3x1x1 ROOT parser: GEANT4 and detsim (MC)

- valid for all files in: /eos/experiment/wa105/offline/LArSoft/MC/MC*/ROOT/g4detsim/
- 1 tick = 400 ns, channel pitch = 3 mm.
- TPC active volume: -50 cm < x < 50 cm, -48 cm < y < 48 cm, 0 < z < 288 cm

Metadata (one entry per event):

- Run: run number
- Subrun: sub run number
- EventNumberInRun: event number in run
- EventTimeSeconds: in Unix time
- EventTimeNanoseconds: nanoseconds elapsed since "EventTimeSeconds"
- IsData: 1 for data, 0 for MC

Raw waveforms:
The following variables have one entry per event.

- RawWaveform_NumberOfChannels: number of channels holding a raw waveform. Only channels with at least one collected electron have a waveform.
- RawWaveform_NumberOfTicks: should always be 1667
- RawWaveform_NumberOfTicksInAllChannels: 1667 * number of channels holding a raw waveform

The following variable has one entry per charge readout channel, is sorted by charge readout channel and is stored in a vector. Length of vector = "RawWaveform_NumberOfChannels".

- RawWaveform_Channel: charge readout channel number. View 0: channel 0-319, view 1: channel 320 - 1279.

The following variable has one entry per charge readout channel and tick, is sorted by charge readout channel and tick and is stored in a vector. Length of vector = "RawWaveform_NumberOfTicksInAllChannels".

- RawWaveform_ADC: ADC count sorted by channel number and tick. First 1667 entries will give the waveform for the first channel in "RawWaveform_Channel" and so on.

Recorded photons:
The following variable has one entry per event.

- MCTruth_GEANT4_NumberOfDetectedPhotons: total number of detected photons for all 5 PMTs

The following variables have one entry per detected photon and are stored in a vector. Length of vector = "MCTruth_GEANT4_NumberOfDetectorPhotons"

- MCTruth_GEANT4_DetectedPhoton_Channel: PMT ID for this photon (0-4)
- MCTruth_GEANT4_DetectedPhoton_Time: time at which this photon was recorded, in nanoseconds

Particle variables from GEANT4 :
The following variables have one entry per event.

- MCTruth_GEANT4_NumberOfParticles: number of particles per event
- MCTruth_GEANT4_NumberOfPrimaries: number of primary CORSIKA particles per event

The following variables have one entry per particle and are stored in a vector. Length of vector = "MCTruth_GEANT4_NumberOfParticles".

- MCTruth_GEANT4_ParticleID: particle ID within event (starts from 1)
- MCTruth_GEANT4_PDGCode: PDG code of the particle
- MCTruth_GEANT4_Status: 0: not tracked in GEANT4, 1: tracked in GEANT4
- MCTruth_GEANT4_IsInTPCAV: 0: particle doesn't enter the TPC active volume
- MCTruth_GEANT4_NumberOfDaughterParticles: number of daughter particles
- MCTruth_GEANT4_MotherParticle: ParticleID of mother particle
- MCTruth_GEANT4_Mass: mass of the particle in GeV/c^2
- MCTruth_GEANT4_StartPoint_X: start point of the particle in x, in cm
- MCTruth_GEANT4_StartPoint_Y: start point of the particle in y, in cm
- MCTruth_GEANT4_StartPoint_Z: start point of the particle in z, in cm
- MCTruth_GEANT4_StartTime: start time of the particle in nanoseconds
- MCTruth_GEANT4_StartEnergy: start energy of the particle in GeV
- MCTruth_GEANT4_StartMomentum: absolute start momentum of the particle in GeV/c
- MCTruth_GEANT4_StartMomentum_X: x-component of the start momentum of the particle in GeV/c
- MCTruth_GEANT4_StartMomentum_Y: y-component of the start momentum of the particle in GeV/c
- MCTruth_GEANT4_StartMomentum_Z: z-component of the start momentum of the particle in GeV/c
- MCTruth_GEANT4_StartDirection_Theta: angle at the start of the particle with respect to the x-axis in degrees, from 0° to 180°. x-axis is drift axis. 0 is in +x direction (upwards), 90° is horizontal, 180° is in -x direction (downwards).
- MCTruth_GEANT4_StartDirection_Phi: angle at the start of the particle in y-z plane in degrees, from -180° to +180°. 0° is in +z direction (parallel to channels in view 0), ±90° in ±y direction (parallel to channels in view 1) and ±180° in -z direction (parallel to channels in view 0)

Particle variables from GEANT4, only for particles inside the TPC active volume:
The following variable has one entry per event.

