



Status report on **DNNROI sigproc**

Hokyeong Nam
Chung-Ang University

Memory Optimization

```
=====
MemoryTracker summary (base-10 MB units used)
```

```
Peak virtual memory usage (VmPeak)  : 17755.8 MB
Peak resident set size usage (VmHWM): 6958.67 MB
Details saved in: 'mem.db'
```

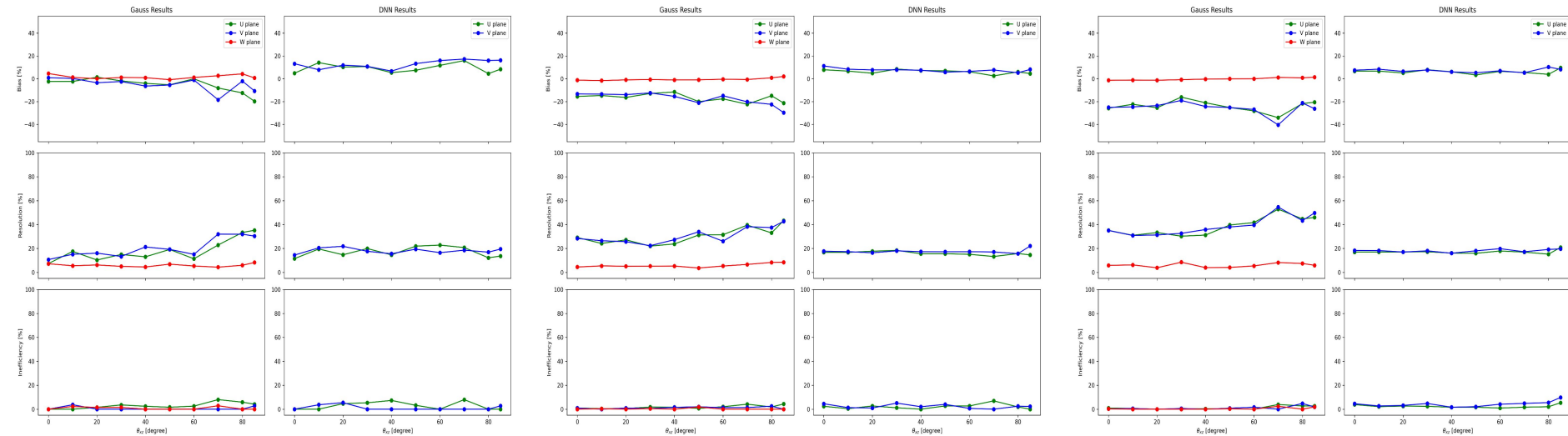


```
=====
MemoryTracker summary (base-10 MB units used)
```

```
Peak virtual memory usage (VmPeak)  : 16437.5 MB
Peak resident set size usage (VmHWM): 5689.09 MB
Details saved in: 'mem.db'
```

- Tested with UNet
- Deactivating `save_data` reduces the memory usage about 1 GB

DNN SP evaluation - single shower event



P0: 100 MeV, SigmaP: 0.05



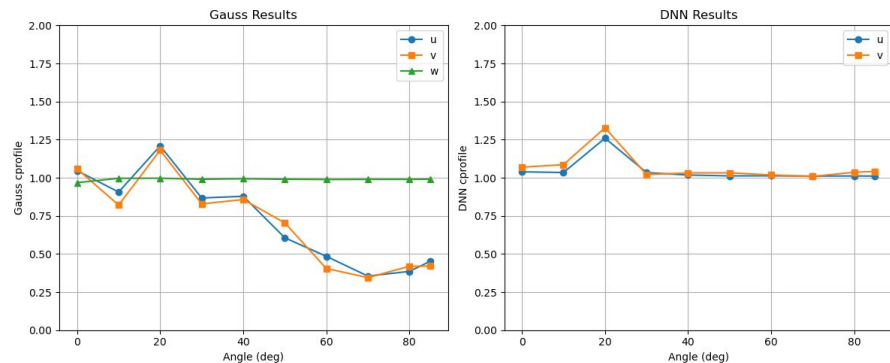
P0: 1 GeV, SigmaP: 0.05



P0: 5 GeV, SigmaP: 0.05

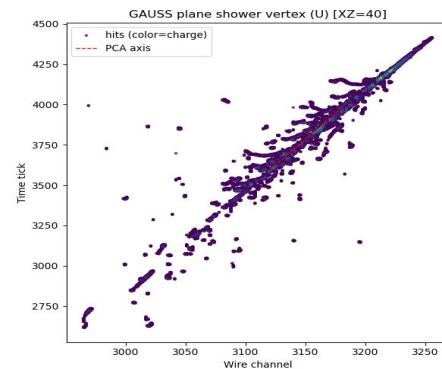
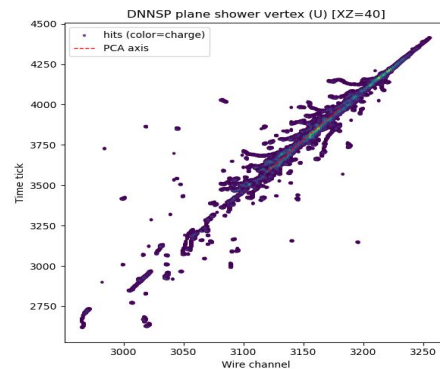
- As the energy increases, the bias and resolution in Gauss is getting worse
- DNN SP maintains more consistent performance across all energy levels

DNN SP evaluation - single shower event



□ P0: 5 GeV, SigmaP: 0.05

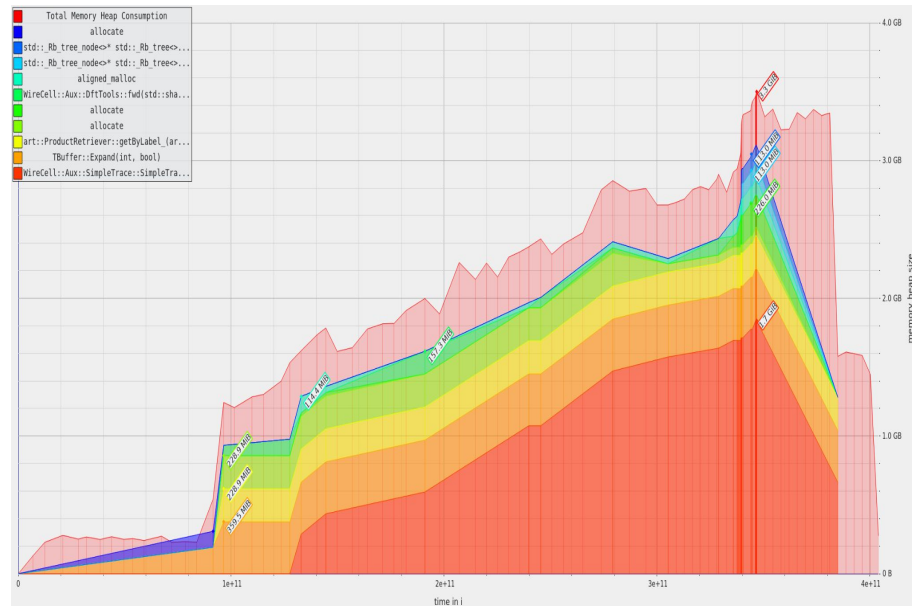
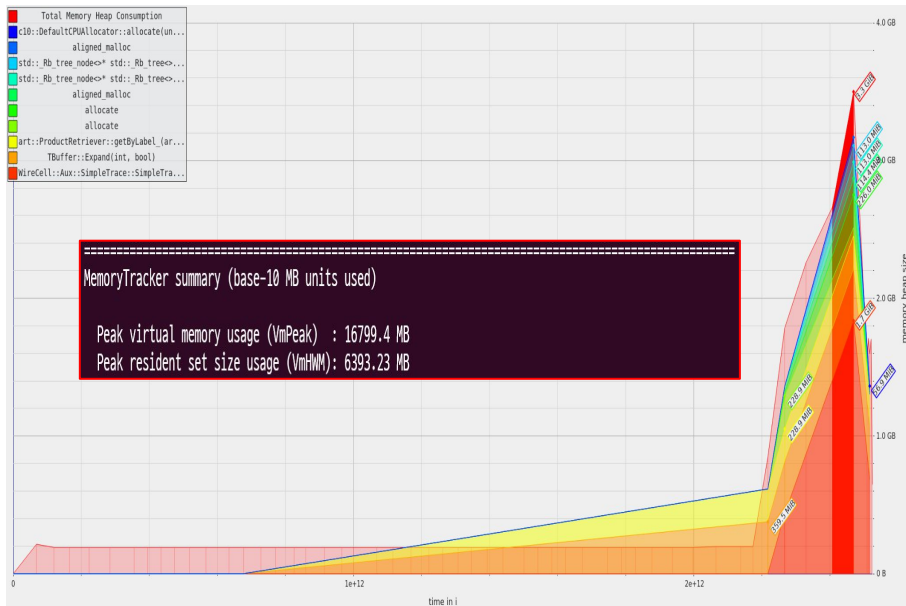
- New metrics for Shower evaluation:
 - Angle diff
 - Charge profile within 1 radiation length (14 cm ~ 47 wire channels)
- Charge Profile: Decon / Truth
- DNN showed better performance when we look at near the vertex



	Angle diff	
	Gauss (deg.)	DNN (deg.)
U plane	0.74	0.82
V plane	0.52	0.51
W plane	1.22	

