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Thoughts on Database for GLAST Tracker Construction

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Abstract

The GLAST tracker consists of many components such as about 10000 silicon strip detectors, 600 HDI's (High-Density Interface; a readout electronics unit), 300 detector trays, and so on. Since those components should be kept track of during assembly of GLAST tracker, we need relational database to include assembly status, test results, and relationship between components. In this report, I summarize what functionality of the database we will need, based on our experience in construction of the GLAST BTEM (Beam-Test Engineering Model) Tracker. Also, names of tracker components and definition of tracker coordinate system are proposed for use in the database.

1. Introduction

A database for the GLAST tracker assembly (hereafter assembly database) should store component description, tracker configuration, assembly status, measurement results, and assembling history of assembled components. In addition to simple manipulation functions such as such as sorting, selecting, relating, and summarizing records in a database, a tracker assembly database should capable to assist tracker administrators and assembly operators.

This document describes what records and functions we will need in our assembly database. Also, it mentions about naming conventions and tracker coordinate system, which we propose to use in our assembly database. At this point of time, we are looking at construction of 17 towers, 18 detector-planes per tower, 4 detector-ladders per detector-layer, 4 detectors in a detector-ladder, 384 strips per detector, and 24 front-end chips per detector-layer. If one or more of those numbers change in the future, some numbers in this document should be modified appropriately.

2. Records in Tracker Assembly Database

A set of records should be organized for each major component of tracker, such as a detector, a tray, and an HDI. A set of records for such a component consists of two types of information: identification information and assembly logging (see Table 1).

A repair is considered a special assembly step. See "Note on repair" below for handling of repairs.

- Identification information

Identification information includes its name, names of components that it consists of, a name of a component that it belongs to, and its location in the component that it belongs to. We need a consistent naming convention throughout the entire tracker system to describe this information. See a later section for naming convention.

- Assembly logging

All assembly steps should be recorded in chronological order. A step may repeat in case of repair (see "Note on repair" below for more explanations). For each step, date and time, initial(s) of operator(s), result of operation or test, and operator's comment should be recorded. A result of operation or test should be one of four levels: “good”, “acceptable with a minor problem”, “postponed to use”, and “rejected”.

Some assembly step may be accompanied with an assembly-specific information. For example, a jig number is such information for a detector gluing into a ladder. Similarly, an IV curve should be accompanied with IV measurement, and a list of bad strips will be a part of a cap-test of a ladder.

Assembly logging is essentially of variable length, even with assembly procedures fixed. This is because of possible repetition of measurements or tests. A measurement or a test should be repeated as many as necessary. And all measurements and tests should be recorded in chronological order as they are performed.

Note on repair

1. A repair is regarded as a special assembly step. In addition to standard set of records (date, initials, etc.), a copy of all the identification records should be saved for future reference. In other words, each repair record should include its identification records before the repair as additional information for the assembly step.
2. An assembly step may repeat due to repair. For example, a ladder assembly could be like gluing, bonding, IV measurement, replacement of a detector with a new one (repair), gluing, bonding, IV measurement, cap-test, and encapsulation. In this case, we should put all of these nine steps in the assembly database in chronological order. This is another reason for assembly logging to be of variable length.

Table 1. Proposed list of records in a tracker assembly database

Type	Record	Associated records
Detector		
ID info	❑ Detector ID, manufacturer name	
	❑ Ladder ID to belong to	
	❑ Location of this detector in a ladder	
Logging	➢ Detector delivery	➢ Results by manufacturer
	➢ Quality acceptance test	➢ IV curve, CV curve, etc.
	➢ IV measurement	➢ IV curve
Ladder		
ID info	❑ Ladder ID	
	❑ List of detectors in this ladder	
	❑ Tray ID to belong to	
	❑ Location of this ladder on a tray	
Logging	➢ Detector gluing	➢ Jig ID
	➢ Wire-bonding	➢ Bond quality
	➢ IV measurement	➢ IV curve
	➢ Cap-testing	➢ List of bad strips
	➢ Encapsulation	➢ Jig ID
	➢ Repair	➢ Copy of ID info
HDI		
ID info	❑ HDI ID	
	❑ Tray ID to belong to	
	❑ Side of a tray this HDI reads out	
Logging	➢ Passive component	
	➢ Right-angle connector	

