LArSoft – Geant4 & Detsim

DUNE-France Analysis Workshop

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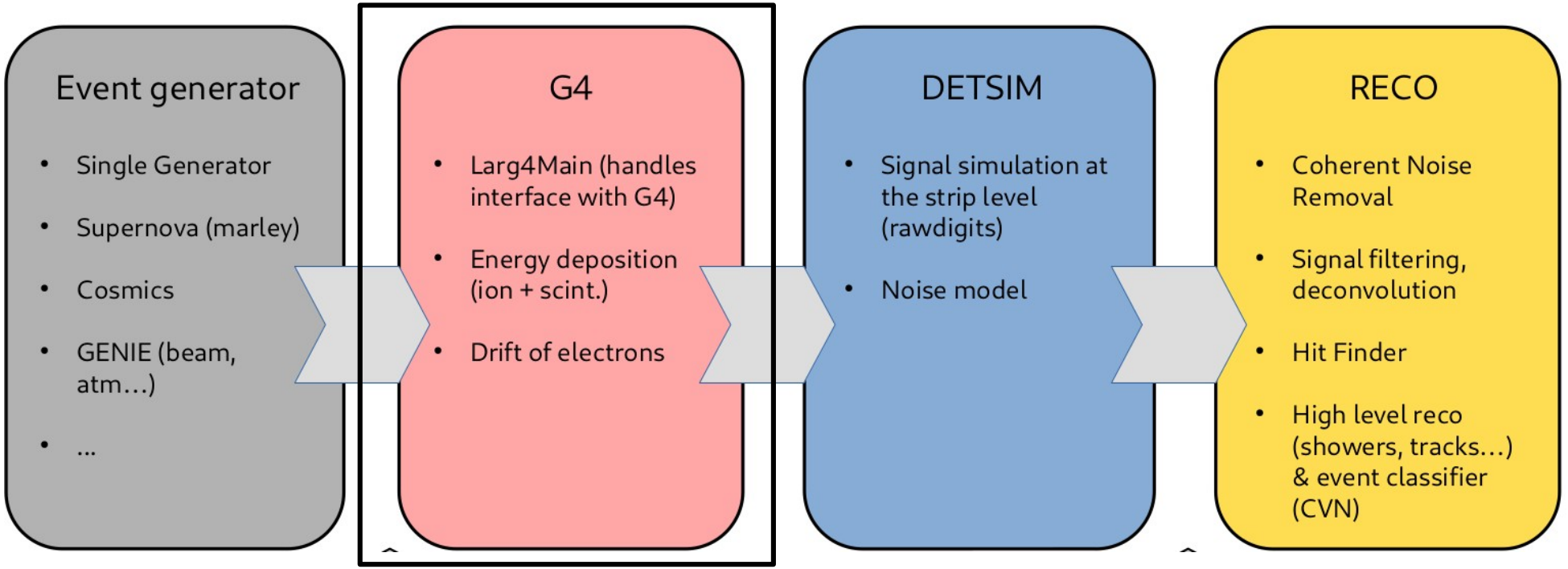
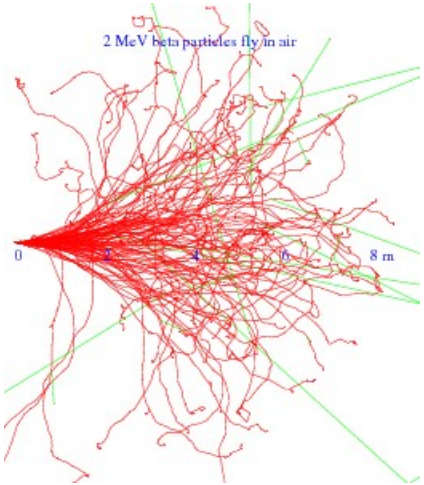
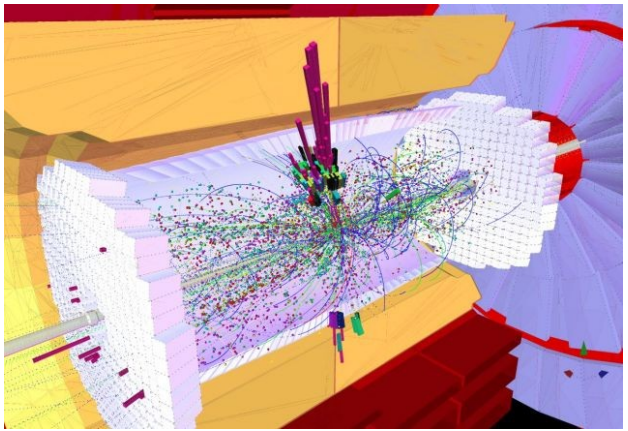
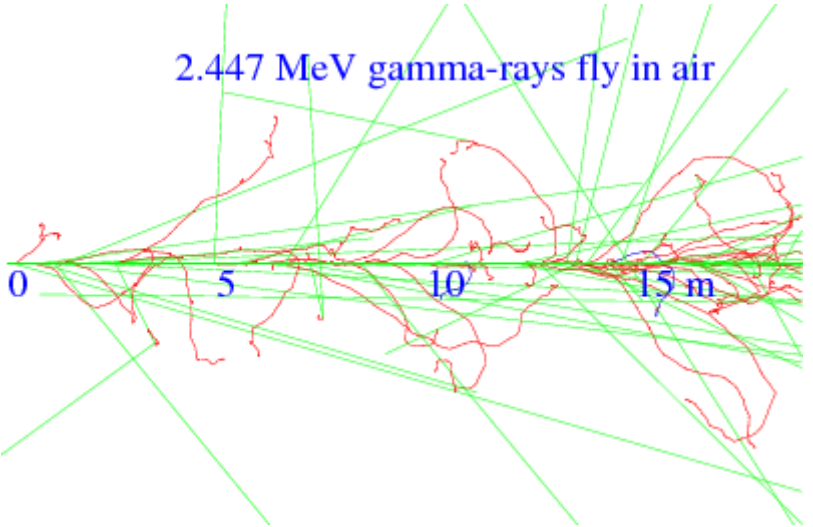
Simulation workflow



Geant-4


2 MeV beta particles fly in air
0
2
4
6
8 m




2.447 MeV gamma-rays fly in air
0
5
10
15 m

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

Generally speaking, it simulate detector materials with LArGeant (local version of Geant-4 implemented in LarSoft). 2 versions: standard and supernova (tuned for low energy interactions)

process_name: G4Stage1

Manage the interaction with materials of the geometry. Define the active detector→ can be seen as the distribution of deposited energy in the volume

process_name: G4Stage2

Manage the transformation of deposited energy into charge/light.

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1 ⟶ `#include "LArG4_dune.fcl"`

```
services:
{
  TFileService: { fileName: "g4_protoDUNE_hist.root" }
  TimeTracker:       {}
  MemoryTracker:     {} # default is one
  RandomNumberGenerator: {} #ART native random number generator
  message:      @local::standard_info
  @table::protodunevd_larg4_services
  NuRandomService:       @local::dune_prod_seedservice
}
```

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1 → `#include "LArG4_dune.fcl"`

```
services:
{
  TFileService: { fileName: "g4_protoDUNE_hist.root" }
  TimeTracker:       {}
  MemoryTracker:     {} # default is one
  RandomNumberGenerator: {} #ART native random number generator
  message:      @local::standard_info
  @table::protodunevd_larg4_services
  NuRandomService:       @local::dune_prod_seedservice
}
```

```
protodunevd_larg4_services: @local::protodune_larg4_services
protodunevd_larg4_services.LArG4Detector: @local::protodunevd_larg4detector

 protodune_larg4_services:
 {
   @table::common_larg4_services
   ParticleListAction: @local::dune_particle_list_action
   PhysicsList:        @local::dune_physics_list_fastoptical
   LArG4Detector:      @local::protodune_larg4detector
 }
```

