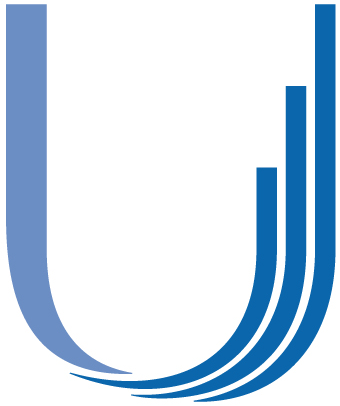


LHC Injectors Upgrade

LHC Injectors Upgrade

Beam Loss Monitoring & Observation

Review of the development, installation and commission plans

christos.zamantzas@cern.ch

CERN

Global Overview

Machine/Area		Documentation	Detectors	Electronics	Installation & Commissioning	Budget	Expected
PSB	Ring (L2 position)	Complete	LHC-IC	Pre-series	On-track	Incomplete	LS1
	Injection & BI Line	Complete	LHC-IC/LIC	Pre-series	Initialising plan	Incomplete	L4C
	Injection (obser.)	Complete	Diamond	TBD	Initialising plan	Incomplete	L4C
	Ring (L3 position)	Complete	FIC	Series	Not started	Incomplete	LS2
	Extraction	Complete	LHC-IC	Series	Not started	Incomplete	LS2
PS	Ring	Only positions	LHC-IC	Series	Not started	Unallocated	TBD
	Ring (observation)	Only positions	Diamond	TBD	Not started	Unallocated	TBD
	Transfer Lines	Only positions	LHC-IC	Series	Not started	Unallocated	TBD
SPS	Ring & Tr. Lines	Advanced	SPS-IC	TBD	Not started	to be verified	LS3
	TT10	Complete	LHC-IC	Series	Not started	Unallocated	TBD

- Plans for LS1 & L4 Connection are clear and agreed.
  - Update of budget needed (times and amounts).
  - Will validate pre-series version of electronics with beam.
- Plans for LS2 and beyond need input and budgets (inc. manpower).

Specifications

Specifications

- **Detector** types and quantities to be used – all defined.
- **Cables** and connections – majority has already been sent to EN/EL.
- **Electronics**
  - use the pre-series production for LS1 and L4 connection needs.
  - use series production for LS2+ (i.e. validate electronic design beforehand).
  - acquisition system for Diamond detectors under study.
  - acquisition system for SPS system under study.

Machine/Area			Detectors		Cables		Electronics	
		Channels	Type	Budget	DIC	Budget	Type	Budget
PSB	Ring (L2 position)	32	LHC-IC	Spares	Sent	LIU	Pre-series	CONS
	Injection & BI line	18	LHC-IC/LIC	Spares	Sent	LIU	Pre-series	LIU
	Injection (obser.)	8	Diamond	LIU	Draft	LIU	TBD	LIU
	Ring (L3 position)	32	FIC	LIU	Sent	LIU	Series	CONS
	Extraction	28	LHC-IC	Spares	Sent	LIU	Series	LIU
PS	Ring	100	LHC-IC	LIU	Sent	LIU	Series	LIU
	Ring (observation)	40	Diamond	LIU	Draft	LIU	TBD	LIU
	Transfer Lines	51	LHC-IC	LIU	Sent	LIU	Series	LIU
SPS	Ring + Tr. Lines	500	SPS-IC	Re-use	TBD	LIU	TBD	LIU
	TT10	30	LHC-IC	LIU	Sent	LIU	Series	LIU

Acquisition & Processing

- **Synchronisation** is **required** with the **start of the cycle** to
  - Perform calculation of integration periods and
  - Schedule comparisons with their corresponding threshold values
  - Record high frequency observation data
  - Schedule the data readout and publish by the CPU

- **Synchronisation** to be **achieved** by
  - Use the Start of Cycle event received through the timing system.
  - Dedicated timing card with broadcast in the backplane.
  - Sync will be done at the processing level (i.e. 2 samples jitter between cards).

Integration Periods

Continuously the processing electronics will calculate 4 **integration period values** for each channel:

- **2 µs**, **400 µs**, **1 ms** and **1.2 s** (full cycle)
  - implemented as moving sum windows in the hardware
  - calculation refreshed at acquisition frequency
- Compare with predefined thresholds
  - **Machine protection** with hardware implementation comparisons on each refresh
  - **Limit radiation levels** with software implementation comparisons at end of cycle
  - See also next slide.
- Calculate for each channel the maximum values recorded on each integration period during the cycle
  - Publish them for the online displays and
  - the long-term logging

Threshold Comparisons

Hardware implementation part:

- All calculated **integration period values**, i.e from **2 μs** to **1.2 s**, will be constantly checked against their threshold values:
  - 4 threshold values, one for each of the integration periods.
  - Comparisons happen at the refresh period – that is, every 2 μs
  - In the case the measured values exceed those the beam permit signal will be removed for **all users**
  - The **blocked** beam permit signal will be **latched** until an operator acknowledges.
- The **threshold values** will be need to be set **unique per channel:**
  - Each card will process 8 channels

Software implementation part:

- All maximum **integration period values** recorded on the cycle will be checked against a second set of threshold values. The outputs will be used for **repeated over threshold function**
  - Additional threshold values for the same integration periods will also be required.
  - In the case found to be over threshold repeatedly *n* times it will be required to block **that user's injections**.
  - The **blocked** beam permit signal will be **latched** until an operator acknowledges.
  - The repeat value *n* will be settable per monitor in the range of 1 to 16.
- The **threshold values** will need to be **unique per user and per channel:**
  - Each CPU will process 8 cards x 8 channels
  - The information of the current user has to be obtained from the telegram per cycle -> dedicated **timing card**
  - Memory for 32 users will be reserved.

Beam Permit Logic

- System [HW and/or SW] will **block** injections
  - i.e. "remove permit" if losses over threshold
- System [SW] will **remember** if the user is allowed to have beam
  - i.e. "give permit" if previous cycle for the user was ok (or previous interlocks were cleared)
- The Beam Interlock Controller will be configured in the "Non-latch" mode.
  - i.e. the system will need to follow timing and notify in advance.
- Aiming to keep the maximum **latency** (from measurement to output) small
  - HW: The target for the fast integration periods is ~ 5 µs
  - SW: Block on next cycle
- Only data from the **current cycle** need to be considered.
  - Timing in the electronics essential (i.e. possible failure mode)

Ambient Radiation Measurement

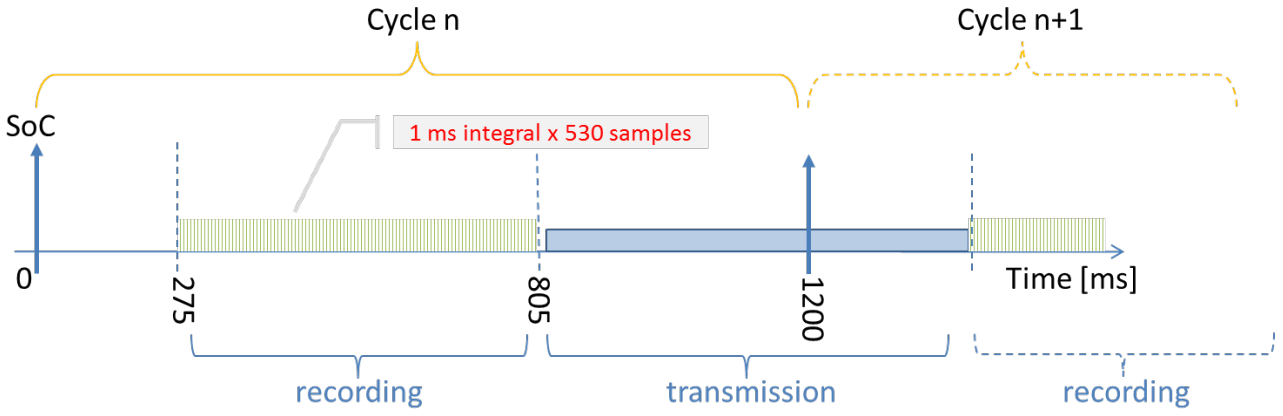
Calculate and log the ambient radiation measured at each cycle