	➢ GTFE64/GTRC mounting	
	➢ Wire-bonding	
	➢ Electrical test	➢ List of dead channels
	➢ Encapsulation	
	➢ Burn-in test	
	➢ Repair	➢ Copy of ID info
Tray		
ID info	❑ Tray ID	
	❑ List of ladders on this tray	
	❑ List of HDI's on this tray	
	❑ Tower ID to belong to	
	❑ Stack position of this tray in a tower	
Logging	➢ Tray closeout assembly	
	➢ Lead/Kapton attachment	➢ Lead thickness
	➢ Tray closeout QC	➢ Mechanical dimensions
	➢ Ladder mounting	
	➢ IV measurement	➢ IV curve
	➢ HDI mounting and wire-bonding	➢ Bond quality
	➢ Readout test through HDI's	➢ List of dead channels
	➢ Repair	➢ Copy of ID info
Tower		
ID info	❑ Tower ID	
	❑ List of trays in this tower	
	❑ Position of this tower on a satellite	
Logging	➢ Tray stack-up	➢ Tension of threads
	➢ Mechanical measurement	➢ Dimensions, alignment
	➢ IV measurement, readout test	➢ IV curve
	➢ Noise measurement	➢ List of noisy channels
	➢ Cosmic runs	➢ Run numbers
	➢ Repair	➢ Copy of ID info

3. Operator Assistance in Production Line

The assembly database should have a user interface to assist operators to assemble components. For example, results of tests or measurements should be automatically sent to the assembly database with minimum operation. Below are examples of helpful assistance for assembly operators.

- **Semi-automatic logging:** Date, time, temperature, operator's name, etc., should be acquired and recorded automatically.
- **Automatic data-transfer:** Result of measurements or tests should be automatically sent to the assembly database.
- **Semi-automatic check of test results:** Measurement or test result should be checked right at the point of measurement or test with conservative criteria and display the check result to an operator.
- **Display of previous measurements or tests:** Results from measurements or tests on a component to be assembled should be displayed before assembly operation. For example, when measuring leakage current of a detector, currents newly measured should be plotted on a plot of previous measurements to compare with.

- **Component list for each assembly step:** For each assembly step, a list of components ready for the assembly step should be displayed. For example, an operator should be able to get a list of ladders ready for wire-bonding at wire-bonding step.
- **Web access:** The operator assistance listed above should be right at the assembly site. This can be done with one central database and many terminal displays to access the database in an assembly line. The access to the database is preferably web-based with access control, so that it can be accessed from foreign countries such as Italy and Japan.

In addition, the assembly database should have an interface to assist tracker administrator to control tracker assembly and check its status.

- **Automatic assignment of component:** For example, detectors gluing into a ladder should be chosen based on results from mechanical measurements or electrical tests, in order to align strips between detectors, or to put a strip with a pin-hole at the farthest from readout electronics.
- **Automatic summary report:** The assembly database should automatically create a summary of tracker construction and send it to the GLAST tracker team.

4. Naming Convention for Tracker Assembly

Two types of names are needed to keep track of tracker assembly: a component name and a location name. A component name corresponds to actual components of a tracker, such as a silicon strip detector, an HDI, a tray, and so on. A location name is to specify the location of a component, such as a position of a detector in a ladder, a stack position of a tray in a tracker tower. Tables 1 and 2 list those names we propose. A location name is used with a component name that the location belongs to. For example, a detector at location “B” of ladder “L0123” can be called “a detector at L0123B”, so you can say “DH04321 is assigned to L0123B.”

A component name with a location name appended can also be used to specify an component that does not have its own name, such as front-end chips, controller chips, bonding wires, and so on. For example, “S123C” specifies a bonding wire on location “C” on “S123”, or the third wire from the readout side on the strip 123, so you can say “S123C was bonded twice” or “H123C05 was replaced with a new chip.”

