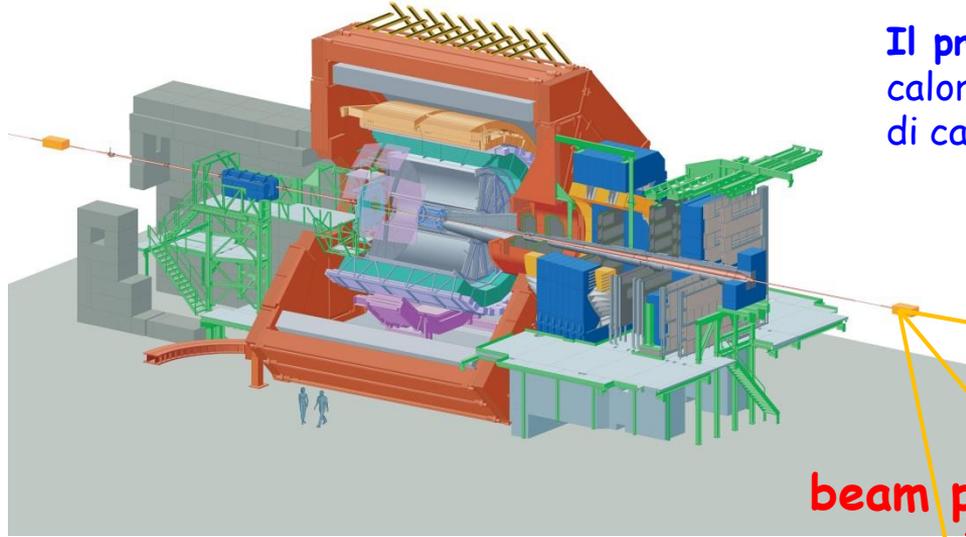


ALICE/ZDC

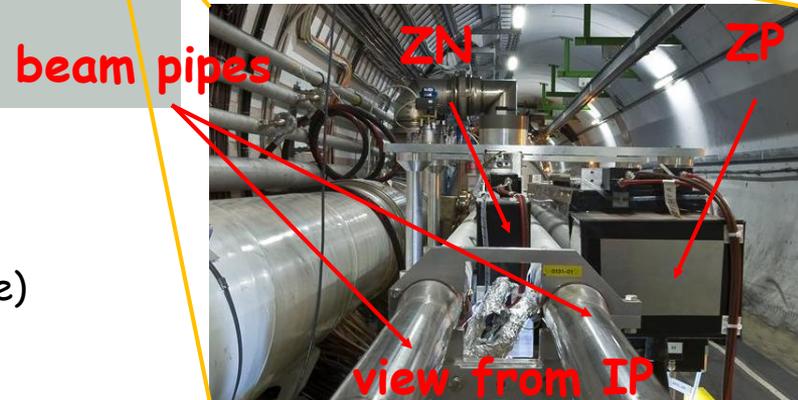


Il progetto ZDC consiste in 2 coppie di calorimetri adronici (112.5 m da IP2) e una coppia di calorimetri elettromagnetici (7.5 m da IP2).

Progetto 100% INFN
Sezione INFN Cagliari
Sezione INFN Torino
(istituti di Alessandria e Torino)

Ruoli di responsabilita':

ZDC Project Leader (N. De Marco)
ZDC Deputy Project Leader (P. Cortese)
ZDC Technical Coordinator (P. Mereu)



ZDC readout for run3

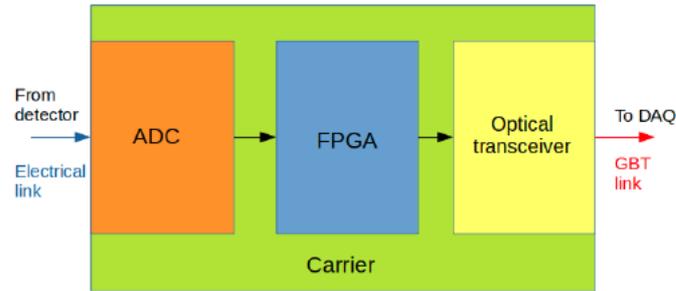


In RUN3 the ZDC will be exposed in PbPb collisions to 5MHz total event rate since the ZDC has acceptance not only to nucleon emission from hadronic interactions but also to the ones resulting from electromagnetic dissociation.

The solution identified to read the ZDC in continuous readout mode is based on the **FMC digitizer**

ADC_3112 IOxOS (12-bit, 1GSps) combined with the use of FPGA.

The **Carrier** is the **IFC_1211 IOxOS**.



