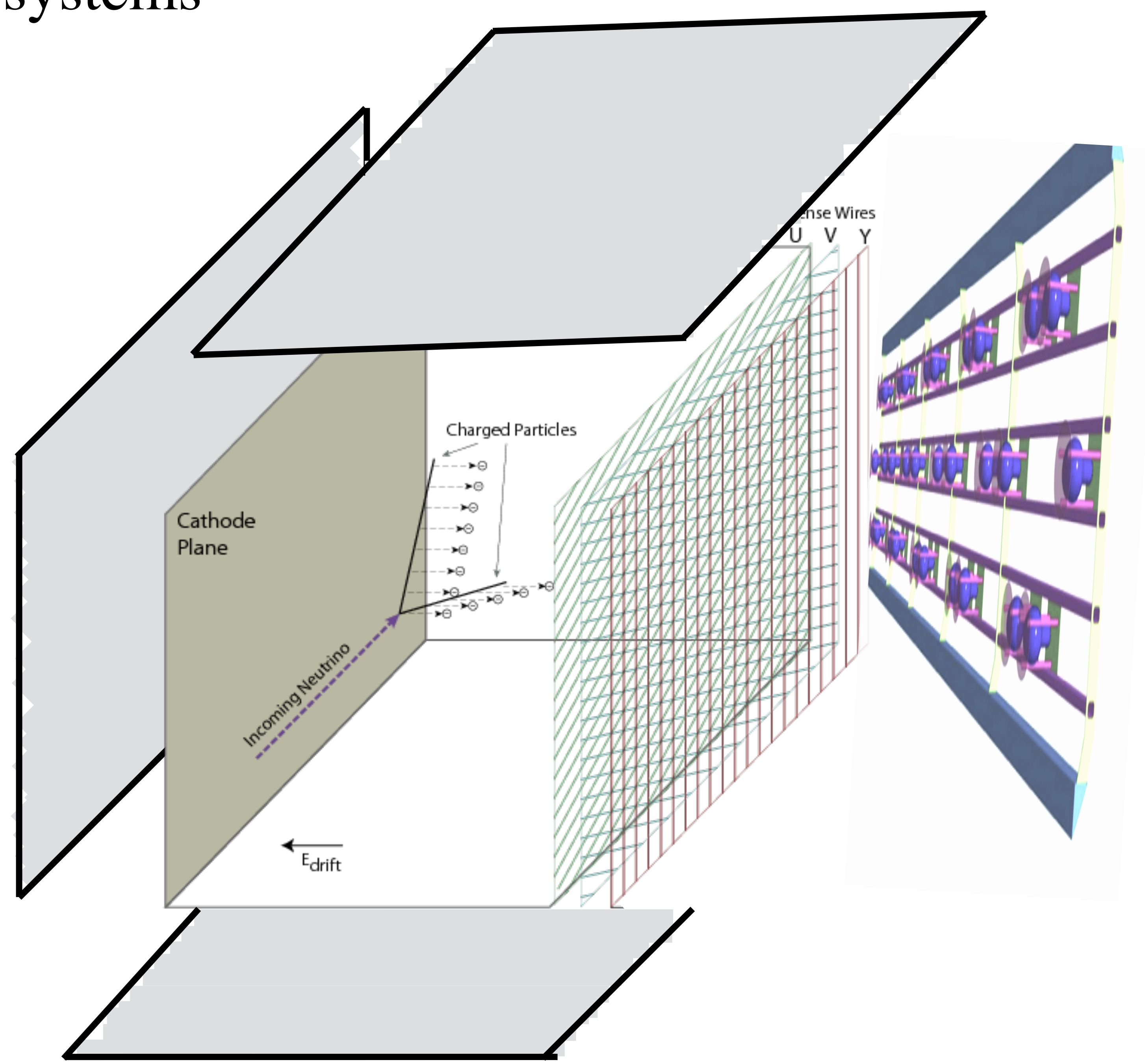
Overlay - adding signals

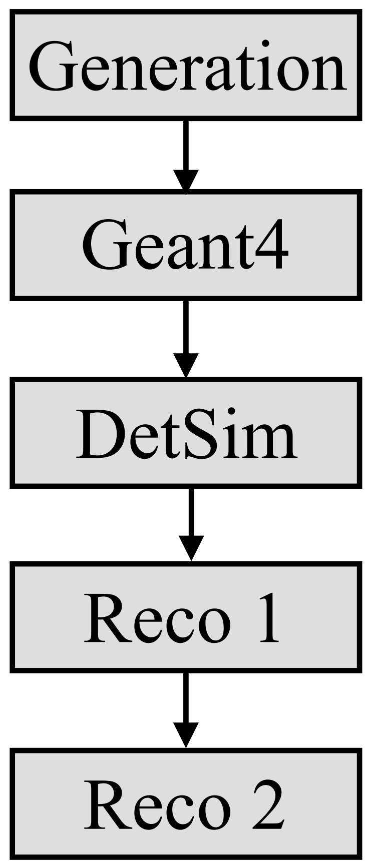
Adi Ashkenazi

Overlay for MicroBooNE

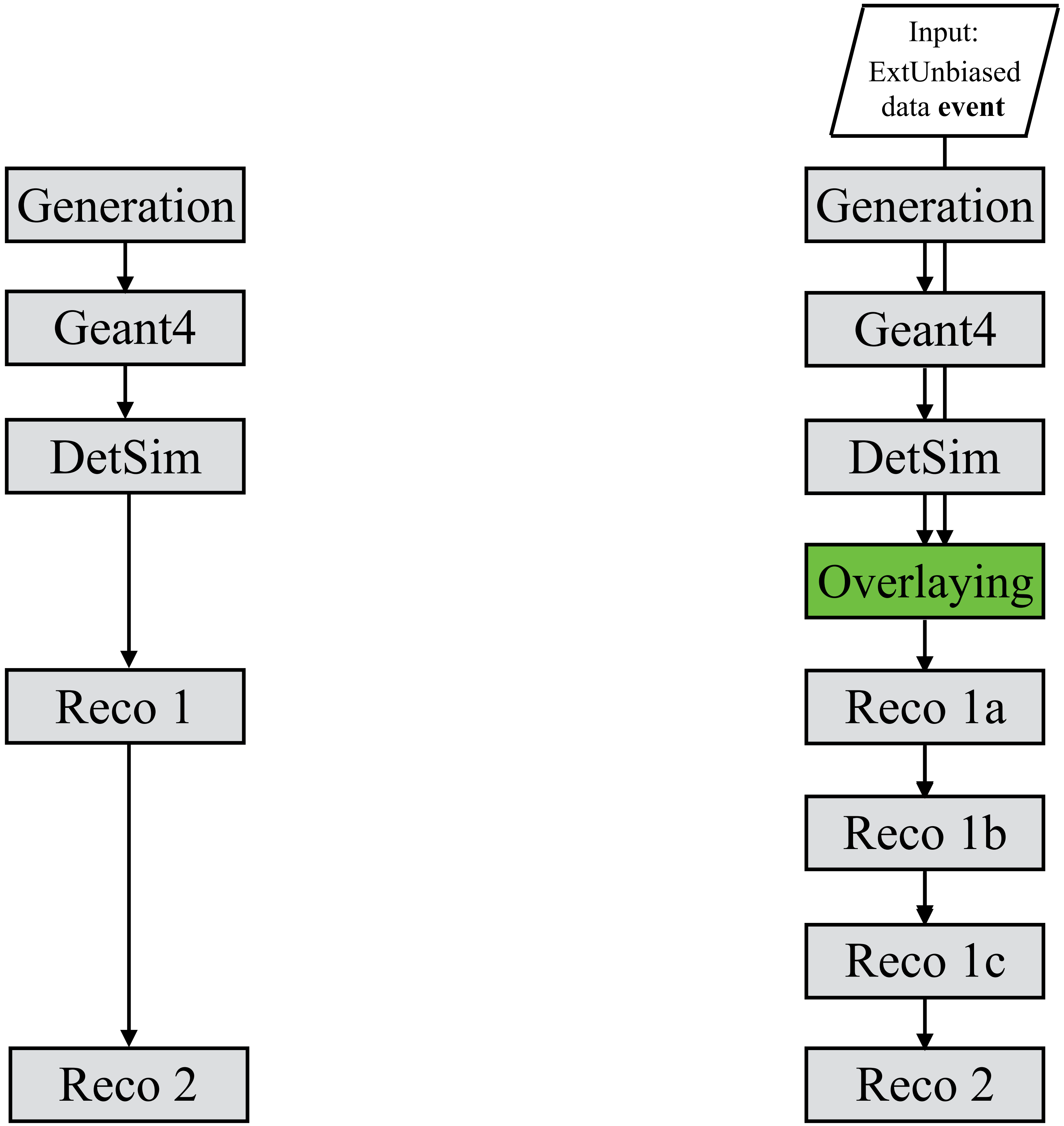
MicroBooNE outputs signals from the PMT, CRT and TPC wires subsystems



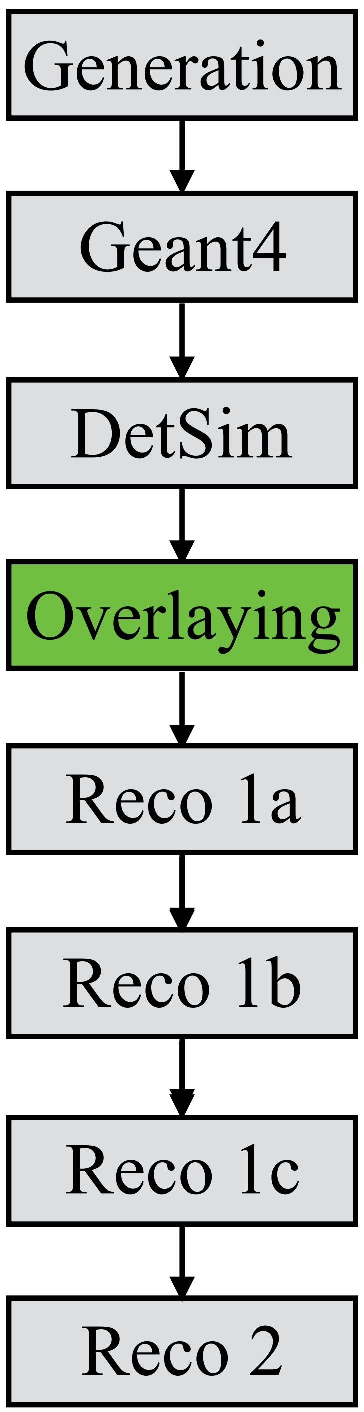
MicroBooNE’s simulation



MicroBooNE’s simulation - Overlay Stage



Overlay package



Introducing the DataOverlay package

Currently as part of the ubevt code:

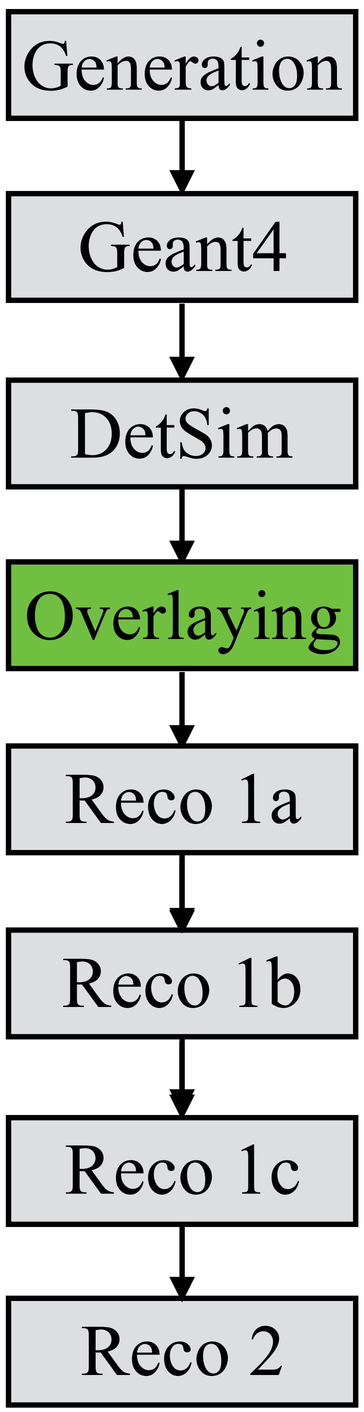
The module

/ubevt/ubevt/DataOverlay/DataOverlayMixer/OverlayRawDataMicroBooNE_module.cc

Calls mixing modules for the three sub detectors

Adding raw waveforms for the PMT and wires

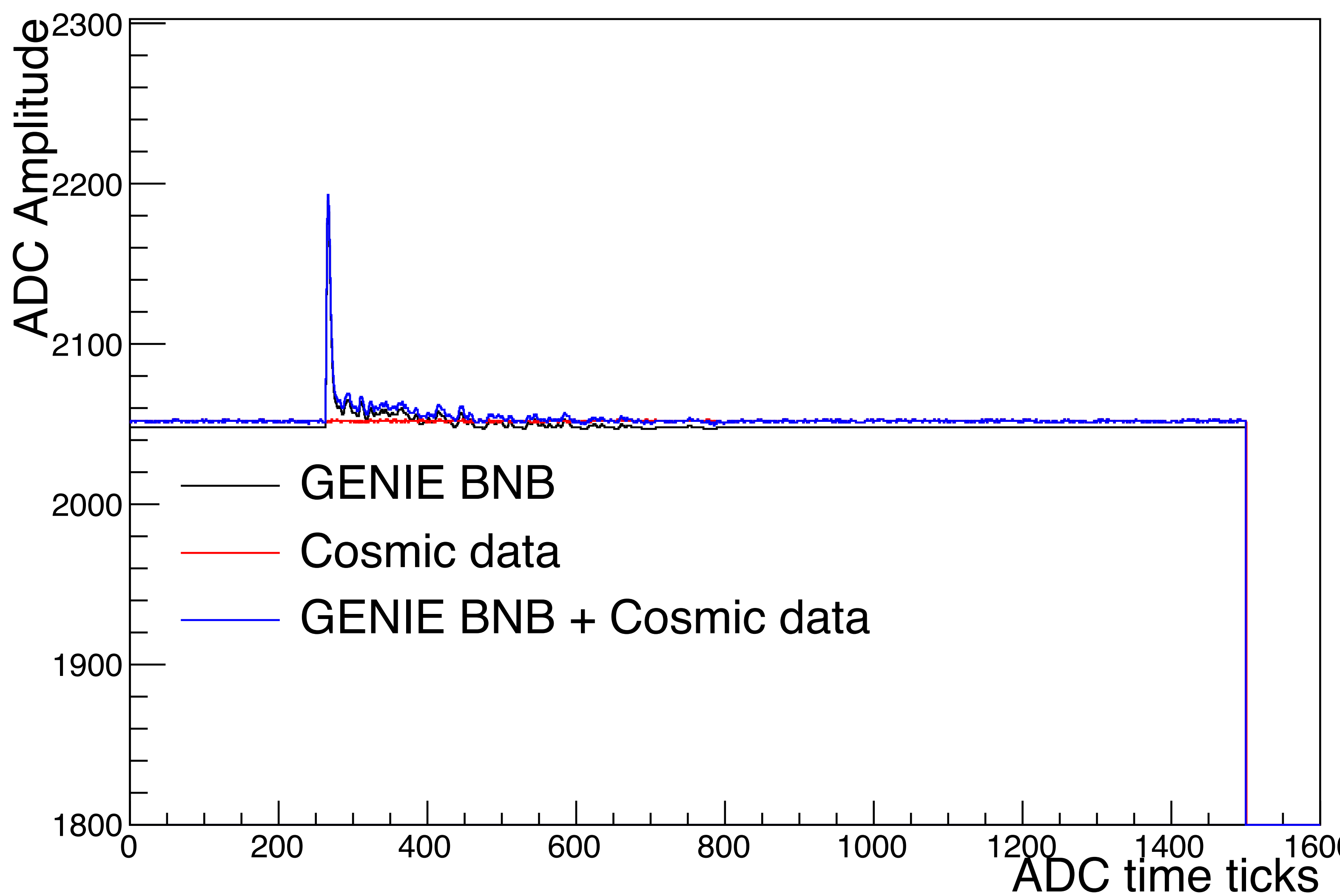
and reconstructed hits for the CRT.



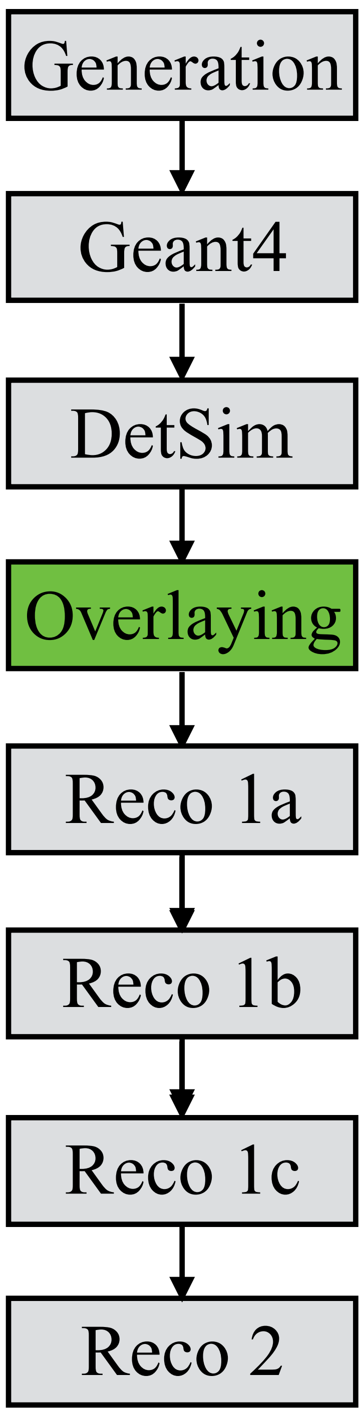
Adding Signal

