1 Performance Studies Based on Phase 1 Pixel Detector

1.1 The L1PixelTrigger Analyzer

An EDAnalyzer is a module in the `CMSSW` framework that allows to extract information from datasets containing simulated or collision data. The extracted information is usually saved in files browsable by ROOT, and organized in a TTree structure. In our particular case, the TTree was called *NtupleMaker* and it contais several branches documented below.

Previous analyzers were useful guidelines to build the *L1PixelTrigger*, between them are the *PixelTree* provided by the Tracker Detector Performance Group (DPG), and the *TrackTriggerStudy* provided by the Track Trigger Integration (TTI) group.

1.1.1 Code and Documentation

The *L1PixelTrigger* analyzer was developed in `CMSSW_6_1_2_SLHC6_patch1`, with the routine *mkedanlzr L1PixelTrigger*. The source code, named *L1PixelTrigger.cc*, is available at *https://github.com/jruizvar/pixel-analysis/*.

The collections retrieved by the analyzer are:

- ***PileupSummaryInfo***: Provides the number of interaction per bunch crossing. This collection stores sixteen bunch crossings (12 early, one in-time, three late). To retrieve the pileup distribution, we have to loop into the collection and use the method `getPU_NumInteractions()` for each bunch. The associated branch in the ROOT file is called *pileup*.

- ***BeamSpot***: Provides the position and error of the beam spot. The associated branches are *beamSpotX0*, *beamSpotX0Error*, *beamSpotY0*, *beamSpotY0Error*, *beamSpotZ0*, and *beamSpotZ0Error*. This collection also provides details about the beam. The width and error in the transverse plane are given by *beamWidthX*, *beamWidthXError*, *beamWidthY*, and *beamWidthYError*. The spread and error along the Z direction is given by *beamSigmaZ*, and *beamSigmaZError*.

- ***GenParticleCollection***: Provides information of the event at the generator level. The multiplicity of *GenParticles* corresponds to the size of the collection, and is stored in the branch *genPartN*. Relevant information is stored in the branches *genPartEt*, *genPartPt*, *genPartEta*, *genPartPhi*, *genPartCharge*, and *genPartId*. The *GenParticleCollection* does not include the underlying particles in samples with pileup.

- ***L1EmParticleCollection***: Provides information of the event as measured by the electromagnetic calorimeter. The size of the collection is stored in the branch *egN*. Relevant information is stored in the branches *egE*, *egEt*, *egEta*, *egPhi*, and *egCharge*. The method `getCalorimeterPosition()` taken from the *TrackTriggerStudy* analyzer, is used to translate from cylindrical to cartesian coordinates. The output of this method is stored in the branches *egGx*, *egGy*, *egGz* and corresponds to the global position in the calorimeter.

- ***SiPixelRecHitCollection***: Provides information of the event as measured by the pixel detector. The multiplicity of reconstructed hits in the barrel is store in the branch *bHitN*. The global position is stored in the branches *bHitGx*, *bHitGy*, *bHitGz*. Relevant branches associated with the pixel barrel are *bHitLayer*, *bHitLadder*, *bHitModule*. The cluster size is stored in the branch *bClSize* .
  The multiplicity of reconstructed hits in the endcap is store in the branch *fHitN*. The global position is stored in the branches *fHitGx*, *fHitGy*, *fHitGz*. Relevant branches associated with the pixel endcap are *fHitDisk*, *fHitBlade*, *fHitModule*. The cluster size is stored in the branch *fClSize*.

1.1.2 Simulation Tools

- What samples have been created

- and tools used for that.

Tabela 1: Official MC samples (`GEN-SIM` for electron-gun and Minimum Bias) used to create `DIGI-RAW` and `Ntuples` files.

Description	Number of Events	Official Samples
GEN-SIM	50K	/SingleElectronFlatPt0p2To50/UpgFall13-POSTLS261_V2-v1/GEN-SIM
Minimum Bias	30M	/MinBias_TuneZ2star_14TeV-pythia6/UpgFall13-POSTLS261_V2-v1/GEN-SIM

Figura 1: RZ view of reconstructed hits in the pixel detector.

Figura 2: Pile up distributions in four different scenarios: zero (top left), 35 (top right), 70 (bottom left) and 140 (bottom right) pile up.

Tabela 2: `DIGI-RAW` and `Ntuple` MC samples created from official electron-gun and Minimum Bias MC samples.

Format	Scenario	File Size (GB)	Number of events (K)
DIGI-RAW	0 pile up	12	50
	35 pile up	110	50
	70 pile up	210	50
	140 pile up	400	50
Ntuples	0 pile up	0.024	50
	35 pile up	5.6	50
	70 pile up	11	50
	140 pile up	22	50

Tabela 3: Beam spot position and associated uncertainty.

1.2 Results on Phase 1 Pixel Detector Performances

- Results based on CMSSW_6 with emphasis on the effect of increasing luminosity
- and different pixel cluster algorithms.

Figura 3: E_T, η and ϕ distributions of generated particles (using single electron-gun).

Figura 4: E_T, η and ϕ distributions of L1EM particles (using single electron-gun) for 0 pile up.

Figura 5: E_T, η and ϕ distributions of L1EM particles (using single electron-gun) for 35 pile up.

Figura 6: E_T, η and ϕ distributions of L1EM particles (using single electron-gun) for 70 pile up.

Figura 7: E_T, η and ϕ distributions of L1EM particles (using single electron-gun) for 140 pile up.

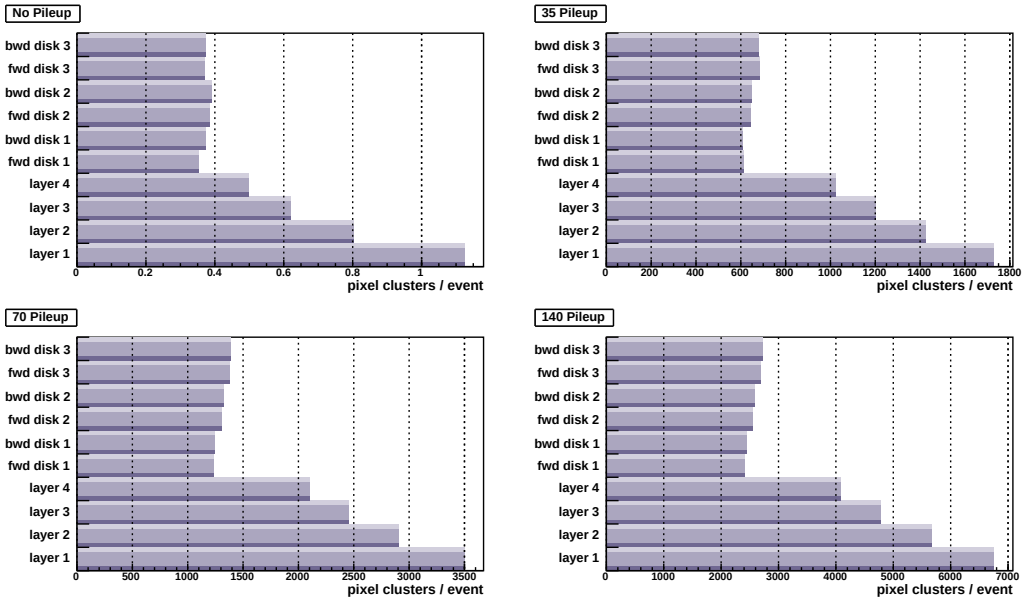

Figura 8: Number of pixel clusters per event in the different components of the pixel detector left by a single electron. Forward $(z > 0)$ and backward $(z < 0)$ disks are taken separately.