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Liquid Argon Hadronic EndCap Production Database

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Chris Oram (oram@triumf.ca)
Mike Losty (losty@triumf.ca)
Monika Wielers (monika.wielers@cern.ch)

TRIUMF, Canada

This document describes the contents of the Liquid Argon Hadronic EndCap (HEC) Production Database. At the time of the PRR (Production Readiness Review), the groups responsible for the production of the LAr HEC components and modules were required to provide a detailed plan as to what data should be stored in the production database and how the data should be accessed, displayed and queried in all reasonable foreseeable circumstances. This document describes the final database.

Data related to the production of the LAr HEC are stored in a MS Access Database maintained by the TRIUMF group, and will be transferred to the CERN Oracle Database, maintained by the CERN IT group. The data will be maintained for the lifetime of ATLAS, and will be useful for both the experts who produced the HEC, and the end-users (technicians, physicists) to access any or all pertinent details regarding a particular HEC module or component. In addition, it is required by the ATLAS Technical Coordination (TC) that any parts of the detector that will be moved to the ATLAS Cavern should have detailed production data in the database at the time of installation. The LAr Production Database will be integrated with the TC database, which is also a CERN Oracle Database.

IMPLEMENTATION:

HEC production data are currently stored in the MS Access Database "HEC Production Database". This effort is now in its final stages, with a few minor modifications required to make it suitable for permanently providing it to LAr. The database will be migrated to the official CERN production database infrastructure upon final review. Additional data on production are available at the manufacturing sites. Many details, such as shipment dates, have not been transferred to the HEC Production Database. However the institutes will keep copies of this information for the first few years of data taking, for use in the very unlikely event of a serious problem.

The structure of this database is shown in Fig. 1. The relationships used in the database are through the serial numbers:

- Module serial number
- Copper serial number
- Honeycomb serial number
- EST serial number
- PAD serial number

The data entry at the stacking sites was by hand, and naturally, some entry errors have occurred (at the 1% level). These errors have lead to some double entries which we have chosen to leave in place. The module serial number does not have this problem and is unique. The *Cold Test at CERN* and the *Location in Wheel* items provide the possibility of connecting this database to the HEC Cold Test Database and the HEC Wheel Assembly Database respectively.

