LAT TECHNICAL NOTE	Document # **LAT-TD-00035-01**	Date 11/20/00
	Author(s) Steve Ritz	
	Subsystem or Sponsoring Office System Engineering	
Document Title **LAT Coordinate System**		

1. Purpose

The hardware and software designs need a clear, consistent and universally accepted definition of the coordinate system for the LAT. This note specifies

- the global LAT instrument coordinate system;
- the terminology, numbering, and orientation of detector planes in the TKR and CAL; and
- tower numbering, the local tower coordinate systems, and detector element numbering within a tower.

The conventions used in this document are based on discussions with the subsystem managers and the I&T manager. This documents builds upon the earlier work of D. Lauben, M. Hirayama, M. Nordby, J. Wallace, S. Williams, R. Williamson, and others.

2. Global LAT coordinate system

The global instrument coordinate system for the LAT is consistent with the coordinate system for the observatory. It is a right-handed coordinate system with the Y-axis parallel to the solar panel axis, the Z axis normal to the planes of the TKR, CAL, and Grid (*i.e.,* parallel to the "bore sight"), and the X axis mutually perpendicular to Y and Z.

a. Orientation

The positive Z-axis points from the CAL to the TKR. Particles entering the instrument at normal incidence are thus oriented along the –**Z** direction. The right-handed characteristic sets the relative orientations of the X- and Y-axes up to a sign. At present, there is nothing intrinsic to the instrument design to break this degeneracy. A clearly visible marking or other feature of the Grid should indicate the +Y side. This should be done in coordination with the project. An additional visible feature on the mechanical interface between the spacecraft and LAT indicating +Y would be useful to avoid confusion.

"Front" and "Back" are used to describe relative locations along the Z-axis. Front sections have a higher value of their Z coordinate relative to back sections. The front section of the TKR has the thin radiators, the back section has the thick radiators. The front face of the Grid is closer to the TKR, the back face of the Grid is closer to the CAL.

b. Origin

The point X=Y=0 is at the center of the Grid. The Z=0 plane is the front plane of the Grid.

3. Terminology, numbering, and orientation of detector planes

a. TKR strips

There have been two orthogonal conventions on the terminology for X- and Y-oriented TKR detector strips. We adopt the following convention, since the people building the TKR hardware and the people writing the software have used it:

- X strips detect the X coordinate of a track. Thus, X strips are physically parallel to the Y-axis.

b. CAL logs

A CAL log usually makes the most precise coordinate measurement along its principal axis. Thus,

- an X log has its principal axis along the X direction.

c. Plane numbering

The TKR trays are numbered in increasing order with *increasing* Z. The back-most TKR tray (closest to the Grid and CAL) is tray 0; and the front-most tray is tray 18. The pair of X and Y silicon detectors closest together are called an XY layer. They are numbered XY0, XY1,…XY17 with increasing Z from the back to front. The individual X or Y layers are numbered Y0, X0, X1, Y1, etc.

The CAL layers are numbered in increasing order with *decreasing* Z. The front-most CAL layer is layer 0; the back-most layer is layer 7.

This convention is much like the numbering of the floors in a building, with Z=0 at the ground floor.

d. TKR and CAL detector plane orientation

All towers are identical with respect to XY orientation.

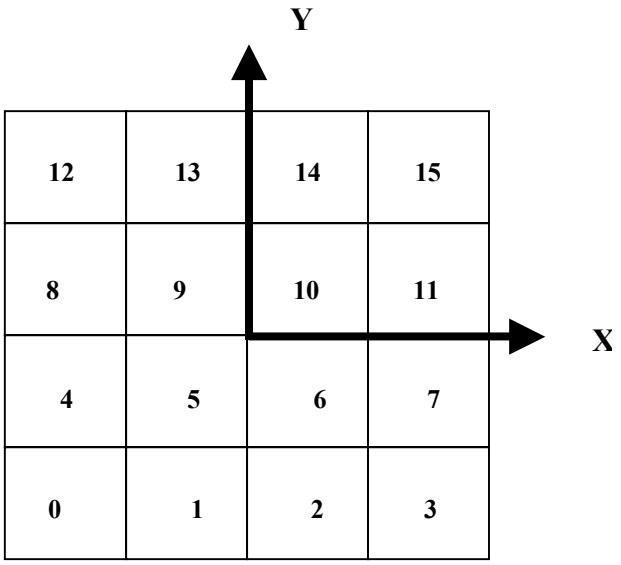
CAL layer 0 (the front-most layer) has X logs, and CAL layer 7 (the back-most layer) has Y logs.

A single tray has the same orientation strips on its front and back faces (except for tray 0, which only has SSDs on its front face, and tray 18, which only has SSDs on its back face). A tray with X strips is an X tray; a tray with Y strips is a Y tray.

Even-numbered trays are Y trays and odd-numbered trays are X trays. In particular, the front-most and back-most trays (0 and 18) are Y trays.

4. Tower numbering, local tower coordinate system, and detector element numbering

Viewed from the front, looking backward, the towers are numbered from the lower to higher values along X and Y, as illustrated below.



In this figure, the Z axis is out of the page (right handed coordinate system). Alternatively, a tower matrix numbering scheme is sometimes used in the analysis. The matrix number is a two-digit number, with the least significant digit denoting the column (X) and the most significant digit representing the row (Y). Thus, the matrix number for towers 0, 1, 4, 5, 6, 8, and 15 are 00, 01, 10, 11, 12, 21, and 33, respectively. There is potential confusion between tower numbering and tower matrix numbering, since both can be two-digit numbers. Unless clearly stated as a matrix number, the tower number will be taken as the number shown in the figure. Note that the matrix number is the tower number in base 4.

For pattern reconstruction purposes, a local tower coordinate system may be useful. The X, Y, Z orientation for the local tower coordinate system and the Z=0 plane are the same as those used for the full instrument. The tower X=Y=0 position is located on the inner wall of the Grid for that tower at the minimum global instrument X and Y positions. In the above figure, this corresponds to the lower left-hand corner of each square.

The four sides of a given tower are distinguished by their relative location in X and Y. The sides of any tower in the figure above, starting from the left-hand side and proceeding counter-clockwise, are labeled -X, -Y, +X, +Y.

Within each TKR and CAL plane in each tower, there are detector elements (logs, SSDs, strips, etc.) For each tower, these are numbered in increasing order, starting from 0, along X and Y. For example, the CAL logs in an X layer are numbered 0, 1, …7 from lower to higher values of Y.

Similarly, the strip numbers in an X layer are numbered 0, 1, 2, … from lower to higher values of X [and the strip numbers in a Y layer are numbered 0, 1, 2, … from lower to higher values

of Y]. Note, however, that the SSDs are arranged in ladders that are 4 detectors long [ladders in an X (or Y) layer are numbered 0, 1, 2, 3 from lower to higher values of X (or Y)], so there are two different strip numberings: by layer and by ladder. The layer strip number, which increases continuously along the plane across ladders, will be more commonly used: a particular strip is uniquely identified by the tower number, layer number (X0, Y0, etc.), and layer strip number. However, the TKR group will also use the ladder strip number, identifying a strip by the tower number, layer number, ladder number and ladder strip number. Of course, the ladder strip number and layer strip number are identical for the first ladder in a layer.

The CAL logs are read out by two PIN diodes on each log end. The log ends are distinguished as plus and minus: the end with the larger value of the coordinate is “plus” and the end with the smaller value of the coordinate is “minus”. The two diodes on a log end have different areas, and are distinguished as large and small. A particular diode is uniquely identified by the tower number, layer number, log number, side (plus or minus),