→ From single phase

A priori the only variable protodunevd specific variable is LArG4Detector

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1 → `#include "LArG4_dune.fcl"`

```
protodunevd_larg4detector:
{
    category      : "world"
    gdmlFileName_ : @local::protodunevd_v1_geo.GDML
    volumeNames   : ["volTPCActive", "volCryostat"] # list of volumes for which the stepLimit should be set
    stepLimits    : [0.3, 0.3] # corresponding stepLimits in mm for the volumes in the volumeNames list
}
```

```
}
```

```
protodunevd_larg4_services: @local::protodune_larg4_services
protodunevd_larg4_services.LArG4Detector: @local::protodunevd_larg4detector

 protodune_larg4_services:
 {
   @table::common_larg4_services
   ParticleListAction: @local::dune_particle_list_action
   PhysicsList:        @local::dune_physics_list_fastoptical
   LArG4Detector:      @local::protodune_larg4detector
 }
```

→ From single phase

A priori the only variable protodunevd specific variable is LArG4Detector

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1 → `#include "LArG4_dune.fcl"`

```
services:
{
  TFileService: { fileName: "g4_protoDUNE_hist.root" }
  TimeTracker:       {}
  MemoryTracker:     {} # default is one
  RandomNumberGenerator: {} #ART native random number generator
  message:      @local::standard_info
  @table::protodunevd_larg4_services
  NuRandomService:       @local::dune_prod_seedservice
}
```

Attention! If you want to simulate Far Detector, using an other LArG4Detector :

- @local::dune10kt_1x2x6_v4_larg4detector,
- @local::dunevd10kt_1x6x6_larg4detector

Or call the corresponding fcl.

standard_g4_dunevd10kt.fcl	Including Ar late component for Xe 10ppm
standard_g4_dunevd10kt_1x6x6.fcl	Remove active volume labels
standard_g4_dunevd10kt_1x6x6_3view.fcl	Add standard fcls for 3view vd
standard_g4_dunevd10kt_1x6x6_3view_30deg.fcl	Add simulation infrastructure for new VD 3 view geometry
standard_g4_dunevd10kt_1x8x14_3view.fcl	adding configurations for dunevd light simulation
standard_g4_dunevd10kt_1x8x14_3view_30deg.fcl	VD fhicl files for gen and g4 stages (mainly for supernova and ndk)
standard_g4_dunevd10kt_1x8x14_3view_30deg_ArOn...	modified the workflow_detsim_dunevd10kt.fcl, added standard_g4_dunevd...
standard_g4_dunevd10kt_1x8x14_3view_30deg_XeO...	modified the workflow_detsim_dunevd10kt.fcl, added standard_g4_dunevd...
standard_g4_dunevd10kt_1x8x6_3view.fcl	disable the light sim in the external part in detsim stage.
standard_g4_dunevd10kt_1x8x6_3view_30deg.fcl	disable the light sim in the external part in detsim stage.

Geant-4

TUTO:

To check the geometry:
Copy the gdml file from:
/cvmfs/dune.opensciencegrid.org/products/dune/dunecore/$LArVersion/gdml/*

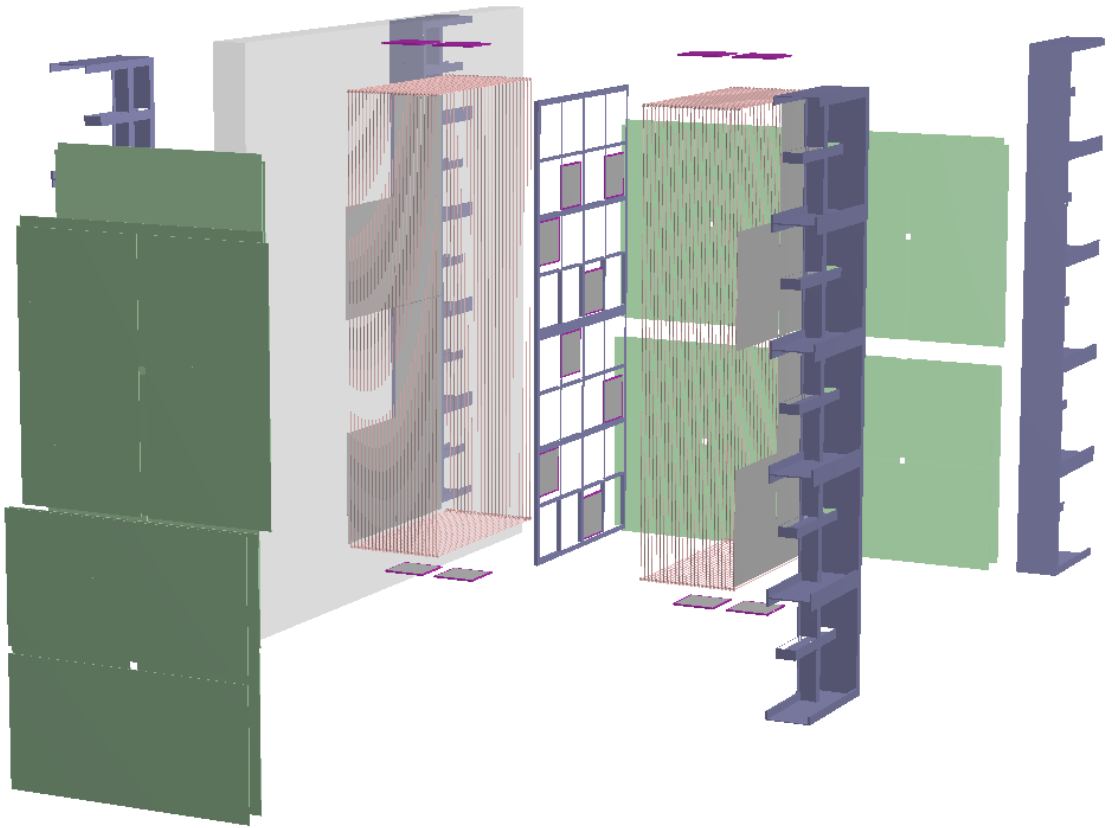
Here: v09_72_00d00/gdml/protodunevd_v2_refactored_nowires.gdml

Then open root, and write:

- TGeoManager::Import("protodunevd_v2_refactored_nowires.gdml")
- gGeoManager→GetTopVolume()→Draw("ogl");

Here we can see the ProtoDUNE-VD.

To be instance, to be checked what is the difference between v1 and v2 and why g4 is using v1?



Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1

```
#include "LArG4_dune.fcl"
```

```
physics:
{

  producers:
  {
    largeant:     @local::protodune_larg4
    rns: {module_type: "RandomNumberSaver"}
  }

  analyzers:
  {

  }

  simulate:       [ largeant ]

  stream1:        [ out1 ]

  trigger_paths: [  simulate ]
  end_paths:     [  stream1  ]
}
```

```
protodune_larg4: @local::standard_larg4


standard_larg4:
{
    module_type: "larg4Main"
    enableVisualization: false
    macroPath: ".:./macros"
    visMacro: "vis.mac"
}
```

In LArG4 module, LArG4Main is used to create, initialize, run, close the run managers and each event. Standard function of Geant4 library.

