Secondary Neutron background in 3DST

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Introduction

- The out-fv neutron background with be at 1% level with a proper lever arm and time window cut regarding the neutrino interaction vertex

- Secondary background means the first neutron induced hit after neutrino interaction vertex is from neutrons coming from a primary particle instead of from neutrino interaction vertex : it may bias the neutron kinetic energy reconstruction using TOF technique.

- Requiring secondary neutron induced energy deposit > 0.5 MeV also appearing first in time after vertex: 66% from charged pions, 9% from neutron, 20% from protons, 5% from others. Pions and protons are the main producers.
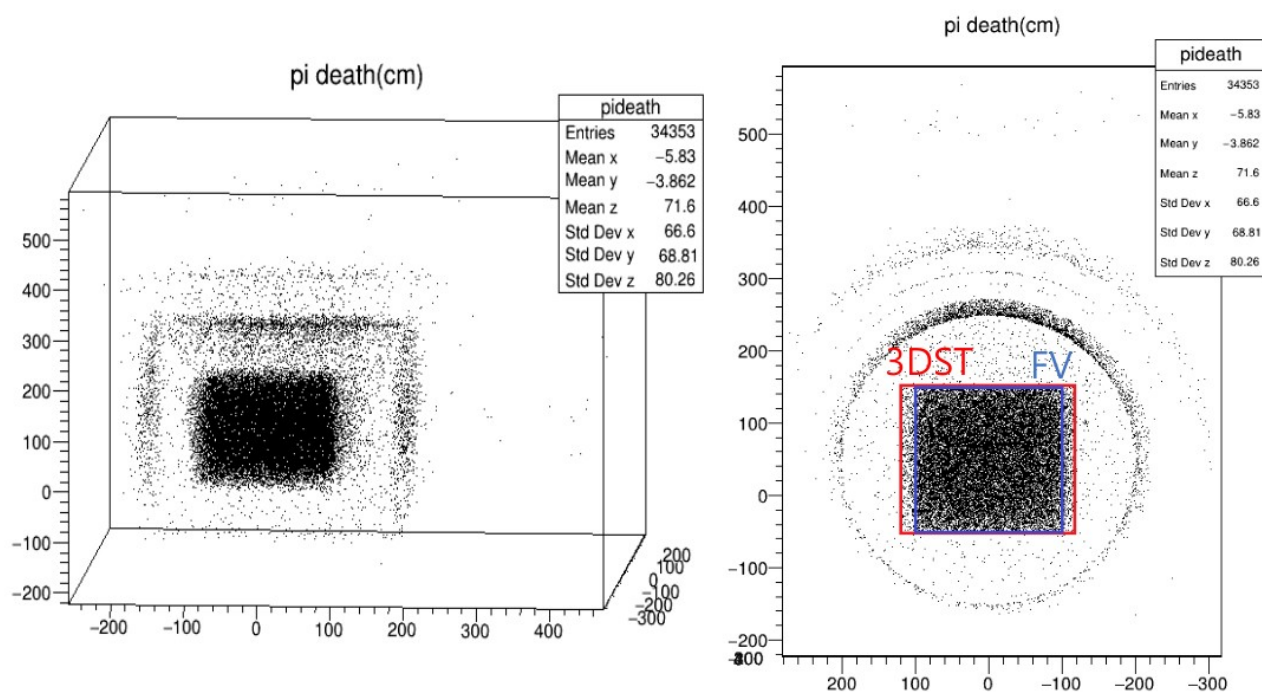
Charged pion end points