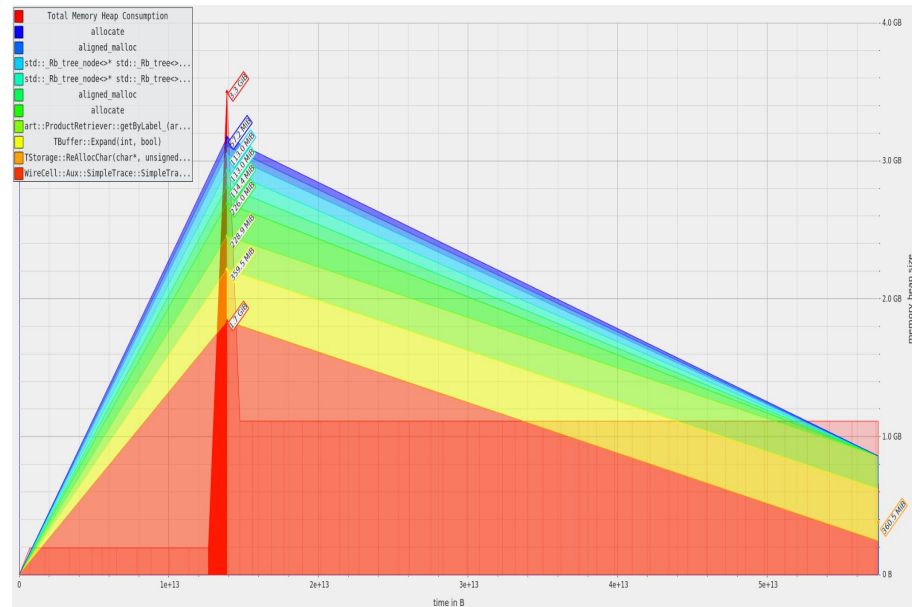
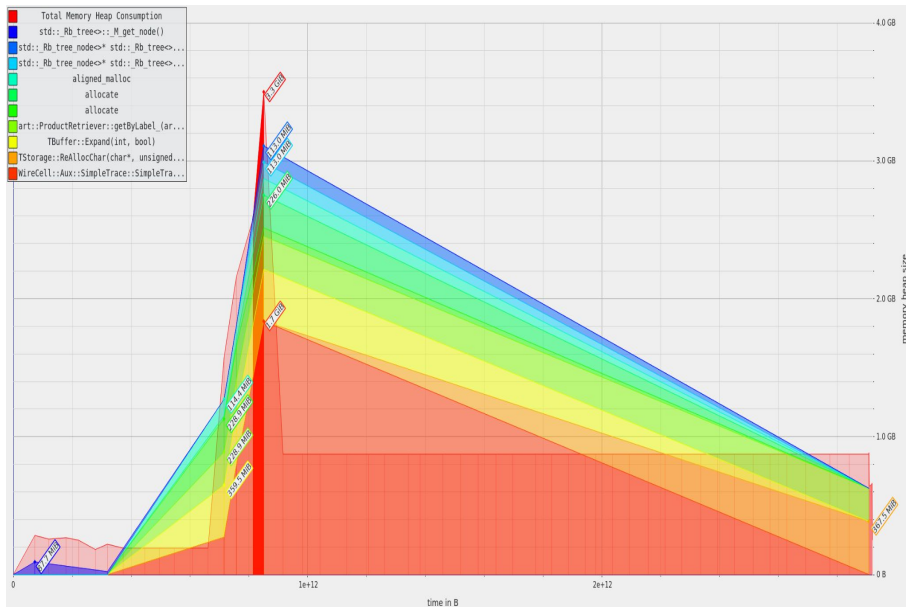
Back Up

Memory Profiling - Valgrind



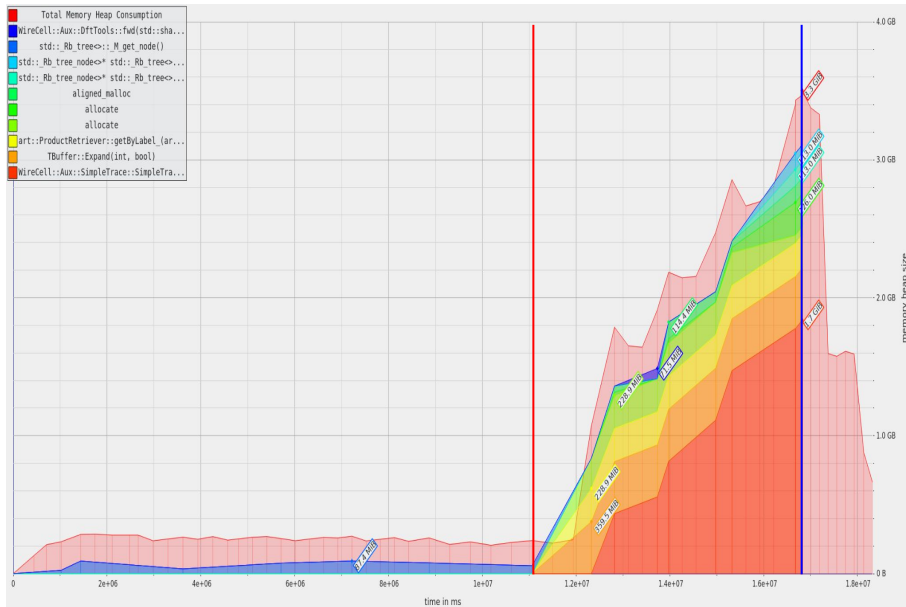
- Profiled twice over DNN SP (MobileNetV2) with a PD-HD data file (one event)
- Time unit: i - instructions (default)
- The left is what I shared in the last meeting, the right one is newly generated
- The peak appears near the end of the instructions
- The peak memory from Valgrind (~ 3.3 GiB) is different from LArSoft's MemoryTracker (~6.4 GB)

Memory Profiling - Valgrind



- Profiled twice over DNN SP (MobileNetV2) with a PD-HD data file (one event)
- Time unit: B - Bytes
- For the same data processing, total amount of heap memory allocated is different
- The peak appears abruptly, and there is low memory usage after the peak

Memory Profiling - Valgrind

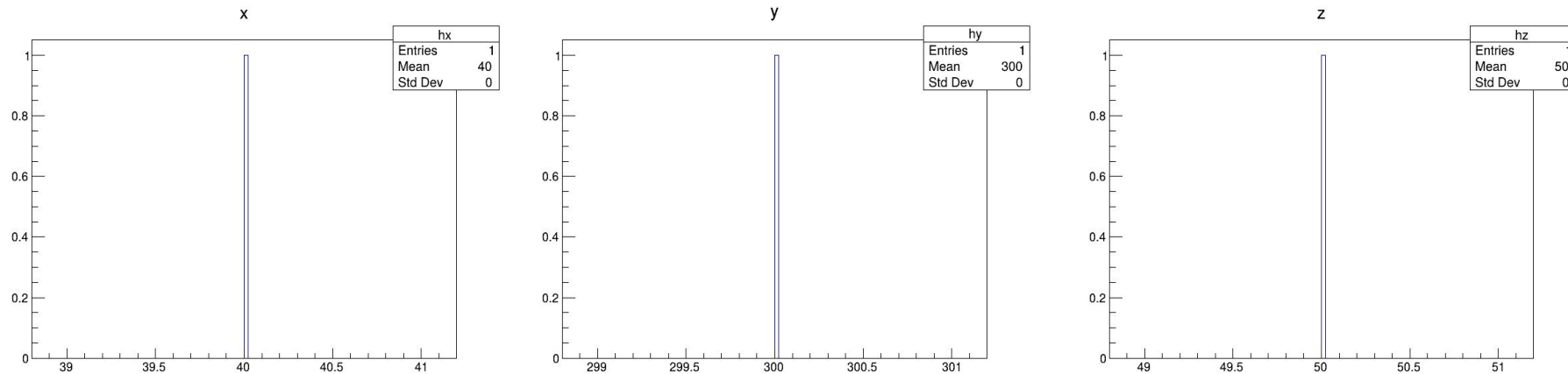


```
=====
MemoryTracker summary (base-10 MB units used)

Peak virtual memory usage (VmPeak) :
XMSG-s ArtException: RootOutput:out1@EndJob 15-Jul-2025 15:33:06 PDT ModuleEndJob
---- SQLExecutionError BEGIN
      unique_value expected of non-unique query.
---- SQLExecutionError END
XMSG
Art has completed and will exit with status 1.
Command exited with non-zero status 1
Command being timed: "valgrind --tool=massif --time-unit=ms --massif-out-file=massif_output_mobilenetv2_timems2.out --stacks=yes -
-log-file=valgrind_timems2.log lar -n1 -c my_standard_reco_stage2_calibration_protodunehd_keepup_dnnroi.fcl -s .././../data/stage1/run
027673/np04hd_raw_run027673_0000_dataflow0_datawriter_0_20240704T050545_reco_stage1.root"
User time (seconds): 6884.62
System time (seconds): 11417.65
Percent of CPU this job got: 99%
Elapsed (wall clock) time (h:mm:ss or m:ss): 5:06:16
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 6398684
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 73
Minor (reclaiming a frame) page faults: 1606802
Voluntary context switches: 307636
Involuntary context switches: 122524
Swaps: 0
File system inputs: 0
File system outputs: 241944
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 1
Done.
Massif output file: massif_output_mobilenetv2_timems2.out
Valgrind log file: valgrind_timems2.log
```