Each simulated waveform from a PMT channel or a TPC wire is added to the signal from the correlated channel in the cosmic data.

While accounting for the gain and pedestal.



The joint signal is then going through the standard data reconstruction.



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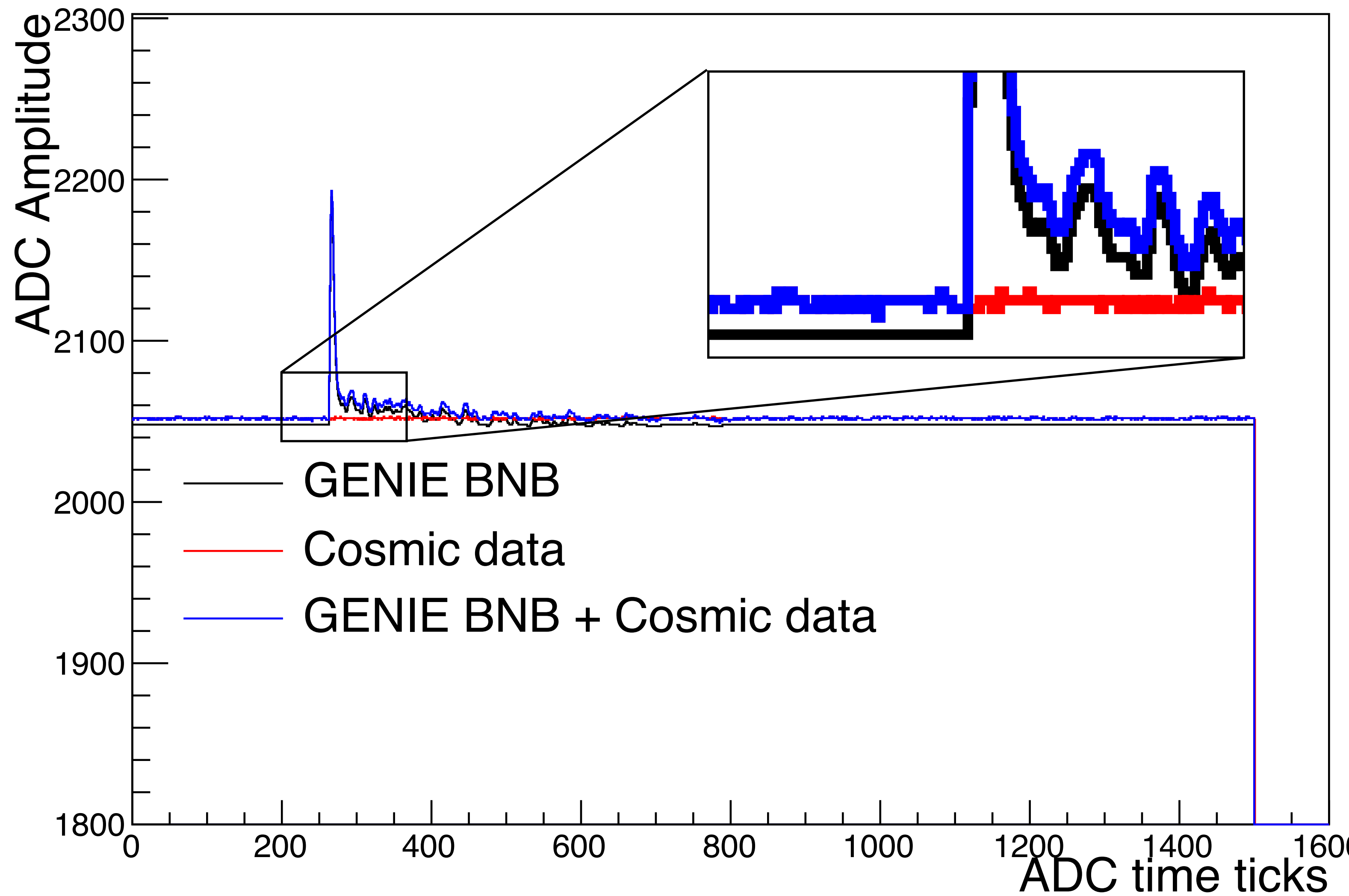