FV 1X1X1
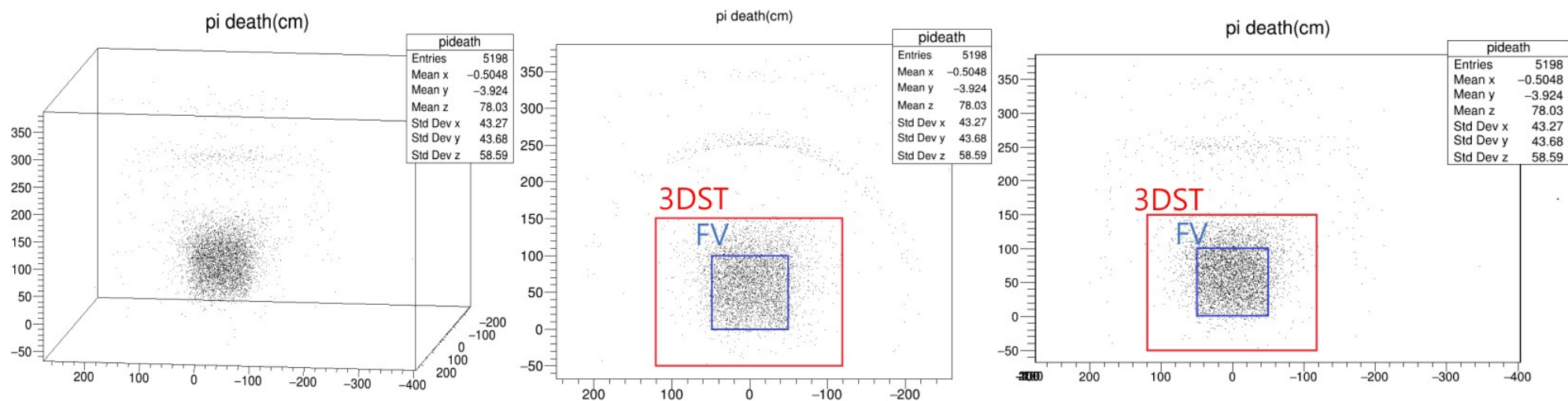
92% of pion death points is contained within 3DST
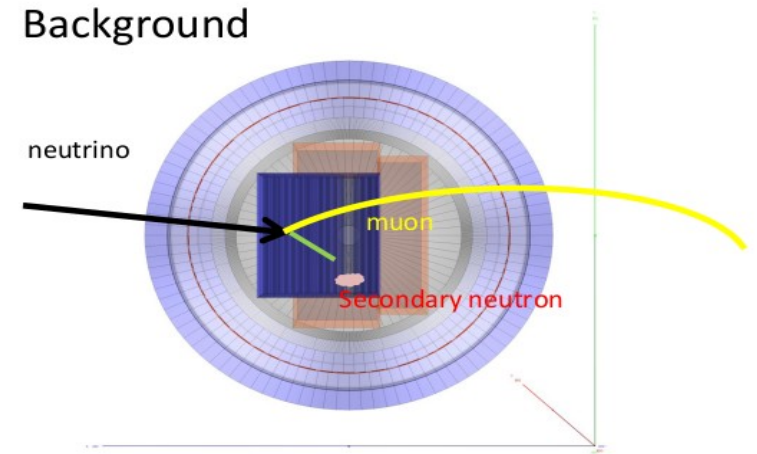*using 100 files
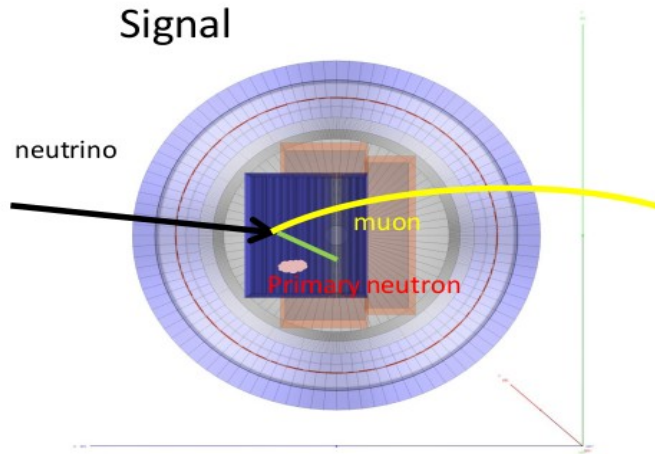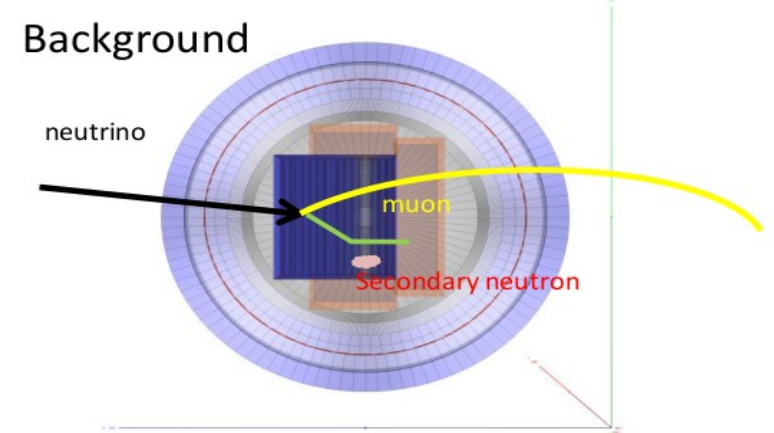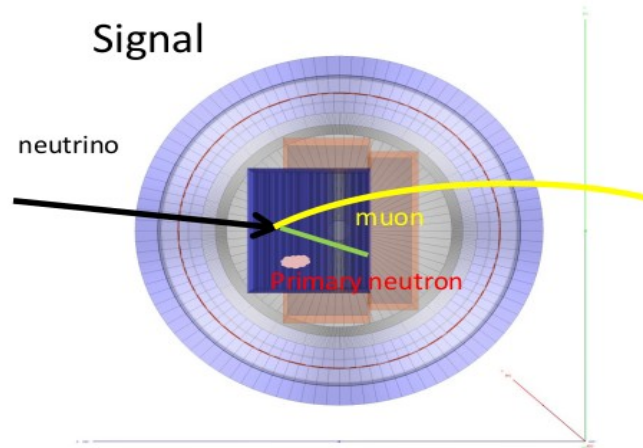
Charged pion end points