- Processing electronics will provide two values:
  - total accumulated in the cycle (already described) and
  - total accumulated with beam present
- Subtraction of the two values in CPU
- Additional timing events to be used for the recording
- Values will come together with number of samples used in the recording to allow accurate conversion to user-friendly units, i.e. Gy, Gy/s, …
- Publish values for the online displays and the long-term logging

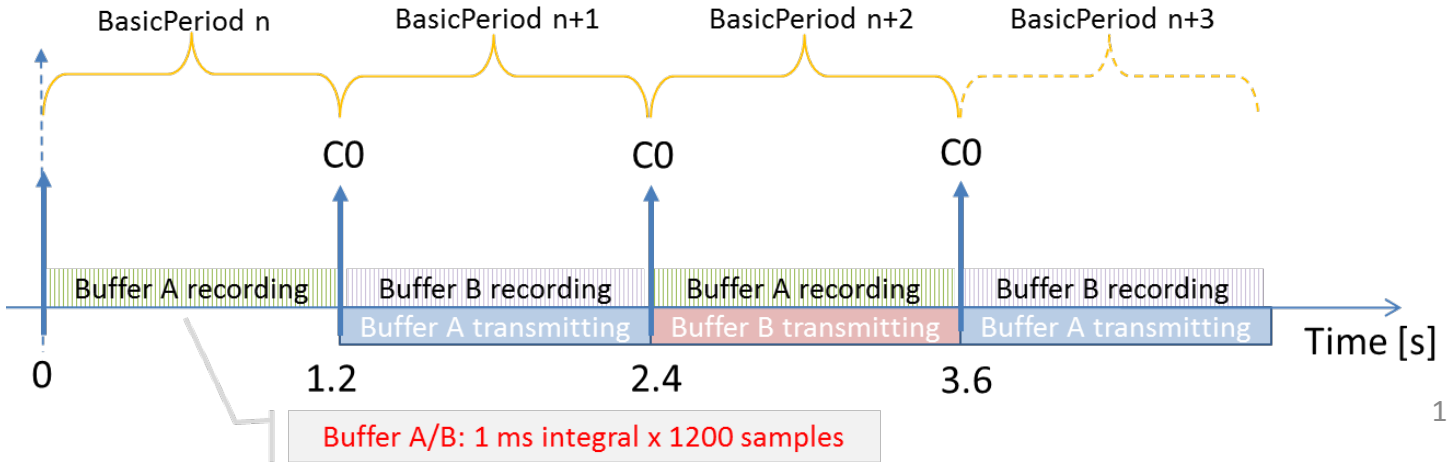
Evolution Over Time buffer

- The system will continuously record multiple consecutive values from each detector over a predefined period.
  - Publish on the online displays and logging on demand

