L2G FIRST STEPS:
SAMPLE PRODUCTION AND ANALYSIS

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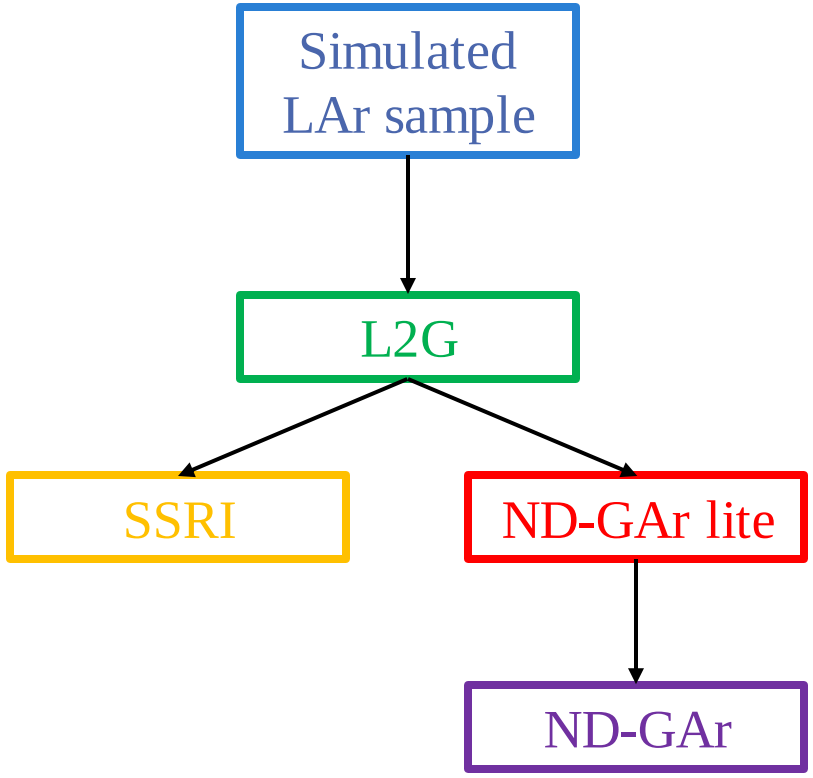
LAR TO GAR SAMPLE: L2G

- Strong need for large LAr samples already propagated in edep-sim
- L2G: interface that takes outgoing LAr particles and feeds them to edep-sim with any TMS detector could simplify the sample simulation/reconstruction and standardize the prcedure between detector designs (ND-GAr/TMS).
- As a first step Eldwan produced a large sample of LAr interactions, developed it up to reconstruction and anatree production and we started studying its properties focusing on the produced muons

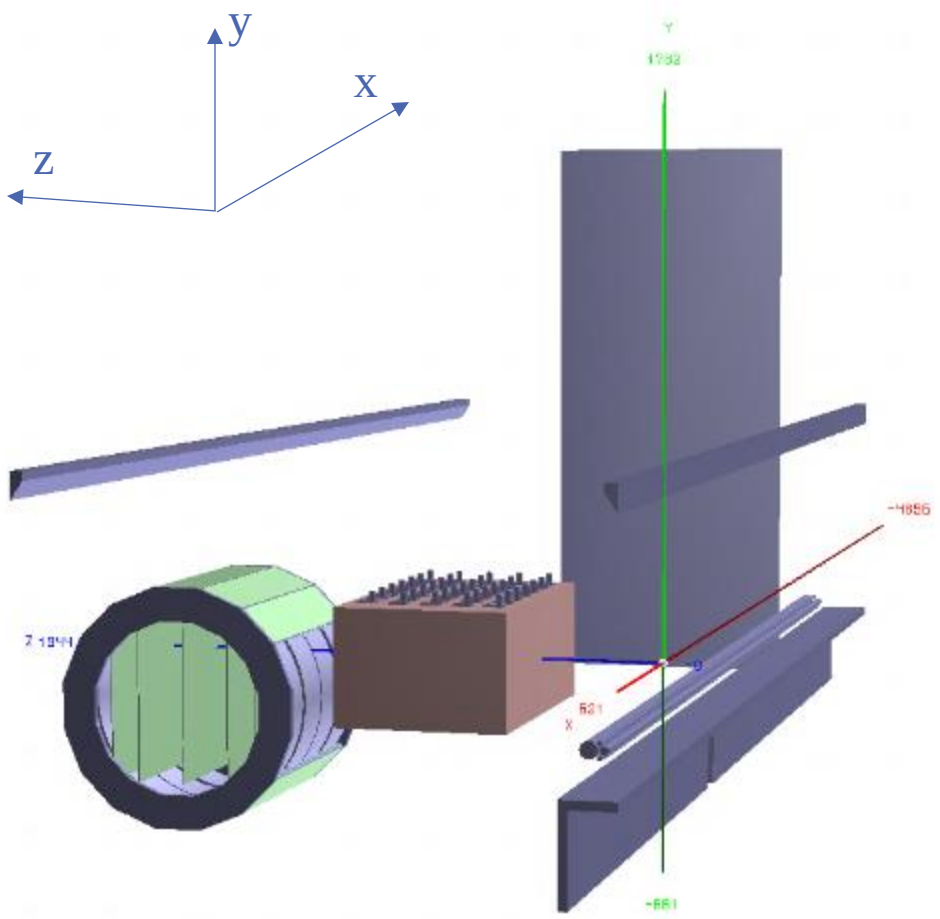


https://indico.fnal.gov/event/44562/contributions/200915/attachments/136745/170170/DUNE_ND_Meeting_28.10.20.pdf

GENERATED SAMPLE: NEUTRINO INTERACTIONS IN LAR

- Sample generated with GENIE v2
  - Gsimple flux in ND-Hall (from Tanaz)
  - 1M events in ND-LAr (volArgonCubeActive)

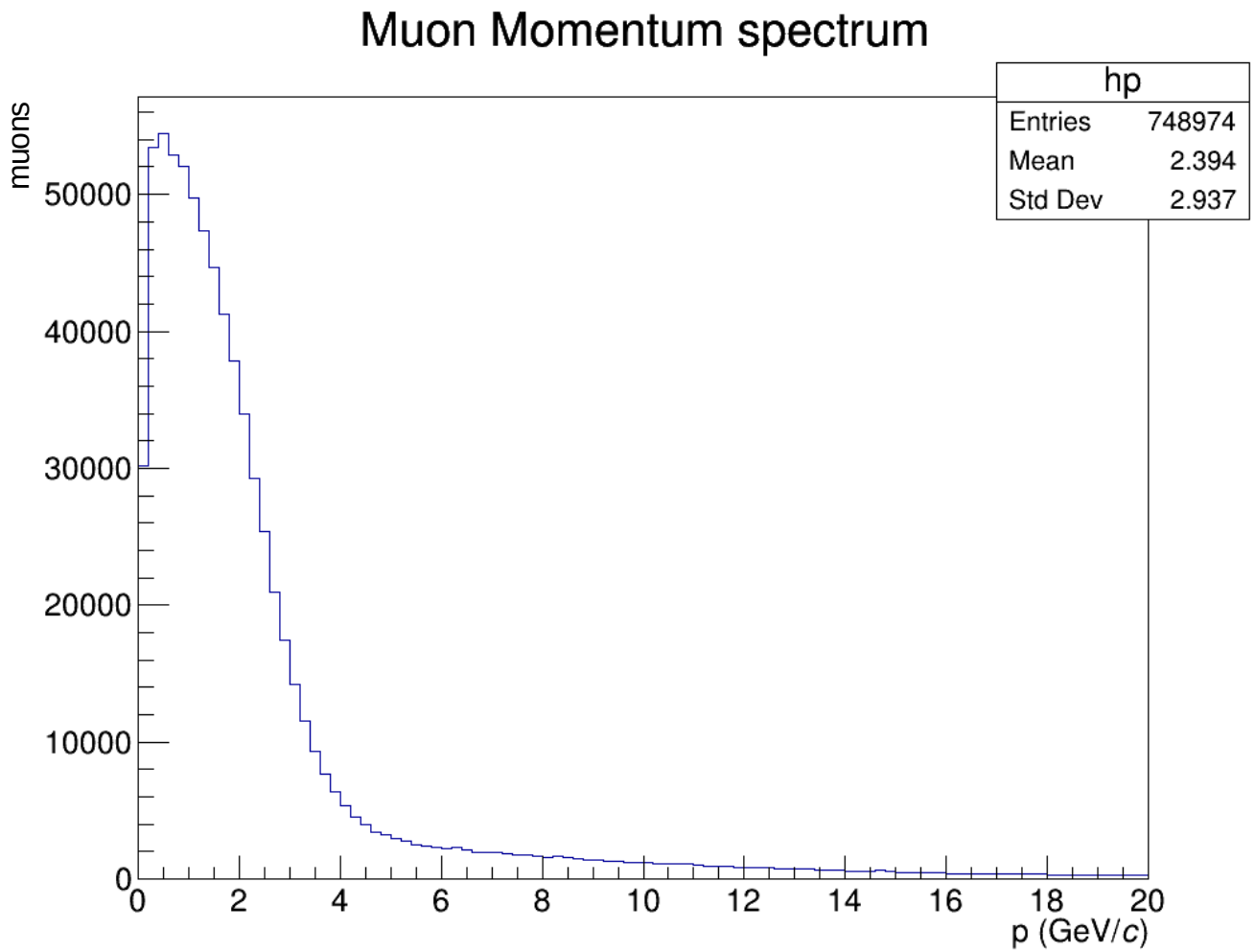
- Geometry used
  - Baseline ND-LAr from dunendggd (apparently some updates are needed but not pushed yet...)
  - ND-GAr-Lite detector with SPY magnet (not the latest one acting as PV)
    - 5 Scintillator planes (Minerva-like) of 6mx5mx4cm at (-240, -150, 0, 150, 240) //Not Optimized yet!
    - Segmented with triangular shapes strips in X/Y (2 cm triangle base)
  - Includes a muon detector (3 planes of Sc of 2 cm) with 2x7.5cm iron



