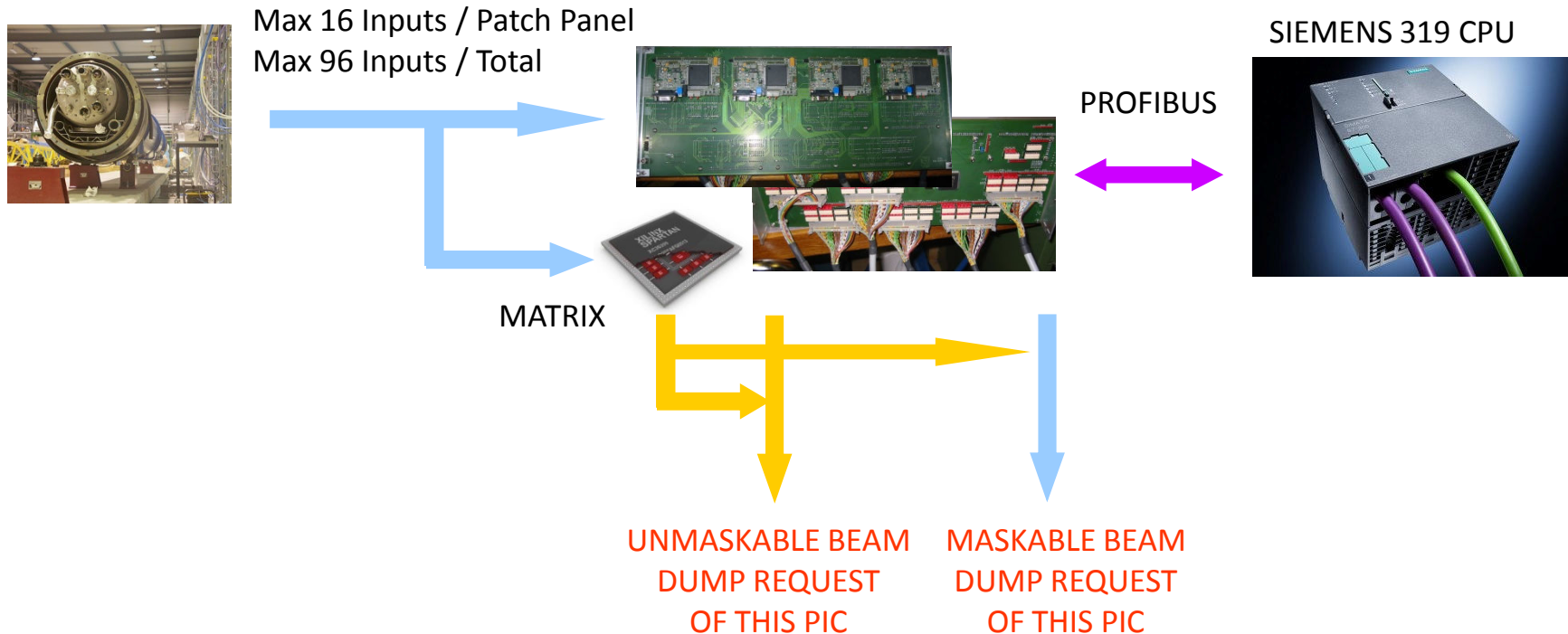
Full LHC system started for 2 years

All looking good 😊

## 2009: R2E Warning regarding radiation in zones considered OK

CNGS test campaign launched to quantify the risk

Interlock Radiation Test Bench



XILINX XC95144 CPLD used for redundancy and speed in beam dump request for Powering Interlock System (PIC)

36 CPLDs used in 36 different installations in the LHC (located in UAs, UJs and RRs)

- Critical Path: Matrix for up to 96 inputs, generating 3 beam permit signals
- Monitoring part: Read-back of Matrix configuration, Glitch Filters, CRCs, SW versions,..

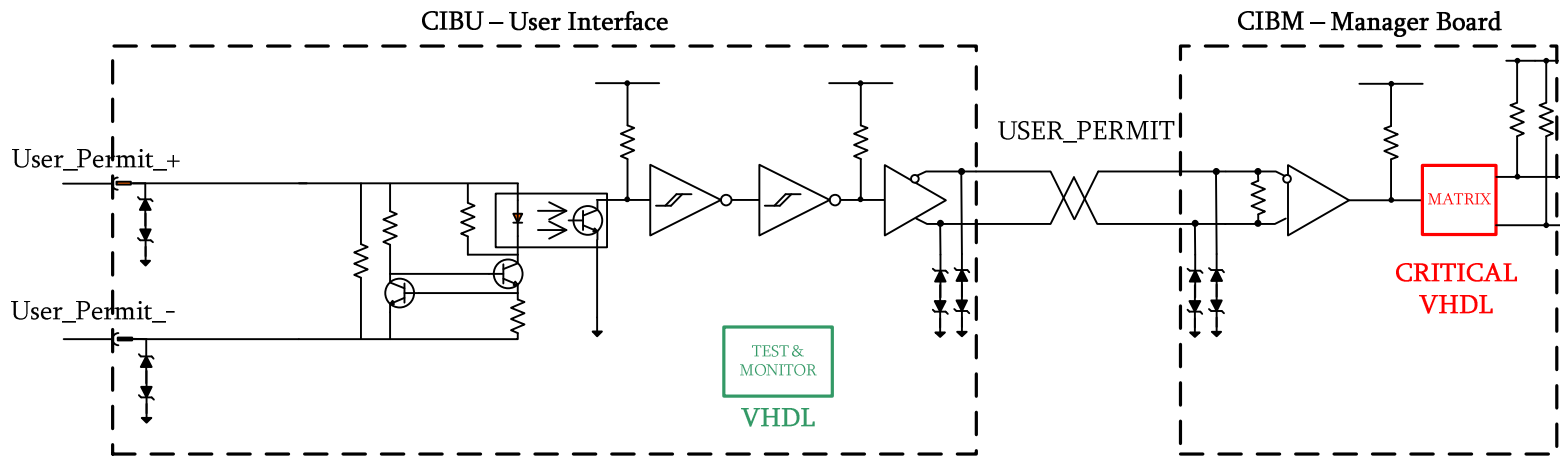
Due to redundant designs throughout the system, CPLD failures would decrease primarily the AVAILABILITY of the machine, not the safety

