SSD performances in CuCu 200 GeV data

Jonathan Bouchet, ViNham Tram

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Abstract

This analysis note aims at studying the SSD performances during Run 5 data involving Cu+Cu collisions data. A brief introduction describing the detector as well as the pattern recognition is presented. A detailed analysis is performed to understand the efficiency using data and simulation. Performance : DCA resolution from Cu+Cu data, V0 signal and so on are presented as well...

1 Introduction

The SSD detector was completely installed and operational for the run 5 data taking in Cu+Cu collisions. Thus, the Cu+Cu data sample is the first sample which benefits from a full coverage of the SSD. In addition, this sample benefits from high luminosity : in total, there were 46 millions Minimum bias events recorded and 22 millions high momentum triggered events with the TPC and the SSD included at full energy (200 GeV). During the low energy (62.4 GeV) run, there were 35 million events recorded with the TPC and SSD. Thus, studying the performance of the SSD using this data sample gives a first estimate of the SSD capabilities and also provides input for physics analysis using these data.
The Cu+Cu collisions data are reconstructed using the code version p07ic of the STAR reconstruction software. This version of code is dedicated to the track reconstruction using the inner vertex detectors SSD and SVT.

1.1 SSD description and pattern recognition

The SSD is a one layer silicon detector, double-sided detector with stereo angle, determine the x and y position. adding one additional point for the track reco...

The SSD was proposed to enhance the tracking capabilities at mid-rapidity by providing a better connection between reconstructed tracks in the TPC and the SVT. It was developed

radius	230 mm
ladder length	1060 mm
acceptance	$\eta \leq 1.2$
number of ladders	20
number of wafer per ladder	16
total readout channels	491520

Table 1: General layout of the SSD

size	$75 \times 42\ mm^2 \times 300\ \mu$m
number of strips	768 per side
wafer pitch	95 μm
strip width	$\simeq$ 15 μm
stereo ange	35mrad
r/ϕ resolution	20 μm
Z resolution	8740 μm
operating voltage	20 - 50 V

Table 2: Summary of wafer characteristics and performances

by the Laboratoire de Physique Subatomique et des Technologies Associes (Subatech) in Nantes,France and the Institut de Recherche Subatomique (IreS) in Strasbourg, France. It uses double-sided silicon microstrip sensors and consists of 320 detector modules arranged on 20 ladders, forming a barrel at a radius of 23 cm from the beam, inserted between the SVT and TPC. The design of the sensor has been constrained by requiring a good position resolution and by minimizing the number of ambiguous hits expected in the high multiplicity environment of central collisions and its compacity was achieved by using a novel Tape Automated Bonding method to connect the silicon wafers to the front end electronics.

1.2 Data sample used

The SSD is a cylinder installed around the beam pipe, the acceptance coverage is η we need to apply a vertex cut in order to have a full η coverage, what is the remanining luminosity here...
what is the statistic we are going to use for this analysis...

2 Efficiency

Here we will put efficiency study... it seems to depend on the noise level observed... to investigate !
Few words about the simulation : in this section we want to compare the results of the slow simulation with the fast simulation. This part is needed in order to understand the behaviour of the detector, before trying to analyze the real data.
The code used the version SL07e of the STAR librairires software. This allows us to benefit of the last modification of the code, as the last CuCu production Hijing production was using an old version of the reconstruction code (SL06d)

2.1 Simulation strategy

2.1.1 Slow simulation

The aim of the slow simulation is to describe as much as it can the processes during the hit reconstruction. It has 3 main parts (module) describing after : a module specific to the SSD has been developed in order to have a more realistic description of the behavior of a silicon microstrip wafer : the SSD Lazy Simulator (**SLS**). The main goal of this module is to convert geant hits into sequences of amplitudes on strips. In more details, this module :