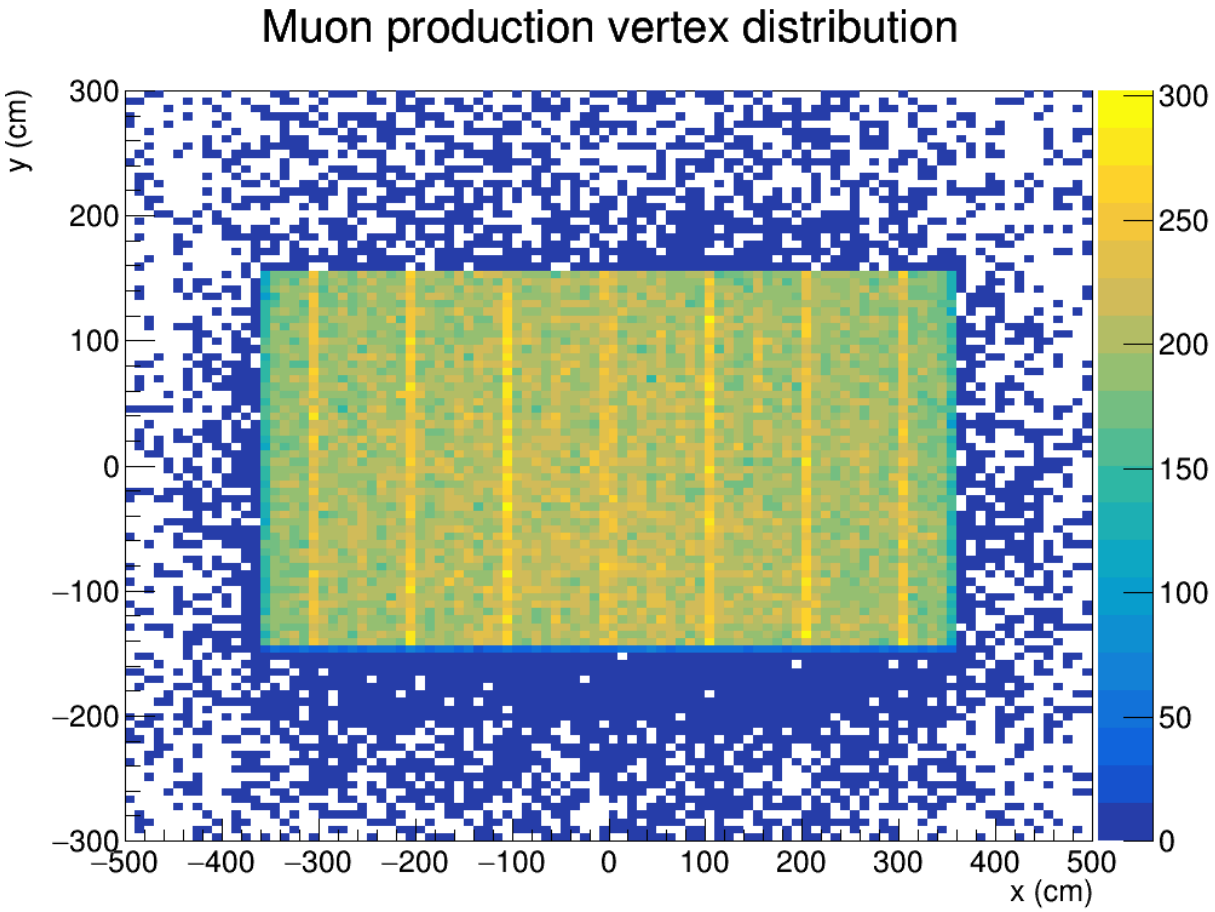
- Got to test the full chain gen/sim/reco for ND-GAr-Lite without major hickups with edep-sim and GArSoft
- LAr digi/reco to be done standalone and merged back
- Note that in our coordinate sytem z is the flux direction, y is the vertical direction and x is the drift direction (i.e. the magnetic field direction)

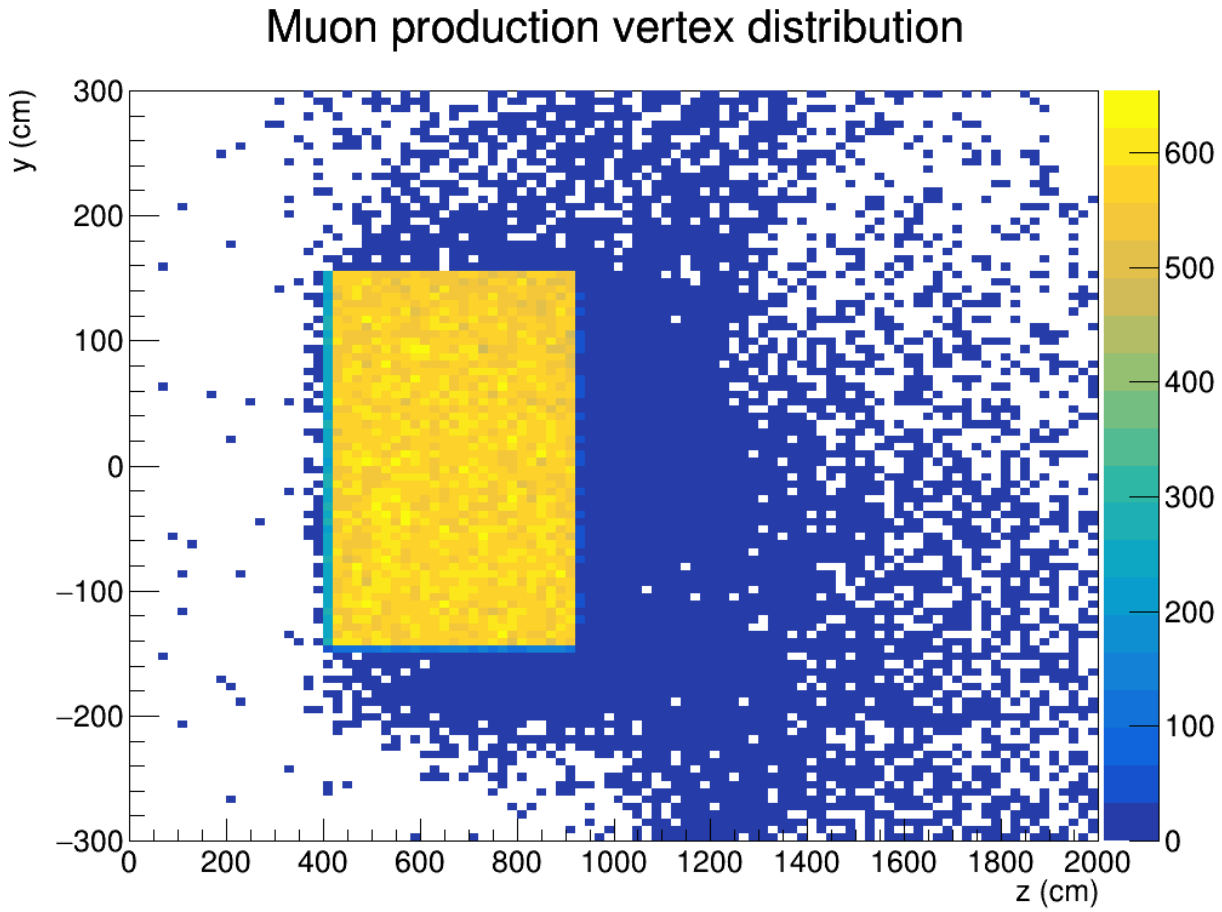
MUON SPECTRUM

- As a first step we looked at the muon spectrum
- Here all the muons present in the sample are considered, irregardeless of where and how they are produced
- Note that all the neutrinos are set to interact in the liquid argon volume, but not all the muons are produced directely in $\nu_\mu(CC)$ interactions, some could be the product of π decay



