Dual-Phase Pandora in LArSoft and more

by Etienne Chardonnet
Laboratory APC, Paris

Dual-Phase Pandora in LArSoft

New block in **dunetpc/dune/DUNEPandora/pandoramodules_dune.fcl** :

```
protodune_pandora:                                  @local::dune_pandora
protodune_pandora.ConfigFile:                       "PandoraSettings_Master_ProtoDUNE.xml"
protodune_pandora.ShouldRunAllHitsCosmicReco:       true
protodune_pandora.ShouldRunStitching:               true
protodune_pandora.ShouldRunCosmicHitRemoval:        true
protodune_pandora.ShouldRunSlicing:                 true
protodune_pandora.ShouldRunNeutrinoRecoOption:      true
protodune_pandora.ShouldRunCosmicRecoOption:        true
protodune_pandora.ShouldPerformSliceId:             true

protodune_dp_pandora:                               @local::dune_pandora
protodune_dp_pandora.ConfigFile:                    "PandoraSettings_Master_ProtoDUNE_DP.xml"
protodune_dp_pandora.ShouldRunAllHitsCosmicReco:    true
protodune_dp_pandora.ShouldRunStitching:            false
protodune_dp_pandora.ShouldRunCosmicHitRemoval:     true
protodune_dp_pandora.ShouldRunSlicing:              true
protodune_dp_pandora.ShouldRunNeutrinoRecoOption:   true
protodune_dp_pandora.ShouldRunCosmicRecoOption:     true
protodune_dp_pandora.ShouldPerformSliceId:          true
```

It is now default reco module in **dunetpc/dune/Protodune/dualphase/fcl/pddp_reco.fcl** :

```
# Define and configure some modules to do work on each event.
# First modules are defined; they are scheduled later.
# Modules are grouped by type.
physics:
{
 producers:
 {
### random number saver
       rns:                { module_type: RandomNumberSaver }

### convert raw::RawDigit to recob::wire
       caldata:            @local::producer_adcprep

###  hit finder
       dprawhit:           @local::dunefddphase_dprawhitfinder

###  reconstruction
       pandora:            @local::protodune_dp_pandora
       pandoraTrack:       @local::dune_pandoraTrackCreation
       pandoraShower:      @local::dune_pandoraShowerCreation
```

You will at the bottom of pddp_reco.fcl the detailed configuration of the reconstruction.

Default config of pddp_reco.fcl will reconstruct cosmic data

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protodune_dp_pandora.ShouldPerformSliceId:          true
```

Dual-Phase Pandora in LArSoft

Two new xml files in **dunetpc/dune/DUNEPandora/scripts/** :

In PandoraSettings_Master_ProtoDUNE_DP.xml

```
<pandora>
    <!-- GLOBAL SETTINGS -->
    <IsMonitoringEnabled>false</IsMonitoringEnabled>
    <ShouldDisplayAlgorithmInfo>false</ShouldDisplayAlgorithmInfo>
    <SingleHitTypeClusteringMode>true</SingleHitTypeClusteringMode>

    <!-- ALGORITHM SETTINGS -->
    <algorithm type = "LArPreProcessing">
        <OutputCaloHitListNameU>CaloHitListU</OutputCaloHitListNameU>
        <OutputCaloHitListNameV>CaloHitListV</OutputCaloHitListNameV>
        <OutputCaloHitListNameW>CaloHitListW</OutputCaloHitListNameW>
        <FilteredCaloHitListName>CaloHitList2D</FilteredCaloHitListName>
        <CurrentCaloHitListReplacement>CaloHitList2D</CurrentCaloHitListReplacement>
    </algorithm>
    <algorithm type = "LArVisualMonitoring">
        <CaloHitListNames>CaloHitListU CaloHitListV CaloHitListW</CaloHitListNames>
        <ShowDetector>true</ShowDetector>
    </algorithm>

    <algorithm type = "LArMaster">
        <CRSettingsFile>PandoraSettings_Cosmic_ProtoDUNE_DP.xml</CRSettingsFile>
        <NuSettingsFile>PandoraSettings_TestBeam_ProtoDUNE.xml</NuSettingsFile>
        <SlicingSettingsFile>PandoraSettings_Slicing_ProtoDUNE.xml</SlicingSettingsFile>
```

In PandoraSettings_Cosmic_ProtoDUNE_DP.xml

« IsDualPhase » as new xml parameter

```
    <!-- VertexAlgorithms -->
    <algorithm type = "LArCosmicRayVertexBuilding">
        <InputPfoListName>MuonParticles3D</InputPfoListName>
        <OutputVertexListName>CRVertices3D</OutputVertexListName>
        <IsDualPhase>true</IsDualPhase>
    </algorithm>
```

New implementation of CosmicVertexBuilding algorithm includes a « DualPhase » mode with X as the vertical direction

- Is set to « **false** » **by default in Single-Phase xml files** (doesn't necessarily appear in the files)
- Can be called **only** in PandoraSettings_Cosmic_*.xml

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    <IsMonitoringEnabled>false</IsMonitoringEnabled>
    <ShouldDisplayAlgorithmInfo>false</ShouldDisplayAlgorithmInfo>
    <SingleHitTypeClusteringMode>true</SingleHitTypeClusteringMode>

    <!-- ALGORITHM SETTINGS -->
    <algorithm type = "LArPreProc
        <OutputCaloHitListNameU>C
        <OutputCaloHitListNameV>C
        <OutputCaloHitListNameW>C
        <FilteredCaloHitListName>
```
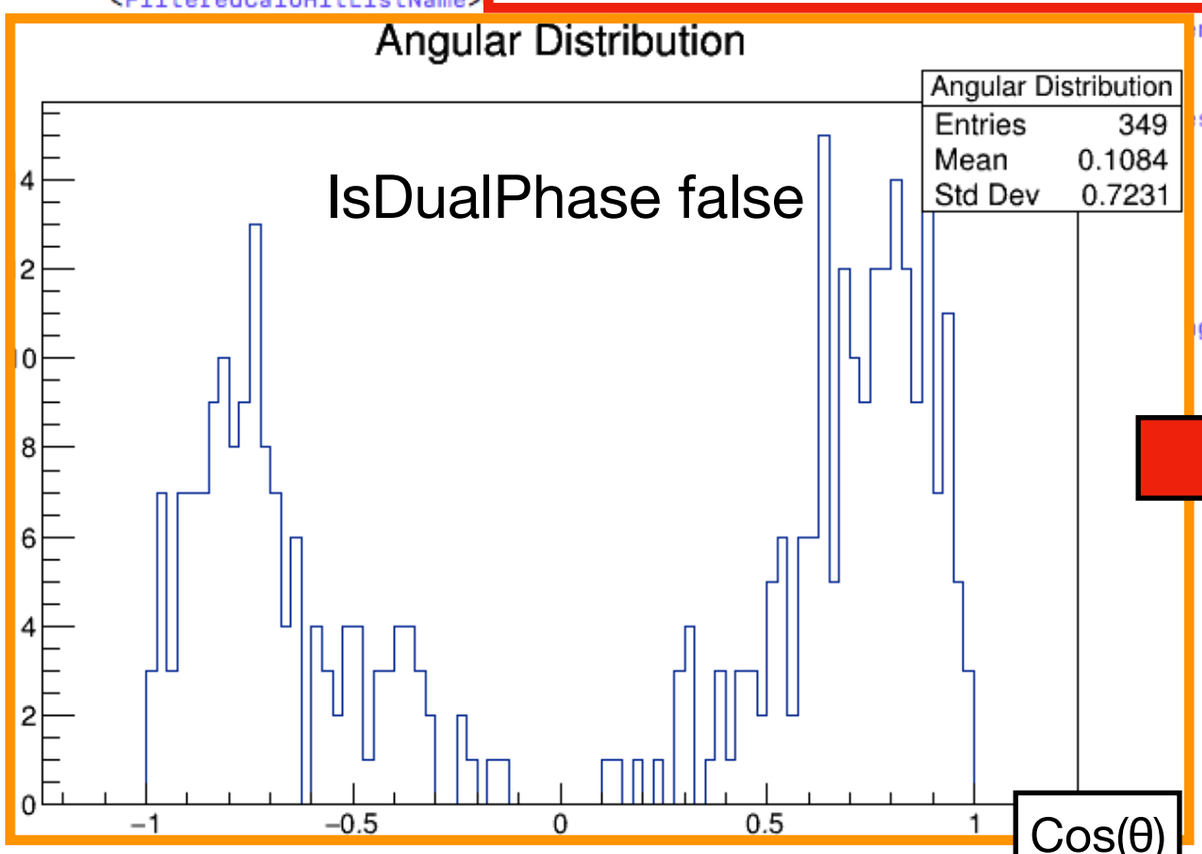
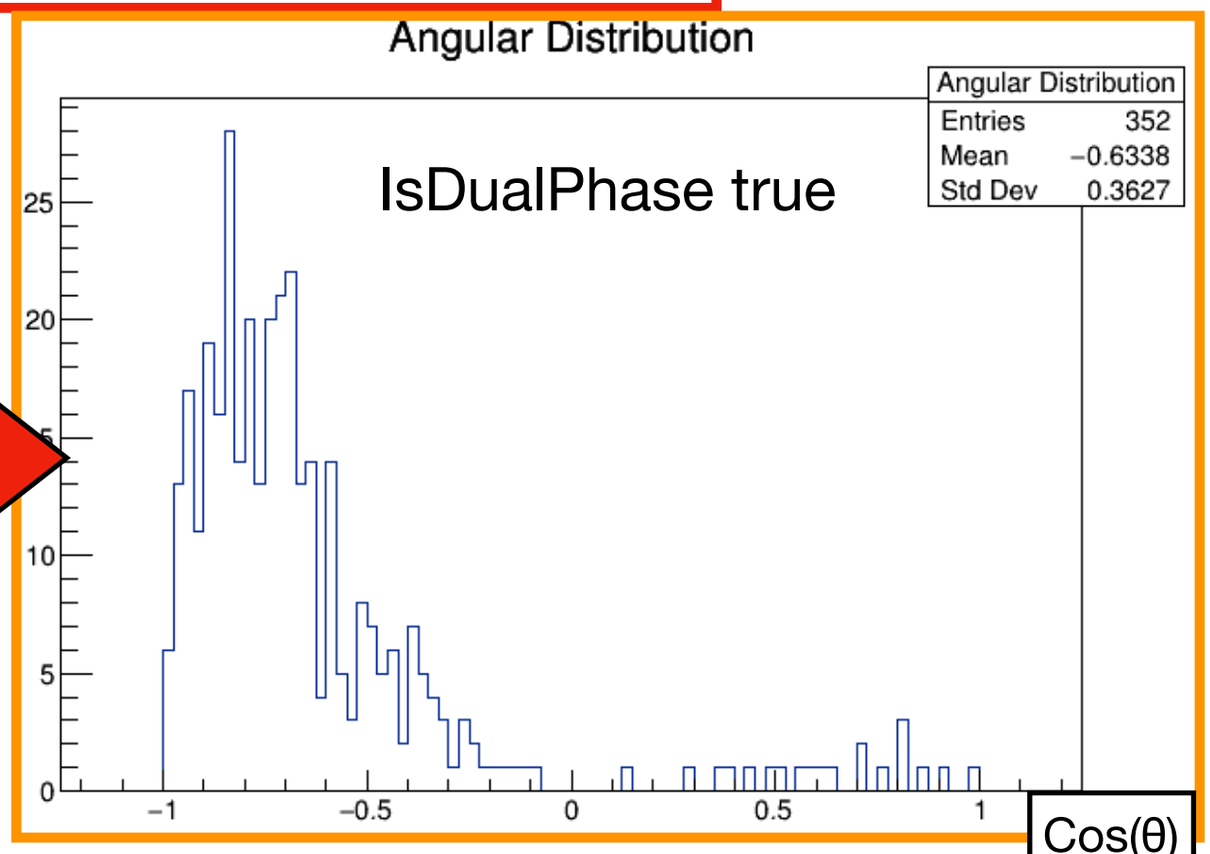

