MPP Meeting
BLMINJ Architecture

Christos Zamantzas & Stephen Jackson

Beam instrumentation

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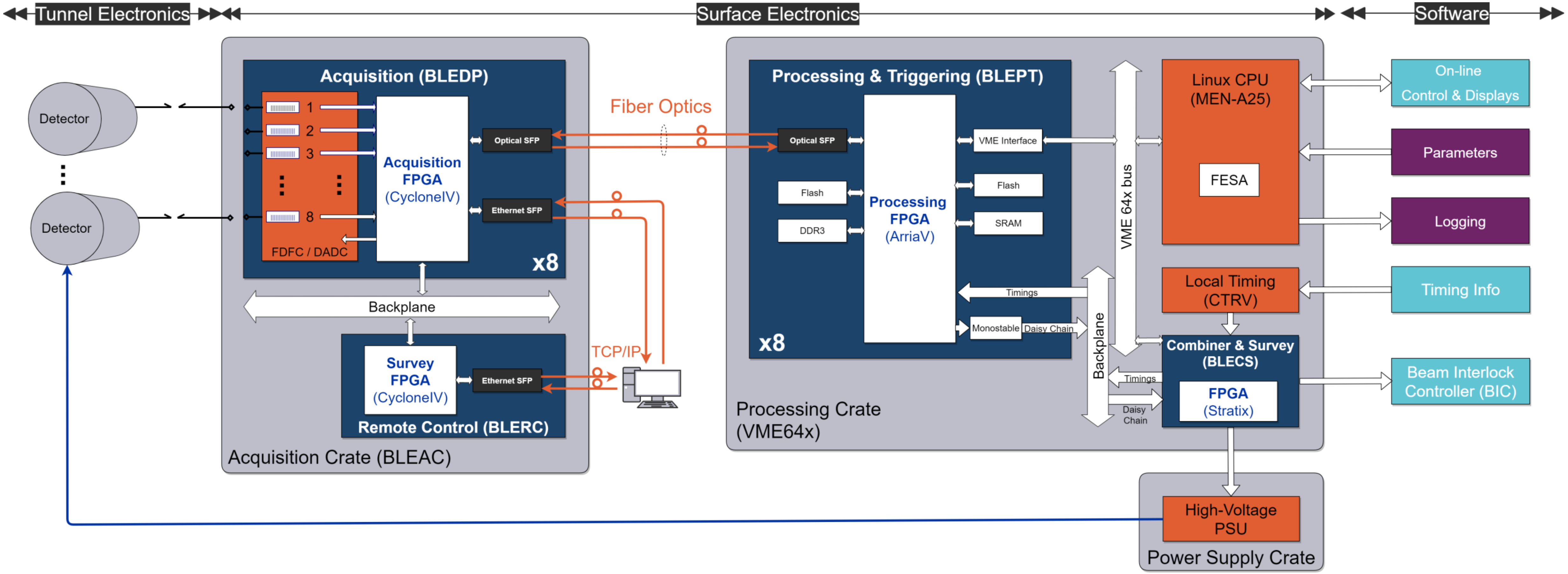
Introduction

This project has undertaken the task to develop up-to-date Beam Loss Monitoring Systems for the Injectors.

Mainly,

- Build a generic, highly configurable and high-performing system
- Acquisition part to accept several detector types
- Use reprogrammable parts to target all injectors' requirements

System Overview



Hardware Deployment

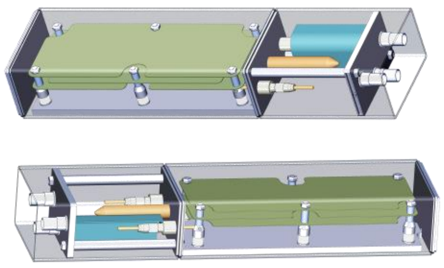
- **Request**
  - LINAC4 asap (connection to LHC)
  - PSB & PS during LS2
- **Risk mitigation (staged deployment)**
  - 2015: PSB prototype
  - 2016: LINAC4 (machine part)
  - EYETS16/17: PSB & PS Rings
  - 2018: LINAC4 transfer line
  - LS2: All transfer lines & Decommission all legacy systems

ACEM detectors in PS

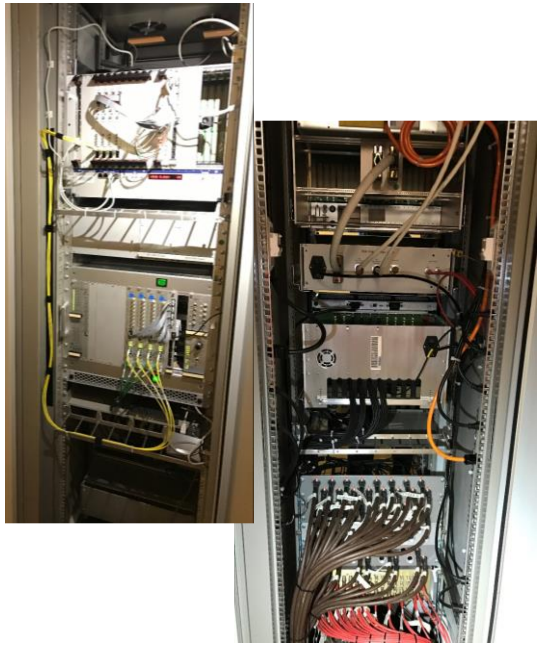
- **Legacy System at PSB & PS**
  - 168 ACEM detectors
  - 3 Electronic racks
- **New system**

