Class StFgtGeom and FGT Disk/Quad/Strip IDs

1,StFgtGeom and FGT Parameters

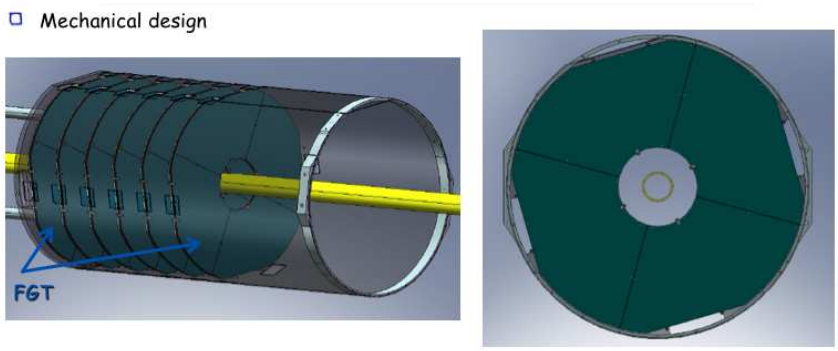

Figure 1: FGT Detector (Left Panel) and an FGT Disk (Righ Panel)

Class StFgtGeom is a geometry class for STAR Forward Gem Tracker (FGT) which is designed for spin physics in high-energy polarized pp collisions. There are eight (six funded and two proposed) GEM disks contained in FGT. The left panel of Fig. 1 shows FGT with the six funded disks. Each of the eight disks consists of four quadrants with the first quadrant of Quad ID = 0 covering ϕ_{FGT} from 0° to 90° in FGT local frame which is built with a rotation of 15° from STAR laboratory frame. Quad ID increases from 0 to 3 clockwise as the numbering of TPC sectors. The layout of the four quadrants of a disk in STAR laboratory frame is shown in the right panel of Fig. 1. It can be seen from the right panel that

1st quadrant of Quad ID = 0 containing $+X$ axis,
2nd quadrant of Quad ID = 1 containing $-Y$ axis,
3rd quadrant of Quad ID = 2 containing $-X$ axis, and
4th quadrant of Quad ID = 3 containing $+Y$ axis in STAR laboratory.

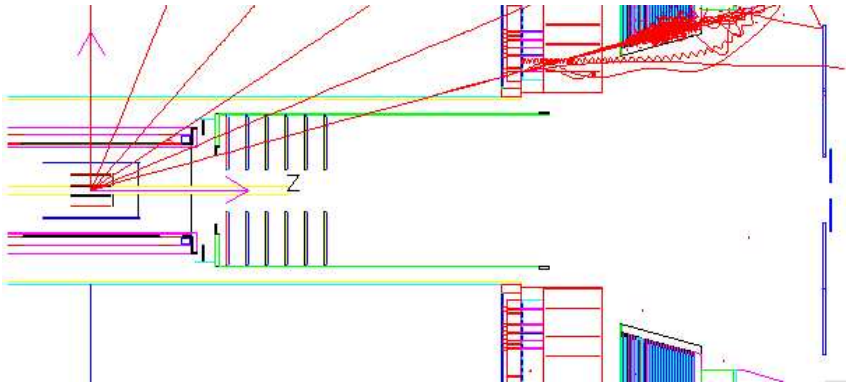

Figure 2: Side View of FGT and Neighbor Detectors

Coordinates conversion from FGT local to STAR laboratory can be expressed with the

following two equations:

$$X_{STAR} = X_{FGT} \times \cos(-15^\circ) + Y_{FGT} \times \sin(-15^\circ)$$

$$Y_{STAR} = -X_{FGT} \times \sin(-15^\circ) + Y_{FGT} \times \cos(-15^\circ)$$

Fig. 2 shows a side view of FGT and neighbor detectors with simulated tracks.