PhysicsList, Geometry and Initial Event are passed from Art and so accessible with fcl.
art::ServiceHandle<artg4tk::PhysicsListHolderService const>

Geant-4

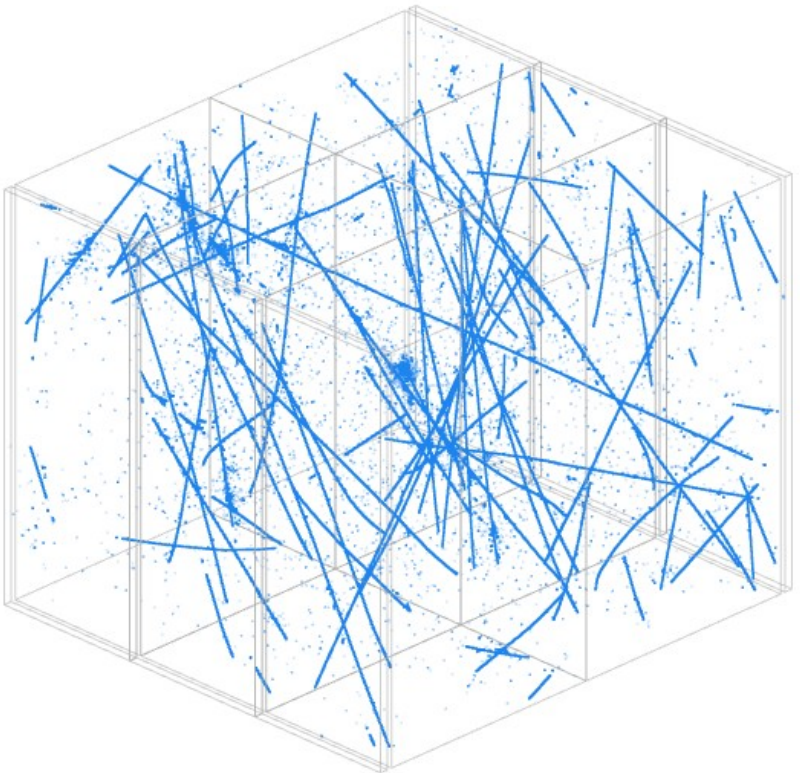
Using **bee** to visualize simulations:
Lar -c celltree_protodunevd.fcl out_step2.root

Then upload the bee/bee_upload.zip here :
https://www.phy.bnl.gov/wire-cell/bee/

You might have to modify the celltree to visualize true_depo instead of reco_depo!

https://www.phy.bnl.gov/wire-cell/bee/set/5633d85e-cefe-442f-8e84-3db7aa227d27/event/0/

Geant-4



https://www.phy.bnl.gov/wire-cell/bee/set/5633d85e-cefe-442f-8e84-3db7aa227d27/event/0/

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1

process_name: G4Stage2 →

```
#include "IonAndScint_dune.fcl"
#include "PDFastSim_dune.fcl"
```

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step
process_name: G4Stage1
process_name: G4Stage2

```
#include "IonAndScint_dune.fcl"
#include "PDFastSim_dune.fcl"
```

```
physics:
{

  producers:
  {
    rns: {module_type: "RandomNumberSaver"}
    IonAndScint:  @local::protodunevd_ionandscint
    #PDFastSim:    @local::protodune_pdfastsim_pvs
  }

  #simulate:      [  rns, IonAndS
  simulate:      [  rns, IonAndSc

  stream1:       [ out1 ]

  trigger_paths: [  simulate ]
  end_paths:     [  stream1  ]
}
```

- Calling different techniques in _dunesim/dunesim/LArG4/IonAndScint_dune.fcl_

```
protodunevd_ionandscint_correlated: @local::protodune_ionandscint_correlated
protodunevd_ionandscint_correlated.Instances:    "LArG4DetectorServicevolTPCActive"

protodunevd_ionandscint_nest: @local::protodunevd_ionandscint_correlated
protodunevd_ionandscint_nest.ISCalcAlg: "NEST"

protodunevd_ionandscint_separate: @local::protodunevd_ionandscint_correlated
protodunevd_ionandscint_separate.ISCalcAlg: "Separate"

# Choose *the* IonAndScint configuration
protodunevd_ionandscint: @local::protodunevd_ionandscint_separate
```

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step

process_name: G4Stage1

process_name: G4Stage2

```
#include "IonAndScint_dune.fcl"
#include "PDFastSim_dune.fcl"
```

```
physics:
{

  producers:
  {
    rns: {module_type: "RandomNumberSaver"}
    IonAndScint:  @local::protodunevd_ionandscint
    #PDFastSim:    @local::protodune_pdfastsim_pvs
  }

  #simulate:      [  rns, IonAndScint, PDFastSim ]
  simulate:      [  rns, IonAndScint ]

  stream1:       [ out1 ]

  trigger_paths: [  simulate ]
  end_paths:     [  stream1  ]
}
```

- Calling different techniques in dunesim/dunesim/LArG4/IonAndScint_dune.fcl
- Calling the NEST package :

  NEST (Noble Element Simulation Technique) is an unprecedentedly comprehensive, accurate, and precise simulation of the excitation, ionization, and corresponding scintillation and electroluminescence processes in liquid noble elements
- Option to correlate or not charge/light emission (“Correlated”,”Separate”, “NEST”)

Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step
process_name: G4Stage1
process_name: G4Stage2

```
#include "IonAndScint_dune.fcl"
#include "PDFastSim_dune.fcl"
```

```
physics:
{

  producers:
  {
    rns: {module_type: "RandomNumberSaver"}
    IonAndScint:  @local::protodunevd_ionandscint
    #PDFastSim:    @local::protodune_pdfastsim_pvs
  }

  #simulate:      [  rns, IonAndS
  simulate:      [  rns, IonAndSc

  stream1:       [ out1 ]

  trigger_paths: [  simulate ]
  end_paths:     [  stream1  ]
}
```

```
protodunevd_ionandscint_correlated: @local::protodune_ionandscint_correlated
protodunevd_ionandscint_correlated.Instances:    "LArG4DetectorServicevolTPCActive"

protodunevd_ionandscint_nest: @local::protodunevd_ionandscint_correlated
protodunevd_ionandscint_nest.ISCalcAlg: "NEST"

protodunevd_ionandscint_separate: @local::protodunevd_ionandscint_correlated
protodunevd_ionandscint_separate.ISCalcAlg: "Separate"

# Choose *the* IonAndScint configuration
protodunevd_ionandscint: @local::protodunevd_ionandscint_separate
```

- Calling different techniques in dunesim/dunesim/LArG4/IonAndScint_dune.fcl
- Calling the NEST package :

NEST (Noble Element Simulation Technique) is an

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Geant-4

In ProtoDUNE-VD – division in 2 steps of the geant-4 simulation step
process_name: G4Stage1
process_name: G4Stage2

```
physics:
{

  producers:
  {
    rns: {module_type: "RandomNumbe
    IonAndScint:  @local::protodune
    #PDFastSim:    @local::protodun
  }

  #simulate:      [  rns, IonAndSci
  simulate:      [  rns, IonAndScin

  stream1:       [ out1 ]

  trigger_paths: [  simulate ]
  end_paths:     [  stream1  ]
}
```