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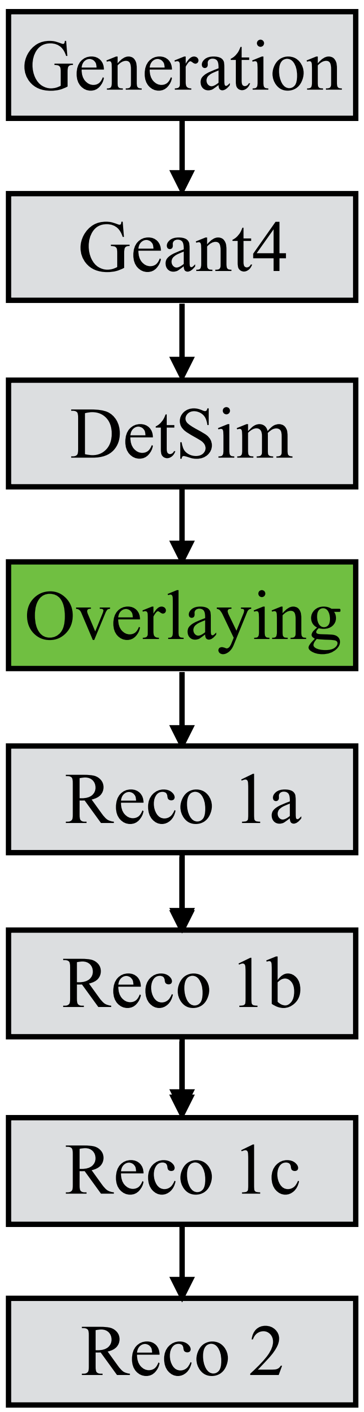


Adding Signal - Technicalities

The mixing is done using the following classes:

/ubevt/ubevt/DataOverlay/DataOverlay/OpDetWaveformMixer.cxx

/ubevt/ubevt/DataOverlay/DataOverlay/RawDigitMixer.cxx

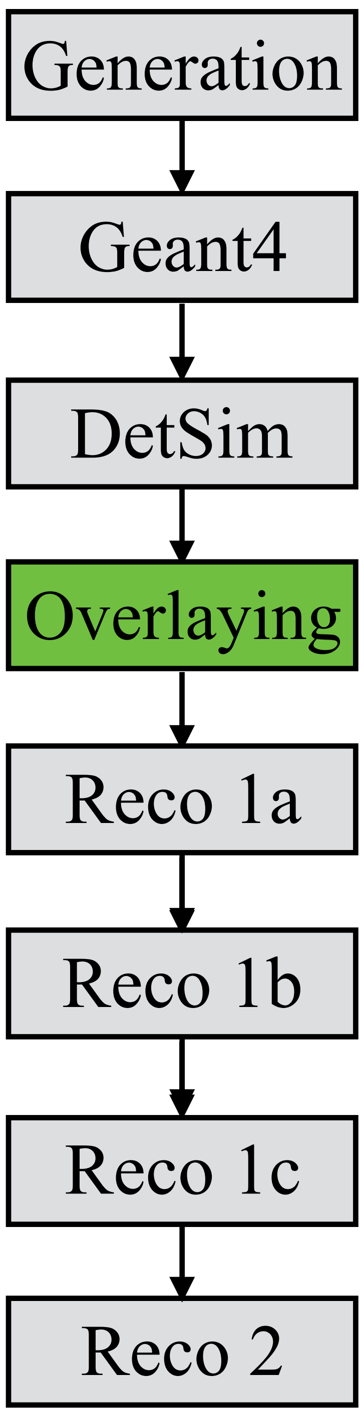
In each:

- The data and the MC raw signals are declared
- Their sizes are matched to the smaller size
- The pedestal value is set using the simulated pedestal, and is subtracted
- A gain can be added to the simulated signal (as in for the PMT)
- A hard saturate value can be specified

The overlay is done using a simple adding of each waveform in:

/ubevt/ubevt/DataOverlay/DataOverlay/RawDigitAdder_HardSaturate.cxx

Adding Signal - Timing

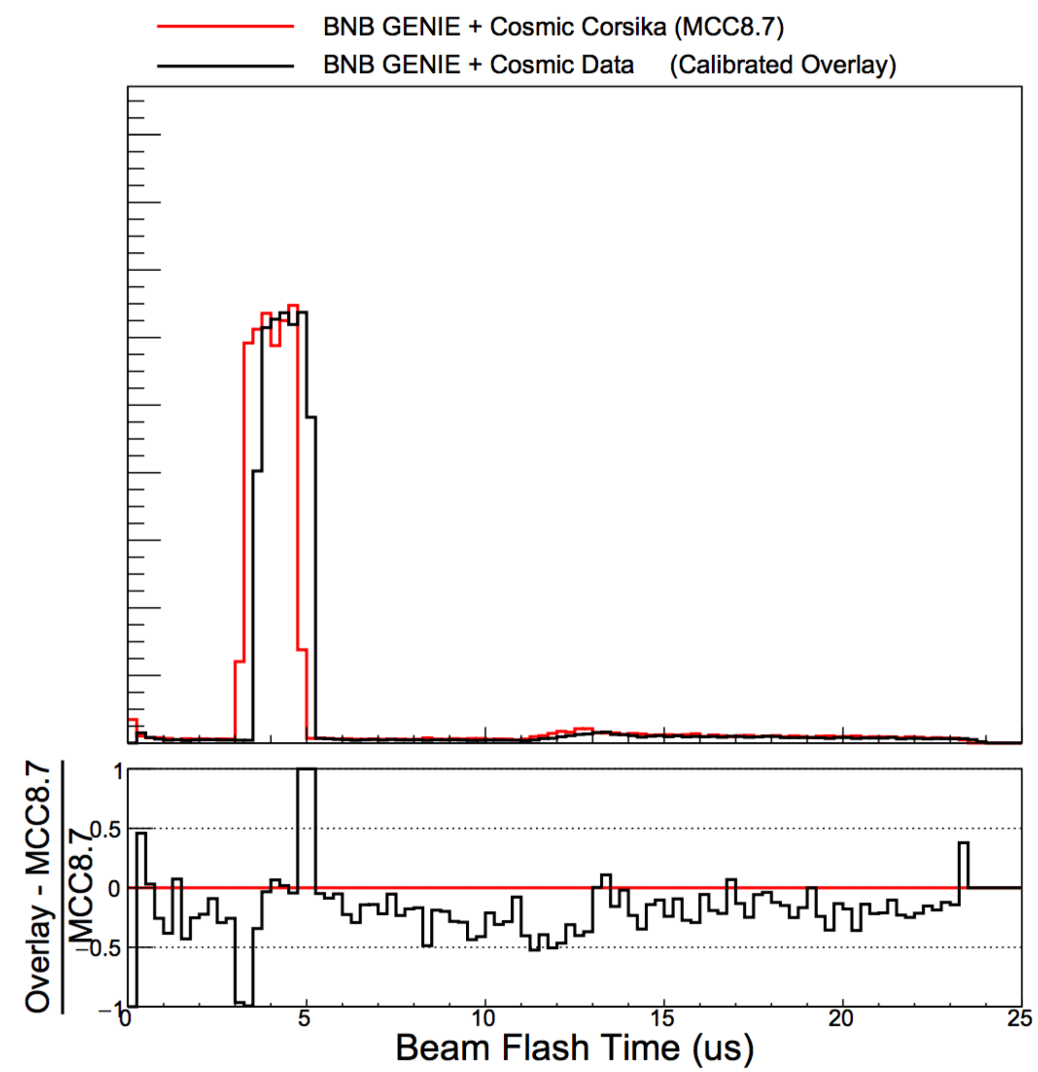


The EXT unbiased events are triggered using a pulser which has a delay of 400 nsec with respect to the beam trigger.

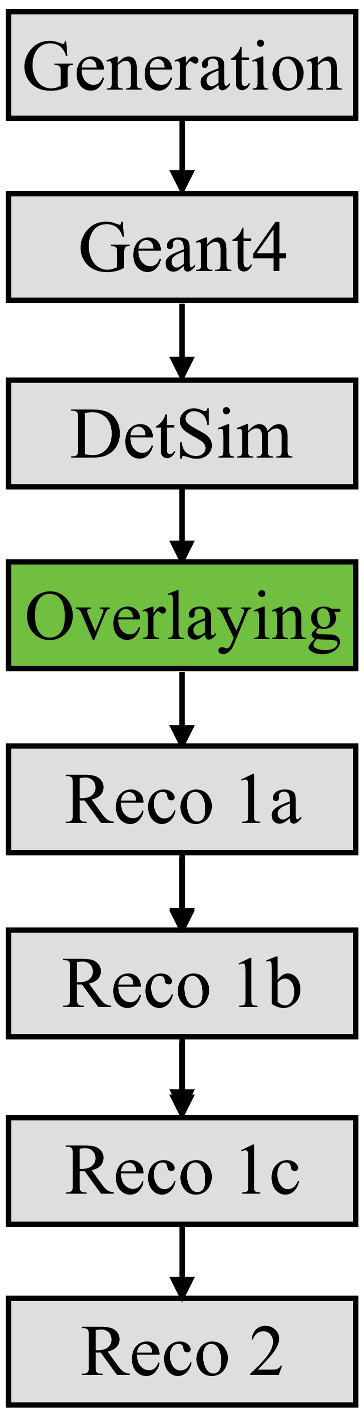
This shift affects:

- Optical filtering

- Truth matching procedure



Adding reconstructed collections



The mixing of the CRT hits is different in its nature

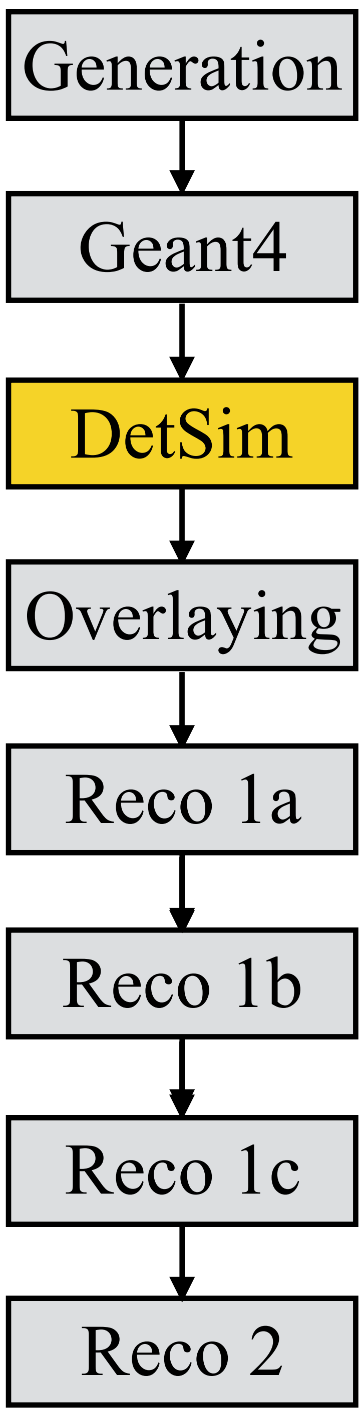
`/ubevt/ubevt/DataOverlay/DataOverlay/CRTMixer.cxx`

The reconstructed CRT hits collections from data and simulation are added.

