SiStrip Simulation overview for aging studies

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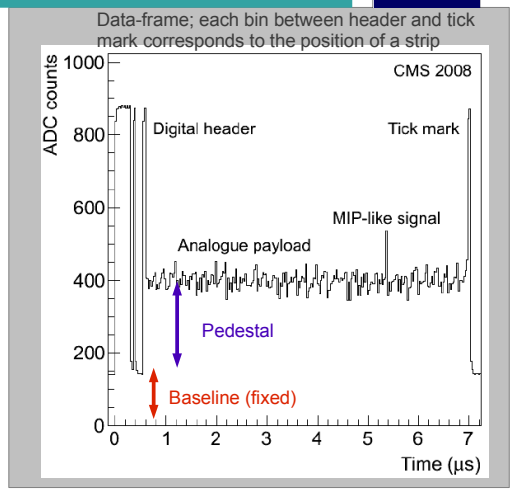
Outline

- SiStrip Digitization steps overview
- SiStrip Digitizer software structure
- Potential aging sensitive parameters
  - Depletion and applied voltage
  - Noise in zerosuppression
  - Noise in VR
  - Gain
  - Coupling

Strip signal simulation steps

- Standard mode of simulation is Zero Suppression (blue boxes)
- Heavy Ion run required Virgin Raw operation (blue+green)



Capacitive couplings tuned to cosmic data

OffDb

Probability tuned to test beam

Signal from Geant4 → Divide deposit → Cross-talk → Remove dead channels → APV Killer for HIP → Baseline shift → Baseline tilt

SiLinearCharge-Divider.cc

SiTrivialInduce-ChargeOnStrip.cc

SiStripDigitizerAlgorithm.cc

SiStripDigitizerAlgorithm.cc

SiGaussianTailNoiseAdder.cc

Shift and tilt being tuned on PbPb data in VR

ZS sim: N=a+b*length, with a,b fitted to data; VR sim: noise from data

CMN tuned to data in VR

Noise (N) → Gain (G); at APV level → Common mode noise → Pedestal → Digitization (incl. saturation) → To reco..