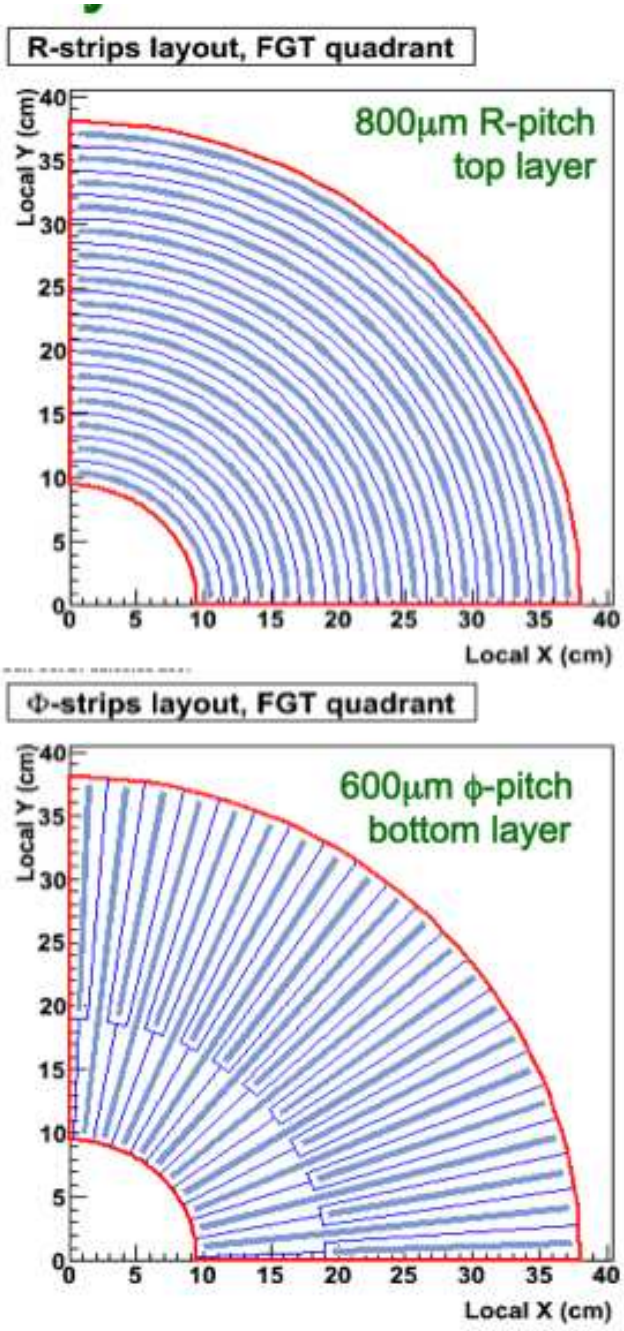

Figure 3: FGT Strip Configuration

The numbers of disks and quadrants are defined as constant parameters in StFgtGeom.

- **kFgtMxDisk**: Number of disks = 8
- **kFgtMxQuad**: Number of quadrants = 4

Layouts of Rad and ϕ strips in a quadrant of a disk are shown in Fig. 3.
Geometry parameters defined in the class for the above layouts are listed at below.

- **kFgtRout**: Radius of the outermost Rad strip = 37.1 cm
- **kFgtRin**: Radius of the innermost Rad strip = 11.5 cm
- **kFgtRmid**: R value of the inner end of short ϕ strip = 18.8 cm
- **kFgtRadPitch**: Pitch of Rad strip = 0.08 cm
- **kFgtPhiPitch**: Pitch of ϕ strip at Rout = 0.06 cm

There are also two geometry offsets: **mRadStripOff** and **mPhiStripOff** defined in the class which reflect misalignments of strips inside a quadrants. The offsets listed below are calculated with the above geometry parameters.

- **mRadStripOff** = 0.0 cm
- **mPhiStripOff** $\times$ **kFgtRout** = 0.0167 cm

Using the offsets, the numbers of Rad and ϕ strips in a quadrant can be calculated with the following formulas.

- Number Of Rad Strips = (**kFgtRout** $-$ **kFgtRin** $-$ **mRadStripOff**)/**kFgtRadPitch** = 320
- Number Of ϕ Strips = ($\pi/2 -$ **mPhiStripOff**)/(**kFgtRadPitch**/**kFgtRout**) = 971

Parameters which define the numbers of strip soft IDs are listed at below.