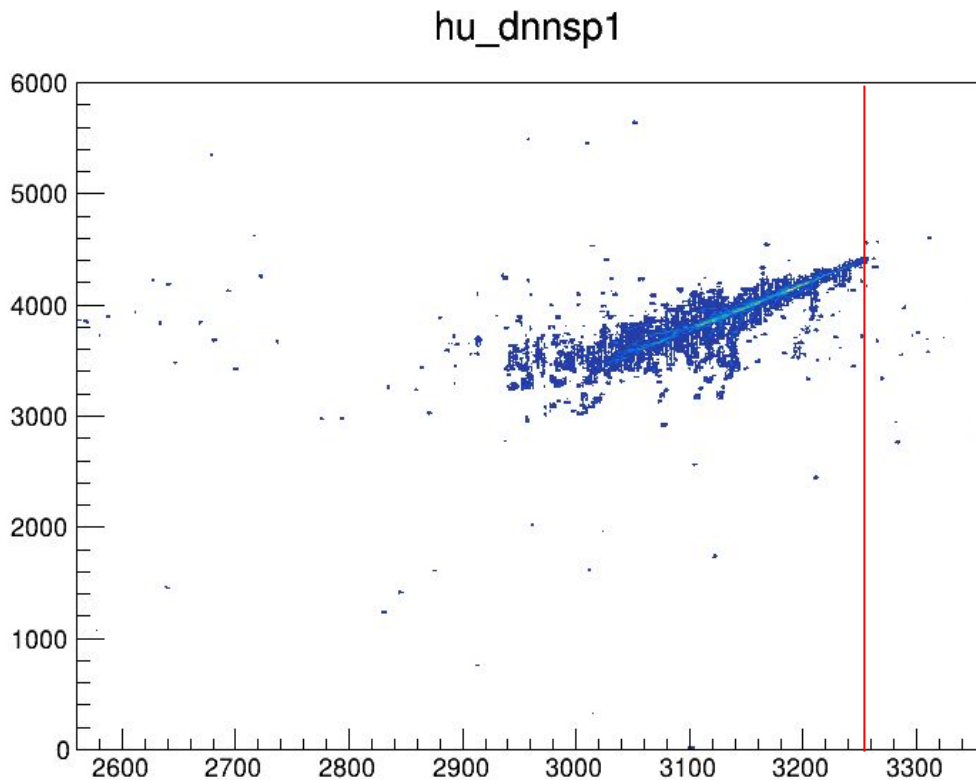
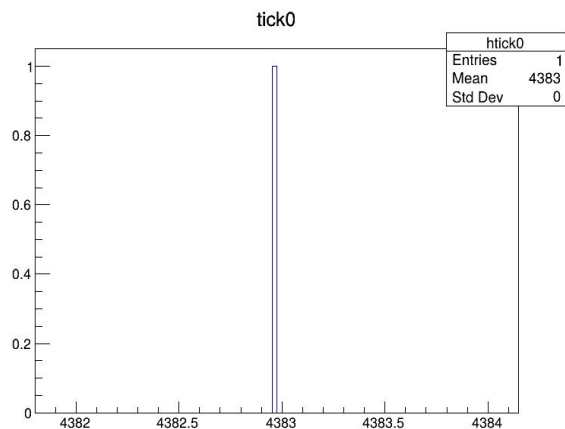
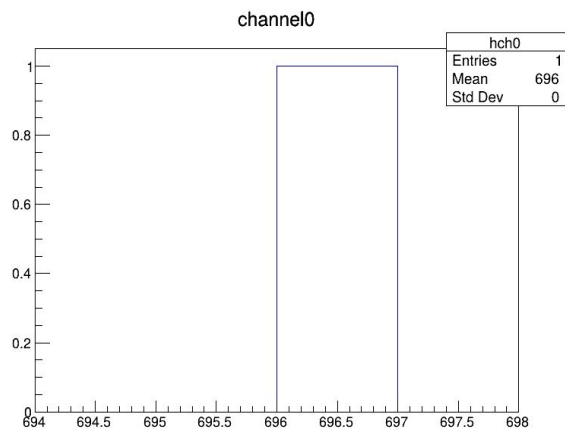
- Profiled twice over DNN SP (MobileNetV2) with a PD-HD data file (one event)
- **Time unit: ms - milliseconds**
- Profiling stopped due to error: unique_value expected of non-unique query
- Run time is almost 5 hours but the memory usage is low for 3 hours (red line)
- The peak snapshot is taken within very short time (blue line)

ShowerAna module



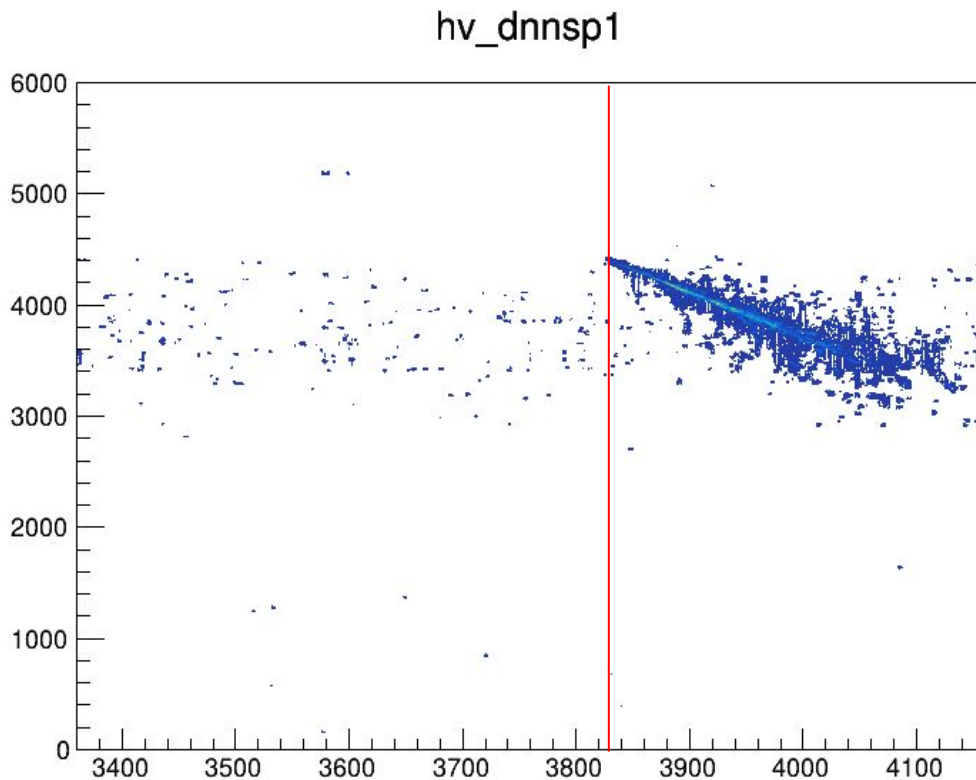
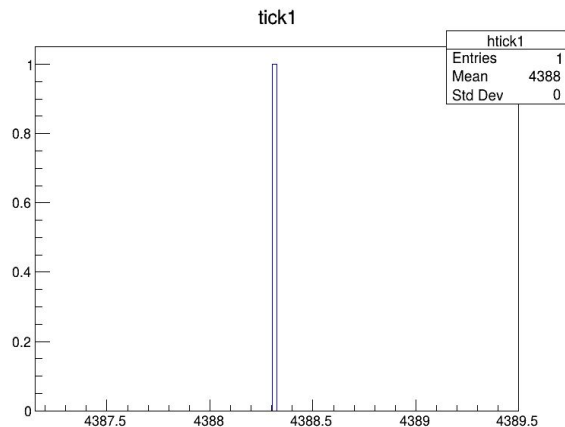
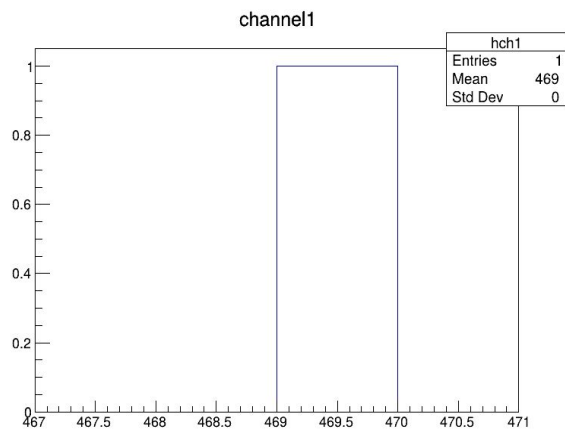
- Get the information of the primary electron, and save the followings:
 - initial position (x, y, z) and corresponding wire channels and time ticks
 - momentum (px, py, pz), pid, tpc id
 - normalized momentum \rightarrow unit direction (dirx, diry, dirz)
 - extrapolated position (x_ex, y_ex, z_ex) and corresponding wire channels and time ticks
ex) $x_ex = x + step * dirx$
- Detector Geometry (@local::protodunehdv6_geo) from fcl files below:
 - standard_g4_protodunehd.fcl
 - standard_detsim_protodunehd.fcl

Truth Info. from MCParticle



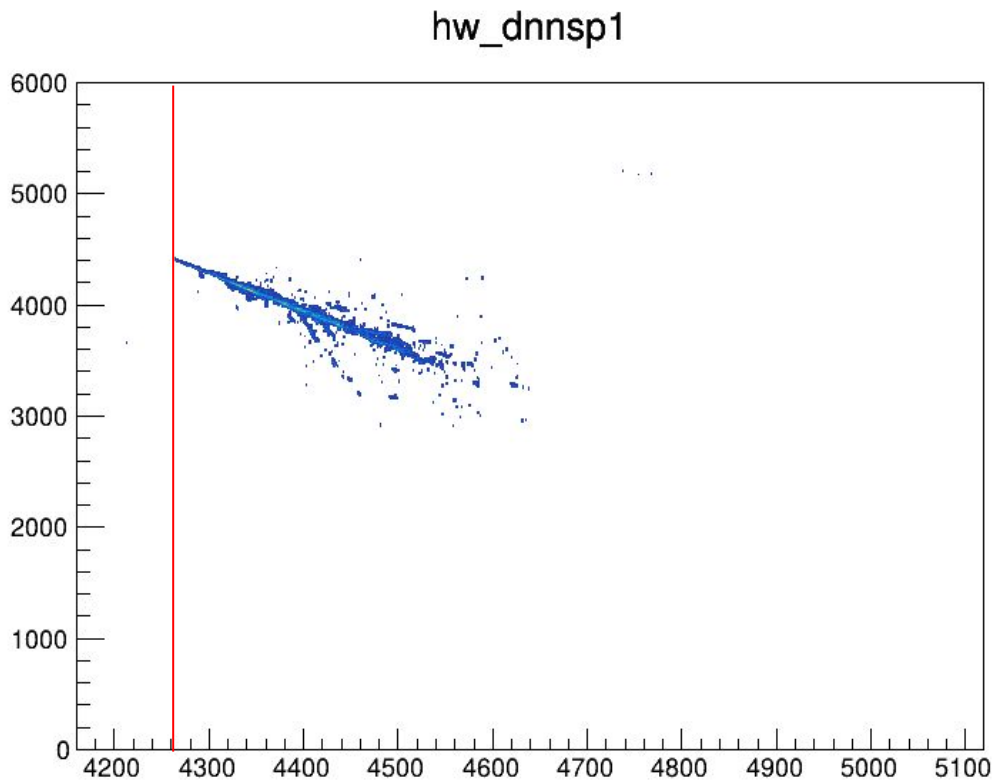
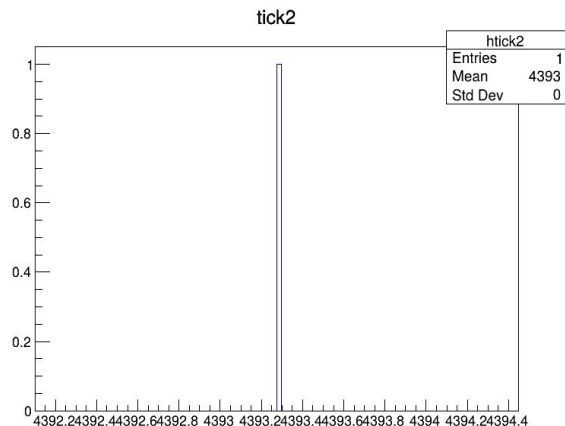
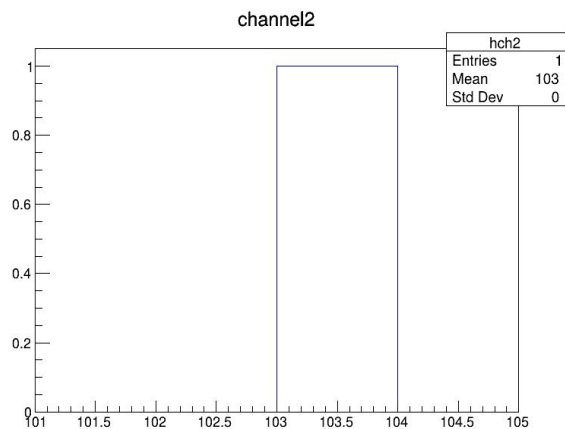
- For u plane of APA2, the (wire channel, time tick) is
 - wire channel: $2560 + 696 = 3256$
 - time tick: 4383