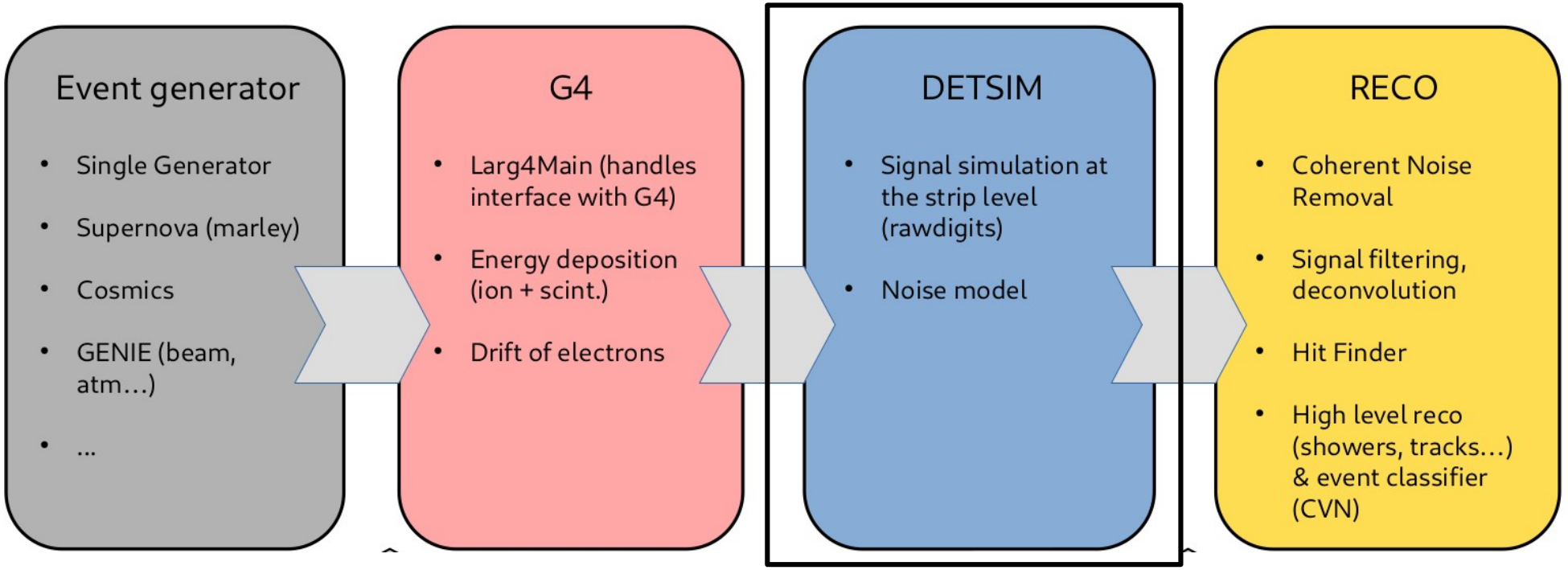
```
////////////////////////////////////////////////////////////////////////
// Class:       IonAndScint
// Plugin Type: producer
// File:        IonAndScint_module.cc
// Description:
// - acts on sim::SimEnergyDeposit from LArG4Main,
// - calculate the number of photons and electrons
// Input: 'sim::SimEnergyDeposit'
// Output: updated 'sim::SimEnergyDeposit' with numPhotons and numElectrons
//
//This module calculate the number of photons and electrons produced at each step where energy is deposited.
//The Separate algorithm is used by default, but this can be changed via the "ISCalcAlg"
//fhicl parameter tag.
//At the end of this module the numPhotons and numElectrons of sim:SimEnergyDeposit have been updated.
```

Geant-4

Dans ProtoDUNE-VD – division in 2 step of the geant-4 simulation step :

```
outputs:
{
  out1:
  {
    module_type: RootOutput
    fileName:    "%ifb_g4_stage2.root"
    dataTier:    "simulated"
    outputCommands: [ "keep *" ]
    #outputCommands: [ "keep *", "drop sim::SimEnergyDeposits_largeant_*_*"]
    #fastCloning: false #will fail if the split level is not the same as for the gen st
    compressionLevel: 1 #zlib argument (0-9)
    #basketSize: 8192 #[Byte] buffer size at 8k
    #splitLevel: 0 #reduces number of buffers
    #treeMaxVirtualSize: 1 #[Byte] limits number of buffers/branch to 1 (default is 10)
  }
}
```

Simulation workflow



DetSim

Simulates signals on strips and photons detectors.

2 versions : standard and nozs (no zero suppression)

https://lar.bnl.gov/wire-cell/

https://indico.fnal.gov/event/18681/contributions/48627/attachments/30239/37216/WireCellSimulation.pdf

DetSim

Simulates **signals on strips** and photons detectors.

2 versions : **standard** and nozs (no zero suppression)

```
process_name: Detsim

services:
{
  TFileService: { fileName: "detsim_single_protoDUNE_hist.root" }
  TimeTracker:       @local::dune_time_tracker
  MemoryTracker:     @local::dune_memory_tracker
  RandomNumberGenerator: {}
  FileCatalogMetadata:  @local::art_file_catalog_mc
  @table::protodunevd_refactored_simulation_services
  IFDH: {}
}

services.DetectorPropertiesService:
```

```
protodunevd_simulation_services:
{
  @table::protodunevd_minimal_simulation_services
  SignalShapingServiceDUNE:     @local::protodunesp_s
  PhotonVisibilityService:      @local::protodune_pho
  OpDetResponseInterface:       @local::protodune_opd
}
```

```
protodunevd_refactored_simulation_services:
{
  @table::protodunevd_simulation_services
  ParticleInventoryService:     @local::standard_particleinventoryservice
  PhotonBackTrackerService:     @local::dunefd_photonbacktrackerservice
}
```

```
protodunevd_minimal_simulation_services: @local::protodune_minimal_simulation_services
protodunevd_minimal_simulation_services.Geometry: @local::protodunevd_v2_geo
protodunevd_minimal_simulation_services.DetectorPropertiesService.NumberTimeSamples:     10000
protodunevd_minimal_simulation_services.DetectorPropertiesService.ReadOutWindowSize:     10000
```

DetSim

Simulates **signals on strips** and photons detectors.

2 versions : **standard** and nozs (no zero suppression)

```
# Full service configuration which includes memory-intensive services
protodune_simulation_services: {
  @table::protodune_minimal_simulation_services
  SignalShapingServiceDUNE:     @local::protodunesp_signalshapingservice
  PhotonVisibilityService:      @local::protodune_photonvisibilityservice
  OpDetResponseInterface:       @local::protodune_opdetresponse
}
```

```
protodunevd_simulation_services:
{
  @table::protodunevd_minimal_simulation_services
  SignalShapingServiceDUNE:     @local::protodunesp_s
  PhotonVisibilityService:      @local::protodune_pho
  OpDetResponseInterface:       @local::protodune_opd
```

```
  @table::protodunevd_refactored_simulation_services
  IFDH: {}
}

services.DetectorPropertiesService:
```

```
protodunevd_refactored_simulation_services:
{
  @table::protodunevd_simulation_services
  ParticleInventoryService:     @local::standard_particleinventoryservice
  PhotonBackTrackerService:     @local::dunefd_photonbacktrackerservice
}
```

```
protodunevd_minimal_simulation_services: @local::protodune_minimal_simulation_services
protodunevd_minimal_simulation_services.Geometry: @local::protodunevd_v2_geo
protodunevd_minimal_simulation_services.DetectorPropertiesService.NumberTimeSamples:     10000
protodunevd_minimal_simulation_services.DetectorPropertiesService.ReadOutWindowSize:     10000
```

DetSim

Simulates **signals on strips** and photons detectors.

```
# Low memory configuration leaving out some heavy services
protodune_minimal_simulation_services: {
 LArFFT:                        @local::dunefd_larfft
 LArG4Parameters:               @local::protodune_largeantparameters
 ExptGeoHelperInterface:        @local::dune_geometry_helper
 GeometryConfigurationWriter:  {}
 Geometry:                      @local::protodune_geo
 DetectorClocksService:         @local::protodune_detectorclocks
 DetectorPropertiesService:     @local::protodune_detproperties
 LArPropertiesService:          @local::dunefd_properties
 DatabaseUtil:                  @local::dunefd_database
 LArVoxelCalculator:            @local::dunefd_larvoxelcalculator
 MagneticField:                 @local::no_mag_larsoft
 SpaceCharge:                   @local::protodune_spacecharge
 NuRandomService:               @local::dune_seedservice
 ChannelStatusService:          @local::dunefd_channel_status
}

# Enable photon simulation for protoDUNE by default
protodune_minimal_simulation_services.LArPropertiesService.ScintYield: 24000
protodune_minimal_simulation_services.LArPropertiesService.ScintPreScale: 0.0287
protodune_minimal_simulation_services.LArPropertiesService.EnableCerenkovLight: false
protodune_minimal_simulation_services.LArG4Parameters.UseCustomPhysics: true
protodune_minimal_simulation_services.LArG4Parameters.EnabledPhysics: [ "Em",
                                                                        "FastOptical",
                                                                        "SynchrotronAndGN",
                                                                        "Ion",
                                                                        "Hadron",
                                                                        "Decay",
                                                                        "HadronElastic",
                                                                        "Stopping" ]
```

zero suppression)

```
gle_protoDUNE_hist.root" }
tracker
y_tracker

e_catalog_mc
tion_services
```

```
protodunevd_simulation_services:
{
  @table::protodunevd_minimal_simulation_services
  SignalShapingServiceDUNE:     @local::protodunesp_
  PhotonVisibilityService:      @local::protodune_pho
  OpDetResponseInterface:       @local::protodune_opd
}
```

```
protodunevd_refactored_simulation_services:
{
  @table::protodunevd_simulation_services
  ParticleInventoryService:     @local::standard_particleinventoryservice
  PhotonBackTrackerService:     @local::dunefd_photonbacktrackerservice
}
```

```
protodunevd_minimal_simulation_services: @local::protodune_minimal_simulation_services
protodunevd_minimal_simulation_services.Geometry: @local::protodunevd_v2_geo
protodunevd_minimal_simulation_services.DetectorPropertiesService.NumberTimeSamples:     10000
protodunevd_minimal_simulation_services.DetectorPropertiesService.ReadOutWindowSize:     10000
```

DetSim

Simulates **signals on strips** and photons detectors.