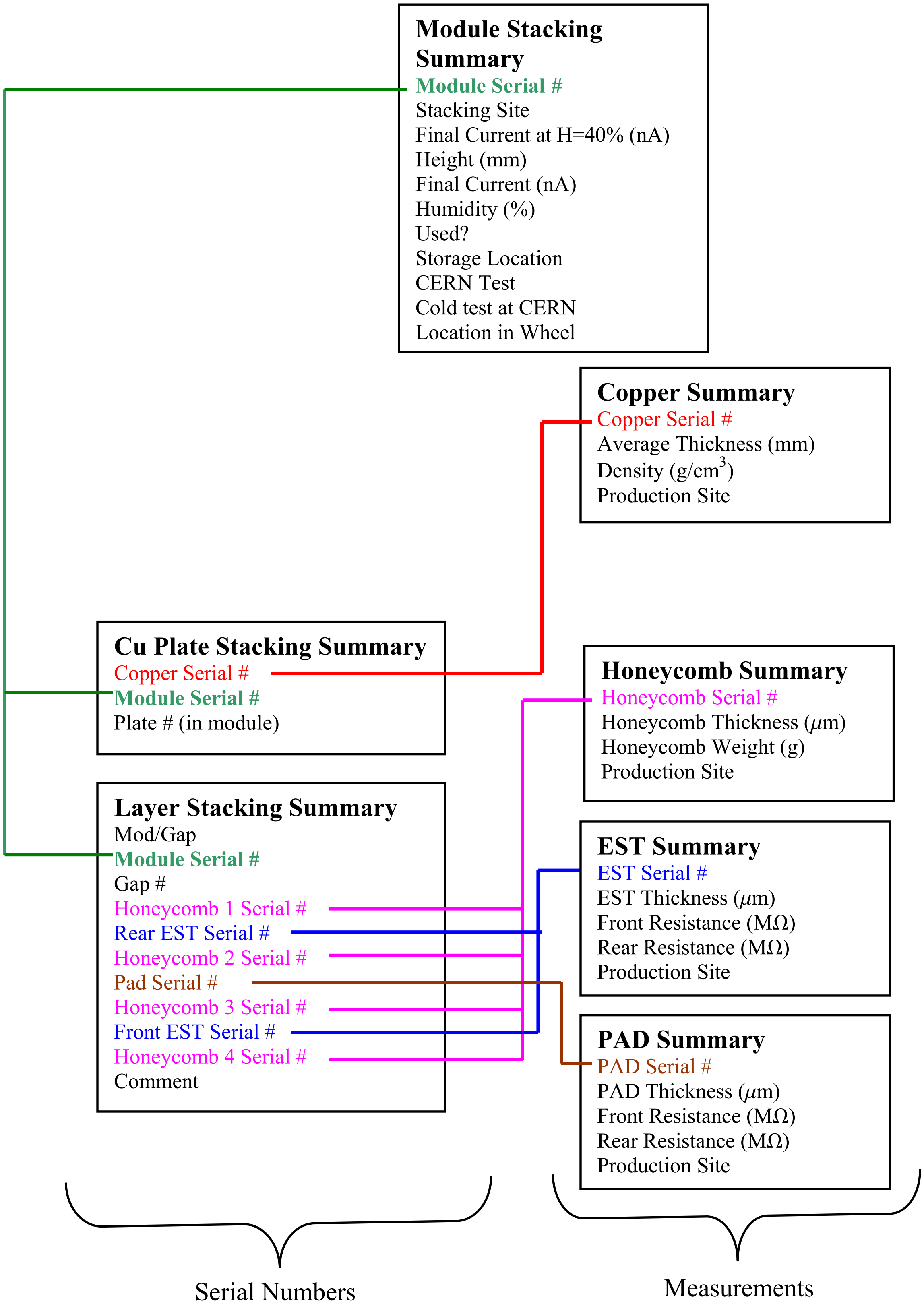

Fig. 1. Architecture of the LAr HEC Production Database. The lines show the how the various parameters are related to each other. The first item in each table is a unique identifier.

SUMMARY OF DATA:

A statistical summary of the data in this database and other data recorded during assembly is given in a separate document, which includes estimates of the impact of the manufacturing variations.

DATA DEFINITIONS:

Here we define in detail the entries in each table in the database. To add clarity, each section starts with a **short specimen** section of the table that is about to be described. The key data definition is the module serial number:

Module Serial #

This has the typical format CF04, for example, where:

- C refers to the wheel (C or A) that the module was nominally built for. Three special modules, SR01, SF01 and SF02, were also initially built. SR01 and SF02 were subsequently declared standard series modules. SF01 exists only as a stack of copper plates.
- F refers to the module being a Front module. Only F (front) and R (rear) modules were produced. Front modules have plate numbers 1 to 25 and rear modules 26 to 42. Front modules have gaps (layers) 1 to 24 and rear modules 25 to 40 (see the LAr TDR).
- 04 refers to the number of that series module 01 to 33.

This number is written on the module, on the rear copper plate at the outer radius.

Cu Plate Stacking Summary

Cu Serial #	Module #	Plate #
0185G04	AF18	1
0185G05	AF19	1
02/86/02/01	CF02	2
02/86/02/02	CF01	2

Copper Serial #

Three serial number formats exist, depending on the plate's origin: one for plates produced and stacked in Canada, one for plates produced and stacked in Europe and one for plates produced in Canada and stacked in Europe:

Canada/Canada format: 39/104/16/28
39 is the nominal plate number, so this plate goes in a rear module that uses plates 26 to 42. 104 is the drawing number that was used to machine the plate. 16 is the copper batch (each batch having a different density). 28 is the nominal module number.

Canada/Europe format: 0185G01
01 is the nominal plate number, so this plate goes in a front module that uses plates 1 to 25. 85 corresponds to the drawing number from which the plate was machined. G is the copper batch (each batch having a different density). 01 refers to the nominal module number.

Europe/Europe format: A23_P14
The plate is number 14 in a front module (plates 1 to 25). A refers to the module being nominally intended for the A end. 23 is the module number. So, this plate is used for layer 14 in module AF23.

These serial numbers are punched onto the copper edges at the outer radius of the plates. The drawings are stored in the EDMS database. The copper batch number present in some serial numbers was used to assign the density to the plates. Every plate in a batch is assumed to have the same density.

Module Serial #

As defined on page 3.

Plate # (in module)

A number between 1 and 42. Plates 1 to 25 go in front modules; plates 26 to 42 go in rear modules.