SiGaussianTailNoiseAdder.cc

SiTrivialDigitalConverter.cc

SiGaussianTailNoiseAdder.cc

SiGaussianTailNoiseAdder.cc

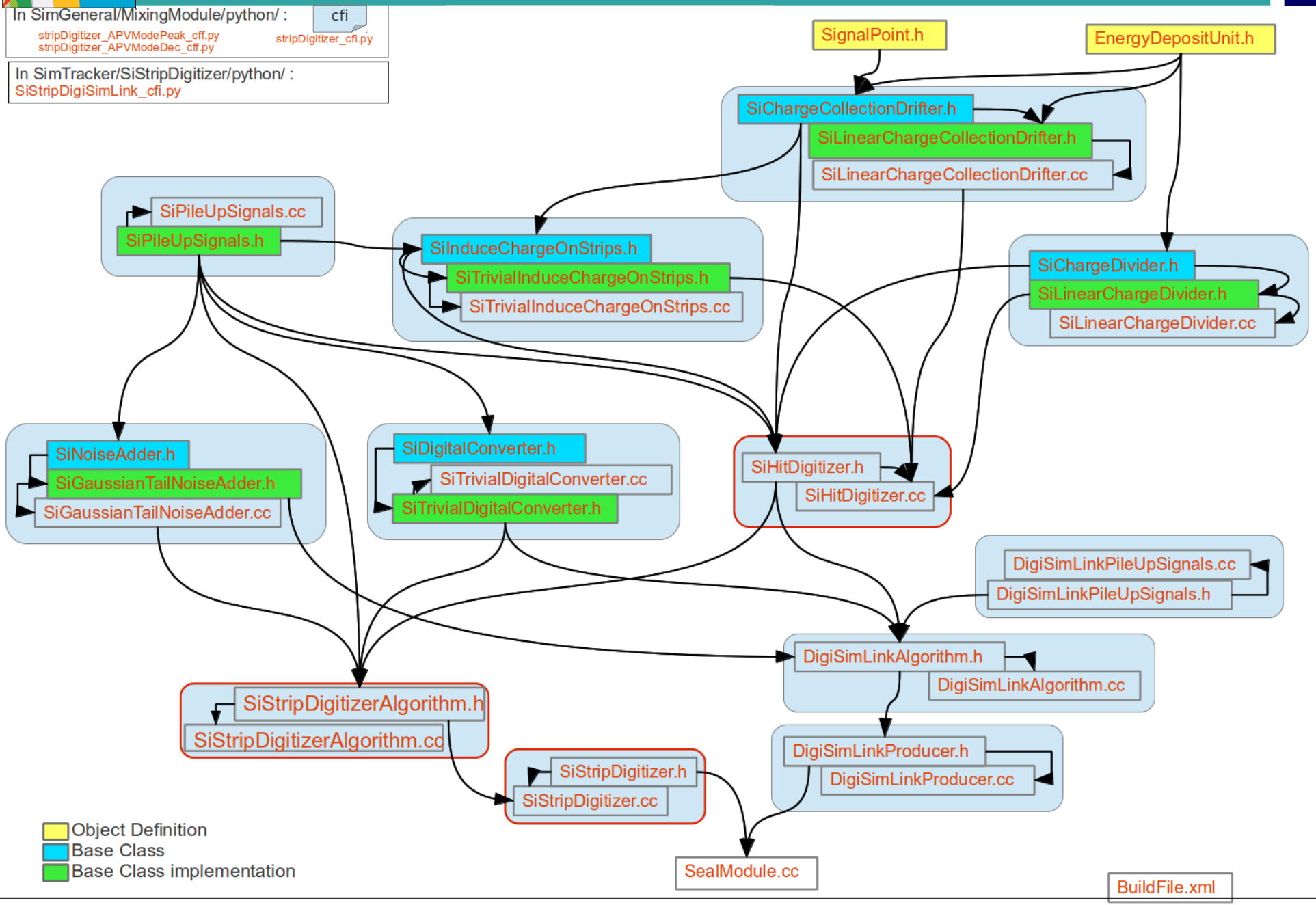
OffDb

OffDb

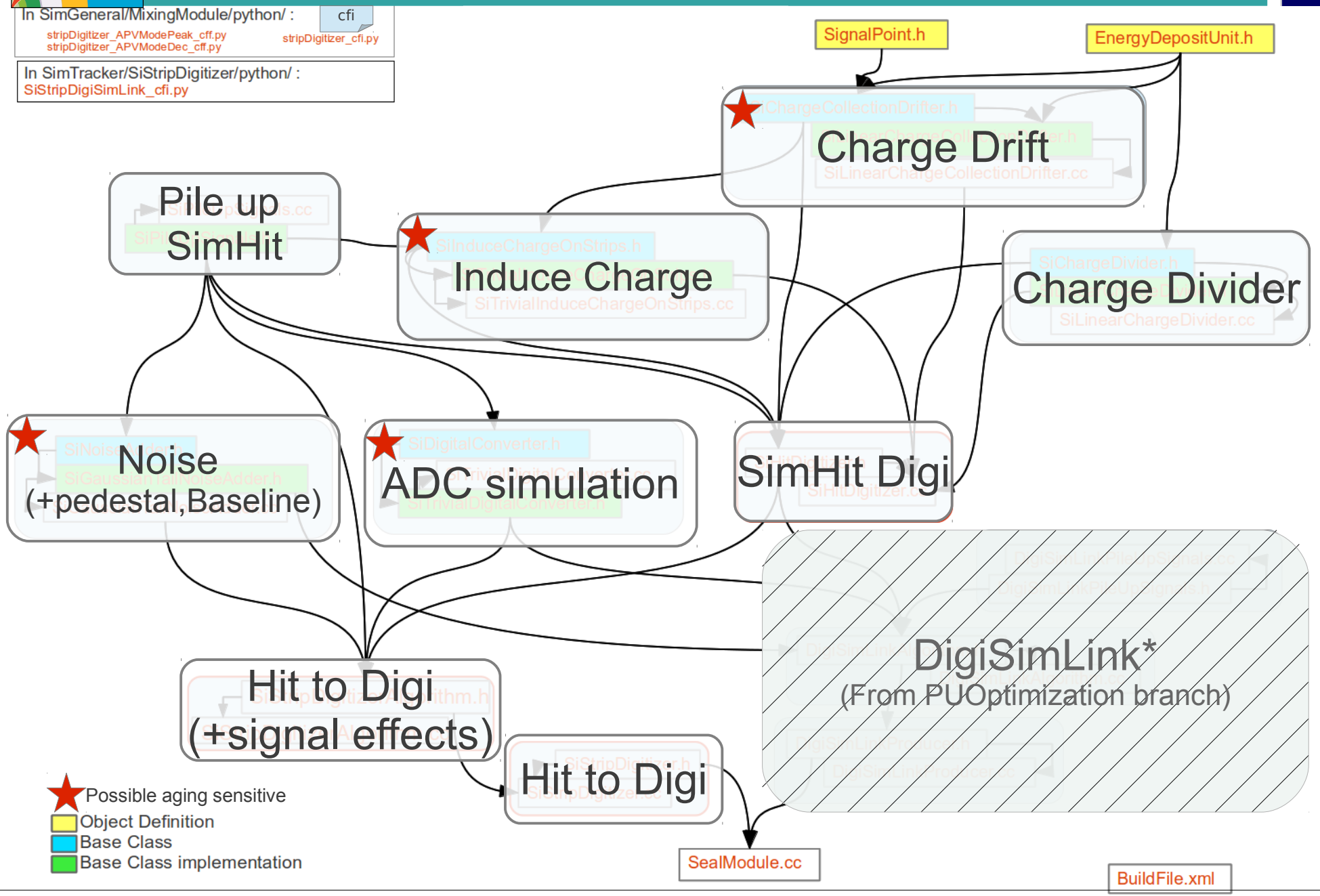
OffDb

*original diagram by Andrea Giammanco

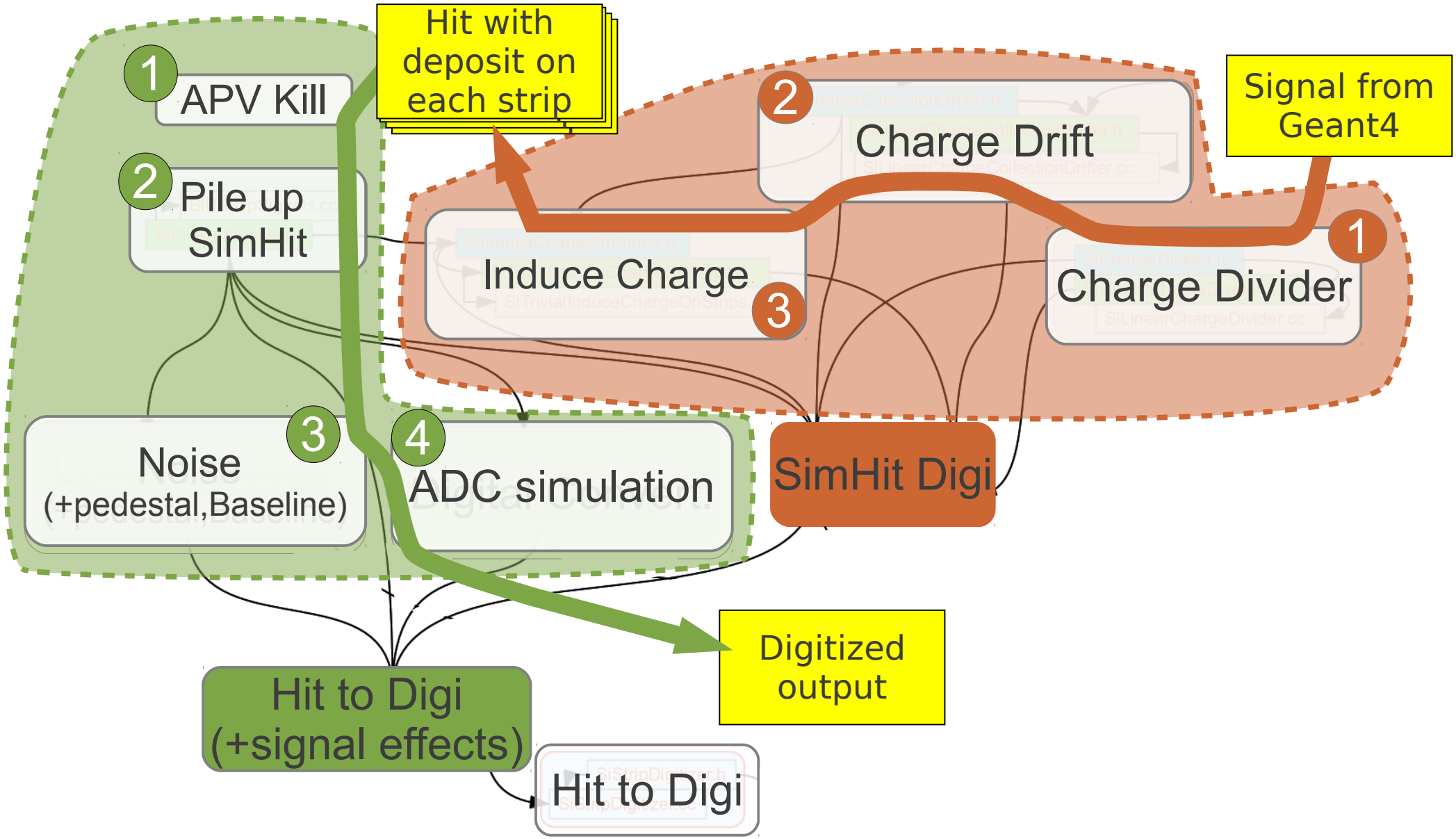
SiStrip Digitizer structure



SiStrip Digitizer structure



SiStrip Digitizer Steps



stripDigitizer_cfi Parameters

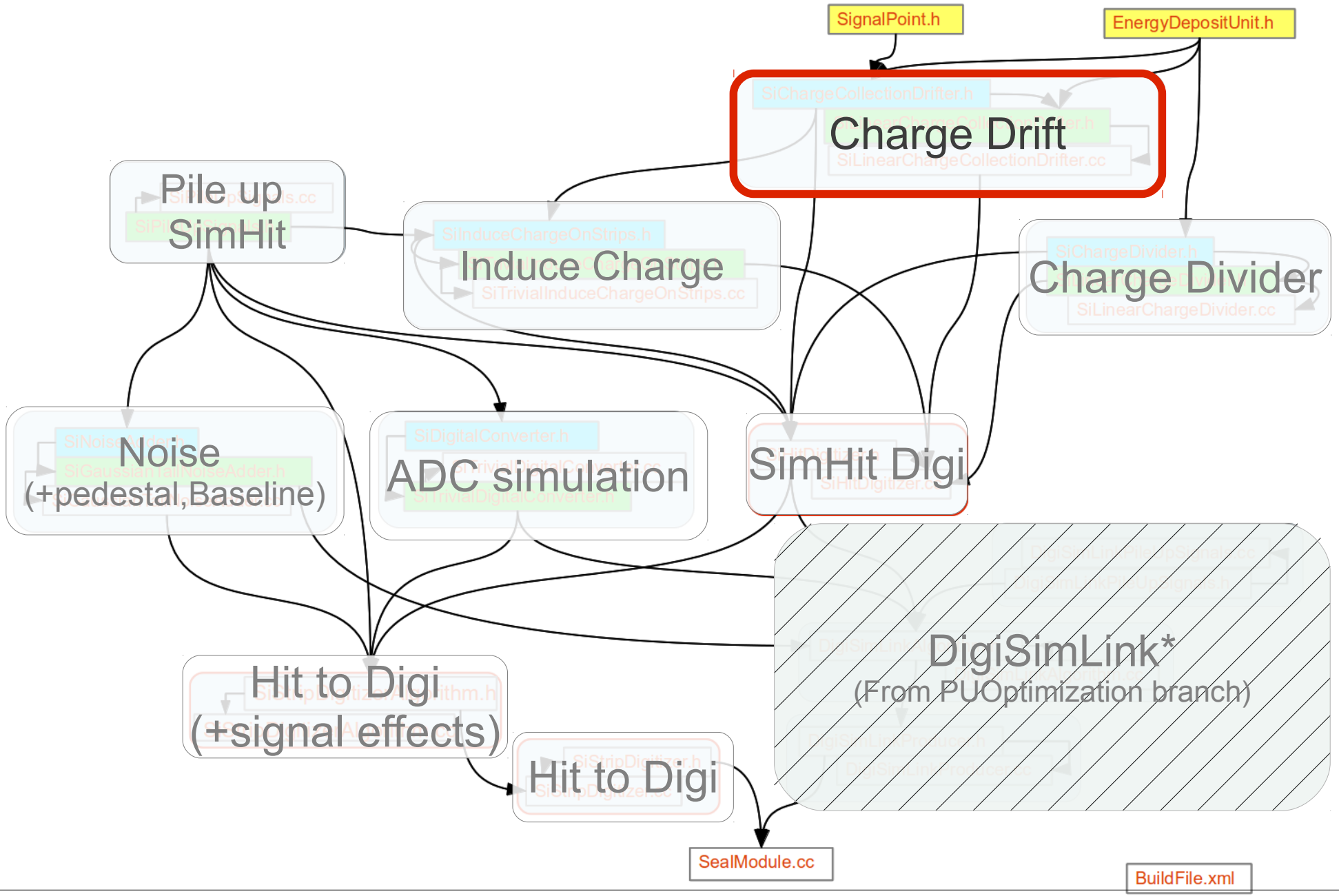
In /SimGeneral/MixingModule/python/stripDigitizer_cfi.py

```
    accumulatorType = cms.string("SiStripDigitizer"),
    hitsProducer = cms.string('g4SimHits'),

SiLinearChargeDivider
    DeltaProductionCut      = cms.double(0.120425),
    APVpeakmode             = cms.bool(False),
            #also in SiStripDigitizerAlgorithm
    LandauFluctuations      = cms.bool(True),
    chargeDivisionsPerStrip = cms.int32(10),
    CosmicDelayShift        = cms.untracked.double(0.0),
            # also SiStripDigitizerAlgorithm

SiHitDigitizer
    DepletionVoltage        = cms.double(170.0),
    AppliedVoltage          = cms.double(300.0),
    ChargeMobility          = cms.double(310.0),
    Temperature             = cms.double(273.0),
    GevPerElectron          = cms.double(3.61e-09),
    ChargeDistributionRMS   = cms.double(6.5e-10),
    noDiffusion             = cms.bool(False),

SiTrivialInduceChargeOnStrips
    CouplingConstant[Mode][subdet]   (so 2*14 coupling constants)
       Mode is Dec or Peak
       Subdet { "IB1","IB2","OB1","OB2","W1a","W2a","W3a","W1b","W2b",
                "W3b", "W4","W5","W6","W7"}

SiStripDigitizer
    DigiModeList = cms.PSet(SCDigi = cms.string('ScopeMode'),
                            ZSDigi = cms.string('ZeroSuppressed'),
                            PRDigi = cms.string('ProcessedRaw'),
                            VRDigi = cms.string('VirginRaw')),
    ROUList = cms.vstring("TrackerHitsTIBLowTof","TrackerHitsTIBHighTof",
                          "TrackerHitsTIDLowTof","TrackerHitsTIDHighTof",
                          "TrackerHitsTOBLowTof","TrackerHitsTOBHighTof",
                          "TrackerHitsTECLowTof","TrackerHitsTECHighTof"),
    GeometryType                = cms.string('idealForDigi'),
    TrackerConfigurationFromDB = cms.bool(False),
    ZeroSuppression             = cms.bool(True),
    LorentzAngle                = cms.string(''),
    Gain                        = cms.string(''),
```

```
SiStripDigitizerAlgorithm
    NoiseSigmaThreshold         = cms.double(2.0),
