Kloe Note 94-115

Original date:December 94

KLOE Metric
(reference systems, numbering/naming conventions, units)

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July 4, 1996

Revision history:

December 95, AC: numbering convention for DC wires changed to take into account layer n.12; introduced new, layer-oriented, numbering scheme.

July 96, AC: commented out references to three original figures because they were so big to make ghostview abort, and in any case they wouldn't print on the new LPS's. The figures are left in the AXLNF1 directory KLOE$DOC, in files KLOE_METRIC_DIS1.PS, KLOE_METRIC_DIS3.PS and KLOE_METRIC_DIS4.PS.

Contents

1 INTRODUCTION

The aim of this note is to illustrate the choice of the reference systems, nomenclature and numbering schemes for the KLOE experiment; it will be included in a more general document about the structure of the data in the experiment: KLOE Data Structure.

2 The Global Coordinate System

The KLOE global reference system is a standard orthogonal, Cartesian, lefthanded system with origin at the nominal beam crossing point, which is also the nominal center of the detector.

1. The x axis is horizontal, and positive outwards with respect to e^+ orbits.[1]. See fig.1.
2. The y axis is vertical, positive upwards.
3. The z axis is along the bisectrix of the e^+ crossing angle and is positive along the positron's motion.

Spherical coordinates (ρ, θ, ϕ) are defined in the standard way, therefore:

$$x = \rho * \sin\theta * \cos\phi$$
$$y = \rho * \sin\theta * \sin\phi$$
$$z = \rho * \cos\theta$$

The cilindrical coordinates (r, ϕ, z) are defined as:

$$x = r * \cos\phi$$
$$y = r * \sin\phi$$
$$z = z$$

3 The Local Coordinate Subsystems

The KLOE detector consists of different sub-detectors. For the moment we limit our discussion to the 3 most relevant ones:

i) The Electromagnetic Calorimeter EmC,

ii) The DRift CHamber DRCH.

iii) The Inner (Vertex) CHamber.

Each sub-detector may be divided in Components.

3.1 The Calorimeter Local Coordinate Subsystems

The EmC is divided in three Components : BARREL, ENDCAP_A (along the negative z axis) and ENDCAP_B (along the positive z axis). Each Component can be further segmented in modules.

For istance the BARREL is formed by 24 modules in ϕ. Further levels of segmentation (plane , column, side) determine uniquely each readout channel (PM).

In the following we define a local reference system for each Component to explain the numbering scheme for the readout channels.

[1] This choice is natural and agrees with the conventions adopted by the machine people

Figure 1: The KLOE global reference system in the DaΦne layout

3.1.1 The local reference system for the BARREL

The local reference system for the BARREL modules, see fig.2, is defined as follows:

1. The origin of the local system is set at the center of the module surface facing the interaction region (inner surface).
2. The Xloc and Yloc axis are orthogonal to each other and lie in the plane orthogonal to the fibers. The Xloc axis is positive on the direction set by the growing calorimeter depth. The Yloc axis is positive on the direction set by the growing ϕ angle.
3. The Zloc axis is parallel to the main z axis (runs along the fibers direction).

3.1.2 The local reference system for the ENDCAPs

The local reference system for the ENDCAP modules, see fig.2, is defined as follows:

1. The origin of the local system is set at the center of the module surface facing the interaction region (inner surface).
2. The Xloc and Zloc axis are orthogonal to each other and lie in the plane orthogonal to the fibers. The Zloc axis is positive on the direction set by the growing calorimeter depth.
3. The Yloc axis is parallel to the main y axis (runs along the fiber direction). The positive Xloc axis is set by the choice of a right-handed system.

3.2 The Drift Chamber Local Coordinate Subsystems

Because of the cylindrical symmetry of the Drift Chamber, its local coordinate subsystem coincides with the KLOE global reference system. The origin of this system is in the centre of the KLOE detector, which is also the centre of the chamber. By definition, the first EndPlate (ENDPLATE$_A$) is along the negative z direction, while the second (ENDPLATE$_B$) is along the positive z axis.

The chamber is uniformly filled by layers of almost square cell; consecutive layers have stereo angle of opposite signs. For any wire, looking towards ENDPLATE$_A$ and called P_0, P_A and P_B its intersection with the $z = 0$ plane, the first and the second EndPlate, respectively, and P the intersection of the plane $z = 0$ with the parallel to the z axis through P_A (the corresponding "axial" wire), the sign of the stereo angle coincides with that of the angle $P\hat{O}P_0$ (see fig. 3).