- The addition is easier

- There is no dead time consideration

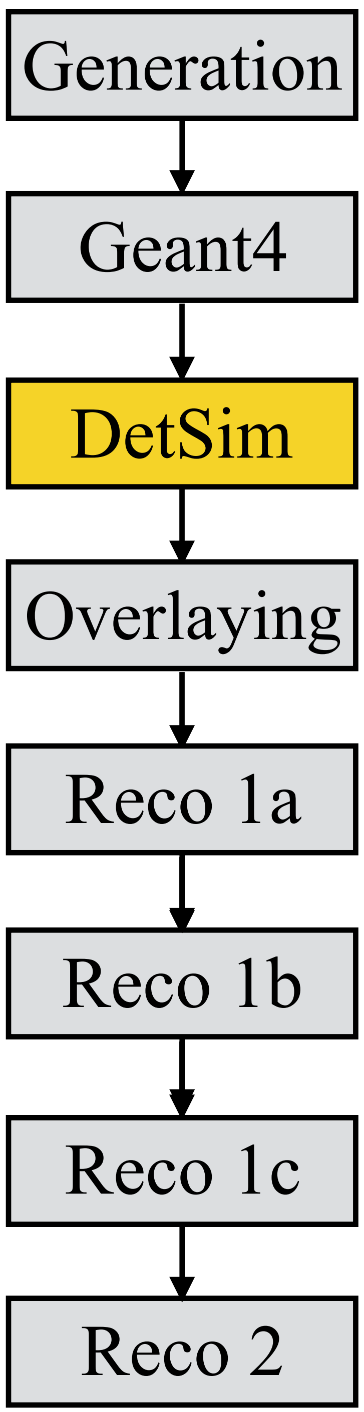
PreOverlay



Some actions must take place before the overlay stage including:

- Calibration (see next talk)
- Proper detector status simulation:
  - Creating a modified copy of the data product

PreOverlay - CRT

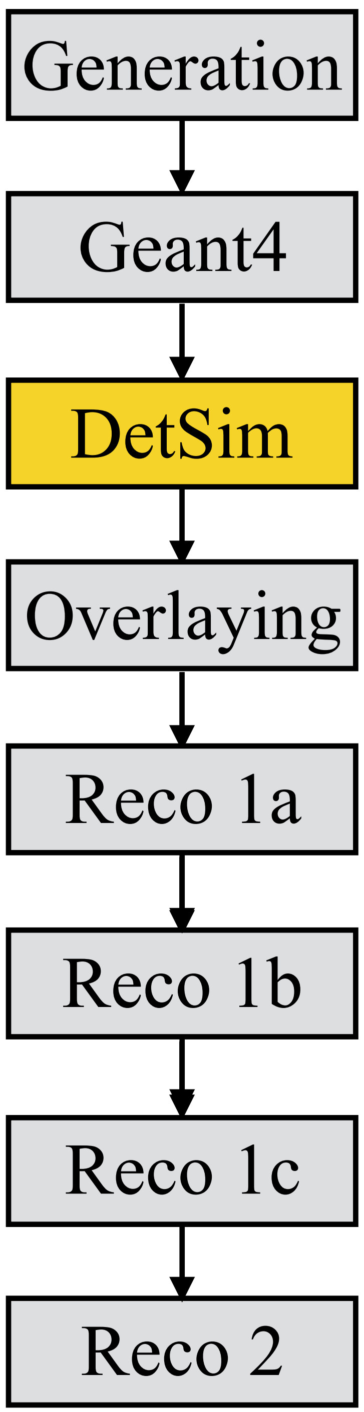


Masking out simulated hits in runs for which the CRT panels were not yet commissioned.

Fixing simulation issues (exp, simulated hit timing)

Allowing a simulation / data flag

PreOverlay - TPC wires

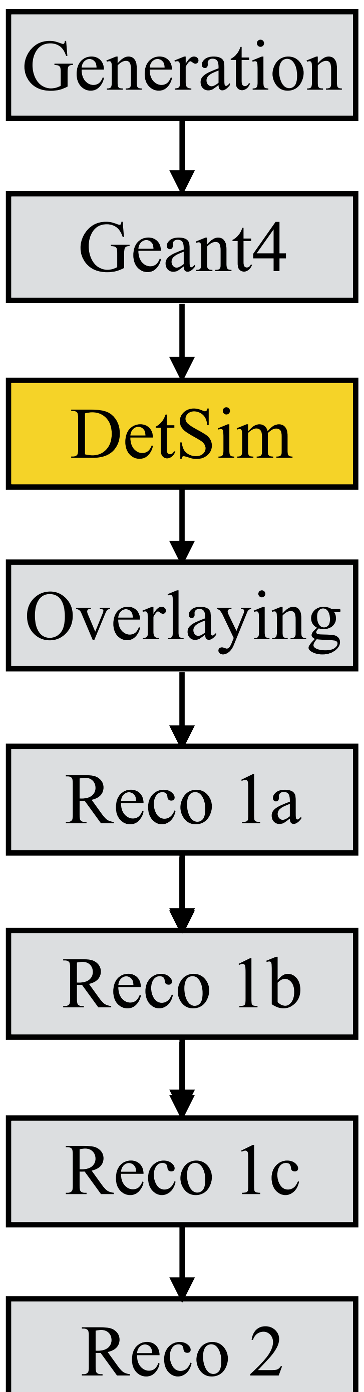


In order to properly simulate the detector status we do not want to simulate signals on dead channels and on saturated channels.

The later can be relevant only between specific time ticks in specific events.

A list of bad and saturated channels is produced whenever a noise filtering module is being ran

PreOverlay - TPC wires



A list of bad and saturated channels is produced whenever a noise filtering module is being ran

At the Detector simulation level a dummy noise filtering is being ran as part fo the wirecell toolkit

(not really filtering, just producing the list)

A copy of the raw digits is being produced in which the signal is zeroed out during the relevant time ticks

Summary

The overlay code is available inside MicroBooNE dedicated package ubevt.

The general adding functions and template for the mixing can be easily moved to larsoft framework.

Preoverlay stage can be detector specific

Overlay - Calibrating

Adi Ashkenazi

Overlay Sample Calibration

Due to its nature, the overlay sample, consisting of both data and MC components, will demand its own calibration scheme.

Nowadays, calibration for a regular MC or data sample is applied to the tracks only.

As calibration depends on an energy deposition coordinates, and those can be easily found for each hit associated with a three dimensional reconstructed track.

Overlay Sample Calibration

Motivation

The derivation of the calibration constants is the same for data and MC but the resulting calibration constants are different due to:

- The time dependencies existing only in data and not regular MC.
- The detector simulation is not perfect and causing different detector effects between data and MC.

When considering calibration procedure for an overlay sample:

- Should we vary the MC signal in time?
- Should we care for tracks only?
- @hich calibration constants should we apply?

Overlay Sample Calibration

approaches

Treat overlay sample as MC

Treat MC part part as MC and data per as data

Treat overlay sample as data

Overlay Sample Calibration
Overlay as data

Premises:

- We want to consider the entire sample as data.
- Every beam induced signal on channel can be traced back to its energy deposition.