FV 2X2X2

In this study, we are using 1x1x1 in order to demonstrate, 2x2x2 is a thing that we can look into later.

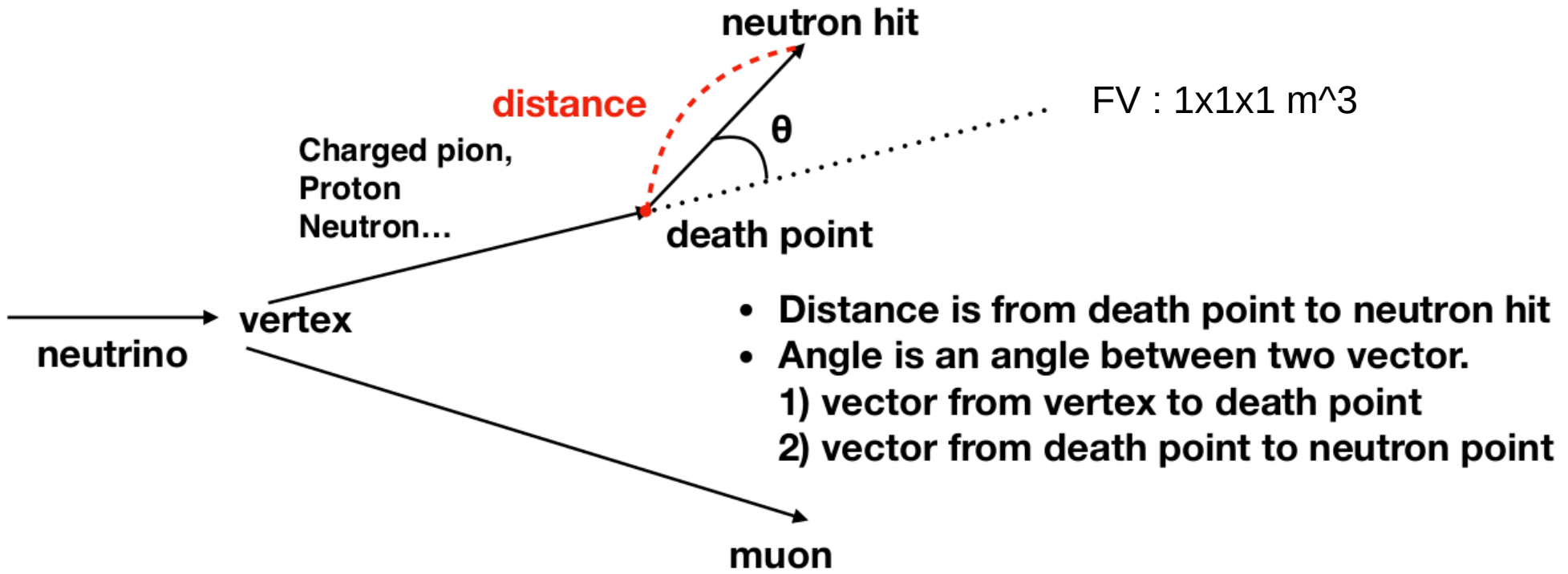**84%** of pion death points is contained within 3DST
*using 100 files

Reducing secondary background

Define a "death point"