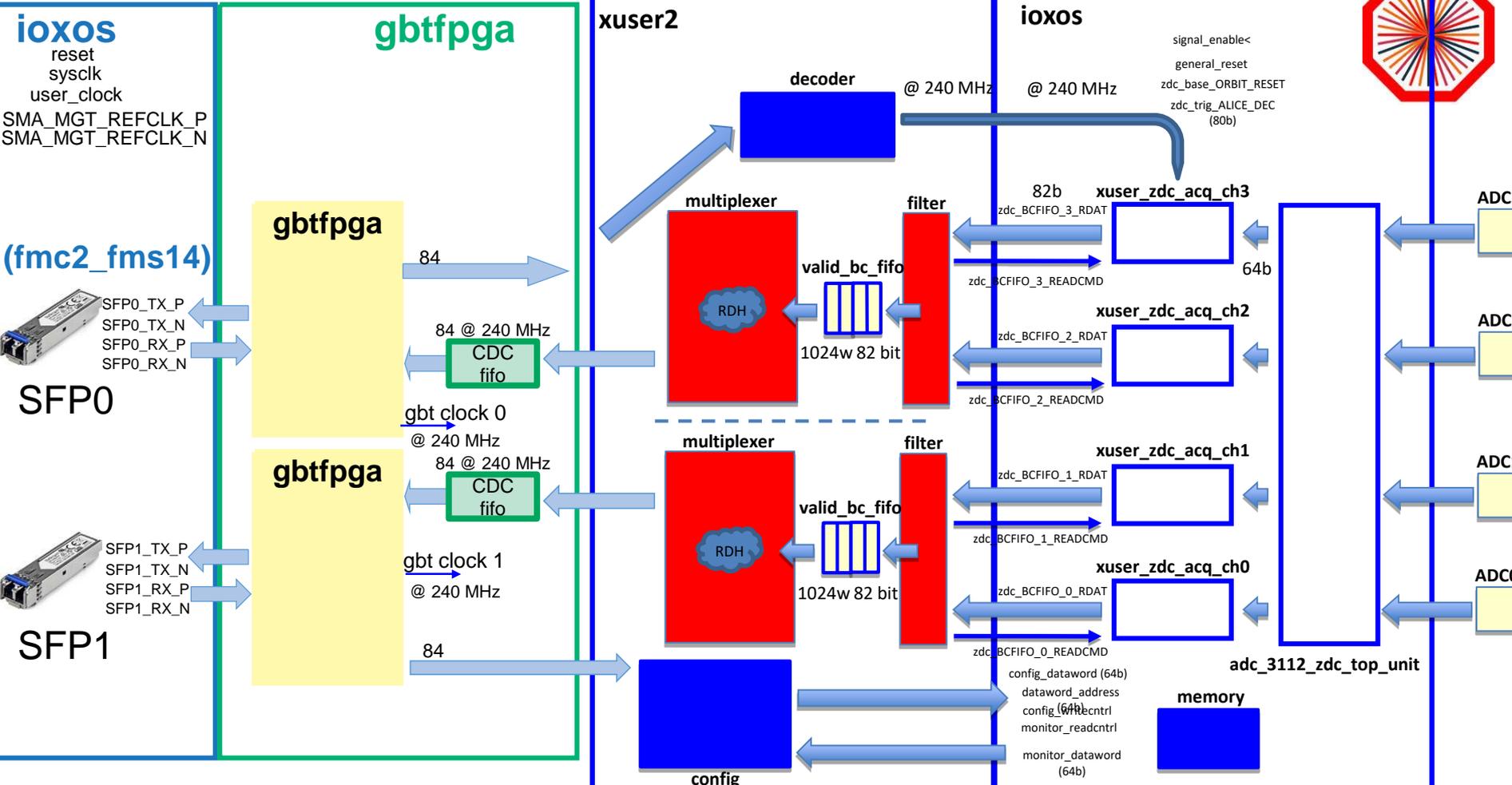
FMC digitizer



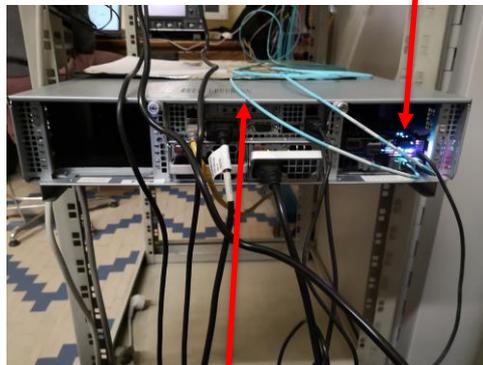
Equipped with two ADCs ADS5409 (Texas Instruments)

| | FMC ADC_3112 |
|----------------------|--------------|
| sample rate (MSps) | 900 (1000) |
| resolution depth (b) | 12 |
| module price (KCHF) | 5 |
| channel number | 4 |
| input coupling | DC |
| input voltage (Vpp) | 500 mV |
| enob ~1GHz (b) | 9,8 |

The **INFN** implemented the code needed to comply with the **ALICE** requirements: **GBT FPGA**, dual clock fifo (ClockDomainCrossing) and Data Packet Manager (multiplexer, filter, fifo, trigger decoding).

