Cs MonSys Design
(Upgrade steps)

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Concept of changes in Cs

- The same amount of Sensors:
  - **411 SIN sensors** for capsule detection,
  - **56 new** pressure sensors,
  - **9 Geiger** for Cs source detection.
- Local Control cards (>15 years old)
  - **38 SIN (capsule detection),**
  - **16 ADC (pressure),**
  - **9 Garage (Locks, SIN, Geiger).**
- Max 11 boxes on a side.
- **3** sub-sections for three barrels.

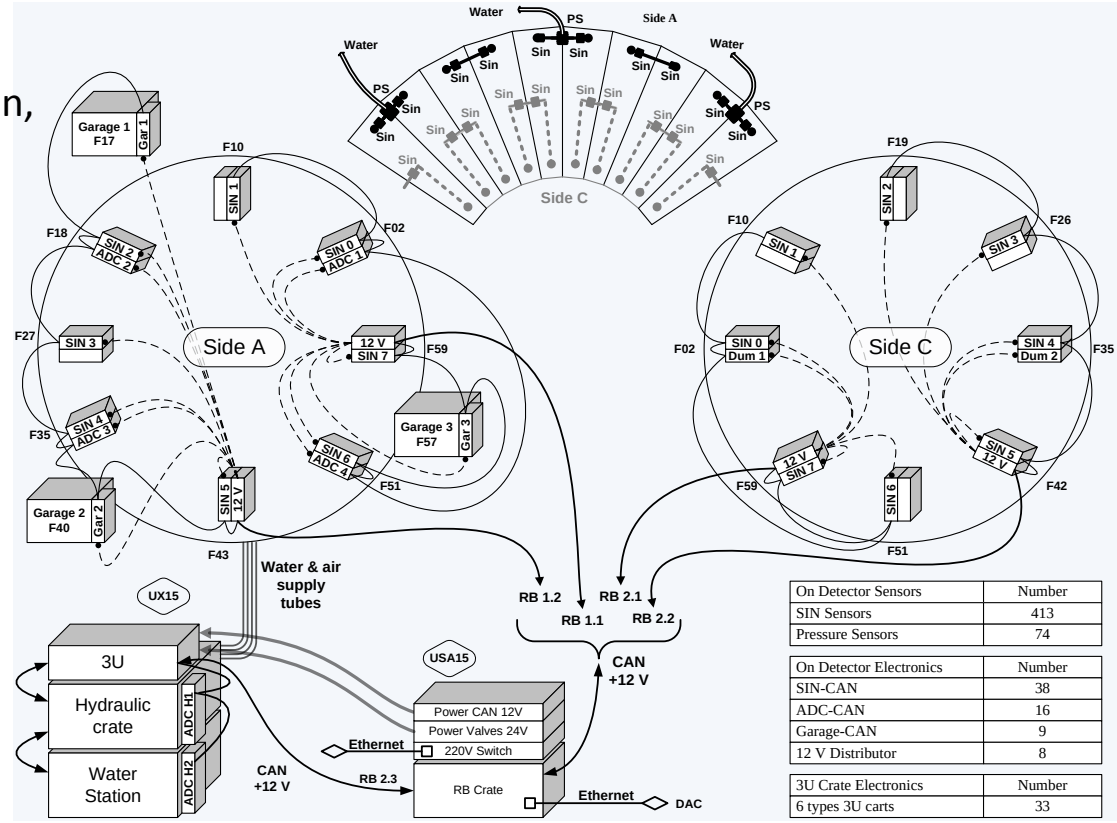
❖ **The architectural concept and mechanical dimensions are preserved.**

❖ **New types of 3U-modules added.**

❖ **New electronic components with increased degree of integration.**

❖ **Difference in communication:**
  - ❖ **optical data transfer should be used.**