Secondary background

neutron hit

distance

θ

FV : 1x1x1 m^3

**Charged pion,
Proton
Neutron...**

death point

vertex

neutrino

- **Distance is from death point to neutron hit**
- **Angle is an angle between two vector.**
  1) vector from vertex to death point
  2) vector from death point to neutron point
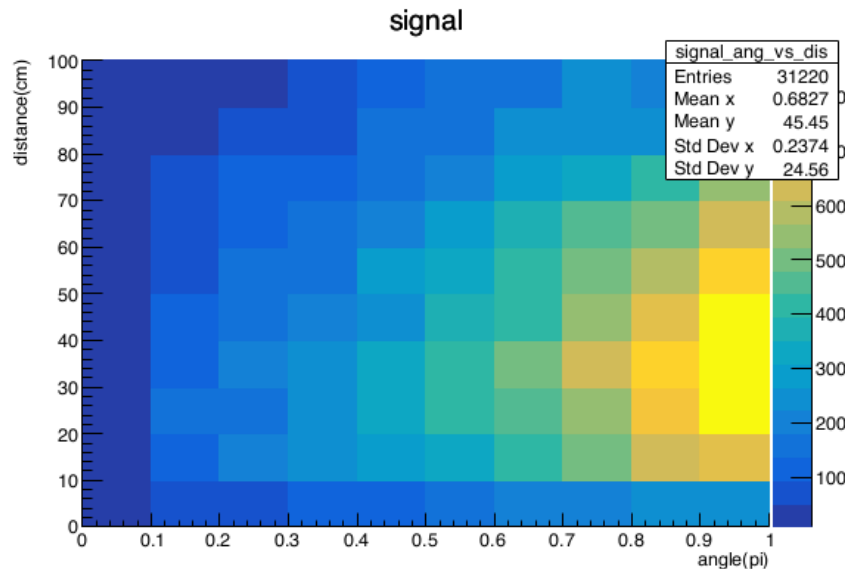
muon

We can get secondary background(which comes from death point) and signal distribution in phase space distance vs angle.
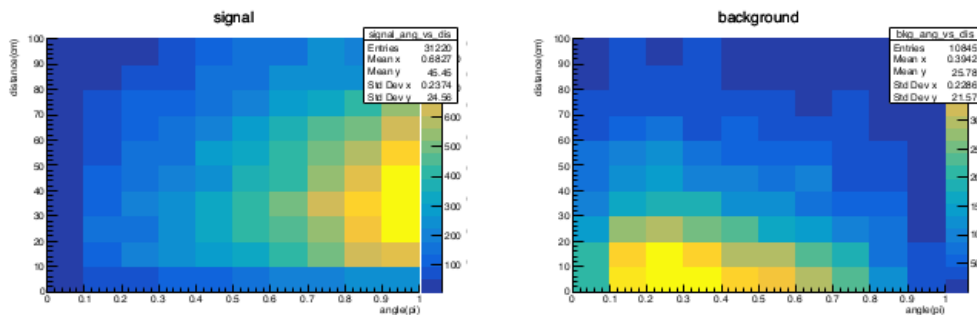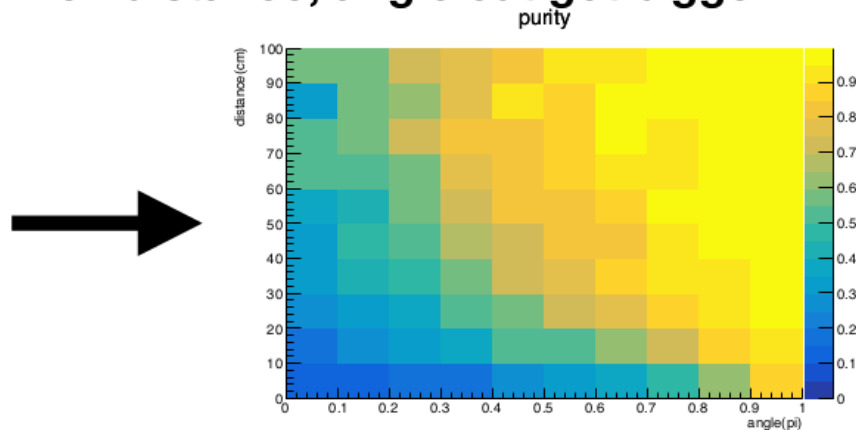