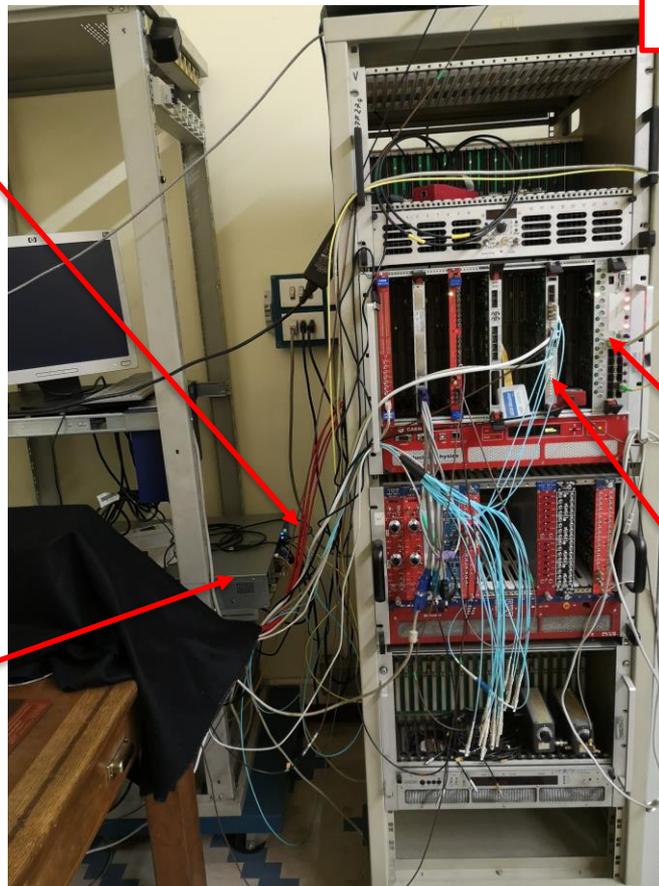


Torino lab



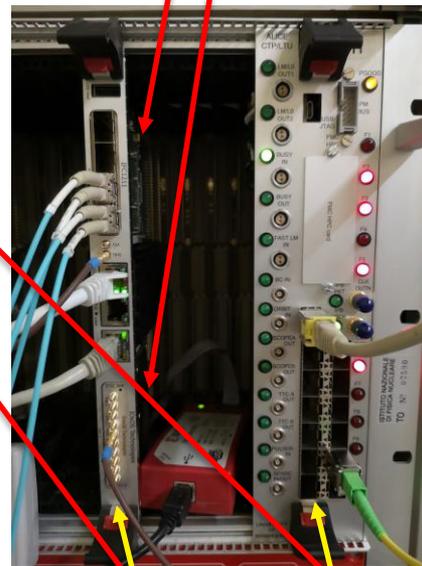
CRU

FLP



FMC2 transceiver
fms14

FMC1 digitizer
ADC3112



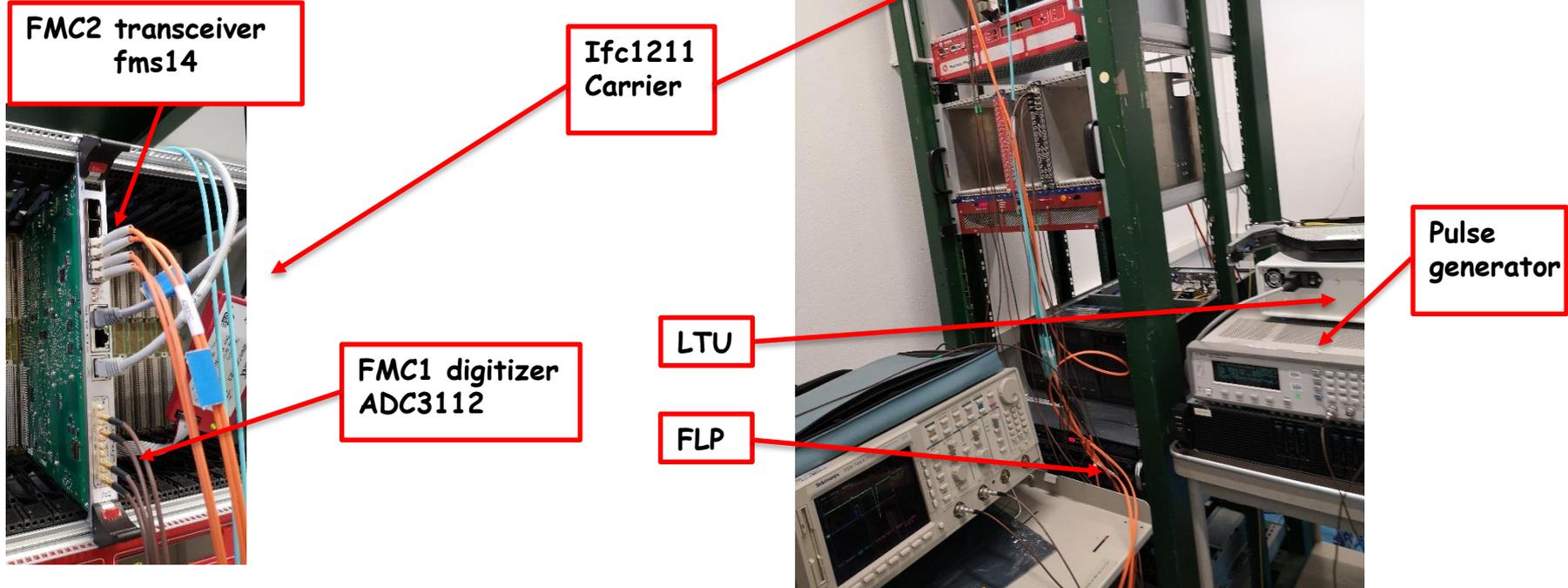
Ifc1211
Carrier

LTU

Meyrin lab



In mid-May a FEE test system was installed in a CERN Meyrin laboratory where the optimization of ZDC FW continues.