    electronPerAdcDec           = cms.double(247.0),
            #tuned on collisions at 7 TeV
    electronPerAdcPeak          = cms.double(262.0),
            #tuned on craft08
    FedAlgorithm                = cms.int32(4),
    Noise                       = cms.bool(True),

Parameters valid only if Noise = True and
                         ZeroSuppression = False

    *RealPedestals               = cms.bool(True),
    *SingleStripNoise            = cms.bool(True),
    CommonModeNoise             = cms.bool(True),
    BaselineShift               = cms.bool(True),
    APVSaturationFromHIP        = cms.bool(True),
    APVSaturationProb           = cms.double(0.001),
    cmnRMStib                   = cms.double(5.92),
    cmnRMStob                   = cms.double(1.08),
    cmnRMStid                   = cms.double(3.08),
    cmnRMStec                   = cms.double(2.44),
    PedestalsOffset             = cms.double(128),

* The pedestal and noise RMS for each stip is read from the
Db. if False it is added to all the strips the cnetral strip
pedestal value, noise RMS

    TOFCutForDeconvolution      = cms.double(50.0),
    TOFCutForPeak               = cms.double(100.0),
    Inefficiency                = cms.double(0.0)
```

Parameters potentially changed by aging

Depletion and applied Voltage



Depletion and applied Voltage

- In **SiHitDigitizer.cc** :

```
double timeNormalisation = (moduleThickness*moduleThickness)/(2.*depletionVoltage*chargeMobility);
```

$$t_{Norm} = \frac{Thickness_{mod}^{2}}{2.V_{Depl}.chargeMobility}$$ ← cfi

$$chargeMobility \propto \left[\frac{cm^2}{V.s}\right]$$

- In **SiLinearChargeCollectionDrifter** (drift time in the sensor) :

```
double driftTime = -timeNormalisation
                   *log(1.-2*depletionVoltage*thicknessFraction/(depletionVoltage+appliedVoltage))
                   +chargeDistributionRMS;
```

`SignalPoint drift (EnergyDepositUnit edu, Localvector drift, moduleThickness, timeNormalisation)`

- computes the fraction of the module the charge has to drift through,

$$depth = \frac{moduleThickness}{2} - energyDeposit.z()$$

$$thicknesFraction = \frac{depth}{moduleThickness}$$

- ensure thicknessFraction Є [0,1]
- Compute the drift time in the sensor

$$driftTime = -t_{Norm} * \log\left(1 - \frac{2.V_{Depl}}{V_{Depl}+V_{Appl.}}.thicknessFraction\right) + chargeDistributionRMS$$

- Return the SignalPoint(x,y,sigma,amplitude): pos., an energy on the surface, with a size due to diffusion.