For exiting pions,
Exiting point = death point
Both of them are observables

cc 1 charged pion , 0 proton
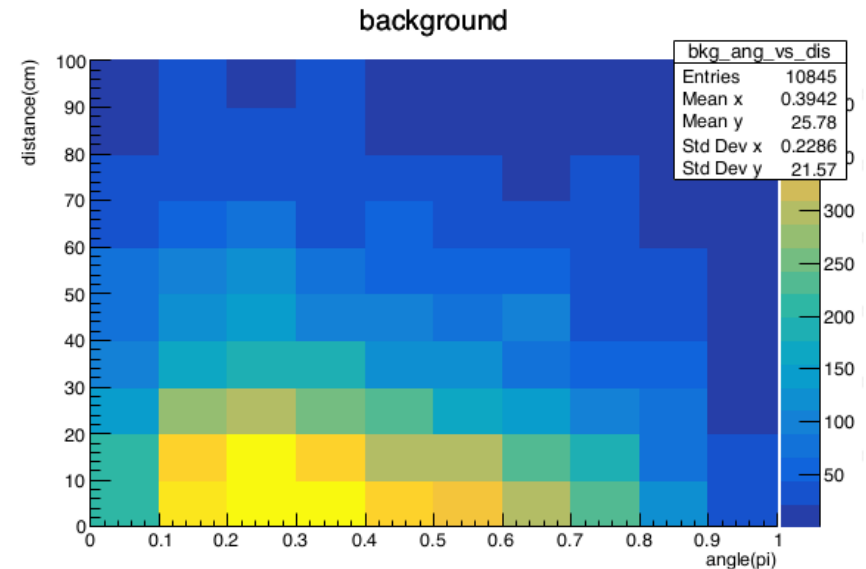
The secondary background which comes from death point is almost around death point.
But the signal is broader than background. So the purity gets better when distance, angle cut get bigger.
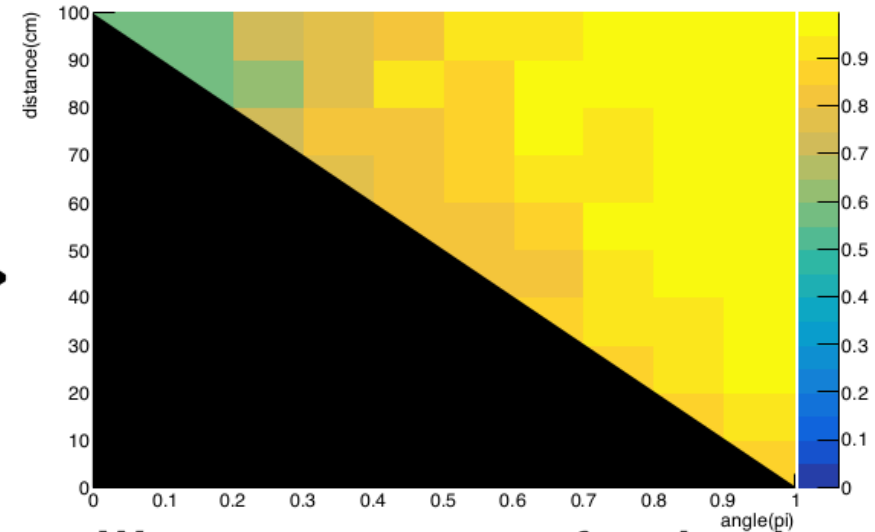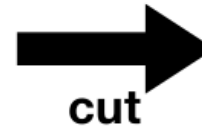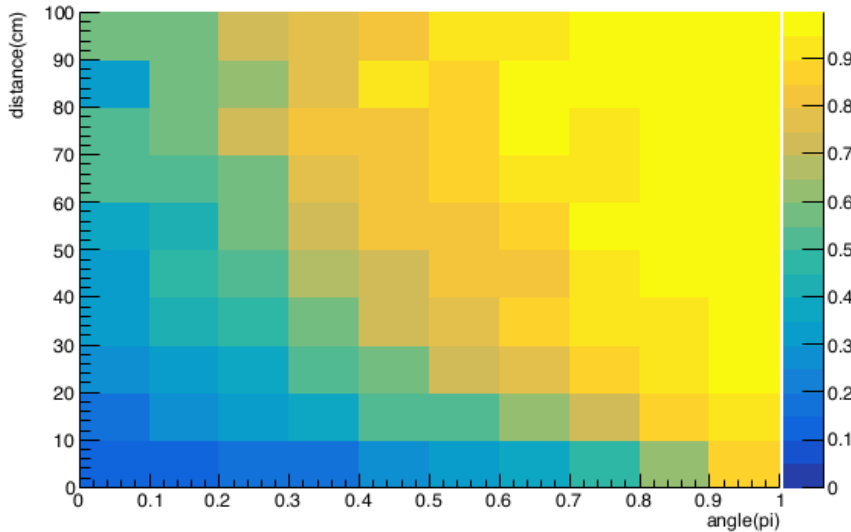