CIBU

1U chassis

CIBM

VME Chassis

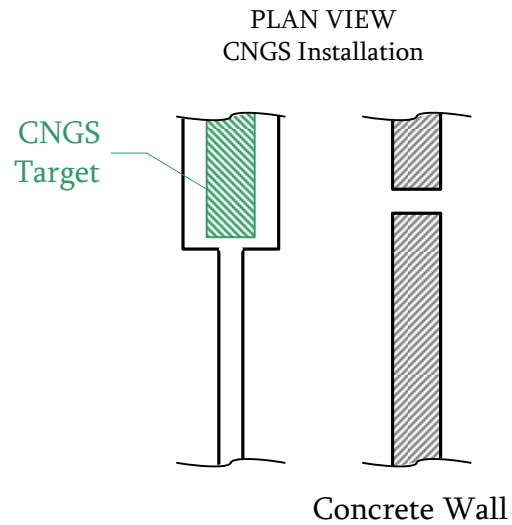


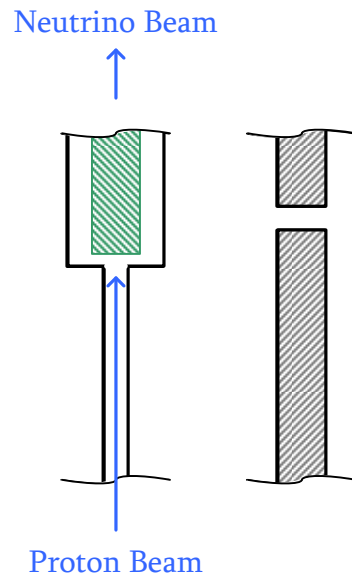
XC95288 = Not safety critical

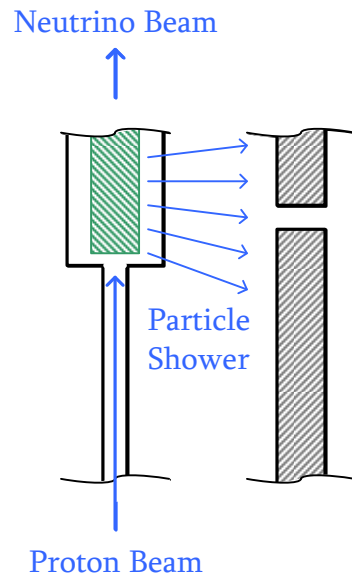
300 in LHC

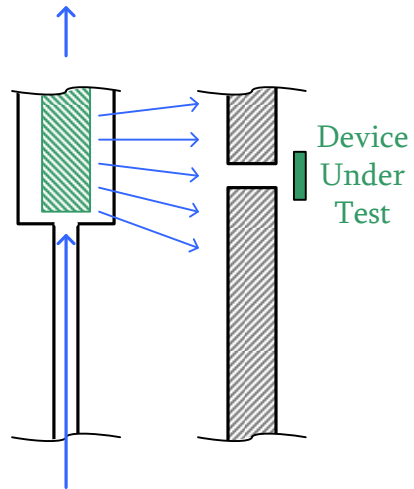