PSB

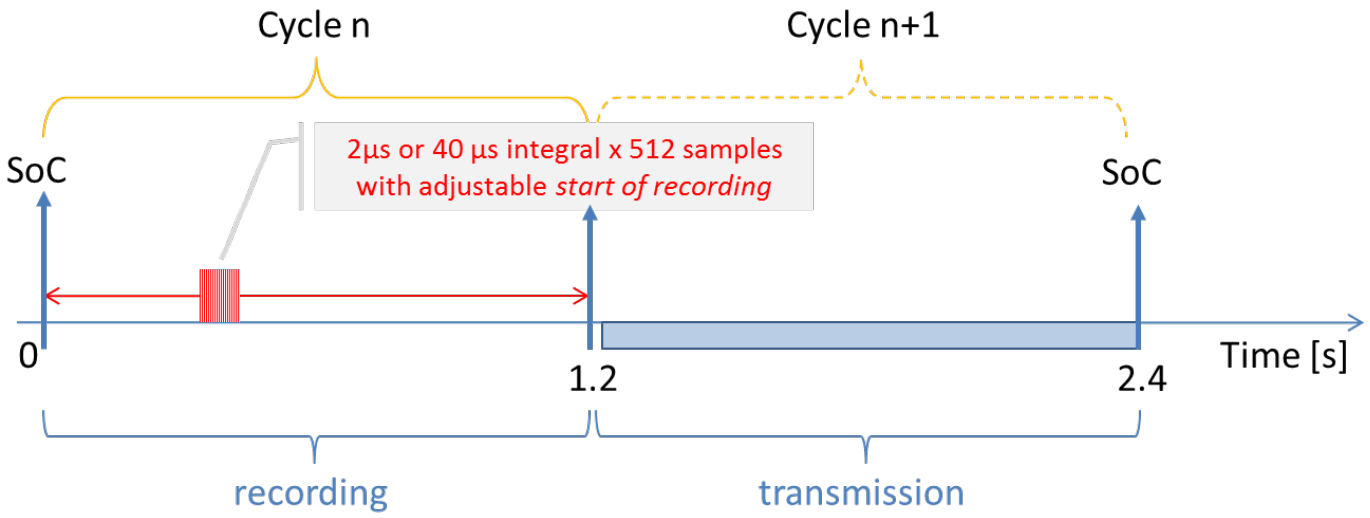


PS & SPS



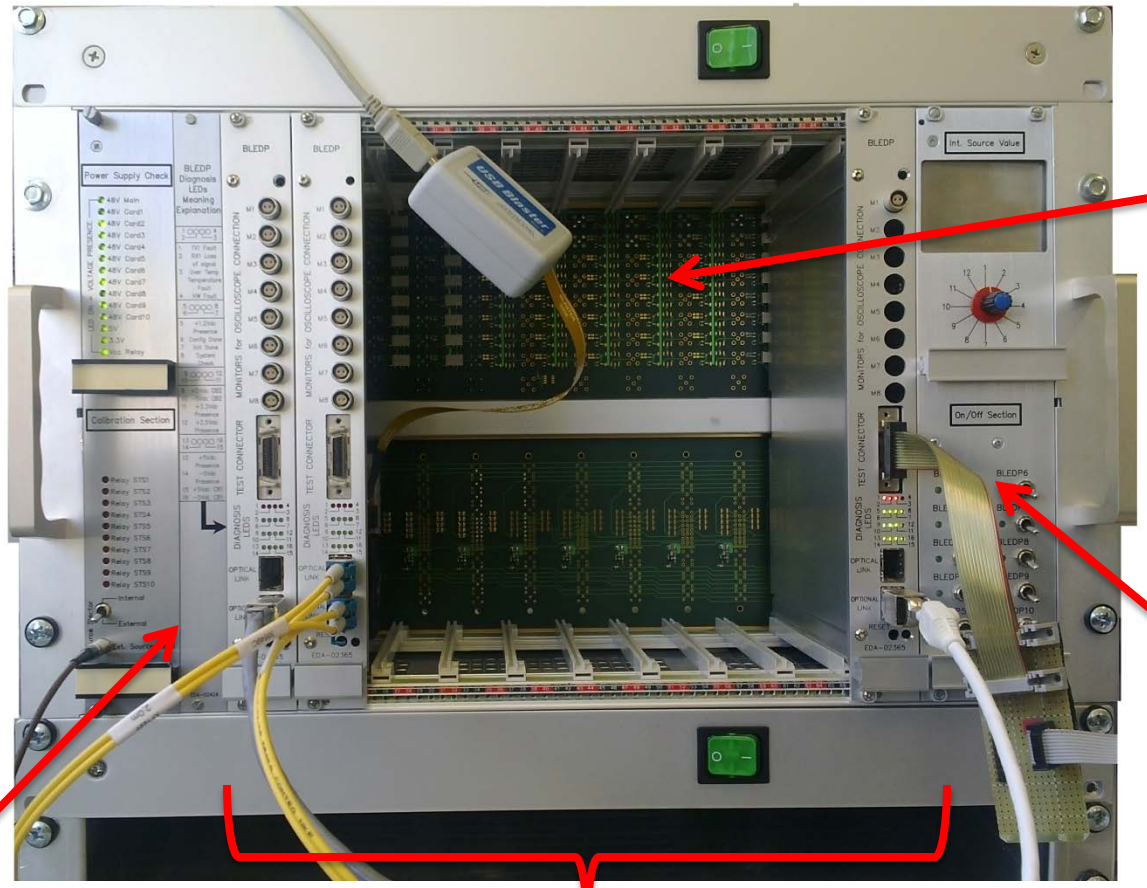
Capture function for PSB & PS

- The system will publish on-demand high resolution time evolutions of the beam losses for each detector.



Status of Development

Acquisition Crate



Custom Backplane
Support 64 connectors and relays for the input channels and distribute signals

Control Unit
Later version w/ advanced remote functions

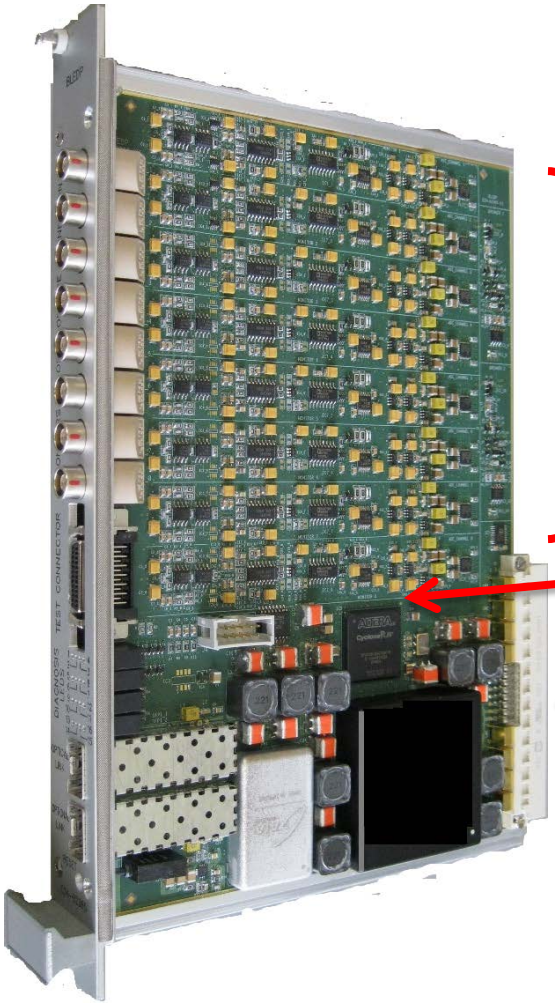
Main panel
- Ref. current Input
- LEDs
- Power switch

Acquisition module (BLEDP)
Up to 8 modules with 8 channel each

Acquisition module (BLEDP)

Completed verification of version 2 of the printed circuit board

Completed design of version 3.
- Noise reduction



Acquisition
digitisation of 8 channels

FPGA
Altera Cyclone IV

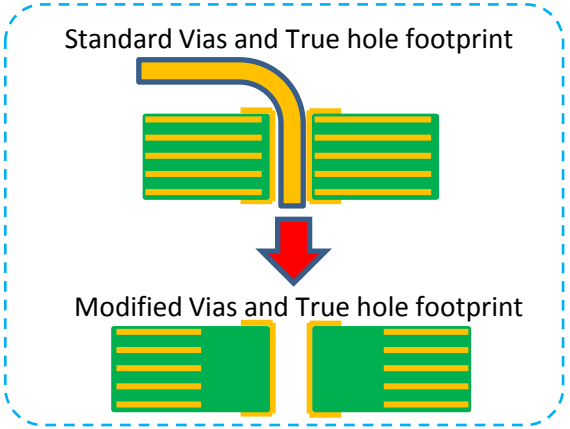
Backplane connection
Analogue inputs, power and control

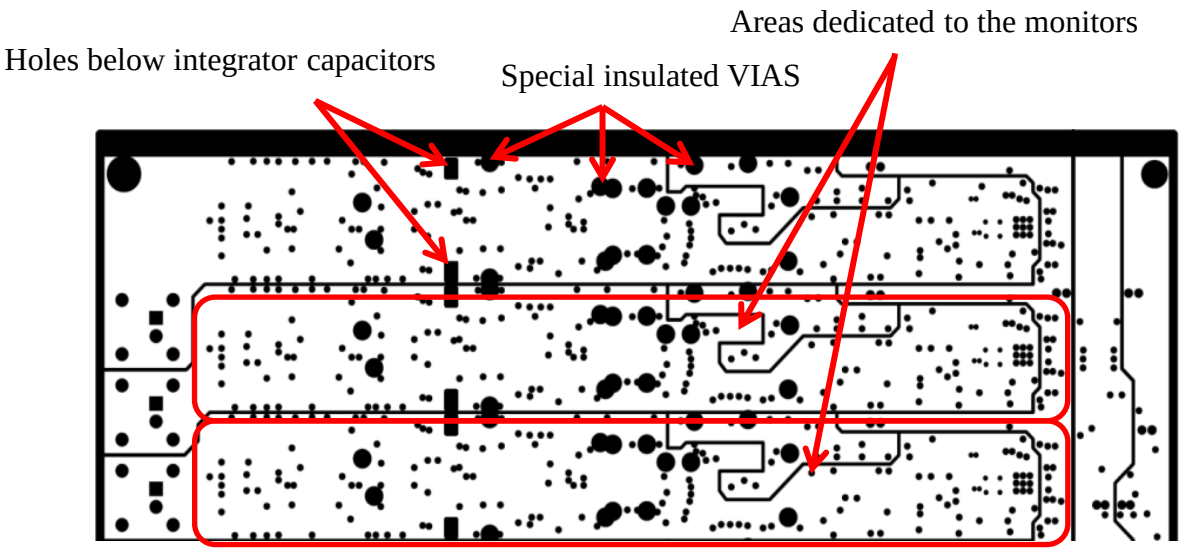
JTAG connection
Local programming and diagnostics