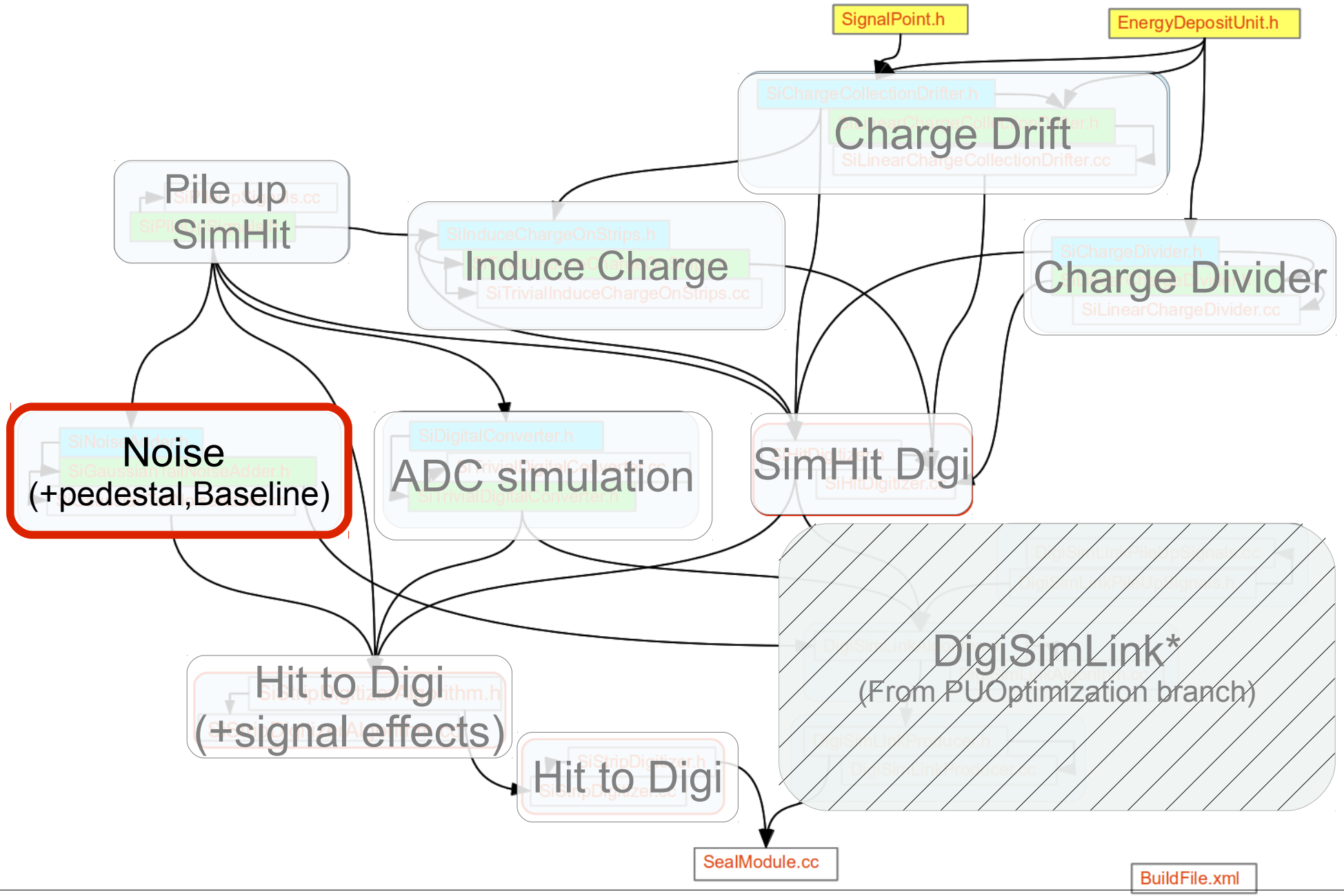
$$SignalPoint\left(edu.x() + \frac{depth*drift.x()}{drift.z()}, edu.y() + \frac{depth*drift.y()}{drift.z()}, \sqrt{2.*diffusionConstant*driftTime}, edu.energy()\right)$$

$$= \frac{C_{BOLTZ}}{e} * chargeMobility * Temp * \begin{bmatrix} 1.0\ if\ noDiffusion \\ 1.0e\text{-}3\ !\ noDiffusion \end{bmatrix}$$

cfi

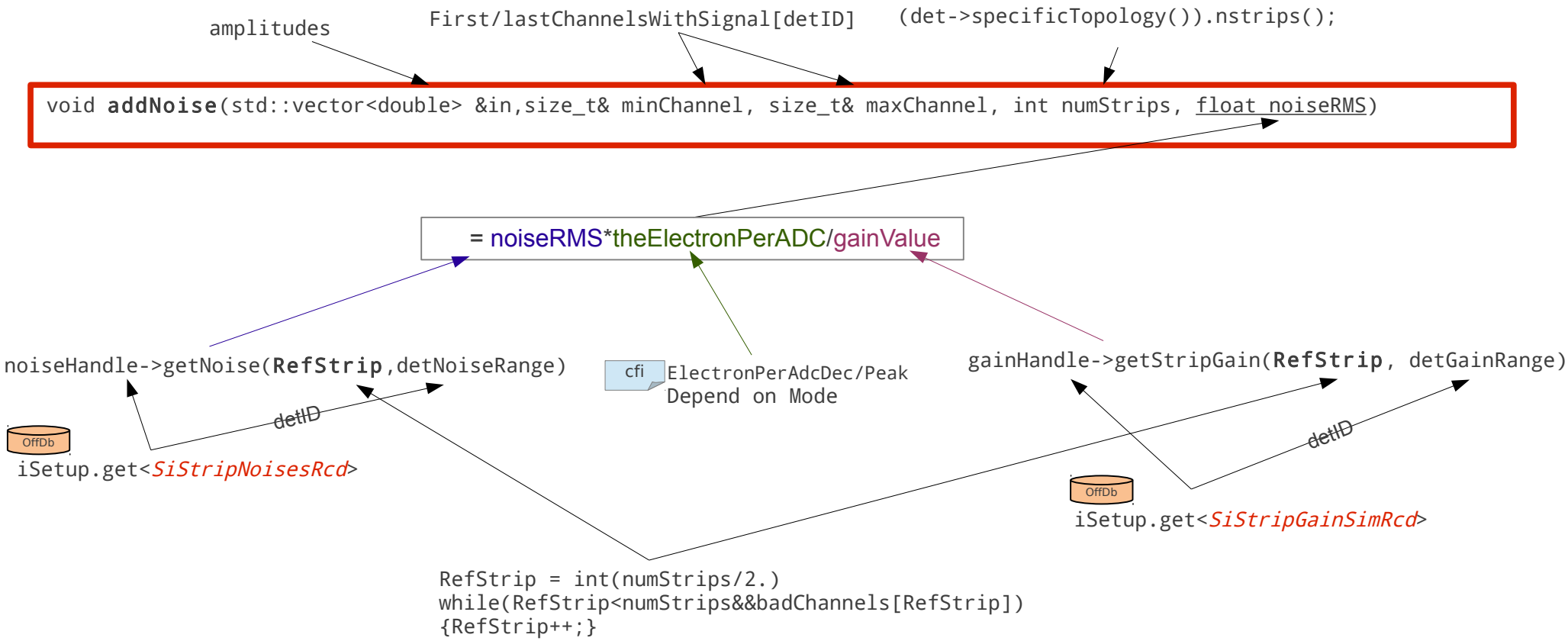
→ **Effect on coupling wich use the chargeSpread**

Noises, pedestal and baseline



Noise in ZeroSuppression (1)

Noise in ZeroSuppression inputs:



Noise in ZeroSuppression (2)

Noise in ZeroSuppression addNoise implementation

- Produce noise using *GaussianTailNoiseGenerator*

```
std::vector<std::pair<int,float> > generatedNoise;
genNoise->generate(numStrips, threshold, noiseRMS, generatedNoise);
```

```
genNoise(new GaussianTailNoiseGenerator(rndEngine))
```

cfi `"NoiseSigmaThreshold"`

Generation of random noise on "numberOfChannels" channels with a given threshold.
The generated noise:
- corresponds to a Gaussian distribution of RMS = "noiseRMS"
- is larger than threshold*noiseRMS.