Layer Stacking Summary

Mod/gap	Module #	Gap #	Honey-comb 1	Rear EST	Honey-comb 2	Pad	Honey-comb 3	Front EST	Honey-comb 4	Comment
AF01/01	AF01	1	0865B	121722	0865C	P1224	0865C	121171	0865D	
AF01/02	AF01	2	0862A	120222	0861F	P1213	1001F	120251	1006E	
AF01/03	AF01	3	0999C	121702	1000F	P1221	1000A	120121	1000D	

Mod/Gap

Format: CF02/08.
This is module serial # CF02, gap # 08. Gaps 01 to 24 are present in front modules, gaps 25 to 40 in rear modules.

Module Serial #

As defined on page 3.

Gap #

Gaps 01 to 24 are present in front modules, gaps 25 to 40 in rear modules.

Honeycomb n Serial #

This is the serial number of the *n*th honeycomb spacer mat to be placed in the gap, where *n* goes from 1 to 4. As modules are stacked from the rear, honeycomb 1 serial # refers to the rearmost honeycomb in the gap, which is the first to be placed in the gap. The serial number was carried with the honeycomb during manufacture on a tag. This tag was removed during stacking, so no serial number remains on the honeycomb.

The serial number is of the form: 1908A, where 1908 refers to the 4 foot by 8 foot sheet the honeycomb spacer was cut out from, and A is the location on that sheet. There were six honeycomb spacers cut from each sheet, so the location number goes from A to F. As the honeycomb originally comes from a solid block, and the sheets were cut sequentially, honeycomb spacer 1907A and 1908A were cut from adjacent sheets at the same location. This serial number scheme was used because if there was a HV failure in the honeycomb due to a conducting strand in the honeycomb block, failures would be seen for, say, the A position from sheets 1621 to 1633. No such failures were observed in the production.

EST Serial #

There are two EST's in each gap, a front and a rear. The front one is closest to the interaction point. EST's were produced at two sites, TRIUMF and LPI. EST's come in 5 types:

- Type 1: Gaps 1-8
- Type 2: Gaps 9-16
- Type 3: Gaps 17-24
- Type 4: Gaps 25-32
- Type 5: Gaps 33-40

LPI serial numbers are of the format 114031, for example, where:

- the first 1 means this is an EST of type 1.
- 1403 in the middle is the number of this EST.

- the final 1 refers to this being a front EST (rear EST's have a final 2).

TRIUMF serial numbers are of the format TER-2284, for example, where:

- T stands for TRIUMF
- E refers to EST
- R is for Rear (F is for Front)
- 2 refers to type 2
- 284 is a unique identifier

The serial number is written on the face of the EST.

Pad Serial #

There is one Pad at the centre of each gap. All the PAD boards were produced at TRIUMF. Pads come in 7 types:

- Type 1: Gaps 1-8
- Type 2: Gaps 9-16
- Type 3: Gaps 17-24
- Type 4: Gaps 25-28
- Type 5: Gaps 29-32
- Type 6: Gaps 33-36
- Type 7: Gaps 37-40

Serial numbers are of the form P1042, for example, where:

- P stands for Pad
- 1 stands for type 1
- 042 refers to a unique identifier for this pad

The serial number is written on the face of the PAD board.

Comment

Free text format.

Module Stacking Summary

Module Serial #	Stacking Site	Final Current at H=40% (nA)	Height (mm)	Final Current (nA)	Humidity (%)	used?	storage location	CERN Test	Cold Test at CERN	Location in Wheel
AF01	TRIUMF	236.9	816.38	125.40	34	Yes		cold tested	CT05	HEC1C09
AF02	TRIUMF	239.9	816.21	92.40	31	Yes		cold tested	CT05	HEC1C22

Module Serial #

As defined on page 3.

Stacking Site

Dubna, Protvino, MPI or TRIUMF.

Final Current at Humidity H = 40% (nA)

Current in nA of module, measured when fully completed, and re-normalised from the measured humidity (*h*%) to a humidity of 40%, using the empirical formula:

Final Current (at humidity 40%) = Measured Current (at humidity h) x $e^{0.106\,(40 - h)}$

Height (mm)

Final height of module.

The nominal height of the front modules is:
12.5mm (first plate) + 24 x 25mm (plates 2-25) + 24 x 8.5mm (gaps 1-24) = *816.5 mm*

The nominal height of the rear modules is:
25mm (plate 26) + 16 x 50mm (plates 27-42) + 16 x 8.5mm (gaps 25-40) = *961.0 mm*

Final Current (nA)

Final current of module, measured when fully completed.