- MCTruth_GEANT4_InTPCAV_NumberOfParticles: number of particles inside the TPC active volume

The following variables have one entry per particle inside the TPC active volume and are stored in a vector. Length of vector = " MCTruth_GEANT4_InTPCAV_NumberOfParticles"

- MCTruth_GEANT4_InTPCAV_ParicleID: particle ID within event (starts from 1)
- MCTruth_GEANT4_InTPCAV_PDGCode: PDG code of the particle
- MCTruth_GEANT4_InTPCAV_Pathlength: path length of the particle in the TPC active volume
- MCTruth_GEANT4_InTPCAV_StartPoint_X: start point of the particle in the TPC active volume x, in cm
- MCTruth_GEANT4_InTPCAV_StartPoint_Y: start point of the particle in the TPC active volume in y, in cm
- MCTruth_GEANT4_InTPCAV_StartPoint_Z: start point of the particle in the TPC active volume in z, in cm
- MCTruth_GEANT4_InTPCAV_StartTime: start time of the particle in the TPC active volume, in nanoseconds
- MCTruth_GEANT4_InTPCAV_StartEnergy: start energy of the particle the TPC active volume, in GeV
- MCTruth_GEANT4_InTPCAV_StartMomentum: absolute start momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_StartMomentum_X: x-component of the start momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_StartMomentum_Y: y-component of the start momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_StartMomentum_Z: z-component of the start momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_StartDirection_Theta: angle at the start of the particle in the TPC active volume with respect to the x-axis in degrees, from 0° to 180°. x-axis is drift axis. 0 is in +x direction (upwards), 90° is horizontal, 180° is in -x direction (downwards).
- MCTruth_GEANT4_InTPCAV_StartDirection_Phi: angle at the start of the particle in the TPC active volume in y-z plane in degrees, from -180° to +180°. 0° is in +z direction (parallel to channels in view 0), ±90° in ±y direction (parallel to channels in view 1) and ±180° in -z direction (parallel to channels in view 0)
- MCTruth_GEANT4_InTPCAV_EndPoint_X: end point of the particle in the TPC active volume x, in cm
- MCTruth_GEANT4_InTPCAV_EndPoint_Y: end point of the particle in the TPC active volume in y, in cm
- MCTruth_GEANT4_InTPCAV_EndPoint_Z: end point of the particle in the TPC active volume in z, in cm
- MCTruth_GEANT4_InTPCAV_EndTime: end time of the particle in the TPC active volume, in nanoseconds
- MCTruth_GEANT4_InTPCAV_EndEnergy: end energy of the particle the TPC active volume, in GeV
- MCTruth_GEANT4_InTPCAV_EndMomentum: absolute end momentum of the particle in the TPC active volume, in GeV/c

- MCTruth_GEANT4_InTPCAV_EndMomentum_X: x-component of the end momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_EndMomentum_Y: y-component of the end momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_EndMomentum_Z: z-component of the end momentum of the particle in the TPC active volume, in GeV/c
- MCTruth_GEANT4_InTPCAV_EndDirection_Theta: angle at the end of the particle in the TPC active volume with respect to the x-axis in degrees, from 0° to 180°. x-axis is drift axis. 0 is in +x direction (upwards), 90° is horizontal, 180° is in -x direction (downwards).
- MCTruth_GEANT4_InTPCAV_EndDirection_Phi: angle at the end of the particle in the TPC active volume in y-z plane in degrees, from -180° to +180°. 0° is in +z direction (parallel to channels in view 0), ±90° in ±y direction (parallel to channels in view 1) and ±180° in -z direction (parallel to channels in view 0)

G4Step variables from GEANT4 :
The following variable has one entry per event.

- MCTruth_GEANT4_NumberOfTrajectoryStepsForAllParticles: number of G4Steps, summed up for all particles in this event

The following variable has one entry per particle and is stored in a vector. Length of vector = "MCTruth_GEANT4_NumberOfParticles".