Truth Info. from MCParticle



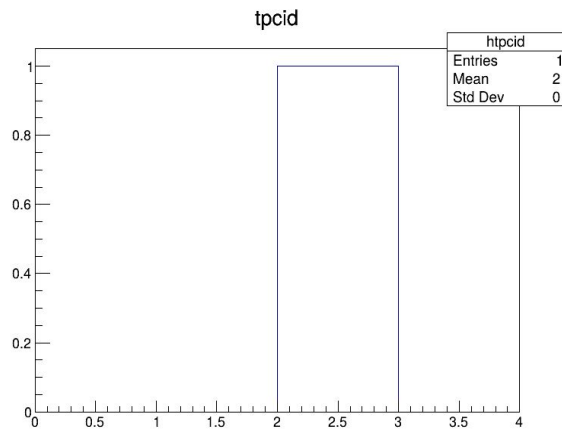
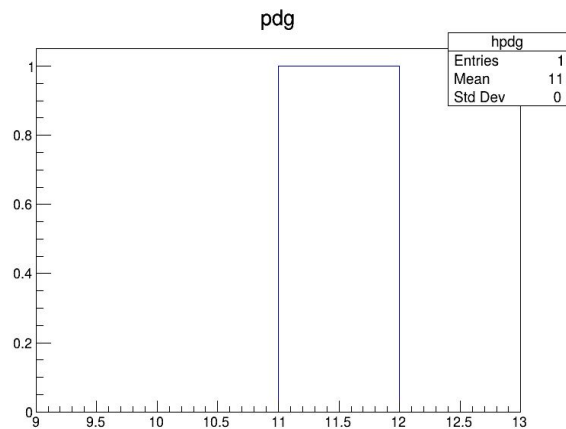
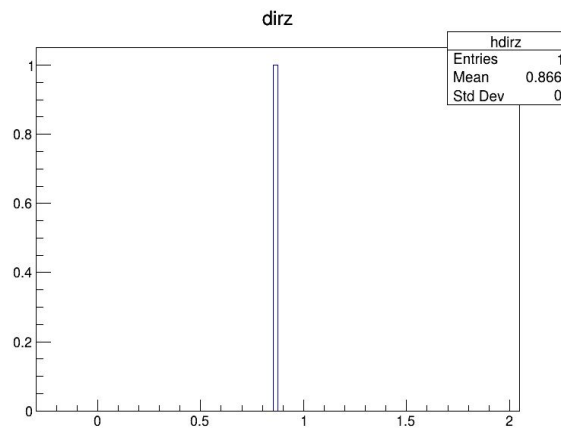
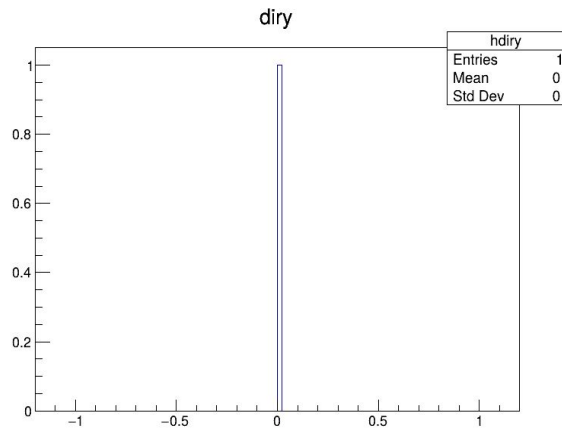
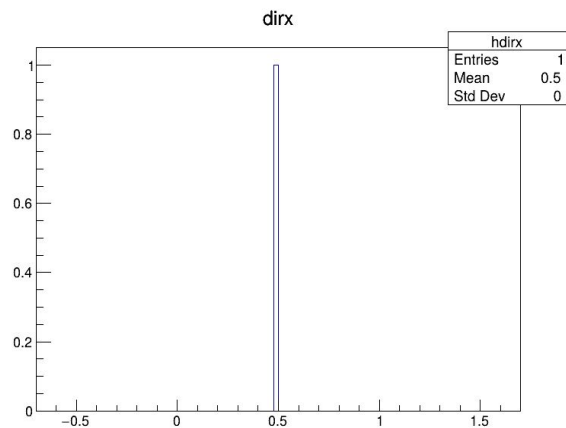
- For ν plane of APA2, the (wire channel, time tick) is
 - wire channel: $2560 + 800 + 469 = 3256$
 - time tick: 4388

Truth Info. from MCParticle



- For w plane of APA2, the (wire channel, time tick) is
 - wire channel: $2560 + 800 + 800 + 103 = 3256$
 - time tick: 4393

Truth Info. from MCParticle



Angle between reco and true direction

$$\frac{(\Delta w_{\text{true}} \Delta t_{\text{true}})}{\hat{v}_{\text{true}}} \equiv \frac{(\Delta w_{\text{reco}} \Delta t_{\text{reco}})}{\hat{v}_{\text{reco}}}$$

- From MCParticle

$$\Delta w_{\text{true}}^2 + \Delta t_{\text{true}}^2 \text{ PCA axis}$$

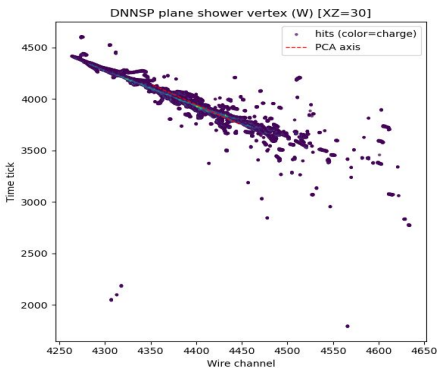
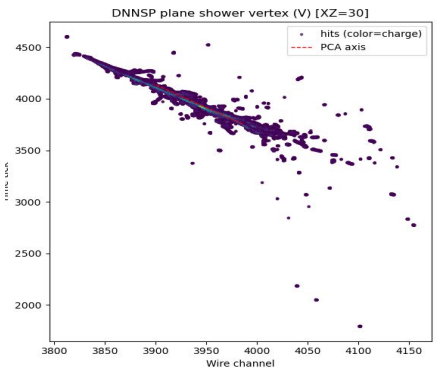
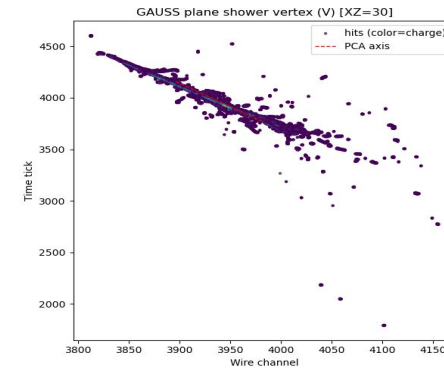
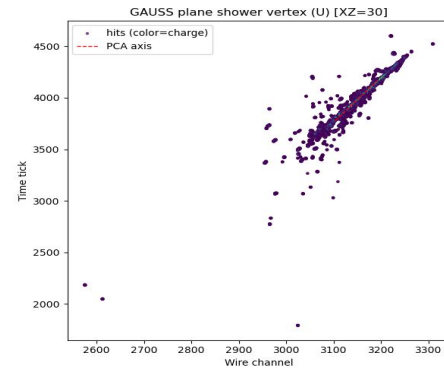
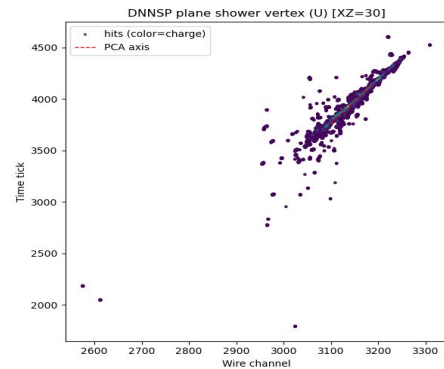
$$\Delta w_{\text{reco}}^2 + \Delta t_{\text{reco}}^2 \text{ PCA axis}$$

$$\Rightarrow \cos \theta \equiv \frac{\Delta w_{\text{true}} \Delta w_{\text{reco}} + \Delta t_{\text{true}} \Delta t_{\text{reco}}}{\Delta w_{\text{true}} \Delta w_{\text{reco}} + \Delta t_{\text{true}} \Delta t_{\text{reco}}}$$