ZDC readout Activities



In the first 2 weeks of June the full electronics was installed.
ZDC in global runs (technical and synthetic). All FEE modules respond correctly.
In parallel optimization of fw on going in Meyrin lab.

Data from the
FEE to the
CRU via
optical fibers



NFS cables towards
switch ethernet

tty cables towards
serial server DigiKey
for RS232

Signals entering
in ADCs

The fw is being optimized and the new bitfile is transferred to the ALICE DCS network thanks to the DCS team. It is very important for us that this transfer takes place in a very short time.

ZDC readout Activities



Activity in Meyrin lab

-Optimization of the fw on going

Last release July 18th: new timing constraints and new logic in the filter module.

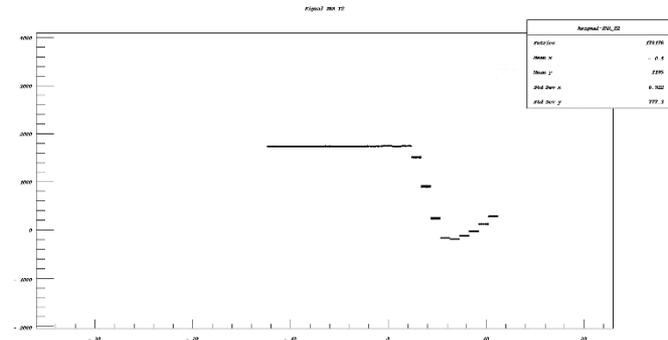
-Tests of FEE (1 ifc1211 card)

Runs in continuous mode (1 autotrigger/BC) and high rate Alice Trigger (~Mhz) performed to assess the performance with respect to the trigger frequency up to the GBT throughput limit. Tests stopped without errors after more than 40 hours.

- Runs with different signals in ADCs for tests of the auto-trigger algorithm.

| Time | Pushed | Read | Throughput (Gbps) | Errors | °C |
|----------|--------|--------|-------------------|--------|------|
| 00:01:00 | 73804 | 73804 | 9.0032 | 0 | 43.6 |
| 00:02:00 | 147602 | 147602 | 9.00259 | 0 | 43.6 |
| 00:03:00 | 221412 | 221412 | 9.00248 | 0 | 43.6 |
| 00:04:00 | 295196 | 295196 | 9.00239 | 0 | 43.6 |
| 00:05:00 | 368994 | 368994 | 9.00236 | 0 | 43.6 |
| 00:06:00 | 442804 | 442804 | 9.00233 | 0 | 43.6 |
| 00:07:00 | 516590 | 516590 | 9.0023 | 0 | 43.6 |
| 00:08:00 | 590386 | 590386 | 9.00226 | 0 | 43.6 |
| 00:08:20 | 616204 | 616204 | 9.00226 | 0 | 43.6 |

| | | | | | |
|----------|-----------|-----------|---------|---|------|
| 46:25:00 | 205526104 | 205526104 | 9.00094 | 0 | 43.6 |
| 46:26:00 | 205599900 | 205599900 | 9.00094 | 0 | 43.6 |
| 46:27:00 | 205673710 | 205673710 | 9.00094 | 0 | 42.9 |
| 46:28:00 | 205747494 | 205747494 | 9.00094 | 0 | 42.9 |
| 46:29:00 | 205821304 | 205821304 | 9.00094 | 0 | 42.9 |
| 46:30:00 | 205895090 | 205895090 | 9.00094 | 0 | 42.9 |
| 46:31:00 | 205968888 | 205968888 | 9.00094 | 0 | 42.9 |
| 46:32:00 | 206042684 | 206042684 | 9.00094 | 0 | 42.9 |
| 46:33:00 | 206116484 | 206116484 | 9.00094 | 0 | 42.2 |
| 46:34:00 | 206190280 | 206190280 | 9.00094 | 0 | 42.2 |
| 46:34:37 | 206231554 | 206231554 | 9.00074 | 0 | 42.2 |



ZDC readout Activities



Tests of FEE at P2 (full electronic)

On going

-ZDC in global technical runs; tests also performed at high rate (up to 500 KHz of Alice Triggers).

Next step

-Inject signal in the FEE using a detector emulator in CR4 for check of auto-trigger algorithm.

CTP team updated the LTU fw in order to generate a Calibration signal; on our side we checked that the Calibration signal is present in CR4 when it is enabled in zdc.par.

The Calibration Signal will be sent to the external trigger of the detector emulator.

The image displays three screenshots from a Linux terminal environment, likely related to the ZDC readout activities.

The leftmost screenshot shows the 'Environment details' for a task named 'TFBuilder'. The task is running and has a status of 'RUNNING'. The readout rate is 2.39 GB/s. The run number is 519635. The task ID is ZZ2786205. The task was created on 09/20/2022 at 6:28:53 PM. The task is running on the 'readout-dashbox' host. The task has 3 readout tasks and 1 FLP event. The task is using the 'ZDC' detector.