In other words, looking along the z axis, but in the opposite direction, so that the x-y plane has the usual orientation (x positive semiaxis pointing to the right, y positive semiaxis pointing upward) the stereo angle for any wire has the same sign of the difference between the ϕ of the wire insertion point at the positive endplate and the ϕ of the wire insertion point at the negative one.

With these definitions the unit vectors of the wires are:

$$x = \sin\theta_{st} * (-\sin\phi_0)$$
$$y = \sin\theta_{st} * \cos\phi_0$$
$$z = \cos\theta_{st}$$

where ϕ_0 is the phi angle from the x axis to P$_0$ in Fig.3.

Figure 2: Local reference system for Barrel and Endcap modules of the e.m. calorimeter.

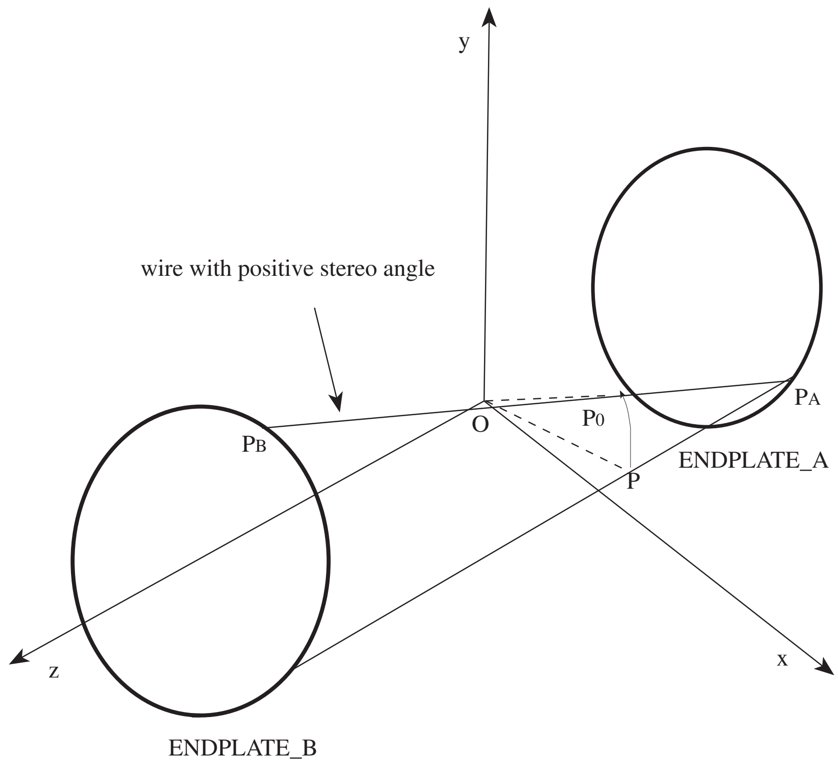

Figure 3: The Drift Chamber local reference system and convention for stereo angle sign.

3.2.1 The local reference system for the sense wires

For $\overline{B} = 0$, the electron drift trajectories lie in planes orthogonal to the sense wires. This defines a preferential plane, which would coincide with the $z = 0$ plane if the chamber geometry was axial. In our stereo geometry, the drift plane changes orientation from wire to wire. The local reference system for each sense wire (see fig. 4) is defined as follows:

1. The Zloc axis runs along the wire direction and the origin Zloc=0 is P_0, at the middle of the wire. The sign of the Zloc axis follows that of the z axis in the global reference system.

2. The Xloc and Yloc axes are orthogonal to each other and lie in the plane orthogonal to Zloc. The Yloc axis is defined by connecting the origin O of the global system with P_0 (the $\overline{OP_0}$ segment is perpendicular to the wire direction) and its positive direction agrees with that of increasing radius in the chamber. The positive Xloc axis is set by the choice of a right-handed system.

3.3 Inner Chamber Local Coordinate Subsystem

The inner chamber center coincides with the center of the Kloe detector. The first endplate (ENDPLATE_A) is along the z negative direction , the second one (ENDPLATE_B) is along the positive z axis. The chamber is divided by the y=0 plane in two equal parts. Each part is filled by layers containing different number of equal axial plastic tubes,having a wire along the axis.