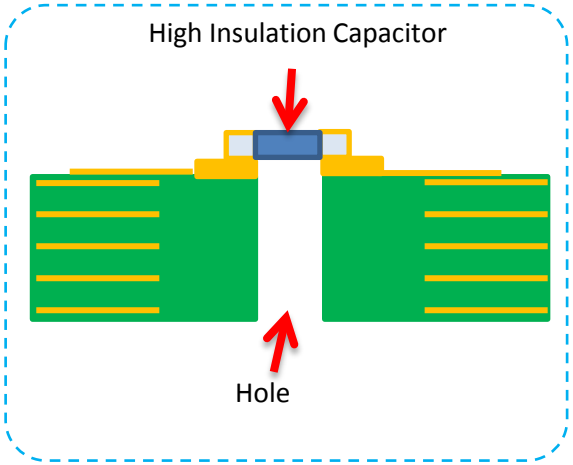
SFP connectors
Gigabit optical and/or Ethernet links

Acquisition module (BLEDP)

- Improve the insulation between input lines and other signals e.g. power supplies.
- This has been done by:
  - creating special VIAS,
  - optimising routing paths and
  - creating holes below the integration capacitor.
  - several ground areas have been created.







Status of Development

- Production and assembly of many parts completed

Status of Development

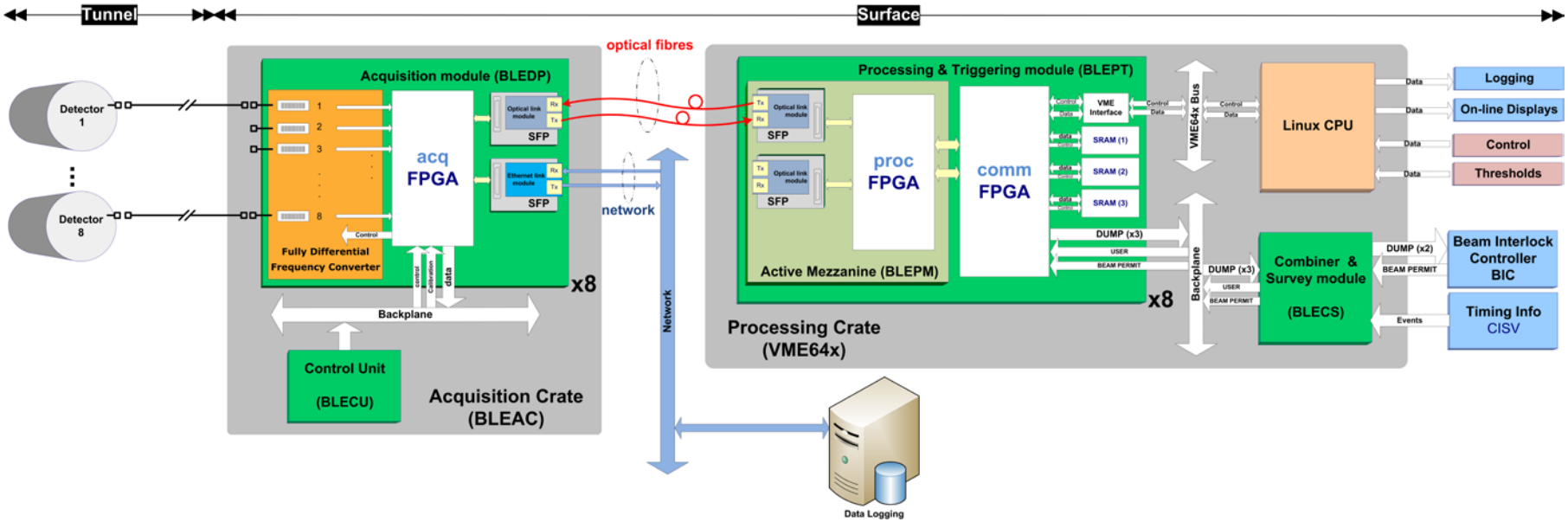
PCB Development

- All prototypes verified and functional.
- Pre-Series production will need to cover needs till LS2.
- Contracts for the Acquisition and Mezzanine modules ready – to be launched around Nov 2013.

Name	Acronym	Number of Components	2010	2011	2012	2013	2014	2016/7
			Prototype Development			Pre-Series		Series
Acquisition Module	BLEDP	1934	First Prototype (1 piece)	**V1.0** (2 pieces)	**V2.0 & V2.1** (3 pieces)	-	Production **V3.0** (20 pieces)	Production **V3.x** (60-100 pieces)
Acquisition Backplane	BLEBP	1173	-	V1.0 (2 pieces)	**V2.0** (1 piece)	Production **V3.0** (7 pieces)	-	Production **V3.0** (10-15 pieces)
Processing Mezzanine	BLEPM	210	-	V1.0 (1 pieces)	-	-	Production **V2.0** (20 pieces)	Production **V2.x** (60-100 pieces)
Crate Main Panel	BLEMP	52	-	First Prototype (2 pieces)	**V1.0** (2 pieces)	Production **V2.0** (7 pieces)	-	Production **V2.0** (10-15 pieces)
Crate Control Unit	BLECU	180	-	First Prototype (1 pieces)	Second Prototype (1 pieces)	Production **V1.0** (7 pieces)	-	Production **V1.0** (10-15 pieces)
Acquisition Crate	BLEAC	200	-	First Prototype (1 pieces)	**V1.0** (2 pieces)	Production **V2.0** (7 pieces)	-	Production **V2.0** (10-15 pieces)
Crate Programmer	BLEJP	160	-	-	First Prototype (1 pieces)	Production **V1.0** (7 pieces)	-	Production **V1.0** (10-15 pieces)
High Voltage Distribution	BLEHV	100	-	-	-	Production **V1.0** (7 pieces)	-	Production **V1.0** (10-15 pieces)