The middle screenshot shows the 'TFBuilder' task configuration. The task is running on the 'readout-dashbox' host. The task has 3 readout tasks and 1 FLP event. The task is using the 'ZDC' detector. The task is running on the 'readout-dashbox' host. The task has 3 readout tasks and 1 FLP event. The task is using the 'ZDC' detector.

The rightmost screenshot shows the output of the 'TFBuilder' task. The output shows the status of the ZDC readout for each board. The status for each board is '0x00000000'. The output also shows the 'Link not ready' status for each board.

ZDC platform Activities



ZN and ZP are fixed on movable platforms controlled via ALICE DCS.

During 2021 the renewal of the control electronics of the hadronic calorimeter platforms has been completed.

New motors drivers have been installed in the LHC service tunnel side A and C and a new PLC replaces the old one in CR4.

The new system has been configured and the PLC programming completed. The handling of the platforms has been carried out and the protection systems (limit switches and collision switches) have been tested.

WinCC interfacing with the PLC program is on going: problem in the communication between WinCC and the PLC is under investigation.

Next step

DCS integration session with platforms



In March 2022, the alignment of the ZDC platforms in the LHC tunnel was carried out.

In Autumn 2021, the ZEM electromagnetic calorimeters was installed and aligned in the new ALICE mainframe in front of the L3 doors.

DCS Activities



Configuration of FEE via DCS using SWT words in the framework ALF-FRED on going.

Panels prepared in WinCC.

| MODULE 0 | | | | | | | |
|------------------------|--------|----------------------------------|---|------------------------|--------|----------------------------------|---|
| Configuration Register | Adress | Write Data (HEX without "0x") | Last Set Data | Configuration Register | Adress | Write Data (HEX without "0x") | Last Set Data |
| delay_sample_0 | 0x00 | | 0x0000000000000006 2022.06.06 14:22:06.315 | difference_delta_0 | 0x0C | | 0x0000000000000004 2022.06.06 14:22:06.355 |
| delay_sample_1 | 0x01 | | 0x000000000000000d 2022.06.06 14:22:06.318 | difference_delta_1 | 0x0D | | 0x0000000000000004 2022.06.06 14:22:06.357 |
| delay_sample_2 | 0x02 | | 0x0000000000000006 2022.06.06 14:22:06.322 | difference_delta_2 | 0x0E | | 0x0000000000000004 2022.06.06 14:22:06.359 |
| delay_sample_3 | 0x03 | | 0x0000000000000006 2022.06.06 14:22:06.327 | difference_delta_3 | 0x0F | | 0x0000000000000004 2022.06.06 14:22:06.360 |
| delay_coarse_0 | 0x04 | | 0x00000000000000C8 2022.06.06 14:22:06.330 | masking_difference_0 | 0x10 | | 0x000000000000FF00 2022.06.06 14:22:06.362 |
| delay_coarse_1 | 0x05 | | 0x00000000000000C8 2022.06.06 14:22:06.334 | masking_difference_1 | 0x11 | | 0x000000000000FF00 2022.06.06 14:22:06.364 |
| delay_coarse_2 | 0x06 | | 0x00000000000000C8 2022.06.06 14:22:06.337 | masking_difference_2 | 0x12 | | 0x000000000000FF00 2022.06.06 14:22:06.365 |
| delay_coarse_3 | 0x07 | | 0x00000000000000C8 2022.06.06 14:22:06.341 | masking_difference_3 | 0x13 | | 0x000000000000FF00 2022.06.06 14:22:06.369 |
| threshold_level_0 | 0x08 | | 0x000000000000000A 2022.06.06 14:22:06.344 | masking_alicet | 0x4C | | 0x0000000000000110 2022.06.06 14:22:06.373 |
| threshold_level_1 | 0x09 | | 0x000000000000000A 2022.06.06 14:22:06.348 | masking_autot | 0x4D | | 0x000000000000000F 2022.06.06 14:22:06.376 |
| threshold_level_2 | 0x0A | | 0x000000000000000A 2022.06.06 14:22:06.350 | masking_readout | 0x4E | | 0x000000000000000F 2022.06.06 14:22:06.379 |
| threshold_level_3 | 0x0B | | 0x000000000000000A 2022.06.06 14:22:06.352 | | | | |

Writing of the Bunch Crossings: Done

Status of the Module Configuration: Not OK Check done

Configure all Module's Registers from file

A new ALF and FRED release is now available with the possibility to enable the full 80 bit length of the SWT word.

The new version of FRED has been installed by the DCS team on ZDC DCS server at P2.

Tests successfully performed at P2 sending SWT words to FEE via the FRED panel.

WinCC: datapoints subscribed to DIM services.

Tests successfully performed at P2 sending SWT words to FEE via the WinCC panel.

The "Electronics Configuration" panels have been added to ZDC_UI.