Method:

- Apply a gain to each waveform: $$\frac{K_{MC}(x,y,z)}{K_{data}(x,y,z,t)}$$
- Apply data calibration to all tracks $K_{data}(x,y,z,t)$

Drawbacks / implied assumptions:

- The same energy deposition causes waveforms in all planes
- The convolution of the charge is linear

Overlay Sample Calibration

Overlay MC part as MC and Data part as data

Method:

- Don't vary gain values.
- Apply MC calibration to beam induced tracks, $K_{MC}(x, y, z)$
- Apply data calibration to cosmic induced tracks, $K_{data}(x, y, z, t)$

Drawbacks:

- Problematic where beam induced track crosses a cosmic induced one
- Unreliable non-tracks objects (showers, energy depositions around vertices)

Overlay Sample Calibration

Overlay as MC

Premises:
- Data calibration is irrelevant to MC part,
- Noise from the data (in overlay sample) similar to simulated noise

Method:
- Don't vary pedestal and gain values in time for MC part.
- Apply MC dedicated calibration constant to sample, $K_{MC}(x, y, z)$
- Accept non calibrated cosmic data.

Drawbacks:
- Non cosmic data
- Problematic where beam induced track crosses a cosmic induced one
- Unreliable non-tracks objects (showers, energy depositions around vertices)

Overlay Sample Calibration

approaches

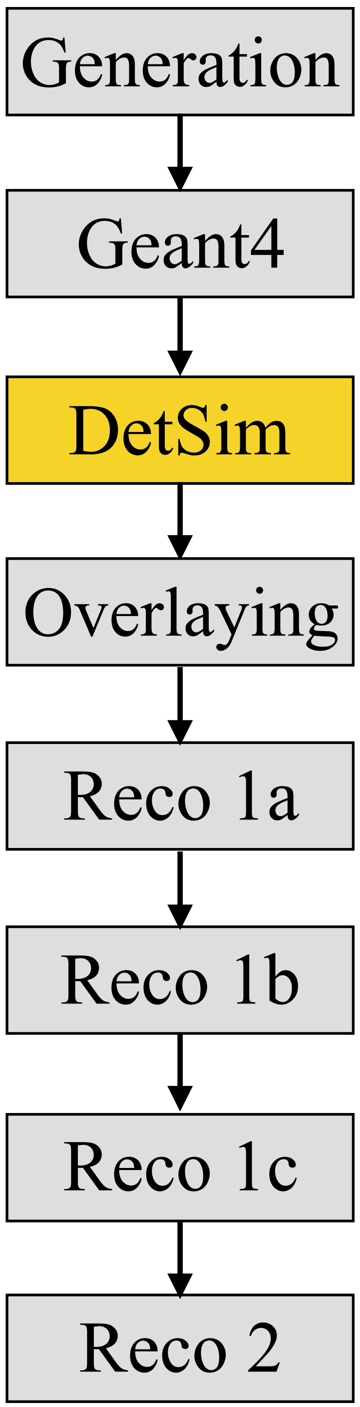
Treat overlay sample as MC

Treat MC part part as MC and data per as data

Treat overlay sample as data

Overlay Production

Detector Simulation no noise



Premise: We want to consider the entire sample as data.

Method:
Apply a gain to each generated waveform :

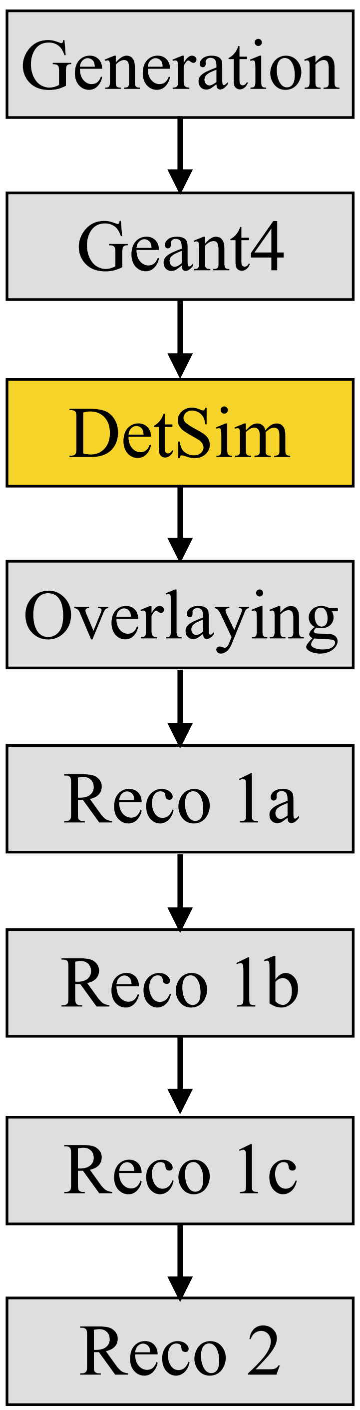
$$\frac{K_{\mathrm{MC}}(x, y, z, \mathrm{plane})}{K_{\mathrm{data}}(x, y, z, t, \mathrm{plane})}$$

YZ correction maps:
The maps are being read inside uboonecode (ubsim)
A new wirecell component `DepoTransform` is reading the maps
Gain is applied within wirecell code

Electron lifetime (for X correction)
Takes electron life value from database

Overlay Production

Detector Simulation no noise

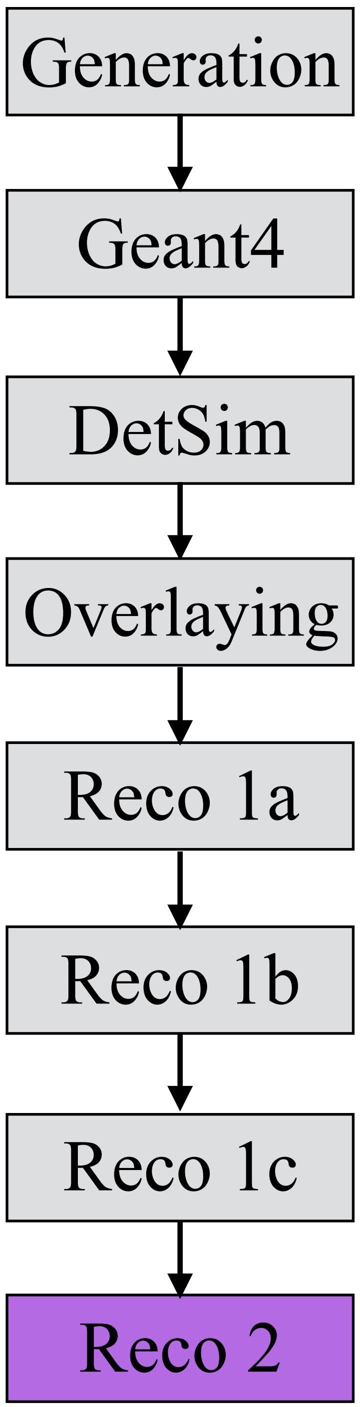


The calibration constants are being read using an art provider, automatically taking the event timestamp.