2 versions : **standard** and nozs (no zero suppression)

```
physics:
{

  producers:
  {
    tpcrawdecoder:  @local::wirecell_protodunevd_mc
    # opdigi:         @local::protodune_opdigi_refactor
    # crt:            @local::CRTSimRefac_standard
    rns:            { module_type: "RandomNumberSaver" }
  }

  simulate: [ rns,
              tpcrawdecoder]
  stream1:  [ out1 ]

  trigger_paths: [simulate]
  end_paths:     [stream1]
}
```

DetSim - Wirecell

Wire-Cell Toolkit

From Hanyu WEI at Collab meeting May 2019

- TPC drift simulation
- Noise filtering
- Signal processing (2D decon + ROI finding)

- WCT is an open source software available from GitHub.
  - https://github.com/WireCell (WCT)
  - https://github.com/BNLIF/wire-cell (WCP)
- Documents:
  - Brett Viren's slides DocDB15360, 13106, 10970, 8924
  - News blog, manual, etc. https://wirecell.github.io/

DetSim

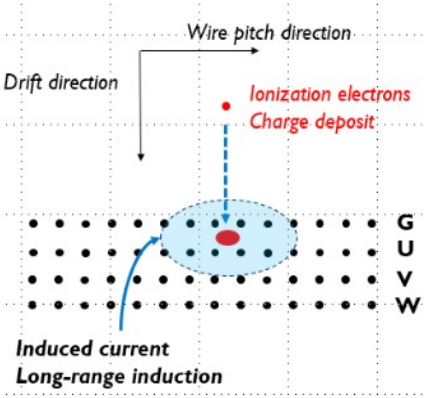
Simulates **signals on strips** and photons detectors.

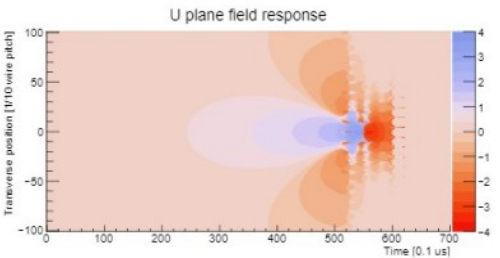
2 versions : **standard** and nozs (no zero suppression)

<SimEnegyDeposit>
* x, y, z, t, # of e

- Ionized electron absorption (lifetime in LAr)
- Gaussian random diffusion (longitudinal/transverse) = 2Dt
- Fluctuation in electron absorption

@Wenqiang Gu





- Electronics response
- Preamp shaping
- AC coupling
- Noise
- Digitizer

From David Rivera (UPenn), Wenqiang Gu (BNL)

DetSim - Wirecell

From Hanyu WEI at Collab meeting May 2019

$$\textbf{ADC Wavform} = (\boldsymbol{Depo} \circledast \boldsymbol{Drifter} \circledast \boldsymbol{Ductor} + \boldsymbol{Noise}) \times \boldsymbol{Digitizer}$$

One charge depo
(x, y, z, t0, # of electrons)

Data-driven input + analytic method

✓Field response (pre-calculated 2D Garfield calculation)
✓Pre-amplifier electronic response (gain, shaping)
✓Additional response (AC coupling)

Kernel:

$$[Gaus(t) \cdot Gaus(x)] \otimes field(x,t) \otimes Preamp\ (t) \otimes RC(t)$$

✓ Ionized electron absorption (electron lifetime in LAr)
✓ Gaussian diffusion (longitudinal / transverse)
✓ Fluctuation (for each gird of the discretized 2D Gaussian cloud)

DetSim – Wirecell

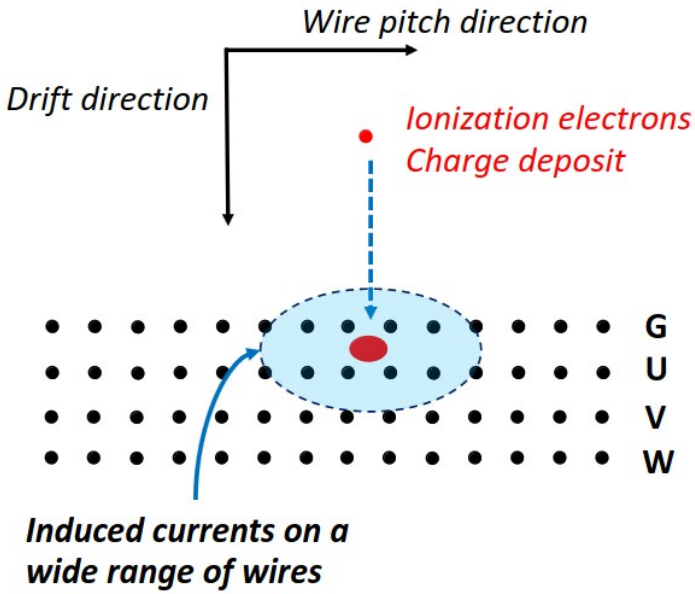
Long-range and fine-grained field response
Garfield simulation

From Hanyu WEI at Collab meeting May 2019

Ramo's theorem

$$i = e\vec{v} \cdot \vec{E}_v = e\vec{v} \cdot (-\nabla\phi)$$

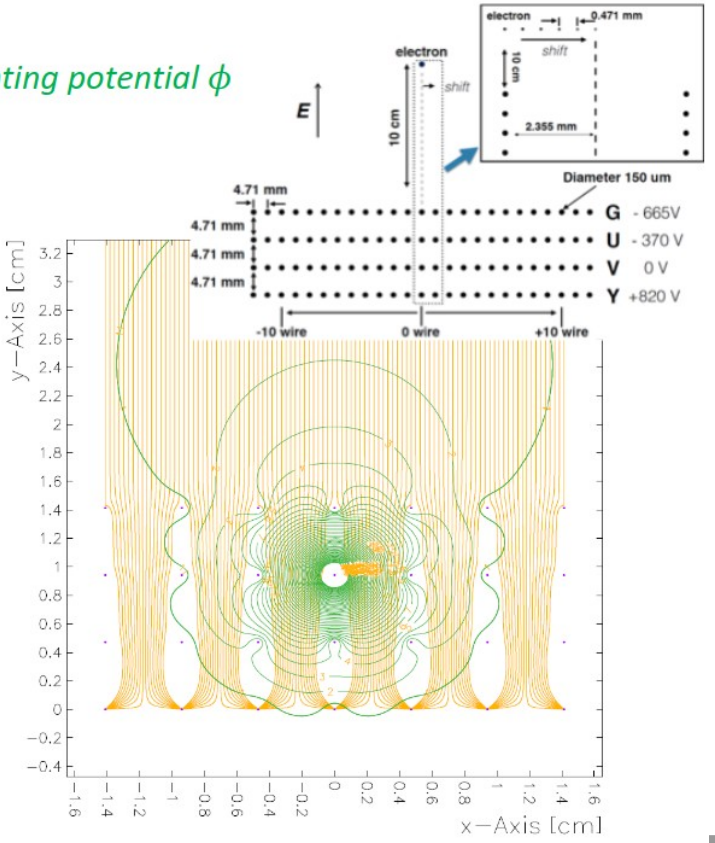
Weighting potential ϕ



Electron drift path (E field)