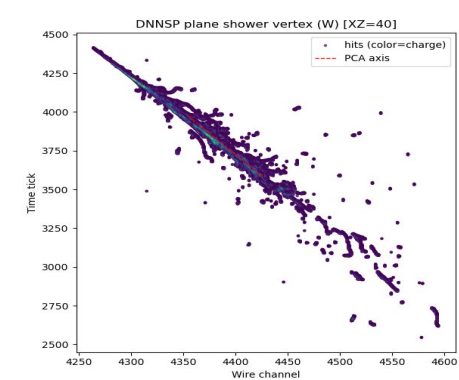
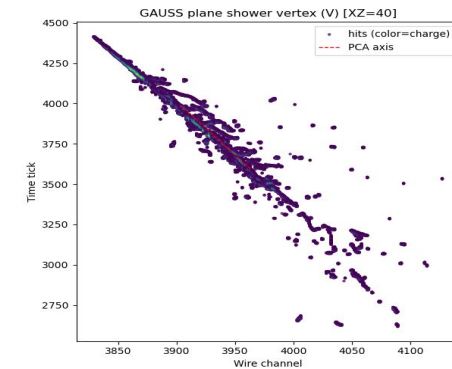
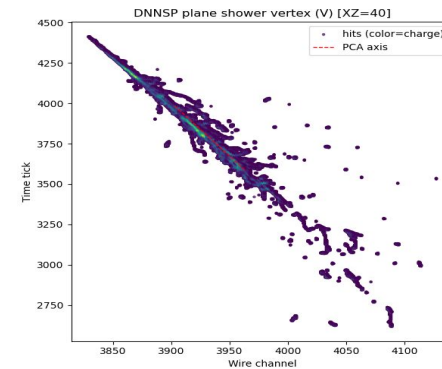
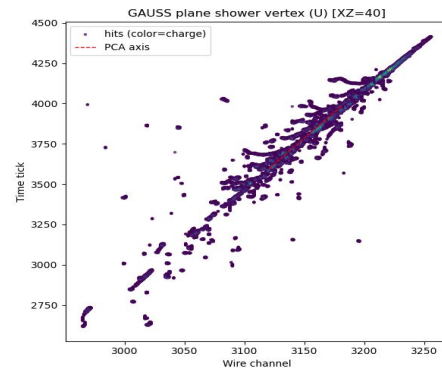
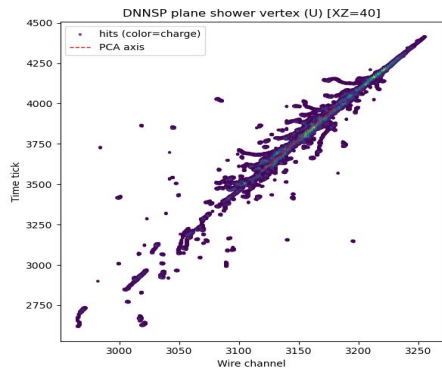
$$\theta = \arccos(\cos \theta)$$

Angle between reco and true direction (E = 5 GeV, XZ = 30)



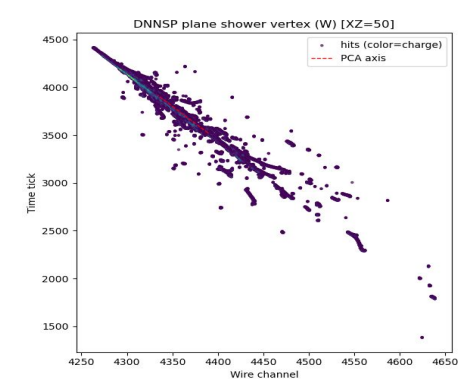
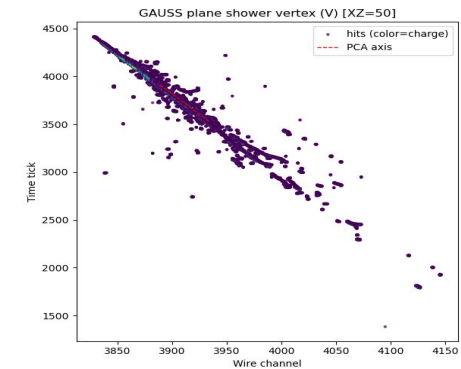
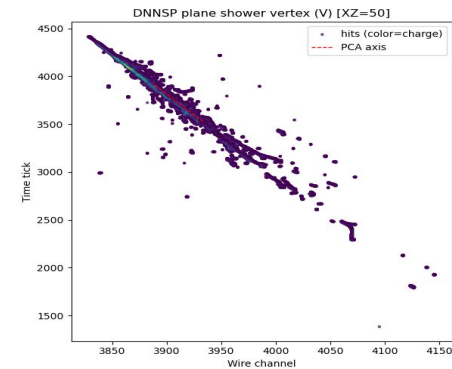
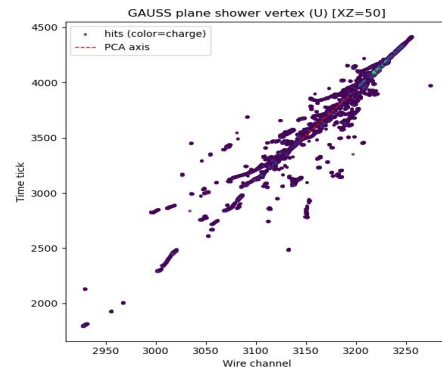
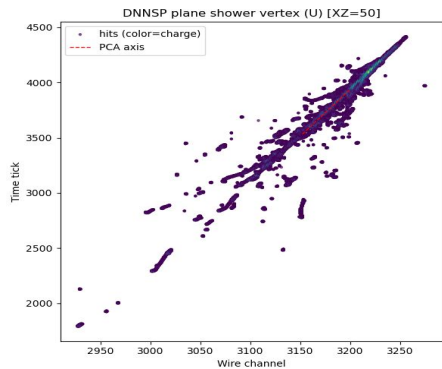
	Angle diff	
	Gauss (deg.)	DNN (deg.)
U plane	0.58	0.53
V plane	1.10	0.83
W plane	2.52	

Angle between reco and true direction (E = 5 GeV, XZ = 40)



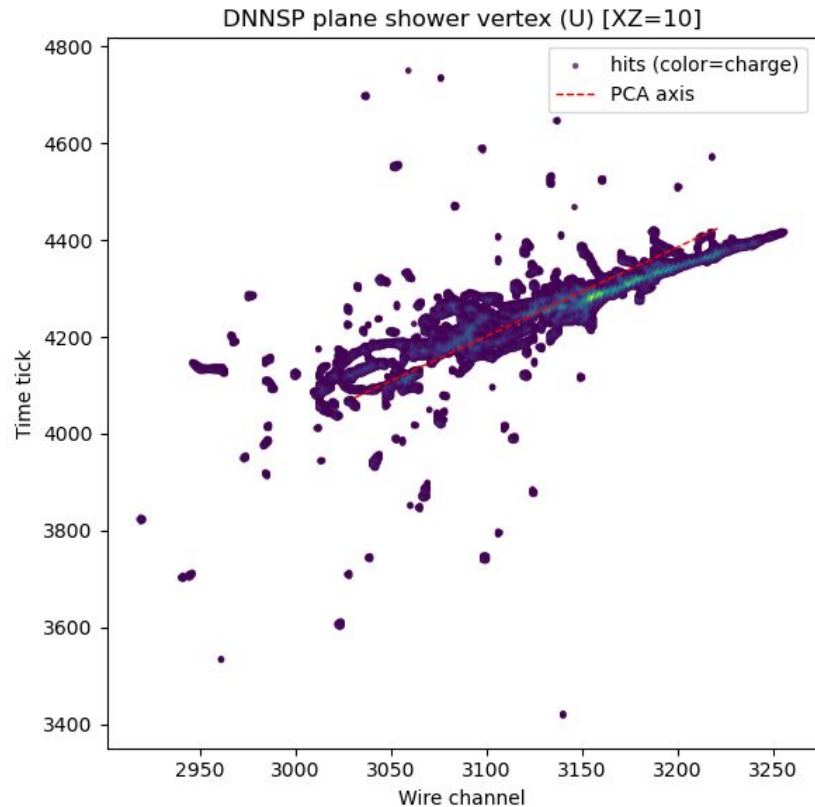
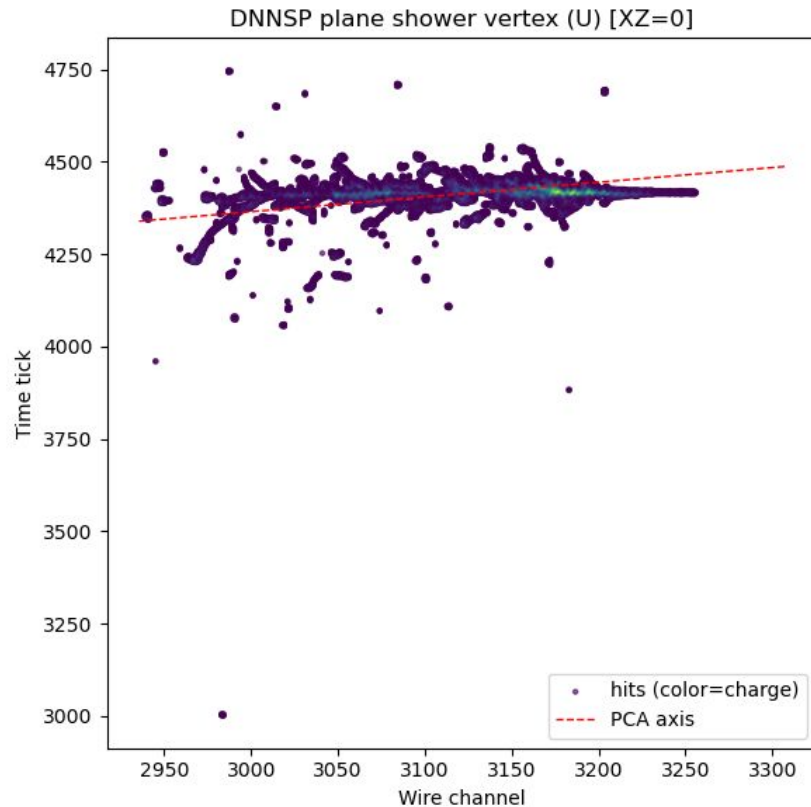
	Angle diff	
	Gauss (deg.)	DNN (deg.)
U plane	0.74	0.82
V plane	0.52	0.51
W plane	1.22	

Angle between reco and true direction (E = 5 GeV, XZ = 50)