So we can choose area where purity is good(upper right region).
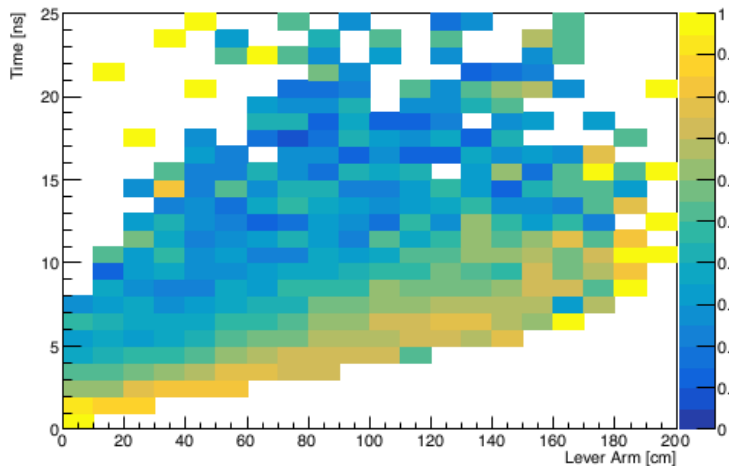
cc 1 charged pion , 0 proton

purity

purity

cut

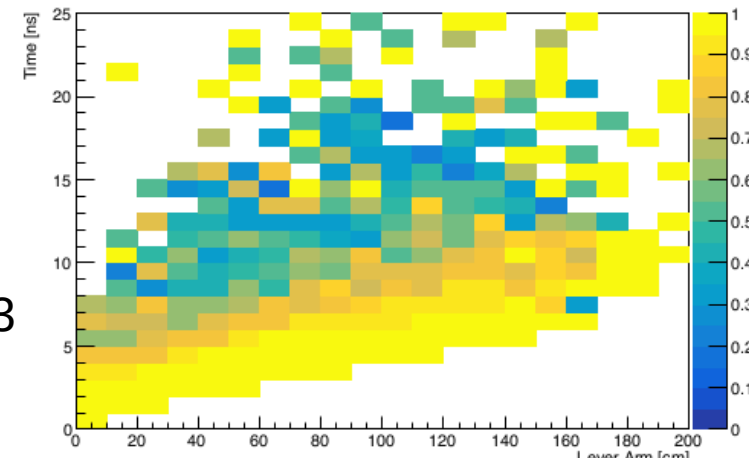**We care upper part of purity plot**
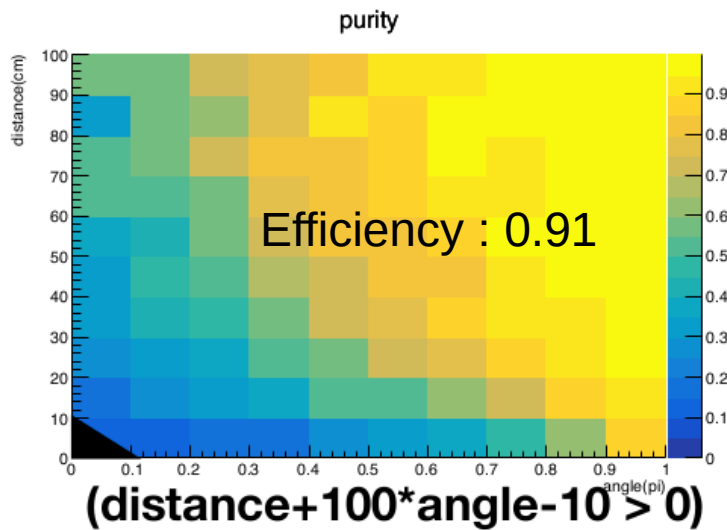**(distance+100*angle-100 > 0)**