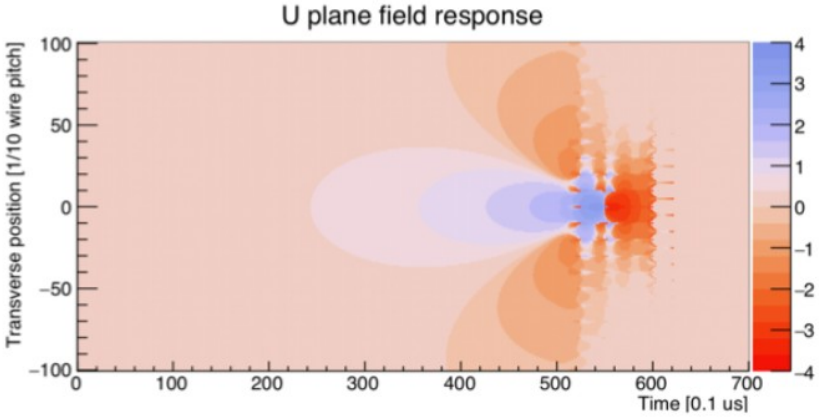
+

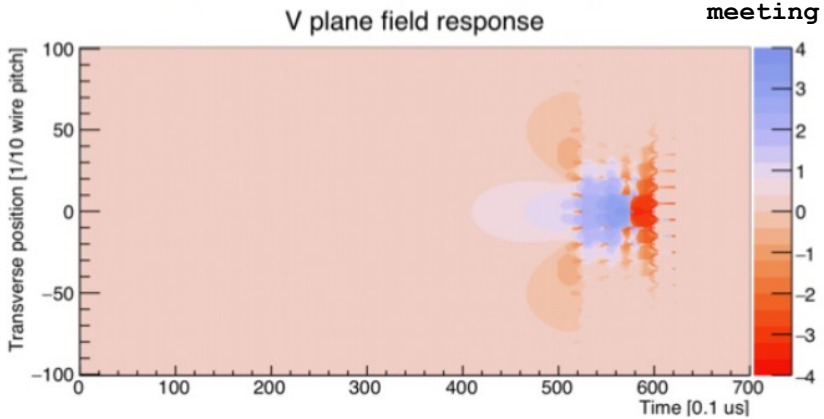
Weighting potential ϕ

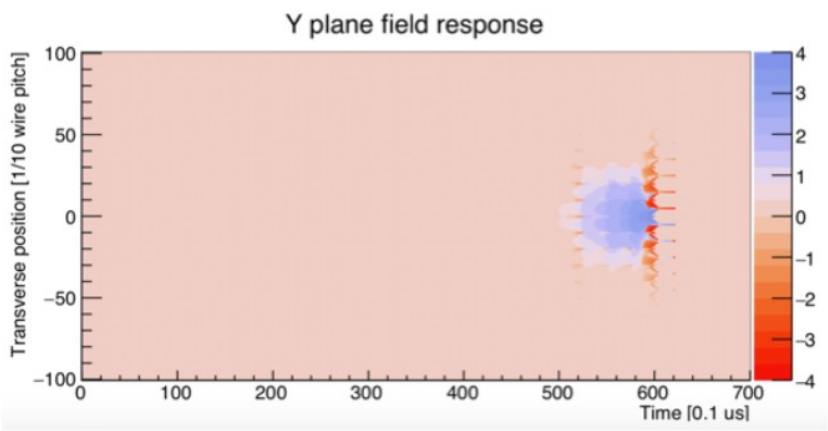


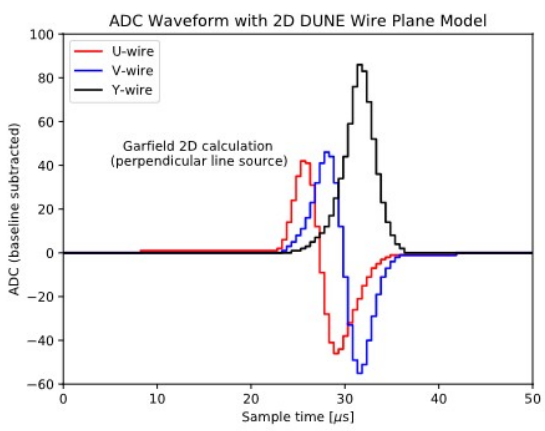
DetSim - Wirecell

From Hanyu WEI at Collab meeting May 2019









Average response over the full range of 2D responses
= isochronous track induced current on the central wire

+ noise model!
Data driven

DetSim

Simulates **signals on strips** and photons detectors.

2 versions : **standard** and nozs (no zero suppression)

```
physics:
{

  producers:
  {
    tpcrawdecoder: @local::wir
    # opdigi:        @local::p
    # crt:           @local::C
    rns:           { module_ty
  }

  simulate: [ rns,
              tpcrawdecoder]
  stream1:  [ out1 ]

  trigger_paths: [simulate]
  end_paths:     [stream1]
}
```

```
wirecell_protodunevd_mc:
{
    module_type : WireCellToolkit
    wcls_main: {
        tool_type: WCLS
        apps: ["Pgrapher"]
        plugins: ["WireCellPgraph", "WireCellGen","WireCellSio","WireCellRoot","WireCellLarsoft"]
        // needs to be found via your WIRECELL_PATH
        configs: ["pgrapher/experiment/protodunevd/wcls-sim-drift-simchannel.jsonnet"]
        inputers: ["wclsSimDepoSource:electron"]
        outputers: [
            "wclsSimChannelSink:postdrift",
            "wclsFrameSaver:simdigits"
        ]

        // Make available parameters via Jsonnet's std.extVar()
        params: {
        }
        structs: {
           nticks: @local::protodunevd_services.DetectorPropertiesService.NumberTimeSamples
           lifetime: @local::protodunevd_services.DetectorPropertiesService.Electronlifetime
           DL: @local::dunefd_largeantparameters.LongitudinalDiffusion
           DT: @local::dunefd_largeantparameters.TransverseDiffusion
           efield: @local::protodunevd_services.DetectorPropertiesService.Efield[0] # kV/cm
           temperature: @local::protodunevd_services.DetectorPropertiesService.Temperature # K
        }
    }
}
```