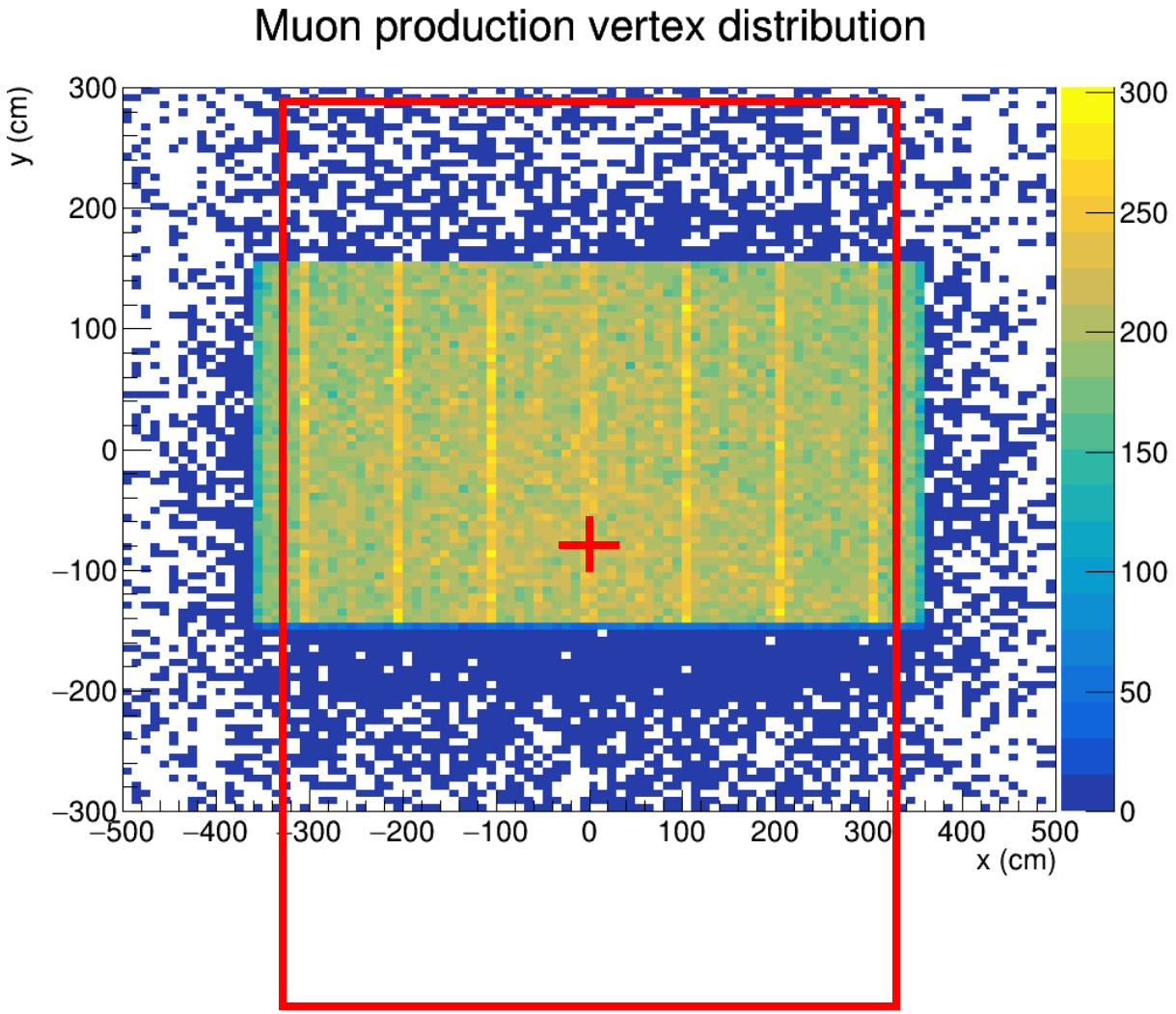
MUON PRODUCTION VERTEX

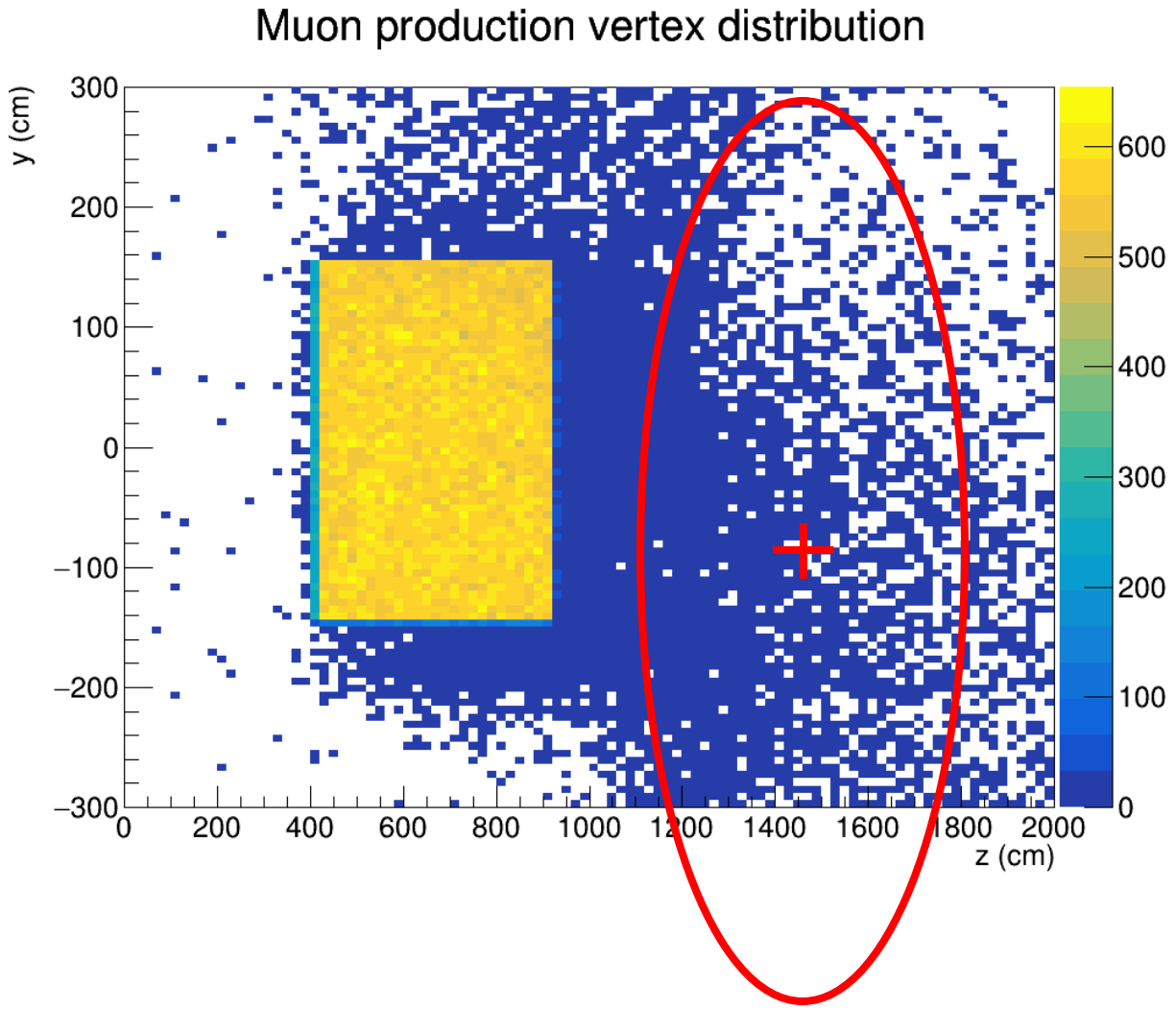




- Here we plot the spacial distribution of the points of productions of the muons i.e. The first poits registered in the muon tracks.