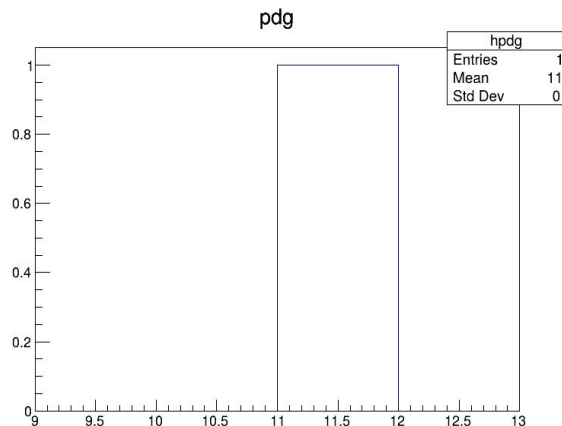
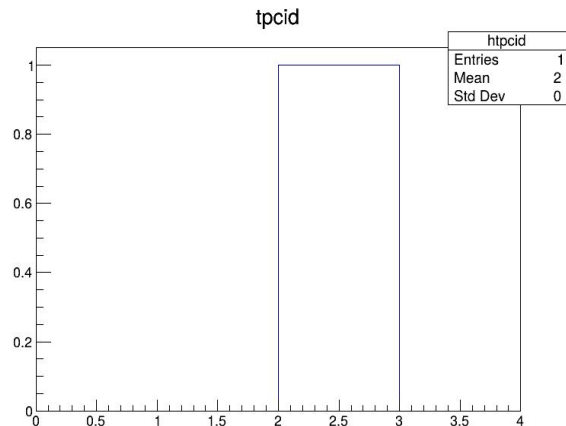
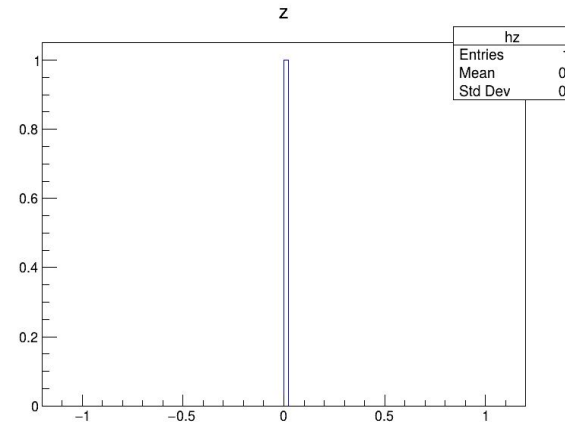
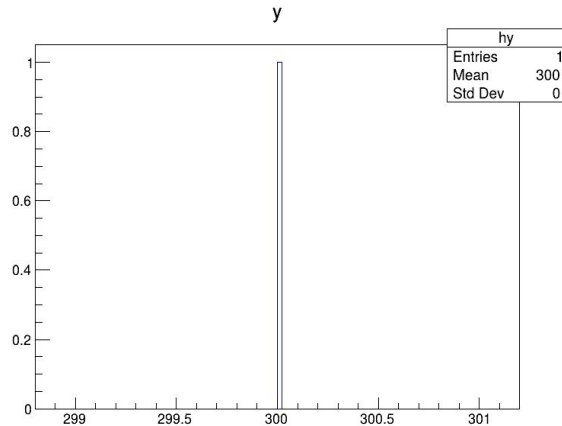
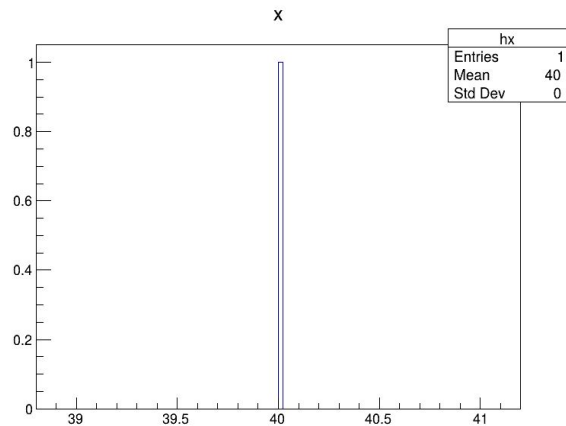
	Angle diff	
	Gauss (deg.)	DNN (deg.)
U plane	0.06	0.09
V plane	0.33	0.29
W plane	0.10	

Issues in PCA axis analysis



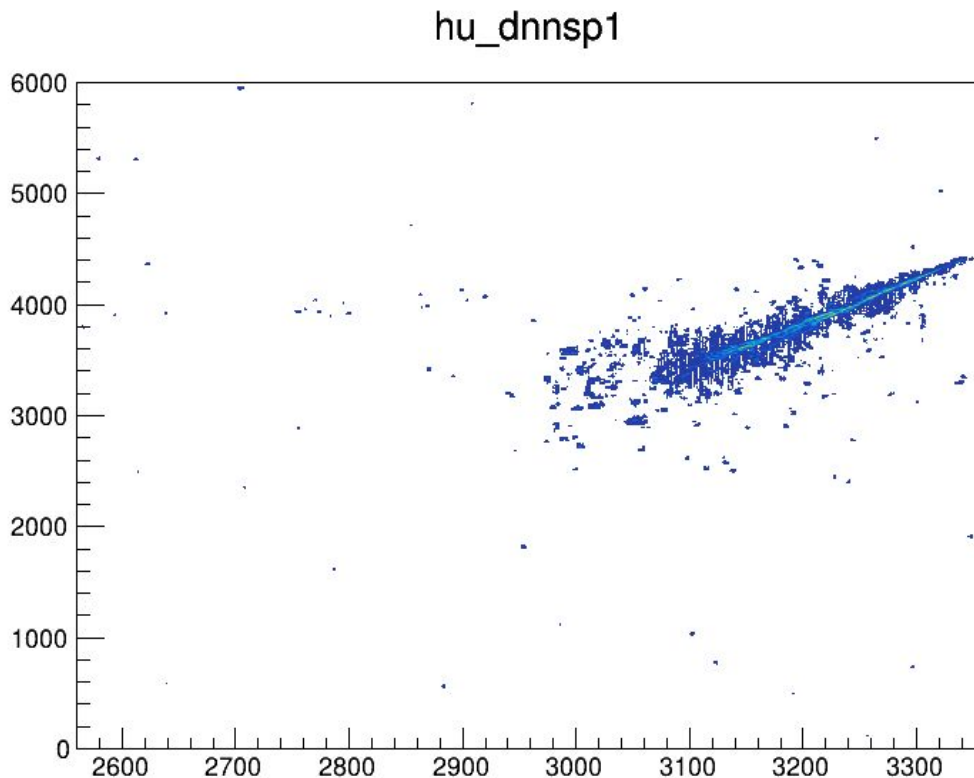
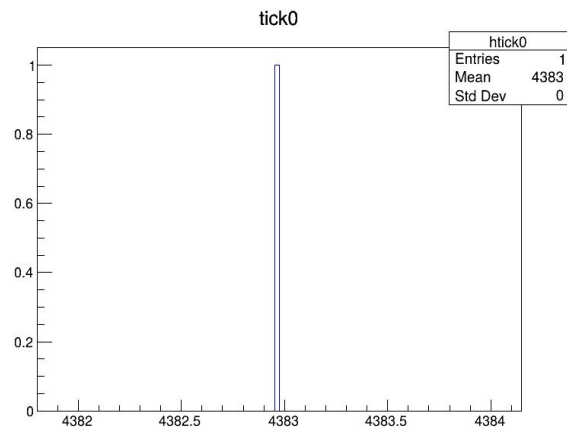
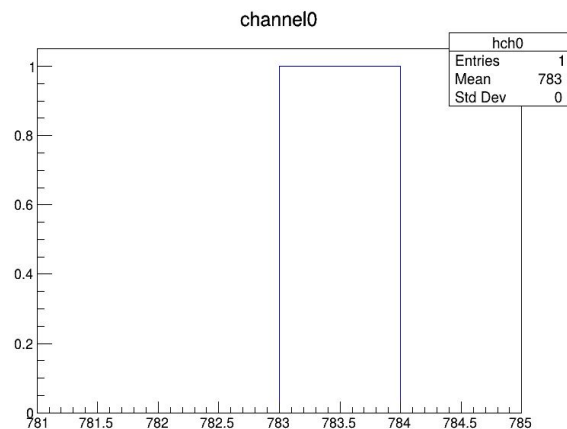
- PCA fails particularly for lower angles

ShowerAna module

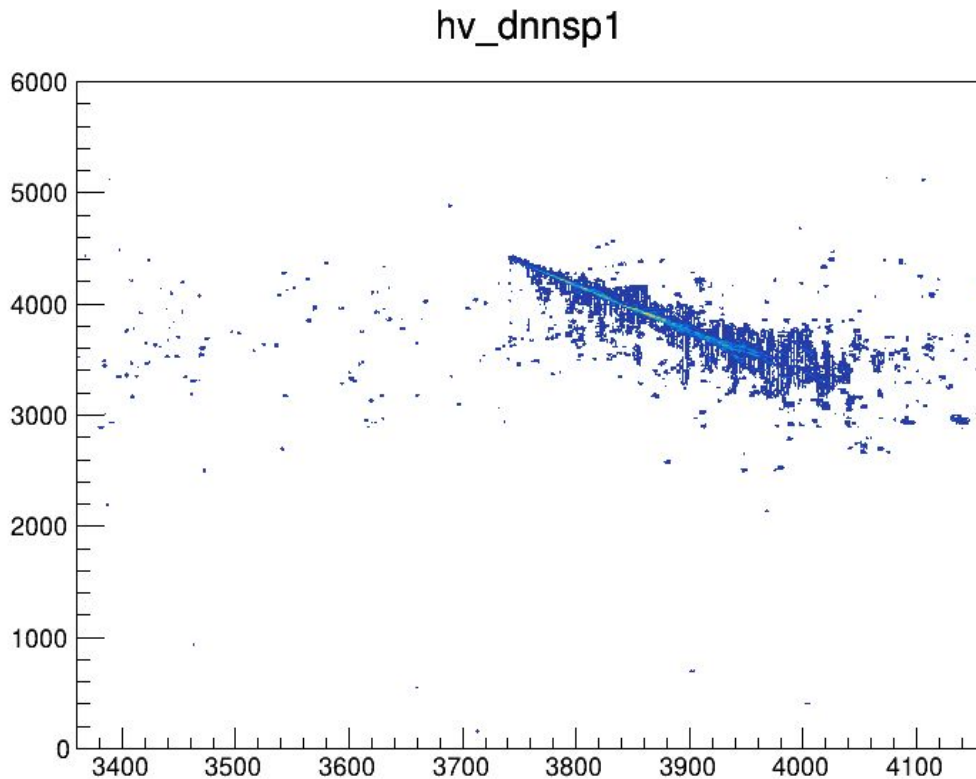
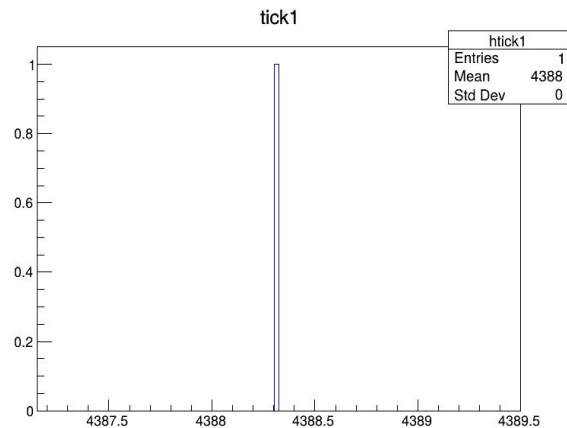
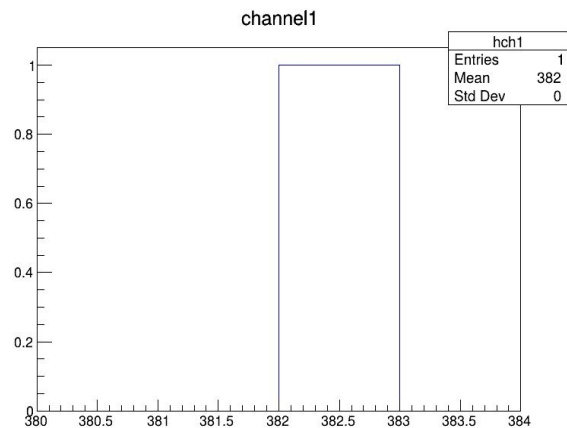


```
# This block defines starting parameters
physics.producers.generator.PosDist: 0
physics.producers.generator.X0: [40.]
physics.producers.generator.Y0: [300.]
physics.producers.generator.Z0: [0.0]
```