XC95288XL = safety critical

34 in LHC

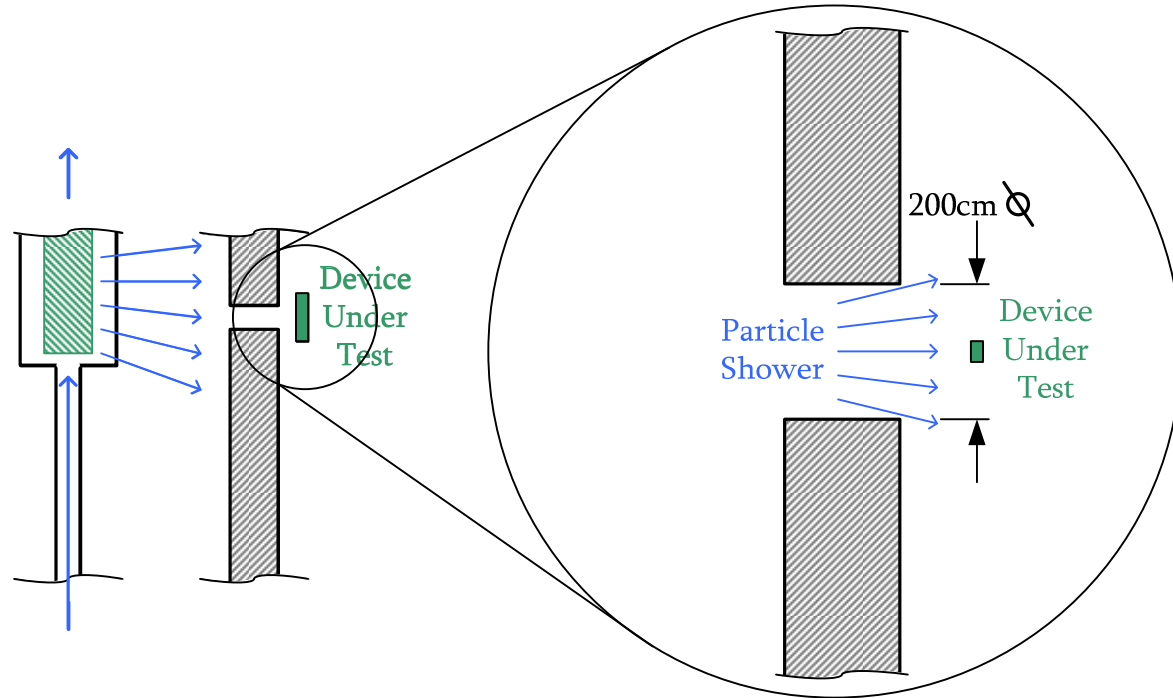


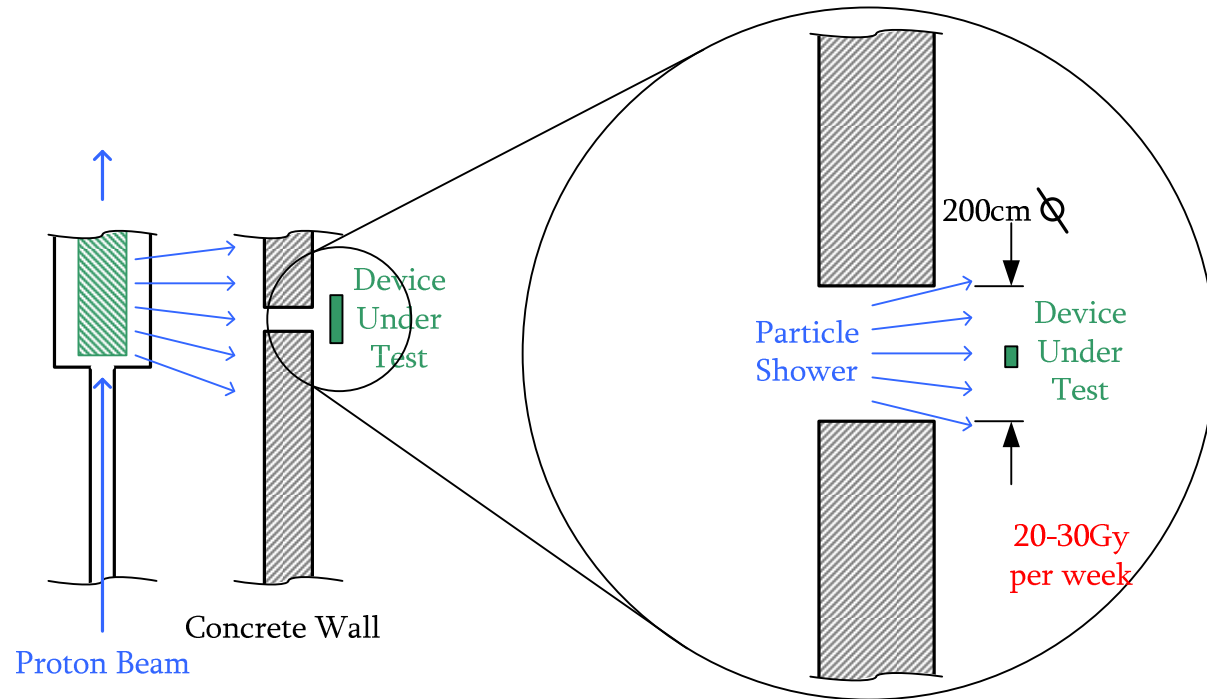


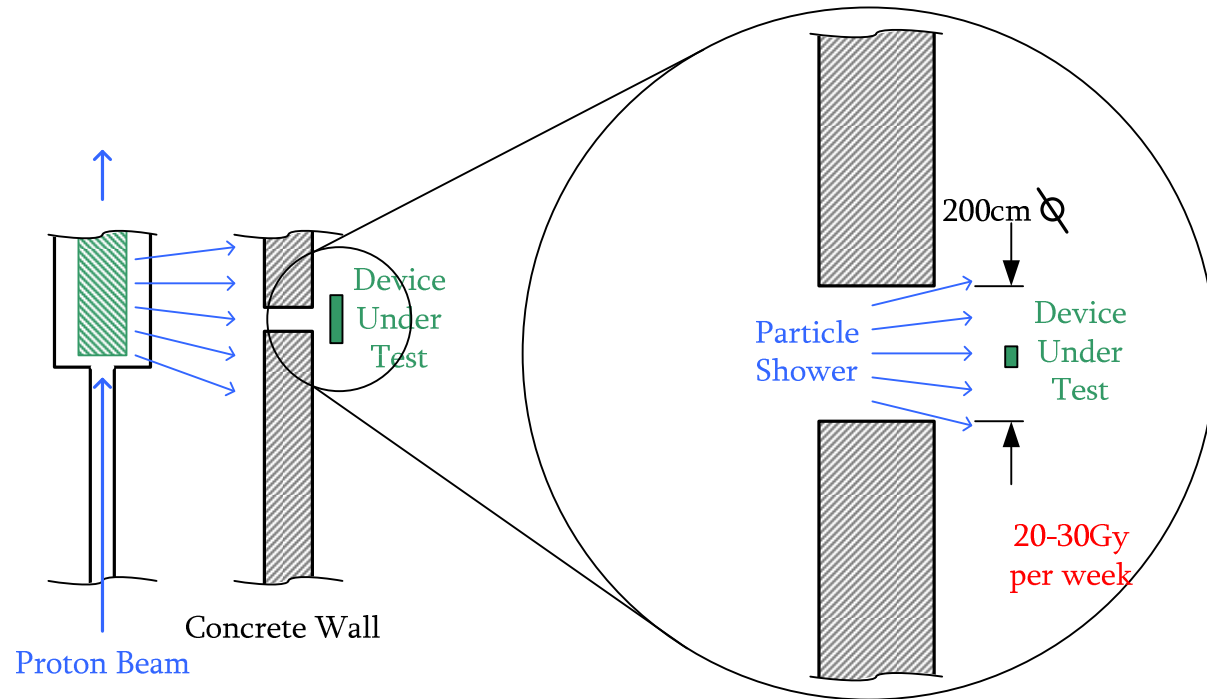




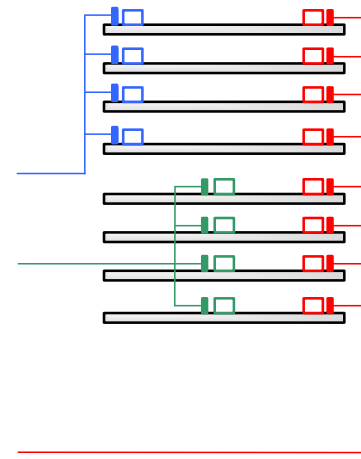




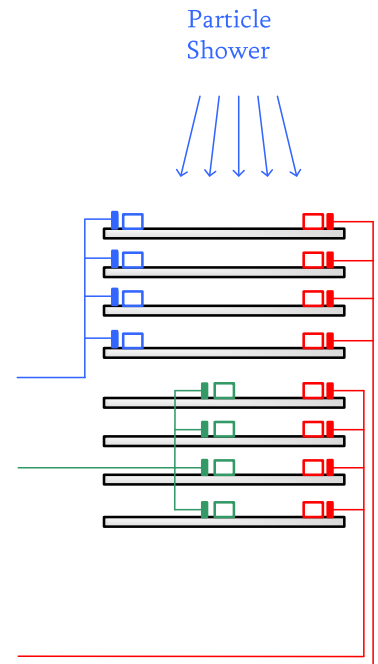