MUON PRODUCTION VERTEX

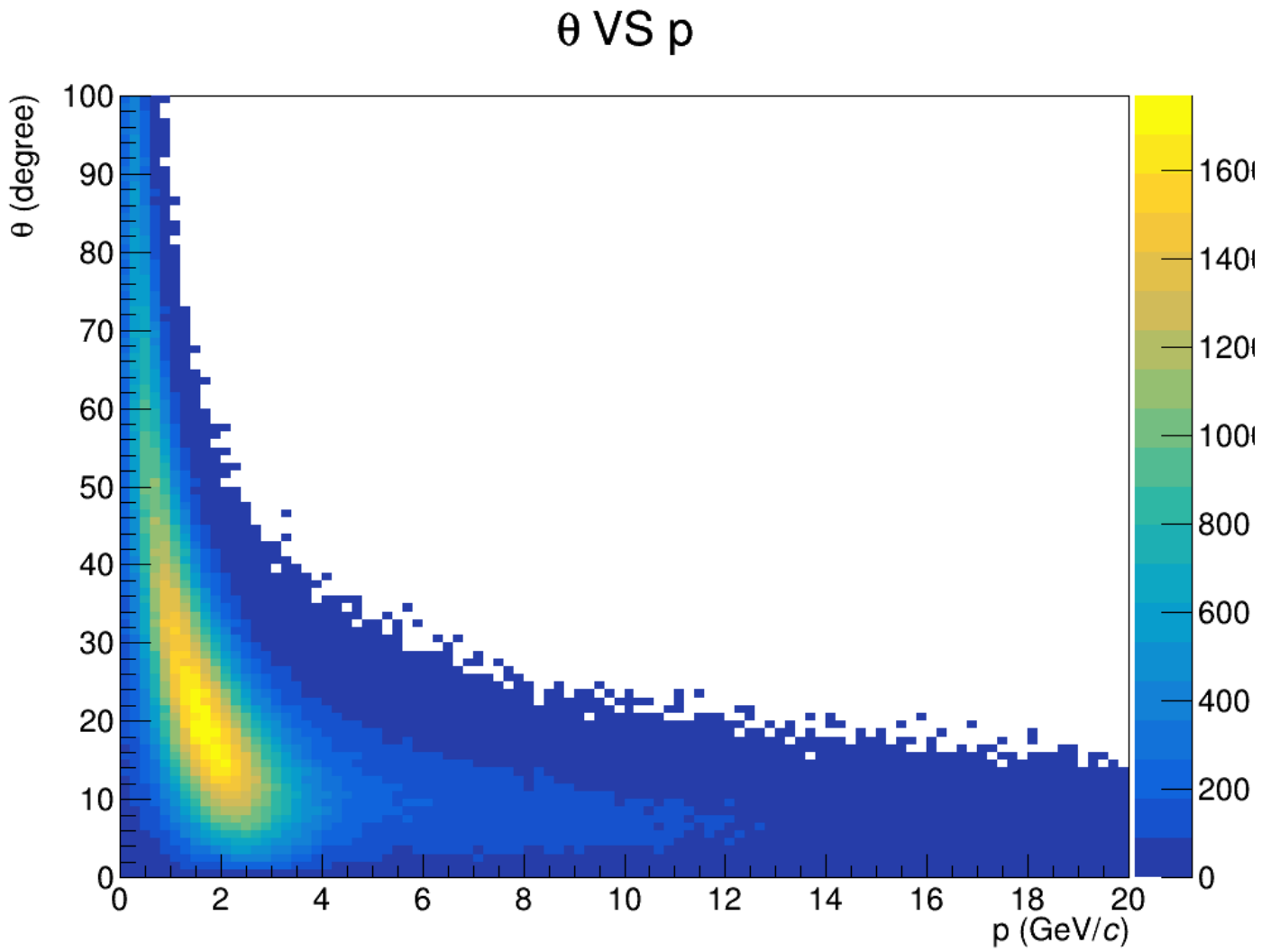




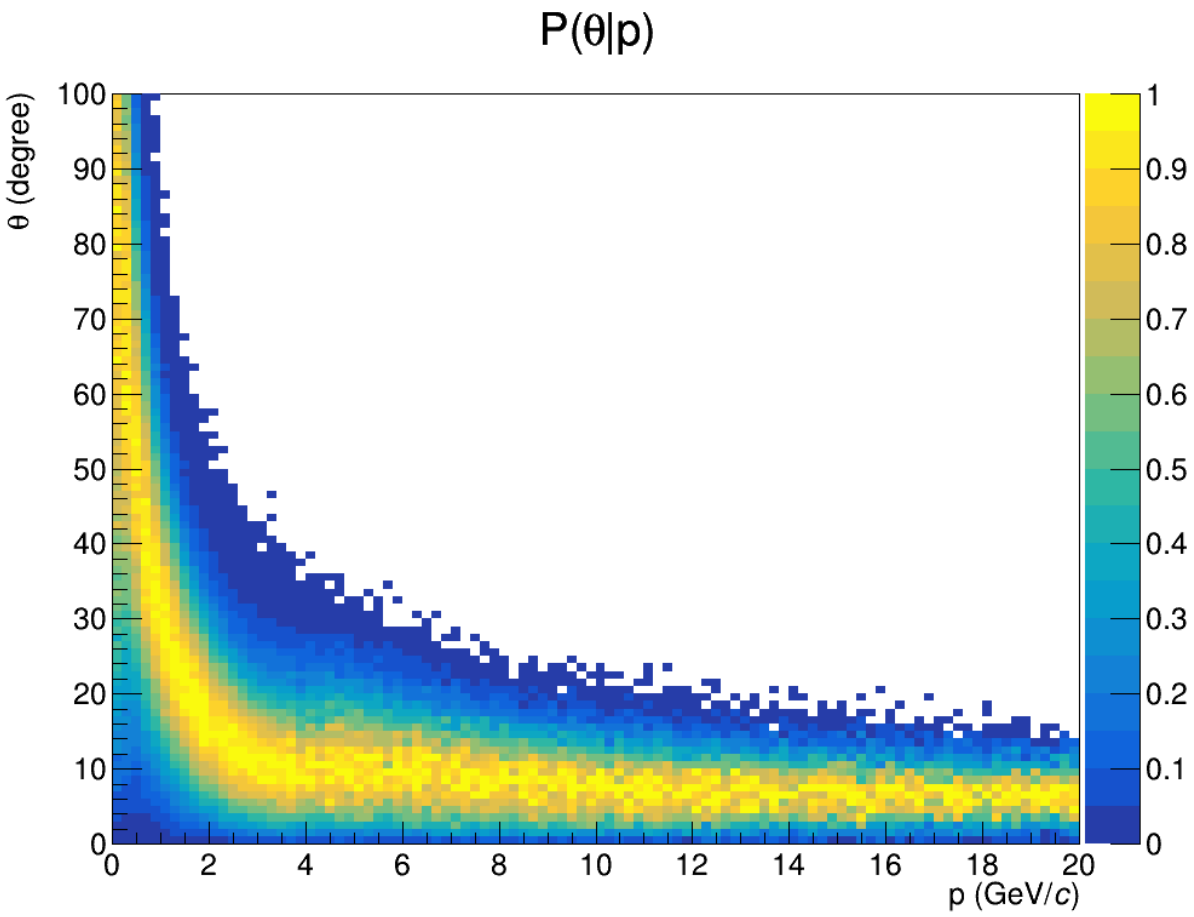
- Here we plot the spacial distribution of the points of productions of the muons i.e. The first poits registered in the muon tracks. The ND-GAr tracker volume is outlined in red