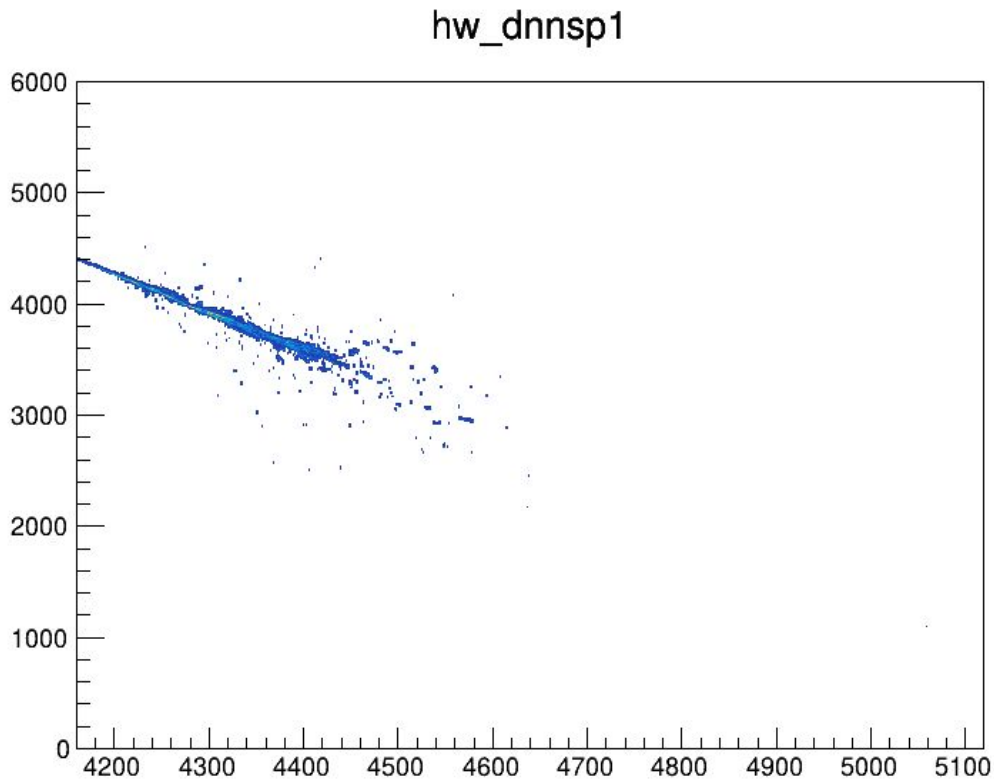
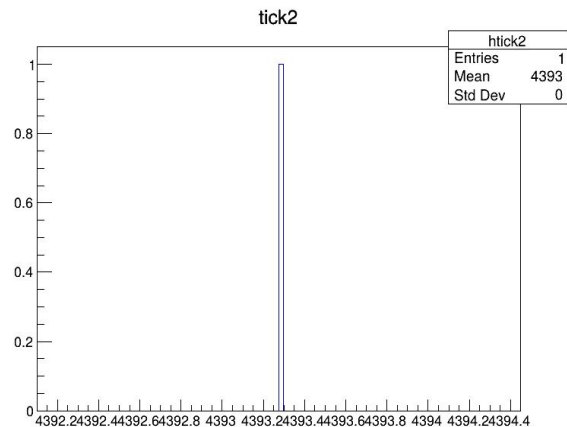
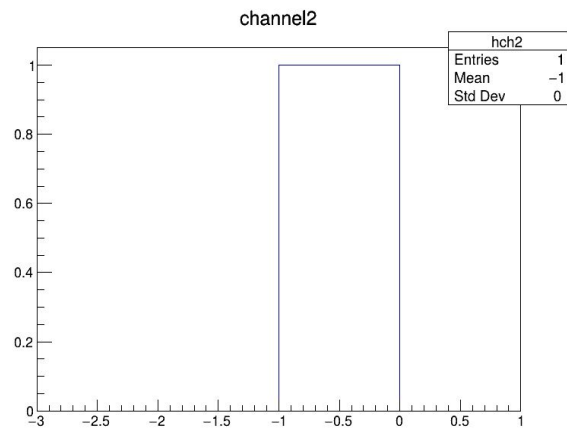
Truth Info. from MCParticle



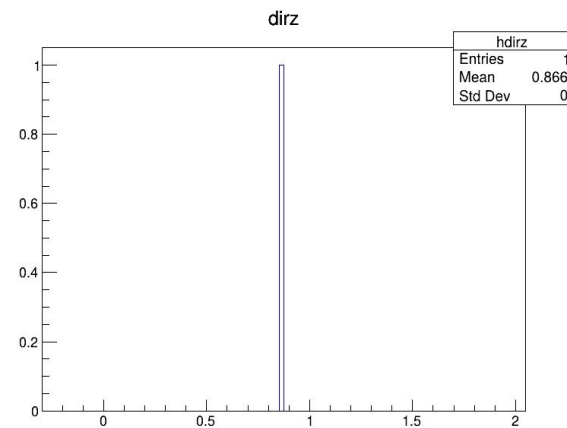
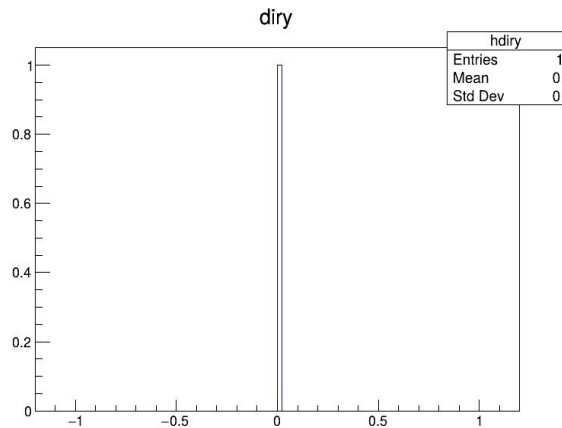
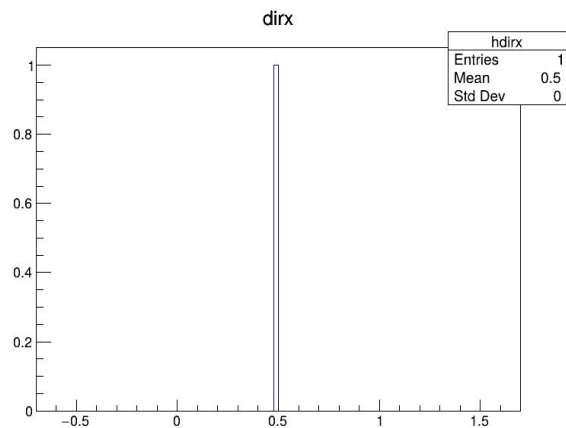
Truth Info. from MCParticle