Status of Development

System Overview

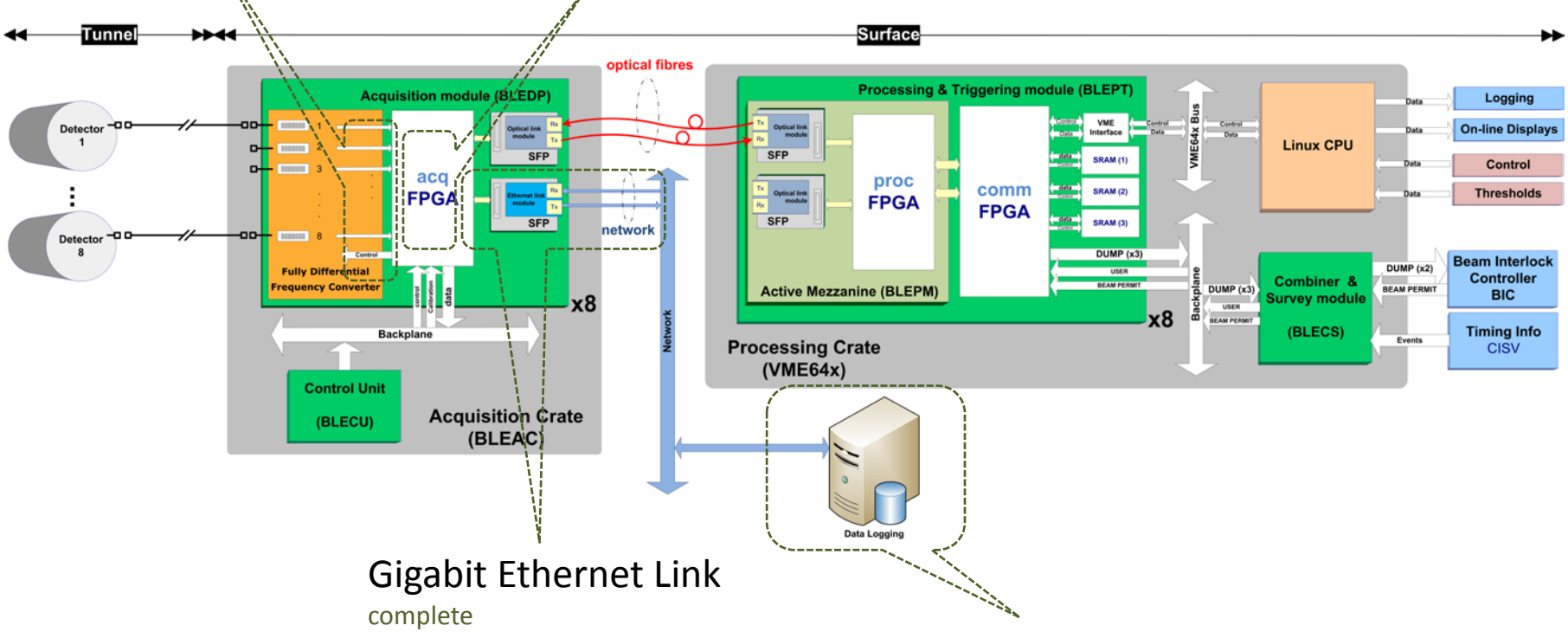


Status of Development

FPGA Development

Acquisition & Control
complete

Data Processing
complete

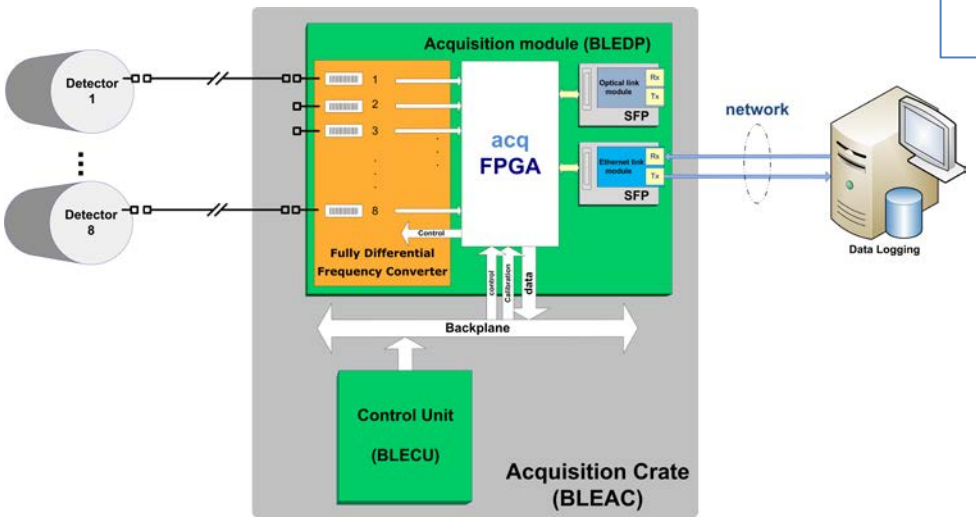


Gigabit Ethernet Link
complete

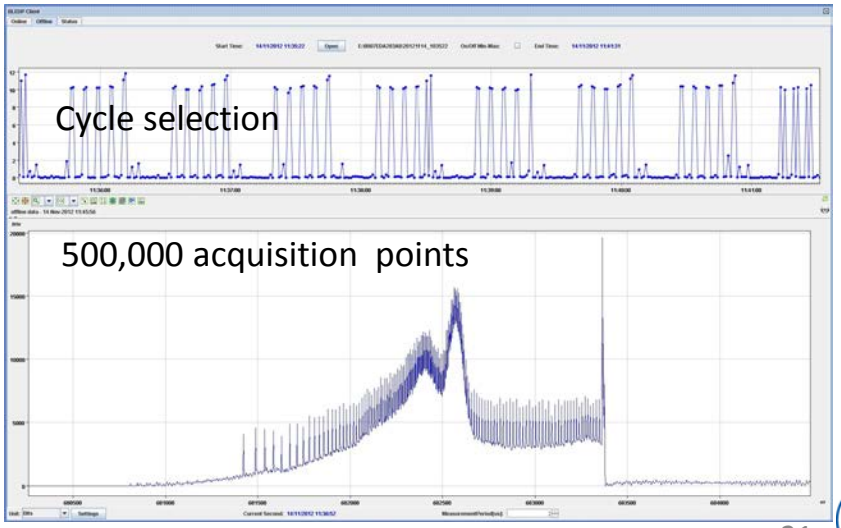
Stand-alone Application
complete

Status of Development

FPGA Development



- Ethernet-based version of the system ready
- Very powerful for
  - verification,
  - commissioning and
  - fine observations