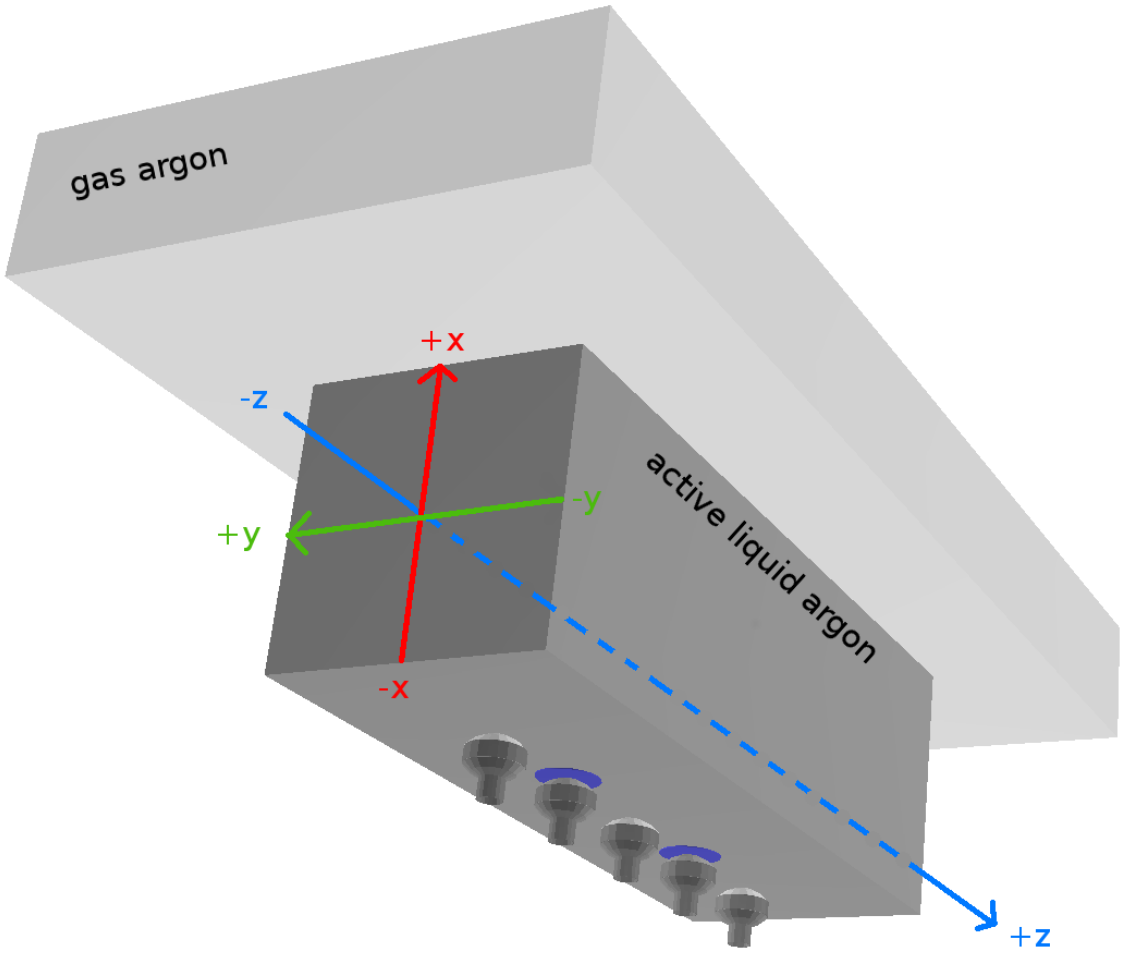
- MCTruth_GEANT4_NumberOfTrajectoryStepsPerParticle: number of G4Steps per particle

The following variables have one entry per G4Step and are stored in a vector. Length of vector = "MCTruth_GEANT4_NumberOfTrajectoryStepsForAllParticles".