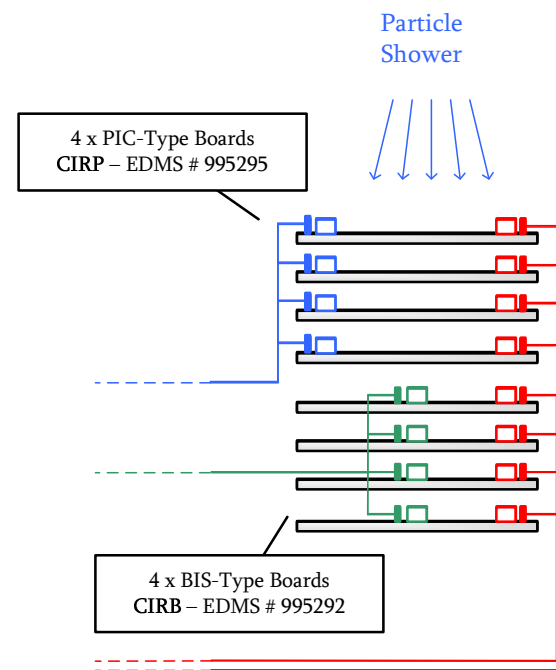


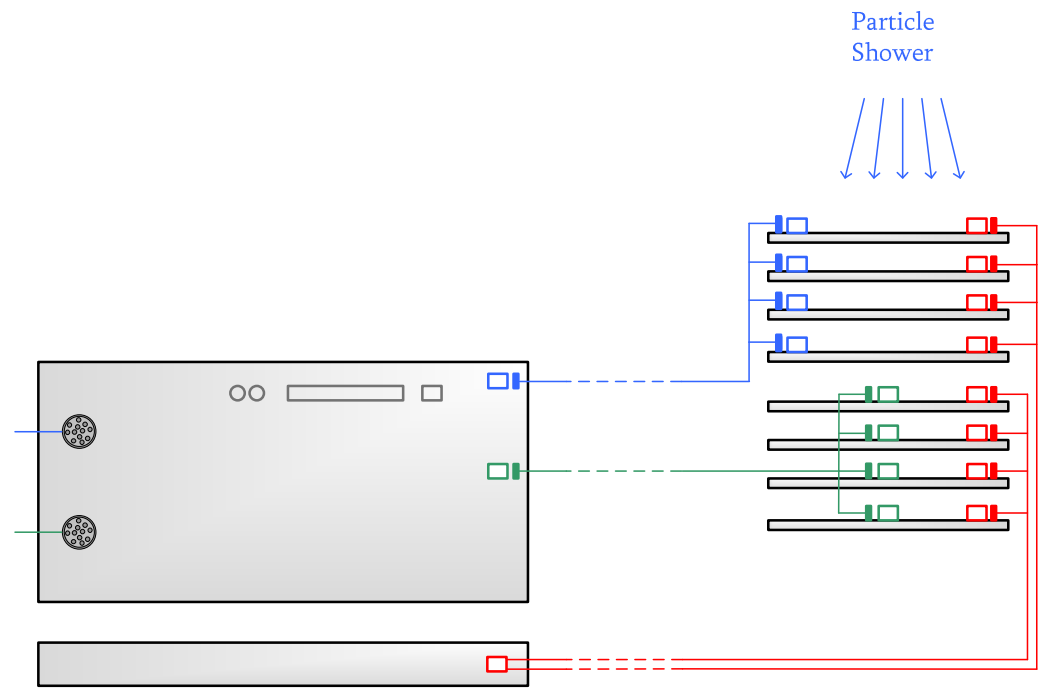
XC95144 x 32  
XC95288XL x 32

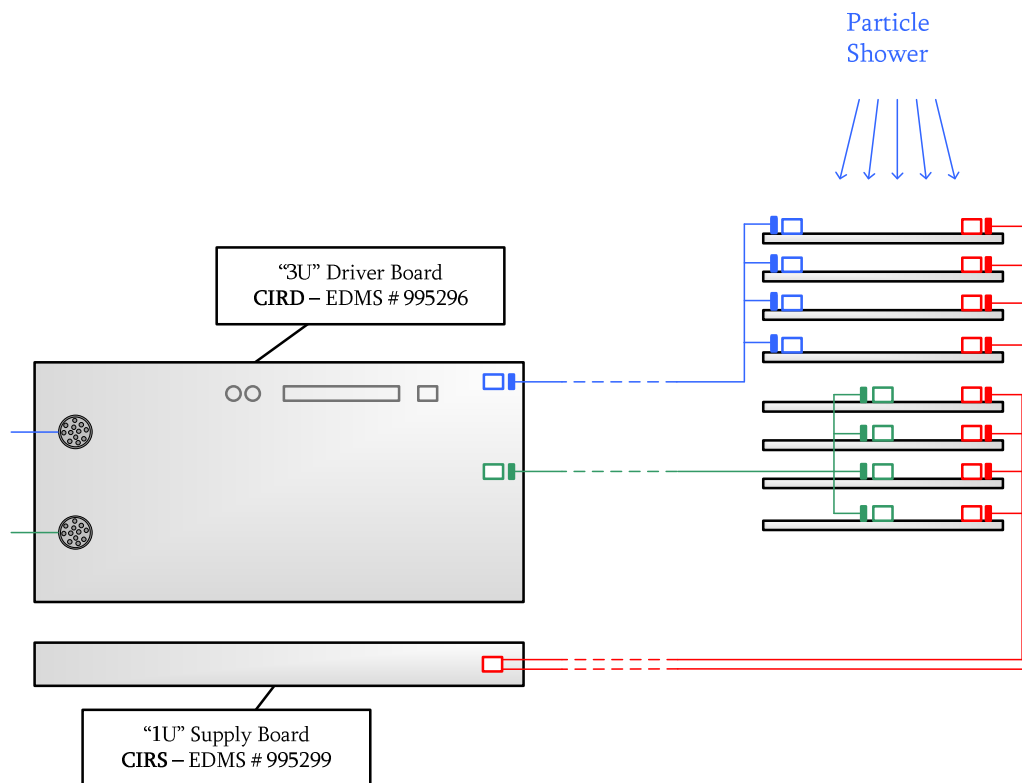


XC95144 x 32  
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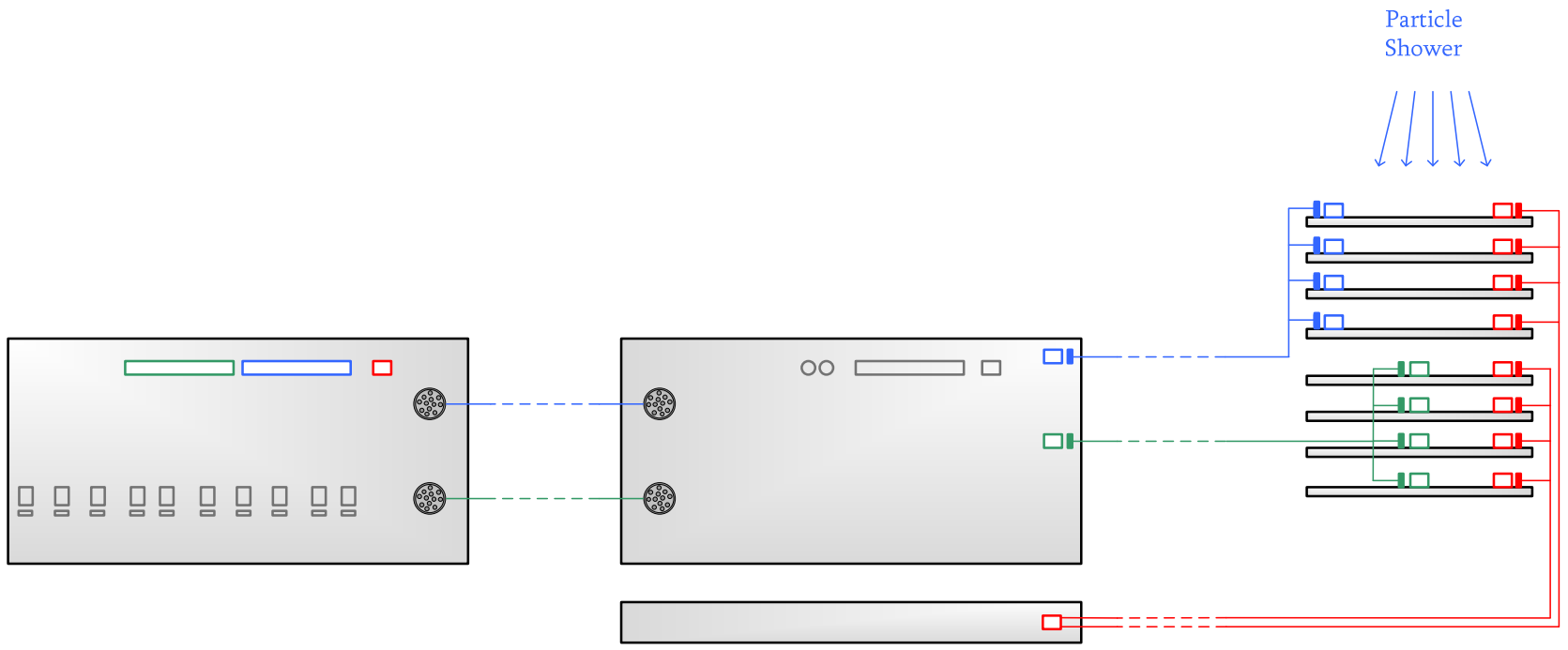