Currently, we are able to call only one provider.
We chose to use the provider to read the
data variables, and the MC variable, which are currently not using the time stamps are being read directly from the maps.

Overlay Production

Reco2



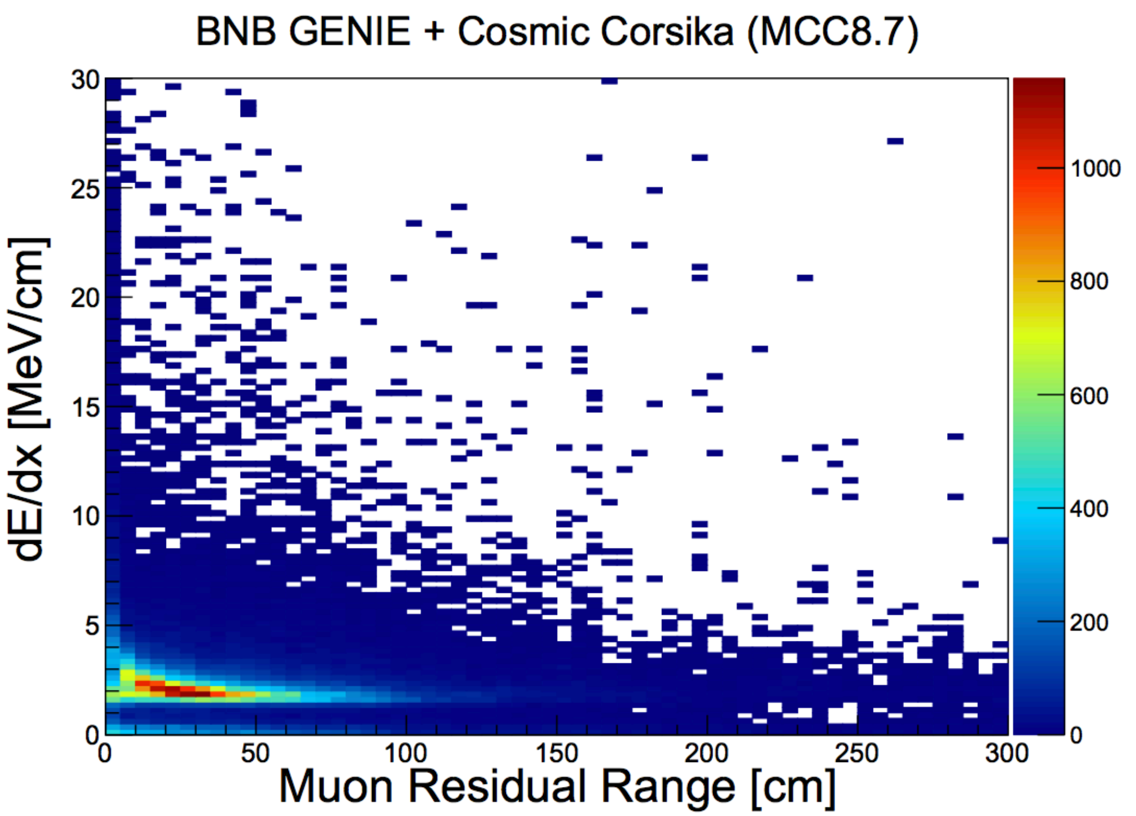
Reco2 is similar to the Data Reco2 stage

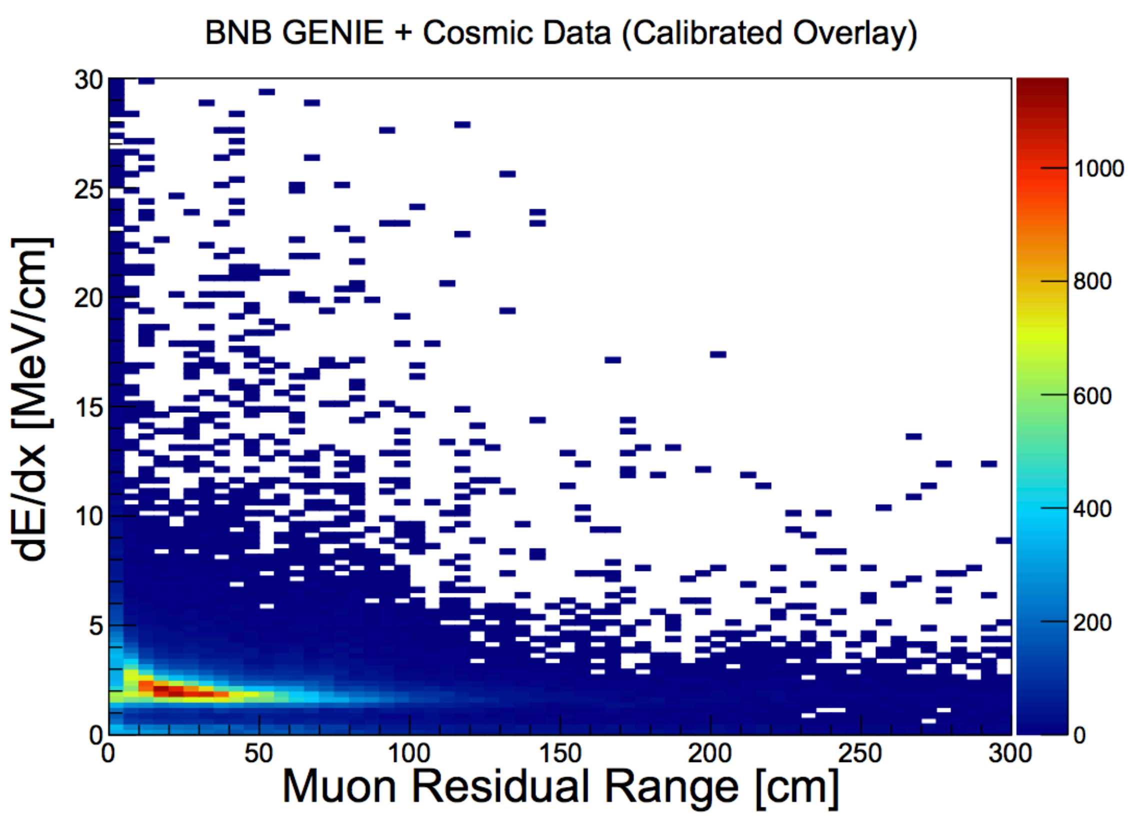
Applying:

$$K_{data}(x, y, z, t)$$

To all hits in all tracks (MC and data parts of the overlay)

Validation using previous production





Validation using previous production