In PandoraSettings_Cosmic_ProtoDUNE_DP.xml

« IsDualPhase » as new xml parameter

```
    <!-- VertexAlgorithms -->
    <algorithm type = "LArCosmicRayVertexBuilding">
                                                    3D</InputPfoListName>
                                                    3D</OutputVertexListName>
```

Cosmic rays vertical angle distribution





BREF*

*Anyway in french

If you want to reconstruct ProtoDUNE-DP cosmic data **just run this two commands** :**

```
$$ lar -c pddp_daq_converter.fcl anything.cosmics -o daq_converted.root

$$ lar -c pddp_reco.fcl daq_converted.root
```

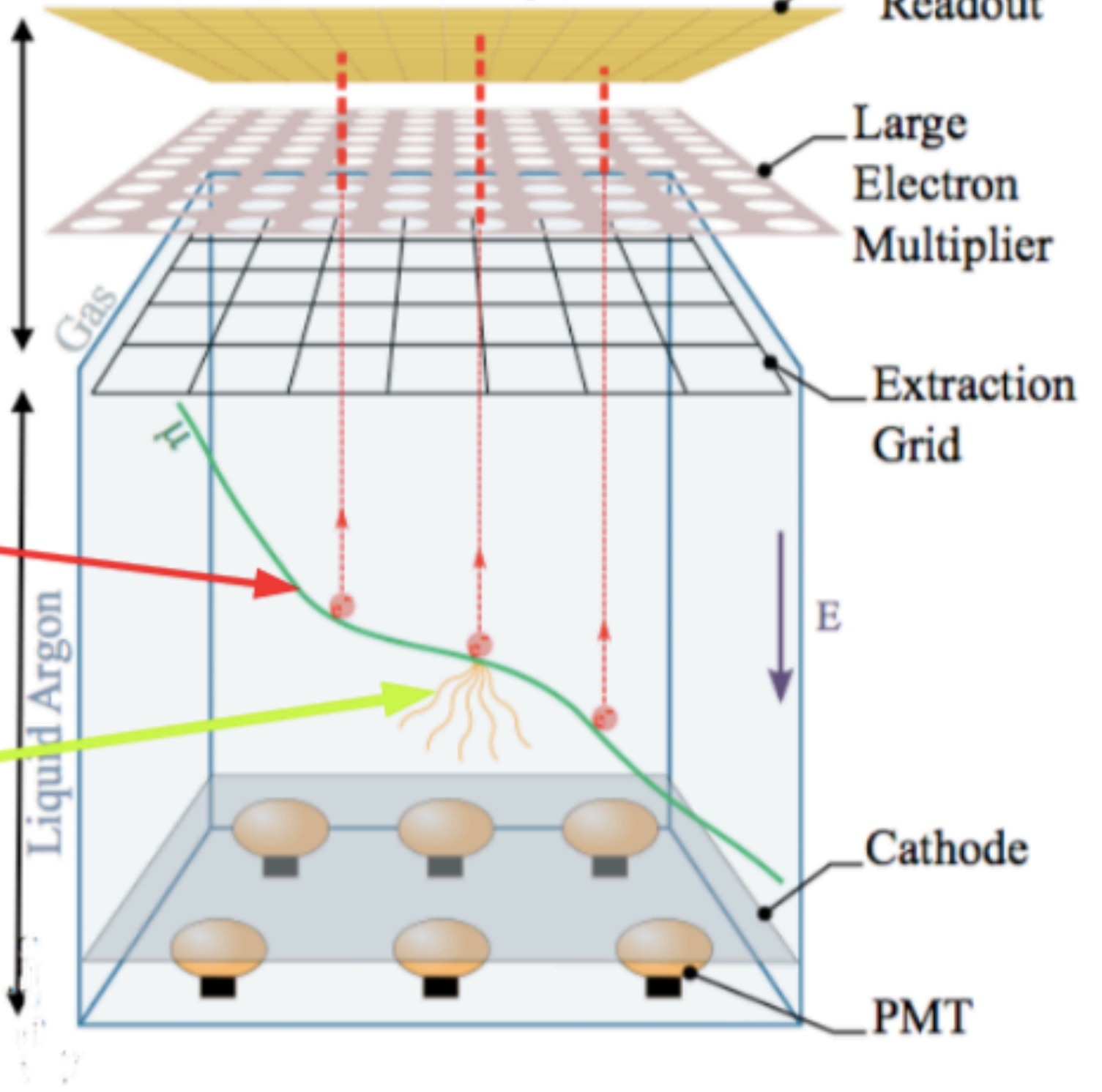
**using dunetpc ≥v08_41_01

The DUNE detector principle

Dual-phase design

Ionization electrons

- Drift vertically towards the anode
  → Give the position in the **horizontal plane**



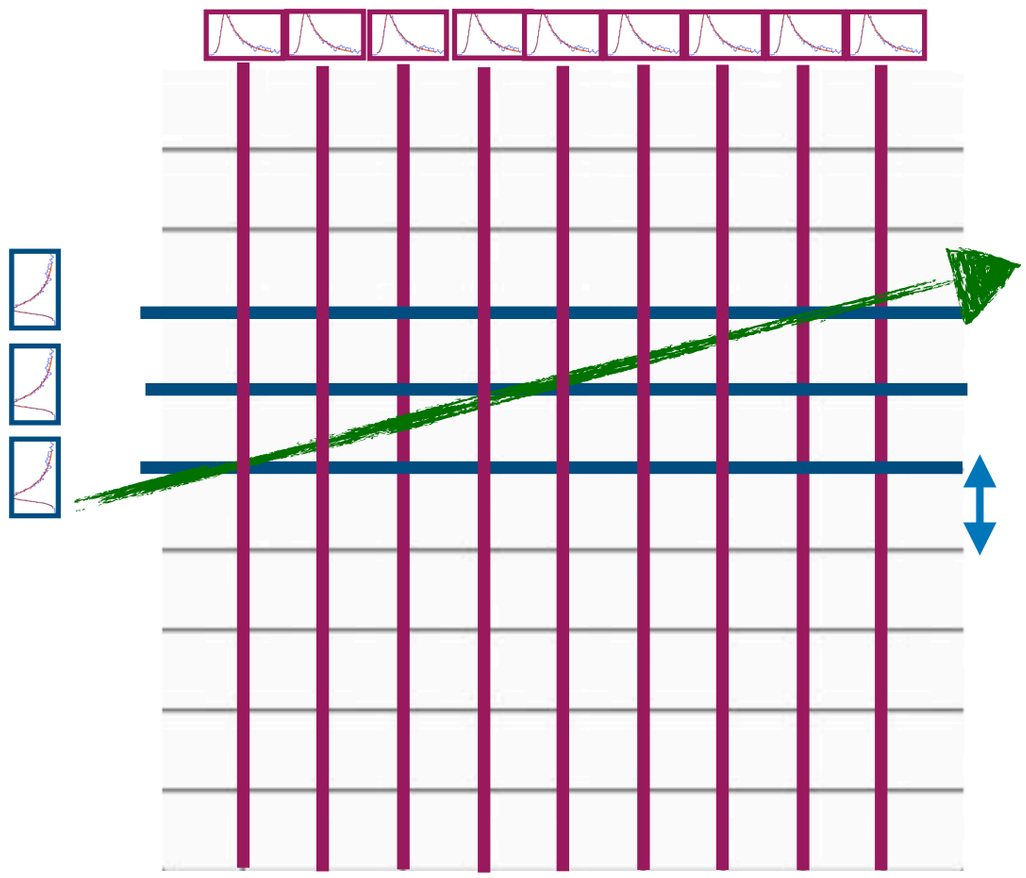
Scintillation photons

T_0 of the ionization
→ Give the **vertical** position

DUNE's Dual-Phase Liquid Argon TPC

Details on **2-view** signal collection

Sketch of the Dual-Phase CRP



Wires for View 0

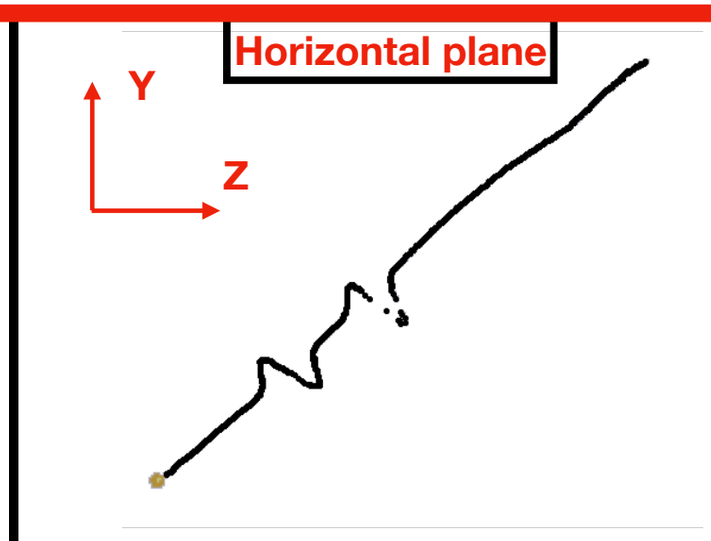
Wires for View 1

One view = Vertical (X) + Horizontal (Y or Z)