- Gaussian Noise **on strips with signal** with *CLHEP::RandGaussQ(rndEngine)*:
  - Loop on channels and add noise if not null

```
in[iChannel] += gaussDistribution->fire(0.,noiseRMS);
```

```
gaussDistribution(new CLHEP::RandGaussQ(rndEngine))
```

- Noise **on the other strips**
  - Loop on generatedNoise vector pair generated at top
    - Add to channel the corresponding noise (and check that value ==0)

```
in[(*p).first] += (*p).second;
```

VirginRaw Noises, Pedestal, baseline

(in Si*NoiseAdder & SiDigiAlgo)

```
void addBaselineShift(std::vector<double> &in, std::vector<bool> &badChannels)
    size_t nAPVs = in.size()/128;
      std::vector<float> vShift;
      double apvCharge, apvMult;

      size_t iChannel;
      for(size_t APVn =0; APVn < nAPVs; ++APVn){
            apvMult=0; apvCharge=0;
            for(iChannel=APVn*128; iChannel!=APVn*128+128; ++iChannel) {
               if(in[iChannel]>0){
                     ++apvMult;
                      apvCharge+= in[iChannel];
               }
               if(apvMult==0) vShift.push_back(0);
               else vShift.push_back(apvCharge/apvMult);
            }
      }
      for (iChannel=0; iChannel!=in.size(); ++iChannel) {
         if(!badChannels[iChannel]) in[iChannel] -= vShift[(int)(iChannel/128)];
      }
```

Are aging studies needed in VirginRaw mode?

```
void addNoiseVR(std::vector<double> &in, std::vector<float> &noiseRMS)
     Add noise
       // Full Gaussian noise is added everywhere
          if(noiseRMS[iChannel] > 0.) in[iChannel] += gaussDistribution->fire(0.,noiseRMS[iChannel]);
```

```
void addCMNoise(std::vector<double> &in, float cmnRMS, std::vector<bool> &badChannels)
   int nAPVs = in.size()/128;
   std::vector<float> CMNv;
   for(int APVn =0; APVn < nAPVs; ++APVn) CMNv.push_back(gaussDistribution->fire(0.,cmnRMS));
   for (size_t iChannel=0; iChannel!=in.size(); iChannel++) {
      if(!badChannels[iChannel]) in[iChannel] += CMNv[(int)(iChannel/128)];
   }
```

```
void addPedestals(std::vector<double> &in,std::vector<float> & ped)
        for (size_t iChannel=0; iChannel!=in.size(); iChannel++) {
          if(ped[iChannel]>0.) in[iChannel] += ped[iChannel];   } }
```

VirginRaw : APV killer

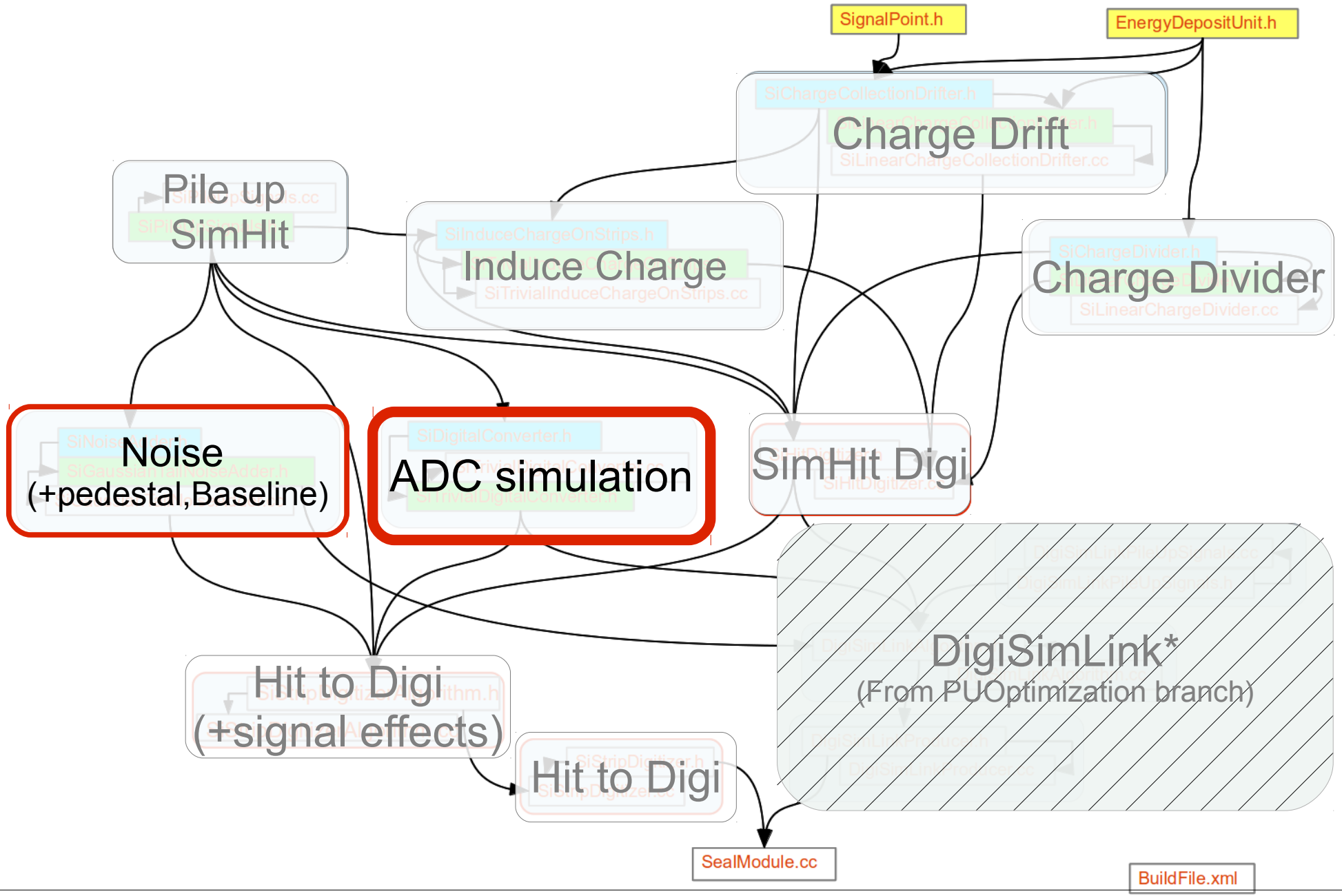
(in Si*NoiseAdder & SiDigiAlgo)

- In SiStripDigitizerAlgorithm
- Aim is to simulate APV « killed » by high « signal » on many strips so no clear signal can be extracted

Are aging studies needed in VirginRaw mode?

```
if(APVSaturationFromHIP&&!zeroSuppression){
                    int pdg_id = simHitIter->particleType();
                        particle = pdt->particle(pdg_id);
                        if(particle != NULL){
                                float charge = particle->charge();
                                bool isHadron = particle->isHadron();
                            if(charge!=0 && isHadron){
                                        if(theFlatDistribution->fire()<APVSaturationProb){
                                                int FirstAPV = localFirstChannel/128;
                                                int LastAPV = localLastChannel/128;
                                                std::cout << "-------------------HIP--------------" << std::endl;
                                                std::cout<<"Killing APVs "<<FirstAPV<< " - " <<LastAPV<< " " <<detID <<std::endl;
                                                for(int strip = FirstAPV*128; strip < LastAPV*128 +128; ++strip) {
                                                        badChannels[strip] = true;
                                                }
                                                //doing like that I remove the signal information only after the
                                                //stip that got the HIP but it remains the signal of the previous
                                                //one. I'll make a further loop to remove all signal
                                        }
                                }
                        }
```

Gains


SignalPoint.h
EnergyDepositUnit.h
Charge Drift
Pile up SimHit
Induce Charge
Charge Divider
Noise (+pedestal,Baseline)
ADC simulation
SimHit Digi
DigiSimLink*
(From PUOptimization branch)
Hit to Digi (+signal effects)
Hit to Digi
SealModule.cc
BuildFile.xml

Gains

- When adding noise (see before)
- When converting to ADC

```
DigitalVecType convert(const std::vector<double>& analogSignal, edm::ESHandle<SiStripGain> & gainHandle, unsigned int detid)
```

```
gainHandle->getStripGain(RefStrip, detGainRange)
```

detID

OffDb

```
iSetup.get<SiStripGainSimRcd>
```

```
RefStrip = int(numStrips/2.)
while(RefStrip<numStrips&&badChannels[RefStrip])
{RefStrip++;}
```