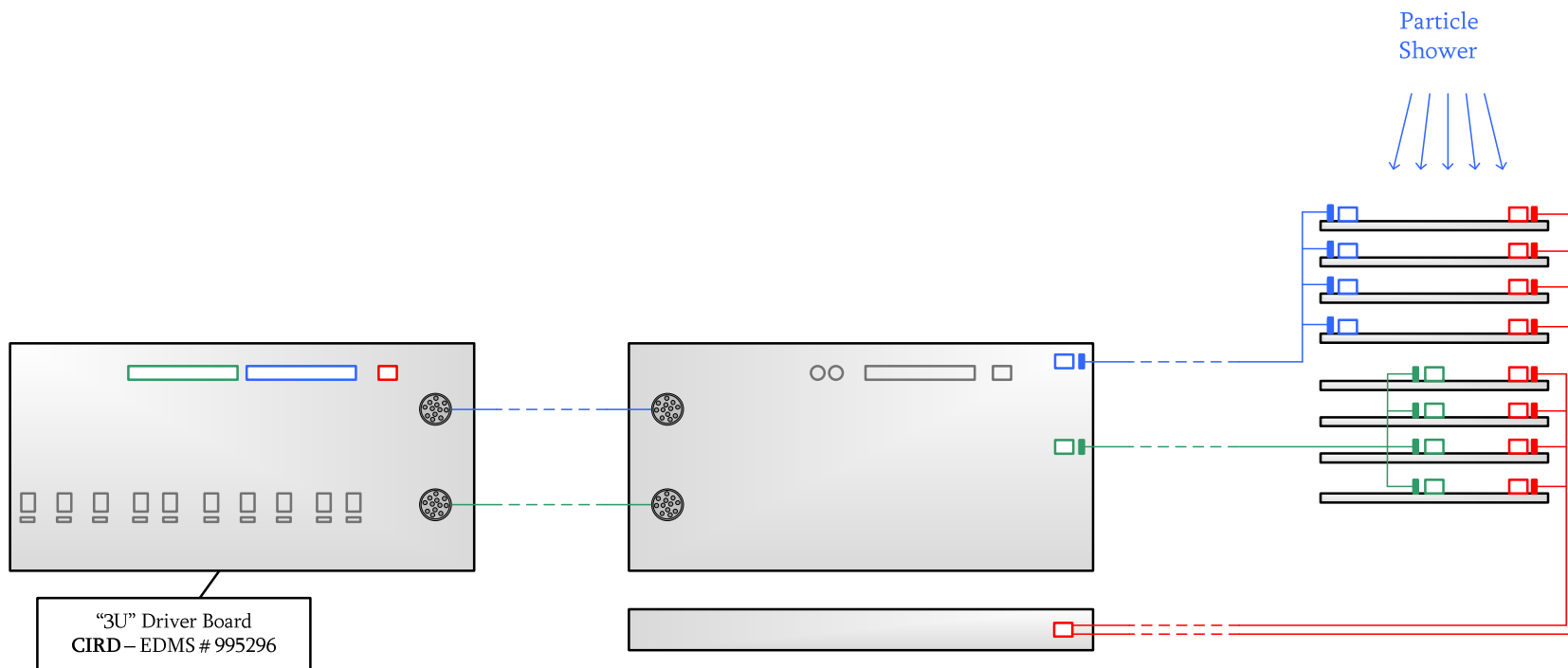


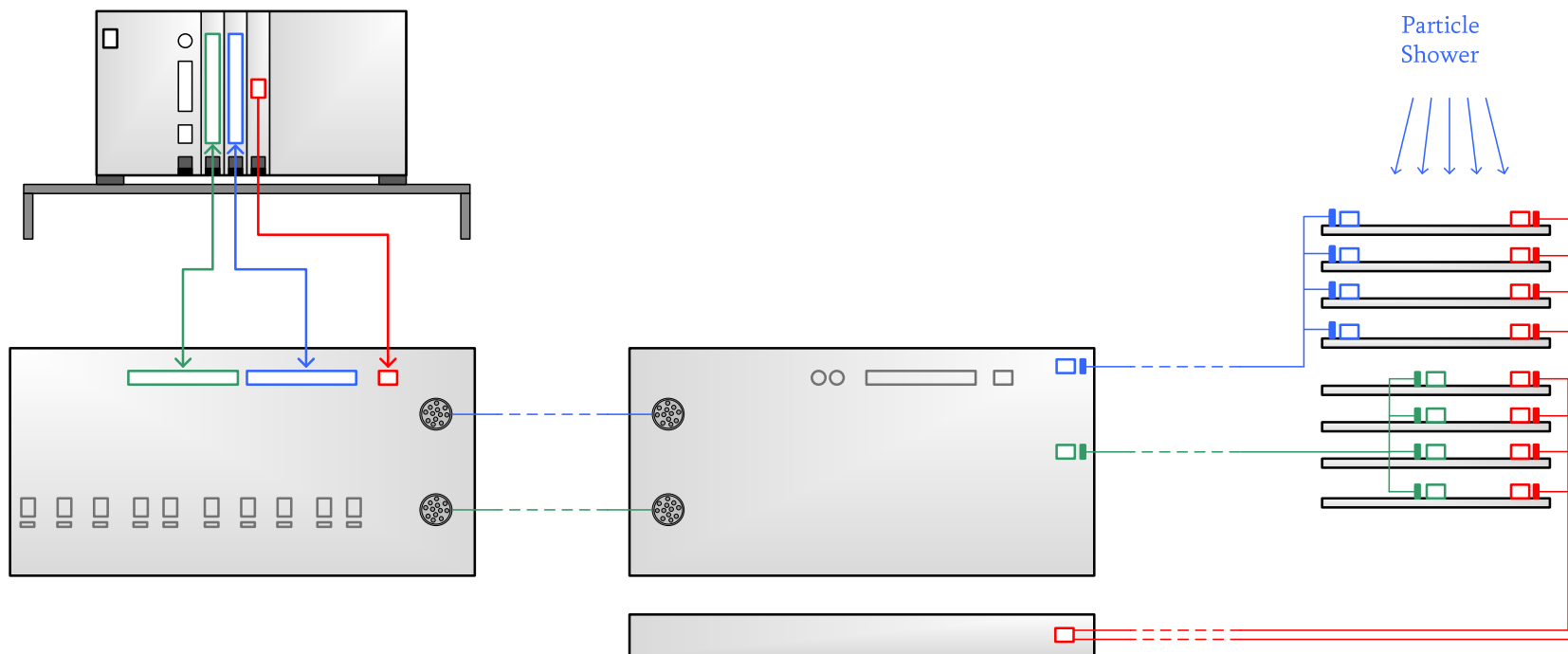


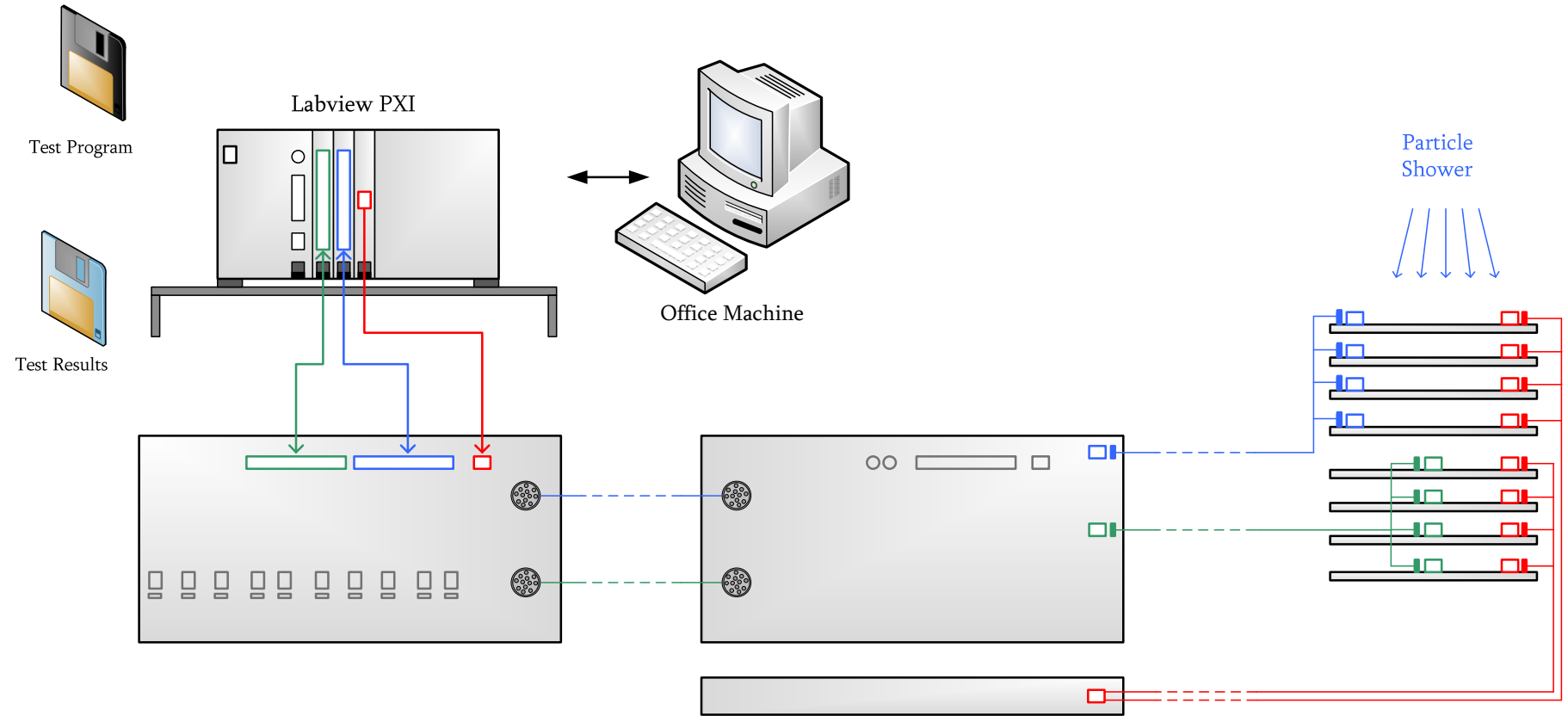