❖ **Integration into the TileCal dataflow.**



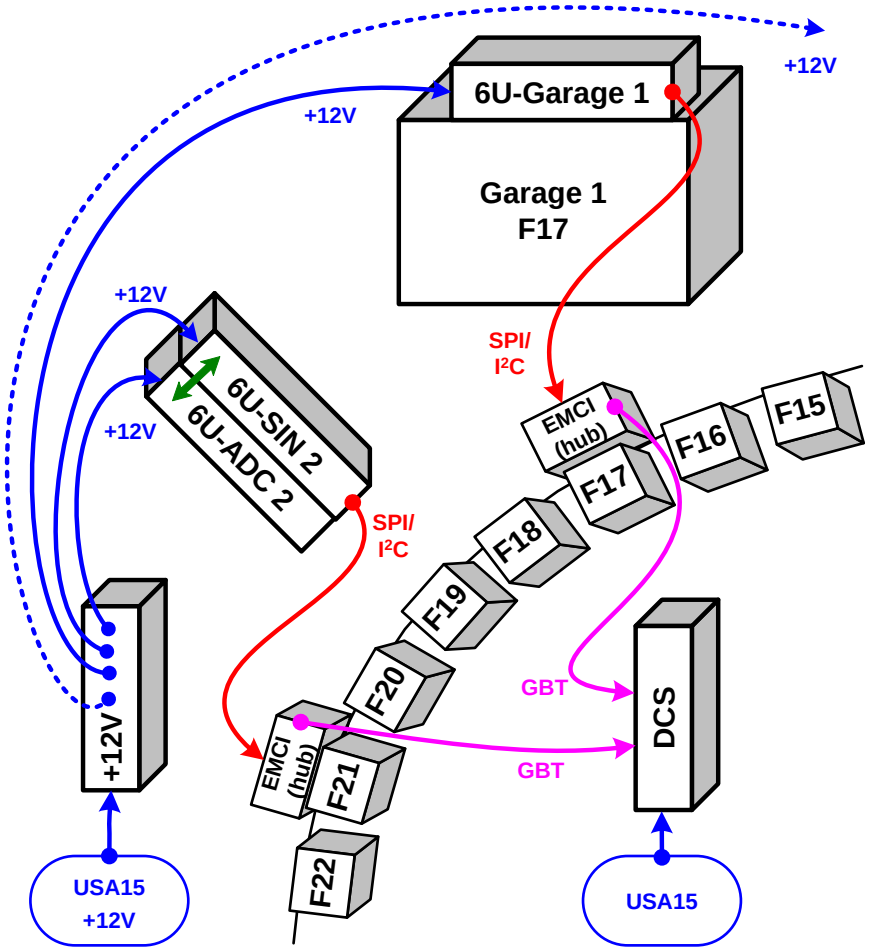
On Detector Sensors	Number
SIN Sensors	413
Pressure Sensors	74

On Detector Electronics	Number
SIN-CAN	38
ADC-CAN	16
Garage-CAN	9
12 V Distributor	8

3U Crate Electronics	Number
6 types 3U carts	33

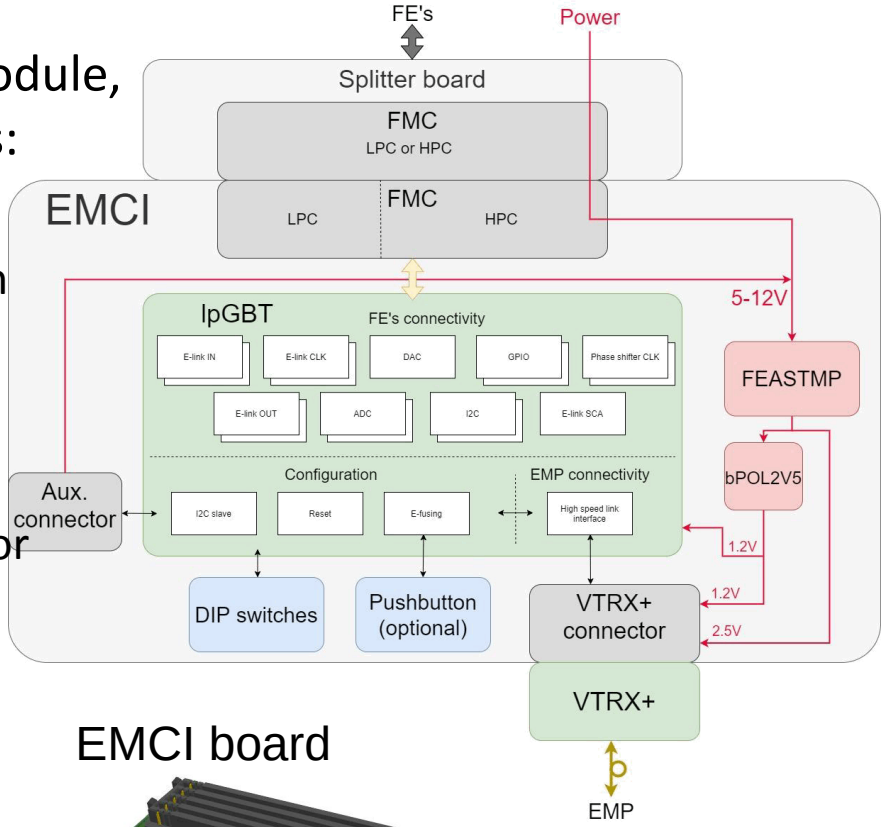
New: Integration with DCS using EMCI

- Garage and Cs-boxes are placed on the fingers, as well as EMCIs (**E**mbedded **M**onitoring and **C**ontrol **I**nterfaces).
- EMCI have optical link to EMP (Embedded Monitoring Processor).
- Proposal is to integrate the Cs control information with the DCS data stream:
  - I^2C interface to mezzanine EMCI;
  - Cs USA15 Independent power source allows to switch on/off power of the EMCI and cesium electronics between the scans.
- EMCIs could be used to connect with 3U-Crate controller via I^2C too.
- ~50 EMCI (hub) boards will be needed
  - 11+8 on LB(A+C)
  - 14 on each EB
  - 3 in 3U-Cs crates near hydro-drives.