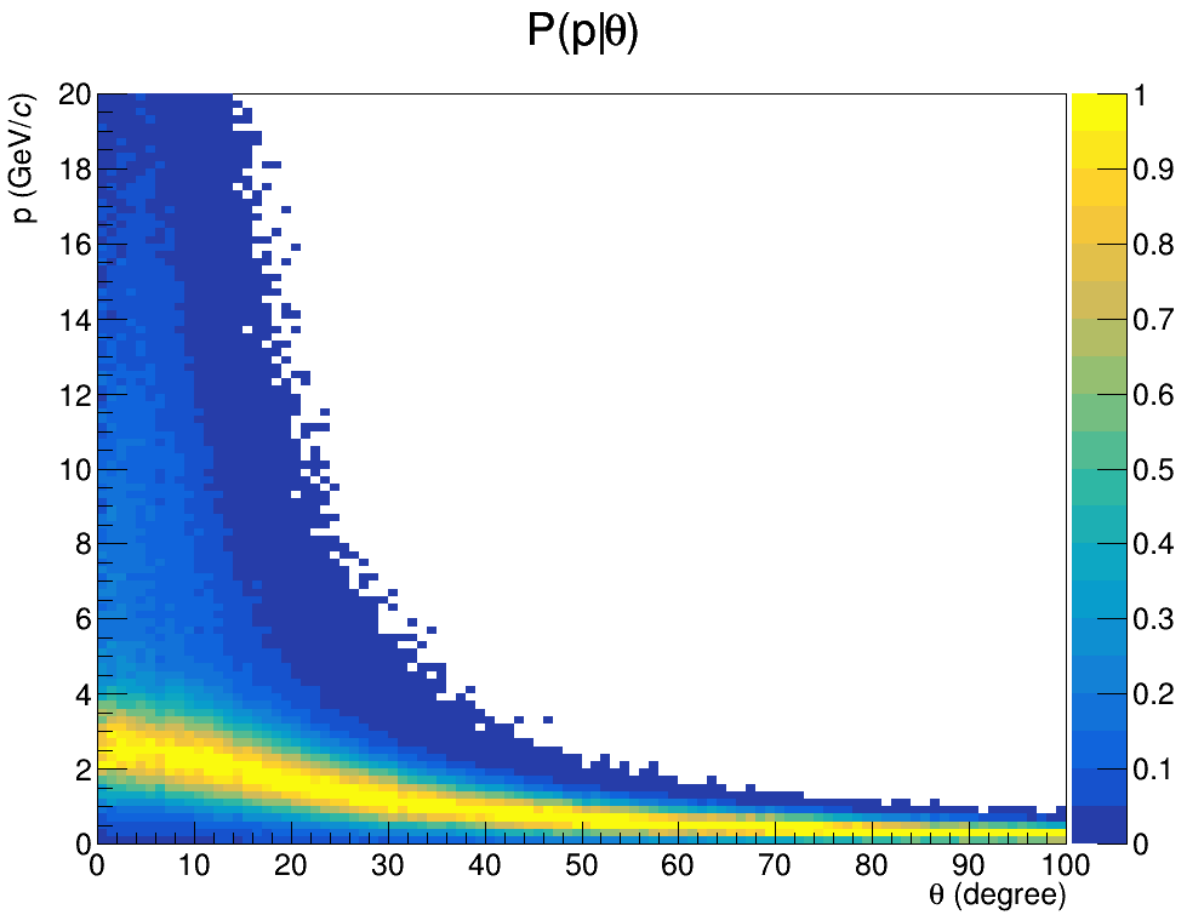
THETA VS P

- Here we analyze the distribution of the angle between the muon initial trajectory and the z axis θ and the muon initial momentum
- We note that, as expected most of the sample is concentrated at low angles and and an initial momentum between 0 and 5 GeV/c
- We also note that the more energetic the muons are the more they tend to be produced at low angles