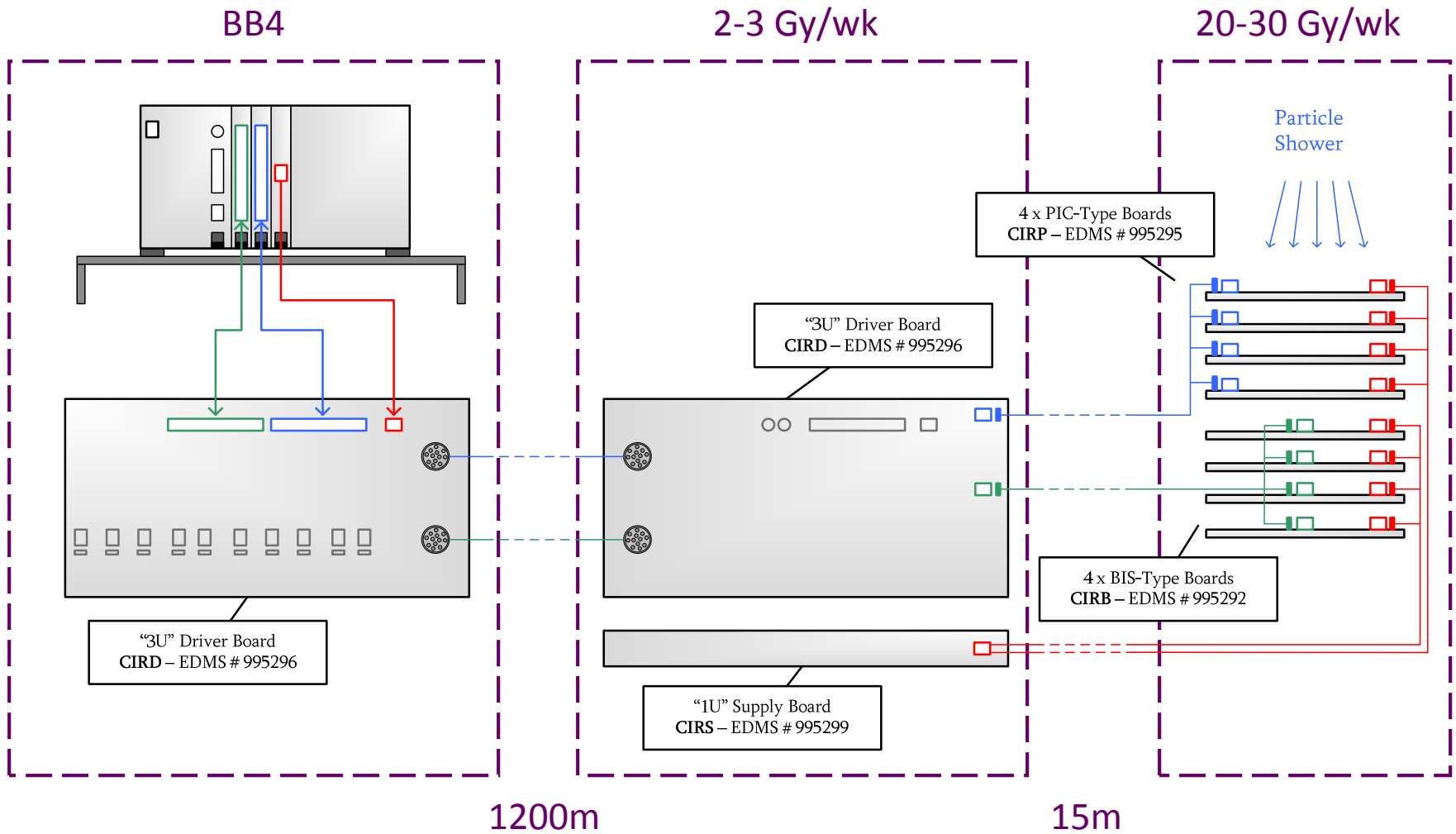




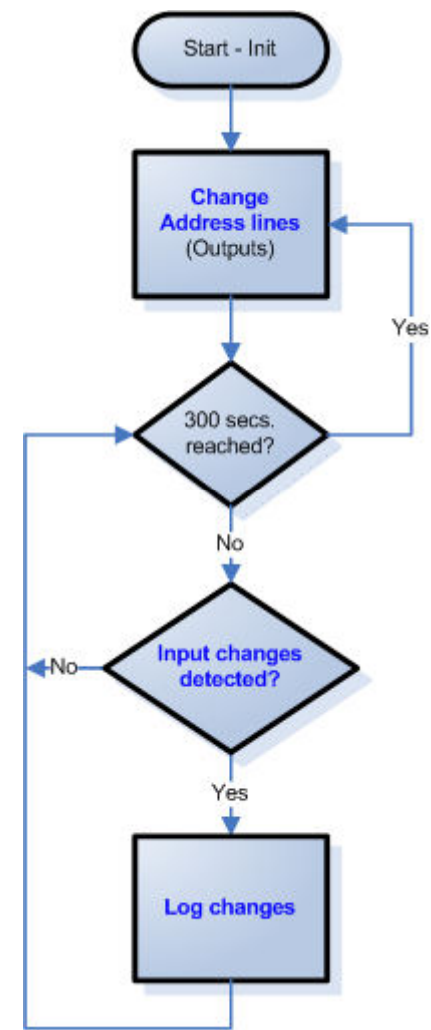
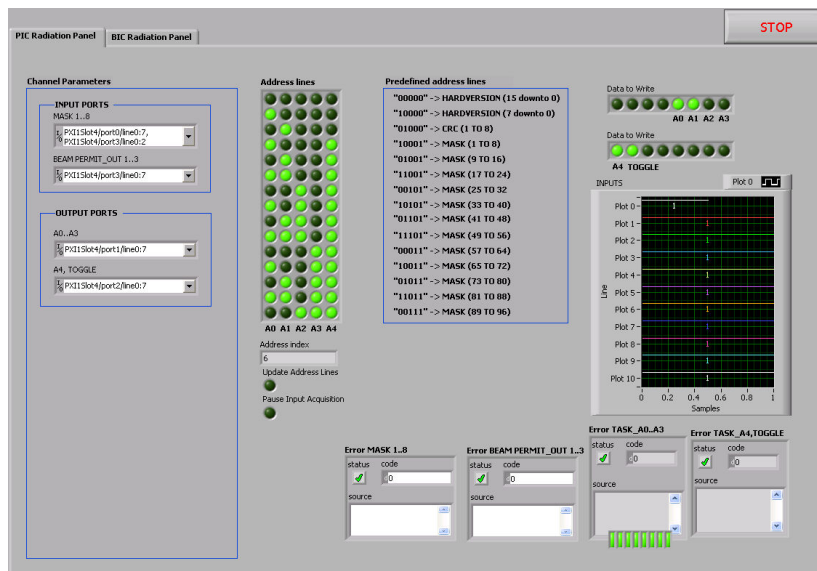