What has been done

- Integrated DP-case in Pandora reconstruction
- Tested the performances with muons (docdb 17519), two problematic cases :

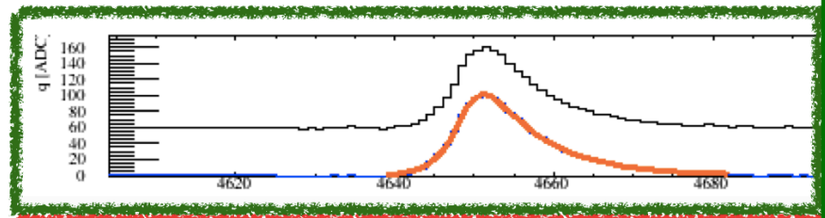
Horizontal tracks



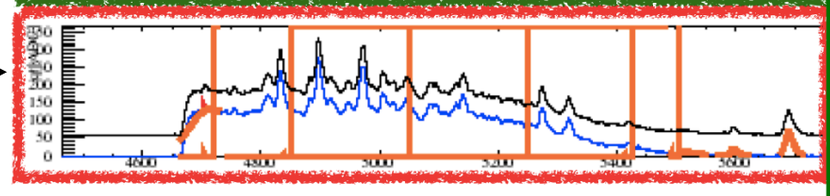
Tracks parallel to one view

Waveforms :

Normal



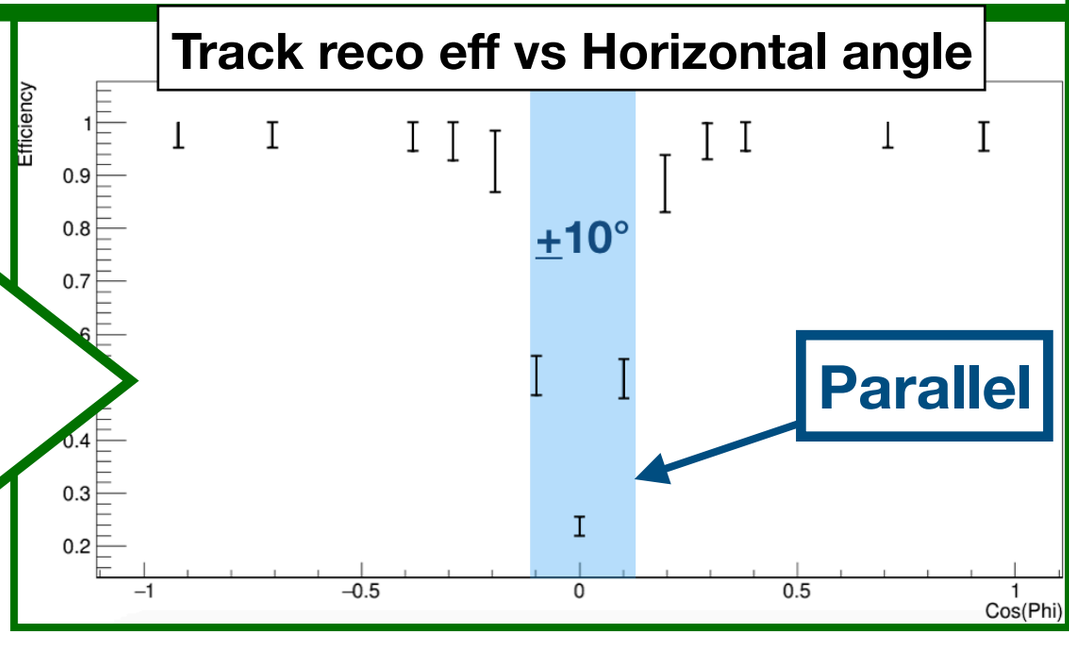
Parallel



View matching failure due to :

- **degeneracy of hits in drift direction**
- **Fit requiring smooth trajectory**

Although, issue is not prioritized due to its rare occurence



Hit reconstruction comparison

Following the test of DP-Pandora on parallel tracks,

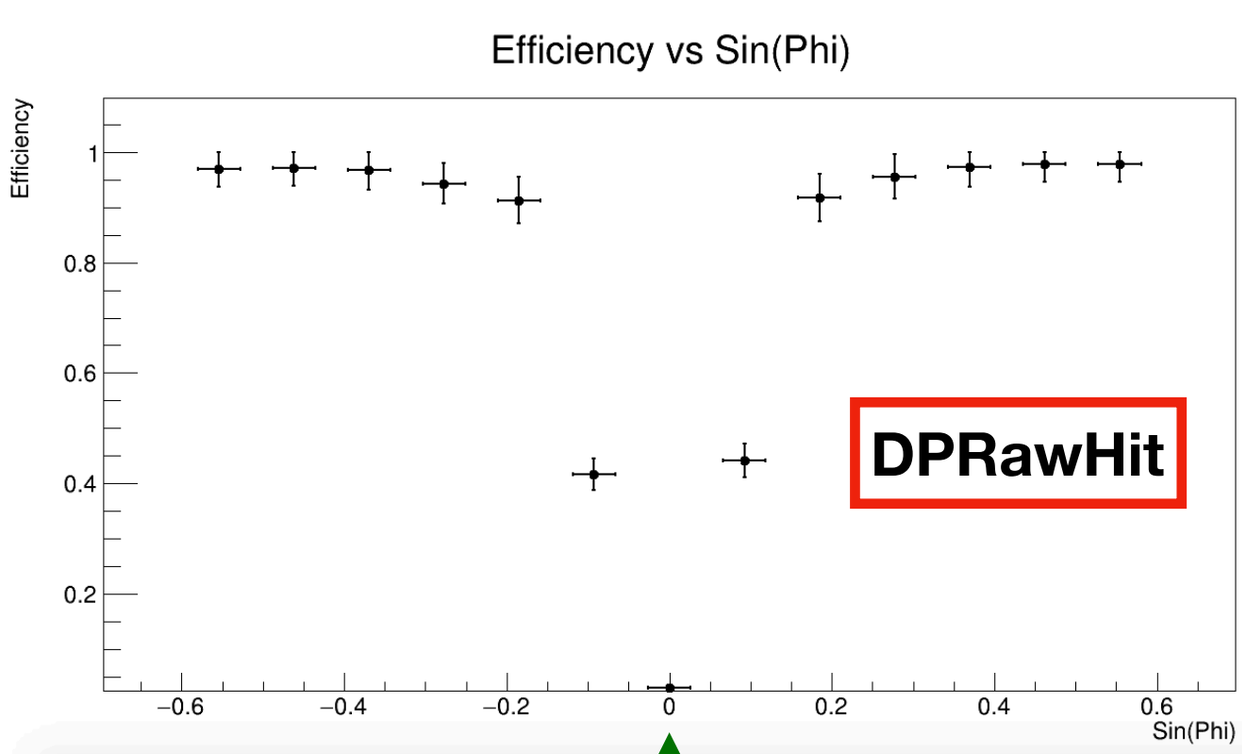
Tested 3 hit reconstruction algorithms :

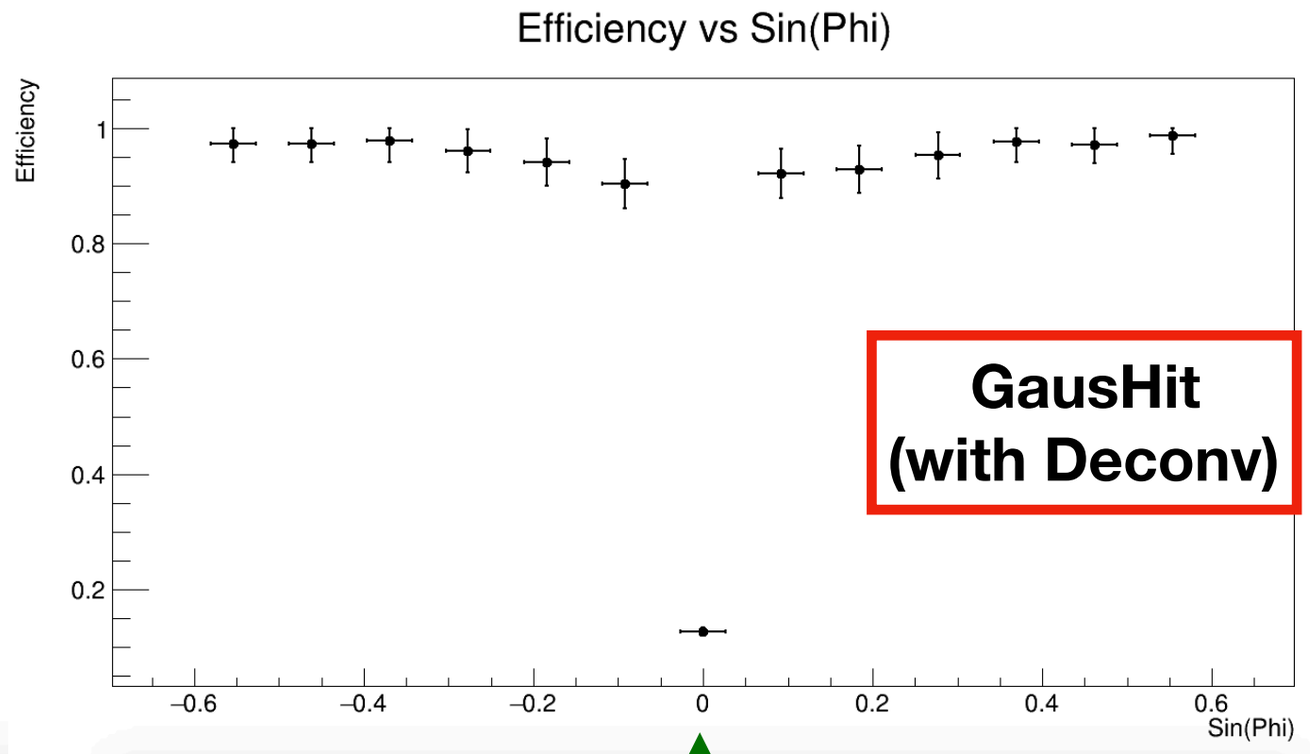
- DPRawHit (current default algorithm)
- GausHit with deconvolution
- GausHit without deconvolution