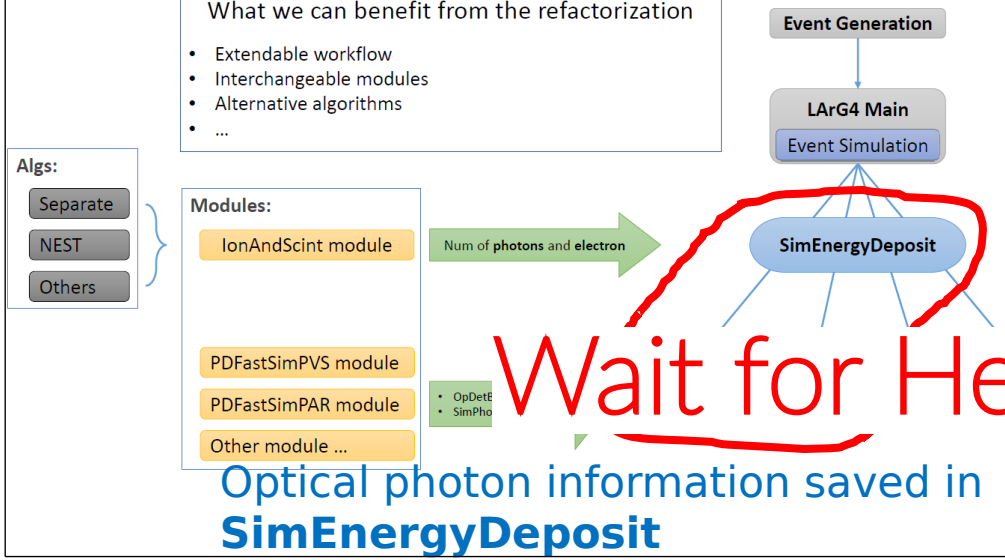
DetSim

Simulation workflow – Refactored model

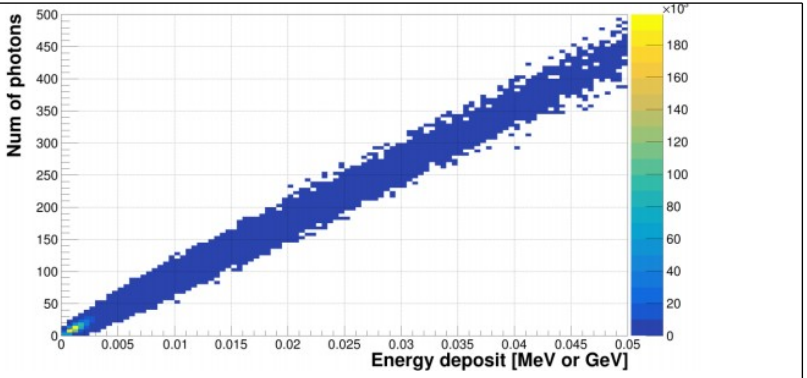
@Muve

What we can benefit from the refactorization

- Extendable workflow
- Interchangeable modules
- Alternative algorithms
- ...

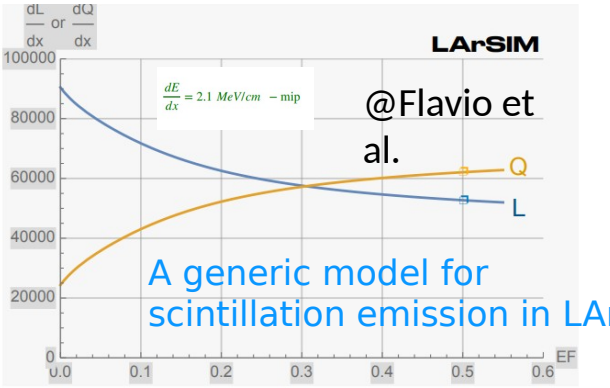


Optical photon information saved in **SimEnergyDeposit**



A "Separate" model – mimics the scintillation NEST model

Wait for Henrique's talk



More readings:

[DUNE collaboration meeting, Sept 2019](#) Muve

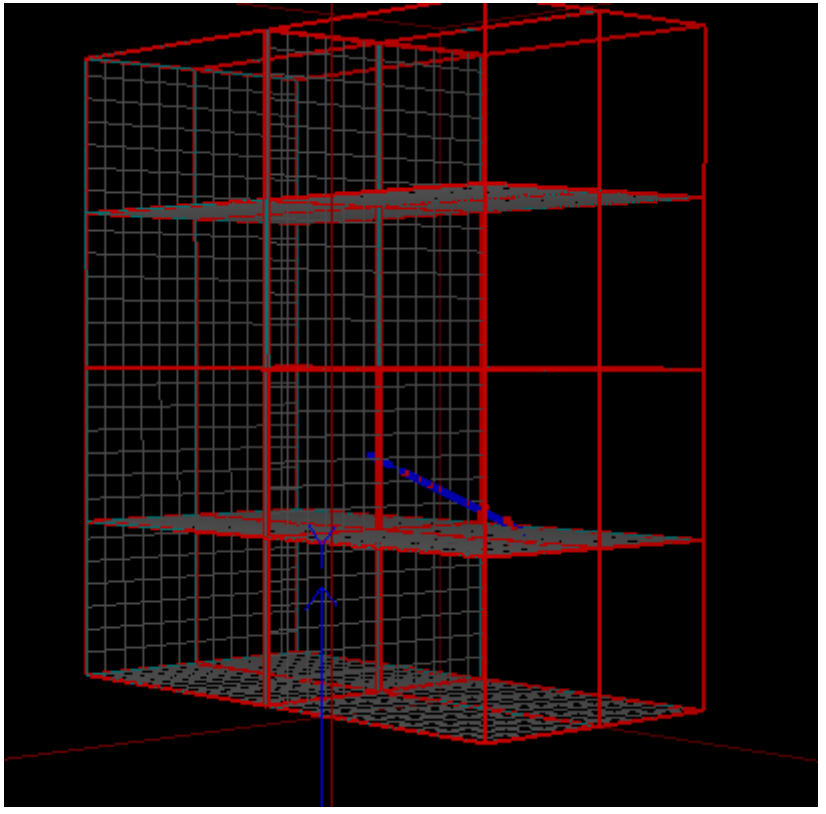
[ProtoDUNE Sim/Reco meeting](#) Falvio (under development)

From [David Rivera](#) (UPenn), Wenqiang Gu (BNL)

DetSim

Simulating a 5 GeV muon in ProtoDUNE-vd with random Angle.
This is before any reconstruction, only using McTruth

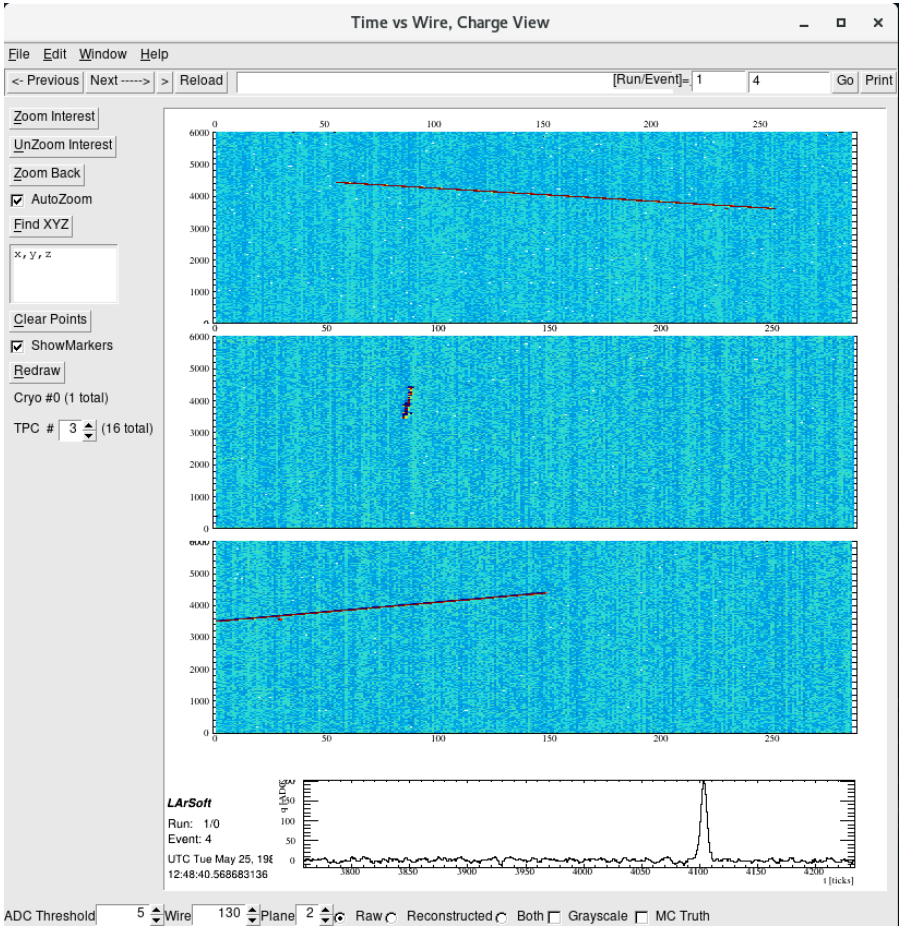
To be explored using the fcl file available at:
https://gitlab.in2p3.fr/dune-france/analysis-workshop/-/tree/master/simu



master ▾ analysis-workshop / simu / +

Name
..
.gitkeep
ProtoDUNE_Muons_step1_SingleGen.fcl
ProtoDUNE_Muons_step2_G4_1.fcl
ProtoDUNE_Muons_step3_G4_2.fcl
ProtoDUNE_Muons_step4_DetSim.fcl
lar_viewer.fcl