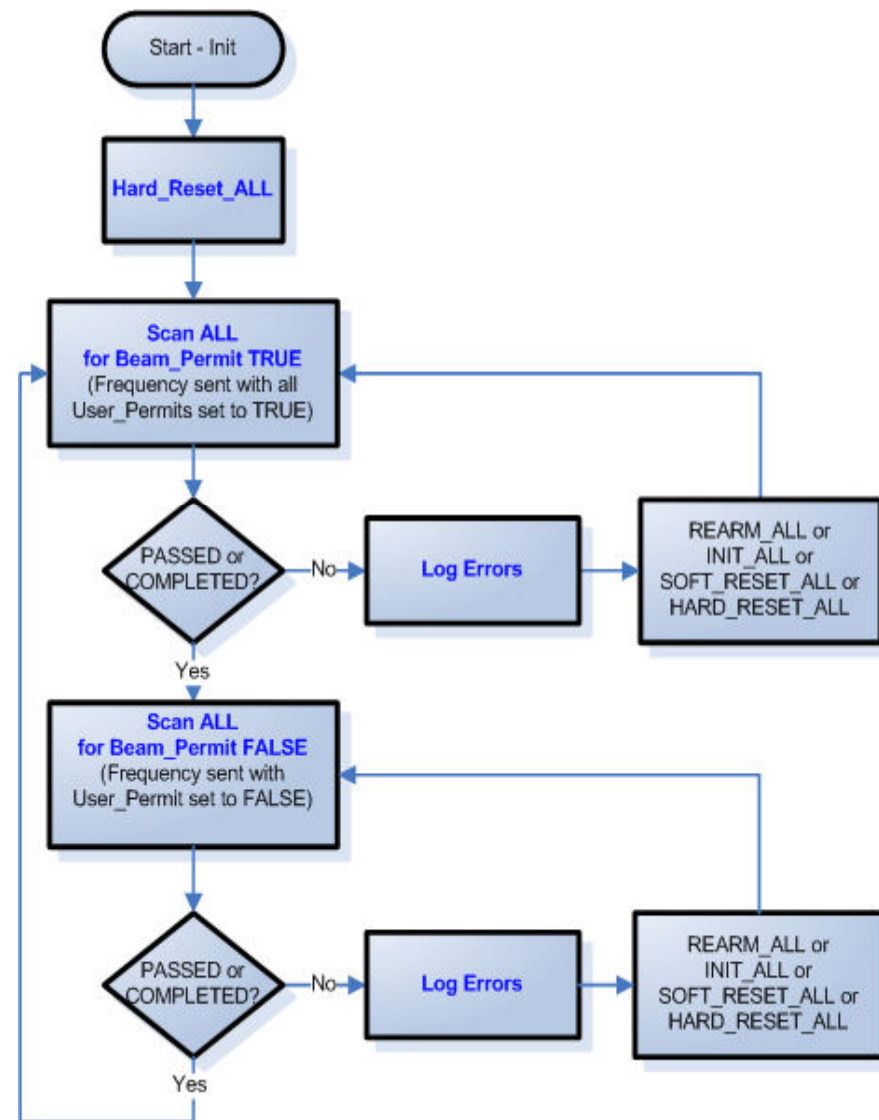
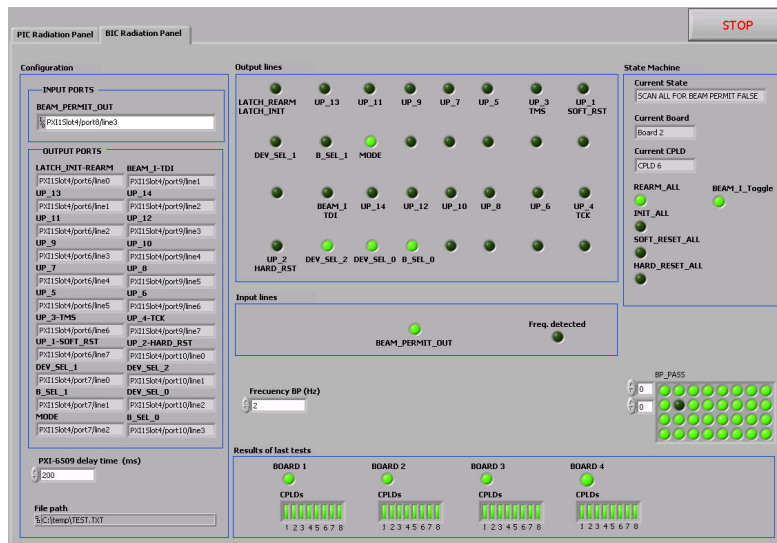




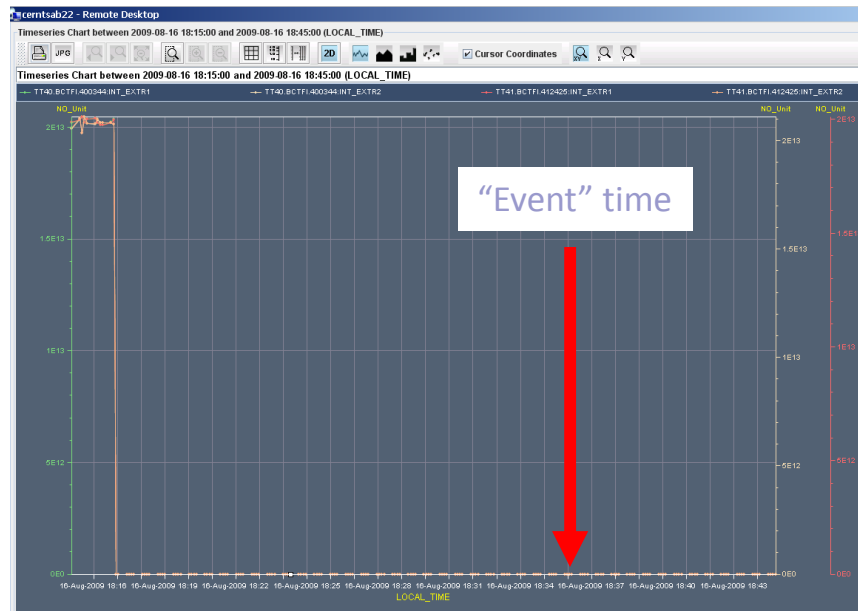
- 96-Channel Digital I/O Board used for detecting changes on:
  - Critical Path (3 Beam Permit signals)
  - Monitoring Part (CRCs, Glitch Counters, Versions....)
- Change detection on Inputs detected with events (no polling is used = less processor usage)
- Address lines (Outputs) change every 300 seconds
- Log-file written in case of inconsistency in the outputs of CPLD (XNORs)