If deconvolution is properly implemented, SP parametrization of GausHit could be used

Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle



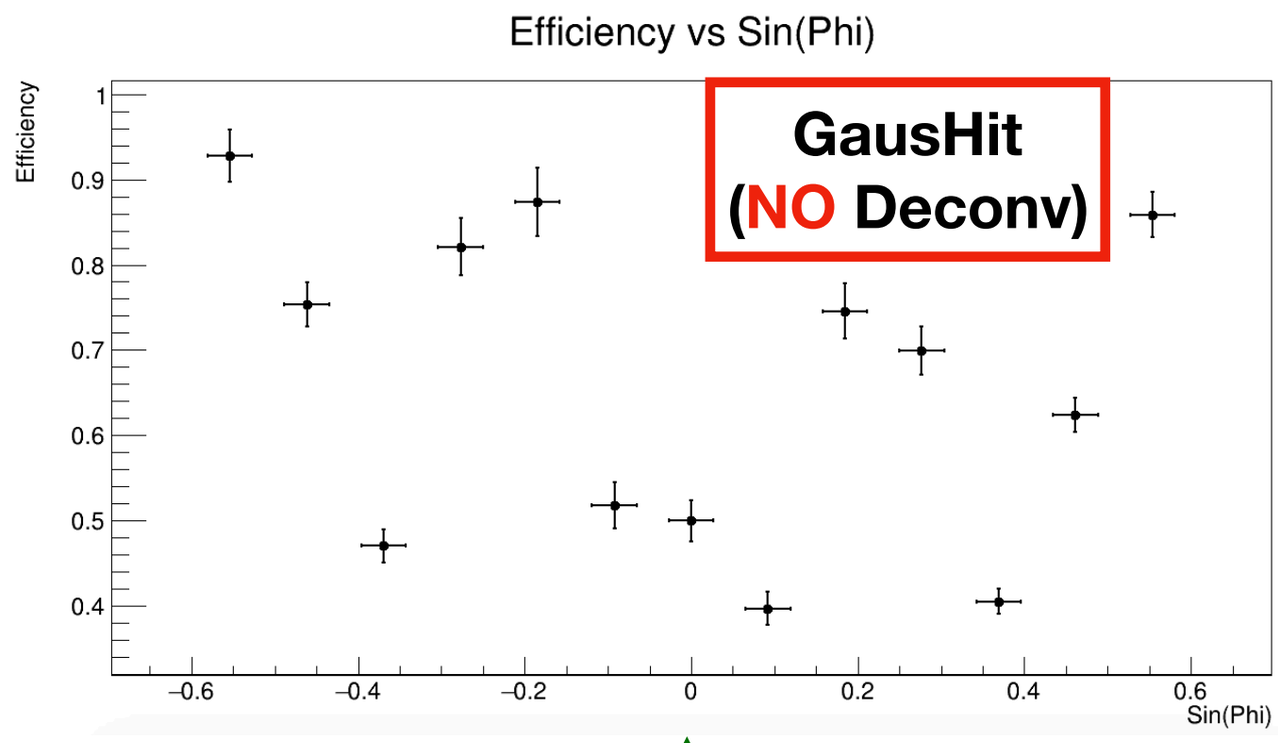


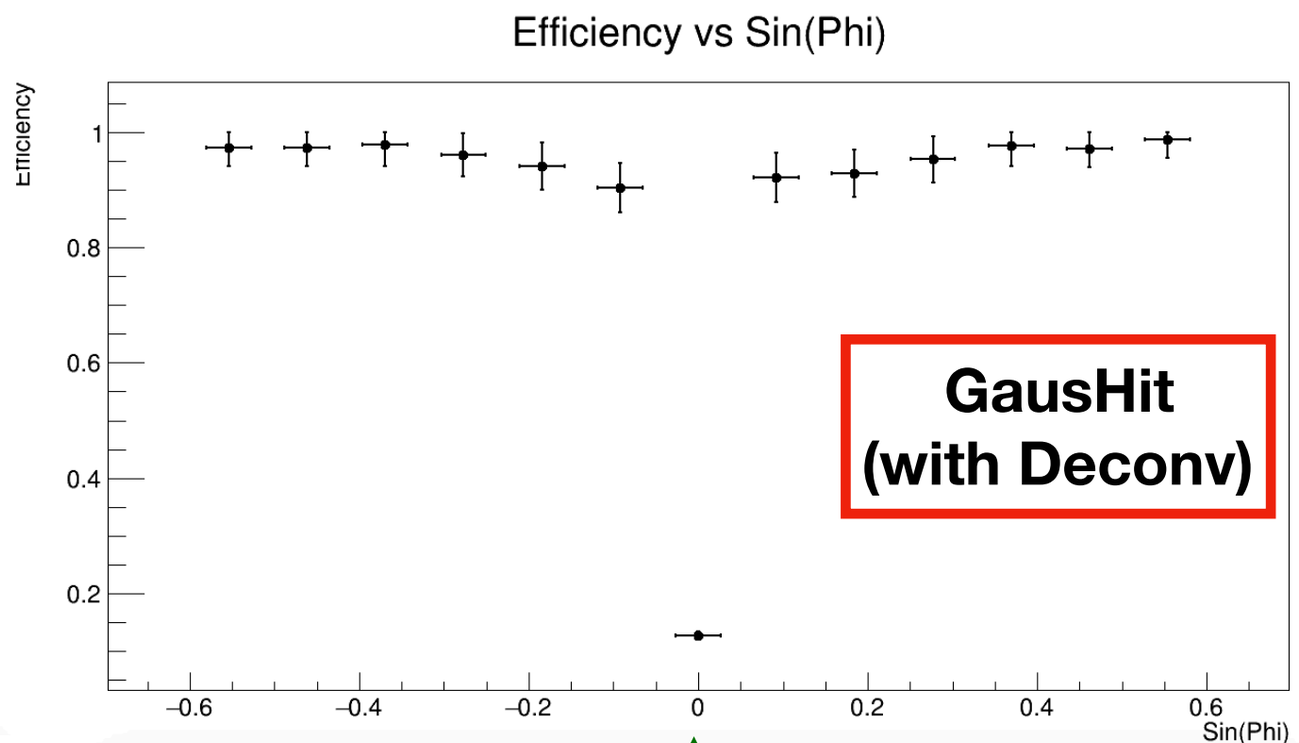
Parallel direction

First try with deconvolution+gaushit already seems to **improve significantly how close to parallel** a track must be to be misreconstructed.

Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle

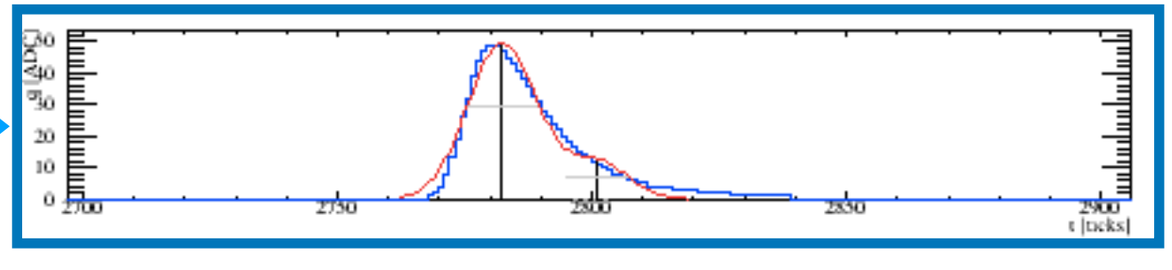




Parallel direction

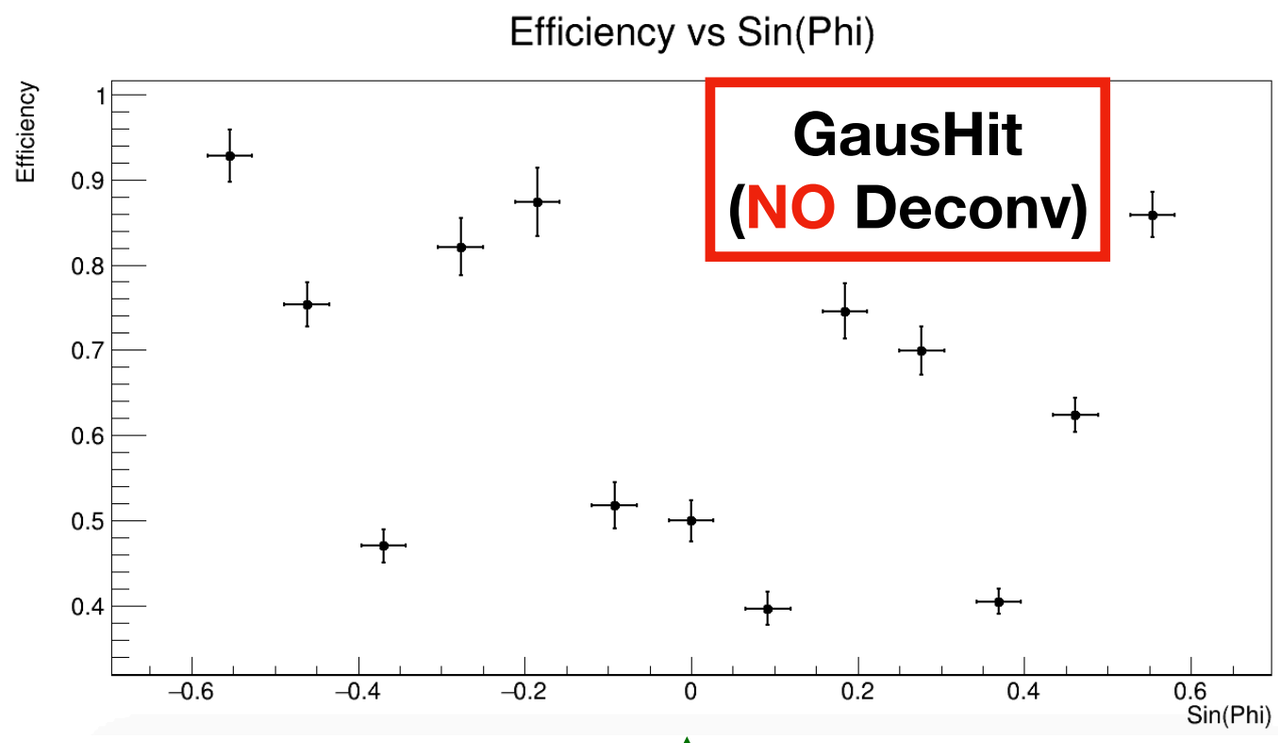
Testing GausHit **without deconvolution** gives terrible results as expected.