- converts the GEANT hits coordinates to a local uv reference frame (according to the strips orientation)
- removes hits in inactive areas
- shares the charge produced using a diffusion factor and a induction factor (due to striptostrip capacitance)
- produces an output sls_strip table

The action of the SSD DAQ on the strip amplitudes is simulated within the SSD Pedestal Annihilator (**SPA**) module. This module :

- reads the strip amplitudes from the sls_strip table
- adds for each strip a pedestal and noise value
- subtracts the pedestal and apply a DAQ cut (typically 3 σ of the noise value)
- creates and fills a spa_strip table with the remaining signals

Once these two tasks are done, the ouput of **SPA** module is injected in the hit reconstruction chain, which first module, SSD Cluster Finder (**SCF**) scans the strip signals on both sides of each SSD wafer in order to build clusters. This module :

- reads and sort the strip signals from the spa_strip table
- searchs clusters by :
  1. scanning the strips and looking for a central strip with an amplitude above a given threshold
  2. scanning the neighboring strips in the list looking for consecutive strips with respect to the central strip
- creates a cluster list and add any new cluster
- scans all the clusters and tries to split the cluster by looking for a local minimum in the cluster profile
- updates and sorts the cluster list and finally stores the cluster in the scf_cluster table.

The last step of the hit reconstruction (SSD Cluster Matcher : **SCM**) associates these clusters and determines the main parameters (position,energy loss) of the resulting space point.
Silicon microstrip wafers are not real bidimentional detectors and consequently clusters found on the nside and the pside of the detector need to be correlated based on some criteria. Depending on the particle multiplicity and their positions in the wafer, such correlation can be non trivial and can lead to ambiguous associations. Hopefully, for a given particle, the charges collected on both sides of the wafer are produced by the same energy deposite and a strategy based on a charge matching can be applied to help to correctly select the true associations.
Depending on the number of clusters on each side (latter on referenced as "packages") involved in this association problem, several configurations can be encountered. The following steps are performed in the module :

- reading of the clusters from the scf_cluster table
- in each wafer, the cluster matching is started by looking for and creating new packages by mean of geometrical correspondances
- an attempt to solve each package is then made by determining which configurations are possible. The charge matching is then used to assign relative probabilities to each configuration and a given weight to the resulting space points
- Each space point is then caracterized (x-y-z position,u-v position)

2.1.2 Fast simulation

The SSD fast simulator has two main functions :

- remove of the geant space points falling outside the wafer active area

- smear the local posiitons of the GEANT hits according to a given resolution ($\sigma_{r/\phi} = 30\ \mu$m and $\sigma_Z = 850\ \mu$m)

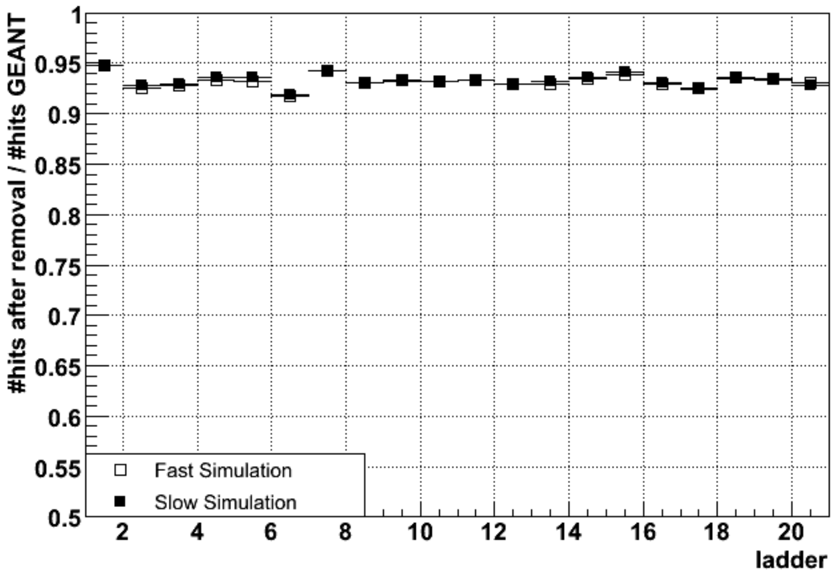

Figure 1: Comparison between ratios of nmuber of hits in SSD after removal of dead and inactive areas with the number of hits coming from GEANT per ladder