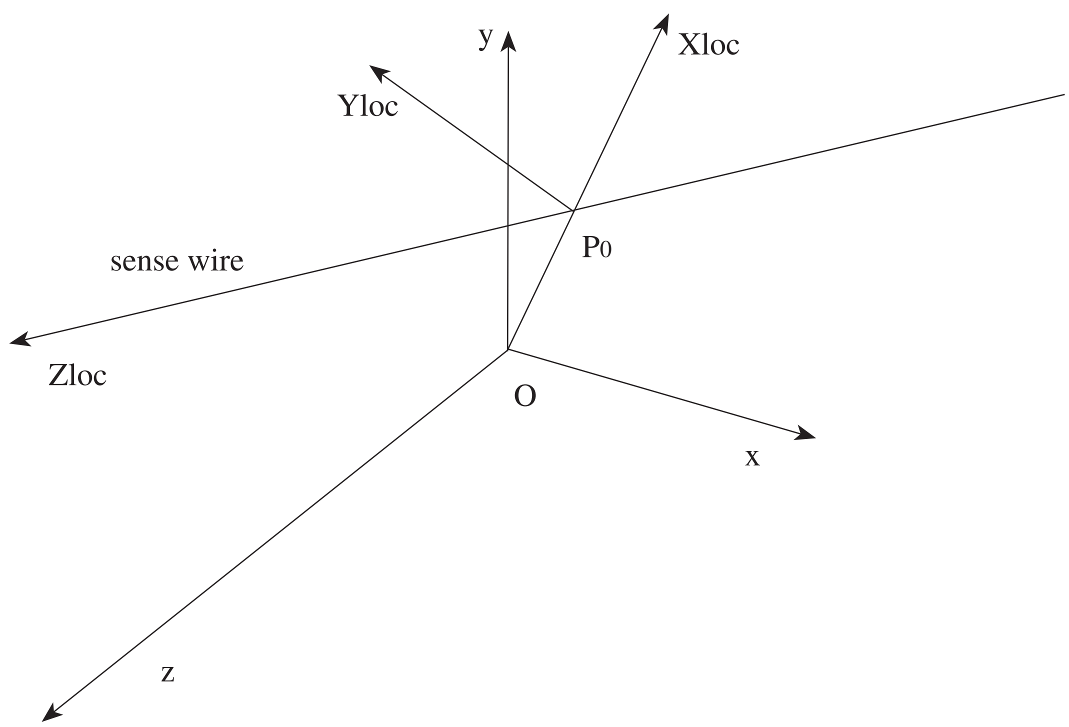

Figure 4: Sense wire local reference system

The local reference system for each tube has the origin at the wire middle and has the axes parallel to the axes of the global reference system and running in the same way.Thus the Zloc axis runs along the wire direction.

4 Calorimeter Numbering scheme

A numbering scheme for the readout channels (PMs) is described in this section. Each channel is identified through a set of numbers related to the actual Component segmentation.

4.1 PMs numbering

Each PM is defined by the numbers ComNum, ModNum, SidNum, PlaNum, ColNum. The Component Number ComNum = 1,2,3 identifies EndcapA, Barrel, EndcapB respectively. The other ones are defined as follows:

i) BARREL

1. ModNum (1:24) identifies the Module. ModNum=1 means phi=0. This number increases for growing Phi (see fig.5).
2. SidNum (1:2) distinguishes between the two PMs attached to the same EmC element : SidNum=1 means negative Z side, Sidnum=2 means positive Z side.

3. PlaNum (1:5) identifies the readout layers along Xloc. Planum=1 is the layer with the lowest value of Xloc, it increases for growing Xloc.
4. ColNum (1:12) identifies the readout columns along Yloc. ColNum=1 is the col. with the lowest value of Yloc, it increases for growing Yloc.

ii) ENDCAPs:

1. ModNum (1:32) identifies the Module. The modules are numbered in such a way that the numeration is symmetric with respect to the beam position. ModNum=32 has the lowest value of x; it decreases for growing x up to 19. The next module after the central hole is number 3 and the numeration increases for increasing x up to 16. For the 4 special modules around the beam pipe hole they are numbered them from top to bottom and from left to right respectively as 1,2,17,18. Endcap A and B will have the numbering so that the same numbers correspond to modules facing each other (see fig.6).
2. SidNum (1:2) distinguishes between the two PM's attached to the same EmC element : SidNum=1 identifies the bottom PM , Sidnum=2 the top one.
3. Planum (1:5) identifies the readout layers along Zloc. Planum=1 is the layer with the lowest value of Zloc, it increases for growing Zloc.
4. ColNum (1:ColMax) identifies the readout columns along Xloc. ColNum=1 is the col. with the lowest value of Xloc, it increases for growing Xloc. ColMax is function of the module number as follows:

ModNum	ColMax
1:4-29:32	2
5:14-19:28	3
15:18	6

5 Drift Chamber Numbering scheme

Two numbering schemes are specified below: the first groups wires according to the cell they belong to, the second does not do the grouping and identifies each wire by layer and wire number.

i) CELL-ORIENTED SCHEME

In the chamber, wires (sense and field) are arranged in cells and all the cells which have sense wires at the same radius form a layer.