- **mRadStripLOCId_number**: Number of Rad strips local IDs in a quadrant = 325
- **mPhiStripLOCId_number**: Number of ϕ strip local IDs in a quadrant = 976
- **mRadStripGBLId_number**: Number of Rad strip global IDs in a disk = **kFgtMxQuad** $\times$ **mRadStripLOCId_number** = 1300
  0-324 for Qaud 0
  325-649 for Qaud 1
  650-974 for Qaud 2
  975-1299 for Qaud 3
- **mPhiStripGBLId_number**: Number of ϕ strip global IDs in a disk= **kFgtMxQuad** $\times$ **mPhiStripLOCId_number** = 3904
  0-975 for Qaud 0
  976-1951 for Qaud 1
  1952-2927 for Qaud 2
  2928-3093 for Qaud 3

The number of strip local IDs is five more than the number of strips in a quadrant for both Rad and ϕ. The five extra IDs are reserves and may not be used. We notice that there are disk-wide global IDs and quadrant-local IDs for each set of Rad and ϕ strips. But, there is no FGT-wide strip ID because of memory limit. Global ID is related to local ID as

global ID = local ID + quad ID (from 0 to 3) $\times$ mRad(Phi)StripLOCId_member

All strip IDs in StFgtGeom are global except those specified as local with names like xXXXLocalStripId. Various methods to convert strip IDs to coordinates or to convert reversely are defined in StFgtGeom. Methods involving local IDs are set to be private to distinguish themselves from others for now. They can be reset to public later if needed. All IDs including those for disks and quadrants range from 0 to N-1 as C++ index convention. Orders of various IDs are listed as follows.

- Disk ID: Following order in Z
- Quad ID: clockwise as described early
- Rad Strip ID: Inward (ID = 0 for the outermost strip)
- ϕ Strip ID: Counter-clockwise

Z positions of the eight disks plus an extra disk (ID = 8) are 69.08, 79.08, 89.08, 99.08, 109.08, 119.08, 168.68, 218.68 and 66.98 cm. The extra disk at Z = 66.96 cm is a special simulated disk used for expert mode only. Any array involving the extra disk in sorting FGT hits are defined with a size of kFgtMxDisk+1 in StFgtGeom. The Z positions will be read out from FGT database in the future.

2, How is **Volume** *for FGT hits encoded in STAR Geant?*

STAR Geant **Volume** for FGT hits is encoded as

$$(Value\ of\ FGGD) \times 10^6 + (Value\ of\ FGZC) \times 10^4$$

for disk1-8 (ID=0-7) or

$$(Value\ of\ FGZD) \times 10^6$$

for the extra disk (ID = 8) where FGGD, FGZC and FGZD are Blocks defined in a FGT geometry file fgtdgeo2.g. Their values carry informations about FGT IDs which can be decoded (See the next section) The encoded **Volume** is stored in FGT hit object (g2t_fgt_hit) as its member of **volume_id** with a Fortran function g2t_fgt.F of STAR simulation for future process and analysis.

3, How to decode FGT IDs from **volume_id**

Here is an example of decoding.

int diskID, quadID;
int numbv1 = volume_id/1000000;

```
int numbv2 = (volume_id/10000)%100;
if(numbv2 != 0) {
diskID = numbv1 - 1;
quadID = numbv2 - 1;
} else {
diskID = 8;
quadID = numbv1 - 1;
}
```

4, Layout of FGT quadrants in Geant

- The layout of FGT quadrants in Geant local frame which is the same for all four quadrants is symmetric with respect to the X axis. It contains +X axis and its ϕ range is between $-45°$ and $45°$. Geant STAR (GSTAR) converts coordinates from Geant local to STAR laboratory.

5, FGT class in StMcEvent

- Classes StMcFgtHit and StMcFgtHitCollection were updated accordingly. To minimize the modification, name "layer" used for a subsystem of other detectors is kept for FGT disk.
- CVS: The updated classes were checked in on 10/13/09.