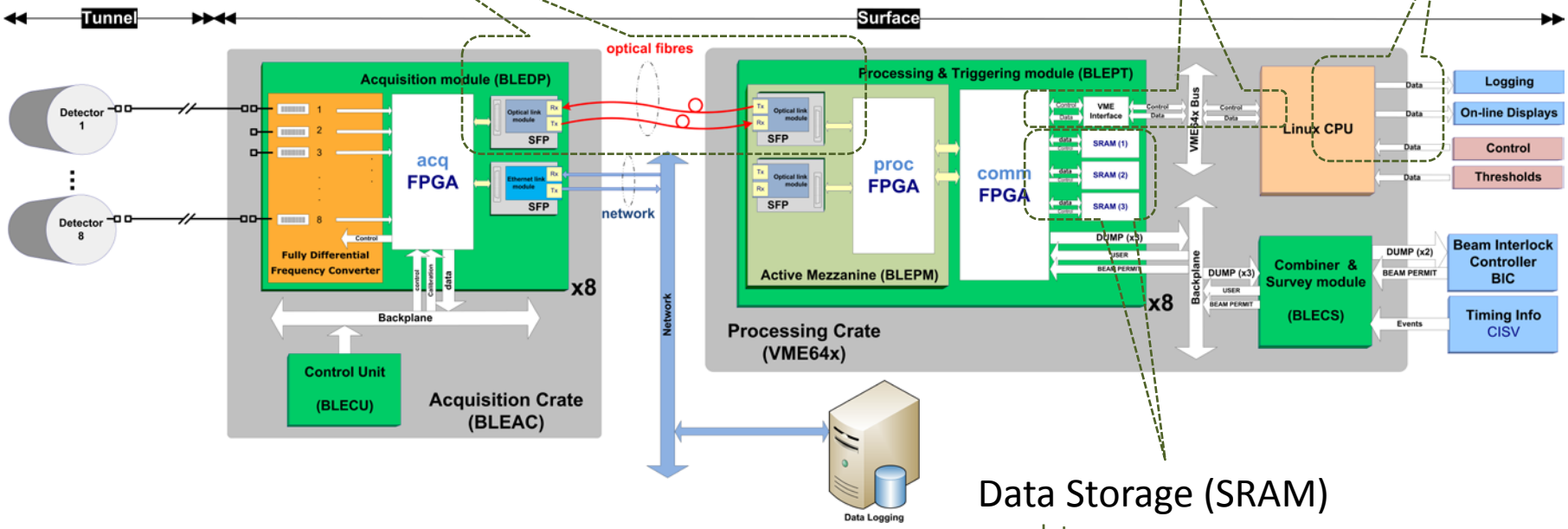
Status of Development

FPGA Development

Gigabit Optical Link
complete

VME Comm.
complete

FESA Class API
complete



Data Storage (SRAM)
complete

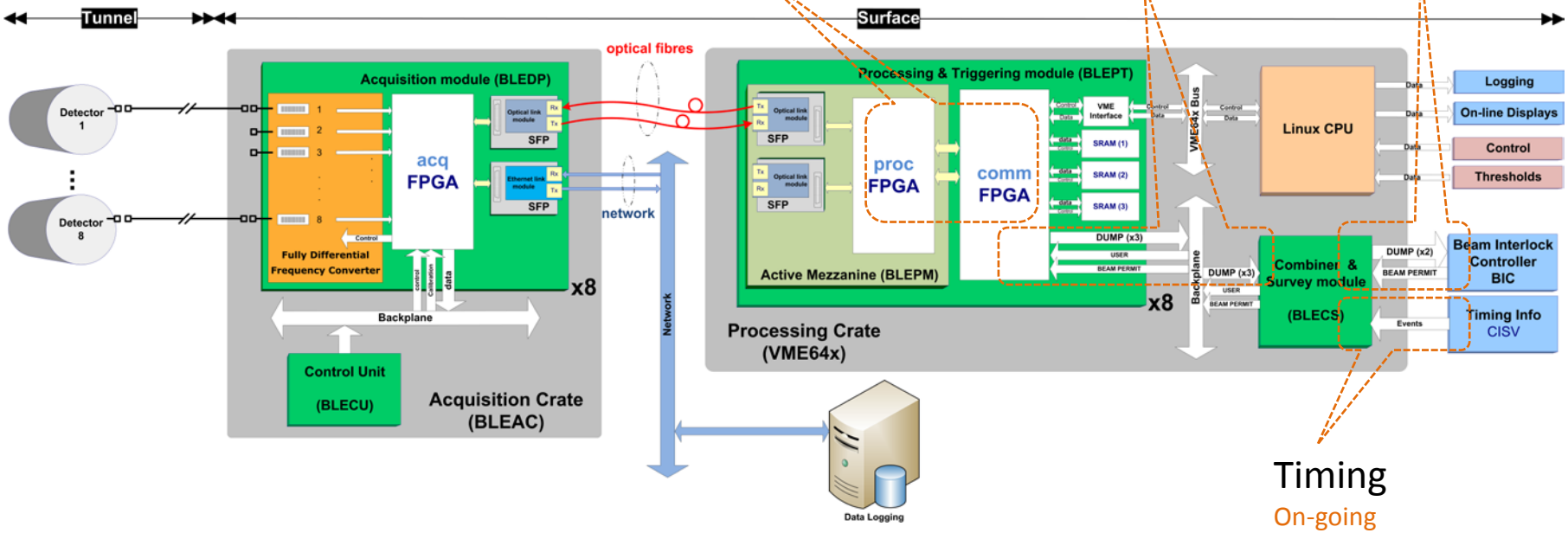
Status of Development

FPGA Development

Data Processing
On-going

Interlocks
On-going

CIBU Connection
On-going



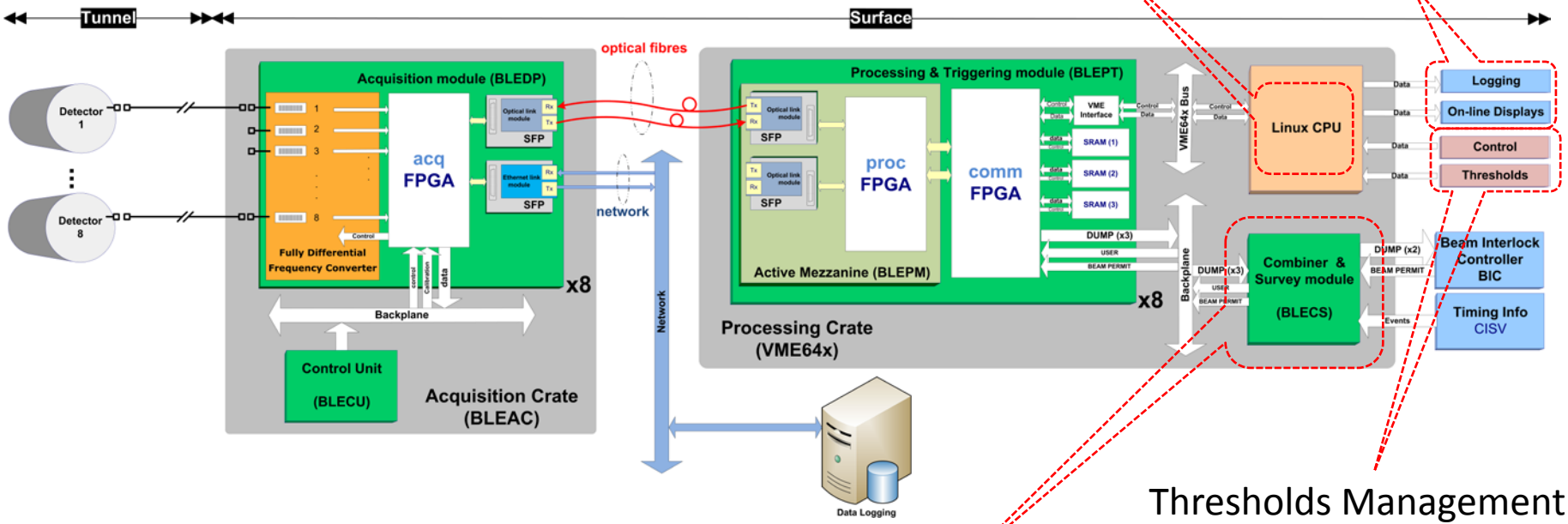
Timing
On-going

Status of Development

FPGA Development

FESA Server
Not Started

Logging Database
Not Started



Thresholds Management
Not Started

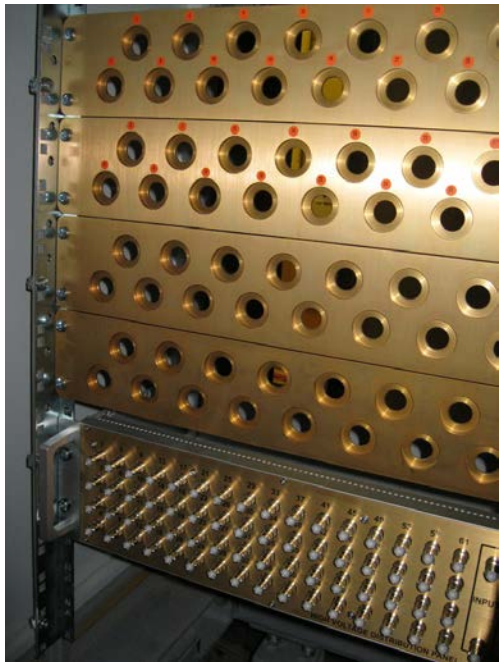
System Supervision
Not Started

Installation and Commissioning Plan

Installation and Commissioning Plan

Racks

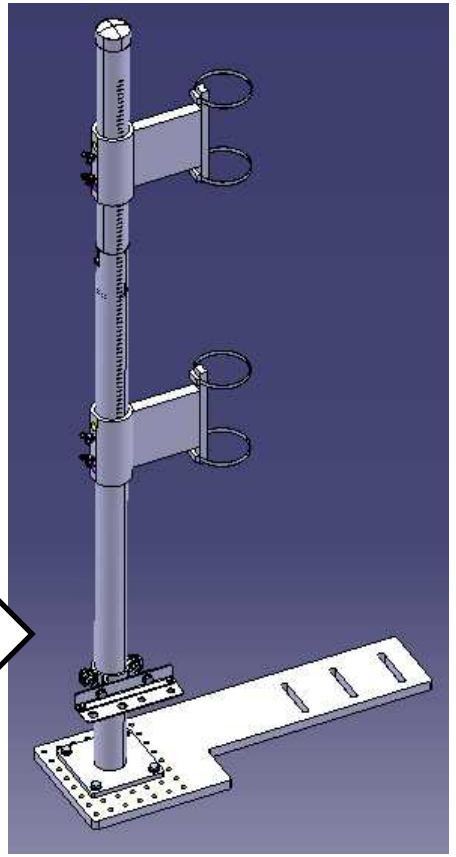
- PSB Ring: completed
  - Floor supports have been designed and installed
  - Rack installed
- PSB Injection & Extraction: on-track
  - Floor supports have been designed and installed
  - Positions defined
- PS Ring and Transfer Lines: not yet planed
  - Identified candidate buildings and positions