- Check if gainHandle is valid
  - Loop on analogsignal vector and if >0 (else set 0)
    - Convert analog to digital

```
int adc = convert( (gainHandle->getStripGain(i, detGainRange))*(analogSignal[i]) );
```

    - Add to to digitalrectype if >0

- If gainHandle not valid :
  - Same but don't multiply by a gain

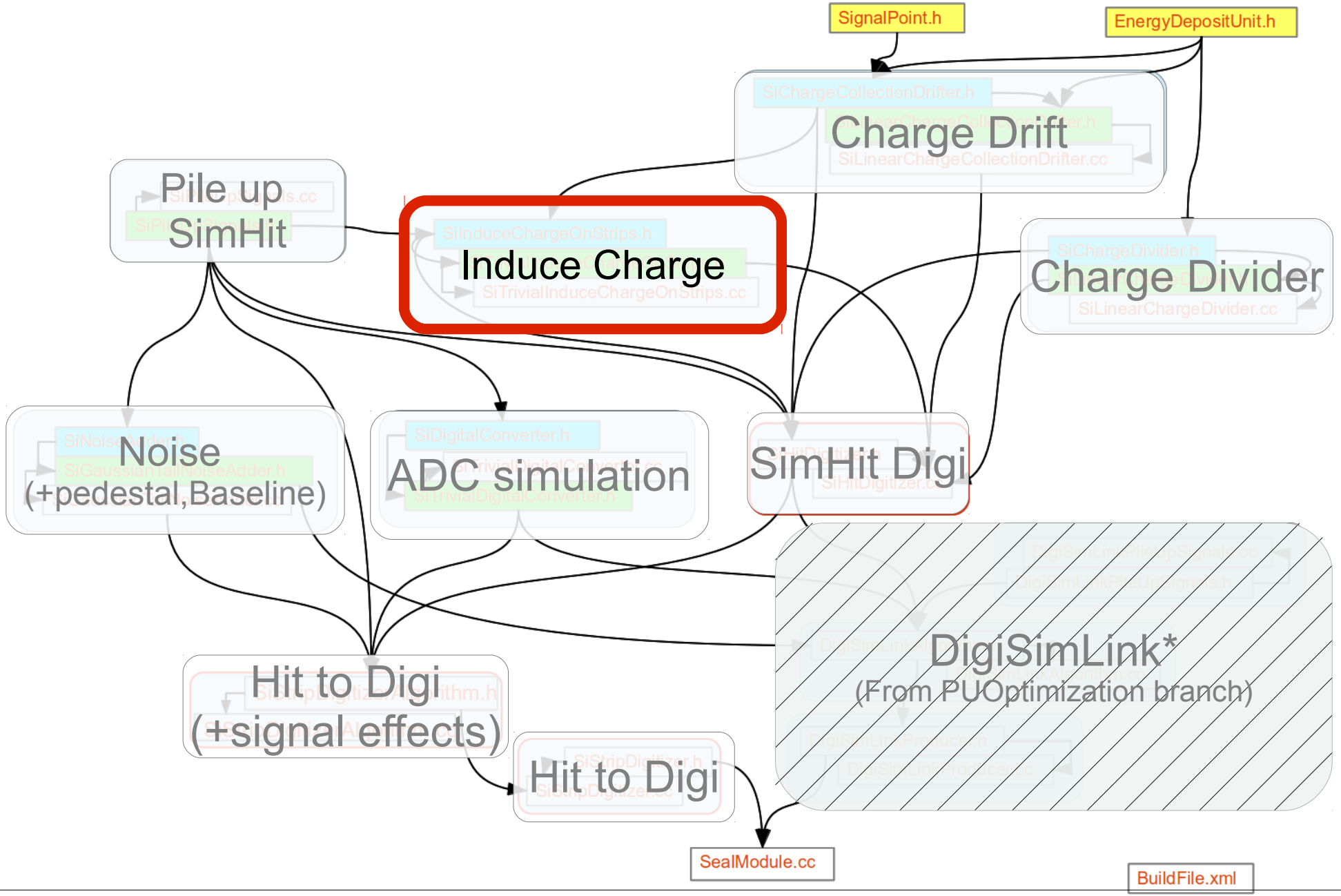
```
adc = convert( analogSignal[i] );
```

int convert(float in) {return truncate(in/electronperADC);}

Truncate :

```
If (raw charge < 254)          -> adc unchanged
If (254  <= raw charge < 1023) -> adc=254
If (raw charge >= 1023)        -> adc=255
```

Couplings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SealModule.cc
BuildFile.xml

Couplings (1)

```
type[Ntypes] = { "IB1", "IB2","OB1","OB2","W1a","W2a","W3a","W1b","W2b","W3b","W4","W5","W6","W7"};
```

```
double chargeDeposited(size_t strip,size_t Nstrips,double amplitude,double chargeSpread,double chargePosition)
```

- Determine integral and fraction of signal
  - integralUpToStrip = (strip == 0) ? 0. : (normal_cdf(strip, **chargeSpread**, chargePosition));
  - integralUpToNext = (strip+1 == Nstrips) ? 1. : (normal_cdf(strip+1, **chargeSpread**, chargePosition));
  - percentOfSignal = integralUpToNext - integralUpToStrip;
- return percentOfSignal * amplitude / geVperElectron;

cfi

```
void induce(collection_type collection_points,StripGeomDetUnit det,localAmplitudes,
            size_t recordMinAffectedStrip, size_t recordMaxAffectedStrip,TrackerTopology *tTopo)
```

- Get the coupling ; Get the topology ; The number of strip in this topology
- Loop on signal points in collection :
  - Define :
    - chargePosition=from signal point ; chargeSpread : $chargeSpread = \frac{signalPoint \rightarrow sigma()}{localPitch}$

Depend on V_{depl} V_{Appl}

    - firtStrip and untilStrip from chargePosition±Nsigma*chargeSpread
  - Loop on strips :
    - Compute charge deposited on the Strip =chargeDeposited(strip, Nstrips, signalpoint->amplitude(), chargeSpread, chargePosition)
    - Strip range affected by deposit (affectedFromStrip, affectedUntilStrip)

      using Nsigma, coupling, position

cfi `CouplingConstant[Mode][subdet]`

    - Loop on affectedStrip to apply induce charge :
      - $affectedStrip_{localAmplitude}$ += chargeDepositedOnStrip * coupling.at(abs(affectedStrip - strip))

Conclusions

- Many parameters aging could be done through modification in cfg or special tag in offline database
  - Depletion and Applied voltage (cfi)
    - used for charge diffusion during drift → Induced charge
  - Noise in ZS, play with :
    - noiseRMS and gains (OffDb)
    - ElectronperADC, NoiseSigmaThreshold (cfi)
  - Gain (OffDb)
  - Coupling (cfi)
- Are effect in Virgin Raw needed to be simulated?
- Peak and deco shape?

Back up slides

SiChargeDivider : why ?

- In Geant4 :
  - the energy deposited on subsections of silicon sensitive section are simulated but not recorded

    $\Rightarrow$ Only the total charge is recorded (E_{tot})
- In the SimTracker/SiStripDigitizer :
  - The pathlength is divided in n subsections
  - $E_{subsection} = \frac{E_{tot}}{n}$
  - Fluctuation δE_i on $E_{subsection,i}$ using « `SampleFluctuations` » routine from Geant4
  - Rescale factor ε in order to have

$$\varepsilon . \sum_i \left(E_{subsection,i} + \delta E_i \right) = E_{tot}$$

SiChargeDivider : why ?

