Implementation of Large Pixel detectors in SLUG/DICE

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Abstract

The possibility of replacing one or more of the Silicon Strip Detector layers with large pixel detectors is an option in the ATLAS Technical proposal[1]. To study the performance of Large Pixels within the `SLUG/DICE` software a geometry using them has been implemented.

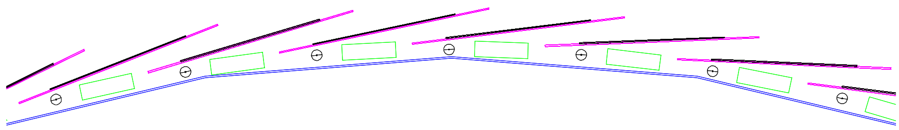

Figure 1: Detector layout plotted by interactive GEANT

1 Introduction

Pixel silicon detectors have some advantages over strip detectors.

Therefore there is no need of a projective readout, and there are no ambiguities concerning the hit positions. The pixel detectors give a clearly defined two-dimensional picture, reduce therefore the amount of time needed and increase the efficiency of the track reconstruction.

Up to now, small pixels are planned for the innermost part of the detector. At larger radii so small patches are neither required nor affordable and the large pixels (Lpix) are sufficient to offer all the pixel advances without exploding the budget. The use of the Lpix-layers would also increase the radiation hardness of the detector. Therefore the option of large pixel replacing one or two strip layers was taken into consideration [2].

But the main effect of the large pixels should be the increase of the track reconstruction efficiency. For example: the reconstruction efficiency of the three-prong τ decay in the barrel region is only $84 \pm 4\%$ [3]. This should be significantly increased as the evaluation of the Lpix information is properly implemented in the pattern recognition routines.

A brief description of the simulation usage is given in section 4, while the reconstruction is described in section 5. Section 6 gives some first results.

In this paper it is assumed that the user is familiar with the ATLAS simulation software (`SLUG` [4]/`DICE`).
The possibility of replacing the silicon strip layers at 30 and 50 cm with Large Pixel layers has been implemented. These two layers differ only by their position, their properties are identical. The default granularity is 100μm in $R\phi$ and 2 cm in z. These and all other parametres of the detector are defined and commented in the subroutine `//LPIXDICE/LPIXEL/LPIXDF10`. Figure 1 shows the geometry of the new layers as plotted by the interactive GEANT in the $R\phi$–plane.

2 Simulating the new geometry

Simulating with one or two large pixel layers is not more difficult than with the geometries already implemented. The steps to be carried out are discussed in this section.

1. Using the correction file and compiling

   The FORTRAN code needed for simulating large pixels is stored in a correction file for the DICE [5] CMZ, version 2.04_00, named `largepixel.corr` (In future versions of DICE these corrections will be implemented). It can be found in the directory `$LHC_ROOT/dev/src/cmz`

   The following is an example macro for CMZ; it is part of the macro `$LHC_ROOT/dev/macros/atl_bin.kumac` with one modification.

   ⋮

```
* ======================= DICE ============================
*
  ELSEIF [fname]='DICE' THEN
```

   ⋮

   attaching `SLUG, GEANT, DICE` *and* `GENZ`

   ⋮

```
*
     IF [use]<>'FALSE' THEN
*       Install DICE executable with latest corrections ...
        MESS Using correction files ...
        USE _WORK$AREA/slugfix.corr
        USE _WORK$AREA/dicefix.corr
        USE _WORK$AREA/_GEANT$VERSION.corr
        USE _WORK$AREA/largepixel.corr       ⇐ this line has to be added
     ENDIF
* Load sequences
     SEQ  //SLUG //_GEANT$VERSION //DICE //GENZ
```

   ⋮

   creating the `FORTRAN` *file*

   ⋮

```
     MESS Compiling & building    [fbin]   from    $AREA   ...
     SHELL $ATL_F77 [option] mainslug.f dice.f _
           [atlas_lib]    _
           [atlas_geant]  _
           [atlas_cern]   _
           [opt_library]  _
           -o $FBIN
```

   ⋮

2. Running the simulation with datacards

   The steering works via datacards. There are two example datacards: `lpixel2.datacard` for two, `lpixel1.datacard` for one Large pixel layer.

They can be found in `$LHC_ROOT/datacard`. Three new geometries for the inner detector have been added: Geometries 10, 11 and 12 which are like those with number 3, 4 and 5 respectively with the exception of the 30 and 50 cm silicon strip layers replaced by large pixel layers.

To activate one of the new geometries, `*MODE 'INNE' 'GEOM'` has to be set to 10, 11 or 12. Changes of the geometry or material parameters can be achieved through the `*DETP 'LPIX' parnum=newvalue` and the `*DETD 'LPIX' parnum=newvalue` datacards. This method is used in the file `lpixel1.datacard` to use only one large pixel layer at $r = 30$cm (two layers are default).

3 Reconstruction

The reconstruction uses the standard `IPatRec`[7] routines, using also the information from the Large Pixel layers.