The Fast simulation seems to remove more hits than the Slow Simulation. (maybe need to see the removal methods)
It seems to depends with the ladder id : not expected (something to fix)

2.2 Cluster efficiency

$$\epsilon_0 = \frac{N_{\text{reco}}}{N_{MC}} \tag{1}$$

$$\epsilon_0 = \frac{N_{\text{reco}}}{N_{MC}} \tag{2}$$

this will be using MC only... look at the number of hits/clusters in the reco vs number of MC hits...

$$\epsilon_0 = \frac{N_{\text{reco}}}{N_{MC}} \tag{3}$$

How do we handle ghost hits? use Jonathan's definition
how noisy strips can affect this efficiency? to do : look at what happens when adding realistic noise

2.3 Reconstruction efficiency

[1]

2.3.1 Tracking efficiency

Each track reconstructed in the TPC is then projected to the SSD. 2 quantities are assigned to each projection (SSD and SVT) :

- number of possible points (*PossiblePoint*) : it corresponds to the number of points within the search window of the projection to that layer
- number of fitted points (*FittedPoint*) : it corresponds to the number of point attached to this track.

The efficiency is defined as a binomial distribution between tracks having $PossiblePoint = FittedPoint$ =1 with the other possibility : $PossiblePoint$ = 1 but $FittedPoint$ = 0 (this point is not used in the tracking).

$$p(k) = \frac{n!}{n!(n-k)!}\epsilon_{track}^{k}(1-\epsilon_{track})^{n-k} \tag{4}$$

with :

- n = number of possible points
- k = number of fitted points

and ϵ_{track}:probability of having $PossiblePoint = FittedPoint$ =1 .
By counting for each track these 2 quantities, we have directly the case n = k then we deduce ϵ_{track}.
in this case, equation 4 becomes:

$$p(n=k) = p_{SSD} = \epsilon_{track}^{n} \tag{5}$$

For the SSD, we look for only one point : $p_{SSD} = \epsilon_{track}$, then it becomes the ratio between tracks having one fitted point with all tracks crossing the SSD.

2.3.2 MC

look at the number of tracks reconstructed with SSD hit vs MC tracks.

$$\epsilon_1 = \frac{N_{\text{reco}}}{N_{MC}} \tag{6}$$

look at the number of tracks as previously but with cut on the TPC tracks from MC to get rid of the TPC track efficiency...

Look at these 2 quantities as a function of p_t for perfect detector, using real geometry (hole), using same noise for each strip, using realistic noise from Run5... Need to compare to real data...

2.3.3 Real data

look at the number of tracks as previously but with cut on the TPC tracks from MC to get rid of the TPC track efficiency...
Put comparison with MC here : need to converge !

2.4 Detection efficiency

May change to something else here...
will use Yuri's definition here to study how the SSD detection efficiency was.
look at the number of tracks reconstructed with a SSD hit vs number of tracks with TPC and SVT hit

$$\epsilon_3 = \frac{N_{(TPC+SSD+SVT)}}{N_{(TPC+SVT)}} \tag{7}$$

Need to compare slow simulator vs fast simulator vs real data...

3 Performances

Here will put the performance...

3.1 DCA resolution

Improvement when adding SSD...
how does the fit funtion affects the resolution ?

3.2 V0 Invariant mass

some nice plots here

3.3 Momentum resolution at high p_t

need to investigate

[1] : Silicon Strip Detector Reconstruction Chain for the STAR Experiment,STAR NOTE 0427 2001.