- Can pulse and decoshape be modified by aging ?
  - Becauses hardcoded in the DividerPart

```
inline float TimeResponse( const PSimHit* hit, const StripGeomDetUnit& det) {
  return (peakMode ? PeakShape(hit,det) : DeconvolutionShape(hit,det));
}
```

```
// pulse shape in peak mode
float PeakShape(const PSimHit*, const StripGeomDetUnit& det);
// pulse shape in deconvolution mode
float DeconvolutionShape( const PSimHit*, const StripGeomDetUnit& det);
```

```
// data table for pulse shape in peak mode
static float peakValues[921];
// data table for pulse shape in deconvolution mode
static float decoValues[651];
```

SiHitDigitizer

```
SiHitDigitizer::SiHitDigitizer(const edm::ParameterSet& conf, CLHEP::HepRandomEngine& eng) :
  depletionVoltage(conf.getParameter<double>("DepletionVoltage")),
  chargeMobility(conf.getParameter<double>("ChargeMobility")),
  theSiChargeDivider(new SiLinearChargeDivider(conf, eng)),
  theSiChargeCollectionDrifter(new SiLinearChargeCollectionDrifter(
         CBOLTZ_over_e_SI * chargeMobility * conf.getParameter<double>("Temperature") *
(conf.getParameter<bool>("noDiffusion") ? noDiffusionMultiplier : 1.0),
         conf.getParameter<double>("ChargeDistributionRMS"),
         depletionVoltage,
         conf.getParameter<double>("AppliedVoltage"))),
  theSiInduceChargeOnStrips(new SiTrivialInduceChargeOnStrips(conf, conf.getParameter<double>("GevPerElectron"))) {
}


processHit(const PSimHit* hit, const StripGeomDetUnit& det, GlobalVector bfield,float langle,
                          std::vector<double>& locAmpl, size_t& firstChannelWithSignal, size_t& lastChannelWithSignal,
                          const TrackerTopology *tTopo){

  // Compute the drift direction for this det
  double moduleThickness = det.specificSurface().bounds().thickness(); // active detector thicness
  double timeNormalisation = (moduleThickness*moduleThickness)/(2.*depletionVoltage*chargeMobility);
  LocalVector driftDir = DriftDirection(&det,bfield,langle);

  // Fully process one SimHit
  theSiInduceChargeOnStrips->induce(
      theSiChargeCollectionDrifter->drift(
          theSiChargeDivider->divide(hit, driftDir, moduleThickness, det),
          driftDir,moduleThickness,timeNormalisation),
      det,locAmpl,firstChannelWithSignal,lastChannelWithSignal,tTopo);
}
```

SiLinearChargeCollectionDrifter

```
Drifts the charges linearly.
 * Drift each energy deposits in the bulk to the surface.
 * The resulting position depends on the Lorentz angle, and a sigma is computed that describes the diffusion.
```

`SignalPoint drift (EnergyDepositUnit edu, Localvector drift, moduleThickness, timeNormalisation)`

- computes the fraction of the module the charge has to drift through,

$$depth = \frac{moduleThickness}{2} - energyDeposit.z()$$

$$thicknesFraction = \frac{depth}{moduleThickness}$$

- ensure thicknessFraction Є [0,1]
- Compute the drift time in the sensor

$$driftTime = -timeNormalisation * \log\left(1. - \frac{2 * depletionVoltage * thicknessFraction}{depletionVoltage + appliedVoltage}\right) + chargeDistributionRMS$$

- Return the signal: an energy on the surface, with a size due to diffusion.

$$SignalPoint\left(edu.x() + \frac{depth * drift.x()}{drift.z()}, edu.y() + \frac{depth * drift.y()}{drift.z()}, \sqrt{2. * diffusionConstant * driftTime}, edu.energy()\right)$$

`SiChargeCollectionDrifter::collection_type drift(ionization_type ion,LocalVector driftDir,double mt, double tn)`

- Call the previous drift method for each deposit
  _temp[i] = drift(ion[i], driftDir, mt, tn);
- Return a collection_type

SiTrivialInduceChargeOnStrip (1)

```
* Given a SignalPoint, computes the charge on each strip, using also the coupling between strips
```

```
type[Ntypes] = { "IB1", "IB2","OB1","OB2","W1a","W2a","W3a","W1b","W2b","W3b","W4","W5","W6","W7"};
```

```
std::vector<std::vector<double>> fillSignalCoupling(edm::ParameterSet& conf, nTypes, string typeArray)
```

- Define mode from *APVPeakmode*
- For each type, fill vector with corresponding coupling constant
- Return vector of coupling constant

```
int indexOf(const std::string& t)
```

- return index of subdetector type in type vector

```
int typeOf(StripGeomDetUnit& det, TrackerTopology *tTopo)
```

- return the corresponding index of subdetector type from the detunit and Topo

```
SiTrivialInduceChargeOnStrips(const edm::ParameterSet& conf,double g)
  : signalCoupling(fillSignalCoupling(conf, Ntypes, type)), Nsigma(3.), geVperElectron(g)  {}
```

- Constructor

```
double chargeDeposited(size_t strip,size_t Nstrips,double amplitude,double chargeSpread,double chargePosition)
```

- Determine integral and fraction of signal
  - integralUpToStrip = (strip == 0) ? 0. : (normal_cdf(strip, chargeSpread, chargePosition));
  - integralUpToNext = (strip+1 == Nstrips) ? 1. : (normal_cdf(strip+1, chargeSpread, chargePosition));
  - percentOfSignal = integralUpToNext - integralUpToStrip;
- return percentOfSignal * amplitude / geVperElectron;

SiTrivialInduceChargeOnStrip (2)

```
void induce(collection_type collection_points,StripGeomDetUnit det,localAmplitudes,
            size_t recordMinAffectedStrip, size_t recordMaxAffectedStrip,TrackerTopology *tTopo)
```

- Get the coupling
- Get the topology
- The number of strip in this topology
- Loop on signal points in collection :
  - Define :
    - chargePosition=from signal point
    - chargeSpread : $chargeSpread = \frac{signalPoint \rightarrow sigma()}{localPitch}$
    - firtStrip and untilStrip from chargePosition±Nsigma*chargeSpread
  - Loop on strips :
    - Compute charge deposited on the Strip

      =chargeDeposited(strip, Nstrips, signalpoint->amplitude(), chargeSpread, chargePosition)
    - Strip range affected by deposit (affectedFromStrip, affectedUntilStrip)

      using Nsigma, coupling, position
    - Loop on affectedStrip to apply induce charge :
      - $affectedStrip_{localAmplitude}$ += chargeDepositedOnStrip * coupling.at(abs(affectedStrip - strip))

SiStripDigitizer (1)

* SiStripDigitizer to convert hits to digis

```
void finalizeEvent (edm::Event &e, edm::EventSetup const &c)
```

- LOOP on StripGeomDetUnit
  - apply the cable map _before_ digitization: consider only the detis that are connected
  - Apply digitization (noise, etc) (using theDigiAlgo->digitize();)
  - Fill digivector (zerosuppression or not)
  - Case zerosuppression or VR
    - create output collection with digivector
    - write output to file

```
void initializeEvent (edm::Event const &e, edm::EventSetup const &c)
```

- Get Inputs
- Initialize noise, etc (using theDigiAlgo->initializeEvent(iSetup))
- clear detectorUnits
- Loop on detector units
  - (re)fill
  - Init them (using theDigiAlgo->initializeDetUnit())

SiStripDigitizer (2)

* SiStripDigitizer to convert hits to digis

```
void accumulateStripHits (edm::Handle< std::vector< PSimHit > >, const TrackerTopology *tTopo)
```

- Check if hit vector is valid
- Loop on hits
  - Check if the insert succeeded, so this detector element has not yet been processed
  - access to magnetic field in global coordinates
  - Accumulate simhits (using theDigiAlgo->accumulateSimHits(it, itEnd, stripdet, bfield, tTopo))

```
void accumulate (edm::Event const &e, edm::EventSetup const &c)
```

- Retrieve tracker topology from geometry
- Loop on trackerContainers
  - Get inputs
  - accumulateStripHits(simHits,tTopo);

```
void accumulate (PileUpEventPrincipal const &e, edm::EventSetup const &c)
```