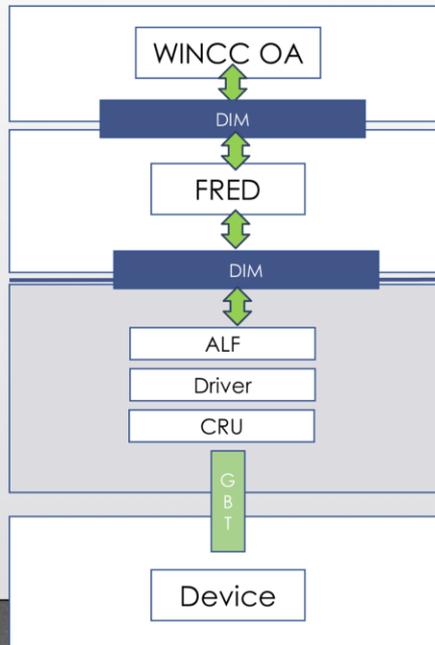
It will be necessary to retest the FSM when the reset of FEE at SOR will be effective.

Electronic configuration at start of run



Through the CRU via DCS using SWT words in the framework ALF-FRED.

ALF FRED architecture



- DCS Server (Windows)
- SCADA project (control, monitoring, archival, alerts)
- DCS Server (Linux)
- Detector specific layer - customizable
- O2 Server – FLP (Linux)
- Detector independent layer
- Detector hardware

DCS
O2

O2 software Activities



QC

-12/7 First tests of ZDC raw QC at P2 performed; problem with CPU usage and backpressure. Code for Raw QC task updated, new pull request sent.

QC workflow for raw data on FLP works correctly; the environment is created without mistakes.

-Code for reconstructed data task in progress, expected in 2-3 weeks

QC workflow for reconstructed data task on EPN will follow.

Reconstruction and Calibration

- Reconstruction software available with most of the functionality implemented; new pull request sent.
- Calibration algorithms: intercalibration of ZN towers, shape calibration, pedestal calibration are integrated in O2. Time calibration under review, energy calibration under development
- Transmission of DCS parameters to CCDB/O2 under development.

Mask of empty BCs

The ZDC needs a mask of empty BCs to compute ADC pedestals. This information is foreseen to come from the CTP via DCS to the FEE and to CCDB. The average baseline in an orbit should be estimated by the FPGA firmware not only in BCs where no collision takes place at IP2, but also where no background is present from incoming beams at the ZDC location (112,5 m from IP).

From CTP team: empty mask on DCS network in July, custom ZDC Empty mask ready at the end of August.

Milestones 2021



30/6/2021

ZDC Upgrade - Installazione e inizio commissioning del sistema di acquisizione al CERN

30/6/2022 -> 100%

A inizio Marzo 2022 primo global run ZDC in ACR con sottoinsieme del FEE installato che ha runnato sia in modalita' continua che triggerata; nella prima meta' di giugno completata l'installazione e il commissioning di tutta l'elettronica.

31/12/2021

Commissioning del nuovo readout all'interno della struttura di controllo O2 (Online-Offline) dell'esperimento ALICE sia in triggered che in continuous mode

30/6/2022 -> 100%

Legata alla milestone precedente.

Milestones 2022-2023



31/10/2022

Commissioning con fascio in parallelo alla presa dati p-p

30/6/2022 -> 0%

La messa a punto dello ZDC con fascio di protoni e' previsto durante la settimana del vdM scan a meta' Settembre quando le condizioni del crossing angle saranno tali da permettere agli ZDC di prendere dati.

31/12/2022

Partecipazione alla presa dati Pb-Pb

30/6/2022 -> 0%

Lo ZDC e' previsto essere operativo durante il periodo di presa dati con fascio di Piombo prevista a partire da meta' Novembre.

Milestone proposta 2023

30/11/2023

Partecipazione alla presa dati con ioni

Richieste specifiche ZDC 2023



Missioni estere

4 KE per manutenzione e test del sistema di readout (0,5 mese x 2 persone)

Manutenzione e ottimizzazione del firmware per conformarsi a cambi di requisiti da parte di ALICE. Manutenzione del FEE.

4 KE per manutenzione del sistema di movimentazione piattaforme (0,5 mese x 2 persone)

Manutenzione delle piattaforme ZDC ed eventuale sostituzione di PMT nel caso si evidenziassero dei problemi. Interventi previsti nei periodi di technical stop di LHC.