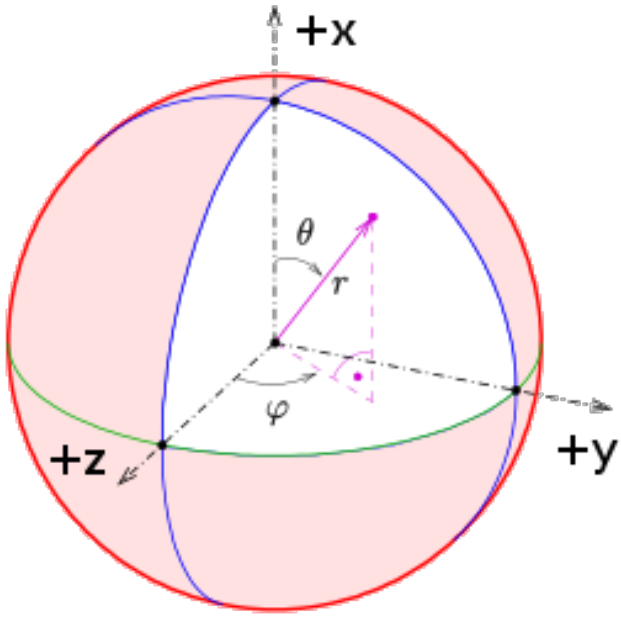
- MCTruth_GEANT4_TrajectoryStep_ParticleID: particle ID within event at this G4Step (starts from 1)
- MCTruth_GEANT4_TrajectoryStep_PDGCode: PDG code of the particle at this G4Step
- MCTruth_GEANT4_TrajectoryStep_Point_X: position of the particle in x at this G4Step, in cm
- MCTruth_GEANT4_TrajectoryStep_Point_Y: position of the particle in y at this G4Step, in cm
- MCTruth_GEANT4_TrajectoryStep_Point_Z: position of the particle in z at this G4Step, in cm
- MCTruth_GEANT4_TrajectoryStep_Time: time of this G4Step, in ns
- MCTruth_GEANT4_TrajectoryStep_Energy: energy of the particle at this G4Step, in GeV
- MCTruth_GEANT4_TrajectoryStep_Momentum: absolute momentum of the particle at this G4Step, in GeV/c
- MCTruth_GEANT4_TrajectoryStep_Momentum_X: x-component of the momentum momentum of the particle at this G4Step, in GeV/c
- MCTruth_GEANT4_TrajectoryStep_Momentum_Y: y-component of the momentum momentum of the particle at this G4Step, in GeV/c

- MCTruth_GEANT4_TrajectoryStep_Momentum_Z: z-component of the momentum momentum of the particle at this G4Step, in GeV/c
- MCTruth_GEANT4_TrajectoryStep_Direction_Theta: angle of the particle at this G4Step with respect to the x-axis in degrees, from 0° to 180°. x-axis is drift axis. 0 is in +x direction (upwards), 90° is horizontal, 180° is in -x direction (downwards).
- MCTruth_GEANT4_TrajectoryStep_Direction_Phi: angle of the particle at this G4Step in y-z plane in degrees, from -180° to +180°. 0° is in +z direction (parallel to channels in view 0), ±90° in ±y direction (parallel to channels in view 1) and ±180° in -z direction (parallel to channels in view 0)

3x1x1 geometry used for ROOT parser files:



Definiton of θ and φ:



$$0° < \theta < +180°$$

$\theta = 0°$: +x direction (upwards)
$\theta = 90°$: horizontal
$\theta = 180°$: -x direction (downwards)

Note: in the reconstruction, start and end points of the tracks are defined w.r.t. to the z-axis: Track_StartPoint_Z < Track_EndPoint_Z

$\rightarrow$ this means that we have $\backsim$ 50% upgoing ($0° < \theta < +90°$) and $\backsim$ 50% downgoing ($+90° < \theta < +180°$) tracks in the reconstruction, although almost all real muon tracks can be considered as downgoing. This shouldn't change any results for through-going tracks.

$$-180° < \varphi < +180°$$

$\varphi = 0°$: +z direction (parallel to channels in view 0)
$\varphi = 45°$: 45° in both views
$\varphi = 90°$: +y direction (parallel to channels in view 1)
$\varphi = 135°$: 45° in both views
$\varphi = 180°$: -z direction (parallel to channels in view 0)

$\varphi = -45°$: 45° in both views
$\varphi = -90°$: -y direction (parallel to channels in view 1)
$\varphi = -135°$: 45° in both views
$\varphi = -180°$: -z direction (parallel to channels in view 0)