Table 2. Naming convention for tracker components

Component ID	Name (*)	Remark
Strip ID	S*nnn*	*nnn* should match printed number on a detector, but with preceding zero(s), i.e., 001 though 384. *nnn* = 000 or 385 for a bias ring for bonding purpose.
Detector ID	D*Mnnnnn*	*M* : Manufacturer ID (e.g. “H” for Hamamatsu) Numbering is not necessarily continuous.
Ladder ID	L*nnnn*	
HDI ID	H*nnn*	
Kapton Cable ID	K*Tnnn*	*T* : Cable type, “A” through “D”
Tray ID	T*nnn*	*nnn* is a close-out number
Tower ID	G*nn*	G for GLAST

(*) *n* : Single digit integer forming an ID number

Table 3. Naming convention for locations

Location of	Belongs to	Name
Detector	Ladder	“A” through “D”

		“A” is the closest one to the readout electronics
Bonding wire	Strip	“A” through “D” “A” is the closest one to the readout electronics
Front-end chip	HDI	“C0” through “C23” (the number matches the address) “C0” for the left-most chip on an HDI (*)
Controller chip	HDI	“L” for the one on the left of an HDI (*) “R” for the one on the right of an HDI (*)
Detector layer	Tray	“T” for the top side “B” for the bottom side
Ladder	Tray	“T1” through “T4” on the top side “B1” through “B4” on the bottom side where “X1” is the left-most one for an HDI to read out the ladder
Tray	Tower	“P1” through “P19” where “P1” is the bottom one
Kapton Cable	Tower	“C0” through “C8”
Tower	Satellite	TBD

(*) The “left” side of an HDI is defined as the left side in top view with front-end chips lined-up on the top of the HDI.

5. Tracker Coordinate and Naming Convention for Track Analysis

In addition to names of tracker components and locations, we also need a tracker coordinate system. The tracker coordinate will be helpful in assembling trays into a tower, useful in finding noisy channels in the assembly database and creating trigger masks, and convenient in correlating analysis results with records in the assembly database.

Definition of tray/HDI orientation

The “left” side of an HDI is defined as shown in Figure 0, or as the left side when looking at the HDI with front-end chips lined-up at the top. Front-end chip addresses are hard-wired on an HDI PC board from left to right. In other words, address 0 is for the left-most chip and address 23 for the right-most one. Locations of front-end chips are also named from left to right, or from “C0” to “C23”, as shown in Figure 0.

Figure 0 indicates definition of the “left” side of a tray. The “left” of a tray comes at the left when looking at a top-side-reading HDI with front-end chips lined-up at the top. Note that the left sides of HDI’s are always at the left side of the tray, whichever side of the tray (top or bottom) an HDI is mounted.

Unique identification of a strip in a tower

To uniquely identify a strip in a tower, we use a combination of three numbers: a strip number on a detector layer, GTRC address of an HDI reading out the detector layer, and a Kapton cable ID connecting the HDI (Figures 0 and 0).

Strips are numbered from 0 (zero) to 1535 on each detector layer (i.e., each side of trays), with numbers increasing from left to right. In other words, strip 0 always resides at the left side of a tray, and it is in ladders at “T1” and at “B1”. For HDI to read out a detector layer, strip 0 is connected to the left-most channel on the HDI, and read out with front-end chip at “C0”.

GTRC address of each HDI on a Kapton cable is hard-wired on a Kapton cable and ranges from 0 (zero) to 8. The HDI closest to a tower controller, or TEM (Tracker Electronics Module), has address 0. GTRC address can be used as a location indicator of an HDI, or that of strips to be read by the HDI.

Definition of coordinate axis

Tracker coordinate system has X- and Y-axis in a detector plane, Z-axis pointing from bottom to top, where "top" is defined as top faces of trays (lead is on the bottom side). This Z-axis is also a pointing direction of the entire instrument.

As in BTEM tracker, we would like strip numbers to increase with X- or Y-coordinate as in BTEM tracker. Also, the top-most detector layer will measure Y-position of a track. In other words, strips on the layer are parallel to X-axis. To make tracker coordinate system right-handed, those requirements define orientation of all trays as shown in Figure 0.