- 96-Channel Digital I/O Board used for :
  - Scanning all 32 CPLDs for frequency detection when all User\_Permits are TRUE
- Log-file is written in case of inconsistency in Beam\_Permit frequency



- 3 'events' in MONITORING PART have been observed since re-start of CNGS with beam, NONE in the safety critical part
  - 15.August 2009 (03:12:08.0289 ) - According to Logbook & TIMBER with beam in CNGS (2E13)
  - 16.August 2009 (15:33:13.7339) - According to Logbook & TIMBER with beam in CNGS (2E13)
  - 16.August 2009 (18:35:46.0737) - According to Logbook WITHOUT beam in CNGS (since 20 minutes)
- Events seen more likely to be due to EMC problems (longer cables, especially the 5m flat cable in CNGS using TTL, shielding issues of NE48 as observed by PO)?
- Will continue to improve SW and exclude problem sources to have clarity (maybe small intervention in tunnel during next shut-down)





- Have seen constant events in the log-file since 15:00 on day of installation
- False Beam Dumps
- Missed Beam Dumps
- Periods without beam in SPS = no errors...

#	Group	Fault	Element	Description	Begin
1	CPS	LINAC2	Linac Intervention	...	19/08/2009 16:23:09
2	BT	Kickers	MKD status	...	19/08/2009 17:09:54
3	RF	RF	TRX3	...	19/08/2009 16:01:01

#	Group	Fault	Element	Description	Begin
1	SPS	1	Louis. Rene		15:00
2	SPS	3	No beam, transmitter 3 tripped, after reset ok		16:01
3	SPS	1	Beam back		16:05
4	SPS	1	No beam		16:23
5	SPS	1	Beam back		16:57
6	SPS	2	No beam		17:09
7	SPS	2	Beam back		17:11

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Copy (2) of TEST - Notepad
File Edit Format View Help
19/08/2009 16:11 3 5 FAILED INIT ALL REQUIRED BEAM PERMIT TC
19/08/2009 16:14 0 2 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:14 1 4 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:14 3 5 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:16 2 0 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:16 2 1 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:16 3 0 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:16 3 5 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:19 3 5 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:19 3 6 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:21 2 0 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:24 0 7 FAILED SOFT RESET REQUIRED BEAM PERMIT TC
19/08/2009 16:29 0 ALL ALL PASS NO ACTION REQUIRED SCAN_ALL_FOR_E
19/08/2009 16:46 ALL ALL PASS NO ACTION REQUIRED SCAN_ALL_FOR_E
19/08/2009 16:48 ALL ALL PASS NO ACTION REQUIRED SCAN_ALL_FOR_E
19/08/2009 17:05 ALL ALL PASS NO ACTION REQUIRED SCAN_ALL_FOR_E
19/08/2009 17:07 0 7 PASS REARM REQUIRED SCAN_ALL_FOR_BP_TRUE
19/08/2009 17:09 2 5 PASS INIT REQUIRED SCAN_ALL_FOR_BP_TRUE
19/08/2009 17:09 3 1 PASS INIT REQUIRED SCAN_ALL_FOR_BP_TRUE
  
```

- Software will be further optimised to get rates/ratios

TE/MPE/MI take the radiation issue seriously

Dedicated testbench designed

Considerable effort

1. We need some time in the next access window to check our equipment
2. XC9500XL = one event every 3 minutes  
(this is in a BIC VME Chassis)
3. XC9500 = one event every 2 days  
(this is in a PIC and User Interface Chassis)
4. Enhance software
5. Establish rates and ratios

## CIBU : User Interface Locations

IR1	IR2	IR3	IR4	IR5	IR6	IR7	IR8	other
SR1	SR2	SR3	SR4	SR5	SR6	SR7	UA83	CCR
US151	UA23	UJ33	UA43	UJ56	UA63	UJ76	UA87	
USA151	UA27		UA47	USC55	UA67	TZ76	UX85	
USA152			SX4	RR53	US65	RR73	US851	
RR13			CR4	RR57	US651	RR77		
RR17			US451					
UJ14								
UJ16								

“critical areas”

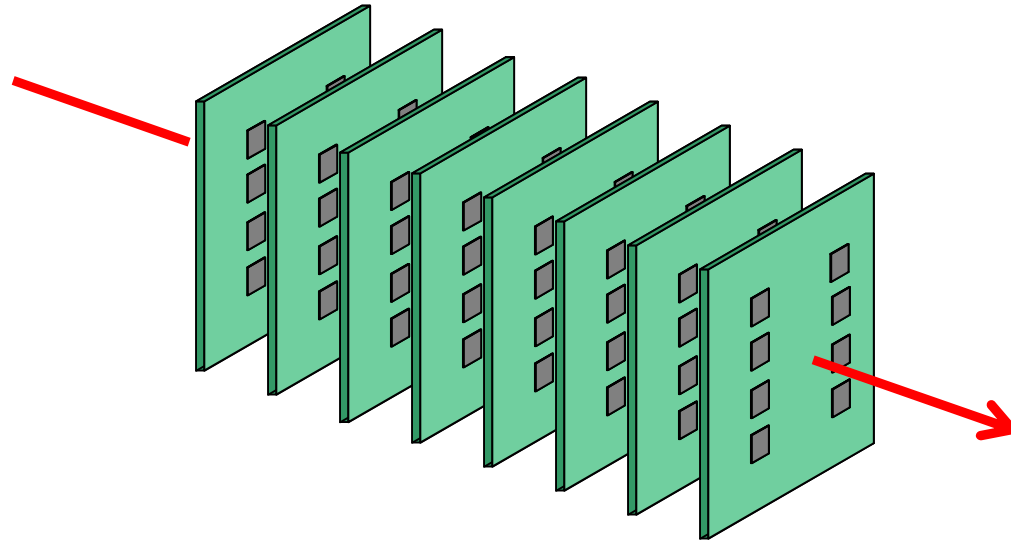
## BIC : Beam Interlock Controller Locations

IR1	IR2	IR3	IR4	IR5	IR6	IR7	IR8	other
US15	SR2	SR3	UA43	UJ56	UA63	SR7	SR8	CCC
	UA23	UJ33	UA47	UCS55	UA67	TZ76	UA83	
	UA27						UA87	



FIN

- 4x8 = 32 CPLDs on dedicated CIRP boards installed
- Identical SW as used in the LHC devices, with dedicated remote monitoring/readout facility (RS485 line drivers and PXI chassis in control room)
- LabView program will change every 300s address lines and input states of the CPLD (throughout all possibilities as used in LHC)
- Setup is constantly comparing against each other the outputs of all 32 CPLDs and will detect and log any output change (along with the current input settings)
- Readout of critical path (Beam Permits) separated from Monitoring part



particles pass through consecutive boards

K. Rooed simulations show 20-30% error in fluence due to this