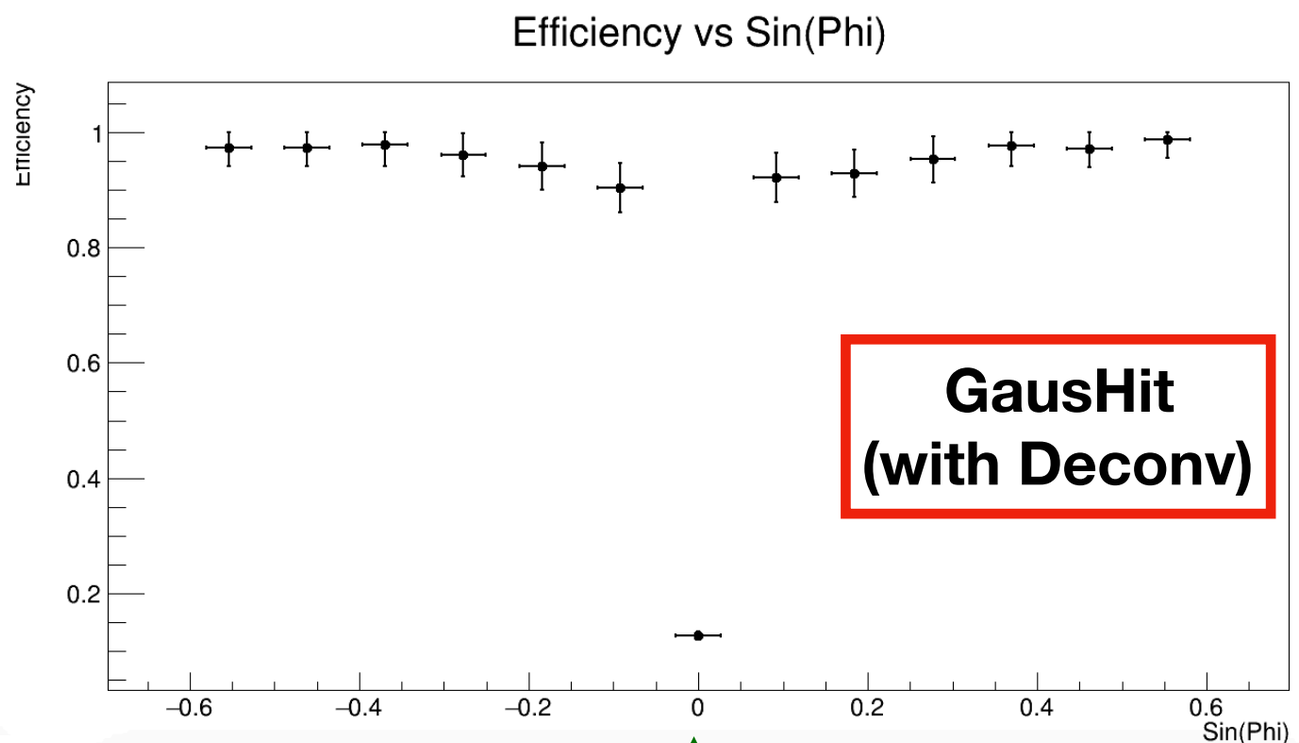
Reason is that one normal hit
Is **reconstructed as two hits**



Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle





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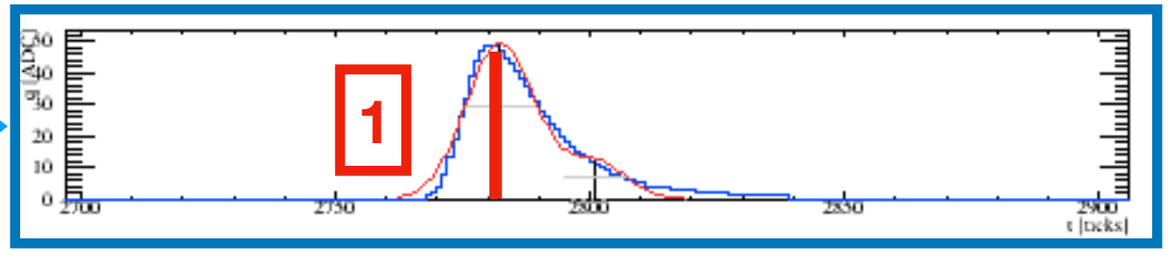

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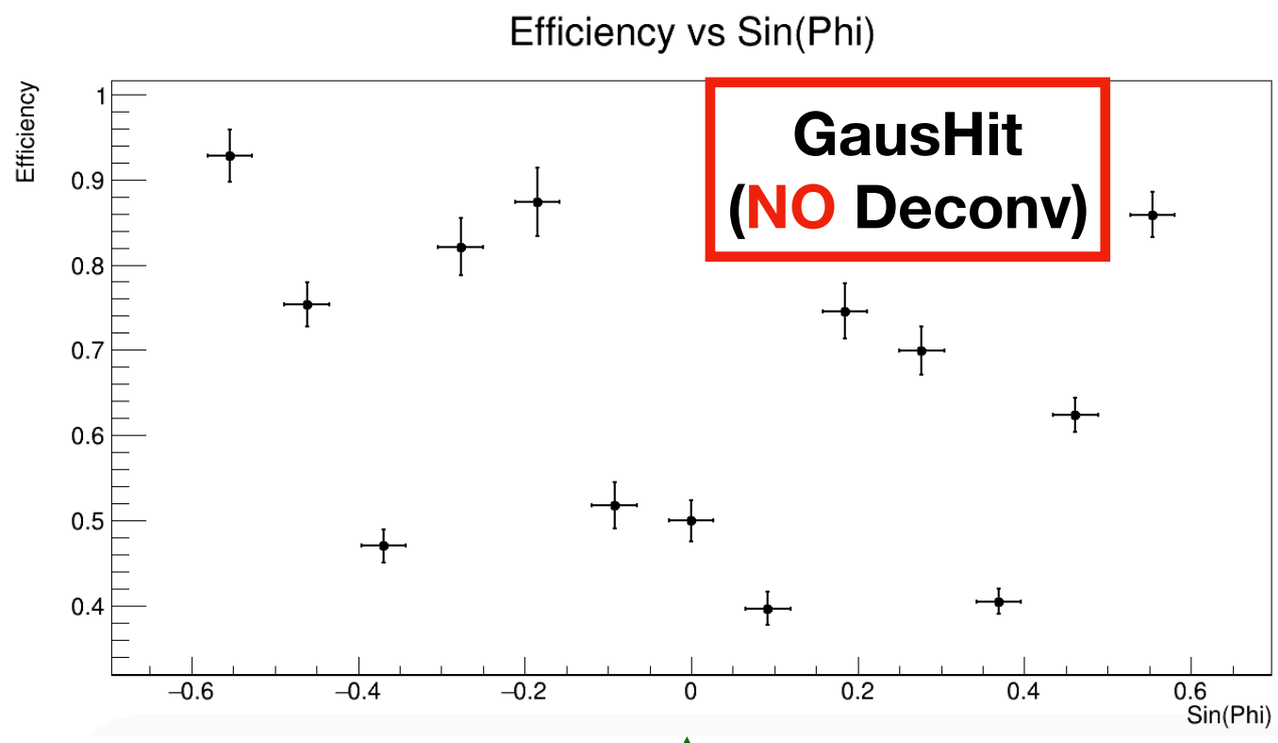
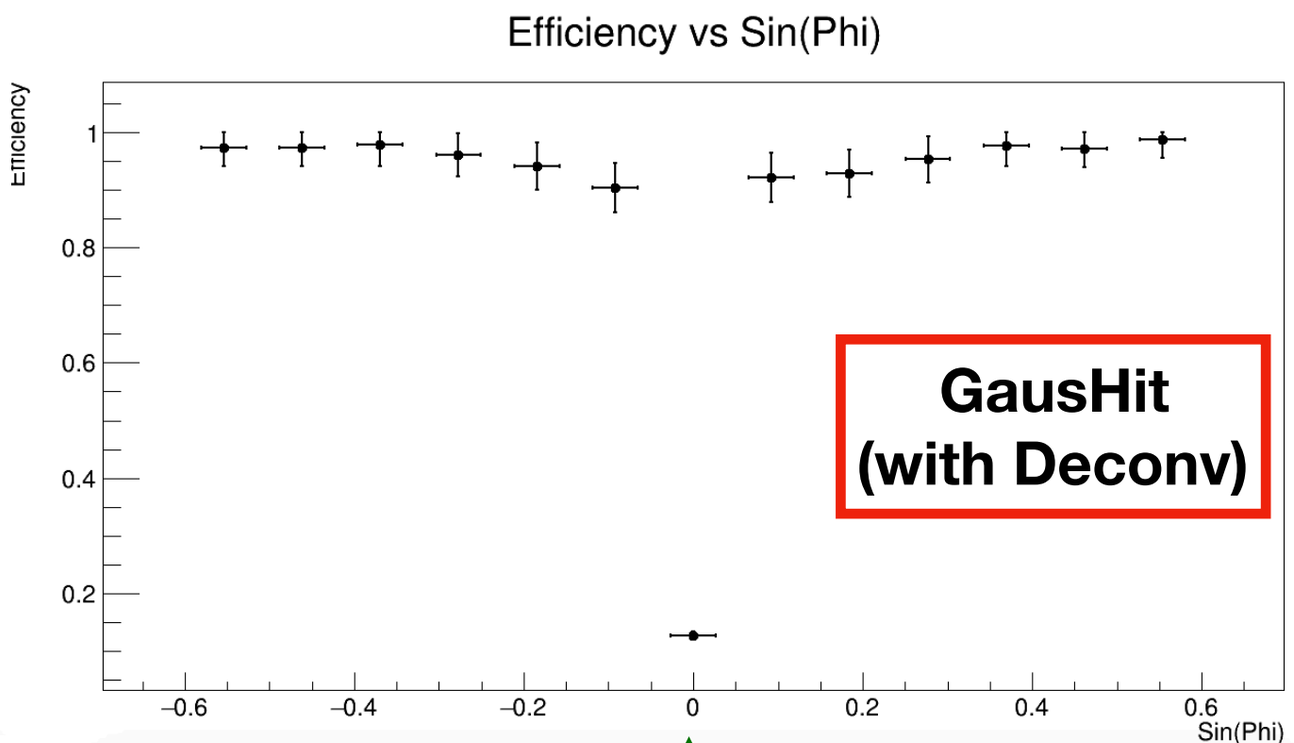
Track reconstruction efficiency vs Horizontal angle