A cell is identified by two numbers: layer number (LayNum) and cell number inside the layer (CelNum).

1. LayNum, increasing from 1 to 58 with radius in the MC generation code, `GEANFI`. The convention used in every `ARGUS`-derived algorythm is however opposite: layer 1 is the outermost, layer 58 the innermost.

Figure 5: Numbering scheme for the Endcap modules of the e.m. calorimeter.

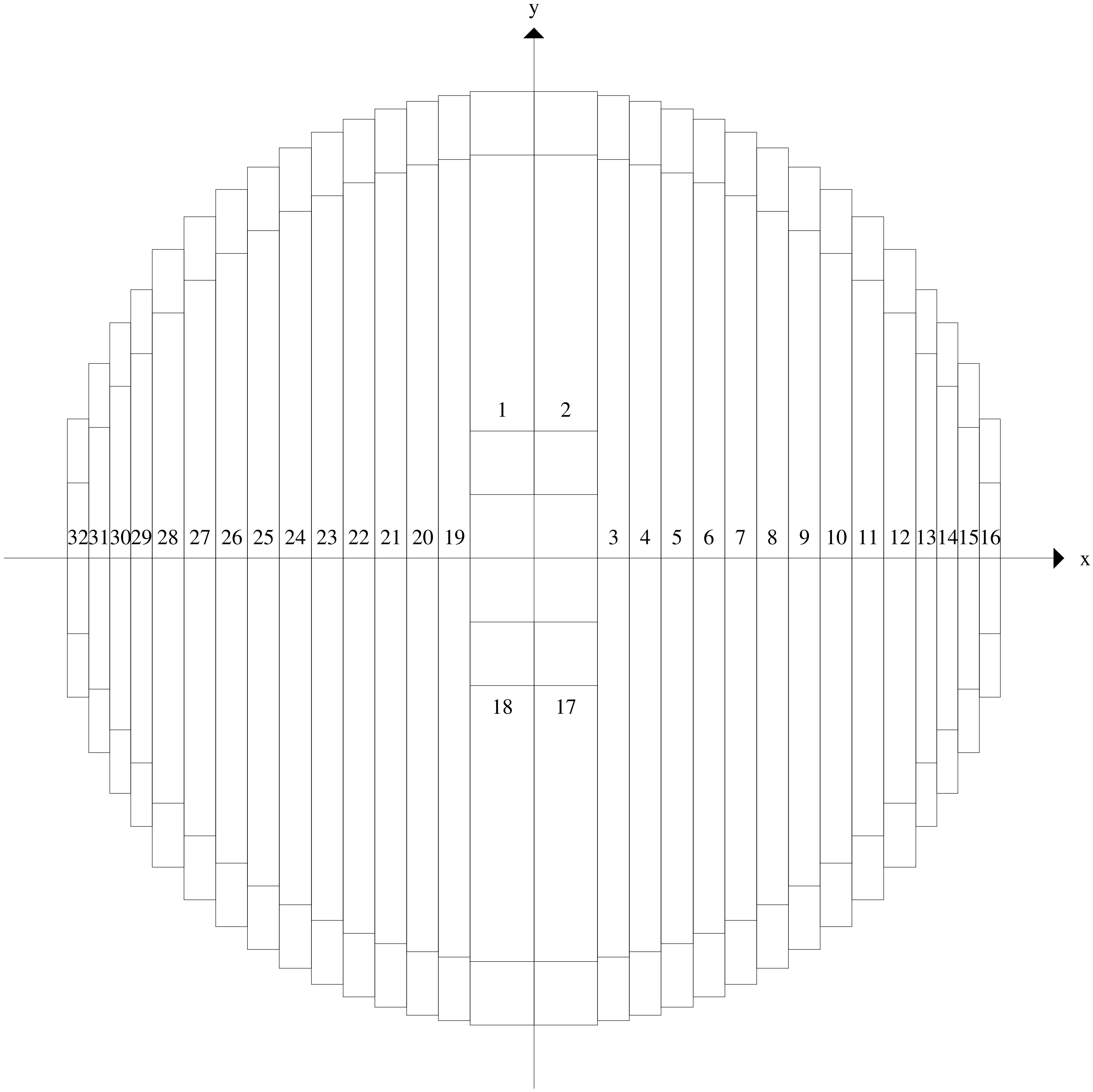

Figure 6: Numbering scheme for the Endcap modules of the e.m. calorimeter.