Names of detector layer/plane

A detector plane, which a pair of two neighboring detector-layers forms, is numbered from 0 (zero) to 17, from bottom to top along Z-axis. In other words, plane 0 is the bottom-most plane and plane 17 is the top-most.

A detector layer can be uniquely identified by a combination of its measuring axis and a plane number. For example, X-measuring layer of plane 13 is called "X13". Since the top-most layer is measuring Y-axis as defined above, physical order of detector layers is "Y17" (top), "X17", "X16", "Y16", …, "X0", and "Y0" (bottom). Note that order of measuring axes in a plane altered because one tray measures the same axis on both sides.

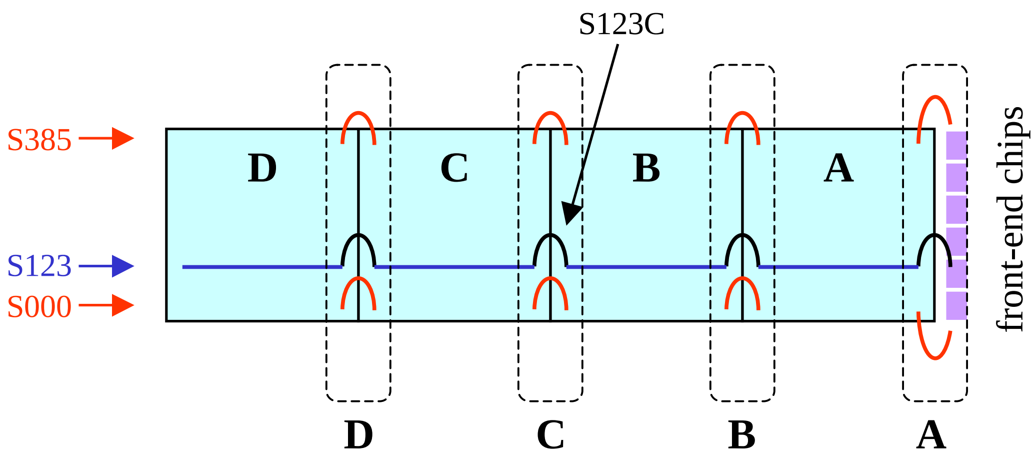

Figure 1. Names of strips, bonding-wires, detector locations, and bonding rows.

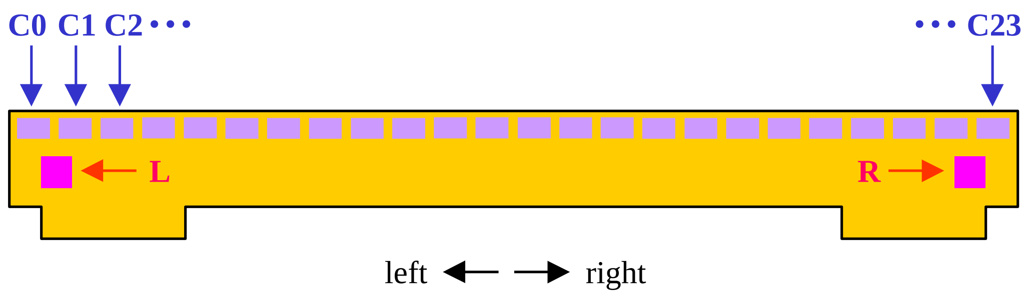

Figure 2. Names of front-end chip locations, controller chip locations. Also, definitions of “left” and “right” of HDI are shown.