Licenze -> 1 KE

Contributo licenza Xilinx Vivado

M&OB ZDC 2023 -> 16 KCHF -> 16 KE

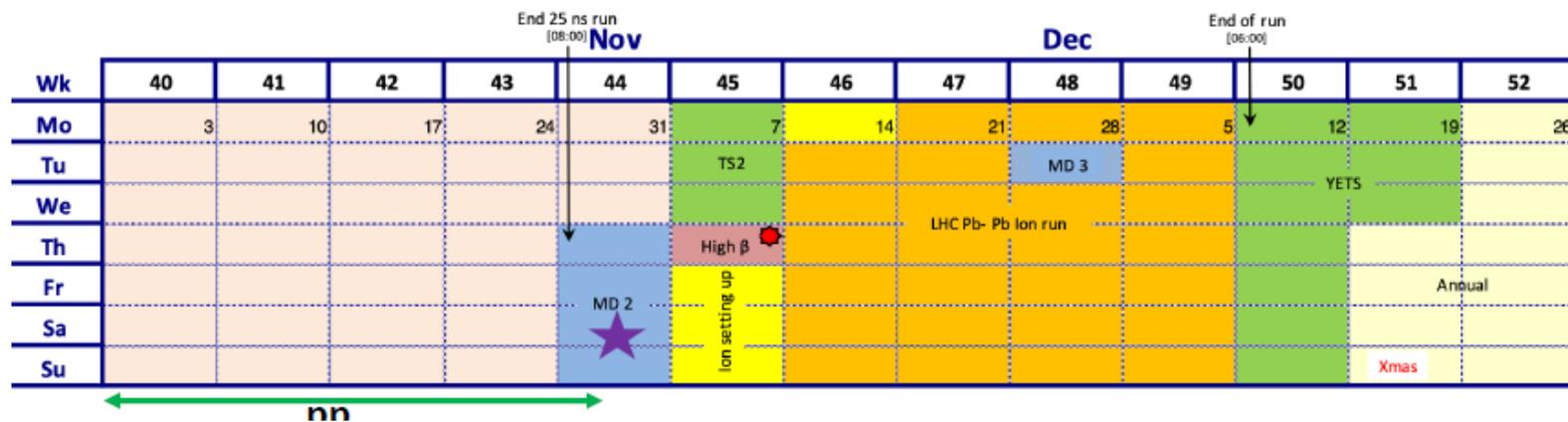
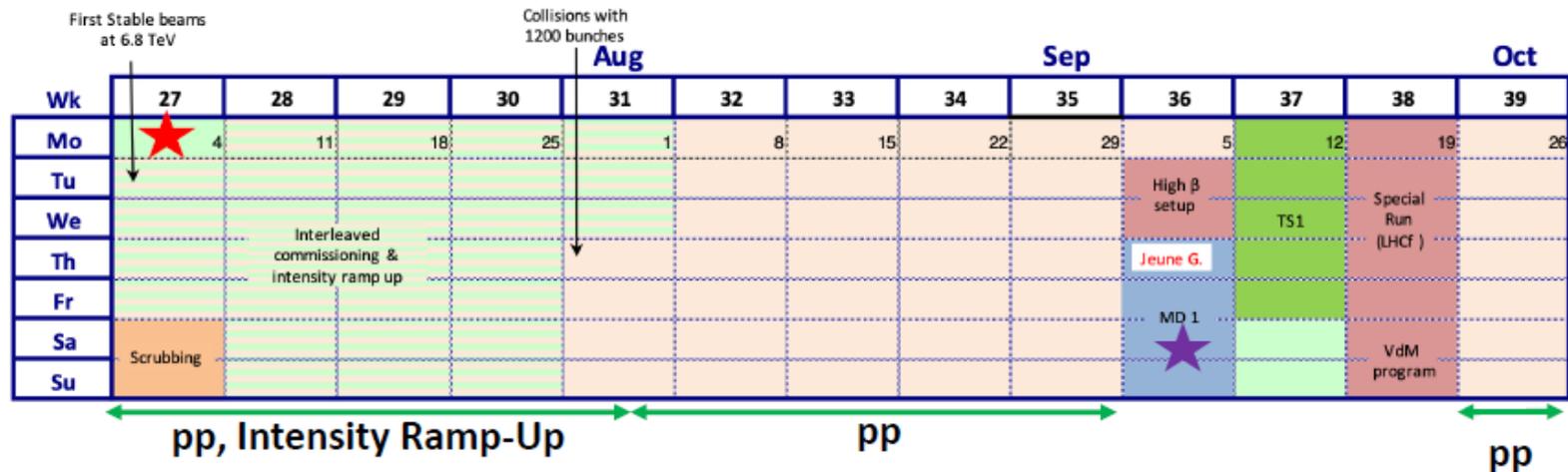
M&OB ZDC (KCHF)



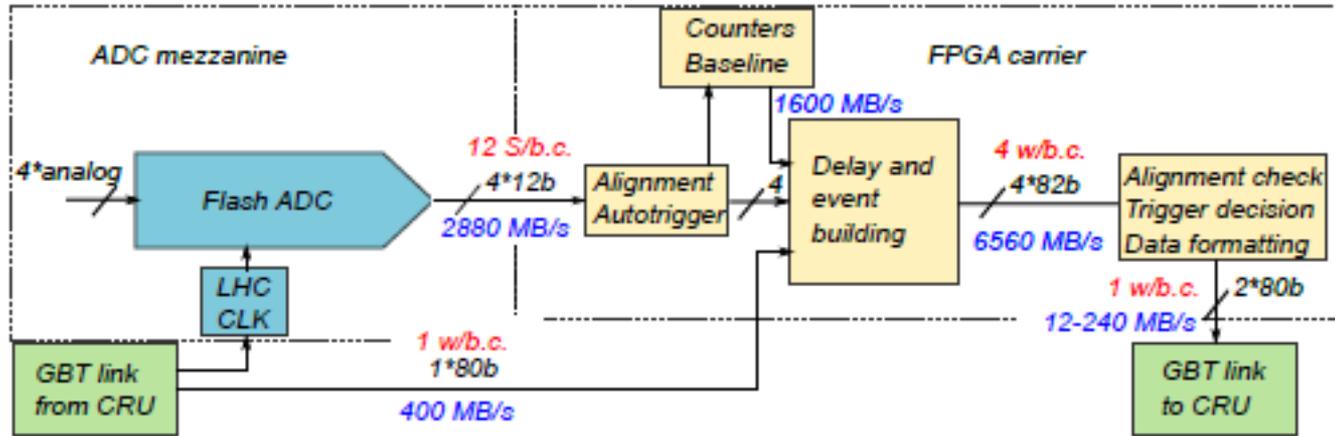
| Ref. | Description | 2023 | 2024 | 2025 | 2026 |
|--------------|---|-----------|------|------|------|
| A01 | Mechanics | 0,5 | 0,5 | 0,5 | |
| A02 | Gas Systems | | | | |
| A03 | Cooling Systems | | | | |
| A04 | FEE spares | 1,5 | 1,5 | 1,5 | |
| A05.1 | Standard Electronics LV/HV PS | | | | |
| A05.2 | Standard Electronics Crates | | | | |
| A05.3 | Standard Electronics R/O modules | 1 | 1 | 1 | |
| A06 | Controls (DCS & DSS) | | | | |
| A07 | Sub-Detector spares | | | | |
| A08 | Areas | | | | |
| A09 | Communications | 1 | 1 | 1 | 1 |
| A10 | Store Items | 6 | 6 | 6 | 6 |
| A11.1 | Technical Manpower @ CERN: Industrial Support | | | | |
| A11.3 | Technical Manpower @ CERN from Collaborating Institutes | 6 | 6 | 6 | 6 |
| Total | | 16 | 16 | 16 | 13 |