The code will be officially released with the 1.06 version of ATRECON. In `$LHC_ROOT/datacard` one can also find an example datacard for the reconstruction called `rec.datacard`. The reconstruction with large pixel layers is activated by adding

```
*MODE 'LPIX' 'RECO' 1 'PRIN' 0
```

in analogy to the reconstruction of other detectors.

With a general print level (from IPAT) of 2 or greater, one can see if Large Pixels are found. The output should contain lines similar to the following:

```
 initPat: Initialising window commons plus /Const/, /BField/ and geometry table
  start building the GEOM table:
   adding MSGC with 26 superlayers, 26 (DICE)layers and 390 elements
   adding GAAS with  4 superlayers,  2 (DICE)layers and  16 elements
   adding  SCT with  2 superlayers,  4 (DICE)layers and  56 elements
   adding BPIX with  2 superlayers,  2 (DICE)layers and  24 elements
   adding LPIX with  2 superlayers,  2 (DICE)layers and  52 elements
```

With the `'PRIN'` statement of `LPIX` the output level can be adjusted. If the print level is set to a higher value, `LPIXUNP` prints out the hit position. An example for the output is shown here:

```
LPIXUNP - DIGITIZED HIT. Layer:  1 Hit #   1 X Y Z   -9.426   28.451  -18.613
LPIXUNP - DIGITIZED HIT. Layer:  1 Hit #   2 X Y Z   -9.426   28.451  -18.413
LPIXUNP - DIGITIZED HIT. Layer:  2 Hit #   1 X Y Z  -15.704   47.333  -25.418
LPIXUNP - DIGITIZED HIT. Layer:  2 Hit #   2 X Y Z  -15.713   47.329  -25.418
```

4 First Studies using LPix

Up to now, our work has concentrated on the performance of the `iPatRec` reconstruction using the Large Pixel layers. We started with performance studies of the new layout by simulating 1000 single muon and electron events with each layout for different transverse momenta. The figure 2 shows an example plot with the resolution for the transverse momentum. The code has been tested on UNIX machines with different architectures including IBM RS/6000, HP and DEC Alpha.

References

[1] ATLAS Technical Proposal

[2] ATLAS Technical Proposal, p.67

[3] P. Luthaus et al., ATLAS Internal Note INDET-No-099 (1995).

[4] R.S. DeWolf, SLUG, ATLAS Internal Paper (1992)

[5] K. Bos et al, DICE, ATLAS Internal Paper (1993)

[6] GEANT, Detector Description and Simulation Tool, CERNLIB Long Writeup W5013

[7] R. Clifft und A. Poppleton, ATLAS Internal Note SOFT-No-009 (1994).

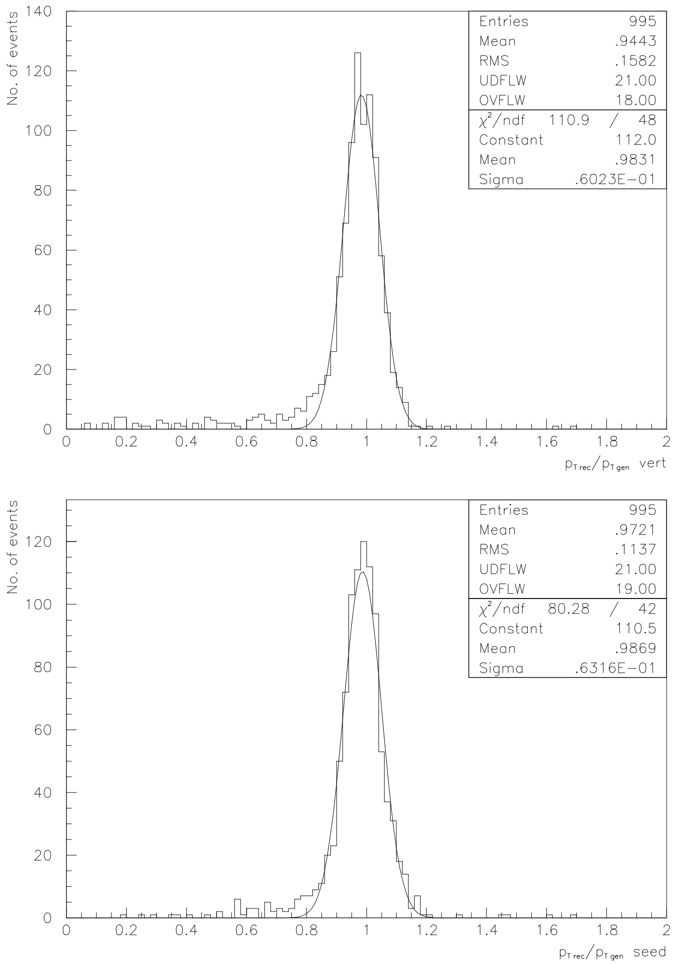

Figure 2: p_T–Resolution for 100 GeV electrons with one large pixel layer; The upper plot shows the vertex constrained fit, the lower one the result with the bremsstrahlung fit (which results in a more gaussian-like distribution)