  Detectors:
  - 291 Ionisation Chambers (LHC type)
  - 32 Flat Ionisation Chambers (new)
  - 25 Diamonds

  Electronics:
  - 14 racks
  - 2 OASIS systems



FIC detectors



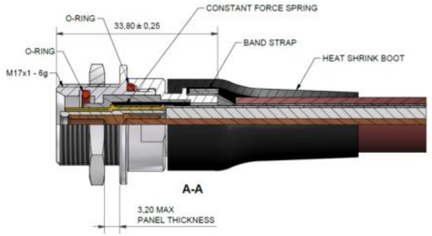
BLM Rack Configuration

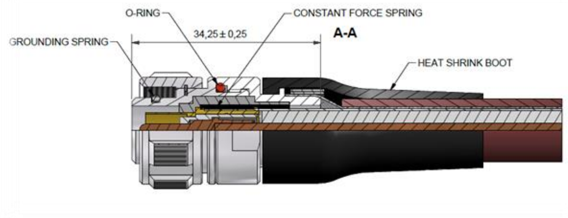
Cabling

Taking experience from other machines (SNS, KEK etc) and their issues with EMI

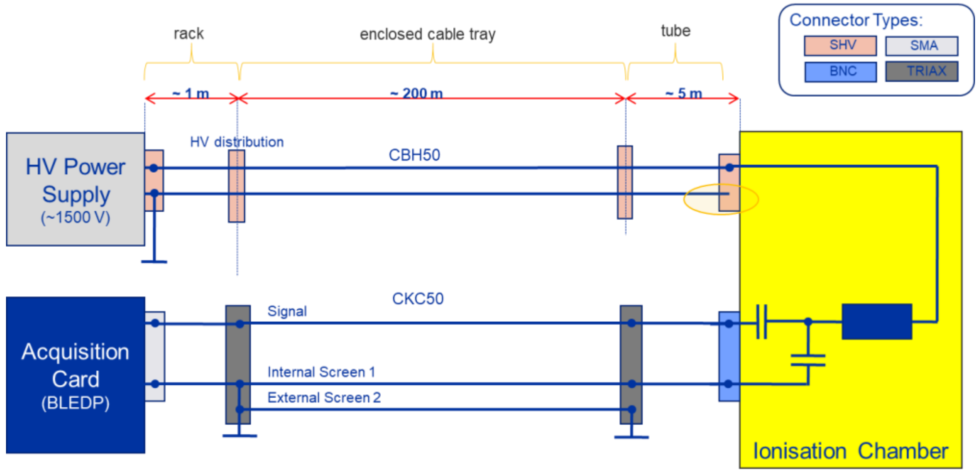
- **Development of new coaxial cable with triple shielding**
  - Partnership with DRAKA (PRYSMIAN group)
  - Based on the CKB50

- **Development of triaxial connectors**
  - Partnership with POLAMCO ltd (TE group)
  - Produced assembly manual, videos & tools