BACKUP



Firmware Architecture



P. Cortese
TIPP 2021

The logic is working at ~240 MHz (6 times larger than LHC frequency).

GBT link from CRU provides commands to configure electronics and readout modes, start/stop commands, synchronization signals, orbit and bunch crossing (b.c.) counter...

Clock recovered from the GBT link used to synchronize the clock of the ADC.

Digitizer data are aligned with the b.c. and autotrigger algorithm is applied -> if satisfied the bunch is flagged for acquisition
Ring buffer delay used to synchronize the digitizer output with trigger information -> end of synchronous stage

A FIFO divides the synchronous world from the asynchronous one

Final selection algorithm: check of data stream alignment, check of autotrigger condition or presence of ALICE trigger, data formatting...

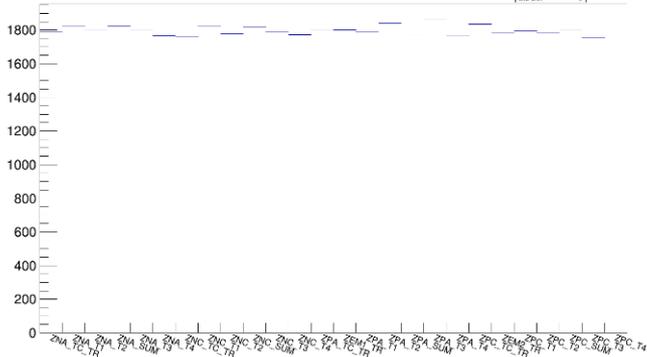
GBT link to CRU transmits triggered bunch crossing (3 GBT words) + previous b.c. for pedestal estimation (3 GBT words)

Example of Raw QC plots



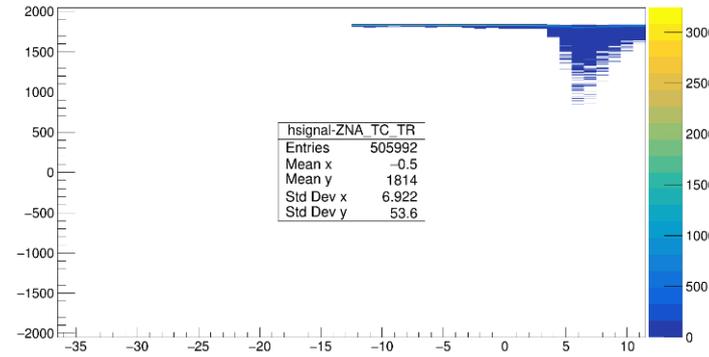
Baseline Summary

| BaselineSummary | |
|-----------------|--------|
| Entries | 130070 |
| Mean | 0 |
| Std Dev | 0 |



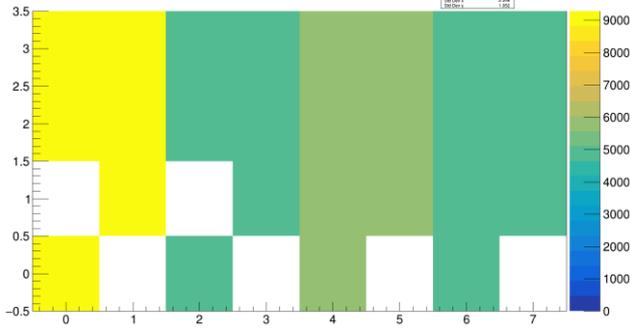
Signal ZNA TC

| hsignal-ZNA_TC_TR | |
|-------------------|--------|
| Entries | 505992 |
| Mean x | -0.5 |
| Mean y | 1814 |
| Std Dev x | 6.922 |
| Std Dev y | 53.6 |



Channels Trasmitted

| ChannelsTrasmitted | |
|--------------------|-------|
| Entries | 1714 |
| Mean | 1.714 |
| Std Dev | 1.008 |



Bunch ZNA TC