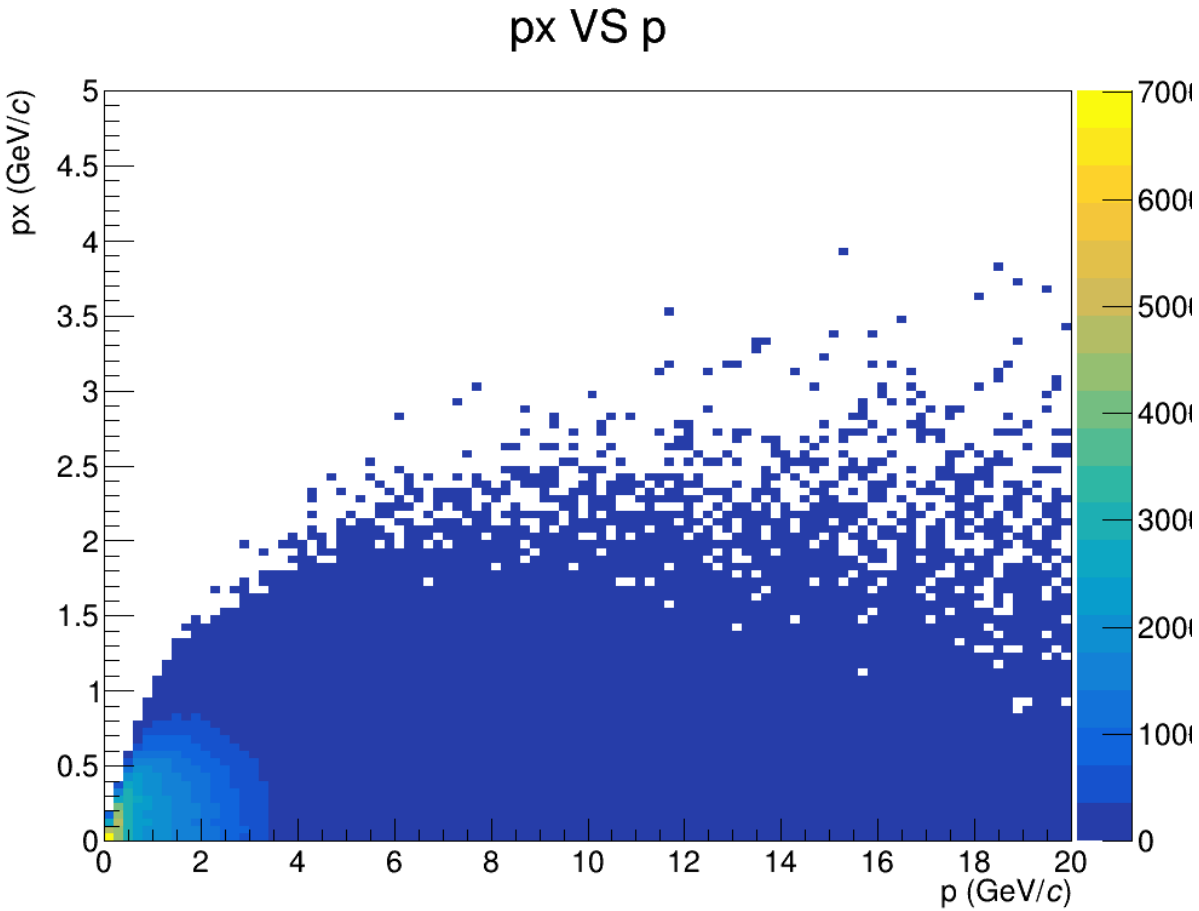
$P(\theta|p)$ AND $P(p|\theta)$

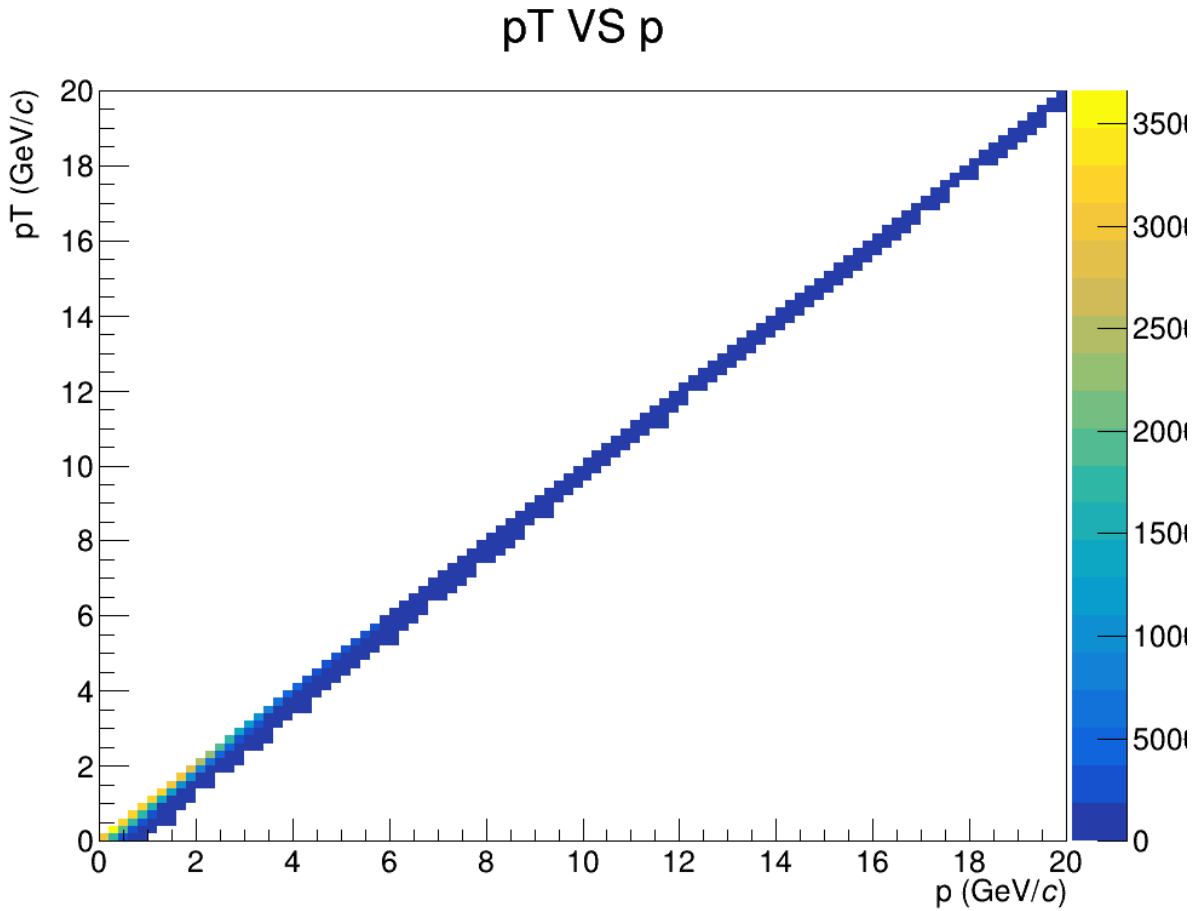




- Conditional probabilities $P(\theta|p)$ and $P(p|\theta)$ normalized so that the points with maximum probability in each slice are assigned the value 1