- SPS Ring & Transfer Lines: not yet planned
- SPS TT10: not yet planned
  - Identified candidate buildings and positions



Signal Cable panel & HV distribution

Installation and Commissioning Plan

- PSB Ring detector support



Prototype support to check integration

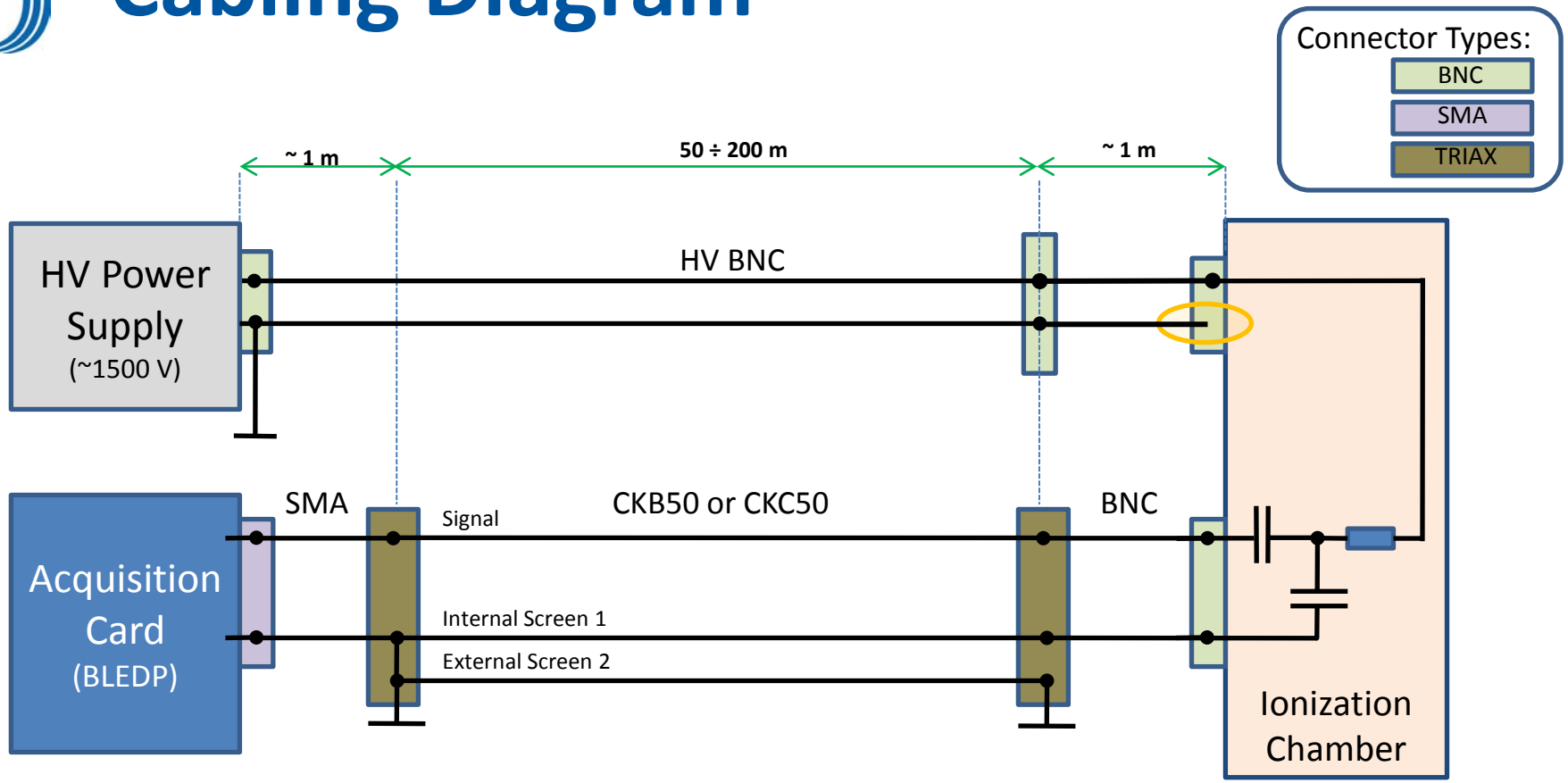
3D version by EN/MME
V. Valganon & N. Chritin

Installation and Commissioning Plan

Detector Supports

- PSB Ring: design complete
  - Prototype is being constructed by the workshop.
  - Production to complete end of Nov. 2013
- PSB Injection & Extraction: not available
  - Design to start towards the end of the year (2013)
- PS Ring and Transfer Lines: not yet planed
- SPS Ring: not needed/keep current installation
- SPS TT10: not yet planned

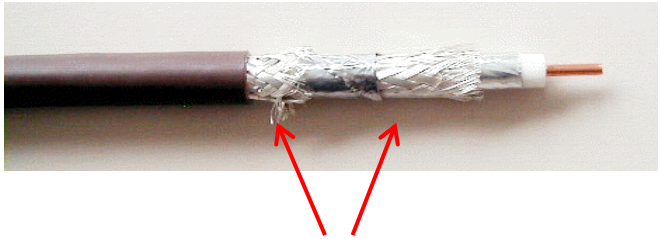
Cabling Diagram



- Screen of HV BNC is open on the IC side to assure there is **no ground loop**.
- Internal screen to **shield low frequency** noise (GND only on electronics side, IC is floating).
- External screen to **shield high frequency** noise.