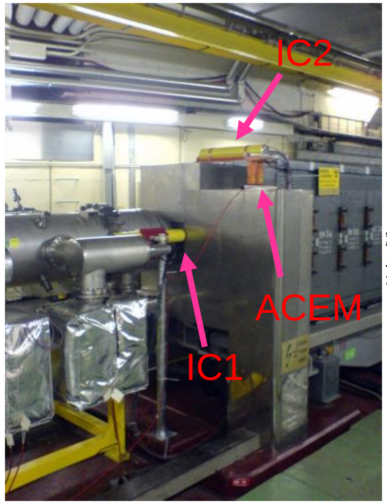


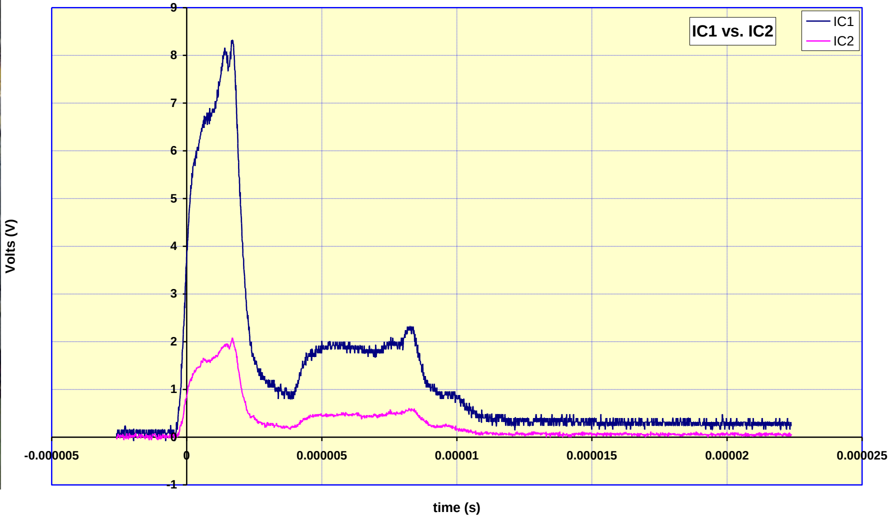
- **Configuration**
  - HV cable's screen open at IC side to avoid ground loops (GND only on electronics side, IC is floating)
  - Int. screen to shield low frequency noise
  - Ext. screen to shield high frequency noise

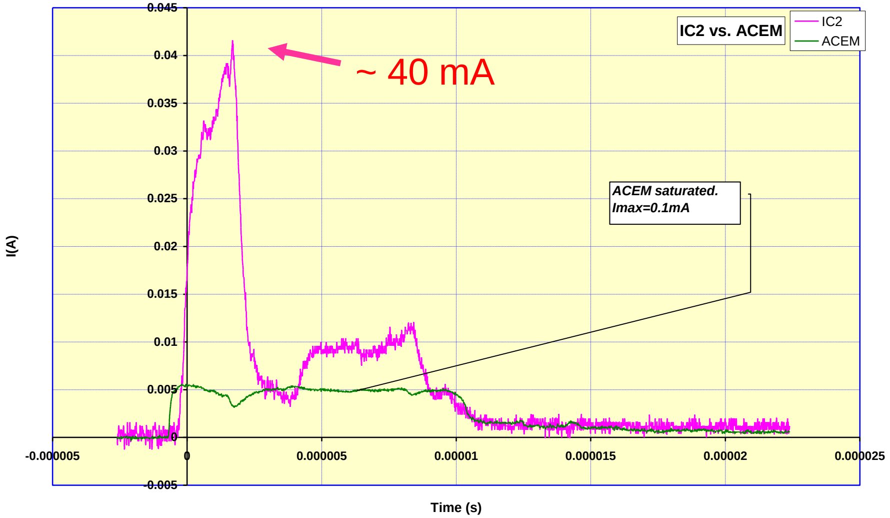


Acquisition

Measurements in PS circa 2008 (courtesy of V. Prieto, E. Effinger and B. Dehning)







Solution: Two acquisition methods with overlapping ranges to cover 10 pA to 200 mA

- **No gain change required: The switch between the 2 ranges is managed by the *FPGA*.**
  - If the maximum of the lower range is reached, the FPGA switches the circuit to the higher range.
  - The sum of all parts is calculated in the acq. FPGA and transmitted as a 2 µs integral.

Processing

Acquisition module acquires signals with internal clock (asynchronous to the beam)

- **Synchronisation 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 achieved by**
  - Use the Start of Cycle, Basic Period, Beam In/Out timing events
  - Dedicated timing card with broadcasts in the backplane
  - Sync will be done at the processing level (i.e. 2 samples jitter between cards)

Software

The software layer is an integral part of the system (some examples)

- **Remote Firmware deployment**
  - Up to 18 FPGAs per electronics rack
- **Configuration parameters**
  - Set thresholds, masks and BIS connections per channel
  - Set system operational limits (detector bias, max. temperature, watchdogs, etc.)
- **Detector families**
  - Groups detectors per destination and publish them accordingly
- **Data concentration**
  - Concentrate data from multiple cards or crates (e.g. ‘BLMSYNC’ for PS Ring)
  - Tags data and propagates them to displays and storage
- **Tracking of loss limits per user**
  - Monitoring of losses per user and generate interlocks
  - See next slide

Interlock Functionality

Hardware implementation part:
‘machine protection’

- **All calculated integration period values, i.e from 2 μs to 1.2 s, are constantly checked against their threshold values:**
  - 6 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 can be unique per channel:**
  - Each module processes 8 channels

Software implementation part:
‘limit radiation levels’

- **All maximum integration period values recorded on the cycle will be checked against a second set of threshold values.**
  - Comparisons happen at the end of every cycle
  - If over threshold repeatedly *n* times it blocks **this user’s injections**
  - The **blocked** beam permit signal for this user is **latched** until an operator acknowledges
  - The repeat value *n* is settable per monitor in the range of 1 to 32
- **The threshold values can be unique per user and per channel:**
  - Each CPU will process up to 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 is reserved

Conclusions

- Highly configurable BLM system
- We believe right balance between protection and flexibility

- Complex deployment due to limited space and variation in topology
- Complex development due to variety of needs to be covered by one system
- Simpler maintenance and spares management

- Coverage of additional locations previously blind to operations home.cern