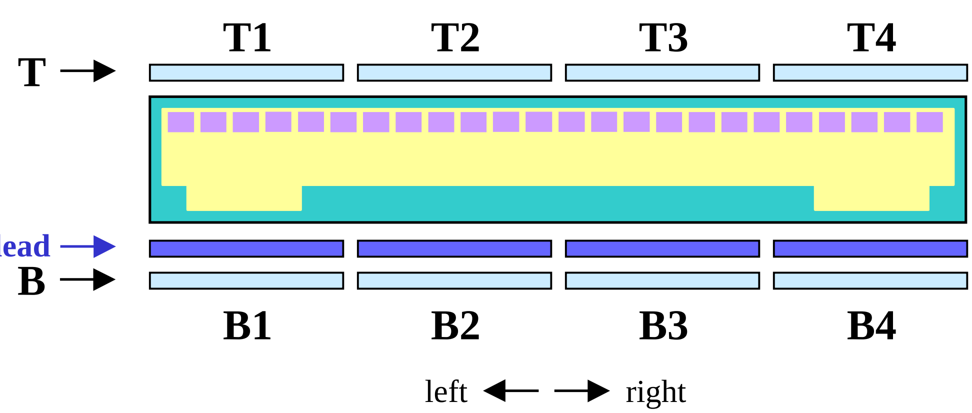

Figure 3. Names of ladder locations and sides of a tray. Also, definitions of “left” and “right” of tray are shown.

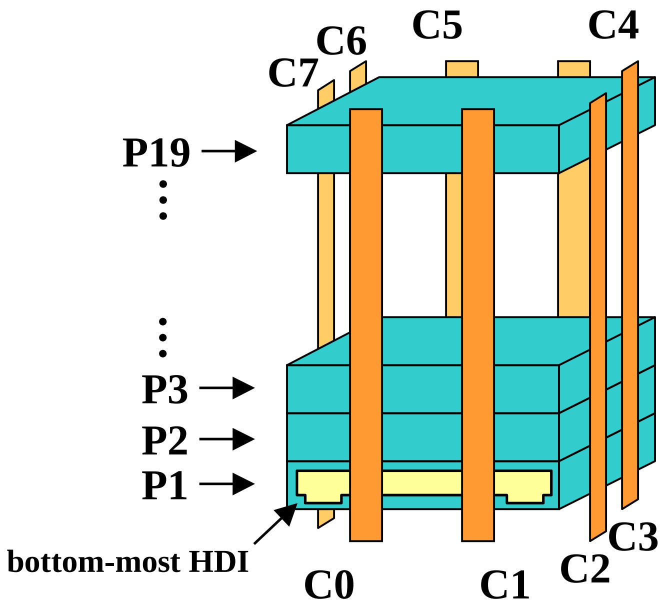

Figure 4. Names of Kapton cable locations and stack positions of tray.

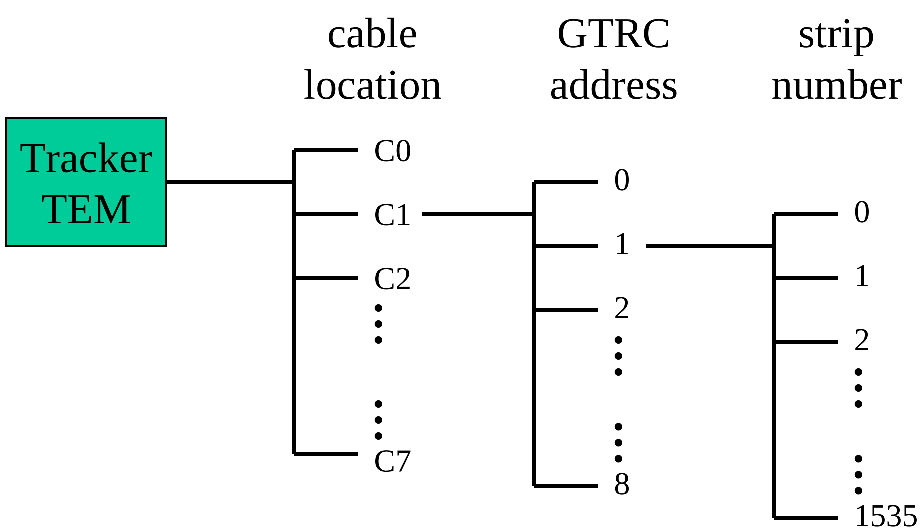

Figure 5. A strip is identified uniquely in a tower by a combination of Kapton cable location, GTRC address and a strip number in a detector layer.