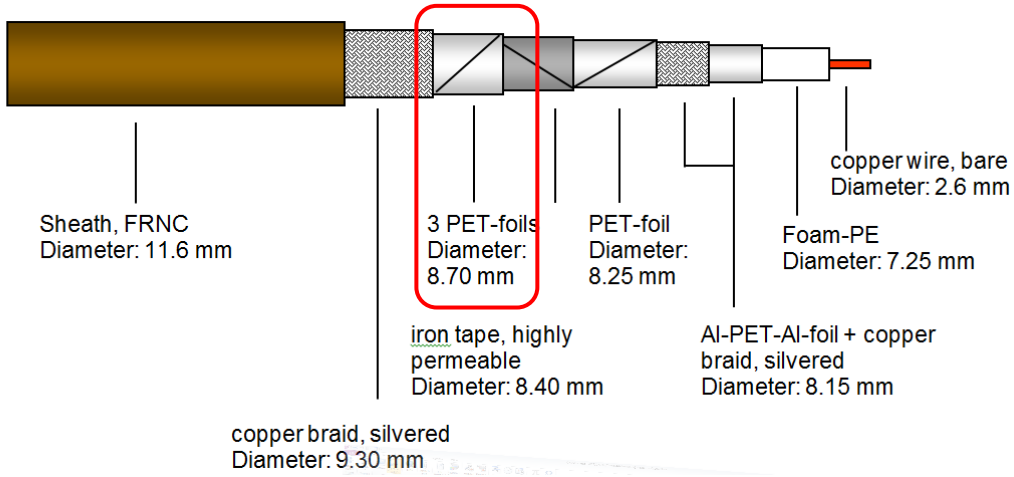
CKC50 Cable production

CKB50



- At random positions discovered shorts between the two shields.
- Not usable for Triaxial functionality.

CKC50



- New cable (CKC50) production agreed with manufacturer:
  - Modification of the CKB50 specs: Additional PET-foils over the magnetic screen. (Avoided problems mounting the connector. The electrical properties will not change.)
  - Manufacturer to run a trial production and testing until end of September
  - We will test the sample and release the cable by mid-October ← We are here
  - If all ok, will manufacture about 6km until end of November
- Re-installation to begin in PSB from January 2014 (6-8 weeks).
  - Some conflict with Injectors 2014 schedule.

Budgetary Requirements

Budgetary Requirements - PSB

- Updated general cost breakdown up until 2019

LIU-PSB	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL LIU (kCHF)
Ring (L2 position)			90						90
Injection & BI Line					52	49			101
Injection (observation)					110	37			147
Ring (L3 position)				50		123			173
Extraction					80	80			160
TOTAL LIU (kCHF)	0	0	90	50	242	289	0	0	671

- Summary of differences on the updated general cost

PSB	original (kCHF)	updated (kCHF)	Diff	Charged		
				cables	electronics	monitors
Ring (L2 position)	90	90	0	LIU	CONS	spares
Injection & BI Line	65	101	36	LIU	LIU	spares
Injection (observation)	77	147	70	LIU	LIU	LIU (Diamond)
Ring (L3 position)	40	173	133	LIU	CONS	LIU (Flat IC)
Extraction	0	160	160	LIU	LIU	spares
TOTAL LIU (kCHF)	272	671	399			

Budgetary Requirements - PS

- Decision needed about the strategy to follow

- Original plan:
  - Keep current detectors
  - Keep cables
  - New electronics (CONS)

LIU-PS	detectors	electronics	installation	TOTAL (kCHF)
Ring	0	272	0	272
Ring (observation)	0	0	0	0
Transfer Lines	0	100	0	100
TOTAL (kCHF)	0	372	0	372

- New request (draft):
  - Replace & 40 new detectors
  - New cables
  - New electronics
  - New Observation system
  - System for FTA & FTN lines

LIU-PS	detectors	electronics	installation	TOTAL LIU (kCHF)
Ring	160	272	290	722
Ring (observation)	490	n/a	145	635
Transfer Lines	84	140	515	739
TOTAL LIU (kCHF)	734	412	950	2096

Budgetary Requirements - SPS

- Estimated general cost up until 2019

LIU-SPS	detectors	electronics	installation	TOTAL LIU (kCHF)
Ring & Transfer Lines	0	TBD	TBD	???
TT10	50	150	500	700
TOTAL LIU (kCHF)	50	150	500	700

- SPS Ring and Transfer Lines:
  - Reuse detectors
  - New electronics under development
  - Cables or fibres will be dictated by electronics design.
- TT10: (new system)
  - 30 LHC-IC type detectors
  - Standard electronics, two racks
  - Long cables

General Planning

General Planning - PSB

Machine/Area		Channels	Documentation	Detectors	Electronics	Installation & Commissioning	Budget	Expected
PSB	Ring (L2 position)	32	Complete	LHC-IC	Pre-series	On-track	Incomplete	LS1
	Injection & BI Line	18	Complete	LIC	Pre-series	Initialising plan	Incomplete	L4C
	Injection (observ.)	8	Complete	Diamond	TBD	Initialising plan	Incomplete	L4C
	Ring (L3 position)	32	Complete	FIC	Series	Not started	Incomplete	LS2
	Extraction	28	Complete	LHC-IC	Series	Not started	Incomplete	LS2

Plans for LS1 & LINAC4 Connection are clear and agreed

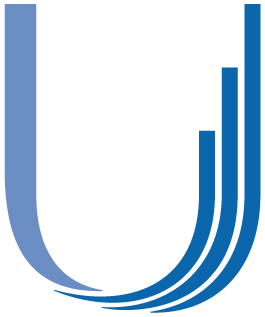
- Update of budget needed (times and amounts).
- Will validate pre-series version of electronics with beam
  - Series production towards the end of 2016
- Development of Firmware and Software will continue after LS1
  - FESA server, Threshold Management, Logging DB, Controls integration
- Additional cables and monitors could be installed during LINAC4 Connection
  - Add electronics in the surface when available.
- Diamond based system's acquisition electronics under study
  - Pursuit more actively after LS1

General Planning – PS & SPS

Machine/Area		Channels	Documentation	Detectors	Electronics	Installation & Commissioning	Budget	Expected
PS	Ring	100	Only positions	LHC-IC	Series	Not started	Unallocated	TBD
	Ring (observation)	40	Only positions	Diamond	TBD	Not started	Unallocated	TBD
	Transfer Lines	51	Only positions	LHC-IC	Series	Not started	Unallocated	TBD
SPS	Ring & Tr. Lines	500	Advanced	SPS-IC	TBD	Not started	to be verified	LS3
	TT10	30	Complete	LHC-IC	Series	Not started	Unallocated	TBD

Plans for LS2 and beyond need input and budgets (incl. manpower).

- PS: need to define strategy and specifications
  - Large system - need to consider manpower
  - Diamond based system: Cables and Detectors could be installed during L4C or LS2.
- SPS Ring & Transfer Lines:
  - Preferred solution is the BLM-ASIC with fibres
  - Results from second version of the ASIC not yet available
- SPS TT10: if budget/manpower is available
  - Cables and Detectors could be installed during L4C or LS2.
  - Use standard version of the electronics when available.
- Possible conflict: Major renovation of the LHC system during LS2



LHC Injectors Upgrade

THANK YOU FOR YOUR ATTENTION!