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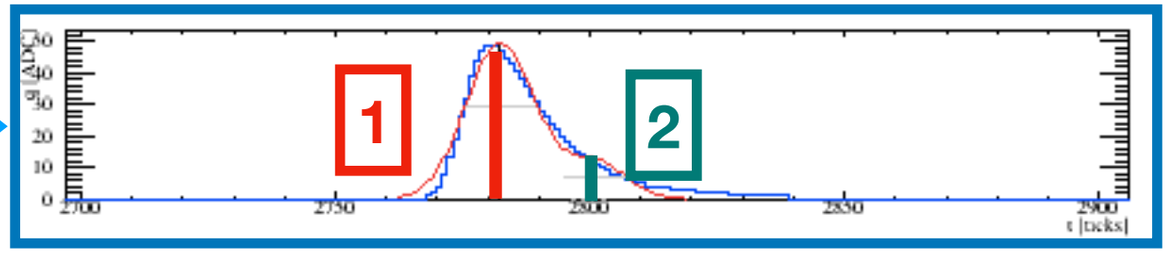
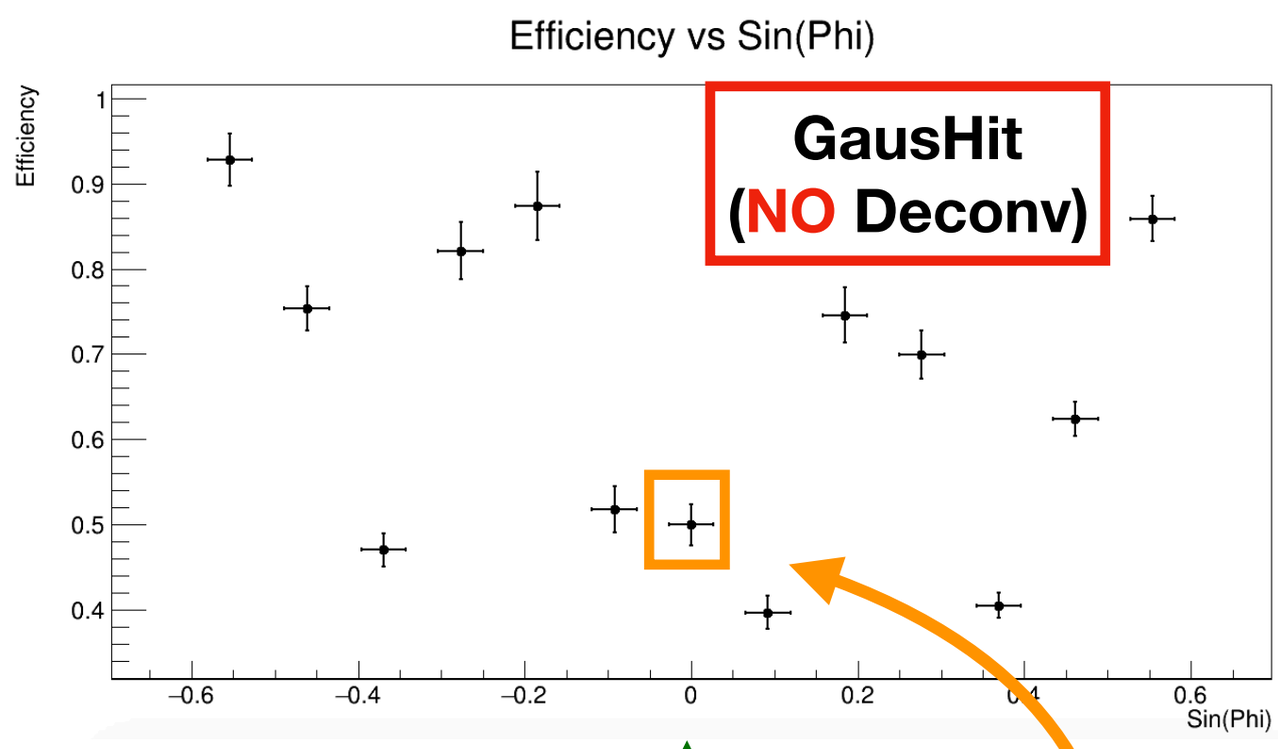
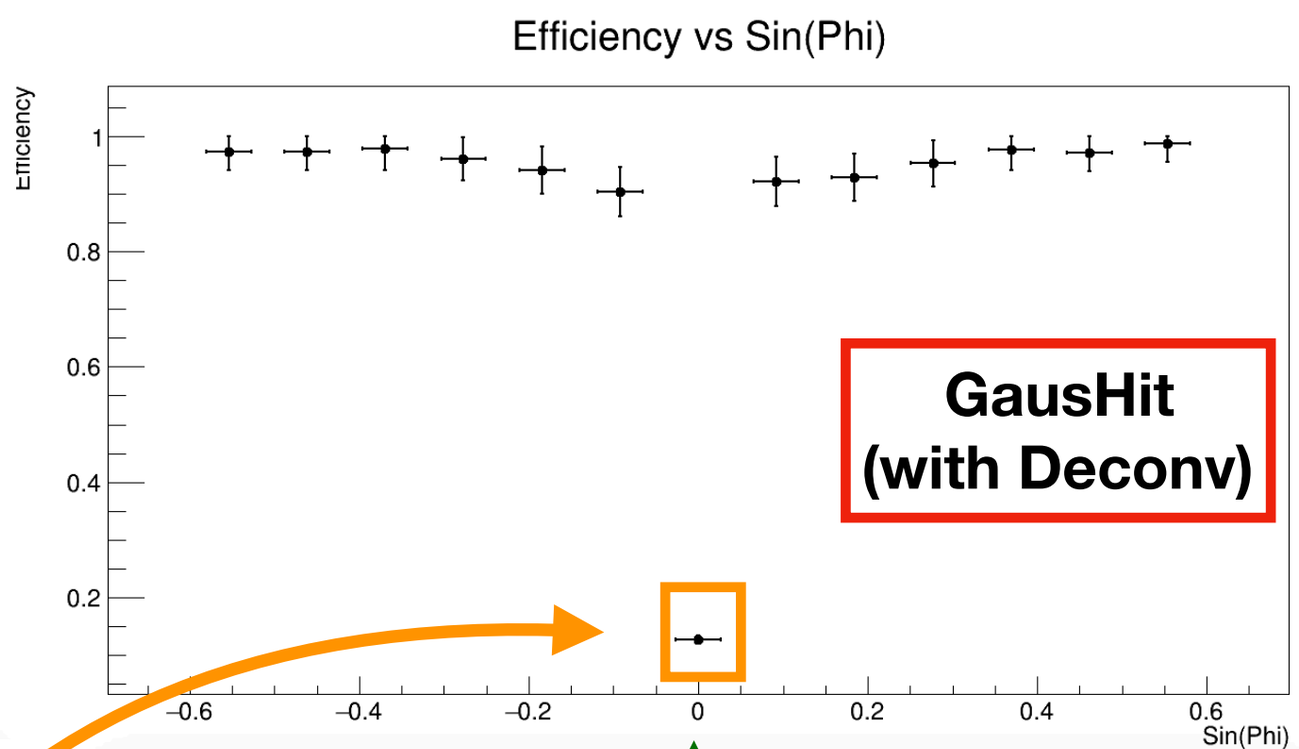


Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle





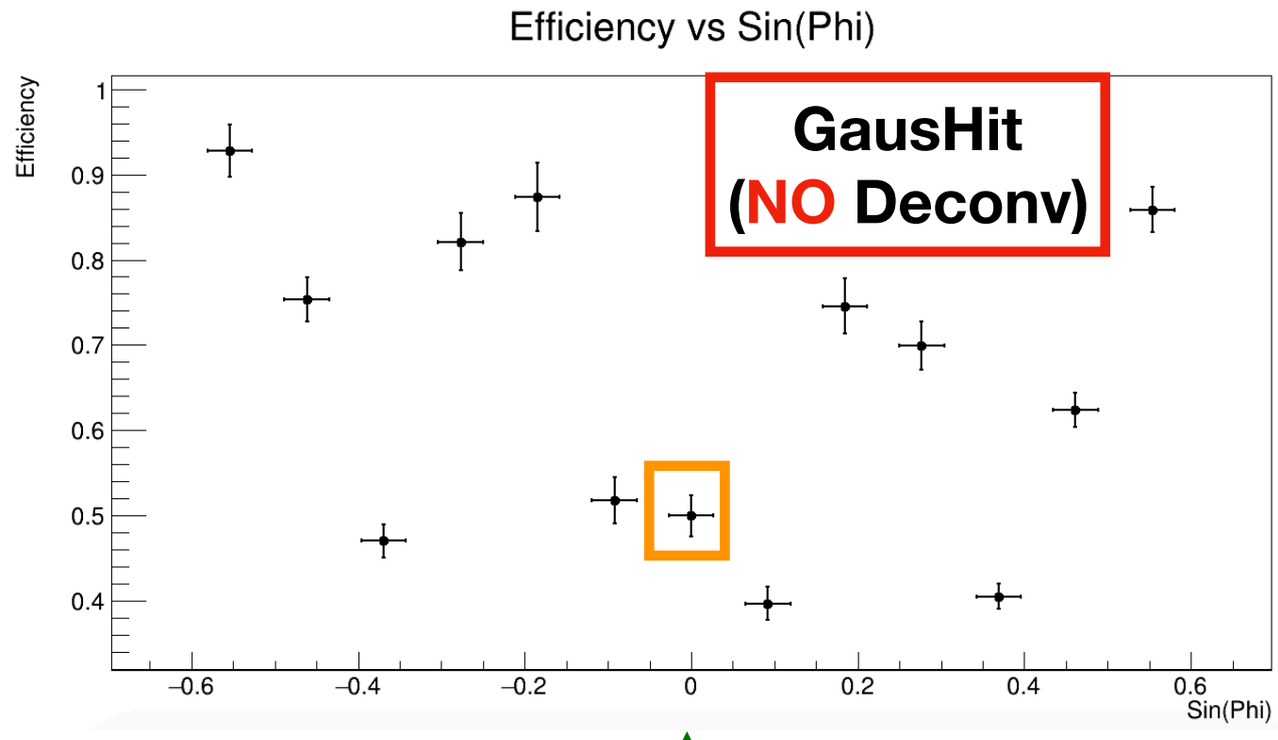
Parallel direction

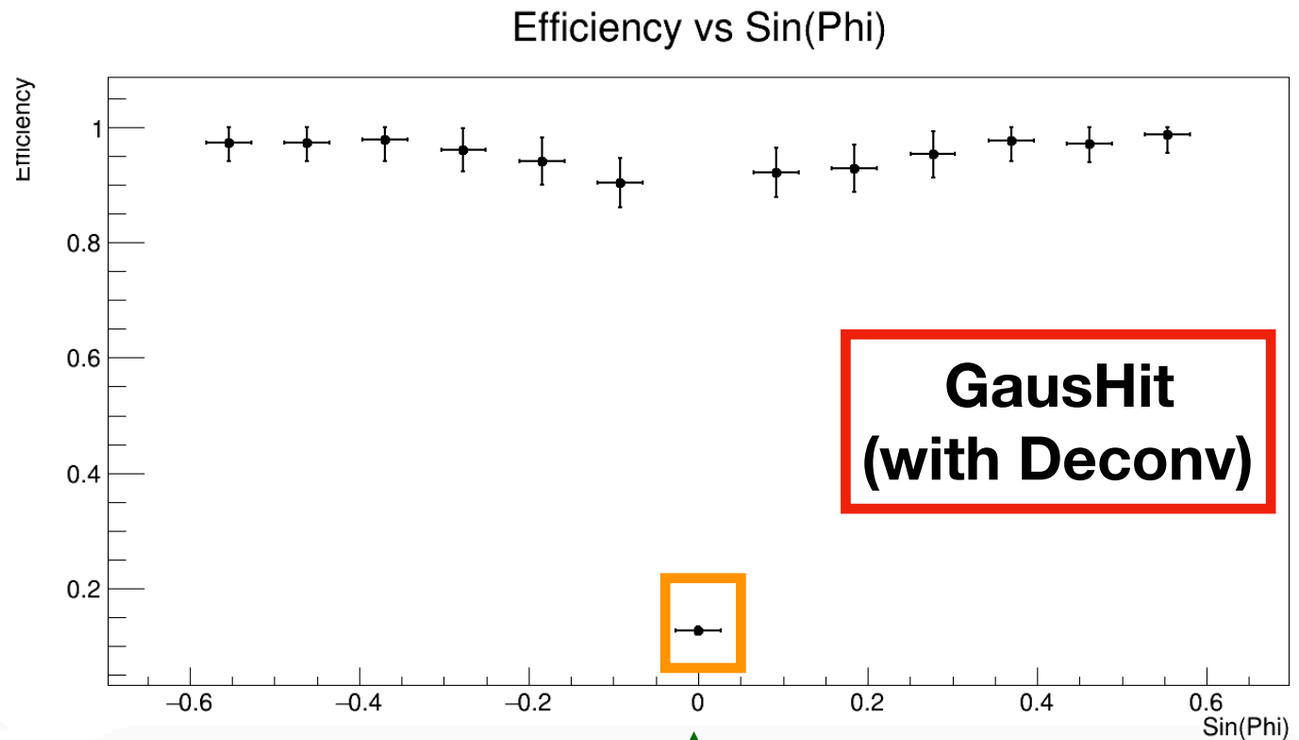
However when comparing the data points **for parallel tracks**
It is actually improving

~48% reco efficiency without deconvolution
VS
~15% reco efficiency with deconvolution

Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle





Parallel direction

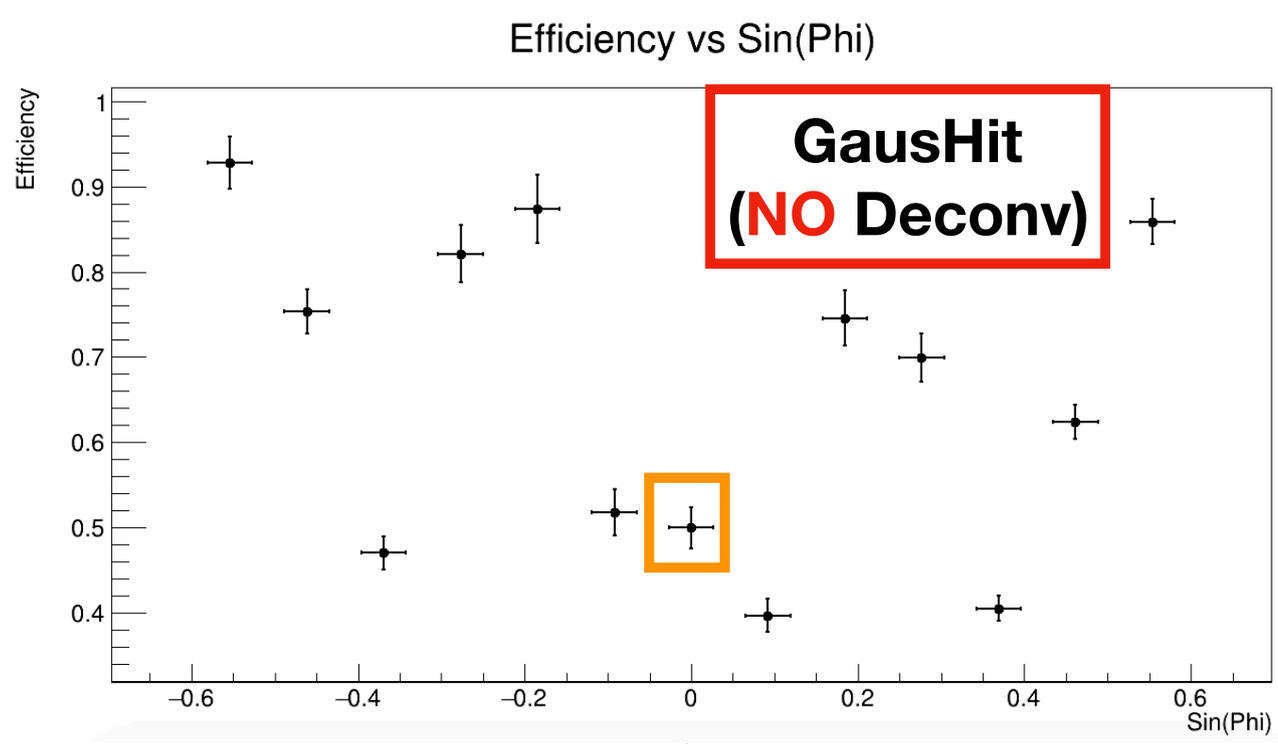
Reco efficiency withouth deconv seems to be random around 65% with 25% dispersion

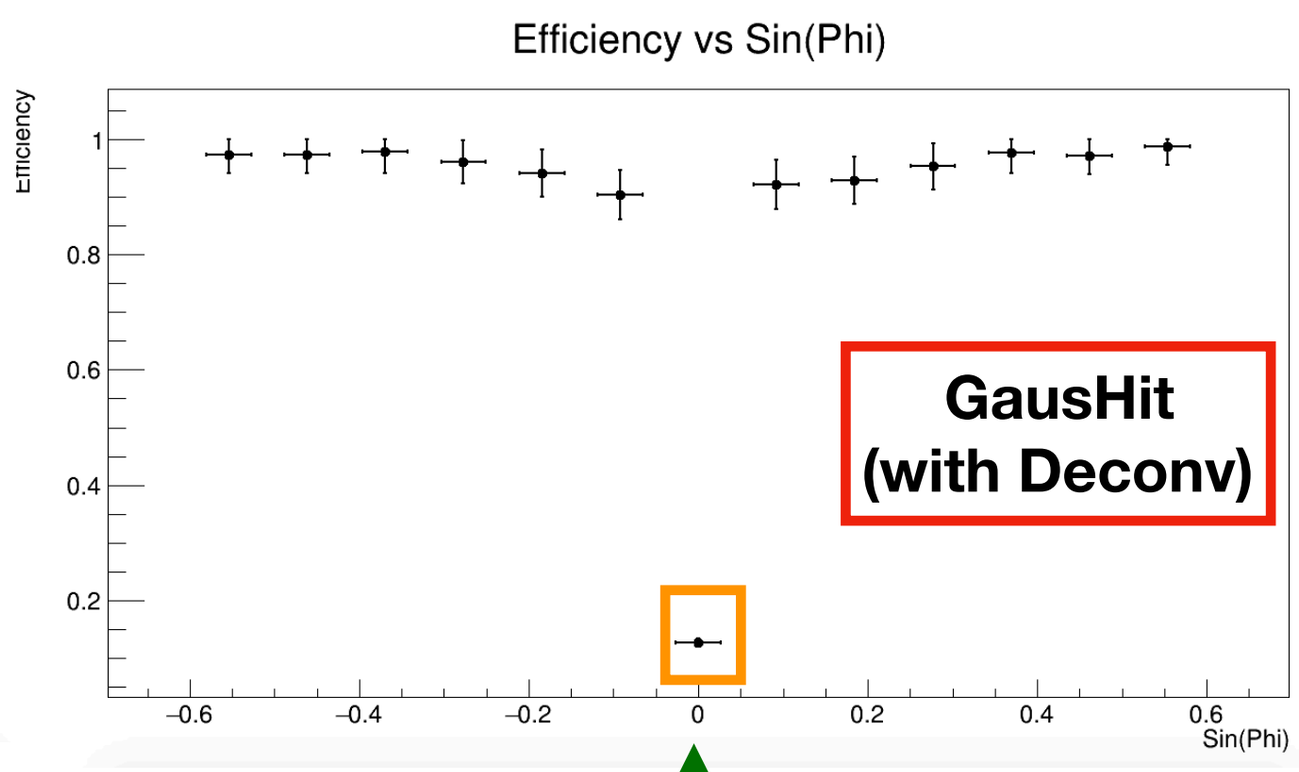
Still an clear improvement

Although need to cross check this

Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle

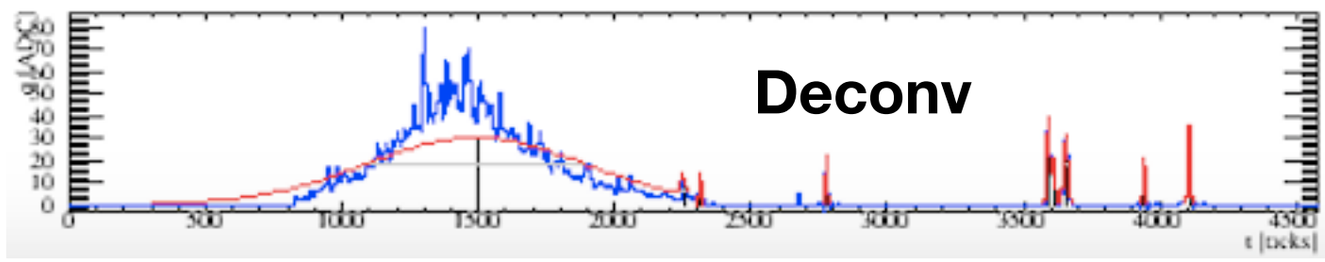


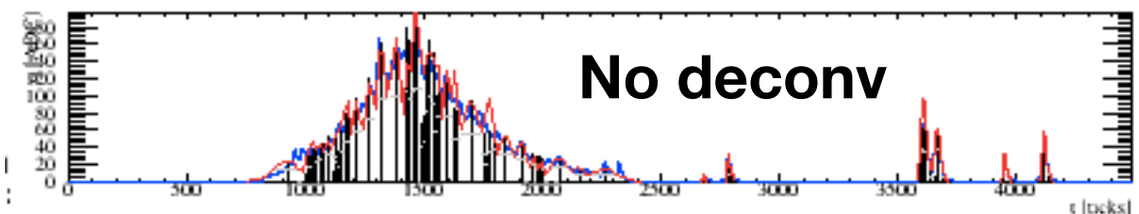


Parallel direction

Main lead :