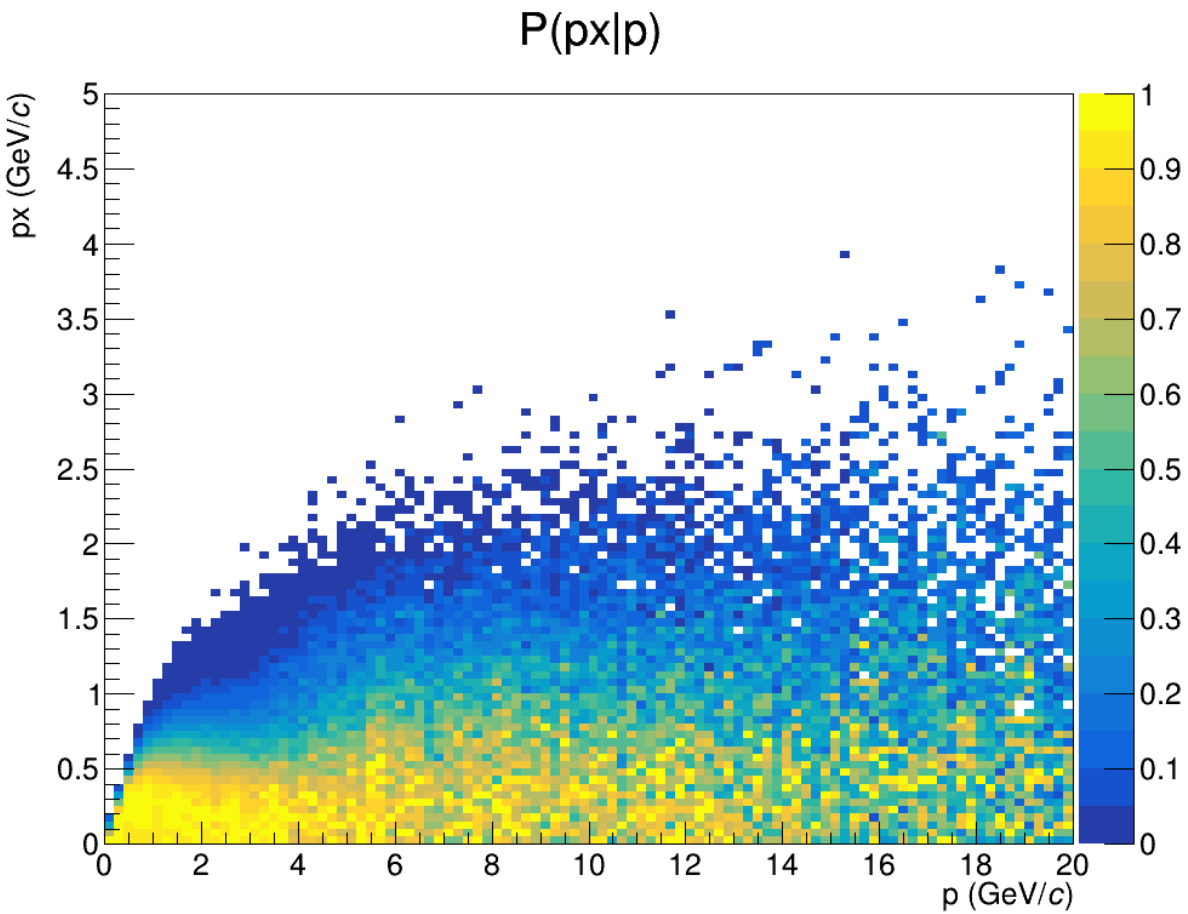
$(p_x\,VS\,p)$ AND $(p_T\,VS\,p)$

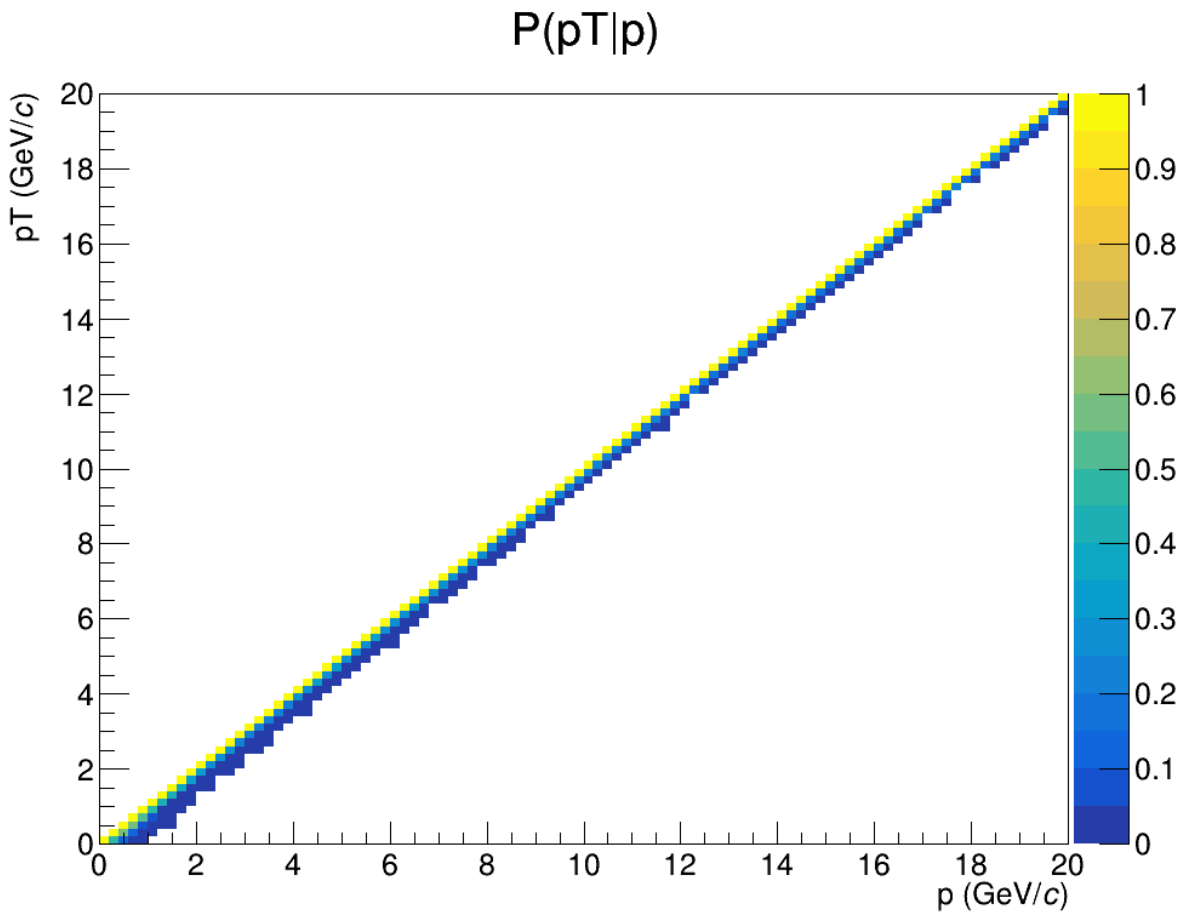




- Distributions of the momentum components along the drift direction p_x and on the transverse plane xy p_T as a function of the total momentum p. The transverse momentum largely dominates, especially at low momenta

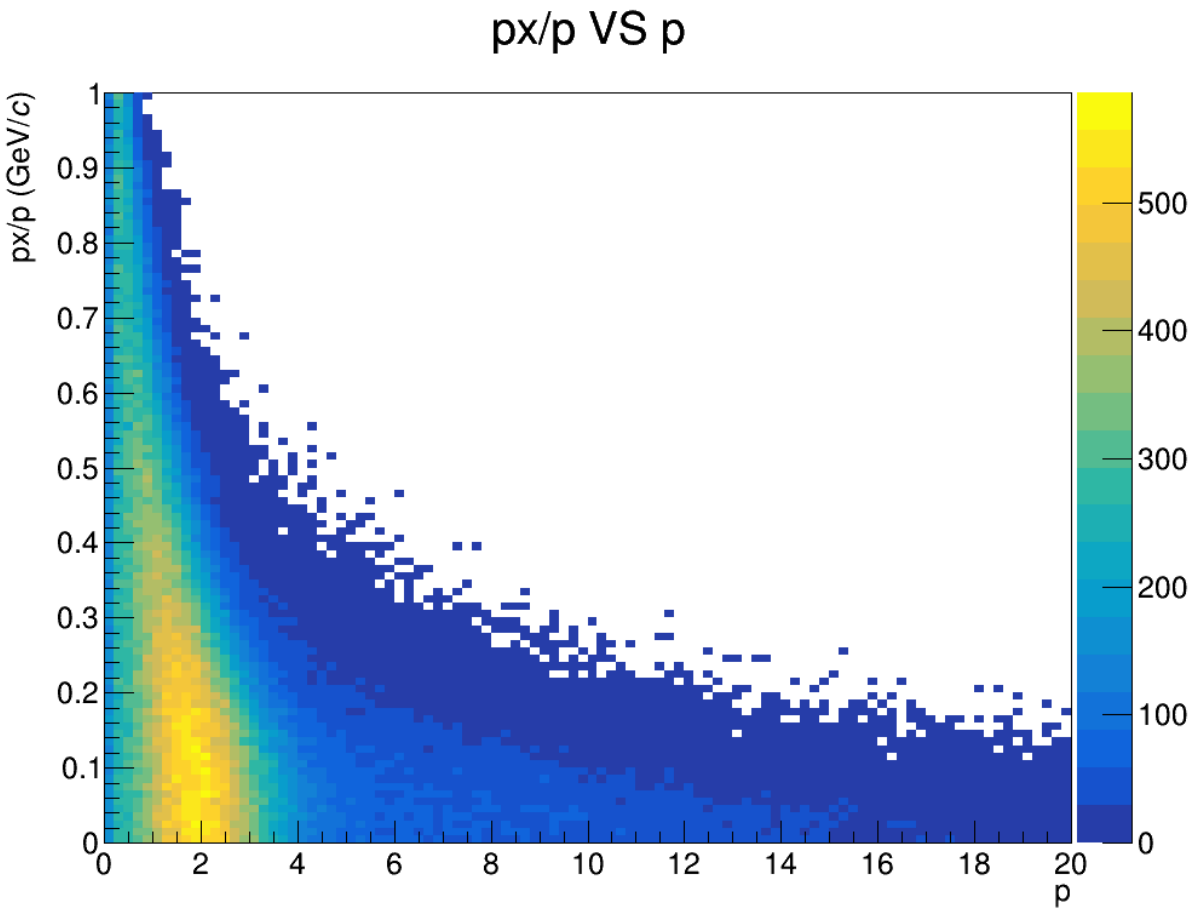
$P(p_x|p)$ AND $P(p_T|p)$

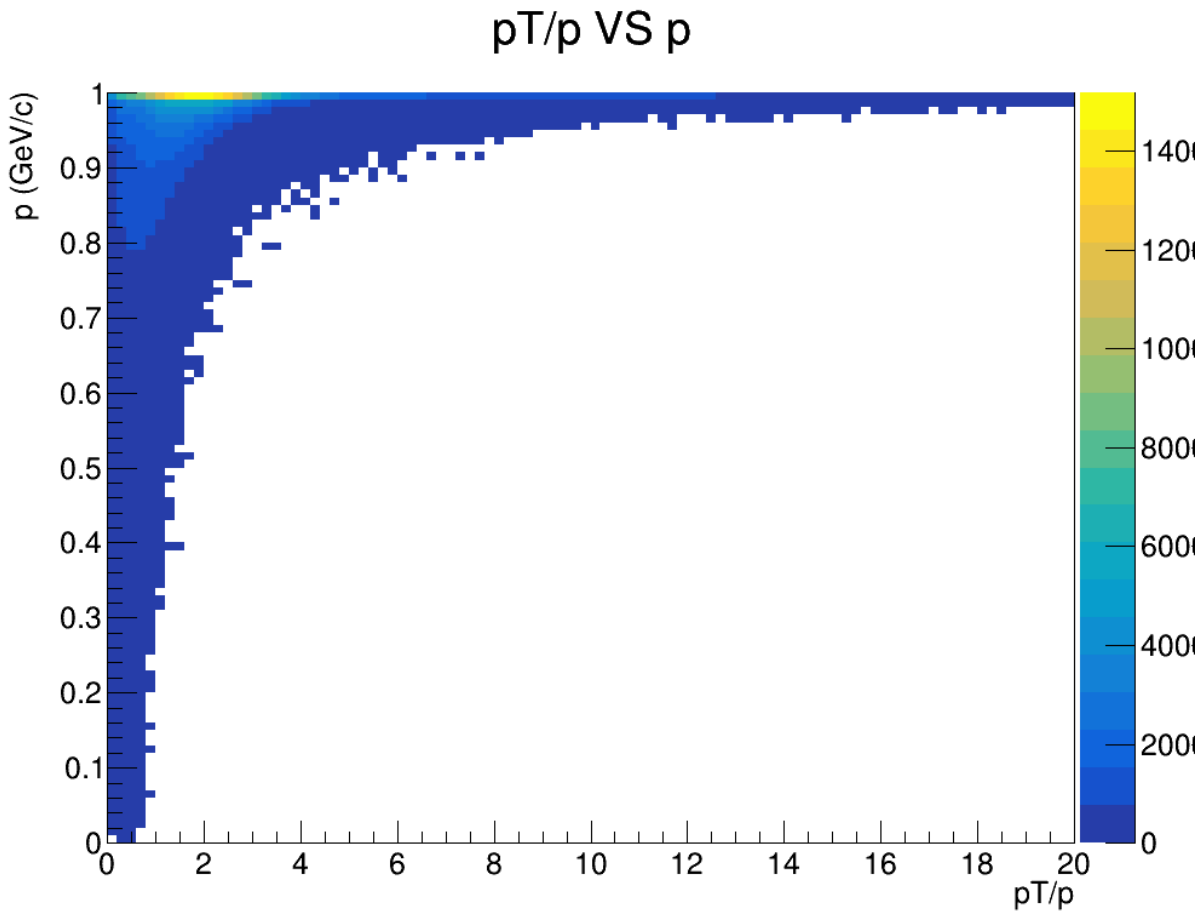




- Same information expressed in the form of conditional probabilities $P(p_x|p)$ and $P(p_T|p)$ ance again normalized with the maxima at 1