- Same as before

SiStripDigitizerAlgorithm (1)

* SiStripDigitizerAlgorithm to convert hits to digis

```
void initializeDetUnit (StripGeomDetUnit *det, const edm::EventSetup &iSetup)
```

- storing the bad strip of the the module. the module is not removed but just signal put to 0

```
void initializeEvent (const edm::EventSetup &iSetup)
```

- get gain noise pedestal lorentzAngle from ES handle

```
void setParticleDataTable (const ParticleDataTable *pardt)
```

- Set particle datatable (using theSiHitDigitizer->setParticleDataTable(pardt))

```
SiStripDigitizerAlgorithm (const edm::ParameterSet &conf, CLHEP::HepRandomEngine &)
```

- constructor

```
void accumulateSimHits (const std::vector< PSimHit >::const_iterator inputBegin, const std::vector< PSimHit >::const_iterator inputEnd, const StripGeomDetUnit *stripdet, const GlobalVector &bfield)
```

- loop on the SimHits
  - skip hits not in this detector.
  - check TOF and energydeposit
  - process the hit (from sihitdigitizer)
  - APV Killer to simulate HIP effect
- Pileup the hits (using theSiPileUpSignals->add())

SiStripDigitizerAlgorithm (2)

* SiStripDigitizerAlgorithm to convert hits to digis

```
void digitize (edm::DetSet< SiStripDigi > &outDigis, edm::DetSet< SiStripRawDigi > &outRawDigis, const
StripGeomDetUnit *stripdet, edm::ESHandle< SiStripGain > &, edm::ESHandle< SiStripThreshold > &, edm::ESHandle<
SiStripNoises > &, edm::ESHandle< SiStripPedestals > &)
```

- removing signal from the dead (and HIP effected) strips
- Zerosuppression :
  - Noise by refstrip
- !zerosuppression
  - calculating the charge deposited on each APV and subtracting the shift
    (BaseLineShift using theSiNoiseAdder->addBaselineShift())
  - Adding the strip noise
    - Either SingleStripNoise
    - Or by refstrip
  - Add noise to signal (using theSiNoiseAdder->addNoiseVR())
  - Adding the Common Mode Noise
    - Get cmnRMS value for detector and multiply by electronPerADC
    - Add noise to signal (using theSiNoiseAdder->addCMNoise)
  - Adding the pedestals
    - Real pedestal by strip
    - Using pedoffset
  - Add to signal (using theSiNoiseAdder->addPedestals())
  - Produce rawdigis (using theSiDigitalConverter->convertRaw(detAmpl, gainHandle, detID))

SiPileUpSignals

```
* Class which takes the responses from each SimHit and piles-up them, within a given module.
* More precisely, it keeps for each strip the link to each individual measurement.
```

```
const SignalMapType* getSignal(uint32_t detID)
```

```
auto where = signal_.find(detID);
    if(where == signal_.end()) {
      return 0;
    }
    return &where->second;
  }
```

```
void resetSignals()
```

- Clear the signal

```
void add(uint32_t detID, vector<double>& locAmpl, size_t firstChannelWithSignal, size_t lastChannelWithSignal)
```

- Loop on channels within signals bounds
  - If signal!=0
    - If channel present :
      - Create pair channe- signal amplitude
    - Else
      - Add signal value to previous piled up values for this channel

SiHiDigitizer

```
* Digitizes the response for a single SimHit.
```

```
void processHit (const PSimHit *, const StripGeomDetUnit &, GlobalVector, float, std::vector< double > &,
size_t &, size_t &)
```

- LOOP on StripGeomDetUnit
  - apply the cable map _before_ digitization: consider only the detis that are connected
  - Apply digitization (noise, etc) (using theDigiAlgo->digitize();)
  - Fill digivector (zerosuppression or not)
  - Case zerosuppression or VR
    - create output collection with digivector
    - write output to file

```
void setChargeCollectionDrifter (SiChargeCollectionDrifter *cd)
```

- Get Inputs

```
void setChargeCollectionDrifter (SiChargeCollectionDrifter *cd)
```

- Get Inputs

```
void setChargeCollectionDrifter (SiChargeCollectionDrifter *cd)
```

- Get Inputs

Noise and Gain

SiStripDigitizerAlgorithm.cc:91: //get gain noise pedestal lorentzAngle from ES handle
SiStripDigitizerAlgorithm.cc:179:   edm::ESHandle<SiStripGain> & gainHandle,
SiStripDigitizerAlgorithm.cc:200: SiStripApvGain::Range detGainRange = gainHandle->getRange(detID);
SiStripDigitizerAlgorithm.cc:216:   float gainValue = gainHandle->getStripGain(RefStrip, detGainRange);
SiStripDigitizerAlgorithm.cc:217:   theSiNoiseAdder-
>addNoise(detAmpl,firstChannelWithSignal,lastChannelWithSignal,numStrips,noiseRMS*theElectronPerADC/gainValue);
SiStripDigitizerAlgorithm.cc:221:   theSiZeroSuppress->suppress(theSiDigitalConverter->convert(detAmpl, gainHandle, detID), digis,
detID,noiseHandle,thresholdHandle);
SiStripDigitizerAlgorithm.cc:321:   DigitalRawVecType rawdigis = theSiDigitalConverter->convertRaw(detAmpl, gainHandle, detID);
SiStripDigitizer.cc:56: gainLabel(conf.getParameter<std::string>("Gain")),
SiStripDigitizer.cc:184: edm::ESHandle<SiStripGain> gainHandle;
SiStripDigitizer.cc:188: iSetup.get<SiStripGainSimRcd>().get(gainLabel,gainHandle);
SiStripDigitizer.cc:212:   gainHandle,thresholdHandle,noiseHandle,pedestalHandle);
SiTrivialDigitalConverter.cc:12:SiTrivialDigitalConverter::convert(const std::vector<double>& analogSignal, edm::ESHandle<SiStripGain> & gainHandle,
unsigned int detid){
SiTrivialDigitalConverter.cc:16: if(gainHandle.isValid()) {
SiTrivialDigitalConverter.cc:17:   SiStripApvGain::Range detGainRange = gainHandle->getRange(detid);
SiTrivialDigitalConverter.cc:21:   int adc = convert((gainHandle->getStripGain(i, detGainRange))*(analogSignal[i]));
SiTrivialDigitalConverter.cc:36:SiTrivialDigitalConverter::convertRaw(const std::vector<double>& analogSignal, edm::ESHandle<SiStripGain> &
gainHandle, unsigned int detid){
SiTrivialDigitalConverter.cc:40: if(gainHandle.isValid()) {
SiTrivialDigitalConverter.cc:41:   SiStripApvGain::Range detGainRange = gainHandle->getRange(detid);
SiTrivialDigitalConverter.cc:45:   int adc = convertRaw((gainHandle->getStripGain(i, detGainRange))*(analogSignal[i]));
SiDigitalConverter.h:6:#include "CalibFormats/SiStripObjects/interface/SiStripGain.h"
SiDigitalConverter.h:18: virtual DigitalVecType   convert(const std::vector<double> &, edm::ESHandle<SiStripGain>& ,unsigned int detid) = 0;
SiDigitalConverter.h:19: virtual DigitalRawVecType convertRaw(const std::vector<double> &, edm::ESHandle<SiStripGain>& ,unsigned int detid) = 0;
SiStripDigitizerAlgorithm.h:24:#include "CalibFormats/SiStripObjects/interface/SiStripGain.h"
SiStripDigitizerAlgorithm.h:77:   edm::ESHandle<SiStripGain>&,
SiStripDigitizer.h:57: const std::string gainLabel;
SiTrivialDigitalConverter.h:13: DigitalVecType   convert(const std::vector<double>&, edm::ESHandle<SiStripGain>& ,unsigned int detid);
SiTrivialDigitalConverter.h:14: DigitalRawVecType convertRaw(const std::vector<double>&, edm::ESHandle<SiStripGain>& ,unsigned int detid);