purity (nocut)
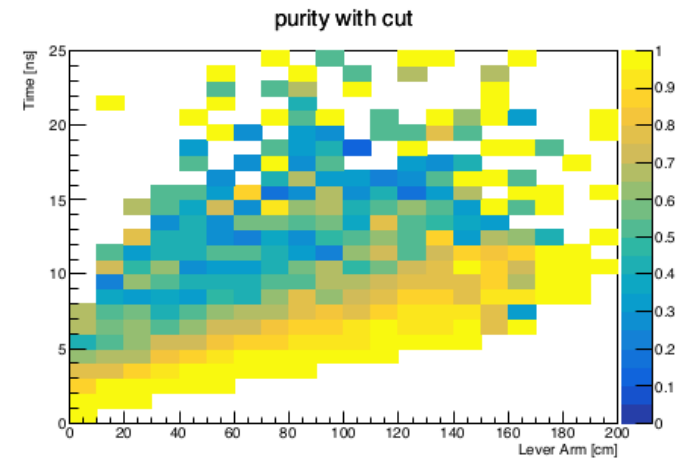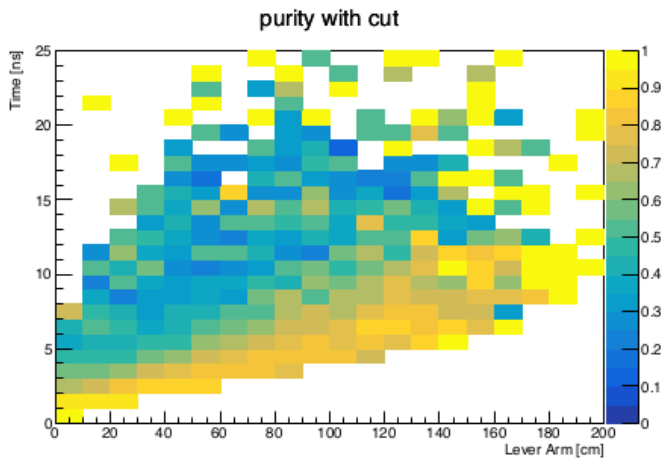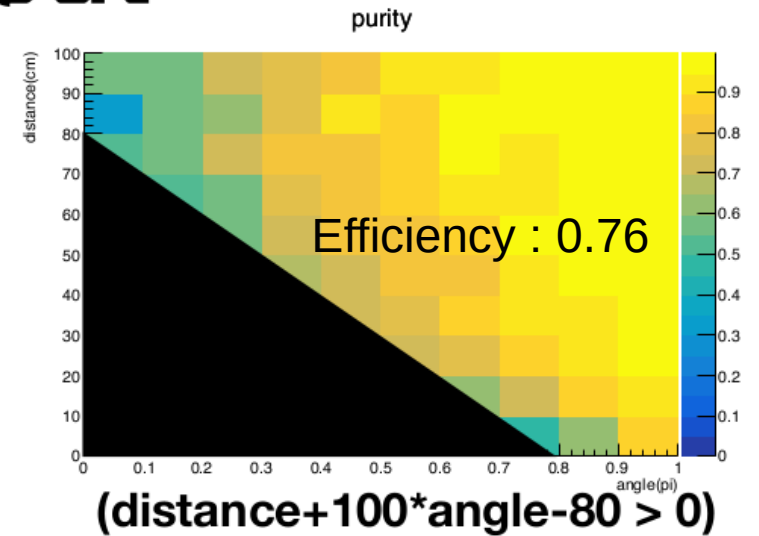
purity with cut

Efficiency : 0.63

A further cut on lever arm and time can provide a pure sample
(effectively a kinetic energy cut removing < 30 MeV KE neutrons)

cc 1 charged pion , 0 proton -varying cut

Efficiency : 0.91

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Efficiency : 0.76
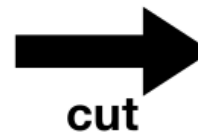
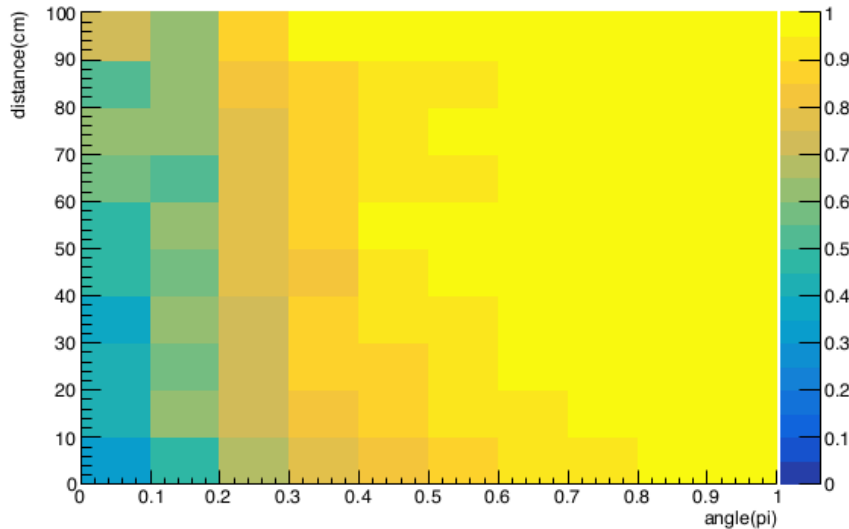(distance+100*angle-10 > 0)

(distance+100*angle-80 > 0)