DetSim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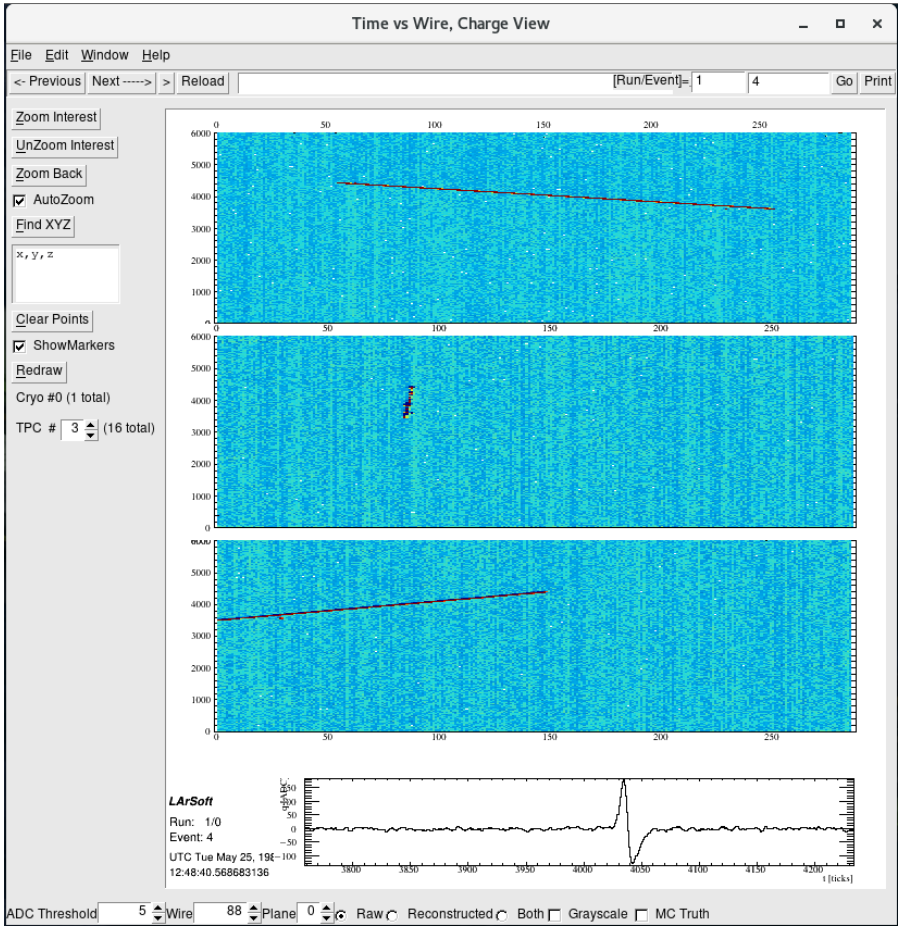
UnZoom Interest
Zoom Back
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
Redraw
Cryo #0 (1 total)
TPC # 3 (16 total)
LArSoft
Run: 1/0
Event: 4
UTC Tue May 25, 19
12:48:40.568683136
t [ticks]
ADC Threshold 5 Wire 130 Plane 2 Raw Reconstructed Both Grayscale MC Truth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Run: 1/0
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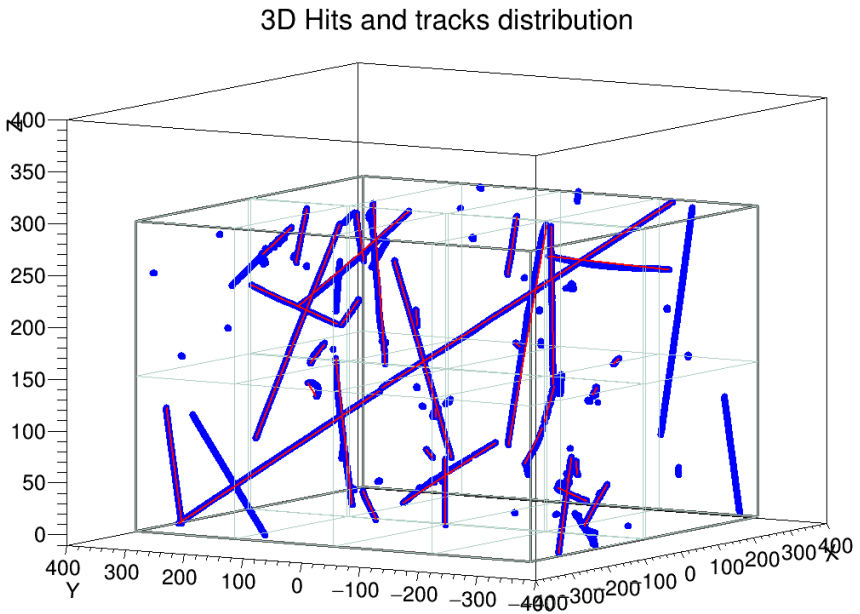
t [ticks]
ADC Threshold 5 Wire 88 Plane 0 Raw Reconstructed Both Grayscale MC Truth

DetSim

lar -c **gen_protodunevd_cosmics.fcl** out1.root
lar -c **protodunevd_g4_stage1.fcl** out1.root -o out2.root
lar -c **protodunevd_g4_stage1.fcl** out2.root -o out3.root
lar -c **protodunevd_detsim.fcl** out3.root -o out4.root
lar -c **protodunevd_reco.fcl** out4.root -o out5.root

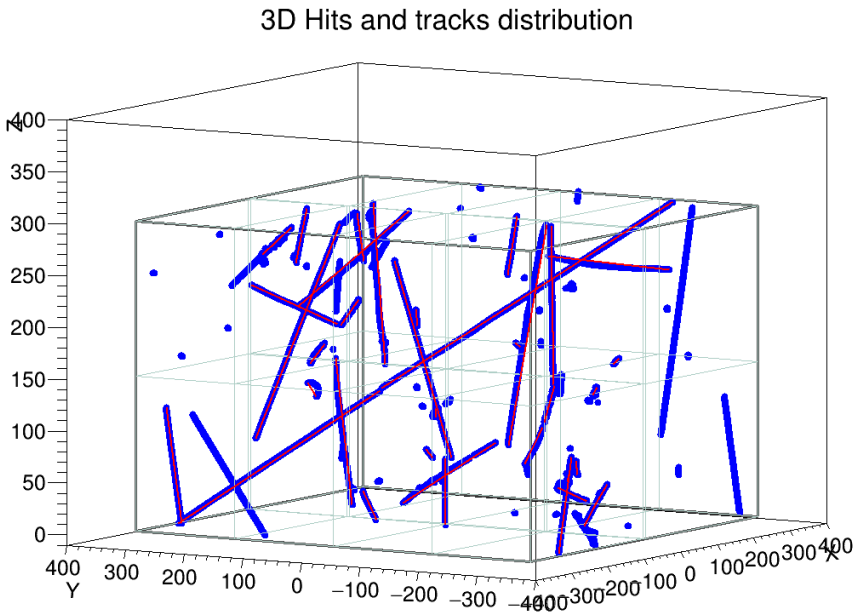


DetSim

Thomas' talk

```
lar -c gen_protodunevd_cosmics.fcl out1.root
lar -c protodunevd_g4_stage1.fcl out1.root -o out2.root
lar -c protodunevd_g4_stage1.fcl out2.root -o out3.root
lar -c protodunevd_detsim.fcl out3.root -o out4.root
lar -c protodunevd_reco.fcl out4.root -o out5.root
```

Laura's talk



Conclusion

Keep in mind that Protodune-VD is still an on-progress simulation, be always critical about your results.

Exciting things to check :
- Are waveforms correctly simulated in Wirecell (strips VS wires)?
- Is the calorimetry correctly simulated?

- What about the **full** vertical drift detector?

- What about very vertical tracks? And showers?
- What about weird geometrical effects (disambiguation)?