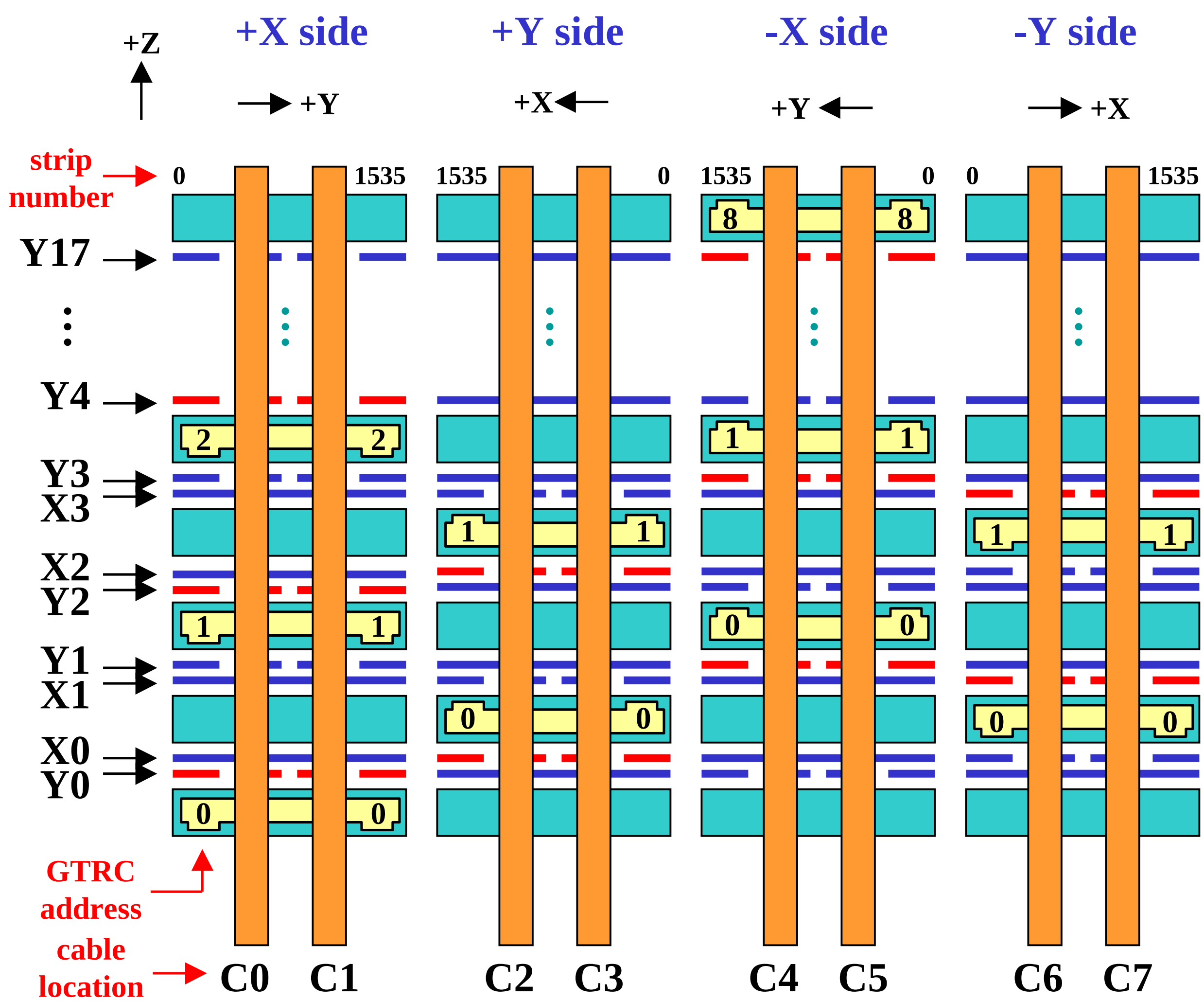

Figure 6. Side views of a tracker tower. Names of detector layers are shown. Also, it illustrates numbering of GTRC addresses and strips.