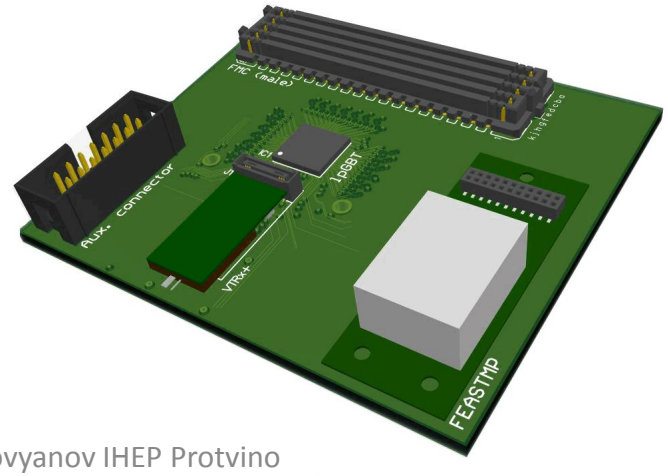


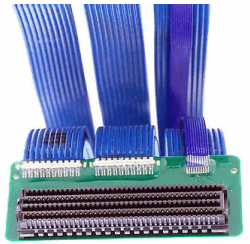
Using EMCI to DCS data flow

- EMCI is the new embedded slow control module, that is based on radiation hard components:
  - lpGBT (low power Giga Bit Transceiver)
  - Versatile Link+ (VL+) optical link to EMP with VTRx+ connector for 10.24 or 5.12 Gb/s
  - FEASTMP (DC-DC converter 5-12V -> 2.5V)
  - bPOL2V5 (DC-DC converter 2.5V -> 1.2V)
  - FMC (FPGA Mezzanine Card) HPC (400 pin) or LPC (160 pin) connector.
- Main features of the EMCI:
  - eLinks - up to 28 devices for uplink
  - 16 general-purpose I/O pins
  - 2 independent I2C master interfaces
  - 8-channel multiplexed 10-bit SAR ADC
  - 12-bit R-2R voltage DAC, from 0 to +1V
  - The EMCI power should not exceed 1W
  - Approximate dimensions: 90x75mm



EMCI board

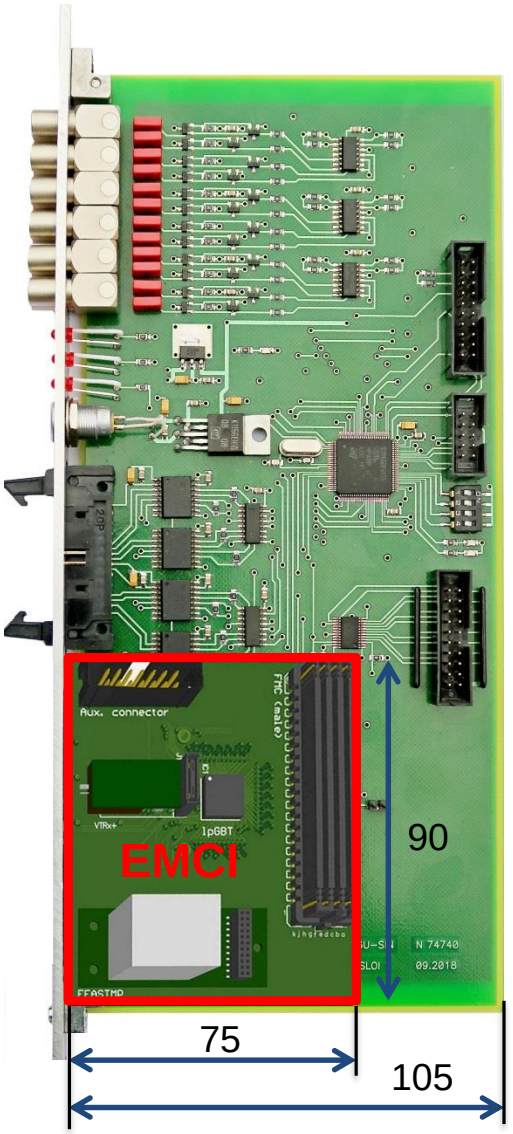




PCB with FMC connector

Concept EMCI installing on 6U-SIN

- 6U-SIN and 6U-Garage Cs-boards are ones to be connected through EMCI to DCS system.
- 90 x 75 mm^2 EMCI board easily fits on 6U-Cs board.
- 6U-Cs board is feeding by 12 volts that is suitable for supply EMCI board that takes < 1 W, i.e. < 100 mA, which is easy to supply.
- PCB with FMC connector can be attached with cable to 6U-board to provide:
  - I^{2}C interface connection from EMCI to 6U-board,
  - +12 V power supply for EMCI mezzanines.
- Auxiliary connector have a I^{2}C slave interface that is used to pre-configure lpGBT and the VTRx+ by the 6U-Cs microcontroller.
- 3U-Crate controller module can also be easy connected to EMCI board for optical link connection to EMC and DCS.