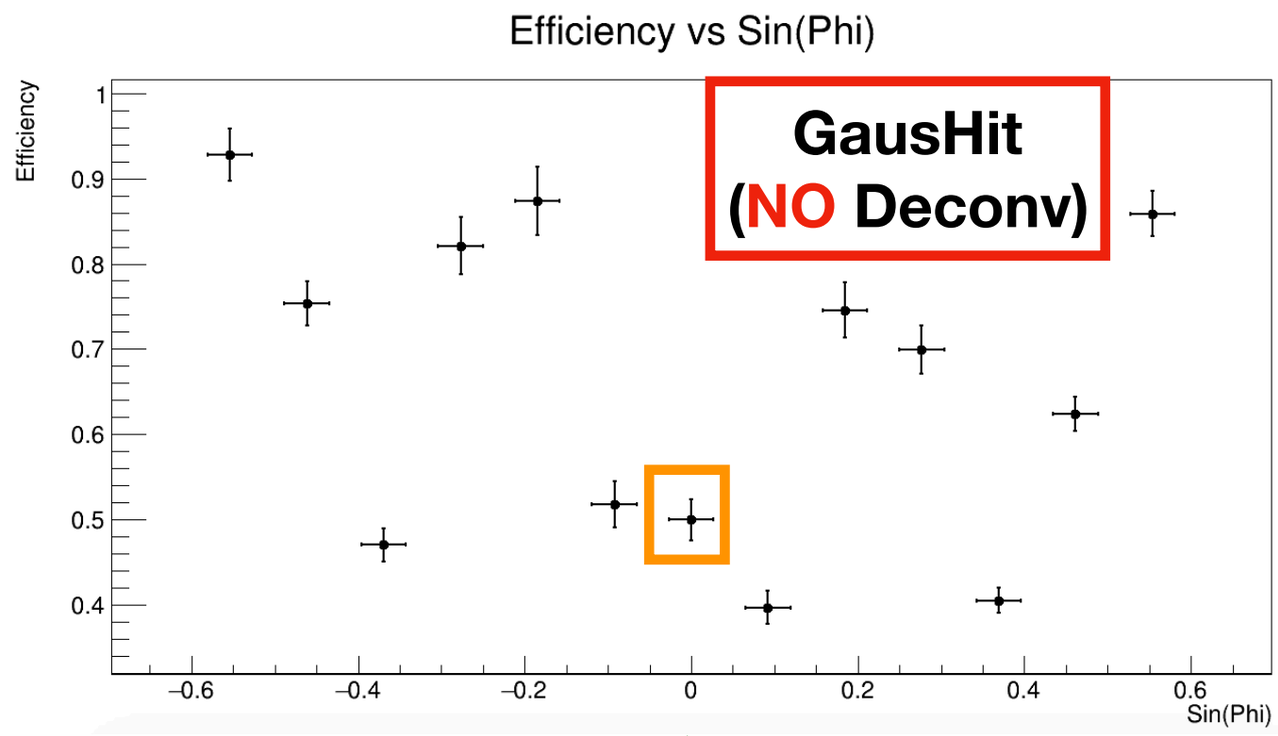
One big hit with deconv
VS
Many hits without deconv

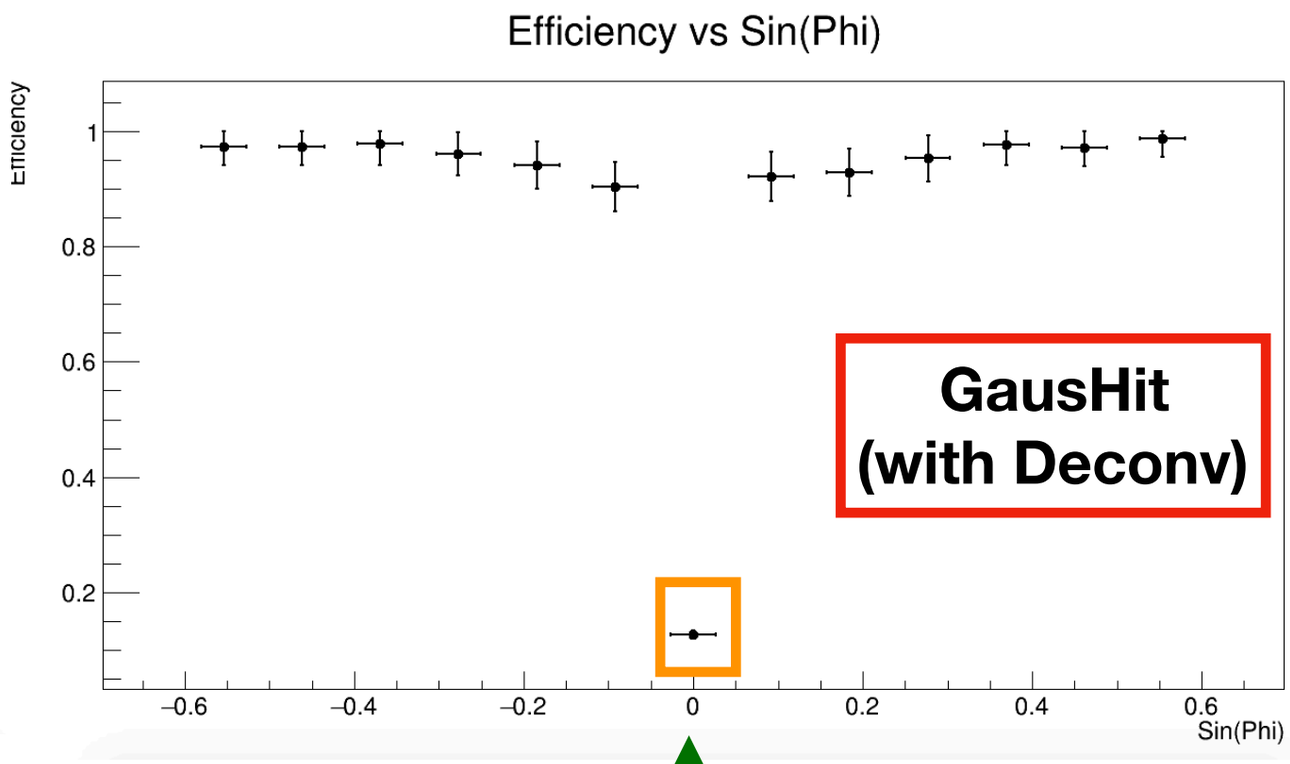




Hit reconstruction comparison

Track reconstruction efficiency vs Horizontal angle





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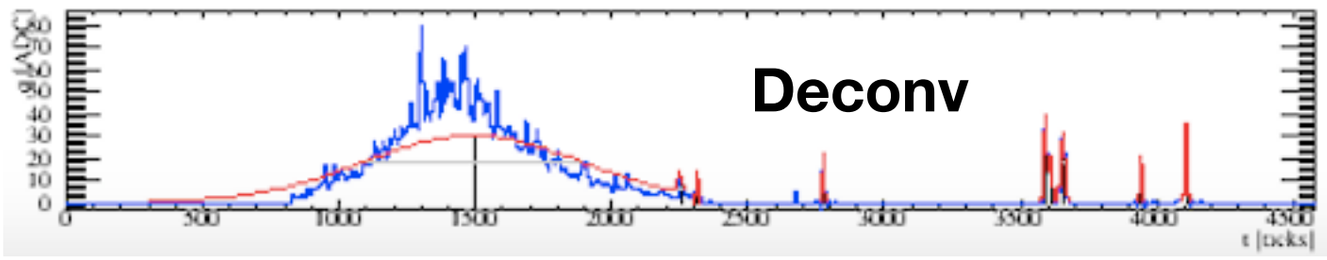

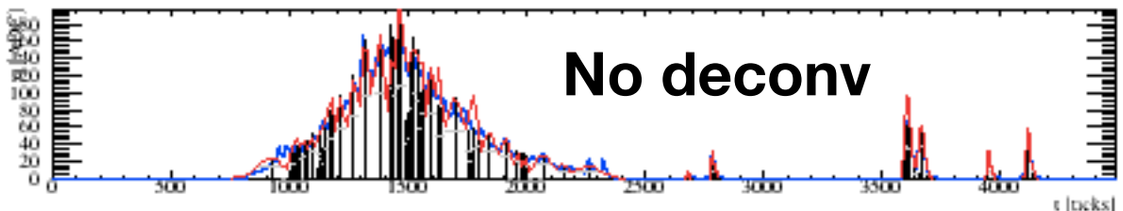

Easier view matching ?

Summary

- DP Pandora is fully integrated in LArSoft and ready to be used by anyone

- Hit reconstruction algorithm comparison is on-going (need to define a precise validation metric). Already went from a 20° to a 10° danger zone around parallel direction. Leaving the deconvolution for parallel track seem to improve drastically the reco (from 15% to 50% efficiency)

- Writing proper modules/fcl for easy simulation (Particle Gun, cosmics and neutrinos) in Dual-Phase

Reconstruction performance

2 quantities are used to **evaluate the quality** of the reconstruction:

- **Purity**

  Proportion of the reconstructed track that actually belongs to the true track

- **Completeness**

Proportion of the true track that is contained in the reconstructed track