Humidity (%)

Humidity in room when final current was measured.

Used?

Used in wheel? True/False

Storage Location

If not used in a wheel, this is intended to indicate the present storage location.

Cold Test at CERN

Every module was cold tested at least once at CERN. This item gives the name of the final cold test of the module.

Location in Wheel

This is the wheel location in ATLAS. Upon completion of each wheel, a drawing was made by Roy Langstaff and placed on the HEC LAr web page. The drawing shows a rear view of the wheel. Locations are denoted 1 to 32. To avoid confusion with the nominal module positions, the notation HEC1A04 is used, where 1 refers to this being a front wheel (module), A to this being the A wheel, and 04 to the location in the wheel. The nominal ϕ location of the centre of module n is given by:

$$\phi = 2\pi (n - 0.5)/32$$

Note that in this location-in-wheel notation, 1 is the front wheel and 2 is the rear wheel, so HEC2A04 is the location exactly behind the location HEC1A04 in the front wheel.

Copper Summary

Cu Serial #	Average thickness (mm)	Density (g/cm^3)	Production Site
03/87/02/01	25.04	8.911	Alberta
03/87/02/02	25.01	8.911	Alberta
03/87/02/03	25.03	8.911	Alberta
03/87/02/04	25.01	8.911	Alberta
03/87/02/20	24.99	8.911	Alberta
03/87/03/05	25.01	8.915	Alberta
03/87/03/06	24.99	8.915	Alberta

Copper Serial #

As in Cu Plate Stacking Summary table.

Average Thickness (mm)

The plate was measured in several locations (typically 8, but this depended on the manufacturing site) and the average is recorded here.

The nominal thickness of:

- Plate 1 is 12.5 mm
- Plates 2-26 is 25 mm
- Plates 27-42 is 50 mm

Density (g/cm^3)

Density in g/cm^3. The average value was found to be slightly lower than the nominal value of 8.96 g/cm^3. This is assumed to be due to slight impurities.

Production Site

Manufacturing sites: Alberta, Protvino or Dubna. Each site was individually responsible for its own QC.

Honeycomb Summary

HC serial number	HC thickness (μm)	HC weight (g)	Production Site
0113E	1902.8	32	TRIUMF
0113F	1904.1	32	TRIUMF
0114A	1902.8	31.8	TRIUMF

Honeycomb Serial #

As in Layer stacking Summary

Honeycomb Thickness (μm)

Thickness as measured under the weight of 25 mm of copper. Typical thickness: *1860μm*.

Honeycomb Weight (g)

Weight of this sheet of honeycomb in grams.

Production Site

TRIUMF

EST Summary

EST Serial #	Thickness (μm)	Front Resistance (MΩ)	Rear Resistance (MΩ)	Production Site
110471	144	22	10	LPI
110482	146	10	20	LPI
110491	144	23	10	LPI

EST Serial #

As in Layer Stacking Summary table.

EST Thickness (μm)

Typical thickness of LPI board: *150μm*, and of TRIUMF board: *175μm.*

Front Resistance (MΩ)

Each board has two HV connections to the carbon loaded Kapton©, which provides the resistive coating to distribute the HV on the face of the board. Here we record the resistance between the pins on these two connections for the face nearest to the interaction point.

Rear Resistance (MΩ)

Here we record the resistance between the pins on the two HV connections for the face furthest away from the interaction point.

Production Site

LPI or TRIUMF.

PAD Summary

Pad Serial #	Thickness (μm)	Front Resistance (MΩ)	Rear Resistance (MΩ)	Production site
P1003	325	7.24	6.4	TRIUMF
P1004	328	7.24	6.5	TRIUMF
P1005	326	6.32	6.54	TRIUMF
P1006	325	7.09	6.87	TRIUMF
P1007	326	6.24	5.68	TRIUMF
P1008	326	6.4	6.03	TRIUMF
P1009	328	6.28	6.92	TRIUMF

PAD Serial #

As in Layer Stacking Summary table.

PAD Thickness (μm)

Typical thickness of board: *335μm.*

Front Resistance (MΩ)

Each board has two HV connections to the carbon loaded Kapton©, which provides the resistive coating to distribute the HV on the face of the board. Here we record the resistance between the pins on these two connections for the face nearest to the interaction point.

Rear Resistance (MΩ)

Here we record the resistance between the pins on the two HV connections for the face furthest from the interaction point.

Production Site

TRIUMF.