2. CelNum (1:MaxCel(LayNum)). MaxCel $= 2 * \pi * R/w$, where R and w are, respectively, the layer radius and the arc of circumference which connects the two field wires adjacents to a sense wire. CelNum increases with the azimuthal angle of the sense wire in the plane $z = 0$ in the global reference system and, for every layer, the sense wire belonging to the cell identified by CelNum = 1 crosses the z=0 plane at $\phi = 0$.

Since there is a one to one correspondence between cells and sense wires the cell numbering specified below will be used also to identify sense wires.

Each field wire is defined by the cell it belongs plus a code (CodNum) specifying his position inside the cell (see fig. 7) so three numbers are used in the numbering:

1. LayNum : defined as above; except for 3 special layers: the last (most external) layer of field wires and the two (external and internal) layers of guard field wires which will have respectively LayNum = 59,60,61
2. CelNum : defined as above; except for the 3 special layers in which a cell coincides with a single field or guard wire.
3. CodNum (1:4)
   CodNum = 1 for the field wire adiacent to the sense wire (the one having higher φ).
   CodNum = 2-3 for the wires in the ring below the sense wires one; numbered according decreasing φ. In the special case of cell layer 12 there is one additional wire, with CodNum = 4.
   For the 3 special layers CodNum = 1.

ii) WIRE-ORIENTED SCHEME

Each wire is defined by the wire layer it belongs to, plus an identifying number inside the layer:

1. LayNum : growing from 1 at low radius to 119 at high radius. Layer 1 is the inner guard wire, layer 119 the outer guard wire, and layer 118 the top of the outermost layer of cells. The remaining 116 layers (2 through 117) form 58 pairs, the layers in each pair having the same sign of the stereo angle. The low-r (LayNum even) layer of each pair is a field layer, containing only field wires. The high-r (LayNum odd) is a sense layer, in which field and sense layers alternate.
2. WirNum : defined as CelNum above, but MaxWir $= 4 * \pi * R/w$; layer n.26 marks the boundary between small and big cells: it has two times the number of wires given by the formula. In every layer WirNum = 1 identifies the wire crossing the z=0 plane at $\phi = 0$.

6 Inner chamber numbering scheme

In the inner detector we have two equal parts: the upper one and the lower one. The lower part is obtained rotating the upper part by 180 degrees around the z axis. In each part tubes (wires) are arranged in layers. Each layer contains wires with the same y coordinate. Each wire is identified by 3 numbers:

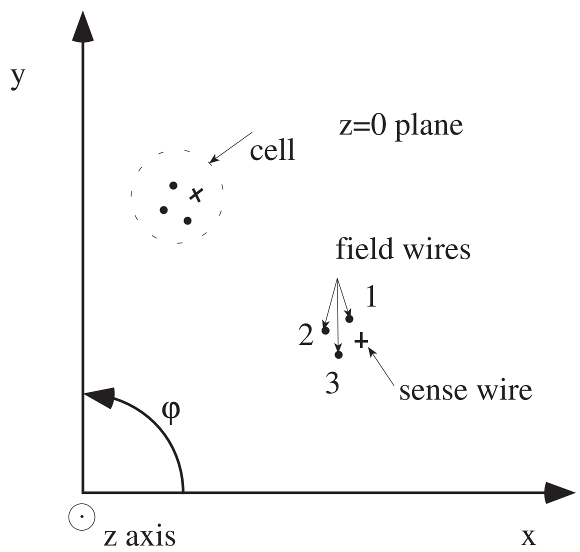

Figure 7: Field wire numbering inside a cell

- Part number [ParNum] (1:2) 1 upper part , 2 lower part
- Layer number [LayNum] (1:19) increasing with absolute value of y .
- Tube number [TubNum] (1:28) increasing moving from negative x values towards the psitive ones for the upper part and viceversa for the lower part.

7 The KLOE Metric

The standard metric adopted in KLOE for Monte Carlo generator, simulation, and offline analysis is described in this section.

The units are (h=c=1):

- Mass/Momentum/Energy = MeV
- Distance = cm
- Time = ns
- Bfield = Kgauss
- Temperature = °C
- Density = g/cm^3

- Electrical Charge = pC

The four momenta are defined as:

- Xi = (x,y,x, cT)
- Pi = (Px,Py,Pz,E)

with x,y,z as defined in the global reference system, t = 0 is the interaction time.

8 Naming Conventions

The modules of the electromagnetic calorimeter should be referred in the drawings and in the software by a four character name; two letters followed by nn = module number (this was defined above) :

BAnn : for the barrel modules; nn = 1-24, see fig. 5.

EAnn : for the endcap A modules; nn = 1-32, see fig. 6.

EBnn : for the endcap B modules; nn = 1-32, see fig. 6.