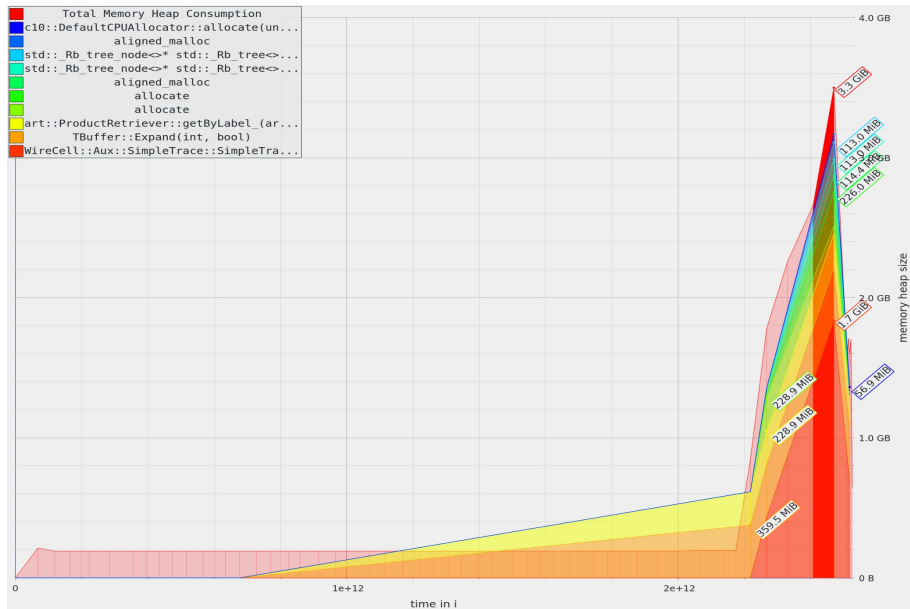
Truth Info. from MCParticle



Truth Info. from MCParticle



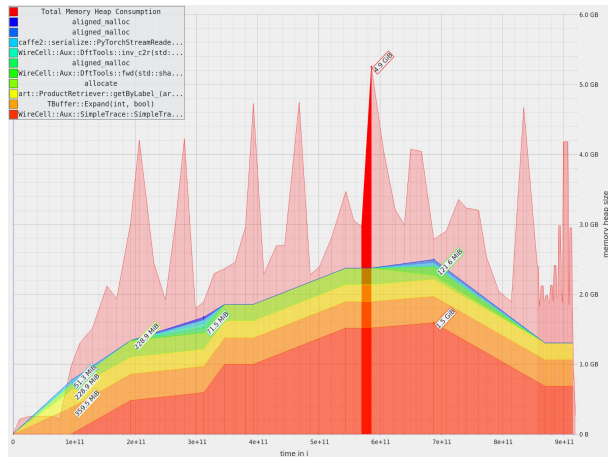
Memory Profiling - Valgrind



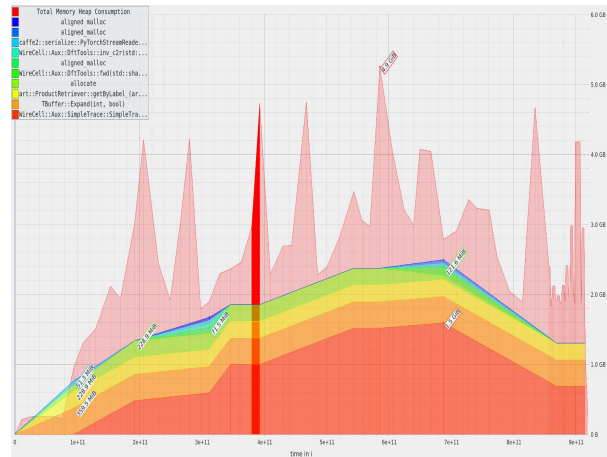
- PD-HD data, DNN SP with MobileNetV2
- The peak memory recorded is 3.3 GiB
- Almost half of the memory (~1.7 GiB) is due to:
 - WireCell::SigProc::OmnibusSigProc::save_data (972 MiB out of 1.7 GiB)
 - WireCell::SigProc::OmnibusSigProc::save_mproi (440 MiB out of 1.7 GiB)

do not mp protect tradtional is set to true

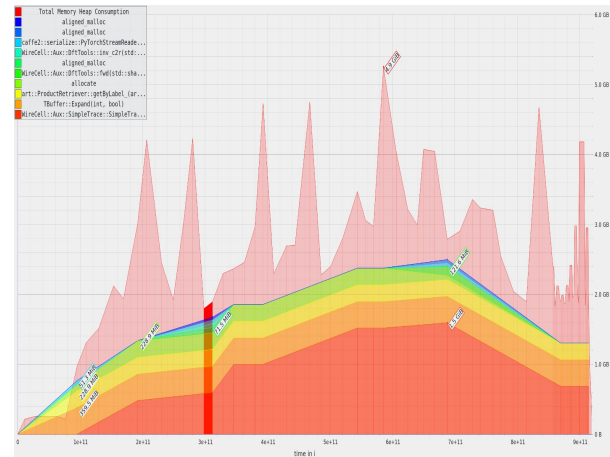
Memory Profiling - Valgrind



❑ 1st peak



❑ 2nd peak



❑ low torch activity

- PD-HD data, DNN SP with UNet
- The peak memory recorded is 4.9 GiB
- Not like a MobileNet result, the total cost graph has several peaks
- Almost half of the memory (~2.5 GiB) is allocated to libtorch_cpu.so around the peak
- Another major contributions are from:
 - WireCell::SigProc::OmnibusSigProc::save_data (853 MiB out of 1.4 GiB)
 - WireCell::SigProc::OmnibusSigProc::save_mproi (343 MiB out of 1.4 GiB)

Memory Profiling - Valgrind

[illegible]

```


25 GB: cllAllocUnsafe(long) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
25 GB: cllDefaultCpuAllocationUnbounded(long) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
23 GB: CllStorageImpl.StorageImpl(CllStorageImpl:byte size, Cll-Symbol:const, Cll-Allocation: bool) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
23 GB: at:TensorBase::detail:empty_gensrc<Cll-ArrayRef>, Cll-Allocation: Cll-DispatchKeySet, Cll-ScalarType: Cll-optional<> in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
23 GB: at:detail:empty_gensrc<Cll-ArrayRef>, Cll-Allocation: Cll-DispatchKeySet, Cll-ScalarType: Cll-optional<> in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
23 GB: at:detail:empty_gensrc<Cll-ArrayRef>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<> in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
21 GB: at:native_empty_gensrc<Cll-ArrayRef>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<> in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
21 GB: cllImpWgVw kernel functor unboxed <>:call(Cll-OperatorNameSet, Cll-DispatchKeySet, Cll-ArrayRef, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
21 GB: at:ops:memory:inplace::split(Cll-DispatchKeySet, Cll-ArrayRef, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
21 GB: cllImpWgVw kernel functor unboxed <>:call(Cll-OperatorNameSet, Cll-DispatchKeySet, Cll-ArrayRef, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
21 GB: at:ops:memory:inplace::call(Cll-ArrayRef<>, Cll-optional<>, Cll-optional<>, Cll-optional<>, Cll-optional<>) in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
245.4 MB: at:detail:empty_gensrc<Cll-ArrayRef>, Cll:TensorOptions:const in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
1172 MB: at:native::resize_bytes(CllStorageImpl):unsigned long in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
513 MB: caffe2::serialize::PyTorchStreamReader::RecordInfo::call_back_string::const() in (com.fasterxml.jackson.core.asyncFileBatchV2_1,1dLunus4k4+10:17-426)(b7C0L5)
521 MB: Malloc: how allocation(137)
952.1 MB: allocate: malloc: traits(484)
952.1 MB: M: allocate: ist: vector(278)
952.1 MB: M: create: storage: ist: vector(295)
952.1 MB: vector: base: ist: vector(332)
952.1 MB: vector: ist: vector(558)
952.1 MB: WVec::Auto::SimpleTensor: SimpleTensor::int, std: vector<>:const() SimpleTensor::const()
572.2 MB: WVec::SgInp::OmniBusSgInp::save: dataset: vector<>, std: vector<>, int, std: vector<>:const(), std: vector<>:const(), std::basic_string::const(), bool() (OmniBusSgInp::const)512
114.4 MB: WVec::SgInp::OmniBusSgInp::operator()(std:shared_ptr<>:const, std:shared_ptr<>:const) (OmniBusSgInp::const)322
114.4 MB: WVec::SgInp::OmniBusSgInp::operator()(std:shared_ptr<>:const, std:shared_ptr<>:const) (OmniBusSgInp::const)369
114.4 MB: WVec::SgInp::OmniBusSgInp::operator()(std:shared_ptr<>:const, std:shared_ptr<>:const) (OmniBusSgInp::const)180
114.4 MB: WVec::SgInp::OmniBusSgInp::operator()(std:shared_ptr<>:const, std:shared_ptr<>:const) (OmniBusSgInp::const)314
71.5 MB: WVec::SgInp::OmniBusSgInp::operator()(std:shared_ptr<>:const, std:shared_ptr<>:const) (OmniBusSgInp::const)378
42.9 MB: in: 1 place, below: mass's threshold(1.00%)
228.9 MB: WVec::SgInp::OmniBusSgInp::save: mp1st:vector<>, std:vector<>, int, std:vector<>:const() (OmniBusSgInp::const)763
114.4 MB: WVec::SgInp::OmniBusSgInp::save: mp1st:vector<>, std:vector<>, int, std:vector<>:const() (OmniBusSgInp::const)612
36.6 MB: in: 1 place, below: mass's threshold(1.00%)
359.5 MB: TStorage:ReLUConv2d::forward: unsigned long, unsigned long (TStorage::const)283
228.9 MB: allocate: how allocation(137)
228.9 MB: allocate: how allocation(137)
1174 MB: in: 1 place, below: mass's threshold(1.00%)

```


```

1.8 GB: Snapshot #18
  * 565.9 MB: allocate (new allocator:h137)
    * 565.9 MB: allocate (alloc_traits:h464)
      * 565.9 MB: _M_allocate (std::vector:h378)
        * 565.9 MB: _M_create_storage (std::vector:h395)
          * 565.9 MB: _Vector_base (std::vector:h332)
            * 565.9 MB: _vector (std::vector:h398)
              * 565.9 MB: WireCell::Aux::SimpleTrace::SimpleTrace(int, int, std::vector<>, const&) (SimpleTrace.cxx:8)
                * 357.6 MB: WireCell::SigProc::OmniBusSigProc::save_data(std::vector<>, std::vector<>, int, std::vector<>, const&, std::vector<>, std::vector<>, const&, const&, const&) (OmniBusSigProc.cxx:1669)
                  * 93.0 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1669)
                  * 71.5 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1678)
                  * 57.2 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1822)
                  * 57.2 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1800)
                  * 57.2 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1814)
                  * 21.5 MB: WireCell::SigProc::OmniBusSigProc::operator()(std::shared_ptr<>, const&, std::shared_ptr<>, const&) (OmniBusSigProc.cxx:1693)
                  * 114.4 MB: WireCell::SigProc::OmniBusSigProc::save_mpol(std::vector<>, std::vector<>, int, std::multimap<>, const&) (OmniBusSigProc.cxx:763)
                  * 57.2 MB: WireCell::SigProc::OmniBusSigProc::save_nol(std::vector<>, std::vector<>, int, std::vector<>, const&) (OmniBusSigProc.cxx:612)
                  * 36.6 MB: Construct<> (std::construct:h119)
  * 359.5 MB: TStorage::ReAllocChar(char*, unsigned long, unsigned long) (TStorage.cxx:283)
  * 228.9 MB: allocate (new_allocator:h137)
  * 228.9 MB: allocate (new_allocator:h137)
  207.8 MB: in 22540 places, all below massfs's threshold (1.00%)
  * 71.5 MB: aligned_malloc (Memory:h216)
  * 53.6 MB: aligned_malloc (Memory:h216)
  * 51.3 MB: c10::alloc_cpu(unsigned long) in /cvmfs/soft.opensciencegrid.org/products/libtorch/v2.1.1_b1/Linux44bit+3.10-2.17-e26/tb/llc10.so)
  * 35.8 MB: aligned_malloc (Memory:h216)

```

 1st peak

Hokyeong Nam

 2nd peak

BNL-ProtoDUNE meeting

- low torch activity

Jul. 16, 2025

26