Radiation Hardness tests

Radiation levels for 4000fb^{-1}.

Radiation type	Simulated Level	Safety Factors				Required Level
		Simulation	Low Dose Rate		Lot Var.	
			no anneal test	anneal test		
Total Ionizing Dose (TID) TLB fingers	37.5 Gy	1.5	5	1	4	1125 Gy
Total Ionizing Dose (TID) UX15 3U crate	<2 Gy	1.5	5	1	4	< 60 Gy
Non-Ionizing Energy Loss (NIEL)	1.4 10^{12} n/cm^2	2	1	1	4	1.12*10^{13} n/cm^2
Single Event Effects (SEE)	2.9 10^{11} p/cm^2	2	1	1	4	2.32*10^{12} p/cm^2

- 6U-Cs control boards are located above the Fingers at

  z = 300-312 cm and r = 425-430 cm.
- 3U-Cs crates and hydraulic racks are placed in UX15 side USA15, Level 0

  z = 935..1055 cm; x = -900..-1000 cm; y = -900..-1100 cm.
- Levels were taken from radiation levels TileCal page:
  https://twiki.cern.ch/twiki/bin/view/Atlas/TileCalRadTestInfo
- Cs electronic supposed to be powered and to be used only when there are no particle interactions in ATLAS.
- We will use active components from a single lot to remove the lot variation factor of 4, and try to perform the anneal test to remove the low dose rate factor of 5.
- Several component test boards by 10 pieces to be done for final rad tests.

Communication

- Now we have CAN-bus communication as a backup solution.
- We checked SPI connection with DB.
- We don’t need big data rates to manage Cs control electronics.
- EMCI board is interesting for us because of optical link communication and integration into DCS system of TileCal.
- If full amount of EMCIs (~50 pieces) will be available, we could use them as mezzanines in every Cs board, that needs communication with DCS.
- EMCI can receive data from Cs in a poling mode with rates of dozen hertz just to have a proper sensor’s response time.

Consideration

- From Cs side we need to connect to one I^2C master interface of EMCI to transmit our data.
- Cs electronic board have a microcontroller that can configure EMCI board using I^2C slave interface in auxiliary connector.
- EMCI mezzanine can be powered through auxiliary connector.
- We would like to use just only auxiliary connector of EMCI mezzanine to communicate with Cs electronic board:
  - FMC connector - very big, 400 pin, costly, complex in managing.
- It's best for us to use only one connector – auxiliary, that:
  - have I^2C slave interface for configuring EMCI and
  - will have I^2C master interface to communicate Data with Cs.
- So, just 2 additional pins in auxiliary connector for I^2C master will significantly decrease cost & time of disign for us!

Summary

- ✓ **The EMCI board can be used as a mezzanine with Cs control electronics boards for transferring data to DCS**
- ✓ **We are waiting for the final specifications on the EMCI, and still have two options: DB and EMCI**
- ✓ **The radiation tolerance requirements, including safety factors, should be ironed out and all active components should be tested before FDR at the end of 2021**

Backup

Prototypes of the Cesium Electronics

- Custom made approach used to all 3U-Cs and 6U-Cs boards.
- The 3U-Cs boards are hosted in the 3U crates at the Level 0 of the cavern and used to control the hydraulic system (drives).
- The 3U boards communicates via 3U crate backplane and then EMCI.
- Mini-crates with 6U-Cs boards and Garages uniformly distributed on TileCal “fingers”.
- The 6U boards communicate via
  - SPI with TileCal electronics drawer`s DB

  or via
  - EMCI system

№		ATLAS	Test Setups	Spares	Total	Fixed Design	Prototypes produced
1	3U-Eth + EMCI	3	2	3	8	+/-	2
2	3U-Valves	24	16	8	48	+	23
3	3U-Pump	3	2	3	8	+/-	3
4	3U-LeM	3	2	2	7	+	5
5	3U-FlowM	3	2	2	7	+	5
6	3U-WeightM	6	4	4	14	+	8
7	3U-Display	3	2	2	7	+	2
8	6U-Garage+EMCI	9	2	3	14	+/-	2
9	6U-SIN + EMCI	38	2	10	50	+/-	2
10	6U-ADC	16	2	4	22	+/-	2