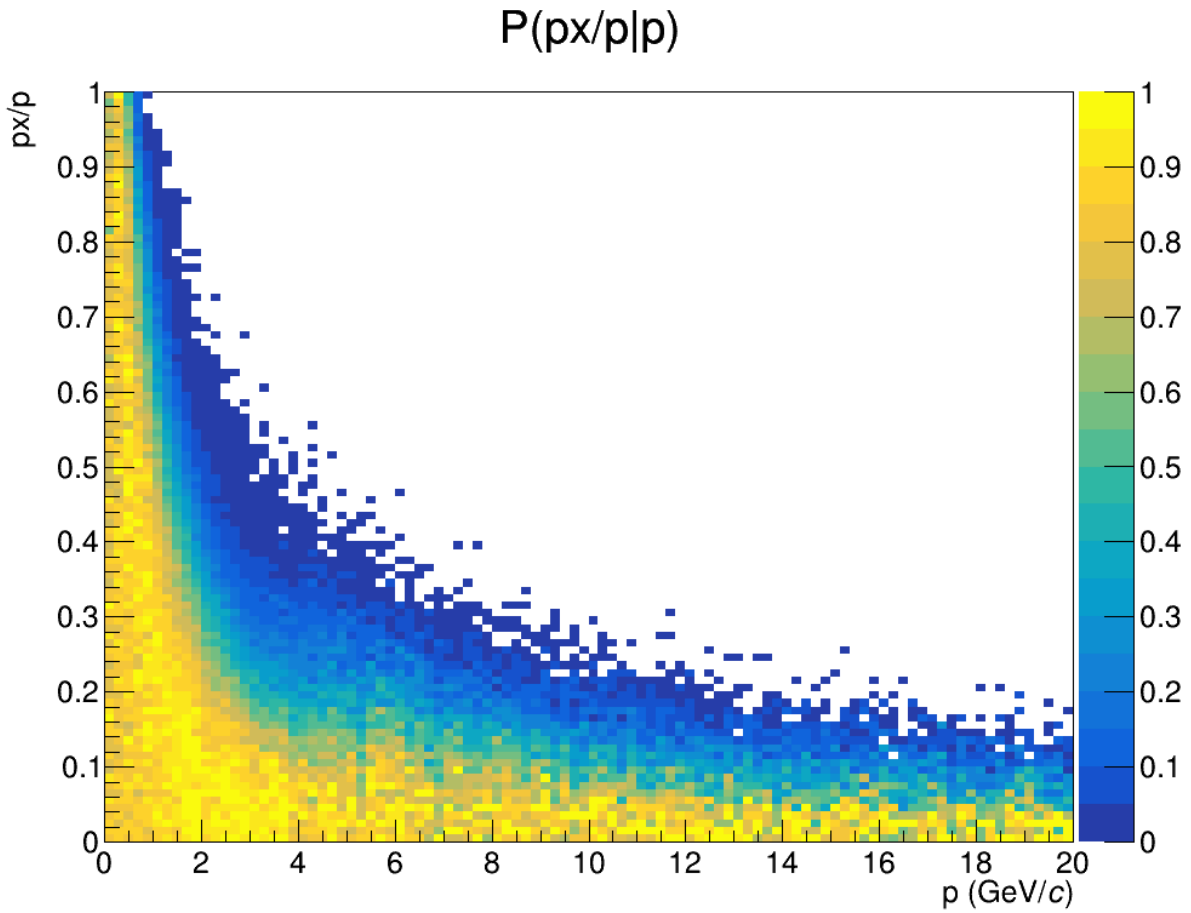
$(p_x/p\,VS\,p)$ AND $(p_T/p\,VS\,p)$

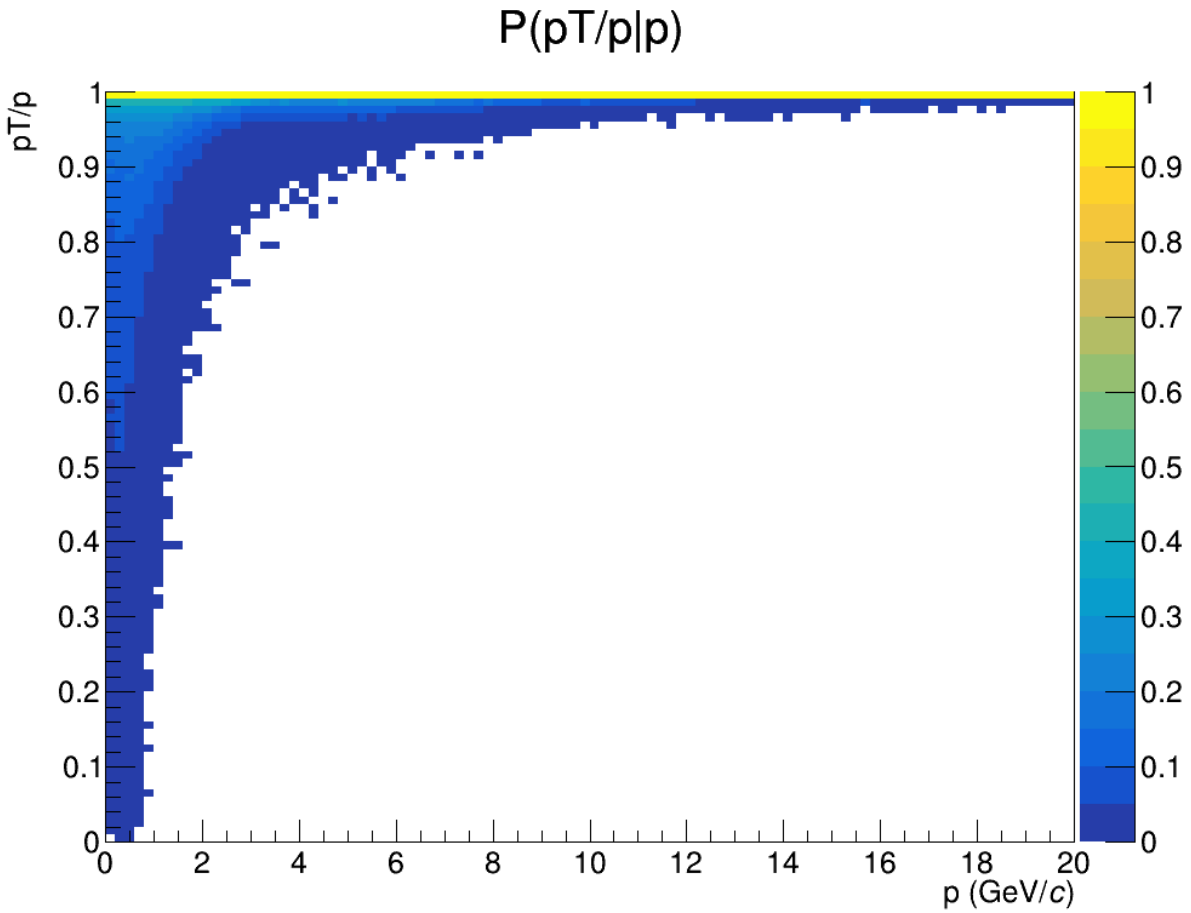




- Distributions of the momentum components fractions along the drift direction p_x/p and on the transverse plane xy p_T/p as a function of the total momentum p. Once again it is clear that the transverse momentum largely dominates, especially at low momenta

$P(p_x/p|p)$ AND $P(p_T/p|p)$





- Conditional probabilities $P(p_x|p)$ and $P(p_T|p)$ once again normalized with the maxima at 1.
- Note that according to pt/p and px/p, almost all L2G muons are inside the perpendicular plane to the B-field. This means that as a spectrometer, we need to optimize (y,z) space point resolution and can relax on drift dimension (i.e. use large sigma in KF)

SUMMARY AND FUTURE STEPS

- The sample of muons produced directly indirectly by neutrino interactions in the Liquid Argon is largely forward going with initial momenta mostly concentrated between 0 and 5 GeV/c

- The next immediate steps in the sample study would be to:
  - Apply fiducial cuts to the sample, for example considering just muon having their start point in the XY window defined by the LAr detector
  - Study how many muons reach the ND-GAr TPC and how many of them fully traverse it

- Once we understand the sample we can start tagging the produced muons and develop the l2g interface. Any suggestions are welcomed, thanks!