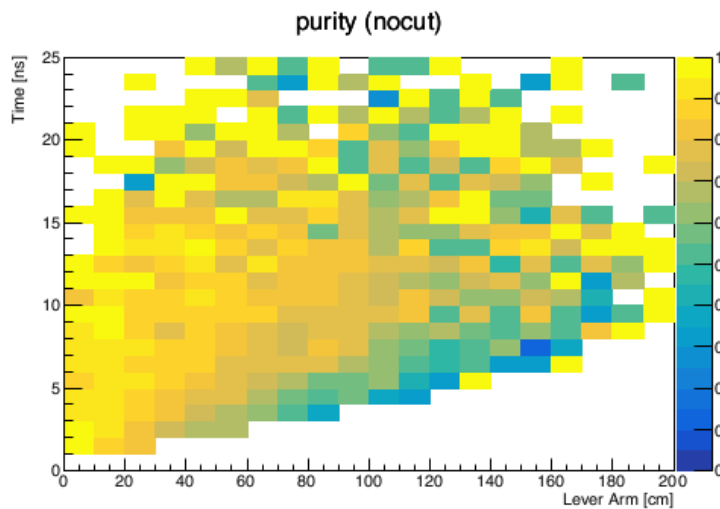**We fix cut's slope and changed y intercept to see what would happen to purity plot.**

01/07/20

cc 0 charged pion , 1 proton

purity

purity

cut

purity

We care upper part of purity plot
(distance+100*angle-100 > 0)

purity (nocut)

Efficiency : 0.43

purity with cut

01/07/20   Similar to 1pi0p, we can optimize the cut to gain higher efficiency
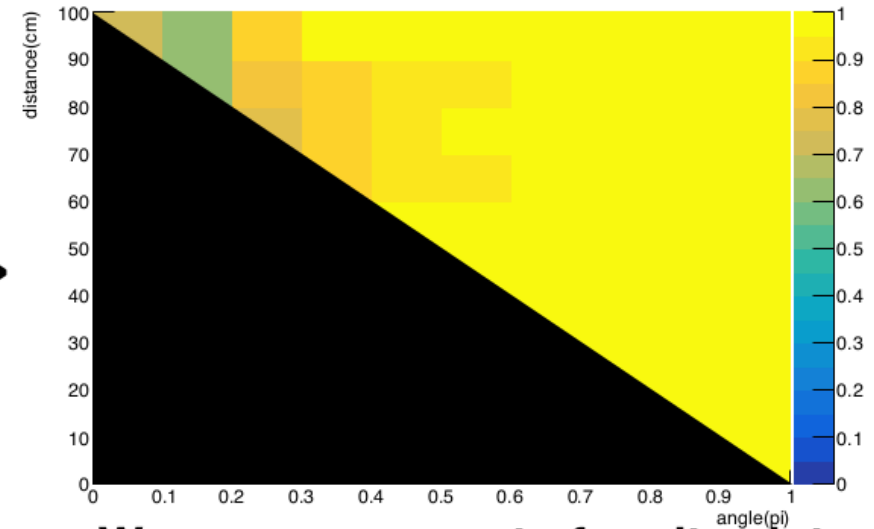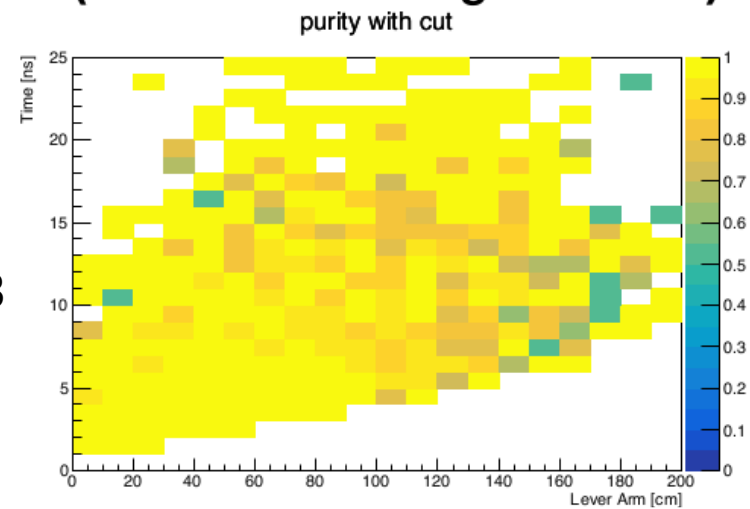
Summary

- The 2D looks promising to reduce the secondary background for CC1p0pi+- and CC0p1pi+- channels.

- Optimizing the 2D cut is on the way

- More channels can be considered